# Glossary

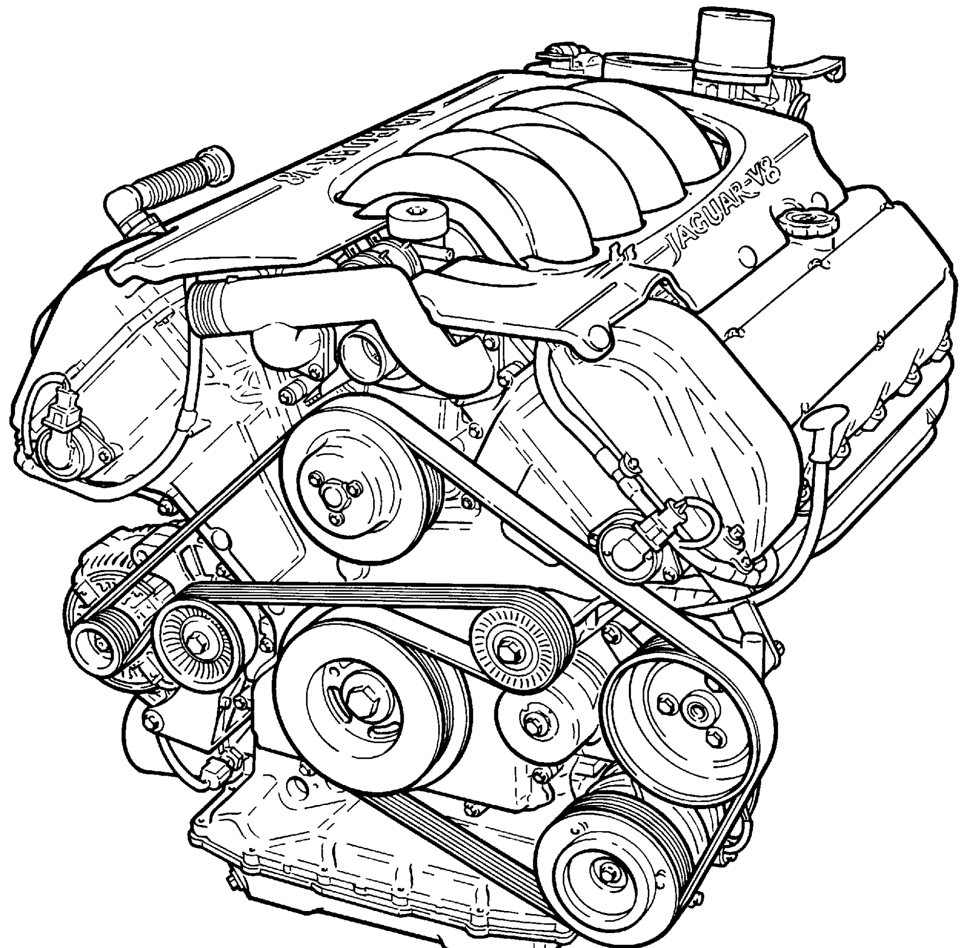
The following abbreviations are used in this document:

| Abbreviation | Description |
|---|---|
| ABS | anti-lock braking system |
| A/C | air conditioning |
| A/CCM | air conditioning control module |
| BPM | body processor module |
| BHP | brake horse power |
| ˚C | degree Celsius |
| CAN | controller area network |
| CDI | cubic inch displacement |
| DIN | Deutsche Institut für Normung |
| dc | direct current |
| DTC | diagnostic trouble code |
| ECM | engine control module |
| ECT | engine coolant temperature |
| EGR | exhaust gas recirculation |
| EMS | engine management system |
| EVAP | evaporative emission |
| ˚F | degree Fahrenheit |
| ft | foot |
| HO2S | heated oxygen sensor |
| in | inch |
| JDS | Jaguar diagnostic system |
| lb | pound |
| lbf.ft | pound force feet |
| kg | kilogram |
| km/h | kilometer per hour |
| kW | kilowatt |
| m | meter |
| MAFS | mass air flow sensor |
| MIL | malfunction indicator lamp |
| mph | miles per hour |
| mm | millimeter |
| ms | millisecond |
| Nm | Newton meter |
| NOx | nitrous oxide |
| OBD | on-board diagnostics |
| O2S | oxygen sensor |
| PAS | power assisted steering |
| PDU | portable diagnostic unit |
| psi | pounds per square inch |
| PTFE | polytetrafluoroethane |
| rpm | revolutions per minute |
| SAE | Society of Automotive Engineers (USA) |
| SCP | standard corporate protocol |
| TCM | transmission control module |
| USA | United States of America |
| V | volt |
| VSV | vacuum solenoid valve |

The AJ-V8 4.0 litre, engine is the first of a new family of Jaguar engines. Designed to give excellent performance, refinement, economy and low vibration levels it also conforms to the strictest emission legislation. Weighing only 200 kilograms (441 lb), the engine is shorter by 12 inches (300 mm) than the current AJ16 4.0 litre engine. Compression ratio is 10.75:1, with four valves per cylinder. The cylinder heads, block and bedplate are all cast aluminum. Cylinders have electro-plated bores which reduce piston friction, improve warm-up and oil retention. A variable valve timing system has been introduced to give improved low and high-speed engine performance and excellent idle quality. The valve gear is chain driven for durability. Low valve overlap improves engine idle speed and low residual fuel levels which improves combustion and reduces hydrocarbon emissions. The inlet manifold is a one-piece, composite moulding with integral fuel rails connecting to the eight side feed fuel injectors. Air flow into the engine is via an electronic throttle assembly. Movement of the throttle is controlled by sensors in the throttle assembly through the ECM. The engine has a low volume, high velocity, cooling system which achieves a very fast warm-up with reduced and even metal temperatures in the combustion chamber and increased bore temperatures.
The generator, A/C pump, and PAS pump are mounted to the cylinder block on rigid cradle supports. Accessory drive is from a single, 7-ribbed vee belt. Hydraulic engine mounts minimise noise and vibration.
A new engine management system adjusts fuel and ignition settings, monitors and controls exhaust emissions and provides an on-board diagnostic capability.

The transmission is a new ZF 5-speed, automatic, electronically controlled unit.
The unit is oil filled for life so does not have an oil gauge (dipstick). Two driver selected modes are available, sport or normal. The TCM is programmed with cruise, traction, gradient, warm-up and hot mode features. It also provides an on-board diagnostic capability.

The engine and transmission meet OBDII USA environmental regulations.
Default limp home modes for both engine and transmission are provided.

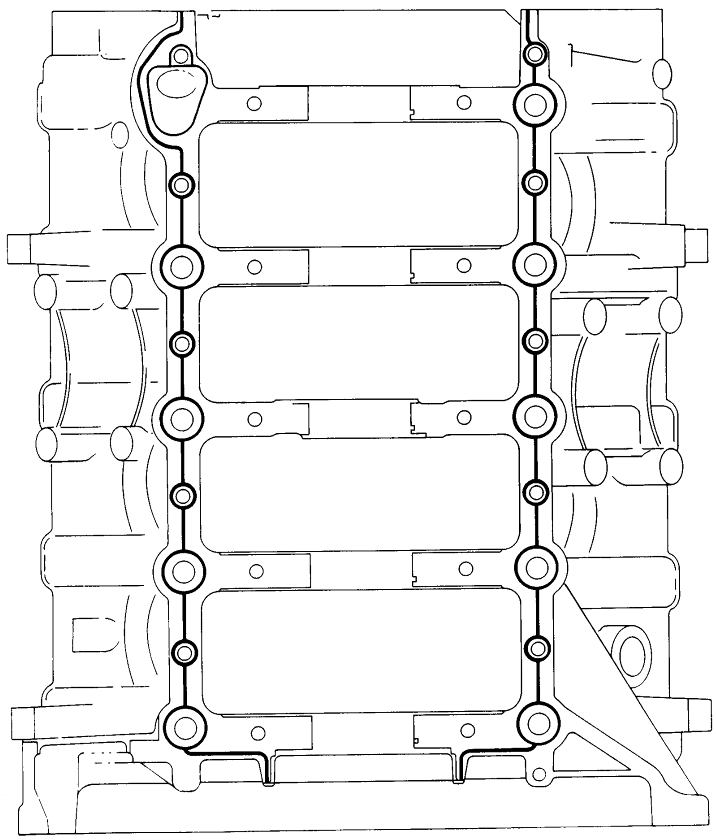



## Basic Engine

The AJ-V8 is an all new 90° V8 liquid cooled engine that gives refined and effortless performance. Constructed in aluminum alloy, the AJ-V8 introduces several innovative design features new to Jaguar engines, the most notable of these being:

- a bedplate
- nikasil coated cylinder bores
- fracture split connecting rods
- variable valve timing
- aluminum alloy valve lifters
- electronic throttle control.

**SEALANT TRACK ON BEDPLATE**



303-012

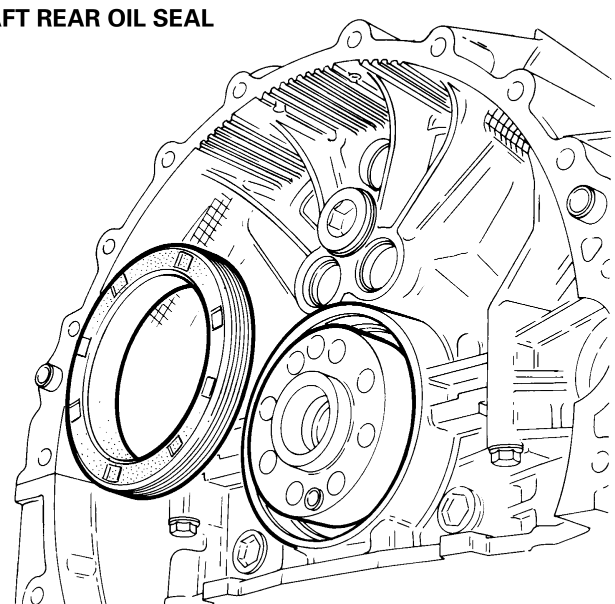
## Bedplate

The bedplate is a structural casting bolted to the bottom of the cylinder block to retain the crankshaft. The use of a bedplate further improves rigidity. Iron inserts, cast into the main bearing supports of the bedplate, minimise main bearing clearance changes due to heat expansion.

Two hollow dowels align the bedplate with the cylinder block.

Beads of sealant seal the joint between the bedplate and the cylinder block.

**CRANKSHAFT REAR OIL SEAL**



303-013

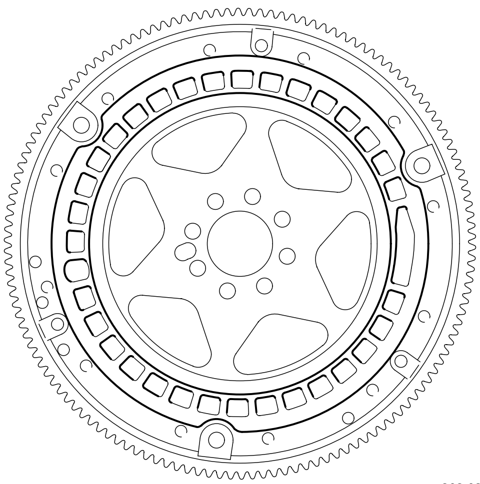
## Crankshaft

Six counter-balance weights ensure good vibration levels from the four throw, five bearing crankshaft. Manufactured in cast iron, the crankshaft also has undercut and rolled fillets for improved strength.

The main bearings are aluminum/tin split plain bearings. An oil groove in the top half of each bearing transfers oil into the crankshaft for lubrication of the connecting rod bearings. A lead/bronze thrust washer is installed each side of the top half of the center main bearing.

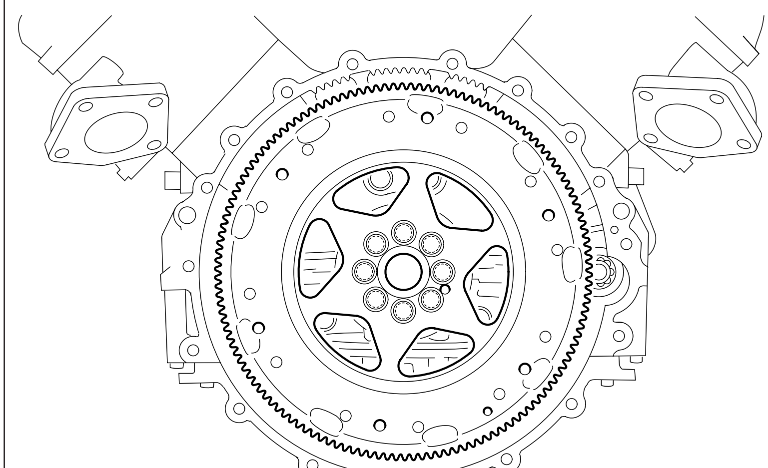
The crankshaft rear oil seal (a lip seal similar to that used on the AJ16 engine) is a press fit in the bedplate to cylinder block interface.

TIMING DISC



303-035

STARTER DRIVE PLATE



303-034

## Cylinder Heads

The cylinder heads are unique to each cylinder bank. Deep seated bolts, to reduce distortion, secure the cylinder heads to the cylinder block. Two hollow dowels align each cylinder head with the cylinder block.

The cylinder head gaskets consist of a silicon beaded composite gasket with metal eyelets for the cylinder bores, similar to that on the AJ16 engine.

Each cylinder head incorporates dual overhead camshafts operating four valves per cylinder via solid aluminum alloy valve lifters. Steel shims in the top of the valve lifters enable adjustment of valve clearances.

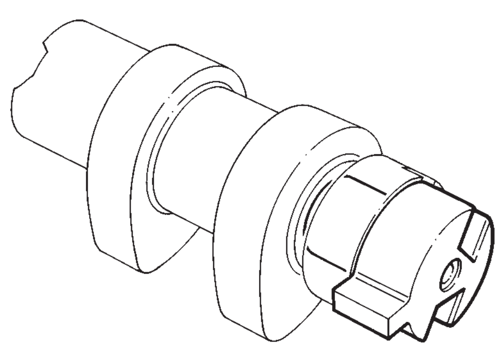
The lightweight valve gear provides good economy and noise levels. Valve head diameters are 31mm (1.220 in) for the exhaust and 35mm (1.378 in) for the intake. All valves have 5mm (0.197 in) diameter stems supported in sintered metal seats and guide inserts. Collets, valve collars and spring seats locate single valve springs on both intake and exhaust valves. Valve stem seals are integrated into the spring seats.

The camshafts are manufactured in chilled cast iron. Five aluminum alloy caps retain each camshaft. Location numbers, 0 to 4 for the intake camshaft and 5 to 9 for the exhaust camshaft, are marked on the outer faces of the caps. The rear of B bank intake camshaft has a timing ring for the camshaft position sensor. A flat, machined near the front of each camshaft, enables the camshafts to be locked during the valve timing procedure.

The 14 mm spark plugs, one per cylinder, locate in recesses down the center-line of each cylinder head.

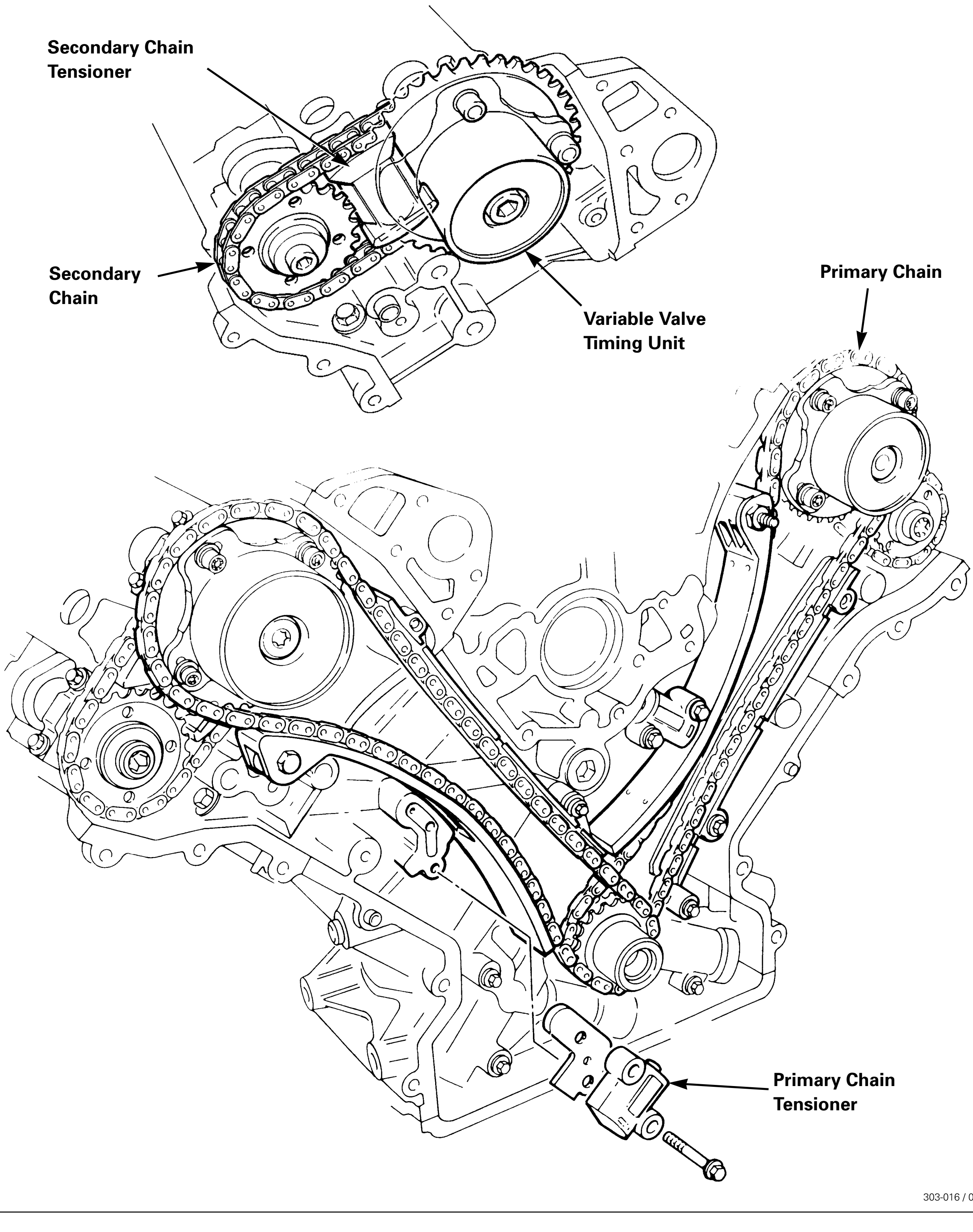
An engine lifting eye is cast into the front of each cylinder head (the rear lifting eyes, one on each cylinder head, are bolt-on tools).

CAMSHAFT POSITION SENSOR TIMING RING

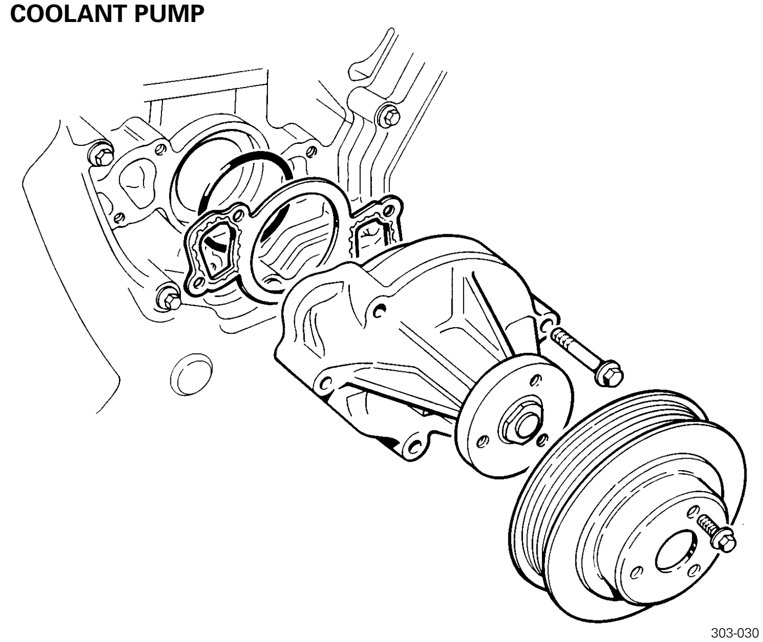


303-054

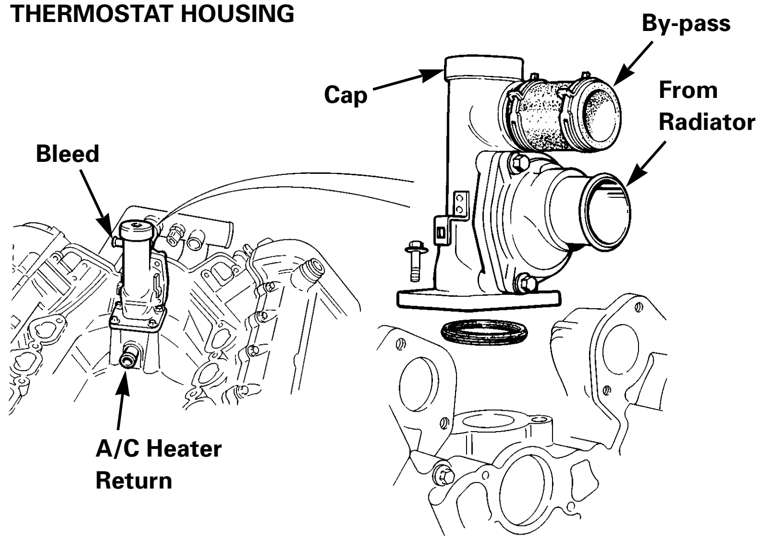
**TIMING GEAR**


Secondary Chain
Tensioner
Secondary
Chain
Variable Valve
Timing Unit
Primary Chain
Primary Chain
Tensioner
303-016 / 017

COOLANT PUMP




THERMOSTAT HOUSING




## Coolant Pump

The coolant pump is installed between the two cylinder banks, on the front face of the cylinder block. The pumping element is a shrouded composite impeller. Coolant escapes from seal breather holes in the housing if the pump's bearing seal fails.

An O-ring and an edge bonded rubber/aluminum alloy gasket seal the pump to cylinder block interface. The O-ring seals the inlet port from the thermostat. The gasket seals the outlet ports into the cylinder banks.

## Thermostat Housing

The composite thermostat housing is installed between the two cylinder banks, immediately above the coolant pump. The thermostat controls the flow of coolant through the radiator. It starts to open at 80 to 84°C (176 to 183˚F) and is fully open at 96°C (205˚F).

A duct in the cylinder block connects the thermostat housing outlet to the pump inlet. A stub pipe connects the duct to the air conditioning heater matrix return line.

An in-groove gasket seals the joint between the thermostat housing and the cylinder block.

In addition to containing the thermostat, the composite thermostat housing incorporates connections for the bleed, bypass and radiator bottom hoses. The bleed outlet vents any air in the system into the vehicle's coolant reservoir.

The cap of the thermostat housing is removable, to allow air out of the system when filling from empty.

**CAUTION: Use the correct torque (marked on the cap) when re-installing the cap, or the cap/thermostat housing could be damaged.**

## Coolant Hoses

Supply and return hoses for the air conditioning heater matrix are installed between the cylinder banks.

A connection at the rear of A bank provides the coolant supply for the electronic throttle and the EGR valve. The outlet from the EGR valve connects to the return hose of the air conditioning heater matrix.

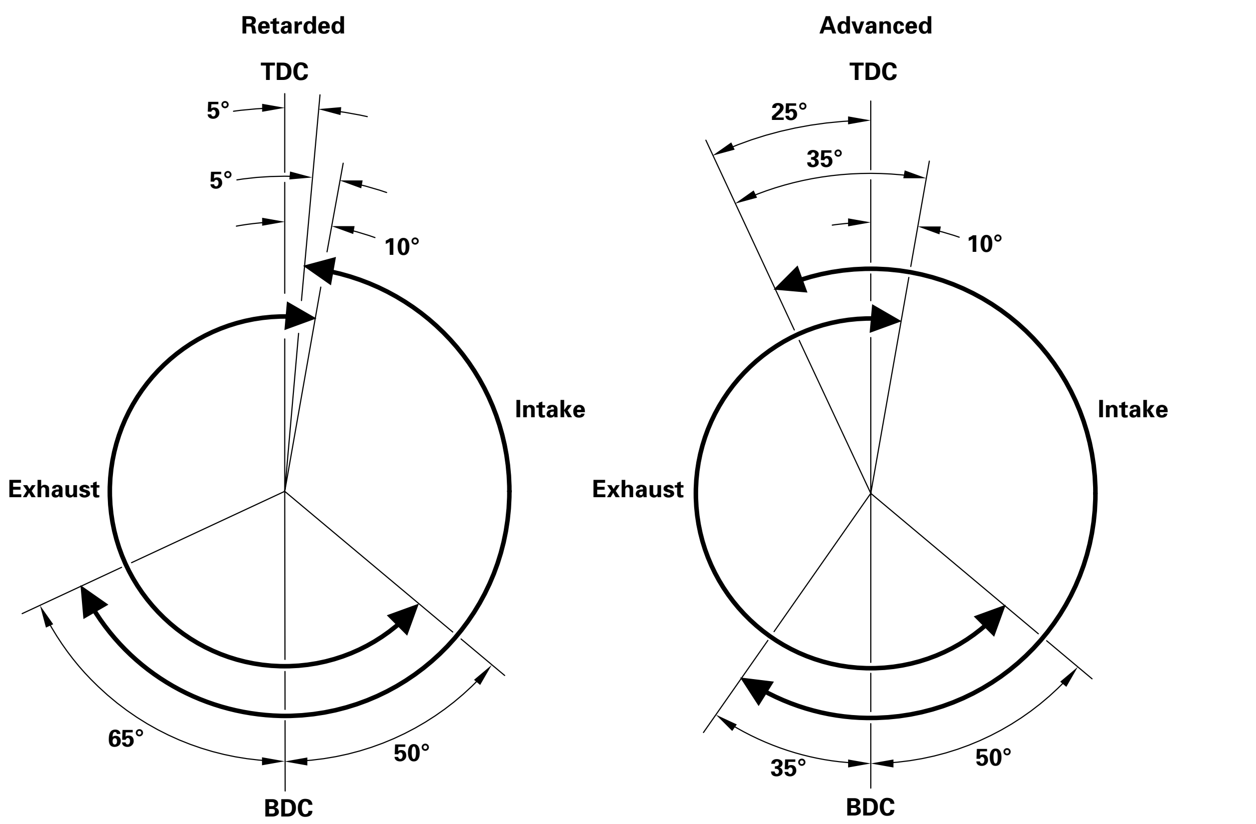
## Variable Valve Timing

The variable valve timing system improves low and high speed engine performance, engine idle quality and exhaust emission. It is a two position system that operates on the intake camshafts only. There are 30° of crankshaft movement between the retarded and advanced positions.
Engine oil pressure operates the system under the control of the ECM.
For each intake camshaft there is a valve timing unit, a bush carrier assembly and a valve timing solenoid.

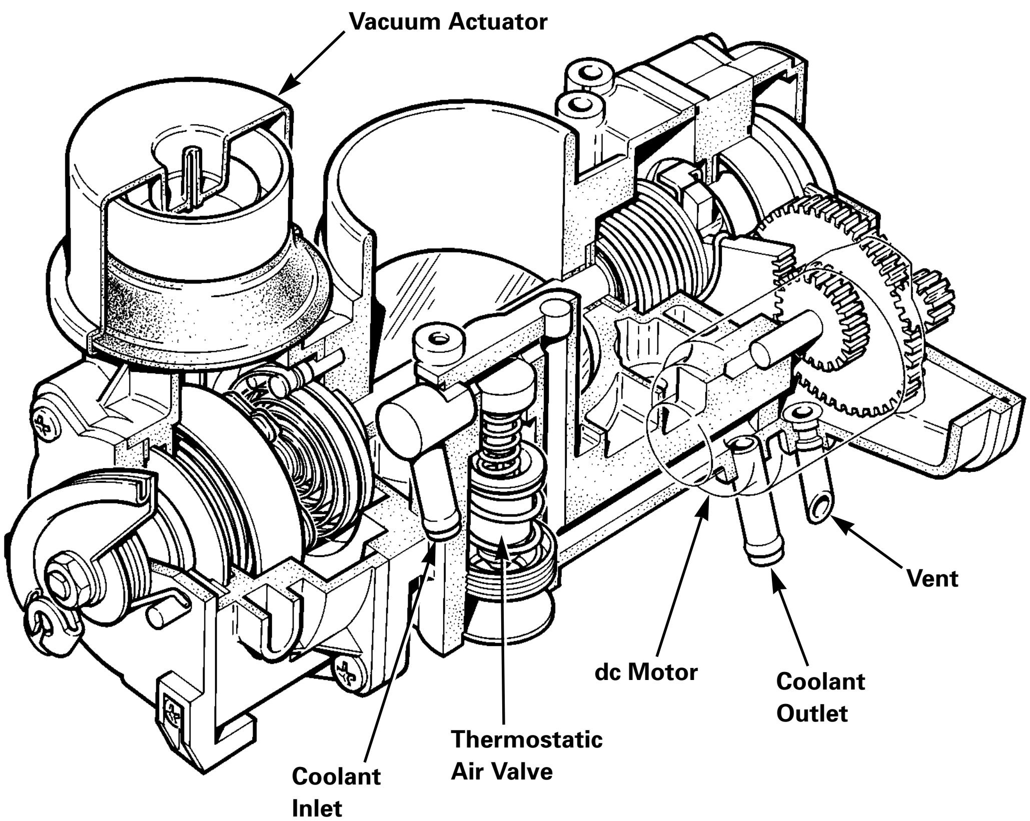
### Valve Timing Unit

The valve timing unit turns the intake camshaft in relation to the primary chain to advance and retard the timing.
The unit consists of a body and sprocket assembly separated from an inner sleeve by a ring piston and two ring gears. A bolt secures the inner sleeve to the camshaft. The ring gears engage in opposing helical splines on the body and sprocket assembly and on the inner sleeve.
The ring gears transmit the drive from the body and sprocket assembly to the inner sleeve and, when moved axially, turn the inner sleeve in relation to the body and sprocket assembly.
Engine oil pressure (controlled by the valve timing solenoid) moves the ring gears and piston to turn the inner sleeve in the advanced timing direction. A return spring moves the ring gears and piston to turn the inner sleeve in the retarded timing direction.
Additional springs absorb backlash to reduce noise and wear. The springs between the ring gears absorb rotational backlash. The spring between the inner sleeve and the end of the body and sprocket assembly absorbs axial backlash.

**VALVE TIMING DIAGRAMS**



**ELECTRONIC THROTTLE**




## Springs

The input shaft spring and the mechanical guard spring oppose movement in the throttle open direction, and provide the "feel" of the accelerator pedal. The throttle valve spring and the drive gear spring oppose movement in the throttle closed direction.

## Operation

The design of the input shaft and the mechanical guard, and the bias of their respective springs, means that, except in cruise control, they always rotate together. The throttle cable turns them in the open direction; the springs keep their adjacent levers locked together and turn them in the closed direction.

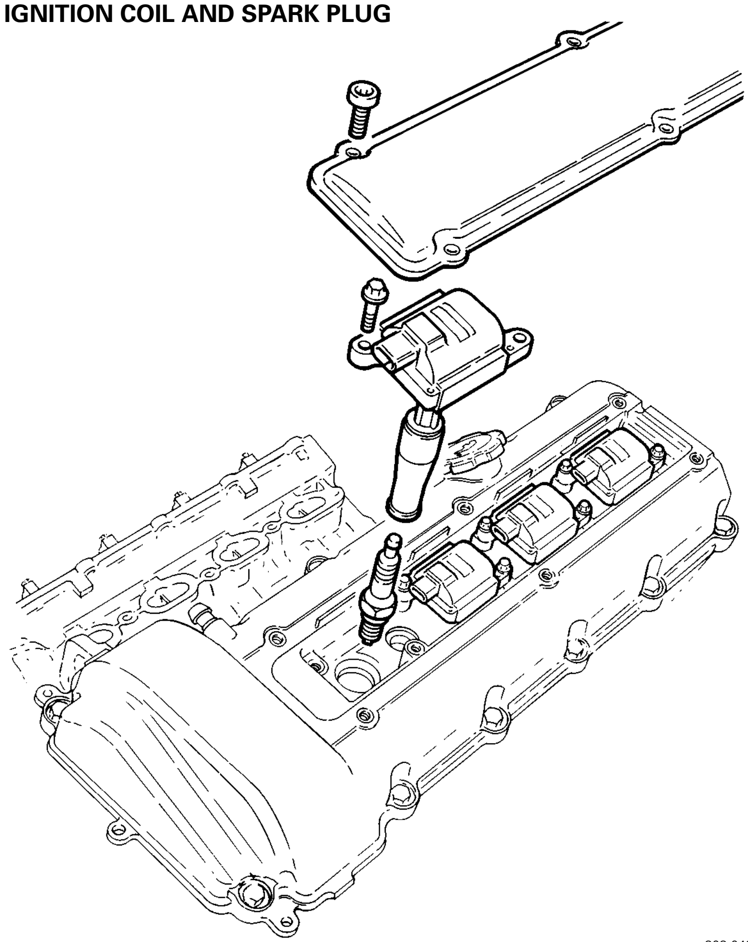
The ECM monitors the position of the input shaft and mechanical guard using the inputs from the accelerator pedal and mechanical guard position sensors. During normal operation, when the ECM detects any movement it signals the dc motor to turn the throttle valve and follow the input shaft and mechanical guard, maintaining a constant gap between the adjacent levers of the throttle valve and mechanical guard. The dc motor drive gears turn the throttle valve in the closed direction; the throttle valve spring turns the throttle valve in the open direction and keeps the throttle valve in contact with the drive gear. Inputs from the throttle valve position sensor enable the ECM to exercise closed loop control.

The arrangement of the throttle valve drive prevents the ECM from exceeding driver demand, since if the motor is driven fully open the throttle valve engages the mechanical guard and disengages from the dc motor drive gears. The arrangement of the mechanical guard to throttle valve interface allows the ECM to reduce throttle opening to less than driver demand, eg. during stability/traction control or engine power limiting.

## Ignition System

The ignition system consists of two ECM controlled ignition amplifier modules, which each supply four spark plug mounted ignition coils.
The 14 mm spark plugs, one per cylinder, locate in recesses down the center-line of each cylinder head.
The on-plug ignition coils are secured to the camshaft covers. The engine harness connects the on-plug ignition coils to the ignition amplifiers located on the vehicle body. A composite cover fits over the on-plug coils.

**IGNITION COIL AND SPARK PLUG**

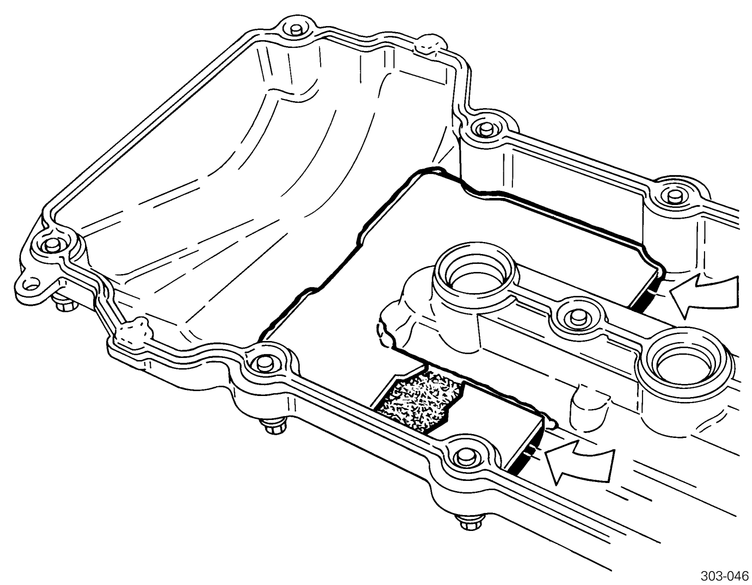


303-049

## Crankcase Ventilation

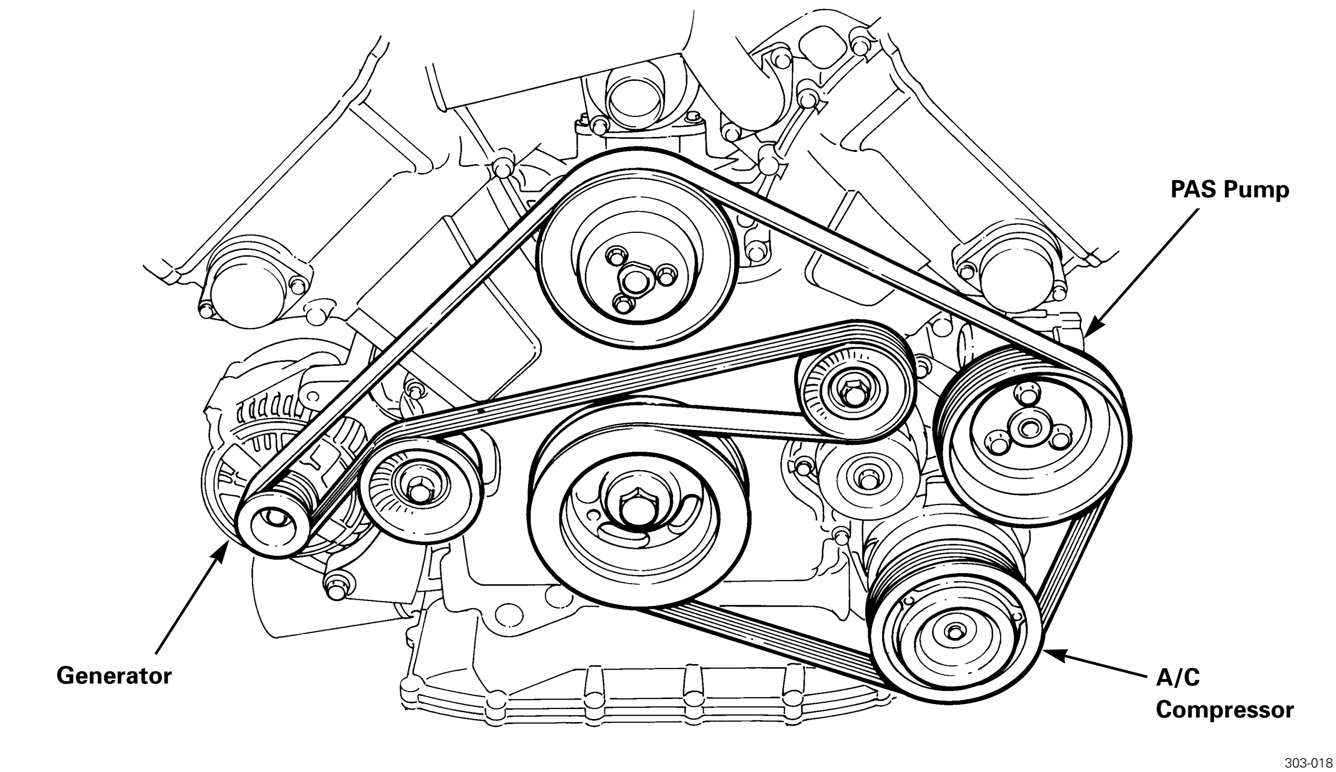
The engine is ventilated through a part load and a full load breather.
The part load breather is a flexible composite hose connected between the oil separator in B bank camshaft cover and the induction elbow. A restrictor in the outlet from the oil separator prevents reverse flow.
The full load breather is a flexible composite hose connected between the oil separator in A bank camshaft cover and the air intake duct.
The ends of the breather hoses incorporate quick release connectors (see figure, page 36).
The oil separators consist of wire gauze packed into an open ended enclosure below the breather outlet.

**OIL SEPARATOR**



303-046

ENGINE ACCESSORIES AND DRIVE BELT



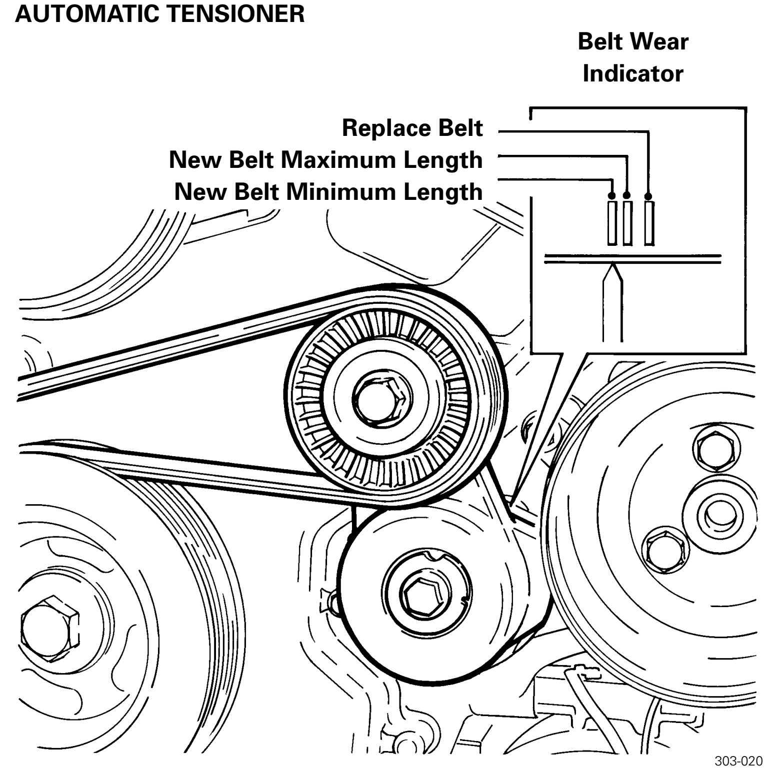

## Accessory Drive

A single seven ribbed belt drives all the engine mounted accessories. The torsional vibration damper on the front of the crankshaft drives the belt. An automatic tensioner, located on the left accessory mounting bracket, keeps the belt at the correct tension. An idler pulley on the right accessory mounting bracket increases the wrap angle around the generator pulley.

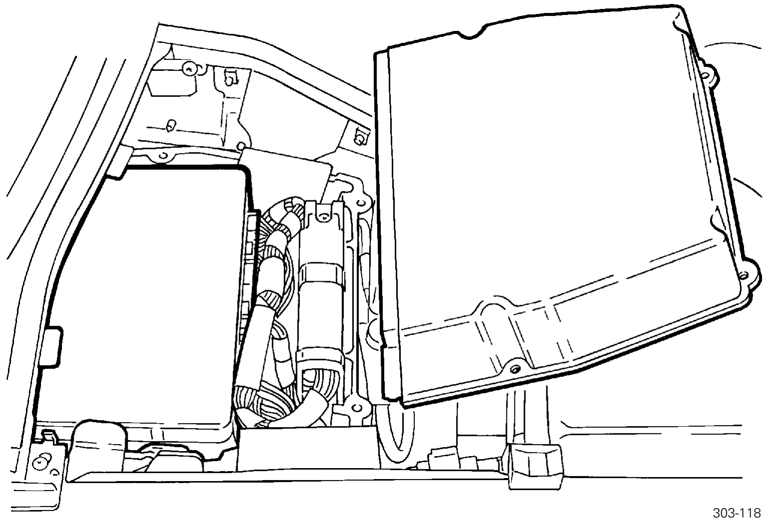
The torsional vibration damper incorporates compressed rubber between its inner and outer diameters to absorb vibration and shock loads.

The automatic tensioner consists of an idler pulley on the end of a spring loaded pivot arm. The pivot arm can be turned counter-clockwise (viewed from the front of the engine) for removal and installation of the belt. A belt wear indicator is incorporated on the rear of the pivot arm.

AUTOMATIC TENSIONER



ECM




# ECM

The engine management system is controlled by the ECM, which is installed in the control module enclosure in the engine compartment. The ECM provides optimum control of the engine under all operating conditions. It also incorporates a comprehensive monitoring and diagnostic capability. Software variations ensure that the system complies with the latest diagnostic and emissions legislation of the destination market.

The ECM receives inputs from engine related sensors and various vehicle systems, and provides outputs for the following:

- electronic throttle
- fuel pump
- fuel injection
- ignition
- EVAP system
- variable valve timing
- EGR system
- engine starting
- HO2S heaters
- instrument cluster
- A/C compressor clutch
- windshield and backlight heaters
- radiator cooling fans
- diagnostics.

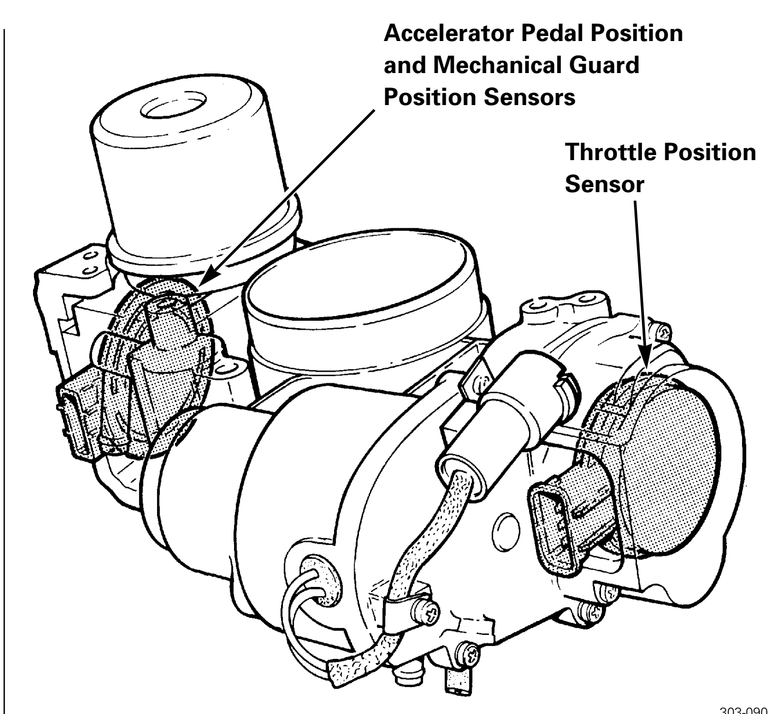
**Camshaft Position Sensor**
The camshaft position sensor is installed in B bank cylinder head at the rear of the intake camshaft. It is a variable reluctance sensor that provides an input of intake camshaft position.

**ECT Sensor**
The ECT sensor is installed in the coolant outlet duct. It provides an input of coolant temperature at the cylinder head outlets.

**Engine Speed Sensor**
The engine speed sensor is installed at the rear of the bed plate. It is a variable reluctance sensor that provides an input of engine crankshaft speed and position.

**Knock Sensors**
The knock sensors are installed in the cylinder block on the inboard side of each cylinder bank. They are piezo-electric sensors that provide inputs to detect and locate detonation during combustion.

**ELECTRONIC THROTTLE SENSORS**




**Accelerator Pedal Position Sensor**
The accelerator pedal position sensor is connected to the input shaft in the electronic throttle. It is a dual track potentiometer that provides inputs of driver demand at the accelerator pedal.

**Mechanical Guard Position Sensor**
The mechanical guard position sensor is a single track potentiometer connected to the mechanical guard in the electronic throttle. It provides an input of the position of the mechanical guard.

**Throttle Position Sensor**
The throttle position sensor is a dual Hall effect sensor in the motor end of the electronic throttle. It provides inputs of the position of the throttle valve.

Once cruise control is engaged, a further momentary press of the **SET+** or **SET-** switch increments or decrements the set speed by 1.6 km/h (1.0 mph). The ECM then accelerates or decelerates the vehicle to the new set speed.

The ECM stores a maximum of five incremental or decremental commands at any one time. Once the ECM has actioned the first stored command, a further command can be added. On momentary operation of the opposite sense switch, the ECM deletes the last command from memory.

Pressing and holding the **SET+** or **SET-** switch causes the ECM to increase or decrease the set speed, and smoothly accelerate or decelerate the vehicle, until the switch is released. To protect against switch failure in the closed position, if either switch is held for longer than 10 minutes, the ECM disables cruise control until the next ignition cycle.

The throttle pedal can be used to accelerate the vehicle beyond the set speed, without disengaging cruise control (since the diaphragm actuator is holding the mechanical guard, there is a noticeable reduction in accelerator pedal load up to the point at which the input shaft in the electronic throttle begins to turn the mechanical guard). When the pedal is released the ECM returns the vehicle to the set speed in a controlled manner. Alternatively, a momentary press of the **SET+** or **SET-** switch causes the increased vehicle speed to be adopted as the new set speed.

On receipt of an input from the **CANCEL** switch, the ECM disengages cruise control and clears the set speed from memory. Disengagement is in a controlled manner to provide a smooth return of throttle control to the driver.

The ECM disengages cruise control, clears the set speed from memory and <u>immediately</u> returns control of the throttle to the driver if any of the following occur:

- the master switch is pressed, to switch the system off
- a fault is detected in the electronic throttle system, the brake switch or the cruise control switches
- the parking brake is applied
- the engine overspeeds.

The ECM disengages cruise control, immediately returns control of the throttle to the driver and <u>retains</u> the set speed in memory, if any of the following occur:

- the brake pedal is pressed
- the vehicle decelerates too fast (ie. as under heavy braking, to guard against sticking contacts in the brake switch)
- the gear selector moves to neutral, park or reverse
- after resuming cruise control the vehicle accelerates to only 50% of the set speed (eg. due to a steep hill)
- the stability/traction control system operates
- vehicle speed decreases below 26 km/h (16 mph).

On receipt of an input from the **RES** switch, if a set speed is stored in the ECM memory, the cruise control function is re-engaged and the vehicle accelerated or decelerated to resume the set speed in a controlled manner.

The ECM continuously monitors the cruise control switches. If a switch fails closed, on the initial failure the input is treated as a driver command and the system responds accordingly. However, after subsequent disengagement then re-engagement of the system, the input from the failed switch is diagnosed as a fault. On detection of a switch fault, operation of cruise control is inhibited until the fault is corrected.

The ECM also conducts internal checking procedures to ensure that only permitted outputs are generated for given input conditions.

## H02S Heaters

The ECM energizes the heater elements of the HO2S during engine warm-up to shorten the time it takes for them to produce accurate outputs.

## Instrument Cluster

The instrument cluster uses CAN messages from the ECM to operate the trip computer, tachometer, engine coolant temperature gauge and the BRAKE, CHECK ENG and general warning lamps.

**Note:** The CHECK ENG lamp is commonly known as the MIL.

## A/C Compressor Clutch

Operation of the A/C compressor clutch is controlled by the ECM, to prevent unnecessary loads on the engine during unfavorable operating conditions.
On receipt of an A/C request signal from the A/CCM, the ECM immediately energizes the A/C compressor clutch relay provided the engine is not at idle speed, the coolant temperature is not above 119˚C (246˚F) and the throttle valve is not fully open. When the A/C compressor clutch relay energizes, the relay output is sensed by the A/CCM, confirming that the A/C compressor clutch is engaged.
If the engine is at idle speed, the coolant temperature is above 119˚C (246˚F) or the throttle is fully open, the ECM outputs a load inhibit signal to the A/CCM and delays energising the A/C compressor clutch relay. At idle speed the delay is only momentary (in the order of 50 ms) while idle speed compensation is implemented, after which the load inhibit signal is removed. At coolant temperatures above 119˚C (246˚F) or with a fully open throttle, the delay is for the duration of the inhibiting condition.
Similarly, with the A/C compressor clutch relay already energized, if the engine coolant temperature exceeds 119˚C (246˚F) or the throttle goes to fully open, the ECM de-energizes the A/C compressor clutch relay and outputs the load inhibit signal to the A/CCM until the inhibiting condition is removed.

## Windshield and Backlight Heaters

When the windshield heaters and/or the backlight heater are requested on, the A/CCM sends a screen request signal to the ECM. Provided the engine is not at idle speed, the coolant temperature is not above 119˚C (246˚F) and the throttle valve is not fully open, the ECM takes no action and the A/C control module subsequently energizes the heaters.
If the engine is at idle speed, the coolant temperature is above 119˚C (246˚F) or the throttle is fully open, the ECM outputs the load inhibit signal (the same one as used for the A/C compressor clutch operation) to the A/CCM to delay energising the heaters. At idle speed the delay is only momentary while idle speed compensation is implemented, after which the load inhibit signal is removed. At coolant temperatures above 119˚C (246˚F) or with a fully open throttle, the delay is for the duration of the inhibiting condition.
Similarly, with the heaters already energized, if the engine coolant temperature exceeds 119˚C (246˚F) or the throttle goes to fully open, the ECM outputs the load inhibit signal to the A/CCM and the heaters are de-energized until the inhibiting condition is removed.

## Radiator Cooling Fans

The ECM monitors inputs from the A/C single and triple pressure switches, and from the ECT sensor on the engine, to control the operation of the two radiator cooling fans. Outputs from the ECM control two relays contained in the radiator fans module, to operate the fans in off, slow or fast mode. In the slow mode the fans are connected in series; in the fast mode the fans are connected in parallel. Hysteresis in the temperature and pressure switching values prevents "hunting" between modes.