(Continued from previous page)

the Lycoming distributors contacted have used one. Lycoming SI#1254 discusses the use of a Gates tensiometer, P/N 150, for use in tightening the narrow V-belts used in air conditioned Navajos.

Target tensions using this tool range from 66 to 104 pounds, depending on the belt part number. These are the same kinds of belts identified in Piper SB#903A.

The Gates tensiometer is also difficult to find but the good news is that SI#1254 also gives criteria for belt tension using the deflection method—something 903A does not. For the narrow belts ...cribed in SI#1254, belts deflected 0.14- to 0.16-inch at the widest expanse should show a spring scale reading of between 4.25 and 6.75 pounds.

For our little Piper belt, these figures can be used to find an equivalent deflection reading for #903A. We would recommend the belt be deflected to 0.14-inch and a reading of 5.5 pounds be used for the in-service tension on the P/N 452-572 or 73965-09 belts.

Note—always verify the part numbers for your specific plane before purchasing. The wrong part will cost you a restocking fee, so buy right the first time—use the latest parts manual.

HASSLE FACTOR

If the roulette table you're playing ...duces ten consecutive even numbers, it would seem likely that any following spins would have a greater than average potential to produce odd numbers. This "law of averages" is called the Monte Carlo Fallacy. It's called that because there is no such thing as the "law of averages."

The wheel does not know nor care what the last number was and so each spin produces a 50-50 chance of being odd or even. This is important because the narrow style alternator belt—no matter what you do—will have about a 50-50 chance of staying together for more than the 500 to 1,000 hours normally expected with V-belt life.

It is for this reason that we suggest you still attach a spare belt to the engine nose case area for ease in belt replacement the next time around.

(Concluded in page 24, third column)

Magnetic Compass 101

Everything you need to know about your magnetic compass, including the ins and outs of swinging it without frustration.

BY LPM STAFF

Do you remember the last time your compass was checked for accuracy on a compass rose? Any changes in avionics, or even adding metallic objects to the glove box may affect the magnetic compass.

Maintenance work can also cause weird things resulting from placement of magnetic metals (ferrous screws/bolts) near the compass. Even running of wires under a cowl-mounted compass can cause magnetic interference such as with the installation/removal of equipment.

OFFICIAL SWING REQUIREMENTS

The specific requirements to swing a compass are outlined in AC 43.13-1B, Methods and Procedures. It should be checked: 1) Anytime accuracy is suspected (off more than 10 degrees). 2) After any cockpit mod involving ferrous metal. 3) Whenever the compass has been subjected to shock such as a hard landing or severe turbulence. 4) After the aircraft has passed through a severe electrical storm. 5) After a lightening strike (this also may cause ferrous components in the structure to become magnetized). 6) Whenever a change is made to the electrical system. 7) Whenever a change of cargo is likely to affect the compass. 8) When an aircraft permanent location is changed to a different geographical location with a major change in magnetic deviation. 9) After an aircraft has been parked on the same heading for over a year. 10) When flux valves are replaced.

Once a compass is installed and "swung," that is adjusted for accuracy and the deviation card filled out, it may never be ground-checked again. That's unfortunate, as the magnetic compass still can bring you home when all other systems fail. It can also appear to be accurate, but only on some headings, thus leading to a false sense of security, handheld GPS notwithstanding.

Let's briefly look into the nature of the compass, the things that can go wrong, and how to take care of troubles.

We should also be aware that any compass work for certified aircraft, such as removal or replacement or swinging (other than to simply check without making adjustments) should be supervised and signed off by an A&P.

In fact, according to FAR 65.81, any repair or alteration of instruments on certificated aircraft (of which a compass is one), may only be performed by a certified instrument repairman.

During research for this story, one of the three IAs interviewed said as far as he's concerned the only legal thing he can do is remove, replace and swing a compass. He will not rebuild or even fill a compass with fluid. Filling a compass is a gray area in our view, but done incorrectly can induce bubbles in the fluid, so even this seemingly simple process has a right and wrong way to do it.

BASIC STUFF

A compass must always be kept topped off with fluid. A partially drained compass will lose accuracy, as well as contribute to oxidation of the upper pivot

UPFRONT TIPS

- Internal compass repair (other than wiring) requires a certified instrument repairman for certificated aircraft
- An A&P may swing or wire a compass. You may check it for accuracy but not make adjustments or open it
- A log entry is required for a swing or any repair—even adding fluid
- All in all, If there is any problem of inaccuracy, the most cost effective approach is simply buying a new one

bearing, making it stick or erratic.

If your compass is a field-refillable model such as the very common Airpath C2300, the correct fluid is MIL-C-5020A. Compass removal is generally very easy, but do not misplace the non-magnetic mounting screws you must use to reinstall the repaired compass.

Alcohol (hence the "whiskey" compass designation) was used at one time in compasses, but now kerosene or aliphatic naphtha is used as a rule. Smell yours to be sure. Use "official" compass fluid or the fluid may become cloudy or fade the compass lettering.

Often a compass repair kit is called for. The process is quite easy and materials cheap. Catalog outfits such as Aircraft Spruce at (877) 477-7823, (www.aircraftspruce.com), have low cost kits available.

FBOs sometimes have them as well. The broad kit availability makes one wonder about the so-called strict rule about adding fluid being the domain of the certified instrument repairman. You should still be aware of the rules, however, if you planned on doing this in plain sight of everyone around.

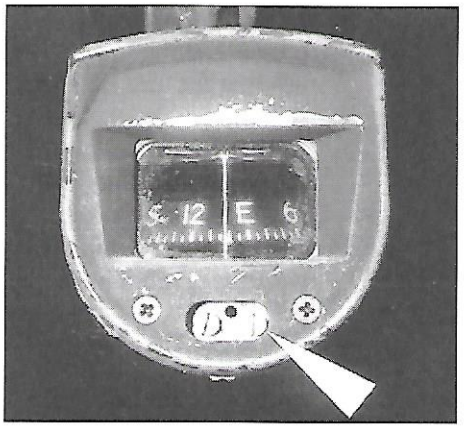
The temperatures a compass tolerates on the panel may reach 200 degrees on a hot day. The fluid in the compass needs room to expand and contract with temperature changes. The internal diaphragm provides that mechanism for expansion/contraction as well as the sealing membrane for the compass.

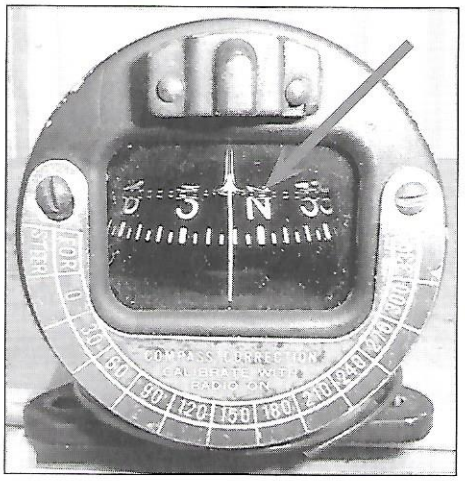
Generally, the only thing that goes wrong is the rear rubber diaphragm of the compass leaks. Typically, it takes just four small screws to expose the diaphragm on the rear compass housing.

Do not substitute any compass components such as screws, since they are all of nonmagnetic material. Second, do not pry things such as the case back apart with a screwdriver. This greatly increases the likelihood of future leaks.

Be sure you do not remove the compensating magnet screws, and do not repaint the compass unless you are positive there are no magnetic pigments.

Once the back is off and the gasket exposed, just replace the old with new. The diaphragm just lies in place, but be sure there are no wrinkles. You should also soak the new diaphragm in compass fluid prior to installation, to help assure every bit of fluid possible is in the compass ahead of time.





Above, this compass, at first glance may seem OK, but the fluid has leaked or evaporated and the compass is not airworthy. Left, adjusting screws are exposed after removal of correction card plate. Adjust with non-magnetic tools.

Be careful with the small screws as they are soft metal and easily stripped. If there is no filler plug, you will have to fill the compass with fluid at this point. Otherwise, it can wait until the compass is back together. Once the diaphragm is in place (it also serves as the gasket), snug up the screws.

With the common filler-plug type compass, the correct way to refill it completely to assure you have no visible fluid line in the window is to dunk the entire compass in compass fluid. You are much more likely to purge all air this way.

Before doing so, however, take a moment to seal off the compensating magnet chamber with sticky tape. This section should always remain dry. Don't worry about the compass slipping off the gimbal mounts, as it's securely in place.

Now submerge it in the fluid, rocking gently back and forth to expel all the air bubbles. Once you have all the bubbles purged, secure the filler cap in place while under the fluid.

Replace the compass with exactly the same hardware in exactly the same place you removed it from. A mechanic's logbook entry is required for certificated aircraft maintenance or swinging. A certified instrument repairman's sign-off may be needed as well for internal compass repair, including fluid.

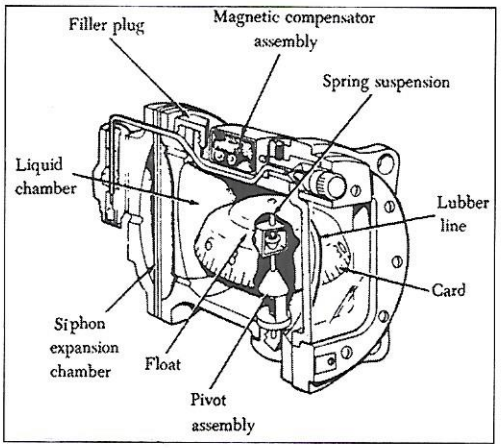
THE SWINGING COMPASS

We know of several methods to swing the compass, but will give a generalized example. A set of specific instructions should come with the compass, and may deviate from this sample procedure. You may have to contact the manufacturer of your compass if you need more information on specific compass procedures.

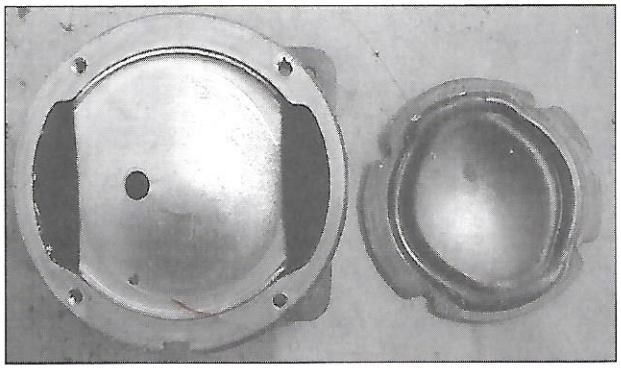
Also, a more complicated, and possibly slightly more accurate method is spelled out by example in AC 65-15A, the Airframe and Power Plant Mechanic's Airframe Handbook. The best way, however, is to follow the directions that come with the compass.

A compass rose is often located at some out of the way spot on an airport, and consists of a large compass rose painted on the cement in which you can place the airplane. The rose is oriented to magnetic north. The cardinal points are normally 30 degrees apart.

These roses are located at an electrically quiet location to minimize the likelihood of interference with the compass



Internal mechanism of common magnetic compass. Swinging a compass can be an exercise in futility as it may take a number of back and forth compromises for basic general accuracy.



The typical diaphragm chamber for fluid and the rubber diaphragm at right. The rubber can deteriorate and leak and repair kits are commonly available. Unfortunately it's only legal for an instrument repair tech to this repair for certified aircraft, despite the apparent ease.

needle (i.e. no overhead or underground magnetic interference like power lines).

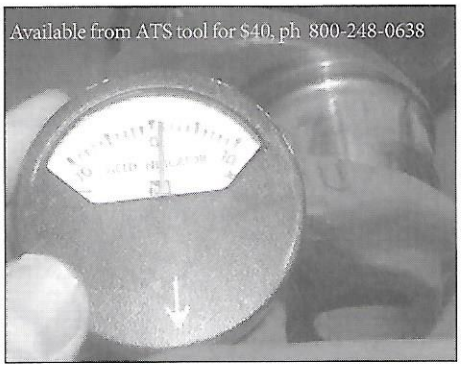
A known accurate master compass may be used for the entire swinging procedure, but a magnetically quiet area is still required. The master compass should be equipped with a sighting apparatus for accurate alignment. A helper stands outside the plane 30 or so feet away and lines up the master compass bearings with the plane center-line.

The compass must be swung with the plane in a flight configuration, meaning a tail dragger will need to be raised to a level flight attitude. The engine should be running and all typical avionics used in flight turned on.

It makes a big difference in the indications. Just watch your compass swing to a new heading the next time you start or stop the engine. AC 43.13 recommends the thorough procedure with a swing done both with all electronics on and then basic flight condition with the avionics off. A compass card should be made to reflect both.

You will need to make adjustments with a brass or other nonmagnetic screwdriver, and often a quite narrow tip is required. If you have a brazing rod, just file the end to match the slot and bend the other end at 90 degrees for a small handle.

Below is a magnetic field strength meter (photo courtesy of Sky Ranch) that is used with a degausser to get rid of residual magnetism on the airframe or engine. Right, you may need to innovate if the airport compass rose is not official or incompletely marked. Be sure to use a compass with a sight line for better accuracy.



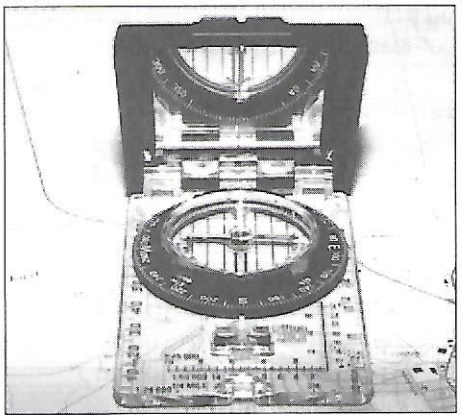
COMPENSATION

What you adjust are the compensating magnets in the compass that are designed to compensate for electrical and magnetic influences of the aircraft. (They affect deviation as opposed to the magnetic influences of the earth—variation.)

There are two screws on the face of the instrument, which move the compensating magnets. The two screws are labeled N/S and E/W. Be sure to remove any material from the glove box that could cause false readings, and remember the engine must be running for the error to be noted accurately.

First, adjust the compensator magnets until the dot on the screw head is aligned with the dot on the instrument case. Next, taxi down the compass rose N/S line very accurately—not about right, but right on the line fore and aft.

Remember to raise the tail if a tail dragger, and set the brakes/chock the wheels before restarting the engine. It wouldn't be a bad idea to have an observer to help and to commiserate with.



Adjust the N/S compensator screw until the compass reads north, 0 degrees. Turn the plane until it's aligned with the east-west line and pointing east. Adjust the E/W compensator until the compass reads east, 090 degrees.

Continue the process by turning the plane to south, 180 degrees, and go back to the N/S screw to remove half the of the south heading correction. Obviously this will throw off the north correction, but the error will now be divided equally between the two headings.

Next, align the plane on the east-west line, heading 270 degrees, and adjust the E/W screw to remove half of the west error. Hopefully, you will have done all the fiddling you need to do with compensator magnets.

Once the compass has been swung successfully, the results are recorded on a compass correction card, which is mounted next to the compass. Errors up to 10 degrees between the compass heading and a magnetic heading are acceptable.

Since the aircraft was last headed west, start the correction card with a west heading both with and without the radios on. Work your way around the rose; making correction notes every 30 degrees. Rather than zeroing out the compensator magnets, it may be faster to leave the compass adjustments as they were and try just small tweaks in the compensator screws, but with the same methodology.

DETECTIVE WORK

If the errors are greater than ten degrees, the chances are there are some strong influences in the cockpit that the compensating magnets cannot cope with, or you were not careful about lining up the plane for heading corrections.

You might try a substitute compass if available, just in case it was the compass that was not operating properly. We are only talking around $100 here, so you need to factor low parts cost into the way you solve problems, rather than paying a pro to fool with a troublesome compass.

In case of excessive heading deviations you need to turn into a detective and start checking section by section. Hopefully, you had a compass check done every time there was a new piece of

avionics or equipment installed, particularly in the vicinity of the compass. That would make the first thing to check a more logical choice.

In addition to the previously mentioned possibilities of error inducements, we have even heard of people placing four or more extremely strong neodymium magnets on their oil filter to capture stray magnetic particles in the filter.

In some cases the filter is quite close to, say, a cowl mounted compass and can cause magnetic influence. Other strong possibilities are using magnetic screws in and on the compass mounting or any fabricated magnetic steel brackets to hold equipment.

Substituting an unapproved generic replacement radio speaker with too powerful a magnet can also cause problems, as can installing an unapproved cooling fan under the panel. Small motors can generate stray magnetic fields.

If you have slack wire under the panel, and try to make things neat by coiling it up, you are making a fine electromagnet with the coils of wire. Keeping up with compass checks can largely eliminate most of these problems when equipment is added or changed. And, as always, get the proper sign-offs.

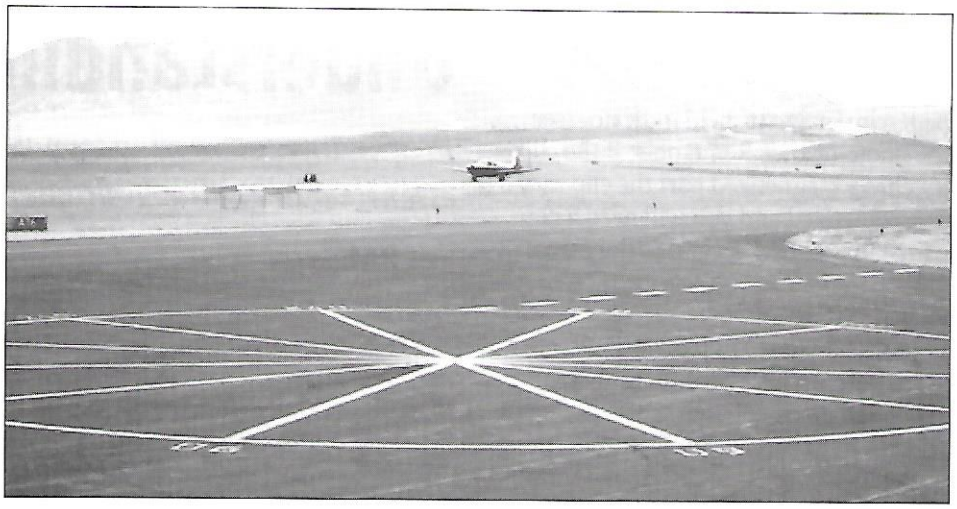
A FINAL NOTE

Before you embark on a compass odyssey, be aware that many mechanics hate dealing with swinging a compass. It sounds so easy, that it's hard to justify to a plane owner that it took several hours of frustration to improve the compass only slightly, and this can happen.

Or worse yet, a mechanic may have to suggest a new compass as the only hope at improvement. A new compass will run about $100 plus installation, and compasses can become unusable, so don't waste time on a tired model.

It is possible that you could get into a bucket of worms, particularly if the plane has had lots of less than professional work done on it. There could be stray sources of magnetism buried throughout the cabin.

You could go through the compass swinging procedure repeatedly only to find the degree of error unacceptable. Nothing will help these planes short of finding and correcting the source of the stray magnetism. Fortunately, this is not all that common—more so with tube structure aircraft like Mooneys.



A compass rose may be found at many airports. It is placed in a magnetically quite place, such as where there are no buried power cables.

A wild card is part of the ferrous structure becoming magnetized by being subjected to a strong induced magnetic field. This may come from electric welding on the airframe or from a lightning strike.

The source must be found by trial and error or the use of a magnetometer. The source then must be demagnetized (degaussed) by a device similar to those used for degaussing cassette tape heads.

Long before you get to this level of detective work be sure to rule out the old compass by substitution. A new one is too cheap to burn time on with what may be the problem—a junk compass.

DEGAUSSING EQUIPMENT RENTAL

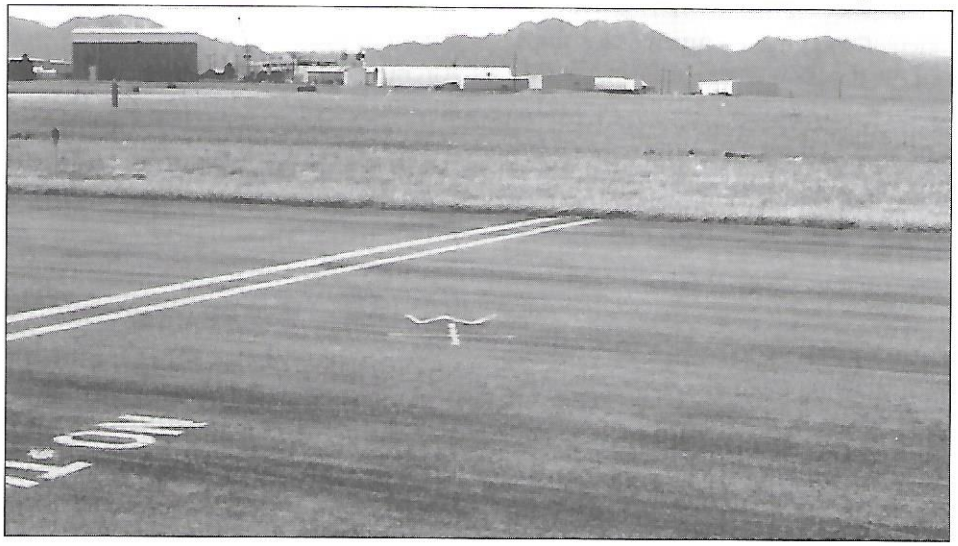
Sacramento Sky Ranch has a rental magnetic field strength meter and degausser available for about $75 a week. If you would like to do this go to: www.sacskyranch.com/degauss.htm for info on degausser rental. Ph 800-433-3564 or 916 421-7672, or email John Schwaner at: john@sacskyranch.com.

Note that degaussing only works on items affected by permanent magnetism, not induced magnetism. This latter form of magnetism is caused by the earth's magnetic field inducing a magnetic field into an iron part.

You need two tools to have a reasonable chance to get rid of magnetized parts—a magnetic field indicator and a degausser. You will also need patience.

If you want to just do a basic check of magnetic fields you can fabricate a

Some airports may have a homemade rose. These may not be reliable or have much more than a north pointer painted. You will have to use your own accurate hand held and sight line compass to make this work successfully.



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paperclip magnetic field indicator (see the photo below). Remember, if the clip touches a magnetized part the clip may be magnetized and you will need a new paperclip so bring several to the plane.

BASIC CHECKS

Is your compass OK? No low fluid, no air bubbles—check at altitude. There should be no discoloration of fluid. Pivot friction must meet manufacturer's specs.

A quick check is to deflect the compass through 10 degrees with a piece of iron/steel and then remove it to see if the indication swings back to the original position within 2 degrees. All equipment not normally carried should be removed and flight controls should be in the normal position.

Another issue is with the ground return path for the electrical system, particularly for high current devices like the starter. It's extremely important to have an adequate ground up to the task or you may have problems with the starter draw magnetizing the airframe.

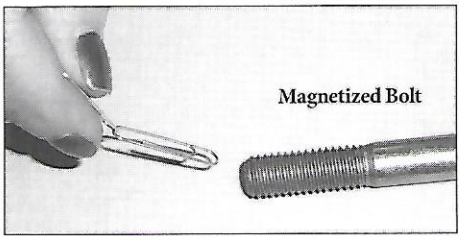
If the compass swings when you hit the starter you could well have this problem. Fix the grounds and check for magnetism with a field strength meter.

Sky Ranch also has a downloadable detailed compass deviation analyzer program that helps predict causes and locations also available on their Web site.

FURTHER STUDY

For going into compass theory, a free 46 page *Handbook of Magnetic Compass Adjustment* By the National Geospatial Intelligence Agency is available. The orientation of the document is for ships, but the theory is cross platform. Go to http://www.nga.mil/MSISiteContent/StaticFiles/Files/HoMCA.pdf.

Two paper clips can detect a magnetized part. If you touch the clip to a magnet it may become magnetized, so run it just above components.



Understanding Mag Timing

Proper internal and external magneto timing are absolute essentials in getting your engine to put out its rated power.

BY LPM STAFF

Before diving into this procedure, you need to know that timing magnetos doesn't fall under "preventive maintenance." Strictly speaking, the able assistance of an A&P is required for certified aircraft, and makes great sense for all owners checking their mags. That said, as long as you are only checking the settings and not adjusting anything, you can do this yourself to verify timing.

It should be further noted that improper application of these timing procedures can cause severe engine damage in the form of detonation, rough running, loss in power, and complete failure, thus the sensible requirement for A&P oversight.

Moreover, if the magneto internal timing is off (E-gap), you will never get optimal performance even with perfect external timing of the mag to the engine. If your engine timing shows itself to be off by more than 2 degrees, chances are the E-gap is off. An E-gap timing kit for most Bendix mags is available from ATS for $76. This article does not discuss internal mag E-gap timing.

Remember, any time the P-leads are disconnected or the mag switch is on the mags are hot! Checking timing can be dangerous if you are not very careful.

DUAL IGNITION

Aircraft engines are equipped with dual ignition systems for two reasons. The safety found in redundancy is the obvious choice but more complete combustion is the other reason. If you have a magneto that is mistimed or cross-firing, the charge can explode rather than burn (as fast as it is, combustion is still supposed to be a controlled burn).

Detonation, on the other hand, is an explosion and can be so severe that pistons can literally melt away and cylinder heads can be blown completely free of the barrel. It is for this reason that magneto-to-engine timing must be maintained within a very narrow tolerance and that both mags should be operating at their peak.

TIMING MARKS

Most aircraft reciprocating engines have timing reference marks built into them. On direct drive engines (no propeller reduction gear), the mark will be on the edge of the propeller flange. The T. C. (top center) mark on the flange will align with the top crankcase split line on most Lycoming engines.

On Continental engines, the T. C. mark on the propeller flange will align with the lower crankcase split line. These marks, when properly positioned, indicate that the number-one piston in the number-one cylinder is at top dead center. Other marks on the flange indicate degrees before or after top dead center.

Some engines have the timing marks on the alternator pulley that will correspond to marks on the accessory housing. Other engines have the timing marks on the crankshaft or some crankshaft drive gear and can be viewed by removing a plug from the crank case. The engine manufacturer's instructions will always give the location of the built-in timing reference marks.

When using built-in timing marks,

UPFRONT TIPS

- This is not preventative maintenance so get A&P supervision if anything will be changed—but you can check it.
- The "flowerpot" timing method is the one recommended and described by Continental in their bulletin
- Be very careful with "eyeball" methods as they tend to be less accurate
- For-mag-to-engine timing to be worthwhile, internal mag timing must be correct first.