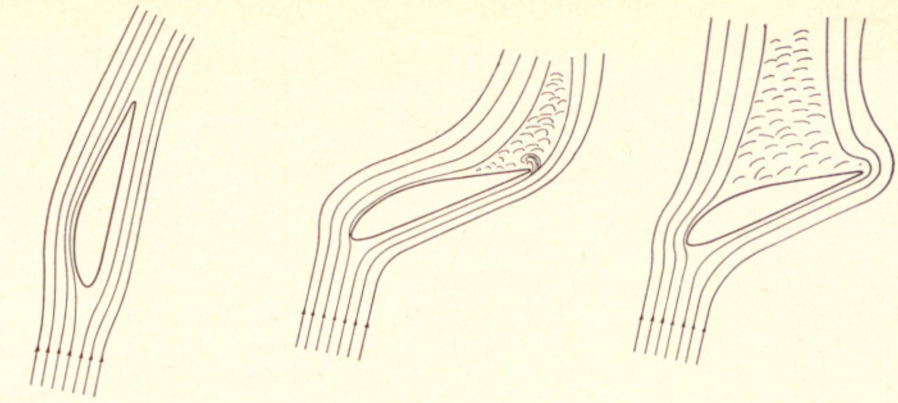
FIGURE 1

Flow with sudden change from low to high angle— Aircraft is in steep dive with very low angle of attack, smooth airflow and maximum lift efficiency (Fig. 1a). Fig. 1b shows increased angle of attack, interrupted airflow and decreased lift efficiency caused by gradual back pressure on stick. In Fig. 1c, angle of attack is sharply increased with complete loss of lift and burbling of airflow on top of wing. Aircraft is stalled even though it is still pointed downward

FAA diagram



Attitude vs. Angle

Your plane can stall without its nose being high—it's the angle of attack that counts. Stalling can be prevented by observing a few simple rules

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Manufacturers are constantly trying to make their airplanes more "pilot-proof," yet the most glaring, frequent, and inexcusable cause of accidents continues to be the stall. It would seem that there would be a way to further diminish this heart-breaking loss of life and aircraft if only pilots could achieve a better understanding of the causes of stalls, so let's see what we can do about it.

To begin with, you should know that the only cause of a stall is an excessive angle of attack. But do you know what is meant by the angle of attack? Too many pilots who should know better confuse the angle of attack with the pitch attitude of the airplane, and arrive at the conclusion that the nose must be high above the horizon in order to be in danger of stalling. The truth is that angle of attack has nothing to do with the horizon. In fact, there are conditions under which you could find yourself in a stall with the nose well below the horizon, because the angle of attack is *not* the relationship between the chord line of the wing and the horizon, but the relationship between the chord line and the relative wind.

That poses a good question. What is the relative wind, and how do we know where it is coming from? The relative wind, so the textbooks tell us, always blows exactly opposite to the direction of motion of the airplane. Therefore, it would seem that the relative wind would always be hitting the leading edge of the wing head-on, but this is not the way it works.

An airplane in level flight, maintaining altitude, could have a positive, neutral, or negative angle of attack, depending on throttle setting.

At cruising throttle, there would probably be a positive angle of attack because of the angle of incidence, which is the angle of attack built into the airplane by the manufacturer. As power is increased, the nose must be lowered accordingly to prevent a climb. With the nose held in a lower attitude, the airspeed increases. The best cruising airspeed is obtained with a negative angle of attack, that is, with the chord line of

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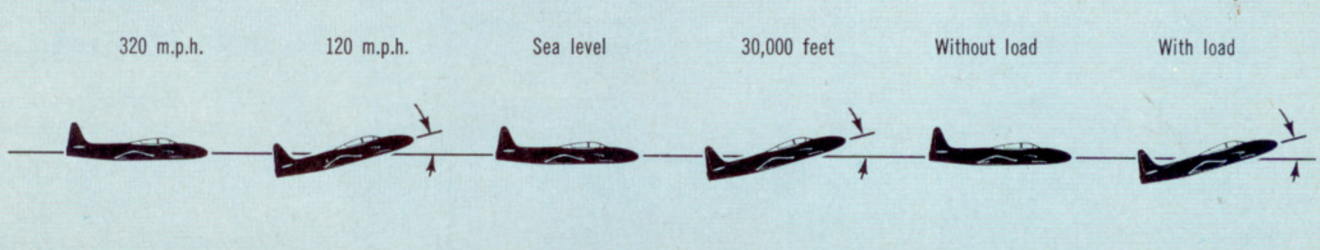
FIGURE 2 Factors affecting attitude in straight and level flight



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the wing slightly below the relative wind. [See Figure 2, page 27.]

Now, if we decrease the throttle setting and still try to maintain altitude, the angle of attack has to be increased. This works fine up to a point, but, as thrust and lift decrease, drag and gravity begin to take over, and the airplane starts losing altitude. As the flight path of the airplane is now downward, the relative wind comes from below to meet it. Unless we lower the nose, the chord line is now well above the relative wind, and a stall becomes imminent.

"Of course," you will say, "I know all that. Don't we all get instruction in stalls as a prerequisite to solo and a license? I wish I had a nickel for every time my instructor had me haul that nose up above the horizon and stall it out, then give it forward stick and throttle to recover."

Fine! So you know how to create a stall of your own making. You even know how to create an excessive angle of attack, although the fact that you had to bring the nose up somewhat higher than in level flight does give the impression that a high angle of attack is actually a high pitch attitude, and therefore must be measured from the horizon. Have you ever stopped to think, though, that an excessive angle of attack does not require a nose-high pitch attitude, that it need not be of your own making, and that the relative wind can be changed without any change of pitch attitude on the part of the pilot? We said that the relative wind is defined as blowing opposite the flight path of the airplane, but that does not necessarily mean that it has to be the *result* of the motion of the airplane. It could, in fact, be the *determining factor* as to what direction the flight path of the airplane will take, provided that some external force acts upon it in such a way as to change it without the volition of the pilot. Herein, I believe, lies the cause of many stalls that never should have occurred.

To illustrate this, let's start with a familiar example, the steep turn. The pilot, of course, knows what he is doing with the controls when he banks the airplane, but do all pilots recall that, as the angle of bank increases, the stalling speed also increases? In any turn the relative wind comes more from the side than head-on, but in an exceedingly steep turn the airplane slides a little toward the inside of the turn, putting the relative wind below as well as to one side of the airplane. Every pilot should be aware of this, but if he has forgotten it, and continues to hold back pressure on the stick, tightening the turn, when he should be decreasing the bank, he may let himself in for a nasty surprise in the form of an over-the-top stall when the relative wind moves so far underneath that the fuselage blocks it off from the high wing. This is especially true of a low-wing aircraft, though I would be glad to prove to any doubters that it can also be done in a high-wing job.

Another case where the pilot does have control over the relative wind if he stops to think about it, is in loading. Every airplane is designed to carry a certain amount of weight for the horsepower it can develop. If the pilot insists on adding extra weight without extra horses, he is asking for trouble, because there will not be enough lift generated to overcome the increased pull of gravity. If the nose is then held in the same attitude as it would be under normal loading conditions, an excessive angle of attack is created, because the flight path of the airplane does not curve upward at the normal angle, and the relative wind will be dangerously below the chord line. The pitch attitude must be lower, especially during takeoff and landing, to insure a safe angle of attack.

No doubt we have all been told at some time or other not to fly an airplane that has frost on its wings, but do you remember why? Certainly not because of additional weight. It would take a lot of frost granules to upset the weight and balance of an airplane, but not many to destroy the lift. Since the amount of lift generated by the airfoils determines the flight path of the airplane, it is plain that the angle of attack will be excessive when we try to make an airplane fly in a normal attitude without sufficient lift.

Hand in hand with frost goes ice formation on the wings. A build-up of ice along the leading edge of the wing can give it the aerodynamic qualities of a lead pipe. Any pilot who tries to hold his airplane in normal, level flight attitude while his relative wind is sneaking lower and lower beneath him is heading for a rendezvous with St. Peter.

Weather conditions labeled as fair can do their share, too, in forcing a wide separation between the chord line and the relative wind, the worst offenders being high temperature, low pressure, and high humidity. You need not have all three in combination at one time. Any one or two of them can be sufficient to cause a lift loss which will necessitate holding the nose in a lower attitude than usual on takeoff, climb, and landing approach. Don't ever expect to climb as well or as steeply in the mountains as at sea level, on a hot summer day as a cold winter one, or before a storm as after, when the "low" has been replaced by a "high."

Speaking of weather, high-powered aircraft can manufacture some of their own that is capable of destroying your lift quite unexpectedly, and sweeping away your relative wind to infinity. Where do you go? Straight down after that missing relative wind. So stay out from under and behind the big ones. You can also encounter something very similar to this atmospheric wake when flying near the ground in close proximity to buildings, clumps of trees, or other obstructions. Remember, there are two things that make an airplane fly: (1) the motion of the wing through the air and (2) the movement of air over the wing. If the air moving over the wing suddenly becomes very turbulent, the motion of the wing through the air may not be sufficient to keep the airplane flying in its normal attitude. If you think this can be nerve-wracking, just try making a steep downwind turn between two patches of woods with a stiff wind swirling between, and you'll find yourself, as I once did on a photographic flight (chasing a fawn), staring down a wing that refuses to come up. I finally succeeded in getting mine up by using both hands and all my strength, but I learned from that experience that there are other factors besides optical illusion which make downwind turns dangerous. Some of these are: increased load factor, overbanking tendency in a fairly steep turn, loss of lift due to turbulent air hitting the side rather than the nose of the airplane, and the friction effect of the surface wind pushing against the large flat area of the wing. What really happens is that the relative wind is changed by an exterior force beyond the pilot's control so that it becomes dangerously out of relation to the chord line.

It does not require a downwind turn, though, to create this type of condition. The airplane could be headed straight into the wind, and if that wind suddenly stopped blowing or changed direction radically, the airplane could suddenly be in an excessive angle of attack without any change of attitude on the part of the pilot. Don't forget that airspeed is the most important ingredient in a landing approach, and that airspeed is created by dynamic pressure over the leading edge of the wing. If you were using an approach speed only 15 m.p.h. above stall, coming into a headwind of 20 m.p.h., and that wind suddenly shifted to a tailwind, your airspeed would suddenly be well below the normal stalling speed, with no altitude to recover from the ensuing stall. At a higher altitude, with cruising speed, a little thing like a sudden windshift would be unnoticed, but at minimum maneuvering speed any sudden change of pressure on the airfoil or controls can precipitate a stall. While we're on the subject, just stop to think what could happen to a slow-cruising airplane caught in a 60-mile-an-hour downdraft close to the leeward side of a mountain.

Just one more don't on landings. Don't drag in power-on below the normal power-off stalling speed unless you are low enough so nothing will break if you drop it in. If the engine quits under these conditions, there is no time or room to get the nose down.

Probably the wickedest lift destroyer of all is that caused by an excessive load factor, the air load on the wings. Maybe you've pulled a buzz job and gotten away with it. A lot of people haven't. Remember that the G load imposed on the wings in an abrupt pull-up from a dive is equal to the square of the terminal velocity divided by the square of the stalling speed, which, in most cases, figures out well above the ultimate load factor for which the airplane was designed. If the pull-up from your dive is not abrupt enough to shed a wing, you may still find that your relative wind has been snatched out from under you, and the result is a high speed stall. (See Figure 1, page 27.)

I hope all this has not scared you out of flying. There are really only a few rules you need to observe to eliminate any possibility of stalls. (1) Be aware of the conditions that could cause the relative wind to change in relation to the chord line without any voluntary change of attitude on your part. (2) Maintain a safe margin of airspeed under conditions over which you do have positive control, such as steep turns, landing in gusty wind, etc. (3) Never pull a buzz-job. If a stall doesn't get you, an inspector will. END

THE AUTHOR

Leone M. Walton, author of "Attitude vs. Angle," is a pilot with both ASEL and commercial flight and instrument instructor ratings. During the past year she has prepared three manuals on instrument flying subjects: "How To Fly By Instruments," "Omni For the Instrument Pilot," and "ADF For the Instrument Pilot." She learned to fly at Beloit, Wis., in 1945, after getting the inspiration from a woman teacher at the University of Colorado who was learning to fly at Boulder Airport while Mrs. Walton was attending a summer school session at the University. She had a ground instructor rating and a commercial pilot license by 1948, meanwhile working at several different airports. During the fall and winter of 1948, she operated a GI flight school almost single-handed at a small airport near Rockford, Ill., besides teaching ground school at four other airports. Mrs. Walton's husband is a pilot and an experimental aircraft enthusiast. Mrs. Walton's one big regret is that the other member of the family, her daughter, Christine, who is in the fourth grade, does not want to learn to fly.