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Evaluation of the Applicability of Inspection/Maintenance Tests On A 1981 Cadillac Seville With Throttle Body Fuel Injection

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NOTICE

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ABSTRACT

This report presents test results which were gathered to determine the suitability of existing I/M short tests on a Cadillac car with a computer based emission control system. This car had a microprocessor-based engine control system with throttle body fuel injection (TBI), modulated displacement and a dual bed catalyst.

After suitable baselines were established, various components were made inoperative in the emission control system. Complete FTP, HFET and I/M tests were run for each vehicle condition. Also an on-board system diagnostic check was performed for each configuration.

This report presents the measured data taken during the tests.

1.0 BACKGROUND

Beginning with the 1981 model year, electronics and computers control many of the vital functions of automotive operation now regulated by mechanical means. As the Inspection/Maintenance effort is expanded it is a prerequisite that the test procedure used by Inspection/Maintenance programs be capable of identifying 1981 and later model year vehicles with equipment failure and parameter maladjustment. With the advent of the use of advanced electronics into automobiles, it is necessary to evaluate the suitability of existing and proposed I/M tests to these future automobiles. To accomplish this evaluation, several prototype and early production cars containing representative electronics of the future have been tested according to both the Federal Test Procedures and I/M test procedures. The data obtained should indicate which I/M test best suits these automobiles. This report presents the data collected on the sixth such automobile tested by EPA, a 1981 Cadillac Seville with a microprocessor controlled emission control system, throttle body fuel injection (TBI), and modulated displacement. This is the first vehicle with TBI tested in this series. Since TBI systems may see widespread use within the next few model years, the results of the tests conducted on this vehicle are of special interest.

2.0 HISTORY

The Cadillac Seville is a 1981 production vehicle rented from a local rental firm. This particular vehicle which has a low altitude emission certification was obtained from the rental agency on 2 February 1981 with 1144 miles on the odometer. One day was allowed for vehicle preparation, and baseline testing started on 4 February 1981.

After two baseline sequences were accomplished, the vehicle was tested with eight different component deactivations. One final confirmatory baseline sequence was then run. Testing was completed on 3 March 1981.

3.0 TESTING PROCEDURE

In order to test the vehicle the following test sequence was used:

a. Federal Test Procedure (FTP) 1979 procedure, non-evaporative, no heat build.

b. 50 MPH Cruise. This test consists of a three minute steady state run at 50 MPH. HC and CO measurements are taken with a garage type analyzer. This test is performed with the hood open and fan on. The three minute 50 MPH cruise also serves as preconditioning for the highway fuel economy test.

c. Highway Fuel Economy Test (HFET). Immediately after the 50 MPH cruise.

d. On-Board System Diagnostic Check. This check took advantage of the on-board self-diagnostic system used on 1981 GM products. See Attachment 3 for a description of the system.

Each of the following steps required a six minute idle preconditioning, hood open, fan on.

e. Four Mode Idle Test with raw HC/CO garage type analyzer. Emissions were tested at Idle (neutral), 2500 rpm, Idle (neutral), and Idle (drive). The hood was open and the fan was on.

f. Loaded Two Mode. Raw HC and CO measurements were taken with the dynamometer set at 9.0 A.H.P. at 30 MPH with the I.W. = 1750 pounds. Immediately afterward, measurements were taken at idle (neutral) using a garage type analyzer. The hood was open and the fan was on.

g. Propane Injection Procedure for three way catalyst vehicles. A description of this test and a sample data sheet are given in Attachment 1.

Note: This propane injection procedure is still in the development stage. Bear in mind when reviewing the obtained data that this is still an experimental procedure.

I/M test HC and CO measurements were recorded before and after the dual bed catalyst. A worksheet recording the I/M test results is shown in Attachment 2.

4.0 VEHICLE DESCRIPTION

The Cadillac used for this testing was a production vehicle with a low altitude Emission Package. The most important components of this automobile's emission control system were the sensors, actuators, and the microprocessor unit. A complete description of these components is given in Attachment 3. Attachment 4 lists specific vehicle parameters.

5.0 BASELINE DATA

To accurately determine the effect of the various component deactivations, it was necessary to have an accurate baseline determined for each pollutant in each mode of every test type. This baseline data is displayed with the component deactivation data.

6.0 TEST CONFIGURATIONS

After the baseline testing was completed, various components of the emission control system were, one by one, deactivated prior to vehicle testing.

a. EGO Sensor Lead Disconnected and Open Circuited - Test numbers 80-7658 and 80-7659 were run with the exhaust gas oxygen (EGO) sensor disconnected. The EGO sensor supplies a voltage signal to the microprocessor based on the oxygen content of the exhaust stream. By disconnecting this sensor and leaving the lead open circuited the microprocessor senses a near zero voltage and the closed-loop system is deactivated.

b. EGO Sensor Lead Disconnected and Short Circuited - Test numbers 80-7661 and 80-7662 were run with the exhaust gas oxygen (EGO) sensor disconnected with the microprocessor input lead shorted. Shorting the EGO sensor lead guaranteed a zero voltage input to the microprocessor. These tests were designated EGO shorted.

c. Throttle Position Sensor Disconnected - Test numbers 80-7663 and 80-7664 were run with the throttle position sensor (TPS) electrically disconnected. This sensor provides the microprocessor with information regarding the throttle blade angle. Disconnecting this device gives a fixed closed throttle input to the microprocessor.

d. Coolant Temperature Sensor Disconnected - Test numbers 80-7665 and 80-7666 were run with the coolant temperature sensor (CTS) disconnected. Because the oxygen sensor does not perform properly until it reaches a specified temperature, the coolant sensor informs the feedback control system to operate in open-loop mode until temperature is reached. With the CTS disconnected the system runs in an open-loop mode.

e. Manifold Absolute Pressure Sensor Disconnected - Test numbers 80-7667 and 80-7668 were run with the manifold absolute pressure sensor (MAP) electrically disconnected. Disconnecting the MAP sensor sends a high manifold pressure (low vacuum) signal to the microprocessor. A high manifold pressure is indicative of a high load situation and consequently the microprocessor provides additional fuel.

f. PROM Errors - Test numbers 80-7669 and 80-7670 were run with one PROM (programmable read only memory) chip removed completely and the other PROM chip installed with the aft pin row insulated from the computer. The PROMs contain engine calibration data that is permanently retained and programmed by the factory. Disabling the PROMs caused the vehicle to operate with random unknown calibration.

g. Throttle Position Sensor Shorted - Test numbers 80-7673 and 80-7674 were run with the TPS leads shorted. This sensor provides the microprocessor with information regarding the throttle blade angle. Shorting this device gives a fixed full open input to the microprocessor.

h. Manifold Air Temperature Sensor Disconnected - Test numbers 80-7675 and 80-7676 were run with the manifold air temperature sensor (MAT) electrically disconnected. With the MAT open circuited the microprocessor senses a low temperature signal.

7.0 TEST RESULTS

The test results are given in several attachments.

a. The FTP and HFET results are given in Attachment 5. The HC, CO, CO_2 and NOx readings are in grams/mile while fuel economy is in miles per gallon. Two disablements, manifold absolute pressure sensor disconnected and PROM errors, produced very high FTP HC and CO emissions.

b. Attachment 6 presents the standard I/M test data. Values are given for readings taken before and after the catalyst. All I/M short tests were able to identify the major FTP failures.

c. Attachment 7 presents the results of the propane injection diagnostic procedure for three-way catalyst vehicles.

d. Attachment 8 presents the results of the on-board system diagnostic check. In each case the trouble code output identified the induced malfunction (diagnostic system inoperative indicates a PROM malfunction).

ATTACHMENT 1

Description of the 3-Way Closed Loop
Propane Test Procedure

Vehicles shall be in a fully warmed-up condition prior to beginning this procedure. Vehicles with manual transmissions will be tested in idle Neutral only. Prior to the test, the vehicle shall be operated at 2500 rpm for two full minutes.

This procedure will be performed in both Neutral and Drive gears for vehicles with automatic transmissions. The entire procedure, steps 1-6, will first be performed with the vehicle in Neutral gear. The vehicle shall then be operated at 2500 rpm for two minutes, brought back to idle, and placed in Drive gear for a repetition of steps 1-6.

Step 1: Present the propane flow rate to 4 CFH.

Step 2: With no propane flowing into the vehicle record idle RPM and idle CO.

Step 3: Induce propane to the air inlet of the carburetor and observe the engine behavior.

a. If the engine RPM rises to a maximum value and then decreases, record the maximum RPM value.

If the engine RPM value rises to a maximum value and continues to run at that speed, record that RPM value. This RPM value will be the same as the RPM value to be recorded in step 4.

b. If the engine RPM falls to a minimum value and then rises, record the minimum value.

If the engine RPM falls to a minimum value and continues to run at that speed, record that RPM value.

Note: The importance of closely observing the engine speed change immediately after induction of propane and until the engine speed stabilizes cannot be overstressed. The success or failure of this procedure as an I/M test key upon the ability of the technician to make a real time observation of the behavior of the engine, observable in engine speed, when propane is introduced.

An analog (meter type) tachometer must be used. A digital tachometer will not shown maximum or minimum transient engine speeds.

c. Self explanatory

d. If engine dies terminate test at this point.

e. If engine speed remains constant (neither rises nor falls) after induction of propane record a yes value (1).

Step 4: When engine stabilizes (not to exceed 60 seconds) and with propane flowing record idle RPM and idle CO.

Step 5: Withdraw the propane supply from the vehicle and observe the engine behavior as in Step 3.

Step 6: When engine stabilizes (not to exceed 60 seconds) record idle RPM and idle CO.

Note: If the engine behaves in an unusual manner add narrative comments in the data sheet margins.

PROPANE GAIN DATA SHEET

3-WAY CLOSED LOOP

		IN NEUTRAL	IN DRIVE
STEP 1	PRESET FLOW RATE		
STEP 2	RECORD: a) FLOW RATE	1	2
	b) RPM	5	10
	c) IDLE %CO	15	20
STEP 3	INDUCE PROPANE, OBSERVE VEHICLE BEHAVIOR		
	RECORD ONE: a) RPM RISES SMOOTHLY TO	25	30
	b) RPM FALLS SMOOTHLY TO	35	40
	c) ENGINE RUNS ROUGH AND THEN STABILIZES (1-YES)	43	44
	d) ENGINE DIES (1-YES)	45	46
	e) RPM STAYS THE SAME (1-YES)	47	48
STEP 4	WHEN ENGINE STABILIZES, RECORD:		
	a) RPM	50	55
	b) IDLE %CO	60	65

3-WAY CLOSED LOOP (Continued)

		IN NEUTRAL	IN DRIVE
STEP 5	WITHDRAW PROPANE, OBSERVE VEHICLE BEHAVIOR		
	RECORD ONE: a) RPM RISES SMOOTHLY TO	5	(10) →
	b) RPM FALLS SMOOTHLY TO	15	20
	c) ENGINE RUNS ROUGH AND THEN STABILIZES (1-YES)	21	22
	d) ENGINE DIES (1-YES)	23	24
	e) RPM STAYS THE SAME (1-YES)	25	26
STEP 6	WHEN ENGINE STABILIZES, RECORD:		
	a) RPM	30	35
	b) IDLE %CO	O 40	O 45
		P 2 80	

ATTACHMENT 2

DISABLEMENT TESTING - SHORT TEST DATA SHEET

DATE ____________ TEST NO. ____________ VEHICLE ____________

DISABLEMENT ____________________ OPERATOR ____________________

	Before Catalysts		After Catalysts	
	HC	CO	HC	CO
50 MPH Cruise				
4 Speed Idle				
Idle (N)				
2500 RPM				
Idle (N)				
Idle (M)				
2 Mode Loaded				
Loaded* (Pendant Mode)				
Idle (N)				

* The loaded mode is a 30 mph cruise @ 9.0 AHP.

ATTACHMENT 3

DIGITAL FUEL INJECTION

GENERAL DESCRIPTION

The Digital Fuel Injection (DFI) is a speed density fuel system that accurately controls the air/fuel mixture into the engine in order to achieve desired performance and emission goals. The Manifold Absolute Pressure sensor (MAP), Manifold Air Temperature sensor (MAT), and the Barometric Pressure sensor (BARO) are used to determine the density (amount) of air entering the engine. The HEI distributor provides engine speed information (RPM), see Figure 6C-65. This information is fed to the Electronic Control Module (ECM), and the ECM performs high speed digital computations to determine the proper amount of fuel necessary to achieve the desired air fuel mixture. Once the ECM has calculated how much fuel to deliver, it signals the fuel injectors to meter the fuel into the throttle body. When the combustion process has been completed, some hydrocarbons (HC), carbon monoxide (CO), and nitrous oxides (NOx) result; therefore, each DFI engine has an emission system to clean these gases out of the exhaust stream. The catalytic converter converts these gases into more inert gases, however, the conversion process is most efficient (lower emission levels) at an air/fuel mixture of 14.7/1.

Since the ECM controls the air/fuel mixture by metering fuel, the ECM would be more accurate if it could check its output and correct the air/fuel mixture for deviations from the ideal ratio of 14.7/1. The oxygen sensor monitors these exhaust gases and sends the information to the ECM which decides if any corrections are necessary. This correction process is known as closed loop operation. Because a vehicle is driven under a wide range of operating conditions, the ECM must provide the correct quantity of fuel under all operating conditions. Therefore, additional sensors and switches are necessary to determine what operating conditions exist so that the ECM can provide an acceptable level of driveability under all operating conditions. See Figure 6C-66 for a component diagram.

In summary, closed loop DFI operation provides acceptable levels of driveability and fuel economy while improving emission levels.

DFI SUBSYSTEMS

The following subsystems combine to form the DFI closed loop system:

1. Fuel Delivery
2. Air Induction
3. Data Sensors
4. Electronic Control Module (ECM)
5. Electronic Spark Timing (EST)
6. Idle Speed Control (ISC)

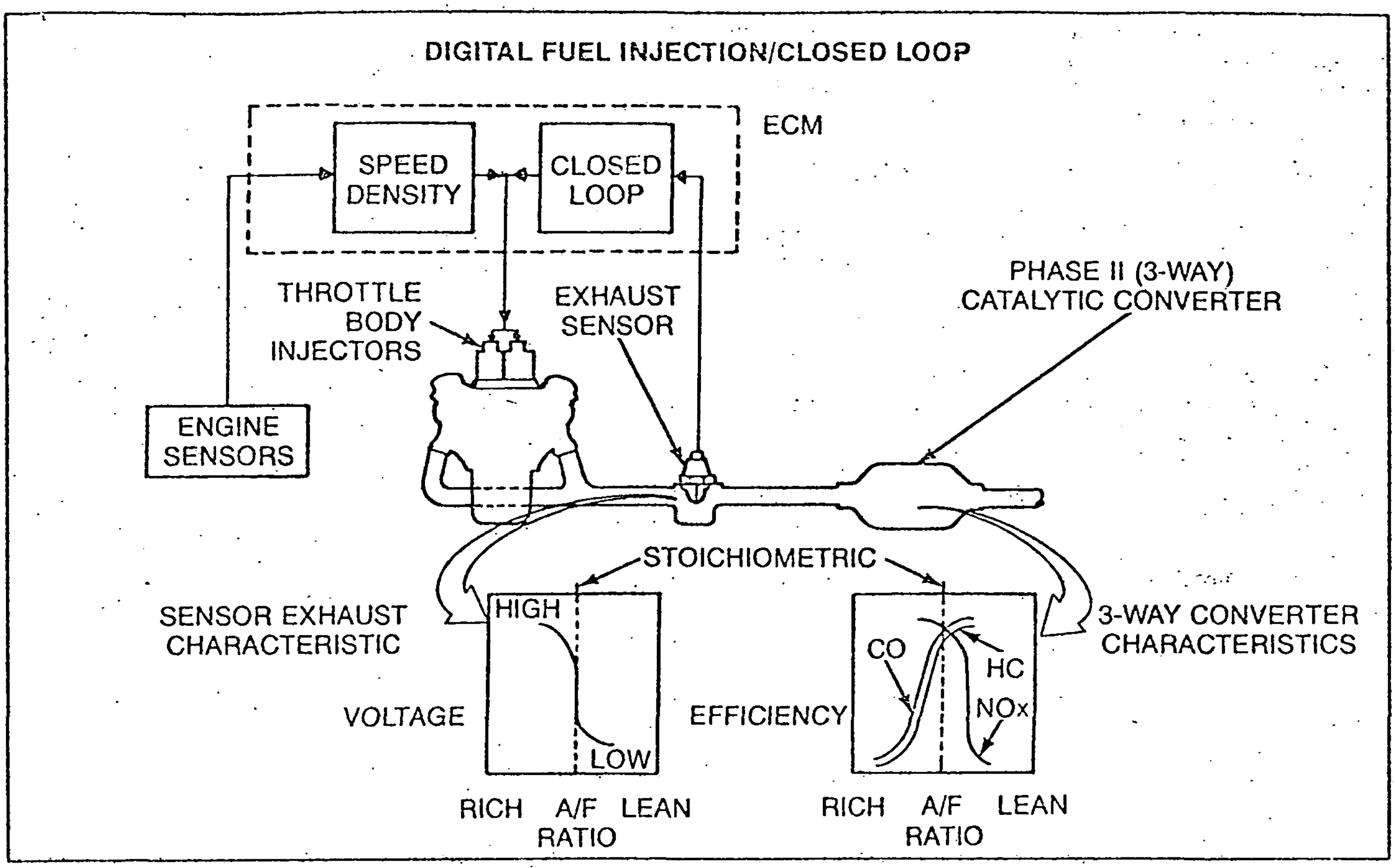

Figure 6C-65 Closed Loop DFI Operation

7. Emission Controls
8. Closed Loop Fuel Control
9. System Diagnostics
10. Cruise Control
11. Modulated Displacement (MD)

Each subsystem is described in the following paragraphs.

1. Fuel Delivery System

Figure 6C-67 shows the various components which comprise the fuel delivery system. The fuel is pumped from the fuel tank through the supply line and through the fuel filter to the throttle body. The throttle body contains the pressure regulator which regulates fuel pressure to a nominal value of 10.5 psi and the fuel injectors which meter the fuel into the throttle body. The injectors are located above the throttle blades and direct atomized fuel into the throttle bores. The ECM controls the timing and the amount of fuel injected into the engine. Any excess fuel is returned to the fuel tank through the fuel return lines.

a. Fuel Pump

An electric motor driven twin turbine type pump is integral with the fuel tank float unit, and the fuel pump supplies fuel to the throttle body at a positive fuel pressure. The pump is not repairable; however, the pump may be serviced separately from the fuel gage unit.

The ECM controls the operation of the fuel pump by activating the fuel pump relay located in the relay panel. When the ignition is placed in the on or start position, the fuel pump is turned on. If the engine is not cranked within one second of turning the ignition on, the fuel pump is turned off. The fuel pump circuit is protected by a 10 amp fuse located in the mini fuse block.

b. Fuel Tank

The fuel tank incorporates a reservoir directly below the pump assembly. The "bath tub" shaped reservoir ensures a constant supply of fuel for the fuel pump even when the fuel is low or when severe maneuvering conditions are encountered.

c. Fuel Filter

The fuel filter consists of a casing which encloses a paper filter element. The filter element is capable of filtering foreign particles of the 10 micron size out of the fuel. The filter element is a throwaway type and should be replaced (AC type GF-157 or equivalent) as described in the Vehicle Maintenance Schedule. The filter is mounted on the frame near the left rear wheel.

d. Fuel Pressure Regulator

The fuel pressure regulator, Figure 6C-68, is an integral part of the throttle body. The valve, which regulates pressure, is a diaphragm-operated relief valve in which one side of the valve senses fuel pressure and the other side is exposed to atmospheric pressure. Nominal pressure is established by the pre-load of a spring. The fuel pressure regulator maintains a constant pressure drop across the injectors. Fuel in excess of that used to maintain a constant pressure drop is returned through the fuel return line to the fuel tank. The regulator is serviced as part of the fuel metering assembly.

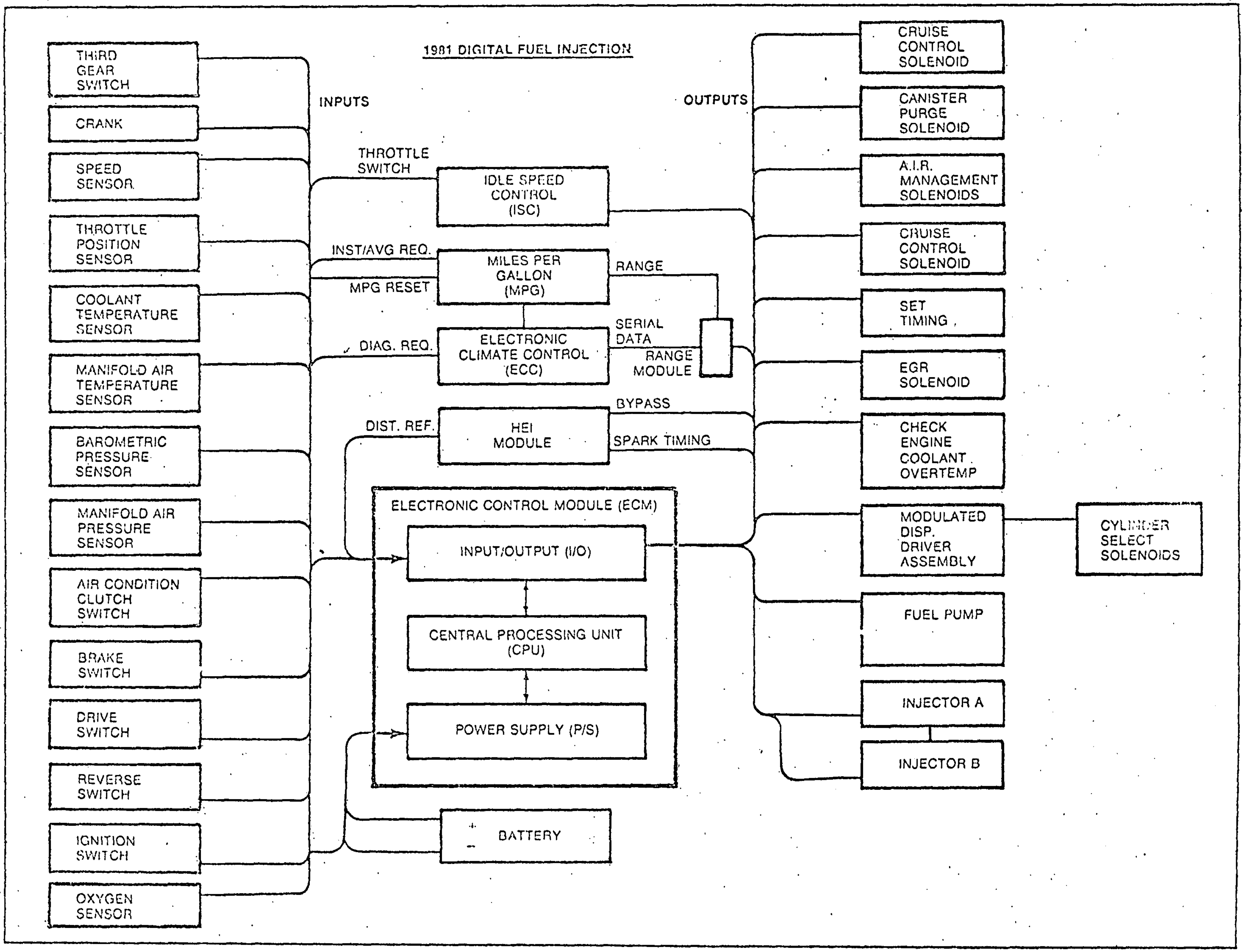

Figure 6C-66 DFI Component Diagram

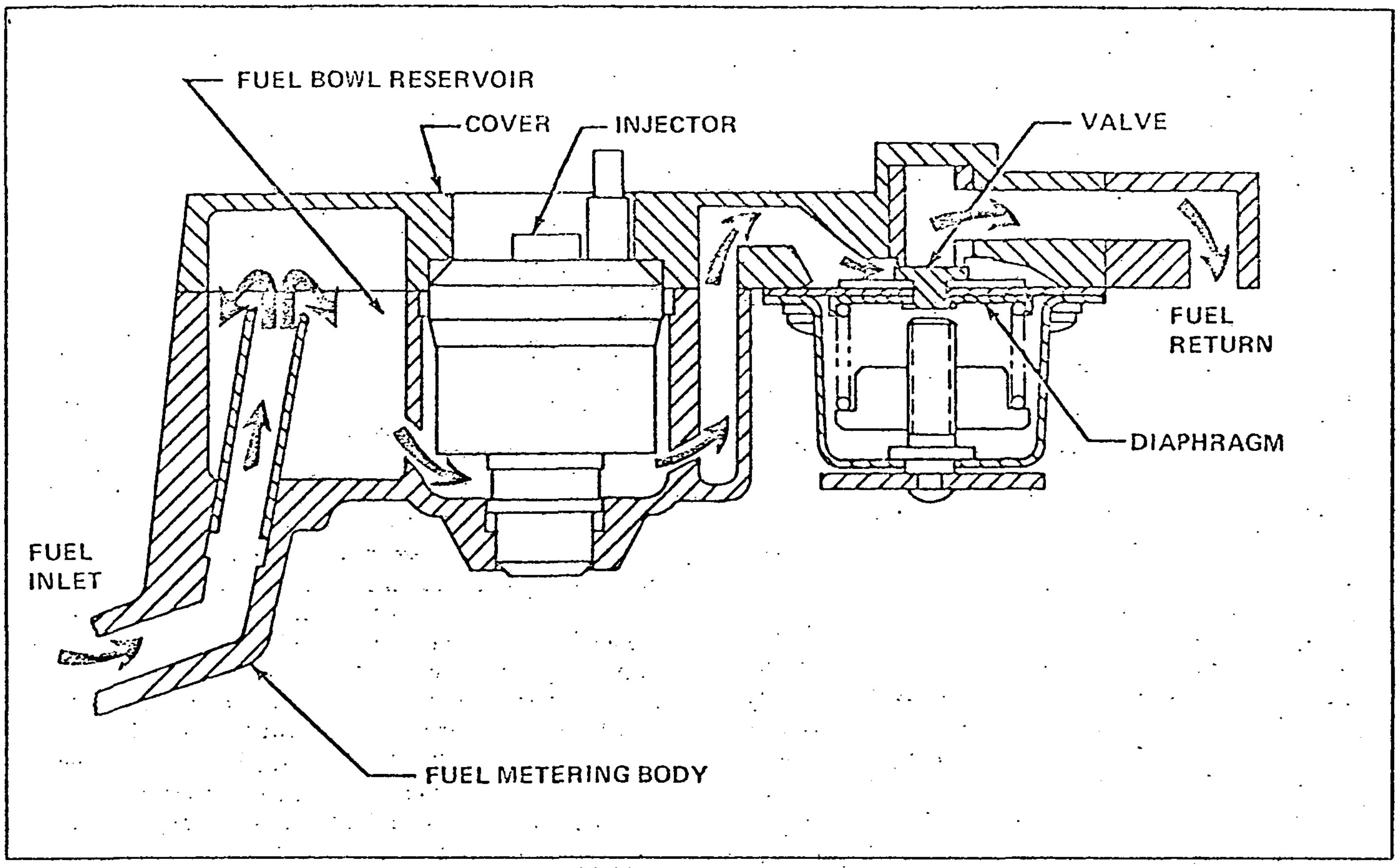

Figure 6C-68 Fuel Pressure Regulator

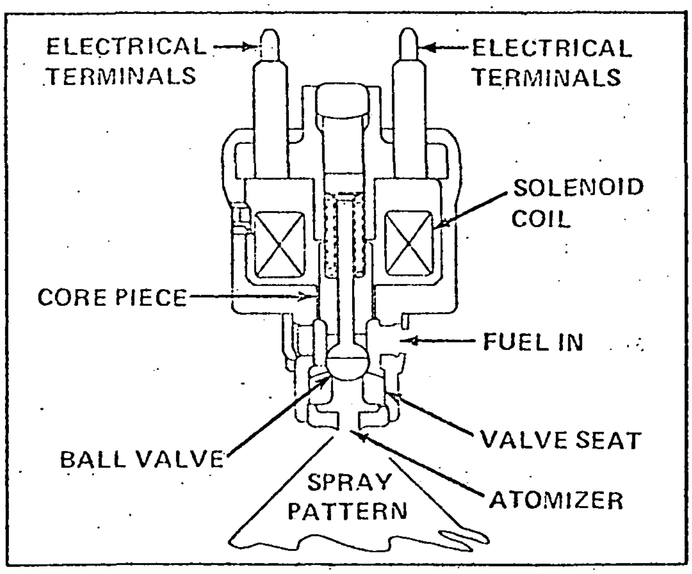

Figure 6C-69 Fuel Injectors - DFI

information to the ECM. The sensor is a thermistor whose resistance changes as a function of temperature. When the temperature is low, the resistance is high and the resistance decreases as the temperature increases.

b. Coolant Temperature Sensor

The coolant temperature sensor is similar in function to the MAT sensor and is installed in the right front corner of the engine directly below the thermostat. This sensor provides coolant temperature information to the ECM for fuel enrichment, ignition timing, EGR operation, canister purge control, air management, EFE operation, closed loop fuel control, and modulated displacement.

c. Manifold Absolute Pressure Sensor (MAP)

The Manifold Absolute Pressure (MAP) Sensor monitors the changes in intake manifold pressure which result from engine load and speed changes. These pressure changes are supplied to the ECM in the form of electrical signals. As intake manifold pressure increases, additional fuel is required. The MAP sensor sends this information to the ECM and the ECM increases the injector on time (or pulse width). Conversely as manifold pressure decreases, the pulse width will be shortened. The MAP sensor is mounted under the instrument panel near the right-hand A/C outlet and is connected electrically to the ECM. A hose from the throttle body provides a signal to the sensor.

d. Barometric Pressure Sensor (BARO)

This unit senses ambient or barometric pressure and provides information to the ECM on ambient pressure changes due to altitude and/or weather. The sensor is mounted under the instrument panel near the right-hand A/C outlet and it sends an electrical signal to the ECM. The sensors' atmospheric opening is covered by a foam filter.

e. Throttle Position Sensor (TPS)

The Throttle Position Sensor is a variable resistor mounted on the throttle body and is connected to the throttle valve shaft. Movement of the accelerator causes the throttle shaft to rotate, and throttle shaft rotation opens or closes the throttle blades. The sensor determines shaft position (throttle angle) and transmits the appropriate

e. Fuel Injectors

The two injector valves are electronically actuated and meter the fuel into the throttle body above the throttle blades, see Figure 6C-69. The valve body contains a solenoid whose plunger or corepiece is pulled upward by the solenoid coil. When the solenoid coil is energized, the plunger is raised and the spring pushes the ball valve away from the valve seat. Fuel flows through the valve. Since the pressure regulator maintains a constant pressure drop across the injectors, the quantity of fuel injected is determined by how long the valve is held open.

f. Fuel Lines

A 3/8" fuel delivery line is routed along the left frame side rail between the fuel pump/sending unit assembly and the throttle body. A teflon hose covered with braided stainless steel is used to provide high system integrity and protection against abrasion.

The fuel return line is 5/16" in diameter and is routed along the right frame side rail. This line is also teflon hose covered with braided stainless steel.

2. Air Induction System

Air for combustion enters the throttle body and is distributed to each cylinder through the intake manifold. A special distribution skirt is added to the throttle body assembly directly below each fuel injector to improve fuel distribution from the injector to the intake manifold. The air flow rate is controlled by the throttle valves which are connected to the accelerator pedal linkage. Idle speed is determined by position of the throttle valves and is controlled by the Idle Speed Control (ISC).

a. Throttle Body

The throttle body consists of a housing with two bores and two throttle blades mounted on a common shaft. One end of the throttle shaft connects to the accelerator pedal by means of mechanical linkage and the other end of the throttle shaft connects to the throttle position sensor. Skirts which are shaped like inverted cones have been added to the bores in order to improve fuel mixing and distribution.

b. Intake Manifold

The aluminum single plane intake manifold is designed especially for DFI engines with MD. The EFE heat riser system requires the use of an exhaust heat crossover passage. Refer to Section 6E of the Service Manual for a description of EFE operation.

3. Data Sensors

The component diagram (Figure 6C-66) lists the data sensors and illustrates how the data sensors are interrelated. Each data sensor will be described below:

a. Manifold Air Temperature Sensor (MAT)

The Manifold Air Temperature (MAT) sensor is installed in the intake manifold in front of the throttle body. This sensor measures the temperature of the fuel/air mixture in the intake manifold and provides this

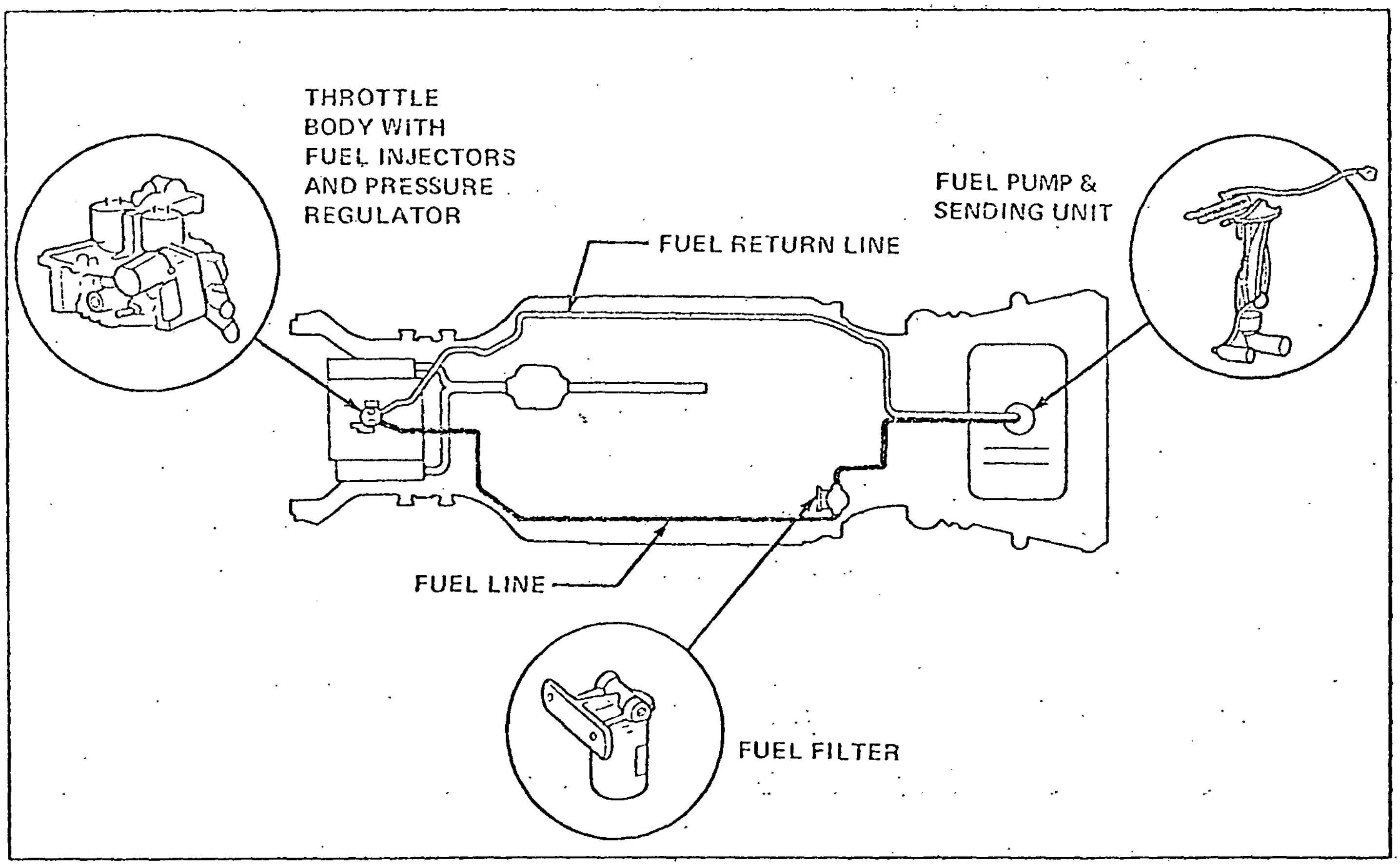

Figure 6C-67 Fuel Supply System

electrical signal to the ECM. The ECM processes these signals and uses the throttle angle information to operate the idle speed control system and to supply fuel enrichment as the throttle blades are opened.

f. Vehicle Speed Sensor

The vehicle speed sensor informs the ECM as to how fast the vehicle is being driven. The ECM uses this signal for the logic required to operate the MPG sentinel, the integral Cruise Control, the modulated displacement feature, and the idle speed control system.

The speed sensor produces a weak signal. Therefore, a buffer amplifier is placed between the speed sensor and the ECM to amplify the speed signal. The speed sensor and the buffer amplifier are located behind the speedometer cluster. Additional information on the speed sensor can be found under the Cruise Control section of this Service Manual and the 1980 Service Manual.

g. Oxygen Sensor

The oxygen sensor used in the DFI system consists of a closed end Zirconia sensor placed in the engine exhaust gas stream. This sensor generates a very weak voltage which varies with the oxygen content of the exhaust stream. As the oxygen content of the exhaust stream increases relative to the surrounding atmosphere, a lean fuel mixture is indicated by a low voltage output; as the oxygen content in the exhaust stream decreases, a rich fuel mixture is indicated by a rising voltage output from the sensor.

When the oxygen sensor is warm (above 200°C), the output voltage swings between 200 millivolts (lean mixture) and 800 millivolts (rich mixture). However, when the oxygen sensor is cold (below 200°C).

> NOTICE: No attempt should be made to measure the oxygen sensor output voltage, as the current drain of any conventional voltmeter would be enough to permanently damage the sensor, shifting its calibration range and rendering it unusable. Similarly, no jumpers, test leads, or other electrical connections should ever be made to the sensor, but only to the harness after disconnection from the sensor. The oxygen sensor has a permanently connected pigtail, with a Weatherpack environmental connector joining it to the engine control harness.

h. Engine Speed Sensor (Distributor)

The engine speed signal comes from the seven terminal HEI module in the distributor. Pulses from the distributor are sent to the ECM where the time between these pulses is used to calculate engine speed. The ECM adds spark advance modifications to the signal and sends this signal back to the distributor.

4. Electronic Control Module (ECM)

The Electronic Control Module monitors and controls all DFI system functions. The switches and data sensors which the ECM monitors are listed in Figure 6C-66. The data sensors supply analog signals to the ECM and the input/output devices convert these signals to digital signals. The signals must be in digital format because the central processing unit can only manipulate digital information. The Central Processing Unit (CPU) is the brain of the ECM and the CPU performs all mathematical computations and logic functions necessary to deliver the proper air/fuel mixture. The CPU also calculates spark timing and idle speed and it commands the operation of the emission systems, closed loop fuel control, Cruise Control, diagnostics, and modulated displacement. The CPU can accomplish all of these functions by following the instructions which have been programmed into the memory of the ECM.

There are three types of memory in the ECM:

1. Read Only Memory (ROM)
2. Random Access Memory (RAM)
3. Programmable Read Only Memory (PROM)

When ROM memory is programmed, the program cannot be changed and information can only read from the memory. If battery voltage is lost, the instructions in ROM memory will be retained.

Random access memory is the scratch pad for the CPU. Information can be read into or out of RAM memory hence it is called scratch pad memory. Engine sensor information, diagnostic codes, and the results of calculations are temporarily stored here. If the battery voltage is removed, all the information in RAM memory is lost (similar to a hand held calculator when the switch is turned off).

Programmable Read Only Memory (PROM) contains engine calibration data for each engine, transmission, body, and rear axle ratio. PROM will always retain this information permanently even if battery voltage is removed, and it can be programmed by the factory easily. These memory devices are removable from the ECM.

To demonstrate how the ECM operates, the events which occur when the ignition switch is turned on will be listed:

1. The ECM receives the ignition ON signal.
2. The Fuel Pump is activated by the ECM. (The pump will operate for approximately one second only, unless the engine is being cranked or has started).
3. All engine sensors are activated and begin transmitting signals to the ECM.
4. The EGR solenoid is activated to block the vacuum signal to the EGR valve.
5. The "check engine" and "coolant" lights are illuminated as a functional check of the bulb and circuit.
6. The HEI bypass line is pulled down to 0 volts.

The following events occur when the engine is cranked.

1. The 12 volt crank signal is sent to the ECM.
2. The fuel pump is operating.
3. After a short prime pulse, injectors alternately deliver a fuel pulse on each distributor reference pulse.
4. The engine sensors continue to transmit signals to the ECM.
5. The other events are similar to the events which occur when the ignition is on.

The following events occur when the engine starts.

1. The crank signal is removed from the ECM.
2. The injectors deliver fuel pulses alternately for each distributor reference pulse.
3. The HEI bypass line is pulled up to 5 volts and the HEI module receives spark advance signals from the ECM.
4. The ISC motor begins to control idle speed if the throttle switch is closed.

5. The fuel pump operates continuously.

6. The pressure regulator maintains fuel pressure at 10.5 psi by returning excess fuel to the fuel tank.

7. The other events are similar to the events which occur when the ignition is on.

The ECM's control of fuel delivery can be considered in three basic modes: cranking, normal operation, and wide open throttle. If the 12 volt cranking signal indicates that the engine is cranking, injectors alternately deliver a fuel pulse for every distributor reference pulse. However, if the engine should flood, smaller alternating fuel pulses are delivered if the throttle is held open and if cranking exceeds approximately 3 seconds.

When the cranking signal is removed, the injectors deliver fuel pulses alternately for every distributor reference pulse. The ECM adjusts the injector pulse width to account for operating conditions such as idle, part throttle, acceleration, deceleration, and altitude.

The MAP, BARO and TPS sensors inform the ECM that a wide open throttle condition occurred and the ECM supplies additional fuel enrichment.

5. Electronic Spark Timing (EST)

The Electronic Spark Timing system consists of the ECM and a modified HEI distributor which use a 7 terminal HEI module. The HEI distributor is designed to provide high secondary output voltages to the spark plugs and is a maintenance free unit. The HEI distributor communicates to the ECM through a 4 terminal connector which contains four circuits. These four circuits are:

1. The Distributor reference circuit
2. The bypass circuit
3. The EST circuit
4. The ground circuit

Whenever the pickup coil signals the HEI module to open the primary circuit, it also sends the spark timing signals to the ECM through the reference line.

When the voltage on the HEI bypass line is 0 volts (engine cranking), the HEI module is forced into bypass mode which means that the HEI module provides of spark advance at base timing and disregards the spark advance signal from the ECM. If the voltage on the HEI bypass line is 5 volts (engine running), the HEI module accepts the spark timing signal provided by the ECM.

The ECM monitors engine speed through the HEI reference line and engine operating conditions through the data sensors, and then the ECM calculates the proper spark advance from these parameters. The spark advance is supplied to the HEI distributor through the EST line.

6. Idle Speed Control (ISC)

The idle speed control system controls the engine speed when the throttle switch is closed. The idle speed control system includes the electric actuator (ISC motor), the idle switch (throttle switch), and the ECM. The ISC motor is a DC reversible motor which has the throttle switch as an integral part of the ISC motor plunger, see Figure 6C-70. The throttle lever rests against the ISC motor plunger which extends and retracts to change the throttle blade angle. The position of the idle switch determines whether the ISC motor should control the idle speed or not. When the switch is closed by the throttle lever resting against the end of the plunger, the ECM issues the appropriate commands to the ISC motor in order to maintain the programmed idle speed. The ECM monitors the data sensors to determine when to increase or decrease throttle blade angle. When the throttle lever moves away from the ISC motor plunger, the throttle switch opens and the ECM stops sending idle speed adjustments to the ISC motor because the driver is controlling the engine speed. When the engine is shut off, the ISC motor fully extends its plunger and opens the throttle blades so that the idle speed will be fast enough to start the car. When an engine is cold, the ECM holds the throttle valve open for a longer period of time to provide faster warmup time.

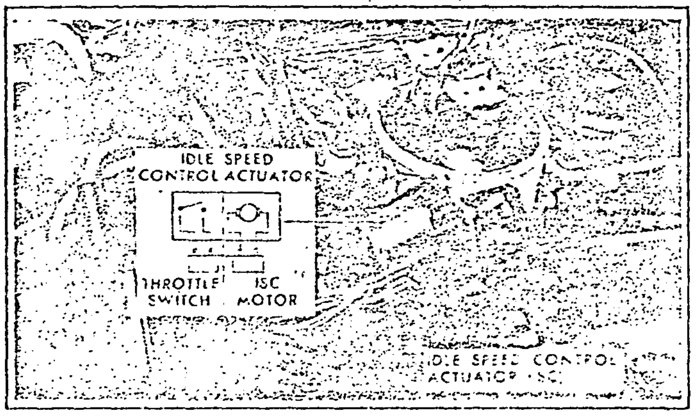

Figure 6C-70 Idle Speed Control Actuator (ISC)

7. Emission Controls

a. EGR Operation

The ECM controls the operation of the EGR system. Whenever the EGR solenoid is energized by the ECM, the EGR system is disabled (no exhaust gas is recirculated through the intake manifold). When the EGR solenoid is deenergized, the EGR system is enabled and exhaust gas is recirculated through the intake manifold.

Refer to Section 6E and 8D of the Service Manual for additional information about the operation of the EGR system.

b. Air Management Operation

The ECM controls the operation of the air management system. The air pump delivers air to the divert (control) valve which sends the air to the air cleaner or the switching valve. The switching valve sends the air either to the catalytic converter or the exhaust ports of the engine.

When the engine is cold, the air is sent to the exhaust ports of the engine. The ECM energizes the air control and air switching solenoids by supplying ground signals to the solenoids. The air flows through the divert (control valve) and the switching valve to the exhaust ports.

When the engine is warm and operating normally, the air is sent to the catalytic converter. The ECM energizes the divert solenoid by supplying a ground signal to the divert solenoid and deenergizes the switching solenoid by removing the ground signal to the solenoid. The air flows through the divert (control) valve (solenoid energized) and the switching valve (solenoid deenergized) to the catalytic converter.

When the engine is decelerating quickly, the air is sent (diverted) to the air cleaner to prevent backfiring. The ECM deenergizes the divert solenoid by removing the ground signal to the divert solenoid. The air flows through the divert valve (solenoid deenergized) to the air cleaner.

c. Canister Purge Control Operation

The ECM controls the operation of the canister purge control system. When the engine is cold, there is no vacuum to the canister control line. The ECM energizes the canister purge control solenoid by supplying a ground signal to the solenoid. When the solenoid is energized, the vacuum to the canister purge control line is blocked.

When the engine is at normal operating temperature, vacuum is supplied to the canister purge control solenoid. The ECM deenergizes the canister purge control solenoid by removing the ground signal to the solenoid. When the solenoid is deenergized, the vacuum is supplied to the canister purge control.

8. Closed Loop Fuel Control

The purpose of closed loop fuel control is to precisely maintain an air/fuel mixture of 14.7/1. When the air/fuel mixture is maintained at 14.7/1, the catalytic converter is able to operate at maximum efficiency which means lower emission levels. Since the ECM controls the air/fuel mixture, it needs to check its output and correct the fuel mixture for deviations from the ideal ratio. The oxygen sensor feeds this output information back to the ECM.

9. System Diagnostics

The DFI diagnostic routine has four types of tests which may be utilized if the situation warrants it. These four tests are:

1. The engine malfunction tests
2. Switch tests
3. Engine data displays
4. Output cycling tests

The engine malfunction tests detect system failures or abnormalities. When these malfunctions occur, the ECM will turn on the amber "check engine" light located in the right hand information center, see Figure 6C-71. The corresponding trouble codes will be stored in the ECM's memory. If a data sensor fails, the ECM substitutes a failsoft value into its calculations and continues to operate the engine with this nominal value. In this mode, there may or may not be some loss of driveability. If the fault should clear up, then the check engine light turns off, but the trouble code remains. This condition is known as an intermittent failure. The digital display panel of the Electronic Climate Control will display on command any of the trouble codes which may have been stored in the ECM.

The switch tests check the operation of various switches which provide inputs to the ECM. During this test series, the technician cycles certain switches and the ECM analyzes this action to determine if the switches are operating properly.

The engine data series displays important engine data information. The technician should compare this information to the information generated by an engine which is operating properly.

The output cycling series cycles various ECM outputs on an off. During this test series, the technican can check the operation of the engine control solenoids and lamps by using command signals originating from the ECM.

See Section 6D for Electronic Diagnosis - Computer Controlled.

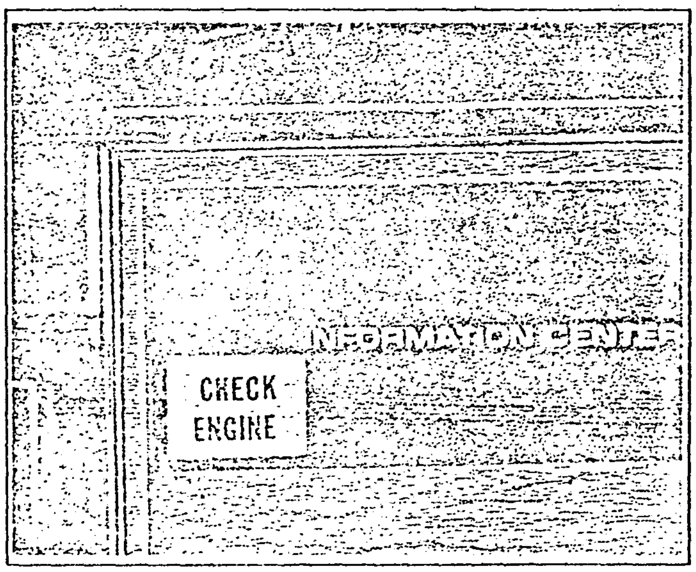

Figure 6C-71 "Check Engine" Light

10. Modulated Displacement (MD)

Modulated Displacement (MD) is an electromechanical system which deactivates certain engine cylinders in order to save fuel. Since the basic operation of the MD engine is similar to the closed loop DFI engine, only the modulated displacement feature will be discussed in this section, see Figure 6C-72.

The following general operating conditions must be met before the ECM will disable certain cylinders:

A. Coolant temperature must be above 48°C
B. The transmission must be operating in 3rd gear
C. The vehicle must be moving faster than 24 mph
D. Engine speed must be below 2,600 rpm
E. Code 25 cannot be set

The ECM controls cylinder selection indirectly throughout the Modulated Displacement Amplifier (MDA), and the Modulated Displacement Amplifier (MDA) switches the cylinder selector solenoids on and off. When the cylinder solenoids are enabled, the mechanical valve selector body will close the intake and exhaust valves of that particular cylinder, and the ECM automatically reduces the amount of fuel delivered to the engine and alters the spark timing.

The cylinder selector solenoids require an initial pull in current of four amps and later require a hold in current of one amp. This is more amperage than the ECM can handle. Therefore, the Modulated Displacement Amplifier (MDA) is connected between the ECM and the solenoids to supply additional power and to perform the switching function. During 6 cylinder operation, the MDA deactivates cylinders #1 and #4 (solenoids energized), and during 4 cylinder operation, the MDA deactivates cylinders #6 and #7 in addition to cylinders #1 and #4 (solenoids energized). Six cylinder operation only occurs above 47 mph.

The ECM monitors the MDA to determine if cylinder selection is actually occurring. The MDA supplies a 12 volt feedback signal to the ECM when the MDA is operating in 8 and 6 cylinder mode; the MDA supplies a volt feedback signal to the ECM when the MDA is operating in 4 cylinder mode. If the MDA feedback signal is not correct, then the ECM sets a check engine light and code 25 because the cylinder selection process is not operating properly. Refer to Section 6A of the Service Manual for more information on the mechanical operation of the cylinder selector valves.

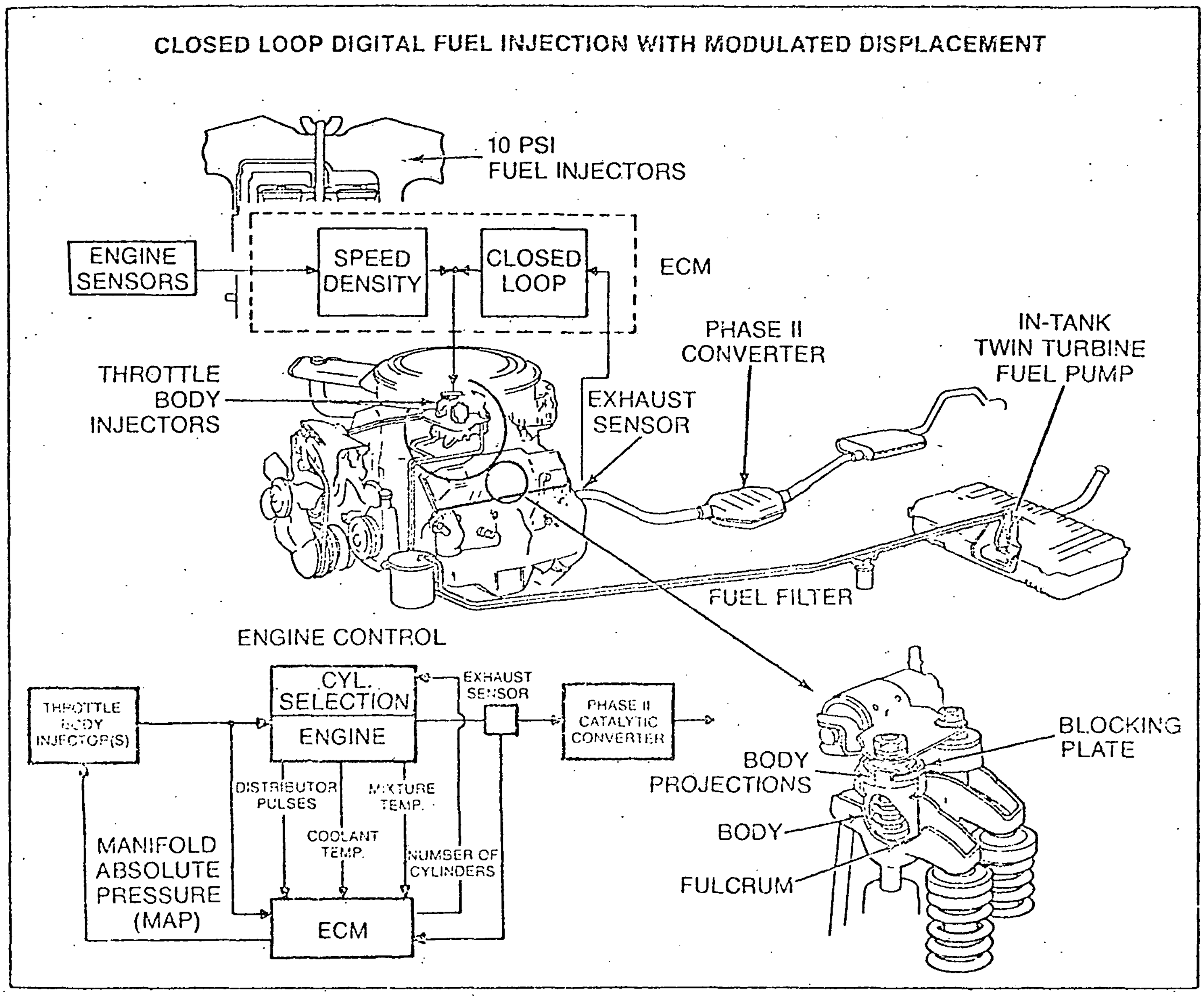

Figure 6C-72 Closed Loop DFI With Modulated Displacement

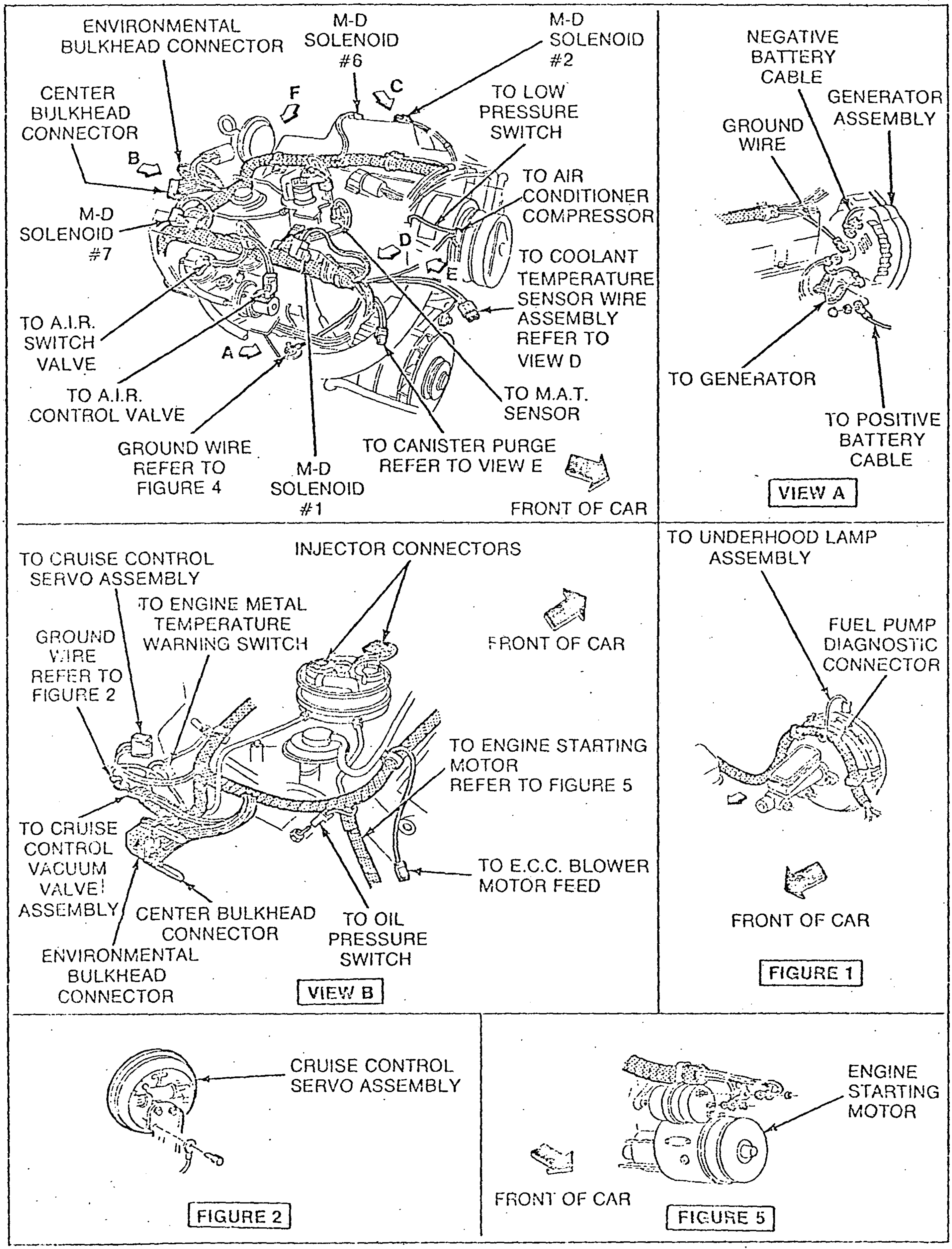

Figure 6D-73 DFI/MD Engine Wiring Assembly (A)

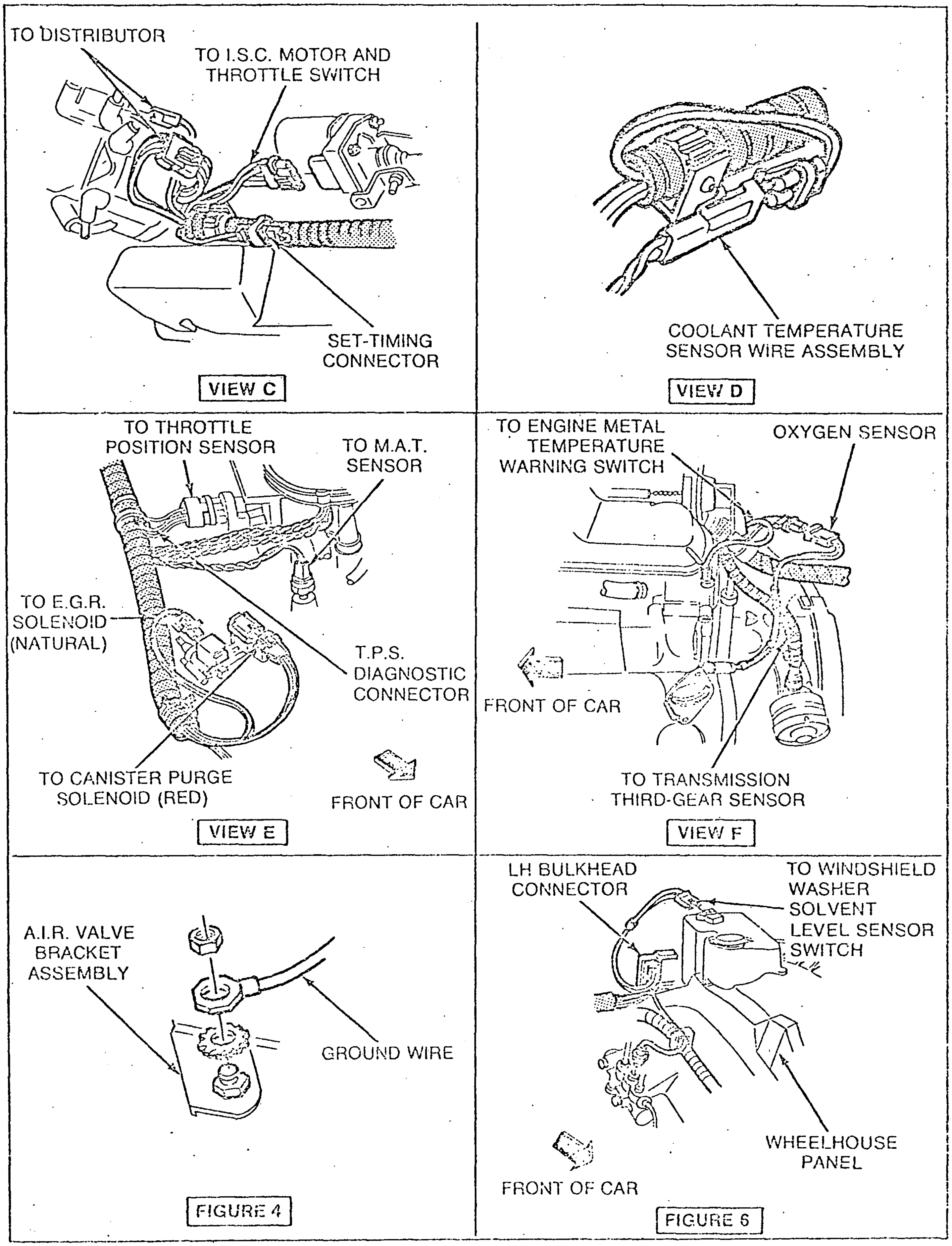

Figure 6D-74 DFI/MD Engine Wiring Assembly (B)

SECTION 8D

ELECTRONIC DIAGNOSIS - COMPUTER CONTROLLED

ALL NEW G.M. VEHICLES ARE CERTIFIED BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AS CONFORMING TO THE REQUIREMENTS OF THE REGULATIONS FOR THE CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES. THIS CERTIFICATION IS CONTINGENT ON CERTAIN ADJUSTMENTS BEING SET TO FACTORY STANDARDS. IN MOST CASES, THESE ADJUSTMENT POINTS EITHER HAVE BEEN PERMANENTLY SEALED AND/OR MADE INACCESSIBLE TO PREVENT INDISCRIMINATE OR ROUTINE ADJUSTMENT IN THE FIELD. FOR THIS REASON, THE FACTORY PROCEDURE FOR TEMPORARILY REMOVING PLUGS, CAPS, ETC. FOR PURPOSES OF SERVICING THE PRODUCT MUST BE STRICTLY FOLLOWED AND, WHEREVER PRACTICABLE, RETURNED TO THE ORIGINAL INTENT OF THE DESIGN.

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DIGITAL FUEL INJECTION (DFI)

DIAGNOSIS

"TROUBLE CODES"

The diagnostic charts in this manual are selected on the basis of trouble codes which can be displayed during the diagnostic readout. Steps of a "tree", which require testing or explanation, are described on the succeeding pages. These paragraphs are keyed to the correct steps in the "tree" by the circled number.

When certain circuits need to be checked, a schematic diagram is included, and reference to a "circuit number" is made. The circuit number (410, 575, etc.) is shown inside the box which represents the connector body in the complete circuit diagram.

Trouble codes programmed into the DFI ECM are listed and identified in Figure 8D-1.

INTERMITTENT PROBLEM DIAGNOSIS

DIAGNOSTIC CHARTS CANNOT BE USED TO DIAGNOSE INTERMITTENT FAILURES. The testing required at various points of the chart depends upon the fault being present to locate the problem. If the fault is intermittent, (not present continually), an unnecessary ECM replacement will be indicated and the problem may remain.

Since many intermittent problems are caused at electrical connections, diagnosis of intermittent problems should start with a visual and physical inspection of the connectors involved in the circuit. These connectors, should be disconnected, examined, and reconnected before replacing any components of the system. Some causes of connector problems are:

1. Improperly formed terminals or connector bodies.
2. Damaged terminals or connector bodies.
3. Corrosion, body sealer, or other foreign matter on the terminal mating surfaces which could insulate the terminals.
4. Incomplete mating of the connector halves.
5. Terminals not fully seated in the connector body ("backed-out" terminals).
6. Terminals not tightly crimped to the wire.

If an affected circuit is one that may be checked by the switch tests, the output cycling tests, or engine data displays, make the check on the appropriate circuit. If the intermittent code is a code 33, a special procedure must be followed. Refer to the procedure labeled 33A -intermittent MAP/BARO Sensor correlation test. If the intermittent code is code 13, 44, or 45, use the diagnostic chart for code 13, 44, or 45 because these particular charts have been designed to account for intermittents.

"TROUBLE CODE" DIAGNOSIS

The following abbreviations will be used in this section:

TPS - Throttle Position Sensor

ECM - Electronic Control Module

ISC - Idle Speed Control (includes Idle Speed Motor and Throttle Switch)

HEI - High Energy Ignition

MAP - Manifold Absolute Pressure (Sensor)

BARO - Barometric Pressure (Sensor)

ECC - Electronic Climate Control

MAT - Manifold Air Temperature (Sensor)

CTS - Coolant Temperature Sensor

MPG - Miles Per Gallon (Display Panel)

EGR - Exhaust Gas Recirculation

MD - Modulated Displacement

MDA - Modulated Displacement Amplifier

The dash-mounted "CHECK ENGINE" light is used to inform the technician of detected system malfunctions or abnormalities. These malfunctions may be related to the various operating sensors or to the ECM itself. The light goes out automatically if the fault clears (intermittent). However, the ECM stores the trouble code associated with the detected failure until the diagnostic system is "Cleared" or until 20 ignition switch (on-off) cycles have occurred without the fault reappearing.

Proper operation of the light is as follows:

a. The light is normally off.

b. A bulb check is performed when the ignition is in the "On" and "Crank" positions. When the engine starts, the bulb goes out.

c. The light comes on and stays on when a constant malfunction is detected.

d. If a malfunction is intermittent, the light will go out when the malfunction is not present. The light will come on each time a malfunction is detected (may flicker).

e. The light stays on when the system is displaying the diagnostic routine.

The dash mounted digital display panel, normally used for the ECC system, can be temporarily directed to display trouble codes stored in the ECM.

HOW TO "ENTER" DIAGNOSTIC MODE

To enter diagnostic mode, proceed as follows:

1. Turn the ignition "ON".

2. Depress the "OFF" and "WARMER" buttons on the ECC panel simultaneously and hold until ".." appears, Figure 8D-2. "88" will then be displayed which indicates the beginning of the diagnostic readout.

3. Trouble codes will be displayed on the digital ECC panel beginning with the lowest numbered code. Note that the MPG panel goes blank when the system is displaying in the diagnostic mode.

1981 DIAGNOSTIC CODES
THE FOLLOWING CODES ARE PROGRAMMED INTO THE ECM.

CODE	CIRCUIT AFFECTED
12	NO TACH SIGNAL
13	O2 SENSOR NOT READY
14	SHORTED COOLANT SENSOR
15	OPEN COOLANT SENSOR CIRCUIT
16	GENERATOR VOLTAGE OUT OF RANGE
17	CRANK SIGNAL CIRCUIT HIGH
18	OPEN CRANK SIGNAL CIRCUIT
19	FUEL PUMP CIRCUIT HIGH
20	OPEN FUEL PUMP CIRCUIT
21	SHORTED THROTTLE POSITION SENSOR CIRCUIT
22	OPEN THROTTLE POSITION SENSOR CIRCUIT
23	EST/BYPASS CIRCUIT SHORTED OR OPEN
24	SPEED SENSOR FAILURE
25	MODULATED DISPLACEMENT FAILURE
26	SHORTED THROTTLE SWITCH CIRCUIT
27	OPEN THROTTLE SWITCH CIRCUIT
30	IDLE SPEED CONTROL CIRCUIT
31	SHORT MAP SENSOR CIRCUIT
32	OPEN MAP SENSOR CIRCUIT
33	MAP/BARO SENSOR CORRELATION
34	MAP HOSE
35	SHORTED BARO SENSOR CIRCUIT
36	OPEN BARO SENSOR CIRCUIT
37	SHORTED MAT SENSOR CIRCUIT
38	OPEN MAT SENSOR CIRCUIT
44	O2 SENSOR LEAN
45	O2 SENSOR RICH
51	PROM INSERTION FAULTY
60	DRIVE (ADL) SWITCH CIRCUIT
61	SET AND RESUME SWITCH CIRCUIT
62	CAR SPEED EXCEEDS MAXIMUM LIMIT
63	CAR AND SET SPEED TOLERANCE EXCEEDED
64	CAR ACCELERATION EXCEEDS MAXIMUM LIMIT
65	COOLANT TEMPERATURE EXCEEDS MAXIMUM LIMIT
66	ENGINE RPM EXCEEDS MAXIMUM LIMIT
68	SET AND RESUME SWITCH CIRCUIT
70	SYSTEM READY — SWITCH TESTS
71	BRAKE LIGHT SWITCH
72	ISC THROTTLE SWITCH
73	DRIVE (ADL) SWITCH
74	BACK-UP LAMP SWITCH
75	CRUISE ON/OFF CIRCUIT
76	SET/COAST CIRCUIT
77	RESUME/ACCELERATION CIRCUIT
78	INSTANT/AVERAGE MPG BUTTON
79	RESET MPG BUTTON
80	A/C CLUTCH CIRCUIT
88	DISPLAY CHECK
90	SYSTEM READY TO DISPLAY ENGINE DATA
95	SYSTEM READY FOR ACTUATOR CYCLING
96	ACTUATOR CYCLING
97	MD CYLINDER SOLENOID CYCLING
00	ALL DIAGNOSTIC COMPLETE

Figure 8D-1 DFI Diagnostic Codes

HOW TO "CLEAR" TROUBLE CODES

Trouble codes stored in the ECM's memory may be cleared (erased) by entering the diagnostic mode and then depressing the "OFF" and "HI" buttons simultaneously, Figure 8D-2. Hold until "00" appears. After "00" is displayed, the ECM will display "70".

HOW TO "EXIT" DIAGNOSTIC MODE

To get out of the diagnostic mode, depress any of the ECC "Function" keys (Auto, Econ, etc. except Rear Defog) or turn ignition switch off for 10 seconds. Trouble codes are not erased when this is done. The temperature setting will reappear in the display panel.

DIAGNOSIS PROCEDURE

When the check engine light turns on, it indicates that a malfunction has occurred for which a trouble code has been stored. The trouble code can be displayed on the ECC control panel. The malfunction may or may not result in abnormal engine operation.

To determine which system(s) has malfunctioned, proceed as follows:

1. Turn the ignition switch "ON" for 5 seconds.

2. Depress the "OFF" and "WARMER" buttons on the Electronic Climate Control panel simultaneously and hold until ".." appears.

3. The numerals "88" should then appear, see Figure 8D-3. The purpose of the "88" display is to check that all segments of the display are working. Diagnosis should not be attempted unless the entire "88" appears as this could lead to misdiagnosis (Code 31 could be Code 34 with two segments of the display inoperative, etc.).

4. If trouble codes are present, they will be displayed on the digital ECC panel as follows:

a. The lowest numbered code will be displayed for approximately two seconds.

b. Progressively higher numbered codes, if present, will be displayed consecutively for two second intervals until the highest code present has been displayed.

c. "88" is again displayed.

d. Parts A, B, and C above will be repeated a second time.

e. When the trouble codes have been displayed, code 70 will then be displayed. Code 70 indicates that the ECM is ready for the next diagnostic feature to be selected.

5. If no trouble codes are present, "88" will be displayed for a longer period of time, and then the ECM will display code 70. Code 70 indicates that the ECM is ready for the next diagnostic feature to be selected.

INTERMITTENT CODES VERSUS HARD FAILURES

The check engine light will go out automatically if the malfunction clears. However, the ECM stores the trouble code associated with the detected failure until the diagnostic system is cleared or until 20 ignition cycles have occurred without any fault reappearing. This condition is known as an intermittent failure.

Therefore, the ECM may have two types of trouble codes stored in its memory. These two code types are:

A. A code for a malfunction which is a hard failure. A hard failure turns on the check engine light and keeps it on as long as the malfunction is present.

B. A code for an intermittent malfunction which has occurred within the last 20 ignition cycles. An intermittent failure turns off the check engine light when the malfunction clears up.

Diagnostic Charts Cannot be Used to Diagnose Intermittent Failures

Intermittent codes should be diagnosed by inspecting the connectors involved with the affected circuits. However, if an affected circuit is one that may be checked by the switch tests, output cycling tests, or engine data displays, make the check on the appropriate circuit.

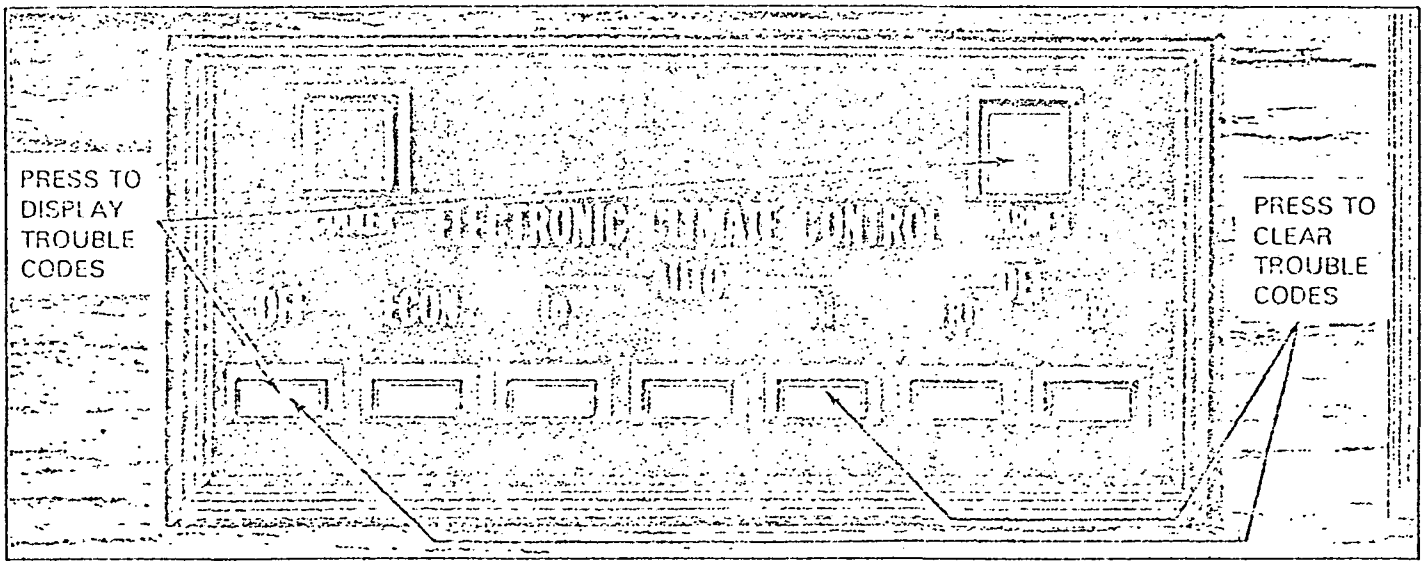


Figure 8D-2 ECC Control Head

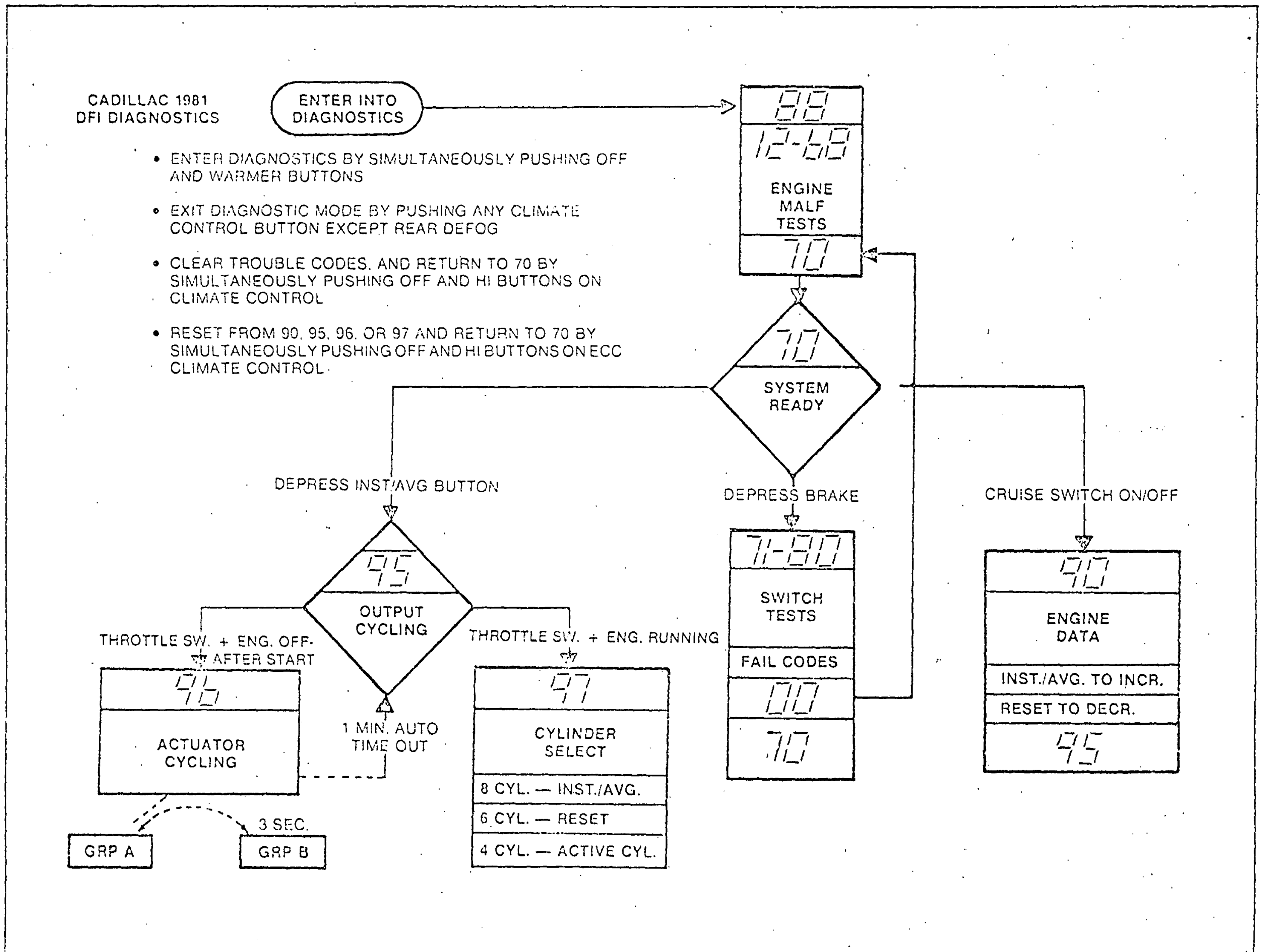


Figure 8D-3 DFI Diagnostics

During any diagnostic interrogation, it is necessary to determine if the diagnostic code or codes are hard failures or intermittent failures. To make this determination, proceed as follows:

1. Enter diagnostics and note stored trouble codes.

2. If one code exists and the "Check Engine" light is on (engine running) follow the appropriate trouble tree. If "Check Engine" light is off (engine running), clear trouble codes. If more than one code exists, clear trouble codes.

3. Exit diagnostics by turning the ignition switch off for 10 seconds.

4. Turn the ignition on, wait 5 seconds, and then start the engine.

5. Accelerate the engine to approximately 2000 RPM for a few seconds.

6. Return the engine to idle speeds.

7. Shift the transmission into drive.

8. Shift the transmission back into park.

9. If the "check engine" light comes on, enter diagnostics, read, and record the trouble codes. This will reveal only "hard failures" codes. The Cruise Control codes 60 through 68 never set a check engine light; therefore, treat them as hard failures. Codes 13, 44, 45, 24 and 25 may require a road test to reset a "hard failure" after the trouble codes have been cleared.

If the light does not come on, then all stored codes are intermittent failures except for codes 13, 33, 44, and 45. If the intermittent code is a code 33, a special procedure must be followed. Refer to diagnostic chart 33A, "Intermittent MAP/BARO Correlation Test". If the intermittent code is code 13, 44, or 45, use the diagnostic chart for code 13, 44, or 45 because these particular charts have been designed to account for intermittents.

If the vehicle exhibits performance problems and has no codes set, refer to the performance diagnosis charts. A component which is checked by the trouble codes will rarely cause a performance problem when no trouble codes are set.

10. Begin the diagnosis with the lowest code number which is displayed. If codes 51 or 16 are present, begin the diagnosis with code 51 and then proceed to code 16.

CODE 70

Code 70 is a decision point. When code 70 is displayed, the technician should select the diagnostic feature that he wants to display. The following choices are available:

A. Switch tests

B. Engine data display

C. Output cycling tests

D. Exit diagnostics or clear codes and exit diagnostics.

SWITCH TESTS PROCEDURE

Code 70 must be displayed on the Electronic Climate Control panel before the switch tests can begin. To perform the switch tests, proceed as follows:

1. Depress and release the brake pedal; the switch tests begin as the display switches from code 70 to code 71, see Figure 8D-3. (If the display doesn't advance to code 71, refer to the diagnosis chart, code 71, because the ECM is not processing the brake signal.)

2. With code 71 displayed, depress and release the brake pedal again to test the Cruise Control brake circuit, see Figure 8D-4. When this check is complete, the display will automatically sequence to code 72. If this check is not performed within 10 seconds, the display will automatically sequence to code 72 but code 71 will be stored in the ECM's memory as a failure.

3. With code 72 displayed, depress the throttle from the idle position to the wide open throttle position and then release the throttle. While this action is being performed, the ECM checks the throttle switch for proper operation. When this check is complete, the display will automatically sequence to code 73. If this check is not performed within 10 seconds, the display will automatically sequence to code 73 but code 72 will be stored in the ECM's memory as a failure.

4. With code 73 displayed, shift the transmission lever into drive and then neutral. This action checks the operation of the drive switch. When this check has been completed, the display will automatically sequence to code 74. If this check is not performed formed within 10 seconds, code 73 will be stored in the ECM's memory as a failure.

5. With code 74 displayed, shift the transmission lever to reverse and then to park. This action checks the operation of the reverse switch. If the transmission is not shifted within 10 seconds, a code 74 will be stored as a failure. When the check is completed, the panel will automatically sequence to code 75.

On cars without Cruise Control, codes 75, 76 and 77 will be displayed during this switch test. When these codes are displayed during the switch test, allow the code to reach its 10 second time out. After this time out has elapsed, the display will advance to the next code. Allow codes 75, 76 and 77 to time out (30 seconds). When code 78 is displayed complete step #9 of the switch test series within the 10 seconds time out to assure test accuracy.

6. With code 75 displayed, switch the Cruise Control instrument panel switch from off to on and back to off. When this check is complete, the display will automatically sequence to code 76. If this check is not performed within 10 seconds, the display will automatically sequence to code 76 but code 75 will be stored in the ECM's memory as a failure.

7. With code 76 displayed and with the cruise instrument panel switch in the on position, depress and release the set/coast button to verify the operation of this switch. When this check is complete, the display will automatically sequence to code 77. If this check is not completed within 10 seconds, the ECM will store code 76 as a failure.

8. With code 77 displayed and with the cruise instrument panel switch in the on position, depress and release the resume/ acceleration switch to check the operation of this switch. If this check is not completed within 10 seconds, the ECM will store code 77 as a failure. The display will advance to code 78.

9. With code 78 displayed, depress and release the "average" button on the MPG panel. When this check is complete, the display will automatically cycle to code 79. This must be completed within 10 seconds or a code 78 will be set as a failure.

10. With code 79 displayed, depress and release the "reset" button on the MPG panel within 10 seconds to test the operation of this switch. The panel will automatically cycle to code 80.

11. With code 80 displayed, depress and release the rear defogger button on the ECC panel. This action checks the ECM's ability to recognize and process the air conditioning clutch signal. However, the compressor cycling switch leading to the compressor drive circuit of the ECC power module must be closed in order to energize the A/C compressor clutch. Sometimes, the engine may need to be running and the ECC may need to be operating in auto and 60 to close the contacts of the compressor cycling switch. This procedure must be completed within 10 seconds to avoid setting code 80 as a failure. This is the end of the switch tests.

On cars **without** rear defogger, code 80 will be displayed during the switch test. When code 80 is displayed, momentarily supply 12 volts to the blue wire in the six wire weather pack connector on the ECC power module (engine compartment) to pass code 80.

12. When the switch tests are completed, the ECM will now go back and display the switch codes which did not test properly. Each code which did not pass will be displayed beginning with the lowest number. The codes will not disappear until the affected switch circuit has either been repaired or retested. Refer to the appropriate diagnosis chart for each trouble code.

13. After the switch tests are completed and all circuits pass, the ECC panel displays "00" and then returns to code 70. "00" indicates that the switch circuits are operating properly.

ENGINE DATA DISPLAY PROCEDURE

Code 70 must be displayed on the Electronic Climate Control panel before the engine data display can begin to display the engine data series. To display the engine data information, proceed as follows:

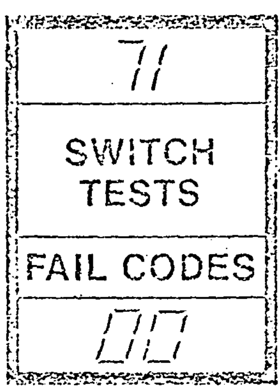
On cars **without** Cruise Control, locate the 6-wire Cruise Control instrument panel switch connector under instrument panel (left of steering column) and momentarily jumper pin C (circuit 904-0.5 yellow) to pin D (circuit #903-0.5 blue-light/black). This momentary jumpering will advance the display to code 90.

1. Slide the cruise instrument panel switch from the on position to the off position, see **Figure** 8D-3. The engine data series begins as the display switches from code 70 to code 90. (If the display doesn't advance to code 90, refer to code 75 of the switch tests.)

2. To advance the display, depress the instant/average button located on the MPG panel. To return to a previously displayed parameter, depress the reset button on the MPG panel. It is possible to leave the engine data series at anytime and return to code 70 by simultaneously depressing the "OFF" and "HI" buttons on the climate control. After the last parameter is displayed, the system advances to code 95 and waits for the next command.

3. When troubleshooting a malfunction, the engine data display can be used to compare the vehicle with problems to a vehicle which is functioning properly. A brief summary of each parameter is provided below: (**Figure** 8D-5).

1981 DFI DIAGNOSTIC ROUTINE
SWITCH TEST SERIES



DURING THIS TEST SERIES THE TECHNICIAN CYCLES CERTAIN SWITCHES AND THE ECM ANALYZES THIS ACTION TO DETERMINE IF THE SWITCHES ARE OPERATING PROPERLY.

SWITCH TEST CODES:

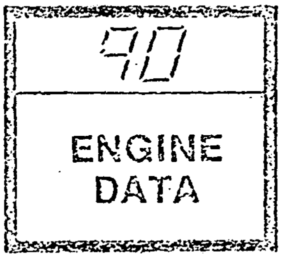
70 SYSTEM READY
71 CRUISE CONTROL BRAKE SWITCH
72 ISC THROTTLE SWITCH
73 DRIVE (ADL) SWITCH
74 BACKUP LAMP SWITCH
*75 CRUISE OFF/ON
*76 CRUISE SET/COAST
*77 CRUISE RESUM/ACCEL.
78 AVG. MPG SWITCH
79 RESET MPG SWITCH
*80 A/C CLUTCH (PRESS REAR DEFOG SWITCH)

*NEW FOR 1981

Figure 8D-4 Switch Test Series

1981 DIAGNOSTIC ROUTINE
ENGINE DATA SERIES

VARIOUS ENGINE SENSOR AND ENGINE CONTROL VALUES CAN BE DISPLAYED AT THE TECHNICIAN'S OPTION



ENGINE DATA DISPLAY

PARAMETER NO.	PARAMETER	VALUE	UNITS
01	TPS–(THROTTLE ANGLE)	XX	DEGREES
02	MAP	XX	kPa
03	BARO	XX	kPa
04	COOLANT	XX	0 = −40°C 99 = 150°C
05	MAT	XX	0 = −40°C 99 = 150°C
06	INJECTOR PULSE WIDTH	X.X	MSEC
07	O_2 SENSOR	.XX	VOLTS
08	SPARK ADVANCE	XX	DEGREES
09	IGNITION CYCLES	XX	KEY CYCLES
10	OPEN/CLOSED-LOOP INDICATOR	X	0 = OPEN LOOP 1 = CLOSED LOOP
11	BATTERY VOLTAGE	X.X	VOLTS — WILL NOT DISPLAY 10'S DIGIT

Figure 8D-5 Engine Data Display

01 The throttle angle is displayed in degrees.

02 The MAP value is displayed as a number between 1 and 99. A pressure reading of 100 and 101 is displayed as a 99 because it is not possible to display more than 2 digits on the ECC panel.

03 The BARO value is displayed in the same manner as the MAP value.

04 The coolant temperature is a scaled number which reads between 0 and 99. The value of 0 corresponds to -40°C, and the value of 99 corresponds to 150°C, see Figure 8D-6 for additional conversion values.

05 The manifold air temperature value is displayed in the same manner as the coolant temperature.

06 The injector pulse width is displayed in milliseconds. A decimal point will not appear but it has to be assumed between the two digits. (i.e. - 32 means 3.2 milliseconds)

07 The oxygen sensor voltage is displayed in volts and the decimal point has to be assumed before the two digits. (i.e. - 60 means .60 volts)

08 The spark advance value is displayed in degrees.

09 The ignition cycle value is the number of times that the ignition has been cycled since the trouble code was set.

10 The open closed loop indicator tells the technician whether the ECM is operating the system in closed loop operation or in open loop operation. A value of 1 indicates closed loop operation; a value of 0 indicates open loop operation.

11 The battery voltage is read in volts; however, the 10's digit will not display and a decimal point has to be assumed between the two numbers (23 should be read as 12.3 volts).

When the engine data display is initiated, the ECC will display 01 for one second to indicate the first parameter check and then a two digit number will be displayed for five seconds to indicate the first parameter value. A single digit parameter value will be displayed as a "blank X". The ECC will continue to repeat his sequence of events until the technician decides to move to the next parameter, see Figure 8D-5.

OUTPUT CYCLING TESTS PROCEDURE

This series of tests can be initiated after 95 is displayed on the ECC panel. The display of 95 can be reached by the following methods:

1. Depress the instant/average button while code 70 is displayed on the ECC panel. see Figure 8D-3. If the display doesn't advance to code 95, refer to code 78 of the switch tests.

2. Depress the instant/average button while parameter #11 of the engine data display series is being displayed.

The output cycling tests consist of two separate operations:

A. With the engine running, the cylinder select test, code 97, operates the modulated displacement solenoids.

B. With the engine off, the actuator cycling test, code 96, turns the ECM's outputs on and off.

To enter the actuator cycling tests, proceed as follows:

A. The engine must be running.

B. Turn the engine off and within 2 seconds, turn the ignition on.

C. Enter diagnostics and display code 95. See Figure 8D-7.

D. Depress the accelerator pedal to the wide open throttle position (throttle switch open) and release it (throttle switch closed). Code 96 will appear on the display.

E. Turn the cruise instrument panel switch to the on position so that the Cruise Control outputs will cycle.

F. The actuator cycling test will end automatically after 1 minutes of cycling and the display will switch from code 96 to code 95.

The group A outputs will cycle on and off for 3 seconds and then the group B outputs will cycle on and off for 3 seconds. The Cruise Control power valve operates continuously. Group A will continue to alternate with Group B until the 2 minute automatic shut off occurs.

To enter the cylinder select tests, proceed as follows:

A. The engine must be running.

B. Enter diagnostics and display code 95, see Figure 8D-7.

C. Depress the accelerator pedal to the wide open throttle position (throttle switch open) and release it (throttle switch closed). Code 97 will appear on the display.

D. With no button of the MPG panel depressed, the ECM will continue to control the cylinders automatically.

E. Depressing the instant/average button of the MPG panel will force the engine to operate in 8 cylinder mode as long as the button is depressed.

COOLANT TEMPERATURE CONVERSION		
CODE	°F	°C
0	−40	−40
8	−12	−25
12	+ 1	−17
16	15	− 9
21	32	+ 0
25	46	8
30	64	18
35	81	27
40	98	37
45	115	46
50	133	56
52	140	60
54	147	64
56	153	67
58	160	71
60	167	75
62	174	79
64	181	83
66	188	87
68	195	90
70	202	94
72	209	98
73	212	100
75	219	104
80	236	113
85	254	123
90	271	133
99	302	150

Figure 8D-6 Temperature Conversion Table

F. Depressing the reset button of the MPG panel will force the engine to operate in 6 cylinder mode until the button is released.

G. Depressing the active cylinder button of the MPG panel will force the engine to operate in 4 cylinder mode until the button is released.

The switch tests, the engine data displays, and the output cycling tests can be used to isolate intermittent failures.

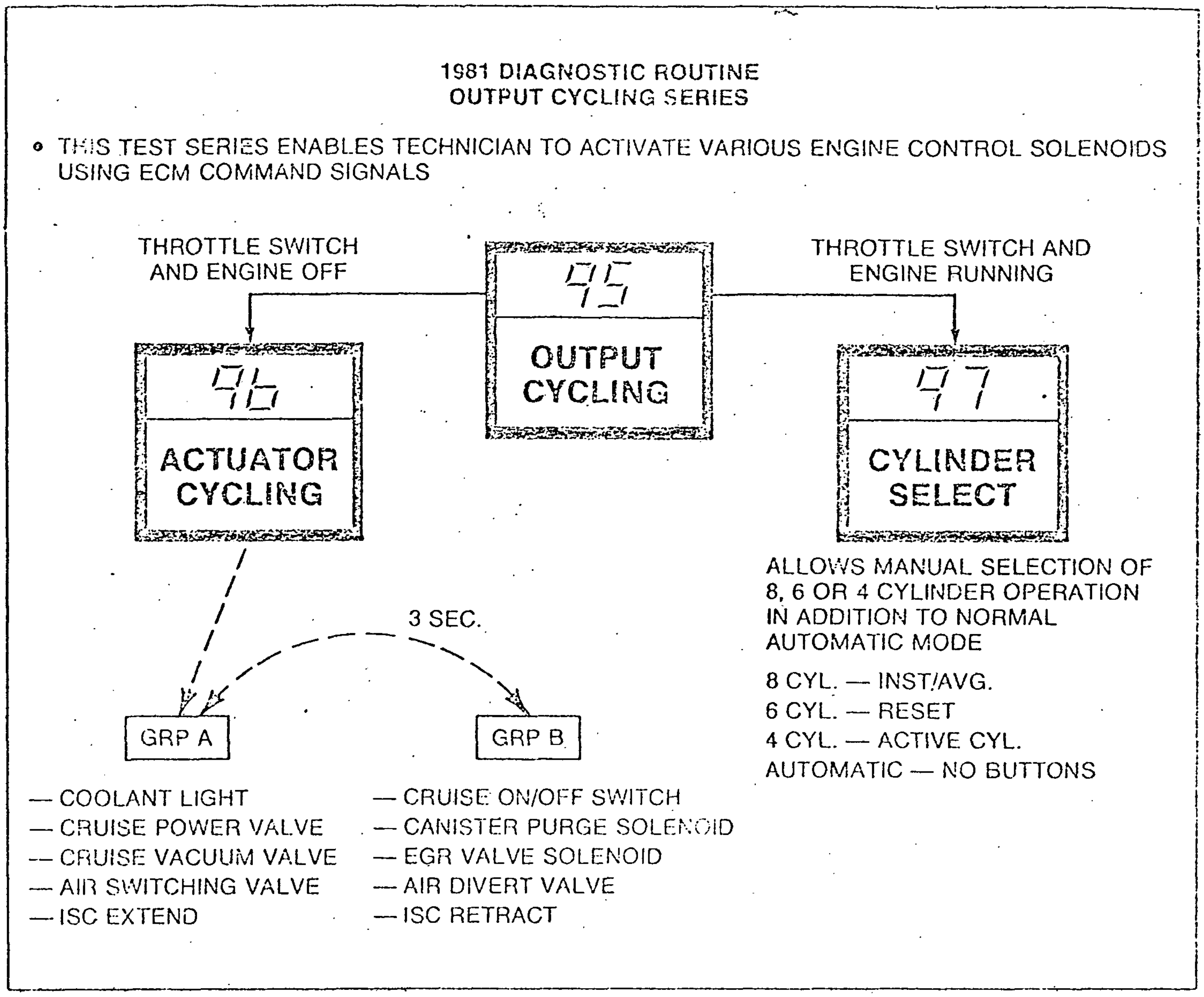


Figure 8D-7 Output Cycling Tests

ATTACHMENT 4

Test Vehicle Description

Model/Year	1981
Make	Cadillac Seville
Emission Control System	EGR, air injection, closed loop TBI, dual bed catalytic converter
Engine Configuration	V-8 modulated displacement
Bore x Stroke	3.8 inches x 4.06 inches
Displacement	368.0 cubic inches
Rated Horsepower	140
Transmission	A-3
Chassis Type	Sedan
Tire Size	P 205/75 R 15
Inertial Weight	4250 lbs.
Vin	1G6AS6991BE692250
AHP	10.0
Engine Family	16T5ADB
Fuel Type	Unleaded - IND HO
Compression Ratio	8.2:1
Differential	4MG

Attachment 5

Dilute Sample Testing

Date	Test Numbers	FTP					HFET					Comments
		HC	CO	CO_2	NOx	FE	HC	CO	CO_2	NOx	FE	
Feb 81	80-7654-55	.299	3.01	621.	0.71	14.2	.063	0.73	399.	0.83	22.2	Baseline
Feb 81	80-7656-57	.292	2.69	623.	0.76	14.1	.078	1.63	421.	0.79	20.9	Baseline
Feb 81	80-7658-59	.491	10.39	604.	0.71	14.3	.244	7.65	408.	0.91	21.1	ECO Disconnected
Feb 81	80-7661-62	.867	27.62	610.	0.39	13.5	.159	4.29	383.	1.10	22.7	ECO Shorted
Feb 81	80-7663-64	.310	4.12	910.	3.94	9.7	.082	2.75	435.	0.56	20.2	TPS Disconnected
Feb 81	80-7665-66	.765	1.72	642.	2.82	13.7	.036	0.05	462.	2.24	19.2	CTS Disconnected
Feb 81	80-7667-68	14.797	204.92	557.	0.24	9.6	3.524	56.87	492.	0.14	15.0	MAP Disconnected
Feb 81	80-7669-70	7.410	256.91	688.	0.11	7.9	3.075	102.36	394.	0.03	15.7	PROM Errors
Feb 81	80-7673-74	.279	2.14	807.	3.90	10.9	.054	1.16	417.	1.16	21.2	TPS Shorted
Feb 81	80-7675-76	1.283	19.64	589.	0.38	14.0	.461	15.14	390.	0.48	21.4	MAT Disconnected
Mar 81	80-7677-7917	.267	1.19	601.	0.86	14.7	.062	0.33	398.	0.98	22.2	Baseline

Attachment 6

I/M Testing Before Catalyst

			Four Mode Idle				Two Mode Loaded		
Date	Test Numbers	50 Cruise HC/CO	Idle HC/CO	2500 HC/CO	Idle HC/CO	Drive HC/CO	30 MPH HC/CO	Idle HC/CO	Comments
4 Feb 81	80-7654-55	125/.5	400/.8	95/.65	400/.85	275/.90	120/.6	100/.8	Baseline
6 Feb 81	80-7656-57	75/.35	300/.7	70/.55	250/.8	275/.8	200/1.0	400/.7	Baseline
11 Feb 81	80-7658-59	100/.14	325/1.2	150/.4	400/.5	200/.2	160/.9	475/.5	EGO Disconnected
12 Feb 81	80-7661-62	200/2.5	250/.3	150/.35	400/.9	250/.2	150/.4	600/.5	EGO Shorted
13 Feb 81	80-7663-64	80/.4	250/.75	45/.5	300/.8	250/1.0	150/.9	275/1.2	TPS Disconnected
19 Feb 81	80-7665-66	60/.13	150/.12	40/.18	150/.15	100/.10	75/.10	175/.12	CTS Disconnected
20 Feb 81	80-7667-68	140/2.0	900/10+	650/10+	1100/10+	550/9.5	165/5.0	250/10+	MAP Disconnecte
24 Feb 81	80-7669-70	160/7.2	100/3.8	70/2.2	100/3.5	280/10	200/8.0	70/1.4	PROM Errors
26 Feb 81	80-7673-74	90/.37	25/.45	30/.40	30/.45	135/.75	90/.45	30/.35	TPS Shorted
27 Feb 81	80-7675-76	120/.45	400/.5	70/.45	400/.5	200/.5	115/.5	200/.5	MAT Disconnecte
3 Mar 81	80-7677-7917	115/.43	300/.7	100/.6	280/.85	280/.85	100/.5	300/.55	Baseline

NOTE: Before catalyst idle emissions fluctuated considerably in most tests. The values recorded represent the mean value of the emissions based on observation of the analog meter on the analyzer.

I/M Testing After Catalyst

Date	Test Numbers	50 Cruise	Four Mode Idle				Two Mode Loaded		Comments
			Idle	2500	Idle	Drive	30 MPH	Idle	
		HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	
4 Feb 81	80-7654-55	45/.03	40/.03	35/.03	40/.03	30/.03	20/.03	10/.03	Baseline
6 Feb 81	80-7656-57	60/.10	60/.03	45/.03	50/.03	40/.03	70/.03	45/.03	Baseline
11 Feb 81	80-7658-59	35/.05	135/.1	40/.03	50/.04	40/.04	60/.7	20/.03	ECO Disconnected
12 Feb 81	80-7661-62	25/.01	40/.01	35/.01	35/.01	35/.01	40/.01	35/.01	EGO Shorted
13 Feb 81	80-7663-64	25/.03	40/.04	30/.04	25/.04	30/.04	30/.04	50/.03	TPS Disconnected
19 Feb 81	80-7665-66	30/.03	25/.03	20/.03	25/.03	25/.03	25/.03	20/.02	CTS Disconnected
20 Feb 81	80-7667-68	110/2.0	800/10+	580/10+	1000/10+	500/9.0	150/4.8	220/10+	MAP Disconnected
24 Feb 81	80-7669-70	150/6.4	100/3.5	50/1.9	100/3.8	260/9.8	190/8.0	70/1.1	PROM Errors
26 Feb 81	80-7673-74	25/.03	15/.03	20/.04	20/.03	20/.03	25/.04	25/.03	TPS Shorted
27 Feb 81	80-7675-76	10/.02	40/.03	25/.03	50/.03	35/.03	35/.03	25/.03	MAT Disconnected
3 Mar 81	80-7677-7917	35/.22	25/.02	35/.02	25/.02	35/.02	25/.02	20/.02	Baseline

Attachment 7

Results of Propane Injection Diagnostic Procedure

4CFH Propane Neutral

Date	Test Numbers	RPM	ICO	CODE	RPM	RPM	ICO	CODE	RPM	RPM	ICO	Comments
4 Feb 81	80-7654-55	580	.03	a	635	600	.03	b	570	600	.03	Baseline
6 Feb 81	80-7656-57	600	.03	a	640	600	.03	b	560	595	.03	Baseline
11 Feb 81	80-7658-59	600	.02	a	645	625	2.5	b	590	600	.02	ECO Disconnected
12 Feb 81	80-7661-62	600	.02	a,c	625	620	1.7	b	590	600	.02	ECO Shorted
13 Feb 81	80-7663-64	500	.03	b	470	490	.03	a,c	550	500	.03	TPS Disconnected
19 Feb 81	80-7665-66	775	.03	a	840	775	.03	a	860	760	.03	CTS Disconnected
20 Feb 81	80-7667-68	600	10+	e		600	10+	a	620	600	10+	MAP Disconnected
24 Feb 81	80-7669-70	1700	1.7	e		1700	2.8	e		1700	1.9	PROM Errors
26 Feb 81	80-7673-74	2170	.02	e		2170	.02	e		2170	.02	TPS Shorted
27 Feb 81	80-7675-76	600	.03	a	630	600	.03	b	540	600	.03	MAT Disconnected
3 Mar 81	80-7677-7917	600	.02	a	640	610	.02	b	560	600	.02	Baseline

ATTACHMENT 7, continued

4CFH Propane Drive

Date	Test Numbers	RPM	ICO	CODE	RPM	RPM	ICO	CODE	RPM	RPM	ICO	Comments
4 Feb 81	80-7654-55	490	.03	a	510	495	.03	b	470	495	.03	Baseline
6 Feb 81	80-7656-57	495	.04	b	470	490	.03	a	510	500	.03	Baseline
11 Feb 81	80-7658-59	500	.01	e		500	1.7	b	490	500	.01	EGO Disconnected
12 Feb 81	80-7661-62	500	.02	a	510	498	1.5	b	490	500	.02	EGO Shorted
13 Feb 81	80-7663-64	490	.03	a	500	490	.03	b	480	495	.03	TPS Disconnected
19 Feb 81	80-7665-66	645	.03	a	650	640	.03	b	620	640	.03	CTS Disconnected
20 Feb 81	80-7667-68	500	9.8	b	490	490	10+	a	510	500	9.4	MAP Disconnected
24 Feb 81	80-7669-70	900	9.0	e		900	10+	e		900	9.2	PROM Errors
26 Feb 81	80-7673-74	1160	.02	e		1160	.02	e		1160	.02	TPS Shorted
27 Feb 81	80-7675-76	490	.03	a	500	500	.03	b	460	500	.03	MAT Disconnected
3 Mar 81	80-7677-7917	495	.02	a	510	500	.02	b	560	600	.02	Baseline

Attachment 8

Results of On-Board Diagnostic Check

Date	Test Numbers	Trouble Code Output	Trouble Code Identification	Closed Loop	Comments
4 Feb 81	80-7654-55	88		Yes	Baseline
6 Feb 81	80-7656-57	88	88 = System operational verification	Yes	Baseline
11 Feb 81	80-7658-59	88,13	13 = ECO sensor not ready	No	ECO Disconnected
12 Feb 81	80-7661-62	88,44	44 = ECO sensor lean	No	ECO Shorted
13 Feb 81	80-7663-64	88,22,30	22 = Open TPS circuit	Yes	TPS Disconnected
			30 = Idle speed control circuit		
19 Feb 81	80-7665-66	88,15	15 = Open CTS sensor circuit	No	CTS Disconnected
20 Feb 81	80-7667-68	88,32	32 = Open map sensor circuit	Yes	MAP Disconnected
24 Feb 81	80-7669-70	..	.. = Diagnostics inoperative	?	PROM Errors
26 Feb 81	80-7673-74	88,21,30	21 = Shorted TPS circuit	Yes	TPS Shorted
27 Feb 81	80-7675-76	88,38	38 = Open mat sensor circuit	Yes	MAT Disconnected
3 Mar 81	80-7677-7917	88		No	Baseline