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.

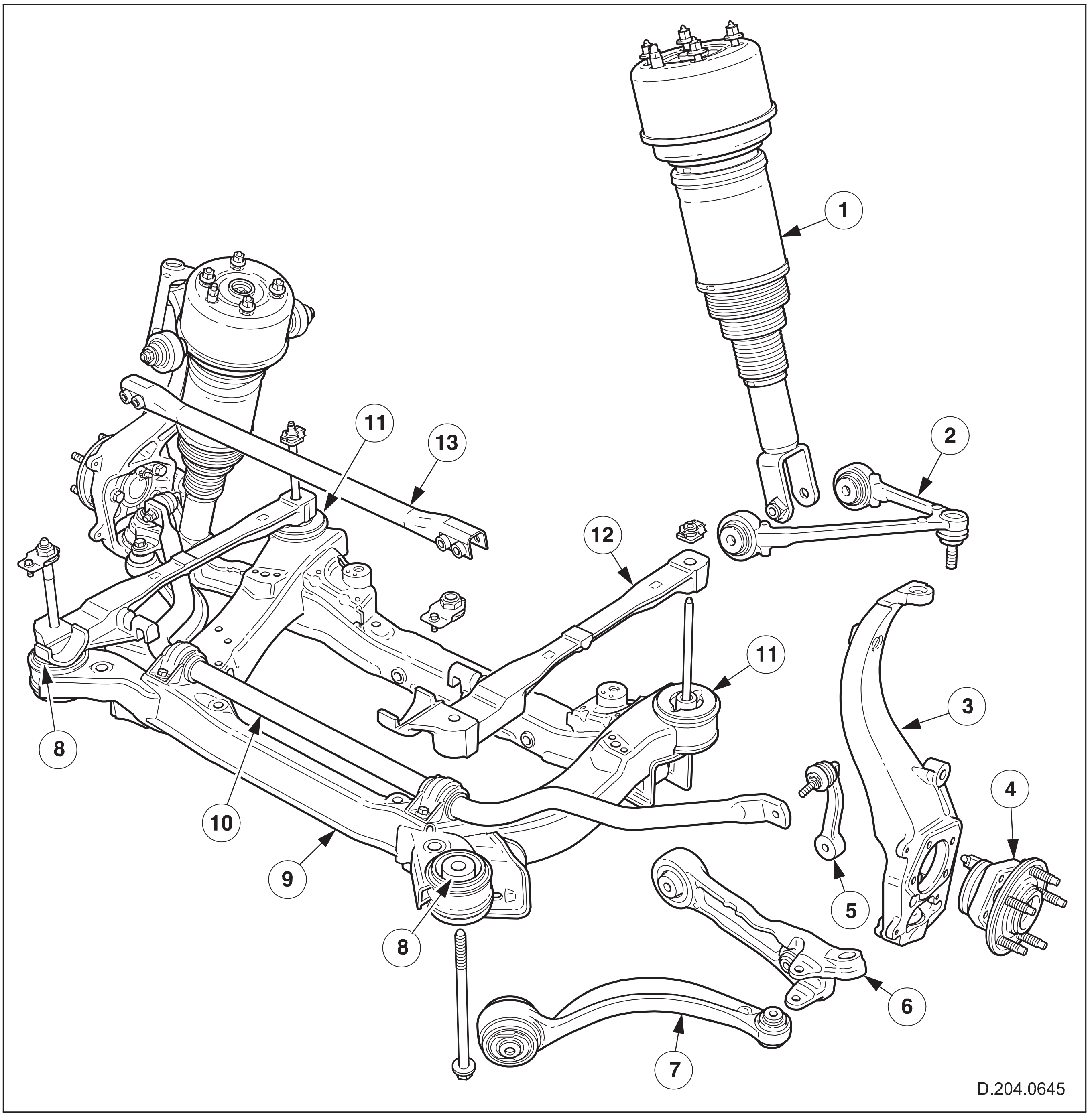

Fig. 2 Front suspension components

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

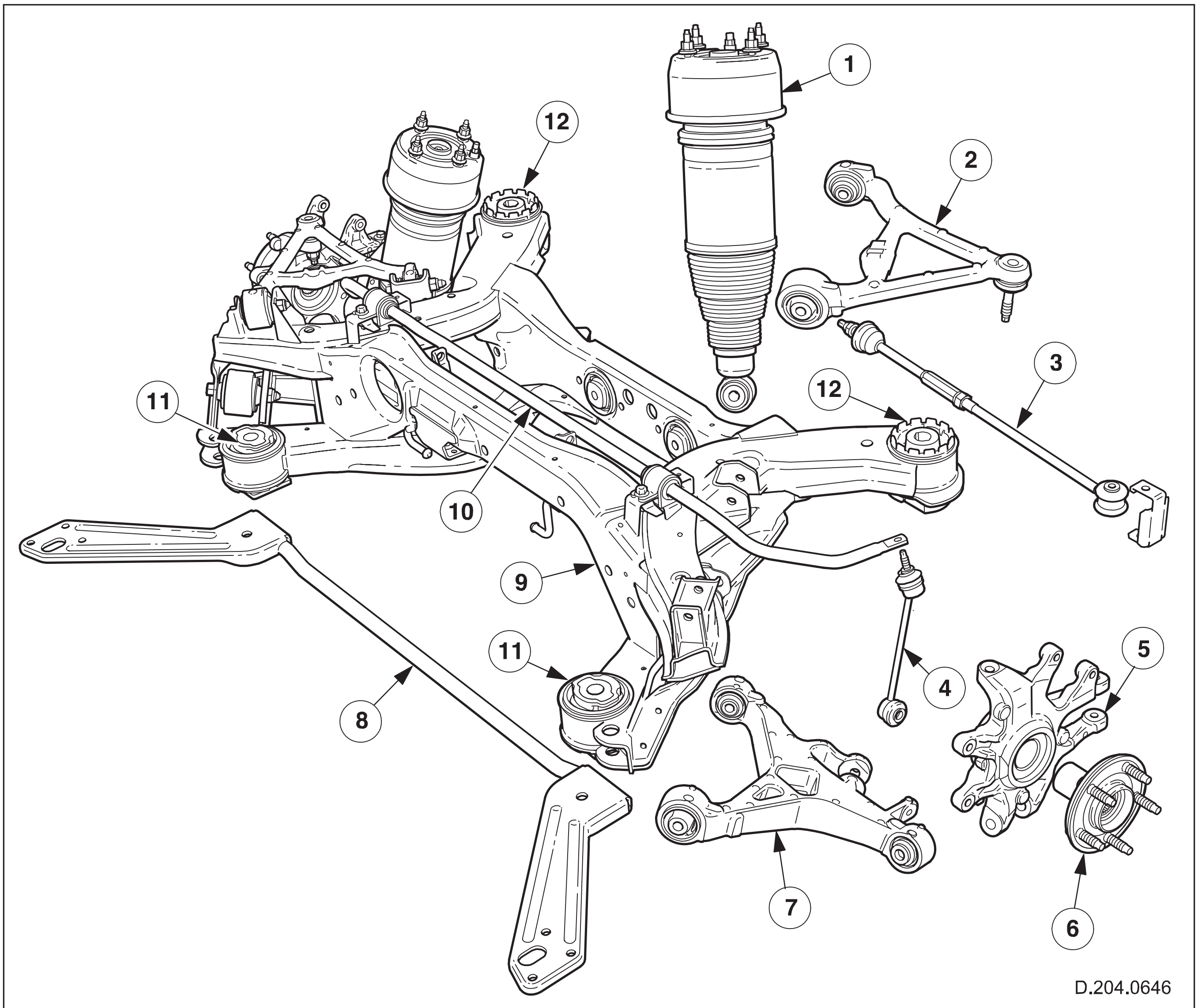

Fig. 3 Rear Suspension Components

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

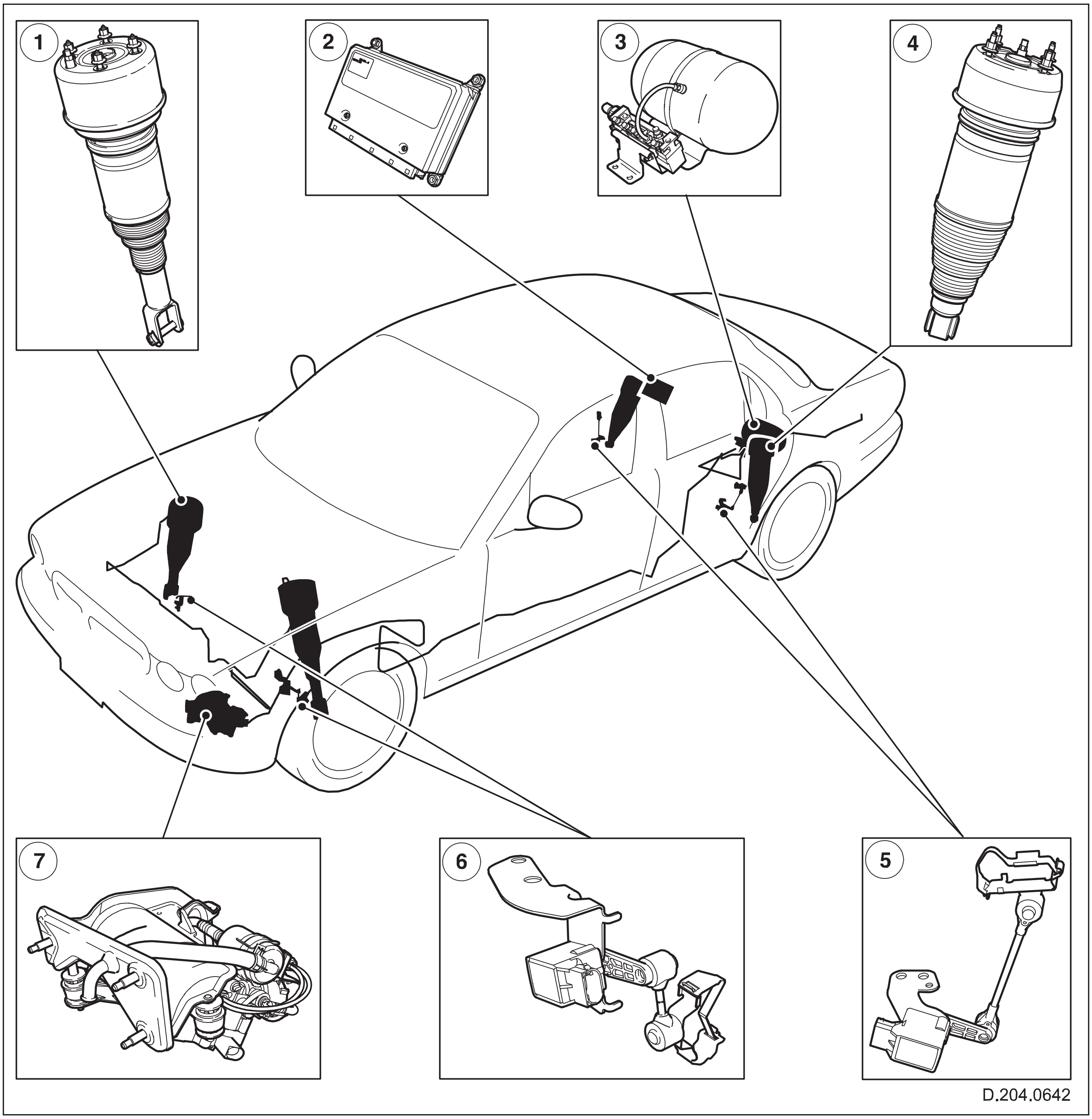

Fig. 4 Air suspension components

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.

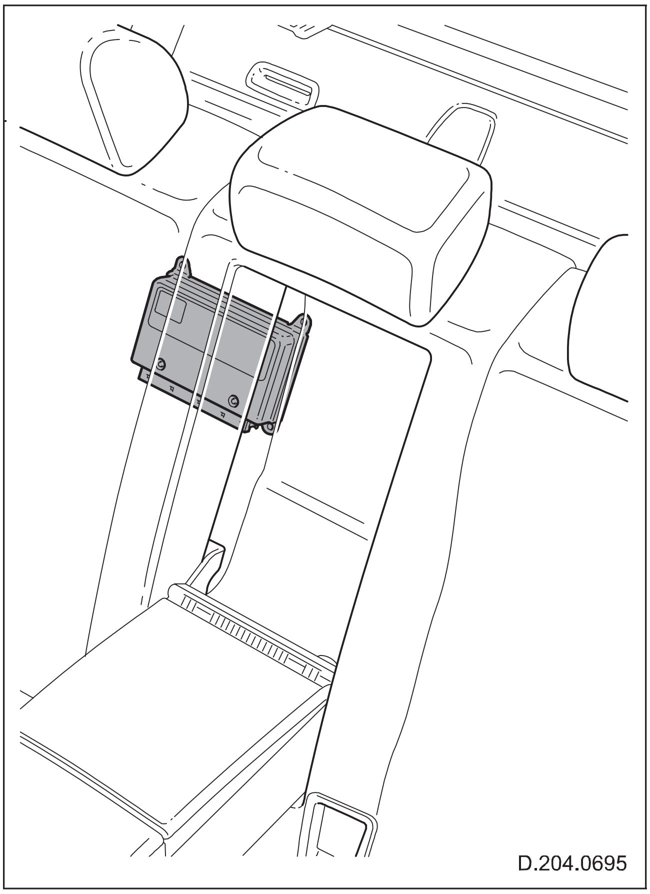

Fig. 5 Air suspension module

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.

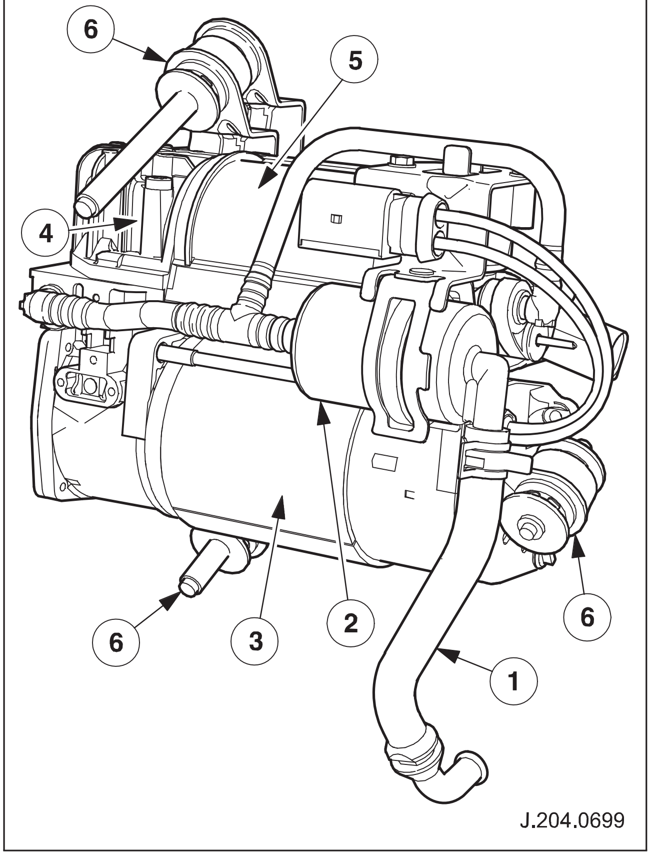

Fig. 6 Air compressor

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.

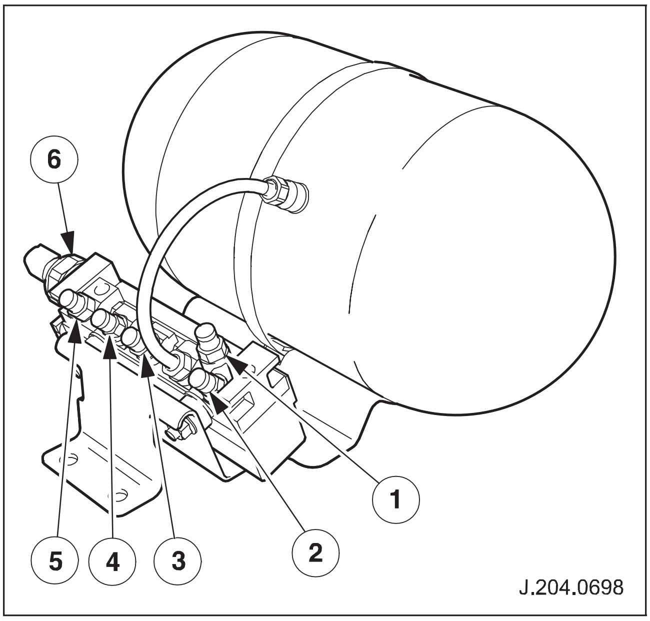

Fig. 7 Reservoir and valve block

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.

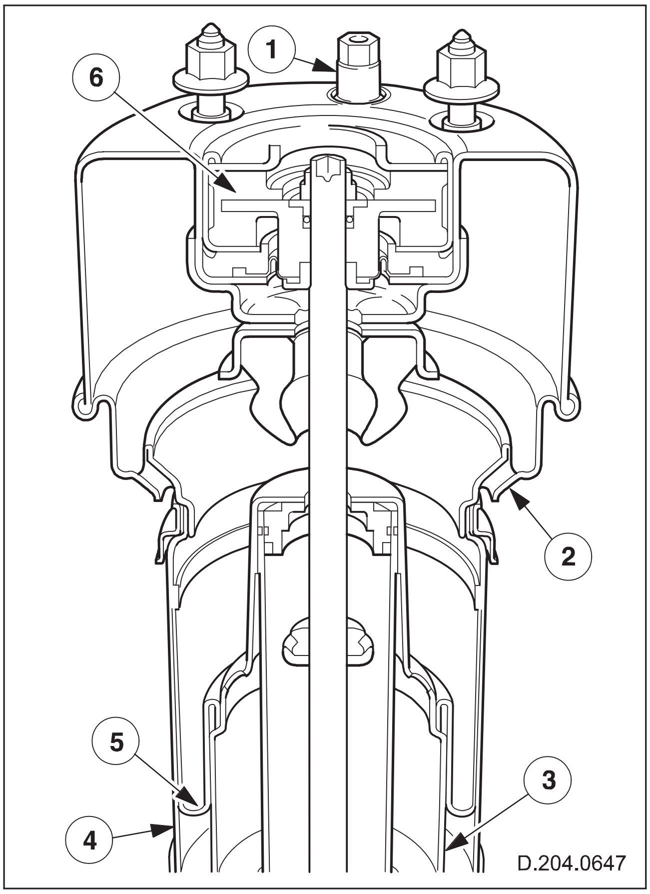

Fig. 8 Air spring internals

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**.

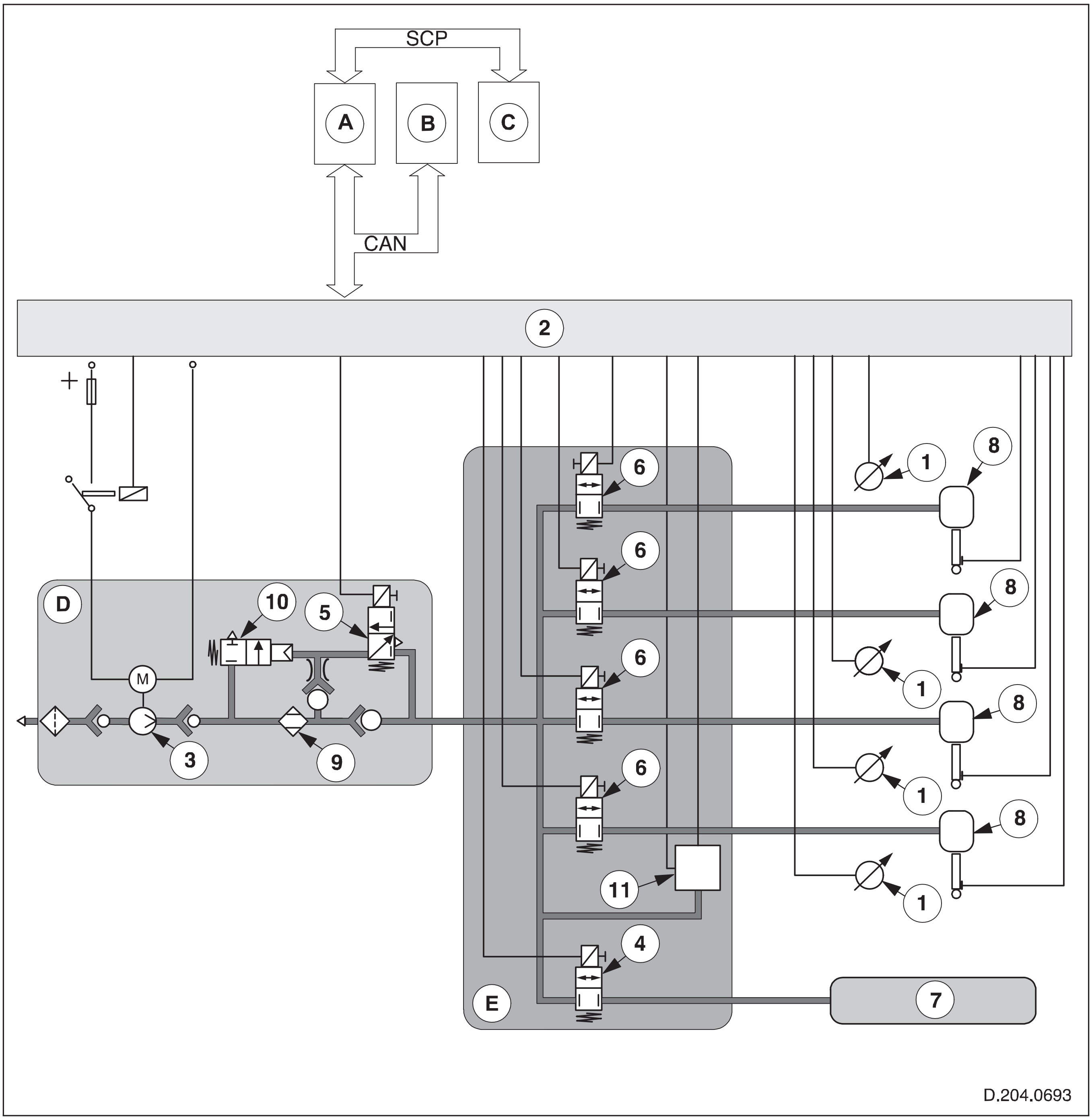

Fig. 9 **System diagram**

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.

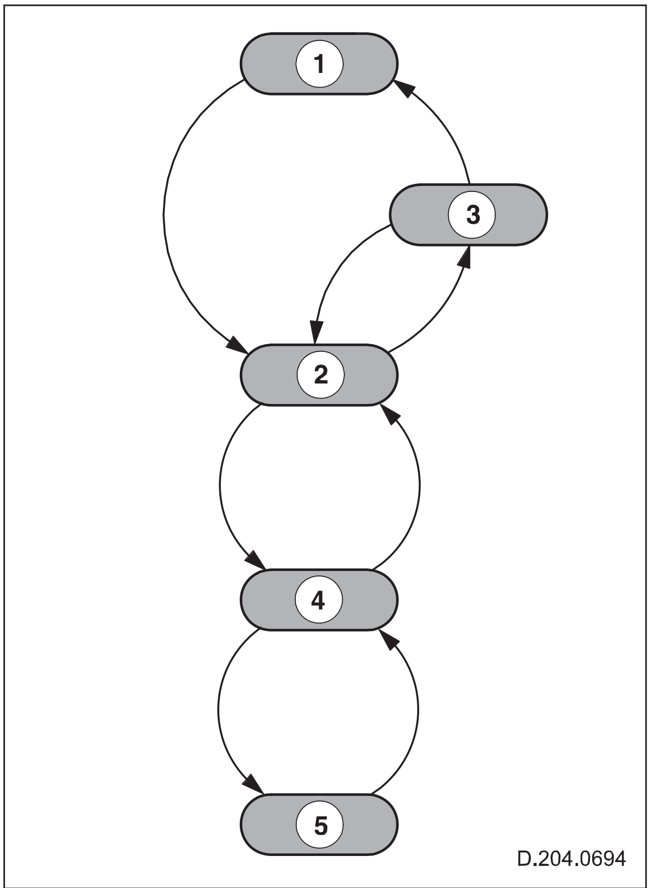

Fig. 10 Customer modes

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.

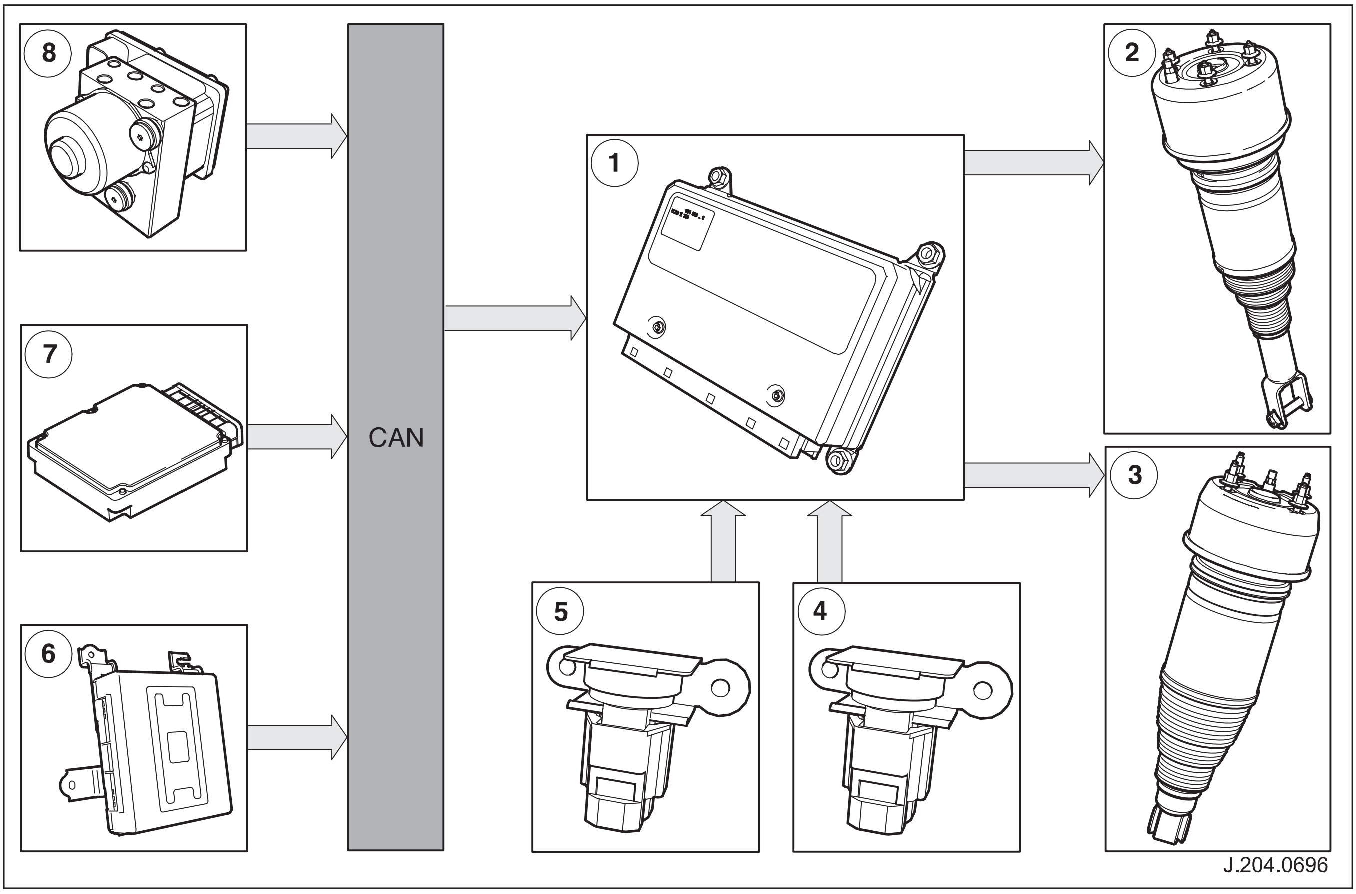

Fig. 11 Control system diagram

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.

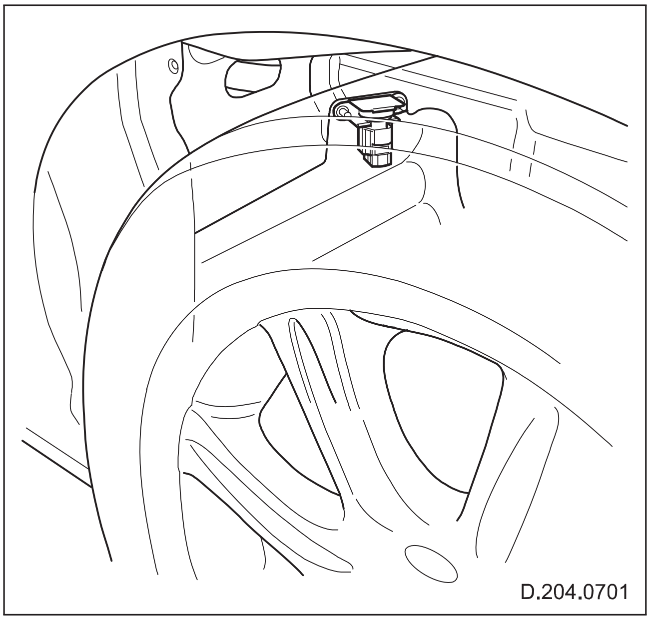

Fig. 12 Front vertical accelerometer

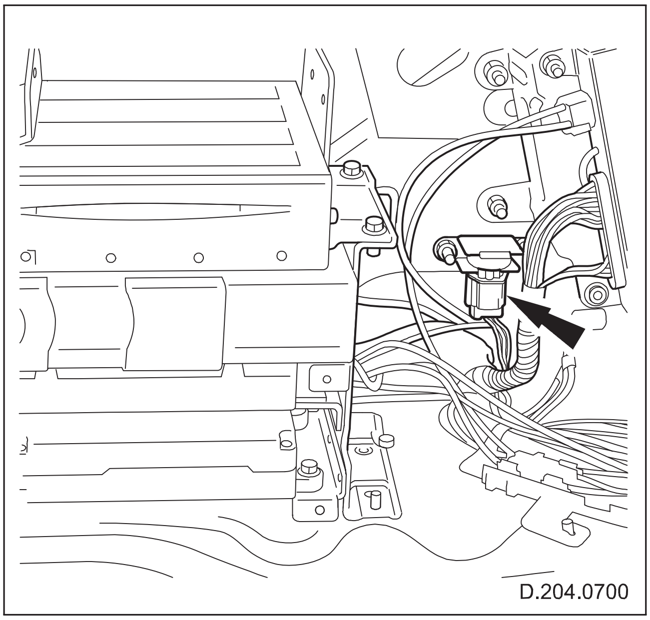

Fig. 13 Rear vertical accelerometer

- 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.

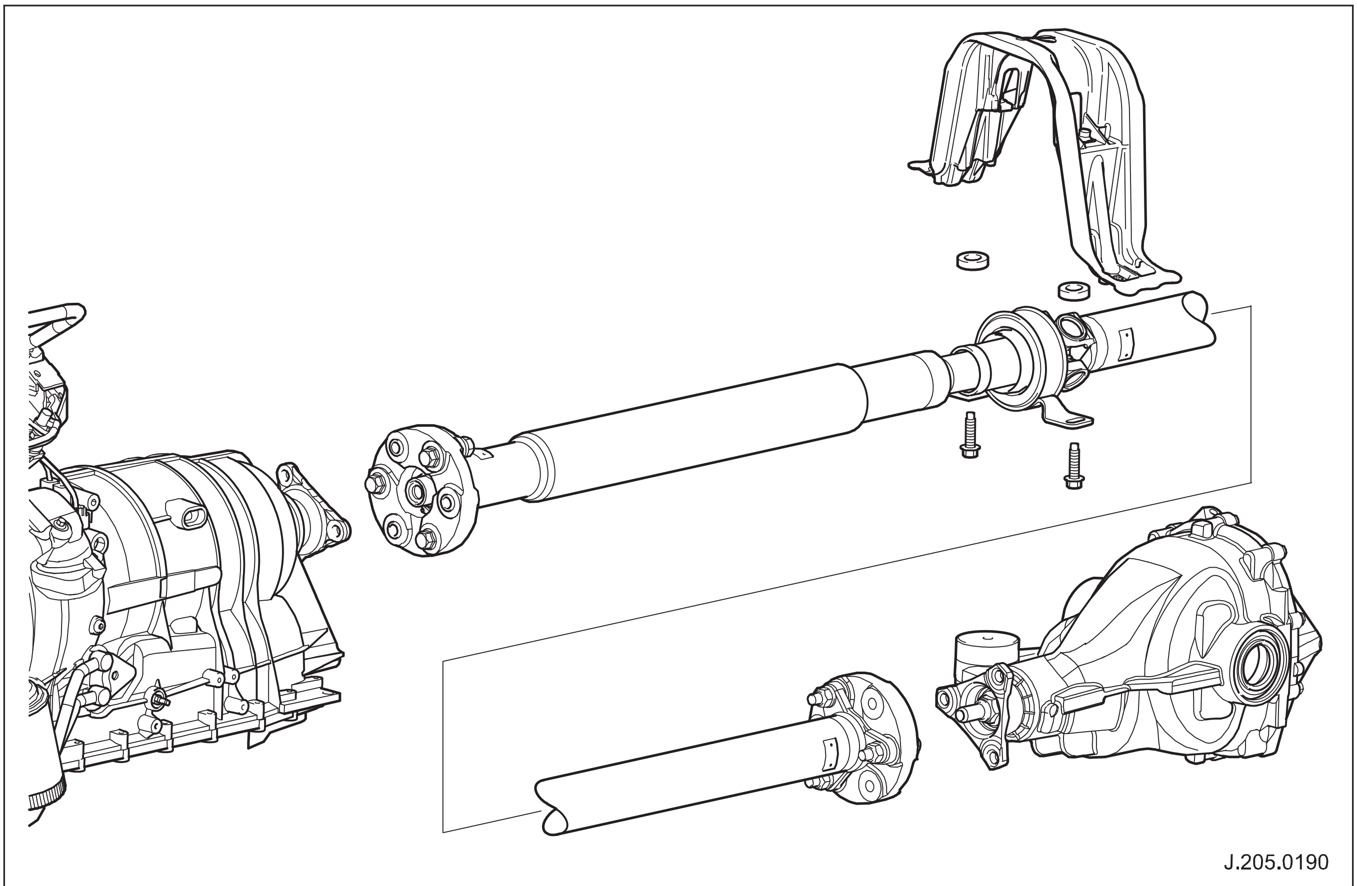

Fig. 14 Driveshaft and final drive unit

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.

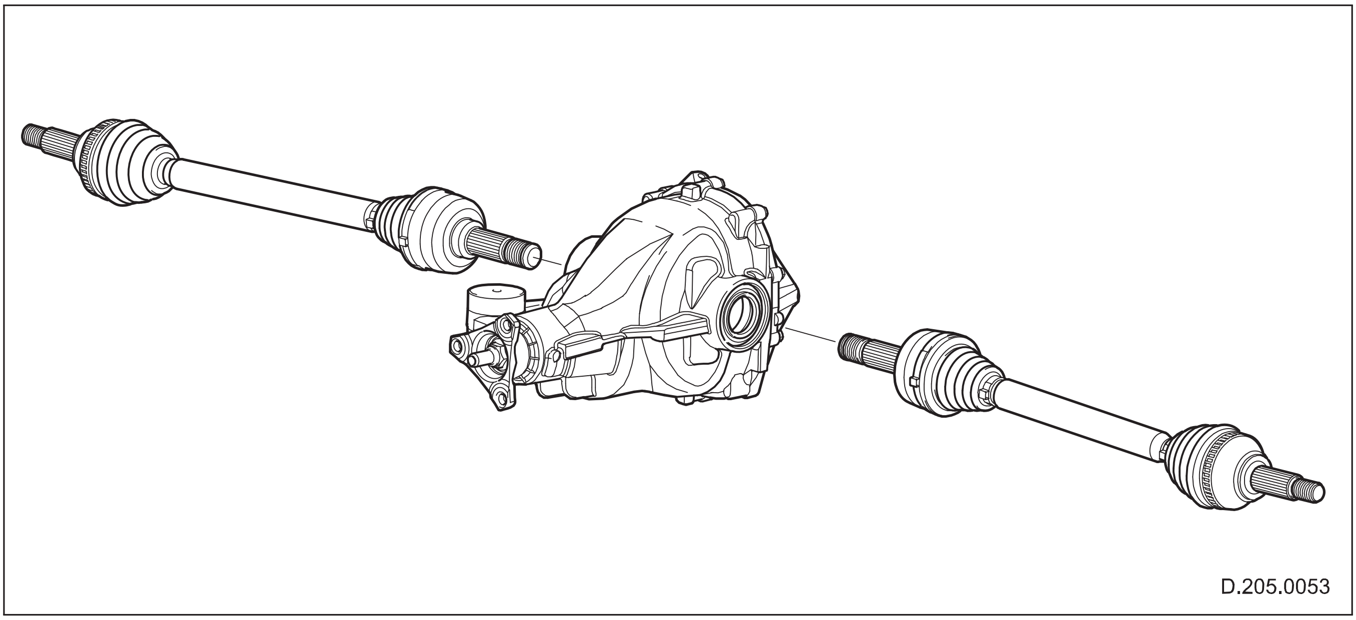

Fig. 15 Axle shafts and final drive unit

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.

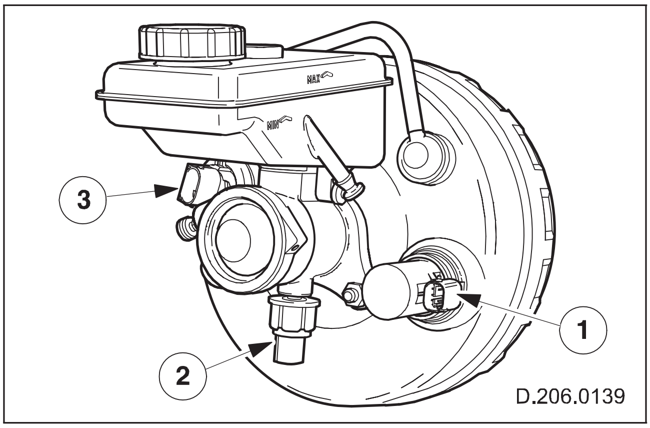

Fig. 16 Active brake booster

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.

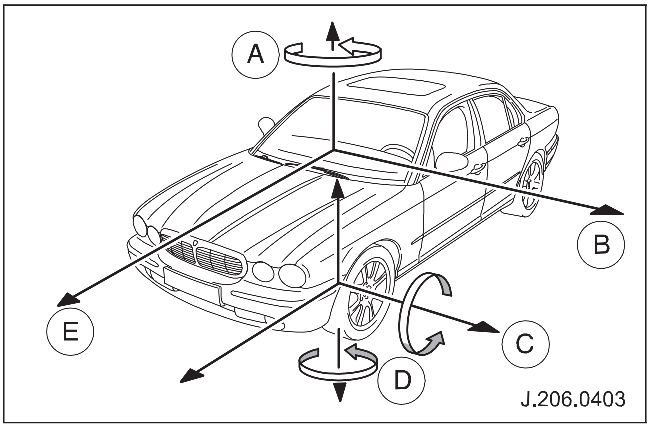

Fig. 17 Vehicle travel directions

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.

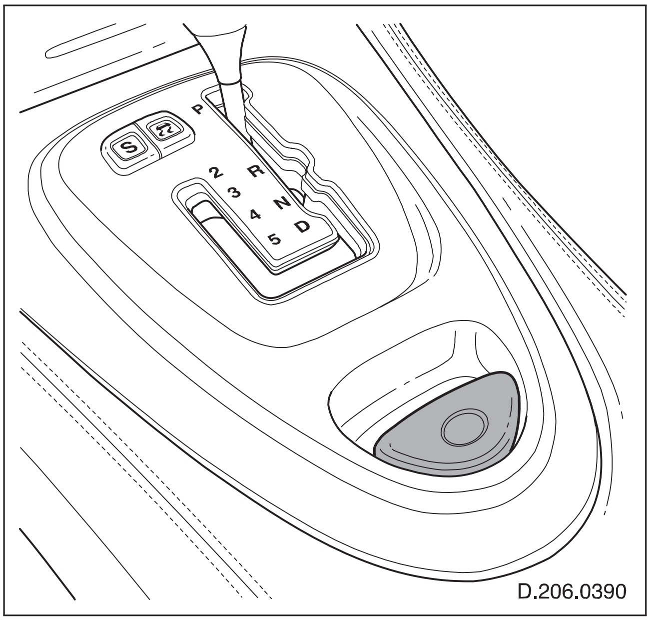

Fig. 18 Parking brake switch

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

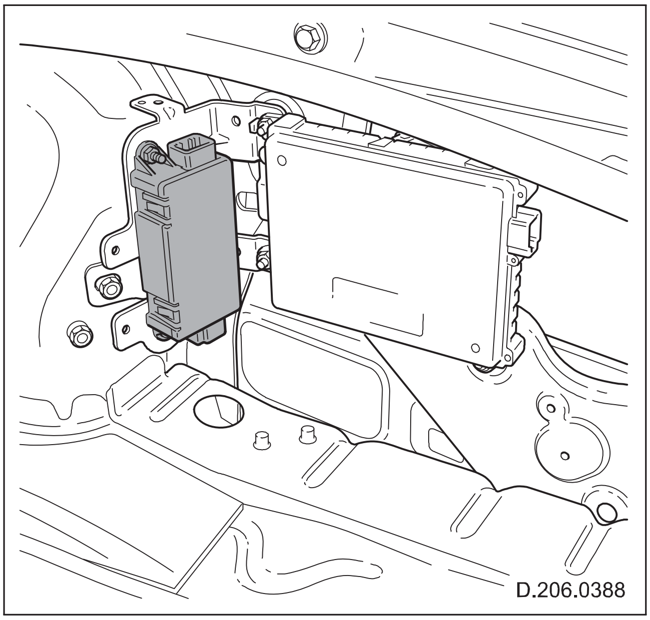

Fig. 19 Parking brake module

- 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.

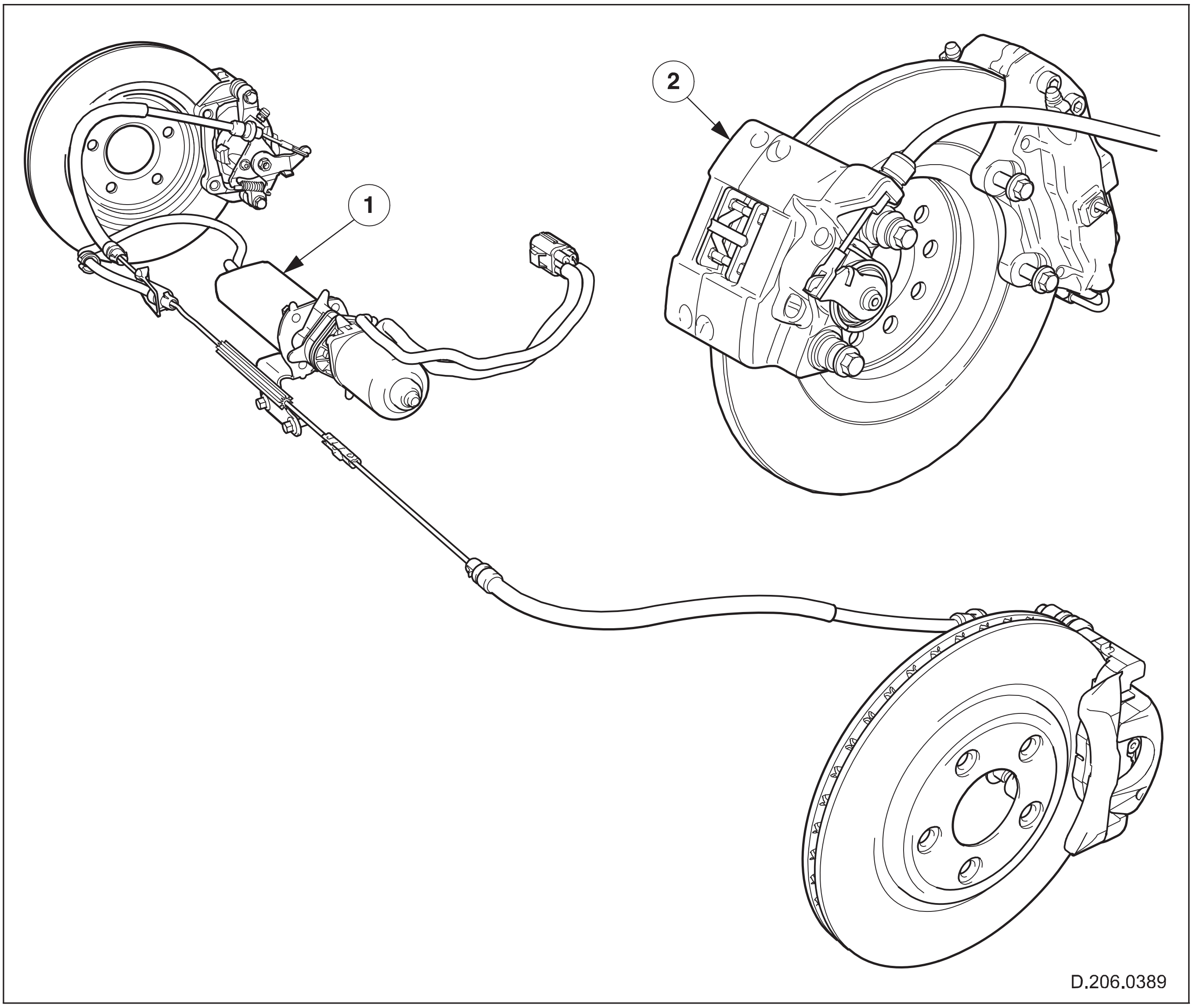

Fig. 20 Actuator unit and cables

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'.