A Brief Wind Tunnel Te

by DANIEL WALTON

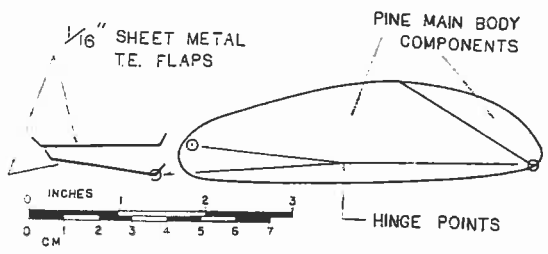

Figure 1: Scale drawing of section

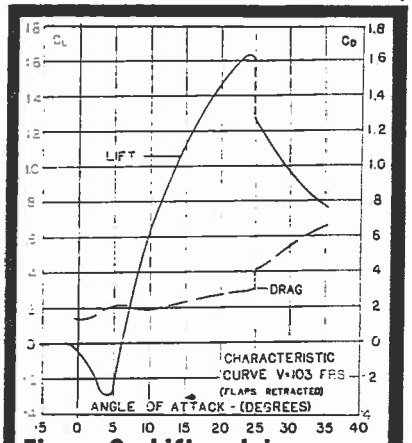

Figure 2: Lift and drag with flaps retracted

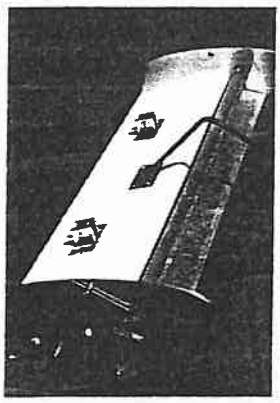

Photo 1: Bottom view of completed model

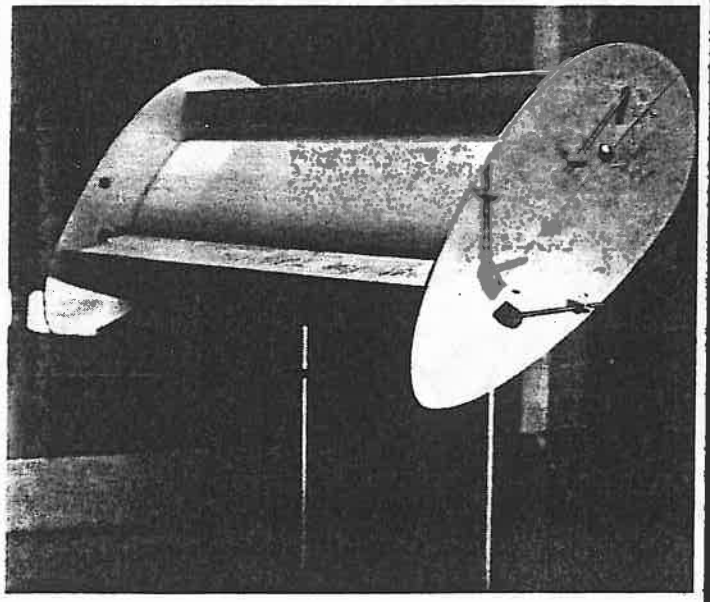

Photo 2: Rear view of model in tunnel

An article on the Kasper Airfoil in the December 1973 issue of SOARING presented a unique approach for achieving increased lift at high angles of attack. Because only limited data was given on the degree of aid the flap system afforded, it seemed that a tunnel test of this concept would be helpful in providing further data. A scale wing section was designed with a 19-inch span and a 6-inch chord. It was to have two large end-plates for attaching the leading-edge and trailing-edge split flaps, the trailing-edge flaps being made of 1/16-inch sheet steel bent to the general shape shown in the article. (Fig. 1, photo 1) An iron-on mylar skin was used as a covering because of the extremely smooth finish possible in a short time.

After the model was completed, a trial run was performed in the tunnel (Photo 2). The tunnel has a test chamber 28 inches wide by 20 inches high with a three-point mounting for the model. Measurements of lift and drag are done with load cells and an electronic counter. As it turned out, the velocities were lower than desired because the drag load cell was rated at 10 pounds maximum. Since greater velocities would overload and possibly damage the expensive unit, it was decided to take the measurements at the lower velocities. These velocities were 103 and 73 feet per second respectively. The only undesirable tendency of the airfoil itself was a slight buffeting in the trailing edge split flaps at certain angles of attack. This buffeting was in the lower angles of attack where the flaps would not normally be activated. The next step was to visually see if the airflow was behaving as described; since no smoke generator was available on the tunnel, the thread-tuft method was used.

Setting the model at a high angle of attack where the vortex phenomenon was expected to occur, the tunnel was started and the velocity gradually increased. At the lower velocities the airflow followed in general the shape of the section, but as the velocity was increased the flow began to reverse itself. At this point it seemed unsteady, but with a further increase in velocity it stabilized in the reverse flow situation (Photo 3). This reversed boundary flow situation in the forward cavity would seem to imply the existence of the forward vortex sketched in the December 1973 SOARING issue. Visual observation showed similar reversed flow in the aft cavity. This same observation was made for several different high angles of attack, always with the same test result. Only the threshold velocity varied which decreased with increase in angle of attack.

Daniel Walton is a 21-year old senior in the Engineering Department at the Northridge campus of the California State University system. Although he is not a Society member, an SSA'er aunt passes along her old copies of SOARING to Dan. Thus, in last December's issue, he read of Witold Kasper's flying wing whose unique slot-and-flaps system sustains the aircraft at half its normal sink rate while flying at half its normal speed, according to its inventor. As far as is known, these claims have never been independently corroborated and controversy has been the result. Walton decided to investigate on his own; though a wind tunnel test might not be as good as careful flight testing, it was still better than verbal theorizing.

"Fortunately, I had the opportunity of killing two birds with one stone. Engineering 391, which deals with fluid mechanics, requires a special three-week project as part of the semesters work. I rounded up two other students to form the required group, secured the permission of Dr. W. J. Rivers, the Department Chairman, and obtained the use of Northridge's slow-speed wind tunnel. This facility had some limitations for the thing we had in mind, but

st of the Kasper Airfoil

A final tunnel test gave measurements of lift and drag which were made with a constant velocity over a range of angles of attack. From these results lift and drag curves were derived. The activated configuration was done at two different velocities, the slower velocity being required to more fully determine the lifting characteristics without overloading the 10-pound drag cell, as mentioned earlier.

The graphed results of the activated section showed a marked difference from the lift and drag curves of a more conventional airfoil. The more orthodox configuration with flaps retracted gave a plot similar to that of a conventional airfoil (Fig. 2), so as to imply it is not a fluke of the model itself. First, (Fig. 3) at the higher velocity the activated configuration showed no clear-cut tendency to stall in the normal sense. Drag gave high values overall and did not increase in the parabolic manner usually associated with an airfoil. Second, both Figures 3 and 4 clearly show the transition region mentioned earlier. This would seem to be between 19 and 30 degrees angle of attack. Third, the L/D ratios were then plotted for the retracted section at 103 fps and the activated section at 73 fps. Even though this gives a difference in Reynolds number, it is felt that the L/D for the lower velocity gives a more complete picture. The retracted section's optimum setting was in the lower angles of attack and the activated section's optimum setting was in the higher angles of attack, thus indicating the Kasper Airfoil is better suited for higher angles of attack.

In the December 1973 article two figures for sink at high angles of attack were given. They were 200 fpm at 30 mph and 100 fpm at 20 mph. If we assume for small angles that

$$\frac{L}{D} = \frac{V}{V_{sink}}$$

we see that this means L/D's of 13.3 and 17.6 respectively. This conflicts sharply with the maximum value of 1.6 measured for the activated section in the experiment. This would seem to imply a high sink rate for the model.

In summary, tests showed the maximum lift coefficient for this model to be 2.98 at 50° angle of attack and that the drag in general was substantial in value. Visual results indicated the formation of the vortices induced by the flap system and that a buffeting problem may be encountered unless certain structural considerations are made.

This experiment was not intended to be an exhaustive study on the Kasper Airfoil but only to check out a prototype airfoil in the tunnel to acquire more detailed information as to the advantages and limitations of the unusual flap system.

I think we succeeded in working around them."

Although supersonic wind tunnels are part of the campus equipment, Dan is not glamorized ("... guided missiles—yyechh ...") and may be symptomatic of the current resurgent interest in low-speed aerodynamics. He is leery of super-specialization. "I would like to work somewhere that would permit me to deal with an entire system. I'm interested in homebuilding, small plants, and that sort of thing."

Could there be such a thing as an engineering Renaissance Man?

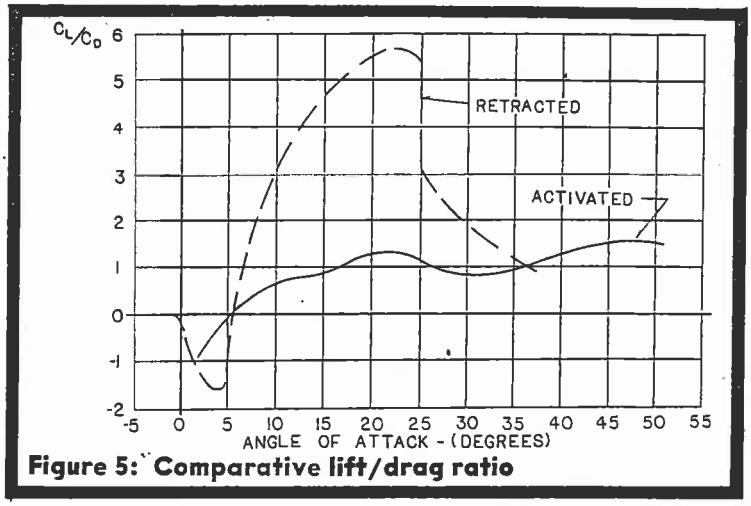

Figure 5: Comparative lift/drag ratio

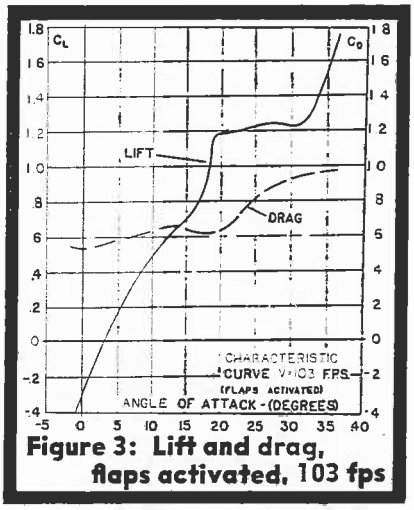

Figure 3: Lift and drag, flaps activated, 103 fps

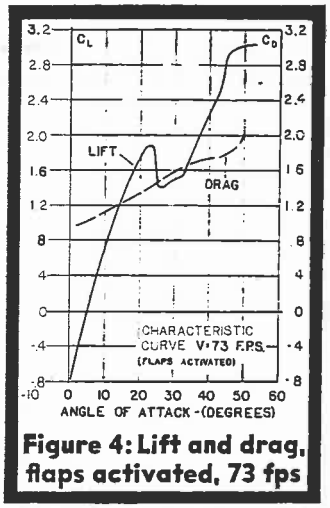

Figure 4: Lift and drag, flaps activated, 73 fps

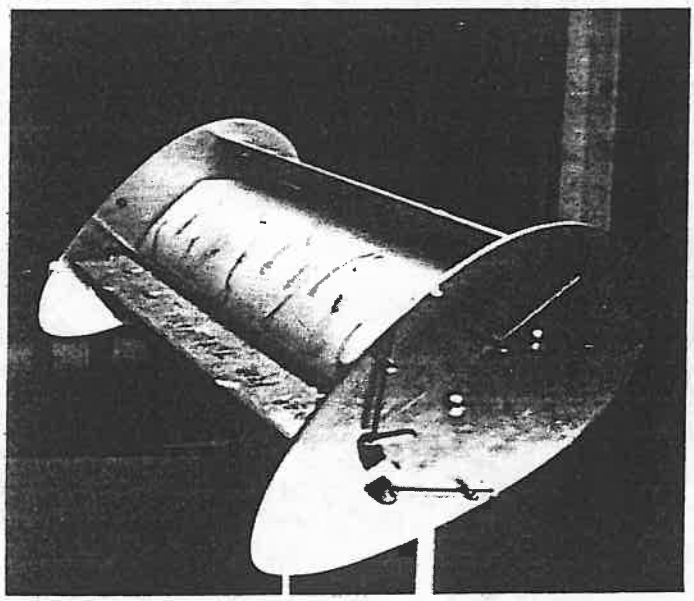

Photo 3: Tufts show reversed flow with activated flaps