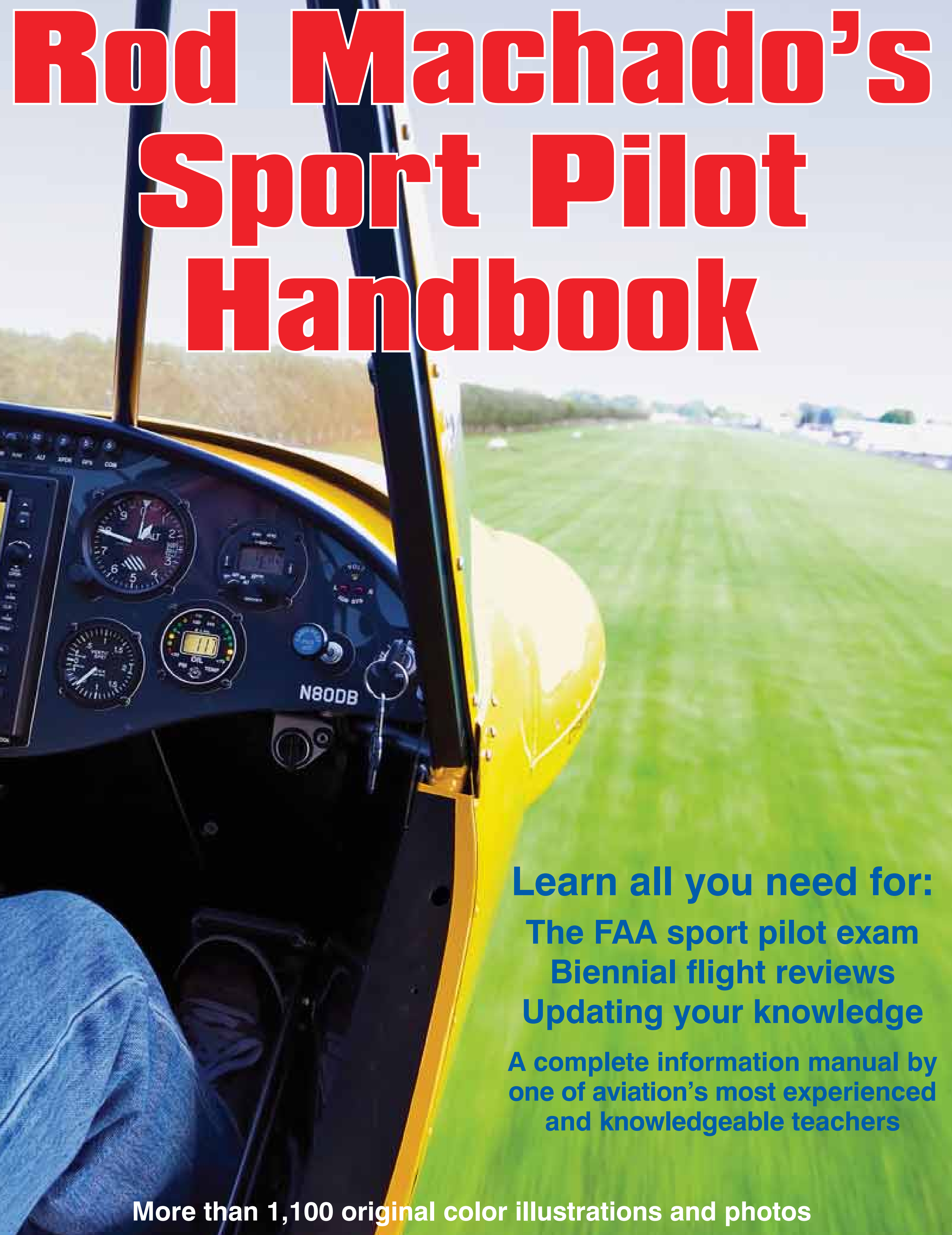
Rod Machado's Sport Pilot Handbook



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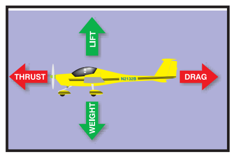
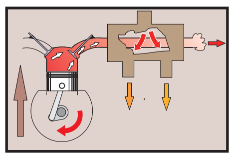
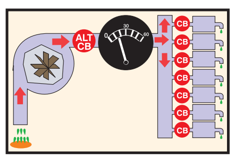
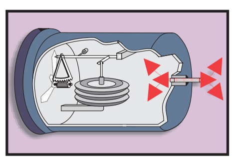
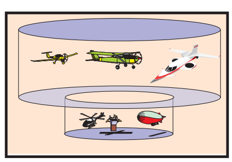
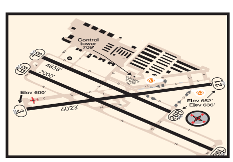


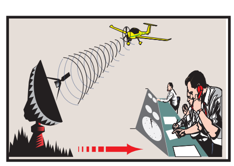


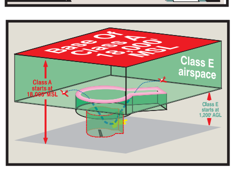


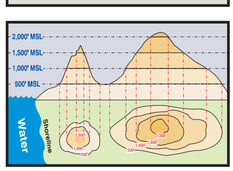


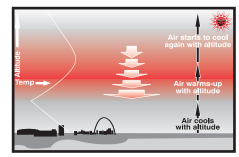


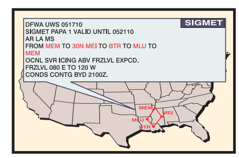


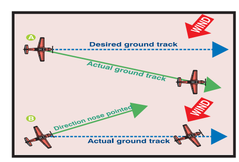


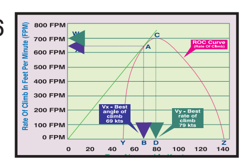


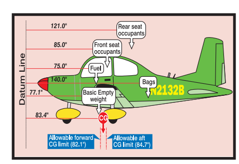


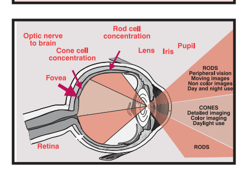












While ailerons change the wing's lift, they also change its drag, and the change in drag is different for each wing. This results in the airplane's nose yawing in a direction opposite the direction of turn. Right turn, left yaw. This is referred to as *adverse yaw*, since it tries to turn the airplane opposite the direction the pilot intended to turn.

Adverse Yaw

A few old sayings are still floating around that I'd like to revise. For instance, "The pen is mightier than the sword." This is true unless you're one-on-one with a modern incarnation of Zorro. A wonderful saying I wouldn't care to upend is, "You can't get something for nothing." It sure works that way in aviation. When an airfoil develops lift, it's always paid for by an increase in drag. The lift produced by the aileron is no different.

Downward moving ailerons create more lift and thus more drag (Figure 50). This results in *adverse yaw*. For instance, in a right turn, the downward moving aileron on the left wing creates more drag than the upward moving aileron on the right wing as shown in Figure 53A, and the airplane yaws (turns) to the left. A similar and opposite effect occurs with a left control wheel deflection (Figure 53B).

ADVERSE YAW

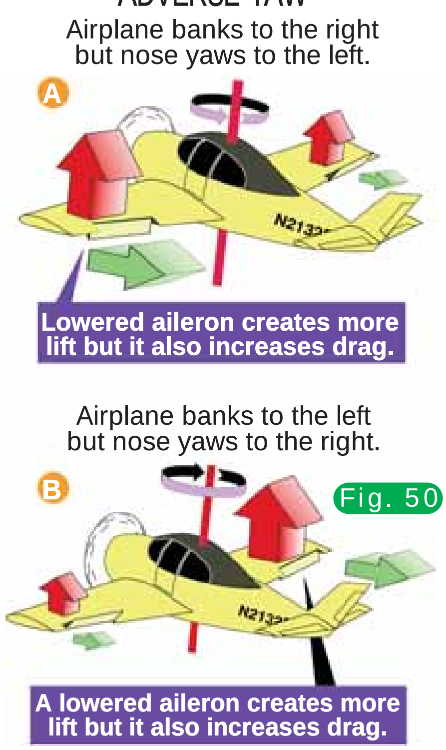


Fig. 50

Fig. 51

Fig. 52

Adverse yaw presents a problem. You can't have the nose yawing or pointing in a different direction than you bank. Fortunately, airplanes have a control surface designed to correct for adverse yaw. It's called a rudder and is shown in Figure 51.

Rudders

The rudder's purpose is to keep the airplane's nose pointed in the direction of turn—not to turn the airplane! Remember, airplanes turn by banking. Rudder simply corrects for adverse yaw and keeps the nose pointing in the direction of turn. Think of a rudder as a vertical aileron located on the tail of the airplane. A right or left deflection of the rudder foot pedals located on the cockpit floor (Figure 52) changes the vertical stabilizer's angle of attack and yaws the airplane about its vertical axis. This yawing motion keeps the airplane's nose pointed in the direction of turn.

Applying right rudder pedal, as shown by Airplane A in Figure 53, forces the tail assembly to swing in the direction of lower pressure. As the tail moves, the airplane rotates

HOW RUDDER COMPENSATES FOR ADVERSE YAW

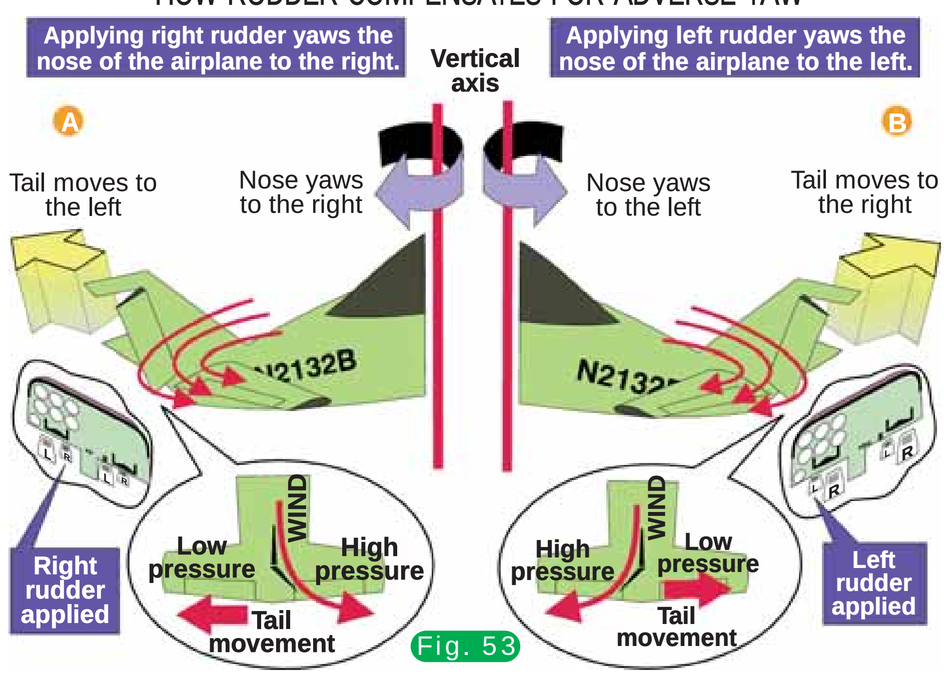


Fig. 53

THE TURN COORDINATOR

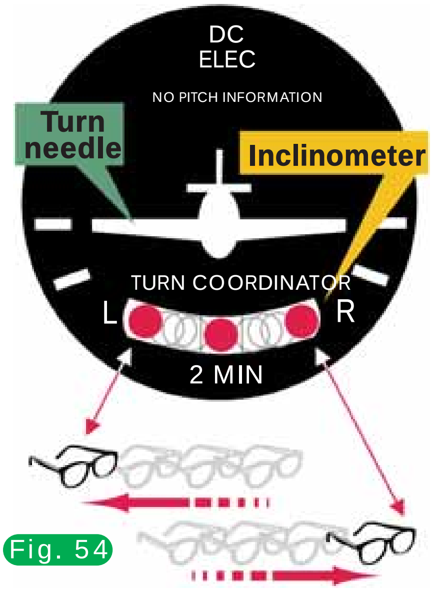


Fig. 54

The movement of the ball corresponds to the movement of the sunglasses on your car's dashboard. The same force that moves the glasses also moves the ball. The ball, however, slides more easily than the glasses. The ball's deflection from center identifies when the airplane's nose is pointed other than in the direction of turn. Rudder is used to move the ball back to the centered position.

about its vertical axis. Application of right rudder pedal yaws the nose to the right. Applying left rudder pedal (I'll just say *rudder* from now on), shown by Airplane B, yaws the nose to the left (surprising, huh?).

When should you use the rudder? Any time you turn the airplane. If you don't use rudder while trying to turn, part of the airplane is going one way, and another part points in the opposite direction. This is not a pretty sight, and your instructor's eyebrows will raise so high that they will scratch his or her back. Right turn, right rudder. Left turn, left rudder. Feet and hands move together.

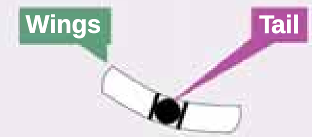
Now the question foremost in your upper brain is "How much rudder is enough?" Good question. Figure 54 shows an inclinometer, also known as *the ball*, as a part of another instrument called the *turn coordinator* (located on the instrument panel).

The little white airplane in the turn coordinator shows the direction of turn, while the ball tells you if the proper amount of rudder is applied. The ball is free to roll right or left within the glass tube. Any inappropriate rudder use (or lack of use) applies an unnecessary side force to the airplane. This deflects the ball in much the same way sunglasses scoot across your car's dash when rounding a sharp corner. Your job is to keep the ball centered by using the rudder.

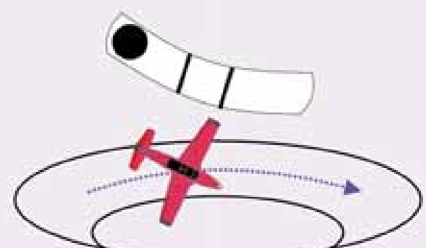
Figure 55 shows an airplane in a turn. Airplane A's nose is pointed outside the turn (probably because of insufficient right rudder or too much

SLIPS & SKIDS MADE EASY

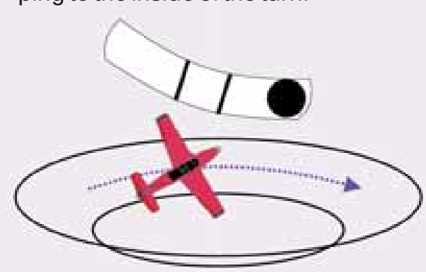
An easy way to understand slips or skids is to think of the ball as the tail and the glass tube at the wings of the airplane. (Right turn shown.)



In a right turn, if the ball (tail) is to the left of center, this implies the tail is skidding to the outside of the turn.



In a right turn, if the ball (tail) is to the right of center, this implies the tail is slipping to the inside of the turn.



AN EASY WAY TO UNDERSTAND SLIPPING & SKIDDING IN AN AIRPLANE

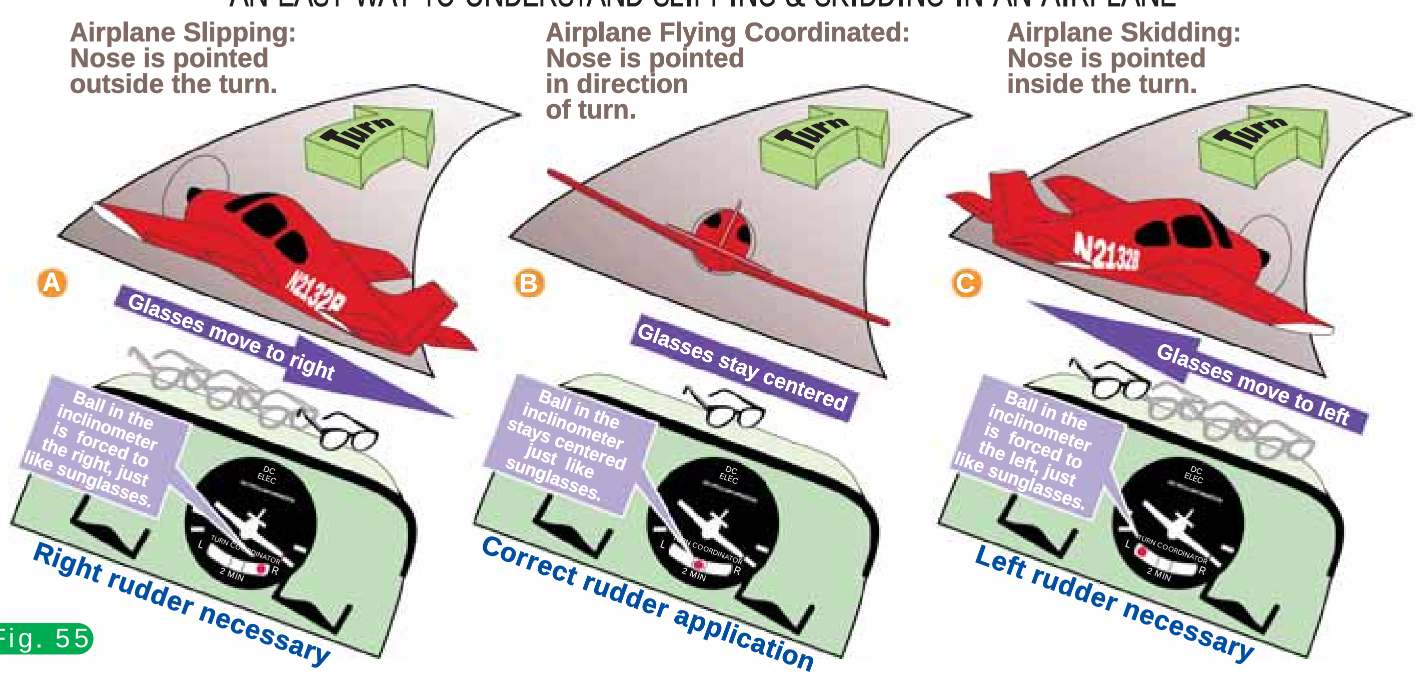


Fig. 55

right aileron is applied). The ball and the airplane slip to the right, toward the inside of the turn. In other words, you need to point the nose slightly to the right for a precisely aligned turn. By adding enough right rudder to align the airplane in the direction it's turning, the ball returns to the center as shown by Airplane B.

Airplane C's nose points toward the inside of the turn (probably because too much right rudder is applied or insufficient right aileron is used.) The ball and the airplane skid to the left, toward the outside of the turn. Adding a little left rudder keeps the nose pointed in the direction the airplane's turning and centers the ball.

Simply stated, if the ball is deflected to the right or left of center, add enough right or left rudder to center the ball. Sometimes you'll hear your instructor say, "Step on the ball!" This is simply your instructor's way of telling you to add right rudder for a right-deflected ball and left rudder for a left-deflected ball. Don't even think about placing your foot on the turn coordinator, or your instructor will question you about your SAT scores. Don't put marbles in your shoes either.

When entering a turn, aileron and rudder are applied simultaneously, in the same direction. This is what pilots mean when they refer to flying coordinated. Aileron establishes the degree of bank and rudder keeps the nose pointed in the direction of turn. If the ball is centered during this process, we say that the controls are properly coordinated.

One last point about the rudder. It is the last control forfeited in a stall. Even when the airplane is stalled, it continues to move forward with airflow over its surface. This allows some degree of rudder authority even at very slow speeds. During a stall you'll find that the rudder is very effective for maintaining directional control. In a spin, the rudder is very important for spin recovery. More on spins in Postflight Briefing #2-1.

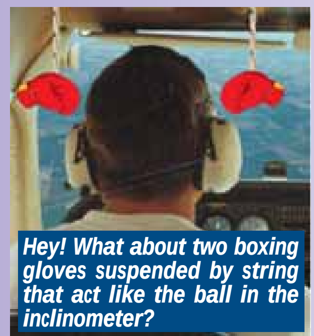
Elevator

The elevator is the moveable horizontal surface at the rear of the airplane. Its purpose is to pitch the airplane's nose up or down.

The elevator control works on the same aerodynamic principle as the rudder and aileron. Applying back pressure on the control wheel of Airplane A in Figure 56 deflects the elevator surface upward. Lower pressure is created on the underside of the tail which moves it downward, and the nose of the airplane pitches up.

Coordination Lube

Devious Instructor Device



Hey! What about two boxing gloves suspended by string that act like the ball in the inclinometer?

It won't take long before you won't need to look at the ball in the inclinometer to know whether or not you're flying coordinated. With a little practice you'll be able to fly by the seat of your pants (assuming you wear pants while flying). Pressure on the right or left side of your derriere is caused by the same force that moves the ball to the right or the left. It doesn't matter how big the airplane is; a 747 or a Cessna Skycatcher Land-o-matic can be flown by the seat of the pants. Use the inclinometer as sort of a biofeedback device cuing you to sense pressure on your derriere when the ball is deflected. And don't feel bad if it takes a little practice to get used to coordinating rudder and ailerons. My first instructor told me that even if they put cold Vaseline in the inclinometer (instead of mineral oil), I would still get the ball to bang back and forth against the ends of the glass.

HOW THE ELEVATOR CONTROL CHANGES THE AIRPLANE'S PITCH

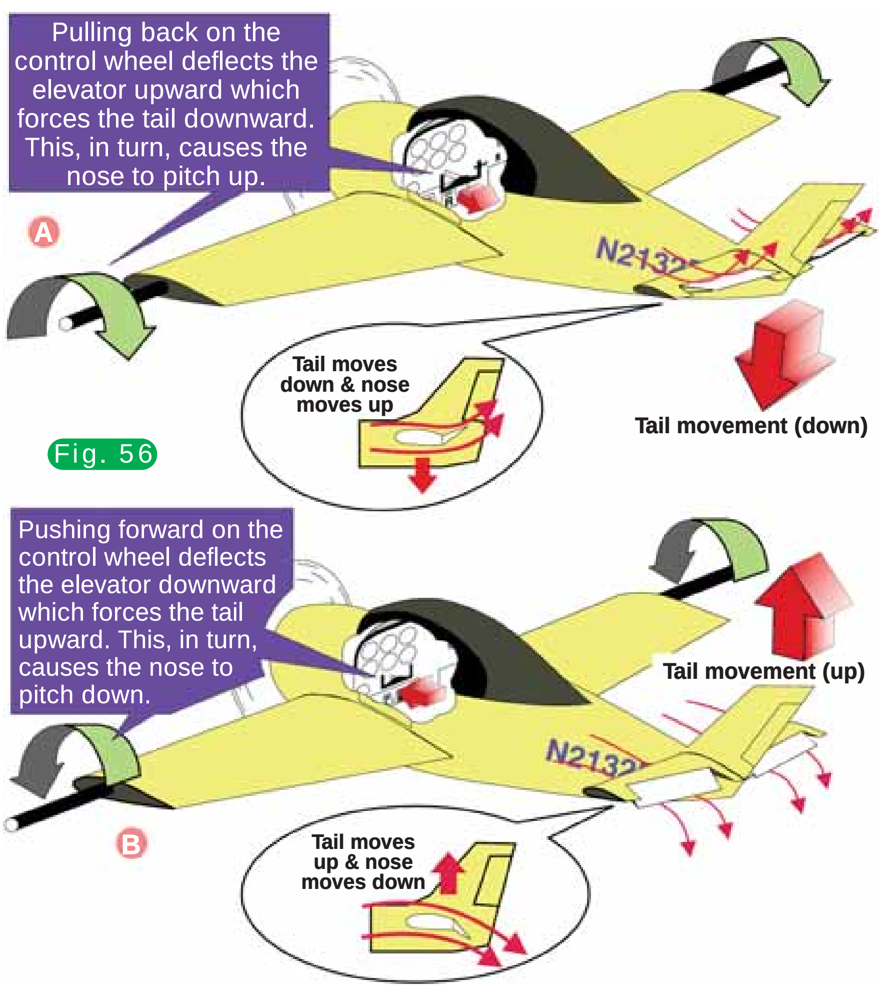


Fig. 56

Some elevator trim tabs are a single tab on one side of the elevator. Fig. 57A

Another version of the trim tab is a single tab spanning the stabilator. Fig. 57B

Fig. 57C

Airplane B shows what happens when the control wheel is moved forward. The elevator surface moves down creating lower pressure on the top side of the tail.

This causes the tail to rise. The nose rotates about the lateral axis in a downward direction. Simply stated, to pitch up, pull the control wheel back; to pitch down, move the control wheel forward.

Trim Tabs

If you had to apply continuous pressure on the control wheel to maintain pitch attitude, your arms would tire quickly (Schwarzenegger would be proud of you but I wouldn't). Fortunately, airplanes have something known as a *trim tab* to take the pressure off the control wheel (and off the pilot!).

A trim tab is a small, moveable surface attached to the main surface you want to control (in this case, it's the elevator. Ailerons and rudder can have trim tabs too). Figures 57A, 57B and 57C show two different types of trim tabs and the trim wheel used to change the trim tab's position (the wheel is usually located between the two front seats or the lower portion of the instrument panel).

Moving the trim tab creates a slight pressure difference on the very end of the control surface to which it's attached (Figure 58). Just enough pressure is created to keep the primary control surface in the desired position without having to hold the control wheel in place. Notice that the trim tab moves in a direction opposite to the primary control surface it affects. If you want the elevator to deflect upward (as if you're pulling back on the wheel in a climb), the trim tab must move down as shown by Elevator A. To maintain a downward deflection of the elevator (as if you're in a descent), the trim tab must move upward as shown by Elevator B.

Using elevator trim is quite simple. Select the attitude desired with the elevator, then rotate the trim wheel (up or down) to take the pressure off the control wheel. How do you know which way to twist the trim wheel? Most trim wheels say *nose down* or *nose up* above or below the wheel. Simply twist the wheel in the direction you want the nose to stay. Aileron and rudder trim are equally simple to use.

When flying with other pilots, accept the fact that they won't like the way you trimmed the airplane. You might have flown the last 200 miles without touching the plane. Hand it over to the other person and the first thing he or she does is start fiddling with the trim. I can only conclude that this action is a form of primitive territorial claim. It's annoying, but it's better than how wild animals claim their territory isn't it?

HOW ELEVATOR TRIM WORKS

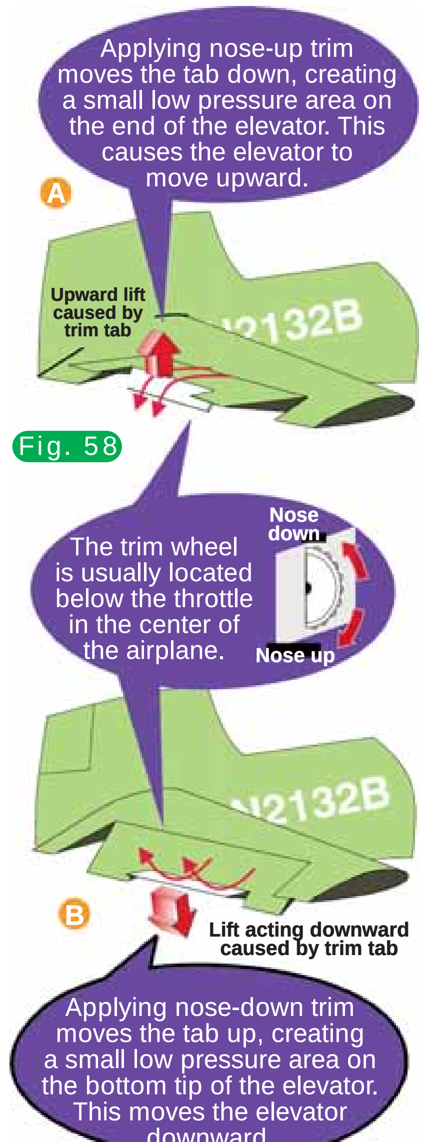


Fig. 58

Postflight Briefing #3-1

THE ROTAX 912 ENGINE

If you hear the word "Rotax" and immediately think of someone from the Klingon empire, you're not alone. There is, however, nothing that's otherworldly about the Rotax engine's clean design and practical utility for today's modern airplanes (Figure 50).

Fig. 50

Rotax began building four stroke piston aircraft engines in 1982. Since then they've provided light weight and compact engines that have found a welcome home in the light sport airplane (LSA) market. These four stroke, four cylinder, horizontally opposed engines operate with an internal gearbox system that allows high engine RPM to be geared down for propellers that operate more efficiently at slower RPMs. Let's poke around a bit to better understand how these engines operate and how to better operate them.

There are two basic Rotax models that you're likely to encounter in the LSA market: the *912* and the *912S*. The 912 produces 81 HP and runs on 87 octane autogas as well as 100 LL (low lead) aviation gasoline (AVGAS). The 912S produces 100 HP and requires a minimum of 91 octane autogas or 100LL AVGAS. (There is also a 914 model that's turbocharged but these are not used in the LSA market so we won't discuss them here.)

The 912 and the 921S both come in two separate versions. The first is an FAA Part 33 certified engine found on airplanes with standard airworthiness certificates. These engines are identified as 912F or 912SF. The non-certified versions of these engines are ASTM (at one time this meant *American Society for Testing Materials*) compliant and are found in your typical LSA. These engines are identified as 912UL or 912ULS.

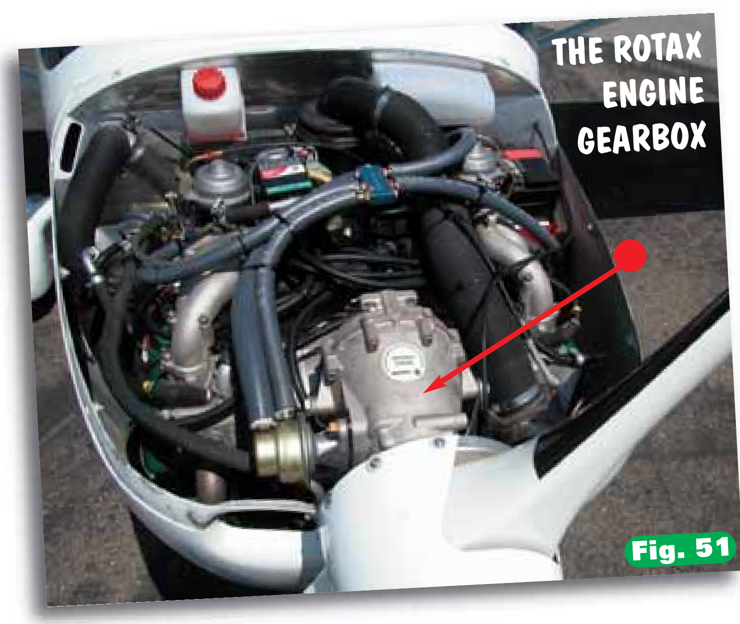


Fig. 51

The Internal Gearbox

Starting right up front behind the propeller of your typical Rotax 912 is the reduction gearbox (Figure 51). One of the great features of the Rotax engine is its ability to generate a great deal of horsepower despite its light weight. This is partially accomplished by having the engine run at RPMs that are typically much higher than the average airplane engine runs.

For example, one very popular airplane engine is the Continental O-200. This engine weighs in at approximately 170 pounds and produces 100 HP at approximately 2,500 RPM. The Rotax 912S, on the other hand, weighs in at 132 pounds, but produces 100 HP at 5,800 (engine) RPM. By reducing the weight by 23% and doubling the engine RPM, Rotax was able to generate the same amount of horsepower. Clearly, a reduction of engine weight allowed the development of reliable, safe light sport airplanes.

But how does higher RPM produce more horsepower? Think about it this way. If the crankshaft turns faster, then there's more rotational energy stored in this rotating assembly of moving parts. Rotate the crankshaft of the Rotax 912 to 5,800 RPM and the engine produces 80 HP. That's a lot of energy that the propeller can use to pull or push the airplane through the air. The only problem is that we can't run your typical airplane propeller at these high RPMs because of propeller inefficiency issues. Don't like the sound of that? That's understandable because the "sound" of that

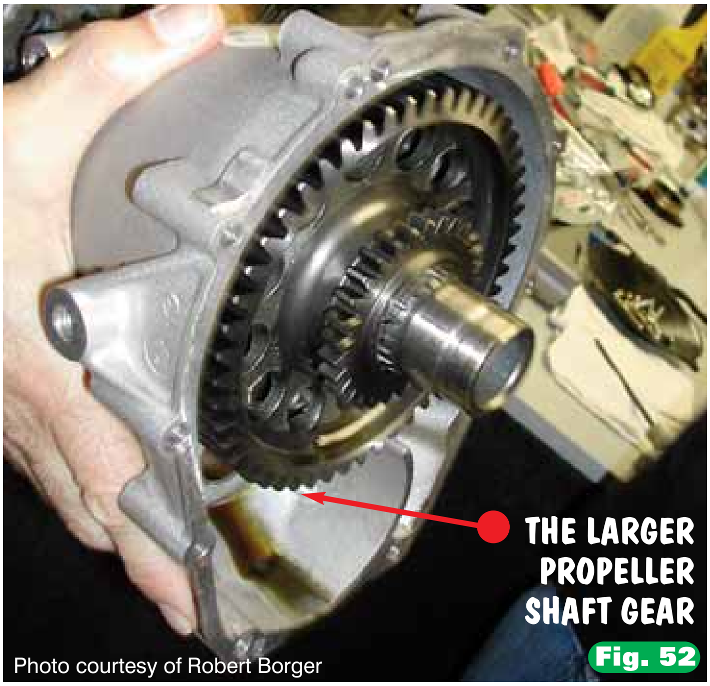


Photo courtesy of Robert Borger
Fig. 52

would be a propeller tip breaking the speed of sound because it's rotating at speeds close to 5,800 RPM. That would make all kinds of noise that irritates our neighbors around the airport. I'm speaking of those with hearing that so sensitive it would make a bat jealous. It turns out that most airplane propellers run efficiently at lower RPMs—generally below 2,700 RPM—where their blade tips stay below the speed of sound. Thus Rotax engine gearing (Figures 52 and 53) gives you the best of both worlds (no, not earth and the Klingon home world) with higher horsepower and good thrust production.

Both certified and non-certified Rotax engines on LSAs have something known as an overload clutch in the gearbox. Technically speaking, the Rotax gearbox is the spur type, with a dog axial shock absorber and an overload clutch that's optional. Now that sounds like something a guy would say if he were trying to impress girl, doesn't it?

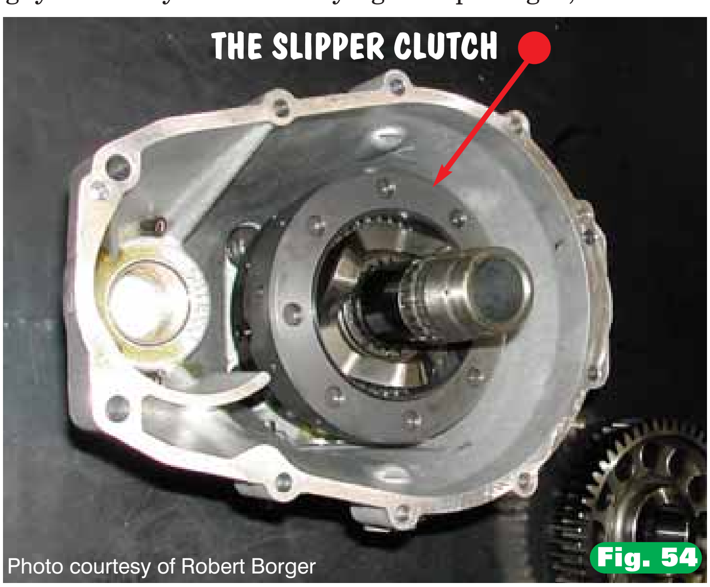


Photo courtesy of Robert Borger
Fig. 54

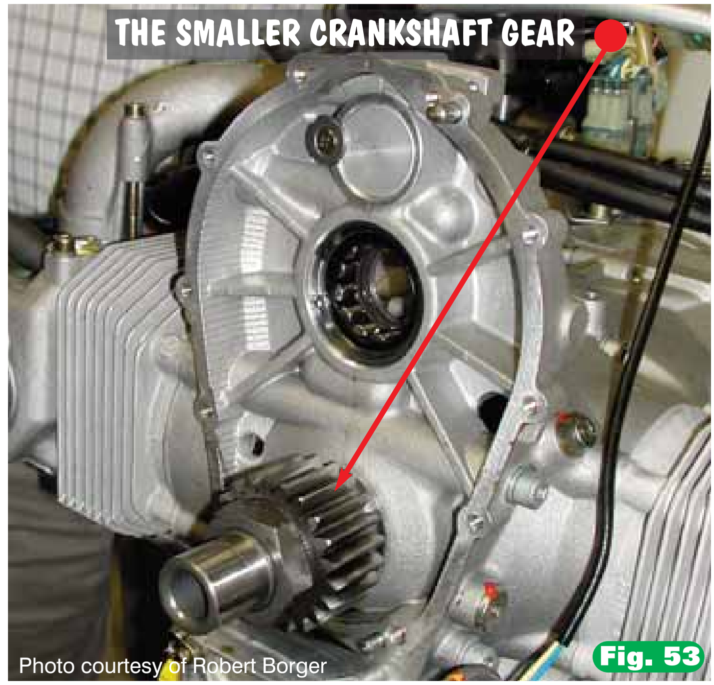


Photo courtesy of Robert Borger
Fig. 53

What this means is that the gears in the gearbox have straight teeth (spur gears) that mesh with one another (dog gearing), with a small crankshaft gear (Figure 53) turning a larger propeller shaft gear (Figure 52), thus, reducing the prop speed. If, for some reason the propeller stopped suddenly (i.e., because of a ground/object strike), then the slipper clutch (Figure 54) would absorb some of that energy in the plane of propeller rotation. Figure 55A is the extracted slipper clutch. Figure 55B is the slipper clutch with the dog gear (Figure 55C) removed (the dog gear connects to backside of the large propeller shaft gear shown in Figure 52. Figure 55D shows the slipping plates extracted from inside the slipper clutch. These are the slipping plates that allow the engine to suffer less damage in the event of a sudden stoppage of the propeller. Whew! You made it. I almost ran out of fuel in that discussion. Speaking of fuel, let's speak about it.

Photos courtesy of Robert Borger
Fig. 55

The Fuel System

To the right of the internal gearbox is the mechanical fuel pump (Figure 56). This pump is turned by the engine and draws fuel from the airplane's main fuel tank. Between this fuel tank and the pump, there is a fuel shutoff valve, a line drain and a fine particle filter (Figure 57). In other words, a drawbridge, a trap door and armed guards. The fuel shutoff valve is used during engine maintenance or if you have an in-flight fire to prevent any fuel flow from the tanks. The line drain allows you to eliminate any water in the fuel lines. The fine particle filter stands guard to catch any solid contamination that might have found its way into the fuel lines. As fuel exits the mechanical pump, it's directed to two Bing, *constant velocity* carburetors (Figure 58). These carburetors automatically adjust the fuel-air mixture entering the engine, thus limiting the need for adjusting the mixture on most light sport airplanes.

Constant velocity (or depression-type) carburetors are a little different than typical carburetors. First of all, they're called "constant velocity" carburetors because they keep the air that flows past the fuel jet (Figure 59, position A) at a constantly high velocity, which helps mixture fuel and air together more efficiently than other carburetor types. How does this happen? Let's see.

Inside the constant velocity carburetor is a vertical sleeve that slides up or down within its chamber, thereby varying the size of the carburetor's throat (Figure 59, position B and C). This sleeve is located ahead (upwind) of the throttle butterfly valve shown at Figure 59, position D. (no, there's not an actual butterfly in there as far as we know). The butterfly valve is controlled by throttle position and regulates the amount of air entering the engine. The top of the hollow vertical sleeve on each carburetor is connected to a sealed diaphragm via a flexible membrane (Figure 59, position E) that splits the chamber in two (Figure 59, position G). Because of a hole in the bottom of that sleeve (Figure 59, position F), the air pressure above the diaphragm (Figure 59, position G) is at the same pressure as that found at the bottom of the sleeve (Figure 59, position H). When the throttle is opened slightly, air flows past the sleeve and is drawn into the engine. As the air flows past the sleeve it experiences that sleeve as a restriction. This causes the air to accelerate down the carburetor's throat because of something known as the *venturi effect*. The pressure within the sleeve as well as above the diaphragm now reduces slightly. Since the area directly below the diaphragm is vented to the outside atmosphere (Figure XX, position I), it has higher pressure pushing constantly upward on the underside of the diaphragm. As the pressure inside the sleeve and above the diaphragm decrease, higher outside atmospheric pressure pushes up on the diaphragm causing the sleeve to rise a little into its sleeve chamber (Figure 59, position C). As a result, the needle connected to the bottom of the sleeve lifts out of the main fuel port slightly (Figure 59, position J), thereby allowing fuel to

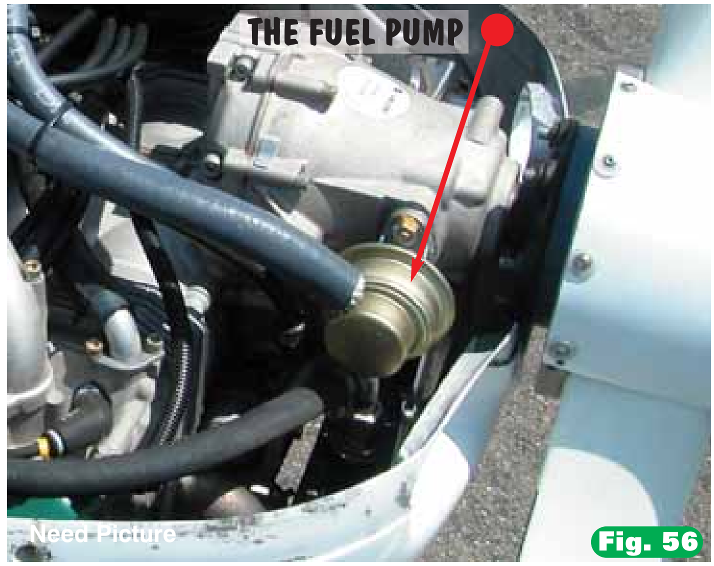


Fig. 56

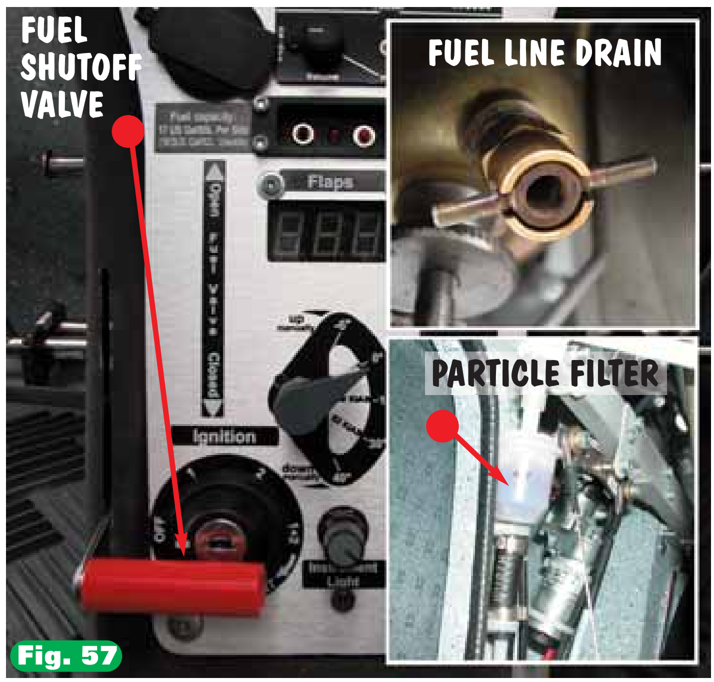


Fig. 57

Fig. 58

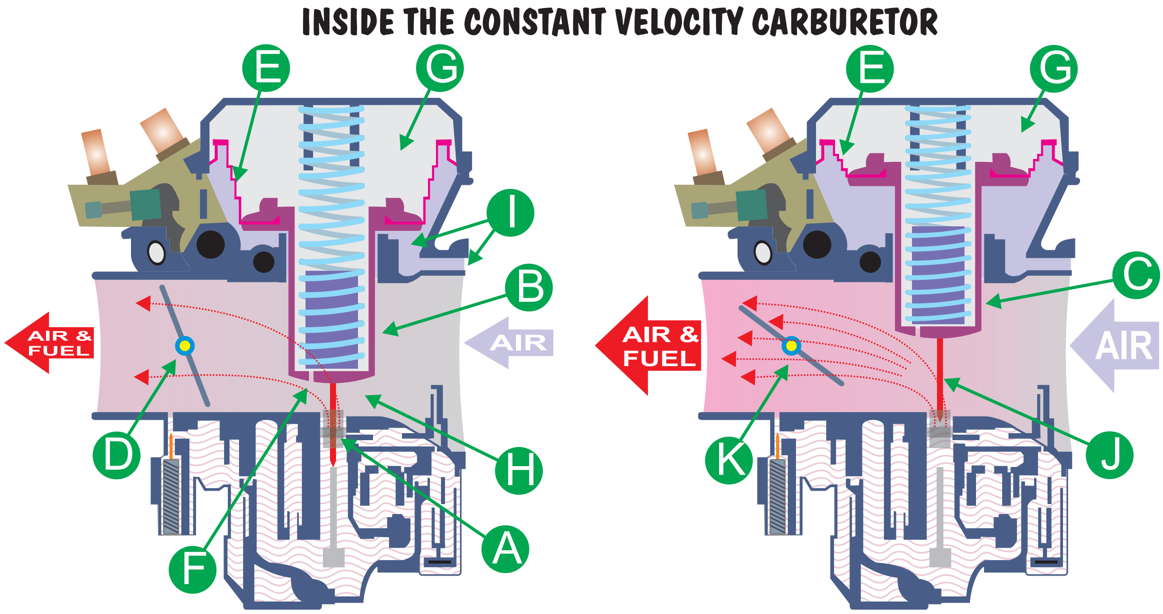


Fig. 59

flow past the throttle valve and into the engine. As the throttle is further opened (Figure 59, position K), the sleeve rises higher and more fuel ultimately enters the engine. The general idea is that there's a constant high velocity of air always flowing past the bottom of the sleeve to help mix the air and fuel together. Got that? If so, you'll definitely impress a girl (then again, you might impress her with the idea that she obtain a restraining order against you for talking like that).

Why use a CV type carburetor? One of the main reasons is that the venturi restriction made between the sleeve and the carburetor's throat provides for higher airstream velocities and much lower pressure in this location as a result. This allows for better engine acceleration since larger quantities of fuel are able to enter the engine as the throttle is opened. It also allows for better combustion since fuel and air are mixed more efficiently.

Since we've been talking about how the fuel moves through the system, you should know that your Rotax is somewhat like a vegetarian when it comes to the type of fuel it consumes. Vegetarians love diets of pigeon milk and wood chips, and your Rotax mostly loves low led fuel. Let's take a look a closer look the menu.

Fuel Considerations

The best fuel to use in your engine is automobile gas (Figure 60A) with a minimum octane rating of 87 or higher for the 912UL (81 HP), and 91 octane for the 921S (100 HP). Both engines can use 100LL AVGAS (Figure 60B) if autogas isn't available. Keep in mind, however, that low lead fuel contains about 18 times the lead found in automobile gas. This means that plug fouling and engine valve stress (caused by lead deposits on the valve seats in the combustion chamber) can be a concern (Figure 61). This is why some light sport airplane manufactures recommend the use of a mineral based engine oil or at least a semi-synthetic oil (not pure synthetic) when using 100LL. This type of oil helps scrub lead from the engine. Using higher power settings also helps reduce led deposits within the engine, too. There are also fuel and oil additives that can minimize lead deposits as per your airplane manufacture's recommendation.

On the other hand, 100LL AVGAS, as compared to autogas, is often an advantage when operating at higher altitudes because it's less likely to vaporize in the fuel lines (i.e., cause vapor lock) due to the lower pressures associated with higher altitudes. Once again, you must

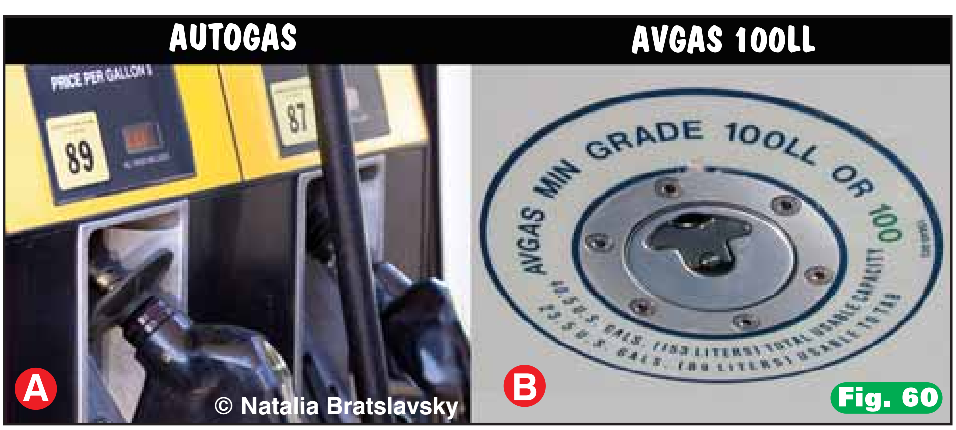


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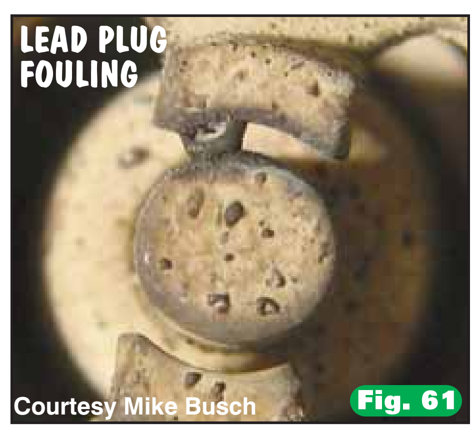
Fig. 60



Courtesy Mike Busch

Fig. 61

The Gyroscopic Instruments

The Attitude Indicator

The *attitude indicator* or *artificial horizon* is one of three gyroscopic instruments in the airplane. The other two are the heading indicator and the turn coordinator. The attitude indicator (Figure 37) is located in the top middle of the panel's six primary instruments (or in the background of the primary flight display). Consider this. If you acquired something important, like Leonardo da Vinci's "Mona Lisa" or its famed counterpart, the "Mona Larry," you'd put it on the wall for everyone would see. Well, that's why the attitude indicator is put smack in the middle of the instrument panel. You can safely assume it has considerable importance in order to merit such a position.

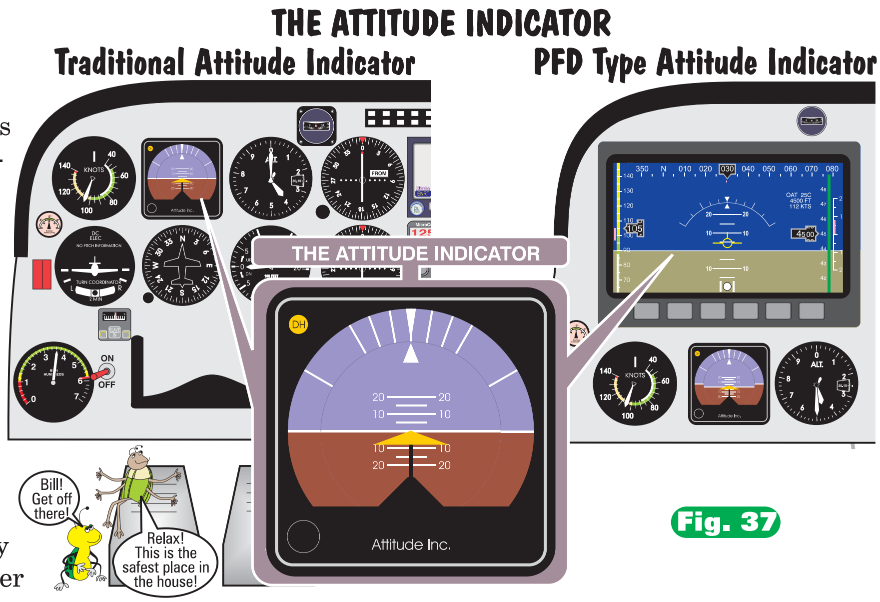


Fig. 37

The attitude indicator provides you with attitude information in much the same way the outside, visible horizon does. Attitude indicators become especially valuable when the outside horizon is no longer visible. Accidentally flying into the clouds, flying in very hazy conditions toward the sun or night flight over the desert are all conditions where the attitude indicator helps you determine the airplane's pitch and bank condition (the only thing the attitude indicator can't help you with is when rear seat passengers put their hands over your eyes and say, "Guess where?" This is why you carry fire extinguishers in the airplane—one warning shot and they always let go).

Figure 38 shows how the attitude indicator presents its pitch and bank information. The basis of this presentation is a symbolic set of airplane wings resting over a moveable horizon card. Painted directly onto the horizon card is a white horizon line, a light colored area above the line representing the sky and a darker colored area below representing the ground (Even in smoggy Los Angeles, these two colors shouldn't be reversed). Bank and pitch markings are also shown on the card.

The symbolic wings are attached to the instrument's case, while the horizon card is free to rotate underneath them. Because the horizon card is mechanically attached to a stabilized gyro, it essentially remains fixed in space while the airplane rotates about it during flight. This gives the impression the symbolic airplane wings are the things that move (they don't move since they're attached to the instrument's case which is bolted to the instrument panel).

Figure 39 shows a sequence of variable attitude conditions on the face of the attitude indicator. (Remember, in each case the airplane has pitched or rolled around the horizon card that's remaining stationary in space.) A straight and level pitch attitude is shown on attitude

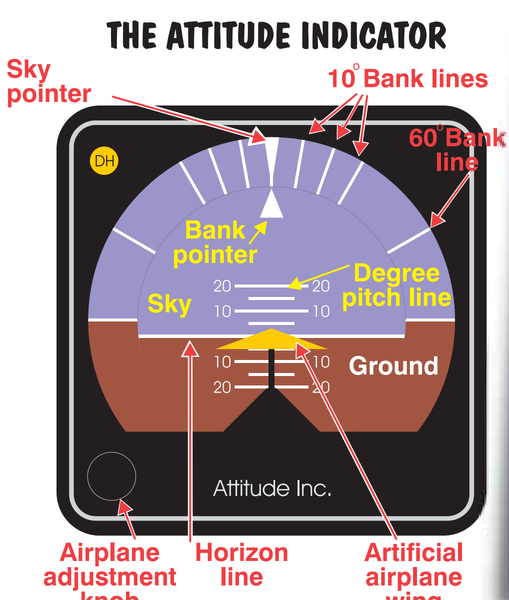
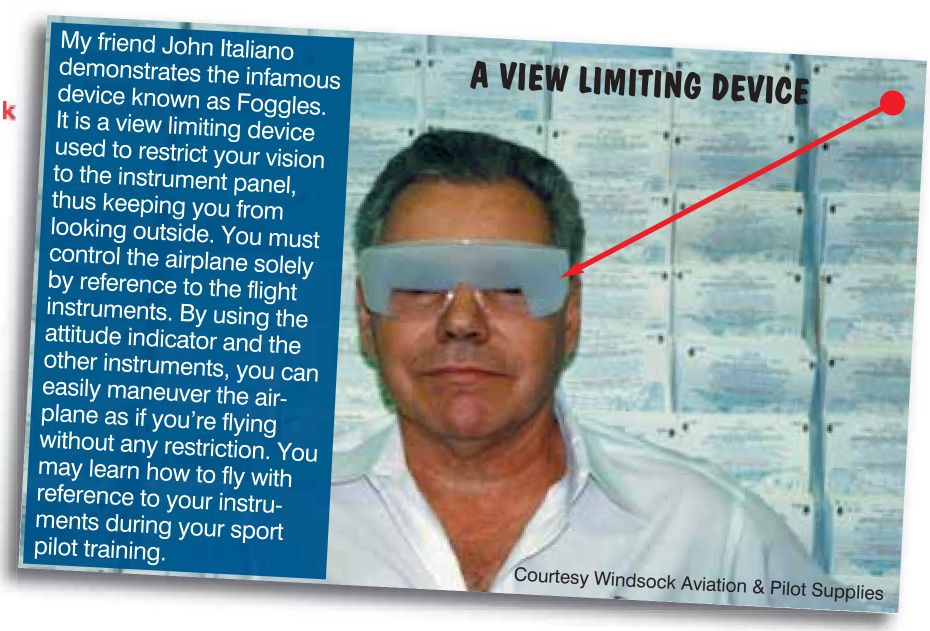
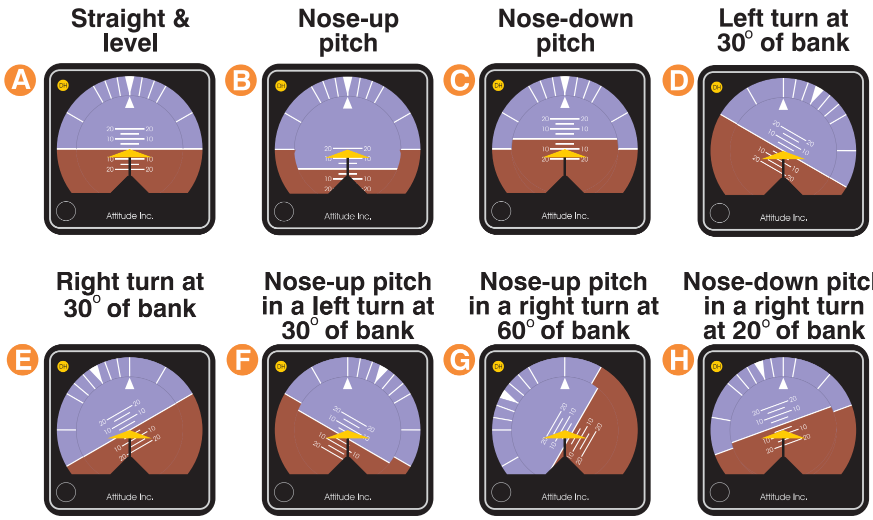


Fig. 38



VARIOUS ATTITUDES AND BANKS **Fig. 39**



indicator A. You know the airplane is flying straight because the symbolic airplane wings are not banked. The airplane's nose is level with the horizon, indicating it is probably holding its altitude (that's *probably* since we'd need to look at the altimeter to be sure). The picture made by the reference airplane is similar to the way reality looks out of your airplane's front windscreen during flight.

Attitude indicator B shows the airplane in straight flight with a nose-up pitch attitude. The little symbolic airplane's nose (the white ball—the head of a bald pilot) rests a little above the 10° pitch up index and the wings are level. Remember, the little airplane in the attitude indicator isn't moving, it's the horizon card behind the symbolic airplane that does all the moving (I'll explain how it does this in a moment).

Attitude indicator C depicts straight flight with a nose-down pitch attitude. The airplane's wings are level and the nose is pointed below the horizon.

Attitude indicator D depicts a left turn in a level pitch attitude. Sometimes it's a little difficult to determine which way the airplane is banked. Ask yourself, "Which wing is pointed toward the ground?" In this picture it's obvious that the left wing is pointed downward. The airplane must be in a left turn. I do hope this is as obvious as a chin strap on a toupee. After all, if the left wing is pointed to the ground, you should be making a left turn. The only time this wouldn't be true is if you're inverted. And if you're making inverted turns at this point in your career, then you either need more dual instruction or you have been anointed by Chuck Yeager or Neil Armstrong (in other words, you probably don't need to read this book).

Another important question to ask is, "If you wanted to return to straight flight in attitude indicator D, which wing would you raise?" (you've got a 50-50 chance on this one). Yes, the left wing. It's the one dipping toward the ground. If you ever lost sight of the horizon, you could maintain straight flight by simply asking which wing needs raising. Then you'd simply keep the small white ball on the white horizon line to maintain a level pitch attitude. Keep in mind that we refer to straight flight as both wings being parallel with the horizon and level flight as the airplane's longitudinal axis being parallel with the horizon. Attitude indicator D shows the airplane in a level pitch attitude while in a bank.

What type of turn does attitude indicator E show? Ask yourself, "Which wing is pointed toward the ground?" The answer is, the right wing. The airplane is in a right turn. The vertical indicator at the top of the instrument points to the 30° bank increment (each of the first three indices represent 10° of bank). Therefore, the airplane is in a 30° right bank. If you wanted to return to straight and level flight, which way would you turn? You must turn the control wheel to the left to raise the right wing and return to straight flight.

Attitude indicator F depicts an airplane in a nose-up pitch attitude while in left 30° bank turn. Attitude indicator G shows an airplane in a nose-up pitch attitude while in a right turn at a very steep 60° of bank. Finally, attitude indicator H shows

GOOD GRIEF!

We were on a pleasure flight to an airport in the foothills of a mountain range...I flew over the airport at what I thought was 1000' above pattern altitude to check wind direction, then began a turn and descent to join the pattern. The hills seemed uncomfortably close as I turned to 45 degree entry, even though I still hadn't reached my target altitude. Ground features on downwind leg were closer than I remembered, even though I was still 1000' high. An uneasy feeling of things not being right was forming when Unicom called a warning to "aircraft on downwind at low altitude." By that time I had turned from base to final and saw that making a normal landing would be chancy, at best. I immediately initiated a go-around, still not understanding what had gone wrong. After getting things stabilized I glanced down at the airport information sheet clipped to the yoke and saw, to my horror, that the "pattern" altitude I had been descending to was, in reality, the altitude of the airport! **ASRS Report**

When things don't look right, immediately start asking questions, mentally and verbally. On Unicom ask if they can verify the altimeter setting. If the altimeter setting checks out, verify the pattern altitude. Pilots like to help one another. Flying foolishly is a lot more hazardous to your health than swallowing some pride and requesting help. **D.T.**

PITCH ATTITUDE AND FLIGHT CONDITIONS

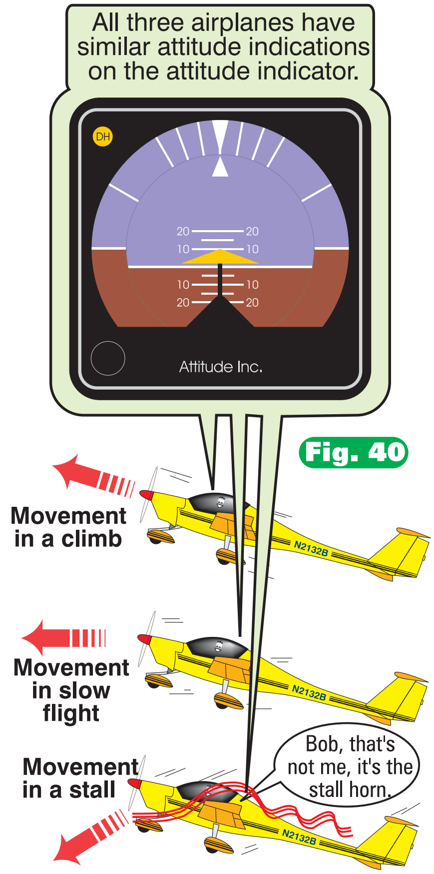


Fig. 40

GYROSCOPIC RIGIDITY IN SPACE

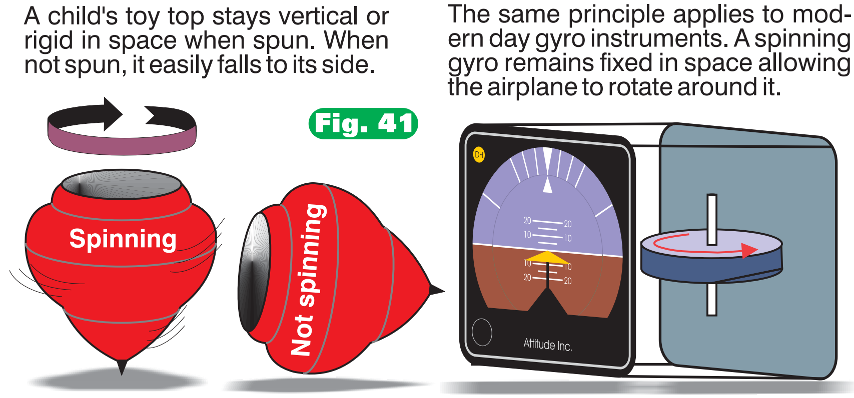
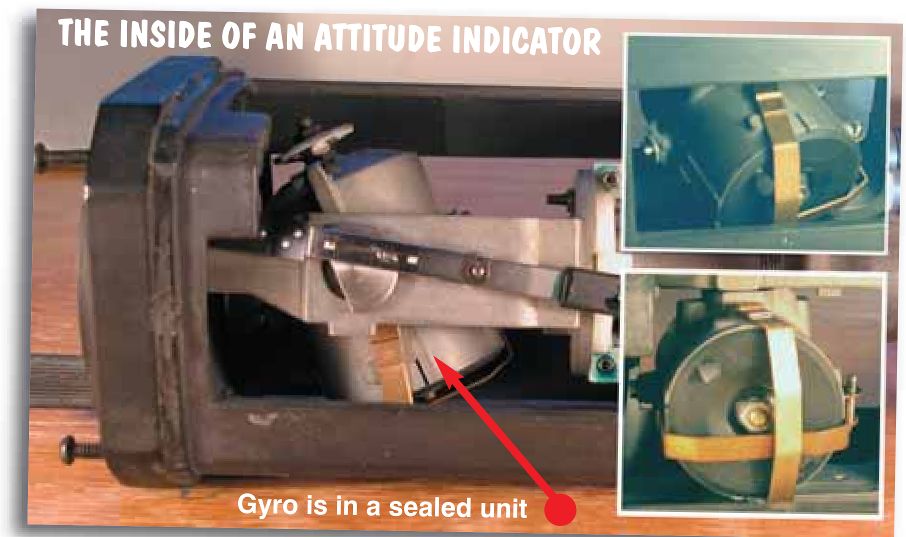


Fig. 41



THE ATTITUDE INDICATOR

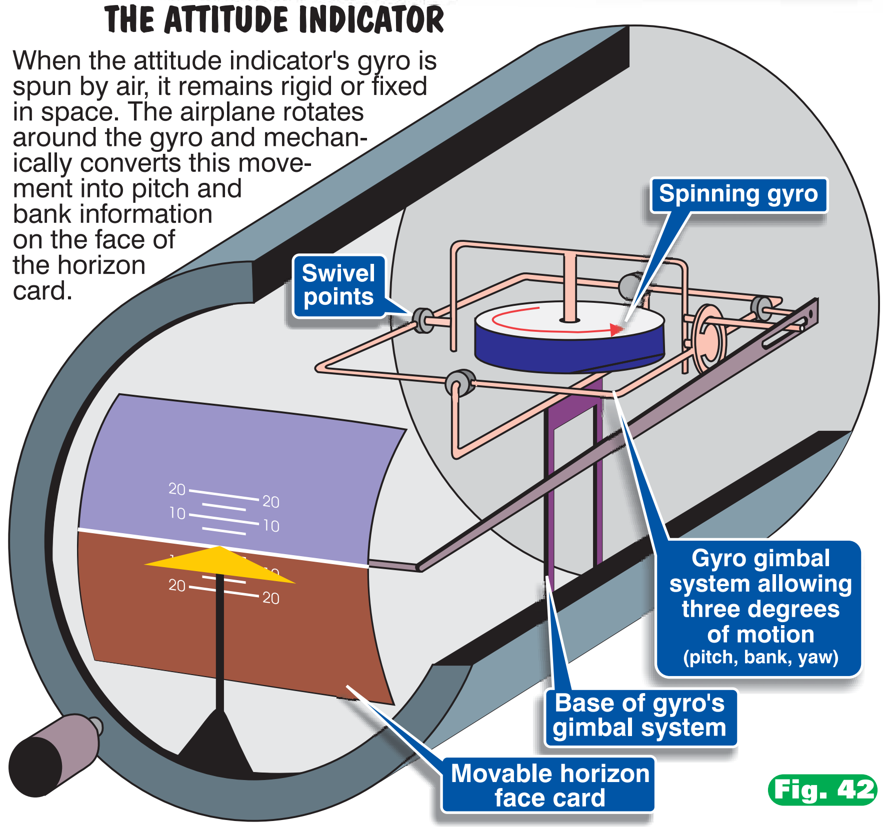


Fig. 42

an airplane in a nose-down pitch attitude while in a right turn at 20° of bank.

Have you noticed that I have not mentioned climbing or descending in reference to pitch attitude? Even though a nose-up pitch attitude is normally associated with a climb, there are occasions where it's not. For instance, Figure 40 shows three different flight conditions associated with a nose-up pitch attitude. The airplane may either be climbing with full power, cruising with limited power, or stalling with no power. All these conditions are associated with a nose-up pitch attitude. When flying by reference to instruments, the only way you can tell what your airplane is doing is to consult some of the other flight instruments. You will learn about this a little later on.

How does the attitude indicator (as well as the other gyro-based instruments) accomplish the mysterious task of portraying attitude? It does this through a gyroscopic principle known as *rigidity in space*. Figure 41 shows a child's top in full spin. A spinning top, just like a spin-

THE HORIZON LINE

The attitude indicator's horizon line remains parallel to the earth's surface at all times and the sky pointer always points upward toward the sky.

Fig. 43

ning wheel inside the attitude indicator (Figure 41), acquires the unusual property known as rigidity in space. A small wheel (a gyro) spun at high speed tends to remain in a fixed or rigid position. That's why the child's top remains upright until is stops spinning. It's this property that allows the attitude indicator's horizon card to portray airplane attitude.

The internal workings of the attitude indicator are displayed in Figure 42 (see Postflight Briefing #5-4 for info on how the solid state gyros of the PFD work). While this is a highly simplified drawing, it does allow you to understand the principles upon which the attitude indicator works. Notice the circular disk in the center of the instrument. This is the gyroscope. It is mechanically connected to the sky/ground horizon card on the face of the indicator. When spun, this disk takes on gyroscopic properties and maintains its position, fixed in space, relative to the earth. Thus, the horizon's face card, which is mechanically connected to the gyro, also remains fixed in space. From inside the airplane, the horizon face card accurately represents the real horizon in either a right or left hand turn as shown in Figure 43. As you can clearly see, the airplane rotates about the attitude indicator's gyro-stabilized (fixed) horizon card.

Most light airplane attitude gyros are spun by air pressure. A vacuum pump (Figure 44) sucks air through the instrument and over the gyro, spinning it at high velocity (Figure 45).

THE SUCTION GAUGE

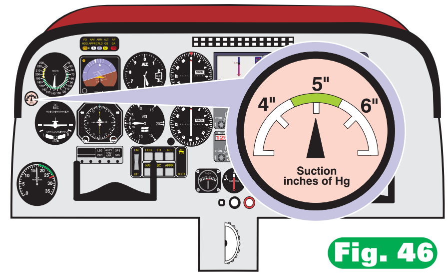


Fig. 46

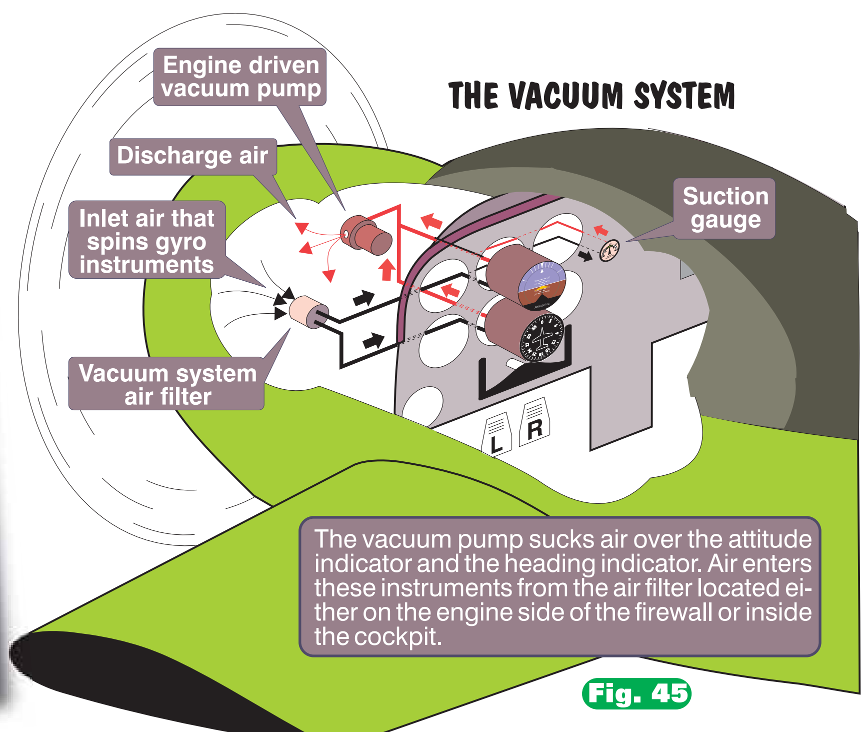
Operation within the green arc tells you that all your gyro instruments are getting enough vacuum pressure for proper operation.

This system is known as the *vacuum system* (and this isn't something you use to keep your airplane clean!).

Notice that the vacuum pump is connected to two instruments—the attitude indicator and the heading indicator. Both these instruments use gyroscopes that are typically spun by vacuum air pressure. You may also come across an airplane with a heading indicator whose gyros are electrically spun. Either way, the spinning of a gyro allows these instruments to work their magic.

Malfunctions of the airplane's air-spun gyro instruments are usually caused by the vacuum pump providing insufficient vacuum pressure. An airplane's vacuum gauge (Figure 46) keeps you informed about the

Fig. 44



The vacuum pump sucks air over the attitude indicator and the heading indicator. Air enters these instruments from the air filter located either on the engine side of the firewall or inside the cockpit.

Fig. 45

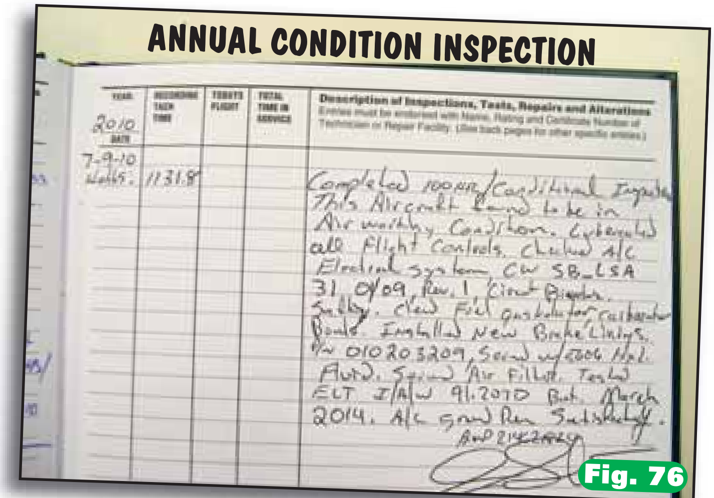


Fig. 76

Fig. 77

to be used for sport and recreation, and not to be used as a for-hire flight training or rental aircraft. Just to be clear, you can take instruction in an ELSA, but you can't use it for hire to instruct others. (Note: ELSAs can, for compensation or hire, be used to tow gliders in the LSA category or unpowered ultralight vehicles).

Experimental exhibition aircraft are those aircraft often found at airshows, such as warbirds. I won't discuss these here since it's unlikely that you'll go to war after receiving your sport pilot certificate. (See Postflight Briefing #6-2.)

Experimental Aircraft Requirements - If your airplane has an experimental airworthiness certificate, you are required to advise your passengers of the experimental nature of the aircraft. I know you'll choose your words carefully, and not say something such as, "By the way, I just wanted to let you know that I built this thing and there's nothing wrong with it...any more." This statement is usually followed by, "Hey wait, come back, don't run away, I was only kidding, geesh." Kit-built and amateur-built aircraft constructed correctly, are as safe to fly as any other aircraft.

Flight operations in experimental aircraft should be conducted under day VFR conditions only, unless you are authorized by the FAA to do otherwise. These operations must also be conducted within the operating limits specified for that particular airplane. When operating out of airports with operating control towers, you must notify the tower of the experimental nature of the aircraft. Keep in mind that experimental aircraft may only be used for the purpose for which their certificate was issued, and that means sport and recreation, and not flight for compensation or hire.

Perhaps you've seen one of those large (and experimentally certified) hot air balloons that drifts around the country and are used by individuals to tout their personal companies and products. There is one in particular that impresses me. It's a large Tyrannosaurus Rex dinosaur that stands many stories tall. The problem with this type of balloon is that it causes the occupants of Japanese restaurants to run out into the street shouting, "No, not again. Make him stop."

Now we're ready to examine the specific maintenance and inspection requirements for both amateur-built aircraft (LSA-definition) and experimental light sport aircraft (ELSA).

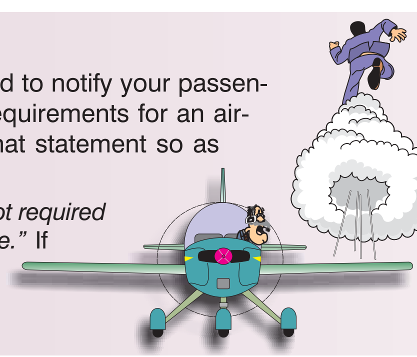
Maintenance and Inspections on Experimental Amateur-built Aircraft (LSA-definition)

We've seen that anyone (you, him, that guy over there, your uncle Fred, and so on) can perform any maintenance on any experimental airplane. You don't need any license, rating or certificate to do so. That's because the FAA believes that anyone who owns an experimental aircraft will use a little common sense and only let someone who knows what they're doing work on the machine. And if you happen to own the experimental airplane, hopefully you won't touch it unless you know the difference between a doohickie and a thingamajig. On the other hand, all aircraft are required to have an inspection every 12 calendar months. Let's see who can do this inspection as well as

There's Something I've Got to Tell You...

As a pilot of an experimental aircraft or a special light sport aircraft, you are required to notify your passenger that he or she is going flying in an aircraft that doesn't meet the airworthiness requirements for an aircraft that was issued a standard airworthiness certificate. Of course, you'll modify that statement so as not to scare anyone, right. Perhaps you'll say:

"I want to advise you that this aircraft has an experimental airworthiness certificate and is not required to meet the airworthiness requirements for aircraft issued a standard airworthiness certificate." If it's an SLSA, you might say, *"Because this aircraft complies with industry consensus design standards, it's allowed to fall into the light-sport aircraft category and isn't required to meet the airworthiness requirements for aircraft issued a standard airworthiness certificate.*



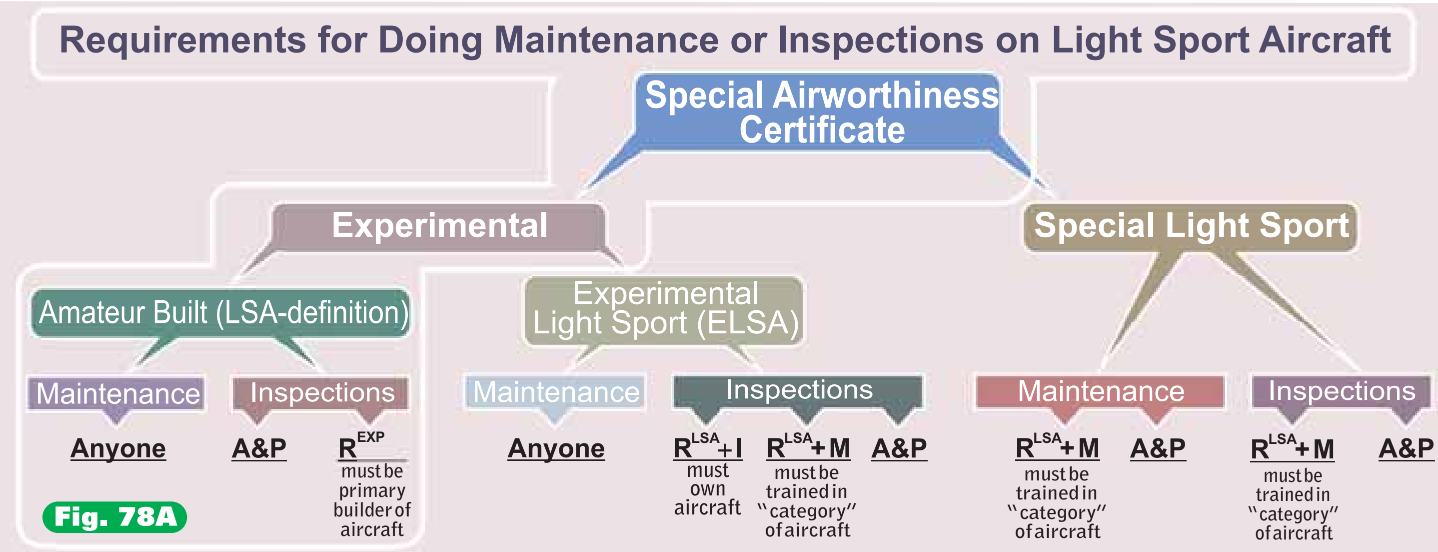


Fig. 78A

who is responsible for ensuring this inspection is completed.

Required Inspections - As a sport pilot, if you own an experimental amateur-built aircraft (LSA-definition), then it must have had a *condition inspection* (Figure 76) within the preceding 12 calendar months to be considered airworthy. This is sometimes called the *annual condition inspection*. The person performing this inspection (we'll discuss who can do this inspection next) must approve the aircraft for return to service by providing the appropriate endorsement in the aircraft's logbooks (Figure 77). Experimental amateur-built aircraft (LSA-definition) typically have three logbooks, one for the airframe, the engine and the propeller. All required inspections and maintenance must be logged in the appropriate logbook(s).

Who is responsible for ensuring that any required maintenance and inspections are logged into the appropriate maintenance records? The pilot? The aircraft fueler? No. The FAA requires the *owner* (the person who has legal title to the aircraft) or the *operator* (this can be the person who *operates* the flight school, but this isn't relevant for amateur-built experimental aircraft since they can't be used as rental aircraft) to ensure that the aircraft is properly maintained and inspected, as well as ensure the maintenance records are endorsed properly.

Who Can Perform the Annual Condition Inspection on Experimental Amateur-Built Aircraft (LSA-definition)?

As you know, if you built or purchased an experimental amateur-built aircraft, then *anyone* can perform the maintenance on that airplane. The annual condition inspection, however, must be done by either:

- a certificated *repairman (experimental aircraft builder)* (Figure 78A and 78B), or
- an appropriately rated mechanic (i.e, an A&P or airframe and powerplant mechanic, Figure 78A and 78C), or
- an appropriately rated repair station.

R^{EXP} = repairman (experimental aircraft builder)

To obtain a repairman (experimental aircraft builder) certificate as the primary builder of your airplane, you would apply to the FAA via an application form. No training is required. The repairman (experimental aircraft builder) certificate allows you to perform the required inspections on the amateur-built aircraft that you personally constructed.

Fig. 78B

A&P = airframe and powerplant mechanic
(or appropriately rated repair station)

This is an FAA issued certificate that requires both practical and knowledge tests as well as many hours of actual hands-on experience. Licensed A&P mechanics can work on almost anything that flies.

Fig. 78C

If you are the *primary builder* of the amateur-built aircraft, then you can obtain a repairman certificate with an *experimental aircraft builder* classification (no, this isn't a home repairman certificate, either. To obtain the certificate, you simply apply to the FAA for one. No training is necessary. This certificate allows you to perform the annual condition inspection on the amateur-built aircraft (LSA definition) listed on your repairman certificate because you were the primary builder of this aircraft.

Since FAR 65.104[a][2]) states that you have to be the "primary builder" of the aircraft for which you're seeing repairman privileges, any future owner of this aircraft cannot qualify for the repairman certificate (experimental aircraft builder) for this airplane. That means if you purchase an already constructed experimental amateur-built LSA, then an A&P (or the person who holds the repairman certificate for that airplane—if one exists) must do the inspections on this machine from now on. Please remember that we are talking about amateur-built aircraft that meet the definition of light sport aircraft here.

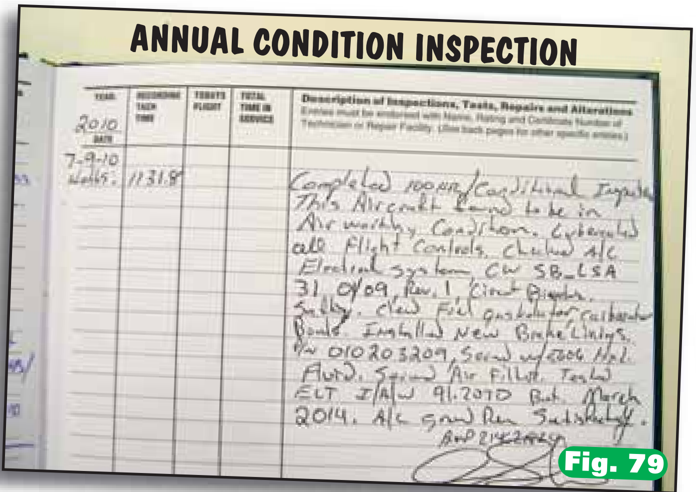


Fig. 79

Fig. 80

Maintenance and Inspections On ELSAs (Experimental Light Sport Aircraft)

Keep in mind that ELSAs are airplane kits (fully or partially built) or special light sport aircraft (SLSAs) that were re-registered so as to convert them to ELSAs. (SLSAs to be discussed next.)

Required Inspections - Despite being allowed to do the maintenance on your ELSA, the aircraft must have an annual condition inspection within the preceeding 12 calendar months for it to be considered airworthy (Figure 79). In addition, if the ELSA is used for hire (i.e., towing services), then the airplane must have had a 100-hour inspection within the preceeding 100 hours of time in service (known as the *100-hour inspection*). The person performing either of these inspections (we'll discuss who can do these inspection next) must approve the aircraft for return to service by providing the appropriate endorsement in the aircraft's logbooks (Figure 80).

ELSAs typically have three logbooks, one for the airframe, the engine and the propeller. All required inspections and maintenance must be logged in the appropriate logbook(s).

Who is responsible for ensuring that any required maintenance and inspections are logged into the appropriate maintenance records? Ricardo, the airport Elvis impersonator? The Pilot? No. The FAA requires the *owner* (the person who has legal title to the aircraft) or the *operator* (this can be the person who *operates* the flight school that provides towing services for compensation or hire to gliders in the LSA category or unpowered ultralight vehicles) to ensure that the aircraft is properly maintained and inspected, as well as ensure the maintenance records are endorsed properly.

Let's be clear on the point about flight instruction. ELSAs (or any experimental aircraft, for that matter) can't be used for hire to instruct others nor can they be used as rental aircraft for the purposes of flight training. Yes, you can take instruction in an ELSA (or any experimental aircraft) and you can pay the instructor for that training. An FBO isn't, however, allowed to rent you an ELSA for that purpose.

Who Can Perform the Annual Condition Inspection on an Experimental Light Sport Aircraft (ELSA)?

You must know by now that anyone can perform the maintenance on an experimental airplane. The annual condition inspection, however, must be done by either:

- a certificated *repairman (light sport aircraft)* with an *inspection* rating in the *category* of aircraft for which the holder has completed training (i.e., *airplane* category), or
- a certificated *repairman (light sport aircraft)* with a *maintenance* rating in the *category* of aircraft for which the holder has completed training (i.e., *airplane* category), or
- an appropriately rated mechanic (e.g., A&P mechanic), or
- an appropriately rated repair station.

Let's examine each of these in more detail.

Repairman Certificate (LSA) - Inspection Rating

If you hold a *repairman (light sport aircraft)* certificate with an *inspection rating,* in the *airplane* category, then you can perform the annual condition inspection on an aircraft that you *own* as shown in Figure 81A and 81B. The reason the FAA wants you to own the airplane is that the *inspection rating* doesn't require a great deal of training to obtain (more on obtaining this certificate shortly). Therefore, owning the airplane assumes that you will have greater familiarity with the machine and a willingness to accept more of the risks associated with performing the annual condition inspection yourself. When you obtain your repairman certificate, the specific aircraft you'll be allowed to inspect will be listed on that repairman certificate by make, model and serial number. If you sell your ELSA and buy another one, or acquire an additional one to add to your neighborhood air-defense fleet, then the annual condition inspection can't be done on that aircraft until you add it to your repairman certificate. That's right. You must have the FAA add this new or additional aircraft to your certificate if you want to perform the annual condition inspection on that machine.

Repairman Certificate (LSA) - Maintenance Rating

You can also do the annual condition inspection if you hold a *repairman certificate (light sport aircraft)* with a

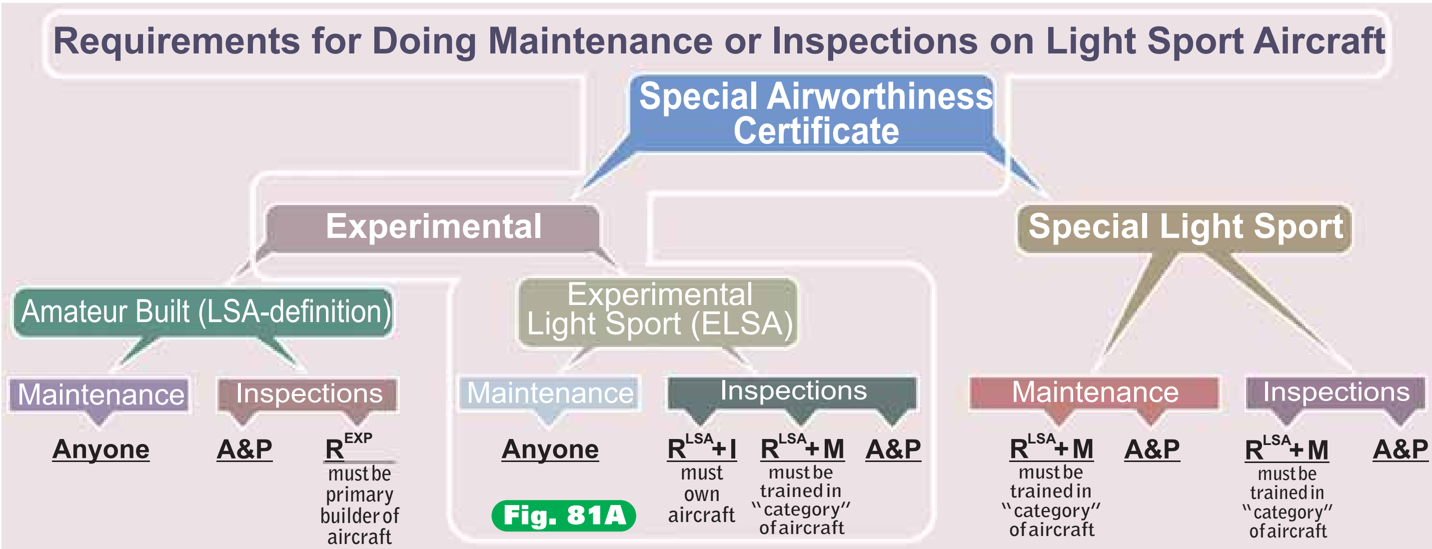


Fig. 81A

maintenance rating (Figure 81A and 81C) in the airplane category. You don't need to own the aircraft to do this inspection with this type of repairman certificate, either. Why? As you'll soon see, this type of repairman certificate requires a great deal more training to obtain than that required for the inspection rating. With more training comes more privilege. Thus, the FAA allows you perform the annual condition inspection on any ELSA (not just the one you own) as long as the aircraft falls within the category of aircraft on which you were trained.

R^{LSA}+I = repairman (light sport aircraft) with an *inspection* rating

To obtain a repairman (light sport aircraft) certificate with an *inspection rating*, you must take an FAA approved 16-hour training course for the same class of ELSA that you own and you can only do the annual condition inspection on the aircraft that you own.

Fig. 81B

R^{LSA}+M = repairman (light sport aircraft) with a *maintenance* rating

To obtain a repairman (light sport aircraft) certificate with a *maintenance rating*, you must complete an FAA approved rating course for the category of aircraft on which you desire to work. This course consists of 80 to 120 hours of training. The course allows you do the annual condition inspections on ELSAs and SLSAs, the 100-hour inspection on an SLSA, as well as perform the maintenance and repair on any SLSA, if authorized by the aircraft manufacturer.

Fig. 81C

A&P or Appropriately Rated Repair Station

Of course, any licensed *airframe and powerplant* mechanic (Figure 81A and 81D) or appropriately rated repair station can do the annual condition inspection, too.

Obtaining the Repairman Certificate and Ratings

To obtain a repairman (light sport aircraft) certificate with an inspection rating, you must attend a FAA approved 16-hour training course and pass a knowledge test at the end of the course. To obtain a repairman (light sport aircraft) certificate with a maintenance rating, you must attend a FAA approved 80- to 120-hour training course for the category of aircraft on which you intend to work (i.e., airplane, weight-shift, glider, etc.), as well as pass a knowledge test at the end of the course (see, I told you it was more extensive).

Keep in mind that an inspection rating on your repairman certificate allows you to perform the annual condition inspection on an ELSA *that you own*. Unlike the repairman certificate (experimental aircraft builder), you aren't required to have built the airplane to perform the annual condition inspection. You are only required to own the airplane, meaning that you might have purchased it from someone, purchased it as a kit and built a little bit of it or none of it. This is one reason why some people obtain a repairman certificate with an inspection rating, then deregister their SLSA. In doing so they convert its airworthiness certificate to the ELSA sub-category, allowing them to do their own maintenance as well as annual condition inspection. This may saves a great deal of money on mechanics, but only if the work is done properly, right?

A&P = airframe and powerplant mechanic
(or FAA certified repair station)

This is an FAA issued certificate that requires both practical and knowledge tests as well as many hours of actual hands-on experience. Licensed A&P mechanics can work on almost anything that flies.

Fig. 81D

Figure 5 shows the VFR cloud distance and flight visibility minimums below 10,000 feet MSL. Any altitude in Class E airspace below 10,000 feet MSL requires that you fly at least 1,000 feet above, 500 feet below and 2,000 feet horizontally from any cloud formation. Three statute miles of flight visibility is also required. Here's Rod Machado's Airspace Simplification Rule #1: Since you're likely to see at least three Cessna 152's below 10,000 feet, let's encode the minimums in an easy-to-remember formula: 3V/152.

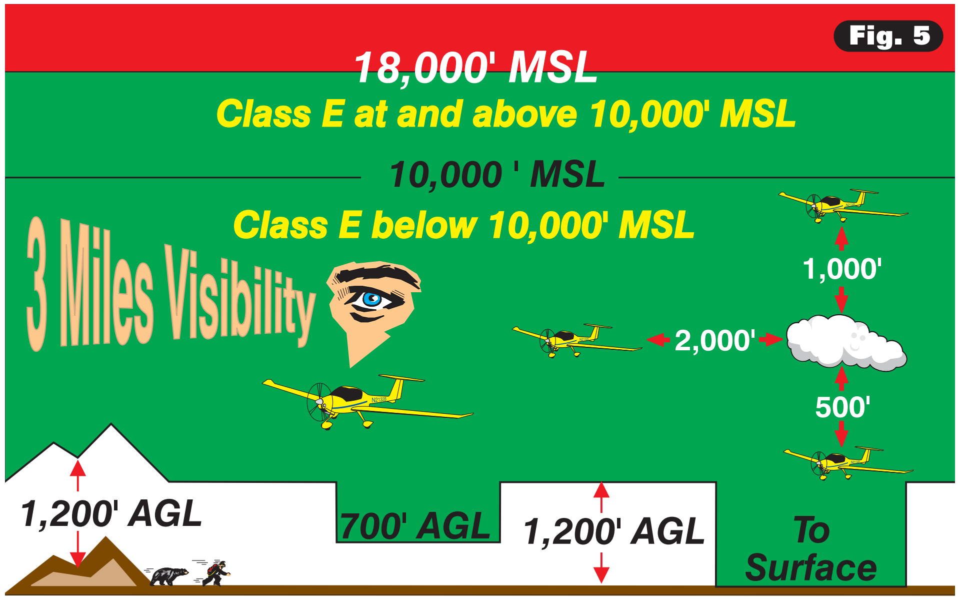


Fig. 5

As I mentioned earlier, it's entirely possible that an airplane on an IFR flight plan could pop out of the side of a cloud that's close to you. Even though there is a 250 knot (288 MPH) indicated airspeed limit for all aircraft operating below 10,000 feet MSL, this should still concern you. Seeing a 250 knot airplane emerging from the side of a cloud could shock you as much as it would a pig seeing someone eating a ham sandwich. Maintaining a distance of no less than 2,000 feet horizontally from any cloud formation minimizes the risk of a collision. To repeat myself for a good cause, stay as far away from any cloud as you need to in order to feel really, really safe. Two thousand feet might not do it for you; it certainly doesn't for me. I prefer three, four or even five thousand feet (big feet too).

Why is a greater distance required above a cloud than below? Many high performance airplanes typically climb faster than they descend. Small jet aircraft, like Learjets, can climb at several thousand feet per minute after takeoff (Learjets feel like someone strapped a little rocket onto your back). Being higher above the cloud tops helps reduce the risk that you will unintentionally become a hood ornament for a Learjet.

Pilots of jet aircraft, particularly big ones, rarely descend at thousands of feet per minute when they are below 10,000 feet MSL. Why? Trying to arrest a 6,000 foot-per-minute sink rate in a fully loaded Boeing 747 would take hundreds of feet. Boeing 747's (also known as "aluminum overcasts") have such inertia that descents in excess of 1,000 feet per minute while close to the ground are done with great care. Since pilots generally descend at lesser rates than they climb, required distances below clouds are typically less than those above.

Class E Airspace Starting At 700 Feet AGL

When Class E airspace starts at 700 above ground level, it will be surrounded by a magenta faded line, as shown in Figures 6 and 7, position 1. Anywhere within this magenta faded area, controlled airspace starts at 700 feet AGL. An aeronautical sectional chart shows this magenta faded border (sharp on the outside, fading to the inside) quite clearly in Figure 7,

CLASS E AIRSPACE AT 700' AGL

Within the borders of the magenta faded area surrounding an airport, Class E (controlled) airspace starts at 700 feet above ground level (AGL) instead of the normal 1,200 feet AGL. The lower base of Class E airspace (i.e., 700' AGL), keeps airplanes flying instrument approaches in controlled airspace as they descend to the airport.

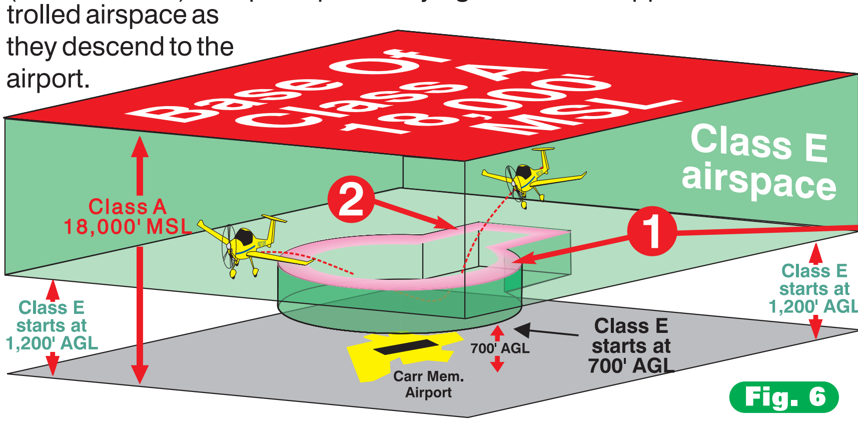


Fig. 6

Carr airport as shown on an aeronautical sectional chart.

Fig. 7

CLASS E AIRSPACE AT THE SURFACE

Within the borders of the magenta (red) dashed line, Class E airspace descends all the way to the surface surrounding McComb-Pike airport. Since some instrument approaches bring pilots real close to the surface of an airport, this lower Class E surface area keeps them in controlled airspace during their descent.

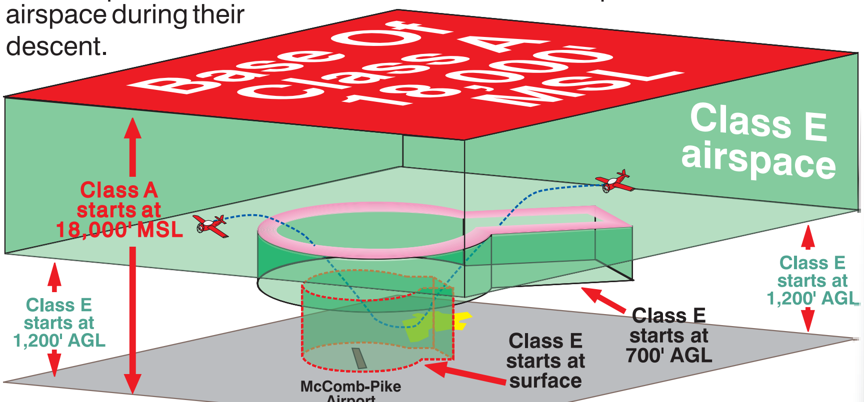


Fig. 8

Fig. 9

position 1. Outside the border of the magenta fade, controlled airspace starts at 1,200 feet AGL.

Within the borders of the magenta fade, at and above 700 feet AGL, Rod Machado's Airspace Simplification Rule #1 applies. In other words, you need a minimum of 3V/152 for VFR flight.

Why would an airspace designer want to lower Class E airspace to 700 feet AGL around or near an airport? To keep VFR pilots from bumping into IFR pilots who are making instrument approaches.

The keyhole type extensions of Class E airspace starting at 700 feet AGL in Figure 6, position 2 identify descent paths followed by IFR airplanes during their instrument approaches. The keyhole slot is shown on the aeronautical sectional chart excerpt in Figure 7, position 3. IFR pilots on an instrument approach typically descend to altitudes of 700 feet AGL (and lower). They remain in Class E airspace during most of their IFR approach. If they see the airport, they land; if they don't see it, they fly off to another airport (hopefully one that has fewer clouds and better visibility).

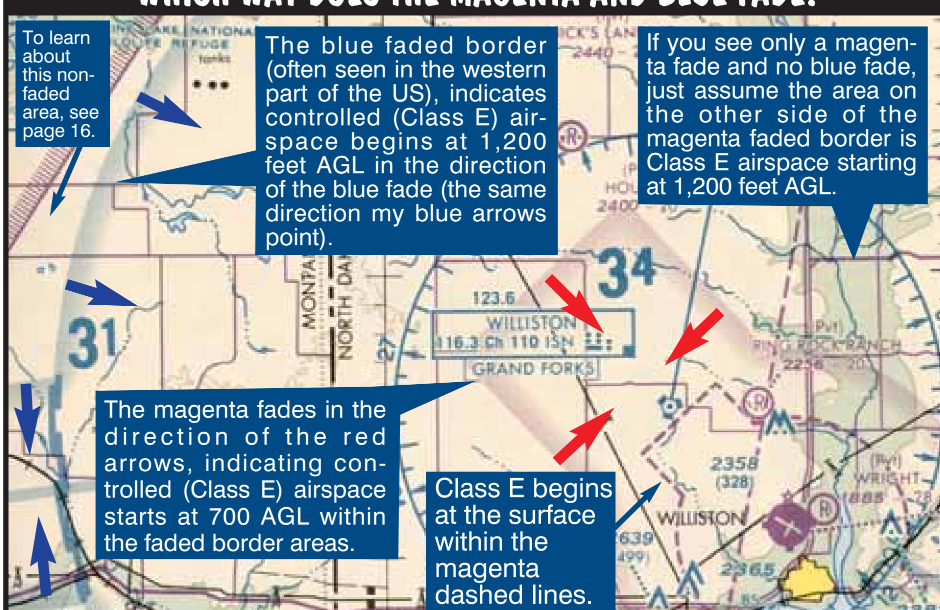
Remember that in Class E airspace *below* 10,000 feet MSL, VFR pilots should be flying with no less than 3V/152. This means if an IFR pilot pops out of the clouds, there should be ample time for the VFR and IFR pilots to see and avoid each other (IFR pilots are equally responsible to see and avoid whenever they are not in instrument meteorological conditions).

Some airports have instrument approaches that bring IFR pilots down closer than 700 feet AGL, as shown in Figure 8. There are airports allowing IFR pilots to come within 200 feet AGL or less while still in the clouds. Since controlled airspace helps VFR pilots see and avoid other pilots, these airports have Class E airspace lowered all the way to the surface. (There are other reasons why controlled airspace is lowered, but these are beyond the scope of this book.)

Figure 9 shows how surface-based Class E airspace is shown on an aeronautical sectional chart. A dotted magenta line defines the lateral boundaries of the controlled airspace surrounding McComb-Pike County airport (position 1). Airports without air traffic control towers use a magenta dashed line to represent this surface-based Class E airspace. (Airports with established control towers, as you'll see a little later, use blue-dashed lines to represent controlled airspace in contact with the surface around that airport.)

What does this surface-based Class E airspace mean to you as a VFR

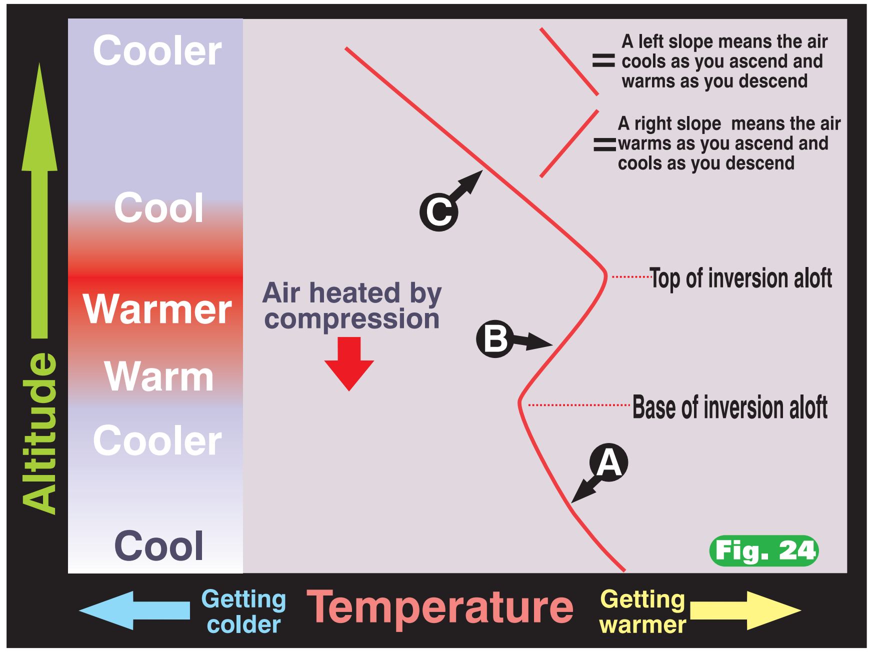
WHICH WAY DOES THE MAGENTA AND BLUE FADE?



An increase in air pressure produces an increase in temperature for the same reason dough becomes warm when it's kneaded (I'm not talking about the $dough$ everyone needs). Compressing dough (or air) increases its temperature. The harder the dough is squeezed, the warmer it gets. If this descending layer of warm air comes to rest on a cooler layer of air, a temperature inversion can form aloft. This type of inversion is sometimes called a subsidence inversion.

In the summer months, a subsidence inversion is more common in the western half of the country than in the eastern half. In particular, it's quite common on or near the Pacific Coast. When warm, high pressure air subsides (lowers) onto the cool, moist inflow of air from the ocean, an inversion aloft forms, as shown in the temperature-altitude profiles of Figure 24.

TEMPERATURE PROFILE OF AN INVERSION ALOFT



An inversion aloft is characterized by a temperature profile that starts decreasing at the surface (position A), increases (position B), then finally decreases again at the top of the inversion (position C). When air aloft is forced to descend (as in a high pressure area) it heats by compression. If warmer air comes to rest over a colder layer of air, an inversion aloft may form.

A pilot faces a decreasing temperature lapse rate when departing an airport beneath the inversion. The climb is initially made in cool air (position A). Upon entering the bottom of the inversion the air becomes warmer as altitude is gained (position B). At the top of the inversion, a decreasing temperature lapse rate once again prevails (position C).

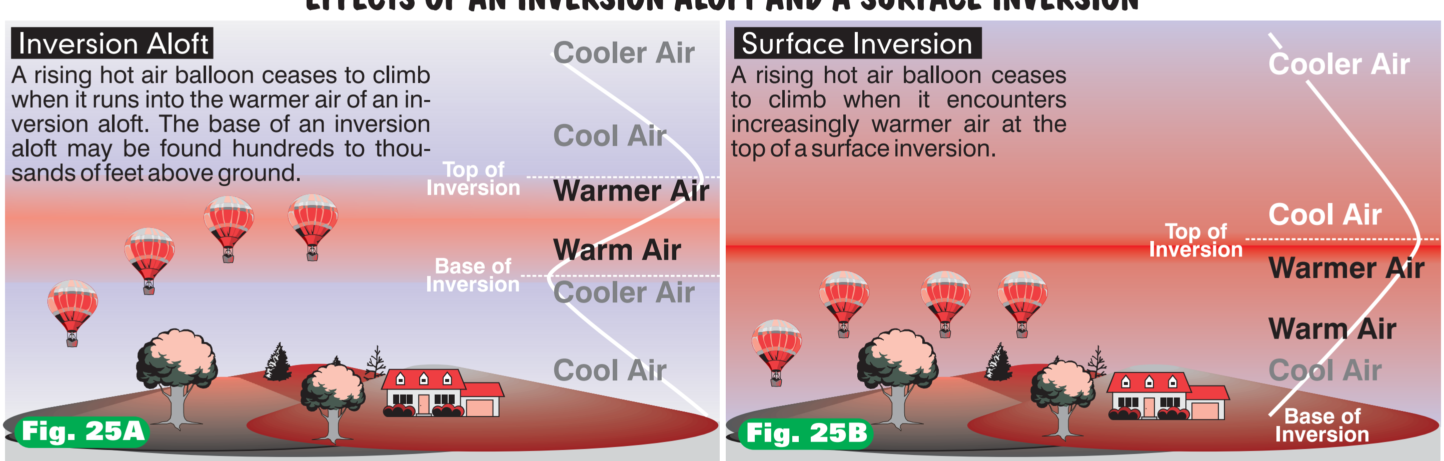
Effects of Temperature Inversions

Recently, a friend and I went flying in a hot air balloon. We departed immediately after sunrise and ascended through the cool, morning air. We rose so quickly it appeared that we were climbing at the best-angle-of-bag (if there were such a thing—there isn't). Suddenly, at approximately 1,500 feet AGL, the balloon ceased climbing (Figure 25A).

Reaching the base of a temperature inversion aloft nullified our lift. The middle or top of a surface inversion can produce the same effect on a balloon but at an altitude closer to the surface (Figure 25B). We just skipped along horizontally, beneath the base of the inversion, until more heat was applied to the balloon. In much the same way a temperature inversion impedes the ascent of a balloon, it can also prevent parcels of warmer air on the surface from ascending any higher.

Have you ever noticed smoke coming from a chimney in the early morning or evening hours? Sometimes this smoke ascends for a short distance then spreads out horizontally, as shown in Figure 26. The flattening of smoke is a sure indication of a temperature inversion (since it's often seen closer to the surface in the evening, it's probably a surface inversion).

EFFECTS OF AN INVERSION ALOFT AND A SURFACE INVERSION



VISUAL SIGNS OF AN INVERSION

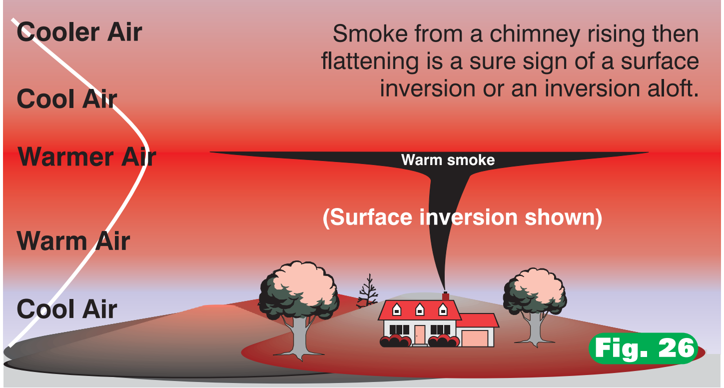


Fig. 26

STRATUS CLOUDS ARE A SIGN OF A TEMPERATURE INVERSION

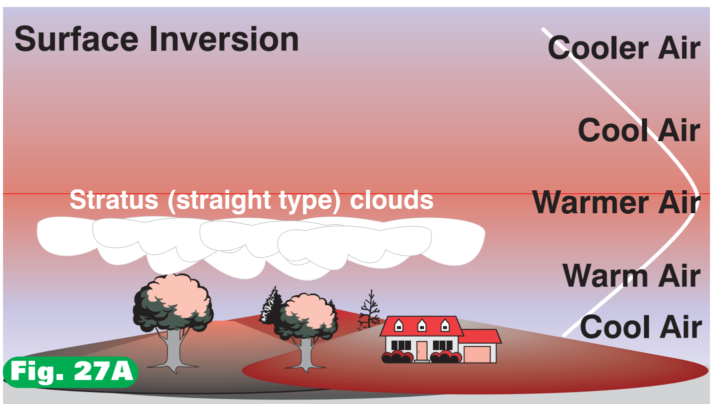


Fig. 27A

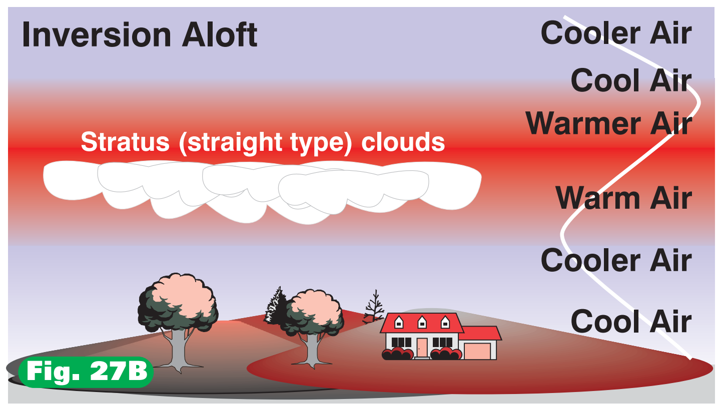
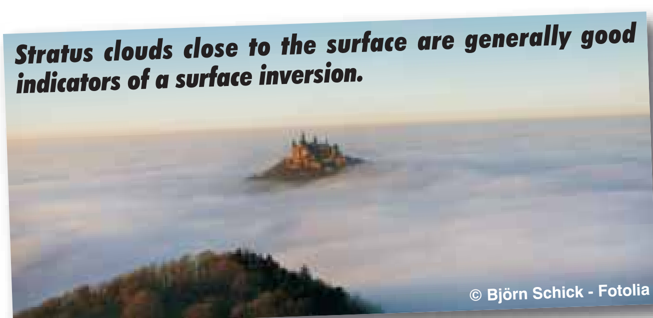
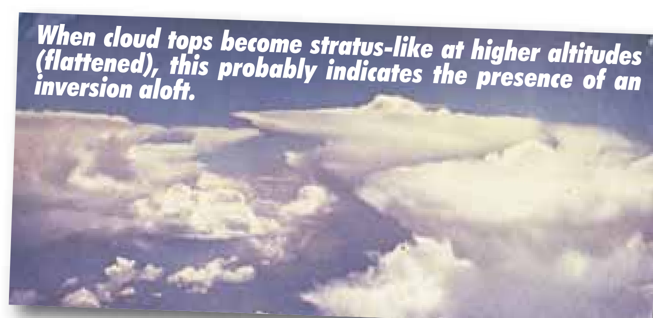


Fig. 27B

As warm parcels of air rise, expand and cool they may eventually form clouds. The inversion acts like a lid that keeps these rising parcels from ascending into the warmer air of the inversion. The parcels form clouds having *straight* tops, called *stratus* clouds.





POOR VISIBILITY IN AN INVERSION

Fig. 28

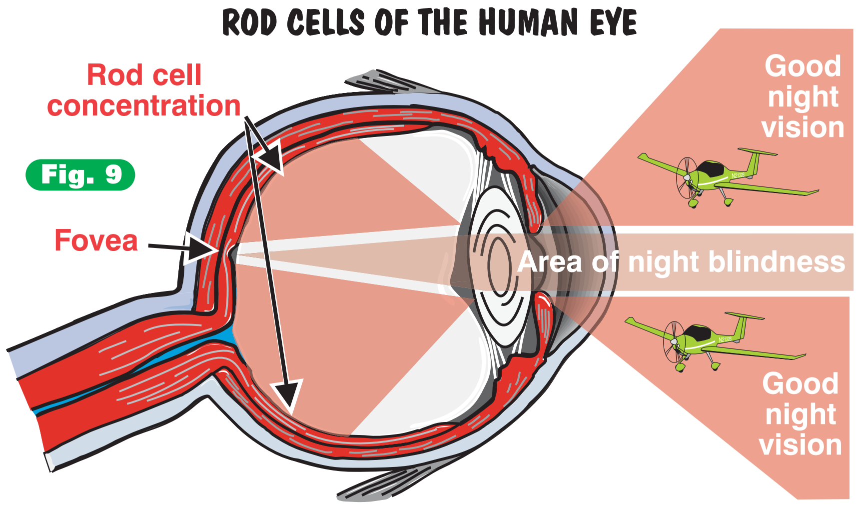
A temperature inversion (surface or aloft) acts like a lid on the atmospheric pollutants beneath it. Unable to rise and disperse, the pollutants remain in a lower layer and restrict visibility.

Warm, rising puffs of smoke, much like a hot air balloon, cannot ascend through the warmer air of an inversion. In a very similar way, the presence of a temperature inversion acts to flatten cloud tops. Therefore, layer-type clouds (otherwise known as stratus or straight type clouds) are another visible indication of a temperature inversion, as shown in Figures 27A and 27B (more on stratus clouds later).

The inability of smoke, haze or pollution to move vertically and be carried away by winds at higher altitudes reduces the local flight visibility. This is especially true in areas of industry, as shown in Figure 28. Mexico City rests in a large valley and is notorious for its temperature inversions. Trapped pollution from the city can become so bad that asphyxiated birds have been known to fold their wings, croak, and just fall to earth. I wonder how many needless hours are spent plucking pigeons from sombreros?

dim-light receptors. Since these rods are located outside the fovea, they are responsible for our peripheral vision, as shown in Figure 9. Moving images are more easily detected by rod cells than by cone cells. Catching an object out of the corner of your eye is an example of rod cells at work.

As I've already mentioned, cone cells don't work well in the dark, which explains why it's difficult to see an object at night even though you're looking directly at it. This is why we have a night blind spot in the center of our vision where the light from a dimly lit object falls directly onto the fovea (Figure 9).



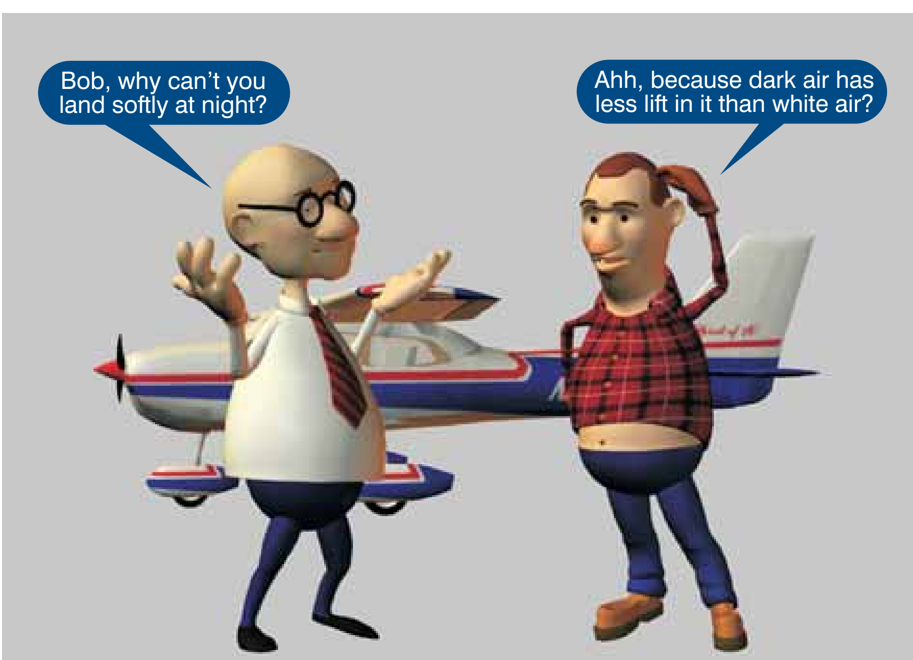
Looking directly at an object at night makes it difficult to see. At night it's best to look 5 to 10 degrees offset from center for better vision. This allows the light from dimly lit objects to fall on the rod cells (surrounding the foveal region) which are better for night vision.

If you want the best view of a dimly lit object you need to expose the rods to the light. You can do this by using your peripheral vision for off-center viewing. Simply look 5 to 10 degrees to the side from the center of the object you want to view. This allows some of the object's reflected light to fall on the rods. You can demonstrate this process at night by looking directly at an airplane's strobe light head on and offset a few degrees. A direct view dims the object while an indirect view increases its brightness. Think of looking at a dim object at night as you might think about looking at a carnival worker. In other words, try not to look directly at their tattoos for fear of finding misspelled words.

Night Vision

How well you see at night is determined by the amount of light passing through the pupil. Pupils close to prevent the eyes from receiving too much light and open when light intensity diminishes. The problem is that it may take at least 30 minutes for your eyes to completely adapt to the dark. This is one reason you want to avoid very bright lights for at least 30 minutes before the flight if you're planning on flying any time past sunset all the way until the end of evening civil twilight (when night officially begins and all sport pilots must be on the ground). The reason being that if you've spent the day sungazing and haven't adapted your eyes to darker conditions, it's possible that you may not be able to see the airport or the runway, much less other airplanes in flight. That's a fact!

Using sunglasses for protection from glare is most helpful in preventing night vision deterioration as well as preventing eye strain and eye damage. Find sunglasses that absorb at least 85% of the visible light (15% transmittance) and have minimal color distortion. Usually, a green or neutral gray is a satisfactory color. I'd recommend that you stay away from sunglass frames like Elton John wears (personally, flaming pink flamingo glasses don't do much for me at all and I can hardly see how they would help you during your sport pilot check ride). I make it a point to ensure all my sunglasses have a high degree of impact resistance. Why? They are excellent eye protectors in the event that something penetrates the windshield.

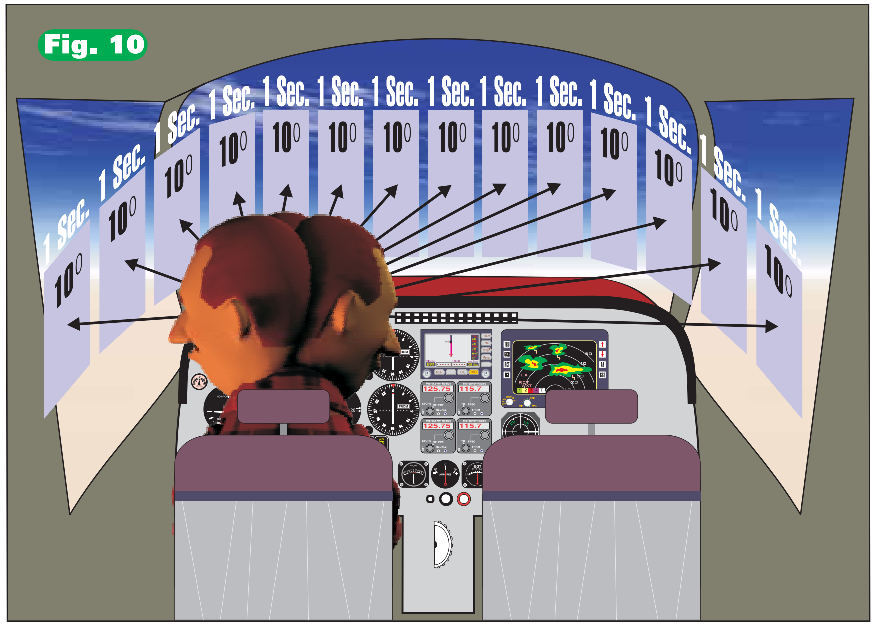


Haze and Collision Avoidance

Keep in mind that all objects (traffic included) appear to be farther away in hazy conditions. The mind equates difficulty in seeing an object with increased distance. As a result, you might allow another airplane to get closer to you under hazy conditions before taking corrective action.

Wearing yellow lens sunglasses is often recommended for hazy, smoggy conditions. Yellow lenses allow for greater definition and contrast of objects. I keep a pair in my flight case for hazy days (I also have a pink-rimmed pair in case I meet Elton John at the airport). Yellow lens sunglasses put a little more strain on my eyes if I wear them for a long time, but the payoff is in easier identification of traffic in smoggy and hazy conditions.

THE SECTOR SCANNING METHOD



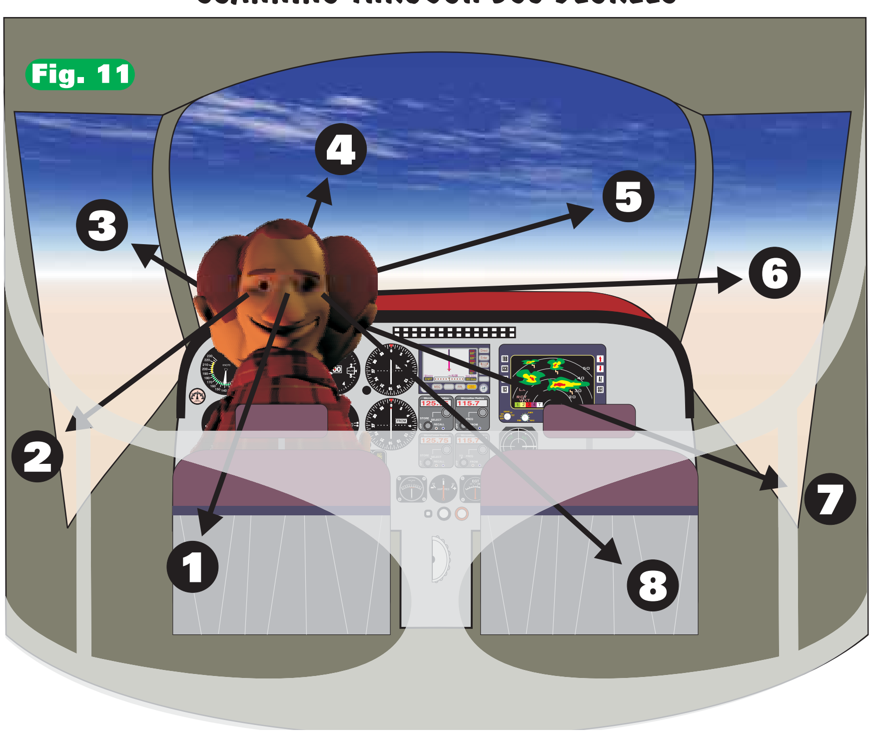
One method of scanning is using the sector scanning method. You simply scan one area 10 degrees in width for one second before moving onto the next sector. By moving your head in a series of short movements, the eye is stationary long enough to focus on an object. This includes scanning the area behind you, too.

Scanning for Traffic During the Day

Avoiding midairs is predicated upon one important premise: you must look outside the cockpit. Far too often, pilots spend their time with their head inside the cockpit staring at instruments instead of honoring the see and avoid concept. How much time should be spent looking outside and inside the cockpit? Many years ago a military study indicated that on a 17 second cycle, approximately 3 seconds should be spent inside the cockpit with 14 seconds spent looking outside. That's approximately a 1 second inside to 5 second outside ratio. These are good numbers to follow.

Looking outside the cockpit is one thing; knowing how to look, another. Scanning for traffic requires that you understand another peculiarity about the eye: objects are difficult to detect when the eye is in motion. Effective scanning requires the eyes be held still for a very short time to detect objects. Perhaps the best way to scan is to move your eyes in a series of short, regularly spaced movements that bring successive areas of the sky into the central visual field. The FAA suggests that each movement should not exceed 10 degrees with each area being observed for at least 1 second to enable detection, as shown in Figure 10.

SCANNING THROUGH 360 DEGREES



Effective scanning assumes that you'll scan 360 degrees for traffic. Starting at the rearmost window, scan in a clockwise direction until reaching the right rearmost window. Sometimes it may be physically difficult to turn your head in a rearward direction. If so, make right or left turns to effectively scan the rear of the airplane.

Since the brain is already trained to process sight information presented from left to right, you will probably find it easier to start your scan from over your left shoulder proceeding to the right across the windshield, as shown in Figure 11.

Whatever you do, don't forget to scan the area behind you. Many years ago an AOPA (Aircraft Owner's and Pilot's Association) study indicated that the majority of midairs occur with one aircraft overtaking another (one study indicated that 82% of the accidents occurred this way). Obviously this is a faster aircraft overtaking a slower one. This becomes a greater concern when you're operating in an area where fast and slow aircraft mix. Scanning the rear quadrants may take some neck bending or turn-

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James Arness
Richard Bach
F. Lee Bailey
Howard Baker
Jacinda Barrett
Dirk Benedict
Chris Boniol
Jimmy Buffet
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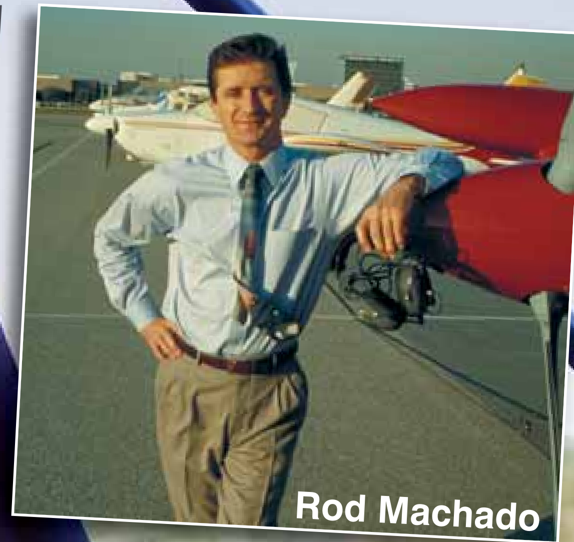

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