The SPIN:

EDITOR'S NOTE: Spinning has always been required for a British private pilot license. In Britain, spinning, stalling and forced landing without power are considered the three main causes of fatal accidents.

The author, Alan Bramson, is chairman of the United Kingdom's Panel of Examiners, which has the responsibility for certification of flight instructors in the U.K. The panel, composed of some 22 top-flight instructors, is part of the British Light Aviation Centre (an affiliate of IAOPA), but operates under Britain's Civil Aviation Authority.

Bramson, who holds a professional pilot's license, has been an A1 instructor in the Royal Air Force and has flown more than 130 types of aircraft. A full-time contributor to British aviation publications, he also is joint author of 11 books on aviation, the most recent of which is "Flight Emergency Procedures For Pilots."

by ALAN BRAMSON

■■ It was just after 9 a.m. on Aug. 25, 1912. A small crowd had gathered at Larkhill Airfield on Salisbury Plain in the south of England, for one Wilfred Park was due to land, having just completed a three-hour endurance test—something of a record in those days. He was flying the new Avro "G" type biplane, a totally enclosed "flying limousine" with no forward view, and precious little in any other direction.

Over the airfield, he pulled back the power before entering a rather steep, gliding turn. Then, to the horror of those watching below, the Avro flicked into a steep spiral descent. It had been seen before—that twisting dive which, to the pilots of the day, was like the sound barrier that perplexed aviation in the mid-1940s. Almost invariably these dives terminated in a heap of airframe with a very dead aviator, but young Park, a lieutenant in the Royal Navy and a highly regarded test pilot, somehow stopped the rotation and pulled out of the dive, missing the ground with a lot of luck, but little to spare.

From that day those sinister spirals were known in Britain as "Park's Dive." Naturally, Park's Dive was a talking point among the pilots of that period. No one really understood the maneuver, and it was not until World War I, when Park's Dive was claiming too many Allied pilots, that Professor F. A. Lindemann (later Viscount Cherwell, scientific advisor to Winston Churchill during World War II) with great courage and skill conducted a series of tests that unlocked the secrets of the maneuver.

In case you have not already recognized it, we are talking about the spin. And although the best part of 40 years has elapsed since Lindemann's learned paper on the subject, there are to this day many pilots—some of them quite experienced—who have little understanding of why an aircraft spins, what happens during a spin, how to recover, and, most important, how to prevent a spin from developing the moment it begins.

There is something about spins that divides nations. The French have no room for the exercise in their private-pilot training syllabus. Conversely, Britain has always insisted on the retention of spinning, while there are now strong pressures to reintroduce spin training in the U.S.A.

Why do some training experts favor the removal of spins from the training syllabus?

Part of their thinking derives from the fact that, as a matter of design policy, many modern lightplanes have little inclination to spin. "They are hard enough to spin intentionally," you will be told, followed by, "To spin by accident you must be born with two left feet and the finesse of a steam tractor."

Yet these pronouncements are not confirmed in reality. One has only to study fatal accident reports from all over the world to find stalling and spinning high on the list of causes. So much for "unspinnable" airplanes! Yet without doubt many modern light aircraft do exhibit a reluctance to spin, so why the fatal accidents? This we shall examine later, but first, what is a spin?

The Aerodynamics

Briefly, when an airplane spins, the sequence of events is this. The aircraft may be gliding or flying at a low airspeed when *yaw* is induced—by harsh rudder in the case of a "single," and by rudder or asymmetric power on a "multi." Further effects of yaw take over and a *roll* develops. (Remember, the outer wing is now moving faster than the inner one.) This is poison in any language, because the relative airflow now coming up to meet the slower, descending wing has the effect of *increasing* the angle of attack, causing that wing to stall. At the same time, the up-going wing likewise experiences a change in relative airflow, one that comes from above and so *reduces* its angle of attack.

By now we have a situation called *autorotation*, where the outer wing is flying and the inner wing is stalled, its additional drag further accentuating the very yaw that started the spin cycle (Figure 1). After a few turns the aircraft will settle in equilibrium, and an instrument check will reveal the following:

- Low indicated airspeed, perhaps fluctuating slightly.
- Maximum-rate turn in the direction of yaw.
- An outward skid on the ball.
- Vertical speed indicator showing a high rate of descent, which is confirmed by the altimeter, by now winding down like a broken clock.

Gyroscopic Forces

While there is no need for civil pilots to learn about spinning at an academic level, certain other factors are involved, and since these have a bearing on the spin behavior of different aircraft, their principles should be understood.

We have already established that during the maneuver an airplane is yawing and rolling. It is not, however, generally realized that in addition, because the nose is turning in towards the center of the spiral, the aircraft is pitching up. If you find this hard to imagine, think of a steep, descending turn.

As the wings roll, they develop momentum and, in effect, become a large gyroscope. And because we are pitching up, a force is directed to the top of this gyro that behaves like any other in producing a reaction at 90 degrees to the "push" applied. The result is a force in the direction of yaw, or "pro-spin" (Figure 2).

Now consider the fuselage, which is pitching up relative to the pilot. It too develops momentum and behaves like an

Advice from an expert on why it happens and how to cope

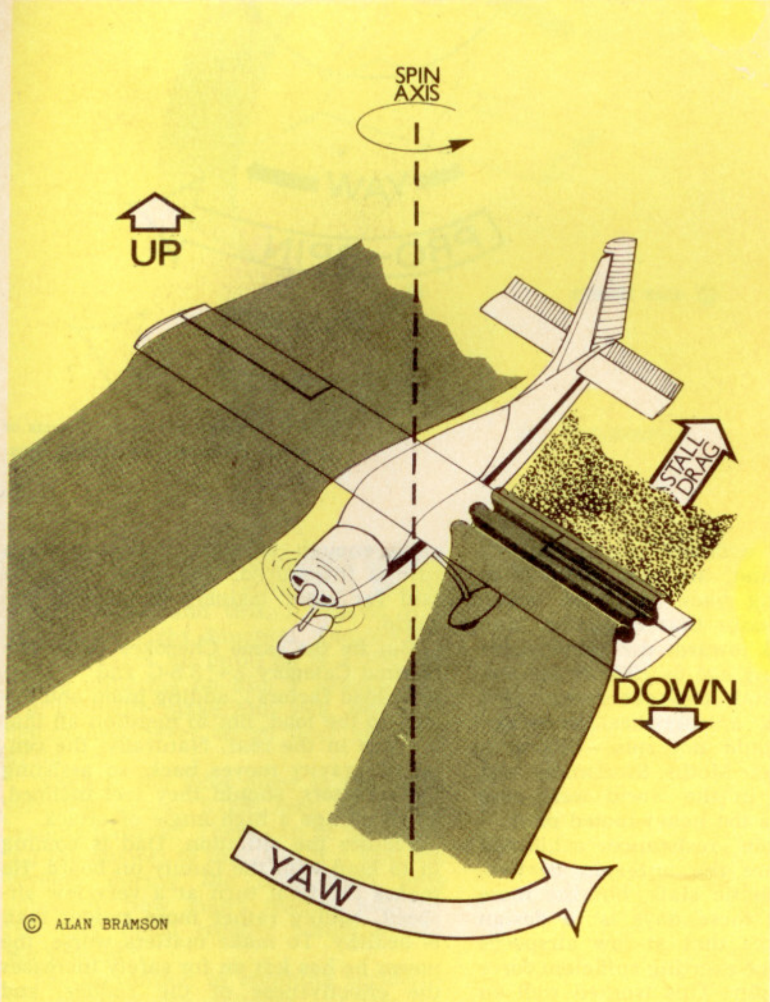


Figure 1. Aerodynamic events in a spin. Low-speed yaw to the left is followed by left roll, which stalls the down-going wing, increasing its drag and setting up autorotation.

outsized gyro. At the top of its plane of rotation, the "fuselage-gyro" is subjected to a force from the roll already mentioned. And due to the "90-degree rule," there is a reaction that is in the opposite direction to yaw, or "anti-spin" (Figure 3).

The relationship between these two forces is known as the *B/A ratio*, but in practical terms this rather complex interaction of forces means that aircraft with long, heavy wings compared to their fuselages will spin fast and may require some stopping (multi-engine types should *not* be spun). Furthermore, those with small wings relative to a long, heavy fuselage will spin very slowly and should recover well. The modern jet fighter will, for this reason, rotate at a slower rate than many lightplanes, although altitude loss per turn is very considerable.

The Recovery

Astonishing as it may seem, even today there are many experienced pilots throughout the world who are unaware of correct spin recovery action. Some even go into print with their own versions of the drill, which, in one or two cases, would either put the aircraft through its never-exceed speed or, even worse, precipitate a spin in the opposite direction.

The proper technique is very simple:

• *Check that the throttle is closed.*

• *Determine the direction of spin* by looking at the turn indicator. This is not so lunatic as it may sound. Remember, it was yaw that started the spin, and this must be checked if recovery is to be effected. In a fast rotation a pilot can become disoriented and may be influenced by roll direction. One and the same thing, you may say, but this is not always so. If you are an aerobatic ace and somehow manage to enter an inverted spin, believe it or not, roll and yaw are in opposite directions to one another.

• *Apply full rudder in the opposite direction to the yaw.* After a brief pause, allowing the rudder to "bite"—

• *Ease the stick forward until spinning stops.* When the spin ceases—

• *Centralize the rudder* (unless you want to spin in the other direction), *allow the speed to increase, level the wings with aileron, and then gently ease out of the dive.*

Some Popular Misconceptions

While the unknown breeds fear, it is equally true to say that fear is banished by enlightenment. Much nonsense is talked about spinning. Here are some of the more common "old wives' tales."

• *You must stall first before the aircraft will spin.*

High on the list of famous last words, this is probably the most often quoted piece of useless information in flying. It is simply not true. In fact, it is because the spin is most likely to occur at, say, 10 knots above stalling speed that it represents such a hazard to the average pilot.

Why is it not true? Simply this. We have already seen that the prime mover in a spin is yaw. In a "single," the only way to produce a yaw is with rudder. And like any other control, the rudder is as effective as the airflow over it. Allow the airspeed to fall below its effective level and even full rudder (power off) will be insufficient to induce enough yaw to start the autorotation cycle. Power on is a different story, and I will come to this shortly.

Twin-engine aircraft are another matter. Long after the rudder has run out of steam, powerful yaw is there for the asking, simply by throttling back one engine. Open up the other motor and a very powerful twin will describe a cartwheel. A friend of mine who happens to be a very experienced instructor at one of our professional schools once lost over 6,000 feet while sorting out a spin that followed an asymmetric stall demonstrated on a light twin of famous make. We have stopped teaching asymmetric stalls in Britain, and if anyone suggests that you should try, politely but firmly tell him to get back in his cage.

- *Use aileron to assist recovery.*

While this may be true of certain military aircraft, it does not apply to light civil planes. In these there are no clever techniques demanded of the pilot while recovering from a spin—just the simple actions already listed.

- *You must get the stick fully forward to recover.*

With most light aircraft, such action would lift you out of the seat as the plane went through the vertical and into the inverted attitude. The amount of forward stick is determined by the previously quoted words "until spinning stops." The majority of aircraft these days require very little forward elevator, but much depends on how developed the spin is allowed to become. After one or two turns, most lightplanes recover almost immediately when the correct action is taken. Wind up six or more rotations and perhaps a turn and a half will be needed to break down autorotation, the recovery calling for more forward elevator, *but only to the point where spinning ceases.*

A word of warning here. In most aircraft types, when the spin has been allowed to develop, correct recovery action will at first have the effect of speeding up the rate of rotation while the gyroscopic forces, already explained, sort themselves out. Many believe this phenomenon explains why some pilots have failed to recover from a spin although correct action may initially have been taken. It is, of course, hardly encouraging when the spin becomes faster at the very time it is supposed to stop, but if it happens to you, be patient—this is the first sign of recovery from the fully developed spin, and not more bad news for the insurance man.

- *To recover, just push the wheel forward—the heck with the rest.*

This action would have had little or no effect on some of the older designs. In a modern aircraft, most likely the spin would become a spiral dive if the stick were moved forward and the original rudder pressure were left on. And the quickest way to build up airspeed is in a spiral dive. Think of the altitude loss. Imagine it all happening near the ground. And settle for the standard recovery method previously explained.

- *My bird is pretty well unspinnable.*

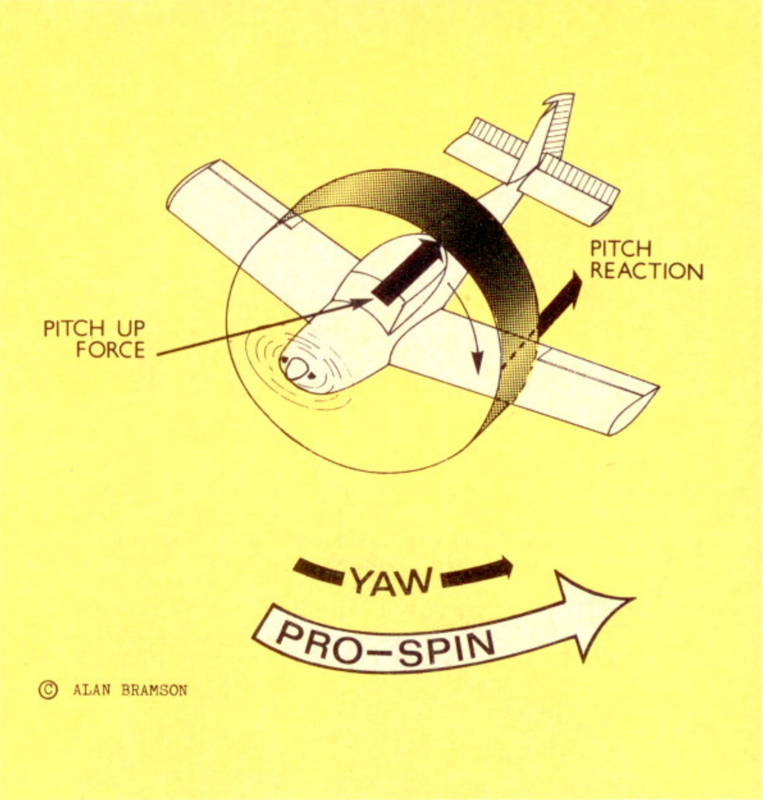


Figure 2. Pro-spin gyroscopic effects of pitch-up force on the rolling wing.

The trouble with this one is that it's a half-truth and, as such, difficult to dispel. Looking back over the years, there is no doubt that designers have tended to work towards the unspinnable aircraft. As long ago as 1936 in Britain, we had a metal, two-seat design (the Cygnet), with a nosewheel undercarriage, that would not spin—this at a time when Tiger Moths, Stearmans, and most aircraft in the world were ever ready to oblige the heavy-footed pilot.

How is spin resistance achieved? First, there are the anti-spin devices, such as automatic slats, but the more usual method these days is to design control surfaces that at low airspeeds are incapable of exerting sufficient force to induce a spin. This worked well on the Cygnet because there were two side-by-side seats with little room for luggage behind.

But things are different with the modern lightplane. Look at the owner's manual for, say, a Piper Cherokee, a very reliable and basically docile trainer. Spinning is only permitted when the aircraft is flown in the Utility Category, and this means limiting the weight to bring the airplane within the required + 4.4-G and − 1.76-G limit-load factors for that category.

Thus a Cherokee 140 may only be spun when the two rear seats are unoccupied. So loaded, a Cherokee is flying with its center of gravity towards the forward limit, and with the aircraft in this condition, particularly with full tanks, the elevators are hard pressed to place the wings at an angle of attack great enough to allow spinning when yaw is introduced. The same could be said for other trainers throughout the world.

But fly the same Cherokee under the Normal Category (+ 3.8-G and − 1.5-G limit-load factors), adding mom and the kids to the load, not to mention all that luggage in the rear. Naturally, the center of gravity moves back, so assisting the elevators, should they feel inclined, to encourage a high angle of attack.

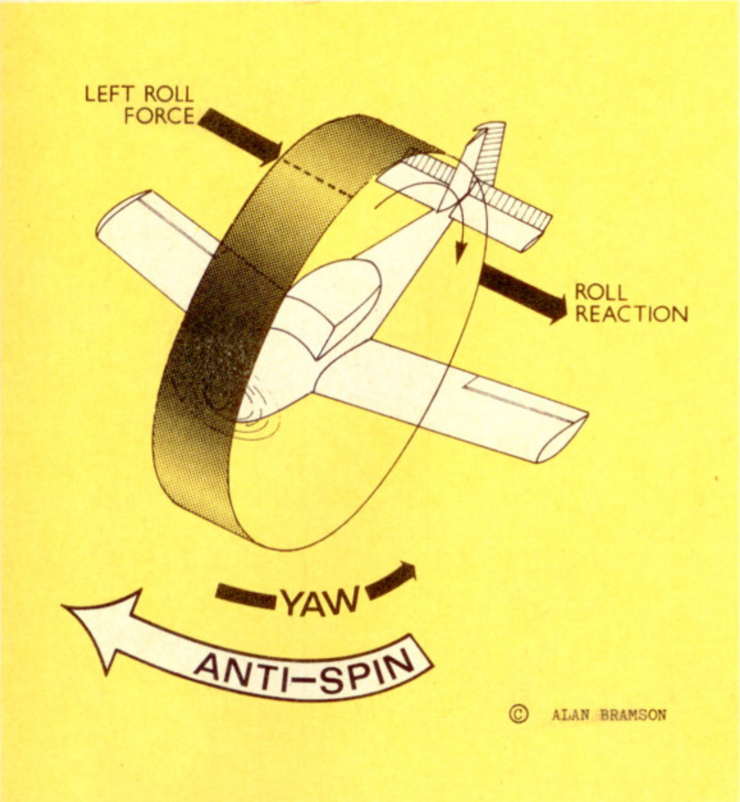
Picture the situation. Dad is coming in to land with the family on board. He makes the final turn at a very low airspeed, adding rather more rudder than is healthy. To make matters worse, the power he has left on for safety increases the effectiveness of the rudder, and bingo! A combination of yaw and high angle of attack, assisted by an aft CG, and our hitherto docile 140 spins like a washing machine.

The odd thing about the modern trainer is that when spinning is permitted, the beast is reluctant to oblige; yet it will spin like a top under loading conditions when the maneuver is not allowed. Furthermore, an aft CG adversely affects spin recovery by shortening the fuselage moment arm. Both rudder and elevator have less leverage to damp the yaw and counter the tail-heavy condition (Figure 4).

Reducing Spin Accidents

Although we in Britain have retained spin training, as head of our testing panel I cannot pretend to be entirely satisfied with the way this exercise is

Figure 3. Anti-spin gyroscopic effects of left-roll force on the pitching-up fuselage. Note that as in Figure 2, the reaction is at 90 degrees to the force applied.



being taught. We are beginning to place more emphasis on recovery at the incipient stage, and this, I believe, is a step in the right direction. The instructor who takes his pupil up to 8,000 feet before inflicting on him a 10-turn spin will probably make him sick, and very determined never to go near spinning again.

When is the pilot more at risk from spinning in—at 5,000 feet, or in the landing pattern? There can be no doubting the answer to this, and if a spin did develop during the final turn onto approach, how many readers honestly feel they could recover before hitting the ground?

The prevention of spinning accidents is everyone's responsibility, but here are some things you, as a pilot, can do:

- Understand the maneuver.
- Do not be afraid of it.
- Every six months or so, check out with a good instructor and practice recovering as the wing and nose drop below the horizon (only partial rudder is required at this stage).
- Be able to distinguish a spin from a spiral dive, in which the speed builds up alarmingly.
- Learn the full spin recovery, so that your actions in an emergency would be automatic.
- Never make low-speed turns near the ground.

As a friend from across the pond, I offer this advice in good spirit, and in the hope that it will be heeded. Or would you rather be a candidate for Park's Dive? □

Figure 4. Effect of an aft CG on the moment arm, through which the tail surfaces have to act during spin recovery. The tail-heavy aircraft is also more likely to reach the high angle of attack required for spinning.