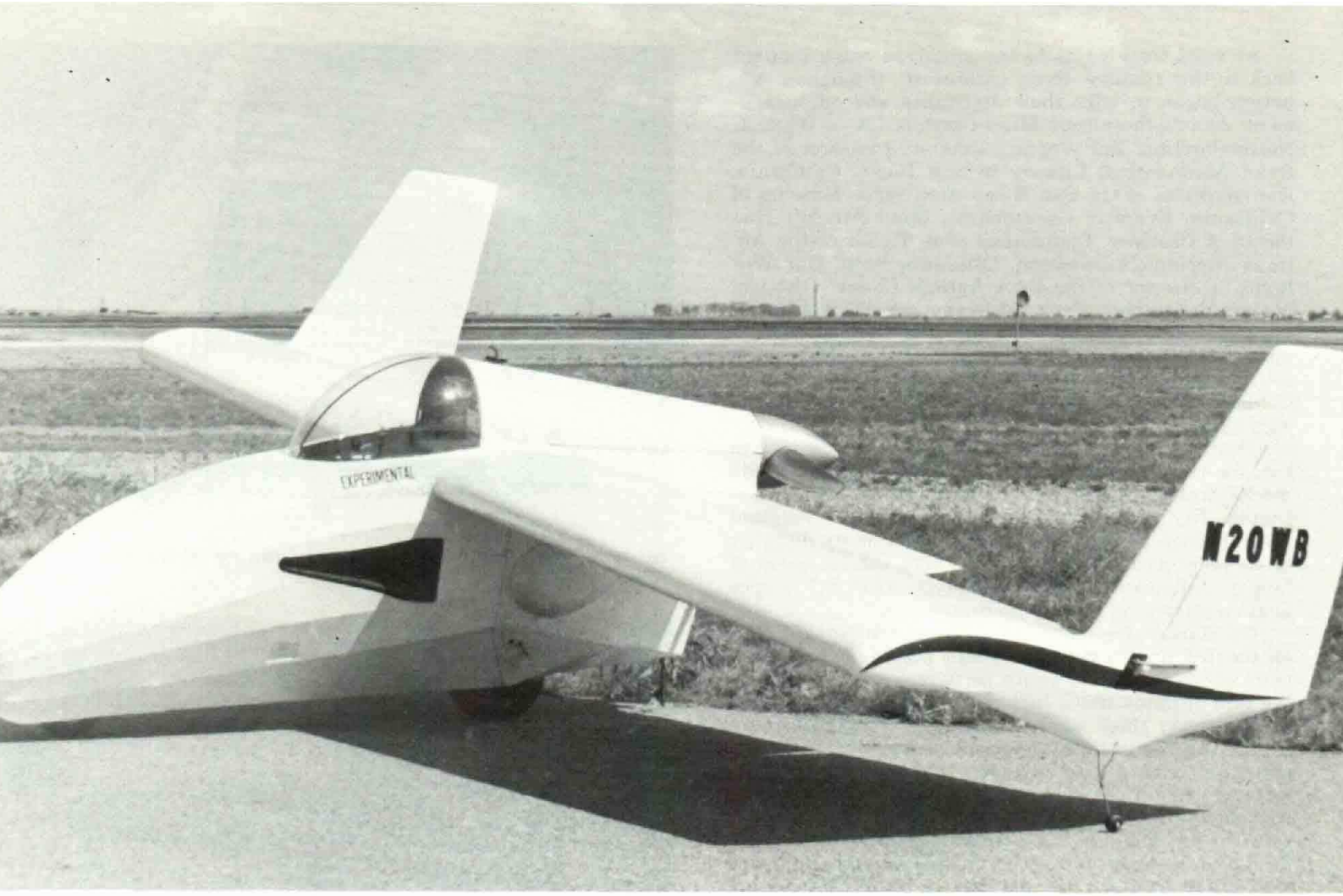


THE WPB-1 FLYING PLANK

By Al Backstrom (EAA 1162)
Rt. 1
Frisco, Texas 75034

(Photos Courtesy the Authors)

Part 1 — The Designer's Story

DUE TO THE success of my Flying Plank sailplane, many powered versions of the configuration have been sketched out over the years. Tractor engine versions all died on the sketch pad as they did not offer enough advantages to justify them. The pusher versions that offered some significant performance advantages were dropped because there never seemed to be a suitable small engine available.

The WPB-1 Powered Plank started as a design study based on using a Fitchel and Sachs Wankel rated at 20 horsepower (later 23) with a 56 pound weight. The basic design objective was to obtain good performance with low power. To achieve this, a minimum airplane was laid out based on the aerodynamics of the best flying of the Plank sailplanes. A review of my basic philosophies for light plane design is contained in an article on ultralights in *SPORT AVIATION*, April 1973. Because I had finished most of the detail design on the WPB-1 when the article was written, some of my thoughts had changed. The primary area of change was that I realized that I had some areas too complex to build, such as the nose fairing. It looks nice, as intended, but it is too complex

to justify the small decrease in drag. Approximate performance was calculated for several sizes of airplane and a 22½ foot wingspan machine with 100 square feet of wing area was considered the best. A major factor in the size selection was to obtain a low minimum speed and to allow a relatively short takeoff run with a good rate of climb. In my opinion, these factors are as important as top or cruise speed for most sport airplanes.

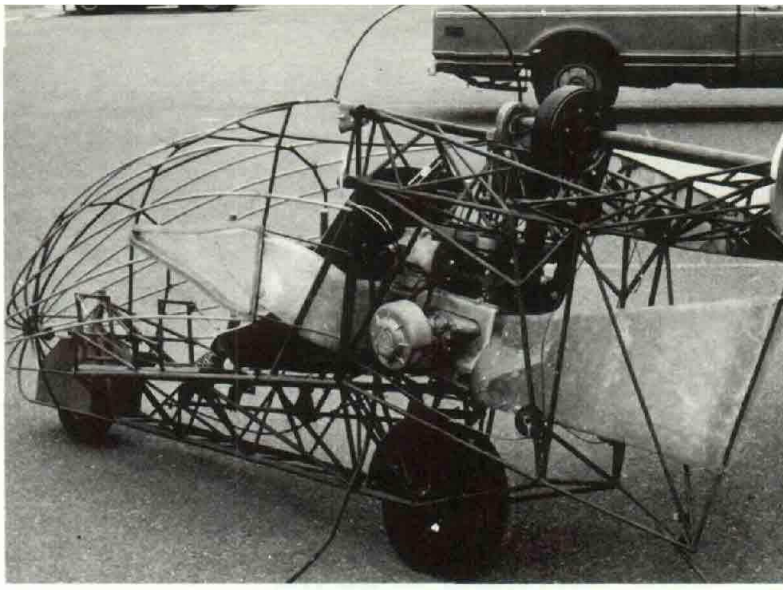
This work was done in the 1969 and 70 period, but was not carried further than the sketches and performance calculations. About the first of January, 1972, I had a call from my friend, Van White, in Lubbock, Texas. Van had a minor problem — he was all out of projects. Van is a long time EAA member who has amateur builts (including the 1959 EAA Workmanship award for one), antique restorations, aerobatic rebuilds, etc. to his credit. With this background, Van felt he wanted a project which was not run of the mill. Boy, was I ever able to solve his problem! As a matter of fact, there have been several times when I believe that I oversolved it.

As there had been no detail design work started on the machine, it required no redesign to use Van's choice of materials. These were wood for the wing and tip fins with steel tube structure in the pod. I have a fair amount of experience with these materials, so I had no objection to them. During the early stages of the design work, Jock Powell was able to provide assistance. The structural and control system design proceeded smoothly with only minor changes being made to the intended configuration. A small change was made in the span due to the wing spars being built when I decided that the wing-pod juncture would be too complex to fair in using a stub wing section on the pod. Well, what's 10 inches of wing span among friends anyway?

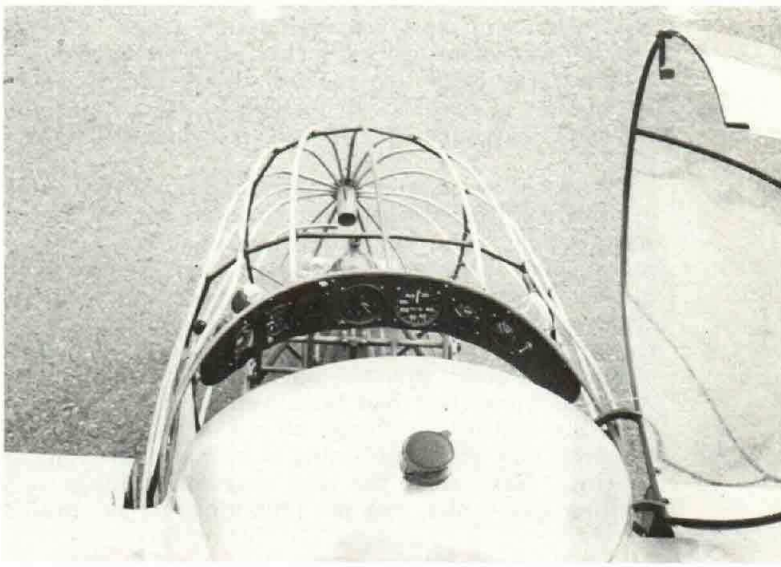
During this period, both Van and I were trying to locate one of the Sachs Wankels or the better looking (on paper anyway) OMC snowmobile Wankel. We were unable to obtain either of these engines, but we did manage to get a new Kiekhaefer Aeromarine 440 (fan cooled, single ignition version). This is a fine basic engine, but since it is bigger, heavier, more powerful, and a recip, it ruined the intended simplicity of the engine installation. Actually, the recip feature was the thing that did us in. The Wankels were designed for hard mounting so that a hard mount could also be used for the propeller shaft. A belt drive reduction was to be used and this was retained for the recip shaft. But recip engines require shock mounting. When this is done, you must maintain belt tension on a moving engine with a fixed point (bearing) at the propeller. If you are interested in or need to use this type of drive system, George Spratt has a much simpler system in use on his Controlwing machines. Unfortunately, we had built the Plank's drive system before we had any information on George's. Our drive system is working well, but it is heavy and complex.

The engine change was not all bad. The extra power is very desirable since the airplane is based at Lubbock, Texas, which is at 3000 feet plus elevation and summer afternoon temperatures in excess of 100 degrees are common. During some of the test work we have taken off with approximately 20 horsepower. Even if the airplane were 60 pounds lighter, as it should have been with the 20 horsepower Wankel, the performance would not be satisfactory at Lubbock in the summer.

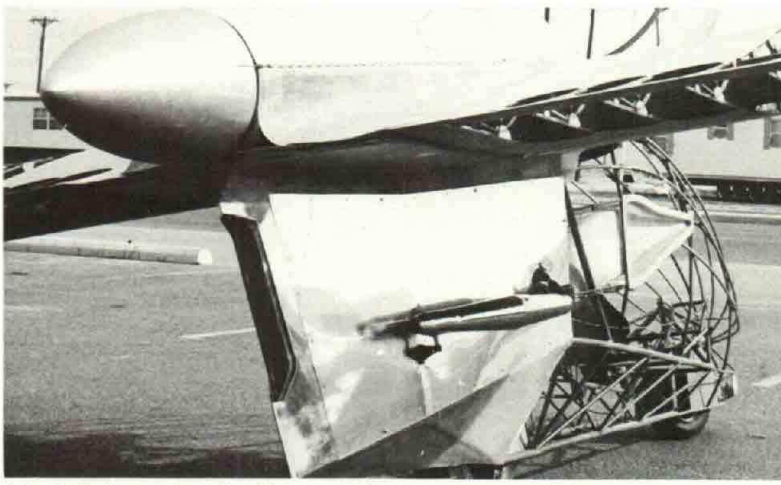
During the design phases the weight and target weights have varied. The original design was for 550 pound gross weight with an intended limit load factor of 5 plus. This was based on an estimated 300 pound empty weight with the Sachs Wankel. When the change was



Fuselage detail showing the inverted Kiekhaefer engine, fiber-glass inlet and exhaust ducts for engine cooling, the belt reduction unit and bicycle or tandem wheel landing gear arrangement. Note that the load carrying tubular structure is essentially a keel with a tower at the aft end for wing attach and mounting of the engine and prop shaft.



Looking forward into the cockpit and at the nose construction detail.



Aft fuselage detail with cowling and wing fairings in place. Note the highly reflexed wing profile, necessary to make the Plank fly without a tail.

made to the Kiekhaefer engine, I made a guess that the empty weight would increase to about 350 pounds. Our flight test weights have been about 390 pounds, which includes 10 pounds of radio and battery that was not included in the original weight estimates. The battery weight was used as ballast and was necessary in the rear of the pod. I think that redesign to eliminate the prototype weights are not too important as the Kiekhaefer engine is not in production and a new engine installation will be required for any subsequent development.

Well, those are the highlights of the designer's story — except to say there are frustrations you wouldn't believe in doing the design of an airplane that is being built 300 miles away.

The Powered Plank in flight.

Part 2 — Building the Powered Plank

By Van White (EAA 155)
EAA Director
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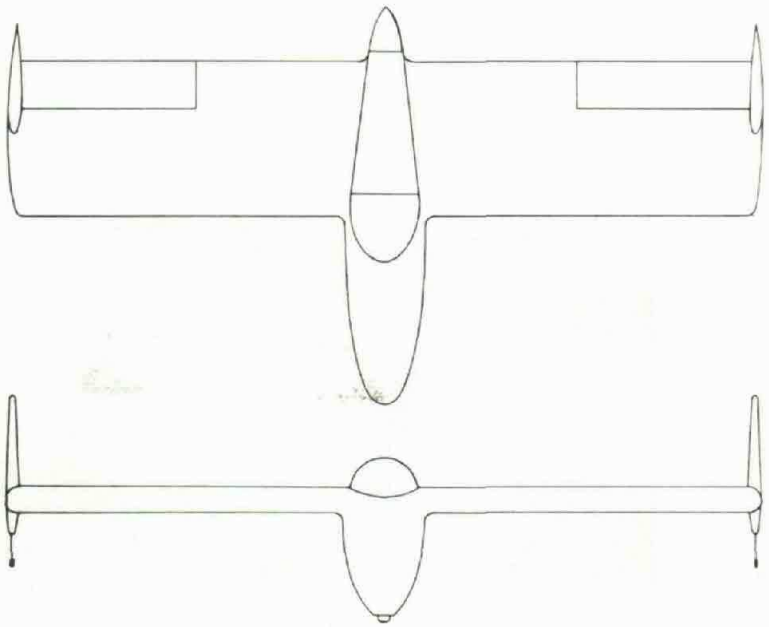
Lubbock, Texas 79417

AS AL STARTED drawings, I started building. I determined that a 4' by 8' plywood bench would serve as work table and jig for the complete airplane because of its small size. The wing spars, ribs, elevons, rudders and all of the wooden parts were built first. Al designed all this to be very light, but with twice as many parts in the wing as in most homebuilts that I have seen. Rib spacing was about every 6 inches, with plywood sections to take drag loads and molded plywood leading edges with miles of scarfing. Being fabric covered and glued instead of rib stitched, a very clean and smooth wing results.

With the wood work completed and another bundle of drawings from Backstrom on hand, I started the tubing fuselage. I did not believe one man could draw so many small tubes in such a small area. One by one, it all went in place using angle iron jigs and templates. By now, the engine had arrived and it was time to start the engine mount and driveshaft. After the usual period of trial and error, this was accomplished with a lot less machine work than had been anticipated, using short cuts like cutting the flange off a Continental shaft for the prop hub, then machining it to mate our shaft and bearings. Next, came the time consuming things — installing gas tanks, canopy, plumbing, fabric, muffler, instruments, etc. About 2 years went by, with an average of 20 to 30 hours labor each week.

At last, we were ready to assemble and start taxi tests. Carefully checking on the weight and balance, we found it very close to what Al had calculated. However, we did have more weight than planned on the nose wheel. This was not a total surprise, for in building the fuselage structure I had made a small mistake in reading the plans that caused the location of the main gear to be back about 2 inches. Al and I discussed this and decided it would not rotate as slowly as we had hoped, but would still rotate at some faster speed. However, with my 220# plus in the cockpit and the bathroom scales under the nose wheel, the problem looked worse. With about 80 pounds on the nose wheel, I started taxi tests and ground handling seemed acceptable. With the tandem configuration, the wings could be leveled into the wind almost immediately after the take-off roll was started. Steering, even in crosswinds, was okay. The one wheel brake did not seem quite adequate. However, initial runs up to 40 mph showed that we could not rotate the nose wheel, even with full back control. As we increased the test by 5 mile increments and approached our calibrated stall speed, it was deemed wise to have but very little up-elevon at take-off speed, to prevent a sudden loop after rotation. I decided, even without rotating, there was a faster speed we could fly off with the main gears on the ground and controls more or less neutral. On the next run, I let it get to about 70 mph indicated and felt it lift off. As planned, I reduced power and let it settle back on the runway. However, all did not go as planned. By habit, on touchdown I gave it a little forward control to stick the nose wheel on more firmly.

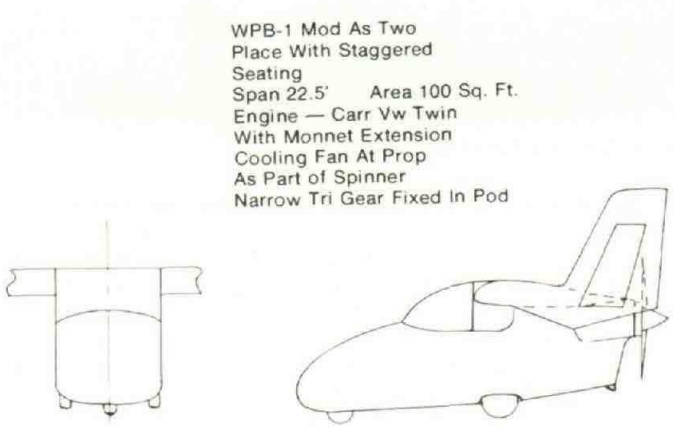


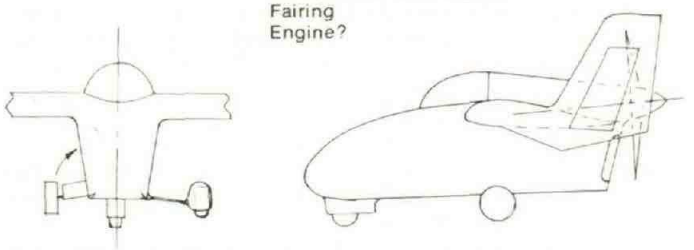
WPB-1 Summer Of 75 Config.
Span 21'8"
Chord 4'6"
Wing Area 97.5 Sq. Ft.
Length 11'1"

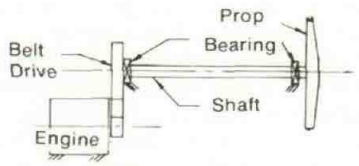
1/20 Scale
10/20/75

However, with the elevons and ground cushion effect combined with excess speed, I found myself with the rear main gear off the ground and the nose wheel on, wheel barrowing, followed by the fastest ground loop on record. I had about the same control of the Plank as I would of a bicycle going backward 90 mph down the runway.

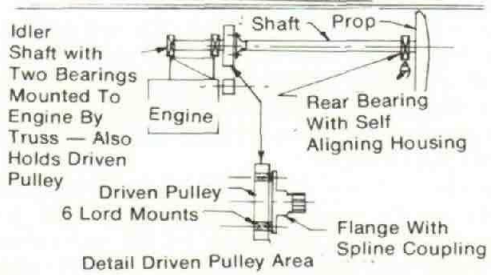
After the dust settled, I was relieved to see the only damage was to the small wheels on the tips of both wings — and my pride. Now, it was apparent that we needed to be able to rotate at a lower speed. A temporary movable rear wheel was fabricated. We found that each inch we moved the wheel forward took eleven pounds off the nose wheel. Also, at this point I began to convince Al that his lighter weight would make a better test pilot. After these modifications, Al had been able to rotate at about 40 mph and the ship lifted off at 50 to 55 mph.







Intended Drive System
For Wankel Engine



Detail Driven Pulley Area

Drive System Used For Recip Engine

Now, more small problems began to show . . . problems that were there all the time, but seemed unimportant on the ground. The engine, while running smoothly static, seemed to change at higher speed. This was considered to be a mixture problem, so many different carburetors were installed. The problem proved to be simple. We were taking intake air off the same scoops used for cooling and static. This was fine, but as speed increased and the engine cooling fan speeded, the position of the air intake pickup caused the pressure to the carburetor to change from positive pressure to a slight negative pressure. This has been changed. We now have a Lake injector with a mixture control that I built on it and the engine problems seem to be solved. The ship is, at present, in my shop while we install a more conventional 2 wheel main gear with some decent hydraulic brakes.

Part 3 — 1975 Tests by Al Backstrom

AFTER VAN'S GLORIOUS groundloop, it was decided that we would mount the main wheel so that it could be moved fore and aft to determine the best location. Also, we would rework the tip fins to use extended outriggers only. In order to have another pilot available, I borrowed Van's Cub to learn to fly again and otherwise gain a little proficiency. It was good to get back to flying.

In the spring Van declared the ship ready to fly again. We were hampered by weather and it was mid April before we could get test work under way. On the first try only brief taxi tests could be made due to engine problems. The engine would only develop about 44-5400 rpm static and would die back or surge when the ship got to moving. In spite of the engine problems we were able to make high speed taxi runs. We were able to lift the nose wheel at speeds down to around 40 kts. indicated with full back stick.

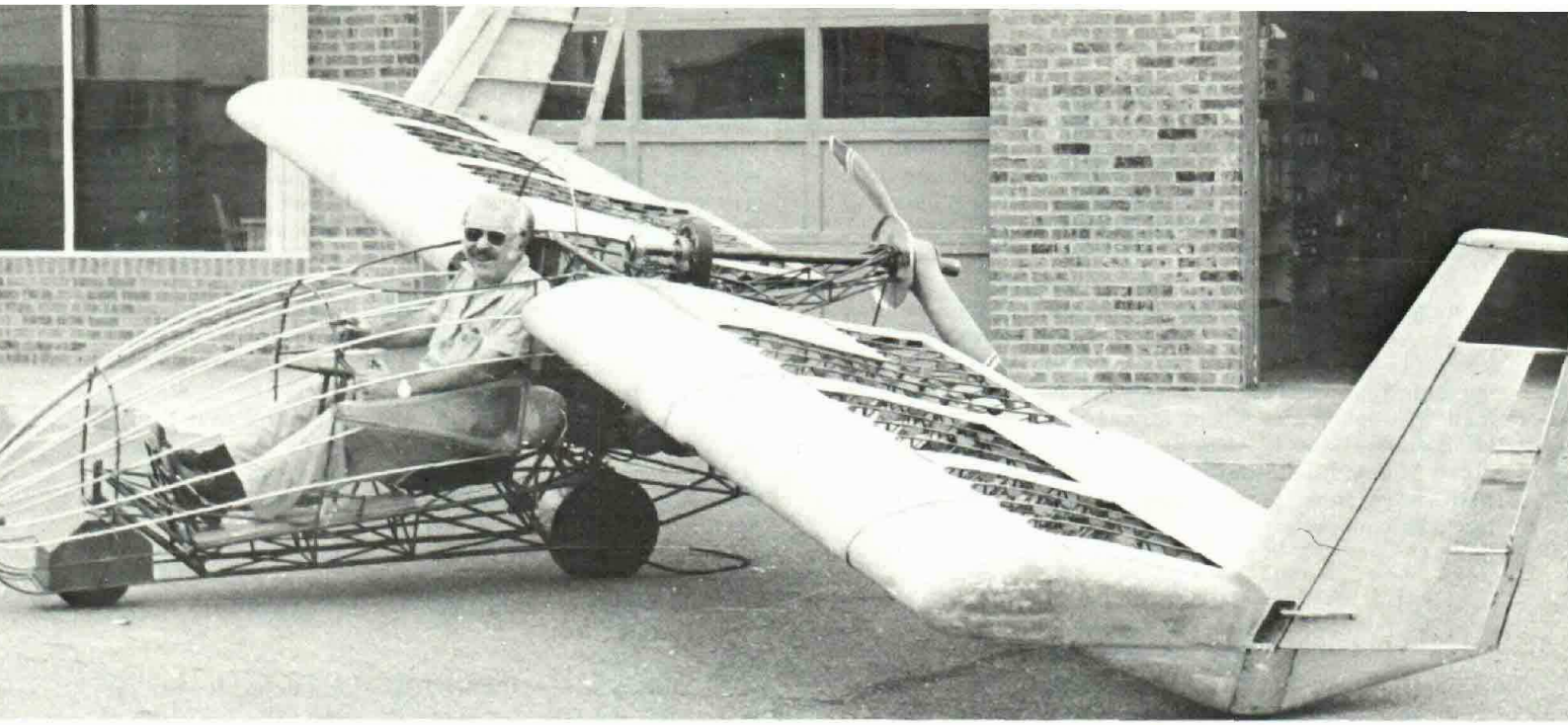
During this period we were being held back by continual problems with the tip outriggers. This detail problem has probably used up as much time as some of the more major problems and still does not have a really satisfactory solution.

About this time, we decided to change from the original to a Lake carburetor. This was done and a small increase in static rpm was achieved. Because of the required change in the air intake system the fall off and surge problem was practically eliminated.

On June 1, in our early tries with the Lake carburetor, I decided to make a normal takeoff run instead of holding full back stick. On this run I let the speed build a little more than intended, and when I eased the stick aft, it started flying. Everything was normal but exciting since I had not intended to get off the ground. We were not satisfied with the engine, but we were out of time for the weekend.

On the July 4th weekend, more flights down the runway were made with the carburetor adjusted as well as we could. We were still not satisfied and decided to rework the propeller. We got the propeller back just in time for Van and I to go to Oshkosh.

The propeller rework got us about 300 rpm on the engine. We were now able to get about 4800 rpm static or more with best tuning of the carburetor. In mid August we tried again with better results. I was ready to go around the pattern but the engine was not consistent enough. Van, Jock Powell, and I were drinking a beer (each) and discussing the problem — basically the rpm was down to the point that if the carburetor was not peaked there wasn't enough power to fly comfortably.



Van White tries the Powered Plank on for size prior to covering.

I will admit that my recent flying had been done almost entirely in Van's 150 horse J-3, so I was used to a lot of performance. During this discussion we decided to try exhaust tuning. We held a piece of pipe with water pump pliers and played trombone with the exhaust. With this we were able to increase the static rpm from 48-49000 to 53-54000. This was the power we needed, but again we were out of weekend and had to quit. We were amazed at what exhaust tuning had done to the two cycle engine. I knew it would help some because the racing boys did it, but none of us expected the increase we got.

Van reworked the exhaust pipe, and when my scheduling delayed a visit to Lubbock until mid September, he took the bull by the horns and built a mixture control for the Lake Carburetor. The mixture control was needed to eliminate the constant tweaking of the carburetor for tuning. We will provide a separate article on the mixture control in the near future.

We finally had a good running engine and tip outriggers that would last awhile. The weather wasn't cooperating this weekend, but finally went VFR with about 10 kts. crosswind and we decided to make a flight down the runway to check things before going around the pattern. On this flight things went too well. I got the bird to indicating 95 kts. and accelerating at about 70 feet but had to get down quick. I did, but I got in too big a hurry to get stopped and got my feet out of sync with the heel brake and the rudder pedals. I guess I got the stick forward too, because I went around. This blew the main gear tire and bent an outrigger. These were fixed so we could go around the pattern Sunday. It rained all day.

As both Van and I have wheelbarrowed and ground looped and have not yet been fully satisfied with any of our outriggers, we have decided to install a narrow two wheel main gear for a try. This will also incorporate a hand operated brake. Hopefully, by the time you read this we will have flown it with the mini trigear.

Part 4 — Correcting the Errors and the Future

Al Backstrom

MOST OF THE troublesome design problems have been discussed, but there are some other errors that should not be repeated. The primary ones are to lower the thrust line and change the engine fire protection design.

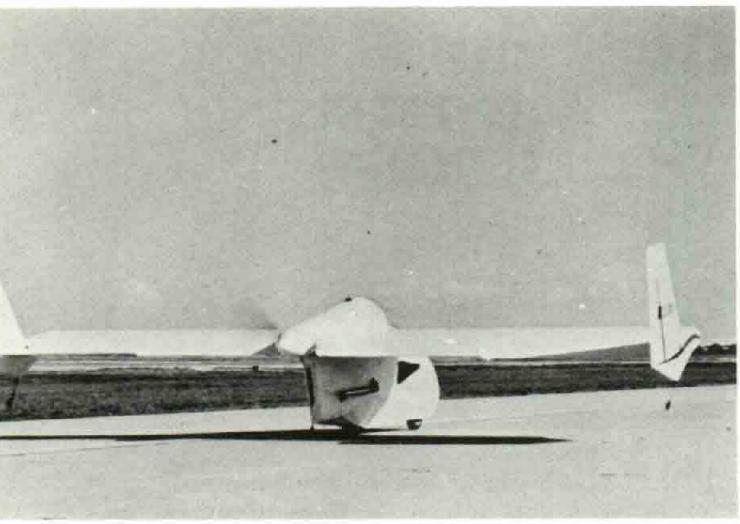
As noted in the flight test discussion we were able to lift the nose wheel at around 40 kts. when the engine was not running properly. At this time we have not conducted additional tests to find out how much the increase in usable power has increased the minimum rotation speed. The effect of power changes on pitch attitude are noticeable, so it seems that the overall design would be improved by moving the thrust line down or by locating the prop below the wing.

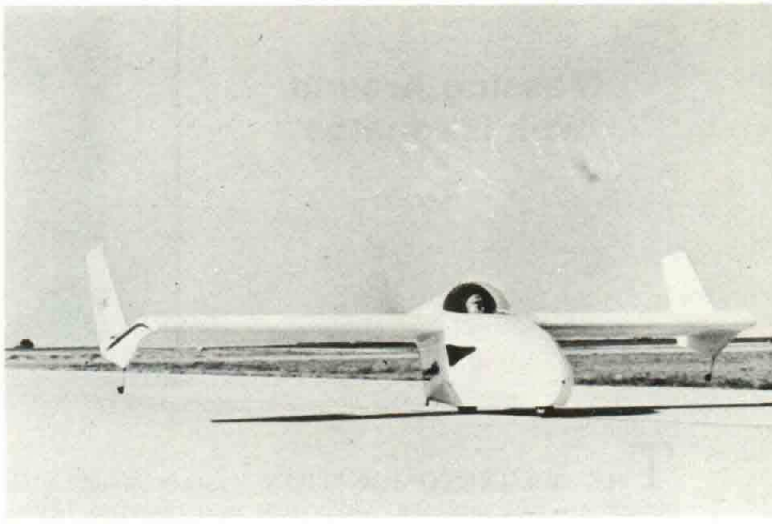
In the initial design it was decided to provide engine fire protection by the separation of flammable fluids and ignition sources. To accomplish this, the fuel tank is mounted in a sealed enclosure with its own drain to vent any leakage overboard. It was intended to shroud all fuel lines, however we do not have a good system worked out at this time. With the carb changes it is just as well since we did not have so much to throw away. We probably have fire protection somewhat worse than the typical recip engined helicopter, but we could have gotten better, for less work, by using a firewall. Also, the engine in the prototype is located forward of the best position and moving the engine aft would allow a simpler firewall installation.

At this time we do not have plans to make these changes in the prototype, but for your information, sketches are shown of two designs with the known errors corrected. These are for a single and two place configurations but a mixture could be used.

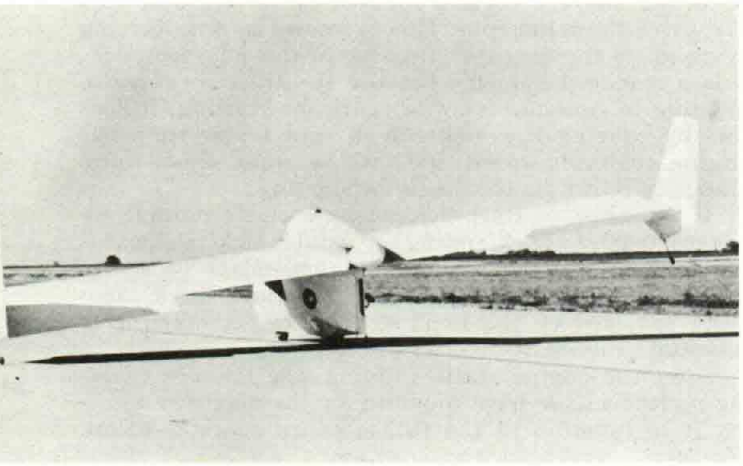
Right now Van and I hope to get the airplane out and flying with the restrictions off for next year. We have decided that we do not want to be in the plans or kit selling business. When we are satisfied that we have an acceptable airplane, the airplane and all design rights will be for sale. To us, the design, and development aspects are the fun part of sport aviation. Please do not write for additional information on the airplane as we do not have time to give individual replies. When there is more to say we will write it up for publication in *SPORT AVIATION*.

In closing, we would like to publicly express our thanks to the people who have provided help on this project. There are too many to list individually, but to the people who gave their time and their support we say again, **THANKS.**

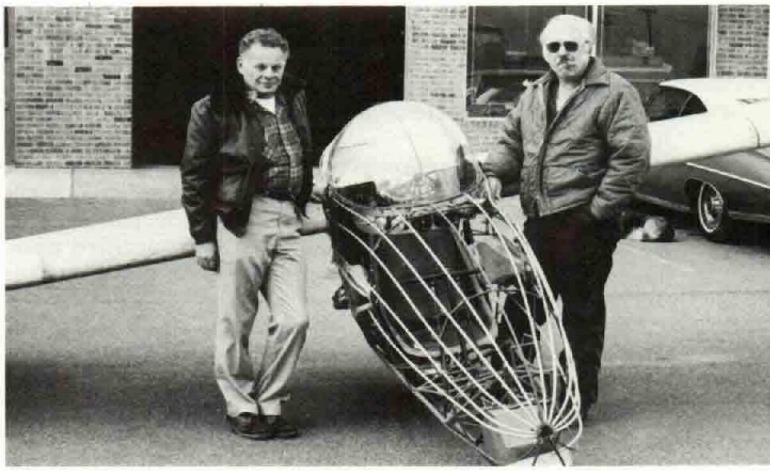




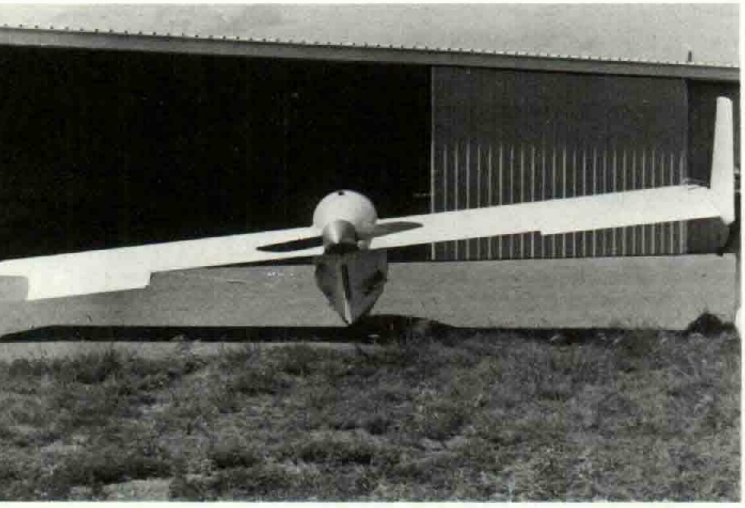
Coming . . . and going. The Powered Plank zips by the photographer with enough speed to be balanced on the bicycle gear.

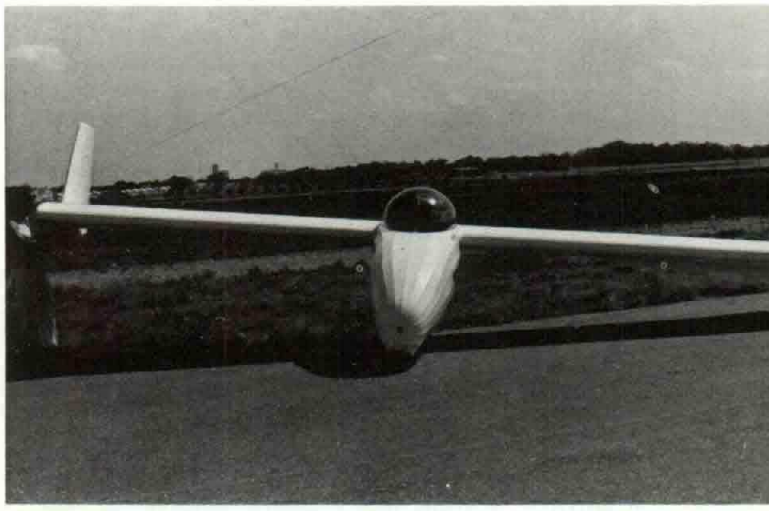


Starting the take-off run with the Powered Plank balanced on the mains and one outrigger. Notice the deflection of the elevons in an effort to get the wings level.



The two principals in the Powered Plank story: left, Al Backstrom, the designer, and Van White, the builder. Al is an aeronautical engineer with the FAA in Dallas and Van is an electrical contractor and a Director of EAA.





Front and rear views of the Powered Plank — obviously a very clean machine. Enduring appeal of the flying wing is the simplicity of the airframe. For a homebuilder it means fewer components to build.