AN UPDATE ON PROJECT PENUMBRA

Some time ago we mentioned our own tailless project, a 'wing for F3B, and promised an update on our progress. Following several flights of our current design we are now able to give an informative report.

As is the case with many projects, our goal with Project Penumbra is not so much to come up with something entirely new and earth shaking, but more to take existing information from a variety of sources and come up with a design which (1) is within our capabilities to construct, (2) can be flown well with but a reasonable increase in flying skill, (3) will provide excellent performance in all flight regimes once sufficient skill is acquired. We are also eager to learn more about flying wing structures and aerodynamics. It is hoped the eventual design will be a competitive F3B machine.

Conventional designs and swept flying wings are rotated in pitch by control surface movement behind the CG; the nose is raised by applying a downforce. Project Penumbra began with the idea a swept 'wing with narrow chord and large sweep angle could have its elevator in front of the CG. This is advantageous in that the force needed to change pitch is in the direction of the desired change; thus down elevator increases lift over the center of the wing and raises the nose. Due to the extreme sweep angle needed and the fact what is really being considered in this case is a canard (in general a poor soaring configuration), the idea was abandoned.

We knew from experience plank designs would not be competitive in the F3B environment as they tend to be one speed airplanes. We also knew trim drag had the potential of reducing the speed range of a swept wing, just as with a conventional tailed sailplane. We wanted our design to have a broad speed range. Our experience with the positive moment coefficients of our planks, and tailed aircraft we had flown, pointed to the use of an airfoil with a pitching moment of close to zero. Very little trim would be needed at high speed, and the trim change needed for

thermaling would actually be beneficial to stability and the lift distribution.

Construction of our first swept 'wing was started. It featured a 9% symmetrical Quabeck section over the entire span, used 1° of twist, elevons, and double spar. One week later we had a pink foam 'wing covered in fiberglass. Built before we had our vacuum bagging equipment, it turned out so heavy and so crude we've never gone to the time, trouble, and expense of putting the finishing coat of epoxy on it. We also realized we had more of a slope racer than a thermal machine, and it has remained flightless for more than two years.

In retrospect, it should have been obvious the symmetrical Quabeck section was not appropriate as it would not be able to provide a large amount of lift. About this time we received some information on the EH series of profiles created by John Yost. These sections are cambered, ranging from 1% to 2%, have high lift capability, and yet have a pitching moment of nearly zero. It looked like we had access to a wing section which would work well.

The 1989 MARCS Symposium featured Dr. Walter Panknin talking about his "Flying Rainbows." Dr. Panknin was quite effective at committing us to our concept. Home from Madison we immediately set up our vacuum bagging system. We laid out constant chord foam cores, installed Walter's spar system, applied several layers of fiberglass and sucked it all down with our GAST vacuum pump. A few nights of work on the control surfaces and our creation was finished. Compared with the previous 'wing, this one was beautiful: accurate, light, and glassy smooth.

First flights of Penumbra.1 were hand launches over wet grass on a cold morning. Several hand tosses indicated much weight could be safely removed from the nose, but running across the field as fast as possible and throwing the 'wing as hard as possible still resulted in its diving to gain speed. The ship was finally roughly trimmed out with the elevons in neutral, and we elected to winch it up.

Not only was it cold, but the fog which had saturated the grass still lingered overhead. Earlier flights that morning with our Blackbird 2m had resulted in "out of sight" performances, so we were careful to limit the launch height of our new 'wing, particularly since the only paint on her was grey primer. We pulsed the winch line tight and threw her hard. She went upon the line with no veering and came off the line with no problems. Turns were made in both directions. There was absolute silence during an overhead pass. Two 360^{o} turns brought her into a long shallow approach. Water sprayed into the air from the entire leading edge of the wing, but she was on the ground in one piece. We decided to pack up and go home with Penumbra.1 still in one piece and wait for a more conducive flying day.

Two days later, while cleaning Penumbra.1, we discovered the upper surface of both wings had failed in compression! This probably occurred during the single winch launch. It suddenly dawned on us fiberglass is not so good in compression as balsa, and Walter's spar system was for a balsa sheeted wing. We were pleased, however, Penumbra.1 had not only continued to fly but had flown so well, even with major structural failure.

Constructed of pink foam and fiberglass, Penumbra.2 is aerodynamically identical to Penumbra.1; structurally, two 3/32" plywood vertical web spars in each wing reach well past the previous point of failure. Penumbra.2 has now been completed and winch launched several times.

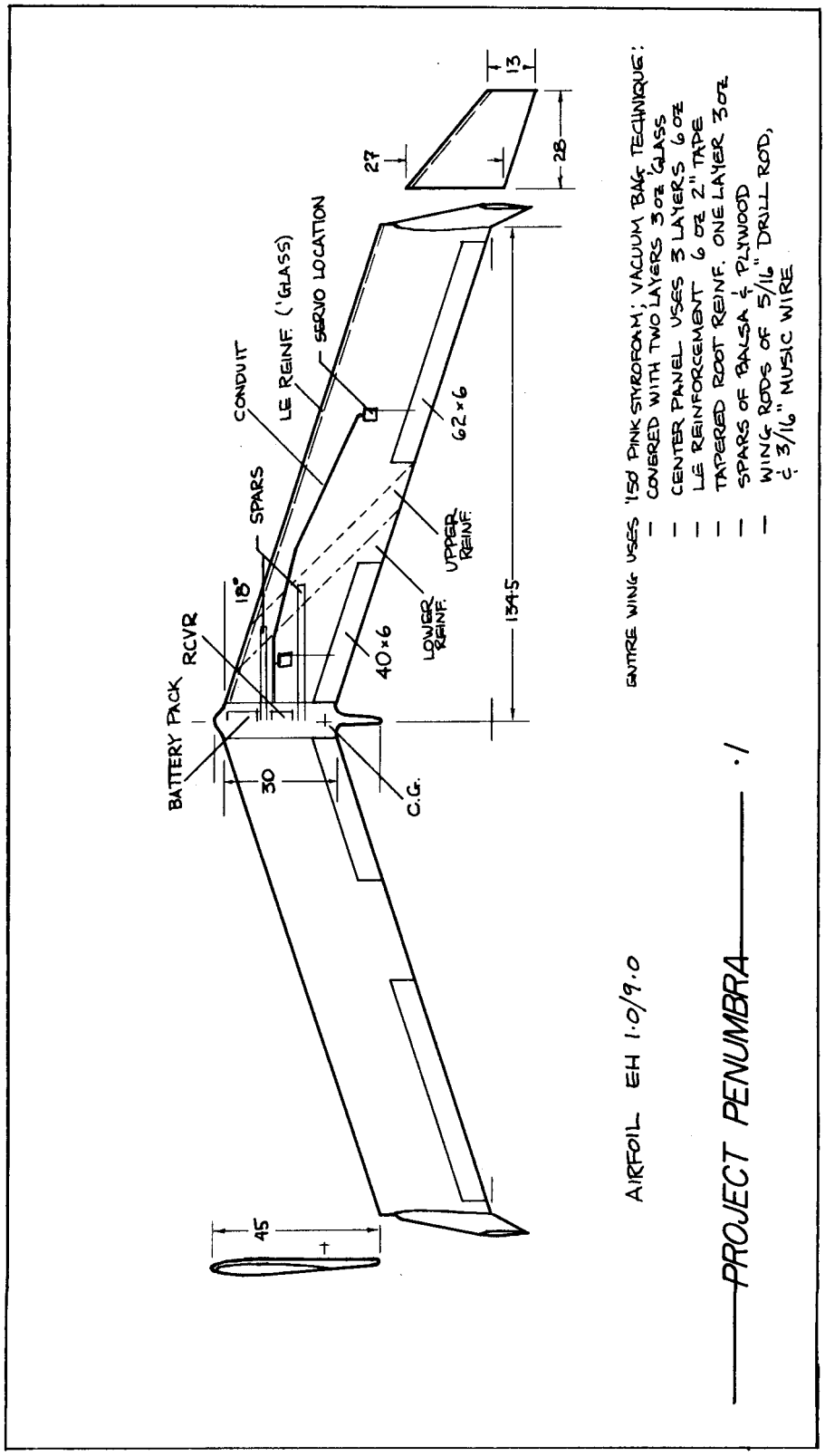
Results of these first flights have been quite satisfying. Air speed is very high, but Penumbra.2 gives obvious indications when in lift, and has been thermaled. Although a bit pitch sensitive, aileron control is quite positive, and the flaps, when deflected 80^{o}, bring her to a nearly complete stop. The airframe is extremely strong, as evidenced by several hard "landings."

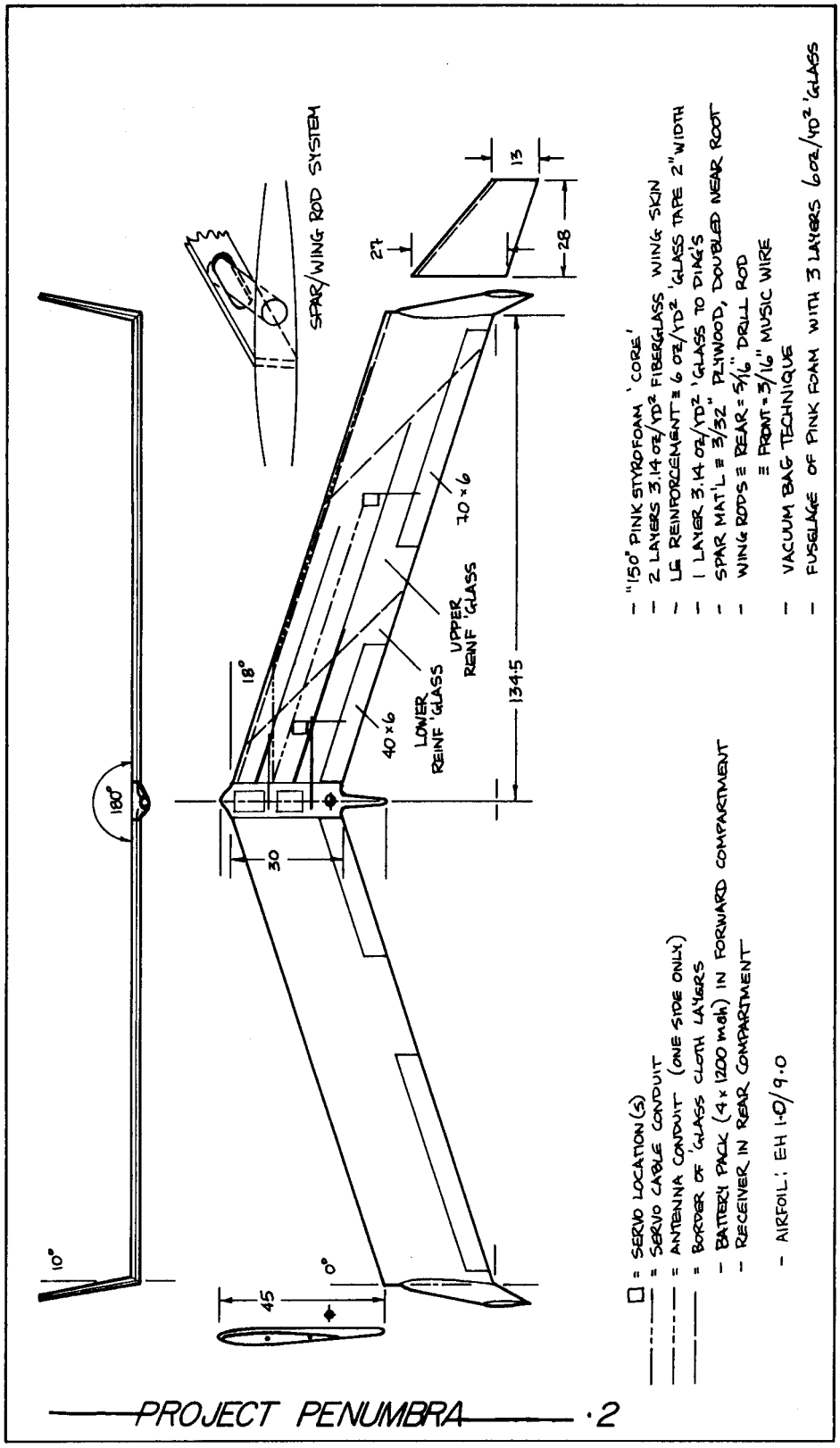
On the negative side, we still haven't entirely eliminated all of the structural problems, as on one launch (the highest) both wings appeared to flutter. This most likely came from the control surfaces. Also, launch

height is not nearly so high as it could be. Improved height off tow will come with proper CG and towhook locations, along with eliminating the flutter and achieving higher speeds.

We are still at the "proof of concept" stage, yet all of the goals we set for Project Penumbra are being met. Our construction techniques have been challenged, but the project falls well within our capabilities. Penumbra.1 proved easier to fly than expected, and demonstrated the great potential of the planform. Penumbra.2 has confirmed these notions. Our goal of learning more about structures and aerodynamics is being fulfilled beyond our expectations, and evaluation and further evolution of the design will continue.

We've drawn some sketches of the structure of Penumbra.1 and Penumbra.2. While these drawings are probably not sufficient for construction of a competition machine, they do include information on materials used in both versions and show the points of failure on Penumbra.1.


PROJECT PENUMBRA
AIRFOIL EH 1.0/9.0
ENTIRE WING USES 1.5# PINK STYROFOAM; VACUUM BAG TECHNIQUE:
– COVERED WITH TWO LAYERS 3 OZ GLASS
– CENTER PANEL USES 3 LAYERS 6 OZ
– LE REINFORCEMENT 6 OZ 2" TAPE
– TAPERED ROOT REINF. ONE LAYER 3 OZ
– SPARS OF BALSA & PLYWOOD
– WING RODS OF 5/16" DRILL ROD, & 3/16" MUSIC WIRE
BATTERY PACK
RCVR
SPARS
18"
CONDUIT
LE REINF. (GLASS)
SERVO LOCATION
30
C.G.
40×6
LOWER REINF.
UPPER REINF.
62×6
134.5
27
28
13
45


SPAR/WING ROD SYSTEM
27
13
28
18°
70×6
UPPER REINF 'GLASS
LOWER REINF 'GLASS
40×6
134.5
180°
30
10°
0°
45
□ = SERVO LOCATION (S)
= SERVO CABLE CONDUIT
= ANTENNA CONDUIT (ONE SIDE ONLY)
= BORDER OF 'GLASS CLOTH LAYERS
- BATTERY PACK (4×1200 mAh) IN FORWARD COMPARTMENT
- RECEIVER IN REAR COMPARTMENT
- AIRFOIL: EH 1.0/9.0
- "150" PINK STYROFOAM 'CORE'
- 2 LAYERS 3.14 OZ/YD² FIBERGLASS WING SKIN
- LG REINFORCEMENT = 6 OZ/YD² 'GLASS TAPE 2" WIDTH
- 1 LAYER 3.14 OZ/YD² 'GLASS TO PINK'S
- SPAR MAT'L = 3/32" PLYWOOD, DOUBLED NEAR ROOT
- WING RODS = REAR = 5/16" DRILL ROD
= FRONT = 3/16" MUSIC WIRE
- VACUUM BAG TECHNIQUE
- FUSELAGE OF PINK FOAM WITH 3 LAYERS 6OZ/YD² 'GLASS
PROJECT PENUMBRA ·2