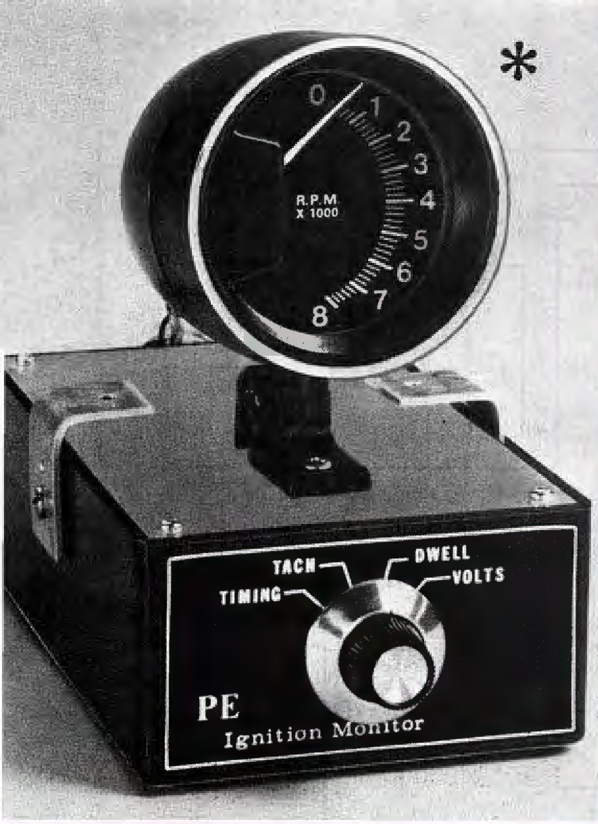


Popular Electronics®
OCTOBER 1976

Build a CAR IGNITION MONITOR

Provides a visual indication of timing angle, rpm, dwell, and system dc voltage while you drive.

BY WALTER B. HENRY

WITH THE high cost of gasoline and annual increases in new car prices, it is becoming increasinggly more important to keep our cars in perfect tune for maximum economy and engine life. Unfortunately, most of us put off periodic checks until our cars get "sick" and force us to do something about them. Hence, what every car needs is a device that keeps tabs on ignition performance at all times and provides a warning of potential problems before the car breaks down. This is exactly what the full-time Ignition Monitor described here is designed to do.

The Ignition Monitor lets you make all the common ignition system checks simply by flipping a switch and glancing at a meter. The parameters the system is designed to check include: ignition timing angle in degrees BTC, rpm, dwell angle, and electrical system voltage. The monitor can be permanently mounted in your car so that these parameters can be checked under all driving conditions—not just at idle. It can also be built into a hand-held case for tuning other cars equipped with the necessary sensor.

The system can be used with any 4-, 6-, or 8-cylinder engine equipped with either conventional (Kettering) or electronic ignition systems with breaker-point, magnetic, or optical switching. It can even be used with most magneto systems. An inexpensive accessory tachometer is used as the system's parameter indicator, while the electronics package is housed in a separate box that mounts under the dashboard.

Once your car is properly tuned and the Ignition Monitor is installed, you will soon get a "feel" for detecting even subtle changes in ignition operation. By monitoring the timing meter and driving for maximum advance, you can stretch your gas mileage and begin to economize immediately.

How It Works. The timing circuit of the ignition monitor utilizes an infrared LED/phototransistor optoelectronic sensor that senses a reference position of the engine's crankshaft. The sensor mounts close to the front pulley, or harmonic balancer. Once each crankshaft revolution a small metal "flag" attached to the pulley passes through the sensor and interrupts the infrared beam. This generates a signal that precisely indicates the position of the crankshaft.

In the circuit shown in Fig. 1, *IC1A* forms a flip-flop. Interruption of crankshaft sensor current causes the flip-flop to turn on. The subsequent arrival of an ignition pulse from the distributor terminal of the car's ignition coil triggers the shaping circuit made up of *IC1B*. The shaper output then turns off the flip-flop via *D6* and resistor R28.

The output of the flip-flop is a series of pulses with a duty cycle that is inversely proportional to the timing angle. A smoothing circuit made up of *IC1C* conditions the pulse train to drive the meter movement.

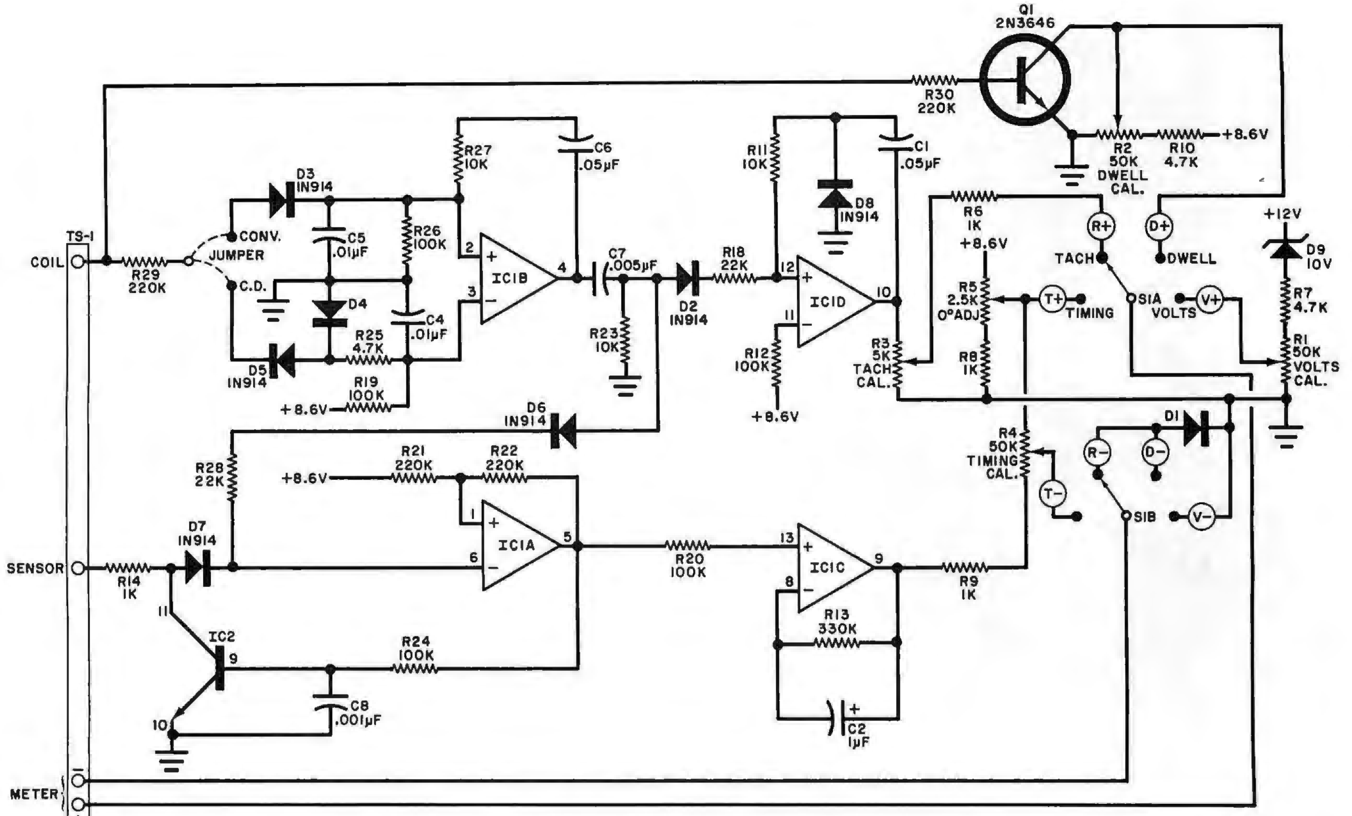
Most conventional and transistorized ignition systems have an initial positive pulse from the coil. This positive signal is routed to the *IC1B* shaper through a jumper in the *IC1B* input circuit. Most capacitive-discharge systems have an initial negative pulse output, which is routed through the C.D. side of the jumper.

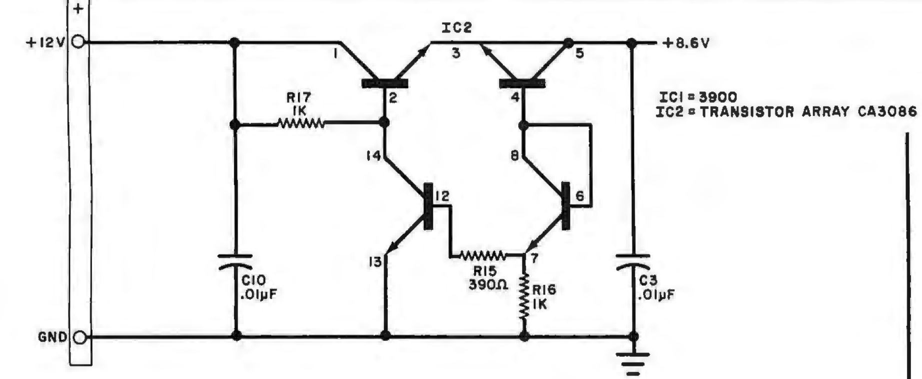
The tachometer circuit uses a one-shot multivibrator circuit formed by *IC1D*. The constant-width pulse output from this stage has a duty cycle that is directly proportional to engine speed. The pulse output is smoothed by the inertia of the meter movement. Transistor *Q1* delivers a pulse output whose duty cycle is proportional to the dwell angle. A 10-volt zener diode, *D1*, allows the meter to function as an expanded-scale volt-meter that registers potentials greater than 10 volts. Any potential less than 10 volts will not register on the meter.

Construction. You can assemble the entire circuit on perforated board or on a printed circuit board, the actual-size etching and drilling guide and components-placement diagram for which are shown in Fig. 2. There are two sets of connections to the circuit board. One set is via terminal strip *TS1*, which is for making connections to the car's ignition coil and electrical system, the sensor, and the meter. The other connections come from mode switch S1. the circuit board assembly

*Tachometer is not included in kit given in Parts List.

AUTO ELECTRONIC PROJECT





PARTS LIST

C1,C6—0.05-μF, 100-V disc capacitor
C2—1-μF, 10-V electrolytic capacitor
C3,C4,C5,C10—0.01-μF, 100-V disc capacitor
C7—0.005-μF, 100-V disc capacitor
C8—0.001-μF, 100-V disc capacitor
C9—Not used
D1 through D8—1N914 diode
D9—1N758 10-volt zener diode
IC1—CA3401, LM3900N, or MC3401P quad operational amplifier
IC2—CA3046, CA3086, LM3046, or LM3086 transistor array
Q1—2N3646 transistor
R1,R2,R4—50,000-ohm upright pc-type trimmer potentiometer
R3—5000-ohm upright pc-type trimmer potentiometer
R5—2500-ohm upright pc-type trimmer potentiometer
The following resistors ¼-watt, 10% tolerance:
R6,R8,R9,R14,R16,R17—1000 ohms
R7,R10,R25—4700 ohms
R11,R27—10,000 ohms
R12,R19,R20,R23,R24,R26—100,000 ohms
R13—330,000 ohms
R15—390 ohms
R18,R28—22,000 ohms
R21,R22,R29,R30—220,000 ohms
R31—680 ohms
S1—Two-pole, four-position nonshorting rotary switch
Sensor—GE Photo-coupled H13A1 or H13A2 module
TS1—Six-lug screw-type terminal strip
Misc.—Suitable metal enclosure (see text); control knob; tachometer (see text); stranded hookup wire for interconnections; metal shim stock for flag (see text); epoxy cement; spacers; machine hardware; solder; etc.
Note: The following items are available from Kingston Instruments, 3805 Ashford Ave., Fort Worth, TX 76133: Etched and drilled printed circuit board for $5.50; pc board with components and sensor for $21.50; complete kit except for tachometer for $26.50; sensor for $3.00. Texas residents, please add 5% tax.

Fig. 1. Output of IC1A is smoothed to provide timing signal. Output of IC1B operates one-shot IC1D to form tach signal. Transistor Q1 forms dwell-angle measurement signal source.

can be mounted inside any metal or plastic enclosure that will comfortably accommodate it.

The mode switch can be mounted on one wall of the circuit board's enclosure. Alternatively, it can be mounted externally, on its own bracket, with suitable stranded hookup wire interconnecting its lugs with the circuit board assembly.

Almost any electronic tachometer can be used for the display. The only requirement is that the meter movement can be driven to full-scale with 1 mA or less current. If the tachometer you buy has an electronic circuit in it, disconnect the circuit from the meter movement. Then solder a length of red stranded hookup wire to the movement's + terminal and a length of black stranded wire to the – terminal. Reassemble the tach's case, and terminate the free ends of the wires to the terminals labelled + (red) and (black) METER on *TS1*.

Different tachometer scales can be used in this application. For example, if you buy a tach with a 0-to-6000-rpm scale, it can indicate timing from 0° to 60° BTC, dwell from 0° to 60°, and voltage from 10 to 16 volts. A 0-to-8000-rpm tach will yield top-end figures of 80° BTC, 80°, and 18 volts, respectively.

The sensor must be mounted close

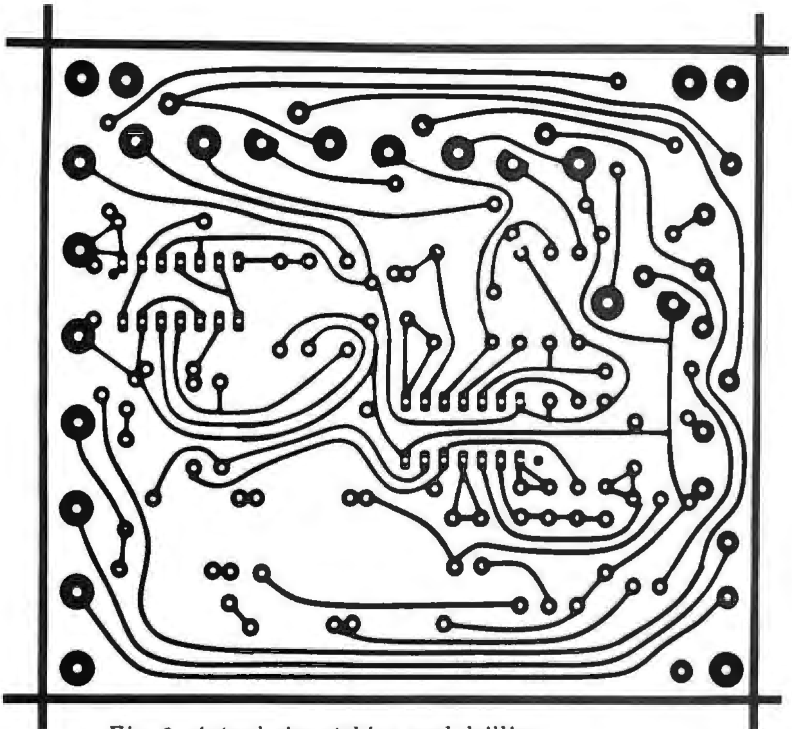
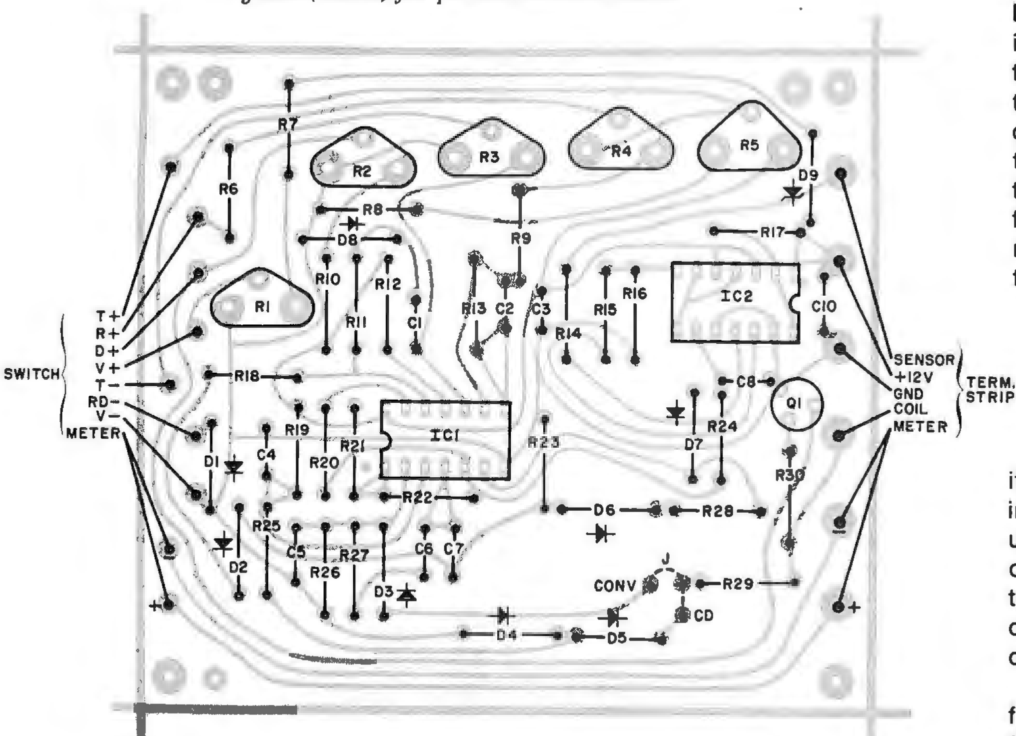


Fig. 2. Actual-size etching and drilling guide (above) and component placement guide (below) for printed circuit board.



to the front engine pulley, or harmonic balancer, as shown in Fig. 3. Fabricate a stiff metal bracket that will support the sensor with its gap facing toward and about ¼" (6.4 mm) away from the pulley's rim. This mounting bracket can be mounted as required on a water-pump bolt, pan bolt, or any other rigid mounting point near the pulley. Make the mounting bracket as short and stiff as possible to eliminate any vibration. Then route the three sensor leads away from any hot areas in the engine well and pass them through the firewall at a point near where the circuit board assembly's enclosure will be mounted inside the passenger compartment.

The sensor flag can be fabricated from thin aluminum or brass shim stock trimmed to about ⅝" × $^3/_{16}$" to ¼" (15.9 × 4.8 to 6.4 mm). Normally, about ¼" of the flag's length will be glued to the rim of the pulley, leaving about ⅜" (9.5 mm) of its length protruding beyond the rim to pass through the sensor's gap once with each revolution of the crankshaft. Anchor the flag to the pulley with epoxy or any other strong water- and oil-resistant cement.

To properly position the flag on the pulley, refer to Fig. 4 and use a large wrench to turn the engine so that the timing mark on the pulley exactly lines up with the 0° timing point. Measure as closely as possible a 73° angle from the sensor in the direction of pulley rotation and attach the flag at this point. (Alternatively, use the wrench to pull the engine through 73° against the direction of rotation and cement the flag so that it is centered in the gap of the sensor.) The angle can be measured with a protractor. Another way to measure the angle is to measure the circumference of the pulley, divide by five, and with the engine on the 0° mark measure the calculated distance from the sensor to the flag position. The angle is not critical, but it must fall between 68° and 78°.

Installation & Adjustments. The installation wiring of the system is detailed in Fig. 5. In conventional ignition systems, the coil lead goes to the distributor terminal. In electronic systems, it may be necessary to try both terminals to locate the "hot" one. (In factory-installed systems, it may be necessary to consult a service manual to determine the proper hookup point if the coil is contained in a module or in the distributor assembly.) Do NOT under any circumstances connect the coil lead to the high-tension (spark) terminal of the coil; if you do, you will destroy the monitor and introduce a dangerous shock hazard.

Route the coil lead through the firewall, spacing it a few inches away from the bundled sensor leads to avoid having noise pulses causing erratic operation. Then wire in a ground lead and a separate +12-volt supply lead. The +12-volt line should go to a source in the car's electrical system that is live when cranking the engine but off when the ignition is switched off.

Connect the meter and power leads to the electronics package. For now, leave the sensor and coil leads unconnected. Also, leave the electronics subassembly box unmounted so that the trimmer potentiometers are easily accessible.

Five adjustments are required for accurate operation of the Ignition Monitor. You will need a voltmeter, tachometer, and timing light. (For a 4-cylinder engine, you will also need a dwell-meter.) Make the adjustments according to the following sequence:

1. Set all trimmer potentiometers to midrange. Connect the meter and the power leads to the electronics box but leave the sensor and coil wires unconnected. Do not start the engine yet.

2. Set the mode switch to VOLTS. Use the voltmeter to measure the vehicle's supply voltage and adjust VOLTS CAL pot *R1* to obtain an identical

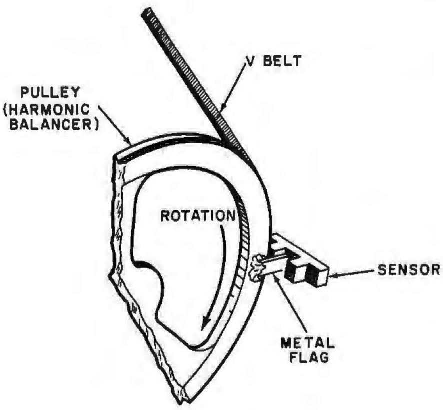


Fig. 3. Metal flag, ⅝ in. by ¼ in. is attached to rim of harmonic balancer pulley to pass through slot in sensor interrupting light beam.

reading on the monitor's tach meter. Bear in mind that only potentials that exceed 10 volts will be indicated on the tach meter. (If the meter's pointer swings below the zero index, reverse the meter leads.)

3. Set the mode switch to DWELL. For an 8-cylinder engine, adjust DWELL CAL pot *R2* for a 45° reading; for a 6-cylinder engine, adjust for a 60° reading. For 4-cylinder engines, the adjustment must be made by comparison with a dwell-meter with the engine running. The correct reading here would be 90°, but most tachs will not have scales calibrated up to 9. Therefore, complete step 4 before making the 4-cylinder dwell adjustment.

4. Connect the reference tachometer and the coil lead to *TS1* and start the engine. For a 4-cylinder engine, connect the reference dwellmeter and adjust for an identical dwell reading. Set the mode switch to TACH and adjust TACH CAL pot *R3* for an identical rpm reading. Check the calibration at various engine speeds. (Note: Accidental connection of the coil lead to the sensor input terminal may damage the IC's if the engine is started.)

5. Stop the engine. Connect the timing light and hook up the sensor leads to the monitor as shown in the wiring diagram. Loosen the distributor, disconnect the vacuum lines, and start the engine. Using the timing light, turn the distributor until the engine is timed at exactly 0° BTC. Then adjust 0° ADJ pot *R5* for a meter reading of exactly 0°.

6. Turn the distributor for the greatest advance that can be read on the engine timing marker with the timing light (usually about 16° to 20°). Then adjust TIMING CAL pot *R4* for the same reading on the meter. Recheck the 0° adjustment, and if it is not right on 0°, repeat steps 5 and 6.

7. This completes the adjustments. Set the timing back to the factory specification and reconnect the vacuum lines.

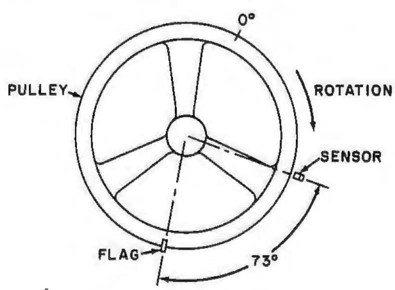


Fig. 4. Flag is positioned approximately 73 deg. from sensor when pulley is at 0-degree timing mark.

How To Use the Monitor. To get the most from your Ignition Monitor, we suggest that you make notes of ignition timing under different operating conditions. Do this when your car has been perfectly tuned, including a full distributor check. Make a note of timing at idle (on some engines, this depends on speed, vacuum, and engine temperature). By developing a feel for what to expect, you will quickly learn how to detect even subtle changes in engine performance.

Ignition timing specifications can be obtained from your car dealer and service manuals. Centrifugal advance and vacuum advance are normally specified separately. The engine can be run at various speeds with the vacuum lines disconnected to check centrifugal advance against the specs and then with the vacuum lines connected to determine vacuum advance. Make sure that the dwell reading is steady. Jittery readings or sudden changes may indicate a worn distributor shaft. With most of the newer CD electronic ignition systems, the dwell reading is meaningless since current does not have to build up in the coil. In some systems, the dwell is electronically varied, depending on engine speed. In these cases, the manufacturer's specifications should always be consulted.

Some newer engines may have a negative timing angle under certain operating conditions (spark occurs after TDC). The Ignition Monitor will read down-scale from O under these conditions, but only until the pointer comes to the mechanical stop. Some newer cars, especially expensive foreign makes, come with voltmeters rather than the more common ammeter. In colder climates, proper voltage readings with the engine running and the battery charged should be 14 to 15 volts, while in hot weather, the reading should be 13 to 14 volts. The voltage regulator is designed to compensate for ambient temperature variations.

If you use your Ignition Monitor in more than one car, the flag must be properly placed by trial and error in each car. The 0° adjustment compensates for flag positioning on first car, so the flag on all other cars must be

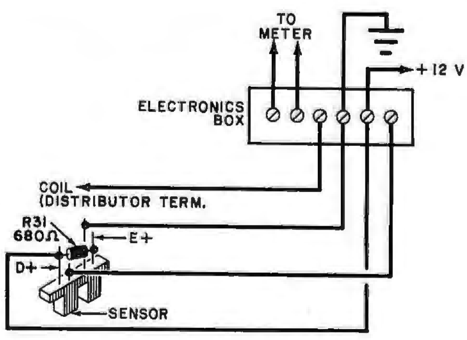


Fig. 5. External connections to the ignition monitor.

positioned in exactly the same manner. Keep in mind that small adjustments can be made by moving the sensor slightly, instead of moving the flag. We suggest that you permanently install a flag and sensor in each car with which the Ignition Monitor is to be used.

The Ignition Monitor has been designed for the serious auto enthusiast. When properly installed and used, it can help you diagnose engine problems and obtain optimum performance and economy. ◈