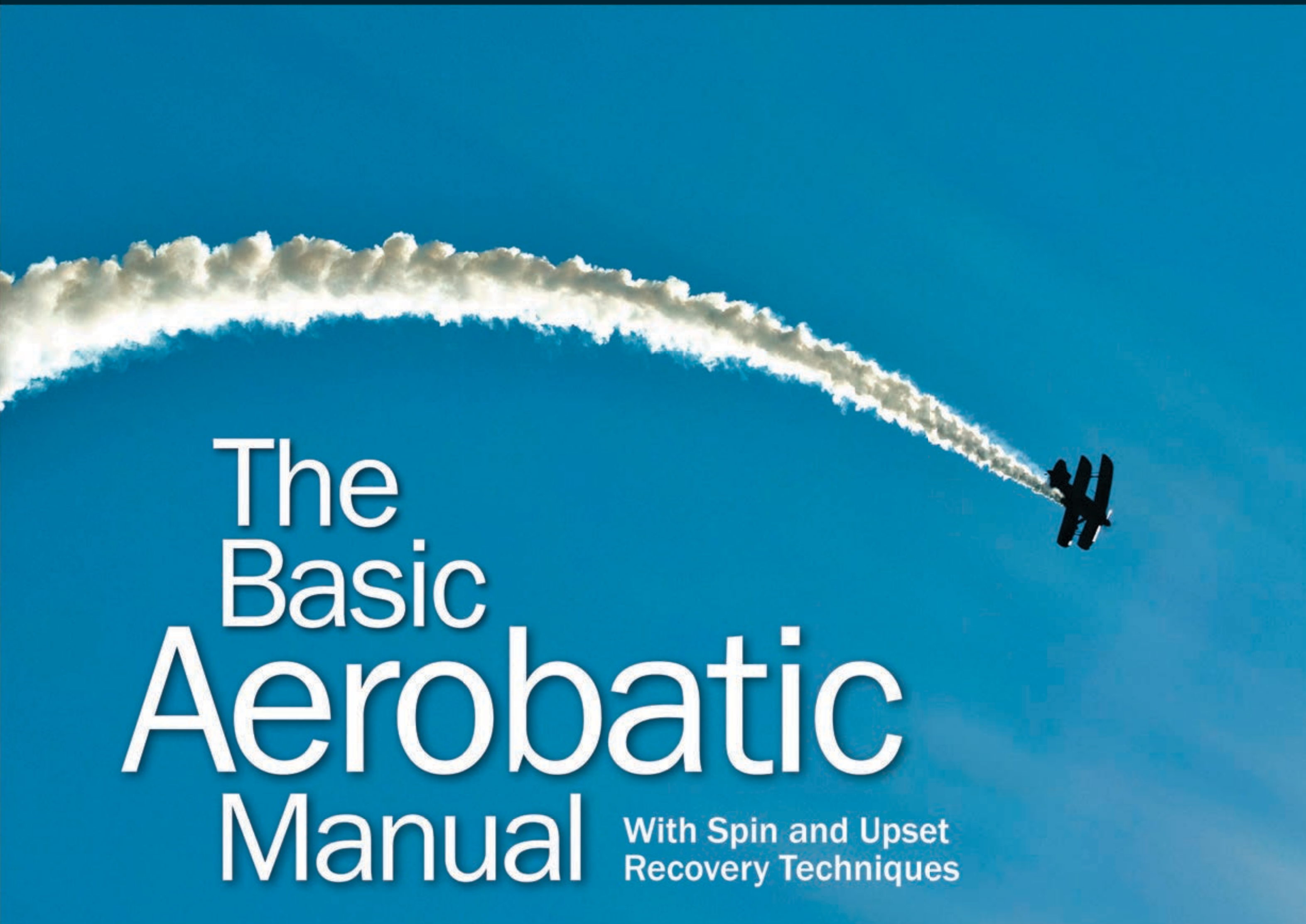

The Basic Aerobatic Manual

With Spin and Upset Recovery Techniques

Based on the original text by

William K. Kershner

2nd Edition | Edited by William C. Kershner

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Aviation Supplies & Academics, Inc.
Newcastle, Washington

After doing his first spin at the age of 16 in an Aeronca TAC, **William K. Kershner** flew and taught aerobatics for 60 years. Bill put his degree in technical journalism and aerodynamics, along with his ability to make complex ideas seem simple, to work in writing *The Student Pilot's Flight Manual, The Instrument Flight Manual, The Advanced Pilot's Flight Manual, The Flight Instructor's Manual* and *The Basic Aerobatic Manual*. He also wrote *Logging Flight Time,* a collection of aviation anecdotes and experiences collected over a lifetime in aviation. The Kershner Flight Manual Series has influenced hundreds of thousands of pilots, with over 1.3 million copies printed in at least 3 languages.

Bill received the General Aviation Flight Instructor of the Year and the Ninety-Nines Award of Merit, among many other honors. He was the only person inducted into both the International Aerobatic Club Hall of Fame and the Flight Instructor's Hall of Fame. He was among the first to be inducted into the Tennessee Aviation Hall of Fame.

Kershner operated an aerobatic school for many years at the Sewanee-Franklin County airport in Tennessee using a Cessna 152 Aerobat. His airplane, N7557L, is on display at the National Air and Space Museum's Udvar-Hazy Center at Dulles International Airport. Bill Kershner died January 8th, 2007.

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William K. Kershner
Illustrated by the Author

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Preparatory Maneuvers

The maneuvers in this chapter are intended to give you a good feel for the airplane in preparation for the basic aerobatic maneuvers. You may want to start learning aileron rolls and more exotic maneuvers, but it's to your advantage to have a good feel of the airplane at various speeds and attitudes before proceeding with basic aerobatics. Here you'll establish habit patterns for safe aerobatic flying (or any flying, for that matter).

Always clear the area before starting a maneuver or sequence of maneuvers. The airplane will be rapidly changing attitudes, altitudes, and headings, and as mentioned earlier, coming out of a loop or other maneuver and finding yourself face-to-face with another airplane is a disappointing situation, indeed.

A fact of life of airplane performance is that *control effectiveness* is a combination of *deflection and calibrated airspeed* (*control effectiveness = deflection × CAS*). While true for all types of flying, this is even more important in aerobatics, where airspeed values may vary widely in one maneuver (the loop and its variations come immediately to mind). A milder example is the aileron roll, which has an entry speed in the Aerobat of 115 K and a completion speed of about 80 K; as the airspeed decays, the rudder (and ailerons and elevator) need to be deflected more to get the same effect. (More about this, later.)

The airplane reacts the same to control inputs, *as far as you are concerned,* whether the airplane is inverted or upright. (A specific note will be brought up in the introduction to the loop, in Chapter 4.) If you ease back on the control wheel, the nose will "move toward you"; moving the wheel forward will ease the nose "away from you." The same applies to yaw and roll, *but* later, when you are competing or doing airshows, you'll have to take into account what you'll do to get a specific path with relation to the ground.

For purposes of easy remembering, a power setting of 2,300 RPM (C-152 Aerobat) and 2,500 RPM (C-150 Aerobat) will be used as "normal cruise" for all maneuvers in this manual, unless otherwise stated. Keep in mind that the general principles cited in this manual apply to basic aerobatic instruction regardless of particular airplane entry speeds or power settings.

Stalls

1-g Stalls

After getting to a safe altitude the instructor may have you review some of the stalls you practiced for the private (or other) certificate some time ago. The point is that you'll want to get the feel and get used again to the idea of deliberately stalling an airplane. You'll be hearing the stall warner quite often during the performance of some of the maneuvers, and it's better to be comfortable with stalls and have quick and effective recovery available if one of the maneuvers goes awry. You'll be high enough for safety during any of the maneuvers, but a poorly recovered inadvertent stall can cost extra altitude, which can take time to get back on a hot summer day. Also, this practice can be a confidence builder; there are plenty of private and commercial pilots who have never felt comfortable with plain, old-fashioned power-on *or* power-off stalls and are secretly nervous about them. In fact, they worry more about stalls in an aerobatic course than doing a loop or roll. There will be inadvertent stalls occurring during the course, as well as deliberate snap rolls (accelerated stalls) and spins.

Common Errors in 1-g Stalls

1. Failing to clear the area before doing straight ahead stalls.
2. Pulling the nose too high in the power-off stall.
3. Not allowing a stall break—recovering at the first indication of buffeting.
4. Using poor recovery techniques—not relaxing enough back pressure during the recovery, resulting in the buffeting and wallowing of the airplane continuing (or even a secondary stall), or

overenthusiastic pushing forward of the control wheel so that excess altitude is lost.

Accelerated Stalls

You know that a stall is caused by a too-great angle of attack—not by slow airspeed. The airplane can be stalled at any airspeed and attitude (disregarding stress problems), and you may find later that by using excessive back pressure on the back side of a loop you can feel the stall nibble—or break—even though the nose is pointed straight down. One possible problem with *accelerated stalls* (the term means that above-normal acceleration forces are in action when the airplane stalls) is that they can be done at too high a speed, and you'll find that the maneuvering speed is the limiting factor for abrupt, full deflection of the controls. At lower weights, the maneuvering speed, which is 108 K (120 mph) for the Aerobat (at the maximum certificated weight), is decreased, so to be well on the safe side, any deliberate accelerated stall maneuvers (such as the snap roll) should be performed at a *maximum* airspeed of 90 K (80 K is the recommended entry speed for snap rolls).

The acceleration forces imposed on the airplane in a stall are a function of the square of the speed at which it is stalled (Figure 2-1); that is, when you slow the airplane gradually and stall it at the normal stall speed, 1 g results and it's not an accelerated stall. If you use the elevators in such a manner that the airplane is stalled at *twice* the normal stall airspeed, 4 g's will result ($2^2 = 4$, obviously). If you were so unthinking as to stall an airplane at 3 times the normal stall speed, 9 g's would result (as well as a number of bent or broken parts, depending on the certification category).

There are three main reasons for the practice of accelerated stalls here: (1) as an introduction to the snap roll and inadvertent accelerated stalls during various aerobatic maneuvers, (2) to become familiar with this maneuver for a flight test, and (3) so that this type of stall may be recognized if encountered in "normal" flying.

Procedure in Accelerated Stalls

First, look at the accelerated stall as an introduction to snap maneuvers. Clear the area and establish a 45° bank at a power setting of 2,300 RPM (2,500 RPM). Slow the airplane to 80 K (90 mph) by gradually increasing back pressure. As the airspeed settles on 80 K (90 mph), smoothly but quickly move the control wheel straight back to the full-aft position so that the airplane is stalled at a higher-than-normal airspeed. (Don't use aileron or rudder during the stall entry.) Recover by relaxing back pressure or applying positive forward pressure, as in the procedure for any stalled condition,

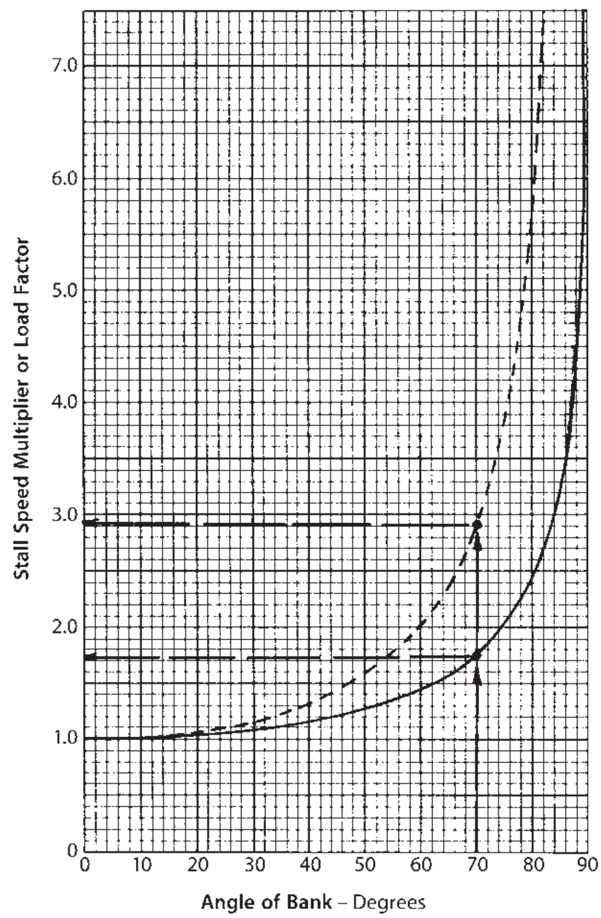


Figure 2-1. Stall speed multiplier (solid line) and load factor (dashed line) versus angle of bank in a constant-altitude turn. At 70° of bank, the load factor is 2.92 g and the stall speed in increased by a factor of approximately 1.71. An airplane that stalls at 60 K at 1 g would stall at 1.71 x 60 = 103 K. To find the stall speed multiplier for turns and pull-ups, take the square root of the load factor (a calculator with this function is useful).

and adding more power (if available) to decrease altitude loss.

Practice this type of accelerated stall from turns in both directions. Again, don't use any aileron or rudder during the initiation or recovery. One reason for the 45° bank is that most pilots get into an accelerated stall when they try to *"tighten the turn."* Their actions may not be as deliberately rapid as yours, but they can usually get the same result, and unfortunately, they may be trying to tighten that final turn on approach. Another reason is that if the pull-up is made wings-level the nose could be raised straight up, creating the possibility of a whip stall, or tail slide. The banked attitude ensures that a whip stall is avoided.

Another method of setting up an accelerated stall situation is to establish a bank of 45° or more and increase the angle of attack at a constant altitude or in a moderate rate of climb until the stall occurs. Power may be reduced below cruising, but any decrease in the rate of climb or a loss of altitude might spoil the effect by relieving the load factor (hence, no accelerated stall). You can figure on the stall occurring at about 20 percent higher airspeed than "normal" in a 45° bank and about 40 percent higher in a 60° bank. It has been suggested that accelerated stalls done in other than aerobatic airplanes should not be started at a speed higher than 1.25 times the normal stall speed. Since the Aerobat is certificated in the aerobatic category, stalling it at up to 1.60 times the normal calibrated stall speed at max weight is an allowed and safe operation. On a flight test you won't be using flaps while demonstrating accelerated stalls. And while the subject is being discussed, you won't do *any* aerobatic maneuvers (including spins) with the flaps extended.

On a flight test you are to avoid such problems during the recovery as a secondary stall, an inadvertent spin, exceeding the airspeed limitations of the airplane, or moving the examiner's voice up a couple of octaves. (This type of flying is what might be expected of pilots who are not trained in aerobatics.)

By experiencing both types of accelerated stalls you can see different situations where a stall could occur in normal operations.

Common Errors in the Accelerated Stall

1. Moving the control wheel back too slowly so that the stall is not accelerated.
2. Not maintaining the 45° bank—allowing it to shallow.
3. Allowing the nose to drop just before the stall is induced so that the airspeed increases to above the safe value for inducing the stall (the procedure must be started again).
4. Making a too-abrupt recovery, with movement toward zero g or even negative g.

Steep Turns

This is a good maneuver for getting back to feeling comfortable in steeper banks when you've been doing mostly straight and level flying. It will help you get the feel of the airplane, as well as smoothing your coordination and improving your planning ability.

The steep power turn, as such, is a required maneuver on the private and commercial flight tests.

The desired angle of bank of the steep turn on the private pilot practical test is 45° (at least 50° on the commercial ride), with limits of ±100 feet altitude, ±10 knots, ±5° stated bank angle, and within ±10° of original heading on roll out. For introduction to an aerobatic course, an average of 60° of bank and 720° of turn is suggested (Figure 2-2).

Procedure in Steep Turns

At a safe altitude and clear area, pick a prominent landmark on the horizon to use as a reference.

Clear the area and roll smoothly into the desired angle of bank. As the roll-in is made, smoothly open the throttle as necessary to help maintain altitude throughout the turn.

One of the problems you might have is anticipating the back pressure to be required in this steeper bank and adding too much, too soon, as you roll in. This, coupled with an overly hasty power increase, could result in an altitude gain at the beginning of the maneuver, setting up a problem that could persist throughout the rest of the turn.

If you are gaining altitude after the turn is established, steepen the bank slightly and relax some of the back pressure. Since the bank will be 60° and the altitude constant (it says here), the accelerometer will be right at +2 g's.

If you are losing altitude, shallow the bank slightly before increasing back pressure. Increasing the back pressure without shallowing the bank puts higher load factors on the airplane and is little or no help in stopping the altitude loss. (The chances are that the altitude loss rate will be *increased* sharply by tightening the turn without shallowing the bank.)

If it becomes evident that things aren't going the way you planned—and may be getting worse—it's best to stop immediately. For instance, if you lose 500 feet in the first 360° of turn and things are generally turning into a goat rope, why not recover and try it again?

Check your bank, nose position, and altimeter as you turn. Get onto any deviations right away, because they usually indicate a trend that could give trouble in a short while.

Remember the *"torque"* (left-turning effects); since you will be indicating slower than cruise and using higher power, right rudder may be needed to keep the ball centered, particularly in a right turn.

Keep up with the reference point; a 1080° turn or making an extra circle doesn't show your planning ability in its best light.

Some pilots want to use the heading indicator as a roll-out reference, but it's best to use an outside reference for heading. Besides, at the 60° bank the heading indicator may "slip" and become inaccurate. You don't want to have your head down in the cockpit while making such a fast direction change - you might meet another airplane.

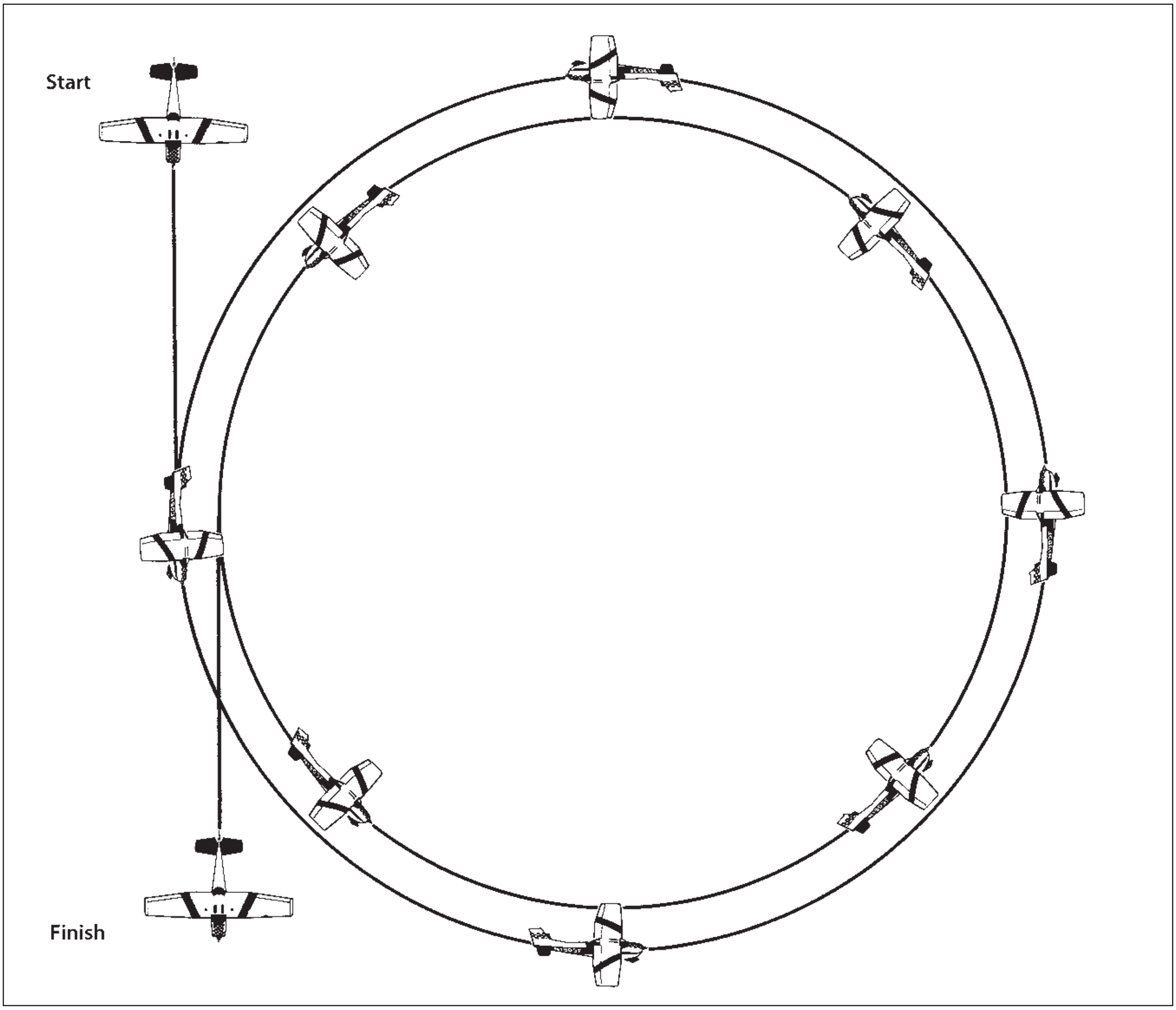


Figure 2-2. The 720° steep turn.

One issue you may have is the nose rising on the roll-out. It takes conscious effort to keep it down as the wings are leveled. The problem is greater if you don't ease the throttle back to cruise as the roll-out is started.

A good procedure is to roll from one 720° power turn into one in the opposite direction; this will iron out any problems in altitude control (or indicate what your problems are). You can roll into the opposite turn *without* changing power, or you can practice changing power during the transition to the new turn.

Pilots have a problem with doing steep turns (or any turns for that matter) in a side-by-side airplane such as the Aerobat in failing to realize that the nose position *appears* to be different for left and right turns. When you are sitting on the left (the pilot's) side, the nose appears high in a left turn and low in a right turn. Actually *a point on the cowling directly in front of you* would be at the same position in a left or right steep turn (Figure 2-3).

Common Errors in Steep Turns

1. Applying too much back pressure at the beginning of the roll-in—the airplane gains altitude.
2. Applying power roughly or too rapidly at the beginning of the roll-in—possibly causing engine overspeed.
3. Using back pressure alone in attempting to correct for a nose-low condition, forgetting that the bank must be shallowed.
4. Using the center of the cowling for pitch reference, instead of a point directly in front of the pilot.
5. "Losing" the reference point.
6. Forgetting "torque" correction or having other coordination problems.

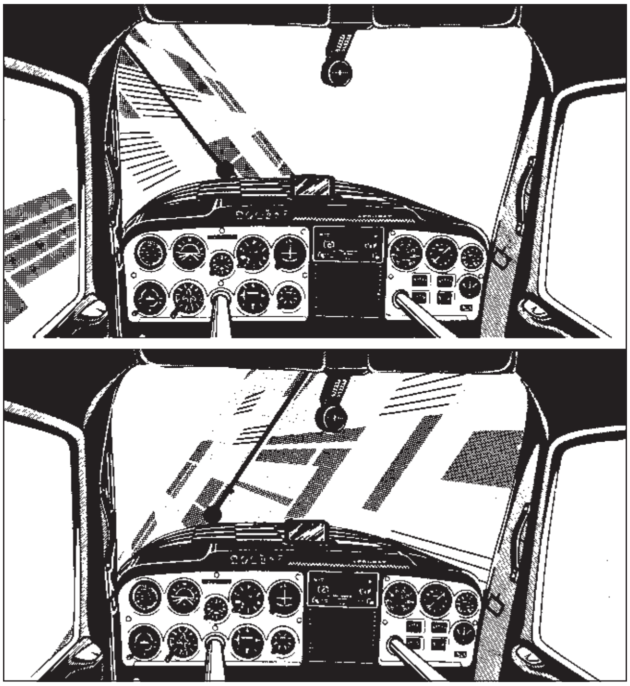


Figure 2-3. View from the left seat in left and right 60°-banked turns. A point on the cowling should be at the same relative position to the horizon when turning in either direction.

7. Letting the nose rise on roll-out-usually a result of neglecting to retard the throttle and relax back pressure as the wings are leveled.

The Chandelle

The chandelle is a required maneuver for the commercial and flight instructor certificate and is also a good introduction to maneuvers that require simultaneous altitude and airspeed changes and turns to predetermined headings in addition to using outside references. (Don't stare over the nose, it won't work.)

The chandelle is a maximum performance climbing turn with a 180° change in direction (Figures 2-4 and 2-5). The airspeed will vary from slightly above cruise to just above a stall.

Good planning is required, and since the speed is changing from the Aerobat recommended entry speed of 105 K (120 mph) to just above a stall, your coordination must take care of changing control pressures and "torque" effects. It's best to make the initial bank and turn into the wind, so that you don't get too far away from the starting point. (The wind, however, has nothing to do with the actual performance of the maneuver—as you know.)

A straight stretch of road or railroad makes a good reference, and you may start the chandelle flying either parallel or perpendicular to it. For most people, starting the dive perpendicular to the reference makes for better checking of the 90° point of turn.

A reference point on the horizon (into the wind) may also be used by putting a wing tip on it during the dive and completing the roll-out with the opposite wing exactly lined up as the airplane approaches the stall.

One big problem for pilots in doing chandelles at first is not looking outside and keeping up with the reference. This often results in either a too-early rollout or a last-minute accelerated roll-out as the pilot suddenly realizes the airplane is about to turn more than 180°.

Procedure in the Chandelle

Figure 2-6 A–H shows the chandelle in sequence.

Line up parallel with, or perpendicular to, a road, railroad, or section line (Figure 2-6A).

Ease the Aerobat nose over to pick up 105 K (120 mph), making sure that the RPM red line is not exceeded (Figure 2-6B). Some airplanes must be *slowed* below the maneuvering speed when starting a chandelle.

As you approach 105 K, bank the airplane 30° with coordinated controls (Figure 2-6C). Because of the bank, the airplane will turn slightly before the pull-up is started—which is the way it should be. *Don't* hold opposite rudder to stop the turn. Keep the ball centered throughout the maneuver. (Neutralize the ailerons so that no further roll is induced as the nose is raised to the climb attitude.) The apparent bank will increase to about 45° as the nose reaches the 90° position, but this is because of the attitude of the airplane, *not* because of any added roll induced by the ailerons. Your instructor, however, may require a constant bank from the initial bank to the 90°-turn position. This means that you will be using opposite aileron (and rudder) as necessary to maintain a constant 30° until the roll-out starts.

Apply power smoothly as the nose is raised to the climb position (Figure 2-6D). Be prepared to correct for "torque." To keep a smooth operation, open the throttle as the airspeed drops to attempt to maintain the cruise RPM. (Full power is applied in the Aerobat. Other airplanes, with constant-speed propellers, may maintain a fixed power setting throughout the chandelle. The *Pilot's Operating Handbook* and/or your instructor will give the procedure.)

The nose is in the process of being raised *only* in the first 90° of turn. At the 90° point of turn, the maximum pitch attitude is reached and maintained (Figure 2-6E). (This is also the steepest bank, if you weren't trying to hold a constant bank of 30°.) Gradually roll out the airplane (Figure 2-6F), so that at 180° of turn the wings are level and the airspeed is just above a stall (Figure 2-6G) (don't raise the nose any higher after the 90°

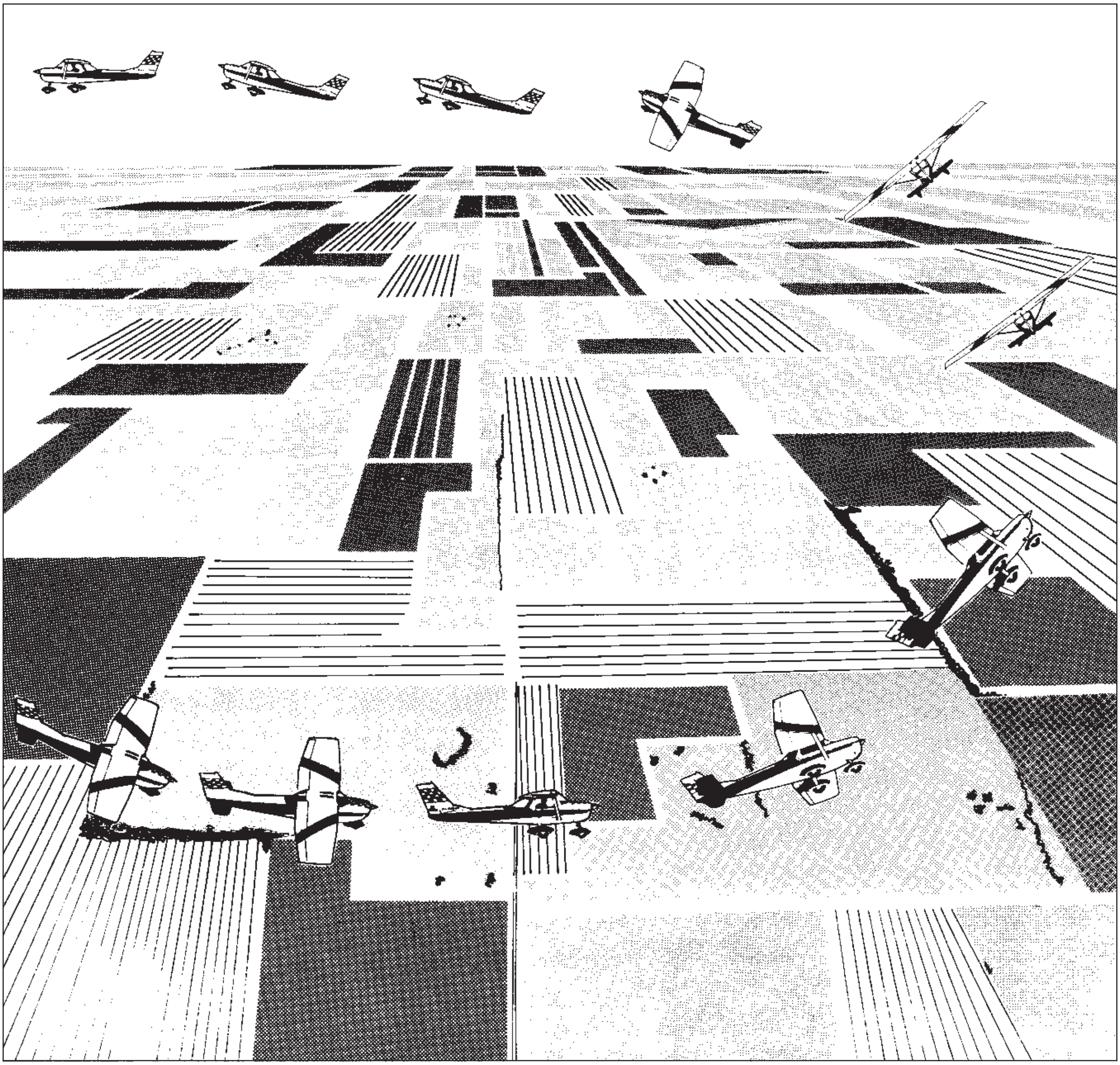


Figure 2-4. Chandelle to the left.

point—continue a constant pitch and constant rate of roll-out for the last 90° of turn). Maintain this condition for 10–20 seconds to prove it wasn't just luck that got the airplane to this point. Then lower the nose to return to normal cruise at the 180° position (Figure 2-6H).

A quick howgozit for the Aerobat is an airspeed of 70 K (80 mph) as the nose moves through the 90° point of turn. Faster than this and you won't be close to the stall (the nose will be too low) as the roll-out is completed. Slower than this and the nose may have to be lowered during the last 90° of turn to avoid a stall. This may seem like a mechanical crutch but can help in working out pitch problems during the last 90° of turn. Naturally, other airplanes will have different entry (and

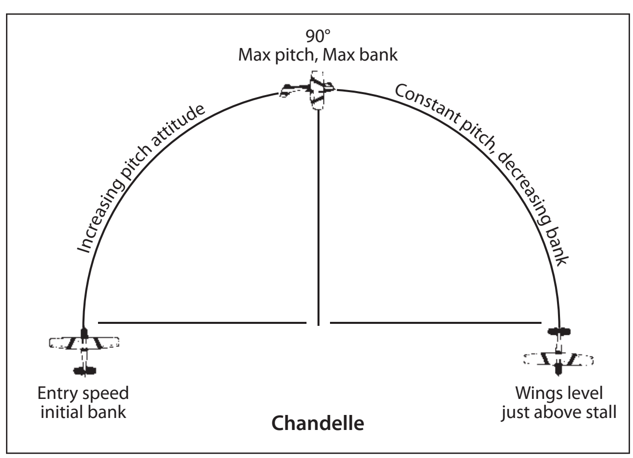


Figure 2-5. Elements of the chandelle.

90°-point) airspeeds, and after a couple of chandelles you can get some numbers for them (a *quick* glance at the airspeed is sufficient).

Watch that correction for "torque." If insufficient right rudder is held in a chandelle to the right, the usual result is that the turn slows down and may be stopped before reaching 180° of turn (and there you are—30° short). In a chandelle to the left, neglect of the left-turning tendency usually results in the airplane turning to the 180° point too soon so the pilot has to make a rapid roll-out. The ideal roll-out procedure is a coordinated one at a constant rate from the 90° point to the 180° position. Some pilots aren't concerned about keeping the ball in the middle during the chandelle, only worrying if the ball breaks the glass and leaves the instrument—unlike you, they're the "stunt pilot" type rather than a precision aerobatic pilot.

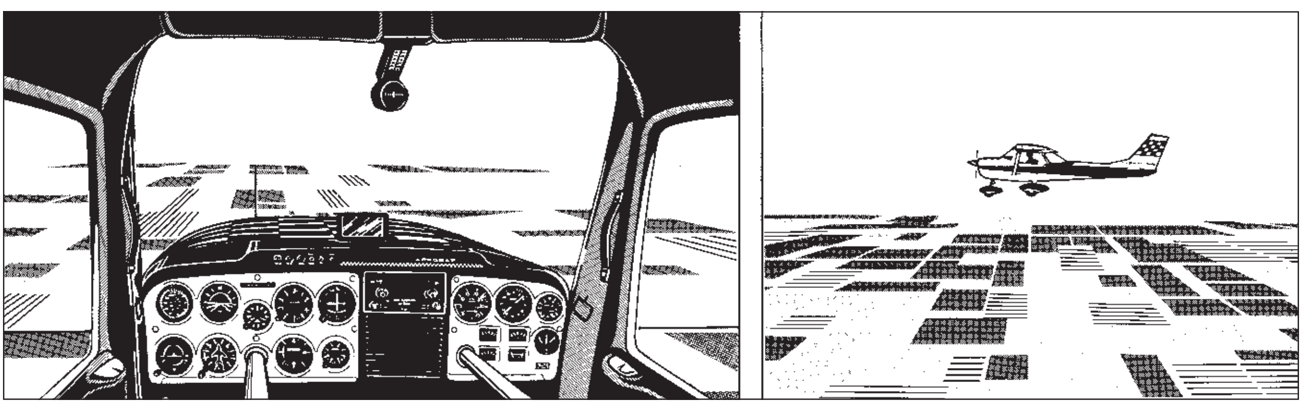
If you gain a couple of hundred feet in a chandelle in the Aerobat (and have had good coordination and planning), consider it a success. The point is to develop your technique so that when you fly that F-16 later, you'll gain *several thousand feet* per chandelle.

During the first couple of chandelles you'll likely feel like you have two left feet, but you'll soon get the idea.

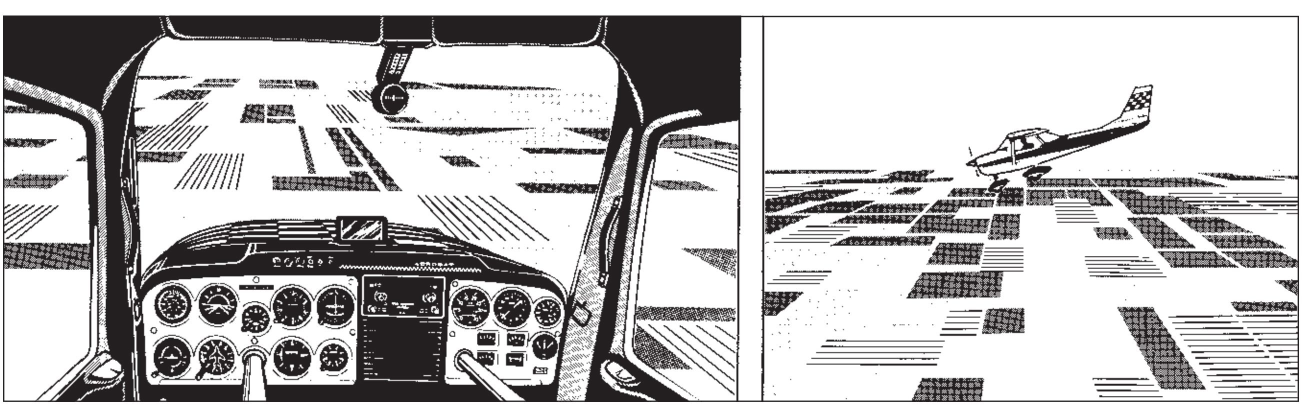
Common Errors in the Chandelle

1. Making initial bank too shallow, so that as the nose continues to be eased up, the airspeed is too low for the amount of turn—a stall is possible before the turn is completed.
2. Making a too-steep initial bank—a maneuver that is all turn with little altitude gain.
3. Having coordination problems on the initial bank—the usual tendency is not to use enough rudder.
4. Not neutralizing the ailerons—making the bank too steep at the 90° position.
5. Having power problems—forgetting to open the throttle or opening it too soon.
6. Not using "torque" correction, particularly during the last 90° of turn.
7. Not looking at the reference (road, railroad, or section line)—instead staring over the nose.
8. Starting the roll-out too late or starting well after passing the 90° point.

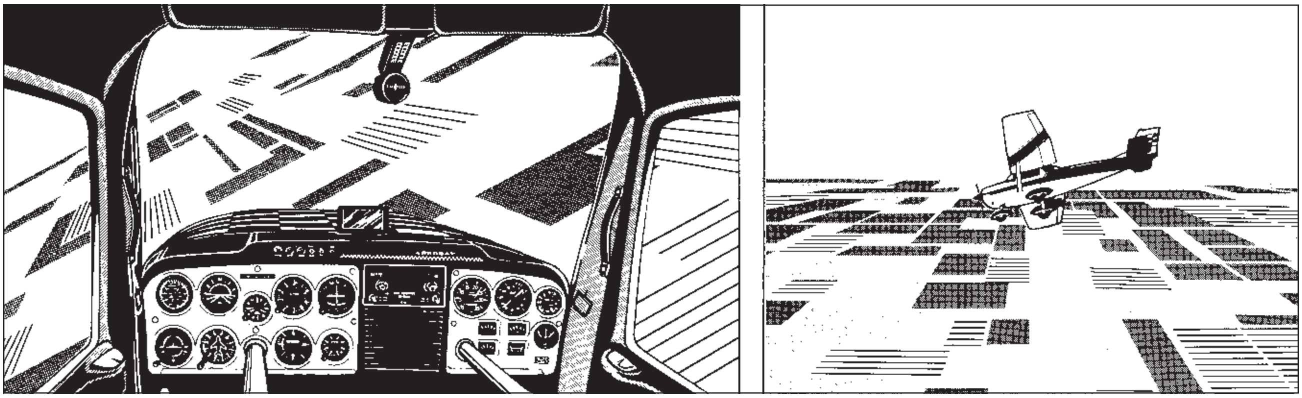
Figure 2-6 A–H. Chandelle as seen from the cockpit and from outside the airplane.



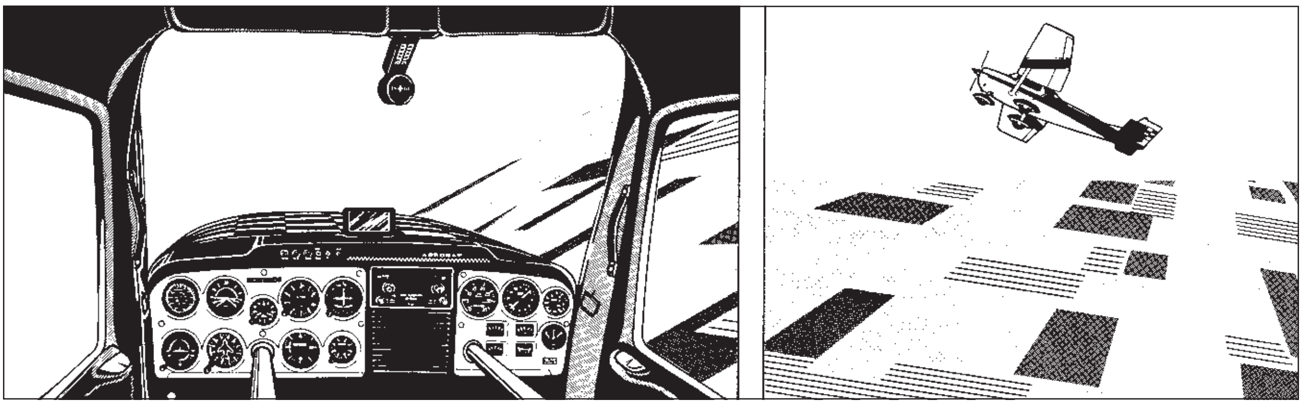
A. Lining up with the reference line.



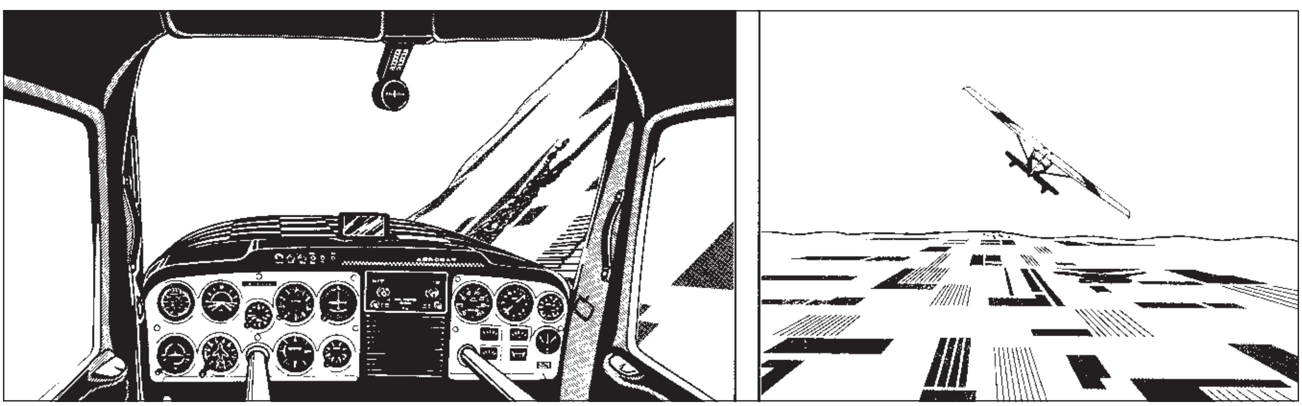
B. Easing the nose over to establish the recommended entry speed.



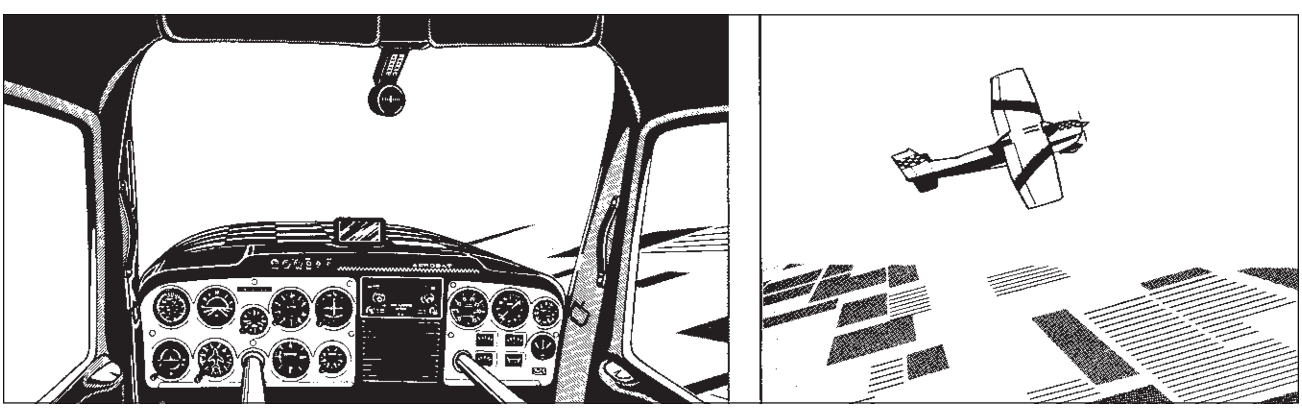
C. Bank of 30° in the desired direction of turn (to the right here).



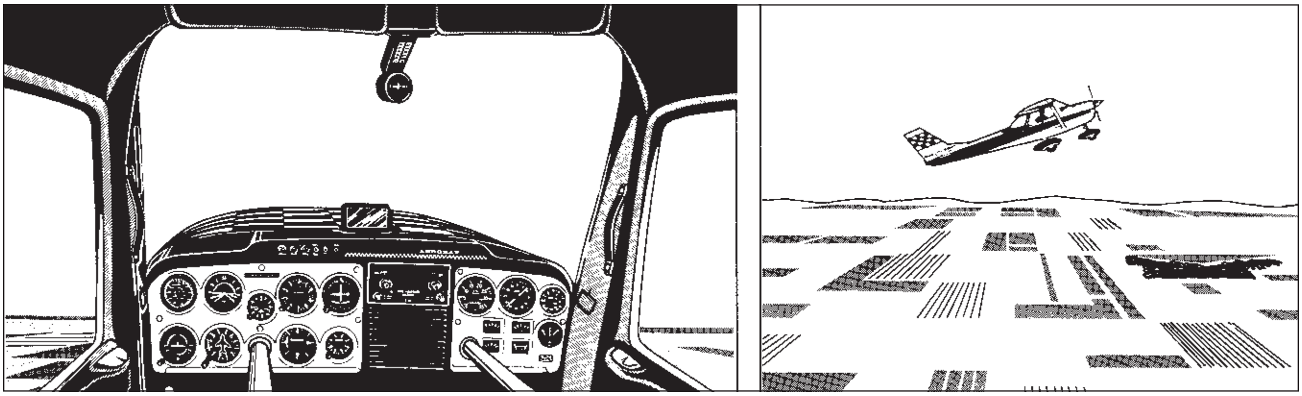
D. The nose crosses the horizon, and power is applied.



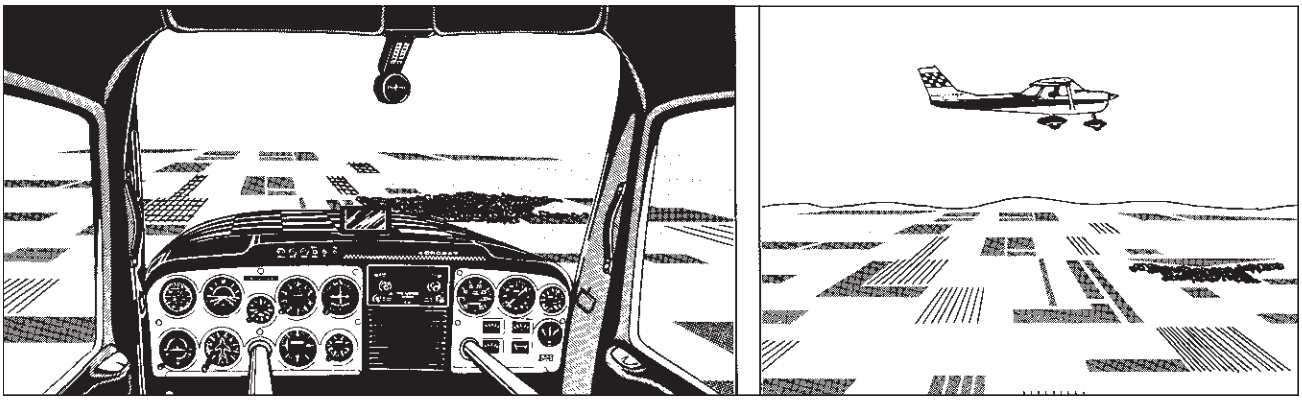
E. The 90°-turn position and the maximum pitch attitude.



F. The 135°-turn position (pitch constant, roll-out continuing, airspeed decreasing.



G. The 180°-turn position (roll-out complete, airspeed just above a stall).



H. Level cruising airspeed and power setting resumed.

9. Keeping the nose too low all the way around so that the airspeed is not near the stall at the 180° point.
10. Becoming so engrossed in airspeed and altitude that the 180° reference point is neglected or lost—completing the roll-out too soon or too late.

The Wingover

The wingover is a good exercise in coordination and also serves as an introduction to the lazy eight, a required maneuver on the commercial flight test. The wing over is basically a 90° climbing turn followed by a 90° diving turn in the same direction with a 180° change in direction. (The lazy eight is discussed in the following section.)

The maximum angle of bank in the wingover is found at the 90° position, and the bank should be 60° when the maneuver is first practiced. Later, the bank may be vertical at the steepest point.

The maneuver is coordinated, and the ball should be centered throughout. This requires judicious use of bottom rudder (and maybe some opposite aileron) at the 90°-turn position, particularly in a wingover to the right, since "torque" will be a factor to consider. The wingover is a good maneuver for maintaining coordination throughout constantly changing banks and airspeeds. Figure 2-7 shows two wingovers in a series, with 60° maximum banks (constant power).

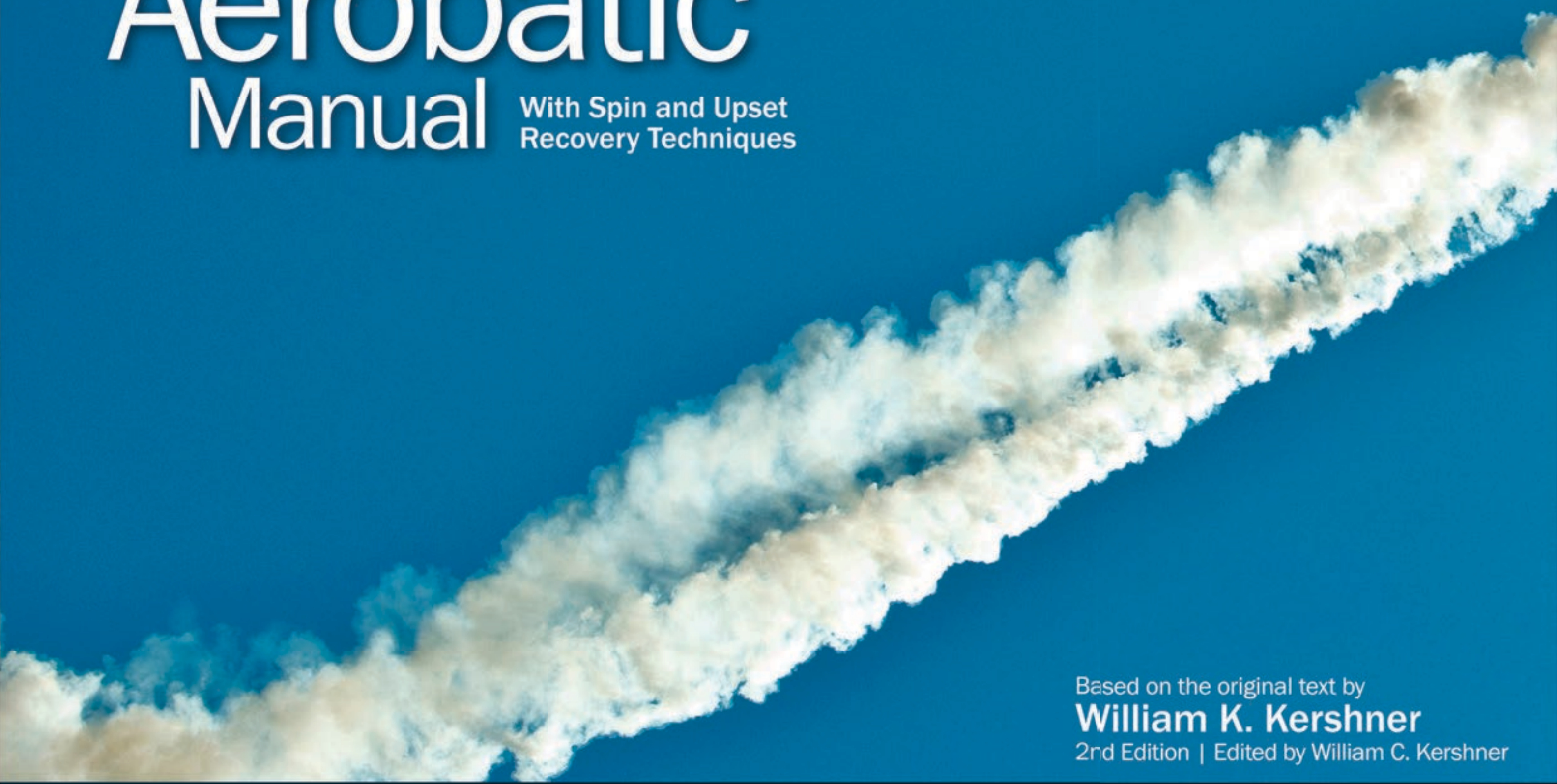
Procedure in the Wingover

Pick an easy-to-see reference on the horizon (preferably into the wind if you plan a series of wingovers). Clear the area as you turn to put it exactly under the wing tip, 90° to the longitudinal axis. (The row of rivets on the Aerobat that run out the wing are a useful reference—your instructor will show you.)

Lower the nose (wings level) to pick up an airspeed of 105 K (120 mph); before the dive set the throttle at the 2,300-RPM (2,500-RPM) cruise value as recommended and don't change it during the wingover. Ease the nose up, and as it passes the level attitude, start a coordinated climbing turn, for example, to the left. At 45° of turn the nose should be at its highest pitch and the bank at 30°, one-half the maximum bank. The steepest bank and lowest airspeed should be at the 90°-turn position. The last 90° of the maneuver is a smooth descending turn. The airplane should be headed exactly 180° from its original heading, and the airspeed should be at 105 K (120 mph) when the wingover is completed

The Basic Aerobatic Manual

With Spin and Upset Recovery Techniques



Based on the original text by
William K. Kershner
2nd Edition | Edited by William C. Kershner

The Basic Aerobatic Manual, Second Edition, is a complete reference for the beginning aerobatic student, with invaluable unusual attitude and spin recovery information for the more straight-and-level flyer. This book emphasizes techniques for the Cessna Aerobat models, but the described maneuvers easily translate to other aerobatics-certified airplanes.

Starting with stalls, chandelles and lazy-8's, the student is guided through spins and the Three Fundamentals of basic aerobatics: the **aileron roll**, **loop**, and the **snap roll**. Once these basics are learned, the combination maneuvers (the *cloverleaf*, for example) are covered in-depth.

For the pilot more interested in flight safety than aerobatics, there is a chapter on unusual attitude (upset) recovery. Returning to controlled flight solely by reference to instruments is examined closely. The chapter on spins and spin recovery benefits from the knowledge gained in over 7,000 spins, each having from 3 to 25 turns, in the Cessna Aerobat.

William K. Kershner started his solo aerobatic career in a Stearman N2S at the age of 17. As a flight instructor, he later operated an aerobatic school in Sewanee, Tennessee using a Cessna 152 Aerobat, until his death in January, 2007.

Other books by William K. Kershner:

The Student Pilot's Flight Manual
The Instrument Flight Manual
The Advanced Pilot's Flight Manual
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