JAGUAR

Technical Guide

The XJ range 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

BY APPOINTMENT TO
HIS ROYAL HIGHNESS THE PRINCE OF WALES
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY

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Technical Guide

The XJ range
Introduction
2004 / 2005 Model Year

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Preface

The Jaguar Technical Guide is intended to provide an overview only and must not be used as a reference source for servicing procedures. All servicing must be carried out in accordance with the appropriate JTIS disc.

While every effort is made to ensure accuracy, design changes to the vehicle may be made in the period between the completion of this publication and the introduction of vehicles. Details of 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
ABS	anti-lock braking system
ac	alternating current
ALR	automatic locking retractor
AM	amplitude modulation
ASM	air suspension module
BTS	belt tension sensor
CAN	controller area network
CATS	computer active technology suspension
CCM	climate control module
CD	compact disc
CKP sensor	crankshaft position sensor
cm	centimeter
D2B	digital data bus
dc	direct current
DDM	driver door module
DSC	dynamic stability control
DSM	driver seat module
DTC	diagnostic trouble code
DVD	digital versatile disc
ECM	engine control module
EGR	exhaust gas recirculation
ELMS	electrical load management system
EVAP canister	evaporative emission canister
FCCS	front climate control system
FEM	front electronic module
FM	frequency modulation
FP module	fuel pump module
GPS	global positioning system
HID	high-intensity discharge
HO2 sensor 1	heated oxygen sensor 1
HO2 sensor 2	Heated oxygen sensor 2
HSW	heated steering wheel
IAT sensor	intake air temperature sensor
IC	instrument cluster
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
LCD	liquid crystal display
LED	light emitting diode
LH	left-hand
LHD	left-hand drive
MAF sensor	mass airflow 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
NCM	navigation control module
NOx	oxides of nitrogen
NVH	noise, vibration and harshness
OBD	on-board diagnostics
ORVR	on-board refueling vapor recovery
PATS	passive anti-theft system
PBA	panic brake assist
PCV	positive crankcase ventilation
PWM	pulse-width modulated
RCCP	rear climate control panel
RCCS	rear climate control system
RCM	restraints control module
REM	rear electronic module
RF	radio frequency
RH	right-hand
RHD	right-hand drive
RKE	remote keyless entry
RMM	rear memory module
SCLM	steering column lock module
SCP	standard corporate protocol
SRS	supplementary restraints system
SSP	switched system power
TCM	transmission control module
TG	technical guide
TP sensor	throttle position sensor
Tset	temperature set
VAM	voice activation module
VAPS	variable assisted power steering
VEMS	vehicle emergency messaging system
VICS	vehicle information communications system
VIN	vehicle identification number
VVT	variable valve timing
W	watt
WDS	worldwide diagnostic system

The new XJ, Jaguar's flagship luxury sedan, takes full advantage of the many new systems and technological developments now available.

- The monocoque body, manufactured almost entirely from aluminum, is approximately 40% lighter than an equivalent steel body and contributes significantly towards improved fuel economy and vehicle performance.
- The instrument panel assembly is built around a magnesium cross-car beam. The glove compartment includes a shelf and an accessory power socket; the door is electrically secured and features one-touch release. In addition to the standard floor-console, a dedicated four-zone version accommodates the rear climate control system.
- All seats are constructed using magnesium frames and incorporate electrically adjustable lumbar supports and head restraints. The front seats incorporate anti-whiplash mechanisms and the now familiar occupant safety features.
- Side-curtain air bags, occupancy sensing and rear safety-belt pre-tensioners are standard installations.

Powertrain features:

- The AJ-V8 4.2-liter, an upgrade and replacement of the previous 4.0-liter engine, is available in both normally aspirated and supercharged variants.
- The AJ-V8 3.5-liter, an upgrade and replacement of the previous 3.2-liter engine, is available as normally aspirated only. The 3.5-liter engine makes its Jaguar debut in the XJ.
- The AJ-V6 3.0 liter completes the line-up.
- All four engines are coupled to the 6-speed automatic transmission, which when compared to the previous 5-speed automatic transmission, provides: higher torque capacity; reduced length and weight; improved fuel consumption and vehicle performance.
- The cooling pack assembly includes: the integration of the receiver-drier into the condenser and the cooling fan directly driven by a brushless motor.
- The exhaust system is constructed of stainless steel with polished, detachable tail-pipe sleeves.
- The fuel system is an electronic returnless fuel type and features a saddle tank positioned underneath the vehicle. A single fuel-pump located inside the tank on normally aspirated vehicles, provides optimum fuel-delivery performance. A twin-pump fuel delivery system meets the flow-rate requirement of supercharged vehicles.

Chassis features:

- A significant development is the microprocessor based chassis control system, comprising an advanced air suspension system and enhanced adaptive damping. Specially designed to accommodate the lightweight aluminum-body of the XJ, the system provides optimum driving stability and comfort.
- The front and rear suspension are both double-wishbone arrangements assembled on isolated subframes. Extensive use of aluminum provides both a lighter and more responsive suspension.
- An enhanced steering system, which when combined with changes made to the suspension system provides excellent steering response and feel.
- The upper steering column features a unique crash-load absorption system and the lower column incorporates a new crash-collapse mechanism.
- Dynamic Stability Control (DSC) features all-new hardware and is fitted as standard.
- Panic brake assist, responds to the driver's reactions in an emergency-braking situation by providing an increased braking force to activate the ABS.
- The adjustable pedals have been designed to complement the adjustable steering column in providing some drivers with a range of improved driving positions.
- An electric parking brake is fitted as standard. In addition to saving space within the passenger compartment, the parking brake is easier to use and automatically actuated when the ignition key is removed.

Introduction

Electrical features:

- An intelligent electrical load management system has been introduced. The system uses a subtle, electrical monitoring and control strategy, designed to accommodate an increase in major electrical features, by limiting the detrimental effect on the battery and ultimately the vehicle.
- A two-zone automatic climate control system is installed as standard. The system includes an air-intake filter, a single blower, a receiver-drier that is integral to the condenser and a clutchless compressor. The four-zone system (where installed) provides rear-seated passengers with the option to control the climate for their individual zones independently from the front two zones.
- The rear multimedia system provides rear seat occupants with the opportunity to select from a choice of different entertainment sources, independent of each other and to that selected by the front passenger.
- In conjunction with the rear multimedia system, multizone voice (where installed) facilitates the voice control of most functions available to the front seat passengers and also provides the option to engage in telephone conference calls.
- Xenon headlamps provide improved visibility and reliability. To comply with legislation, signals from the air suspension system are utilized for automatic headlamp adjustment. Tail and stop lighting features LED technology for improved reliability and responsiveness.
- The telematics system with optional multi-functional touch-screen, allows control of audio, climate, phone, navigation and TV. DVD technology is used for the navigation system.

Dimensions

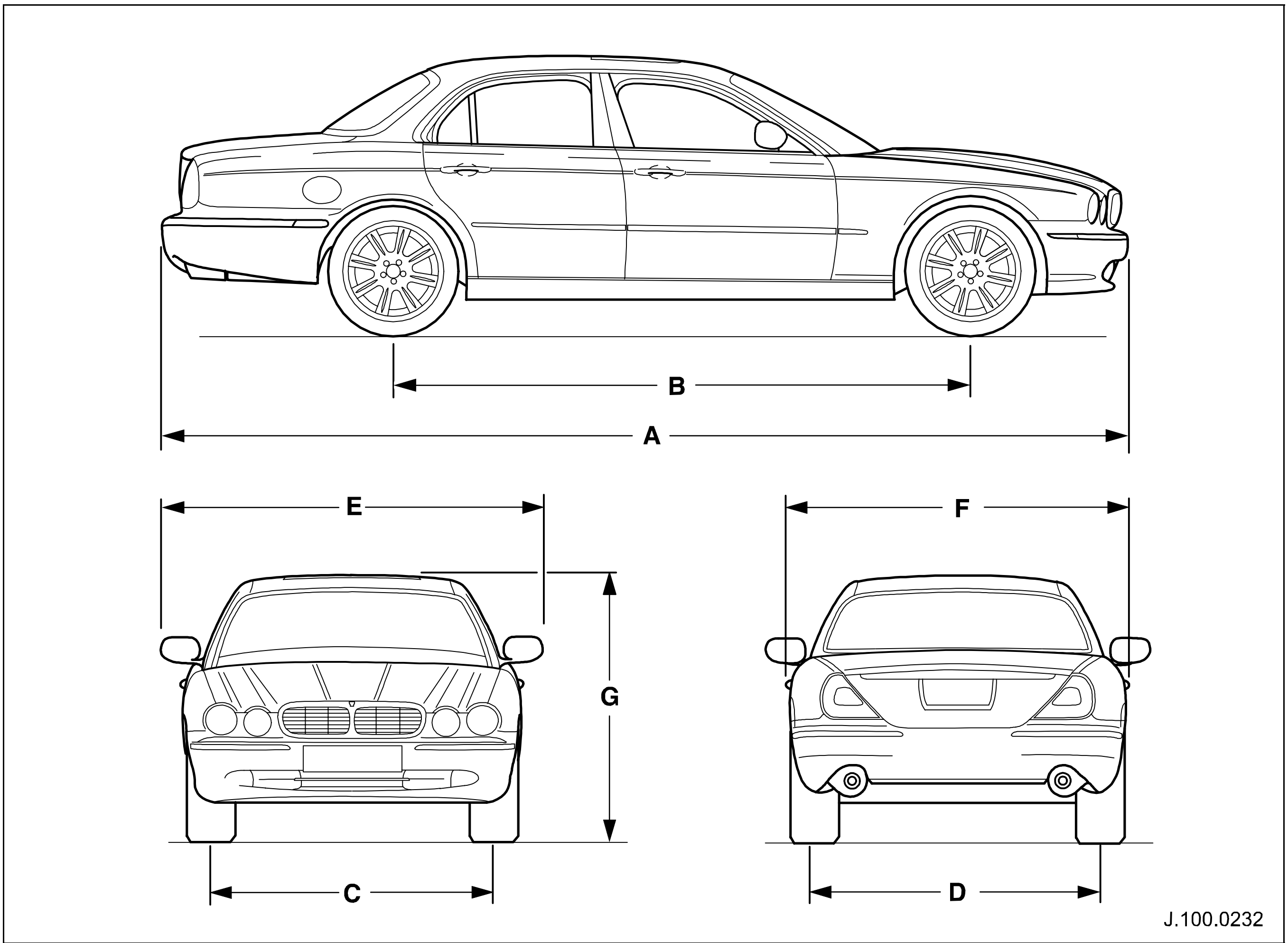

Fig. 1 External dimensions

Dimension	inches	millimeters
A	200.4	5090
B	119.5	3034
C	61.3	1556
D	60.9	1546
E	83	2108
F	73.3	1860
G	55	1448

Table 1 External dimensions (refer to Fig. 1)

Measurement **G** is the vehicle standard ride-height; refer to **Air Suspension**.

Jacking and Lifting

CAUTION:

- **Jacking and lifting points are critical.**
- **Vehicle support stands should only be used in conjunction with cushioned pads.**

Refer to JTIS for detailed information.

Vehicle Recovery and Towing

CAUTION: It is critical that the correct recovery method is always employed; refer to JTIS for detailed information.

Repair Technology

Body And Paint Repairs

Repairs to aluminum requires different tools and techniques to those used for steel. Repairs should only be undertaken by trained Body and Paint Repair technicians; refer to **New XJ Range Body and Paint Repair Supplement** for detailed information.

General Repairs

- Avoid using components that could damage the paint system, such as, self-tapping screws, spring-steel clip or paint-clearing screws.
- To ensure anti-corrosion integrity is maintained, use only genuine Jaguar fasteners; refer to **JTIS**.
- Always reinstate the paintwork to its condition prior to commencing the repair; refer to **New XJ Range Body and Paint Repair Supplement** for detailed information.

The new XJ has been carefully designed to take into account the benefits of using aluminum but also to prevent the electrolytic interaction of dissimilar metals; refer to **Body Construction**.

Accessories

Only Jaguar approved accessories should be installed.

CAUTION: Always install accessories in accordance with the fitting instructions supplied and using the recommended fasteners.

Suspension

Introduction

A completely redesigned suspension system, provides the following enhancements:

- improved noise, vibration and harshness (NVH) suppression,
- enhanced damping performance,
- improved roll-control,
- revised suspension geometry,
- strengthened structure,
- improved vehicle crash performance.

An extensive use of aluminum is used in the manufacture of the suspension components to provide a lighter and more responsive suspension.

A further and significant development is the microprocessor based chassis control system, comprising an advanced air suspension system and enhanced adaptive damping. The system consists of a number of components interconnected by pneumatic lines and an air suspension module (ASM). The system provides optimum driving stability and comfort, and is specially designed to accommodate the lightweight aluminum-body of the XJ. Refer to the **Air Suspension** and **Adaptive Damping** sections.

CAUTION: Do not use jacking equipment on suspension components, use identified jacking points only; refer to 'JTIS'.

Front Suspension

The front suspension is assembled on an isolated subframe, mounted via four bolts to the vehicle body. Hydrabushes incorporated in the rear mountings of the subframe provide added suspension refinement; the front mounting bushes are conventional rubber types. Spacer bars located between the subframe and vehicle body provide support for the vehicle's cooling pack and cross-brace. The cross-brace improves NVH characteristics by increasing body stiffness.

The front suspension arrangement is a double-wishbone type, with the length ratio between the two control arms calculated to optimize track and camber control. In addition, the upper control-arm is designed to improve castor trail and subsequently steering-feel. Inclination of the upper control-arm axis provides an anti-dive and anti-squat action during vehicle braking and acceleration. The lower control arm is a split design, which de-couples to allow for improved bush adaptation. A hydrabush fitted to the forward lower-control arm where it attaches to the subframe provides vibration damping. The swan-neck wheel knuckle is supplied in two derivatives to accommodate the different caliper mounting points of normally aspirated and supercharged vehicles.

NOTE: The subframe must be correctly aligned to the vehicle's body to ensure the correct operating angle of the drive shaft; refer to JTIS for the installation procedure.

Front Spring and Damper Assembly

Refer to **Air Suspension** and **Adaptive Damping** sections.

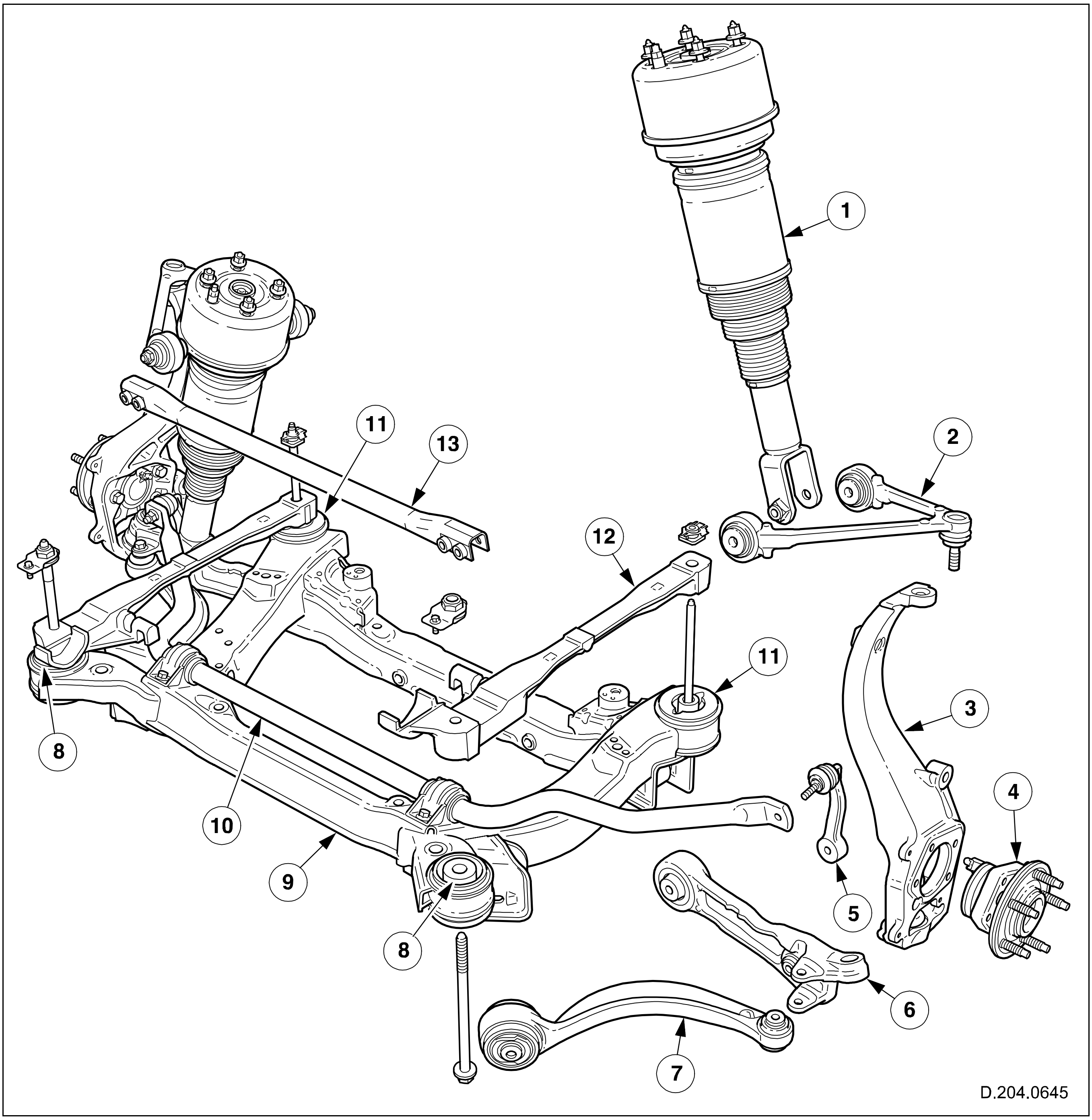

Fig. 2 Front suspension components

Key to Fig. 2

1. Air spring and damper assembly
2. Upper control arm
3. Swan neck wheel knuckle
4. Wheel hub and bearing assembly
5. Stabilizer-bar drop link
6. Lower control arm - lateral
7. Lower control arm - forward
8. Conventional mounting bush
9. Subframe
10. Stabilizer bar
11. Hydrabush mounting
12. Spacer rail
13. Cross brace

Rear Suspension

The rear suspension is assembled on an isolated subframe, mounted via four bolts to the vehicle body. Two hydrabushes incorporated in the forward mountings and two void-type bushes in the rear mountings provide optimum suspension refinement. The double-shear bracket brace improves NVH characteristics by providing additional mounting stiffness.

As with the front suspension the rear suspension is also a double-wishbone type. Inclination of the upper control-arm axis provides an anti-dive and anti-squat action during vehicle braking and acceleration. The wheel knuckle is supplied in two derivatives to accommodate the different caliper mounting points of normally aspirated and supercharged vehicles.

NOTE: The subframe must be correctly aligned to the vehicle's body to ensure the correct operating angle of the drive shaft; refer to 'JTIS' for the installation procedure.

Rear Spring and Damper Assembly

Refer to **Air Suspension** and **Adaptive Damping** sections

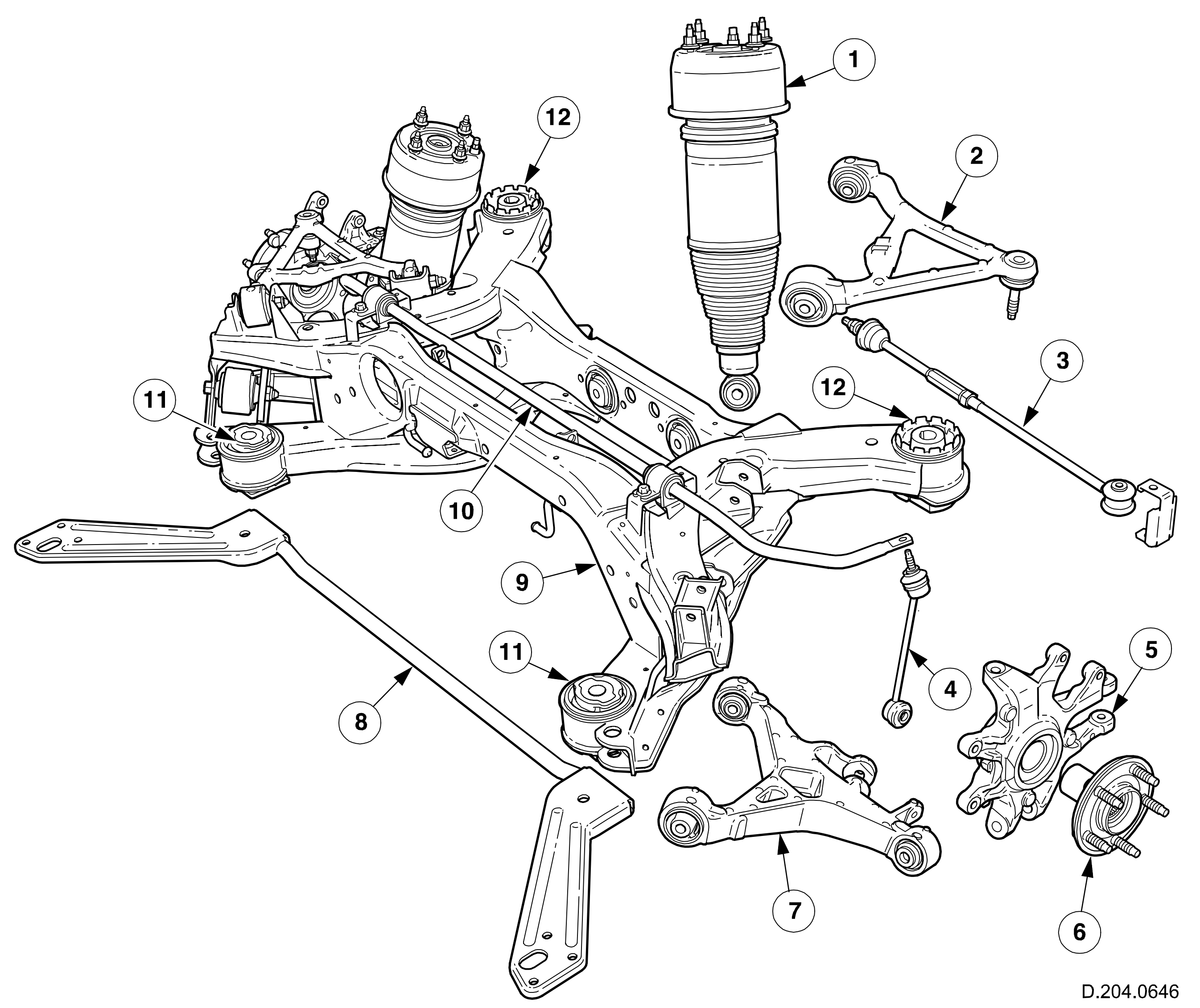

Fig. 3 Rear Suspension Components

1. Air spring and damper assembly
2. Upper control arm
3. Toe control link
4. Stabilizer-bar drop link
5. Wheel knuckle
6. Wheel hub and bearing assembly
7. Lower control arm
8. Double-shear brackets and brace
9. Subframe
10. Stabilizer bar
11. Hydrabush
12. Voided rubber bush

Air Suspension

With the introduction of the lightweight aluminum body, the payload of the new XJ is now a higher percentage of the vehicle's total weight. To accommodate this reduction in body-weight a vehicle with a conventional coil-spring suspension would need either:

- an increase in unladen height, or
- a higher spring-rate.

Both of which would mean a compromise between driving dynamics, ride comfort and the vehicle's stance appearance. To overcome these compromises and maintain a constant vehicle height independent of load changes, the XJ features a newly developed four-corner air suspension system in place of the coil-spring suspension.

Air suspension ensures maximum spring travel is always available providing excellent ride comfort and optimum driving safety. Another benefit of the system is the ability to lower the vehicle at a configured road speed to improve aerodynamic efficiency and further improve vehicle stability and fuel efficiency. The air suspension system is fully automatic, requiring no driver intervention.

The air suspension is available in either standard ride or sport ride derivatives depending on vehicle specification.

System Overview

The air suspension is a microprocessor based chassis-control system, comprising a number of components interconnected by pneumatic lines and the air suspension module (ASM). The vehicle weight is supported by compressed air enclosed in the rubber bellows of the air springs. Suspension height and level control are obtained by supplying or releasing compressed air with instantaneous response from the air springs. This process is actuated individually at each wheel by means of fast acting solenoid valves.

The necessary values for controlling the valves are supplied to the ASM by the height sensors located inboard of each wheel. The height sensors measure the distance between the suspension and the vehicle's body. Various other vehicle status values processed by the ASM are supplied via the controller area network (CAN). The ASM uses these values to provide the optimum suspension condition for existing road and driving conditions.

Driver Information

There are two messages that may be displayed on the vehicle message center associated to the air suspension system; refer to table below:

Message	Warning Light	Priority Indicator	Meaning
AIR SUSPENSION FAULT	None	None	Drive the vehicle with caution and inform your nearest Jaguar Dealer to have the fault rectified.
VEHICLE TOO LOW	None	None	The air suspension system is too low. Start the engine and wait for the message to clear before driving the vehicle. If the message is displayed while you are driving, restrict your speed until the message is cleared. If the message is persistently shown, inform your Jaguar Dealer.

Components

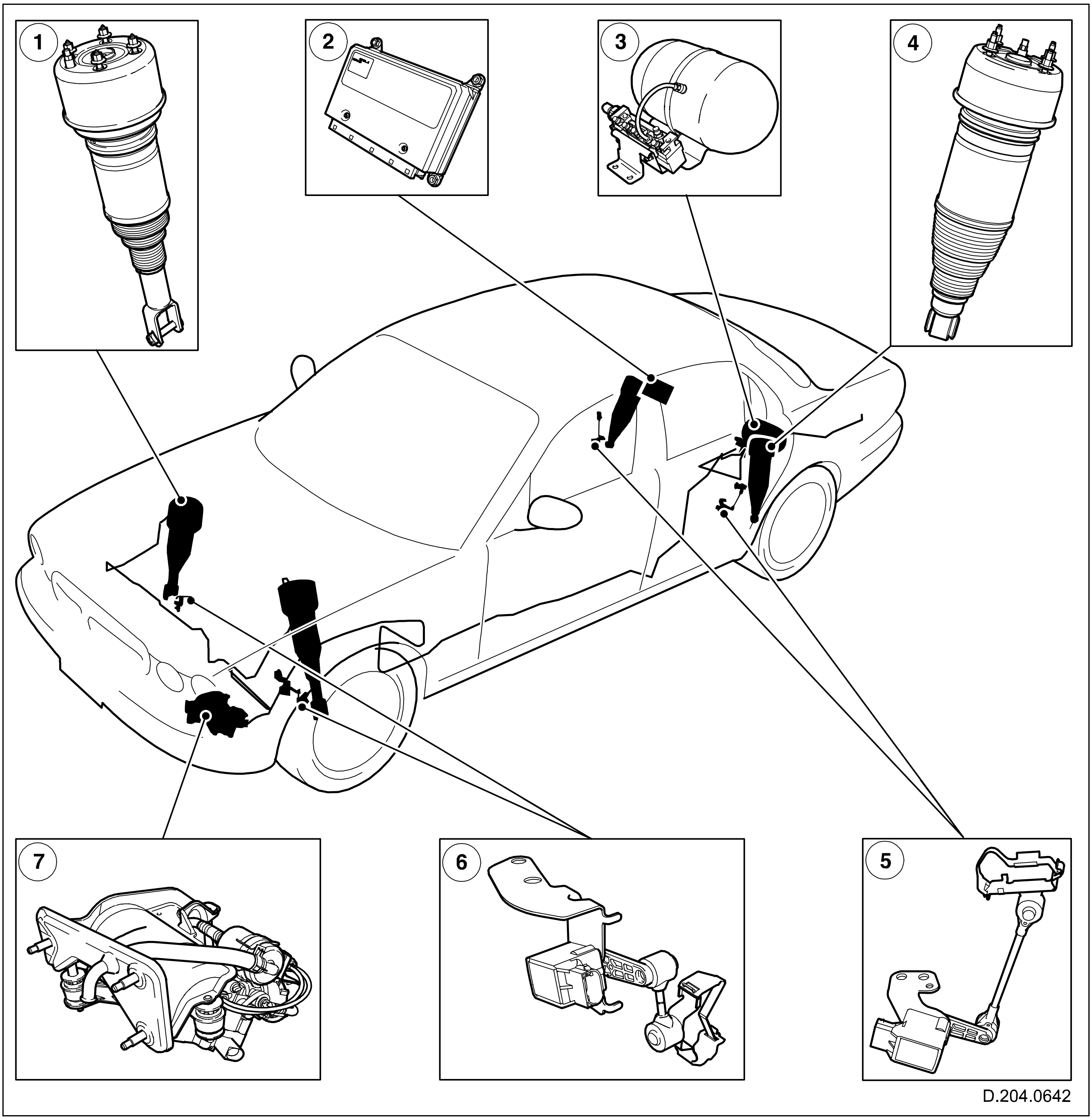

Fig. 4 Air suspension components

1. Front air spring and damper assembly
2. Air suspension module
3. Air reservoir and valve block
4. Rear air spring and damper assembly
5. Rear height sensor
6. Front height sensor
7. Air compressor

WARNING: The air suspension system must be depressurized using WDS before commencing any repair operations on the air suspension system; refer to 'JTIS' for further information.

Air Suspension Module

The air suspension module (ASM), which also controls the adaptive damping system and provides height sensor information for the automatic headlight leveling, is located behind the rear seat. The ASM provides a number of air suspension operational modes dependent on the vehicle state; refer to **Operating Modes and Strategies**.

ASM hardwired inputs:

- Height sensors
- Valve block pressure sensor
- Vertical accelerometers (adaptive damping only)
- Valve block solenoid control

ASM inputs, via the CAN:

- Vehicle speed
- Engine speed
- Engine torque
- Lateral acceleration
- Steering wheel angle
- Steering wheel velocity
- Brake line pressure
- Ambient temperature

The ASM will require calibrating using WDS if:

- the ASM is replaced;
- a height sensor is removed and reinstalled;
- a height sensor is replaced.

Refer to 'JTIS' for further information.

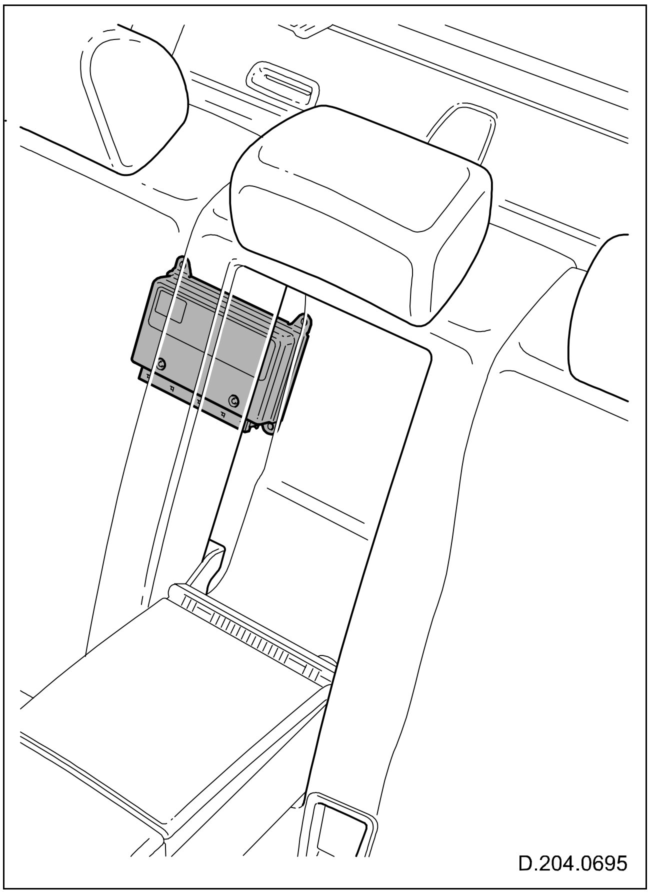

Fig. 5 Air suspension module

Air Compressor

The air compressor is mounted on the left-hand side of the vehicle behind the front bumper beam. To maintain a quiet operation the compressor is isolated from the vehicle's body by three mounting rubbers. The compressor performs the following functions:

- Air compression: Air is drawn into the compressor through a snorkel located inside the vehicle's front bumper, via a filter, and compressed by a motor-driven, single-cylinder reciprocating piston.
- Air drying: An integral air-drier maintains a low-moisture environment inside the suspension's pneumatic system. Desiccant in the drier removes moisture from high-pressure air as it is pumped into the suspension system. Air vented from the suspension system flows over the desiccant at low pressure, removing moisture from the desiccant and returning it to atmosphere. This regenerates the desiccant so it can remove moisture during subsequent compression cycles.
- Operating pressure: Nominal operating pressure is 15 bar, a pressure-retaining valve maintains a minimum pressure of 3 bar in the system to protect the air springs.
- Pressure relief: A pressure relief valve set at 17.5 bar diverts high-pressure air to atmosphere when the nominal operating threshold is exceeded. This protects the air springs and other system components in the event of a system malfunction.
- Thermal protection: Compressor run time is limited to two minutes. If the operating temperature exceeds a defined limit within this time the compressor will shutdown. The compressor will resume operation when it cools to its normal operating temperature (usually within 30 to 40 seconds).
- Air release: Air exhausted from the suspension system exits through the snorkel located inside the vehicle's front bumper.

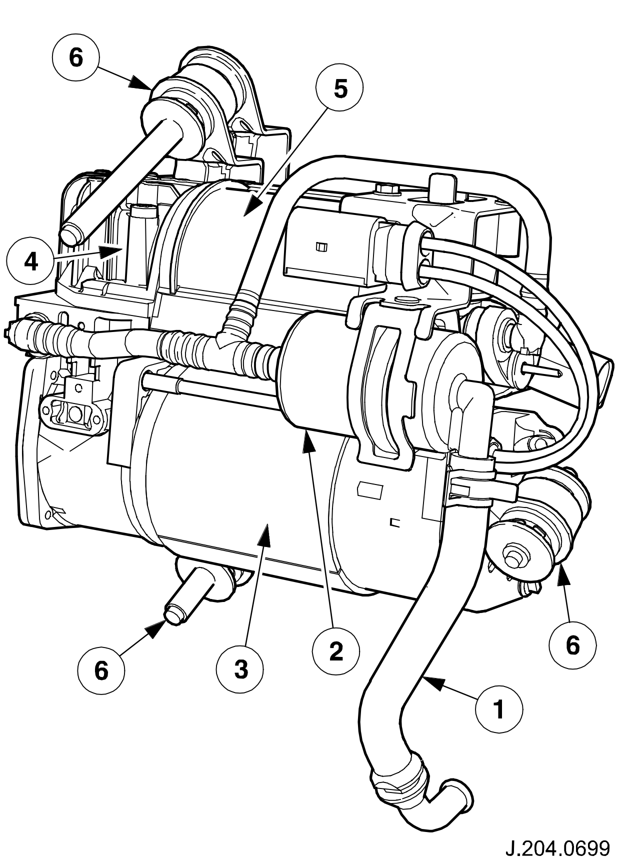

Fig. 6 Air compressor

1. Air intake/outlet snorkel
2. Filter
3. Motor
4. Piston cylinder-head
5. Air drier
6. Mountings

Reservoir and Valve Block

The reservoir and valve block, are installed underneath the spare wheel and protected by a cover; the cover also acts to suppress noise emitted from the solenoid valves.

Reservoir:

- Reservoir volume is 4.5 liters with a maximum pressure of 15 bar, as controlled by the ASM.
- The compressor operates for approximately two minutes to complete a full recharge of the reservoir.
- With the reservoir at maximum pressure, the reservoir is capable of one complete lift of the vehicle.
- The air suspension operates within a defined pressure range; under normal operating conditions the reservoir does not deplete below the pressure of 9 bar. This prevents the air pressure held within the air springs transferring to the reservoir.

Valve Block:

- The valve block is mounted onto the reservoir bracket via isolators to reduce noise being transmitted to the vehicle body when the solenoid valves switch.
- The solenoid valves as commanded by the ASM perform the air distribution within the air suspension system.
- There are five solenoid valves installed in the valve block one for each of the four springs and one for the reservoir.
- The valve block contains a pressure sensor to monitor the pressure within the air springs and reservoir. The data supplied by the pressure sensor is one of the inputs used by the ASM to determine whether to raise the vehicle using the compressor or the reservoir reserves.

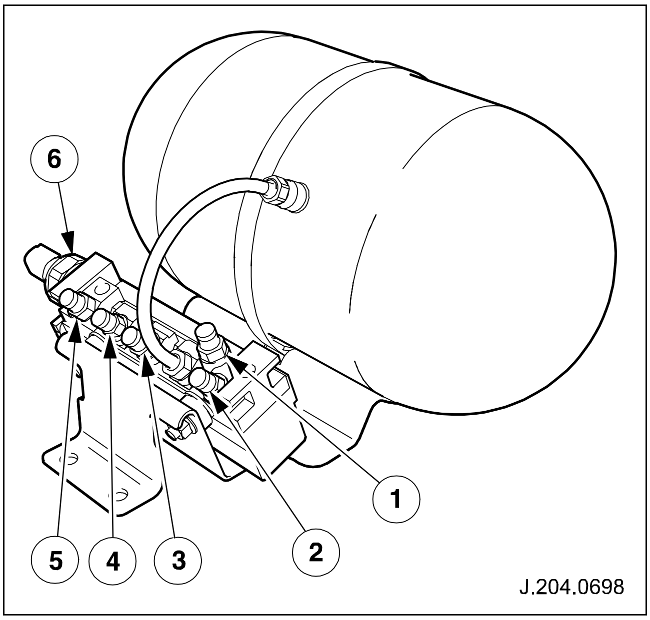

Fig. 7 Reservoir and valve block

1. Air compressor port
2. Air spring port - left-hand-rear
3. Air spring port - right-hand-front
4. Air spring port - right-hand-rear
5. Air spring port - left-hand-front
6. Pressure sensor

Air Springs and Dampers

WARNING: The air suspension system must be depressurized using WDS before commencing any repair operations on the air suspension system; refer to 'JTIS' for further information.

CAUTION: Care must be taken not to damage the air springs during repair operations; refer to 'JTIS' for care points.

- The air springs are integrated into the suspension in a manner similar to conventional coil springs and are actuated by either the air compressor or reservoir to control vehicle ride height and leveling.
- The front air springs are controlled as a pair, whereas the rear air springs are controlled independently. This is to provide level correction for uneven distribution of loads, which is usually more severe in the rear of a vehicle. Load distribution usually remains constant in the front of a vehicle.
- An outer support sleeve assembled over the damper, guides the air spring. An integral pressure retaining-valve ensures that the air pressure never drops below 3 bar within the spring. This pressure maintains the spring's internal components in their correct orientation and prevents the bellow's membrane from creasing.
- Normal operating pressure of the air spring is approximately between 7 and 9 bar, with a maximum 'full bump' pressure of approximately 20 bar.
- There are two derivatives of air spring dependant on vehicle specification:
  – Comfort: high air volume = softer ride.
  – Sport: low air volume = stiffer ride.
- The air springs are complemented by adaptive damping actuation; refer to the **Adaptive Damping** section.
- Other air spring features which improve ride quality and noise, vibration and harshness (NVH) refinement include:
  – A unique top-mount feature to isolate the damper from the body.
  – An air spring isolator, which reduces generated high frequency inputs, for example when traveling over rough terrain.
- Due to the nature of the sealing arrangement between the air spring and damper, the two parts cannot be separated and must be replaced as a complete unit.

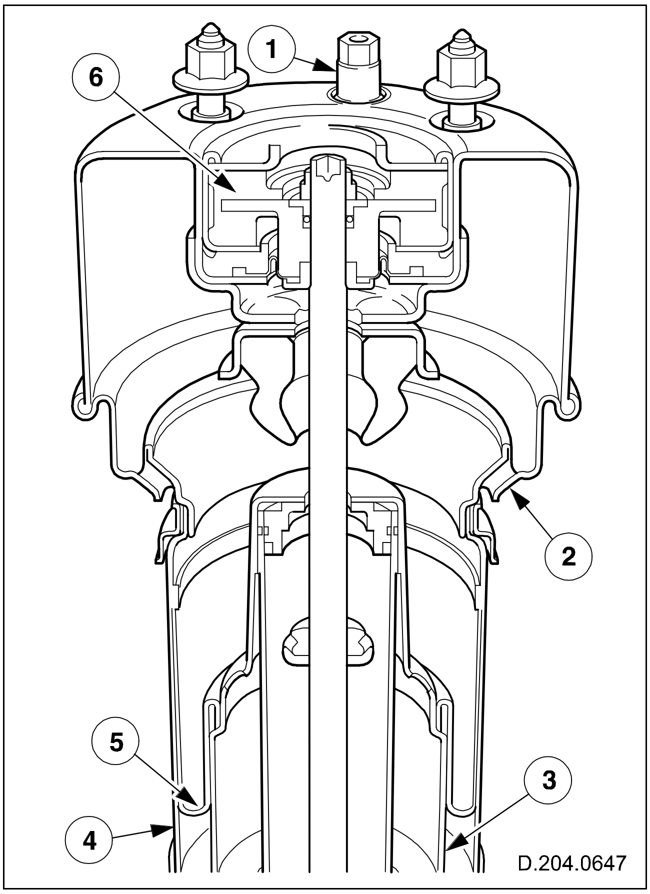

Fig. 8 Air spring internals

1. Retaining valve
2. Isolator
3. Piston
4. Outer sleeve
5. Rolling bellow's membrane
6. Top mount

Height Sensors

- Four Hall effect rotary height sensors measure relative displacement between the body and a suspension component. The motion ratio of the height sensor attachment to the suspension component and the measured height sensor displacement are used to determine vehicle ride height.
  - The front height sensors are mounted to the front subframe and connected to the lower control arm.
  - The rear sensors are mounted to the rear subframe and connected to the upper control arm.
- Each sensor transmits raw unfiltered data to the ASM, where the data is then filtered to respond to either fast or slow vehicle loading/unloading:
  - Fast filter: Sudden weight changes due to passenger and luggage loading/unloading; or the vehicle traveling over rough terrain. The suspension reacts instantaneously to correct the ride height.
  - Slow filter: Gradual weight reduction due to fuel consumption, the suspension counters the weight loss by slowly adjusting the ride height.

Air Harness

- The rear air harness is integrated into the electrical harness; the front air harness is routed underneath the floor and within the engine compartment.
- The front harness has a 6mm diameter; the rear harness has a 4mm diameter. This difference in diameter is to balance the response time in air spring actuation and exhaust, in respect to the distance of the springs from the valve block and reservoir.
- The harness tubes are color coded to ensure correct installation; refer to 'JTIS'.
- The harness is manufactured from Polyamide tube, which has good abrasion resistance properties.

System Operation

This subsection discusses the base operation of the air suspension system and should be read in conjunction with the subsection **Operating Modes and Strategies**.

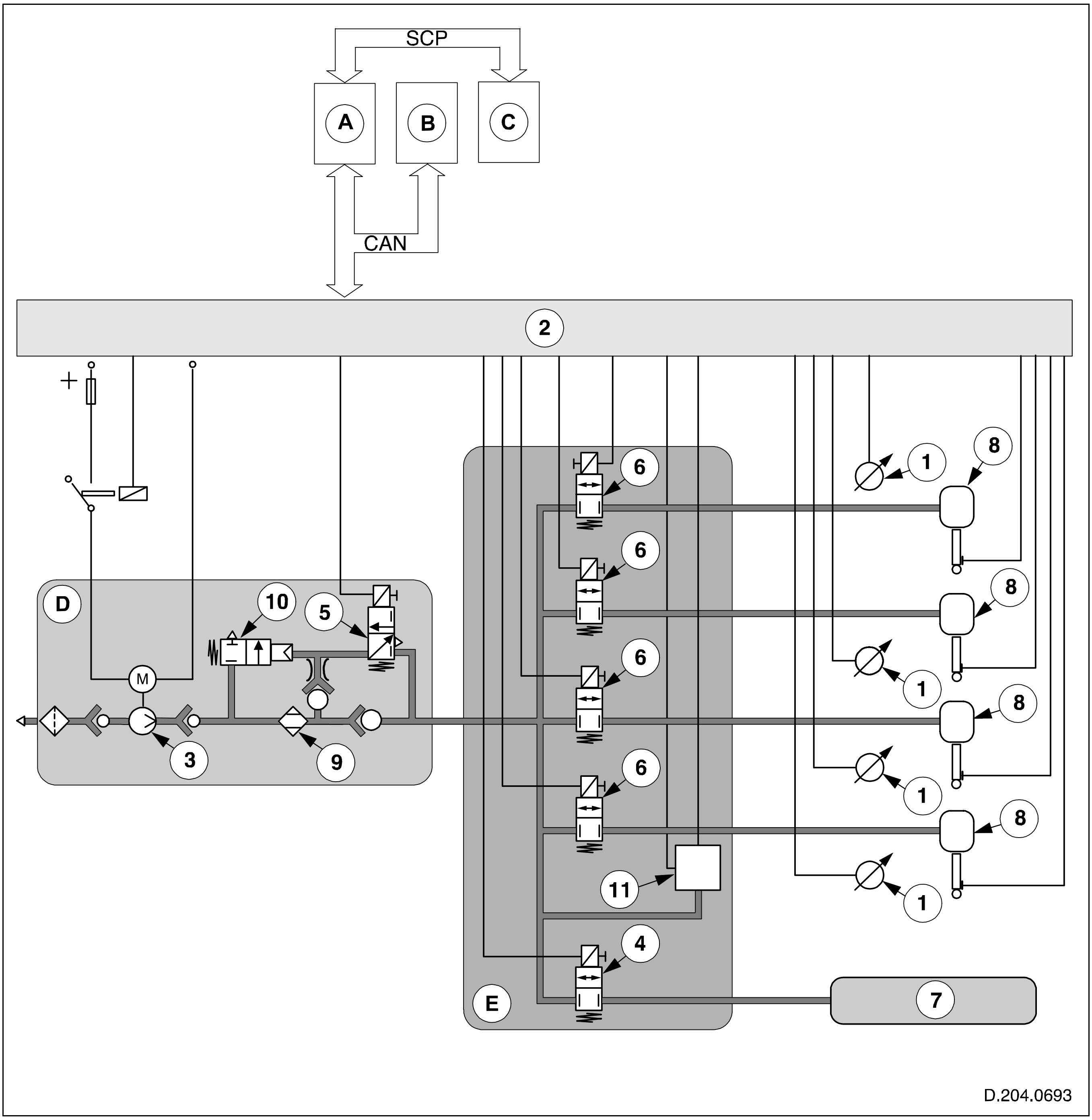

Fig. 9 System diagram

Key to Fig. 9

A. Instrument cluster - provides signals of vehicle system status
B. ABS module - provides vehicle speed signals
C. REM - provides trailer tow, brake switch on/off status and system switch power (SSP) signals
D. Air compressor unit
E. Valve block
1. Height sensors
2. Air suspension module (ASM)
3. Air compressor motor
4. Reservoir solenoid
5. Vent solenoid
6. Air spring solenoid valves
7. Reservoir
8. Air springs
9. Air drier
10. Relay valve
11. Pressure sensor

- The height sensors (**1**) monitor the distance between the vehicle's suspension and body. In response to changes in ride height, the electronic signals from the sensors reflect the height changes. These signals are monitored by the ASM (**2**), and compared to stored reference values. The ASM calculates this information to either raise or lower the vehicle and retain a constant suspension level.
- To raise the vehicle the ASM, depending on vehicle status, activates either:
  - the electric motor of the compressor (**3**), or
  - the reservoir solenoid (**4**).
- To lower the vehicle the ASM activates the vent solenoid (**5**).
- Every process simultaneously causes the air-spring solenoid valves (**6**) to be actuated to allow air to flow, to and from the air springs.
- When the vehicle is being raised:
  - the compressor motor (**3**) via air drier (**9**), or the
  - reservoir (**7**) via the reservoir solenoid (**4**),
  - delivers air into the air-spring bellows (**8**) until required height has been reached.
- When the vehicle is being lowered, the air flows from the air spring bellows (**8**), through the vent solenoid (**5**) of the air drier (**9**), via the relay valve (**10**) and evacuated to atmosphere.
- The pressure sensor (**11**) is incorporated to monitor spring and reservoir pressure. The ASM uses the pressure sensor data plus the data received via the CAN relating to vehicle status, to determine whether to raise the vehicle using the compressor or the reservoir reserves.

Operating Modes and Strategies

The ASM provides a number of air suspension operational modes dependent on the vehicle state:

Transportation Mode

Vehicles arrive at dealers in transportation mode and will need to be switched, using WDS, to customer mode.

- Transportation mode levels the vehicle to 15mm above the standard ride height to avoid ground clearance issues when loading the vehicle on to transporters, ships, etc.
- When the engine is running the compressor only is used to level the vehicle, independent of road speed.
- When in transportation mode the message center will continuously display 'Air Suspension Fault' until the vehicle is switched to customer mode.

WARNING: Once the vehicle has been switched to 'customer mode', body-securing straps/chains must not be used to secure the vehicle to a recovery transporter. Use straps over the wheels/tires only, to secure the vehicle to the transporter.

Leveling Strategy

- Raising has priority over lowering.
- The rear axle will rise before the front axle.
- The front axle will lower before the rear axle.
- To compensate for uneven loading of the vehicle, the rear air springs are regulated individually, this means the comparison of the nominal and actual level is performed for both sides individually.
- As front loading is not as extreme as rear loading, and to allow for a stable adjustment process, the front air springs are regulated and adjusted as a pair.

Customer Mode

The modes diagram below shows the transitions between the different modes within customer mode, these modes are dependant on various ASM input signals and the switched system power (SSP) signal. The SSP signal is functioned by the rear electronic module (REM) and is used to monitor and switch the modes, as necessary, when the ignition key is removed.

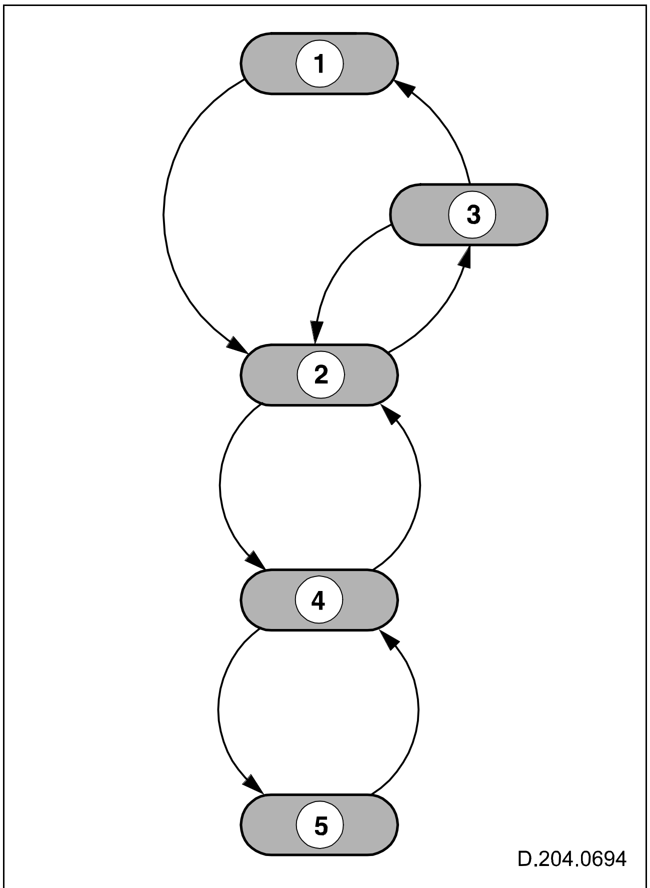

Fig. 10 Customer modes

1. Sleep mode
2. Preliminary mode
3. Post mode
4. Stance mode
5. Drive mode

NOTE: Ambient temperatures affect the vehicle ride height; the suspension lowers as the ambient temperature lowers, and rises as the ambient temperature rises.

1. Sleep Mode
   Sleep mode is invoked approximately thirty minutes after the ignition is switched off and the last door or luggage lid activity has been detected. The air suspension system shuts down when the vehicle is not in use and automatically wakes up every twenty-four hours to check the vehicle ride height. Twenty-four hour multiples are used to avoid temperature variation, for example to avoid the variability between day and night temperatures.
   If the suspension level requires correcting, the suspension's lowest corner will be used as the height value and the suspension will be lowered to meet that height. If the suspension lowers to the minimum height, the ASM makes no further adjustments. To conserve reservoir pressure and battery power the system does not raise the ride height when in sleep mode.
   When the SSP signal detects a door or luggage lid activity the suspension will switch to preliminary mode.
2. Preliminary Mode
   This mode is activated by any of the three following actions:
   - The SSP signal detecting a door or luggage lid activity when in sleep mode.
   - The SSP signal detecting a door or luggage lid activity when in post mode.
   - Switching the engine 'off' in stance mode.

   To avoid excessive leveling actions during vehicle loading/unloading, the ride height tolerances in preliminary mode are greater than those used in stance and drive modes. In preliminary mode the ride-height is raised using the reservoir's supply only. Suspension lowering is also functioned if necessary. The height sensors use a fast filter signal to enable a quick leveling response to load changes; refer to **Height Sensors**.
   The preliminary mode will switch to either of the two following modes depending on signals transmitted to the ASM:
   - If the engine is started the suspension will switch to stance mode.
   - When there has been no loading/unloading or door activity for a predetermined length of time, the SSP instructs the ASM to switch to post mode.

3. Post Mode
   Post mode is activated if SSP detects no loading/unloading or door activity for a predetermined length of time in preliminary mode.
   Post mode will raise the vehicle to the standard ride height if there is enough pressure within the reservoir. Compressor function is inhibited.
   The post mode will switch to either of the two following modes depending on signals transmitted to the ASM:
   – If the SSP signal detects a door or luggage lid activity the suspension will switch to preliminary mode.
   – If a predetermined amount of time elapses with no loading/unloading or door activity, the suspension will switch to sleep mode.
4. Stance Mode
   The ASM switches from preliminary mode to stance mode when the vehicle is stationary and the engine is started.
   The vehicle is leveled to a tighter tolerance to ensure the ride height is correct before vehicle moves off. The ride height is raised using the reservoir's supply, unless the vehicle is below a minimum height and the reservoir's supply is depleted. In this event the compressor is used to raise the vehicle. The height sensors use a fast filter signal to enable a quick leveling response to load changes; refer to **Height Sensors**.
   The stance mode will switch to either of the two following modes depending on signals transmitted to the ASM:
   – If the vehicle accelerates above 1 km/h (0.6 mile/h) the suspension will switch to drive mode.
   – If the engine is switched 'off' the suspension will switch to preliminary mode.
5. Drive Mode
   The ASM switches from stance mode to drive mode when the vehicle accelerates above 1 km/h (0.6 mile/h).
   Above a predetermined road speed, the compressor is used to raise the vehicle ride height. This mode is also used to replenish the reservoir. The height sensor filtering is switched to slow filter at speeds above 1 km/h (0.6 mile/h), although this will change to fast filter when leveling occurs; refer to **Height Sensors**.
   If vehicle speed is lower than 1 km/h (0.6 mile/h), the ASM switches to stance mode.

Additional Modes and Strategies

- Speed Lowering Mode
  The speed-lowering mode is a function of drive mode:
  – When the vehicle maintains a speed of 160 km/h (100 mile/h) or above, and 10 seconds elapse, the suspension lowers 15 mm below the standard ride height.
  – The suspension returns to the standard ride height when the vehicle speed decreases below 140 km/h (88 mile/h) and 5 seconds elapse.
- Towing Mode
  The ASM inhibits the speed lowering function when the vehicle is towing.

  WARNING: The towing mode inhibits speed lowering, when using Jaguar approved towing equipment only.
- Rough Road Detection
  The ASM inhibits the speed lowering function when a rough road surface is detected; the vehicle is raised to the standard ride height to ensure passenger comfort.
- Leveling Inhibits
  The ASM recognizes significant cornering, braking and acceleration actions and inhibits suspension leveling during these periods.
- Jacking Mode
  The ASM detects when the vehicle is being raised using jacking equipment by monitoring height changes at the individual wheels. The ASM will initially attempt to adjust the suspension, but will recognize that the vehicle height is not responding as normal and inhibit suspension leveling.
  A suspension inhibit will also be initiated when the vehicle is suspended on a lift, and all four-wheels are being lowered. In this condition, when the suspension travel exceeds a predetermined value, air exhausting will be inhibited.
  The inhibit function will remain initiated until the vehicle height returns to normal, or a wheel speed signal of 3 km/h (2 mile/h) is detected.
- Inclination Mode
  The ASM activates the inclination mode when the vehicle is parked on an uneven surface for example, with one wheel on a curb. If the ASM detects what is effectively a sufficient twist between the front and rear axles, the axles will be leveled as a pair. This avoids suspension leveling when the vehicle is moving away.
- Diagnostics
  System fault codes are stored in the ASM for diagnosis using worldwide diagnostic system (WDS).

Adaptive Damping

The adaptive damping system also known as computer active technology suspension (CATS) has been enhanced to improve vehicle:

- control when accelerating and braking;
- stability when making lane change maneuvers;
- stability and comfort when cornering.

As with the previous version the dampers, depending on road and vehicle dynamic conditions, are switched between:

- a 'soft' setting for a comfort saloon ride, or
- a 'firm' setting for a stiffer sports ride.

Further enhancements made to the system can now function the damper settings to switch in pairs:

- front or rear,
- left or right (inside or outside when the vehicle is cornering).

Adaptive damping is fully automatic, with no visual indication communicated to the driver when the dampers switch between settings.

System Functionality

The dampers are switched between a 'soft' or 'firm' setting by electronics integrated into the air suspension module (ASM); refer to **Air Suspension**. Various vehicle status values are processed by the ASM; refer to **Fig. 11**. The ASM compares this data with stored data and starts a programmed arithmetic process (algorithm) to calculate the optimum setting to apply to the dampers at a specific vehicle state. For example, when the vehicle is either: braking, accelerating or cornering.

The damper-setting control signals are transmitted to an actuator integrated into each of the dampers. The actuators change the speed of damper piston movement by altering the rate of fluid-flow within the dampers:

- Soft setting - maximizes fluid flow to produce less resistance, therefore a quicker piston movement.
- Firm setting - minimizes fluid flow to produce more resistance, therefore a slower piston movement.

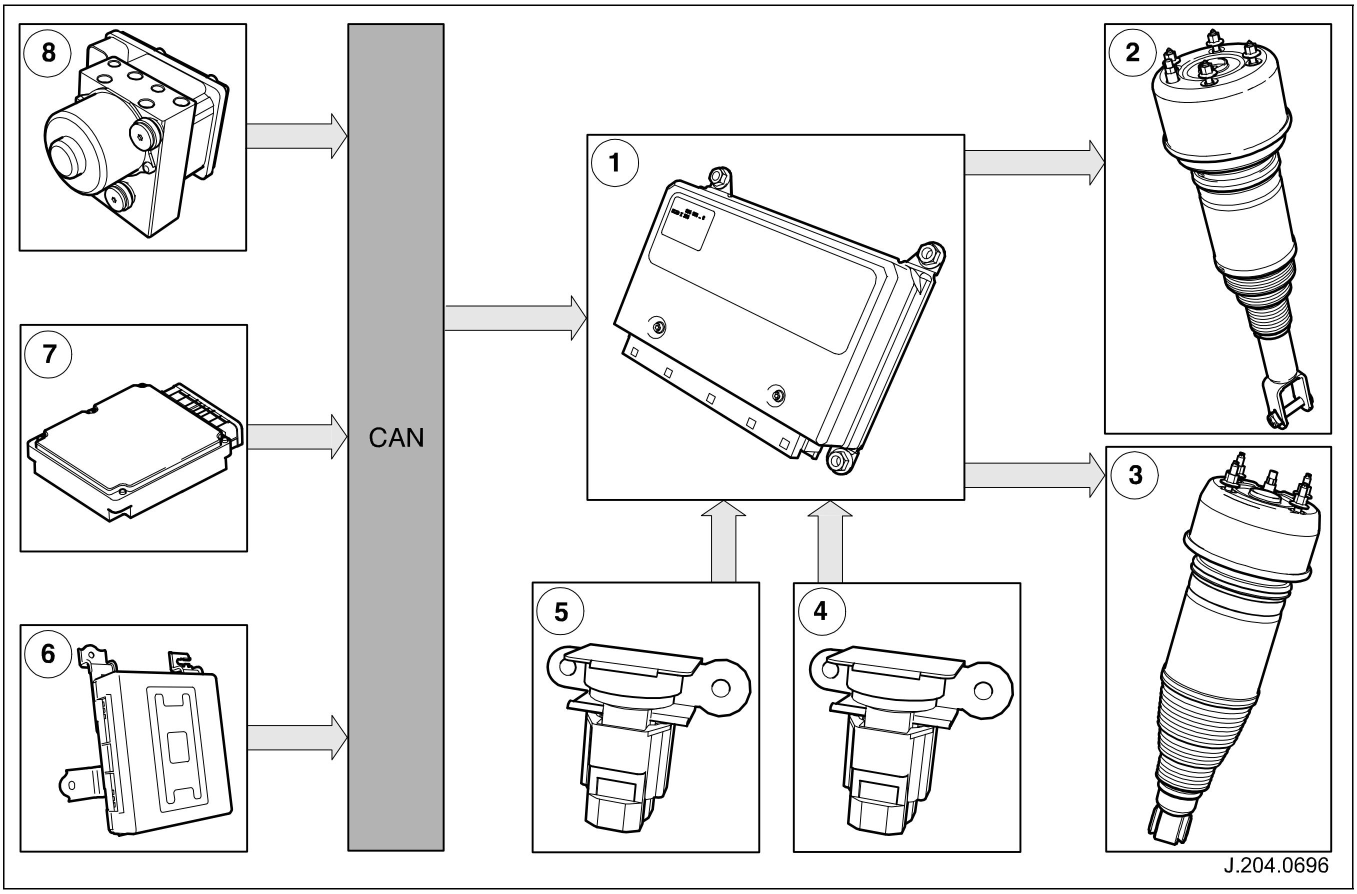

Fig. 11 Control system diagram

1. Air suspension module
2. Front damper (integral with air spring)
3. Rear damper (integral with air spring)
4. Front vertical accelerometer
- vertical acceleration
5. Rear vertical accelerometer
- vertical acceleration
6. Climate control module
- ambient air temperature
7. Engine control module
- engine speed
- engine torque
8. ABS module
- brake line pressure
- vehicle reference speed
- lateral acceleration
- steering wheel angle
- steering wheel velocity

Adaptive Damping Strategy

The following strategies are an overview only.

Under normal driving conditions, the adaptive damping system adopts the following strategy:

- At system start-up and up to 1 km/h (0.6 mile/h) the system will be set to 'firm'. This is the default setting in the event of a malfunction.
- At 1 km/h (0.6 mile/h) the setting is switched to 'soft' to provide a saloon-ride comfort.
- At speed of 145 km/h (90 mile/h) and above, the system is switched to 'firm'. This setting provides further vehicle stability at higher speeds.

Using the above strategy as a base, the adaptive damping system adopts the following strategies to adjust to changes in vehicle dynamics, road conditions and ambient temperatures:

- Braking
  The front dampers switch to 'firm' slightly before the rear dampers to prevent the front of the vehicle lowering.
- Acceleration
  To maintain optimum vehicle control when accelerating the 'firm' damper setting is adopted.
- Cornering
  The front and rear algorithm improves the stability and comfort performance of the vehicle during cornering:
  - At low speeds, the rear dampers switch to 'firm' slightly before the front dampers to reduce transient understeer.
  - At high speeds, the front dampers switch to 'firm' slightly before the rear dampers to increase transient understeer.

  If the vehicle is still cornering after the front-rear algorithm has finished, the left-right algorithm checks if the inner dampers can be switched to 'soft'. If initiated this further switching helps to generate less motion in the vehicle, and maintains the driven wheels with a more consistent contact with the road surface.
- Long Wave Detection
  The two vertical accelerometers identify natural vehicle-body undulations when the vehicle is traveling on a relatively straight road. In these circumstances, the 'firm' damper setting is adopted as this increases the ability of the vehicle's wheels to follow the contours of the road surface, therefore counteracting vertical-body undulations and increasing tire to road contact. The dampers will switch back to 'soft' when vehicle body undulations subside. The vertical accelerometers are located:
  - Front: right-hand-front wheel arch.
  - Rear: left-hand-side of luggage compartment.

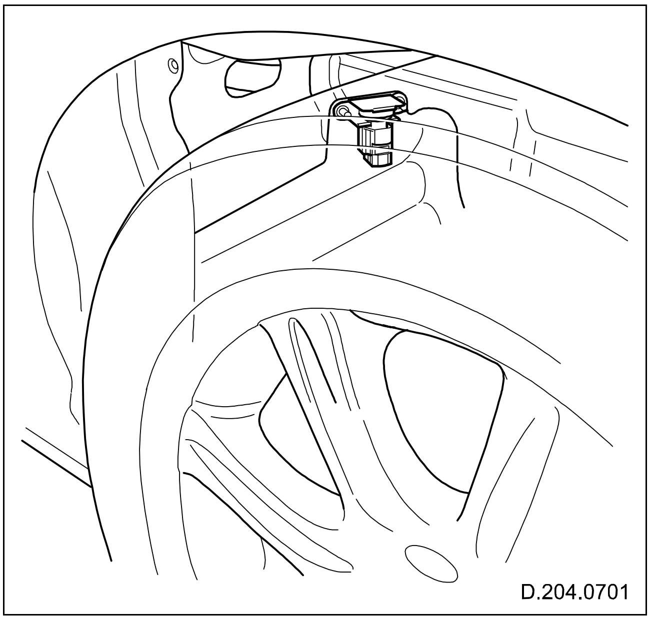

Fig. 12 Front vertical accelerometer

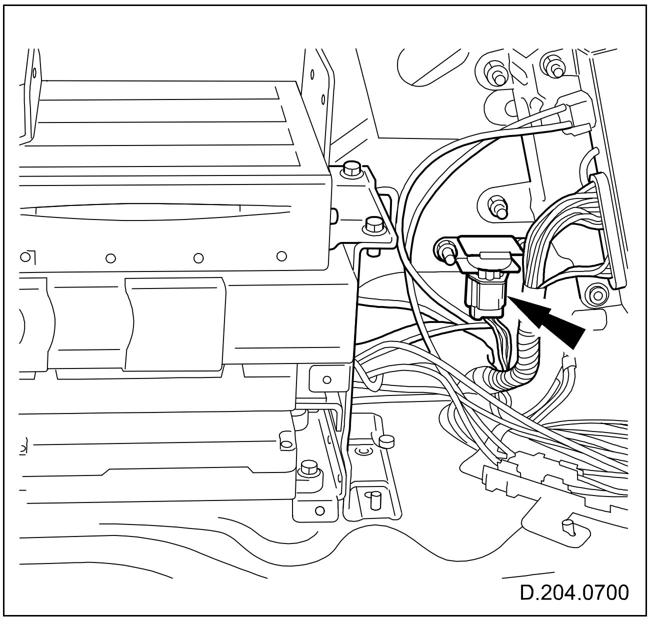

Fig. 13 Rear vertical accelerometer

- Cold Environment
  To improve air-suspension performance in cold environments, when the damper fluid is thick (high viscosity) making damper movement slow, the dampers are switched to the 'soft' setting. This maximizes fluid-flow within the damper when the air-suspension is either lifting or lowering the vehicle. This function operates below a preset vehicle speed and ambient air-temperature.
- System Malfunction
  The 'firm' damper setting provides greater vehicle stability at all driving conditions and has a higher priority than the 'soft' setting. Therefore, in the event of a malfunction in the adaptive damping or air-suspension systems the dampers will default to the 'firm' setting.
- Diagnostics:
  System fault codes are stored in the ASM for diagnosis using worldwide diagnostic system (WDS).

Driveline

Driveshaft

- A new two-piece driveshaft manufactured of lightweight steel is used, which comes in two derivatives to accommodate both powertrain applications:
  - V6 engine with automatic transmission.
  - V8 engine with automatic transmission.
- The driveshaft aligns with the centerline of the vehicle's body and is supported in a rubber center bearing.
- The driveshaft comprises the following:
  - Rubber couplings at each end of the driveshaft.
  - Center Hookes joint.
  - The driveshaft's front-tube is of swage construction, designed to collapse in a controlled manner in the event of the vehicle being involved in a front-end collision.
  - Low friction splines at the center of the driveshaft provide the driveshaft's plunge capability. There is no spline-locking feature on this driveshaft.

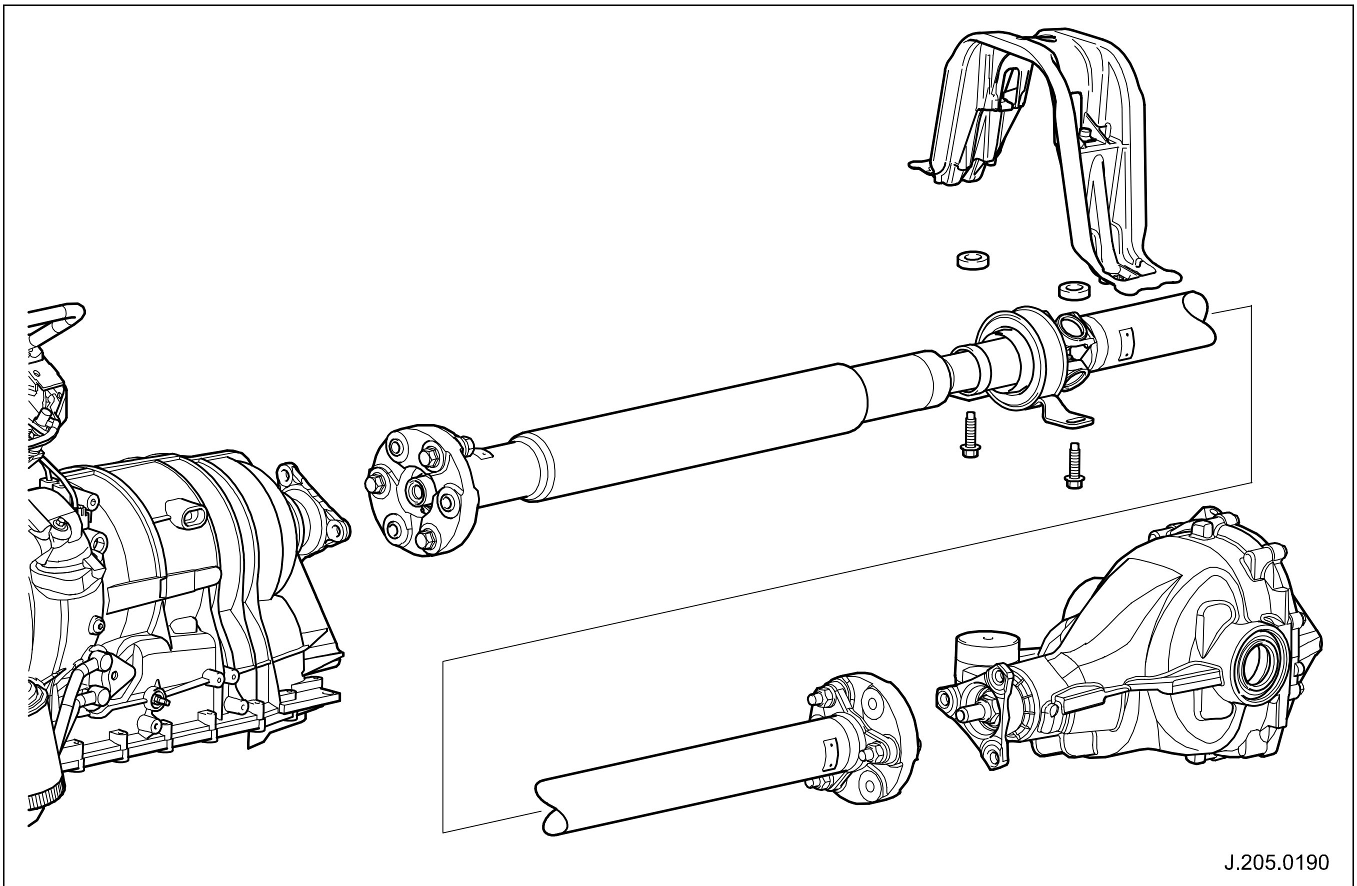

Fig. 14 Driveshaft and final drive unit

Final Drive Unit

- The final drive unit is supported at three mounting points, one at the front of the unit, and two at the rear, through rubber bushes to the vehicle's rear subframe. This mounting arrangement plus the subframe to vehicle-body mounting arrangement, refer to the **Suspension** section, provides the rear driveline with double isolation from the vehicle's body.
- The final drive unit is constructed of a new lightweight cast-iron main casing, with an aluminum rear cover.
- The pinion shaft aligns with the centerline of the vehicle's body and is supported by two taper-roller bearings.
- The hypoid-gear set is supported by taper roller bearings.
- The final drive lubricant is fill for life; the level-plug is located in the rear cover.
- Final drive ratios:
  - V6 3.0 liter - 3.31:1
  - V8 3.5 liter - 3.07:1
  - V8 4.2 liter normally aspirated - 2.87:1
  - V8 4.2 liter supercharged - 2.87:1

Axle Shafts

- There are two derivatives of axle shaft:
  - V6 and V8 normally aspirated engines: tubular axle-shafts including constant-velocity joints with high-torque capacity.
  - V8 supercharged engine: solid axle-shafts including constant-velocity joints with high-torque capacity.
- The left-hand and right-hand axle shafts are different lengths.
- The inboard constant-velocity joint is a sliding arrangement, providing the axle shaft's plunge capability. The outboard constant-velocity joint is fixed.
- The axle shaft is a spline interference-fit into the wheel hub, and a spline slide-fit into the final drive unit retained by a spring circlip.

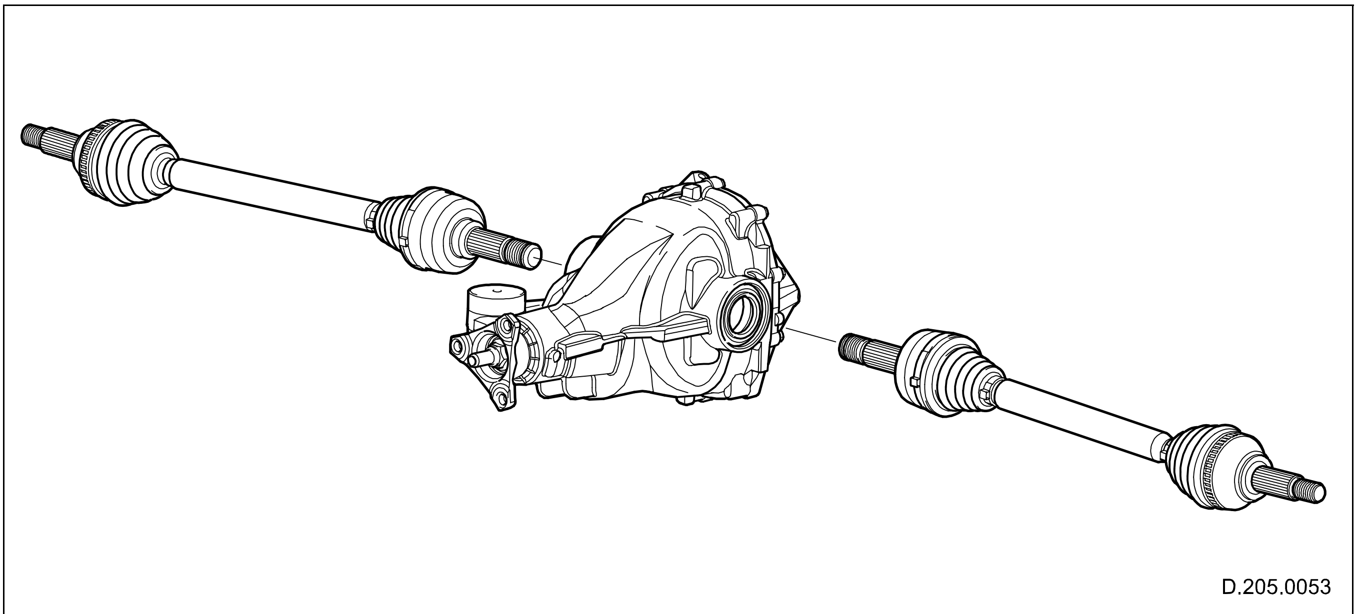

Fig. 15 Axle shafts and final drive unit

Brake System

Introduction

The XJ incorporates a new braking system comprising the following components and functions:

- Panic brake assist.
  - An enhancement to the anti-lock braking system (ABS).
- Dynamic stability control (DSC).
  - Incorporates all new hardware.
- Electric parking brake.
  - Refer to **Electric Parking Brake**.
- Pedal-adjustment system.
  - Refer to **Pedal-adjustment System**.

To complement the new braking system and further enhance the vehicle's braking capability the foundation brakes have also been upgraded:

Front calipers:

- Normally aspirated vehicles incorporate a double-piston sliding arrangement.
- Supercharged vehicles incorporate a Brembo monobloc four-piston fixed arrangement.

Rear calipers:

- Normally aspirated vehicles incorporate a single-piston sliding arrangement with a self-adjusting mechanism.
- Supercharged vehicles incorporate a Brembo two-piece four-piston fixed arrangement; the electric parking brake uses a separate caliper.

Steel-braided brake hoses are installed, providing the following advantages over conventional hoses:

- reduced expansion under pressure,
- light-weight design,
- reduced permeability.

The following table shows the application of the foundation brake components:

Components	Normally Aspirated Vehicles	Supercharged Vehicles
Ventilated Front Discs 320 x 30	X	
Solid Rear Discs 288 x 20	X	
Aluminum Front Caliper	X	
Rear Aluminum Caliper	X	
Brembo Front Ventilated Disc 365 x 32		X
Brembo Rear Solid Disc 330 x 15		X
Brembo Front Caliper		X
Brembo Rear Caliper		X
Electric Parking Brake	X	X
Separate Rear Brake Caliper		X
Steel Braided Hoses - Front and Rear	X	X

Table 3 Brake components

Brake Booster and Master Cylinder

The active brake booster is used to provide the panic brake assist function. The booster also provides improved crash capability, with the elimination of the internal retaining studs as used on the previous booster.

A short-stroke master-cylinder, offering less protrusion from the booster, is incorporated to provide improved packaging and crash performance. The master-cylinder is of tandem design, which in the event of one brake circuit failing, the other circuit will remain operational. An integral fluid-level switch is incorporated in the master-cylinder's reservoir. If brake fluid is low, the brake warning light in the instrument cluster will illuminate and 'LOW BRAKE FLUID' will be displayed in the message center.

The pressure transducer attached to the master-cylinder provides the ABS/DSC module with brake pressure information. This information informs the system how hard the driver is braking and is used as an aid for the DSC to achieve accurate brake pressure control.

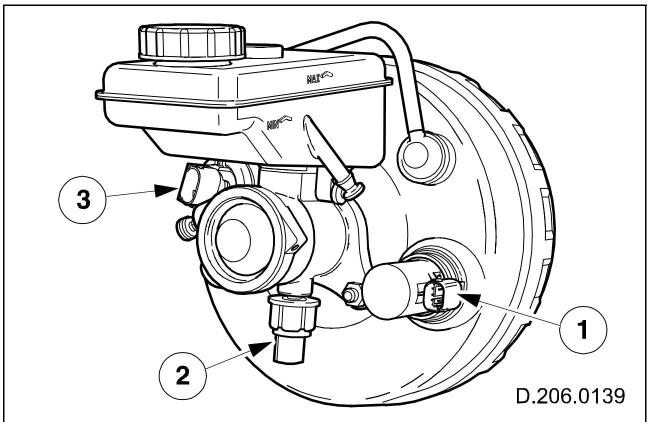

Fig. 16 Active brake booster

1. Diaphragm travel sensor
2. Pressure transducer
3. Solenoid connector

Panic Brake Assist

In an emergency braking situation, a driver presses down on the brake pedal much faster than in normal braking conditions, but often without sufficient force. The initial application of the brake pedal is a reflex reaction. After the initial application, many drivers do not brake hard enough because of concerns that they might cause the vehicle to skid. To aid the driver, the panic brake assist (PBA) intervenes in bringing the vehicle to a halt, sooner and in a controlled manner, in emergency braking situation. The PBA system monitors the speed of brake pedal activation, and at a calibrated pedal activation speed, the PBA provides maximum brake force and makes full use of the ABS.

PBA is controlled by the ABS/DSC module, which monitors a travel sensor attached to the internal vacuum diaphragm of the brake booster. The sensor determines the position of the diaphragm and the speed of the diaphragm movement. If the sensor's signal indicates an emergency braking situation, the ABS/DSC module will open an electric solenoid on the brake booster. The solenoid directs atmospheric pressure into the rear of the brake booster, causing the booster diaphragm to move forward to fully apply the brakes. PBA takes full benefit of ABS to stop the vehicle in a controlled manner and in the shortest distance possible. When the brake pedal is released the ABS/DSC module instantly releases the brakes.

Anti-lock Braking System

The anti-lock braking system (ABS) is a four-channel system having independent inputs from all four-wheel speed sensors. The ABS module, monitors signals from the sensors to calculate: brake slip, acceleration and deceleration of individual wheels. When the brake pedal is depressed, and the ABS module detects incipient wheel lock-up from the incoming signals, it triggers the re-circulation pump inside the module's hydraulic modulator, and the solenoid valves for the wheel(s) concerned. Brake pressure, is then modulated to increase/decrease or remain constant at the wheel(s) concerned until wheel lock-up is eliminated.

The ABS provides self-diagnosis and any malfunction within the system will be indicated to the driver by the illumination of the brake warning light and 'ABS FAULT' displayed in the message center. Should a fault develop within the ABS, the brake system will operate conventionally and with the same standard of performance as a vehicle not equipped with ABS.

Traction Control

Traction control is a function of dynamic stability control (DSC), and is operated in association with the DSC system; refer to **Dynamic Stability Control** 'Driver Interface and Control' subsection.

Traction control prevents excessive wheel-spin at standing starts, or during acceleration. Wheel-spin is usually caused by excessive use of the accelerator pedal, or slippery, loose or bumpy road surfaces. To prevent excessive wheel-spin and maintain vehicle stability such situations are overcome by the intervention of the traction control system by:

- braking the driven-wheel when it starts to slip,
- and/or adapting the engine torque to a level corresponding to the traction available on the road surface.

Functional Description

Traction control uses the ABS electronic and mechanical/hydraulic hardware with additional valves and control to enable the system to generate braking pressure at the calipers. An engine interface also enables the engine to respond to torque reduction requests from the traction control.

As with ABS, the signals from the wheel-speed sensors are supplied to the ABS module, where they are used to calculate the wheel-slip of the individual wheels. Traction control intervention is initiated if the slip at one of the wheels is excessive.

Engine Intervention

In the event of wheel-slip the ABS/DSC module calculates the torque, which should be applied by the engine to reduce the wheel-slip (this torque does not exceed driver demand). Engine torque reduction is then requested from the ECM via the CAN bus. The ECM, in response to these signals, reduces engine torque by controlling the ignition and fuelling.

A traction control gearshift pattern is automatically selected within the automatic transmission software whenever traction control is active.

Brake Intervention

This function operates by increasing the pressure in the brake caliper of the slipping wheel, by closing the separation valve and the inlet valve of the non-slipping wheel and running the modulator pump. This takes fluid from the fluid reservoir via the non-actuated master cylinder and pressurizes the brake caliper. The pressure is modulated at the caliper via the inlet and outlet valves to achieve the desired wheel-slip target to maximize traction.

Dynamic Stability Control

Dynamic Stability Control (DSC) is a closed-loop system designed to enhance driving safety by improving vehicle handling when the tires are at the limits of their grip capabilities. This is achieved through instantaneous electronically controlled reduction of engine torque and strategic application of the brakes at individual wheels.

By using the principle that by controlling the brakes individually it is possible, to an extent, to steer the vehicle. This principle can be used to enhance driving safety by correcting the vehicle's yaw moment (turning force), when the vehicle fails to follow the driver's steering inputs.

Examples of DSC capabilities:

- When the vehicle fails to follow the driver's steering input, the DSC generates precisely defined braking forces at individual wheels to pull the vehicle into line. For example, in a left-hand bend a vehicle that oversteers tends to 'slide out' at the rear wheels. This motion is counteracted by applying the brake at the right-hand front wheel to provide a corrective yaw moment and can reduce side-forces at that wheel in order to stabilize the vehicle.
- Similarly, in the same left-hand bend when the vehicle understeers, the vehicle tends to 'slide out' at the front wheels. Applying the brakes at the left-hand rear wheel to generate a corrective yaw moment to help to turn the vehicle can counteract this motion.
- Even when the tires are at the limits of their grip, such as in sharp steering maneuvers due to driver panic responses, DSC can intervene to reduce the dangers of skidding or breakaway.
- If understeer or oversteer is caused by excessive engine torque, the DSC will reduce the engine torque to provide the corrective yaw moment.

Driver Interface and Control

- DSC is switched 'On' when the engine is started.
- When the system is operating, the DSC light in the instrument cluster will flash, at the rate of twice a second.
- DSC can be switched 'OFF' by pressing the control switch, located on the J-gate surround.
  - The DSC light in the instrument cluster will illuminate continuously when the system is switched 'OFF'.
  - 'DSC OFF' will be displayed in the message center to indicate the system has been switched 'OFF'.
  - If the control switch is pressed again the system will be switched 'ON'.
- A malfunction in the traction control system will be indicated to the driver by the following:
  - The DSC light in the instrument cluster will illuminate continuously.
  - The message 'DSC NOT AVAILABLE' will be displayed in the message center.
- If vehicle speed control is engaged it will automatically disengage when traction control is operating.

Dynamic Stability Control Concept

Satisfactory handling is determined according to whether a vehicle maintains a path, which accurately reflects the driver's input (steering wheel angle) while at the same time remaining stable.

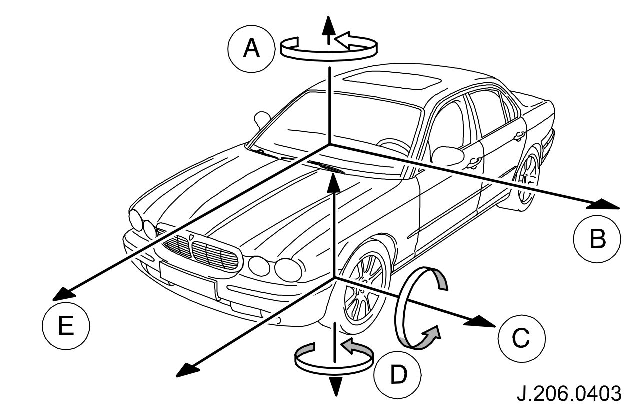

Fig. 17 Vehicle travel directions

A. Yaw rate
B. Lateral acceleration
C. Wheel roll
D. Steering motion
E. Longitudinal acceleration

The ABS/DSC module measures the vehicle's motion using the sensors below and processes the information to maintain vehicle control and stability within its ultimate control limits, which are determined by the physical limits set by the tire's grip.

- Longitudinal acceleration as measured through the wheel speed sensors;
- Lateral acceleration as measured through the lateral acceleration sensor;
- Yaw rate, defined as the rotation around the vertical axis, as measured by the yaw rate sensor.

When there is insufficient tire grip for the driving situation (for example, the driver has entered a corner too fast) the DSC will maintain stability and optimize the cornering and stopping performance, but cannot always prevent the vehicle from running wide.

Driver demand is measured by using the steering wheel angle sensor and vehicle speed to calculate the optimum yaw rate. This is compared to the actual measured yaw-rate and a yaw-rate calculated from the lateral acceleration and the vehicle speed. If the deviation between these measurements is too great, an understeer or oversteer correction is made.

The first step in this process is to determine how the vehicle should respond to driver demand (ideal response) and how it actually does respond (actual response). Hydraulic control valves can then be activated to generate brake pressure and/or engine torque reduction can be used to maintain the difference between the ideal and actual response within a tolerance band. This directly influences the forces on the tires to generate a corrective yaw moment to reduce the side forces of the tires where appropriate.

System Overview

The DSC system embraces capabilities far beyond that of ABS, or ABS and traction control combined, while relying on the components of these systems. It also incorporates these additional sensors for measuring the vehicle's motion and brake system pressure:

- Yaw rate sensor - located to the rear of J-gate in the transmission tunnel;
- Lateral acceleration sensor - integrated with the yaw rate sensor;
- Steering angle sensor - located on the upper steering column;
- Pressure transducer - located on master cylinder.

The ABS/DSC module supports data exchange with other vehicle electronic systems via the CAN; the module also enables diagnostic interrogation using WDS.

The following components register driver demand and the ABS/DSC module processes their signals as a basis for defining an ideal response:

- Electronic engine control system: position of accelerator pedal.
- Brake master cylinder pressure transducer: driver's braking effort.
- Steering angle sensor: position of steering wheel.

There are many supplementary parameters also included in the processing calculations these include the coefficient of friction and vehicle speed. The ABS/DSC module monitors these factors based on signals transmitted by the sensors for:

- wheel speed,
- lateral acceleration,
- brake pressure,
- and yaw rate.

Using these parameters, the function of the ABS/DSC module is to determine the current vehicle status based on the yaw-rate signal and the slip as estimated by the ABS/DSC module. It then maintains the vehicle response within a tolerance of the 'normal' behavior, which is easily controlled by the driver.

In order to generate the desired yaw behavior the ABS/DSC module controls the selected wheels using the ABS hydraulic system and engine control system. In the event of engine intervention the ABS/DSC module calculates the torque which should be supplied by the engine to the wheels, and relays this request signal to the ECM which implements the torque request.

The electronic engine control system in response to signals from the DSC reduces engine torque in three ways:

- The throttle is positioned to provide the requested engine target torque.
- During the transient phase of torque reduction caused by mechanical and combustion delays, other alternative torque reduction methods are used to provide a quicker response.
  - The ignition is retarded and/or the fuel is cut-off at the injectors at selected cylinders.
- Ignition and fuelling are reinstated when the engine torque, controlled by the throttle reaches the requested value.

Electric Parking Brake

An electric parking brake is fitted as standard to the XJ, providing the following benefits over the conventional parking brake:

- Space - deletion of the conventional parking-brake lever provides more vehicle interior space.
- Ease of use - the electric parking brake does not depend on the strength of the driver to achieve full parking-brake application.
- Safety - the electric parking brake automatically applies when the ignition key is removed.

Overall control of the electric parking brake is via a control module, which controls an actuator unit to operate the rear brake calipers. The control module, depending on the vehicle status, is either functioned by the driver-operated switch, or various control signals to apply or release the parking brake.

Components

The electric parking brake comprises the following components:

- Switch - mounted in the floor console.

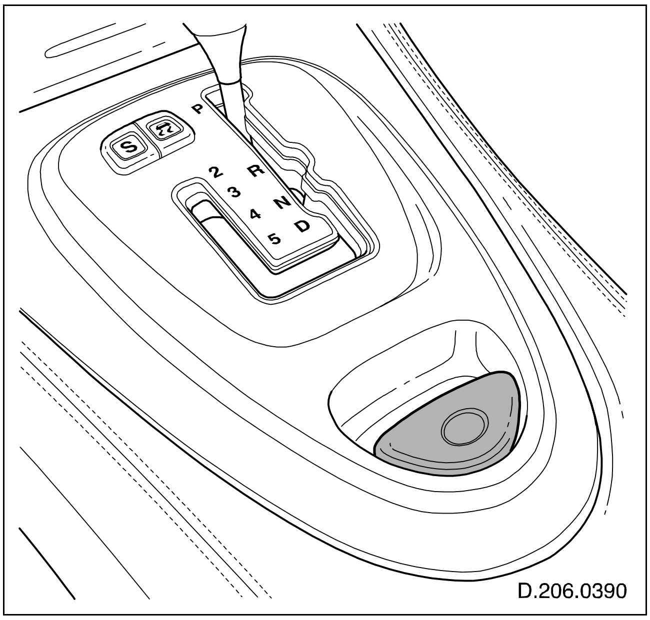

Fig. 18 Parking brake switch

- Parking brake module - located behind the trim, on the right-hand-side of the luggage compartment.

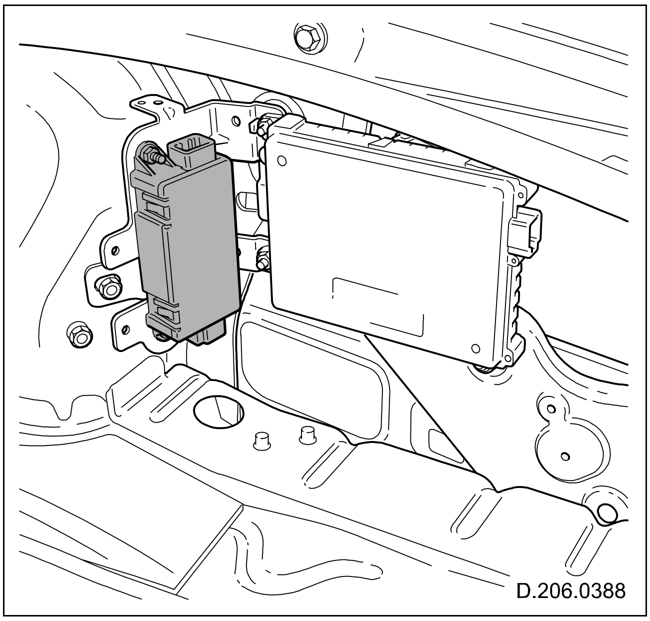

Fig. 19 Parking brake module

- Motorized actuator unit and cables - mounted on the rear subframe.
  - The actuator mounting and cable routing is different on normally aspirated and supercharged vehicles to correspond with the positioning of the calipers.
  - On normally aspirated vehicles, the brake and parking brake caliper is a combined unit.
  - On supercharged vehicles, the brake caliper and parking brake caliper are separate units.

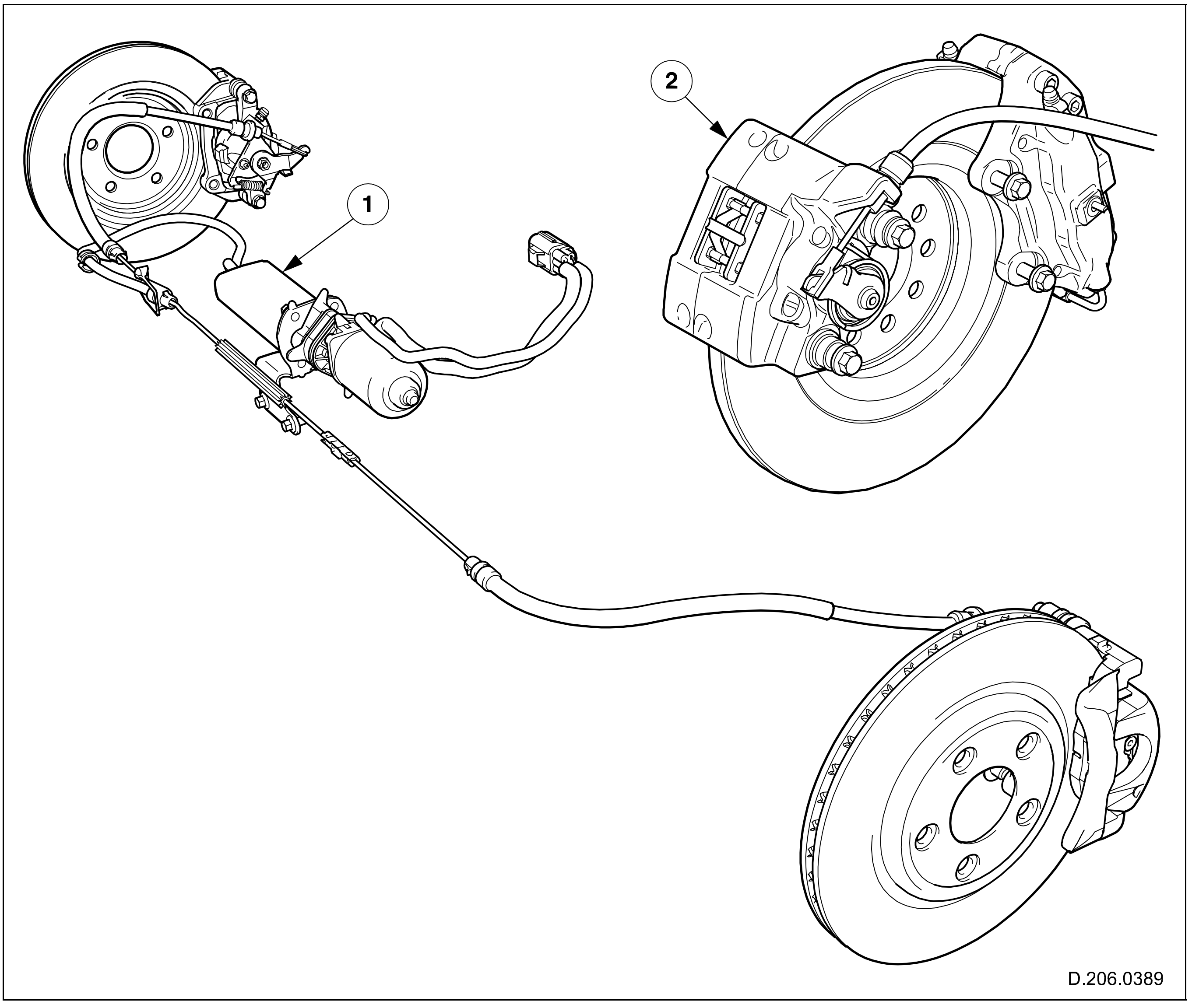

Fig. 20 Actuator unit and cables

1. Actuator unit and cables - normally aspirated vehicle arrangement
2. Parking brake caliper - supercharged vehicle arrangement

Driver Operation

The parking brake switch is mounted on the floor console, to the rear of the gear selector. The switch is a pull/push operation providing the following functions:

Pull up - applies the parking brake.

Neutral - central default position; the switch, when released by the driver, returns to this position regardless of parking brake state.

Push down - releases the parking brake.

The parking brake can be applied in two ways:

1. Pull the switch up and then release. The 'Brake' warning light on the instrument cluster will illuminate to confirm parking brake application.

NOTE: The 'Brake' warning light, on the instrument cluster, will remain illuminated for a short period if the ignition key is turned to position '0' or the key is removed.

2. The parking brake will automatically apply when the ignition key is removed.

The parking brake can be released in three ways:

1. With the ignition switch in position 'II' or with the engine running, apply the footbrake and push the switch down.
2. The parking brake will automatically release when the gear selector is moved from the park 'P' position.
3. With the parking brake applied and the gear selector in either drive 'D' or reverse 'R'. The parking brake will automatically release when the accelerator pedal is depressed.

NOTE: The 'Brake' warning light, on the instrument cluster, will extinguish to confirm parking brake release.

In circumstances when the parking brake needs to be released when the ignition key is removed:

- hold the parking brake switch down,
- at the same time, remove the ignition key.

CAUTION: Ensure the vehicle's wheels are securely wedged, if parking the vehicle with the parking brake released.

Drive-away Release

Drive-away release is activated when the gear selector is in either drive 'D' or reverse 'R' and a positive throttle angle is detected. The ECM, via the SCP BUS, provides the throttle position signals.

Safety Functions

CAUTION: With the exception of emergency conditions, the electric parking brake should not be applied while the vehicle is moving.

If the parking brake is applied while the vehicle is moving, the message 'PARK BRAKE ON' will be displayed on the message center, the 'Brake' warning light will illuminate, and a warning chime will sound.

To release the parking brake while the vehicle is moving:

- Push the switch down to release the parking brake.
- If the switch is in the neutral position after parking brake application, depressing the accelerator pedal will release the parking brake.

Mechanism and Activation

CAUTION: With the exception of emergency conditions, the electric parking brake should not be applied while the vehicle is moving.

There are three modes of parking brake operation dependant on vehicle speed:

- Static - speeds, up to 3 km/h (2 mile/h), in this mode:
  - Pulling-up the switch, results in the parking brake applying at full force.
- Low Speed Dynamic - speeds between 3 and 32 km/h (2 and 20 mile/h), in this mode:
  - The Parking brake applies at full force to the corresponding time the switch is pulled-up and held therefore, the parking brake will apply until the switch is depressed or the vehicle comes to a halt.
- High Speed Dynamic - speeds above 32 km/h (20 mile/h), in this mode:
  - One pull and release of the switch will apply the parking brake for 500 ms. Each subsequent pull and release of the switch will apply the parking brake for 250 ms. Full parking brake force will be achieved at between ‘3 and 4 pull and releases’ of the switch.
  - If the switch is pulled and held the parking brake will be automatically applied in a ramp-up sequence as follows:
  - APPLY for 500 ms,
  - HOLD for 500 ms,
  - APPLY for 250 ms,
  - HOLD for 500 ms,
  - APPLY for 250 ms.
  - This sequence is repeated until full parking-brake load is registered at the control module

Resetting the Parking Brake

If the electrical supply is disconnected from the electric parking-brake module, for example battery disconnection, the actuator will lose its position memory. On battery connection, ‘APPLY PARK BRAKE’ will be displayed, in the message center, when the ignition is next switched on. This indicates the parking brake requires re-setting.

To reset the parking brake:

- with the foot brake depressed,
- pull-up and release the parking brake switch.

Service

To allow work to be performed on the rear calipers, a special tool is available to release parking-brake cable tension; refer to ‘JTIS’.

Parking brake adjustment:

- An initial setting is necessary when replacing the brake pads; refer to ‘JTIS’. After the initial setting, the parking brake adjusts automatically with use of the vehicle.

Diagnostics

Diagnosis of the electric parking brake system is achieved using ‘WDS’.

Actuator Internals

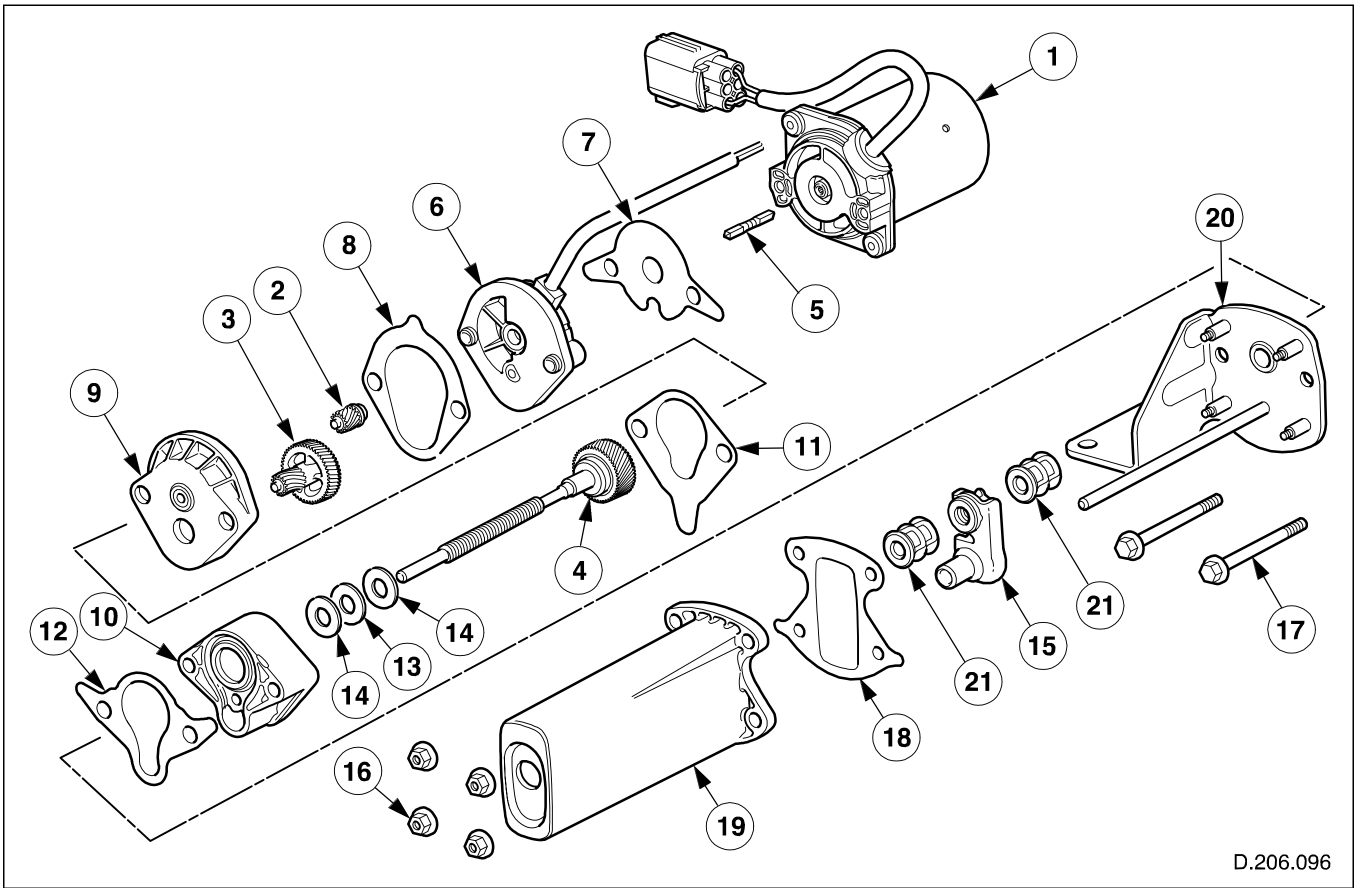

Fig. 21 Motorized actuator unit — internals

1. Motor
2. Gear pinion
3. Idler gear
4. Gear-lead screw
5. Flex shaft
6. End-plate transmission housing
7. Gasket end-plate motor
8. Gasket end-plate housing
9. Transmission housing
10. End-cap transmission housing
11. Gasket end-cap housing
12. Gasket end-cap bracket
13. Thrust bearing
14. Thrust washer
15. Drive nut
16. Nut - cover
17. Bolt
18. Gasket - cover
19. Cover
20. Bracket
21. Bumper

Pedal-adjustment System

The pedal-adjustment system is an optional installation, designed to allow drivers of particular statures, to improve their driving-position.

The system provides a range of adjustments up to a maximum of 2.75in (70mm) and comprises:

- front electronic module (FEM);
- pedal-adjustment motor;
- pedal-adjustment sensor;
- pedal-adjustment switch.

NOTE: The motor and sensor are part of the accelerator-pedal assembly.

The front electronic module (FEM) controls the position of the pedals by providing an electrical output signal to the motor, in response to the:

- current position of the pedal-adjustment position sensor;
- pedal position chosen by the driver (using the pedal-adjustment switch).

NOTE: Using the driver switchpack, three different pedal-position settings may be stored in the vehicle memory-system.

Fig. 22 shows the basic system interconnections; refer to **New XJ Range Electrical Guide** for detailed information.

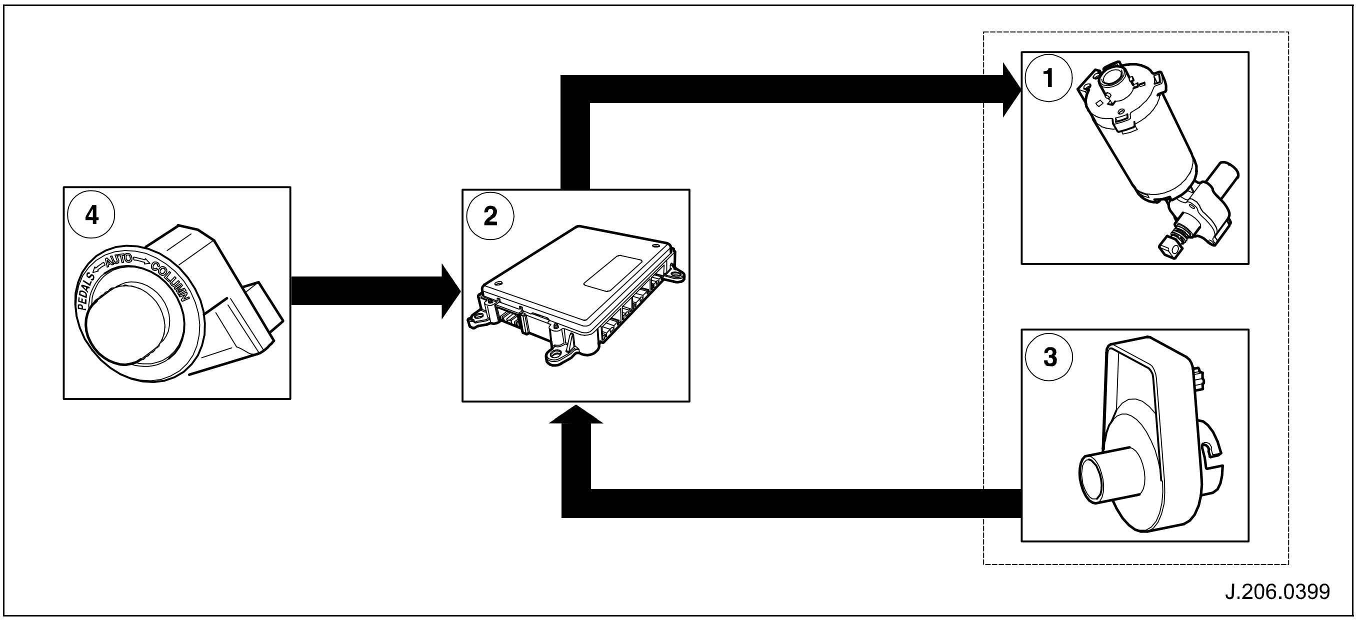

Fig. 22 Pedal adjustment system

1. Pedal-adjustment motor
2. Front electronic module
3. Pedal-adjustment position sensor
4. Pedal-adjustment switch

The pedal-adjustment system:

- can be activated when the ignition key is in any position;
- cannot be activated when the ignition key has been removed;
- is inhibited during the operation of the adaptive speed control (where installed);
- requires initialization after any component of the system has been replaced; refer to **JTIS**.

NOTE: Diagnostics should be undertaken using WDS.

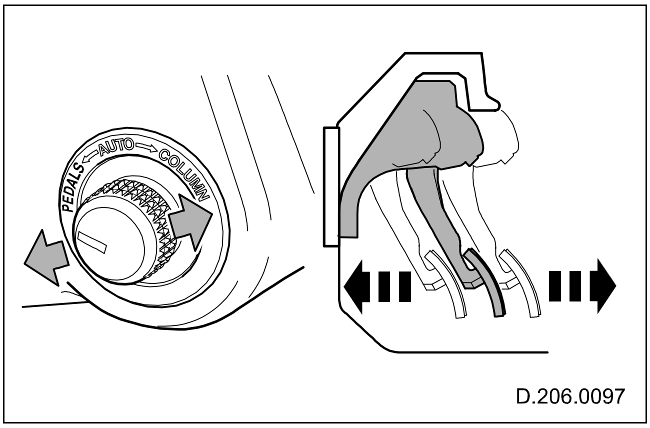

Fig. 23 Pedal-adjustment switch

Pedal adjustment is enabled by setting the 3–way, rotary switch situated on the left-hand side of the steering column, to the appropriate position. Pedal adjustment is then controlled by operating the switch upwards, for pedals 'out' and downwards for pedals 'in'.

The pedal-adjustment motor connects directly to the accelerator-pedal module; a flexible drive-cable connects the motor to the pedal-adjustment drive-gear.

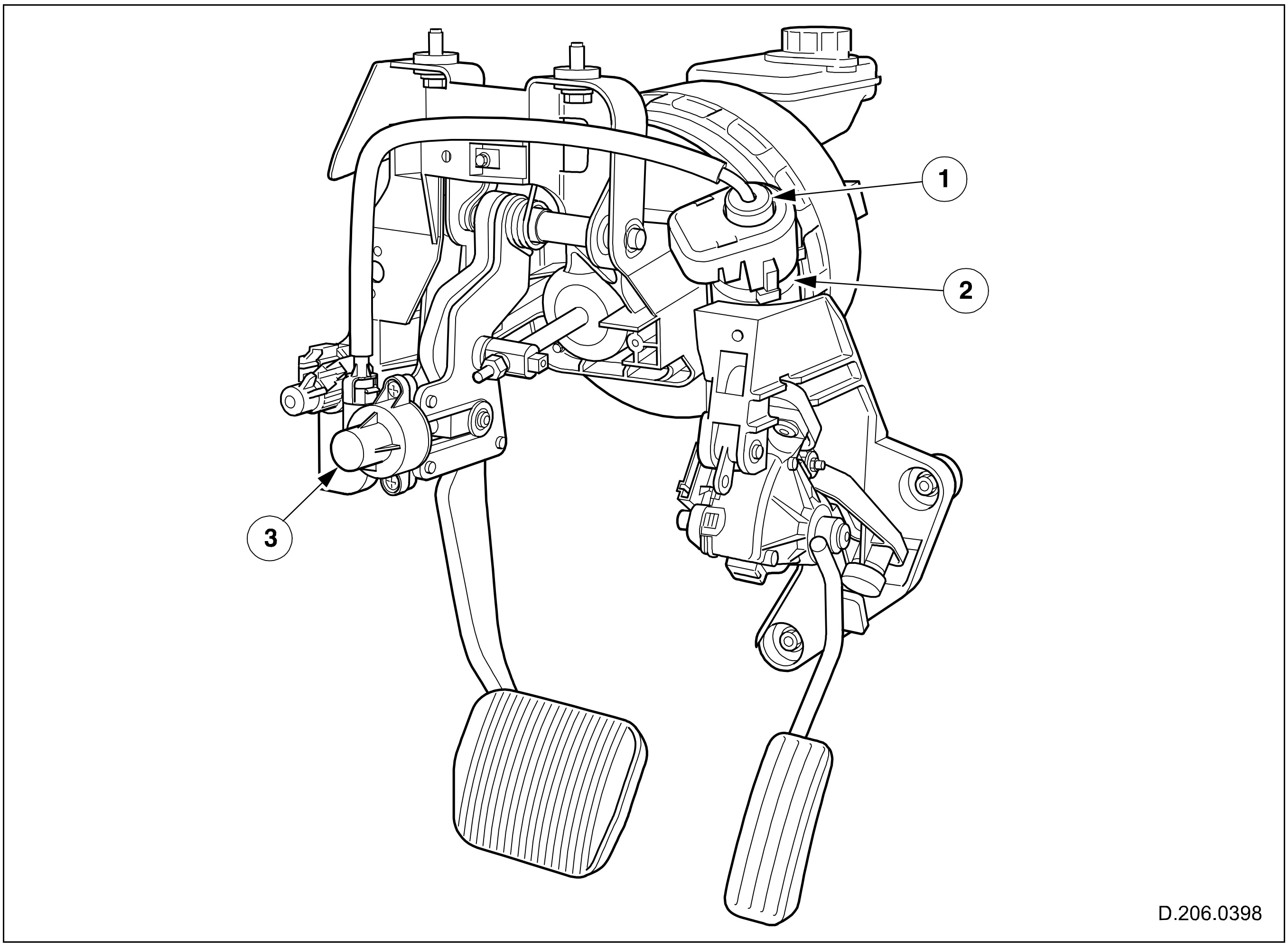

Fig. 24 Pedal-adjustment assembly

1. Pedal-adjustment position sensor
2. Pedal-adjustment motor
3. Brake-pedal adjustment drive-gear cover

Steering System

Introduction

An enhanced steering system is introduced into the XJ Range, which when combined with changes made to the suspension system provides excellent steering response and feel. The steering system is also specially tuned to complement the suspension changes, providing a further enhancement to the vehicle's ride characteristics; refer to **Suspension**.

Changes made to the steering system include:

- New upper steering column, refer to **Steering Column** below.
- New lower steering column, refer to **Steering Column** below.
- The hydraulic pressure switches have been removed from the high-pressure hoses; functionality is now integrated into the front electronic module (FEM), providing a faster response time; refer to **Servotronic Power Steering** below.
- All XJ models share the majority of steering system components, with the main exception of the pump pulley, which is smaller on the V8 derivative.

Servotronic Power Steering

The Servotronic power steering system operates using a conventional hydraulically operated rack and pinion, equipped with a rotary valve and added electronics to control the system's hydraulics. This system provides the driver with steering assistance proportional to the vehicle's speed:

- with full hydraulic power assistance provided at low vehicle speeds, for example when parking the vehicle, and
- a gradual reduction of hydraulic steering assistance as the vehicle speed increases, allowing the driver a precise feel of road contact.

The operating function of the Servotonic system is explained below:

- Road speed data, as measured by the electronic speedometer is transmitted to the FEM by the instrument cluster, via the SCP bus.
- Using the variable assisted power steering (VAPS) curve data stored within its memory, the FEM calculates the amount of current needed to supply the VAPS solenoid, which is an integral part of the Servotronic transducer.
- Based on the amount of current received from the FEM, the VAPS solenoid controls the hydraulic reaction of the rotary valve.
- This hydraulic reaction determines the amount of torque (effort) the driver needs to apply to the steering wheel at various vehicle speeds.

A further advantage of the Servotronic system is the fact that the oil pressure and flow are never reduced and can therefore be utilized immediately in emergencies, where sudden and unexpected steering corrections become necessary.

The power steering pump is mounted to the engine and is driven by the accessory drive belt. The pump provides a constant flow rate of 7.5 liters per minute and has a maximum pressure of 110 bars. The fluid reservoir incorporates a 10-micron internal filter to ensure cleanliness of the system.

Steering Rack

The steering rack is a variable ratio design, providing ease of parking maneuverability while maintaining the on-center steering precision required at high vehicle speeds. The steering rack is a compact unit, mounted via dual-rate rubber bushes to the rear of the vehicle's front subframe. The rotary motion of the steering-wheel is transformed by the pinion into the axial motion of the rack. The tie rods, attached at each end of the steering rack, transmit the steering motion to the wheel knuckles. From lock-to-lock the steering rack requires 2.8 turns of the steering wheel.

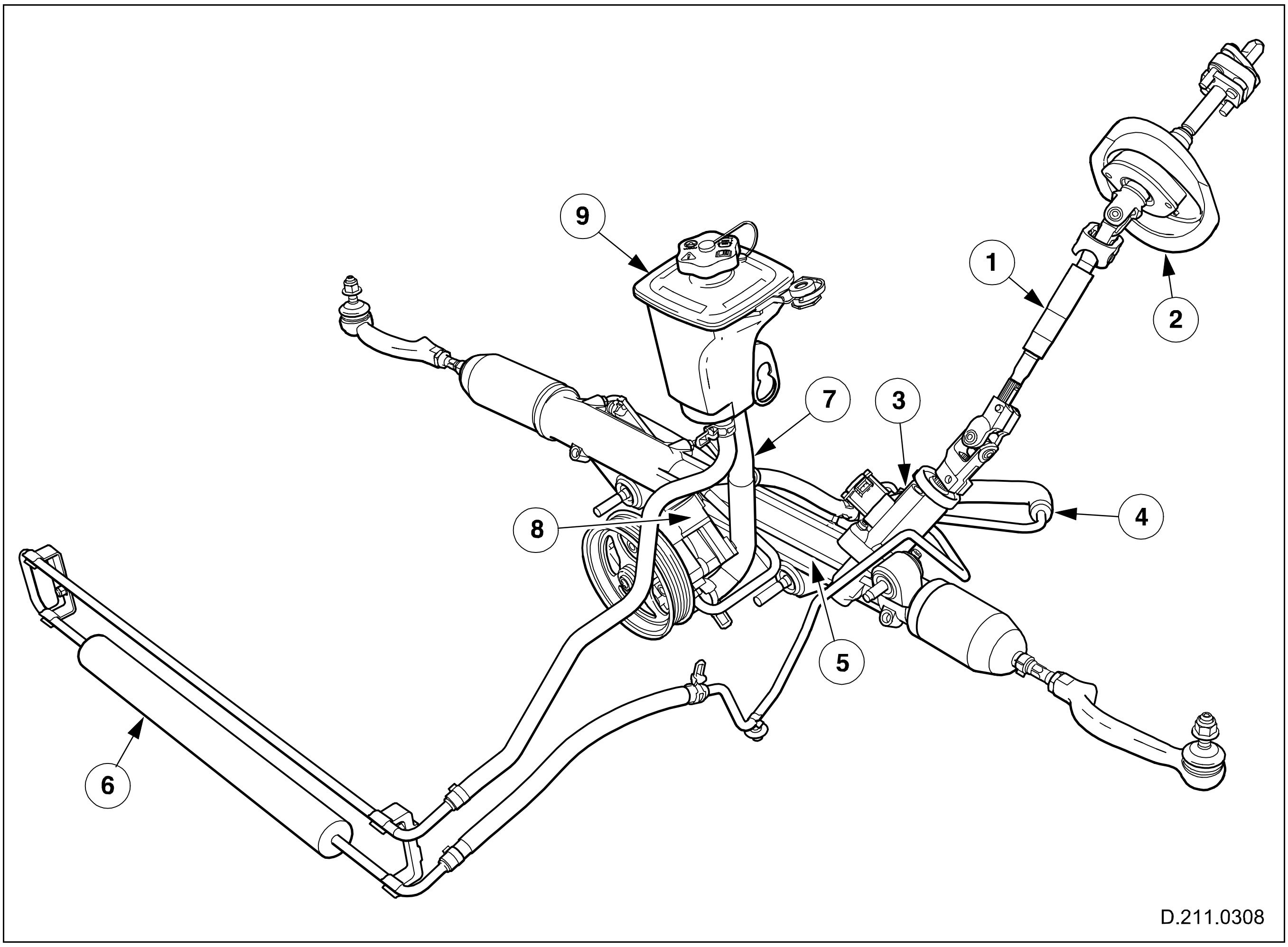

Fig. 25 Steering system assembly — V8 derivative shown

1. Lower steering column
2. Body seal and bearing
3. Rotary-valve housing and Servotronic transducer
4. High-pressure feed line
5. Steering rack
6. Fluid cooler
7. Suction hose
8. Power steering pump
9. Fluid reservoir

Steering Column

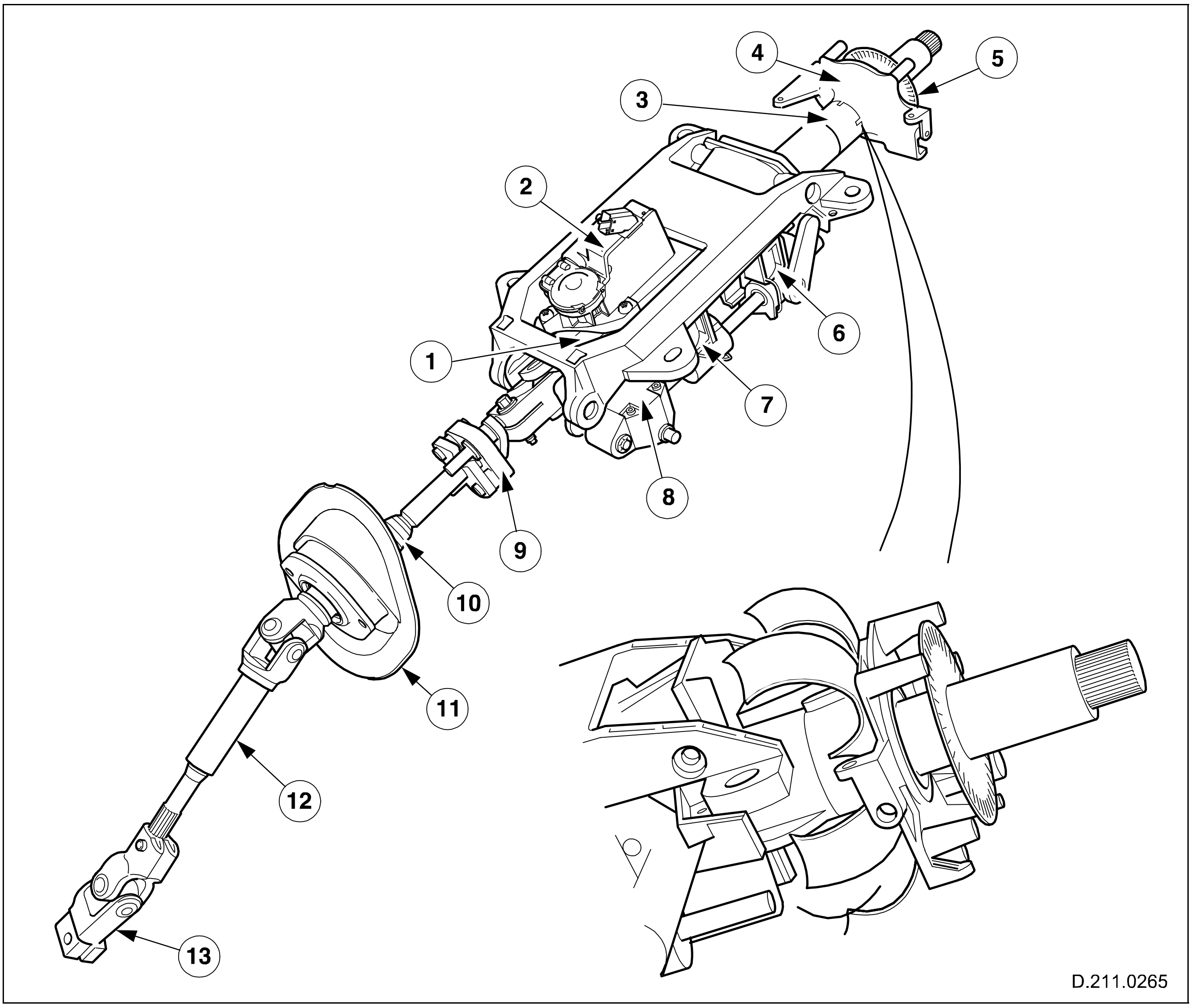

Fig. 26 Steering column

1. Upper column
2. Column lock
3. Peeling-tube crash mechanism
4. Crash adaptor
5. Sensor ring — dynamic stability control
6. Rake adjustment housing, lever and solenoid
7. Reach adjustment housing and solenoid
8. Adjustment motor
9. Rubber NVH isolator
10. Lower column
11. Body seal and bearing
12. Collapsible mechanism
13. Universal-joint

Upper Steering Column

- The upper column is a new design attached to the in-vehicle cross-member.
- A unique crash-load absorption system is provided by a peeling-tube mechanism; refer to **Fig. 26**.
- The column is equipped with a sensor ring, which is monitored by the steering angle sensor for dynamic stability control (DSC) functionality.
- All steering column electrical connections are via a single ten-way connector module, mounted on the side of the column.
- Steering column adjustment is calibrated at vehicle production. If either the column or the instrument cluster is replaced in service, the steering column adjustment range must be calibrated using WDS.

Column Adjustment

A single motor provides the drive for both the reach and rake adjustment of the column:

- reach adjustment is +/- 25 mm from the nominal setting,
- rake adjustment is +/- 2.5 degrees from the nominal setting.

The steering column is adjusted for reach and rake by operating the four-way control switch on the steering column; refer to **Fig. 27**.

Steering column adjustment:

- Moving the switch forwards and backwards controls reach adjustment.
- Moving the switch up and down controls rake adjustment.

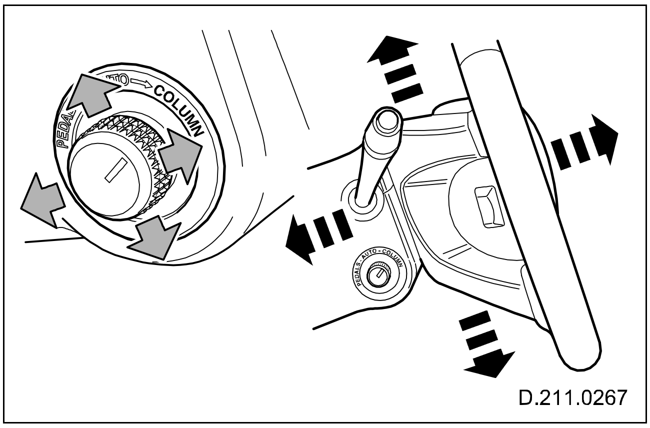

Fig. 27 Steering column adjustment

Driver Position Memory System

The driver-position memory system, functioned by the instrument cluster, stores three column positions that can be recalled in conjunction with the driver position setting, plus an entry/exit mode to give the driver maximum room to enter and exit the vehicle.

The entry/exit mode is selected by setting the steering column adjustment switch to the 'AUTO' position. When the ignition key is removed the steering column will move to the uppermost rake position.

Refer to vehicle owner literature for further information on the above memory functions.

Steering Column Lock

The steering lock is remote from the ignition switch and controlled electronically. The lock engages when the ignition key is removed; the lock disengages when the key is placed in the ignition switch.

Steering Column Shrouds

The shroud comprises an upper and lower section. Contained in the lower shroud is an energy absorbing foam-pad/spreader plate to optimize leg protection in the event of an accident.

NOTE: If the foam pad shows signs of damage, the lower shroud assembly must be replaced.

Lower Steering Column

- The lower column incorporates a new crash-collapse mechanism in the lower section. It is a tube-in-tube arrangement, where the inner tube is designed to breakaway from the crimped fixing of the outer tube at a predetermined load.
- The rubber isolator is part of the lower column, and is located in the column's upper section. The isolator controls axial and torsional movements between the steering and suspension systems while also providing noise, vibration and harshness (NVH) damping.
- The body bearing seal is part of the lower column assembly.
- The lower steering column attaches to the steering-rack's pinion via a universal joint.

V6 Engine

Introduction

The 3.0 liter AJ-V6 engine is introduced into the XJ Range, which when combined with the lightweight aluminum body provides excellent performance and economy figures. The engine performance figures have mainly been achieved by the use of continuous variable valve timing on the intake camshafts to provide optimum engine torque over a wide-range of engine speeds. Continuous variable valve timing was first used on the V6 in the X-TYPE and later the S-TYPE.

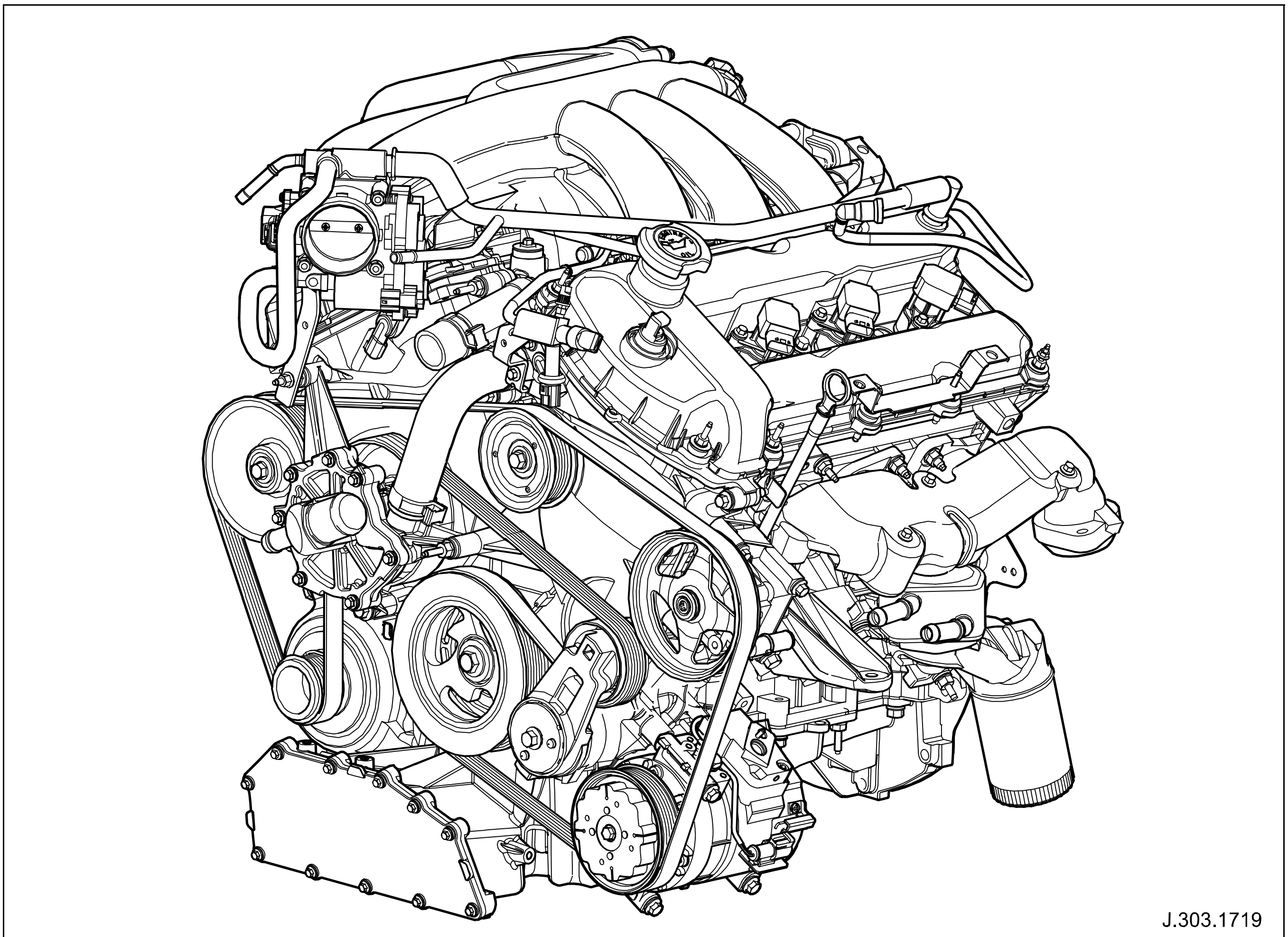

Fig. 28 V6 engine

Engine Components

The engine is a water-cooled six-cylinder unit, arranged in two planes in a 60 degree 'V' configuration, comprising:

- A lightweight aluminum cylinder-block with dry steel-liners.
- Aluminum pistons with valve cutouts in the crown to accommodate the advanced inlet timing of the variable valve timing system.
- A cylinder bore of 89 mm and piston stroke of 79.5 mm, provides:
  - 2967 cm^3 engine capacity, and a
  - 10.5:1 compression ratio.
- A steel crankshaft supported by four main-bearings.
- Sinter forged and fractured split connecting rods.
- A lightweight aluminum, engine-bedplate design, which combined with the inherent strength of the compact V6 configuration, minimizes vibration, increases torsional stiffness, and enhances engine refinement.
- Aluminum cylinder heads with precision cooling technology and square squish chambers to provide optimum economy and emissions.
- Continuously variable valve timing on the intake camshafts, refer to **Continuous Variable Valve Timing** below.
- Two chain-driven, overhead-camshafts per bank.
- Four-valves per cylinder, activated by direct acting mechanical bucket tappets with top mounted steel shims.
- Single spark plug positioned central to each of the cylinder's four valves.
- Crankshaft mounted oil-pump, providing increased-flow characteristics to supply the requirements of the variable valve timing system.
- Magnesium camshaft covers with rubber seals to reduce airborne noise.
- An extensive use of aluminum, and some magnesium components to minimize engine weight.
- A positive crankcase ventilation (PCV) valve, which regulates crankcase depression, and controls the flow of crankcase gases into the intake manifold and oil separator. The PCV valve is located in the bank-2 camshaft cover.

Continuous Variable Valve Timing

The continuous variable valve timing (VVT) used on this engine is a further development of the two-positional system. Where instead of selecting one of two possible intake camshaft positions, the continuous system operates over a range of 30 degrees and is advanced or retarded to the optimum angle within this range. Providing improved low and high-speed engine performance and excellent idle quality.

The VVT system changes the phasing of the intake valves, relative to the fixed timing of the exhaust valves, to alter:

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

The VVT unit uses a vane device to control the camshaft angle, refer to **VVT Operation** below.

The VVT is controlled by the engine control module (ECM), which uses engine control signals pertaining to engine speed and load, plus 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.

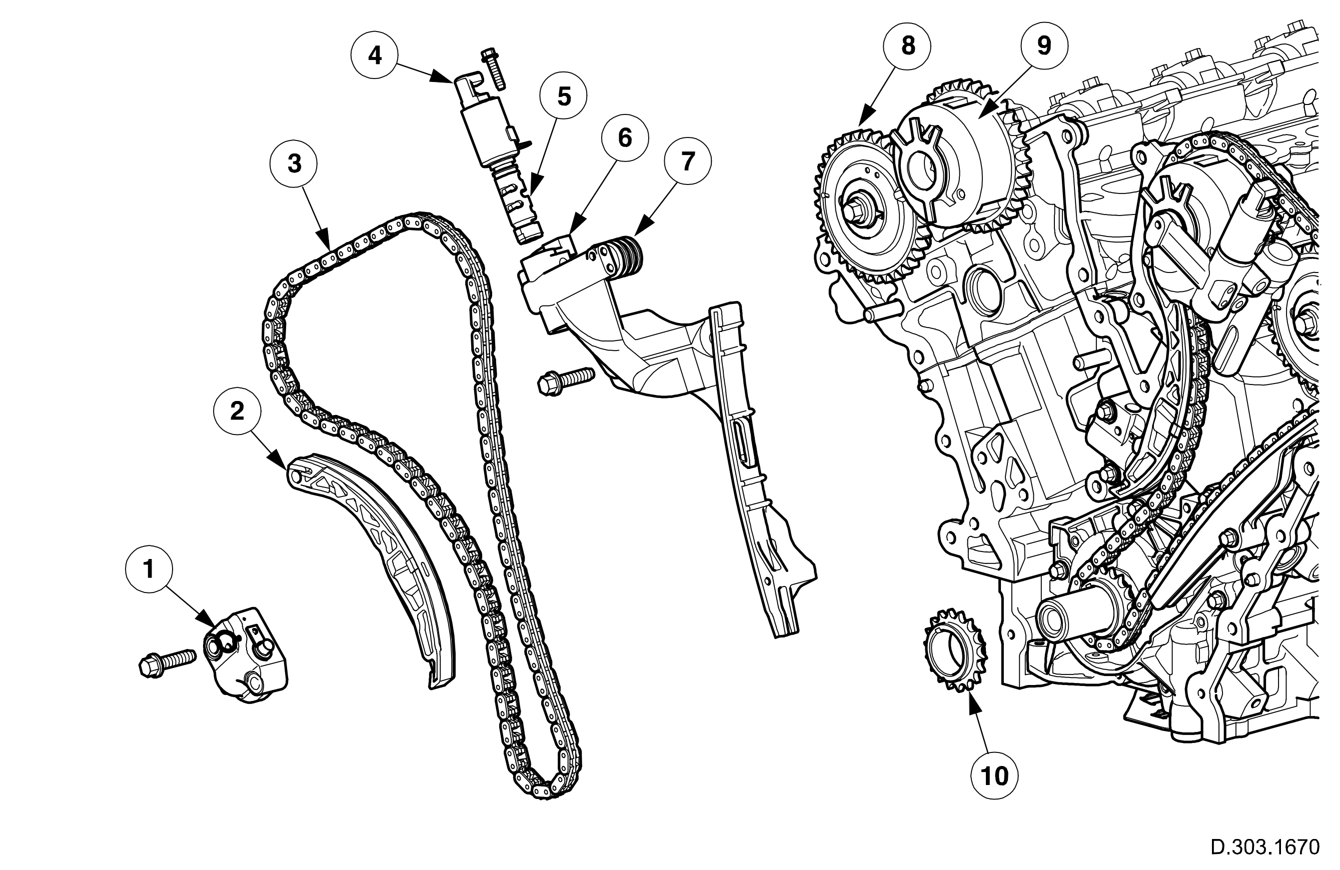

Fig. 29 Timing mechanism

1. Tensioner
2. Tensioner arm
3. Timing chain
4. Oil control solenoid
5. Shuttle valve
6. Bush carrier and chain guide
7. Oil feed bush
8. Exhaust camshaft sprocket
9. VVT unit - intake camshaft
10. Crankshaft sprocket

VVT Operation

The VVT unit is a hydraulic actuator mounted on the end of the intake camshaft, which advances or retards the intake camshaft timing and thereby alters the camshaft to crankshaft phasing. The oil control solenoid, controlled by the ECM, routes oil pressure to either the advance or retard chambers located either side of the four vanes interspersed within the machined housing of the unit.

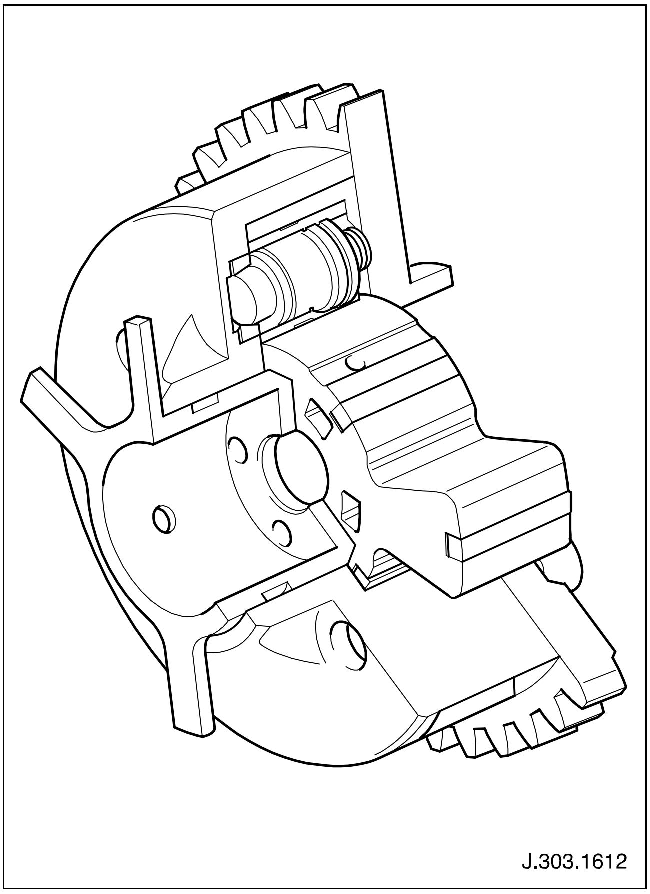

Fig. 30 VVT unit

The timing chain drives the VVT unit, which 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 intake 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. The VVT system is normally under closed-loop control except in extreme temperature conditions. For example, at very-low oil temperatures, such as cold starts below 0° Celsius, movement of the VVT mechanism is sluggish due to increased viscosity and may have to be limited by the ECM. Similarly, at extremely high oil temperatures the ECM may have to limit the amount of VVT advance to prevent the engine from stalling when returning to idle speed.

V8 Engine

Introduction

Two new V8 engines are introduced into the XJ Range:

- The AJ-V8 4.2-liter, an upgrade and replacement of the previous 4.0-liter engine, is available in both normally aspirated and supercharged variants. Jaguar first introduced this engine in the S-TYPE.
- The AJ-V8 3.5-liter, an upgrade and replacement of the previous 3.2-liter engine, is available as normally aspirated only. The 3.5-liter engine makes its Jaguar debut in the XJ Range.

Improvements made to the engines provide excellent performance data, and when combined with the lightweight aluminum body of the XJ produces best-in-class performance, economy, and refinement figures.

Engine Data

- AJ-V8 4.2-liter engine:
  - cylinder bore: 86 mm
  - piston stroke: 90.3 mm
  - engine capacity: 4196 cm^3
  - compression ratio - normally aspirated: 11.0:1
  - compression ratio - supercharged: 9.0:1
- AJ-V8 3.5-liter engine:
  - cylinder bore: 86 mm
  - piston stroke: 76.5 mm
  - engine capacity: 3555 cm^3
  - compression ratio: 11.0:1

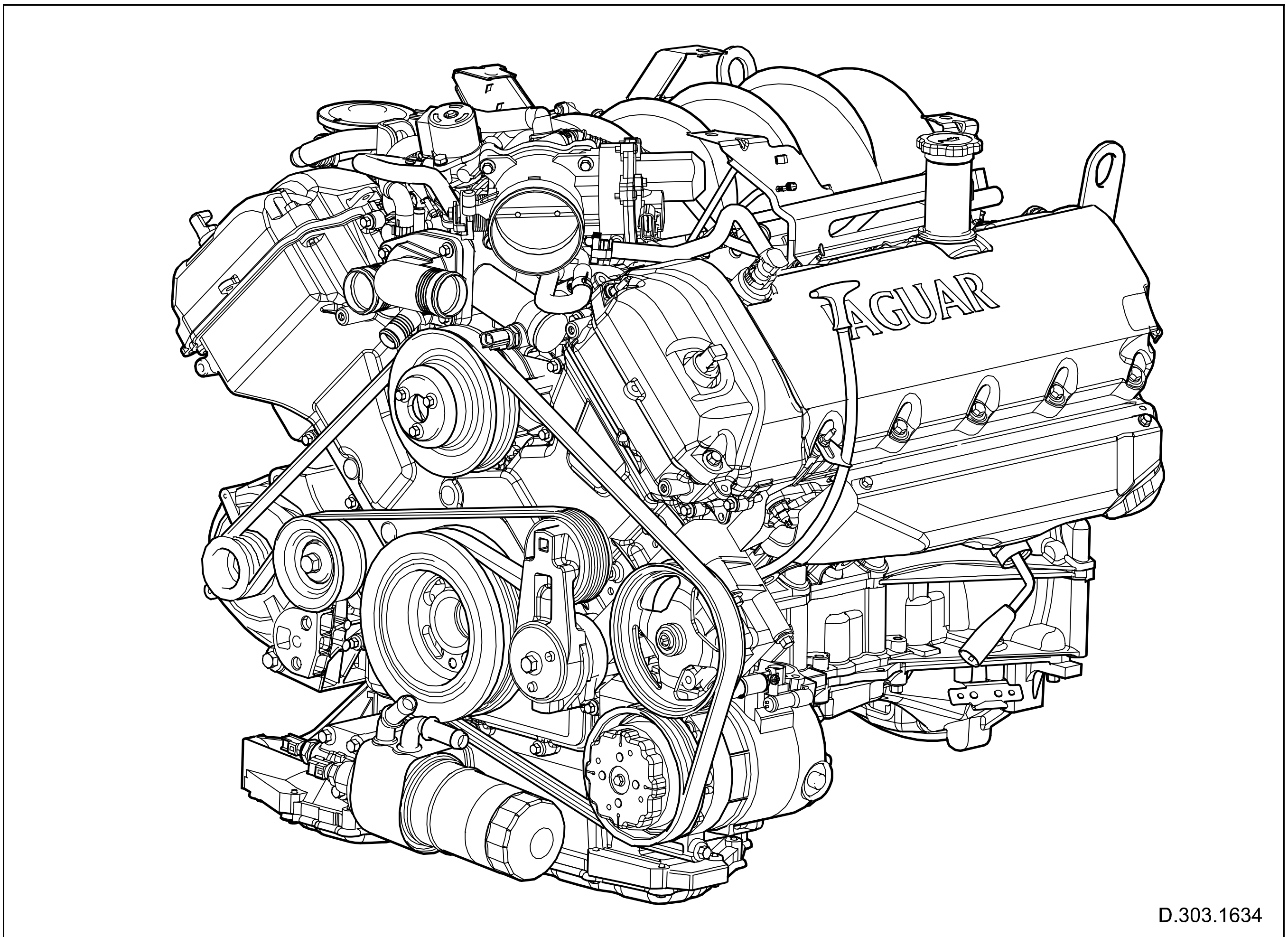

Fig. 31 V8 normally aspirated engine

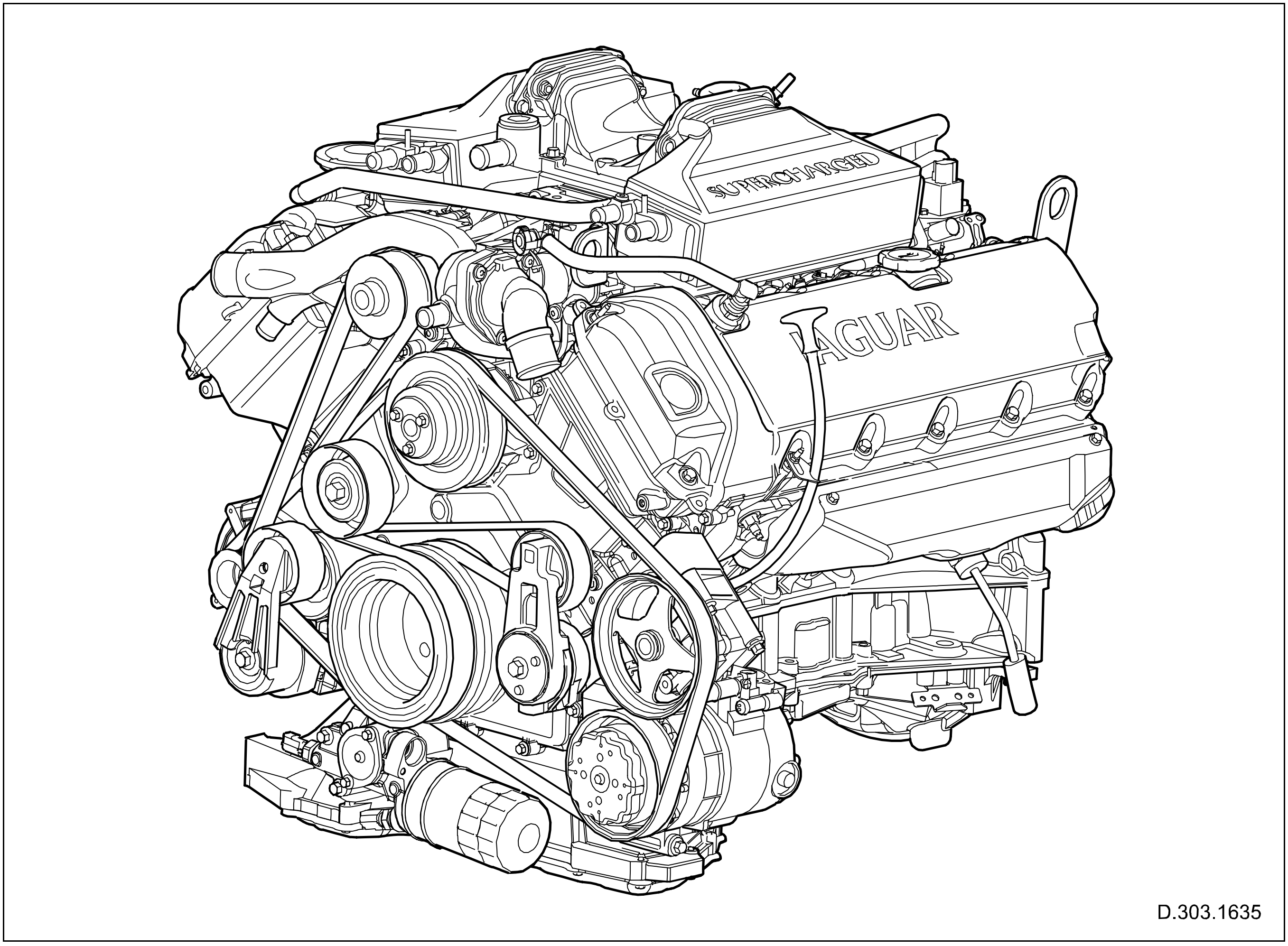

Fig. 32 V8 supercharged engine

Engine Components

The water-cooled engines, are constructed of aluminum alloy with eight cast-iron cylinder liners, arranged in two-planes in a 90-degree 'V' configuration. An extensive use of aluminum and some magnesium-alloy engine components provides a low engine-weight. The 3.5-liter and 4.2-liter engines share the majority of engine components.

New and upgraded engine features are discussed in this section.

Cylinder Heads

The cylinder heads are unique to each cylinder bank and incorporate, two chain-driven overhead camshafts per-bank, which activate four-valves per cylinder via direct acting bucket tappets. The cylinder heads have been modified as follows:

- Adapted intake ports improve volumetric efficiency.
- Redesigned combustion chambers with the inclusion of 'squish' areas around the valves improve economy and emissions.
  - The 'squish' area is a raised feature on the periphery of the piston crown, which enables the piston to get within approximately 1mm distance of the cylinder head at TDC compression. At TDC, the 'squish' area forces the fuel/air charge into the center of the combustion chamber with significant turbulence to aid combustion.
- New thinner cylinder head gaskets, constructed from multi-layer steel with sintered steel combustion rings.
- The engine lifting-eye, which was part of the cylinder-head cast, is replaced by a threaded hole to accept a steel lifting-bracket.

Pistons

The pistons are a lightweight design with reduced crown height. A new piston ring pack is introduced to contain increased combustion gas-pressure and enhance temperature performance.

- The normally aspirated pistons are cast aluminum with a three-piece oil control ring.
- For improved robustness and to withstand mechanical and thermal stresses, the supercharged pistons are manufactured of forged aluminum with a two-piece ultra compact oil control ring.
  - The supercharged engine also employs piston-cooling jets, which inject oil on the underside of the piston's crown to provide improved temperature control; refer to **Fig. 33**

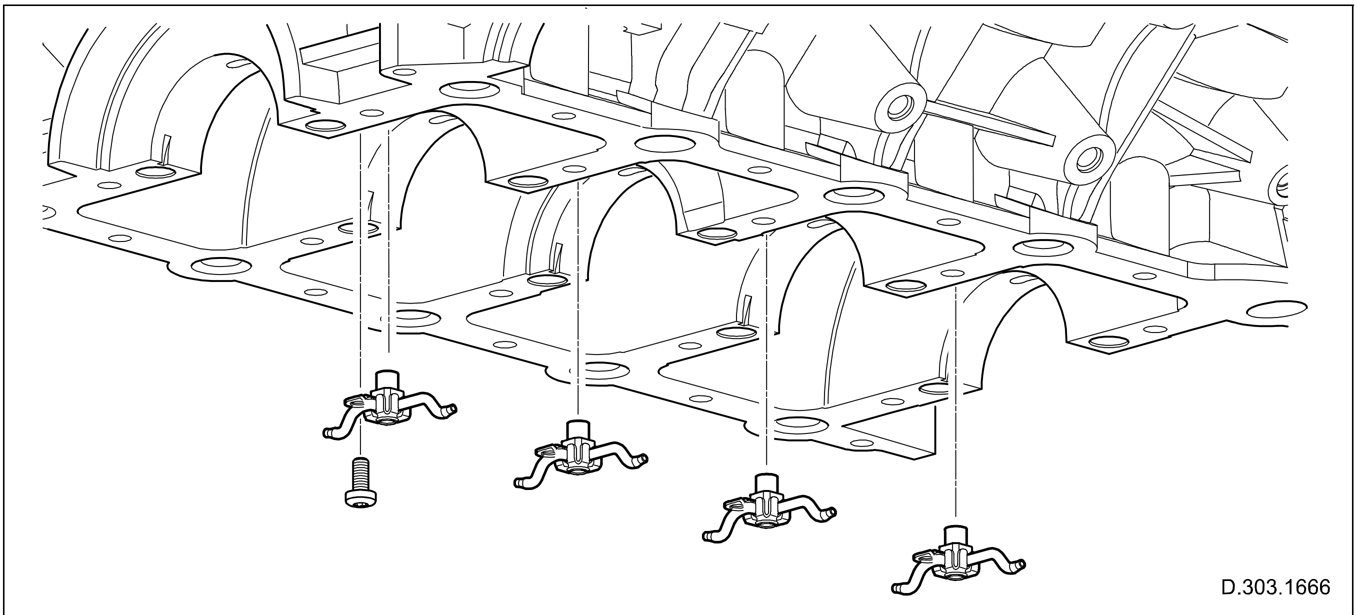

Fig. 33 Piston cooling jets - supercharged engine only

Connecting Rods

Connecting rods are sinter forged and fractured split. The small-end bearings have a 'Y' style oil groove for optimized bearing surface area.

Crankshaft

The crankshaft is supported by five main bearings.

- AJ-V8 4.2-liter engine: the crankshaft stroke has been increased for 4.2-liter displacement. To reflect the stroke increase the crank-pin journal diameter has been reduced to accommodate the revised stroke within existing cylinder block constraints.
- AJ-V8 3.5-liter engine: the crankshaft stroke has been reduced for 3.5-liter displacement. To reflect the stroke reduction and to allow for the use of a shared cylinder block with the 4.2-liter engine, the connecting rods have been lengthened to maintain the required compression ratio.

Primary Chain

A new primary chain, with a reduced-pitch and inverted-tooth design reduces loading and radiated noise levels. The chain's associated sprockets are also modified to accommodate the new chain design.

In addition, the crankshaft's primary-chain sprocket is now a one-piece unit located on the crankshaft by a woodruff key. A torsional-vibration-damper with revised vibration tuning retains the sprocket in position.

Lubrication of the primary chain and crankshaft sprockets is via two squirt-jets directly mounted to the oil pump.

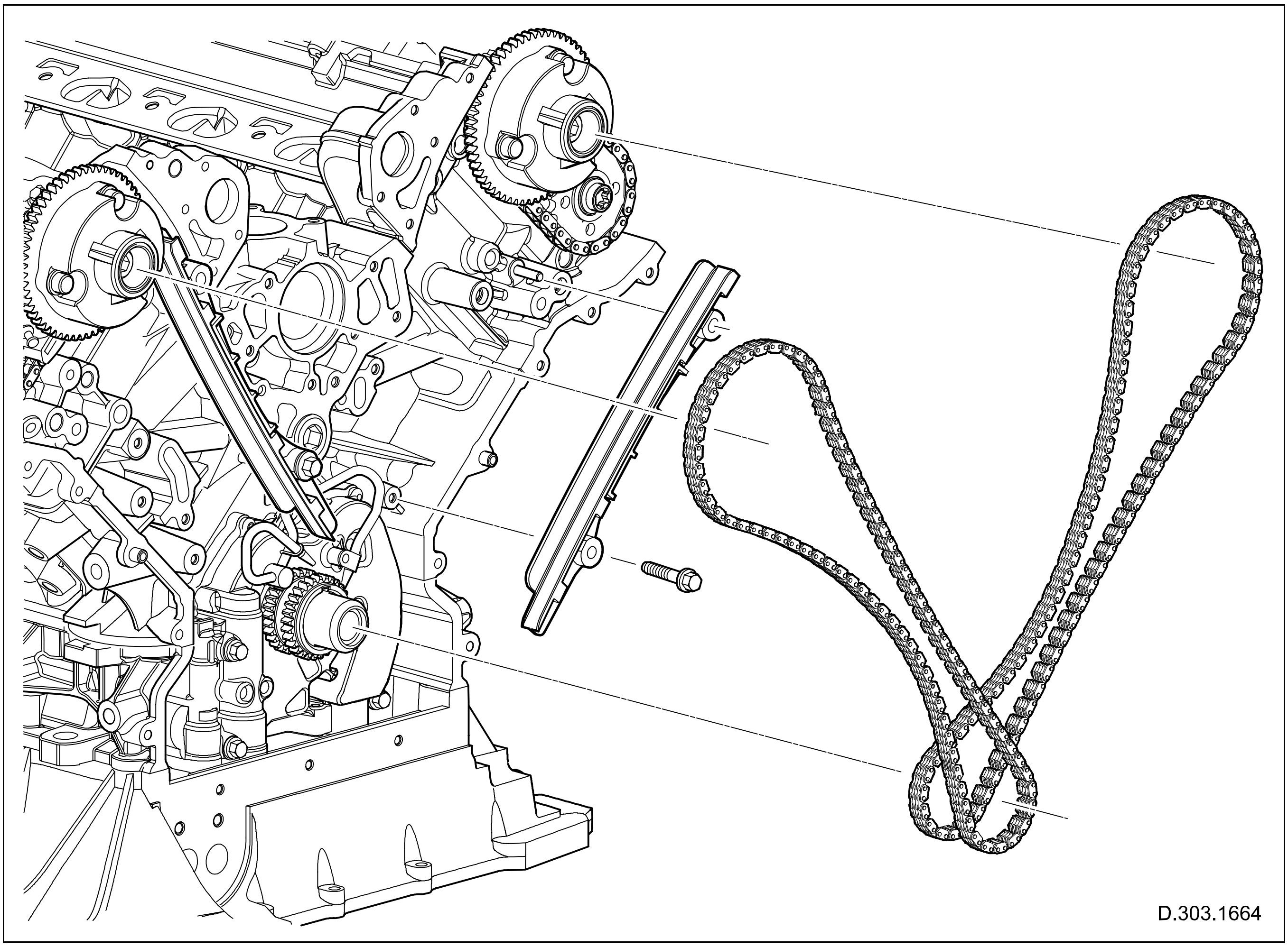

Fig. 34 Primary chain

Fuel Injectors

New multi-hole injector's supply improved spray performance and targeting within the combustion chamber, enabling the engine to extract the full-energy potential from every droplet of fuel. This acts to boost engine performance and improve fuel economy, without the additional components of air-assist injection.

Engine Lubrication

An upgraded lubrication system, mainly to provide improved variable valve timing (VVT) response on normally aspirated engines is introduced. The pumping element is an eccentric rotor, directly driven by the crankshaft. The oil inlet of the pump is through a directly mounted pick-up pipe; the outlet port aligns with the oil passage in the engine's bedplate. An integral pressure relief valve regulates pump pressure at 4.7 bar.

Two squirt-jets directly mounted to the pump provide lubrication to the primary chain. An over-pressure valve incorporated within the pump protects the engine components during cold starts.

Supercharged variants incorporate a thermostatically controlled oil-diverter valve, installed in the pump's outlet passage, to divert the oil through to the engine's oil cooler at high engine temperatures.

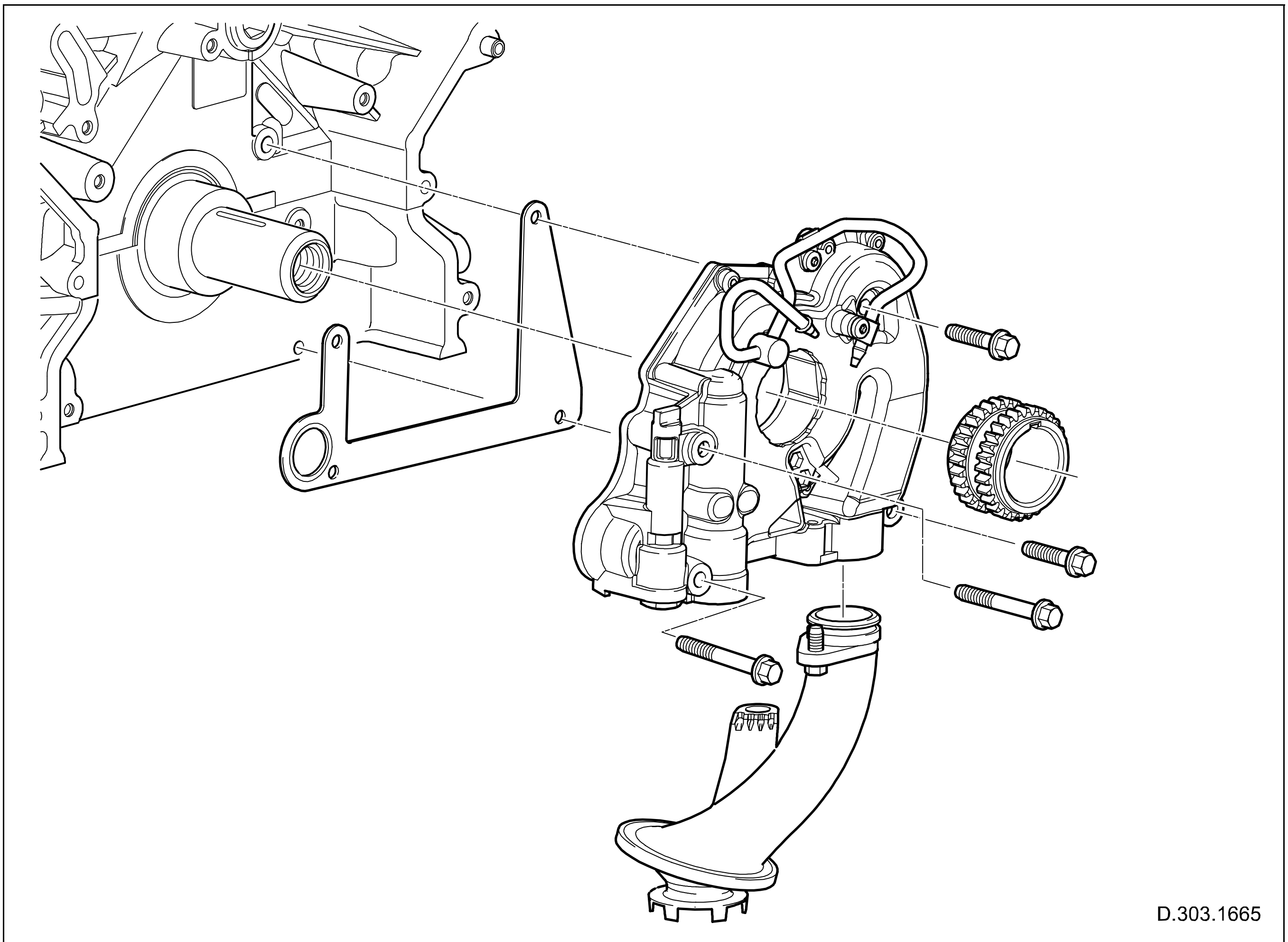

Fig. 35 Oil pump

Exhaust Manifold

The exhaust manifolds are now manufactured from cast stainless steel. On the normally aspirated engine, the manifolds are branched, providing a tuning effect that increases torque at low engine speed. The exhaust manifold on the supercharged engine remains as the conventional 'log' design.

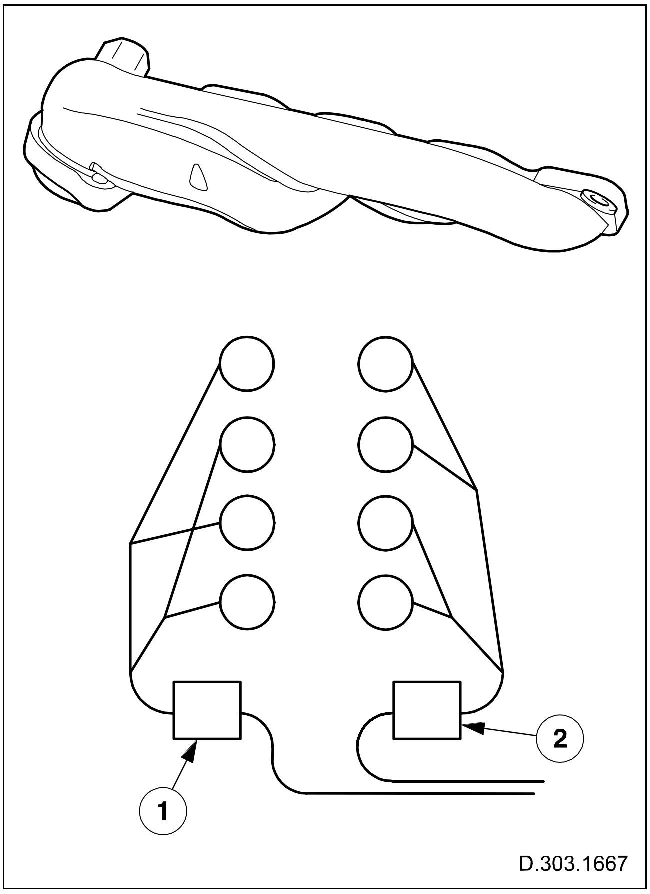

Fig. 36 Branched exhaust manifold - normally aspirated engines only

1. Catalytic converter left-hand
2. Catalytic converter right-hand

Variable Valve Timing (normally aspirated engine)

The continuous variable valve timing (VVT) on the normally aspirated engine continues the theme of improved low and high-speed engine performance and excellent idle quality.

To optimize engine performance, the valve timing on the 4.2-liter and 3.5 liter engines is specially tuned to reflect the size of the engine.

The VVT system changes the phasing of the intake valves, relative to the fixed timing of the exhaust valves, to alter:

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

Although the principle function of this VVT system is the same as that used on the V8 (AJ-27) engine, the internal operating components of this VVT unit are different. Instead of a helical gear construction, this VVT unit uses a vane device to control the camshaft angle, refer to **VVT Operation**. The system operates over a range of 48 degrees and is advanced or retarded to the optimum angle within this range.

The engine control module (ECM) controls the VVT, using 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:

- 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.
- Improves full-load torque characteristics as the camshaft timing is optimized at all engine speeds for superior volumetric efficiency.
- Improves fuel economy by optimizing torque over the engine's speed range.

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

VVT Operation

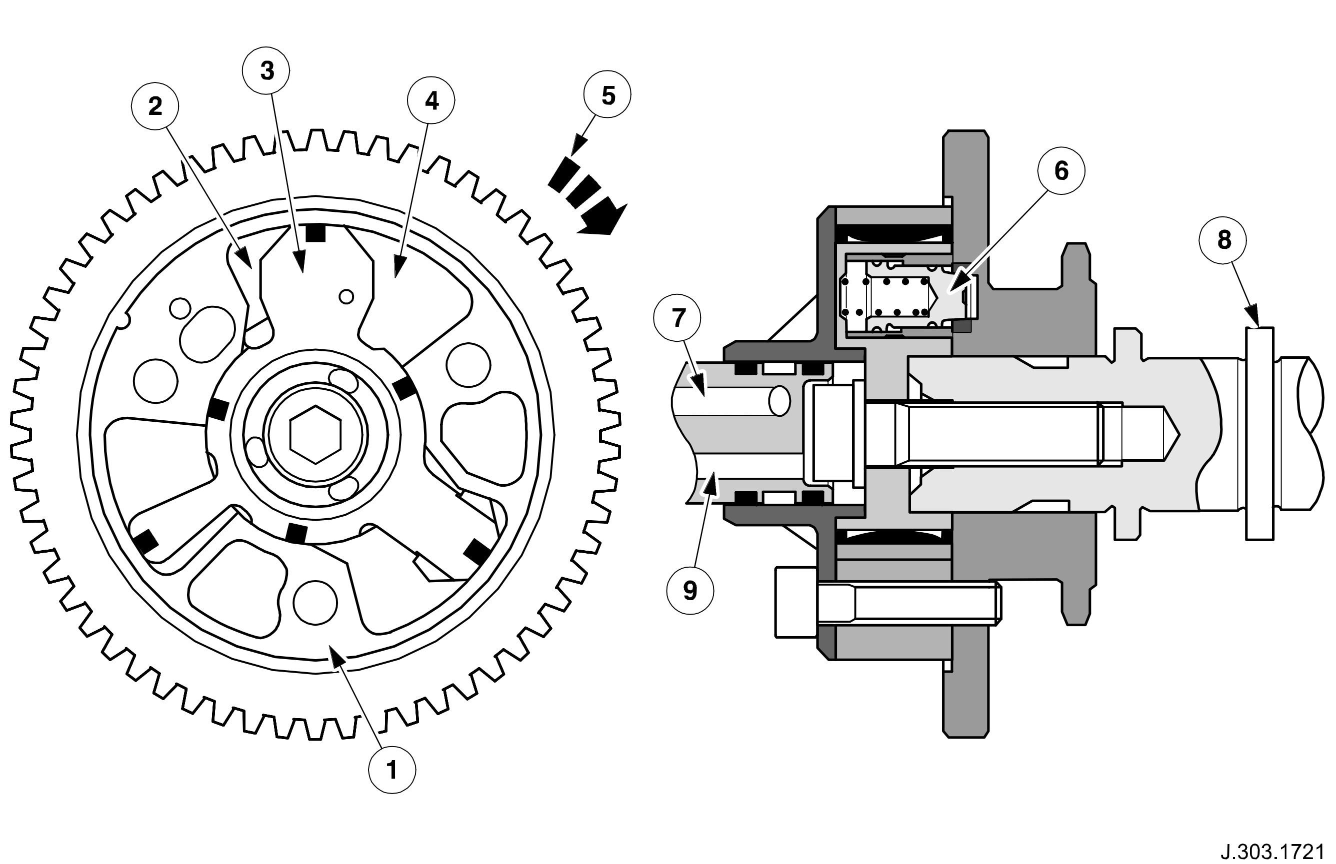

Fig. 37 VVT unit

1. Vane housing
2. Advance chamber
3. Vane shaft
4. Retard chamber
5. Rotation direction
6. Stopper pin
7. Advance chamber oil-channel
8. Intake camshaft
9. Retard chamber oil-channel

The VVT unit is a hydraulic actuator mounted on the end of the intake camshaft, which advances or retards the intake camshaft timing and thereby alters the camshaft to crankshaft phasing. The oil control solenoid, controlled by the ECM, routes oil pressure to either the advance or retard chambers located either side of the three vanes interspersed within the machined housing of the unit.

The VVT unit is driven by the primary 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 optimum position between full advance and retard for a particular engine speed and load. This is achieved by the ECM sending the energizing signal to the oil control solenoid until the target position is met. At this point, the energizing signal is reduced to hold the solenoid position, and as a result the position of the shuttle valve. This function is under closed-loop control, where the ECM will assess any decrease in shuttle-valve oil-pressure, via signals from the camshaft position sensor. The ECM will increase the energizing signal, when required, to maintain the shuttle-valve hold position.

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 oil-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, plus 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.

The VVT does not operate when engine oil-pressure is below 1.25 bar, as there is insufficient pressure to release the VVT unit's internal stopper pin. This usually occurs when the engine is shutting-down and the VVT has returned to the retarded position. The stopper pin locks the camshaft to the VVT unit to ensure camshaft stability during the next engine start-up.

Engine Cooling

Cooling Pack Assembly

The cooling pack assembly is common to all derivatives and comprises:

- Radiator.
- Cooling fan (incorporating brushless motor with integral speed controller).
- Condenser (with integral receiver-drier).
- Transmission fluid cooler (integral to the radiator end-tank); refer to **Automatic Transmission**.

NOTE: The coolant drain-plug is located beneath the radiator end-tank.

The coolant expansion tank has an integral bleed screw and coolant-level sensor.

The auxiliary coolant-flow pump is fitted as standard, except for vehicles installed with the V6 engine and 2-zone climate control.

Vehicles fitted with the V8 supercharged (SC) engine have the following additional components:

- Coolant pump (SC).
- Radiator (SC).
- Oil cooler (SC).

The cooling-fan speed is controlled directly by the engine control module (ECM) based on input data measured by the engine coolant temperature sensor, the climate control pressure-transducer and the transmission oil temperature sensor. The ECM processes this input data and outputs a pulse width modulated signal which determines the fan speed. Should the output signal fall outside predetermined parameters, to protect the engine, maximum fan-speed is initiated. High engine temperature is indicated by the illumination of the engine over-temperature warning light, located on the instrument cluster.

Where appropriate, to provide an extended period of engine cooling, the ECM continues to control the fan speed after the ignition has been turned off.

NOTE: 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.

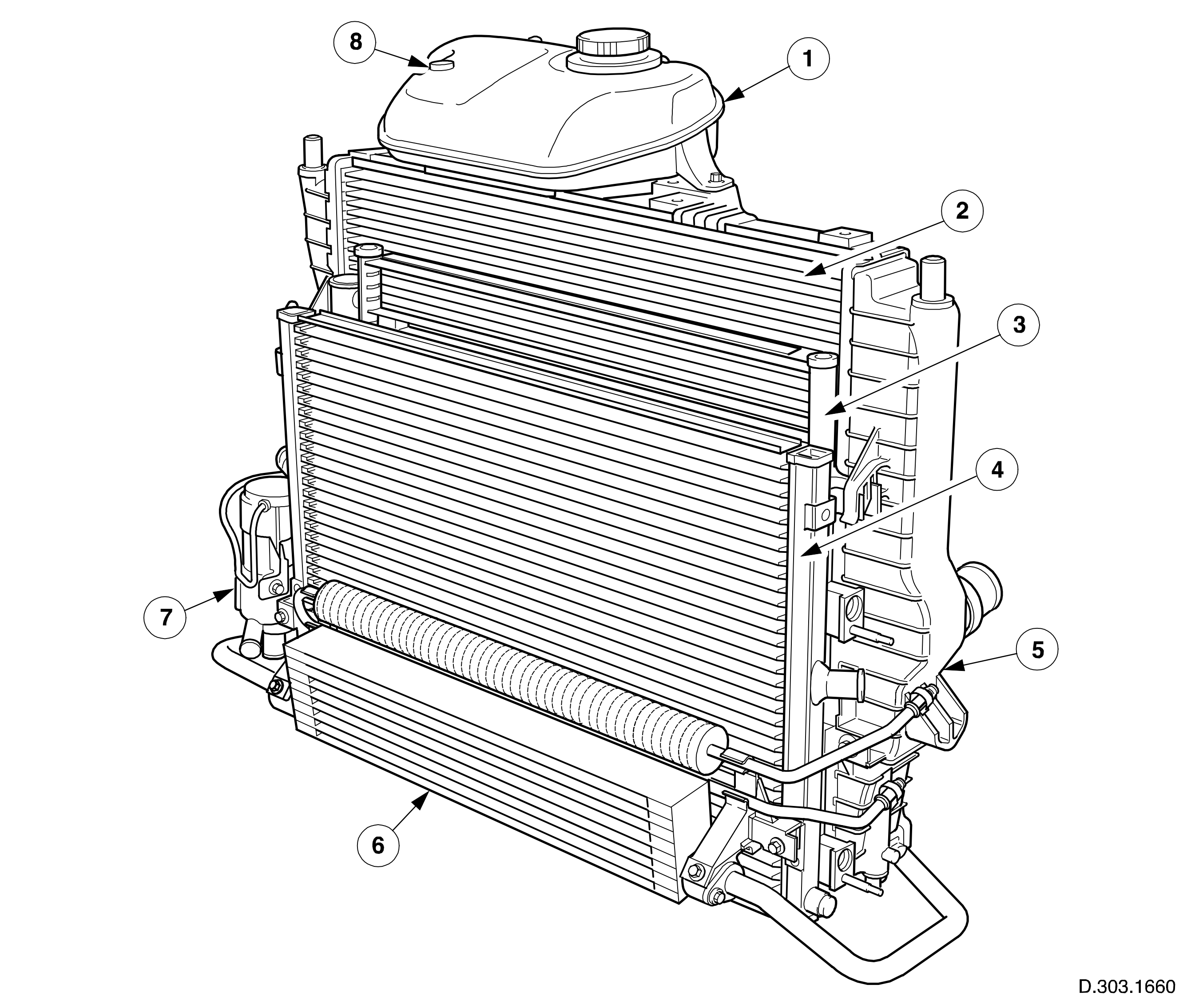

Fig. 38 Cooling pack (SC)

1. Coolant expansion tank
2. Radiator
3. Condenser/receiver-drier
4. Radiator (SC)
5. Radiator end-tank
6. Oil cooler (SC)
7. Coolant pump (SC)
8. Bleed screw

Cooling System (V6)

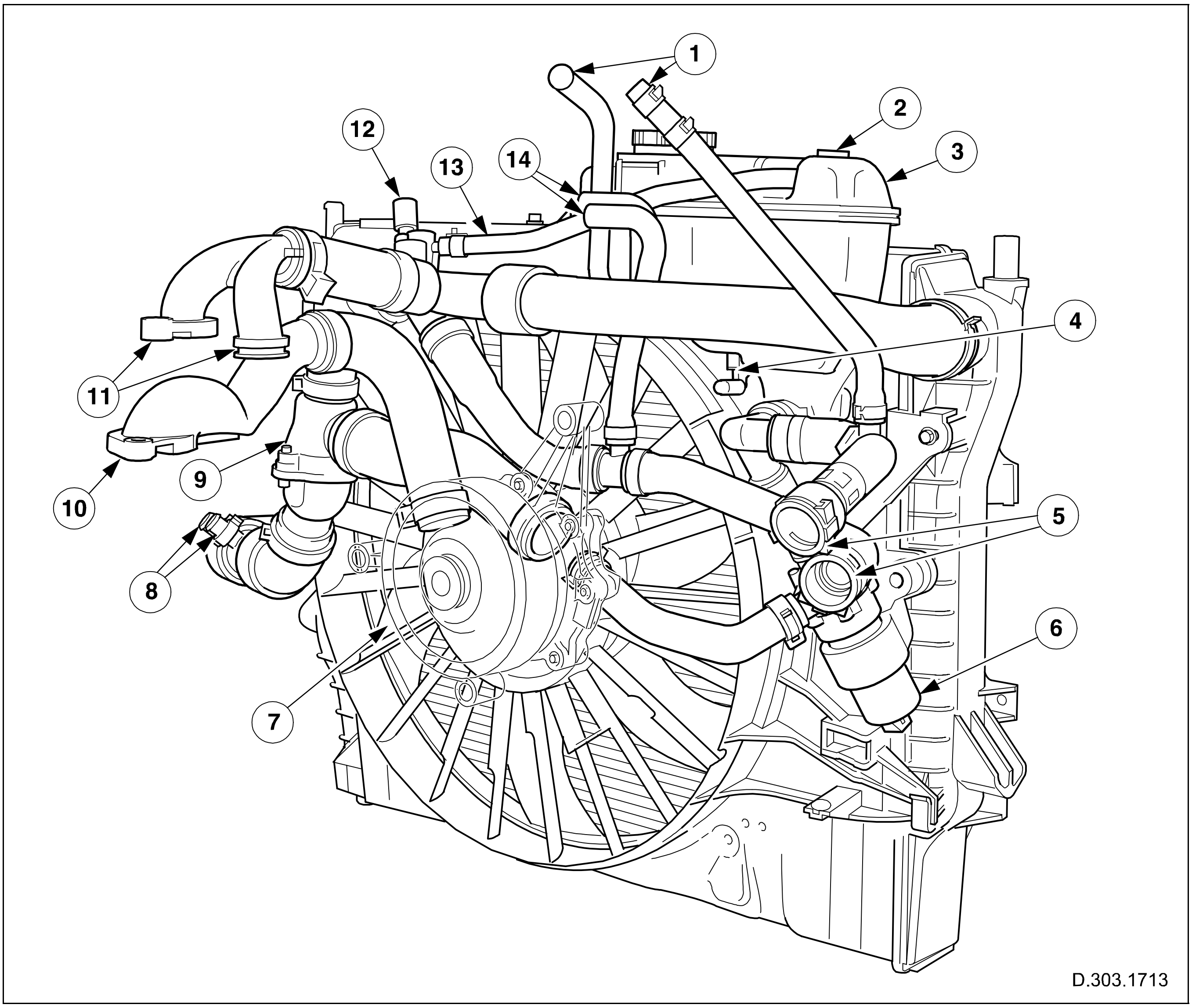

Fig. 39 V6 cooling system components and connections (4-zone climate control variant)

1. Throttle body connections (air intake manifold side)
2. Bleed screw
3. Coolant expansion tank
4. Coolant level sensor
5. Heater hose connections
6. Auxiliary coolant-flow pump
7. Coolant pump
8. Engine oil-cooler connections
9. Thermostat housing
10. Engine coolant inlet
11. Engine coolant outlet
12. Engine coolant temperature sensor
13. Vent hose
14. Throttle body connections

Coolant Flow (V6)

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

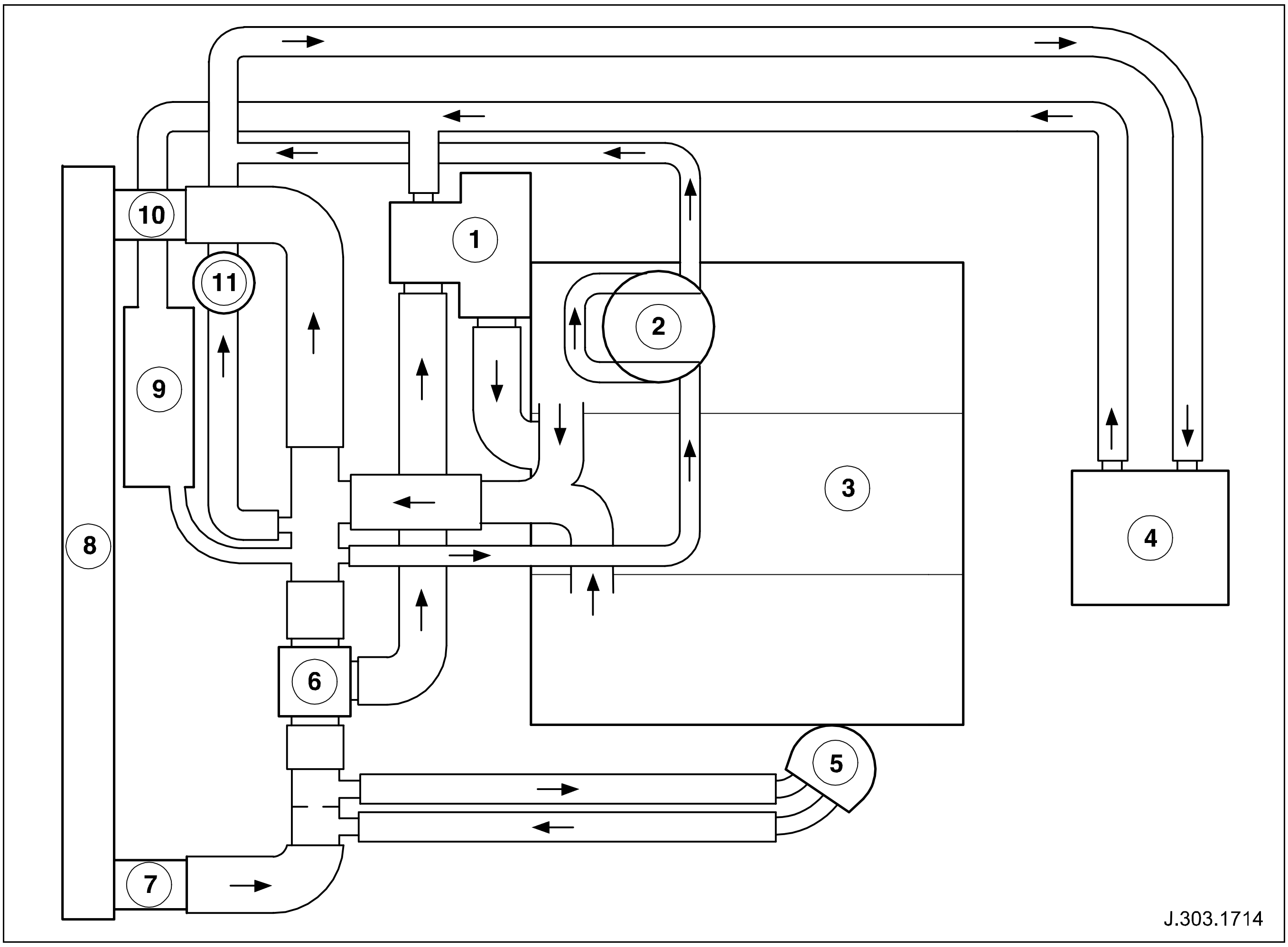

Fig. 40 V6 coolant-flow diagram (4-zone climate control variant)

1. Coolant pump
2. Throttle body
3. V6 engine
4. Heater core
5. Engine oil cooler
6. Thermostat
7. Bottom hose
8. Radiator
9. Coolant expansion tank
10. Top hose
11. Auxiliary coolant-flow pump

Cooling System (V8)

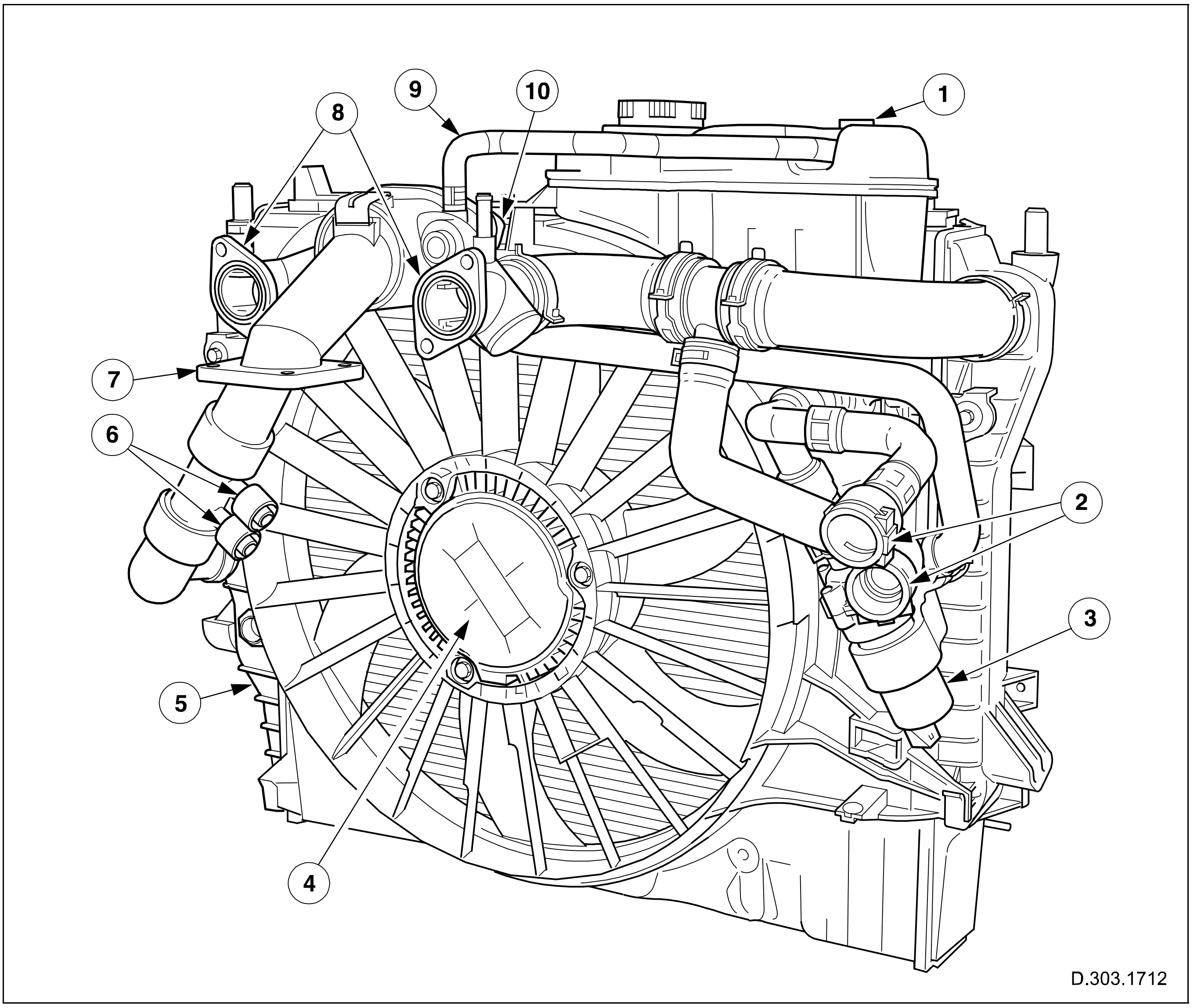

Fig. 41 V8 cooling system components and connections

1. Bleed screw
2. Heater hose connections
3. Auxiliary coolant-flow pump
4. Cooling fan motor
5. Radiator end-tank
6. Engine oil-cooler connections
7. Engine coolant inlet
8. Engine coolant outlet
9. Vent hose
10. Thermostat housing

Coolant Flow (V8)

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

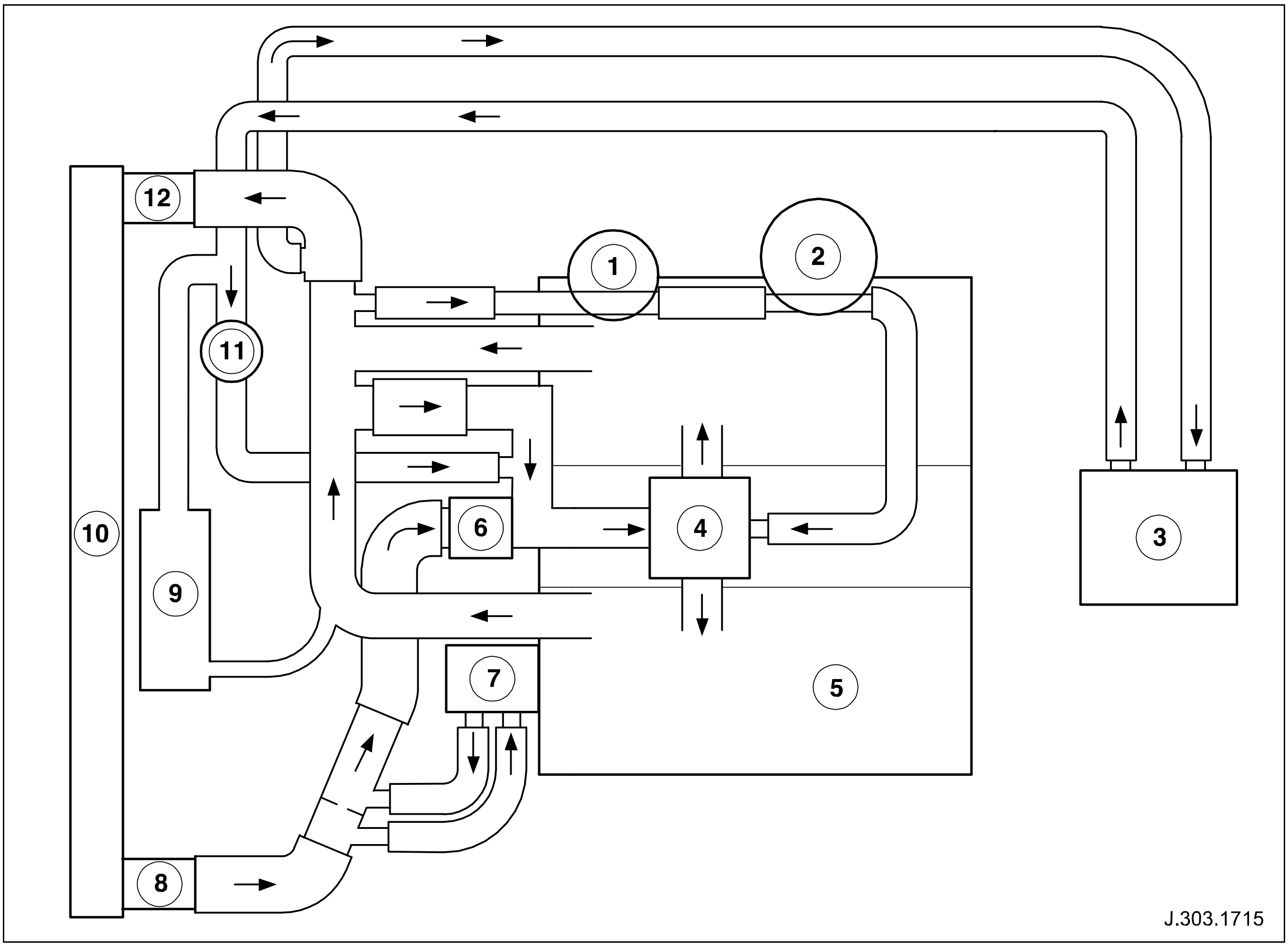

Fig. 42 V8 coolant-flow diagram

1. EGR valve
2. Throttle body
3. Heater core
4. Coolant pump
5. V8 engine
6. Thermostat
7. Engine oil cooler
8. Bottom hose
9. Coolant expansion tank
10. Radiator
11. Auxiliary coolant-flow pump
12. Top hose

Cooling System (V8 SC)

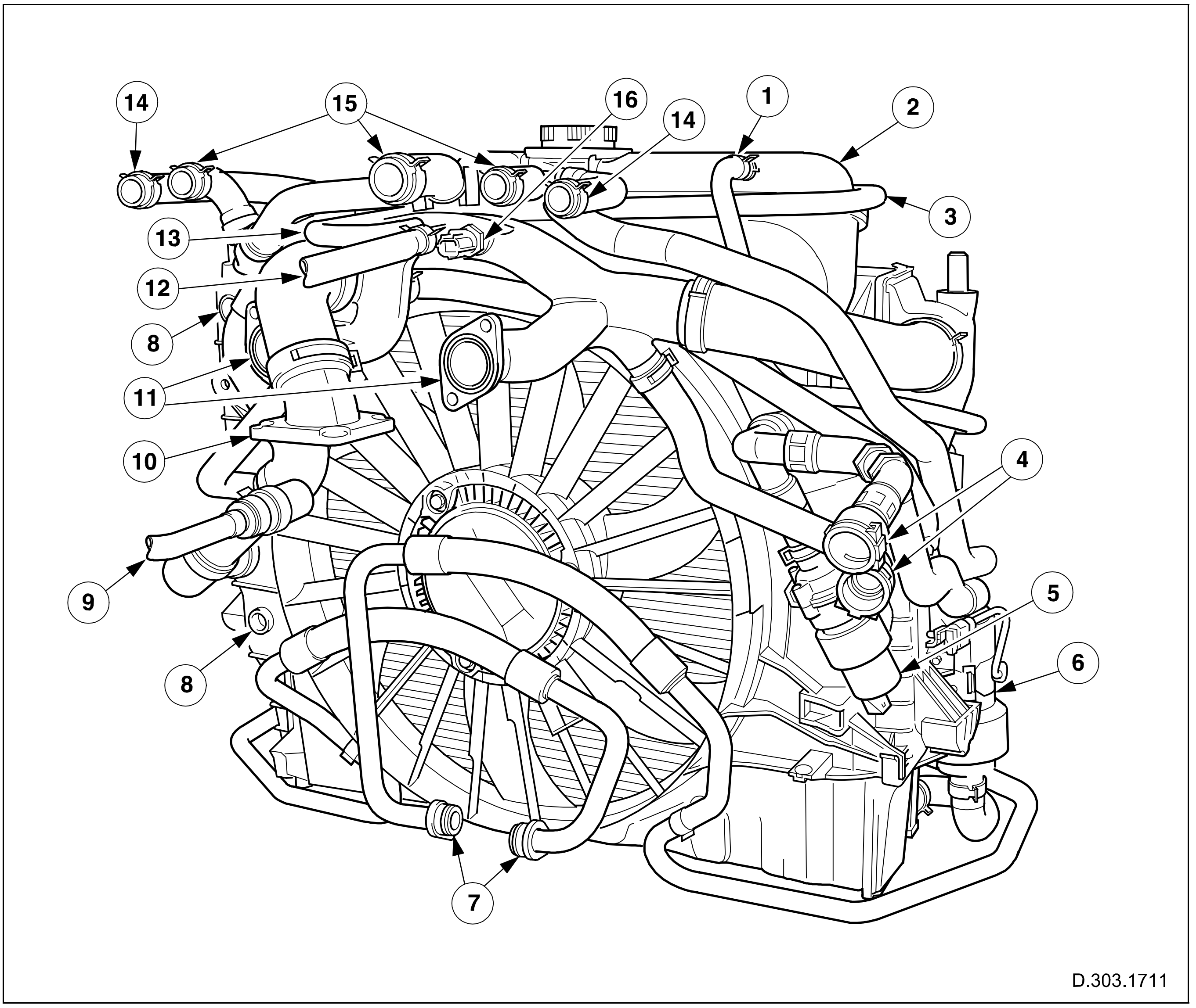

Fig. 43 V8 SC cooling system components and connections

1. Vent hose (SC radiator)
2. Coolant expansion tank
3. Vent hose (radiator)
4. Heater hose connections
5. Auxiliary coolant-flow pump
6. Supercharger coolant-pump
7. Engine oil-cooler connections
8. Transmission oil-cooler connection
9. Throttle-body return hose
10. Engine coolant inlet
11. Engine coolant outlet
12. EGR coolant inlet hose
13. Thermostat housing
14. Charge air cooler return hoses
15. Charge air cooler feed hoses
16. Engine coolant temperature sensor

Coolant Flow (V8 SC)

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

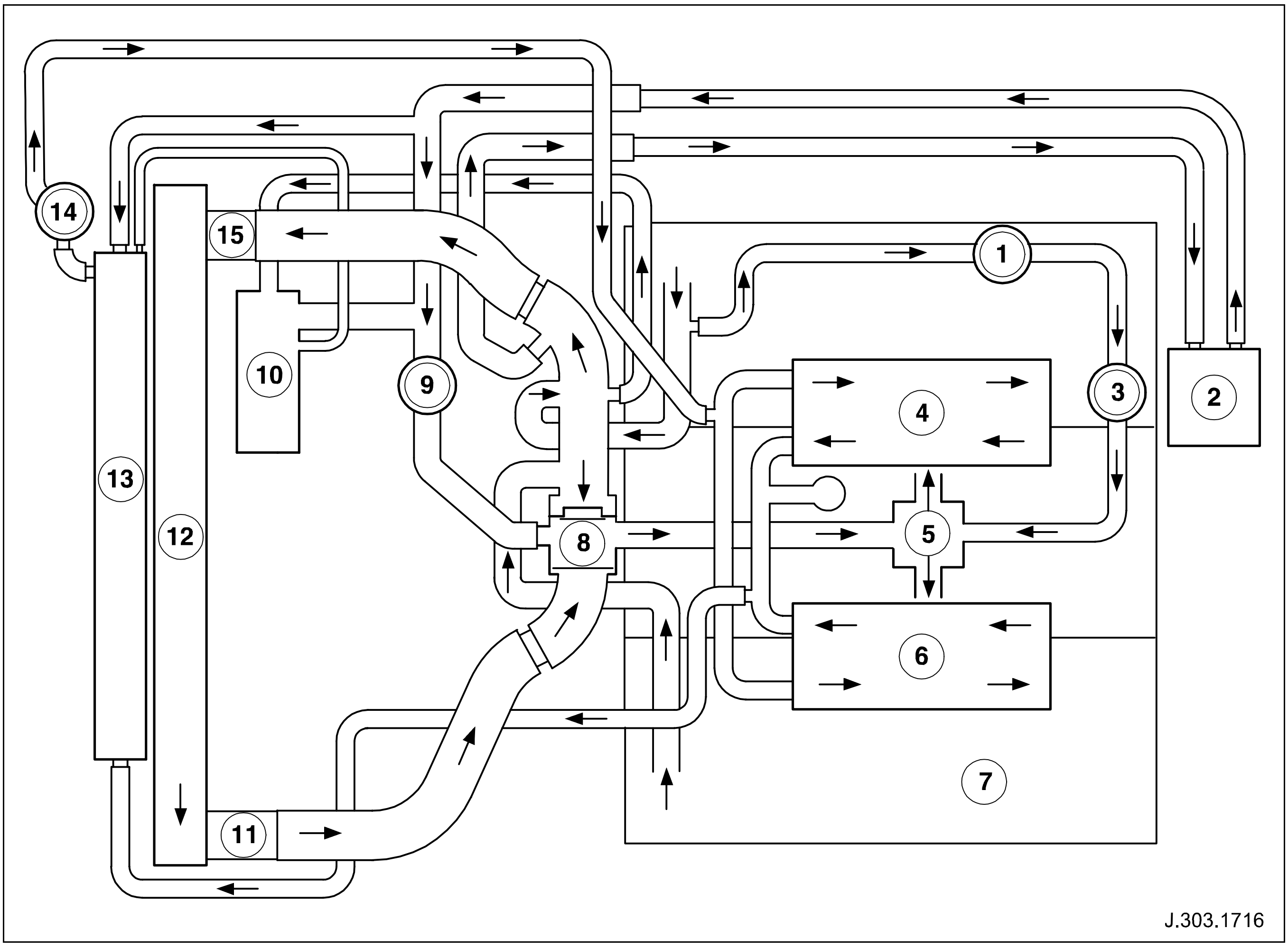

Fig. 44 V8 SC coolant-flow diagram

1. EGR valve
2. Heater core
3. Throttle body
4. Charge air cooler (bank 1)
5. Coolant pump
6. Charge air cooler (bank 2)
7. V8 SC engine
8. Thermostat
9. Auxiliary coolant-flow pump
10. Coolant expansion tank
11. Bottom hose
12. Radiator
13. SC Radiator
14. SC coolant pump
15. Top hose

Fuel Charging and Controls

Electronic Throttle Control

An 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. These signals are used by the engine control module (ECM) to analyze 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. For further information refer to **Electronic Engine Controls**.

Fuel and Air Charging

Fuel Charging

The fuel pump module(s) controls the amount of fuel supplied by the fuel pump(s) to the fuel rail. This is achieved by the ECM receiving signals from the:

- fuel pressure sensor,
- engine fuel temperature sensor,
- plus driver demand and other engine control signals, to indicate the fuel pressure in the fuel rail.

In response to these signals, the ECM calculates the amount of fuel required by the engine at any given moment and requests the fuel pump module(s) to vary the fuel pump(s) delivery. Refer to **Fuel Tank and Lines** for more information on the returnless fuel delivery system.

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 airflow from the intake manifold. Refer to **Electronic Engine Controls** for more information on fuel injection.

NOTE: New multi-hole injectors are introduced, supplying improved spray performance and targeting within the combustion chamber, enabling the engine to extract the full-energy potential from every droplet of fuel. This type of injector helps to boost engine performance and improve fuel economy, without the additional components of air-assist injection.

Air Charging

Throttle Body

The throttle body 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 body.

V6 Normally Aspirated

A reduced volume three-stage variable-geometry upper intake-manifold is introduced into the XJ Range with identical concept and operating parameters as the intake manifold used on the S-TYPE and X-TYPE V6 engines.

The intake manifold; refer to **Fig. 46**, is designed to improve response rates and 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, this type of manifold can set the geometry to three different configurations. This is achieved by the ECM, individually switching the intake manifold tuning valves (IMT valves) between fully open and fully closed at calibrated engine speeds. Each of these configurations modifies the geometry of the manifold plenum chamber, maximizing the tuning effect over different parts of the engine range. The resulting optimized volumetric efficiency provides optimized engine torque output throughout the engine's entire speed range. Optimized plenum volume also acts to improve transient response where required.

V8 Normally Aspirated

The air-intake manifold on the 3.5 liter and 4.2 liter normally aspirated engines; refer to **Fig. 47**, operates on the same concept as the previous 4.0 liter system.

The very smooth inner walls of the injection molded manifold offer minimum air flow restriction. This, combined with low thermal conductivity of the nylon manifold, helps improve engine performance by as much as 1% to 2% over that of an aluminum manifold. The low thermal conductivity of the nylon manifold also helps improve engine performance. The nylon manifold insulates the air inside it from engine heat, and thus allows high-density intake air to flow into the engine.

V8 Supercharged

The introduction of the 4.2 liter supercharged engine, also introduces a revised air intake system and supercharger unit into the XJ Range; refer to **Fig. 45** and **Fig. 48**. The modifications as listed below, enhance engine performance by either improving intake airflow or increasing supercharger speed by 5%.

- Supercharger rotors driven by helical-cut gears in place of spur-cut gears.
- Supercharger rotors have a more efficient coating to improve airflow.
- A more efficient air-intake trunking to improve airflow.
- Low loss supercharger outlet ducts.
- Twin air-intake into the air cleaner housing.
  - The ECM directly controls the solenoid; refer to **Fig. 45**, to open and close the air intake control-flap in the air-cleaner housing. The control flap is opened at high engine speeds and loads to satisfy engine air-charge requirements.
- High-density fin intercoolers also provide improved supercharger cooling efficiency.

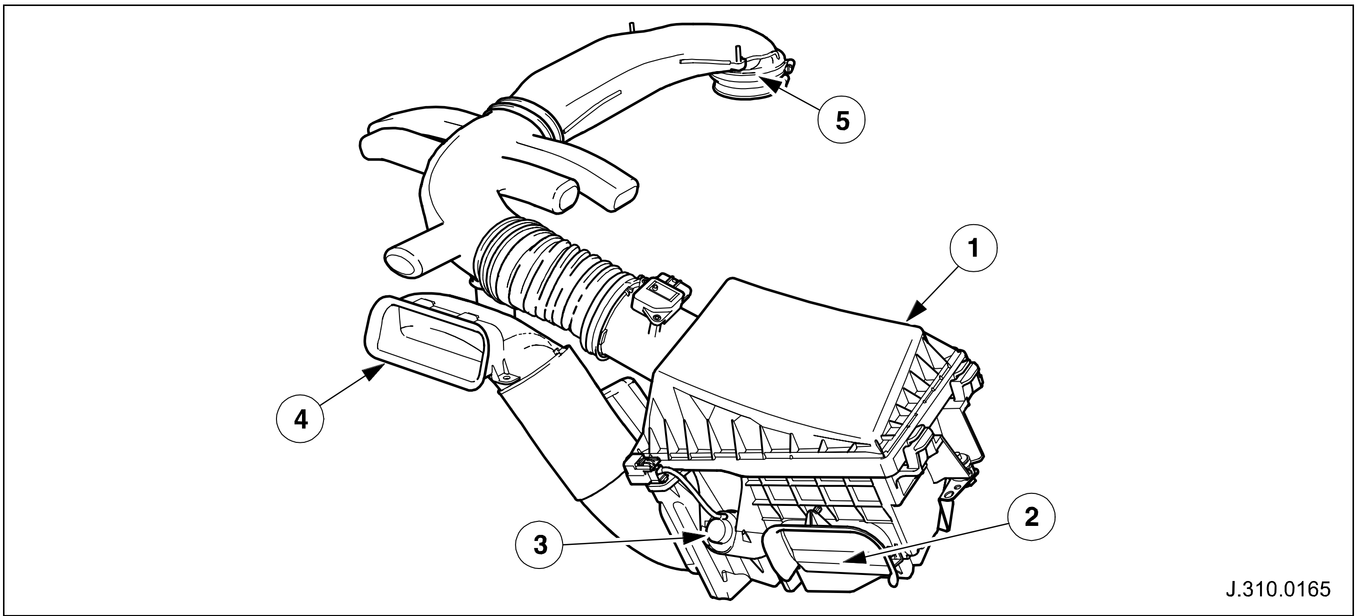

Fig. 45 V8 supercharged air-intake assembly

1. Air cleaner housing
2. Control flap
3. Control flap solenoid
4. Air intake
5. Air outlet to throttle body

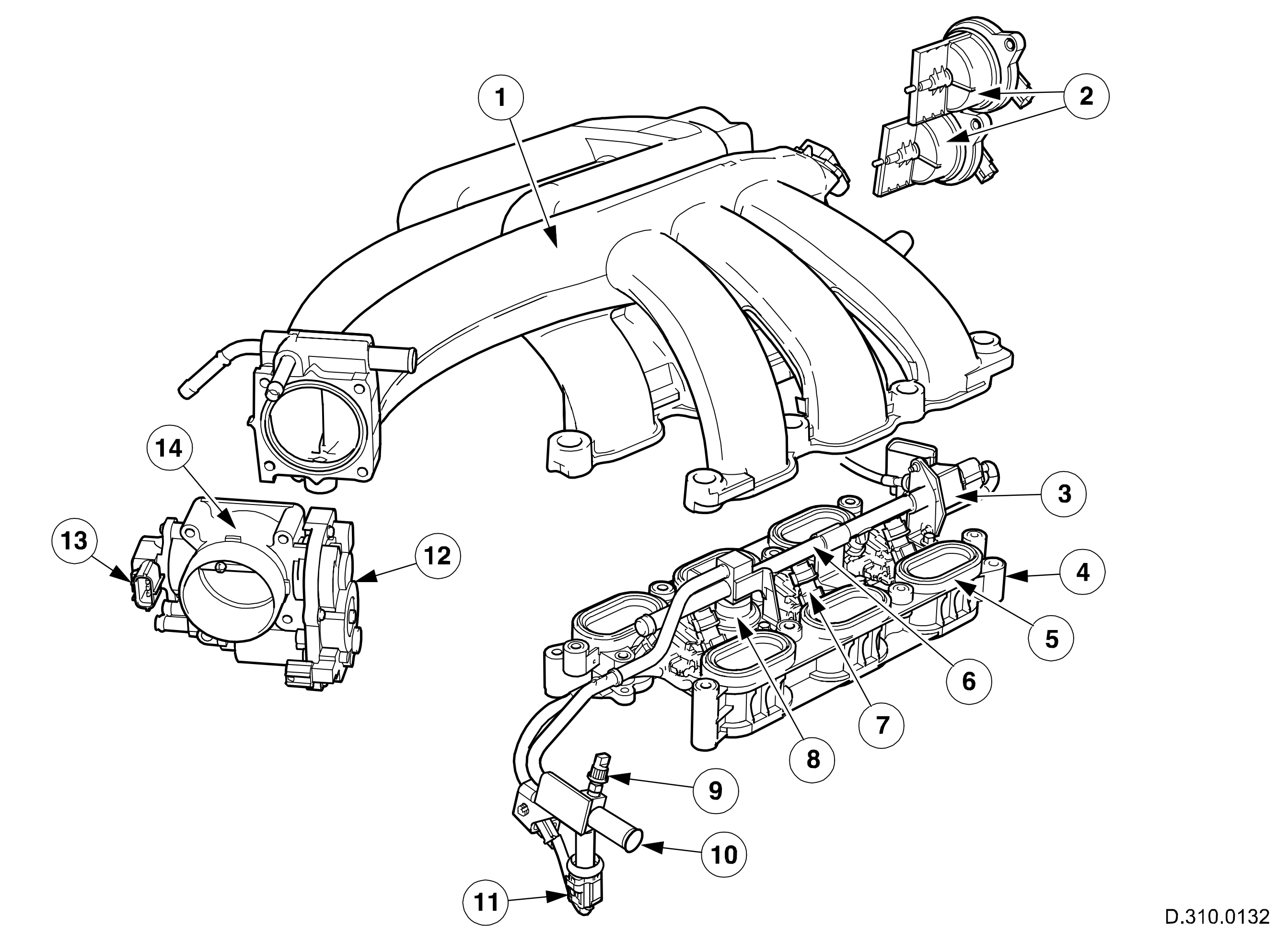

Fig. 46 Fuel charging system - V6 normally aspirated

1. Intake manifold
2. Intake manifold tuning valves
3. Fuel pressure sensor
4. Lower intake manifold
5. Gasket
6. Fuel rail
7. Injector
8. Fuel pulse damper
9. Depressurization valve
10. Fuel supply
11. Engine fuel temperature sensor
12. Throttle motor
13. Throttle position sensor
14. Throttle body

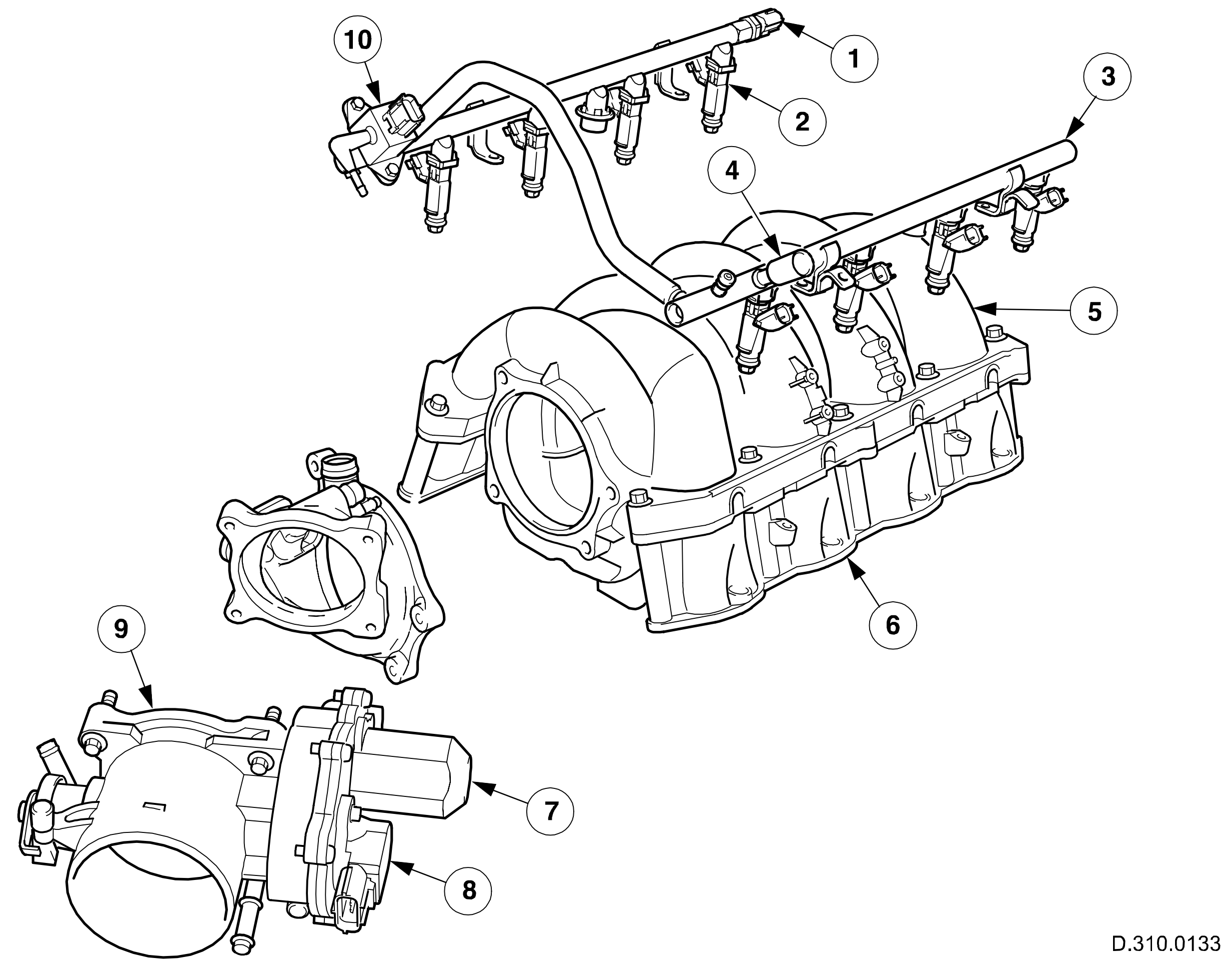

Fig. 47 Fuel charging system — V8 normally aspirated

1. Engine fuel temperature sensor
2. Injector
3. Fuel rail
4. Fuel supply
5. Intake manifold
6. Lower intake manifold
7. Throttle motor
8. Throttle position sensor
9. Throttle body
10. Fuel pressure sensor

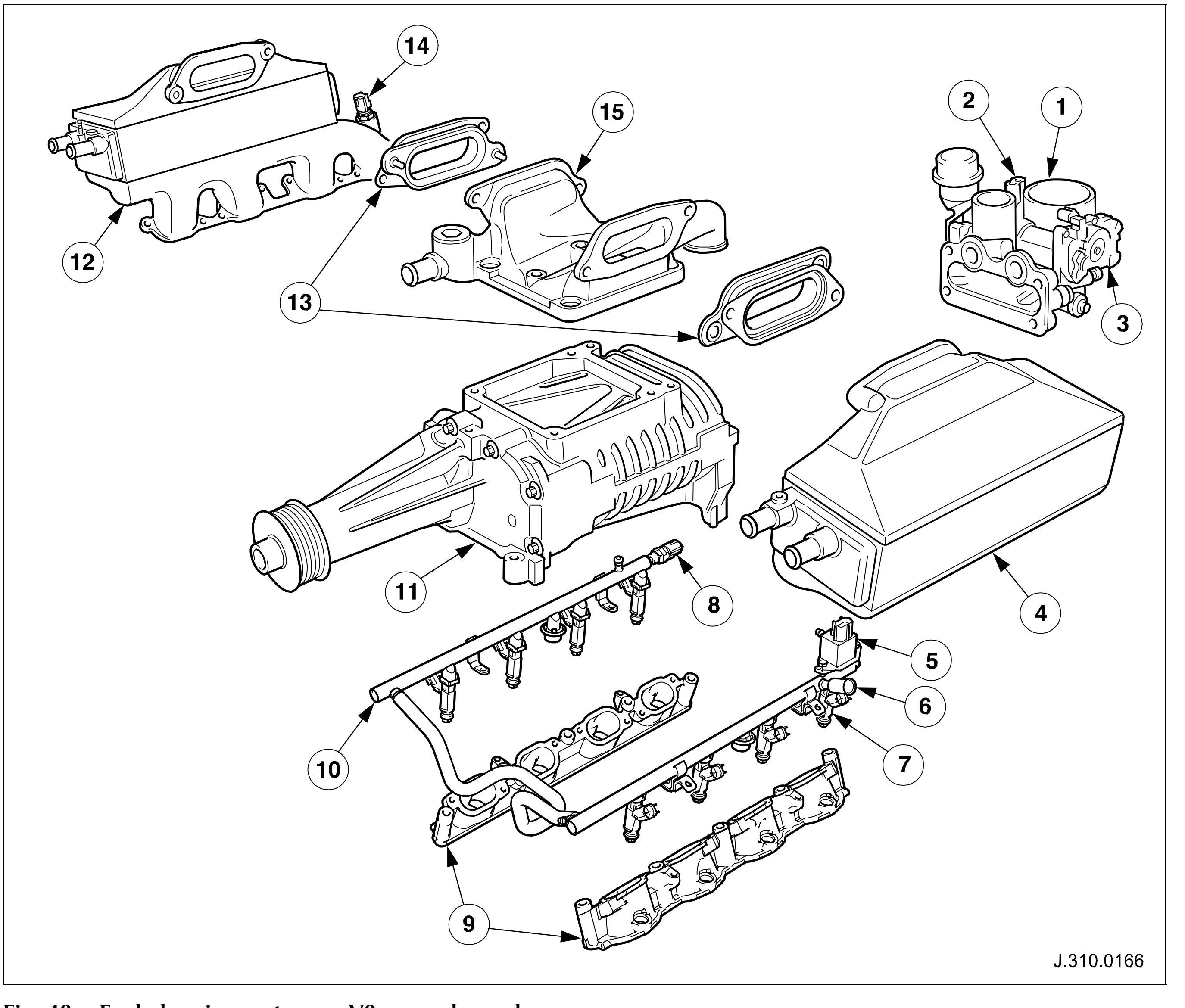

Fig. 48 Fuel charging system — V8 supercharged

1. Throttle body
2. Throttle position sensor
3. Throttle motor
4. Charge air cooler and intake manifold
5. Fuel pressure sensor
6. Fuel supply
7. Injector
8. Engine fuel temperature sensor
9. Fuel rail adaptors
10. Fuel rail
11. Supercharger
12. Charge air cooler and intake manifold
13. Cool-air engine charge duct
14. Air temperature sensor
15. Supercharger outlet duct

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 fuel-dispenser nozzle region, provides a liquid seal against the escape of vapor. A check valve also located 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. Then through to the EVAP canister where hydrocarbons are removed from the vapor to meet emission regulations. The purified air passes to atmosphere through the vent pipe; refer to **Evaporative Emission Canister**. The remaining hydrocarbons are stored in the EVAP canister, where at intervals they are purged into the engine for combustion; refer to **Evaporative Emission Canister Purge Valve**.

The rising fuel-level in the fuel tank closes the float-level vent-valve when the fuel tank reaches full, and the resulting backpressure 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.

NOTE: 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.

If a malfunction occurs in the fuel tank delivery system and the tank overfills, an integral pressure relief valve in the float-level valve opens, to provide a direct vent to atmosphere.

The ORVR system 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 rollover.

Evaporative Emission Canister

A new single EVAP canister is introduced, replacing the twin canister system; refer to **Fig. 49**. The canister has a volume of 2.3 liters and 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 is continually regenerated. This is achieved when the engine is running, by drawing air through the EVAP canister, via the vent pipe, into the engine for combustion.

An EVAP canister close-valve is attached to the EVAP canister, which when instructed by the ECM seals the vent pipe. At the same time, the purge valve is opened to allow a vacuum from the intake manifold to be created in the fuel system. The purge valve is then closed to allow the ECM to perform fuel-vapor leak-check diagnostics. The ECM monitor's signals received from the fuel tank pressure sensor to measure the rate of increase in fuel tank pressure, to determine if there is a leak within the system.

The dust box acts as a filter to protect the close valve from the ingress of moisture and dust particles.

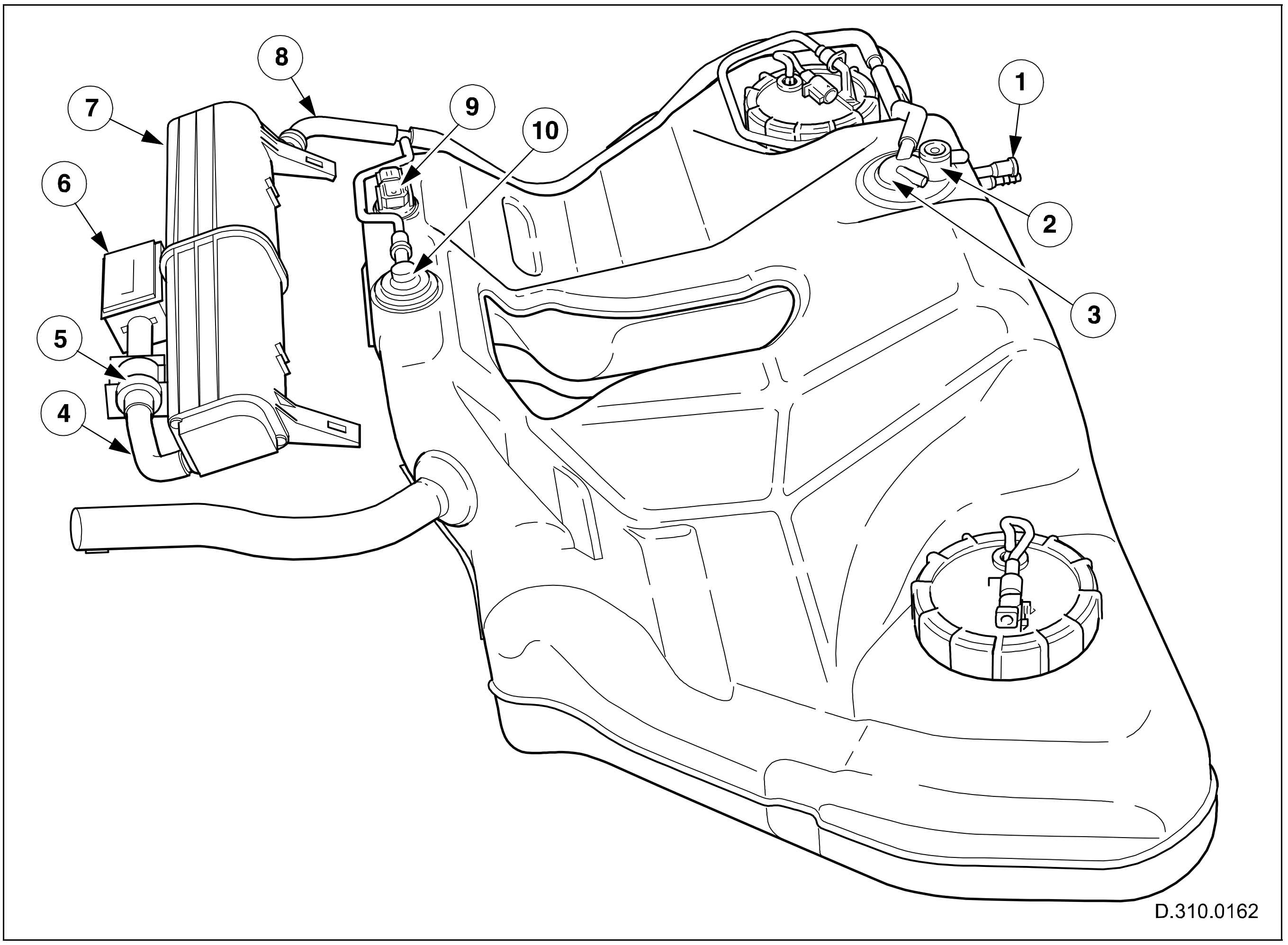

Fig. 49 Evaporative emission system

1. Pipe to EVAP canister purge valve
2. Pressure relief valve
3. Float level valve
4. Vent pipe
5. EVAP canister close valve
6. Dust box
7. EVAP canister
8. EVAP canister, inlet and outlet pipe
9. Fuel tank pressure sensor
10. Grade vent valve

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 (the extent that the purge valve opens) are determined by the engine operating conditions and the vapor concentration level. The purge rates are adjusted to maintain vehicle, 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 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 modifies while purging is in process.

NOTE: A test port, for use in NAS markets only, is provided on the purge valve line to enable leak test diagnosis of the fuel system.

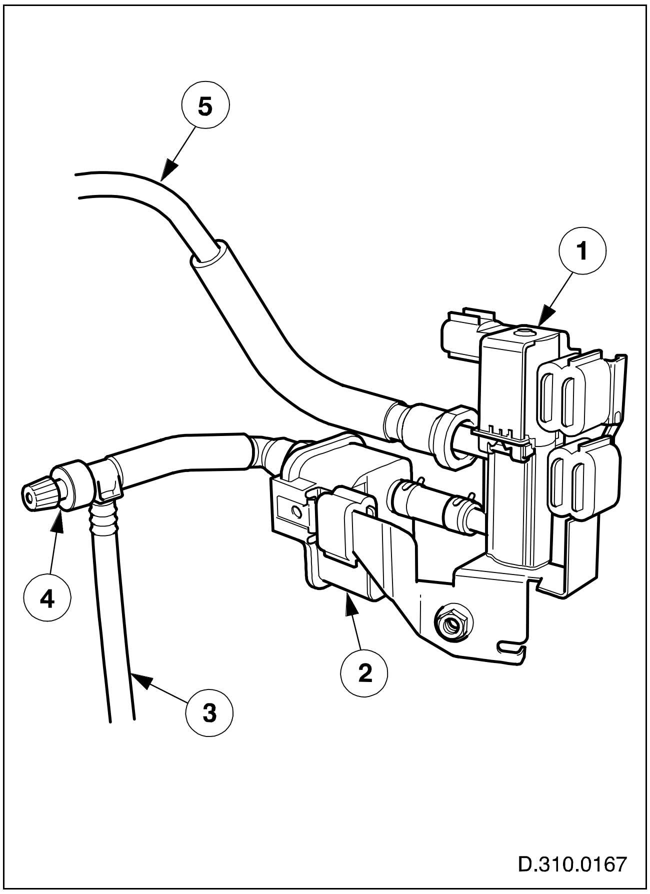

Fig. 50 Evaporative emission canister purge valve

1. Purge valve
2. Reservoir
3. Pipe to fuel tank
4. Test port — NAS function only
5. Pipe to engine

Electronic Engine Controls

Introduction

A new electronic engine control system is introduced into the new XJ, used on both V6 and V8 engines. The 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 ECM, using calibrated data-tables and maps, evaluates the sensor information. 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 via the controller area network (CAN).

Engine Control Module

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

- Starting: ensures that conditions are safe to crank the engine.
- Engine:
  - controls the rate of air and fuel flow into the cylinders,
  - adjusts the intake manifold volume,
  - controls the ignition and intake camshaft timing.
- Fuel supply: controls the operation of the fuel pump(s) 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.
- Speed control: provides the option to maintain a fixed vehicle speed without driver intervention.
- Robustness: maintains engine-running condition under intermittent or permanent single point failures on any sensors or actuators fitted to the system, and records fault codes of these failures for system diagnosis.
- Diagnosis: notifies the driver when a system malfunction occurs and records data for system diagnosis.

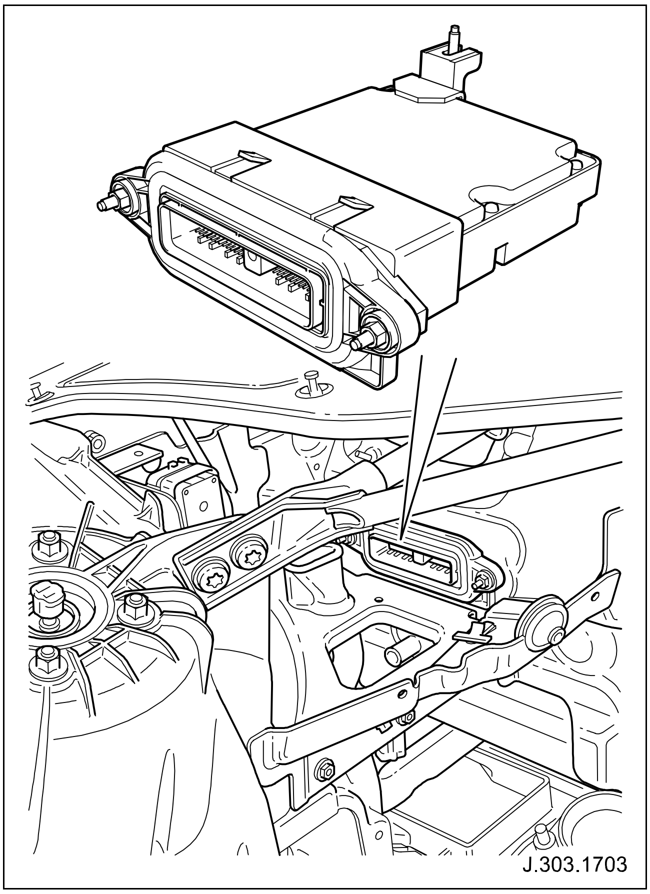

Fig. 51 Engine control module

Electrical Load Management

The electrical load management system used on the XJ is a new concept. The system utilizes the capability of existing vehicle messaging and subsystems, including the ECM, to analyze the overall power supply condition. Using this data the system makes its decision on which electrical features can be supported at any one time, therefore preventing the risk of damaging the battery.

For further information on this system; refer to **Battery and Charging Systems**.

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 various systems and the ECM is discussed in the relevant section of the publication.

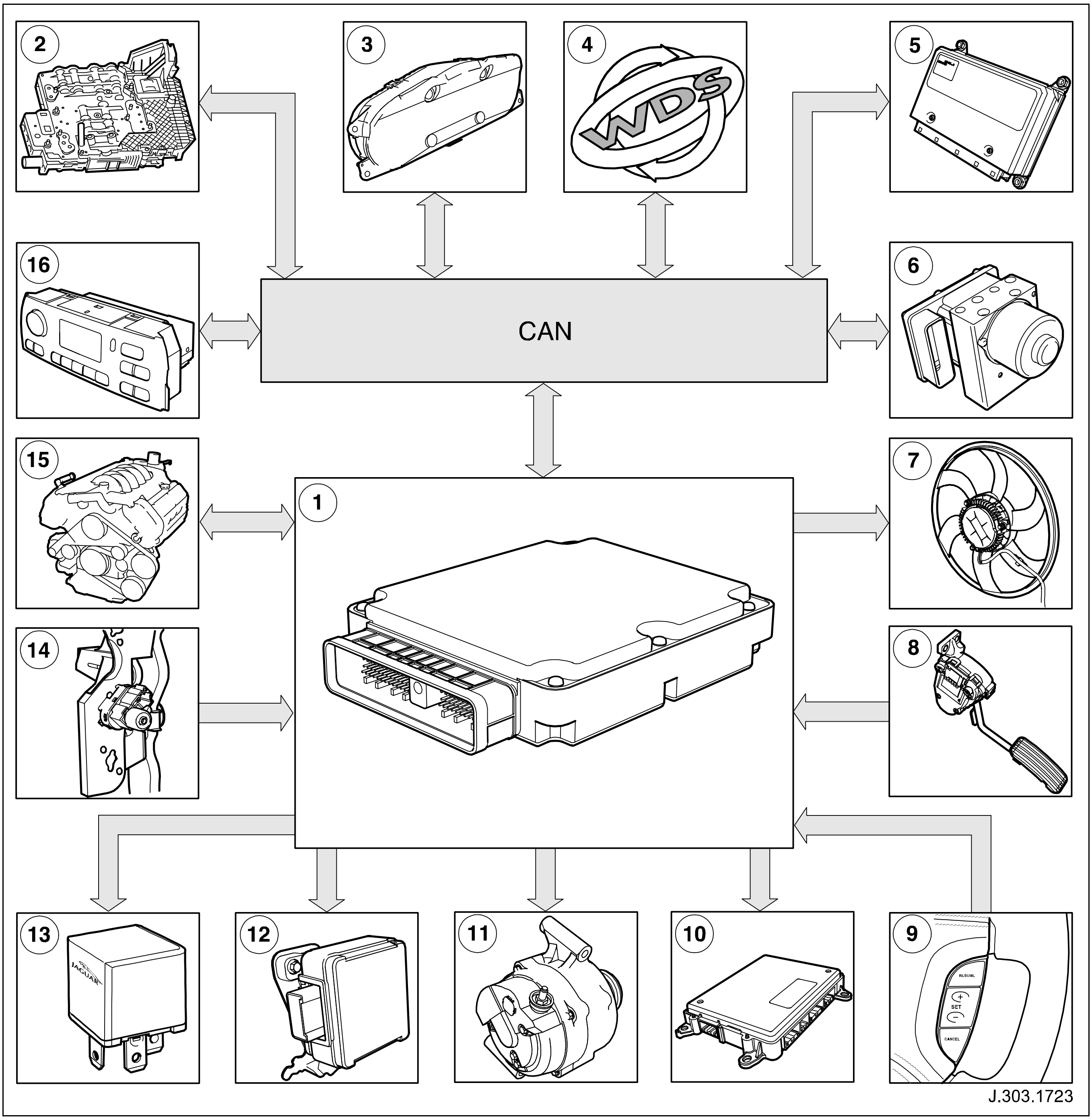

Fig. 52 System interfaces

Key to Fig. 52

1. Engine control module
2. Transmission control module (TCM)
3. Instrument cluster
4. Diagnostics
5. Air suspension module (ASM)
6. ABS / TC / DSC
7. Fan control module - integrated with fan motor
8. Accelerator pedal - electronic throttle control
9. Cruise control switches
10. Fuel pump driver module - integrated in rear electronic module (REM)
11. Alternator
12. Second fuel pump driver module - supercharged vehicles only
13. Starter relay
14. Brake pedal switches
15. Engine
16. Climate control module

Engine Interface

NOTE: The following is an overview of the engine interface only.

Fuel Injection

- The ECM controls one injector per-cylinder in sequential operation.
- The size of the injector used, is determined so that:
  - exact fuel control is possible at minimum engine load, with the allowance for purge valve correction,
  - and also to provide a sufficient fuel-flow at all engine speeds and maximum engine load.

- The timing of injector-firing relative to intake valve closing, during normal starting and running conditions, is optimized to provide:
  - the best compromise between emissions and performance,
  - and time to first-ignition and smooth engine operation at start-up, for all engine conditions at all temperatures.

- The mass of fuel required per-injection is derived from a calculation based on a ratio-metric match to the metered airflow.
- The ECM is capable of adapting to fuel system tolerances and engine internal wear under all operating conditions.
- The ECM continuously monitors the differential pressure between the fuel rail and plenum, and uses this value to calculate the injector pulse-width with the required mass of fuel per-injection.
- The ECM continuously monitors the temperature of the fuel being injected into the engine and provides compensation for the changing flow characteristics of the fuel system at different temperatures.
- The ECM continuously monitors the battery supply voltage and using this information the ECM ensures that the fuel supply to the engine is unaffected by voltage fluctuation.

Ignition

The system uses one individual ignition coil per-cylinder.

- Base ignition map: provided so that the engine can be optimized for emissions, fuel economy, performance and avoidance of cylinder knock throughout its speed and load range.
- Ignition timing during starting: initialized and used during engine cranking and under-speed modes to provide the best compromise between emissions, time to first-ignition and smooth engine operation at start-up, at all temperatures.
- Air intake temperature correction: provision is made to compensate for the effect of changing air intake temperature on the combustion detonation limit.
- Knock control: the system contains the necessary hardware for the detection of combustion knock within the engine cylinders, the ECM uses this information to gradually adjust the ignition timing until the combustion knock is at a safe and inaudible level.

Variable Valve Timing (Normally Aspirated Engines)

The ECM controls the fully-variable phase change system which acts on the intake camshafts.

- The target position of both camshafts is optimized to provide the best compromise between performance, refinement, fuel economy, and emissions.
- During transient operation the rate of change of the camshaft position is controlled to provide a smooth vehicle operation.
- Operation of variable valve timing (VVT) will be restricted if environmental conditions exist that could affect normal operation of the VVT, for example very low ambient temperatures.
- Provision is made to ensure that the intake camshafts are restrained in the retard position during engine start.
- The ECM will detect a VVT mechanical malfunction, and act to compensate for the malfunction.

Variable Air Intake System (V6 Engines)

- The ECM controls two intake manifold tuning valves (IMT valves). Each valve is a two positional device; the switching point of the valve is dependant on engine speed and a definable change in engine performance.
- The valve switching points are optimized for maximum torque in the wide-open throttle position.

Exhaust Gas Recirculation (V8 Engines)

- The ECM controls the flow of exhaust gases to reduce oxides of nitrogen (NOx) in emissions by recirculating metered amounts of exhaust gas into the intake of the engine. This lowers the combustion temperature, limiting the formation of NOx.
- The exhaust gas recirculation (EGR) flow is optimized for fuel economy, emissions, and a smooth vehicle operation for all engine operating conditions.

Interface to Electronic Throttle

- The system incorporates an electronic throttle to control the airflow into the engine under closed-loop feedback control of the ECM.
- The correct throttle-disc position is calculated as a function of driver demand value and of the engine's momentary operating mode.
- A fail-safe system is incorporated that complies with legislative requirements, including mechanical limp-home operation.

Idle Speed Control

- Idle speed is dependant on engine coolant temperature and gear selection (neutral or drive).
- Idle speed is optimized for combustion stability, idle quality, idle-speed control capability, and fuel economy at all operating conditions.
- Compensations to the idle speed will be made for conditions, such as variable ambient air temperature, to increase idle speed to satisfy charging system requirements.

Vehicle Speed Control

- The system incorporates a speed control system. The speed control switches are momentary action and are mounted on the steering wheel. This enables the driver to set a speed, and control and maintain the speed of the vehicle without having to operate the accelerator pedal.
- The function of the switches is organized so that a function relating to a switch of a higher priority always overrides a function relating to a lower priority switch. The switch priority is shown in descending order:
  1. Cancel
  2. Set
  3. Resume

Failure Modes and Effects Management

- Each electronic engine control function will revert to a default value if the signal controlling the function is out of normal operating range.
- System fault diagnosis is achieved using WDS.

Function of Sensors and Actuators

- Fuel injector:
  - Delivers fuel to the engine cylinder intake ports in sequential order. There are 12 fuel injection-holes per injector, delivering fuel droplets as small as 60 microns in diameter. This size of fuel droplet reduces fuel wetting of the intake port and promotes excellent fuel-air mixing. Reducing noxious emissions and improving fuel economy while the engine is warming up.
- On-plug ignition coil with integrated amplifier:
  - The ECM controls one coil per spark plug in sequential order. The ignition coil provides the energy to the spark plug to ignite the air/fuel mixture in the engine cylinder. The ignition coil works on the principle of 'mutual induction', by closing and then opening the ignition-coil primary circuit. The primary current increases, and then suddenly decreases to induce the high voltage in the secondary circuit needed to fire the spark plug.
- Camshaft position sensor:
  - Signals from the camshaft position sensors are used to synchronize the ECM to the engine cycle during engine starting. For example, whether the crankshaft position sensor is indicating an induction or firing stroke.
  - The position of both intake camshafts is monitored to allow the ECM to control the phase of the intake camshafts relative to the position of the crankshaft.
  - On engines with VVT the camshaft position sensor provides feedback control on the intake camshaft's position relative to the position of the crankshaft and exhaust camshafts.
- Oil control solenoid — variable valve timing (normally aspirated engines):
  - The oil control solenoid is a hydraulic actuator, which advances and retards the intake camshaft timing, thereby altering the camshaft-to-crankshaft phasing.
- Manifold absolute pressure sensor:
  - The manifold absolute pressure sensor (MAP sensor) is used for EGR diagnostic testing only.
- Knock sensor:
  - The knock sensors produce a voltage signal with respect to the engine's combustion knock level.
  - The 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 at a safe and inaudible level. The knock control system cannot advance the ignition past the mapped values. It retards the ignition timing to reduce combustion knock and then advances to its original value.
- 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.
- Engine fuel temperature sensor:
  - Continuously monitors the temperature of the fuel being injected into the engine. The ECM uses this value to provide compensation for the changing flow-characteristics of the fuel system when affected by changes in temperature.
- Intake manifold tuning valves (V6 engines):
  - The intake manifold tuning valves (IMT valves) are a two positional 'open or close' device used to create a variable air intake system. The position of the IMT valves is 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 sensors.
- Throttle body assembly:
  - The throttle body controls the airflow into the engine by use of the throttle motor andthrottle position sensor (TP sensor).
  - The throttle motor, via signals received from the accelerator-pedal position sensor, operates the throttle disc position; the ECM transmits these signals.
  - The ECM via the TP sensor, monitors throttle-disc angle.
  - The ECM on the application of external loads, for example the air conditioning compressor, makes compensation to the throttle disc angle.

- Mass air flow sensor with integrated intake air temperature sensor:
  - The mass airflow sensor (MAF sensor) informs the ECM of the rate of airflow entering the engine by producing a voltage which increases as the rate of airflow increases.
  - The MAF sensor also takes into account the density of air entering the engine so it is possible to maintain the required air to fuel ratio, and compensate for variations in atmospheric pressure temperatures.
  - The integral intake air temperature sensor (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:
  - The crankshaft position sensor (CKP sensor) is an inductive pulse generator, which scans protrusions on a pulse ring, to inform the ECM of the crankshaft's position and engine speed.
- Engine coolant temperature sensor:
  - The thermistor type sensor provides an input signal to the ECM, which is proportional to the temperature of the coolant 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 circulated around the engine oil passageways.
- Heated oxygen sensor 1:
  - The heated oxygen sensor 1 (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 used in conjunction with the ECM provides closed-loop fuelling control.
- Heated oxygen sensor 2:
  - The Heated oxygen sensor 2 (HO2 sensor 2), is a non-linear characteristic type sensor fitted to the exhaust system's catalytic converter.
  - The sensor is used by the ECM as a 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.
  - The sensor also monitors catalyst efficiency.
- Exhaust gas recirculation valve:
  - As controlled by the ECM, a defined portion of the engine's exhaust emissions are extracted and returned to the intake mixture via a solenoid valve.
- Air intake control-flap solenoid (supercharged engine):
  - The ECM directly controls the solenoid, to open and close the air intake control-flap in the air-cleaner assembly. The control flap opens at high engine speeds and loads to satisfy engine air-charge requirements.
- Engine oil pressure switch:
  - The switch is connected to the instrument cluster and is not directly used as part of the engine control system.

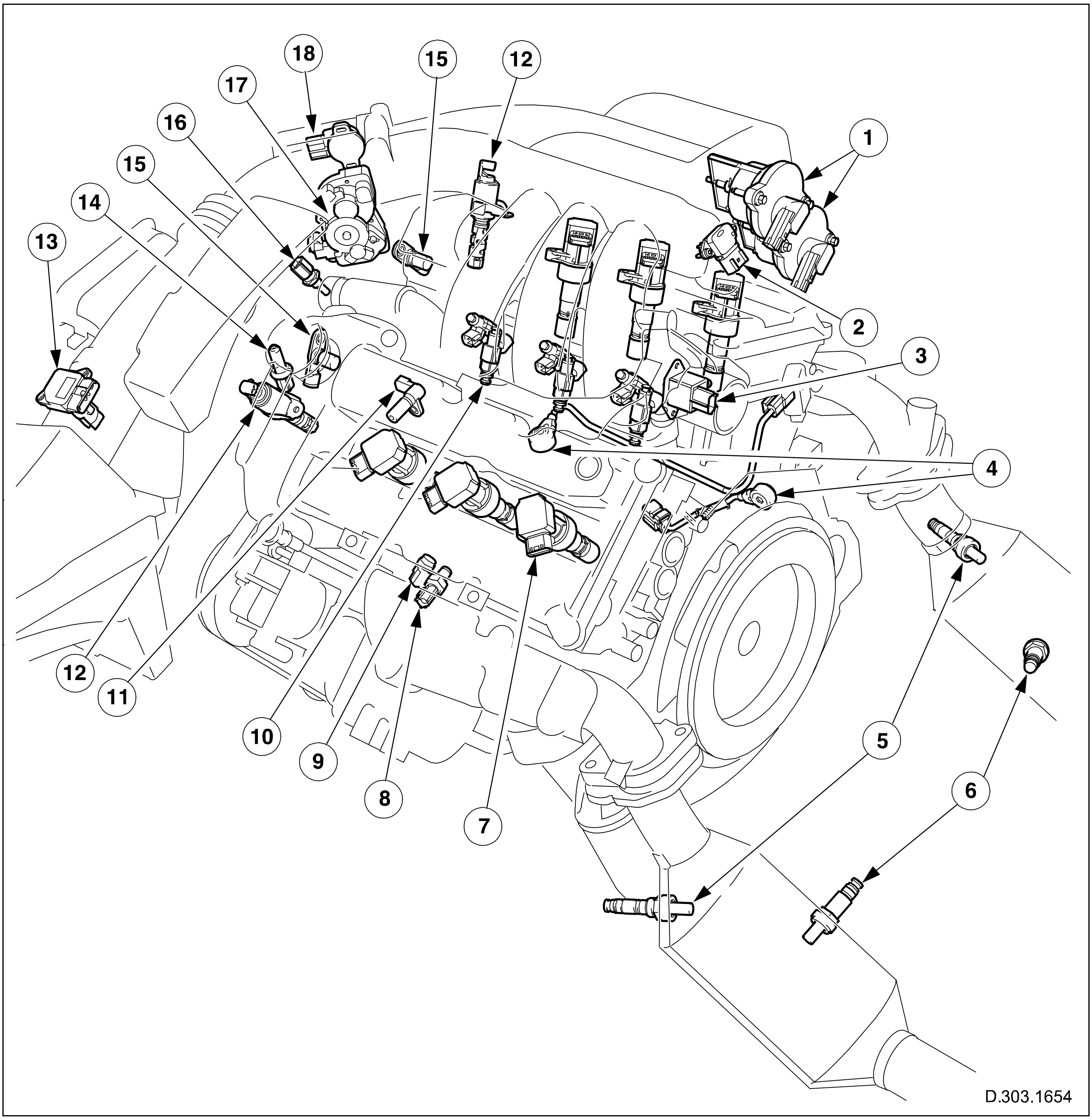

Fig. 53 V6 Normally Aspirated Engine — sensor and actuator location

Key to Fig. 53

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

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

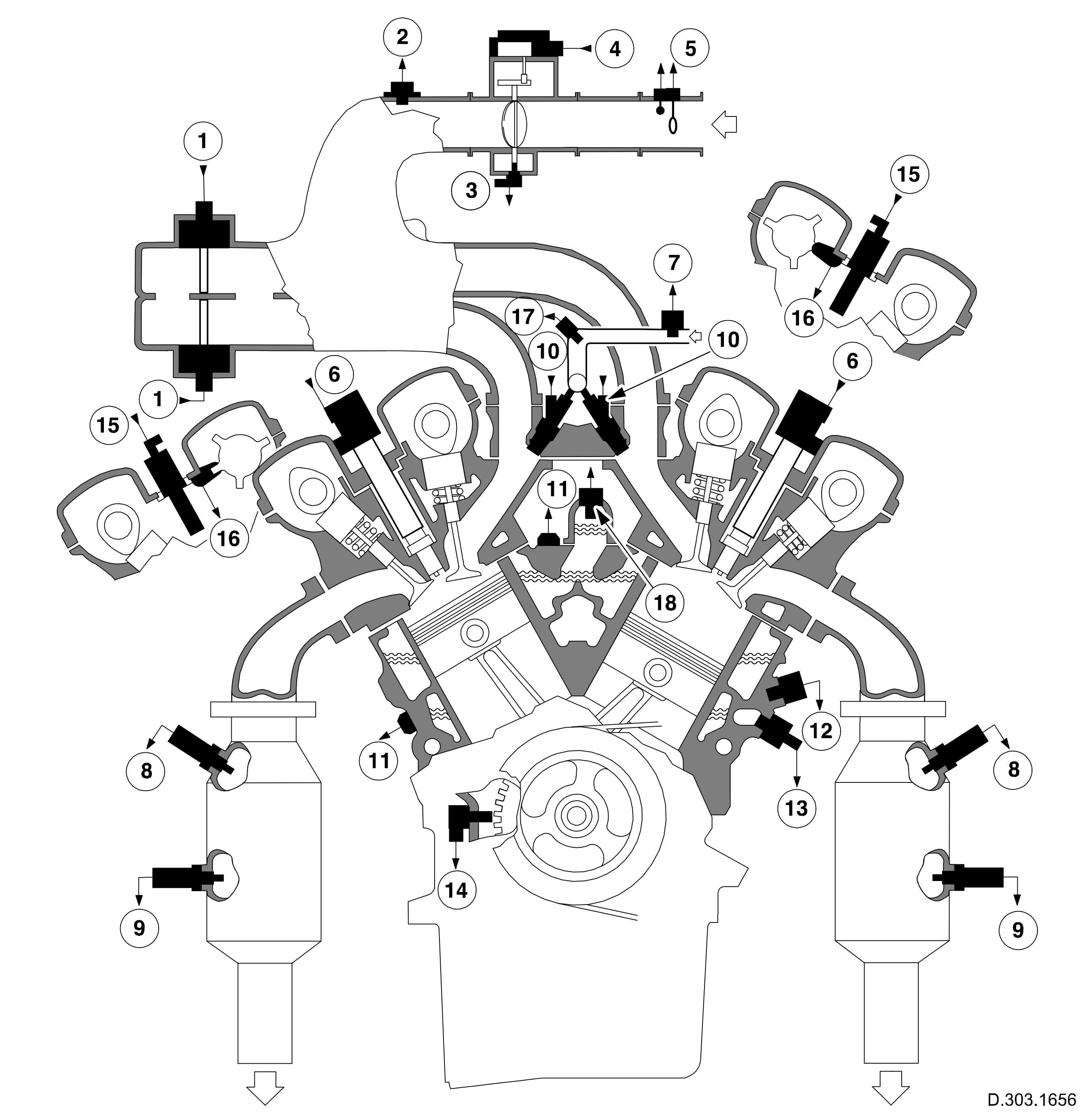

Fig. 54 V6 Normally Aspirated Engine — sensors and actuators schematic

Key to Fig. 54

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. Engine 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

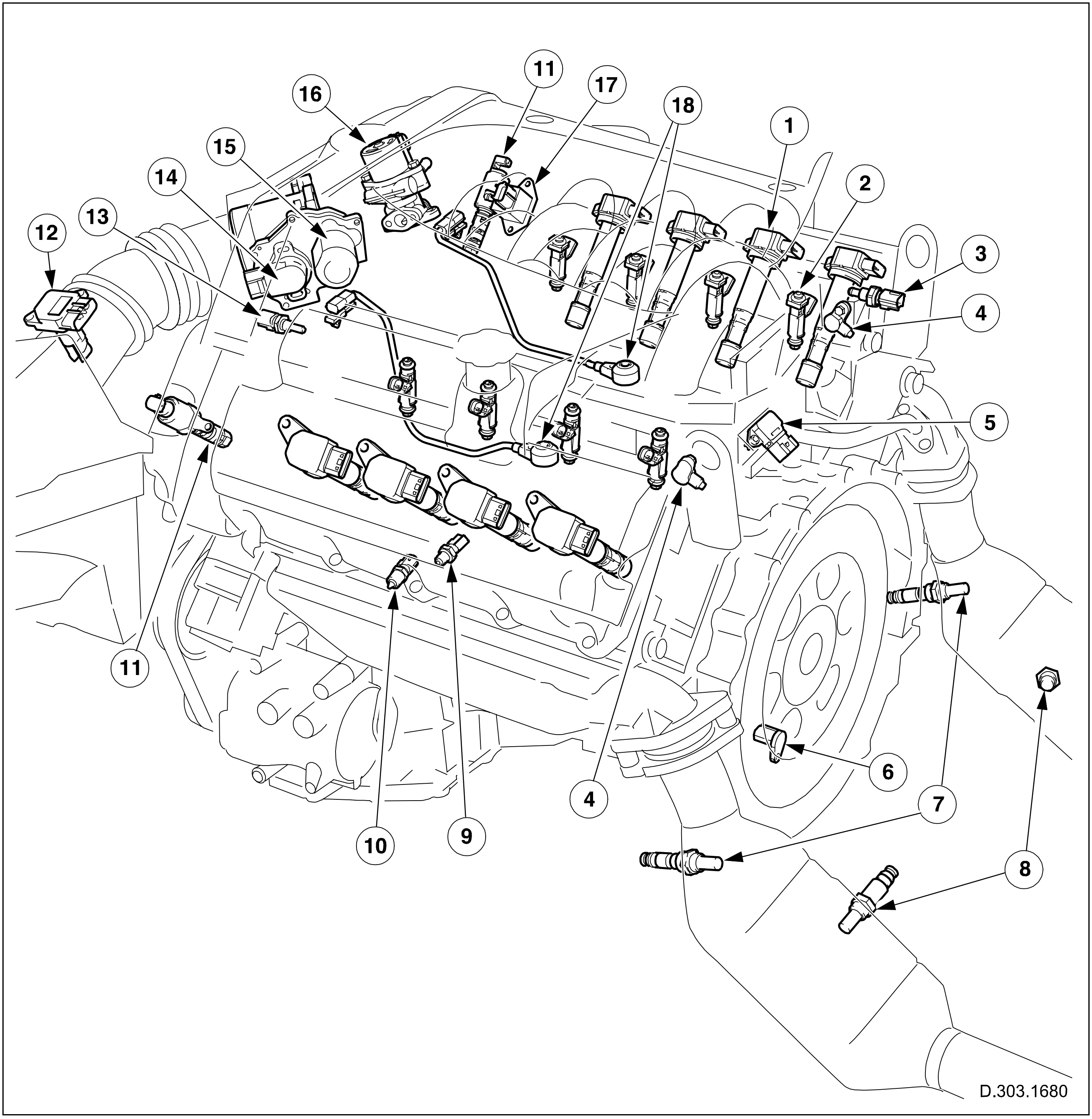

Fig. 55 V8 Normally Aspirated Engine — sensor and actuator location

Key to Fig. 55

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

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

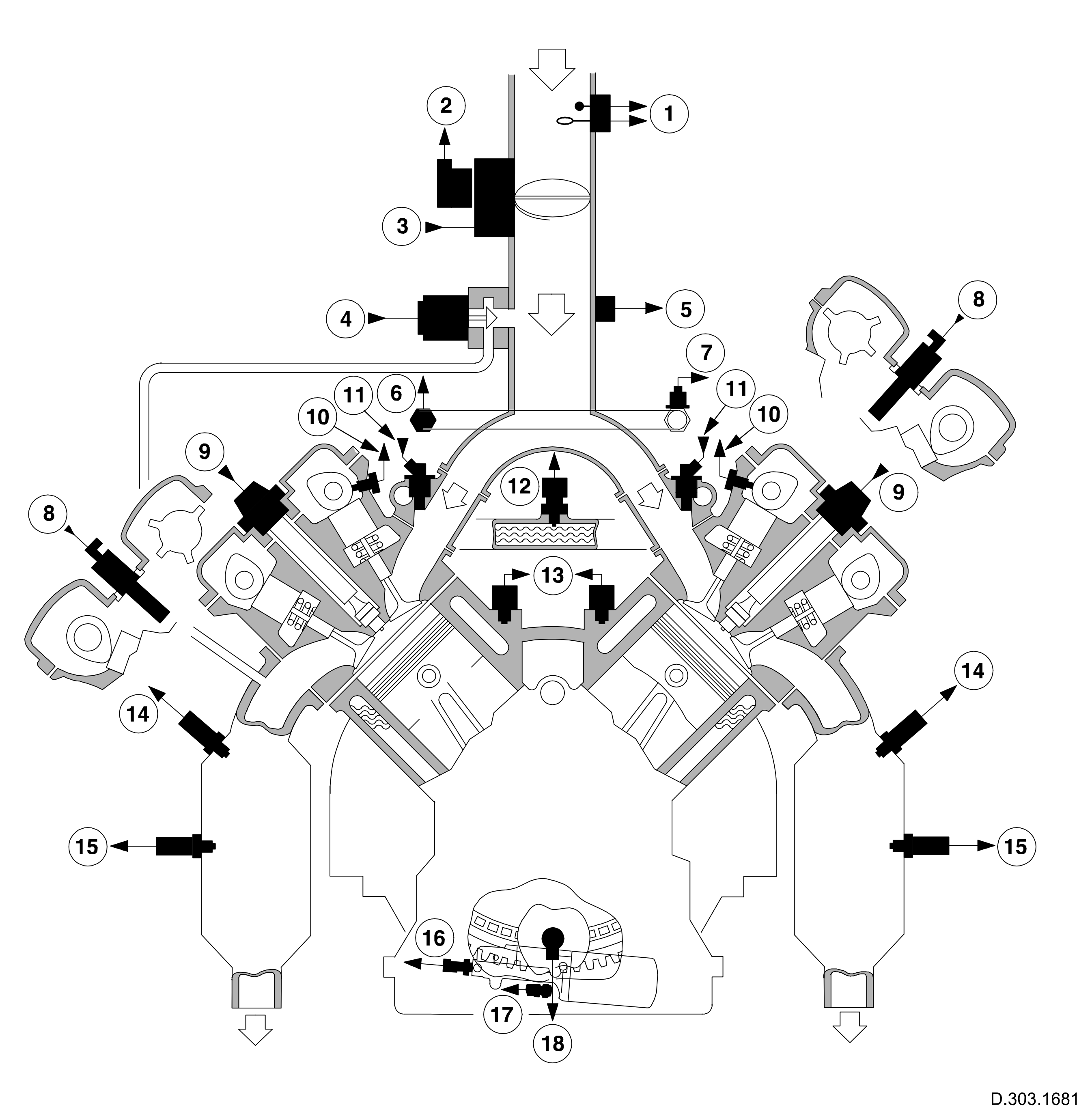

Fig. 56 V8 Normally Aspirated Engine — sensors and actuators schematic

Key to Fig. 56

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

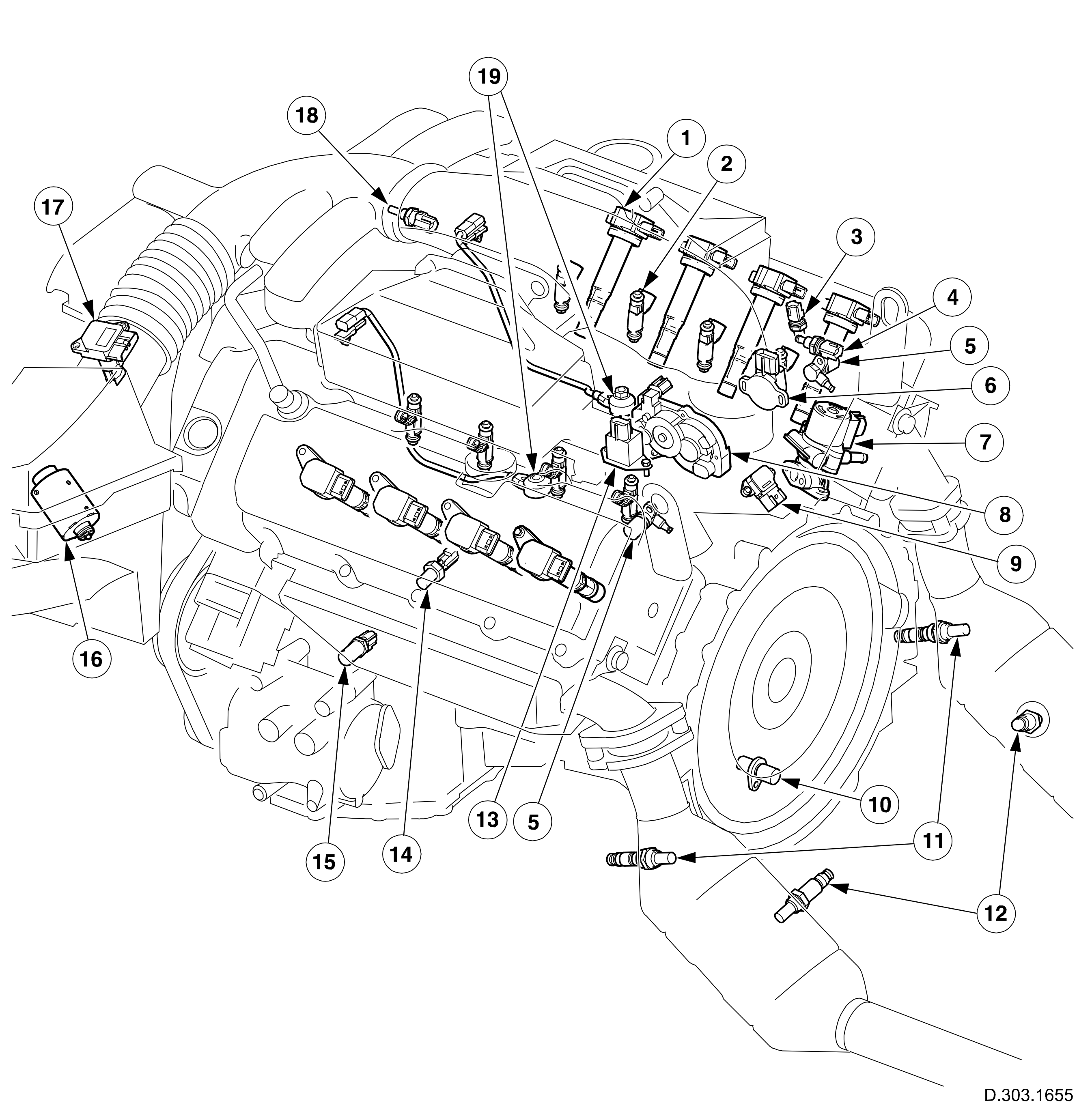

Fig. 57 V8 supercharged Engine — sensor and actuator location

Key to Fig. 57

1. On-plug ignition coil with integrated amplifier
2. Fuel injector
3. Air temperature sensor
4. Engine fuel temperature sensor
5. Camshaft position sensor
6. Throttle position sensor
7. Exhaust gas recirculation valve
8. Throttle motor
9. Manifold absolute pressure sensor
10. Crankshaft position sensor
11. Heated oxygen sensor 1
12. Heated oxygen sensor 2
13. Fuel pressure sensor
14. Engine oil pressure switch
15. Engine oil temperature sensor
16. Air intake control-flap solenoid
17. Mass air flow sensor with integrated intake air-temperature sensor
18. Engine coolant temperature sensor
19. Knock sensor