HAROLD HOLMES'

COCKPIT CLASSROOM

STRAIGHT AND LEVEL FLIGHT, CLIMBS AND GLIDES

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THE OBJECTIVE OF straight and level flight as stated in the Haldon Books Flight Maneuvers Manual is as follows: To fly a constant heading and to maintain a level flight attitude. Straight flight is the maintenance of altitude and direction. Level flight requires constant minor corrections for climbs, glides and turns.

In order to understand straight and level flight, there are two types of forces that may act on an airplane in level or steady flight. "They may be termed as body forces and surface forces. Body forces act on the body from a distance. For the airplane this is the gravitational force or weight. Surface forces act because of contact between medium and the body; in pilot talk this means between the air and the airplane surface (NASA, 1975)." Lift, drag and thrust, the other main forces acting on an airplane, are all surface forces. Basically, the four forces acting on an airplane are weight, thrust, lift and drag (Figure 1).

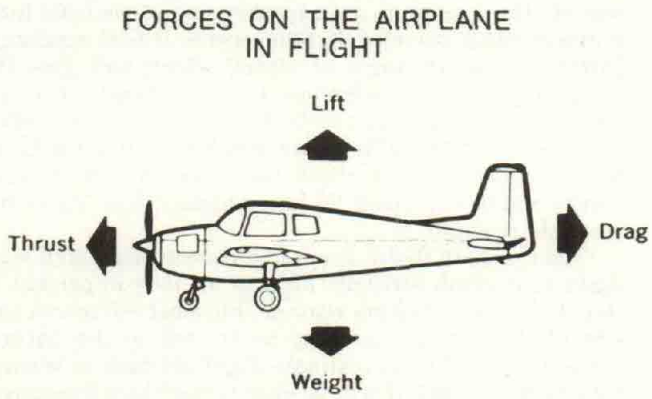


Fig. 1

The weight includes the airplane itself, the payload and the fuel. Since fuel is consumed as the airplane flies, the weight decreases. (An important factor is calculating weight and balance before takeoff for later takeoff and landing weight of your aircraft.) Weight acts in a direction toward the center of the earth. Thrust is defined as the driving force of whatever propulsive system is used, engine driven propeller, jet engine, rocket engine and so forth. It generally acts along the longitudinal axis of the airplane except for vertical take-off aircraft. **Lift** is the force generated by the flow of air around the airplane, the major portion resulting from the wing. It represents the component of the resultant aerodynamic force normal to the line of flight. The by-product of creating lift is induced drag. **Drag** arises from the flow of air around the airplane. It is the component of the resultant aerodynamic force along the line of flight.

From a purely aerodynamic standpoint an airplane will travel in straight and level flight at a uniform airspeed. Figure 1 shows the disposition of the four forces in a level flight condition. To maintain level flight, the lift equals weight, and the thrust equals drag. As we mentioned earlier, weight and thrust are physical attributes of an airplane, which are easily determined and controlled. However, lift and drag arise from the dynamic movement of the airplane through the air, in our case, in level flight. "A major concern of aerodynamics is the manner in which the **lift** and **drag** forces arise (NASA, 1975)."

The FAA **Flight Training Handbook**, AC61-21A, points out the importance of the proper pitch attitude for level flight. This is usually done by selecting some portion of the airplane's nose as a reference point. This point is then maintained in a fixed position relative to the horizon. Now the position of the nose relative to the horizon is cross-checked occasionally against the altimeter to determine the pitch attitude. (See Figure 2)

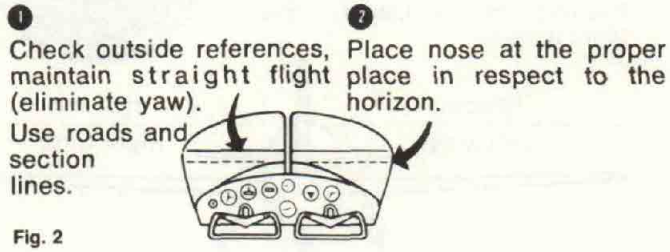


Fig. 2

As a CFI I have found it important, when communicating with students, to always relate such terms as **pitch**, roll and yaw to the appropriate axis and the control surface which moves the airplane around each of these three axes.

In the flight situation of controlling the pitch attitude for level flight, this is very simply done by raising or lowering the nose with the elevator around the lateral axis. There are actually two different kinds of pitch. One is called **aerodynamic pitch** which means the rotation

about the lateral axis of an aircraft; whereas, **pitch attitude** means the up or down reference to the horizon looking out from the pilot's seat of an airplane. In level flight we also need to concern ourselves with the roll axis and yaw axis. We roll around the longitudinal axis using ailerons and yaw around the vertical axis using the rudder. Coordinated flight involves control of the airplane about these three axes (Figure 3).

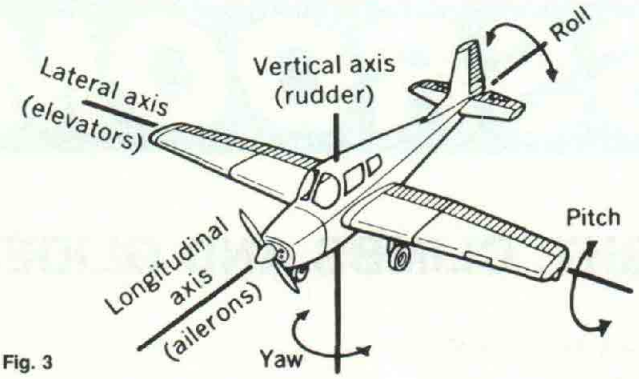


Fig. 3

In order to maintain straight flight at a constant heading, it is important to select prominent reference points directly ahead of the airplane. Fields, towns, mountains, lakes, railroad tracks, etc. are good for this purpose. An occasional glance at the heading indicator is recommended while using outside references. I have always encouraged my students to practice holding a constant heading and altitude anytime they are flying level to and from the practice area. This is what develops proficiency and reduces the tendency to develop bad habits such as continuously varying altitudes or headings while attempting to fly at a level flight attitude.

Straight and level flight requires keeping the lateral axis level with the horizon. We sometimes refer to this as laterally level flight. (Figure 4)

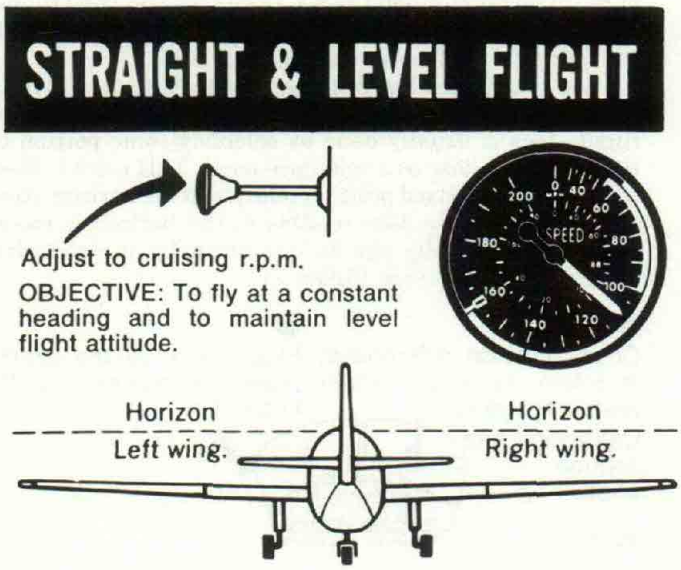


Fig. 4

By continually observing the wingtips in relation to the horizon, we can also scan the horizon for other airplanes. Unfortunately, many pilots have developed the habit of only scanning the pilot's side or left side of the horizon. The habit of visually scanning from wingtip to wingtip as well as a 360° scan periodically is vital. Mid-air collisions many times occur when the faster, overtaking airplane strikes a slower aircraft from the 4 to 8 o'clock direction. Remember that most mid-air collisions occur within 5 miles of an airport involving airplanes on **training, personal** or **pleasure** flights.

Straight and level flight can best be accomplished by trimming the airplane so it will fly level in almost "hands-off flight". Long cross-country flights can become very tiring physically if the airplane is not properly trimmed. When trimming, first apply control pressure to establish the desired attitude and then trim out the pressure to maintain the proper attitude.

While evaluating pilot applicants on flight tests in straight and level flights, I have found the major deficiencies to be uncoordinated corrections such as making changes for heading with rudder alone; gaining or losing altitude, especially when the applicant's attention is diverted; flying with one wing low because the instructor has allowed the student to look out of only one side of the airplane or for the student to keep a heavy hand on the yoke. Other errors include rough use of controls and overcontrolling in rough air. In order to summarize straight and level flight, the following evaluative criteria is from the Flight Maneuvers Manual:

Evaluation -

- Fly a definite heading
- Maintain a definite altitude
- Use definite power setting and airspeed
- Trim for level flight
- Airplane should be guided, not flown
- For altitude deviations ± 100 feet correct with throttle
- In turbulence reduce to maneuvering speed

Note: Use left hand on yoke, controlling yoke with thumb and two fingers. Make tiny corrections.

In a previous article I referred to climbs established after takeoff which result in VY - the best rate of climb, VX - the best angle of climb, the normal climb and the manufacturer's recommended cruise climb speeds. The **best rate of climb** is used to gain the maximum amount of altitude in a minimum amount of time or about 50 percent above stall speed. The **best angle of climb** will provide the maximum gain in altitude for the least horizontal distance traveled. In other words, it is at maximum power and at an angle of attack which will give the steepest path with reference to the ground. It is accomplished at approximately 25 percent above normal stall speed. **Normal climbs** are about 5 to 10 knots faster than the best rate of climb (see manufacturer's recs). Cruise climbs are about 20 knots higher than Vy or the best rate of climb.

The climb, in flight, is entered from straight and level flight to a climb attitude. First of all it is important to establish a correct climb attitude. Physical references outside of the airplane need to be related to the natural horizon. Once the approximate flight attitude is learned for a normal climb, it will be easy to maintain the correct airspeed to maintain the desired climb attitude. The illustration (Figure 5) shows the few simple steps necessary to enter a normal climb.

As stated in the Flight Maneuvers Manual, to enter the climb apply back elevator pressure to establish the proper pitch attitude. Next, increase power to the recommended climb power setting. After climb speed and attitude are attained trim out the back pressure. While the pitch attitude increases and as the airspeed decreases, progressively more right rudder pressure must be used to correct for P-factor and torque. Rudder will be important here for directional control.

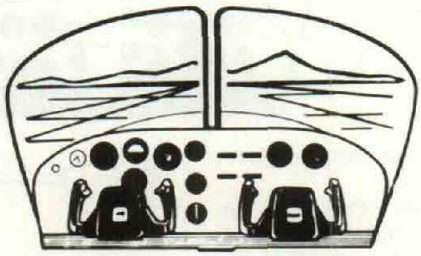
During the climb listen to both airframe and engine

CLIMB (NORMAL)

ENTRY

- From straight and level cruising flight. Normal lift and angle of attack. To climb attitude.

(Vx Best Angle—60 knots)
(Vy Best Rate—70 knots)
(Cruise Climb—80 knots)
See Mfr.'s Recs.



To increase lift:
- Apply back pressure to raise nose to pitch attitude to correspond to climb airspeed.

- Back pressure with yoke (elevators) increases angle of attack.

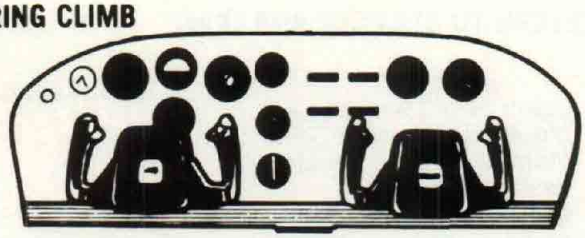
After climb speed and attitude are attained apply full climb power and trim out back pressure.

Trim tab

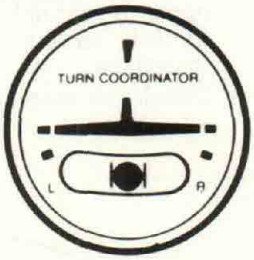
- Bank shallow through medium bank.

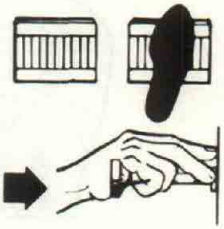
Fig. 5

DURING CLIMB



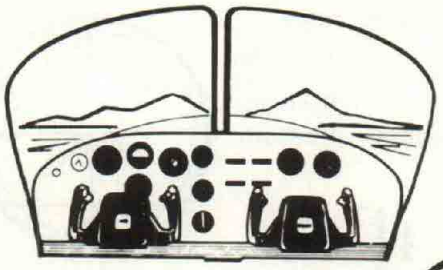
- Check instruments.
- Check turn and slip indicator for P factor effect.
- Correct airspeed (consult owner's manual).
- Normal lift-climb.
- Normal angle of attack for climb.
- Use right rudder to correct for torque.





- Trim airplane to stabilize climb.

Airplane's ability to climb is affected by power available above that required for straight and level flight.



- Yoke (ailerons) in neutral position.
- For proper climb attitude check position of nose on horizon.
- Check attitude indicator.
- Check rate of climb and altimeter.

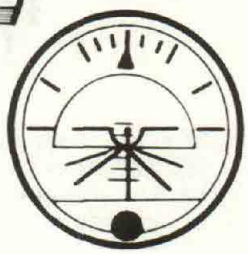


Fig. 6

sounds and note the position of the nose in relation to the horizon. The pilot should also cross-check the airspeed indicator as well as the attitude indicator to determine if the pitch attitude is correct. (Figure 6)

A constant heading should be maintained with the wings level. An exercise that I use with my students in the climb is to have them vary the airspeed. First, I'll have them raise the nose and decrease airspeed by 10 knots and then lower the nose and increase the speed by 10 knots. There will be a straight perceptible change in sound levels. I'll also point out a perceptible lag in the airspeed or what appears to be so. There may be some lag in airspeed, however, most of the lag is produced by the time it takes for the airplane to accelerate to the different airspeed as the attitude is changed. This same exercise can be performed in a gliding attitude.

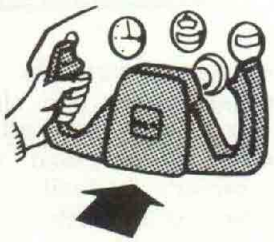
To return to straight and level flight (Figure 7) from a climbing attitude, start to lower the nose to a level position approximately 50 feet below the desired altitude. After the nose has been lowered, gradually check the outside horizon for level attitude. The wings should be level. Next, the climb power should be retained allowing the airplane to accelerate to the desired cruise airspeed. Now, reduce power to the cruise power setting and the next move is to trim the aircraft for level flight - "hands off". Climbing turns should also be practiced using 20 to 30 degrees of bank.

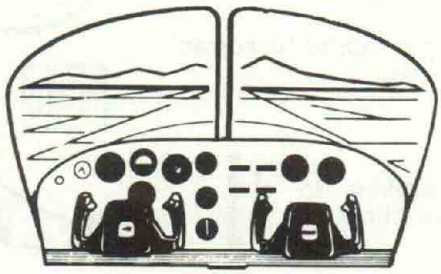
Another maneuver which is started from a level flight attitude is the normal glide. It is a basic maneuver in which the airplane is losing altitude in a controlled descent with little or no engine power. The glide can be related to power-off landings, normal approaches and to forced landings. Various descents can be confusing to pilots. There is a power-off descent and a power-on descent. Another factor is flap settings. When I first learned to fly in Aeroncas and Cubs, we were not concerned about flap settings and we established the glide with power at idle. Today, we perform glides at various flap and power settings. There is a best glide speed for each make and model. This speed, whether we refer to it as best angle of glide,

RETURN TO STRAIGHT AND LEVEL

- Lower nose (decrease angle of elevators) to level flight attitude 50 ft. below desired altitude.

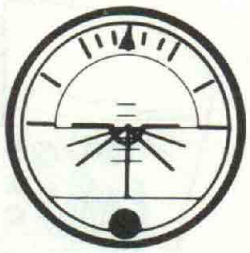
  Optional — Overshoot altitude by 50 ft. and lower nose to normal cruising attitude as the airspeed increases.
- Check the altimeter.





• Check outside horizon for level flight attitude.

- Check attitude indicator.
- Reduce power to cruising (after airspeed nears cruising speed), e.g., 100 knots.
- Relieve control pressure (trim).



• Trim last.

- Practice climbing turns both left and right (20° to 30° of bank). Loss of lift will result in climbing turns.

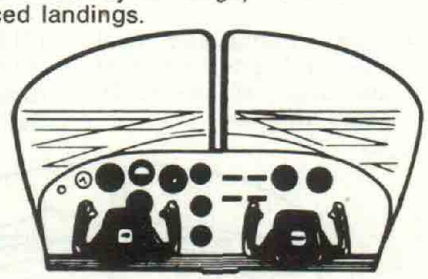
Fig. 7

NORMAL GLIDES
(STRAIGHT DESCENTS)

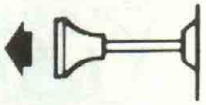
Related to power-off accuracy landings, normal approaches and forced landings.

ENTRY

To start glide—transition from level cruising flight to descent.

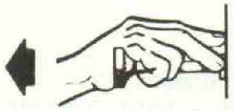


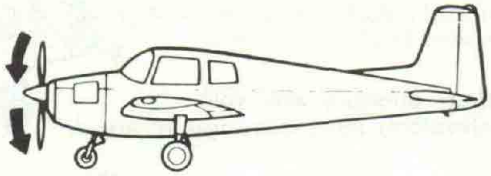
Carburetor heat "on" before closing throttle.



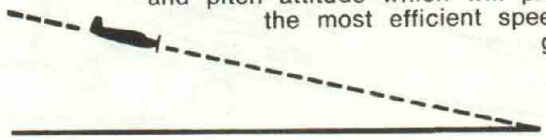
Reduce power. The rate of descent is determined by amount of power reduction.

Hold back pressure on wheel to hold normal glide attitude, until best glide speed.

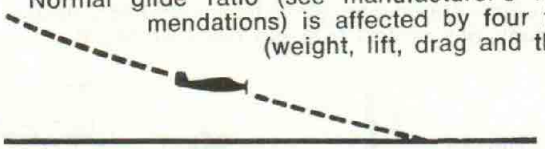




Establish and maintain the proper configuration and pitch attitude which will produce the most efficient speed for glides.



Normal glide ratio (see manufacturer's recommendations) is affected by four forces (weight, lift, drag and thrust).



Don't stretch your glide — glide ratio suffers. Check for too slow glide speed by use of elevator or applying power.

Fig. 8

Vmin, drag or usually, it is about the same as Vy or the best rate of climb speed. It is the airspeed that will give us the best glide distance over the ground for your altitude. Let's say, if your airplane travels 5,000 feet forward while descending 500 feet, its glide ratio is 10 to 1. This is only an estimate for each airplane.

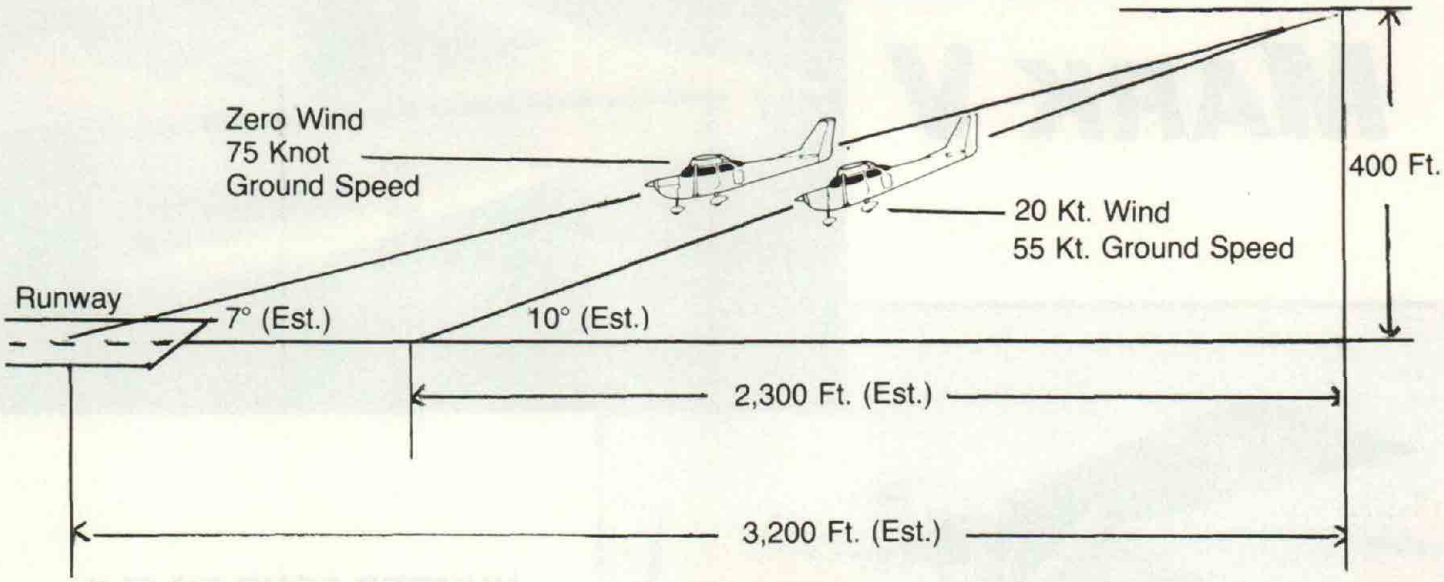
Earlier in this article I referred to the four fundamental forces that act on any airplane - weight, lift, drag and thrust. If all of these factors are constant, the best glide performance - the greatest distance forward per unit of height loss, occurs when the airplane is flown at its best lift/drag ratio angle of attack. For most aircraft, including my Cessna 172, we are talking about an angle of about 4 to 6 degrees which is an estimate without an angle-of-attack indicator. Our owner's manual will provide us with the best glide speed. It is important, in order to achieve a maximum glide ratio, to keep all of the forces constant.

There is only one airspeed for best glide performance. Any attempt to glide at a higher speed, or trying to stretch the glide and reducing airspeed, will cause the rate of sink to increase in relation to forward speed. It is not often realized that a small change in the angle of attack will affect the lift/drag ratio substantially. By disturbing that ratio by increasing or decreasing airspeed above or below the best angle of glide airspeed will affect the lift/drag ratio which will materially affect gliding distance. In other words even a small change in the glide angle of attack will reduce the gliding distance. When we are talking about forced landings, we need to relate flight path distances to ground distances. Too much or too little airspeed will have a significant effect on gliding distance. Wind is another important additional factor which can greatly affect gliding distance - the stronger the headwind, the shorter the gliding distance. In turbulent wind conditions, or when the effects of wind gradient are anticipated, it will be necessary to increase the gliding speed by 5-10 knots depending on wind speed and then an allowance needs to be made for the reduction in gliding distance. Remember that any attempt to depart from the best angle of glide speed will result in a reduction in gliding distance meaning a steeper glide path (see Figure 8).

Let's say we have just completed our turn from base to

Figure 9

Effects Of Wind On Optimum Glide Path Angle



final and we began to encounter a headwind of 20 knots. We can be grateful for having picked a spot for landing farther up the runway. We have already mentioned that wind has a marked effect on glide ratio. The main reason for this is because ground speed is reduced (see Figure 9).

A sport aviator will probably talk about the glide as a power-off descent, whereas another pilot flying a Piper Warrior or a Cessna 172 would most likely talk about a partial power glide at a specified flap setting. Let's face it, in today's traffic most of our approaches at busy airports are not of the power-off variety; instead, they are performed under partial power conditions. The result is a longer glide, more time to look for other aircraft plus better engine cooling. Today we are more apt to listen for engine sounds during glides rather than the exciting sounds experienced by the sport aviator listening to the wind rushing past his open canopy and the guide wires during the glide.

The major purpose of this article on basic maneuvers was to provide a short review of flight fundamentals most of us probably learned years ago. However, during any proficiency check or BFR the check pilot will, no doubt, evaluate all of the basic maneuvers included in this article. Hopefully, a few of the ideas and basic theories will help you on your next check ride.

References:

1. Talay, T. A., **Introduction to the Aerodynamics of Flight,** Langley Research Center, NASA, Washington, DC 1980, pp 23-24.

2. Federal Aviation Administration, Flight Training Handbook (AC 61-21A* U. S. Dept. of Transportation, Flight Standards Service, Washington, DC 1980, pp 60-66.

SOMETHING NEW IN AEROBATIC FLIGHT

by Gene Chase

Duane Cole, the master aerobatic instructor and air show performer has created a new training tool in the form of a video tape for video cassette players entitled FLIGHT AROUND THE AXES. With a camera mounted at student's eye level in the front seat of his Decathalon, Duane narrates as he flies through aerobatic maneuvers including the spin, loop, immelman, hammerhead, Cuban eight, knife edge, half roll, two point roll, slow roll, reverse Cuban eight, barrel roll and snap roll.

With the camera re-positioned, the sequences were taped looking out the side window. The maneuvers were also filmed from the ground giving the student a complete look at this basic series of aerobatics.

The filming was done by F&F Productions of St. Petersburg, Florida, the foremost independent producer of sport shows in America. The site was Pilot Country Airport, 25 miles north of Tampa where Duane flew the sequence at low altitude for improved ground reference for students. He is quick to point out the film is not an endorsement of low altitude aerobatics.

The tape is not only an excellent educational device, but also is entertaining and all pilots concerned with precision flight should find it most useful. Students taking aerobatic dual should benefit by studying the film because it most assuredly will result in fewer hours in the air to learn these basic maneuvers.

FLIGHT AROUND THE AXES is available in VHS or Beta, and both MasterCard and Visa cards are accepted. The cost is $199.00 postpaid from:

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Burleson, TX 76028
817/295-4582