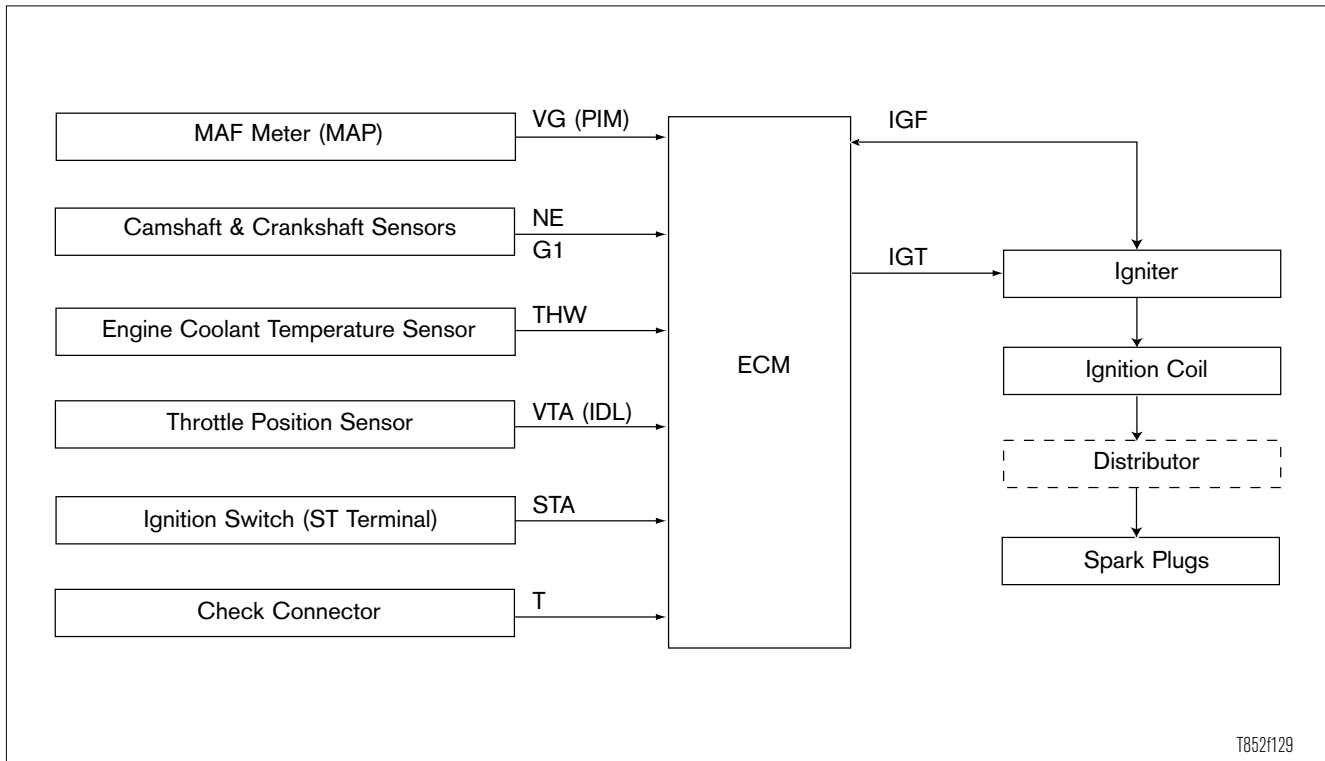


# Ignition Systems



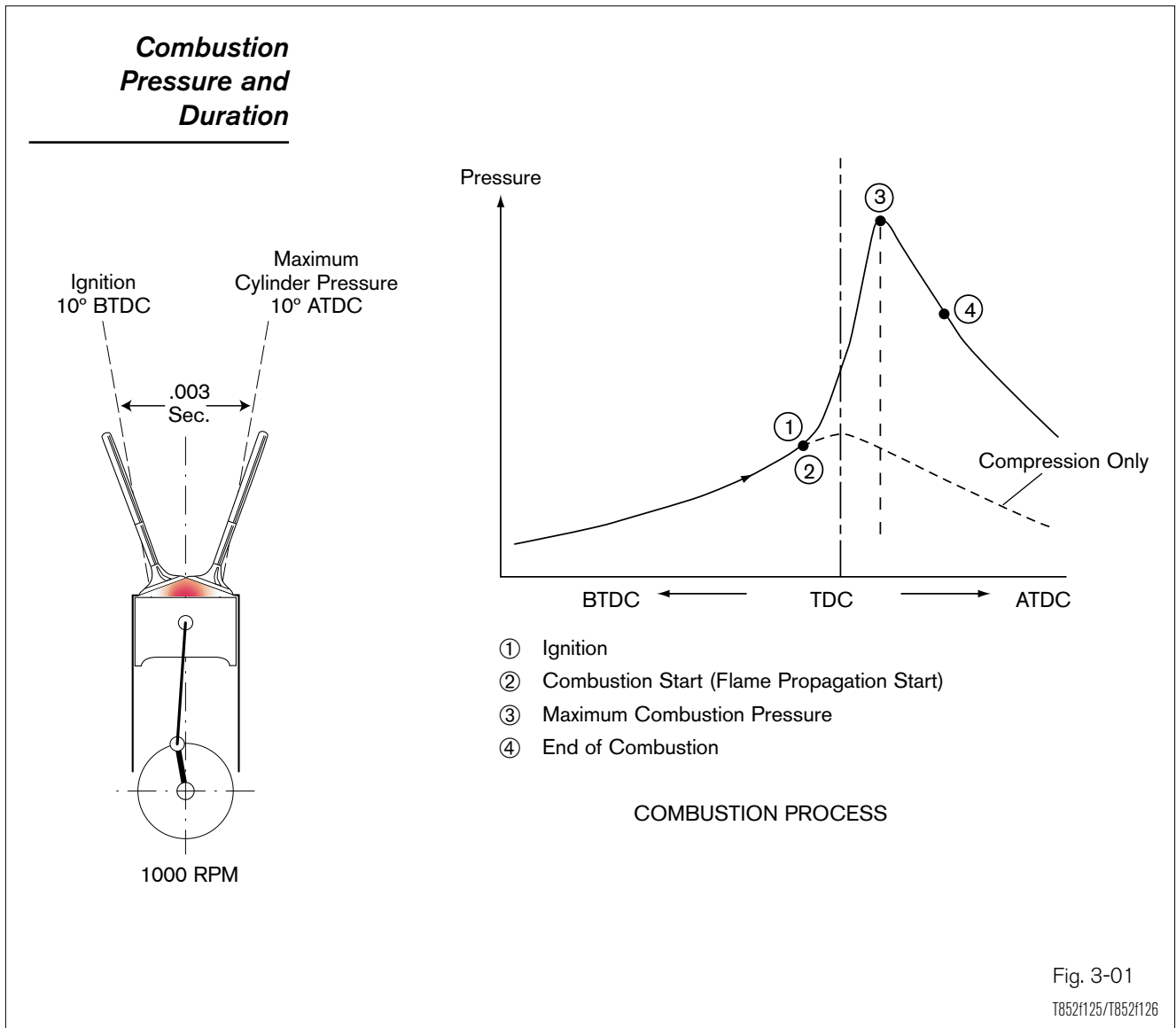
- Lesson Objectives**
1. Determine the condition of the ignition system based on relevant input sensor signals and output signals
  2. Determine the root cause of a failure(s) in the ignition system using appropriate diagnostic procedures

# Ignition Systems

## Ignition System Overview

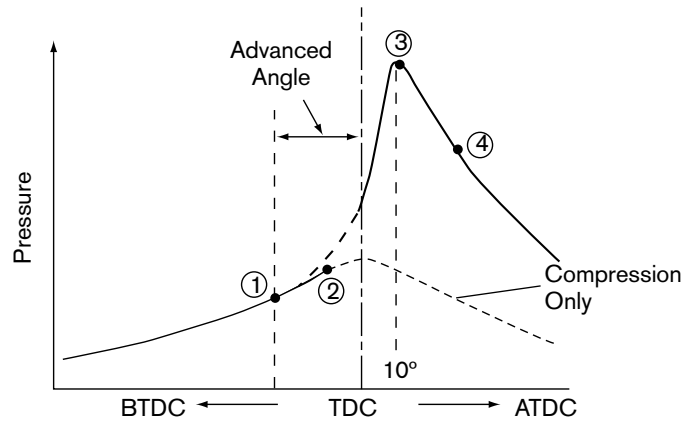
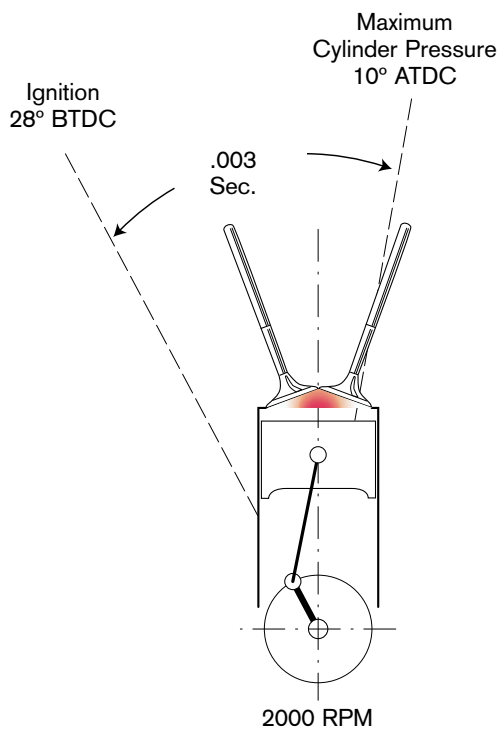
The purpose of the ignition system is to ignite the air/fuel mixture in the combustion chamber at the proper time. In order to maximize engine output efficiency, the air-fuel mixture must be ignited so that maximum combustion pressure occurs at about 10° after top dead center (TDC).

However, the time from ignition of the air-fuel mixture to the development of maximum combustion pressure varies depending on the engine speed and the manifold pressure; ignition must occur earlier when the engine speed is higher and later when it is lower. In early systems, the timing is advanced and retarded by a governor in the distributor.



### Ignition Advance

Ignition must occur earlier so that the cylinder achieves maximum cylinder pressure as engine RPMs increase.



- ① Ignition
- ② Combustion Start (Flame Propagation Start)
- ③ Maximum Combustion Pressure
- ④ End Of Combustion

COMBUSTION PROCESS

Fig. 3-02

T852f127/T852f128

Furthermore, ignition must also be advanced when the manifold pressure is low (i.e. when there is a strong vacuum). However, optimal ignition timing is also affected by a number of other factors besides engine speed and intake air volume, such as the shape of the combustion chamber, the temperature inside the combustion chamber, etc. For these reasons, electronic control provides the ideal ignition timing for the engine.

### ESA Block Diagram

*The distributor is not used on Distributorless and Direct Ignition Systems.*

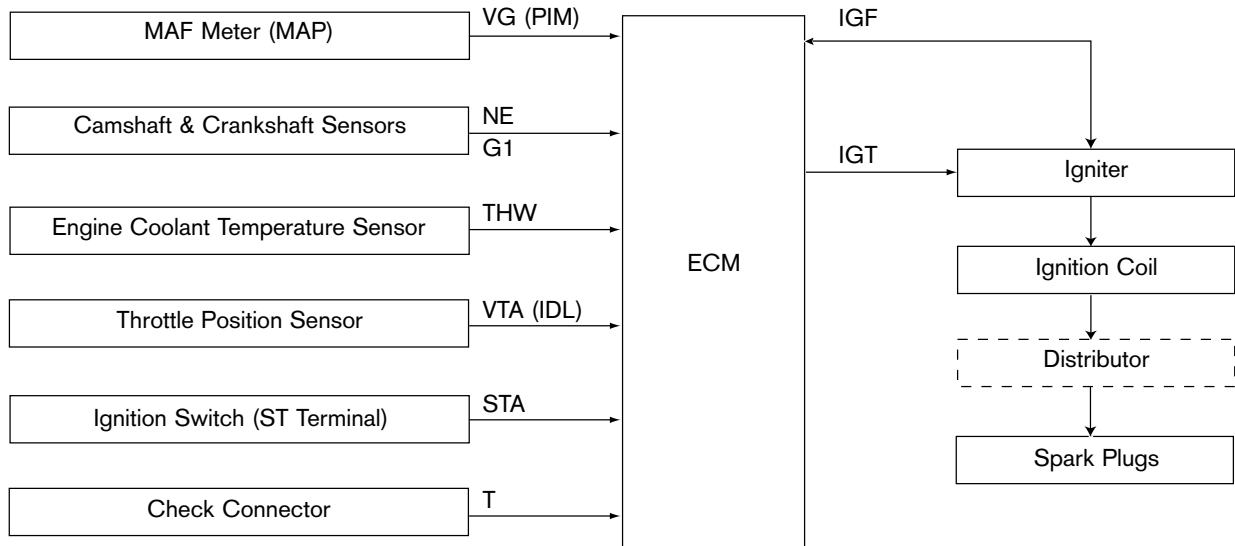


Fig. 3-03

T852f129

### Electronic Spark Advance Overview

In the Electronic Spark Advance (ESA) system, the engine is provided with nearly ideal ignition timing characteristics. The ECM determines ignition timing based on sensor inputs and on its internal memory, which contains the optimal ignition timing data for each engine running condition. After determining the ignition timing, the ECM sends the Ignition Timing signal (IGT) to the igniter. When the IGT signal goes off, the Igniter will shut off primary current flow in the ignition coil producing a high voltage spark (7kV - 35kV) in the cylinder.

Since the ESA always ensures optimal ignition timing, emissions are lowered and both fuel efficiency and engine power output are maintained at optimal levels.

### Types of Ignition Systems

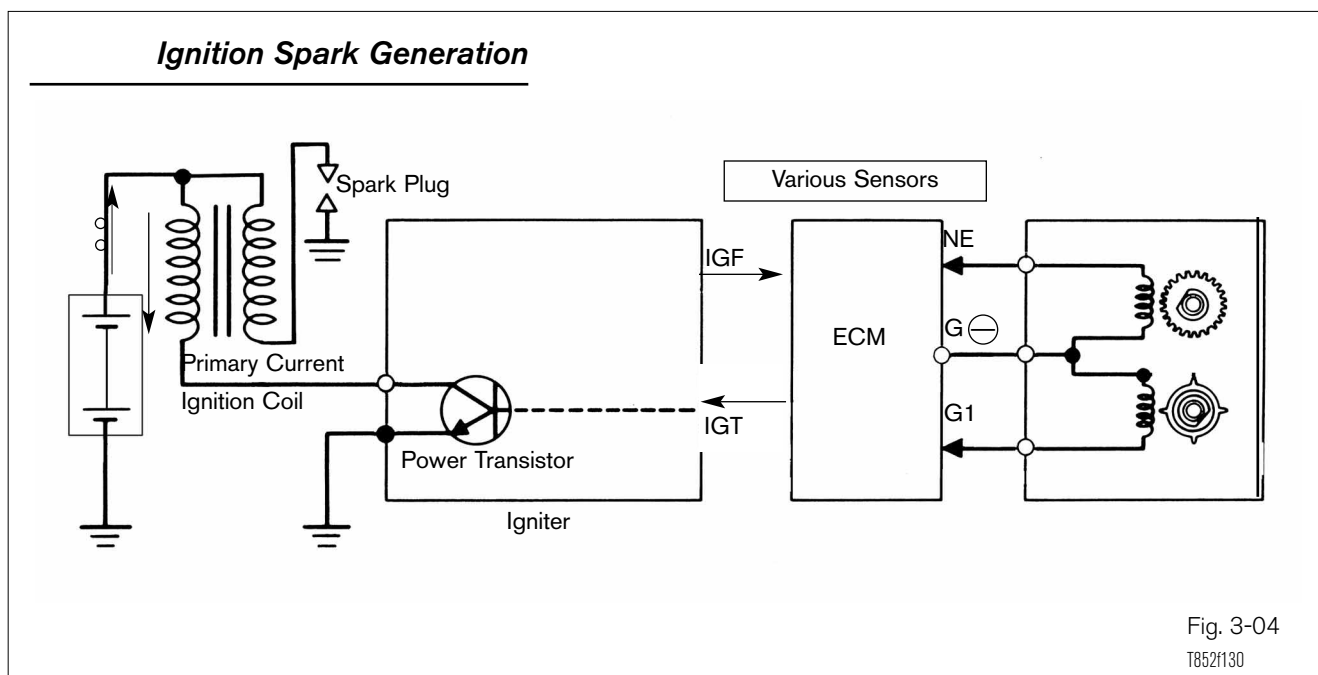
Ignition systems are divided into three basic categories:

- Distributor.
- Distributorless Ignition System (DLI) Electronic Ignition.
- Direct Ignition System (DIS).

## Essential Ignition System Components

Regardless of type the essential components are:

- Crankshaft sensor (Ne signal).
- Camshaft sensor (also called Variable Valve Timing sensor) (G signal).
- Igniter.
- Ignition coil(s), harness, spark plugs.
- ECM and inputs.



## Ignition Spark Generation

The ignition coil must generate enough power to produce the spark needed to ignite the air/fuel mixture. To produce this power, a strong magnetic field is needed. This magnetic field is created by the current flowing in the primary coil. The primary coil has a very low resistance (approximately 1-4 ohms) allowing current flow. The more current, the stronger the magnetic field. The power transistor in the igniter handles the high current needed by the primary coil.

Another requirement to produce high voltages is that the current flow in the primary coil must be turned off quickly. When the transistor in the igniter turns off, current flow momentarily stops and the magnetic field collapses. As the rapidly collapsing magnetic field passes through the secondary winding, voltage (electrical pressure) is created. If sufficient voltage is created to overcome the resistance in the secondary circuit, there will be current flow and a spark generated.

**NOTE** The higher the resistance in the secondary circuit, the more voltage that will be needed to get the current to flow and the shorter spark duration. This is important when observing the ignition spark pattern.

**IGT Signal**

The IGT signal determines when ignition will occur.

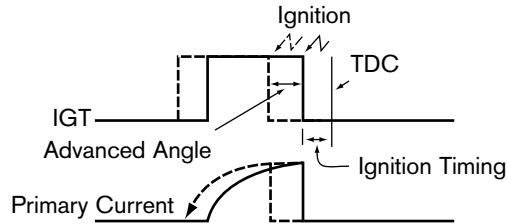


Fig. 3-05  
T852f131

**IGT Signal** The primary coil current flow is controlled by the ECM through the Ignition Timing (IGT) signal. The IGT signal is a voltage signal that turns on/off the main transistor in the igniter. When IGT signal voltage drops to 0 volts, the transistor in the igniter turns off. When the current in the primary coil is turned off, the rapidly collapsing magnetic field induces a high voltage in the secondary coil. If the voltage is high enough to overcome the resistance in the secondary circuit, there will be a spark at the spark plug.

**IGC**

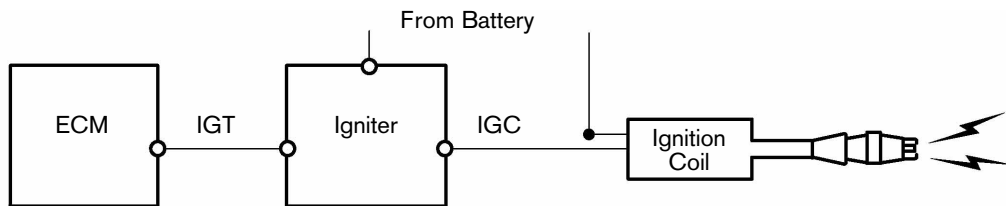


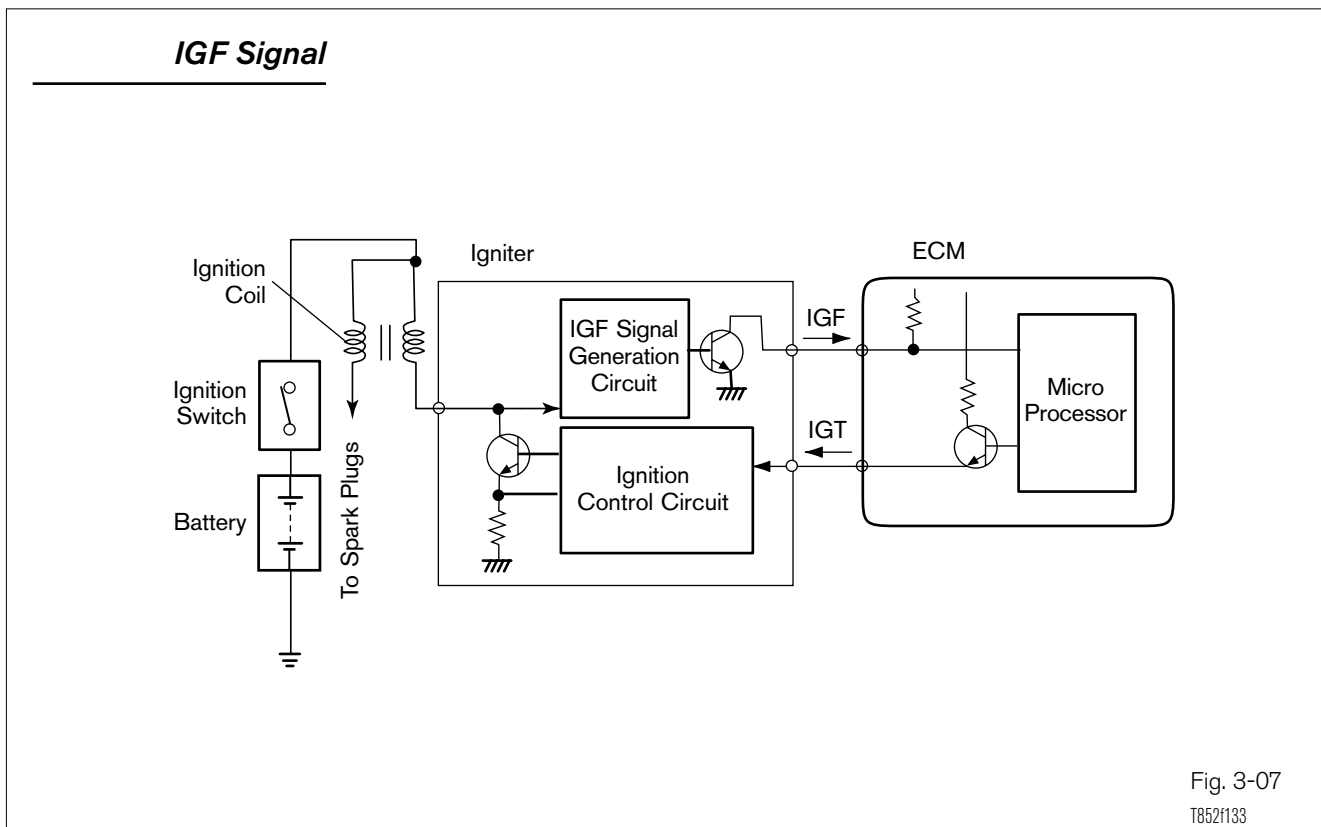
Fig. 3-06  
T852f132

**IGC** On some ignition systems, the circuit that carries the primary coil current is called IGC. IGC is turned on and off by the igniter based on the IGT signal.

**Igniter** The primary function of the igniter is to turn on and off the primary coil current based on the IGT signal received from the ECM. The igniter or ECM may perform the following functions:

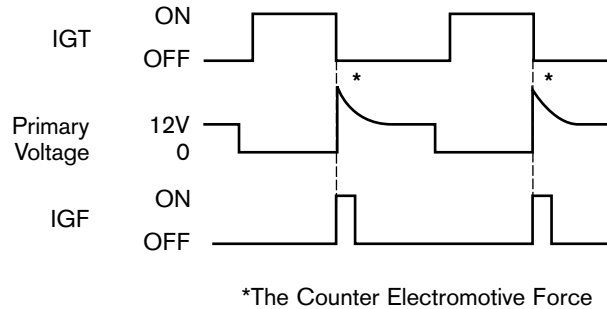
- Ignition Confirmation (IGF) signal generation unit.
- Dwell angle control.
- Lock prevention circuit.
- Over voltage prevention circuit.
- Current limiting control.
- Tachometer signal.

It is critical that the proper igniter is used when replacing an igniter. The igniters are matched to the type of ignition coil and ECM.



**IGF Signal** The IGF signal is used by the ECM to determine if the ignition system is working. Based on IGF, the ECM will keep power supplied to the fuel pump and injectors on most ignition systems. **Without IGF, the vehicle will start momentarily, then stall. However, with some Direct Ignition Systems with the igniter in the coil, the engine will run.**

**IGF Signal Detection Using CEMF**

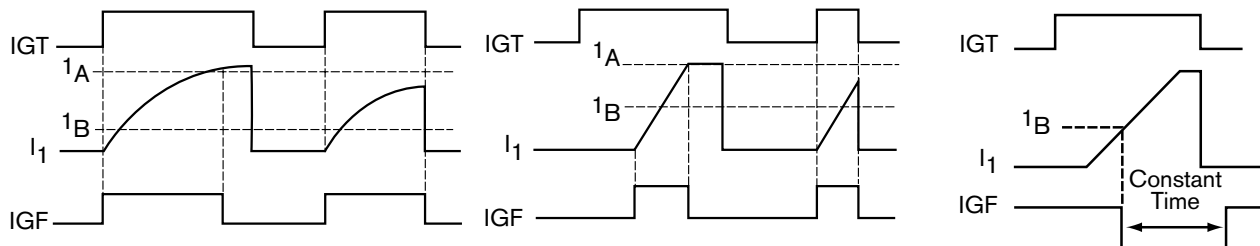


\*The Counter Electromotive Force

Fig. 3-08  
T8521134

**IGF Signal Detection using CEMF** There are two basic methods of detecting IGF. Early systems used the Counter Electromotive Force (CEMF) created in the primary coil and circuit for generating the IGF signal. The collapsing magnetic field produces a CEMF in the primary coil. When CEMF is detected by the igniter, the igniter sends a signal to the ECM. This method is no longer used.

**IGF Detection through Primary Current**



- $I_1$  Primary current
- $I_A$  Maximum current level for successful spark generation
- $I_B$  Minimum current level for successful spark generation

Fig. 3-09  
T8521135/T8521136  
T8521137

**IGF Detection Using Primary Current Method** The primary current level method measures the current level in the primary circuit. The minimum and maximum current levels are used to turn the IGF signal on and off. The levels will vary with different ignition systems. Regardless of method, the Repair Manual shows the scope pattern



or provides you with the necessary voltage reading to confirm that the igniter is producing the IGF signal.

Lack of an IGF on many ignition systems will produce a DTC. On some ignition systems, the ECM is able to identify which coil did not produce an IGF signal and this can be accomplished by two methods.

The first method uses an IGF line for each coil.

With the second method, the IGF signal is carried back to the ECM on a common line with the other coil(s). The ECM is able to distinguish which coil is not operating based on when the IGF signal is received. Since the ECM knows when each cylinder needs to be ignited, it knows from which coil to expect the IGF signal.

### IGF Circuit (8 Cylinder Engine)

*Note that there are only two IGF lines for eight cylinders. Because the ECM knows when the coil is triggered, it knows when to expect the IGF signal. This capability allows the ECM to correctly identify the cylinder and set the appropriate DTC.*

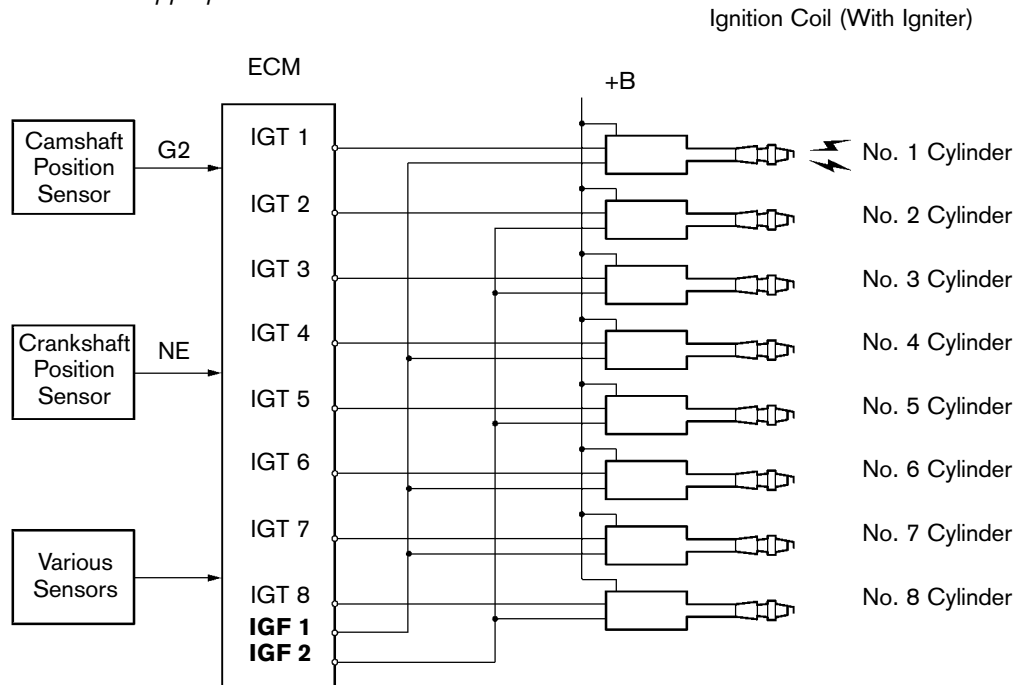
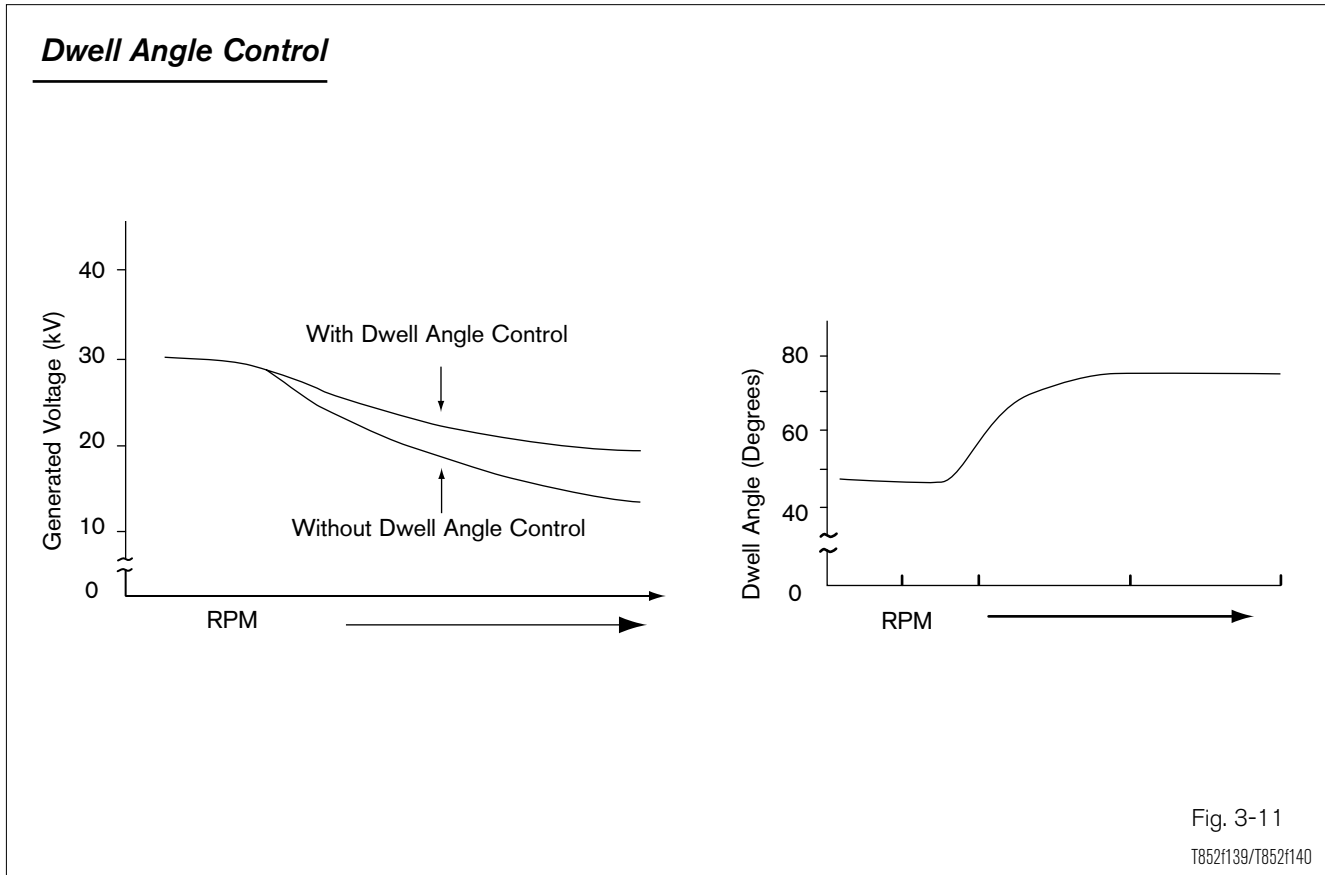


Fig. 3-10

T852f138



**Dwell Angle Control** This circuit controls the length of time the power transistor (current flow through the primary circuit) is turned on.

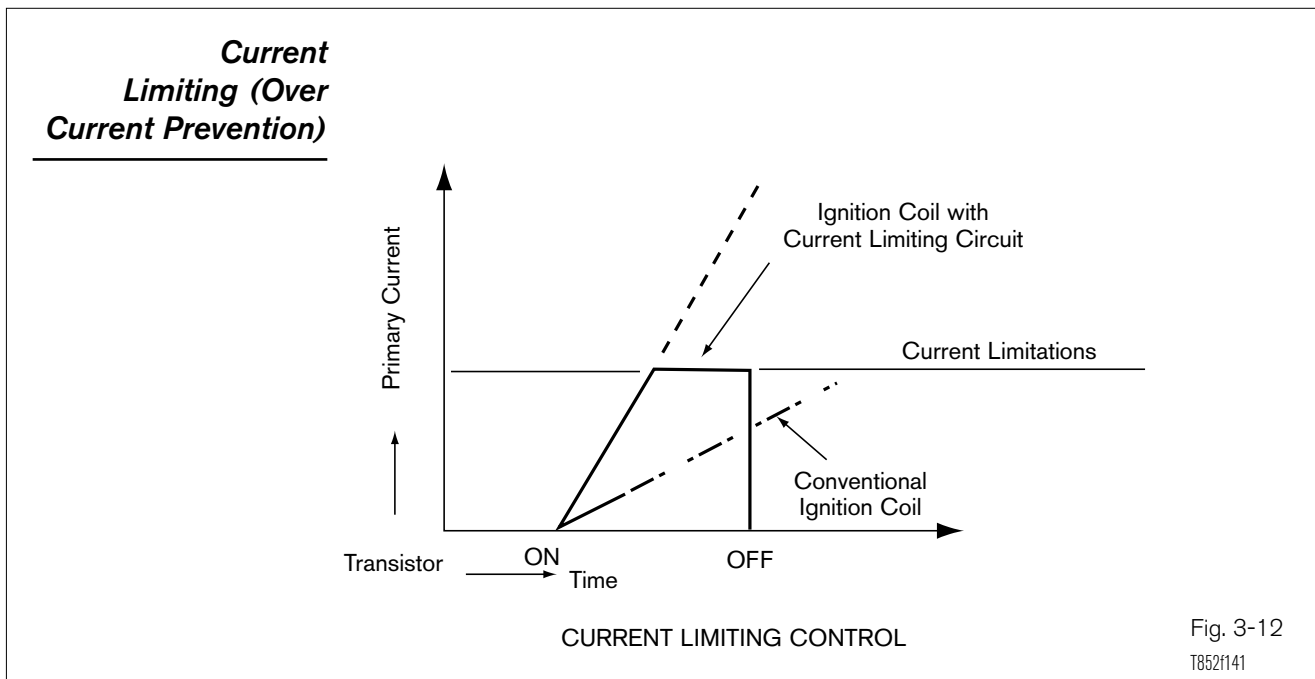
The length of time during which current flows through the primary coil generally decreases as the engine speed rises, so the induced voltage in the secondary coil decreases.

Dwell angle control refers to electronic control of the length of time during which primary current flows through the ignition coil (that is, the dwell angle) in accordance with distributor shaft rotational speed.

At low speeds, the dwell angle is reduced to prevent excessive primary current flow, and increased as the rotational speed increases to prevent the primary current from decreasing.

**Lock Prevention Circuit** This circuit forces the power transistor to turn off if it locks up (if current flows continuously for a period longer than specified), to protect the ignition coil and the power transistor.

**Over Voltage Prevention Circuit** This circuit shuts off the power transistor(s) if the power supply voltage becomes too high, to protect the ignition coil and the power transistor.



**Current Limiting  
(Over Current  
Prevention)**

Current limiting control is a system that improves the rise of the flow of current in the primary coil, ensuring that a constant primary current is flowing at all times, from the low speed to the high speed range, and thus making it possible to obtain a high secondary voltage.

The coil's primary resistance is reduced improving the current rise performance, and this will increase the current flow. But without the current limiting circuit, the coil or the power transistor will burn out. For this reason, after the primary current has reached a fixed value, it is controlled electronically by the igniter so that a larger current will not flow.

Since the current-limiting control limits the maximum primary current, no external resistor is needed for the ignition coil.

**NOTE**

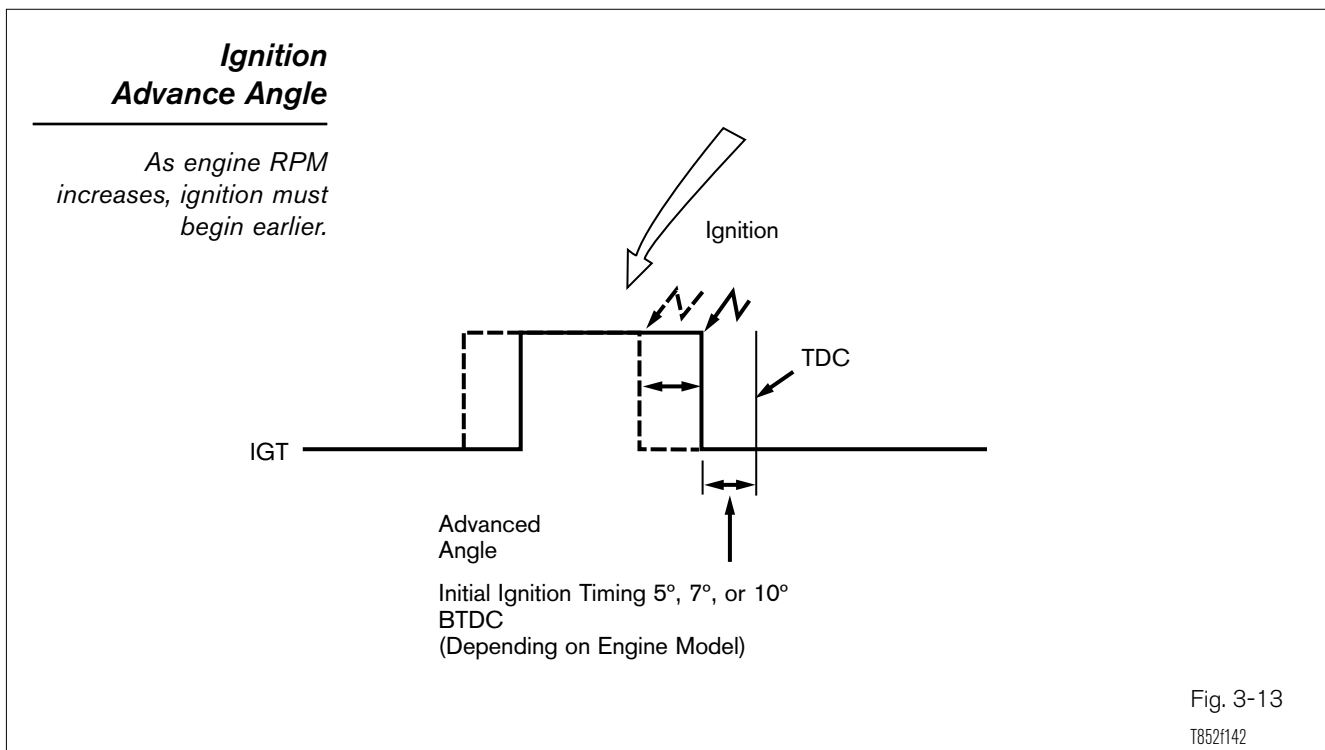
**Since igniters are manufactured to match ignition coil characteristics, the function and construction of each type are different. For this reason, if any igniter and coil other than those specified are combined, the igniter or coil may be damaged. Therefore, always use the correct parts specified for the vehicle.**

**Tachometer Signal** On some systems the Tach signal is generated in the igniter.

**NE Signal and G Signal** Though there are different types of ignition systems, the use of the NE and G signals is consistent. The NE signal indicates crankshaft position and engine RPM.

The G signal (also called VVT signal) provides cylinder identification. By comparing the G signal to the NE signal, the ECM is able to identify the cylinder on compression. This is necessary to calculate crankshaft angle (initial ignition timing angle), identify which coil to trigger on Direct Ignition System (independent ignition), and which injector to energize on sequential fuel injection systems.

As ignition systems and engines evolved, there have been modifications to the NE and G signal. Timing rotors have different numbers of teeth. For some G signal sensors, a notch is used instead of a tooth to generate a signal. Regardless, you can determine what style is used by visually examining the timing rotor or consulting the Repair Manual. Many of the different styles are represented with their respective ignition system.



**Electronic Spark Advance Operation** For maximum engine output efficiency, the air/fuel mixture must be ignited so that maximum combustion pressure occurs approximately 10°-15° after TDC. As engine RPM increases, there is less time for the mixture to complete its combustion at the proper time because the piston is traveling faster. The ECM controls when the spark occurs through the IGT signal. By varying the time the IGT signal is turned off, the ECM changes ignition spark timing.

### **Ignition Advance Modes and Corrections**

The ECM calculates the IGT signal on time based on engine operating modes and conditions. The IGT signal is based primarily on the crankshaft position sensor signal, engine load, temperature, knock sensor, etc.

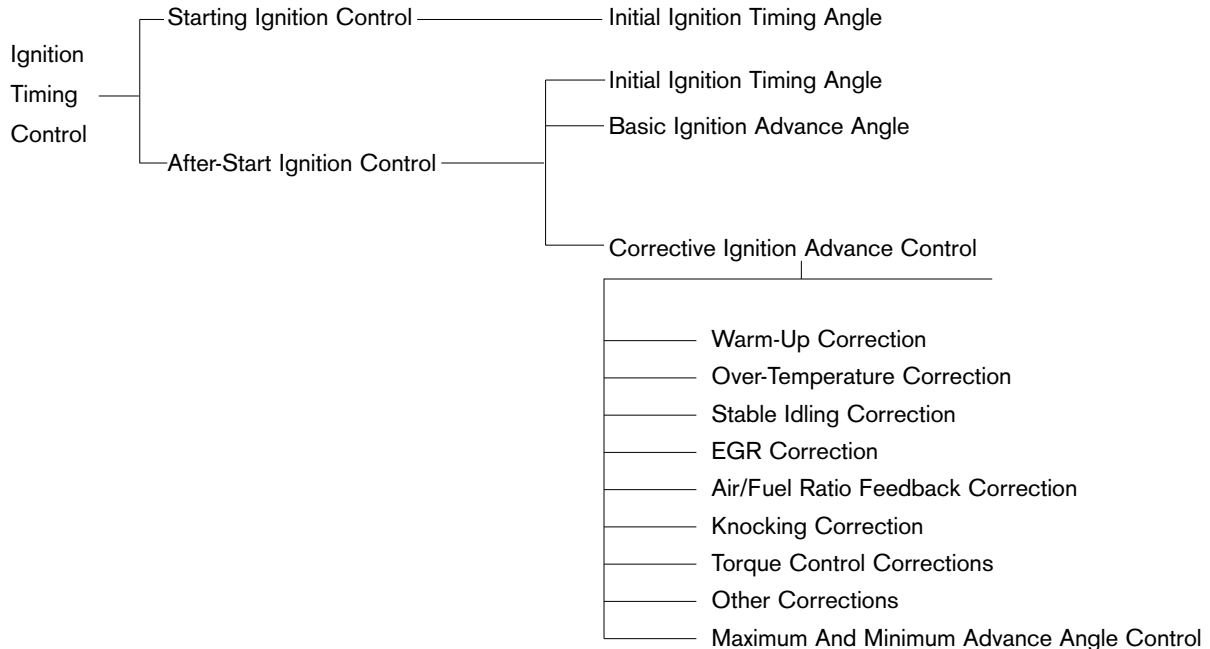


Fig. 3-14

**Starting Ignition Control** Ignition timing control consists of two basic elements:

- Ignition control during starting.
- After-start ignition control.

**Ignition Control During Starting** Ignition control during starting is defined as the period when the engine is cranking and immediately following cranking. The ignition occurs at a fixed crankshaft angle, approximately 5°-10° BTDC, regardless of engine operating conditions and this is called the initial timing angle.

Since engine speed is still below a specified RPM and unstable during and immediately after starting, the ignition timing is fixed until engine operation is stabilized.

The ECM recognizes the engine is being cranked when it receives the NE and G signal. On some models, the starter (STA) signal is also used to inform the engine is being cranked.

### Initial Ignition Timing Angle

This angle is calculated from the first NE signal that follows a G signal. The ignition occurs at a fixed crankshaft angle, approximately 5°-10° BTDC, regardless of engine operating conditions, and this is called the initial timing angle.

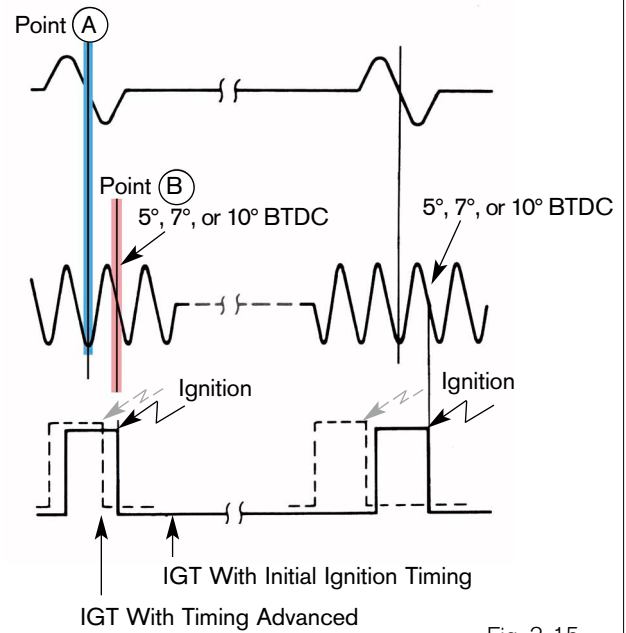
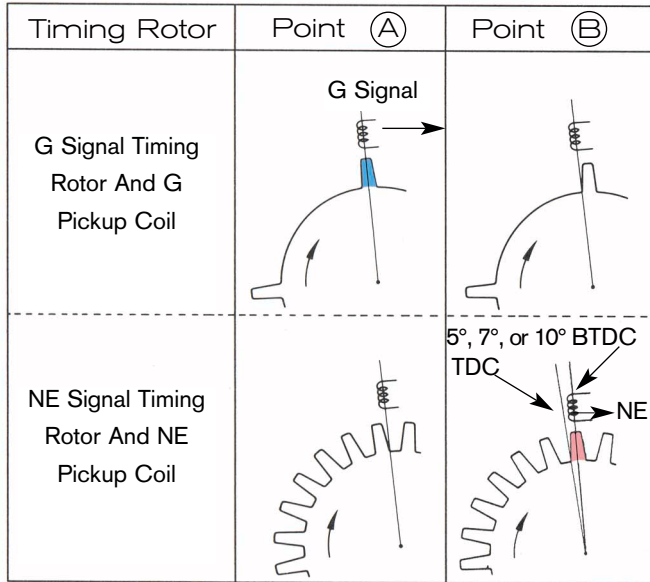


Fig. 3-15  
T8521143/T8521144

### Initial Ignition Timing Angle Symbol

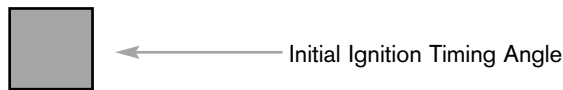


Fig. 3-16  
T8521145

**After-Start Ignition Control** After-start ignition control will calculate and adjust ignition timing based on engine operating conditions. The calculation and adjustment of ignition timing is performed in a series of steps, beginning with basic ignition advance control.

Various corrections are added to the initial ignition timing angle and the basic ignition advance angle during normal operation.

After-start ignition control is carried out during normal operation.

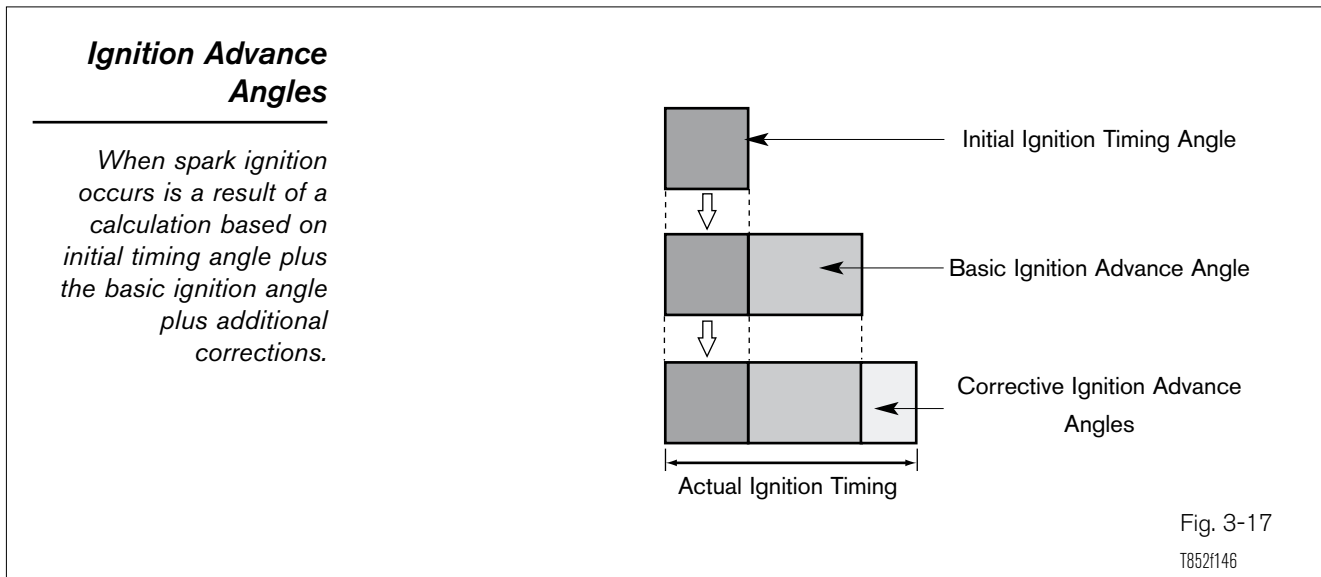
The various corrections (that are based on signals from the relevant sensors) are added to the initial ignition timing angle and to the basic ignition advance angle (determined by the intake air volume signal or intake manifold pressure signal) and by the engine speed signal:

Ignition timing = initial ignition timing angle

+ basic ignition advance angle

+ corrective ignition advance angle

During normal operation of after-start ignition control, the Ignition Timing (IGT) signal calculated by the microprocessor in the ECM and is output through the back-up IC.



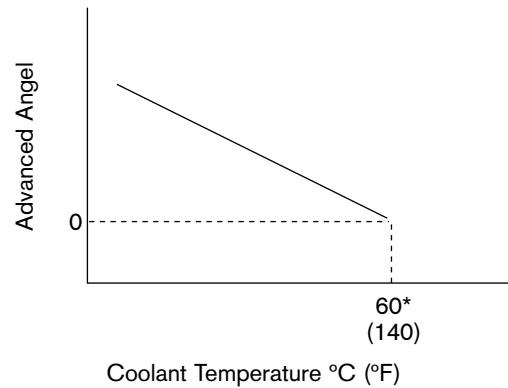
**Basic Ignition Advance Control** The ECM selects the basic ignition advance angle from memory based on engine speed, load, throttle valve position, and engine coolant temperature.

#### **Relevant Signals:**

- Intake air volume (VS, KS, or VG) (Intake manifold pressure (PIM)).
- Engine speed (NE).
- Throttle position (IDL).
- Engine Coolant Temperature (THW).

**Corrective Ignition Advance Control** The Corrective Ignition Advance Control makes the final adjustment to the actual ignition timing. The following corrective factors are not found on all vehicles.

**Warm Up Correction**



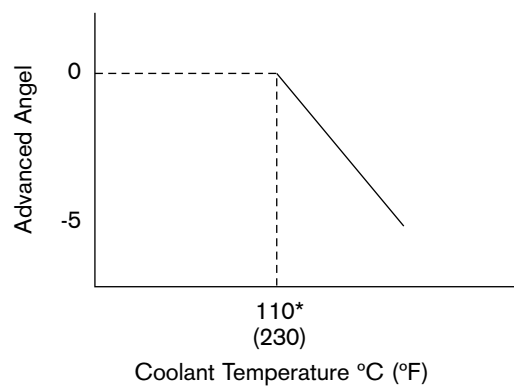
\*Depending on the Engine Model.

Fig. 3-18

T8521147

**Warm-Up Correction** The ignition timing is advanced to improve driveability when the coolant temperature is low. In some engine models, this correction changes the advance angle in accordance with the intake air volume (intake manifold pressure) and can advance approximately 15° (varies with engine model) by this correction during extremely cold weather.

**Over Temperature**



\*Depending on the Engine Model.

Fig. 3-19

T8521148

**Over Temperature Correction** To prevent knocking and overheating, the ignition timing is retarded when the coolant temperature is extremely high. The timing may be retarded approximately 5° by this correction.

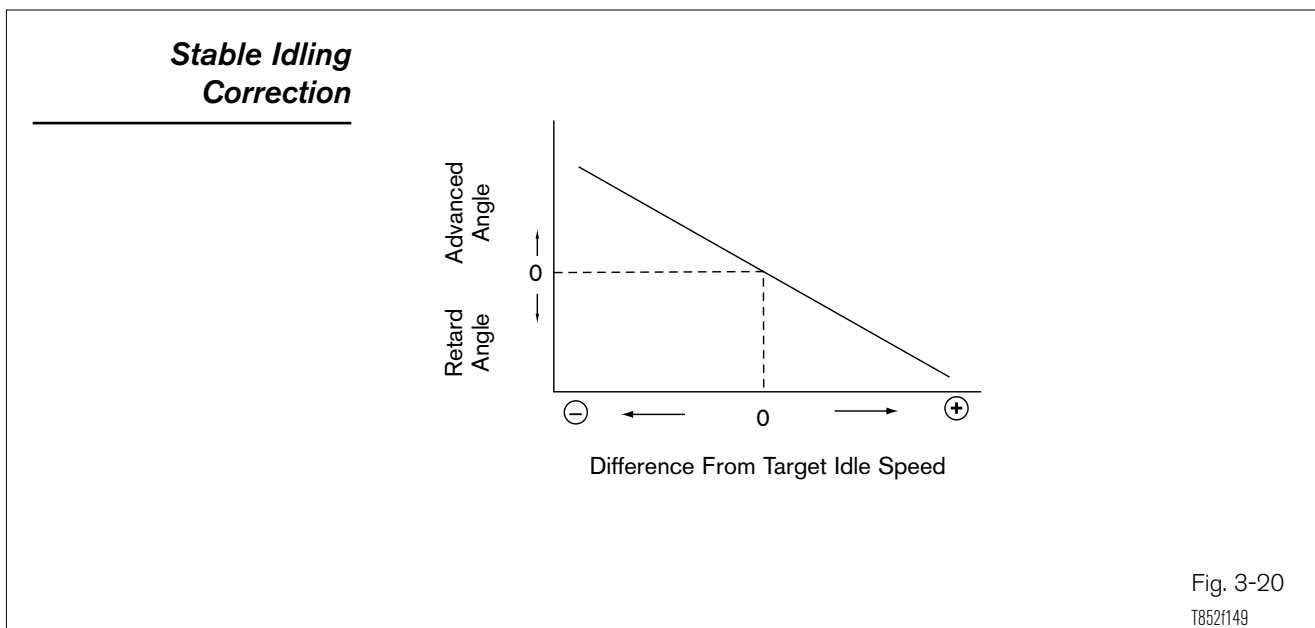


**Relevant Signals:**

- Engine Coolant Temperature (ECT) - THW.

The following may also be used on some engine models:

- MAF (VS, KS, or VG).
- Engine Speed - NE signal.
- Throttle position VTA or (IDL).



**Stable Idling Correction** When the engine speed during idling has fluctuated from the target idle speed, the ECM adjusts the ignition timing to stabilize the engine speed. The ECM is constantly calculating the average engine speed. If the engine speed falls below the target speed, the ECM advances the ignition timing by a predetermined angle. If the engine speed rises above the target speed, the ECM retards the ignition timing by a predetermined angle.

This correction is not executed when the engine exceeds a predetermined speed.

In some engine models, the advance angle changes depending on whether the air conditioner is on or off. In other engine models, this correction only operates when the engine speed is below the target engine speed.

**Relevant Signals:**

- Engine Speed (NE)
- TPS (VTA or IDL)
- Vehicle Speed (SPD)

**EGR Correction** When EGR is operating, the ignition timing is advanced according to intake air volume and engine RPM to improve driveability. EGR has the effect of reducing engine knocking, therefore the timing can be advanced.

**Relevant Signals:**

- Engine Speed (NE)
- TPS (VTA or IDL or PSW)
- Intake air volume (VS, KS, or VG) (Intake manifold pressure (PIM))

**Torque Control Correction** This correction reduces shift shock and the result is that the driver feels smoother shifts. With an electronically-controlled transaxle, each clutch and brake in the planetary gear unit of the transmission or transaxle generates shock to some extent during shifting. In some models, this shock is minimized by delaying the ignition timing when gears are upshifted. When gear shifting starts, the ECM retards the engine ignition timing to reduce the engine torque. As a result, the shock of engagement and strain on the clutches and brakes of the planetary gear unit is reduced and the gear shift change is performed smoothly. The ignition timing angle is retarded a maximum of approximately 20° by this correction. This correction is not performed when the coolant temperature or battery voltage is below a predetermined level.

**Relevant Signals:**

- Engine Speed (NE)
- TPS (VTA or IDL or PSW)
- ECT (THW)
- Battery voltage (+B)

**Knock**

When the spark plug ignites the air/fuel mixture, cylinder pressure increases. If the increase in heat and pressure is high enough, the air/fuel mixture will ignite at a location other than the spark plug. This is referred to as spontaneous combustion and produces engine knock.

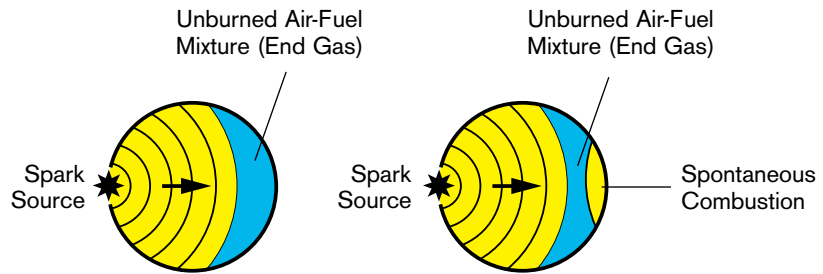


Fig. 3-21  
T8521150

**Knock Correction** Engine knock, if severe enough, can cause engine damage. Combustion chamber design, gasoline octane, air/fuel ratio, and ignition timing all affect when knock will occur. Under most engine conditions, ignition timing needs to be near the point when knock occurs to achieve the best fuel economy, engine power output, and lowest exhaust emissions. However, the point when knock occurs will vary from a variety of factors. For example, if the gasoline octane is too low, and ignition takes place at the optimum point, knock will occur. To prevent this, a knock correction function is used.

**Engine Knock Control Loop**

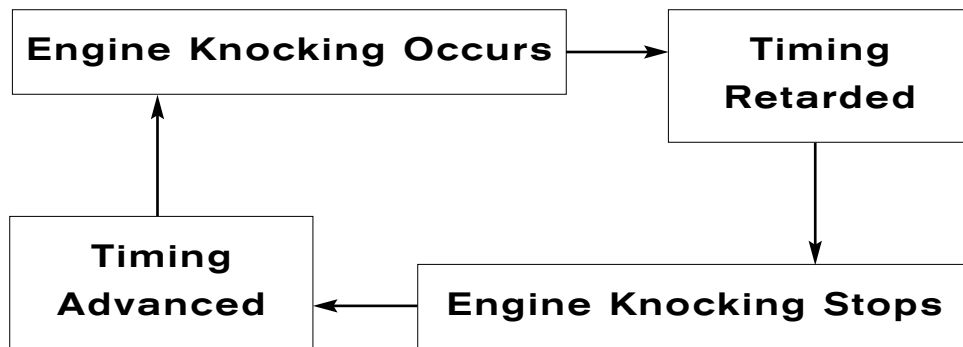


Fig. 3-22

### Engine Knock Control

The ECM retards the timing in fixed steps until the knock disappears. When the knocking stops, the ECM stops retarding the ignition timing and begins to advance the timing in fixed steps.

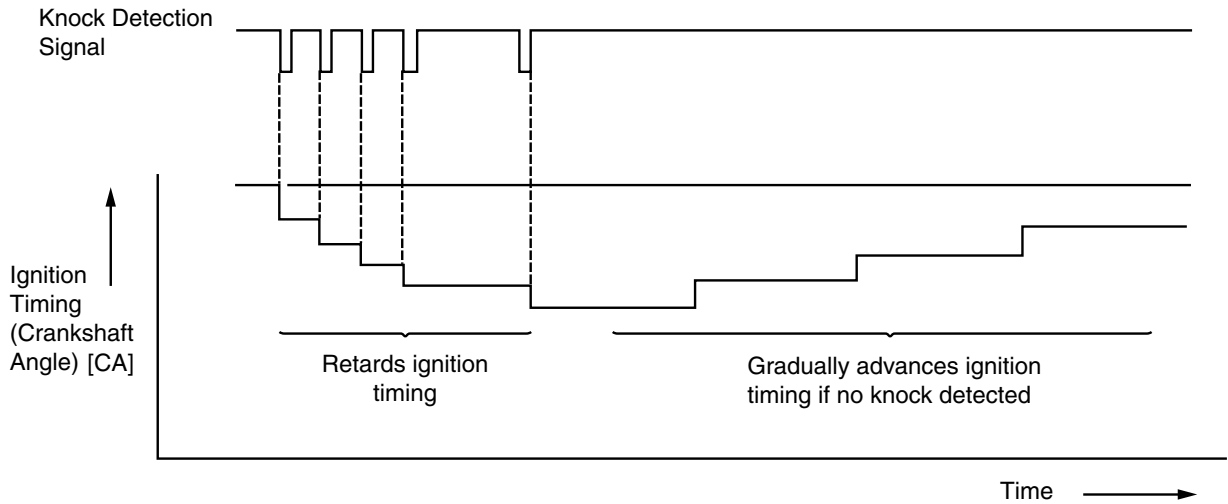


Fig. 3-23  
T852f151

When engine knocking occurs, the knock sensor converts the vibration from the knocking into a voltage signal that is detected by the ECM. According to its programming, the ECM retards the timing in fixed steps until the knock disappears. When the knocking stops, the ECM stops retarding the ignition timing and begins to advance the timing in fixed steps. If the ignition timing continues to advance and knocking occurs, ignition timing is again retarded.

### Knock Signal Identification

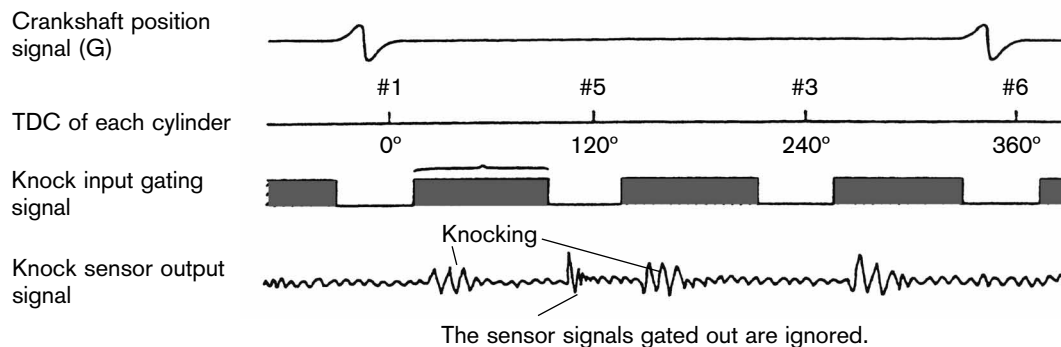


Fig. 3-24  
T852f152

The ECM is able to determine which cylinder is knocking by when the knock signal is received. The ECM knows the cylinder that is in the power stroke mode based on the NE and G signals. This allows the ECM to filter any false signals.

Some mechanical problems can duplicate engine knocking. An excessively worn connecting rod bearing or a large cylinder ridge will produce a vibration at the same frequency as engine knocking. The ECM in turn will retard the timing.

**Air/Fuel Ratio Correction** The engine is especially sensitive to changes in the air - fuel ratio when it is idling, so stable idling is ensured by advancing the ignition timing at this time in order to match the fuel injection volume of air - fuel ratio feedback correction.

This correction is not executed while the vehicle is being driven.

**Relevant Signals:**

- Oxygen or A/F sensor.
- TPS (VTA or IDL).
- Vehicle Speed (SPD).

**Other Corrections** Engines have been developed with the following corrections added to the ESA system (in addition to the various corrections explained so far), in order to adjust the ignition timing with extremely fine precision.

**Transition Correction** - During the transition (change) from deceleration to acceleration, the ignition timing is either advanced or retarded temporarily in accordance with the acceleration.

**Cruise Control Correction** - When driving downhill under cruise control, in order to provide smooth cruise control operation and minimize changes in engine torque caused by fuel cut-off because of engine braking, a signal is sent from the Cruise Control ECU to the ECM to retard the ignition timing.

**Traction Control Correction** - This retards the ignition timing, thus lowering the torque output by the engine, when the coolant temperature is above a predetermined temperature and the traction control system is operating.

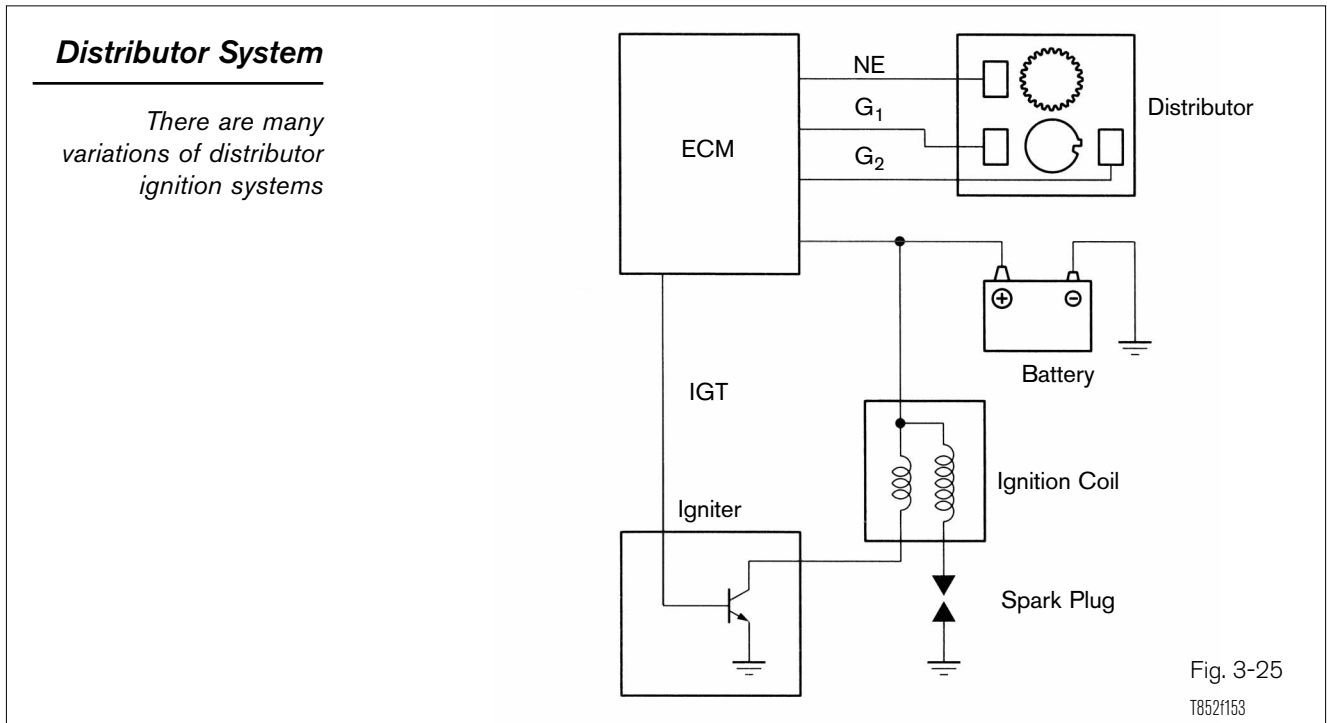
**Acoustic Control Induction System (ACIS) Correction** - When the engine speed rises above a predetermined level, the ACIS operates. At that time, the ECM advances the ignition timing simultaneously, thus improving output.

**Maximum and Minimum Ignition Advance Control** If the actual ignition timing (basic ignition advance angle + corrective ignition advance or retard angle) becomes abnormal, the engine will be adversely affected. To prevent this, the ECM controls the actual advance so that the sum of the basic ignition and corrective angle cannot be greater or less than preprogrammed minimum or maximum values.

Approximately, these values are:

- MAX. ADVANCE ANGLE: 35°-45°.
- MIN. ADVANCE ANGLE: 10°-0°.

Advance angle = Basic ignition advance angle + Corrective ignition advance angle



**Distributor Ignition (DI) Systems** The NE signal is generated by the Crankshaft Position Sensor (also called engine speed sensor). The G signal is generated by the Camshaft Position sensor that may be located in the distributor or on the engine.

### Distributor

*This distributor has two G signal pick up coils and an NE signal rotor.*

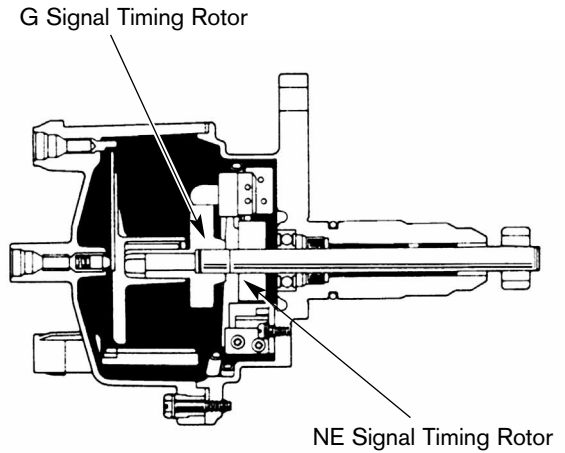
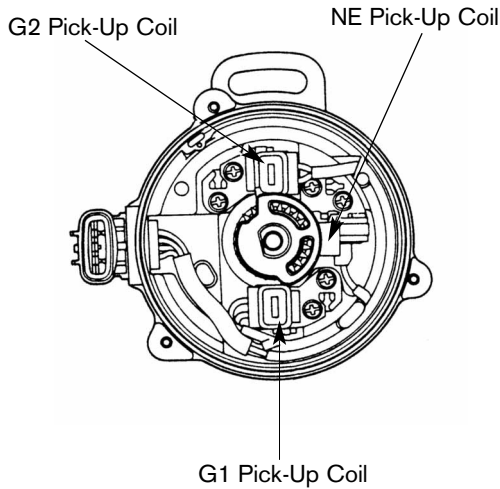


Fig. 3-26

T8521154/T8521155

### Distributor System Circuit

*The IGT signal turns the igniter on and off at the correct time for ignition to occur.*

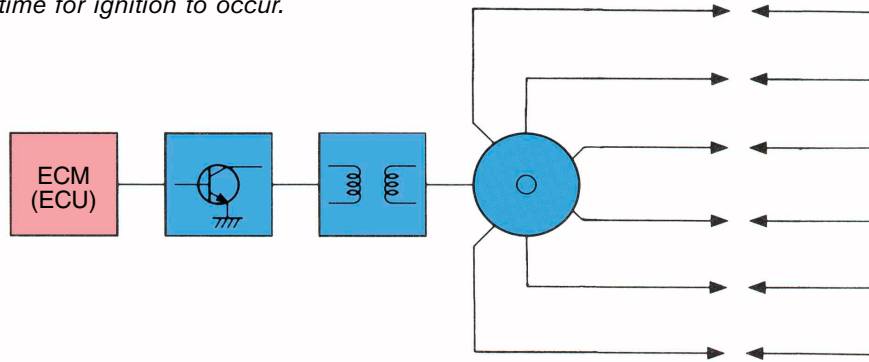


Fig. 3-27

T8521156

At the appropriate time during cylinder compression, the ECM sends a signal called IGT to the igniter. This will turn on the transistor in the igniter sending current through the primary winding of the ignition coil. At the optimum time for ignition to occur, the ECM will turn off IGT and the transistor will turn off current flow through the primary winding. The induced current will travel through the coil wire, to the distributor

cap, rotor, to the distributor terminal the rotor is pointing at, high tension wire, spark plug, and ground. The rotor position determines the cylinder that receives the spark.

**Firing Order** The firing order can be found in the New Car Features book. The cylinders are identified as follows:

- V-8 engine cylinders are numbered with odd numbered cylinders on the left bank and even numbered cylinders on the right bank.
- V-6 engine cylinders are numbered with even on left bank and odd numbered cylinders on the right bank.
- In-line 6 engines are numbered consecutively 1-6, with the number 1 cylinder at the front.
- Four cylinder engines are numbered consecutively from front to back.

Many times, original equipment distributor caps have the firing order molded into the cap.

***Firing Order***

<b>Engine Configuration</b>	<b>Firing Order</b>
<b>V-8</b>	<b>1-8-4-3-6-5-7-2</b>
<b>V-6</b>	<b>1-2-3-4-5-6</b>
<b>In-line 6</b>	<b>1-5-3-6-2-4</b>
<b>In-line 4</b>	<b>1-3-4-2</b>

Fig. 3-28



**V-6 Cylinder Identification**

*Note that the cylinder numbering is opposite the V-8.*

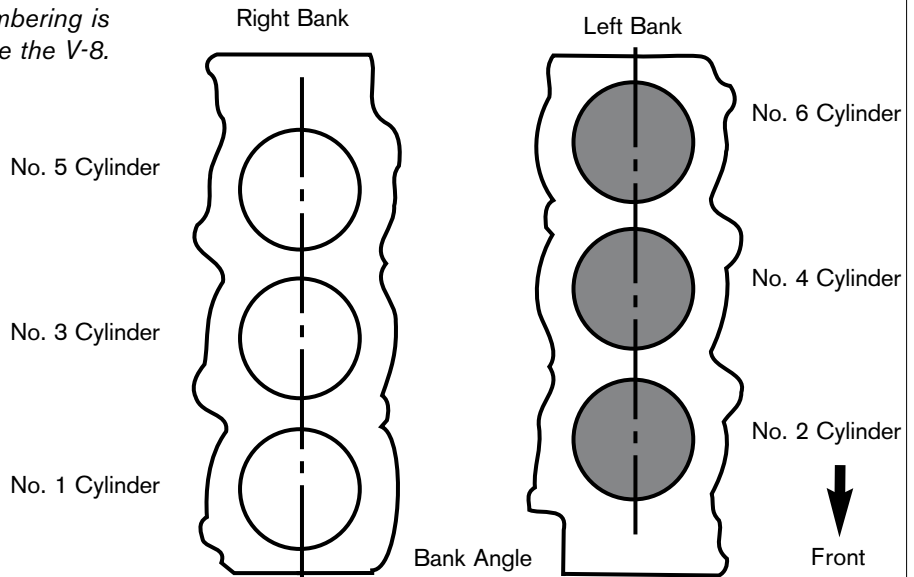


Fig. 3-29  
T8521157

**V-8 Cylinder Identification**

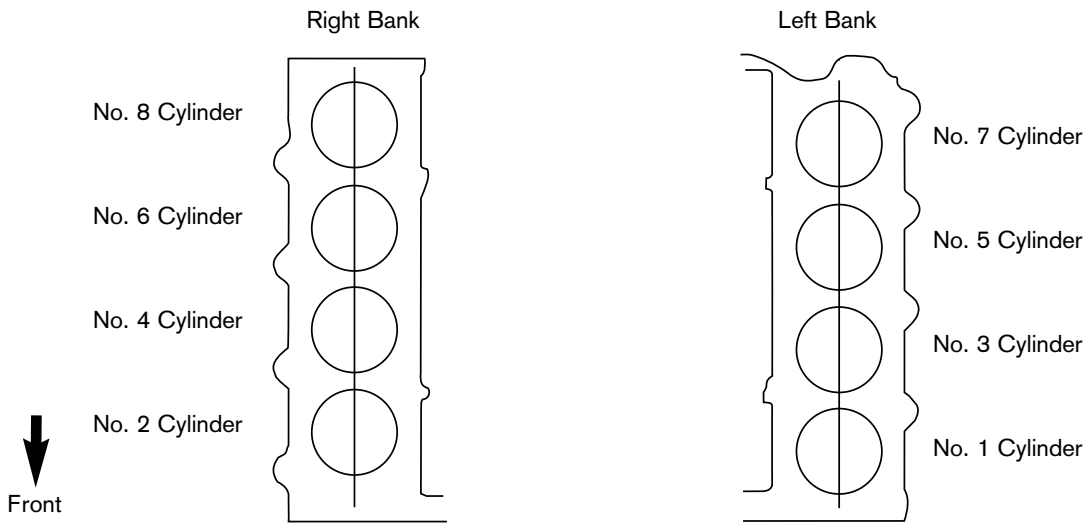


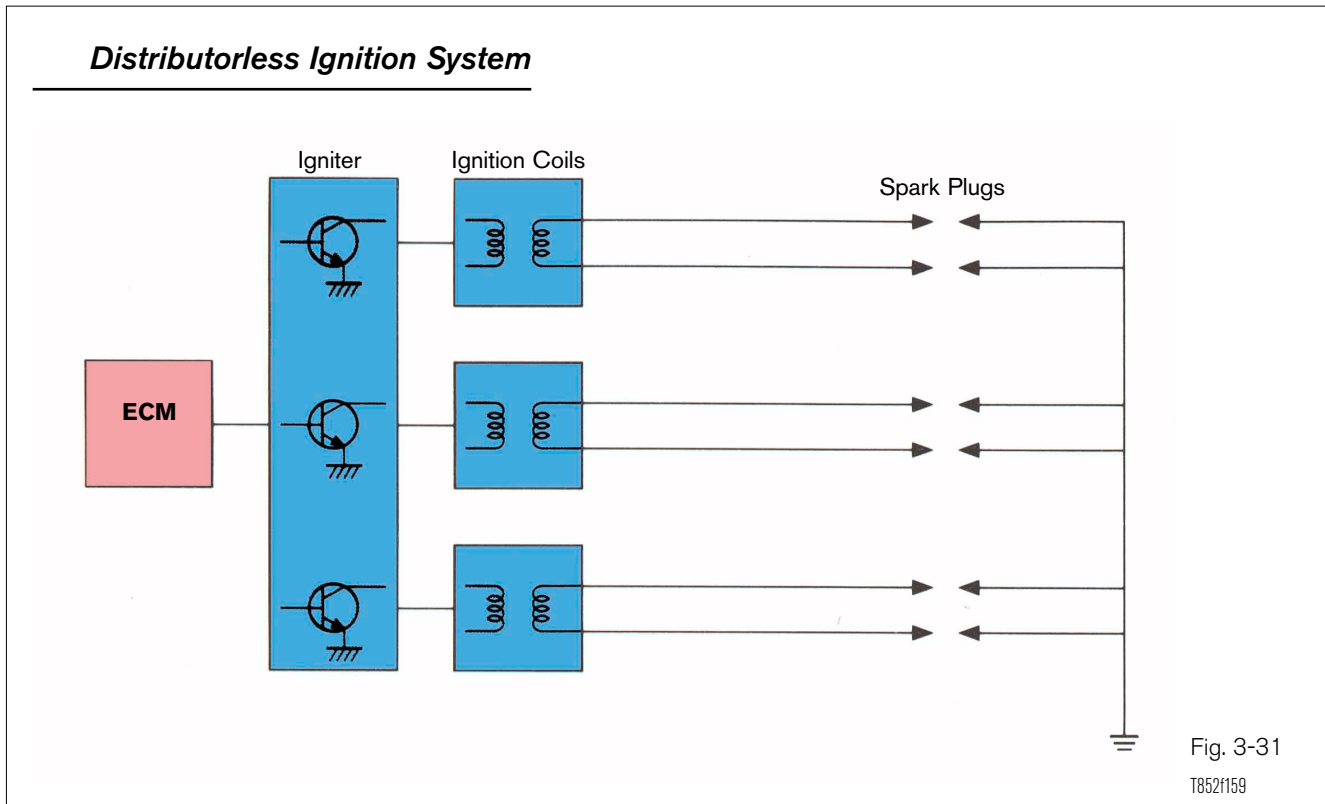
Fig. 30  
T8521158

**Distributorless & Direct Ignition Systems Overview**

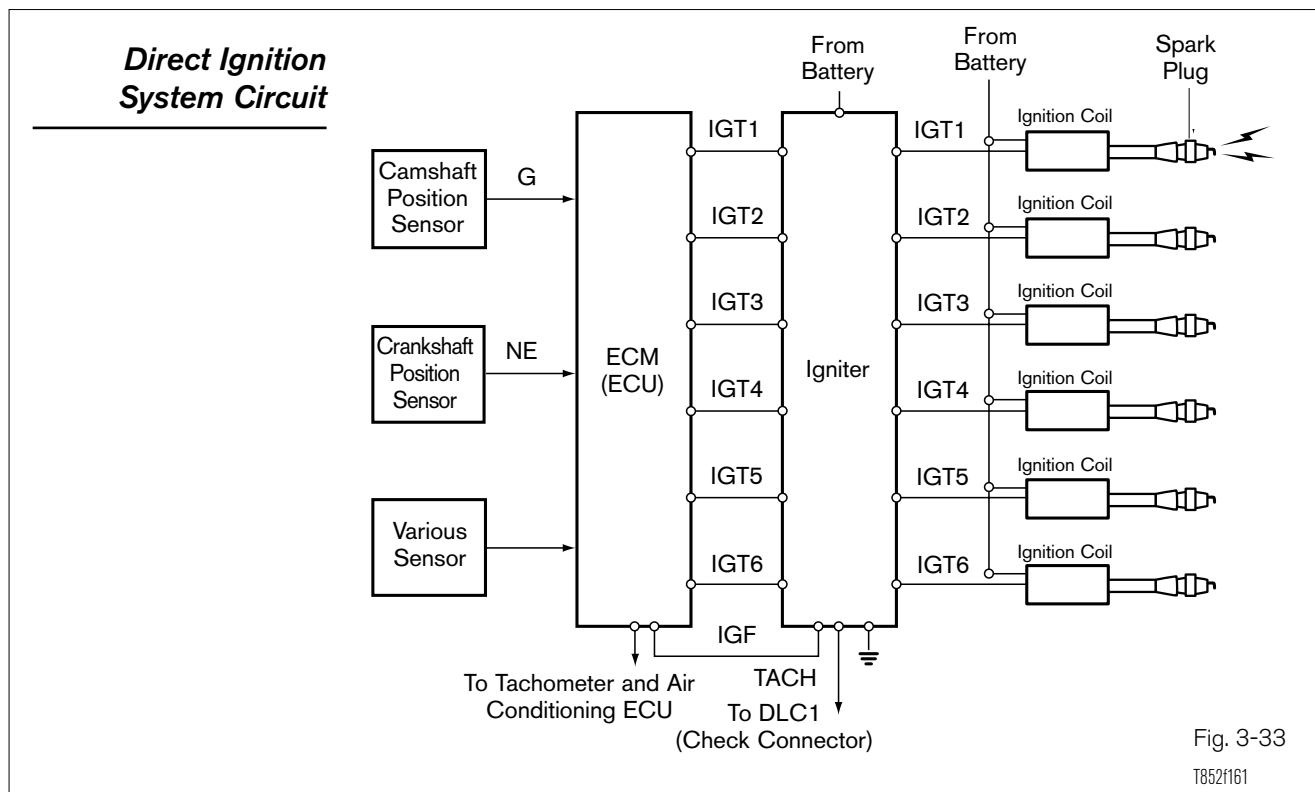
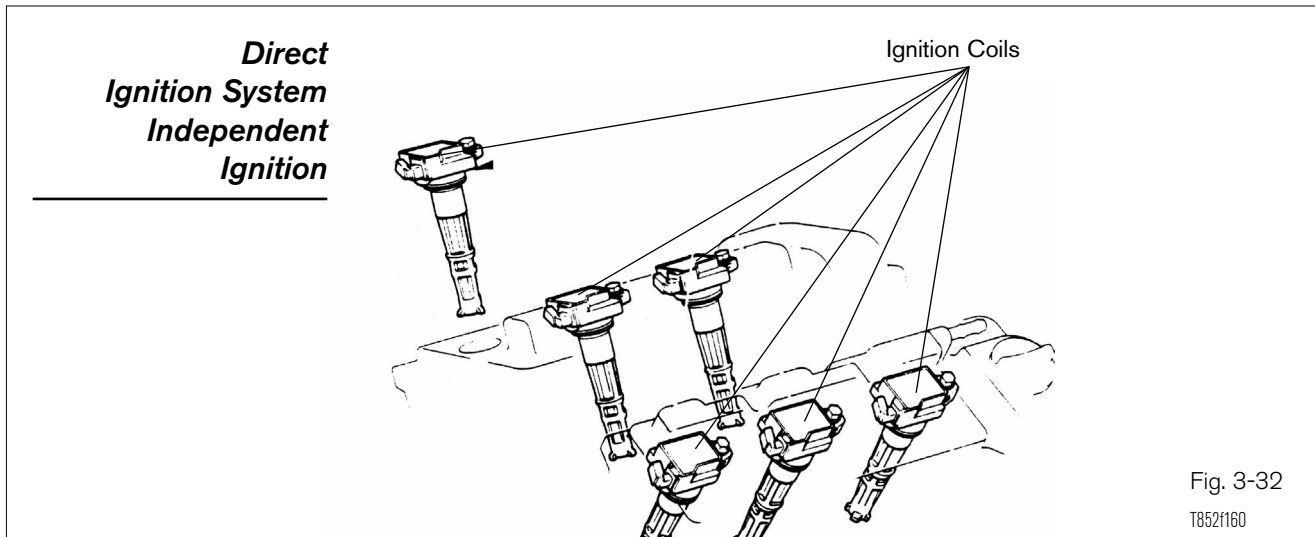
Essentially, a Distributorless Ignition System is an ignition system without a distributor. Eliminating the distributor improved reliability by reducing the number of mechanical components. Other advantages are:

- Greater control over ignition spark generation - There is more time for the coil to build a sufficient magnetic field necessary to produce a spark that will ignite the air/fuel mixture. This reduces the number of cylinder misfires.
- Electrical interference from the distributor is eliminated - Ignition coils can be placed on or near the spark plugs. This helps eliminate electrical interference and improve reliability.
- Ignition timing can be controlled over a wider range - In a distributor, if too much advance is applied the secondary voltage would be directed to the wrong cylinder.

All of the above reduces the chances of cylinder misfires and consequently, exhaust emissions.

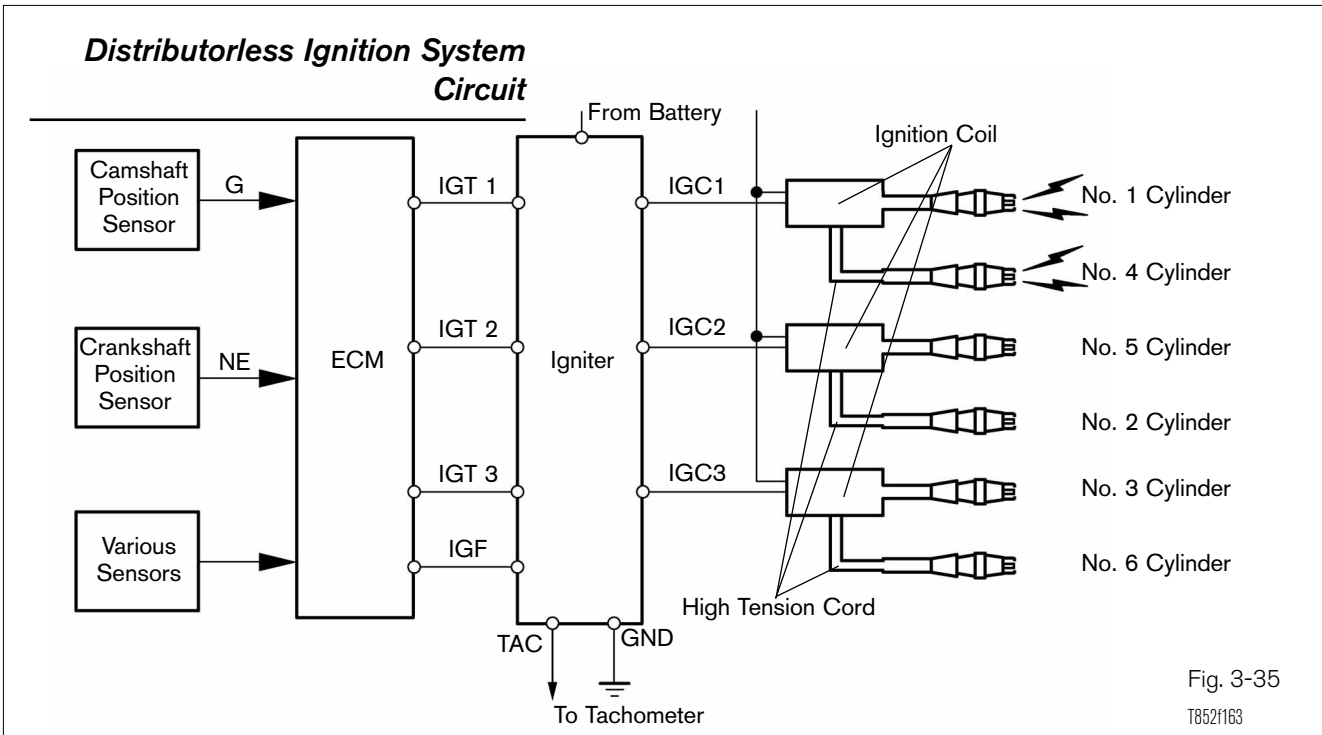
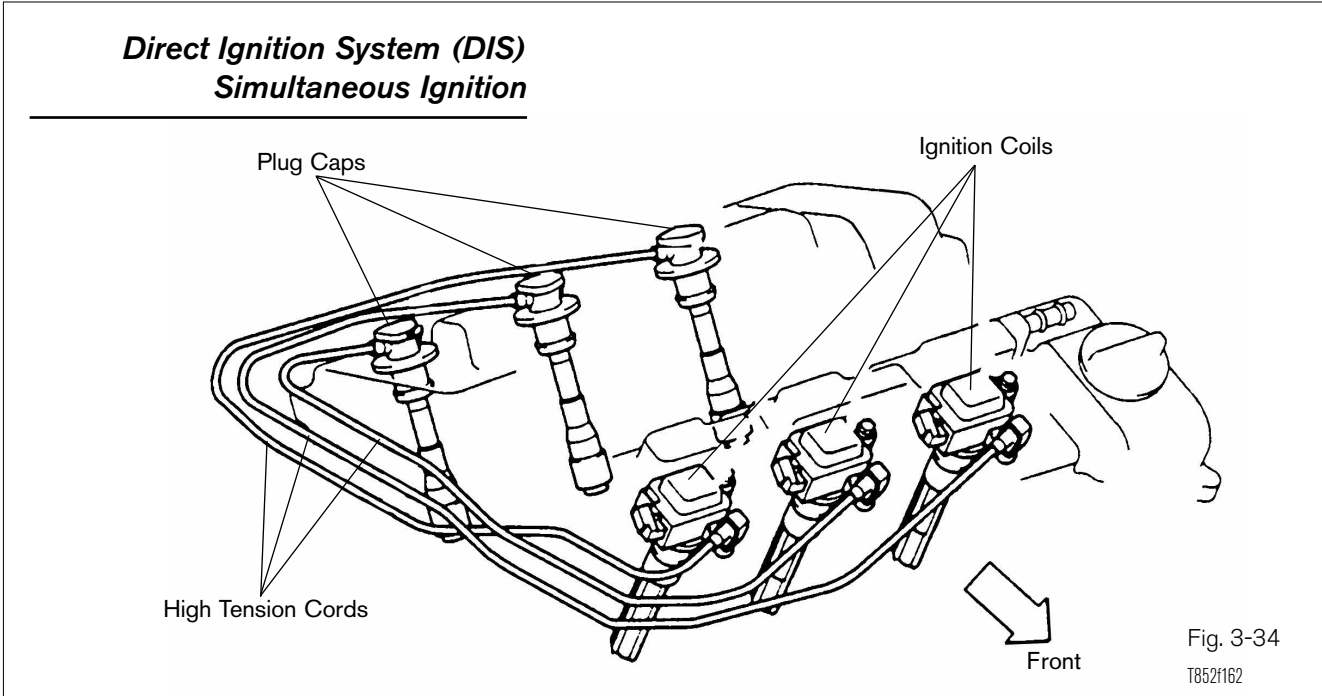


Distributorless Ignition systems are usually defined as having one ignition coil with two spark plug wires for two cylinders. Distributorless Ignition Systems use a method called simultaneous ignition (also called waste spark) where an ignition spark is generated from one ignition coil for two cylinders simultaneously.



Direct Ignition Systems (DIS) have the ignition coil mounted on the spark plug. DIS can come in two forms:

- **Independent ignition** - one coil per cylinder.
- **Simultaneous ignition** - one coil for two cylinders. In this system an ignition coil is mounted directly to one spark plug and a high tension cord is connected to the other spark plug. A spark is generated in both cylinders simultaneously.



**Distributorless (Simultaneous Ignition) Operation** Distributorless Ignition Systems and Direct Ignition Systems that use one coil for two cylinders use a method known as simultaneous ignition. With simultaneous ignition systems, two cylinders are paired according to piston position. This has the effect simplifying ignition timing and reducing the secondary voltage requirement.

For example, on a V-6 engine, on cylinders one and four, the pistons occupy the same cylinder position (both are at TDC and BDC at the same time), and move in unison, but they are on different strokes. When cylinder one is on the compression stroke, cylinder four is on the exhaust stroke, and vice versa on the next revolution.

**Simultaneous Ignition Sequence**

*Two cylinders simultaneously will have spark, though only one cylinder will be on the compression stroke. Note that cylinders 2 and 5 both have spark, but cylinder No. 5 is compression. One crankshaft revolution later cylinder No. 3 is on compression.*

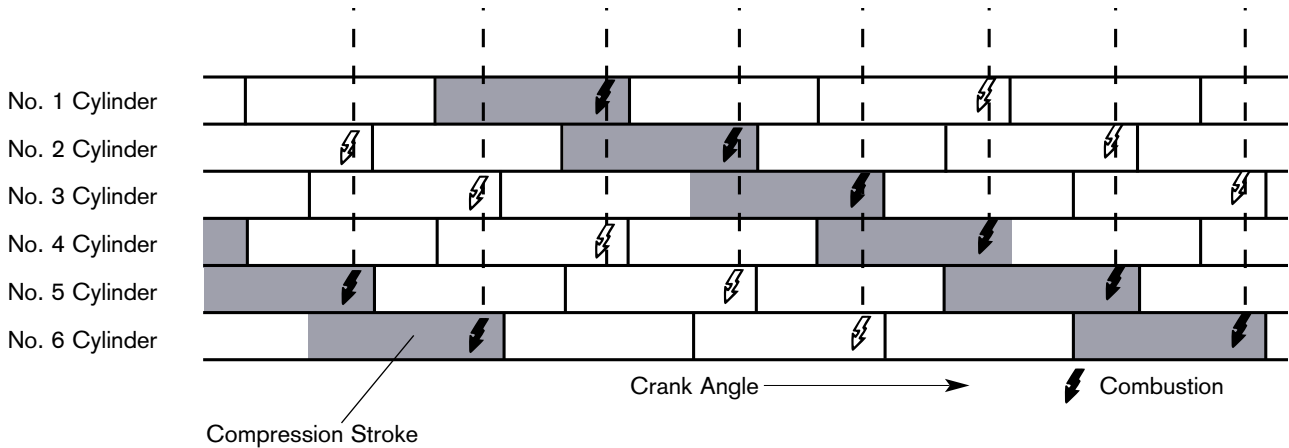


Fig. 3-36  
T8521164

The high voltage generated in the secondary winding is applied directly to each spark plug. In one of the spark plugs, the spark passes from the center electrode to the side electrode, and at the other spark plug the spark is from the side to the center electrode.

### Simultaneous Ignition Current Flow

One spark plug will always have the spark going from the center to side electrode, the other spark plug from the side to center electrode.

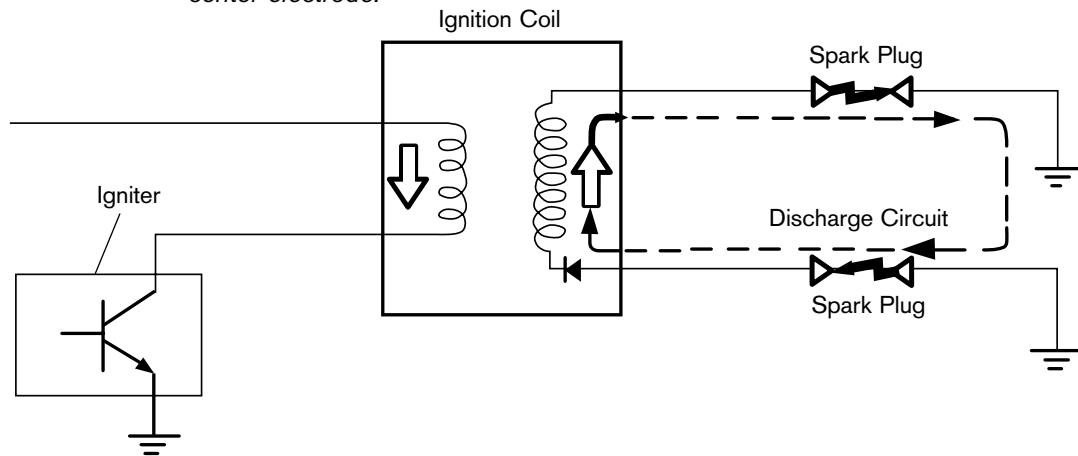


Fig. 3-37  
T852f165

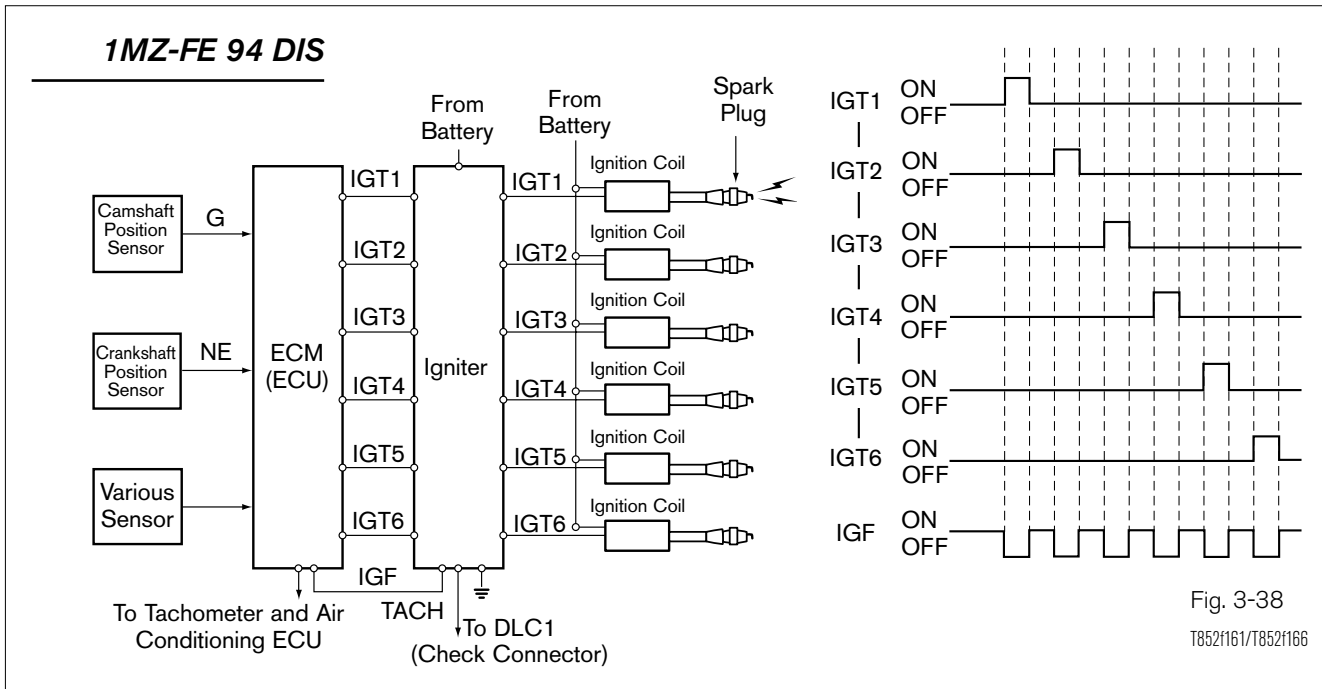
Typically, the spark plugs with this style of ignition system are platinum tipped for stable ignition characteristics.

The voltage necessary for a spark discharge to occur is determined by the spark plug gap and compression pressure. If the spark plug gap between both cylinders is equal, then a voltage proportional to the cylinder pressure is required for discharge. The high voltage generated is divided according to the relative pressure of the cylinders. The cylinder on compression will require and use more of the voltage discharge than the cylinder on exhaust. This is because the cylinder on the exhaust stroke is nearly at atmospheric pressure, so the voltage requirement is much lower.

When compared to a distributor ignition system, the total voltage requirement for distributorless ignition is practically the same. The voltage loss from the spark gap between the distributor rotor and cap terminal is replaced by the voltage loss in the cylinder on the exhaust stroke in the Distributorless Ignition System.

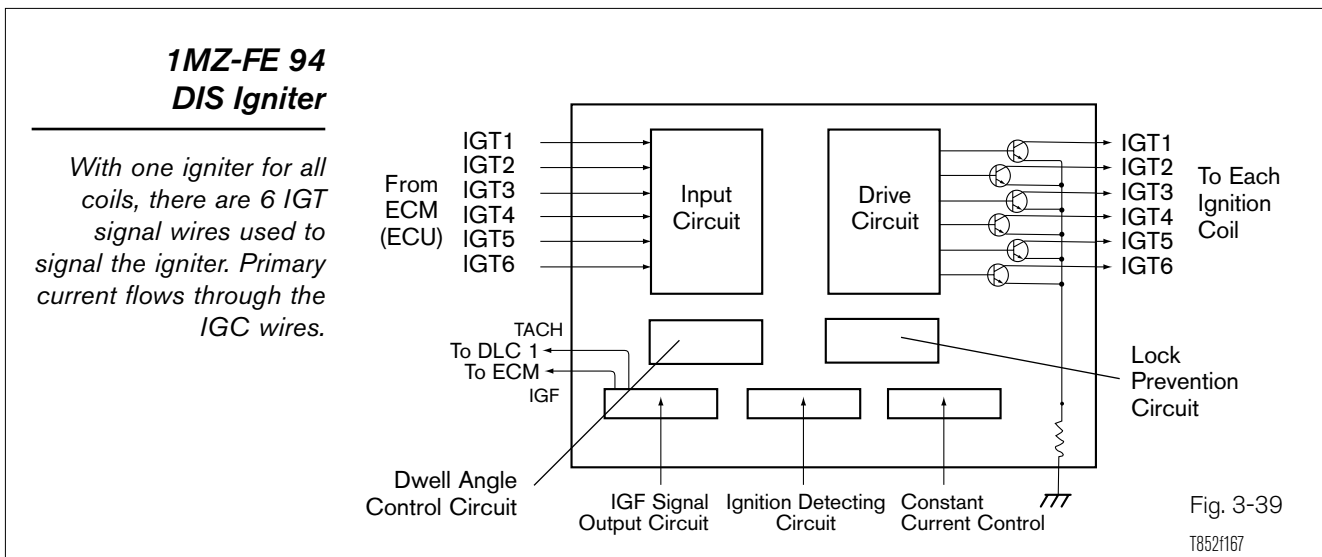
## Direct Ignition System (DIS)

As DIS has evolved, there have been changes to the function and location of the igniter. With independent ignition DIS, there may be one igniter for all cylinders or one igniter per cylinder. On simultaneous ignition DIS there is one igniter for all coils. The following gives an overview of the different types used on various engines.



### 1MZ-FE 94 DIS

This DIS uses one igniter for all coils. The IGF signal goes low when IGT is turned on. The coils in this system use a high voltage diode for rapid cutoff of secondary ignition. If a coil is suspected of being faulty, swap with another coil.



**Ignition Coil with Diode**

*With the diode in the circuit, it is recommended to swap coils to test for a faulty coil.*

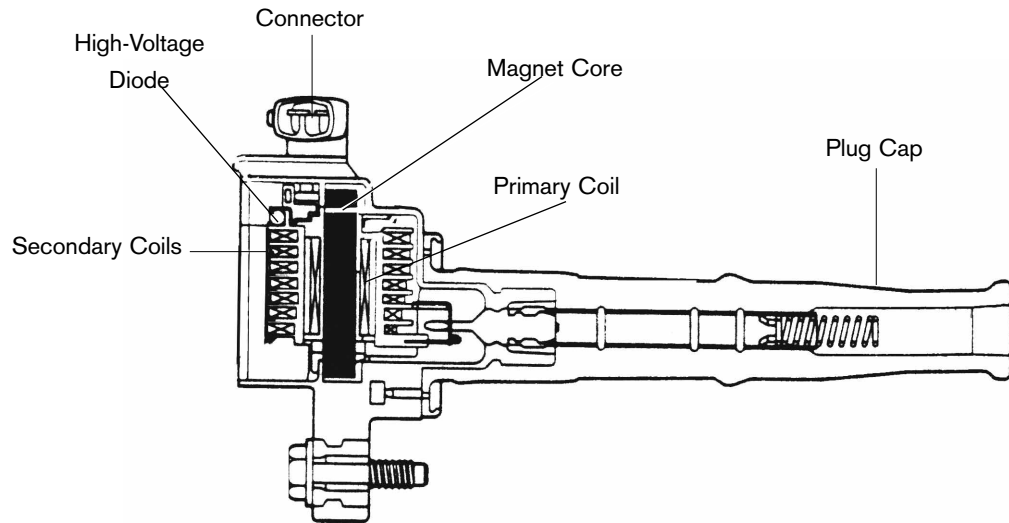


Fig. 3-40  
T852f168

**High Voltage Diode**

*The diode is in the secondary circuit.*

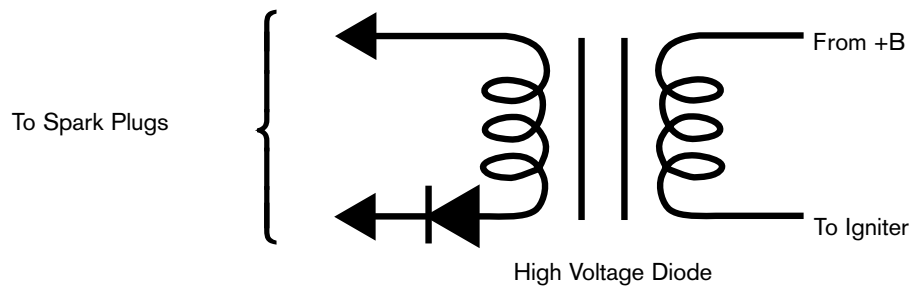


Fig. 3-41  
T852f169

**1MZ-FE with DIS Simultaneous Ignition** This system uses three IGT signals to trigger the ignition coils in the proper sequence. When a coil is turned on, IGF goes low.



**1MZ-FE with DIS  
Simultaneous Ignition**

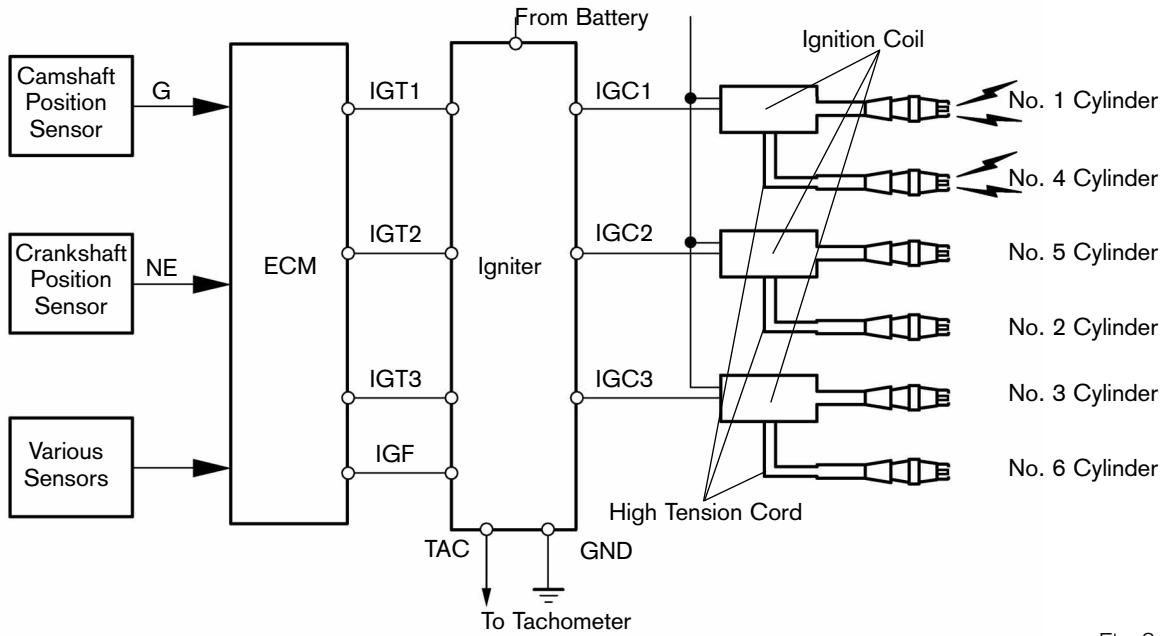


Fig. 3-42  
T852f163

**Igniter**

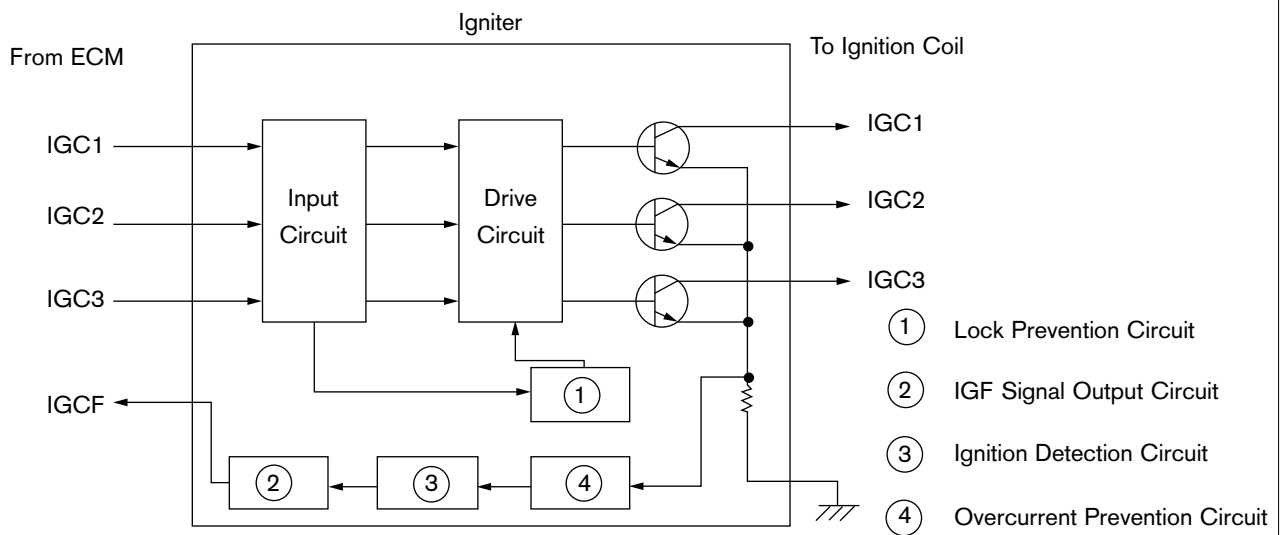


Fig. 3-43  
T852f170

### V-6 Igniter Sequence

When a coil is turned on, IGF goes low.

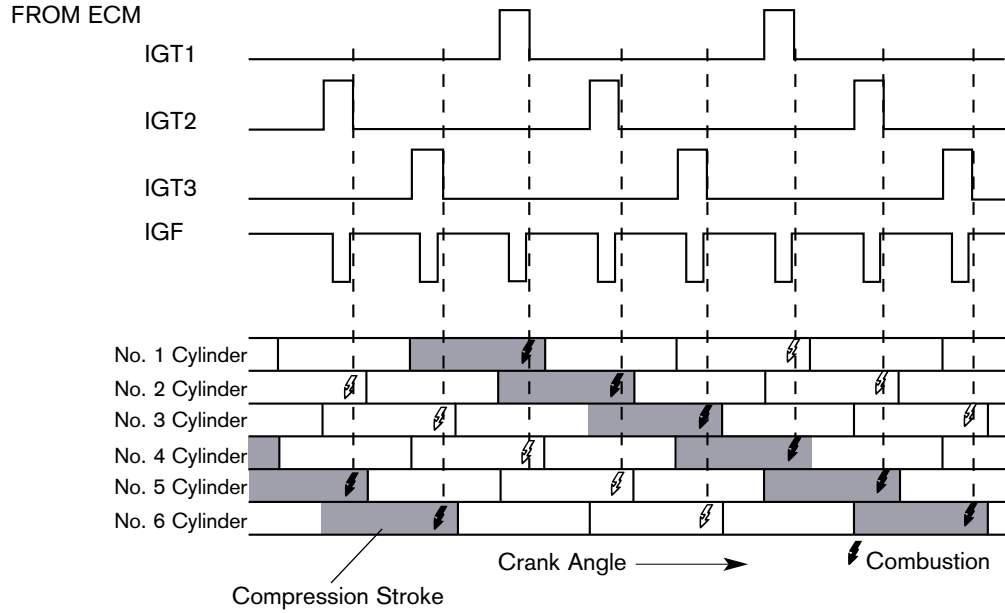


Fig. 3-44

T8521164

### In-Line 6 Cylinder

The in-line 6 has a different firing order and cylinders are paired differently.

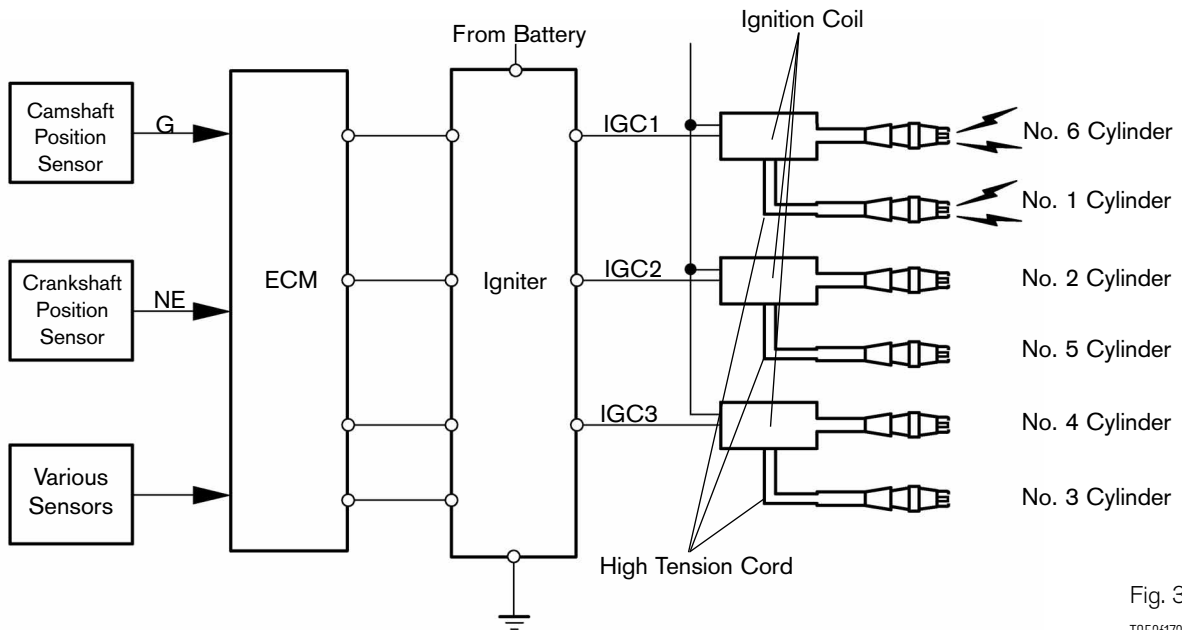
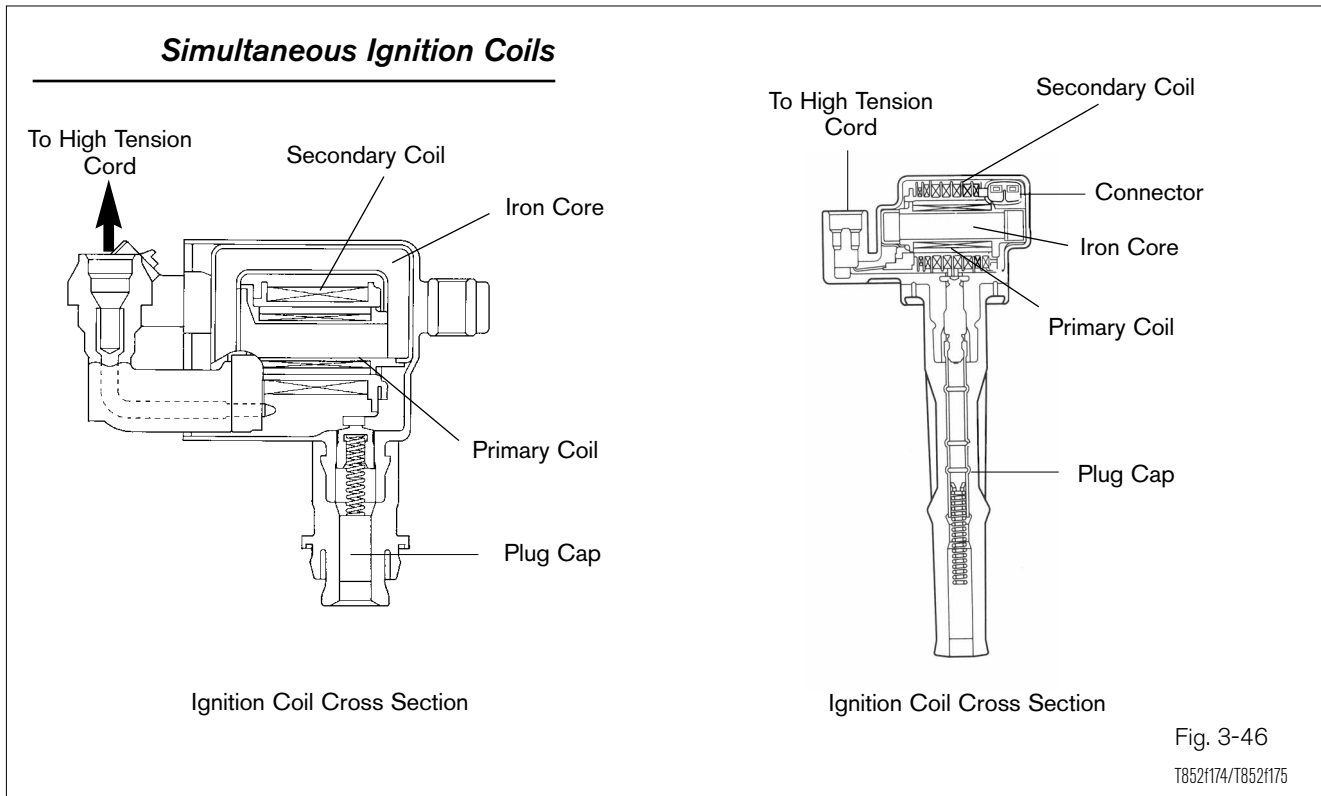


Fig. 3-45

T8521172/T8521173



### DIS with Independent Ignition

The DIS with independent ignition has the igniter built into the coil. Typically, there are four wires that make up the primary side of the coil:

- +B.
- IGT signal.
- IGF signal.
- Ground.

The ECM is able to distinguish which coil is not operating based on when the IGF signal is received. Since the ECM knows when each cylinder needs to be ignited, it knows from which coil to expect the IGF signal.

The major advantages of DIS with independent ignition are greater reliability and less chance of cylinder misfire.

**V-6 1MZ-FE  
with DIS**

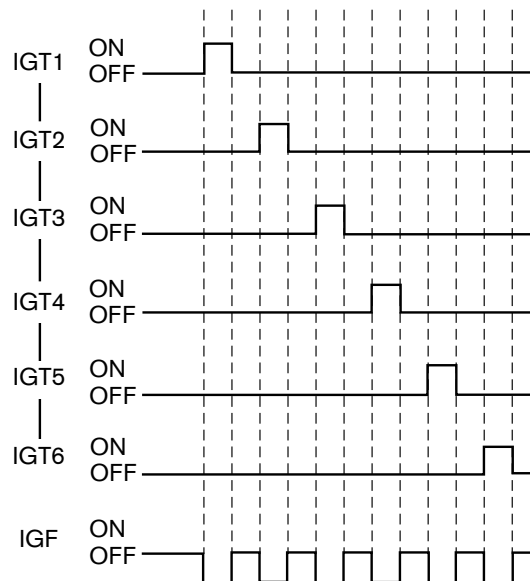
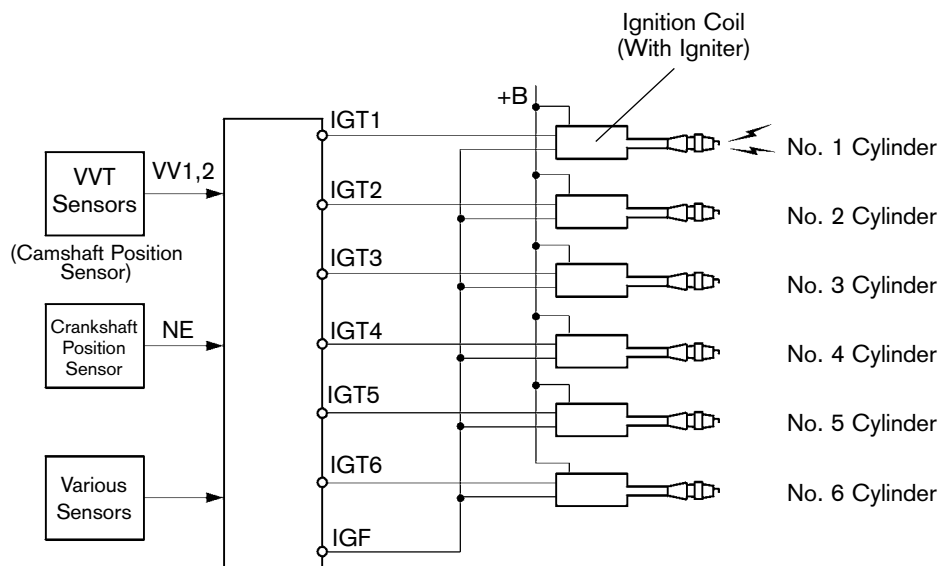


Fig. 3-47

T8521176/T8521166

### Ignition Coil with Integrated Igniter

*This style is used on DIS with independent ignition.*

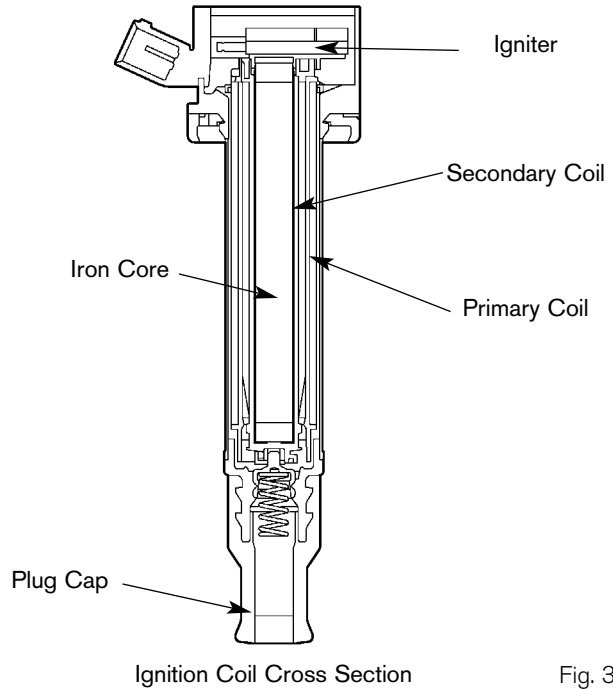


Fig. 3-48  
T852f171

### V-8 with DIS

*Each coil is controlled by the IGT signal.*

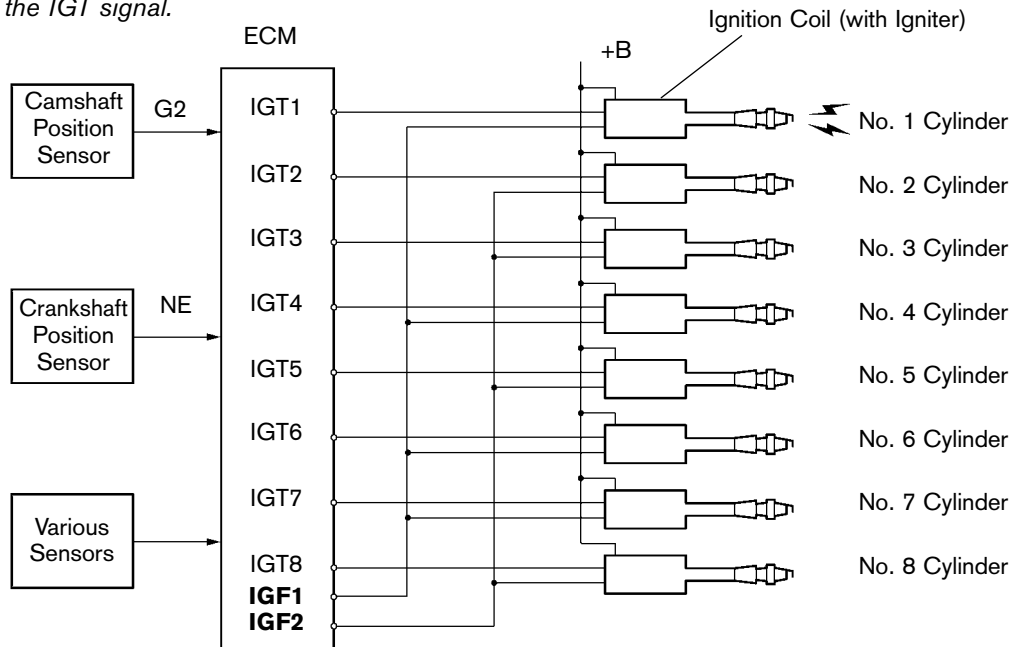
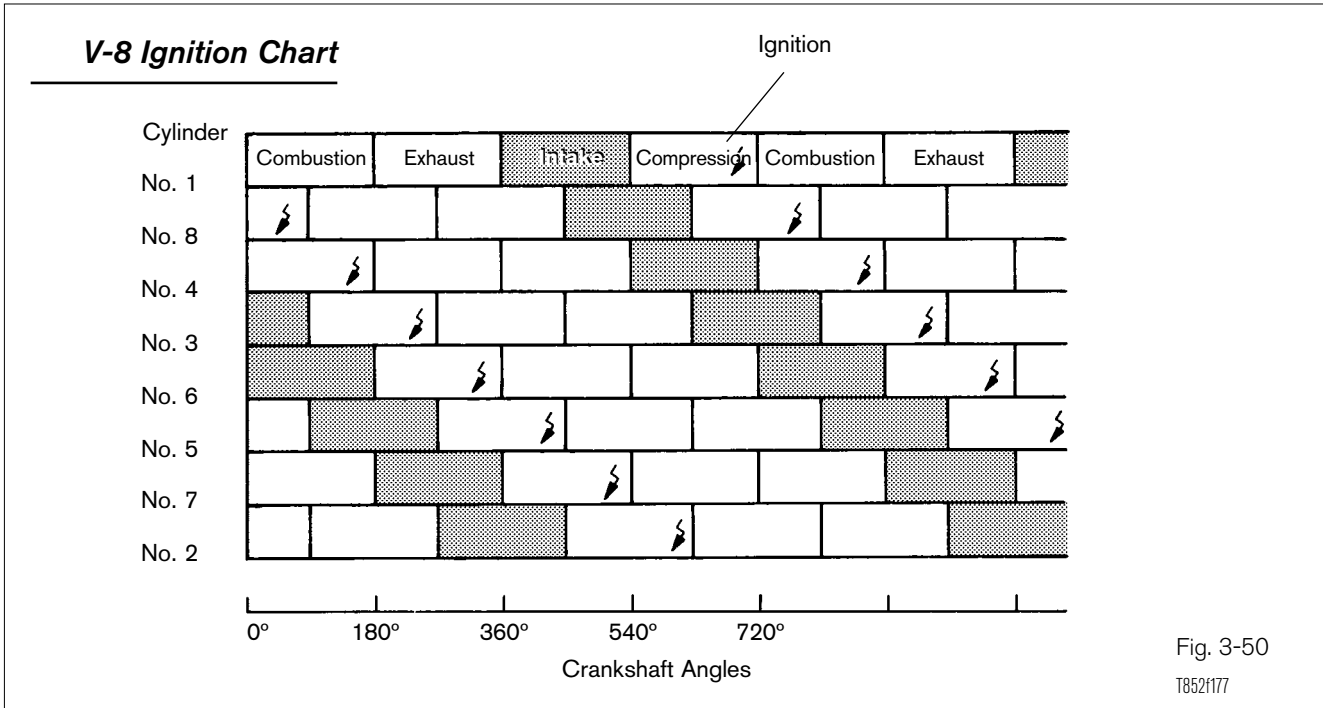


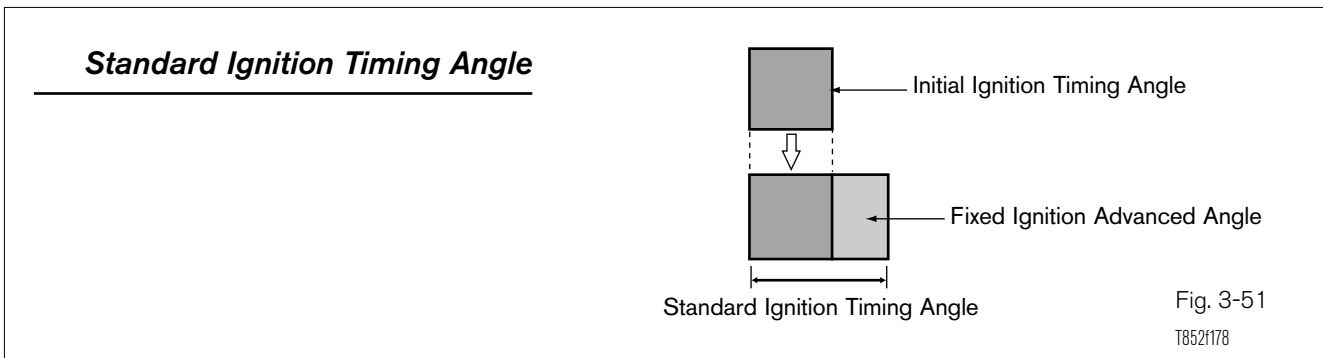
Fig. 3-49  
T852f138



**Ignition Advance Service** Though the Diagnostic Tester shows the computed ignition, advance, using a timing light confirms that advance took place and the timing marks are in the correct position.

With Distributor Ignition Systems, the point at which ignition occurs may vary because the base reference point can be moved. It is critical that the base reference point be set to factory specifications.

With DLI and DIS, the base reference point is determined by the Crankshaft Position Sensor and rotor, which is non-adjustable.



The angle to which the ignition timing is set during ignition timing adjustment is called the "standard ignition timing." It consists of the initial ignition timing, plus a fixed ignition advance angle (a value that is stored in the ECM and output during timing adjustment regardless of the corrections, etc., that are used during normal vehicle operation).

## Ignition Timing Adjustment

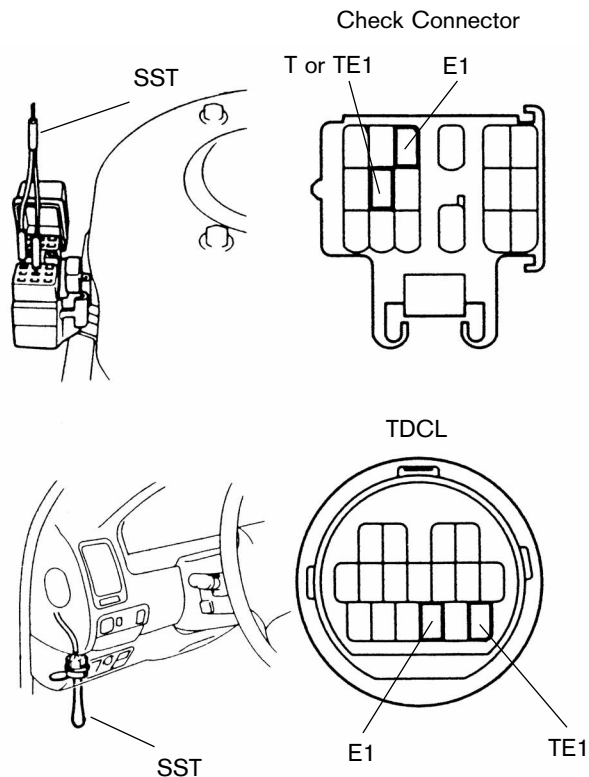


Fig. 3-52

T8521179

Ignition timing adjustment is initiated by connecting terminal T1 (or TE1) of the check connector or TDCL with terminal E1, with the idle contacts on. This will cause the standard ignition timing signal to be output from the back-up IC in the same way as during after-start ignition control.

The standard ignition timing angle differs depending on the engine model. When tuning up the engine, refer to the repair manual for the relevant engine.

### NOTE

Even if terminal T1 or TE1 and terminal E1 are connected, the ignition timing will not be fixed at the standard ignition timing unless the idle contacts are on.

Where the G and NE signal generators are in a fixed position (distributorless or direct ignition systems), ignition timing cannot be adjusted.

## Diagnostics

When the igniter is built into the ignition coil, it is not possible to do a resistance check of the primary coil winding. A bad primary winding will have to be determined by checking other functions of the coil and the ignition circuit.

DTC 1300 series will set, depending on the engine and type of ignition system, when the ECM does NOT receive the IGF signal. IGF confirms the primary circuit of the ignition system is working. Lack of IGF signal indicates a malfunction in the primary circuit or IGF signal related components.

If the DTC 1300 is set based on IGF, visually check the ignition system and then check for spark. If spark is present, the engine will start then stall when the ECM does not detect IGF (EXCEPT on some engines equipped with DIS with integrated igniter). In addition, when spark is present this confirms the secondary and primary circuits are good. The problem is most likely with the IGF circuitry.





**Notes**



## **WORKSHEET 3-1**

### **Ignition System**

Vehicle	Year/Prod. Date	Engine	Transmission
---------	-----------------	--------	--------------

### **Technician Objectives**

With this worksheet, you will learn to locate and test ignition power and ground circuits, igniter, secondary ground circuits, and timing using the required tools and equipment, retrieve and apply the needed service information, and retrieve and interpret service data information.

### **Tools and Equipment**

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

### **Section 1**

1. What is the engine firing order?

---

2. According to the EWD, match the ignition coil to the engine cylinder(s) and IGT wire color (may be called IGC on some older ignition systems).

---

<b>Ignition Coil</b>	<b>Cylinder</b>	<b>IGT Wire Color</b>

3. List any fuses and relays that supply the igniter and ignition coil(s).

---

### Section 2

1. According to the Repair Manual, perform an ignition timing check. Use the Diagnostic Tester for readings. What happened to ignition timing?

---

### Section 3

1. If the ignition coil puts out a spark, but there is a DTC 1300, what part of the ignition circuit do you need to check?

---

2. For no spark coming from all ignition coils condition, list four possible components.

---

3. What method is used to determine if the coil is defective?

---

4. For OBD II vehicles. Disconnect the injector connector from any cylinder. Start the engine. With the DT, use Data List to bring up cylinder misfire. Does the DT show the cylinder misfire? What indicates a misfiring cylinder?

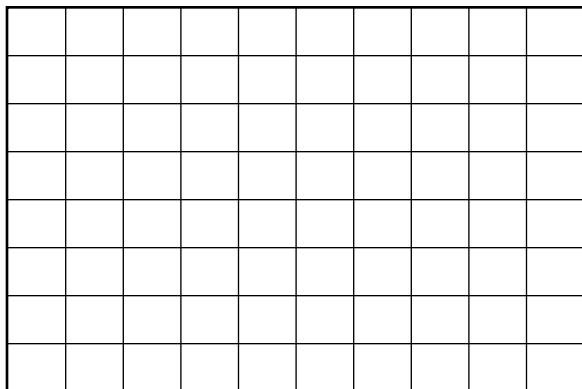
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### Section 4

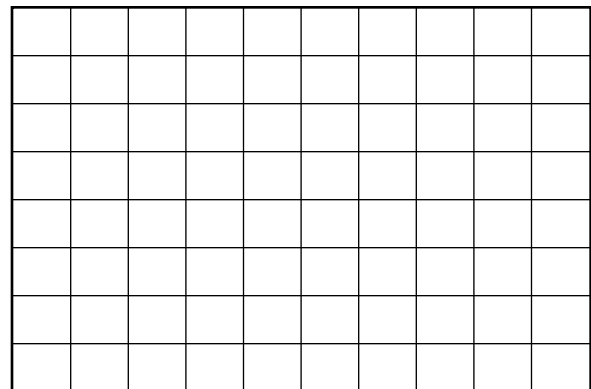
#### IGT & IGF Signals

1. Set the Diagnostic Tester to the Oscilloscope function, refer to Repair Manual for settings. Start the engine and draw or print the waveform at between IDLE and 1500 RPM, whichever provides the best signal.

IGT



IGF



2. Does the waveform match the Repair Manual waveform?

---

3. With a DVOM, what is the voltage specification for checking IGF?

---

# Ignition System

Name \_\_\_\_\_ Date \_\_\_\_\_

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

*I have questions*

*I know I can*

Topic	Comment
Locate components in the ignition system using the EWD and RM	
Find wire colors, pin numbers in the ignition system using the EWD and RM	
Locate the ignition system components readings from the Data List	
Measure the IGF voltage signal with a DVOM	
Check base ignition timing and adjust if applicable	
Observe the IGF and IGT voltage signal pattern with an oscilloscope	
Test ignition system power circuits for voltage and ground side for continuity	
Test wires for continuity/resistance and compare to specifications to determine condition	
Test ignition coil(s) and compare to specifications to determine condition	
Check and retrieve relevant DTCs	
Describe purpose of IGT and IGF signal	