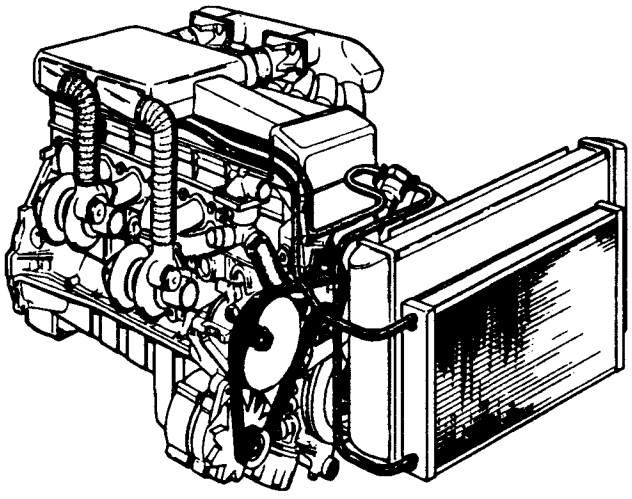
# LOTUS

## TRAINING

## LOTUS - OMEGA / CARLTON



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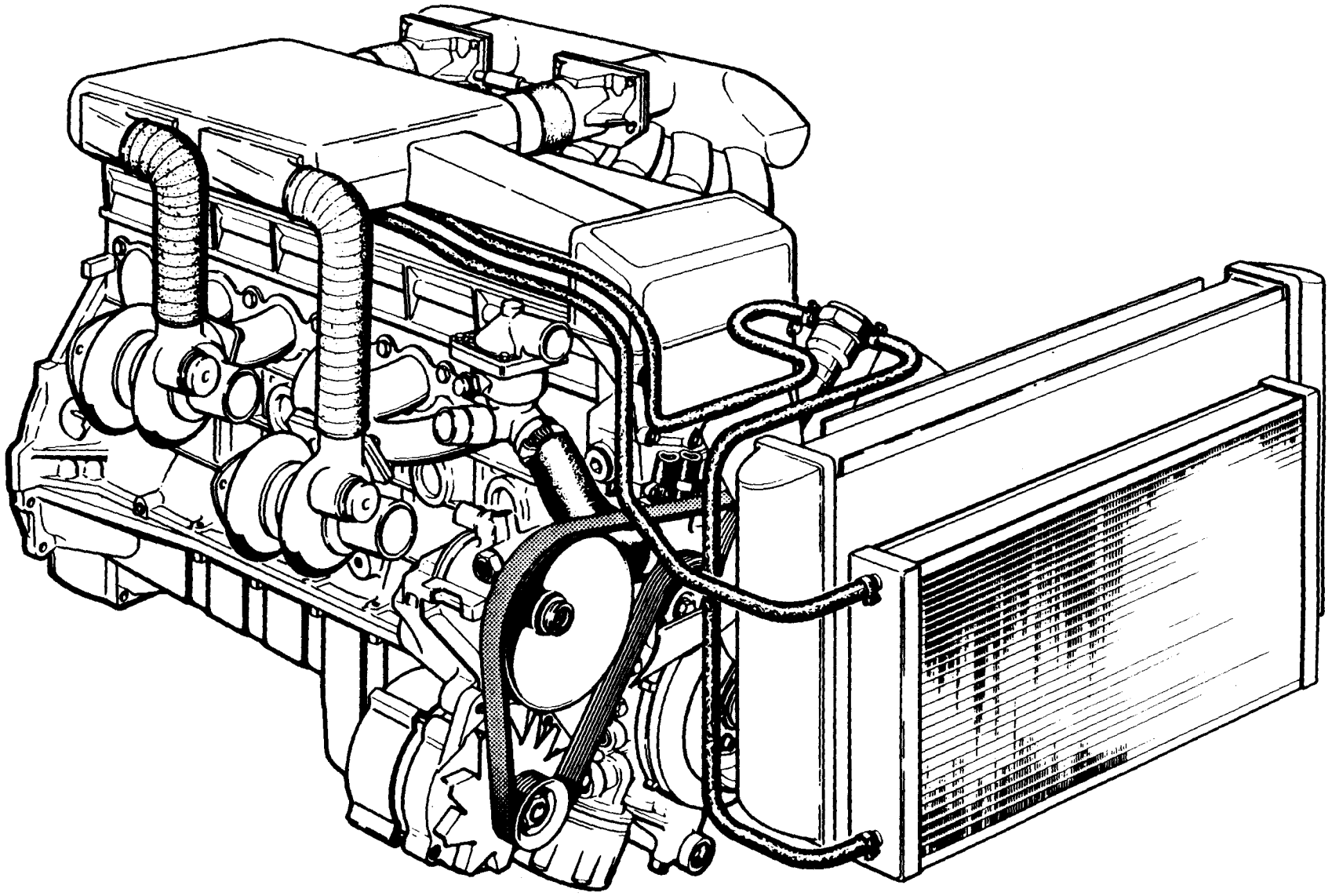
# LOTUS - OMEGA / CARLTON TRAINING



# TRAINING

# LOTUS - OMEGA / CARLTON

## THREE DAYS SESSION

## FIRST DAY

SYSTEM & COMPONENT DESCRIPTION

THEORY OF OPERATION

## SECOND DAY

DIAGNOSTIC CHARTS EXPLANATION

## THIRD DAY

ON CAR DIAGNOSIS WITH "TECH 1" TOOL

# 1.0 GENERAL DESCRIPTION

The Multipoint Fuel Injection (MPFI) system is used on the LOTUS - OMEGA / CARLTON is a GM fully electronic micro-processor controlled system. The main functions of the system are:

1) Fuel Management
2) Spark Timing
3) Idle (Air) Speed Control
4) Turbocharger Wastegate Control

The system provides maximum reduction of tailpipe emissions at optimum performance and driveability.

1) FUEL MANAGEMENT

The injectors are controlled by a microprocessor called an "Electronic Control Module" (ECM). It calculates the amount of fuel required by the engine at all conditions from information supplied by a series of sensors.

The engine is equipped with 6 injectors, 1 for each cylinder. The injectors are generally operated (pulsed) in a sequential manner, once each engine cycle. This "sequential" fuel injection follows the firing order of the engine *(1, 5, 3, 6, 2, 4)*. The fuel requirement for each cylinder is delivered by one fuel pulse per engine cycle *(intake, compression, power, exhaust)*. The fuel pulse is usually delivered when the intake valves are closed. This improves fuel vapourization, which maximizes power while minimizing emissions.

2) SPARK TIMING

This engine has a "Direct Ignition System" (DIS) which is a distributorless type of ignition system. It contains an ignition module, 3 ignition coils, and a crankshaft position (crank angle) sensor. The position sensor generates electrical signals by magnetic interaction with 7 "teeth" machined into the crankshaft torsional balancer. The ignition module receives and processes the signal from the crankshaft position sensor, interfaces with the ECM, and controls the primary current in the ignition coils. Each ignition coil drives two spark plugs.

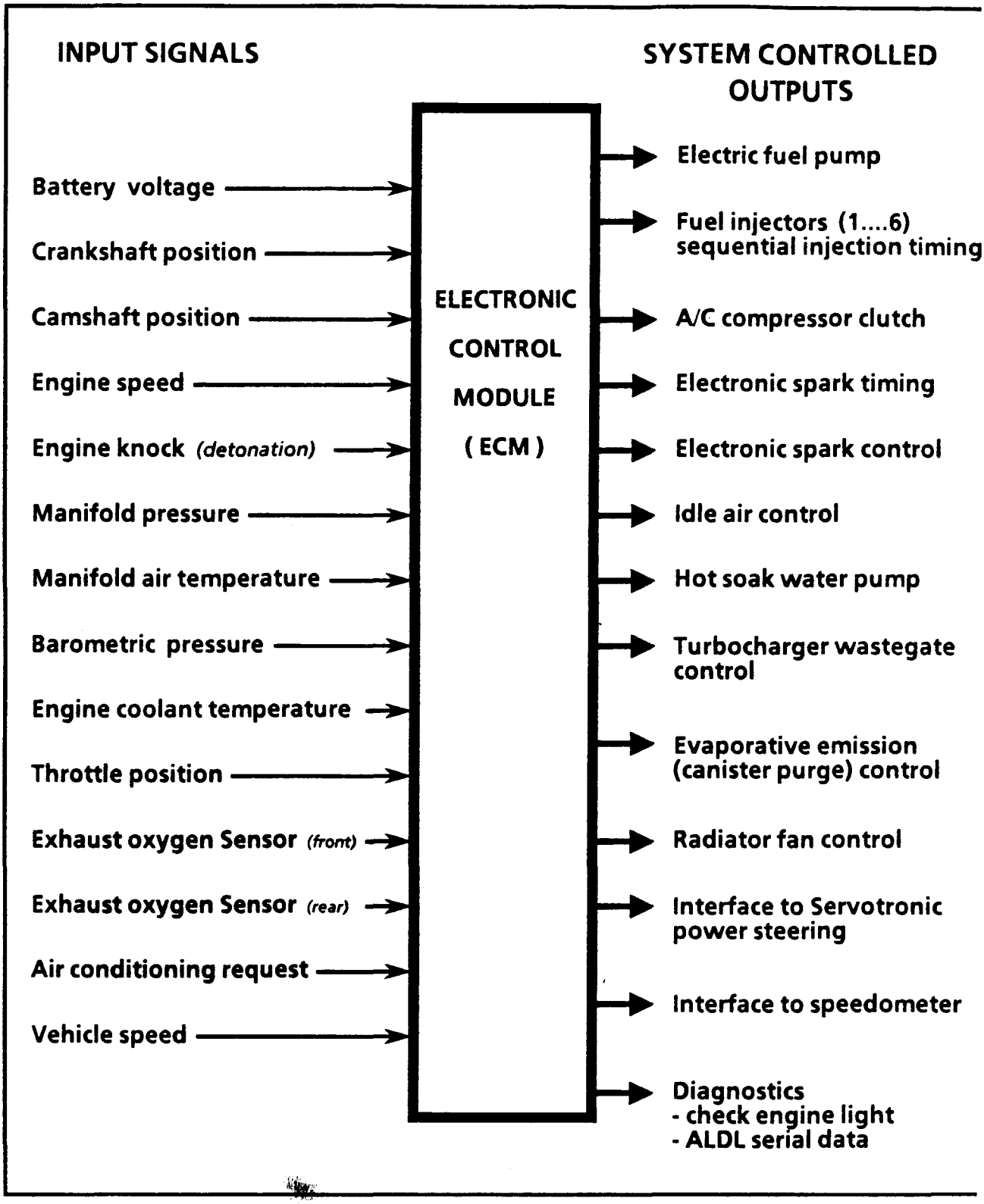
3) IDLE (AIR) SPEED CONTROL

The ECM controls idle speed by means of an "Idle Air Control" (IAC) motor. It provides control of bypass air around the throttle plates. If RPM is lower than desired, the actuator pintle of the motor is retracted and more air diverted around the throttle plates to increase RPM; if RPM is too high the motor is extended.

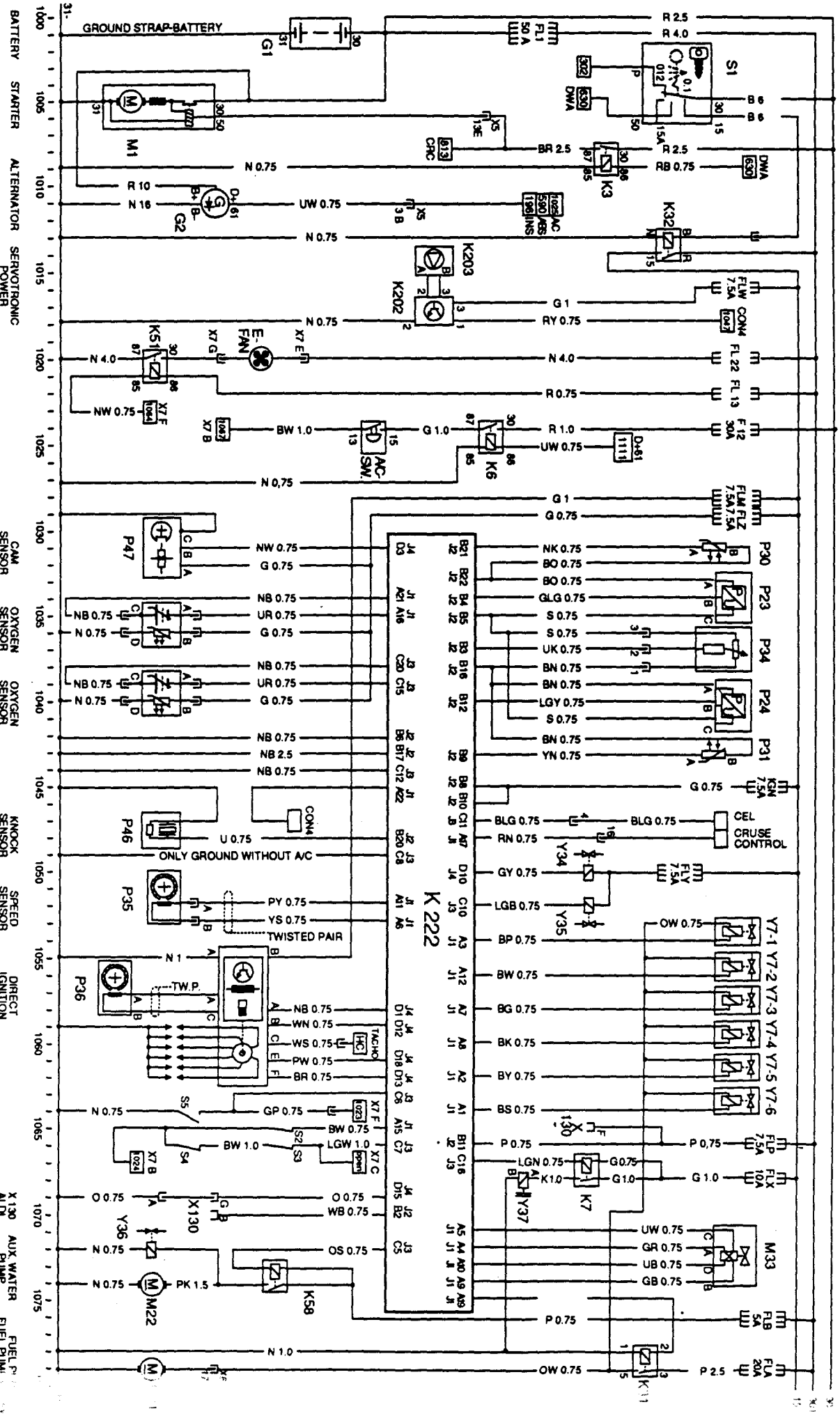
4) TURBOCHARGER WASTEGATE CONTROL

This engine uses two turbochargers. Each turbo has it's own conventional wastegate actuator, but both actuators are controled by one electrical solenoid. The solenoid acts to control boost pressure, and is controled by the ECM. The ECM uses information from the MAP and knock sensors to control the wastegate solenoid.

# 1.1 BLOCK DIAGRAMME



# 6.1 Circuit Diagram LOTUS CARLTON



# 6 Circuit Diagram

## 6.1 Circuit Diagram LOTUS OMEGA

TACHO = Interface Connector (Tacho)
X7 Ter."B = A/C Interface Connector (Control Switch)
X7 Ter."C" = A/C Interface Connector (Not used)
X7 Ter."F" = A/C Interface Connector (Rad Fan Coil)
CON 4 = Servotronic Electronic Module Line
FAN = FAN (Controled by ECM)
FL 1 = Maxi Fuse 50 Amp.
FLA = Fuel Pump /Injectors Relay Fuse 20 Amp.
FLX = A/C Fuse 10 Amp.
FLZ = 02 / CAM-Sensor Fuse
G 1 = Battery
G 2 = Alternator
K 3 = Theft Deterant Relay
K 6 = Engine Run Relay
K 7 = A/C Clutch Relay
K 31 = Fuel Pump Relay
K 32 = Ignition Power Relay
K 58 = Hot Soak Pump Relay
K 202 = Servotronic Electronic Module
K 203 = Electronic Hydr. Transducer
K 204 (K51) = Fan Relay
K 222 = ECM = Electronic Control Modul
L 1 = Oxygen Sensor Left
L 2 = Oxygen Senor Right
M 1 = Starter
M 21 = Fuel Pump
M 22 = Hot Soak Water Pump
M 33 = IAC Motor = Idle Air Control Valve
P 23 = MAP-Sensor = Manifold Absolute Pressure
P 24 = BARO-Sensor = Barometric Pressure Sensor
P 30 = MAT-Sensor = Mass Air Temperature
P 31 = CT -Sensor = Coolant Temperature Sensor
P 34 = TPS-Sensor = Throttle Position Sensor
P 35 = Magnetic Vehicle Speed Sensor
P 46 = Knock Sensor
P 47 = CAM-Sensor
S 1 = Ignition Switch
S 2 = Idle Pressure Switch (H.P.Line)
S 3 = H.P. Cut Out Switch (A/C Comp.)
S 4 = L.P. Cut Out Switch (H.P. Line)
S 5 = High Pressure Switch (A/C Compressor)
X 130 = ALDL-Connector Engine
Y 34 = Waste Gate Solenoid
Y 35 = Charcoal Canister Purge Solenoid
Y 36 = Hot Soak Pump Solenoid
Y 37 = A/C Clutch

# LOTUS - OMEGA / CARLTON TRAINING

| Lotus Colors | Vauxhall Colors | Opel Farben |
|---|---|---|
| G | Green | Grün |
| K | Pink | Rosa |
| N | Brown | Braun |
| P | Purple | Lila |
| S | Slade | Grau |
| U | Blue | Blau |
| BR | Black Red | Schwarz Rot |
| BO | Black Orange | Schwarz Orange |
| GB | Green Black | Grün Schwarz |
| GR | Green Red | Grün Rot |
| GY | Green Yellow | Grün Gelb |
| NB | Brown Black | Braun Schwarz |
| NW | Brown White | Braun Weiß |
| OP | Orange Purple | Orange Lila |
| PK | Purple Pink | Lila Rosa |
| PY | Purple Yellow | Lila Gelb |
| RN | Red Brown | Rot Braun |
| RY | Red Yellow | Rot Gelb |
| UG | Blue Green | Blau Grün |
| UK | Blue Pink | Blau Rosa |
| US | Blue Slade | Blau Grau |
| UW | Blue White | Blau Weiß |
| WB | White Black | Weiß Schwarz |
| WN | White Brown | Weiß Braun |
| YS | Yellow Slade | Gelb Grau |
| YN | Yellow Brown | Gelb Braun |
| BLG | Black Light Green | Schwarz Hellgrün |
| GLG | Green Light Green | Grün Hellgrün |
| LGB | Light Green Black | Hellgrün Schwarz |
| LGN | Light Green Brown | Hellgrün Braun |
| LGW | Light Green White | Hellgrün Weiß |
| LGY | Light Green Yellow | Hellgrün Gelb |

BAD : HOT START COOLING PUMP

# LOTUS - OMEGA / CARLTON TRAINING

BAD : HOT START COOLING PUMP

## 1.4 PARAMETERS SENSED VS. PARAMETERS CONTROLLED

| PARAMETERS SENSED | PARAMETERS CONTROLLED | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | FUEL | IDLE SPEED | SPARK TIMING | CANISTER PURGE | BOOST CONTROL | RADIATOR FAN | AIR CONDITION | CHECK ENGINE LIGHT |
| ENGINE SPEED | X | X | X | X | X | | X | X |
| VEHICLE SPEED | | X | X | | X | X | X | X |
| COOLANT TEMP. | X | X | X | X | | X | X | X |
| MASS AIR TEMP. | X | X | X | | | | | X |
| MANIFOLD PRESSURE | X | X | X | X | X | | | X |
| BAROMETRIC PRESS. | X | X | X | | | | | X |
| THROTTLE POSITION | X | X | X | | X | | X | X |
| BATTERY VOLTAGE | X | X | X | | | X | | X |
| INJECTOR VOLTAGE | X | | | | | | | X |
| EXHAUST OXYGEN | X | | | X | | | | X |
| ENGINE DETONATION | | | X | | X | | | X |
| A/C REQUEST | | X | | | | X | X | |
| FLYWHEEL POSITION | X | | X | | | | | |
| TIME | X | X | X | X | X | X | X | |

# 1.5 CATALYTIC CONVERTER

Two catalytic converters are used on the Lotus Omega / Carlton.

The catalytic converter is the best way of controlling tailpipe emissions.

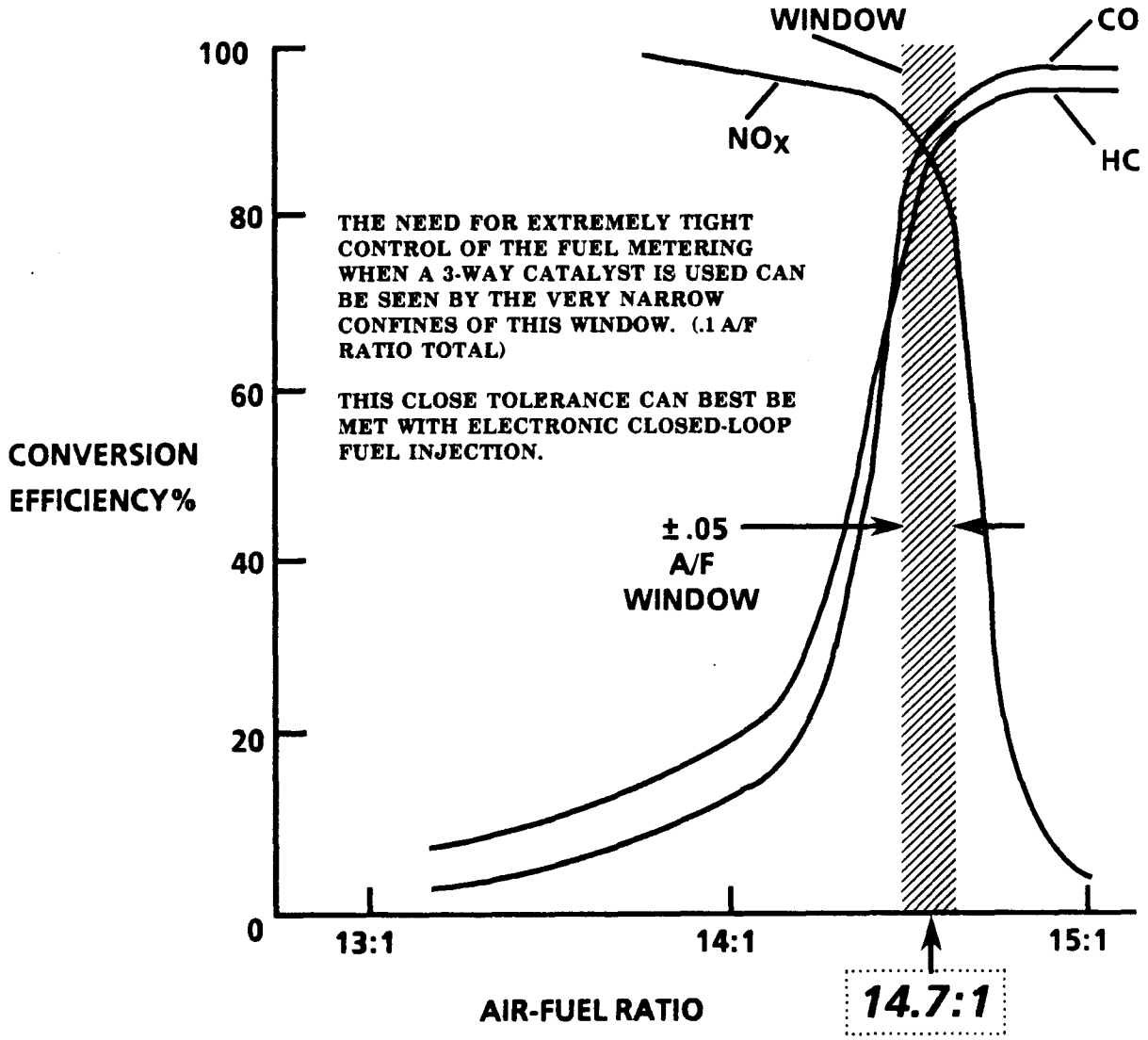
The major tailpipe pollutants are hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen ($NO_x$).

The LOTUS-OMEGA/CARLTON catalytic converter is a three-way converter. It contains two oxidizing catalysts and a reducing catalyst. A catalyst accelerates a chemical reaction without changing its own properties. The oxidizing catalysts used are platinum and palladium. In the presence of oxygen, they aid in reducing hydrocarbons and carbon monoxide. They add oxygen to HC and CO to convert them to water vapor and carbon dioxide. For this to occur, the fuel injection system must supply an air/fuel ratio of 14.7 to 1 or leaner. If the air/fuel ratio is richer than 14.7 to 1, the converter does a poor job of oxidizing the HC and CO.

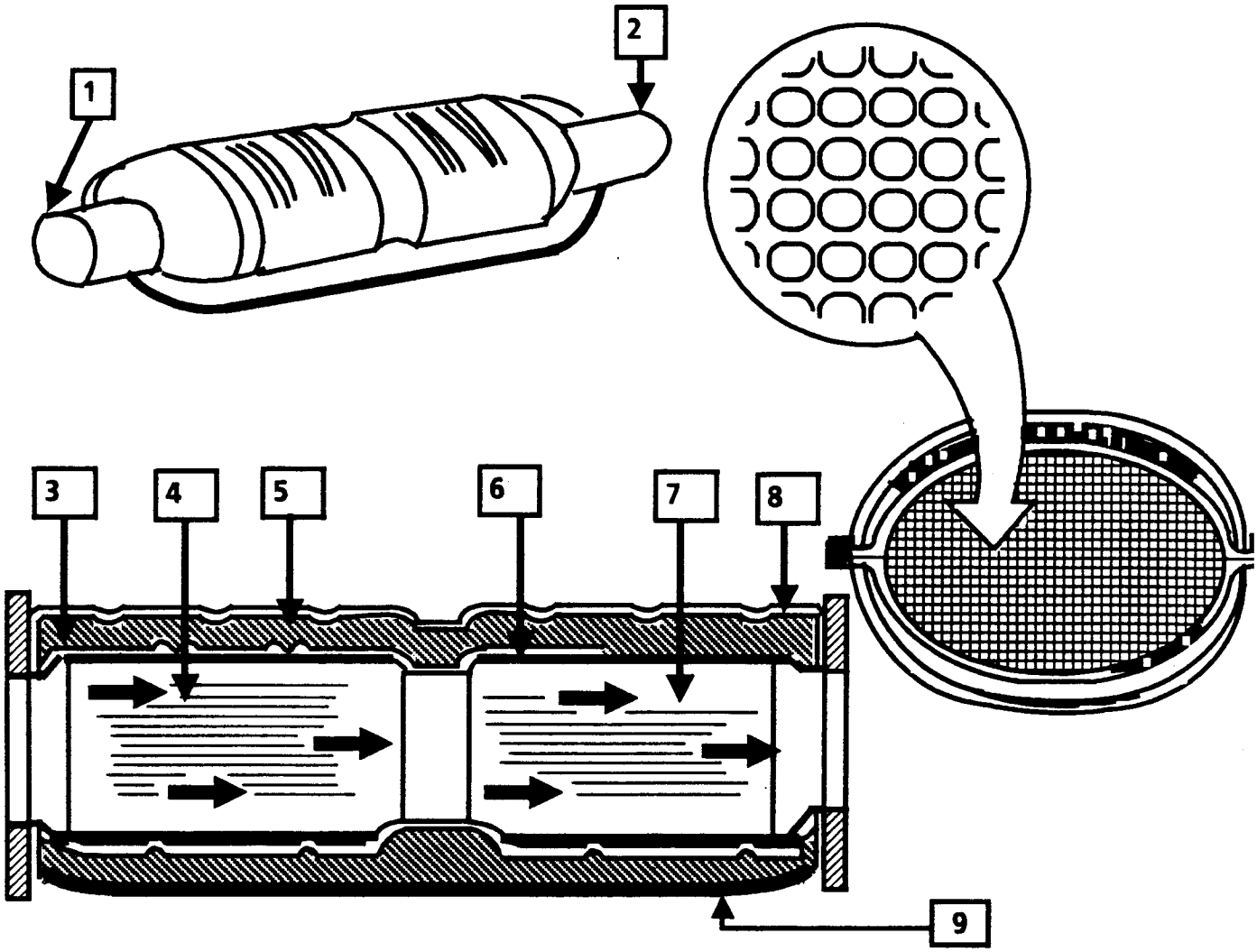
The reducing catalyst is rhodium. It speeds up the chemical reaction removing oxygen from $NO_x$, thus reducing $NO_x$ to nitrogen. For this to occur, the air/fuel ratio must be 14.7 to 1 or richer. If the air/fuel ratio becomes leaner than 14.7 to 1, the efficiency of $NO_x$ conversion is greatly reduced. As seen in the figure on the next page, any air/fuel ratio except 14.7 to 1 greatly reduces the efficiency of one or the other type of catalyst in the converter.

To maintain a high conversion efficiency of HC, CO, and $NO_x$, the air/fuel ratio must be maintained as close to 14.7 to 1 as possible.

# PRINCIPLE OF OPERATION 3-WAY CATALYST



## DUAL BED MONOLITH CONVERTER




| | |
|---|---|
| 1 INLET | 6 CONTAINMENT MATERIAL |
| 2 OUTLET | 7 REAR BED |
| 3 HOUSING | 8 INSULATION COVER |
| 4 FRONT BED | 9 PERFORATED SHIELD |
| 5 INSULATION MATERIAL | |

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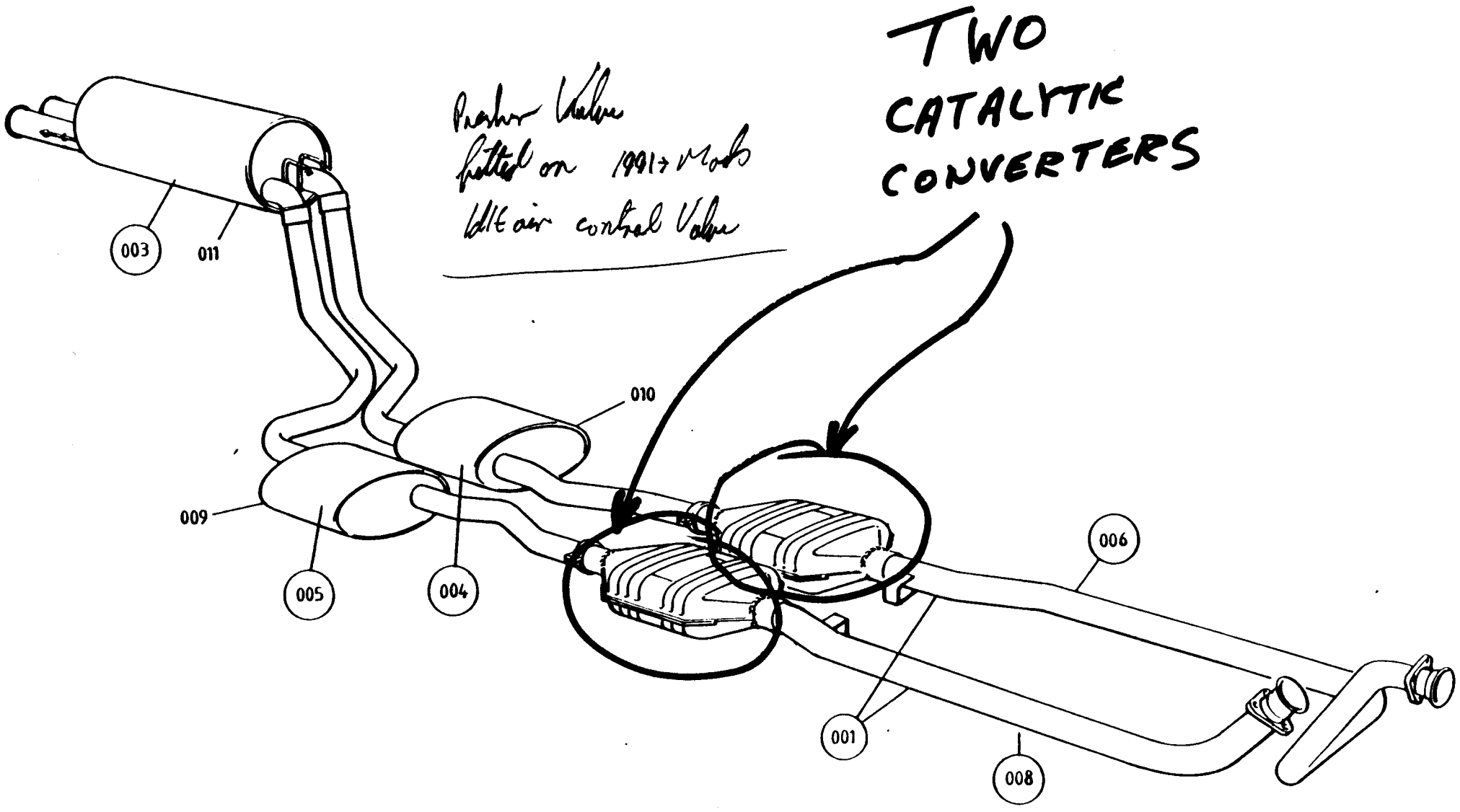
# LOTUS - OMEGA / CARLTON TRAINING



# 2.1 MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The MAP sensor is mounted to the inlet manifold between the throttle bodies, and is connected directly to the manifold using a silicone rubber seal.

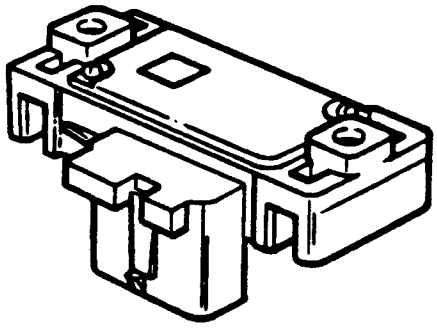
The Manifold Absolute Pressure sensor measures the changes in the intake manifold pressure which result from engine load and speed changes, as well as turbo boost. The sensor is a "2 bar" sensor, capable of measurring pressure up to 210 kPa (2 atmospheres).

The sensor uses a silicon chip approximately 3mm square. The chip is attached to a pyrex plate to form a diaphragm approximately 0.25mm thick. Resistors are diffused into the chip to form a wheatstone bridge resistor network. When the chip is sealed to a pyrex plate, a vacuum cavity is formed called a reference vacuum cavity. As pressure or vacuum is applied to the opposite side of the reference cavity, the diaphragm deflects, causing the diffused resistors to change value proportional to the pressure.

The sensor's resistor bridge network is connected to a microcircuit, also part of the sensor. The ECM provides a 5-volt reference voltage to the sensor, as well as a ground. The sensor's internal microcircuit sends an output voltage to the ECM, proportional to the manifold pressure.

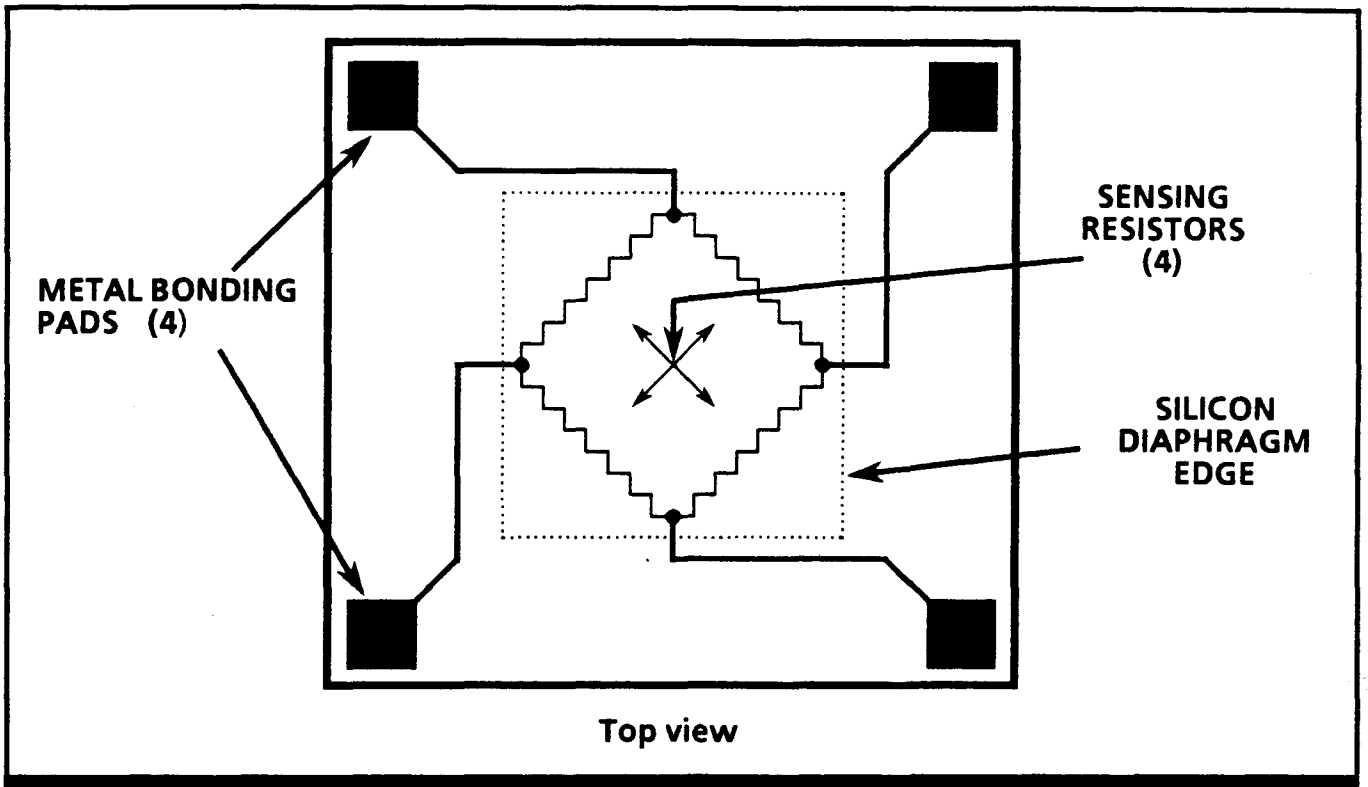
Output voltage is approximately 0.5 to 1.0 volts at idle, and 2.5 volts at 105 kPa *(1 bar) (athmospheric pressure).* Maximum output voltage of 5 volts is available at 210 kPa *(2 bar)* manifold pressure. The ECM uses this voltage to compute intake manifold pressure.

**MANIFOLD ABSOLUTE PRESSRURE SENSOR**



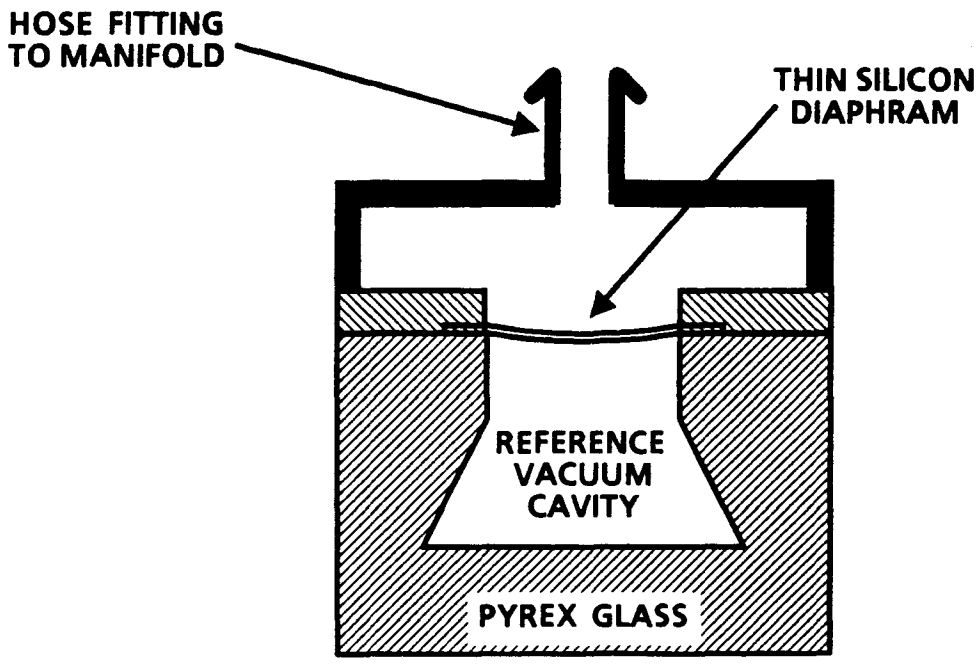
Delco Electronics manufactures eight different pressure senors with the same physical appearance. These sensors are not interchangeable and are color coded by the plastic insert in the plug. The sensor plug inserts are keyed so they cannot be used in th wrong system application. The Turbo MAP sensor insert is orange. The Barometric pressure sensor has a blue color sensor plug insert.

# LOTUS - OMEGA / CARLTON TRAINING

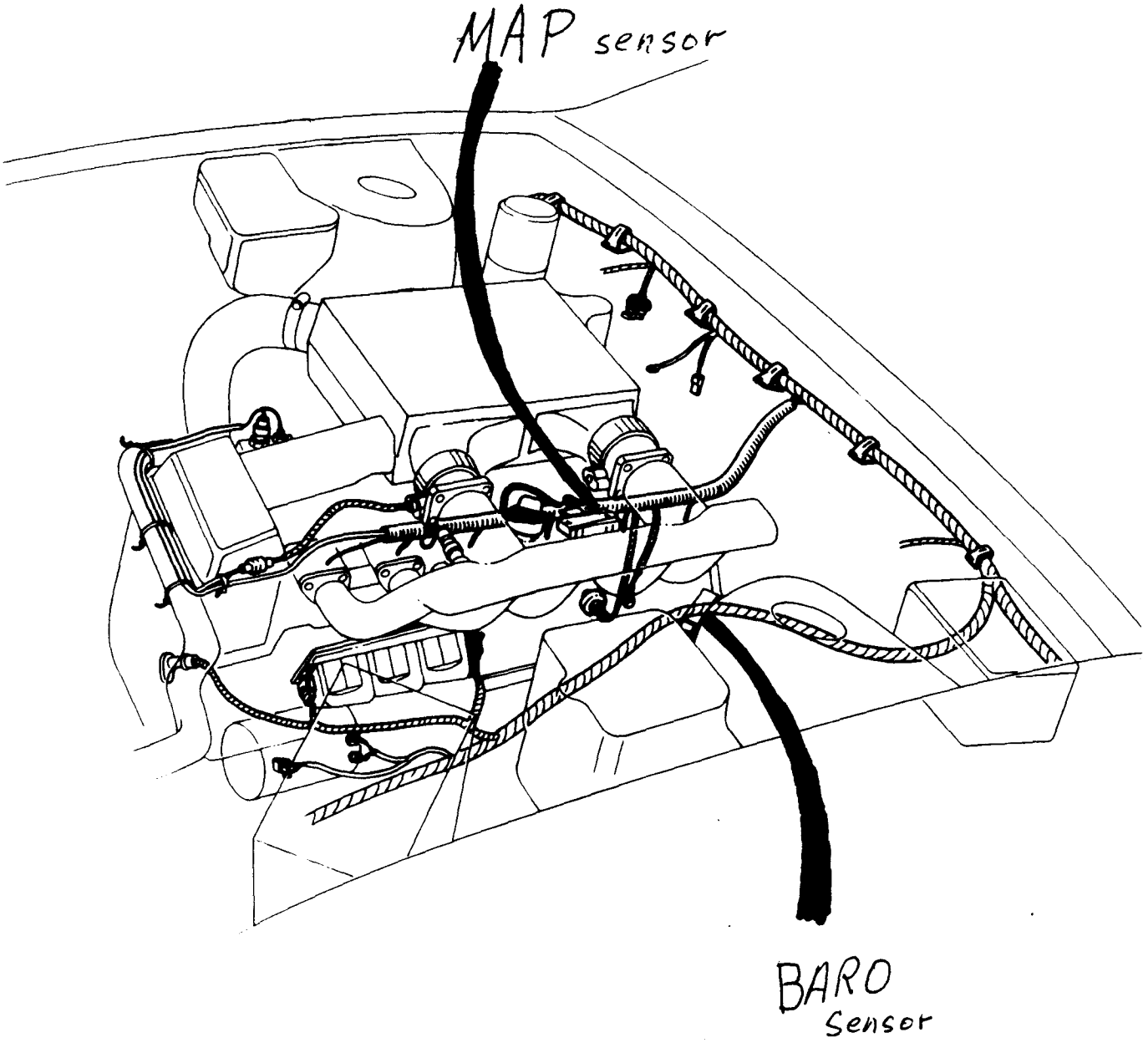


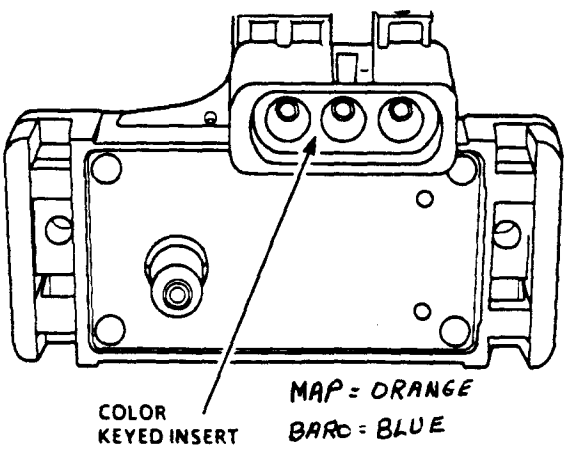

Top view

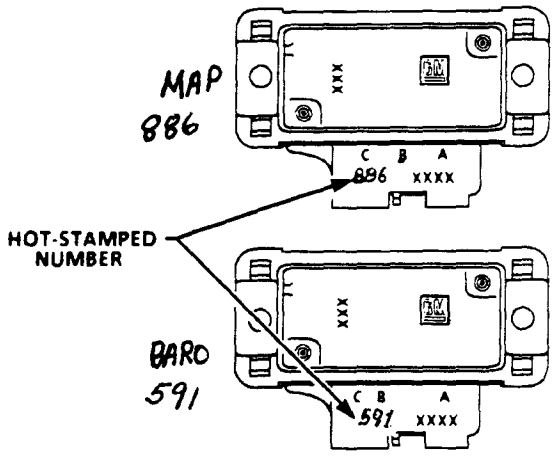
PRESSURE SENSOR CELL
SIDE VIEW



# LOTUS - OMEGA / CARLTON TRAINING



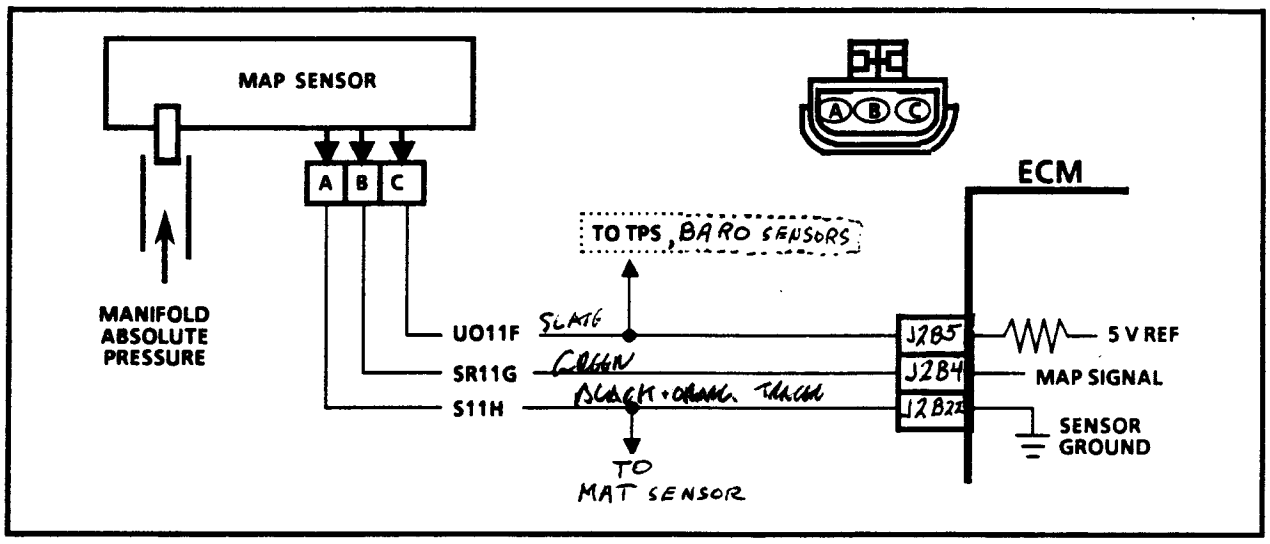
# MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT

## Circuit Description:

The Manifold Absolute Pressure (MAP) sensor responds to changes in manifold pressure (engine vacuum or boost). The ECM receives this information as a signal voltage that will vary from about 0.5 to 1.0 volts at idle, when manifold pressure is low (high vacuum), to between 4 and 5 volts at wide open throttle during full boost.

If the MAP sensor fails, the ECM will substitute a "default" MAP value, using the throttle position sensor (TPS) and other sensors to control fuel delivery and spark timing.

P 23



# 2.2 BAROMETRIC (BARO) PRESSURE SENSOR

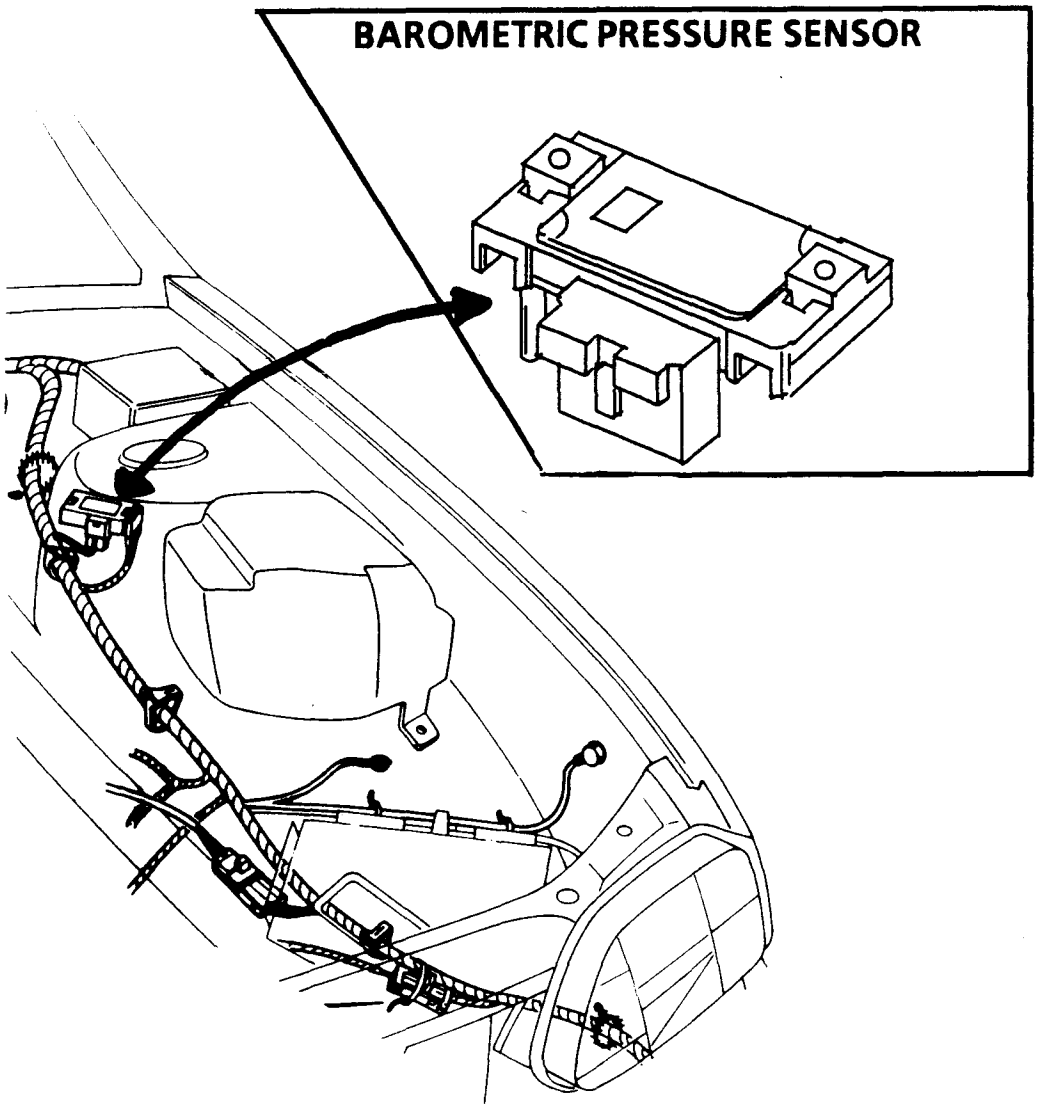
A barometric pressure signal is used by the ECM to regulate fuel delivery relative to atmospheric pressure, and to accommodate operation of the vehicle at high altitude.

The baro sensor operates in principle very similar to the MAP sensor. The major difference is that the baro sensor has no vacuum hose, and it's 0 to 5 volt operating range is spread out over 105 kPa, as opposed to 210 kPa on the MAP sensor. The BARO sensor is a "1 bar" sensor, capable of measurring pressure up to 105 kPa (1 atmosphere).

The barometer sensor is mounted on a plate, on the left front strut tower. The ECM provides a 5-volt reference voltage to the sensor, as well as a ground. The sensor's internal microcircuit sends an output voltage to the ECM, proportional to the barometric pressure.

Low barometric pressure (high altitude) produces a low sensor signal for a lower fuel requirement. If the barometric sensor should fail, a fixed value would be substituted by the ECM.

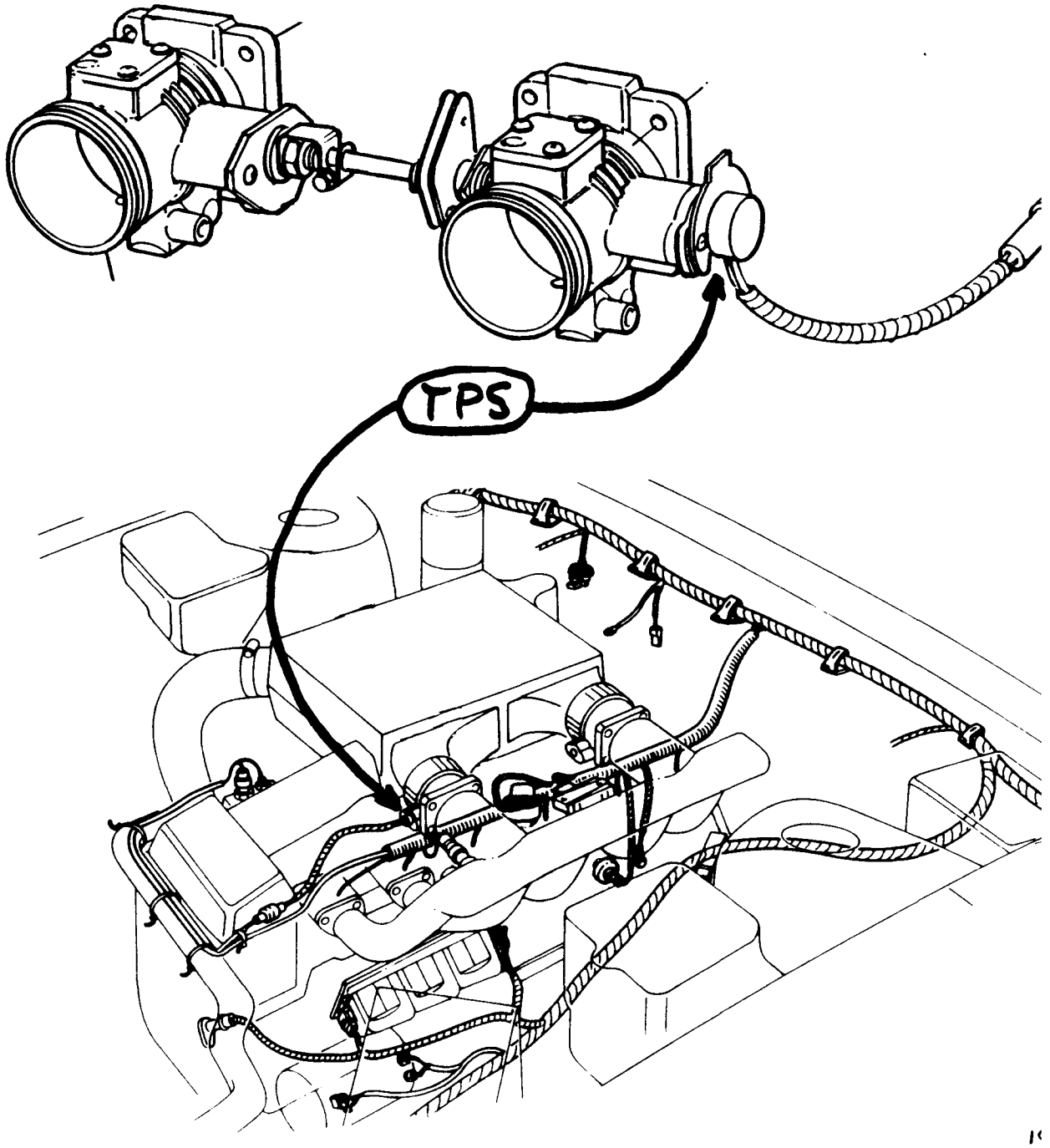
Output voltage is approximately 5.0 volts at 105 kPa *(1 bar) (athmospheric pressure at sea level)*. The output voltage will reduce at higher altitudes.

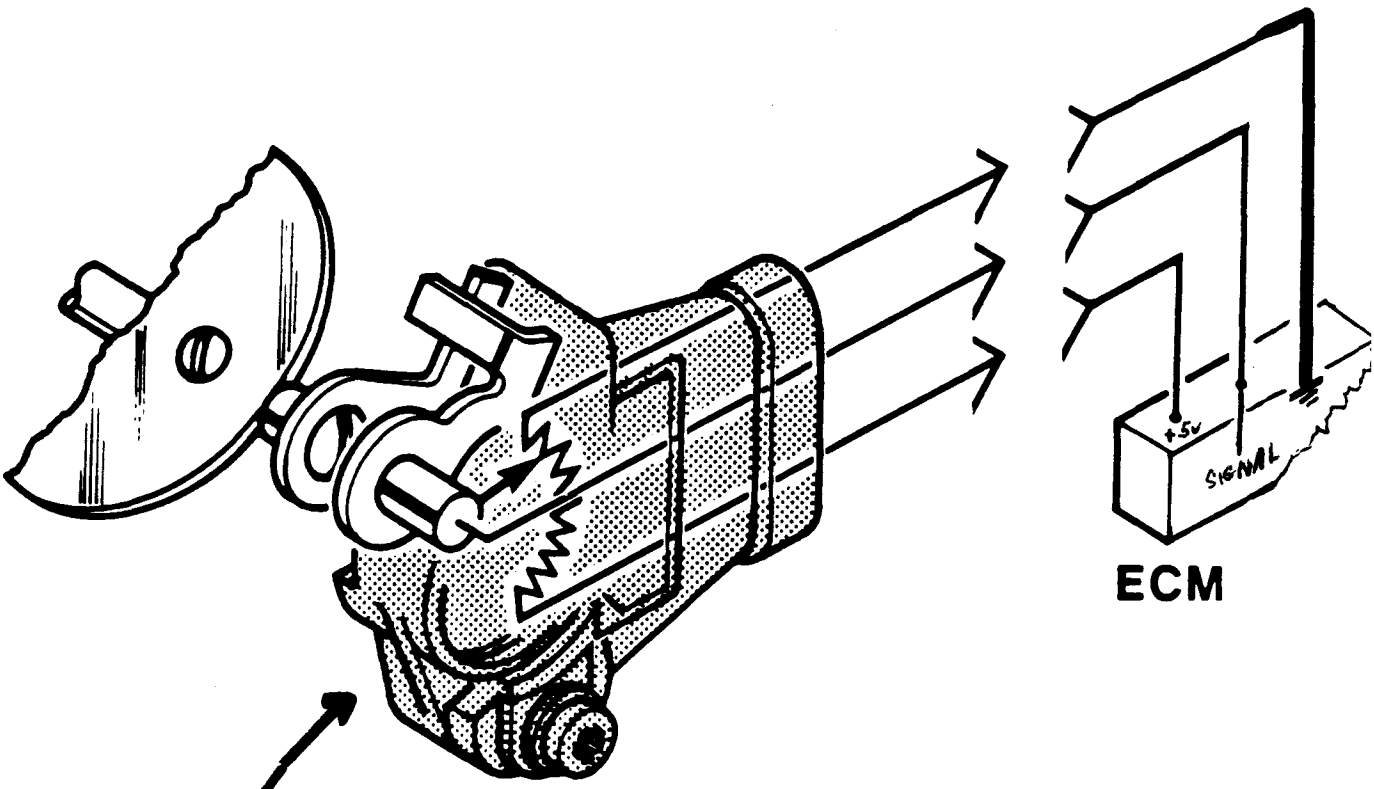


## 2.3 THROTTLE POSITON SENSOR

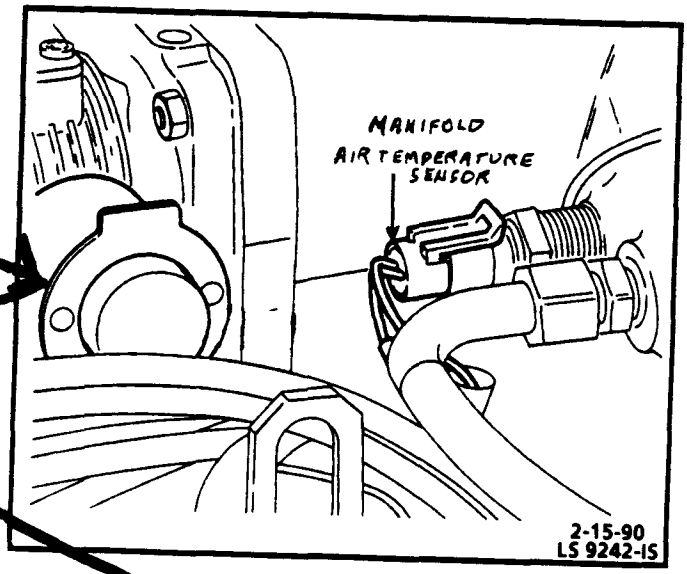
The throttle positon sensor is a potentiometer fitted to the front end of the throttle spindle, on the front throttle body. See picture below D 2161 "A". The ECM supplies a 5 volt refereance voltage and a ground circuit to the sensor, and by monitoring the sensor output voltage on a returning signal line, the ECM is able to determine throttle position. TPS is used as one of the inputs to determine fuel requirements.

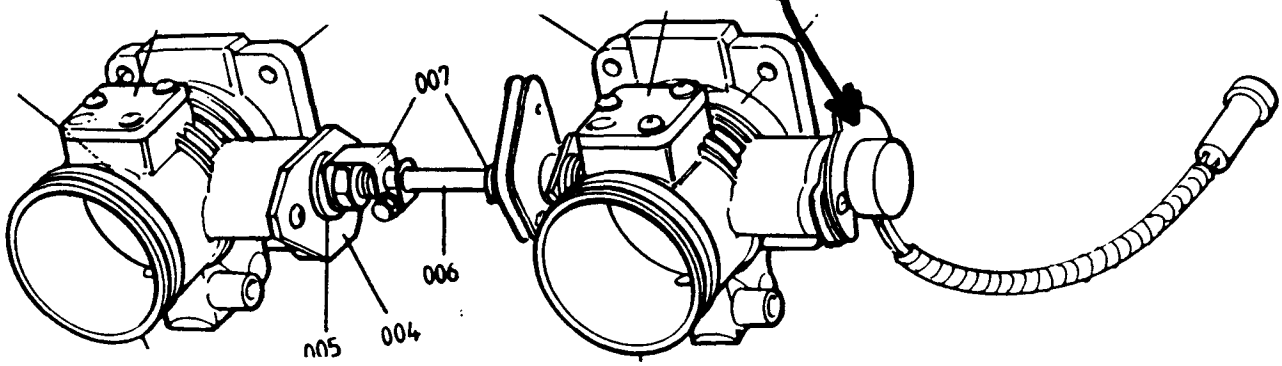
With the throttle closed, the TPS output is low ( typical 0.25 volt), but increases as the throttle is opend until at wide open throttle output voltage is about 5.0 volts. This signal is used by the ECM for fuel control and for many of the ECM controlled outputs. If a fault is detected and a trouble code set, the ECM will substitute an artificial default value for the TPS signal based on RPM, to enable the vehicle to " limp home". This mode may result in a high idle speed.



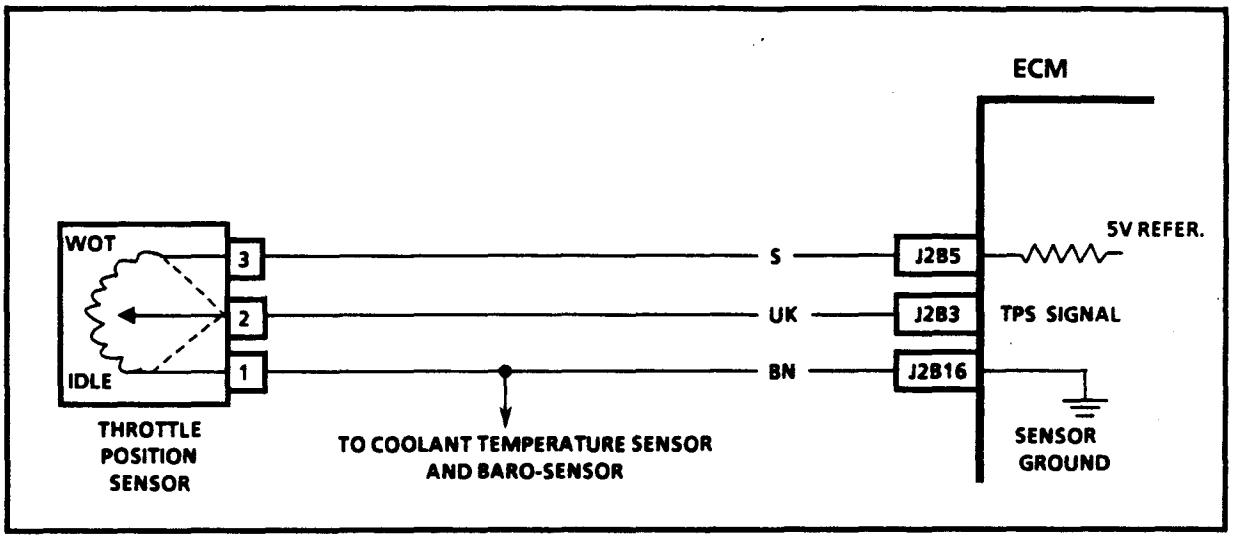

+5v
SIGNAL
ECM

TPS


MANIFOLD
AIR TEMPERATURE
SENSOR
2-15-90
LS 9242-1S


007
006
005
004

# THROTTLE POSITION SENSOR (TPS) CIRCUIT




## Circuit Description:

The ECM applies a "reference voltage" of 5 volts on J2B5, and supplies a ground circuit on J2B16.

The throttle position sensor (TPS) sends back a voltage signal that changes relative to the throttle opening. Signal voltage will vary from about 0 .2 to 0.3 volt at idle to about 5.0 volt at wide open throttle (WOT).

The TPS signal is one of the inputs used by the ECM for fuel control and for most other ECM controlled outputs.

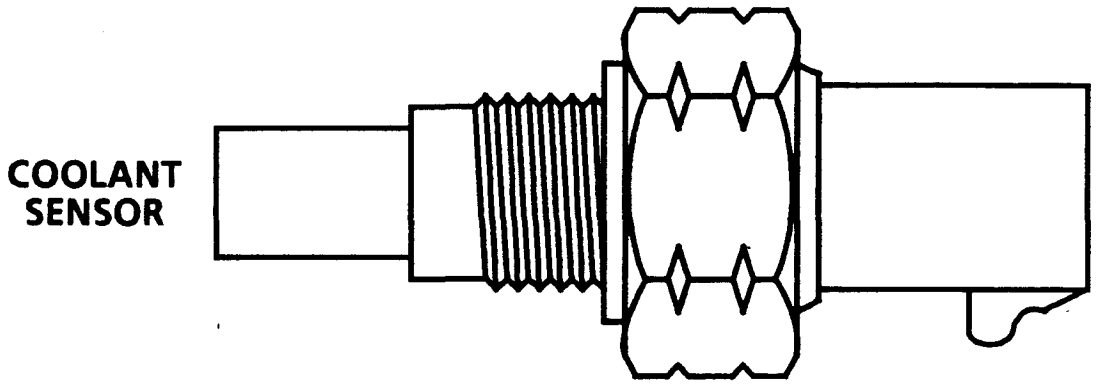
## 2.4 COOLANT TEMPERATURE SENSOR (CTS)

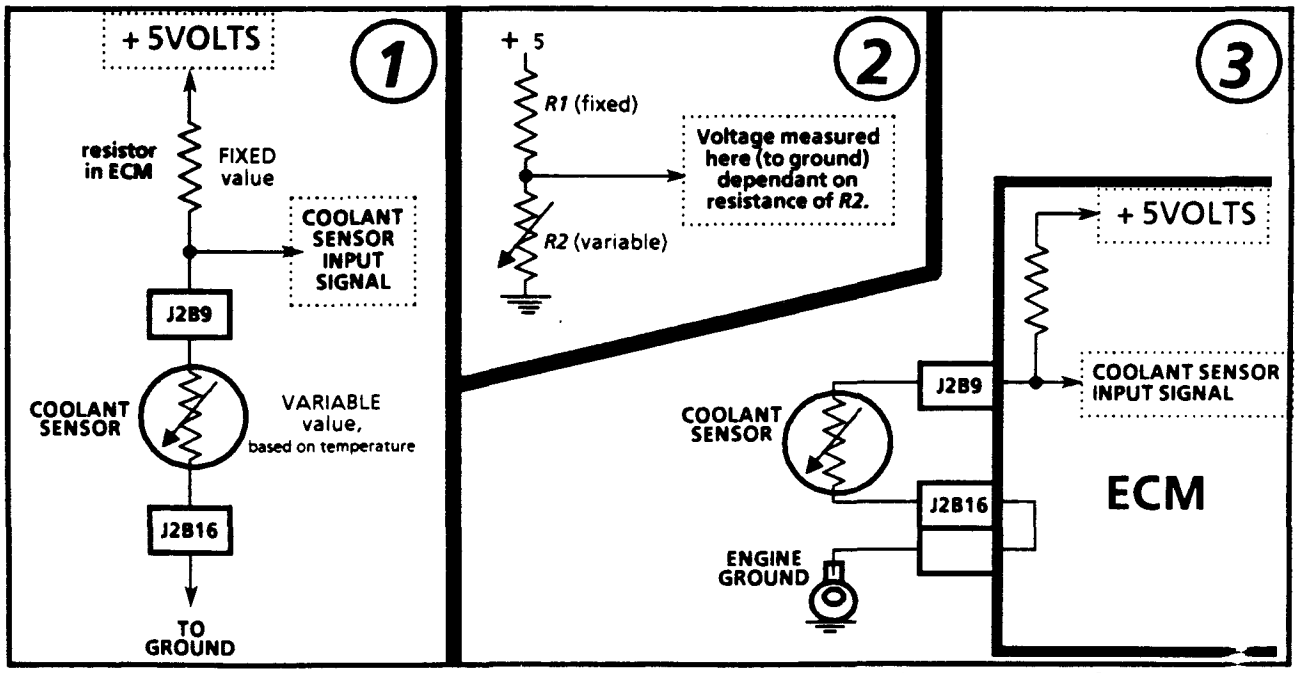
The coolant tepmerature sensor (CTS) is a thermistor mounted in the coolant stream. On the Lotus Omega / Carlton, the CTS is mounted in the thermostat housing in front of the temp. gauge sender, The thermistor changes its resistance with changes of coolant temperature. Low temperature produces a high resistance, approximately 25,000 ohms at -20°C. As coolant temperature increases, sensor resistance decreases to about 185 ohms at 100°C.

The voltage drop across the coolant sensor varies from 0 to 5 volts. This voltage, measured at the ECM, will decrease as coolant temperature increases; therefore, disconnecting the coolant sensor simulates a cold engine, and shorting across the sensor simulates a hot engine.

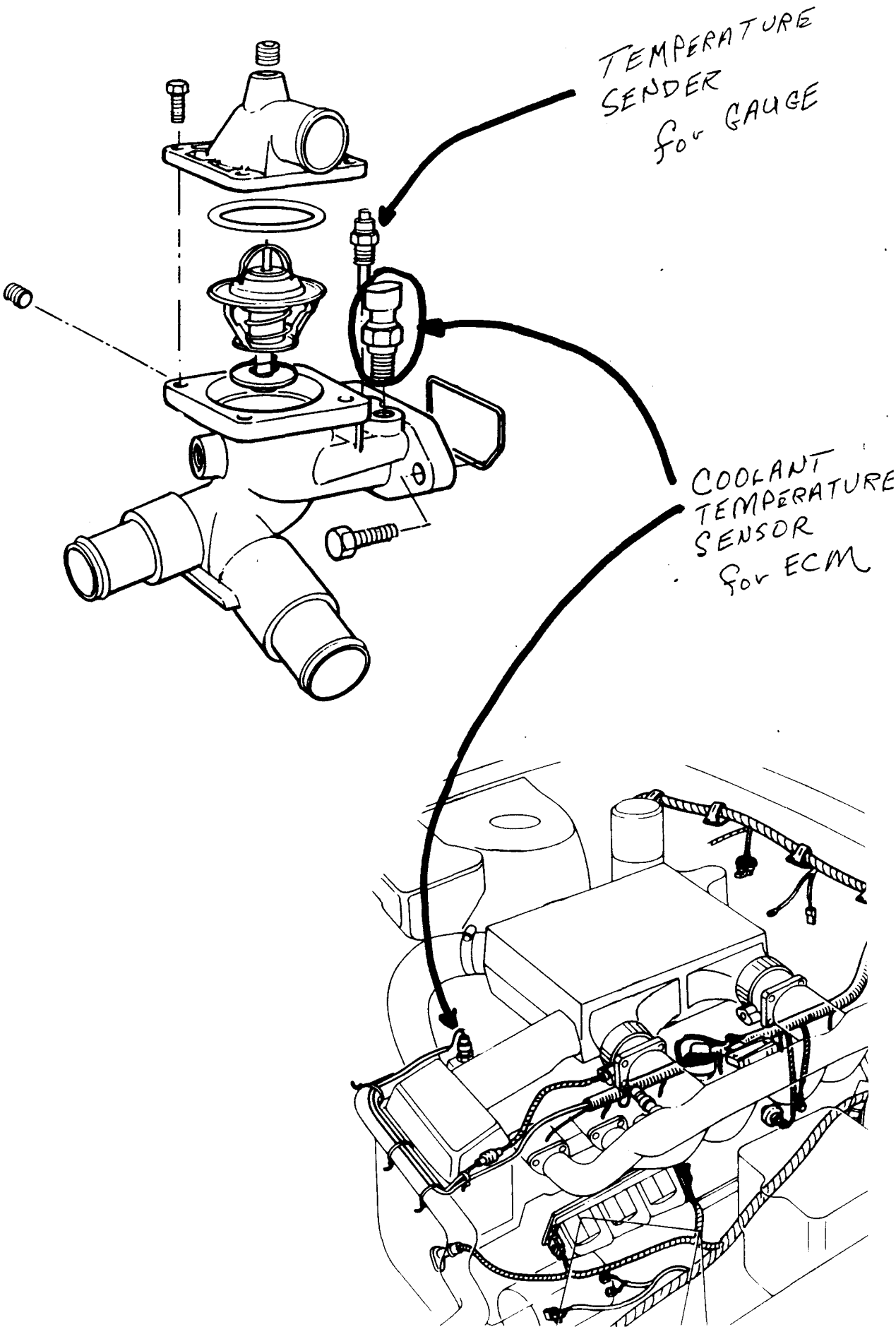
The circuit operation for the Coolant and MAT sensors are the same. The way the ECM interprets the voltage is also the same for each, although each sensor's signal is used for different functions by the ECM.

Both the coolant and MAT temperature sensors are negative temperature coefficient thermistors. As they become hotter, their resistance becomes less.

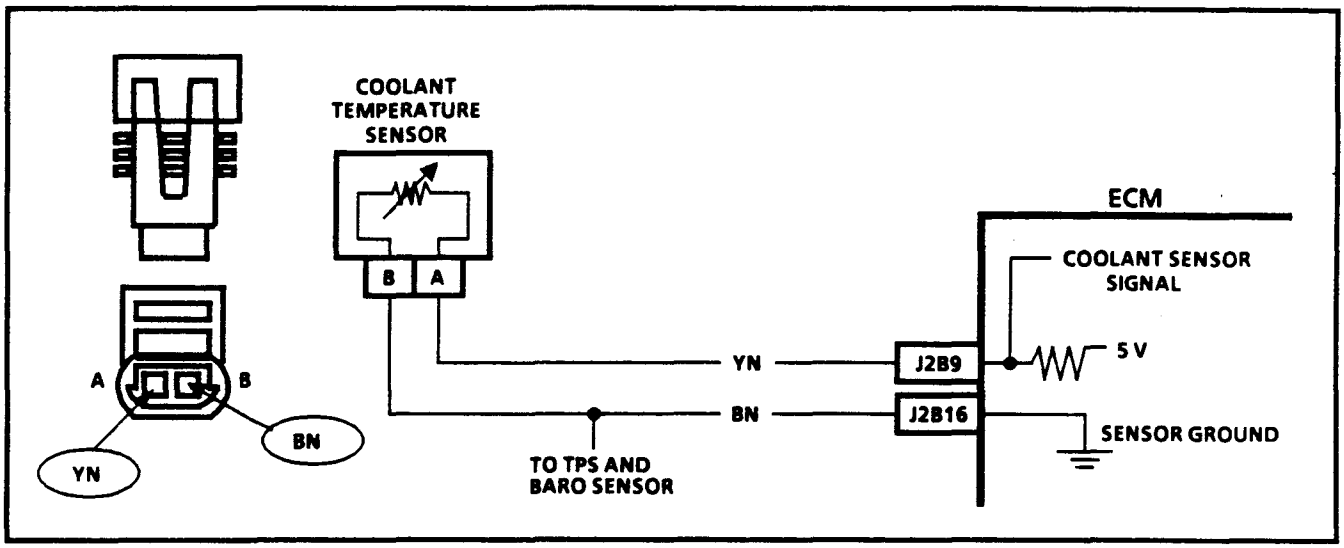



VOLTAGE DIVIDER NETWORKS USING 2 RESISTORS AND A 5 VOLT SOURCE.


TEMPERATURE
SENDER
for GAUGE
COOLANT
TEMPERATURE
SENSOR
for ECM

# COOLANT TEMPERATURE SENSOR CIRCUIT




## Circuit Description:

The coolant temperature sensor uses a thermistor to control the signal voltage at the ECM. The ECM applies a voltage on J2B9 to the sensor. When the engine is cold the sensor (thermistor) resistance is high, therefore ECM terminal J2B9 voltage will be high.

As the engine warms, the sensor resistance becomes less, and the voltage drops. At normal engine operating temperature, the voltage will measure about 1.5 to 2.0 volts at ECM terminal J2B9.

See MAT sensor circuit for approximate temperature -to- resistance values.

Coolant temperature is one of the inputs used to control:

- Fuel delivery
- Engine Spark Timing (EST)
- Idle Air Control (IAC)
- Evaporative Emission Control (Canister Purge) System (EECS)
- Radiator Fan
- Air conditioner compressor clutch
- Auxiliary water pump

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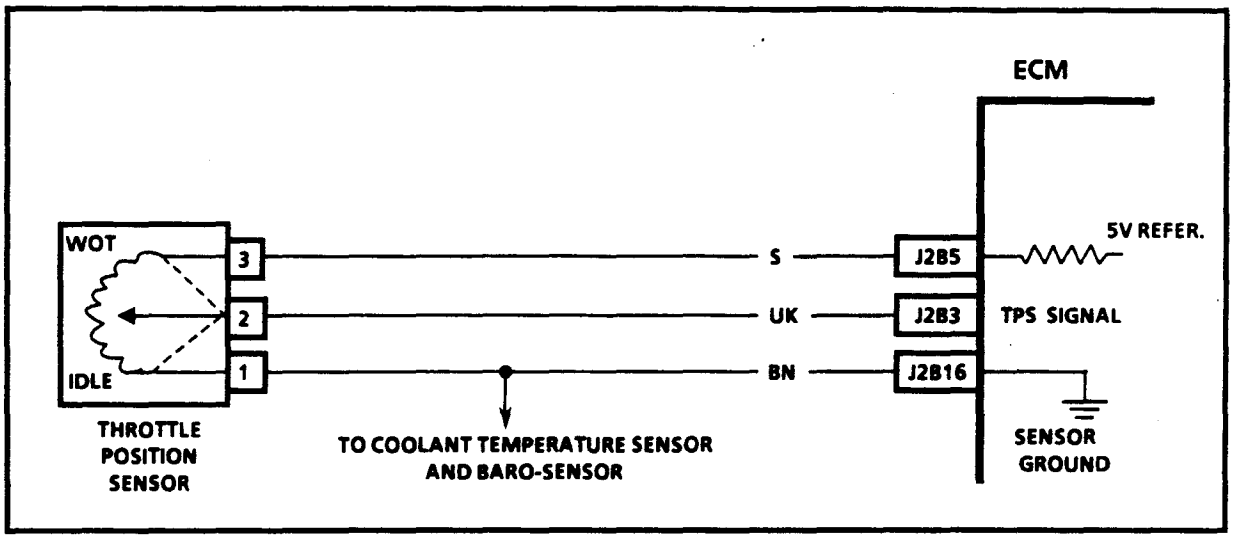
# THROTTLE POSITION SENSOR (TPS) CIRCUIT

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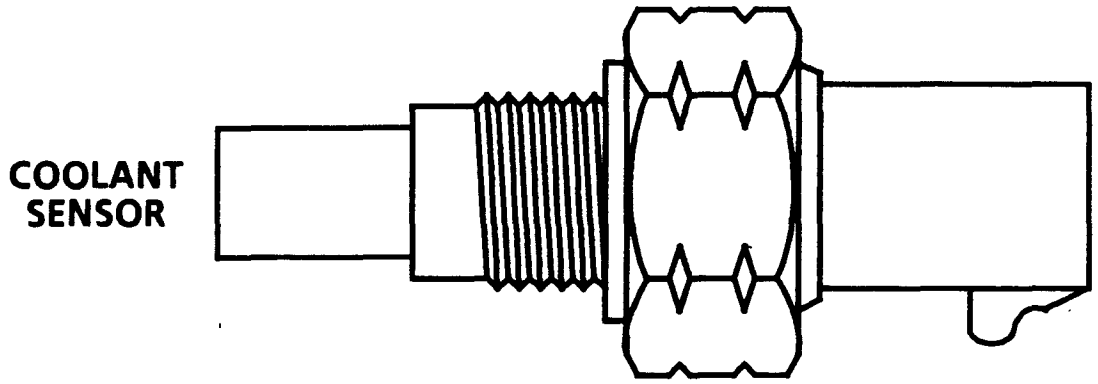
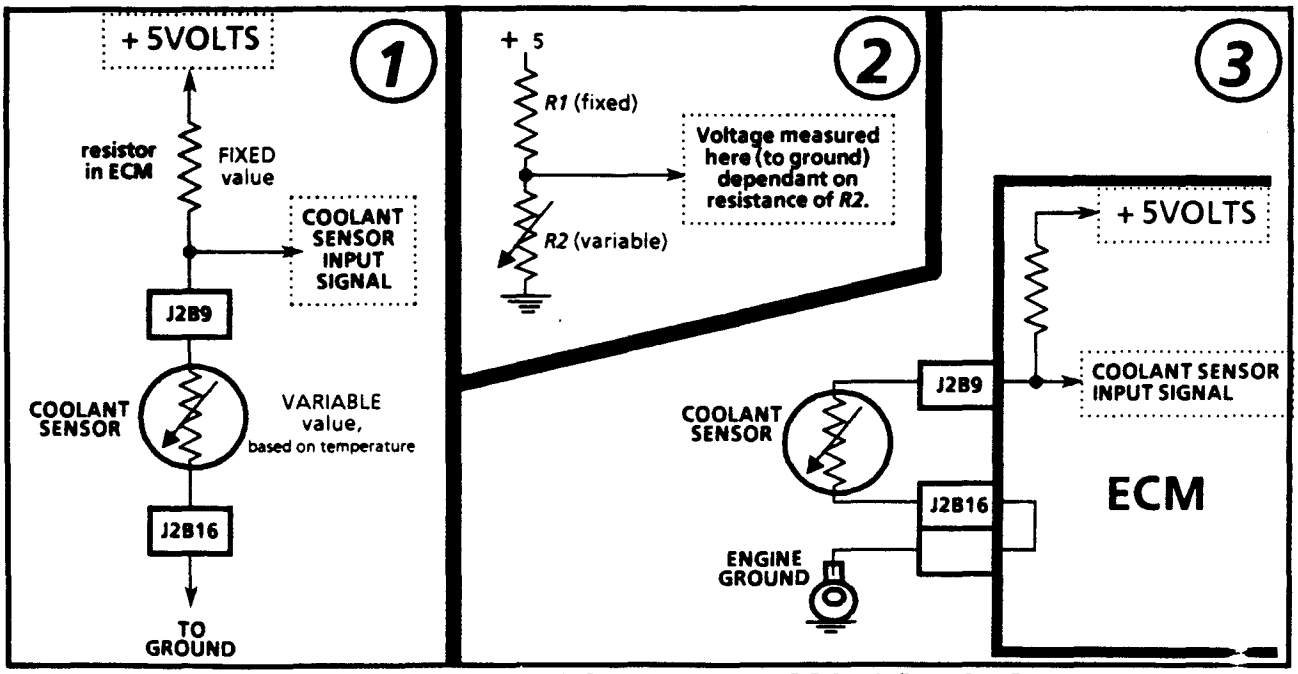
The voltage drop across the coolant sensor varies from 0 to 5 volts. This voltage, measured at the ECM, will decrease as coolant temperature increases; therefore, disconnecting the coolant sensor simulates a cold engine, and shorting across the sensor simulates a hot engine.

The circuit operation for the Coolant and MAT sensors are the same. The way the ECM interprets the voltage is also the same for each, although each sensor's signal is used for different functions by the ECM.

Both the coolant and MAT temperature sensors are negative temperature coefficient thermistors. As they become hotter, their resistance becomes less.



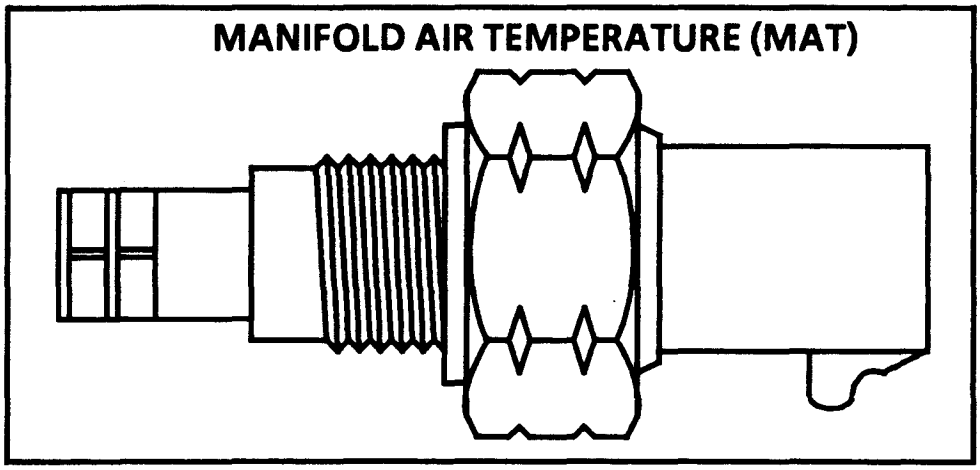

VOLTAGE DIVIDER NETWORKS USING 2 RESISTORS AND A 5 VOLT SOURCE.

# 2.5 MANIFOLD AIR TEMPERATURE (MAT) SENSOR

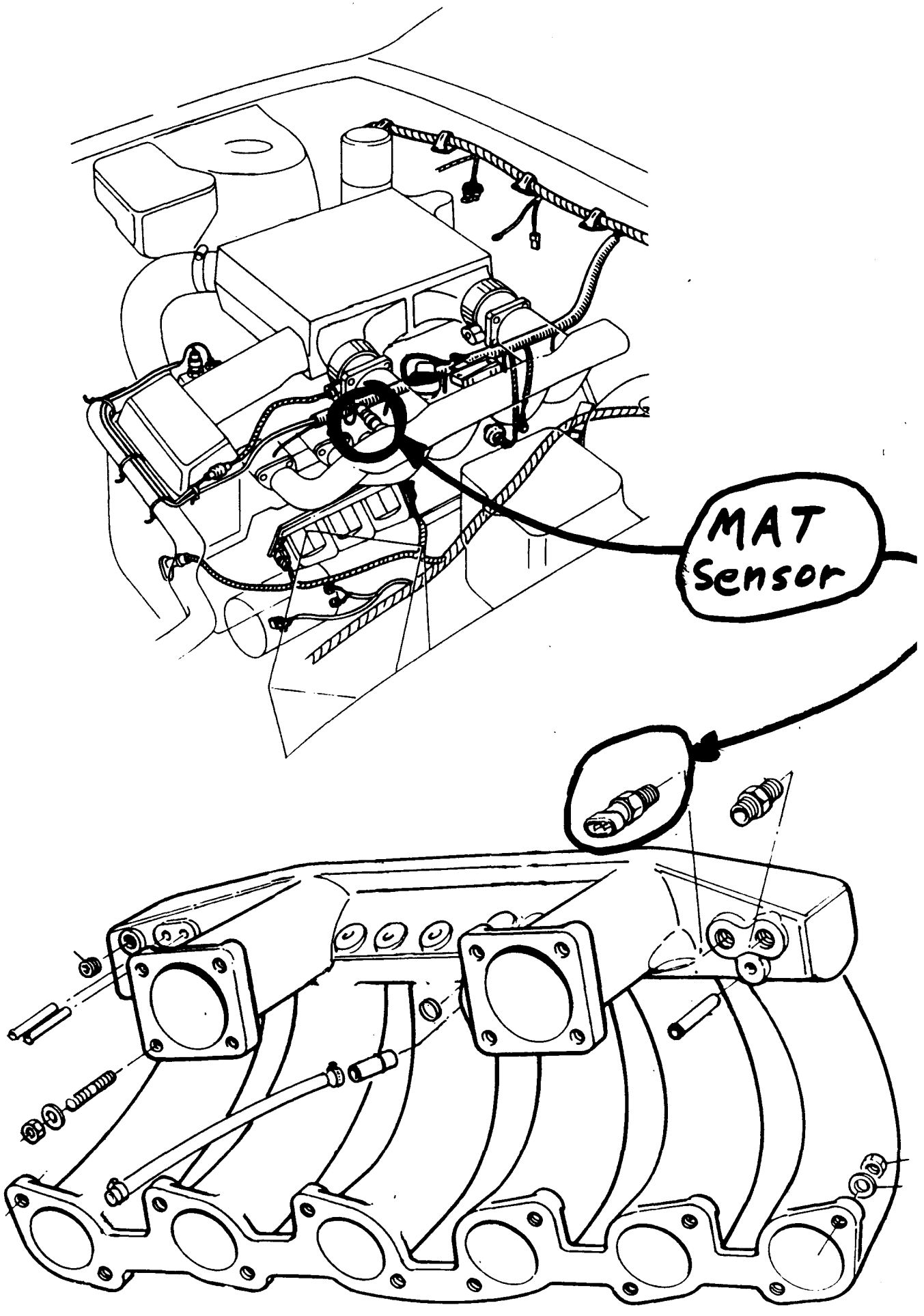
The Manifold Air Temperature (MAT) sensor is fitted into the intake manifold, above the front cylinder runner. The ECM uses this signal in conjunction with others to calculate air density and the appropriate fuel delivery for both starting and running. The MAT sensor is also used in determinig when to operate the auxiliary water pump and radiator fan after engine shutdown.

The MAT sensor is a thermistor (a resistor which charges value with temperature) similar to the coolant temperature sensor. *(See coolant sensor for circuit operation.)* Low temperature produces a high resistance (100,000 ohms at minus 40°C) while high temperature causes low resistance (185 ohms a100°C). The ECM supplies, through an internal resistor, a 5 volt signal to the MAT sensor. By measuring the resulting circuit voltage is able to calculate the manifold air temperature.

Low air temperature produces a high sensor resistance for a higher fuel requirement.



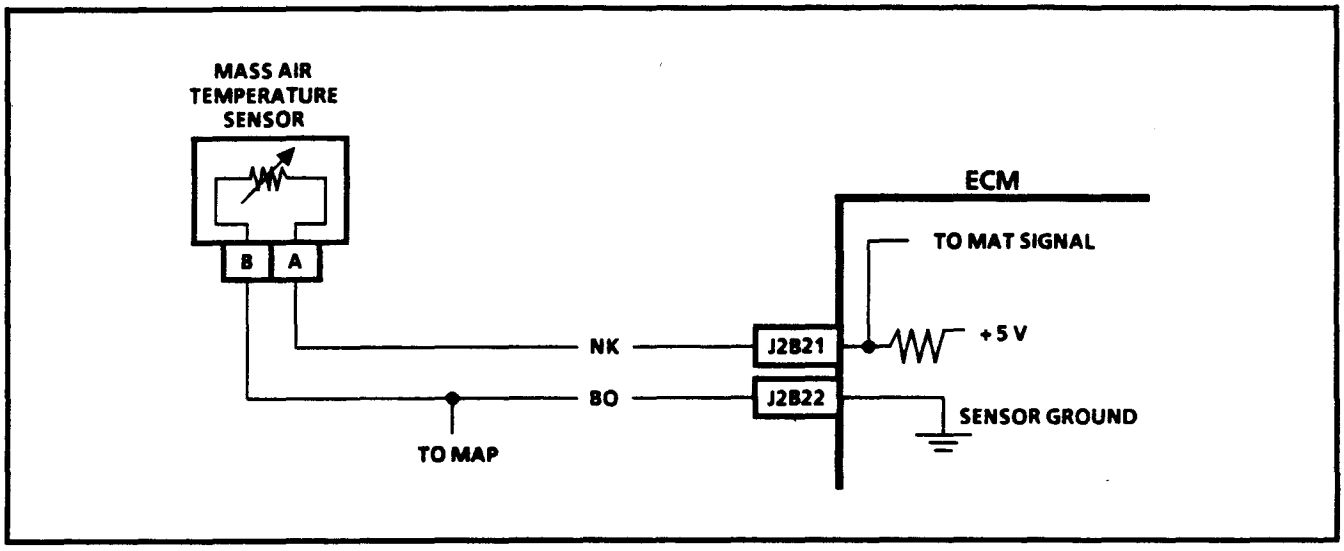

| COOLANT and MAT SENSOR TEMP. TO RESISTANCE VALUES (APPROXIMATE) | |
|---|---|
| °Centrigrade | OHMS |
| 110° | 90 |
| 100° | 185 |
| 90° | 225 |
| 70° | 450 |
| 40° | 1,750 |
| 20° | 3,400 |
| 0° | 10,000 |
| -20° | 25,000 |
| -40° | 100,000 |


MAT
Sensor

# MANIFOLD AIR TEMPERATURE (MAT) SENSOR CIRCUIT

## Circuit Description:

The MAT sensor uses a thermistor to control the signal voltage to the ECM. The ECM applies a voltage of about 5 volts on CKT J2B21 to the sensor. When the air is cold, the sensor (thermistor) resistance is high, therefore, the ECM terminal "J2B21" voltage is high. As the air warms, the sensor resistance becomes less, and the voltage drops. As the incoming air gets warmer, the sensor resistance decreases, causing ECM terminal "J2B21" voltage to decrease.



# 2.6 EXHAUST OXYGEN ($0_2$) SENSORS

The Lotus - Omega / Carlton engine uses two oxygen sensors; one for the front three cylinders, and a second sensor for the rear three cylinders. Both sensors contain an electric heating element, to ensure fast warmup of the sensors, and thus a faster transition to closed loop fuel control.

The oxygen sensors monitor the oxygen content in the exhaust. The oxygen sensor consists of zirconia electrolyte between two platinum plates. Zirconia comes from zirconium, which is a basic chemical element. When zirconia comes in contact with oxygen, it becomes an electrical conductor (electrolyte). A chemical reaction takes place on the platinum plates, causing oxygen ions to build up on the platinum plates (an ion is an atom or molecule with too many or too few electrons). The oxygen ion has two more electrons than a normal oxygen atom, so the ions have a negative electrical charge.

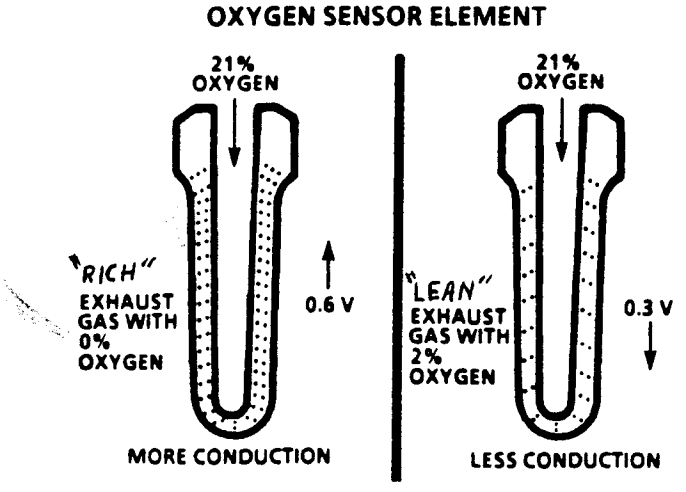
The oxygen sensor is installed so that exhaust gas is passed through louvers in the bottom of the oxygen sensor. One plate is in contact with the exhaust gas side and the other plate is in contact with outside air. Outside air enters the top of the oxygen sensor and flows down the center of the sensor to the inner chamber.

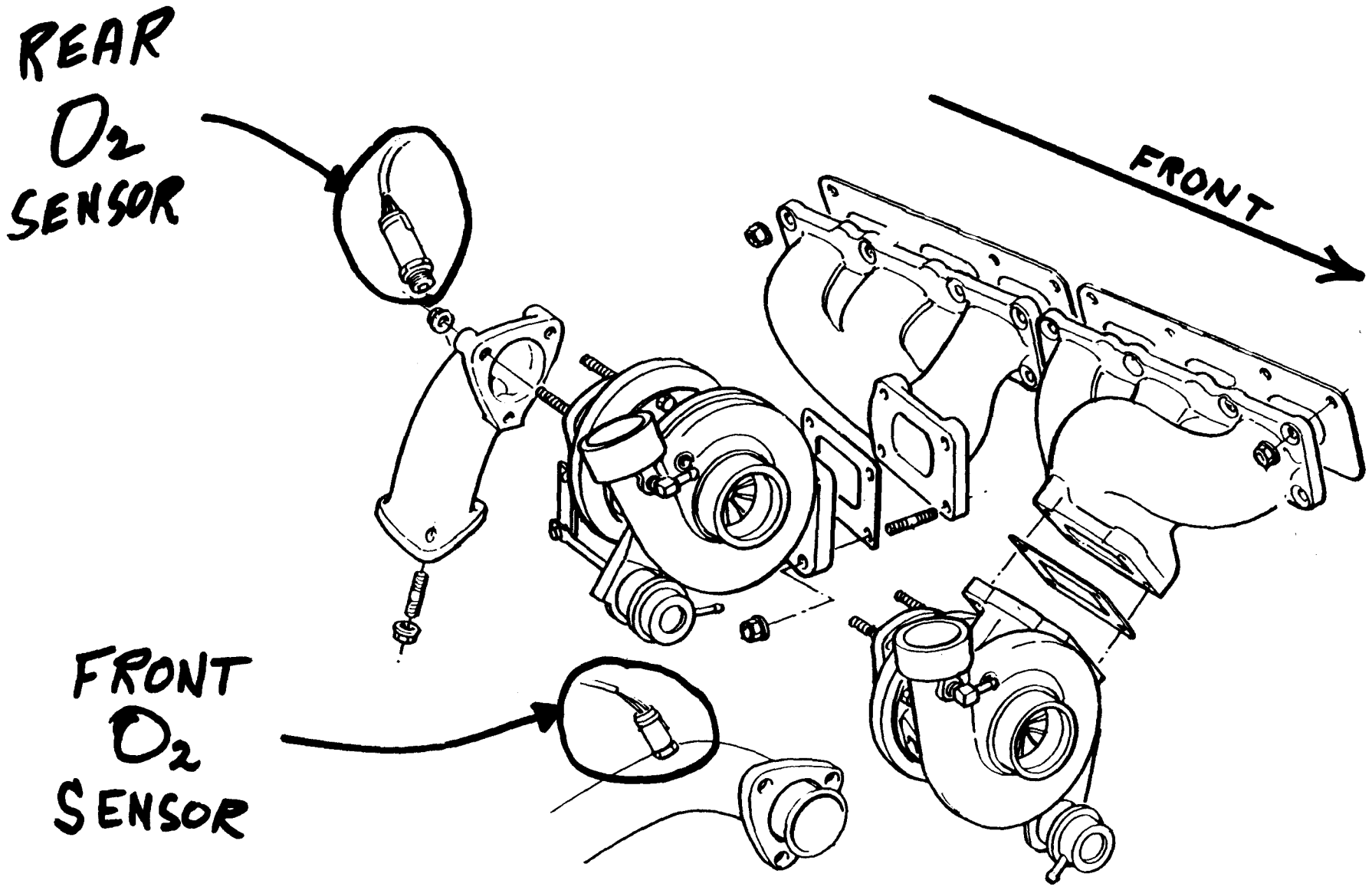
Oxygen ions build up on both platinum plates. The platinum plate on the air-reference side of the sensor has more oxygen ions than the platinum plate on the exhaust gas side of the sensor. Therefore, the platinum plate on the air-reference side is electrically negative, and the platinum plate on the exhaust gas side of the sensor is positive. A difference in electrical potential or voltage is developed between the two platinum plates. The voltage across the platinum plates ranges from approximately 100 millivolts to 900 millivolts, dependent on the oxygen content of the exhaust.

If the air/fuel mixture is rich, few oxygen ions appear in the exhaust gas side of the sensor. The platinum plate on the exhaust gas side of the sensor becomes more positive. The electrical charge on the platinum plate at the air-reference side does not change; therefore, the voltage difference between the two platinum plates increases.

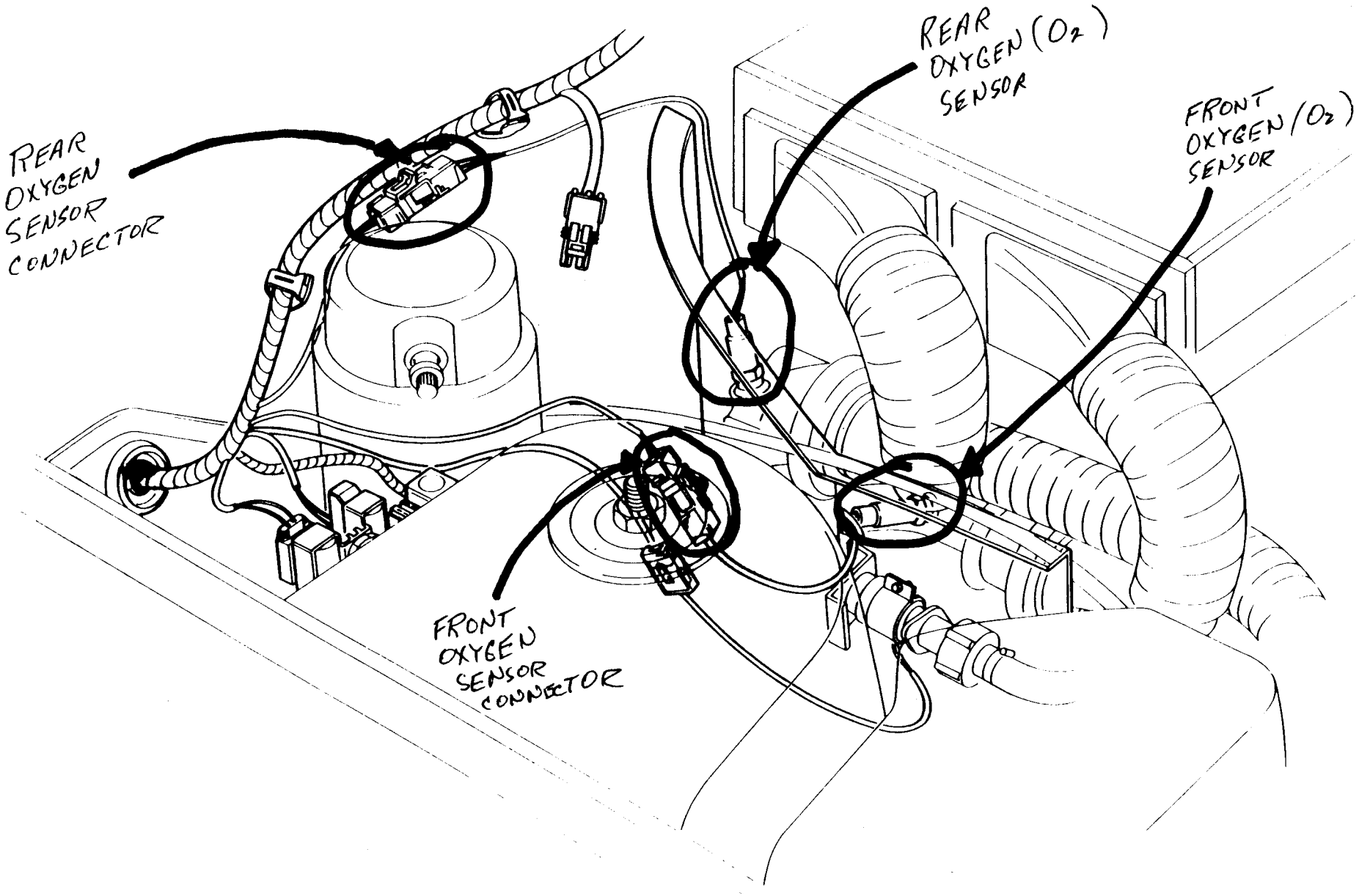
When air/fuel mixture is lean, a large number of oxygen ions will appear on the exhaust side of the oxygen sensor. This makes the platinum plate on the exhaust gas side of the sensor more negative. The voltage difference between the two platinum plates decreases.

Therefore, if the air/fuel mixture is rich, the oxygen sensor voltage is high. If the air/fuel mixture is lean, the oxygen sensor voltage is low. The ECM measures the voltage difference between the platinum plates to determine whether the air/fuel mixture is rich or lean.



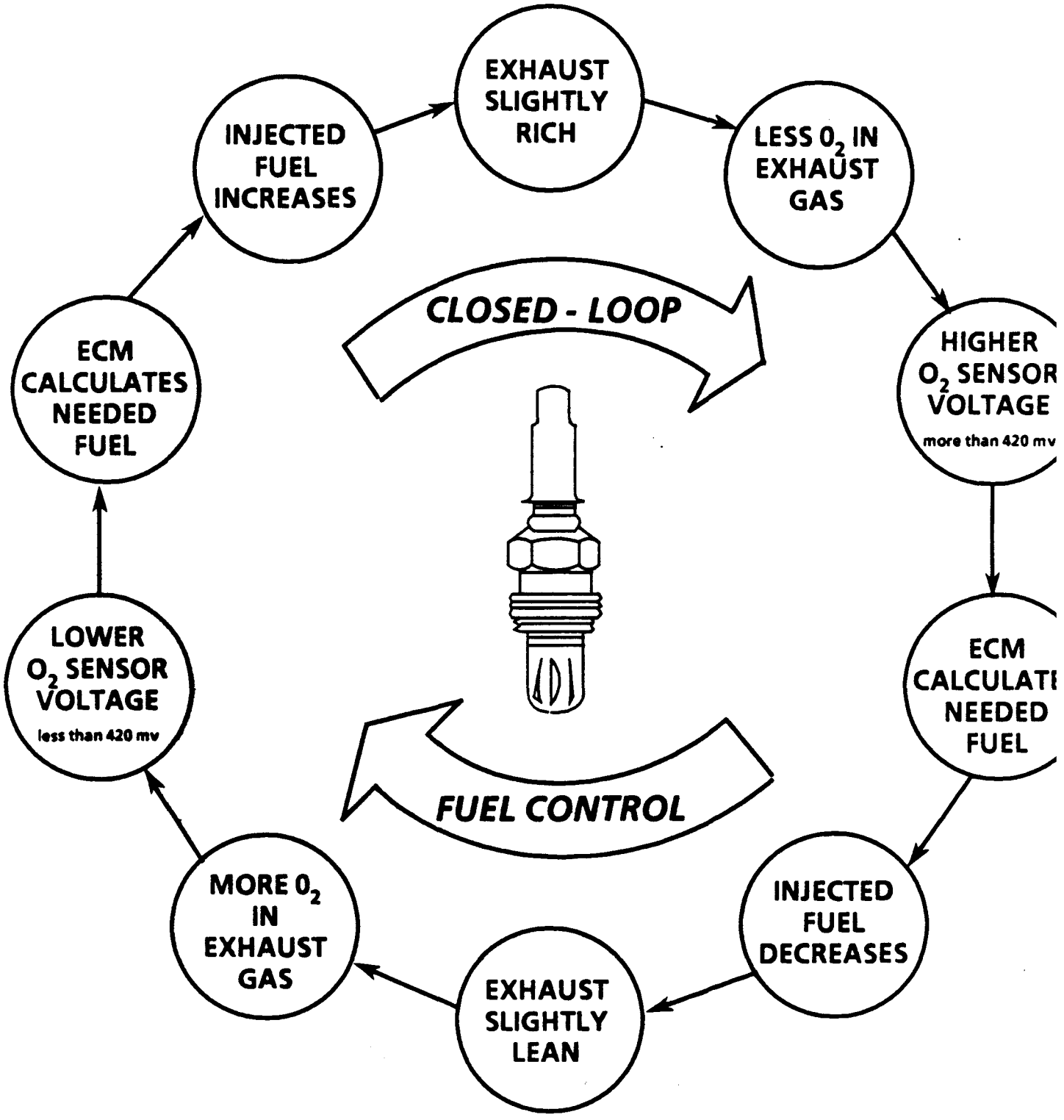

REAR
O2
SENSOR
FRONT
FRONT
O2
SENSOR

# LOTUS - OMEGA / CARLTON TRAINING

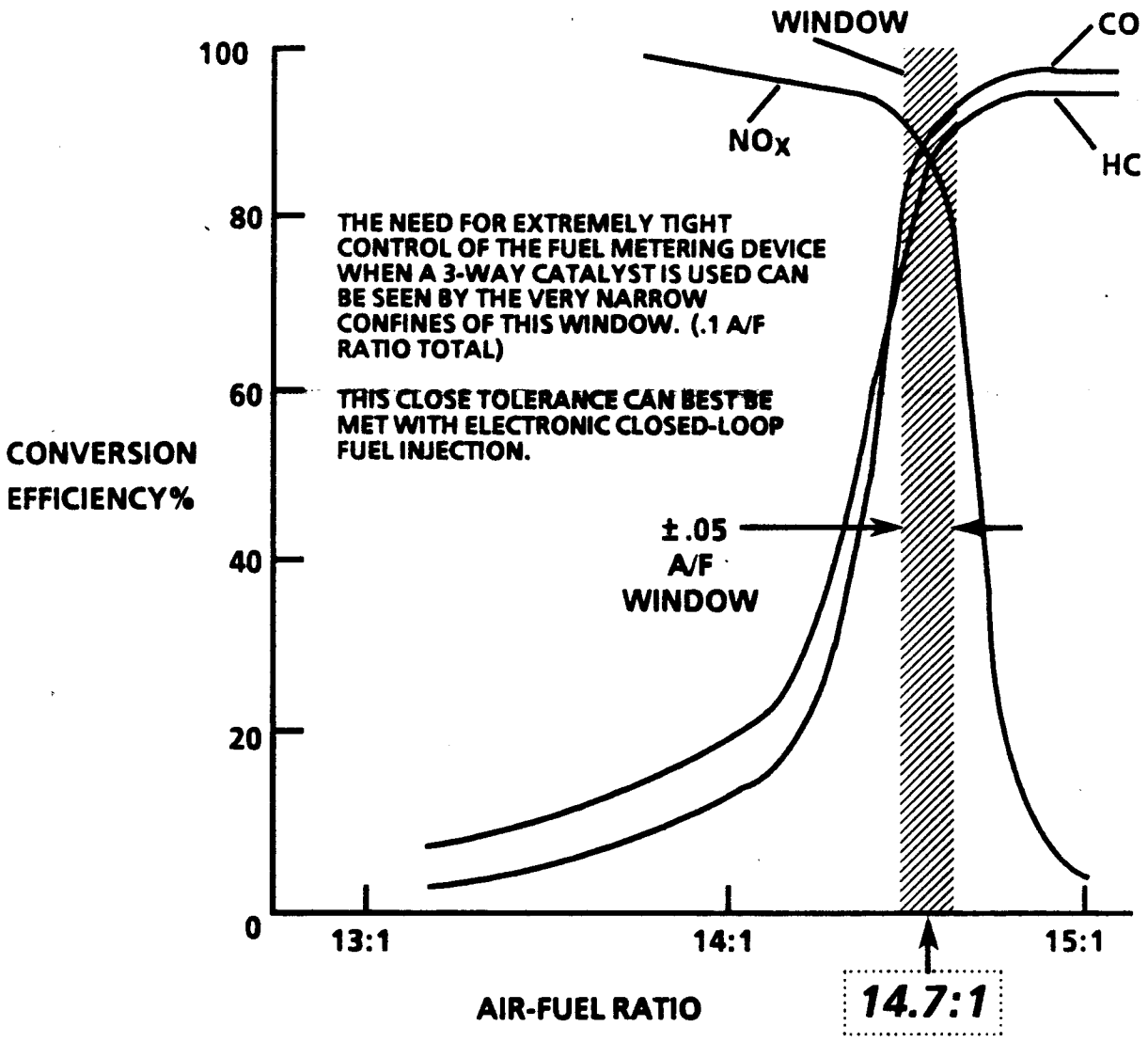


CAMRA-ONE

# LOTUS - OMEGA / CARLTON TRAINING

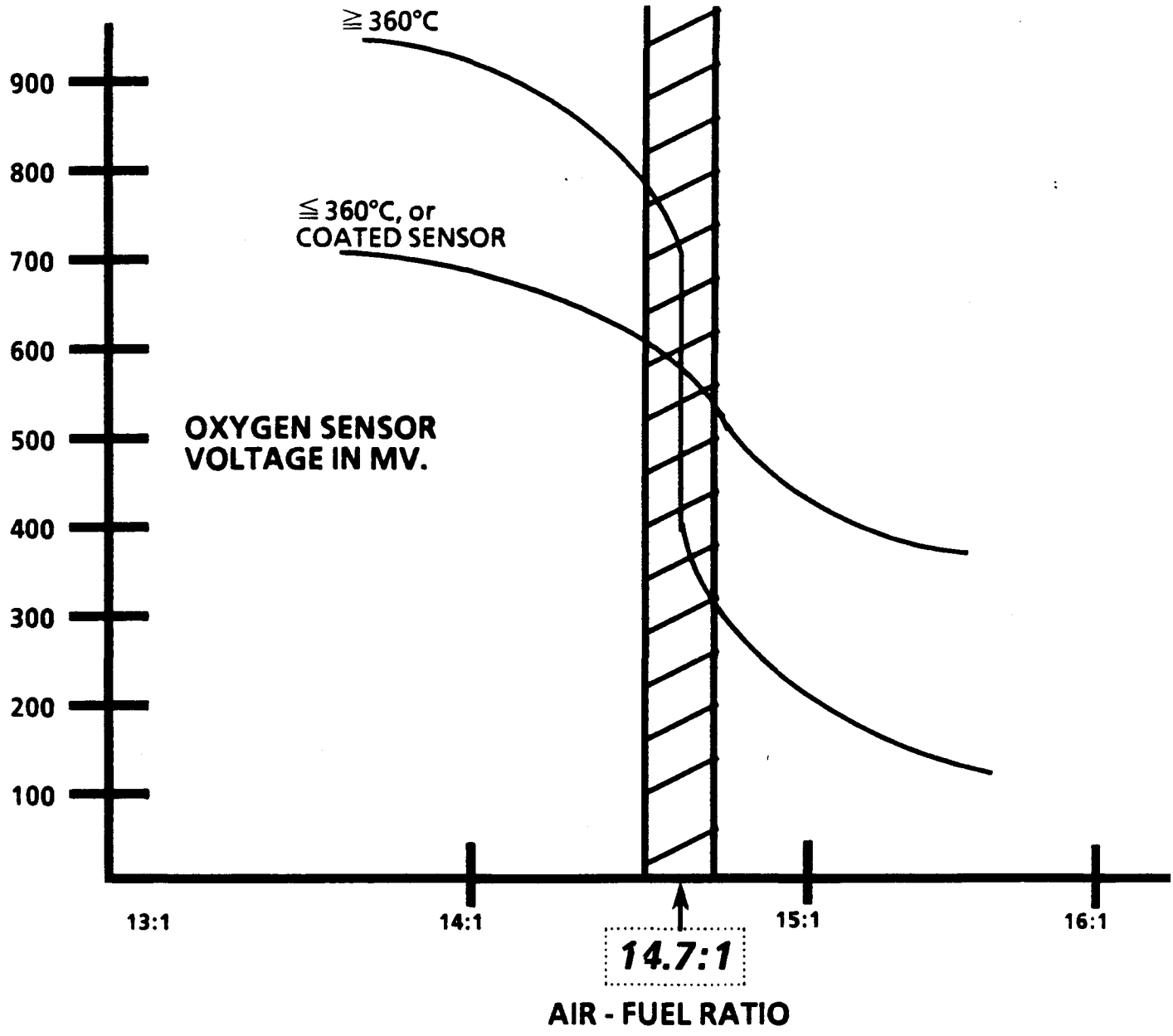


# PRINCIPLE OF OPERATION 3-WAY CATALYST

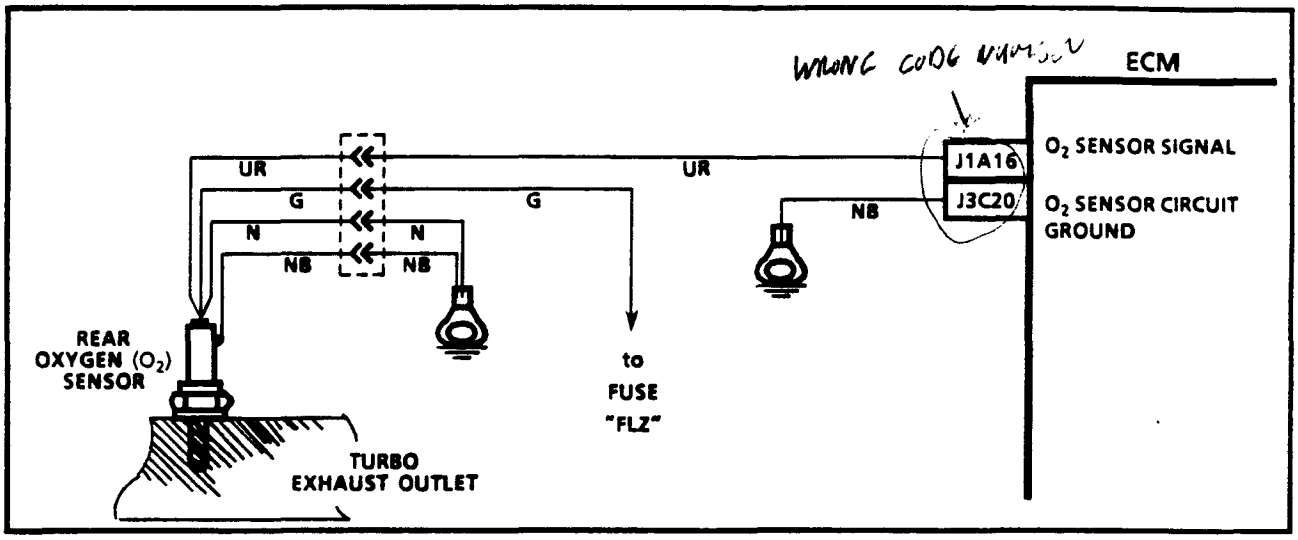



IS 0431
3-5-86

# OXYGEN SENSOR VOLTAGE OUTPUT CHARACTERISTIC CURVE



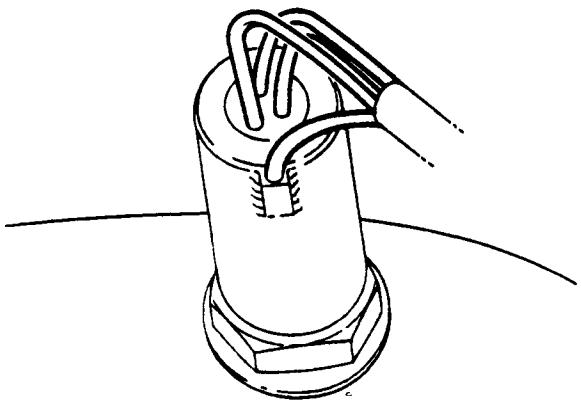
# OXYGEN SENSOR CIRCUIT



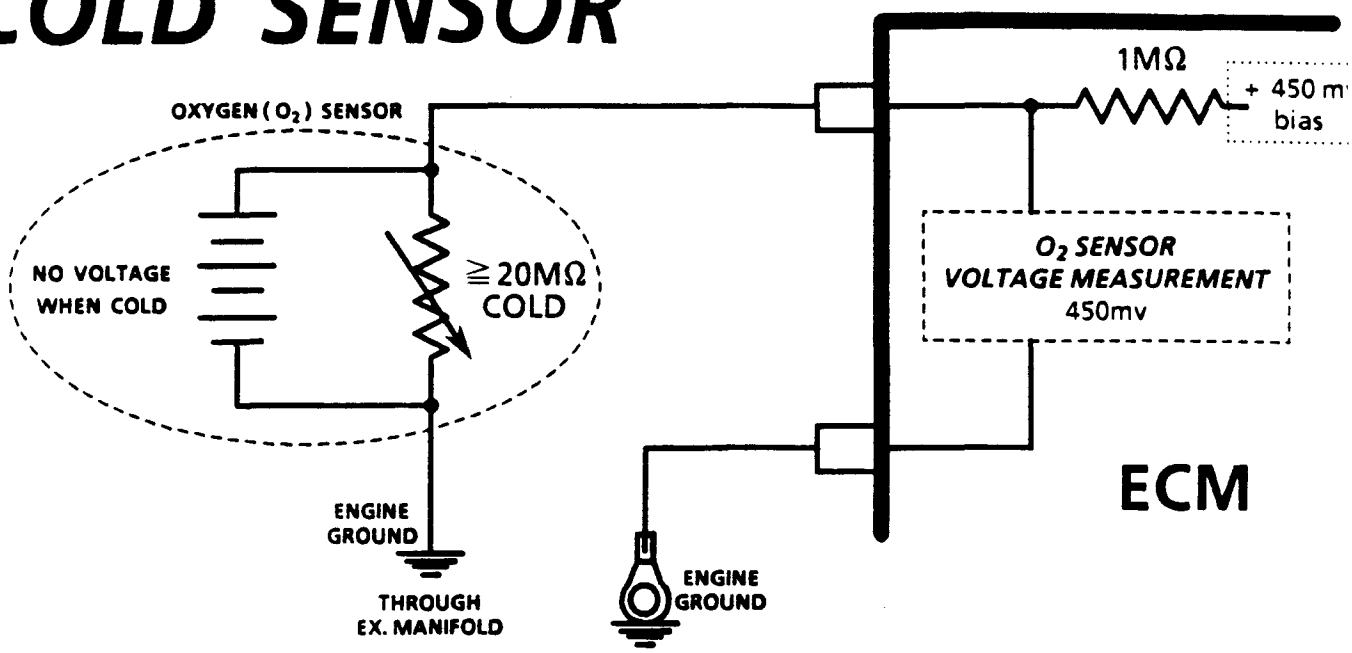

## Circuit Description:

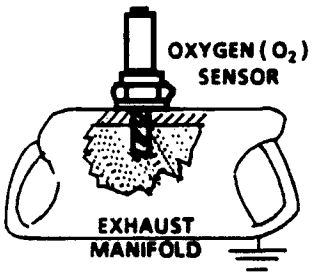
The ECM supplies a voltage of about .45 volt between terminals "J3E14" and "J2B4". (If measured with a 10 megohm digital voltmeter, this may read as low as .32 volt.) The $O_2$ sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about .10 volt if exhaust is lean.

The sensor is like an open circuit and produces no voltage when it is below 360°C (600° F). An open sensor circuit or cold sensor causes "Open Loop" operation. A not functional sensor heater causes a delayed " Closed Loop " operation.

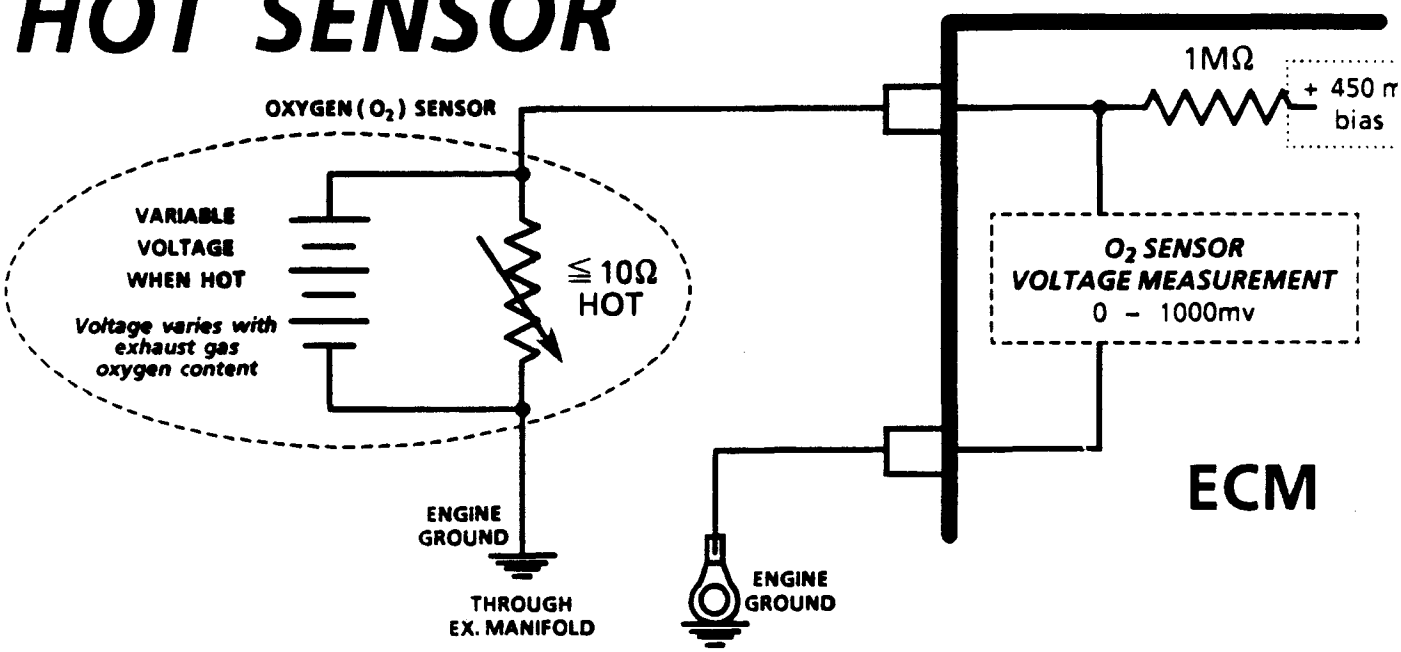


# COLD SENSOR

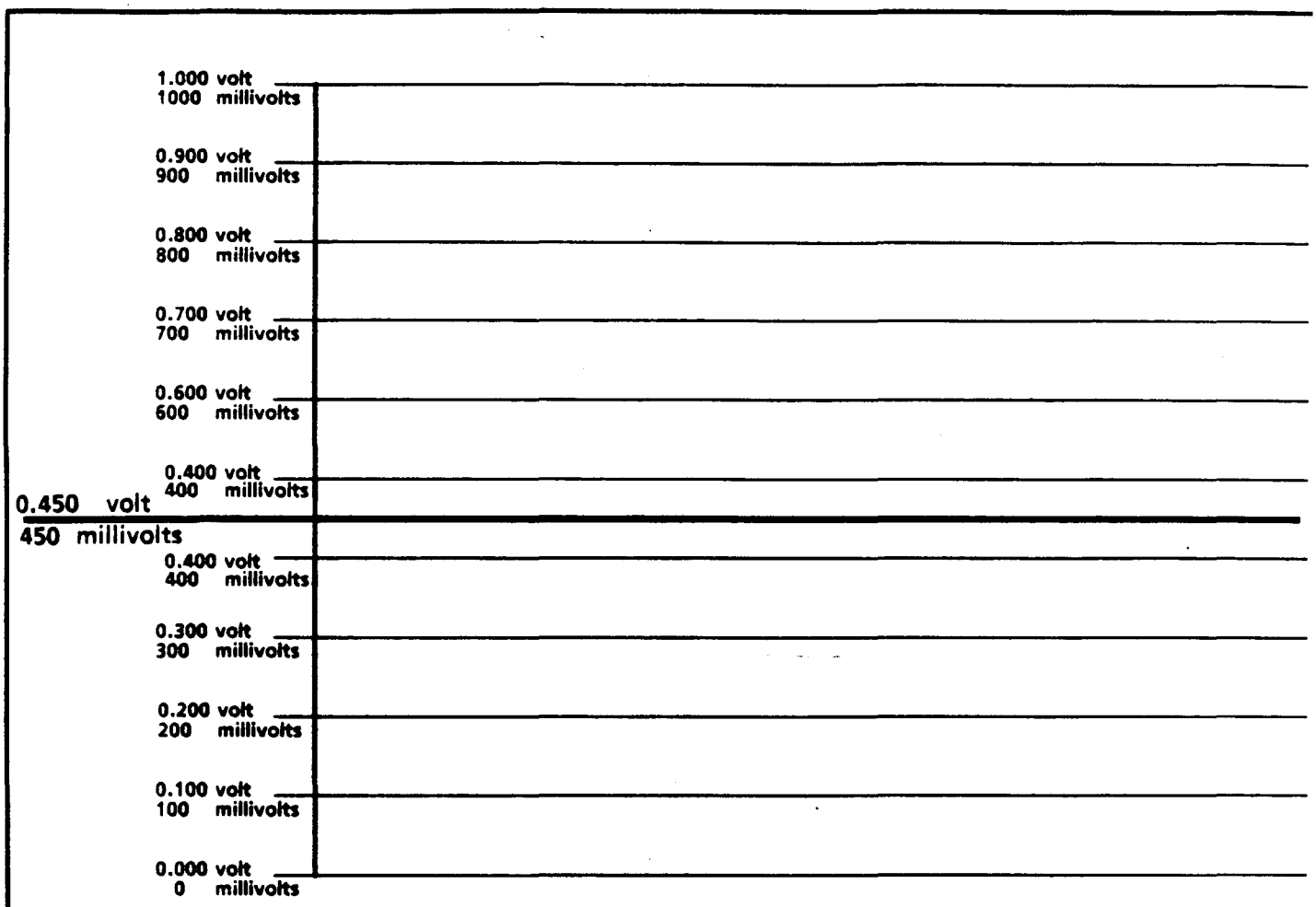


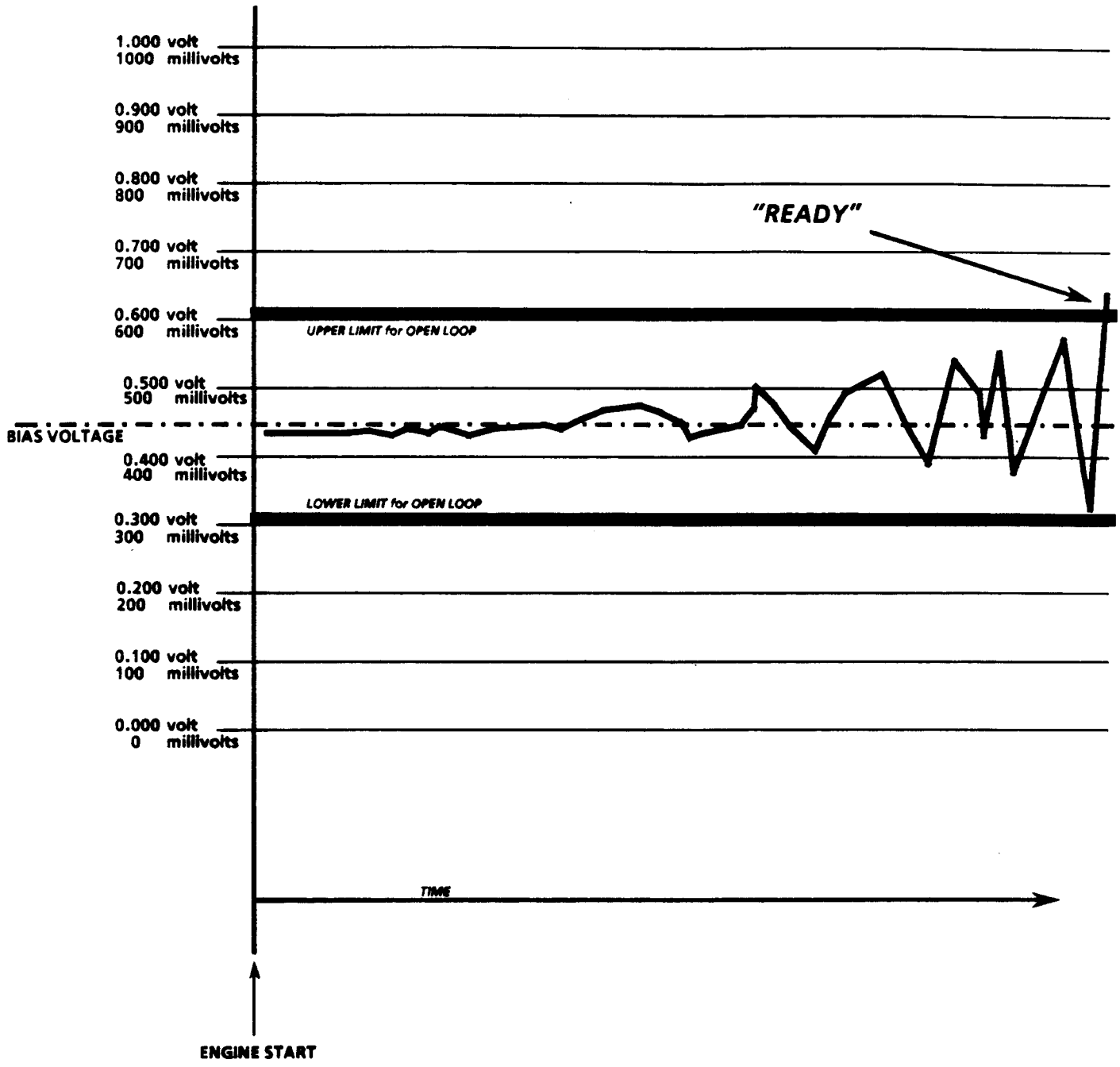

# HOT SENSOR



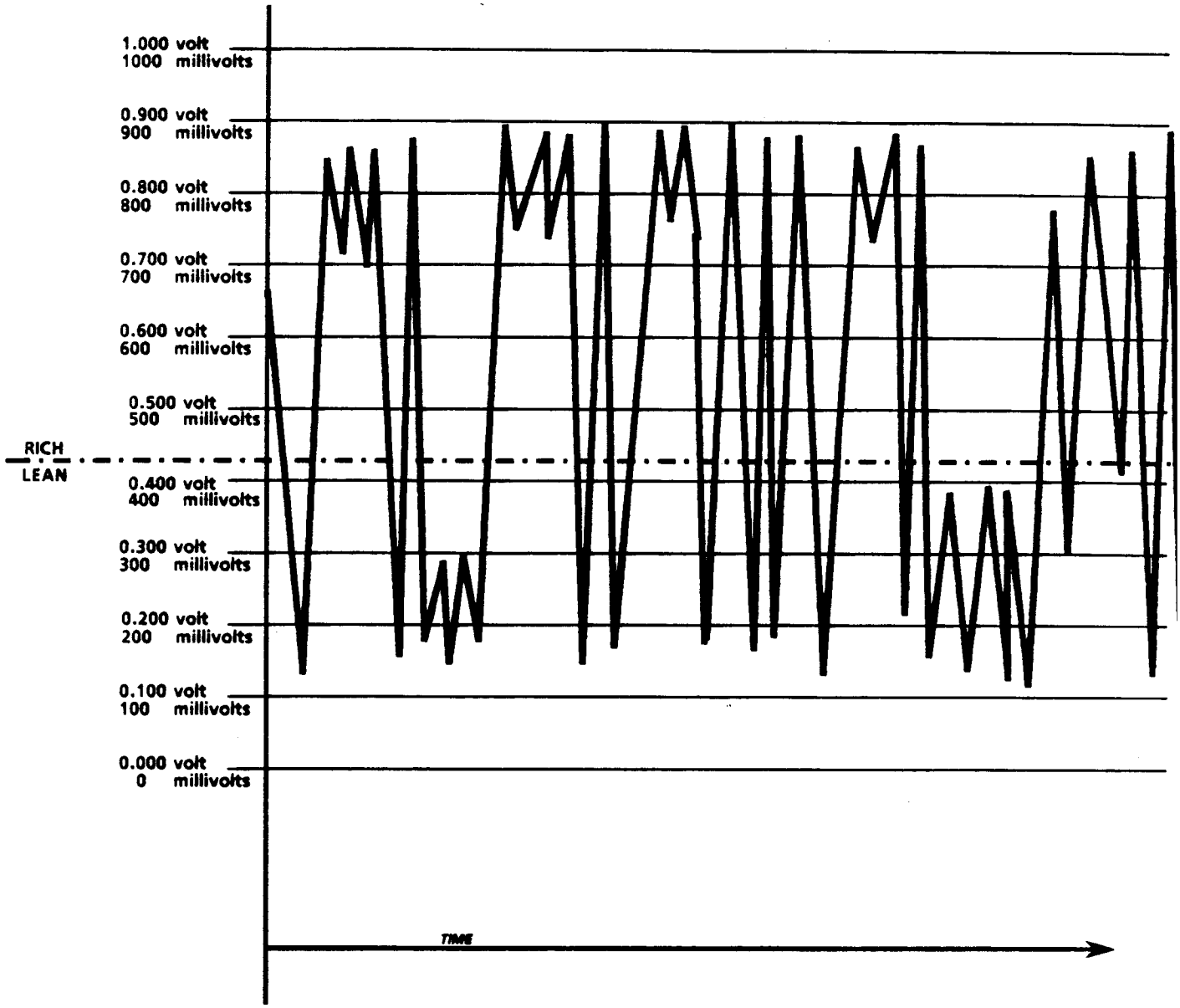

**When the sensor is hot, the 450mv bias voltage goes to ground through the sensor's low internal resistanc**




# $O_2$ SENSOR BIAS VOLTAGE

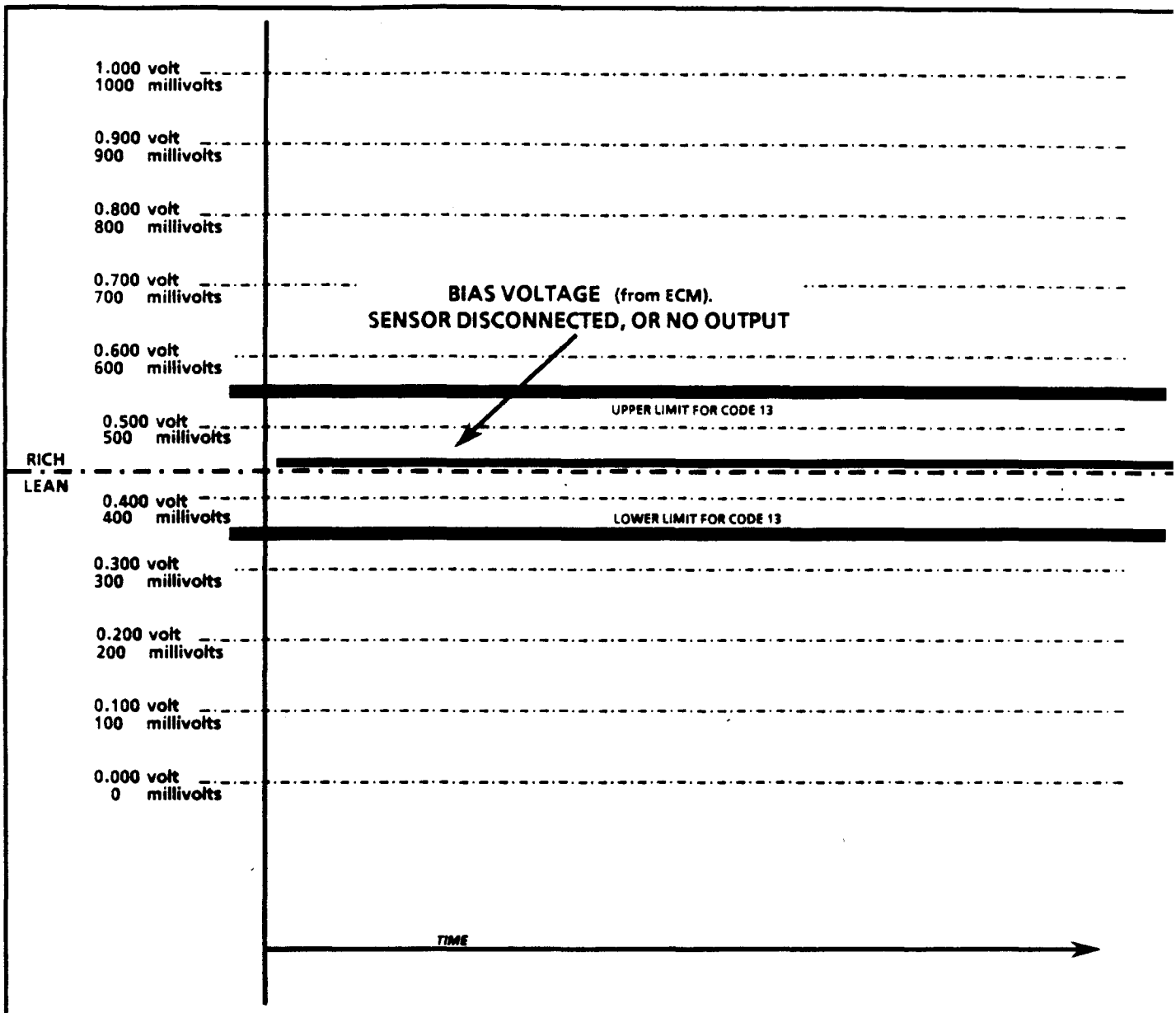



# $O_2$ sensor voltage output during warm-up transition



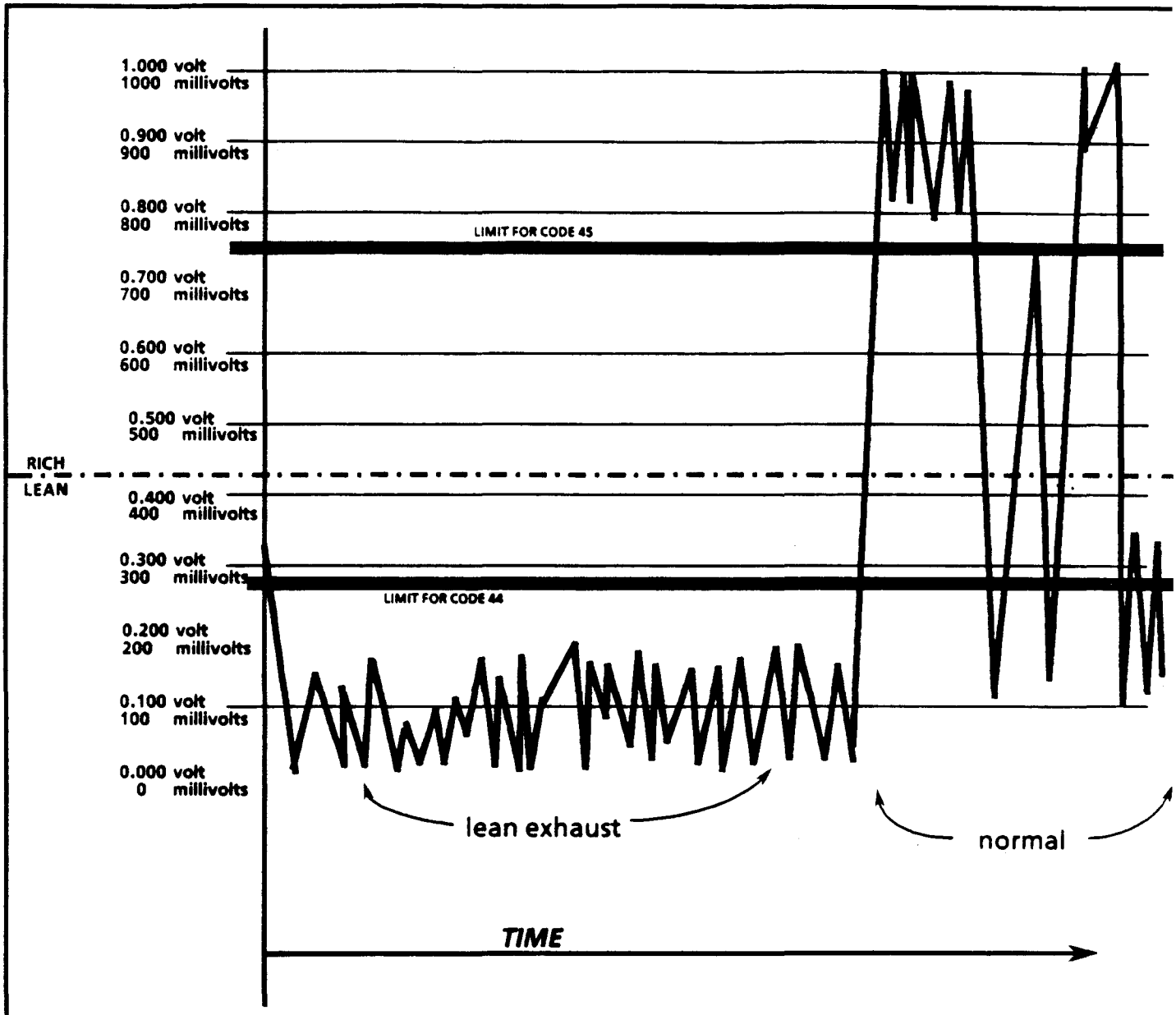

# $O_2$ sensor voltage output during closed loop operation

(steady engine load)



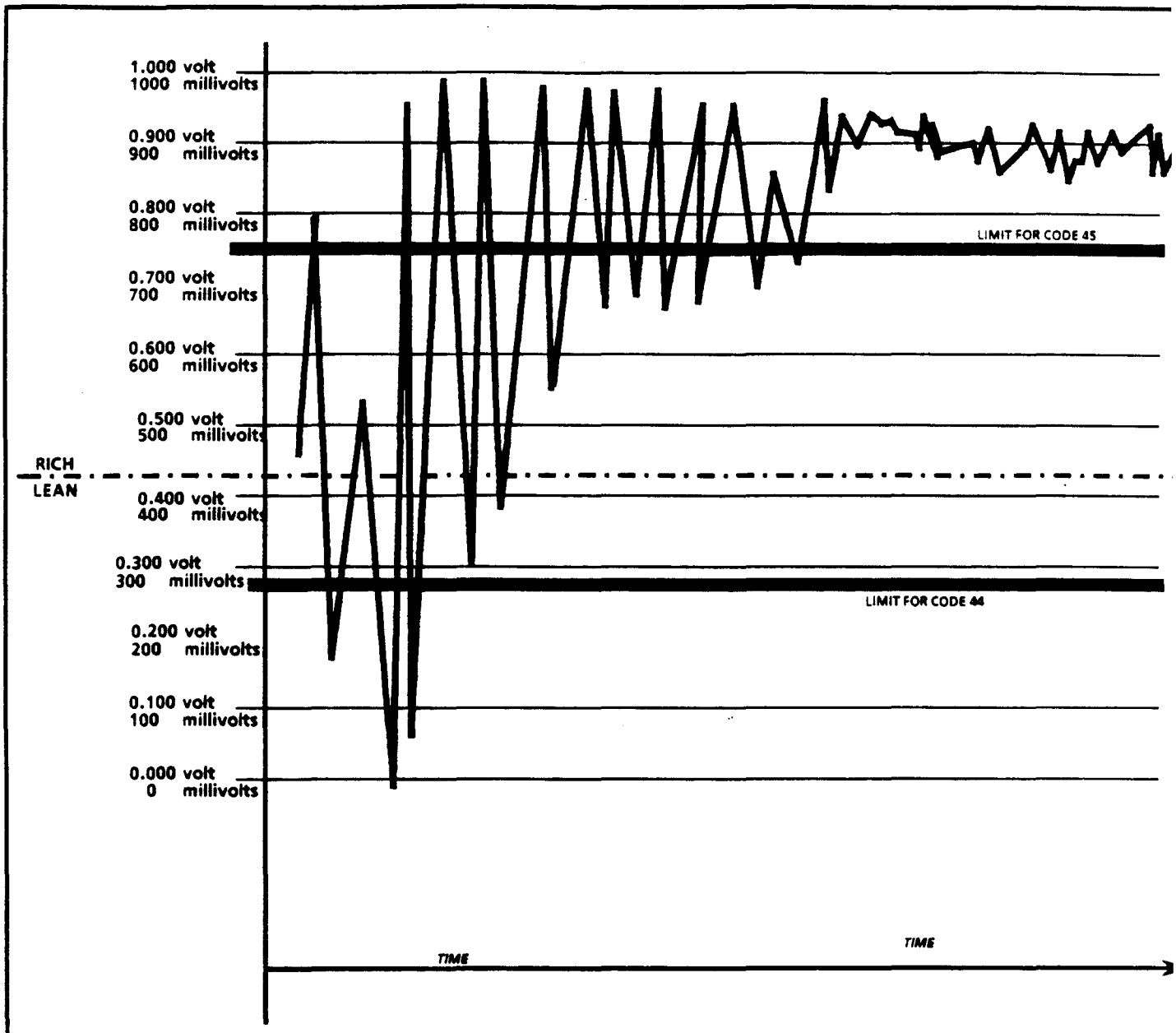

# $O_2$ SENSOR OUTPUT VOLTAGE CODE 13

63

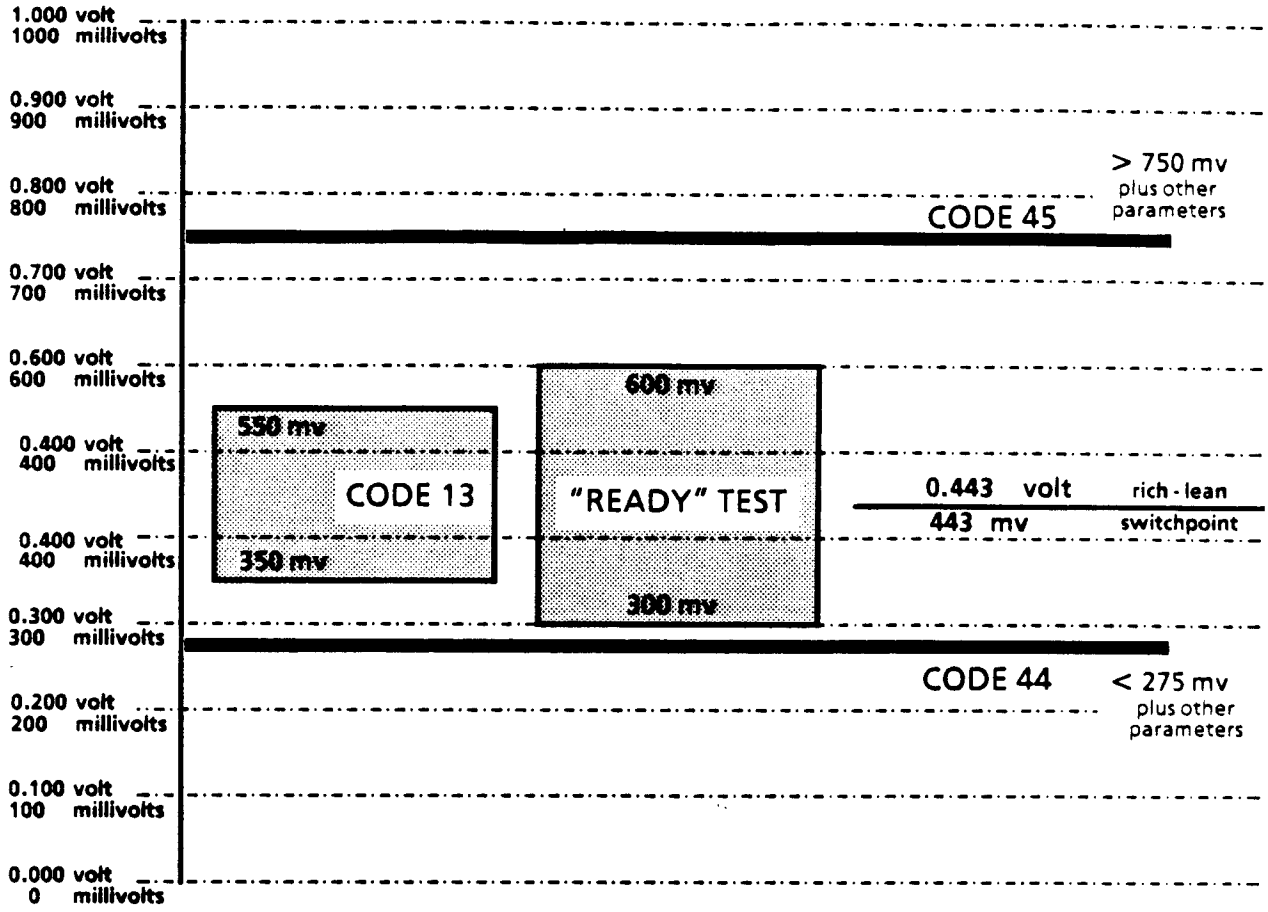



# $O_2$ SENSOR OUTPUT VOLTAGE
# CODE 44 - lean exhaust indication

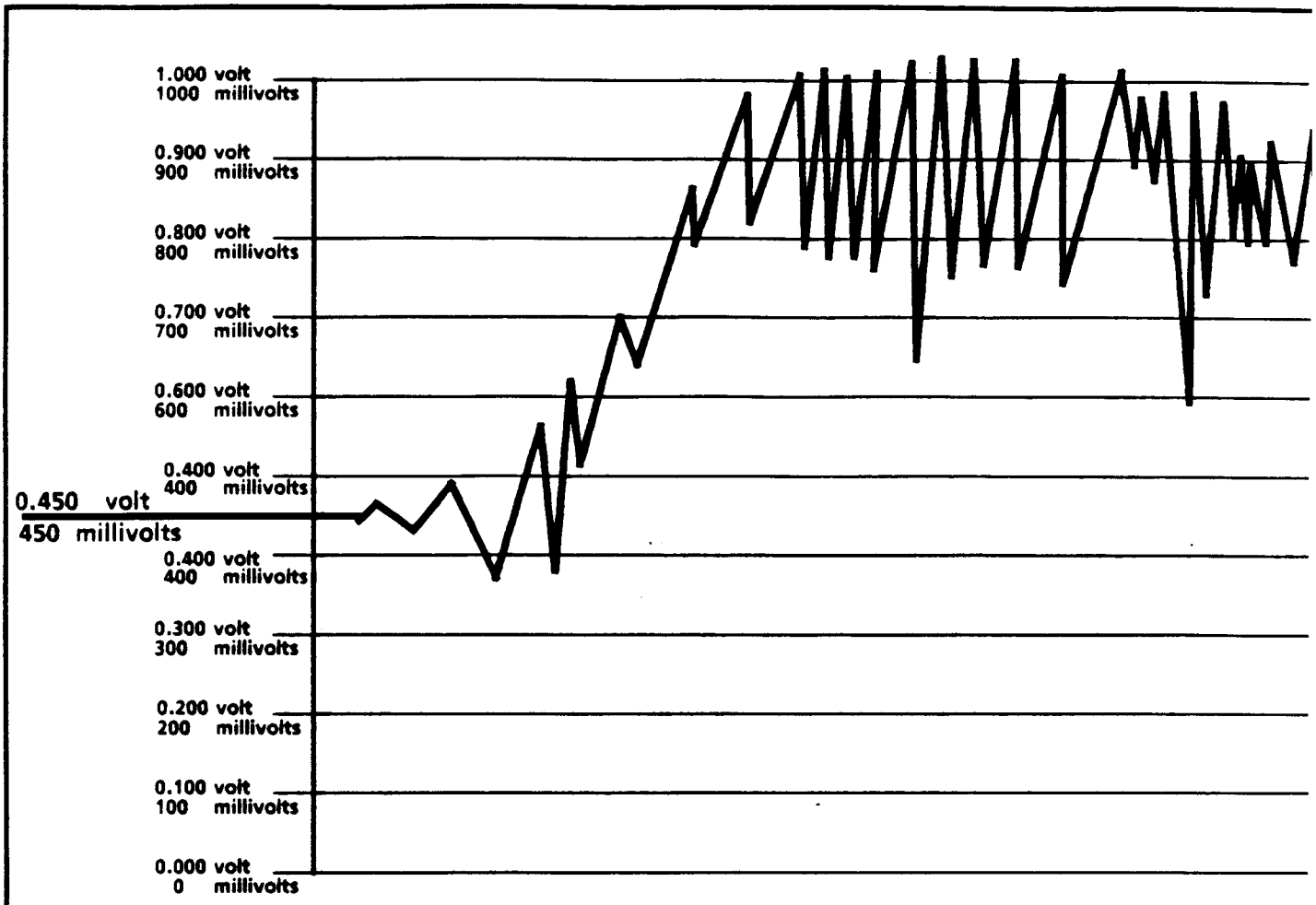
64




O₂ SENSOR OUTPUT VOLTAGE
CODE 45 - rich exhaust indication

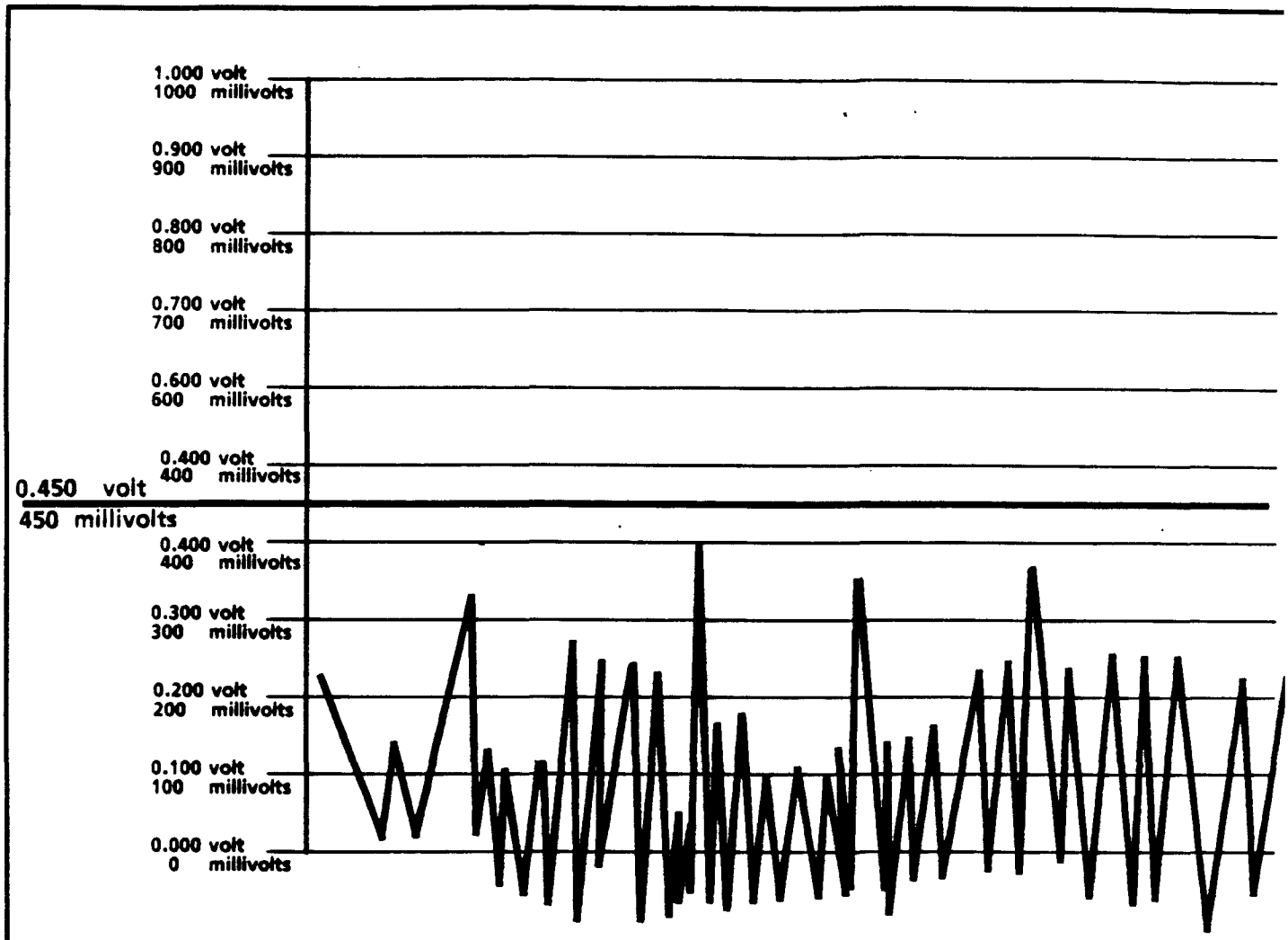



# $O_2$ SENSOR operating voltages




# $O_2$ SENSOR VOLTAGE OUTPUT

**SENSOR COATED (CONTAMINATED) ON EXHAUST GAS SIDE**




# $O_2$ SENSOR OUTPUT VOLTAGE

with *ATMOSPHERIC VENT PLUGGED*

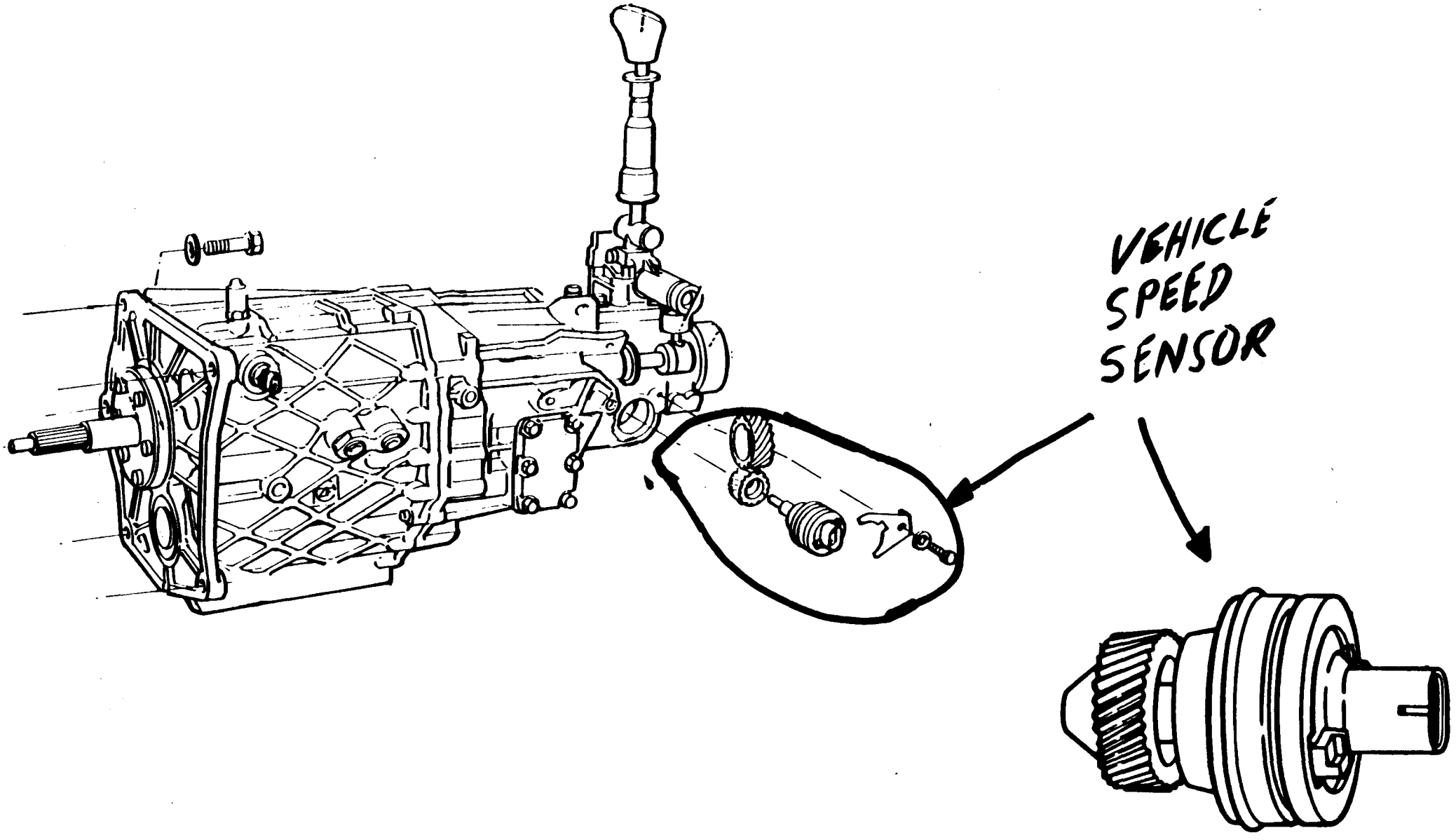
## 2.7 VEHICLE SPEED SENSOR (V.S.S.)

Vehicle speed information is supplied to the ECM by the vehicle speed sensor which is a permanent magnet generator mounted on the transmission. The generator produces a pulsing AC voltage whenever vehicle speed is over about 3 mph (5 Km/h) and which increases in value and frequency with increasing vehicle speed.

The VSS signal information is used by the ECM to assist in the control of:

- Idle Air Control
- Canister Purge Control
- Air Conditioner Clutch Control
- Electric Radiator Fan
- Turbo Wastegate Control
- SETUD TRONIC
- SPEEDO

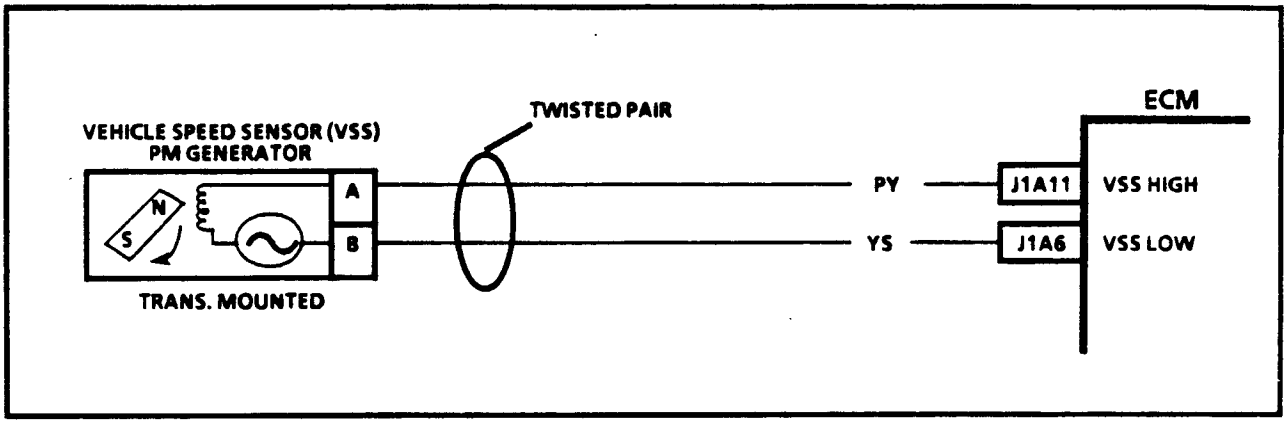
# LOTUS - OMEGA / CARLTON TRAINING



# VEHICLE SPEED SENSOR CIRCUIT

## Circuit Description:

Vehicle speed information is provided to the ECM by the vehicle speed sensor (VSS) which is a permanent magnet (PM) generator that is mounted in the transmission. The PM generator produces a pulsing voltage whenever vehicle speed is over about 3 mph, (5 Km/h). The AC voltage level and the number of pulses increases with vehicle speed. The ECM then converts the pulsing voltage to Km/h which is used for calculations and the interpreted Km/h can be displayed with Tech 1. Output of the generator can also be seen by using a digital voltmeter on the AC scale while rotating the generator.



# 2.9 ELECTRONIC SPARK CONTROL (ESC) & WASTEGATE ACTUATOR SOLOENOID CONTROL

This system comprises an engine "knock" sensor mounted below the intake manifold in the cylinder block, a turbo boost control solenoid valve, and an ESC module which is incorporated into the ECM "Mem-Cal" cartridge.

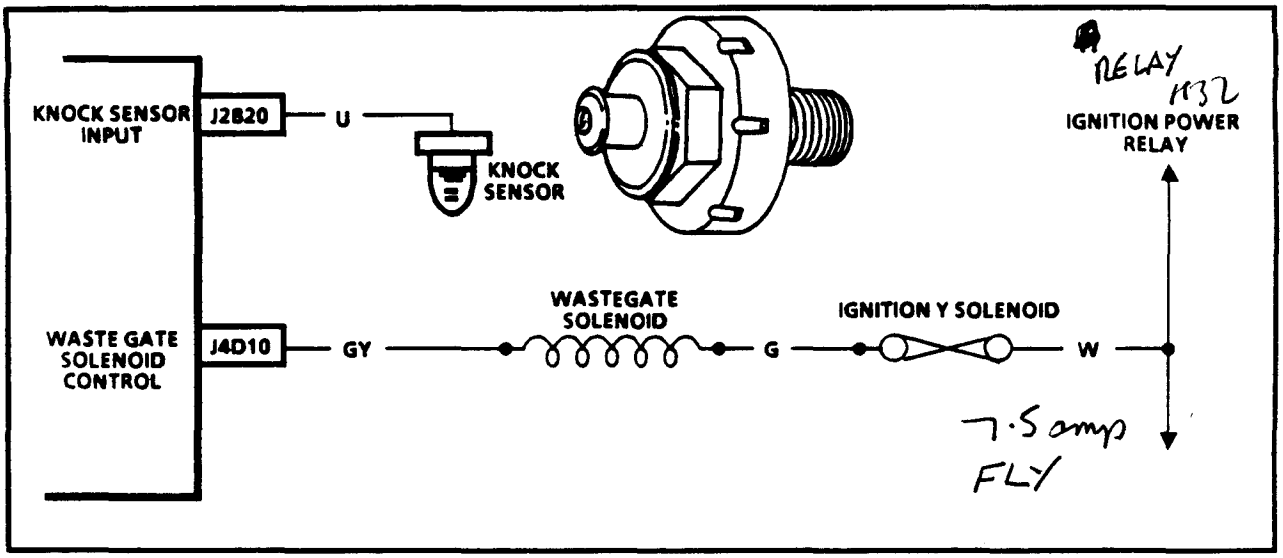
The ignition timing required for optimum performance can lead, under certain operating conditions, to detonation of the fuel mixture in the combustion chamber, causing excessive heat and pressures and a characteristic "knocking" noise. If allowed to continue unchecked, major engine damage can occur. The ESC system allows the engine to adhere as closely as possible to the optimum ignition timing and turbo boost settings without a damaging level of detonation.

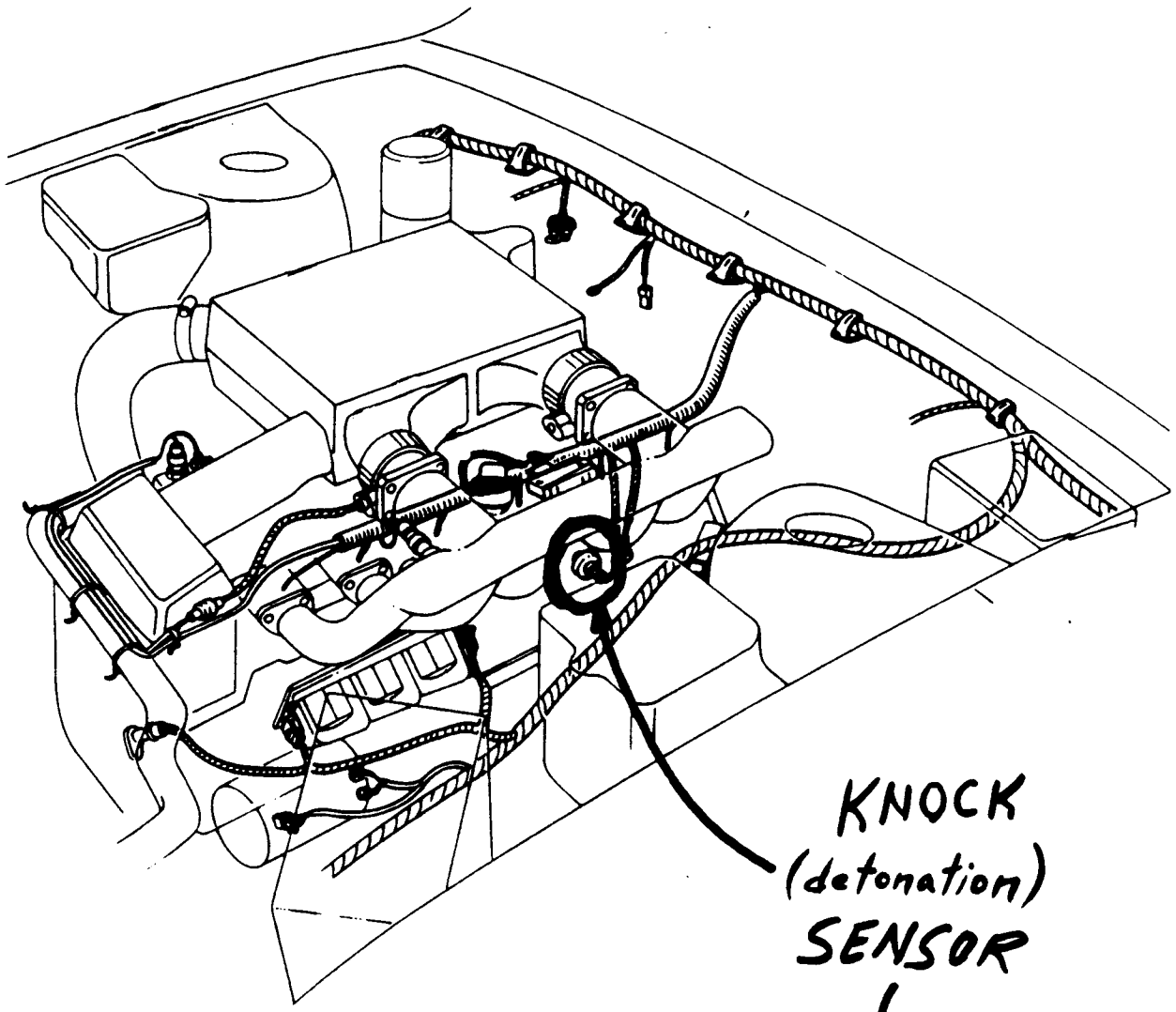
When the knock sensor detects the onset of detonation, the ECM both retards ignition and reduces turbo boost pressure to a safe level, and then progressively advances ignition and raises boost until detonation is again detected and the cycle repeats.

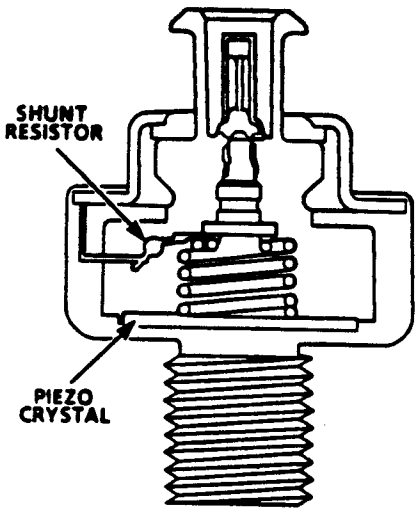
## KNOCK SENSOR

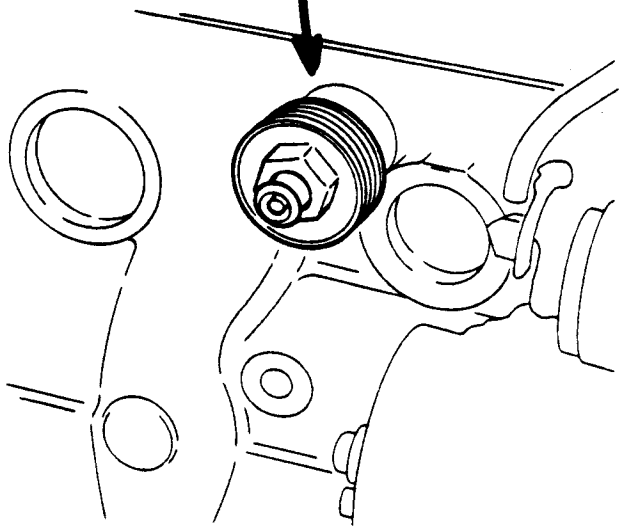
The knock sensor is mounted in the cylinder block, and is able to identify the detonation "knocking" noise and produce an AC output voltage which increases with the severity of the knock. The ECM monitors this signal and adjusts the electronic spark timing (EST) and boost pressure as necessary to reduce detonation to a safe level.

WASTEGATE SOLENOID VALVE and KNOCK SENSOR




KNOCK
(detonation)
SENSOR


SHUNT
RESISTOR
PIEZO
CRYSTAL



# ELECTRONIC SPARK CONTROL (ESC) & BOOST CONTROL

The wastegate actuator contains an internal spring to preload the wastegate closed. Normally, boost pressure is controlled by applying intake manifold pressure through a small hose to the wastegate actuator. The actuator is constructed with spring pressure applied to one side of it's diaphragm, and the opposite side of the diaphragm exposed to manifold pressure through the connecting hose. At 1.55 bar (8 psi boost), manifold pressure would overcome spring pressure, and the diaphragm would begin to move, causing the wastegate to open. If the hose is either blocked or removed from the actuator, or a leak exists in the hose, the wastegate would not open, and engine protection would be achieved only by the overboost protection in the ECM. When the ECM detects a manifold pressure of 1.98 bar *(from the MAP sensor)*, the ECM will discontinue all fuel injection pulses until manifold pressure drops below 1.6 bar.

Inserted into the hose, between the actuator and the compressor-side of the turbocharger, is a normally-open, ECM-controlled solenoid. The solenoid controls how much manifold pressure is directed to the wastegate actuator. Recall that if unrestricted manifold pressure is applied to the actuator, boost pressure would only achieve 1.55 bar. (This would be the case if the solenoid were to become electrically disconnected.) In order to achieve higher controlled boost pressures, the ECM pulses the solenoid, to close off the passageway, effectively raising the boost pressure above 1.55 bar. The ECM pulses the solenoid many times each second with a constant-frequency square wave, but varying the pulsewidth. I.e., duty cycle, or proportion of time the solenoid is pulsed shut. This controls the amount of "extra" boost that may be developed.

When TPS>80%, if the knock sensor detects the onset of detonation, the ECM alters the duty cycle of the solenoid to lower the amount of boost until detonation ceases. This "WASTE GATE solenoid duty cycle" is stored in the PROM/MEMCAL of the ECM.

The "WASTE GATE BLOCK LEARN MEMORY" is a protion of ECM memory used to make long-term corrections to desired boost pressure. This correction is to compensate for small tolerances and/or normal aging of parts in each of the various system components.

The ECM has a memory portion of 16 cells to modify the above mentioned tolerances.

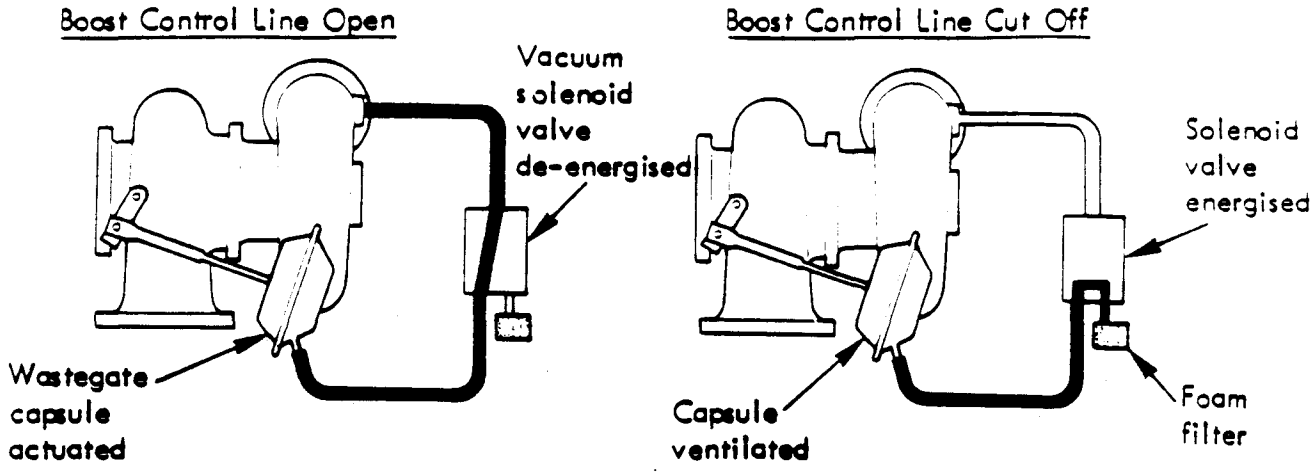
For example: If the MAP-Sensor detects a boost pressure greater or less than stored on the PROM/MEMCAL for this engine speed and load, the concerning WASTE GEATE BLOCK LEARN MEMORY cell will be updated.
Following this update, the WASTE GATE SOLENOID duty cycle will be modified to prevent under- or overboost.

Attention: The content of the WASTE GATE BLOCK LEARN MEMORY cell is not **identical** to the WASTE GATE SOLENOID VALVE duty cycle. The content will only be used to modify thisWASTE GATE SOLENOID VALVE duty cycle.

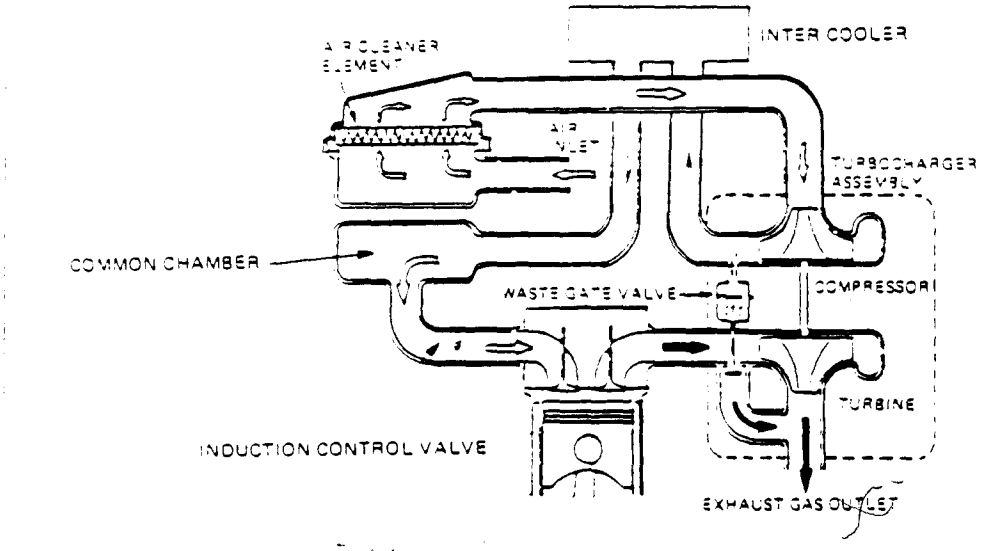
Content of the WASTE GATE BLOCK LEARN MEMORY cells below only for example:

| (+4%) cell 09 | (+3%) cell 10 | (+2%) cell 11 | (+1%) cell 12 | (0%) cell 13 | (-1%) cell 14 | (-2%) cell 15 | (-4%) cell 16 | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Engine speed ---> | | |
| 4000-4500 | 4500-5000 | 5000-5500 | 5500-6000 | 6000-6500 | 6500-7000 | 7000-7500 | 7500-8000 | RPM |

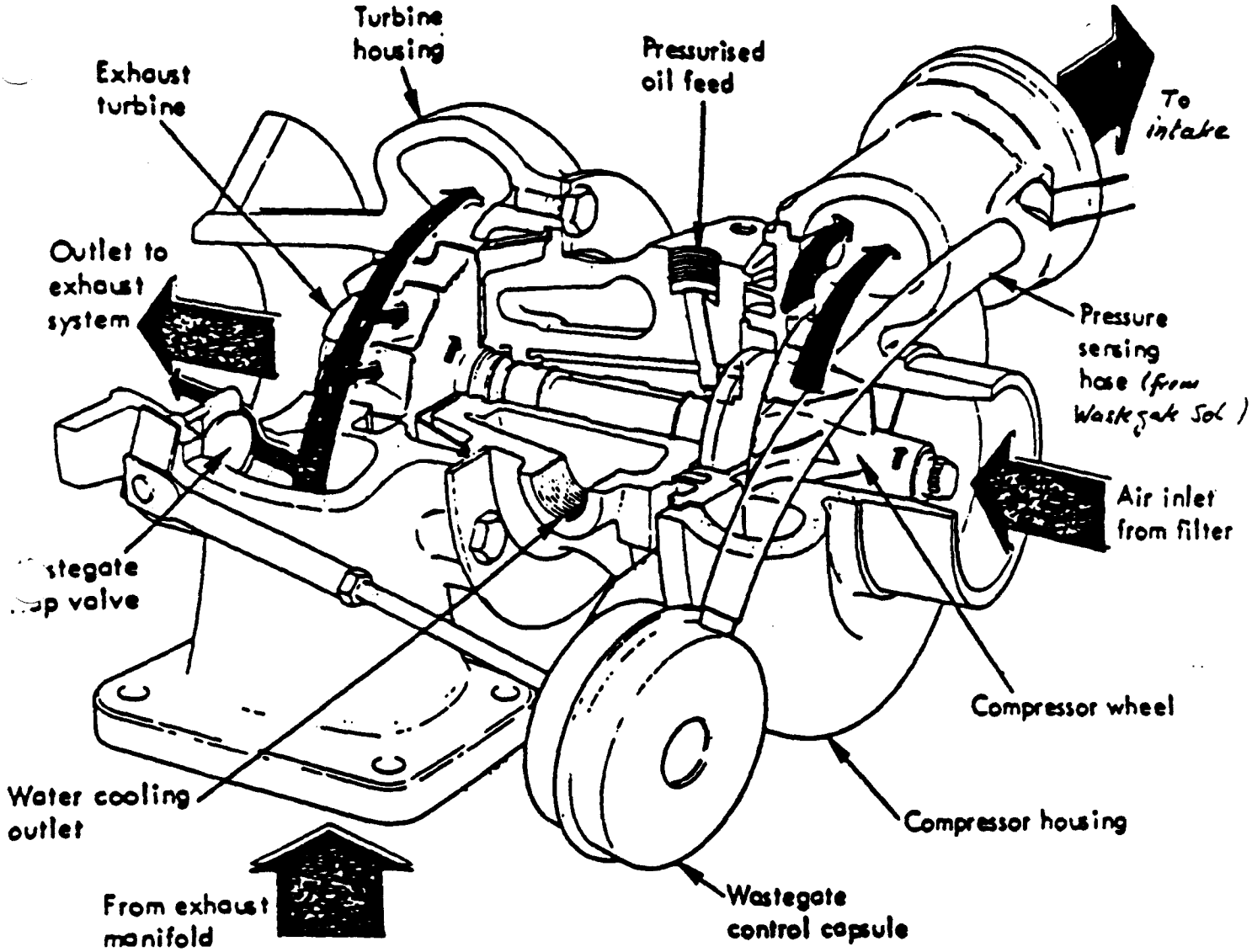
| (0%) cell 01 | (-6%) cell 02 | (+1%) cell 03 | (-2%) cell 04 | (-3%) cell 05 | (+5%) cell 06 | (+6%) cell 07 | (+5%) cell 08 | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Engine speed ---> | | |
| 0-500 | 500-1000 | 1000-1500 | 1500-2000 | 2000-2500 | 2500-3000 | 3000-3500 | 3500-4000 | RPM |

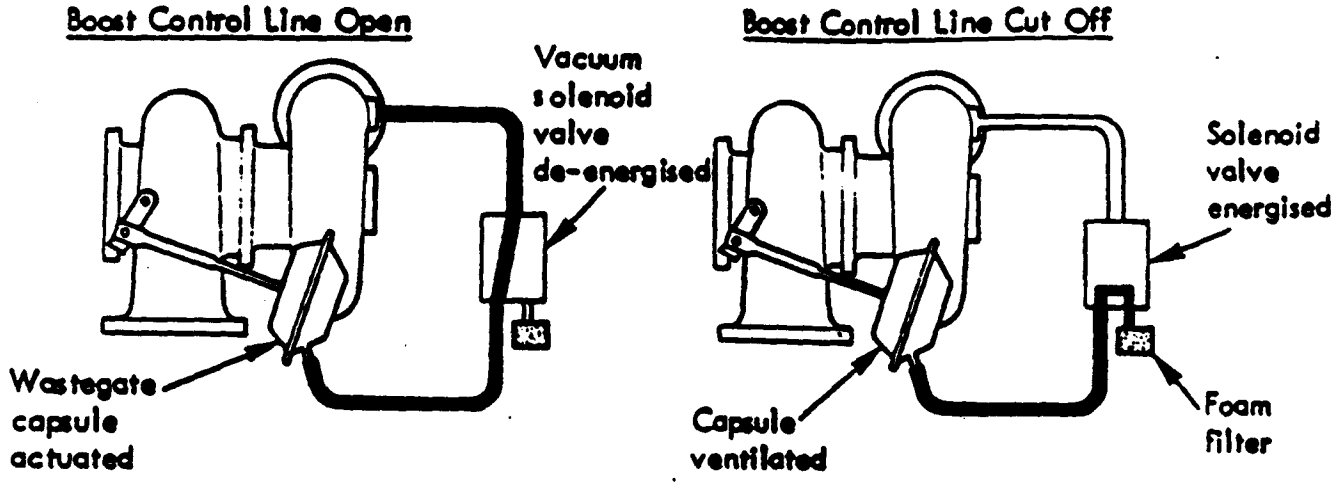



Note that because the ECM monitors boost pressure via the MAP sensor, maximum boost pressure is controlled to absolute values which are independent of atmospheric pressure. For this reason, the maximum readings of the boost gauge in the instrument panel will tend to rise with increasing altitude and decreasing atmospheric pressure.


INTER COOLER
AIR CLEANER ELEMENT
AIR INLET
TURBOCHARGER ASSEMBLY
COMMON CHAMBER
WASTE GATE VALVE
COMPRESSOR
TURBINE
INDUCTION CONTROL VALVE
EXHAUST GAS OUTLET

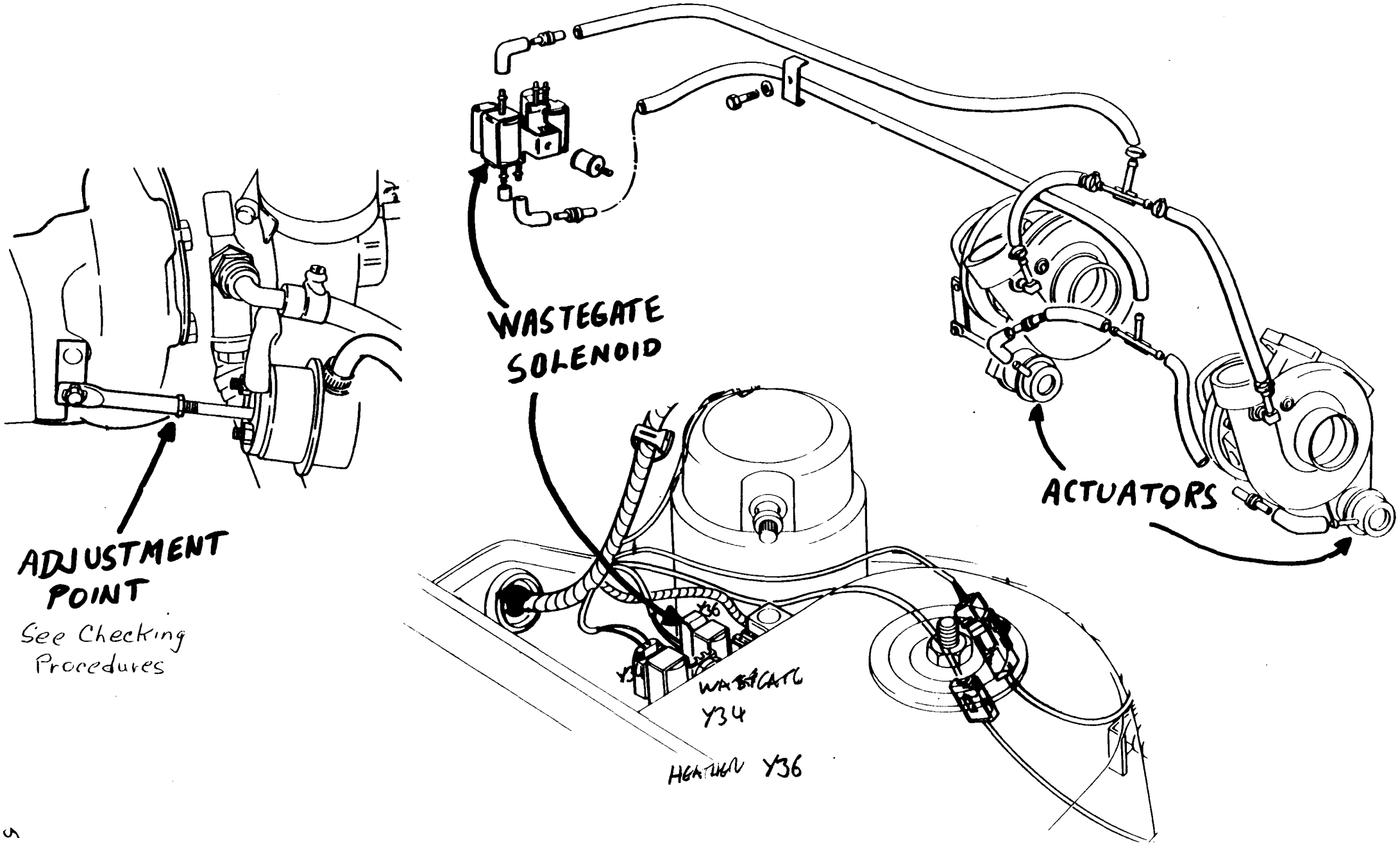
# BOOST CONTROL




Note that because the ECM monitors boost pressure via the MAP sensor, maximum boost pressure is controlled to <u>absolute</u> values which are independent of atmospheric pressure. For this reason, the maximum readings of the boost gauge in the instrument panel will tend to rise with increasing altitude and decreasing atmospheric pressure.

# LOTUS - OMEGA / CARLTON TRAINING

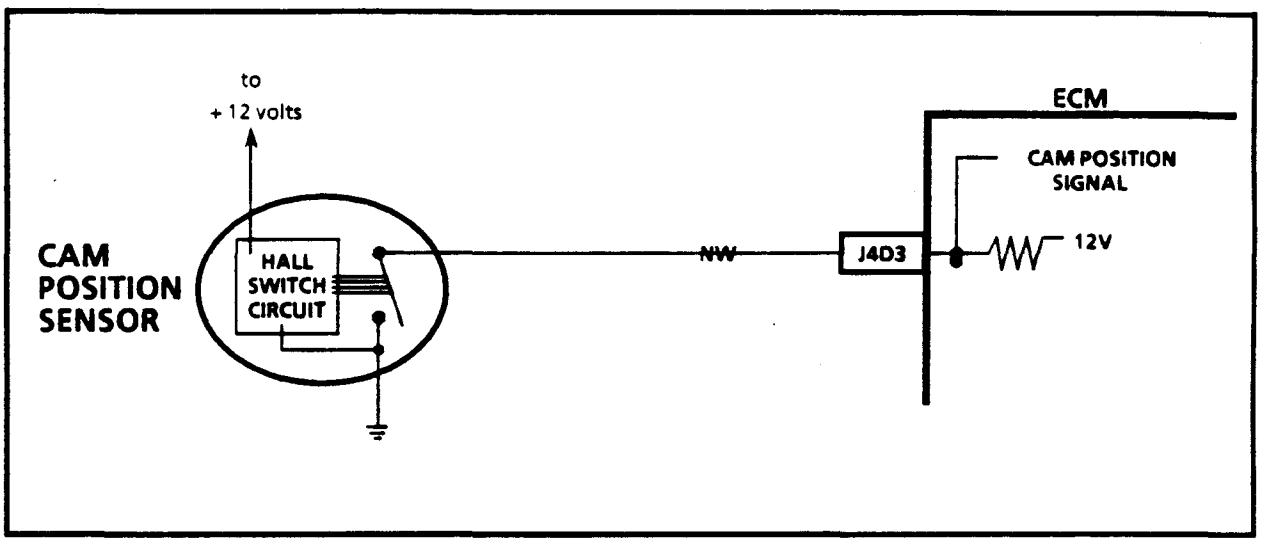


# 2.10 CAM POSITION SENSOR

## Circuit Description:

The cam position sensor is used to allow the ECM to calculate when number 1 cylinder is at the top of it's stroke (TDC) AND on compression. This signal is used by the ECM to "sequence" the fuel injectors. This engine uses sequential fuel injection. That means the fuel injectors follow the firing order of the engine. (1, 5, 3, 6, 2, 4)

Each fuel injector "spray" at closed intake valves. This is to improve vapourization of the fuel, which improves performance and reduces emissions. In order to accomplish this, the ECM; must know the camshaft position, in order to properly sequence the injector firing order.



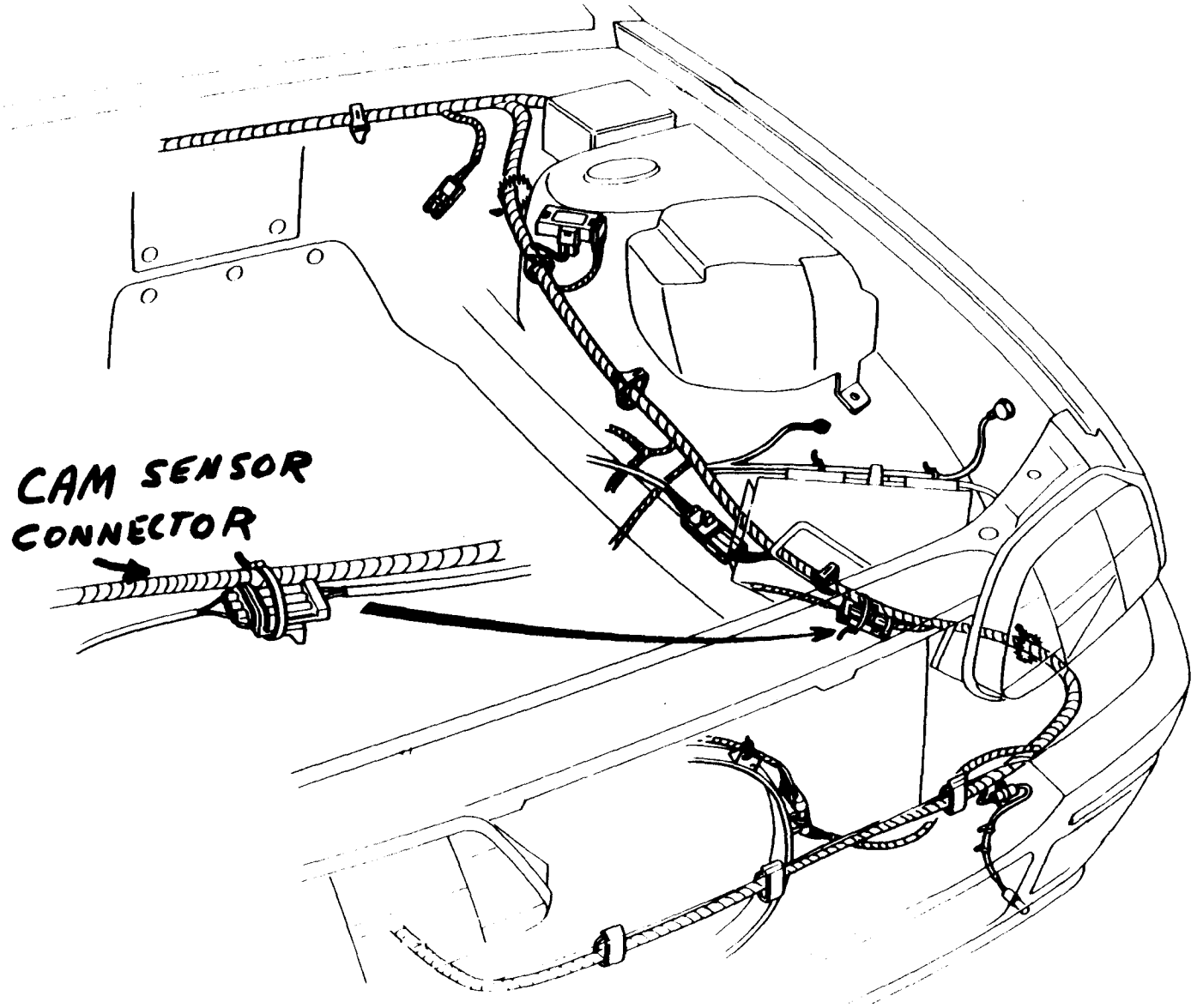

[redacted]

[redacted] SURGING
CODE 31

CAM [redacted] FAILURE
[redacted] SENSOR
UNDER [redacted]

P.T.O

# LOTUS - OMEGA / CARLTON TRAINING




BACKFIRING,
SURGING,
FAILURE,

UNDER BATTERY.

CODE 31.

# 3.1 AIR CONDITIONING

When the air conditioning is switched on at the instrument panel, a 12 volt signal voltage is sent through two pressure switches to the ECM. The two pressure switches prevent the compressor from operating if the R-12 refrigerant is either inadequare *(low pressure cutout switch, located in the high pressure line)*, or if the refrigerant pressure becomes too high *(high pressure cutout switch, located in the A/C compressor)*. If both switches are closed, the ECM receives an A/C request signal.

When the ECM receives the request signal, it will first reposition the Idle Air Control (IAC) valve, to compensate for the additional load placed on the engine by the A/C compressor. Then the ECM will energize the A/C control relay.

This air conditioning system has a "idle pressure" switch connected to the ECM. The switch is installed in the high pressure refrigerant line. This idle pressure switch has the possibility of acting as an additional input to the ECM, to alter idle speed during certain A/C system operating conditions, but presently the ECM does not use it.

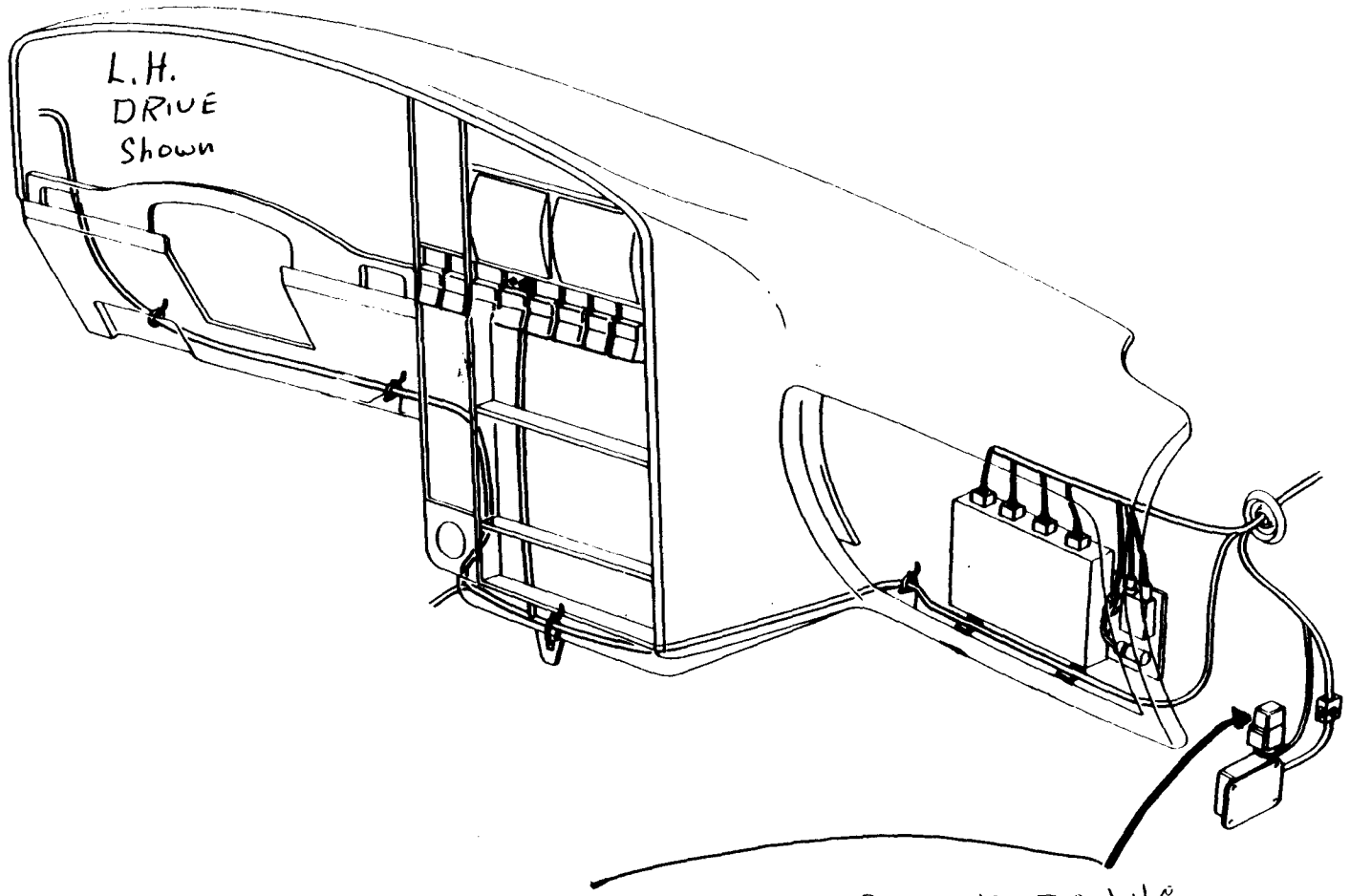
If the A/C was off and is just being turned on, some engine operating conditions will overide the A/C request signal and prevent the the air conditioning from being operated. These include:

- Engine speeds above 5000 RPM
- High throttle openings (>83% TPS) to make full engine power available
- Vehicle speed has been above 211 Km/h for more than 3 minutes
- Coolant temperature more than 117°

If the A/C is presently operating, certain engine operating conditions will de-energize the A/C compressor. These include:

- Throttle wide open (>99% TPS)
- Coolant temperature above 124°
- Vehicle speed has been above 211 Km/h for more than 3 minutes.
  If de-energized due to high vehicle speed, speed must remain below 211 Km/h for at least 3 minutes for the A/C to be turned on again.

# LOTUS - OMEGA / CARLTON TRAINING



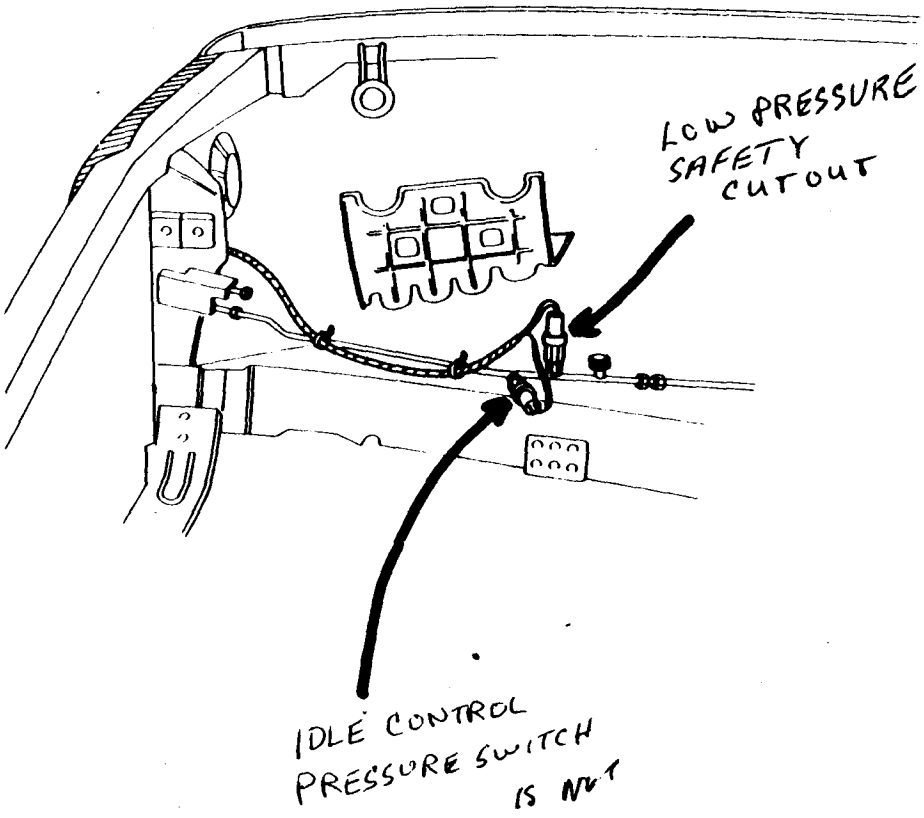

K35

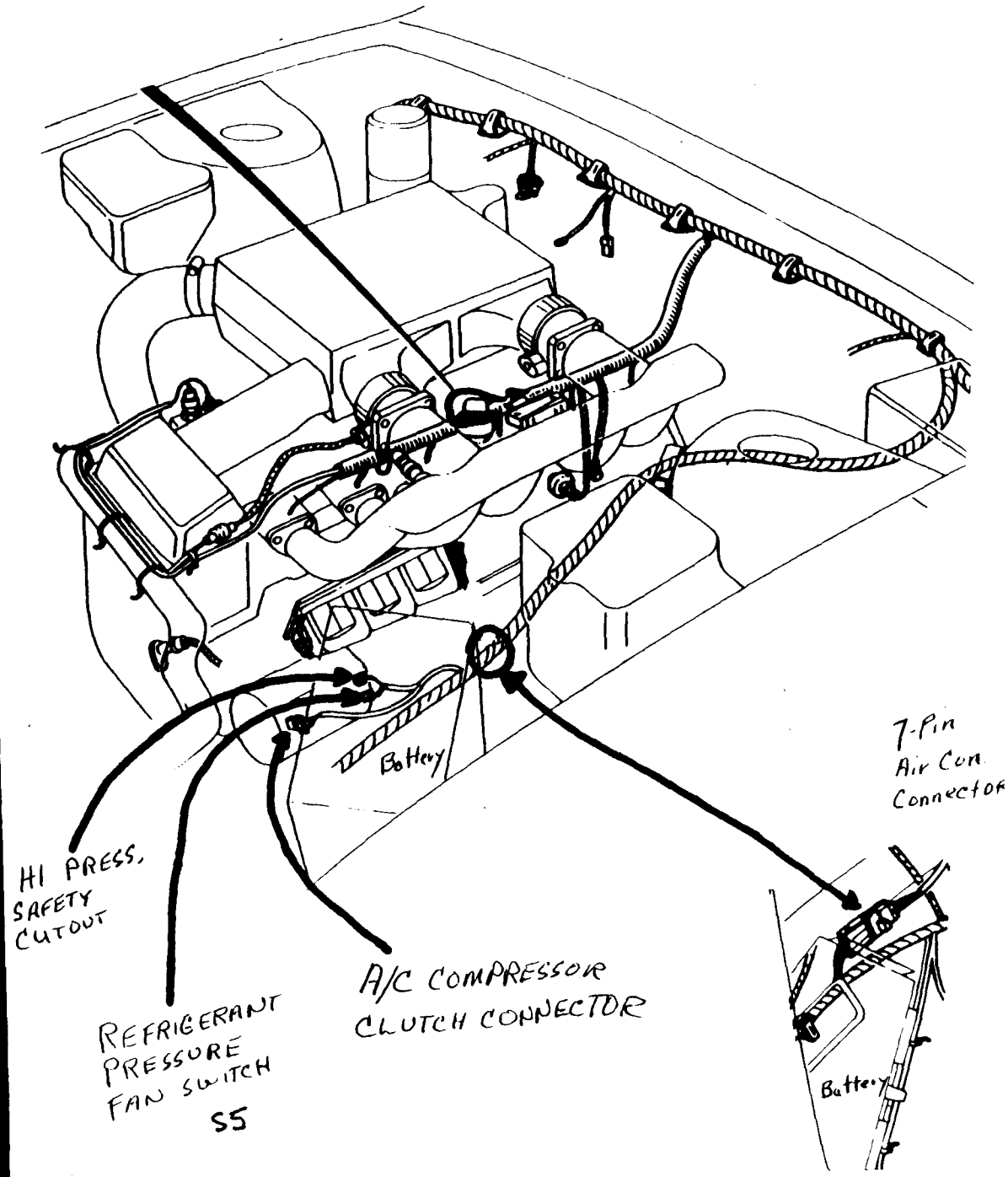
FLX
10AMP FUSE

AIR CONDITIONING
RELAY
-and-
FUSE

LEFT and RIGHT DRIVE,
SAME POSITION for
A/C RELAY and FUSE

# LOTUS - OMEGA / CARLTON TRAINING



# 3.2 RADIATOR FAN CONTROL

On the Lotus - Omega / Carlton, the engine is equipped with an engine driven radiator fan. Also used is an electric fan, placed in front of the A/C condensor coil, which is in front of the radiator. The electric radiator fan is a "pusher" fan, and when energized, will aid in cooling both the coolant radiator and A/C condenser.

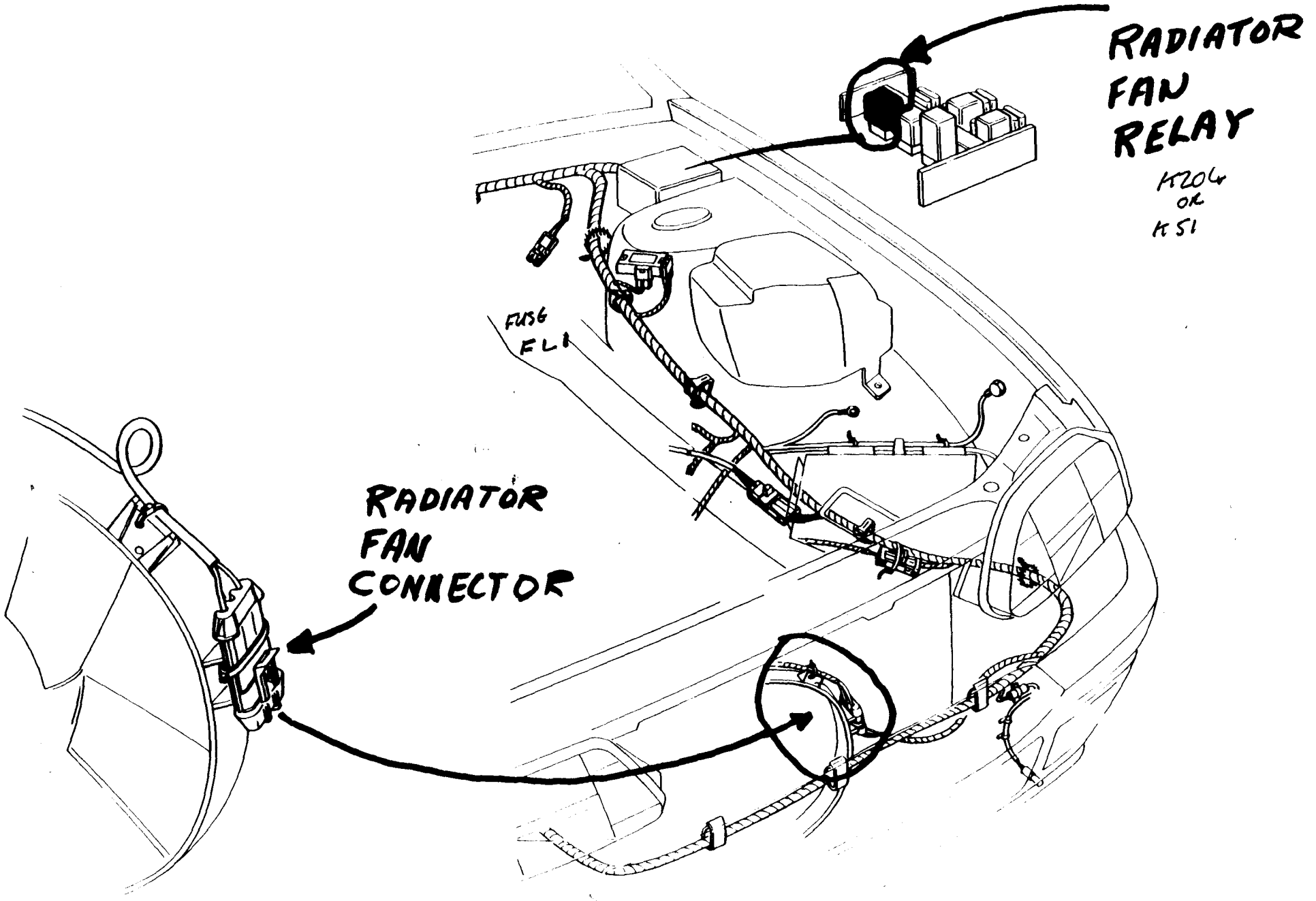
The ECM controls the fan relay. When the relay is energized, it's switch contacts close to provide power to the fan directly from the battery, and the fan will run.

The electric radiator fan relay is energized by the ECM when the engine is running by these conditions:

- Any malfunction codes are "active" (Check Engine Light ON with engine running)
- A/C is on and vehicle speed less than 8 Km/h.
- Coolant temperature more than 99°. If energized due to coolant temperature, temp. must drop below 96° for fan to be de-energized.

A high refrigerant pressure switch, located in the A/C compressor, can also energize the fan relay directly, anytime A/C refrigerant pressure is high. This switch is not connected to the ECM, only to the relay.

# LOTUS - OMEGA / CARLTON TRAINING



# 3.3 AUXILIARY WATER PUMP and RADIATOR FAN *OPERATION AFTER IGNITION IS OFF*

A new feature of the Lotus - Omega / Carlton engine management sytem is that the ECM has the ability to operate an auxiliary water pump and radiator fan even AFTER the ignition is turned OFF. The ECM monitors coolant temperature and manifold air temperature to determine whether or not to run the auxiliary water pump and electric radiator fan after the ignition is off. The calibration of the ECM allows the auxiliary pump and radiator fan to be energized independantly, during "engine not running" operation.

The auxiliary water pump is a small electric water pump, mounted on a plate that is secured to the right front strut tower. It's purpose is to circulate coolant through the engine, turbochargers, and radiator after the engine is stopped if high engine temperatures are present. A solenoid is connected with the aux. pump to block coolant flow to the heater core during aux. pump operation. The solenoid controls vacuum from the vacuum reservoir tank, to close the heater core water valve.

**AUXILIARY WATER PUMP** relay will be energized after the ignition is OFF if:

- Coolant temperature >92° *(Runs until coolant temp. < 90°)*,
  *-OR-*
- Manifold air temperature exceeds 116° *(Runs until MAT temp. < 106°)*,
  *-OR-*
- Radiator fan has been energized.

If both the CTS and MAT sensors indicate that temperatures are below the listed values, and the radiator fan is not energized, the pump will be de-energized.

**RADIATOR FAN** relay will be energized after the ignition is OFF if:

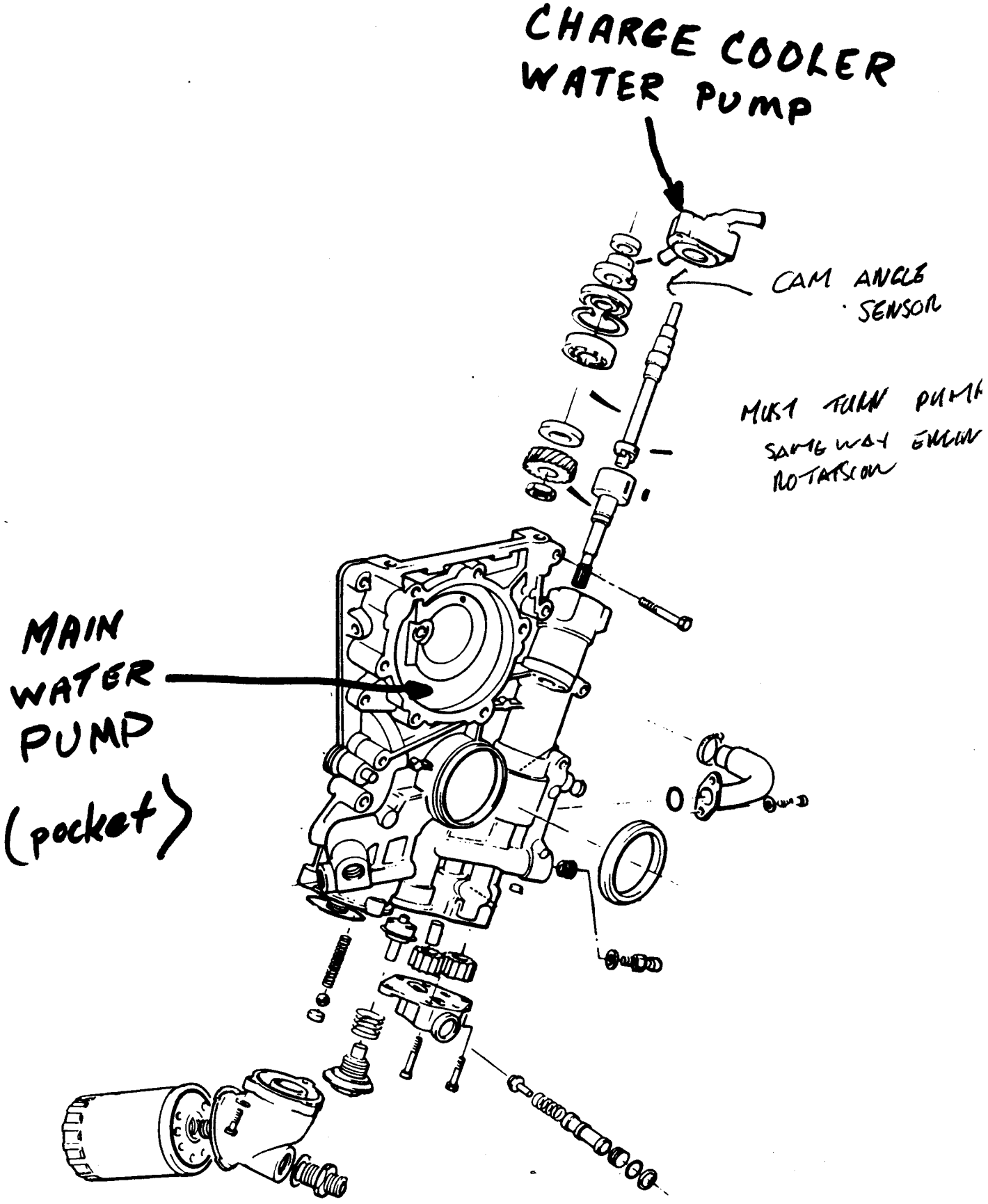
- Coolant temperature >97°
  *-OR-*
- Manifold air temperature >113°.

If both the CTS and MAT sensors indicate that temperatures are below the listed values, the fan will be de-energized.

Maximum continuous "ignition off" running time for the fan or aux. water pump is 15 minutes.

If neither the fan nor the aux. pump is running and the ignition is off, the ECM will remain "alive" or "powered up" for an additional 10 minutes to monitor the coolant and manifold temperatures. If either temperature raises above the listed values, the fan or pump can be re-energized again until temperatures are reduced. The 10 minute timer in the ECM is reset to 0 each time the fan or pump is re-energized.

If after 10 minutes the coolant temperature and manifold air temperature remain below the listed valies, the ECM will "power down", or "go to sleep".


CHARGE COOLER WATER PUMP
CAM ANGLE SENSOR
MAIN WATER PUMP (pocket)

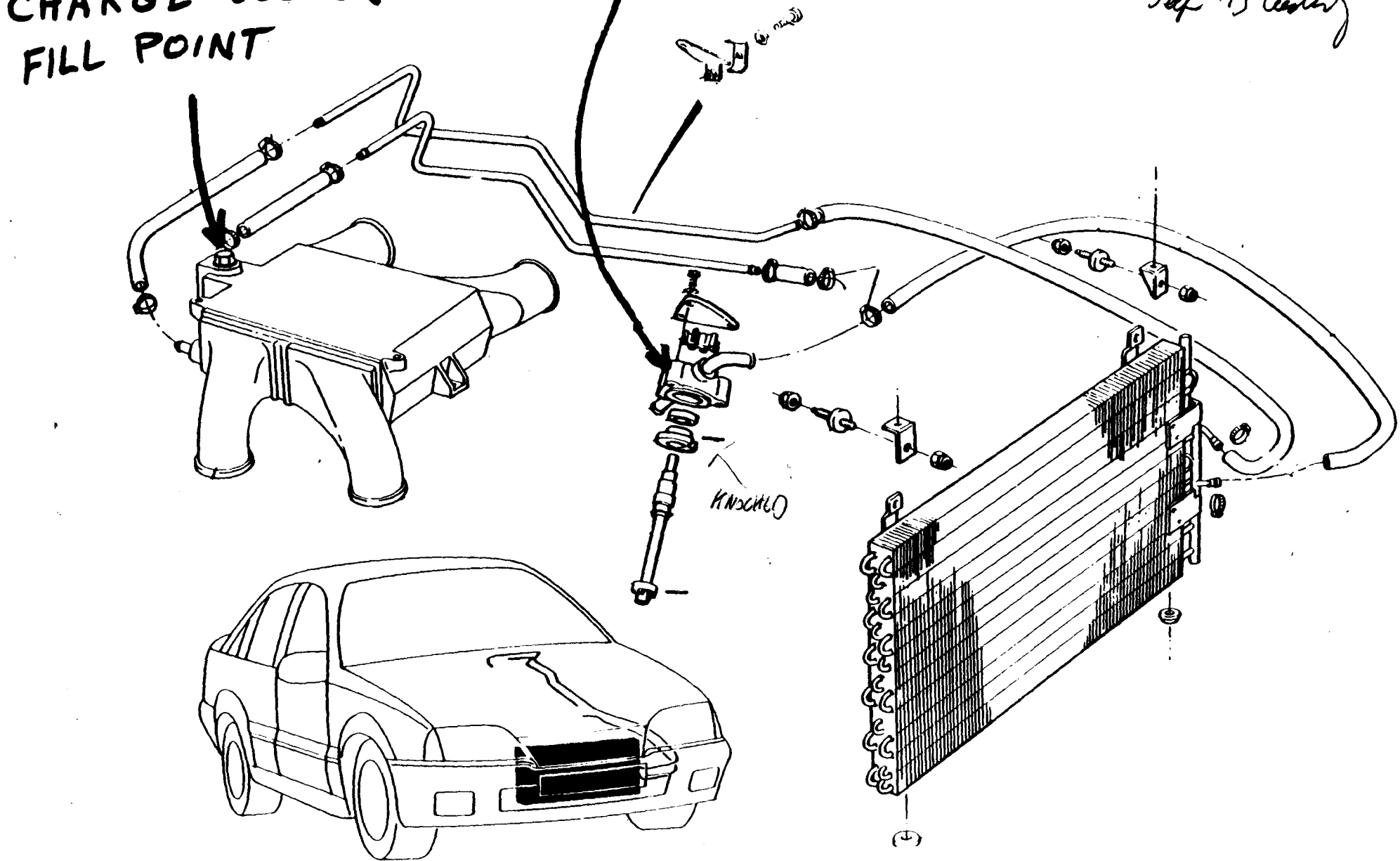
# LOTUS - OMEGA / CARLTON TRAINING

NO MORE THAN
30° TO 60° TEMP

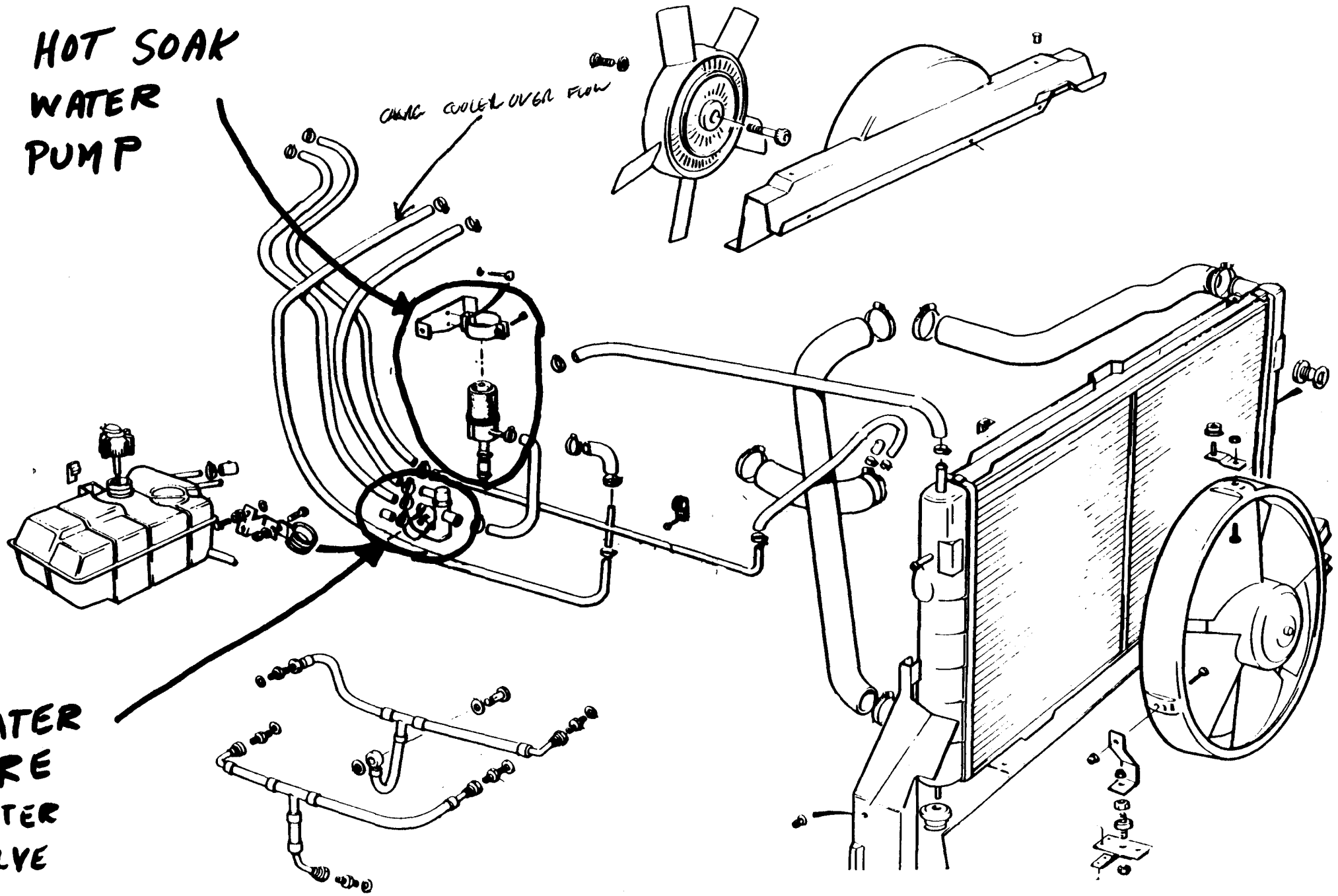
CHARGE COOLER
FILL POINT

CHARGE COOLER
WATER PUMP

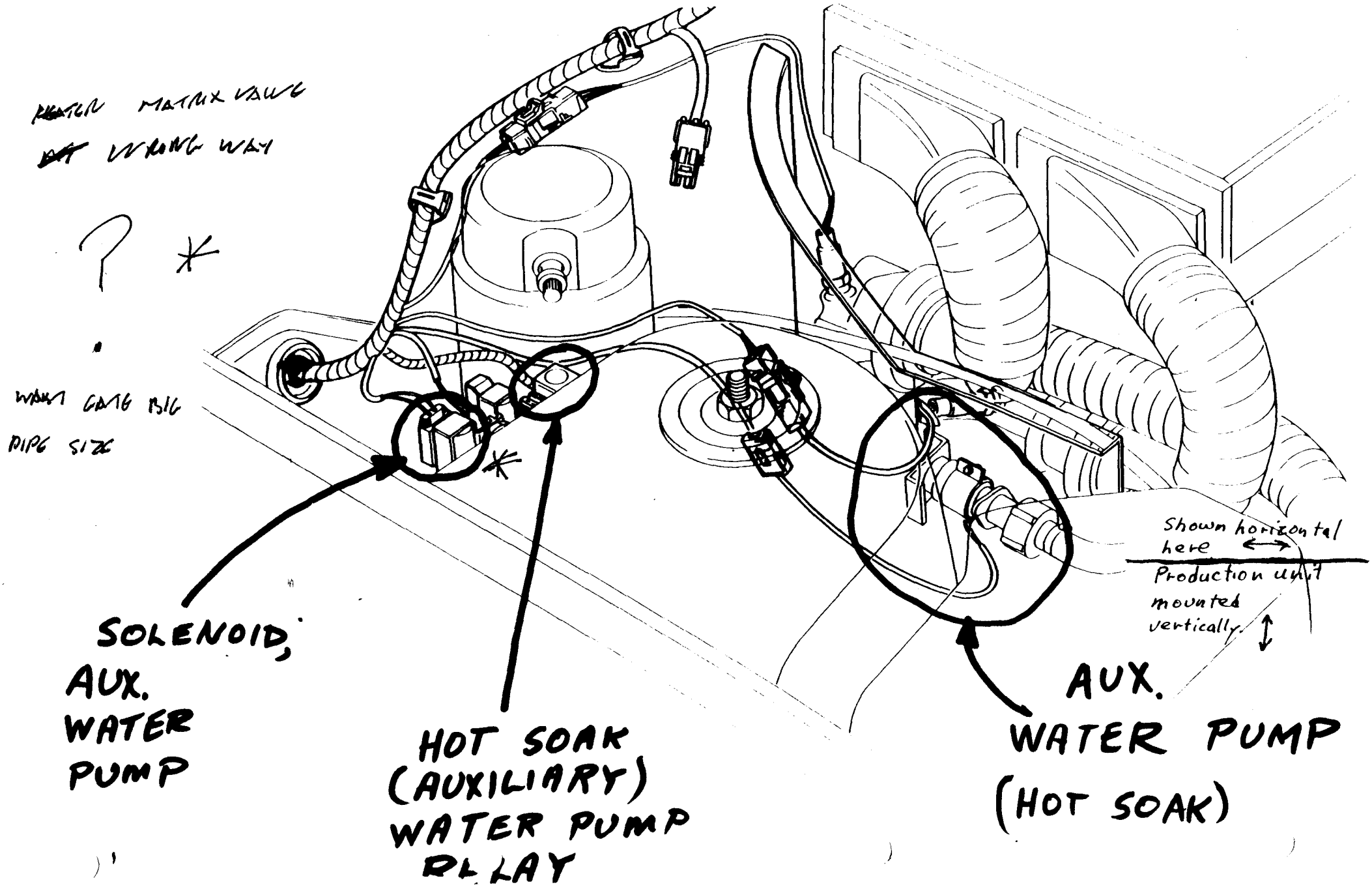
Self Bleeding



# LOTUS - OMEGA / CARLTON TRAINING



# LOTUS - OMEGA / CARLTON TRAINING



* IF FOUR STAR PETROL ONLY) CANISTER MUST BE REPLACED )



# 3.4 EVAPORATIVE EMISSION (CANISTER PURGE) CONTROL SYSTEM (EECS)

The system uses a charcoal canister to absorb fuel vapours from the fuel tank when the vehicle is not operating. When the engine is running, the fuel vapour is purged from the charcoal by a flow of air through the unit, which is then consumed in the normal combustion process.

## VAPOUR CANISTER

This is located above the rear axle, close to the right rear tyre.

Fuel vapour from the fuel tank filler neck is routed via a roll-over-valve (to prevent fuel spillage if the car is inverted) to the canister port labelled "tank". Any liquid fuel collects in a reservoir in the bottom of the canister to protect the integrity of the carbon bed above.

Ambient air enters the canister through an air tube in the top and mixes with the vapour before being drawn through the controlling solenoid valve into the intake manifold.

TPS - 2 - 3%
COOLANT 80°
VSS 35 M.P.H

~~TPS~~ - ~~COOLANT~~ IGNITION 2%
~~VSS~~

## CONTROL SYSTEM

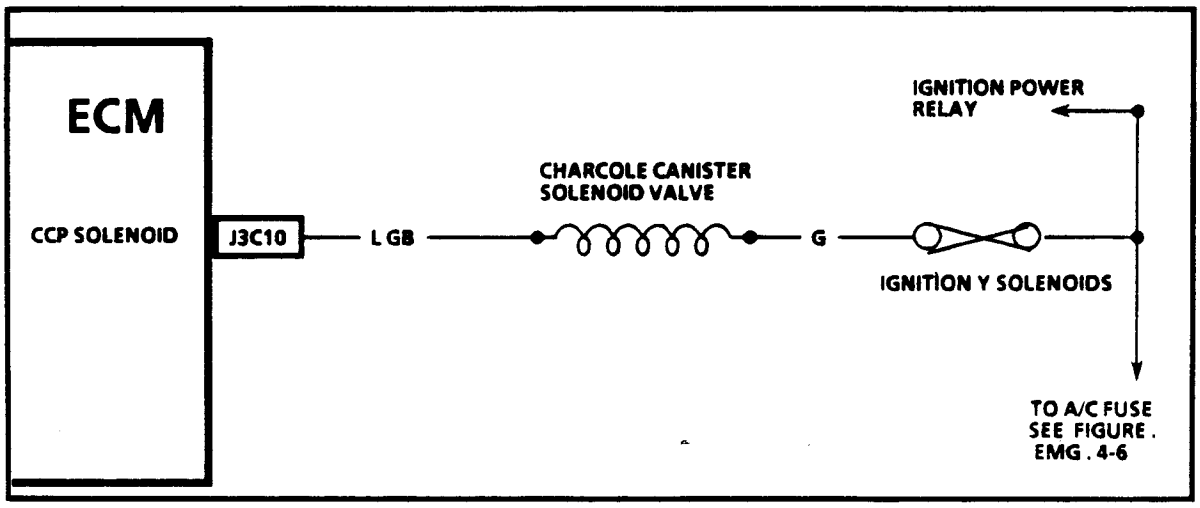
A solenoid valve is mounted on top of the canister, and controls the purge line. It uses pulse width modulation to control purge. This signal is supplied by the ECM which opens and closes the normally closed solenoid valve many times a second.

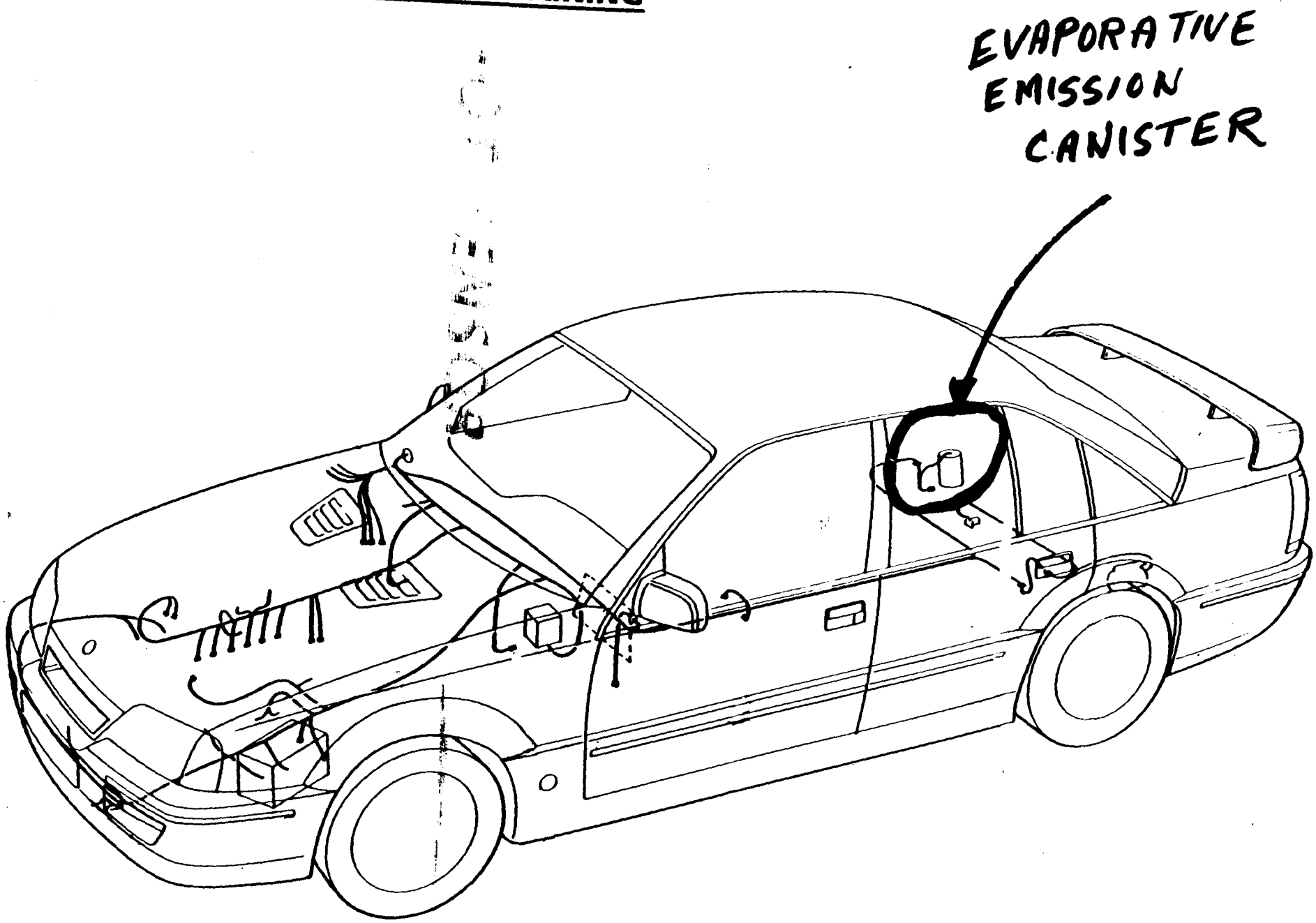
Under cold engine or idle conditions, the solenoid valve remains closed and no purging takes place. The ECM energizes the solenoid valve and allows purging when:

1) the engine is warm 80°

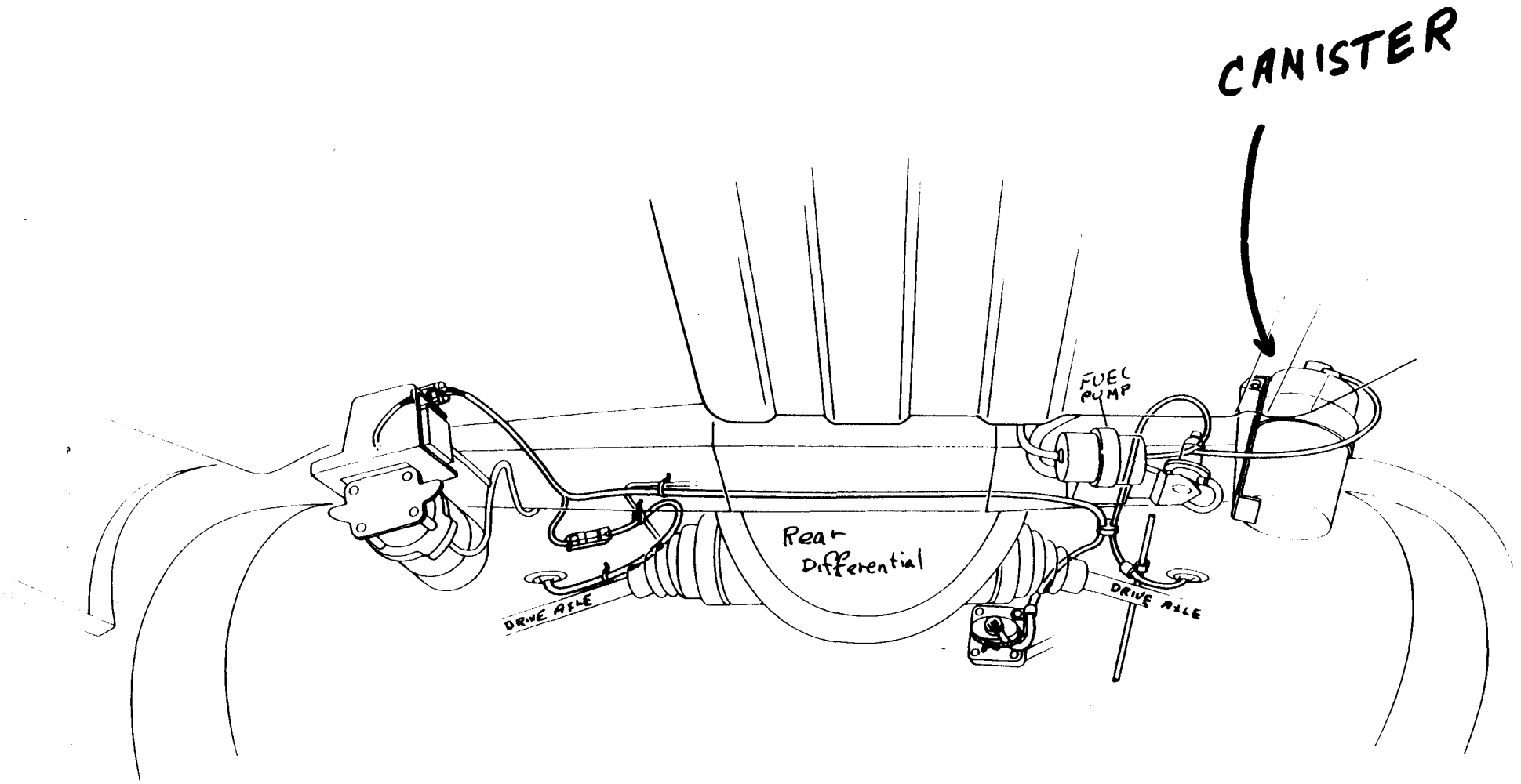
2) the engine has been running for a specified period of time.

The pulse width of the solenoid valve signal is controlled by the ECM, which uses various sensors, including the exhaust oxygen ($O_2$) signal to determine the quantity of vapour which may be fed into the engine under the operating conditions at that time.




EVAPORATIVE
EMISSION
CANISTER

# LOTUS - OMEGA / CARLTON TRAINING



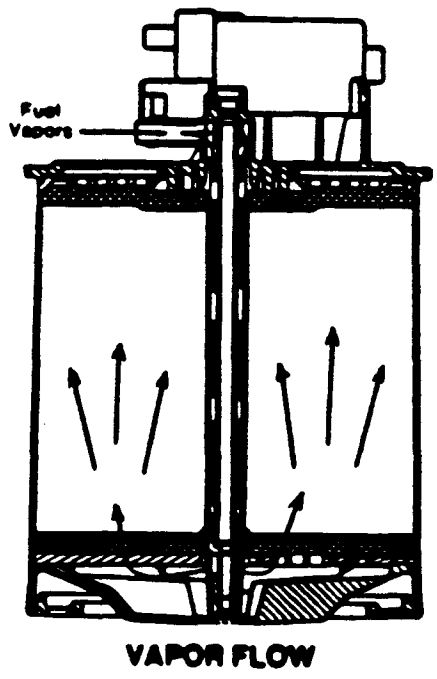
## CANISTER FUNCTION

The inverted function canister pictured is a solenoid-controlled, double dip tube model. Vapours are vented into that canister through the larger, outside dip tube. They travel to the bottom of the canister and are there released into the carbon.

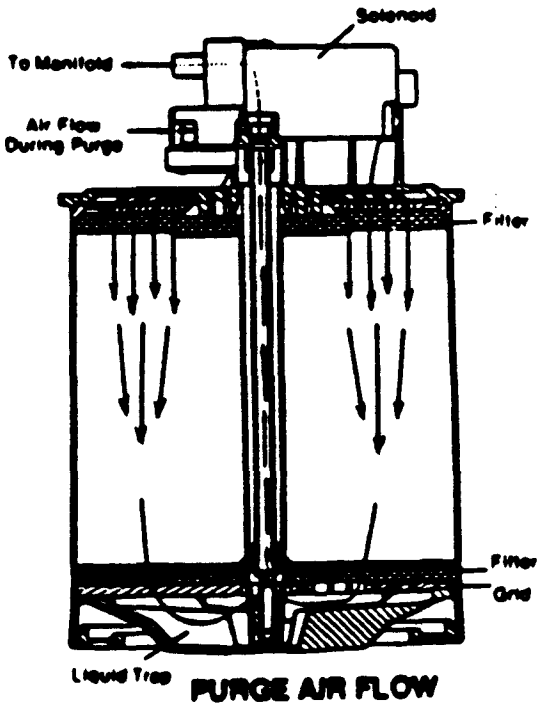
Purge air enters the canister at the top, is pulled down through the carbon, then up the smaller, inside dip tube.

Another feature which is being included on thIS canister is a trap for liquid fuel. While liquids are not supposed to enter a canister, they sometimes do. A canister becomes "loaded" with the liquid and loses its ability to trap vapours.

The trap collects the liquid fuel, and when the canister is purged, the purge air flow vaporizes the liquid. A fine mesh screen at the bottom of the dip tube acts as a wick, holding the liquid so it is more effectively vaporized and removed.




VAPOR FLOW




PURGE AIR FLOW

## 3.5 IDLE AIR CONTROL (IAC) VALVE

The purpose of the idle air control (IAC) valve assembly is to control engine idle speed, while preventing stalls due to changes in engine load.

The IAC valve is mounted on the top of the intake manifold and controls an airway between the upstream side of the throttle body (to which it is connected by hose) and an air rail which connects with each of the six intake ports. By moving a conical valve (called a pintle) IN (to decrease air flow) or OUT (to increase air flow), a controlled amount of air is allowed to bypass the throttle plate. If rpm is too low, more air is bypassed around the throttle valve to increase rpm. If rpm is too high, less air is bypassed to decrease rpm.

The electronic control module (ECM) moves the IAC valve in small steps, called "Counts". These can be measured by the "Tech 1" tool.

During idle, the proper position of the IAC valve is calculated by the ECM, based on battery voltage, coolant temperature, engine load, and engine rpm. If the rpm drops below specification, and the throttle valve is closed, the ECM senses a near stall condition and calculates a new valve position to prevent stalls.

The ECM "learns" the proper positioning of the IAC valve and retains this information in memory. This means that disconnecting power to the ECM can result in incorrect idle control after start. Reset of the IAC is necessary. See TECH 1 MODE F7: ECM Reset
SUBMODE F0: IAC Motor

If the IAC valve is disconnected and reconnected while the engine is running, the resulting idle rpm may be wrong, and resetting of the IAC valve will be required.

The ECM resets the IAC valve by seating it (all the way out) to establish the zero count position and then backing it in to the desired position.

This occurs:

- Each time the ignition is turned OFF. The ignition must be off for at least 10 seconds for the reset maneuver to be completed.

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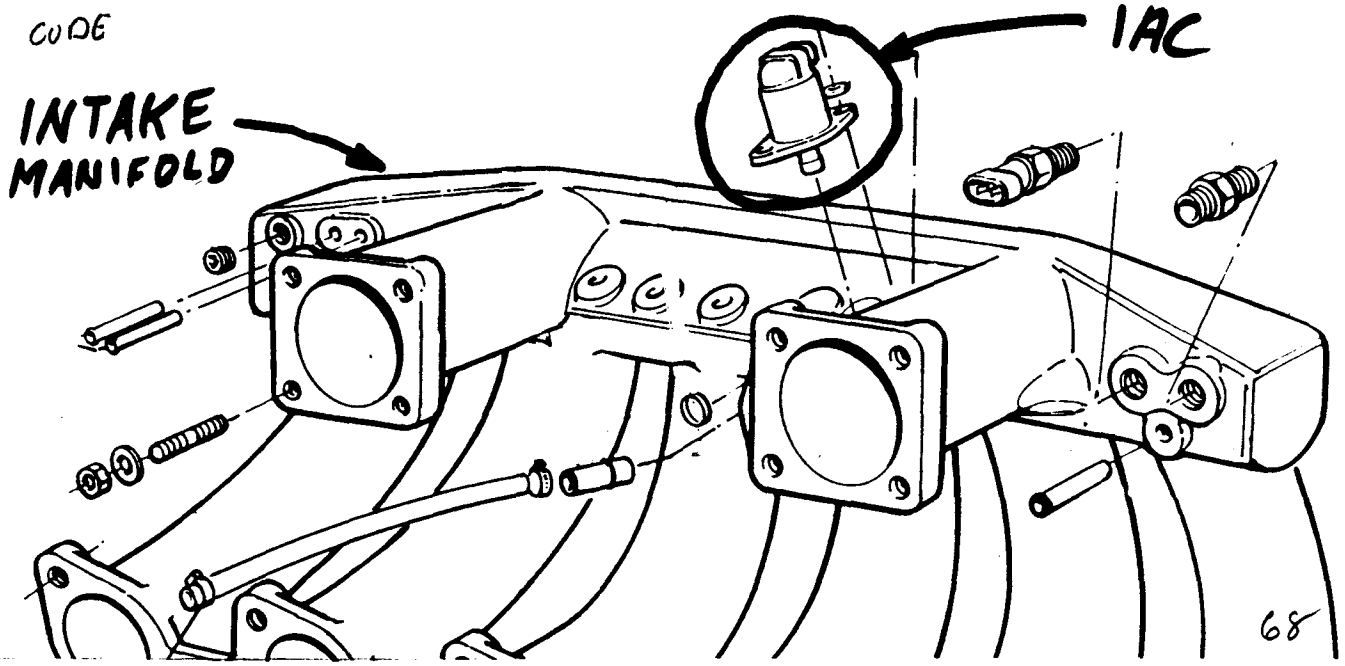
When servicing the IAC valve, it should only be disconnected or connected after the ignition has been "OFF" for at least 10 seconds. This allows time for the ECM to move the IAC valve to the 80 count position where it is "parked" while the ignition is "OFF". If this procedure is not followed, the ECM will lose track of IAC valve position resulting in starting or idle control problems.

10 FAULT CODE

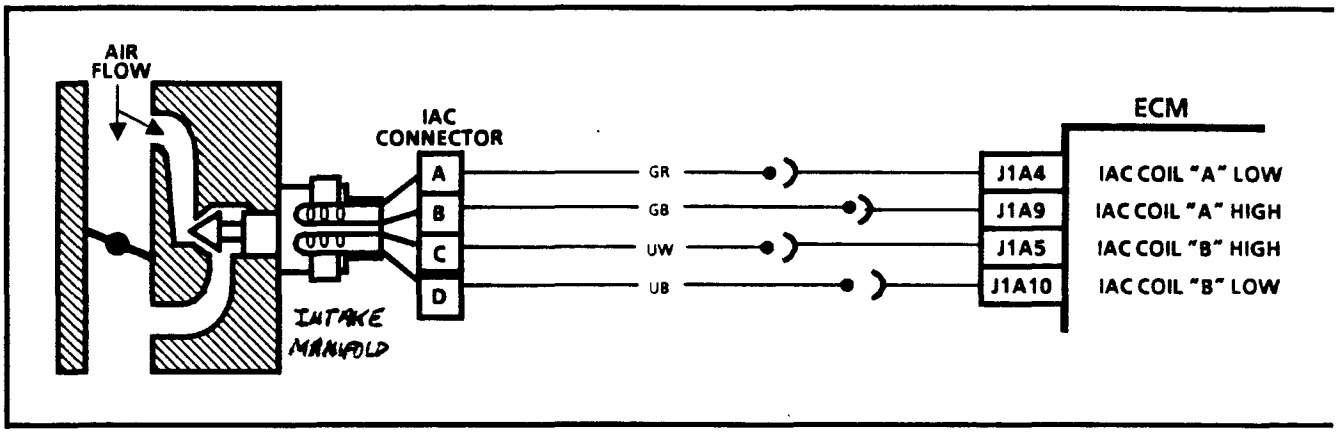


# IDLE AIR CONTROL (IAC) VALVE

## IAC CIRCUIT

The idle air control stepper motor consists of a housing with two coils. The rotor on the inside consits of permanent magnets. The rotary motion of the 24 pole rotor with alternating north and south poles is converted to a linear motion with the aid of a worm gear.

The ECM closes the coil circuits alternately. This results in a torque acting on the rotor, which then turns in a specific direction.




## IAC TEST

Use TECH 1 MODE F5: Actuator Test
SUBMODE F4: IAC Motor

See also Checking Procedrue Table 5

MPFI FUEL SYSTEM

# 4.0 FUEL CONTROL SYSTEM

AND PULSATOR

## FUEL PUMP

The fuel pump is a roller vane type, high pressure electric pump mounted ~~submerged within the fuel tank~~. The pump supplies fuel at a pressure of 211- 379 kPa ??? (30.5 - 55 psi) dependent on operating conditions, through an in line filter to the fuel rail assembly. A fuel strainer is attached to the fuel pump inlet line and prevents dirt particles from entering the fuel line and tends to seperate water from the fuel .

The pump is able to deliver 4 - 5 times the engines maximum requirement, so that fuel is constantly circulated through the fuel rail, and via the fuel pressure regulator, back to the tank. This fuel circulation helps avoid excessive fuel temperature with consequent risk of vapour locks.

When the ignition is switched on, the ECM energizes the fuel pump which will continue to run for as long as the ECM receives ignition pulses from the ignition module (engine cranking or running). If no ignition pulses are received, the ECM switches off the pump ~~either~~ 2 seconds ~~(approx.) after the ignition was switched on, or about 10 seconds after a stall~~.

↳ LATER

## FUEL RAIL + PRESSURE REGULATOR

The fuel rail receives fuel ~~at its forward end~~ (from the in-line filter) and supplies all six injectors with fuel, the pressure of which is controlled by the fuel pressure regulator ~~fitted to the rear end of the rail~~. The pressure regulator assembly is a diaphragm operated relief valve with fuel pump pressure acting on one side of the diaphragm, and regulator spring pressure and intake manifold pressure on the other. The function of the regulator is to maintain a constant pressure differential across the injectors at all times. i.e. a constant difference between fuel pressure supplied to the injector, and inlet manifold pressure at the injector nozzle. By using an inlet manifold pressure signed to supplement regulator spring pressure in the valve, the valve is able to regulate fuel supply pressure in accordance with engine load. The pressure regulator is not adjustable and is serviced as a complete assembly.

## FUEL INJECTORS

The port fuel injector assembly is a solenoid-operated device, controlled by the electronic control module (ECM), that meters pressurized fuel to a single engine cylinder. The ECM engergizes the high impedence (12.2Ω@20°) solenoid to open a normally closed ball valve. and through a recessed flow director plate at the injector outlet. The director plate has six machined holes that control the fuel flow, generating a conical spray pattern of finely atomized fuel at the injector tip. Fuel from the tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

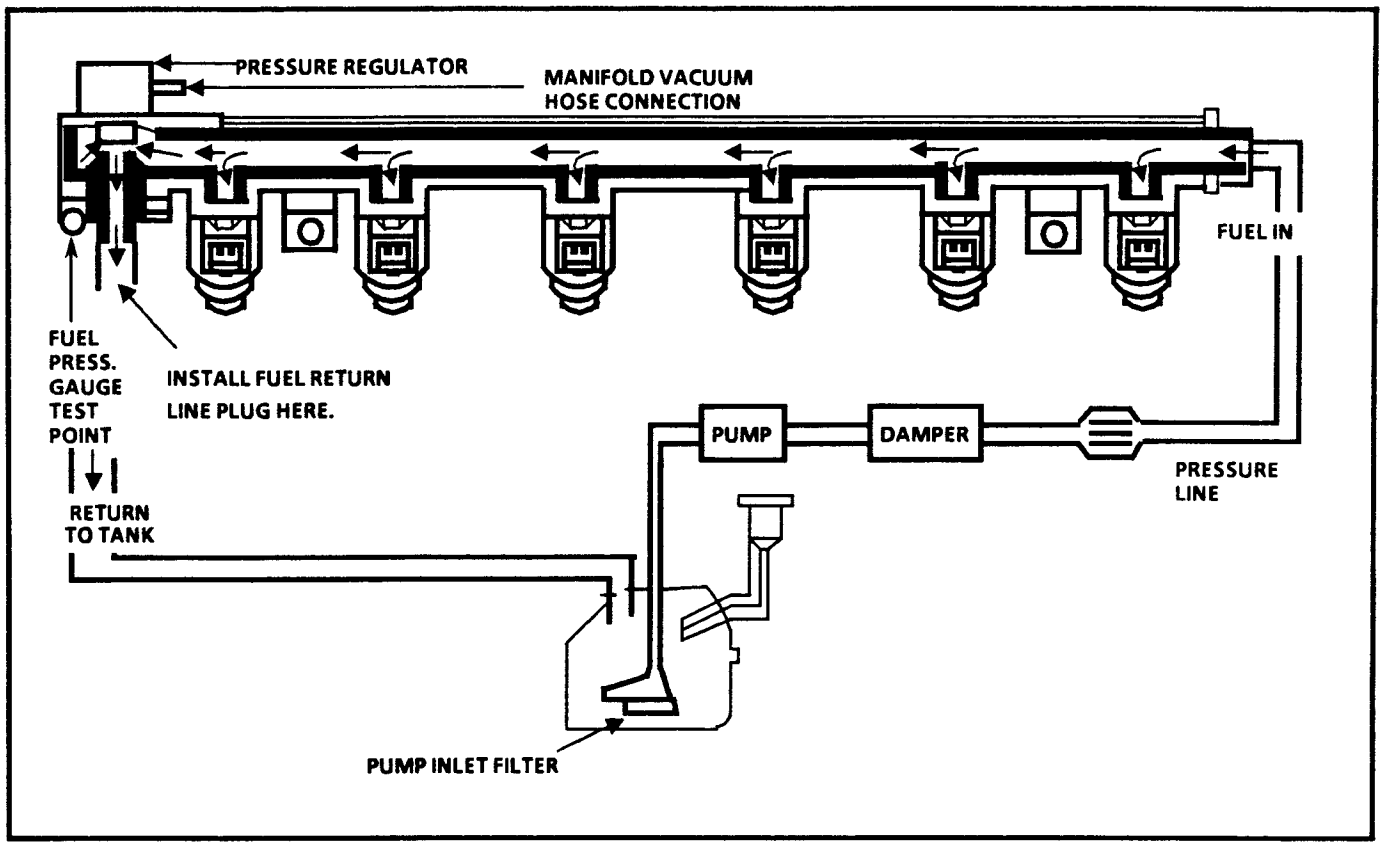
NEW O. RINGS TO BE FITTED ON INJECTORS WHEN REMOVED

SEALS

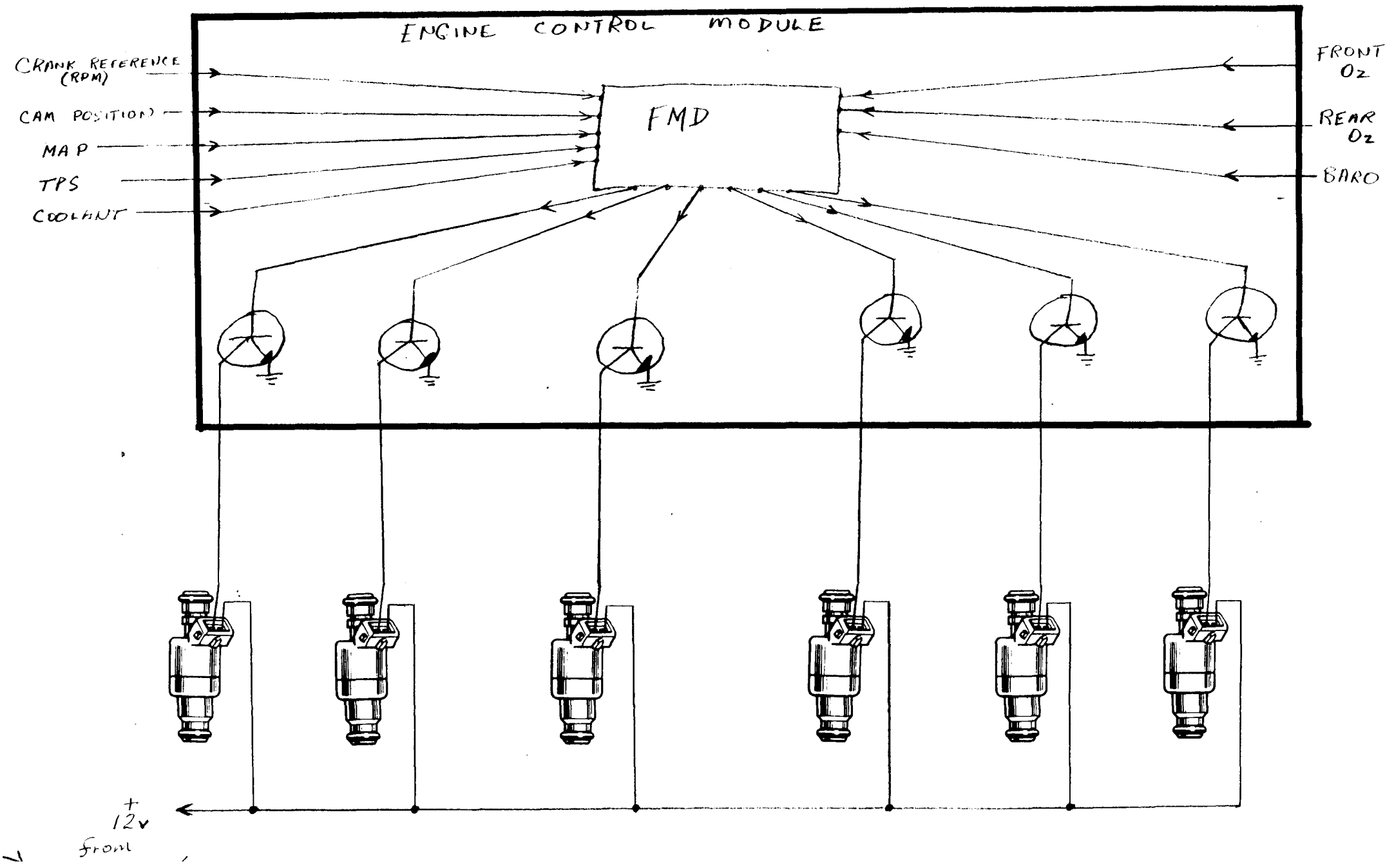
## FUEL CONTROL SYSTEM CONTINUED

The ECM uses six injector driver circuits. Each circuit pulses the injector sequentialy once every two crankshaft revolutions, with all of the fuel necessary for each cylinders combustion delivered by each injector pulse.

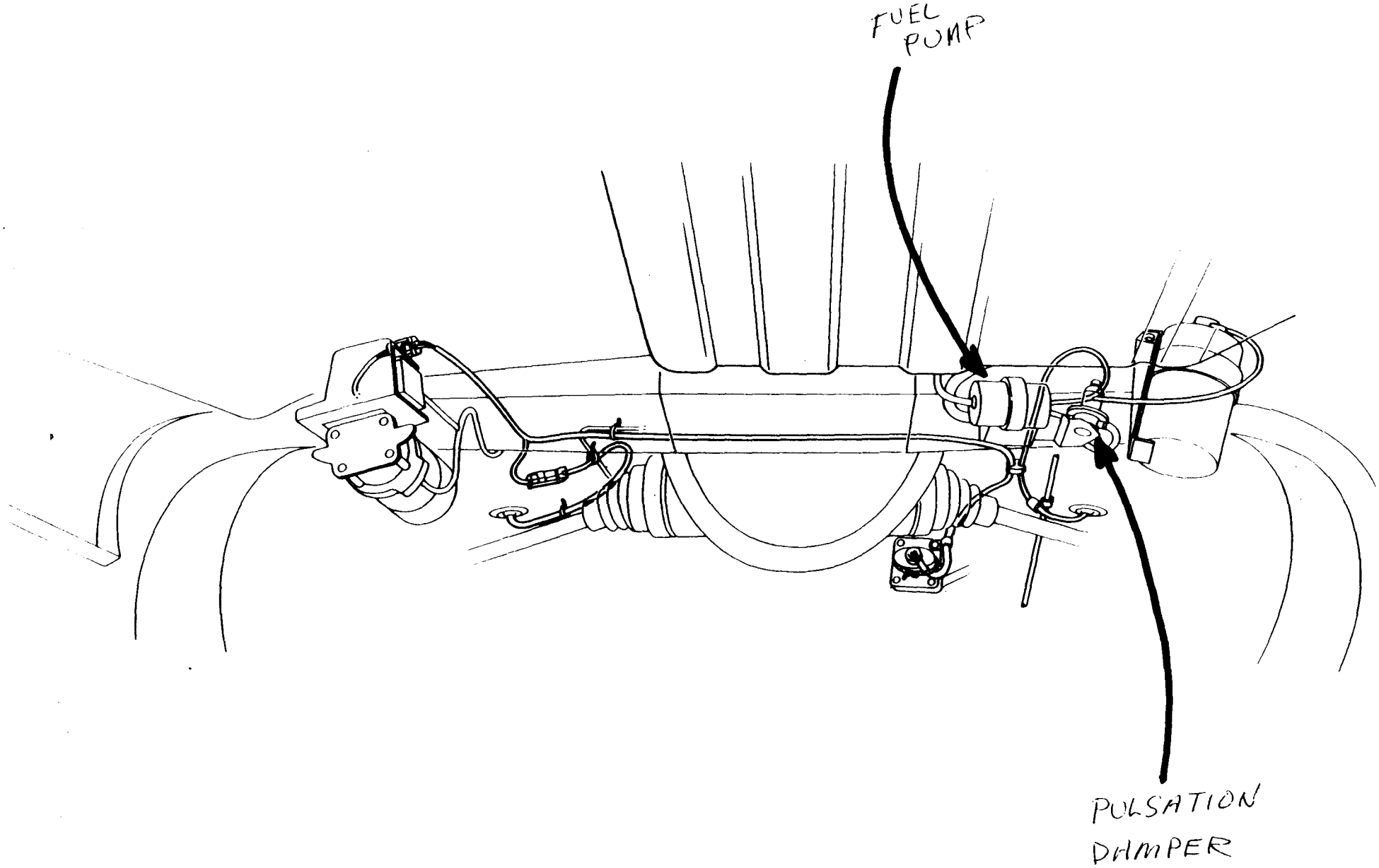
The ECM receives an engine speed, crankshaft positon, and camshaft position signal six times per engine revolution from the ignition module, and uses these to trigger the injector timing sequence. To synchronize the engine revolution with the fuel injector timing sequenze, a camshaft signal is necessary.

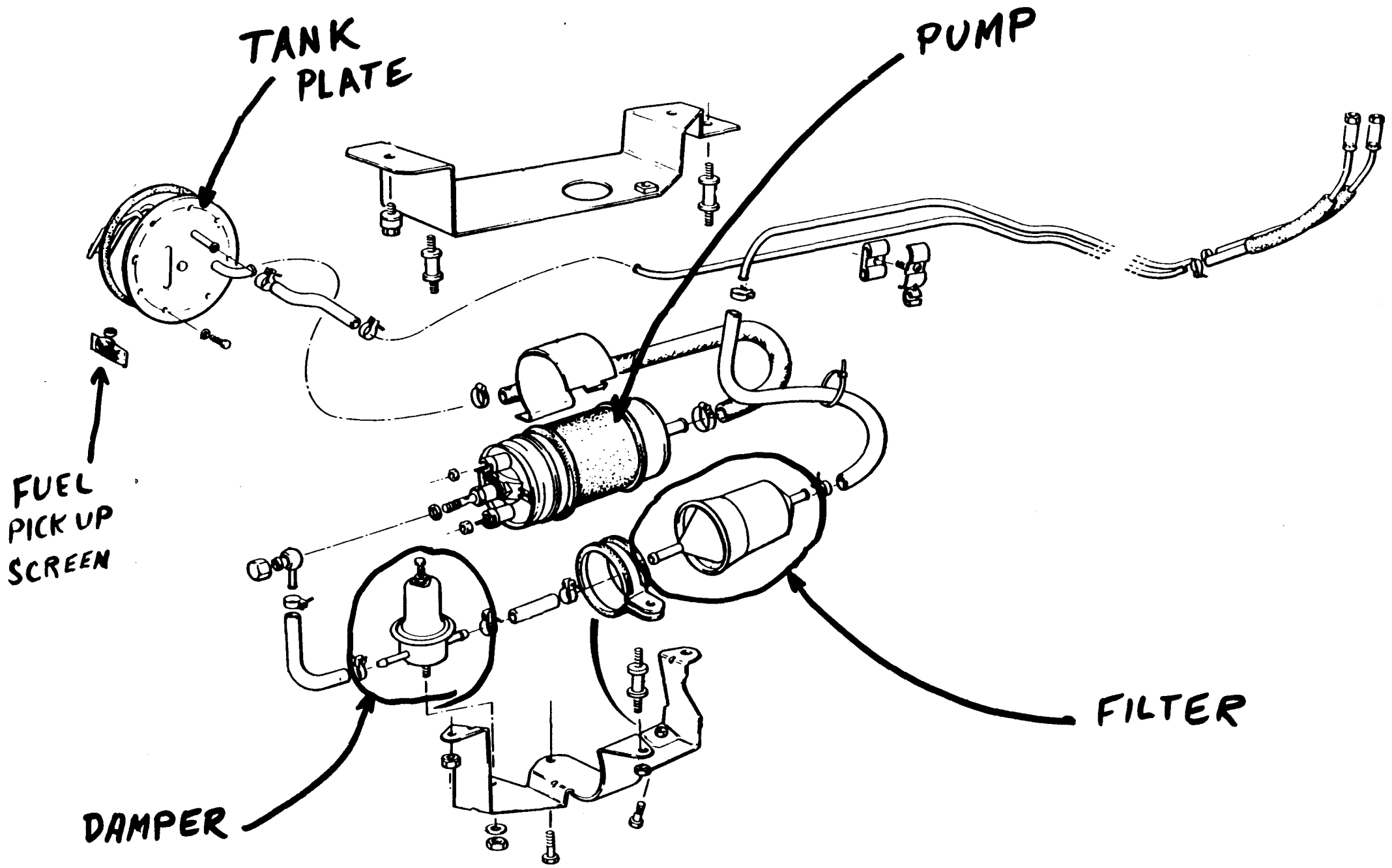


# LOTUS - OMEGA / CARLTON TRAINING



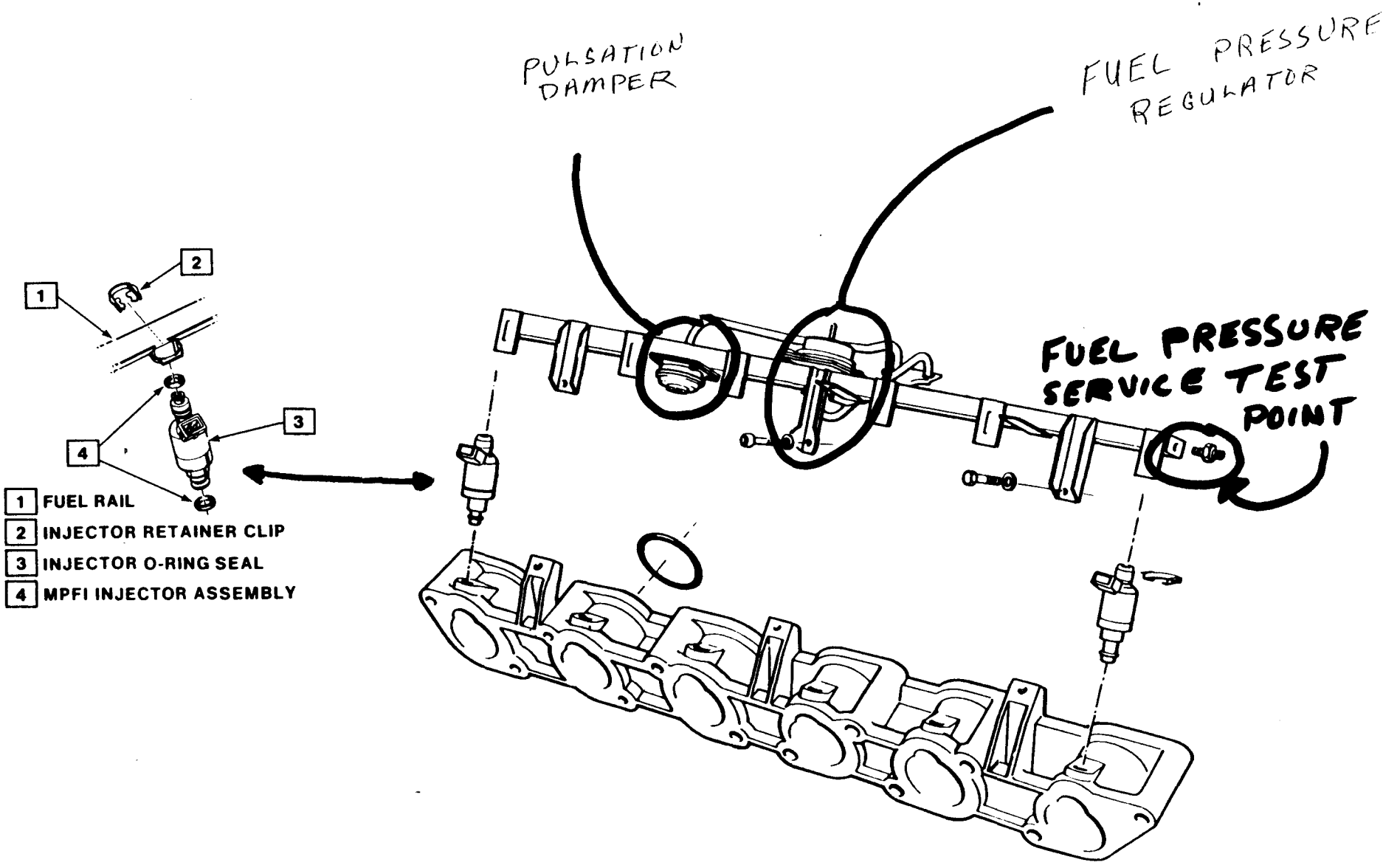
# LOTUS - OMEGA / CARLTON TRAINING

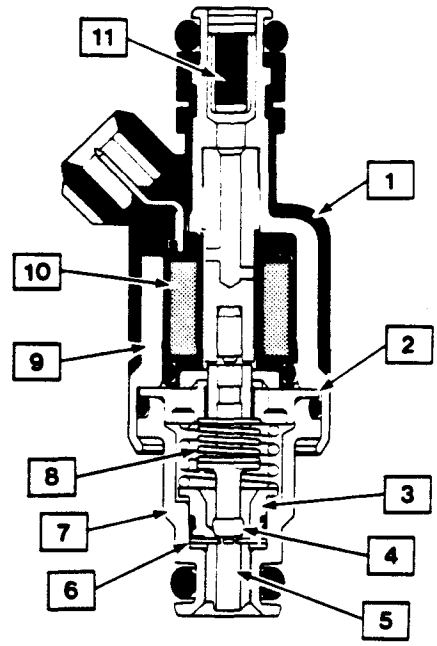



TANK PLATE
PUMP
FUEL PICK UP SCREEN
FILTER
DAMPER

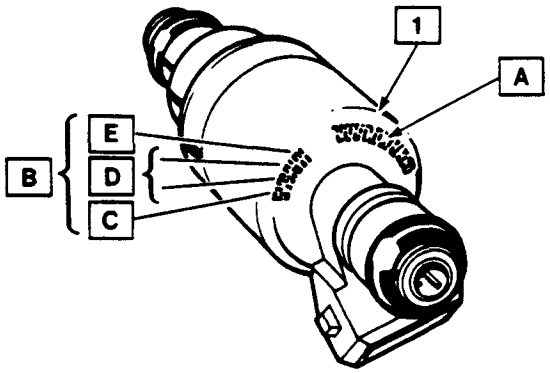
# LOTUS - OMEGA / CARLTON TRAINING

NONE RETURN VALVE BUILT INTO PUMP






| | | | |
|---|---|---|---|
| 1 | SOLENOID ASSEMBLY | | |
| 2 | SPACER & GUIDE ASSEMBLY | | |
| 3 | CORE SEAT | 7 | SPRAY HOUSING |
| 4 | BALL VALVE | 8 | CORE SPRING |
| 5 | SPRAY TIP | 9 | SOLENOID HOUSING |
| 6 | DIRECTOR PLATE | 10 | SOLENOID |
| | | 11 | FUEL INLET FILTER |



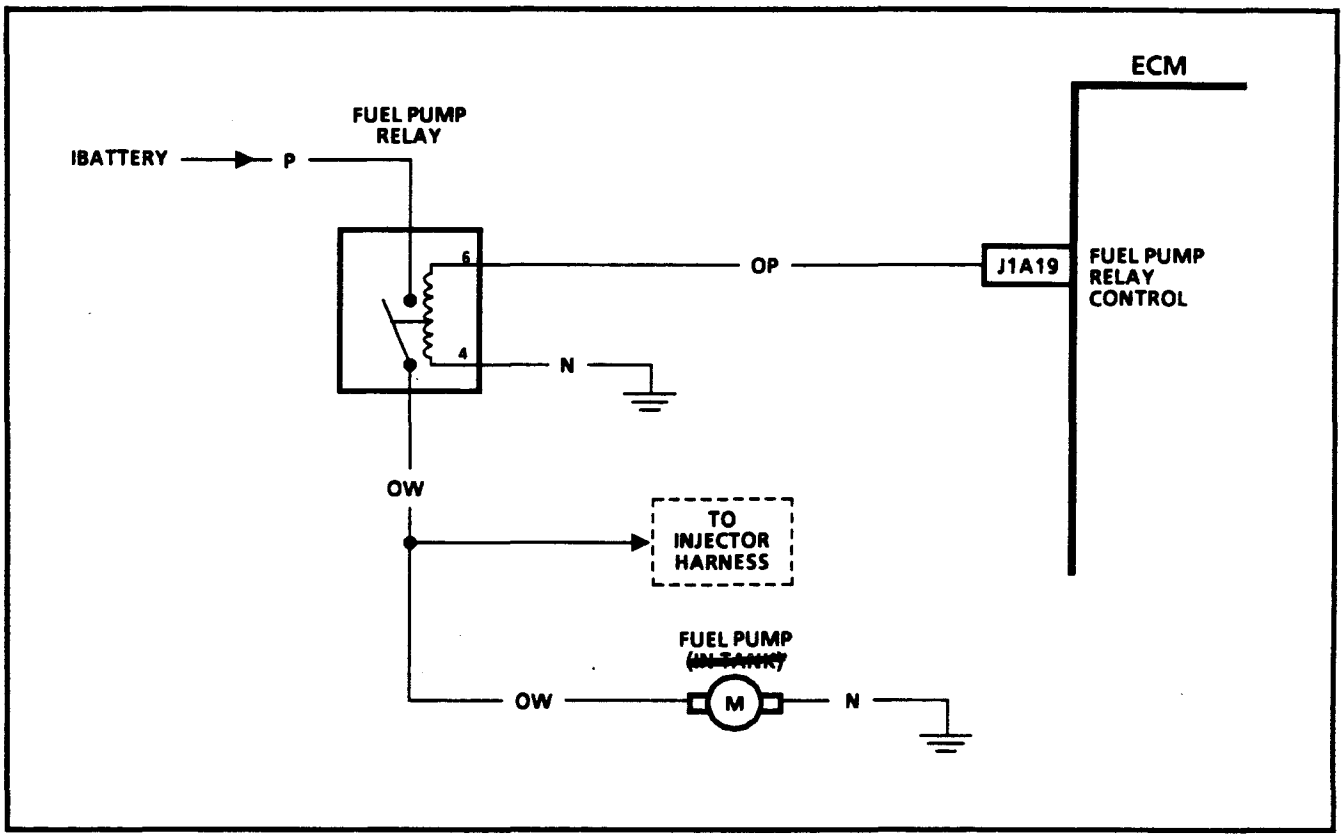

| | | | |
|---|---|---|---|
| 1 | MPFI INJECTOR (TOP VIEW) | | |
| A | PART NUMBER IDENTIFICATION | | |
| B | BUILD DATE CODE | D | DAY |
| C | MONTH 1-9 (JAN-SEPT)<br>O,N,D (OCT,NOV,DEC) | E | YEAR |

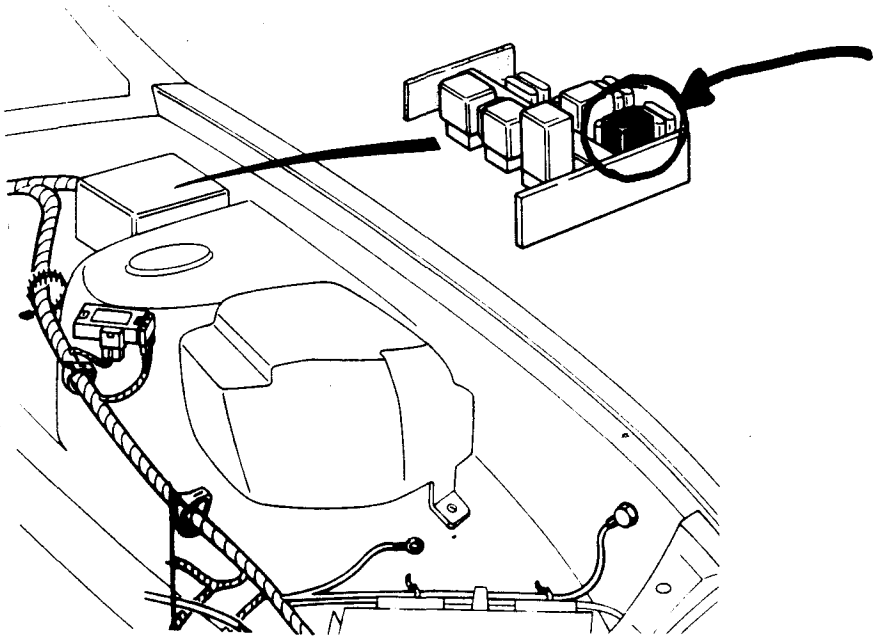
# 4.1 FUEL PUMP CIRCUIT

**Circuit Description:**

When the ignition switch is turned "ON", the electronic control module (ECM) turns "ON" the in-tank fuel pump. It will remain "ON" as long as the ECM is receiving ignition reference pulses from the Direct Ignition module (DI).
If there are no reference pulses, the ECM will shut "OFF" the fuel pump about 2-3 seconds after key "ON", ~~or about 10 seconds after reference pulses stop~~.

See also Checking Procedure Test step 02.



# 4.2 MODES OF FUEL SYSTEM OPERATION

STARTING MODE

CLEAR FLOOD MODE

RUN MODES

- OPEN LOOP MODE

- CLOSED LOOP MODE

- ACCELERATION MODE

- DECELERATION MODE

- BATTERY VOLTAGE CORRECTION MODE

- FUEL CUT-OFF MODE

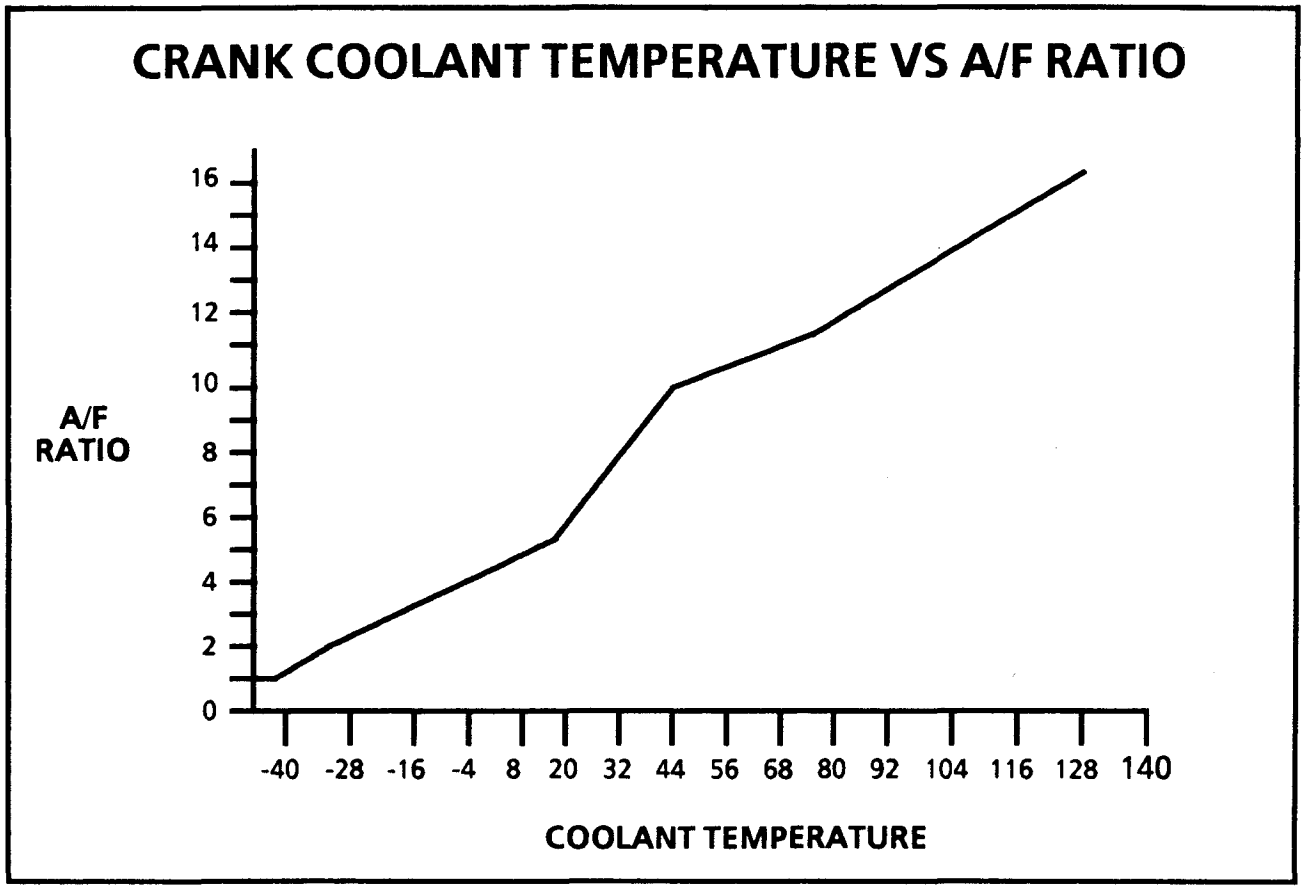
# FUEL CONTROL MODES

The ECM uses voltage inputs from the sensor to determine how much fuel to deliver to the engine. The fuel may be delivered in any one of several different "modes" with the ECM controlling which mode is appropriate according to the readings it receives from the sensors at that particular time.

## 4.3 STARTING MODE

When the igntion is first turned on, the ECM turns on the fuel pump relay for two seconds to pressurize the system ready for starting. The ECM also checks the coolant temperature sensor and throttle position sensor readings and determines the appropriate air/fuel ratio for starting. This ranges from approximately 0.8 : 1 at minus 40°C to 16.8 : 1 at 104°C engine coolant temperature.

The ECM controls the quantity of fuel delivered by changing the injector pulse width i.e. length of time the injector is energised and opened.



## 4.4 CLEAR FLOOD MODE

Provision is made for clearing a flooded engine as follows:

If the throttle is held fully open and the engine cranked, the ECM will decrease injector on time for as long as engine speed is below approx. 600 rpm. If throttle opening becomes less than approx. 70% the ECM returns to the starting mode.

## 4.5 RUN MODE

Above 600 rpm the ECM switches to RUN MODE.

The amount of fuel supplied depends:

- engine speed
- manifold air pressure
- athmospheric pressure (baro)
- throttle position
- coolant temperature

# 4.6 TRANSIT FUEL MODES

## DECELERATION FUEL CUTOFF

The purpose of the decel fuel cutoff function is to remove fuel from the engine during deep deceleration conditions.

@ 12 M.PH
TPS 4°
TPS 0°
MAP 30 KPA
R.PM 1000

## DECELERATION ENLEANMENT

During light deceleration injector pulse width is decreased depending on change of throttle position, change of MAP and engine speed.

## ACCELERATION ENRICHMENT

During acceleration the mixture becomes richer based on engine speed, coolant temperature, TPS and MAP and difference in TPS and MAP readings in a given time.

# 4.7 FUEL CUTOFF MODES

There will be no fuel supplied when

- ignition is turned off
- RPM is greater than ~~7719 (N/A)~~ ~~7188 (T/C)~~ 6,400
- RPM is greater than ~~4000~~ 3500 and trouble codes stored 42
- Boost pressure is greater than ~~192 kPa~~ 198 KPa

# 4.8 RUN MODES

The run mode has two possible conditions "Open Loop" or "Closed Loop".

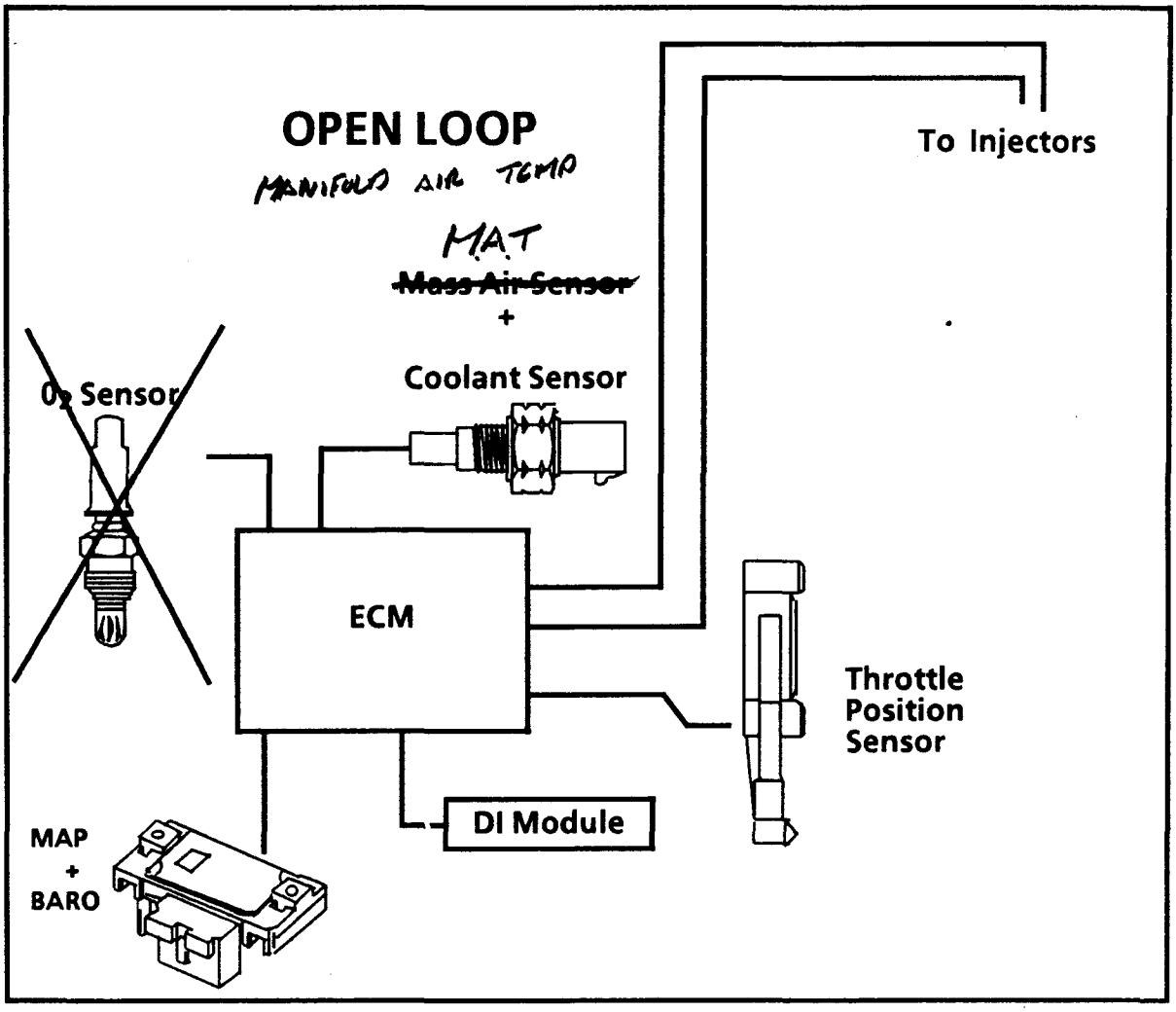
**"OPEN LOOP"**

When the engine is first started, the system goes into "Open Loop" operation. In "Open Loop," the ECM ignores the signal from the oxygen ($0_2$) sensor, and calculates the air/fuel ratio based on inputs from the coolant temperature and manifold absolute pressur (MAP) sensors.
The system will stay in "Open Loop" until the following conditions are met:

1. The $0_2$ sensor has varying voltage output, showing that it is hot enough to operate properly. (This depends on temperature.)

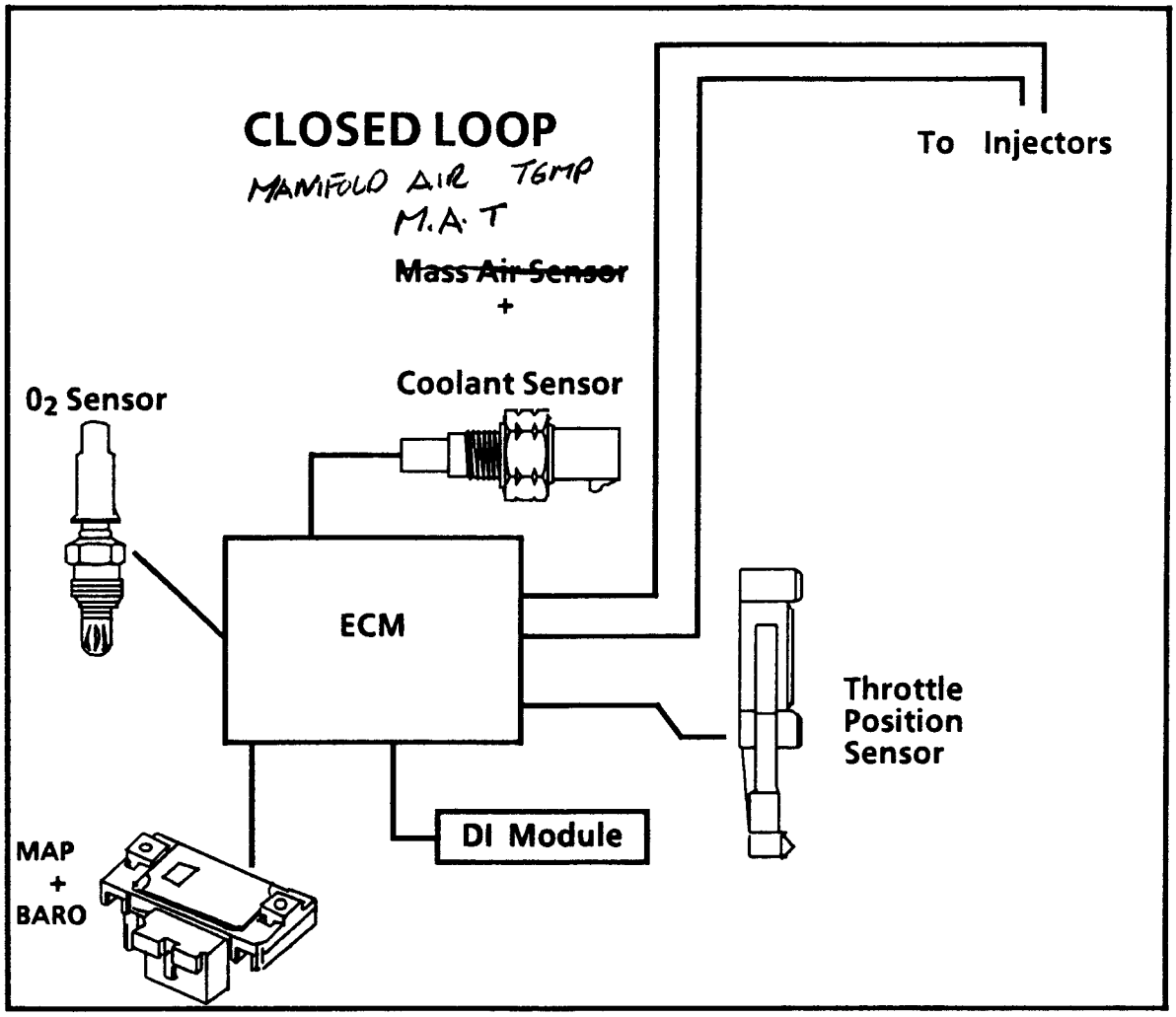
2. The coolant temperature sensor is above a specified temperature. 54°

3. A specific amount of time has elapsed after starting the engine.



## 4.9 CLOSED LOOP FUEL CONTROL

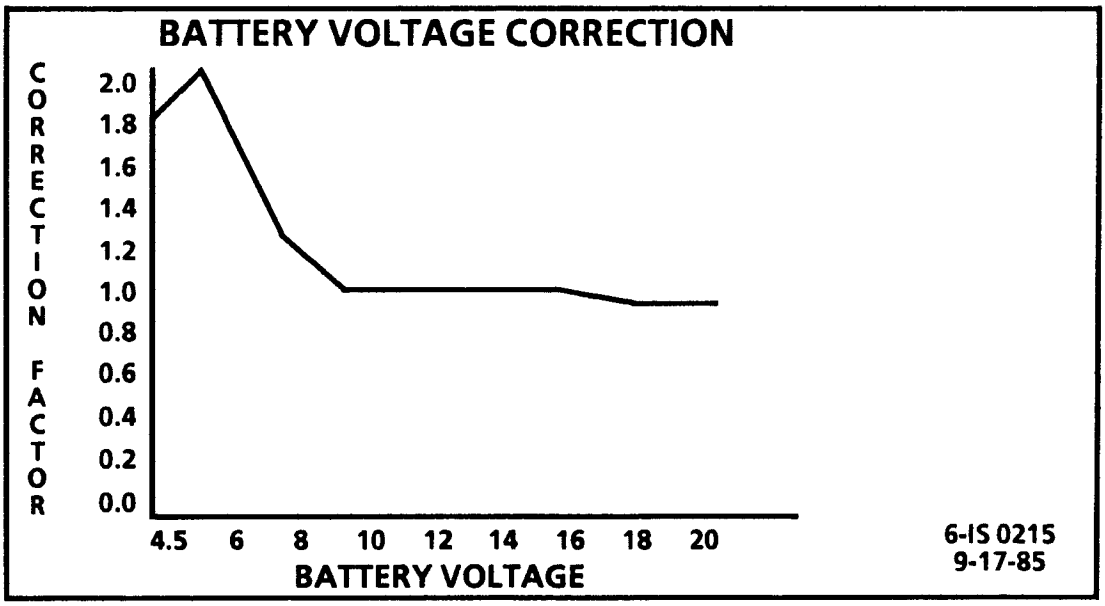
The specific values for the above conditions are stored in the memory calibration module (Mem-Cal). When these conditions are met, the system goes into "Closed Loop" operation.
In "Closed Loop," the ECM calculates the air/fuel ratio (injector on-time) based on the signal from the $O_2$ sensor. This controls the air/fuel ratio very close to 14.6:1.
WILL GO INTO OPEN LOOP



# 4.99 BATTERY VOLTAGE CORRECTION MODE

When battery voltage is low, the ECM can compensate for ~~the weak spark delivered by the direct ignition (DI) module by~~:

- Increasing the injector pulse width;
- Increasing the idle rpm;
- Increasing ignition dwell time




* WILL NOT START [redacted] IF [redacted] BATTERY CHARGED FULL * ?

NO JUMP START) NOT ON RUNNING CAR +
ONLY ON STANDING BATT
NO BOOST STA



# 5.0 DIRECT IGNITION SYSTEM

The direct ignition (DI) system does not use the conventional distributor and coil. This ignition system consists of 3 separate ignition coils and an ignition module mounted on a base plate.

A crankshaft position sensor, related connecting wires and the electronic spark timing (EST) portion of the ECM make up the remainder of the system.

A distributorless ignition system, such as this one, uses a "waste spark" method of spark distribution. Each cylinder is paired with its opposite number with each pair of plugs being connected to a single, double-ended coil such that a spark occurs simultaneously in the cylinder coming up on the compression stroke and in the cylinder coming up on the compression stroke and in the cylinder coming up on the exhaust stroke.

The cylinder on the exhaust stroke requires very little of the available energy to fire the spark plug. The remaining engergy will be used as required by the cylinder on the compression stroke. The same process is repeated when the cylinders reverse roles.

## CRANKSHAFT POSITION SENSOR

A magnetic sensor mounted at the front of the engine , and protruding to within 1.5 mm of the torsional balancer, has a voltage pulse induced in it each time a machined slot in the balancer periphery passes the sensor. There are 6 such slots equi-spaced (60° apart) around the torsional balancer, phased such that one slot passes the sensor when pistons 1/6 ~~1/4~~ are at TDC. A seventh slot, positioned at 10° before the next slot, serves to generate a "sync-pulse".

These pulses are received by the ignition module (located with the ignition coils), which by noting the frequency of the pulses is able to determine engine rpm, and by comparing the time interval between individual pulses can recognize the positional "sync" pulse. The ignition module uses this information to control ignition timing during engine cranking, and also sends reference signals to the ECM at the rate of one every 120° of crankshaft rotation (3 per engine revolution).

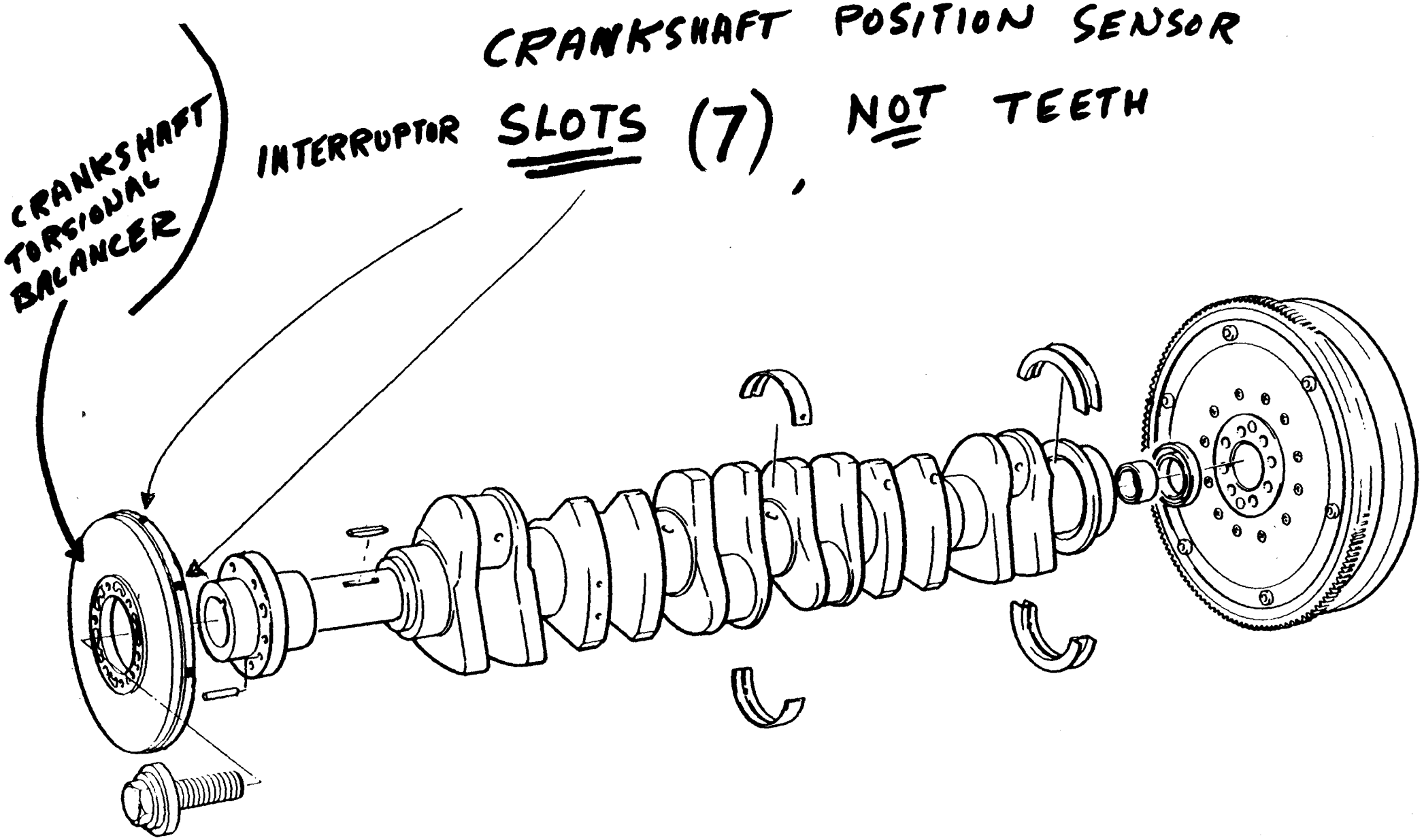
Theses signals inform the ECM of engine speed and position, which it uses to control fuel delivery and, at speeds over ~~700~~ 400 rpm, the ignition timing.

## IGNITION MODULE & H.T. COILS

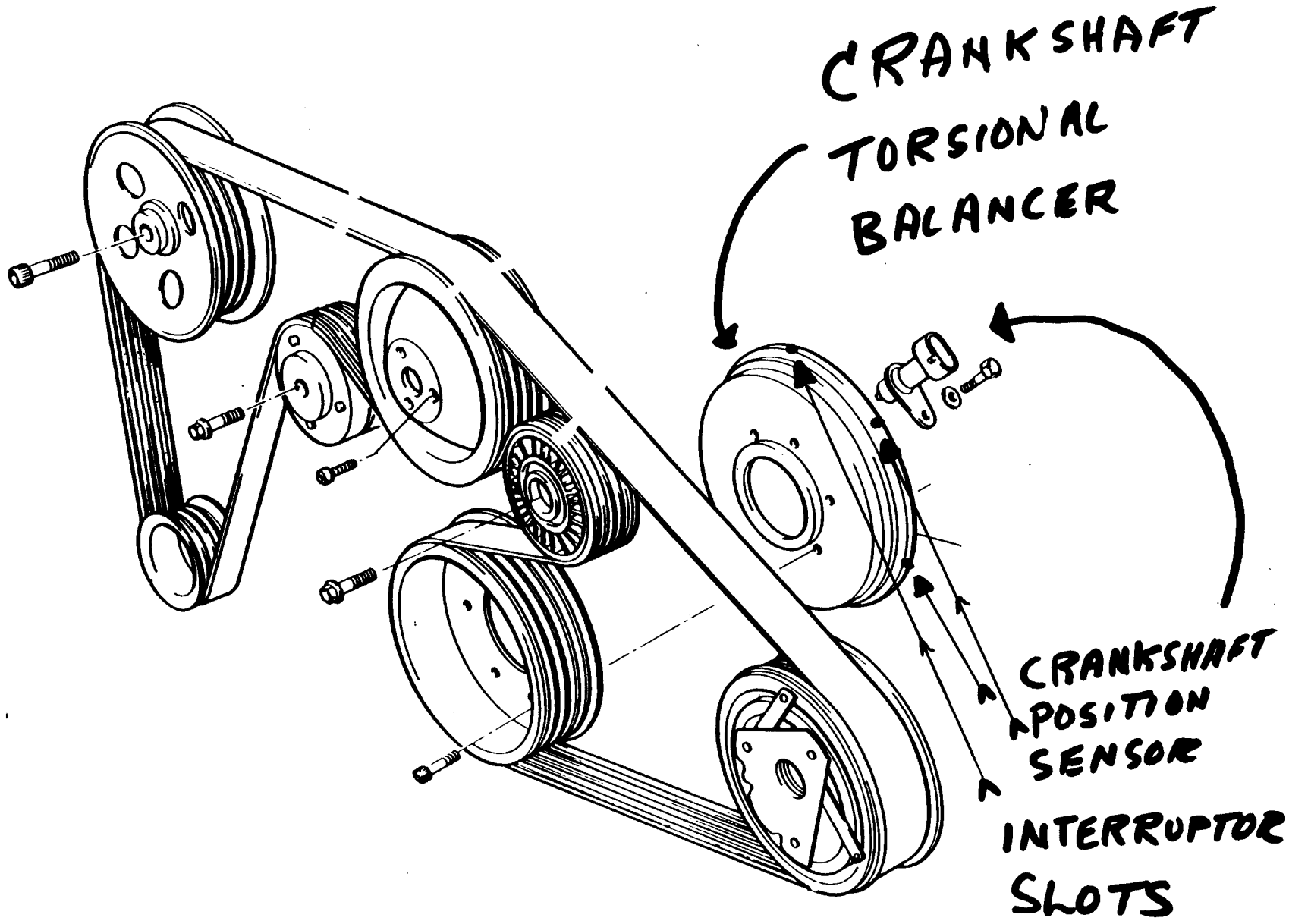
The ignition module and H.T. coils are mounted as a unit to a chassis bracket at the (RH) LH side of the engine. Each coil, provides the spark for two plugs simultaneously.

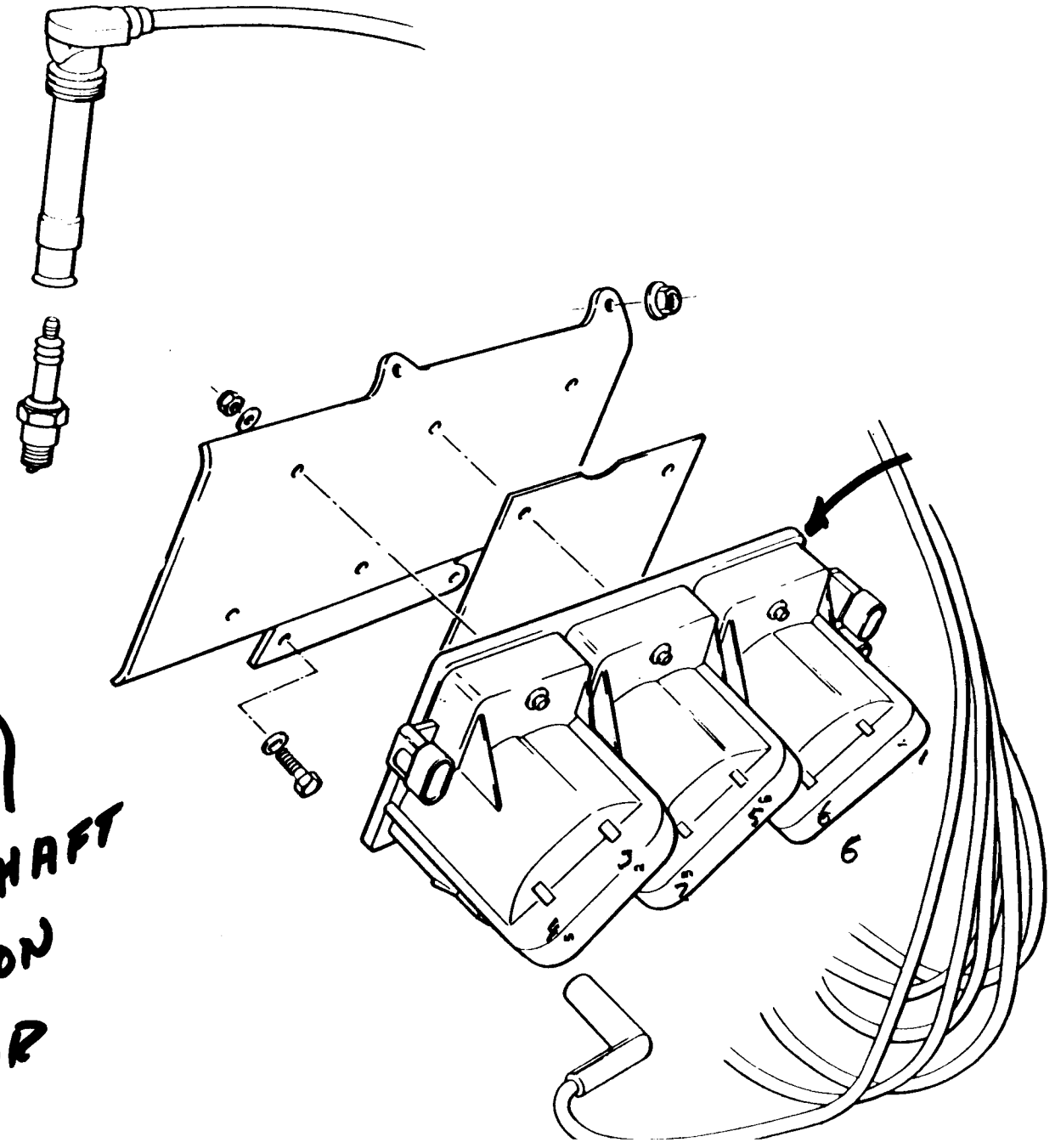
The ignition module monitors the crankshaft position sensor signals and sends reference signals to the ECM so that correct spark and fuel injector control can be maintained during all driving conditions. During cranking, the ignition module monitors the "sync-pulse" to begin the ignition firing sequence and below ~~700~~ 400 rpm the module controls spark advance by triggering each of the three coils at a pre-determined interval based on engine speed only.

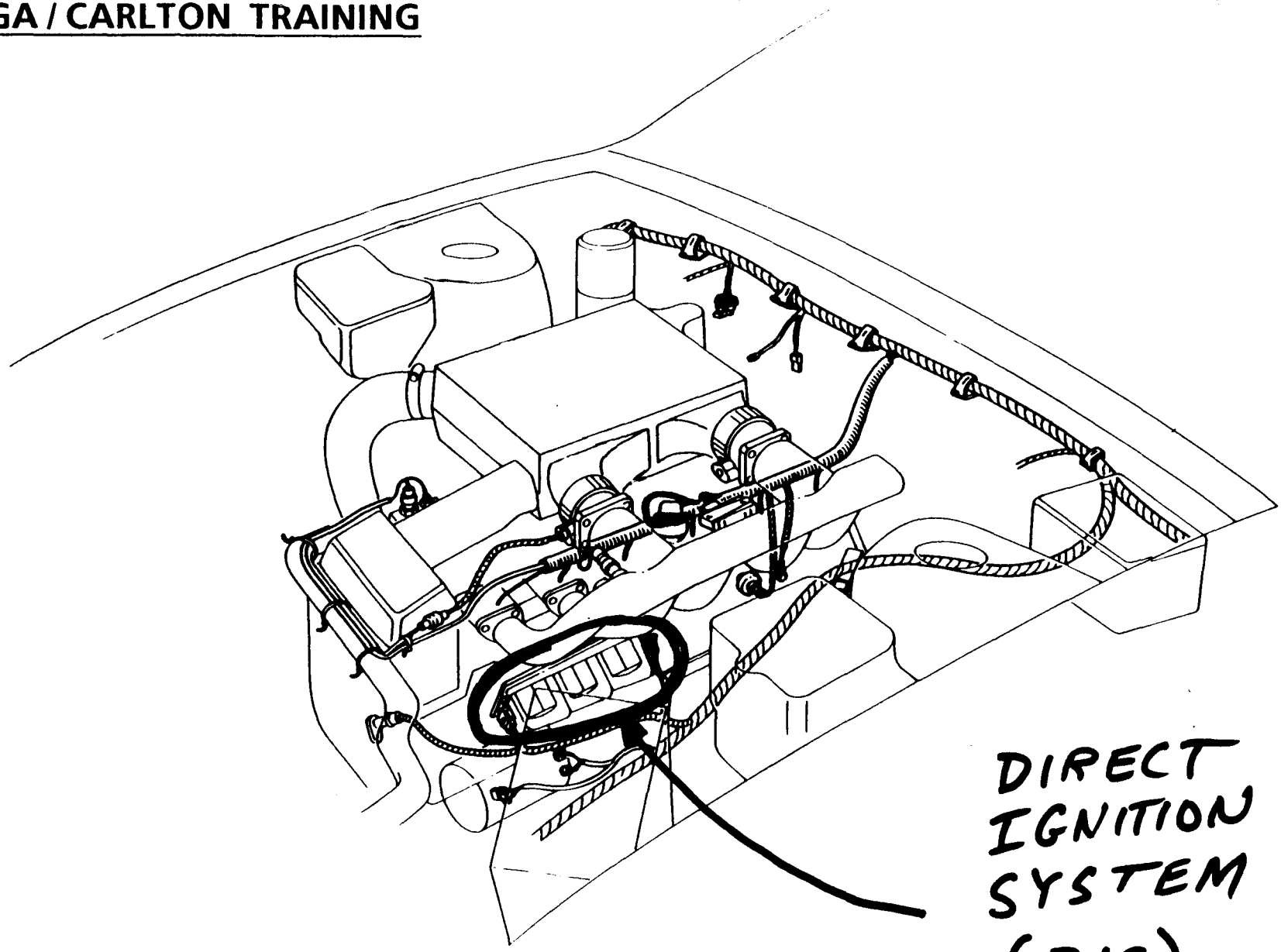
Above ~~700~~ 400 rpm the ECM controls the spark timing (EST) and compensates for all driving conditions. The ignition module must receive a "sync-pulse" and then another pulse in that order to enable the ignition coils to be properly sequenced


CRANKSHAFT POSITION SENSOR
INTERRUPTOR SLOTS (7), NOT TEETH
CRANKSHAFT TORSIONAL BALANCER

MISFIRING TO CHECK IF DIRT ON CRANKSHAFT ? PICK UP

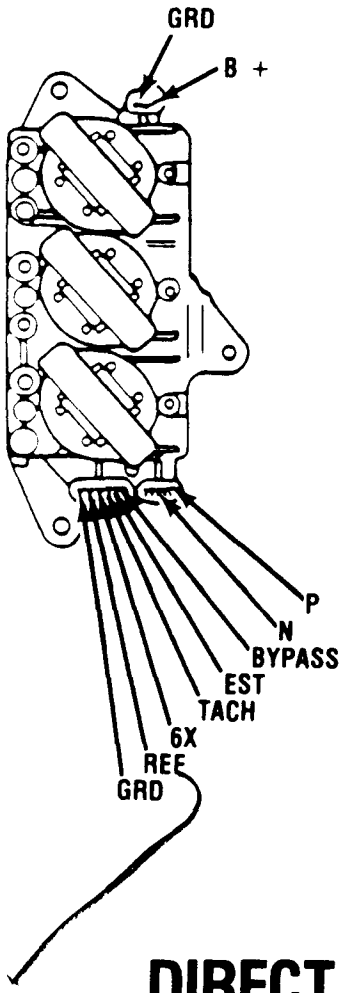


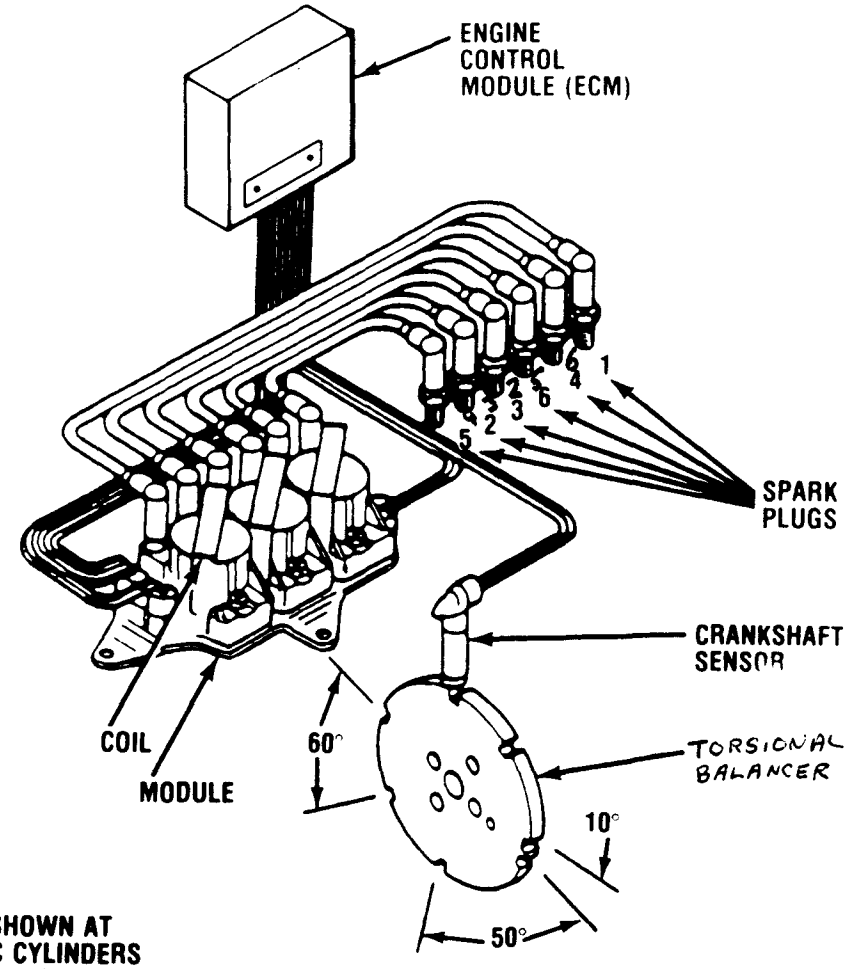

CRANKSHAFT
POSITION
SENSOR



DIRECT IGNITION SYSTEM (DIS)

IGNITION MODULE
-and
COIL ASSEMBLY (3)

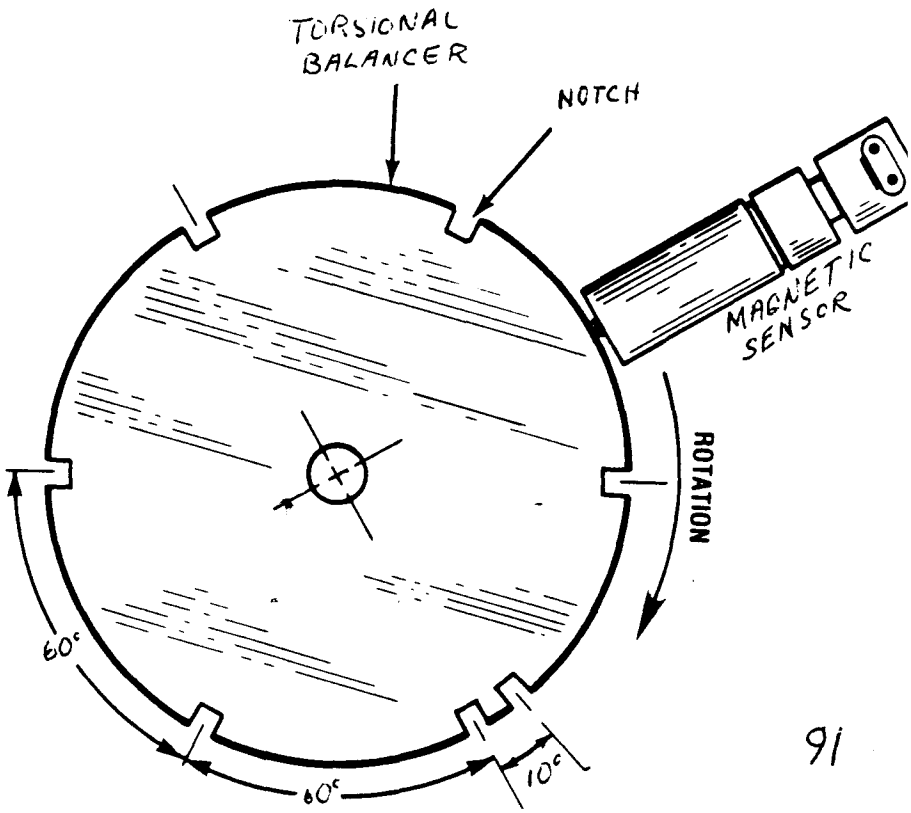


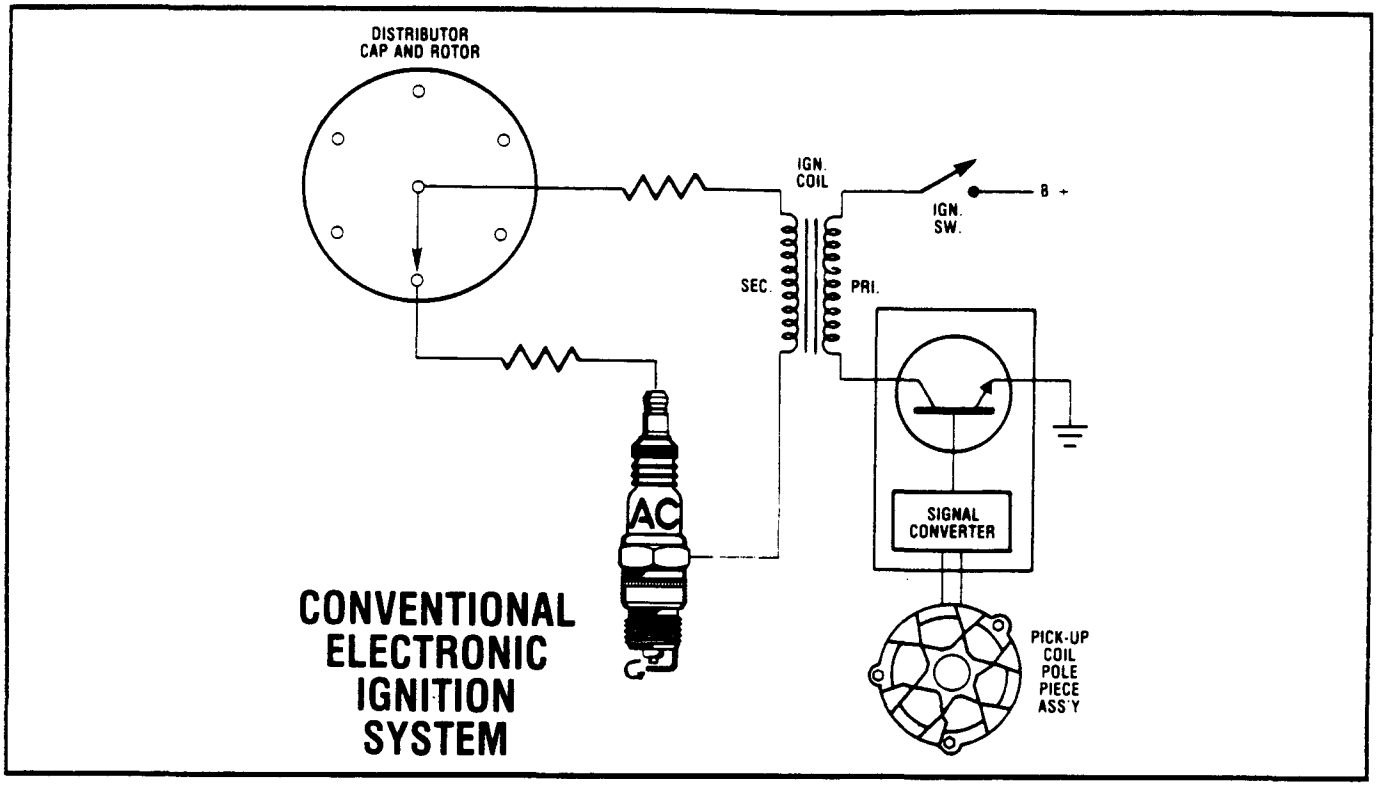




SHOWN AT TDC CYLINDERS 6 AND 3

# DIRECT IGNITION SYSTEM

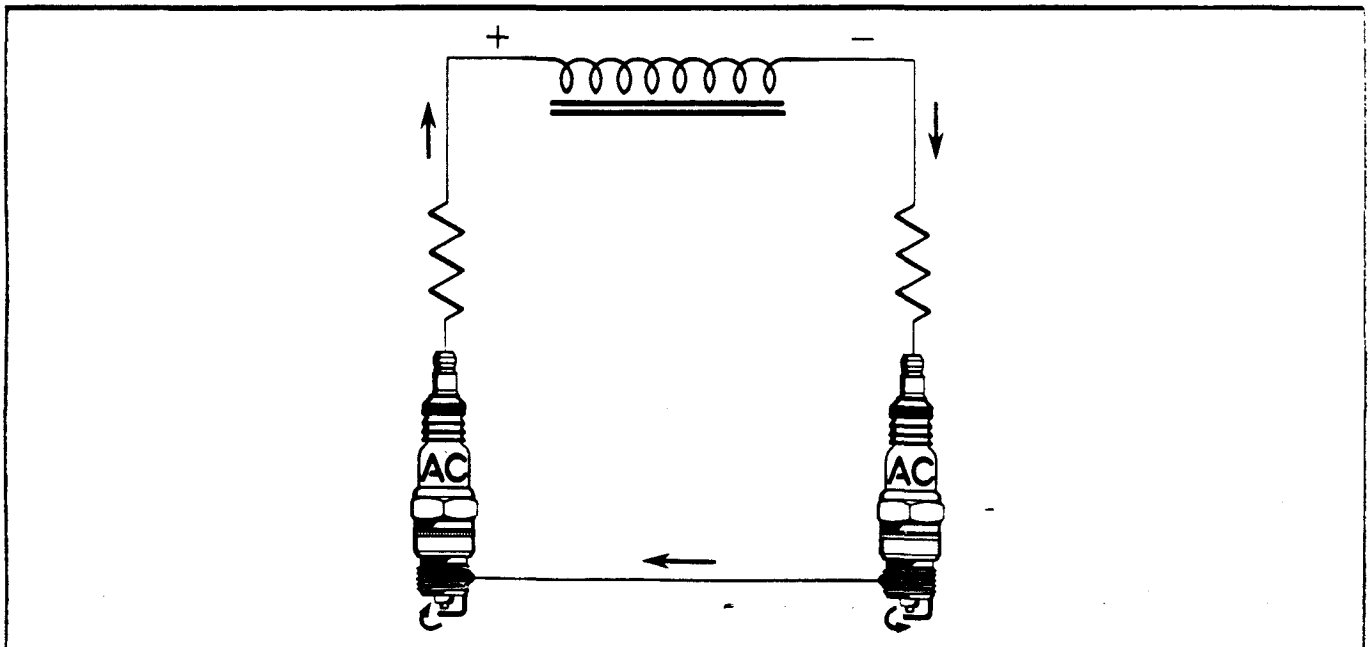
3 pulses
C.R.



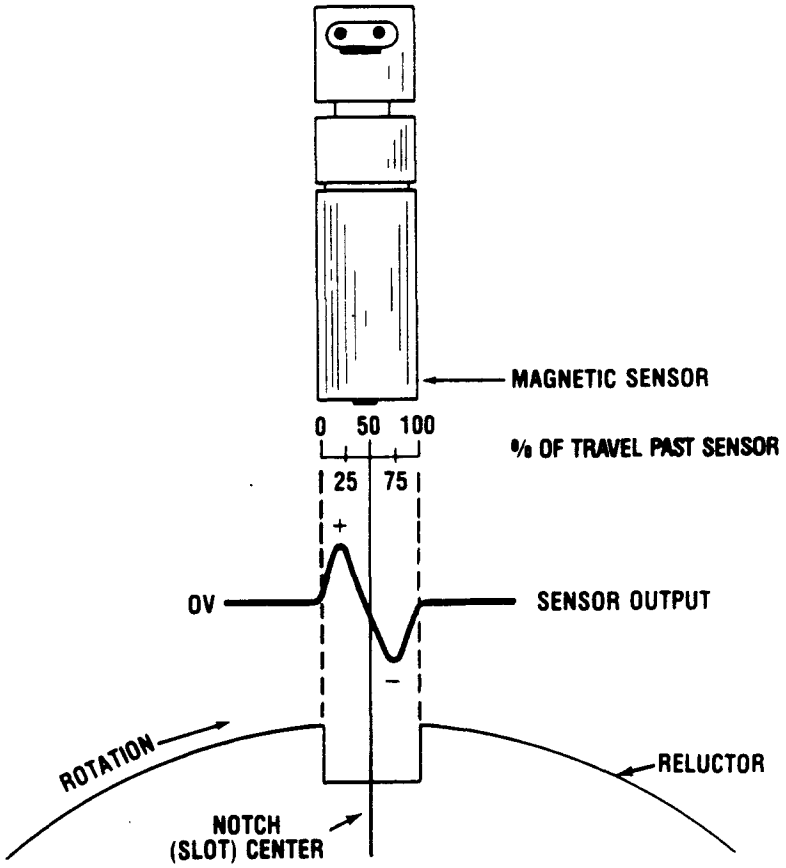



CONVENTIONAL ELECTRONIC IGNITION SYSTEM

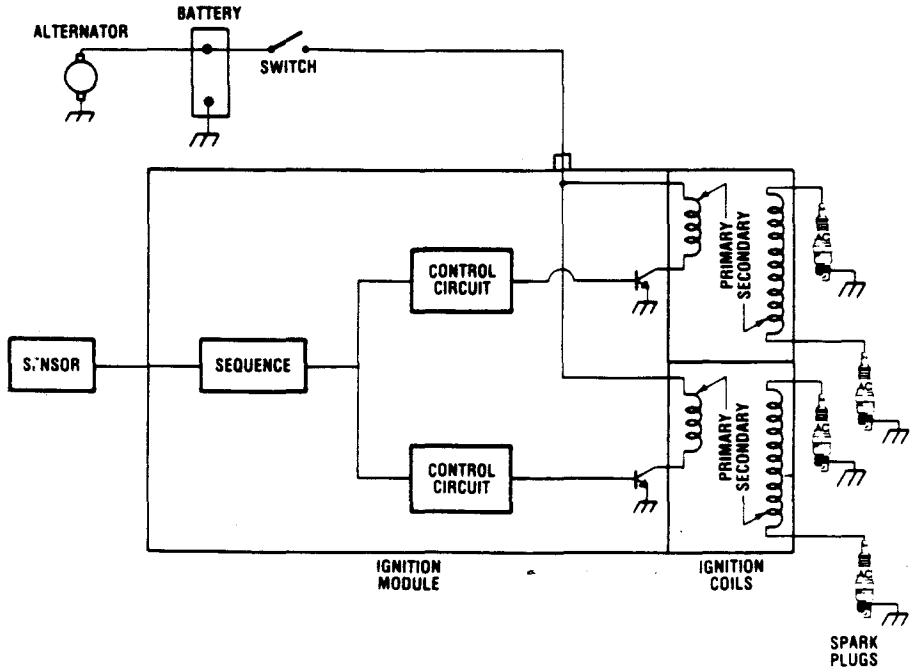
+
12
v




D.I.S. CURRENT FLOW

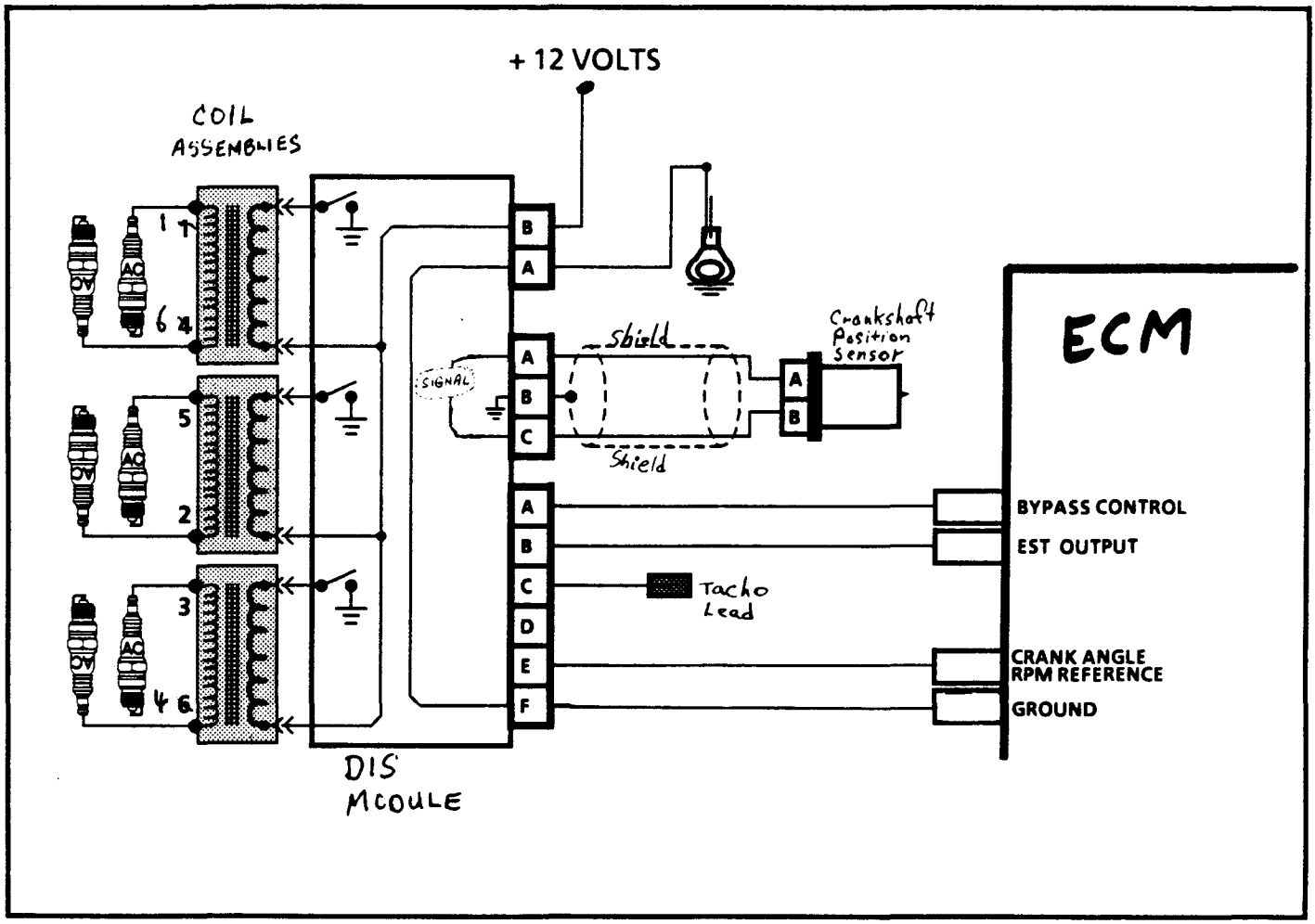



## NOTCH EFFECT ON OUTPUT SIGNAL



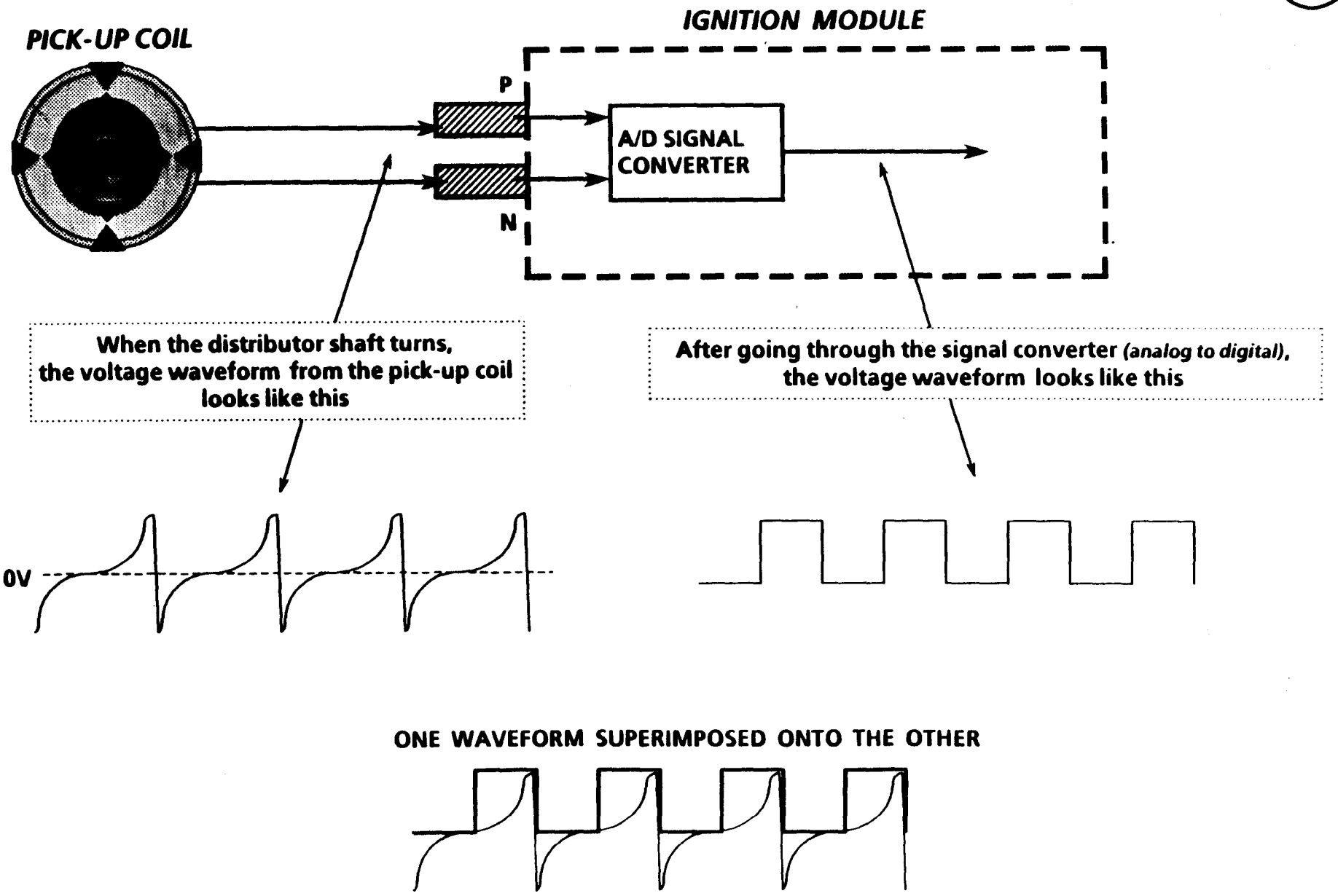

## DIRECT IGNITION SYSTEM

# DIRECT IGNITION SYSTEM CIRCUITS



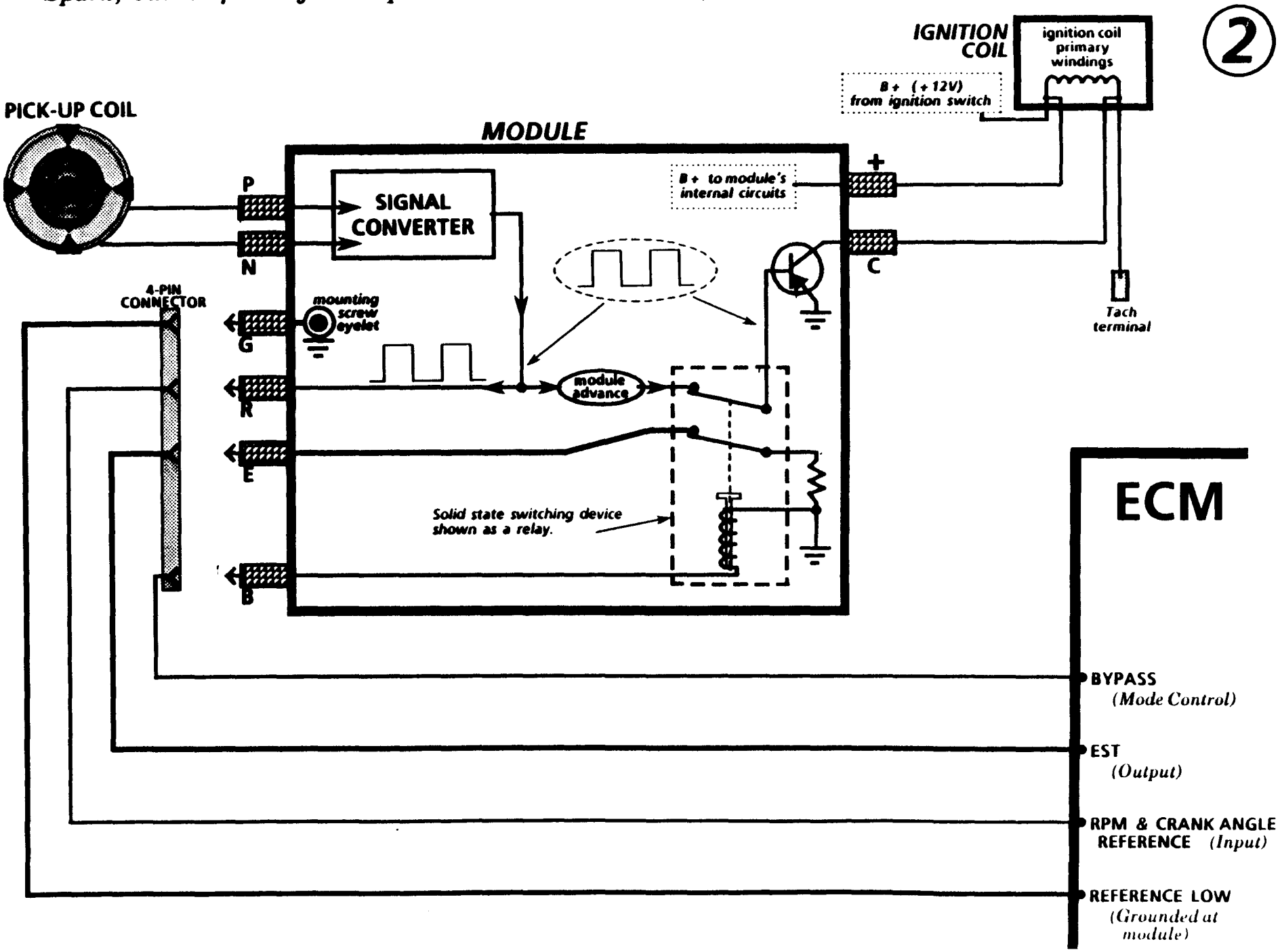
# IGNITION MODULE *ANALOG - to - DIGITAL* SIGNAL CONVERTER OPERATION

1



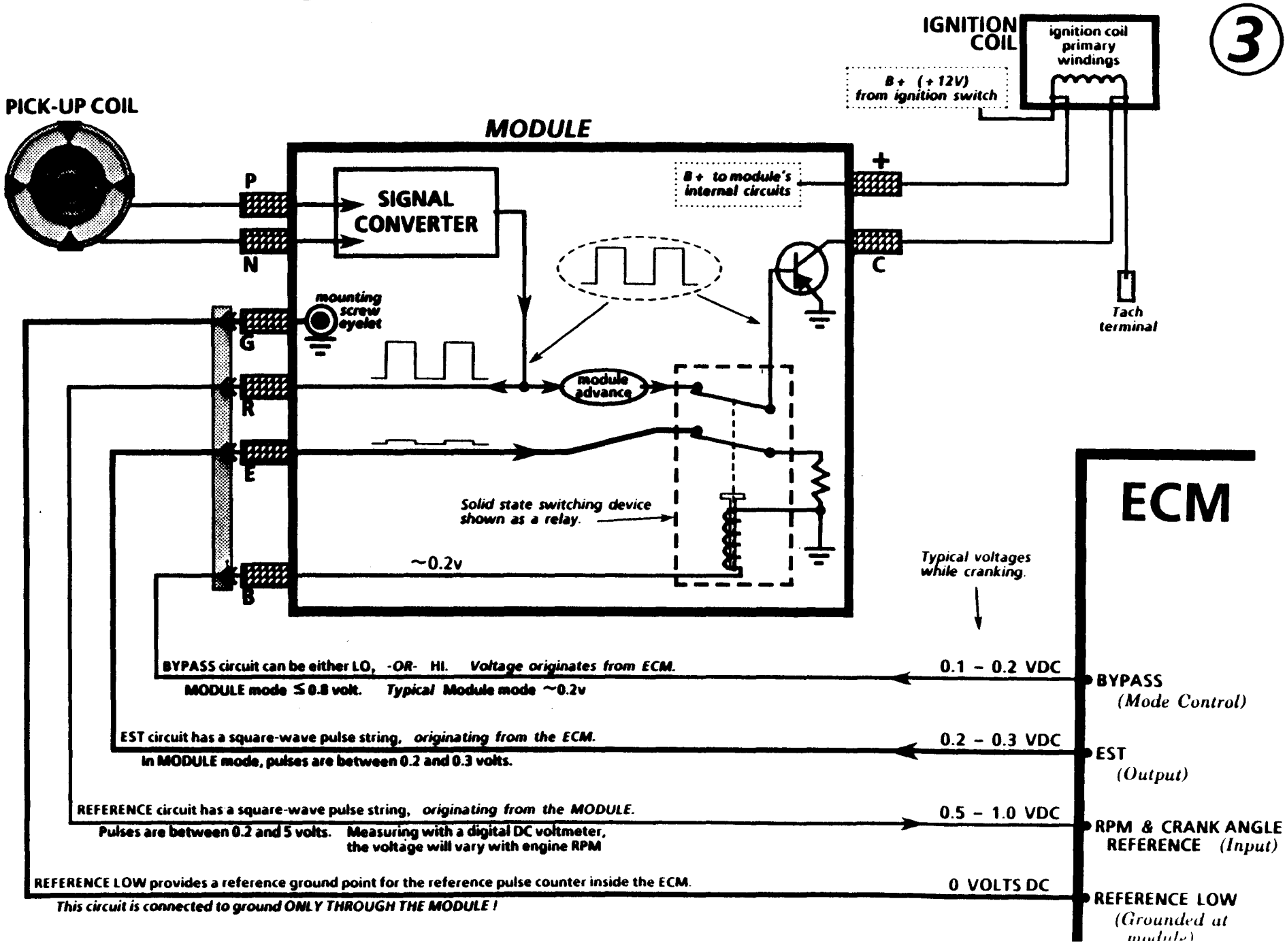
# IGNITION MODULE DISCONNECTED FROM ECM

*Spark, but no fuel injection pulses*



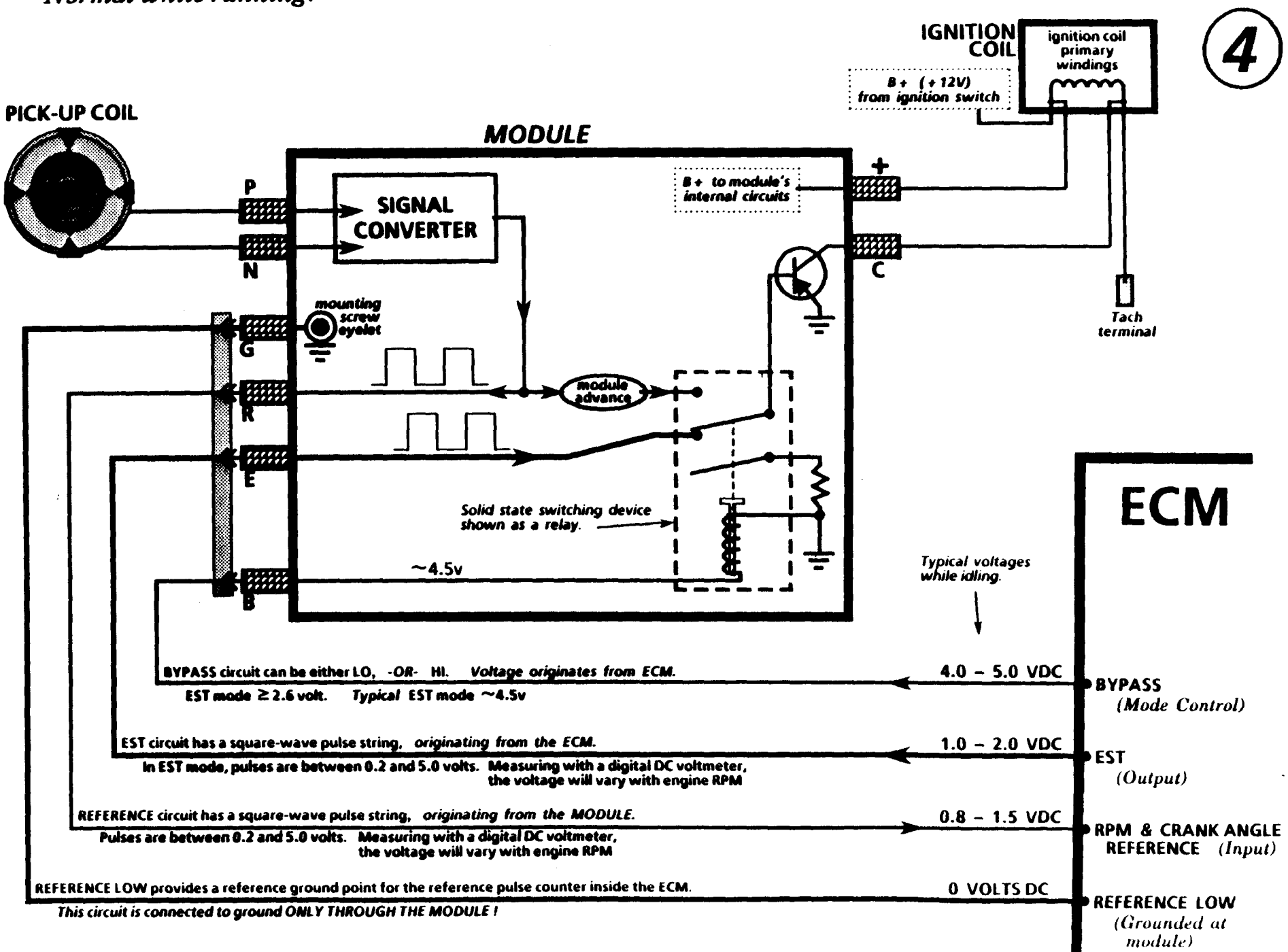
# IGNITION MODULE CONNECTED TO ECM — Module (or bypass) mode

*Normal while cranking to start.*



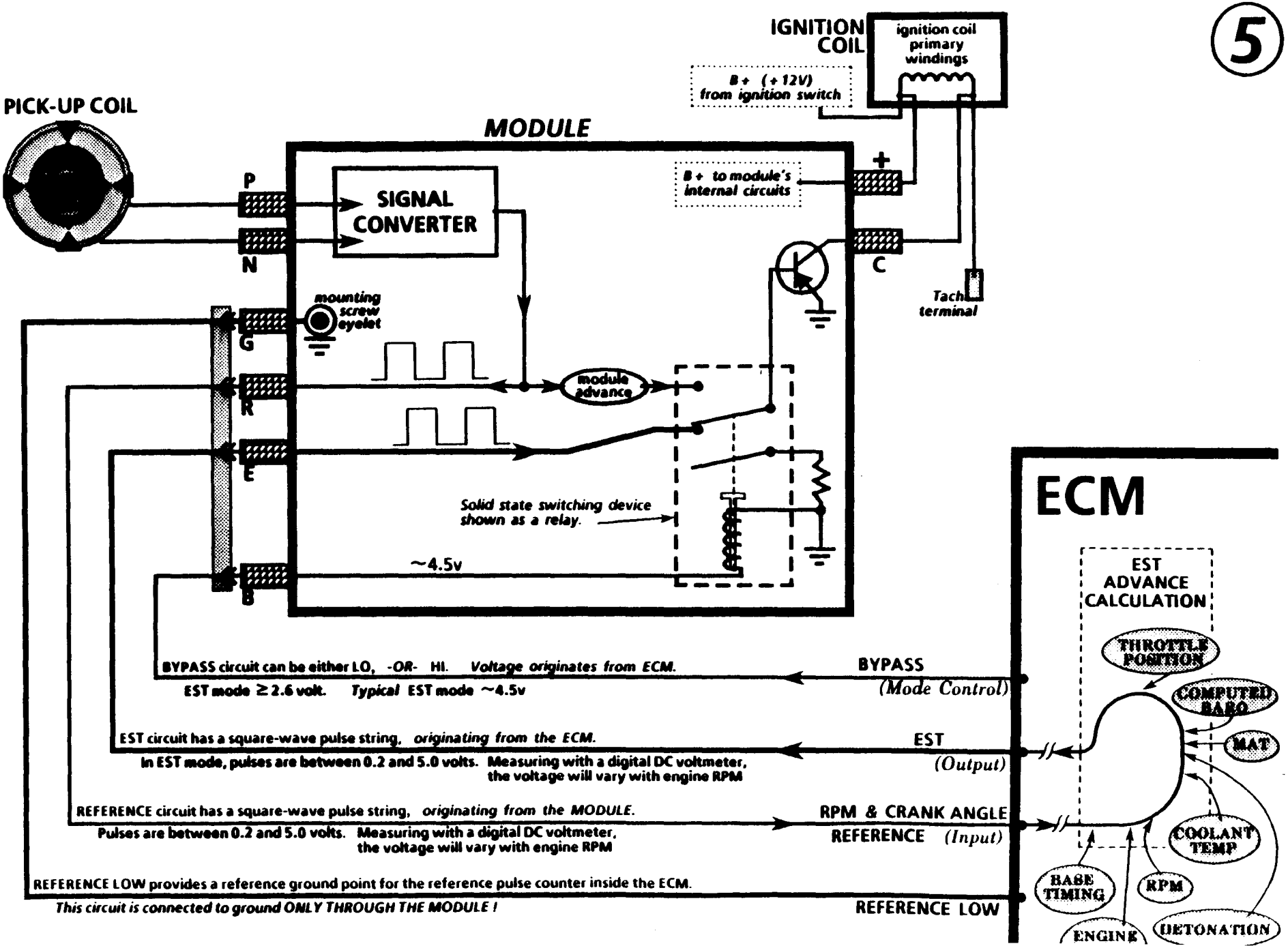
# IGNITION MODULE CONNECTED TO ECM ... EST mode

*Normal while running.*

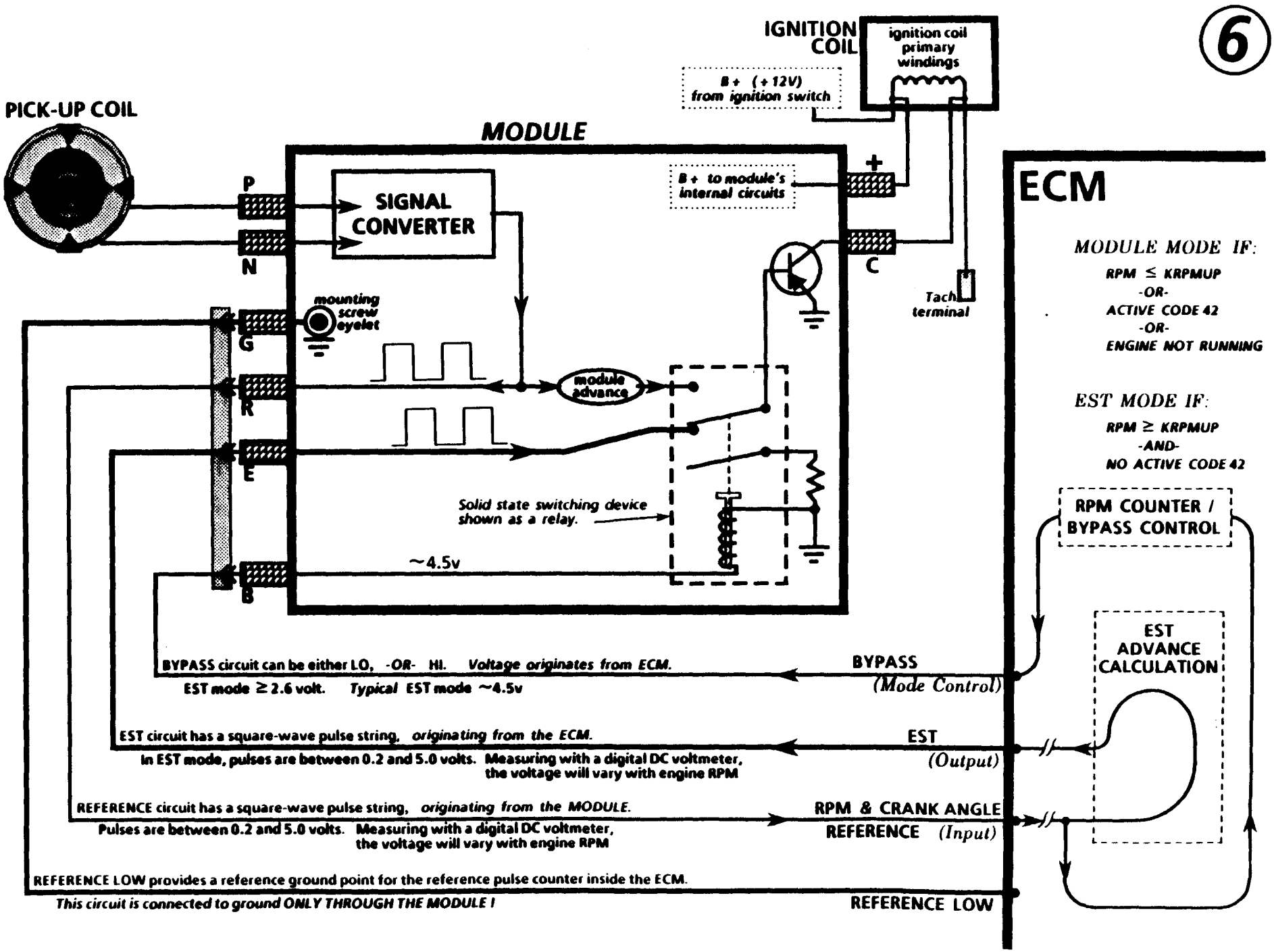


# IGNITION MODULE CONNECTED TO ECM - EST mode

*Shown with ECM inputs that affect spark advance*

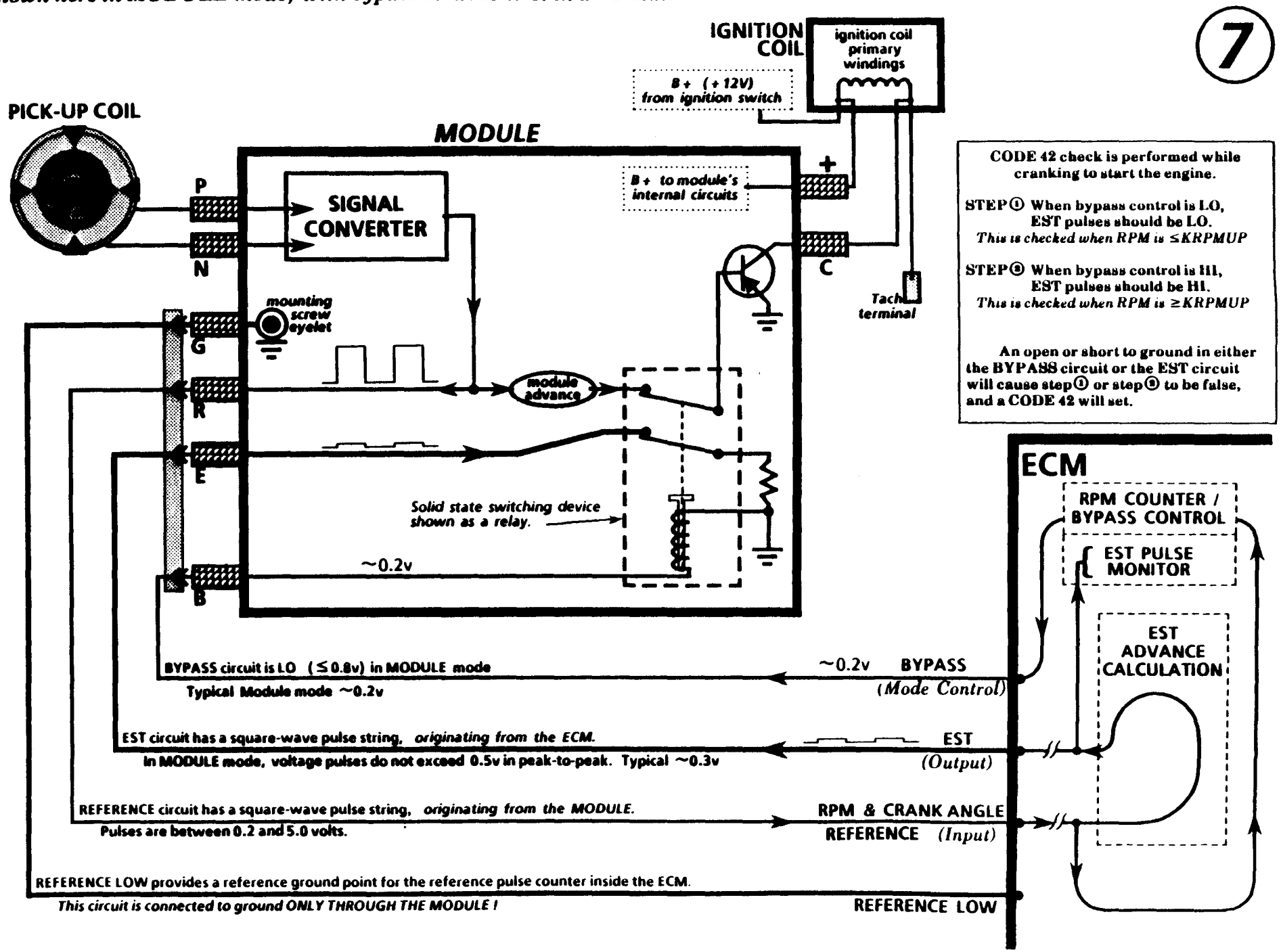


# IGNITION MODULE CONNECTED TO ECM - BYPASS CONTROL



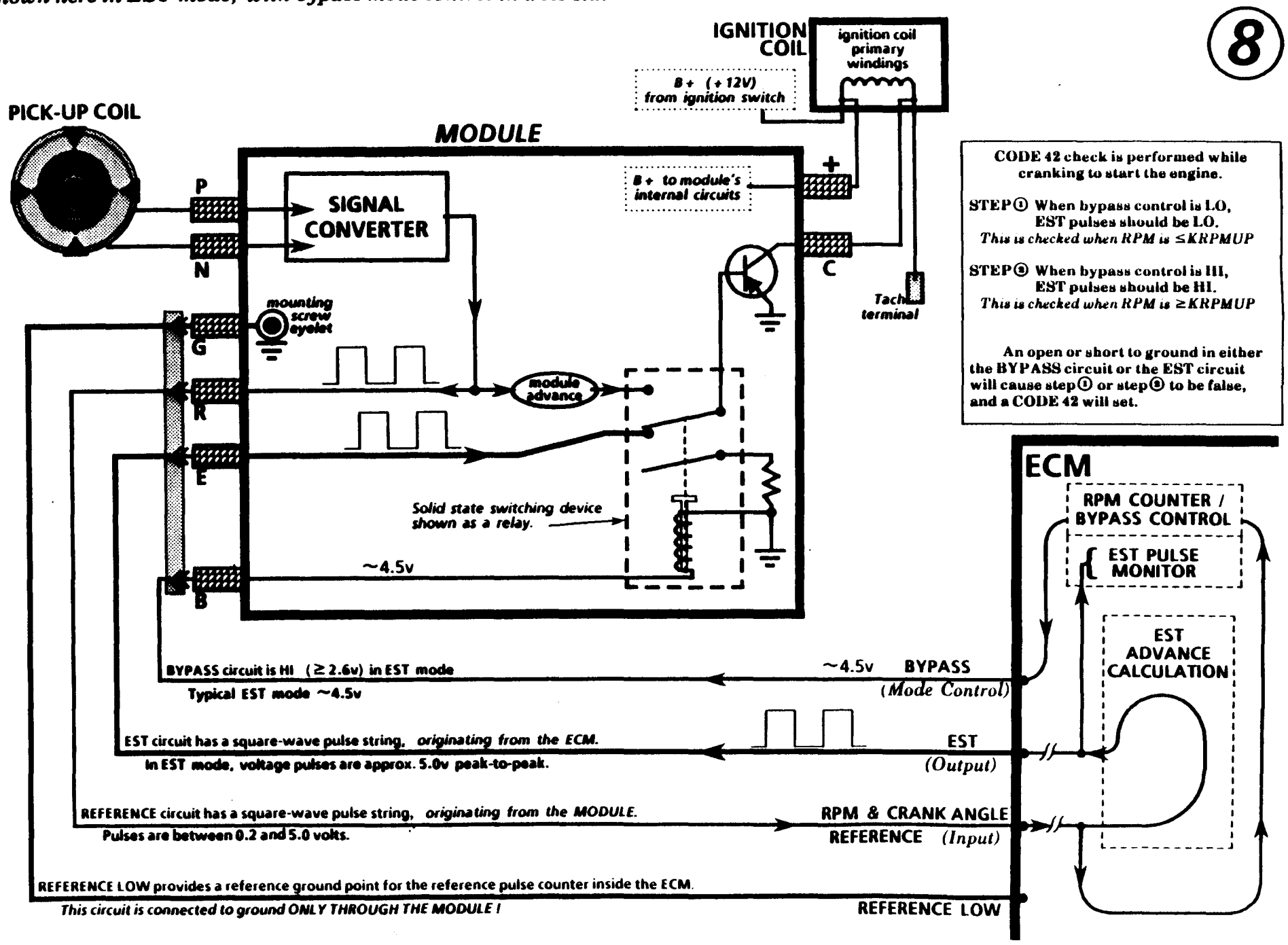
# IGNITION MODULE CONNECTED TO ECM - CODE 42 DEFINED, *step ① shown*

*Shown here in MODULE mode, with bypass mode control in a LO state.*



# IGNITION MODULE CONNECTED TO ECM — CODE 42 DEFINED, *step ② shown*

*Shown here in EST mode, with bypass mode control in a HI state.*



# 5.1 ELECTRONIC SPARK TIMING MODES

## BYPASS MODE

The bypass mode allows the DIS to operate independently of the ECM when the ECM is incapable of providing the spark timing information such as at low speeds like cranking, low system voltage, and with certain ECM or system malfunctions.

In the bypass mode, two conditions of operation occur. As shown in the Break Amp (BA) curves, at cranking speeds (defined as below four hundred RPM) where system voltages are expected to be low, the coil current will start at sixty degrees BTDC and stop at TDC. Ingnition occurs at the time that the coil break amps stop. This means that at speeds below four hundred RPM, the spark will occur at TDC. As the engine starts and the RPM's increase above four hundred, two changes in operation happen.

1. The point at which ignition occurs will be earlier which will advance the spark timing. The amount of advance is a function of speed and is built into the ignition module. ~~A typical advance for the DIS system is shown in Figure 7.~~

The start of current flow will be delayed so that the time from start of current to ignition will be just sufficient to allow the coil current to rise to the desired break amps. The circuitry constantly monitors this current and adjusts on-time or dwell thus closed loop dwell control. This feature results in less average current and less power dissipation in the system.

## EST MODE

The EST mode of operation occurs after system voltage is up, engine speed is satisfactory and the ECM is computing. At this time the bypass input to the module is raised by the ECM to approximately five volts, and an EST signal is fed into the module. With DIS the fall of current will occur, causing ignition, at the fall of the EST signal, but the start of current will be controlled by the closed loop dwell control and is independent of the rise of the EST signal. The DIS will still select the proper coil to fire.

# 7.0 ELECTRONIC CONTROL MODULE (ECM)

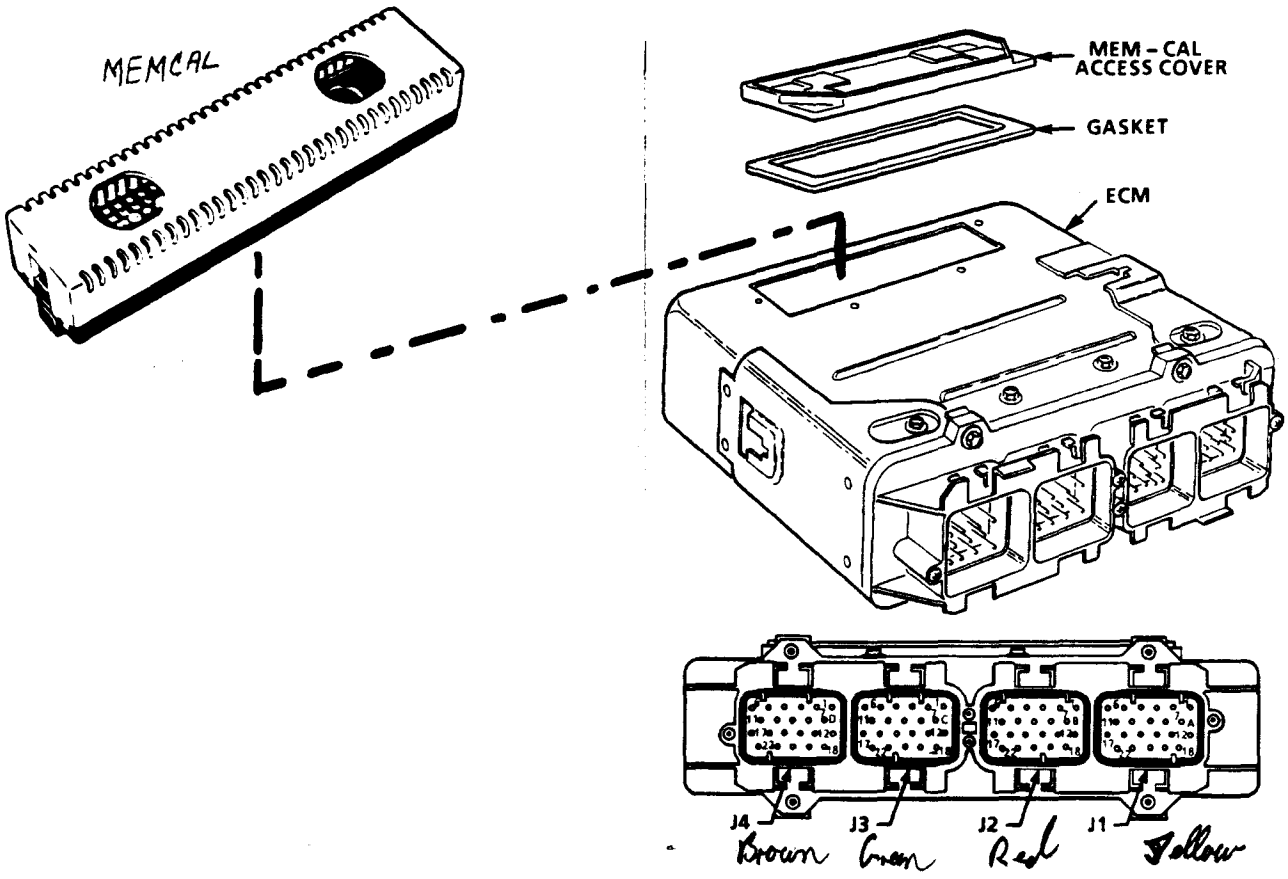
The Electronic Control Module (ECM), ~~located on the right hand fuel tank board~~, is the controlling computer for the fuel injection and engine management system. It constantly monitors data received from various sensors and controls engine operation (fuel management, spark timing and idle speed) to provide optimum performance and driveability consistent with the minimum of harmful emissions.

For service, the ECM consists of only two parts:

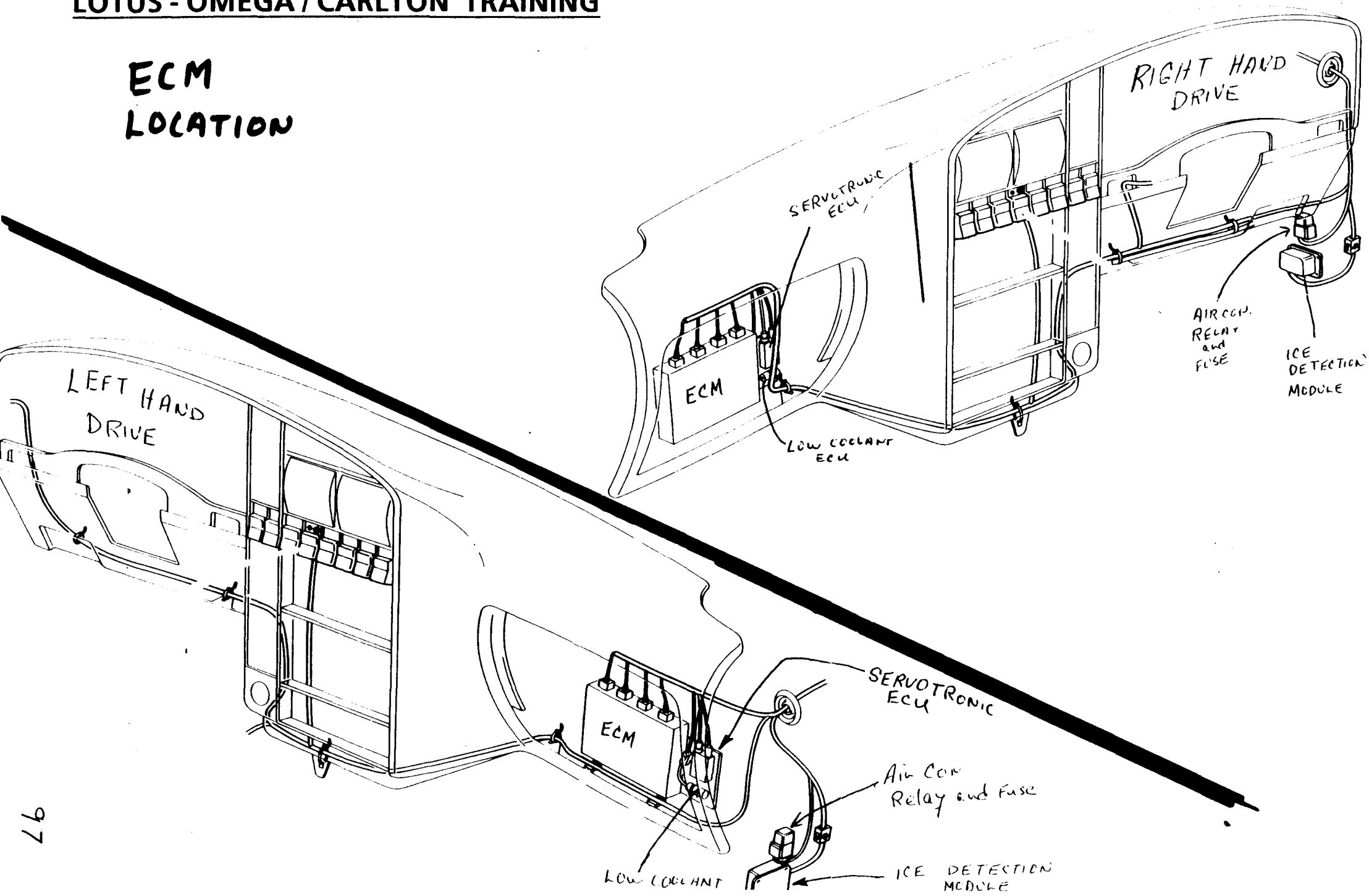
- Controller. This is the main body of the ECM and includes the basic control circuits.

- Mem-Cal. This is a "Memory and Calibration" cartridge which plugs into the controller. It is specific to the particular model year of the vehicle, and contains the functions of the PROM - programmable read only memory, Cal Pak - calibration pakage designed to allow fuel delivery in the event of malfunction in the controller or PROM, as a "get you home" facility, and ESC electronic spark control module.

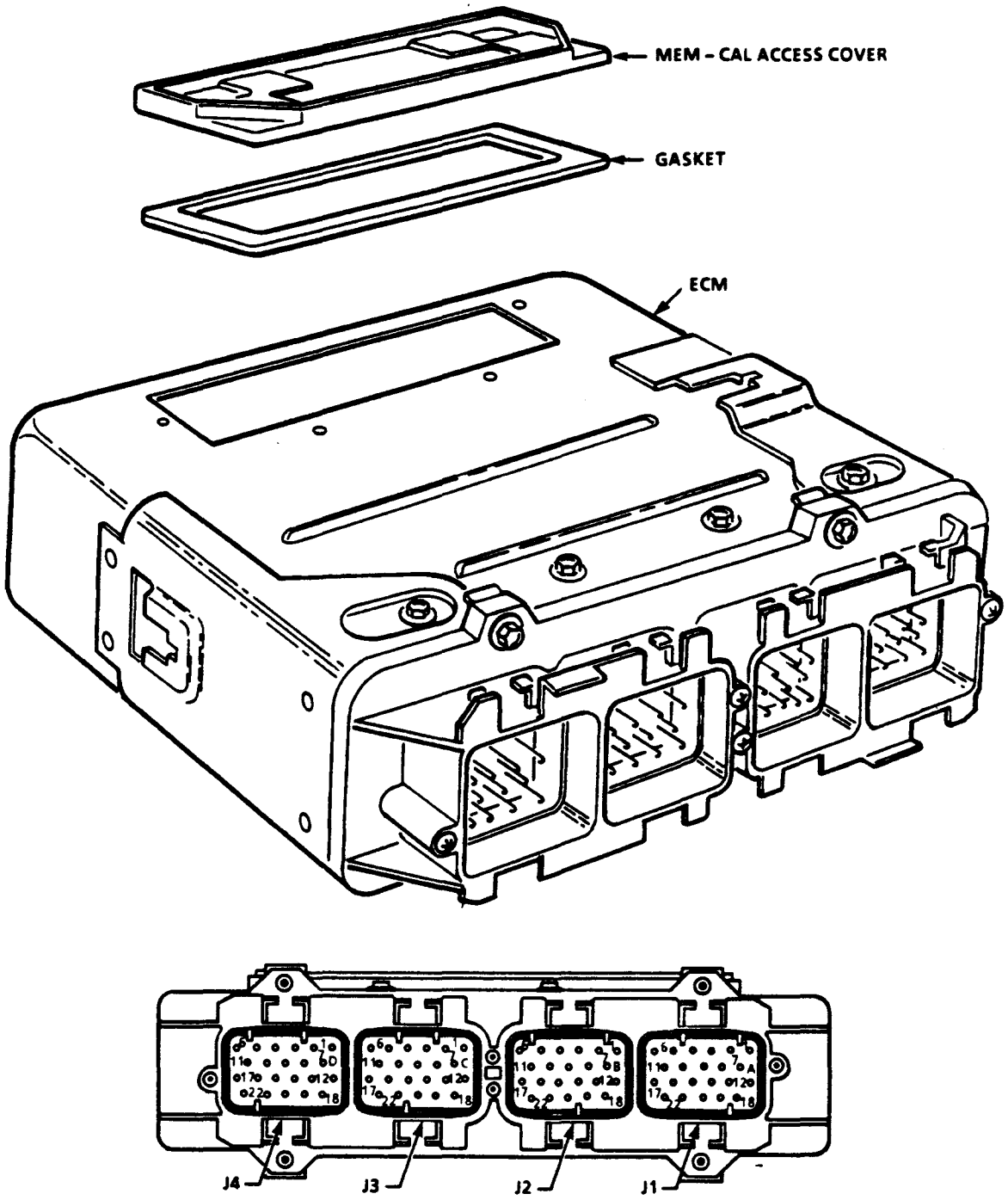
Sealed Unit



# ECM LOCATION



# 7.1 ECM CONNECTORS



# 8.0 DEFAULT & DIAGNOSTIC MODES

- The system has SELFDIAGNOSTIC capability. In case of a problem it alerts the driver via the "Check Engine Light".

- In case of an input sensor circuit problem the ECM automatically refers to pre-programmed "DEFAULT" values.

- The problem will be stored in ECM memory as a "TROUBLE CODE".

- A technician can read the code when the ECM "DIAGNOSTIC MODE" is requested or when a hand held "Tech 1" scanner tool is connected.

- The ECM also transmits sensor readings and other system parameters to the Tech 1 when "DATA MODE" is requested; this will aid rapid fault diagnosis.

- With the Tech 1 the ECM can be commanded to turn "ON/OFF" relays or solenoids in various "OUTPUT" checking modes.

# 8.2 TROUBLE CODES

## OMEGA/CARLTON

THIS IS A SUMMARY OF POSSIBLE TROUBLE CODES ON THE OMEGA/CARLTON. THE "CHECK ENGINE LIGHT" IS SWITCHED "ON" AND A CODE STORED WHEN THE ECM DETECTS ANY OF THE PROBLEMS LISTED BELOW. FOR MORE INFORMATION AND DIAGNOSTIC PROCEDURES REFER TO THE FOLLOWING CHARTS.

| CODE | COMPONENT / CIRCUIT | INDICATION |
|---|---|---|
| 13 | Front Oxygen Sensor | Sensor or circuit is open |
| 14 | Coolant Temp Sensor | High temperature indicated |
| 15 | Coolant Temp Sensor | Low temperature indicated |
| 16 | Wastegate | Overboost |
| 21 | Throttle Position Sensor | Signal voltage to ECM high |
| 22 | Throttle Position Sensor | Signal voltage to ECM low |
| 23 | Manifold Air Temp. Sensor | Low temperature indicated |
| 24 | Vehicle Speed Sensor | Incorrect signal to ECM |
| 25 | Manifold Air Temp. Sensor | High temperature indicated |
| 31 | Camshaft speed | Speed NOK |
| 33 | Manifold Absolute Pressure | Signal voltage high |
| 34 | Manifold Absolute Pressure | Signal voltage low |
| 41 | Cylinder select | PROM defect |
| 42 | Electronic Spark Timing | EST line fail / BY PASS ALSO |
| 43 | Electronic Spark Control | Detonation circuit failure |
| 44 | Front Oxygen Sensor | Lean exhaust indicated |
| 45 | Front Oxygen Sensor | Rich exhaust indicated |
| 51 | MEM - CAL Error | ECM / MEM-CAL fault |
| 53 | Battery Voltage High | Above 17.1 volts at ECM |
| 63 | Rear Oxygen Sensor | Sensor or circuit is open |
| 64 | Rear Oxygen Sensor | Lean exhaust indicated |
| 65 | Rear Oxygen Sensor | Rich exhaust indicated |

66 TURBO BOOST CONTROL OUTER LIMITS

Summary Lotus Omega/Carlton Trouble Codes

Notes on Use of F0: DATA LIST

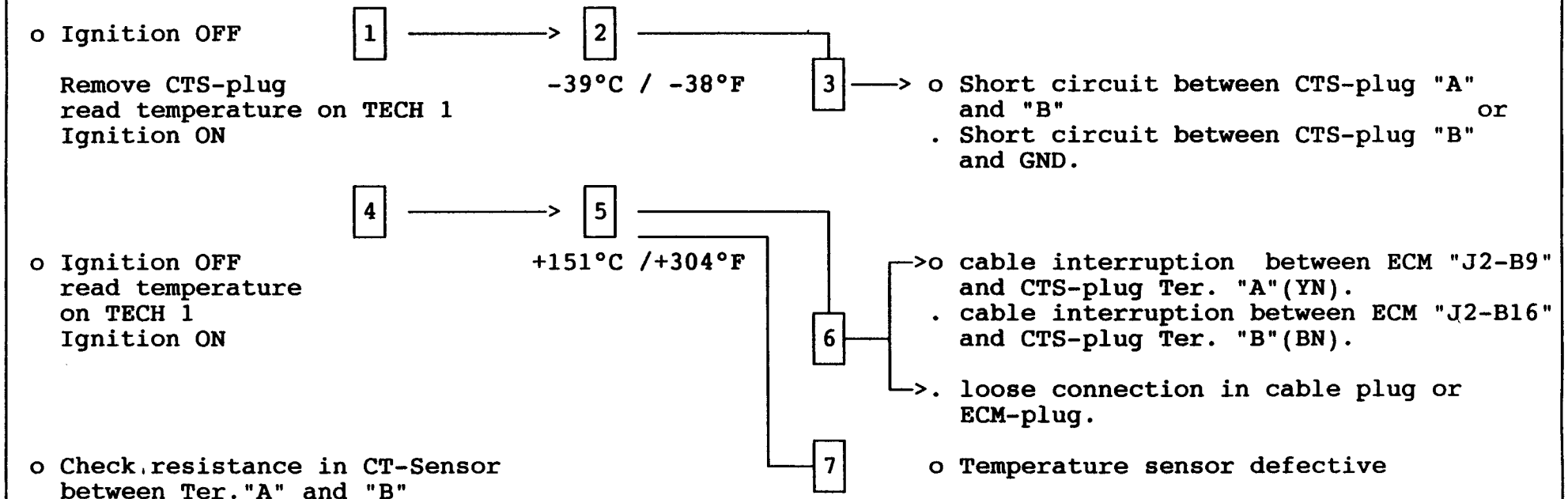
- Should the nominal values not be attained during a test according to the quick ckeck list, trouble-shooting with F0:DATA LIST must be carried out.

In doing this proceed (see example on the following page - test step 06):

- Commence in the column "Trouble-shooting" upper left. This is operating instruction [1]
- The control unit will recognise the manipulations corried out in [1] and the TECH 1 will display the nominal value [2] but only if the causes of the trouble listed in [3] are not present.
- If nominal value [2] is attained, carry out operating instruction [4].
- If nominal value [5] is also attained, the temperature sensor is defective in the example given below, otherwise check which of the causes of trouble listed under [6] applies.

F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 07 | COOLANT TEMP. | Engine at idle, operating temp. | > 85° (185°F) | 14, 15 |

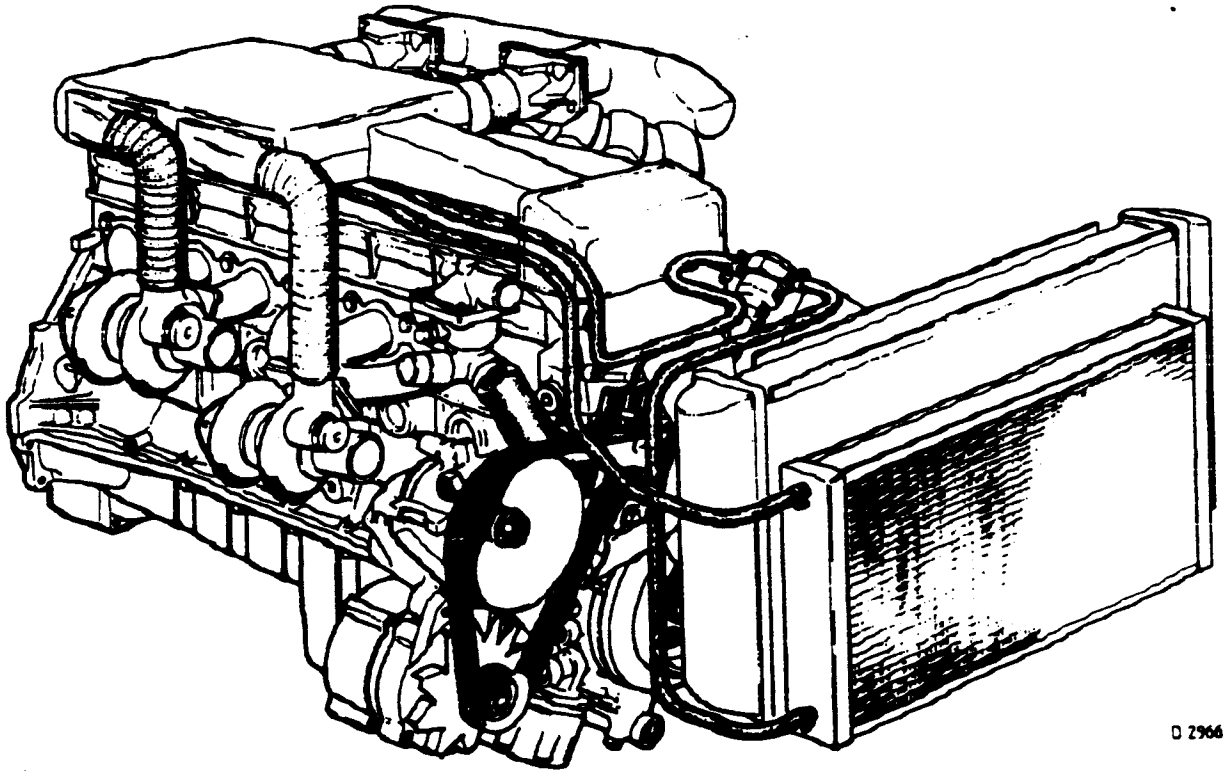



| Temperature °C/°F | Resistance kΩ |
|---|---|
| 100 / 212 | 0.185 |
| 70 / 158 | 0.45 |
| 38 / 100 | 1.80 |
| 20 / 68 | 3.40 |
| - 4 / 25 | 7.5 |
| - 7 / 19 | 25.0 |
| - 18 / 0 | 100.7 |

# CHECKING PROCEDURES

## LOTUS OMEGA/CARLTON

## CHECKING WITH TECH 1
## PROGRAM-MODUL LOTUS OMEGA/CARLTON 90 ECU




SERVICE
PRODUCT INFORMATION

## Table of contents

# 1 Introduction

This brochure describes in detail the checking of the LOTUS Omega/Carlton fuel injection system with TECH 1 and the newly developed Program Module "LOTUS Omega/Carlton ECU". These Checking Procedures can also be used to carry out non-electronic troulbe-shooting and to read off blink codes.

## 1.1 The OPEL/VAUXHALL Checking System

The "OPEL/VAUXHALL Checking System", a technical testing concept developed by Opel/Vauxhall, has pointed the way for the checking of electronic systems in vehicles.

At the heart of this system are the TECH 1and TECH 80. With the checking cables and the Electronic Kit I, all Opel vehicles, including those of the new generation, can be checked using the most modern electronic methods.

With the TECH 1 it is possible to read out streams of data from electronic control units. A precondition for this is the use of electronic systems with

- Microprocessor techniques
- Self-diagnosis
- Serial date lines

Before starting the diagnosis the program module appropriate to the model year of the vehicle is plugged in and TECH 1 connected to the idagnostic plug in the vehicle. The streams of data captured on TECH 1 are presented on a 4-line, 16-character display.

The current actual values displayed are compared with the nominal values from the data list. Where there are deviations from the relevant nominal values, a trouble-shooting program is available, so that the user can make a clear diagnosis. The TECH 1 checking concept means rapid and accurate trouble-shooting.

With a special mode called the snapshot mode, misfiring during a test drive caused by loose contacts can be localised - see also TECH 1 Operating Instructions.

## 1.2 General Instructions/Safety Precautions

Readout of date using TECH 1 takes place with IGNITIONS ON and/or with engine operating.

To erase trouble code:

With TECH 1: press key F4

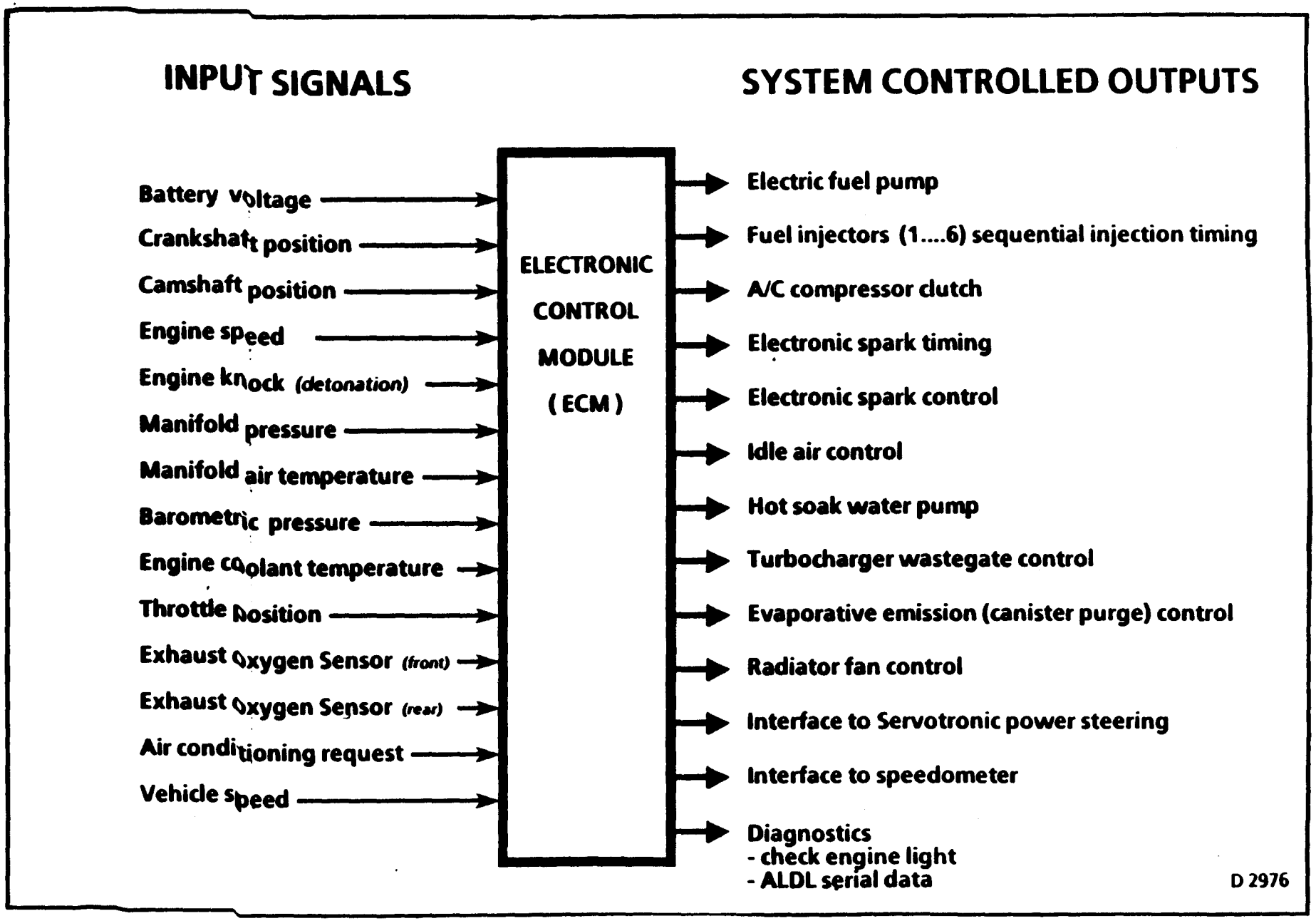
Without TECH 1: switch ignition OFF and disconnect ground from battery for at least 1 minute. This also deletes trouble codes, pattern recognition memories etc. of other electronic systems later installed.

Safety Precautions:

- During welding work control units must be removed.
- At temperatures above +80°C/+176°F (drying oven), control units must be removed.
- Never connect or disconnect wiring harness plugs of control units or trigger boxes with ignition switched on.
- Before charging or quick-charging, disconnect the battery from the vehicle electrical system.
- Never use the quick-charger for starting.
- Caution when touching voltage-bearing parts of the ignition system!

**Attention:** **After reconnecting the battery it may be necessary to reprogram the electronic window-system and the Anti-Theft-System in the Radio**

Block Diagram of Control Unit



## 3 MODE - Description (Checking with TECH 1)

The Mode description dealt with in this paragraph refers only to checking with TECH 1.
A complete description is to found in the TECH 1 Operator's Manual.

### 3.1 MODE F0: DATA LIST

The actual conditions of all sensors and signals important for proper functioning of the equipment can be called up via the F0 DATA LIST. The actual values shown must then be checked against the nominal values listed in the Checking Procedure.
In this way a clear fault diagnosis can be made.

### 3.2 MODE F1: NOT USED

### 3.3 MODE F2: TROUBLE CODE

The F2 mode gives a display of trouble code numbers that have been stored.

### 3.4 MODE F3: SNAPSHOT

The snapshot mode can identify sporadically occuring faults (loose connectors) in the course of a test drive.
Extensive description is in the TECH 1 Operators Manual.

## 3.5 MODE F4: CLEAR CODES

By operating key F4 the trouble codes stored in the ECM can be deleted.

## 3.6 MODE F5: ACTUATOR TEST

By pressing the key F5 the submodes F0 to F4 are available. In all F5-submodes below the engine should be "OFF" and ignition "ON".

### 3.6.1 SUBMODE F0: FAN RELAY

In submode F0 the FAN RELAY can be activated and checked with the help of TECH 1.

### 3.6.2 SUBMODE F1: A/C RELAY

In submode F1 the A/C RELAY can be activated and checked with the help of TECH 1.

### 3.6.3 SUBMODE F2: CCP VALVE

In submode F2 the CHARCOAL CANISTER PURGE SOLENOID can be activated and checked with the help of TECH 1.

### 3.6.4 SUBMODE F3: WASTE GATE

In submode F3 the WASTE GATE SOLENOID can be activated and checked with the help of TECH 1.

### 3.6.5 SUBMODE F4: IAC MOTOR

In submode F4 the IDLE AIR CONTROL VALVE can be activated and checked with help of TECH 1.

## 3.7 MODE F6: ECM CONTROL

By pressing the key F6 the submodes F0 and F1 are available. In both F6-submodes below the engine is "ON" at idle state.

### 3.7.1 SUBMODE F0: RPM CONTROL

In submode F0 the engine idle speed can be adjusted by using the DESIRED RPM option. The ECM will adjust the IAC until the engine speed is the same as the desired RPM.

### 3.7.2 SUBMODE F1: IAC CONTROL

In submode F1 the IDLE AIR CONTROL VALVE can be adjusted.
The ECM will adjust the commanded IAC steps to the desired value. The idle RPM will follow.

## 3.8 MODE F7: ECM RESET

By pressing the key F7 the submodes F0 and F1 are available. In both F7-submodes below the engine is "ON" at idle state.

### 3.8.1 SUBMODE F0: IAC MOTOR

In submode F0 the ECM will make an IDLE AIR CONTROLER VALVE reset, to find the correct position.

### 3.8.2 SUBMODE F1: O2 BLM CELLS

In submode F1 the O2 BLOCK LEARN MEMORY CELLS will be reset to 128.

# 4 Checking
## 4.1 Connecting TECH 1 to Vehicle

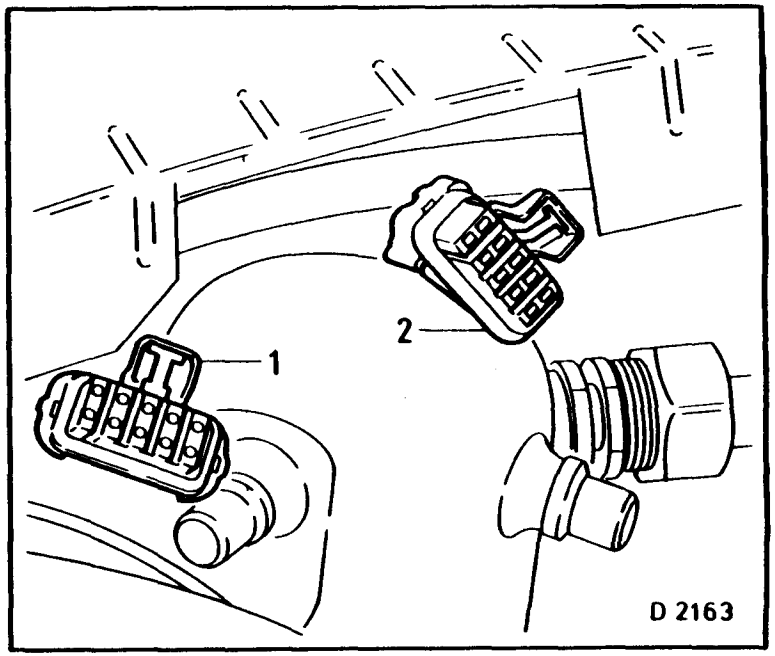
Before connecting the instrument one should observe the instructions contained in the TECH 1 Operating Instructions.

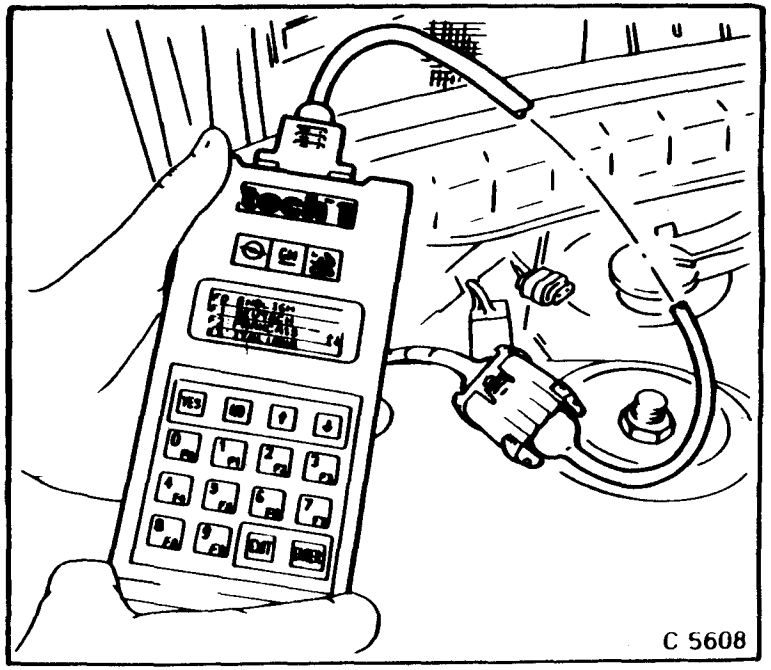
- o Igition OFF
- o Connect TECH 1 to the right ALDL-connector X 130.

Language menu appears in display.

- o Answer LOTUS OMEGA 90-91 ECM with "YES"
- o Answer DISPLAY CAPTURED DATA FROM LAST SNAPSHOT with "NO"
- o Type in Model Year - key 0 = Model Year 1990
  or key 1 = Model Year 1991

- o Answer SELECT BY YES with "YES"
- o Answer COMPARE PROM/MEMCAL ID CODE with "YES" if correct.
- o See chart 3. The ECM now sends data to TECH 1.
  Should there be one or more faults stored in the ECM these will be shown in the display.
- o Note trouble codes.
- o Select F0: DATA LIST with "YES" key.
- o Start engine, idling engine at normal operation temperature.
- o Compare all data shown in display from test step 01 to 39 with following nominal data - section 4.3 and 4.4
- o Actuate "EXIT" key and select F5: ACTUATOR TEST
  Carry out tests.
- o With deviations from the prescribed data, carry out trouble-shooting according to instructions - section 4.4



## 4.2 Trouble Shooting Chart

**Should these complaints takes place, the test steps marked with a X should be examined more closely.**

**Customer Complaint**

| Leaks/blockages (air or fuel) | Starter turns, engine starts poorly or not all | Engine starts but stalls again | Idling problems (engine speed, exaust) | Poor acceptance of fuel, transitional trouble | Engine misfiring (ignition, injection) | Fuel consumption too high | Engine diesels | Engine pings, knocks | Engine get too hot | WOT problem (no top speed) | Warning lamp permanently or occasionally on | Possible Causes | Test Step No. | Trouble Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | x | | x | | | | | | | | x | BATTERY VOLTAGE | 01 | |
| | x | x | | | | | | | | x | x | FUEL PUMP RELAY | 02 | 14, 15 |
| x | x | | x | | x | | x | | | | x | ENGINE SPEED | 03 | 33, 34 |
| x | | | x | | x | | x | | | | x | DESIRED IDLE | 04 | 21, 22 |
| x | x | x | x | x | x | | | | | x | x | TPS SIGNAL | 05 | ~~25~~ |
| x | x | x | x | x | x | | | | | x | x | IDLE AIR CONTROL | 06 | ~~35~~ |
| | x | x | x | | | | x | x | x | | x | COOLANT TEMP. | 07 | 13, 44, 45 |
| | | x | x | x | | | x | x | x | x | x | MAT SENSOR | 08 | 13, 44, 45 |
| x | x | x | x | x | x | x | | | x | x | x | MAP SENSOR | 09 | 13, 44, 45 |
| | x | x | | x | x | x | | x | x | x | | BAROMETER SENSOR | 10 | 13, 44, 45 |
| | x | x | x | | | | x | x | x | x | x | SPARK ADVANCE | 11 | 13, 44, 45 |
| | | | | | | | | x | x | x | x | KNOCK SIGNAL | 12 | 24 |
| | | | | | | | | x | x | x | x | KNOCK RETARD | 13 | 24 |
| x | x | x | x | | | x | | | | x | x | FRONT INJ. PULSE, REAR INJ. PULSE | 14, 15 | 24 |
| | | | | | | x | | x | x | x | x | WASTE GATE FUNCT, WATE GATE D.C.,WASTE GATE BLM | 16, 17, 18 | |

## 4.2 Trouble Shooting Chart

Should these complaints takes place, the test steps marked with a X should be examined more closely.

Customer Complaint

| Leaks/blockages (air or fuel) | Starter turns, engine starts poorly or not all | Engine starts but stalls again | Idling problems (engine speed, exaust) | Poor acceptance of fuel, transitional trouble | Engine misfiring (ignition, injection) | Fuel consumption too high | Engine diesels | Engine pings, knocks | Engine get too hot | WOT problem (no top speed) | Warning lamp permanently or occasionally on | Possible Causes | Test Step No. | Trouble Codes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| x | | | x | x | | x | | | | | x | FRONT O2 SENSOR, REAR O2 SENSOR, O2 SENSOR LOOP | 19, 20, 22, | |
| | | | | | | | | | | | | FRONT O2 SENSOR, FRONT O2 INT., REAR O2 SENSOR | 23, 24, 25, | |
| | | | | | | | | | | | | REAR O2 INT., O2 BLM ENABLE, O2 BLM CELL NO. | 26, 27, 28, | |
| | | | | | | | | | | | | FONT O2 BLM, REAR O2 BLM | 29, 30 | |
| x | x | x | x | x | | x | | | | | | MAP SENSOR | 31 | 14, 15 |
| | | | | | | x | x | x | | | | FAN STATUS | 32 | 33, 34 |
| | | x | x | | | | | | | | | A/C REQUEST SW., A/C CLUTCH | 33, 34 | 21, 22 |
| | x | x | x | | | | | x | | | | AUX. WATER PUMP | 35 | 35 |
| | | | x | | | | | | x | x | | VEHICLE SPEED | 36 | 35 |
| | x | x | x | | | x | x | | x | | | IGNITION STATUS | 37 | 13, 44, 45 |
| | | x | x | x | x | x | x | x | x | x | | CAMSHAFT SIGNAL | 38 | 13, 44, 45 |

## 4.3 Quick Check F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 01 | BATTERY VOLTAGE | Ignition ON<br>Start engine<br>Engine at idle speed | 11.5 to 13.5V<br>>8V<br>13.0 to 15.9V | 53 |
| 02 | FUEL PUMP RELAY | Ignition OFF<br>Ignition ON<br>After 3 seconds<br>Start engine, Engine at idle speed | 0 to 0.2V<br>11.5 to 13.5V<br>0 to 0.2V<br>13.0 to 15.9V | |
| 03 | ENGINE SPEED | Engine at idle, operating temp.<br>AC-switch OFF. | 700 to 800 RPM | |
| 04 | DESIRED IDLE | Desired Idle*<br>Note: Select TECH 1<br>- Mode F6: ECM CONTROL and<br>Submode F0: RPM CONTROL. | 750 RPM | |
| 05 | TPS SIGNAL | Accelerator in idle position<br>Accelerator in WOT position | 0.12 to 0.28<br>4.8 to 5.0V | 21, 22 |
| 06 | IDLE AIR CONTROL | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 3 to 12 STEPS | |
| 07 | COOLANT TEMP. | Engine at idle, operating temp. | > 85° (185°F) | 14, 15 |
| 08 | MAT SENSOR | Engine OFF, engine cold<br>Manifold air between 10°.. 30°C<br>50°.. 86°F<br>Start engine, after 5 seconds<br>Engine OFF | CTS - MAT | 14, 15,<br>23, 25 |

* 750 RPM is only the desired idle value for engines at operating temperature, that means > 85°C(185°F)

4.3 Quick Check F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 09 | MAP SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar, 2.1-2.65 V<br>0.25-0.4 bar, 0.62- 1 V | 33, 34 |
| 10 | BAROMETER SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar, 4.16-5.0 V<br>0.9-1.1 bar, 4.16-5.0 V | |
| 11 | SPARK ADVANCE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 10 °CA BTDC | |
| 12 | KNOCK SIGNAL E | Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block* | NOT RECEIVED<br>RECEIVED | 16, 66 |
| 13 | KNOCK RETARD | Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block* | 0 °CA BTDC<br>01 to 03 °CA BTDC | 16, 66 |
| 14 | FRONT INJ. PULSE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 2.3 to 3.0 ms | |
| 15 | REAR INJ. PULSE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 2.3 to 3.0 ms | |
| 16 | WASTE GATE FUNCT | Engine at idle, operating temp. | ENABLED | 16, 66 |

* Near Knock Sensor . Use a one pound (400..600 g) hammer. If no reaction : drive car on road.

## 4.3 Quick Check F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 17 | WASTE GATE D.C. | Engine at idle, operating temp. | 100 % or 0 %<br>but not between !! | 16, 66 |
| 18 | WASTE GATE BLM | Engine at idle, operating temp. | -5 % .. +5 % | 16, 66 |
| 19 | FRONT O2 SENSOR | Engine at idle, operating temp.<br>AC-switch OFF. | READY | 13, 44, 45 |
| 20 | REAR O2 SENSOR | Engine at idle, operating temp.<br>AC-switch OFF. | READY | 63, 64, 65 |
| 21 | TIME FROM START | Ignition ON<br>Start engine<br>Engine at idle speed | 00:00:00<br>> 00:00:00 | |
| 22 | O2 SENSOR LOOP | Ignition ON<br>Start engine<br>Engine at idle speed | OPEN<br>CLOSED | |
| 23 | FRONT O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 440 to 460 mV<br>50 to 950 mV | 13, 44, 45 |
| 24 | FRONT O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br>123 to 133 STEPS | 13, 44, 45 |

4.3 Quick Check F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 25 | REAR O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 440 to 460 mV ✓<br><br>50 to 950 mV ✓ | 63, 64, 65 |
| 26 | REAR O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS ✓<br><br>123 to 133 STEPS ✓ | 63, 64, 65 |
| 27<br>27A | O2 BLM ENABLE<br>ETS - | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | <br><br>ACTIVE ✓ | 13, 44, 45,<br>63, 64, 65 |
| 28 | O2 BLM CELL NO. | Ignition ON, Start engine<br>Engine at idle speed<br>Engine speed > 2000 RPM and<br>MAP-Sensor > 0.65 bar | 0 ✓<br><br>> 0 ✓ (10) cell 10 | BLIP THROTTLE, quick. |
| 29 | FRONT O2 BLM | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS ✓<br><br>110 to 145 STEPS | 63, 64, 65 |
| 30<br>30A | O2 BLM CELL NO<br>REAR O2 BLM<br>MAP (LOAD) | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>110 to 145 STEPS ✓ | 63, 64, 65 |
| 31 | CANISTER PURGE | Ignition ON<br>Start engine<br>Engine at idle speed<br>Engine speed out of idle, TPS >4% | <br><br>0%<br>>1% ? | |
| 32<br>37 A | FAN STATUS<br>ETS | Ignition ON<br>Start engine, Engine at idle speed<br>Coolant temperature > 97°C, 207°F | OFF 12V ✓<br><br>ON 0V | |

## 4.3 Quick Check F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 33 | A/C REQUEST | Engine at idle speed<br>AC-switch OFF<br>AC-switch ON | OFF 12V 0V<br>ON 0V 12V | |
| 34 | A/C CLUTCH Cut off Relay | Engine at idle speed<br>AC-switch OFF<br>AC-switch ON , after 1 second | Disengaged<br>OFF 12V<br>ON 0V<br>Engaged | |
| 35 | AUX. WATER PUMP | Ignition ON<br>Start engine,Engine at idle speed<br>Coolant temperature > 93°C, 200°F<br>Engine OFF, ignition OFF | OFF 12V<br>ON 0V | |
| 36 | VEHICLE SPEED<br>Engine Speed | Compare speedometer reading with TECH 1 value | Aprox. same speed<br>RPm. | 24 |
| 37 | IGNITION STATUS<br>Engine Speed | Ignition ON<br>Start engine<br>Engine at idle speed | BYPASS<br>EST | |
| 38 | CAMSHAFT SIGNAL<br>Engine Speed | Ignition ON<br>Start engine<br>Engine at idle speed | VALID | |
| 39 | CONTROLLED IAC | Desired IAC step value<br>Note: Select TECH 1<br>EXIT MODE F6: ECM CONTROL and<br>SUBMODE F1: IAC CONTROL. | -26 STEPS<br>max 96 Normal 8 | |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 01 | BATTERY VOLTAGE | Ignition ON<br>Start engine<br>Engine at idle speed | 11,5 to 13,5V<br>>8V<br>13,0 to 15,9V | 53 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| Measure battery voltage using Multimeter | | |
| o Engine OFF | > 11.5 V | o Battery flat |
| o Start engine | > 8.0 V | o Battery flat |
| o Engine running | >13.0 V | o Check alternator or regulator |
| o Voltage acc. to TECH 1 | 13 to 17.1 V | o If alternator and regulator OK, ECM defective. |

If ECM detects a battery voltage greater than 17.1 V without setting a CODE 53 change ECM.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 02 | FUEL PUMP RELAY | Ignition OFF<br>Ignition ON<br>After 3 seconds<br>Start engine,Engine at idle speed | 0 to 0,2V<br>11,5 to 13,5V<br>0 to 0,2V<br>13,0 to 15,9V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Measure relay voltage between relay terminal-color "P" and ground. Using Multimeter.(20V/DC) | > 11 V | o Fuse "FUEL PUMP RELAY","MAXIFUSE" blown<br>. CKT open between Fuse "FUEL PUMP RELAY" and "MAXIFUSE" or<br>. CKT open between Fuse-"FLA" "FUEL PUMP RELAY" and relay Ter. (color "P"). |
| o Disconnect fuel pump relay. Short fuel pump relay Ter.(color "P" and "OW") | > 11 V<br>Fuse OK | o Short to ground in CKT from FUEL PUMP RELAY Ter.(color "OW") to FUEL PUMP Ter.(color "OW") or FUEL PUMP defective. |
| o Measure resistance between relay Ter. (color "N") and ground. Using Multimeter (200 Ω). Ignition OFF | < 1 Ω | o CKT open. |
| o Measure voltage on ECM "J1-A19" to ground. Using Multimeter.(20V/DC) Ignition OFF, Ignition ON | > 11 V<br>3 seconds later<br>< 1 V | o ECM defective or grounded CKT between Fuel pump relay "OP" and ECM "J1-A19" |

## 4.4 F0: DATA LIST

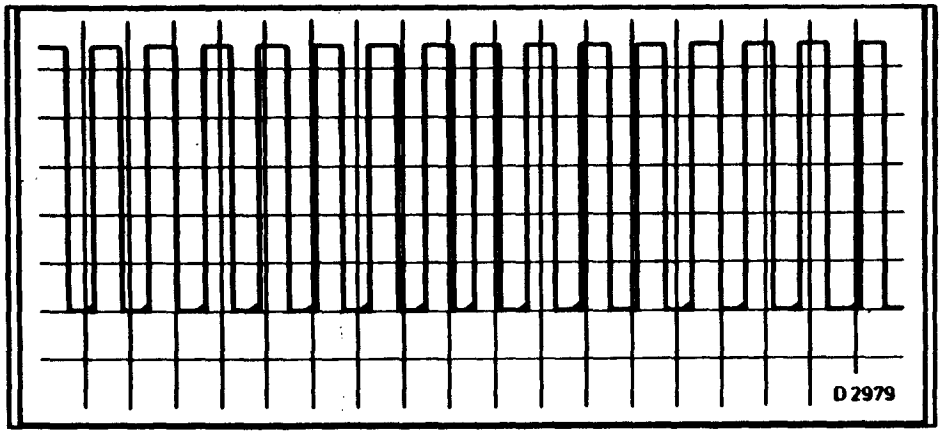
| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 02<br><br>Part - 2 | FUEL PUMP RELAY | Ignition OFF<br>Ignition ON<br>After 3 seconds<br>Start engine,Engine at idle speed | 0 to 0,2V<br>11,5 to 13,5V<br>0 to 0,2V<br>13,0 to 15,9V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Measure relay voltage between relay terminal-color "OP" and ground. Using Multimeter.(20V/DC) Reconnect fuel pump relay. Ignition OFF, Ignition ON | > 11 V, relay ON<br>3 seconds later<br>< 1 V , relay OFF | o Open CKT between Fuel pump relay "OP" and ECM "J1-A19" or<br>. Fuel pump relay defective. |
| o Measure relay voltage between relay terminal-color "OW" and ground. Using Multimeter.(20V/DC) Ignition OFF, Ignition ON | > 11 V, relay ON<br>Fuel pump ON<br>3 seconds later<br>< 1 V , relay OFF<br>Fuel pump OFF | o Open circuit between relay and fuel pump or<br>. Fuel pump defective. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 03 | ENGINE SPEED | Engine at idle, operating temp. AC-switch OFF. | 700 to 800 RPM | |

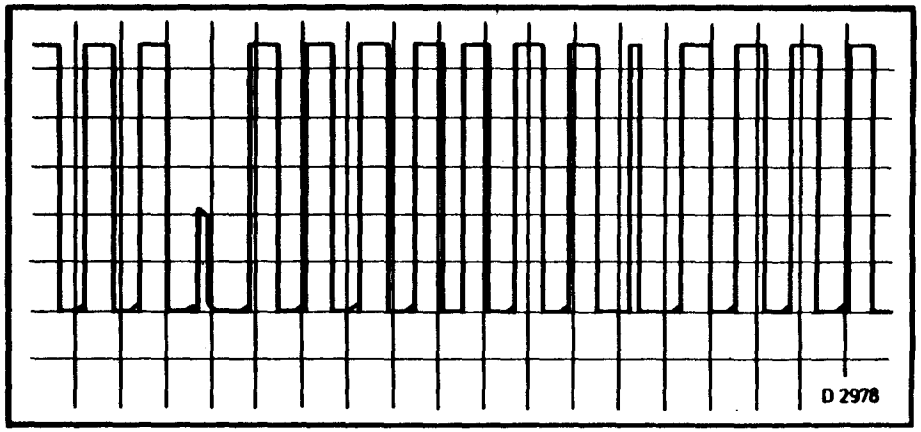
| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Engine starts | OK | o See Table 4 |
| o Engine running at idle | 700 to 800 RPM | o Compare wave form |




Multimeter Voltage (20V/AC) ~ 2.4 - 2.6 V

o Engine running at idle or use Multimeter

wave form OK
See voltage above




Signal not OK

o Short or open CKT between "J4-D13" and DIS-Module "F" or "J4-D18" and DIS-Module "E"

or

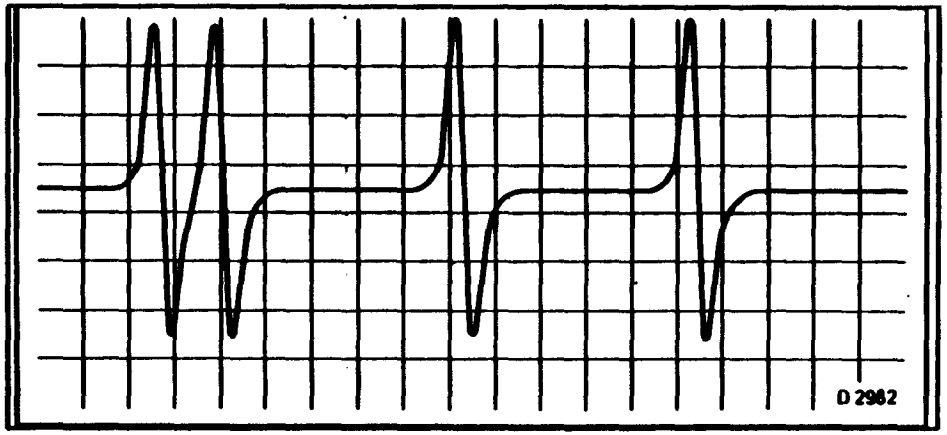
or o See next page

## 4.4 FO: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 03 Part - 2 | ENGINE SPEED | Engine at idle, operating temp. AC-switch OFF. | 700 to 800 RPM | |

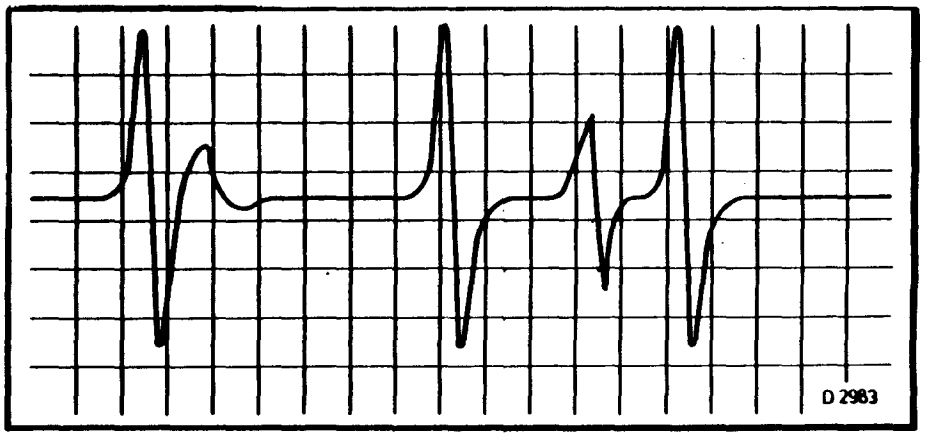
**Trouble-shooting:** **Nominal Value:** **Cause of Fault:** (If nominal values NOT attained)

o Engine running at idle — 700 to 800 RPM — o See wave form: DIS-Module, crank signal input between terminal "A" und "C"




Multimeter Voltage (20V/AC) ~ 1.8 - 2.2 V

o Engine running at idle or use Multimeter — wave form OK See voltage above




Signal not OK

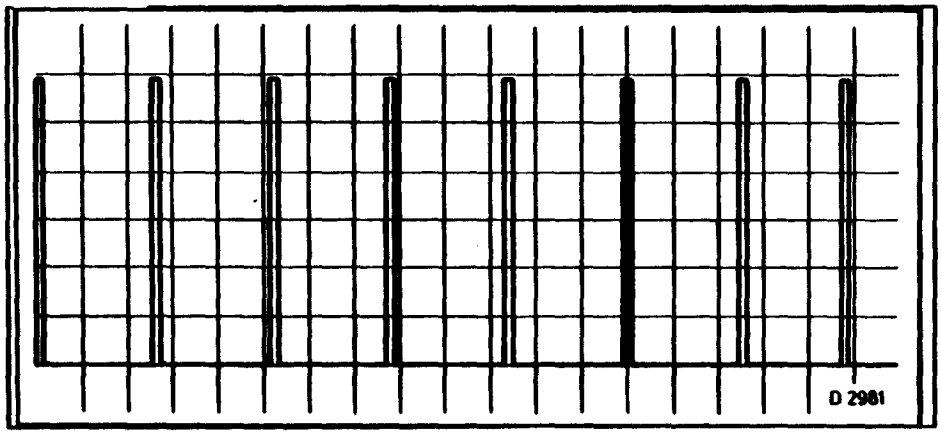
o Short or open CKT between Crank sensor and DIS-Module "A" or Crank sensor and DIS-Module "C".

o Crank sensor defective.
o Segment disc/teeth corrodet.
o Metal shavings on pulse pick-up.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 03<br>Part - 3 | ENGINE SPEED | Engine at idle, operating temp.<br>AC-switch OFF. | 700 to 800 RPM | |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Engine running at idle | CAM signal OK<br>No Code 31 | o See wave form: CAM-signal on Ter. "J4-D3" |
| | | o CAM-sensor has no connection to +12 V<br>. CAM-sensor has no connection to ground<br>o Open or short CKT between CAM-sensor Ter. "B" and "J4-D3", color "NW" |
| o Engine running at idle | 700 to 800 RPM | o See test step 5, 6, 7, 8, 9, 10, 13, 32, 33 ,34 and 36 |
| o Engine running at idle | all above named test steps OK | o Repair system. |
| o Check spark plugs | spark plugs OK | o Change defective spark plug. |




Multimeter Voltage (20V/AC) ~ 1.35 - 1.55 V

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 04 | DESIRED IDLE | Desired Idle<br>Note: Select TECH 1<br>Mode F6: ECM CONTROL and<br>Submode F0: RPM CONTROL. | 750 RPM | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o The test step DESIRED IDLE is only in TECH 1 Mode F6:ECM CONTROL part F0:RPM CONTROL available. This test step can be used to examine the conduct of the engine, when the engine speed is greater or less than idle. | | |
| . In this test step, the ECM instructs the IAC stepper motor to increase or decrease the step value until the desired engine speed is reached. | | |
| o Select Mode F6:ECM CONTROL<br>Submode F0:RPM CONTROL | TECH 1 display:<br>yyy RPM*<br>engine speed yyy RPM* | o ECM defective<br>. see test step 06 |
| o Press arrow key 'up' | speed increases up to 1600 RPM | o ECM defective<br>see test step 06 |
| Press arrow key 'down' | speed decreases down to 600 RPM | |

Note: The TECH 1 SNAPSHOT Mode is enabled.

* If the Submode F0:RPM CONTROL is enabled by using the "YES" key, the displaed idle speed will be equal to the actual idle speed.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 05 | TPS SIGNAL | Accelerator in idle position<br>Accelerator in WOT position | 0.12 to 0.28V<br>4.8 to 5.0V | 21, 22 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove MAP-sensor plug<br>Remove Baro-sensor plug<br>Ignition ON<br>Accelerator in idle position --><br>Accelerator in WOT position --> | <br><br><br><br>0.12 to 0.28V<br>4.8 to 5.0V | o See next page |
| o Ignition OFF<br>Connect MAP-sensor plug<br>Ignition ON<br>Accelerator in idle position --><br>Accelerator in WOT position --> | <br><br><br>0.12 to 0.28V<br>4.8 to 5.0V | o MAP-sensor defective or short or open in CKT to MAP-sensor to ECM<br>. See test step 9 |
| o Ignition OFF<br>Connect Baro-sensor plug<br>Ignition ON<br>Accelerator in idle position --><br>Accelerator in WOT position --> | <br><br><br>0.12 to 0.28V<br>4.8 to 5.0V | o Baro-sensor defective or short or open in CKT to Baro-sensor to ECM<br>. See test step 10 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 05<br>Part - 2 | TPS SIGNAL | Accelerator in idle position<br>Accelerator in WOT position | 0.12 to 0.28V<br>4.8 to 5.0V | 21, 22 |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove TP-Sensor<br>Ignition ON | 0 V | o Short circuit between cable TPS-plug ter."2"(UK) and TPS-plug ter."3"(S).<br>. ECM defective |
| o Ignition OFF<br>Jumper wire between TPS-plug ter."2"(UK) and TPS-plug ter."3"(S). | 5 V | o Short circuit between cable TPS-plug ter."2"(UK) and TPS-plug ter."1"(BN).<br>. cable interruption "J2-B5" to TPS-plug ter."3"(S).<br>. cable interruption "J2-B3" to TPS-plug ter."2"(UK).<br>. ECM defective. |
| o Check connection between TPS-plug ter."1"(BN) and ECM "J2-B16" | Continuity | o cable interruption |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 05<br>Part - 3 | TPS SIGNAL | Accelerator in idle position<br>Accelerator in WOT position | 0.12 to 0.28V<br>4.8 to 5.0V | 21, 22 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Measure resistance between<br>Ter. "1" and "3" | 5 to 6 kΩ | o Throttle valve potentiometer defective |
| o Measure resistance between<br>Ter. "1" and "2"<br>Thottle closed | 500 to 550 Ω | o Throttle valve potentiometer defective |
| o Measure resistance between<br>Ter. "1" and "2"<br>Thottle open | 5.5 to 6.0 kΩ | o Throttle valve potentiometer defective |
| o Check TPS-plug for corrosion | OK | o Repaire or replace plug. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 06 | IDLE AIR CONTROL | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 3 .. 12 STEPS | |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Disconnect IAC-plug<br>Select TECH 1 mode:<br>F5: ACTUATOR TEST<br>Select Submode:<br>F4: IAC MOTOR<br>Measure voltage between<br>Ter."A" and "C"(female) and<br>Ter."B" and "D"(female)<br>(Multimeter 20V/AC)<br>== | A/C : ~ 6,6 V<br>B/D : ~ 6.6 V | o Interruption between IAC-valve and ECM<br>IAC: Ter. "A" --> ECM :J1-A4<br>IAC: Ter. "B" --> ECM :J1-A9<br>IAC: Ter. "C" --> ECM :J1-A5<br>IAC: Ter. "D" --> ECM :J1-A10<br>. or short to ground. |
| o Ignition OFF<br>Remove IAC stepper motor<br>Reconnect IAC-plug.<br>Ignition ON<br>Select TECH 1 mode:<br>F5: ACTUATOR TEST<br>Select Submode:<br>F4: IAC MOTOR | Pintle moves out an in. | o IAC stepper motor defective. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 06<br><br>Part - 2 | IDLE AIR CONTROL | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 3 .. 12 STEPS | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Disconnect IAC-plug<br>Check coil resistance between<br>Ter. "A" and "B" and<br>Ter. "C" and "D" | 20 to 100 Ω | o IAC stepper motor defective. |
| o Check isolation between<br>Ter. A,B,C and D against<br>IAC-body. | ∞ Ω | |
| o Select TECH 1 Mode:<br>F6: ECM CONTROL<br>Select TECH 1 Submode:<br>F1: IAC CONTROL<br>Push arrow "UP" to<br>increase engine idle<br>speed to 1500 RPM ---><br>Push arrow "DOWN" to<br>decrease engine idle<br>speed to 800 RPM ---> | engine Speed 1500 RPM<br><br>engine Speed 800 RPM | o leakage in manifold system.<br>. Code 21 or 22 detected.<br>. Thottle valve bypass screw out of adjustment.<br>(change basic setting only in emergency. See next page)<br><br>o Further reasons see next page. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 06<br><br>Part - 3 | IDLE AIR CONTROL | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 3 .. 12 STEPS | |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Further reasons : | | o Seat of IAC stepper motor is dirty<br>o Odometer frequency sensor or circuit is defective.<br>o Throttle valve not closing<br>o TP - Sensor is defective.<br>o Ignition cable, spark plugs defective<br>o Mixture to rich/lean<br>o Batt. voltage to high/low |
| NEW BASIC SETTING of the Throttle valve bypass screws:<br>Test followed test steps first<br>Engine at idle speed all consumers swiched off | all test steps OK | o repaire system |
| o BATTERY VOLTAGE o MAP SENSOR<br>TPS SIGNAL BAROMETER SENSOR<br>COOLANT TEMP. ENGINE SPEED<br>MAT SENSOR KNOCK RETARD<br>FRONT O2 INT. REAR O2 INT.<br>FRONT O2 BLM REAR O2 BLM<br>CANISTER PURGE FAN STATUS<br>A/C REQUEST SW. A/C CLUTCH<br>IGNITION STATUS VEHICLE SPEED | if OK then ---> | o TPS between 0.12 and 0.28 V<br>. Close front bypass screw. IAC step rate<br>. increases.<br>. Close rear bypass screw. IAC step rate increases again.<br>. Open both bypass screws synchron until IAC step rate decreases to 10 steps.<br>. In this case the MAP SENSOR value will be between 0.29 and 0.4 bar |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 07 | COOLANT TEMP. | Engine at idle, operating temp. | > 85° (185°F) | 14, 15 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove CTS-plug.<br>read temperature on TECH 1<br>Ignition ON | -39°C / -38°F | o Short circuit between CTS-plug "A" and "B" or<br>. Short circuit between CTS-plug "B" and GND. |
| o Ignition OFF (Jumper CTS-plug)<br>read temperature<br>on TECH 1<br>Ignition ON | +151°C /+304°F | o cable interruption between ECM "J2-B9" and CTS-plug Ter. "A"(YN).<br>. cable interruption between ECM "J2-B16" and CTS-plug Ter. "B"(BN).<br>. loose connection in cable plug or ECM-plug. |
| o Check resistance in CT-Sensor between Ter."A" and "B" | | o Temperature sensor defective |

| Temperature °C/°F | Resistance kΩ |
|---|---|
| 100 / 212 | 0.185 |
| 70 / 158 | 0.45 |
| 38 / 100 | 1.80 |
| 20 / 68 | 3.40 |
| - 4 / 25 | 7.5 |
| - 7 / 19 | 25.0 |
| - 18 / 0 | 100.7 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 08 | MAT SENSOR | Engine OFF, engine could<br>Manifold air between 10°.. 30°C<br>50°.. 86°F<br>Start engine, after 5 seconds<br>Engine OFF | CTS ~ MAT | 14, 15,<br>23, 25 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove MAT plug.<br>read temperature on TECH 1<br>Ignition ON | -39°C / -38°F | o Short circuit between MAT-plug "A" and "B" or<br>. Short circuit between MAT-plug "B" and GND. |
| o Ignition OFF<br>Jumper MAT plug<br>read temperature<br>on TECH 1<br>Ignition ON | +151°C /+304°F | o cable interruption between ECM "J2-B21" and MAT-plug Ter. "A"(NK).<br>. cable interruption between ECM "J2-B22" and MAT-plug Ter. "B"(BO).<br>. loose connection in cable plug or ECM-plug. |
| o Check resistance in MAT-Sensor between Ter. "A" and "B" | | o MAT-Sensor defective |

| Temperature °C/°F | Resistance kΩ |
|---|---|
| 100 / 212 | 0.185 |
| 70 / 158 | 0.45 |
| 38 / 100 | 1.80 |
| 20 / 68 | 3.40 |
| - 4 / 25 | 7.5 |
| - 7 / 19 | 25.0 |
| - 18 / 0 | 100.7 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 09 | MAP SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,2.1-2.65 V<br><br>0.25-0.4 bar,0.62- 1 V | 33, 34 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove TP-Sensor plug<br>Remove MAT-sensor plug<br>Ignition ON<br>Start engine<br>Engine at idle speed | <br><br><br>0.9-1.1 bar, 2.1-2.65 V<br><br>0.25-0.4 bar, 0.62-1.0 V | o See next page |
| o Ignition OFF<br>Connect MAT-sensor plug<br>Ignition ON<br>Start engine<br>Engine at idle speed | <br><br>0.9-1.1 bar, 2.1-2.65 V<br><br>0.25-0.4 bar, 0.62-1.0 V | o MAT-sensor defect or short or open in CKT to MAT-sensor to ECM<br>. See test step 08 |
| o Ignition OFF<br>Connect TP-Sensor plug<br>Ignition ON<br>Start engine<br>Engine at idle speed | <br><br>0.9-1.1 bar, 2.1-2.65 V<br><br>0.25-0.4 bar, 0.62-1.0 V | o TP-Sensor defect or short or open in CKT to TP-Sensor to ECM<br>. See test step 05 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 09<br><br>Part - 2 | MAP SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,2.1-2.65 V<br><br>0.25-0.4 bar,0.62- 1 V | 33, 34 |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove MAP-sensor<br>Ignition ON | 0 V | o Short circuit between cable MAP-plug ter."B"(GLG) and MAP-plug ter."C"(S).<br>. ECM defective. |
| o Ignition OFF<br>Jumper wire between MAP-plug ter."B"(GLG) and MAP-plug ter."C"(S). | 5 V | o Short circuit between cable MAP-plug ter."B"(GLG) and MAP-plug ter."A"(BO).<br>. cable interruption "J2-B4" to MAP-plug ter."B"(GLG).<br>. cable interruption "J2-B5" to MAP-plug ter."C"(S).<br>. ECM defective. |
| o Check connection between MAP-plug ter."A"(BO). and ECM "J2-B22" | Continuity,< 1 Ω | o cable interruption |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 09<br><br>Part - 3 | MAP SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,2.1-2.65 V<br><br>0.25-0.4 bar,0.62- 1 V | 33, 34 |

**Trouble-shooting:**

Reconnect MAP-Sensor.

- Connect vacuum pump KM-J-23994-8 to MAP-Sensor. Set vacuum pressure at nominal value and after each change in pressure, switch ignition OFF and ON again.

**Nominal Value:**

| Vacuum-value on vacuum tester | Volt-value on TECH 1 |
|---|---|
| 0 kPa, 0 bar (0 lbf/in²) | 2.3 .. 2.6 Volt |
| 20 kPa, 0.2 bar (2.9 lbf/in²) | 1.7 .. 1.9 Volt |
| 60 kPa, 0.6 bar (8.7 lbf/in²) | 0.6 .. 0.9 Volt |
| 80 kPa, 0.8 bar (11.6 lbf/in²) | 0.1 .. 0.4 Volt |

**Cause of Fault:**
(If nominal values NOT attained)

- MAP-Sensor defective.
- Vacuum pressure hose to sensor is leaking or blocked.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 10 | BAROMETER SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,4.16-5.0 V<br><br>0.9-1.1 bar,4.16-5.0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove TP-Sensor plug<br>Remove CT-Sensor plug<br>Ignition ON | 0.9-1.1 bar,4.16-5.0 V | o See next page |
| o Ignition OFF<br>Connect CT-sensor plug<br>Ignition ON | 0.9-1.1 bar,4.16-5.0 V | o MAT-sensor defect or short or open in CKT to MAT-sensor to ECM<br>. See test step 08 |
| o Ignition OFF<br>Connect TP-Sensor plug<br>Ignition ON | 0.9-1.1 bar,4.16-5.0 V | o TPS-sensor defect or short or open in CKT to TPS-sensor to ECM<br>. See test step 05 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 10<br><br>Part - 2 | BAROMETER SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,4.16-5.0 V<br><br>0.9-1.1 bar,4.16-5.0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Ignition OFF<br>Remove Baro-sensor<br>Ignition ON | 0 V | o Short circuit between cable BPS-plug ter."B"(LGY) and BPS-plug ter."C"(S).<br>. ECM defect |
| o Ignition OFF<br>Jumper wire between BPS-plug ter."B"(LGY) and BPS-plug ter."C"(S). | 5 V | o Short circuit between cable BPS-plug ter."B"(LGY) and BPS-plug ter."A"(BN).<br>. cable interruption "J2-B12" to BPS-plug ter."B"(LGY).<br>. cable interruption "J2-B5" to BPS-plug ter."C"(S).<br>. ECM defective |
| o check connection between BPS-plug ter."A"(BN). and ECM "J2-B16" | Continuity,< 1 Ω | o cable interruption |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 10<br><br>Part - 3 | BAROMETER SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 0.9-1.1 bar,4.16-5.0 V<br><br>0.9-1.1 bar,4.16-5.0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| Reconnect Baro-sensor.<br>o Connect vacuum pump KM-J-23994-8 to Baro-sensor. Set vacuum pressure at nominal value and after each change in pressure, switch ignition OFF and ON again. | | o Baro-sensor defective. |

| Vacuum-value on vacuum tester | Volt-value on TECH 1 |
|---|---|
| 0 kPa, 0 bar (0 lbf/in²) | 4.7 .. 5.1 Volt |
| 20 kPa, 0.2 bar (2.9 lbf/in²) | 3.5 .. 3.9 Volt |
| 60 kPa, 0.6 bar (8.7 lbf/in²) | 1.3 .. 1.7 Volt |
| 80 kPa, 0.8 bar (11.6 lbf/in²) | 0.3 .. 0.7 Volt |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 11 | SPARK ADVANCE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 10°CA BTDC on TECH 1<br>9 .. 11 °CA BTDC<br>on TECH 80 | |

**NOTE:**
o 10 °CA BTDC for LOTUS Omega/Carlton is the value programmed in the ECM. This does not mean that this park advance is actually present. Check with TECH-80 whether the programmed and actual values agree.

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 03 | OK | o Repair sensor or CKT. |
| o Compare °CA BTDC | TECH-80 ~ TECH 1 | o Replace PROM |
| o Compare °CA BTDC | TECH-80 ~ TECH 1 | o Replace ECM |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 12 | KNOCK SIGNAL | Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block* | NOT RECEIVED<br><br>RECEIVED | 16, 66 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Check connection between Knock sensor plug (U) and ECM "J2-B20" | Continuity,< 1 Ω | o cable interruption |
| . Check connection between Knock sensor screw and engine block. | Continuity,< 1 Ω | o clean block cavity and knock sensor. |
| o Reconnect knock sensor Ignition ON, Disconnect knock senor plug. Measure voltage on ECM "J2-B20" to GND | 4.5 .. 5.2 V (rang 20V/DC) | o replace ECM. |
| o Reconnect knock sensor plug Measure voltage on ECM "J2-B20" to ground. | 2.1 .. 2.9 V (rang 20V/DC) | o replace Sensor |
| o Ignition OFF<br>Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block | <br>NOT RECEIVED<br><br><br>RECEIVED | o replace ECM. |
| o Ignition ON | NOT RECEIVED | o replace new spark-plugs.<br>. remove combustion chamber deposits. |

* Near Knock Sensor . Use a one pound (400..600 g) hammer.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 13 | KNOCK RETARD | Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block* | <br><br>0 °CA BTDC<br>1 to 3 °CA BTDC | 16, 66 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 12 | OK | o Repair sensor or CKT. |
| o Ignition OFF<br>Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block | <br><br>0 °CA BTDC<br>1 to 3 °CA BTDC | o replace Sensor |
| o Ignition OFF<br>Ignition ON<br>Start engine<br>Engine at idle speed<br>Knock with hammer on engine block | <br><br>0 °CA BTDC<br>1 to 3 °CA BTDC | o replace ECM |
| o Ignition ON<br>Start engine<br>Engine at idle speed | <br><br>0 °CA BTDC | o replace new spark-plugs.<br>remove combustion chamber deposits. |

* Select TECH 1 Mode F6: ECM CONTROL. Use Submode F0:RPM CONTROL and set idle speed to 1600 RPM. Knock near Sensor . Use a one pound (400..600 g) hammer. If no reaction: drive car on road.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 14 | FRONT INJ. PULSE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 2.3 to 3.0 ms | |

This test step serves as a learning and checking value to understand the system better and to evaluate the system on external influences.

The injection time is composed of several elements, which have a influence on the pulsewidth of the signal.
The ECM handles the injection time for the cylinders Nr. 1, 2, and 3 ( front engine) independent from the rear engine (cylinders Nr. 4, 5, and 6), so may it be possible, that one part of the engine is running closed loop and the other open loop.
If no fault exists, the TECH 1 should show the same values for front and rear part of the engine.

The following test steps may have influence of the correct injection time.

| Test step No.: | Checking of |
|---|---|
| 01 | BATTERY VOLTAGE |
| 03 | FUEL PUMP RELAY |
| 05 | TPS SIGNAL |
| 06 | IDLE AIR CONTROL |
| 07 | COOLANT TEMP. |
| 08 | MAT SENSOR |
| 09 | MAP SENSOR |
| 10 | BAROMETER SENSOR |
| 11 | SPARK ADVANCE |
| 13 | KNOCK RETARD |
| 17 | WASTE GATE D.C. |
| 18 | WASTE GATE BLM |
| 24 | FRONT O2 INT. |
| 29 | FRONT O2 BLM |
| 26 | REAR O2 INT. |
| 30 | REAR O2 BLM |
| 31 | CANISTER PURGE |
| 32 | FAN STATUS |
| 33 | A/C REQUEST |
| 36 | VEHICLE SPEED |

o Further additional causes of trouble are:
. Pressure regulator defective.
. Injectors blocked up.
. lead interruptions from fuel pump relay Ter.-color (OW) to Injectors.
. Fuel pump pressure/flow less than necessary.

4.4 3000 #2

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 14<br><br>Part - 2 | FRONT INJ. PULSE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 2.3 to 3.0 ms | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Compare injection time in test step 14 and test step 15 | test step 14 ~ test step 15<br>value value | o search for leaks (air and/or fuel) in intake manifold<br>. see test step 06, 09, 10, 17, 24, 31 and 29(cell No. 0) |
| o Select F5: ACTUATOR TEST | Injectors OK | o replace defective valves. |
| o Search for leaks in exaust system. | no leaks | o repair exhaust system. |
| o Search for defective CKT in test step 23 | CKT's OK | o repair system. |

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 15 | REAR INJ. PULSE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | 2.3 to 3.0 ms | |

Note: See Text in test step 14 (Part 1)

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Compare injection time in test step 14 and test step 15 | test step 14 ~ test step 15<br>value value | o Search for leaks (air and/or fuel) in intake manifold<br>. See test step 06, 09, 10, 17, 25, 31 and 30(cell No. 0) |
| o Select F5: ACTUATOR TEST | Injectorss OK | o Replace defective valves. |
| o Search for leaks in exaust system. | no leaks | o Repair exhaust system. |
| o Search for defective CKT in test step 25 | CKT's OK | o Repair system. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 16 | WASTE GATE FUNCT | Engine at idle, operating temp. If DISABLED displaed on TECH 1 a Malfunction is recognized | ENABLED | 16, 66 |

The waste gate actuator contains an internal spring to preload the waste gate closed. Normally boost pressure is controlled by applying intake manifold pressure to a small hose to the waste gate actuator. The actuator is constructed with spring pressure applied to one side of the diaphragm, and the opposite side of the diafragm exposed to manifold pressure through the connecting hose. At 1.55 bar (8 PSI), manifold pressure would overcome spring pressure, and the diafragm would begin to move, causing the waste gate to open. If the hose is either blocked or removed from the actuator, or a leak exists in the hose, the waste gate would not open, and engine protection would be achieved only by the overboost protection in the ECM. When the ECM detects a manifold pressure of 1.98 bar the ECM will discontinue all fuel injection pulses until manifold pressure drops below 1.6 bar. Inserted to the hose, between the actuator and the compressor side of the turbocharger, is a normal open, ECM controlled solenoid (WASTE GATE SOLENOID VALVE). The solenoid controls how much manifold pressure is directed to the waste gate actuator.

If the WASTE GATE SOLENOID VALVE or control circuit were to fail in a fully-energized,100% duty cycle mode, the maximum boost pressure could be reached. At this manifold pressure (1.98 bar) the ECM will discontinue any injector pulses until the pressure drops to 1.6 bar.
If the WASTE GATE SOLENOID VALVE or control circuit were to fail in a 0% duty cycle mode, the boost pressure will only reach 1.55 bar.

The "WASTE GATE duty cycle" of the WASTE GATE SOLENOID VALVE is stored in the PROM/MEMCAL of the ECM. The "WASTE GATE BLOCK LEARN MEMORY" is a portion of ECM memory used to make long-term corrections to conditions of the engine. Further information about "WASTE GATE BLOCK LEARN MEMORY" in test step 18.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 17 | WASTE GATE D.C. | Engine at idle, operating temp. | 100 % or 0 %<br>but not between !! | 16, 66 |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Measure voltage between<br>Waste Gate Solenoid<br>Ter."A" and ground. | > 11.0 V | o Fuse SOLENOIDS blown. or<br>. Short to ground or open in CKT between Fuse SOLENOIDS and Waste Gate Solenoid Ter."A". |
| o Ignition ON<br>Disconnect Waste Gate Solenoid plug.<br>Measure voltage between<br>Waste Gate Solenoid<br>Ter."B" and ground. | > 11.0 V | o Short to ground or open in CKT between ECM plug Ter."J4-D10" and Waste Gate Solenoid Ter."B".<br>. ECM defective |
| o Measure voltage between<br>Waste Gate Solenoid<br>Ter."B" and Ter."A"<br>Drive car on road. ~ 30 mph (50 km/h)<br>4-th gear. Accelerator in WOT position<br>for less than 5 seconds. | > 1.0 V | o ECM defective. |
| o Measure resistance between<br>Waste Gate Solenoid<br>Ter."B" and Ter."A" | 28 to 35 Ω | o Waste Gate Solenoid defective. |
| o Reconnect Waste Gate Solenoid | Waste Gate Valve OK | o See test step 17 part 2 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 17<br><br>Part - 2 | **WASTE GATE D.C.** | **Engine at idle**, operating temp. | 100 % or 0 %<br>but not between !! | 16, 66 |

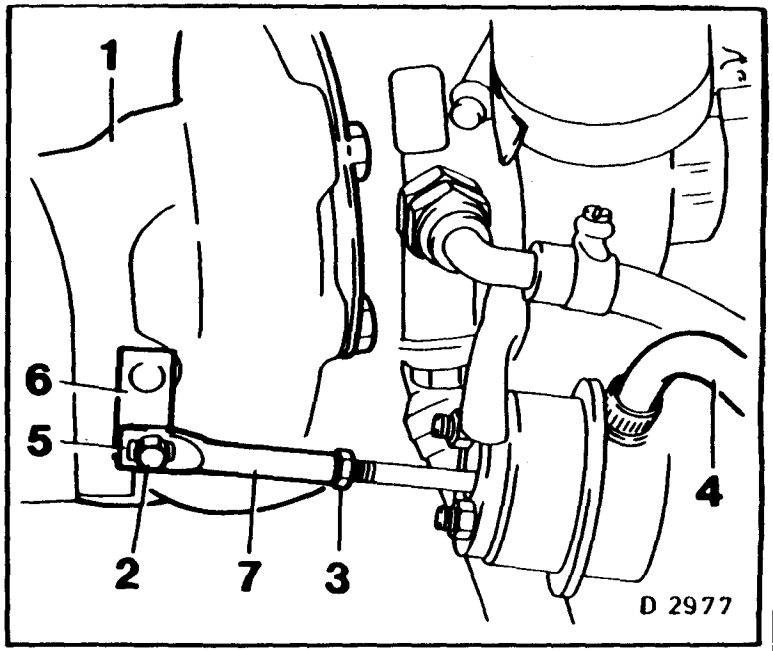
o Checking Procedure Turbocharger Wastegate Preload:

1) Remove hose "4" and apply a pressure of 8 psi ± 0.25 psi ( 0.55 .. 0.57 bar).!! Do not apply more than 10 psi ( 0.69 bar) as this may damage the diaphragm.

2) Measure movement of rod end "5" using a DTI (Micrometer) this should be between 0.010" .. 0.020" (0.25..0.5 mm) ( Kent-moore tool No: J 800/1 )

3) Ensure the DTI is normal to the rod end.

4) Check each turbocharger individually. Should one or both turbochargers be out of specification, reset the preload to the following procedure.
See test step 17 part 3



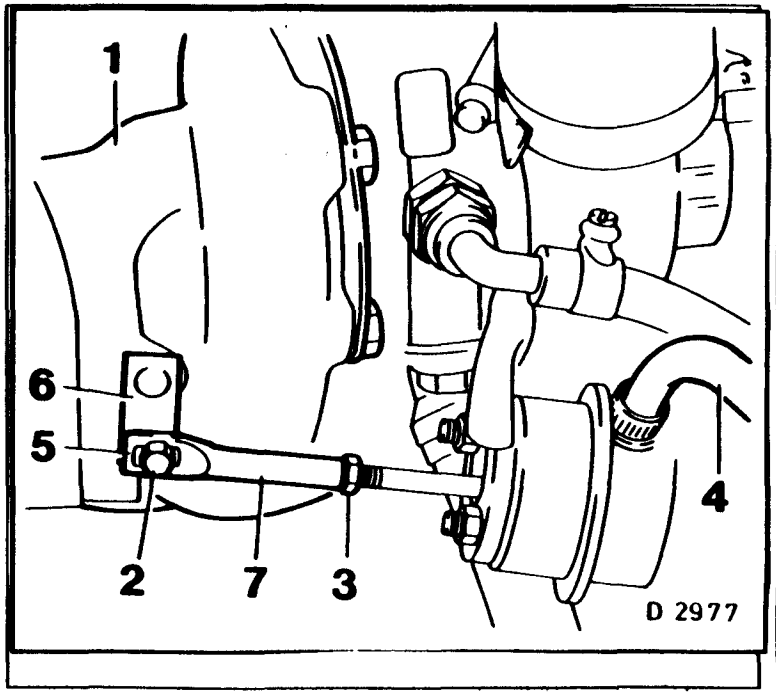
## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 17<br><br>Part - 3 | WASTE GATE D.C. | Engine at idle, operating temp. | 100 % or 0 %<br>but not between !! | 16, 66 |

**Trouble-shooting:** **Nominal Value:** **Cause of Fault:**
(If nominal values NOT attained)

o Setting Procedure Turbocharger WASTE GATE Preload:

1) Apply pressure of 8 psi ± 0.5 psi to "4".
2) Stacken off locknut "3"
3) Remove retaining clip "2"
4) Pull actuator rod off pin on crank "6".
5) Push crank "6" towards actuator while maintaining pressure, screw actuator rod end "7" in or out to engage on the crank pin. The rod shod be as short as possible, so that the rod eye just engages on the pin without forcing
6) Fit retaining clip "2"
7) Tigthen locknut "3" to 7 Nm
8) Relieve pressure to port "4"
9) Check settings using "checking procedure"
See test step 17 page 2.



## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 18 | WASTE GATE BLM | Engine at idle, operating temp. | -5 % .. +5 % | 16, 66 |

**The "WASTE GATE BLOCK LEARN MEMORY" is a portion of ECM memory used to make long-term corrections to desired boost pressure. This correction is to compensate the small manufacturing tolerances and/or normal aging of parts in each of the various system components.**

**The ECM has a memory portion of 16 cells to modify the above mentioned tolerances.**

**For example: If the MAP-Sensor detects a boost pressure greater or less than stored in the PROM/MEMCAL for this engine speed and load, the concerning WASTE GATE BLOCK LEARN MEMORY cell will be updated.**
**Following this update, the WASTE GATE SOLENOID duty cycle will be modify to prevent under- or overboost.**

**Attention : The content of the WASTE GATE BLOCK LEARN MEMORY cell is not identical to the WASTE GATE SOLENOID VALVE duty cycle. The content will only be used to modify this WASTE GATE SOLENOID VALVE duty cycle.**

**Content of the WASTE GATE BLOCK LEARN MEMORY cells below only for example.**

| (+4 % ) cell 09 | (+3 % ) cell 10 | (+2 % ) cell 11 | (+1 % ) cell 12 | ( 0 % ) cell 13 | (-1 % ) cell 14 | (-2 % ) cell 15 | (-4 % ) cell 16 |
|---|---|---|---|---|---|---|---|
| | | | | | | Engine speed ---> | |
| 4000-4500 | 4500-5000 | 5000-5500 | 5500-6000 | 6000-6500 | 6500-7000 | 7000-7500 | 7500-8000 RPM |

| ( 0 % ) cell 01 | (-6 % ) cell 02 | (+1 % ) cell 03 | (-2 % ) cell 04 | (-3 % ) cell 05 | (+5 % ) cell 06 | (+6 % ) cell 07 | (+5 % ) cell 08 |
|---|---|---|---|---|---|---|---|
| | | | | | | Engine speed ---> | |
| 0-500 | 500-1000 | 1000-1500 | 1500-2000 | 2000-2500 | 2500-3000 | 3000-3500 | 3500-4000 RPM |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 19 | FRONT O2 SENSOR | Engine at idle, operating temp. AC-switch OFF. | READY | 13, 44, 45 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Check connection between ECM "J1-A21" and front O2-Sensor Ter."C" | Continuity,< 1 Ω | o cable interruption |
| o Check connection between ECM "J3-C15" and front O2-Sensor Ter."A" | Continuity,< 1 Ω | o cable interruption |
| o Ignition ON<br>Mesure voltage on front O2-Sensor Ter."B" to ground.<br>Using Multimeter.(20V/DC) | > 11 V | o Ignition fuse blown<br>. short to ground between ignition fuse "I" and O2-Sensor Ter."B". |
| o Check connection between Ignition fuse "I" and front O2-Sensor Ter."B" (reconnect fuse) | Continuity,< 1 Ω | o Cable interruption between ignition fuse "I" and O2-Sensor Ter."B". |
| o Check connection between ground and front O2-Sensor Ter."D" | Continuity,< 1 Ω | o cable interruption |
| o See test step 23 | | |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 20 | REAR O2 SENSOR | Engine at idle, operating temp. AC-switch OFF. | READY | 63, 64, 65 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Check connection between ECM "J3-C20" and rear O2-Sensor Ter."C" | Continuity,< 1 Ω | o cable interruption |
| o Check connection between ECM "J1-A16" and rear O2-Sensor Ter."A" | Continuity,< 1 Ω | o cable interruption |
| o Ignition ON<br>Measure voltage on rear O2-Sensor Ter."B" to ground.<br>Using Multimeter.(20V/DC) | > 11 V | o Ignition fuse blown<br>. short to ground between ignition fuse "I" and O2-Sensor Ter."B". |
| o Check connection between Ignition fuse "I" and rear O2-Sensor Ter."B" (reconnect fuse) | Continuity,< 1 Ω | o Cable interruption between ignition fuse "I" and O2-Sensor Ter."B". |
| o Check connection between ground and rear O2-Sensor Ter."D" | Continuity,< 1 Ω | o cable interruption |
| o See test step 25 | | |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 21 | TIME FROM START | Ignition ON<br>Start engine<br>Engine at idle speed | 00:00:00<br><br>> 00:00:00 | |

**NOTE:**
**This test step serves as a learning and checking value to understand the system better and to evaluate the system on external influences.**

**By using the TECH 1 keys F1 and/or F2 one of the TECH 1 displayed test steps will be frozen. The other test step can be changed by using the arrow keys.**

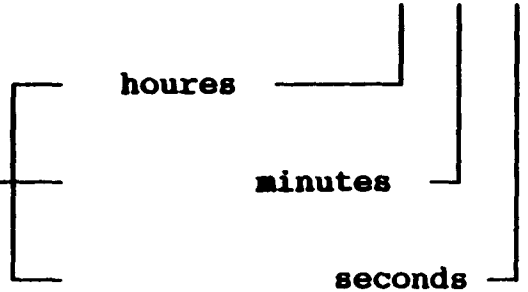
**Trouble-shooting:**

**o Ignition OFF**
**Ignition ON**
**Start engine**
**Engine at idle speed**

**Nominal Value:**

00:00:00

> 00:00:01




**Cause of Fault:**
**(If nominal values NOT attained)**

**o if engine run timer doesn't work and some other test steps don't work correct follow directions below:**

**Remove and re-install PROM/MEMCAL Ensuring that latches secured properly. Retest test step 21. If problem is still present replace PROM/MEMCAL. Retest test step 21. If problem is still exists replace ECM.**

**o if only engine run timer doesn't work go to test step 22.**

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 22 | O2 SENSOR LOOP | Ignition ON.<br>Start engine. Engine at idle speed. Operating temperature. | OPEN<br><br>CLOSED | |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Engine at idle speed | No trouble code set ! | o Repaire system |
| o Engine at idle speed | TECH 1 display shows:<br>CLOSED | o See test step 19 |
| o Engine at idle speed | test step 19 OK | o See test step 20 |
| o Engine at idle speed | test step 20 OK | o See test step 05, 07, 36 |
| o Engine at idle speed | test steps OK | o if test step 22 doesn't work and all other test steps are OK, then follow directions below:<br><br>Remove and re-install PROM/MEMCAL Ensuring that latches secured properly. Retest test step 22. If problem is still ahead replace PROM/MEMCAL. Retest test step 22. If problem is still ahead replace ECM.<br><br>o if test step 22 doesn't work and some other test steps don't work correct then repaire system first. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 23 | FRONT O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 13, 44, 45 |

| Trouble-shooting: | Nominal Value: | Cause of fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Go to test step 19 first | Test step 19 OK | o Repair sensor wiring harness. |
| o Disconnect front O2-Sensor.<br>Measure voltage between O2-Sensor plug (ECM-side) Ter."A" and ground. | TECH 1 display:<br>400 to 460 mV<br><br>Multimeter display:<br>400 to 460 mV | o If test step 19 OK, repeat measure between ECM Ter. J3-C15 and ground.<br>if not OK then ECM defective.<br>else temporary interruption in wiring harness. |
| o Connect Adapter Cable KM-609 and reestablish connection between ECM and O2-Sensor except line "A".<br>Measure voltage between Ter."A" of the O2-Sensor plug (O2-Sensor side) to ground.<br>Start engine.<br>Engine at idle speed. | TECH 1 display:<br>50 to 950 mV<br><br>Multimeter display:<br>50 to 950 mV | o If control loop closes only very slowly<br>- Oxygen Sensor heater defective.<br>o Oxygen Sensor defective.<br>o Mixture always to rich (see test step 23 part 02)<br>o Mixture always to lean (see test step 23 part 03)<br>o ECM defective. |

* See terminal assignments in section 6

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 23<br><br>Part - 2 | FRONT O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 13, 44, 45 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Mixture always rich.<br>(Oxygen sensor voltage > 600 mV)<br><br>Connect Manometer KM-J-34730-1 to test fuel pressure test point.<br>In addition<br>- Slowly open fuel connection valve to fuel rail to reduce pressure in system<br>- Connect second manometer to return (use T-adapter)<br>- Bleed manometer before measuring<br>- Start engine and allow to run<br>- Remove vacuum hose from pressure regulator<br>Pressure in feed :<br>Pressure in return :<br>o Install vacuum hose feed : | <br><br><br><br><br><br><br><br><br>3.0 ± 0.2 bar<br>0.3 to 1.5 bar<br>Pressure must fall by 0.4 to 0.6 bar | o Fuel pressure to high<br>. Pressure regulator defective<br>. Return line blocked or kinked<br>. Vacuum hose to pressure regulator leaky<br>. splash baffle in fuel tank blocked<br><br>Further Causes of Faults:<br><br>. Charcoal canister purge solenoid open<br>. Charcoal canister or line leaky<br>. Leaky Injectors : cylinder 1, 2 or 3<br>. CT-Sensor defective (see test step 07)<br>. MAP-Sensor not linear (see test step 09)<br>. BP-Senor defective (see test step 10) |
| o Ignition OFF, Reconnect ECM-plug "J1" and inj.-valves and measure resistance between injector plugs (female) and ground. | > 20 kΩ | o Line between Injector 1 and J1-A3 or Injector 2 and J1-A12 Injector 3 and J1-A7 temporary or permanent short to ground.<br>o ECM defective |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 23<br><br>Part - 3 | FRONT O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 13, 44, 45 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Mixture always lean.<br>(Oxygen sensor voltage < 300 mV)<br><br>Connect Manometer KM-J-34730-1 to test fuel pressure test point.<br>In addition<br>- Slowly open fuel course connection to distributor pipe to reduce pressure in system<br>- Connect second manometer to return (use T-adapter)<br>- Bleed manometer befor measuring<br>- Start engine and allow to run<br>- Remove vacuum hose from pressure regulator<br>Pressure in feed :<br>Pressure in return : | <br><br><br><br><br><br><br><br><br>3.0 ± 0.2 bar<br>0.3 to 1.5 bar | o Fuel pressure too low<br>. Fuel pump defective (see test step 02)<br>. splash baffle in fuel tank loose<br>. Pressure regulator defective<br>. Fuel filter dirty<br>. Check fuel pump supply (see Technical Data)<br><br>Further Causes of Faults:<br>. Injectors :<br>cylinder 1, 2 or 3 defective<br><br>. CT-Sensor defective (see test step 07)<br>. MAP-Sensor not linear (see test step 09)<br>. Baro-sensor defective(see test step 10)<br>. Poor fuel quality<br>. Exaust system leaky |
| o Install vacuum hose feed : | Pressure must fall by 0.4 to 0.6 bar | o ECM defective |
| o Ignition OFF, Reconnect ECM-plug "J1" and injector plugs and measure resistance between injector plugs (female) and U-batt. | > 20 kΩ | o Line between Injector 1 and J1-A3 or<br>Injector 2 and J1-A12<br>Injector 3 and J1-A7<br>temporary or permanent short to U-batt. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 24 | FRONT O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>123 to 133 STEPS | 13, 44, 45 |

In the discussion below the "front part" of engine refer to cylinders Nr. 1, 2, and 3 and the corresponding (front) O2-sensor and O2-integrator.

The tendency (rich or lean mixture) of the front oxygen sensor regulation can be evaluated with FRONT O2 INT.
If for example the intake air/fuel mixture is too lean (actual value > 133 STEPS), the value of FRONT O2 INT. and thereby the injection timing increased in stages until the oxygen sensor signals too rich a mixture. The integrator is subseguently reduced again. ( closed loop )

Integrator = 128 STEPS : Mixture stoichiometric. That means, for 14.7 active materials of air is 1 active material of fuel available.

or : System goes to open loop in the front part of the engine. The FRONT O2 INT. is frozen to 128 because either the conditions for closed loop are not reached or the system detected a malf-code.

NOTE : If the system goes closed loop and no fault is detected, the FRONT O2 INT. fluctuate between 120 and 135.

> 128 STEPS : Mixture too lean, Injection timing is increased.

< 128 STEPS : Mixture too rich, Injection timing is decreased.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 24<br><br>Part - 2 | FRONT O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>123 to 133 STEPS | 13, 44, 45 |

**Trouble-shooting:** **Nominal Value:** **Cause of Fault:** (If nominal values NOT attained)

o In order to be able to determine a change in the FRONT O2 INT. the FRONT O2 BLM correction must be used. See also test step 28 O2 BLM CELL NO.

o Erase trouble code.

1. FRONT O2 INT. > 133 and FRONT O2 BLM < 128 than : wait a few minutes for system stabilisation
2. FRONT O2 INT. > 133 and FRONT O2 BLM > 145 than : See test step 23 part 3<br>Mixture always lean.<br>(Oxygen sensor voltage < 300 mV)
3. FRONT O2 INT. < 123 and FRONT O2 BLM > 128 than : wait a few minutes for system stabilisation
4. FRONT O2 INT. < 123 and FRONT O2 BLM < 110 than : See test step 23 part 2<br>Mixture always rich.<br>(Oxygen sensor voltage > 600 mV)

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 25 | REAR O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 63, 64, 65 |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Go to test step 20 first | Test step 20 OK | o Repair sensor wirering harness. |
| o Disconnect front O2-Sensor.<br>Measure voltage between<br>O2-Sensor plug (ECM-side)<br>Ter."A" and ground. | TECH 1 display:<br>400 to 460 mV<br><br>Multimeter display:<br>400 to 460 mV | o If test step 20 OK, repeat measure<br>between ECM Ter. J1-A16 and ground.<br>if not OK then ECM defective.<br>else temporary interruption<br>in wiring harness. |
| o Connect Adapter Cable KM-609<br>and reestablish connection<br>between ECM and O2-Sensor<br>exept line "A".<br>Measure voltage between<br>Ter."A" of the O2-Sensor plug<br>(O2-Sensor side) to ground.<br>Start engine.<br>Engine at idle speed. | TECH 1 display:<br>50 to 950 mV<br><br>Multimeter display:<br>50 to 950 mV | o If control loop closes only very slowly<br>- Oxygen Sensor heater defective.<br>o Oxygen Sensor defective.<br>o Mixture always too rich<br>(see test step 25 part 02)<br>o Mixture always too lean<br>(see test step 25 part 03)<br>o ECM defective. |

* See terminal assignments in section 6

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 25<br><br>Part - 2 | REAR O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 63, 64, 65 |

| Trouble-shooting: | Nominal Value: | Cause of Fault:<br>(If nominal values NOT attained) |
|---|---|---|
| o Mixture always rich.<br>(Oxygen sensor voltage > 600 mV)<br><br>Connect Manometer KM-J-34730-1 to test fuel pressure test point.<br>In addition<br>- Slowly open fuel connection valve to the fuel rail to reduce pressure in system<br>- Connect second manometer to return (use T-adapter)<br>- Bleed manometer befor measuring<br>- Start engine and allow to run<br>- Remove vacuum hose from pressure regulator<br>Pressure in feed :<br>Pressure in return :<br>o Install vacuum hose<br>feed : | <br><br><br><br><br><br><br><br><br>3.0 ± 0.2 bar<br>0.3 to 1.5 bar<br>Pressure must fall<br>by 0.4 to 0.6 bar | o Fuel pressure to high<br>. Pressure regulator defective<br>. Return line blocked or kinked<br>. Vacuum hose to pressure regulator leaky<br>. splash baffle in fuel tank blocked<br><br>Further Causes of Faults:<br><br>. Charcoal canister purge solenoid open<br>. Charcoal canister or line leaky<br>. Leaky Injectors :<br>cylinder 4, 5 or 6<br>. CT-Sensor defective (see test step 07)<br>. MAP-Sensor not linear<br>(see test step 09)<br>. Baro-sensor defective(see test step 10) |
| o Ignition OFF, Reconnect ECM-plug "J1" and injector plugs and measure resistance between injector plugs (femal) and ground. | > 20 kΩ | o Line between Injector 4 and J1-A8 or<br>Injector 5 and J1-A2<br>Injector 6 and J1-A1<br>temporary or permanent short to ground.<br>o ECM defective |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 25<br><br>Part - 3 | REAR O2 SENSOR | Ignition ON<br>Start engine<br>Engine at idle speed | 400 to 460 mV<br><br>50 to 950 mV | 63, 64, 65 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Mixture always lean.<br>(Oxygen sensor voltage < 300 mV)<br><br>Connect Manometer KM-J-34730-1 to test fuel pressure test point.<br>In addition<br>- Slowly open fuel course connection to distributor pipe to reduce pressure in system<br>- Connect second manometer to return (use T-adapter)<br>- Bleed manometer befor measuring<br>- Start engine and allow to run<br>- Remove vacuum hose from pressure regulator<br>Pressure in feed :<br>Pressure in return : | <br><br><br><br><br><br><br><br><br><br>3.0 ± 0.2 bar<br>0.3 to 1.5 bar | o Fuel pressure too low<br>. Fuel pump defective (see test step 02)<br>. splash baffle in fuel tank loose<br>. Pressure regulator defective<br>. Fuel filter dirty<br>. Check fuel pump supply (see Technical Data)<br><br>Further Causes of Faults:<br>. Injectors : cylinder 4, 5 or 6 defective<br><br>. CT-Sensor defective (see test step 07)<br>. MAP-Sensor not linear (see test step 09)<br>. Baro-sensor defective(see test step 10)<br>. Poor fuel quality<br>. Exhaust system leaky |
| o Install vacuum hose feed : | Pressure must fall by 0.4 to 0.6 bar | o ECM defective |
| o Ignition OFF, Reconnect ECM-plug "J1" and injector plugs and measure resistance between injector plugs (female) and U-batt. | > 20 kΩ | o Line between Injector 4 and J1-A8 or Injector 5 and J1-A2 Injector 6 and J1-A1 temporary or permanent short to U-batt. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 26 | REAR O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>123 to 133 STEPS | 63, 64, 65 |

In the discussion below the "rear part" of engine refer to cylinders Nr. 4, 5, and 6 and the corresponding (rear) O2-sensor.

The tendency (rich or lean mixture) of the rear oxygen sensor regulation can be evaluated with REAR O2 INT.
If for example the intake air/fuel mixture too lean (actual value > 133 STEPS), the value of REAR O2 INT. and thereby the injection timing increased in stages until the oxygen sensor signals too rich a mixture. The integrator is subseguently reduced again. ( closed loop )

Integrator = 128 STEPS : Mixture stoichiometric. That means, for 14.7 active materials of air is 1 active material of fuel available.

or : System goes to open loop in the front part of the engine. The REAR O2 INT. is frozen to 128 because either the conditions for closed loop are not reached or the system detected a malf-code.

NOTE : If the system goes closed loop and no fault is detected, the REAR O2 INT. fluctuate between 120 and 135.

> 128 STEPS : Mixture too lean, Injection timing is increased.

< 128 STEPS : Mixture too rich, Injection timing is decreased.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 26<br><br>Part - 2 | REAR O2 INT. | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>123 to 133 STEPS | 63, 64, 65 |

**Trouble-shooting:** **Nominal Value:** **Cause of Fault:** (If nominal values NOT attained)

o In order to be able to determine a change in the REAR O2 INT. the REAR O2 BLM correction must be used. See test step 28 O2 BLM CELL NO.

o Erase trouble code.

1. REAR O2 INT. > 133 and REAR O2 BLM < 128 than : wait a few minutes for system stabilisation

2. REAR O2 INT. > 133 and REAR O2 BLM > 145 than : See test step 25 part 3
   Mixture always lean.
   (Oxygen sensor voltage < 300 mV)

3. REAR O2 INT. < 123 and REAR O2 BLM > 128 than : wait a few minutes for system stabilisation

4. REAR O2 INT. < 123 and REAR O2 BLM < 110 than : See test step 25 part 2
   Mixture always rich.
   (Oxygen sensor voltage > 600 mV)

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 27 | O2 BLM ENABLE | Engine at idle, operating temp.<br>AC-switch OFF.<br>Switch OFF all consumers. | ACTIVE | 13, 44, 45,<br>63, 64, 65 |

**Trouble-shooting:** **Nominal Value:** **Cause of Fault:**
(If nominal values NOT attained)

o If the O2 BLM ENABLE is INACTIVE with engine idling at operating temperature, the following test steps should be checked in acc. with fast check list:

| Test step No.: | Checking of | Test step No.: | Checking of |
|---|---|---|---|
| 03 | ENGINE SPEED | 09 | MAP SENSOR |
| 05 | TPS SIGNAL | 10 | BAROMETER SENSOR |
| 07 | COOLANT TEMP. | 19 | FRONT O2 SENSOR |
| 08 | MAT SENSOR | 20 | REAR O2 SENSOR |
| | | 22 | O2 SENSOR LOOP |

o Engine at idle speed test steps OK

o if test step 27 doesn't work and all other test steps are OK, then follow directions below:

Remove and re-install PROM/MEMCAL Ensuring that latches secured properly. Retest test step 27. If problem is still present replace PROM/MEMCAL. Retest test step 27. If problem is still exists replace ECM.

o if test step 27 doesn't work and some other test steps don't work correct then repair system first.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 28 | O2 BLM CELL NO. | Engine at idle speed<br>Engine speed > 2000 RPM and<br>MAP-Sensor > 0.65 bar | 0<br><br>> 0 | |

Block learn, also called Block Learn Memory,or BLM is a portion of ECM memory used to make long-term corrections to fuel delivery across all operating conditions of the engine. This correction is to compensate for small manufacturing tolerances and/or normal aging of parts in each of the various system components. The ECM reserves memory locations for various load conditions of the engine specified by MAP and RPM. Each location represents a "block" or "cell", or specific operating condition of the engine. Some systems use more cells, while others use as few as two - idle and off-idle. This two cell system is used in Motronic or IEFI-Multec ECM's. In this case, we have two groups of cells each with 16 cells.

Front BLOCK LEARN CELLS

| | | | |
|---|---|---|---|
| ( 127 ) cell 12 | ( 129 ) cell 13 | ( 128 ) cell 14 | ( 129 ) cell 15 |
| ( 126 ) cell 08 | ( 127 ) cell 09 | ( 129 ) cell 10 | ( 130 ) cell 11 |
| ( 127 ) cell 04 | ( 129 ) cell 05 | ( 131 ) cell 06 | ( 129 ) cell 07 |
| ( 127 ) cell 0 | ( 127 ) cell 01 | ( 129 ) cell 02 | ( 128 ) cell 03 |

Engine speed---->

800 2000 4000 6000 RPM

MAP-Sensor pressure

160 kPa
140 kPa
100 kPa
60 kPa
20 kPa

Rear BLOCK LEARN CELLS

| | | | |
|---|---|---|---|
| ( 127 ) cell 12 | ( 129 ) cell 13 | ( 128 ) cell 14 | ( 129 ) cell 15 |
| ( 130 ) cell 08 | ( 127 ) cell 09 | ( 129 ) cell 10 | ( 130 ) cell 11 |
| ( 133 ) cell 04 | ( 132 ) cell 05 | ( 130 ) cell 06 | ( 129 ) cell 07 |
| ( 138 ) cell 0 | ( 135 ) cell 01 | ( 131 ) cell 02 | ( 130 ) cell 03 |

Engine speed---->

800 2000 4000 6000 RPM

The values in the brackets are the Block-Learn-Memory values for example. The values in the front BLOCK LEARN CELLS are OK. The values in the Rear BLOCK LEARN CELLS are also OK, but maybe a leak is in the exhaust system for cylinder 4, 5 or 6 between cylinder head and exhaust pipe. In this case only the cells No.: 0, 1, 4 and 5 are affected. For further info. see LOTUS/OMEGA Training.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 29 | FRONT O2 BLM | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>110 to 145 STEPS | 43, 44, 45 |

NOTE: In the discussion below the "front part" of engine refer to cylinders Nr. 1, 2, and 3 and the corresponding front O2-Sensor ,the front O2-Integrator and front O2-Block learn memory.

Via front O2-Block learn memory (FRONT O2 BLM), learned deviations from the ideal mixture conditions (e.g. by air leakage in front part of the engine) are captured by the control unit (ECM) and stored in the permanent memory. This memory is a long term memory, so that the corrected values are available also after the supply voltage has been swiched off and the engine re-started. With front O2-Block learn memory an evaluation of the learned values of the system can be made.

In each part (front and rear) of the engine are 16 Block learn cells available. Which cell will be modified depends of the actual engine speed and load.
For idle select in test step 28 the cell No.: 0

In order to be able to evaluate the deviation of the front O2-Block learn memory (FRONT O2 BLM) the front O2-Interator must be observed.

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Select cell No.: 0<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>110 to 145 STEPS | o See test step 24 part 2 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 30 | REAR O2 BLM | Ignition ON<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>110 to 145 STEPS | 63, 64, 65 |

**NOTE:** In the discussion below the "rear part" of engine refer to cylinders Nr. 4, 5, and 6 and the corresponding (rear) O2-Sensor ,the rear O2-Integrator and rear O2-Block learn memory.

Via rear O2-Block learn memory (REAR O2 BLM), learned deviations from the ideal mixture conditions (e.g. by air leakage in rear part of the engine) are captured by the control unit (ECM) and stored in the permanent memory. This memory is a long term memory, so that the corrected values are available also after the supply voltage has been switched off and the engine re-started. With rear O2-Block learn memory an evaluation of the learned values of the system can be made.

In each part (front and rear) of the engine are 16 Block learn cells available. Wich cell will be modified depends of the actual engine speed and load.
For idle select in test step 28 the cell No.: 0

In order to be able to evaluate the deviation of the rear O2-Block learn memory (REAR O2 BLM) the rear O2-Interator must be observed.

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Select cell No.: 0<br>Start engine<br>Engine at idle speed | 128 STEPS<br><br>110 to 145 STEPS | o See test step 26 part 2 |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 31 | CANISTER PURGE | Ignition ON<br>Start engine<br>Engine at idle speed<br>Engine speed out of idle,TPS >4% * | <br><br>0%<br>>1% | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Measure voltage at<br>Charcoal cannister<br>purge solenoid Ter."A" | 11.5 to 13.5 V | o lead interruption from Ignition "Y" fuse (Solenoids) to charcoal can. sol.<br>or<br>. Ignition "Y" fuse blown |
| o Ignition ON<br>Start engine<br>Engine at idle speed<br>* Engine speed out of idle,TPS >4%<br>Measure voltage between<br>Charcoal cannister<br>purge solenoid Ter."A"<br>and Ter."B" | 0 V<br>1 to 13.5 V | o lead interruption between ECM "J3-C10" and<br>Charcoal cannister purge solenoid Ter."B" |
| o Ignition OFF<br>Reconnect C.C.Solenoid<br>Measure resistant between<br>Ter."A" and "B" at<br>C.C.Solenoid | xx to yy Ω | o C.C.Solenoid defective<br><br>o ECM defective |

* Drive on steet ~ 30 mph (50km/h) constant!.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 32 | FAN STATUS | Ignition ON<br>Start engine,Engine at idle speed<br>Coolant temperature > 97°C, 207°F | OFF 12 V<br>ON 0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Engine OFF<br>Disconnect ECM plug "J3"<br>Measure Voltage between<br>ECM plug "J3-C6"(female) and | > 11.0 V | o Line interrupt between ECM J3-C6 and FAN RELAY COIL Ter.(color"NW") or<br>A/C INTERFACE Connector faulty or<br>A/C HIGH PRESS. SW. closed or<br>Line interrupt between Fuse FL13 and FAN RELAY COIL Ter.(color "R") |
| o Disconnect A/C INTERFACE Con.<br>Measure Voltage between<br>A/C INTERFACE Con.(female)<br>Ter. "E" and ground. | > 11.0 V | o Line interrupt between Fuse "FL22" and A/C INTERFACE Connector Ter."E" |
| o Measure resistance between<br>A/C INTERFACE Con.(female)<br>Ter. "G" and FAN RELAY | < 2 Ω | o Line interrupt between FAN RELAY and A/C INTERFACE Connector Ter."G" |
| o Measure resistance between<br>A/C INTERFACE Con.(male)<br>Ter. "E" and "G" | 0.4..0.9 Ω | o FAN defective or<br>Line interrupt between<br>A/C INTERFACE Con. Ter."G" and FAN or<br>A/C INTERFACE Con. Ter."E" and FAN. |
| o Reconnect A/C INTERFACE Con.<br>Jumper Relay connector<br>Ter.(color "N 2.5" to "N 2.5") | FAN is running | o Line interrupt between Relay con. and ground. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 33 | A/C REQUEST SW. | Engine at idle speed<br>AC-switch OFF<br>AC-switch ON | <br>OFF 0 V<br>ON 12 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Disconnect the A/C Interface. Jumper Ter. X7 "B" (ECM side) to 12 V. (engine idleing) | TECH 1 display: AC-switch ON | o Line interrupt or short to ground between X7"B" and ECM J3-C6 or<br>. HIGH PRESS.SW. open or<br>. LOW PRESS.SW. open.<br>. ECM defective. |
| o Remove jumper. Measure voltage between X7 "B" (A/C SW. side) and ground<br>Engine at idle speed<br>AC-switch OFF<br>AC-switch ON | Ω<br><br>0 V<br>12 V | o Engine run relay K .. not energized or defective.<br>. Fuse F12 blown.<br>. Line interrupt between relay K .. and A/C switch or<br>between relay K .. and Fuse F12 or<br>between alternator Ter."61" and relay K..coil. or<br>relay K..coil and ground. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 34 | A/C CLUTCH | Engine at idle speed<br>AC-switch OFF<br>AC-switch ON , after 1 second | OFF 12 V<br>ON 0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault; (If nominal values NOT attained) |
|---|---|---|
| o Ignition ON<br>Engine OFF<br>Disconnect ECM plug "J3"<br>Measure Voltage between<br>A/C Clutch Relay (color "G")<br>and ground. | > 11.0 V | o Fuse A/C blown or<br>Open or short to ground between<br>A/C Clutch Relay (color "G") and<br>Fuse A/C |
| o Measure Voltage between<br>ECM plug "J3-C16"(male) and<br>ground. | > 11.0 V | o ECM defective |
| o Measure Voltage between<br>ECM plug "J3-C16"(female) and<br>ground. | > 11.0 V | o A/C Clutch Relay defective or<br>. Open or short to ground between<br>A/C Clutch Relay (color "LGN") and<br>ECM plug "J3-C16" |
| o Jumper ECM plug "J3-C16"(female)<br>to ground.<br>Measure Voltage between<br>A/C Clutch Relay (color "K")<br>and ground. | > 11.0 V<br>A/C Clutch<br>engaged | o A/C Clutch Relay defective or<br>. A/C Clutch defective or<br>. Open or short to ground between<br>A/C Clutch Relay (color "K") and<br>A/C Clutch plug Ter."A" (in case of<br>short to gnd the Fuse A/C blows again)<br>. Open between A/C Clutch plug Ter."B"<br>and ground. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 35 | AUX. WATER PUMP | Ignition ON<br>Start engine, Engine at idle speed<br>Coolant temperature > 93°C, 200°F<br><br>Engine OFF, ignition OFF | <br><br>OFF 12 V<br><br>ON 0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Measure voltage at HOT SOAK PUMP RELAY color "P" to ground. | 11.5 to 13.5 V | o lead interruption between U-batt. and HOT SOAK PUMP RELAY. |
| o open CKT between ECM "J3-C5" and HOT SOAK PUMP RELAY. (Disconnect ECM plug J3) Jumper harness ter."J3-C5" (female) to ground. | HOT SOAK PUMP starts<br>HOT SOAK PUMP SOLENOID works. | o HOT SOAK PUMP RELAY defective or<br>. HOT SOAK PUMP defective or<br>. HOT SOAK PUMP SOLENOID always short or<br>. lead interruption between HOT SOAK PUMP RELAY and HOT SOAK PUMP or between HOT SOAK PUMP and ground. |
| o Disconnect HOT SOAK PUMP RELAY. Measure resistance between ter."J3-C5"(female) and HOT SOAK PUMP RELAY Plug | < 1 Ω | o lead interruption between HOT SOAK PUMP RELAY and ECM ter."J3-C5" |
| o Measure resistance between ter."J3-C5"(female) and ground. | > 20 kΩ | o short to ground. |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 36 | VEHICLE SPEED | Compare speedometer reading with TECH 1 value | Aprox. same speed | 24 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o Disconnect VEHICLE SPEED SENSOR plug. Measure Voltage between Ter."A" and "B" | > 10 V | o open or short to ground in CKT. |
| o Disconnect ECM plug "J1" Measure resistance between J1-A6 and ground | > 20 kΩ | o short to ground in CKT. |
| o Measure resistance between J1-A6 and VEHICLE SPEED SENSOR plug Ter. "B" | < 1 Ω | o open in CKT. |
| o Disconnect ECM plug "J1" Measure resistance between J1-A11 and ground | > 20 kΩ | o short to ground in CKT. |
| o Measure resistance between J1-A11 and VEHICLE SPEED SENSOR plug Ter. "A" | < 1 Ω | o open in CKT. |
| o Measure resistance at VEHICLE SPEED SENSOR between plug Ter. "A" and "B" | xx Ω | o VEHICLE SPEED SENSOR defective<br>o ECM defective |

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 37 | IGNITION STATUS | Ignition ON<br>Start engine<br>Engine at idle speed | INVALID<br><br>VALID | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 03 | test step 03 OK | o reapair system |
| o Engine at idle speed means > 700 RPM | TECH 1 display: VALID | o ECM defective |

## 4.4 F0: DATA LIST

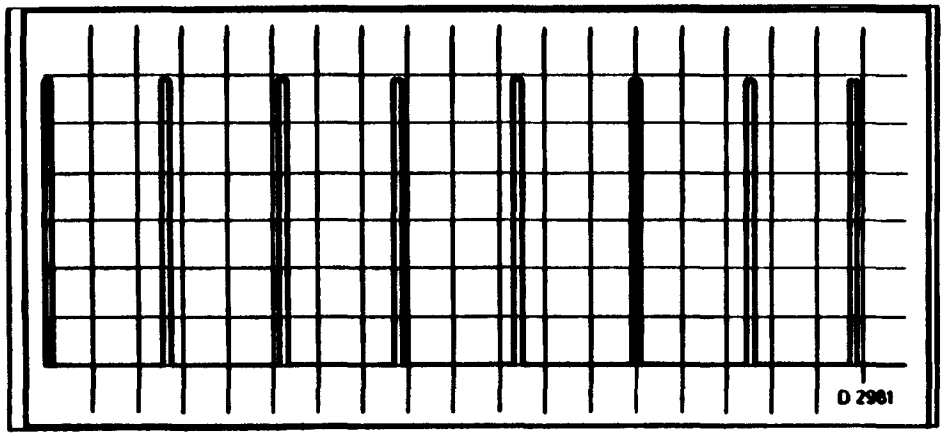
| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 38 | CAMSHAFT SIGNAL | Ignition ON<br>Start engine<br>Engine at idle speed | VALID | |

**Trouble-shooting:**

o Engine running at idle

**Nominal Value:**

CAM signal OK
No Code 31




Multimeter Voltage (20V/AC) ~ 1.35 - 1.55 V

**Cause of Fault:**
(If nominal values NOT attained)

o See wave form: CAM-signal on Ter. "J4-D3"

o CAM-sensor has no connection to +12 V
. CAM-sensor has no connection to ground
o Open or short CKT between CAM-sensor Ter. "B" and "J4-D3", color "NW"

Further Causes of Faults:
. CAM sensor defective.
. Segment disc/teeth corrodet.
. Metal shavings on pulse pick-up.

## 4.4 F0: DATA LIST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 39 | CONTROLLED IAC | Desired IAC step value<br>Note: Select TECH 1<br>Mode F6:ECM CONTROL and<br>Submode F1:IAC CONTROL. | --- STEPS | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|

o The test step CONTROLLED IAC is only in TECH 1 Mode F6:ECM CONTROL part F1:IAC CONTROL available. This test step can be used to examine the effect on the engine, when the IAC step value is greater or less than normal.

. In this test step, the ECM instructs the IAC stepper motor to increase or decrease the step value until the desired step value is reached. The engine speed will follow.

| | | |
|---|---|---|
| o Select Mode F6:ECM CONTROL<br>Submode F1:IAC CONTROL | TECH 1 display:<br>XX Steps* | o ECM defective or<br>. see test step 06 |
| o Press arrow key 'up' | step value and speed increases | o see test step 06 |
| Press arrow key 'down' | step value and speed decreases | |

Note: The TECH 1 F3:SNAPSHOT Mode is enabled.

* If the Submode F1:IAC CONTROL is enabled by using the "YES" key, the displaed step value will be equal to the actual IAC Motor step rate.
! The TP-SENSOR signal must be 0% !

## 4.5 Table 1, Diagnostic Plug ALDL and Voltage Supply, Check

| Test step | Tester Multimeter MKM-587-A | TEST from | between | | Notes | Nominal Value | Possible Cause of Fault, Trouble - shooting |
|---|---|---|---|---|---|---|---|
| 1 | Ohmmeter | Diagnostic plug (ALDL) : ground | A | ground | Ignition OFF | approx. 0 Ω | o Transfer resistance at grounding point too high. |
| 2 | Voltmeter range: 20 V/DC | Diagnostic plug (ALDL) : excitation lead | B | ground | Ignition ON | > 5,0V | o Lead interruption betw. ALDL ter."B" and ECM ter."J2-B2" or<br>o ECM defective |
| 3 | Voltmeter range: 20 V/DC | Diagnostic plug (ALDL) : Voltage supply (ECM power fuse) | F | ground | Ignition ON | >11,0V | o Battery voltage too low<br>o Lead interruption betw. ALDL ter."F" and ECM power fuse 7.5 AMP |
| 4 | Voltmeter range: 20 V/DC | Diagnostic plug (ALDL) : data lead | G | ground | Ignition ON | > 4,0V | o Lead interruption betw. ALDL ter."G" and ECM ter."J4-D15".<br>o ECM defective |

## 4.5 Table 1, Diagnostic Plug ALDL and Voltage Supply, Check

| Test step | Tester Multimeter MKM-587-A | TEST from | TEST between | | Notes | Nominal Value | Possible Cause of Fault, Trouble - shooting |
|---|---|---|---|---|---|---|---|
| 5 | - | Telltale H30 | | - | Ignition ON | Telltale ON | o Telltale H30 defective<br>o Lead interruption betw. Telltale H30 and ECM ter."J3-C11".<br>o Lead interruption betw. Telltale H30 and fuse "instument panel" |
| | | | J3-C11 | + 12 V | Ignition ON | > 11 V | o short to batt. voltage<br>o ECM defective |

## 4.5 Table 1, Diagnostic Plug ALDL and Voltage Supply, Check

| Test step | Tester Multimeter MKM-587-A | TEST from | TEST between | | Notes | Nominal Value | Possible Cause of Fault, Trouble - shooting |
|---|---|---|---|---|---|---|---|
| 6 | - | TECH 1 self test | - | - | See TECH 1 Operating instructions | - | |
| | Note. After test step 7 and 8 any trouble codes may be stored are deleted. | | | | | | |
| 7 | Ohmmeter | ECM plug J2 and J3<br><br>Ground | J2 - B6<br>J2 - B17<br>J3 - C12 | GND | Ignition OFF Disconnect ECM J2 and J3 | ca. 0 Ω | o Transfer resistance at grounding point too high<br>o Lead interruption betw. and ground.<br>o ECM defective |
| 8 | Voltmeter range: 20 V/DC | ECM plug J2<br><br>Voltage supply | J2 - B8<br>J2 - B10<br>J2 - B11 | GND | Ignition ON | >11,5V | o Battery voltage too low<br><br>o See test step 01 |

## 4.6 Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 13 | TC 13:<br>FRONT O2 SENSOR<br>OPEN CIRCUIT | 19<br>23 | In the discussion below the "front part" of engine refer to cylinders Nr. 1, 2, and 3 and the corresponding (front) O2-sensor.<br><br>o O2 Signal voltage steady between 350 und 550 mV<br>o Engine has been running longer than 2 minutes.<br>o Engine coolant temperature greater than 69.5°C (158°F).<br>o Throttle position sensor signal has been above 5% for 60 seconds or longer.<br><br>. If the condition for code 13 exists the system will not go "Closed Loop" in the "front part" of the engine. |
| 14 | TC 14:<br>COOLANT TEMP.<br>VOLTAGE LOW | 07 | o Engine coolant temperature sensor signal voltage indicated a coolant temperature above 130°C (266°F).<br><br>. If the condition for code 14 exists the system will take a default value (61°C, 142°F) instead of 130°C |
| 15 | TC 15:<br>COOLANT TEMP.<br>VOLTAGE HIGH | 07 | o Engine coolant temperature sensor signal voltage indicated a coolant temperature below -32°C (-26°F).<br><br>. If the condition for code 15 exists the system will take a default value (61°C, 142°F) instead of -32°C |
| 16 | TC 16:<br>WASTE GATE<br>OVERBOOST | 09 | o Engine fuel cut off is indicated for a time greater than 3 seconds and a MAP is greater than 190 kPa.<br>. If the code was once disabled, the re-enable time is 1 second. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in FO:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 21 | TC 21:<br>THROTTLE POSIT. SENSOR VOLTAGE HIGH | 05 | o Engine has been running at idle and TPS signal voltage is greater than 2.56 volt for more than 2 seconds.<br>or<br>o TPS signal voltage is greater than 4.80 volt.<br><br>. If the condition for code 21 exists the system will take a default value (0.94 volt) instead of the input value. |
| 22 | TC 22:<br>THROTTLE POSIT. SENSOR VOLTAGE LOW | 05 | o TPS signal voltage is less than 0.1 volt.<br><br>. If the condition for code 22 exists the system will take a default value (0.94 volt) instead of input value. |
| 23 | TC 23:<br>MAT SENSOR VOLTAGE LOW | 08 | o Engine has been running longer than 3 minutes at idle and MAT signal voltage indicated an intake air temperature below -30°C (-22°F). Vehicle is not moving. Above conditions are present for more than 1 second.<br>or<br>o MAT signal voltage indicated an intake air temperature below -30°C (-22°F) and an engine temperature (CTS) above 60°C (140°F) and the engine is not running.<br><br>. If the condition for code 23 exists the system will take a default value 4°C (39°F) instead of input value. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 24 | TC 24:<br>NO VEHICLE SPEED SIGNAL | 36 | o Engine running<br>No MALF CODE 21 or 22<br>Throttle position is less than 2%<br>MAP load less than 25.0 KPa (z.B. decellaration with fuel cut off)<br>Engine speed between 900 and 4400 RPM<br>Vehicle speed less than or equal to 5 km/h (3 MPH)<br>Above conditions present for more than 2 seconds<br><br>. If code 24 exists the system will disable the closed loop conditins for idle run mode.<br>In this case, the idle speed will be higher than normal. |
| 25 | TC 25:<br>MAT SENSOR VOLTAGE HIGH | 08 | o Engine has been running longer than 1 minutes at idle and MAT signal voltage indicated an intake air temperature above 150°C (302°F). Vehicle is not moving.<br>Above conditions are present for more than 3 second.<br>or<br>o Engine has been running longer than 1 minutes and MAT signal voltage indicated an intake air temperature above 150°C (302°F) and vehicle speed is greater than 8 km/h (5 MPH).<br>Above conditions are present for more than 3 second.<br><br>. If the condition for code 25 exists the system will take a default value 4°C (39°F) instead of the input value. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 31 | TC 31:<br>CAMSHAFT SPEED SENSOR SIGNAL | 37 | o Engine cranks and camshaft signal is missing<br>o Engine is in run mode and camshaft signal is missing for a time greater than 180 seconds.<br>or<br>o Engine is in run mode and camshaft signal sensor registered more signals than possible. Time > 1 second.<br><br>. If the condition for code 31 exists the system will lose the synchronisation for proper sequencing of the fuel injectors. System remains in sequential mode but without synchronisation. |
| 33 | TC 33:<br>MAP SENSOR VOLTAGE HIGH | 09 | o Engine running and fuel cut off activated for a time greater than 3 sec. and MAP sensor indicated a pressure >190 kPa.<br>or<br>o Engine running. MALF CODE 21 or 22 are not set. MAP sensor indicated a pressure >190 kPa and TPS sensor indicated a position less than 3% for more than 0.4 sec.<br><br>. If the condition for code 33 exists the system will take a default value depending on the engine speed and TPS. |
| 34 | TC 34:<br>MAP SENSOR VOLTAGE LOW | 09 | o Engine running. MALF CODE 21 are not set. MAP sensor indicated a pressure < 20 kPa and TPS sensor indicated a position greater than 20% or engine speed is less than 700 RPM for more than 0.44 sec.<br><br>. If the condition for code 34 exists the system will take a default value depending on the engine speed and TPS. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 41 | TC 41:<br>CYLINDER SELECT ERROR; REPLACE PROM | | o ECM detected a mismatch between the calibrated numbers of fuel injectors and the real existent fuel injector CKT's for this engine.<br>. See test step 03 or replace PROM/MEMCAL |
| 42 | TC 42:<br>BYPASS OR EST LINE FAIL | 38 | o ECM had not seen a EST-pulse by EST monitor for more than 0.2 seconds. Engine speed greater than 450 RPM. or<br>o Engine cranking less than 450 RPM. Bypass mode enabled. No EST-pulse seen by ECM. EST line may be open or shorted to ground. |
| 43 | TC 43:<br>KNOCK SENSOR CIRCUIT | 11<br>12<br>13<br><br>13 | o the CT-sensor registered a engine temperature greater than 75°C (151°F) AND<br>. ECM had seen a sensor voltage greater than 4.51 volt on knock sensor input (J2-B20) for more than 0.2 sec. or<br>. ECM had seen a sensor voltage less than 0.65 volt on knock sensor input (J2-B20) for more than 0.2 sec.<br>. The MALF CODE is cleared if the ECM detects an knock signal under normal conditions. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 44 | TC 44:<br>FRONT O2 SENSOR<br>LEAN EXHAUST | 19<br>23<br>24<br>27<br>28 | In the discussion below the "front part" of engine refer to cylinders Nr. 1, 2, and 3 and the corresponding (front) O2-sensor and O2-integrator.<br><br>o The front oxygen (O2) sensor signal is less than 0.2 volt for more than 2 minutes and the O2 front Integrator is not forced to 128.<br><br>. If the condition for code 44 exists the system will not go "Closed Loop" in the "front part" of the engine. |
| 45 | TC 45:<br>FRONT O2 SENSOR<br>RICH EXHAUST | 19<br>23<br>24<br>27<br>28 | In the discussion below the "front part" of engine refer to cylinders Nr. 1, 2, and 3 and the corresponding (front) O2-sensor and O2-integrator.<br><br>o The front oxygen (O2) sensor signal is greater than 0.75 volt for more than 30 seconds. The O2 front Integrator is not forced to 128 and the TPS sensor is greater than 20% or less than 2.7%.<br><br>. If the condition for code 45 exists the system will not go "Closed Loop" in the "front part" of the engine. |
| 51 | TC 51:<br>REPLACE ECM OR<br>PROM/MEMCAL | | o ECM is not able to read correct data from the calibration PROM/MEMCAL.<br><br>. Remove and re-install PROM/MEMCAL. Ensuring that latches secured properly. Clear codes. If code resets, replace PROM/MEMCAL and retest. If code still resets, replace ECM. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 53 | TC 53:<br>BATTERY<br>VOLTAGE HIGH | 01 | o ECM detects a battery voltage greater or equal than 17.1 volt.<br><br>. All outputs are turned off to protect the hardware. |
| 63 | TC 63:<br>REAR O2 SENSOR<br>OPEN CIRCUIT | 20<br>25 | In the discussion below the "rear part" of engine refer to cylinders Nr. 4, 5, and 6 and the corresponding (rear) O2-sensor.<br><br>o O2 Signal voltage steady between 350 und 550 mV<br>o Engine has been running longer than 2 minutes.<br>o Engine coolant temperature greater than 69.5°C (158°F)<br>o Throttle position sensor signal has been above 5% for 60 seconds or longer.<br><br>. If the condition for code 63 exist the system will not go "Closed Loop" in the "rear part" of the engine. |
| 64 | TC 64:<br>REAR O2 SENSOR<br>LEAN EXHAUST | 20<br>25<br>26<br>27<br>28 | In the discussion below the "rear part" of engine refer to cylinders Nr. 4, 5, and 6 and the corresponding (rear) O2-sensor.<br><br>o The rear oxygen (O2) sensor signal is less than 0.2 volt for more than 2 minutes and the O2 rear Integrator is not forced to 128.<br><br>. If the condition for code 64 exists the system will not go "Closed Loop" in the "rear part" of the engine. |

Table 2, Trouble Code Table

| Trouble Code | Information sensor Cause of Fault | Remedy in F0:DATA L. Test Step | Trouble Code Storage when ... |
|---|---|---|---|
| 65 | TC 65:<br>REAR O2 SENSOR<br>RICH EXHAUST | 20<br>25<br>26<br>27<br>28 | In the discussion below the "rear part" of engine refer to cylinders Nr. 4, 5, and 6 and the corresponding (rear) O2-sensor.<br><br>o The rear oxygen (O2) sensor signal is greater than 0.75 volt for more than 30 seconds. The O2 rear Integrator is not forced to 128 and the TPS sensor is greater than 20% or less than 2.7%.<br><br>. If the condition for code 65 exists the system will not go "Closed Loop" in the "rear part" of the engine. |
| 66 | TC 66:<br>BOOST SYSTEM<br>OUT OF LIMITS | 09<br>16<br>17<br>18 | o RPM greater than 2700 RPM and learning duty cycle of the waste gate solenoid is less or equal than -49.6%<br>or<br>o RPM greater than 2700 RPM and learning duty cycle of the waste gate solenoid is greater or equal than +49.6%<br><br>Note:<br>The learning duty circle is equal to the WASTE GATE BLM.<br><br>Repair system :See test step 09 and 17 part 2<br>System info. :See test step 16 and 19 |

## 4.7 Table 3, Part Numbers

| | | |
|---|---|---|
| MEMCAL ID CODE : | 65 535 | |
| ECM - Part No.: | P 530.417 657AF | |
| Catalytic Coverter No: | left | right |
| | P 530.4501 862A | P 530.4501 861A |

## 4.8 Table 4, Instructions for "Engine Does Not Start, Data Transfer OK"

If the TECH 1 receives data from the control unit (ECM), no trouble code is stored, but engine does not start, the necessary tests are outlined in Table 4.

o follow further directions:

| | | | |
|---|---|---|---|
| 1) | Battery | OK ? | .See test step 01 |
| 2) | Fuel Pump | OK ? | .See test step 02 |
| 3) | Starter | | |
| 4) | Compression | | |
| 5) | MODE F4: ACTUATOR TEST | | |
| | Submode F0 .. F4 | OK ? | .Repair system |
| 6) | Fuel pressure | OK ? | |
| 7) | Injectors | OK ? | .See test step 14 and 15 |
| 8) | Engine speed signal | OK ? | .See test step 03 |
| 9) | Primary voltage | OK ? | |
| 10) | Secondary voltage | OK ? | |
| 11) | Leakage in intake manifold | | |
| 12) | Restricted exhaust gas flow | | . Check catalytic converter |

## 4.9 Table 5, F5: ACTUATOR TEST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 01 | FAN STATUS<br><br>COOLANT TEMP. | Engine OFF<br>Ignition ON<br>TECH 1 Submode: F0: FAN RELAY<br>Press 'UP' arrow key | ACTIVE ON<br>5 sec. later OFF<br><br>... °F(C) .... V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 32 | | |

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 02 | A/C CLUTCH<br><br>A/C REQUEST SW. | Engine OFF<br>Ignition ON<br>TECH 1 Submode: F1: A/C RELAY<br>Press 'UP' arrow key | DISENGARGED ON<br>5 sec. later OFF<br><br>OFF 0 V | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 33, 34 | | |

## 4.9 Table 5, F5: ACTUATOR TEST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 03 | CANISTER PURGE<br><br>ENGINE SPEED | Engine OFF<br>Ignition ON<br>TECH 1 Submode: F2: CCP VALVE<br>Press 'UP' arrow key | .... %  ON<br>5 sec. later  OFF<br><br>.... RPM | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 31 | | |

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 04 | WASTE GATE FUNCT<br><br>WASTE GATE D.C. | Engine OFF<br>Ignition ON<br>TECH 1 Submode: F3: WASTE GATE<br>Press 'UP' arrow key | ENABLED  ON<br>5 sec. later  OFF<br><br>60 % | 16, 66 |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 16, 17 and 18 | | |

## 4.9 Table 5, F5: ACTUATOR TEST

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 05 | IDLE AIR CONTROL | Engine OFF<br>Ignition ON<br>TECH 1 Submode: F4: IAC MOTOR<br>Press 'UP' arrow key | 0,1,2 .. 95,96 Steps alternately up and down | |

| Trouble-shooting: | Nominal Value: | Cause of Fault: (If nominal values NOT attained) |
|---|---|---|
| o See test step 06 | | |

## 4.10 Table 7, F7: ECM RESET

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 01 | RESET IAC MOTOR<br><br>: RESET | Ignition ON<br>Engine at idle speed<br>TECH 1 Submode: F0: IAC MOTOR<br>Press "YES" key | ENGINE SPEED<br>... RPM ___IAC<br>IDLE AIR CONTROL<br>... STEPS ___RST | |

Trouble-shooting: Nominal Value: Cause of Fault:
(If nominal values NOT attained)

If the Submode: F0: IAC MOTOR is enabled, the ECM will control the IAC MOTOR to find the correct position. The IAC MOTOR will move to the closed position. The ECM will further accept this position as "0 STEPS". After reset, the IAC MOTOR will move to a posiotion who allow the engine to run on idle speed.

o See test step 06

## 4.10 Table 7, ECM RESET

| Test Step | TECH 1 - Display | Notes | Nominal Values | Possible Trouble Codes |
|---|---|---|---|---|
| 02 | RESET O2 BLM CELLS TO 128 : RESET | Ignititon ON<br>Engine at idle speed<br>TECH 1 Submode: F1:O2 BLM CELLS<br>Press "YES" key | O2 BLM CELL NO.<br>... ___BLM<br>FRONT O2 BLM<br>... STEPS ___RST | |

**Trouble-shooting:** **Nominal Value:** **Cause of Fault:**
(If nominal values NOT attained)

If the Submode: F1:O2 BLM CELLS is enabled, the ECM will allow the user to reset the O2 BLOCK LEARN MEMORY cells to 128 ( all learned values are lost ).

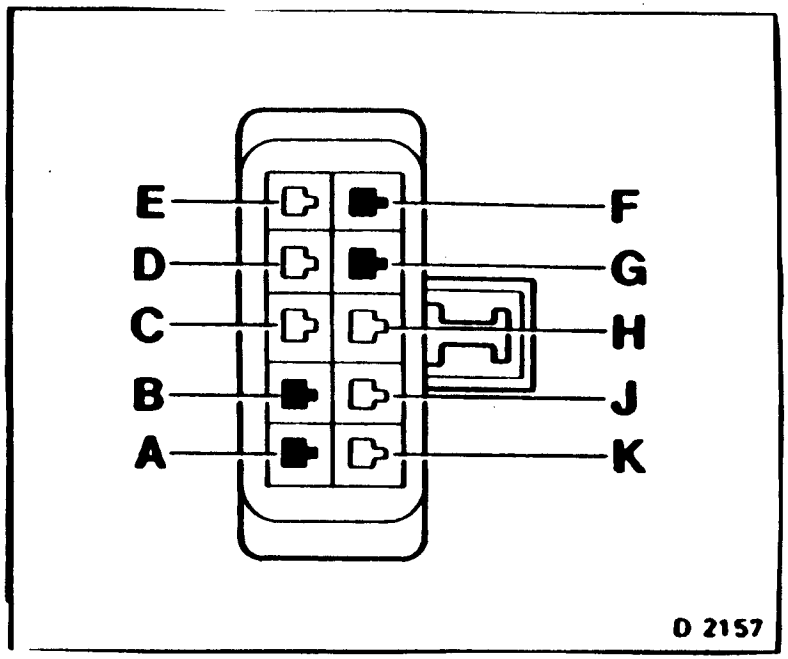
o If the programming is not possible, replace ECM

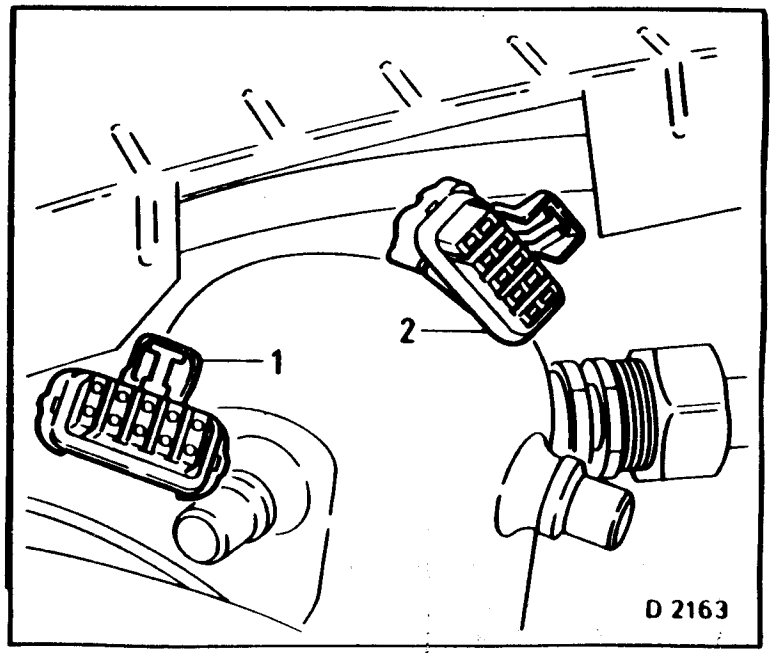
## 5 Terminal Assignment

### 5.1 Terminal Assignment in Diagnosic Plug X 130

A = Ground
B = Diagnostic excication lead for engine electronics

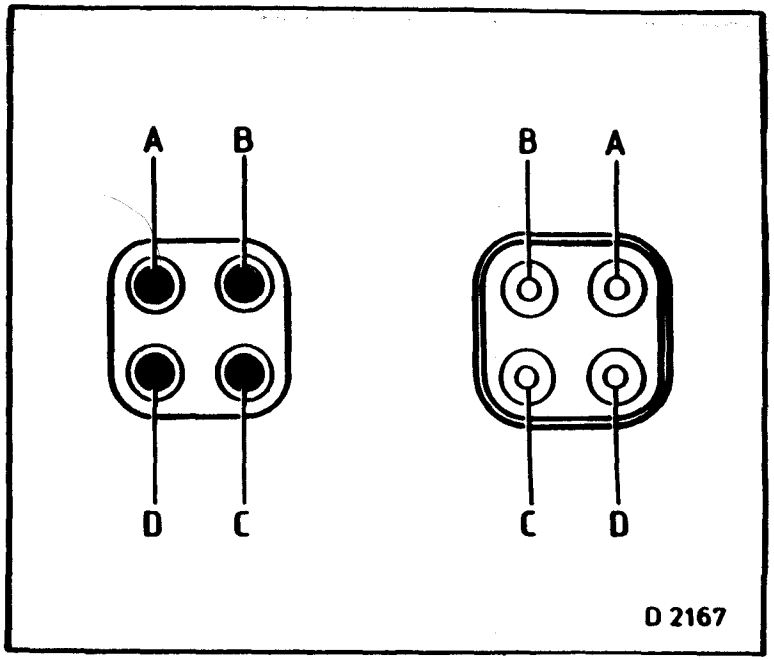
F = Battery voltage (Ter.30)
G = Bidirectional Data lead



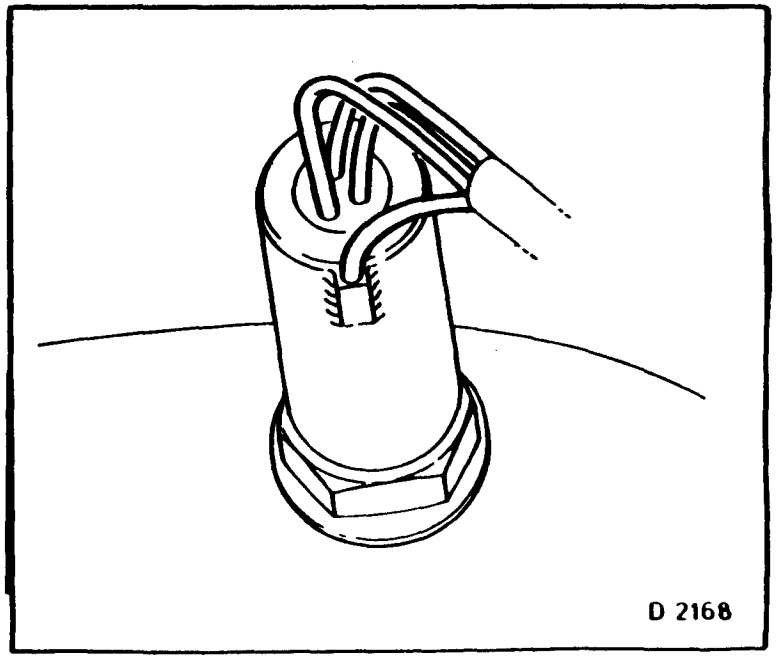



## 5.2 Terminal Assignment Oxygen sensor plug

A = Signal line to ECM
B = Oxegen Sensor heater line to 12 V
C = Signal line to ground (ECM pin J1-A21 and J3-C20)
D = Oxegen Sensor heater line to GND



D 2167

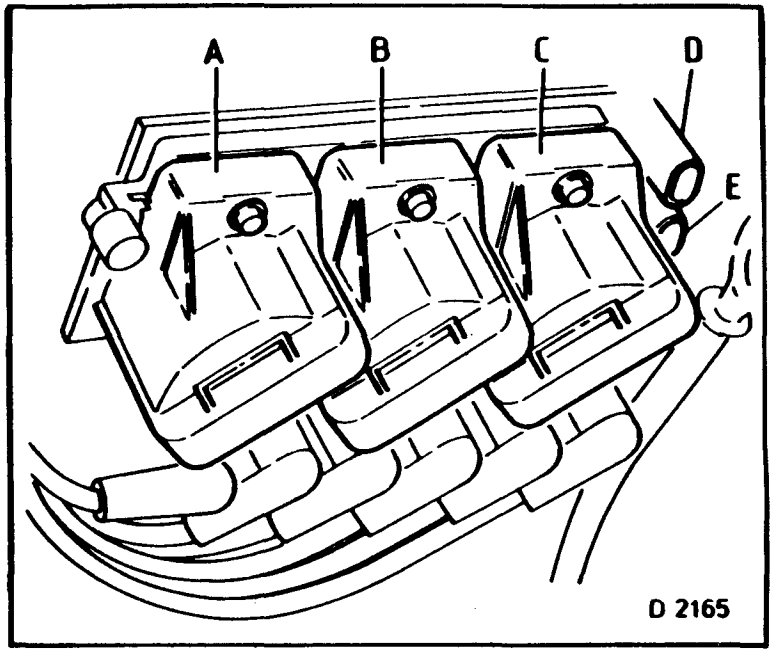

D 2168

## 5.3 Terminal Assignment DI-Module

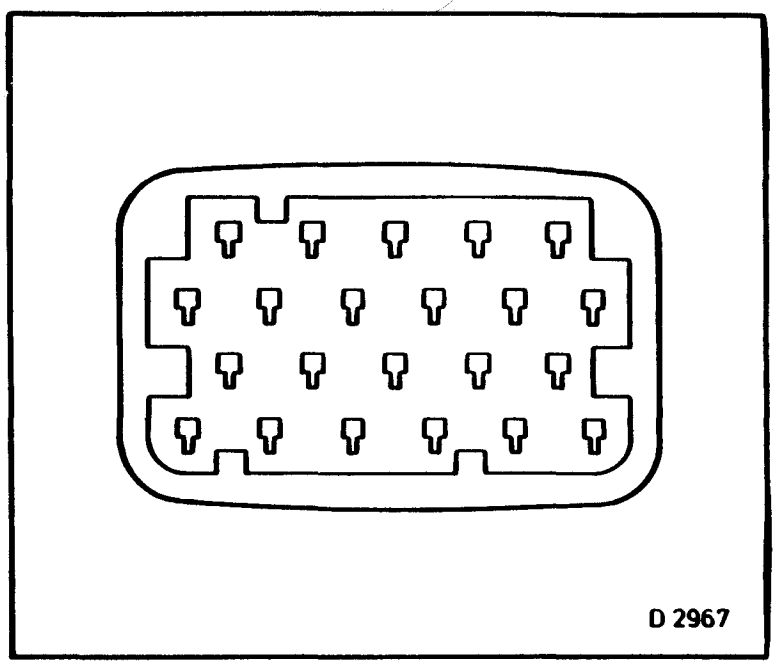
A = DI-Module ground
B = DI-Module to DIS_FUSE (7.5 AMP) and Ignition Power Relay

A = Line to Crank-Sensor, color "PG", twisted pair
B = not used
C = Line to Crank-Sensor, color "YR", twisted pair

A = BYPASS line to ECM J4-D1
B = EST line to ECM J4-D12
C = Tacho out to interface connector 2
D = not used
E = REF line to ECM J4-D18 "high"
F = REF line to ECM J4-D13 "low "



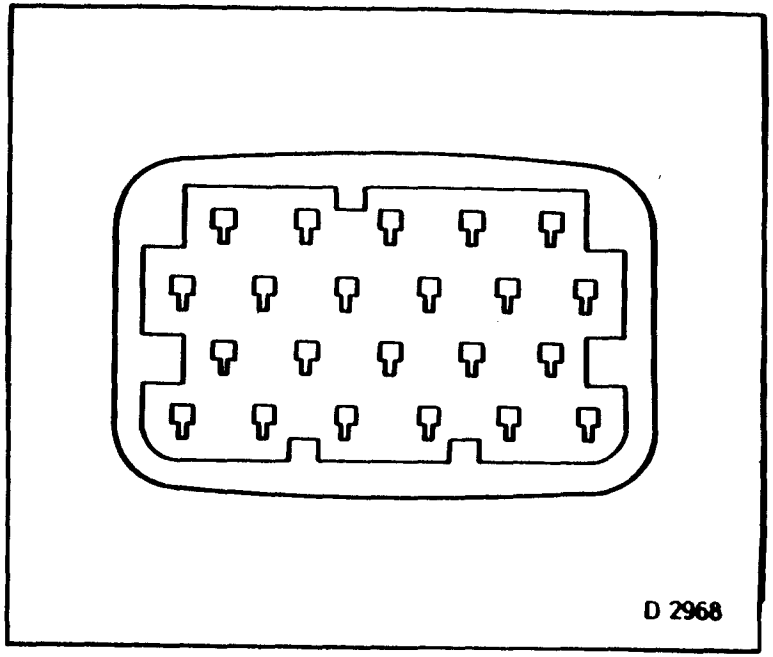
## 5.4 Terminal Assignment ECM "J1"




J1-A1 Injector "6" line
J1-A2 Injector "5" line
J1-A3 Injector "1" line
J1-A4 IAC stepper motor line "A"
J1-A5 IAC stepper motor line "C"
J1-A6 Vehicle Speed Sensor line "B"
J1-A7 Injector "3" line
J1-A8 Injector "4" line
J1-A9 IAC stepper motor line "B"
J1-A10 IAC stepper motor line "D"
J1-A11 Vehicle Speed Sensor line "A"
J1-A12 Injector "2" line
J1-A13 --
J1-A14 --
J1-A15 A/C Control Switch (color BW)
J1-A16 Right Oxygen Sensor line "A" (input)
J1-A17 To interface conector Speedometer
J1-A18 --
J1-A19 Line to Fuel Pump Relay Ter."6" (color OP)
J1-A20 --
J1-A21 Left Oxygen Sensor signal line "GROUND"
J1-A22 Line to Servotronic Electronic Module (color RY)
J1-A23 --
J1-A24 --

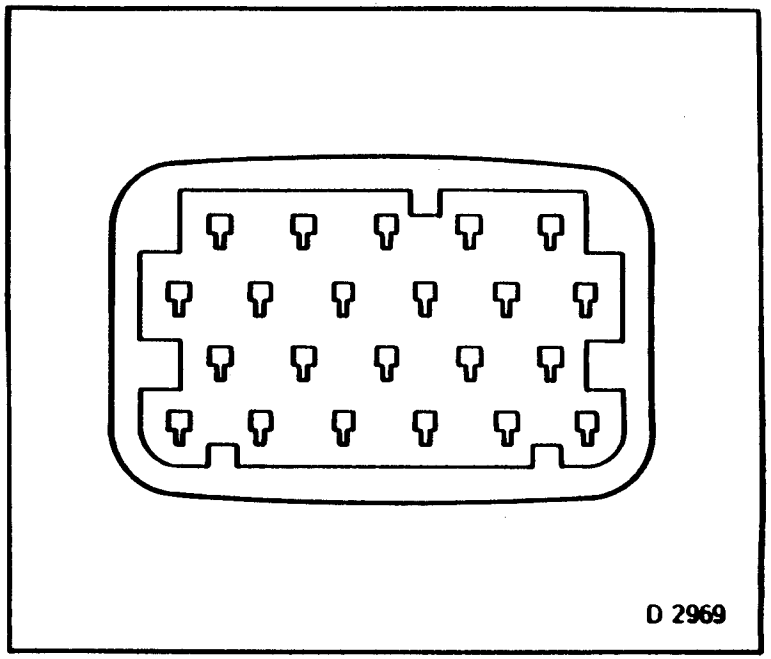
## 5.5 Terminal Assignment ECM "J2"

J2-B1 --
J2-B2 Line to ALDL-Conector "B" (excication lead)
J2-B3 Throttle Position Sensor line "2" (input)
J2-B4 MAP-Sensor line "B" (input)
J2-B5 ECM output +5 Volt to MAP, Baro- and TP-Sensor
J2-B6 ECM-Sensor Ground
J2-B7 --
J2-B8 ECM Voltage Supply
J2-B9 Coolant Temperature Sensor line "A" (input)
J2-B10 ECM Voltage Supply
J2-B11 ECM Voltage Supply (long-term memory)
J2-B12 Baro-Sensor line "B" (input)
J2-B13 --
J2-B14 --
J2-B15 --
J2-B16 ECM output GROUND to Baro-, TP- and CT-Sensor
J2-B17 ECM POWER GROUND
J2-B18 --
J2-B19 --
J2-B20 Electronic Spark Control Knock Sensor line (input)
J2-B21 Manifold air temperature Sensor line "A" (input)
J2-B22 --
J2-B23 --
J2-B24 --



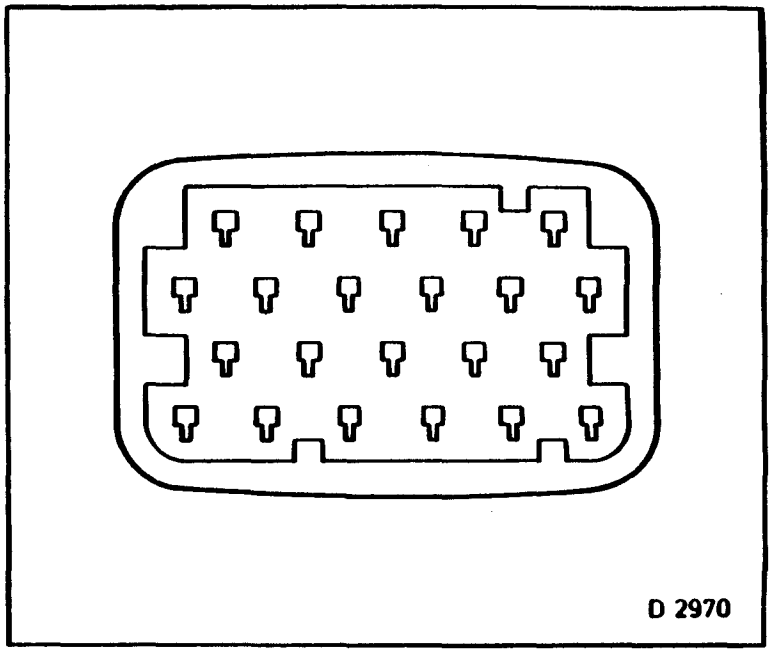
## 5.6 Terminal Assignment ECM "J3"

J3-C1 --
J3-C2 --
J3-C3 --
J3-C4 --
J3-C5 Line to HOT SOAK PUMP Relay coil (color OS)
J3-C6 Line to A/C - Interface conn. RAD FAN Relay coil
J3-C7 Line to A/C - Interface conn. A/C control switch
J3-C8 Only GND when A/C is not fitted.
J3-C9 --
J3-C10 To CHARCOAL CANNISTER PURGE SOLENOID
J3-C11 To interface conn. CHECK ENGINE LIGHT (color BLG)
J3-C12 ECM-POWER GROUND REDUNDANT
J3-C13 --
J3-C14 --
J3-C15 Left Oxygen Sensor line "A" (input)
J3-C16 ECM output to A/C-Clutch Relay (color LGN)
J3-C17 --
J3-C18 --
J3-C19 --
J3-C20 Right Oxygen Sensor line "GROUND"
J3-C21 --
J3-C22 --
J3-C23 --
J3-C24 --



## 5.7 Terminal Assignment ECM "J4"

J4-D1 BYPASS line to DI-Module
J4-D2 --
J4-D3 CAM Sensor input (color NW)
J4-D4 --
J4-D5 --
J4-D6 --
J4-D7 --
J4-D8 --
J4-D9 --
J4-D10 To WASTE GATE SOLENOID
J4-D11 --
J4-D12 EST-Line to DI-Module
J4-D13 REF-Line to DI-Module "low"
J4-D14 --
J4-D15 Line to ALDL-Conector "G" (bidirectional data lead)
J4-D16 --
J4-D17 --
J4-D18 REF-Line to DI-Module "high"
J4-D19 --
J4-D20 --
J4-D21 --
J4-D22 --
J4-D23 --
J4-D24 --



# 6 Circuit Diagram
## 6.1 Circuit Diagram LOTUS OMEGA

| | | |
|---|---|---|
| CON 2 | = | Interface Connector 2 (Tacho) |
| X7 Ter."B" | = | A/C Interface Connector (Control Switch) |
| X7 Ter."C" | = | A/C Interface Connector (Not used) |
| X7 Ter."F" | = | A/C Interface Connector (Rad Fan Coil) |
| CON 4 "1" | = | Servotronic Electronic Module Line |
| FAN | = | FAN (Controled by ECM) |
| FL 1 | = | Maxi Fuse 50 Ampere |
| FLA | = | Fuel Pump /Injectors Relay Fuse 20 Amp. |
| FLX | = | A/C Fuese 10 Ampere |
| FLZ | = | 02 / CAM-Sensor fuse |
| G 1 | = | Battery |
| G 2 | = | Alternator |
| K 3 | = | Theft Deterant Relay |
| K 31 | = | Fuel Pump Relay |
| K 32 | = | Ignition Power Relay |
| K 35 | = | A/C Clutch Relay |
| K 58 | = | Hot Soak Pump Relay |
| K 202 | = | Servotronic Electronic Module |
| K 203 | = | Electronic Hydr. Transducer |
| K 204 | = | Fan Relay |
| K 222 | = | ECM = Electronic Control Modul |
| L 1 | = | Oxygen Sensor Left |
| L 2 | = | Oxygen Senor Right |
| M 1 | = | Starter |
| M 21 | = | Fuel Pump |
| M 22 | = | Hot Soak Water Pump |
| M 33 | = | IAC Motor = Idle Air Control Valve |
| P 23 | = | MAP-Sensor = Manifold Absolute Pressure |
| P 24 | = | BARO-Sensor = Barometric Pressure Sensor |
| P 30 | = | MAT-Sensor = Mass Air Temperature |
| P 31 | = | CT -Sensor = Coolant Temperature Sensor |
| P 34 | = | TPS-Sensor = Throttle Position Sensor |
| P 35 | = | Magnetic Vehicle Speed Sensor |
| P 46 | = | Knock Sensor |
| P 47 | = | CAM-Sensor |
| S 1 | = | Ignition Switch |
| S 2 | = | Idle Pressure Switch (H.P.Line) |
| S 3 | = | H.P. Cut Out Switch (A/C Comp.) |
| S 4 | = | L.P. Cut Out Switch (H.P. Line) |
| S 5 | = | High Pressure Switch (A/C Compressor) |
| X 130 | = | ALDL-Connector Engine |
| Y 34 | = | Waste Gate Solenoid |
| Y 35 | = | Charcoal Canister Purge Solenoid |
| Y 36 | = | Hot Soak Pump Solenoid |
| Y 37 | = | A/C Clutch |

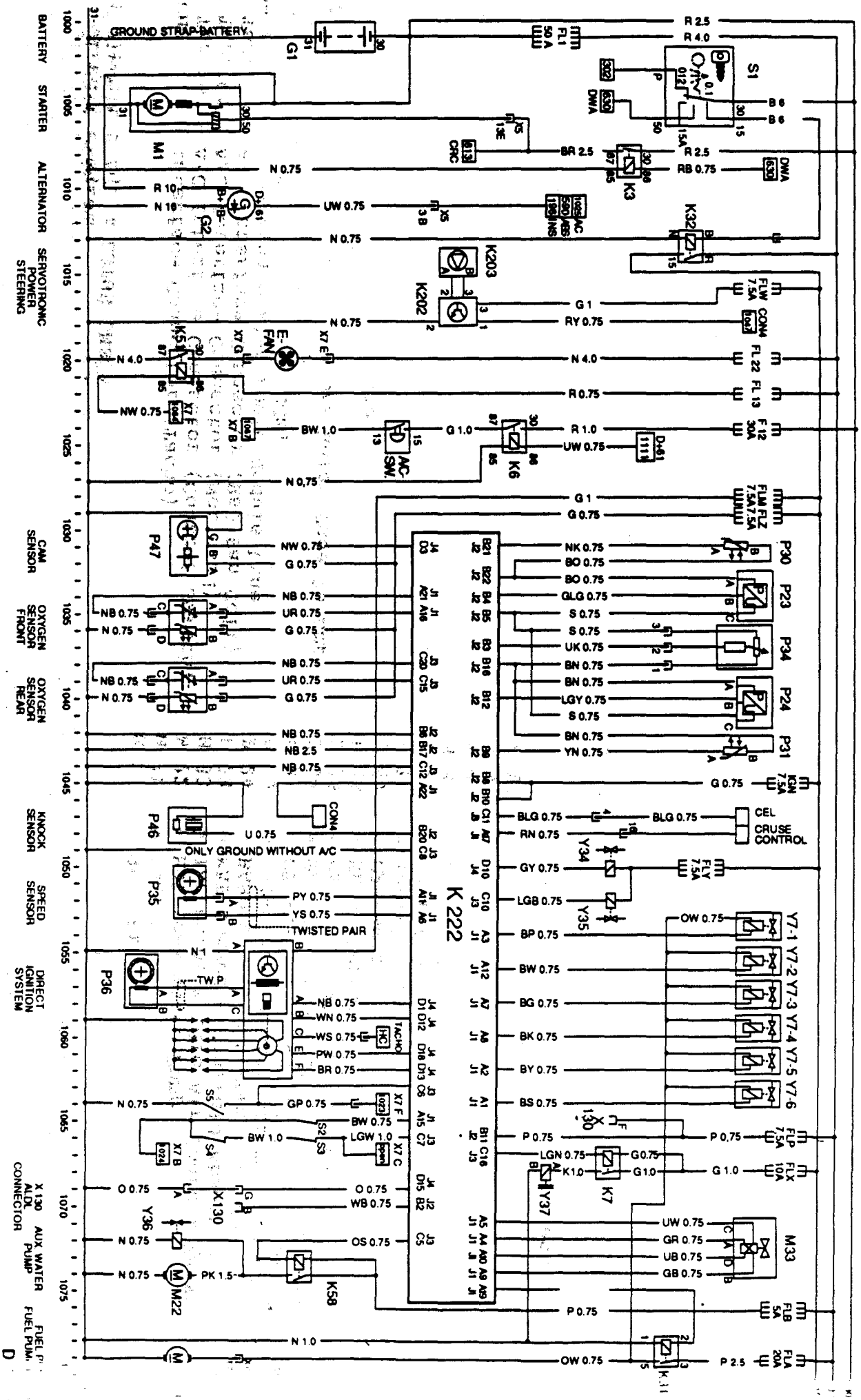
# 6 Circuit Diagram

## 6.1 Circuit Diagram LOTUS OMEGA

TACHO = Interface Connector (Tacho)
X7 Ter."B = A/C Interface Connector (Control Switch)
X7 Ter."C" = A/C Interface Connector (Not used)
X7 Ter."F" = A/C Interface Connector (Rad Fan Coil)
CON 4 = Servotronic Electronic Module Line
FAN = FAN (Controled by ECM)
FL 1 = Maxi Fuse 50 Amp.
FLA = Fuel Pump /Injectors Relay Fuse 20 Amp.
FLX = A/C Fuse 10 Amp.
FLZ = 02 / CAM-Sensor Fuse
G 1 = Battery
G 2 = Alternator
K 3 = Theft Deterant Relay
K 6 = Engine Run Relay
K 7 = A/C Clutch Relay
K 31 = Fuel Pump Relay
K 32 = Ignition Power Relay
K 58 = Hot Soak Pump Relay
K 202 = Servotronic Electronic Module
K 203 = Electronic Hydr. Transducer
K 204 (K51) = Fan Relay
K 222 = ECM = Electronic Control Modul
L 1 = Oxygen Sensor Left
L 2 = Oxygen Senor Right

M 1 = Starter
M 21 = Fuel Pump
M 22 = Hot Soak Water Pump
M 33 = IAC Motor = Idle Air Control Valve
P 23 = MAP-Sensor = Manifold Absolute Pressure
P 24 = BARO-Sensor = Barometric Pressure Sensor
P 30 = MAT-Sensor = Mass Air Temperature
P 31 = CT -Sensor = Coolant Temperature Sensor
P 34 = TPS-Sensor = Throttle Position Sensor
P 35 = Magnetic Vehicle Speed Sensor
P 46 = Knock Sensor
P 47 = CAM-Sensor
S 1 = Ignition Switch
S 2 = Idle Pressure Switch (H.P.Line)
S 3 = H.P. Cut Out Switch (A/C Comp.)
S 4 = L.P. Cut Out Switch (H.P. Line)
S 5 = High Pressure Switch (A/C Compressor)
X 130 = ALDL-Connector Engine
Y 34 = Waste Gate Solenoid
Y 35 = Charcoal Canister Purge Solenoid
Y 36 = Hot Soak Pump Solenoid
Y 37 = A/C Clutch

# 6.1 Circuit Diagram LOTUS CARLTON



# LOTUS - OMEGA / CARLTON TRAINING