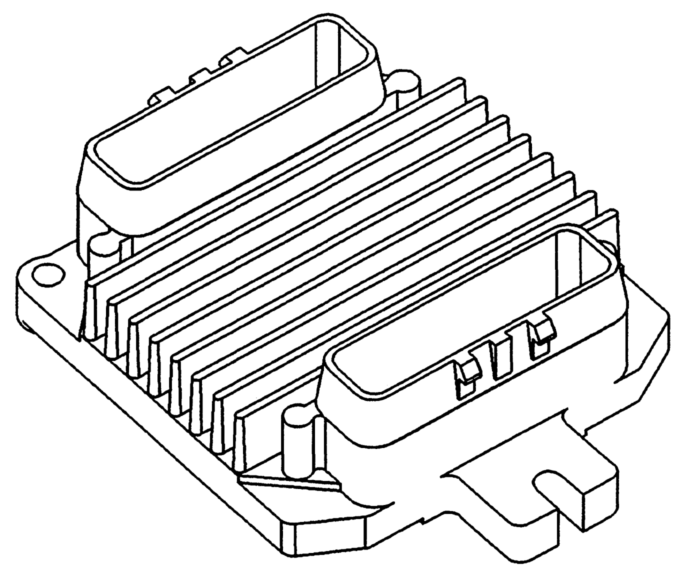
# ELECTRONIC ENGINE CONTROL

## DESCRIPTION AND OPERATION

### GM 3.0 L ENGINES
### S2.0-3.2XM (S40-65XM)
### H2.0-3.2XM (H45-65XM)
### GM 4.3 L ENGINES
### S3.50-7.00XL (S70-155XL)
### H3.50-7.00XL (H70-155XL)



HYSTER

PART NO. 1474823

2200 SRM 781

# SAFETY PRECAUTIONS
# MAINTENANCE AND REPAIR

- When lifting parts or assemblies, make sure that all slings, chains or cables are correctly fastened and that the load being lifted is balanced. Make sure that the crane, cables and chains have the capacity to support the weight of the load.
- Do not lift heavy parts by hand. Use a lifting mechanism.
- Wear safety glasses.
- DISCONNECT THE BATTERY CONNECTOR before doing any maintenance or repair on electric lift trucks. Disconnect the battery ground cable on internal combustion lift trucks.
- Always use correct blocks to prevent the unit from rolling or falling. See "How To Put The Lift Truck On Blocks" in the **OPERATING MANUAL** or the **PERIODIC MAINTENANCE** section.
- Keep the unit and working area clean and in order.
- Use the correct tools for the job.
- Keep the tools clean and in good condition.
- Always use **HYSTER** *APPROVED* parts when making repairs. Replacement parts must meet or exceed the specifications of the original equipment manufacturer.
- Make sure that all nuts, bolts, snap rings and other fastening devices are removed before using force to remove parts.
- Always fasten a DO NOT OPERATE sign to the controls of the unit when making repairs or if the unit needs repairs.
- Make sure you follow the **WARNING** and **CAUTION** notes in the instructions.
- Gasoline, Liquid Petroleum Gas (LPG), and Diesel are flammable fuels. Make sure that you follow the necessary safety precautions when handling these fuels and when working on these fuel systems.
- Batteries generate flammable gas when they are being charged. Keep fire and sparks away from the area. Make sure the area has ventilation.

# CONTENTS



This section is for the following models:

S2.00-3.20XM(S40-65XM)(D187)
S3.50-5.50XL (S70-120XL)(D004)
S6.00-7.00XL (S135-155XL)(B024)
H2.00-3.20XM(H45-65XM)(H177)
H3.50-5.00XL (H70-110XL)(G005)
H6.00-7.00XL (H135-155XL)(F006)

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# "THE QUALITY KEEPERS"

# HYSTER APPROVED PARTS

# INTRODUCTION

## GENERAL

This section has the description and operation of the electronic engine control system and the components in that system. The repair and troubleshooting procedures for the system used in the GM 3.0L and 4.3L engines is in the section **ELECTRONIC ENGINE CONTROL, TROUBLESHOOTING AND REPAIR, 2200 SRM 782.**

**NOTE:** Engines that have an LPG fuel system use a microprocessor spark timing system (MSTS) or a carburated engine management system (CEMS). They do not have an electronically controlled fuel injection system.

# DESCRIPTION AND OPERATION

## GENERAL

When a carburetor and distributor are used for fuel supply and ignition control, a single adjustment can not be made to give the best adjustment for all operating speeds and conditions. The use of microprocessors has enabled the development of electronic systems that can better control engines that use gasoline or liquid petroleum gas (LPG) during all operating conditions.

An electronic engine control continuously makes adjustments to control the spark timing and fuel mixture to the engine. This control gives the following benefits:

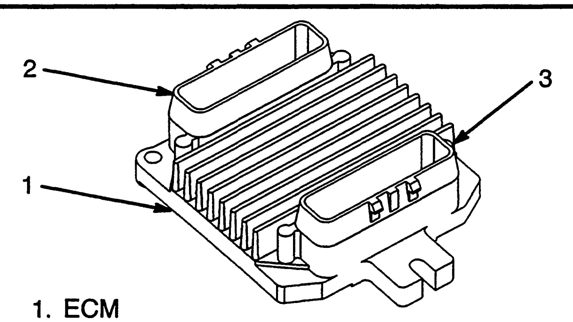
- Engine is easier to start and operate during changing conditions.
- An electronic governor is installed for finer engine speed control.
- Electronic monitoring of engine operation as an aid to troubleshooting.

## ELECTRONIC CONTROL MODULE (ECM)

The ECM is a small computer that controls the ignition timing and fuel supply in a gasoline engine. See FIGURE 1. An Electronically Erasable Programmable Read Only Memory (EEPROM) is installed in the ECM. This EEPROM is programmed with information for the best operation of the engine according to the fuel, temperature, load and other conditions. The ECM receives signals from sensors on the engine and electronically controls the following systems and components for the best fuel use and engine performance:

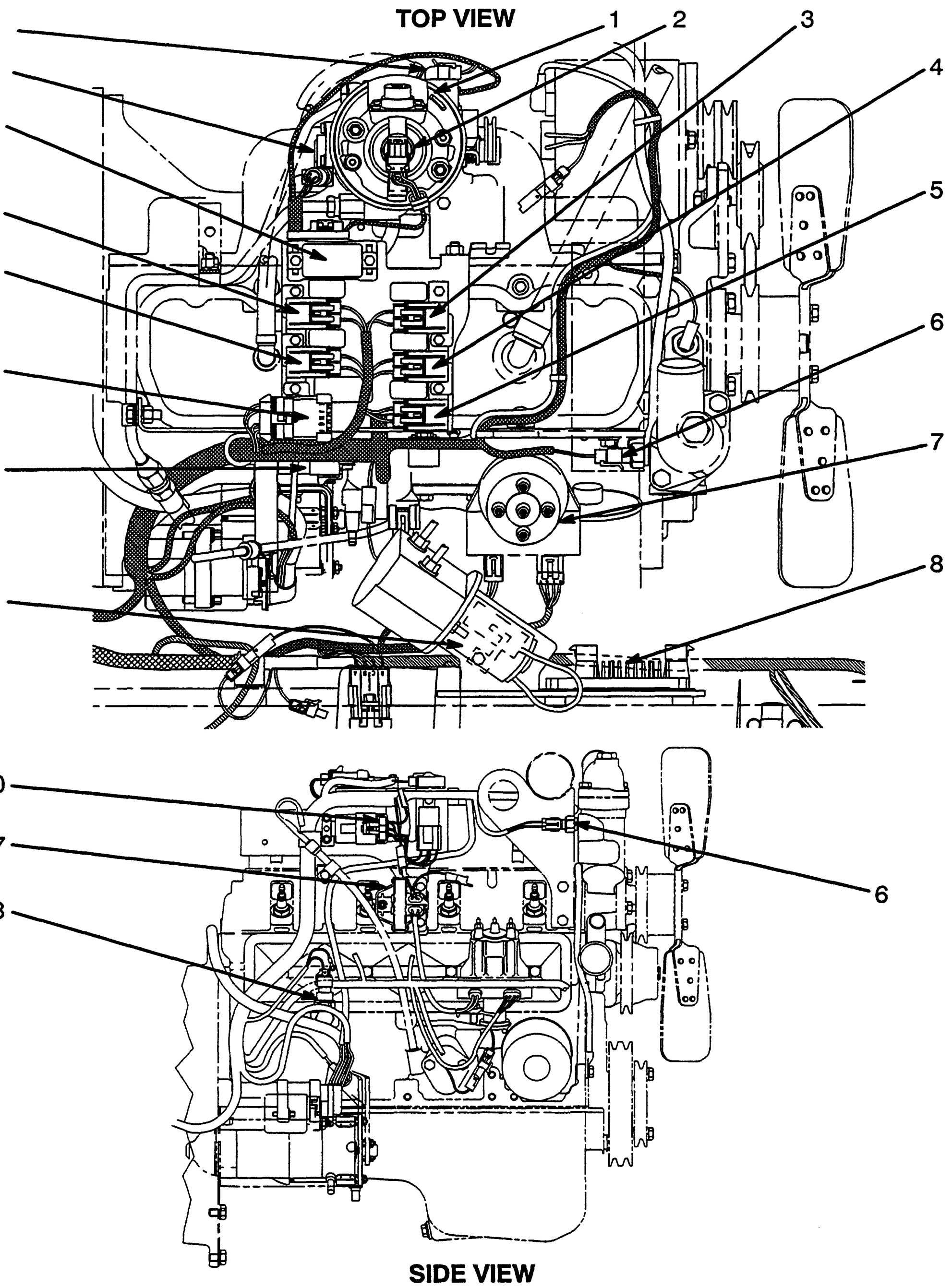
- A fuel injection system
- Electronic spark timing (EST)
- An electronic governor
- Check Engine light
- Idle air control (IAC)
- Fuel pump relay
- A serial data link for troubleshooting

Each ECM has a specific program for the model of lift truck in which it is installed. A replacement ECM must have the same part number so that the lift truck will operate correctly.




1. ECM
2. CONNECTOR, J1
3. CONNECTOR, J2

FIGURE 1. ECM




1. THROTTLE BODY INJECTION (TBI) UNIT
2. FUEL INJECTOR
3. FUEL INJECTOR FUSE
4. ECM FUSE (IGNITION)
5. STARTER FUSE
6. ENGINE COOLANT TEMPERATURE (ECT) SENSOR
7. DISTRIBUTOR
8. ELECTRONIC CONTROL MODULE (ECM)
9. GOVERNOR MOTOR
10. FUEL PUMP RELAY
11. DIAGNOSTIC CONNECTOR
12. FUSE PUMP FUSE
13. ECM FUSE (B+)
14. MANIFOLD ABSOLUTE PRESSURE (MAP)
15. THROTTLE POSITION SENSOR (TPS)
16. IDLE AIR CONTROL (IAC)
17. IGNITION COIL
18. OIL PRESSURE SWITCH

FIGURE 2. ELECTRONIC ENGINE CONTROL COMPONENTS ARRANGEMENT (GM 3.0L ENGINE)

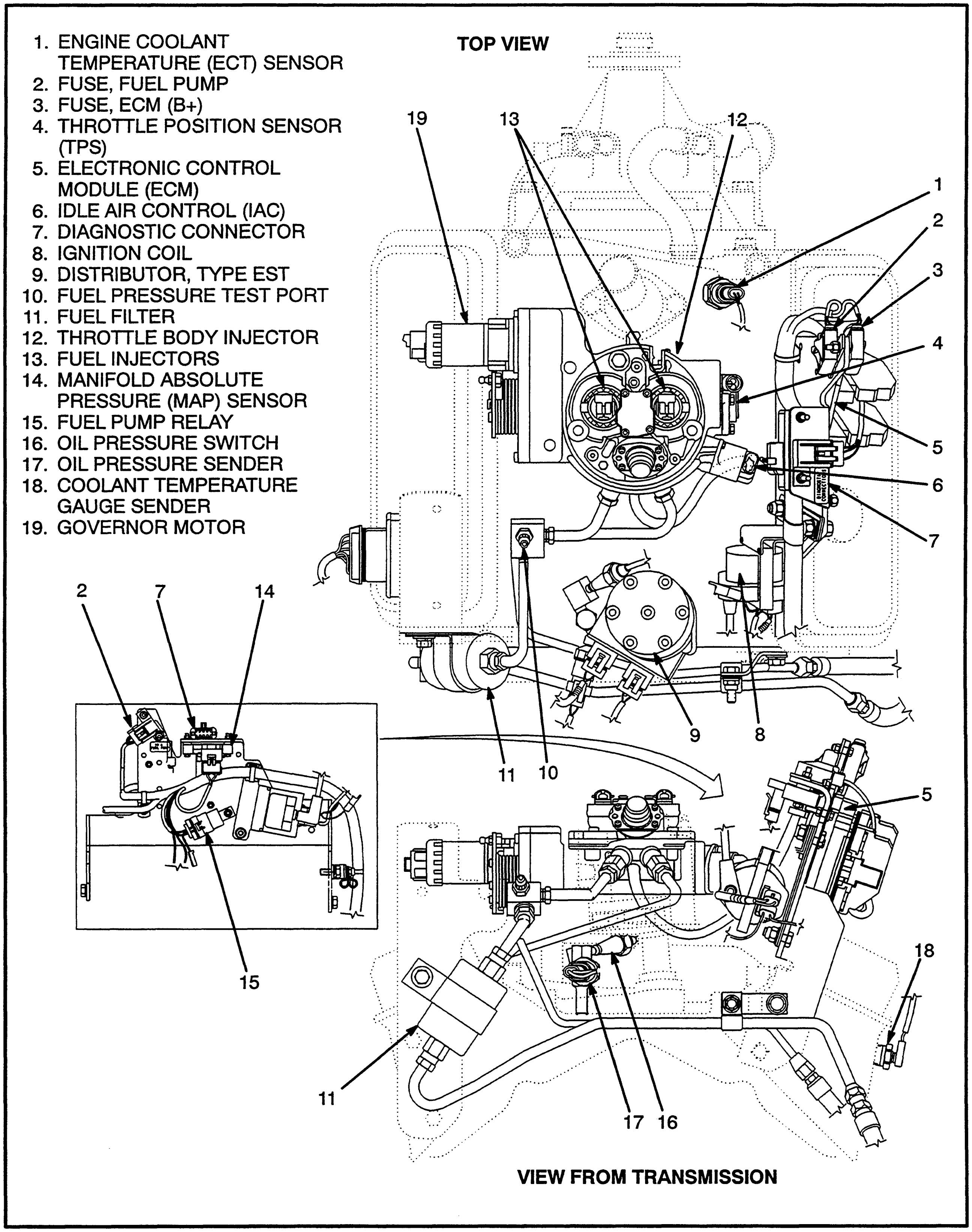
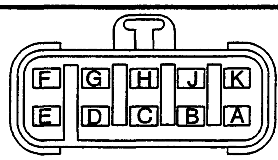



FIGURE 3. ELECTRONIC ENGINE CONTROL COMPONENTS ARRANGEMENT (GM 4.3L ENGINE)

## Diagnostic Connector (See FIGURE 4.)

The diagnostic connector is connected through a wiring harness to the ECM. The diagnostic connector is an important link for troubleshooting the operation of the ECM and the electronic engine control system. The diagnostic connector is found in the engine compartment. (See Item 11, FIGURE 2. and item 7, FIGURE 3.) The use of the diagnostic connector is described in the **ELECTRONIC ENGINE CONTROL, TROUBLESHOOTING AND REPAIRS** section for these engines.




A = GROUND
B = FAULT ANALYSIS TERMINAL
E = CHECK ENGINE LIGHT
F = +12 VOLTS
G = SERIAL DATA FOR SCAN TOOL TESTER

FIGURE 4. DIAGNOSTIC CONNECTOR

## How The ECM Begins Operation

When the ignition switch is turned to **ON**, the ECM does the following functions:

- Measures the atmospheric pressure (BARO signal) from the MAP sensor.
- Checks the signal from the coolant temperature sensor (ECT).
- Energizes the fuel pump relay for approximately two seconds.
- Checks that the throttle position sensor indicates that the throttle is less than 80% open. (If the throttle is more than 80% open, the ECM determines that the engine is flooded with fuel and delivers less fuel to the engine.)
- **Distributor System:** Checks the starting mode from the ignition module. [When the starter is engaged, the ignition module sends electronic pulses to the ECM. The frequency of the pulses indicates to the ECM that the engine is being started. The ignition module also electronically energizes (ON) and deenergizes (OFF) the primary circuit of the ignition coil to create a spark at the spark plugs.]

OPERATING CONDITIONS SENSED BY ECM

- Engine Coolant Temperature (ECT)
- Engine Crank Signal
- Distributor Reference
- Engine Speed (rpm)
- Manifold Absolute Pressure (MAP)
- System Voltage
- Throttle Position
- Fuel Pump Voltage

→ ECM →

SYSTEMS CONTROLLED BY ECM

Electronic Spark Timing (EST)
Fuel Control
- Idle Air Control
- Electric Fuel Pump

Troubleshooting
- Check Engine Light
- Troubleshooting Terminal
- Data Output

Governor Control

FIGURE 5. ELECTRONIC ENGINE CONTROL SYSTEM

The ECM makes the checks in a few milliseconds and determines the correct air and fuel ratio for starting the engine. The range of this air and fuel ratio is 1.8:1 at -40° C (-40° F) to 17:1 at 150° C (302° F) as indicated by the signal from the coolant temperature sensor. The ECM controls the amount of fuel sent to the engine by changing the pulse times [how long the fuel injector is energized and deenergized].

When the engine starts, the frequency of the pulses from the ignition module increases and indicates to the ECM that the engine is running. The ECM takes control of the ignition timing and the EEPROM within the ECM follows its program to give ignition timing and fuel control for the best engine operation. When the engine is operating, the ECM continuously checks the signals from the Manifold Absolute Pressure (MAP), the Engine Coolant Temperature (ECT) Sensor, the Throttle Position Sensor (TPS) and engine speed sensors to make timing and fuel adjustments for the engine operating conditions.

## ELECTRONIC ENGINE CONTROL (See FIGURE 6.)

### What The ECM Does

The ECM receives signals from the following components:

- **Manifold Absolute Pressure** (MAP) sensor. This sensor is a pressure transducer that measures the atmospheric pressure before the engine is started and the ECM uses this pressure as a reference. This sensor then measures changes in pressure in the intake manifold during engine operation.

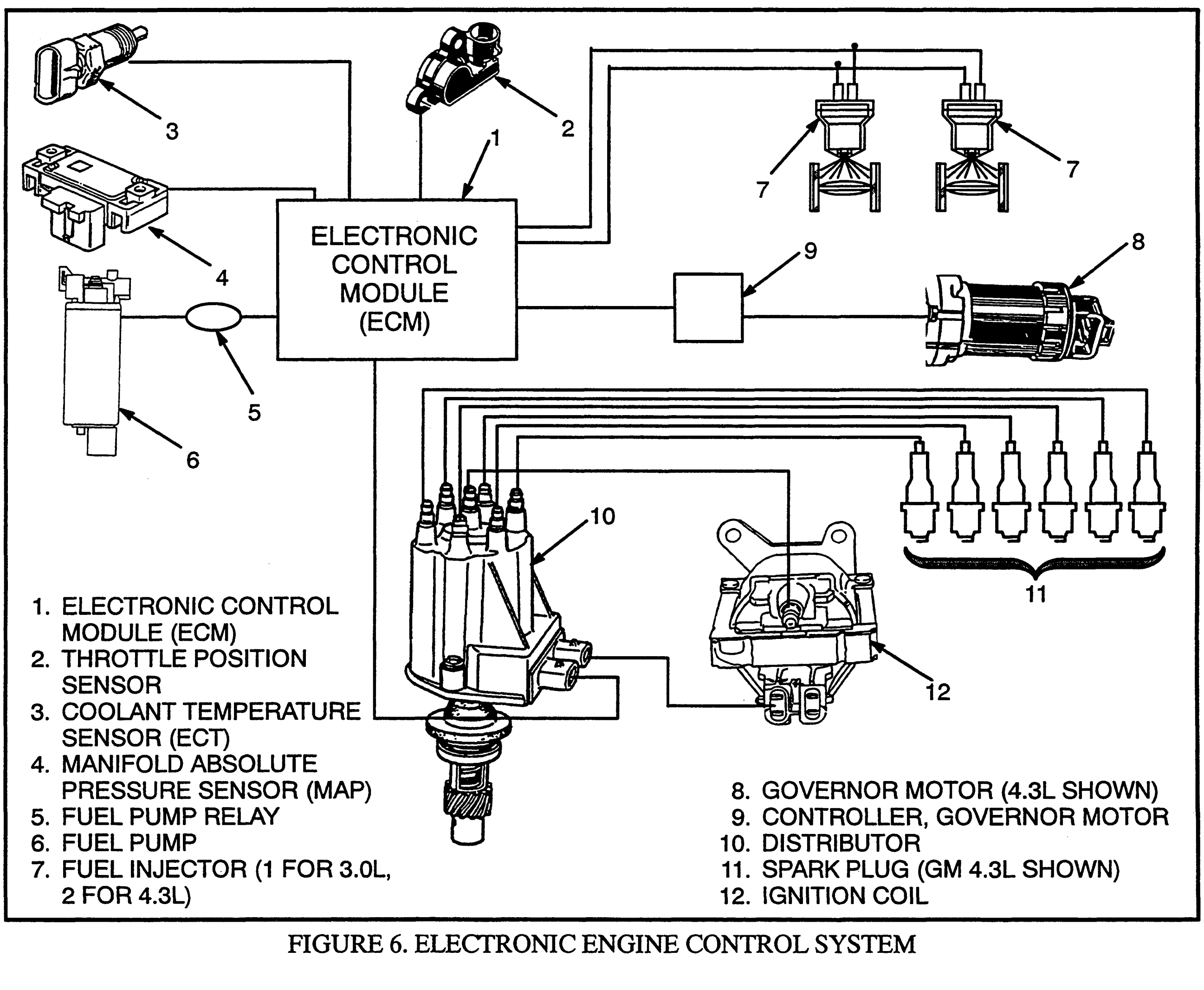



FIGURE 6. ELECTRONIC ENGINE CONTROL SYSTEM

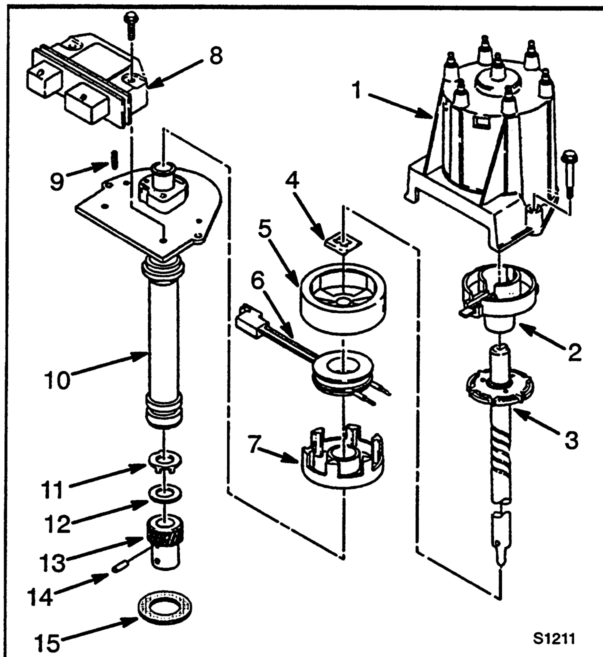
- **Engine Coolant Temperature (ECT) Sensor.** This sensor is a thermistor (resistor that is calibrated to change its value as its temperature changes) that monitors the engine coolant temperature.

- **Throttle Position Sensor (TPS).** This sensor indicates the position of the throttle that is set by the operator and is used with the indications from the other sensors to determine the correct engine operation.

- **Fuel Pump.** When the key switch is first turned to ON, the ECM energizes the fuel pump relay for two seconds. This action quickly raises the fuel pressure to the fuel injectors. If the engine is not cranked or started within two seconds, the ECM deenergizes the fuel pump relay and the fuel pump turns off. When the engine is cranked by the starter, the ECM energizes the fuel pump relay to operate the fuel pump.

- **Ignition module.** This component is a small electronic module within the distributor. See FIGURE 7. This ignition module is a signal converter that senses the operation of the distributor. A sensor coil in the distributor senses the rotation of the timer core and the ignition module senses the speed of rotation. A square wave generator in the ignition module converts the pulses from the sensor coil to a square wave signal that is sent to the ECM. If the signals from the ignition module to the ECM indicate that the crankshaft is rotating at less than 400 rpm, the ECM determines that the engine is being cranked by the starter. The ignition module controls the ignition for an engine being started. The Electronic Spark Timing (EST) function from the ECM is deenergized. If the signals from the ignition module to the ECM indicate that the crankshaft is rotating at greater than 400 rpm, the ECM determines that the engine is running and the Electronic Spark Timing (EST) from the ECM controls the ignition.

- **Electronic governor.** The ECM senses the engine speed from the ignition module and operates the governor motor on the throttle body to control the engine speed. The governor motor overrides the throttle position set by the operator to control the engine speed within the limits set in the ECM.




1. CAP
2. ROTOR
3. SHAFT/TIMER CORE
4. RETAINER
5. SHIELD
6. COIL
7. POLE PIECE
8. IGNITION MODULE
9. ALIGNMENT PIN
10. HOUSING
11. WASHER
12. SEAL
13. DRIVE GEAR
14. ROLL PIN
15. GASKET

FIGURE 7. DISTRIBUTOR PARTS (GM 4.3L SHOWN)

## Distributor

A timer core (permanent magnet) on the shaft of the distributor has external teeth which align with an equal number of teeth on the pole piece. See FIGURE 8. When the teeth of the timer core rotate past the teeth of the pole piece, there is a decrease in the air gap between the timer core and the pole piece. The magnetic field increases. When teeth are not aligned, the magnetic field decreases between the timer core and the pole piece. As the timer core rotates, the magnetic field increases and decreases in a cycle.

When a coil is near a changing magnetic field, a voltage is generated in the coil. This principle is called magnetic induction. A sensing coil is installed over the permanent magnet. As the magnetic field near the pole piece changes, a small voltage is generated in the sensing coil.

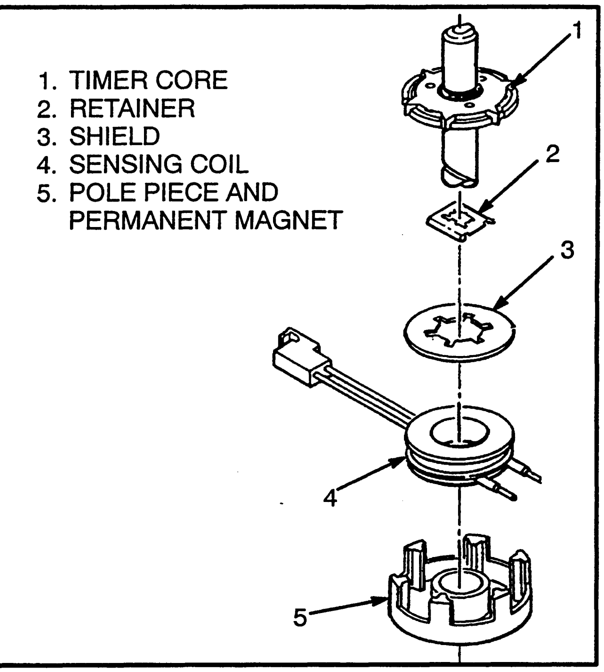



FIGURE 8. DISTRIBUTOR PULSE GENERATING PARTS

The principle of magnetic induction also controls the polarity of the voltage generated in the coil. An increasing magnetic field will generate a voltage in the coil that is the opposite polarity of a magnetic field that is decreasing. This signal pulse causes the integrated circuits in the ignition module to generate a square wave signal.

The ignition module and a magnetic pulse generator control the primary circuit to the ignition coil when the engine is started. The ECM receives the square wave signal from the magnetic pulse generator and ignition module as one of the signals to control the EST. The pole piece has the same number of teeth as the engine has cylinders so that a spark voltage is correctly sent to each spark plug as the shaft in the distributor rotates.

## Ignition Module (See FIGURE 9.)

The ignition module is a solid-state electronic device that operates like a fast switch except that it does not have any moving or mechanical parts. See FIGURE 9. and FIGURE 10. Small electrical pulses from the sensing coil of the pulse generator go to the ignition module. The ECM must always know the speed at which the engine is operating. The engine speed signal is generated by the ignition module. The signal converter (3) changes the signal voltage from the sensing coil to a square wave reference signal for the ECM. This square wave reference signal for engine speed is called REF HI. The ECM must also have a reference to compare with REF HI. An additional wire between the ECM and the ignition module is called REF LO (GROUND). The REF HI and REF LO connections give the EEPROM in the ECM the necessary information about engine speed.

The other two wires between the ECM and the distributor control the Electronic Spark Timing and are called EST and BY-PASS.

**NOTE:** The ignition module controls spark timing only when the the engine is being started or if the ECM fails. The ECM controls the spark timing during engine operation. The ignition module will also control the spark timing if there are some failures in the signals to the ECM. This back-up mode of operation will often permit operation of the engine so that the lift truck can be moved to an area for repair. The result of failures in signals to the ECM is described in the paragraphs under Electronic Control Module (ECM), Corrections.

## When the Engine Is Being Started

See FIGURE 9. When the engine is cranked by the starter, the electronic relay (2) is in the deenergized position. The sensing coil is connected through the square wave generator (3) to the base of the transistor (8).

When the sensing coil (4) applies a positive voltage (the square wave voltage is increasing) to the transistor (8), the transistor turns on. When the voltage from the sensing coil changes to negative (the square wave voltage is decreasing), the transistor turns off. When the transistor is on, current flows through the primary winding of the ignition coil. When the transistor turns off, the current flow through the primary winding stops. The changing magnetic field in the primary winding generates a high voltage in the secondary winding of the ignition coil. This high voltage generates a spark at the spark plug.

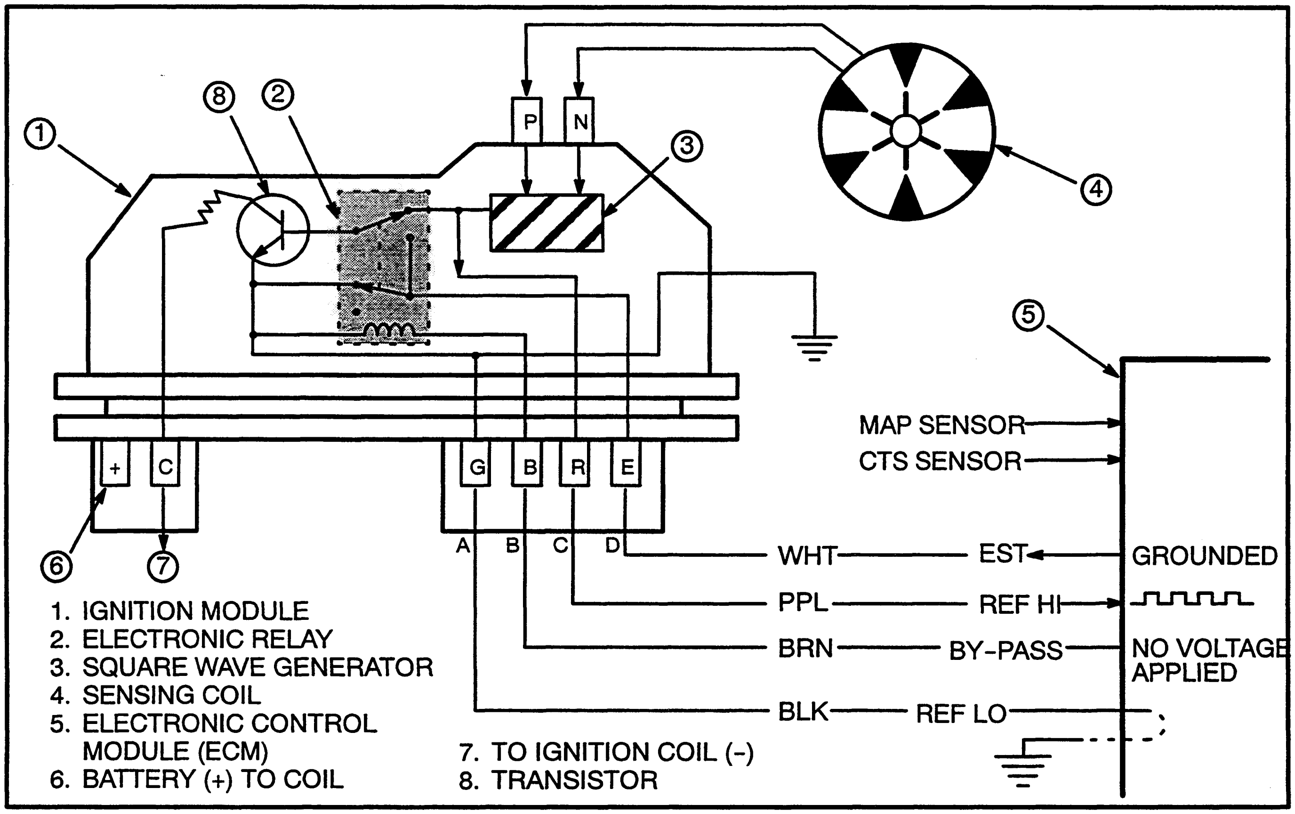



FIGURE 9. IGNITION MODULE WHEN ENGINE IS BEING STARTED

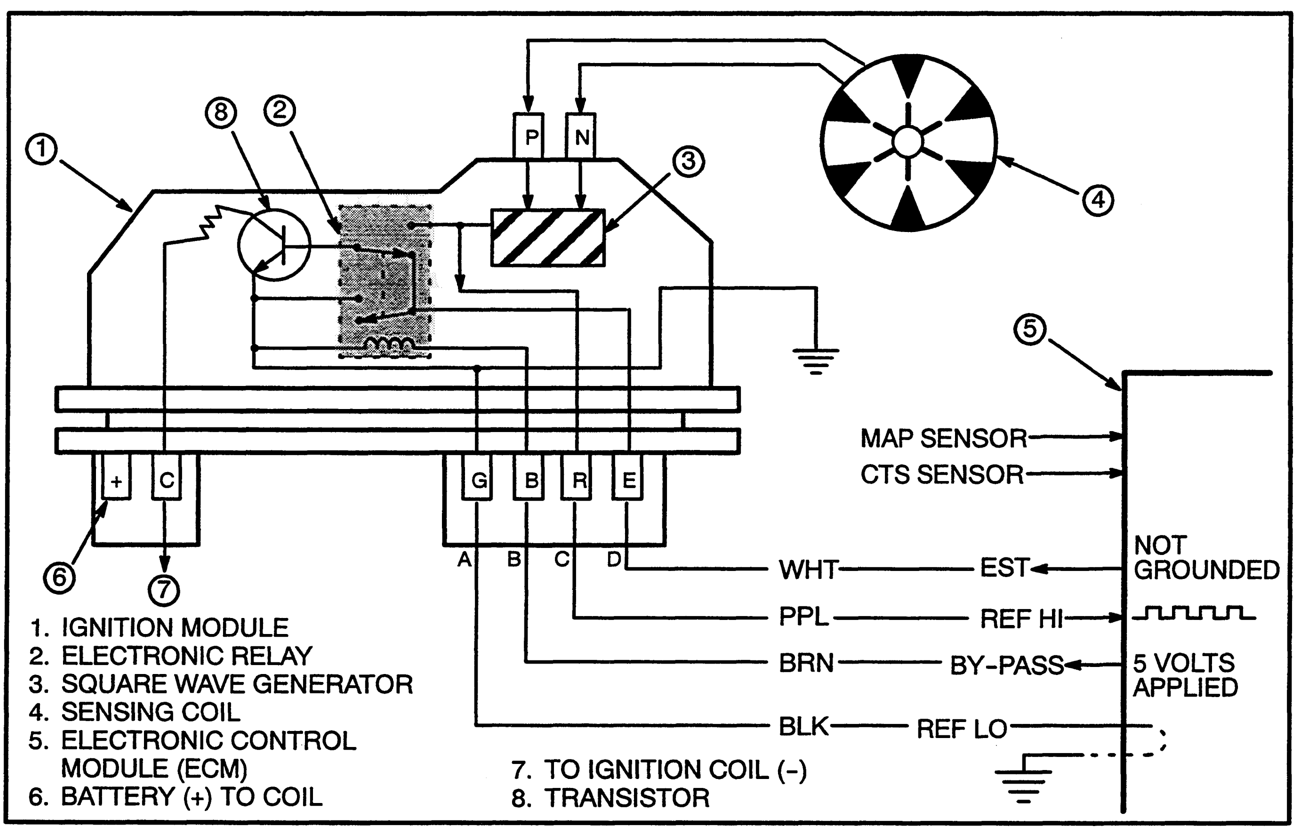



FIGURE 10. IGNITION MODULE WHEN ENGINE IS RUNNING

## When the Engine Is Running

See FIGURE 10. When the engine speed is greater than approximately 400 rpm, the ECM determines that the engine is running and applies 5 volts on the BY-PASS wire to the ignition module. This voltage energizes the electronic relay (2) and makes the following changes: The EST wire is not grounded and is now connected to the base of the transistor (8). The sensing coil (4) is disconnected from the base of the transistor (8).

The ignition module and the ignition timing are now controlled by the EST signal from the ECM. This operating mode is the EST mode.

## Electronic Control Module (ECM) With Ignition Module Distributor, Corrections

The operation of the ECM was described in earlier paragraphs, (See the description in **What The ECM Does**). These paragraphs describe the corrections made by the ECM in an engine with an ignition module distributor.

The ECM does a check of the system components of the EST circuit. A set of normal operating limits are part of the EEPROM program. If a sensor sends a signal that is outside of the limits of the EEPROM program, the ECM will not use the information. The ECM uses a standard value from its program and continues to operate the ignition module.

The following examples are the action of the ECM if it detect a problem:

**MAP Sensor Signal Voltage Is Too High Or Too Low.** The ECM will use a MAP value from its EEPROM program and use this value to calculate the ignition timing.

**ECT Signal Voltage Is Too High Or Too Low.** If the coolant sensor sends a signal voltage that is outside of the range programmed by the ECM, the ECM determines that the engine is cold. The ECM uses a value for a cold engine.

**Open Circuit In EST Wire.** Normally, the signal from the ECM to the ignition module rises and falls as the voltage from the sensing coil rises and falls. If the EST circuit is open, the electronic relay in the ignition module is not at ground potential.The engine starts but will not continue to run. If the EST circuit becomes open during engine operation, the engine stops.

**Short-Circuit (Grounded Circuit) In EST Wire.** When the engine is being rotated by the starter, the ECM normally deteECT 0 volts in the EST circuit because the circuit is at ground potential in the ignition module. The ECM would not detect a problem until the engine began to run. The ECM could not operate in the EST mode and the engine will not operate. If the EST circuit has a short-circuit (grounded circuit) when the engine is running, the engine stops.

**Open Circuit Or Short-Circuit In The BY-PASS Circuit.** The ECM would not detect a problem until the engine began to run. The ECM could not operate in the EST mode and the engine would operate with reduced power. If this problem occurs when the engine is running, the engine will only operate in the starting mode with the ignition module.

**Open Circuit Or Short-Circuit In The REF HI Circuit.** The ECM would not detect that the engine was operating. The ECM could not operate in the EST mode and the engine will not operate.

**Open Circuit Or Short-Circuit In The REF LO Circuit.** The ECM would not have a comparison for operation. The ECM could not operate in the EST mode and the engine will not operate correctly.

## FUEL CONTROL

The fuel control system is controlled by the ECM. The purpose of the fuel control system is to deliver fuel to the engine for the most efficient operation in all operating modes. The **Starting Mode** and the **Run Mode** are described in the paragraphs under HOW THE ECM BEGINS OPERATION. When the ECM is in the **Run Mode**, the ratio of the air and fuel mixture is controlled for best operating conditions.

**Clear Flood Mode.** If the engine floods, it can be cleared by opening the throttle to 100% (wide open) during cranking. The ECM then shuts down the fuel injectors so no fuel is delivered. The ECM holds this injector rate as long as the throttle stays at 100%, and the engine speed is below 300 RPM. If the throttle position becomes less than 100%, the ECM returns to the starting mode.

The **Acceleration Mode** occurs when the ECM senses rapid changes in the throttle position and manifold pressure. The ECM sends additional fuel to the engine.

The **Deceleration Mode** occurs when the ECM senses rapid changes in the throttle position and manifold pressure. The ECM reduces fuel to the engine. If the deceleration is very fast, the ECM can stop the fuel supply completely for short periods.

**Voltage Correction Mode.** When battery voltage is low, the ECM can make adjustments for a weak spark from the distributor. The **ON** time for the fuel injectors can be increased, the engine idle can be increased, and the ignition dwell time can be increased.

**Fuel Shut-Off Mode.** When the ignition switch is turned to **OFF**, the ECM stops the pulses to the fuel injectors. This procedure stops a condition called dieseling in a gasoline engine. Also, no fuel is sent to the engine if there are no reference pulses from the distributor. This condition indicates that the engine is not running.

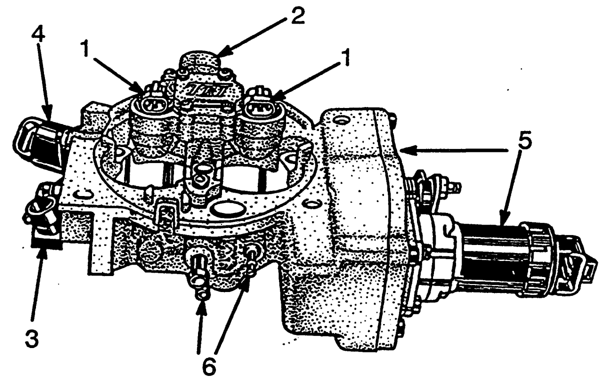
If the ECM senses that the engine speed is above the maximum set (rev limit) in the EEPROM, the fuel to the engine is stopped until the engine RPM drops below the maximum set (rev limit). This action normally occurs if the governor is not operating correctly.

## Throttle Body Injection

This system is similar to a carburetor system because it has a throttle body installed on an inlet manifold. There are two injectors in the GM 4.3L throttle body that mixes the air and fuel. See FIGURE 11.

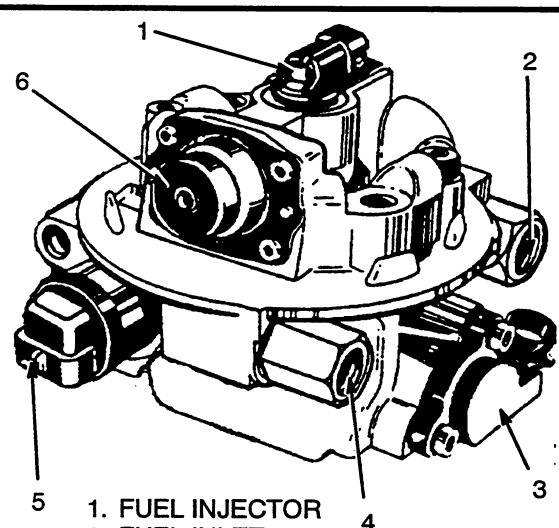
**NOTE:** In the GM 3.0L engine there is only one injector. See FIGURE 12.

The fuel injection system is controlled by the ECM. The basic function of the fuel injection system is to control the fuel delivery for the most efficient operation of the engine. Fuel is sent to the throttle body injection unit by the fuel pump. The ECM senses the operation of the engine from the signals from its sensors and controls the air and fuel ratio to the engine by controlling the operation of the fuel injectors and the spark timing. The ECM controls the air and fuel ratio for the best operating conditions of the engine. All modes of engine operation are controlled by the ECM and the conditions set in its EEPROM.




1. FUEL INJECTOR (2)
2. FUEL PRESSURE REGULATOR
3. THROTTLE POSITION SENSOR
4. IDLE AIR CONTROL VALVE
5. GOVERNOR MOTOR AND THROTTLE DRIVE ASSEMBLY
6. VACUUM PORTS

FIGURE 11. GM 4.3L THROTTLE BODY INJECTION (TBI) UNIT




1. FUEL INJECTOR
2. FUEL INLET
3. THROTTLE POSITION SENSOR
4. FUEL OUTLET
5. IDLE AIR CONTROL VALVE
6. FUEL PRESSURE REGULATOR

FIGURE 12. GM 3.0L THROTTLE BODY INJECTION (TBI) UNIT

The following paragraphs describe the Throttle Body Injection unit (TBI) fuel injection system designed by General Motors®. See FIGURE 11. The TBI has the following assemblies:

- Fuel injectors
- Fuel pressure regulator
- Throttle position sensor

- Idle air control valve
- Governor motor and throttle drive assembly
- Vacuum ports

## Fuel Injectors

The fuel injectors are solenoids controlled by the ECM. The ECM energizes a solenoid which lifts a normally closed ball valve from its seat. The fuel is under a constant pressure and is injected in a cone spray pattern into the bore of the throttle body above the throttle plate. The fuel which is not used by the fuel injector flows through the pressure regulator and returns to the fuel tank.

**NOTE:** The 3.0L engine has one fuel injector while the 4.3L engine has two fuel injectors.

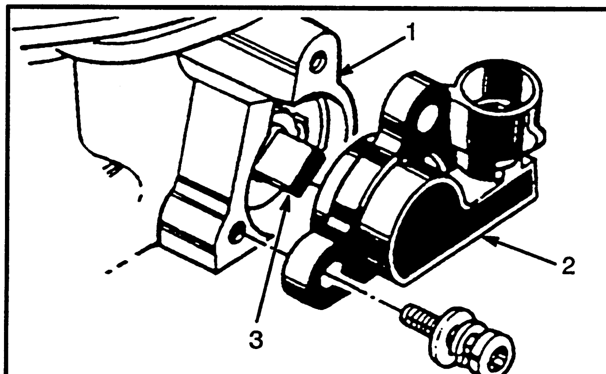
## Fuel Pressure Regulator

The fuel pressure regulator is part of the fuel metering assembly of the TBI. The function of the fuel pressure regulator is to keep a constant fuel pressure at the fuel injectors during all operating modes. An air chamber and a fuel chamber are separated by a diaphragm-operated relief valve and a calibrated spring. Fuel pressure at the fuel injectors is controlled by the difference in pressure on each side of the diaphragm. The fuel pressure from the fuel pump on one side of the diaphragm acts against the force from the calibrated spring on the other side of the diaphragm. The system operates at a pressure of 72 ±3 kPa (10.5 ±0.5 psi).

## Throttle Position Sensor

The throttle position sensor (TPS) is fastened to the side of the throttle body. See FIGURE 13. The function of the throttle position sensor is to sense the throttle position and send a signal to the ECM. This information permits the ECM to generate the correct pulses to the fuel injectors for fuel control. If the throttle position sensor indicates a fully opened throttle to the ECM, the ECM then increases the pulse width to the fuel injectors. An increased pulse width increases the fuel flow.

The TPS electrical circuit has a 5 volt supply line and a ground path line, both from the ECM. A third wire is used as a signal line to the ECM. By monitoring the voltage on this signal line, the ECM calculates throttle position. As the throttle plate angle is changed (accelerator pedal moved), the signal voltage of the TPS also changes. At a closed throttle position, the signal of the TPS is below 1.25volts. As the throttle plate opens, the signal voltage increases, so that at wide open throttle, it is approximately 5 volts.

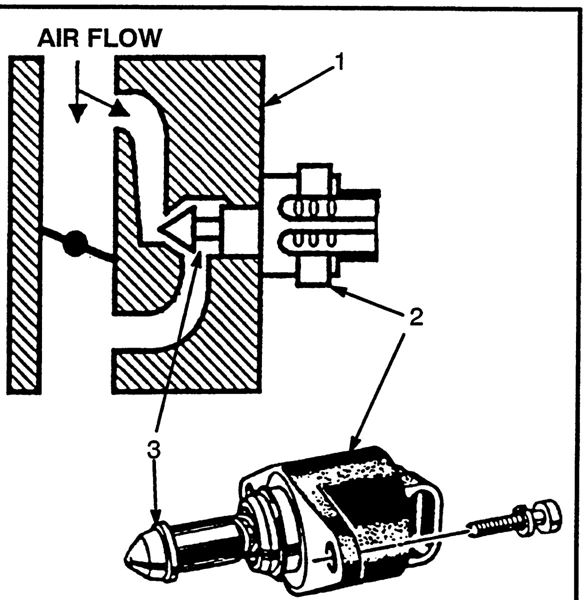



1. THROTTLE BODY ASSEMBLY
2. THROTTLE POSITION SENSOR
3. THROTTLE SHAFT

FIGURE 13. THROTTLE POSITION SENSOR

## Idle Air Control

The idle speed of the engine is controlled by the ECM through the idle air control valve. The idle air control valve has a linear DC step motor that moves a pintle valve to control the idle air system. See FIGURE 14. The shaft of the pintle valve moves through 256 steps. The step motor moves the pintle one step for each count that it receives from the ECM. Each voltage pulse from the ECM to move the pintle valve is a count.




1. THROTTLE BODY
2. LINEAR DC STEP MOTOR
3. PINTLE VALVE

FIGURE 14. IDLE AIR CONTROL VALVE

This movement of the pintle valve controls the air flow around the throttle plates. This air flow controls the engine idle speed at all operating temperatures. A minimum idle is set at the factory with a set screw. This minimum setting is for engine idle at sea level and normal operating conditions. A heavier load from the alternator, hydraulic pumps, and other accessories will cause the ECM to set a higher number of counts on the pintle valve.

The number of counts that indicates position of the pintle valve can be seen when the Scan tool is connected for troubleshooting.

## GM 4.3L Engine Governor System

The components of the governor system are the ECM, governor control module, and the governor throttle drive assembly. See FIGURE 15. The governor prevents engine speeds above the specification when operating with light loads, and permits the throttle to open for full power for heavy loads.

A control cable connects the accelerator pedal to the throttle lever cam. See FIGURE 16. The throttle lever cam (3) is not connected directly to the throttle shaft (6). The throttle lever cam is connected to its own shaft that has a throttle drive lever (4). This throttle drive lever engages a fixed lever on the throttle shaft (6). This split arrangement permits the throttle lever cam to close the throttle plates, but not to open them directly. The throttle lever cam only gives a limit to the maximum opening of the throttle plates. When the engine speed increases to its maximum rpm, the governor motor controls the actual position of the throttle plates from signals from the ECM. The ECM senses the engine speed and load and controls the engine speed within the specifications.

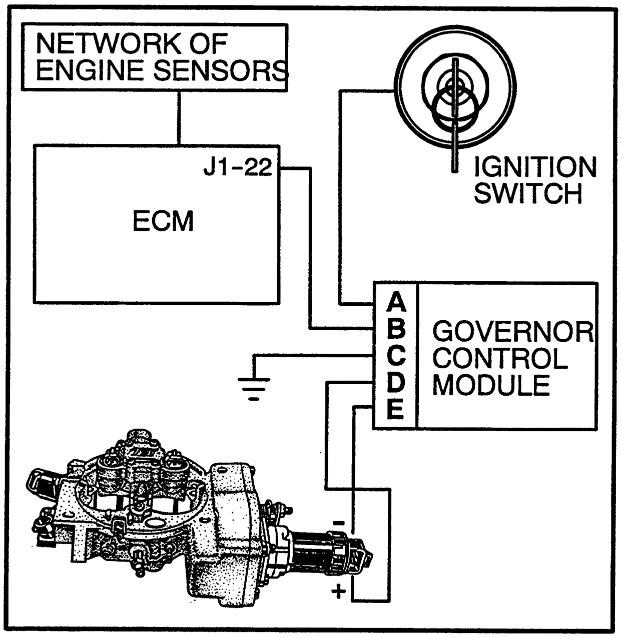



FIGURE 15. GM 4.3L ENGINE GOVERNOR SYSTEM

A network of engine sensors (throttle position sensor, coolant temperature sensor, manifold absolute pressure sensor, and distributor reference pulses) send data about operating conditions to the ECM. The ECM uses the data to determine whether or not governed operation is needed.

When the engine speed is less than approximately 2500 rpm, the governor motor is not energized and a return spring keeps the governor motor lever at its parked position (item 5, FIGURE 16.). The throttle plates can move with the position of the throttle lever cam and no governor action is used.

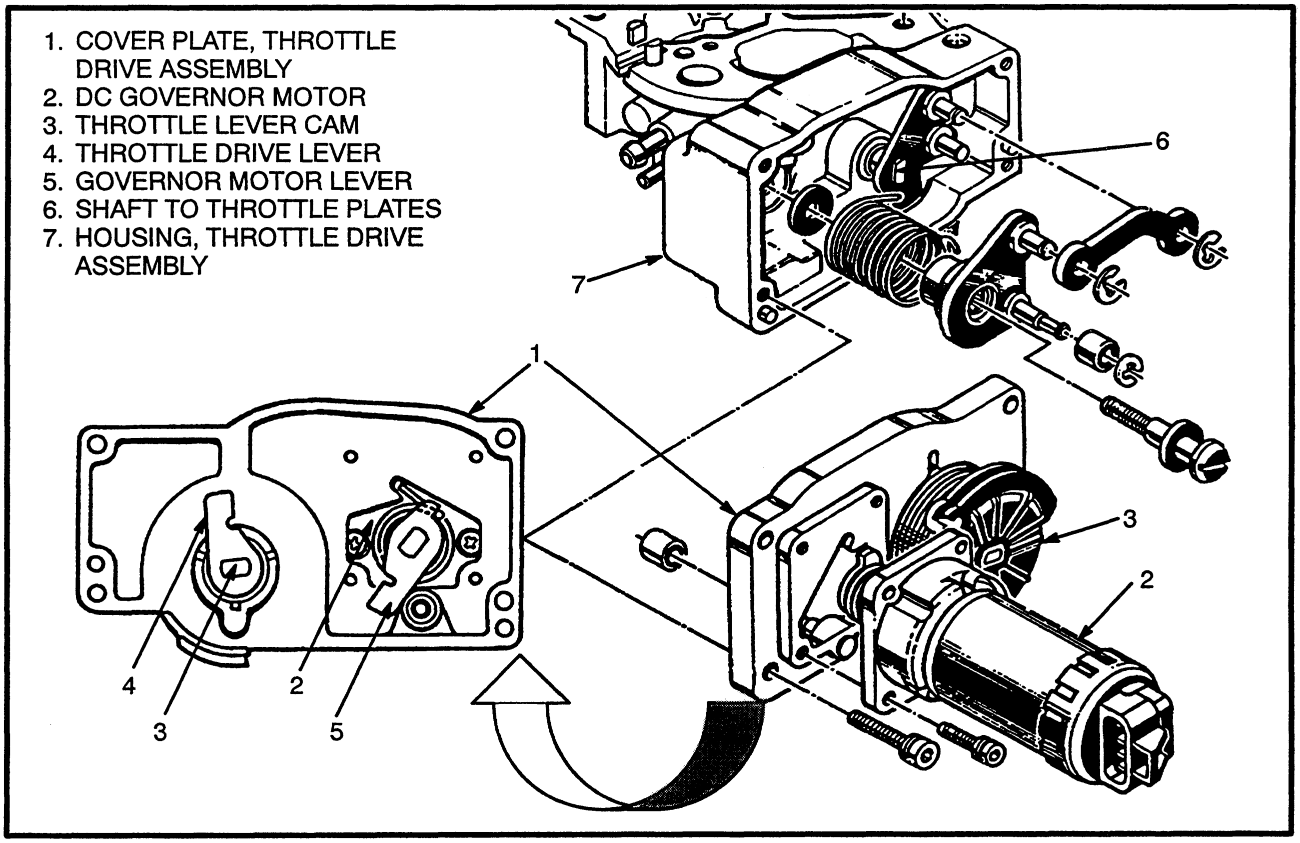



FIGURE 16. GOVERNOR MOTOR AND THROTTLE DRIVE ASSEMBLY

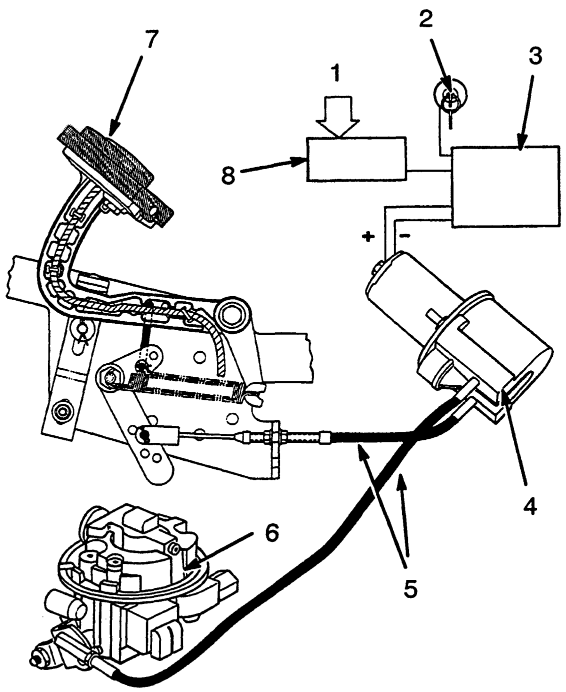
When the engine speed increases toward approximately 2500 rpm, the ECM sends signals to the governor control module to energize the governor motor. The governor control lever (5) moves from its parked position to control the opening of the throttle plates. If the engine load increases and the engine rpm decreases, the governor motor moves the governor control lever to permit the throttle plates to open further. If the governor system is not operating correctly, the ECM stops fuel to the engine at engine speeds greater than 2900 rpm.

## GM 3.0L Engine Governor System (See FIGURE 17.)

The governor motor is an electric DC motor that is actuated and controlled by the Electronic Control Module (ECM) through the governor control module (governor motor driver circuit). The governor prevents engine speeds above specifications when operating with light loads, and permits the throttle to open for full power for heavy loads.

The components of the governor system are the ECM, the governor control module and the governor motor assembly and cables. The cables and drum allow the throttle control to be split. This split arrangement allows the governor motor drum to close the throttle plate, yet open them indirectly. The first drum is turned by the accelerator pedal. A spring located inside the drum pushes on the second drum. This action allows the operator to open the throttle when under heavy load, but the motor will rotate the drum, against the spring, to close the throttle plate under light load-high rpm. Using engine speed and load, the governor controls the actual position of the throttle plate, within that range of possible opening.

The engine sensors, such as the Throttle Position (TP) Sensor, Manifold Absolute Pressure (MAP) sensor, and crankshaft reference pulses (rpm) gives constant information on engine operating conditions to the Electronic Control Module (ECM). The ECM uses the information on throttle plate position and engine rpm to determine whether or not governed operation is needed.




1. SENSOR INPUTS
2. KEY SWITCH
3. GOVERNOR CONTROL MODULE
4. GOVERNOR
5. THROTTLE CABLES
6. TBI UNIT
7. THROTTLE (MONOTROL) PEDAL
8. ELECTRONIC CONTROL MODULE (ECM)

FIGURE 17. GM 3.0L ENGINE GOVERNOR SYSTEM

At low engine speeds, below calibration rpm, the governor drive motor is not energized. At higher engine speeds, above calibration rpm, where the governor is needed, the ECM sends a signal to the governor control module to increase current flow to the governor motor. The governor motor rotates the drum and this causes the throttle plate to rotate toward the closed position. Control of the throttle plate is determined by the TP Sensor and engine speed signals to the ECM. When engine load increases and rpm decreases, the electrical current to the motor is reduced by the ECM through the governor control module, thus allowing the throttle plate to open farther.

## Vacuum Ports

The TBI has vacuum ports to provide a source of vacuum for the MAP sensor and PCV valve that require a vacuum source to operate.

## Fuel Pump

The fuel injection system must have a constant fuel pressure to operate correctly. A check for the correct fuel pressure is often the first test when troubleshooting a fuel injection system. A test port is installed in the fuel pressure line for this purpose. A typical fuel system is shown in FIGURE 18.

A small turbine pump connected to an electric motor is installed in the fuel tank below the liquid level. See FIGURE 19. The fuel pressure regulator on the throttle body keeps the fuel pressure at a constant 72 kPa (10.5 psi). Fuel that is not used by the throttle body is returned to the fuel tank. A screen is connected to the fuel pump to prevent large particles from entering the fuel system. Baffles are installed in the fuel tank to make sure that fuel is always available to the fuel pump during normal operation of the lift truck.

A fuel filter must be used in series with the fuel pump to prevent any dirt from entering the fuel injectors in the throttle body. The orifices in the fuel injectors are very small in diameter and a particle of dirt can stop the operation. A liquid level sender for the fuel gauge is often fastened to the support for the fuel pump.

A fuse and fuel pump relay switch for the fuel pump is mounted in the engine compartment. See FIGURE 2. and FIGURE 3. When the key switch is first turned to **ON**, the ECM energizes the fuel pump relay for two seconds. This action quickly raises the fuel pressure to the fuel injectors. If the engine is not started within two seconds, the ECM deenergizes the fuel pump relay and the fuel pump turns off. When the engine is cranked by the starter, the ECM energizes the fuel pump relay again so that the fuel pump operates.

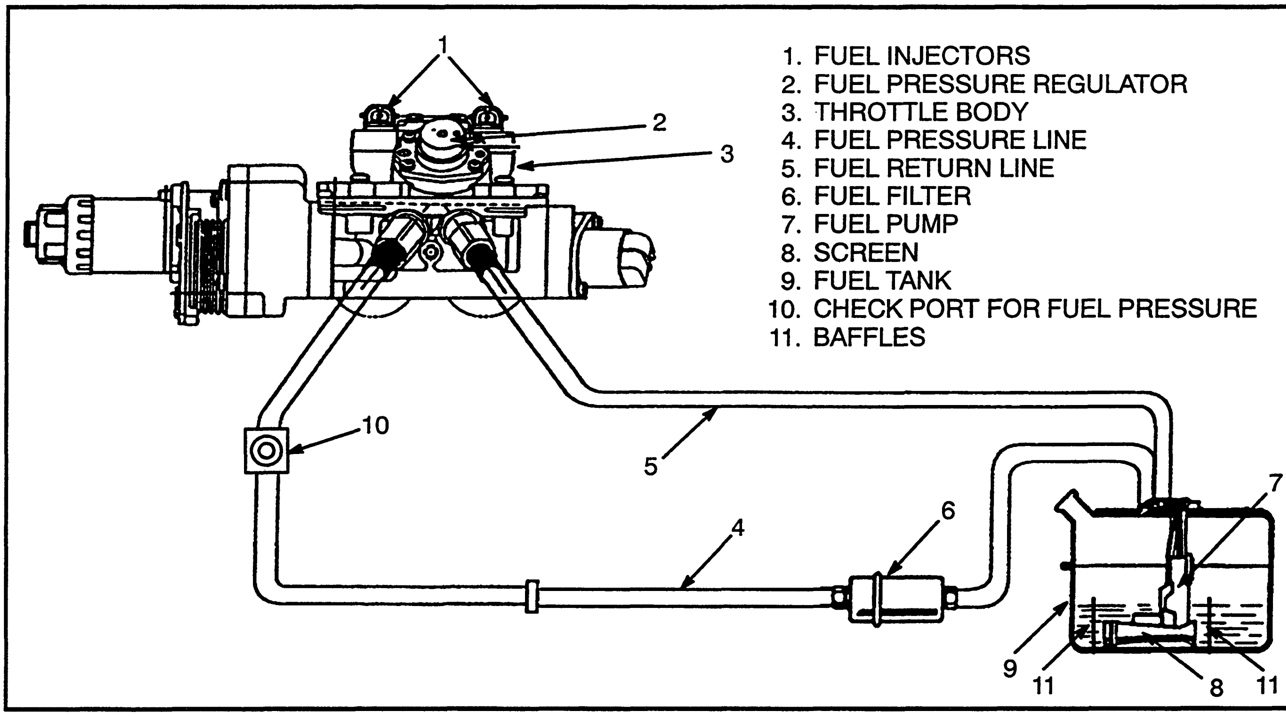



FIGURE 18. TYPICAL FUEL SUPPLY SYSTEM

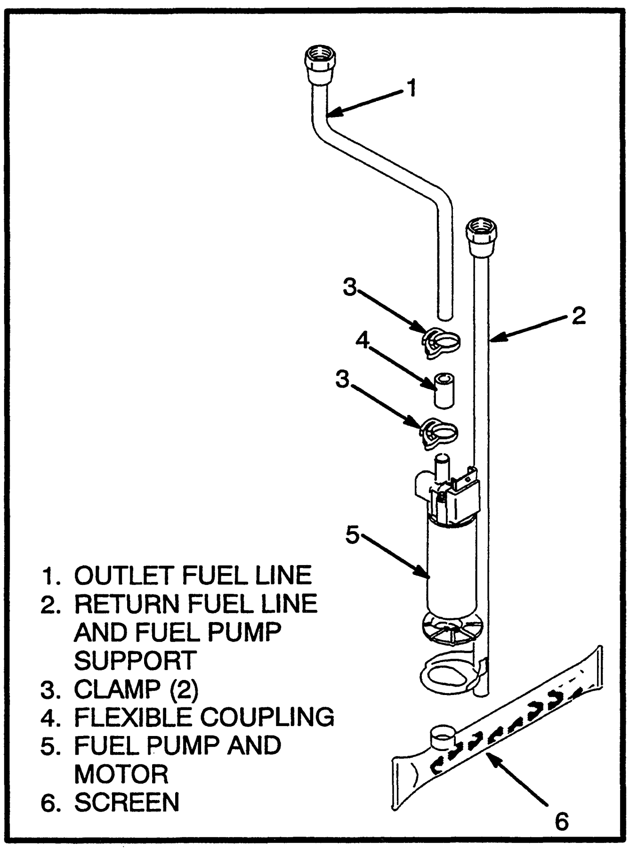



FIGURE 19. FUEL PUMP

This ECM control also prevents the fuel pump from operating if the ignition switch is turned to **ON** and the engine is not running. This control prevents emptying the fuel tank through an open fuel line if the engine is not running and the ignition switch stays **ON**.

When the engine is running or being cranked by the starter, the ECM receives reference pulses from the EST distributor or the DIS module. The ECM then energizes the fuel injectors.

The fuel pump can also be energized by the oil pressure sensor. When the engine is being cranked by the starter and engine oil pressure is approximately 28 kPa (4 psi), the oil pressure switch closes a circuit to operate the fuel pump. If the fuel pump relay is not operating correctly, a long cranking time for a cold engine will be the result. The oil pressure switch will energize the fuel pump when the engine oil pressure increases to approximately 28 kPa (4 psi).

## ECM SENSORS AND CONTROLLERS

### Manifold Absolute Pressure (MAP)

The Manifold Absolute Pressure (MAP) sensor is a pressure transducer that measures changes in the pressure in the intake manifold. See FIGURE 20. The pressure changes are a result of engine load and speed changes. The MAP sensor converts these pressure changes to a signal voltage to the ECM.

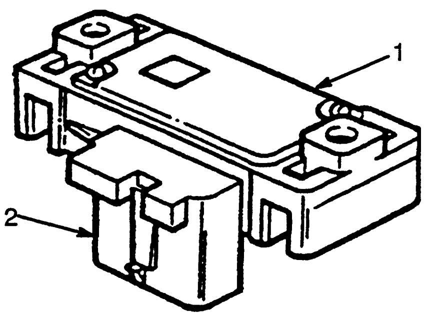



FIGURE 20. MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The ECM sends a 5 volt reference signal to the MAP sensor. When the pressure in the intake manifold changes, the electrical resistance in the MAP sensor also changes. The change in the voltage signal from the MAP sensor enables the ECM to sense the pressure in the intake manifold.

A closed throttle causes a low pressure (high engine vacuum) in the intake manifold. This low pressure causes a low voltage signal from the MAP sensor to the ECM. A fully opened throttle causes a higher pressure (low engine vacuum) in the intake manifold. This higher pressure causes a higher voltage signal from the MAP sensor to the ECM. These pressure changes indicate the load on the engine and sends a signal to the ECM. The ECM then calculates the spark timing and fuel requirements for best engine performance.

The MAP sensor also measures the barometric pressure when the key switch is turned to **ON** and before the engine is started. The ECM remembers the barometric pressure (BARO signal) after the engine is running. This method enables the ECM to automatically adjust the ignition timing for different altitudes and atmospheric conditions.

## Engine Coolant Temperature (ECT) Sensor (See FIGURE 21.)

The Engine Coolant Temperature (ECT) Sensor is a resistor that changes its resistance value when the temperature changes (thermistor). This sensor is installed in the engine coolant system. A low coolant temperature makes the thermistor have a high resistance [101,000 ohms at -40° C (-40° F)]. A higher coolant temperature makes the thermistor have a lower resistance [70 ohms at 130° C (266° F)].

The ECT sensor uses a thermistor to control the signal voltage to the ECM. The ECM applies a 5-volt reference voltage to the ECT sensor. The measured voltage will be high when the engine coolant is cold. The measured voltage will be lower when the engine coolant is at operating temperature. The ECM will adjust the range of the air and fuel ratio between 1.5:1 at -36° C (-33° F) to 14.7:1 at 94° C (201° F) from the ECT sensor signal. The ECM will also adjust the ignition timing for more spark advance when the engine coolant is cold and less spark advance when the engine coolant is hot. An engine at operating temperature normally needs less spark advance.

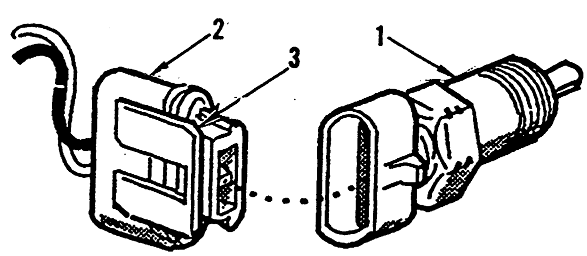



FIGURE 21. ENGINE COOLANT TEMPERATURE (ECT) SENSOR

**NOTE:** If the connection between the ECT sensor and the ECM is open during starting or operation of the engine, the ECM determines that the engine is cold and adjusts the air and fuel mixture to the full 1.5:1 ratio. This condition can flood the engine with fuel.

# NOTES

Hyster Easy Language Program

**HYSTER** TECHNICAL PUBLICATIONS