

As the Gyro Spins



Behind the Curtain of the Steam Gauges

A show of hands, please. How many of you have ever had a computer crash? Oh, wait. That's too many hands up. Let's ask another way: How many of you have *never* had a computer crash?

Really? Nobody?

OK, that's the reason we'll have backup "steam gauges" in our glass cockpits for a long time to come. While modern avionics are amazingly reliable, failures — even total failures — do happen. So when was the last time you gave your traditional flight instruments much thought?

You probably remember that steam gauge instruments run primarily on two systems, one using air pressure, and the other using gyros that might be spun by electric power, engine-driven vacuum pumps, or simple venturi systems. But if you had a really bad day and lost all your modern toys and some of your old-school backups at the same time, while your head (and your airplane) was in the clouds, would you remember what instruments share which systems?

What goes wonky if the vacuum system fails? What would it look like? How fast would it happen? What instruments are offline and which still work? What if a bug smashes into your pitot tube? What primary instruments are affected, and how do they read? Do you remember which traditional instru-

ments share juice with the modern computerized panels that are becoming increasingly common in general aviation aircraft?

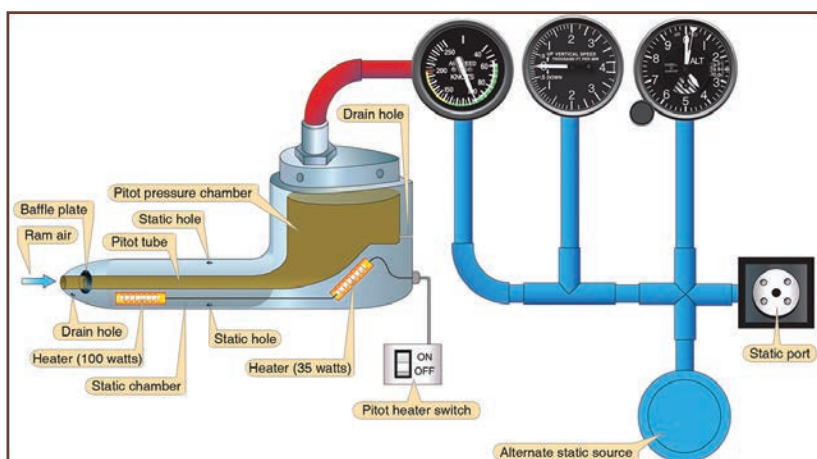
Let's preflight that old panel and review the drivers behind the dials.

The Pressure Instruments

Your plane's pressure instrument system, more correctly called the pitot-static system, is powered by measuring air pressure. The dials on the panel that are driven by this system are the airspeed indicator, the altimeter, and the vertical speed indicator. You can remember that these instruments are a single family by the fact that they all resemble each other: They have clock-like dials with hands. The remaining three instruments in the traditional six-pack have a more graphical appearance with miniature airplanes on them.

Your airspeed indicator is the only one of the three pressure instruments that uses the whole system, and it works by comparing air entering the pitot tube to air from a static port outside of the slipstream. The altimeter and vertical speed indicator only use the static system.

Failures of the pitot-static system come in three flavors: Blockage of the pitot, blockage of the static port, or blockage of both.



A typical electrically heated pitot-static head.

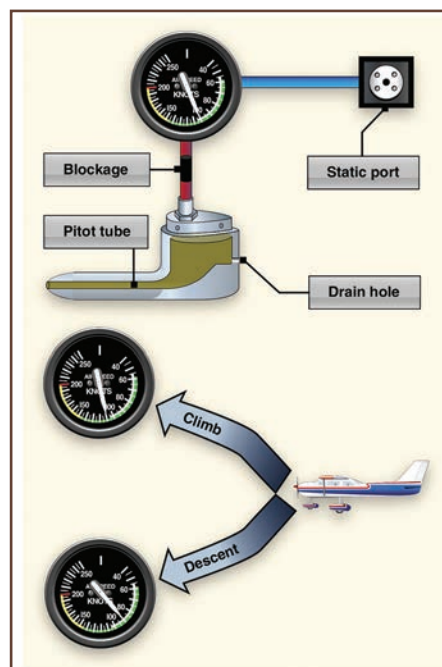
Plugged Pitot Tube

The most common causes of pitot tube blockages are insect impact, icing, and leaving the bright red “remove before flight” pitot tube cover on the tube during preflight.

Pop quiz: Regardless of cause, if the pitot tube is blocked, which pressure instruments fail?

Answer: Only the airspeed indicator. It’s the only instrument in the plane that actually uses the pitot tube. The other two pressure instruments rely solely on the static port.

In one of the common causes of a blocked pitot tube, a bug impact in which the forward facing part of the tube is blocked but the drain hole in the back remains clear, the airspeed



Blocked pitot system with clear static system.

shown on the indicator rapidly drops to zero as the system de-pressurizes. Recognizing what has happened is a no-brainer. But a blockage from icing is more insidious. Icing on the forward opening of the pitot causes a slow-motion failure, showing falsely dropping airspeed as the pitot is strangled off by the building ice.

On the other hand, in the case of icing where *both* the pitot and its drain hole get blocked, the airspeed indication stays constant

in level flight, but it works in reverse of what you’d expect with changes in attitude. It “increases” in a climb and shows a slowing airspeed in a descent, as the air trapped inside the system turns the airspeed indicator into a crude altimeter.

While the airspeed indicator is the only instrument that uses the pitot, it also needs the static port, so it — along with the other two pressure instruments — can be affected by a plugged static port.

Plugged Static Port

The most common cause of a static port blockage in-flight is airframe ice, while on the ground a static port can be blocked by debris or wax from cleaning the plane (preventable by even a casual pre-flight inspection). A blocked static port will affect all three instruments in the family.

With a blocked static port, the altimeter will remain “stuck” at the altitude the blockage occurred, the VSI will always show zero, and the airspeed indications will be inaccurate: Reading lower when operating at an altitude above where the blockage happened and reading faster when operating below the altitude of the blockage event.

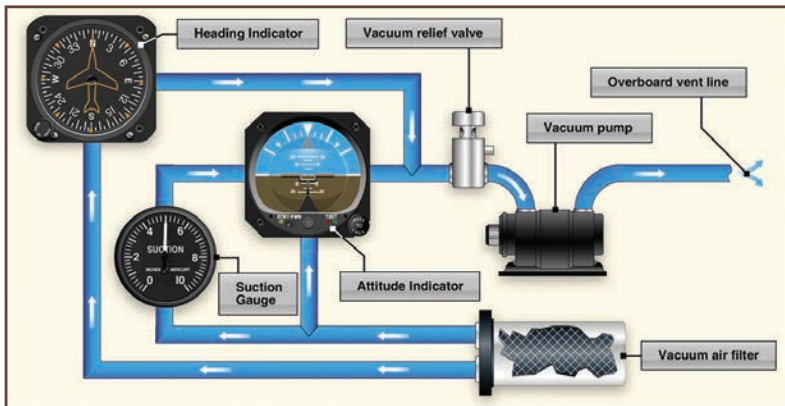
Blockage of Both the Pitot Tube and the Static Port

Ice build-up on both the pitot and the airframe is the only likely cause of total system failure. When the whole system freezes, all three instruments freeze as well. The altimeter won’t budge, and neither will the VSI. Only the airspeed indicator will change, but only with a change in altitude, showing a mind-fuddling increase of speed if the plane rises and a drop in speed if the plane descends.

The Gyroscopic Instruments

Your plane’s gyro instruments are individually driven by rapidly spinning gyroscopes mounted inside each instrument. The dials on the panel that are driven by gyros are the attitude indicator, the heading indicator, and the turn coordinator. All of these instruments commonly have small airplane graphics on them, and you can use this fact to remember that they are all part of the same system.

The gyros inside each instrument are “spun” by air from a vacuum pump or a venturi system, by electricity, or (in most planes) by some combination of the two. This creates a mind-boggling number of possible failure configurations, but it also makes it unlikely that you’ll lose all three instruments at once. But when the gyro family starts to squabble, it’s important to understand how each gyro in your



Typical vacuum system.

plane is being spun so you know which ones to trust.

Gyro System Failures

The air supply to the gyros that run on a vacuum system can be stopped in a number of ways. Vacuum pumps fail. In fact, the modern “dry” vacuum pumps common in much of the GA fleet have such a reputation for early catastrophic failure that many airplane owners periodically replace them before the end of their warranted service life. But beyond that, lines and filters can get clogged. Hoses can rupture and instrument case seals can leak. If you’re paying attention, regardless of the cause, you’ll notice the problem on your suction gauge that monitors the pressure in the vacuum system.

A total vacuum system failure will cripple all the air-powered gyros, most commonly the attitude and heading indicators, but a partial blockage resulting in low pressure may leave them functioning but inaccurate.

A total or partial electrical system failure will knock out any electric gyros, most commonly the turn coordinator — although some light airplanes have electric attitude indicators as well. Oh, and while we’re on the subject of the turn coordinator, it’s worth noting that the “ball” that indicates rudder coordination (more properly called the *inclinometer*) does not rely on the gyro, or power, and will still function properly if the instrument or its driving system fails.

But regardless of power source, gyro failures have one thing in common: They fail in slow motion. If the “fuel” behind the spin is cut off, the gyro slowly spools down and the instrument becomes progressively more inaccurate. Gyro failures are not immediately apparent in many cases, and are often recognized only when discrepancies among the primary flight instruments are noted.

Individual Gyroscope Failures

It’s also more than possible for an individual

gyroscope to fail independently of the system spinning all the gyros. Most gyros in general aviation aircraft spin at a mind-boggling 18,000 rpm. Their bearings can — and do — wear out, ultimately causing the instrument to fail. And just like total system failure, it can be difficult to recognize the problem at first. Even a gyro instrument that suddenly stops is likely to indicate its last status. There’s nothing to point out its failure until the plane

changes pitch or bank.

Tying it All Together

Failures of either the pressure or gyro systems are often slow and subtle. Sometimes they simply freeze an instrument in place where it’s “supposed” to be. In either case, scanning your instruments to see if they are all telling you the same story is often the only way to recognize the problem.

Even in a modern glass cockpit, your scan should include the back-up steam gauges, and the steam gauges should be telling you the same story the expensive glass is. If not, something has failed and you need to correctly ferret out which instrument, or system, is out to ruin your day... not to mention your flight.

And, should that cockpit computer crash at the same time your steam gauges can’t agree on what the airplane is doing, take the time to work the problem in your mind. First compare your “clock” instruments to your “graphic airplane” instruments. This is comparing your pressure system to your gyro system.

Think about the clues each instrument is giving you, and think about what systems they share. And remember that a cockpit isn’t a democracy where you can just count the votes and declare that the greatest number of instruments that show the same thing prevails. A failure of an entire system can affect the whole family. Sometimes the lone dissenting vote is the right one. But if you remember to think about the boilers that drive your various steam gauges, you’ll be ready for anything that fate flies your way. ✈️

What goes wonky if the vacuum system fails? What would it look like? How fast would it happen? What instruments are offline and which still work?

William E. Dubois is an aviation writer whose work appears in a wide variety of aviation publications. He is a commercial pilot and ground instructor, has a degree in aviation, and holds a world speed record. He blogs his personal flying adventures at www.PlaneTales.net.

Headquarters Hangar Flying

An Interview with FAA Deputy Administrator Michael Whitaker

Michael Whitaker was appointed Deputy Administrator of the FAA in June of 2013. His background in the airline industry, working for both TWA and United Airlines, has provided an excellent foundation for understanding the complex and dynamic world that makes up aviation transport. He and Administrator Michael Huerta are the FAA leaders ultimately responsible for ensuring the safe and efficient operation of our National Airspace System.

The *FAA Safety Briefing* team got the opportunity to sit down with the Deputy Administrator (and newly certificated private pilot) in late June. We wanted to know more about his thoughts and challenges in obtaining a private pilot certificate, his interest in pursuing an instrument rating, and his ideas and visions for the future of GA.

How do you feel working for the airline industry prepared you for your role as Deputy Administrator?

My time with the airlines, about 20 years in all, gave me a pretty good understanding of the airline business — how hubs operate and the major economics of the industry. This helps me to understand aviation transportation, and how important it is, as a whole.

What made you decide to pursue a private pilot certificate?

I wanted to better understand the air traffic system and how it is integrated — it now makes a lot more sense. I also wanted to understand GA better. The accident rates are much higher [than commercial] and I wanted to understand the pressures that might lead pilots into bad situations.

Now that you have been through the ground and flight training, tell us what your experiences were working towards your private pilot certificate.

One thing that struck me was that you have to learn a lot of different technologies. Some are considered a bit obsolete, while others are more advanced. Regardless, when you take the practical test you have to know and operate them. I intentionally wanted to learn on an older aircraft with steam gauges because I wanted to understand the older technologies and be able to contrast them with the newer.

The process you go through to get your private certificate is pretty extensive; there is a lot of stuff you have to know and each thing has to build on the last. It can feel like a pretty big barrier to getting what you want.



FAA Deputy Administrator Michael Whitaker shortly after his first solo flight.

Photo by Dave Frostbutter