

1981 Computerized Engine Controls 1a-97

GENERAL MOTORS DFI CONTROL SYSTEM

Cadillac

DESCRIPTION

The Digital Fuel Injection system (DFI) is an advanced speed density system that combines engine control, fuel metering and emission monitoring into a computer-controlled system. The Electronic Control Module (ECM) is the "brain" of the DFI system. The ECM is a digital electronic computer which receives and processes engine data, computes and interprets engine information and signals operational instructions to various components to provide fuel efficient operation of engine with reduced exhaust emissions.

OPERATION

The DFI system consists of 12 major sub-assemblies: Fuel delivery, air induction, data sensors, Electronic Control Module (ECM), Electronic Spark Timing (EST), Idle Speed Control (ISC), emission controls, closed loop fuel control, diagnostic system, cruise control, Modulated Displacement (MD) and catalytic converter.

FUEL DELIVERY

Fuel delivery system consists of an electric in-tank fuel pump (integral part of fuel sending unit), fuel filter, fuel pressure regulator, fuel injectors and fuel lines. Fuel is supplied to engine through 2 electronically pulsed (timed) injector valves located in throttle body on top of intake manifold. The ECM controls amount of fuel metered through injectors based upon engine demand and efficiency information.

AIR INDUCTION

The air induction system consists of throttle body and intake manifold. Air for combustion enters throttle body and is distributed to each cylinder through intake manifold. Throttle body contains special distribution skirt below each injector to improve fuel distribution. Air flow rate is controlled by throttle valves which are connected to accelerator linkage. Idle speed is determined by position of throttle valves and is controlled by Idle Speed Control (ISC).

DATA SENSORS

Each sensor furnishes electronic impulses to ECM. The ECM computes spark timing and fuel delivery rate necessary to maintain desired air/fuel mixture, thus controlling amount of fuel delivered to engine. Data sensors are interrelated to each other as illustrated in Fig. 1. Operation of each sensor is as follows:

Manifold Air Temperature (MAT) – This sensor is mounted in intake manifold directly in front of throttle body. The MAT sensor measures air/fuel mixture temperature in intake manifold. Sensor resistance changes as air temperature changes. The ECM receives this change in signal and adjusts injector pulse accordingly. Low temperature produces high resistance.

Coolant Temperature Sensor (CTS) – The CTS is located in right front corner of engine directly below thermostat. This sensor provides information to ECM for fuel enrichment, ignition timing, EGR operation, canister purge control, air management, early fuel evaporation control, closed loop fuel control and modulated displacement.

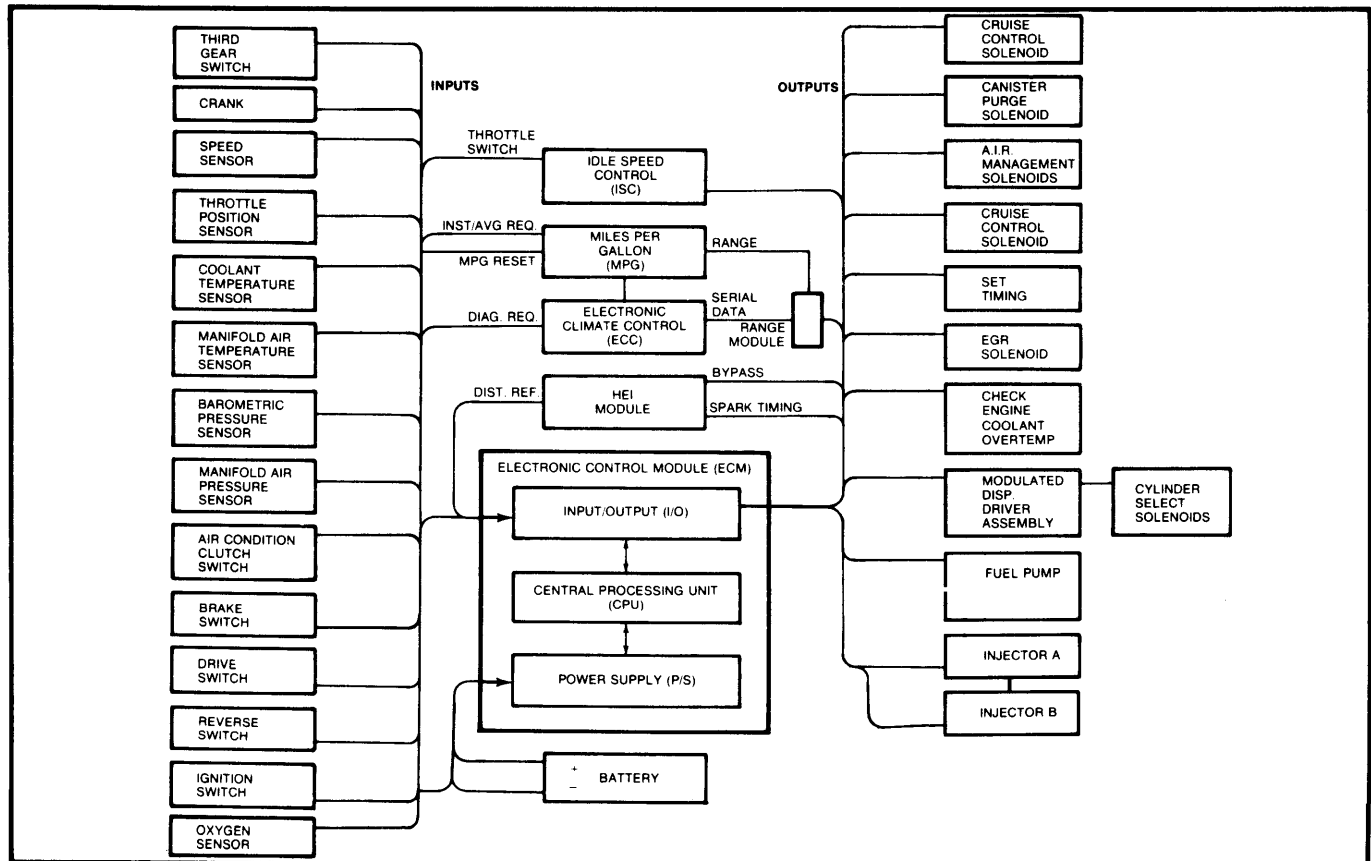


Fig. 1 Diagram of DFI Components

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Manifold Absolute Pressure (MAP) — The MAP sensor is mounted under instrument panel near right side A/C outlet. A hose from throttle body to MAP sensor provides vacuum signal. Sensor monitors changes in intake manifold pressure which result from engine load, speed and barometric pressure variations. As intake manifold pressure increases, additional fuel is required by engine. The MAP sends this information to ECM and ECM increases injector pulse width (time injector is open). As pressure decreases, pulse width is decreased.

Barometric Pressure Sensor (BARO) — The BARO sensor is mounted on MAP sensor bracket. This sensor measures ambient or barometric pressures and signals ECM on pressure changes due to altitude and/or weather.

Throttle Position Sensor (TPS) — The TPS sensor is mounted on side of throttle body and connected directly to throttle shaft. This unit senses throttle movement and position of throttle, then transmits appropriate electrical signals to ECM. The ECM processes these signals to operate the ISC and to supply fuel enrichment.

Vehicle Speed Sensor — Vehicle speed sensor informs ECM of vehicle speed. Speed sensor produces a weak signal which is amplified by a buffer amplifier. Speed sensor and buffer amplifier are mounted behind speedometer cluster. The ECM uses vehicle speed sensor signals for logic required to operate MPG sentinel, integral cruise control, modulated displacement and ISC.

Oxygen Sensor — Oxygen sensor used in DFI system is a closed end Zirconia sensor placed in exhaust gas stream. This sensor produces a very weak voltage which varies with oxygen content of exhaust gases. As oxygen content of exhaust gases increases, a leaner mixture is indicated by low voltage output. As oxygen content decreases, a richer mixture is indicated by higher voltage output. The ECM corrects air/fuel ratio according to signals received from oxygen sensor.

NOTE — *No attempt should be made to measure oxygen sensor voltage output. Current drain of conventional voltmeter could permanently damage sensor, shift sensor calibration range and/or render sensor unusable. Do not connect jumper wire, test leads or other electrical connectors to sensor.*

Engine Speed Sensor — The engine speed sensor signal comes from 7 terminal HEI module in distributor. Pulses from distributor are sent to ECM where time between pulses is used to calculate engine speed. The ECM adds spark advance modifications to signal and sends this signal back to distributor.

ELECTRONIC CONTROL MODULE (ECM)

The ECM monitors and controls all DFI system functions. The ECM consists of input/output devices, Central Processing Unit (CPU), power supply and memories. A brief description and operation of each component is as follows:

Input/Output Devices — These integral devices of ECM convert electrical signals received by data sensors and switches to digital signals for use by CPU.

Central Processing Unit (CPU) — Digital signals received by CPU are used to perform all mathematical computations and logic functions necessary to deliver proper air/fuel mixture. The CPU also calculates spark timing and idle speed information. The CPU commands operation of emission controls, closed loop fuel control, cruise control, diagnostic system and modulated displacement.

Power Supply — Main source of power for the ECM is from the battery, through the No. 1 ignition circuit.

Memories — The 3 types of memories in the ECM are: Read Only Memory (ROM), Random Access Memory (RAM) and Programmable Read Only Memory (PROM). Function of each memory is as follows:

- **Read Only Memory (ROM)** — The ROM is programmed information that can only be read by ECM. The ROM program cannot be changed. If battery voltage is removed, ROM information will be retained.
- **Random Access Memory (RAM)** — This memory is the scratch pad for the CPU. Information can be read into or out of RAM memory; similar to a calculator. Data sensor information, diagnostic codes and results of calculations are temporarily stored in RAM memory. If battery voltage is removed, all information stored in this memory is lost.
- **Programmable Read Only Memory (PROM)** — This memory consists of 2 units which is factory-programmed information containing engine calibration data for each engine, transmission, body and rear axle ratio application. The PROM's are easily replaced when defective. If battery voltage is lost, PROM information will be retained.

ELECTRONIC SPARK TIMING (EST)

The EST system consists of ECM and modified HEI distributor with 7 terminal HEI module. The HEI distributor communicates to ECM through a 4 terminal connector which contains 4 circuits: Distributor reference circuit, by-pass circuit, EST circuit and ground circuit.

Whenever pick-up coil signals HEI module to open primary circuit, it also sends spark timing signals to ECM through reference line. When voltage on HEI by-pass line is 0 volts (engine cranking), HEI module switches to by-pass circuit. In by-pass circuit, HEI module provides spark advance at base timing and disregards spark advance signal from ECM. When voltage on HEI by-pass circuit is 5 volts (engine running), HEI module accepts spark timing signal provided by ECM.

The ECM monitors engine speed through HEI reference line and engine operating conditions through data sensors. From these parameters, ECM calculates proper spark advance and supplies signal to HEI distributor through EST line.

IDLE SPEED CONTROL (ISC)

The ISC is an electrically driven actuator which changes throttle valve angle (in idle position), according to commands from ECM. This function is by-passed when throttle is opened enough to bring TPS off its idle circuit. When engine is cold, ECM holds throttle valve open for longer period of time to provide faster warm-up. The ISC is located on side of throttle body.

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EMISSION CONTROLS

The ECM controls operation of EGR system, AIR management system and canister purge control operation. Description of each system is as follows:

- **EGR System** — Signals received from coolant sensor provides ECM with engine temperature. When engine is cold, ported vacuum to EGR is closed with a solenoid valve. When engine is warm, solenoid valve is opened and EGR is allowed.
- **AIR Management System** — This system is controlled in similar manner as EGR system. When engine is cold, ECM energizes an air control solenoid which allows air to flow to air switching valve. The switching valve is energized by ECM to direct air to exhaust ports to aid in quickly raising temperature of oxygen sensor to 600°F. When engine is warm or in closed loop operation, ECM de-energizes air switching valve and air is sent directly to catalytic converter to assist in oxidation of HC and CO. If air control valve detects rapid increase in manifold vacuum (deceleration), certain operating modes or ECM detects any failure in system; air is diverted to air cleaner or dumped to atmosphere.
- **Canister Purge Control Operation** — Vacuum to canister purge control valve is controlled by ECM with a solenoid valve. When engine is in open loop operation, solenoid valve is energized and vacuum is blocked to purge valve. When system is in closed loop operation, solenoid valve is de-energized and vacuum can be applied to purge valve to draw collected vapors to intake manifold.

CLOSED LOOP FUEL CONTROL

Closed loop fuel control maintains an air/fuel ratio of 14.7:1. Oxygen sensor monitors oxygen content of exhaust gases, sends information to ECM. The ECM then corrects air/fuel mixture for deviations from ideal ratio.

CRUISE CONTROL

The ECM receives input signals from cruise control engagement switches, instrument panel switch, brake release switch, drive switch and speed sensor. The ECM processes cruise control inputs together with DFI engine control inputs and transmits command signals to vacuum control solenoid valve and power unit solenoid valve to control vehicle speed.

DIAGNOSTIC SYSTEM

The ECM of the DFI control system has a built-in diagnostic system to constantly monitor engine/vehicle performance and operation. The diagnostic system consists of 4 tests: Engine malfunction tests, switch tests, engine data displays and output cycling tests. Description of each test is as follows:

Engine Malfunction Test — This test is constantly performed by ECM to detect system failures or malfunctions. When a malfunction occurs, ECM will light the amber "CHECK ENGINE" lamp located in right hand information center. When a malfunction occurs and lamp is turned on, a corresponding trouble code is stored in ECM memory. Malfunctions are recorded as "hard failures" or "intermittent failures".

- "Hard failures" cause "CHECK ENGINE" lamp to glow and remain on until malfunction is repaired. If the "CHECK

ENGINE" lamp comes on and remains on during vehicle operation, cause of malfunction MUST be determined.

- "Intermittent failures" cause "CHECK ENGINE" lamp to flicker or go out after malfunction clears. "Intermittent failures" may be sensor related. If a sensor fails, ECM will use a substitute value in its calculations to continue engine operation. In this condition, service is not mandatory; but loss of driveability may be encountered. If the related sensor malfunction does not recur within 20 ignition cycles, related trouble code will be erased from ECM memory.

Switch Tests — This series of tests checks operation of various switches which provide inputs to ECM. During this operation, specific switches are cycled and ECM analyzes the action to determine if switches are operating properly.

Engine Data Displays — This is a series of checks which display important engine data information. This information may then be compared to that information received from a properly operating engine for analysis.

Output Cycling Tests — This series of tests cause ECM to cycle various output signals on and off. During this test, operation of engine control solenoids and lamps may be checked by using command signals from ECM.

As a lamp and system check, "CHECK ENGINE" lamp should glow when ignition is turned on and go out after 1-4 seconds after engine has started. If not, ECM has detected fault in system.

NOTE — The 4 tests which comprise the diagnostic system should be performed in the sequence given to diagnose any failure in the shortest period of time.

MODULATED DISPLACEMENT (MD)

Modulated displacement is an electromechanical system which deactivates certain engine cylinders to reduce fuel consumption. The MD system consists of ECM, Modulated Displacement Amplifier (MDA) and cylinder selector solenoids.

The ECM indirectly controls cylinder selection through the MDA. The MDA switches cylinder selector solenoids on and off. When activated, cylinder solenoids cause mechanical valve selector bodies to simultaneously close intake and exhaust valves of selected cylinders. This is accomplished by changing rotation point of rocker arm for that particular cylinder while remainder of valve train operates normally.

The MDA is connected between ECM and cylinder selector solenoids to supply additional power and to perform switching function. Cylinder select solenoids require initial pull in current of 4 amps. to be activated and a holding current of 1 amp. During 6-cylinder operation, MDA deactivates cylinders No. 1 and No. 4; during 4-cylinder operation, MDA deactivates cylinders No. 1, No. 4, No. 6 and No. 7.

The ECM monitors MDA to determine if cylinder selection is actually occurring. In 4-cylinder operation, MDA supplies 0 volt feedback signal to ECM; in all other modes, MDA supplies 12 volt feedback signal. If feedback signal is not correct, ECM sets "CHECK ENGINE" light and code "25" is stored in memory. The following general operating conditions must be met before ECM will allow modulation:

- Coolant temperature above 148°F.
- Transmission in 3rd gear.

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- Vehicle speed above 24 MPH.
- Engine speed below 2600 RPM.
- Code "25" not set (MD malfunction).

CATALYTIC CONVERTER

Proper emission control is accomplished with a special 3-way catalytic converter; that is, it converts all 3 major pollutants (HC, CO and NOx). The converter contains pellets coated with platinum and palladium (California vehicles have additional coating of rodium).

The 3-way catalytic converter used in the DFI system is a dual-bed converter. The "upstream" section of the converter contains a reducing/oxidizing bed to reduce NOx while at the same time oxidizing HC and CO. An air supply pipe from the AIR pump introduces an extra amount of air between the dual beds (during closed loop mode), so the second bed can oxidize any remaining HC and CO with a high conversion efficiency to minimize overall emissions.

DIAGNOSIS & TESTING

The ECM stores component failure information for DFI system under a related trouble code which can be recalled for diagnosis and repair. When recalled, these codes will be displayed on Electronic Climate Control (ECC) panel starting with lowest numbered code. Only codes in which a related malfunction has occurred will be displayed. When system is displaying in diagnostic mode, MPG panel will show no readings.

Entering Diagnostic Mode — Turn ignition on. Depress "OFF" and "WARMER" buttons on ECC panel simultaneously and hold buttons until "." appears on digital display panel. Release buttons and code "88" should appear indicating beginning of diagnostic readout. Trouble codes will be displayed beginning with lowest numbered code and be repeated a second time. After second time, trouble code "70" will appear indicating ECM is ready for next diagnostic feature. If no codes are stored, "88" will appear for longer period of time, then code "70" will appear. See Fig. 2.

NOTE — Trouble code "70" is a decision point. When this code is displayed, select diagnostic feature (switch test, engine data display, output cycling test), 'Exit' diagnostic mode or clear codes and 'Exit' diagnostic mode.

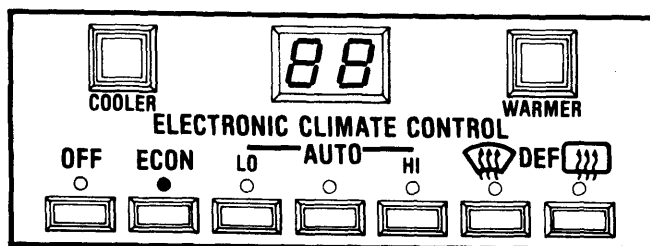


Fig. 2 Trouble Code "88" Displayed on Electronic Climate Control (ECC) Panel

Clearing Trouble Codes — Trouble codes stored in ECM memory may be cleared (erased) by entering diagnostic mode and then depressing "OFF" and "HI" buttons at the same time. Hold buttons until "00" is displayed. Release buttons and code "70" should appear.

Exiting Diagnostic Mode — Depress any ECC function keys except rear window defroster. Turn ignition switch "OFF" for 10 seconds. This will 'Exit' ECC panel from diagnostic mode,

but will not clear any trouble codes. Original temperature setting should appear on ECC panel.

NOTE — The terms "enter diagnostics" and "exit diagnostics" will be used periodically throughout this section. Follow the procedure for entering diagnostic mode when instructed to "enter diagnostics". Follow the procedure for exiting diagnostic mode when instructed to "exit diagnostics".

Failure Code Determination — During any diagnostic procedure, "hard failure" codes MUST be distinguished from "intermittent failure" codes. Diagnostic charts CANNOT be used to analyze "intermittent failure" codes, except as noted under Diagnostic Procedure. To determine "hard failure" codes and "intermittent failure" codes, proceed as follows:

1) Enter diagnostics and note stored trouble codes. Clear trouble codes. Exit diagnostics. Turn ignition on, wait 5 seconds and start engine. Accelerate to 2000 RPM for a few seconds and return to idle speed.

2) Shift transmission into drive. Shift transmission into park. If "CHECK ENGINE" light comes on, enter diagnostics, read and record trouble codes. This will reveal "hard failure" codes. Cruise control codes "60-68" never set "CHECK ENGINE" light; treat them as "hard failures". Codes "13", "24", "25", "44" and "45" may require road test to reset "hard failure" after trouble codes were cleared.

3) If "CHECK ENGINE" light does not come on, all stored trouble codes were "intermittent failures", except as noted under Diagnostic Procedure.

PROGRAMMED ECM TROUBLE CODES

| Code | Circuit Affected |
|---------|---|
| 12 | No tach signal. |
| 13 | Oxygen sensor not ready. |
| 14 | Shorted coolant sensor circuit. |
| 15 | Open coolant sensor circuit. |
| 16 | Generator output 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 TPS circuit. |
| 22 | Open TPS circuit. |
| 23 | EST/By-pass circuit shorted or open. |
| 24 | Speed sensor failure. |
| 25 | Modulated displacement failure. |
| 26 | Shorted throttle switch circuit. |
| 27 | Open throttle switch circuit. |
| 30 | ISC circuit. |
| 31 | Shorted MAP sensor circuit. |
| 32 | Open MAP sensor circuit. |
| 33 | MAP/BARO sensor correlation. |
| 34 | MAP sensor circuit. |
| 35 | Shorted BARO sensor circuit. |
| 36 | Open BARO sensor circuit. |
| 37 | Shorted MAT sensor circuit. |
| 38 | Open MAT sensor circuit. |
| 44 | Oxygen sensor lean. |
| 45 | Oxygen sensor rich. |
| 51 | PROM insertion faulty. |
| 60 | Drive (ADL) switch faulty. |
| 61 & 68 | Set and resume switch circuit. |
| 62 | Car speed exceeds maximum limit. |
| 63 | Car and set speed tolerance exceeded. |
| 64 | Car acceleration exceeds maximum limit. |

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PROGRAMMED ECM TROUBLE CODES (Cont.)

| Code | Circuit Affected |
|------|--|
| 65 | Coolant temperature exceeds maximum limit. |
| 66 | Engine RPM exceeds maximum limit. |
| 70 | System ready — Switch tests. |
| 71 | Brake light switch. |
| 72 | ISC throttle switch. |
| 73 | Drive (ADL) switch. |
| 74 | Back-up light 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 diagnostics complete. |

DIAGNOSTIC PROCEDURE

NOTE — If vehicle exhibits performance problems and no codes are set, refer to the performance charts. Components recorded by trouble codes generally do not cause performance problems when no codes are stored.

Engine Malfunction Test Procedure — 1) Enter diagnostics and record stored trouble codes. Begin diagnosis with lowest numbered code which is recorded. If codes "51" or "16" are shown, begin diagnosis with code "51", then proceed to code "16".

2) If "intermittent failures" "13", "44" or "45" are displayed, use diagnostic chart for corresponding "hard failure" code. If "intermittent failure" code "33" appears, refer to diagnostic chart 33A.

3) Code "25" indicates that ECM has detected a malfunction in the MD circuitry. When code "25" is set, ECM will only allow 8-cylinder operation. Refer to Performance Chart No. 16 for diagnosis of this code.

4) Code "51" (if detectable by ECM) indicates faulty PROM installation. Refer to PROM removal and installation in this article for diagnosis of this code.

5) Code "62" indicates that cruise control was engaged and vehicle speed exceeded 80 MPH. ECM allows operation of cruise control between 20 and 80 MPH. Clear code and road test vehicle.

6) Code "64" indicates that cruise control was engaged and vehicle acceleration exceeded preset rate which was programmed into ECM. This could be caused by icy or wet pavement. Clear code and road test vehicle.

7) Code "65" indicates that cruise control was engaged and coolant exceeded maximum temperature. Check cooling system, clear codes and road test vehicle.

8) Code "66" indicates that cruise control was engaged and engine speed exceeded maximum allowable limit. This code can be caused by removing engine load (transmission in

neutral) when cruise control is engaged and operating. Clear codes and road test vehicle.

NOTE — After diagnosing trouble codes; switch tests, engine data displays and output cycling tests can be used to isolate "intermittent failures". DO NOT perform any adjustment or repairs on any component until malfunction has been positively located.

Switch Test Procedure — 1) Enter diagnostics and with code "70" displayed, begin switch test procedure. To begin switch test procedure, depress and release brake pedal. Code "71" should appear.

NOTE — Each test action must be performed within 10 seconds after codes appear on display panel or ECM will store code as failure and proceed to next code.

2) With code "71" displayed, depress and release brake pedal again. Code "72" should appear. With code "72" displayed, depress throttle to wide open position and release. Code "73" should appear.

3) With code "73" displayed, shift transmission into drive then back to neutral. Code "74" should appear. With code "74" displayed, shift transmission to reverse and back to park. Code "75" should appear.

4) With code "75" displayed, switch cruise control on then off. Code "76" should appear. With code "76" displayed, switch cruise control on, then depress and release "Set/Coast" button. Code "77" should appear. With code "77" displayed, switch cruise control on, then depress and release "Resume/Acceleration" switch. Code "78" should appear.

NOTE — To pass codes "75", "76" and "77" on vehicles without cruise control, allow codes to appear for 10 seconds each and proceed with step 5). Codes will cycle through ECM and be processed as operational.

5) With code "78" displayed, depress and release "INSTANT/AVG" button on MPG panel. Code "79" should appear. With code "79" displayed, depress and release "MPG RESET" button. Code "80" should appear.

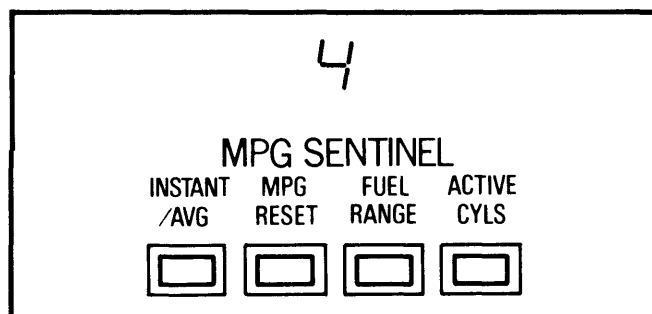


Fig. 3 Diagram of MPG Panel With 4-Cylinder Mode of Operation Displayed

6) With code "80" displayed, depress and release rear window defogger button. This test checks ECM's ability to recognize and process air conditioning clutch signal. This test may require engine running with A/C operating in "Auto" mode with temperature selection set at 60°F.

NOTE — To pass code "80" on vehicles without rear window defogger, momentarily supply 12 volts to Blue wire in 6-wire

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connector on ECC power module in compartment with code "80" displayed.

7) When switch tests are completed, ECM will display codes which did not pass test. Each code will appear beginning with lowest code. Codes will not disappear until affected switch circuit is repaired and retested. After switch tests are completed, ECC will display code "00" and return to code "70". Code "00" indicates all switch circuits are operating properly.

Engine Data Display Procedure – 1) Enter diagnostics and with code "70" displayed, slide cruise instrument panel switch off. Code "90" should appear. If code "90" does not appear, refer to switch test code "75".

NOTE – To advance to code "90" on vehicles without cruise control, momentarily jumper Yellow wire (Pin C, Circuit No. 904) and Lt. Blue/Black wire (Pin D, Circuit No. 903) in 6-wire cruise control instrument panel switch connector. Connector is located on left side of steering column under instrument panel.

2) Engine data display shows values of 11 parameters monitored by ECM. Parameter numbers (01-11) will be displayed for 1 second on ECC panel, followed by a 1-digit or 2-digit value. The parameter value will be displayed for 5 seconds. Each parameter and value will be repeated until manually advanced to next parameter.

3) To advance display, depress "INSTANT/AVG" button on MPG panel. To return to previously displayed parameter, depress "MPG RESET" button. After last parameter is displayed, code "95" should appear. To clear engine data display at anytime, depress "OFF" and "HI" buttons on ECC panel at the same time. Code "70" should appear.

4) Engine data display information can be used to compare information of engine to that of properly functioning engine for diagnosis of malfunctions. Parameters read and values displayed are as follows:

- 01 – Throttle angle displayed in degrees (2 digits).
- 02 – MAP value displayed as number between 1 and 99. Reading above 100 will appear as 99.
- 03 – BARO value displayed in same manner as MAP value.
- 04 – Coolant temperature displayed as number between 0 and 99. See conversion chart.
- 05 – Manifold air temperature displayed in same manner as coolant temperature.
- 06 – Injector pulse width is displayed in milliseconds. Decimal point will not appear and MUST be assumed between 2 digits. (32 means 3.2 milliseconds).
- 07 – Oxygen sensor voltage is displayed in volts. Decimal point will not appear and MUST be assumed before 2 digits. (60 means .60 volts).
- 08 – Spark advance value displayed in degrees (2 digits).
- 09 – Ignition cycle value is number of times ignition has been cycled since trouble code was stored.
- 10 – Open/Closed loop indicator displays which mode ECM is operating the system. Open loop is indicated by "0" and closed loop is indicated by "1".
- 11 – Battery voltage is displayed in volts. Decimal point and 10's will not appear and MUST be assumed. (23 means 12.3 volts).

| COOLANT TEMPERATURE CONVERSION CHART | |
|--------------------------------------|-----------|
| Code | Degrees F |
| 0 | -40 |
| 8 | -12 |
| 12 | +1 |
| 16 | 15 |
| 21 | 32 |
| 25 | 46 |
| 30 | 64 |
| 35 | 81 |
| 40 | 98 |
| 45 | 115 |
| 50 | 133 |
| 52 | 140 |
| 54 | 147 |
| 56 | 153 |
| 58 | 160 |
| 60 | 167 |
| 62 | 174 |
| 64 | 181 |
| 66 | 188 |
| 68 | 195 |
| 70 | 202 |
| 72 | 209 |
| 73 | 212 |
| 75 | 219 |
| 80 | 236 |
| 85 | 254 |
| 90 | 271 |
| 99 | 302 |

Output Cycling Tests Procedure – 1) Enter diagnostics and with code "70" displayed on ECC panel, depress "Instant/Average" button on MPG panel. Code "95" should appear. If code "95" does not appear, refer to switch test code "78". Depress "Instant/Average" button while parameter "11" of Engine Data Display appears.

2) Output cycling tests consist of 2 operations: Actuator cycling test and cylinder select test. Actuator cycling test turns ECM's outputs on and off with engine off. Cylinder select test operates modulated displacement solenoids with engine running.

3) To enter actuator cycling tests, start engine. Turn engine off and within 2 seconds, turn ignition on. Enter diagnostics and display code "95" on ECC panel. Depress accelerator pedal to wide open throttle position and release pedal. Code "96" should appear.

4) Turn cruise instrument panel switch on. Output cycling tests will cycle Group A outputs on and off for 3 seconds and then cycle Group B outputs on and off for 3 seconds. Group A outputs consist of coolant light, cruise power valve, cruise vacuum valve, air switching valve and ISC extend. Group B outputs consist of cruise "On/Off" switch, canister purge solenoid, EGR valve solenoid, air divert valve and ISC retract.

5) Cycling test will alternate between Group A and Group B outputs and automatically shut off after 1 minute. Cruise power valve operates continuously. After cycling output is complete, display should switch from code "96" back to code "95".

6) To enter cylinder select tests, start engine. With engine running, enter diagnostics and display code "95". Depress ac-

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celerator pedal to wide open throttle position and release. Code "97" should appear on ECC panel.

7) With code "97" displayed, ECM will control modulated displacement automatically. Depressing "Instant/Average" button on MPG panel will force engine to operate in 8-cylinder mode as long as button is depressed. Depressing "Reset" button on MPG panel will force engine to operate in 6-cylinder mode as long as button is depressed. Depressing "Active Cylinder" button will force engine to operate in 4-cylinder mode as long as button is depressed.

automatic shut off, depress "Instant/Average" button. Code "95" should appear on display panel.

TROUBLE CODE CHART REFERENCE

| Code | Problem Area |
|-----------------|--|
| 12 | No tach signal to ECM. |
| 13* | Oxygen sensor not ready. |
| 14 | Shorted coolant sensor circuit. |
| 15 | Open coolant sensor circuit. |
| 16 | Generator output voltage out of range. |
| 17 | Crank signal circuit high. |
| 18 | Open crank signal circuit. |
| 19 | Fuel pump circuit high. |
| 20 | Open fuel pump circuit (2 charts). |
| 21 | Shorted TPS circuit. |
| 22 | Open TPS circuit. |
| 23 | EST/By-pass circuit. |
| 24 | Speed sensor failure. |
| 26 | Shorted throttle switch circuit. |
| 27 | Open throttle switch circuit. |
| 30 | ISC circuit. |
| 31 | Shorted MAP sensor circuit. |
| 32 | Open MAP sensor circuit. |
| 33 | MAP/BARO sensor circuit. |
| Intermittent 33 | MAP/BARO sensor correlation. |
| 34 | MAP sensor circuit. |
| 35 | Shorted BARO sensor circuit. |
| 36 | Open BARO sensor circuit. |
| 37 | Shorted MAT sensor circuit. |
| 38 | Open MAT sensor circuit. |
| 44* | Oxygen sensor lean. |
| 45* | Oxygen sensor rich. |
| 60 | Drive (ADL) switch circuit. |
| 61 & 68 | "Set/Coast" and "Resume/Accelerate" circuit. |
| 63 | Car and set speed tolerance exceeded. |
| 71 | Brake release switch circuit. |
| 72 | ISC throttle switch circuit. |
| 73 | Drive (ADL) switch circuit. |
| 74 | Back-up light switch circuit. |
| 75 | Cruise control on/off circuit. |
| 76 | Cruise control "Set/Coast" switch circuit. |
| 77 | Cruise control "Resume/Accelerate" circuit. |
| 78 | MPG "Average" circuit. |
| 79 | MPG "Reset" circuit. |
| 80 | Air conditioning clutch circuit. |

Trouble codes marked with an * apply to "Hard Failures" and "Intermittent Failures".

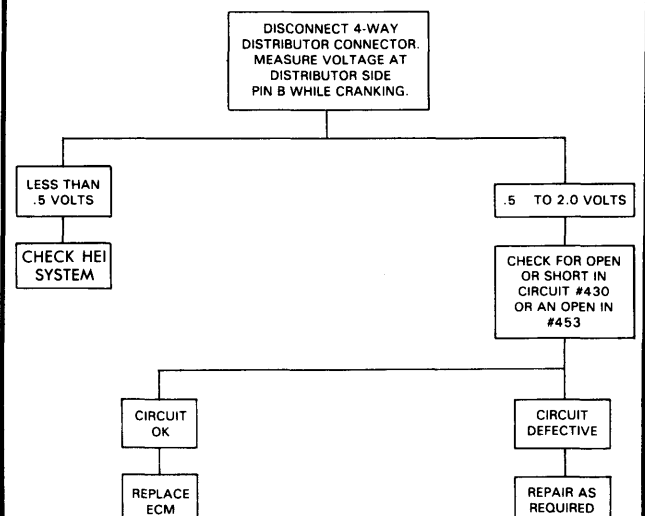
PERFORMANCE CHARTS

| Chart | Condition |
|--------|--|
| No. 1 | No start or stall after start. |
| No. 2 | "Check Engine" light on - No codes set. |
| No. 3 | "Check Engine" light inoperative. |
| No. 4 | Fuel system diagnosis. |
| No. 5 | Poor performance. |
| No. 6 | Injector system diagnosis. |
| No. 7 | EGR diagnosis. |
| No. 8 | AIR management diagnosis. |
| No. 9 | Canister purge control diagnosis. |
| No. 10 | No cruise control. |
| No. 11 | MPG display problem. |
| No. 12 | Diagnostic display problem. |
| No. 13 | Improper idle speed. |
| No. 14 | Oxygen sensor test. |
| No. 15 | Coolant light on - Temperature normal. |
| No. 16 | Modulated displacement solenoid test. |
| No. 17 | Modulated displacement electrical test. |
| No. 18 | Modulated displacement operating at all times. |

TROUBLE CODE CHARTS

TROUBLE CODE 12

NOTE: Engine must be cranked for 5 seconds for this code to set.

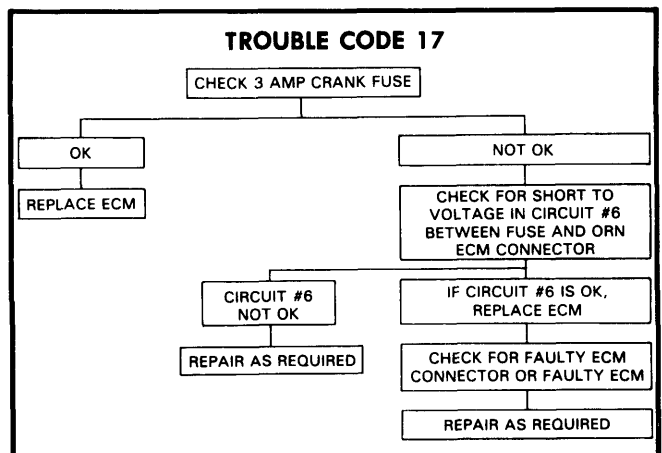
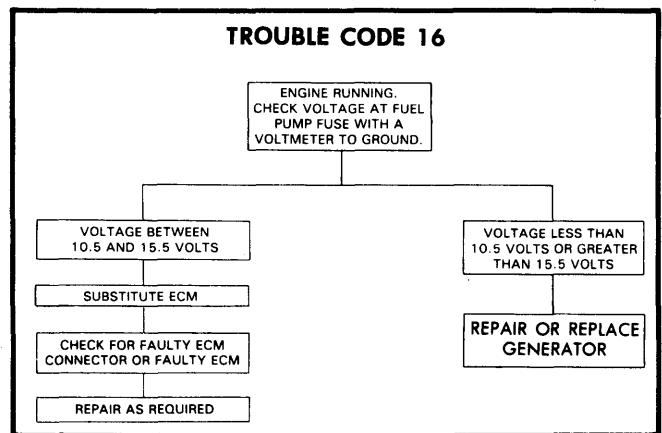
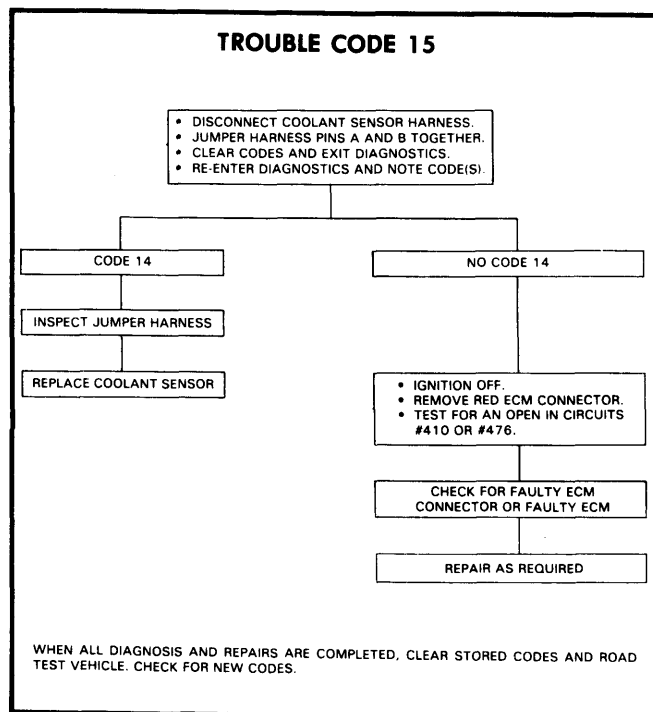
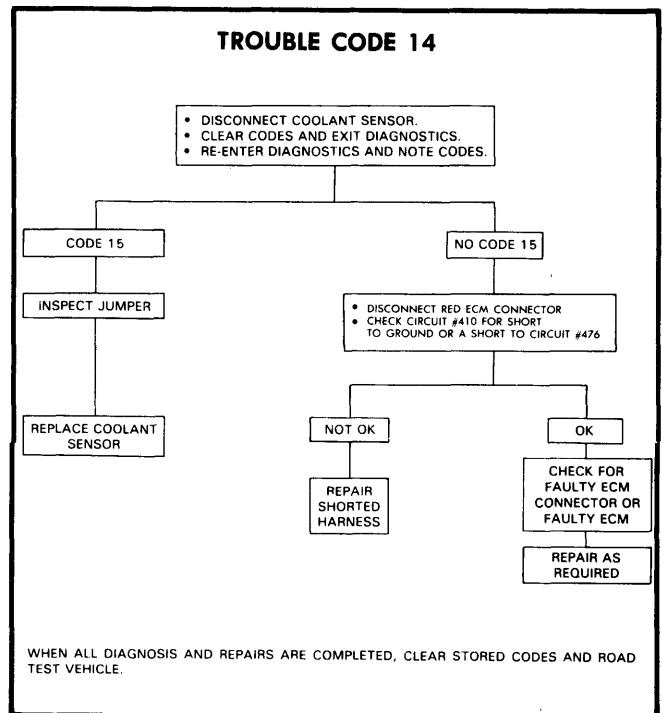
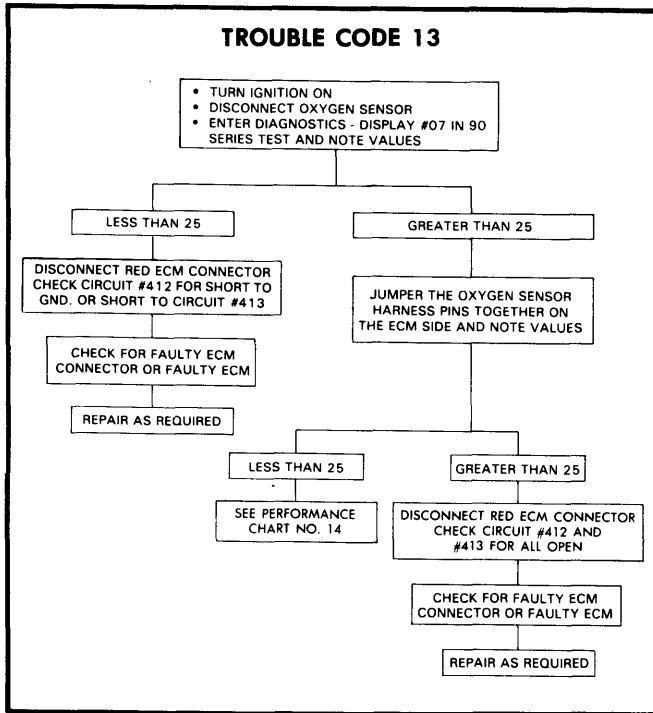


WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

8) Cylinder select test will automatically shut off after 1 minute of operation. To deactivate cylinder select test prior to

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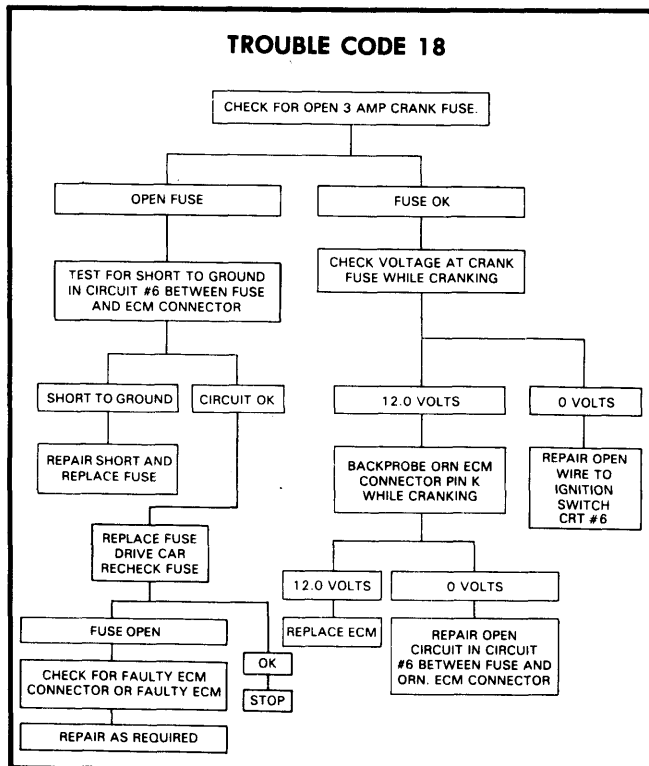
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



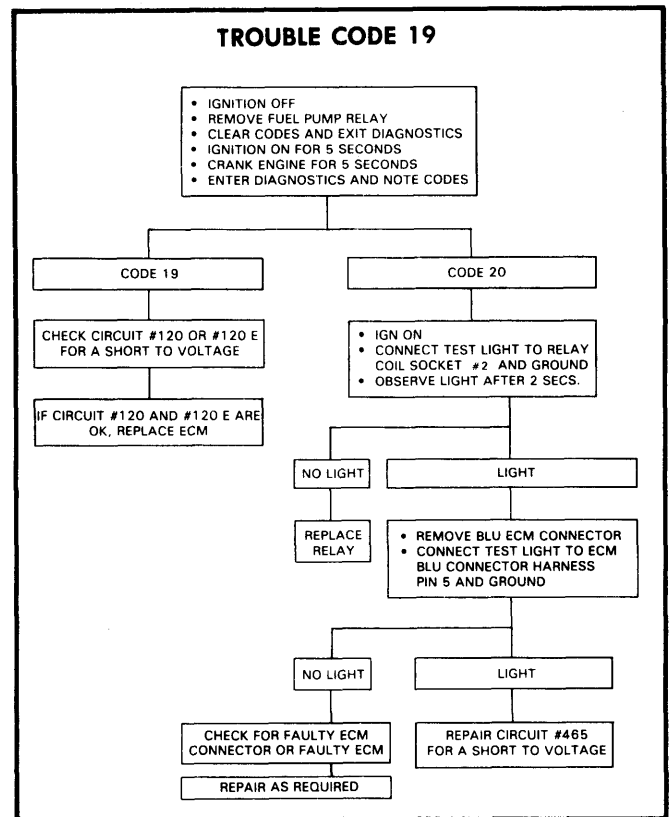
1981 Computerized Engine Controls_{1a-105}

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

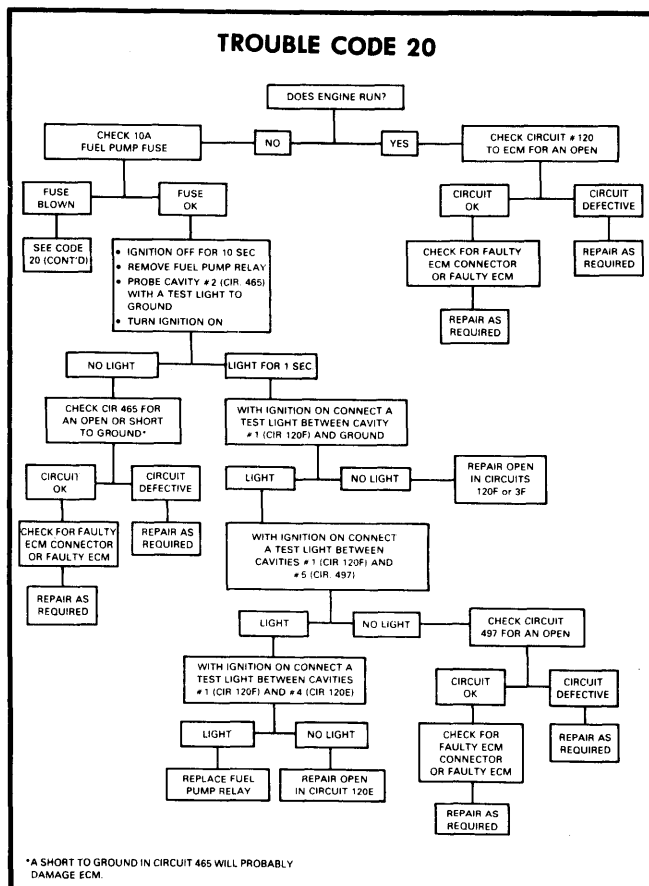
TROUBLE CODE 18



TROUBLE CODE 19

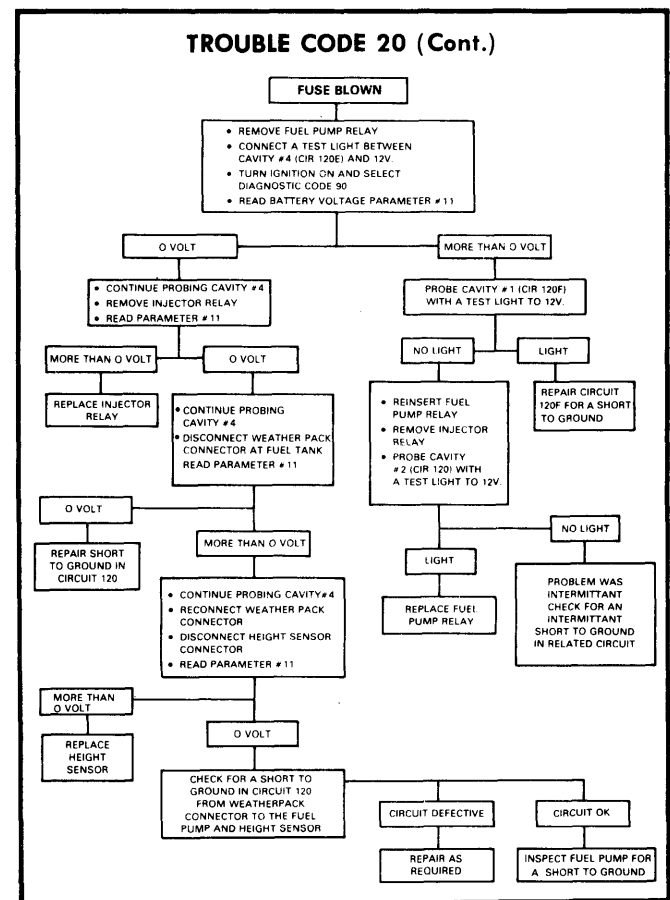


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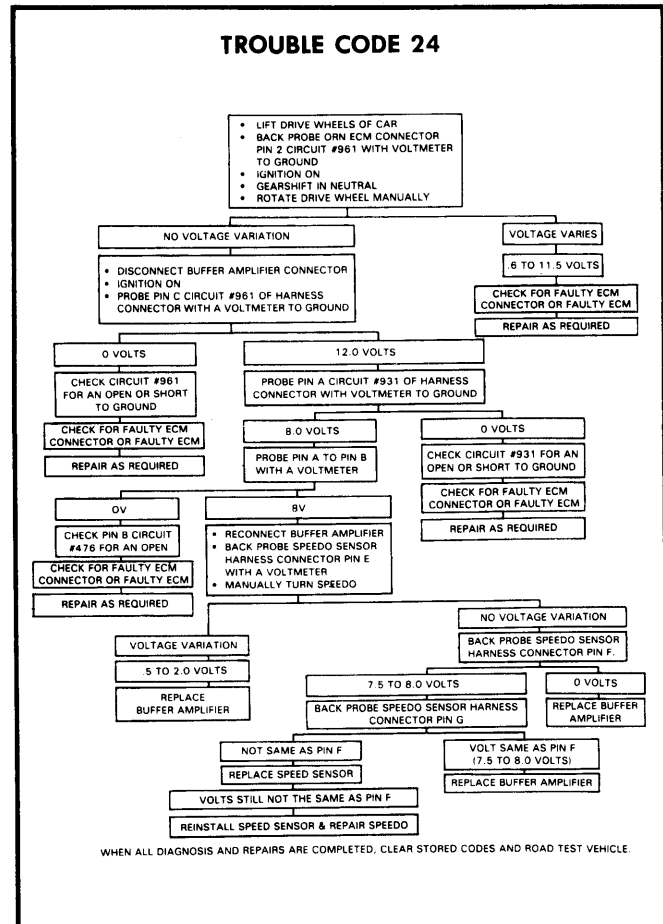
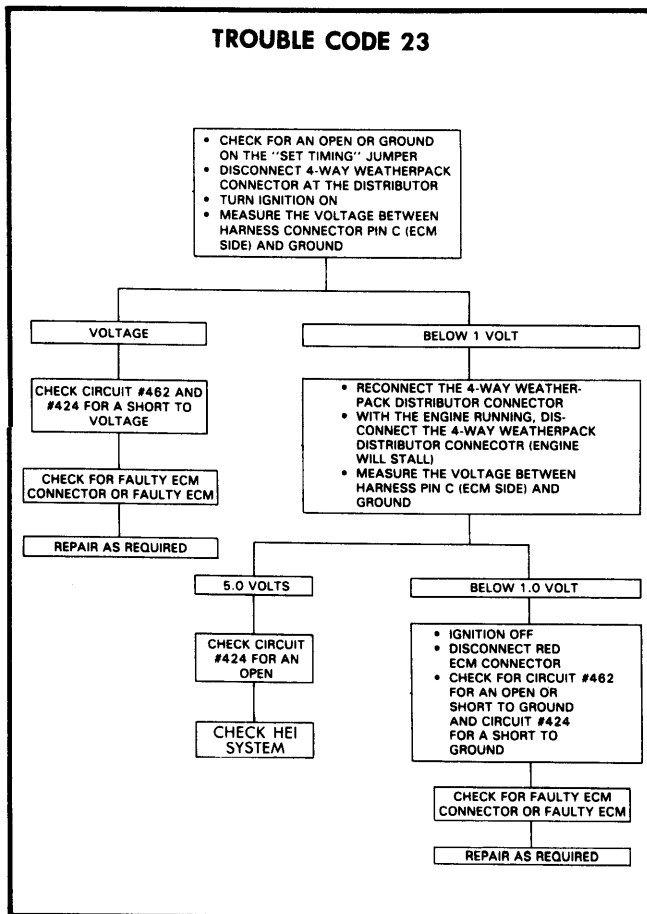
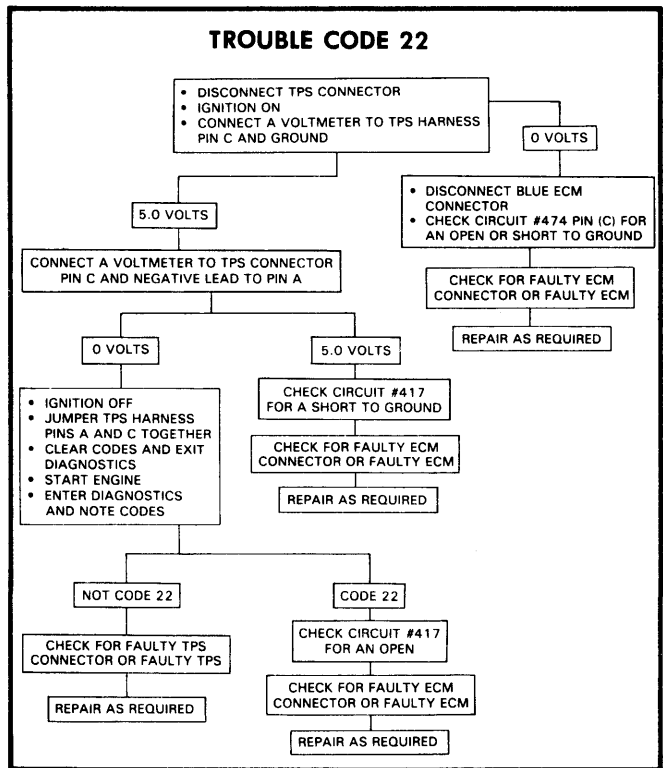
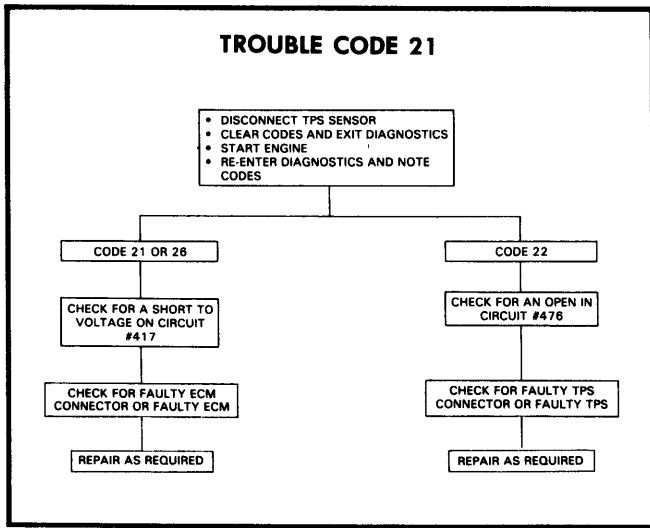


*A SHORT TO GROUND IN CIRCUIT 465 WILL PROBABLY DAMAGE ECM.

TROUBLE CODE 20 (Cont.)

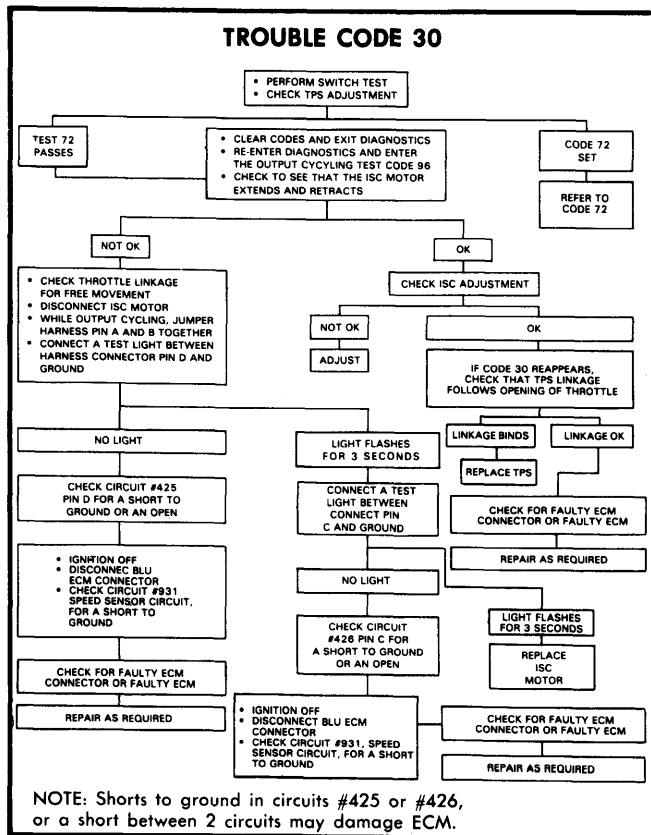
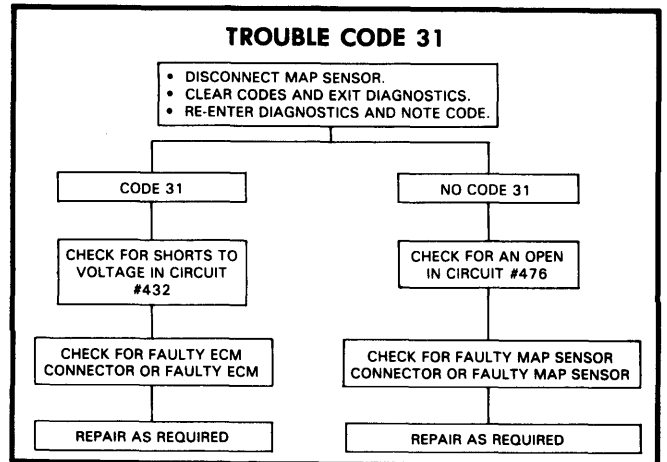
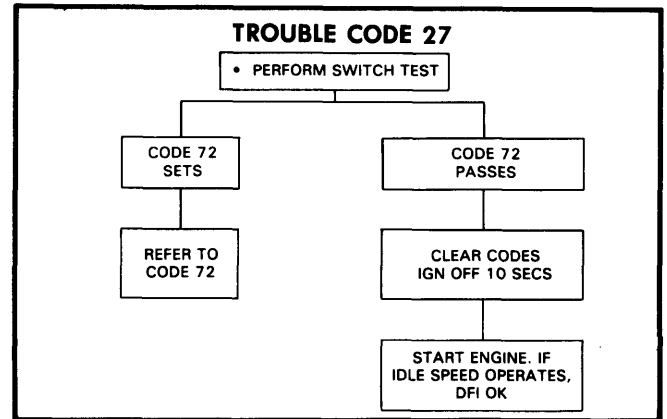
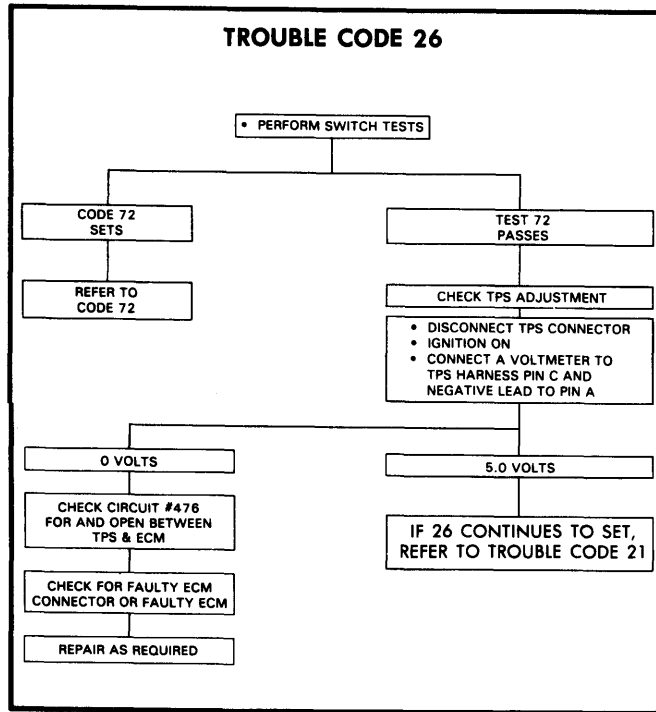


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

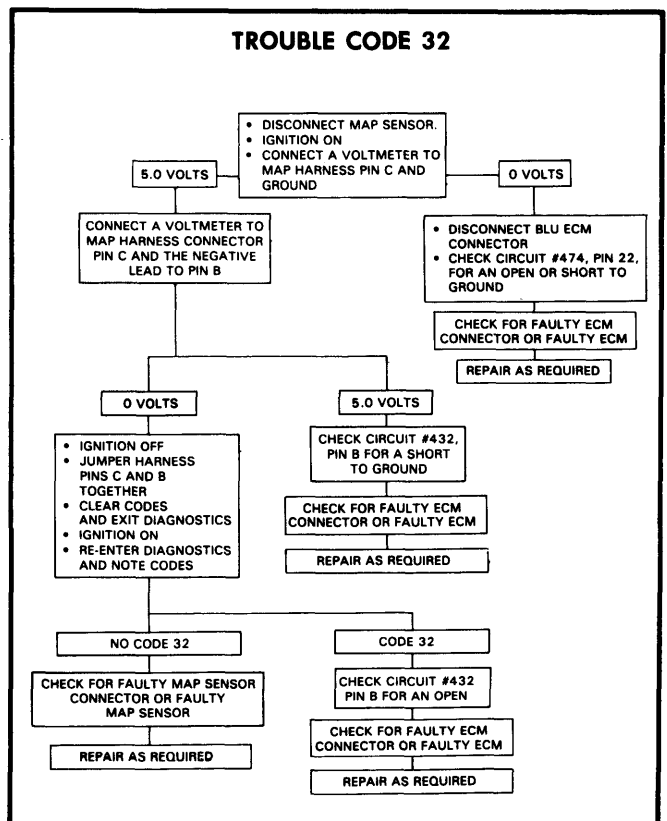


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GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



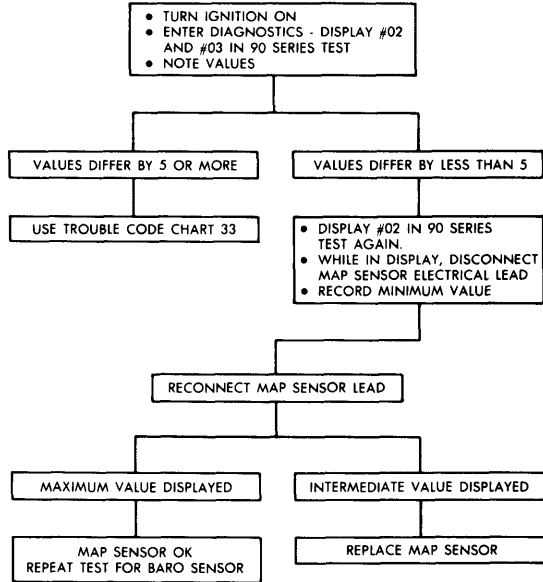
NOTE: Shorts to ground in circuits #425 or #426, or a short between 2 circuits may damage ECM.



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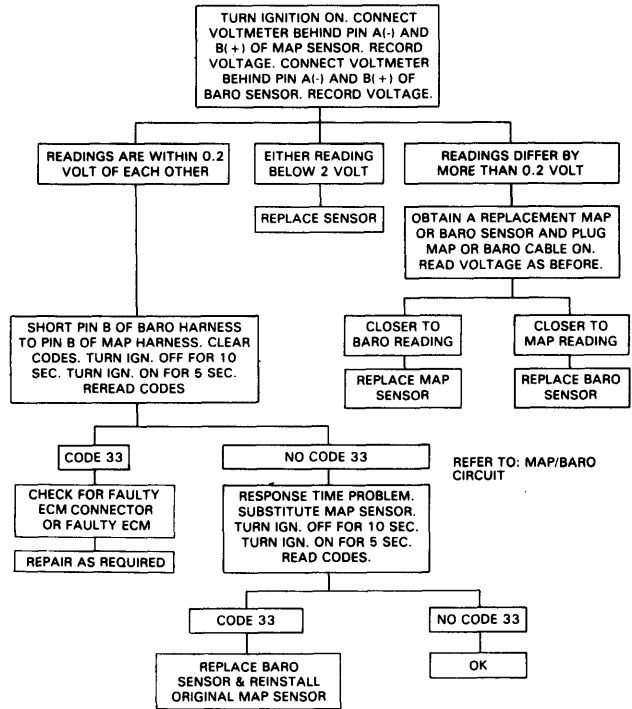
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

INTERMITTENT TROUBLE CODE 33



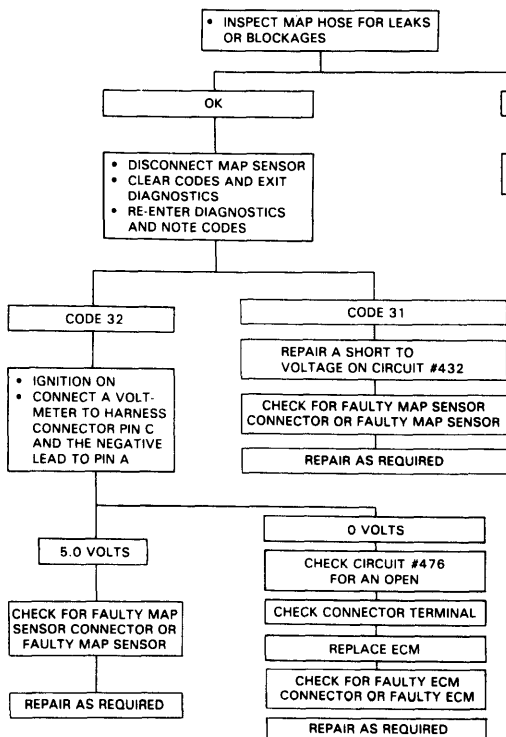
NOTE: If this procedure does not determine failure, check for intermittent loss of distributor reference pulses. (Check circuit #430 and #453 for open).

TROUBLE CODE 33

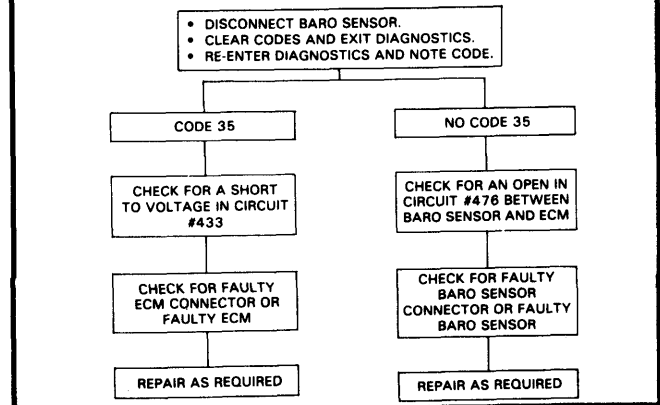


WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

TROUBLE CODE 34

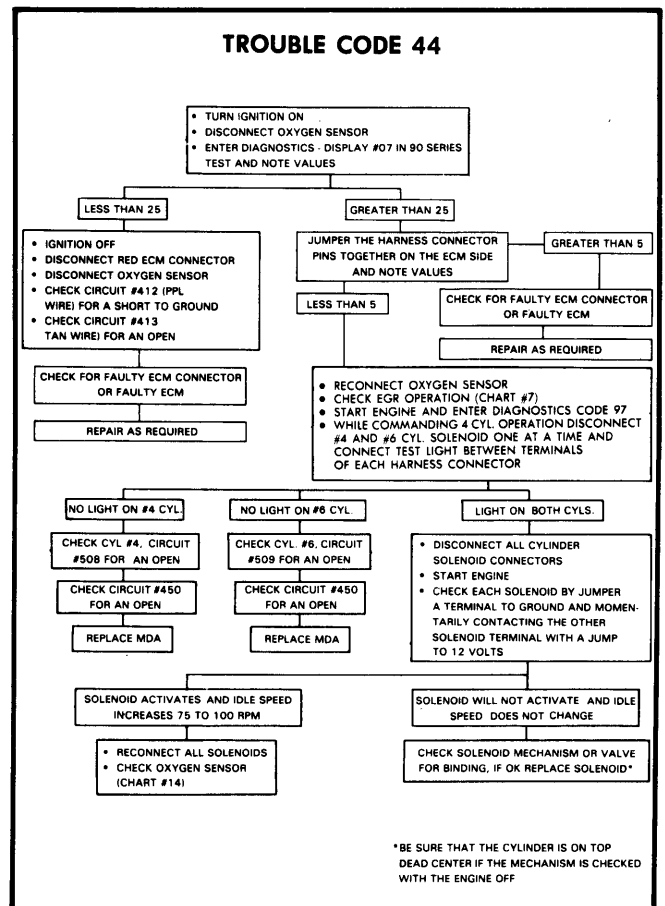
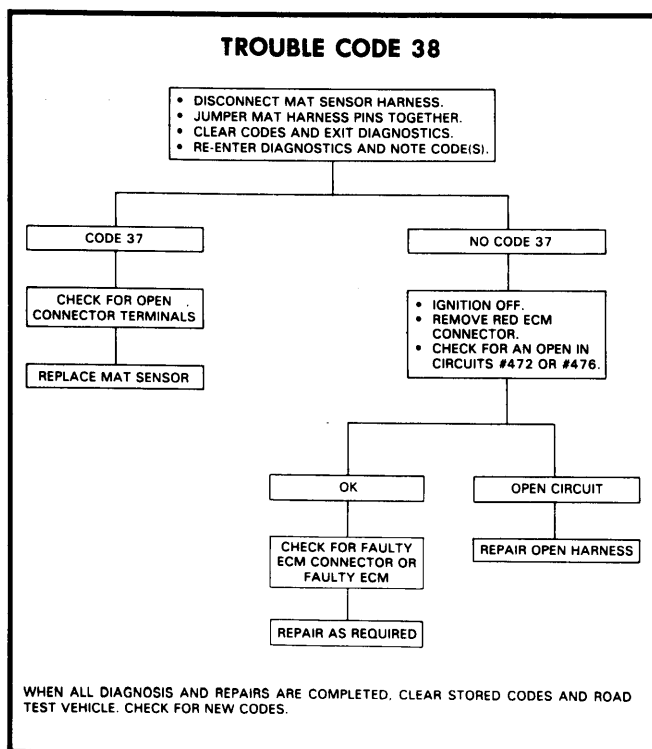
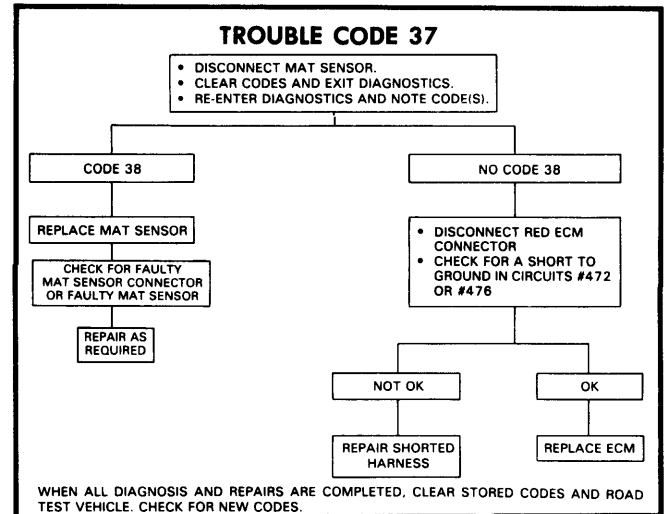
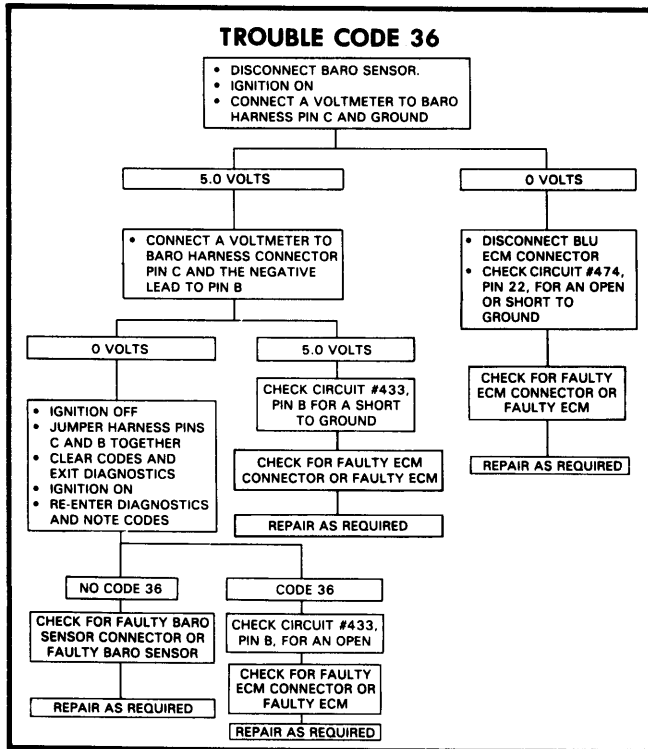


TROUBLE CODE 35

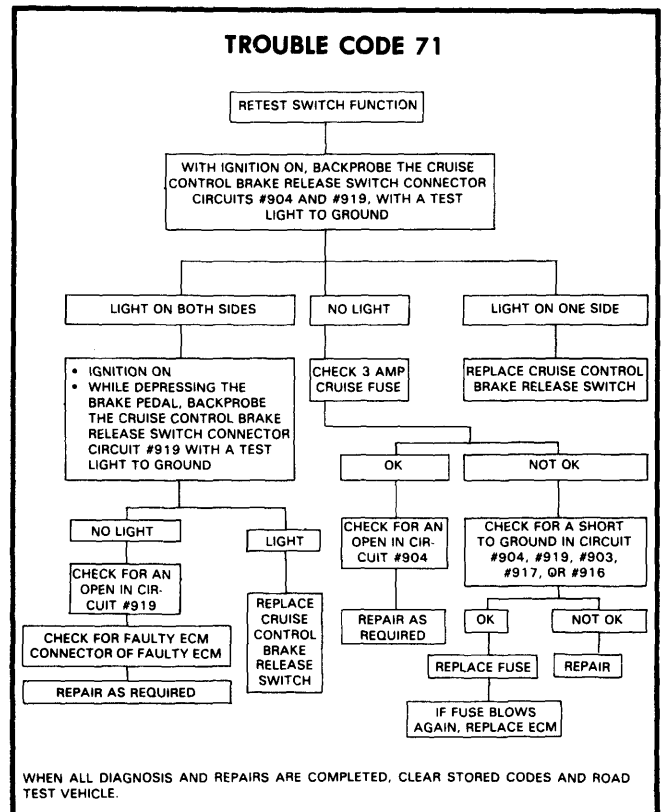
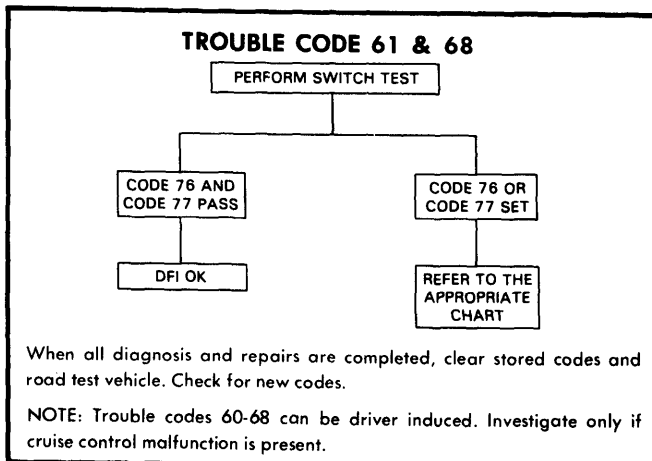
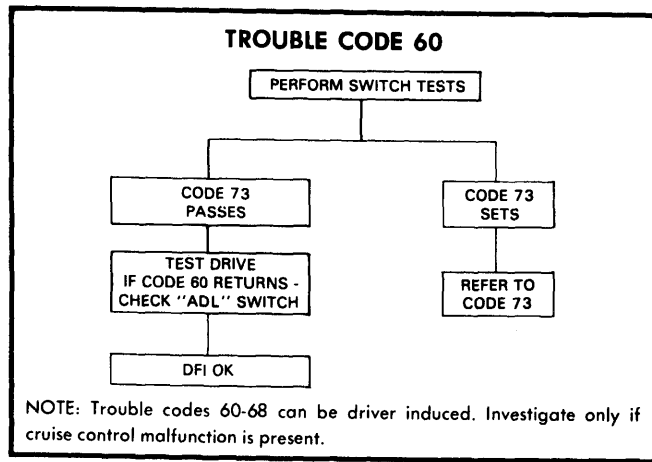
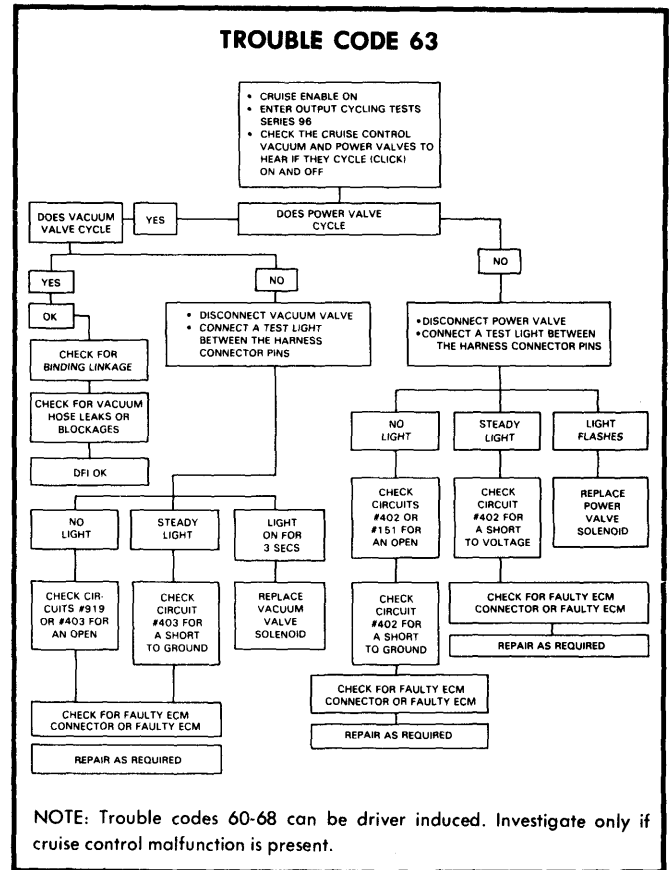
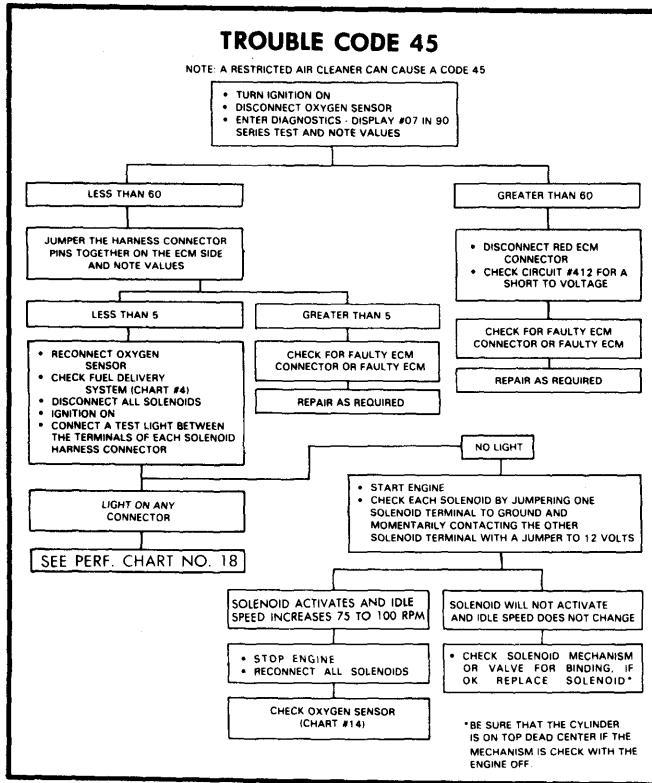


1981 Computerized Engine Controls 1a-109

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

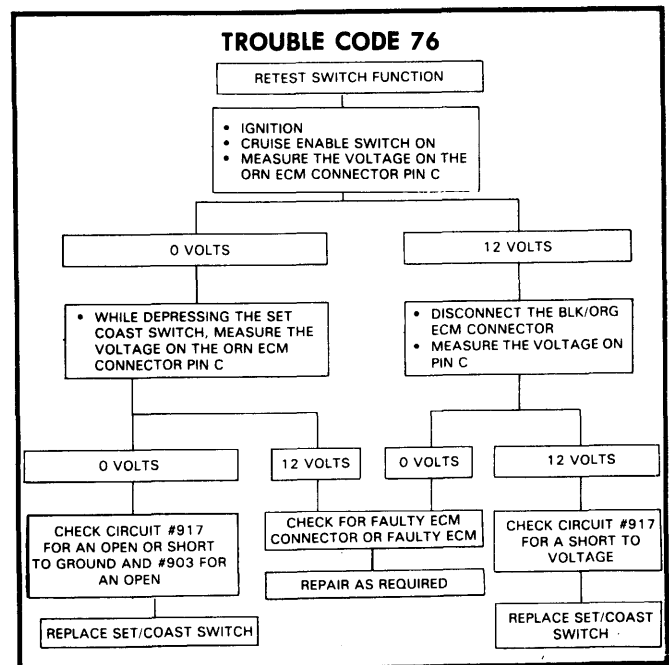
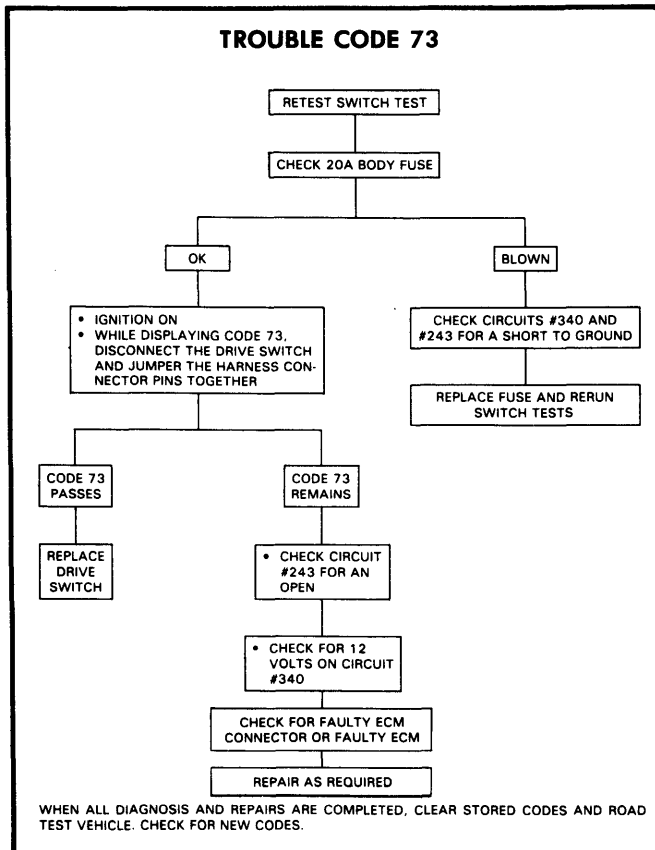
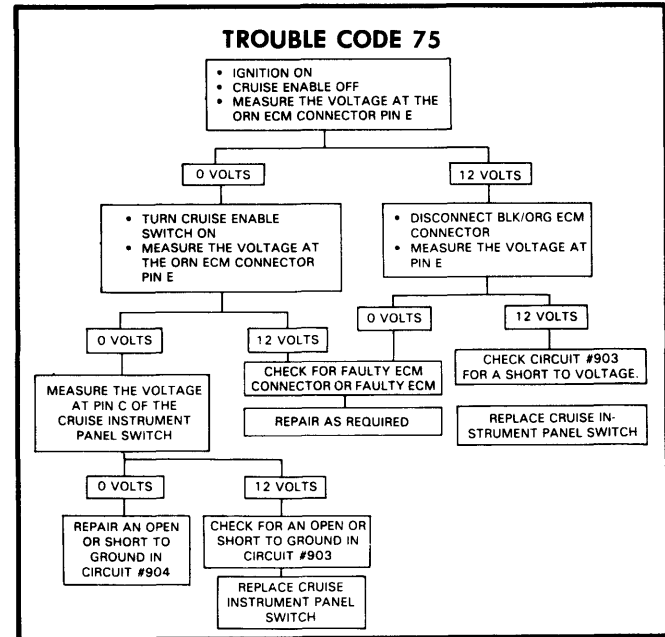
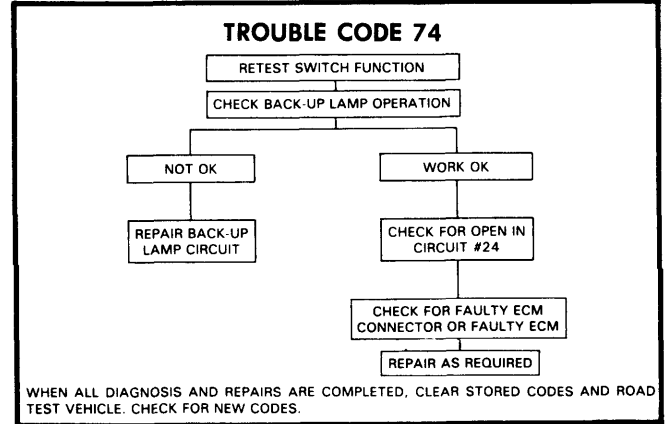
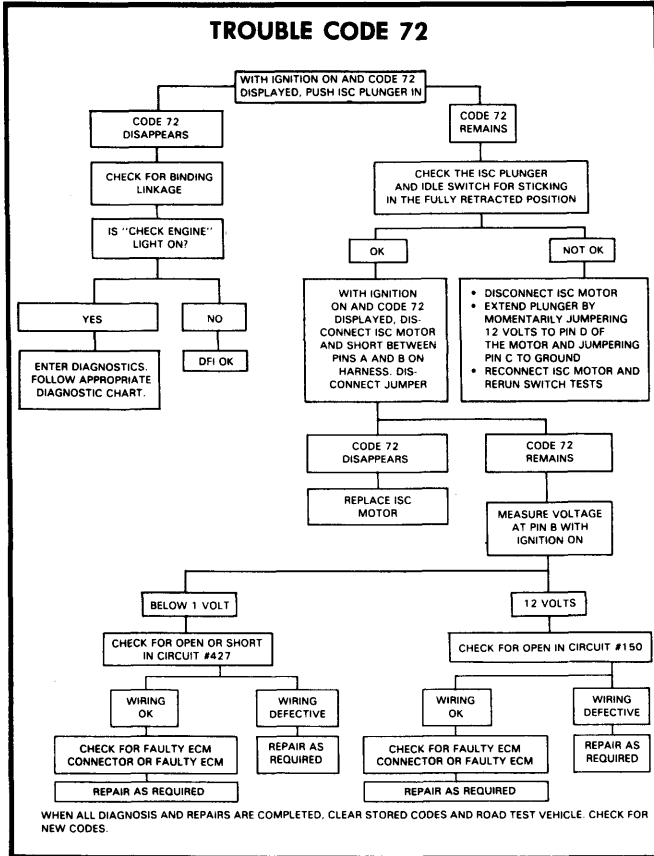


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

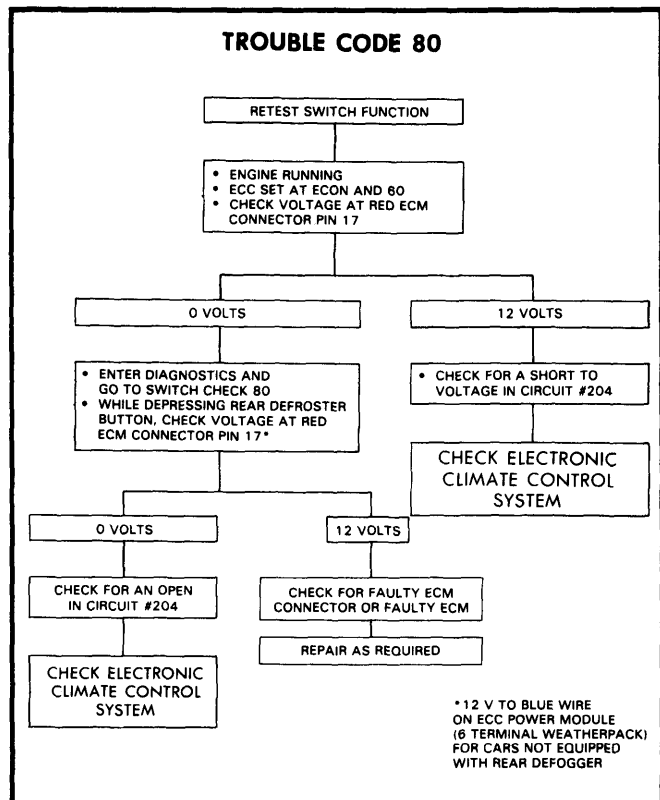
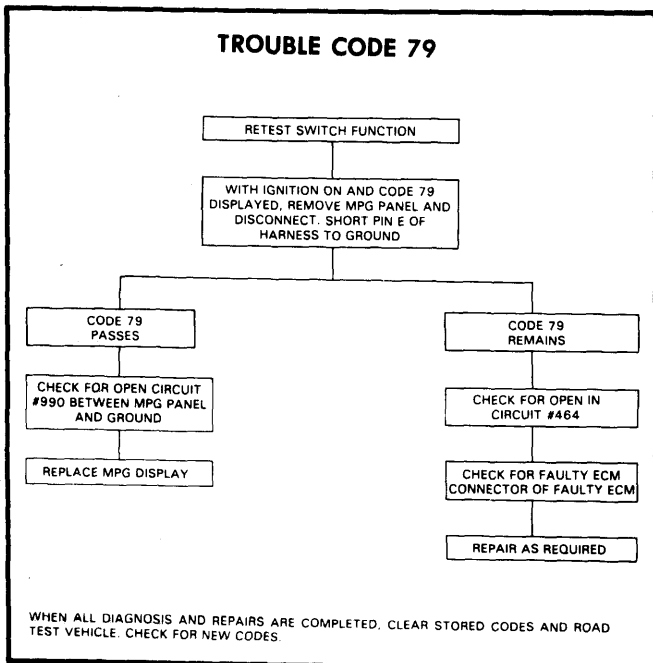
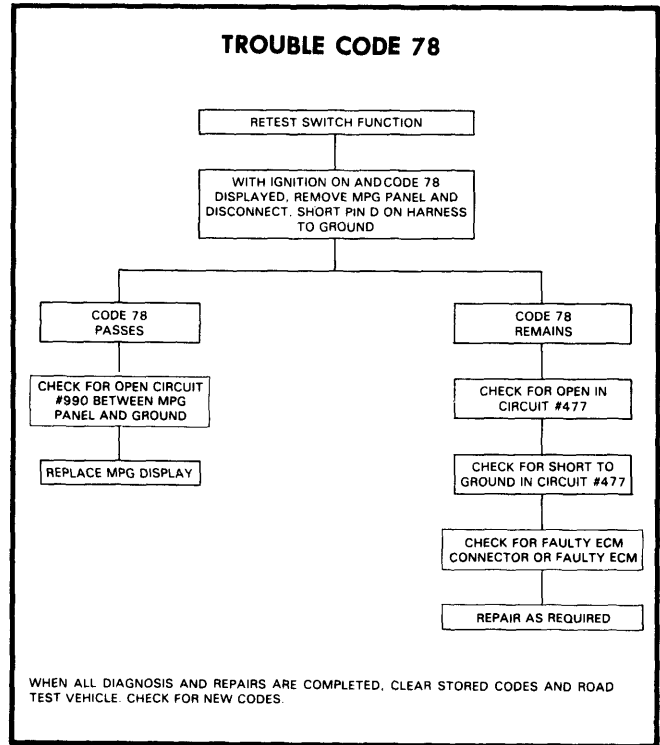
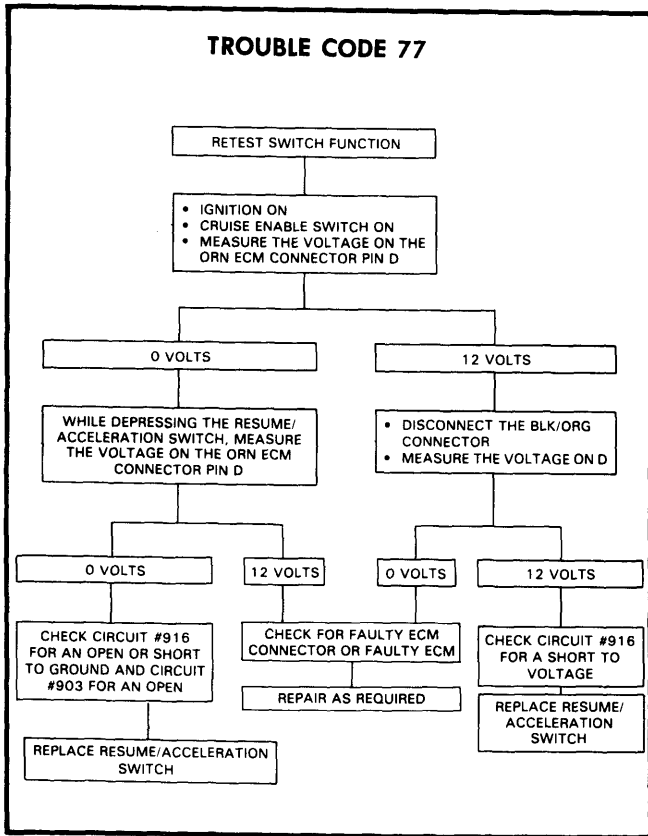


1981 Computerized Engine Controls_{1a-111}

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



1981 Computerized Engine Controls_{1a-113}

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

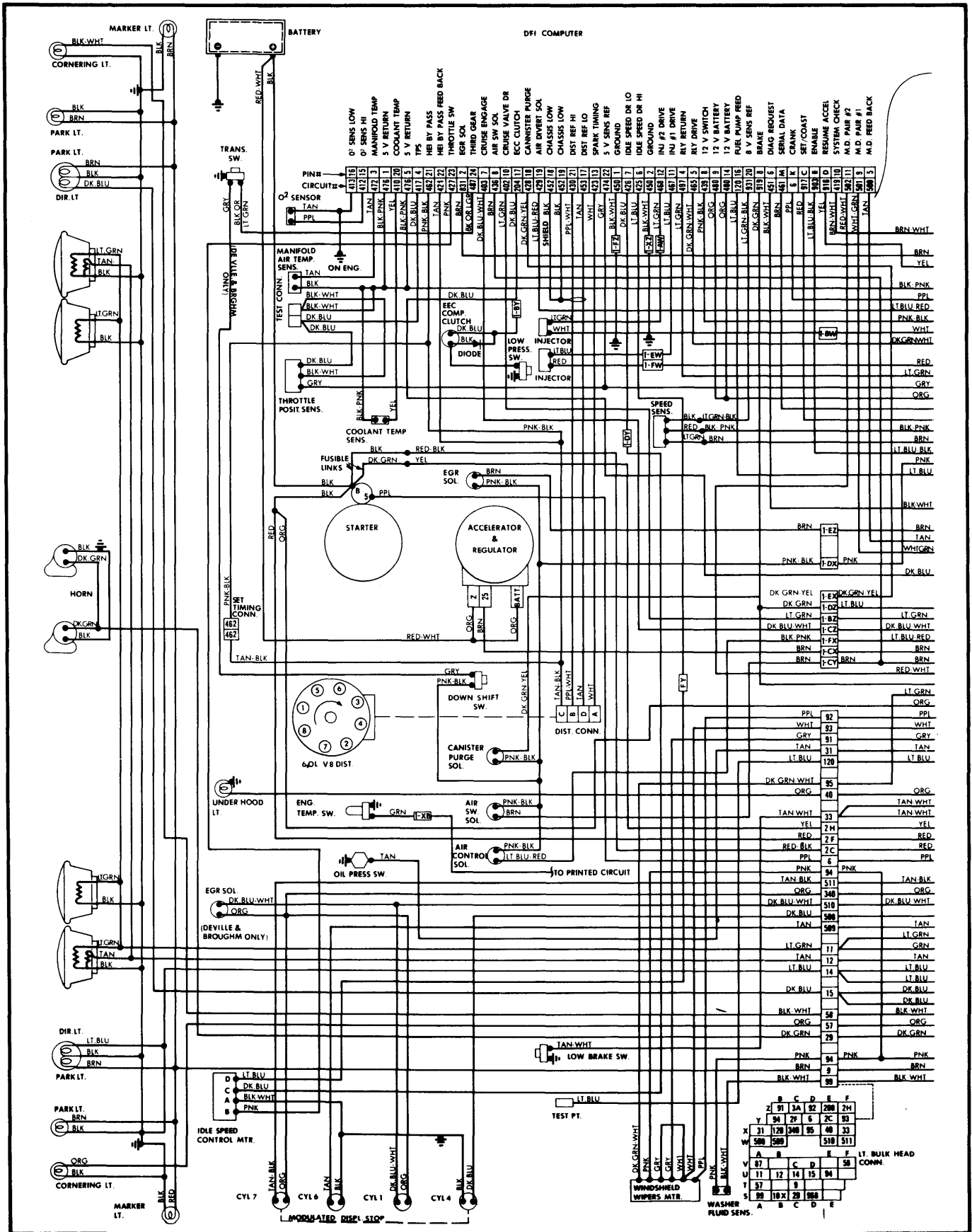


Fig. 4 Cadillac DFI Control System Wiring Diagram (Part 1)

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GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

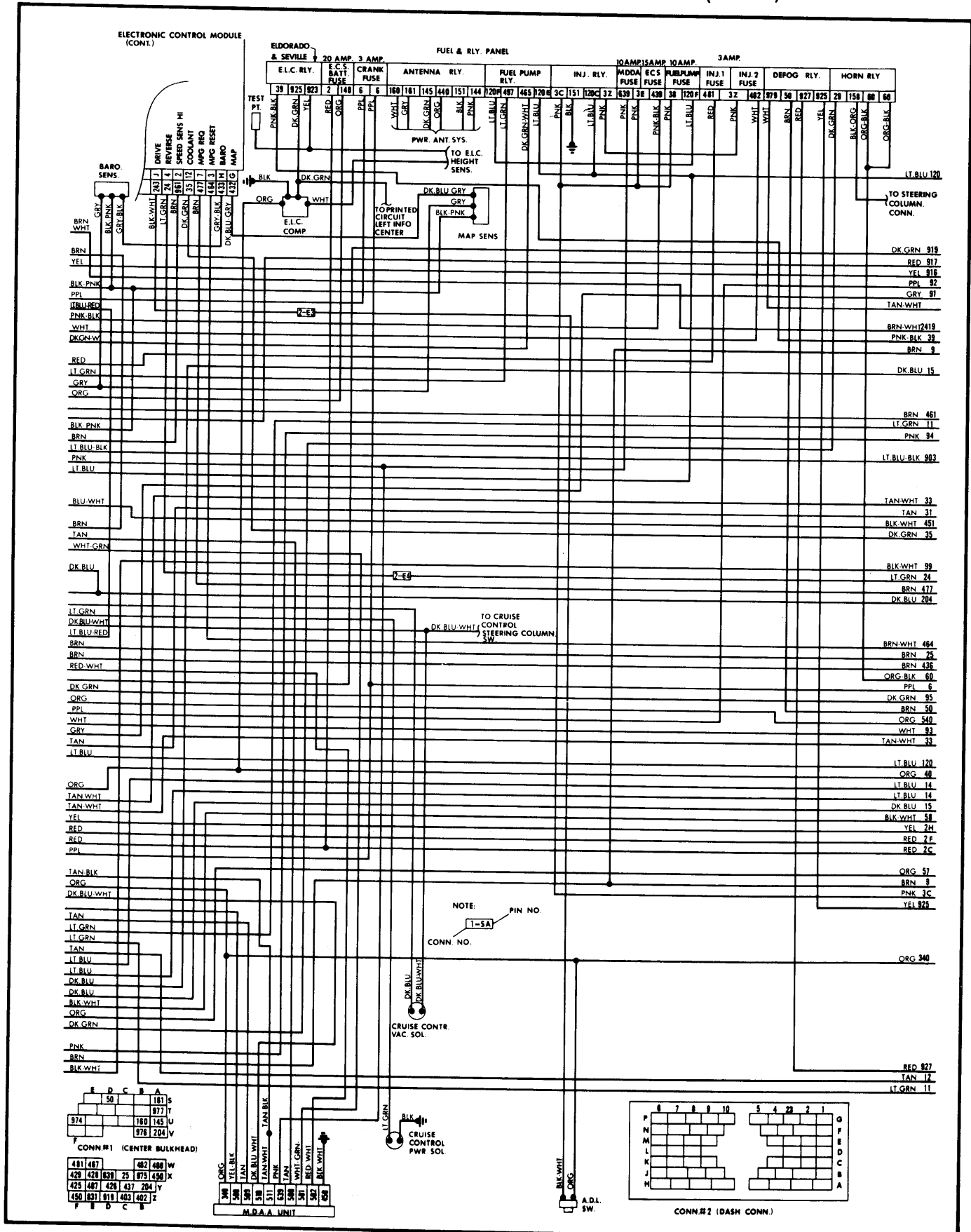
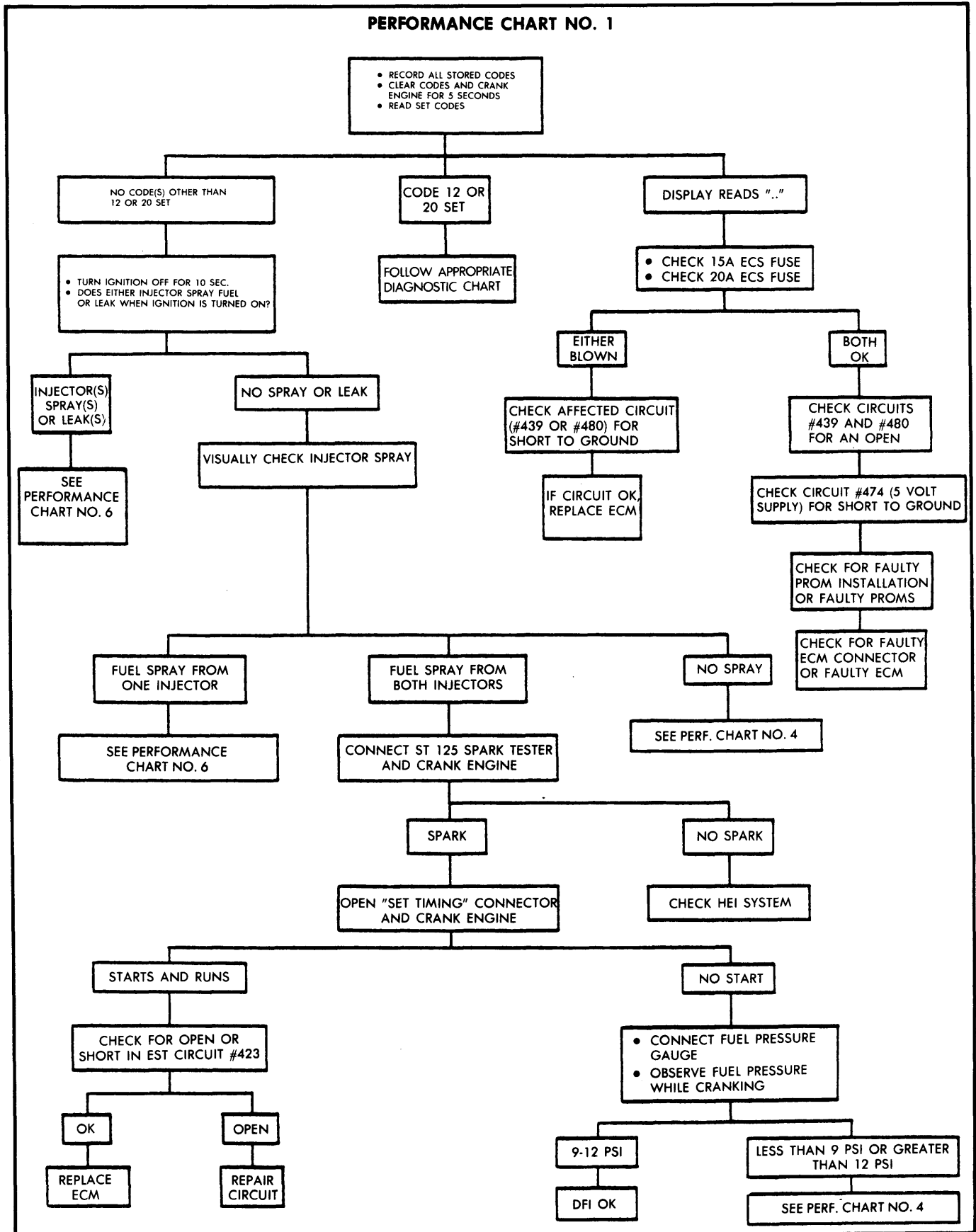


Fig. 5 Cadillac DFI Control System Wiring Diagram (Part 2)

1981 Computerized Engine Controls^{1a-115}

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

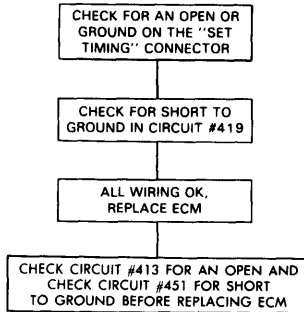
PERFORMANCE CHARTS



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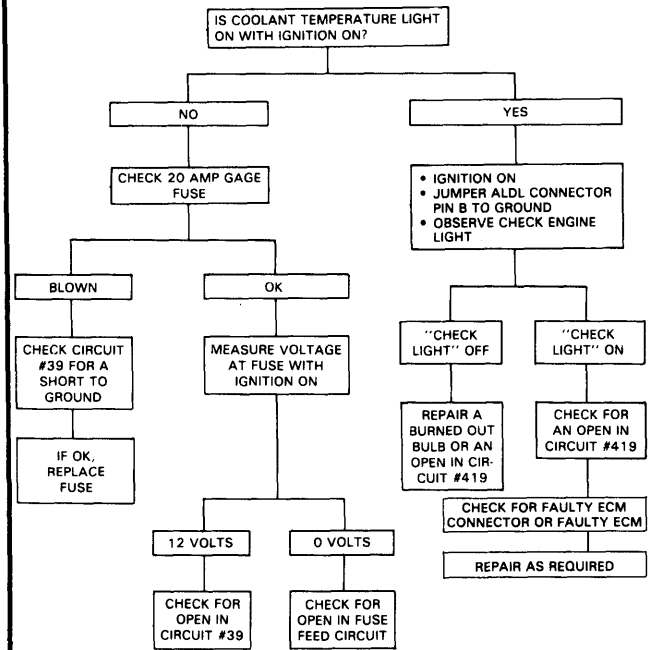
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 2



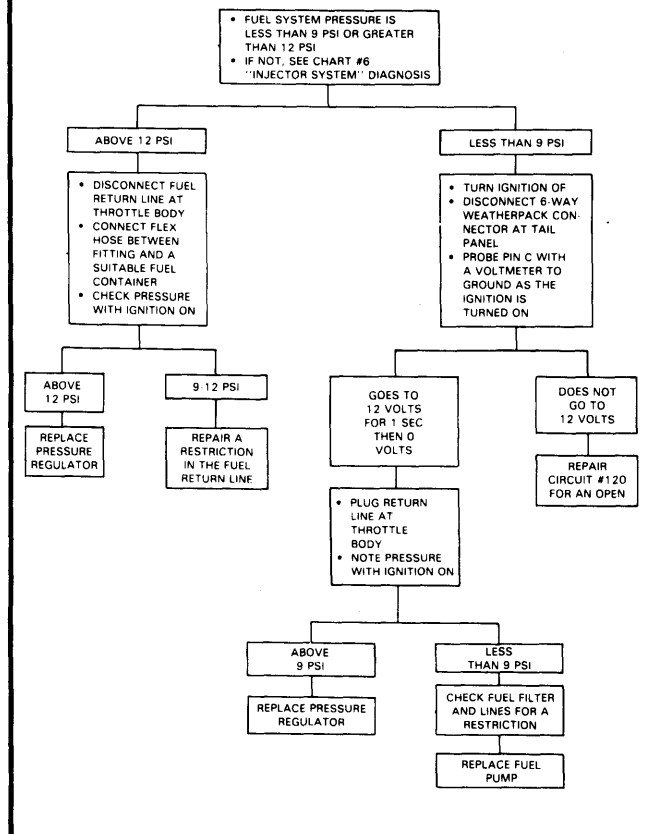
NOTE: Improperly installed or defective PROM may be suspect.

PERFORMANCE CHART NO. 3

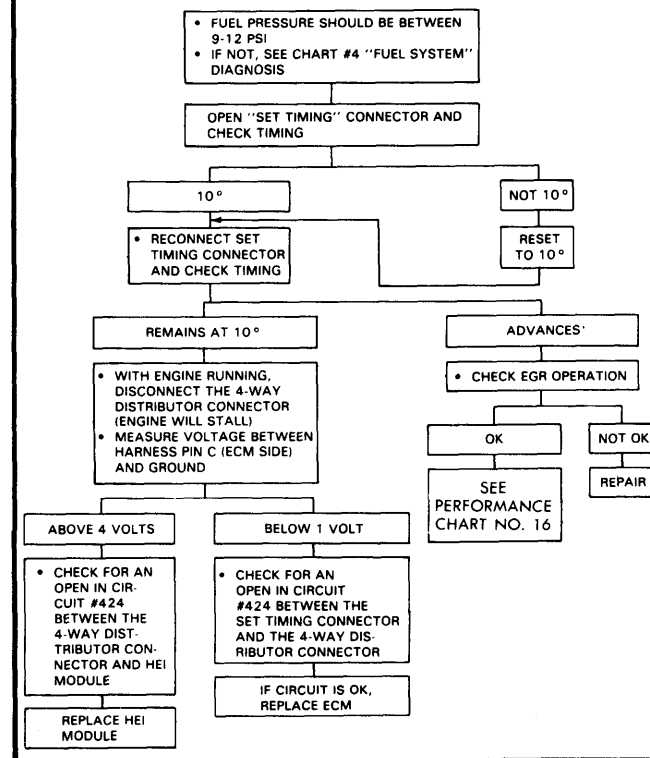


WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

PERFORMANCE CHART NO. 4

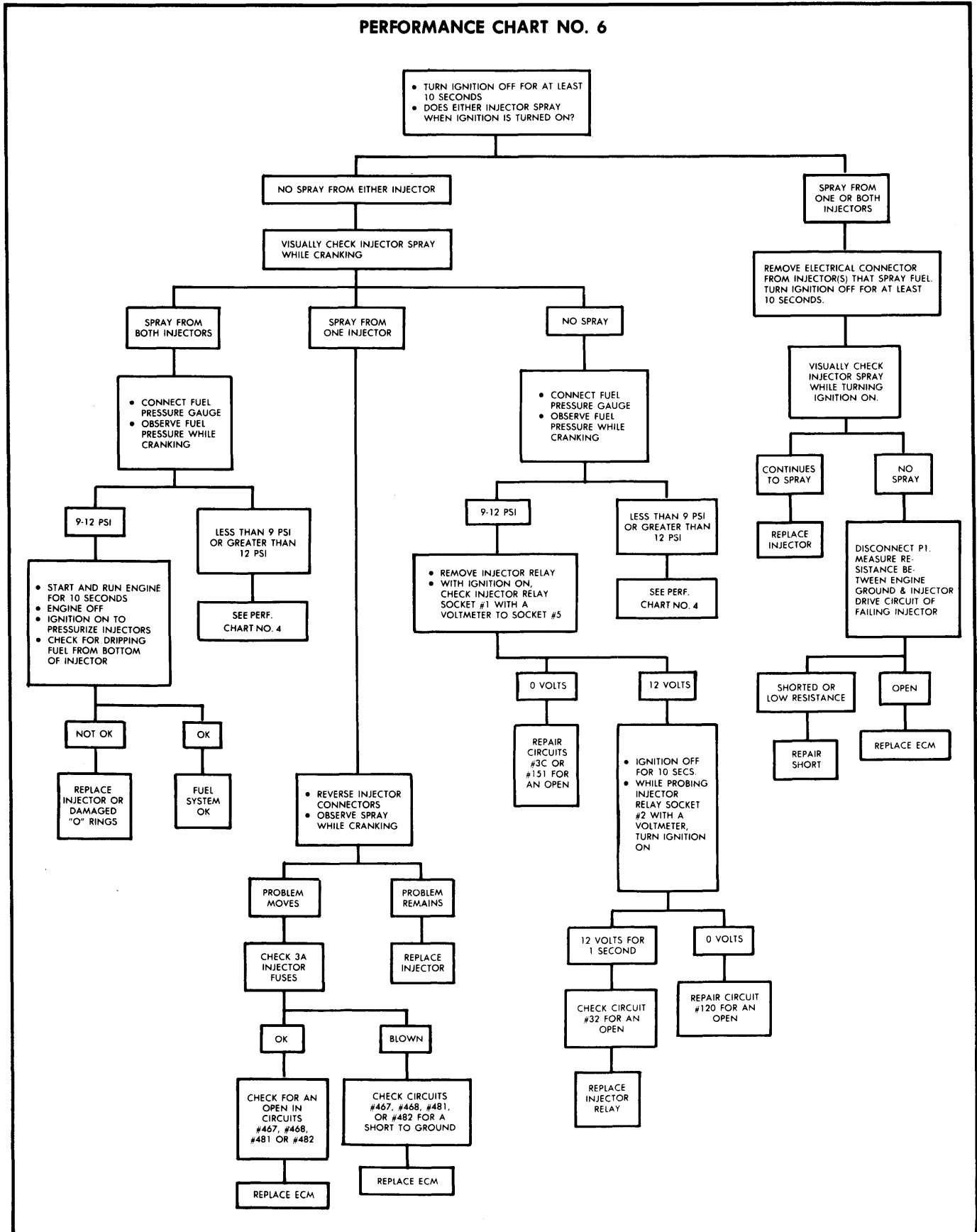


PERFORMANCE CHART NO. 5

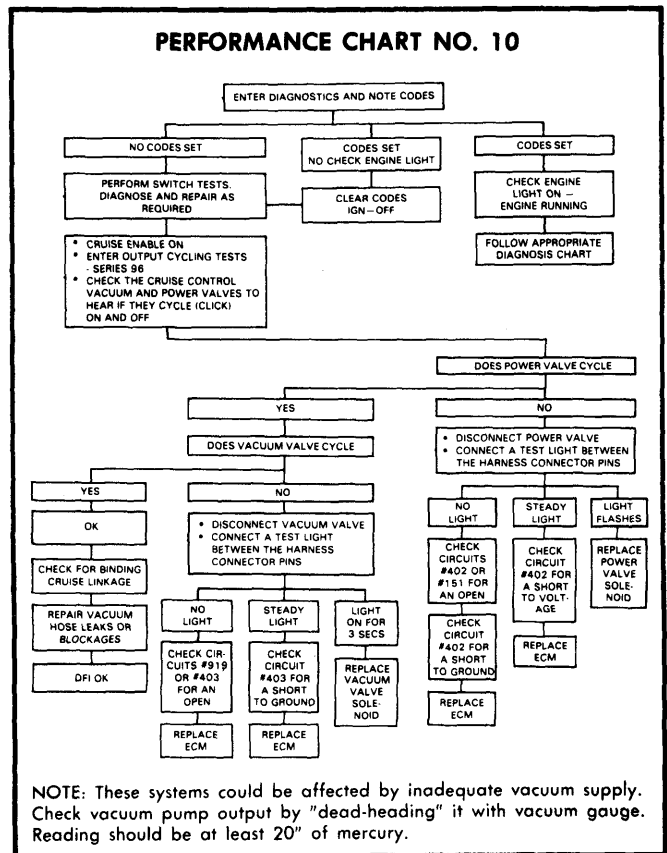
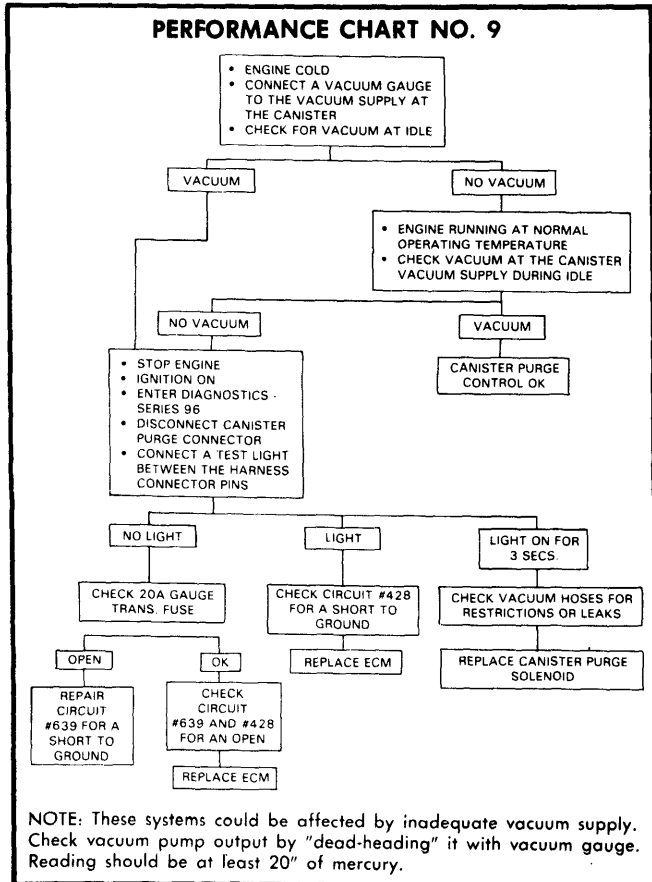
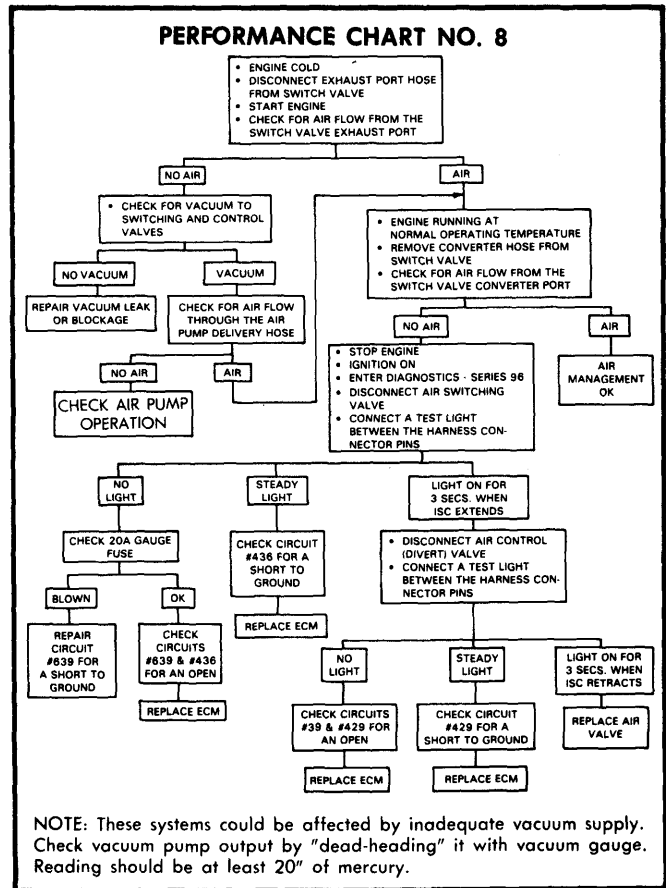
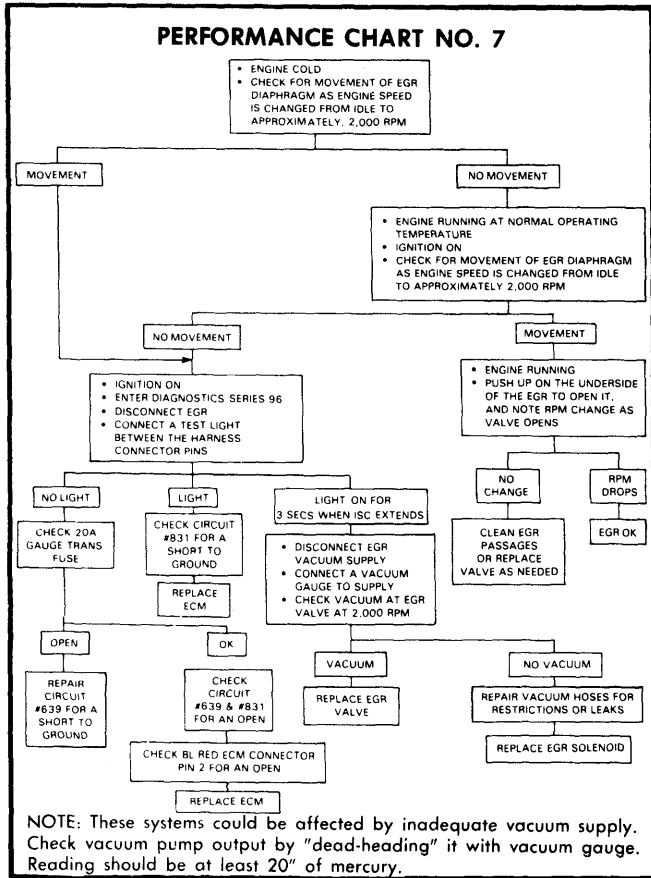


1981 Computerized Engine Controls 1a-117

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

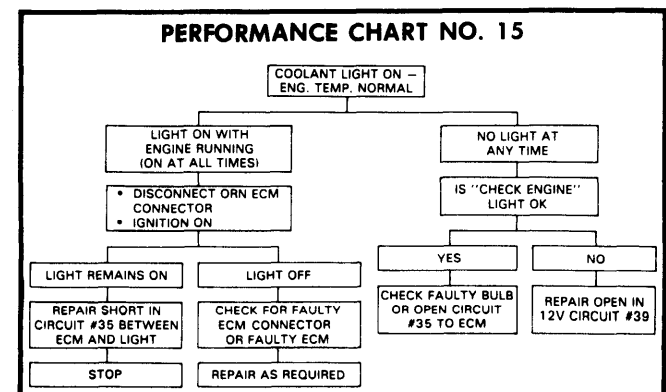
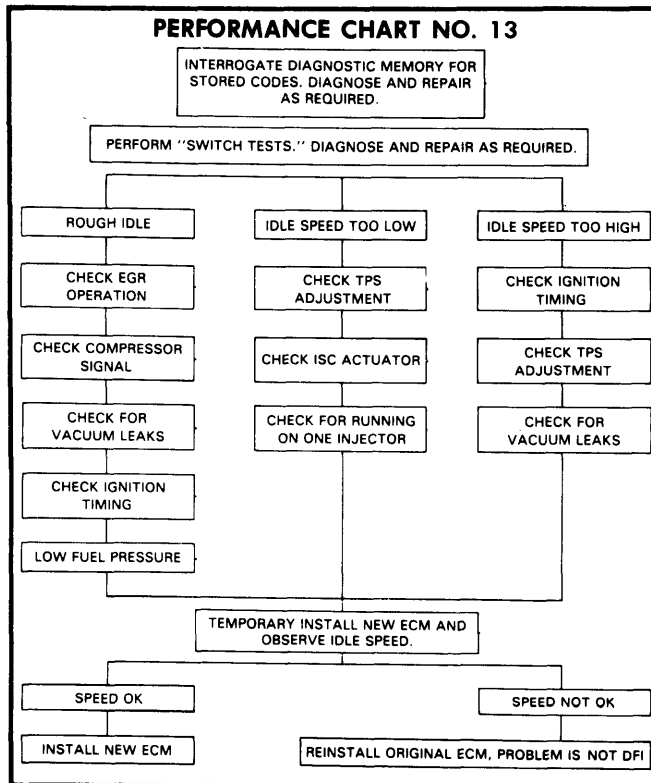
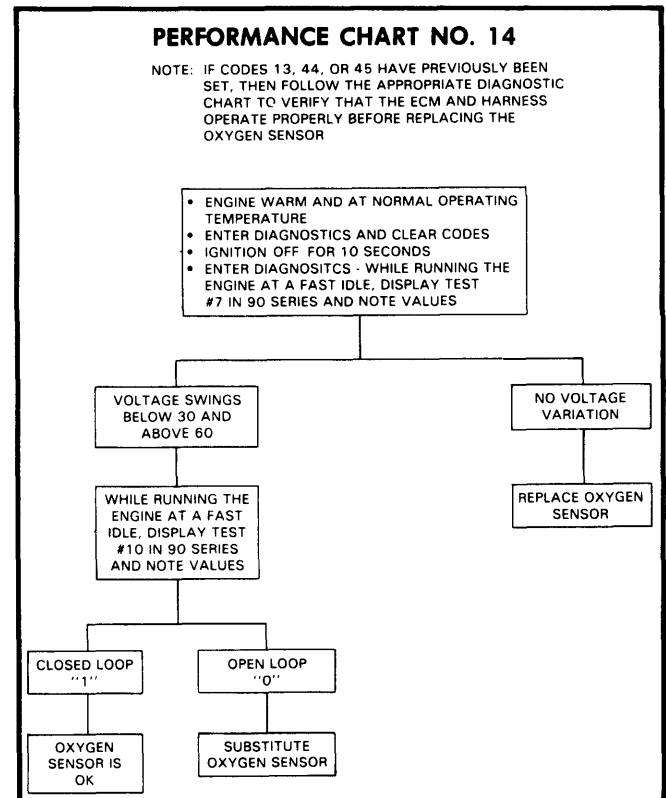
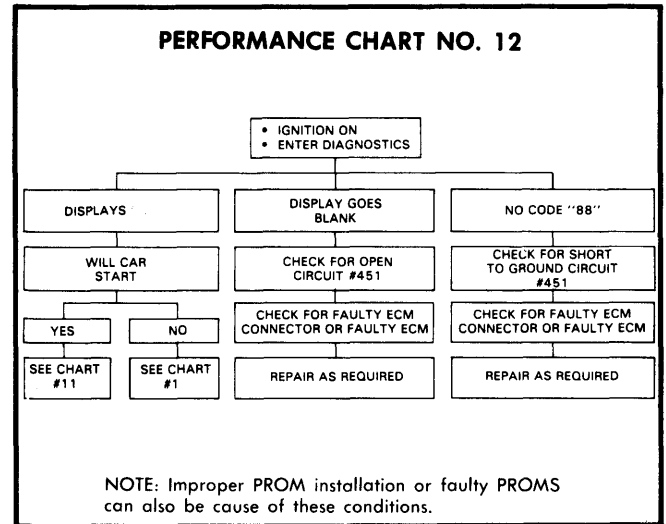
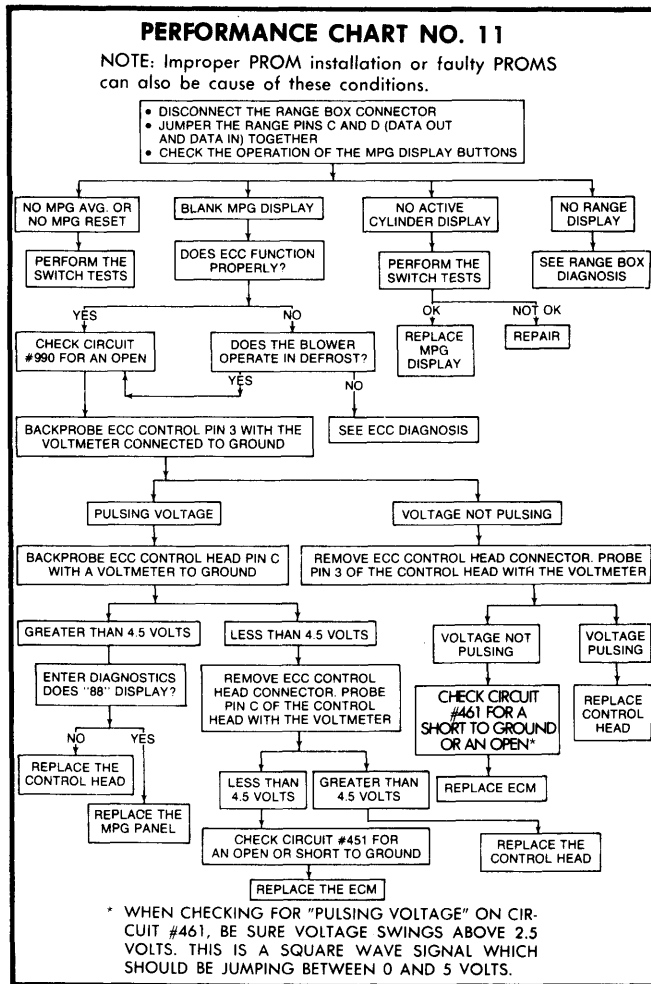


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



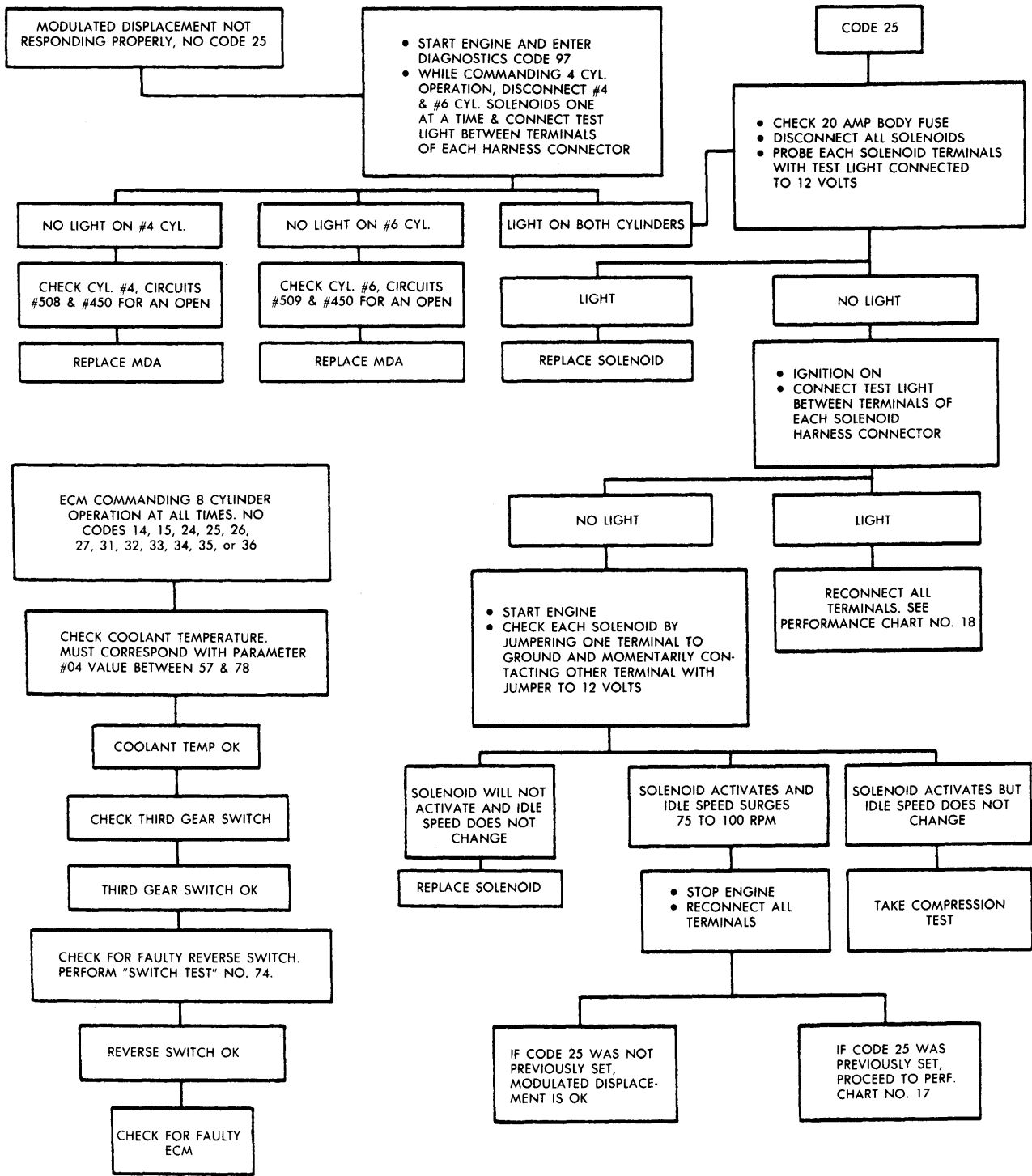
1981 Computerized Engine Controls_{1a-119}

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)



GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 16

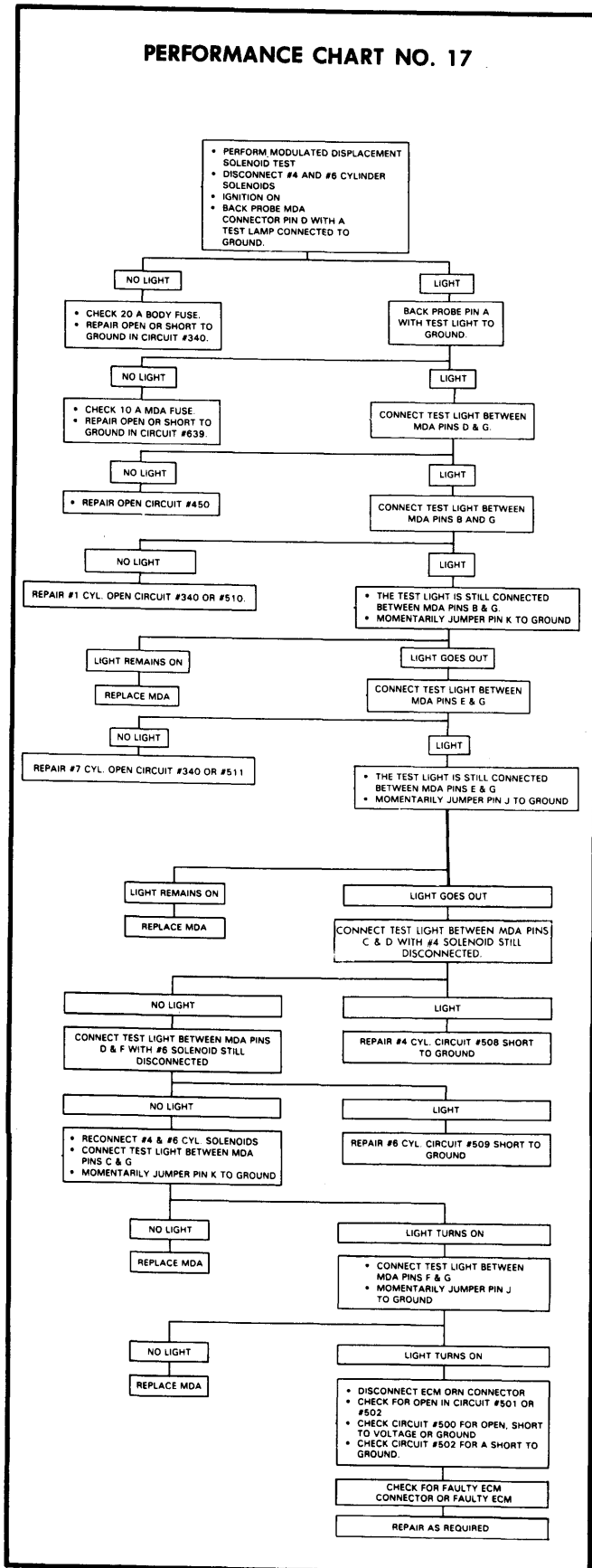


NOTE: BE SURE CYLINDER IS ON TOP DEAD CENTER IF MECHANISM IS CHECKED WITH ENGINE OFF.

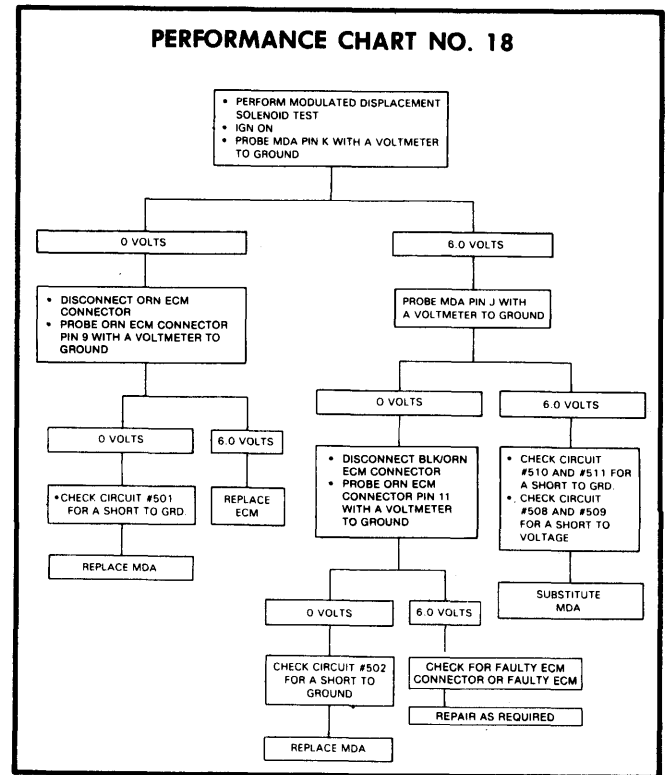
1981 Computerized Engine Controls 1a-121

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 17



PERFORMANCE CHART NO. 18



MAINTENANCE

The DFI control system does not require periodic maintenance. The ECM signals need for repair or replacement of oxygen sensor. However, if the vehicle is raised for other services, check the general condition of the catalytic converter and exhaust system.

REMOVAL & INSTALLATION

ELECTRONIC CONTROL MODULE (ECM)

Removal & Installation – Remove lower instrument panel cover. Remove 3 nuts securing ECM to instrument panel mounting brackets and ground strap. Remove 3 electrical connectors and remove ECM from vehicle. To install ECM, reverse removal procedure and ensure ground strap is securely attached.

PROGRAMMABLE READ ONLY MEMORY (PROM)

Removal – 1) Remove ECM as previously described. Insert tip of small blade screwdriver into keyhole of locking tab on PROM access cover. Carefully bend tab slightly to unlock access cover and slide cover off ECM.

2) Note positions of each PROM before removal. Replacement PROM's must be installed in same position as original PROM's. Small reference boss (dimple) on PROM carrier must align with boss (dimple) on PROM socket. Grasp clear PROM between thumb and forefinger. Gently rock PROM back and forth while applying upward force to remove PROM and carrier. Repeat procedure for green PROM.

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

NOTE — PROM's are not interchangeable. PROM's designed for first generation ECM's cannot be installed in second generation ECM's and second generation PROM's cannot be installed in first generation ECM's. Ensure PROM part numbers correspond to those of PROM's originally installed in ECM.

Installation — 1) Place PROM in clear carrier upside down on flat surface with pins facing up. Using a narrow blunt tool, press PROM body down on both sides of retainer bar so top of PROM is flush with top of carrier. Repeat procedure for PROM mounted in green carrier. See Fig. 6.

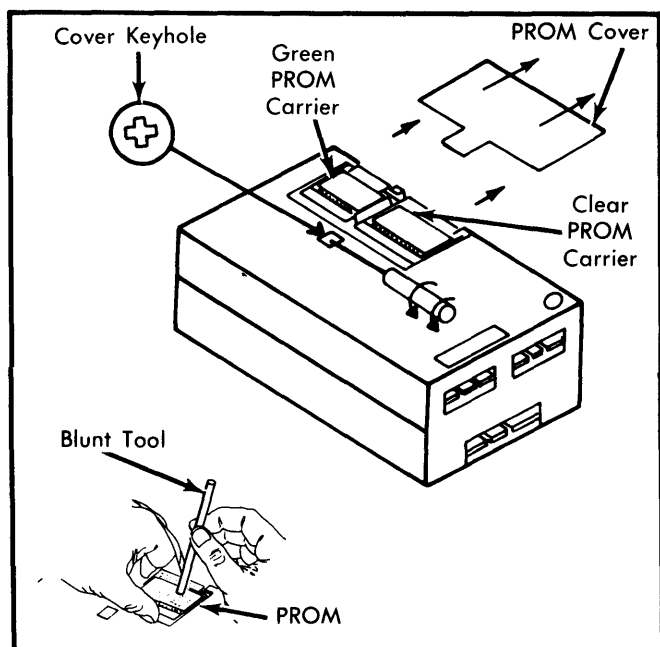


Fig. 6 Installing PROM into Electronic Control Module

2) Position clear PROM carrier squarely over PROM socket in ECM. Firmly press down on top of carrier. While holding carrier down, press body of PROM down with a blunt tool. Alternately pressing down on either end will securely seat PROM. Repeat procedure for PROM mounted in green carrier.

3) Install access cover on ECM and ensure it locks in place. Install ECM in vehicle. Start engine, enter diagnostics and check for code "51". If code "51" does not appear, PROM installation is correct. If code "51" is displayed, one or both PROM's are not fully seated, installed backwards, have bent pins or are defective.

4) If pins are bent, straighten pins and reinstall PROM. If pins break or crack during straightening process, replace BOTH PROM's. If PROM's are installed backwards, replace BOTH PROM's.

NOTE — First generation ECM's are not able to recognize an improperly seated PROM and cannot set a code "51". Poorly seated PROM's on first generation ECM's may produce these symptoms; Display of false codes which cannot be cleared, erratic cycling of various lights and components, or a "Hard Failure" code "74".

MPG DISPLAY

Removal & Installation — Remove center instrument panel applique. Remove 2 MPG mounting screws and pull display out of instrument panel. Disconnect electrical connector. To install, reverse removal procedure.

THROTTLE POSITION SENSOR (TPS)

NOTE — DO NOT remove TPS unless all diagnosis confirms that TPS requires adjustment or repair.

Removal — 1) Remove TPS electrical connector. Remove air cleaner and throttle body assembly. Turn throttle body upside down and support assembly to prevent damage to injector connectors. Using a $\frac{5}{16}$ " drill bit, drill completely through both TPS access holes in base of throttle body to remove spot welds holding screws in place.

2) Remove and discard TPS attaching screws. Remove lock washers and retainers. Remove TPS from throttle body, noting location of TPS pick-up lever in relation to throttle shaft lever tang for installation reference.

Installation — Position TPS over throttle shaft with TPS pick-up lever following throttle lever tang. Install retainers, lock washers and 2 new screws. Tighten screws so TPS will move but is not loose. Install throttle body, reconnect electrical connector and adjust TPS.

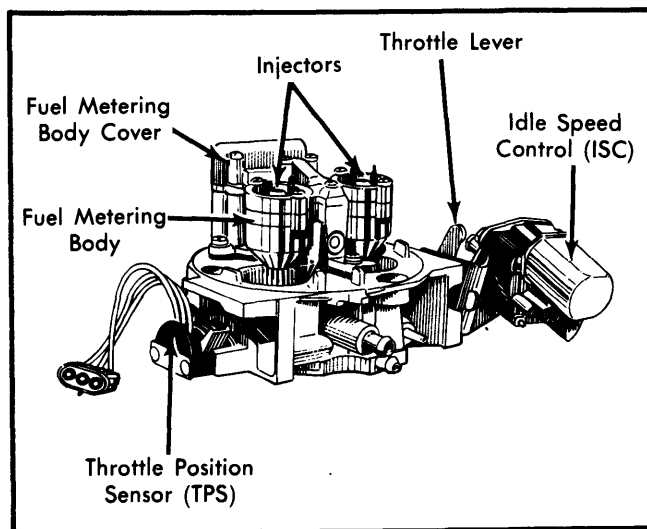


Fig. 7 View of Throttle Body Assembly

IDLE SPEED CONTROL ACTUATOR (ISC)

Removal & Installation — Disconnect harness connector from ISC. Remove 2 mounting screws and ISC. To install, position ISC on left side of throttle body, install mounting screws and adjust ISC.

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP) & BAROMETRIC PRESSURE SENSOR (BARO)

Removal — Remove right side lower instrument panel and glove box liner. Disconnect harness connectors from both sensors and vacuum hose from MAP sensor. Remove screw holding

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GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

ground strap to mounting bracket and remove mounting bracket screws. Remove sensors and bracket as an assembly.

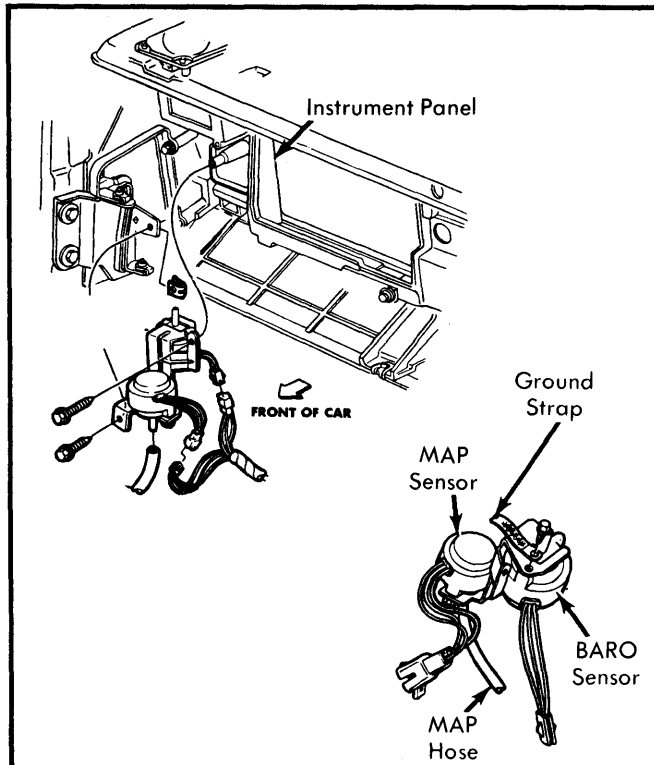


Fig. 8 Replacement of MAP/BARO Sensors

Installation — To install, reverse removal procedure and note the following: MAP sensor has female connector on sensor and BARO sensor has male connector on sensor.

COOLANT TEMPERATURE SENSOR (CTS)

Removal — Drain radiator until coolant level is below sensor. Remove alternator if required to gain access to sensor. Disconnect harness connector from sensor and remove sensor from block.

Installation — Apply non-hardening sealer to threads of sensor and install sensor. Reconnect harness connector and install alternator (if removed). Refill radiator.

MANIFOLD AIR TEMPERATURE SENSOR (MAT)

Removal & Installation — Remove sensor from manifold (directly in front of throttle body). When installing sensor, coat threads with a non-hardening sealer.

OXYGEN SENSOR

Removal & Installation — Disconnect electrical connector and remove oxygen sensor. Install new oxygen sensor and ensure clearance is maintained at boot. When installing new sensor, do not remove coating from threads or install with any type of sealant. Reconnect electrical harness. See Fig. 9.

NOTE — DO NOT attempt to reinstall an oxygen sensor. Reinstallation of a sensor without the special glass bead thread coating may require replacement of exhaust system.

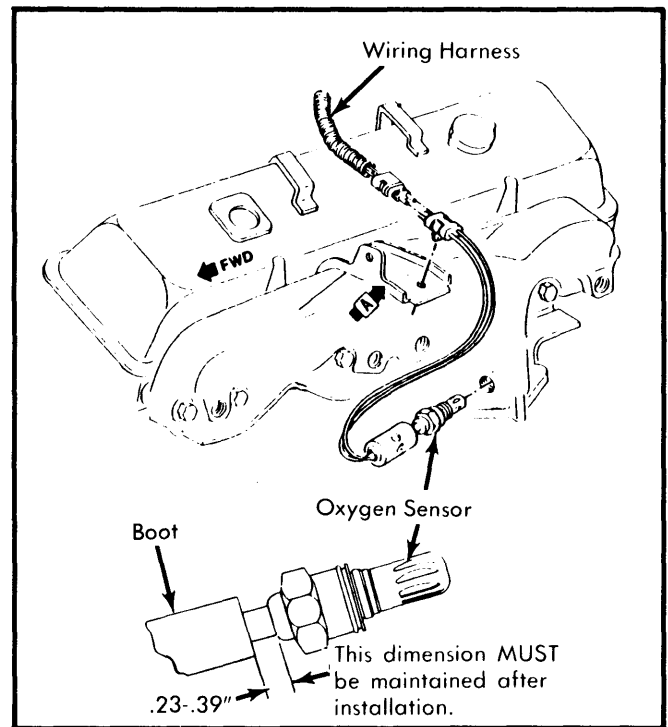


Fig. 9 View Showing Oxygen Sensor Location

TIGHTENING SPECIFICATIONS

| Application | Ft. Lbs. |
|-----------------------------------|----------|
| Oxygen Sensor | 30 |
| Coolant Sensor & MAT Sensor | 15 |
| Throttle Body | 15 |