CHAPTER 12

Aerobatics

Aerobatics are smoothly executed maneuvers which exploit the entire performance envelope of the aircraft.

The purpose of teaching you aerobatic maneuvers is to help you develop a more sensitive feel in handling the aircraft and to improve your ability both to coordinate the flight controls and to maintain full awareness of your orientation, regardless of attitude, and put the aircraft where you want it. Learning to perform aerobatics skillfully will give you more confidence in your flying ability, help you become familiar with all attitudes of flight, and increase your ability to fly an aircraft throughout a wide performance range. Aerobatics will teach you to feel at ease when your body is oriented at any angle—and that you can think, plan, observe, and perform as easily while inverted as while upright. Though having the ability to perform aerobatics is important within itself, the confidence you gain from performing these maneuvers is equally important.

The aerobatic maneuvers which you will learn to perform are the loop, barrel roll, aileron roll, Immelmann, cloverleaf, and cuban 8. Although not precision aerobatic maneuvers, the split S, recovery from inverted flight, recovery from dives, and vertical recovery will be taught preceding your introduction to the other maneuvers.

★Minimum altitude during any aerobatic maneuver will be 5,000 feet above the terrain, or higher as directed locally. Remember, the minimum altitude during any solo maneuver is 8,000 feet above the terrain.

Before entering aerobatic maneuvers trim the aircraft for straight-and-level flight. Prior to entry, clear the area visually.

SPLIT S

The split S is a maneuver designed to show how much altitude may be lost if recovery from inverted flight should be attempted in this manner. It is basically the same as the last half of a loop.

To enter the maneuver, the aircraft should be set up for normal cruise at 90% rpm. Clear the area keeping in mind that the aircraft climbs during the entry and descends during the recovery.

From straight-and-level flight with 90% rpm, lower the speed brake and simultaneously raise the nose to a 20° to 30° pitch attitude. When the airspeed decreases to 120 knots, retract the speed brake and simultaneously roll the aircraft to the wings-level inverted attitude. From inverted flight, start back pressure to bring the nose through the horizon. Hold maximum back pressure possible without high-speed stalling. Release back pressure when the half-loop is completed and the aircraft resumes straight-and-level flight.

RECOVERY FROM INVERTED FLIGHT

The correct procedure to recover from inverted flight is to execute a roll back to the level-flight attitude. The technique employed is the same as in executing any roll maneuver. Apply aileron pressure in the direction you want to roll. The direction of the roll depends on the attitude of the aircraft. Roll in the shortest direction to an upright attitude.

Since inverted flight at very low airspeeds might be inadvertently encountered, there

could be insufficient control effectiveness to make an immediate roll. Therefore, it may be necessary to lower the nose slightly before or during the recovery.

Whenever possible, maintain a fairly constant pitch attitude as the recovery is made. If this cannot be done because of low airspeed, let the nose of the aircraft lower while performing the roll back to the level flight attitude. This prevents an excessive loss of altitude.

Your instructor will give you the opportunity to practice this recovery technique. He will fly the aircraft into an inverted attitude, then let you make the recovery. This will be practiced at various airspeeds. The correct recovery technique is a roll back to level flight. Do not split S.

RECOVERY FROM DIVES

Many of the maneuvers demonstrated and practiced in flying training will result in intentional or unintentional dives. The information below will provide you with a sound basis for a recovery technique.

Recovery from all dives should be made smoothly, without excessive airspeed or loss of altitude. All aircraft are "redlined" at a definite maximum allowable airspeed. This is indicated by a red mark on the face of the airspeed indicator. Should this maximum be exceeded at any time, an entry should be made in the AFTO Form 781. This writeup will result in an overall inspection of the wing, tail, and control surfaces.

Another factor in the recovery from dives is the G (gravity) force. It is present any time a change of direction is made which increases wing loading of the aircraft. This increased loading can be identified by the increased seat pressure present whenever back pressure is applied to the stick.

In a high-speed dive, a sharp pullout may result in the wings, tail, and controls being subjected to undue stress. This may pop rivets, twist the fuselage, and buckle or completely collapse the wing or control surfaces. This is why you must never exceed the design G-force limits of the aircraft. Learn them from the T-37 Flight Manual.

The pullout from any dive should be made with smooth back pressure and started before the airspeed has increased to such an extent that the limitations will be exceeded. Anytime you are in a high speed dive, retard the throttles to idle, extend the speed brake, and return the aircraft to level flight. Recovery should not involve the use of maximum allowable "G" forces unless the altitude available for recovery is critical. For most practice high-speed dive recoveries, it should not be necessary to approach the maximum limitation. Remember, the airspeed does not stop increasing as you begin raising the nose. It may increase until just before level flight is attained.

VERTICAL RECOVERY

This maneuver is designed to teach the best method to regain straight-and-level flight if the aircraft is maneuvered into vertical flight inadvertently. (See figure 12-1.)

You will intentionally fly through the vertical attitude many times during aerobatic

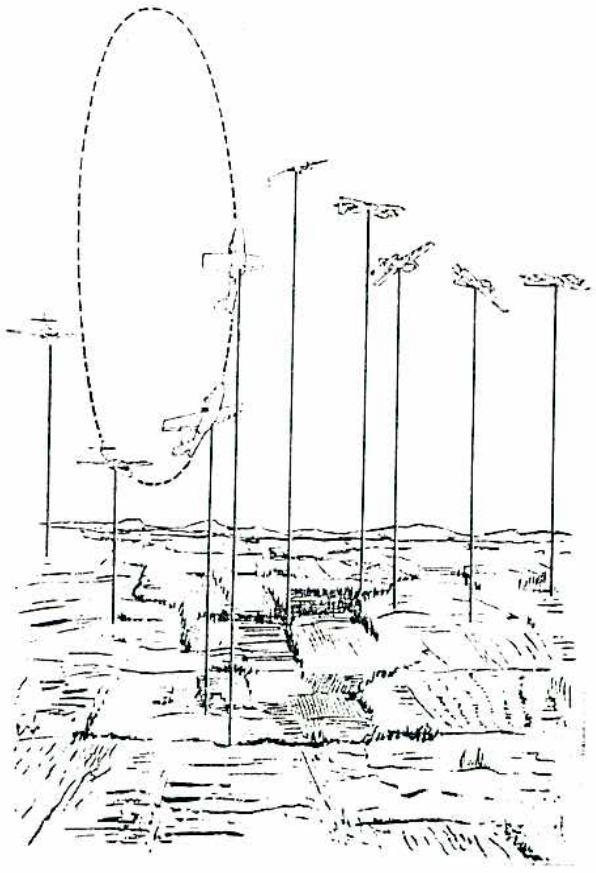

Figure 12-1. Vertical Recovery

practice. Suppose that you unintentionally arrive in this attitude without a predetermined plan for recovering. Unless a safe recovery is effected, you could fly into a severe stall or spin, or place undue stress on the aircraft.

The recovery technique outlined here incorporates smooth, coordinated flight and is identical to the recovery used in tactical jet aircraft. It will return you to level flight without negative G forces being applied to the aircraft.

Before entering the maneuver, adjust the throttles to 90% and clear the area. Enter a shallow dive to gain sufficient airspeed so that, as the aircraft is returned to level flight, the entry airspeed of 250 knots is attained.

When the nose reaches this attitude, begin applying greater back pressure to increase the pitch attitude at a more rapid rate. Use aileron and rudder pressure to keep the wings level and to maintain directional control.

Since this maneuver is accomplished with a high entry airspeed, you should use smooth pressures in flying to the vertical attitude.

When you can no longer see the horizon over the nose, look at the wingtips and keep them equidistant from the horizon. To determine when you are in vertical flight refer to the wingtips. At approximately the vertical attitude, advance the throttles to 100%, continue back pressure, and coordinate aileron and rudder pressure to initiate a roll. If the aircraft is not perfectly vertical this roll should be made toward the low wing; otherwise, the direction is optional.

Caution must be used to avoid a stall from excessive back pressure; but sufficient back pressure must be applied to keep the aircraft's nose coming down smoothly toward the horizon.

Continue these control pressures to execute approximately a one-quarter roll and fly the aircraft smoothly down through the horizon. As the nose of the aircraft reaches the horizon the aircraft should be inverted with the wings approximately level. After the nose is below the horizon, roll out to a level flight attitude. Adjust the throttles to the desired setting. In this maneuver, the nose of the aircraft will describe an arc through and then below the horizon and back to level-flight attitude.

Use outside references, the altimeter, and the vertical velocity indicator to aid in determining level flight upon completion of the maneuver.

LOOP

The loop is a 360° turn in the vertical plane. (See figure 12-2.) Since it is executed in a single plane, the elevator is the basic control. The ailerons and rudder are used for coordination and directional control.

To remain oriented, you should select a road or section line for a ground reference. Align the aircraft with this reference and keep it aligned throughout the loop.

Adjust the throttles to 100% and begin the maneuver by clearing the area. Enter a shallow dive to gain sufficient airspeed so that, as the aircraft is returned to level flight, the entry airspeed of 250 knots is attained.

Increase back pressure to maintain a constant rate of movement of the nose throughout the pull-up. Centrifugal force will cause you to feel a definite seat pressure. Use this seat pressure (about 3 G's on the accelerometer) to determine the correct rate of movement of the nose. For example, if there is very little seat pressure, your rate of pullup is too slow.

Keep the wings level and maintain direction with a combination of aileron and rudder. When you can no longer see the horizon ahead, look at the wingtips and keep them equidistant from the horizon. After passing the vertical flight position rotate your head back and watch for the horizon to appear. Use the horizon to maintain a wings-level attitude, and locate the road or section lines on the ground that you used to begin the maneuver.

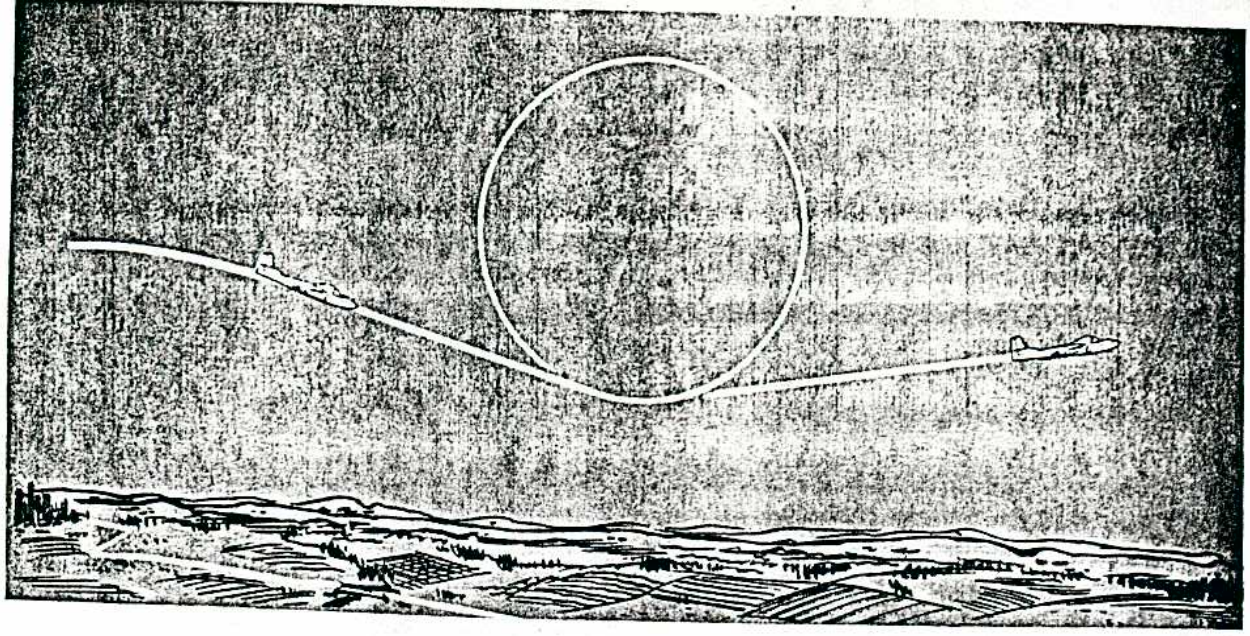

Figure 12-2. The Loop

As the inverted position is attained, a very small amount of back pressure should be released. However, maintain a definite seat pressure. This prevents a stall at the low airspeed encountered at the top of the loop. Use aileron pressure as needed to keep the wings level.

As the nose passes through the horizon and the aircraft re-enters a dive, you should increase back pressure to return the nose to the level flight attitude. Throughout the last half of the maneuver, you should use the selected road or section lines for reference to follow or to parallel with the nose of the aircraft.

The elevator is the basic control used to execute the loop. The ailerons and rudder are used to maintain direction and coordination. If you pull up too fast, you will exceed the critical angle of attack and will stall. If your initial pull-up is slow, you will lose too much momentum and a stall will occur before the aircraft reaches the inverted position because of too low an airspeed.

Keep the nose moving at a constant rate throughout the maneuver. The directional indicator may be crosschecked before and after the maneuver to determine whether direction was maintained in the vertical plane.

BARREL ROLL

A barrel role (figure 12-3a & b) is a coordinated roll in which the nose of the aircraft describes a circle around a point on the horizon. Definite seat pressure should be maintained throughout the roll.

The barrel roll should be practiced both to the right and to the left, and there should be little or no net loss or gain of altitude from the maneuver.

Adjust throttles to 90% and clear the area. Select a reference point on or near the horizon—a cloud or a landmark.

Attain the entry airspeed of 200 to 230 knots by diving the aircraft while clearing. This airspeed should be attained with the nose of the aircraft below the reference point.

Begin a coordinated turn in the opposite direction of the desired roll. Keep the aircraft nose below level flight until it has turned approximately 20° to 30° to the side of the reference point. Then begin rolling out of the initial turn and allow the nose to rise so that the wings are level just as the aircraft passes through a level-flight attitude.

At this point the number of degrees or distance to the side of the reference point depends on the speed of the rollout. This distance from the reference point should remain the same throughout the barrel roll.

Continue with coordinated stick and rudder pressure causing the climb and bank to increase. As the wings reach the vertical attitude the aircraft should be at its highest point above the reference point. After you pass this position, relax some of the back pressure but continue the roll by blending in more aileron pressure.

Plan the roll so that the wings become level just as the aircraft reaches the inverted level flight attitude. The aircraft nose track should now be the same distance on the opposite side of the reference point as it was at the beginning of the maneuver. The aircraft nose should have described a semicircle about the reference point. As the aircraft passes this position, continue the roll and begin applying increased elevator pressure.

As the wings again reach the vertical attitude at the bottom of the maneuver, the nose track should continue to be an arc of a circle with the reference point as its center. In this last quarter you must begin to blend in more elevator and maintain coordinated control pressures to continue the roll so that the nose track completes the circle around the reference point while positive seat pressures are held throughout the roll.

The reason for blending in additional aileron pressure at the vertical position in the first quarter of the roll is to maintain a

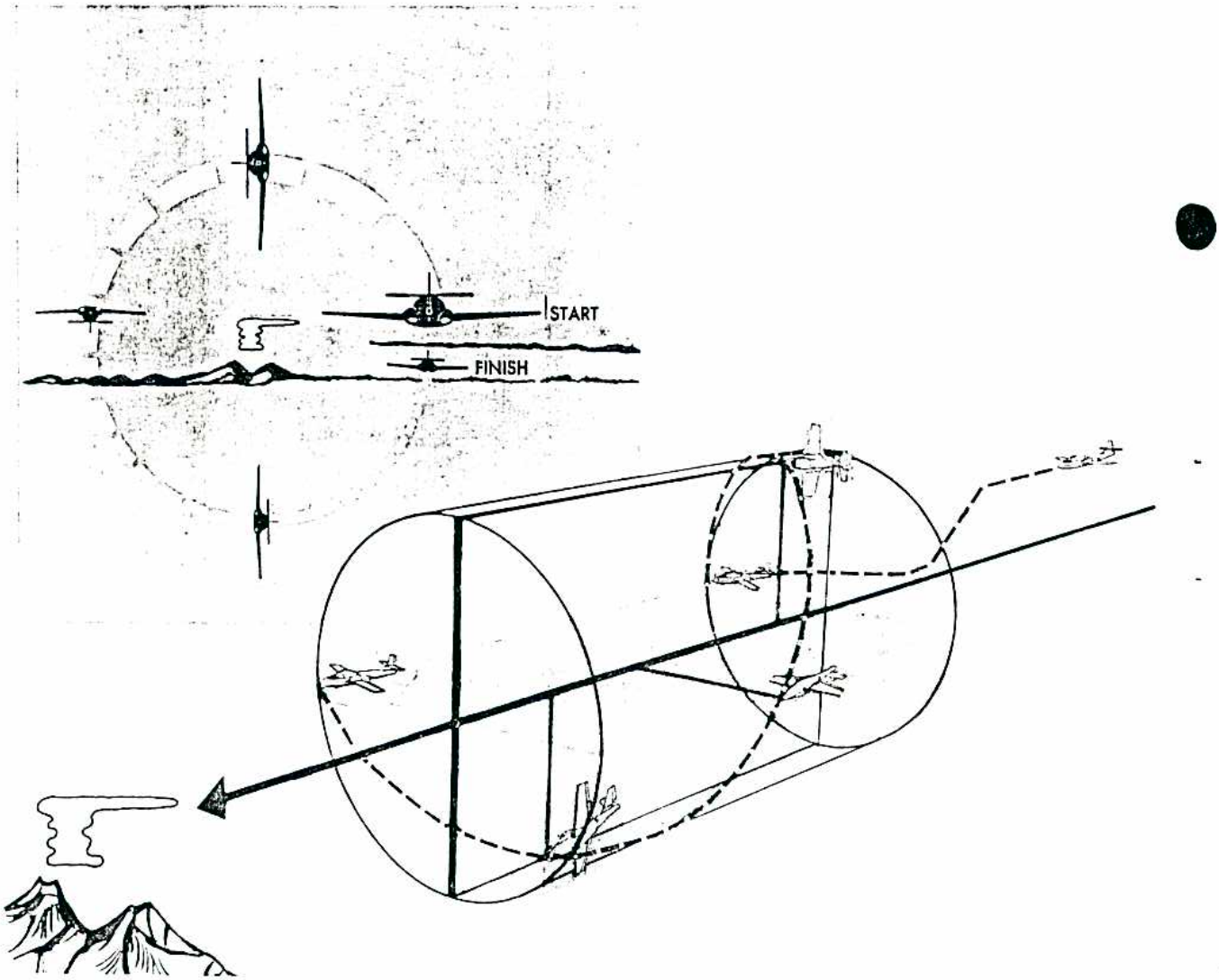

Figure 12-3a. The Barrel Roll

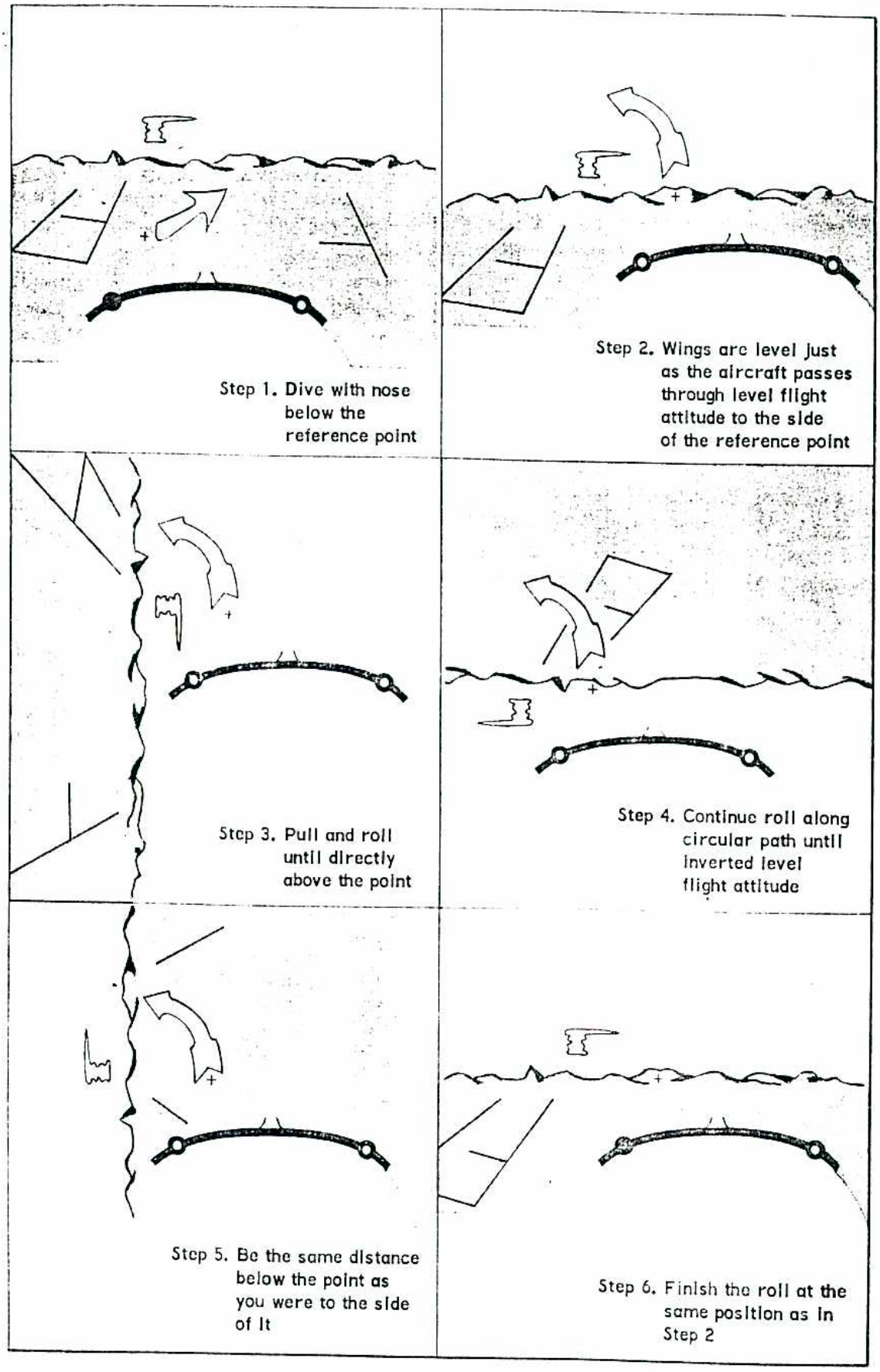

Figure 12-3b. Left Seat View of Left Barrel Roll Around a Cloud

constant rate of roll. Since the nose is rising continuously up to this point, and the airspeed is decreasing, the aileron deflection is less effective than it was at the beginning of the maneuver. This means that the rate of roll will slow down unless more aileron surface is presented to the relative wind. By applying added aileron pressure the rate of roll is held constant.

In the second quarter of the roll, if you held the same amount of back pressure as was used in the first quarter, it would pull the nose down too fast in relation to the horizon because gravity is now assisting lift (downward).

In the third and fourth quarters, the application of additional back pressure helps to coordinate the pitch with the roll to describe the proper nose track.

These control effects apply to any rolling aerobatic maneuver although they may be modified.

It is the ailerons that roll the aircraft; and you should maintain a constant rate of roll throughout the maneuver. Do not overcontrol with the rudder or elevator; they are used only to maintain coordination. Throughout the maneuver, the aircraft should remain in coordinated flight. Definite seat pressures should be maintained.

AILERON ROLL

The aileron roll is similar to the barrel roll although much easier to execute. The greatest difference in the two maneuvers is the reduced importance of the elevator in the aileron roll. All controls are of almost equal importance in executing a smoothly coordinated barrel roll. The ailerons are of primary importance in the aileron roll, which may be performed in either direction.

Adjust the throttles to 90% and clear the area. Attain the entry airspeed of 200 to 230 knots. Then smoothly raise the nose to 20° to 30° pitch attitude, relax back pressure, and initiate the roll by applying aileron and a slight amount of rudder pressure to help coordinate the roll.

After the aircraft begins to roll, relax rudder pressure and steadily increase the aileron pressure. Apply aileron as necessary to obtain the desired rate of roll. No attempt should be made to keep the nose on a point.

As the wings-level attitude is approached, aileron pressure must gradually be released and appropriate rudder pressure must be applied to insure a smooth, coordinated return to wings level.

IMMELMANN

The Immelmann is a half loop followed by a half roll. To enter the Immelmann, adjust the throttles to 100% and select one or more ground reference lines, as explained for the LOOP. Be especially careful to clear the area behind you.

Enter a shallow dive to gain sufficient airspeed so that as the aircraft is returned to level flight the entry airspeed of 270 knots is attained. Continue the movement of the nose by increasing the back pressure to maintain a constant rate of movement of the nose throughout the pull-up (about 3 G's on the accelerometer). Maintain wings level with aileron.

As the aircraft reaches a point approximately 20° above the horizon inverted, apply aileron in either direction to initiate a half roll. Rudder through the first portion of the roll should be opposite to applied aileron pressure. Rudder will be reversed and coordinated in the same direction as applied aileron in the last portion of the roll.

During the first 45° of the half roll it will become necessary to relax some back pressure to keep the nose track in the same vertical plane. This back pressure must be increased again as the level-flight attitude is approached because with your decreased airspeed the nose will want to drop. Increase the blended rudder pressure during the last part of the rollout to hold the nose in the vertical plane.

The maneuver is complete after a momentary pause in the level flight attitude following the rollout.

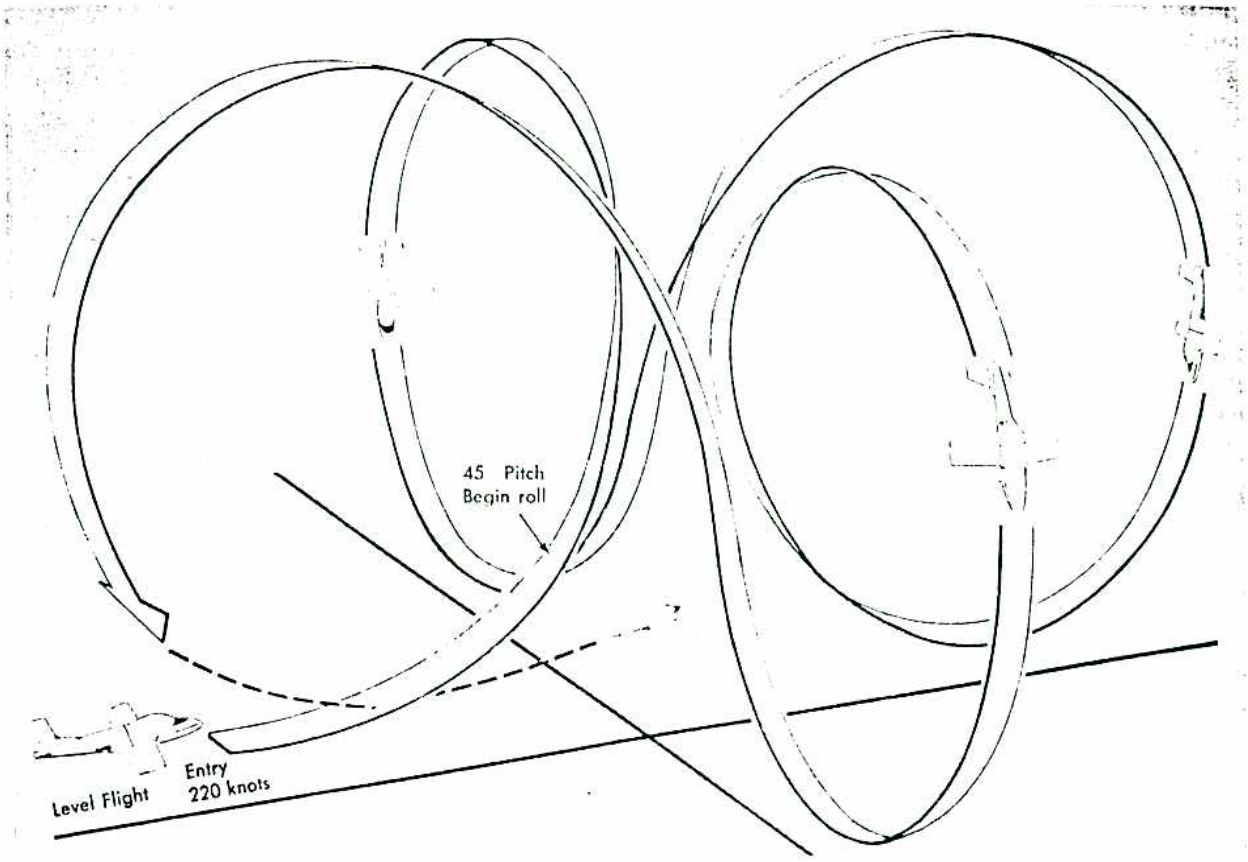

Figure 12-4. The Cloverleaf

CLOVERLEAF

The top part of this maneuver is similar to the recovery from vertical flight. The lower part resembles a loop. It is composed of four identical maneuvers, each begun in a new direction 90° from the preceding one. (See figure 12-4.) It will help develop your timing and your planning.

The cloverleaf should be performed smoothly, without rapid rates of roll or excessive G forces. If possible, choose an area with ample section lines for repeated easy reference.

Adjust the throttles to 90% and clear the area. Enter a shallow dive to gain sufficient airspeed so that as the aircraft is returned to level flight the entry airspeed of 220 knots is attained.

The initial part of the maneuver is the same as the loop except for the airspeed. Pick your first reference point 90° from the nose, as you would in a lazy 8. Start a climb and keep checking this point as you progress through the climb.

As the aircraft reaches approximately 45° of pitch, begin a coordinated roll toward the selected 90° point. Allow the nose to continue climbing during the roll, so that the maneuver will be fairly slow and lazy. Your first objective is to roll so that the wings become level just as the aircraft reaches the inverted level flight attitude at a relatively low airspeed. (You should not be staring at the airspeed indicator but should check it as you pass through your selected point.)

As the aircraft is brought through the 90° point, keep the wings level and pull through the bottom of the maneuver, the same as the bottom of a loop. Plan the pull-up so that level flight is reached with 220 knots. To

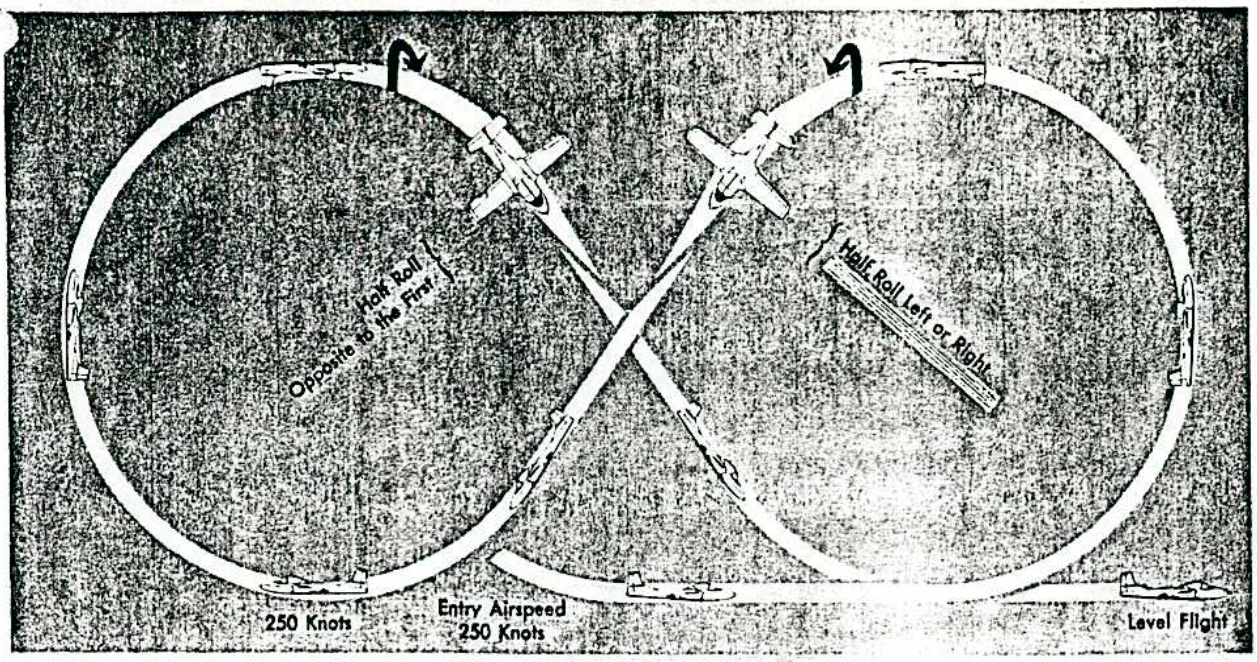

Figure 12-5. The Cuban 8

avoid excessive G's at the bottom of the pull-up, apply more back pressure soon after the nose track descends below the horizon and hold it sufficiently to keep the airspeed from building up too quickly during the initial part of the pullout. Some back pressure then may have to be eased off in order to reach 220 knots.

If you have let the airspeed build up too fast you will probably exceed 220 knots and find yourself pulling high G-forces in the pullout. In starting your increased back pressure early, however, you should do it smoothly and avoid the buffet range. The buffet is not injurious to the aircraft but is poor technique.

Having completed one quarter of the maneuver, again select a point 90° from the nose and repeat the maneuver just described. Four complete loops make the cloverleaf; and the aircraft is on the same heading used for entry.

You should be proficient in cloverleafs to both right and left. If the first selected 90° point is to the left, the following selections should also be to the left; or if begun to the right, continue to the right.

As in all aerobatic maneuvers, clearing the area is a continuing requirement.

CUBAN 8

Each half of this maneuver is a slightly modified combination of the loop and the Immelmann. It is approximately the first three-quarters of a loop followed by a half roll. It must then be repeated in the opposite direction. (See figure 12-5.)

Adjust the throttles to 100%, clear the area, and begin the maneuver by making a normal loop entry at 250 knots. Proceed over the top, and as the nose lowers below the horizon inverted, execute a half roll in either direction so as to reach approximately 45° nose low when the roll is completed. Use rudder pressure as in the Immelmann to hold the aircraft on the desired heading. Release the elevator pressure to keep the nose track in the same vertical plane.

After completing the half roll, plan a pull-up so as to attain 250 knots when passing through level flight. Continue the pull-up into another loop entry.

The second half of the cuban 8 is identical to the first except that the roll is in the opposite direction. That is, if the first roll was to the right, the second will be to the left, and vice versa.