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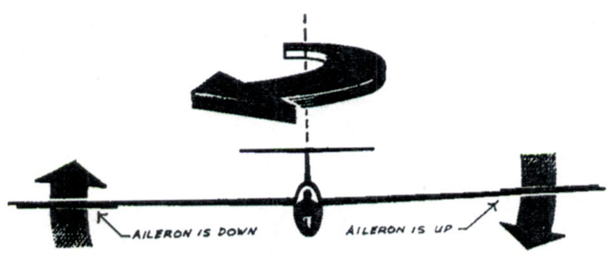
Safety Is No Accident

The 5 Undesired Side Effects of a Turn

Excerpt from Joy Of Soaring by Carl Conway

In turning a glider, the pilot must counteract five undesired side effects, undesired in the sense that if they did not already exist, the designer would not design them into the aircraft. During student training, the development of habit patterns to overcome these side effects, is perhaps the largest single factor in learning to fly. Success will be much easier when the student understands the causes behind his vexations.

The _first_ side effect is called *adverse yaw,* and is encountered whenever the ailerons are not streamlined, such as when banking into or out of a turn; for example, the pilot moves the stick to the left, raising the left aileron and depressing the right. Since the down aileron produces more drag than the other, an undesirable yawing to the right (against the direction of the turn) takes place, generating unwanted drag as the fuselage moves sideways through the air. To



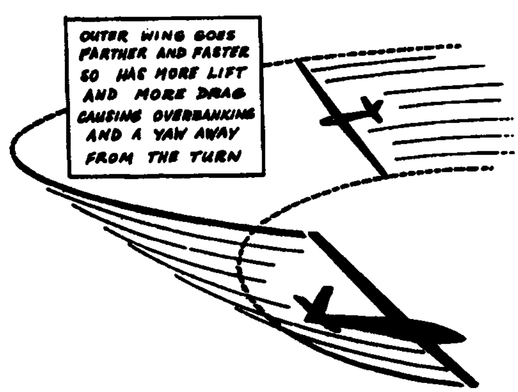
ADVERSE YAW

balance out this adverse yaw and so streamline the fuselage, the pilot applies left rudder with the left aileron. This action is called "coordinating stick and rudder", and the result is called a properly coordinated turn when the yaw string and the slip-skid ball are centered.

Adverse yaw is mild at low angles of attack but becomes severe when the wing is nearly stalled. For example, in a tight turn which is close to an accelerated stall, the application of full aileron to roll out can stall the low wingtip. The severe drag on this wing yaws the glider into a dive. If the pilot now makes the understandable error of trying to raise the glider's nose by pulling the stick even farther back the result will be a sudden spin. To recover from such an excessively tight turn, the angle of attack must first be reduced by moving the stick forward, followed by coordinated use of aileron and rudder to level the wings. A normal rollout results.

The *diving tendency* is the <u>second</u> "I wish it wouldn't happen" in a turn. When the glider is banked some of the wing's lift is transferred from the task of support to that of pulling the glider around the turn, as previously explained. In consequence, the rate of sink increases, stabilizing action causes the glider's nose to drop, and the airspeed increases. If the pilot does not oppose this reaction of the glider by moving the stick back, the airspeed will soon stabilize at a higher level than formerly. To maintain the same speed in the turn as in straight flight the pilot must use the elevator to keep the nose at such a position on the horizon as to hold that speed. The steeper the bank, the more back pressure of the control stick is needed.

The *overbanking tendency* is the <u>*third*</u> annoyance in turning. Having established the desired angle of bank, the pilot finds that he has to hold top aileron (against the angle of bank) to keep the bank from steepening. In a glider this is true in all but the shallowest banks because of the long span and normally small radius of turn.



OVERBANKING TENDENCY AND YAW IN A TURN

The outer wingtip moves faster than the inner, so the outer wing has more lift, causing the bank to steepen.

The <u>*fourth*</u> unwanted side effect, *a yaw against* ***the direction of an established turn*** **(not the adverse** yaw caused by aileron drag) appears because the faster-moving outer wing has more drag. Rudder is needed to oppose the wing's yawing force, the amount being indicated by the yaw string or slip-skid ball. If these are centered the turn is correctly coordinated, even though the controls are "crossed", which means rudder is applied on one side and aileron on the other. "Crossed controls" is a heinous sin in powered flight. Power pilots please note that a glider is flown so the fuselage slips through the air with minimum drag, ball in the center, whatever position of the controls is required to accomplish this end. No spin will result since the drags of wing and rudder balance one another.

The *fifth* and last (thank goodness) side effect **of turning is the *increase in stalling speed*. As was** explained earlier, during a turn the pilot applies back pressure on the stick to increase the angle of attack. Thus the glider is closer to a stalled angle than in a level glide at the same speed. Another way to look at the situation is that the load of centrifugal force is added to the weight of the glider; this higher total load on the wing raises the stalling speed. The thermaling pilot soon learns that he has to increase his airspeed as he steepens his bank in order to keep from stalling. It should be noted that the increase in stalling speed is caused by the increased wing loading rather than by the angle of bank *per se*. In the performance of aerobatic maneuvers such as a wingover the bank maybe vertical and the stick is not brought back; there is no turning and no centrifugal force, and the glider's wing is not stalled even though the glider is momentarily hanging almost motionless in a vertical bank.

The following table gives an idea of the degree to which stalling speed increases with the angle of bank in a properly executed turn. The percentage increase is included so the reader can calculate actual values for any glider. Figures are also given for a typical trainer and a high-performance sailplane. The glider turns because he can see the effect just by watching the ground. He feels that the airspeed indicator must be wrong, and that the instructor, who is saying the wind doesn't affect the way a glider turns, simply doesn't believe the evidence of his eyes.

Angle of Bank	"G" Load	% increase in speed	Trainer Stalling Speed	High-Performance Stalling Speed
0	1.0	0	31	46
30	1.18	8	33.5	50
45	1.4	18	36.5	54
60	2.0	40	43.5	64.5
75	4.0	100	62	92
90	A "properly executed" turn is impossible			