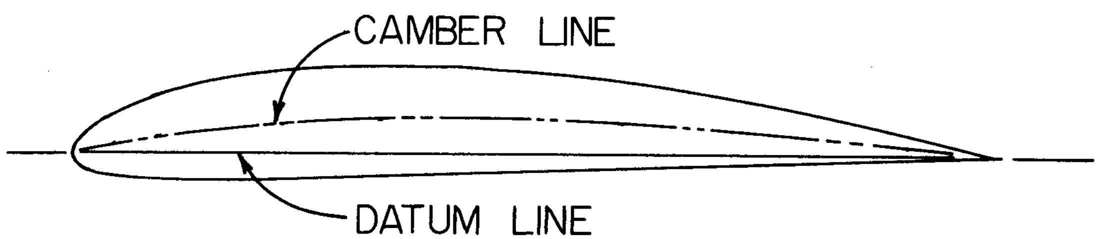
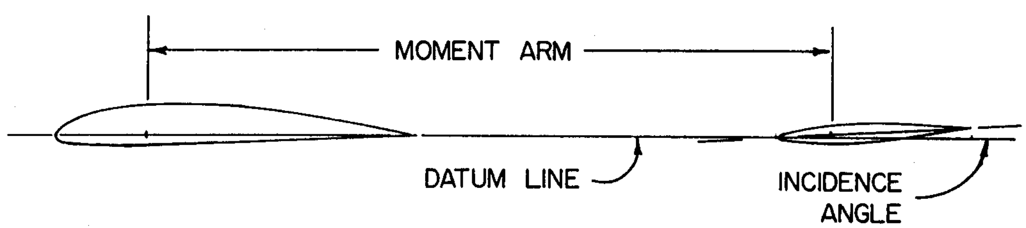
HOW "PLANKS" FLY

One of the strangest sights imaginable is that of a plank type tailless sailplane cruising serenely overhead. How do these sailplanes, looking for all the world like boards, manage to fly? And why are they so stable?

To begin, let's look at a common and unsophisticated airfoil, the Clark Y.

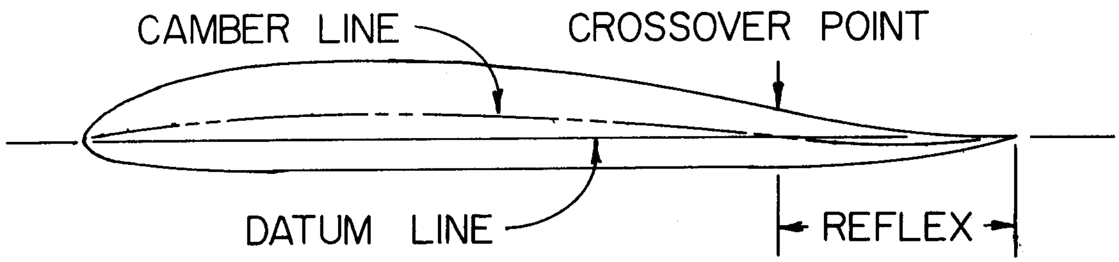


The Clark Y, in addition to being capable of providing a large amount of lift, has a negative pitching moment. Due to the shape of its camber line, shown in the drawing above, it tries to pitch forward as it moves through the air. Left alone, the Clark Y will tumble in flight unless provided with a sufficiently strong stabilizing force. This stabilizing force can be provided by a conventional horizontal tail (the stabilizer).

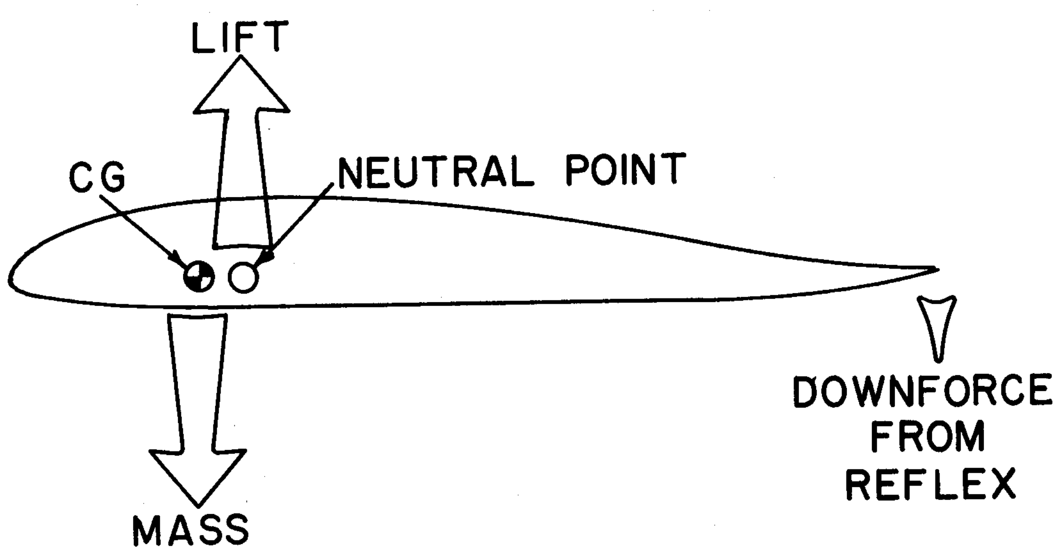


Neglecting the effects of downwash off the wing but recognizing the need to hold the wing at a positive angle to the oncoming air, the stabilizer must be set at a negative angle in relation to the wing.

If we move the stabilizer closer to the trailing edge of the wing we will find we need to make the stabilizer larger in order to produce the same stabilizing effect. Taken to the extreme, with the stabilizer trailing edge matching the wing's trailing edge, we see the following:



Notice the camber line and the fact it crosses over the mean chord line at the 75% chord point. The resulting section, the Clark YS, is an inherently stable airfoil because, contrary to what occurs with a normally cambered section, the center of pressure moves forward as the angle of attack decreases, and more rearward as it increases. Sections with greater camber will require more reflex in order to be made stable.



In trimming our plank, we place the CG ahead of the neutral point, thus producing a constant nose down force. When the CG is placed at the point where the nose down force can be exactly balanced by the aerodynamic downforce produced by the reflex in gliding flight, the airfoil is dynamically stable.

Finding the proper CG location is not difficult, it just requires some experimentation. Too far forward and the elevators will need to be trimmed to a slightly raised position; too far to the rear and the plank will be very pitch sensitive. Once the CG's proper location is discovered, however, it will remain constant.

The plank's marvelous stability is now easy to figure out. If the airfoil's speed slows, the forward CG overpowers the aerodynamic downforce of the reflex, thus increasing the speed in response. Traveling too fast, the reflex forces the leading edge up, increasing both drag and the effects of gravity.

No wonder planks make such wonderful free flight ships and R/C trainers. Reflexed sections, however, are not capable of producing large amounts of lift. The downforce which makes their stability possible is directly counter to the lift generated, and the reflex creates substantial drag. A plank's sink rate is therefore greater than we'd like to see and their speed range relatively narrow. But for some reason planks generally thermal quite well.

What can be done to improve the performance of the plank design? Reduce the amount of reflex to lower drag, increase lift, and allow a more rearward CG. The critical part of this manipulation is maintaining enough reflex to keep the CG in front of the neutral point (mean 1/4 chord line) while retaining a comfortable margin of stability. It is imperative that the CG be kept in front of the neutral point.

As planks are very easy to build perhaps some of you may wish to do some experimentation in reducing the pitching moment to a minimum. Let us know what you discover!

Suggestions for further reading...

Bates, Ken; "Windlord." The construction article for this fine performing plank was published in Model Aviation. It includes a great explanation of plank stability, both in the air and on tow.

Werner, Reinhard; "Nurflugelsegler Ferngesteurt." Covers a wide variety of plank designs through 3-views and text. Also discusses moveable CG, airfoils, control systems, and other topics. German text.

Lichte, Dipl. Ing. Martin; "Nurflugel-modelle." An explanation of tailless aircraft stability and how it can be achieved. Presents a simple method of estimating airfoil pitching moments, with examples. German text.