Old Wings

Peter Garrison

Dean Siracusa owns a Meyers 200. He showed me the airplane the other day, and had a question about the wing, which has a rather short 30-foot span with a broad chord at the root and quite a lot of taper. Why, he wondered, is the current trend toward long wings with narrower chords?

The Meyers is one of about 100 of the type that were built half a century ago. It was an era of cheap fuel, simple airplanes, unturbocharged engines and 75-percent-of-power cruise at 7,000 or 8,000 feet. Since then the broad trend has been toward increased weights, rising fuel costs, and higher cruising altitudes. All of these are addressed by increasing wingspan. Wing area principally affects landing speed, but not rate of climb or fuel consumption; pure span is the key to carrying more weight on less fuel, flying higher and getting to altitude more quickly. In piston twins, it is also essential to acceptable single-engine performance.

As a practical matter, wingspan is usually increased by extending an existing wing (Baron) or by replacing an outer panel with a longer, tapered one (Cherokee). But if the wing is being designed from scratch (Malibu, Cirrus) the logical route is to reduce chord so as to keep wing area about the same. The result is a wing of higher aspect ratio.

There is no compelling aerodynamic or structural reason for tapering the wings of airplanes whose gross weight is below 6,000 pounds or so. The motive is aesthetic: Tapered wings look graceful. But there is a penalty for tapering wings. Whereas rectangular wings naturally tend to stall first at the root, preserving aileron control well into the stall, tapered wings tend to stall first at mid-span. Various techniques have been used to alleviate this tendency. One is to use a more cambered airfoil at the wingtip than at the root. A conspicuous example of this approach is the Navion, whose wing is way too cambered in the first place, and whose tip airfoil, a NACA 6410, is curved like a leaping fish. In order to alleviate the nose-down force produced by all that camber, both airfoils are reflexed; that is, their trailing edges are flexed upward. All in all, I'd say the Navion's wing is a draggy mess, but its low-speed handling qualities, if memory serves, are very good, and that is probably what the designers had in mind.

The Meyers wing is less extreme than the Navion's, but reflects the same thinking. Like the Bonanza, at its root it uses the venerable 23015 airfoil; the tip, however, is a NACA 4412, a slightly less hunchbacked relative of the Navion's 6410. (The last two digits of all these designations are the thickness/chord ratio -- 15%, 12%, and so on.) Now, the 23000-series airfoils maintain lift up to an unusually high angle of attack -- around 18 degrees -- and then lose it all of a sudden. The 4412, on the other hand, begins to stall at about 14 degrees, but continues to generate about the same lift until 18 degrees. At that point the lift does not drop off all at once, as with the 23000 series, but diminishes gradually.

In order to ensure that the tip is still hanging on when the root is stalled, the entire wing is twisted several degrees, so that the onset of the stall at the root precedes, or at least coincides with, the onset at the tip. And then, just to make sure that everything goes according to plan, a stall strip is added to the wing leading edge, near the root, to "trip" the stall there. The end result is a mild stall -- just what you would have gotten from an untwisted rectangular wing, if you could stand the sight of it.

Throttling the Dead

In the January issue, I talked about the results of some impromptu glide tests I had performed in order to assess the effects of prop pitch and throttle position on a power-off glide with a windmilling propeller. I found -- to no one's surprise -- that moving the prop control to coarse pitch (that is, low rpm) had a very powerful influence on gliding distance. I also found that the effect of closing the throttle was about equally large, but opposite. That surprised me, because I had expected that opening the throttle would allow the engine to pump more air in and out, requiring more power, whereas closing the throttle would allow the trapped air in the cylinders to act like a spring, trading power back and forth on up and down piston movements, but not consuming as much power.

Several readers wrote to explain why I was wrong. As often happens when one tries to figure out what is happening in nature, I had gotten tangled up in the details and overlooked the broad, simple essence of the problem.

It turns out that my careful mental simulation of pistons and valves going up and down was unnecessary. For one thing, a throttle set for idle is not truly closed, and so rather than eliminate pumping it merely increases the resistance to it. But it is not necessary to analyze the flow of air through the engine in detail. The engine itself is an efficient integrator of pressures, and so the indicated manifold pressure is a measure of the time-averaged force on a piston. The displacement of the engine provides a shorthand for combining the piston area and the distance traveled, while rpm introduces the time component needed to produce a result in terms of horsepower, which is the ability to do work at a certain rate. The math is encumbered by some thermodynamic complications, but what it boils down to is that all you really need to know is the rpm, the engine displacement, and the difference between the indicated manifold pressures with open and closed throttles, to learn that at 10,000 feet my 360-cubic-inch engine theoretically requires almost six more horsepower to windmill at 2,000 rpm against a closed throttle than against an open one. At sea level the figure is doubled. Throw in the additional losses due to the inefficiency of the windmilling propeller in converting forward speed into engine rotation, and you have numbers in just the same range as my in-flight experiments seemed to indicate.

So, to reiterate the part of this that's worth remembering: to significantly improve the power-off gliding performance, put the throttle all the way forward and the prop control all the way back.

Knot Nuts

A couple of months ago I remarked that I didn’t see why we use knots as a measure of speed. This passing comment left most readers untroubled, but it made one Canadian air traffic controller almost apoplectic with rage. He all but accused me of crimes against humanity. But his most unkindest cut was that I couldn't be a true pilot if I didn’t love knots.

Gee, and all this time I thought...

A knot is one nautical mile per hour. It is merely coincidental that "knot" and "naut" nearly rhyme. The name comes from an old method of measuring the speed of ships. A weighted board at the end of a cord is tossed overboard, and the number of equally-spaced knots in the cord that pass through a sailor's fingers during an hourglass-measured period of 30 seconds gives the ship's speed, relative to the water, in nautical miles per hour. (The original knot spacing was seven fathoms, or 42 feet -- by the way, as long as we're measuring speed in knots, why don’t we measure altitude in fathoms? -- which wasn't too accurate, but it was good enough, since there was no way of knowing the drift due to ocean currents anyway. Actually, and somewhat ironically, a 42-foot knot spacing yields a speed that's closer to miles per hour than to knots.)

The nautical mile's existence is probably due to a widespread post-Enlightenment impulse to objectify units of measure by relating them to Nature rather than, say, to portions of the anatomy of a king. The kilometer, which is the foundation of the entire SI or "metric" system, was originally intended to be 1/10,000th of a quadrant of a meridian -- that is, 1/40,000th of the earth's polar circumference -- and was established as such in 1793. The meter, 1/1,000th of a kilometer, is the world standard for measurement today; even the traditional English units, Anglophone chauvinists will grieve to learn, are officially defined in terms of the meter.

The nautical mile, like the kilometer, is a unit based on the dimensions of the earth. It is the length of one minute of arc along a meridian. (The meridians are the lines that run from pole to pole on the globe; the other ones are called parallels, and minutes of arc on them shrink toward the poles.) One minute of arc is 1/21,600th of a full circumference, and so the polar circumference of the earth -- or of some idealized surrogate for the earth, more spherical and less bumpy than the real thing) is 21,600 nautical miles.

Back in the day when navigators stood by, or sat at, tables before large maps and plotted lines of position using dividers, the nautical mile was a convenient unit because the one-minute tick marks along meridians could be used in lieu of a ruler. This method was not altogether accurate, because the length of a minute of arc on a meridian is not constant, the earth not being a perfect sphere; but what doth it profit a man to know precisely where he is upon the trackless deep? In any case, no one today uses large charts and

dividers to locate an airplane on a map, and so the identity of nautical miles and minutes of arc is no longer of any practical interest. (To the extent that one might occasionally use the tick marks on a Sectional to help estimate distances, nautical and statute miles are sufficiently similar that minutes of arc can stand in for either. In the southern United States, minutes of arc along parallels are about equal to statute miles.)

Some partisans of the knot probably believe that it represents an ancient tradition in aviation. Actually, aircraft speeds were officially stated in miles per hour, and distances in statute miles, until 1969, when the FAA decided to bow to maritime and meteorological usage and switch to knots and nautical miles. Until that turning point, *Jane's All the World's Aircraft* gave speeds in kilometers per hour and, parenthetically, in miles per hour.

My objection to the knot is that it is a pointless complication that requires translation for the benefit of the uninitiated -- which is to say, just about everybody. The only justification I can see for maintaining a special unit of measure for aviation, meteorology, and messing about with boats is that it identifies its users as a fraternity possessed of secret knowledge. Its use is an affectation, supported not by reason but by vanity.