KNOWING YOUR VACUUM PUMP

If your plane has gyro instruments, here's information you can use.

BY GARY R. JONES

It had been a great trip. My Q200 homebuilt airplane performed flawlessly as my son and I were about to wrap up another cross-country flight. But somewhere over Wyoming, during one of many map-foldings, I caught a frightening glimpse of my attitude indicator. Forgetting about the map-folding, I looked out the canopy and took hold of the control stick. Nothing unusual here: wings level and still heading west.

Scanning the instrument panel revealed that the suction gauge was reading zero. The suspected was confirmed: vacuum pump failure. On today's homebuilt airplanes, gyros—powered by engine-driven vacuum pumps—are common. Usually, gyro instruments consist of attitude indicators and directional gyros. Both are necessary for instrument flight. Gyros can be powered electrically, but because of cost, vacuum-powered gyros are the mainstay, making the vacuum pump the heartbeat of gyro operation.

The modern dry vacuum pump offers many advantages over its wet ancestor, which was pretty well phased out in the 1960s. A dry vacuum pump is much lighter, less expensive to build, offers a higher capacity, and requires less maintenance.

If you have ever had a vacuum pump failure, it probably happened in VFR day conditions. If not, you have a story to tell, having survived partial-panel flying in actual IFR conditions—often a harrowing cxperience. Because of the seriousness of vacuum pump failure, many aircraft manufacturers now offer backup systems for both single- and multi-engine aircraft.

It could be argued that losing your vacuum system in IFR conditions shouldn't be a big deal. Think back to your basic instrument training. Remember when your instructor used to cover the attitude indicator and directional gyro, leaving only needle, ball and airspeed? It was tough at first, but in time you improved. The problem is that after.the instrument checkride, you gradually lost the skill of basic, partial-panel instrument flying. But thinking that you will never need this skill is like believing you can forget all you learned about navigation because you have a loran receiver.

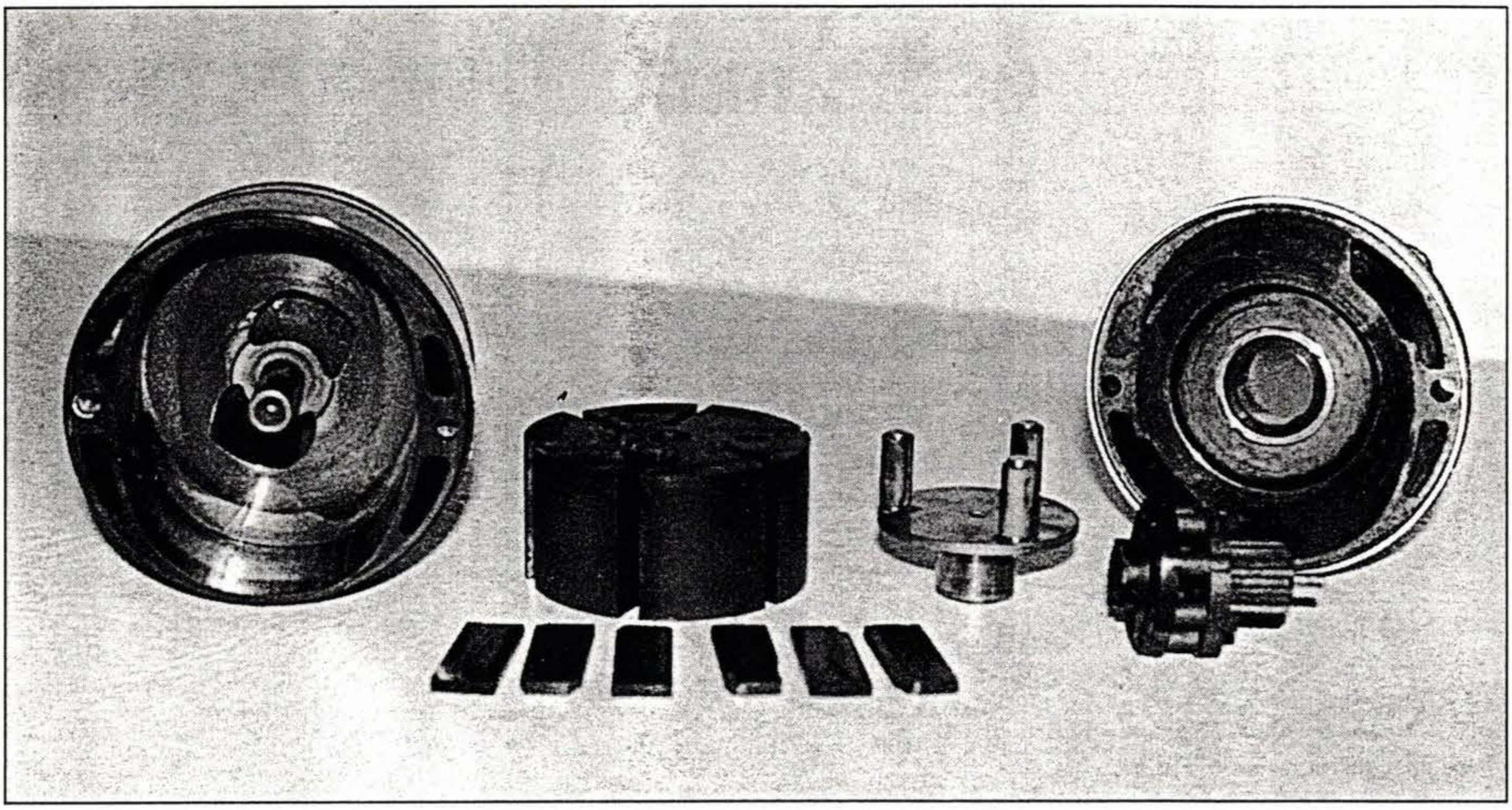
On the Continental 0-200, which powers many of today's homebuilts, the vacuum pump hangs below the engine, upside down. The problem with this installation is that gravity allows engine oil to seep past the oil seal unless the seal is in near perfect condition. Engine oil and cleaning solvents are devastating to the vacuum pump's dry carbon bearings and drive coupling.

The vacuum pump is also in a perfect position to catch any oil that might seep past the crankshaft oil seal. As with any mechanical device, dirt and heat shorten a vacuum pump's life.

How It Works

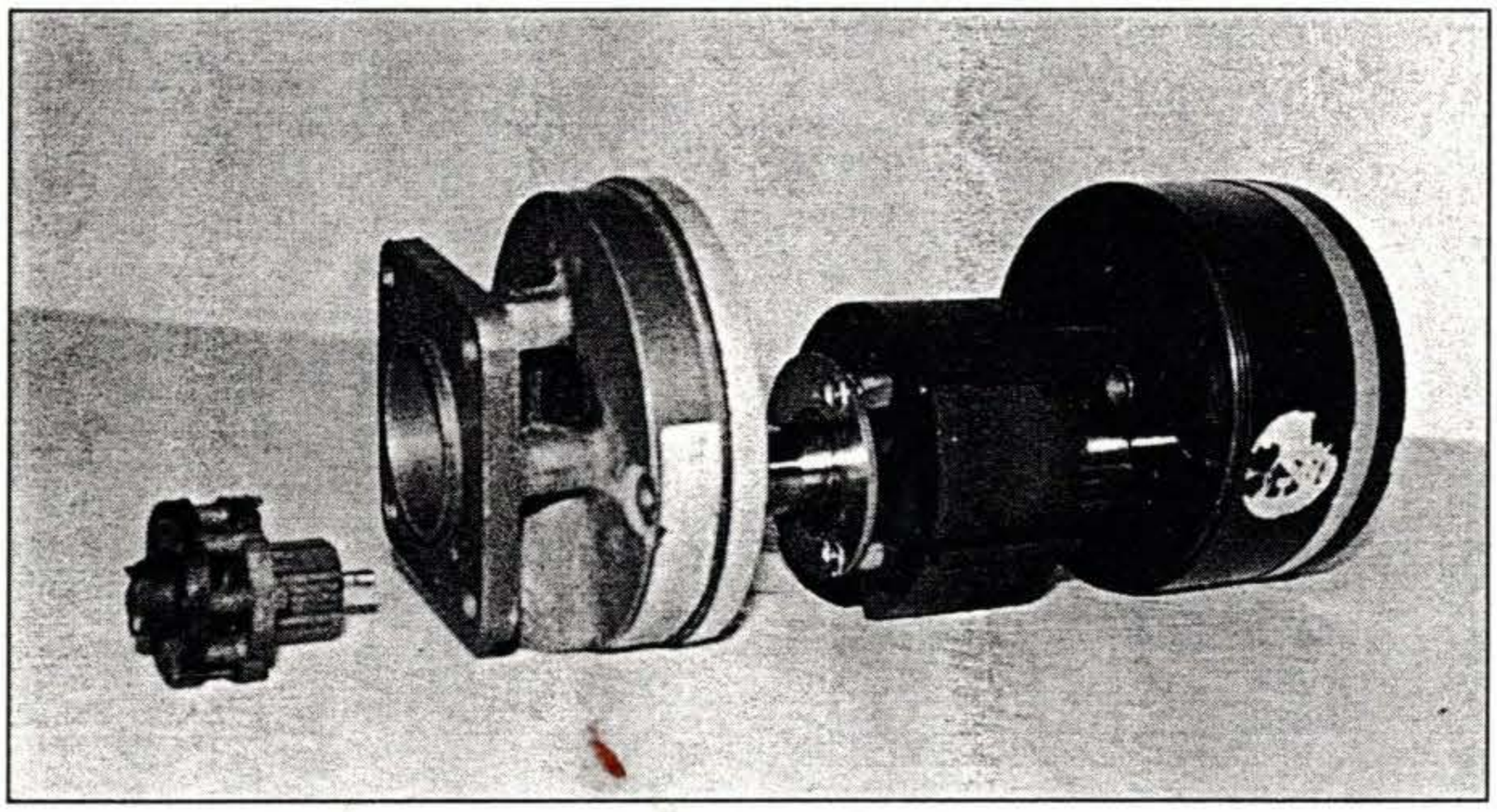
To understand why a vacuum pump fails, let's look at how it works. The first photo shows a disassembled vacuum pump. The drive apparatus to the left is actually three parts—two splines and the drive coupling—assembled as one unit. One spline slips into a pump pad on the accessory case of the engine, and the other spline slides into the vacuum pump.

The weak point here is the coupling. It is designed to fail if the pump should refuse to rotate freely. Failed, the coupling prevents damage to the accessory drive in the engine. It is important to note that the coupling should be



PHOTOS: GARY R. JONES

These parts make up a modern dry vacuum pump. From left to right: oval-shaped bore, rotor and six vanes, coupling with dowels, drive coupling and backing plate.



This photo shows the parts ready for assembly.

replaced every six years.

Next comes the vacuum pump housing. It contains a rotor, six carbon vanes, and the surface that the vanes rub up against. The carbon vanes press against a precisely ground bore made of aluminum, but the surface is hard-coat anodized to 0.003-inch thick when new. The bore is not a perfect oval as it has a defined series of scalloped ridges that dictate the displacement of the pump; the inlet portion of the developed bore has more distance between the scalloped ridges than at the discharge portion. Consequently, the tip loading of the carbon vanes varies with rotation.

Airborne, a division of Parker Hannifin, and a large manufacturer of vacuum pumps, puts every new pump through a breakin period of 5-6 minutes. This allows the vanes to wear into the bore. Lubricant comes from graphite and other elements that are added to the vanes during manufacture.

The rotor has six slots where the carbon vanes ride. As the rotor spins, the carbon vanes slide against the inside of the housing wall bore. Over a period of time, particles from the carbon vanes can build up in the slots. This can cause the vanes to stick or in some cases, fail altogether. If one or more vanes are sticking, you will notice a drop in suction. If a vane breaks, it can cause the rotor to drag, probably causing the coupling to fail.

Effects of Time

If we examine an aircraft logbook, we would discover that the original vacuum pump (from when the airplane was new) lasted 1600-1800 hours. The second pump lasted considerably less than the original, and the third one lasted less than the second. This is because, over a period of time, the vacuum plumbing lines break down. Loose clamps, worn-out hoses and fittings are common. In addition, the oil seal located on the mounting pad becomes worn, allowing engine oil to attack the dry carbon bearings and coupling.

All of these problems slowly overload the vacuum pump.

Adjusting the Vacuum Regulator

Once the vacuum regulator has been adjusted on a new system, it shouldn't ever have to be adjusted again. Typically, when the regulator is readjusted, you are compensating for a problem elsewhere in the system. When a decrease in performance has been

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continued

detected, a thorough inspection of the lines, fittings and filters should be conducted. In this situation, readjustment of the regulator is only a temporary fix.

Turning the regulator's adjustment screw in to raise performance of the system also decreases the amount of free-flowing air through the pump. The pump will now be operating hotter than before. The vacuum pump must have a full and free flow of air through it if a full service life is to be achieved. As you probably have guessed, the amount of airflow through the pump influences its operating temperature. To drop the operating temperature farther, heat shrouds are available and are recommended by vacuum pump manufacturers. The use of a heat-sensitive sticker applied directly to the pump gives the operator a good indication what the operating temperatures are. To get good service life from your vacuum pump, the discharge temperature at the pump should be kept at 200°F or less.

More often than not, a premature pump failure is a symptom rather than the primary cause for a problem.

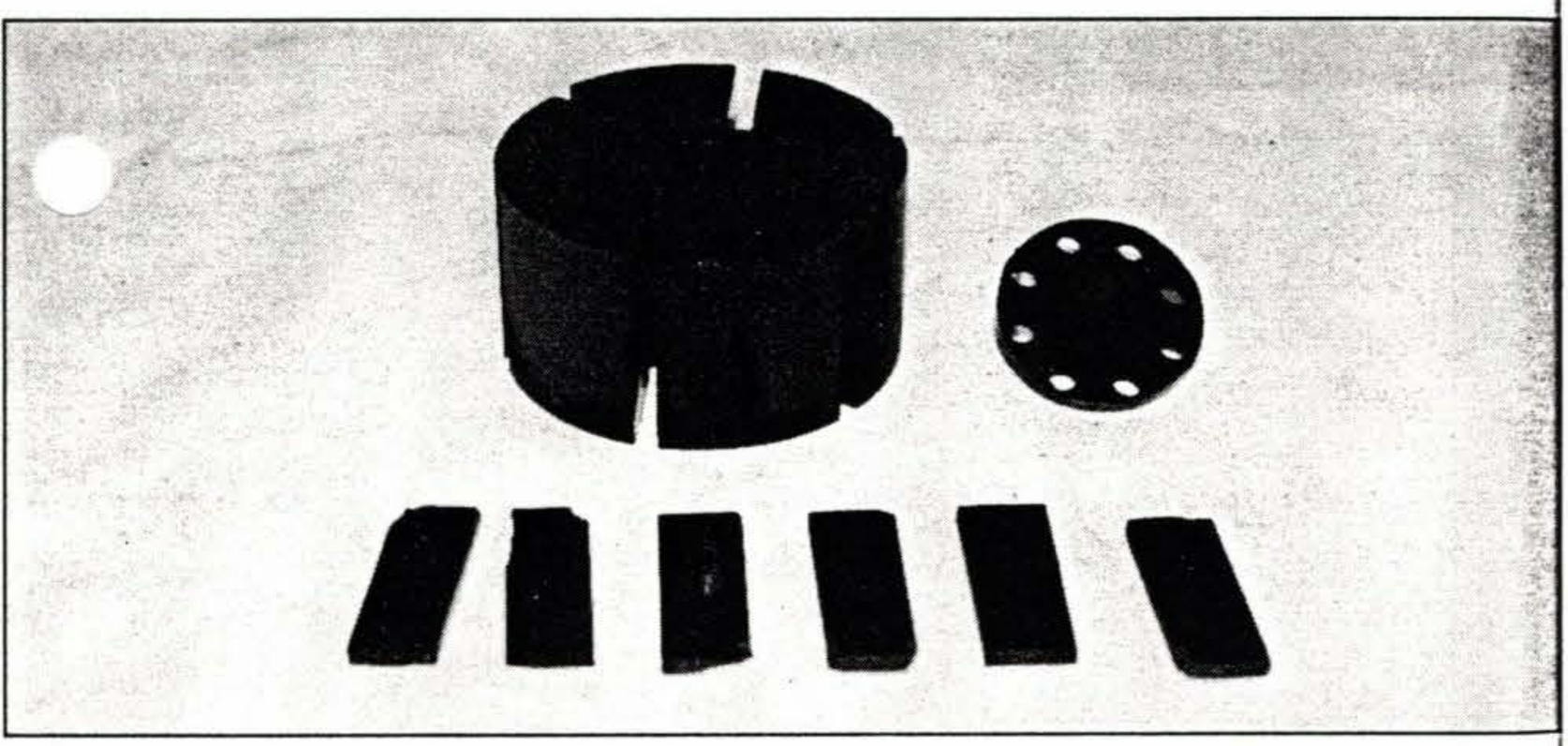
Troubleshooting

Richard Lane, product support manager at Airborne, was quick to point out that most maintenance manuals are woefully inadequate at troubleshooting vacuum systems, and he offered some tips for the homebuilder.

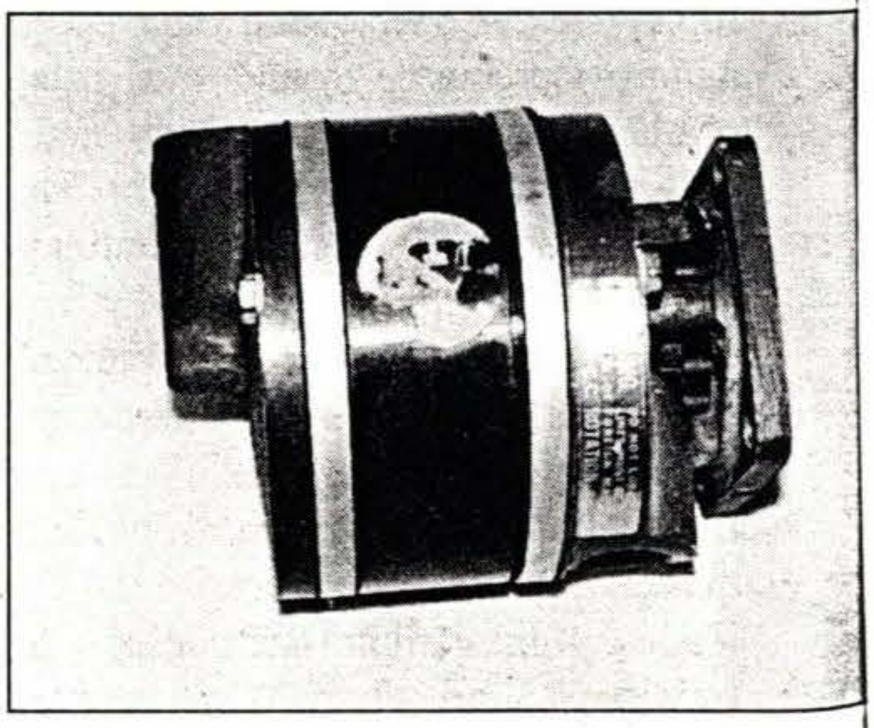
The next time you perform an inspection, look at the discharge line coming from the vacuum pump. A small amount of black powder is normal, but if there is a significant amount, your vacuum system is being overloaded or it's operating too hot. It's also an indication that your vacuum pump has just about reached its service life.

The black powder is coming from either the carbon vanes, carbon rotor or both. It is important to note that assuming a normal wear rate, a dry vacuum pump works right up to time of failure with little warning to either the pilot or maintenance personnel.

Another tip: If you are experiencing one pump failure after another, look to see if you have the proper pump. For example, if the pad drive on the engine accessory case is turning clockwise, a clockwise rotation of the vacuum pump is needed and vise versa.



A vacuum pump overhaul kit includes a new rotor, drive coupling and a set of vanes.



Back together, the newly overhauled pump is ready for installation.

Third, if the suction gauge varies with engine rpm, there is foreign matter under the regulator seat. To correct this, use a thin blunt tool to raise the diaphragm and remove the contaminant. If no contaminants are found, the vacuum regulator is probably bad. In addition, freshly overhauled pumps or pumps that are reaching the end of their service life exhibit this malfunction.

Know that the panel suction gauge is only telling how much vacuum is being applied at the gyros. It is not telling how hard the vacuum pump is working to generate the vacuum.

Choices

When the time comes to replace the vacuum pump, the homebuilder has three choices. A new pump can be purchased ($400+), the worn-out pump can be exchanged for a pump that has been overhauled by a certified repair station (approximately $230), or the builder can overhaul the failed unit himself ($70 for parts).

Before allowing cost to sway your decision, consider these findings. Experienced mechanics and manufacturers recommend purchasing a new pump if the airplane is going to be used for regular instrument flight. The other two options should be considered if instrument flight is something of a rarity.

Rebuilding Your Own

For several reasons, I chose to rebuild my worn-out vacuum pump. The repair kit includes instructions, rotor, drive coupling and six vanes. The entire project took approximately 1 hour and it was easy. When the vacuum pump was reinstalled, the setting of the vacuum regulator had to be reduced, and this is normal if someone has increased vacuum to compensate for an aging pump.

Thanks to Richard Lane of Airbornem for his assistance and willingness to share his many years of experience. ❑

FOR MORE INFORMATION, contact Airborne Division, Parker Hannifin Corp., 711 Taylor Street, Elyria, OH 44036.