Editorial

What's it all about, alpha?

WHAT IT'S ALL ABOUT is that we have been flying wrong, all these years. We have been trying to determine the safe margin of lift in our wings by looking at an airspeed indicator. This was an improvement over the seat-of-the-pants method that preceded it, but the ASI is nevertheless such a rubbery instrument that it has been leading us into stall accidents at an intolerable rate. The stall accidents will continue unless we begin looking at something that really tells the truth.

That "something" has existed for many years; in fact, the Wrights invented it. It is an angle-of-attack indicator. Angle of attack, or alpha, is defined as the angle between the chord line of the wing and the relative wind. This is not the same as pitch (or body) angle, or flight-path angle. Airflow over the wing is essential: no wind, no lift; but when it comes to measuring lift, or more properly the coefficient of lift (C_L), angle of attack is the key. As alpha is increased, C_L increases also, up to the critical angle. At that point, the airflow over the wing separates, lift is lost and the wing stalls.

Under some conditions, critical angle of attack correlates fairly well with airspeed. In the flight regimes under which correlation is poor, however, we most often get bitten. The indicated airspeed at stall depends on load and distribution of load: The higher the weight, the higher the indicated airspeed will be at the stall. It makes no difference whether the load consists of pounds of weight or maneuvering loads or gust loads.

Let's say the manual notes that the airplane's stalling speed, wings level, in unaccelerated flight, is 60 mph CAS, standing for calibrated air speed. Since the standard panel airspeed indicator shows indicated, not calibrated, speed, we must refer to a comparison chart. This tells us that when the ASI is indicating 50 mph, the calibrated airspeed is 60. So far, so good; if we hold 60 mph IAS, we are well above the CAS stall speed. So we go try it out, and we find that the airplane doesn't stall until the ASI needle is well below 50 mph. Hell, we say, this thing really doesn't want to stall at all. This unscientific observation starts us on the road to ruin, for the reason the indicated speed was so low in our experiment was simply that the airplane was well below gross weight.

Now let's check stall speed in a 60-degree banked turn. Here, the book says, the CAS at stall will be about 85 mph. Good, we say to ourselves; IAS is lower than CAS, so as long as we are showing 85 IAS, we're safe. Unfortunately, this is not true. The difference between IAS and CAS at 85 mph is unreadable. If we set up the turn and then decelerate slowly, we'll get the stall so close to 85 IAS as to make no difference, as long as we are at full gross weight. If we are light, the indicated speed at stall will be less, but not so much less as in the level flight example.

Most approach stalls occur at the end of cross-country flights. (You'll have to take that statement on faith, because the official records aren't clear enough to support it without more research than is reasonable.) The conditions include an airplane that is below max gross but still heavier than solo flight; a pilot who is tired; and some amount of turbulence. In many cases, the approach is made to an unfamiliar airport.

The pilot enters the pattern, turns from downwind to base, observes the wind, and begins his turn from base to final. Let's assume that he is maintaining 70 mph IAS, and that he perceives that his rate of turn—properly gentle—will be insufficient to get him lined up on his final approach path. He steepens the turn, still making sure that his ASI is showing 70. Just about the time he thinks that he should start to roll out, a vertical gust hits him. If he is able to remember anything after ground contact, two things puzzle him: The ASI was still showing 70, and the stall horn came on too late.

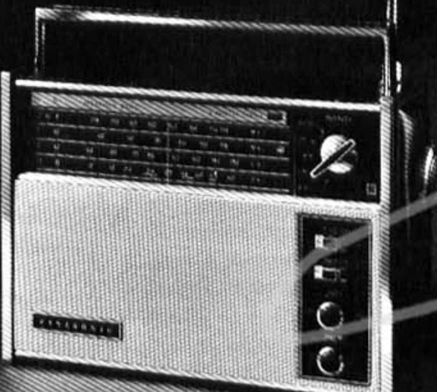
The NTSB report will say, as countless CAB reports said before the NTSB was invented, that the pilot "failed to attain/maintain flying speed." What rot! "Flying speed" is the least correct explanation. What happened was much more direct: The pilot allowed alpha to go past the critical angle, and nobody gave him a way to observe alpha. The vane-type stall-warning horn works on the same aerodynamic phenomenon that at least one type of angle-of-attack indicator does. Both instruments depend on the "stagnation point" of the airflow over the wing. This is the point at which the air divides—some to go over the top, the rest beneath. As the angle of attack is increased, the stagnation point moves up.

The stall-warner vane is spring-loaded so that it is at rest in its down position. When the stagnation point is in its normal position—that is, when the wing is flying at an angle of attack less than stall angle—the normal flow of air keeps the vane in that position. When the angle of attack approaches stall, the air flow reverses, and pushes the vane up and closes the contact, which sounds the horn. The standard stall-warner vane is set so that the horn blows somewhere between five and 10 miles an hour before the wing stalls in level flight; and though the same aerodynamic phenomenon occurs in turning flight, the margin in miles per hour above stall is much less. When the rate of turn is accelerating, stall can easily occur at the same instant the stall horn blows.

It is important to observe also that the stall warner is an off-on (or binary) device: It says only that a stall is not about to occur, or that it is occurring, or that it has. It gives the pilot no information whatever on how close his wing is to stall. In a dive at maximum speed, it says nothing; in cruising flight, it is mute; one or two degrees below stall angle, it is still speechless. It is at its most awkward, tongue-tied phase just when the pilot needs it most.

Stall speed is dependent on weight, bank angle and load factor; the critical (stall) angle of attack is always the same for a given wing, regardless of the other variables. The particularly serious danger in trying to use airspeed

(continued on page 94)



Editorial

continued from page 38

as a stall reference lies in the fact that there is little change in load factor or stall speed at bank angles less than 30 degrees, while above 45 degrees, the increase is very sharp. This is the key factor in approach stalls.

The problem of teaching ourselves to cut our ties with the airspeed indicator is complicated by the differences of opinion on how angle-of-attack indicators should display their information. The controversy is still going on, with partisans on all sides. One inexpensive indicator (the SC-100, made by the Safe Flight Instrument Corporation) mounts on the glare shield, in the center of the pilot's line of sight. For aid in adaptation, "SLOW" appears in a curved red area at the left of the scale, "FAST" at the right. In the center, there is a double-wiggle vertical line, called the barber pole; to left and right of the barber pole are diamonds: slow diamond on the left, fast diamond on the right. A vertical needle, which reports the position of the vane mounted on the wing, moves left and right across the scale. Because of the left-right movement, and the placement of the indicator, the pilot can "read" the instrument in his peripheral vision even when he is looking out to one side.

We all know how slow the standard airspeed indicator is; at least we have been exposed to the fact that it lags. The difference between this theoretical knowledge and the practical indictment alpha lays on the ASI has to be seen to be fully understood. When this is combined with the errors introduced by the single static source on many airplanes, your scalp prickles and your skin hairs stand on end.

In a slipping turn, the lowered pressure at the static source makes the ASI read high; it is quite likely that, slow as it may be, the ASI's attempt to show lower speed is neatly offset by the artificial increase induced by the slip. A skid works the other way, of course; yet a skid is a more dangerous kind of uncoordination than a slip, and can be a quick entry to an accidental spin—quicker than a slip.

In either a slip or a skid, one side of the fuselage will be at a lower air pressure than the other, and if the static source is on that side, the airspeed indicator will read higher than it should. In the classic approach-stall case, if the static port is on the left side, and the pilot is skidding his left turn (which is more common than anybody wants to admit), the ASI will tend to read high, and the chance of disaster is equally high. It's hard to understand why all airplanes don't have two static sources, one on each side, and connected together with a piece of pipe, to eliminate the ASI error caused by slips and skids.

Even so, alpha takes care of the problem. It will show promptly if the margin below critical stall angle is getting smaller. Slipping or skidding, if the pilot keeps the alpha needle centered (or whatever else the indicator's referencing requires), he is not going to be surprised and trapped. Even if he is holding the needle on the slow side, and is aware of that, he can easily reverse any trend toward critical alpha.

We installed an SC-100 angle-of-attack indicator in a test aircraft—a Cessna 172—and made numerous experimental flights with it, both alone and in company with FAA research pilot Joe Tymczyszyn. At one point, we made several simulated approaches from about 3,000 feet above ground, to see what the alpha needle would tell us, and if we could recognize what to do about it in time. In the conventional constant-airspeed method, the alpha needle moved toward the slow side at almost the precise instant back pressure was applied to keep the nose in position, and long before any trend was observable on the ASI.

Then we tried flying a constant alpha, and this was even more striking: On the simulated steep turn from base to final, the nose had to be lowered so much that it was clear the approach would have to be abandoned.

From the results of these and many other tests, we are convinced that an angle-of-attack indicator is an important safety instrument; and that if pilots are properly trained in understanding it and using it—which is really not much of a training problem—we will see an improvement in the safety record of general aviation in stall-spin accidents, particularly those that occur in the approach phase.

We had hoped that the FAA could be persuaded to accept this as an alternate to the standard stall warner, but we soon found that this was unlikely. The reason is that the FAA used to approve stall warners with visual signals only, and found that these were not satisfactory. It's not hard to see why: The visual warning was a red light, which is about the worst possible color; the warning light was almost always installed near the bottom of the panel, where it was outside the pilot's peripheral vision; and in bright sunlight coming from behind, it was all but invisible even if the pilot happened to be looking at it. The predictable result was decision without evaluation; instead of trying to find out if there might be a way for a visual stall-warning signal to be reliable, FAA simply decided that an audible warning would be required.

Very well, then. Why not combine a standard stall-warning, horn-blowing contact with a standard alpha indicator? Wouldn't that solve both problems? Indeed it would, and such a device already exists. At present, it is being used only on a limited number of airplanes, and it is unlikely that your next new plane will come out of the factory equipped with an angle-of-attack indicator.

Two things, however, are certain. The first is that angle-of-attack indicators could do more than anything else in the history of powered flight to reduce accidents, especially fatals. The second is that only customer demand can persuade the manufacturers of airplanes that people want alphas.

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