

ENGINE

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ENGINE <6G74>

GENERAL INFORMATION

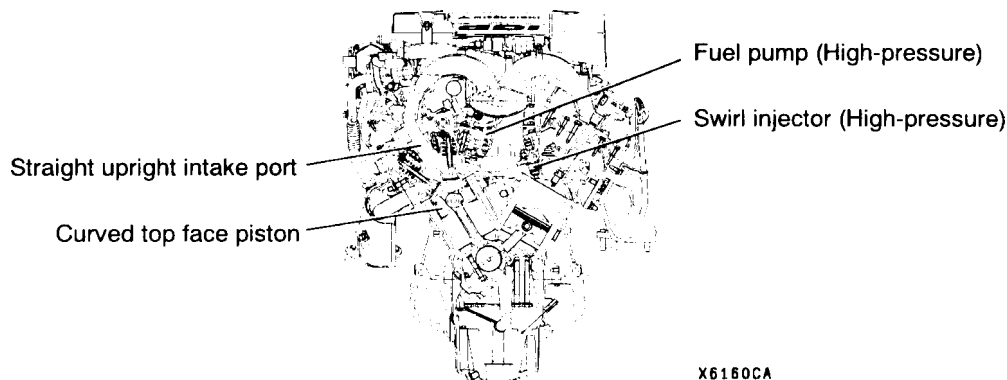
The GDI engine used in the new PAJERO was developed from the 6G74-MPI engine used previously. The main areas of new technology are the combustion chambers, intake system, and fuel system.

MAJOR SPECIFICATIONS

Items		6G74-GDI
Total displacement mℓ		3497
Bore × Stroke mm		93.0 × 85.8
Compression ratio		10.4
Compression chamber		Pentroof type + curved top piston
Camshaft arrangement		DOHC
Valve timing	Intake opening	BTDC 12°
	Intake closing	ABDC 48°
	Exhaust opening	BBDC 48°
	Exhaust closing	ATDC 12°
Fuel system		Electronically controlled multipoint fuel injection/Gasoline direct injection
Rocker arm		Roller type
Lash adjuster		Equipped
Engine oil	Engine oil API classification	SG or higher
	Engine oil quantity ℓ	4.6 (Includes oil filter capacity 0.3)

GASOLINE DIRECT INJECTION SYSTEM (GDI)

- By directly injecting the gasoline into the cylinder, the GDI engine realizes a high-response, high-precision fuel control and allows a leaner and higher-efficiency combustion.
By fuel injection to the cylinder, the volumetric efficiency is improved, and a higher power output is realized through the high-compression ratio.
- The following three items were considered for the layout of the combustion chamber when studying the basic construction of the GDI engine:
 - Positioning the spark plug closer to the centre of the combustion chamber, optimizing the combustion
 - Injector offset towards the intake port
 - Realization of layered combustion using the flow of the gas in the cylinder
 Importance was also paid to the structure of the fuel supply system to efficiently supply the fuel against the pressure of compression stroke, giving optimum injection for layered combustion.
As a result, we have succeeded in developing the following four items as the basic construction elements of the GDI engine which realized lower fuel consumption and a higher power output:
 - Control the air flow in the cylinder [straight upright intake port]
 - Supply of high-pressure fuel required for direct injection into the cylinder [Fuel pump (High-pressure)]
 - Control of the atomised fuel into the cylinder [Swirl injector (High-pressure)]
 - Control of combustion [Curved top face piston]

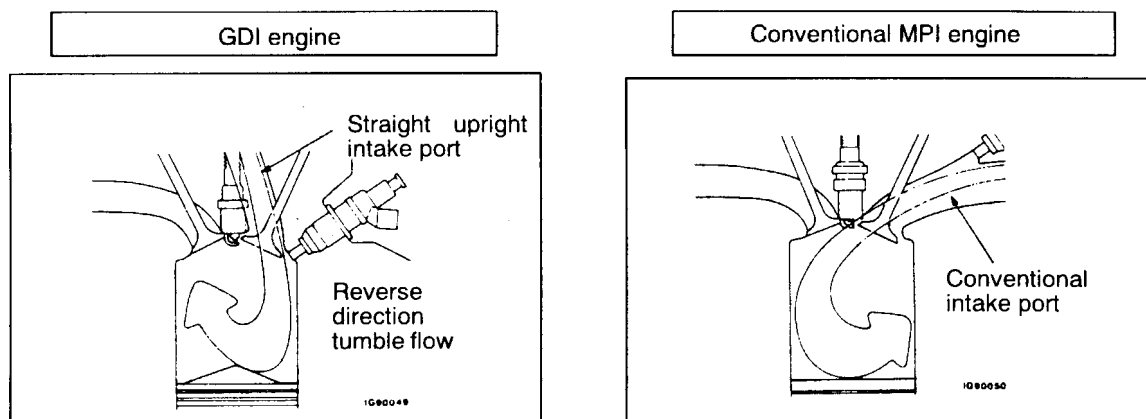


REALIZATION OF LOW FUEL CONSUMPTION

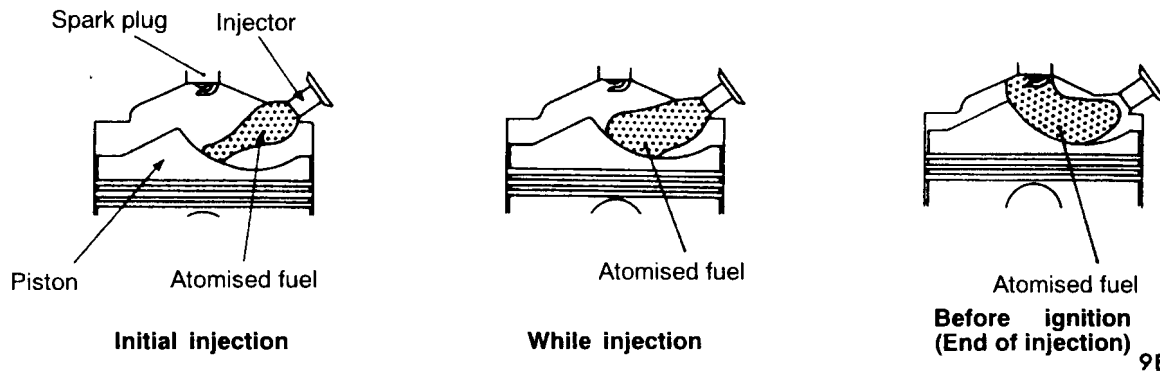
- By injecting the fuel directly into the cylinder, the fuel distribution in the combustion chamber can be fully controlled. By using the air flow generated by the straight upright intake port and the curved top piston, we have succeeded in creating a layered air/fuel mixture in the cylinder. With this, a stabilized combustion with an ultra-lean air/fuel mixture of up to 40:1 was obtained.

Air Flow in Cylinder

- The strong downflow generated during the intake stroke by the straight upright intake port creates an air flow (tumble flow) in the cylinder at the reverse direction of the conventional engine.



- The curved top piston strengthens the tumble flow and at the same time collects the fuel injected during the latter half of the compression stroke near the spark plug so that it does not scatter throughout the combustion chamber. Through this, this part plays an important role in controlling the air-fuel state in the cylinder.



Fuel Injection Process

- During ultra-lean combustion operation, the fuel is injected during the latter half of the compression stroke just before ignition. Since the pressure in the cylinder is high, the fuel that is atomised by the high-pressure swirl injector is formed into a spherical compact mist structure. This atomised fuel is swiftly vaporized by the tumble swirl flow (In addition, some fuel hits the piston, and vapourizes due to the heat of the piston.) without being scattered into the space at the curved piston top face, and is transferred next to the spark plug in the layered air/fuel mixture state. With this, an optimum air/fuel ratio that can be ignited easily is kept near the spark plug allowing an extremely lean air/fuel mixture to be realized for the entire combustion chamber.

Fuel Consumption Reduction Effect

- The fuel consumption improvement rate differs according to the operation conditions, but compared with the conventional engine the improvement is larger for the low load operation.
 - During idling**
A major fuel consumption reduction is realized by the ultra-lean combustion, due to the excessive air state, torque fluctuation and quick engine response can be easily controlled by the amount of fuel injected. With this, the idling speed can be set at 600 r/min (for lean mixture) or 700 r/min (for rich mixture), allowing an improvement of approximately 40% in fuel consumption rate compared to the conventional engine.
 - During constant speed travel**
With the conventional engine, the combustion starts to deteriorate at an air/fuel ratio of 20:1, but with the GDI engine, the combustion is extremely stable even when the air/fuel ratio is 40:1. This allows a fuel consumption improvement.

REALIZATION OF HIGH POWER

- The basic concept for realizing a high power is to cool the intake air by the fuel injection during the intake stroke. With this, the volumetric efficiency is improved and a high compression ratio can be realized, because this cooling effect prevents engine knocking.

Improvement of Volumetric Efficiency

- To improve the volumetric efficiency during a high-load operation, the smooth intake flow obtained by the vertical intake flow is used together with the intake cooling obtained by directly injecting the fuel during the intake stroke. By directly injecting the fuel into the cylinder, the fuel is in the combustion chamber. At this time, the intake air is cooled by the vaporization heat and the air density increases.

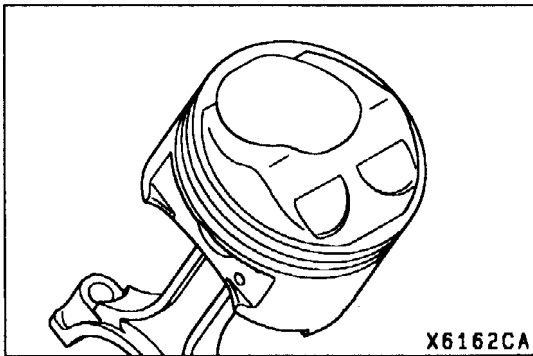
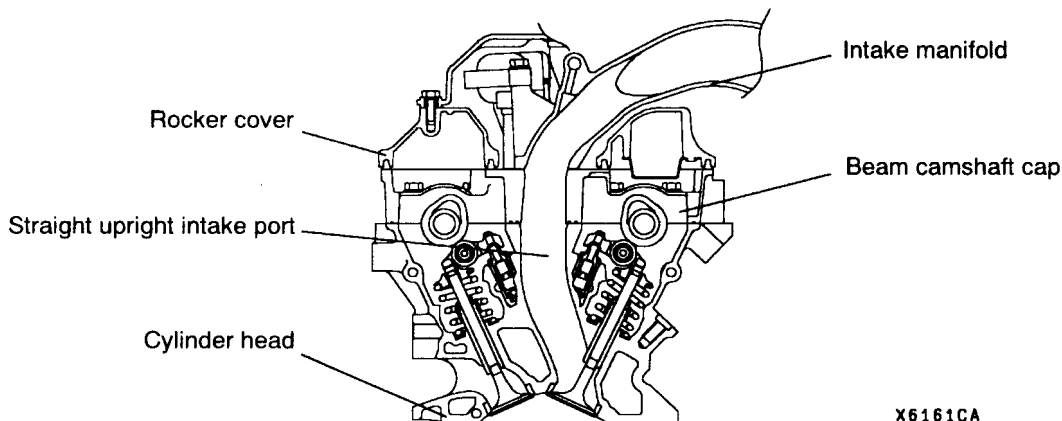
High-compression Ratio

- The temperature in the combustion chamber is lowered when the gasoline directly injected into the cylinder is vaporized, so knocking does not occur easily, and a high compression ratio can be set. Through this, a high compression ratio of 10.4, which was difficult with the conventional MPI engine has been realized.

BASE ENGINE

CYLINDER HEAD, CAMSHAFT CAP

- The intake port is arranged vertically at the centre of the cylinder head. The intake air is led in from the top of the combustion chamber, and is fed with a strong downward flow to create a tumble flow in the reverse direction of the conventional engine. The smooth air flow from this vertical intake port reduces the intake resistance and improves the volumetric efficiency.
- The spark plug is mounted in the centre of the combustion chamber to optimize the combustion.
- An integrated beam camshaft cap that incorporates the intake ports, ignition plug holes and camshaft caps are installed at the upper surface of the cylinder head.

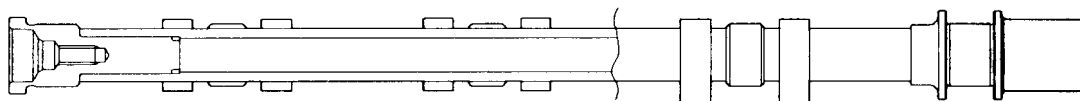


PISTON

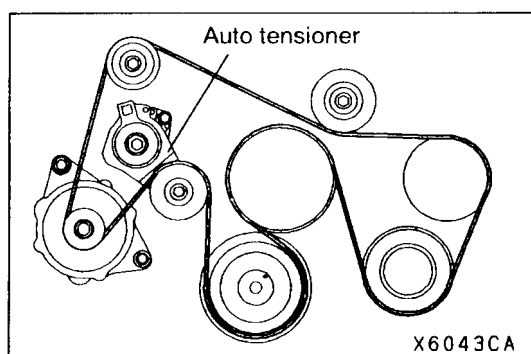
- The piston top face shape is curved to control the tumble flow and to give stable combustion. The atomised fuel from the injector is directly injected at the cavity section during the injection in the compression stroke. It is transferred near the spark plug with the strengthened tumble flow without allowing the mist from escaping from the cavity. By realizing a layered air/fuel mixture state favorable for combustion, ultra-lean combustion is realized.
- By reducing the top land height (distance between top ring and piston top face), the incomplete combustion section displacement is reduced, and the incomplete combustion gas element (HC) in the exhaust gas is reduced.

CAMSHAFT

A hollow assembly-type camshaft which is approximately 30% lighter than the previously-used camshaft (made from solid steel) has been adopted in order to reduce weight.

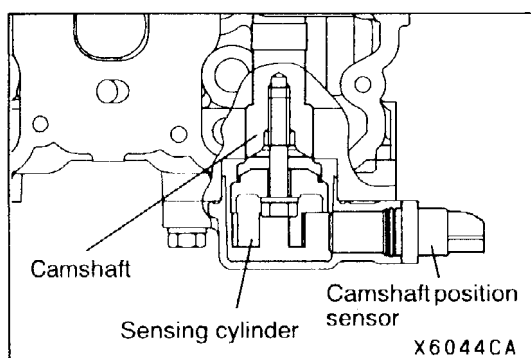


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DRIVE BELT

A serpentine-type drive belt which combines all of the auxiliary engine belts into a single belt has been adopted. This type of belt employs an auto tensioner, which not only keeps the belt tension stable and extends the belt life, but also makes tension adjustment unnecessary.



CAMSHAFT POSITION SENSOR

The camshaft position sensor detects the camshaft position using a sensing cylinder which is mounted at the rear end of the camshaft.

COOLING SYSTEM

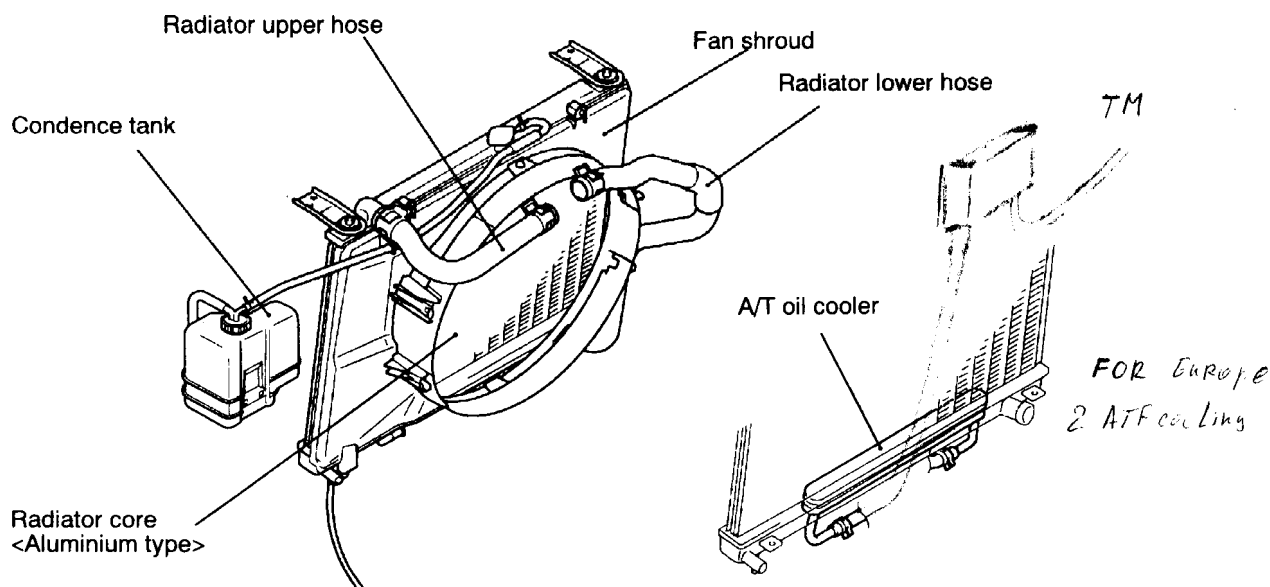
The cooling system is a water-cooled forced recirculation system which has the following features.

- The radiator has a large high-performance aluminum core in order to improve cooling performance and to reduce weight.
- Water-cooled A/T oil cooler which is built into the radiator lower tank has been adopted. (Refer to GROUP 2 - Automatic Transmission.)

SPECIFICATIONS

ITEMS			SPECIFICATIONS
Cooling water control method			Intake control method
Cooling fan	Type		With engine driven-type thermo clutch
Cooling water	Brand		High quality ethylene glycol antifreeze coolant
	Cooling water amount ℓ	Without rear heater	9.0
		With rear heater	10.5
Water pump	Type		Centrifugal-type impeller
	Drive method		Drive belt
Thermostat	Type		Wax type
	Valve open temperature °C	6G72	88
		6G74	76.5
Radiator	Type		Corrugate type
	Core size (width × height × thickness) mm		703.6 × 500 × 16
	Performance kJ/h		203,023
A/T oil cooler	Type		Layer type
	Performance kJ/h		9,460

CONSTRUCTION DIAGRAM



INTAKE AND EXHAUST

AIR INTAKE SYSTEM

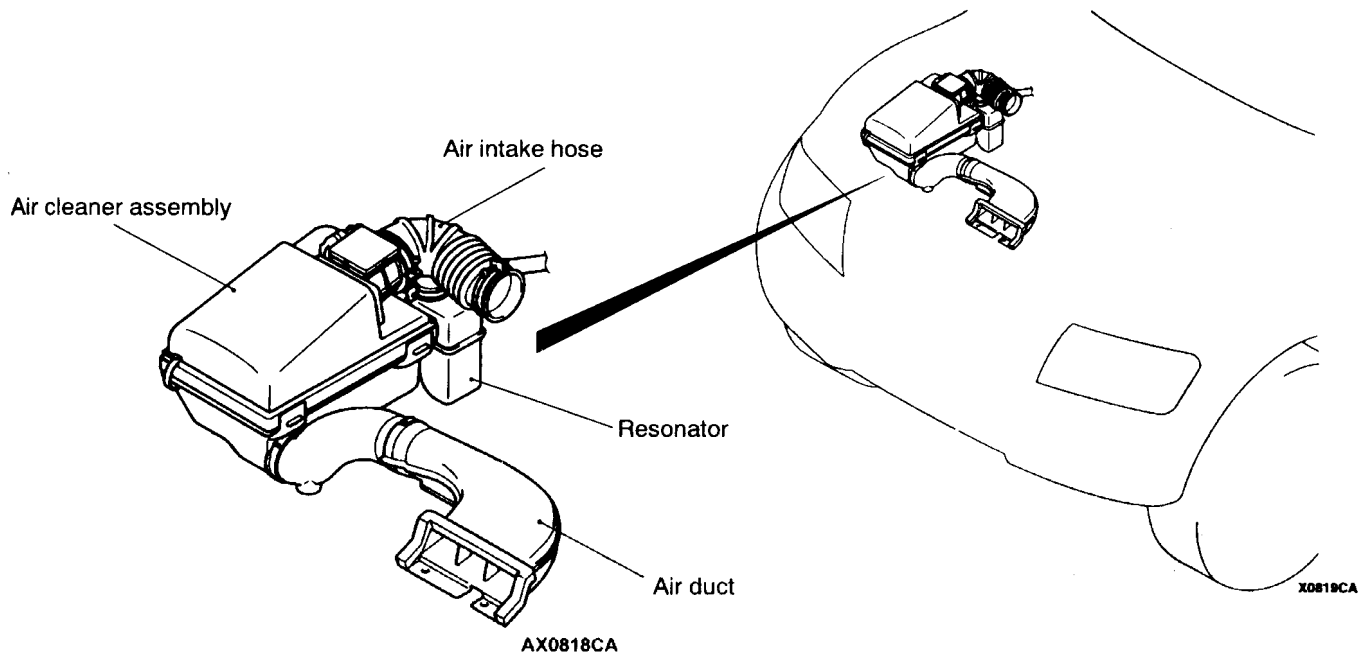
AIR CLEANER

A large 12 ℓ-capacity air cleaner has been adopted. It has the following features.

- In order to give further consideration to reducing amounts of industrial waste produced and preserving the global environment, the air cleaner case incorporates plastic mixed with recycled paper which can be incinerated.
- In order to give further consideration to preserving the global environment, the air intake hose is manufactured from rubber which contains no lead.

- An air intake resonator has been adopted in order to reduce air intake noise.
- The intake port of the air duct is located at the top of the radiator to provide a layout which effectively draws in the cooling air. This boosts engine output performance and reduces the amount of intake air noise inside the passenger compartment.

CONSTRUCTION DIAGRAM



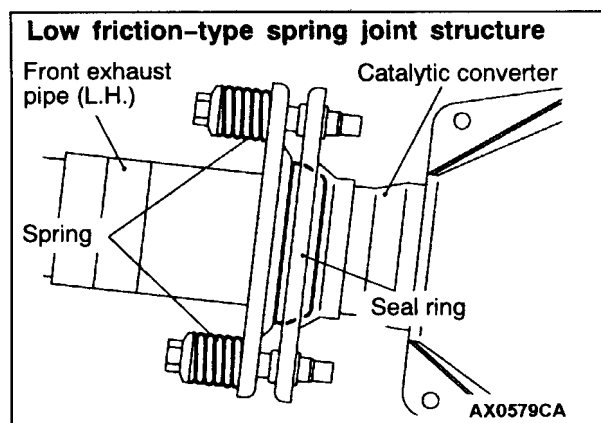
EXHAUST SYSTEM

EXHAUST PIPE

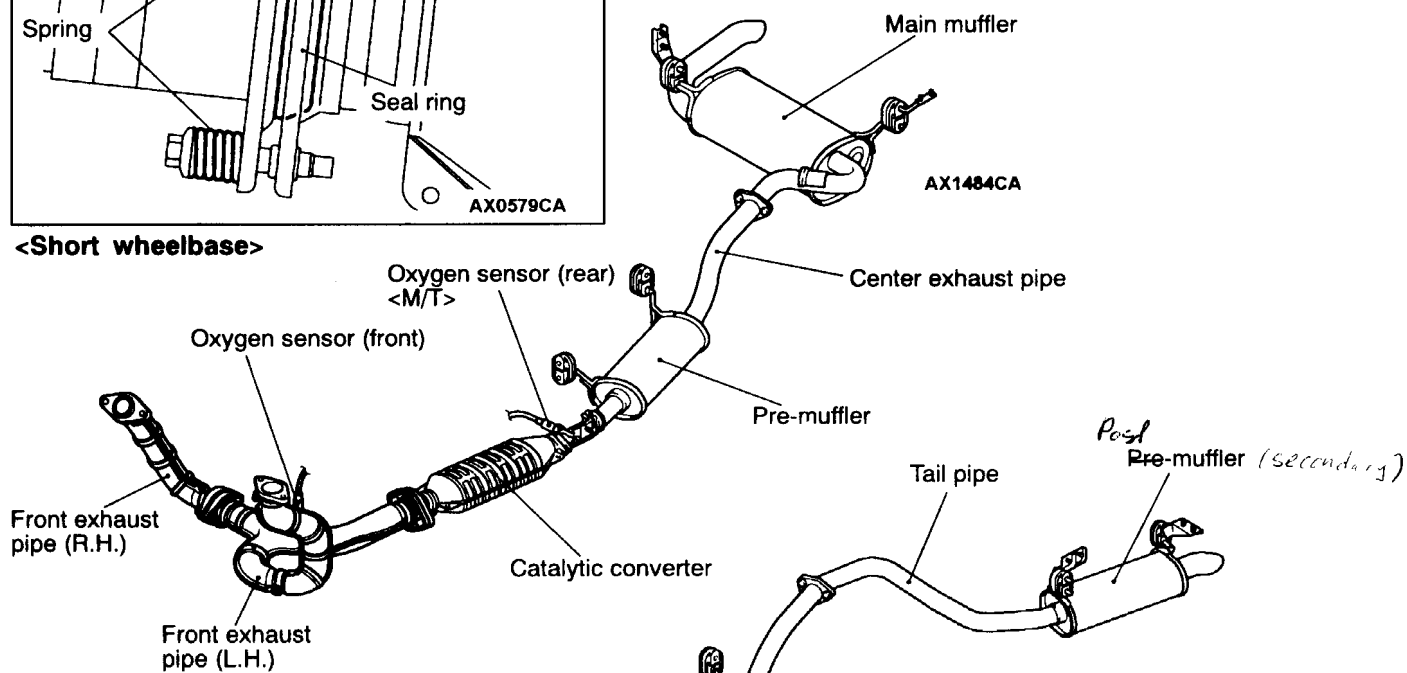
The exhaust pipe is divided into four parts and has the following features:

- A large main muffler (17 ℓ) has been adopted to reduce the low-to medium-frequency noise components.
- The connection between the front exhaust pipe (L.H.) and the catalytic converter has a low friction-type spring joint structure, to reduce vibration of the exhaust pipe.
- The noise absorbing-type pre-muffler absorbs high-frequency exhaust noise.
- The right and left sections of the front pipe are equal in length to each other.
- Special rubbers with low dynamic spring constant are used for exhaust pipe hangers, which substantially reduce the transmission of the exhaust pipe vibration to the body.
- The exhaust pipe is made from stainless steel.

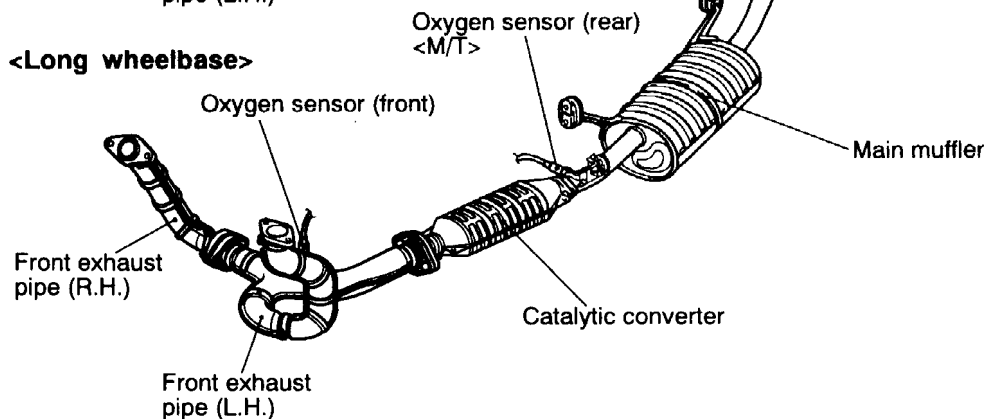
CONSTRUCTION DIAGRAM



<Short wheelbase>



<Long wheelbase>



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FUEL SYSTEM

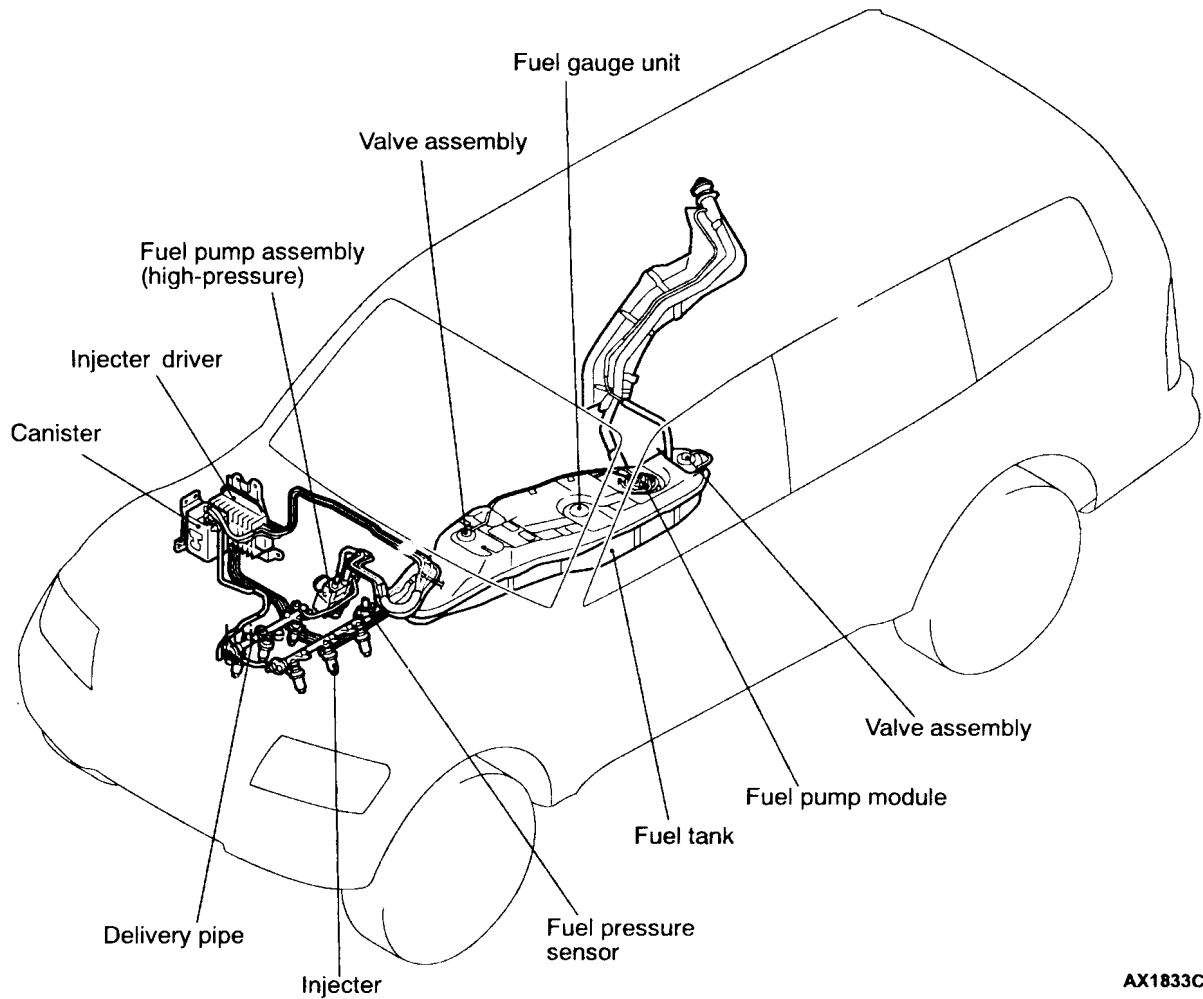
The fuel system consists of components such as the injectors, delivery pipe, fuel pump (high pressure), canister, injector driver, fuel pump module, fuel gauge unit and fuel tank. This system has the following features.

- A new type of fuel pump (high pressure) with a built-in fuel pressure regulator (high pressure) has been adopted in order to make the unit more compact and light-weight.
- The adoption of a new type of fuel pump (high pressure) and the abolition of the high-pressure return pipe makes the system more simple and improves reliability.
- The activated carbon layer in the canister has a two-section construction in order to reduce the amount of fuel vapor discharged into the atmosphere.
- A fuel pump module which integrates the fuel pump (low pressure), fuel filter and fuel pressure regulator (low pressure) has been adopted.
- The adoption of a fuel pump module means that the fuel filter and fuel pressure regulator (low pressure) could be located inside the fuel tank to improve safety in the event of an impact.

SPECIFICATIONS

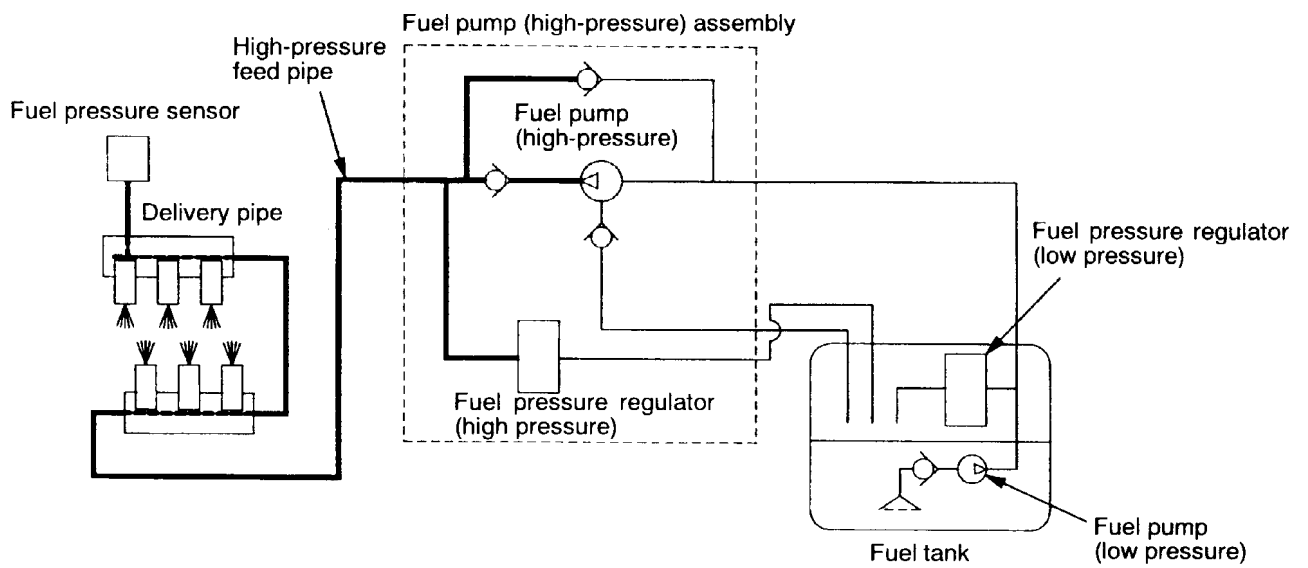
Items		Specifications
Fuel tank capacity ℓ	Short wheelbase	71
	Long wheelbase	90
Fuel pump type (high-pressure)		Mechanical type
Fuel pump type (low-pressure)		Electric type
Fuel filter type		Double mesh filter type (incorporates fuel pump module)
Fuel return system		Fuel pressure regulator return
Fuel pressure regulator (low-pressure) control pressure kPa		324
Fuel pressure regulator (high-pressure) control pressure MPa		5.0
Injector	Type	Electromagnetic type
	Quantity	6
Evaporative emission control system		Canister type

CONSTRUCTION DIAGRAM



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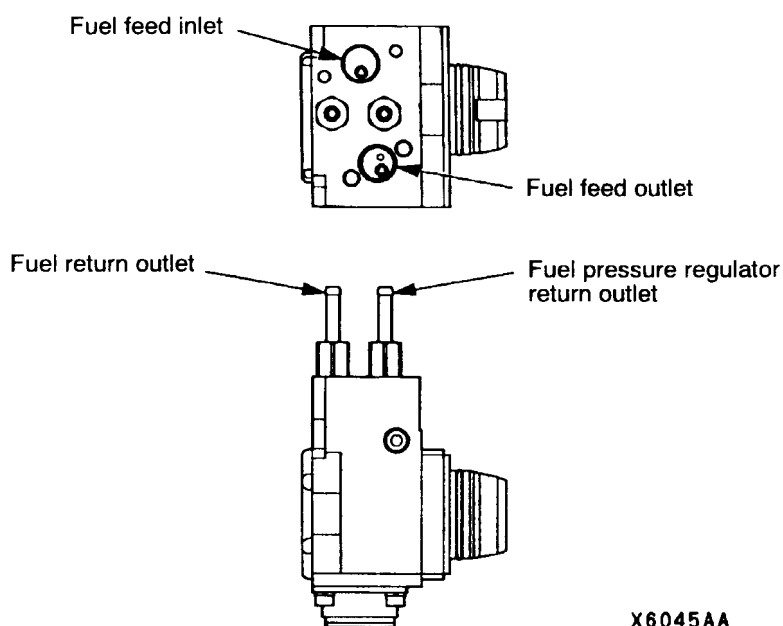
FUEL LINE DIAGRAM



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FUEL PUMP (HIGH-PRESSURE)

- A single-plunger pump with a built-in fuel pressure regulator (high pressure) has been adopted.
- Similar to previous pumps, this pump is installed to the cylinder head on the right bank and is driven by the inlet camshaft. It supplies fuel at the necessary pressure for fuel atomisation (5.0 MPa) under all driving ranges.
- The high pressure regulator assembly which was used in the previous system has been abolished because the fuel pressure regulator (high pressure) is now built into the fuel pump (high pressure).

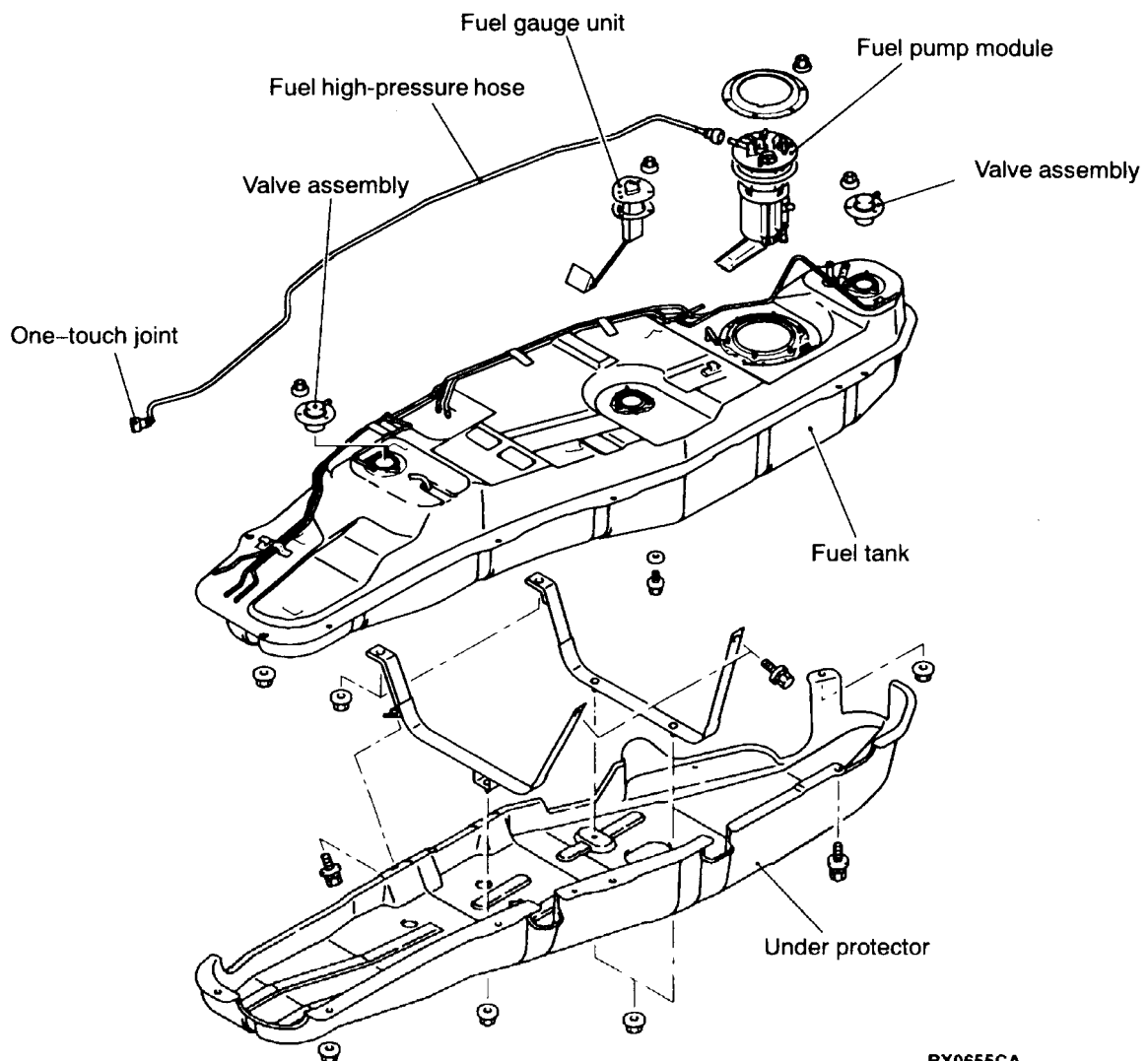


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FUEL TANK

The fuel tank is a steel fuel tank which is located underneath the passenger seat floor. It has the following features.

- Lead-free materials have been adopted for the main fuel tank unit in consideration of protection of the global environment.
- A plastic under protector which is light in weight and has excellent corrosion resistance has been adopted.
- A fuel pump module which integrates the fuel pump (low pressure), fuel filter and fuel pressure regulator (low pressure) has been adopted.
- A valve assembly with an integrated cut-off valve which prevents fuel outflow and two-way valve which adjusts the fuel pressure inside the fuel tank has been adopted.
- A one touch joint-type nylon tube has been adopted as the fuel high pressure hose in order to improve serviceability.



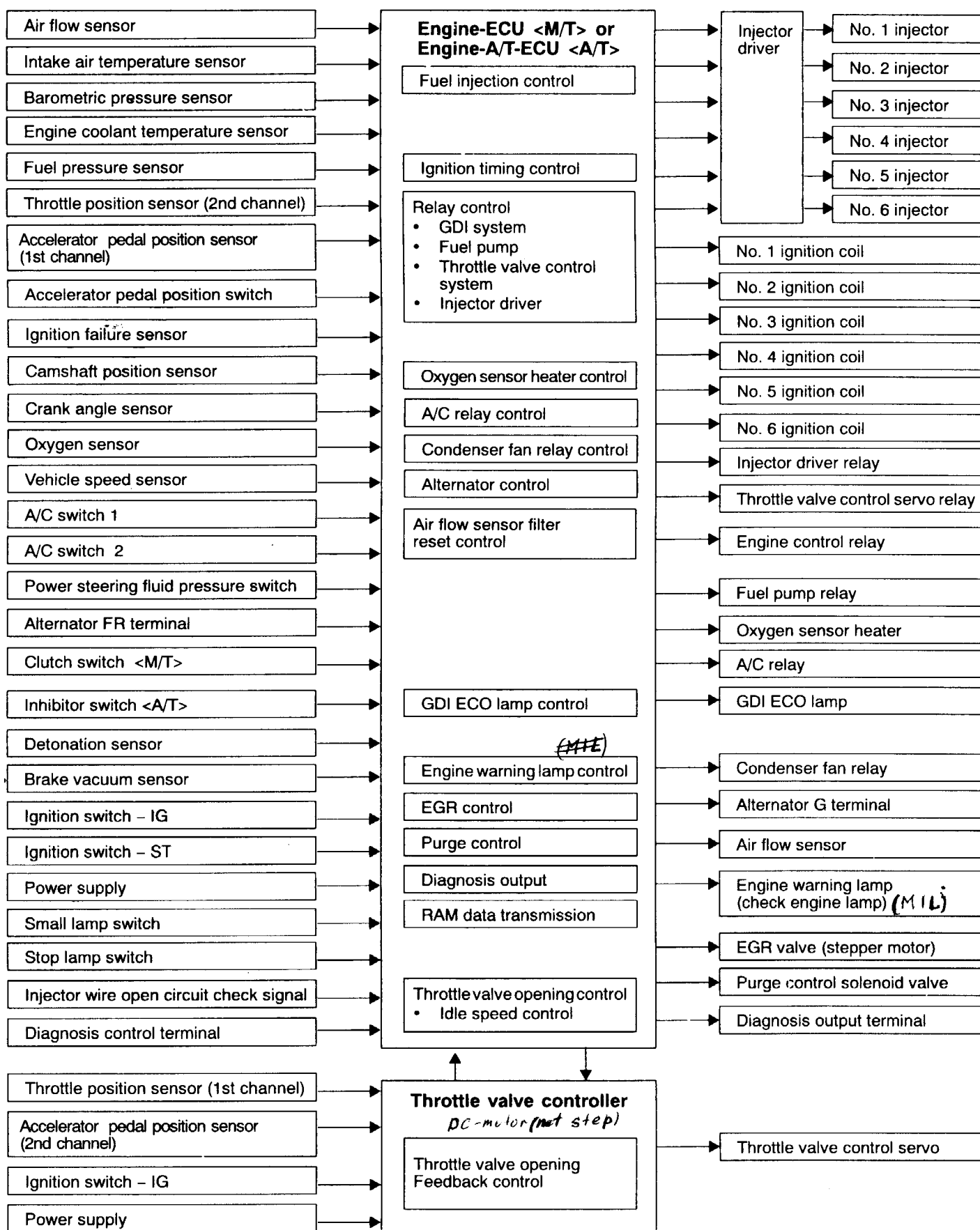
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CONTROL SYSTEM

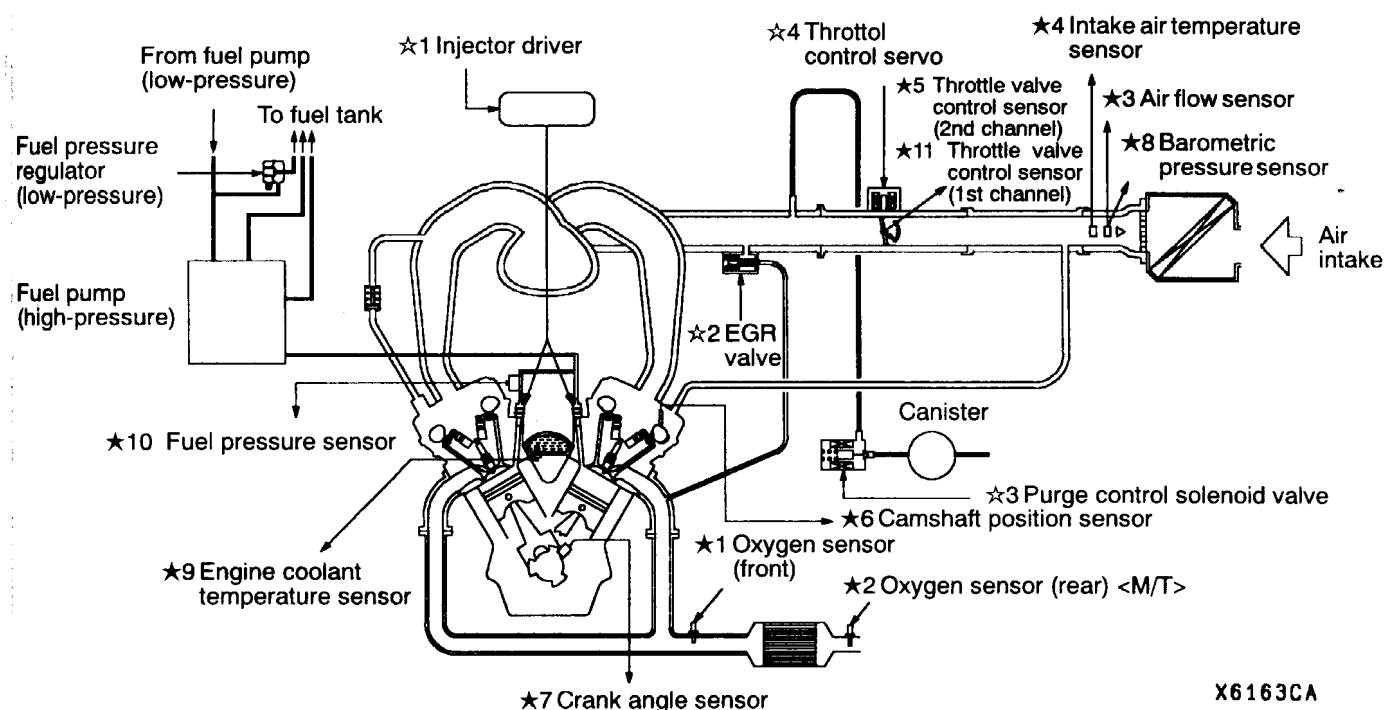
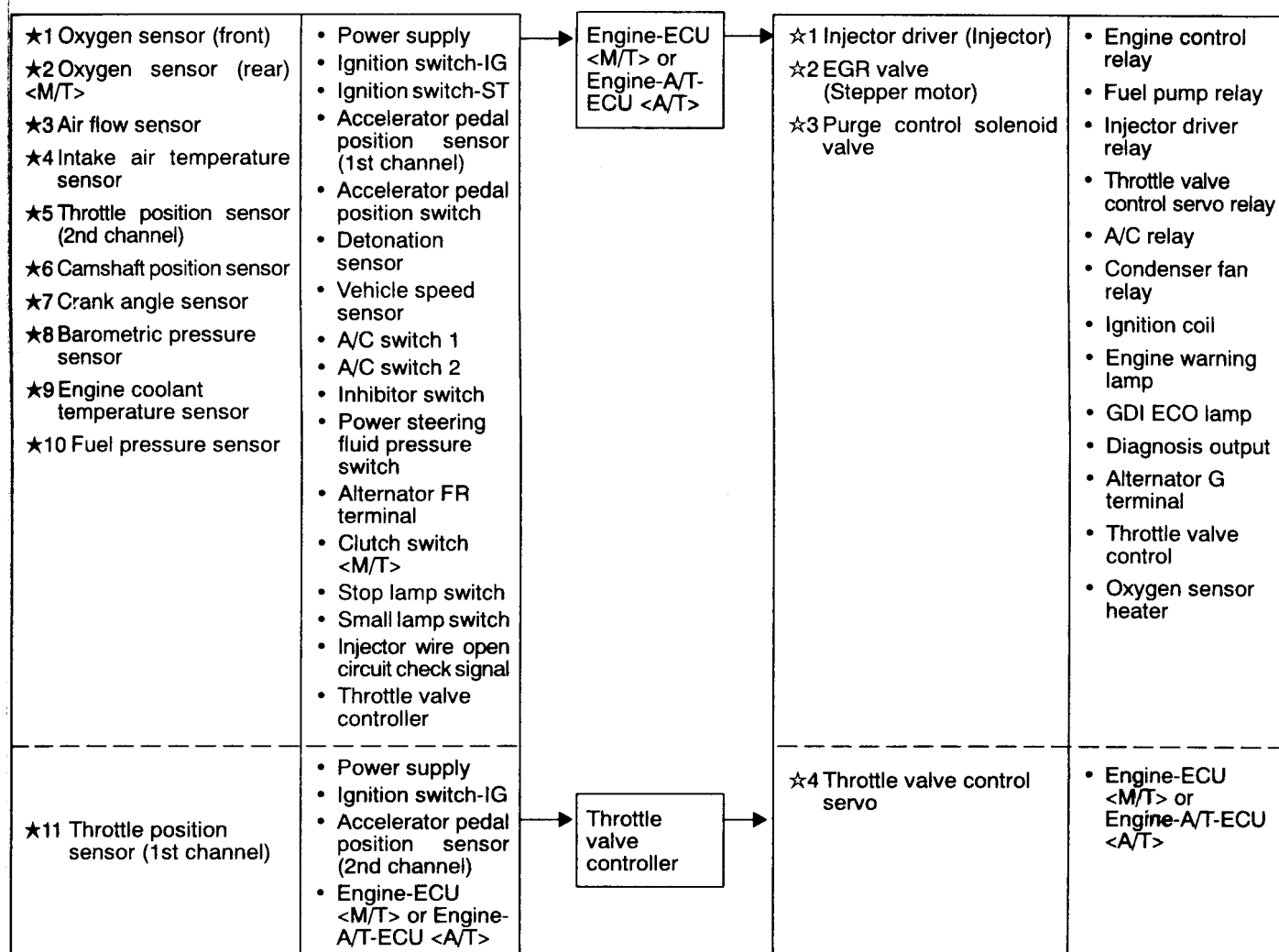
The control system is based upon that of the 4G6-GDI engine used in the SPACE WAGON. It incorporates the following enhancements:

Improvements/Additions	Remarks
GDI ECO lamp	Notifies the driver that low fuel consumption driving mode is active.
An ignition coil built in the power transistor has been used. With this, the ignition signal errors can be detected with the ignition failure sensor.	Simplified ignition circuit
Dual oxygen sensor has been adopted. (M/T)	Higher reliability of air-fuel ratio control Essentially the same as in the 4G6 engine mounted in the GALANT

SYSTEM BLOCK DIAGRAM



CONTROL SYSTEM DIAGRAM

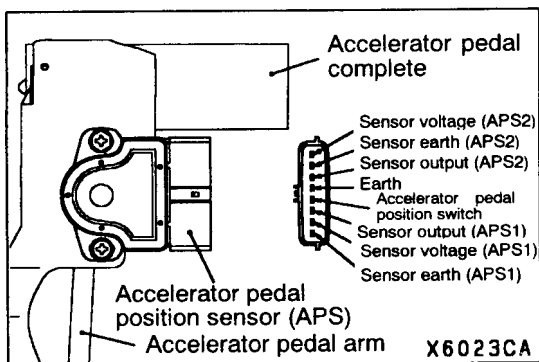


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LIST OF COMPONENT FUNCTION

Name		Function
ECU	Engine-ECU <M/T> Engine-A/T-ECU <A/T>	Controls actuators in accordance with operating conditions indicated by inputs from sensors.
	Throttle valve controller	Controls throttle opening in accordance with target throttle opening inputs from engine-ECU <M/T> or engine-A/T-ECU <A/T>.
Sensors	Ignition switch-IG	Detects ON/OFF status of ignition switch. Upon receipt of signal from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> supplies power to injector driver, air flow sensor, throttle control servo, crank angle sensor, and other components.
	Ignition switch-ST	Detects cranking of engine. In accordance with signal from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> controls fuel injection, throttle valve opening, and ignition timing as required for engine startup.
	Air flow sensor (AFS)	Senses air intake volume using Karman flow meter. In accordance with this information and engine speed, engine-ECU <M/T> or engine-A/T-ECU <A/T> controls injectors' basic activation duration.
	Barometric pressure sensor	Senses atmospheric pressure using diffused-junction-transistor-type pressure sensor. In accordance with data from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> determines vehicle's height above sea level and adjusts fuel injection rate as a function of altitude to ensure appropriate air/fuel ratio.
	Oxygen sensor	Uses zirconia and platinum electrodes to sense oxygen concentration in exhaust gas. In accordance with sensed oxygen concentration, engine-ECU <M/T> or engine-A/T-ECU <A/T> determines whether air/fuel ratio is stoichiometric.
	Intake air temperature sensor	Uses thermistor to sense intake air temperature. In accordance with output voltage from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> adjusts fuel injection rate to suit intake air temperature.
	Engine coolant temperature sensor	Uses thermistor to sense engine coolant temperature. In accordance with data from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> determines extent to which engine has warmed up and controls fuel injection rate, idling speed, and ignition timing as required.
	Throttle position sensor	Uses potentiometer to sense throttle valve opening. In accordance with output voltage from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> controls throttle valve and controls fuel injection as required for acceleration.
	Accelerator pedal position sensor	Uses potentiometer to sense accelerator pedal position. In accordance with output voltage from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> controls fuel injection and throttle valve to meet driver's requirements.
	Accelerator pedal position switch	Detects completely released condition of accelerator pedal using movable-contact-type switch incorporated into accelerator pedal position sensor.
	Vehicle speed sensor	Uses magnetic resistance element to sense vehicle speed.
	Camshaft position sensor	Uses magnetic resistance element to sense presence of No. 1 piston at top dead centre on compression stroke.
	Detonation sensor	Uses piezoelectric element to sense vibration of cylinder block caused by detonation. In accordance with intensity of knocking, engine-ECU <M/T> or engine-A/T-ECU <A/T> retards ignition timing.
	Crank angle sensor	Uses Hall element to sense crank angle. In accordance with signals from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> controls injectors and other components.
	Ignition failure sensor (engine ignition signal)	Checks voltage fluctuations at the (+) side of the ignition coil to detect whether the engine ignition signal is being generated.
	Alternator FR terminal	Allows sensing of alternator field coil's energization duty ratio.

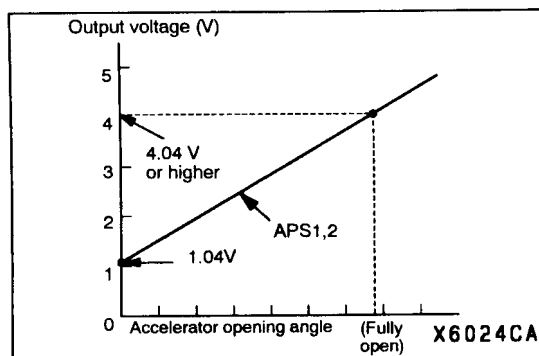
Name		Function
Sensors	Inhibitor switch	Senses presence of automatic transmission selector lever in P or N position. In accordance with signal from this sensor, engine-ECU <M/T> or engine-A/T-ECU <A/T> activates throttle valve control servo to control idling speed.
	Power steering fluid pressure switch	This contact-type switch provides data on presence or absence of power steering loading.
	Fuel pressure sensor	Uses metal-diaphragm-type pressure sensor to sense fuel pressure applied by fuel pump (high-pressure). In accordance with this fuel pressure, engine-ECU adjusts fuel injection rate.
	Brake vacuum sensor	Uses semiconductor pressure sensor to sense deficiency in brake booster vacuum pressure. (NOT for H138)
	Small lamp switch	Provides data on electrical loading to engine-ECU <M/T> or engine-A/T-ECU <A/T>.
	Stop lamp switch	Uses contact-type switch to detect depression of brake pedal.
	A/C switch 1	Provides data on ON/OFF condition of air conditioner.
	A/C switch 2	Provides data on loading condition of air conditioner.
	Injector wire open circuit check signal	Enables engine-ECU <M/T> or engine-A/T-ECU <A/T> to detect open circuits in injector wiring.
	Diagnosis control terminal	When OBD-II is not active Enables indication of diagnosis codes stored in memory. (When terminal is shorted to body earth, codes are indicated by flashing of engine warning lamp.) When OBD-II is active Notifies the engine-ECU that the MUT-II is connected to the diagnosis connector so that communication between the MUT-II and the engine-ECU can be enabled.
Actuators	Engine control relay	Turns ON/OFF engine-ECU <M/T> or engine-A/T-ECU <A/T> power supply circuit.
	Throttle valve control servo relay	Turns ON/OFF throttle valve controller power supply circuit.
	Injector driver	Activates injectors in accordance with drive signals from engine-ECU <M/T> or engine-A/T-ECU <A/T>.
	Injector driver relay	Turns ON/OFF injector driver power supply circuit.
	Injector	Injects fuel in accordance with drive signals from injector driver.
	Ignition coil (with power transistor)	Supplies and interrupts primary current of ignition coil in accordance with ignition signals from engine-ECU <M/T> or engine-A/T-ECU <A/T>, causing coil to produce high voltage required for ignition.
	Throttle valve control servo	Controls throttle valve opening in accordance with signals from throttle valve controller.
	EGR valve (stepper motor)	Controls exhaust gas recirculation rate in accordance with signals from engine-ECU <M/T> or engine-A/T-ECU <A/T>.
	Fuel pump relay	Controls power supply to low-pressure fuel pump.
	Purge control solenoid valve	Controls rate at which purge air is introduced into surge tank in accordance with signals from engine-ECU <M/T> or engine-A/T-ECU <A/T>.
	Alternator G terminal	Used to control alternator output in accordance with signals from engine-ECU <M/T> or engine-A/T-ECU <A/T>.
	A/C relay	Controls activation of air conditioner compressor.
	GDI ECO lamp	Illuminates during low fuel consumption driving mode to notify the driver that this mode is active.
	Engine warning lamp	Illuminates to alert driver in event of sensor fault. When OBD-II is active Also, flashes to indicate diagnosis codes when code output procedure is performed.



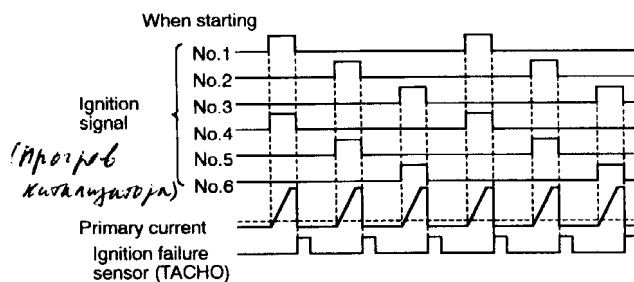
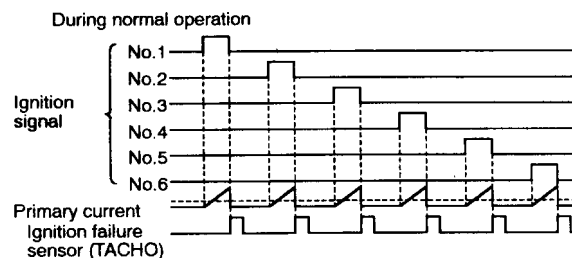
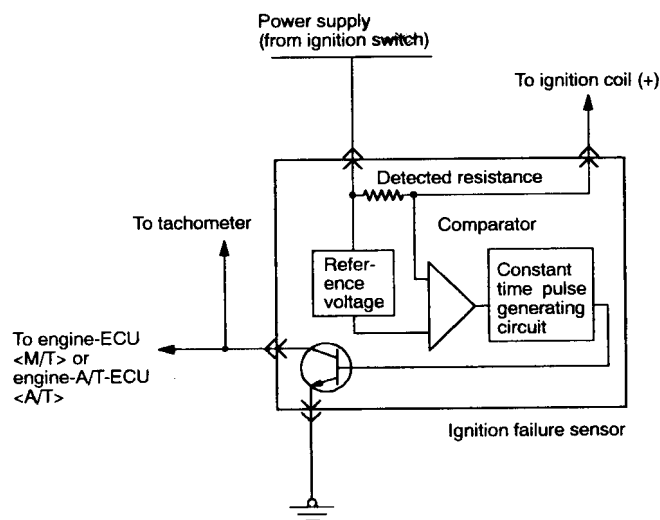
SENSOR

ACCELERATOR PEDAL POSITION SENSOR (APS)

A dual-type APS has been installed directly to the accelerator pedal.

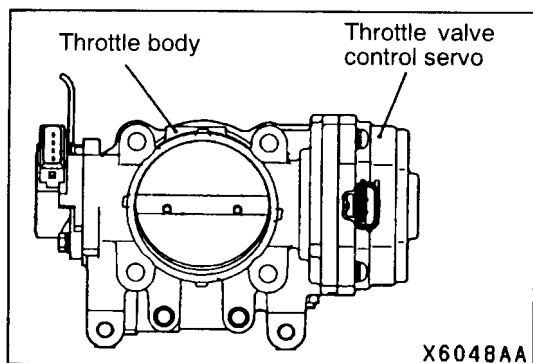


IGNITION FAILURE SENSOR



X6164CA

The voltage fluctuation at the ignition coil side (+) is checked, and the engine ignition signal generator status is detected with this and input to the engine-ECU <M/T> or engine-A/T-ECU <A/T>.

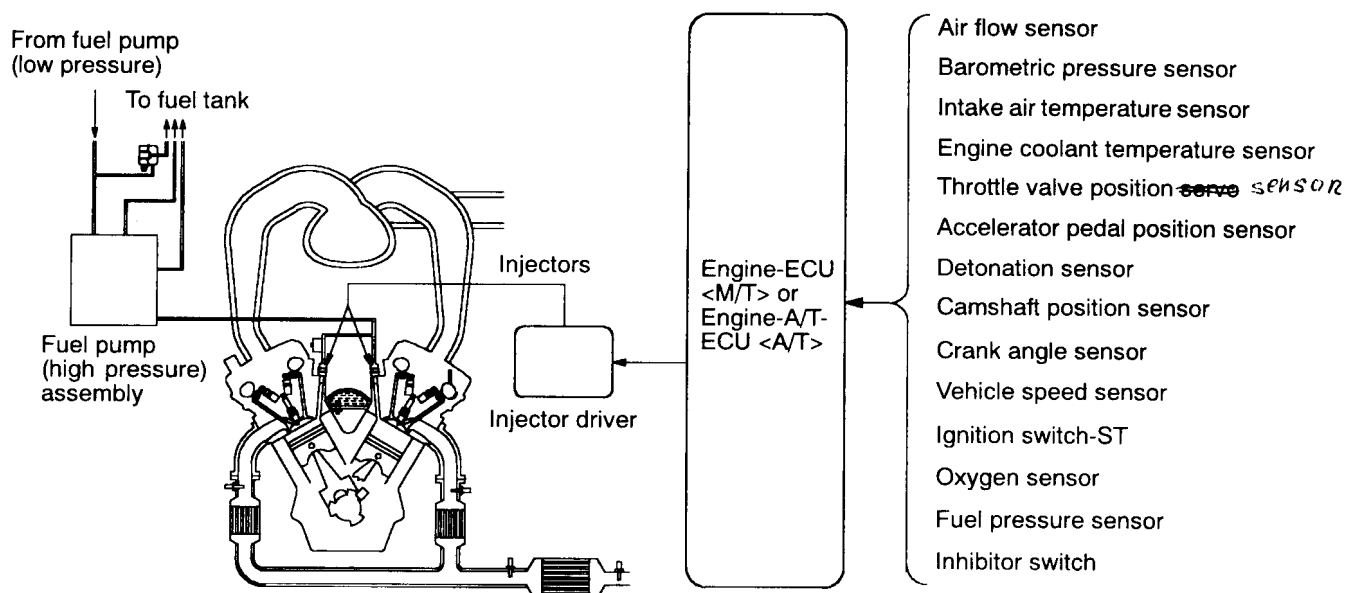


ACTUATOR

THROTTLE VALVE CONTROL SERVO

- The stator of the motor is manufactured from moulded plastic in order to reduce electromagnetic noise.
- When the flow of current to the throttle valve control servo is interrupted, the opening spring causes the throttle valve to stop in the half-open angle position, so that the minimum amount of air flow necessary for driving can still be supplied.

FUEL INJECTION CONTROL SYSTEM CONFIGURATION DIAGRAM



X6165CA

FUEL INJECTION MODE

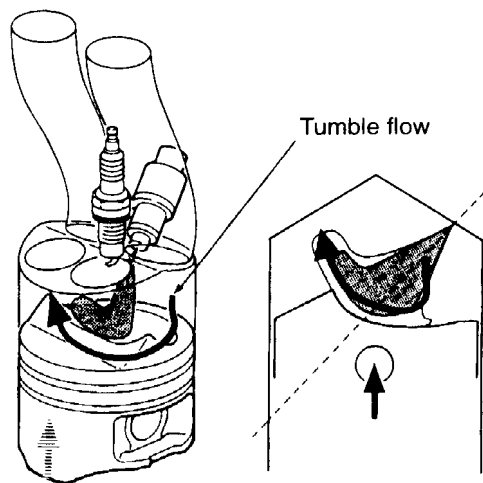
- The GDI engine has three main fuel injection modes, which are classified in accordance with the fuel injection timing and air/fuel ratio.

Fuel injection mode	Injection on compression stroke (lean air/fuel mixture)* ¹	Air/fuel ratio feedback* ² or open-loop control
Fuel injection timing	Compression stroke	Intake stroke
Air/fuel ratio	30 to 40	Stoichiometric or rich
Mixture condition	Stratified	Homogeneous
Engine loading	Light	Heavy
Air/fuel ratio feedback control	Not used	Used
EGR control	Used	Used
Throttle opening control	Used	Used

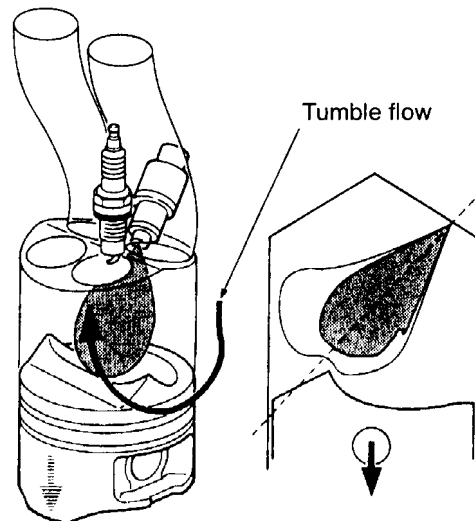
NOTE

*1: With the fuel injection mode used under light engine loading, combustion of a stratified, ultra-lean mixture enhances fuel efficiency and reduces carbon-dioxide (CO₂) emissions.

*2: With the fuel injection mode used under heavy engine loading, feedback control is performed using an oxygen sensor to maximize driveability.

Compression stroke injection

1G90030

Intake stroke injection

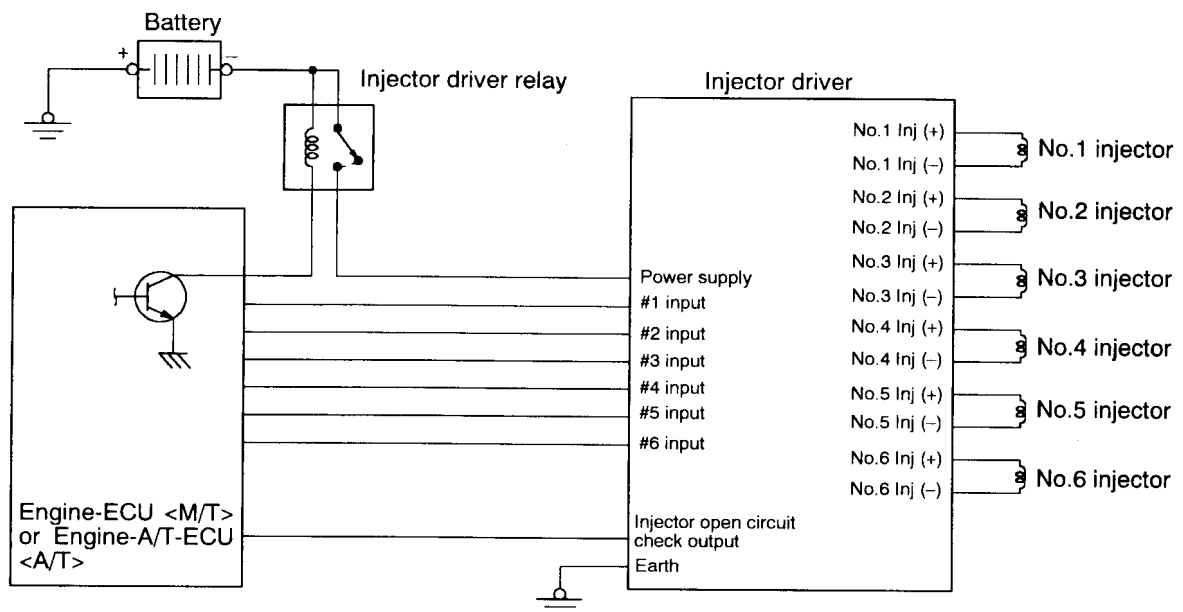
1G90031

INJECTOR DRIVER CONTROL

- To ensure optimally responsive, precise injector operation, the injectors are activated by an injector driver.
- The injector driver applies high levels of voltage and current to the injectors in response to drive signals from the engine-ECU <M/T> or engine-A/T-ECU <A/T>. It controls the injectors by varying the current supplied to them.
- If the injector driver detects a surge voltage when the injector valves are closed, it produces an injector open circuit check output, which causes the engine-ECU <M/T> or engine-A/T-ECU <A/T> to check for an open circuit in the injectors.

Safety caution:

Due to the nature of this system (pulse current of 100 V 20 A, which is generated for extremely short period). There is the possibility of electrical shock.

System Configuration Diagram

7FU2065

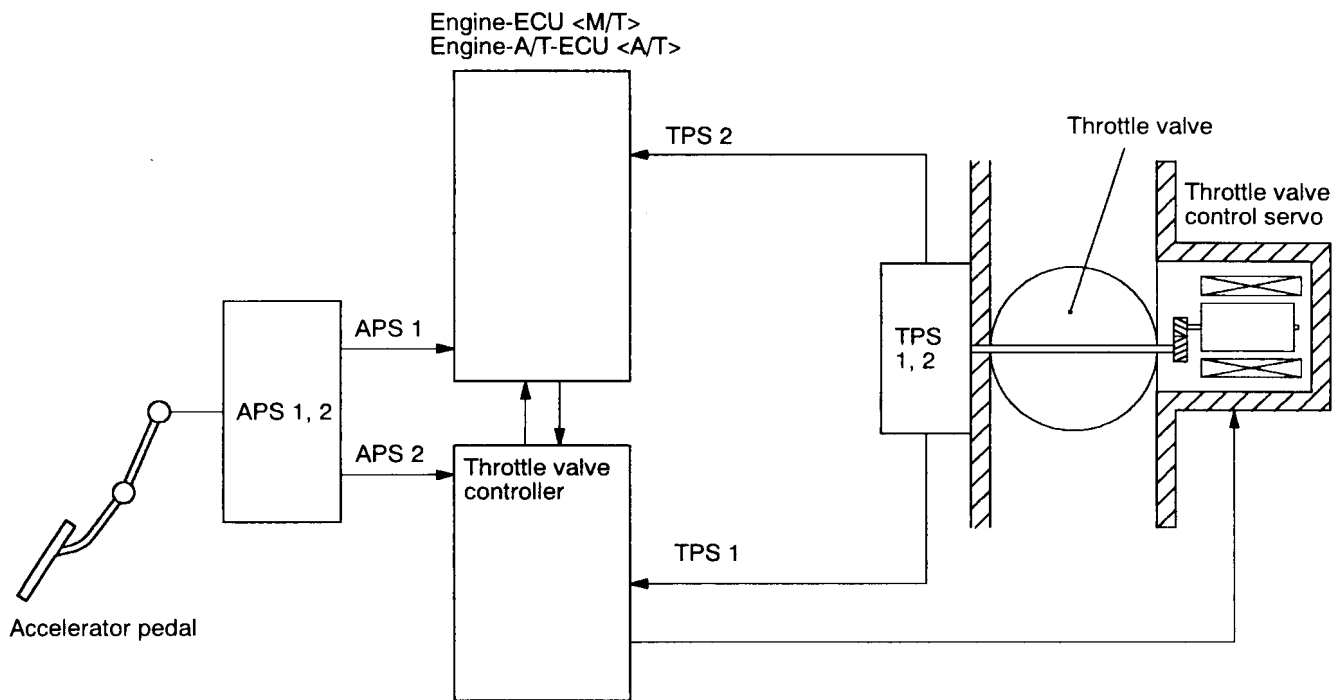
FUEL INJECTION RATE CONTROL

- Fuel injection is more-or-less synchronized with crankshaft rotation. The fuel injection rate is adjusted to suit the air intake rate through variation of the injectors' activation duration.
- In accordance with the fuel injection mode, the injectors' basic activation duration (this is determined in accordance with the air intake rate and engine speed) is corrected to yield the actual fuel injection (injector activation) duration.

Operation mode	Low fuel consumption	High power
Fuel injection mode	Compression stroke fuel injection lean A/F	Air/fuel ratio feedback or open loop rich
Injector basic activation duration	Determined in accordance with number of air flow sensor output pulses between crank angle sensor output signals (number of pulses in this period correlates with air intake volume per engine stroke).	
Intake air temperature correction	○	○
Atmospheric pressure correction	○	○
Warmup correction	○	○
Post-startup fuel increase correction	○	○
Air/fuel ratio correction	○	-
Air/fuel ratio feedback correction	-	○
Air/fuel ratio learning correction	○	○
Idling correction	○	-
Acceleration fuel increase/deceleration fuel decrease correction	○	○
Waste time correction	○	○
Fuel pressure correction	○	○

THROTTLE VALVE OPENING CONTROL

- An electronically controlled throttle valve system, which adjusts the throttle valve opening by electrical means, is employed. The engine-ECU <M/T> or engine-A/T-ECU <A/T> monitors the degree of accelerator pedal depression using the accelerator pedal position sensor (APS) and issues premapped target throttle valve opening values to the throttle valve controller in accordance with operating conditions. In response, the throttle valve controller achieves the target throttle valve openings by controlling the current supplied to the throttle valve control servo, which is attached to the throttle body.
- The adoption of this system allows idle speed control to be performed as an adjunct to throttle valve opening control. Thus, the previously used idle speed control (ISC) servo has been eliminated.

SYSTEM CONFIGURATION DIAGRAM

X6004AN

CONTROL WHILE DRIVING

- The throttle valve is controlled to the target throttle valve opening angle which is determined from factors such as the accelerator opening angle and driving conditions.

IDLE SPEED CONTROL (ISC)

- Several methods of ISC control are used. In engine speed feedback control, the actual idle speed is constantly calculated by the engine-ECU <M/T> or engine-A/T-ECU <A/T>, and if there is a difference between it and the target idle speed, the throttle valve is driven to correct the actual idle speed until it equals the target idle speed. In throttle valve position control, the throttle valve is driven until it is at the target opening angle in response to fluctuations in engine load caused by items such as the air conditioner.

ENGINE SPEED FEEDBACK CONTROL

When the engine is idling, the throttle valve is driven to control the volume of air passing through the throttle valve in order to maintain the engine speed at the target idle speed.

The target idle speed is set to the optimum speed for different engine operating conditions (such as if the A/C switch is on or off). Furthermore, this engine speed feedback control is only carried out when specified idle speed conditions are fulfilled. At other times, throttle valve position control is carried out.

THROTTLE VALVE POSITION CONTROL

If any operations such as turning the steering wheel, operating the A/C switch or shifting the transmission range (vehicles with A/T only) are carried out while the engine is idling, the load on the engine changes and thus the idle speed changes rapidly. Immediately after the changed signal is detected, the throttle valve is driven to the target position. This controls the volume of air passing through the throttle valve in order to suppress fluctuations in the idle speed.

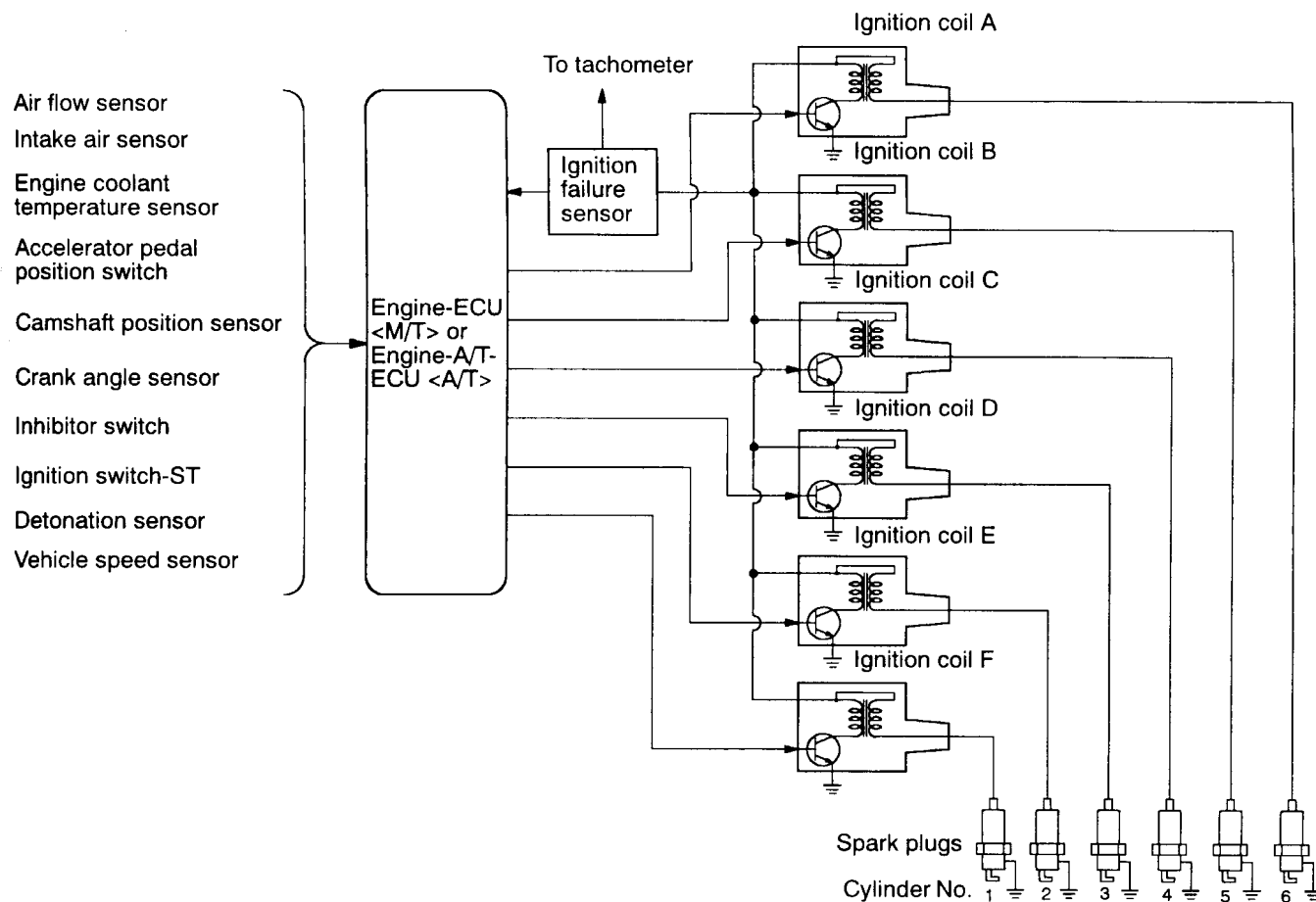
FAIL-SAFE CONTROL

- If the engine-ECU <M/T> or engine-A/T-ECU <A/T> or the throttle valve controller detects a system abnormality, the engine warning lamp illuminates and the engine output is reduced by limiting the throttle valve opening angle and cutting the amount of fuel supplied. Alternatively, the throttle valve control servo relay is turned off and power to the throttle valve control servo is interrupted.
- When the power supply to the throttle valve control servo is interrupted, the throttle valve is designed to open to a specific opening angle (the angle at which sufficient air can be supplied in order to allow a minimum level of driving). This ensures that a minimum level of driving is still possible even if a problem occurs in the throttle valve control system.

IGNITION TIMING AND INJECTOR ENERGIZATION DURATION CONTROL

- Each cylinder is provided with a direct-ignition-type ignition coil, which is attached directly to the spark plug. This arrangement enhances ignition performance by eliminating spark plug cables and losses resulting from exhaust-stroke sparks.
- The control arrangement is otherwise basically the same as that of the 6G7 engine used in the Pajero.

SYSTEM CONFIGURATION DIAGRAM



X6027CA

IGNITION TIMING CONTROL

- The ignition timing consists of basic spark advance timing to which various corrections are added.

Driving mode	During normal driving	When starting
Basic spark advance	The optimum spark advances for the intake air amount per cylinder during each cycle (engine load) and the engine speed are recorded inside the engine-ECU <M/T> or engine-A/T-ECU <A/T>. These settings are used as basic spark advances to control ignition timing.	—
Fixed angle (5° BTDC)	—	○
Engine coolant temperature correction	○	—
Barometric pressure correction	○	—
Intake air temperature correction	○	—

RELAY CONTROL (ENGINE CONTROL, FUEL PUMP, THROTTLE CONTROL SYSTEM, INJECTOR DRIVER), OXYGEN SENSOR, GDI ECO LAMP CONTROL

The control arrangement is basically the same as that 4G6 engine using Galant.

CONDENSOR FAN CONTROL

The control arrangement is basically the same as that 6G7 engine using Pajero.

EGR CONTROL

Refer to "EMISSION CONTROL SYSTEM" (P.1-31).

DIAGNOSIS SYSTEM

A vehicle diagnosis system (OBD [On-Board Diagnostics] System) which is based on international standards has been adopted in M/T vehicles with the aim of standardising vehicle problem diagnosis.

OBD SYSTEM

This is a vehicle diagnosis system which is based on international standards with the aim of standardising vehicle problem diagnosis.

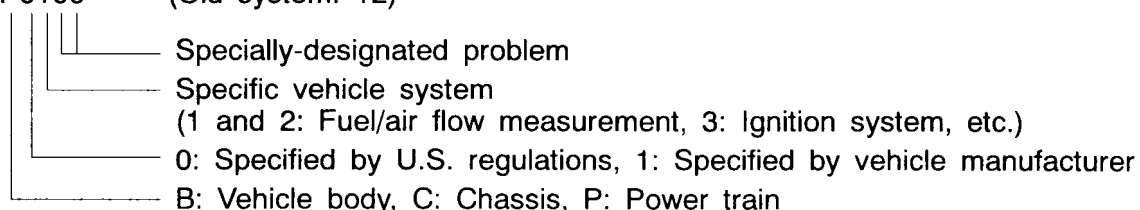
A full range of diagnosis items has been adopted, and changes have been made to the diagnosis code assignment system to correspond to the adoption of the OBD system. The assignment system used is as follows.

- A U.S. (American) format is used for communication between the MUT-II and the engine-ECU, and as a result of this, the diagnosis code number display has been changed from a 2-digit display to a "P" plus four digits (U.S. format).
- DTC output by means of the flashing of the MIL has been abolished in line with standardisation of the self-diagnosis functions.

Example: For the air flow sensor system

New system: P0100

(Old system: 12)



FREEZE-FRAME DATA

When the engine-ECU detects a problem and stores the resulting diagnosis code, the engine condition at that time is also memorised. The MUT-II can then be used to analyze this data in order to increase the effectiveness of troubleshooting. The freeze-frame data display items are given below.

DATA	UNIT
Engine coolant temperature	°C
Engine speed	r/min
Vehicle speed	km/h
Long-term fuel compensation (long-term fuel trim)	%
Short-term fuel compensation (short-term fuel trim)	%
Fuel control condition	• Open loop • Closed loop • Open loop-drive condition • Open loop-Diagnosis code set • Closed loop-Oxygen sensor (rear) failed
Calculation load value	%
Diagnostic trouble code during data recording	–

DIAGNOSIS CODE

The diagnosis and engine warning lamp items are given in the table below.

Code No.	Diagnosis item	Main diagnosis contents	Engine warning lamp
P0100	Air flow sensor (AFS) system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0105	Barometric pressure sensor system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0110	Intake air temperature sensor system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0115	Engine coolant temperature sensor system	Open circuit or short-circuit in sensor-related circuits Excessive connector contact resistance	ON*1
P0120	Throttle position sensor (1st channel) system	Open circuit or short-circuit in sensor-related circuits	ON*2
P0125	Feedback system monitor	Oxygen sensor not operating	ON*1
P0130	Oxygen sensor (front) <Sensor 1> system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0135	Oxygen sensor heater (front) <Sensor 1> system	Open circuit or short-circuit in heater-related circuits	ON*1
P0136	Oxygen sensor (rear) <Sensor 2> system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0141	Oxygen sensor heater (rear) <Sensor 2> system	Open circuit or short-circuit in heater-related circuits	ON*1
P0170	Fuel system abnormality system	Leanness or richness problem	ON*1
P0190	Fuel pressure abnormality system	Open circuit or short-circuit in sensor-related circuits	ON*1
P0201	No. 1 injector system	Open circuit in injector-related circuits	ON*1
P0202	No. 2 injector system	Open circuit in injector-related circuits	ON*1
P0203	No. 3 injector system	Open circuit in injector-related circuits	ON*1
P0204	No. 4 injector system	Open circuit in injector-related circuits	ON*1
P0205	No. 5 injector system	Open circuit in injector-related circuits	ON*1
P0206	No. 6 injector system	Open circuit in injector-related circuits	ON*1
P0220	Accelerator pedal position sensor (1st channel) system	Open circuit or short-circuit in sensor-related circuits	ON*3
P0225	Accelerator pedal position sensor (2nd channel) system	Open circuit or short-circuit in sensor-related circuits	ON*2
P0301	No. 1 cylinder mis-fire detection system	Mis-firing	ON*1
P0302	No. 2 cylinder mis-fire detection system		
P0303	No. 3 cylinder mis-fire detection system		
P0304	No. 4 cylinder mis-fire detection system		
P0305	No. 5 cylinder mis-fire detection system		
P0306	No. 6 cylinder mis-fire detection system		

Code No.	Diagnosis item	Main diagnosis contents	Engine warning lamp
P0325	Detonation sensor system	Abnormal sensor output	–
P0335	Crank angle sensor system	Abnormal sensor output	ON*1
P0340	Camshaft position sensor system	Abnormal sensor output	ON*1
P0403	EGR valve system	Open circuit or short-circuit in EGR valve-related circuits	ON*1
P0420	Catalyst deterioration system	Abnormal exhaust gas purification performance of catalyst	ON*1
P0443	Purge control solenoid valve system	Open circuit or short-circuit in solenoid valve-related circuits	ON*1
P0500	Vehicle speed sensor system	Open circuit or short-circuit in sensor-related circuits	–
P1200	Injector driver system	Open circuit or short-circuit in injector driver-related circuits	ON*1
P1220	Electronically-controlled throttle valve system	Abnormal throttle valve opening angle	Flashing
P1221	Throttle valve position feedback system	Motor problem Abnormal throttle valve actual opening angle	Flashing
P1222	Throttle control servo system	Abnormal throttle control servo drive circuit	Flashing
P1223	Throttle valve controller communication line system	Communication error between engine-ECU and throttle valve controller	Flashing
P1225	Accelerator pedal position sensor (2nd channel) system	Open circuit or short-circuit in sensor-related circuits	ON*3
P1226	Throttle valve controller system	Malfunction of controller	Flashing
P1500	Alternator FR terminal system	Open circuit in sensor-related circuits	–
P1610	Immobilizer system	Open circuit in system-related circuits	–
–	Engine-ECU	Abnormality in engine-ECU	ON*1

NOTE

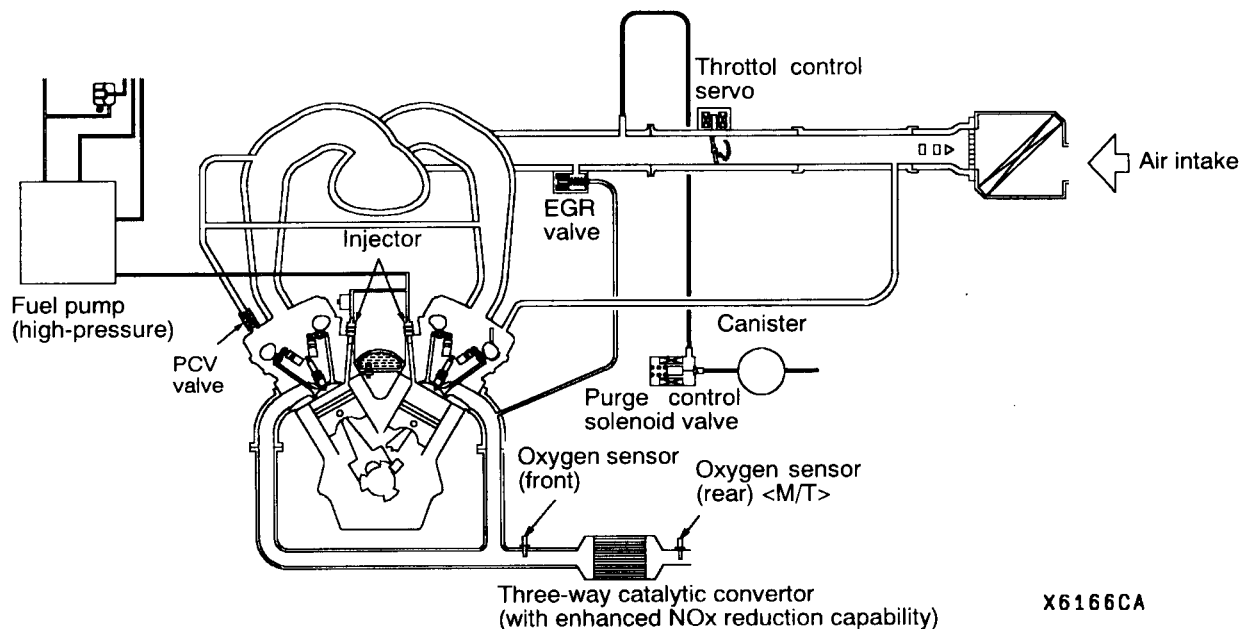
- Code No. P0190 can also be output when air gets into the high-pressure fuel line as a result of the vehicle running dry of fuel.
- Sensor 1: Indicates that this sensor is located on the engine side of the catalyst.
- If the problem is detected, and then the ignition switch is turned to OFF and then back to ON again and the problem is detected once more, the trouble code is displayed and the engine warning lamp illuminates.
- If there is a problem in both the throttle position sensor (1st channel) and the throttle position sensor (2nd channel) at the same time, the engine warning lamp flashes.
- If there is a problem in both the accelerator pedal position sensor (1st channel) and the accelerator pedal position sensor (2nd channel) at the same time, the engine warning lamp flashes.

EMISSION CONTROL SYSTEM

The emission control system is basically the same as that of the 4G9-GDI engine used in the Carisma.

System	Remarks
Crankcase ventilation system	Closed type
Evaporative emission control system	Electronic control type
Exhaust gas recirculation (EGR) system	Electronic control (stepper motor) type
Air/fuel ratio closed loop control	Oxygen sensor signal used
Catalytic converter	Three-way catalytic converter with enhanced NOx reduction capability.

EMISSION CONTROL SYSTEM DIAGRAM

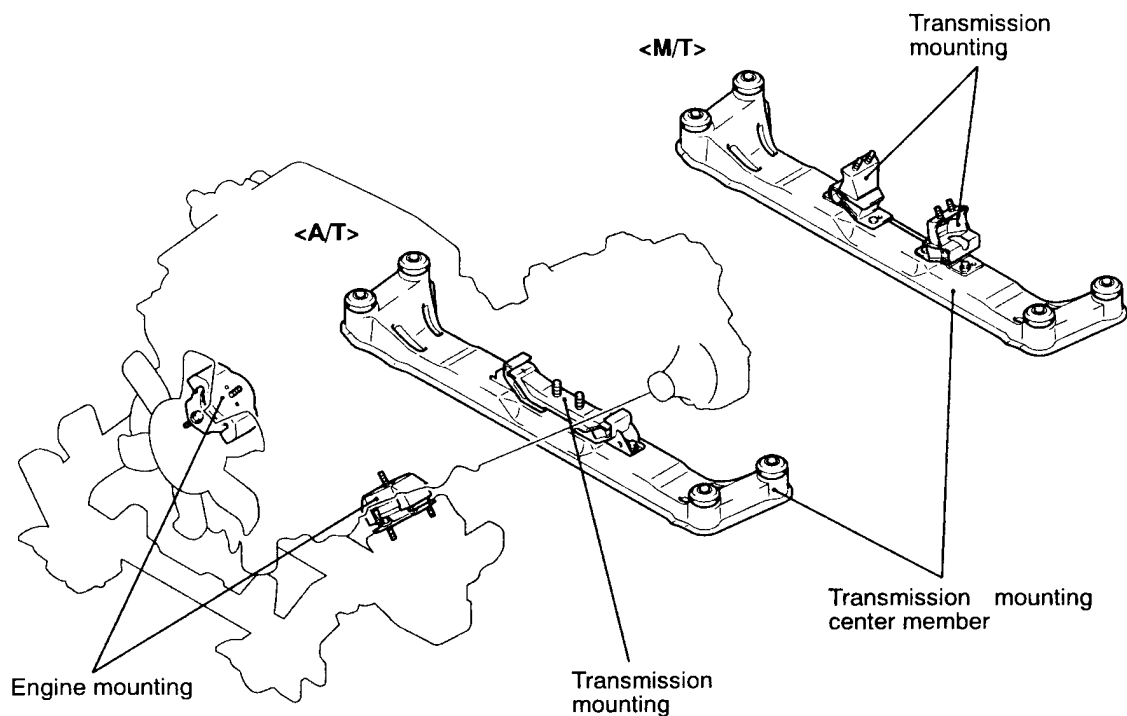


MOUNT

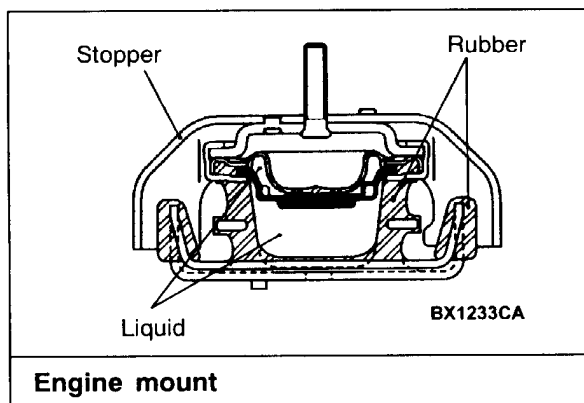
The engine mount system has the following features.

- The engine mounts are liquid-filled mounts which improve ride comfort and reduce vibration and noise when idling.
- The transmission mount provides elastic support (dual anti-vibration) at the transmission support and the transmission centermember support, to reduce the amount of vibration transmitted to the vehicle body.
- Shear-type insulators have been adopted as the transmission mount insulators.

CONSTRUCTION DIAGRAM



AX1814CA



*shear-type
(подшипник на 6G7-GDI)
подшипник - (монтаж)*

AUTO-CRUISE CONTROL SYSTEM

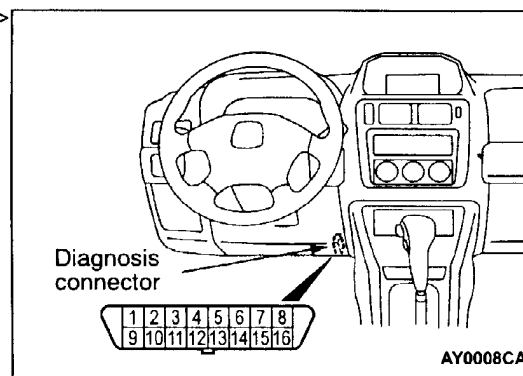
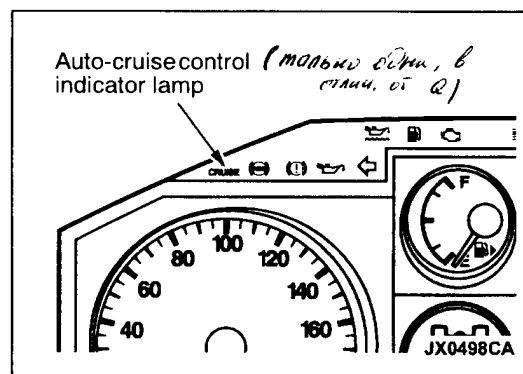
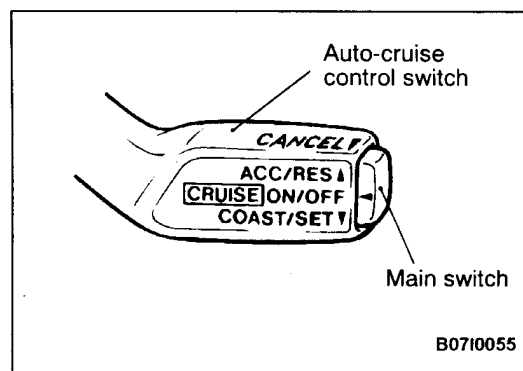
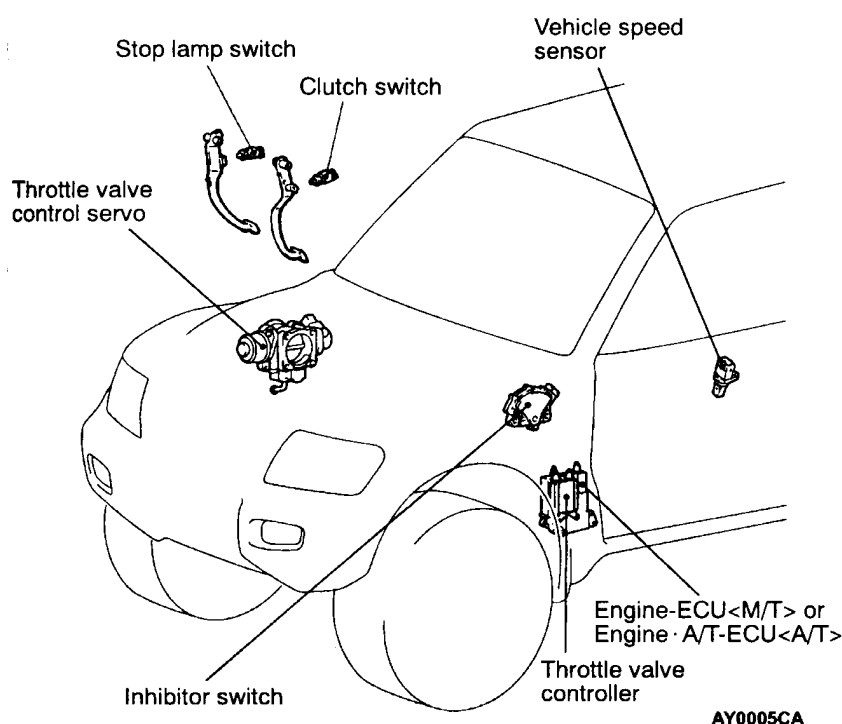
By using the auto-cruise control, the driver can drive at preferred speeds in a range of approximately 40 to 200 km/h without depressing the accelerator pedal.

In line with the adoption of an electronically-controlled throttle valve system, the auto-cruise control system has been changed from the 6G7-MPI system in which a negative pressure actuator is used to

drive the throttle valve to a system in which a throttle valve controller and the engine-ECU <M/T> or engine-A/T-ECU <A/T> control the throttle valve electronically.

In addition, the main switch and control switch have been combined into a auto-cruise control switch to improve operability.

CONSTRUCTION DIAGRAM



COMPONENTS AND OUTLINE OF FUNCTIONS

Components		Outline of function
Auto-cruise control switch	Main switch	System operation switch.
	SET (COAST) switch	Vehicle speed setting switches.
	RESUME (ACCEL) switch	
	CANCEL switch	Cruise control cancel switch.
Vehicle speed sensor		Outputs pulse signals which are directly proportional to the vehicle speed (the speed of the transmission output gear) to the engine-ECU.
Stop lamp switch		Outputs a cruise control cancel signal (stop lamp switch : ON, clutch switch : ON, inhibitor switch : N position) to the throttle valve controller. In addition, the stop lamp switch outputs an ON signal to the engine-ECU.
Clutch switch <M/T>		
Inhibitor switch <A/T>		
Engine-ECU <M/T> or Engine·A/T-ECU <A/T>		• Outputs a throttle valve opening angle command signal which corresponds to the cruise control input signal from the throttle valve controller to the throttle valve controller. • Outputs diagnosis codes and service data which are related to the cruise control system to the diagnosis output terminal.
Throttle valve controller		• Outputs the input signals from the various switches and sensors to the engine-ECU <M/T> or engine·A/T-ECU <A/T>. • Receives the throttle valve opening angle command signal from the engine-ECU <M/T> or engine·A/T-ECU <A/T> and drives the throttle valve control servo.
Throttle valve control servo		Opens and closes the throttle valve in accordance with the drive signals from the throttle valve controller.
Diagnosis connector		Allows the diagnosis codes and service data output from the engine-ECU <M/T> or engine·A/T-ECU <A/T> which are related to the cruise control system to be read by connecting the MUT- II .
Auto-cruise control indicator lamp		Built into the combination meter, this lamp illuminates when the auto-cruise control switch is turned on.

SYSTEM OUTLINE

The throttle valve controller transmits the input signals from the auto-cruise control switch and CANCEL switch (stop lamp switch, Clutch switch <M/T>, inhibitor switch <A/T>) to the engine-ECU <M/T> or engine A/T-ECU <A/T>.

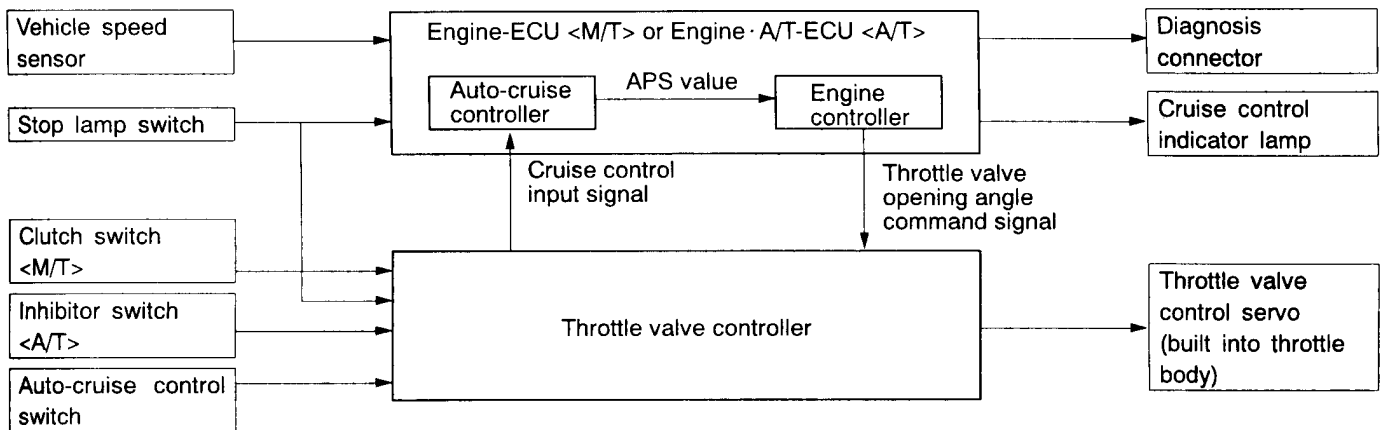
The engine-ECU <M/T> or engine A/T-ECU <A/T> calculates the target accelerator opening angle val-

ue (APS value) at the auto-cruise controller, and outputs this to the engine controller.

When the engine controller receives this signal, it outputs a throttle valve opening angle command signal to the throttle valve controller.

This drives the throttle valve control servo to control the throttle valve.

BLOCK DIAGRAM



SYSTEM FUNCTION

SET (COAST) SWITCH FUNCTION

• SET

The vehicle speed at the moment the "SET" switch was switched from ON to OFF while driving within the limit vehicle speed range is memorized as the "set vehicle speed" and thereafter the actuator is controlled so that fixed-speed driving at that speed is possible. However, if this "SET" operation was made while driving at a speed higher than the high speed limit, the high speed limit speed is memorized as the "set speed" and the actuator is controlled to maintain that speed.

• COAST

While the "COAST" switch is held ON during auto-cruise driving, the vehicle keeps decelerating. If the "COAST" switch is turned OFF before the vehicle speed decreases to 40 km/h, the vehicle runs at the fixed speed at the moment the switch is turned OFF. If the "COAST" switch is turned OFF after the vehicle speed decreases to less than 40 km/h, the auto-cruise control is cancelled.

RESUME (ACCELERATING) SWITCH FUNCTION

• RESUME

When the fixed speed driving is cancelled by the conditions given in "CANCEL FUNCTION", switching the "RESUME" switch from OFF to ON while driving at a speed higher than the set speed causes the vehicle to be driven at a fixed speed which is the memorized speed just before cancelling.

• ACCELERATING

While the "RESUME" switch is ON during fixed speed driving, the vehicle is accelerated with the target acceleration. The vehicle speed at the moment the switch is turned OFF is then memorized and thereafter the vehicle is controlled for fixed speed driving at this speed. When the "RESUME" switch is ON, the vehicle may be accelerated to speeds above the high-speed limit but after the "RESUME" switch is turned OFF, the vehicle is thereafter controlled to drive at this speed.

CANCEL FUNCTION

When any of the following conditions occur, the power supply to the motor-driven negative pressure pump is shut off and the auto-cruise control is cancelled.

1. "CANCEL" switch ON
2. Stop lamp switch ON (brake is applied)
3. Clutch switch ON (clutch is applied) <M/T>
4. Inhibitor switch ON <A/T>
5. Vehicle speed at the low-speed limit (about 40 km/h) or lower

HIGH SPEED LIMIT FUNCTION

The vehicle cannot be driven at a fixed speed which is at or higher than the high speed limit (about 200 km/h). When the "SET" switch is pressed while travelling at a speed above the high speed limit, a speed of about 200 km/h is memorized.

FAIL-SAFE FUNCTION

Vehicle speed control is not carried out if the conditions given below are satisfied. In addition, if the conditions are satisfied while vehicle speed control is in progress, vehicle speed control should be cancelled immediately. At this time, vehicle speed control should be possible if the condition returns to normal.

1. "SET," "RESUME" switch held ON for 60 seconds or more.
2. Fault in cancel state holding circuit.
3. Vehicle speed signal failing to be input for 0.1 seconds or longer.
4. When the vehicle speed increases to become 10 km/h or more higher than the setting speed

OVERDRIVE RELEASE FUNCTION <A/T>

When during fixed speed driving, the actual vehicle speed decreases to (or below) the memorized speed, the overdrive is cancelled temporarily for a specified period of time and then the memorized speed is restored within a short period of time.

DIAGNOSIS FUNCTIONS**1. Self-diagnosis**

When there is a cancellation of the auto-cruise control system operation not intentionally made by the

6. Vehicle speed going lower than memorized speed by 15 km/h or more
7. Vehicle speed once increasing to memorized speed less 10 km/h and then decreasing more than 15 km/h during "RESUME" operation
8. Vehicle speed changing sharply
9. Stoplight switch input (malfunction or open circuit)

Then when the accelerator pedal is released to decrease the vehicle speed (to a speed below the high speed limit), the auto-cruise control comes into action and the vehicle is controlled to travel at 200 km/h.

during fixed speed driving, cruise control is momentarily cancelled, and after the vehicle speed drops to within 7 km/h of the setting speed, cruise control is resumed.

5. If there is a problem with the engine-ECU <M/T> or engine-A/T-ECU <A/T>
6. If there is a problem with communication between the engine-ECU <M/T> or engine-A/T-ECU <A/T> and the throttle valve controller
7. If there is a problem with the throttle position sensor (TPS)
8. If there is a problem with the accelerator pedal position sensor (APS)

Overdrive is cancelled in the following case:

- The actual vehicle speed decreases from the preset speed by 7 km/h or more during fixed speed driving when the vehicle speed is lower than 130 km/h.

driver, it is possible to determine the cause simply by reading the diagnosis code.

Diagnosis trouble code chart

Code No.	Major contents of diagnosis
15	Auto-cruise control switch system abnormality
21	Cancel latch signal system abnormality
22	Stop lamp switch system abnormality
23	Engine-ECU <M/T> or engine-A/T-ECU <A/T> system abnormality

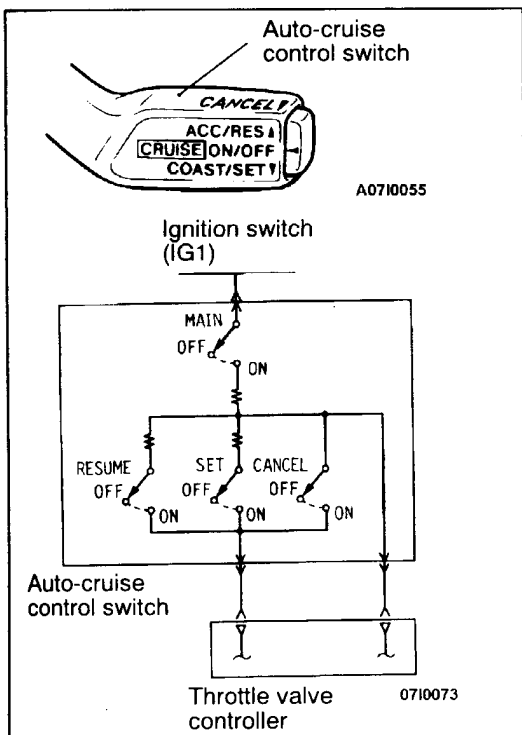
2. Service data output

The service data output are shown in the following.

ITEMS NO.	SERVICE DATA ITEM	UNIT
01	Auto-cruise control switch	"MAIN"
02		"SET"
03		"RESUME"
04		"CANCEL"
05	Stop lamp switch	ON/OFF
08	Accelerator switch (Idle switch)	ON/OFF
10	Vehicle speed sensor	km/h
13	TPS	mv
14	Clutch switch <M/T> or inhibitor switch <A/T>	ON/OFF
15	Over drive detective	ON/OFF

NOTE

If two more actions are taken at the same time, codes are output in ascending order of code number.



AUTO-CRUISE CONTROL SWITCH

An auto-cruise control switch which integrates the main switch (which used to be located on the meter bezel) and the control switch (which used to be located on the steering column) has been adopted in order to improve ease of operation.

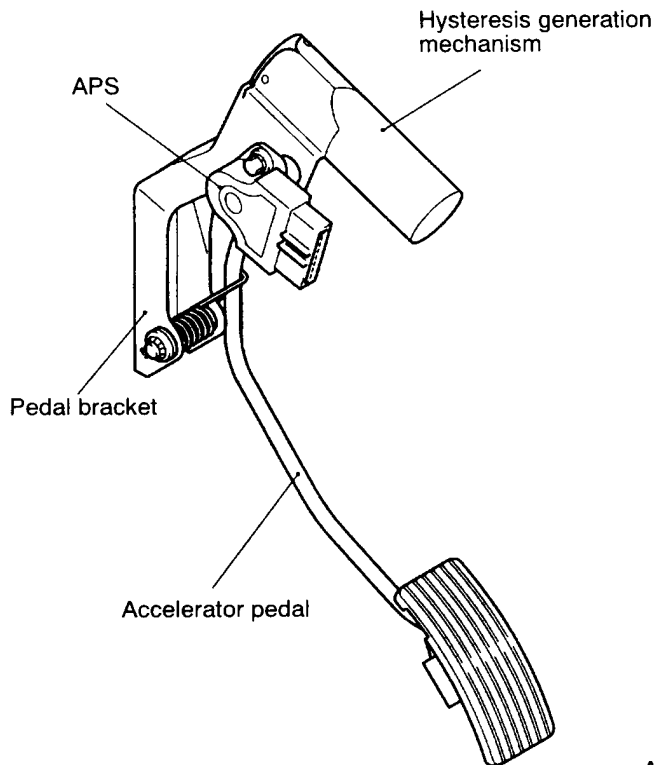
ACCELERATOR SYSTEM

The accelerator system is an electronically-controlled throttle valve system in which the accelerator cable has been abolished.

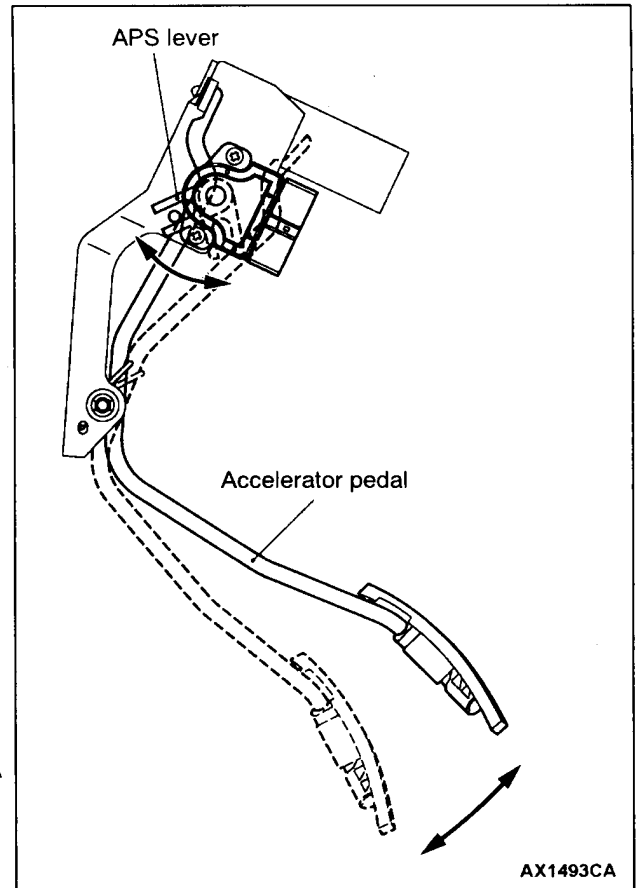
The accelerator pedal depression amount is detected by the accelerator pedal position sensor (APS) which is installed to the pedal bracket, and this is used to control the throttle valve opening angle electronically. (Refer to page 1-16.)

In addition, the pedal bracket is provided with a hysteresis generation mechanism to improve the operating feel of the accelerator pedal.

CONSTRUCTION DIAGRAM



AX0388CA



AX1493CA

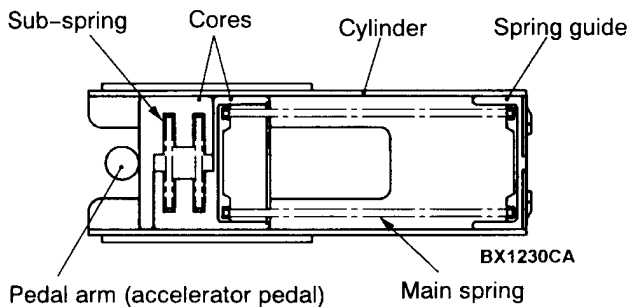
HYSTERESIS GENERATION MECHANISM

DESCRIPTION OF STRUCTURE AND OPERATION

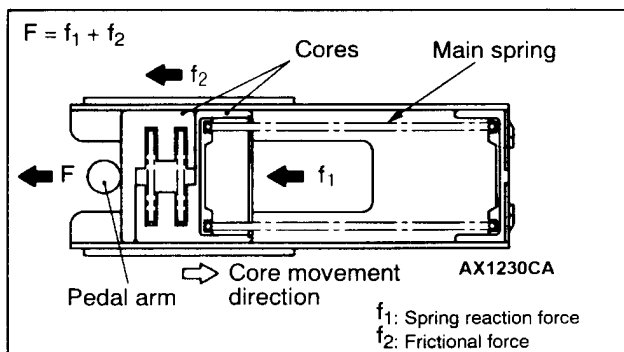
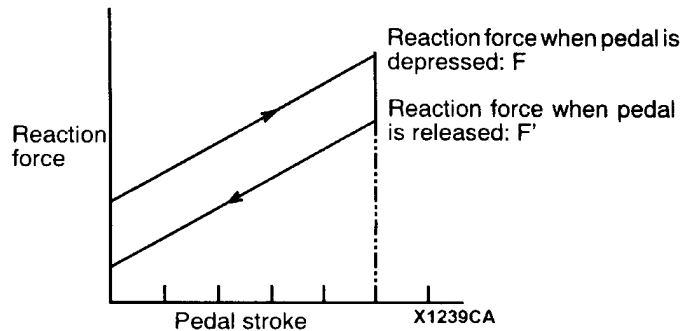
The hysteresis generation mechanism consists of a main spring which generates a reaction force during pedal operation, cores which generates a frictional force between the cylinders from the spring guide and cores, a cylinder and a sub-spring. The sub-spring operates to keep the frictional force between the cylinder and the cores at a constant level.

The pedal arm and the cores move simultaneously so that the direction of the previously-mentioned frictional force changes when the pedal is depressed and released. This causes a difference (hysteresis) to be generated when the accelerator pedal is depressed and when it is released, so that the force when the pedal is released is less than the force when the pedal is depressed.

Hysteresis generation mechanism cross-section



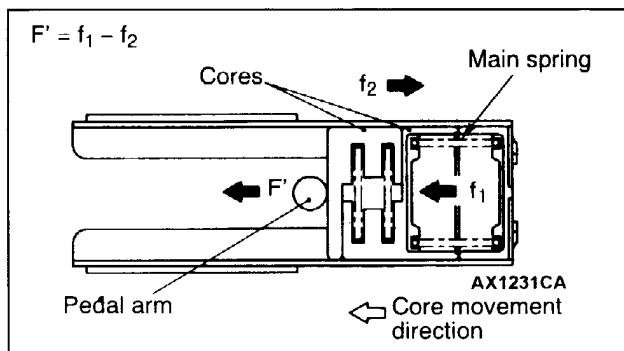
Hysteresis generation mechanism depression force graph



When accelerator pedal is depressed

The pedal arm pushes the edges of the cores, and the cores move to the right in the illustration to push the main spring and compress it.

At this time, the force (F) which tends to push the pedal back in the direction of release is the sum of the reaction force (f_1) of the main spring and the frictional force (f_2) between the cylinder and the cores ($F = f_1 + f_2$).



When accelerator pedal is released

The cores are moved to the left in the illustration by the reaction force (f_1) of the main spring, and they push the pedal arm at this time.

Also at this time, the frictional force (f_2) acts in the opposite direction to when the accelerator pedal was depressed, so that the difference between the main spring reaction force (f_1) and the frictional force (f_2) becomes the force (F') which tends to cause the pedal to return ($F' = f_1 - f_2$).

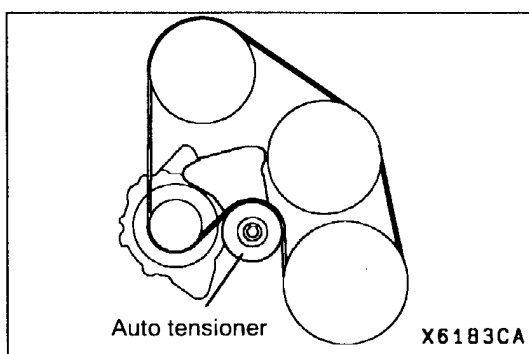
ENGINE <4D5>

GENERAL INFORMATION

The 4D5 engine is essentially the same in construction as the 4D5 engine mounted in the current PAJERO series.

MAJOR SPECIFICATIONS

Items		Specifications
Total displacement ml		2,477
Bore × Stroke mm		91.1 × 95.0
Combustion ratio		21.0
Combustion chamber		Swirl chamber type
Camshaft arrangement		SOHC
Valve timing	Intake opening	BTDC 20°
	Intake closing	ADDC 49°
	Exhaust opening	BBDC 55°
	Exhaust closing	ATDC 22°
Fuel system		Distributor-type injection pump
Rocker arm		Roller type
Adjusting		Elephant foot type
Oil level sensor		Equipped



BASE ENGINE

DRIVE BELT

An auto tensioner is installed between the alternator pulley and the crankshaft pulley. This auto tensioner not only keeps the belt tension stable and extends the belt life, but also makes tension adjustment unnecessary.

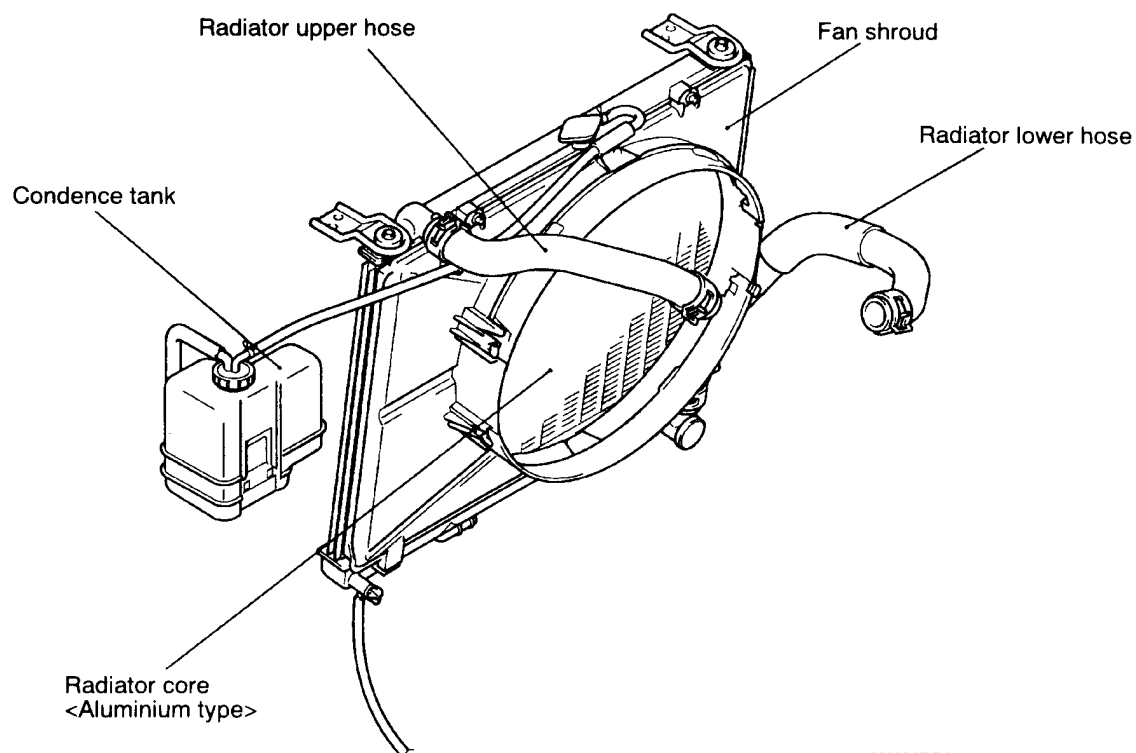
COOLING SYSTEM

The cooling system is basically the same as that of the 6G7 engine. (Refer to P1-8.)

SPECIFICATIONS

ITEMS			SPECIFICATIONS
Cooling water control method			Intake control method
Cooling fan	Type		With engine driven-type thermo clutch
Cooling water	Brand		High quality ethylene glycol antifreeze coolant
	Cooling water amount ℓ	Without rear heater	9.0
		With rear heater	10.5
Water pump	Type		Centrifugal-type impeller
	Drive method		Drive belt
Thermostat	Type		Wax type
	Valve open temperature °C		82
Radiator	Type		Corrugate type
	Core size (width × height × thickness)		703.6 × 525 × 24
	Performance kJ/h		223,326

CONSTRUCTION DIAGRAM



AX1817CA

INTAKE AND EXHAUST

AIR INTAKE SYSTEM

AIR CLEANER

A large 14 ℓ-capacity air cleaner has been adopted. It has the following features.

- A pre-cleaner has been provided to reduce the tendency of the air cleaner element to become blocked quickly.
- In order to give consideration to reducing amounts of industrial waste produced, the air cleaner case and pre-cleaner assembly incorporate plastic mixed with recycled paper which can be incinerated.

- In order to give further consideration to preserving the global environment, the air intake hose is manufactured from rubber which contains no lead.
- The intake port of the air duct is located at the top of the radiator to provide a layout which effectively draws in the cooling air. This boosts engine output performance and reduces the amount of intake air noise inside the passenger compartment.

INTER COOLER

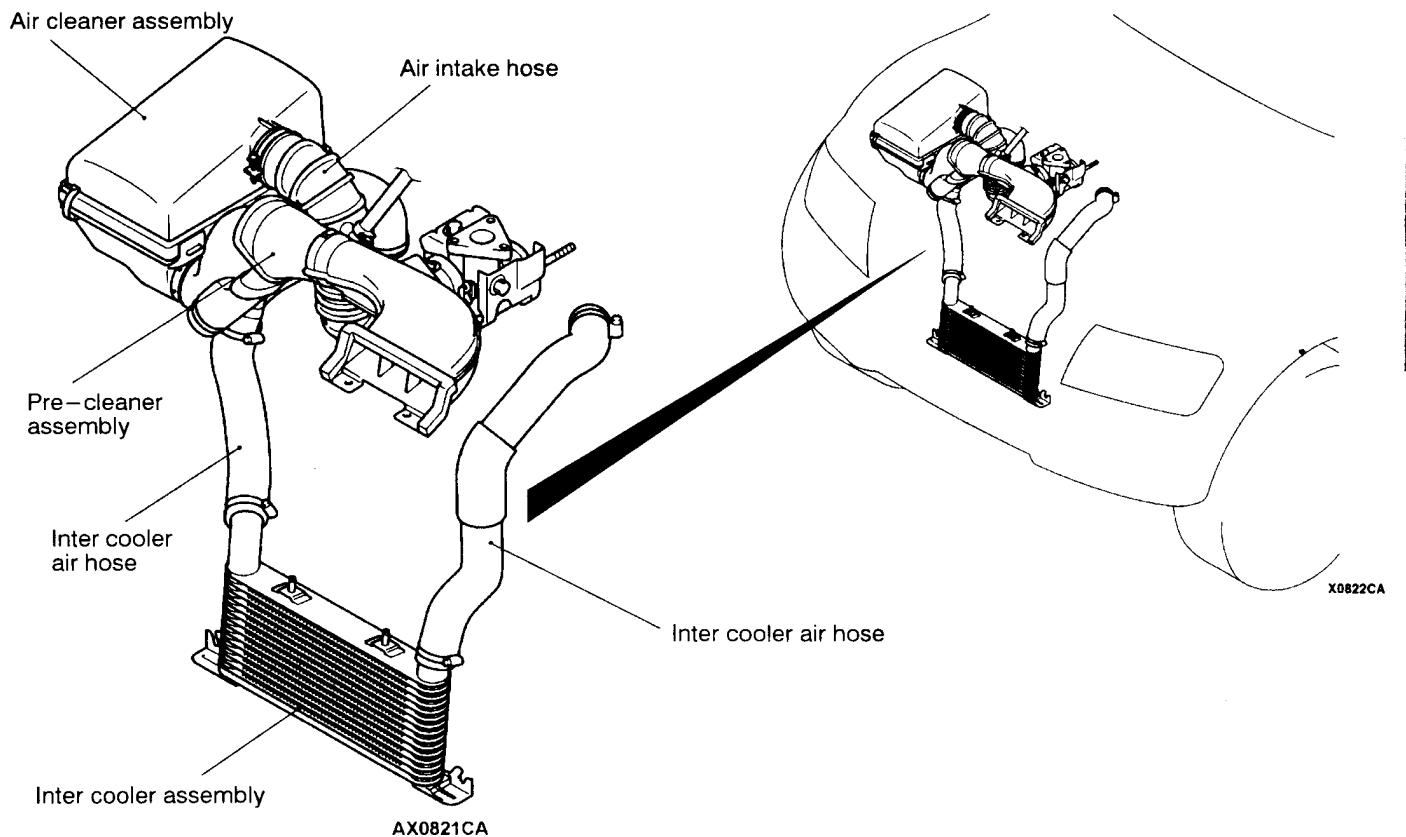
The intercooler assembly is located underneath at the bottom of the radiator to maintain forward and downward visibility.

It also has the following features.

- The intercooler air hose is free from lead compounds to give consideration to preservation of the global environment.

Items		Specifications
Inter cooler	Type	Air cooling type
	Core size (width × height × thickness) mm	350 × 187 × 64
	Performance kJ/h	28,800

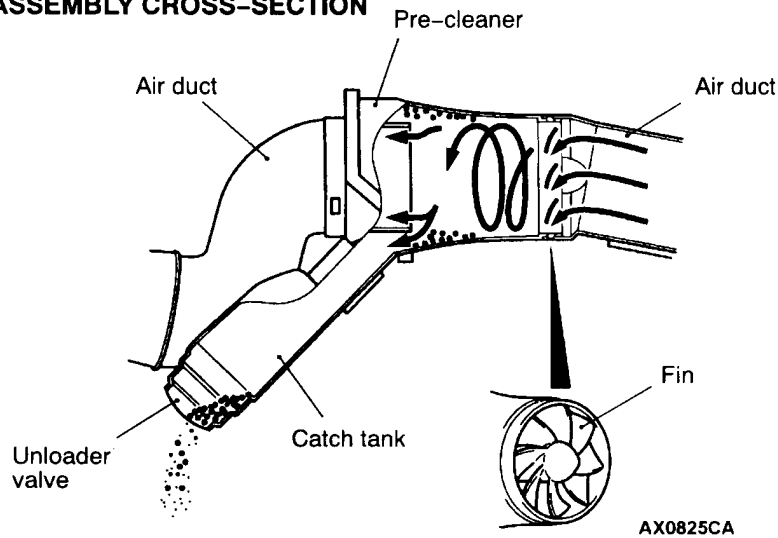
CONSTRUCTION DIAGRAM



PRE-CLEANER ASSEMBLY

The pre-cleaner assembly consists of fins, a catch tank, an unloader valve and an air duct. The fins have inlet ports to create eddies in the intake air in the direction of rotation. The centrifugal force thus provided removes particles such as water and

dust from the air, and these are collected in the catch tank, where they are discarded via the unloader valve by the action of vehicle vibration and pulsation of the intake air.

PRE-CLEANER ASSEMBLY CROSS-SECTION

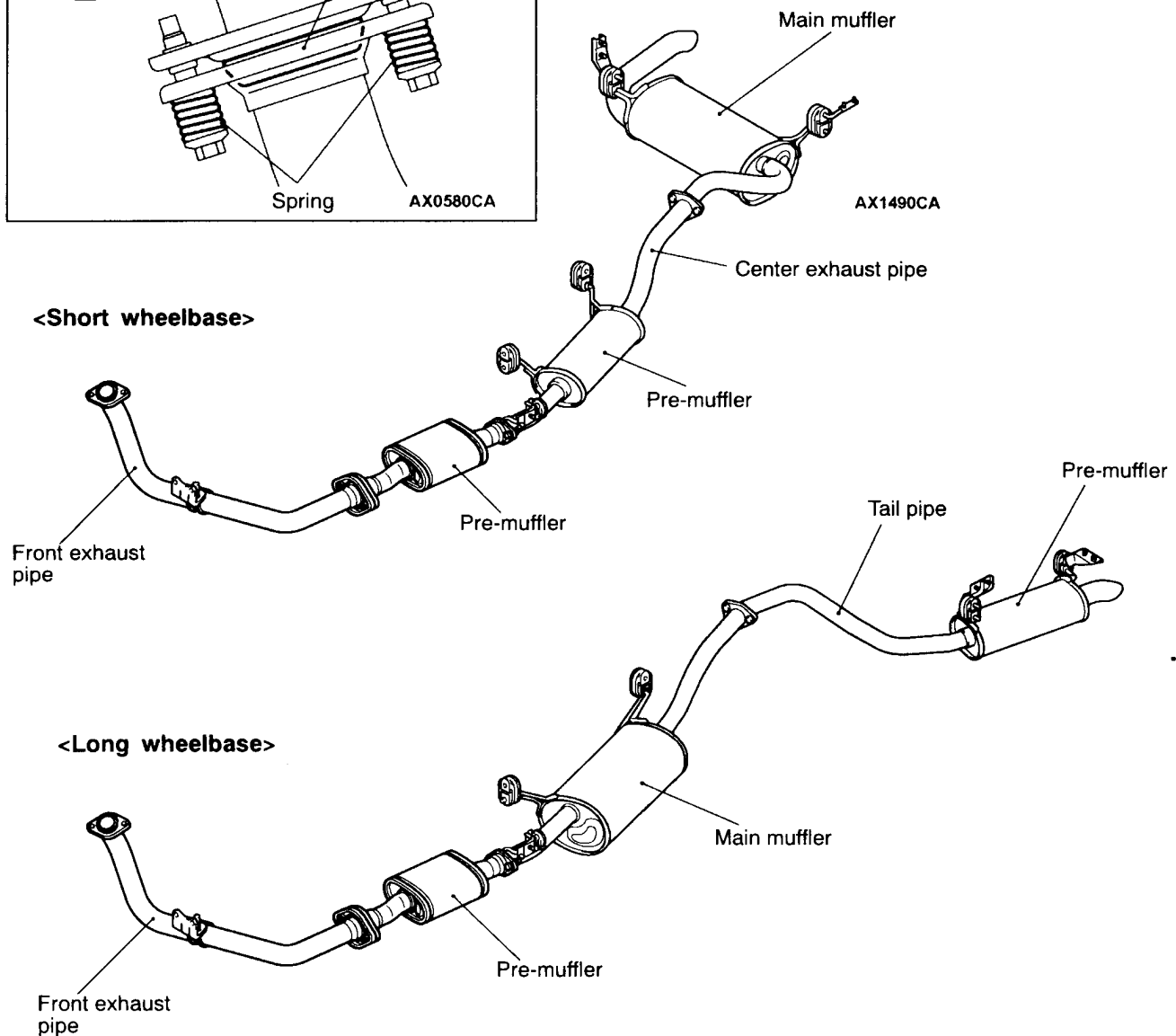
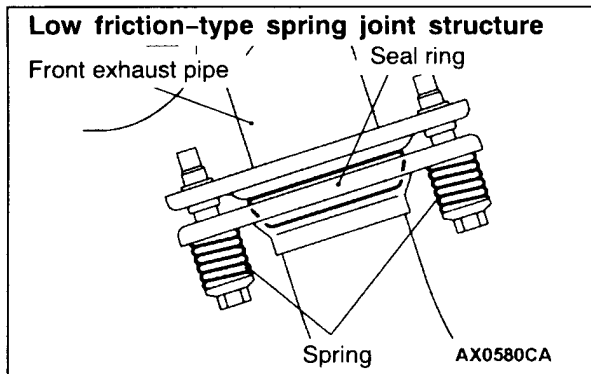
EXHAUST SYSTEM

EXHAUST PIPE

The exhaust pipe is divided into four parts and has the following features:

- A large main muffler (17 ℓ) has been adopted to reduce the low-to medium-frequency noise components.
- The connection between the front exhaust pipe and the pre-muffler assembly has a low friction-type spring joint structure, to reduce vibration of the exhaust pipe.
- The noise absorbing-type pre-muffler absorbs high-frequency exhaust noise.
- Special rubbers with low dynamic spring constant are used for exhaust pipe hangers, which substantially reduce the transmission of the exhaust pipe vibration to the body.
- The exhaust pipe is made from stainless steel.

CONSTRUCTION DIAGRAM



AX1488CA

FUEL SYSTEM

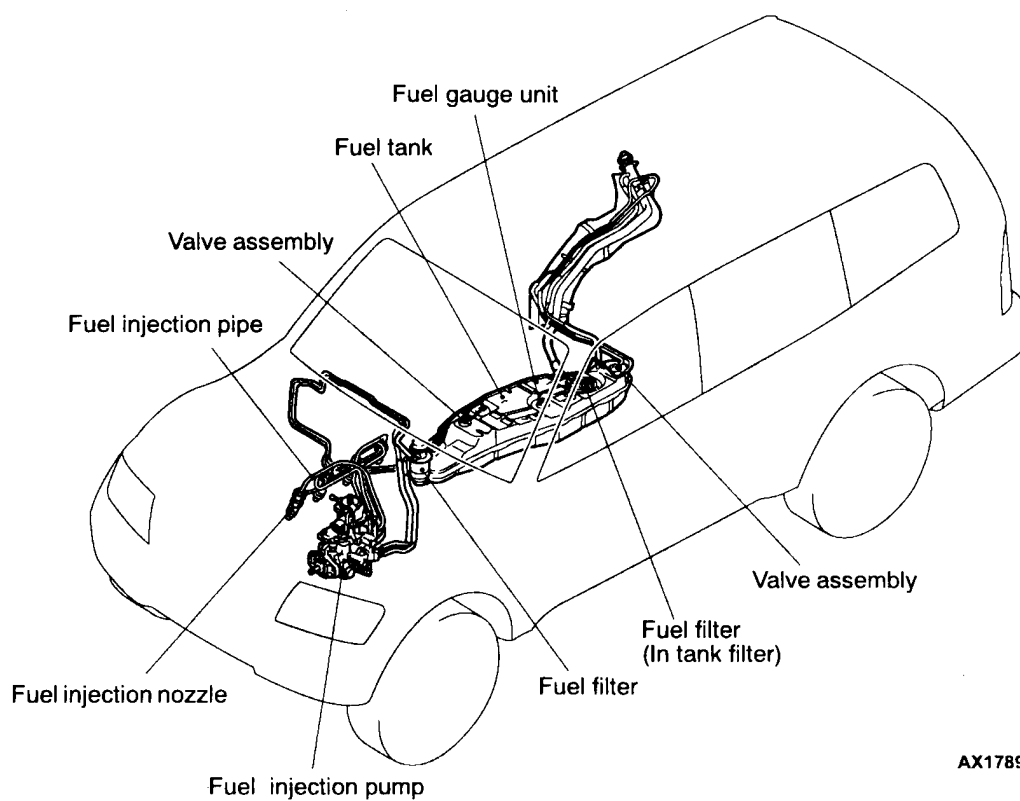
The fuel system consists of components such as the fuel injection nozzles, fuel injection pipe, fuel injection pump, fuel filter, fuel pipe and fuel tank.

The hoses use no chlorine-based solvents to give consideration to preservation of the global environment.

SPECIFICATIONS

Items		Specifications
Fuel tank capacity ℓ	Short wheelbase	71
	Long wheelbase	90
In-tank filter		Equipped
Fuel filter type		Cartridge (filter type – with level warning device)

CONSTRUCTION DIAGRAM

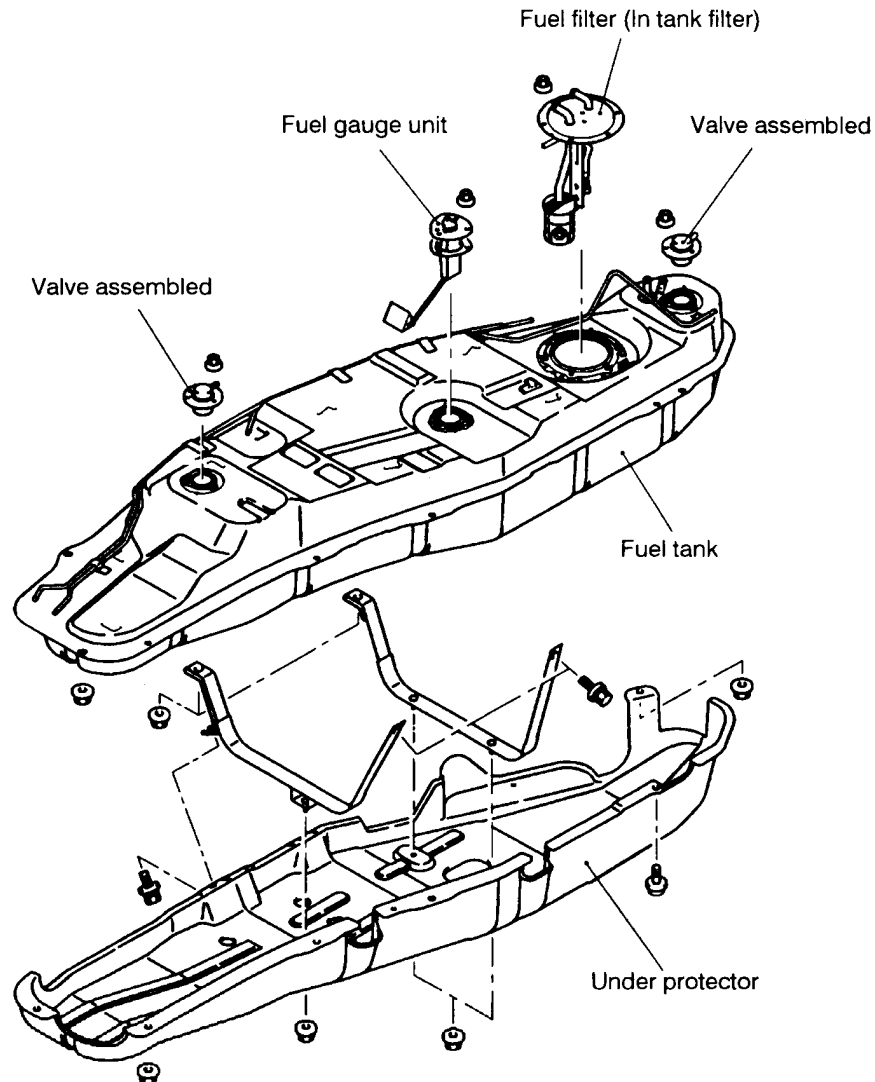


AX1789CA

FUEL TANK

The fuel tank is a steel fuel tank which is located underneath the passenger seat floor. It has the following features.

- Lead-free materials have been adopted for the main fuel tank unit in consideration of protection of the global environment.
- A plastic under protector which is light in weight and has excellent corrosion resistance has been adopted.
- A valve assembly with an integrated cut-off valve which prevents fuel outflow and two-way valve which adjusts the fuel pressure inside the fuel tank has been adopted.



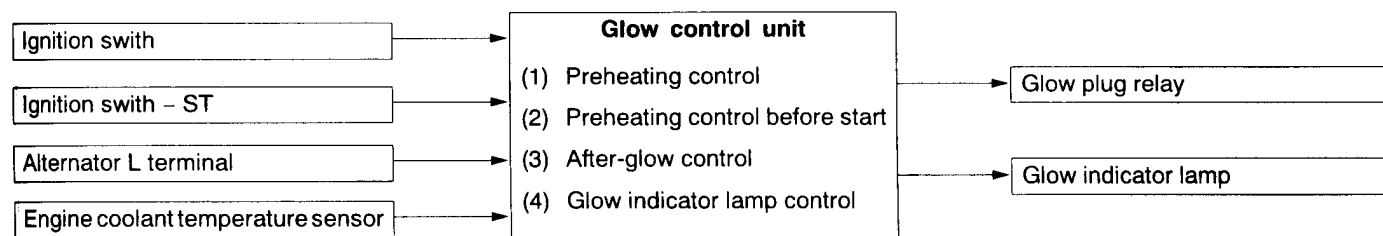
BX0653CA

CONTROL SYSTEM

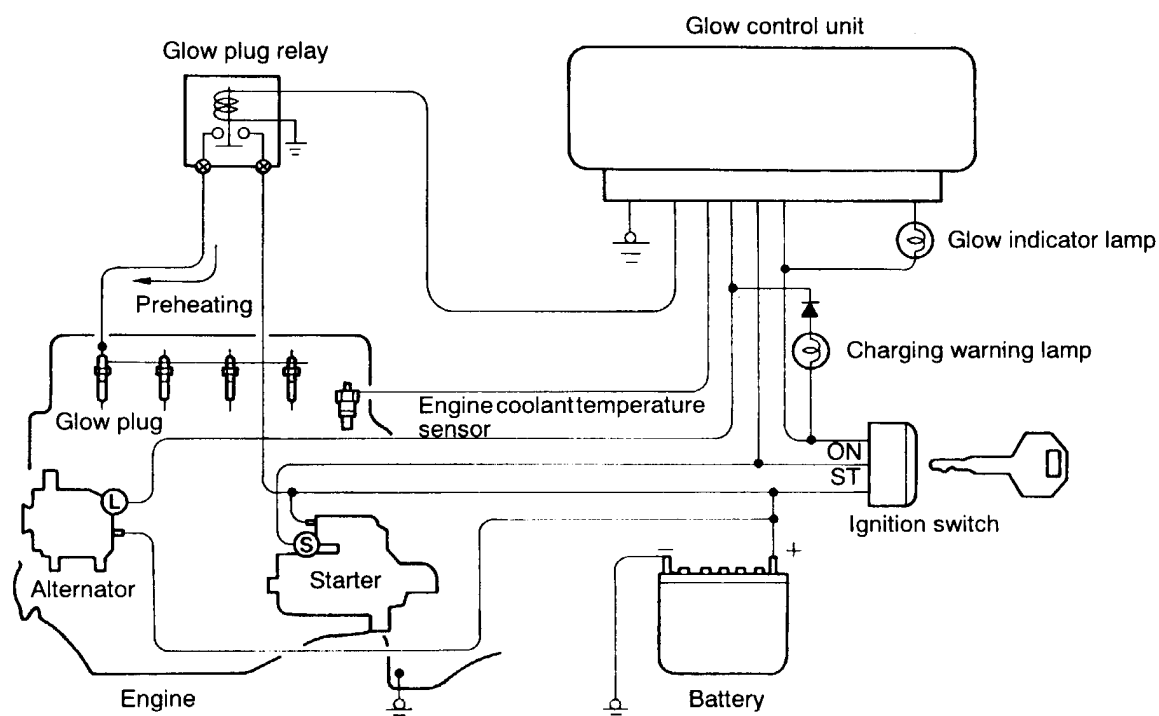
SELF-REGURATING GLOW SYSTEM

The self-regulating glow system is essentially the same as the one for the conventional 4D5 engines.

SYSTEM BLOCK DIAGRAM



CONTROL SYSTEM DIAGRAM



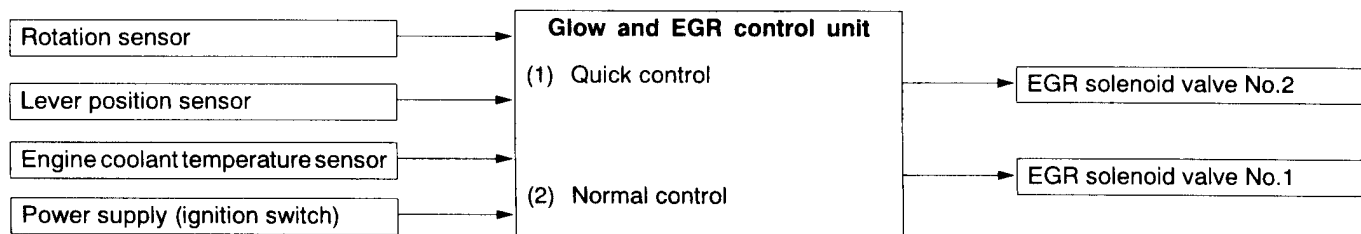
DEN0062

EMISSION CONTROL SYSTEM

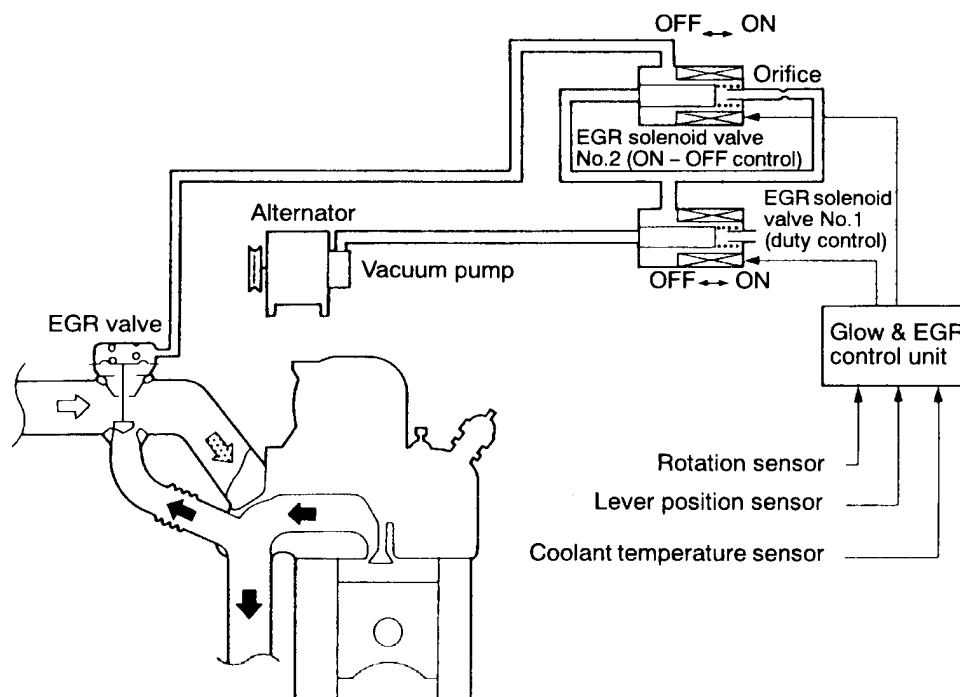
The emission control system is essentially the same as the one for conventional 4D5 engines.

EGR SYSTEM

SYSTEM BLOCK DIAGRAM



EGR CONTROL SYSTEM DIAGRAM

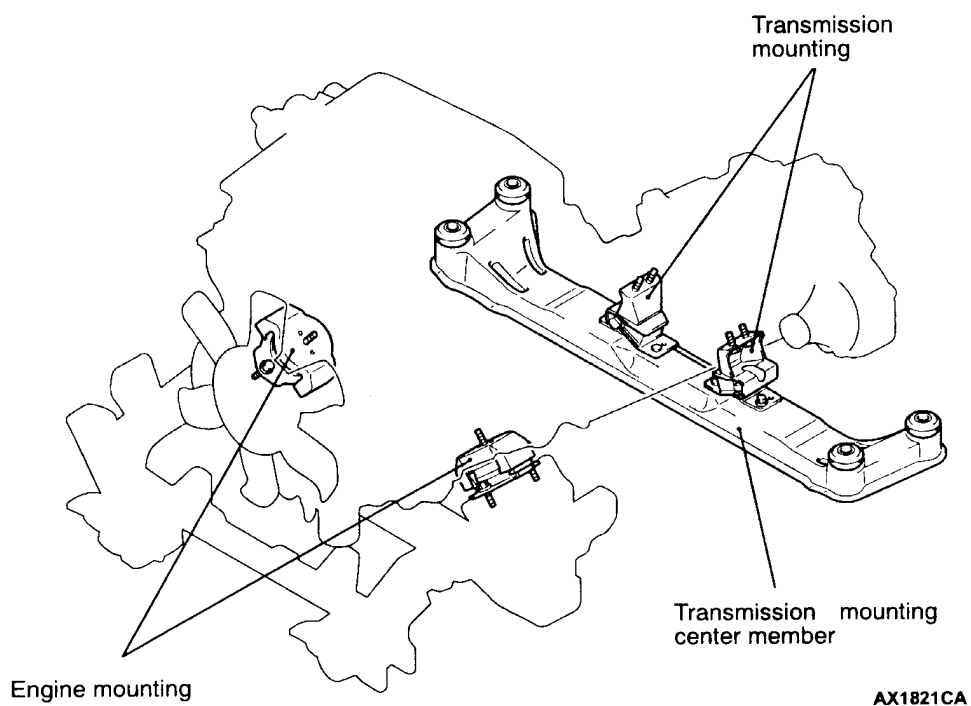


DEM0652

MOUNT

The mount is basically the same as that of the 6G7 engine. (Refer to P.1-32.)

CONSTRUCTION DIAGRAM



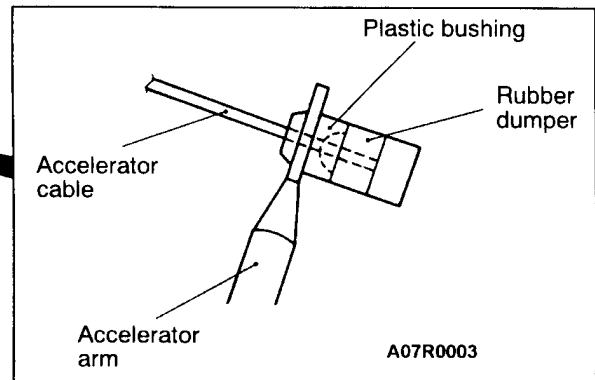
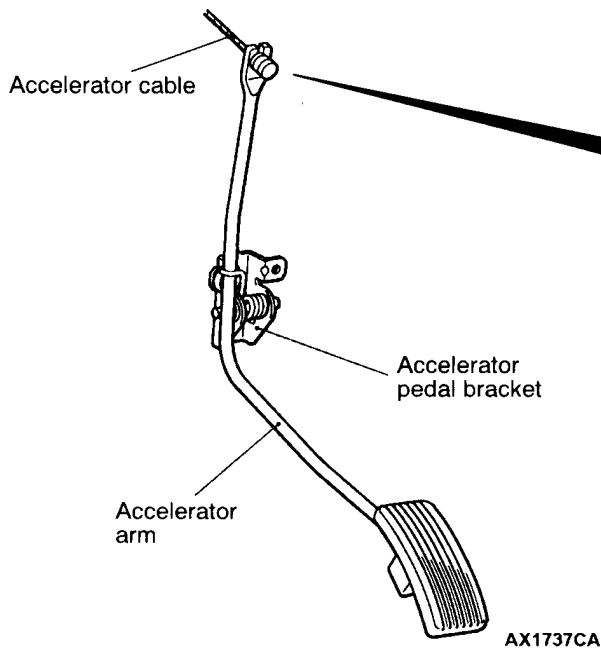
ACCELERATOR SYSTEM

ACCELERATOR PEDAL AND ACCELERATOR CABLE

The accelerator system is a cable and suspended pedal combination.

Plastic bushing and rubber damper have been attached to the end of the accelerator cable, to pre-

vent noise and vibration when the cable and accelerator arm contact.

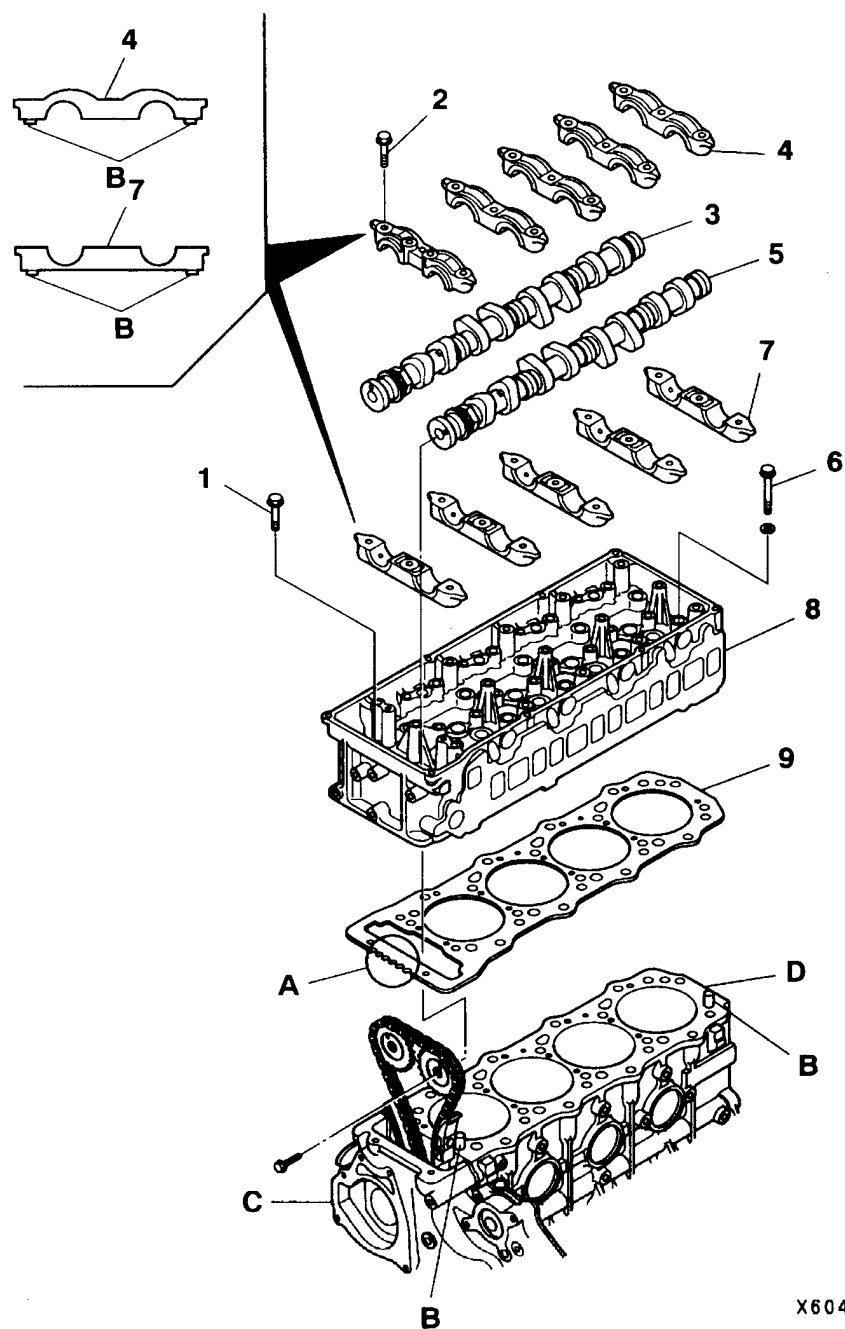


ENGINE <6G74> 4M41**GENERAL INFORMATION**

The 4M41 engine which is used in the new PAJERO is basically the same as the 4M40 engine which has received wide acclaim, with the addition of DOHC and direct fuel injection. Furthermore, a number of improvements have also been made to reduce engine noise and to improve engine output.

MAJOR SPECIFICATIONS

Item	Specification	
	4M41	4M40
Total displacement dm ³	3200	2835
Bore x stroke mm	98.5 × 105	95 × 100
Combustion chamber	Direct injection type	Vortex chamber type
Compression ratio	17	21
Valve arrangement	DOHC 4-valve	SOHC 2-valve
Maximum output PS/r/min	165/3800	140/4000
Maximum torque kgf·m/r/min	38.0/2000	32.0/2000

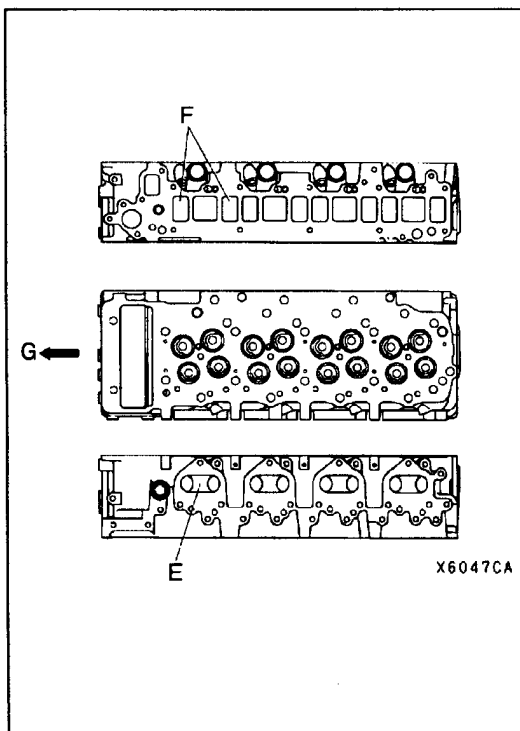
BASE ENGINE**CYLINDER HEAD, CYLINDER HEAD GASKET, CAMSHAFT**

X6046CA

1. Bolts (x2)
2. Bolts (x15)
3. Exhaust camshaft
4. Camshaft cap
5. Inlet camshaft
6. Bolts (x18)
7. Camshaft holder

8. Cylinder head
9. Cylinder head gasket
- A: Notch
- B: Positioning pin
- C: Timing gear case
- D: Upper crankcase

- The journals of the exhaust camshaft 3 and inlet camshaft 5 are supported by the camshaft holders 7, and are also supported at the top by the camshaft caps 4.
- The order of the camshaft caps 4 and the camshaft holders 7 should not be changed when they are being re-installed.
- The exhaust camshaft 3 and the inlet camshaft 5 have the same camshaft sprockets, but the cams are different, so be careful not to install them in reverse.
- The cylinder head gasket 9 is a metal gasket which has been selected to have the appropriate thickness to match the projection amounts of the pistons. The thicknesses of the gaskets can be identified by the differences in the shape of notches A.
- The 18 bolts 6 are installed to the top of the upper crankcase D, but the two bolts 1 are installed to the timing gear case C.
- The 15 bolts 2 are installed to the cylinder head 8.
- The cylinder head bolts 1 and 6 must be tightened in a specific way.

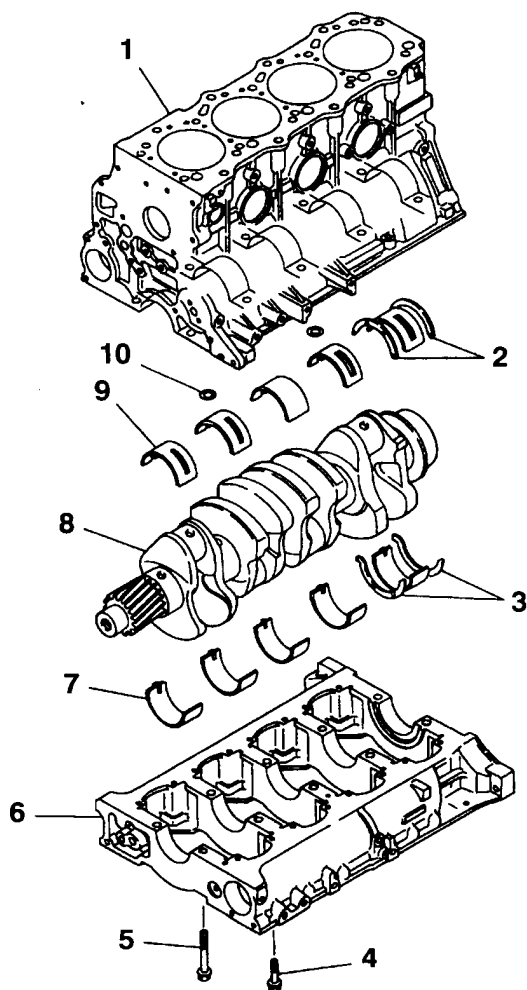


CYLINDER HEAD

The inlet and exhaust ports are positioned in a cross-flow layout, with the exhaust ports E on the right side and the inlet ports F on the left side.

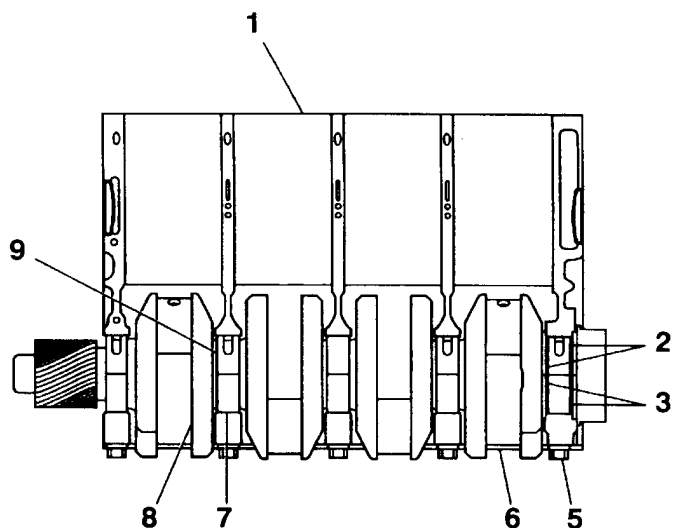
G: Front of engine

CRANKCASE, MAIN BEARINGS



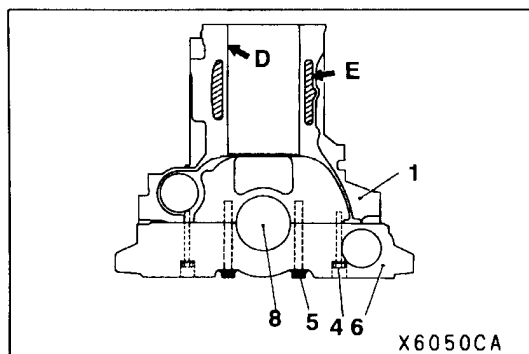
- 1. Upper crankcase
- 2. Upper thrust plates
- 3. Lower thrust plates
- 4. Bolt
- 5. Main cap bolt

X6048CA



X6049CA

- 6. Lower crankcase
- 7. Lower main bearing
- 8. Crankshaft
- 9. Upper main bearing
- 10. O-ring

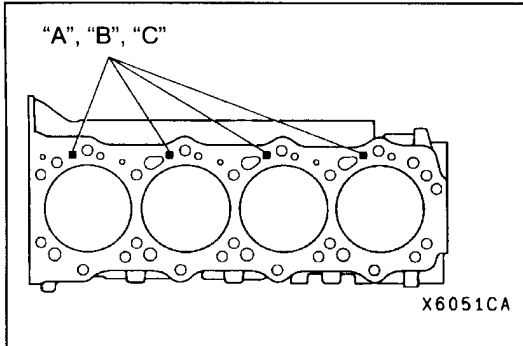


X6050CA

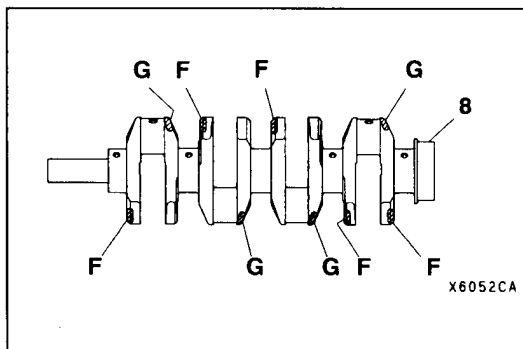
CRANKCASE

- The crankcase is separated into the upper crankcase 1 and the lower crankcase 6, with the crankshaft 8 clamped between the two.
- The cylinder block D is positioned on the upper crankcase 1, and is designed so that the pistons can slide directly. The cylinder block has a water jacket E around it for cooling.

- The main cap bolts 5 which are used to join the upper crankcase 1 and the lower crankcase 6 must be tightened in a specific way.
- The oil holes for the upper crankcase 1 and the lower crankcase 6 are connected, so that O-rings 10 are installed in two locations.

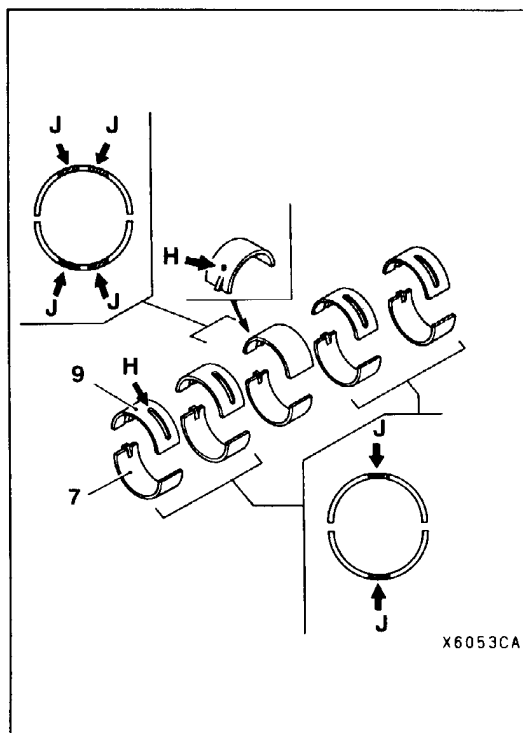


The upper crankcase 1 has "A", "B" and "C" size symbols marked on it so that the correct pistons can be selected for each cylinder.



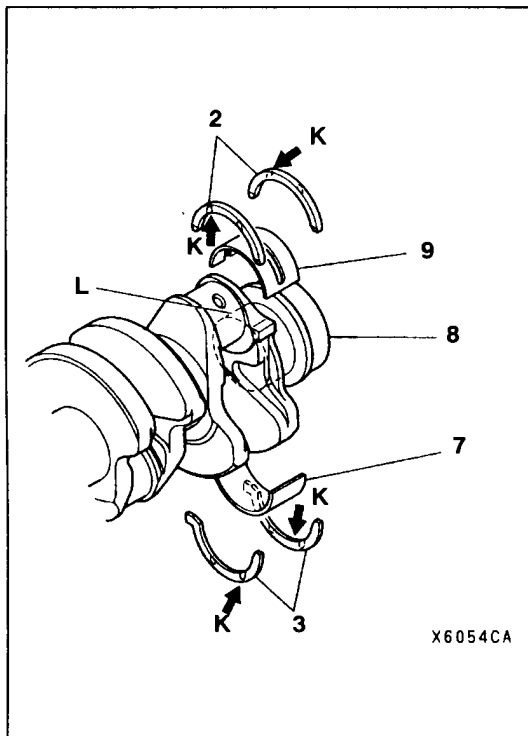
CRANKSHAFT

- The crankshaft 8 is marked with identification colours F (clear or blue in five locations) to indicate the journal outer diameters, and identification colours G (clear or blue in four locations) to indicate the pin outer diameters.



MAIN BEARINGS

- The upper main bearings 9 have oil holes H so that engine oil can be supplied to journals of the crankshaft 8.
- The main bearings are selected for their thicknesses in order to provide the optimum clearance at the bearing mounts.
The thicknesses of the bearings can be distinguished by the identification colours J (black, blue and yellow) on their sides.
- The No. 3 bearings of both the upper main bearings 9 and the lower main bearings 7 are different from the other bearings.



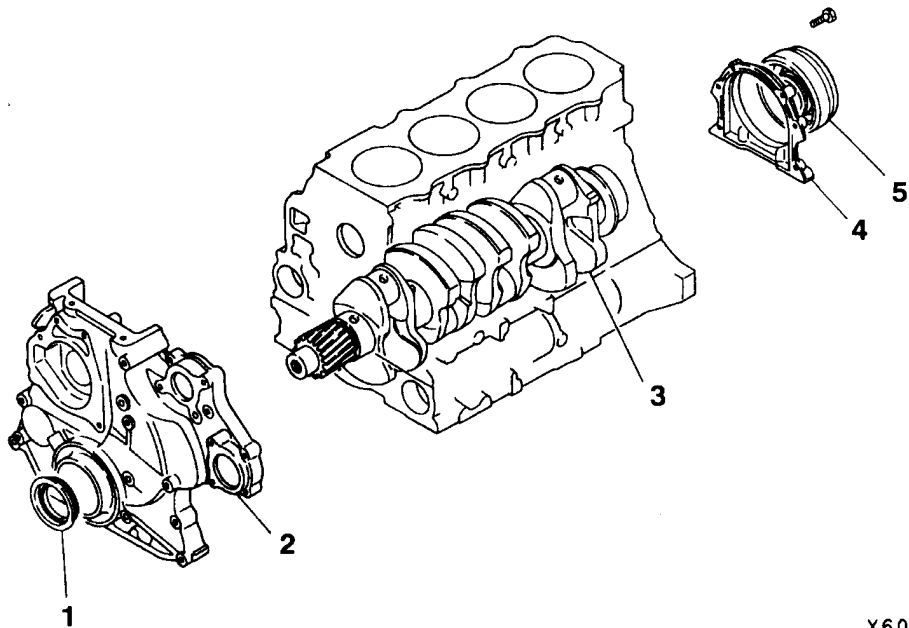
THRUST PLATES

There are two types of thrust plates used: the upper thrust plates 2 and the lower thrust plates 3. The thrust plates are respectively installed on both sides of the upper main bearing 9 and lower main bearing 7 at the rear end of the crankshaft 8.

These thrust plates have appropriate thicknesses for reducing the amount of end play of the crankshaft 8.

The thrust plates have oil holes K located in two places to assist with smooth movement between them and the journals L of the crankshaft 8.

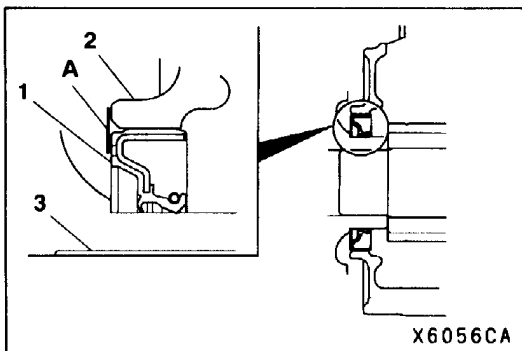
OIL SEAL



X6055CA

- 1. Front oil seal
- 2. Timing gear case
- 3. Crankshaft

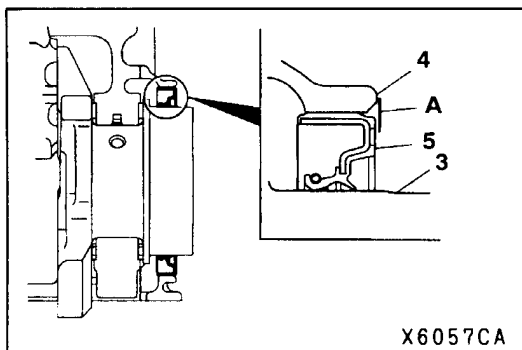
- 4. Rear oil seal case
- 5. Rear oil seal



X6056CA

FRONT OIL SEAL

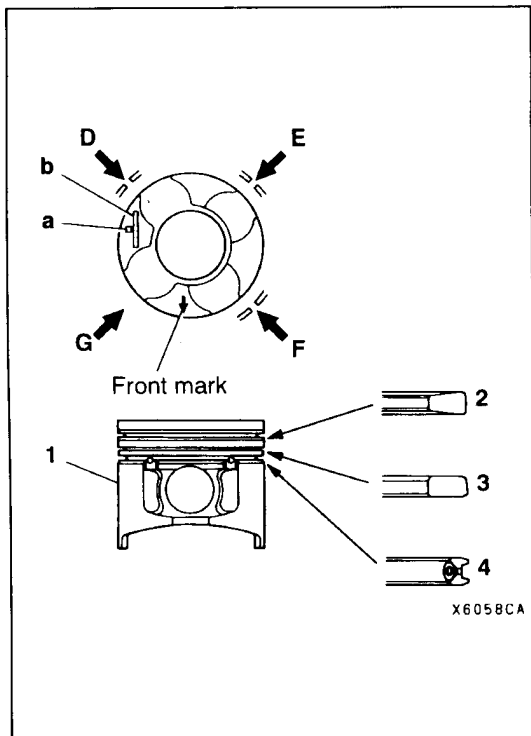
The front oil seal 1 is a radial-type oil seal and is installed so that it forms a flush surface A with the timing gear case 2.



X6057CA

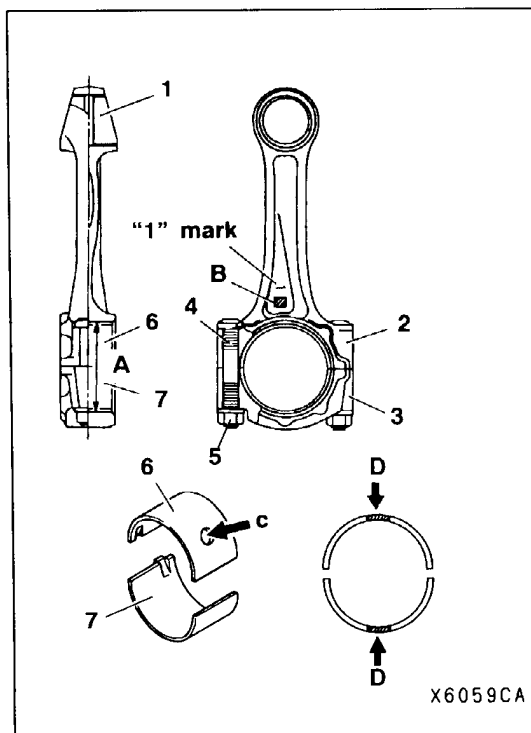
REAR OIL SEAL

The rear oil seal 5 is a radial-type oil seal and is installed so that it forms a flush surface A with the rear oil seal case 4.



PISTONS, PISTON RINGS

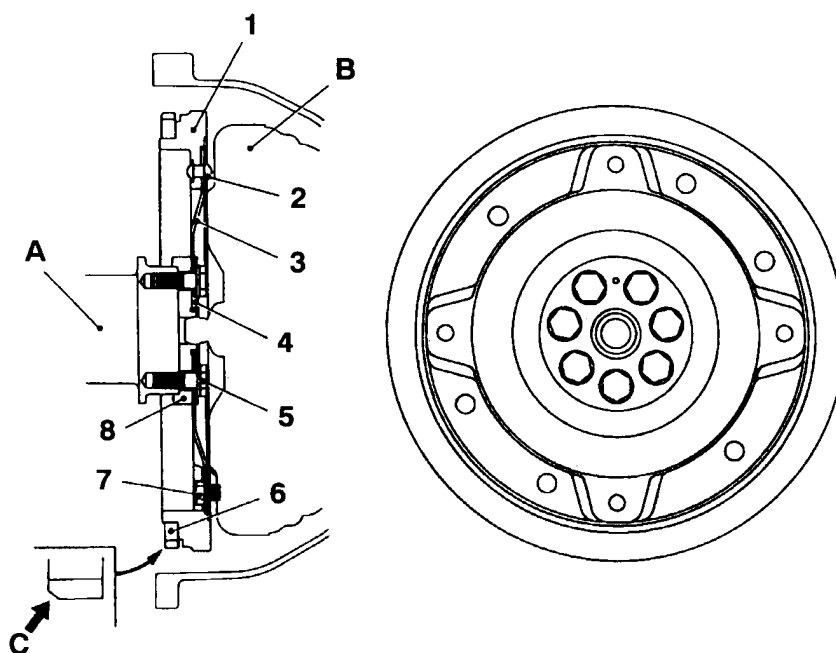
- The head of the piston 1 has a "→" front mark on it to indicate the direction for inserting the piston into the crankcase.
- The piston rings are installed so that the end gaps of each ring are in different positions.
 - D: End gap for 1st compression ring 2
 - E: End gap for oil ring 4
 - F: End gap for 2nd compression ring 3
 - G: Expander spring end gap for oil ring 4
- The correct pistons for each position in the upper crankcase can be selected by matching the size symbols on the pistons with the size symbols on the upper crankcase.
 - Piston
 - 1st compression ring
 - 2nd compression ring
 - Oil ring
 - a: Size symbols "A", "B", "C"
Pistons marked with "A" have the smallest outside diameter, and those marked with "B" and "C" have progressively larger outside diameters.
 - b: Part number



CONNECTING RODS

- The connecting rod 2 has a "1" mark to indicate the direction of installation to the piston.
- The nuts 5 must be tightened in a specific way.
 - Connecting rod bushing
 - Connecting rod
 - Connecting rod cap
 - Connecting rod bolt
 - Nut
 - Upper connecting rod bearing
 - Lower connecting rod bearing
 - A: Diameter of large end
 - B: Identification colour indicating large-end diameter "Clear", "Blue"
Those marked with blue have the larger diameter.
 - C: Oil hole
 - D: Identification colour indicating centre thickness "Blue", "Clear", "Yellow"
Blue is the thinnest, and clear and yellow are progressively thicker.

DRIVE PLATE (AT)



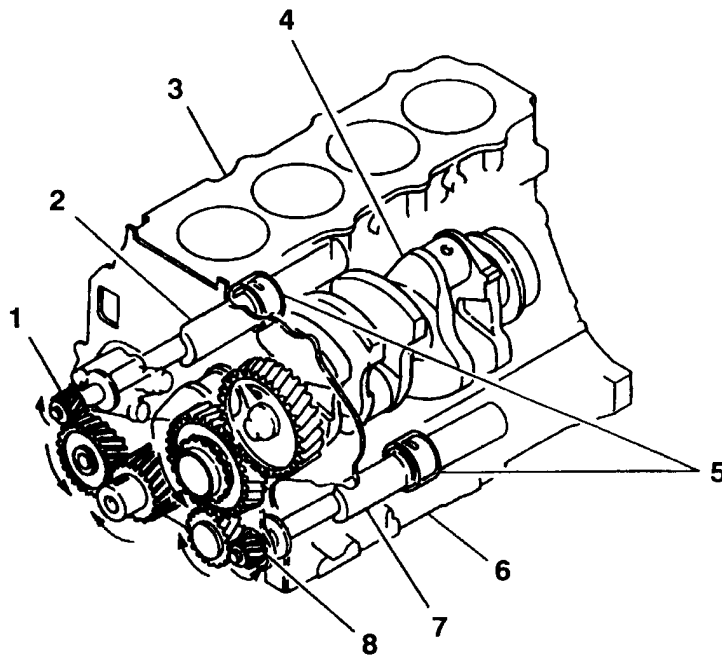
X6060CA

- 1. Inertia ring
- 2. Rivet
- 3. Drive plate
- 4. Adapter plate
- 5. Bolt
- 6. Ring gear

- 7. Bolt
- 8. Crankshaft adapter

A: Crankshaft
B: Torque converter

- The inertia ring 1 and the drive plate 3 are joined by means of a rivet 2.
- The drive plate 3 is secured at the crankshaft A side by the bolt 5, and at the torque converter, B side by the bolt 7 respectively.
- One side of the ring gear 6 has a bevel C so that the starter pinion can engage easily.

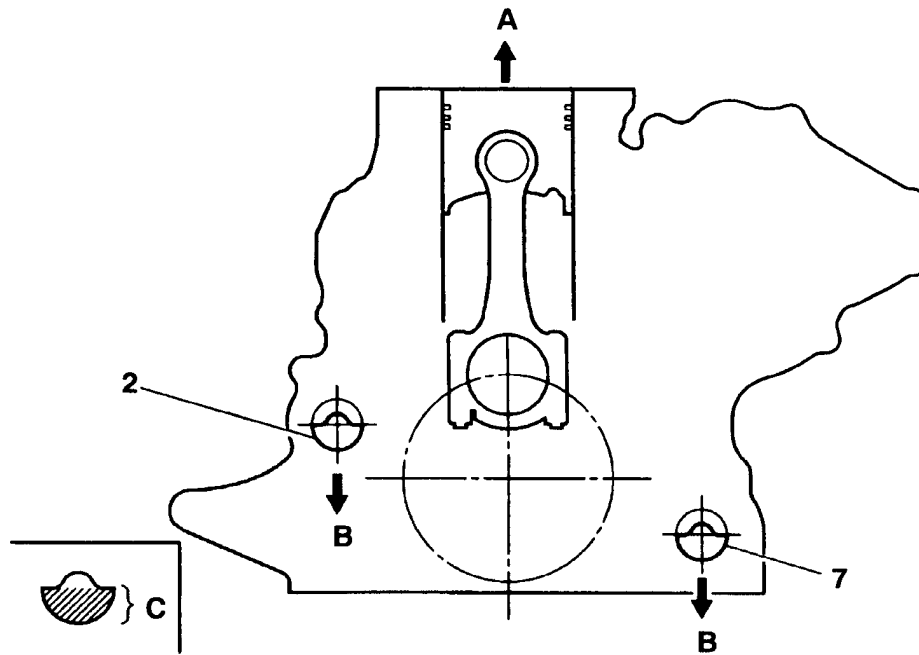
BALANCE SHAFT

X6061CA

- | | |
|----------------------------|----------------------------|
| 1. Balance shaft gear R.H. | 5. Balance shaft bushings |
| 2. Balance shaft R.H. | 6. Lower crankcase |
| 3. Upper crankcase | 7. Balance shaft L.H. |
| 4. Crankshaft | 8. Balance shaft gear L.H. |

- The balance shaft R.H. 2 is installed to the upper crankcase 3, and the balance shaft L.H. 7 is installed to the lower crankcase 6 with the crankshaft 4 in between. The balance shafts reduce the vibration in the engine which is generated when the crankshaft rotates.
- The balance shaft R.H. 2 and balance shaft L.H. 7 are both driven by timing gears, and are supported by the balance shaft bushings 5 which are installed to the upper crankcase 3 and to the lower crankcase 6.

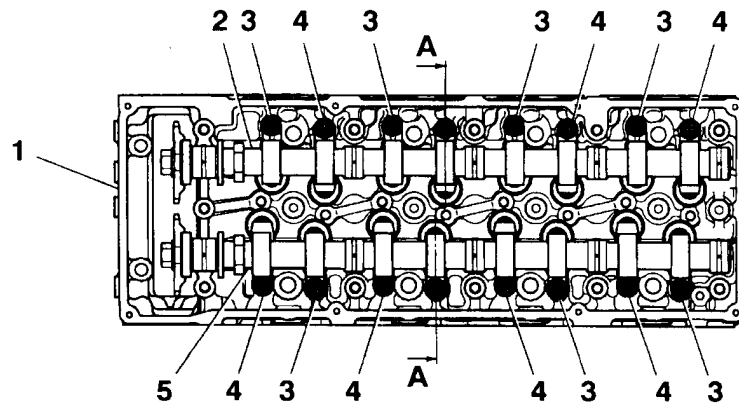
REDUCTION OF VERTICAL VIBRATION (SECONDARY COMPONENT)



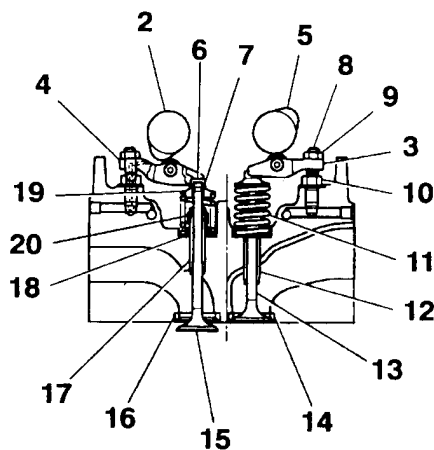
X6062CA

- The inertial force A which is generated at the top dead centre point and bottom dead centre point as a result of the reciprocal motion of the pistons is a source of vertical vibration.
- The balance shaft R.H. 2 and balance shaft L.H. 7 rotate in such a way that the semi-circular weights C on each shaft are always positioned in a direction which is opposite to the head of the piston when the piston is at the top dead centre or bottom dead centre position. As a result, when the piston is at the top dead centre or bottom dead centre position, the balance shaft R.H. 2 and balance shaft L.H. 7 both generate an equal centrifugal force B, and this counteracts the inertial force A generated by the piston in order to reduce the vertical vibration.
- The engine and crankshaft turning moments (secondary components) are also reduced by the balance shafts when the engine is running in medium to high-speed ranges.

VALVE MECHANISM



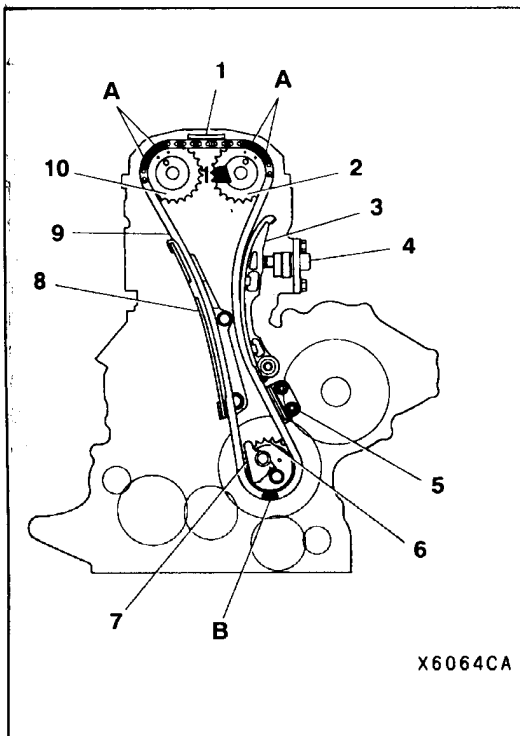
SECTION A – A



X6063CA

- | | |
|---------------------|---------------------------|
| 1. Cylinder head | 11. Valve spring |
| 2. Exhaust camshaft | 12. Inlet valve guide |
| 3. Short rocker | 13. Inlet valve |
| 4. Long rocker | 14. Inlet valve seat |
| 5. Inlet camshaft | 15. Exhaust valve |
| 6. Valve cap | 16. Exhaust valve seat |
| 7. Valve cotter | 17. Exhaust valve guide |
| 8. Adjusting screw | 18. Valve spring seat |
| 9. Lock nut | 19. Valve spring retainer |
| 10. Pivot bolt | 20. Stem seal |

- The valve mechanism uses two types of rocker: a long rocker 4 and a short rocker 3. The installation directions for each rocker differ as shown in the illustration.

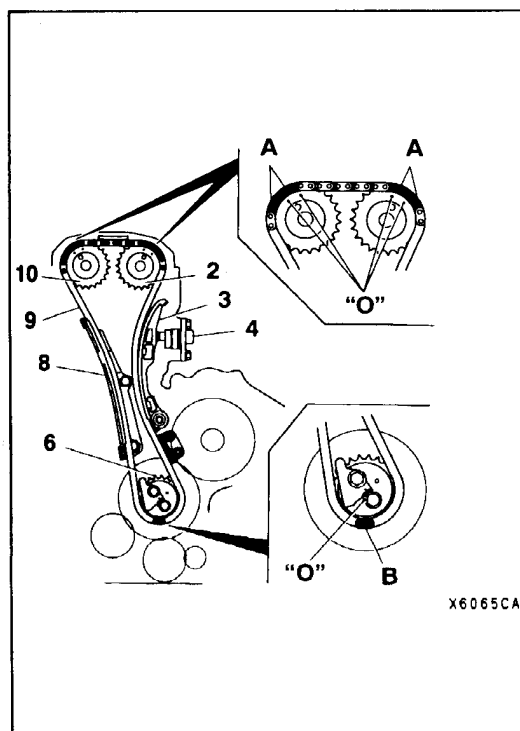


TIMING CHAIN

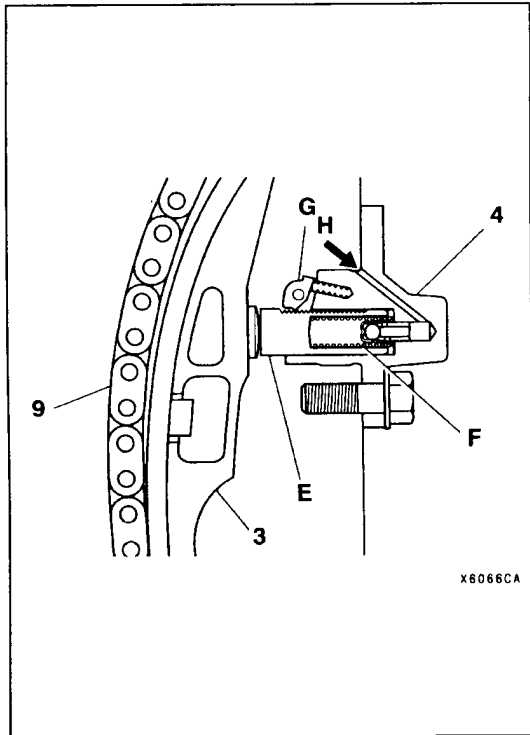
1. Upper guide plate
2. Camshaft sprocket (inlet side)
3. Tension lever
4. Tensioner
5. Lower guide plate
6. Idler sprocket
7. Oil jet
8. Guide plate
9. Timing chain
10. Camshaft sprocket (exhaust side)

A: Mark link plate (2 plates)

B: Mark link plate (1 plate)



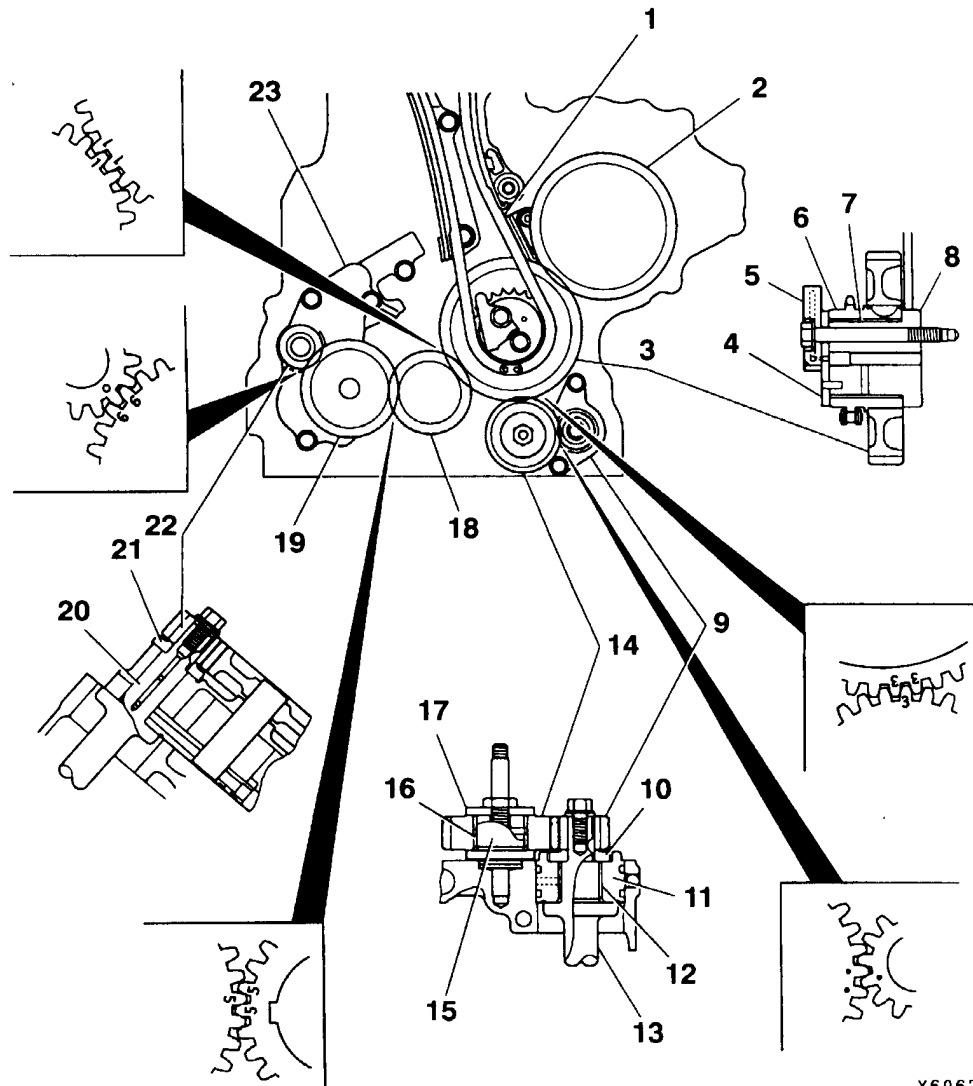
- The timing chain 9 is an endless chain consisting of 110 links which is installed to the camshaft sprockets 2 and 10 and to the idler sprocket 6.
- The timing chain 9 has three mark link plates (glossy white) which are used to ensure that the crankshaft and camshaft are installed in the correct timing positions. There are two plates installed in position A and one plate in position B. For correct installation, the two plates at position A should be aligned with the "O" marks on the camshaft sprockets 2 and 10, and the single plate at position B should be aligned with the "O" mark on the idler sprocket 6.



TENSIONER

- The tension of the timing chain 9 is regulated by the tensioner 4. The tensioner 4 includes a plunger E, and has a built-in plunger spring F inside it.
- When the tensioner 4 is installed, the plunger E directly presses against the tension lever 3, and the tension of the timing chain 9 is determined automatically by the force of the plunger spring F and hydraulic pressure H.
- A cam G is used to lock the plunger E in position after installation, in order to prevent any runout in the timing chain 9 when it is being driven. Care should be taken if cranking the engine anti-clockwise (reverse direction) after the tensioner 4 has been installed, as this can cause excessive force to be applied to the plunger, which can in turn cause problems such as slippage of the cam.

TIMING GEAR



X6067CA

- | | |
|---------------------------------------|--|
| 1. Timing chain | 13. Balance shaft L.H. |
| 2. Injection pump gear (56 teeth) | 14. Idler gear L.H. (29 teeth) |
| 3. Idler gear (56 teeth) | 15. Idler shaft |
| 4. Idler washer | 16. Idler gear bushing L.H. |
| 5. Oil jet | 17. Idler washer |
| 6. Idler sprocket | 18. Crankshaft gear (28 teeth) |
| 7. Idler bushing | 19. Oil pump gear (37 teeth) |
| 8. Idler shaft | 20. Balance shaft R.H. |
| 9. Balance shaft gear L.H. (14 teeth) | 21. Thrust spacer |
| 10. Thrust spacer | 22. Balance shaft gear R.H. (14 teeth) |
| 11. Thrust plate L.H. | 23. Oil pump |
| 12. Bushing | |

The timing gears have mating marks such as "1", "3", "5", "6" and "O" on them so that the various gears can be engaged in the correct positions when they are installed. However, the injection pump gear has the mating marks on the tip of the gear tooth so that it can be checked from the side of the plunger pump through the plunger plate and front plate.

IDLER GEAR

- The idler gear 3 is press-fitted to the idler sprocket 6 which drives the timing chain 1, and rotates with the idler shaft 8 as its axis.
- The idler shaft 8 is secured to the crankcase together with the oil jet 5 by means of the idler washer 4 and a bolt.
- The idler bushing 7 is installed to the idler sprocket 6.

IDLER GEAR L.H.

- The idler gear L.H. 14 rotates with the idler shaft 15 as its axis.
- The idler shaft 15 is secured to the crankcase by means of the idler washer 17 and a bolt.
- The idler gear bushing L.H. 16 is installed to the idler gear L.H. 14.

BALANCE SHAFT GEAR L.H.

- The balance shaft gear L.H. 9 is installed to the balance shaft L.H. 13 by means of a bolt, and rotates together with the balance shaft L.H.
- The thrust plate L.H. 11 is attached to the balance shaft 13, and is secured to the crankcase by means of a bolt.
- The balance shaft L.H. 13 rotates inside the thrust plate L.H. 11.
- The bushing 12 is installed to the thrust plate L.H. 11.

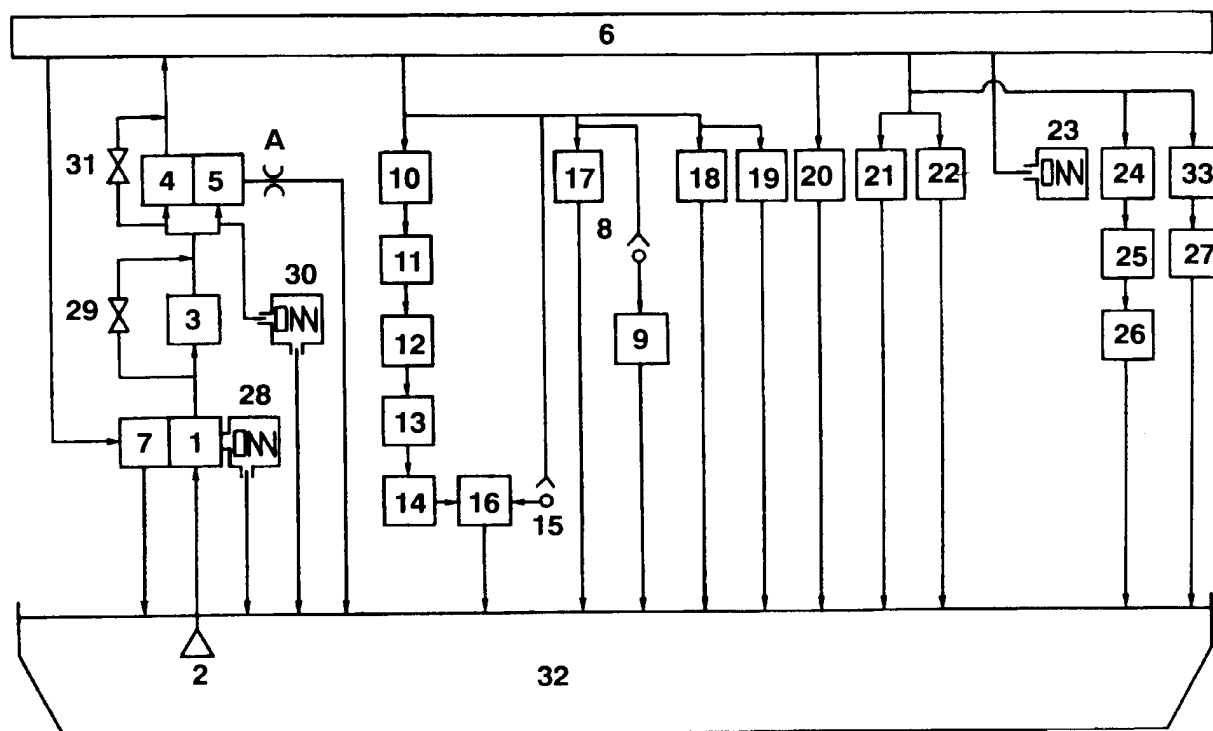
BALANCE SHAFT GEAR R.H.

- The balance shaft gear R.H. 22 is installed to the balance shaft R.H. 20 by means of a bolt, and rotates together with the balance shaft R.H.
- The balance shaft R.H. 20 is attached to the oil pump 23.
- The oil pump 23 is secured to the crankcase by means of a bolt, and the balance shaft R.H. 20 rotates inside the oil pump.

LUBRICATION SYSTEM

The lubrication system is a fully-pressurised, fully flow-filtered system which includes an engine oil cooler to improve engine cooling performance. It is basically the same as the system used in previous engines, except that there are changes in the valve system.

LUBRICATION SYSTEM (Flow of oil)

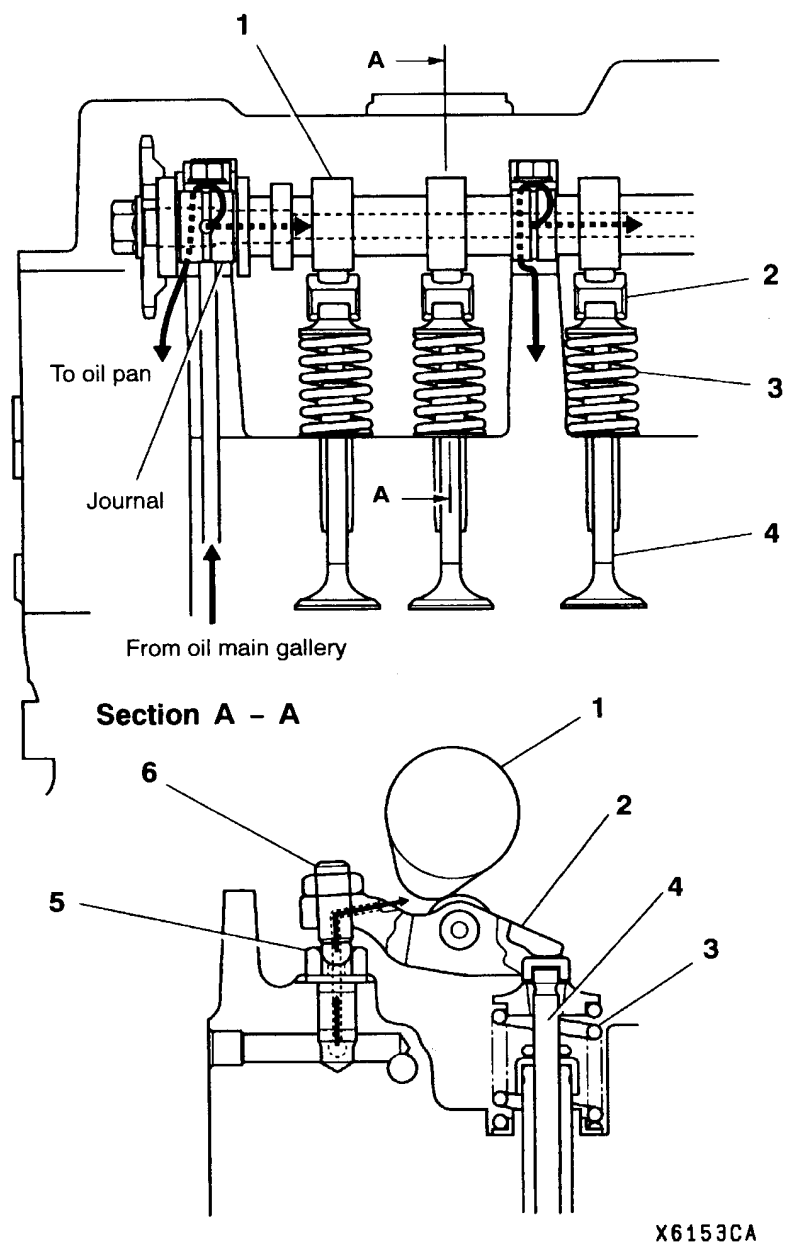


X6152CA

1. Oil pump
2. Oil strainer
3. Oil cooler
4. Full-flow filter
5. Bypass filter
6. Oil main gallery
7. Balance shaft R.H.
8. Oil jet
9. Timing chain
10. Main bearing
11. Crankshaft
12. Connecting rod bearing
13. Connecting rod
14. Connecting rod bushing
15. Oil jet
16. Piston
17. Idler bushing
18. Idler gear bushing L.H.

19. Balance shaft L.H.
20. Turbocharger
21. Tensioner
22. Vacuum pump
23. Oil pressure switch
24. Camshaft journal (No. 1)
25. Camshaft
26. Camshaft journal (Nos. 2 – 5)
27. Valve mechanism
28. Relief valve
29. Bypass valve
30. Regulator valve
31. Relief valve
32. Oil pan
33. Pivot bolt

A: Orifice



- 1. Camshaft
- 2. Rocker
- 3. Valve spring

- 4. Valve
- 5. Pivot bolt
- 6. Adjusting screw

The engine oil which passes through the pivot bolt and adjusting screw oil lines lubricates the camshaft and the rockers.

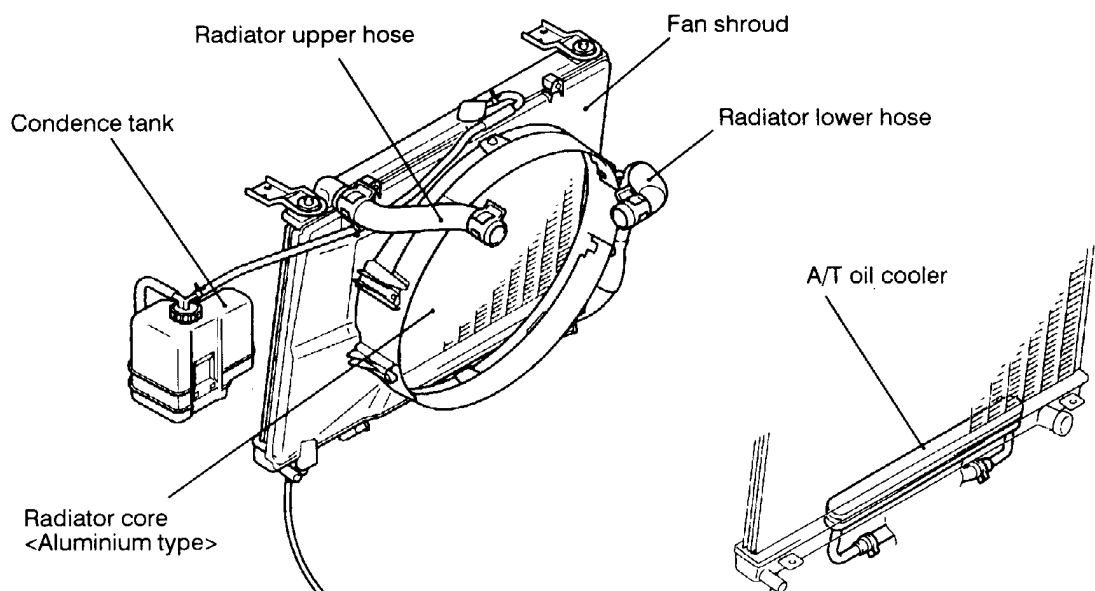
COOLING SYSTEM

The cooling system is basically the same as that of the 6G7 engine. (Refer to P.1–8.)

SPECIFICATIONS

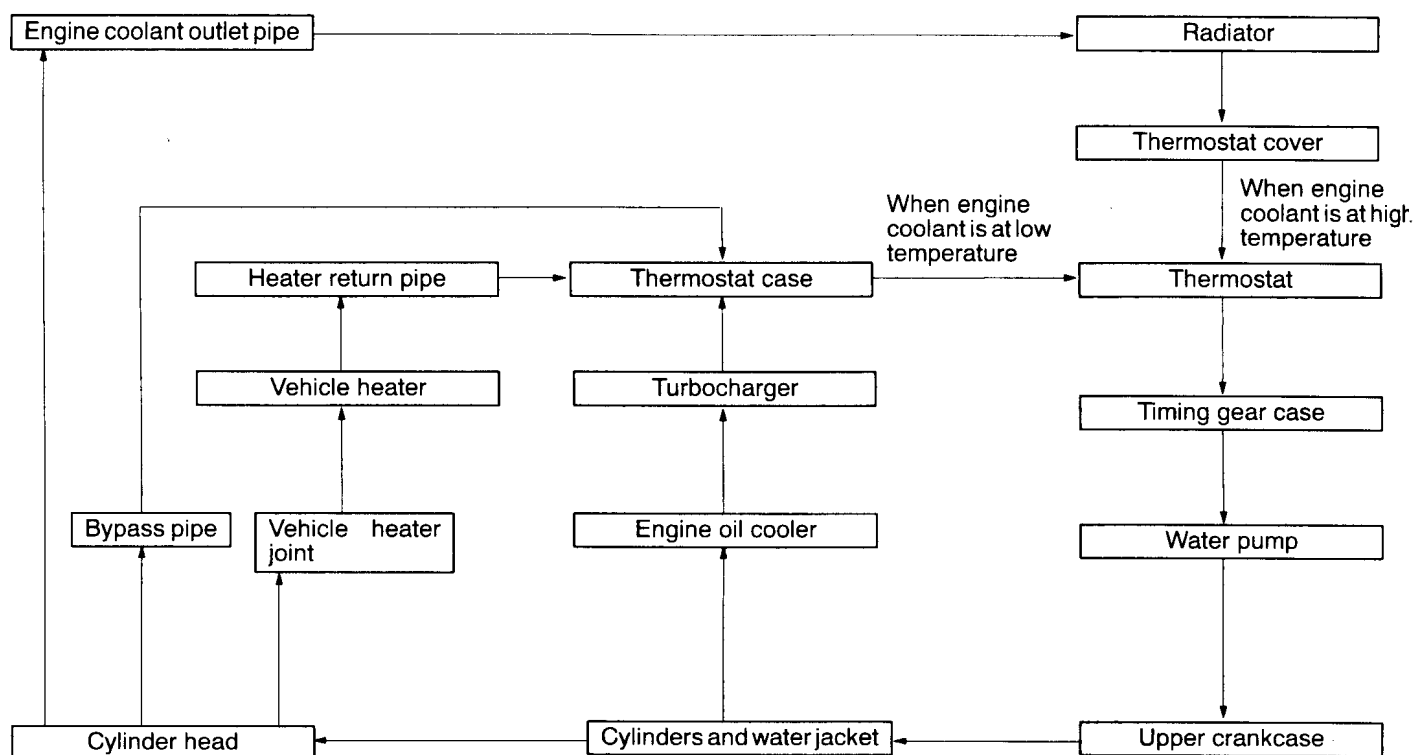
ITEMS			SPECIFICATIONS
Cooling water control method			Intake control method
Cooling fan	Type		With engine driven–type thermo clutch
Cooling water	Brand		High quality ethylene glycol antifreeze coolant
	Cooling water amount ℓ		9.0
Water pump	Type		Centrifugal–type impeller
	Drive method		Drive belt
Thermostat	Type		Wax type
	Valve open temperature °C		76.5
Radiator	Type		Corrugate type
	Core size (width × height × thickness) mm	M/T	703.6 × 525 × 16
		A/T	703.6 × 525 × 24
	Performance kJ/h	M/T	232, 326
		A/T	251, 163
A/T oil cooler	Type		Layer type

CONSTRUCTION DIAGRAM



BX0198CA

COOLING SYSTEM (Flow of coolant)



INTAKE AND EXHAUST

AIR INTAKE SYSTEM

TURBOCHARGER

A TF035HL water-cooled turbocharger has been adopted.

AIR CLEANER

Refer to P.1-42.

INTER COOLER

Refer to P.1-42.

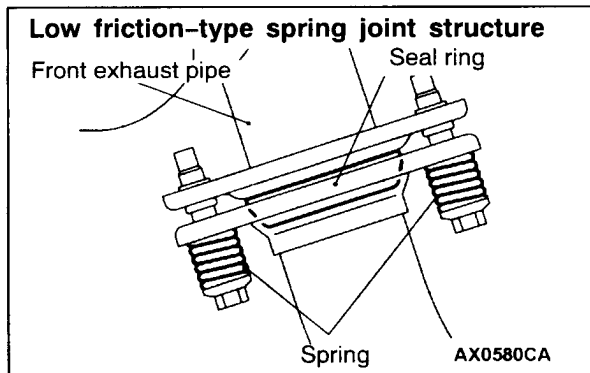
EXHAUST SYSTEM

EXHAUST PIPE

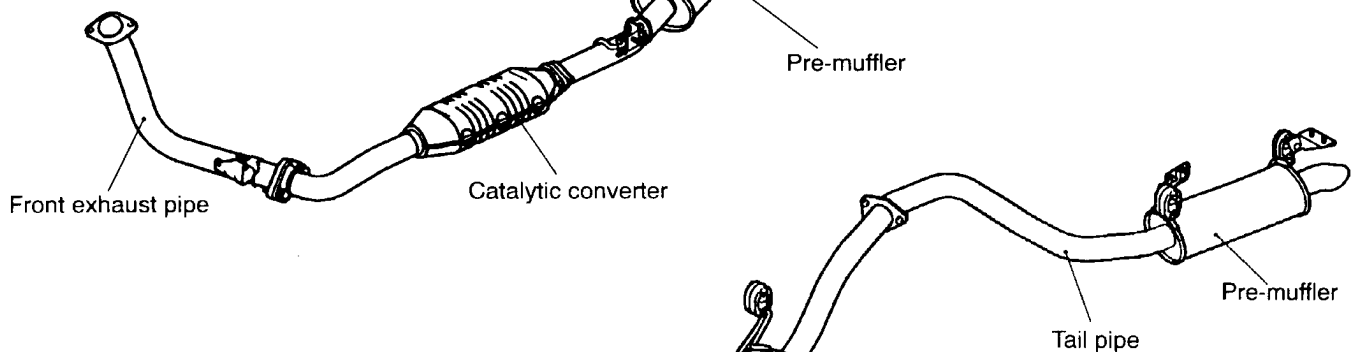
The exhaust pipe is divided into three parts. It is basically the same as the exhaust pipe in vehicles with 4D5 engine, and has the following features.

- The connection between the front exhaust pipe and the catalytic converter has a low friction-type spring joint structure, to reduce vibration of the exhaust pipe.

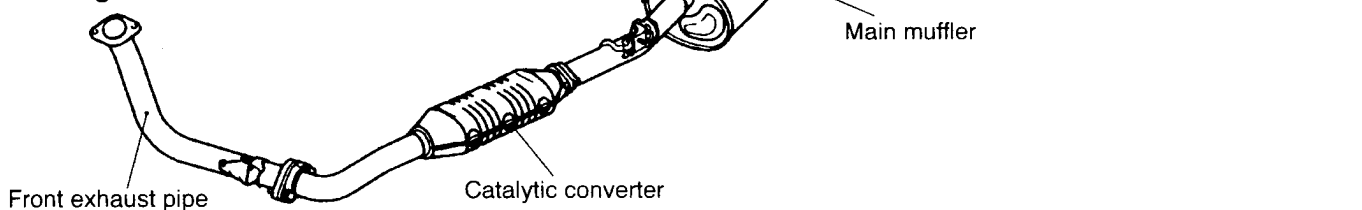
CONSTRUCTION DIAGRAM



<Short wheelbase>



<Long wheelbase>



FUEL SYSTEM

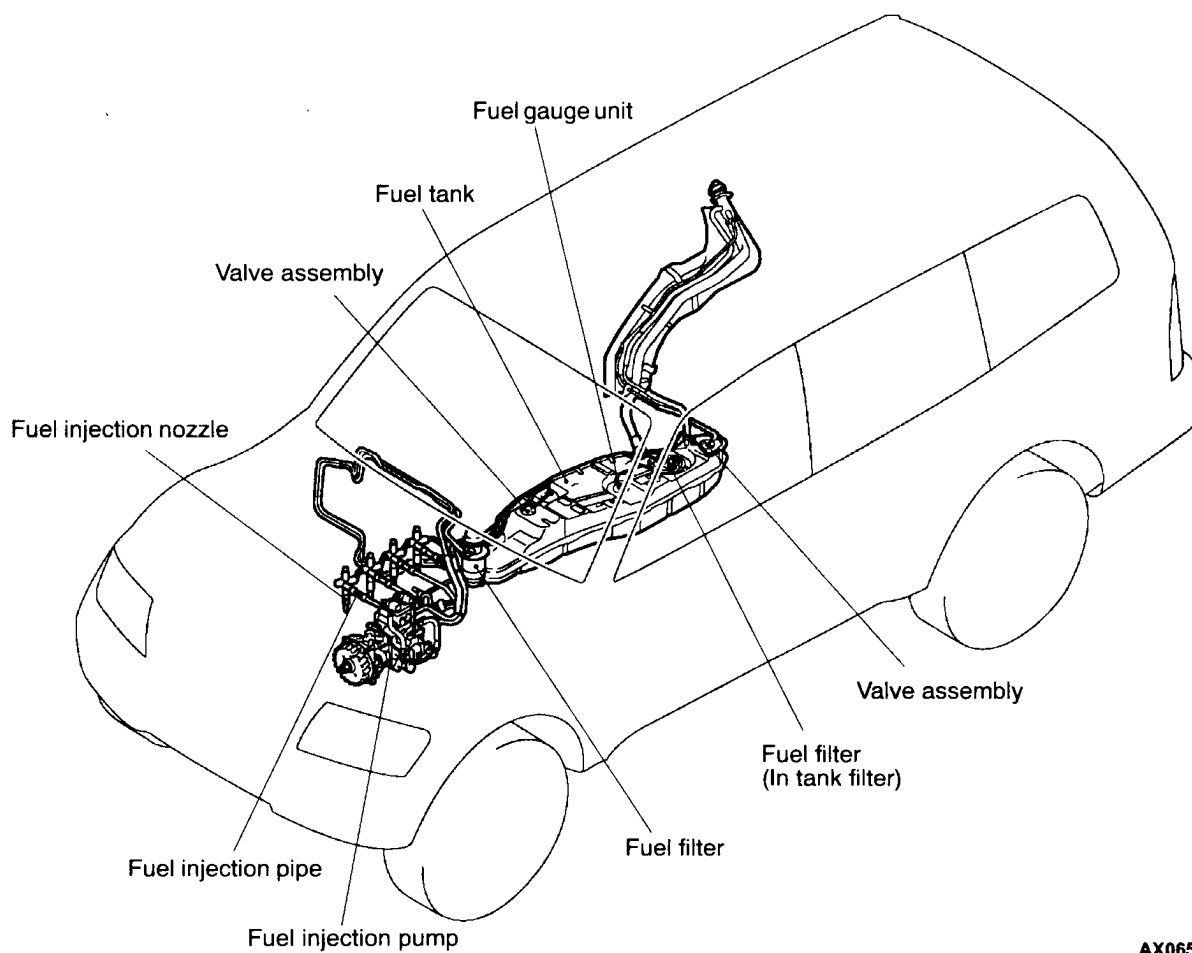
The fuel system consists of components such as the fuel injection nozzles, fuel injection pipe, fuel injection pump, fuel filter, fuel pipe and fuel tank.

The hoses use no chlorine-based solvents to give consideration to preservation of the global environment.

SPECIFICATIONS

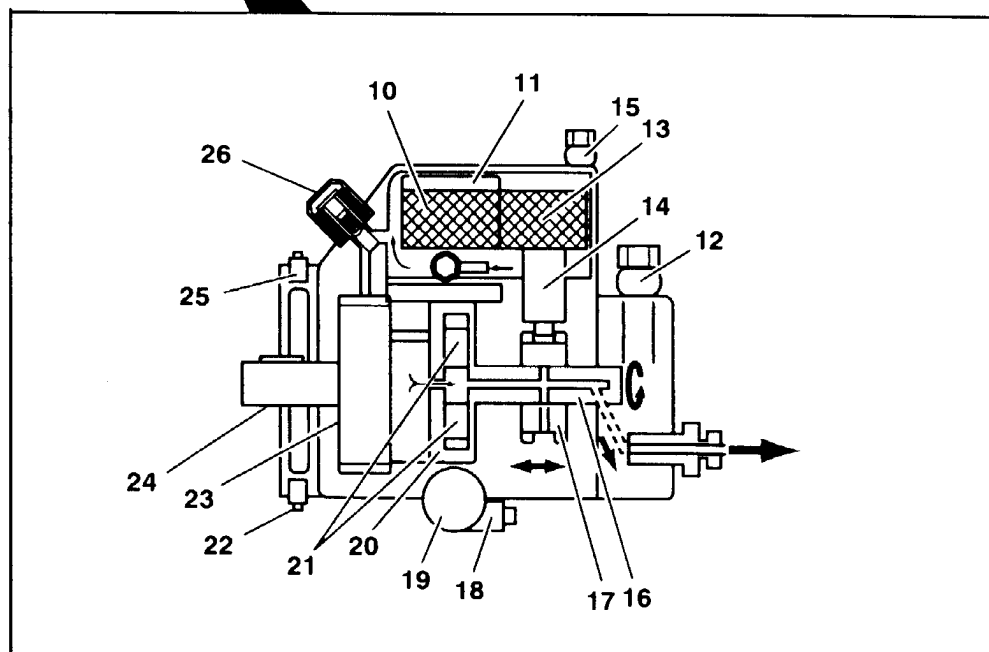
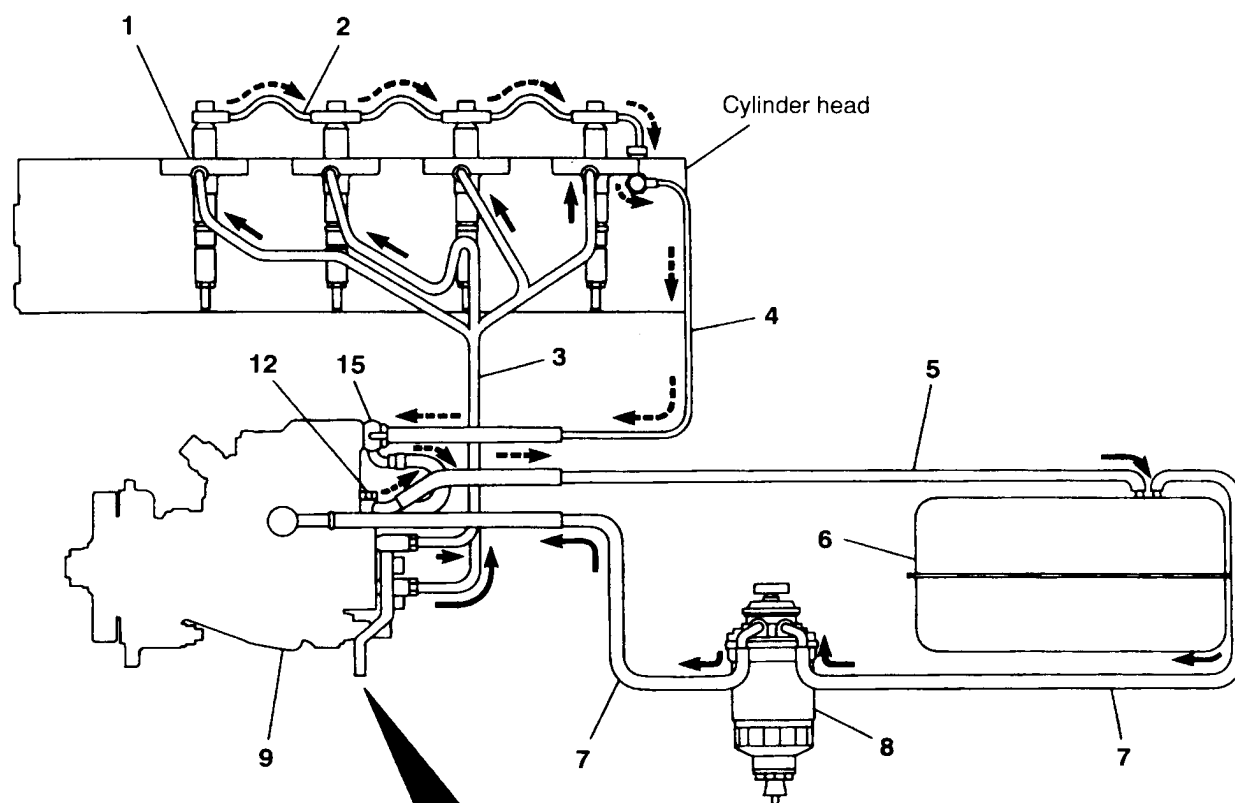
Items		Specifications
Fuel tank capacity ℓ	Short wheelbase	71
	Long wheelbase	90
In-tank filter		Equipped
Fuel filter type		Cartridge (filter type - with level warning device)
Injection timing BTDC		4°
Idle speed r/min		750 ± 20
Injection pump	Type	Separate-type electronically-controlled type
	Plunger diameter mm	11
	Injection sequence	1-3-4-2
	Rotation direction	Clockwise when seen from drive side
Governor	Type	Electronically-controlled
	Model	GE
Timer (injection timing controller) type		Electronically-controlled type timing control valve (TCV)
Timer piston position sensor		Equipped
Feed pump type		Vane type
Fuel cut solenoid valve		Equipped
Engine speed sensor (main, backup)		Equipped
Accelerator pedal position sensor		Equipped
Injection nozzles	Type	Hall-type 2-spring type
	No. of spray holes	5

CONSTRUCTION DIAGRAM



AX0652CA

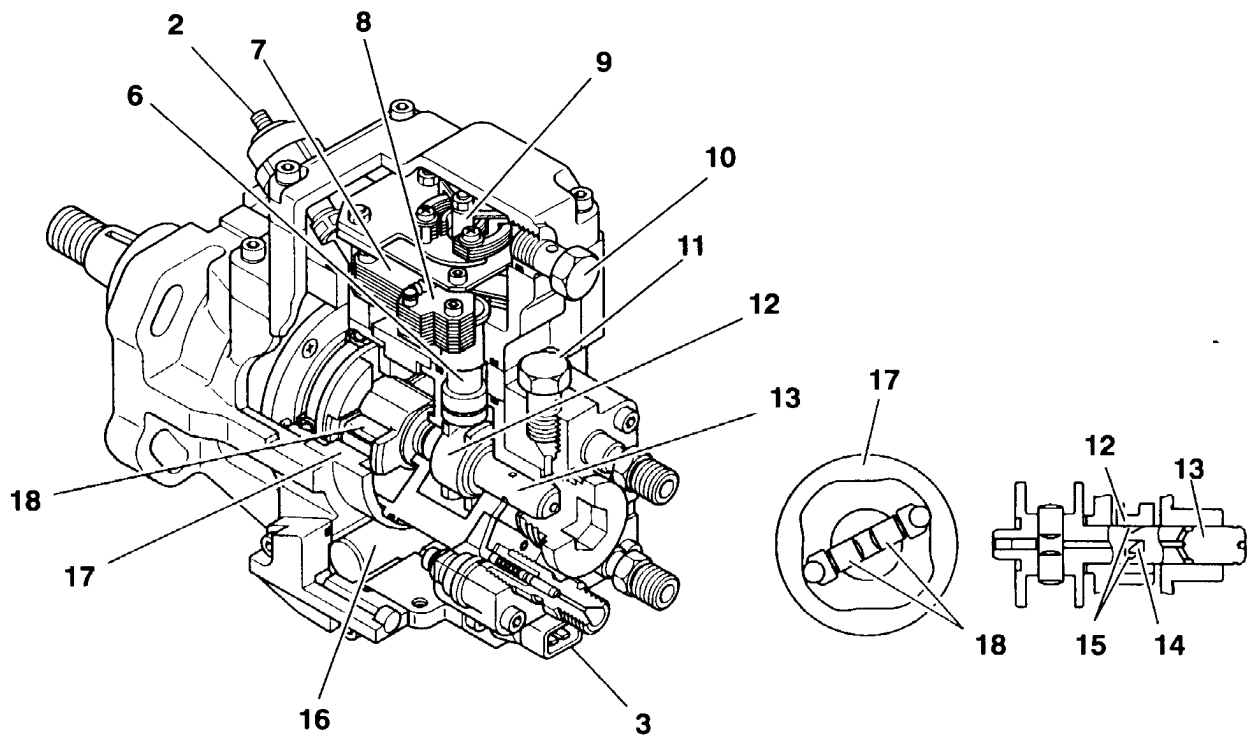
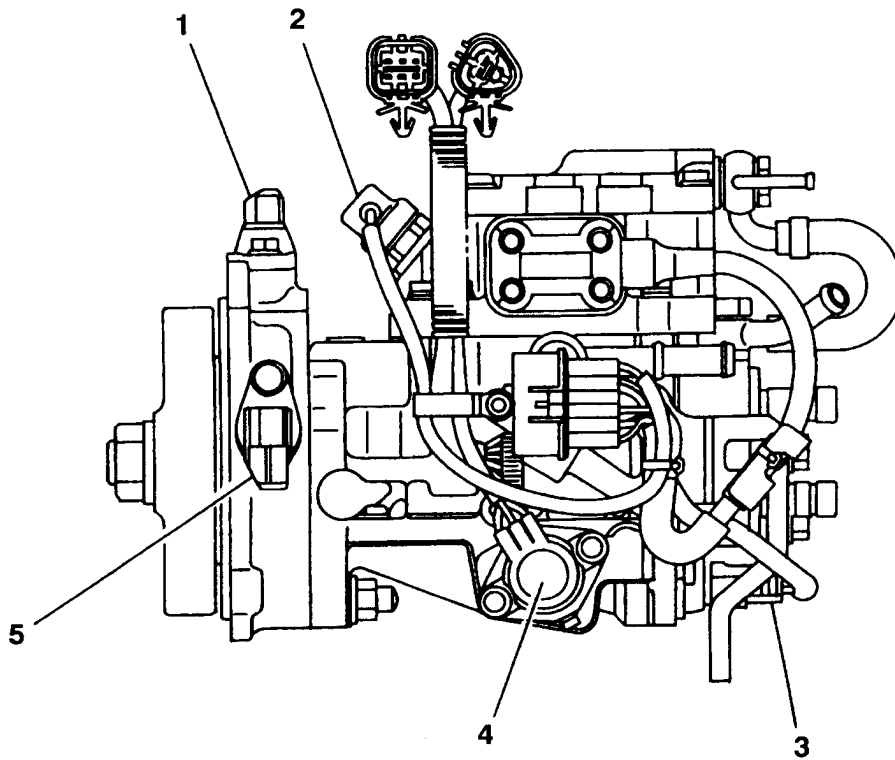
FUEL FLOW DIAGRAM



- | | |
|---------------------------|----------------------------------|
| 1. Fuel injection nozzle | 14. Shaft |
| 2. Leak-off pipe | 15. Overflow valve (sub) |
| 3. Injection pipe | 16. Rotor |
| 4. Fuel return pipe | 17. Control sleeve |
| 5. Fuel return pipe | 18. Timing control valve |
| 6. Fuel tank | 19. Timer piston sensor |
| 7. Fuel feed pipe | 20. Inner cam |
| 8. Fuel filter | 21. Plungers |
| 9. Injection pipe | 22. Engine speed sensor (main) |
| 10. Coil | 23. Feed pump |
| 11. GE actuator | 24. Shaft |
| 12. Overflow valve (main) | 25. Engine speed sensor (backup) |
| 13. Drive unit | 26. Fuel cut solenoid valve |

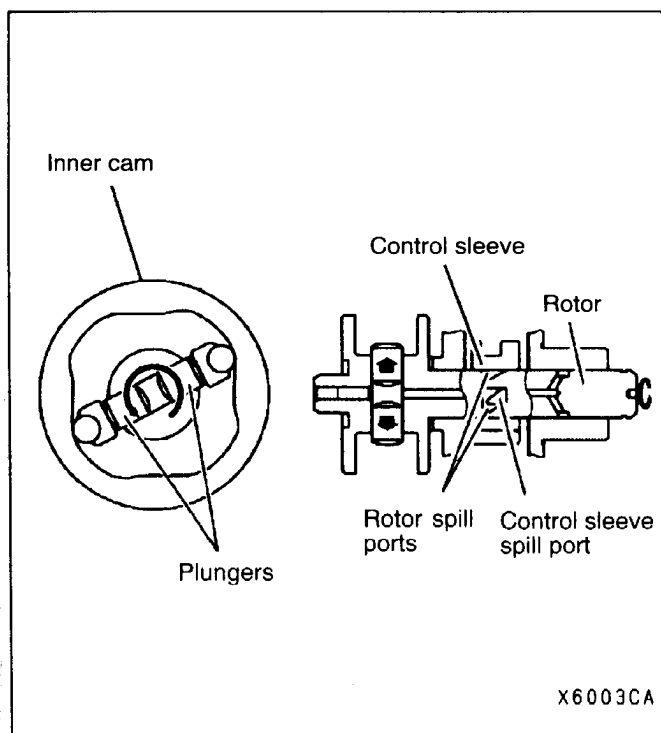
- The fuel which is pumped up from the fuel tank passes through the fuel filter and into the injection pump. The action of the feed pump ensures that the inside of the injection pump body is always full.
- The fuel injection amount is controlled by the control sleeve moving in the same direction as the rotor axial direction to increase or decrease the distance until the wedge-shaped spill ports of the control sleeve and the rotor meet.
- The plungers inside the rotor pressurise the fuel inside the rotor by the action of the inner cam.
- The pressurised fuel is sprayed out of the injection nozzles into the combustion chambers.
- The control sleeve on the rotor shaft adjusts the fuel injection amount, and the timing control valve causes the inner cam to move in order to control timing advancing and retarding.
- If the fuel pressure inside the injection pump is at a certain pressure or higher, fuel is returned to the fuel tank via the overflow valve (main) and the overflow valve (sub).
- The excess fuel from the injection nozzles passes through the leak-off pipe and is returned to the fuel tank.

ELECTRONICALLY-CONTROLLED INJECTION PUMP ASSEMBLY



1. Engine speed sensor (main)
2. Fuel cut solenoid valve
3. Timing control valve
4. Timer piston position sensor
5. Engine speed sensor (backup)
6. Shaft
7. Coil
8. Drive unit
9. GE actuator (with built-in control sleeve position sensor and fuel temperature sensor)
10. Overflow valve (GE actuator side)
11. Overflow valve (Distributor head side)
12. Control sleeve
13. Rotor
14. Control sleeve spill port
15. Rotor spill ports
16. Timer piston
17. Inner cam
18. Plungers

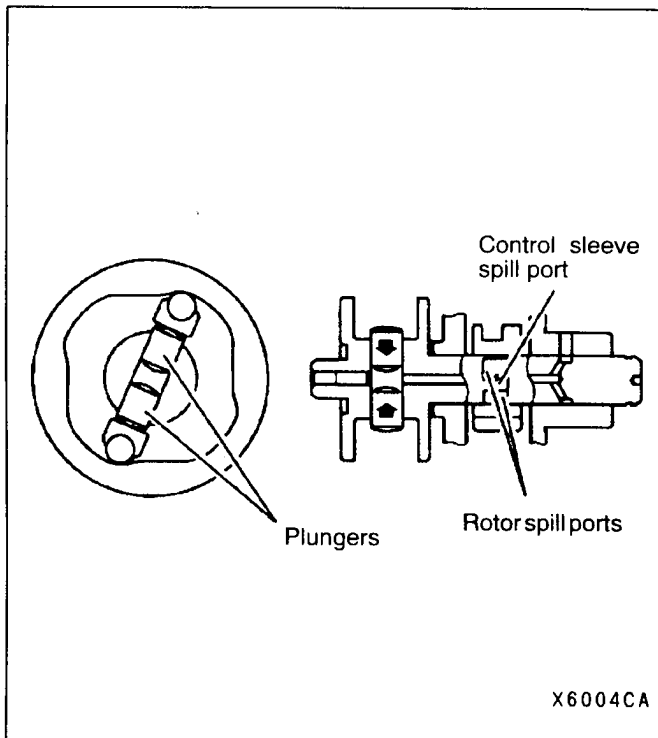
- The GE actuator of the injection pump electronically controls the fuel injection amount, and the timing control valve electronically controls the fuel injection timing.
- The engine speed sensor (main) has a sensor plate with 17 projections which is installed to the injection pump gear, and which converts the engine speed into an electrical signal. The electrical signal which is thus generated is sent to the engine-ECU as the engine speed signal, where it is used by the engine-ECU to control the fuel injection timing and the fuel injection amount.
- The engine speed sensor (backup) provides a backup function if a problem develops with the operation of the engine speed sensor (main).



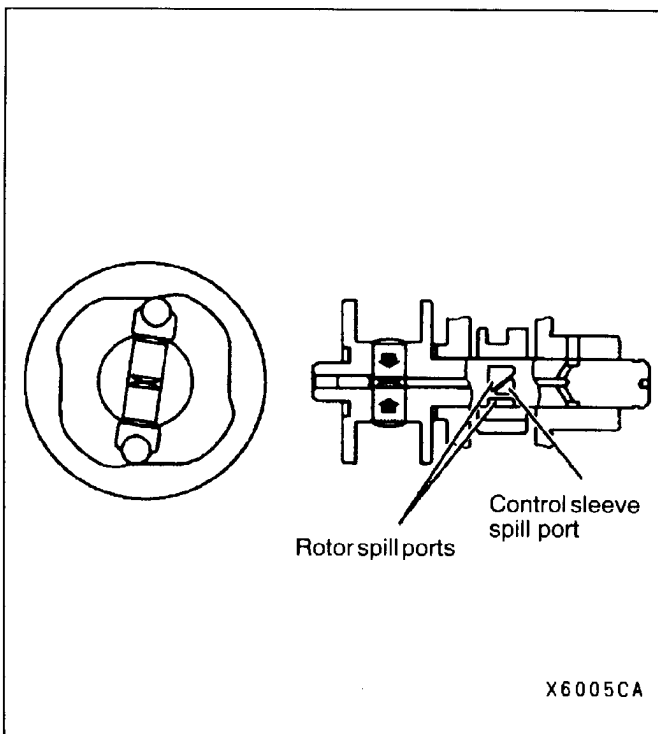
FUEL INJECTION

INTAKE

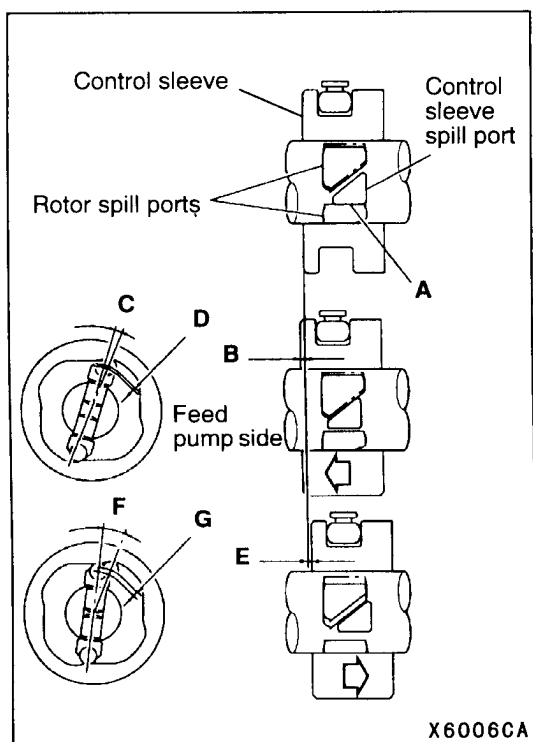
When the control sleeve spill port of the control sleeve and the spill ports of the rotor meet, the intake stroke starts, and the plungers which are attached to the inner cam open the intake line so that fuel flows into the rotor.

**START OF INJECTION**

The control sleeve spill port of the control sleeve and the spill ports of the rotor separate, and when they are fully closed, the plungers close the intake line and the fuel is pressurised.

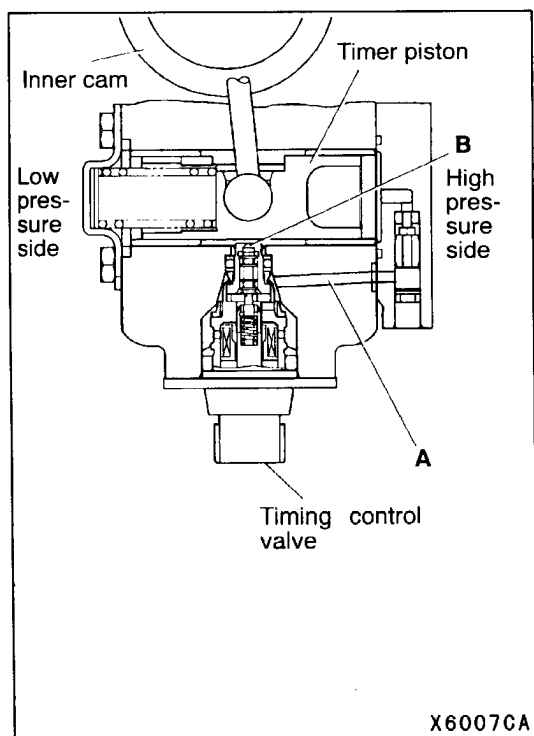
**END OF INJECTION**

Fuel injection ends at the same time that the control sleeve spill port of the control sleeve and the spill ports of the rotor meet.



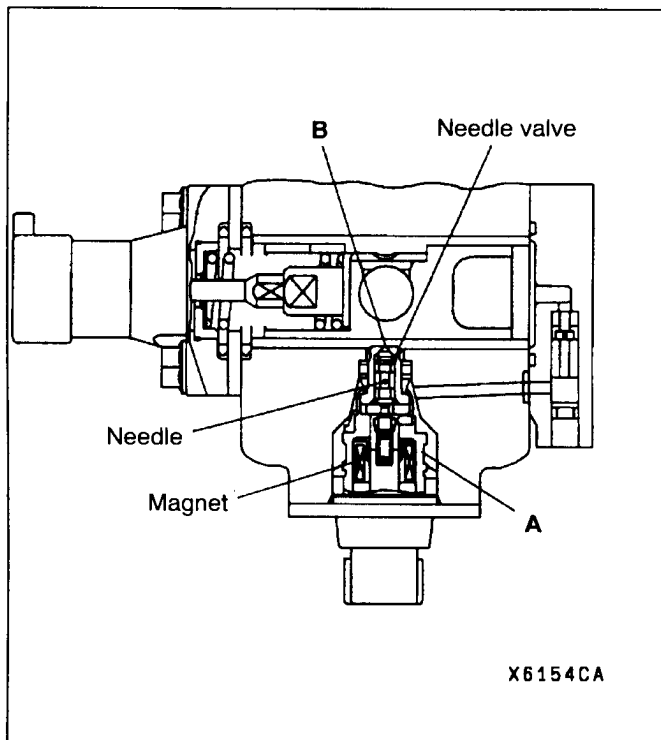
CHANGING THE FUEL INJECTION AMOUNT

- Fuel injection starts when the control sleeve spill port and the rotor spill port overlap at edge A.
- When the control sleeve moves to the feed pump side B, the pressurisation time C is reduced and the effective stroke D becomes shorter, which causes the fuel injection amount to be reduced.
- Furthermore, when the control sleeve moves away from the feed pump E, the pressurisation time F is increased and the effective stroke G becomes longer, which causes the fuel injection amount to be increased.



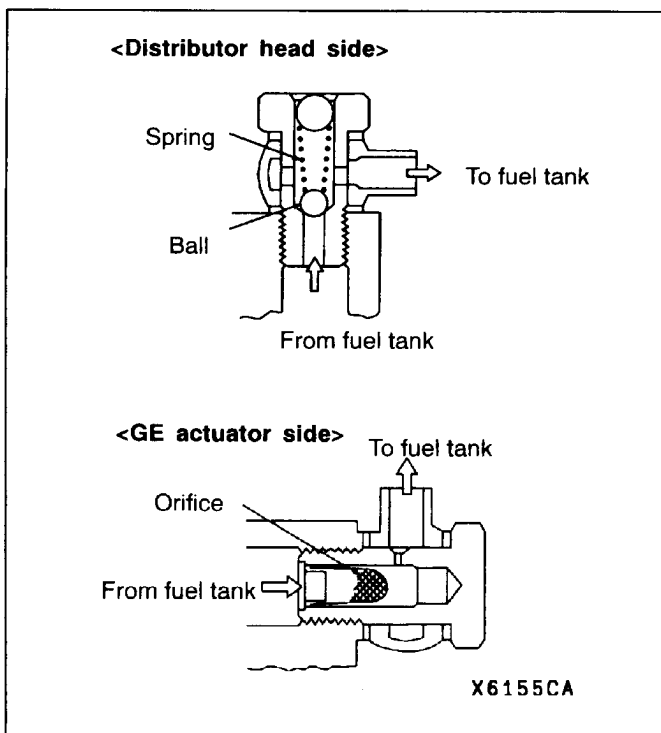
FUEL INJECTION TIMING CONTROL

- The timing control valve controls the fuel pressure which is applied to the timer piston in order to carry out fuel injection timing control.
- High pressure is constantly applied to one end of the timer piston, and low pressure is always applied to the other end. Furthermore, there are two fluid lines, line A at the high-pressure side and line B at the low-pressure side, and the timing control valve is located between the two.
- When the timing control valve opens in response to a signal from the engine-ECU, fuel flows from the high-pressure side to the low-pressure side, which causes the timer piston to move. This in turn causes the inner cam to rotate to control the fuel injection timing.



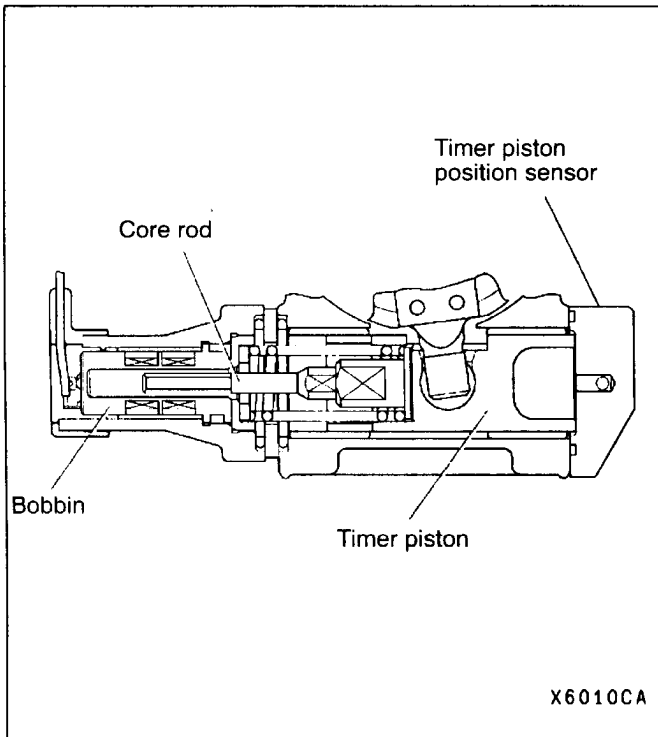
TIMING CONTROL VALVE (TCV)

- The timing control valve has a fuel inlet on the side of the middle section of the valve body, and a filter is attached to this inlet.
- This side hole connects internally with hole B at the end of the valve.
- The timing control valve has a needle valve inside it, and the end hole is seated inside this valve like a nozzle. When current flow to the timing control valve 3, the needle is pulled to the left by the magnet, so that the seated section at the end of the needle valve opens.



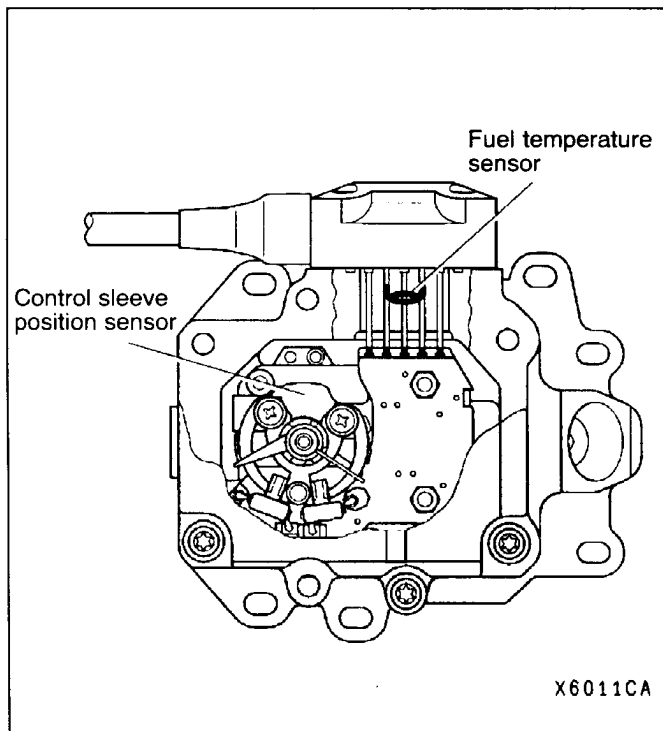
OVERFLOW VALVES

- There are two overflow valves: one at the distributor head and one at the GE actuator.
- The overflow valve at the distributor head has a check valve function. The setting force of the ball and spring inside the valve prevent the fuel from overflowing until the pressure inside the pump chamber reaches a certain level.
- The overflow valve at the GE actuator only has an orifice, and does not include a check valve function.



TIMER PISTON POSITION SENSOR

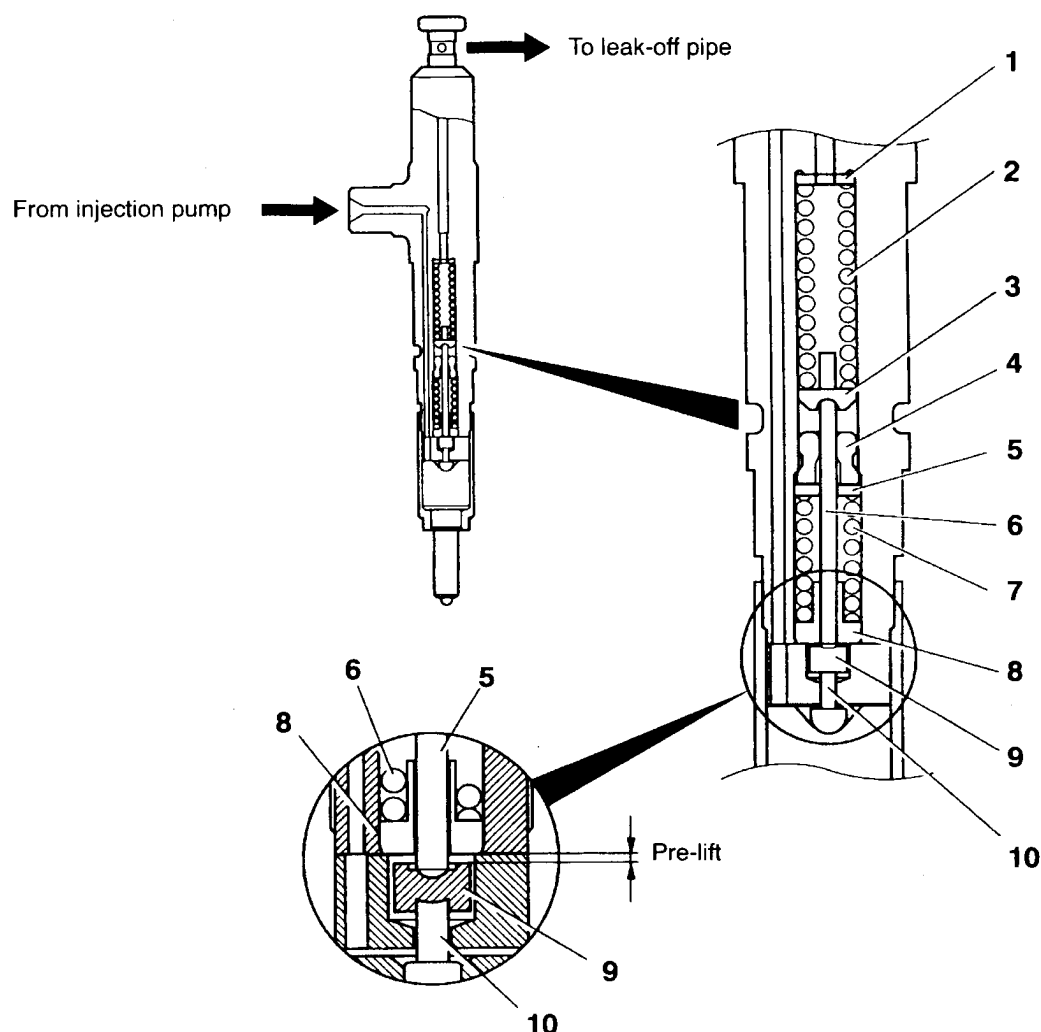
The timer piston position sensor consists of a core rod and a bobbin. It converts the position of the timer piston into an electrical signal and sends this to the engine-ECU as a timer piston position signal for feedback.



GE ACTUATOR

- The GE actuator has a built-in control sleeve position sensor and a fuel temperature sensor.
- The control sleeve position sensor detects the control sleeve position and sends feedback signals to the engine-ECU.
- The fuel temperature sensor detects the temperature of the fuel and sends corresponding signals to the engine-ECU.

INJECTION NOZZLE



X6012CA

1. Shim (for adjusting No. 1 opening valve pressure)
2. No. 1 spring
3. Spring seat A
4. Collar
5. Push rod
6. No. 2 spring
7. Shim (for adjusting No. 2 opening valve pressure)

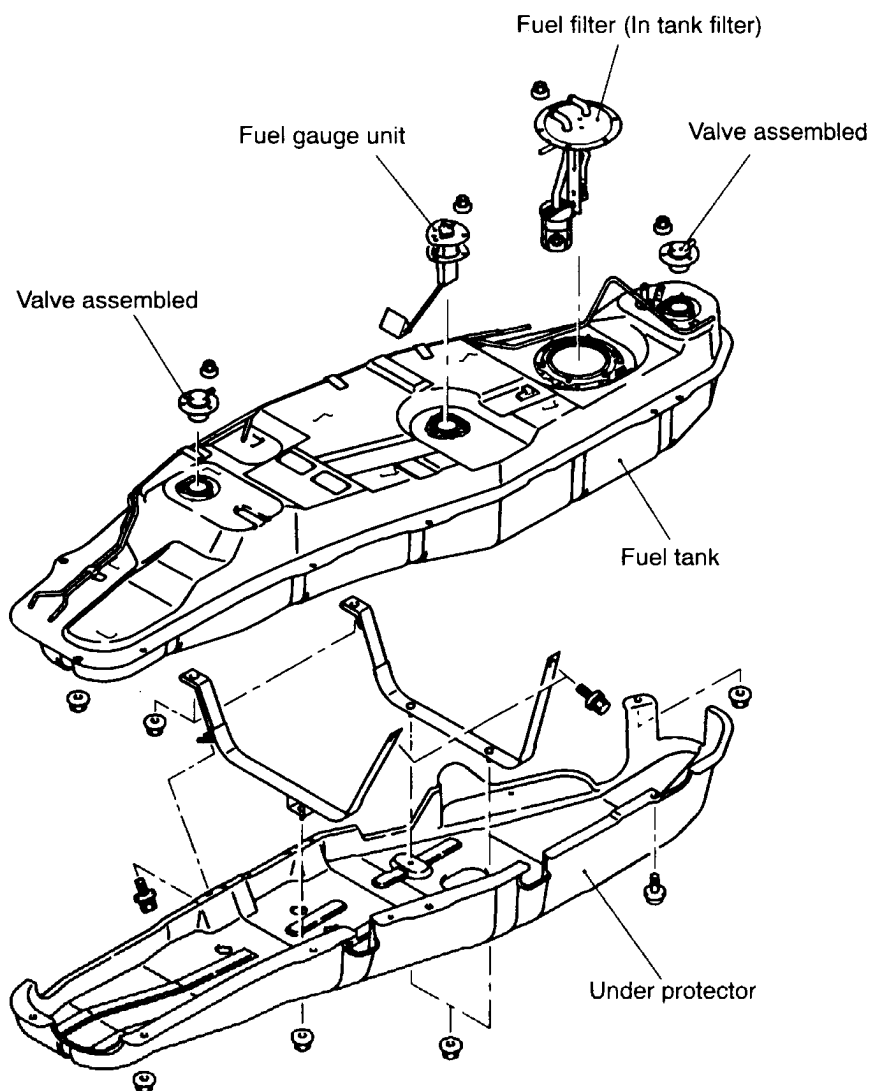
8. Spring seat B
 9. Lift piece
 10. Needle valve
- This nozzle has a pre-lift (clearance) between spring seat B and the lift piece, and the nozzle injection start pressure is determined by the spring force of the No. 1 spring.

- When the pressure (nozzle pipe pressure) of the fuel which is sent from the injection pump is applied to the No. 1 spring, the needle valve rises only by the pre-lift amount. The force at this time is transmitted to the needle valve, the lift piece, the push rod, spring seat A and the No. 1 spring to lift the No. 1 spring.
- When the lift piece rises by the pre-lift amount, it touches spring seat B. The No. 1 spring force and the No. 2 spring force combine at this time, and so the needle valve lift is momentarily stopped.
- When the fuel pressure increases and the nozzle pipe pressure defeats the combined pressure of the two springs, the needle valve rises further and the fuel is injected from the nozzle. At this time, the force is transmitted to the needle valve, the lift piece, spring seat B and the No. 2 spring, and so the No. 2 spring is lifted.

FUEL TANK

The fuel tank is a steel fuel tank which is located underneath the passenger seat floor. It has the following features.

- Lead-free materials have been adopted for the main fuel tank unit in consideration of protection of the global environment.
- A plastic under protector which is light in weight and has excellent corrosion resistance has been adopted.
- A valve assembly with an integrated cut-off valve which prevents fuel outflow and two-way valve which adjusts the fuel pressure inside the fuel tank has been adopted.

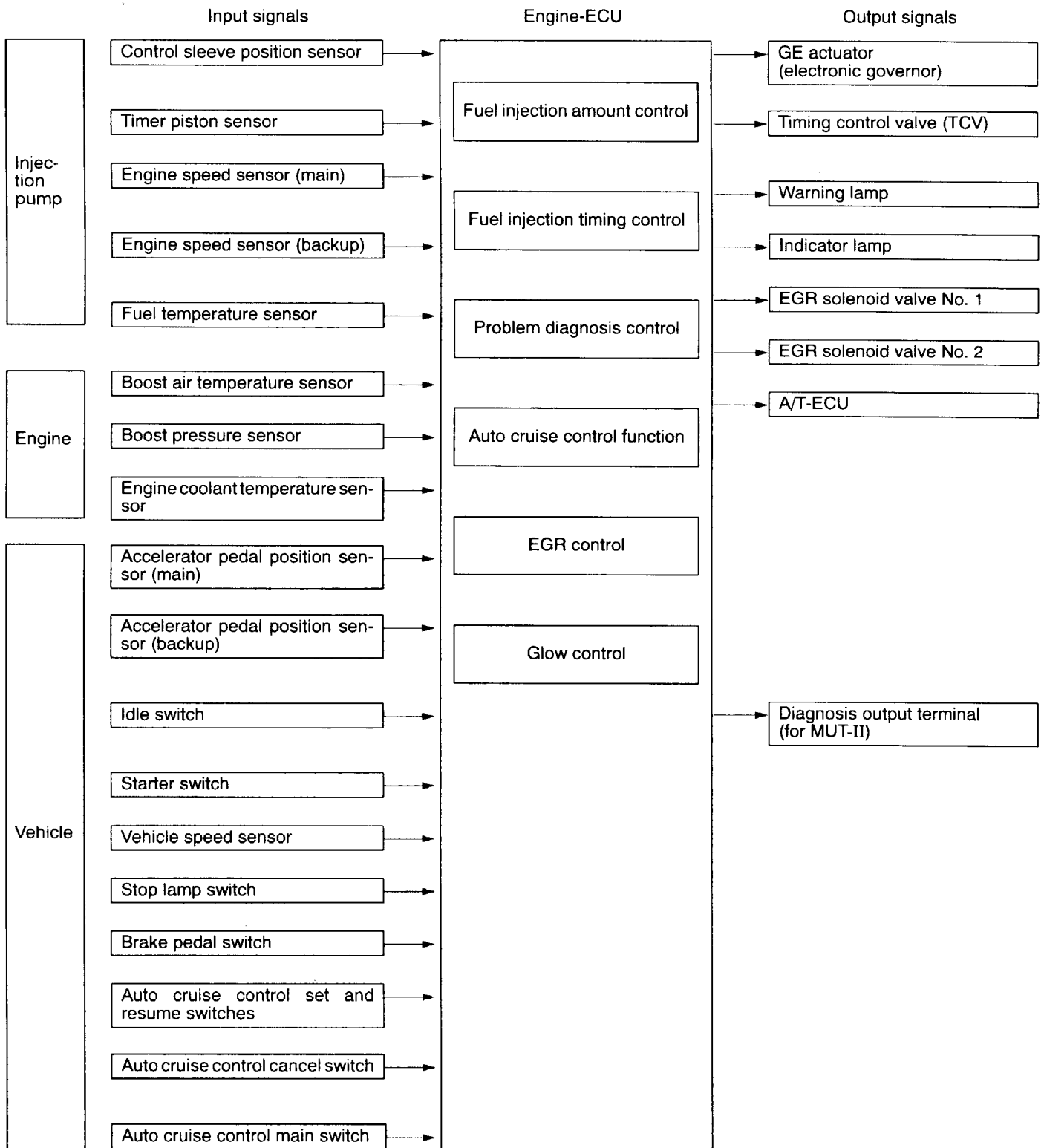


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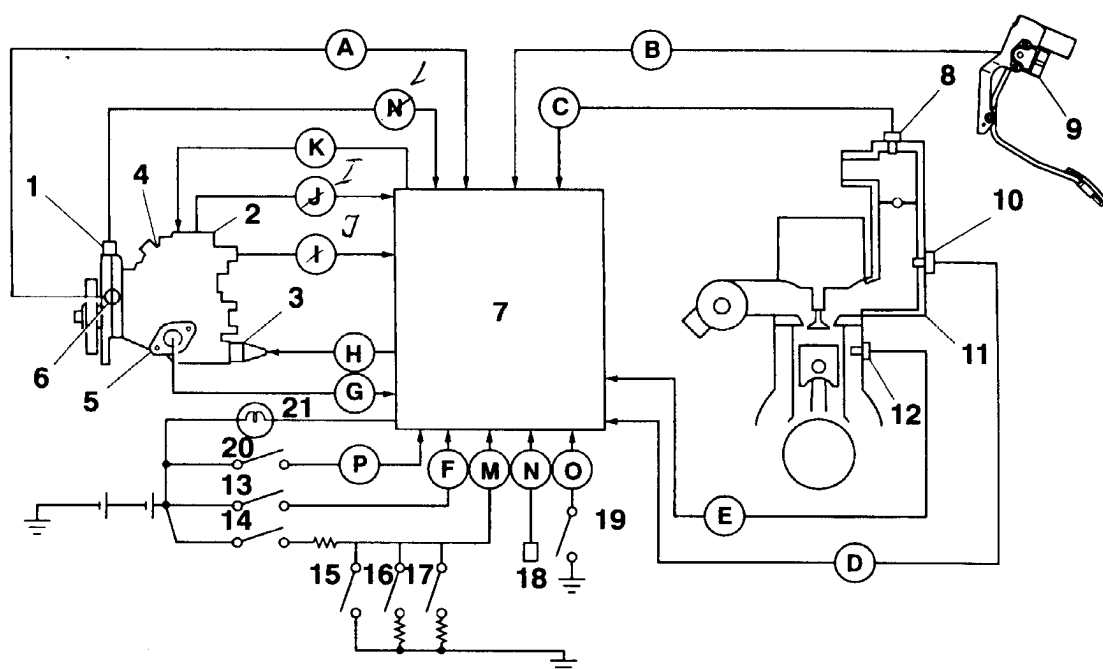
CONTROL SYSTEM

- The control system is basically the same as the electronically-controlled fuel injection system for the 4M40 engine installed in the previous PAJERO.

SYSTEM BLOCK DIAGRAM

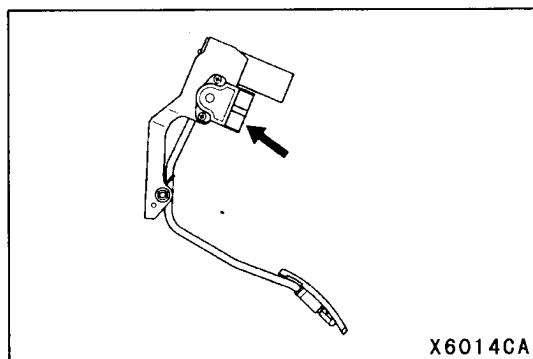


ELECTRONICALLY CONTROLLED FUEL INJECTION SYSTEM CONFIGURATION DIAGRAM



X6013CA

- | | |
|---|---|
| 1. Engine speed sensor (backup) | A. Engine speed signal |
| 2. GE actuator (with built-in control sleeve position sensor and fuel temperature sensor) | B. Accelerator opening angle signal and accelerator ON/OFF signal |
| 3. Timing control valve | C. Intake air temperature signal |
| 4. Injection pump | D. Boost pressure signal |
| 5. Timer piston position sensor | E. Engine coolant temperature signal |
| 6. Engine speed sensor (main) | F. Start signal |
| 7. Engine-ECU | G. Timer piston position signal |
| 8. Boost air temperature sensor | H. Timing control valve drive signal |
| 9. Accelerator pedal position sensor (idle switch) | I. Fuel temperature signal |
| 10. Boost pressure sensor | J. Control sleeve position signal |
| 11. Intake manifold | K. Fuel injection control signal |
| 12. Engine coolant temperature sensor | L. Engine speed signal (backup) |
| 13. Starter switch | M. Auto cruise control operation signal |
| 14. Auto cruise control main switch | N. Vehicle speed signal |
| 15. Auto cruise control cancel switch | O. Brake pedal switch ON signal |
| 16. Auto cruise control set switch | P. Brake pedal depression signal |
| 17. Auto cruise control resume switch | |
| 18. Vehicle speed sensor | |
| 19. Brake pedal switch | |
| 20. Stop lamp switch | |
| 21. Indicator lamp | |

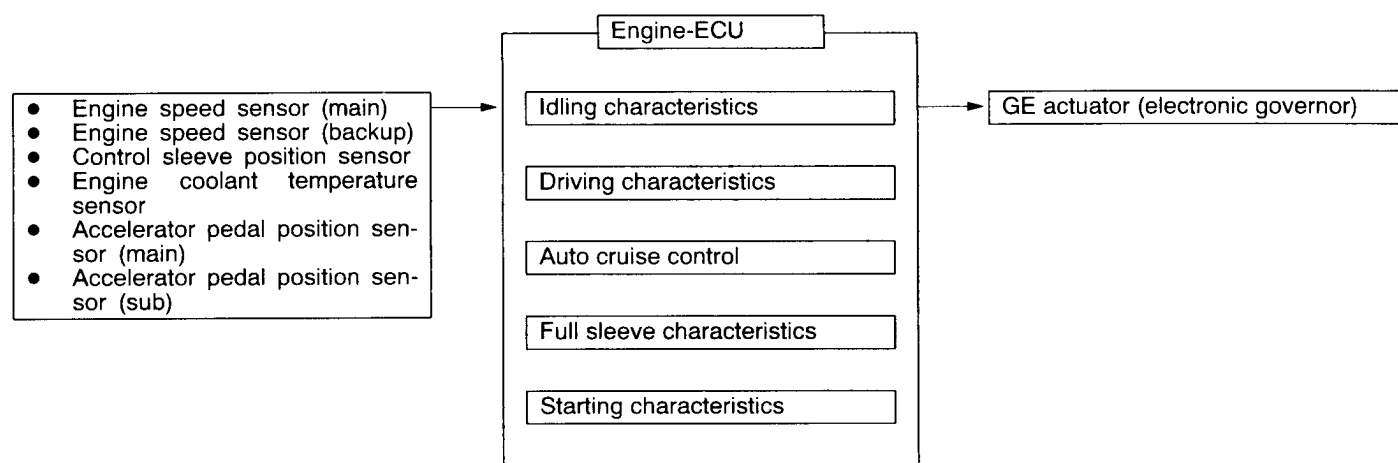


SENSOR

ACCELERATOR PEDAL POSITION SENSOR (APS)

- The dual-type accelerator pedal position sensor is installed directly to the accelerator pedal arm.
- The accelerator pedal position sensor detects the depression amount of the accelerator pedal, and electronically controls the throttle valve opening.

FUEL INJECTION AMOUNT CONTROL

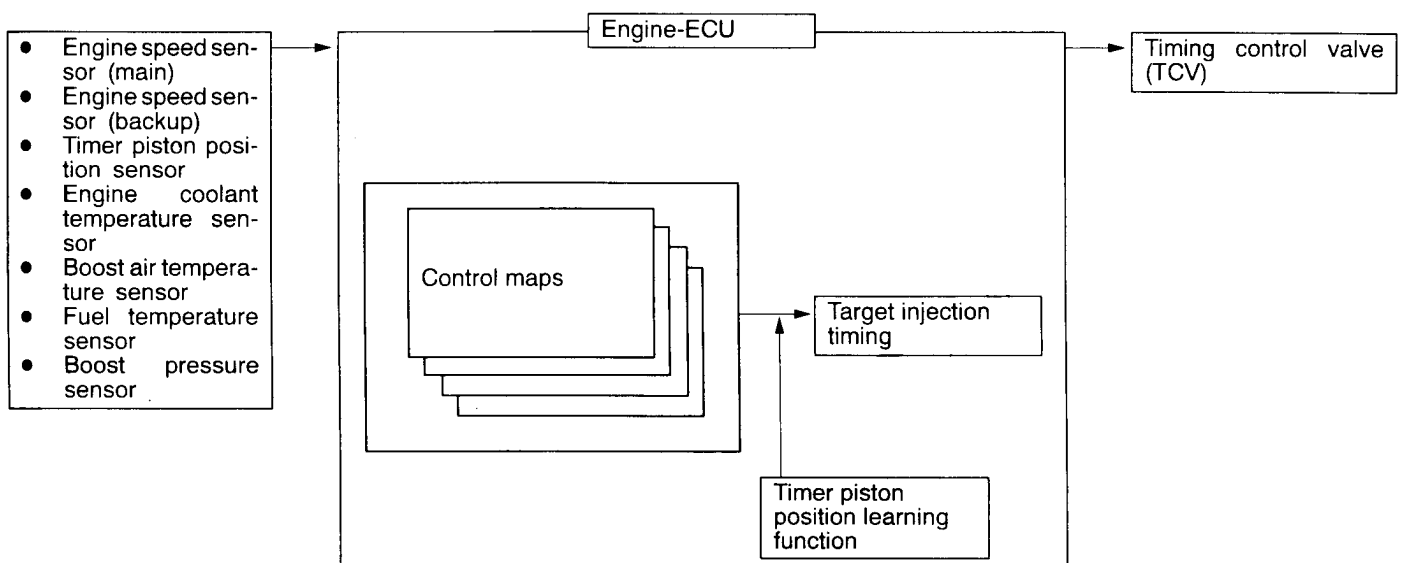


CONTROL BY ENGINE-ECU

- When the engine is running, control is carried out using the idling characteristics, driving characteristics and auto cruise control characteristics. The maximum fuel injection amount is selected based on the resulting output signals.
- After the fuel injection amount is selected, the fuel injection amount derived from the full sleeve characteristics is processed to select a minimum value so that the amount does not exceed the maximum fuel injection amount, and this is used to determine the target sleeve position. On the other hand, when the engine is starting, control is carried out using the starting characteristics, and the target sleeve position is set directly according to the data signal.
- The sleeve position signal thus determined is converted into an analogue signal (continuous) by the D/A converter, and then passes through the servo circuit and the drive circuit to drive the GE actuator in order to move the control sleeve.

CONTROL BY CONTROL SLEEVE POSITION SENSOR

- The control sleeve position sensor detects the operating condition of the control sleeve. In other words, it detects the control sleeve position in order to judge whether the control sleeve has moved to the target position or not, and sends a feedback signal to the engine-ECU.
- When the feedback signal is received, the engine-ECU calculates the actual measurement value for the control sleeve position, and if this differs from the target position, it issues a correction command.
- This operation is carried out repeatedly so that the control sleeve position is always at the target position for controlling the fuel injection amount.

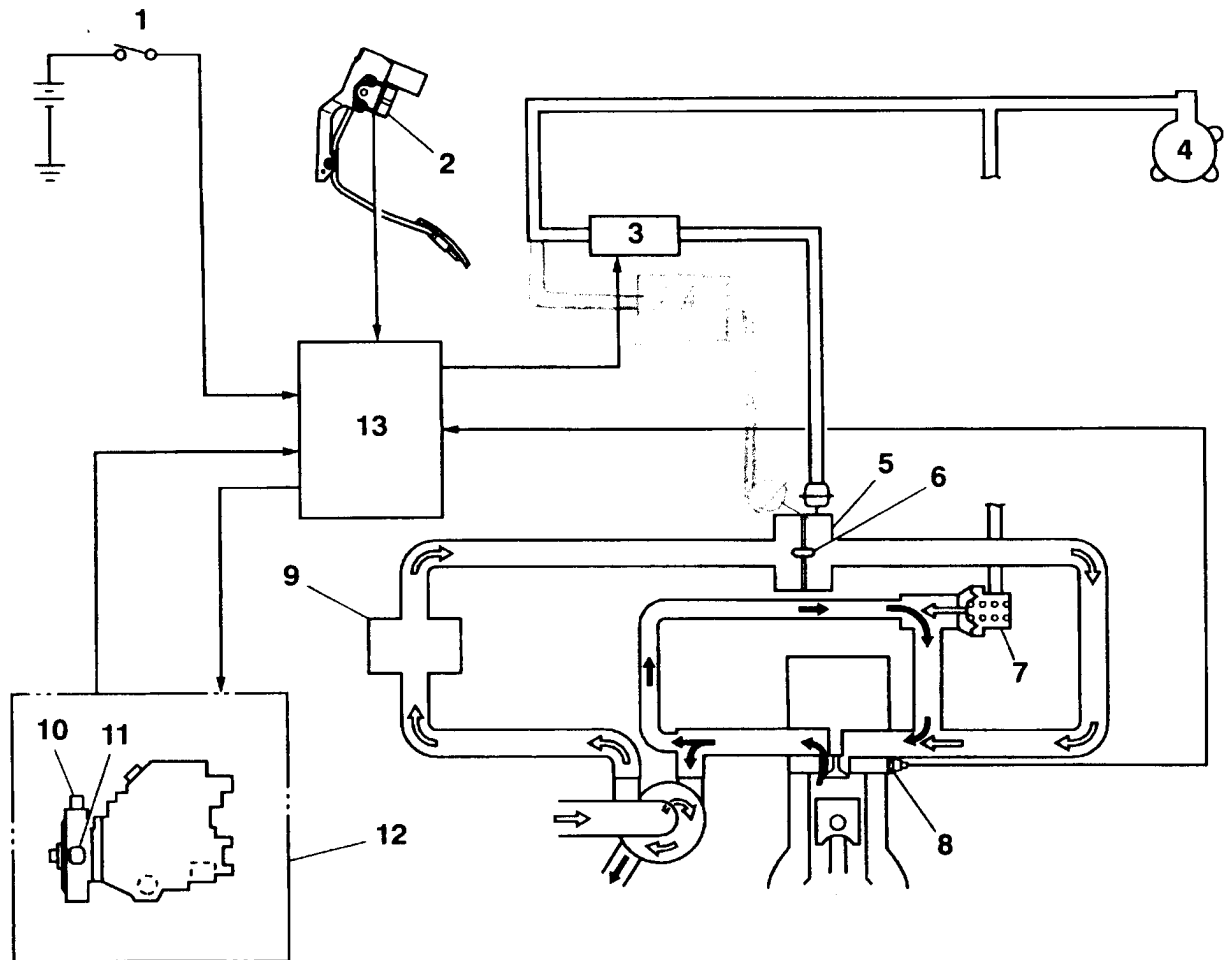
FUEL INJECTION TIMING CONTROL**CONTROL BY ENGINE-ECU**

- When the engine is running, control is carried out by each control map.
- Furthermore, errors in injection pump operation such as incorrect adjustment of the timer piston position sensor found by the timer piston position learning function are corrected by the timer piston position sensor output voltage to determine the target injection timing.
- The engine-ECU drives the timing control valve (TCV) based on the target injection timing thus determined to control the fuel injection timing.
- When the engine is starting, the fuel injection timing is controlled by the starting correction map in each control map.

CONTROL BY TIMER PISTON POSITION SENSOR

- The timer piston position sensor detects the position of the timer piston. In other words, it detects the timer piston position in order to judge whether the fuel injection timing is being controlled to the target value to the target position or not, and sends a feedback signal to the engine-ECU.
- When the feedback signal is received, the engine-ECU it issues a correction command if the target value and the actual measurement value are different.
- This operation is carried out repeatedly so that the timer piston position is always at the target position in order to determine the final fuel injection timing.

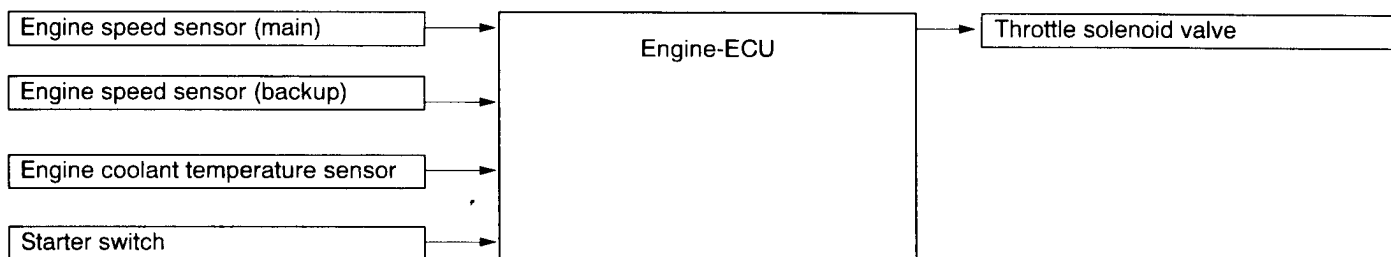
THROTTLE VALVE CONTROL



X6156CA

- | | |
|--|--------------------------------------|
| 1. Starter switch | 7. EGR valve |
| 2. Accelerator pedal position sensor
(built-in idle switch) | 8. Engine coolant temperature sensor |
| 3. Throttle solenoid valve | 9. Intercooler |
| 4. Vacuum pump | 10. Engine speed sensor (main) |
| 5. Throttle body assembly | 11. Engine speed sensor (backup) |
| 6. Throttle valve | 12. Injection pump |
| | 13. Engine-ECU |

- In throttle body assembly control, the driving condition is detected by means of input signals from the various sensors, and the engine-ECU then controls the throttle solenoid valve in accordance with the driving condition to open and close the throttle valve.

SYSTEM BLOCK DIAGRAM**THROTTLE VALVE OPERATION****When engine is stopped**

When the starter switch changes from on to off, the throttle solenoid valve turns on for 0.3 seconds to close the throttle valve. After this, the throttle solenoid valve turns off and the throttle valve opens.

When engine starts

The throttle solenoid valve is normally off, so that the throttle valve is normally open.

When engine is running

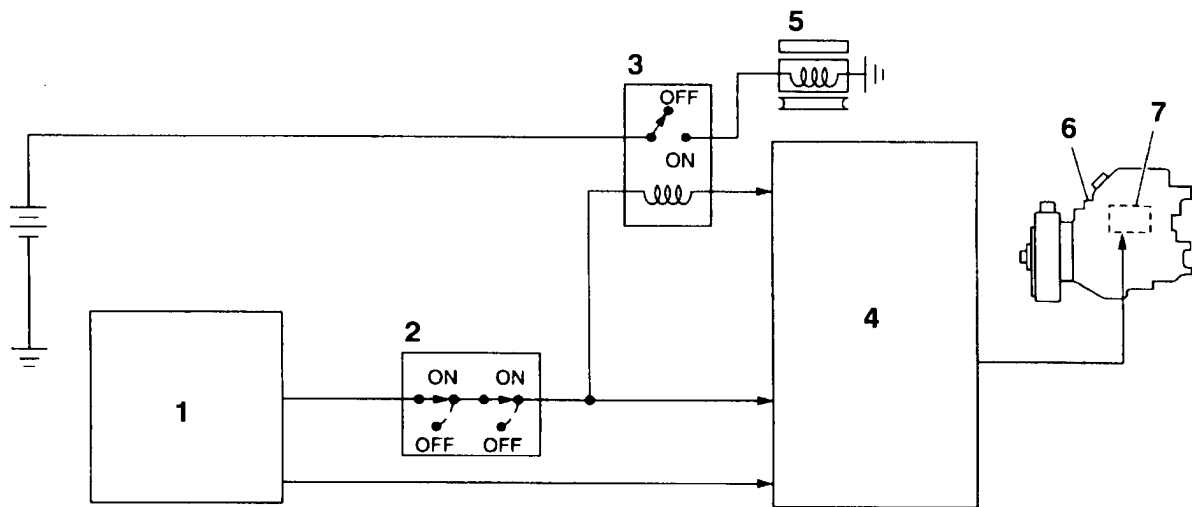
The throttle solenoid valve is normally off, so that the throttle valve is open. However, if the following conditions occur, the throttle solenoid valve turns on and the throttle valve closes.

- 1) Engine coolant temperature $\geq 65 - 77^{\circ}\text{C}$
- 2) Barometric pressure $> 92 - 94 \text{ kPa}$
- 3) Engine speed $< 1000 \text{ r/min}$
- 4) Accelerator pedal position sensor output $< 1.17 - 2.34 \%$

When a problem develops

The throttle valve closes if diagnosis code No. 21, 26 or 48 is generated.

A/C RELAY CONTROL, IDLE SPEED CONTROL



X6016CA

- 1. A/C compressor-ECU
- 2. Dual pressure switch
- 3. A/C relay
- 4. Engine-ECU

- 5. A/C compressor magnet clutch
- 6. Injection pump
- 7. GE actuator

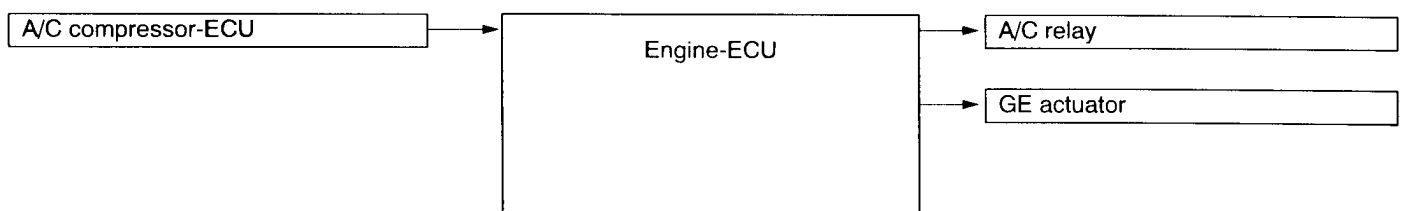
A/C RELAY CONTROL

- For A/C relay control, the driving condition is detected by means of input signals from the various sensors, and the A/C relay is controlled in accordance with the driving condition.
- The A/C compressor-ECU applies system voltage to the engine-ECU when the air conditioner is running.
- When an A/C ON signal is input to the engine-ECU, the engine-ECU turns on the power transistor. This causes current to flow to the power coil of the A/C relay. The relay switch then turns on to operate the A/C compressor magnet clutch.

IDLE SPEED CONTROL

- In N or P range, the idle speed is controlled in three stages according to the air conditioner load.
- The A/C compressor-ECU applies three different voltages to the engine-ECU depending on the air conditioner load.
- The engine-ECU detects the A/C compressor-ECU voltage and sends a corresponding signal to the GE actuator to control the idle speed.

SYSTEM BLOCK DIAGRAM



SELF-DIAGNOSIS SYSTEM

The engine-ECU is provided with the following functions to make system inspection easier.

- Engine warning lamp control
- Diagnosis function
- Actuator tests

NOTE

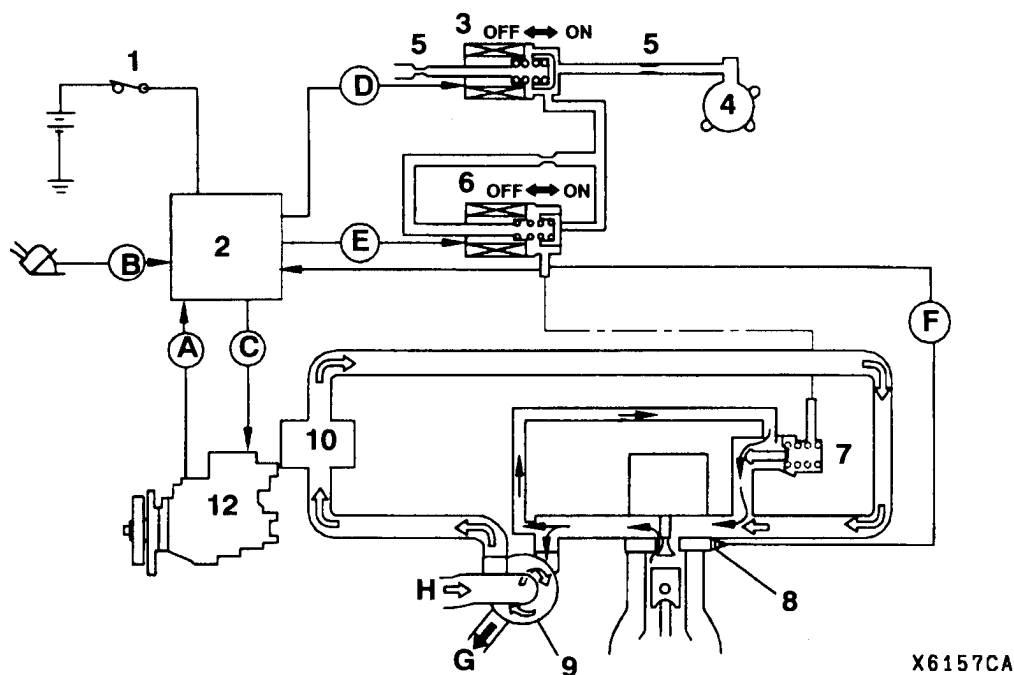
Refer to the Workshop Manual for details on each function.

EMISSION CONTROL SYSTEM

The exhaust gas purification system is basically the same as the system used for the 4M40 engine in the previous PAJERO.

EGR SYSTEM

EGR SYSTEM DIAGRAM



1. Starter switch
2. Engine-ECU
3. EGR solenoid valve No. 1
(duty control)
4. Vacuum pump
5. Orifice
6. EGR solenoid valve No. 2
(ON-OFF control)
7. EGR valve
8. Engine coolant temperature sensor
9. Turbocharger
10. Intercooler
11. Fuel injection pump

- A. Engine speed signal
- B. Accelerator opening angle signal
- C. Fuel injection timing control signal
- D. Duty control signal
- E. ON-OFF control signal
- F. Engine coolant temperature signal
- G. Exhaust gas
- H. Intake air

MOUNT

The engine is basically the same as that of the 6G7 engine. (Refer to P.1–32.)

AUTO-CRUISE CONTROL SYSTEM

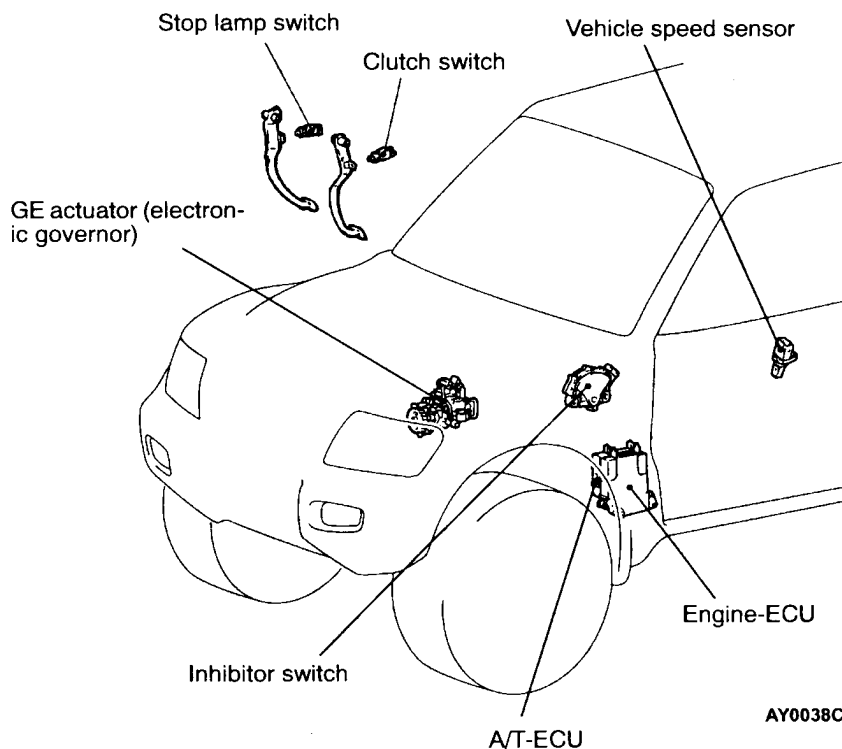
By using the auto-cruise control, the driver can drive at preferred speeds in a range of approximately 40 to 200 km/h without depressing the accelerator pedal.

In line with the adoption of an electronically-controlled fuel injection system, the previous system in which a negative pressure actuator was used to operate the throttle valve in order to control the

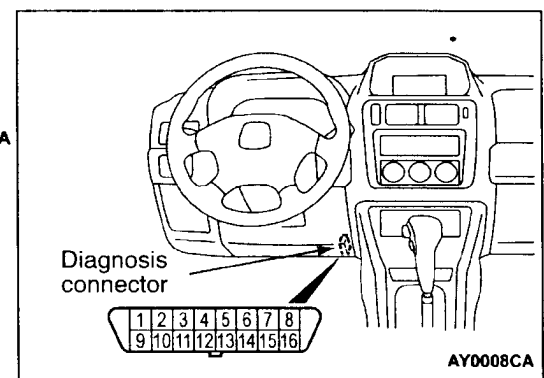
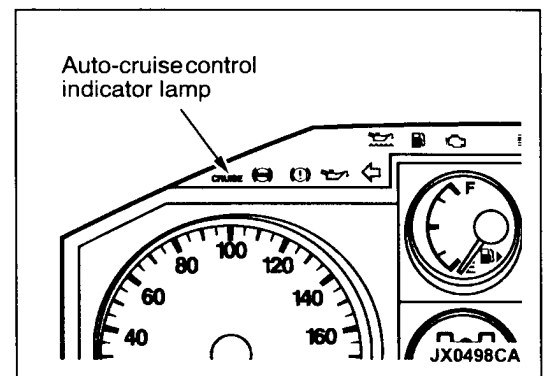
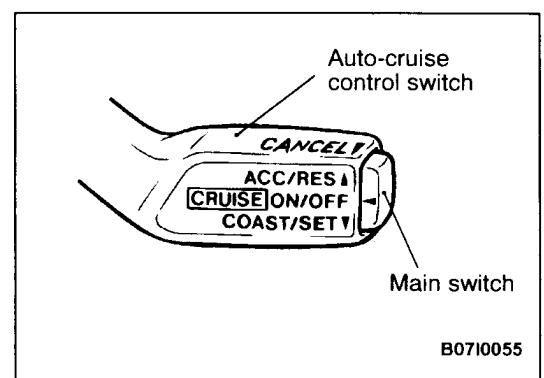
injection pump has been replaced with a system in which a GE actuator (electronic governor) is controlled by signals from the engine-ECU.

In addition, the same auto-cruise control switch used for the 6G7 engine which integrates the main switch and the control switch has been adopted in order to improve ease of operation.

CONSTRUCTION DIAGRAM



AY0038CA



COMPONENTS AND OUTLINE OF FUNCTIONS

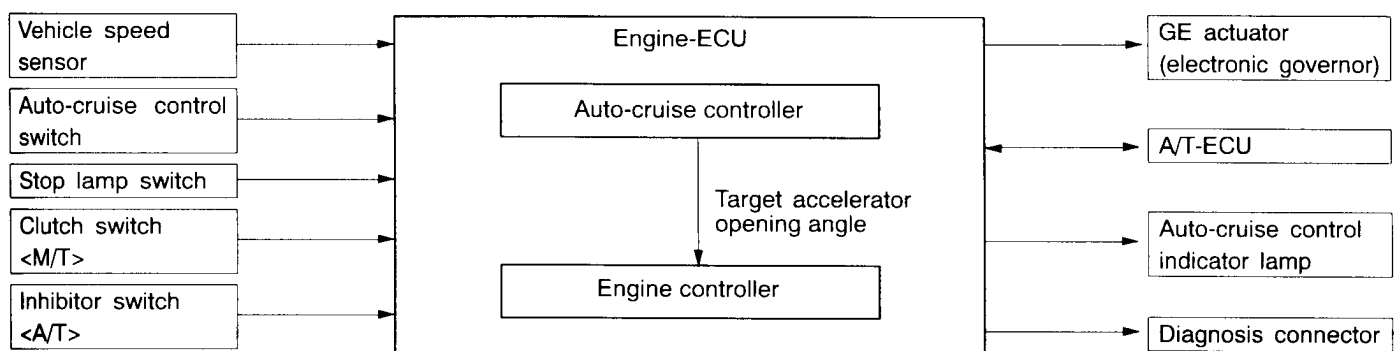
Components		Outline of function
Auto-cruise control switch	Main switch	System operation switch.
	SET (COAST) switch	Vehicle speed setting switches.
	RESUME (ACCEL) switch	
	CANCEL switch	Cruise control cancel switch.
Vehicle speed sensor		Outputs pulse signals which are directly proportional to the vehicle speed (the speed of the transmission output gear) to the engine-ECU.
Stop lamp switch		Outputs a cruise control cancel signal (stop lamp switch : ON, clutch switch : ON, inhibitor switch : N position) to the throttle valve controller. In addition, the stop lamp switch outputs an ON signal to the engine-ECU.
Clutch switch <M/T>		
Inhibitor switch <A/T>		
Engine-ECU		Performs calculation in the auto-cruise controller based on the various input signals, and transmits the fuel injection amount from the engine controller to the GE actuator (electronic governor). In addition, it transmits shift-up and shift-down signals to the A/T-ECU in accordance with the driving condition.
GE actuator (electronic governor)		Controls the fuel injection amount for the electronically-controlled injection pump in accordance with signals from the engine-ECU.
A/T-ECU		Causes the transmission to shift down or shift up in accordance with signals from the engine-ECU. In addition, it outputs the state of the A/T to the engine-ECU.
Diagnosis connector		Allows the diagnosis codes and service data output from the engine-ECU which are related to the cruise control system to be read by connecting the MUT- II .
Auto-cruise control indicator lamp		Built into the combination meter, this lamp illuminates when the auto-cruise control switch is turned on.

SYSTEM OUTLINE

The engine-ECU calculates the target accelerator opening angle at the auto-cruise controller based on signals which are input from the vehicle speed sensor, cruise control switch, stop lamp switch and inhibitor switch, and outputs the result to the engine controller. When it receives this signal, the engine

controller outputs a fuel injection command signal to the GE actuator (electronic governor) in order to control the fuel injection amount. In addition, it outputs shift-down or shift-up signals to the A/T-ECU as required.

BLOCK DIAGRAM



SYSTEM FUNCTION

All functions other than those given below are the same as for the 6G7 engine. (Refer to P.11-35.)

DIAGNOSIS FUNCTIONS**1. Self-diagnosis**

When there is a cancellation of the auto-cruise control system operation not intentionally made by the driver, it is possible to determine the cause simply by reading the diagnosis code.

Diagnosis trouble code chart

Code No.	Major contents of diagnosis
15	Auto-cruise control switch system abnormality
22	Stop lamp switch system abnormality
23	Engine-ECU system abnormality

2. Service data output

The service data output are shown in the following.

ITEMS NO.	SERVICE DATA ITEM	UNIT
01	Auto-cruise control switch	"MAIN"
02		"SET"
03		"RESUME"
04		"CANCEL"
05	Stop lamp switch	ON/OFF
06	Brake switch	ON/OFF
07	Clutch switch <M/T> or inhibitor switch <A/T>	ON/OFF
08	Accelerator switch (Idle switch)	ON/OFF
09	During cruise control	ON/OFF
10	Vehicle speed sensor	km/h
12	Accelerator pedal position sensor (APS)	mV

NOTE

If two more actions are taken at the same time, codes are output in ascending order of code number.

ACCELERATOR SYSTEM

Refer to P.1-38.