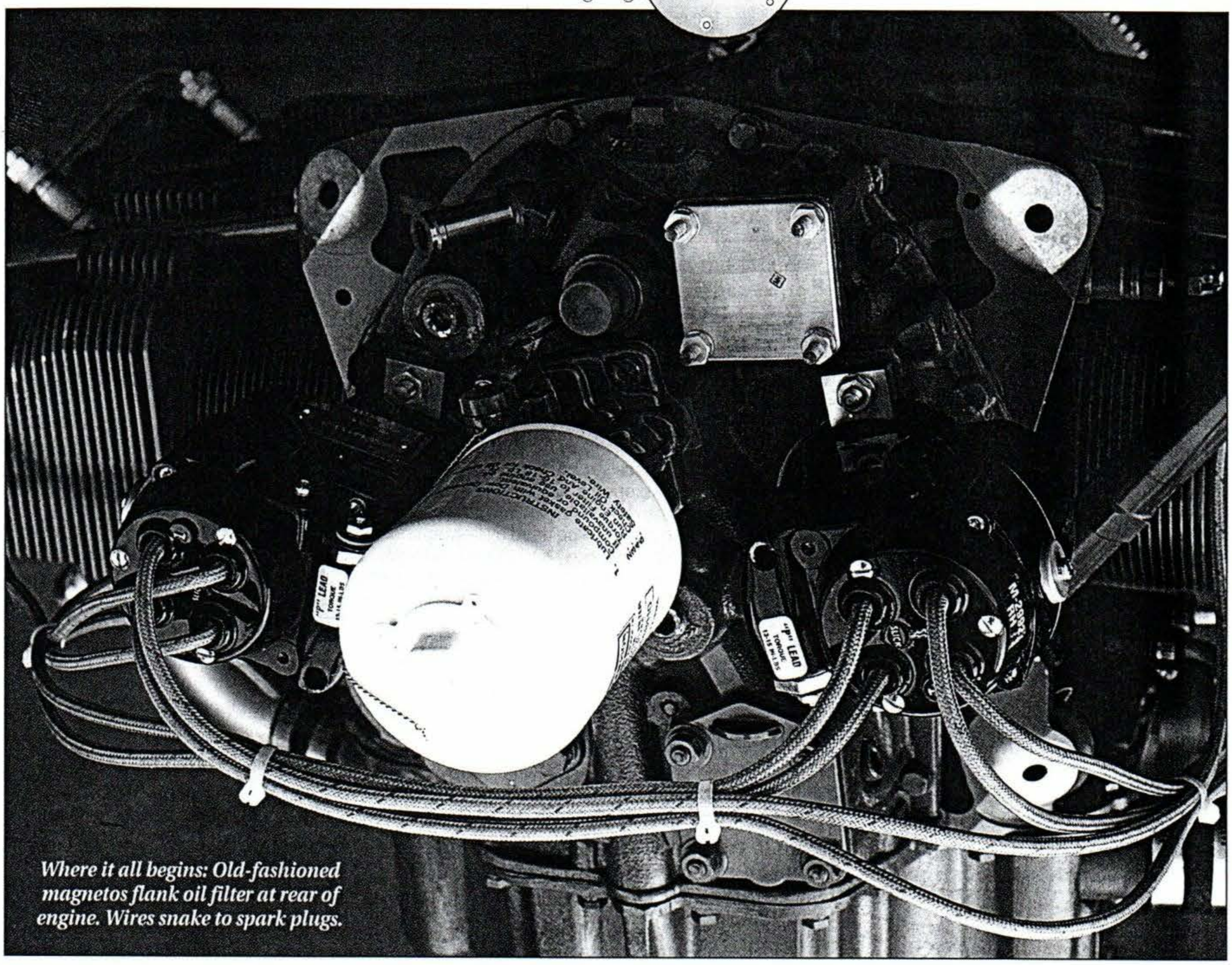


Where it all begins: Old-fashioned magnetos flank oil filter at rear of engine. Wires snake to spark plugs.

SHOCK TREATMENT

Inside the ignition system

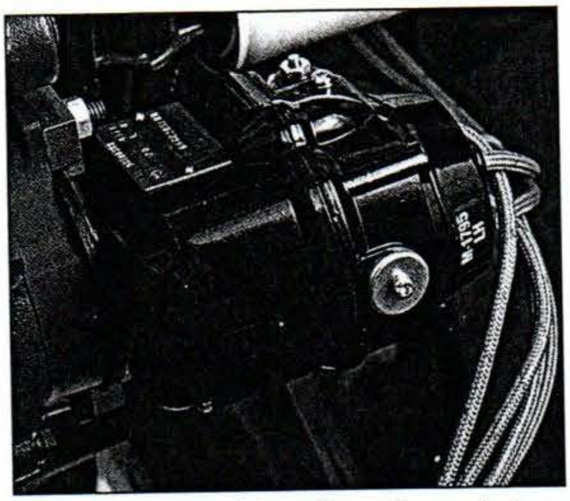
BY MARC E. COOK

There's hardly anything on modern airplanes that seems to cause as much head-scratching as the ignition system—except, maybe, the electrical system. (And that's a topic for another time.) Many an owner and mechanic has cast aspersions at the familiar old spark makers, whether the ignition components merely act up or quit cold. Many pilots wish for the day when fully electronic ignition becomes common on aircraft, replacing the magneto once and for all. Experimental aircraft regularly fly with electronic ignition these days, with good results; also, don't forget the Porsche/Mooney PFM had a modern ignition setup, too. ■ What troubles we have with magnetos are, according to many maintenance personnel we have interviewed, self-inflicted. The technicians say that pilots often assume the magneto and ignition leads ought to last to the engine's recommended

PHOTOGRAPHY BY MIKE FIZER

time between overhauls or longer. Put simply, the mags just don't have that kind of lifespan, at least not without interim inspections and periodic parts replacement. This attitude typically leads to the ignition system receiving little or no attention until something nasty happens.

In discussions with engine overhaulers, we have heard many tales of magnetos showing up that hadn't been opened up since bell bottoms were in style—the last time. We also visited with John Schwaner, of the Sacramento Sky Ranch. Schwaner has literally written the book on magnetos and ignition systems, called, not surprisingly, *The Magneto Ignition System.* At his Sky Ranch post, Schwaner has seen scores of mags come through the shop, virtually begging for attention. He's seen charred coils, breaker points whose contacts look like the surface of the moon, and impulse couplings on the verge of self-destruction. "If these had been opened up every 500 hours, we would have a lot less work to do here," he says, surveying a pile of magnetos on the workbench. It is worth noting that Schwaner still sees magnetos come through containing parts that should have been replaced under an airworthiness directive two decades ago.



Magnetos are driven from the engine's accessory case. Here, 4000-series Slicks.

Speaking of which, Schwaner says that too much has been made of a recent AD on Bendix mags calling for replacement of certain coils and rotors. He points out that most of the parts mentioned in the AD should have been replaced when a 1973 AD was published. The AD applies to all Bendix models except the D-2000 and D-3000 dual mags.

Before launching into the trials and tribulations of life as a magneto, some description of the components is in order. At the heart of it, a magneto is a very simple device. Among the mag's virtues is that it provides its own source of electrical energy, rendering it independent of the aircraft electrical system. For most mags, the only connection to the airframe, the P-leads to the ignition switch, acts to stop the supply of sparks, making possible shutting down the engine (that's how it was done before mixture controls became common) or removing a misfiring mag from service in flight.

Magnetos are driven from the engine's accessory case, often at the back of the powerplant. Sometimes the mags are located atop the engine cases, with the leads facing forward; they are still driven by the same accessory gear set as rear-mounted mags. Gearing rotates the magneto's rotor shaft at engine speed on four-cylinder models and at 1.5 times crank speed on sixes.

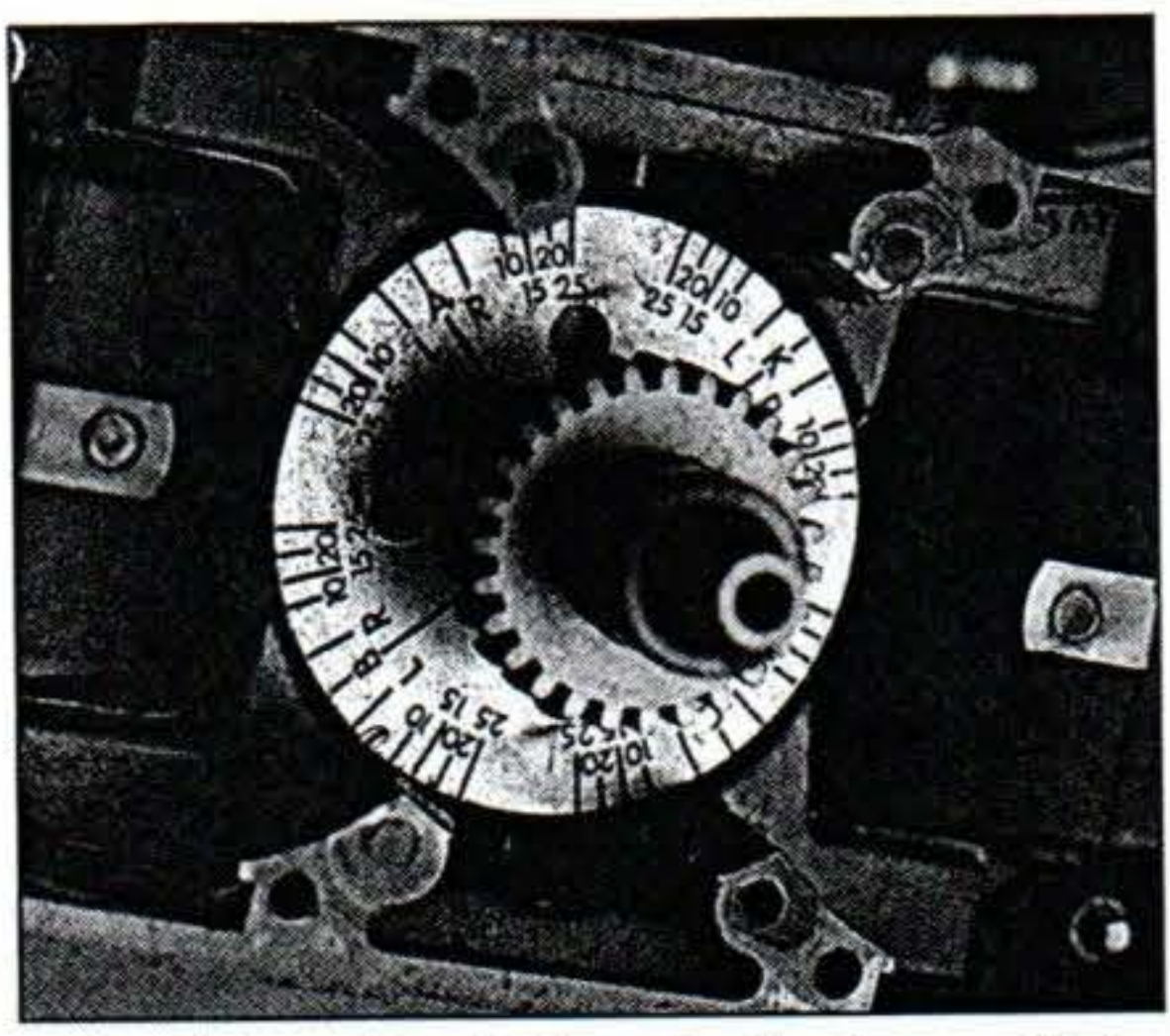
On the magneto's drive shaft is a circular permanent magnet or magnets and a rotor cap, similar to an automotive distributor rotor, which routes high-voltage pulses to the individual spark plug leads.

How is this voltage generated? As the magnets on the rotor shaft spin, they set up a magnetic field in the coil, which is located directly adjacent to the rotor inside the magneto housing. The coil contains wires wrapped around a laminated iron core in two circuits, primary and secondary. On the primary side, there are 100 to 200 turns of wire separated by an insulating layer from the secondary winding; the primary side is closest to the iron core. Typical coils have about 15,000 turns of wire, finer than a human hair, in the secondary winding.

As the rotor's magnets move by the coil and the primary winding, magnetic lines of force or flux create a current flow. This current remains trapped in the primary windings until the breaker points—which we'll discuss momentarily—open. When they do, the primary coil becomes ungrounded, and this causes the magnetic field to collapse, sending a surge of energy through the secondary windings. This energy is multiplied by the ratio of the number of turns of wire in the primary and secondary windings. That's how you start with 200 volts from the magnet's movement and get 20,000 volts going to the spark plugs.

Inside the mag, the rotor cap directs the voltage to the appropriate spark plug lead. These leads, which on virtually all modern aircraft are insulated with a braided steel jacket, snake around the engine to the spark plugs. When confronted with the gap between the plug's center and encircling ground electrodes, the voltage jumps the gap, creating a spark.

We have been discussing single mags, and there is yet another type, called the dual mag. This is essentially two ignition sources in one housing,



The drive side of a Bendix dual mag. Note timing marks inscribed on rotating magnet.

sharing a four-pole magnet and a single drive shaft. Among the advantages of a dual mag are fewer total parts and a smaller installed package. Two models have been produced by Bendix, the D-2000 and the D-3000. The dual mag was factory fitted to several four- and six-cylinder Lycomings in the 1970s. If the last letter of the engine model is "D"—a Lycoming O-320-H2AD, for example—you have a dual mag. Schwaner isn't particularly fond of the 2000, although he says that the 3000 is a very good magneto, capable of long life if properly maintained. He thinks the bad reputation of the dual mag belongs only to the 2000.

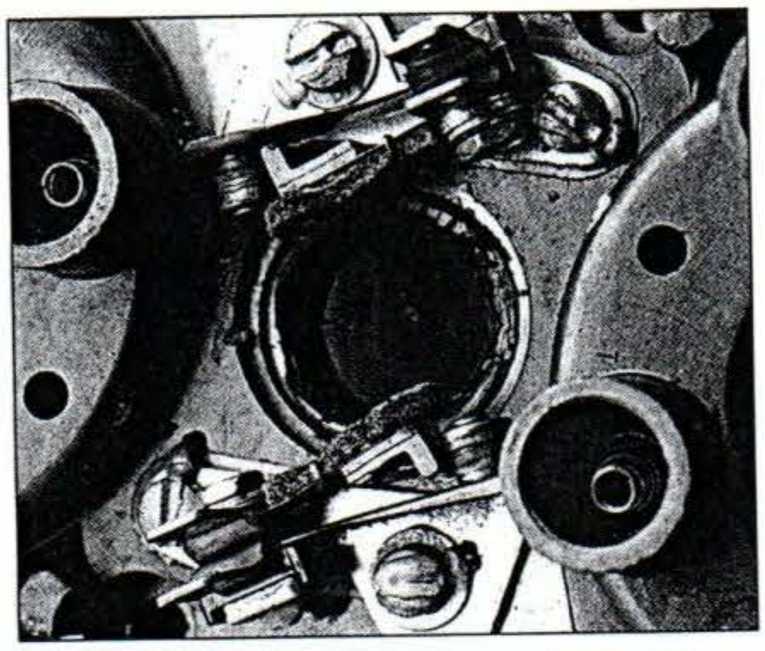
It's worthwhile to note that in magnetos, aircraft owners have the opportunity to choose from different makes. In most cases, Slick and Bendix brands of magnetos are interchangeable and can legally be swapped. This allows for some price competition among the two current mag makers. Bendix is now owned by Teledyne Continental.

So what's likely to cause an owner or mechanic ignition system grief? Poor starting appears near the top of the list. Engine starting requirements point up the mag's primary shortcoming. Its voltage output is dependent upon engine speed; the "coming in"

speed is the lowest engine speed at which the magneto will produce useful sparks. At cranking revs, the output is quite weak (when the engine most needs a strong spark), and it comes at the wrong time. For starting, the engine needs spark timing to be retarded significantly, something the basic mag cannot accommodate because its timing is fixed.

Two systems have been used to ease starting. Most common is the impulse coupling. This is a purely mechanical setup using spring-loaded weights and a clutch mechanism between the engine and the magneto proper. As the engine begins to crank, the coupling allows the mag's rotor shaft to lag behind and then, like a slingshot, rush ahead. Such monkey motion accomplishes two things: It allows the mag to get up to speed, and it delays the timing of the spark. Once the engine starts, the flyweights in the coupling positively lock the mag to the correct engine timing.

It's a good and effective system, but there are maintenance considerations. Parts in the couplings, specifically the pins that hold the flyweights in place, can wear. Reaching the extreme, the twirling flyweights can come in contact with the mag housing, causing a catastrophic failure and, possibly, metal chips on a journey through the engine's innards. Inspection of the impulse couplings should be accomplished during the annual inspection or every 500 hours, says Schwaner. This is made mandatory by AD on some mags; check your engine logbook for details.



Breaker points determine when mags release high-voltage charges to spark plugs.

Also aimed at better starts is a system called shower of sparks. This uses a second set of contact points in one of the magnetos and battery current supplied to the coil to provide a late and powerful spark. This eliminates the impulse coupling and can be found on both Slick and Bendix magneto installations; the "shower of sparks" moniker was a Bendix construct.

Assuming the dedicated sub-systems function correctly, hard starting is often attributed to a weak or partially shorted coil. If, as often happens, part of the coil's secondary circuit is internally shorted, the voltage multiplication factor will be reduced. This, naturally, robs juice from the system when it's needed most.

A high coming-in speed of the magneto might also be a function of mistimed E-gap. Understand there are two types of magneto timing. One is the point at which the spark fires against crank position; the timing is generally adjusted by moving the mag on its mounting pad.

This so-called E-gap has to do with internal magneto timing. If the voltage flows through the secondary winding only when the points open, it would make sense to time this event to the moment at which the magnets, moving

st the coil, exert the maximum ener- into it. If, for example, the contact ints are badly worn or the cam that erates them is losing its lobes, the ernal timing will change. This will grade the strength of the sparks.

Pilots of turbocharged airplanes ten complain of high-altitude mis- e, which results from internal arcing the magneto or, less often, among e spark plug leads. The thinner the r, the less effective it is as an insula- r to prevent internal cross-firing; as remedy, many turbo installations se pressurized mags. Such an rrangement takes compressed air nd sends it to the mag housings. An nportant note: The mags will need irflow, not just pressure, and an ffective filtering system. Schwaner oesn't care for what he sees in some ressurized mag configurations. "You vouldn't believe the junk we find in here," he says. Contamination will, of ourse, lead to internal corrosion and ltimately failure of the mag.

Maintaining the ignition harness in good condition and keeping spark plug gaps tight will help prevent high- altitude misfire. If you have a choice of mags that includes the large Bendix S-1200 series, those may well be your answer. In the grand scheme, the larg- er the mag, and therefore the greater the air gap between individual lead contacts within the distributor, the greater its altitude ability. Earlier S-20 and S-200 Bendixes are much smaller than even the 4000- and 6000-series Slicks and are generally considered to be ill suited to high-altitude work unless pressurized.

Engine roughness during the runup generally can be divided into two categories. Roughness on one mag usually means one cylinder is not firing. Often, the spark plug is the culprit, although contamination or failure of the distributor gear or ignition leads could also be the cause. Roughness that cannot be attributed to a particular cylinder, or if the leads and plugs are known to be good, generally points to breaker point or capacitor problems. Capacitors can fail intermittently, causing roughness only during some flight regimes or at certain altitudes. If all other troubleshooting methods fail to clean up an intermittent rough mag, try replacing the capacitor. (What's it for, anyway? It helps the breaker points collapse the primary coil's magnetic field more quickly and to suppress arcing across the face of the points. An open capacitor will allow the faces to destroy themselves rather quickly.)

What about the ignition harness? Visual inspection isn't always the last word in determining its health, says Schwaner. Over time, the insulation under the steel sheathing will break down, allowing cross-firing between the conductor and the grounded shield. He recommends a new harness at overhaul time and a switch to the all-weather, ¾-inch terminals. This calls for a change of spark plug type, but the better sealing potential over the ⅝-inch terminals will be worth the slight extra cost of the swap. Any fraying of the shielding would be cause for replacement, too.

Regular inspection and maintenance of the magneto and harness system will go a long way toward reliability and, for many pilots, peace of mind. It will have to do, until the day we get electronics into the ignition game, and it's anyone's guess when that might be. □