



IGNITION SYSTEMS

CONTENTS

	page		page
3.3L AND 3.5L ELECTRONIC IGNITION SYSTEM—SYSTEM OPERATION	1	3.3L ELECTRONIC IGNITION SYSTEM—DIAGNOSTIC PROCEDURES	9
3.3L AND 3.5L ELECTRONIC IGNITION SYSTEMS—SERVICE PROCEDURES	11	IGNITION SWITCH AND INTERLOCK	17
		SPECIFICATIONS	23

3.3L AND 3.5L ELECTRONIC IGNITION SYSTEM—SYSTEM OPERATION

INDEX

	page		page
Auto Shutdown and Fuel Pump Relays	8	Knock Sensors—3.5L Engine	7
Camshaft Position Sensor	4	Manifold Absolute Pressure Sensor	8
Charge Air Temperature Sensor	5	Powertrain Control Module (PCM)	2
Crankshaft Position Sensor	5	Spark Plug Cables	2
Engine Coolant Temperature Sensor	7	Spark Plug Condition	2
General Information	1	Spark Plugs	2
Ignition Coil	6		

GENERAL INFORMATION

This section describes the electronic ignition system for the 3.3L and 3.5L engines used in LH vehicles.

The On-Board Diagnostics Section in Group 14 describes diagnostic trouble codes.

Group 0, Lubrication and Maintenance, contains general maintenance information for ignition related items. The Owner's Manual also contains maintenance information.

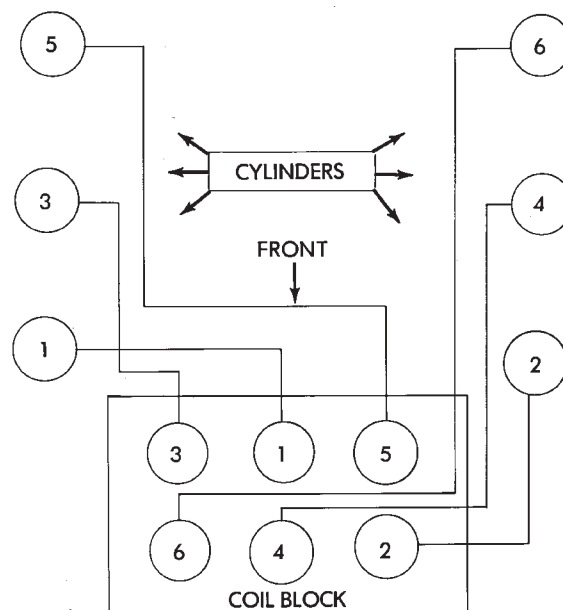
The 3.3L and 3.5L engines use a fixed ignition timing system. The distributorless electronic ignition system is referred to as the Direct Ignition System.

Basic ignition timing is not adjustable. The powertrain control module (PCM) determines spark advance. The system's three main components are the coil pack, crankshaft position sensor, and camshaft position sensor.

The crankshaft position sensor and camshaft position sensor are hall effect devices. The camshaft position sensor and crankshaft position sensor generate pulses that are the inputs to the PCM. The PCM determines crankshaft position from these sensors. The PCM calculates injector sequence and ignition timing from crankshaft position. For a description of both sensors, refer to Camshaft Position Sensor and Crankshaft Position Sensor in this section.

FIRING ORDER

The firing order of the 3.3L and 3.5L direct ignition system is 1-2-3-4-5-6 (Fig. 1).



938D-18

Fig. 1 Spark Plug Wire Routing—3.3L and 3.5L Engine



POWERTRAIN CONTROL MODULE (PCM)

The powertrain control module (PCM) regulates the ignition system (Fig. 2). The PCM supplies battery voltage to the ignition coil through the Auto Shutdown (ASD) Relay. The PCM also controls the ground circuit for the ignition coil. By switching the ground path for the coil on and off, the PCM adjusts ignition timing to meet changing engine operating conditions.

During the crank-start period the PCM advances ignition timing a set amount. During engine operation the following inputs determine the amount of spark advance provided by the PCM.

- Charge air temperature (3.5L engine)
- Coolant temperature
- Engine RPM
- Available manifold vacuum
- Knock sensor (3.5L Engine)

The PCM also regulates the fuel injection system. Refer to the Fuel Injection sections of Group 14.

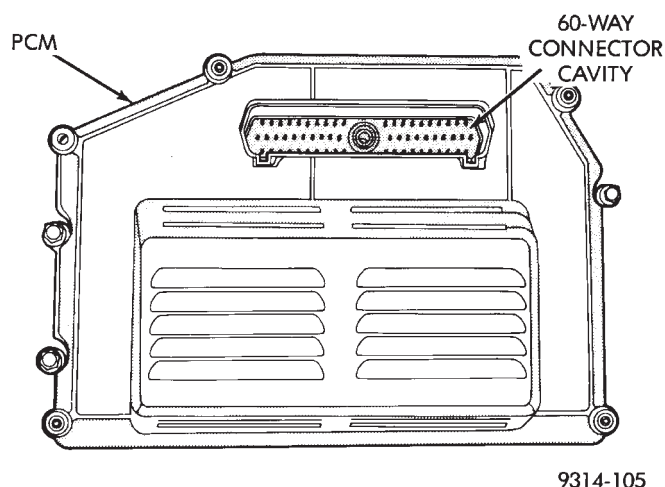


Fig. 2 Powertrain Control Module

SPARK PLUG CABLES

Spark plug cables are sometimes referred to as secondary ignition wires. The wires transfer electrical current from the distributor to individual spark plugs at each cylinder. The resistor type, nonmetallic spark plug cables provide suppression of radio frequency emissions from the ignition system.

Check the spark plug cable connections for good contact at the coil and spark plugs. Terminals should be fully seated. The nipples and spark plug covers should be in good condition. Nipples should fit tightly on the coil and spark plug cover should fit tight around spark plug insulators. Loose cable connections will corrode, increase resistance and permit water to enter the towers. These conditions can cause ignition malfunction.

SPARK PLUGS

The 3.3L and 3.5L engines use resistor spark plugs. They have resistance values of 6,000 to 20,000 ohms

when checked with at least a 1000 volt tester. For spark plug identification and specifications, Refer to the Specifications section at the end of this group.

Remove the spark plugs and examine them for burned electrodes and fouled, cracked or broken porcelain insulators. Keep plugs arranged in the order in which they were removed from the engine. An isolated plug displaying an abnormal condition indicates that a problem exists in the corresponding cylinder. Replace spark plugs at the intervals recommended in Group 0.

Spark plugs that have low mileage may be cleaned and reused if not otherwise defective. Refer to the Spark Plug Condition section of this group. After cleaning, file the center electrode flat with a small point file or jewelers file. Adjust the gap between the electrodes (Fig. 3) to the dimensions specified in the chart at the end of this section.

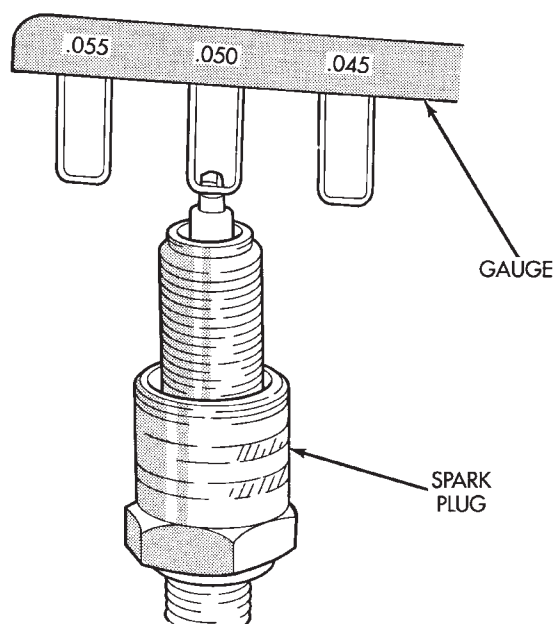


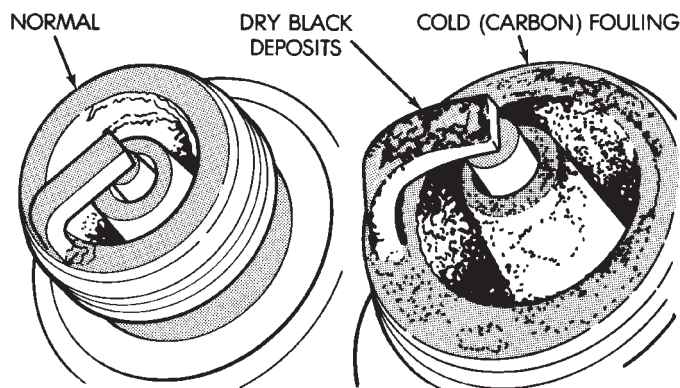
Fig. 3 Setting Spark Plug Electrode Gap—Typical

Always tighten spark plugs to the specified torque. Over tightening can cause distortion and change the spark plug gap. Tighten spark plugs to 28 N•m (20 ft. lbs.) torque.

SPARK PLUG CONDITION

NORMAL OPERATING CONDITIONS

The few deposits present will be probably light tan or slightly gray in color with most grades of commercial gasoline (Fig. 4). The spark plug will not show evidence of electrode burning. Gap growth will average less than approximately 0.025 mm (.001 in) per 1600 km (1000 miles) of operation. Spark plugs with normal wear can usually be cleaned, have the electrodes filed and regapped, and then reinstalled.



J908D-15

Fig. 4 Normal Operation and Cold (Carbon) Fouling

Some fuel refiners in several areas of the United States have introduced a manganese additive (MMT) for unleaded fuel. During combustion, fuel with MMT may coat the entire tip of the spark plug with a rust colored deposit. The rust color deposits can be misdiagnosed as being caused by coolant in the combustion chamber. Spark plug performance is not affected by MMT deposits.

COLD FOULING (CARBON FOULING)

Cold fouling is sometimes referred to as carbon fouling. The deposits that cause cold fouling are basically carbon (Fig. 4). A dry, black deposit on one or two plugs in a set may be caused by sticking valves or defective spark plug cables. Cold fouling of the entire set may be caused by a clogged air cleaner.

Cold fouling is normal after short operating periods. The spark plugs do not reach a high enough operating temperature during short operating periods.

WET FOULING

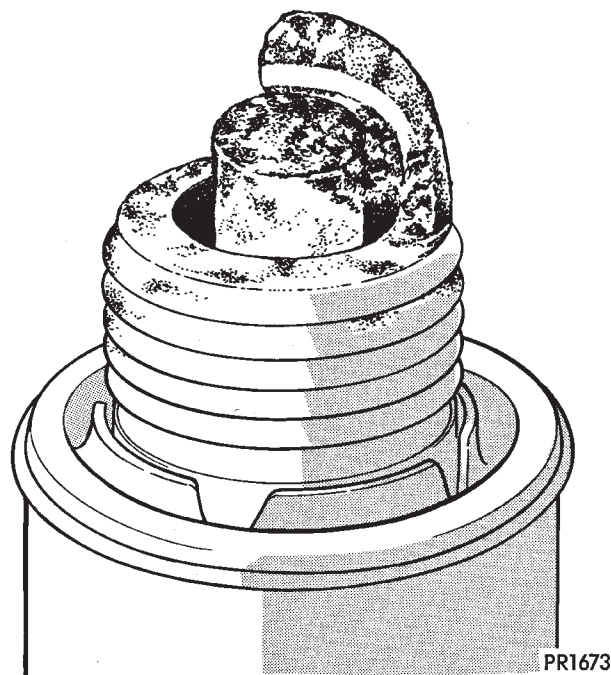
A spark plug coated with excessive wet fuel or oil is wet fouled. In older engines, worn piston rings or excessive cylinder wear can cause wet fouling. **Break-in fouling may occur before new engines achieve normal oil control. In new or recently overhauled engines, wet fouled spark plugs can usually be cleaned and reinstalled.**

OIL OR ASH ENCRUSTED

If one or more plugs are oil or oil ash encrusted, evaluate the engine for the cause of oil entry into the combustion chamber (Fig. 5).

HIGH SPEED MISS

When replacing spark plugs because of a high speed miss condition; **avoid wide open throttle operation for approximately 80 km (50 miles) after installation of new plugs.** This will allow deposit



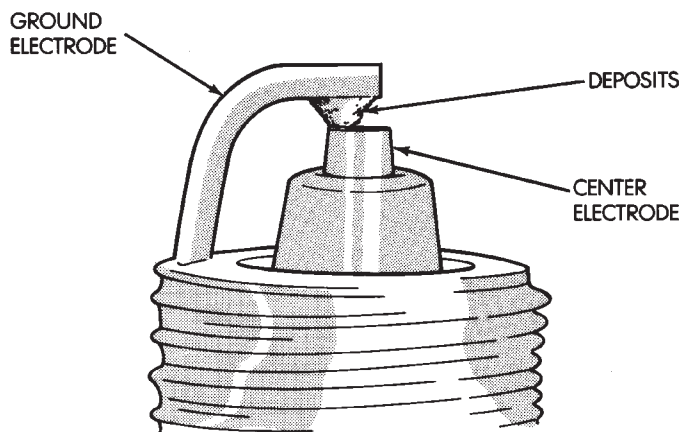
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Fig. 5 Oil or Ash Encrusted

shifting in the combustion chamber to take place gradually and avoid splash fouling shortly after the plug change.

ELECTRODE GAP BRIDGING

Loose deposits in the combustion chamber can cause electrode gap bridging. The deposits accumulate on the spark plugs during continuous stop-and-go driving. When the engine is suddenly subjected to a high torque load, the deposits partially liquefy, bridge the gap, and short circuit the electrodes (Fig. 6). Use standard procedures to clean spark plugs with electrode gap bridging.



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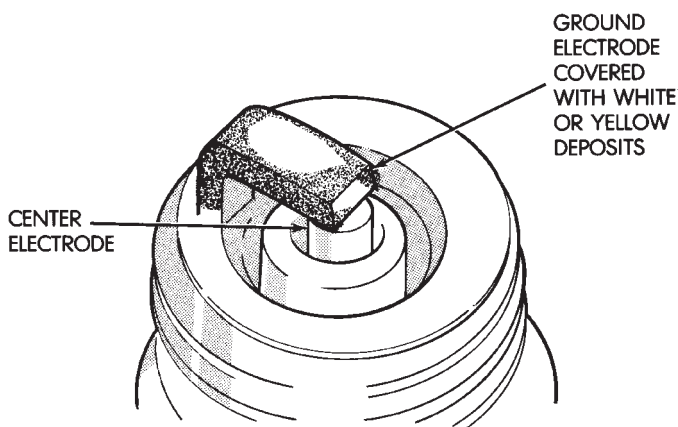
Fig. 6 Electrode Gap Bridging

SCAVENGER DEPOSITS

Fuel scavenger deposits may appear either white or yellow (Fig. 7). They may look harmful, but are a



normal condition caused by chemical additives in certain fuels. These additives are designed to change the chemical nature of deposits and decrease spark plug misfire tendencies. Accumulation of deposits on the ground electrode and shell area may appear heavy but remove easily. Consider spark plugs with scavenger deposits as normal. Use standard procedures to clean plugs with scavenger deposits.

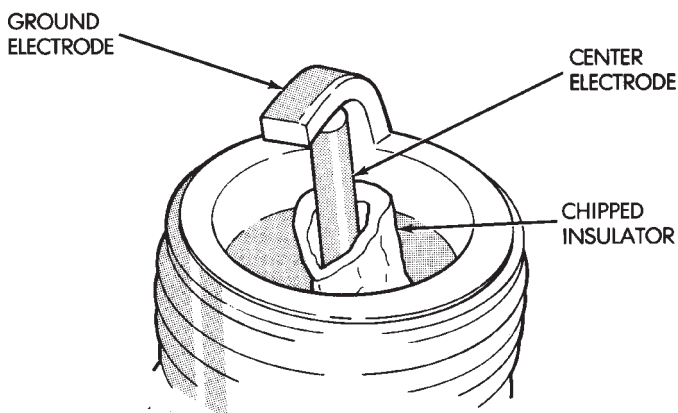


J908D-12

Fig. 7 Scavenger Deposits

CHIPPED ELECTRODE INSULATOR

A chipped electrode insulator usually results from bending the center electrode while adjusting the spark plug gap. However, under certain conditions, severe detonation can separate the insulator from the center electrode (Fig. 8). Replace spark plugs that have chipped electrode insulators.



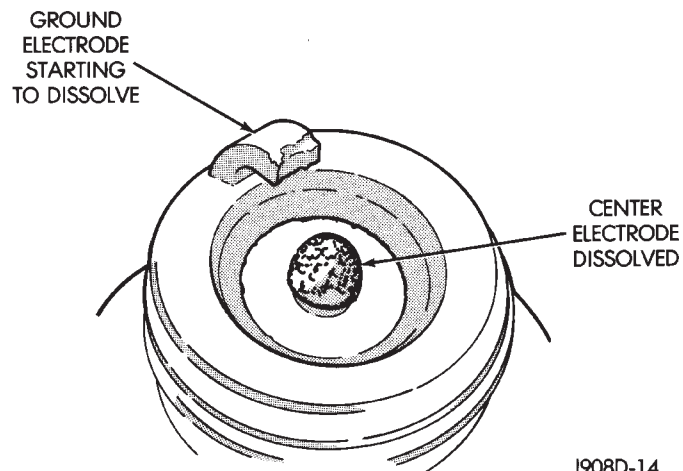
J908D-13

Fig. 8 Chipped Electrode Insulator

PREIGNITION DAMAGE

Excessive combustion chamber temperature can cause preignition damage. First, the center electrode dissolves. Then the ground electrode dissolves somewhat later (Fig. 9). Insulators appear relatively deposit free. Determine if the spark plug has the correct heat range rating for the engine, if ignition

timing is over advanced or if other operating conditions are causing engine overheating. (The heat range rating refers to the operating temperature of a particular type spark plug. Spark plugs are designed to operate within specific temperature ranges depending upon the thickness and length of the center electrode and porcelain insulator.)

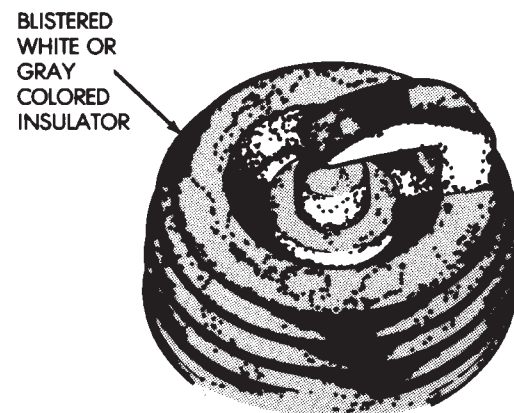


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Fig. 9 Preignition Damage

SPARK PLUG OVERHEATING

A blistered white or gray appearing center electrode indicates overheating (Fig. 10). Overheating increases electrode gap in excess of 0.001 inch per 1000 miles of operation. This suggests that a plug with a cooler heat range rating should be used. Over advanced ignition timing, detonation and cooling system malfunctions can also cause spark plug overheating.



J908D-16

Fig. 10 Spark Plug Overheating

CAMSHAFT POSITION SENSOR

The camshaft position sensor provides cylinder identification to the powertrain control module (PCM) (Fig. 11 or Fig. 12). The sensor generates pulses as groups of notches on the camshaft sprocket pass underneath it (Fig. 13 or Fig. 14). The PCM



keeps track of crankshaft rotation and identifies each cylinder by the pulses generated by the notches on the camshaft sprocket. Four crankshaft pulses follow each group of camshaft pulses.

When the PCM receives two cam pulses followed by the long flat spot on the camshaft sprocket, it knows that the crankshaft timing marks for cylinder one are next (on driveplate). When the PCM receives one camshaft pulse after the long flat spot on the sprocket, cylinder number two crankshaft timing marks are next. After 3 camshaft pulses, the PCM knows cylinder four crankshaft timing marks follow. One camshaft pulse after the three pulses indicates cylinder five. The two camshaft pulses after cylinder 5 signals cylinder six (Fig. 13 or Fig. 14). The PCM can synchronize on cylinders 1 or 4.

When metal aligns with the sensor, voltage goes low (less than 0.3 volts). When a notch aligns with the sensor, voltage spikes high (5.0 volts). As a group of notches pass under the sensor, the voltage switches from low (metal) to high (notch) then back to low. The number of notches determine the amount of pulses. If available, an oscilloscope can display the square wave patterns of each timing event.

Top dead center (TDC) does not occur when notches on the camshaft sprocket pass below the cylinder. TDC occurs after the camshaft pulse (or pulses) and after the 4 crankshaft pulses associated with the particular cylinder. The arrows and cylinder call outs on Figures 13 and 14 represent which cylinder the flat spot and notches identify, they do not indicate TDC position.

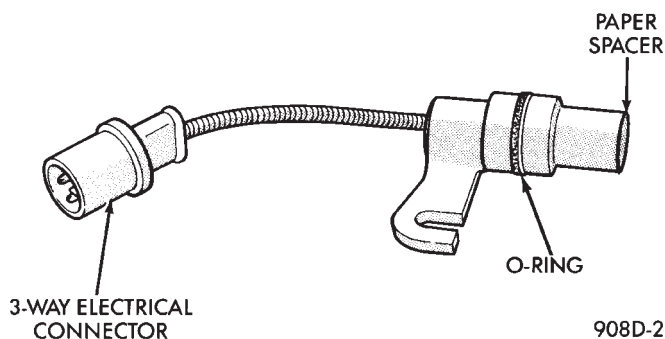


Fig. 11 Camshaft Position Sensor—3.3L Engine

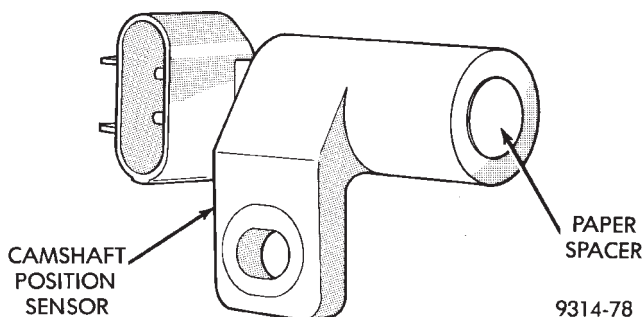


Fig. 12 Camshaft Position Sensor—3.5L Engine

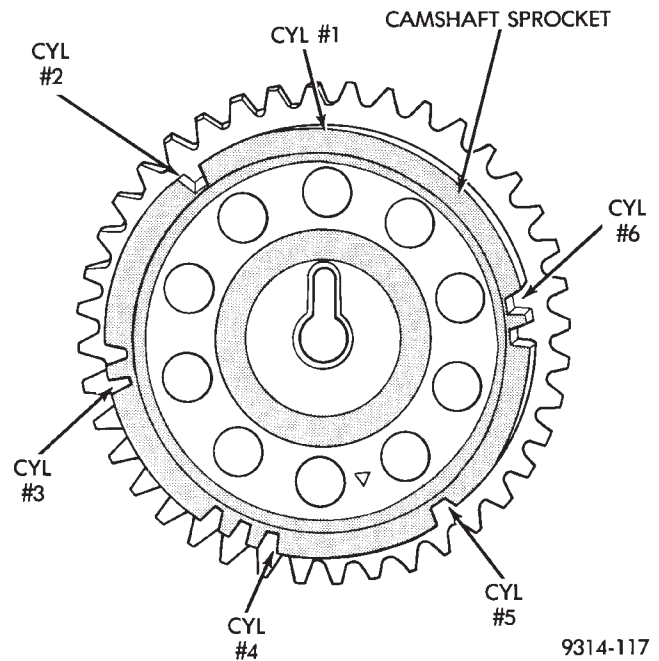


Fig. 13 Camshaft Sprocket—3.3L Engine

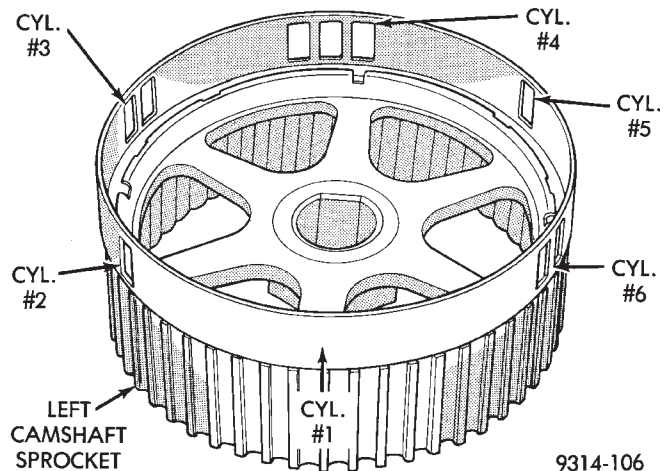


Fig. 14 Camshaft Sprocket—3.5L Engine

The camshaft position sensor is mounted in the front of the timing case cover (Fig. 15 or Fig. 16).

CHARGE AIR TEMPERATURE SENSOR

The 3.5L engine uses a charge air temperature sensor, the 3.3L engine does not. The sensor threads into the intake manifold plenum and measures air temperature (Fig. 17). The sensor provides one of the inputs the PCM monitors when it adjust injector pulse width and spark advance.

CRANKSHAFT POSITION SENSOR

The crankshaft position sensor detects slots cut into the transmission driveplate extension. There are 3 sets of slots. Each set contains 4 slots, for a total of 12 slots (Fig. 18). Basic timing is set by the position of the last slot in each group. Once the powertrain

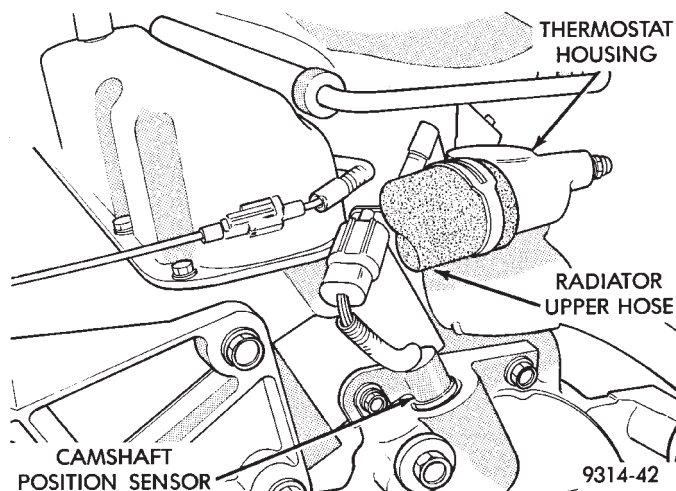


Fig. 15 Camshaft Position Sensor Location—3.3L Engine

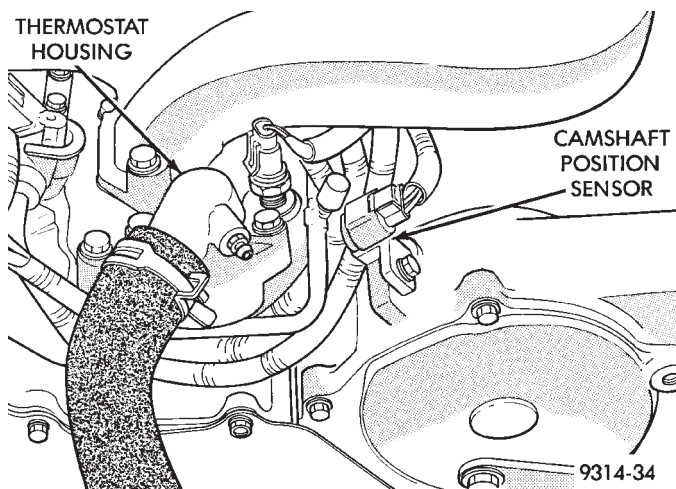


Fig. 16 Camshaft Position Sensor Location—3.5L Engine

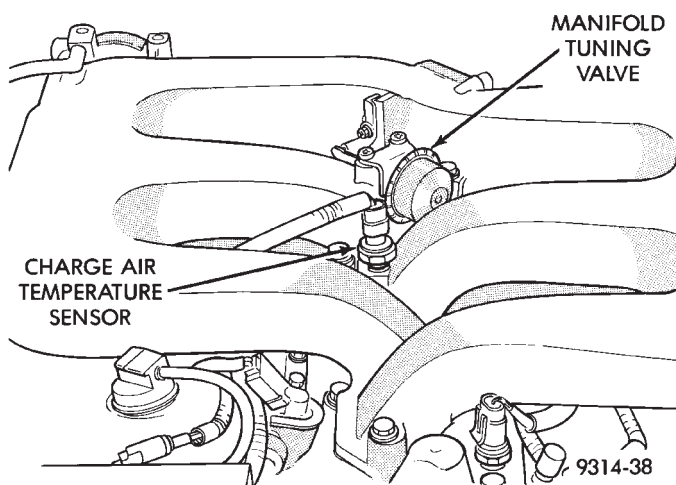


Fig. 17 Charge Air Temperature Sensor—3.5L Engine Only

control module (PCM) senses the last slot, it determines crankshaft position (which piston will next be

at TDC) from the camshaft position sensor input. The 4 pulses generated by the crankshaft position sensor represent the 69°, 49°, 29°, and 9° BTDC marks. It may take the PCM one engine revolution to determine crankshaft position.

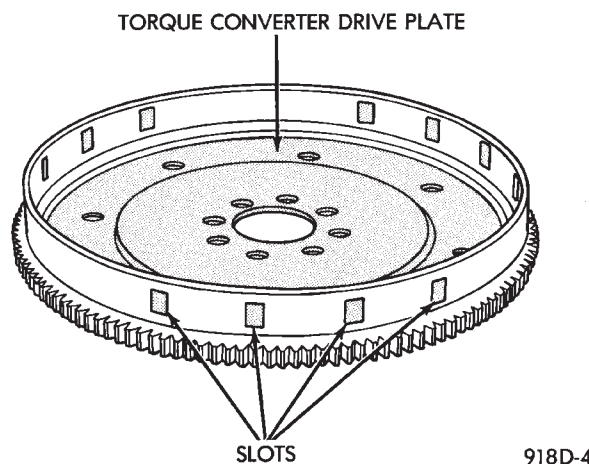


Fig. 18 Timing Slots

The PCM uses crankshaft position reference to determine injector sequence and ignition timing. Once the PCM determines crankshaft position, it begins energizing the injectors in sequence.

The crankshaft sensor is located on the passengers side of the transmission housing, above the differential housing (Fig. 19). The bottom of the sensor is positioned next to the drive plate.

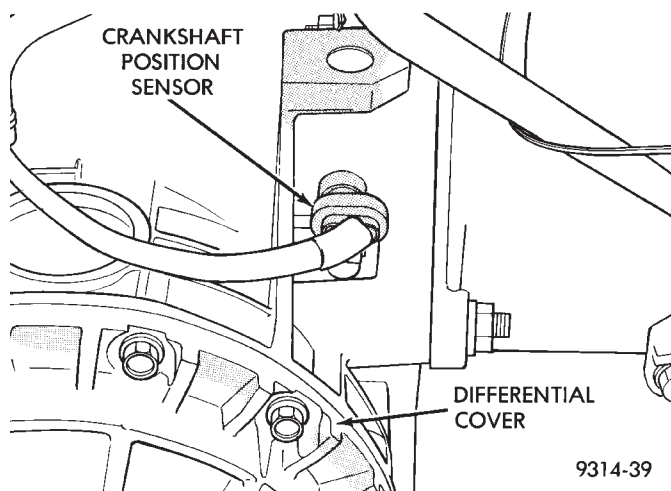


Fig. 19 Crankshaft Position Sensor Location

IGNITION COIL

WARNING: THE DIRECT IGNITION SYSTEM GENERATES APPROXIMATELY 40,000 VOLTS. PERSONAL INJURY COULD RESULT FROM CONTACT WITH THIS SYSTEM.

The coil pack consists of 3 coils molded together (Fig. 20). High tension leads route to each cylinder



from the coil. The coil fires two spark plugs every power stroke. One plug is the cylinder under compression, the other cylinder fires on the exhaust stroke. The powertrain control module (PCM) determines which of the coils to charge and fire at the correct time.

Coil number one fires cylinders 1 and 4, coil number two fires cylinders 2 and 5, and coil number three fires cylinders 3 and 6.

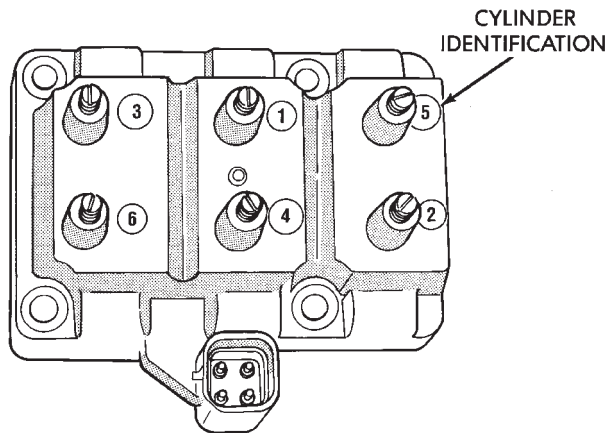


Fig. 20 Coil Pack

The coil's low primary resistance (0.5 - 0.7 ohm) allows the PCM to fully charge the coil for each firing.

ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor threads into the water jacket next to thermostat housing (Fig. 21 or Fig. 22). The sensor provides an input to the powertrain control module (PCM). As coolant temperature varies, the sensor resistance changes, resulting in a different input voltage to the PCM.

The PCM contains different spark advance schedules for cold and warm engine operation. The schedules reduce engine emission and improve driveability. When the engine is cold, the PCM will demand slightly richer air-fuel mixtures and higher idle speeds until normal operating temperatures are reached.

The engine coolant sensor input also determines operation of the low and high speed cooling fans.

KNOCK SENSORS—3.5L ENGINE

The 3.5L engine has two knock sensors. One sensor for the right bank of cylinders, one for the left bank. The knock sensors thread into the top of the cylinder block below the cylinder heads (Fig. 23). When a knock sensor detects a knock in one of the cylinders, it sends a input signal to the PCM. In response, the PCM retards ignition timing by a scheduled amount.

Knock sensors contain a crystal which constantly vibrates and sends an input voltage (signal) to the

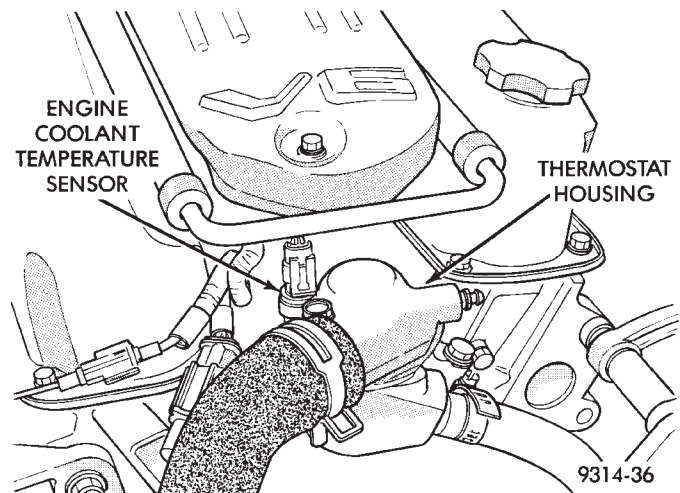


Fig. 21 Engine Coolant Temperature Sensor—3.3L Engine

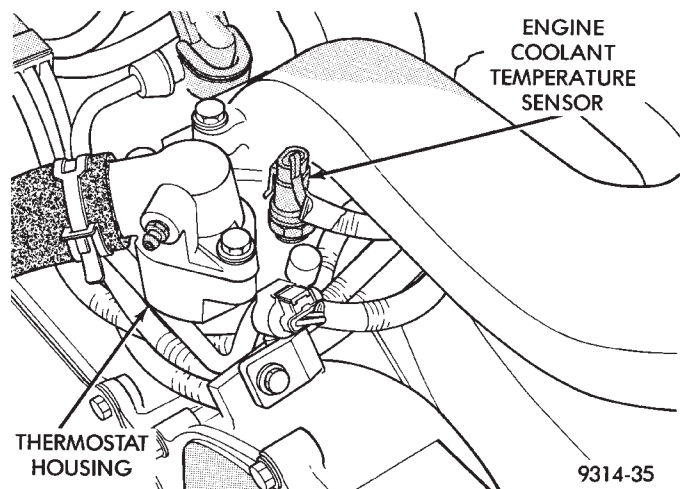


Fig. 22 Engine Coolant Temperature Sensor—3.5L Engine

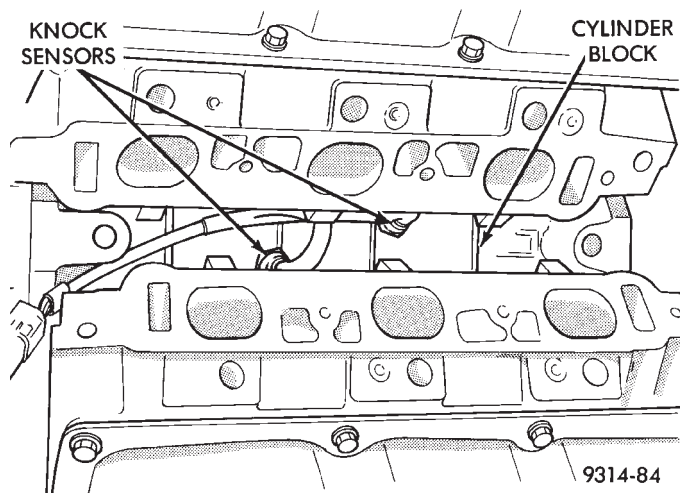


Fig. 23 Knock Sensor Locations—3.5L Engine Only

PCM while the engine operates. As the intensity of the crystal's vibration increase, the knock sensor output voltage also increases.



MANIFOLD ABSOLUTE PRESSURE SENSOR

The powertrain control module (PCM) supplies 5 volts to the MAP sensor. The MAP sensor converts intake manifold pressure into voltage. The PCM monitors the MAP sensor output voltage. As vacuum increases, MAP sensor voltage decreases proportionately. Also, as vacuum decreases, MAP sensor voltage increases proportionately.

During cranking, before the engine starts running, the PCM determines atmospheric air pressure from the MAP sensor voltage. While the engine operates, the PCM determines intake manifold pressure from the MAP sensor voltage. Based on MAP sensor voltage and inputs from other sensors, the PCM adjusts spark advance and the air/fuel mixture.

On 3.3L engines the MAP sensor mounts to the rear of the intake manifold plenum (Fig. 24). On 3.5L engines, the MAP sensor mounts to the drivers side of the intake manifold plenum (Fig. 25).

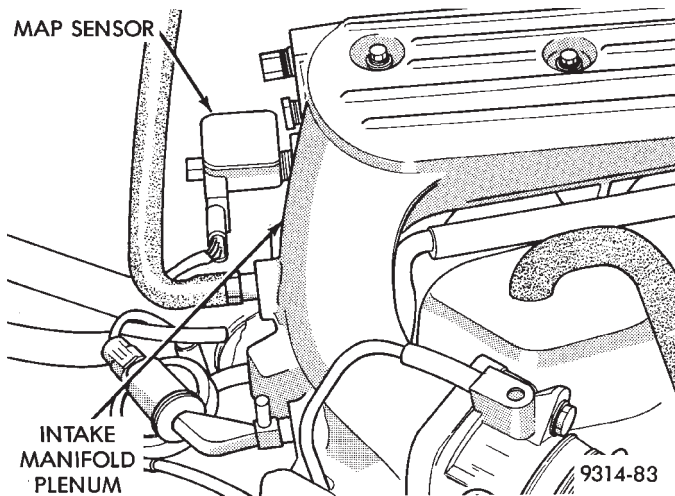


Fig. 24 MAP Sensor—3.3L Engine

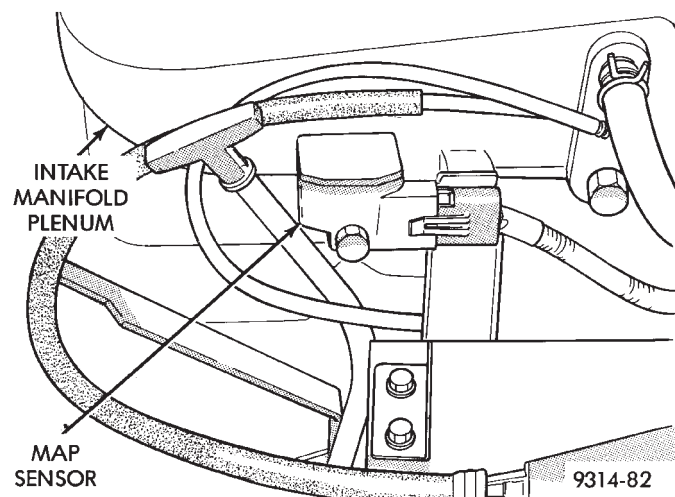


Fig. 25 MAP Sensor—3.5L Engine

AUTO SHUTDOWN AND FUEL PUMP RELAYS

The PCM operates the auto shutdown (ASD) relay and fuel pump relay through one ground path. The PCM operates them by switching on and off the ground path for the solenoid side of the relays. Both relays turn on and off at the same time.

The ASD relay connects battery voltage to the fuel injectors and ignition coil. The fuel pump relay connects battery voltage to the fuel pump.

The PCM turns the ground path off when the ignition switch is in the Off position. Both relays are off. When the ignition switch is in the On or Crank position, the PCM monitors the crankshaft position sensor and camshaft position sensor signals to determine engine speed and ignition timing (coil dwell). If the PCM does not receive a crankshaft position sensor signal and camshaft position sensor signal when the ignition switch is in the Run position, it de-energizes both relays. When the relays de-energizes, battery voltage is not supplied to the fuel injectors, ignition coil and fuel pump.

The ASD relay and fuel pump relay are located in the power distribution center (PDC) near the battery (Fig. 26). A decal on the underside of the PDC cover shows the locations of each relay and fuse contained in the PDC.

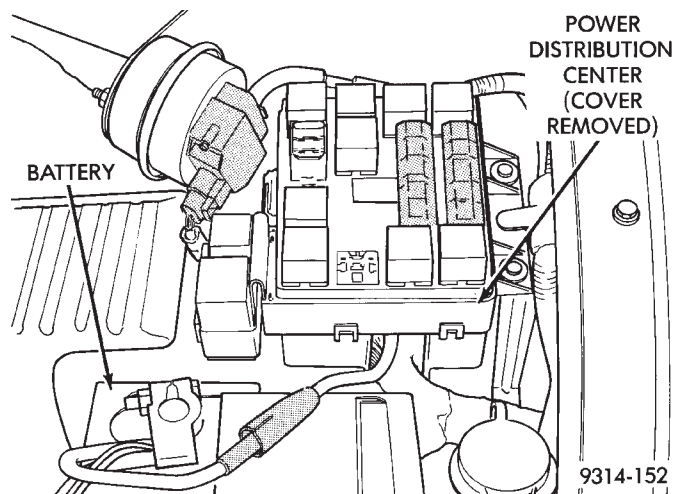


Fig. 26 Power Distribution Center



3.3L ELECTRONIC IGNITION SYSTEM—DIAGNOSTIC PROCEDURES

INDEX

	page		page
Check Coil Test—3.3L Engine	9	Failure to Start Test	9
Coolant Temperature Sensor Test	10	Manifold Absolute Pressure (MAP) Sensor Test	10
Crankshaft Position Sensor and Camshaft Position Sensor Tests	10	Testing for Spark at Coil	9

TESTING FOR SPARK AT COIL

WARNING: THE 3.3L ENGINE DIRECT IGNITION SYSTEM GENERATES APPROXIMATELY 40,000 VOLTS. PERSONAL INJURY COULD RESULT FROM CONTACT WITH THIS SYSTEM.

The coil pack contains 3 independent coils. Each coil must be checked individually.

CAUTION: Spark plug wire damage may occur if the spark plug is moved more than 1/4 inch away from the engine ground.

Remove the cable from number 2 spark plug. Insert a clean spark plug into the spark plug boot, and ground plug to the engine (Fig. 1).

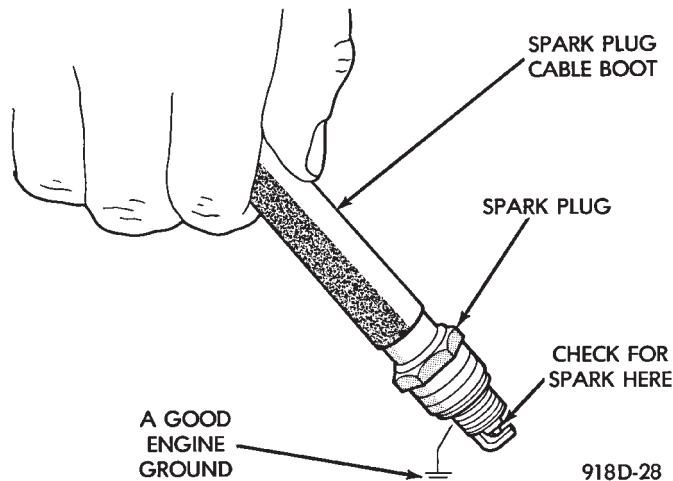


Fig. 1 Testing For Spark

Crank the engine and look for spark across the electrodes of the spark plug. Repeat the above test for the five remaining cylinders. If there is no spark during all cylinder tests, proceed to the failure to start test.

If one or more tests indicate irregular, weak, or no spark, proceed to Check Coil Test.

CHECK COIL TEST—3.3L ENGINE

Coils one fires cylinders 1 and 4, coil two fires cylinders 2 and 5, coil three fires cylinders three and six.

Each coil tower is labeled with the number of the corresponding cylinder.

(1) Remove the ignition cables and measure the resistance of the cables. Resistance must be between 3,000 to 12,000 ohms per foot of cable. Replace any cable not within tolerance.

(2) Disconnect the electrical connector from the coil pack.

(3) Measure the primary resistance of each coil. At the coil, connect an ohmmeter between the B+ pin and the pin corresponding to the cylinders in question (Fig. 2). Resistance on the primary side of each coil should be 0.5 - 0.7 ohm. Replace the coil if resistance is not within tolerance.

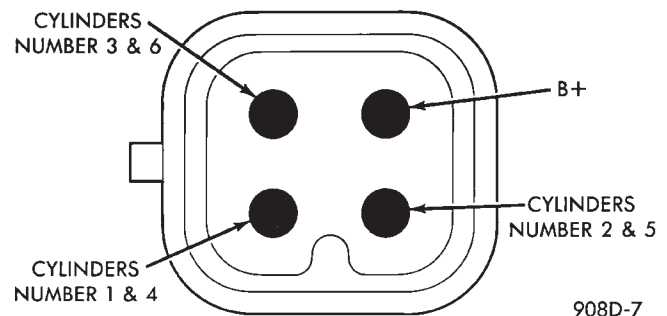


Fig. 2 Ignition Coil Terminal Identification

(4) Remove ignition cables from the secondary towers of the coil. Measure the secondary resistance of the coil between the towers of each individual coil (Fig. 3). Secondary resistance should be 7,000 to 15,800 ohms. Replace the coil if resistance is not within tolerance.

FAILURE TO START TEST

This no-start test checks the camshaft position sensor and crankshaft position sensor.

The PCM supplies 8 volts to the camshaft sensor and crankshaft sensor through one circuit. If the 8-volt supply circuit shorts to ground, neither sensor will produce a signal (output voltage to the powertrain control module).

When the ignition key is turned and left in the On position, the powertrain control module (PCM) automatically energizes the auto shutdown (ASD) relay. However, the PCM de-energizes the relay within one

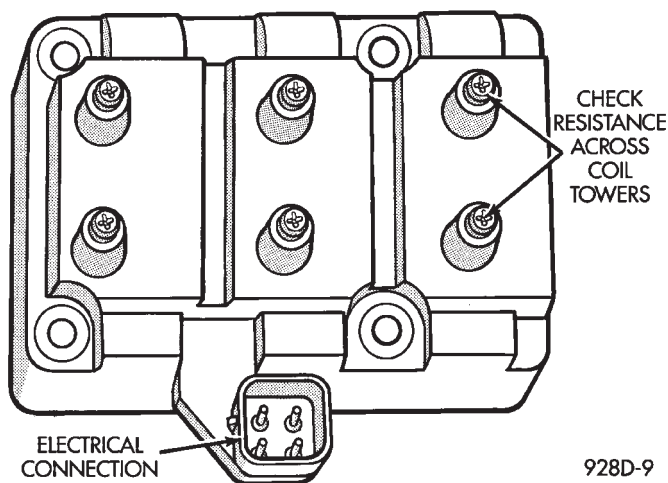


Fig. 3 Checking Ignition Coil Secondary Resistance

second because it has not received a crankshaft signal indicating engine rotation.

During cranking, the ASD relay will not energize until the PCM receives a crankshaft signal. Secondly, the ASD relay remains energized only if the PCM senses a camshaft sensor signal immediately after detecting the crankshaft sensor signal.

(1) Check battery voltage. Voltage should be approximately 12.66 volts or higher to perform failure to start test.

(2) Disconnect the harness connector from the coil pack.

(3) Connect a test light to the B+ (battery voltage) terminal of the coil electrical connector and ground. The wire for the B+ terminal is dark green with a orange tracer.

(4) Turn the ignition key to the **ON position**. The test light should flash On and then Off. **Do not turn the Key to off position, leave it in the On position.**

(a) If the test light flashes momentarily, the PCM grounded the auto shutdown (ASD) relay. Proceed to step 5.

(b) If the test light did not flash, the ASD relay did not energize. The cause is either the relay or

one of the relay circuits. Use the DRBII scan tool to test the ASD relay and circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

(5) Crank the engine. (If the key was placed in the off position after step 4, place the key in the On position before cranking. Wait for the test light to flash once, then crank the engine.)

(a) If the test light momentarily flashes during cranking, the PCM is not receiving a camshaft position sensor signal. Use the DRBII scan tool to test the camshaft position sensor and sensor circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

(b) If the test light did not flash during cranking, unplug the camshaft sensor connector. Turn the ignition key to the off position. Turn the key to the On position, wait for the test light to momentarily flash once, then crank the engine. If the test light momentarily flashes, the camshaft position sensor is shorted and must be replaced. If the light did not flash, the cause of the no-start is in either the crankshaft position sensor/camshaft position sensor 9-volt supply circuit, or the crankshaft sensor 5-volt output or ground circuits. Use the DRBII scan tool to test the crankshaft position sensor and the sensor circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

COOLANT TEMPERATURE SENSOR TEST

Refer to the appropriate Powertrain Diagnostic Procedure manual.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR TEST

Refer to the appropriate Powertrain Diagnostic Procedure manual.

CRANKSHAFT POSITION SENSOR AND CAMSHAFT POSITION SENSOR TESTS

Refer to the appropriate Powertrain Diagnostic Procedure manual.



3.3L AND 3.5L ELECTRONIC IGNITION SYSTEMS—SERVICE PROCEDURES

INDEX

	page		page
Camshaft Position Sensor—3.3L Engine	13	Knock Sensors—3.5L Engine	15
Camshaft Position Sensor—3.5L Engine	14	Manifold Absolute Pressure (MAP) Sensor	16
Crankshaft Position Sensor	14	Powertrain Control Module (PCM)	11
Electronic Ignition Coil Pack—3.3L Engine	14	Spark Plug Cables	11
Electronic Ignition Coil Pack—3.5L Engine	15	Spark Plug Service	13
Engine Coolant Temperature Sensor	11	Spark Plug Tubes—3.5L Engine	13
Ignition Timing Procedure	13	Throttle Body Minimum Air Flow	13

POWERTRAIN CONTROL MODULE (PCM)

REMOVAL

- (1) Remove air cleaner.
- (2) Remove stud bolt and push pin attaching PCM to body (Fig. 1).
- (3) Lift PCM up. Disconnect PCM 60-way connector (Fig. 2).
- (4) Remove PCM.

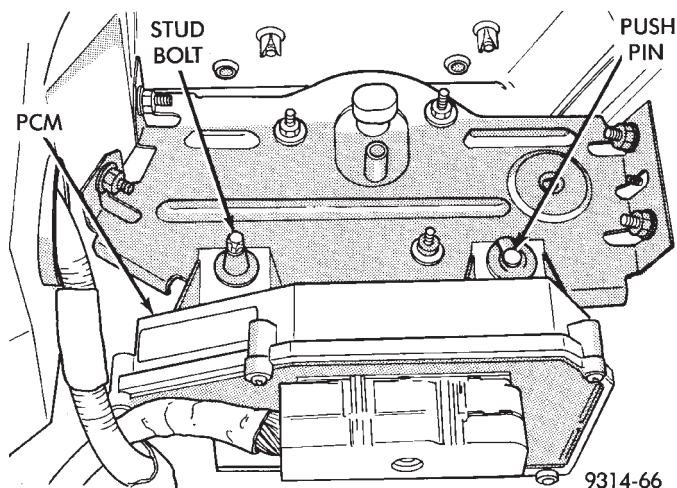


Fig. 1 PCM Location

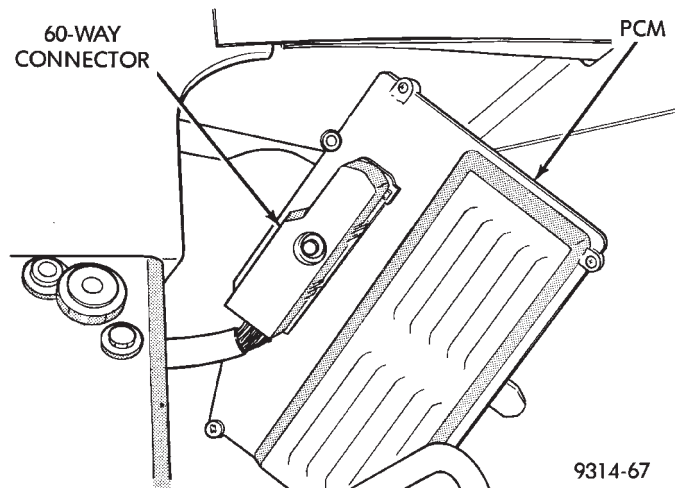


Fig. 2 PCM 60-Way Connector

INSTALLATION

- (1) Attach 60-way connector to PCM.
- (2) Install 60-way connector. Tighten 60-way connector screw to 4 N•m (35 in. lbs.) torque.
- (3) Install PCM. Tighten stud bolt to 10 N•m (7 ft. lbs.) torque. Install push pin.
- (4) Install air cleaner.

ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant sensor is located next to the thermostat housing (Fig. 3 or Fig. 4).

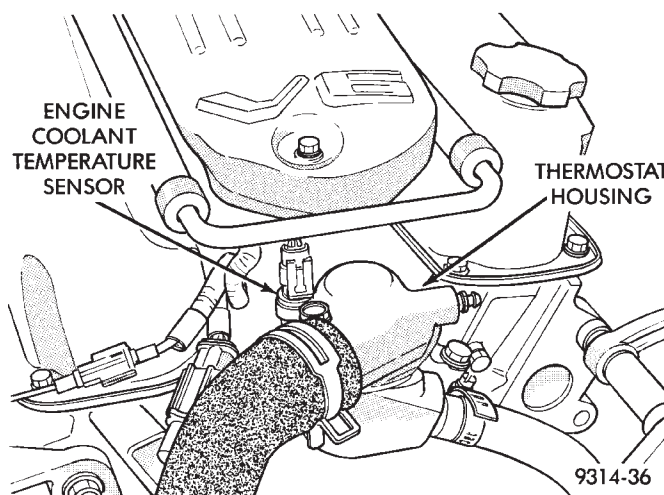


Fig. 3 Engine Coolant Temperature Sensor—3.3L Engine

REMOVAL

- (1) With the engine cold, disconnect coolant sensor electrical connector.
- (2) Remove coolant sensor.

INSTALLATION

- (1) Install coolant sensor. Tighten sensor to 28 N•m (20 ft. lbs.) torque.
- (2) Attach electrical connector to sensor.

SPARK PLUG CABLES

Clean high tension cables with a cloth moistened with a non-flammable solvent. Wipe the cables dry. Check for brittle or cracked insulation.



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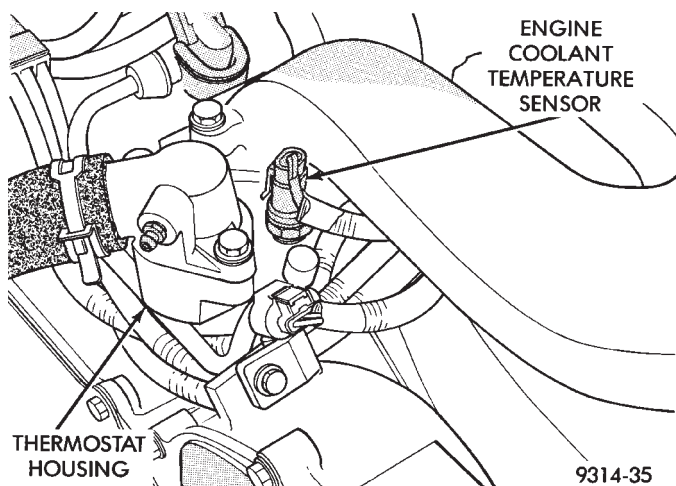


Fig. 4 Engine Coolant Temperature Sensor—3.5L Engine

Resistance cables are identified by the words **Electronic Suppression**.

SPARK PLUG CABLE SERVICE—3.3L ENGINE

Remove the cable from the retaining bracket. Grasp the terminal as close as possible to the spark plug. Rotate the cover (boot) slightly and pull straight back. **Do not use pliers and do not pull the cable at an angle.** Doing so will damage the insulation, cable terminal or the spark plug insulator. **Wipe spark plug insulator clean before installing cable and cover.**

SPARK PLUG CABLE SERVICE—3.5L ENGINE

The cables insulate the spark plugs and seal the top of the spark plug tube. A grooved tray routes the cables from the coil to each cylinder. The cables for the even number cylinders run along the bottom of the tray (Fig. 5). Cables for the odd number cylinders run along the top of the tray. Access the cables through the openings between the runners of the intake manifold plenum.

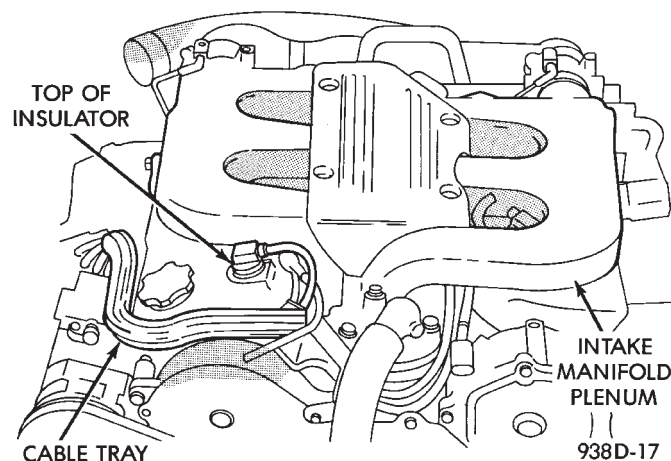


Fig. 5 Spark Plug Cables—3.5L Engine

CAUTION: When routing cables under the fuel rail on the left side of the engine during the cable removal or installation process, do not pry up on the fuel rail because permanent damage may occur to the rail. This damage could result in a fuel leakage condition. Sufficient clearance exists between the fuel rail and cam sensor for cable routing without moving the fuel rail.

To remove the cables, lightly grasp the top of the cable with pliers. Rotate the cable slightly and pull straight up. To replace the cables, disconnect the cable from the ignition coil. Remove the cable from the tray and route the coil end under the center of the intake manifold plenum.

To install the cables, run the coil end under the plenum and through the cable tray. Route the cables for the left side of the engine under the front of the fuel rail and then down the side of the rail (Fig. 6). Connect the cable to the coil. Slide the insulator into the tubes and over the spark plug. Ensure the insulator fully seats to the top of the spark plug tube.

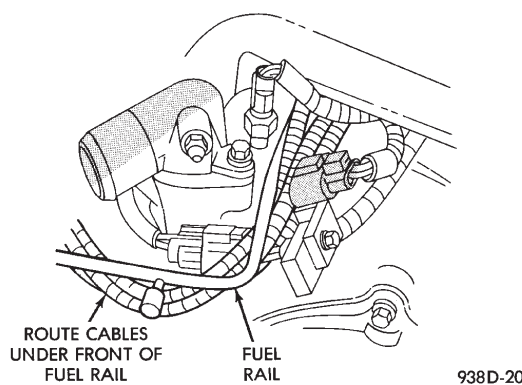


Fig. 6 Fuel Rail—3.5L Engine

TESTING—ALL ENGINES

When testing cables for punctures and cracks with an oscilloscope, follow the instructions of the equipment manufacturers.

CAUTION: Do not leave any one spark plug cable disconnected any longer than necessary during test or possible heat damage to catalytic converter will occur. Total test time must not exceed ten minutes.

If an oscilloscope is not available, test cables as follows:

(1) With the engine not running, connect one end of a test probe (i.e. a piece of wire with insulated alligator clips on each end) to a good ground, other end free for probing.

WARNING: THE DIRECT IGNITION SYSTEM GENERATES APPROXIMATELY 40,000 VOLTS. PERSONAL INJURY COULD RESULT FROM CONTACT WITH THIS SYSTEM.

(2) With engine running, move test probe along entire length of all cables (approximately 0 to 1/8 inch gap). If punctures or cracks are present there will be a noticeable spark jump from the faulty area to the probe. Cracked, leaking or faulty cables should be replaced.



(3) Use an ohmmeter to check cables for opens, loose terminals or high resistance.

(a) Remove cable from spark plug.

(b) Remove cable from the coil tower.

(c) Connect the ohmmeter between spark plug end terminal and the coil end terminal. Resistance should be within tolerance shown in the cable resistance chart. If resistance is not within tolerance, replace cable assembly. Test all spark plug cables in same manner.

CABLE RESISTANCE CHART

MINIMUM	MAXIMUM
250 Ohms Per Inch	1000 Ohms Per Inch
3000 Ohms Per Foot	12,000 Ohms Per Foot

J908D-43

SPARK PLUG SERVICE

When replacing the spark plug cables, route the cables correctly and secure them in the appropriate retainers. Failure to route the cables properly can cause the radio to reproduce ignition noise, cross ignition of the spark plugs or short circuit the cables to ground.

SPARK PLUG REMOVAL

Always remove the spark plug cable by grasping at the spark plug boot, turning the boot 1/2 turn and pulling straight back in a steady motion.

(1) Prior to removing the spark plug spray compressed air around the spark plug hole and the area around the spark plug.

(2) Remove the spark plug using a quality socket with a rubber or foam insert.

(3) Inspect the spark plug condition. Refer to Spark Plug Condition in this section.

SPARK PLUG GAP ADJUSTMENT

Check the spark plug gap with a gap gauge. If the gap is not correct, adjust it by bending the ground electrode (Fig. 7).

SPARK PLUG INSTALLATION

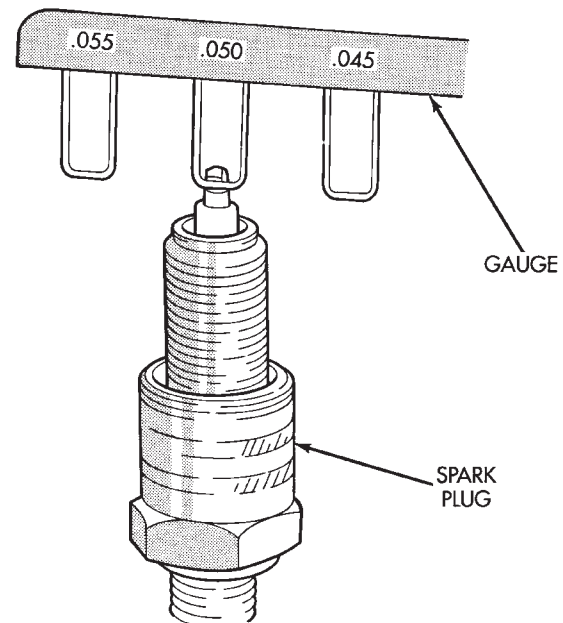
(1) To avoid cross threading, start the spark plug into the cylinder head by hand.

(2) Tighten spark plugs to 28 N•m (20 ft. lbs.) torque.

(3) Install spark plug cables over spark plugs. On 3.5L engines, ensure the top of the spark plug insulator seals the upper end of the spark plug tube.

SPARK PLUG TUBES—3.5L ENGINE

On 3.5L engines, the spark plugs thread into the top of cylinders. Tubes isolate the spark plugs and cables. For spark plug tube service, refer to Group 9, Engines.



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Fig. 7 Setting Spark Plug Gap—Typical

THROTTLE BODY MINIMUM AIR FLOW

Refer to the General Diagnosis section of Group 14.

IGNITION TIMING PROCEDURE

The 3.3L and 3.5L engines use a fixed ignition system. The PCM regulates ignition timing. Basic ignition timing is not adjustable.

CAMSHAFT POSITION SENSOR—3.3L ENGINE

The camshaft position sensor is mounted in the front of the timing case cover (Fig. 8).

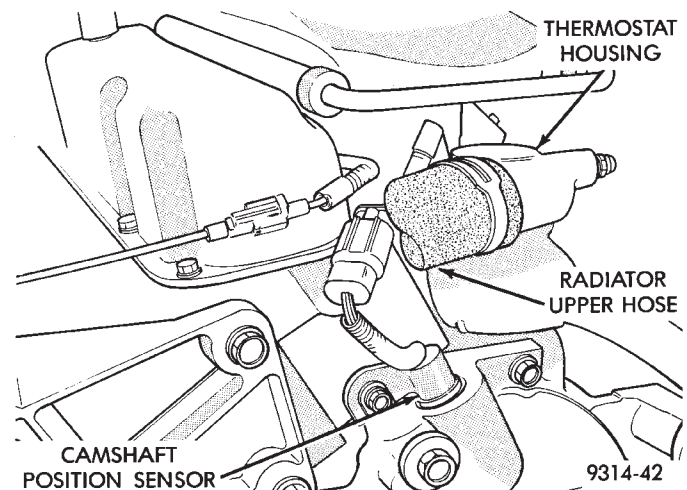


Fig. 8 Camshaft Position Sensor Location

REMOVAL

(1) Disconnect electrical connector from sensor.

(2) Loosen camshaft position sensor screw.

(3) Without pulling on the connector wires, pull the sensor up out of the chain case cover.



INSTALLATION

If the removed sensor is reinstalled, clean off the old spacer on the sensor face. Attach a NEW SPACER to the face of the sensor before installation. If installing a new sensor, confirm that the paper spacer is attached to the face and O-ring is positioned in groove (Fig. 9).

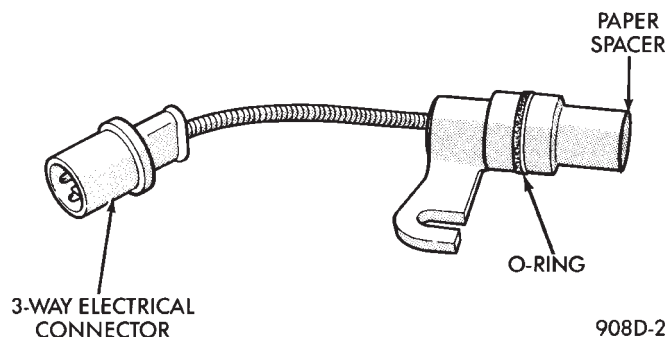


Fig. 9 Paper Spacer—3.3L Engine

(1) Install sensor in the chain case cover and push sensor down until contact is made with the camshaft sprocket. While holding the sensor in this position, install and tighten the retaining bolt to 12 N•m (105 in. lbs.) torque.

(2) Attach electrical connector to sensor.

CAMSHAFT POSITION SENSOR—3.5L ENGINE

The camshaft position sensor is installed in the timing case cover above the left camshaft sprocket (Fig. 10).

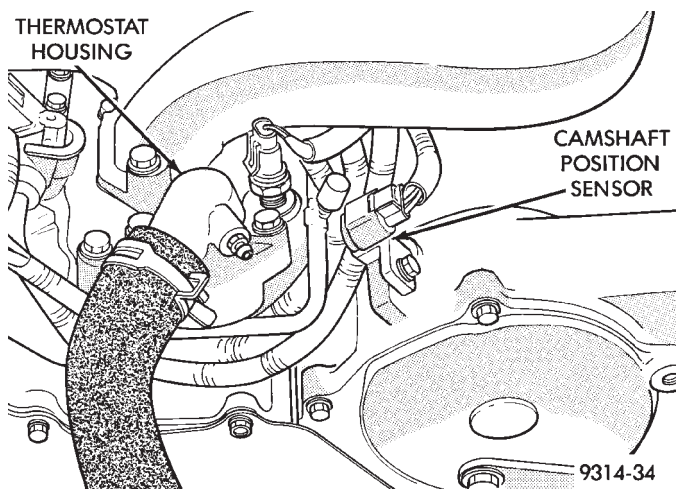


Fig. 10 Camshaft Position Sensor—3.5L Engine

REMOVAL

- (1) Disconnect electrical connector from sensor.
- (2) Remove camshaft position sensor screw.
- (3) Pull sensor up out of the chain case cover.

INSTALLATION

If the removed sensor is reinstalled, clean off the old spacer on the sensor face. Attach a NEW SPACER to the face of the sensor before instal-

lation. If installing a new sensor, confirm that the paper spacer is attached to the face (Fig. 11).

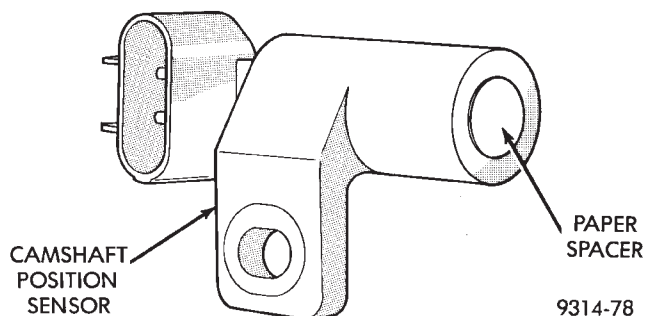


Fig. 11 Paper Spacer—3.5L Engine

(1) Install sensor in the chain case cover and push sensor down until contact is made with the camshaft sprocket. While holding the sensor in this position, install and tighten the retaining bolt to 12 N•m (105 in. lbs.) torque.

(2) Attach electrical connector to sensor.

CRANKSHAFT POSITION SENSOR

The crankshaft sensor is located on the passengers side of the transmission housing, above the differential housing (Fig. 12). The bottom of the sensor sits above the drive plate.

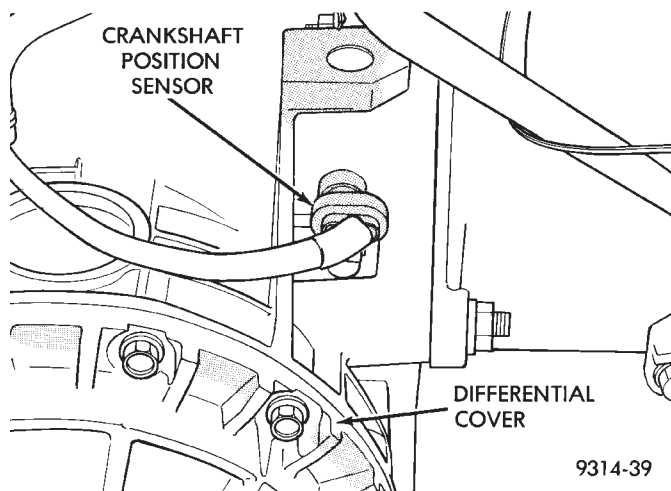


Fig. 12 Crankshaft Sensor Location

REMOVAL

- (1) Disconnect electrical connector from crankshaft position sensor.
- (2) Remove sensor mounting screw. Remove sensor.
- (3) Reverse procedure for installation.

ELECTRONIC IGNITION COIL PACK—3.3L ENGINE

The electronic ignition coil pack attaches to the a bracket mounted on the left cylinder head (Fig. 13).

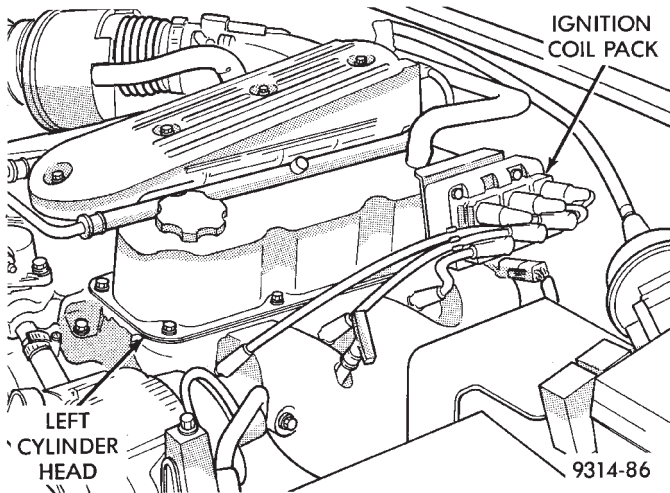


Fig. 13 Electronic Ignition Coil Pack—3.3L Engine

REMOVAL

- (1) Disconnect electrical connector from coil pack.
- (2) Remove coil pack mounting screws.
- (3) Remove coil. The spark plug cables are numbered for cylinder identification.
- (4) Transfer spark plug cables to new coil pack. The coil pack towers are numbered with the cylinder identification (Fig. 14).

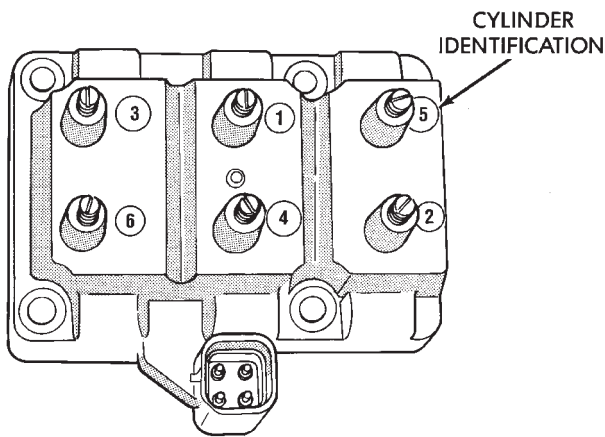


Fig. 14 Cylinder Identification

- (5) Reverse procedure for installation.

ELECTRONIC IGNITION COIL PACK—3.5L ENGINE

The ignition coil pack attaches to the right cylinder head (Fig. 15).

REMOVAL

- (1) Remove air cleaner hose.
- (2) Disconnect electrical connector from coil pack.
- (3) Remove coil pack mounting screws.
- (4) Remove coil. The spark plug cables are numbered for cylinder identification (Fig. 16).

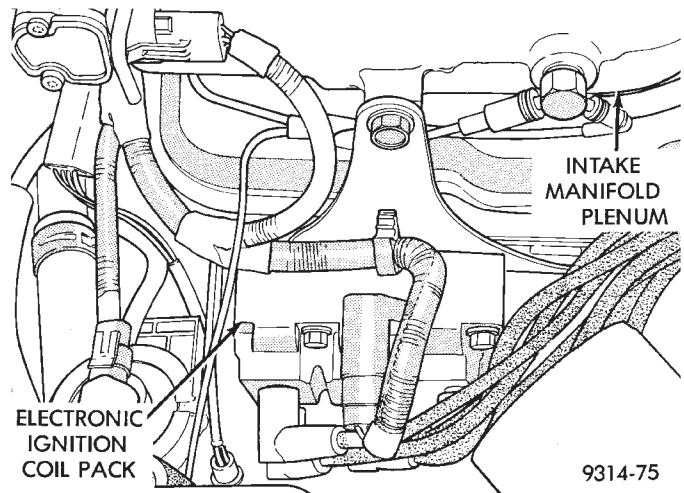


Fig. 15 Electronic Ignition Coil Pack—3.5L Engine

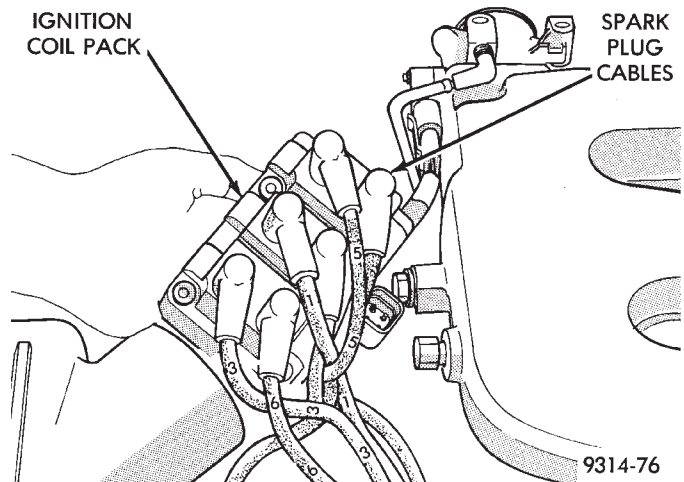


Fig. 16 Spark Plug Cable Identification

- (5) Transfer spark plug cables to new coil pack. The coil pack towers are numbered with the cylinder identification (Fig. 14).

- (6) Reverse procedure for installation.

KNOCK SENSORS—3.5L ENGINE

The 3.5L engine uses two knock sensors. The sensors thread into the cylinder block, directly below the intake manifold.

REMOVAL

- (1) Remove intake manifold plenum. Refer to Intake Manifold Plenum in Group 11.
- (2) Remove intake manifold. Refer to Group 11.
- (3) Disconnect electrical connector from knock sensor(s) (Fig. 17).
- (4) Use a crows foot socket to remove the knock sensors.

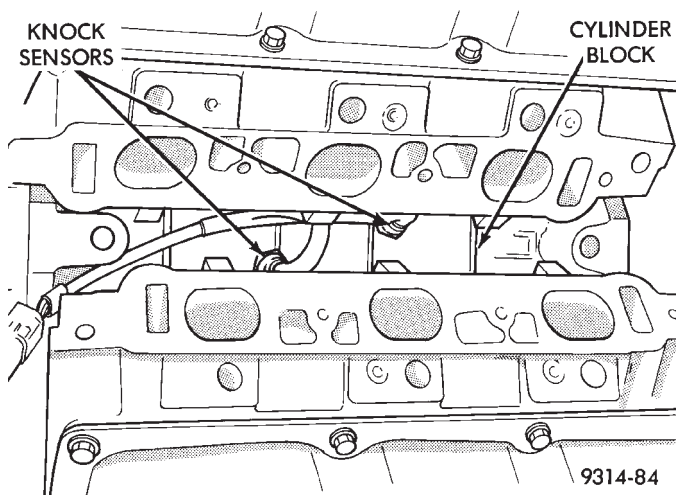


Fig. 17 Knock Sensor Location—3.5L Engine

INSTALLATION

- (1) Install knock sensor. Tighten knock sensor to 10 N•m (7 ft. lbs.) torque. **Over or under tightening effects knock sensor performance, possibly causing improper spark control.**
- (2) Attach electrical connector to knock sensor.
- (3) Install intake manifold. Refer to Group 11.
- (4) Install intake manifold plenum. Refer to Intake Manifold Plenum in Group 11.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

On 3.3L engines, the MAP sensor threads into the rear of the intake manifold plenum (Fig. 18). On 3.5L engines, the MAP sensor threads into the left side of the intake manifold plenum (Fig. 19).

REMOVAL

- (1) Disconnect the electrical connector from the MAP sensor.
- (2) Remove sensor.

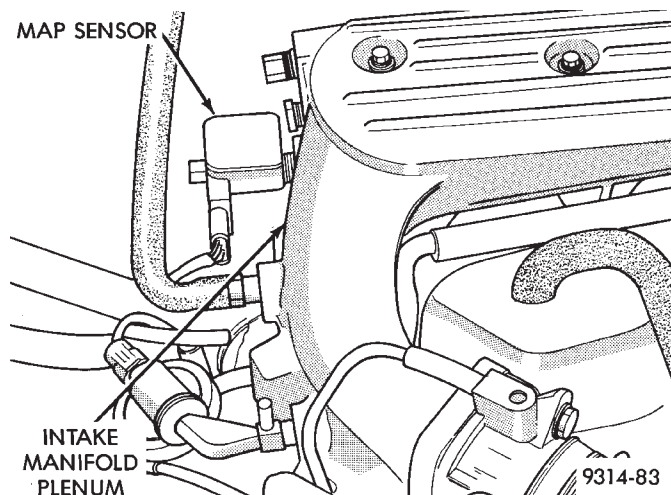


Fig. 18 MAP Sensor—3.3L Engine

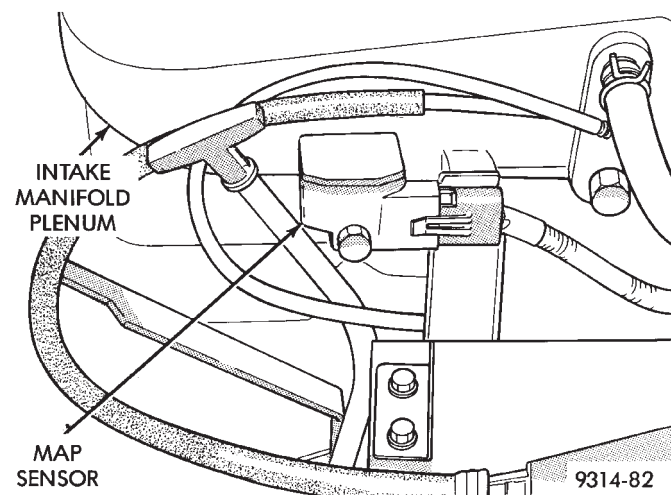


Fig. 19 MAP Sensor—3.5L Engine

INSTALLATION

- (1) Thread sensor into intake manifold plenum. Tighten sensor to 10 N•m (90 in. lbs.) torque and then rotate it to horizontal position.
- (2) Attach electrical connector to sensor.



IGNITION SWITCH AND INTERLOCK

INDEX

	page		page
Column Shift Interlock Service	19	Ignition Interlock	19
Floor Shift Interlock Adjustment	21	Ignition Switch	17
Floor Shift Interlock Service	20	Lock Cylinder Housing	22
General Information	17	Lock Key Cylinder	18

GENERAL INFORMATION

LH vehicles have an interlock system. The system prevents shifting the vehicle out of Park unless the ignition lock cylinder is in the Off, Run or Start position (Fig. 1 or Fig. 2). In addition, the operator cannot rotate the key to the lock position unless the shifter is in the park position.

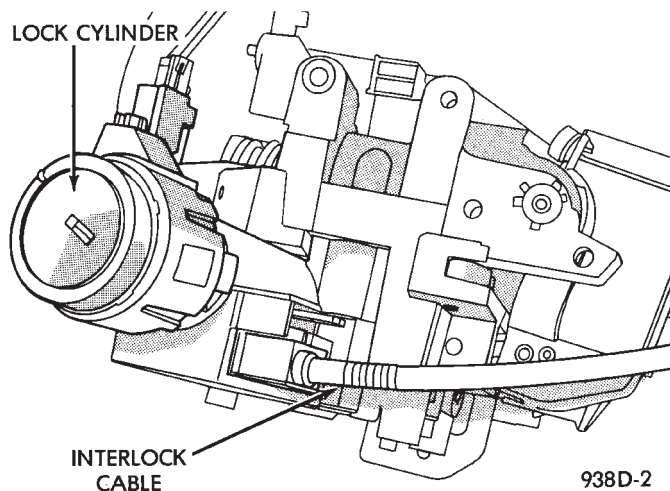


Fig. 1 Ignition Interlock—Floor Shift

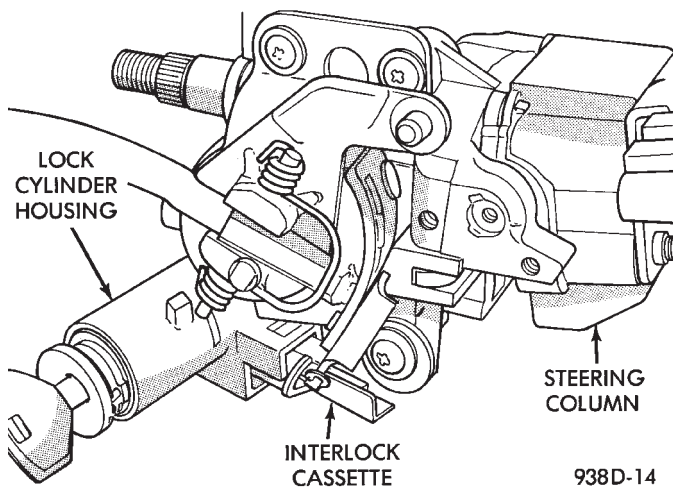


Fig. 2 Ignition Interlock—Column Shift

IGNITION SWITCH

The ignition switch attaches to the lock cylinder housing on the end opposite the lock cylinder (Fig.

3). For ignition switch terminal and circuit identification, refer to Group 8W, Wiring Diagrams.

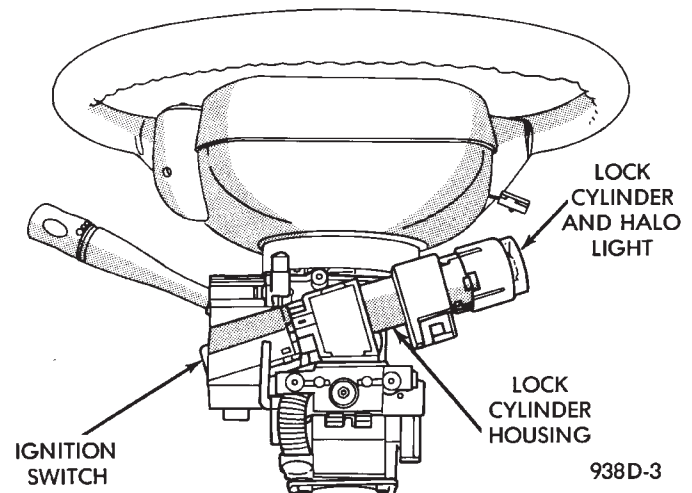


Fig. 3 Ignition Switch

REMOVAL

- (1) Disconnect the negative cable from the battery.
- (2) Remove the tilt lever attaching screw. Remove lever.
- (3) Remove the upper and lower cover from steering column.
- (4) Disconnect electrical connector from ignition switch (Fig. 4).
- (5) Remove Ignition switch mounting screws. Remove switch.

INSTALLATION

- (1) A tab on the ignition switch indexes to a notch in the lock cylinder housing (Fig. 5). Also, a slot in the end of the ignition switch fits over the shaft in the end of the lock cylinder housing. Use the ignition key to rotate the lock cylinder to align the ignition switch with lock cylinder housing.
- (2) Install and tighten ignition switch mounting screws.
- (3) Attach electrical connector to ignition switch.
- (4) Install tilt lever.
- (5) Install upper and lower cover on steering column.
- (6) Connect negative cable to battery.

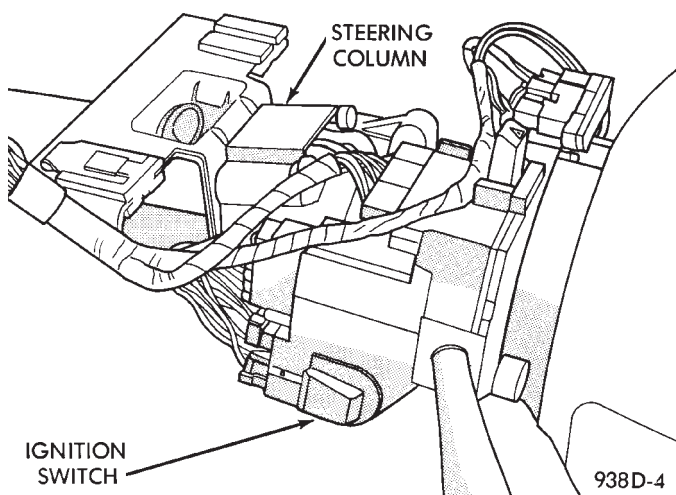


Fig. 4 Ignition Switch Removal/Installation

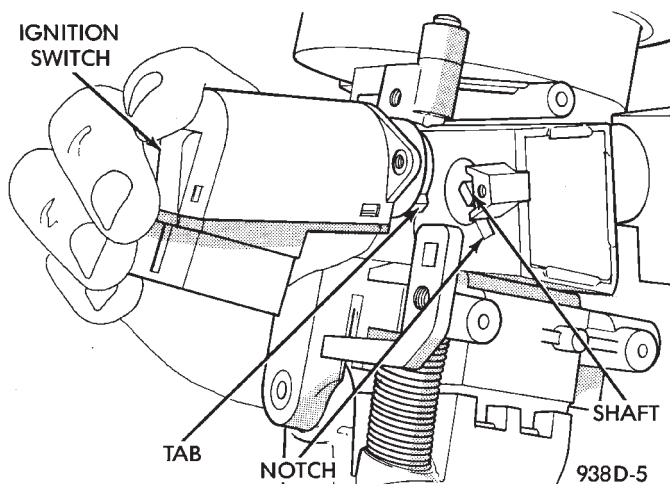


Fig. 5 Ignition Switch Alignment

LOCK KEY CYLINDER

The lock cylinder is inserted in the end of the housing opposite the ignition switch (Fig. 3). The ignition key rotates the cylinder to 5 different detents (Fig. 6):

- Accessory
- Off (lock)
- Unlock
- On/Run
- Start

When replacing the lock cylinder, if the vehicle has a column shifter, install a new interlock cassette. If the vehicle has a floor shift, adjust the interlock cable when the lock cylinder is replaced.

REMOVAL

- (1) Disconnect negative cable from the battery.
- (2) Remove the tilt lever attaching screw. Remove lever.
- (3) Remove the upper and lower covers from the steering column.

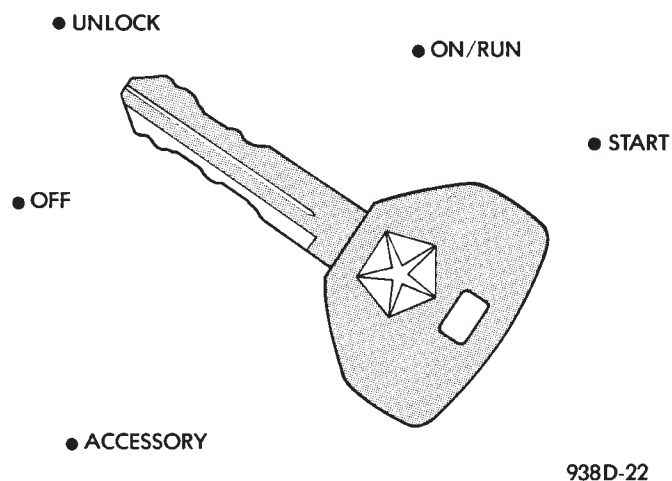


Fig. 6 Ignition Lock Cylinder Detents

(4) Turn the ignition key to the run position. When ignition switch is in the run position, the lock cylinder retaining tab will depress.

(5) Depress tab and slide lock cylinder out of housing (Fig. 7).

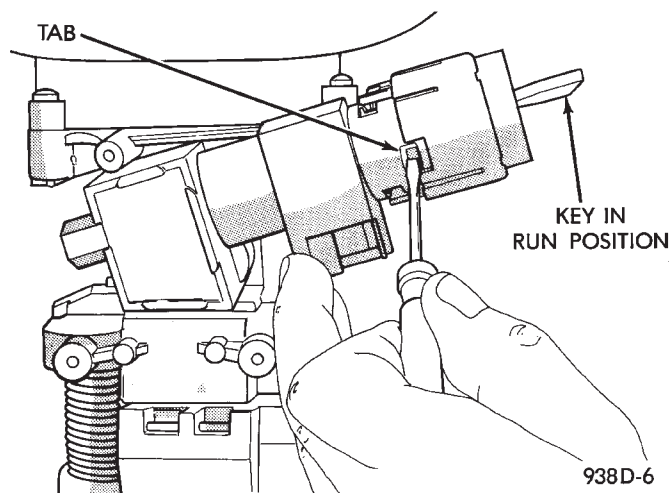


Fig. 7 Lock Cylinder Removal

INSTALLATION

(1) Install key in lock cylinder. Turn key to run position (retaining tab on lock cylinder can be depressed).

(2) The shaft at the end of the lock cylinder aligns with the socket in the end of the housing. To align the socket with the lock cylinder, ensure the socket is in the Run position (Fig. 8).

(3) Align the lock cylinder with the grooves in the housing. Slide the lock cylinder into the housing until the tab sticks through the opening in the housing (Fig. 9).

(4) Turn the key to the Off position. Remove the key.

(5) If the vehicle has column shift and a new lock cylinder was used, install and adjust a new interlock cassette. Refer to Ignition Interlock in this section. If

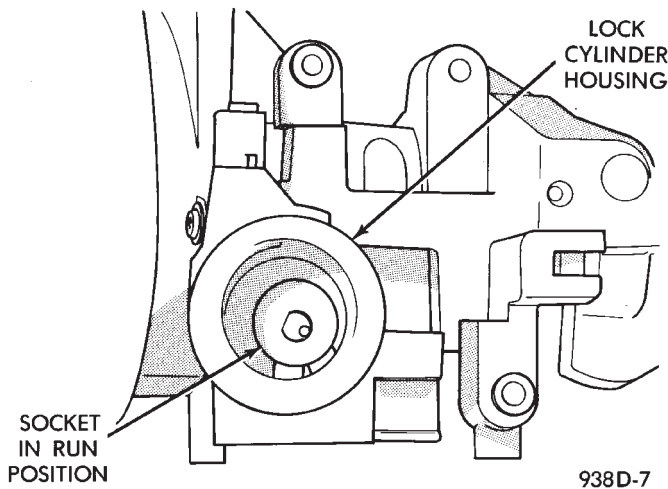


Fig. 8 Socket in Lock Cylinder Housing

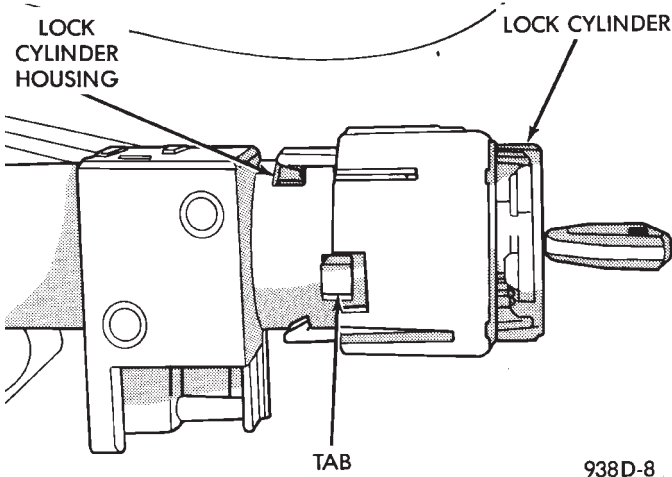


Fig. 9 Lock Cylinder Installation

the vehicle has a floor shift, adjust the interlock cable when the lock cylinder is replaced. Refer to the Floor Shift Interlock Adjustment procedure in this section.

- (6) Install tilt lever.
- (7) Install upper and lower cover on steering column.
- (8) Connect negative cable to battery.

IGNITION INTERLOCK

The ignition interlock system connects the automatic transmission shifter and the lock system. With the ignition key in the OFF or ACCESSORY position, the interlock system holds the transmission shifter in park. When the key is in the RUN position the shifter unlocks and can be moved to any position. Also, if the shifter is not in PARK, the system prevents the operator from turning the ignition switch to the OFF or ACCESSORY positions.

If the vehicle has column shift, install a new interlock cassette (column shift) when replacing

the ignition lock cylinder. Adjust the system after replacing the cassette.

If the vehicle has floor shift, adjust the interlock cable after replacing the lock cylinder.

DIAGNOSIS

COLUMN SHIFT

If the interlock cable breaks while the shifter is in the park position, the shifter will remain in park. Should the interlock cable break when the shifter is in neutral, the operator won't be able to shift to park. In either case, replace and adjust the interlock cassette or interlock cable.

FLOOR SHIFT

(1) With the ignition key in the Lock (Off) position, place the floor shifter in Park. The operator should not be able to remove the shifter from Park (button on shifter won't depress) when the ignition key is in the Lock position.

(2) Turn the ignition key to the On position. With the ignition key in the On position, the shifter should move to any gear position. With the shifter in a gear selection, the operator should not be able to remove the ignition key.

(3) Return the shifter to the Park position. The operator should be able to remove the key after placing it in the Lock (Off) position.

If the interlock system works as described in the above steps, check the system for incorrect adjustment or a binding cable. Refer to the Adjustment procedure or the Removal procedure as necessary.

COLUMN SHIFT INTERLOCK SERVICE

The interlock cassette slides into the housing behind the lock cylinder (Fig. 10). The cable at the rear of the cassette attaches to a locking arm on the shifter mechanism. **The column shift interlock system is only adjusted after installing a new cassette. It can't be adjusted more than once. If the system operates incorrectly, install and adjust a new interlock cassette.**

REMOVAL

- (1) Depress the tab on the top of the cassette (Fig. 10).
- (2) Slide the interlock cassette out of the housing.
- (3) Remove the cable from the locking arm on the shifter mechanism.

INSTALLATION

(1) Ensure the latch rotates freely on the shifter gate (Fig. 11).

(2) With the shifter in Park and the key removed, install the cable over the hook on locking arm of the shifter mechanism.

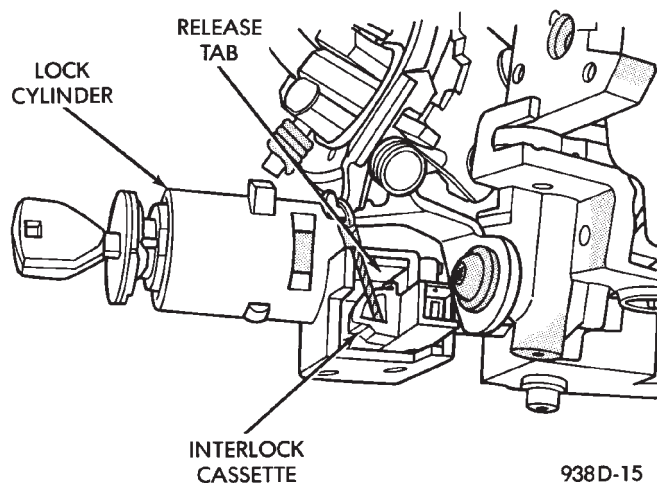


Fig. 10 Ignition Interlock Cassette—Column Shift

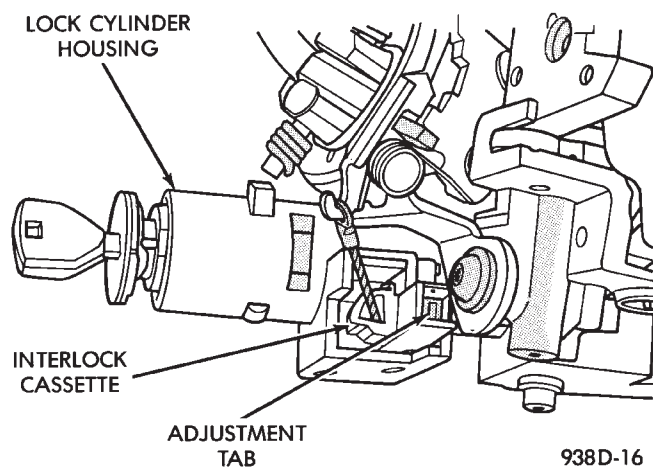


Fig. 12 Ignition Interlock Adjustment Tab—Column Shift

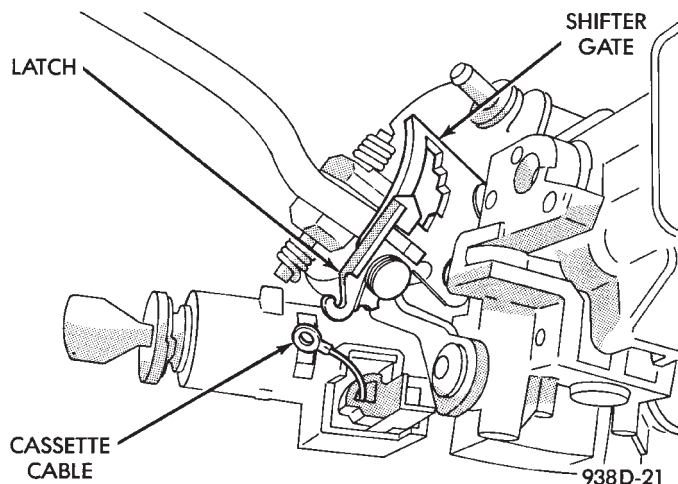


Fig. 11 Latch and Shifter Gate

(3) Slide the cassette into the housing until it locks in place.

(4) To adjust the interlock system, push the adjustment tab in until it stops (Fig. 12). The adjustment tab will click as it moves into position. Ensure the tab is fully depressed.

FLOOR SHIFT INTERLOCK SERVICE

The interlock cable slides into the housing behind the lock cylinder (Fig. 1) and attaches to the floor mounted shifter. The floor shift interlock system is adjusted by a nut at the shifter.

If the system requires adjustment and not replacement, refer to the Floor Shift Interlock Adjustment procedure in this section.

REMOVAL

- (1) Remove shifter handle.
- (2) Remove the bezel from the shifter console.
- (3) Remove the drivers side kick panel of the center console.
- (4) Remove the tilt lever attaching screw. Remove lever.

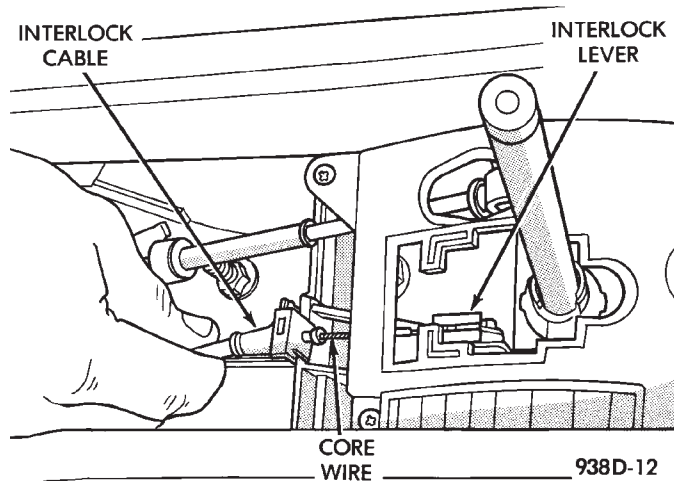


Fig. 13 Interlock Cable at Floor Shifter

(5) Remove upper and lower covers from the steering column.

(6) Loosen the nut on the interlock adjustment lever.

(7) Move ignition key to the Run position.

(8) Remove the interlock cable from the shifter housing (Fig. 13). Slide the cable out of the groove in the interlock lever.

(9) Depress the lock tab on the interlock cable and pull the cable out of the lock cylinder housing (Fig. 14).

(10) Remove interlock cable.

INSTALLATION

- (1) Ensure ignition switch is in the On position.
- (2) Route the interlock cable down the steering column, past the air distribution center duct. Route the cable between the support strut and air bag module mounting bracket and down to the shifter housing.

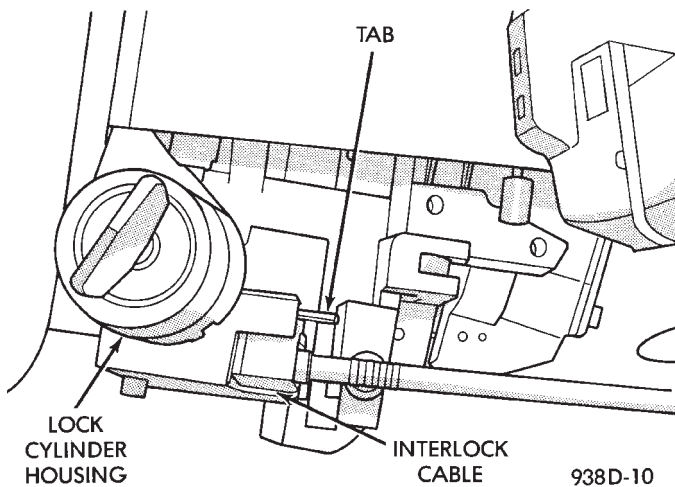


Fig. 14 Interlock Cable at Ignition Switch

(3) Slide the steering column end of the interlock cable into the lock cylinder housing until it snaps into place (Fig. 14).

(4) Turn the ignition key to the Off/Lock position

(5) Put the shifter in the PARK position.

(6) Slide the interlock cable core wire into the groove on the adjustment lever. Ensure the cable end seats in the groove (Fig. 13).

(7) Slip the cable into the housing until it snaps into place.

(8) Ensure the shift lever remains in PARK. Remove the ignition key from the lock cylinder (switch in OFF position).

When the adjustment nut on the interlock lever is loosened, the cable indexes itself to the correct position (Fig. 15).

(9) Loosen the adjustment nut. Allow the cable to adjust itself to the correct position. Tighten the adjustment nut.

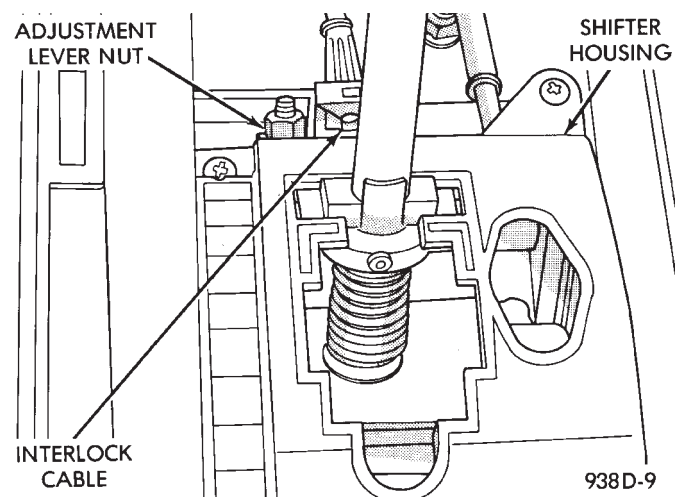


Fig. 15 Interlock Cable at Floor Shifter

(10) Inspect the interlock cable:

- With the lock cylinder in the OFF (lock) position and ignition key removed, the cable core wire should

not move when pulled. If the cable core wire moves, the cable is improperly installed or kinked.

- With the ignition key in the RUN position, the cable core wire should slide freely when pulled. Also, the cable should return to the bottomed out position when released. If the cable core wire does not move in the RUN position, the cable is improperly installed or kinked.

(11) Check the interlock adjustment:

- With the ignition key in the OFF (lock) position, the shifter should be locked in the PARK position. If not, repeat the adjustment procedure.

- **Without starting the engine**, place the ignition switch in the run position. Move the shifter to the reverse position. You should be unable to remove the ignition key from the lock cylinder. If you can remove the key at this point, repeat the adjustment procedure.

- Place the shifter in the PARK position. Turn the ignition key to the OFF (lock) position. You should be able to remove the ignition key from the lock cylinder. If not, repeat the adjustment procedure.

(12) Install the bezel on the shifter console.

(13) Install shifter handle.

(14) Install the lower kick panel.

(15) Install tilt lever

(16) Install upper and lower covers from the steering column.

FLOOR SHIFT INTERLOCK ADJUSTMENT

(1) Remove the shifter handle.

(2) Remove the console bezel.

(3) Loosen the adjustment nut on the interlock lever (Fig. 15).

(4) Move ignition key to the RUN position.

(5) Remove the interlock cable from the shifter housing (Fig. 13). Slide the cable out of the groove in the interlock lever.

(6) Inspect the interlock cable:

- With the lock cylinder in OFF (lock) position and the ignition key removed, the cable core wire should not move when pulled. If the cable core wire moves, the cable is improperly installed or kinked.

- With the ignition key in the RUN position, the cable core wire should slide freely when pulled. Also, the cable should return to the bottomed out position when released. If the cable core wire does not move in the RUN position, the cable is improperly installed or kinked.

(7) Put the shifter in the PARK position.

(8) Slide the interlock cable core wire into the groove on the adjustment lever. Ensure the cable end seats in the groove.

(9) Slip the cable into the housing until it snaps in place.



(10) Ensure the shift lever remains in PARK. Remove the ignition key from the lock cylinder (switch in OFF position).

When the adjustment nut on the interlock lever is loosened, the cable indexes itself to the correct position (Fig. 15).

(11) Loosen the adjustment nut. Allow the cable to adjust itself to the correct position. Tighten the adjustment nut.

(12) Check the interlock adjustment:

- With the ignition key in the OFF (lock) position, the shifter should be locked in the PARK position. If not, re-adjust the interlock and tighten the adjustment nut (Fig. 15).

- **Without starting the engine**, place the ignition switch in the run position. Move the shifter to the reverse position. You should not be able to remove the ignition key from the lock cylinder. If the key can be removed at this point, re-adjust the interlock and tighten the adjustment nut (Fig. 15).

- Place the shifter in the PARK position. Turn the ignition key to the OFF (lock) position. You should be able to remove the ignition key from the lock cylinder. If not, re-adjust the interlock and tighten the adjustment nut (Fig. 15).

(13) Install the bezel on the shifter console.

(14) Install shifter handle.

(15) Install the lower kick panel.

(16) Install upper and lower covers from the steering column.

LOCK CYLINDER HOUSING

The lock cylinder housing attaches to the steering column with tamper-proof screws and hardened washers (Fig. 16).

REMOVAL

(1) Remove the upper and lower covers from the steering column.

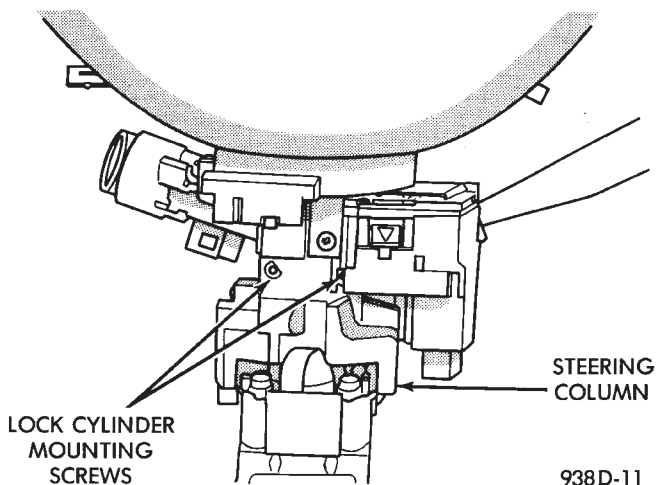


Fig. 16 Lock Cylinder Housing Mounting Screws

(2) Remove the tilt lever attaching screw. Remove lever.

(3) Remove the ignition switch. Refer to Ignition Switch in this section.

(4) Center punch the tamper-proof screws.

(5) Using a 6 mm (1/4 inch) drill bit, drill out the screw heads. Drill until the bit contacts the hardened washer under the screw head.

(6) Remove the lock cylinder housing from the steering column.

(7) Use a pair of pliers to remove the bolts from the lock steering column.

INSTALLATION

The heads of the tamper-proof mounting screws shear off when tightened.

(1) Position lock cylinder housing on steering column.

(2) Tighten new mounting screws until the heads of the tamper-proof screws shear off.

(3) Install ignition switch.

(4) Install tilt lever

(5) Install upper and lower covers on steering column.

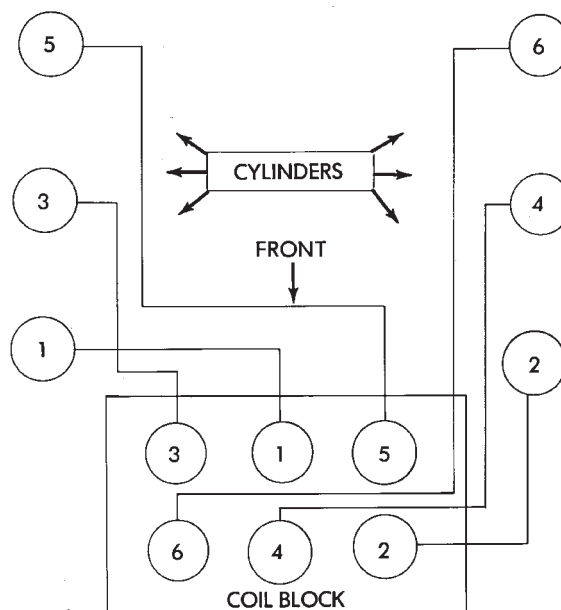


SPECIFICATIONS

GENERAL INFORMATION

The following specifications represent the latest information available at the time of publication. If anything differs from the specifications on the Vehicle Emission Control Information Label, use the specifications on the label.

SPARK PLUG CABLE ROUTING—3.3L AND 3.5L ENGINES



938D-18

IGNITION COILS

COIL MANUFACTURER	PRIMARY RESISTANCE AT 21°C - 27°C (70°F - 80°F)	SECONDARY RESISTANCE AT 21°C - 27°C (70°F - 80°F)
Diamond	0.52 to 0.63 Ohms	11,600 to 15,800 Ohms
Toyodenso	0.51 to 0.61 Ohms	11,500 to 13,500 Ohms

928D-43

SPARK PLUGS

Engine	Spark Plug	Gap	Thread Size
3.3L	RN14MC5	0.048 to 0.053 in.	14 mm (3/4 in.) reach
3.5L	** RC12LYC **	** 0.033 to 0.038 in. **	14 mm (3/4 in.) reach

938D-13

TORQUE

Description	Torque
3.3L/3.5L Camshaft Position Sensor Screw	12 N•m (105 in. lbs.)
3.3L/3.5L Coolant Sensor	28 N•m (20 ft. lbs.)
3.3L/3.5L Crankshaft Position Sensor Screw	12 N•m (105 in. lbs.)
3.3L/3.5L Ignition Coil	12 N•m (105 in. lbs.)
3.5L Knock Sensor	10 N•m (7 ft. lbs.)

Description	Torque
3.3L/3.5L MAP Sensor (tighten to specification then rotate to horizontal position) ...	10 N•m (90 in. lbs.)
Powertrain Control Module	10 N•m (7 ft. lbs.)
Spark Plugs	28 N•m (20 ft. lbs.)

938D-19

