benchwrenching PAUL GLAVES

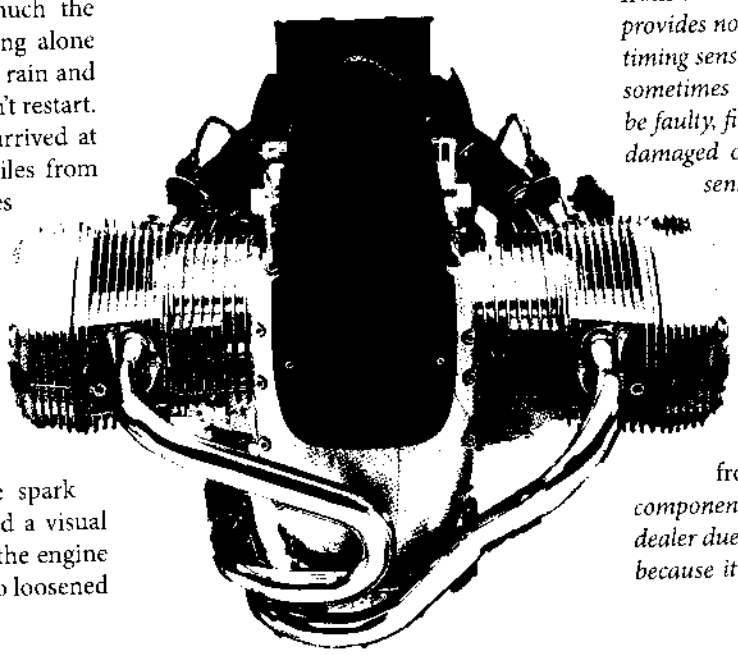
HALL EFFECT IGNITION SENSORS

As is usually the case with this type of problem, the symptoms first manifested themselves on an R1100RS being ridden in heavy rain. After exiting the highway to obtain fuel, 140 miles from home, the bike died and wouldn't restart with any reliability. It might start—it might not. It might run fine for a moment or two, or it might misfire, then run fine, then misfire some more. Some basic diagnostics disclosed that part of the time the spark plugs had spark, and part of the time the injectors squirted, and part of the time neither did either. Trying to find the source of the problem on a drenched bike, parked beside the road in a downpour didn't seem promising so my wife Voni and I rode home two-up on my bike, got the trailer and towed her bike home and put it in the shop. The next day when I proceeded to troubleshoot the problem, the bike ran fine. I did expose the Hall sensors and look at them. I did trace the wiring and clean the connections to the wiring harness. But I didn't necessarily fix the problem.

The second episode was much the same. This time Voni was riding alone on her other R1100RS, in heavy rain and wind. The bike died and wouldn't restart. She called me. By the time I arrived at her location—this time 144 miles from home and exactly four miles from where it happened to her other R1100RS the first time, this bike exhibited the same symptoms. But this time it hadn't dried out and cured itself by the time I started serious troubleshooting back in the shop. I attached a spark tester in series, between one spark plug and its wire. This allowed a visual inspection of the spark while the engine was cranking or running. I also loosened the retaining clamp on one of the fuel injectors so I could visibly observe the spray pattern as the starter was cranking the engine.

I was able to observe that when it briefly ran fine, it had good spark and squirt as would be expected. I was also able to observe that when it wouldn't run or ran poorly, it had erratic spark and erratic fuel injection at the same time. This quickly narrowed the possible causes, eliminating those such as coil or spark plug wire problems which would affect only the ignition.

Sometime during this process I noticed a faint buzzing sound—like a little bee trapped some place. It faintly sounded like a chattering relay, but not quite. It would come and go when the key was on. While trying to locate the sound I looked down and noticed the spark plug tester glowing brightly. It wasn't as steady as if the engine were revving, but it was steadier than if the engine had been at idle, and the engine wasn't turning a single rpm. Turning the key off would make things stop buzzing and glowing. Turning it back on again might allow it to do it again, but not always. While it was buzzing, disconnecting the leads to the fuel injectors stopped the buzzing.



Some of the real benefits which riders obtain from their newer BMW motorcycles come from the electronic ignition and electronic fuel injection components fitted to the engines—although, as noted above, it doesn't always seem that way. Probably every reader has uttered, or heard the lament, "You just can't do your own work on these bikes anymore.

BMW has in many ways made it simpler for the dealership technicians to work on the newer models by building diagnostic equipment into neatly packaged machines: a "hook this here and push that there" approach to diagnostics. But in so doing they have contributed to misunderstanding about the sophistication of the machines, and certainly about the serviceability of the machines.

The publishers of a widely used aftermarket repair manual can be even worse. Consider the following quotation regarding Hall effect ignition sensors from an Oilhead repair manual: *"BMW provides no resistance specification for the timing sensors, or Hall sensors as they are sometimes known. If they are thought to be faulty, first check that this is not due to damaged or broken wiring between the sensors and the Motronic control unit, or a corroded wiring connector... Other than a wiring check, operation of the sensors can only be checked by a BMW dealer equipped with the Bosch diagnostic tester."* Or, consider the following from a similar manual from a different publisher: *"This component must be serviced by a BMW dealer due to any applicable warranty and because it requires complicated electronic*

troubleshooting equipment and a thorough knowledge of the ignition system."

I was convinced that there was some sort of a problem with the Hall sensors in both bikes. Considering that these sensors have been widely used in automobiles since the 1970s, I wondered what all the service technicians in all those car dealerships all over the world did, since they were unlikely to have access to that BMW Bosch diagnostic tester. So, I started looking at the Internet web pages of ignition component manufacturers and distributors, and other web based references, and posted a description of the problem on a couple of Internet BMW Riders mailing lists. Imagine my surprise to discover that these sophisticated sensors can be tested using nothing more complicated than two small jumper wires, one readily available 12 volt light emitting diode (LED), one 9 volt radio battery, and a kitchen knife. In fact, once you have accessed the connecting plug, the sensors can be tested in place, without even the putty knife, by simply turning the engine over by hand and watching the little diode.

So, let's look at just what Hall effect sensors are, what they do, where they are located, and how to test them. In this article I am going to specifically address the sensors on the BMW oil cooled twin motorcycles, but the principles are exactly the same on the K series motorcycles, although some of the specifics are slightly different. I am emphasizing the Oilhead motorcycles because they sometimes exhibit Hall sensor problems while as far as I can tell, this is much less the case with the K series bikes.

In the most simple sense, Hall effect sensors are used on engines with electronic ignitions in place of ignition contact points. They send a signal to the ignition control unit at a predetermined point in each revolution—usually top-dead-center. The ignition module or engine control unit uses this signal to determine when the ignition coils should be fired, and in fuel injection equipped engines the same signal is used by the engine control unit to determine how often and when the fuel injectors should squirt. The Hall effect sensors are solid state electronic devices with no moving parts, and unlike points do not wear and require no routine adjustment.

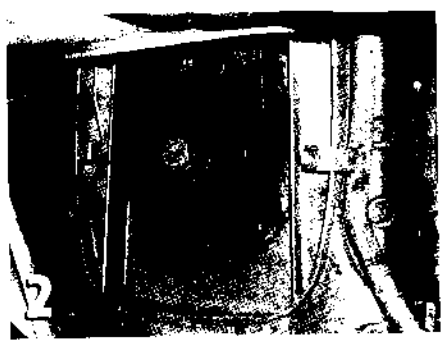
Each Hall sensor essentially has two parts. The first part creates a magnetic

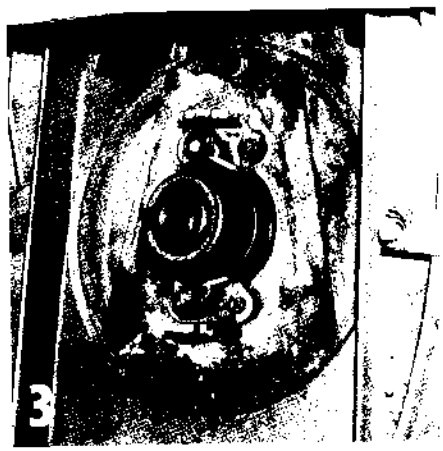
bench [illegible]

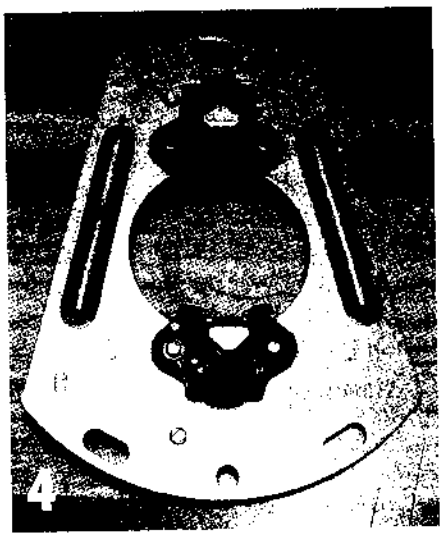
field and the second part will pass electric current only when that magnetic field is present. If a thin piece of steel is placed between the first part and the second part then the magnetic field cannot be detected and no current is passed. When the steel is removed the magnetic field is detected and current passes through the sensor. This current flow is what signals the engine control unit.

On BMW Oilhead motorcycles, the Hall sensors (there are two of them) are located behind the front engine cover, above and below the very front end of the crankshaft, behind the lower alternator drive belt pulley (Photo 1 and Photo 2). The sensors are attached to a metal plate which is bolted to the front of the engine cases centered around the crankshaft. The sensors are shown in place in Photo 3, and a new sensor set is shown on the bench in Photo 4. The top sensor


1

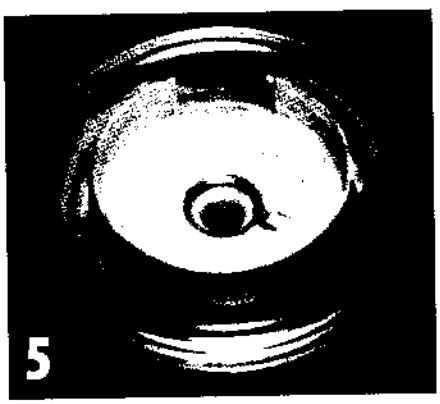

2


3


4

signals that the crankshaft is at top-dead-center. The bottom sensor signals that the crankshaft is at bottom-dead center. The Motronic engine control unit uses these signals to compute ignition timing and fuel injection.

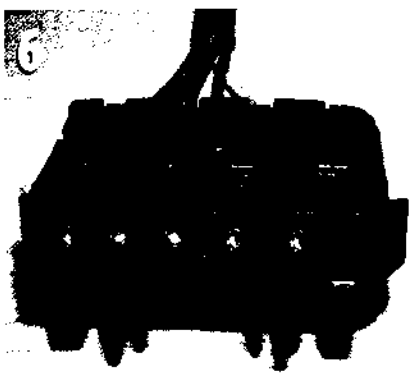
There is a slotted cylinder on the inside (back) of the belt pulley bolted to the end of the crankshaft. This slotted cylinder fits between the electro-magnet portion and the detector portion of each Hall sensor. The slotted cylinder on the back of the pulley is shown in Photo 5. As the crankshaft rotates, the slot in the cylinder moves past each sensor. When the metal cylinder is between the magnet and the detector the magnetic field is blocked and there is no current flow through the detector. As soon as the slot in the cylinder on the pulley reaches the sensor so that no metal is between the magnet and the detector, the sensor allows current to flow. This signal provides crankshaft position information to the engine control unit. One sensor signals the ECU when the crankshaft is at top-dead-center and the other signals the ECU when the crankshaft is at bottom-dead-center.


5

The 5-pin wiring harness connector

for the Hall sensor is located underneath the fuel tank. It can be located by tracing the wiring bundle up and rearward from where it runs from the front of the block beneath the alternator. The wiring connector is protected by a rectangular shroud for weather protection, which will help you identify it. From the connector one bundle of wires goes forward to the Hall sensor unit. The wire bundle from the other side of the connector goes up to the main wiring harness near the large multi-pin connector at the Motronic ECU.

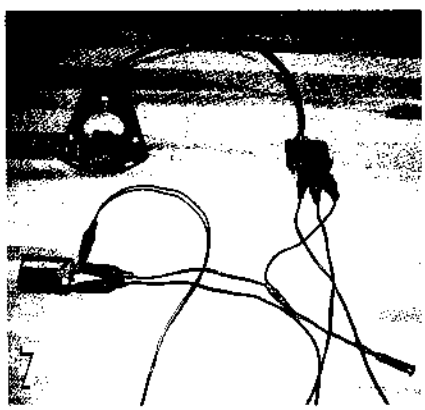
The connector on the bundle of wires going forward to the Hall sensors is shown on Photo 6. One end of the connector is rounded. The other end is

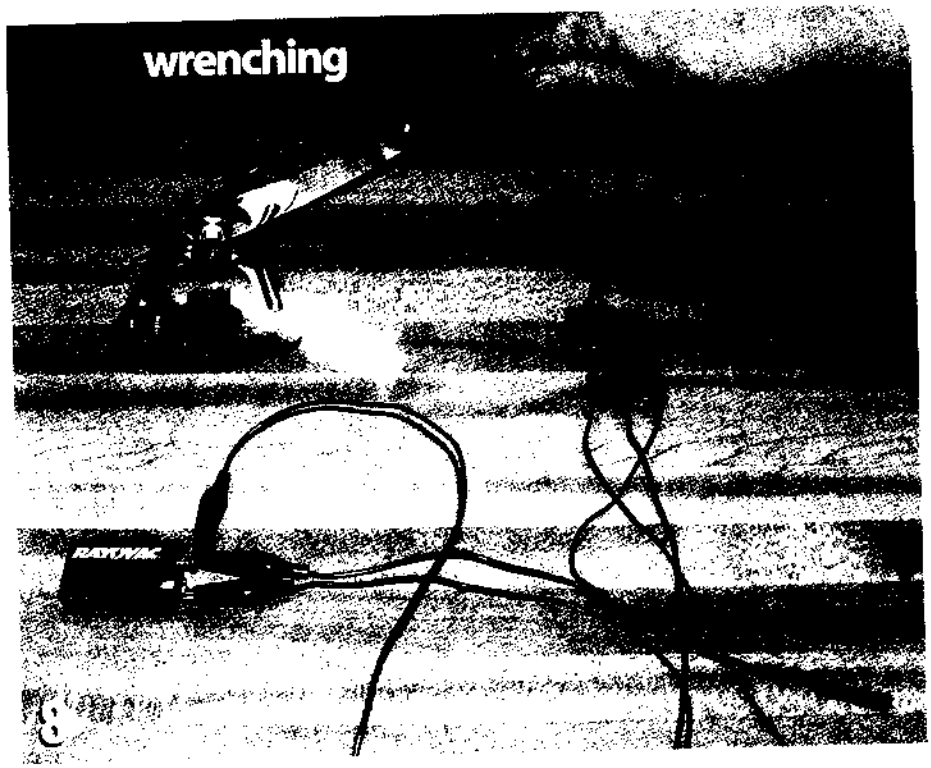


molded square. The connector position closest to the rounded end is blank. Starting at that end the connectors (right to left in the photo), and their wire colors, are as follows:

1. Orange Wire.....Top Sensor
2. Red Wire.....+12 volts
3. Brown Wire.....Ground
4. Black Wire.....Bottom Sensor
5. Silver Braid.....Wiring Shield

If you suspect that the Hall sensor on your bike is bad, it can be tested in place, on the bike. Photos 7 and 8 illustrate a sensor being bench tested using a 12 volt direct current LED (light emitting diode), a 9 volt radio battery, and two test





leads with alligator clips. You may ignore the fact that the LED and Hall sensors are rated at 12 volts and you are using a 9 volt battery. Nine volts is ample to light the LED and test the sensors. The LED used is a 12 volt LED with a built-in resistor. This one came from Radio Shack—catalog #276-270—and had alligator clip leads added for simplicity of connection.

The test leads are connected to the connector on the bundle going forward to the HES, as follows: Battery Positive (+) to connection #2 (red wire), Battery Negative (-) to connection #3 (brown wire), LED Positive (+) to Battery Positive (+).

The LED negative connects to connector #1 (orange wire) to test the top sensor and then to connector #4 (black wire) to test the bottom sensor. Photo 7 shows the LED connected to the top sensor and the LED glowing because the magnetic field is not interrupted and current is flowing. Photo 8 shows the magnetic field interrupted with a table knife and the LED not glowing.

You can initially test the sensors with the pulley still on the crankshaft by slowly rotating the engine and observing the LED. With the connections to test the top sensor (LED negative to connector #1) the LED should not glow until you reach top dead center. As you turn the crankshaft clockwise it should come on and then go off. Test the bottom sensor in the same manner, with the LED negative lead connected to connection 4, black wire.

If you have a completely failed sensor it will show up in this test. However, Hall sensors sometimes work when cold but fail or become erratic when hot. You can obtain a more reliable result if you test the HES both cold and hot. To do so requires that you remove the pulley from the end of the crankshaft. Loosen the alternator mounting bolts to slacken and remove the alternator drive belt. To loosen the bolt in the center of the pulley you must restrain the crankshaft from turning. If you have an assistant handy you can do this by putting the transmission in gear and tightly depressing the rear brake while turning the pulley mounting bolt. This is hard for one person to do alone.


9

BMW does provide a means to lock the engine in position with the crankshaft at top-dead-center. There is an access hole located in the bellhousing above the starter cover. When the crankshaft is at top-dead-center, an 8mm rod at least 100 mm long can be inserted into this hole. It passes through a corresponding hole in the flywheel and into a hole in the engine case, locking the flywheel from turning. I use an old Allen wrench for this purpose, as shown in Photo 9.

With the pulley removed, either sensor should pass current and light the LED when connected as shown above, unless the magnetic field for that sensor is interrupted as illustrated in Photo 8. Warm each sensor with a hair dryer (or carefully with a heat gun) and test the sensor while warm. If you are using a heat gun be very careful. It is possible to blister and ruin a sensor if too much heat is applied. The sensors are rated to at least 250 degrees, but be careful beyond that point. A remote sensing infrared thermometer is very handy in this application—$49 from Sears.

Even if the sensors test OK both warm and cold, it is still possible for the sensor assembly to be defective. There have been a number of cases where the insulation on the wires from the sensors to the connector has cracked and failed. The wiring actually attached to the sensors themselves is high temperature wiring. However, the wiring from splices about 4 inches from the sensors to the connector plug does not seem to be. The insulation cracks and allows shorts or arcing within the wiring bundle. This was the case on both of the R1100RS motorcycles described at the beginning of this article, causing either loss of signal or a spurious signal, or both when moisture found its way into the wiring harness. Both of these bikes were 10 years old and had about 300,000 and 125,000 miles respectively, so breakdown of the wiring insulation in the high-heat conditions under the front cover was not totally unexpected—though completely avoidable if BMW's supplier had built the whole HES assembly with high temperature insulation on the wires.

A new sensor assembly is expensive—between $250 and $300 last time I bought one. If you are skilled in doing such things it is possible to re-wire the assembly from the good high temperature wire at the sensors to the connector plug. On one R1100RS I did rewire the old sensors. On the other, I installed a new assembly purchased from my BMW dealer because one of the sensors tested bad when hot.

Either case requires the removal and re-installation of the Hall sensor assembly from the motorcycle. The wiring is clamped to the front of the engine case with a small metal clamp, and the assembly is held in place with three Allen cap screws. After removing the small wire clamp, the wiring can be withdrawn forward, underneath the alternator. Some jiggling and wiggling of the connector is required. Then the plate can be removed from the engine cases by removing its three mounting bolts. Mark one edge of the plate and engine case with matching scribe marks so that the assembly can be installed in the original position.

Even if the sensors test OK both warm and cold, it is still possible for the sensor assembly to be defective.

Installation of the new or renewed unit is the reverse. You must set the timing with the pulley in place. Install the plate so the scribe mark aligns with the edge of the plate. This will be very close. Then put the pulley back on the crankshaft, making certain that the tang on the pulley engages in the notch in the crankshaft. Set the engine to top-dead-center and lock the crankshaft in place. The three bolts for the sensor plate are all accessible with the pulley in place. Attach the battery leads and LED leads to test the top sensor. Rotate the plate clockwise until the LED goes out. Then rotate the plate back counter clockwise until the LED just comes on. Tighten the mounting plate bolts carefully so as to not turn the plate at all. Confirm the timing with a timing light through the hole in the bellhousing, or by rotating the engine clockwise by hand and observing that the LED comes on just as the engine is at the "OT" mark in the timing hole.

Good wrenching!