



Technical Guide



X-TYPE Powertrain Introduction



BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH II
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY



BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH
THE QUEEN MOTHER
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY



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Technical Guide

X-TYPE Powertrain Introduction

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Preface

This Technical Guide introduces the Jaguar X-TYPE. It is intended to give Jaguar Dealer workshop personnel an overview of the vehicle and is for information purposes only. The contents of this Technical Guide must not be used as a reference source for servicing procedures; all servicing must be carried out in accordance with the appropriate JTIS disc.

This Technical Guide will not be updated. While every effort is made to ensure accuracy, changes may occur between going to press and the equipment being introduced to the market. Once the equipment is in service, details of the changes can be obtained from Service Bulletins and revisions to the JTIS disc.

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Glossary

The following abbreviations and acronyms are used in this publication:

Abbreviation / Acronym	Description
ac	alternating current
AM	amplitude modulation
AWD	all-wheel drive
CAN	controller area network
CD	compact disc
CKP sensor	crankshaft position sensor
cm	centimeter
CO	carbon monoxide
D2B	digital data bus
dc	direct current
DSC	dynamic stability control
DTC	diagnostic trouble code
DVD	digital versatile disc
ECM	engine control module
EGR	exhaust gas recirculation
EVAP canister	evaporative emission canister
FC module	fan control module
FM	frequency modulation
FP module	fuel pump module
HO2 sensor 1	heated oxygen sensor 1
HO2 sensor 2	heated oxygen sensor 2
IAT sensor	intake air temperature sensor
IFS switch	inertia fuel shutoff switch
IMT valves	intake manifold tuning valves
in	inch
ISO	International Standards Organization
JTIS	Jaguar technical information system
kbps	kilobits per second
km/h	kilometers per hour
kV	kilovolt
LED	light emitting diode
LH	left-hand
LHD	left-hand drive
MAF sensor	mass air flow sensor
MAP sensor	manifold absolute pressure sensor
MHz	megahertz
MIL	malfunction indicator lamp
mile/h	miles per hour
mm	millimeter
ms	millisecond
MY	model year
N	newton
NAS	North American specification
NOx	oxides of nitrogen
NVH	noise, vibration and harshness
OBD	on-board diagnostics
ORVR	on-board refueling vapor recovery

RF	radio frequency
RH	right-hand
RHD	right-hand drive
SRS	supplementary restraints system
TCM	transmission control module
TFT sensor	transaxle fluid temperature sensor
TG	technical guide
TP sensor	throttle position sensor
VEMS	vehicle emergency messaging system
VIN	vehicle identification number
VVT	variable valve timing
W	watt
WDS	worldwide diagnostic system

This publication compliments the X-TYPE Sedan Introduction, Technical Guide.

The new X-TYPE is the first Jaguar to feature all-wheel drive (AWD), providing the vehicle with added safety with regards to vehicle traction and handling and with the benefits of nimble and sporting driving dynamics. The AWD is controlled by the transfer case providing a torque split of 39% to the front wheels and 61% to the rear wheels.

Another new feature is the 'transversely mounted' normally aspirated engine, derived from the AJ-V6 engine already successfully proven in the Jaguar S-TYPE sedan. The engine is available in either 2.5 or 3.0 liter form, both of which provide an effortless and refined performance. Both engines are controlled by a completely new electronic control system.

The X-TYPE is also the first Jaguar to be installed with a transversely mounted transaxle which combines both the transmission and front differential into one unit. The term transaxle, developed from the terms transmission and axle, is used to describe this type of arrangement. The transaxle is available in either automatic or manual versions.

A returnless fuel system is employed to reduce the formation of fuel vapor (evaporative emissions) in the fuel tank. The fuel tank is saddle-shaped, a design also used on the S-TYPE to allow for the route of the driveshaft and exhaust system.

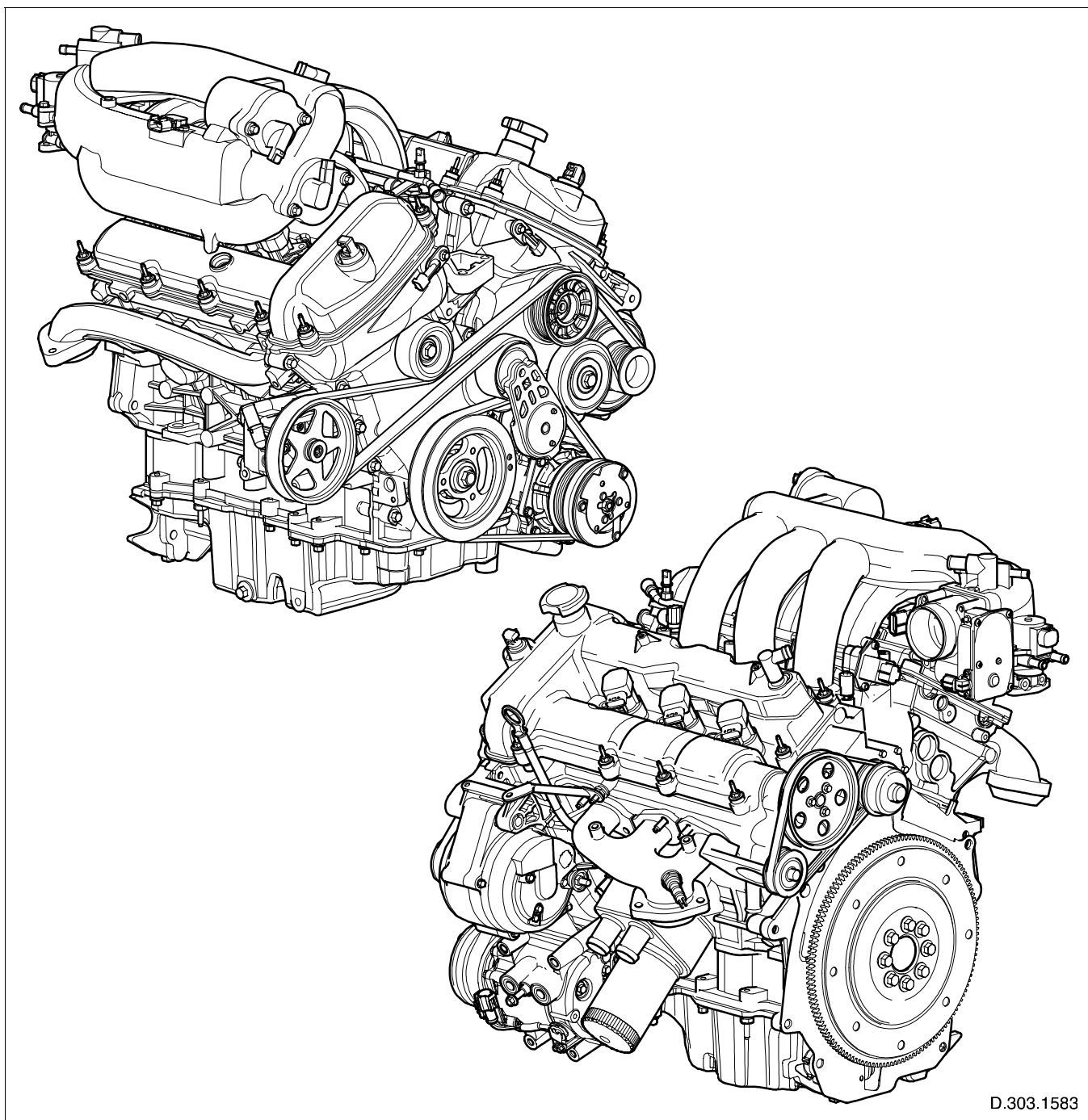
Engine

Transverse Engine

The X-TYPE is the first Jaguar to be installed with a transversely mounted engine. This arrangement provides the following benefits over the longitudinal engine arrangement when applied to a compact vehicle:

- Enables the major powertrain components to be accommodated in the engine compartment providing more occupant space within the vehicle by eliminating floor protrusions created by the longitudinal installation of gearboxes, etc.
- A shorter hood length can be attained for vehicle styling purposes.
- The all-wheel drive system is easier to adapt to a transverse engine and is less space consuming when compared to installing to a longitudinal engine arrangement.

The 2.5 and 3.0 liter AJ-V6 engines, are both variants of the S-Type 3.0 liter engine, the design changes implemented to accommodate the transverse installation and enhance engine performance are discussed in this section.



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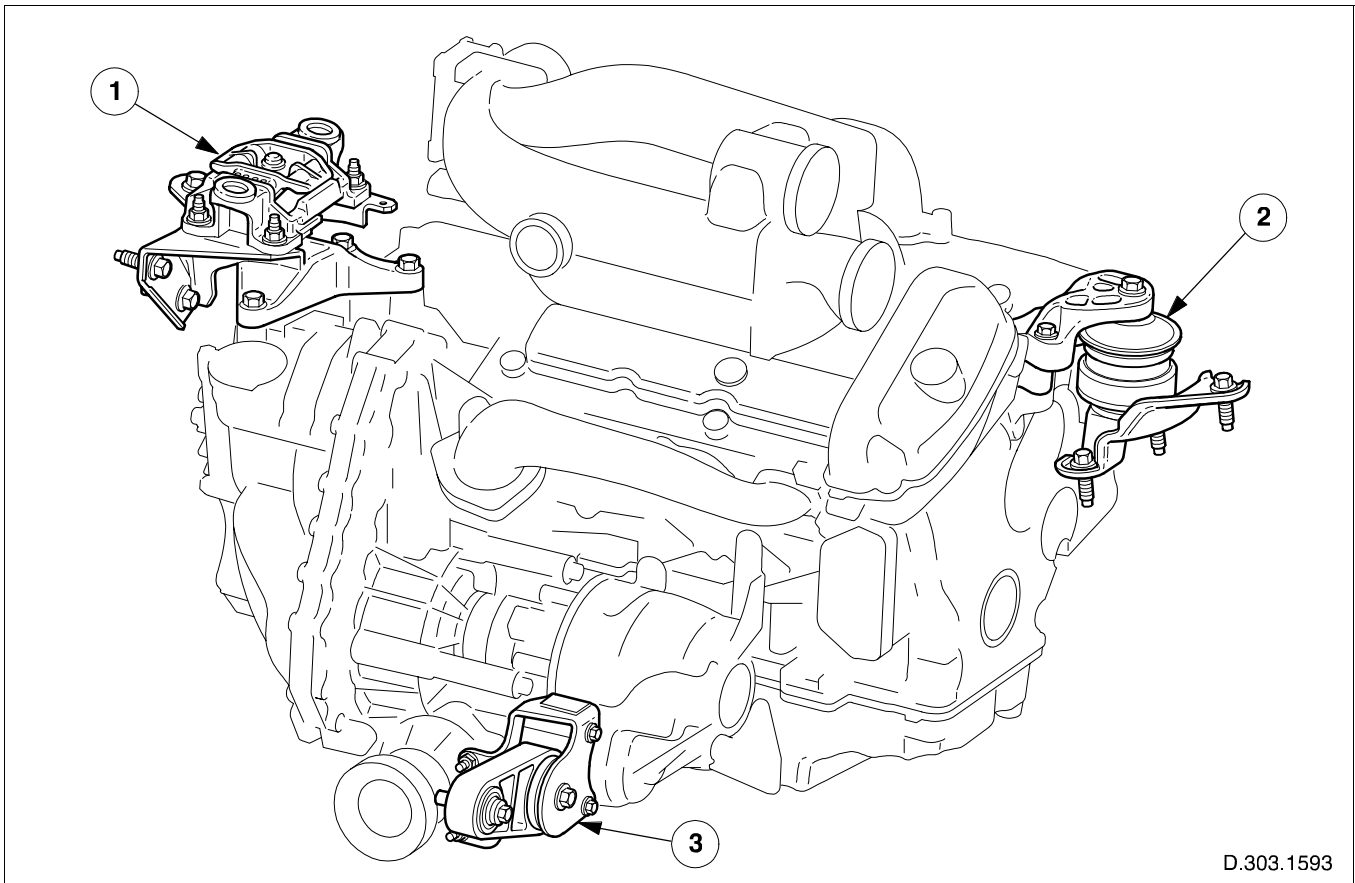
Fig. 1 Transverse AJ-V6 Engine

Engine

Engine Mountings

The engine mountings are designed to accommodate the transverse engine configuration. The hydramount and transaxle mountings provide optimum ride performance, and noise, vibration and harshness (NVH) damping.

The torque roll restrictor controls powertrain stability while also providing optimum NVH damping.



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Fig. 2 Engine mountings

1. Transaxle mount (automatic variant design shown)
2. Hydramount
3. Torque roll restrictor

Engine Capacity and Cylinder Heads

3.0 Liter Engine

The 3.0 liter cylinder head and gasket have been modified to accommodate the continuous variable valve timing (VVT) system, and coolant pump relocation; refer to **Fig. 6**.

2.5 Liter Engine

The engine cylinder bore and pistons have been reduced to achieve the 2.5 liter capacity; piston stroke remains the same as the 3.0 liter engine. A 2.5 liter cylinder head and gasket have been designed to accommodate the smaller-bore cylinder block and continuous VVT system; intake and exhaust valves are also a reduced size. Coolant pump relocation has also been accommodated; refer to **Fig. 6**.

Variable Valve Timing

The variable valve timing (VVT) system changes the phasing of the intake valves, relative to the fixed timing of the exhaust valves and with respect to fixed valve timing alters:

- the mass of air-flow into the engine's cylinders,
- the engine's torque response and emissions.

The continuous VVT used on the X-TYPE is a further development of the two-positional system used on the S-TYPE 3.0L engine. This continuous system works on the same principle as that used on the V8 (AJ27) engine 1999 MY, where instead of selecting one of two possible inlet camshaft positions, the continuous system operates over a range of 30 degrees and is advanced or retarded to the optimum angle within this range.

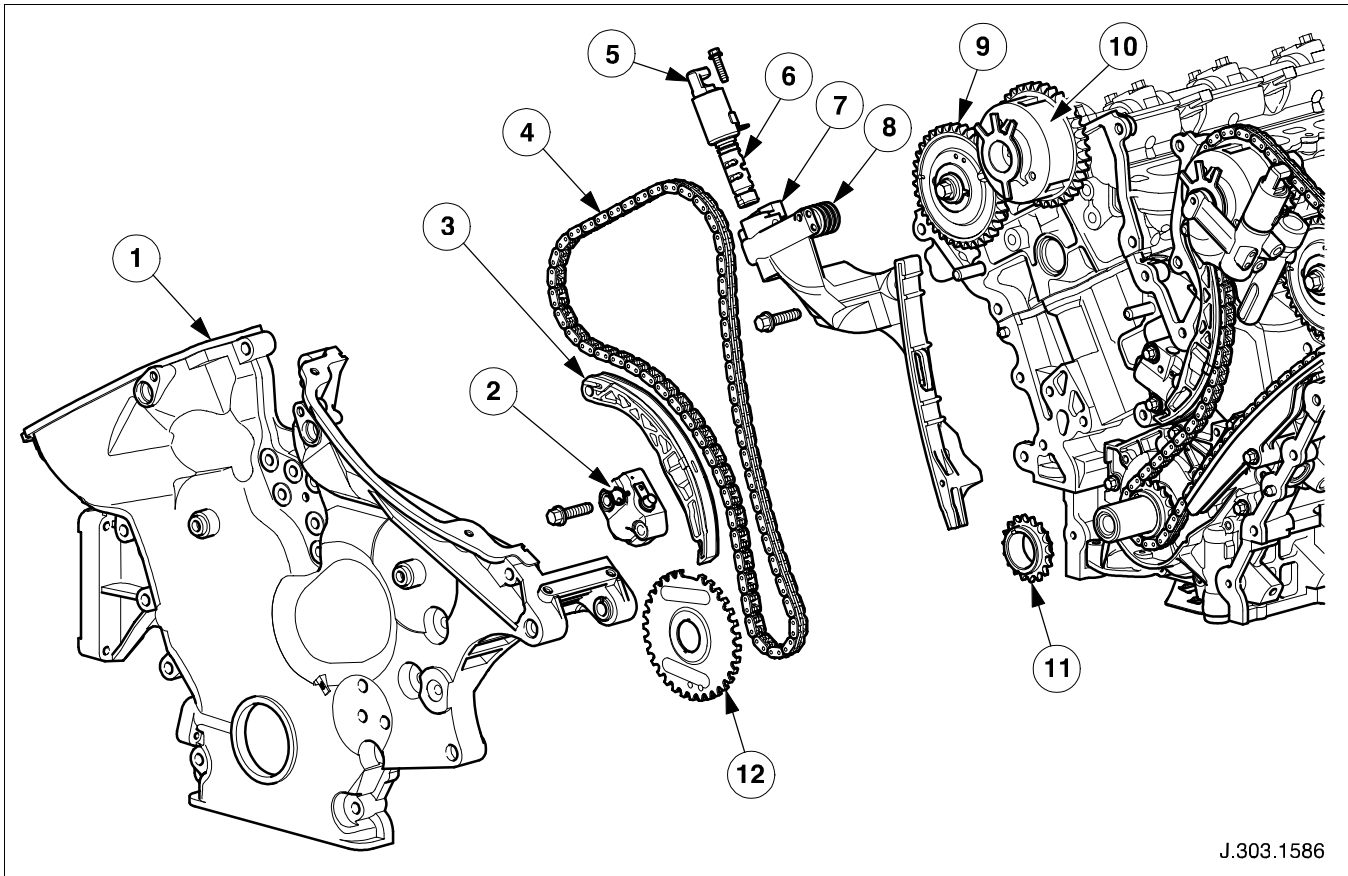
Although the principle function of the X-TYPE VVT is the same as that used on the AJ-27 engine the internal operating components of this VVT unit are different. Instead of a helical gear construction the X-TYPE unit uses a vane device to control the camshaft angle. Refer to **VVT Operation**.

The VVT is controlled by the engine control module (ECM) which uses engine control signals pertaining to engine speed and load, and engine oil temperature to calculate the appropriate camshaft position.

The continuous VVT system provides the following advantages over the two-positional system:

- Reduces engine emissions and fuel consumption by further optimizing the camshaft timing, this improves the engine's internal exhaust gas recirculation (EGR) effect over a wider operating range, therefore eliminating the need for an external EGR system.
- Improved full-load torque characteristics as the camshaft timing can be optimized at all engine speeds for superior volumetric efficiency.
- Improves fuel economy by optimizing torque over the engine's speed range, this is not fully achievable with the two positional system.

The system also has the added benefits of operating at a lower oil pressure and faster response time.



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Fig. 3 Timing gear

- | | |
|-------------------------|--|
| 1. Front engine cover | 7. Bush carrier and chain guide |
| 2. Tensioner | 8. Oil feed bush |
| 3. Tensioner arm | 9. Exhaust camshaft sprocket |
| 4. Timing chain | 10. VVT unit — intake camshaft |
| 5. Oil control solenoid | 11. Crankshaft sprocket |
| 6. Shuttle valve | 12. Crankshaft position sensor — pulse wheel |

VVT Operation

The VVT unit is a hydraulic actuator mounted on the end of the inlet camshaft, which advances and retards the inlet camshaft timing and thereby alters the camshaft to crankshaft phasing. Engine oil pressure operates the VVT unit, under the control of the ECM which activates the oil control solenoid. Oil pressure is routed to either the advance or retard chambers, located either side of each of the four vanes interspersed within the machined housing of the unit.

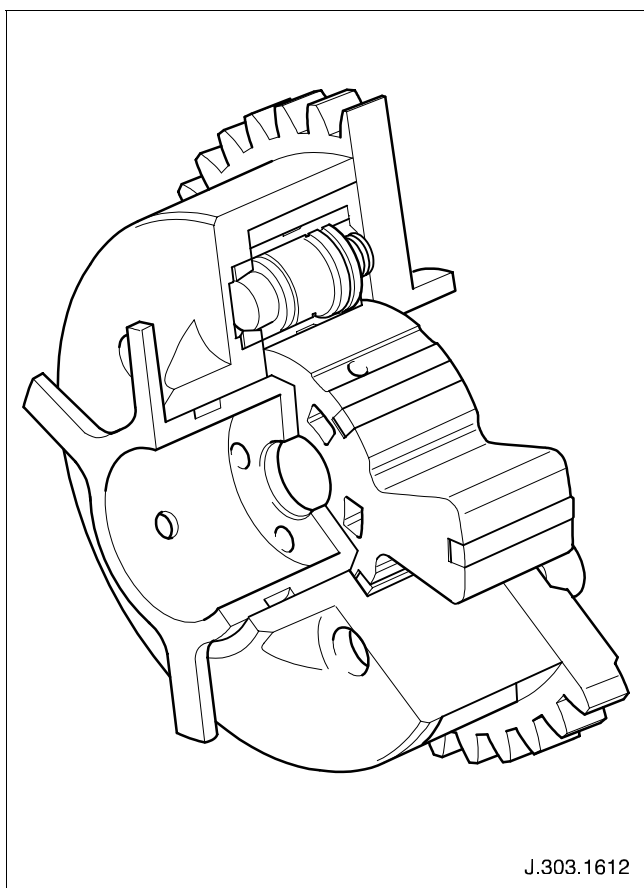


Fig. 4 VVT unit

The VVT unit is driven by the timing chain and rotates relative to the exhaust camshaft sprocket. When the ECM requests the camshaft timing to advance, the oil control solenoid is energized moving the shuttle valve to the relevant position to allow engine oil pressure, via a filter, into the VVT unit's advance chambers. When the camshaft timing is requested to retard the shuttle valve moves position to allow oil pressure to exit the advance chambers, while simultaneously routing the oil pressure into the retard chambers.

When directed by the ECM the VVT unit will be set to the optimal position between full advance and retard for a particular engine speed and load. This is achieved by the ECM rapidly pulsing the energizing signal to the oil control solenoid. Due to this rapid pulsing the shuttle valve assumes a position between the limits of its travel and is continuously controlled by the ECM to maintain the requested camshaft angle. The actual position of the inlet camshaft is monitored by the camshaft position sensor which transmits signals to the ECM.

Engine oil properties and temperature can affect the ability of the VVT mechanism to follow demand changes to the cam phase angle. At very low oil temperatures, movement of the VVT mechanism is sluggish due to increased viscosity and at high temperatures the reduced viscosity may impair operation if the oil pressure is too low. To maintain satisfactory VVT performance, an increased capacity oil pump is installed and an engine oil temperature sensor to enable monitoring by the ECM. The VVT system is normally under closed-loop control except in extreme temperature conditions: such as cold starts below 0° Celsius. At extremely high oil temperatures the ECM may limit the amount of VVT advance to prevent the engine from stalling when returning to idle speed.

Engine

Camshafts

Cast iron camshafts with steel tappet shims are installed, this change of component material increases durability by reducing friction wear.

Accessory Drive

The front-end accessory drive has been reconfigured to make the arrangement more compact. This has also been achieved by mounting the coolant pump at the rear of the engine; refer to Fig. 6.

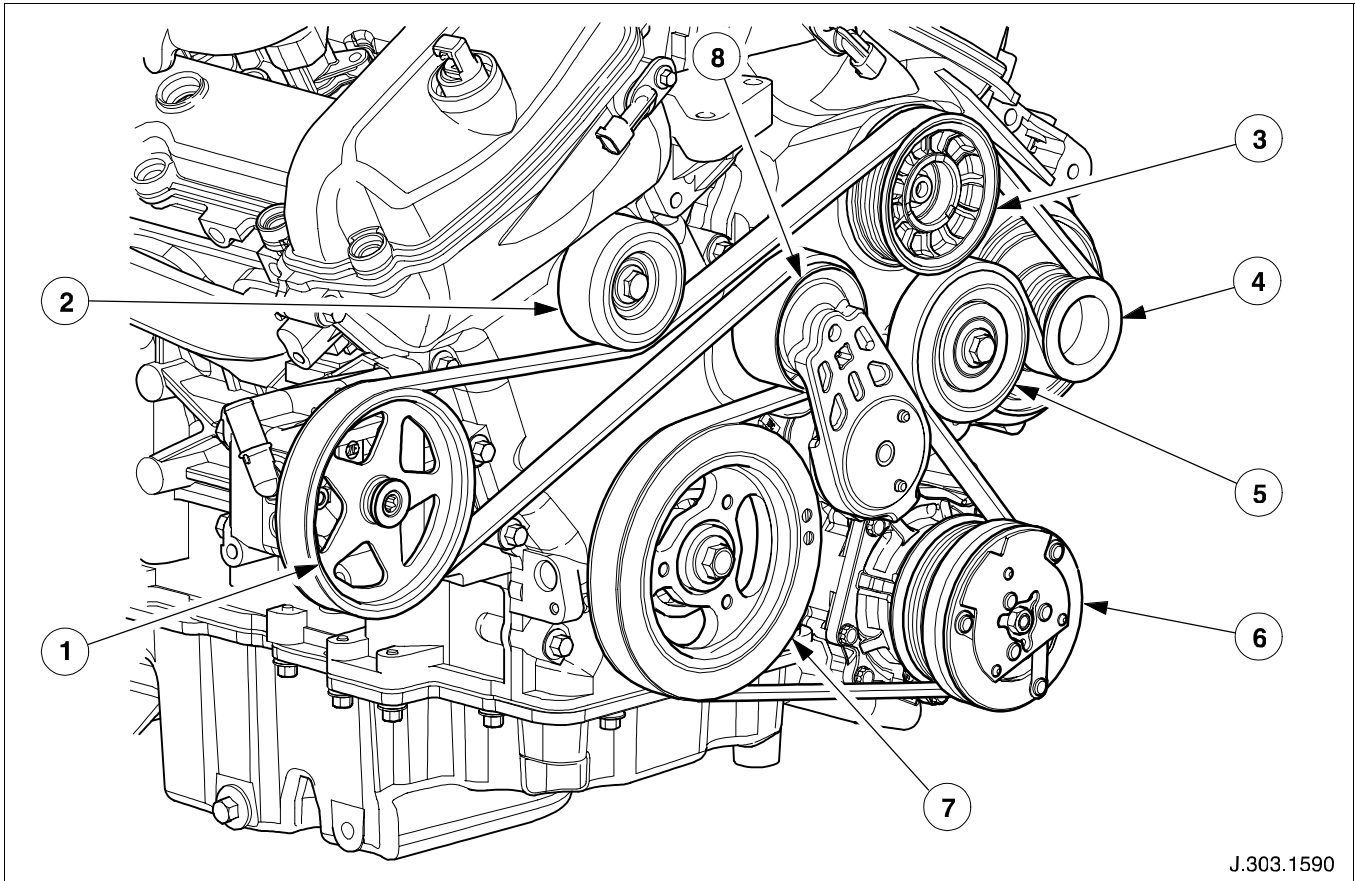


Fig. 5 Front accessory drive

- | | |
|------------------------|--------------------------------|
| 1. Power steering pump | 5. Idler pulley |
| 2. Idler pulley | 6. Air conditioning compressor |
| 3. Idler pulley | 7. Crankshaft pulley |
| 4. Generator | 8. Tensioner |

Coolant Pump

The coolant pump assembly is located at the rear of the engine and consists of a three pulley drive-system. The centre pulley, which is driven by the exhaust camshaft, transmits the drive to the coolant pump via the drive-belt. Drive-belt tension is maintained by an automatic drive-belt tensioner.

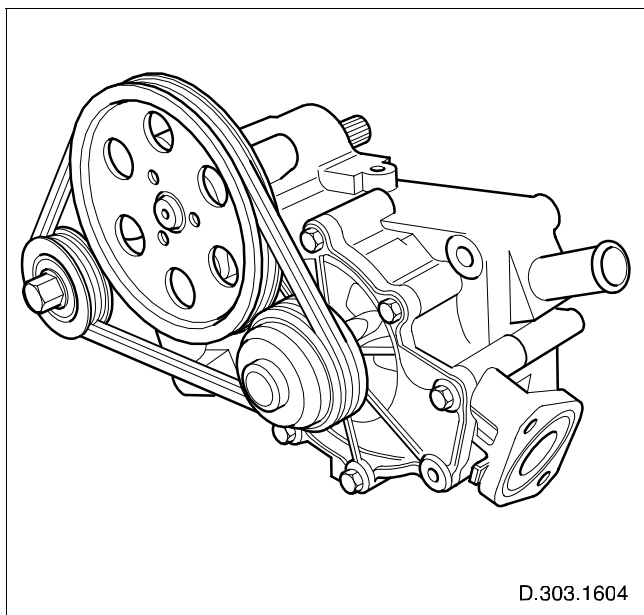


Fig. 6 Coolant pump

Engine Cover

The engine's front cover is designed to accommodate the transverse engine mounting and new VVT system. Refer to Fig. 3

Oil Pan

The oil pan is designed to accommodate the transverse engine and transaxle configuration.

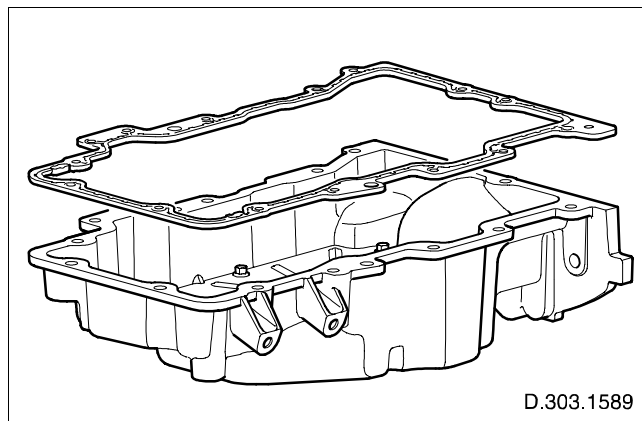


Fig. 7 Oil pan

Intake Manifold

The three-stage variable intake manifold has been redesigned although the operating concept remains the same; refer to **Fuel Charging and Controls** for details.

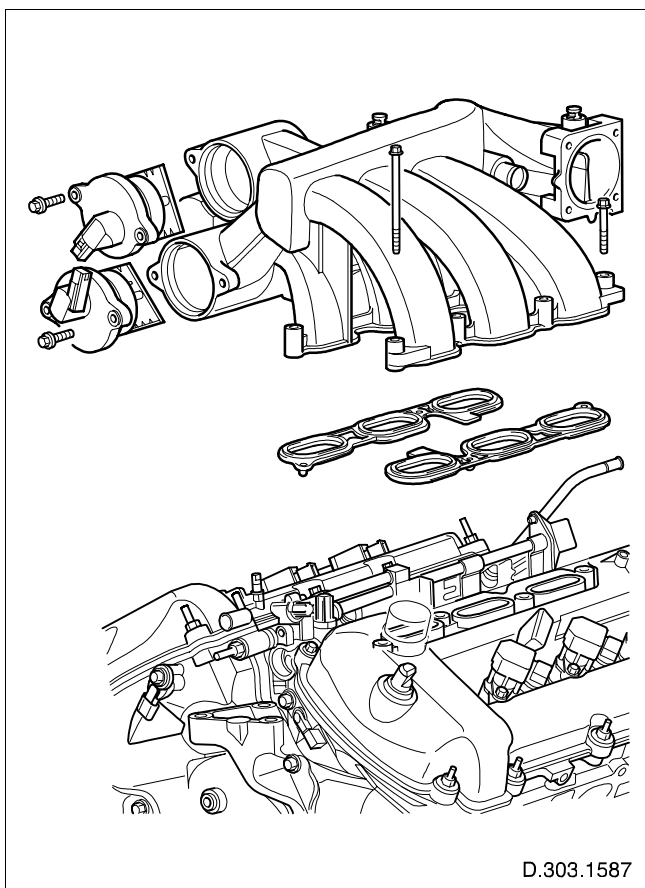


Fig. 8 Intake manifold

Exhaust Manifolds

The exhaust manifolds are designed to accommodate the transverse engine configuration, the front manifold is fabricated and the rear manifold is cast manufactured.

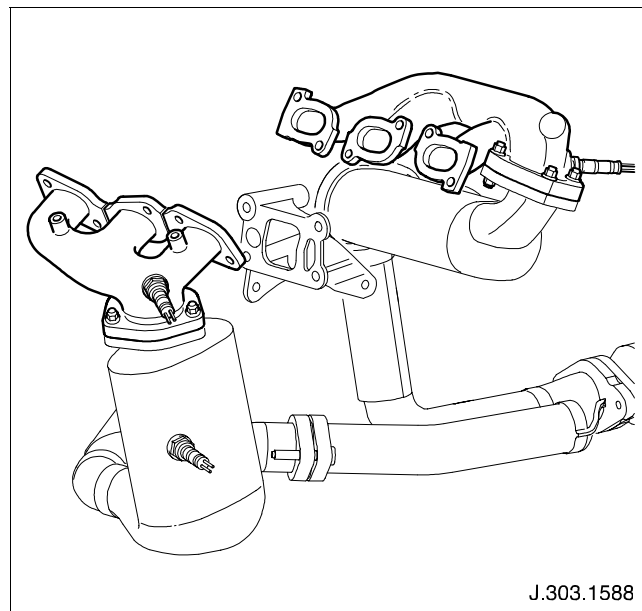


Fig. 9 Exhaust manifolds

Air Cleaner Assembly

The air cleaner assembly is mounted forward of the front camshaft cover with the engine air intake being drawn from above and in front of the engine coolant radiator. This location provides the benefit of:

- a reduction in noise being transmitted from the engine compartment;
- and reduced intake air temperatures which is beneficial to engine performance.

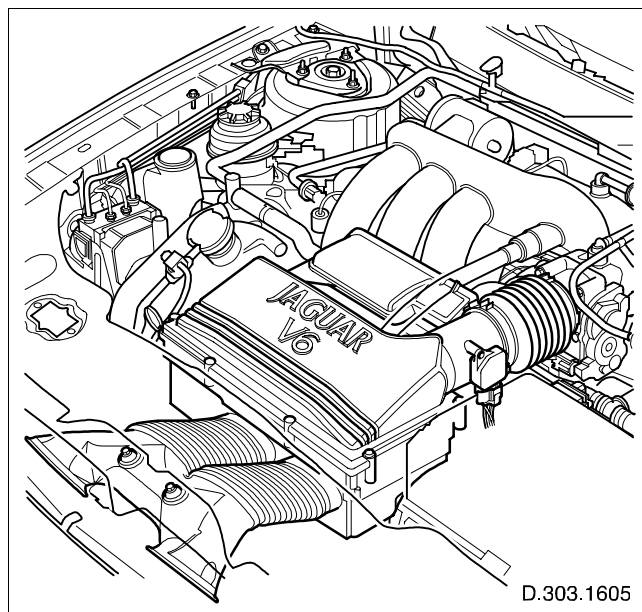


Fig. 10 Air cleaner assembly

Engine Cooling

Engine Cooling

Cooling System

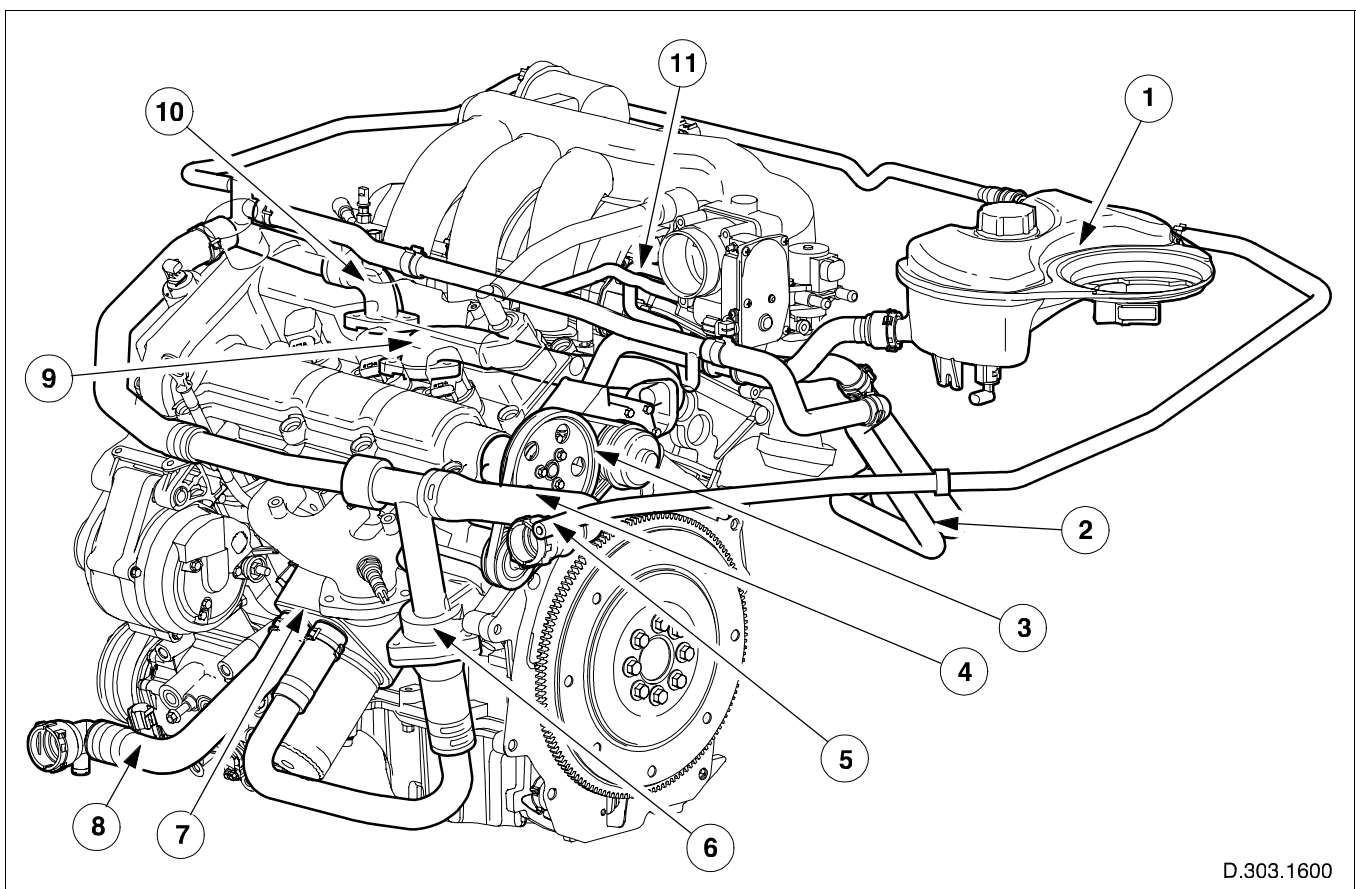
The cooling system is a low volume, high velocity system with good warm-up and temperature profile characteristics. The thermostat which controls the system's coolant flow is located in a housing in the upper coolant hose.

When the engine is cold and the thermostat is closed, coolant travels from the coolant pump, circulates through the engine and returns directly to the pump via the upper coolant hose. The coolant flow to the heater core located in the climate control assembly is on a parallel circuit and is unaffected by the thermostat's position.

As the engine warms-up and the thermostat opens, coolant is then directed from the engine, through the radiator and engine oil-cooler via the lower hose before returning to the coolant pump.

A continuous vent to the coolant expansion tank from the engine and radiator, via the bypass hoses, ensures continuous de-aeration of the coolant system. There are no manual bleed points on the system.

The engine cooling system is identical on both the 2.5 and 3.0 liter vehicles.



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Fig. 11 Cooling system

- | | |
|---------------------------|--------------------------------|
| 1. Coolant expansion tank | 7. Engine oil cooler |
| 2. Heater core hoses | 8. Radiator lower hose |
| 3. Coolant pump | 9. Engine coolant inlet pipe |
| 4. Radiator upper hose | 10. Engine coolant outlet pipe |
| 5. Radiator bypass hose | 11. Throttle body hoses |
| 6. Thermostat | |

Coolant Flow

The diagram below shows the coolant flow at normal running temperature (thermostat open).

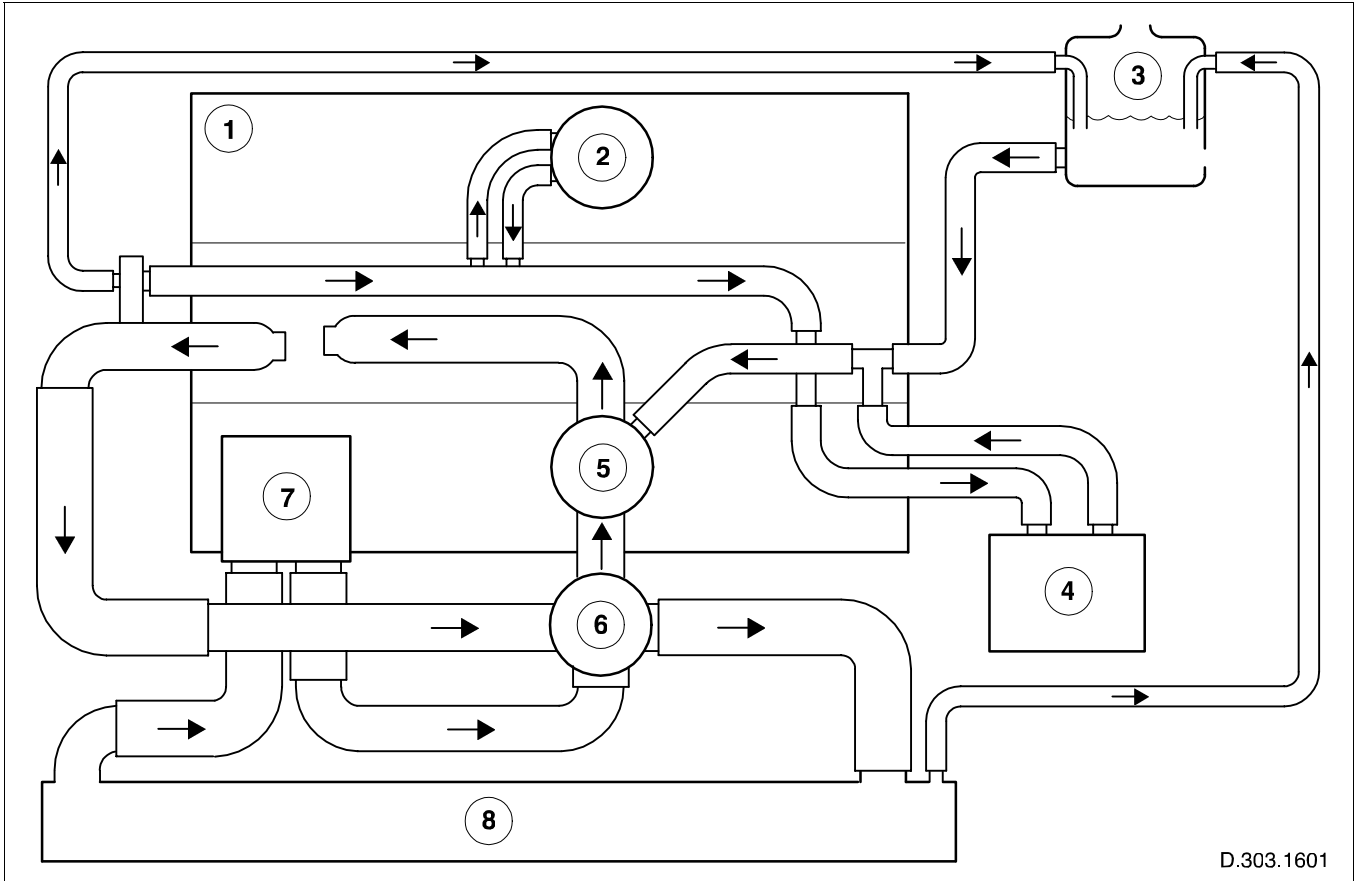


Fig. 12 Flow diagram

- | | |
|-------------------|----------------------|
| 1. Engine | 5. Coolant pump |
| 2. Throttle body | 6. Thermostat |
| 3. Expansion tank | 7. Engine oil cooler |
| 4. Heater core | 8. Radiator |

Engine Cooling

Coolant Pump

The coolant pump assembly is located at the rear of the engine and consists of a three pulley drive-system. The centre pulley, which is driven by the exhaust camshaft, transmits the drive to the coolant pump via the drive-belt. Drive-belt tension is maintained by an automatic drive-belt tensioner.

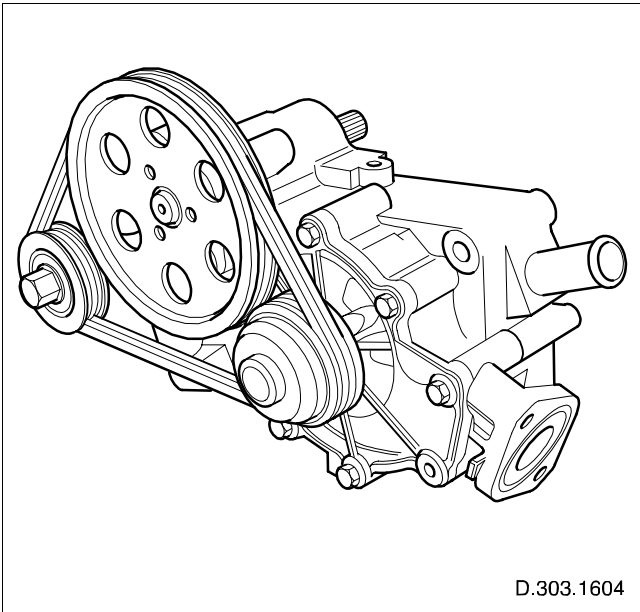


Fig. 13 Coolant pump

Engine Block Heater

For markets subject to very low temperatures, an engine block heater, for connection to an external mains electrical supply, is screwed into the engine block, next to the engine oil cooler. In other markets the heater is substituted for an engine-coolant drain plug.

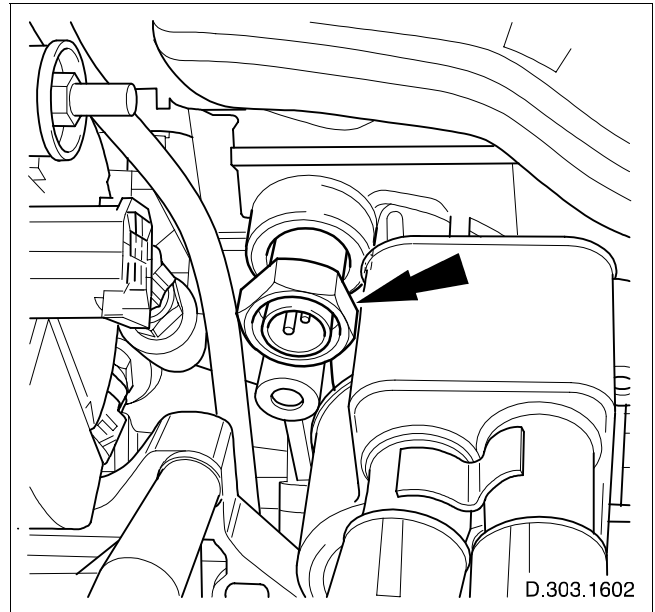


Fig. 14 Cylinder block heater

Radiator and Cooling Fan Assembly

The radiator, which is constructed of an aluminum core and plastic end-tanks, is isolated from the vehicle's body by four rubber mountings. The radiator provides the mounting location for the air conditioning condenser, transmission cooler (automatic transmission only), and the twin fan and motor assembly. Fan speed is controlled by a fan control module (FC module), located at the top left-hand side of radiator shroud. The module is cooled by a small air-duct moulded into the radiator shroud.

The FC module is controlled by the engine control module (ECM) which calculates the engine cooling requirement via sensors located on the engine. The ECM produces a pulse width modulation signal, which operates within a set frequency to control the FC module. A signal outside the frequency, will initiate maximum fan speed delivery to protect the engine. High engine temperature is indicated by the illumination of the engine over-temperature warning light, located on the instrument cluster; refer to **X-TYPE Sedan Introduction TG, Electrical, Instrument Cluster**.

The ECM also controls the fan speed after the ignition has been turned off to provide an extended period of engine cooling as required to protect the engine.

Airflow seals located around the edge of the radiator have a significant effect on performance of the cooling and air conditioning systems by preventing uncontrolled air from entering the assembly.

The coolant drain plug is located in the radiator lower hose.

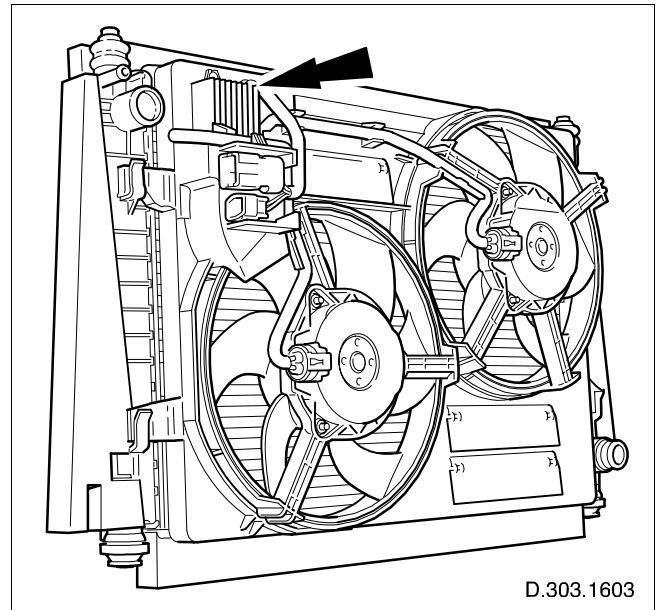


Fig. 15 Radiator and cooling fan assembly

Fuel Charging and Controls

Electronic Throttle Control

A fully electronic throttle control is installed, requiring no mechanical connection between the accelerator pedal and throttle body. As the driver operates the accelerator pedal the accelerator pedal position sensor on the pedal shaft converts the mechanical rotation to electrical signals, which are sent to the engine control module (ECM) to indicate driver demand. Driver demand signals in conjunction with other engine control signals are processed by the ECM to provide the engine with the required charge of fuel and air.

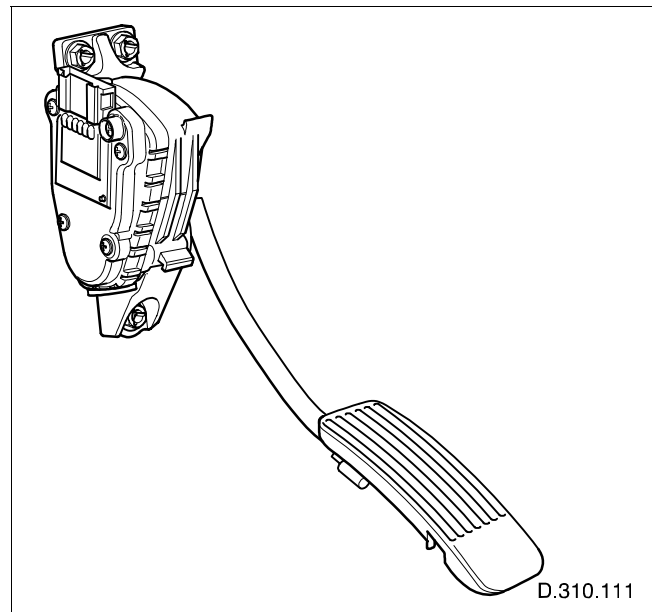


Fig. 16 Accelerator pedal

Fuel and Air Charging

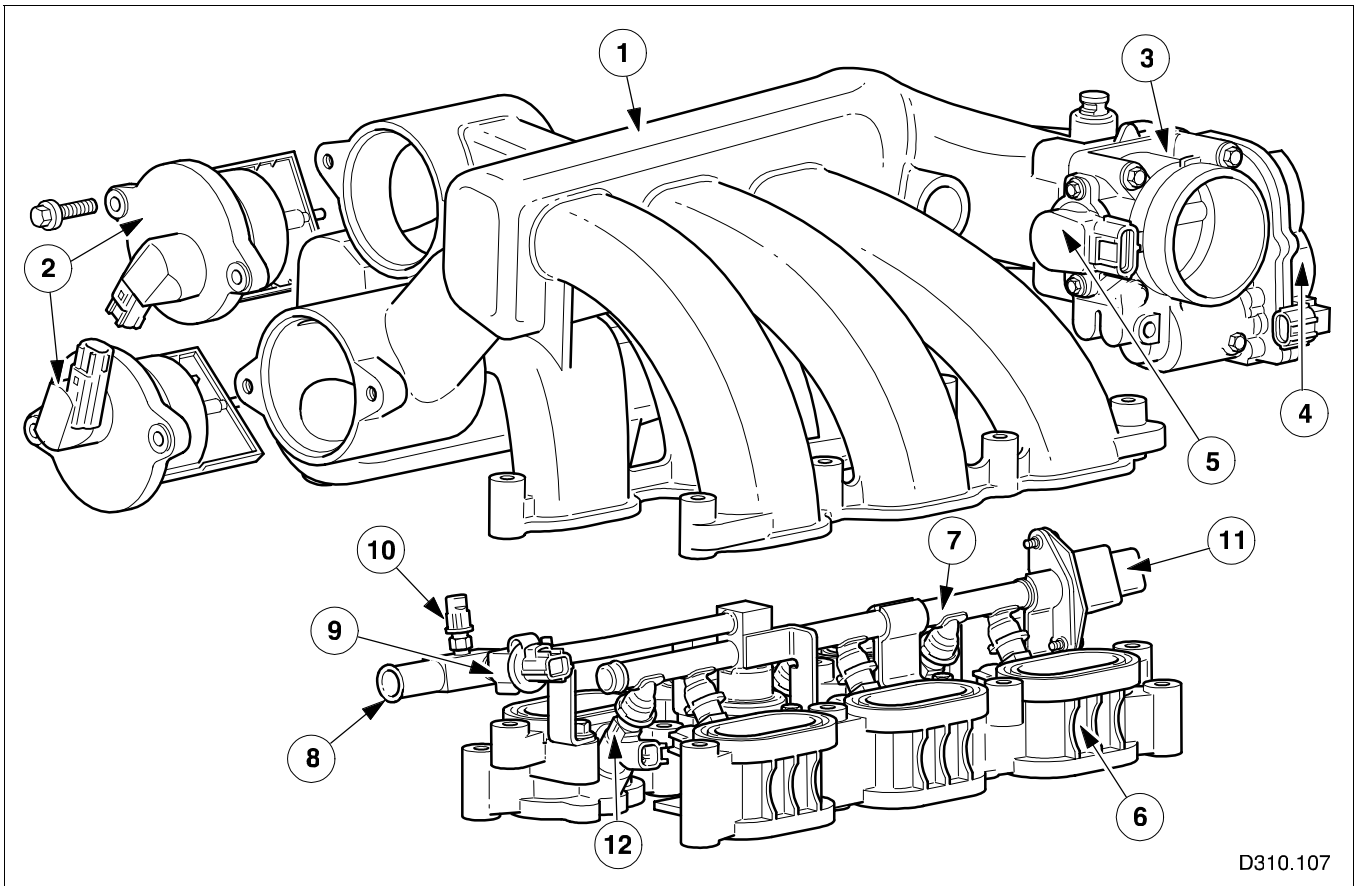


Fig. 17 Fuel charging system

1. Intake manifold
2. Intake manifold tuning valves
3. Throttle body
4. Throttle motor
5. Throttle position sensor
6. Lower intake manifold
7. Fuel rail
8. Fuel supply
9. Engine fuel temperature sensor
10. Depressurization valve — NAS market only, used for diagnostic purposes
11. Fuel pressure sensor
12. Injector

Fuel Charging and Controls

Fuel Charging

The fuel pump module, via signals from the ECM, controls the amount of fuel supplied by the fuel pump to the fuel rail. The ECM receives signals from the fuel pressure and engine fuel temperature sensors to indicate fuel pressure in the fuel rail. In response to these signal, plus driver demand and other engine control signals, the ECM calculates the amount of fuel required and requests the fuel pump module to vary the fuel pump delivery to suit the engine's requirements.

- The fuel pump module is located underneath the rear passenger seat.

Other fuel related functions controlled by the ECM include:

- When the ignition switch is turned from 'OFF' to position 'I' or 'II', the fuel system is primed by running the pump for one second at full speed.
- The pump is switched off one second after the engine is stopped.
- During hot starts the fuel pressure is increased to prevent vapor lock.

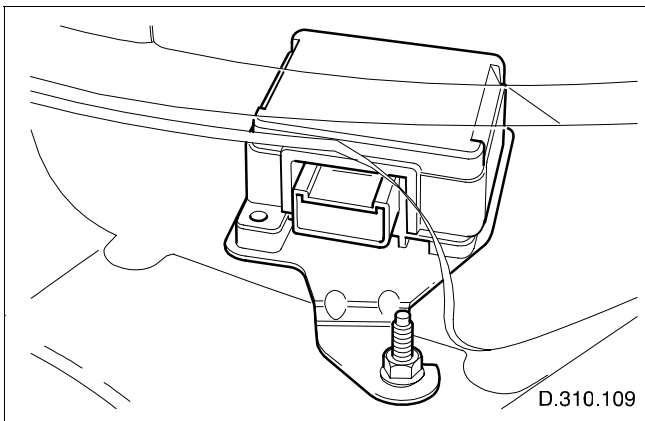


Fig. 18 Fuel pump module

Fuel injectors

The ECM controls one injector per cylinder in sequential order, the timing of the injector-firing during normal running conditions is optimized to give the best compromise between emissions and engine performance. The mass of fuel required per injection is derived from a calculation held in the ECM to match the metered mass air-flow from the intake manifold.

Air Charging

Throttle body

The throttle body, refer to **Fig. 17** houses the throttle disc which governs the volume of air entering the intake manifold. The throttle motor controls the position of the throttle disc, via driver demand and engine control signals provided by the ECM. The actual angle of the throttle disc is indicated to the ECM by the throttle position sensor, which works in conjunction with the throttle motor to provide closed loop control of the throttle.

- The throttle body is connected to the engine cooling system to provide throttle de-icing.

Intake manifold

The intake manifold, refer to **Fig. 17**, is specially designed to optimize torque across the engine speed and load range. The air-charge enters the intake manifold from the throttle body and passes through a plenum chamber for distribution to the cylinders. The function of the plenum chamber is to provide a resonance (or maximizing) effect so that large pulses of charge air will arrive at the inlet ports at the correct time for induction into the cylinders. This ram charging action is only effective over a restricted speed and load range for a particular plenum chamber volume and geometry. To extend the effect over the whole engine speed range, the manifold geometry can be set to three different configurations, each of which maximizes the tuning effect over different areas of the engine range. This variable geometry is achieved by the use of two intake manifold tuning valves (IMT valves), which are controlled by the ECM. The IMT valves act as gates which rotate through 90 degrees between the open and closed positions, the valves can only be set to either of these two positions.

Evaporative Emissions

On-board Refueling Vapor Recovery

To meet on-board refueling vapor recovery (ORVR) requirements the fuel tank and associated components are designed to minimize fuel vapor loss by preventing fuel vapor from the fuel tank venting directly to the atmosphere. Fuel vapor therefore is vented into the evaporative emission canister (EVAP canister) where it is stored before being purged at intervals to the engine's inlet manifold.

During refueling the narrow fuel filler-tube below the nozzle region provides a liquid seal against the escape of vapor. A check valve also in the filler tube opens to incoming fuel to prevent splash-back. As the fuel tank fills, fuel vapor is routed through the open float-level vent valve located in the top of the tank, and then through to the EVAP canister where the fuel vapor passes through an activated-charcoal filter. The filter removes a regulated amount of hydrocarbons from the fuel vapor, to meet emission regulations, before the fuel vapor is discharged into the atmosphere. The fuel vapor is discharged through the EVAP canister atmosphere vent, refer to **Evaporative Emission Canister**. The remaining hydrocarbons are stored in the EVAP canister where at intervals are purged into the engine for combustion, refer to **Evaporative Emission Canister Purge Valve**.

As refueling continues, the rising fuel-level in the fuel tank closes the float-level vent valve when the fuel tank reaches full. The resulting back pressure causes refueling to stop automatically. While the float-level vent valve is closed, any further rise in vapor pressure is vented to the EVAP canister via the grade vent valve.

The float-level vent valve is always open when the fuel-tank level is below full, providing an unrestricted vapor outlet to the EVAP canister.

The ORVR system also incorporates the following safety devices:

- The fuel filler cap incorporates both pressure and vacuum relief valves.
- Both the float-level vent valve and the grade vent valve incorporate protection against leakage in the event of a vehicle roll-over.

Evaporative Emissions

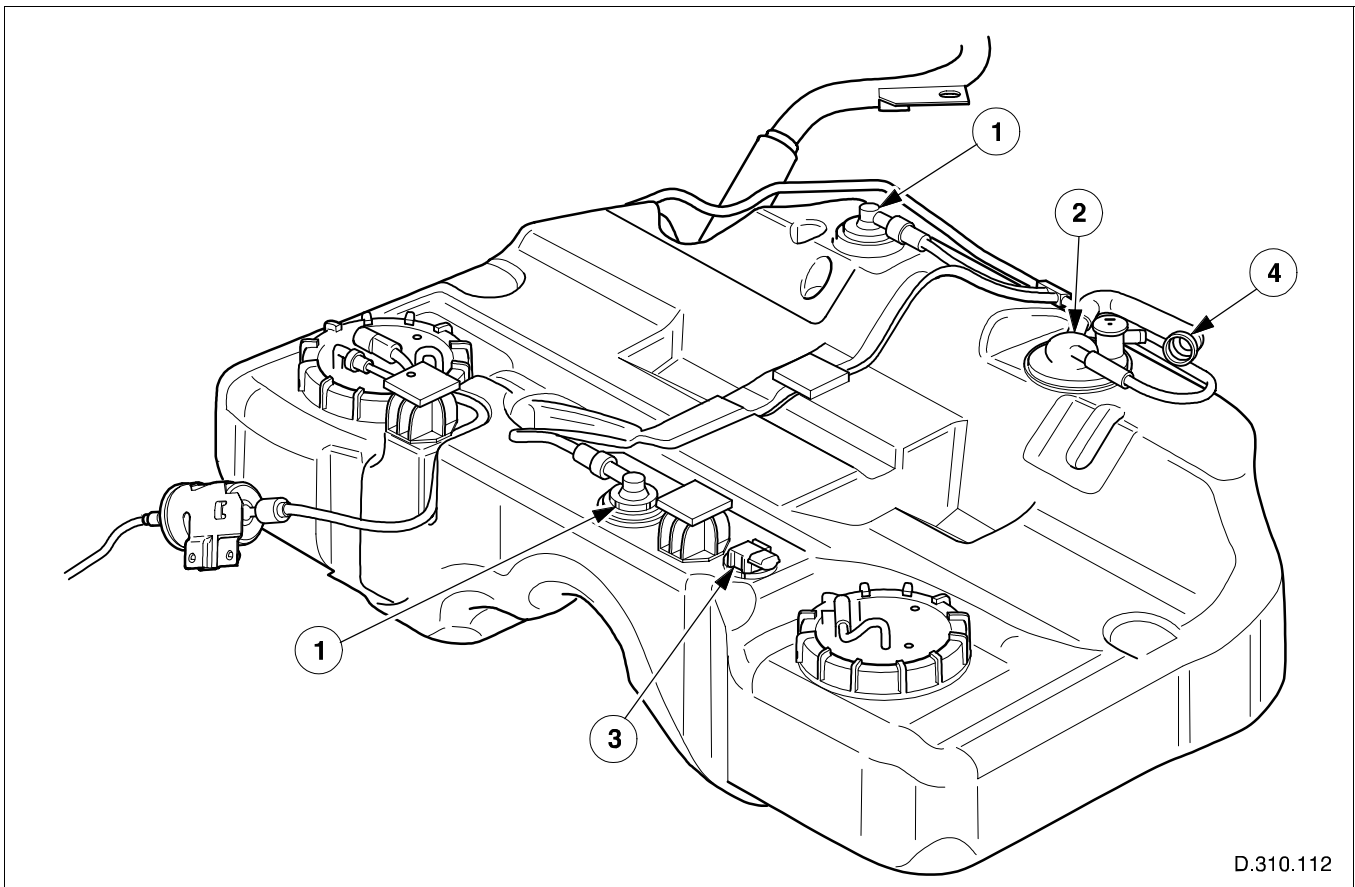


Fig. 19 Fuel tank emission components

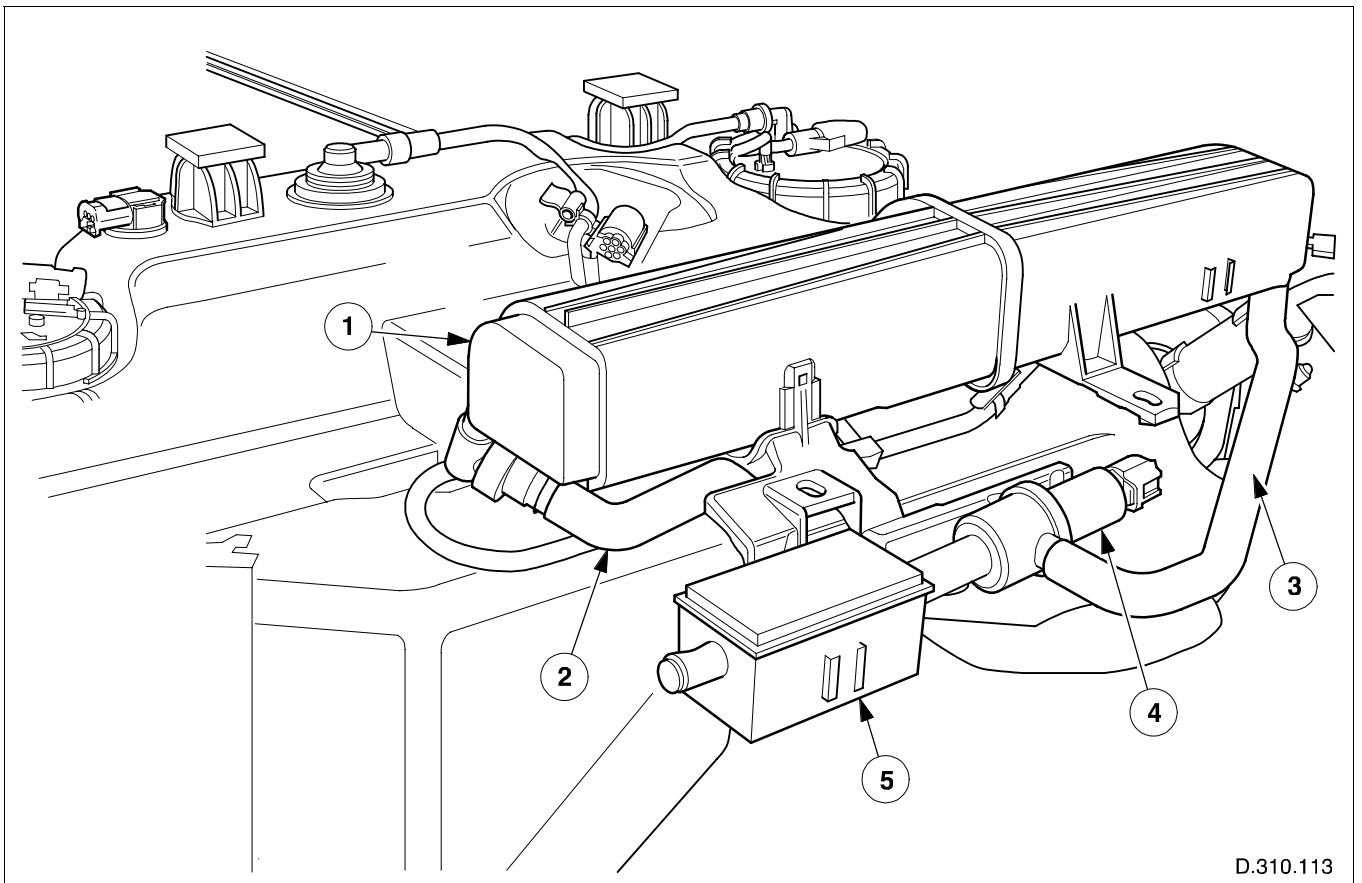
1. Grade vent valve
2. Float level vent valve
3. Fuel tank pressure sensor
4. EVAP canister feed pipe

Evaporative Emission Canister

The EVAP canister, which has a volume of 2.3 liters, is positioned above the fuel tank and mounted to the vehicle's underbody. Owing to the limited storage volume of the EVAP canister the charcoal filter must be continually regenerated. This is achieved when the engine is running by drawing air through the EVAP canister, via the atmosphere vent, into the engine for combustion.

An EVAP canister close valve is fitted to the EVAP canister which when instructed by the ECM, seals the atmosphere vent pipe to allow the ECM to perform fuel-vapor leak check diagnostics. The ECM monitors signals received from the fuel tank pressure sensor mounted on the fuel tank to check for leaks within the evaporative emission control system.

The fuel vapor separator acts as a filter to protect the close valve from foreign particles, when air is entering the EVAP canister.



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Fig. 20 Evaporative emission canister

1. EVAP emission canister
2. EVAP canister feed pipe
3. Atmosphere vent pipe
4. EVAP canister close valve
5. Fuel vapor separator

Evaporative Emissions

Evaporative Emission Canister Purge Valve

The EVAP canister purge valve is located on the engine compartment bulkhead. The ECM operates the valve to purge fuel vapor from the EVAP canister into the engine for combustion. Purge rates, that is the extent the purge valve opens, are determined by the engine operating conditions and the vapor concentration level. The purge rates are adjusted to maintain driving characteristics and exhaust emissions at optimum levels.

The engine operating conditions that affect the purge rate are:

- speed and load;
- coolant temperature;
- time from engine start-up;
- closed loop fueling.

To determine the vapor concentration level, the ECM applies stepped opening signals to the purge valve and monitors the subsequent fuelling correction. This is usually performed before purging, so that when purging starts, the purge valve can immediately be set to the optimum position. If the ECM is unable to determine the vapor concentration before purging, it uses a default value which it then modifies while purging is in process.

A test port is provided on the purge valve line to enable leak test diagnosis of the fuel system.

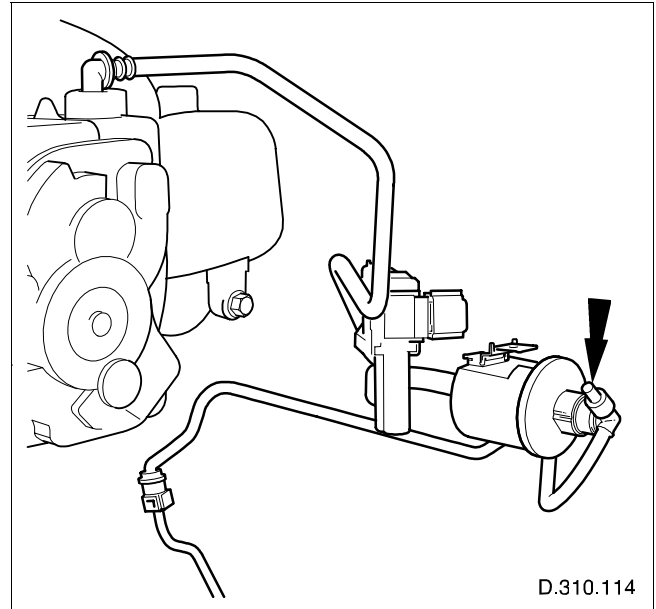


Fig. 21 Evaporative emission canister purge valve

Electronic Engine Controls

Introduction

The electronic engine control system consists of an engine control module (ECM) and a number of sensing and actuating devices. The sensors supply the ECM with input signals which relate to engine operating conditions and driver requirements. The sensor information is evaluated by the ECM using calibrated data tables and maps, the ECM then uses the results to command an appropriate response from the actuating devices. The system provides the necessary engine control accuracy and adaptability to:

- minimize exhaust emissions and fuel consumption;
- provide optimum driver control under all conditions;
- minimize evaporative fuel emissions;
- provide system diagnostics when malfunctions occur.

In addition to these functions the ECM also interfaces with other vehicle systems through the controller area network (CAN).

The electronic engine control system is identical on both the 2.5 and 3.0 liter vehicles.

Engine Control Module

The (32 bit) ECM is at the center of the system and provides the overall control. Its functions are listed below, each of which are dependent on engine and vehicle state at any moment of time and driver requirements.

- Starting: ensures that conditions are safe to crank the engine.
- Engine: controls the rate of air and fuel flow into the cylinders; adjusts the inlet manifold volume; controls the ignition and inlet camshaft timing.
- Fuel supply: controls the operation of the fuel pump and vapor purge valve.
- Cooling: controls the engine cooling fans.
- Battery: optimizes the battery charging conditions.
- Air conditioning and screen heater: controls the speed of the engine when these additional loads are added, also disables the air conditioning when it is beneficial to reduce the load on the engine.
- Cruise control: provides the option to maintain a fixed vehicle speed without driver intervention.
- Robustness: maintain engine running condition under intermittent or permanent single point failures on any sensors or actuators fitted to the system, and record fault codes of these failures for system diagnosis.
- Diagnosis: notifies the driver when a system malfunction occurs and records data for system diagnosis.

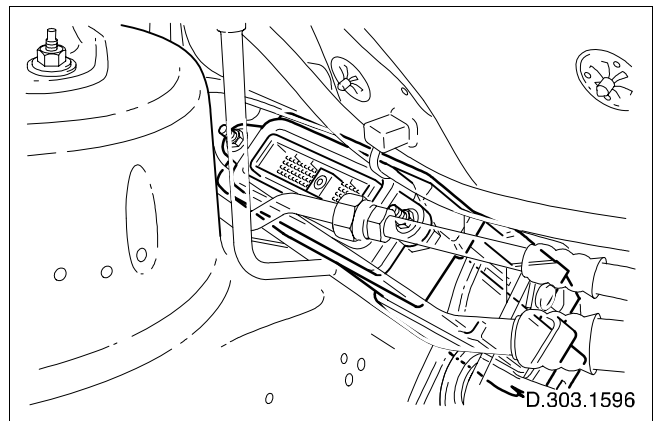


Fig. 22 Engine control module

Electronic Engine Controls

System Interfaces

In the diagram below each rectangular box represents a system with which the ECM interfaces. The arrows represent the data flow between the system and the ECM.

The interface between the systems and the ECM is discussed in the relevant section of the publication.

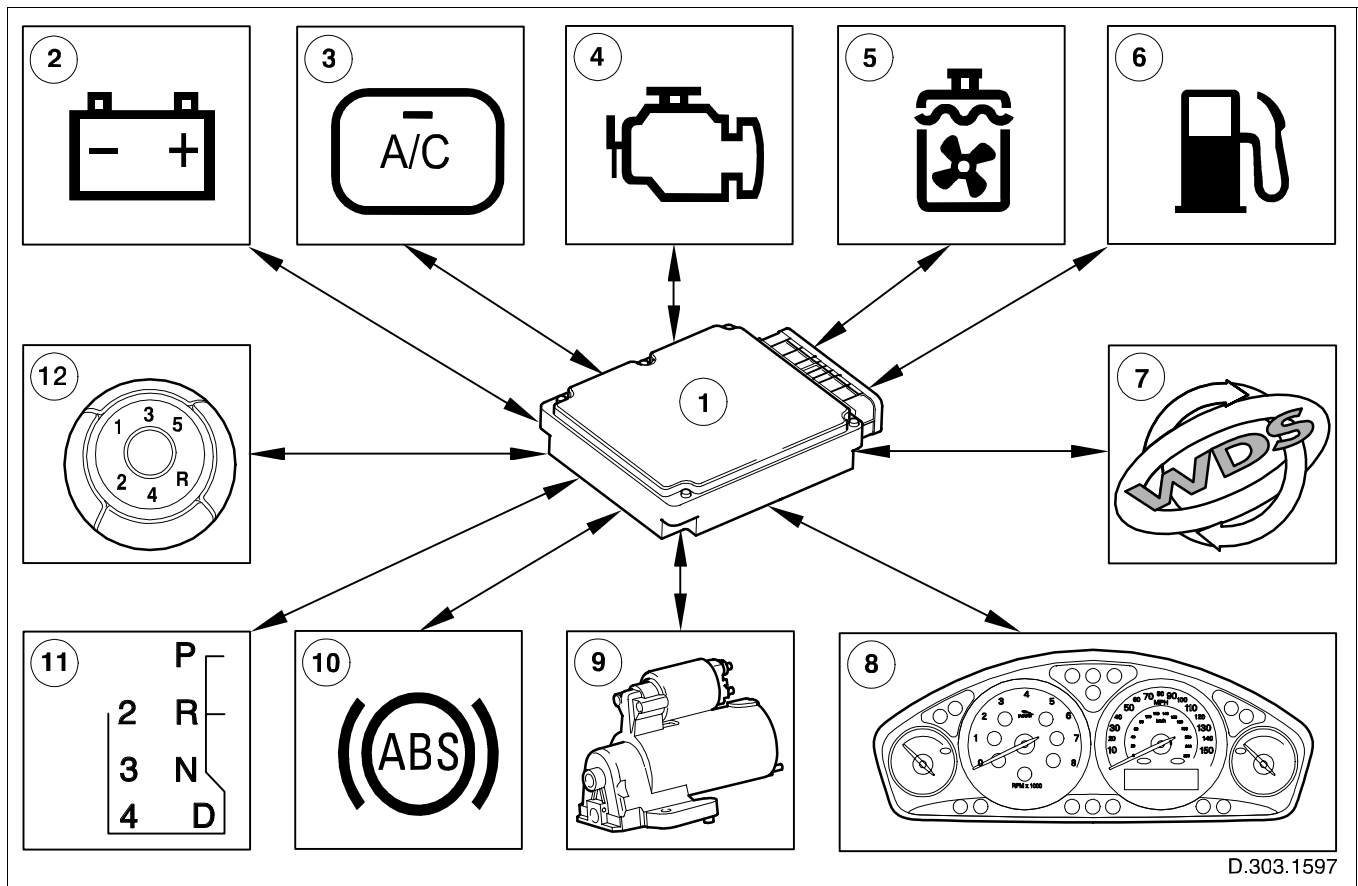
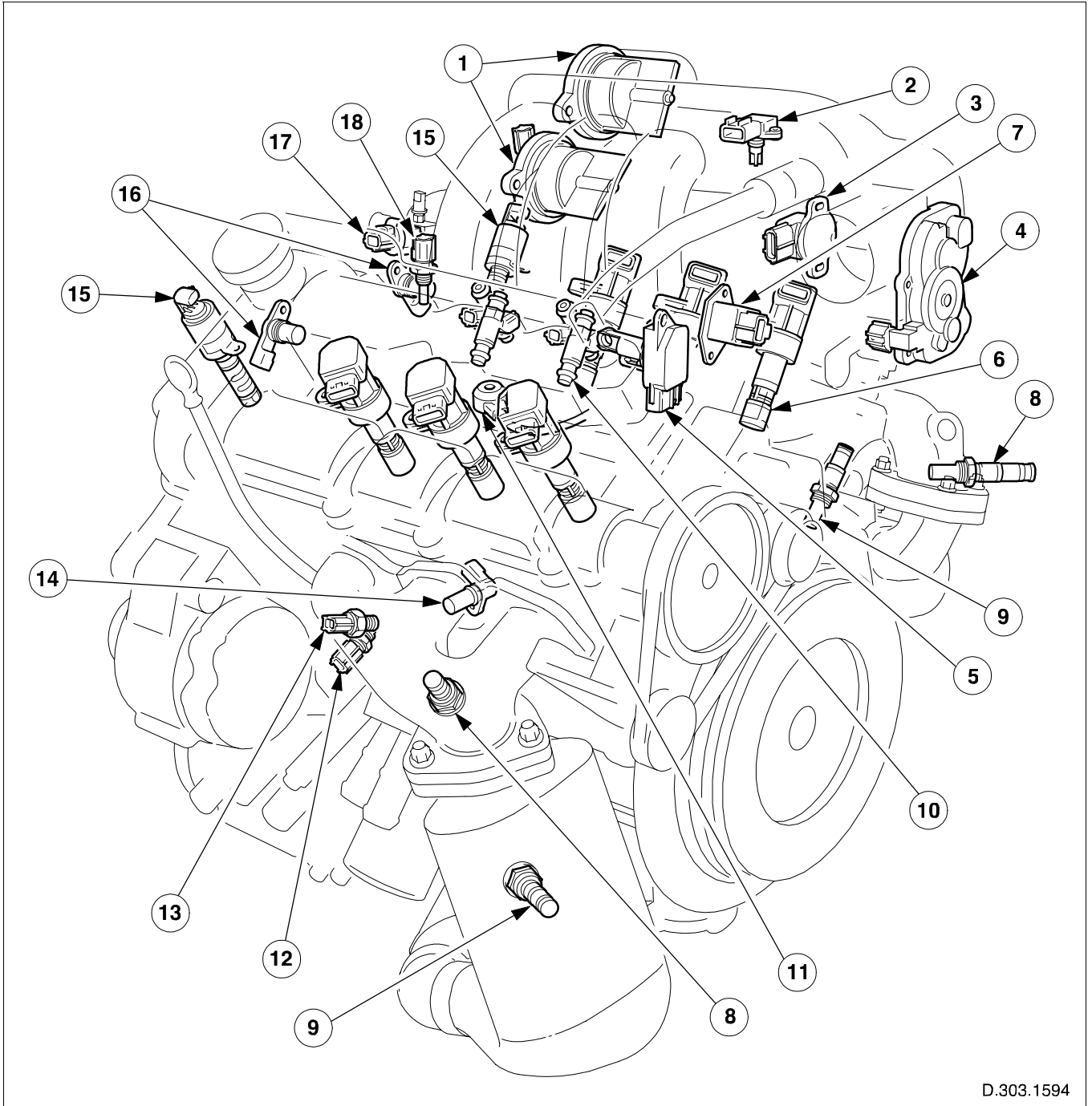


Fig. 23 System interfaces

- | | |
|----------------------------|--------------------------------|
| 1. Engine control module | 7. Diagnostic interface |
| 2. Charging system | 8. Instrument cluster |
| 3. Air conditioning system | 9. Starting system |
| 4. Engine | 10. Brakes and related systems |
| 5. Cooling system | 11. Automatic transaxle (TCM) |
| 6. Fuel system | 12. Manual transaxle |

Sensors and Actuators

Location of Engine Sensors and Actuators



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Fig. 24 Sensor and actuator location

Electronic Engine Controls

Key to Fig. 24

1. Intake manifold tuning valves
2. Manifold absolute pressure sensor
3. Throttle position sensor
4. Throttle motor
5. Mass air flow sensor with integrated intake air-temperature sensor
6. On-plug ignition coil with integrated amplifier
7. Fuel pressure sensor
8. Heated oxygen sensor 1
9. Heated oxygen sensor 2
10. Fuel injector
11. Knock sensor
12. Oil pressure switch
13. Engine oil temperature sensor
14. Crankshaft position sensor
15. Oil control solenoid — variable valve timing
16. Camshaft position sensor
17. Engine fuel temperature sensor
18. Engine coolant temperature sensor

Function of Sensors and Actuators

- Fuel injector:
 - The ECM controls one injector per cylinder in sequential order.
 - Timing of injector opening is optimized to give the best compromise between emissions and performance.
- On-plug ignition coil with integrated amplifier:
 - The ECM controls one coil per spark plug in sequential order.
 - The ECM is calibrated so that the ignition timing is optimized for emissions, fuel economy and performance, throughout the engine's speed and load range.
 - Ignition timing in the idle condition is optimized for idle quality, idle speed control, economy and emissions.
 - A separate ignition timing value is provided for engine starting, this is to give the best compromise between emissions, time to first fire and smooth engine response at all temperatures.
- Camshaft position sensor:
 - The position of both inlet camshafts are monitored to allow the ECM to control the phase of the inlet camshafts relative to the position of the crankshaft; see 'oil control solenoid'.
- Oil control solenoid — variable valve timing:
 - The oil control solenoid is a hydraulic actuator, which advances and retards the inlet camshaft timing, thereby altering the camshaft-to-crankshaft phasing; refer to **Engine** section.
- Manifold absolute pressure sensor (MAP sensor):
 - The MAP sensor measures manifold pressure, the ECM uses this information in conjunction with data from other sensors, to set the opening time of the injector in proportion to the volume of air that the engine is receiving.
- Knock sensor:
 - Detects and reports combustion knock within the engine cylinders, the ECM uses this information to gradually adjust the ignition timing until the combustion knock is eliminated.

- Fuel pressure sensor:
 - Continuously monitors the fuel pressure between the fuel rail and plenum, this value is used by the ECM as one of its factors to calculate the injector pulse-width required to deliver the correct mass of fuel per injection.
 - The ECM also uses this information to demand a specific fuel flow rate from the fuel pump via the fuel pump module; the module is located underneath the rear passenger seat; refer to **Fig. 25**

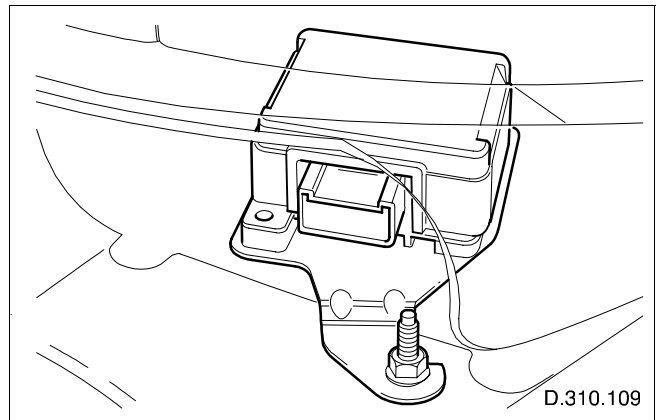


Fig. 25 Fuel pump module

- Engine fuel temperature sensor:
 - Continuously monitors fuel temperature, this value is used by the ECM as one of its factors to calculate fuel rail pressure and the injector pulse-width required to deliver the correct mass of fuel per injection.
- Intake manifold tuning valves (IMT valves):
 - The IMT valves are a two positional (open or close) device used to create a variable air intake system. The IMT valve's positions are switched, via signals from the ECM, to optimize torque across the engine's speed and load range.
 - The IMT valves work in conjunction with the operation of the throttle body.

Electronic Engine Controls

- Throttle body assembly:
 - The throttle body controls the air-flow into the engine by use of the throttle motor and throttle position sensor (TP sensor).
 - Throttle position is operated by the throttle motor via signals received from the accelerator pedal position sensor, via the ECM; refer to **Fig. 26**
 - Throttle angle is monitored by the ECM via the TP sensor.
 - Compensation is made to the throttle angle by the ECM on the application of external loads for example, the air conditioning compressor.

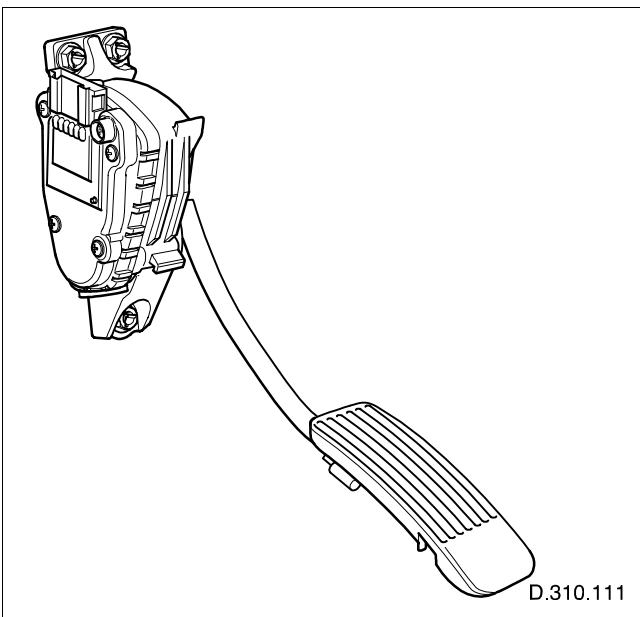


Fig. 26 Accelerator pedal position sensor

- Mass air flow sensor (MAF sensor) with integrated intake air temperature sensor (IAT sensor):
 - The MAF sensor informs the ECM of the rate of air-flow entering the engine by producing a voltage which increases as the rate of air-flow increases.
 - The MAF sensor also takes into account the density of air entering the engine so it possible to maintain the required air to fuel ratio, and compensate for variations in atmospheric temperatures and pressure.
- The integral IAT sensor measures the temperature of the air entering the intake system. The ECM uses this information to compensate for higher than normal air intake temperatures upon combustion detonation.
- Crankshaft position sensor (CKP sensor):
 - The CKP sensor is an inductive pulse generator which scans protrusions on a pulse ring, to inform the ECM of the crankshaft's position.
- Engine coolant temperature sensor:
 - The thermistor type sensor provides an input signal to the ECM which is proportional to the temperature of the coolant being circulated around the coolant system.
- Engine oil temperature sensor:
 - The thermistor type sensor provides an input signal to the ECM which is proportional to the temperature of the oil being circulated around the engine oil passageways.
- Heated oxygen sensor 1 (HO2 sensor 1):
 - The HO2 sensor 1, is a linear characteristic type sensor, fitted forward of the exhaust system's catalytic converter.
 - The sensor is used by the ECM as a primary sensor to measure oxygen content within the exhaust system.
 - The sensor is used in conjunction with the ECM to provide closed-loop fuelling control.
- Heated oxygen sensor 2 (HO2 sensor 2):
 - The HO2 sensor 2, is a non-linear characteristic type sensor fitted to the exhaust system's catalytic converter, and is used by the ECM as secondary sensor to measure oxygen content within the exhaust system.
 - Used in conjunction with the ECM and the HO2 sensor 1, the HO2 sensor 2 aids closed-loop fuelling control.
- Oil pressure switch: the switch is connected to the instrument cluster and is not directly used as part of the engine control system.

Schematic of Engine Sensors and Actuators

The arrows represent the ECM's input and output signals.

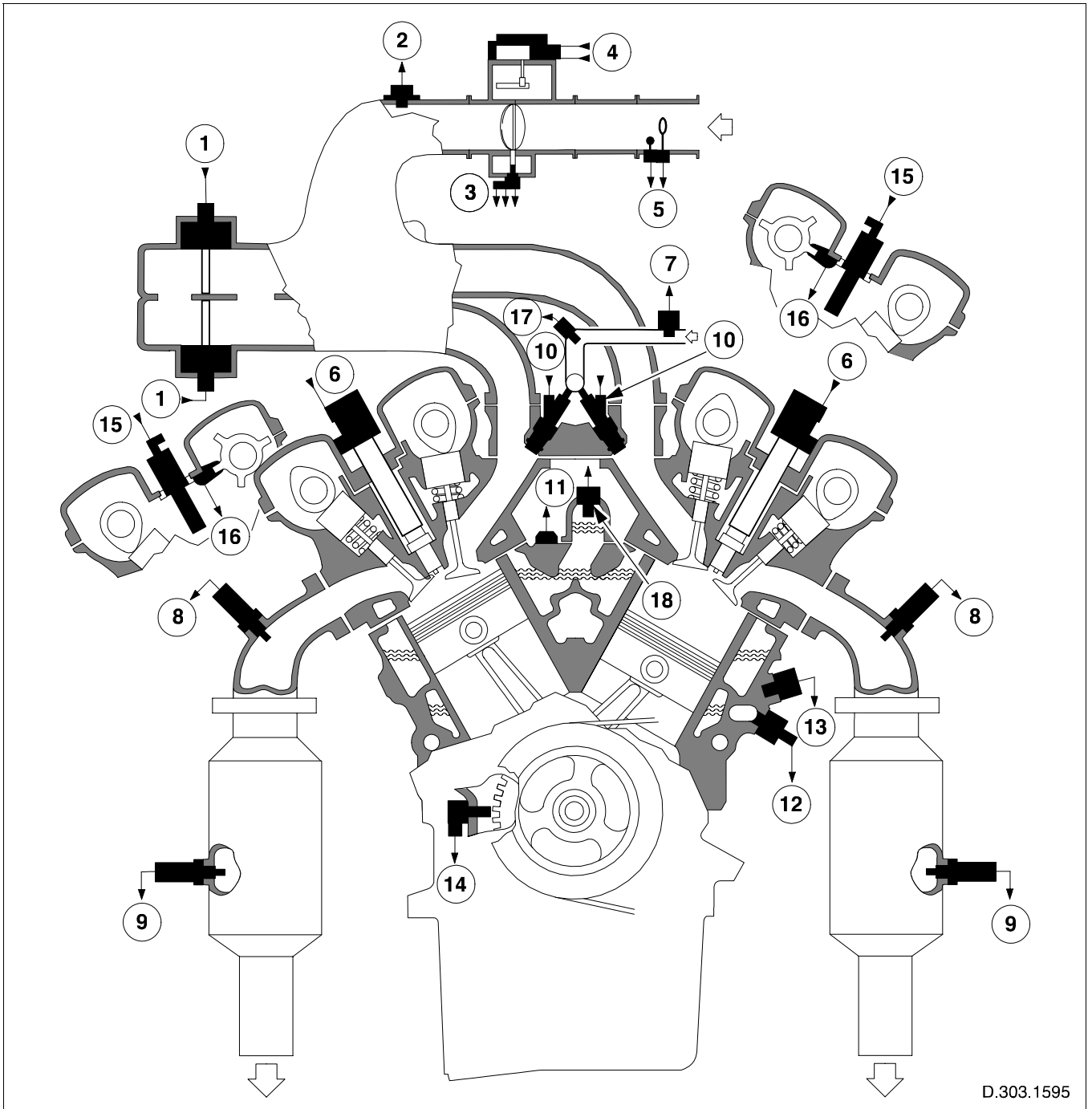


Fig. 27 Engine sensors and actuators schematic

Electronic Engine Controls

Key to Fig. 27

1. Intake manifold tuning valves
2. Manifold absolute pressure sensor
3. Throttle position sensor
4. Throttle motor
5. Mass air flow sensor with integrated intake air-temperature sensor
6. On-plug ignition coil with integrated amplifier
7. Fuel pressure sensor
8. Heated oxygen sensor 1
9. Heated oxygen sensor 2
10. Fuel injector
11. Knock sensor
12. Oil pressure switch
13. Engine oil temperature sensor
14. Crankshaft position sensor
15. Oil control solenoid — variable valve timing
16. Camshaft position sensor
17. Engine fuel temperature sensor
18. Engine coolant temperature sensor

Automatic Transaxle

Introduction

The X-TYPE is the first Jaguar to be installed with a transversely-mounted automatic transaxle which combines both the automatic transmission and differential into one unit. The term transaxle, developed from the terms transmission and axle, is used to describe this type of arrangement.

The automatic transaxle with 5-speed lock-up provides a smooth and fast operation. The transaxle comprises a torque converter, shift solenoids, hydraulic valve body and pressure regulators. The transmission control module (TCM) operates these components to control the flow of transaxle fluid, to hydraulically-control, gear selection and shift quality.

The TCM processes the information it receives, relating to transaxle input and output speed, engine torque, transaxle-fluid temperature, mode switch and gear selector position. This information is then used to decide which shift pattern to implement and which gear to select. Under normal conditions shift determination is performed by monitoring the appropriate shift lines and determining the relationship of the vehicle speed and throttle opening to these lines. The shift lines are selected according to the shift pattern, present range selection and the gear selector position.

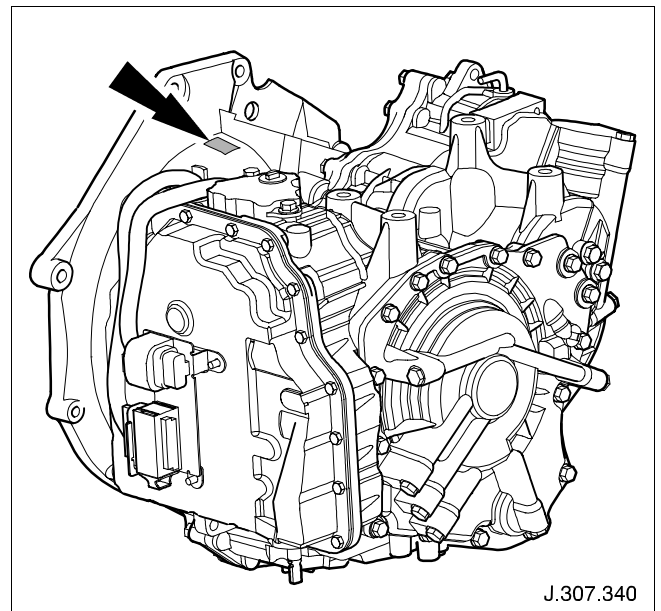
In the event of electrical failures the system has a failure management system to provide for a wide range of circumstances from individual signal loss to total loss of electrical power. Transaxle faults are indicated to the driver via the instrument cluster and a fail safe 'limp home' mode is entered where appropriate.

Gear selection is achieved using the J-gate selector; refer to **Transaxle External Controls** for gear selection information.

A mode switch operated by the driver is used to select between 'Normal' and 'Sport' modes. In 'Sport' mode the TCM will use higher engine revolutions, according to the unique shift map, than when in 'Normal' mode. The status of the mode switch is indicated to the driver by the illumination of a lamp in the switch when 'Sport' mode is selected.

Torque is transmitted from the reduction gear to the differential which then transmits the torque to the transfer case to provide the all-wheel drive system, refer to **Transfer Case** section for information.

CAUTION: To prevent damage to the automatic transaxle; refer to **JTIS, Jacking and Lifting for vehicle recovery procedures**.



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Fig. 28 Identification code label

Automatic Transaxle

Specifications

Table 1 Transaxle Specifications

Item		Specification
Automatic transaxle		5-forward speeds, 1–reverse, with planetary gears
Torque converter	Type	Symmetrical 3–element, 1–step 2–phase, with lock-up mechanism
	Stall torque ratio	1.91 (3.0 liter engine), 1.96 (2.5 liter engine)
Fluid pump		Trochoid gear drive
Control system		Electronically controlled
Gear ratio type		Wide ratio
Gear ratios	1st gear	3.802
	2nd gear	2.132
	3rd gear	1.365
	4th gear	0.935
	5th gear	0.685
	Reverse	2.970
Final gear ratio		3.898 (4.15 Mexico)
Lubricating system		Forced fluid delivery from fluid pump
Cooling system		External cooling system
Automatic transaxle fluid		Refer to Jaguar Technical Information System (JTIS)

Transaxle Control System

The signal interface between the engine control module (ECM) and the TCM is transmitted via the CAN.

The ECM supplies the TCM with powertrain:

- configuration data;
- status information;
- control information;
- plus speed (cruise) control status to enable the transaxle to operate to the adjusted setting.

The TCM supplies the ECM with transaxle control signals to provide:

- smooth operation during gear changes through reduction in engine torque;
- torque limiting to protect the transaxle from damage;
- fault codes for storage and later interrogation via WDS.

Transaxle control is achieved using nine solenoids that respond to electrical input signals received from the TCM, to regulate control valve operation. The control valves cause changes in the fluid-flow passages, which results in fluid pressure changes within the transaxle. These fluid pressure changes control the transaxle operation.

The illustration below shows the driveline and control system.

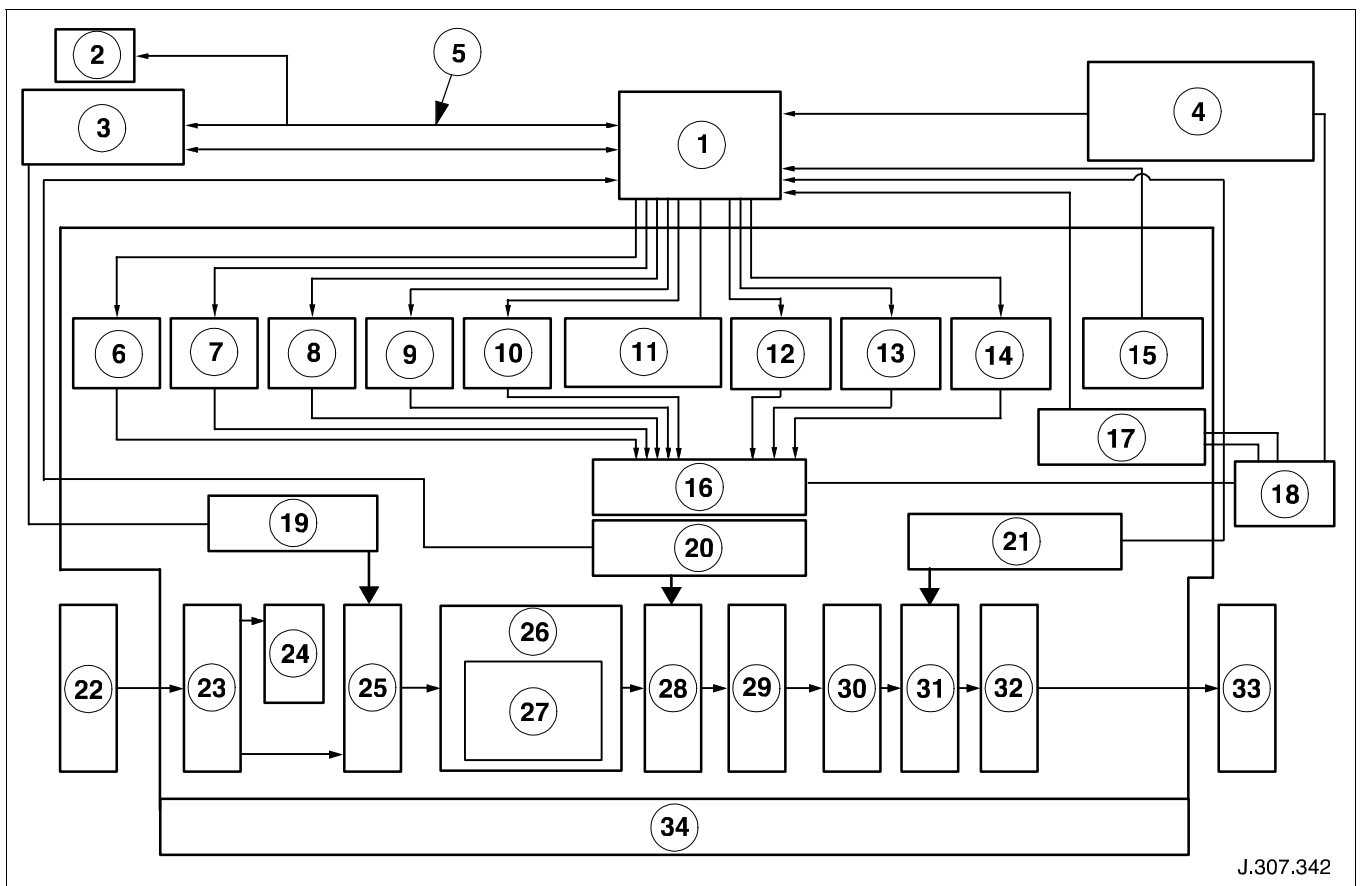


Fig. 29 Driveline and control system

Automatic Transaxle

Key to Fig. 29

1. Transmission control module
2. Anti-lock braking system
3. Engine control module
4. D/4 switch, sports mode switch
5. CAN (including torque down signal)
6. Line pressure solenoid
7. Lock-up solenoid
8. Shift solenoid A
9. Shift solenoid B
10. Shift solenoid C
11. Low clutch timing solenoid
12. Reduction timing solenoid
13. 2-4 brake timing solenoid
14. 2-4 brake duty solenoid
15. Transaxle fluid temperature sensor
16. Control valve
17. Transmission rotary switch
18. Select lever
19. Turbine sensor
20. Intermediate sensor
21. Vehicle speed sensor
22. Engine
23. Torque converter
24. Fluid pump
25. Input shaft
26. Four-speed gear train
27. Clutch, brake, planetary gear, etc
28. Output gear
29. Idler gear
30. Reduction gear train
31. Parking gear
32. Final gear and differential
33. Transfer case
34. Transaxle assembly

A general outline of transaxle control functions are shown in the table below:

Table 2 Transaxle Control Functions

Item	Function
Gear change control	Shifts the gear in range from '1st to 5th' according to the shift schedule set for each driving range and enables selection of engine brake mode depending on the range.
Line pressure control	Required clutch and brake operating fluid pressure vary with selected transaxle speed. The line pressure control regulates these changing pressures. Finer control of fluid pressure change during gear shift assures smooth and comfortable ride.
Lock-up control	The torque converter and lock-up clutch are directly connected. The lock-up control regulates the lock-up clutch operation. Lock-up is possible in '1st to 5th gears' of the 'D, 4, 3 and 2 ranges'. Establishes lock-up control for cruise control in a certain speed range to enhance fuel economy and quietness.
Timing solenoid control: A. Reduction timing solenoid, B. Low clutch timing solenoid, C. 2, 4 brake timing solenoid	Controls the clutch and brake operational timing during start or gear change operation to enhance gear change response and to ease gear change shock. It also prevents erroneous shifting into 'R' range when the vehicle is moving forward.
Torque-down control	Reduces the engine torque during gear changes reducing gear change shock. A control signal is sent from the TCM to the ECM
Gear change timing control using turbine sensor and intermediate sensor	Closely monitors automatic transaxle internal operating conditions using the turbine sensor and intermediate sensor. It optimizes lock-up control as well as brake and clutch operational timing during gear changes, therefore reducing gear change shock.
1. Abnormal signal control 2. Fail safe control	The TCM fail-safe mechanism functions whenever an abnormal input or output signal is detected. The mechanism redirects the control functions so running efficiency losses are minimized.
Reverse prohibition control	When 'R' range is selected at the speed of 8 km/h (5 m.p.h.) or more, the TCM sets the low-clutch timing solenoid 'ON' to drain the low and reverse brake pressure. This brings about 'N' range condition superseding, 'R' range being selected.
Engine speed restriction	When in 'Neutral' or 'Park' the engine speed is restricted to 3000 rev/min

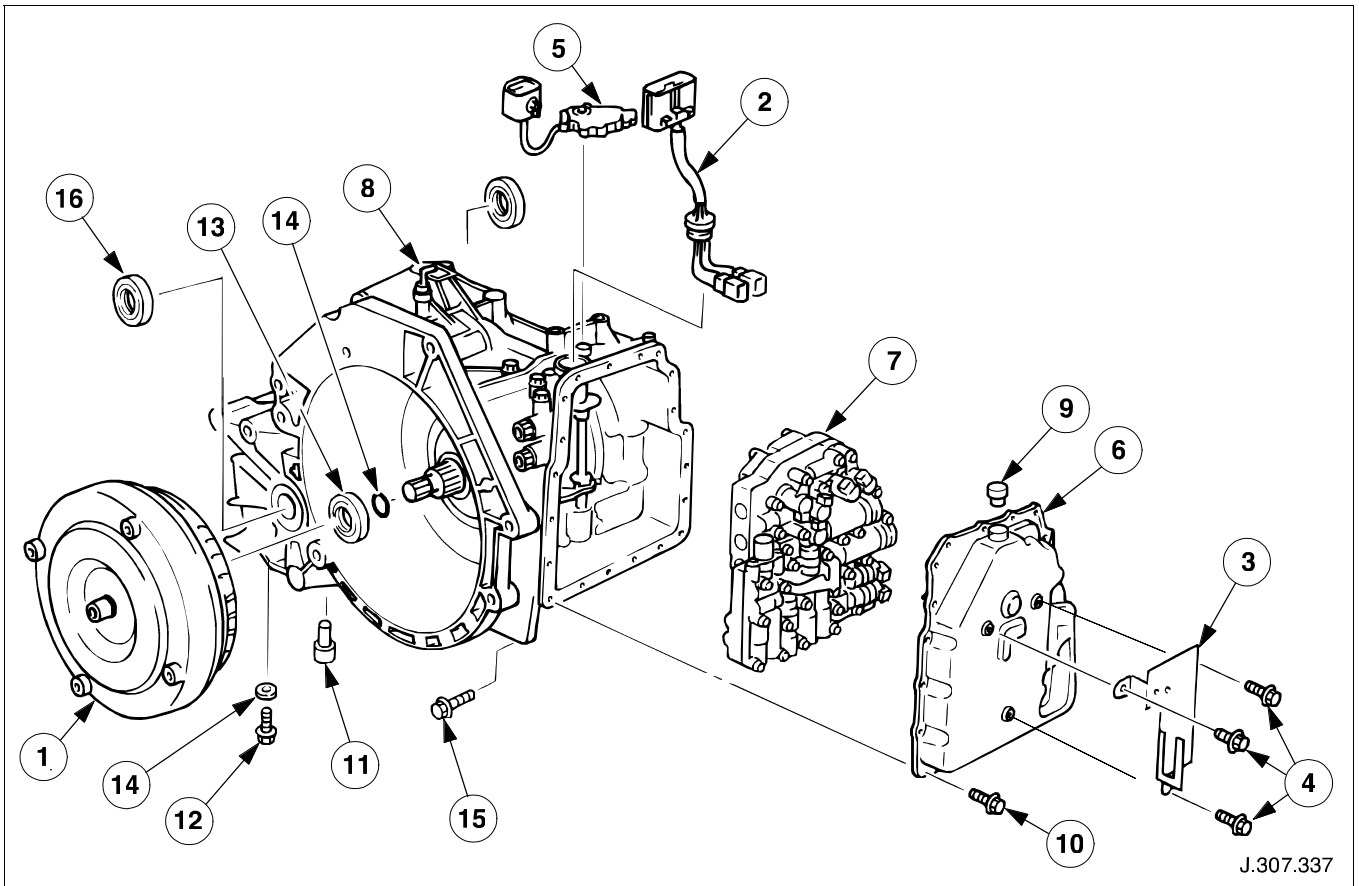
Automatic Transaxle

The transaxle's input and output signals are detailed below:

Table 3 Input and output signals

	Component / Signal	Function
Input Signal	Vehicle speed sensor	Senses the parking gear rotational speed to determine the vehicle speed
	Turbine sensor	Senses the turbine runner rotational speed to determine the input rotation power being delivered to the transaxle
	Intermediate sensor	Senses the rotational speed of output gear of 4-speed gear train
	Transmission rotary switch	Senses the position (range) of the select lever
	Sport mode switch	Senses which driving mode is selected among 'Sport'
	D/4 switch	Detects the selector lever position in 'D or/and 4' ranges
Output Signal	Shift solenoid A	Operates the shift valve 'A' in the control valve as part of gear change control.
	Shift solenoid B	Operates the shift valve 'B' in the control valve as part of gear change control
	Shift solenoid C	Operates the shift valve 'C' in the control valve as part of gear change control
	Line pressure solenoid	Adjusts the throttle pressure as part of line pressure control
	Low clutch timing solenoid	Adjusts roller clutch pressure as part of gear change and line pressure control
	Lock-up solenoid	Operates the lock-up control valve in the control valve for lock-up control.
	Reduction timing solenoid	Adjusts reduction brake pressure as part of gear change control
	Torque-down request signal	The signal supplied to the ECM during gear change The signal requests the reduction of engine torque
Communication	1. 2, 4 brake timing solenoid 2. 2, 4 brake duty solenoid	Adjusts pressure during the gear change to and from '2nd, 4th and 5th' gear
	CAN	Provides communication between the TCM, ECM and diagnosis tester

Transaxle Construction

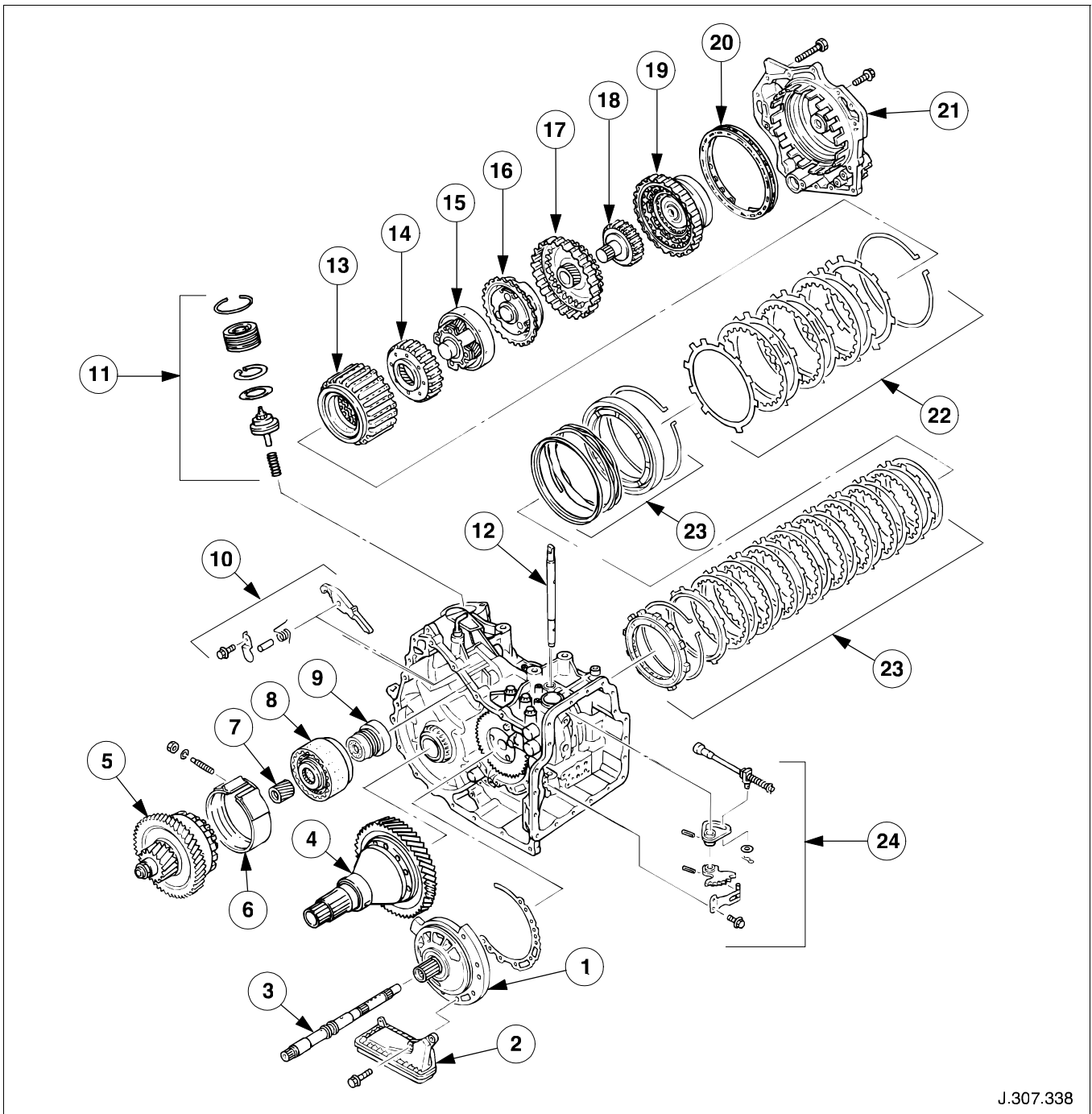


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Fig. 30 Transaxle construction 1

- | | |
|-------------------------------|---|
| 1. Torque converter | 9. Cap |
| 2. Terminal assembly | 10. Control valve cover installation bolt |
| 3. Bracket | 11. Fluid level tube |
| 4. Bracket installation bolt | 12. Magnet plug |
| 5. Transmission rotary switch | 13. Fluid seal |
| 6. Control valve cover | 14. O-ring |
| 7. Control valves | 15. Converter housing installation bolt |
| 8. Air breather | 16. Differential fluid seal |

Automatic Transaxle



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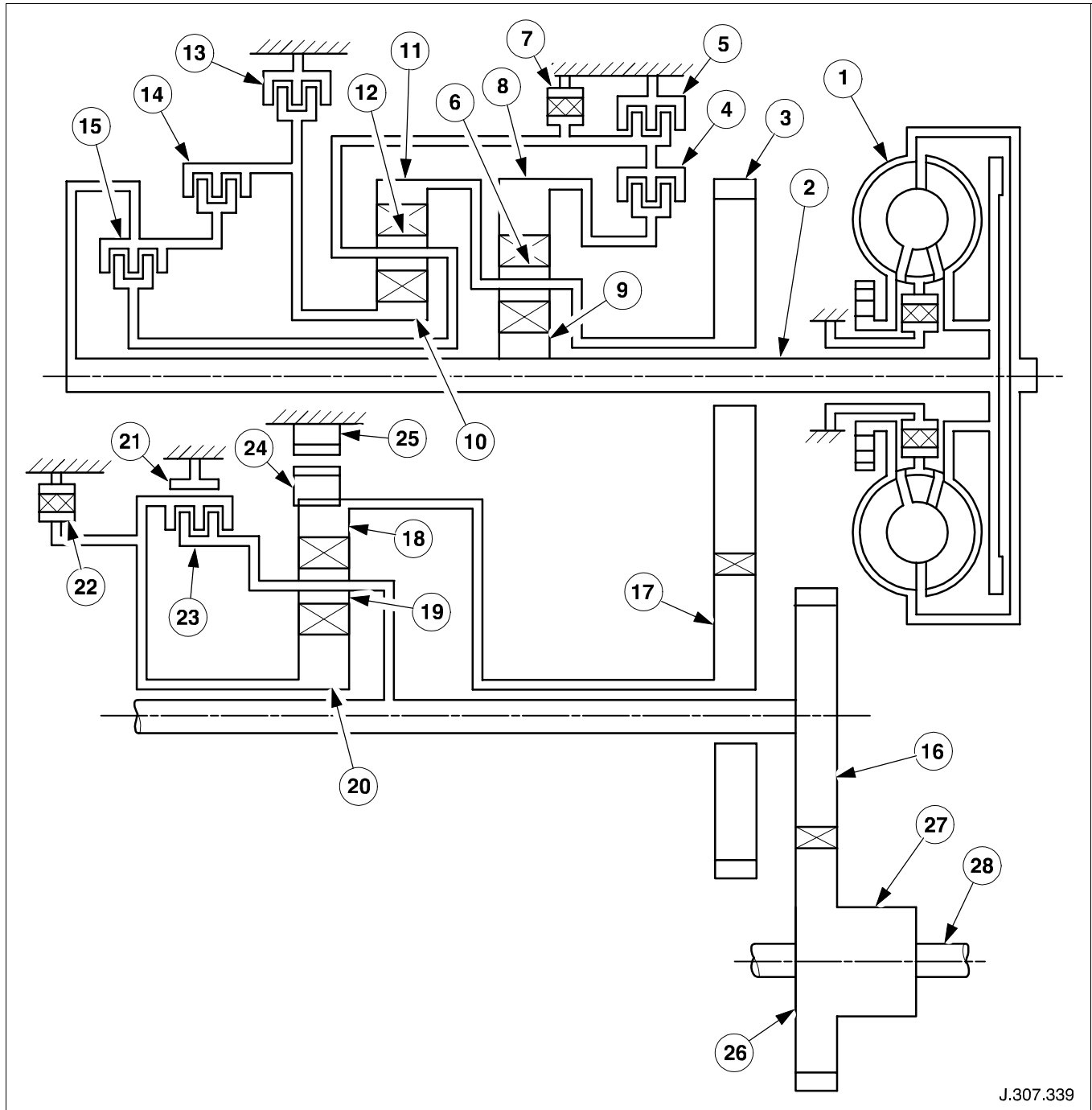
Fig. 31 Transaxle construction 2

Key to Fig. 31

1. Fluid pump
2. Fluid strainer
3. Input shaft
4. Differential gear
5. Reduction gear
6. Reduction brake band
7. Sun gear
8. Direct clutch
9. One-way clutch inner race
10. Parking mechanism
11. Band servo
12. Manual shaft
13. Low clutch
14. Internal gear
15. Rear planetary carrier
16. Front planetary carrier
17. Low clutch hub
18. High clutch hub
19. Reverse and high clutch assembly
20. Return spring
21. Side cover
22. 2-4 brake
23. Low and reverse brake
24. Parking component

Automatic Transaxle

Illustration shows a cross-section view of the transaxle's power train configuration.



J.307.339

Fig. 32 Power train

Key to Fig. 32

1. Torque converter
2. Input shaft
3. Output gear
4. Low clutch
5. Low and reverse brake
6. Rear planetary pinion gear
7. Low one-way clutch
8. Rear internal gear
9. Rear sun gear
10. Front sun gear
11. Front internal gear
12. Front planetary pinion gear
13. 2-4 brake
14. Reverse clutch
15. High clutch
16. Reduction gear
17. Idler gear
18. Reduction internal gear
19. Reduction planetary pinion gear
20. Reduction sun gear
21. Reduction brake band
22. Reduction one-way clutch
23. Direct clutch
24. Parking gear
25. Parking pawl
26. Final gear
27. Differential gear
28. Drive shaft

Automatic Transaxle

Description of Transaxle Components

The following describes the features of the major automatic transaxle components and electronic control components and their relationship with one another.

Transmission control module

- The TCM is located forward of the left-hand-side lower 'A' post, refer to **Transaxle Control System** for function information.

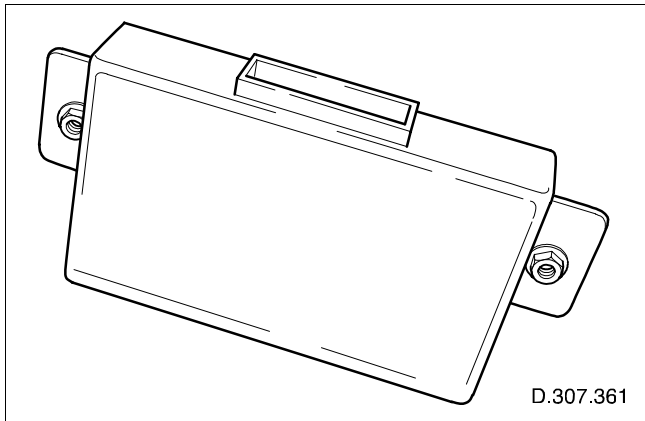


Fig. 33 Transmission control module

Solenoids

- The transaxle uses nine solenoids which control the transaxle, the solenoids are actuated by TCM output signals.
- All the nine solenoids can be classified in two types by their operating types. Three of them are duty solenoids, the remaining six solenoids are ON-OFF solenoids.
- Each solenoid has an internal coil. Current through the coil actuates the needle valve. The needle valve opens and closes the fluid pressure circuits.
- ON-OFF solenoids close the fluid pressure circuits in response to current flow.
- ON-OFF solenoids: shift solenoid A, shift solenoid B, shift solenoid C, low clutch timing solenoid, reduction timing solenoid, 2-4 brake timing solenoid.
- The duty solenoids repeatedly turn ON and OFF in 50 Hz cycles. This opens and closes the fluid pressure circuits.
- A spring is installed inside the duty solenoid. The spring applies force against the needle valve. The needle valve operates in response to current flow (ON). Spring force is overcome when current flow ceases (OFF), spring force returns the needle valve to its original position.
- Duty solenoids: line pressure solenoid, lock-up solenoid, 2-4 brake duty solenoid.

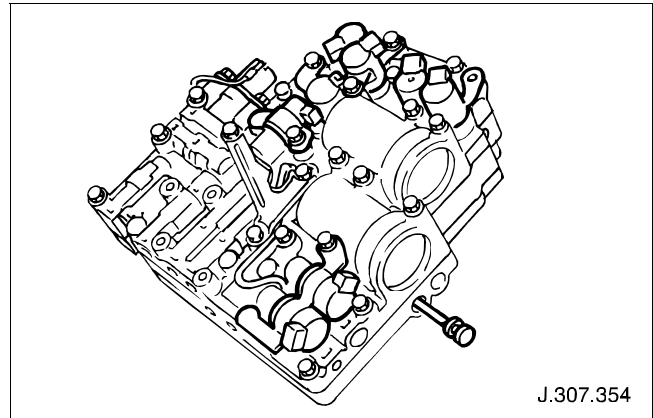


Fig. 34 Solenoid valves

Control valves

- The control valves cause changes in the fluid-flow passages, which results in fluid pressure changes within the transaxle. These fluid pressure changes, control the transaxle operation.

Transaxle fluid temperature sensor

- The transaxle fluid temperature sensor (TFT sensor) is installed in the transaxle case. It constantly monitors automatic transaxle fluid temperature.
- Automatic transaxle internal operational resistance varies with automatic transaxle fluid temperature change. The TCM detects transaxle fluid temperature according to the voltage produced by the TFT sensor.

Turbine sensor

- The turbine sensor detects the reverse clutch drum revolution speed. The reverse clutch drum is connected to the input shaft and rotates at the same speed. The TCM calculates the input shaft speed to determine the turbine speed.
- The turbine sensor uses a magnetic coil. As the input shaft rotates, the sensor detects a pulse signal according to the gear teeth on the outside of the reverse clutch drum, and sends it to the TCM.

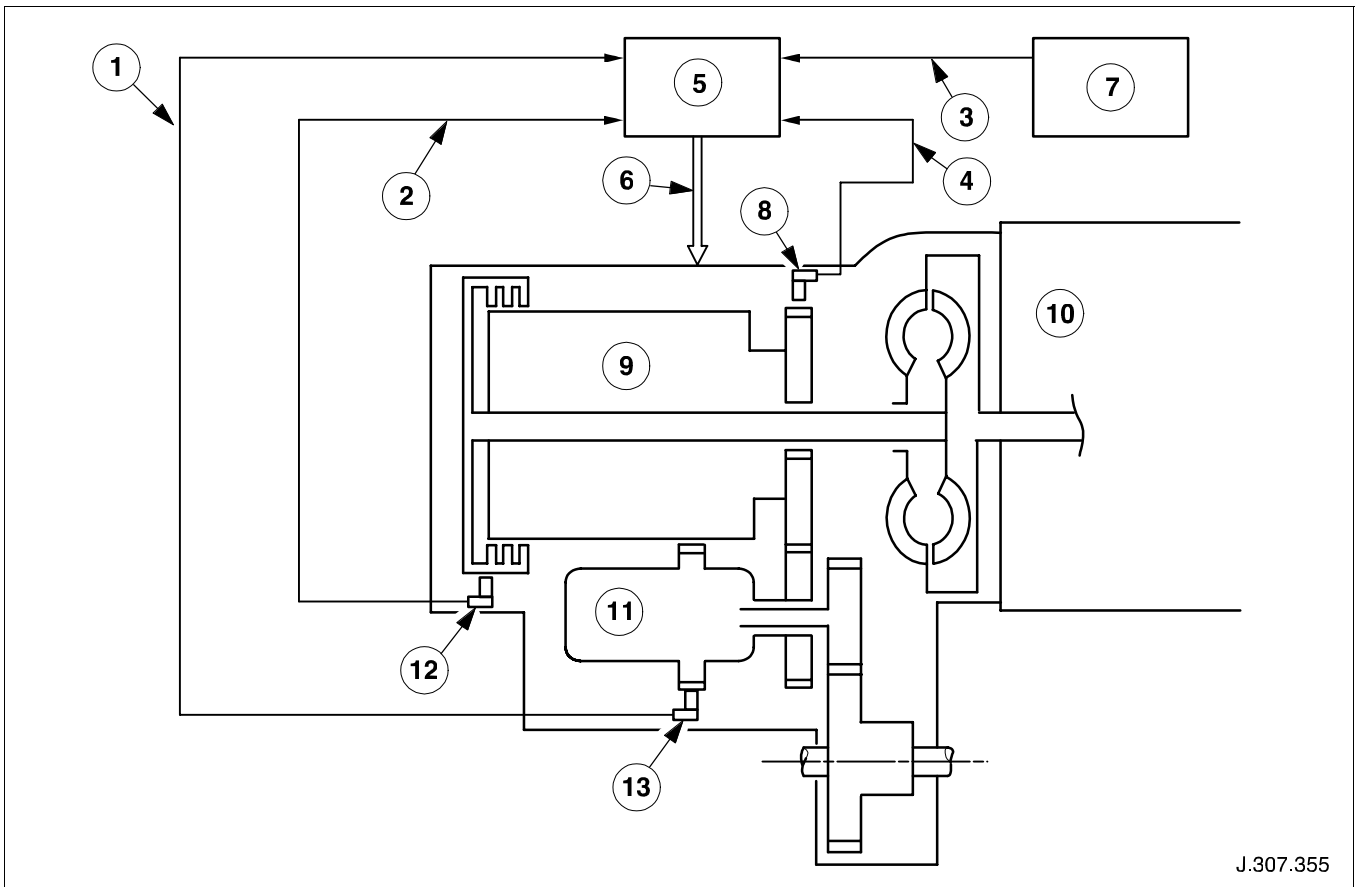
Vehicle speed sensor

- The vehicle speed sensor detects the parking gear rotation speed. The TCM calculates vehicle speed based on the parking gear rotation speed.
- The vehicle speed sensor uses a magnetic coil. As the parking gear rotates, the sensor detects a pulse signal according to the gear teeth rotation speed, and sends it to the TCM.

Intermediate sensor

- The intermediate sensor detects the output gear rotation speed which is calculated by the TCM
- The intermediate sensor uses a magnetic coil. As the output gear rotates, the sensor detects a pulse signal according to the gear teeth rotation, and sends it to the TCM.

Automatic Transaxle



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Fig. 35 Sensor schematic

- | | |
|---|--------------------------|
| 1. Output shaft rotational speed sensor | 8. Intermediate sensor |
| 2. Input shaft rotational speed sensor | 9. Gear train |
| 3. Engine speed signal (on CAN bus) | 10. Engine |
| 4. Output gear rotational signal | 11. Reduction gear train |
| 5. Transmission control module | 12. Turbine sensor |
| 6. Transaxle control | 13. Vehicle speed sensor |
| 7. Engine control module | |

Torque converter (with lock-up mechanism)

- The torque converter delivers the engine drive power to the transaxle. When the lock-up clutch is released, the power delivery is depended on transaxle fluid. When the lock-up clutch is engaged, the engine power is delivered to the transaxle through the lock-up clutch.
- A symmetrical element 1-step 2-phase torque converter is used with the transaxle.
- The 3 symmetrical elements (impeller, turbine, and stator) are shown; refer to **Fig. 36**. Note the symmetrical arrangement of the 3 elements.
- The term '1-step' refers to the single turbine and runner assembly.
- The term '2-phase' refers to the turbine runner speed relative to the pump impeller speed. When the turbine runner speed is lower than the pump impeller speed, the mechanism operates as a simple torque converter. When the turbine runner speed is higher than pump impeller speed, the mechanism acts as a fluid coupling.

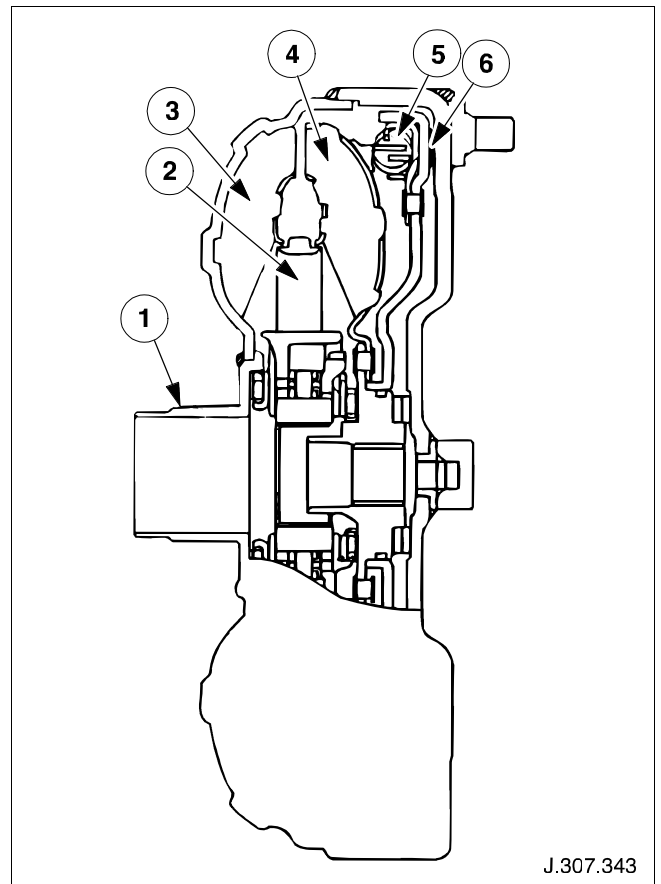


Fig. 36 Torque converter (with lock-up mechanism)

1. Sleeve
2. Stator
3. Pump impeller
4. Turbine runner
5. Torsion damper
6. Lock-up clutch

Automatic Transaxle

Transaxle fluid pump

- A trochoid fluid pump is used which has the advantage of very low power loss.
- The fluid pump is driven by the engine. The inner rotor connects to the torque converter sleeve.

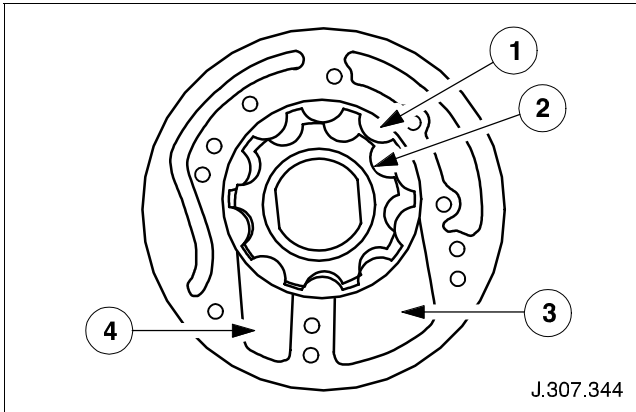


Fig. 37 Transaxle fluid pump

1. Outer rotor
2. Inner rotor
3. Suction port
4. Discharge port

Planetary gear

The planetary gear assembly consists of sun gear, pinion gear, pinion carrier, and internal gear.

Definition of component parts:

- Sun gear: is located in the central position.
- Pinion gear: revolves in mesh while rotating around the sun gear.
- Pinion carrier: rotates to support the pinion gear.
- Internal gear: located outside the pinion gears and is always in mesh with the pinion gear, it rotates on the same axis as the sun gear.

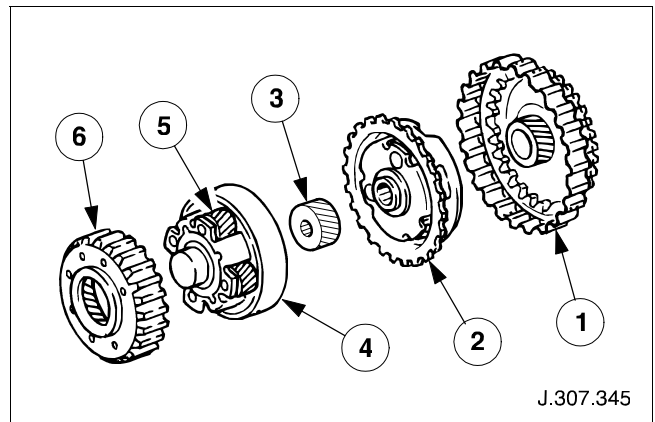


Fig. 38 Planetary gear

1. Front sun gear
2. Front pinion gear
3. Rear sun gear
4. Front internal gear
5. Rear pinion gear
6. Rear internal gear

Clutch

- The transaxle has four built-in wet-type multiple disc clutches (the low clutch, the high clutch, the reverse clutch, and the direct clutch). Typical clutch structure and operation are shown in **Fig. 39**.
- Each clutch has two primary rotating parts (the clutch drum and the clutch hub). Power transmission is effected and controlled by these two parts. The clutch drum and hub are connected to a clutch plate. Pressure applied to the clutch plate results in power transfer. When this pressure is released from the clutch plate, power does not transfer.
- The clutch plates at the clutch drum-side function as the driven plates. The clutch plates at the clutch hub-side function as the drive plates. The drive plates have friction materials on the faces. The retaining plate is attached to the driven plate. The retaining plate also serves as a spacer when the clutch is disengaged, it ensures specified clutch clearance.

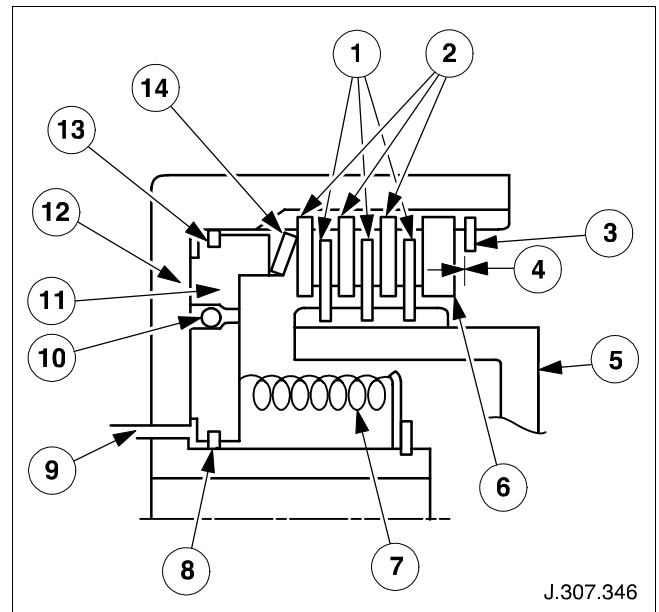


Fig. 39 Clutch

1. Driven plate
2. Drive plate
3. Snap ring
4. Clutch clearance
5. Clutch hub
6. Retaining plate
7. Return spring
8. Rubber seal
9. Hydraulic circuit
10. Check ball
11. Piston
12. Clutch drum
13. Rubber seal
14. Dish plate

- Clutch engagement occurs when fluid pressure is applied to the piston in the clutch drum. The dish plate acts as a cushion, to prevent sudden and violent force applied to the clutch plates, which may causes a rough clutch engagement.
- The piston is returned by return spring forces to ordinal position when the fluid pressure is removed through the drain hole. As a result, the clutch is disengaged.
- The check ball is forced to seal the fluid circuit by fluid pressure against the fluid input hole when the clutch is engaged.

Automatic Transaxle

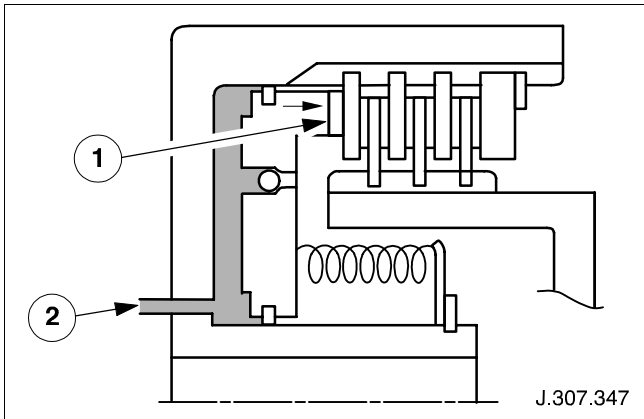


Fig. 40 Clutch engaged

1. Dish plate
2. Line pressure

- When the clutch is released, the check ball moves back from the input hole to open the circuit, and air is led into the fluid chamber. This prevents residual fluid pressure build-up in the clutch drum.
- The clutch drum and the clutch hub are connected to the planetary gears respectively. Planetary gear rotation acts as the controlling element of the clutch.

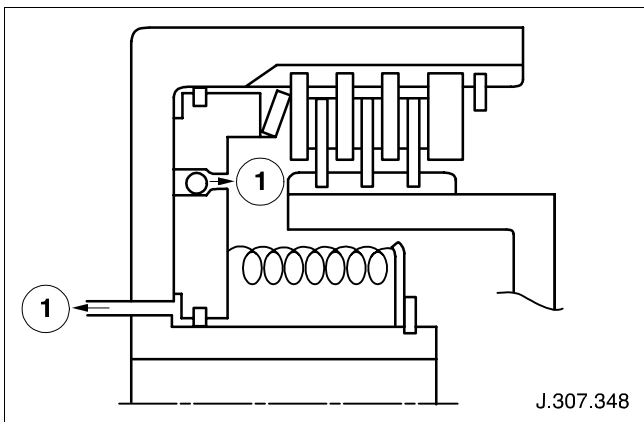


Fig. 41 Clutch released

1. Drain

Cancel force cover

- The transaxle is equipped with a centrifugal fluid pressure cancel in low and high clutch.
- The centrifugal fluid pressure cancel improves clutch release time by applying force to the low and high clutch.
- This system improves operating performance of the piston, compared with the check ball system. The piston returns

to the original position by centrifugal force that is kept at the pressure located at the other side of the piston cylinder. Therefore, the response of the clutch release operation is improved, and quick gear change is obtained.

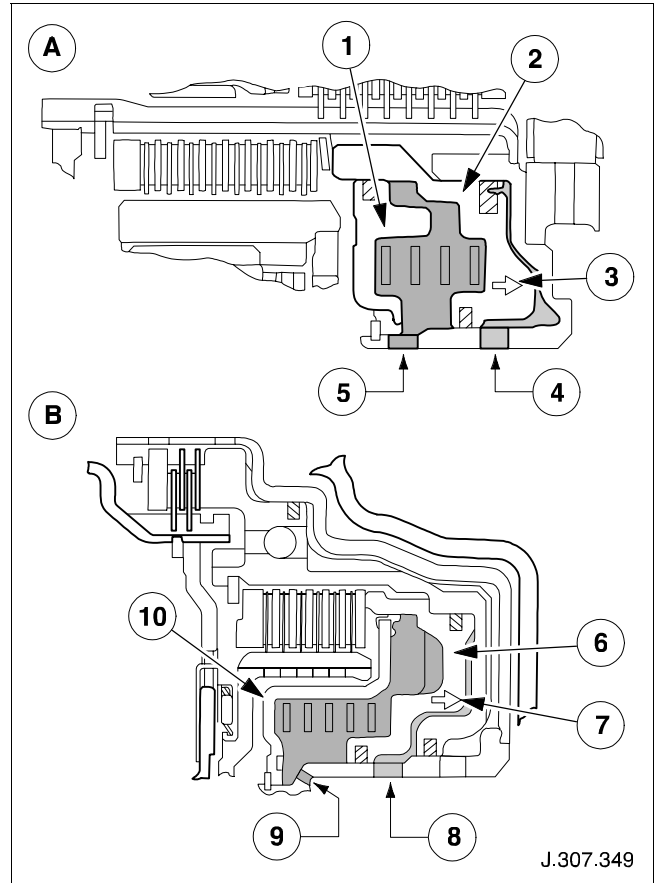


Fig. 42 Cancel force cover

- A. Low clutch
 1. Cancel force cover
 2. Low clutch piston
 3. Cancel force
 4. Low clutch pressure
 5. Lubricating pressure
- B. High Clutch
 6. High clutch pressure
 7. Cancel force
 8. High clutch pressure
 9. Lubricating pressure
 10. Cancel force cover

Low and reverse brake, and 2-4 brake

- The low and reverse brake and the 2-4 brake are multi-disc type brakes. Basic brake operation is similar to the clutch. The clutch drum is mounted to an appropriate position on the transaxle case. The low and reverse brake and the 2-4 brake act to stop the clutch hub rotation when the clutch plate is engaged.

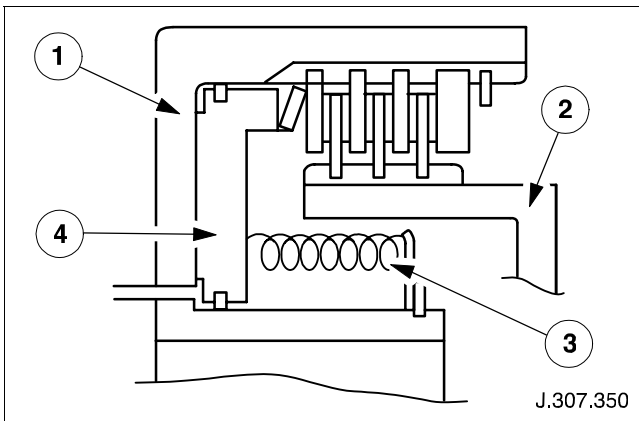


Fig. 43 Low and reverse, and 2-4 brake

- Transaxle case
- Brake hub
- Return spring
- Piston

Reduction brake band and band servo

CAUTION: Care must be taken not to confuse the brake-band anchor end bolt with the fluid drain plug; refer to JTIS for further information.

- The brake band acts in response to the servo to stop the direct clutch drum rotation.
- The servo has a piston that operates in response to changes in fluid pressure. The piston expands in P and N ranges, 1st, 2nd, 3rd, 4th, and reverse gears to stop the direct clutch drum rotation.
- When the line pressure reaches the band servo, the servo piston operates. The downward piston stroke causes the piston stem to tighten the brake band. The direct clutch drum rotation stops.

- The anchor end bolt is used to maintain appropriate clearance between the brake band and the direct clutch drum when the brake band is released. This clearance can be adjusted with the adjusting nut on the anchor end bolt.

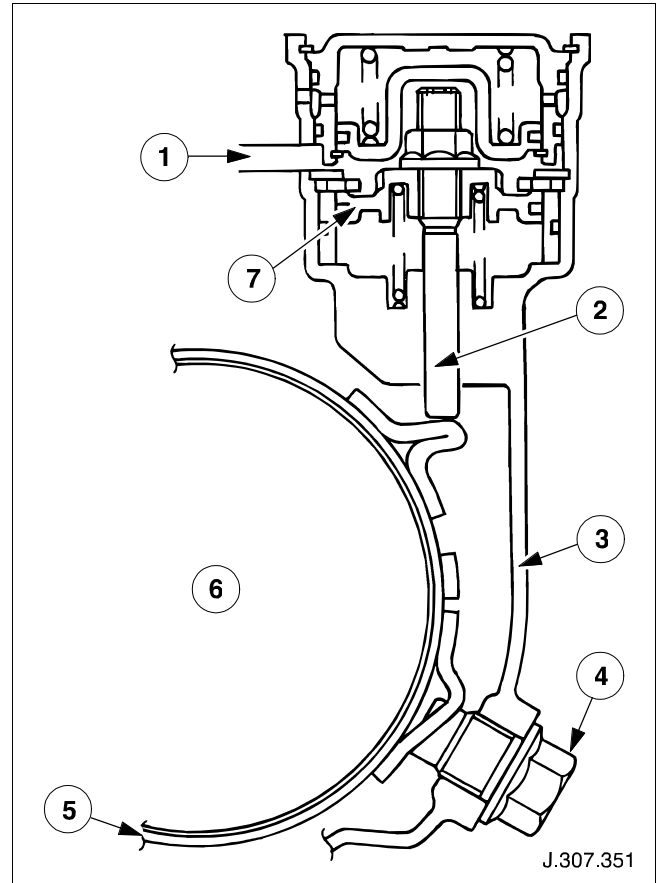


Fig. 44 Reduction brake band and band servo

- Brake band engagement pressure
- Piston stem
- Transaxle case
- Anchor end bolt
- Brake band
- Direct clutch drum
- Brake piston

Automatic Transaxle

Low one-way clutch and reduction one-way clutch

- The transaxle uses a roller-type one-way clutch for low clutch, and uses a sprag-type one-way clutch for reduction brake.
- Low one-way clutch: the front planetary carrier is fixed by the inner race which runs idle during 1st gear operation.
- Reduction one-way clutch: the reduction sun gear is fixed by the inner race which runs idle during 1st, 2nd, 3rd, and 4th gear operations.

(Roller type one-way clutch)

- Normally, rollers are energized to the narrower section via a spring. Therefore, in the direction where the rollers are engaged between the cam and inner race, they are united to transmit torque. In the reverse direction, because the rollers move in the direction where the clearance is larger, clearances occur between races, and the inner and outer races can rotate to each other.

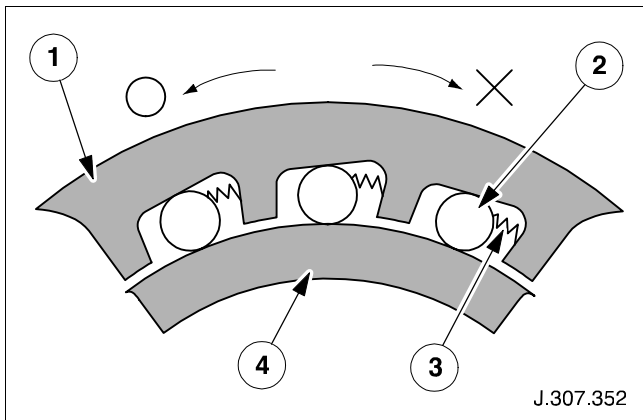


Fig. 45 Roller type

1. Outer race
2. Roller
3. Spring
4. Inner race

(Sprag-type one-way clutch)

- Note the difference between sprag diameters 'a' and 'b'. If the inner race tries to turn toward the left, radius 'b' (longer than gap 'c') firmly locks the sprag to prevent the sprag from moving to the left.

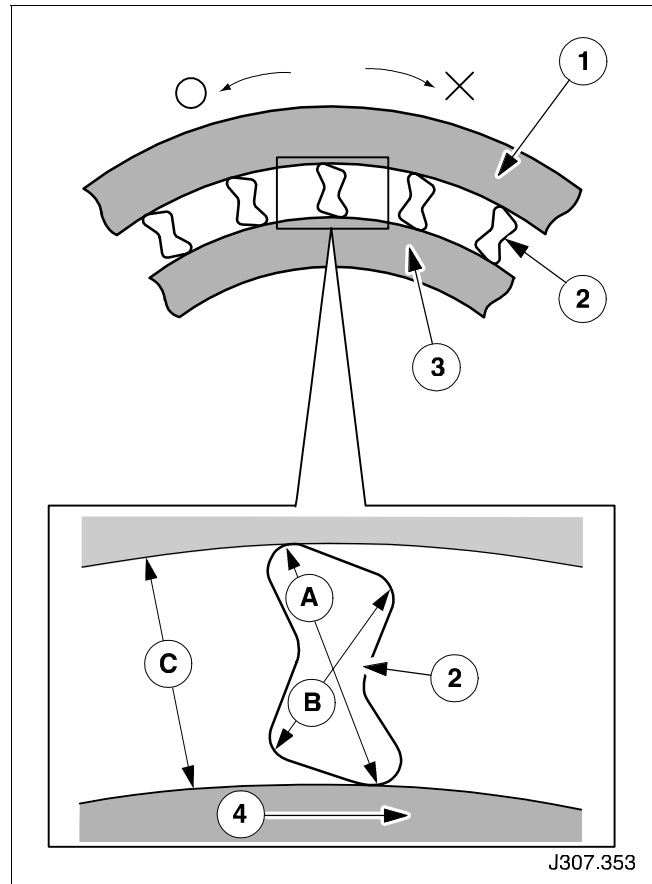


Fig. 46 Sprag type

1. Outer race
2. Sprag
3. Inner race
4. Direction of rotation

Transaxle External Controls

The J-gate accommodates two driving techniques:

- Automatic selection — the right-hand side of the selector gate.
- Manual selection — the left-hand side of the selector gate for the individual selection of 4th, 3rd, 2nd gear; the transaxle operates automatically but will not engage gears higher than the one selected.

A brake pedal/gear-shift interlock feature is also incorporated in the J-gate selector mechanism which is operated by a

solenoid which receives its signal from the ECM via the CAN bus. This feature allows the transaxle to be shifted out of 'Park' only when the ignition is in position 'II' or the engine is started and, the brake pedal is depressed.

The 'Sport' mode switch illuminates to indicate that 'Sport' mode is selected.

Cable adjustment is achieved at the transaxle end of the cable by the means of a sliding clamp adjuster. There are no adjustment capabilities within the selector mechanism.

The cable is attached at both ends with ball connections.

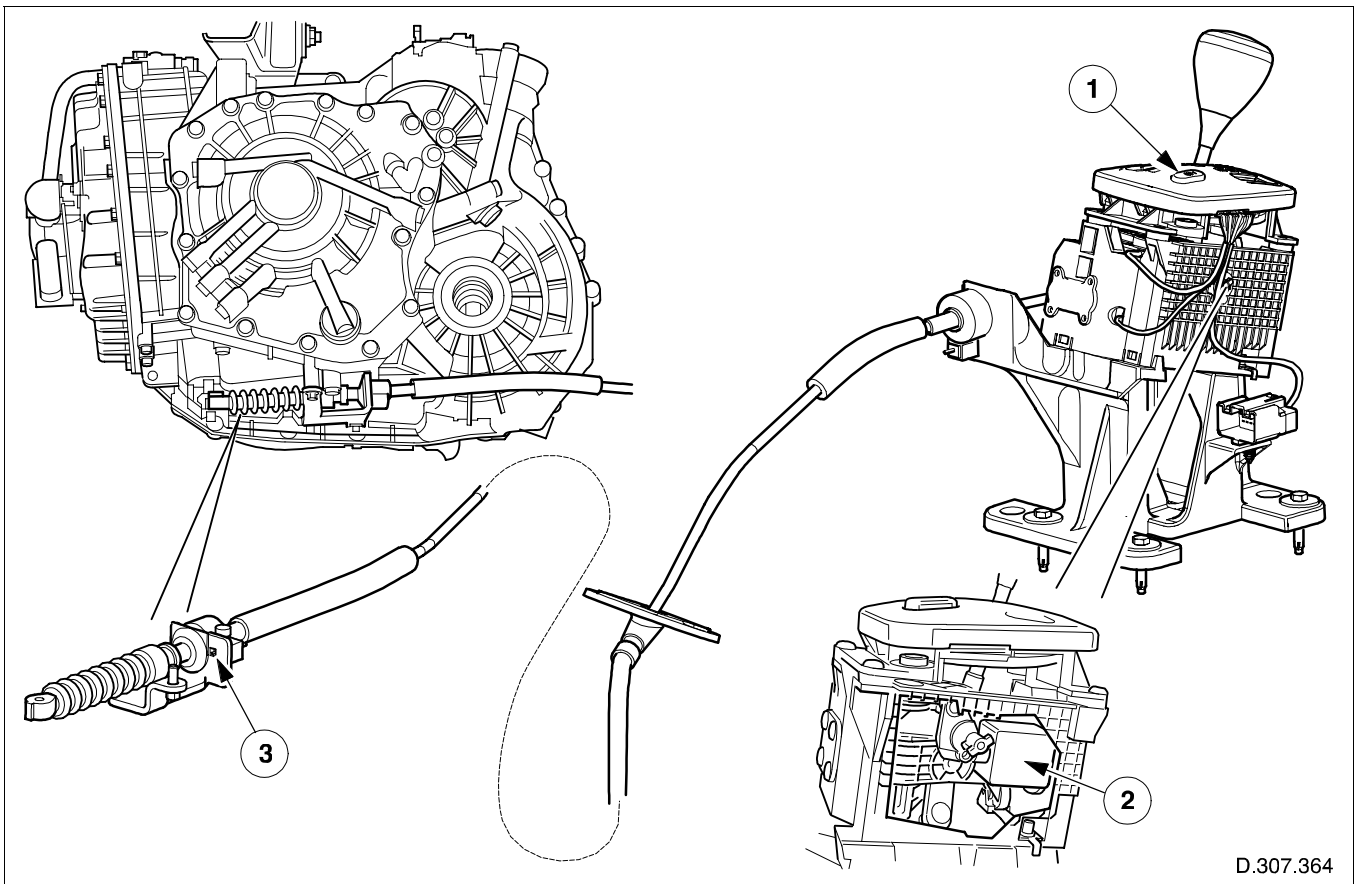


Fig. 47 Automatic gearshift selector

1. Sport mode switch
2. Gear-shift interlock solenoid
3. Cable adjuster

Automatic Transaxle

Transaxle Cooling

The transaxle cooling radiator is installed forward of the engine cooling radiator, below the air-conditioning condenser. It has an integrated thermostat on the left-hand side, which controls the transaxle's fluid temperature.

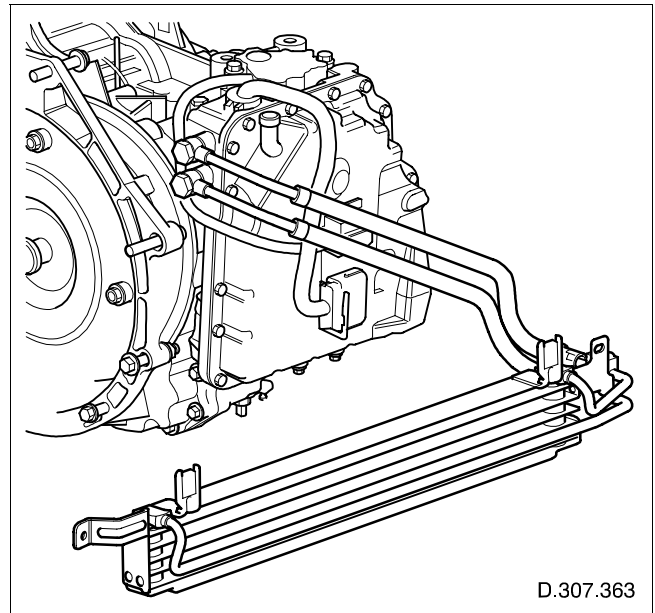


Fig. 48 Transaxle cooling

Manual Transaxle and Clutch

Introduction

The X-TYPE is the first Jaguar to be installed with a transversely-mounted manual transaxle which combines both the manual transmission and differential into one unit. The term transaxle, developed from the terms transmission and axle, is used to describe this type of arrangement.

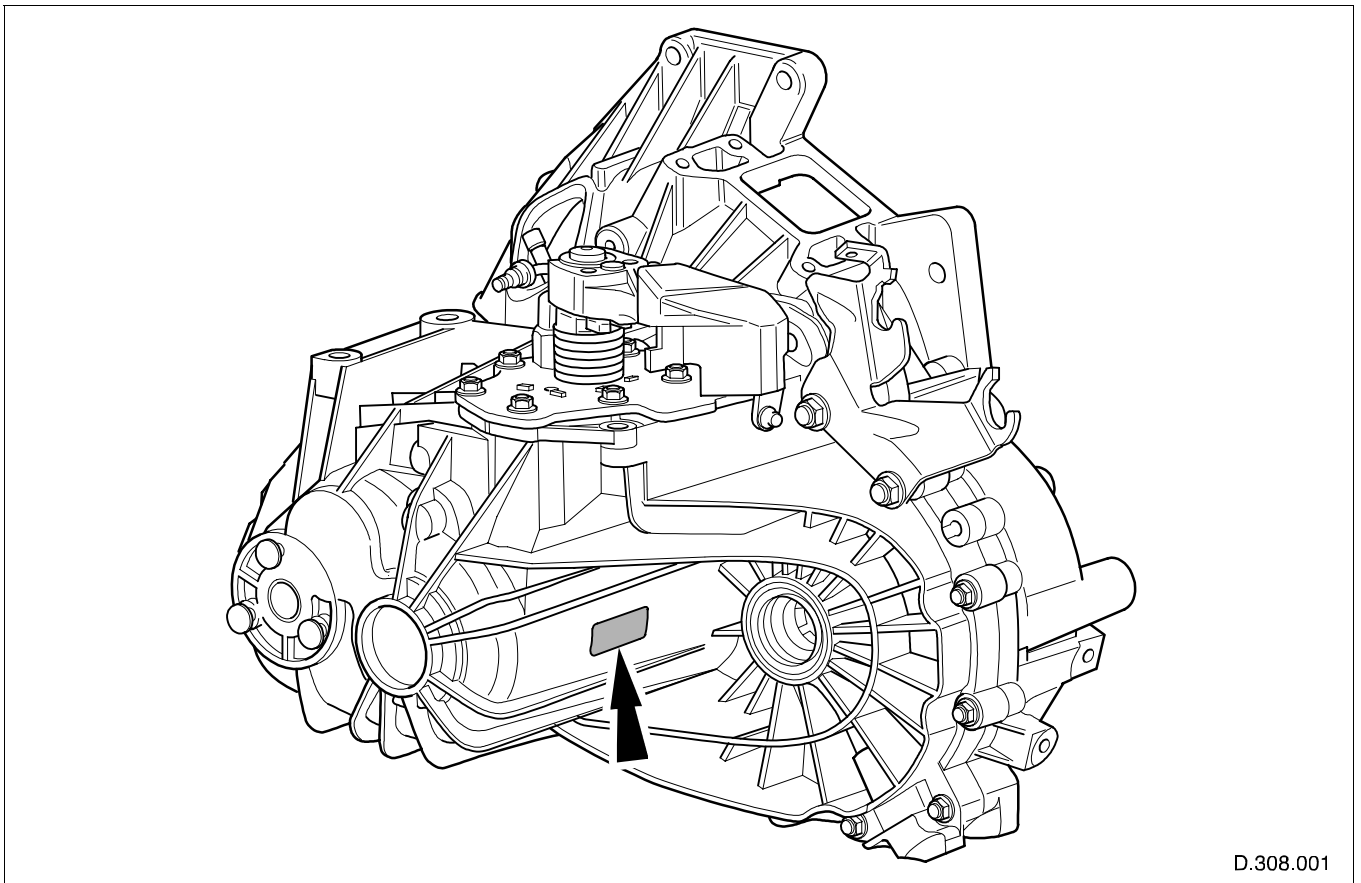
The transaxle is a 5 speed, 2 shaft design with all pairs of gears in continuous mesh. Each forward gear ratio is produced through a single pair of dedicated gears, with the direction of power flow being reversed in the transaxle. Direction of rotation of the output shaft is reversed by an idler gear when reverse gear is selected.

All gears are helical-cut including reverse, this type of gearing enables a higher gear contact ratio which can be transmitted with minimum rolling noise, resulting in a quiet operation.

Torque is transmitted from the output shaft to the differential which then transmits the torque to the transfer case to provide the all-wheel drive system, refer to **Transfer Case** section for information.

The aluminium transaxle housing consists of two closed sections, the reinforcing ribs on the transaxle housing reduce noise and vibration.

CAUTION: To prevent damage to the manual transaxle; refer to **JTIS, Jacking and Lifting** for vehicle recovery procedures.



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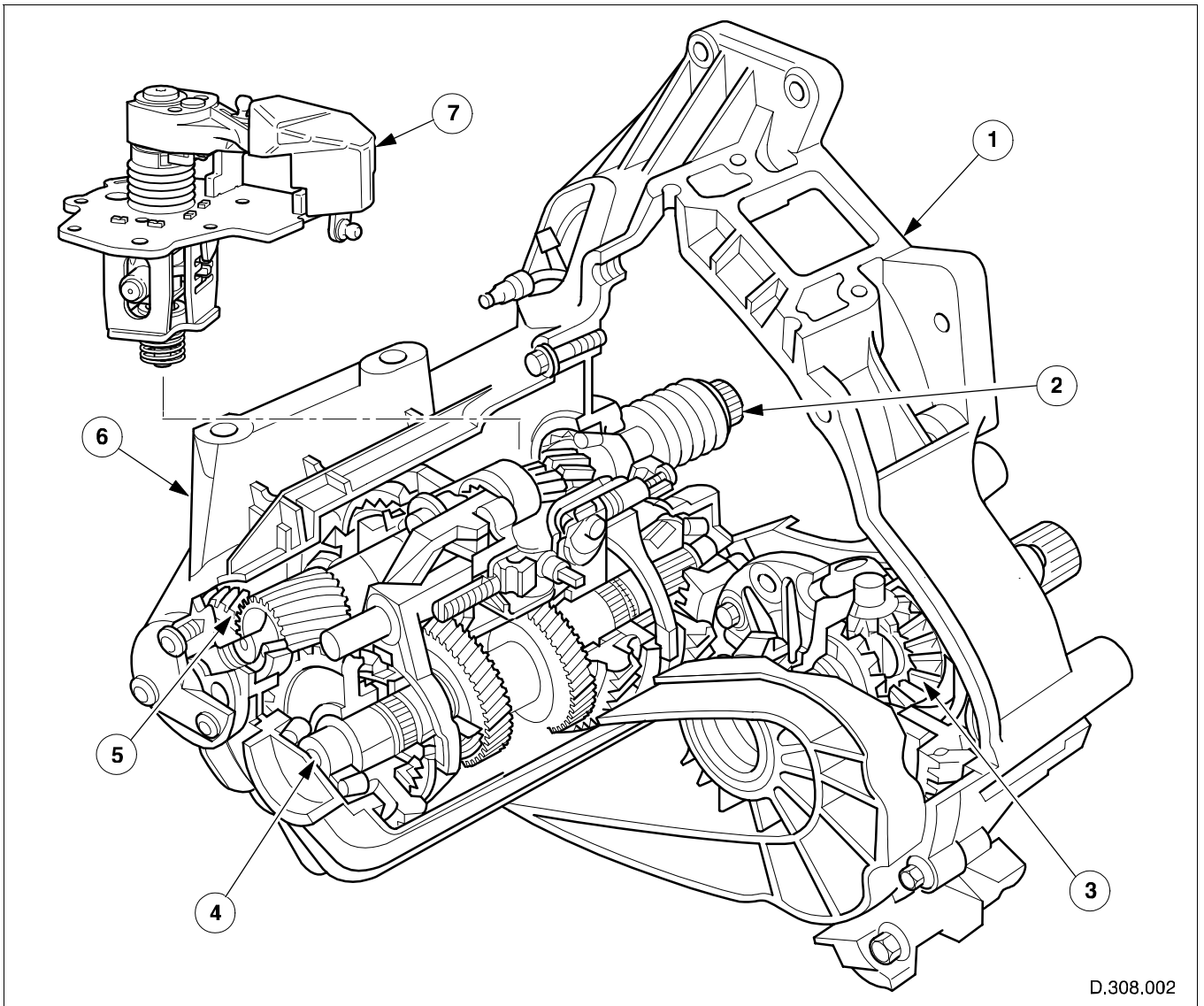
Fig. 49 Identification code label

Manual Transaxle and Clutch

Specifications

Item		Specification
Manual Transaxle		5-forward speeds, 1–reverse
Gear ratios	1st gear	3.42
	2nd gear	2.14
	3rd gear	1.45
	4th gear	1.03
	5th gear	0.77
	Reverse	3.47
Final gear ratio		3.80
Manual transaxle lubricant		Refer to Jaguar Technical Information System (JTIS)

Transaxle Construction



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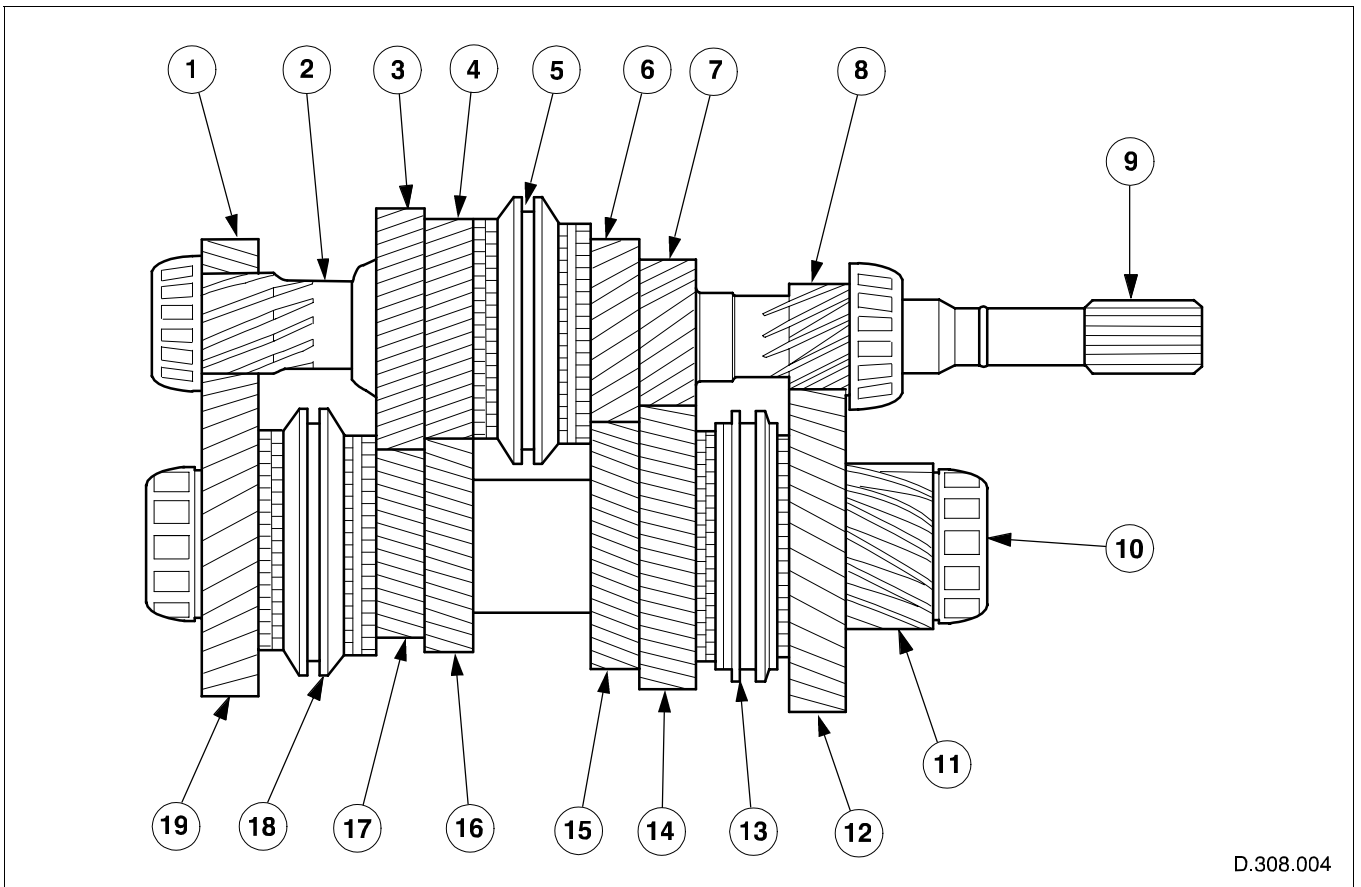
Fig. 50 Transaxle construction

- | | |
|------------------------------------|-----------------------|
| 1. Transaxle housing - clutch side | 5. Reverse gear idler |
| 2. Input shaft | 6. Transaxle housing |
| 3. Differential | 7. Selector mechanism |
| 4. Output shaft | |

Manual Transaxle and Clutch

Input and Output Shafts

- The input and output shafts are both seated in taper roller bearings at each end of the transaxle housing.
- All the gear wheels are in permanent mesh.
- All the gear wheels, including reverse gear, are helical-cut, synchronized, and run on needle roller bearings.
- The first, second and third gear are double-synchronized, to ensure smooth gear changes.
- The relevant ratio is achieved by using one pair of gearwheels per gear.
- The output-shaft drive pinion is in constant engagement with the differential drive annulus.
- The 3rd and 4th gear wheels and the 3rd and 4th gear synchronizer are located on the input shaft. The 1st, 2nd and reverse gears are part of the input shaft.
- The 1st, 2nd, 5th and reverse gear wheels; and the 1st and 2nd gear synchronizer; and the 5th and reverse gear synchronizer are located on the output shaft. The 3rd and 4th gears and drive pinion are part of the output shaft.
- When reverse gear is selected, the direction of rotation of the output shaft is changed by the idler gear.
- In neutral, gears are not connected via the synchronizers to the input or output shafts, therefore no torque is transmitted to the differential.



D.308.004

Fig. 51 Input and output shafts

- | | |
|----------------------------------|---------------------------------------|
| 1. Reverse gear idler | 11. Output pinion |
| 2. Reverse gear (fixed) | 12. 1st gear wheel |
| 3. 5th gear wheel | 13. 1st and 2nd gear synchronizer |
| 4. 4th gear wheel | 14. 2nd gear wheel |
| 5. 3rd and 4th gear synchronizer | 15. 3rd gear (fixed) |
| 6. 3rd gear wheel | 16. 4th gear (fixed) |
| 7. 2nd gear (fixed) | 17. 5th gear wheel |
| 8. 1st gear (fixed) | 18. 5th and reverse gear synchronizer |
| 9. Input shaft | 19. Reverse gear wheel |
| 10. Output shaft | |

Manual Transaxle and Clutch

Reverse Idler Gear

- The reverse idler gear is driven by the input shaft. Its function is to reverse the direction of rotation of the output shaft in reverse gear.
- The reverse idler is seated in a needle roller bearing on the idler shaft, the idler shaft is supported in a mounting bracket.

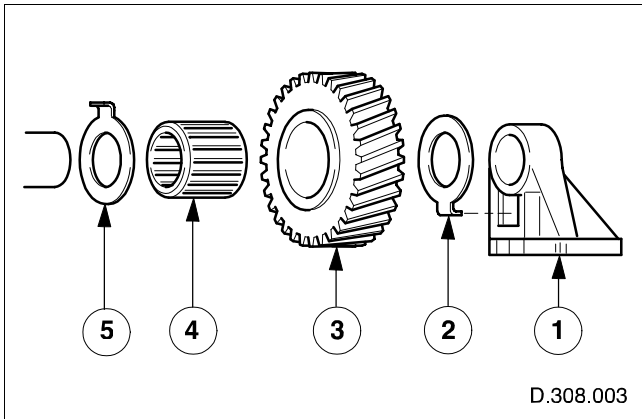


Fig. 52 Reverse idler gear

1. Idler shaft mounting bracket
2. Thrust washer
3. Reverse gear idler
4. Needle roller bearing
5. Thrust washer

Selector Mechanism

The selector interlock mechanism and the selector finger are mounted on a sleeve in the selector mechanism housing and keep the selected gear engaged with the aid of a spring-loaded ball until another gear is selected. The selector interlock mechanism has three positions. The reversing lamp switch is mounted on the side of the selector mechanism housing.

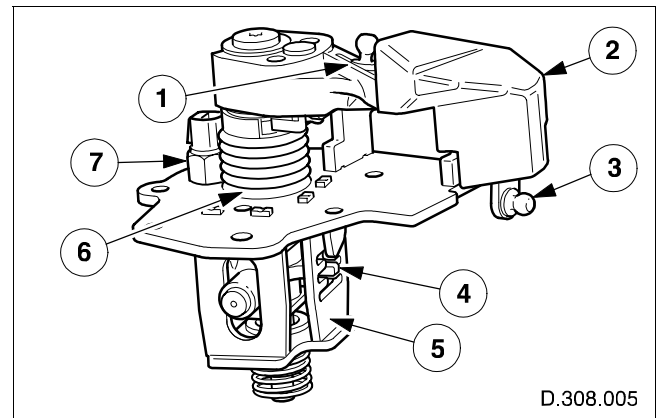


Fig. 53 Selector mechanism

1. Selector lever
2. Damper weight
3. Gearshift lever
4. Selector finger
5. Selector gate
6. Selector shaft boot-cover
7. Reverse-light switch

Vehicle Speed Sensor

Vehicle speed is calculated by pulse signals supplied to the engine control module (ECM) from speed-sensor readings of the differential's output shaft. The signal from the sensor is a pulse train of 26 pulses per revolution of the output shaft.

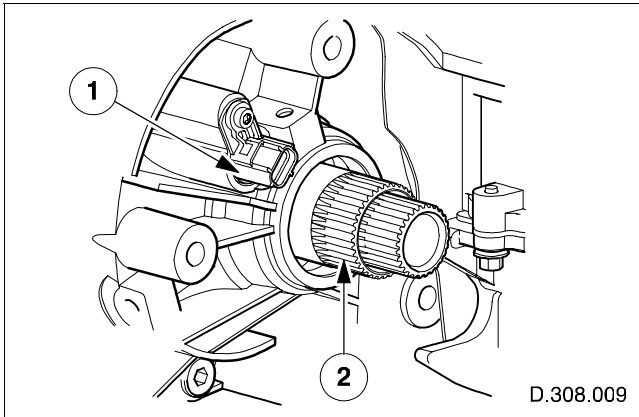


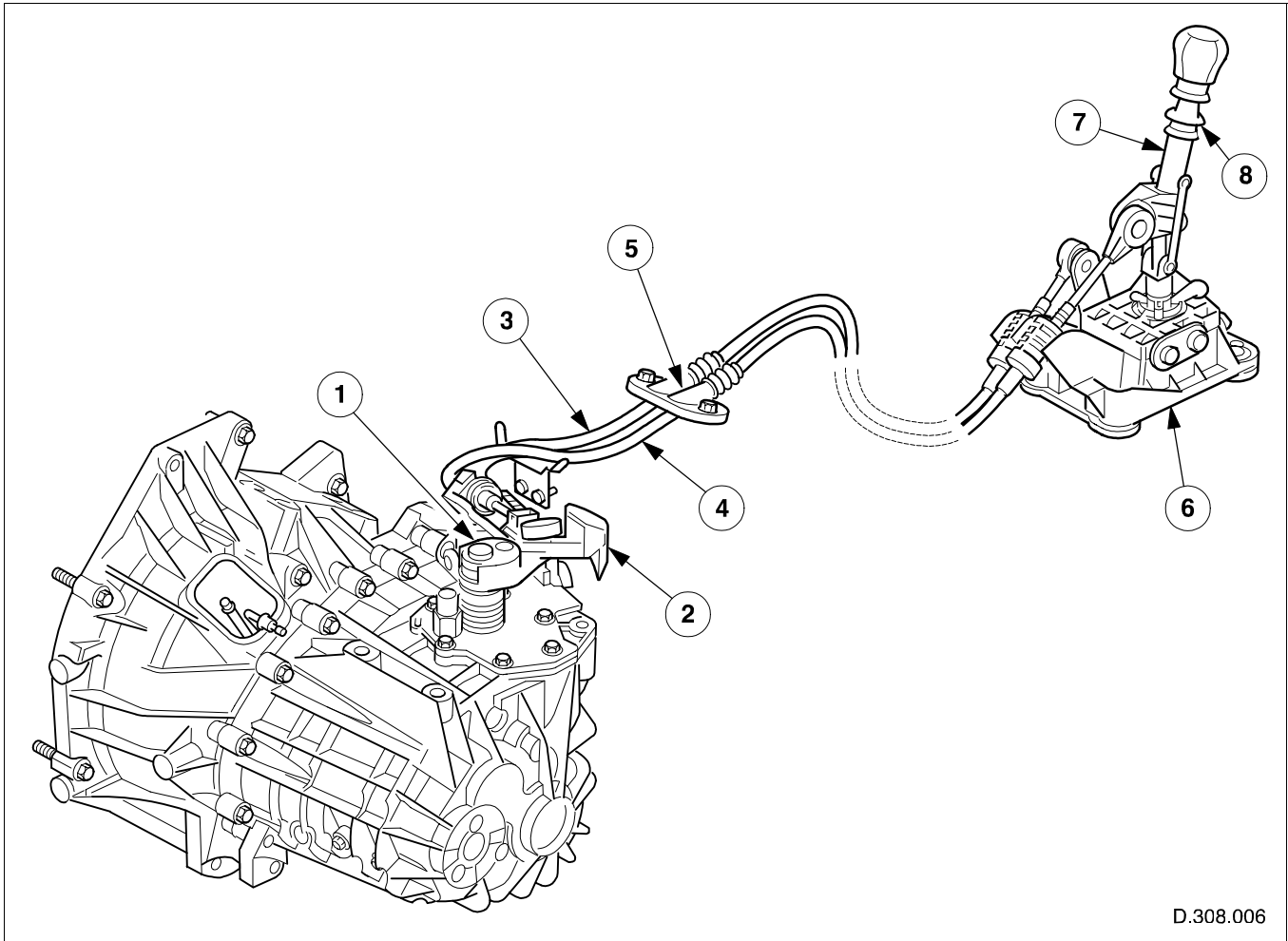
Fig. 54 Vehicle speed sensor

1. Speed sensor
2. Differential output shaft

Manual Transaxle and Clutch

Transaxle External Controls

- The gear selector lever mechanism is designed to provide a smooth positive action.
- Cable adjustment is achieved at the transaxle end of the cables by the means of sliding plastic blocks which are seated in an abutment bracket. There are no adjustment capabilities within the gear-selector lever mechanism.
- Cables are attached at both ends with ball connections incorporating a button release.
- A damping weight is located on the shift cable lever to prevent vibration.
- Reverse gear is selected by pulling up the ring below the gear knob and then moving the lever to the reverse position.



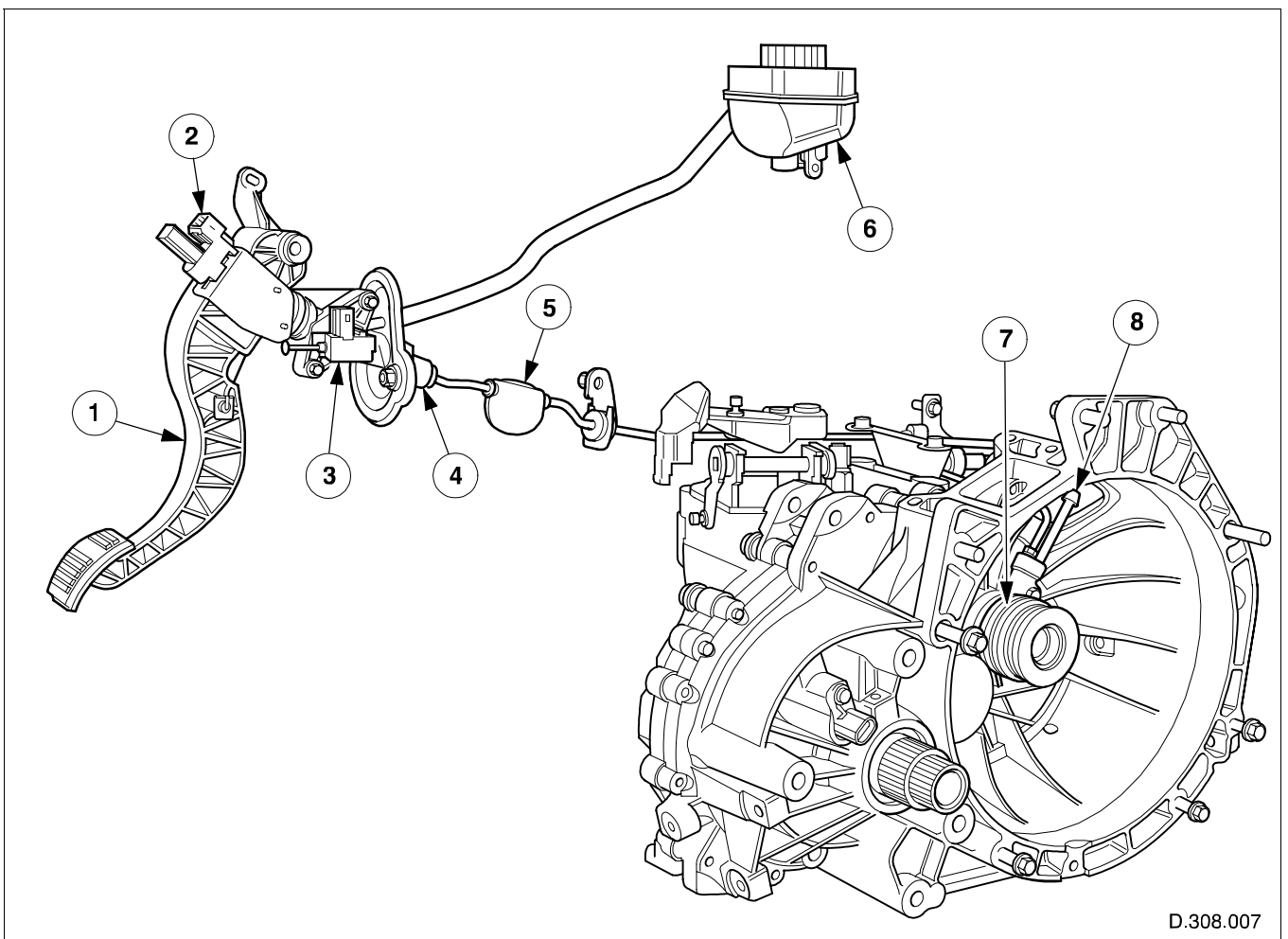
D.308.006

Fig. 55 Gearshift mechanism

1. Shift actuating lever
2. Damping weight
3. Selector cable
4. Shift cable
5. Body seal
6. External shift mechanism
7. Gear shift lever
8. Reverse gear ring

Clutch

- The clutch is a hydraulically operated, self adjusting system which improves operation and driver comfort by enabling a constant pedal pressure to be applied as the friction faces of the clutch plate wear.
 - The system employs a concentric slave cylinder, located on the transaxle's input shaft behind the pressure plate. The concentric slave cylinder eliminates the need for a release lever mechanism and improves operating efficiency.
 - The clutch pedal, which is mounted on a combined assembly with the brake pedal, employs an assister spring to reduce pedal load.
- The clutch master cylinder is directly actuated by the clutch pedal, and shares a common fluid reservoir with the brake system.
 - Operation of the clutch pedal when the vehicle is in speed (cruise) control mode activates a switch which supplies a signal to the ECM to deactivate speed control.
 - NAS markets only: To enable engine starting the clutch pedal must be fully depressed. This activates a switch which sends a signal to the ECM to provide one of the requirements for activating the starter relay.



D.308.007

Fig. 56 Clutch

1. Clutch pedal
2. Speed control deactivation switch
3. Starter relay activation switch (NAS markets only)
4. Master cylinder
5. Frequency modulator
6. Combined brake and clutch fluid reservoir
7. Concentric slave cylinder
8. Bleed point

Manual Transaxle and Clutch

Flywheel

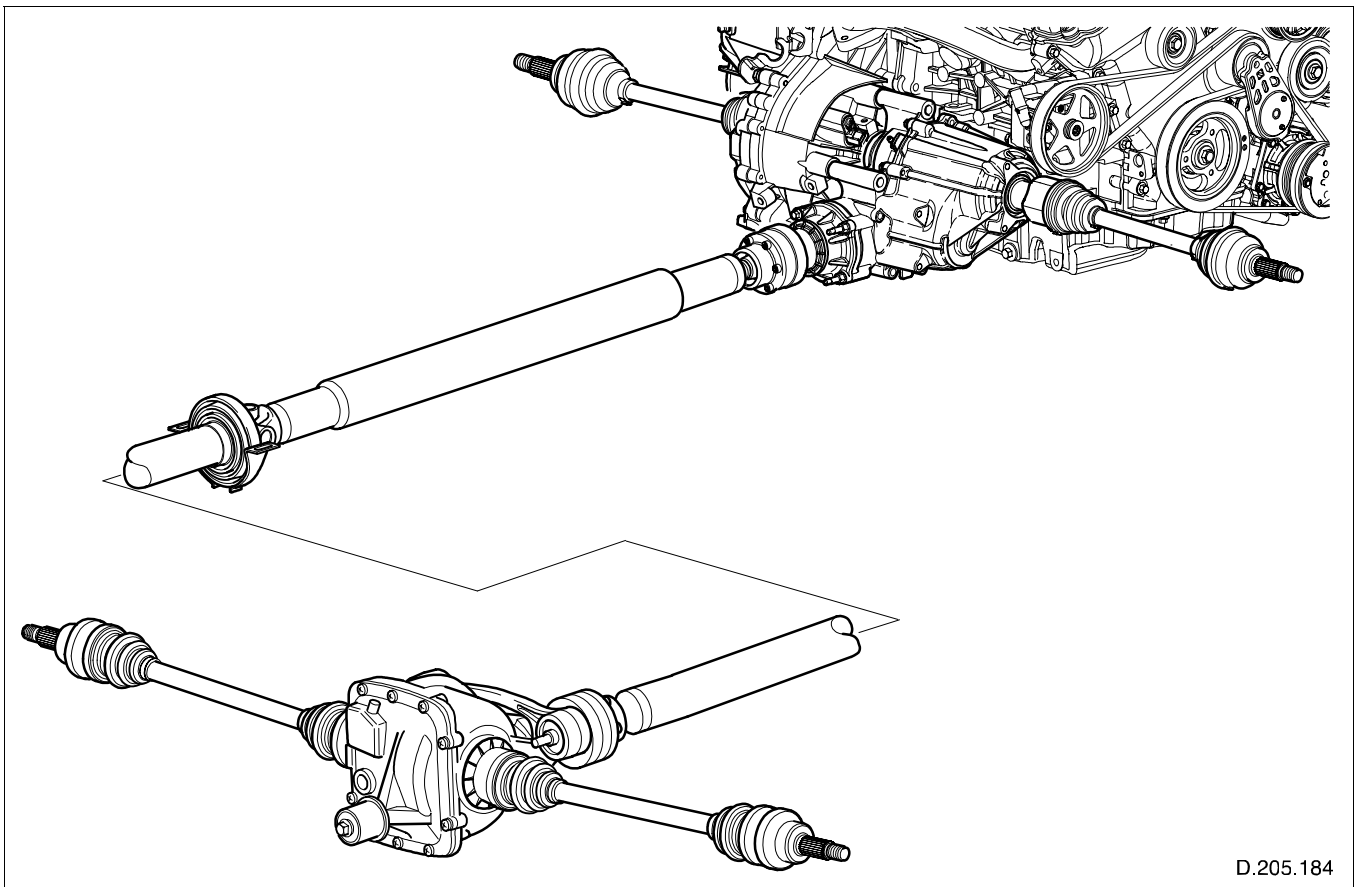
A dual-mass flywheel is employed to isolate torsional vibration and reduce stresses on the crankshaft and drivetrain.

Transfer Case

All-Wheel Drive

All-wheel drive (AWD) increases control and offers full-time availability of power to all the wheels for optimum traction in all driving conditions. The superior traction in comparison to two-wheel drive vehicles is achieved by the full utilization of the vehicle's weight over all of the driving wheels. This considerably increases the tractive effort that can be applied to the vehicle and as a result a higher rate of acceleration can also be achieved.

Greater control and therefore safety is also achieved by backing up the AWD with dynamic stability control (DSC) which is a device that maintains the vehicle's stability and steering response. DSC achieves this by intervening to prevent wheel spin and slip by automatically controlling the power output from the engine and by applying controlled brake force to individual wheels. For more information concerning DSC refer to **X-TYPE Sedan Introduction TG, Brake System**.



D.205.184

Fig. 57 All-wheel drive system

Transfer Case

Transfer Case

Graphics of the transfer case construction and the power-flow through the transfer case are shown under their respective headings: **Transfer Case Construction**, **Transfer Case Power-flow**.

CAUTION: To prevent damage to the transfer case; refer to JTIS, Jacking and Lifting for vehicle recovery procedures.

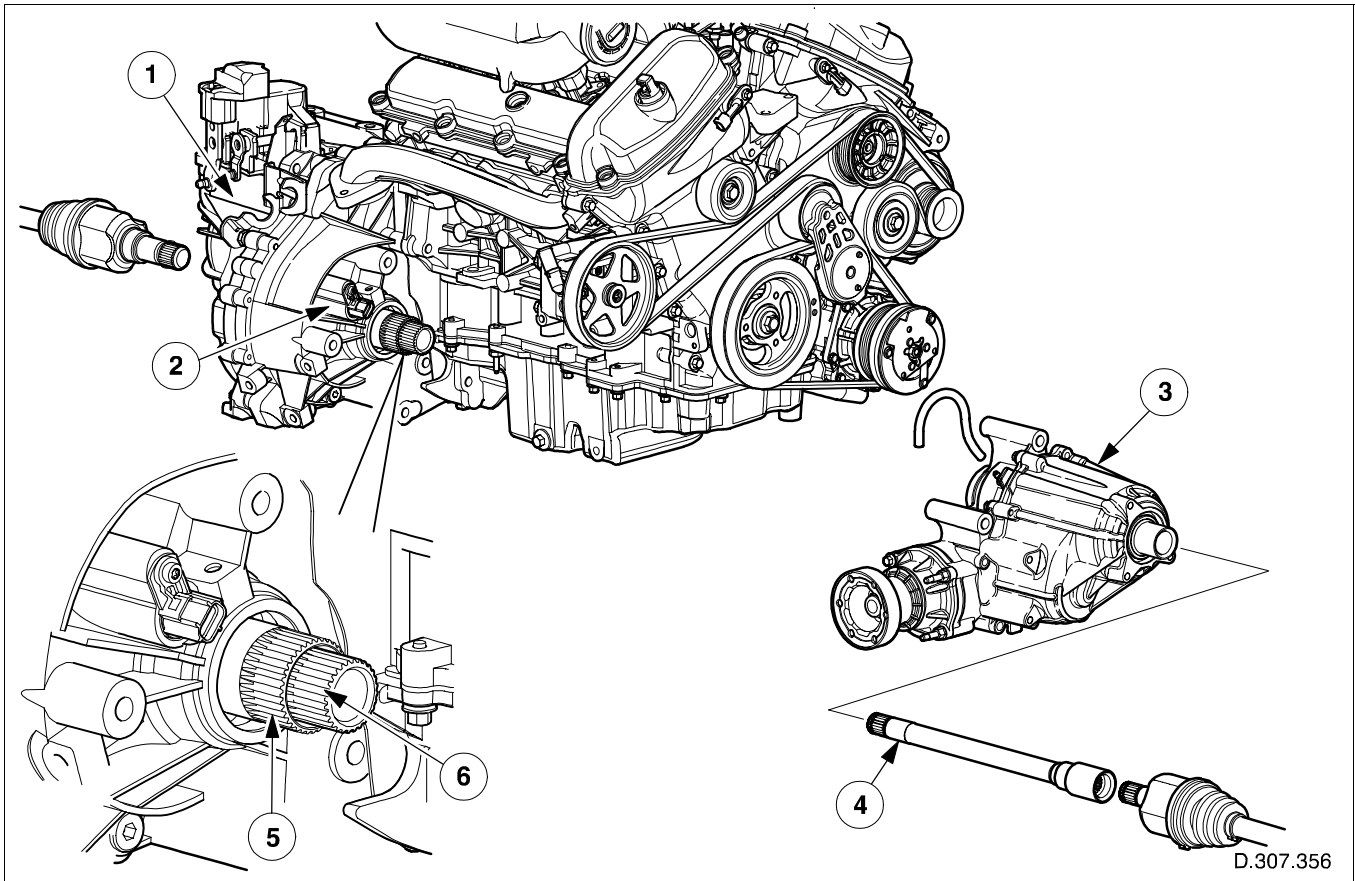


Fig. 58 Transfer case

1. Transaxle (manual derivative shown)
2. Transaxle differential
3. Transfer case
4. Link shaft to right-hand-front axle shaft
5. Differential outer case (output)
6. Differential cage

The heart of the AWD system is the transfer case which performs the function of a central differential. The transfer case receives torque from the outer case of the transaxle's differential and splits it between the front and rear wheels, refer to **Fig. 58**. In the case of the X-TYPE, the torque split is 39% to the front wheels and 61% to the rear wheels. This torque split is achieved by using an epicyclic gear set, and the proportion of torque split is determined by the ratio of the sun gear to that of the annulus gear; refer to **Fig. 59**.

The outer case of the transaxle's differential is connected to the planet carrier which provides torque to the planet gears.

- The rear wheel output is linked to the annulus.
- The front wheel output is linked to the sun gear.

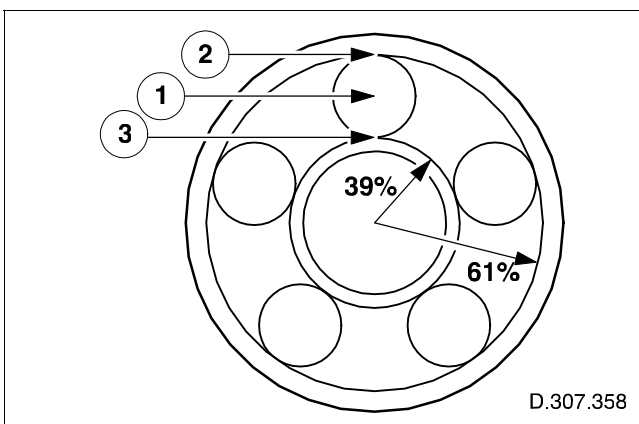


Fig. 59 Epicyclic differential torque split

1. Planet gears (input torque from transaxle differential)
2. Annulus (output torque to rear wheels)
3. Sun gear (output torque to front wheels)

A viscous coupling is used as a control unit to limit the action of the epicyclic gear set, therefore controlling the speed difference between the front and rear wheels. The viscous coupling is a sealed unit filled with a highly viscous silicon fluid, which acts as a limited slip device installed at the point where the power distribution to the front and rear wheels is split. The viscous coupling consists of a series of thin metal discs, alternately connected to the two outputs it governs:

- the annulus drive gear for the rear wheels;
- and the sun-gear shaft for the front wheels.

In the event that one set of wheels start to spin faster than the other set for example, the front wheels faster than the rear wheels. The shearing effect of the faster rotating coupling discs causes the silicon fluid to become more viscous, resulting in a binding force between the discs, therefore transferring torque to the rear wheels.

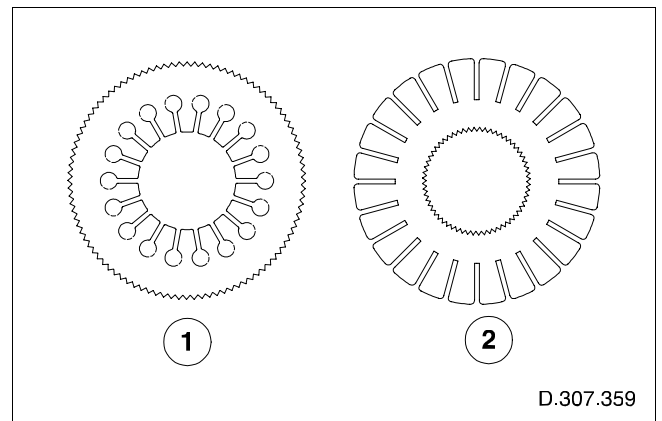
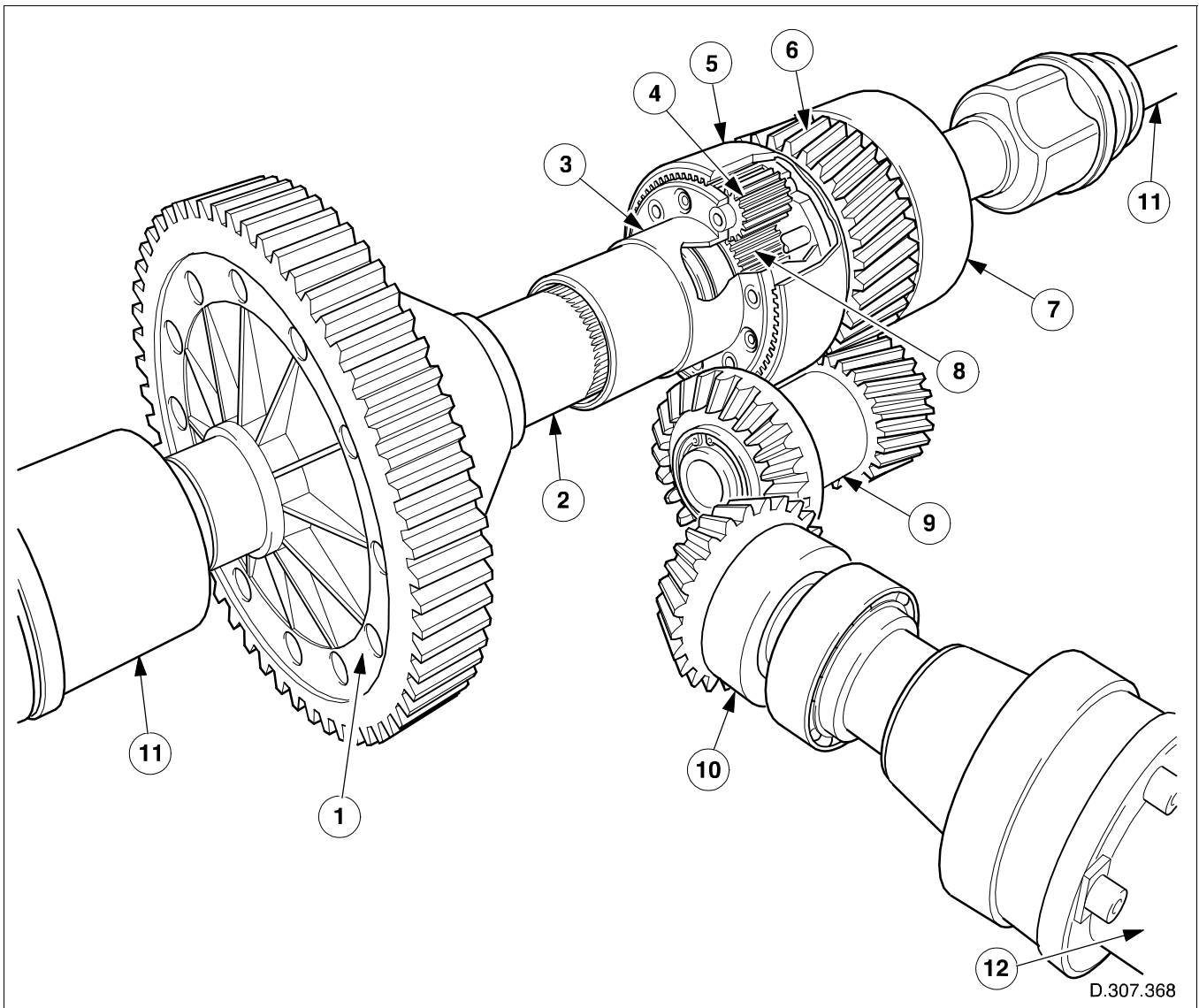


Fig. 60 Viscous coupling discs

1. Outer disc
2. Inner disc



D.307.368

Fig. 61 Gear train

- | | |
|--------------------------------------|-----------------------|
| 1. Transaxle differential | 7. Viscous coupling |
| 2. Transaxle differential outer case | 8. Sun gear |
| 3. Planet carrier | 9. Counter shaft |
| 4. Planet gear | 10. Pinion |
| 5. Annulus | 11. Front axle shafts |
| 6. Annulus drive gear | 12. Driveshaft |

Transfer Case Lubrication

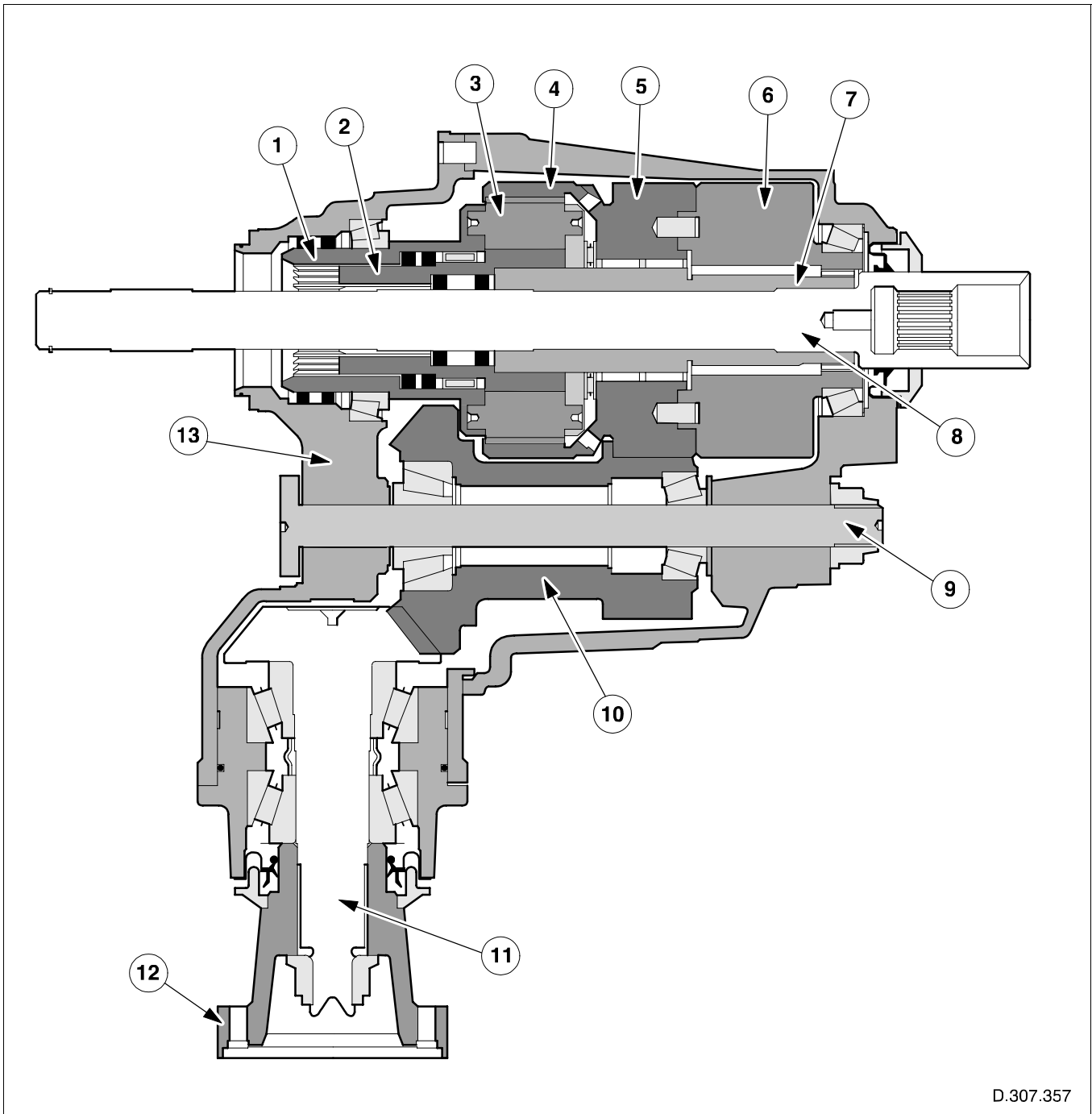
Lubrication of the transfer case is achieved by the rotating gears churning the oil stored in the base of the transfer case. This churning effect creates a splash lubrication system for the other transfer case components.

Transfer Case Cooling

An air scoop which deflects air onto the transfer case is located between the engine oil-pan and transfer case.

Transfer Case

Transfer Case Construction



D.307.357

Fig. 62 Section view of transfer case

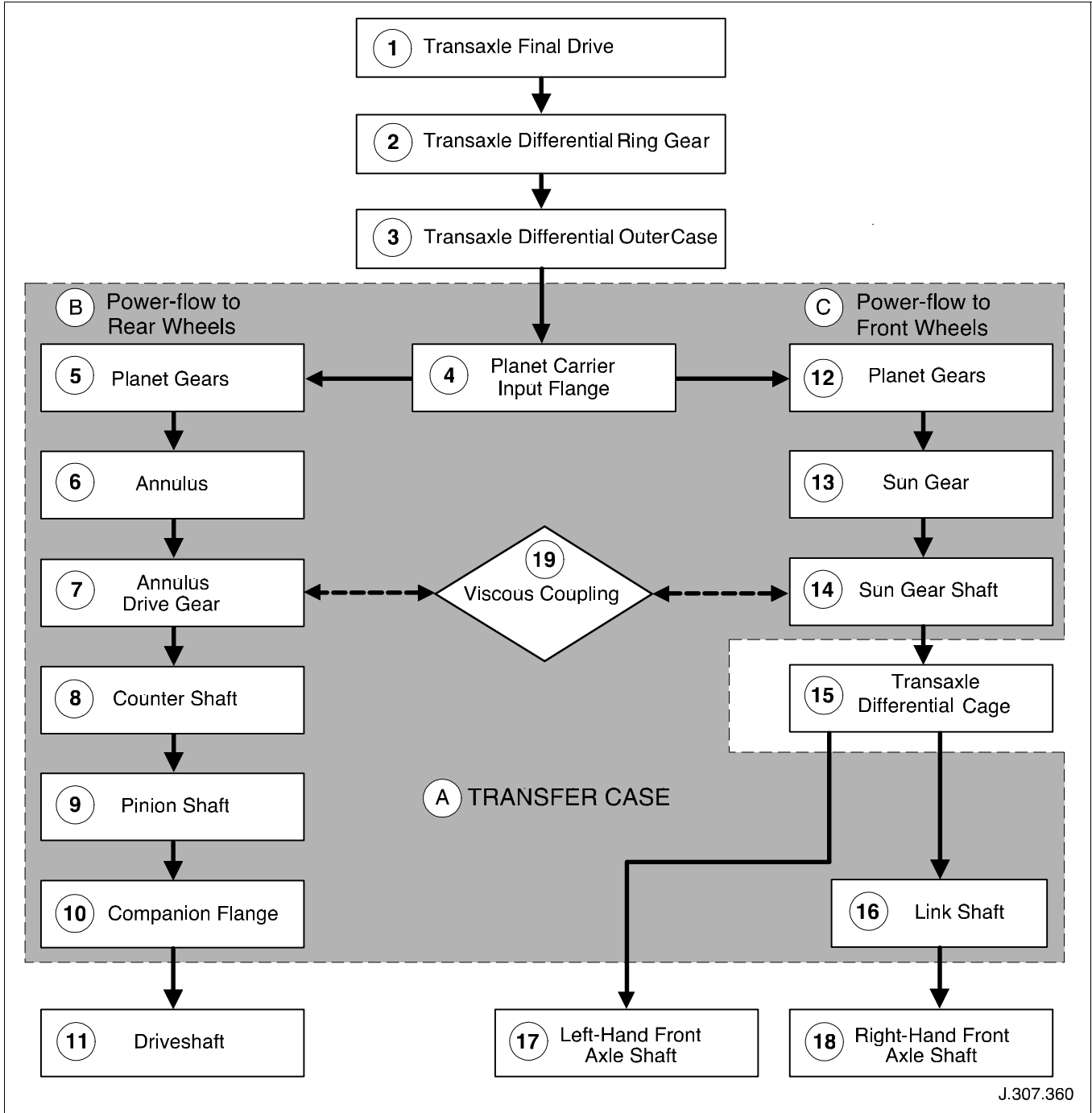
Key to Fig. 62

1. Planet carrier
2. Sun gear
3. Planet gear
4. Annulus
5. Annulus drive gear
6. Viscous coupling
7. Sun gear shaft
8. Link shaft
9. Counter shaft, support shaft
10. Counter shaft
11. Pinion
12. Companion flange
13. Casing

Transfer Case

Transfer Case Power-flow

The graphic below shows the power-flow from transaxle through the transfer case to the front and rear wheels:



J.307.360

Fig. 63 Transfer case power-flow

Key to Fig. 63

- A. Transfer case
- B. Power-flow to rear wheels
- C. Power-flow to front wheels
- 1. Transaxle final drive
- 2. Transaxle differential ring gear
- 3. Transaxle differential outer case
- 4. Planet carrier input flange
- 5. Planet gears
- 6. Annulus
- 7. Annulus drive gear
- 8. Counter shaft
- 9. Pinion shaft
- 10. Companion flange
- 11. Driveshaft
- 12. Planet gears
- 13. Sun gear
- 14. Sun gear shaft
- 15. Transaxle differential cage
- 16. Link shaft
- 17. Left-hand front axle shaft
- 18. Right-hand front axle shaft
- 19. Viscous coupling

The link shaft which runs through the transfer case acts as an extension from the transaxle's differential to the right-hand-front axle shaft.

Exhaust System

Exhaust System

The exhaust system is constructed of stainless steel and consists of:

- two catalytic converters,
- front muffler inlet pipes,
- front muffler assembly including flexible coupling,
- rear 'Y' section including mufflers and tail pipes.

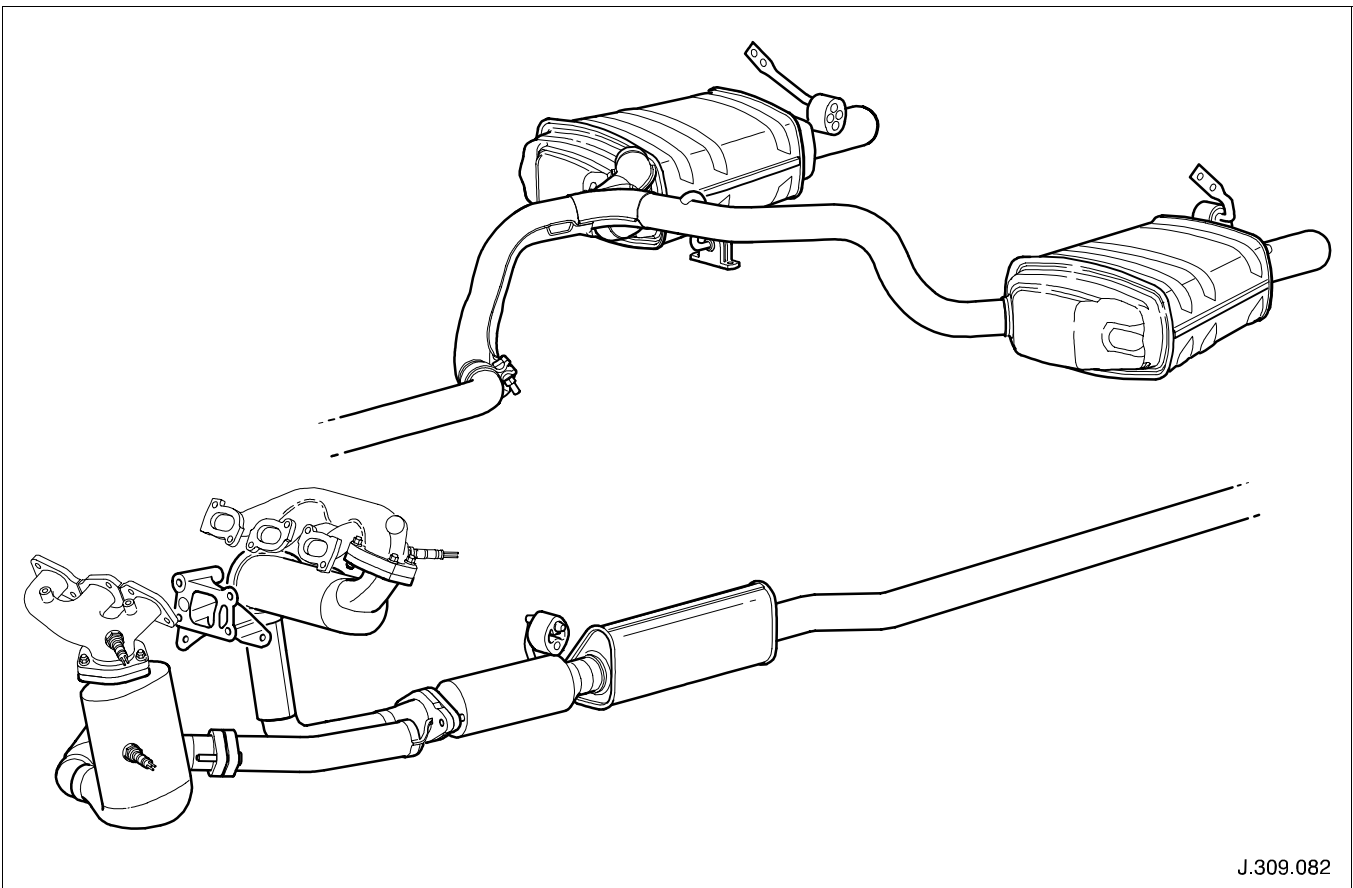
The system is attached at the front, to the two catalytic converters which are retained directly to the exhaust manifolds. The remainder of the system is supported by four rubber hanger insulators. A flexible coupling forward of the front muffler is fitted to isolate the exhaust system from engine movement and vibration. The rear 'Y' pipe including the rear mufflers and tail pipes are manufactured as one

assembly. A service fix is provided for the replacement of each rear muffler and tail pipe as a single unit, refer to **JTIS** for information.

Catalytic Converters

The three-way catalytic converters each contain two-bricks coated with palladium and rhodium. These elements are used to reduce the emissions of hydrocarbons, carbon monoxide (CO), and oxides of nitrogen (NOx), from the engine.

The system is designed to meet the rising vehicle emission standards, complying with LEV in NAS markets, and European stage III emission legislation, effective from January 2001.



J.309.082

Fig. 64 Exhaust system

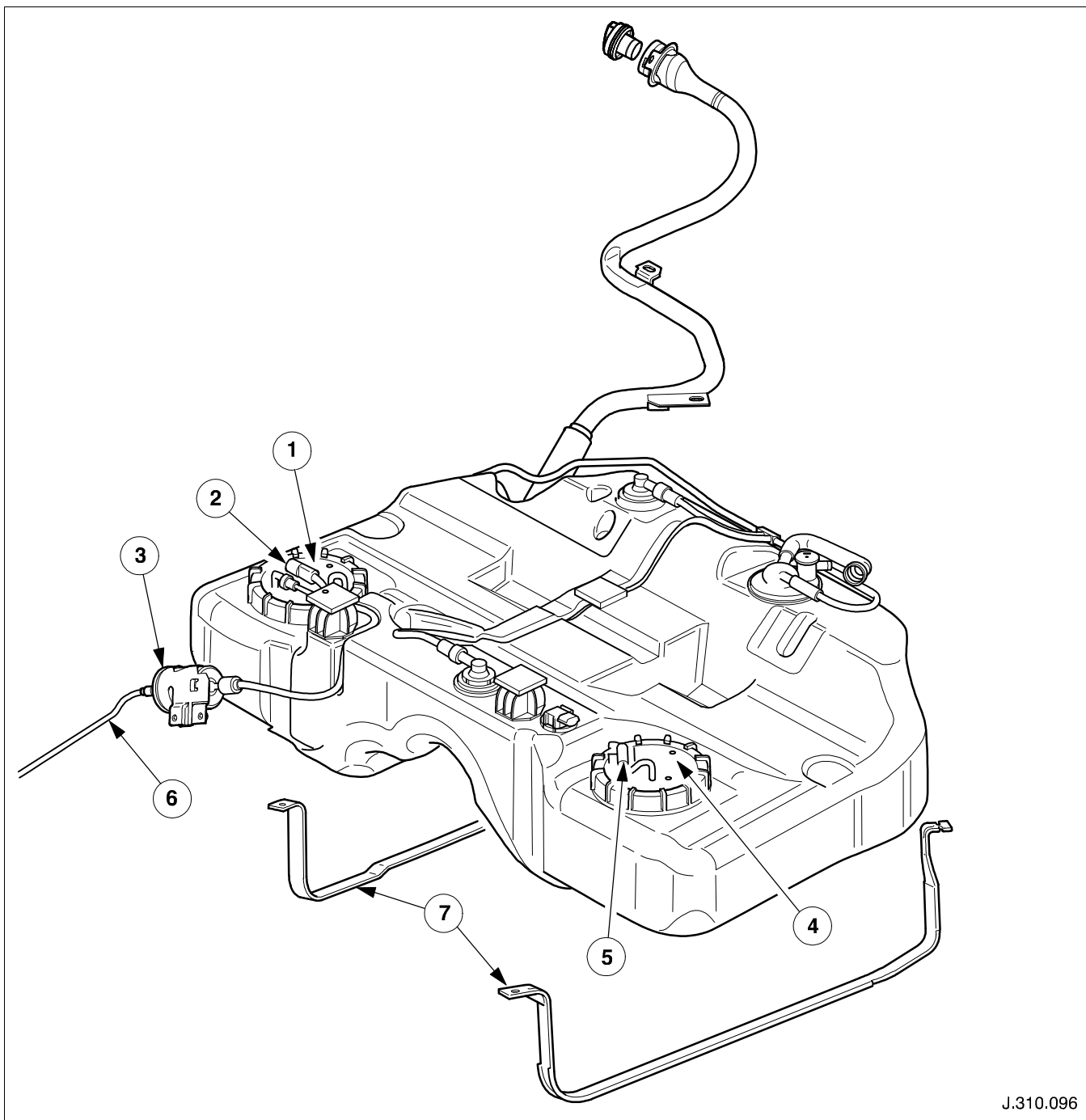
Fuel Tank and Lines

Fuel Tank

- The fuel tank is constructed of high density polyethylene and is 'saddle' shaped with left-hand and right-hand fuel compartments.
- The fuel tank is located underneath the vehicle, below the rear passenger seat.
- The driveshaft and exhaust pass through the arch of the fuel tank.
- The fuel tank is retained by two metal straps fixed to the vehicle's underbody, with the underside of the tank being protected by a fitted heatshield.

The variable-speed fuel pump, which operates in a fuel reservoir, is located in the right-hand fuel tank compartment and a transfer module is located in the left-hand compartment. Both components are secured by screw-on plastic closure rings and have integral top plates for external pipe-work and electrical connectors.

Fuel Tank and Lines



J.310.096

Fig. 65 Fuel tank and lines

- | | |
|--|--|
| 1. Fuel pump | 5. Fuel level sensor, electrical connector |
| 2. Fuel pump and fuel level sensor, electrical connector | 6. Fuel delivery pipe |
| 3. Fuel filter | 7. Fuel tank retaining straps |
| 4. Fuel transfer module | |

Fuel level is maintained equal in the fuel tank compartments by circulating the fuel through internal cross-over pipes via suction jet-pumps. Pressurized fuel from the fuel pump is forced through the jet-pumps, creating a suction which draws the fuel from the compartments into the cross-over pipes.

Each fuel tank compartment incorporates an independent fuel level sensor. Signals from each sensor are calculated by the engine control module (ECM) and then relayed to the instrument cluster to enable the display of the total quantity of fuel in the tank. Low-fuel warning is indicated by the illumination of a light located on the face of the fuel gauge.

Fuel is pumped from the fuel pump to the fuel rail via the parallel pressure relief valve and fuel filter. The parallel pressure relief valve contains two spring-loaded valves which operate in opposite directions. The function of the valve is to:

- help engine starting by retaining fuel in the supply line and fuel rail;
- limit fuel-rail pressure due to temporary vapor increase in hot conditions;
- limit fuel-rail pressure caused by sudden load changes for example, a fully open to closed throttle transition;
- prevent leakage from the tank in the event that the fuel supply line is severed.

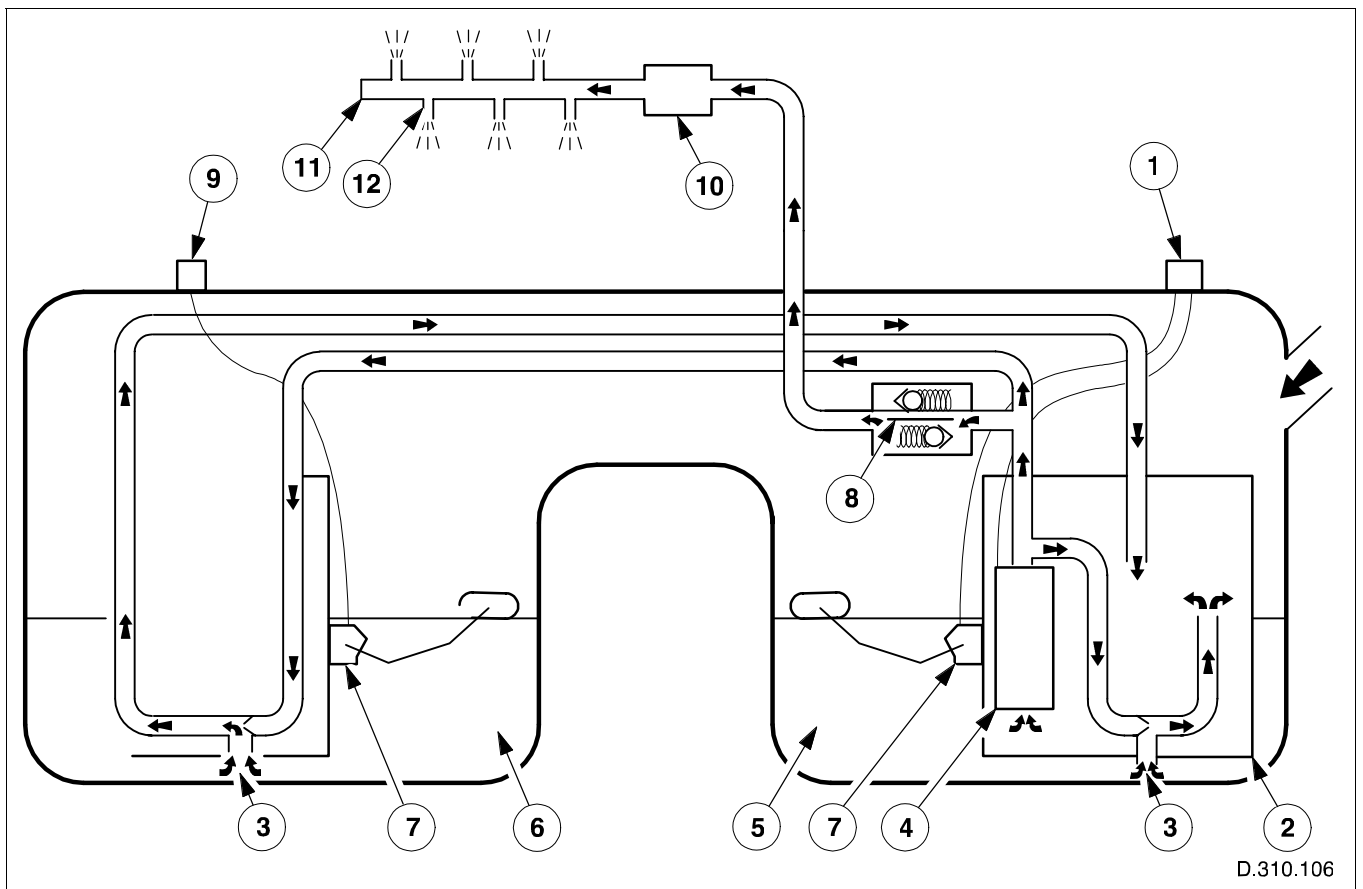


Fig. 66 Schematic of fuel tank internals

- | | |
|--|--|
| 1. Fuel pump and fuel level sensor, electrical connector | 7. Fuel level sensor |
| 2. Fuel pump reservoir | 8. Parallel pressure relief valve |
| 3. Suction jet-pump | 9. Fuel level sensor, electrical connector |
| 4. Fuel pump | 10. Fuel filter |
| 5. Right-hand fuel compartment | 11. Fuel rail |
| 6. Left-hand fuel compartment | 12. Fuel injector |

Fuel Tank and Lines

Returnless Fuel System

The returnless fuel system supplies the correct amount of fuel as required by the engine at any given moment. Eliminating the requirement for excess fuel returning to the fuel tank. The returnless fuel system:

- reduces load on the electrical system;
- improves fuel economy;
- eliminates the effects of fuel pressurization and depressurization;
- eliminates the effects of engine-heat causing extra fuel vapor being generated in the fuel tank by returning fuel.

The fuel pump module (FP module), via signals from the ECM, controls the amount of fuel supplied by the fuel pump to the fuel rail. The ECM receives signals from the fuel pressure and engine fuel temperature sensors, located on the fuel rail, to indicate the pressure of the fuel in the fuel rail. In response to these signal, plus other engine and driver demand signals, the ECM calculates the amount of fuel required and requests the FP module to vary the fuel pump delivery to suit the engine's requirements.

- The fuel pump driver module is located underneath the rear passenger seat.

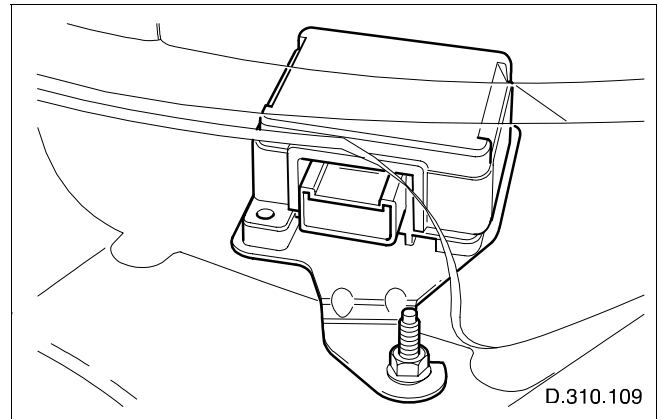


Fig. 67 Fuel pump module

Inertia Fuel Shutoff Switch

In the event of an accident, the inertia fuel shutoff switch (IFS switch) will trip, isolating the fuel pump operation. Once the IFS switch has tripped it must be reset before attempting to restart the engine.

The IFS switch is located behind the trim on the right-hand side of the vehicle, forward of the front door post, below the fascia. Pull open the small panel in the trim to reset the switch.

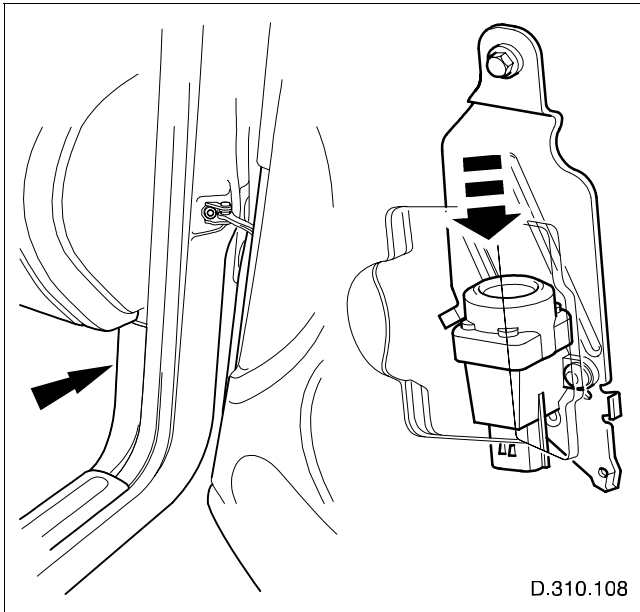


Fig. 68 Inertia fuel shutoff switch

Resetting the Switch

WARNING: To avoid the possibility of fire or personal injury, do not reset the inertia switch if you see or smell fuel.

If no fuel leaks are apparent, reset the inertia switch as follows:

1. Turn the ignition switch to position 'O'.
2. Pull open the small panel in the trim.
3. Press down the flexible cover on top of the inertia switch.
4. Turn the ignition switch to position 'II', pause for two seconds, then return the key to position 'O'.
5. Make a further check for fuel leaks.
6. Close the trim panel.

