GENERAL MOTORS DFI CONTROL SYSTEM

Cadillac
4.1L (250") V8

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 the following 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, torque converter clutch and catalytic converter.

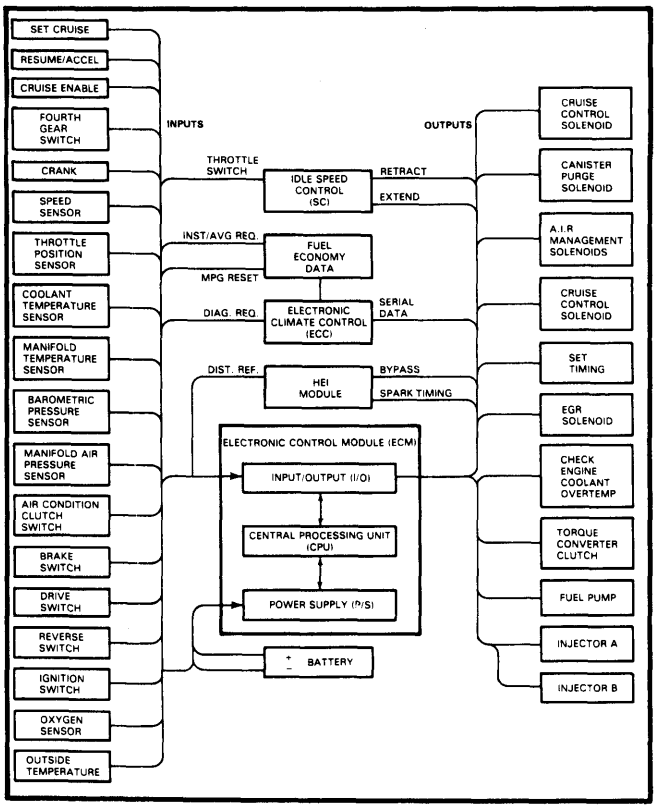

Fig. 1 Diagram of DFI Components

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 the left front corner of the intake manifold. This sensor provides information to ECM for fuel enrichment, ignition timing, EGR operation, canister purge control, air management, early fuel evaporization control and closed loop fuel control.

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 signals for logic required to operate fuel economy data panel, integral cruise control 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.

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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.

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 a similar manner to that of the 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.

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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.*

TORQUE CONVERTER CLUTCH (TCC)

Torque converter clutch is controlled by ECM via an electrical solenoid mounted in the transmission. At a specific speed, the ECM energizes the solenoid and the torque converter is mechanically coupled to the engine. Under specific operating conditions (when normal fluid coupling is required) the solenoid is de-energized.

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, Fuel Data 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 "–1.8.8" should appear indicating beginning of diagnostic readout. Trouble codes will be displayed beginning with the lowest numbered code. If no codes are stored, "–1.8.8" will appear for longer period of time, then code ".7.0" will appear. See *Fig. 2*.

NOTE – *Trouble code ".7.0" is a decision point. When this code is displayed, either select diagnostic feature (switch test, engine data display, output cycling test or fixed spark mode), exit diagnostic mode, or clear codes and then exit diagnostic mode.*

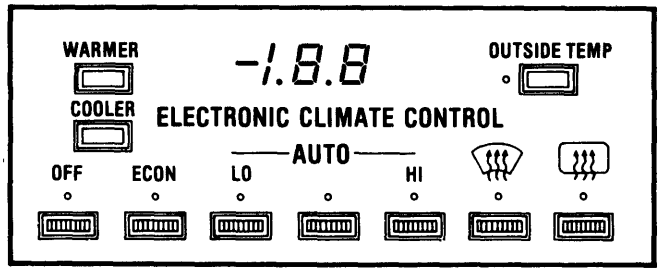

Fig. 2 Trouble Code "–1.8.8" Displayed on Electronic Climate Control (ECC) Panel

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 ".0.0" is displayed. Release buttons and code ".7.0" should appear.

Exiting Diagnostic Mode – Depress any ECC function keys except "LO" or "OUTSIDE TEMP", or turn ignition switch "OFF" for 10 seconds. This will take ECC panel out of 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

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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. ECC will display trouble codes beginning with lowest numbered code. Each code will be displayed for 2 seconds until the highest code present has been displayed. Then "−1.8.8" will appear.

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 voltage out of range.
18	Open crank signal circuit.
19	Shorted fuel pump circuit.
20	Open fuel pump circuit.
21	Shorted TPS circuit.
22	Open TPS circuit.
23	EST circuit problem in run mode.
24	Speed Sensor circuit.
25	EST circuit problem in bypass mode.
26	Shorted throttle switch circuit.
27	Open throttle switch circuit.
28	Open 4th gear circuit.
29	Shorted 4th gear circuit
30	ISC circuit.
31	Shorted MAP sensor circuit.
32	Open MAP sensor circuit.
33	MAP/BARO sensor correlation.
34	MAP signal too high.
35	Shorted BARO sensor circuit.
36	Open BARO sensor circuit.
37	Shorted MAT sensor circuit.
38	Open MAT sensor circuit.
39	TCC engagement.
44	Lean exhaust signal.
45	Rich exhaust signal.
51	PROM error.
52	ECM memory reset indicator.
60	Transmission not in "DRIVE".
63	Car speed exceeds maximum limit.
64	Car exceeds maximum acceleration limit.
65	Coolant temperature exceeds maximum limit.
66	Engine RPM exceeds maximum limit.
67	Shorted "SET" or "RESUME" circuit.
.7.0	System ready for further tests.
.7.1	Cruise control brake circuit test.
.7.2	Throttle switch circuit test.
.7.3	Drive (ADL) circuit test.
.7.4	Reverse circuit test.
.7.5	Cruise ON/OFF circuit test.
.7.6	SET/COAST circuit test.
.7.7	RESUME/ACCELERATION circuit test.
.7.8	INSTANT/AVERAGE circuit test.
.7.9	RESET circuit test.
.8.0	A/C clutch circuit test.
−1.8.8	Display check.
.9.0	System ready to display engine data.
.9.5	System ready for output cycling or in fixed spark mode.
.9.6	Output cycling.
.0.0	All diagnostics complete.

2) Display procedure will repeat twice. On the 3rd pass through the display, "hard" failure codes ONLY, will be displayed. Any codes which appeared during the 1st and 2nd passes but not during the 3rd, are intermittent failures. If no codes are displayed during the 3rd pass, there are no "hard" failures, and the "CHECK ENGINE" light should have been out before entering diagnostics.

3) The 3rd pass ends with "−1.8.8" display. When trouble code sequence is completed, ".7.0" will display. If a code "51" is present, it must be diagnosed before further testing can be begun. As long as "51" is displayed, no other diagnostic features are possible.

4) Begin code diagnosis with the lowest code number unless code "16" is present. Code "16" should always be diagnosed first (except Code "51") since it may have an affect on setting of other codes. If no trouble codes are present, ECC will display "−1.8.8" for 2 seconds and then ".7.0".

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", "20", "33", "39", "44" or "45" are displayed, use diagnostic chart for corresponding "hard failure" code.

3) Code "51" (if detectable by ECM) indicates faulty PROM installation. Refer to **TROUBLE CODE 51** in this article for diagnosis of this code.

4) Code "63" indicates that cruise control was engaged and vehicle speed exceeded maximum limit. Clear code and road test vehicle.

5) 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.

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

7) 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 ".7.1" displayed, begin switch test procedure. To begin switch test procedure, depress and release brake pedal. Code ".7.1" should appear.

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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 ".7.1" displayed, depress and release brake pedal again. Code ".7.2" should appear. With code ".7.2" displayed, depress throttle to an open position and release. Code ".7.3" should appear.

3) With code ".7.3" displayed, shift transmission into drive then back to neutral. Code ".7.4" should appear. With code ".7.4" displayed, shift transmission to reverse and back to park. Code ".7.5" should appear.

4) With code ".7.5" displayed, switch cruise control on, then off. Code ".7.6" should appear. With code ".7.6" displayed, switch cruise control on, then depress and release "Set/Coast" button. Code ".7.7" should appear. With code ".7.7" displayed, switch cruise control on, then depress and release "Resume/Acceleration" switch. Code ".7.8" should appear.

NOTE – *To pass codes ".7.5", ".7.6" and ".7.7" 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 failures.*

5) With code ".7.8" displayed, depress and release "INSTANT/AVERAGE" button on Fuel Data panel. Code ".7.9" should appear. With Code ".7.9" displayed, depress and release "RESET" button. Code ".8.0" should appear.

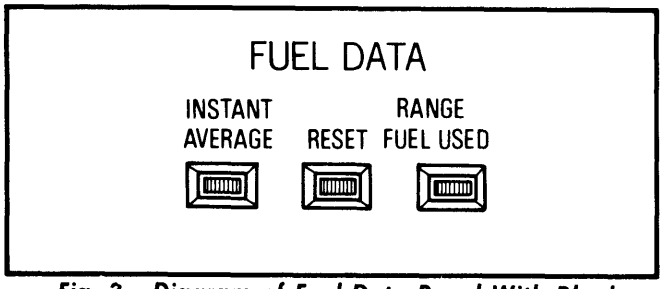

Fig. 3 Diagram of Fuel Data Panel With Blank Display During Diagnostic Testing

6) With code ".8.0" displayed, depress and release "OUTSIDE TEMP" button twice. 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.

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 ".0.0" and return to code ".7.0". Code ".0.0" indicates all switch circuits are operating properly (remember that ".0.0" will never be obtained on vehicles without cruise control).

Engine Data Display Procedure – 1) Enter diagnostics and with code ".7.0" displayed, press "RESET" button on Fuel Data panel. Code ".9.0" should appear. If code ".9.0" does not appear, refer to switch test code ".7.9".

2) Engine data display shows values of 13 parameters monitored by ECM. Parameter numbers (.0.1-.1.3) will be displayed for 1 second on ECC panel, followed by a numerical value. The parameter value will be displayed for 9 seconds. Each parameter and value will be repeated until manually advanced to the next parameter.

3) To advance display, press "INSTANT/AVERAGE" button on Fuel Data panel. To return to a previously displayed parameter, press the "RESET" button on Fuel Data panel. After last parameter is displayed, code ".9.5" should appear. Engine data display may be cleared at any time by pressing "OFF" and "HIGH" buttons on the ECC panel, simultaneously. Code ".7.0" 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:

- .0.1 – Throttle angle displayed in degrees.
- .0.2 – MAP value displayed in kilopascals (kPa).
- .0.3 – BARO value displayed in kPa.
- .0.4 – Coolant temperature in °C.
- .0.5 – Manifold air temperature in °C.
- .0.6 – Injector pulse width in milliseconds.
- .0.7 – Oxygen sensor voltage in volts.
- .0.8 – Spark advance in degrees.
- .0.9 – Ignition cycles since a trouble code was last set.
- .1.0 – Battery voltage in volts.
- .1.1 – Engine RPM divided by 10. Engine speed over 2000 RPM is displayed as "199" since this is the highest number the ECC can display.
- .1.2 – Vehicle speed in MPH.
- .1.3 – PROM identification number. To ensure that the correct PROMs are installed.

Output Cycling Tests Procedure – 1) Enter diagnostics and with code ".7.0" displayed on ECC panel, depress "INSTANT/-AVERAGE" button on Fuel Data panel. If code ".9.5" does not appear, refer to switch test code".7.8". Press "INSTANT/-AVERAGE" button while parameter ".1.3" of Engine Data Display appears.

2) The output cycling test turns ECM's outputs on and off. To enter the output cycling tests, start engine. Turn engine off and within 2 seconds, turn ignition on. Enter diagnostics and display code ".9.5" on ECC panel. Depress accelerator pedal and release. Code ".9.6" should appear (if ".9.6" does not appear, refer to switch test ".7.2").

3) Turn cruise instrument panel switch on. Cruise control outputs will cycle. Output cycling will end automatically after 2 minutes. Display will switch from code ".9.6" to ".9.5". Additional output cycling may be obtained by pressing and releasing the throttle switch.

Fixed Spark Mode Procedure – 1) Purpose of test is to verify proper adjustment of spark timing. Enter diagnostics and with code ".7.0" displayed on ECC panel, depress "INSTANT/-AVERAGE" button on Fuel Data panel. Code ".9.5" should appear.

2) With engine at normal operating temperature, idling at less than 900 RPM and transmission in "P" position, attach a timing light and observe ignition timing. Under these conditions, and with HEI operating properly (codes 23 and 25 not set), ignition timing should be 20° ±2° BTDC. If not, the base timing of 10° BTDC should be adjusted accordingly.

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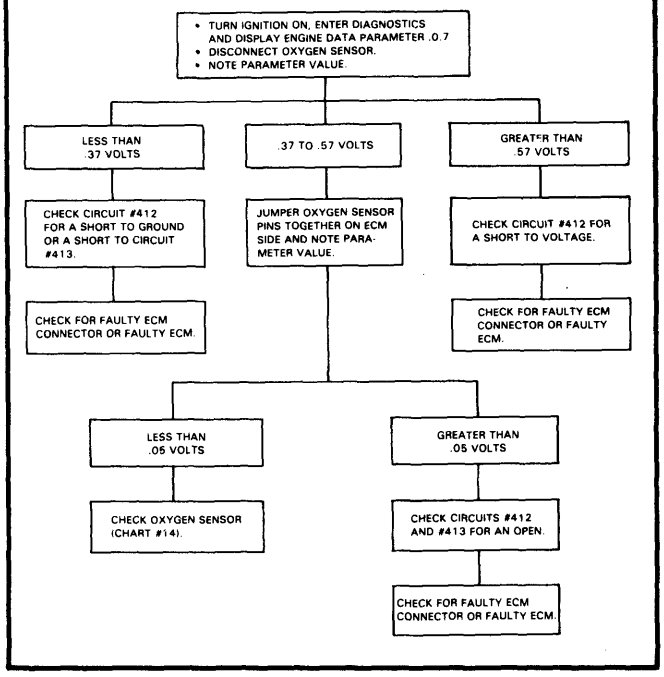
PERFORMANCE CHARTS

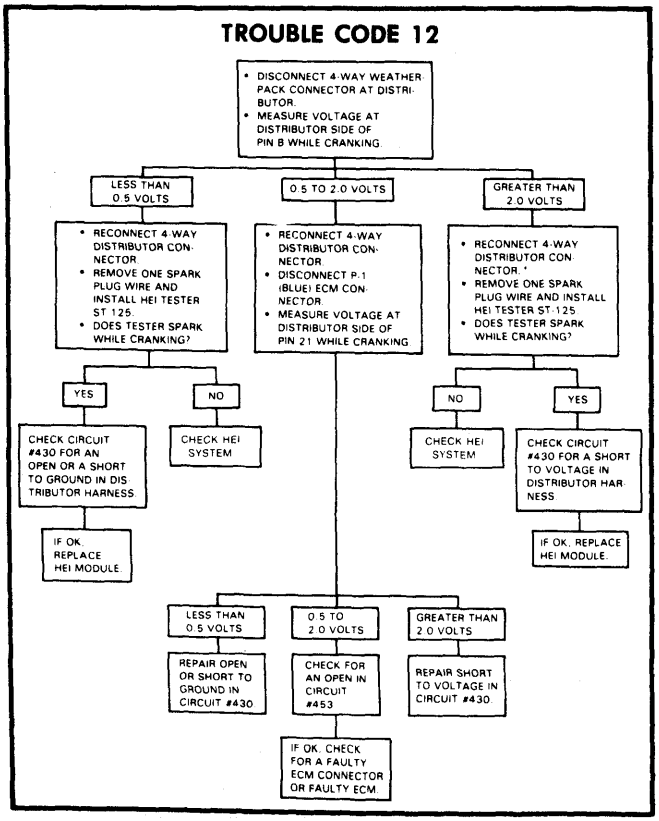
Chart	Condition
No. 1	No start or stall after start.
No. 2	"Check Engine" light on - No codes set.
No. 3	"Check Engine" light inoperative.
No. 4	Fuel system diagnosis.
No. 5	Poor performance.
No. 6	Injector system diagnosis.
No. 7	EGR diagnosis.
No. 8	AIR management diagnosis.
No. 9	Canister purge control diagnosis.
No. 10	No cruise control.
No. 11a	Fuel Data display blank.
No. 11b	Fuel Data display incorrect (not blank).
No. 12	Diagnostic display.
No. 13	Improper idle speed.
No. 14	Oxygen sensor test.
No. 15	Improper coolant temperature operation.
No. 16	TCC electrical test.

TROUBLE CODE 13



TROUBLE CODE CHARTS

TROUBLE CODE 12



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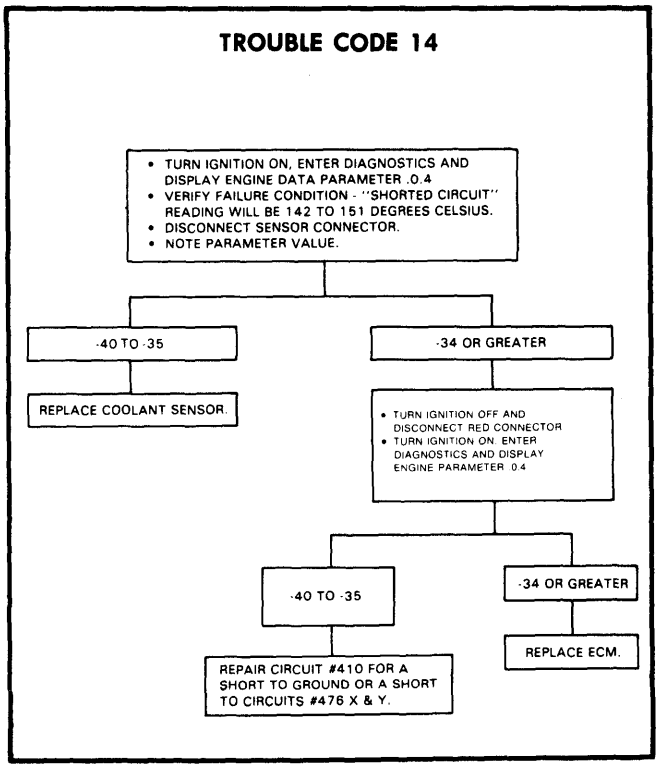

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MULTIPLE TROUBLE CODES

A-1 CONDITION: CODES 22, 32, AND 36 ALL STORED HARD.
CAUSE: LOSS OF "5 VOLT REFERENCE" VOLTAGE TO SENSORS.

CORRECTION

- VERIFY "CAUSE" BY DISCONNECTING THE MAP, BARO AND TPS SENSOR CONNECTORS AND MEASURING VOLTAGE BETWEEN CIRCUIT #474 AND GROUND ON EACH SENSOR HARNESS CONNECTOR.

0 VOLTS FOR ALL SENSORS	NOT 0 VOLTS FOR ALL SENSORS
• CHECK FOR AN OPEN OR SHORT TO GROUND IN CIRCUIT #474. • CHECK FOR A FAULTY ECM CONNECTOR OR FAULTY ECM.	CAUSE NOT VERIFIED. FOLLOW DIAGNOSTIC PROCEDURE FOR INDIVIDUAL CODES.

A-2 CONDITION: CODE 15 STORED HARD ALONG WITH HARD CODE 21, 26 OR 33.
CAUSE: OPEN IN "SENSOR GROUND" TO SENSORS.

CORRECTION

- VERIFY "CAUSE" BY DISCONNECTING THE COOLANT TEMP., TPS AND BARO SENSOR CONNECTORS AND MEASURING THE VOLTAGE BETWEEN 12 VOLTS AND CIRCUIT #476-X ON EACH SENSOR HARNESS CONNECTOR.

0 VOLTS FOR ALL SENSORS	NOT 0 VOLTS FOR ALL SENSORS
• CHECK FOR AN OPEN IN CIRCUIT #476-X. • CHECK FOR A FAULTY ECM CONNECTOR OR FAULTY ECM.	CAUSE NOT VERIFIED. FOLLOW DIAGNOSTIC PROCEDURE FOR INDIVIDUAL CODES.

A-3 CONDITION: CODE 38 STORED HARD ALONG WITH A HARD CODE 33, 34 OR A VERY LOW OUTSIDE TEMP DISPLAY.
CAUSE: OPEN IN "SENSOR GROUND" TO SENSORS.

CORRECTION

- VERIFY "CAUSE" BY DISCONNECTING THE MAT, MAP AND OUTSIDE TEMP SENSOR CONNECTORS AND MEASURING THE VOLTAGE BETWEEN 12 VOLTS AND CIRCUIT #476-Y ON EACH SENSOR HARNESS CONNECTOR.

0 VOLTS FOR ALL SENSORS	NOT 0 VOLTS FOR ALL SENSORS
• CHECK FOR AN OPEN IN CIRCUIT #476-Y. • CHECK FOR A FAULTY ECM CONNECTOR OR FAULTY ECM.	CAUSE NOT VERIFIED. FOLLOW DIAGNOSTIC PROCEDURE FOR INDIVIDUAL CODES.

WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND VERIFY PROPER OPERATION.

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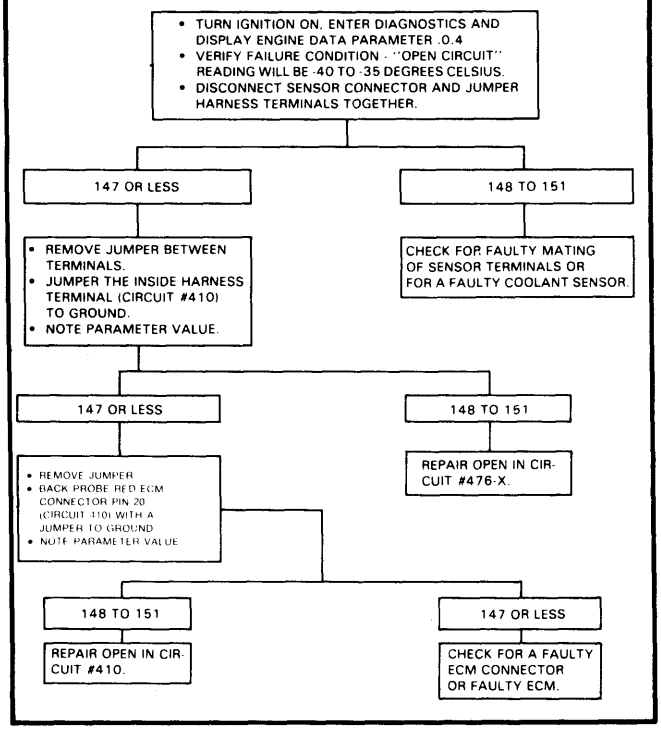
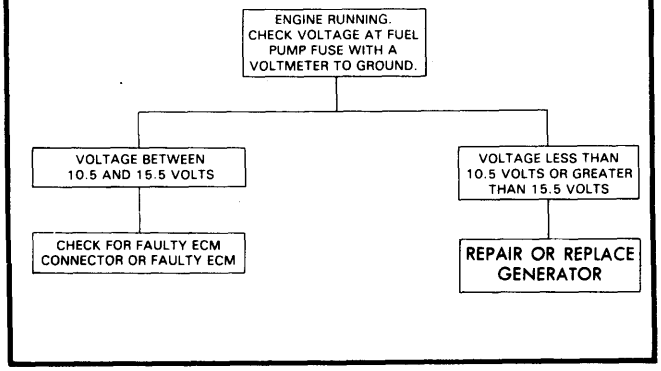
TROUBLE CODE 15

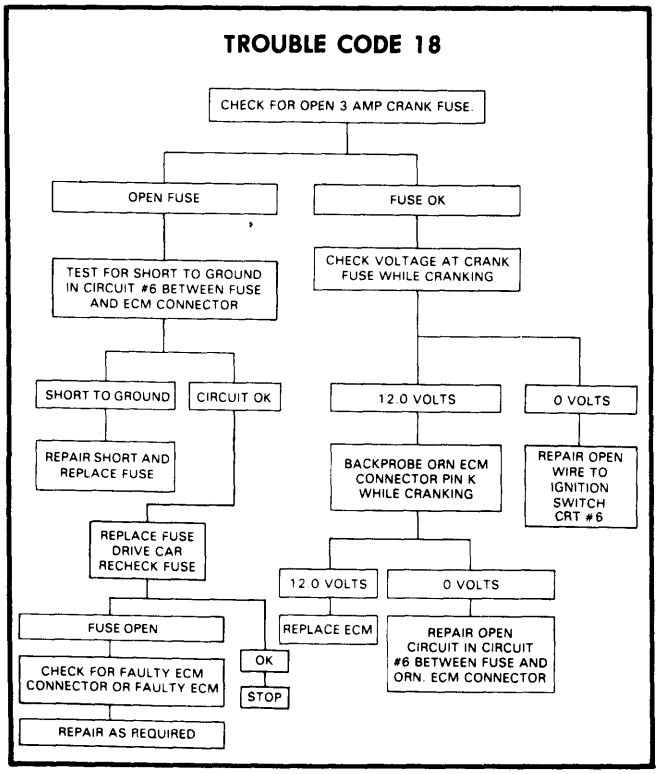
NOTE: If a hard code 21, 26 or 33 is stored along with a hard code 15, follow chart A-2 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



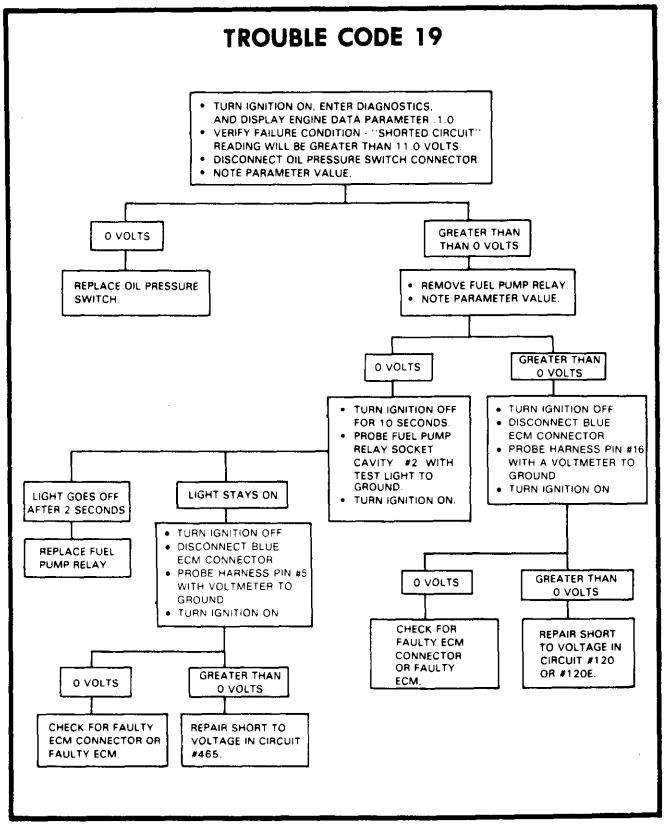
TROUBLE CODE 16



TROUBLE CODE 18

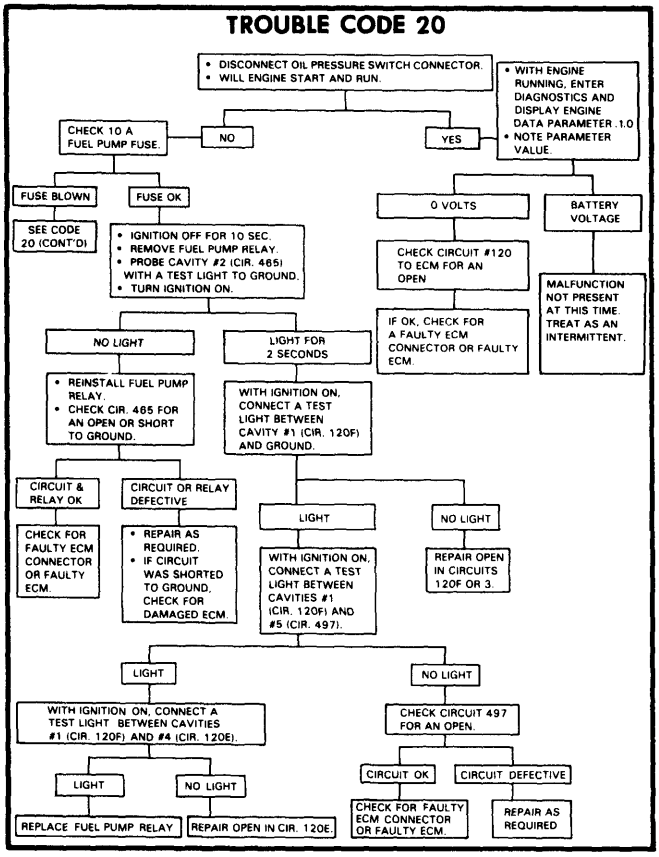


TROUBLE CODE 19

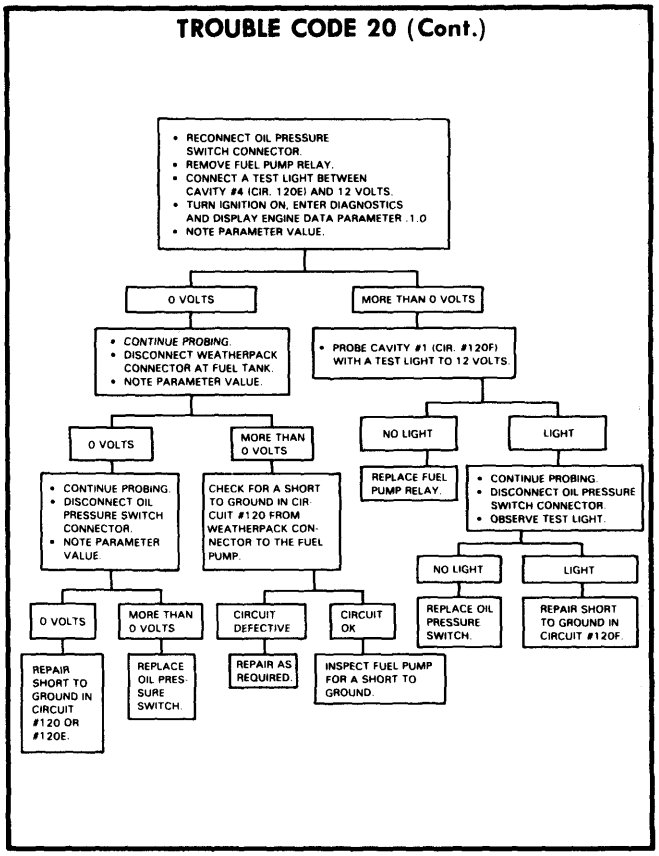


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

TROUBLE CODE 20

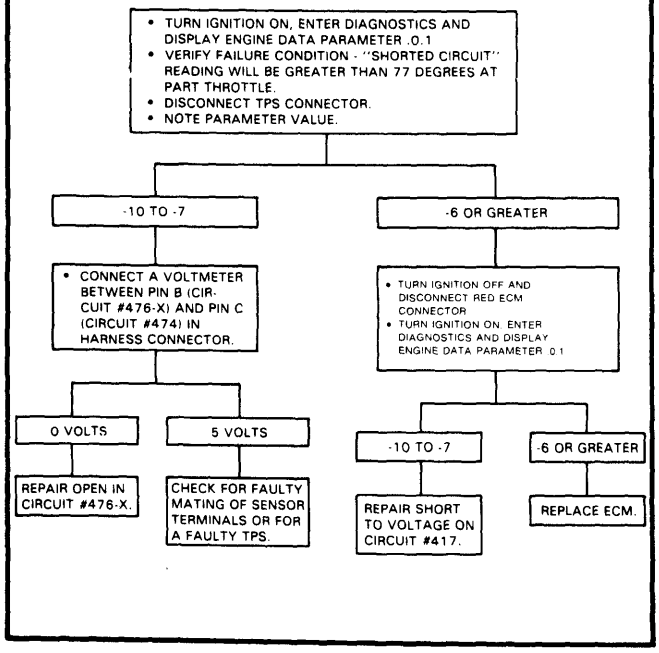


TROUBLE CODE 20 (Cont.)



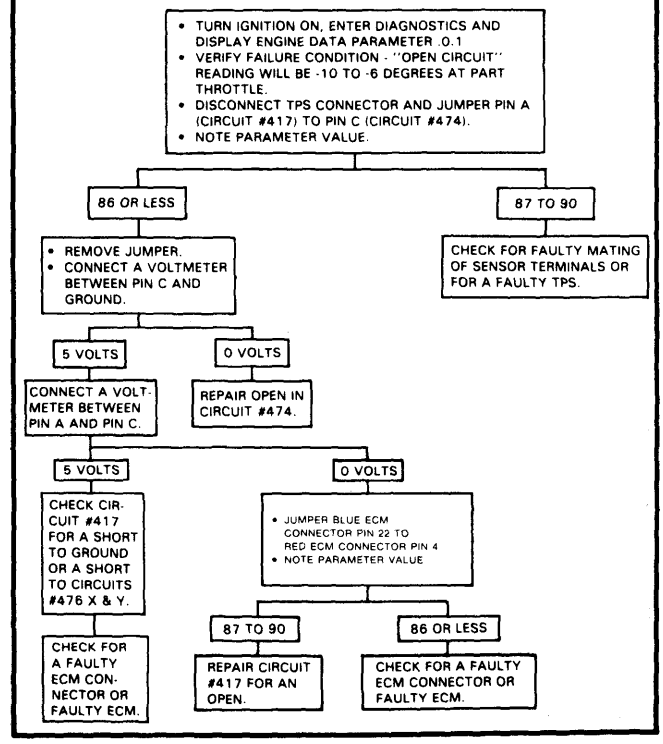
TROUBLE CODE 21

NOTE: If a hard code 15 is stored along with a hard code 21, follow chart A-2 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



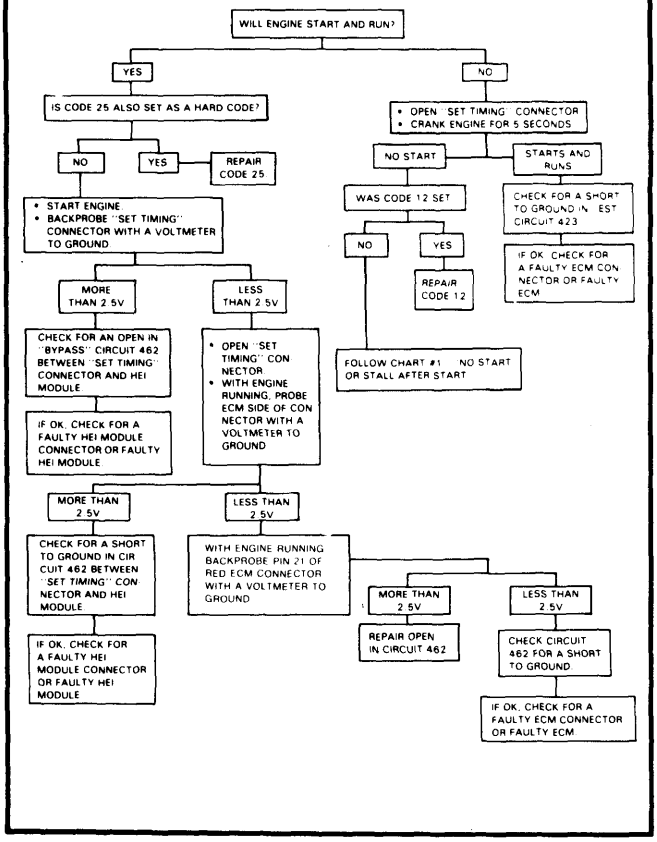
TROUBLE CODE 22

NOTE: If hard codes 32 and 36 are stored along with a hard code 22, follow chart A-1 in "MULTIPLE TROUBLE CODES" chart before using this procedure.

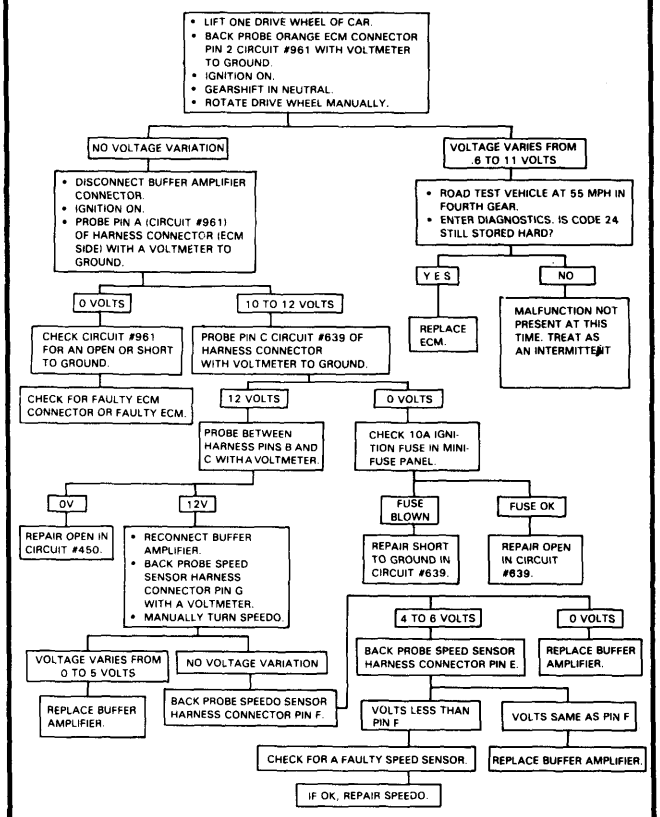


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

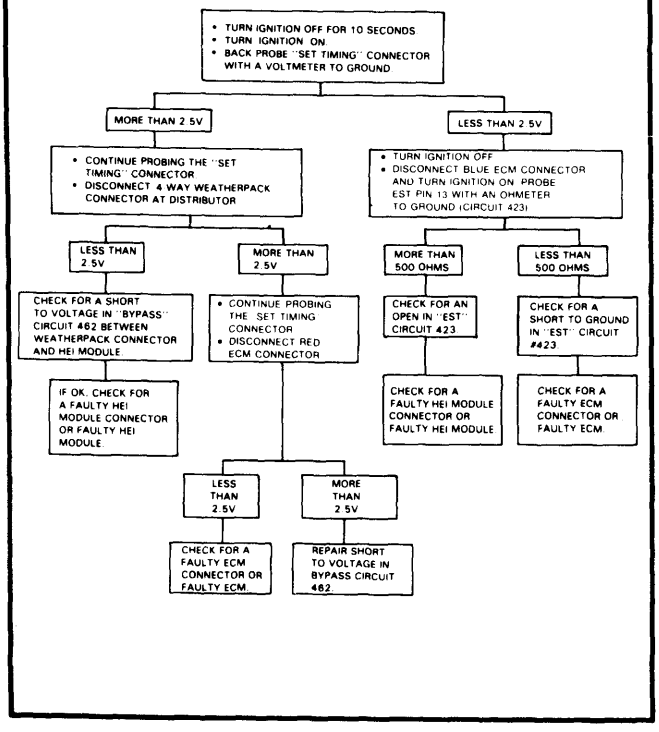
TROUBLE CODE 23



TROUBLE CODE 24

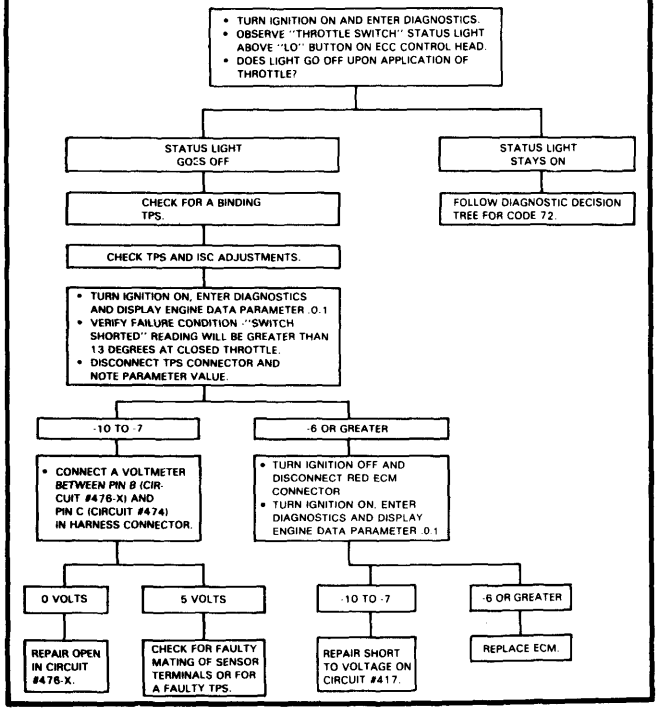


TROUBLE CODE 25



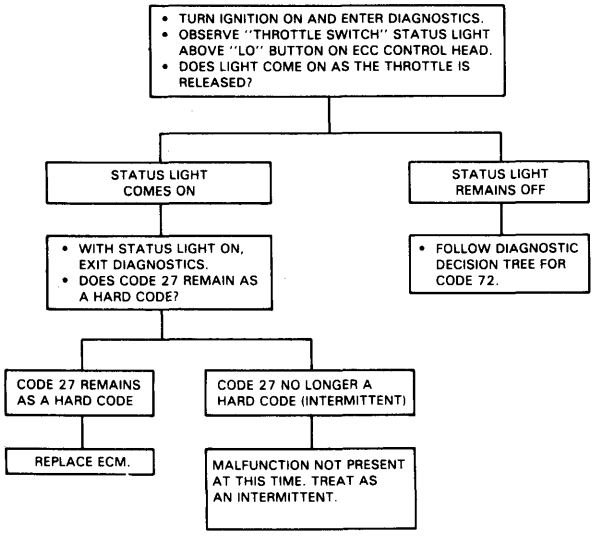
TROUBLE CODE 26

NOTE: If a hard code 15 is stored along with a hard code 26, follow chart A-2 in "MULTIPLE TROUBLE CODES" chart before using this procedure.

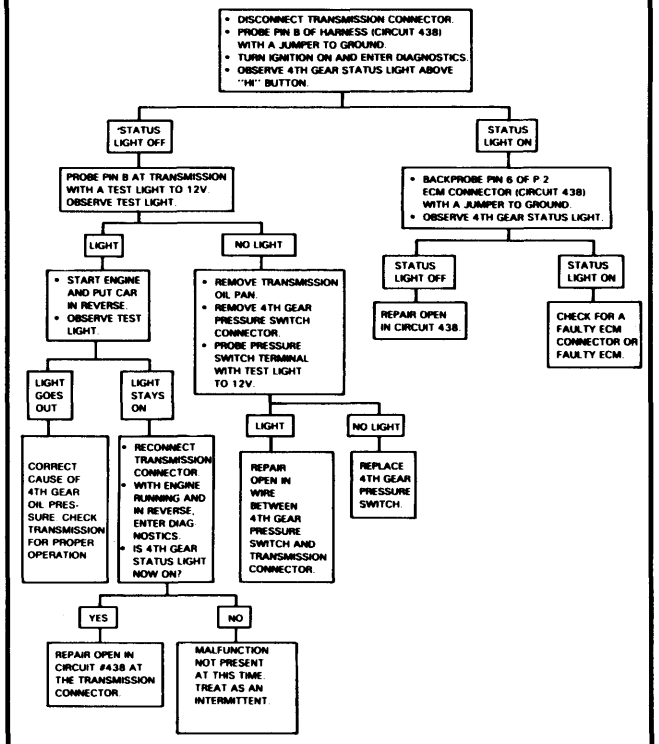


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

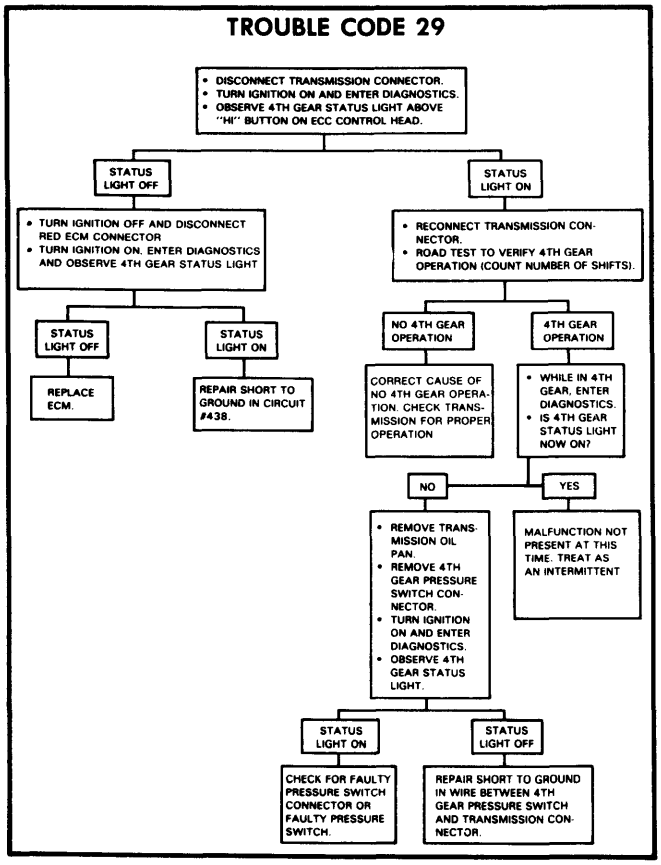
TROUBLE CODE 27



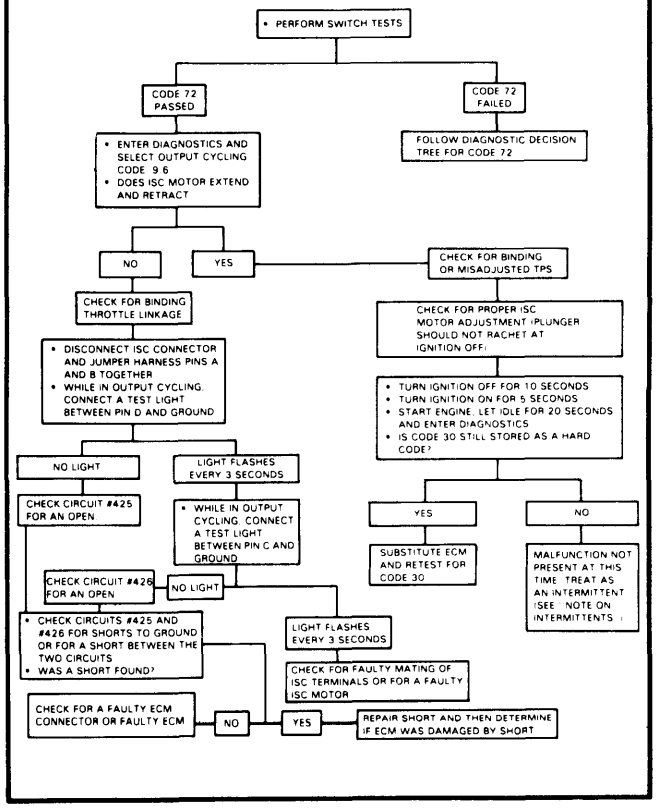
TROUBLE CODE 28



TROUBLE CODE 29

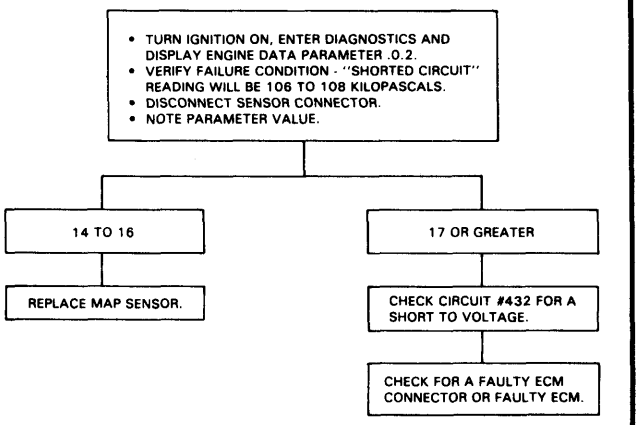


TROUBLE CODE 30



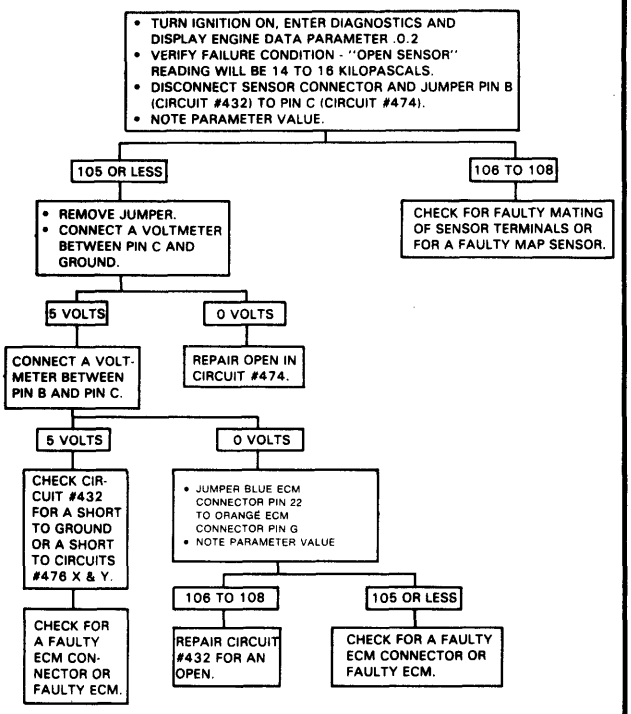
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

TROUBLE CODE 31



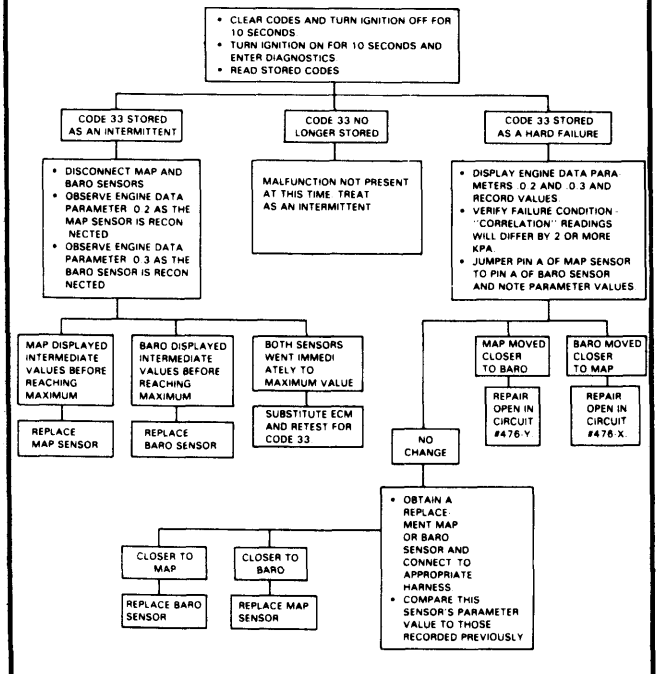
TROUBLE CODE 32

NOTE: If codes 22 and 36 are stored hard along with a hard code 32, follow A-1 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



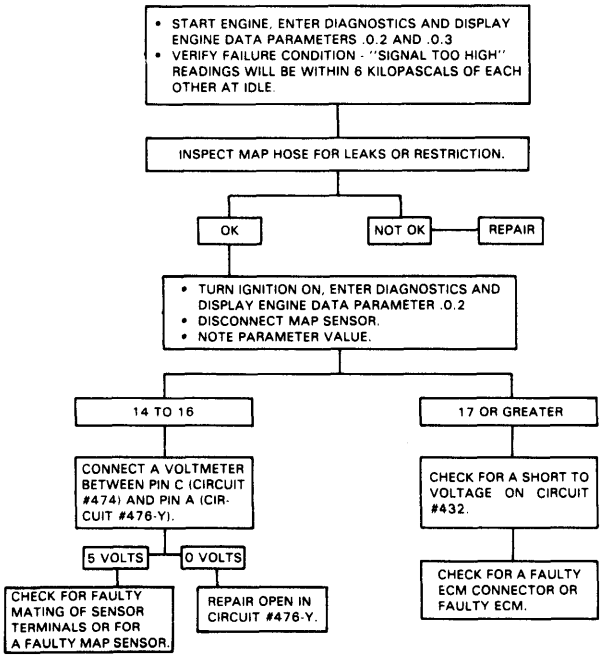
TROUBLE CODE 33

NOTE: If a hard code 15 or 38 is stored along with a hard code 33, follow chart A-2 or A-3 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



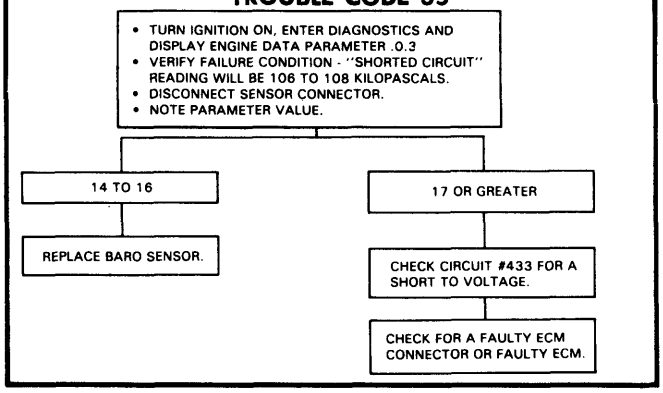
TROUBLE CODE 34

NOTE: If a hard code 38 is stored along with a hard code 34, follow chart A-3 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



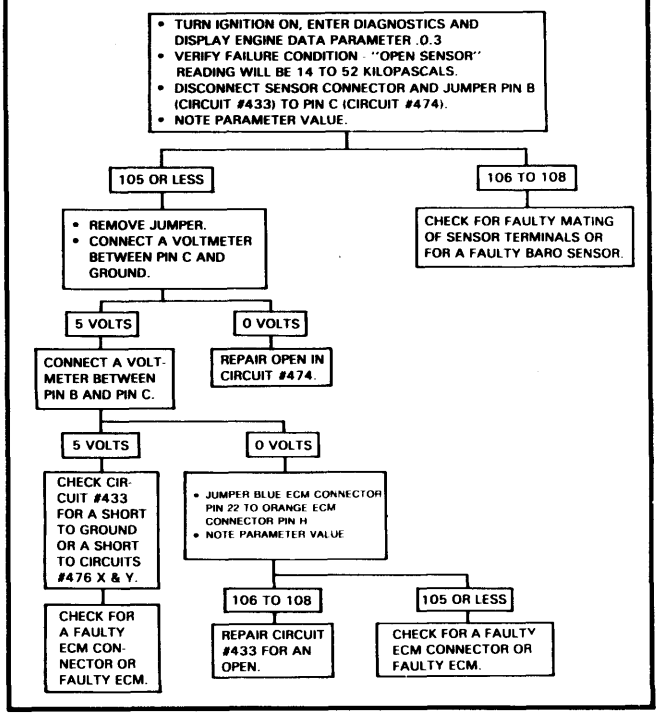
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

TROUBLE CODE 35

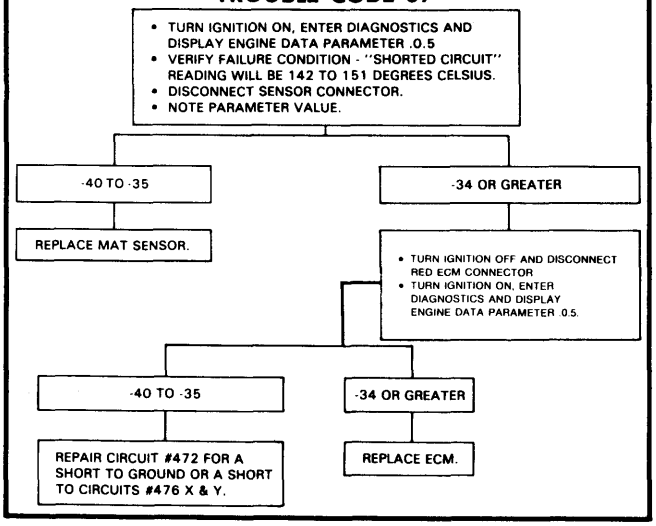


TROUBLE CODE 36

NOTE: If codes 22 and 32 are stored hard along with a hard code 36, follow chart A-1 in "MULTIPLE TROUBLE CODES" chart before using this procedure.

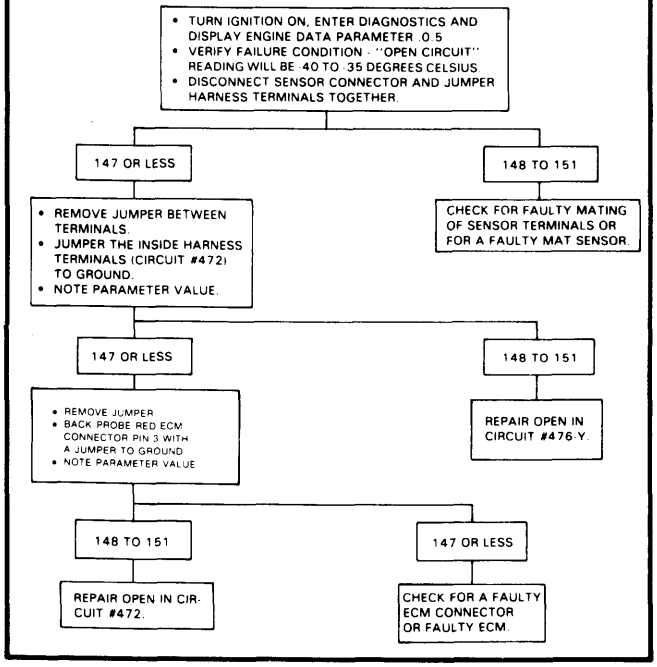


TROUBLE CODE 37



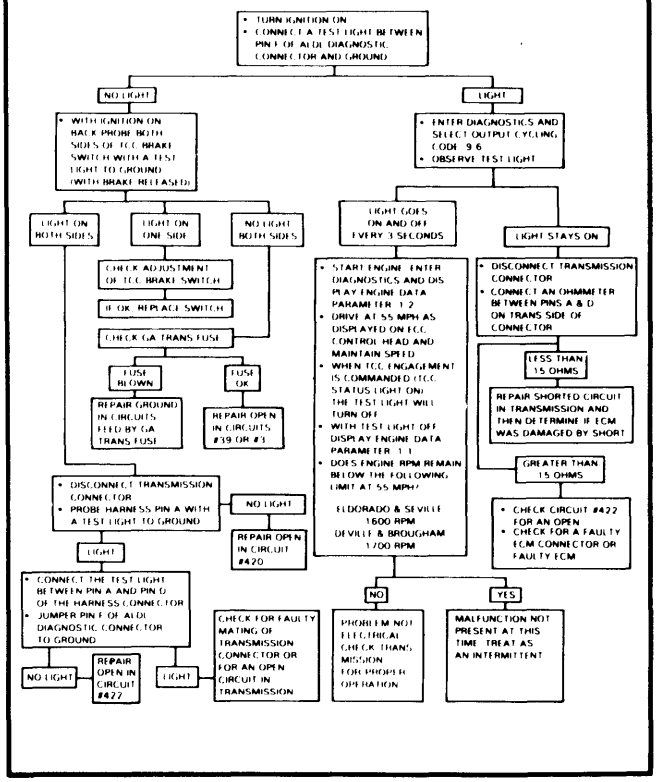
TROUBLE CODE 38

NOTE: If a hard code 33 or 34 is stored or an outside temperature of −36°F is displayed along with a hard code 38, follow chart A-2 or A-3 in "MULTIPLE TROUBLE CODES" chart before using this procedure.



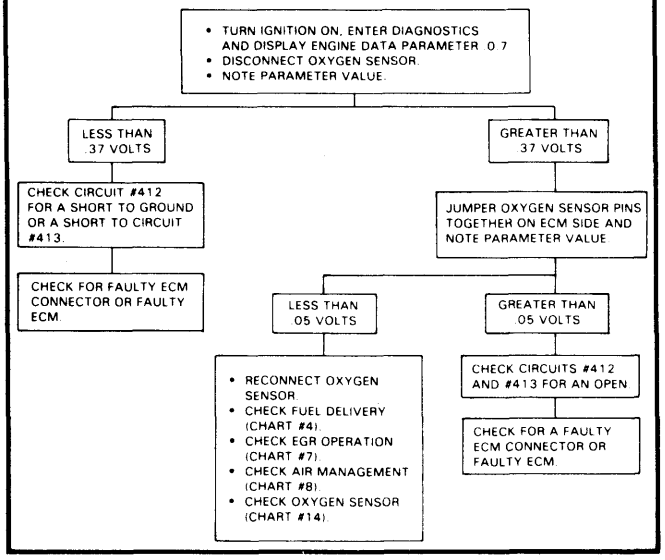
TROUBLE CODE 39

NOTE: DO NOT use this procedure if a code 21, 22 or 24 is stored hard.



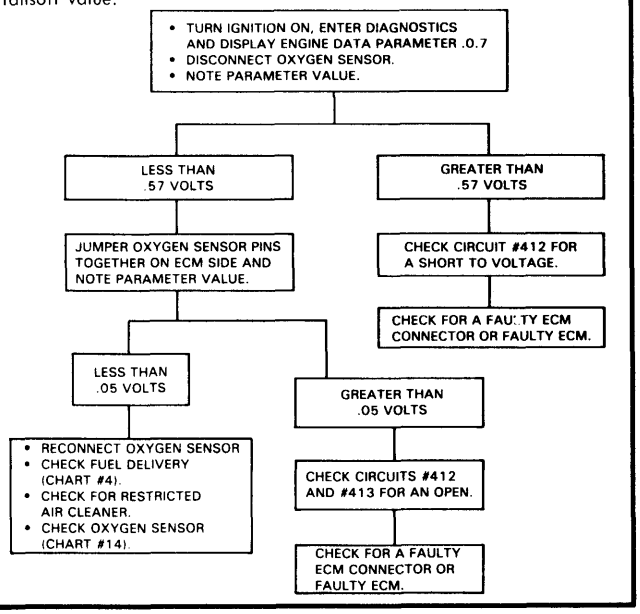
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

TROUBLE CODE 44



TROUBLE CODE 45

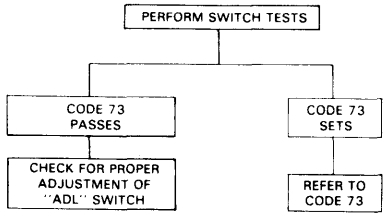
NOTE: If codes 31, 32, 33 or 34 are also stored, DO NOT follow this procedure until they have been corrected. After making the necessary corrections, clear codes and determine if code 45 was set due to the MAP failsoft value.



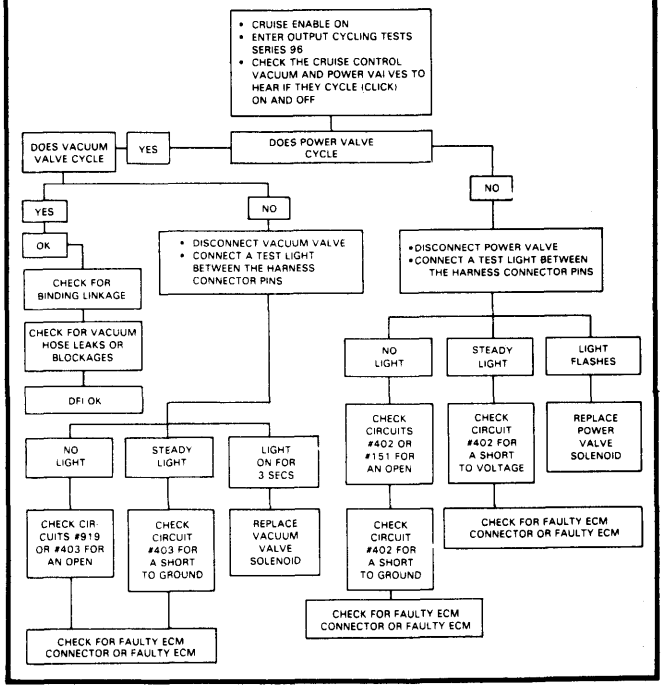
TROUBLE CODE 51

Indicates that calibration PROMs are not being read properly by the ECM. Check PROM installation (backwards, bent or missing pins). Replace as needed. If installed properly, turn ignition off for 10 seconds and check for code 51. If code remains, replace PROMs. Repeat procedure and check for code 51 again. If code remains after replacing PROMs, replace ECM.

TROUBLE CODE 60

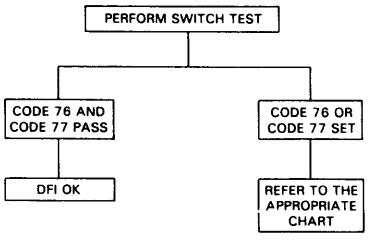


TROUBLE CODE 63

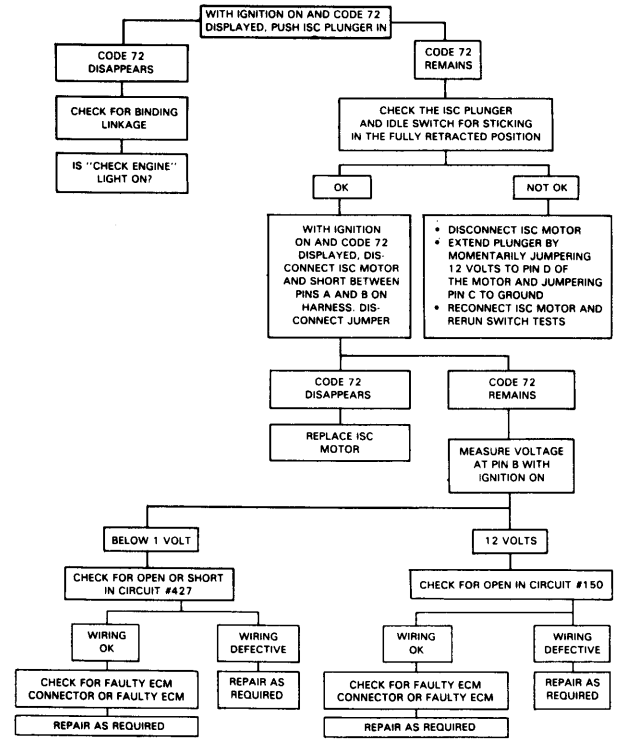


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

TROUBLE CODE 67

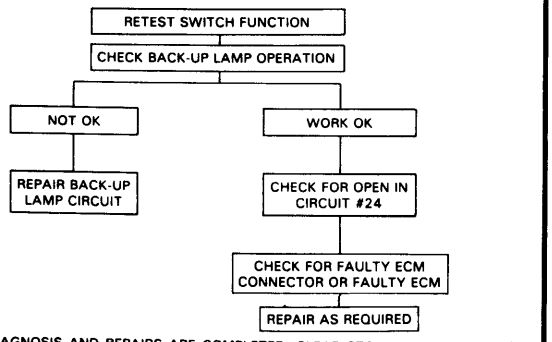


TROUBLE CODE 72



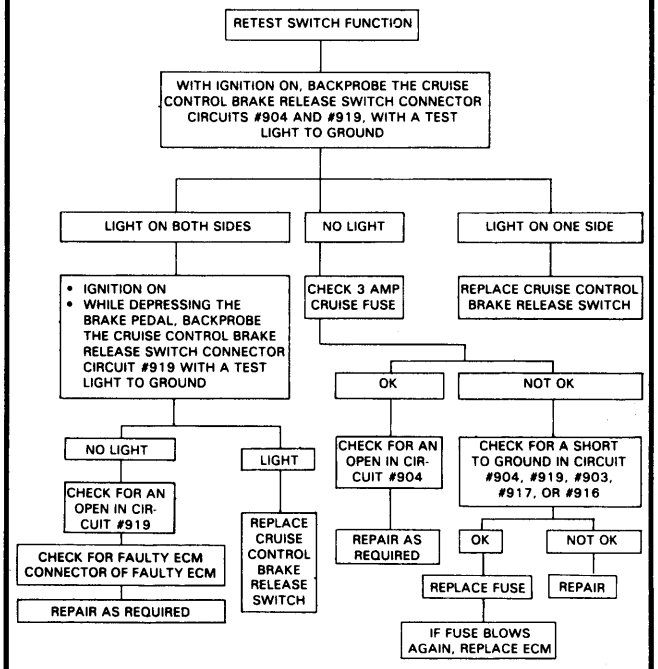
WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

TROUBLE CODE 74



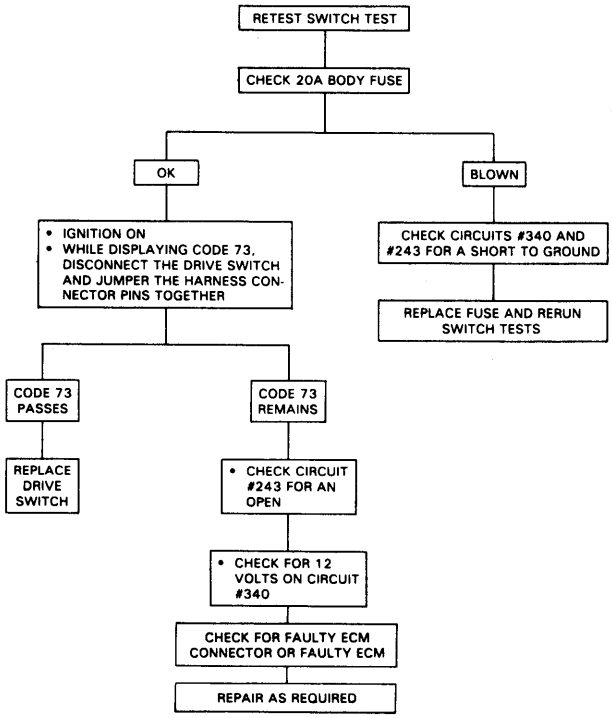
WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

TROUBLE CODE 71



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

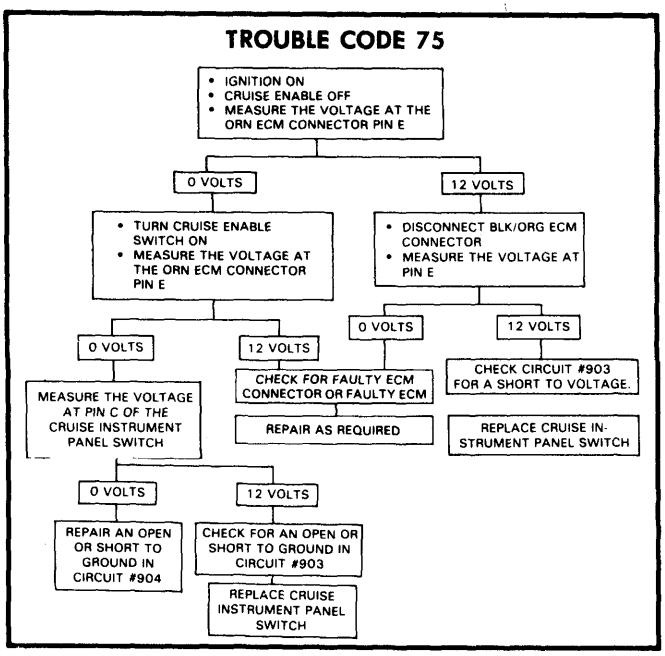
TROUBLE CODE 73



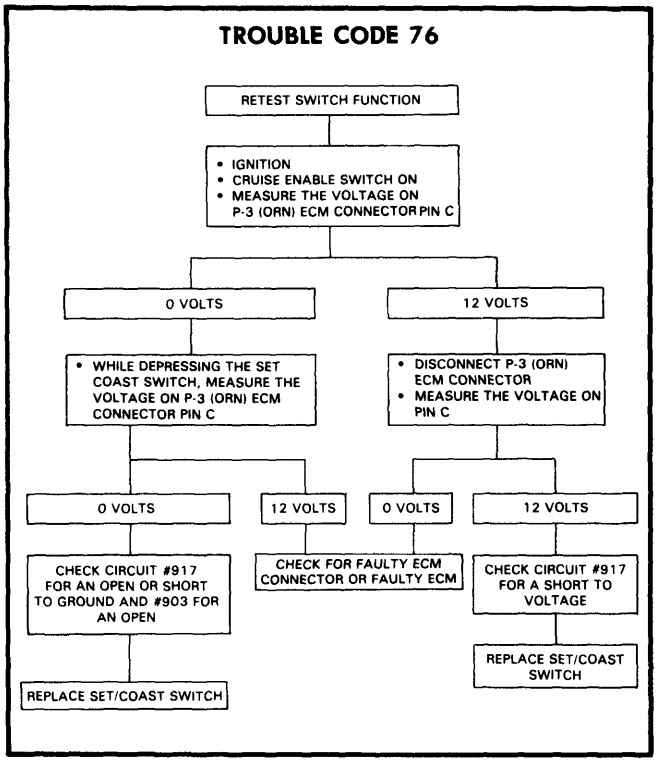
WHEN ALL DIAGNOSIS AND REPAIRS ARE COMPLETED, CLEAR STORED CODES AND ROAD TEST VEHICLE. CHECK FOR NEW CODES.

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

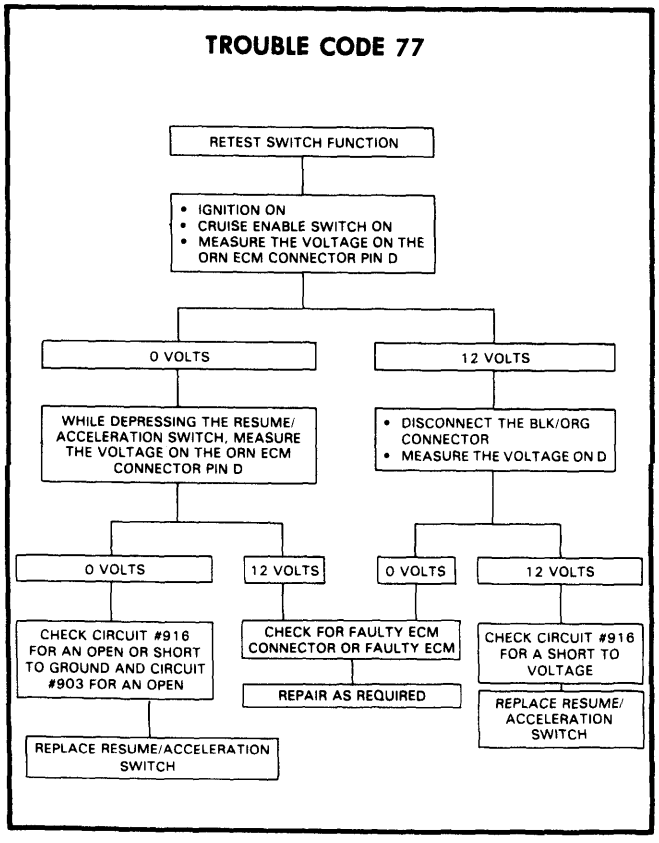
TROUBLE CODE 75



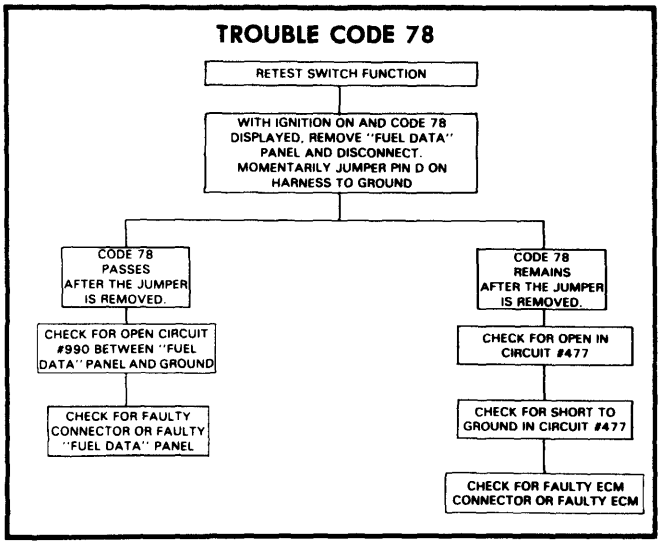
TROUBLE CODE 76



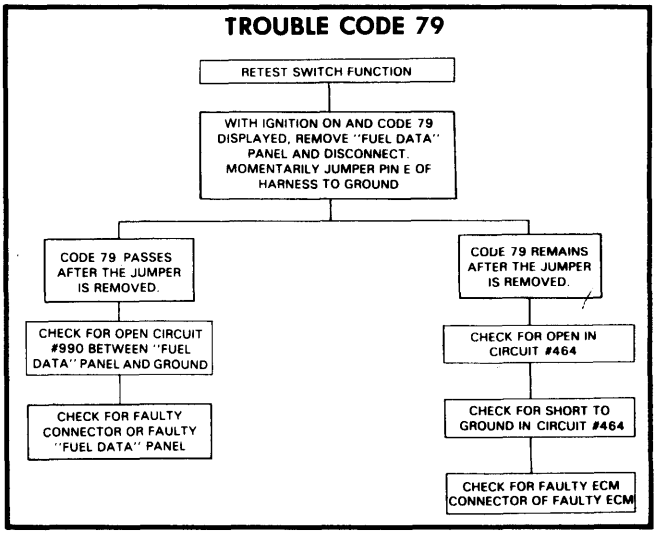
TROUBLE CODE 77

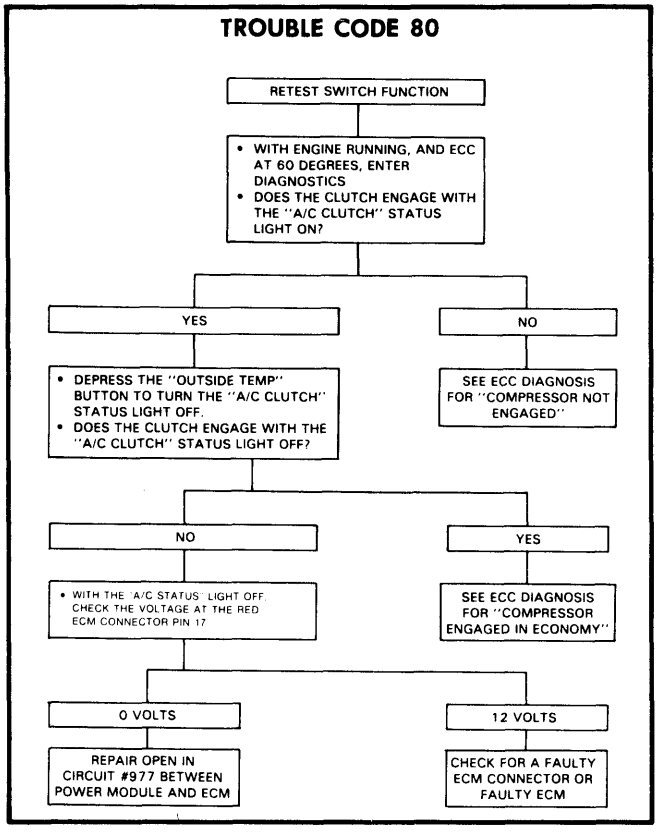


TROUBLE CODE 78



GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)





GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

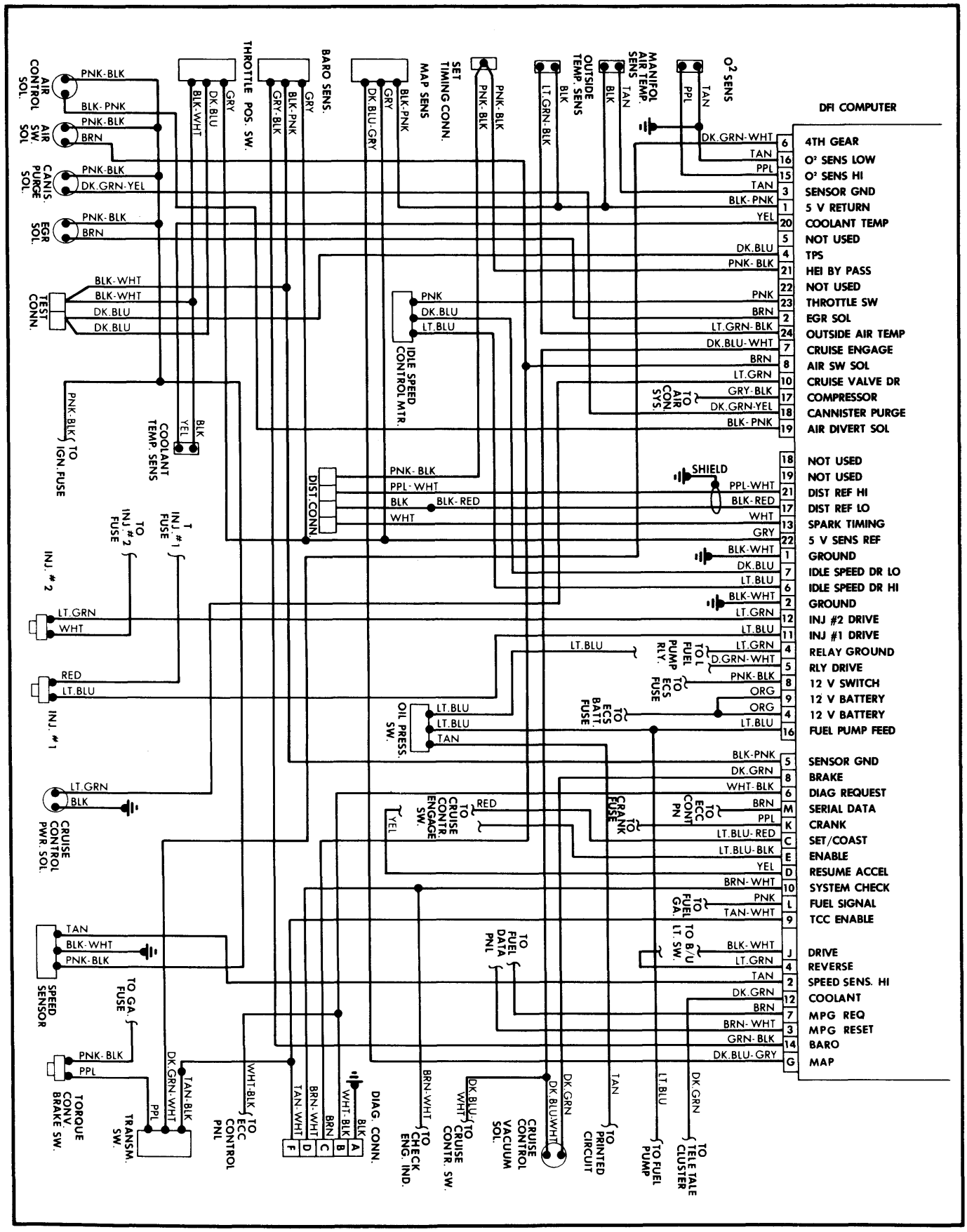
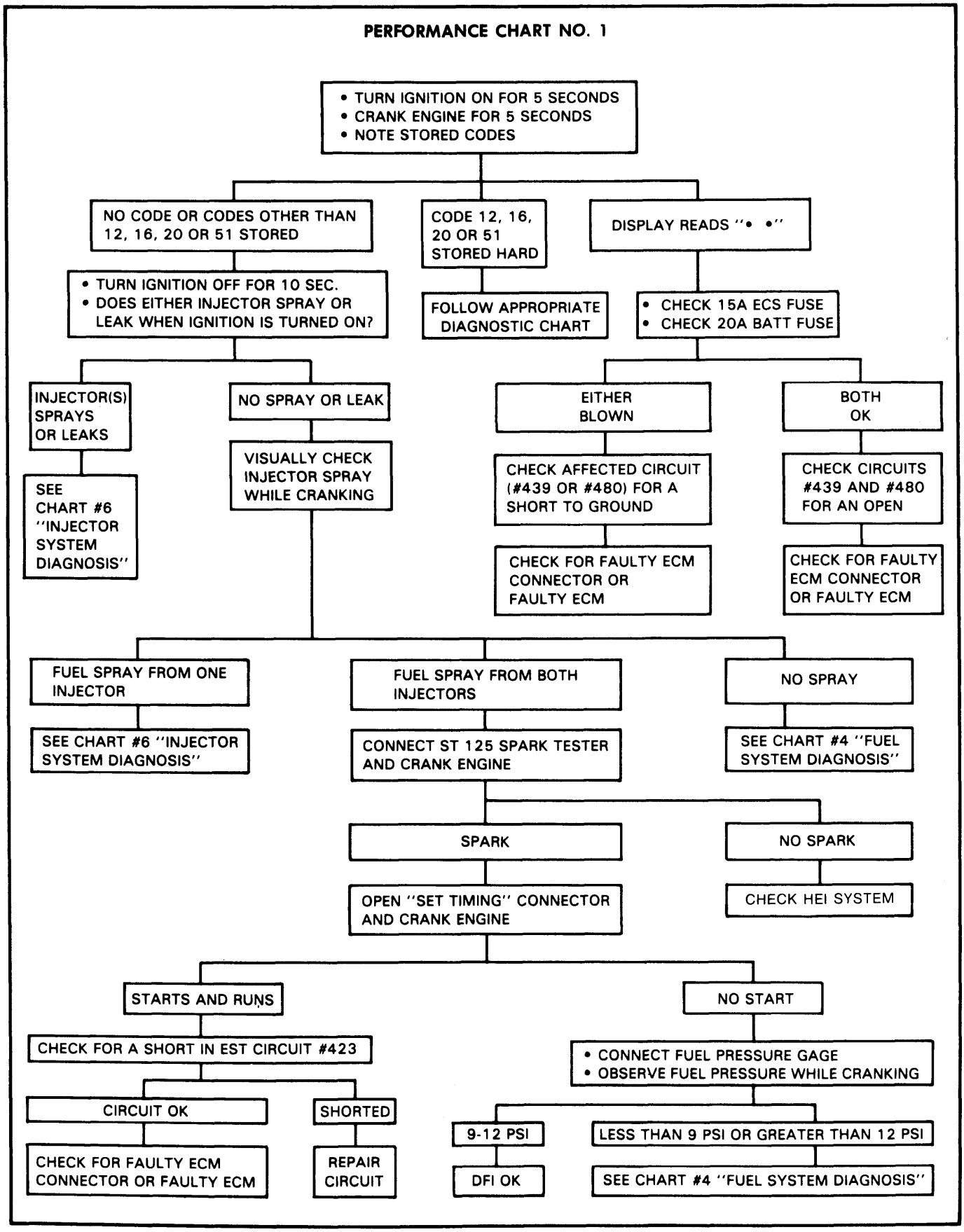


Fig. 4 Cadillac DFI Control System Wiring Diagram

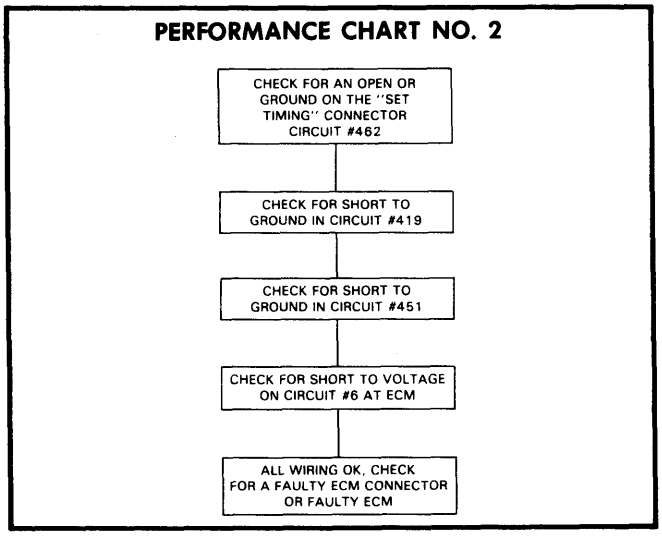
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHARTS

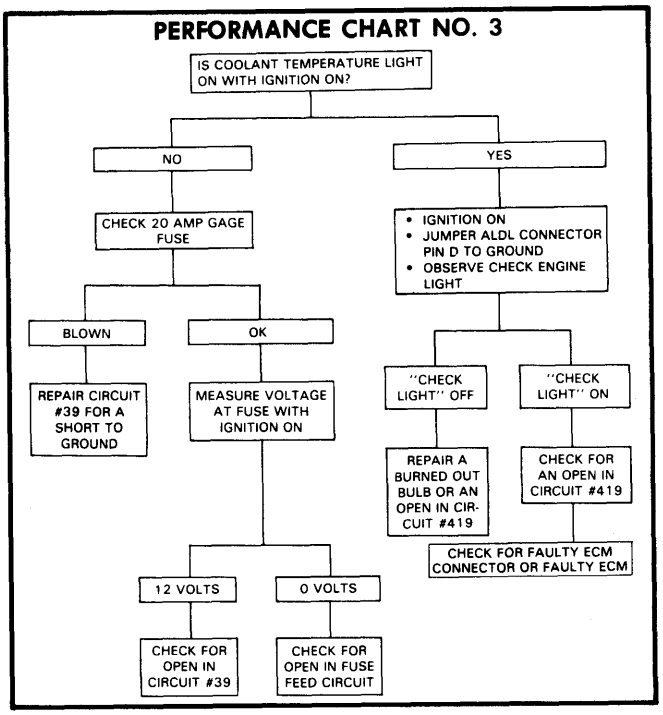


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

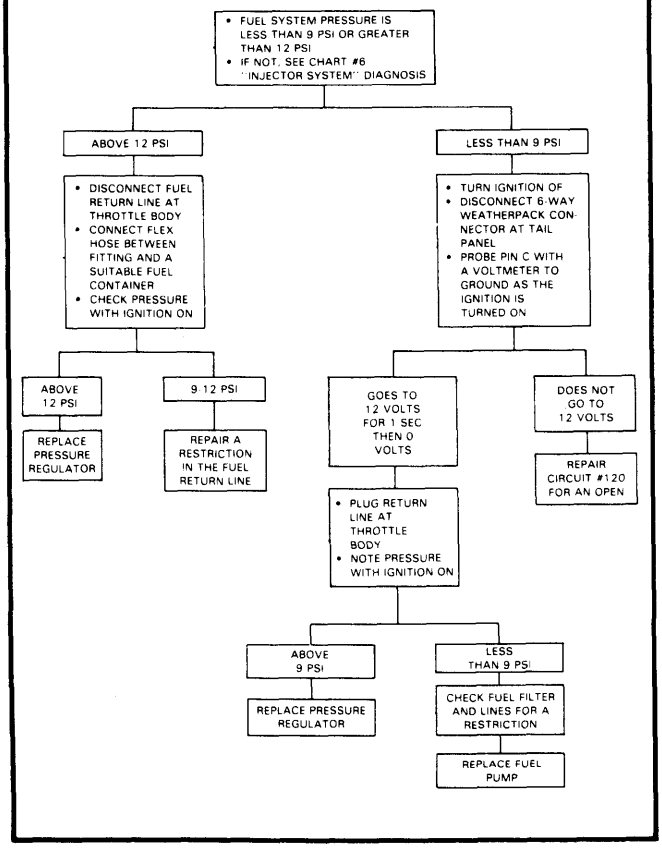
PERFORMANCE CHART NO. 2



PERFORMANCE CHART NO. 3

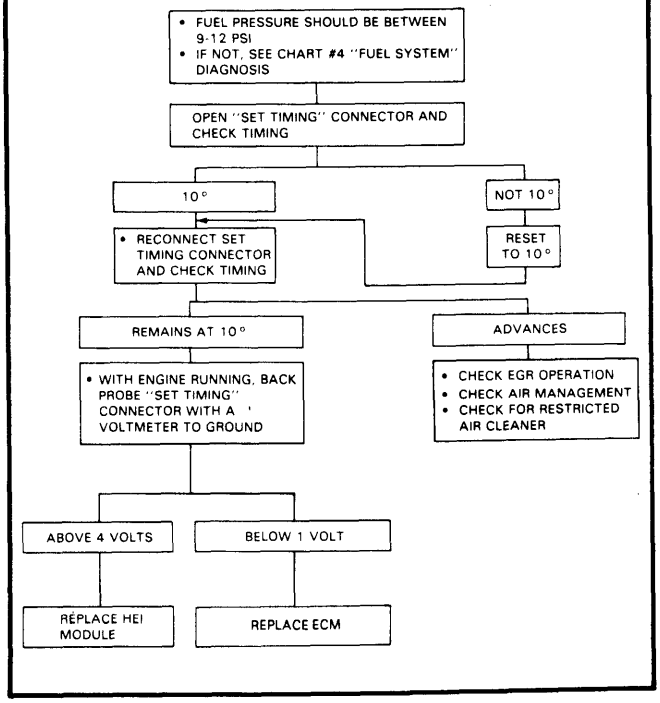


PERFORMANCE CHART NO. 4

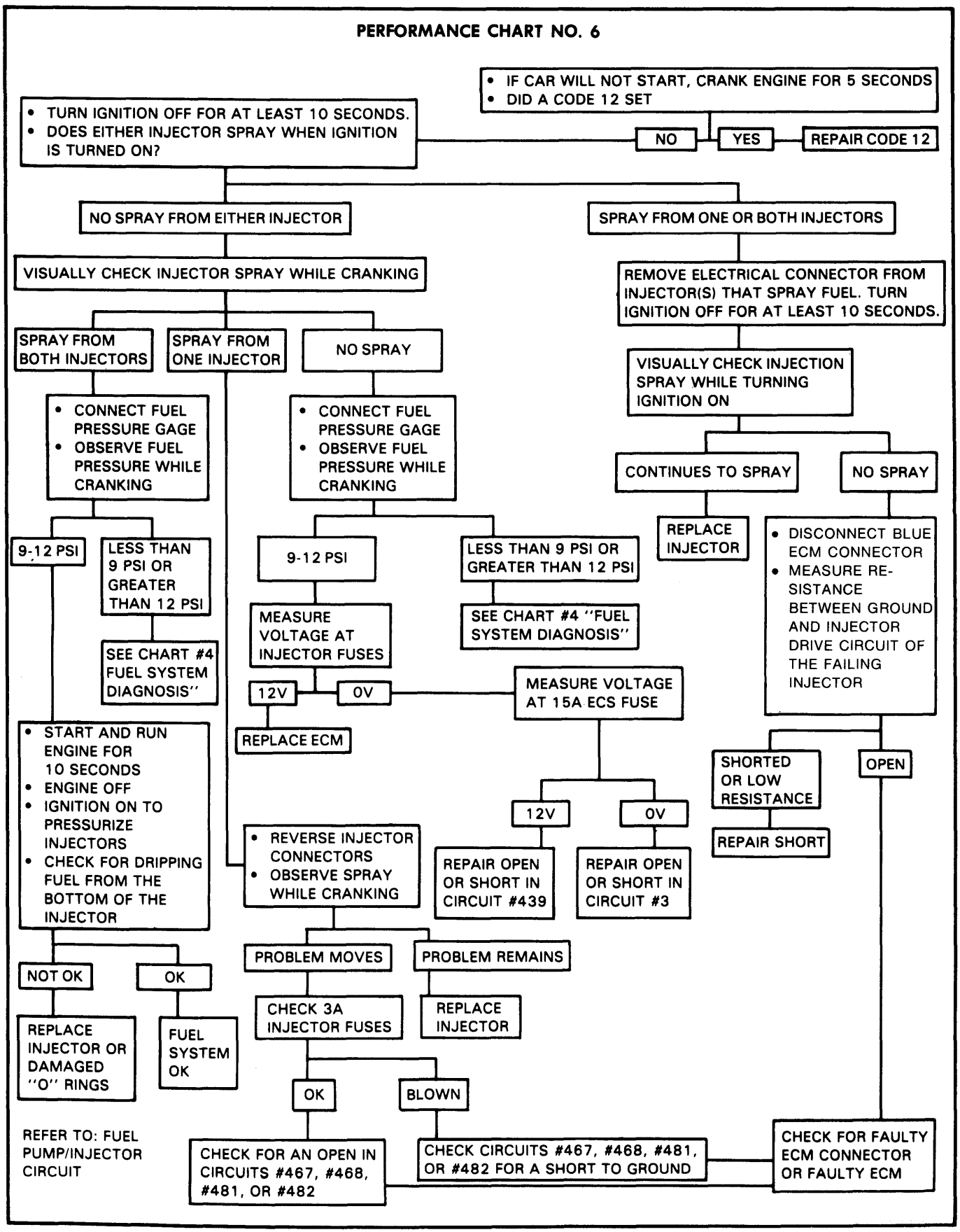


PERFORMANCE CHART NO. 5

NOTE: Repair all hard diagnostic codes before following this procedure.

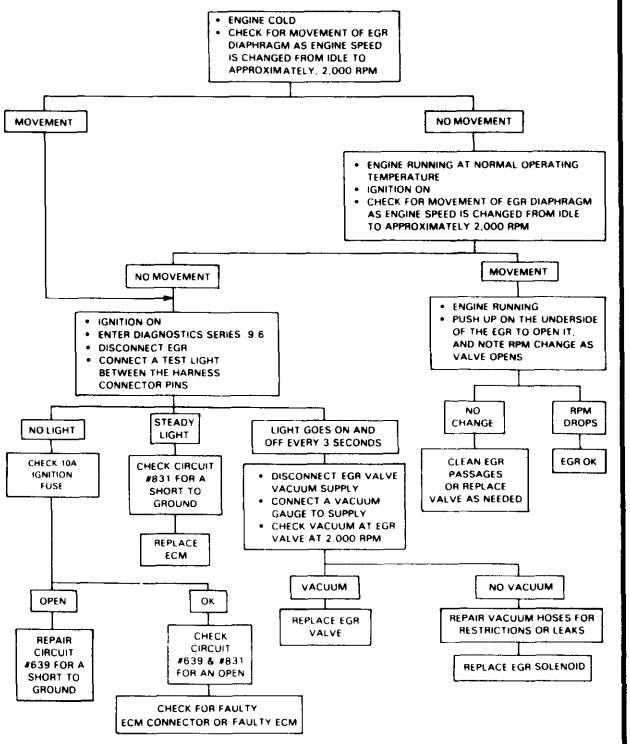


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

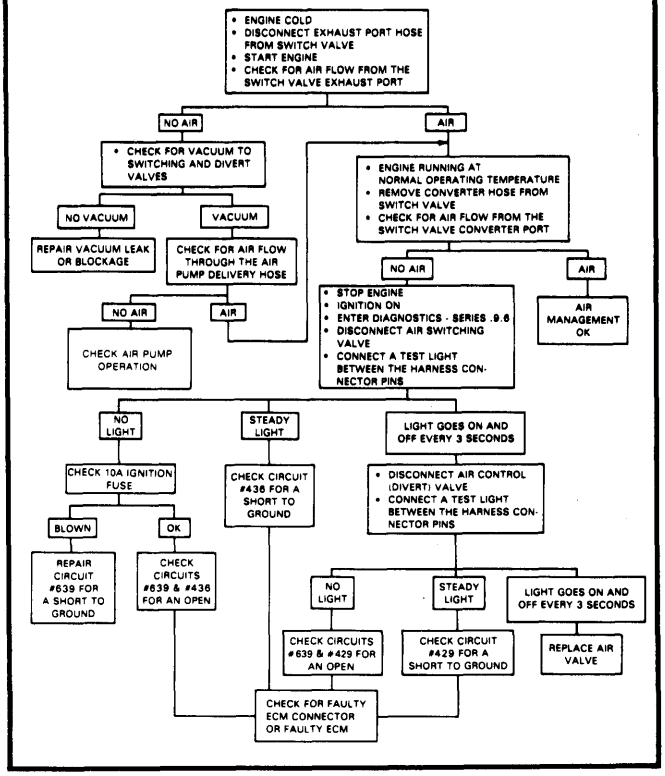


GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

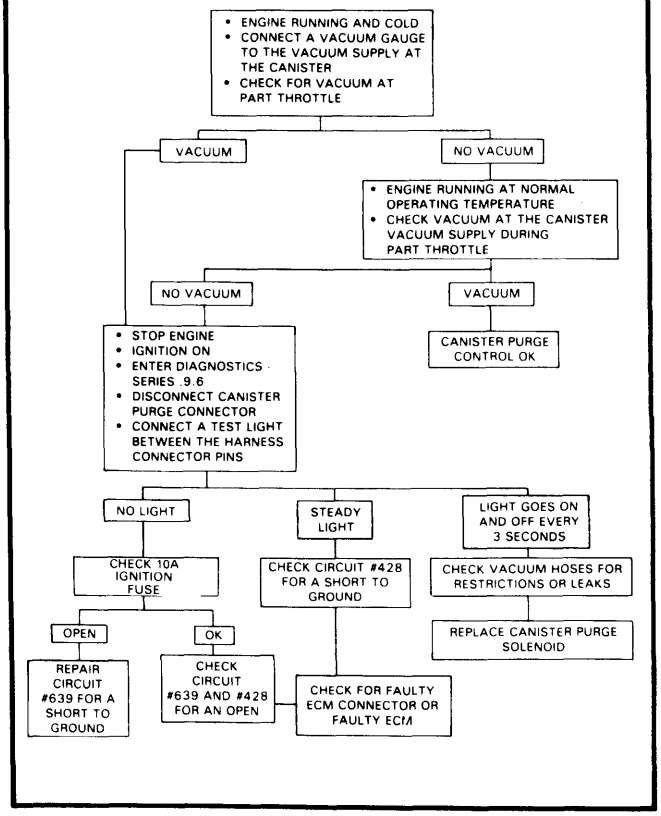
PERFORMANCE CHART NO. 7



PERFORMANCE CHART NO. 8

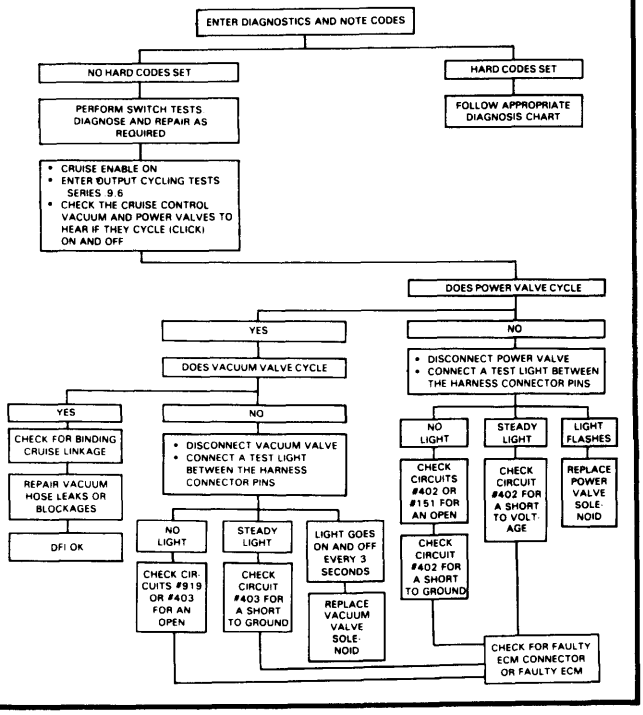


PERFORMANCE CHART NO. 9



PERFORMANCE CHART NO. 10

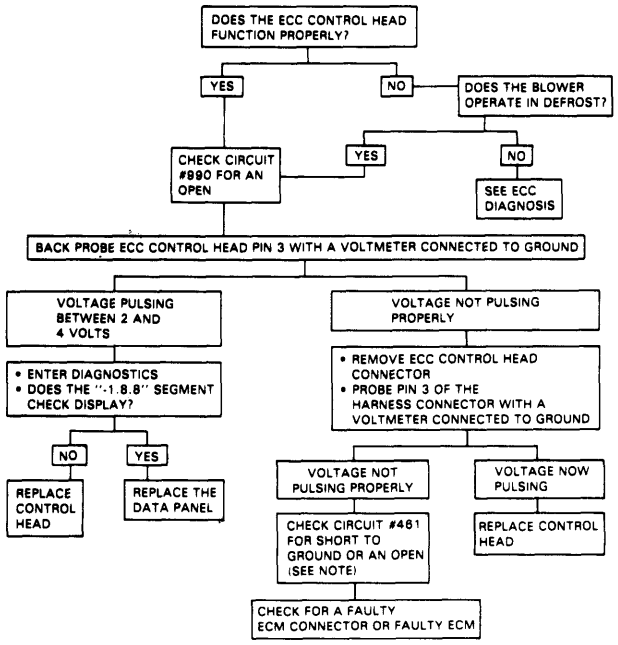
NOTE: Intermittent settings of codes 24 or 67 will disable cruise control operation during ignition cycle in which they occur.



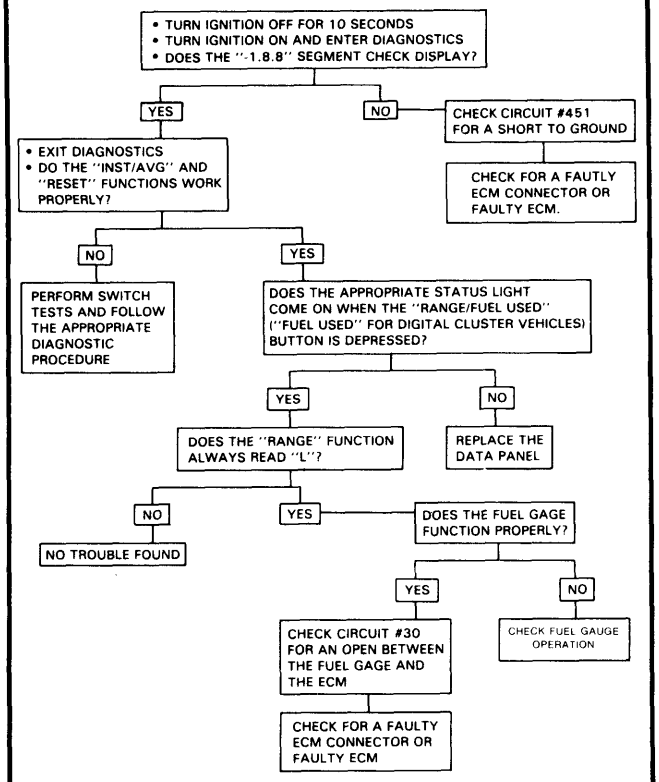
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 11a

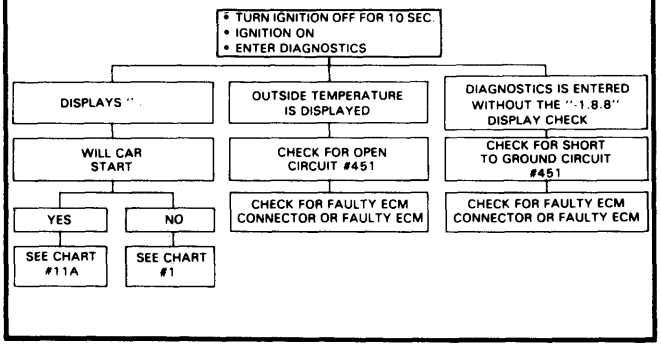
NOTE: On vehicles with digital cluster, branch of circuit #461 between cluster and ECC control head need only be checked for a short to ground.



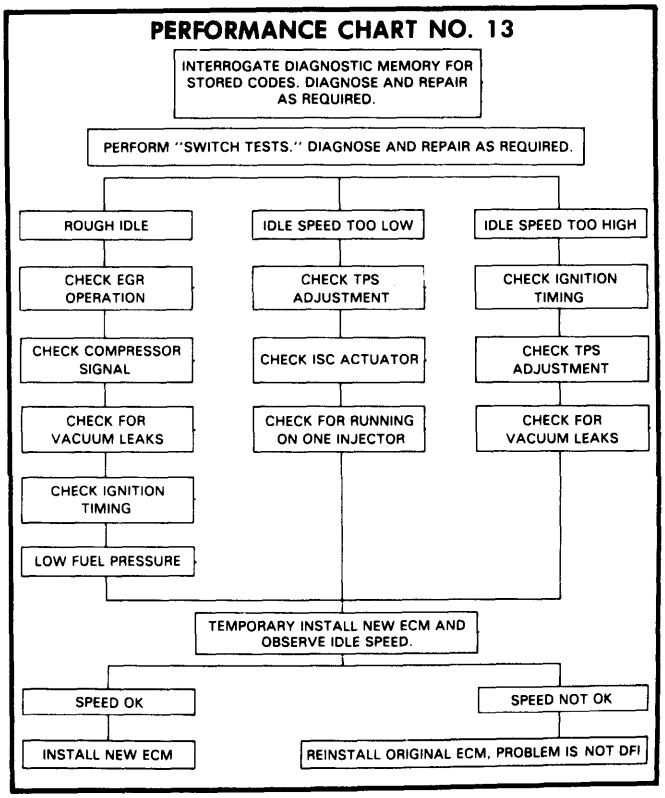
PERFORMANCE CHART NO. 11b



PERFORMANCE CHART NO. 12



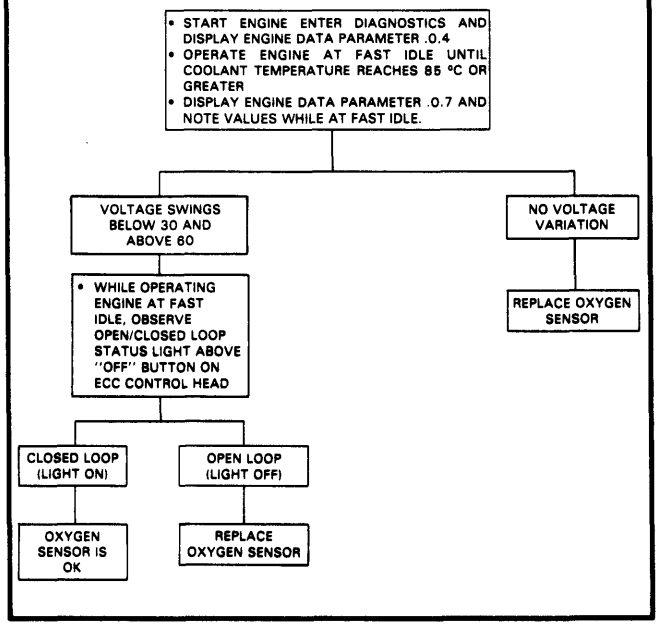
PERFORMANCE CHART NO. 13



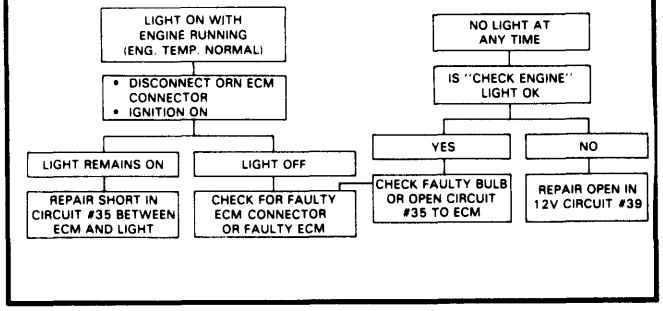
GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 14

NOTE: Repair all hard codes, other than 13, 44 or 45, before using this procedure. If codes 13, 44 or 45 have been set, then follow the appropriate diagnostic chart to verify that the ECM, harness and fuel system operate properly before replacing the oxygen sensor.



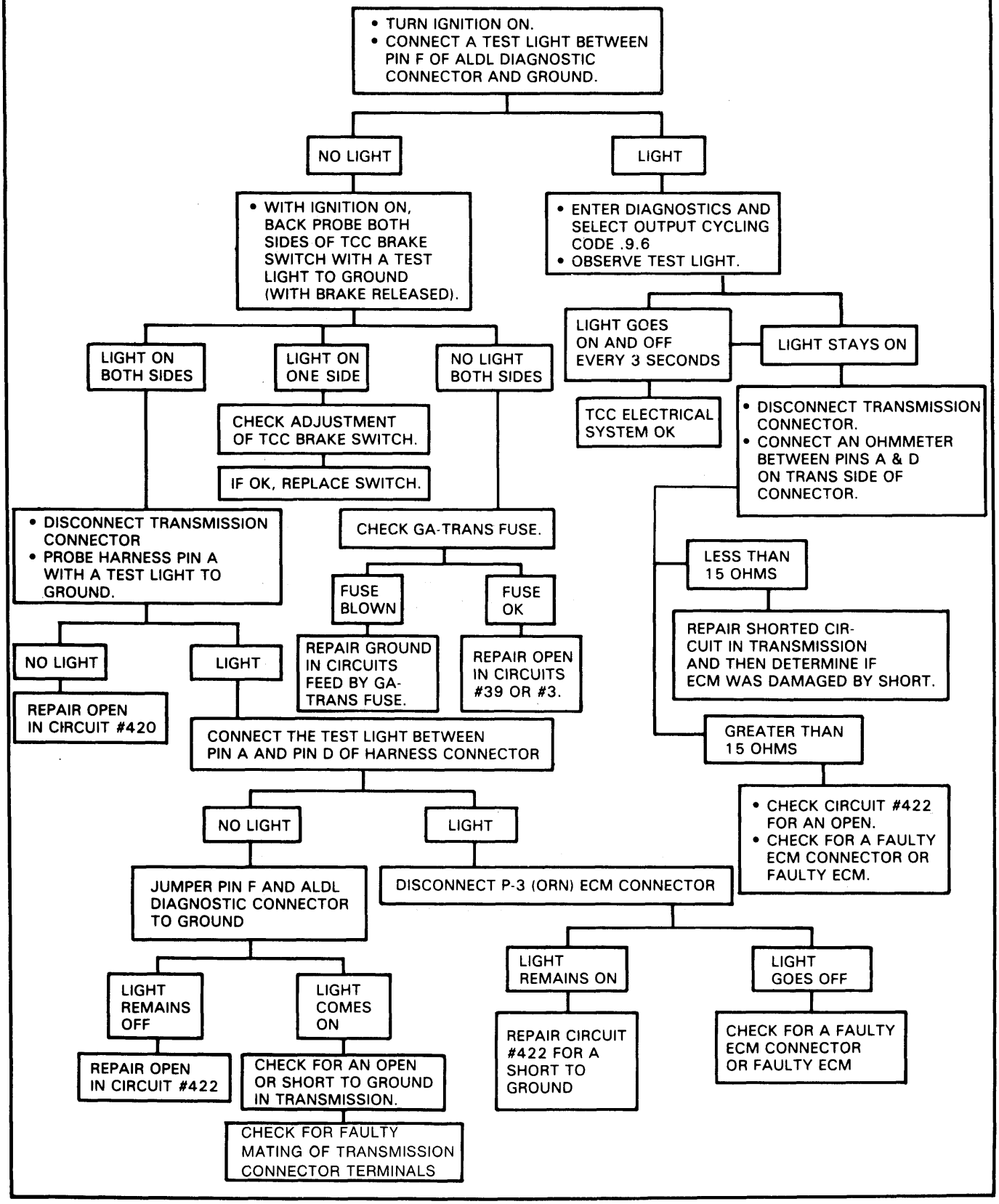
PERFORMANCE CHART NO. 15



GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

PERFORMANCE CHART NO. 16

NOTE: This procedure MUST NOT be followed if a code 21, 22 or 24 is stored hard.



GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

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.

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. 5.*

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 wih 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.

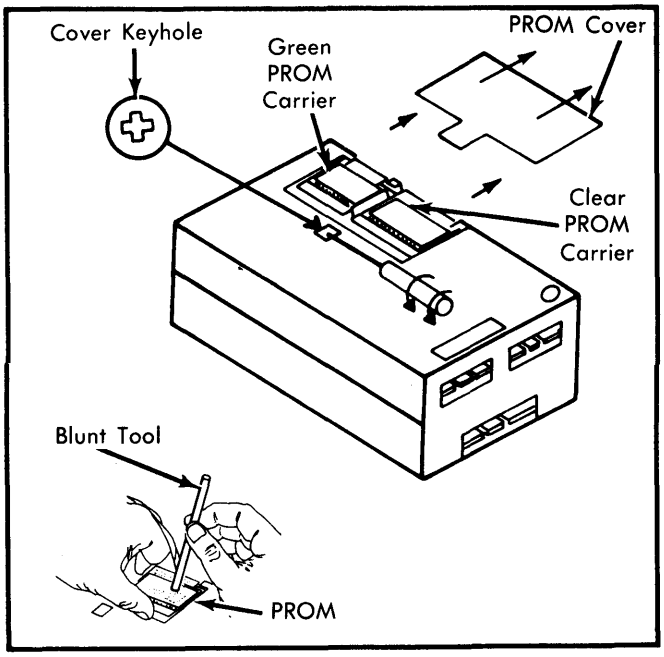


Fig. 5 Installing PROM into Electronic Control Module

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 connecter. 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 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.

GENERAL MOTORS DFI CONTROL SYSTEM (Cont.)

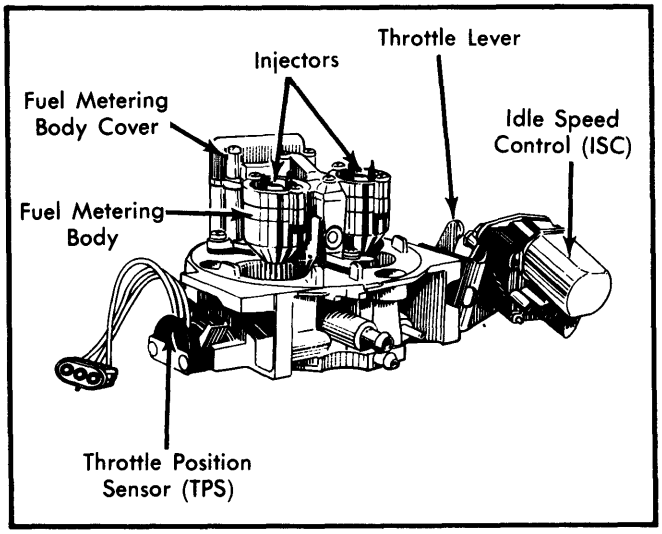


Fig. 6 View of Throttle Body Assembly

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)

Removal – Remove instrument panel lower cover. Disconnect MAP vacuum hose and electrical connector. Remove screw securing MAP sensor to MAP/BARO bracket and remove sensor.

Installation – Reverse removal procedure to install.

BAROMETRIC PRESSURE SENSOR (BARO)

Removal – Remove instrument panel lower cover and glove box liner. Disconnect BARO sensor electrical connector. Remove retaining screw holding MAP/BARO bracket to instrument panel. Remove screw securing BARO sensor and ground strap to bracket. Remove sensor.

Installation – Reverse removal procedure to install.

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.

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.*

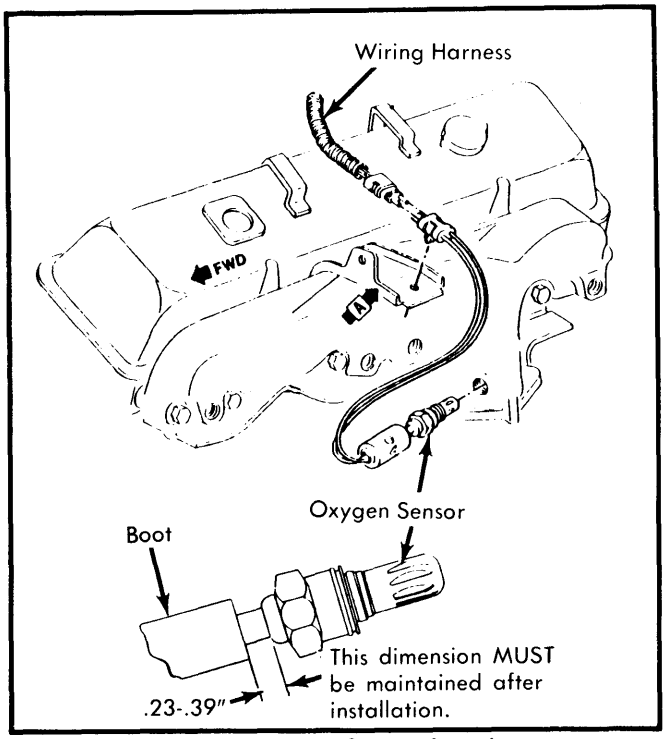


Fig. 7 Oxygen Sensor Location

TIGHTENING SPECIFICATIONS

Application	Ft. Lbs. (N·m)
Oxygen Sensor	30 (41)
Coolant Sensor & MAT Sensor	15 (20)
Throttle Body	15 (20)