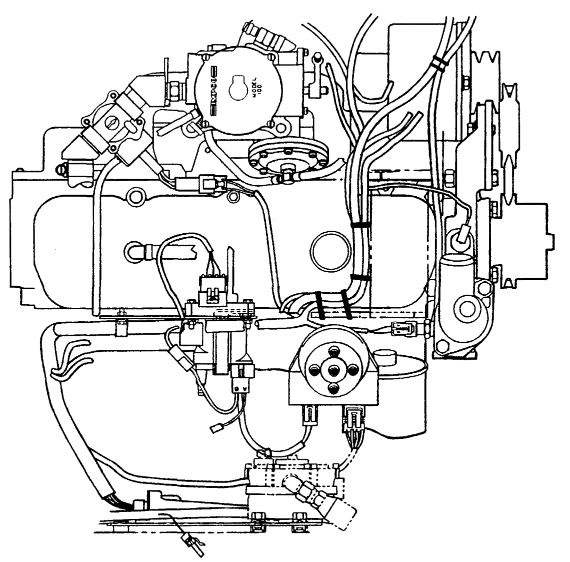
MICROPROCESSOR SPARK TIMING SYSTEM (MSTS)

GM 3.0L

S/H2.00–3.20XM
(S/H40–65XM)



HYSTER

PART NO. 897844

2200 SRM 603

SAFETY PRECAUTIONS
MAINTENANCE AND REPAIR

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

CONTENTS

This section is for the following models:
S/H2.00–3.20XM (S/H40–65XM)

INTRODUCTION

GENERAL

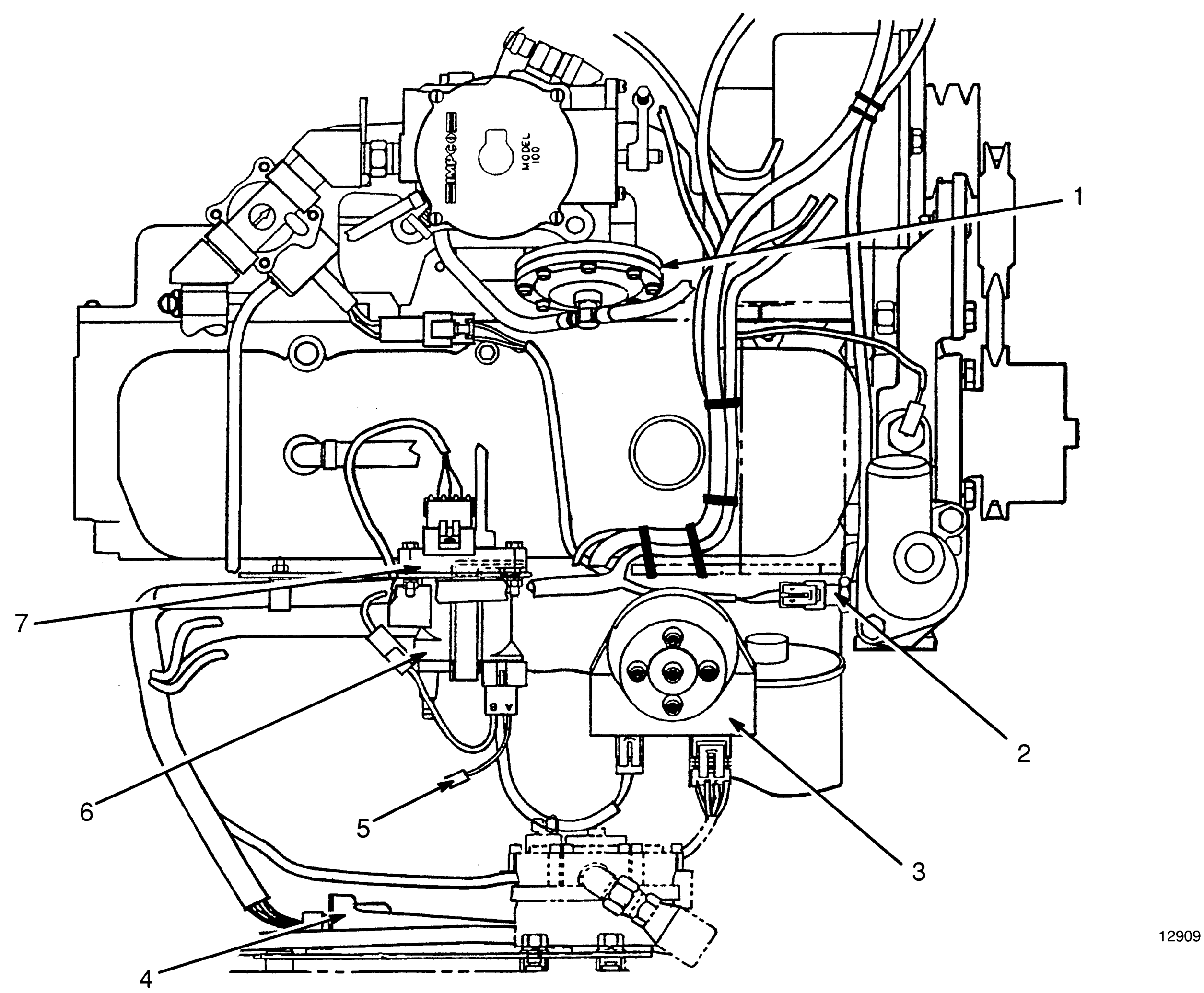
This section describes the operation of the Microprocessor Spark Timing System (MSTS). The MSTS ignition system is used on engines that use an LPG fuel system. REPAIRS and TROUBLESHOOTING procedures are also in this section

DESCRIPTION

The general operation of the MSTS system is described in the following paragraphs. The description of the components and a circuit analysis is given in the paragraphs under OPERATION.

What MSTS Does

The MSTS module receives signals from sensors mounted on the engine and electronically processes the information to adjust the ignition timing for the best fuel use and engine performance.



1. GOVERNOR
2. ENGINE COOLANT TEMPERATURE (ECT) SENSOR
3. DISTRIBUTOR
4. MSTS MODULE
5. TACHOMETER CONNECTOR
6. IGNITION COIL
7. MAP SENSOR

FIGURE 1. MSTS ARRANGEMENT IN THE ENGINE COMPARTMENT

The MSTS module receives signals from the following sensors:

- Manifold Absolute Pressure (MAP) sensor. This sensor is a pressure transducer that measures the atmospheric pressure before the engine is started. The MSTS module uses this pressure as a reference. This sensor then measures changes in pressure in the intake manifold during engine operation.
- Engine Coolant Temperature sensor (ECT). This sensor is a thermistor (resistor that is calibrated to change its value as its temperature changes).
- The ignition module is a small electronic module within the distributor. This module is a signal converter that senses the operation of the distributor. A sensing coil in the distributor senses the rotation of the timer core and the ignition module senses the speed of rotation. A square wave generator in the ignition module converts the pulses from the sensing coil to a square wave signal that is sent to the MSTS module. If the signals from the ignition module to the MSTS indicate that the engine is rotating at less than 400 rpm, the MSTS module determines that the engine is being rotated by the starter. The ignition module controls the ignition for an engine being started. The Electronic Spark Timing (EST) function from the MSTS module is deenergized. If the signals from the ignition module to the MSTS module indicate that the engine is rotating at greater than 400 rpm, the MSTS module determines that the engine is running and the Electronic Spark Timing (EST) controls the ignition.

How MSTS Begins Operation

When the ignition switch is turned to **ON**, the MSTS module measures the atmospheric pressure (BARO signal) from the MAP sensor. The MSTS module also checks the signal from the engine coolant temperature sensor (ECT). When the starter is engaged, the ignition module sends electronic pulses to the MSTS module. The frequency of the pulses indicates to the MSTS module that the engine is being started. The ignition module also electronically energizes (**ON**) and deenergizes (**OFF**) the primary circuit of the ignition coil to create a spark at the spark plugs.

When the engine starts, the frequency of the pulses from the ignition module increases and indicates to the MSTS module that the engine is running. The MSTS module then sends a by–pass signal to the ignition module that removes control of the spark (ignition) timing from the ignition module. The MSTS module takes control of the ignition timing and follows its program to give ignition timing for the best engine operation. When the engine is operating, the MSTS module continuously checks the signals from the MAP, ECT, and distributor speed to make timing adjustments for the engine operating conditions.

OPERATION

Distributor

A timer core (permanent magnet) on the shaft of the distributor has external teeth which align with an equal number of teeth on the pole piece. See FIGURE 2. When the teeth of the timer core rotate past the teeth of the pole piece, there is a decrease in the air gap between the timer core and the pole piece. The magnetic field increases. When teeth are not aligned, the magnetic field decreases between the timer core and the pole piece. As the timer core rotates, the magnetic field increases and decreases in a cycle.

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

The principle of magnetic induction also controls the polarity of the voltage generated in the coil. An increasing magnetic field will generate a voltage in the coil that is the opposite polarity of a magnetic field that is decreasing. This signal pulse causes the integrated circuits in the ignition module to generate a square wave signal. The ignition module and a magnetic pulse generator control the primary circuit to the ignition coil when the engine is started. After the engine is started, the MSTS module receives the square wave signal from the magnetic pulse generator and ignition module as one of the signals to control the EST. The pole piece has the same number of teeth as the engine has cylinders so that a spark voltage is correctly sent to each spark plug as the shaft in the distributor rotates.

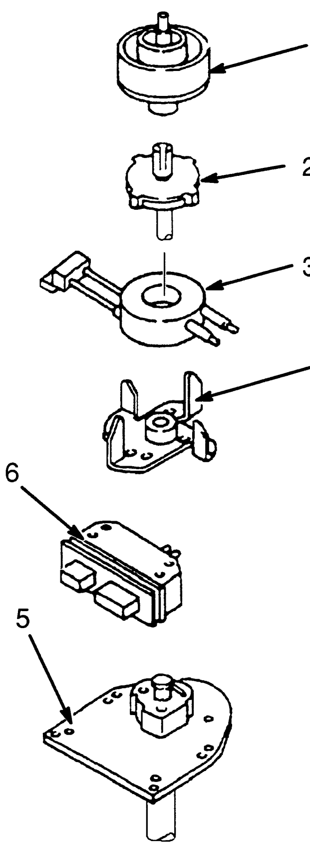


FIGURE 2. DISTRIBUTOR

Ignition Module

The ignition module is a solid–state electronic device that operates like a fast switch except that it does not have any moving or mechanical parts. See FIGURE 3. Small electrical pulses from the sensing coil of the pulse generator go to the ignition module.

The MSTS module must always know the speed at which the engine is operating. The engine speed signal is generated by the ignition module. The signal converter in the ignition module changes the signal voltage from the sensing coil to a square wave reference signal to the MSTS module. This square wave reference signal for engine speed is called "REF HI". The MSTS module must also have a reference to compare with "REF HI". An additional wire between the MSTS module and the ignition module is called "REF LO". The "REF HI" and "REF LO" connections give the PROM in the MSTS module the necessary information about engine speed.

The other two wires between the MSTS module and the distributor control the Electronic Spark Timing and are called "EST" and "BY–PASS".

NOTE: The ignition module controls spark timing only when the the engine is being started. The MSTS module controls the spark timing during engine operation. The ignition module will also control the spark timing if there are some failures in the signals to the MSTS module. This "back–up" mode of operation will often permit operation of the engine so that the lift truck can be moved to an area for repair. The results of the failures in signals to the MSTS module is described in the paragraphs under MSTS Module Corrections.

When the Engine Is Being Started

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

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

When the Engine Is Running

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

The ignition module and the ignition timing is now controlled by the "EST" signal from the MSTS module. This mode of operation is called the "EST mode".

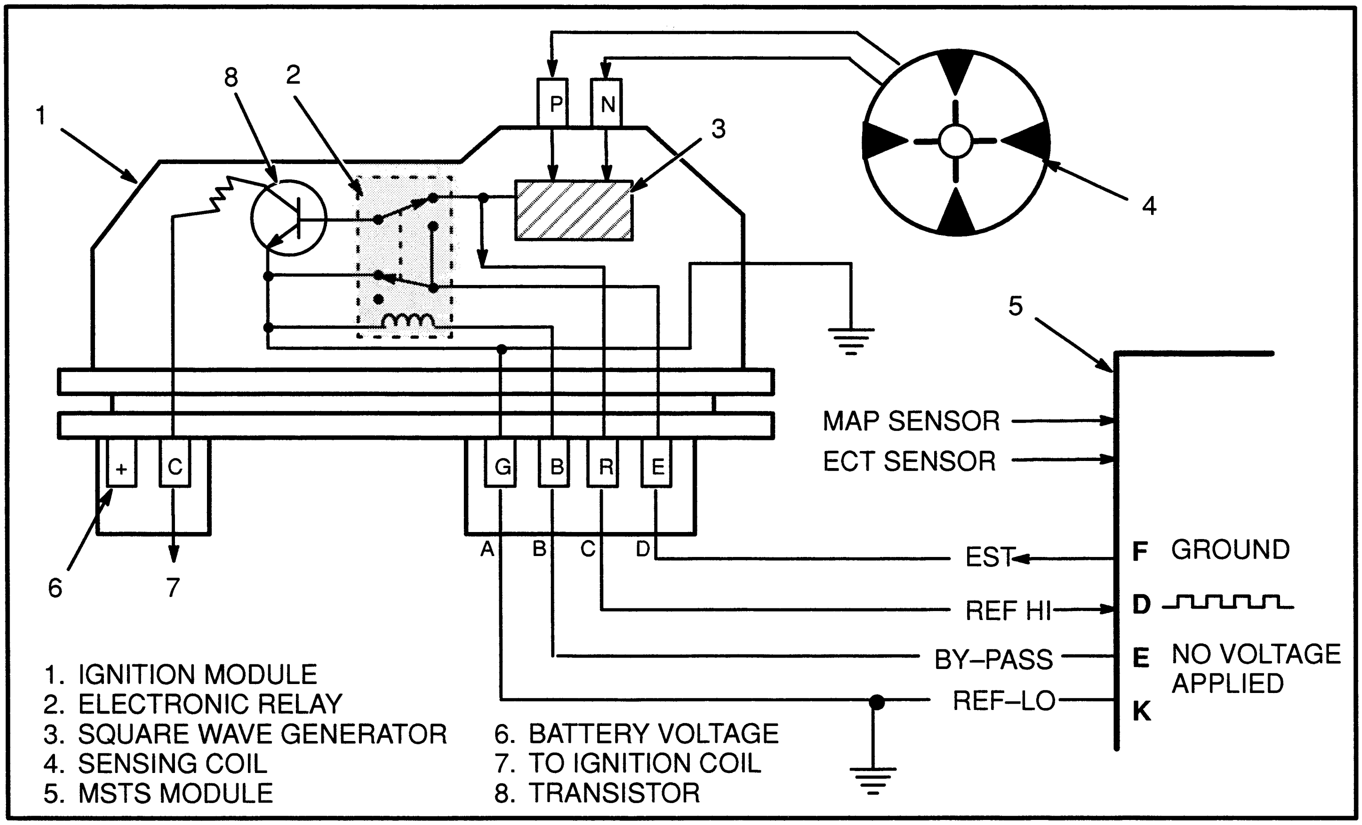


FIGURE 3. IGNITION MODULE WHEN ENGINE IS BEING STARTED

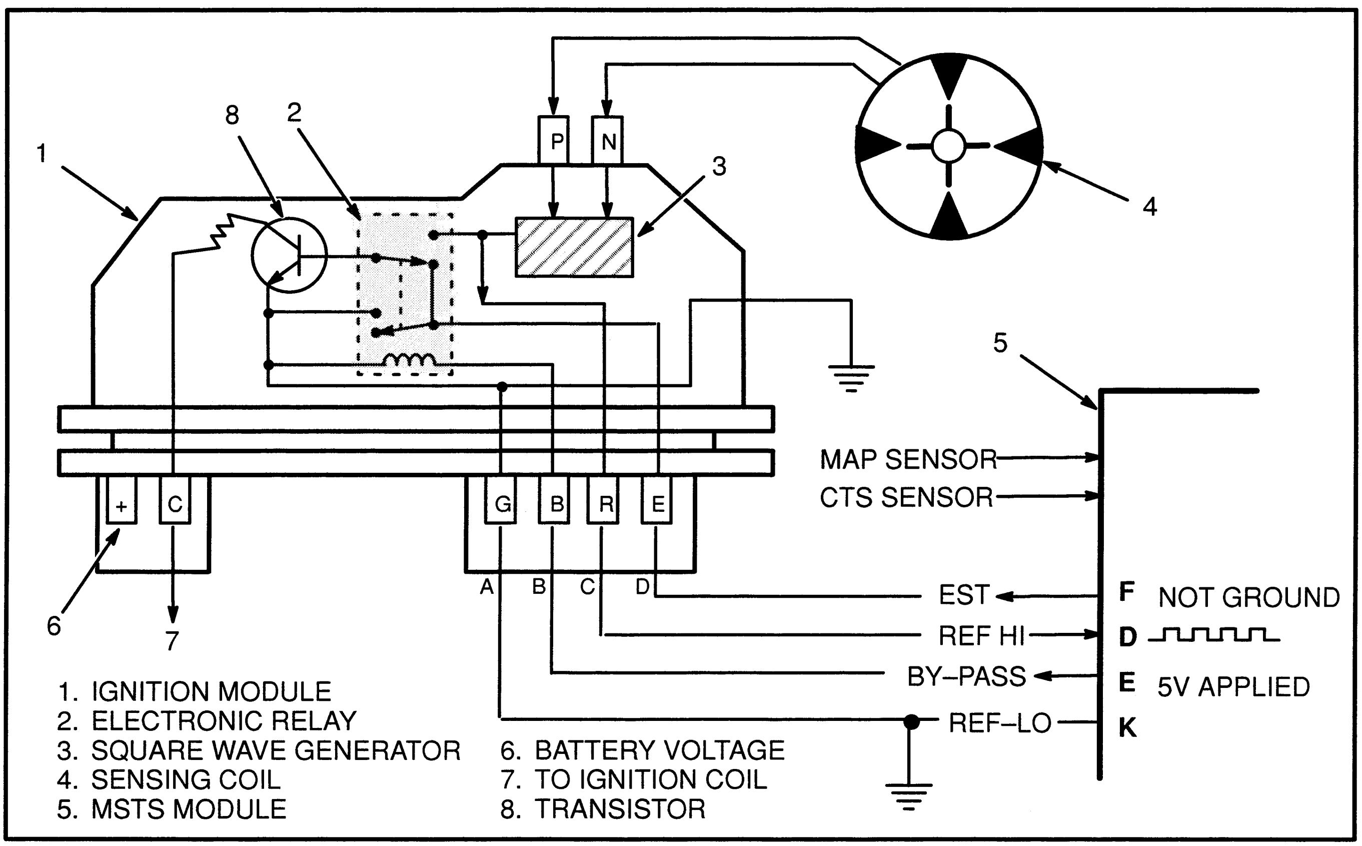


FIGURE 4. IGNITION MODULE WHEN ENGINE IS RUNNING

Manifold Absolute Pressure (MAP) Sensor

The Manifold Absolute Pressure (MAP) sensor is a pressure transducer that measures changes in the pressure in the intake manifold. See FIGURE 5. The pressure changes are a result of engine load and speed changes. The MAP sensor converts these pressure changes to a signal voltage to the MSTS module.

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

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

The MAP sensor also measures the barometric pressure when the key switch is turned to **ON** and before the engine is started. The MSTS module "remembers" the barometric pressure (BARO signal) after the engine is running. The MSTS module then automatically adjusts the ignition timing for different altitudes and atmospheric conditions.

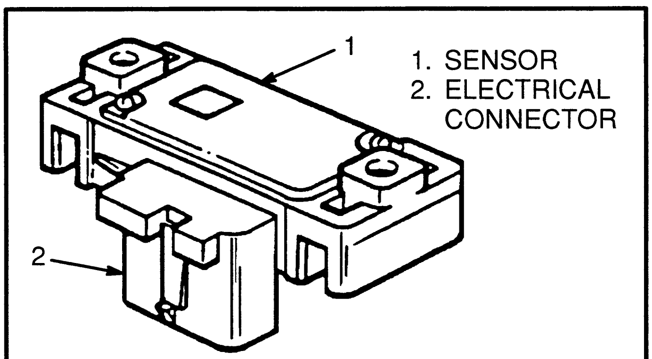


FIGURE 5. MAP SENSOR

Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature (ECT) sensor (FIGURE 6.) is a resistor that changes its resistance value when the temperature changes (thermistor). This sensor is installed in the engine coolant system. A low coolant temperature makes the thermistor have a high resistance [100 700 ohms at –40°C (–40°F)]. A higher coolant temperature makes the thermistor have a lower resistance [77 ohms at 130°C (266°F)].

The engine coolant temperature sensor uses a thermistor to control the signal voltage to the MSTS module. The MSTS module applies a 5–volt reference voltage to the ECT. See FIGURE 7. The reference voltage will be high when the engine coolant is cold. The reference voltage will be lower when the engine coolant is at operating temperature. The MSTS module will adjust the ignition timing for more spark advance when the engine coolant is cold and less spark advance when the engine coolant is hot. An engine at operating temperature normally needs less spark advance.

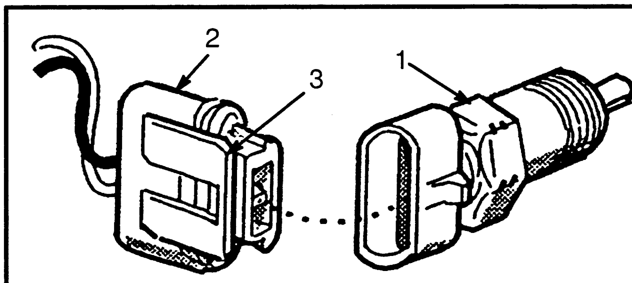


FIGURE 6. ENGINE COOLANT TEMPERATURE (ECT) SENSOR

MSTS Module Corrections

The operation of the MSTS module was described in earlier paragraphs. (See the description in "What MSTS Does") These paragraphs describe the corrections made by the MSTS module.

The MSTS module does a check of the system components. A set of normal operating limits are part of the PROM program. If a sensor sends a signal that is outside of the limits of the PROM program, the MSTS module will not use the information. The MSTS module will use a standard value from its program and continue to operate the MSTS.

The following examples are the action of the MSTS module if it finds a problem:

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

ECT Signal Voltage Is Too High Or Too Low. When a coolant sensor error occurs, the MSTS module will use a value that is approximately the normal operating temperature of the coolant.

Open Circuit From The MSTS Modules To The Ignition Module. If the EST circuit is open, it can not be at ground potential and the EST signal will rise and fall from the sensing coil. The engine will not run. If the EST circuit becomes open when the engine is running, it will stop.

Short–Circuit (Grounded Circuit) From The MSTS Module To The Ignition Module. When the engine is being rotated by the starter, the MSTS module normally detects 0 volts in the EST circuit because the circuit is at ground potential in the ignition module.

The MSTS module would not detect a problem until the engine began to run. The MSTS module could not operate in the EST mode and the engine will not operate. If the EST circuit has a short–circuit (grounded circuit) when the engine is running, it will stop.

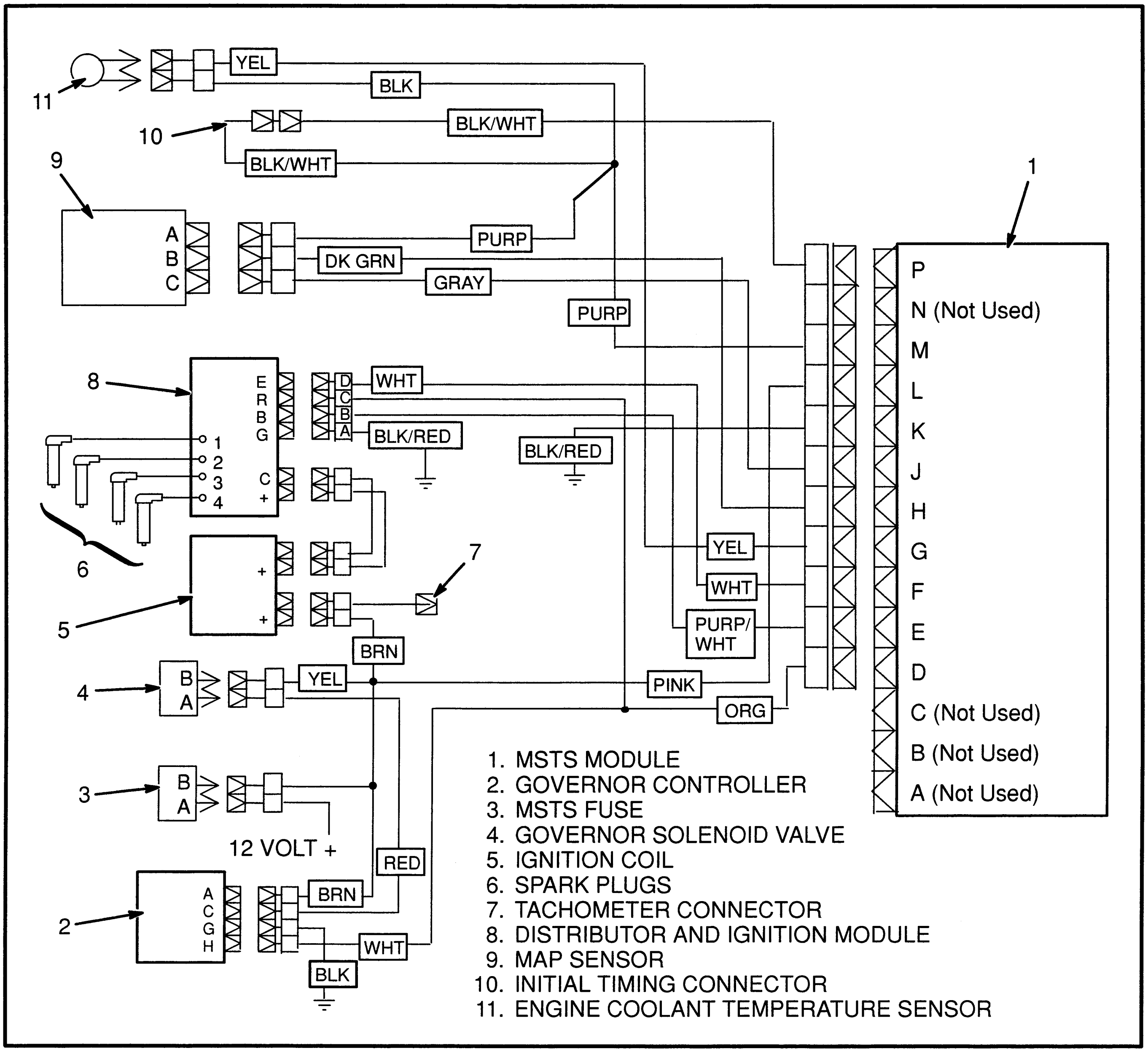


FIGURE 7. MSTS WIRING DIAGRAM

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

Open Circuit Or Short–Circuit In The REF HI Circuit. The MSTS module would not detect that the engine was operating. The MSTS module could not operate in the EST mode and the engine would operate with reduced power. If this problem occurs when the engine is running, the engine will only operate in the starting mode with the ignition module.

Open Circuit Or Short–Circuit In The REF LO Circuit. The MSTS module would not have a comparison for operation. The MSTS module could not operate in the EST mode and the engine will not operate. If this problem occurs when the engine is running, it will stop.

Initial Timing Connector

In addition to the sensor inputs, the MSTS module checks the voltage in a wire from a special plug called the "initial timing connector".

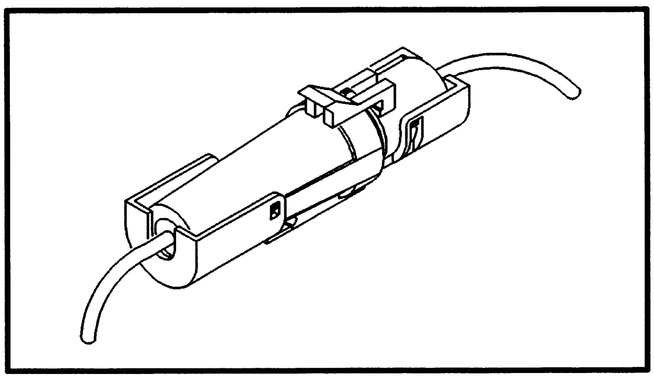


FIGURE 8. INITIAL TIMING CONNECTOR

This initial timing connector is installed in the engine electrical harness to the distributor. This initial timing connector is opened to adjust the initial ignition timing. When the initial timing connector is opened, the correct timing adjustment is 8° BTDC. The ignition timing after the initial timing connector is installed is controlled by the MSTS module.

GOVERNOR SYSTEM (See FIGURE 1.)

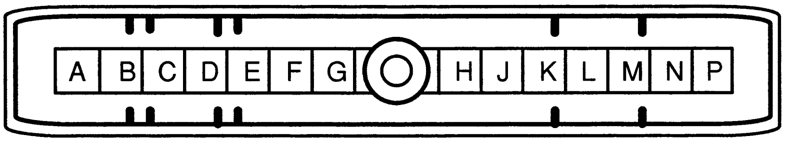
The governor system controls the maximum engine speed under variable load conditions. The governor attaches to the carburetor throttle assembly. The governor controller is on the cowl in the operator compartment. Vacuum lines connect the governor solenoid valve to the carburetor and to the diaphragm of the governor. The governor controller is electrically connected to the governor solenoid valve, MSTS module and the ignition coil.

The operation of the governor is controlled by the governor controller. Manifold vacuum and air pressure provide the force to actuate the governor. The governor controller controls this force. The governor diaphragm operates the throttle plate of the carburetor. Linkage from the diaphragm closes the throttle plate when the vacuum is high. A spring in the governor opens the throttle plate.

The governor controller is connected to the MSTS module and controls the operation of the governor solenoid valve. The governor solenoid valve controls the vacuum at the diaphragm in the governor. During operation, the governor controller receives the engine speed signals. As the engine speed reaches the limit of the governor, current flows to the governor solenoid valve. The solenoid valve closes, causing vacuum to operate the diaphragm. When actuated, the diaphragm works against the governor spring to close the throttle plate and decrease engine speed. The governor solenoid valve opens and closes as necessary to keep the engine speed within the governor limits.

This voltage chart is for use with a digital voltmeter when doing troubleshooting. There can be small variations in the voltage shown in the chart from those voltages measured during troubleshooting. These small variations are because of the battery charge and other resistances in the connections. A variation of more than 0.5 volts can be an indication of a malfunction.

When this chart is used for troubleshooting, the engine must be at its operating temperature and the engine must be at idle speed (for ENGINE RUNNING column).



14–PIN CONNECTOR

MSTS MODULE CONNECTOR		WIRE COLOR	**SENSOR CONNECTOR**		**NORMAL VOLTAGE**	
PIN	FUNCTION		PIN	FUNCTION	KEY **ON**	ENGINE RUNNING
A	Not Used	–	–		–	–
B	Not Used	–	–		–	–
C	Not Used	–	–		–	–
D	Reference	Orange White	C H	Ignition Module Governor Controller	0	1.3
E	By–pass	Purp/White	B	Ignition Module	0	4.75
F	EST	White	D	Ignition Module	0	1.3
G	ECT Sensor	Yellow	B	MSTS To ECT Sensor	1.6*	1.6*
H	MAP Sensor Signal	Dk Green	B	Manifold Absolute Pressure	4.75**	1.1**
J	+5 Volt Reference – MAP	Gray	C	Manifold Absolute Pressure	5.0	5.0
K	System Ground	Black/Red			0	0
L	Ignition	Pink		Battery Voltage From Ignition Switch	B+	B+
M	Ground Connector For Sensors	Purple	A	MAP Sensor, ECT Sensor, Initial Timing Connector	0	0
N	Not Used	–	–		–	–
P	Initial Timing Connector	BLK/WHT	–		5.0	5.0

* Voltage changes with temperature.
** Voltage changes with atmospheric pressure.

FIGURE 9. MSTS MODULE CONNECTIONS

TROUBLESHOOTING

GENERAL

The following troubleshooting charts are designed to give an efficient method of fault analysis on the MSTS.

⚠ WARNING

This troubleshooting requires the operation of the engine for some of the tests. Make sure the tests are done carefully to prevent injury:

- **Put the lift truck on a level surface. Lower the carriage and forks and apply the parking brake. Make sure the lift truck can not move and cause an injury during the tests. Put blocks in front and back of the drive tires to prevent movement of the lift truck.**
- **The fuel system and the engine must operate correctly. Any problems or leaks in the fuel system or the engine must be repaired before doing troubleshooting on the MSTS.**
- **The fan and the drive belts can remove fingers or cause other injuries. Be careful that your hands and tools do not touch the moving fan or the drive belts.**
- **The engine exhaust and other parts of the engine are hot. Do not touch a hot surface and cause a burn.**

⚠ CAUTION

Electronic equipment can be damaged if trouble–shooting and repairs are not done correctly. The following CAUTIONS must be followed when doing troubleshooting or repairs on an engine with MSTS:

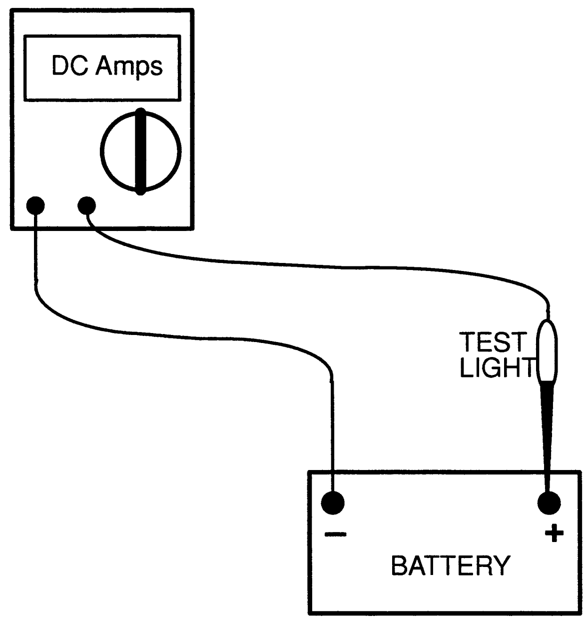
- **Always disconnect the battery negative cable before disconnecting and removing any parts of ignition system.**
- **Never disconnect the battery from any equipment when the engine is running.**
- **If the battery must be charged with a battery charger, ALWAYS disconnect the battery from the electrical system.**
- **Make sure that all electrical connections are clean and have good electrical contact.**
- **Never connect or disconnect the wiring harness at the MSTS module when the key switch is "ON".**
- **Always disconnect the battery and the MSTS module connectors if electric arc welding must be done on the vehicle.**
- **Make sure that any water or steam is not sent toward the MSTS module or its sensors if the engine compartment is cleaned with steam. The heat and steam can damage the electronic components and cause corrosion in the electrical connections.**
- **Use only the tools and test equipment described in "TOOLS AND TEST EQUIPMENT" to prevent damage to good components and to obtain correct test results.**
- **All voltage measurements must be done with a digital voltmeter with a rating of 10 megohm input impedance.**
- **When a test light is used in troubleshooting, the test light must have less than 0.3 amps (300 milliamps) of maximum current flow. A test for a correct test light is shown in FIGURE 10.**

TOOLS AND TEST EQUIPMENT

The following tools are necessary for troubleshooting the MSTS:

- Ohmmeter
- Digital voltmeter. The voltmeter must have a minimum input impedance of 10–megohms. (A digital voltmeter and ohmmeter are normally included in a multi–meter test instrument.
- Tachometer with inductive trigger signal sensor.
- Test light that has a low current draw as described in FIGURE 10.
- Vacuum pump with a gauge. This vacuum pump is held and operated with the hand. The gauge must be able to indicate a gauge pressure (vacuum) of 34 kPa [20 inches of mercury (20" Hg)]. (See the PRESSURE CONVERSION CHART at the end of this section.)

- Spark tester. The spark tester is used to check the secondary ignition. The spark tester is also called an ST125 and creates a 25 kilovolt load on secondary ignition components.



If the ammeter indicates **less** than 0.3 amps (300 milliamps), the test light **can be used**.

If the ammeter indicates more than 0.3 amps (300 milliamps), the test light **can not be used** because it can cause damage to the electronic components.

FIGURE 10. CURRENT FLOW TEST FOR A TEST LIGHT

MSTS

Test Description (See FIGURE 11.)

The numbers in circles on the troubleshooting chart have the following indications:

① This step checks if there is a problem in the basic distributor or ignition coil assembly.

② This step checks if the Electronic Spark Timing (EST) is working. If the initial timing connector is disconnected when the engine is running, the EST reference signal is removed from the ignition module. The engine runs only with a timing of 8° BTDC.

③ This step checks the operation of the MAP sensor.

④ The parts of the MSTS operate correctly when the engine is at normal operating temperature, but not when the engine is cold. There is a troubleshooting chart for the engine coolant temperature sensor (ECT).

⑤ In addition to checking the wires for an open circuit, make sure to check the fastening screw for the ignition module. The MSTS is grounded through this screw.

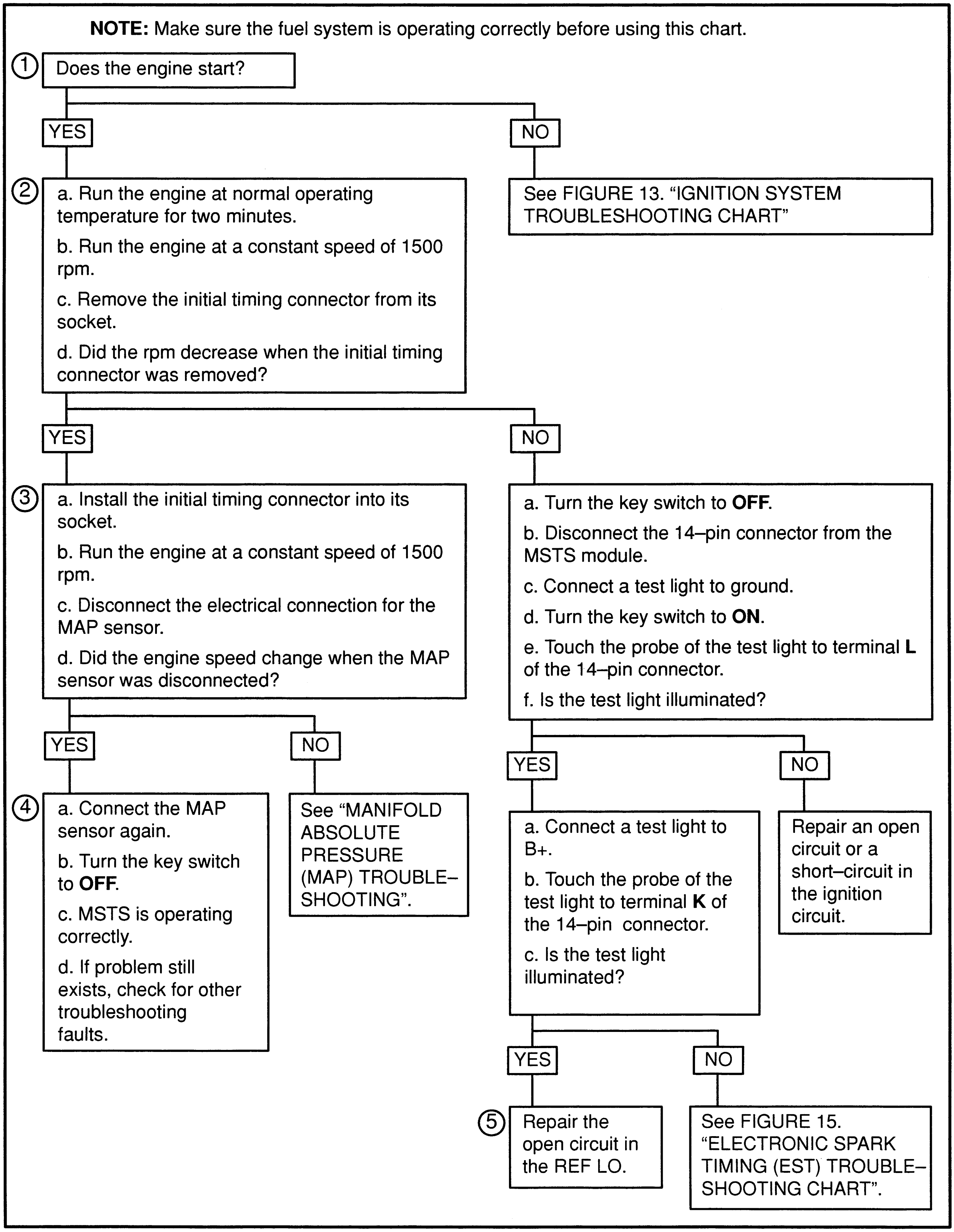


FIGURE 11. MSTS TROUBLESHOOTING CHART

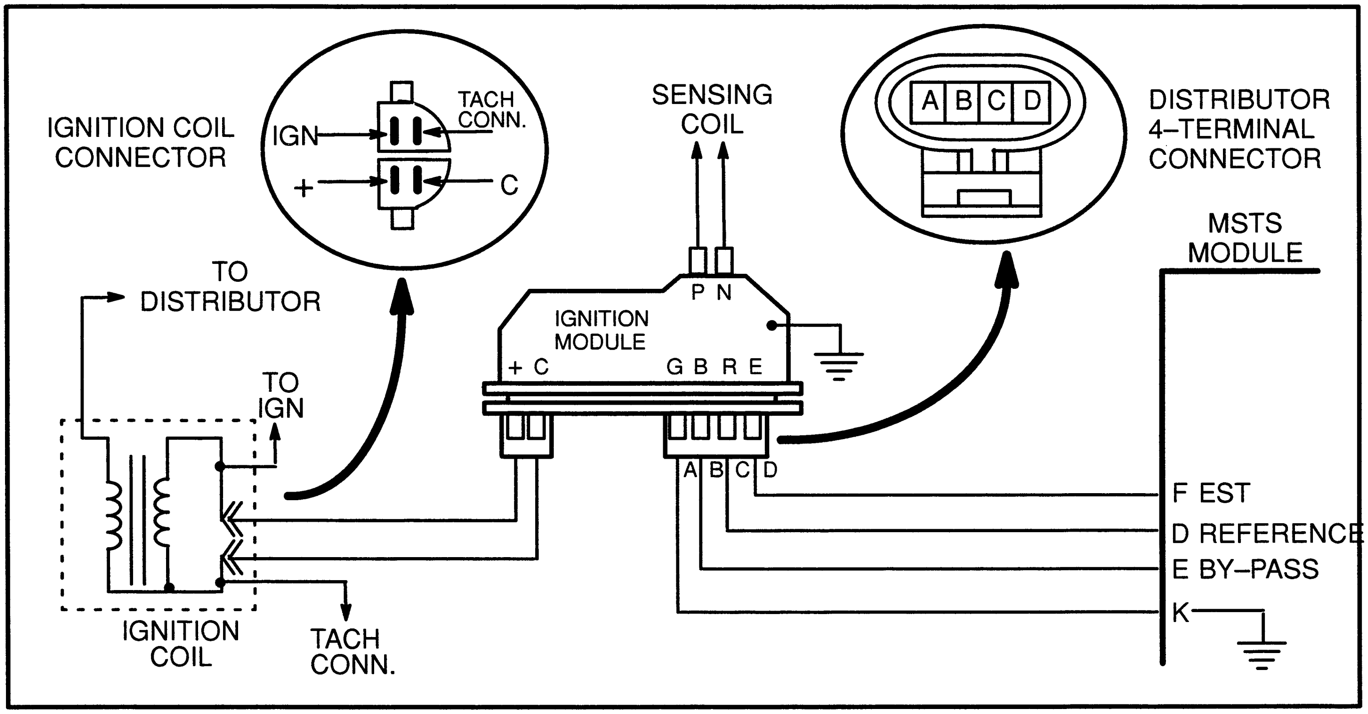


FIGURE 12. IGNITION SYSTEM CIRCUIT

IGNITION SYSTEM

Test Description (See FIGURE 12.)

If a tachometer has been connected to the **TACH CONN.**, disconnect it before doing this test. The numbers in circles on the troubleshooting chart (FIGURE 13.) have the following indications:

(1) Check a minimum of two spark plug wires to make sure that one of the spark plug wire does not have an open circuit.

(2) If a spark occurs when the EST connector is disconnected, the output from the sensing coil is too low for EST operation.

(3) A spark indicates that the fault is in the distributor cap or the rotor.

(4) The normal voltage at the **C** and the + terminals is battery voltage. A low voltage can indicate:
a. An open circuit or a high resistance circuit from the distributor to the ignition coil or
b. An open circuit in the primary winding of the ignition coil.

If the voltage at **C** is less than battery voltage, and there is 10 volts or more at +, there is an open circuit from **C** to the ignition coil or an open circuit in the primary winding of the ignition coil.

(5) Check for a short–circuit in the ignition module or in the circuit from the ignition coil to the ignition module. Check for approximately 12 volts between the **TACH CONN.** and ground.

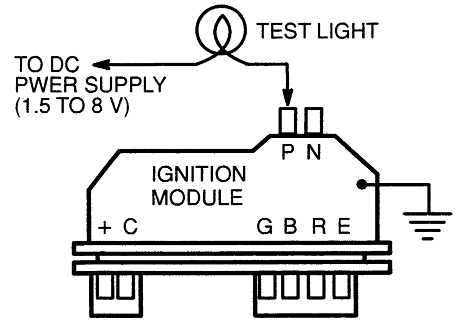
If the voltage is low (approximately 1 to 6 volts), there can be a fault in the ignition coil. This condition can cause a failure in the ignition coil from too much heat. If there is an open circuit in the primary winding of the ignition coil, a low voltage can "leak" through the ignition module from the **B+** to the **TACH CONN.** terminal.

(6) The ignition module normally goes **ON** when 1.5 to 8 volts is applied to terminal **P**. When the ignition module is **ON**, the voltage between the **TACH CONN.** and ground will normally decrease to 7 to 9 volts. This test checks if the sensing coil or the ignition module has a fault. When 1.5 to 8 volts is momentarily applied to terminal **P**, this voltage acts as a trigger voltage that replaces the voltage from the sensing coil. The procedure in FIGURE 13. shows a test light, but any low voltage, low current source can be used as a trigger voltage.

(7) When the momentary trigger voltage is removed, a spark is normally generated through the ignition coil. If no spark occurs, replace the ignition coil. If a spark occurs, check the sensing coil and the rotating timer core.

(1) a. If a tachometer has been connected to the TACH CONN., disconnect it.

b. Turn the key switch to **ON** and use the starter to rotate the engine. Check for a spark at the spark plug. Use a spark tester (ST–125) if it is available. If there is no spark on one wire, check another wire. A few sparks and then nothing is the same as no spark.



- **SPARK**: Check for fuel supply to engine. Check spark plugs. Check for other faults not in the ignition system.
- **NO SPARK**: go to (2).

(2) Disconnect the 4–terminal distributor connector and check for a spark.

- **SPARK**: Replace sensing coil.
- **NO SPARK**: go to (3).

(3) Check for spark at coil wire while rotating the engine with the starter. (If the spark tester is being used, leave the spark tester connected to the coil wire for steps (4) through (7) .)

- **SPARK**: Inspect the distributor cap for water, cracks, or other damage. If the distributor cap is correct, replace the distributor rotor.
- **NO SPARK**: go to (4).

(4) a. The engine is stopped. Turn the key switch to **ON**.

b. Disconnect the 2–terminal **C** and **+** connector at the distributor.

c. Check the voltage at the **C** and **+** terminals of the wires from the ignition coil.

Go to (5) on next page.

FIGURE 13. IGNITION SYSTEM TROUBLESHOOTING CHART (1 of 2)

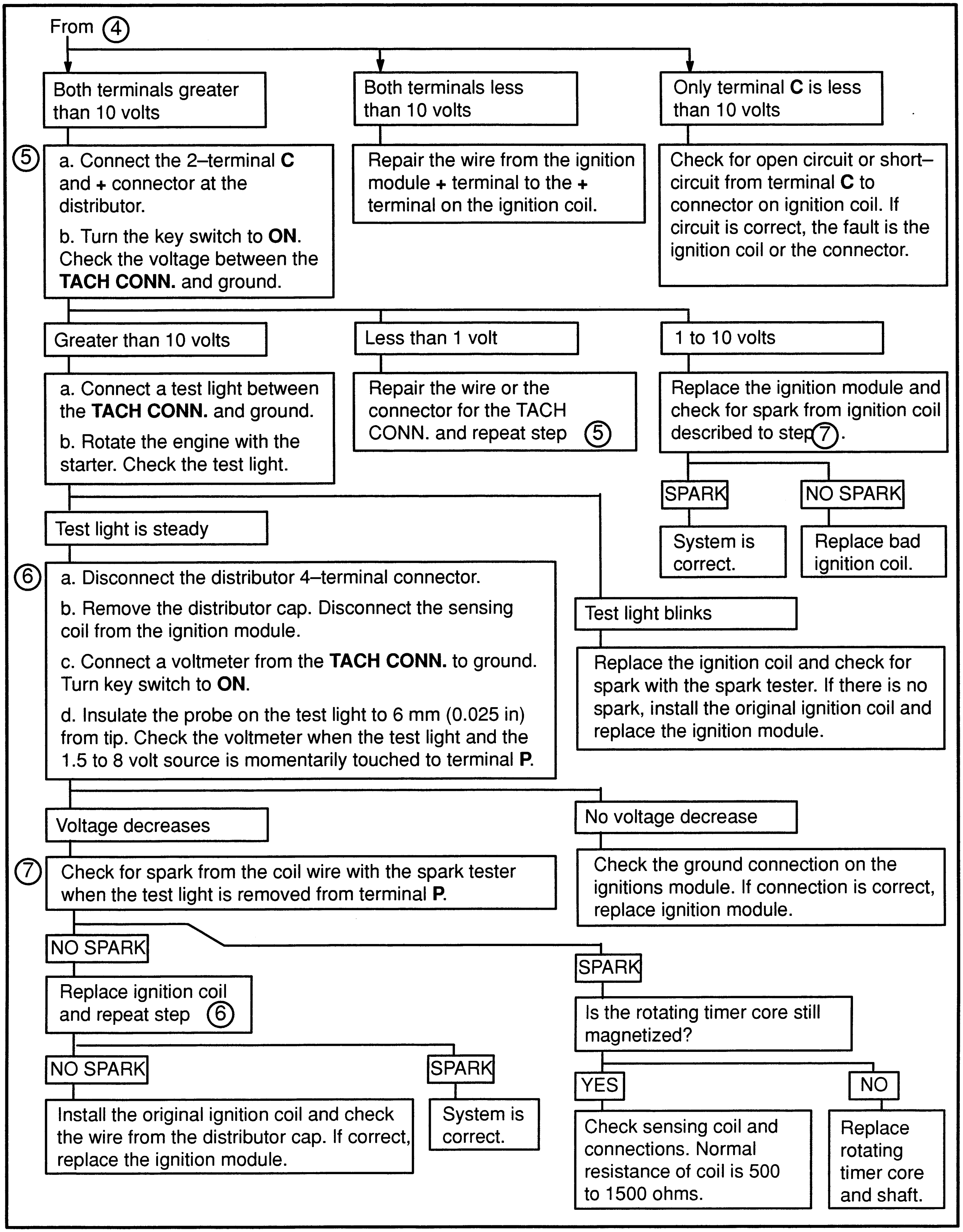


FIGURE 13. IGNITION SYSTEM TROUBLESHOOTING CHART (1 of 2)

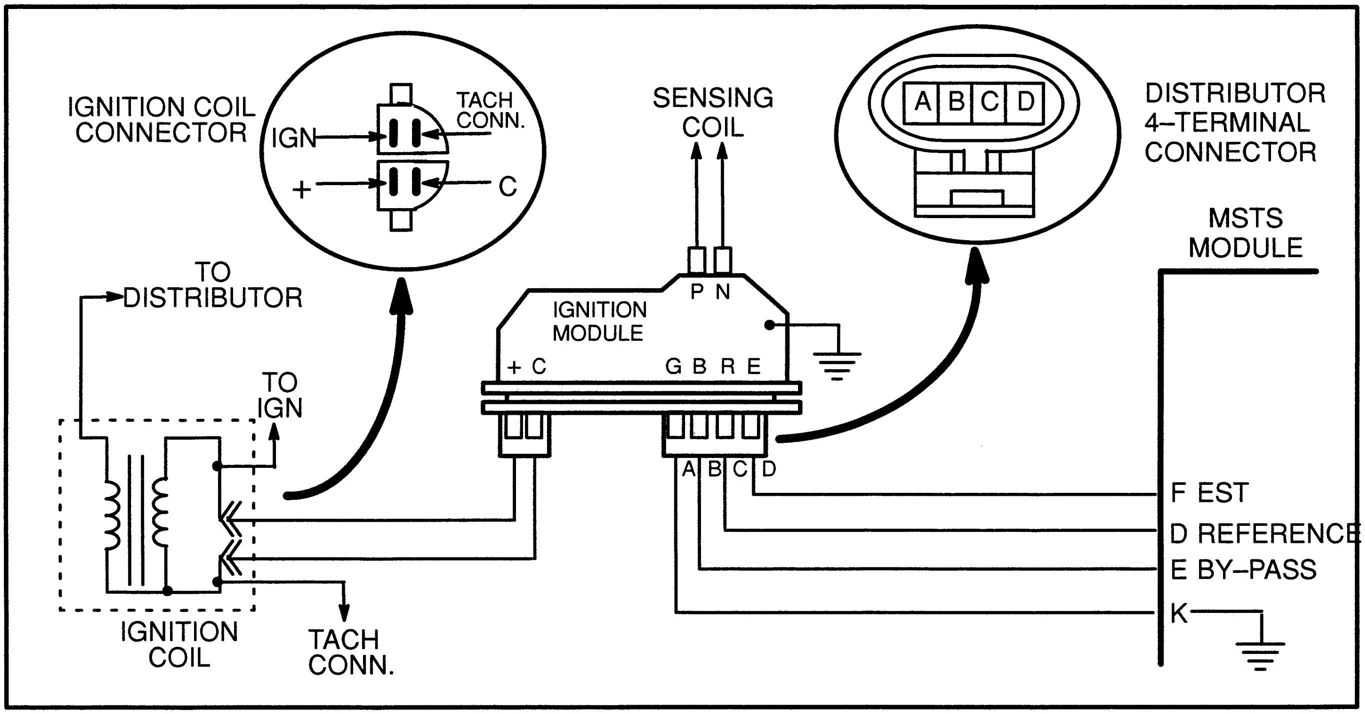


FIGURE 14. ELECTRONIC SPARK TIMING (EST) TROUBLESHOOTING

ELECTRONIC SPARK TIMING (EST) TROUBLESHOOTING

NOTE: If a malfunction indicates a possible fault in the EST, check how close the wires of the EST are to spark plug wires and high–current electrical device. The induction from a high–voltage or high–current source can cause an error in the EST circuit if it is too close to the EST wires.

Circuit Description

When the system is in the starting mode, there is no voltage signal on the BY–PASS, and the ignition module sends the EST signal to ground. The MSTS module will not normally have a voltage on the EST terminal **F** when the system is in the starting mode. If there is a voltage signal on terminal **F**, the system will not change to EST mode of operation.

When the engine speed is greater than approximately 400 rpm, the BY–PASS signal is applied and EST signal will not be at ground (0 volts) in the ignition module. During this mode of operation, there is normally a variation in the EST voltage.

If the BY–PASS circuit has an open circuit or is at ground (0 volts), the ignition module will not change to EST mode and the EST voltage signal will be low.

If the EST circuit is at ground (0 volts), the ignition module will change to EST mode, but there will not be an EST signal.

Test Description (See FIGURE 15.)

The numbers in circles on the troubleshooting chart have the following indications:

(1) If the initial timing connector is disconnected when the engine is running, the EST control is removed and the engine runs only in the starting mode with the ignition module. If there is a variation in the timing when the engine rpm is increased, a fault is indicated. There is either a open circuit or a short–circuit to ground in the EST or BY–PASS circuits.

(2) This step checks if the MSTS module is receiving REFERENCE pulses from the ignition module. There can be a small variation in the voltage levels because the engine is operating at idle rpm. The important part of this step is to check that there is a voltage signal.

(3) This step checks for a normal EST circuit to ground (0 volts) through the ignition module. If the EST circuit has a short circuit, the resistance will also indicate less that 500 ohms. This possi-

ble fault will be checked later in the troubleshooting.

(4) When the test light voltage is momentarily touched to the by–pass circuit the ohmmeter can indicate out of its range. The important indication in this test is that the ignition module made the switch.

(5) If the ignition module did not switch, this step checks for the following faults:
a. EST circuit short–circuit to ground
b. BY–PASS circuit is open
c. Fault in the ignition module or a connection

(6) This step checks for a fault in the MSTS module and not a fault that is not regular in the EST circuit and the by–pass circuit.

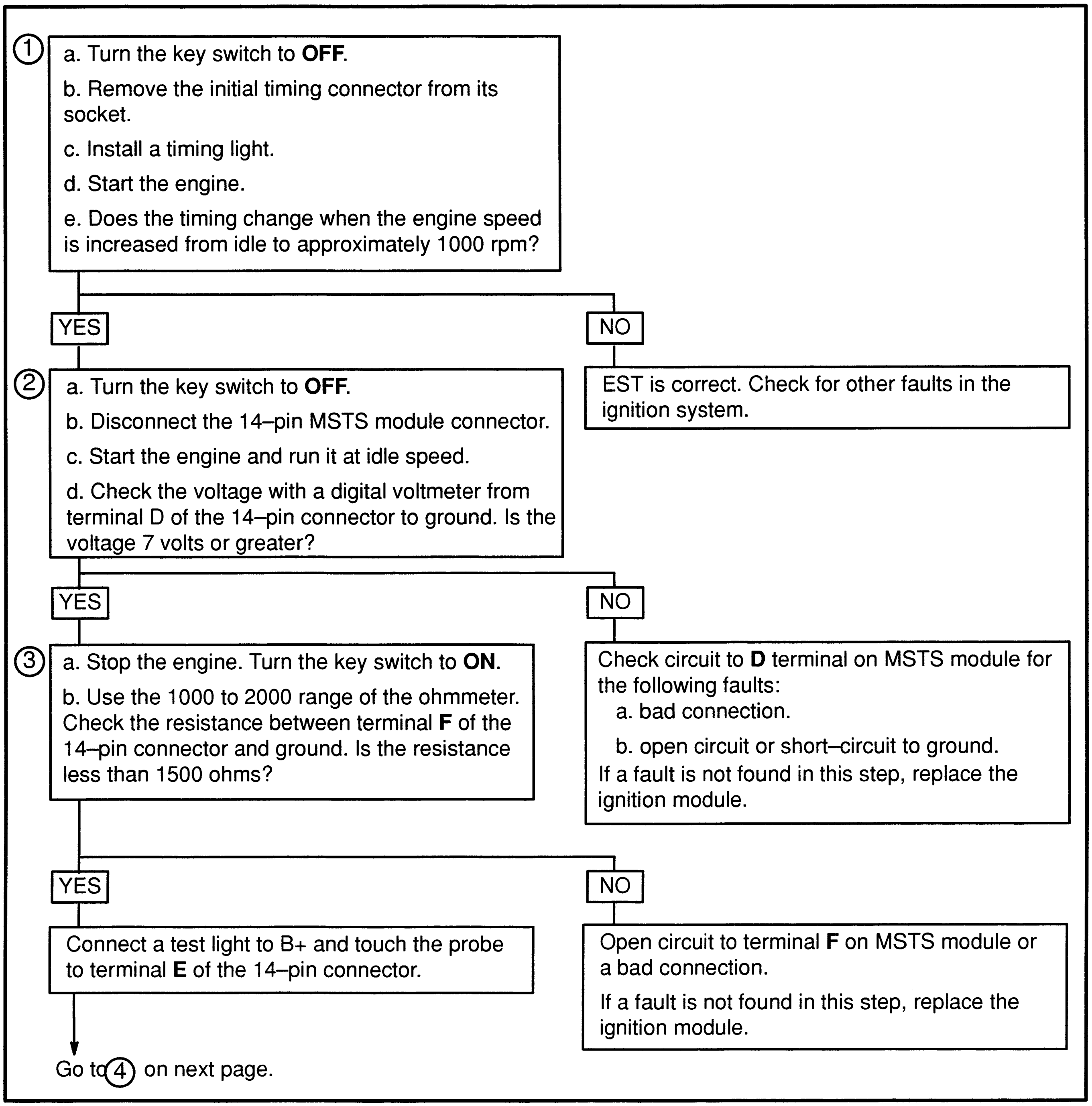


FIGURE 15. ELECTRONIC SPARK TIMING (EST) TROUBLESHOOTING CHART (1 of 2)

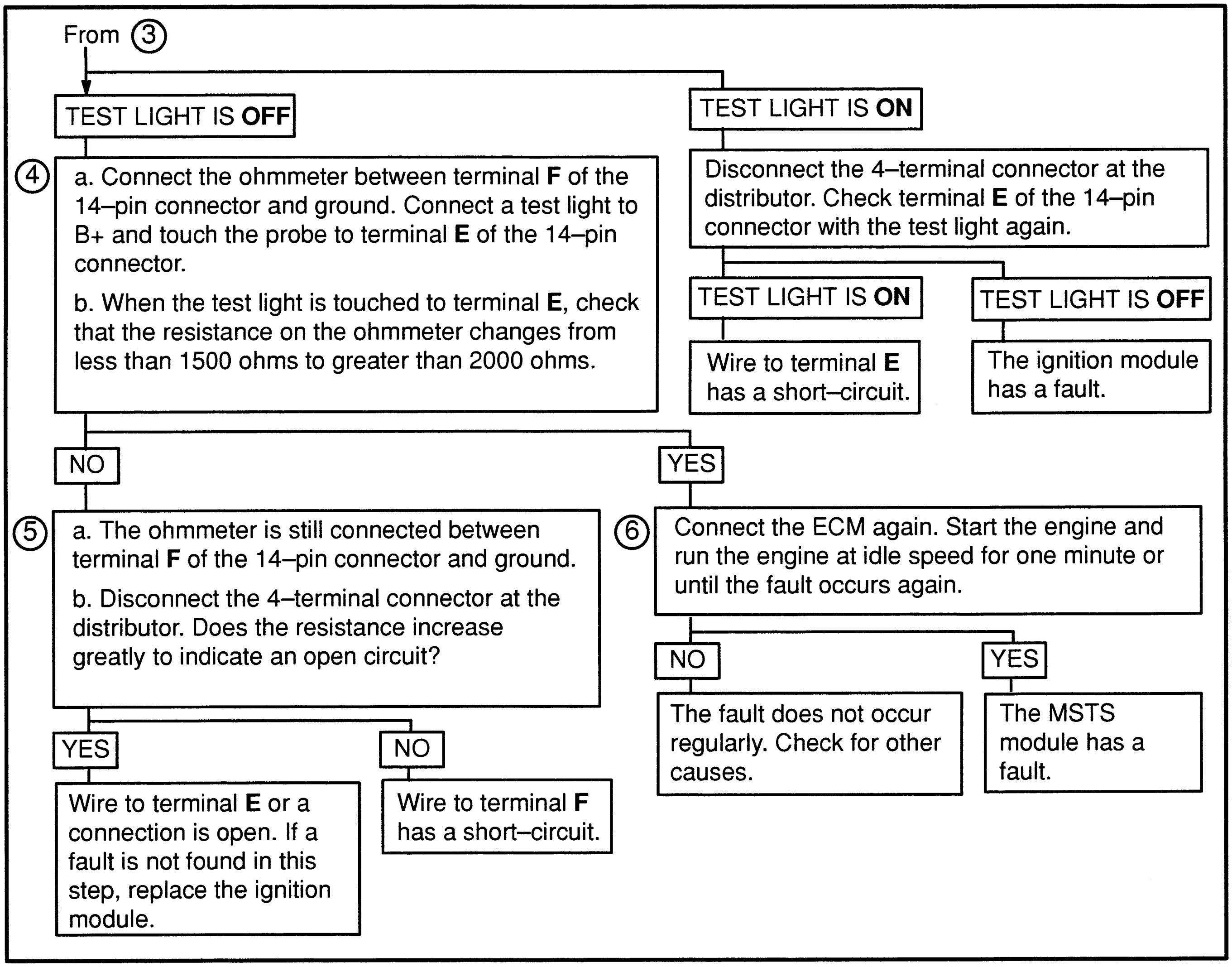


FIGURE 15. ELECTRONIC SPARK TIMING (EST) TROUBLESHOOTING CHART (2 of 2)

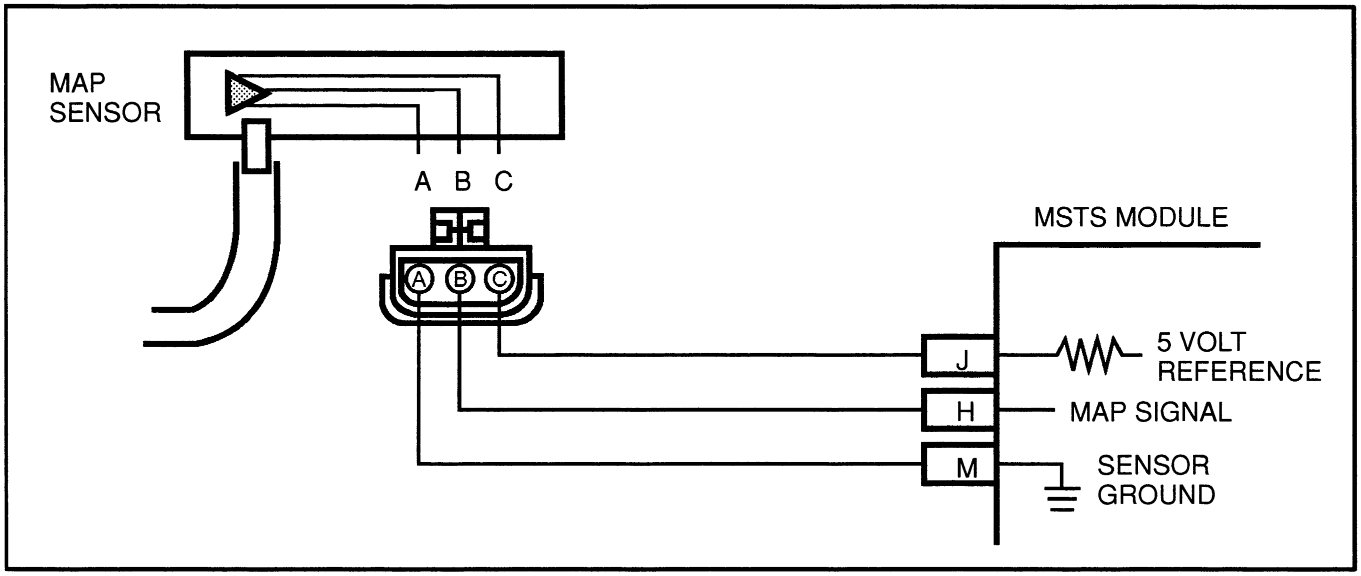


FIGURE 16. MAP SENSOR TROUBLESHOOTING

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

Circuit Description

When the load on the engine changes, the pressure in the intake manifold changes. This pressure is less than the atmospheric pressure. The Manifold Absolute Pressure (MAP) sensor measures the changes in the intake manifold pressure and converts these changes to a voltage signal. The MSTS module sends a reference signal (5.0 volts) to the MAP sensor. When the manifold pressure changes, the electrical resistance of the MAP sensor changes and a variation of the voltage signal is received by the MSTS module.

When the engine is at idle speed and does not have a load on it, the normal signal voltage from the MAP sensor is approximately 1.0 to 1.5 volts. When the throttle valve is fully opened, the intake manifold pressure is higher (lower vacuum) and the signal voltage from the MAP sensor is approximately 4.5 to 4.8 volts.

When the ignition switch is turned to **ON**, the initial voltage signal from the MAP sensor indicates the barometric pressure (BARO signal) to the MSTS module. The MSTS module "remembers" the barometric pressure (BARO signal) after the engine is running. The MSTS module then automatically adjusts the ignition timing for different altitudes and atmospheric conditions.

Test Description

NOTE: If a malfunction indicates a fault in the MAP sensor, make the following checks before doing tests on the MAP sensor:

a. Make sure that the vacuum hose is not damaged. Disconnect the vacuum hose from the MAP sensor. Connect a vacuum gauge to the end of the hose and start the engine. Check that the vacuum indication from the engine to the MAP sensor is correct. The engine will normally apply greater than 34 kPa (10" Hg) of vacuum to the MAP sensor.

b. If a malfunction indicates a fault in the MAP sensor, make sure that the electrical connections do not have dirt and corrosion. A bad electrical connection can give an indication of a malfunction in the MAP sensor.

NOTE: Make sure that the same digital voltmeter is used for all measurements. The voltage and resistance measurements must be carefully done. The differences in measurements are small and the use of more than one measuring instrument can give errors.

There are two tests in this procedure. The first test checks the electrical signals between the MAP sensor and the MSTS module. The second test checks the signal output of the MAP sensor when a standard vacuum is applied to it.

Test 1. Do the following test procedure:

a. The key switch is **OFF**. Disconnect the connector from the MAP sensor. The engine is stopped and the key switch is **ON**. Connect a digital voltmeter between terminal **A** and terminal **C** the plug connector. Terminal **C** is the 5 volt reference voltage and terminal **A** is the sensor ground. Carefully measure the actual reference voltage ("5V REFERENCE") between the two terminals.

b. Use a barometer or call a local weather station to find the local atmospheric pressure. Find the number in the "Atmospheric Pressure" column in the chart that is the closest to the atmospheric pressure. See TABLE 1.

c. Find the "5V REFERENCE" column in the chart that is closest to the actual reference voltage measured in step a. Follow the "5V REFERENCE" column into the signal voltage area until it intersects with the horizontal column for "Atmospheric Pressure" that was found in step b. Make a note of the "MAP Sensor Signal Voltage" where the two columns intersect.

d. Three jumper wires are needed so that the voltage can be measured when the connector to the wiring harness is connected to the MAP sensor. Use the jumper wires to connect the terminals **A**, **B**, and **C** to their connections in the wiring harness.

e. Connect the "+" probe of the digital voltmeter to terminal **B** (MAP signal voltage). Connect the negative (or COMM) probe to terminal **A** (sensor ground).

f. The engine is stopped and the key switch is **ON**. Measure the MAP sensor signal voltage. The voltage must be within $\pm$0.4 volts of the voltage value found on the chart in step c. If the voltage is not within these limits, replace the MAP sensor.

Test 2. The jumper wires must be installed as described in Test 1, step d. The voltmeter must be connected as described in Test 1, step e. Do the following procedure:

a. Disconnect the vacuum hose at the MAP sensor and install a plug in the hose. Connect a vacuum pump that can be operated by hand to the MAP sensor.

b. Start the engine and run the engine at idle speed.

c. Use the vacuum pump to apply 34 kPa (20" Hg) of vacuum to the MAP sensor. (See the PRESSURE CONVERSION CHART at the end of this section.) Look at the voltage change indicated on the voltmeter. The voltage change will normally occur as quickly as the vacuum is applied to the MAP sensor.

d. Compare the voltage indicated on the voltmeter with the voltage indicated in Test 1, step f. The correct voltage indicated in this step will be 1.2 to 1.3 volts less that the voltage indicated in Test 1, step f.

e. If the voltage signals are correct, check for vacuum leaks in the hoses and connections. If the voltage signals are not correct, replace the MAP sensor.

TABLE 1. VOLTAGE AND PRESSURE FOR MAP SENSOR TROUBLESHOOTING

ATMOSPHERIC PRESSURE		5 VOLT REFERENCE				
		4.80	4.90	5.00	5.10	5.20
kPa	inches of Hg	MAP SENSOR SIGNAL VOLTAGE				
64.35	19.0	2.75	2.80	2.86	2.92	2.97
66.04	19.5	2.83	2.89	2.95	3.01	3.07
67.73	20.0	2.92	2.98	3.04	3.10	3.16
69.43	20.5	3.00	3.07	3.13	3.19	3.25
71.12	21.0	3.09	3.15	3.22	3.28	3.35
72.81	21.5	3.18	3.24	3.31	3.37	3.44
74.51	22.0	3.26	3.33	3.40	3.47	3.53
76.20	22.5	3.35	3.42	3.49	3.56	3.63
77.89	23.0	3.43	3.51	3.58	3.65	3.72
79.59	23.5	3.52	3.59	3.67	3.74	3.81
81.28	24.0	3.61	3.68	3.76	3.83	3.91
82.97	24.5	3.69	3.77	3.85	3.92	4.00
84.67	25.0	3.79	3.86	3.94	4.01	4.09
86.36	25.5	3.86	3.94	4.03	4.11	4.19
88.05	26.0	3.95	4.03	4.11	4.20	4.28
89.75	26.5	4.04	4.12	4.20	4.29	4.37
91.44	27.0	4.12	4.20	4.29	4.38	4.47
93.13	27.5	4.21	4.30	4.38	4.47	4.56
94.83	28.0	4.29	4.38	4.47	4.56	4.65
96.49	28.5	4.38	4.47	4.56	4.65	4.75
98.19	29.0	4.47	4.56	4.65	4.75	4.84
99.88	29.5	4.55	4.65	4.74	4.84	4.93
101.57	30.0	4.64	4.74	4.83	4.93	5.03
103.27	30.5	4.72	4.84	4.92	5.02	5.12
104.96	31.0	4.81	4.91	5.01	5.11	5.21

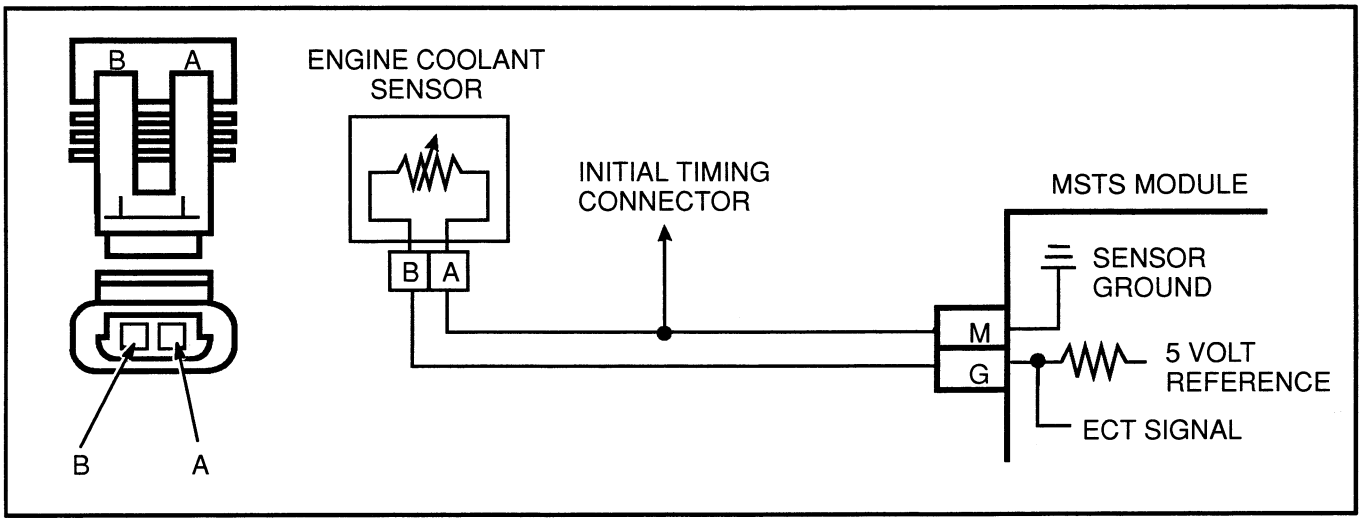


FIGURE 17. ECT SENSOR TROUBLESHOOTING

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

NOTE: This troubleshooting is normally used only if there is a problem when the engine coolant is cold. A fault in the ECT normally causes a problem before the engine coolant has increased to operating temperature. The problem can be a short delay when the throttle is opened or a decrease in engine power.

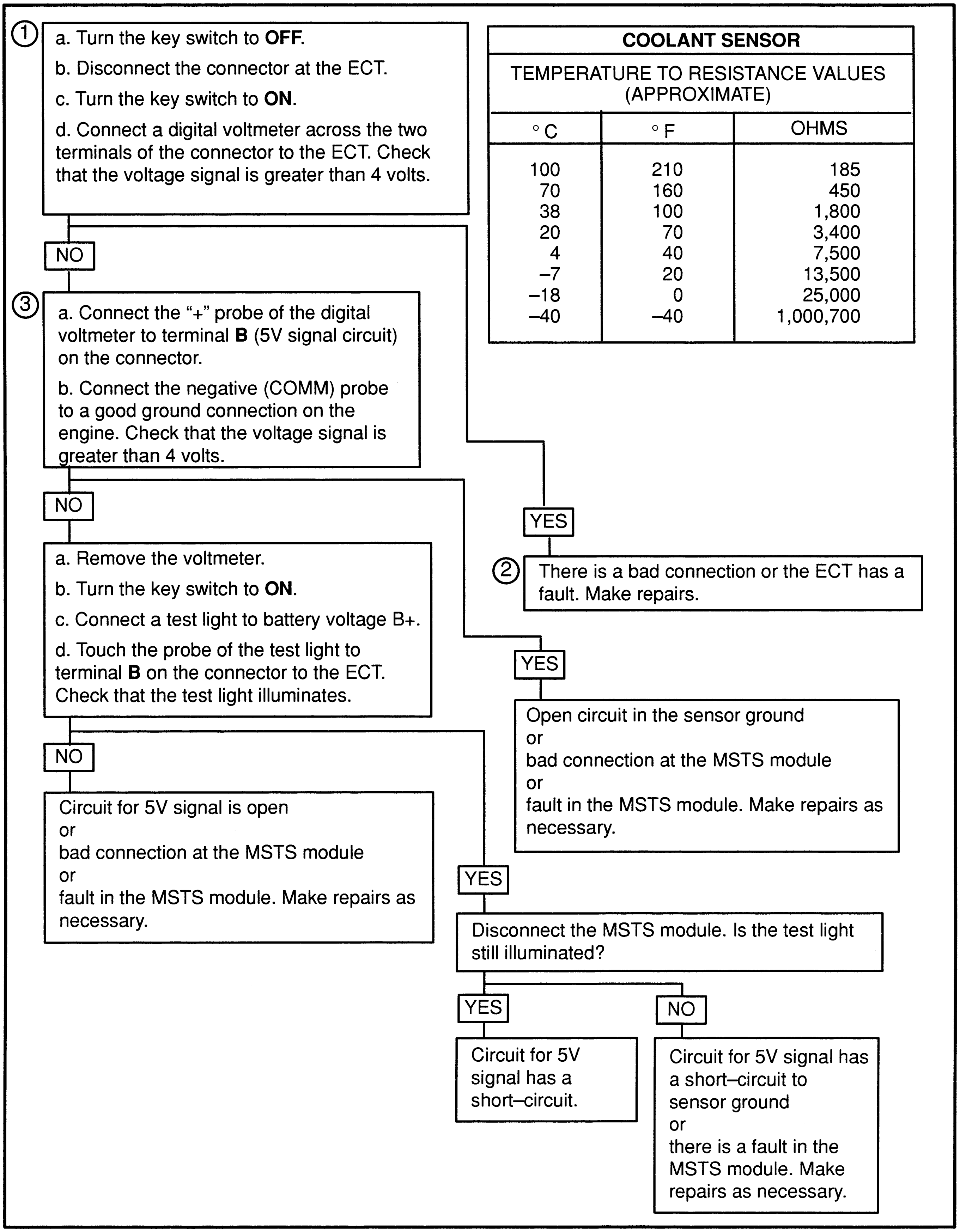
Circuit Description (See FIGURE 17.)

The Engine Coolant Temperature sensor (ECT) uses a thermistor to control the signal voltage to the MSTS module. The MSTS module (terminal **G**) applies a 5–volt reference voltage to the ECT. When the engine coolant is cold, the thermistor resistance is higher than when the engine coolant is at operating temperature. As the temperature of the engine coolant increases after the engine is started, the resistance decreases and the signal voltage decreases. When the engine is operating at 85 to 95°C (185 to 203°F), the signal voltage is approximately 1.5 to 2.0 volts.

Test Description (See FIGURE 18.)

The numbers in circles on the troubleshooting chart have the following indications:

1. This step checks if there is a fault in the wiring or the MSTS module or if the fault is in the ECT.
2. Make sure the electrical connections do not have dirt and corrosion. If an ohmmeter is connected across the terminals **A** and **B** of the ECT, the resistance normally decreases as the temperature of the engine coolant increases.
3. This step checks if there is a fault in the wiring to the ECT or the sensor ground.



COOLANT SENSOR

TEMPERATURE TO RESISTANCE VALUES (APPROXIMATE)

°C	°F	OHMS
100	210	185
70	160	450
38	100	1,800
20	70	3,400
4	40	7,500
–7	20	13,500
–18	0	25,000
–40	–40	1,000,700

FIGURE 18. ENGINE COOLANT TEMPERATURE SENSOR TROUBLESHOOTING CHART

NOTE: This REPAIR section describes the components of the MSTS and how to remove or replace them.

DISTRIBUTOR

A distributor with a separate ignition coil is used on all MSTS engines. The ignition coil is connected to the rotor in the distributor through a high voltage wire. The operation of the ignition module and the magnetic pulse generator is described under OPERATION at the beginning of this section.

When the current in the primary circuit of the ignition coil quickly decreases, the induction in the secondary circuit sends a high voltage pulse (35 000 volts) to the rotor in the distributor. The rotor is aligned with one of the leads to a spark plug wire and this high voltage pulse is sent to one of the spark plugs.

Removal

⚠ CAUTION

Carefully lift and release the lock tabs on the connectors to the distributor. The lock tabs can be easily broken if too much force is applied with a screwdriver or other tool.

Never permit the TACH CONN. terminal to touch ground. The ignition module or the ignition coil can be damaged.

1. Disconnect the battery negative (ground) cable.

2. If removal of the spark plug wires are not required for the repairs, leave them connected to the distributor cap. Remove the two capscrews that fasten the distributor cap to the distributor. Move the distributor cap away from the work area.

3. Disconnect the distributor 4–terminal connector.

4. Disconnect the ignition coil connector.

5. Remove the bolt and clamp that hold the distributor in the engine. Make a note of the positions of the rotor to distributor housing and the distributor to the engine. Slowly pull the distributor from the engine until the rotor just stops turning counterclockwise and make a note of the position of the rotor. This position must be used when the distributor is installed again.

Disassembly (See FIGURE 19.)

1. Remove the rotor (2). Make a match mark on the gear (6) and the shaft (3) so that can be assembled in the same position.

2. Use a punch to remove the roll pin (5) from the shaft (3).

3. Remove the gear (6).

4. Remove the shaft (3) with the timer core from the housing (8).

5. Remove the retainer (4) from the housing (8). Use a screwdriver as a prybar.

6. Disconnect the sensing coil (12) from the ignition module (9).

⚠ CAUTION

Carefully lift and release the lock tab on the connector to the sensing coil. The lock tab can be easily broken if too much force is applied with a screwdriver or other tool.

7. Use a screwdriver to lift the lock tab. Remove the sensing coil (12).

8. Remove the two screws that hold the ignition module (9) in the housing. Remove the ignition module.

Inspection

Inspect the shaft for a loose fit between the shaft and its bushing in the housing. If the bushing or the shaft is worn so that the shaft moves from side to side in the bushing, replace the shaft or the housing.

Inspect the housing for cracks or damage.

Assembly (See FIGURE 19.)

1. Apply silicon grease to the bottom of the ignition module (9). Install the ignition module into the housing (8) and tighten the two screws.

NOTE: Hyster Part No. 304408 is a silicon bearing grease used between electronic components and their heat sinks. A small container of silicon grease is enclosed in the package with a new ignition module.

2. Install the sensing coil (12). The tab on the bottom of the sensing coil fits into the anchor hole in the housing (8).

3. Connect the sensing coil to the ignition module. Make sure that the lock tab on the connector is fastened.

4. Install the retainer (4).

5. Install the shaft assembly (3) into the housing (8).

6. Install the seal (7) on the housing. Install the gear (6) on the end of the shaft.

7. Align the marks on the gear and shaft. Install the roll pin (5). Turn the shaft assembly and make sure the teeth of the timer core on the shaft assembly do not touch the pole piece.

8. Install the rotor (2) on the shaft.

Installation

1. Put the rotor and distributor in the same position as it was removed from the engine.

If the engine has been rotated after the distributor was removed, the following procedure must be used before the distributor is installed again:

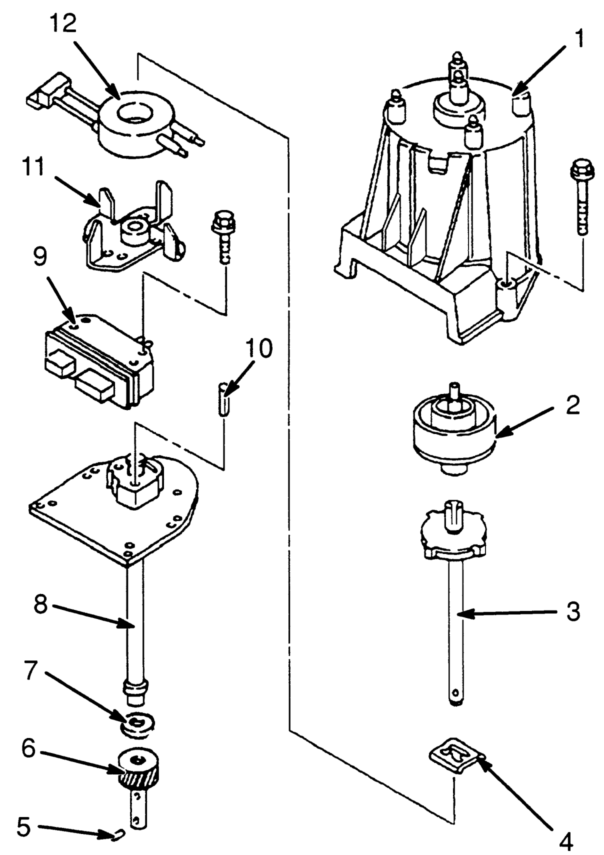
a. Remove the No. 1 spark plug.

b. Put a finger over the No. 1 spark plug hole and slowly rotate the engine until pressure is felt on the compression stroke.

c. Align the timing mark on the crankshaft pulley to 0° (TDC) on the engine timing indicator.

d. Turn the distributor rotor to point between the positions on the distributor cap for No. 1 and No. 4 spark plug leads.

e. Install the distributor in the engine. The rotor and shaft will rotate a few degrees when the gear on the distributor shaft engages the drive gear on the engine cam. The timing is correct if the rotor points at the position on the distributor cap for the No. 1 spark plug lead.



1. CAP
2. ROTOR
3. SHAFT/ TIMER CORE
4. RETAINER
5. PIN
6. DRIVE GEAR
7. SEAL
8. HOUSING
9. MODULE
10. ALIGNMENT PIN
11. POLE PIECE
12. COIL

FIGURE 19. DISTRIBUTOR

2. Install the clamp and bolt. Tighten the bolt with your hand.

3. Install the distributor 4–terminal connector.

4. Install the ignition coil connector.

5. Install the distributor cap and the two capscrews. If the spark plug wires were removed. install them in the correct sequence.

6. Connect the battery negative cable.

7. Start the engine and check the engine timing. See the following paragraphs about "Ignition Timing".

8. Tighten the bolt for the distributor clamp to 43 N.m (25 lb_f ft).

Ignition Timing

1. Disconnect the initial timing connector.

2. Connect a timing light to the No. 1 spark plug wire.

⚠ WARNING
Do not touch moving parts (fan, belt, shafts, pulleys).

3. Run the engine at 1200 rpm. The correct setting for the initial timing set point is 8° BTDC.

4. Check for the correct timing. If the timing is not correct, loosen the clamp that holds the distributor housing. Rotate the housing right or left to get the correct timing. Tighten the clamp when the timing is correct.

5. If necessary, check and adjust the idle speed at the carburetor.

IGNITION MODULE

Test For A Fault (See FIGURE 20.)

NOTE: The ignition module can be checked in the distributor. A test light and three jumper wires are needed to make the tests. The battery in the vehicle must be fully charged so that the starter rotates the engine at the normal speed.

1. Disconnect the 4–terminal connector from the distributor. Use two jumper wires between the distributor and the 4–terminal connector to connect the following circuits:
REFERENCE (Purple)
GROUND (Black)

2. Connect the test light to a 12 volt positive source. Start the engine. Touch the probe of the test light to pin **B** in the 4–terminal connector on the distributor. When 12 volts are applied through the test light to pin **B** (BY–PASS), the ignition module changes to EST mode. The EST connection (pin **D**) is open and the engine will normally stop. This step checks the BY–PASS operation of the ignition module.

3. Use a jumper to connect pin **D** (EST) to pin **C** (REFERENCE) at the distributor. Apply 12–volts through the test light to pin **B** (BY–PASS) as described in step 2. Start the engine. If the engine starts, this step checks that the EST circuit in the ignition module is good.

4. Remove the test light from pin **B** (BY–PASS) while the engine is running. If the engine stops, this check shows that the ignition module internally changes the EST circuit to ground. Since there is a jumper wire between pin **D** (EST) to pin **C** (REFERENCE), the REFERENCE signal is also sent to ground and the engine stops.

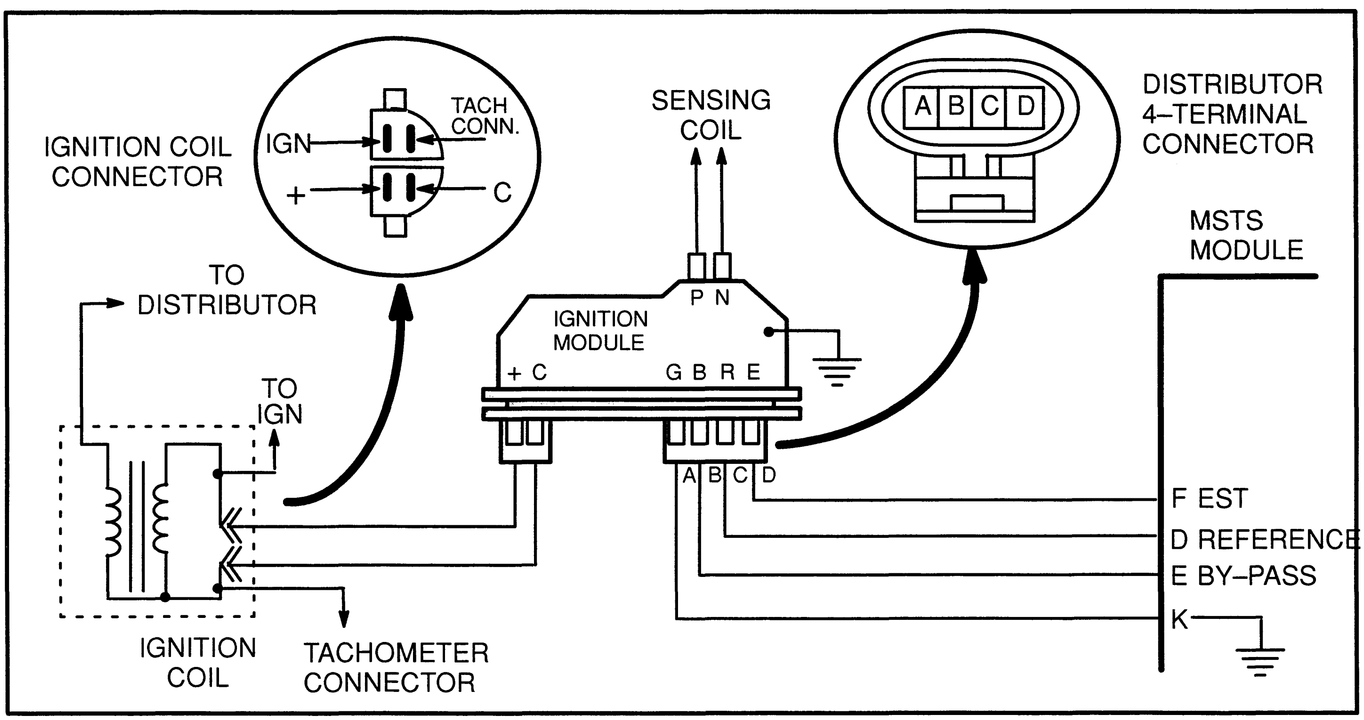


FIGURE 20. IGNITION SYSTEM TROUBLESHOOTING

5. If any tests described in steps 2, 3, or 4 do not work as indicated, check the wiring harness for a short–circuit or an open circuit. If the wiring harness is good, replace the ignition module.

6. When the tests are complete, connect the system for normal operation.

Ignition Module Replacement

1. Remove the distributor cap and rotor.

2. Remove the two screws that hold the ignition module in the distributor.

3. Lift the ignition module and disconnect the connections. Make a note of the connections so that they can be correctly connected again. Remove the ignition module from the distributor.

NOTE: Do not remove the silicon grease from the ignition module or the distributor if the same ignition module will be installed again. If a new ignition module is installed, a small container of silicon grease is in the package. Clean the old silicon grease and apply a new layer of silicon grease to both the ignition module and the distributor housing. This silicon grease is necessary for cooling the ignition module.

4. Connect the connectors in the distributor to the ignition module. Make sure the connectors are the same as when they were removed.

5. Install the ignition module in the distributor.

6. Install the two screws that fasten the ignition module in the distributor.

7. Install the distributor cap and rotor.

SENSING COIL

Test For A Fault

1. Disconnect the battery negative cable.

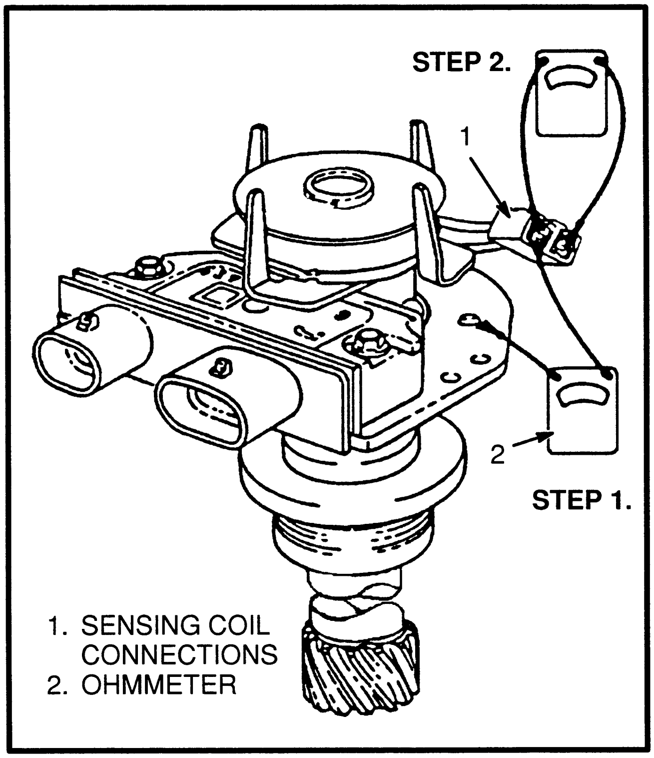


FIGURE 21. TEST THE SENSING COIL

2. Remove the distributor cap. Disconnect the connection from the sensing coil to the ignition module.

3. Check the resistance of the sensing coil with an ohmmeter. Connect ohmmeter to the sensing coil connections as shown in step 1 of FIGURE 21. Check the resistance between both connections and ground. The ohmmeter will indicate infinity for both connections, if the sensing coil is good.

4. Connect ohmmeter across both sensing coil connections as shown in step 2 of FIGURE 21. If the ohmmeter does not indicate 500 to 1500 ohms, replace the sensing coil. Check the wires for a loose connection.

Sensing Coil Replacement

Remove and disassemble the distributor as described in the repairs for the DISTRIBUTOR.

IGNITION COIL

Test For A Fault

1. Disconnect the battery negative (ground) cable.

2. Disconnect the high voltage wire.

3. Disconnect the connectors at the ignition coil.

4. Set the ohmmeter on one of the higher scales. Connect the ohmmeter as shown in step 1 of FIGURE 22. If the

ohmmeter indication is less than infinity, install a new ignition coil.

5. Set the ohmmeter on one of the low scales. Connect the ohmmeter as shown in step 2 of FIGURE 22. If the ohmmeter indication is greater than zero to one ohm, install a new ignition coil.

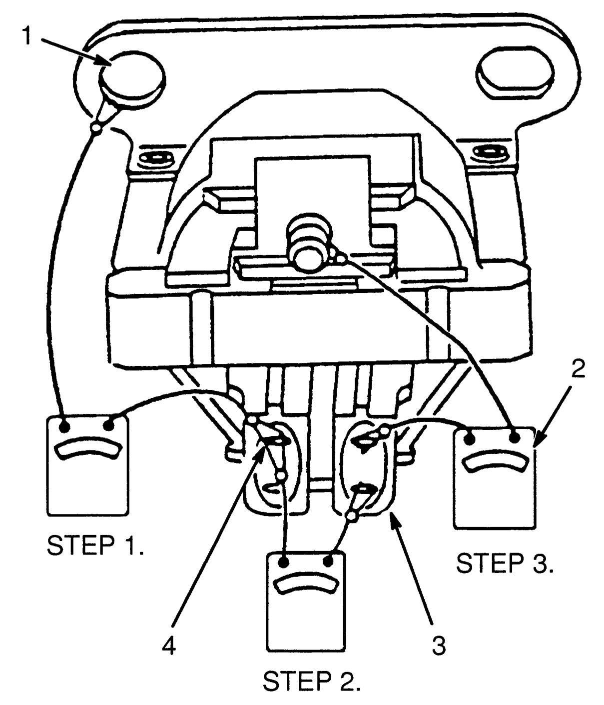
6. Set the ohmmeter on one of the middle scales. Connect the ohmmeter as shown in step 3 of FIGURE 22. If the ohmmeter indication is infinity (open circuit), install a new ignition coil.

Removal

1. Turn the key switch to "OFF". Apply the parking brake.

2. Disconnect the negative battery cable.

3. Put tags for identification on the connectors and disconnect them from the coil.



1. CLEAN METAL FOR GROUND CONNECTION
2. OHMMETER
3. **C–** AND TACH CONNECTOR
4. **B** AND **+** TERMINALS

FIGURE 22. IGNITION COIL

⚠ CAUTION

Do not damage the high voltage wires (spark plug wires) during removal. Hold the wire by the boot near the end of the wire. Rotate the boot before pulling it and the connection from the terminal.

4. Remove the high voltage wire.

5. Remove the nuts (or capscrews) that fasten the bracket for the ignition coil to the engine.

6. Remove the ignition coil and bracket assembly from the engine.

7. Use a drill and punch to remove the two rivets that fasten the bracket to the coil.

Installation

1. Install the original bracket on the replacement coil using screws (supplied with replacement coil).

2. Install the ignition coil assembly on the engine with nuts (or capscrews).

3. Install the control wire connectors and the high voltage wire on the ignition coil.

4. Connect the negative (ground) battery cable.

MSTS MODULE

NOTE: See the TROUBLESHOOTING descriptions to check the operation of the MSTS module. The following paragraphs describe the removal and installation of the MSTS module.

⚠ CAUTION

Never connect or disconnect the wiring harness at the MSTS module when the key switch is "ON". Never connect jumper wires or test instruments to the MSTS module when the key switch is "ON". The best procedure is to disconnect the battery negative cable when removing or installing electrical components.

Do not touch the connector pins or the soldered connections on the circuit board. The MSTS module can be damaged with an electrostatic discharge.

Removal

1. Disconnect the battery negative cable. Disconnect the 14–pin connector at the MSTS module.

2. Remove the three bolts that fasten the MSTS module to its mount. Remove the MSTS module.

Installation

1. Install the MSTS module on its mount surface and install the three bolts.

2. Connect the 14–pin connector at the MSTS module. Connect the battery negative cable.

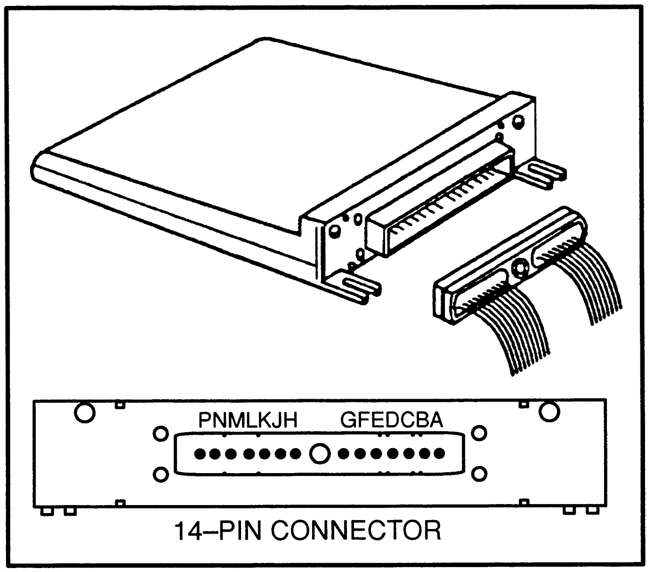


FIGURE 23. MSTS MODULE

ECT SENSOR REPLACEMENT (See FIGURE 24.)

NOTE: See the TROUBLESHOOTING descriptions to check the operation of the ECT sensor. The following paragraphs describe the disconnection or the removal and installation of the ECT sensor.

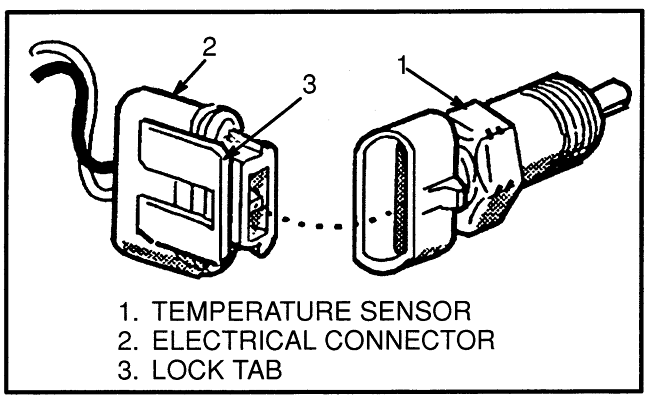


FIGURE 24. ENGINE COOLANT TEMPERATURE SENSOR (ECT)

1. Disconnect the battery negative cable. Disconnect the connector at the ECT sensor.

2. Use a wrench and carefully loosen the ECT from the coolant manifold.

3. Install the ECT in its hole in the coolant manifold and carefully tighten it with a wrench.

4. Connect the connector at the ECT. Connect the battery negative cable.

MAP SENSOR REPLACEMENT (See FIGURE 25.)

NOTE: The MAP sensor is on the left–hand side of the bracket that is on top of the valve cover.

1. Disconnect the battery negative cable. Disconnect the vacuum hose from the MAP sensor. Disconnect the electrical connector at the MAP sensor.

2. Remove screws that fasten the MAP to its mount. Remove the MAP sensor.

3. Install the MAP sensor on its mount surface and install the screws.

4. Connect electrical connector at the MAP sensor. Connect the vacuum hose to the MAP sensor. Connect the battery negative cable.

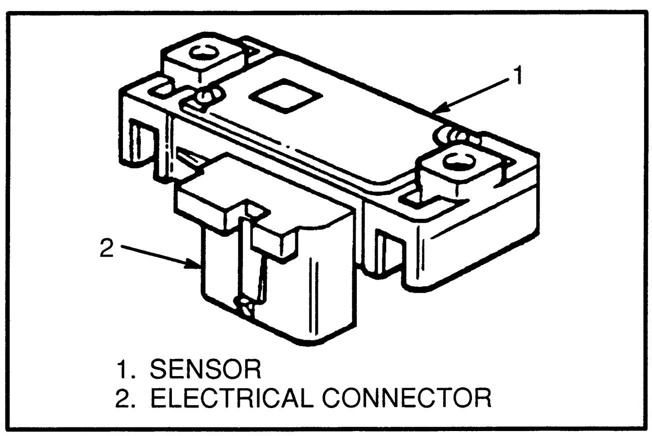


FIGURE 25. MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

PRESSURE CONVERSION CHART

Vacuum and pressure readings often cause confusion because everyone does not use the same point of reference. "Absolute pressure" is the "gauge pressure" plus the atmospheric pressure. The standard atmospheric pressure is also called the standard barometric pressure and is equal to 101.325 kPa (14.695 psi) or [29.92 inches of mercury (Hg)] at sea level. The reference point for these measurements is zero pressure or an absolute vacuum.

Service people normally use "gauge pressure" as the reference point which does not add the atmospheric pressure. The reference point for "gauge pressure" is atmospheric pressure. It is important to know when reading a pressure chart whether the units are given in "absolute pressure" or "gauge pressure".

The gauges used by most service people indicate "gauge pressure". However, most gauges calibrated in a metric scale (kilopascals) and used to measure less than atmospheric pressure normally indicate absolute pressure as shown in the chart. A gauge calibrated in inches of Hg and used to measure a vacuum begins at zero and increases its indication as the vacuum increases as shown in the "gauge pressure" column of the chart.

An additional cause of confusion is that the manifold pressure gauge for an engine with a turbocharger is normally calibrated for absolute pressure for both kilopascals and inches of Hg. The Manifold Absolute Pressure (MAP) sensor described in this section is also calibrated for absolute pressure, but the service person doing checking or troubleshooting will often be using gauges calibrated for "gauge pressure".

ABSOLUTE PRESSURE		GAUGE PRESSURE	
kPa	Inches of Hg	Inches of Hg	
121.92	36	6	Pressure ↑
115.14	34	4	
108.4	32	2	
101.6	30	0	- - - - -
94.8	28	2	
88.0	26	4	
81.3	24	6	↓ Vacuum
74.51	22	8	
67.73	20	10	
60.96	18	12	
54.18	16	14	
47.41	14	16	
40.64	12	18	
33.87	10	20	
27.09	8	22	
20.32	6	24	
13.55	4	26	

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Hyster Easy Language Program