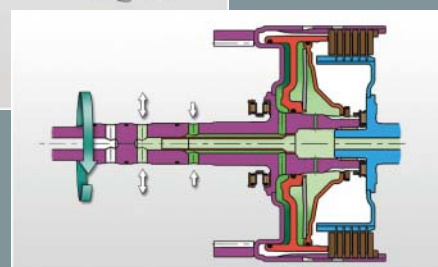
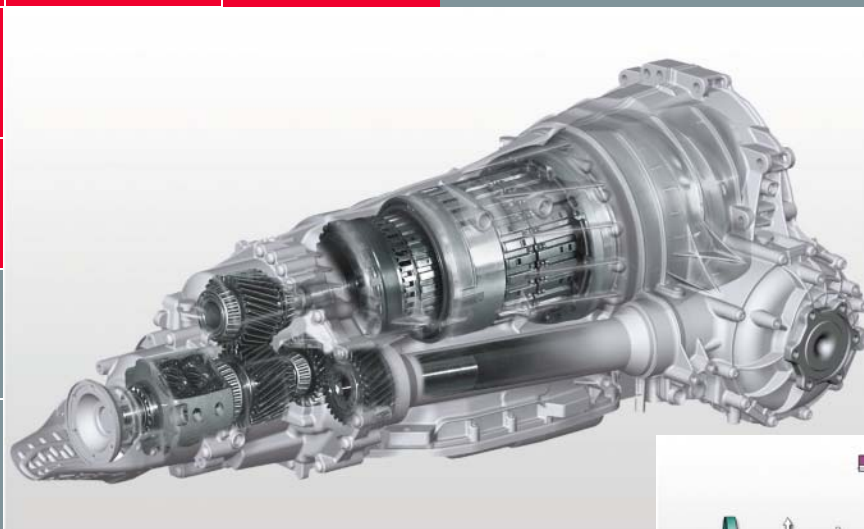


Service.



6-speed automatic gearbox 09E in the Audi A8 '03 - Part 1

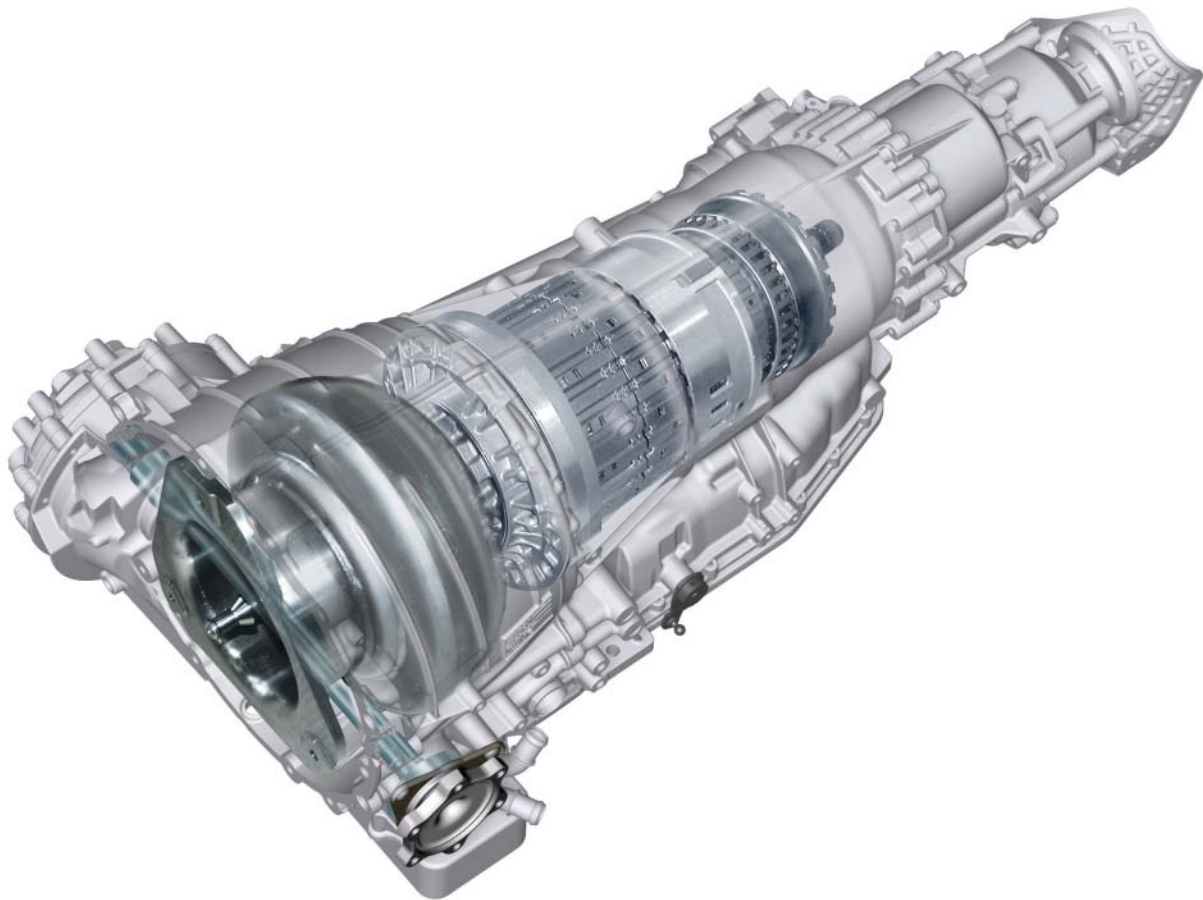
Self Study Programme 283

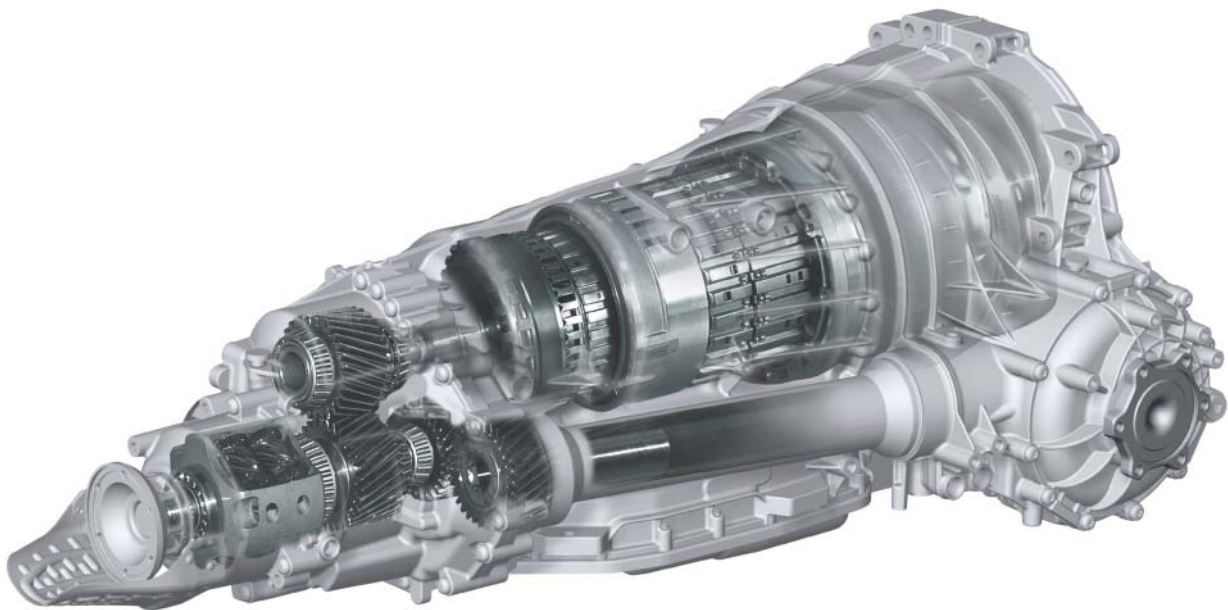
Speed-change gearboxes are of prime importance with regard to fuel consumption, emission levels, dynamics and comfort in the vehicle.

New concepts such as automatic gearshift systems or continuously variable automatic transmission represent alternatives to the conventional multi-step automatic gearbox.

For a combination of high torque transmission levels with corresponding ride comfort, the multi-step automatic gearbox remains the uncompromising option in terms of torque conversion.

The new 6-speed automatic gearbox 09E represents the logical next stage in the development of the multi-step automatic gearbox concept. It sets new standards in its class as regards economy, dynamics and comfort.





The 09E was developed and is manufactured by the renowned system supplier ZF. Together with the gearbox development specialists at Audi, the unit was adapted to the quattro drive concept and vehicle-specific requirements.

The 09E is the first representative of a new 6-speed gearbox family which is to include further additions to both the top and bottom end of the torque transmission scale.

The new 6-speed generation is designed to replace the familiar 5-speed 01V and 01I automatic gearboxes.

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The Self Study Programme contains information on design features and functions.

The Self Study Programme is not intended as a Workshop Manual.

Values given are only intended to help explain the subject matter and relate to the software version applicable when the SSP was compiled.

Use should always be made of the latest technical publications when performing maintenance and repair work.

New
Note



Attention
Note



Part 2 SSP 284

Page

Gearbox Control

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General

Technical data

Designation	09E
Audi factory designation	AL 600-6Q
ZF factory designation	6HP-26 A61
Code letters ²⁾	GNT (V8 3.7 l) GNU (V8 4.2 l) GKY (V8 4.0 l TDI)
Gearbox type	Electrohydraulically controlled 6-speed planetary gearbox (multi-step automatic gearbox) with hydrodynamic torque converter and slip-controlled torque converter lock-up clutch Four-wheel drive with integrated Torsen centre differential and front-axle differential in front of torque converter
Control	Mechatronik (hydraulic control unit and electronic control integrated into one unit) Dynamic shift program DSP with separate sports program in "Position S" and tiptronic shift program for manual gear change
Max. torque/power transmission ²⁾	Up to 650 Nm 320 kW/5800 rpm
Torque converter	Hydrodynamic torque converter with controlled torque converter clutch
(2WK stands for two-lining torque converter clutch) ¹⁾	W 280 S - 2WK (650 Nm version) W 260 S - 2WK (440 Nm version)
Torque converter multiplication ¹⁾ (torque increase)	1.66 (GNT) 1.70 (GNU)

¹⁾ These values depend on the version concerned.

²⁾ Two versions are currently available:
Up to 440 Nm for the V8 5V 4.2 l/3.7 l
Up to 650 Nm for the V8 TDI 4.0 l and W12 6.0 l

³⁾ The differences in weight result from the different torque converters, clutches and planetary gear train design.

Transmission ratios

Planetary gearbox

1st gear	4.171
2nd gear	2.340
3rd gear	1.521
4th gear	1.143
5th gear	0.867
6th gear	0.691
R gear	3.403

Primary drive

32Z/30Z 1.067

Front-axle spur gear unit

31Z/29Z 1.069

Front-axle bevel gear unit

32Z/11Z 2.909

Rear-axle bevel gear unit

31Z/10Z 3.100

i constant (front/rear axle)

3.317 / 3.307

(data apply to GNU only)

Spread

6.04

Front/rear axle torque distribution

Torsen centre differential type A 50/50

Gear oils

Lifetime fill

ATF specification

G 055 005 A2

Shell ATF M-1375.4

Front-axle differential and
transfer case specification

G 052 145 A1/S2

(Burmah SAF-AG4 1016)

Gear oil quantities

ATF

approx. 10.4 l (fresh fill)

Front-axle differential

approx. 1.1 l (fresh fill)

Transfer case

approx. 1.1 l (fresh fill)

Total weight (incl. oil and ATF cooler) ³⁾

approx. 138 kg (440 Nm version)

approx. 142 kg (650 Nm version)

Length (from engine flange to rear-axle flange
shaft)

approx. 98 cm (95 cm with 01L gearbox)

General

Brief description

The development aims....

- Improved performance
- Reduced consumption and emissions
- Greater efficiency
- Better weight distribution of drive system components
- Less weight
- High degree of gearshift spontaneity with outstanding shift comfort
- Minimisation of manufacturing costs with increased reliability and durability

....were implemented as outlined in the following.

One of the main factors in achieving the development goals in the fields of consumption, emissions and performance was the increase in gear ratio steps to include 6 forward gears in conjunction with a greater overall spread.

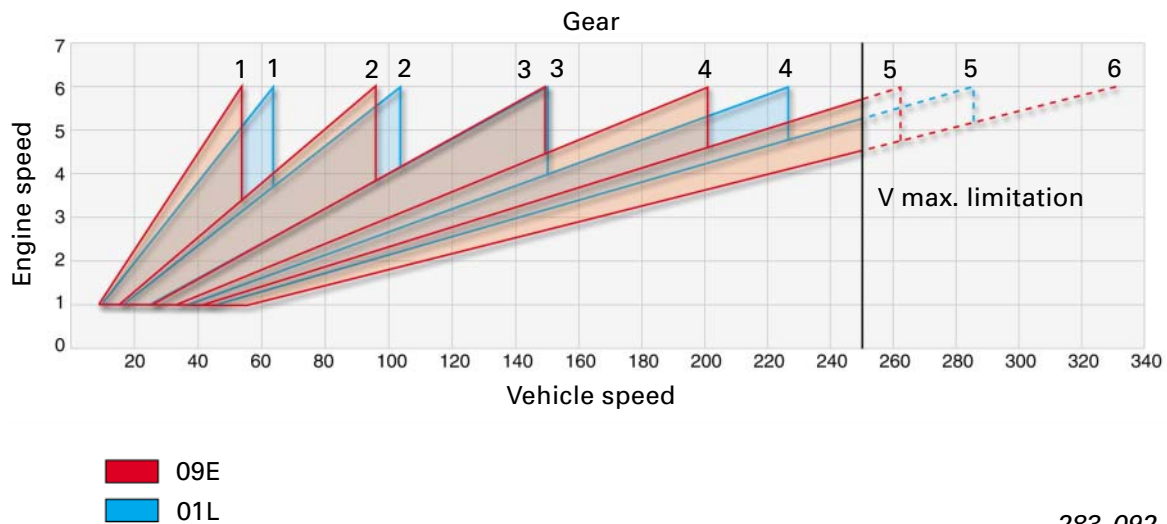
With a spread of 6.04, the 09E attains levels which were previously the sole domain of continuously variable transmission systems.

The 6-speed planetary gearbox is based on the Lepelletier principle. This concept is characterised by harmonic gear ratio steps and the implementation of six forward gears and one reverse gear with only five selector elements.

Explanatory note:

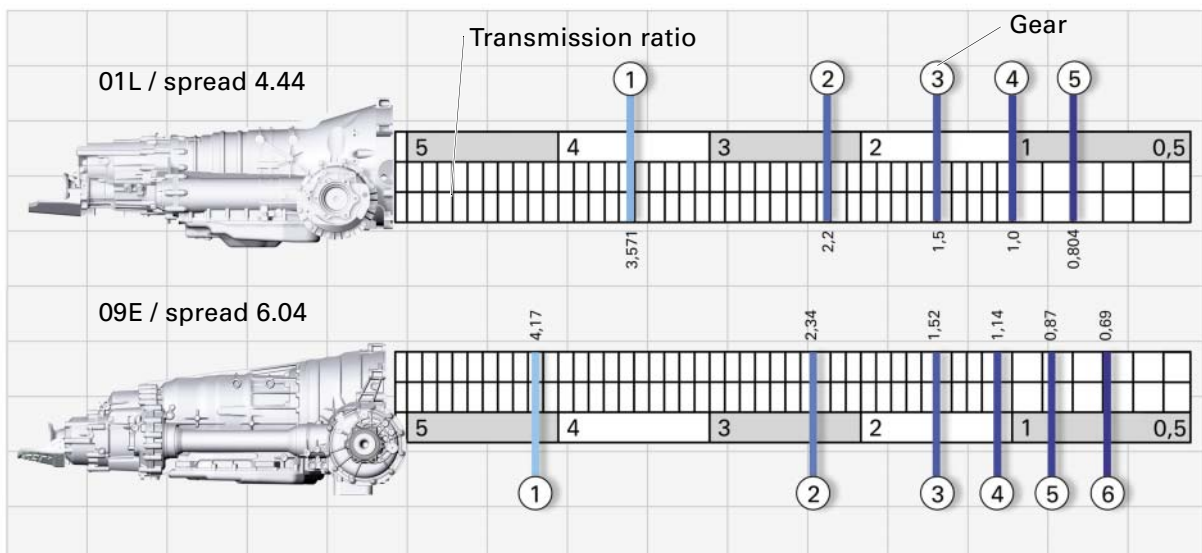
The gear train configuration used here was designed some 10 years ago by the now 75-year old engineer M. Lepelletier, the owner of the patent for this design which now bears his name.

01L / 09E transmission ratio comparison



283_092

Transmission ratio comparison / spread



283_086

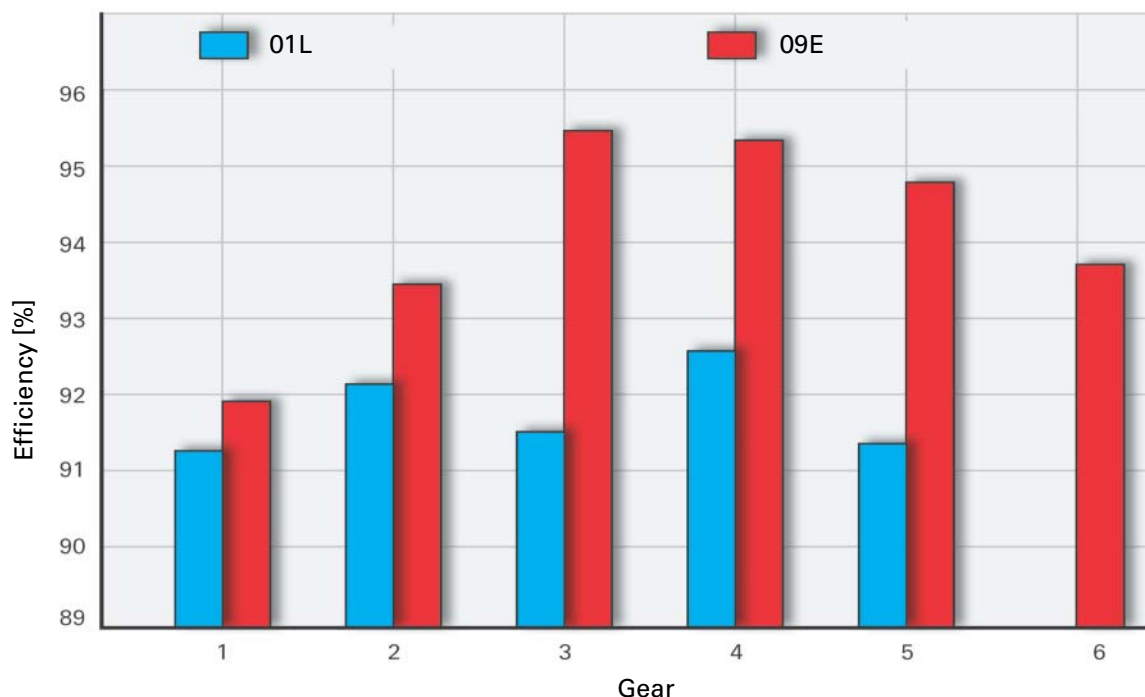


Petrol and diesel engines attain maximum speed in 5th and 6th gear respectively.

General

Optimisation of a wide range of details and technical concepts resulted in enhanced gearbox efficiency:

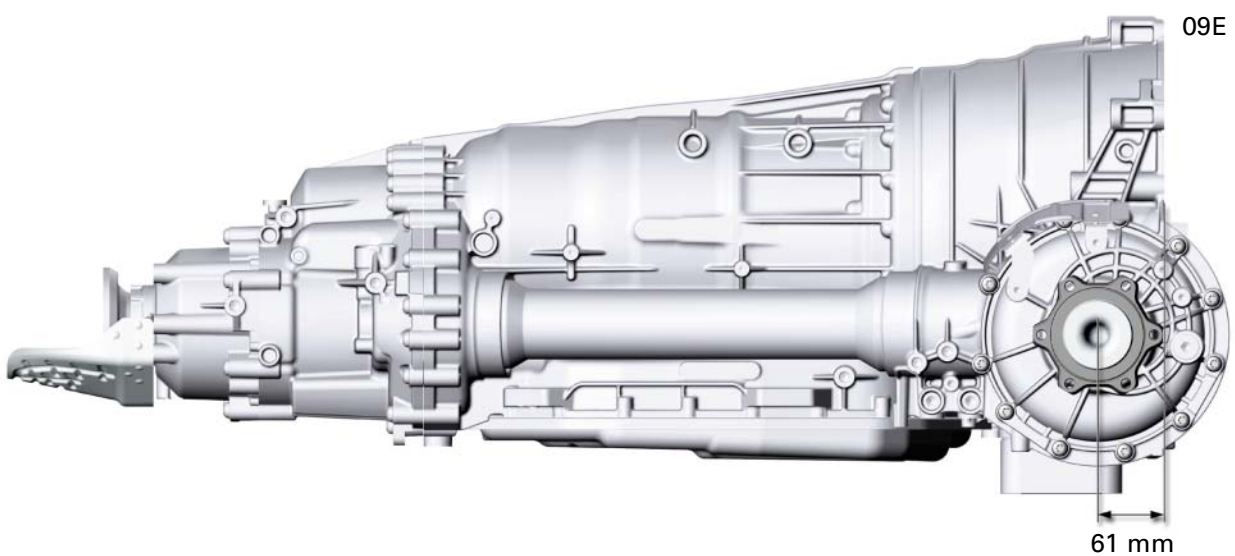
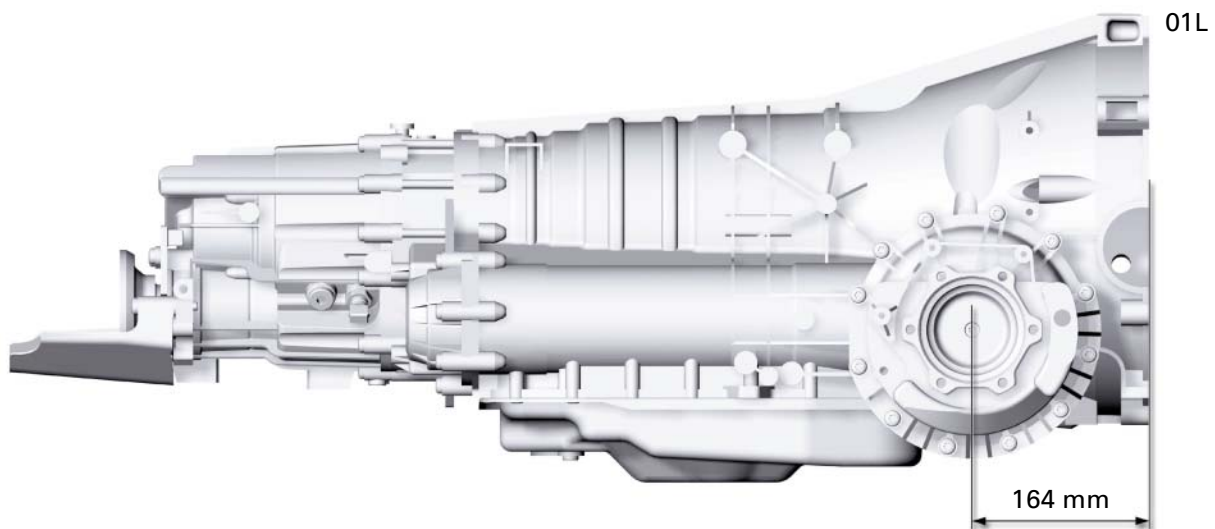
- The fact that there are only five selector elements reduces the friction torque in the clutches with no power transmission.
- A new, optimised gear oil with lower viscosity particularly at low gearbox temperatures reduces the friction loss.
- Improved internally geared oil pump with smaller delivery volume and reduced leakage.
- Optimisation of oil supply with reduced leakage in hydraulic control system.
- Increase in gearing efficiency to greater than 99% through optimisation of gear trains.
- Increase in permissible friction power of controlled torque converter clutch, thus extending the operating range (for more details, refer to Page 34 onwards).
- The "stationary vehicle decoupling" function reduces engine output when the vehicle is stopped with a gear engaged by interrupting power transmission. In addition to reducing consumption, ride comfort is enhanced due to the fact that less braking force is required (for more details refer to Part 2 SSP 284, Page 30 onwards).



283_136

A special feature of particular note with regard to the 09E automatic gearbox is the location of the front axle differential (flange shaft) in front of the torque converter.

The distance between flange shaft and engine flange is now only 61 mm (01L = 164 mm).



283_004

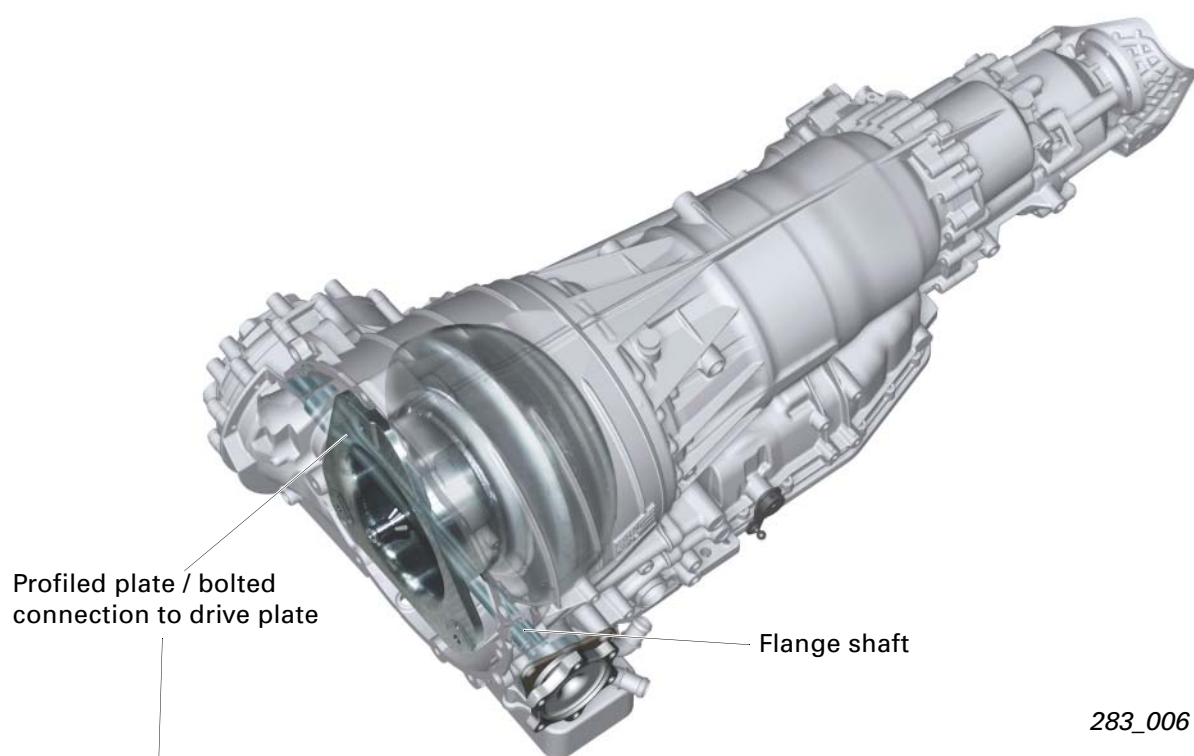
General

The method of bolting the torque converter to the drive plate by means of a profiled plate meant that it was possible to move the torque converter to the rear and create space for the flange shaft.

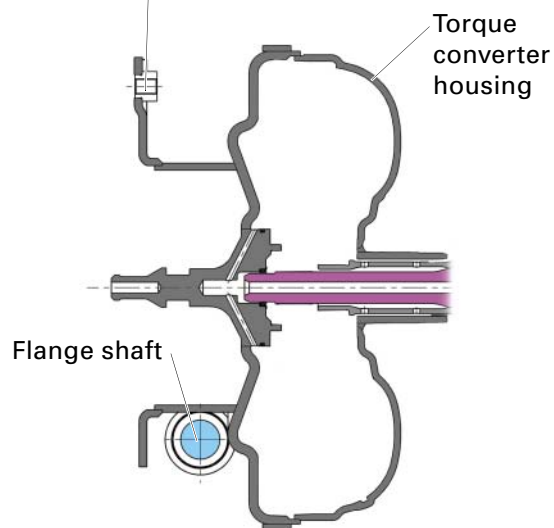
Thanks to this sophisticated concept, the entire drive unit is now closer to the centre of the vehicle.

The resultant more even weight distribution between front and rear axle is of significant benefit to vehicle handling.

To make optimum use of this advantage for all engine versions, various spacers are fitted between engine and gearbox to adapt each engine type to the given installation situation.



283_006



283_111



283_157

Spacers:

W12 6.0 I	13 mm
4.2 I / 3.7 I with toothed belt drive	23 mm
V8 TDI 4.0 I	None

The Mechatronik integrated into the gearbox housing is a new development. It combines the hydraulic control unit, sensors/actuators and electronic gearbox control unit in a coordinated assembly (for more details refer to Part 2 SSP 284, Page 4 onwards).

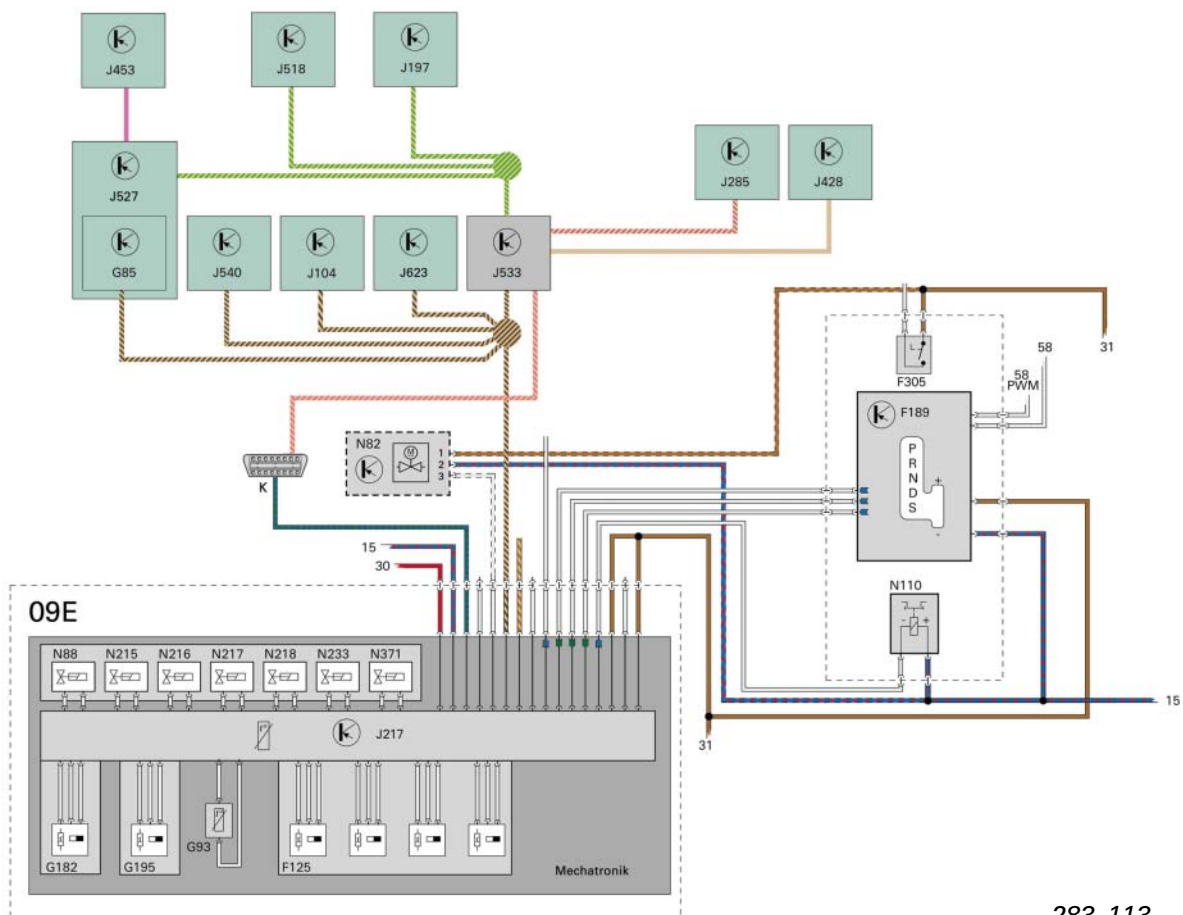


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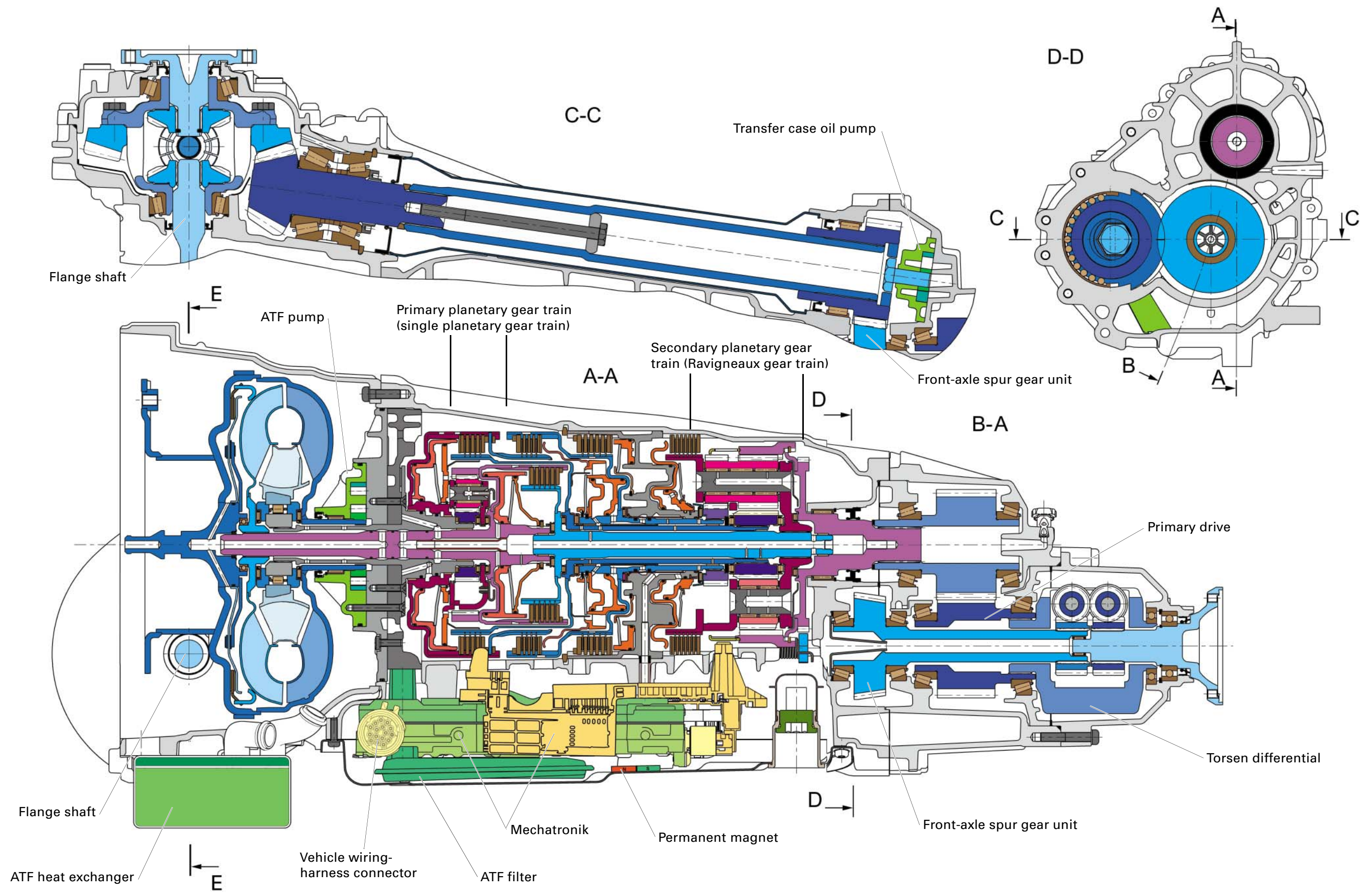


283_112

All data exchange with the vehicle periphery takes place via the drive system CAN, thus reducing the number of vehicle periphery interfaces to a minimum (13 pins) and at the same time enhancing operational reliability (for more details refer to Part 2 SSP 284, Page 25 onwards).

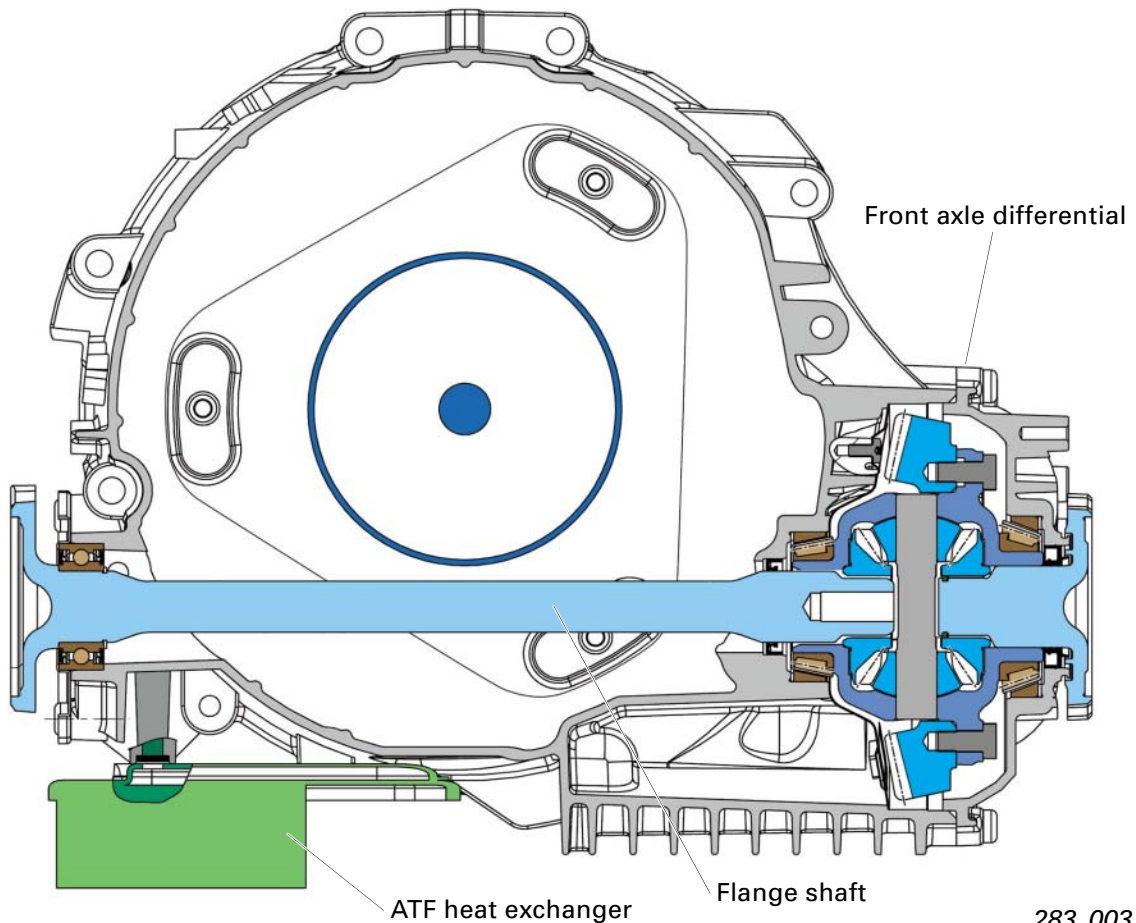


283_113











Sectional view of gearbox

E-E



283_003

Colour coding

	Hydraulic components / control
	Planetary gear train components
	Shafts / gears
	Electronic components / control unit
	Multi-plate clutches, bearings, washers, circlips
	Plastic, gaskets, rubber, washers
	Selector element components, cylinders / pistons / baffle plates
	Housings, bolts, pins

Gearbox Periphery

Selector mechanism

The selector lever forms the mechanical link between the driver and the selector slide of the hydraulic control system.

The selector lever permits "mechanical" selection of the following positions:

***P = Park position** for actuation of parking lock and interruption of power flow (neutral)
The ignition key can only be removed in this position (for more details refer to Ignition key removal lock, Page 26 onwards).

It is only possible to move out of P position with ignition switched on (for more details refer to Selector lever lock emergency release, Page 22 onwards).

R = Reverse gear
Reverse gear can still be engaged in gearbox emergency operation (for more details refer to Control of reversing lights in Part 2 SSP 284, Page 32 onwards).

***N = Neutral position**
Interruption of power flow (neutral)

D = Drive position
Automatic gearbox drive position, automatic selection of gears 1-6 with dynamic shift program DSP (for more details refer to Part 2 SSP 284, Page 36 onwards).

S = Sports program

Selector lever position "S" provides drivers with a power-oriented shift program. On receiving the information "Selector lever position S", the electronic control unit moves the characteristic shift curves to higher engine speeds, thus providing a higher level of vehicle dynamics. The DSP also ensures adaption to driver inputs (driving style factor) and driving situations in position "S".

Special features of "S" program:

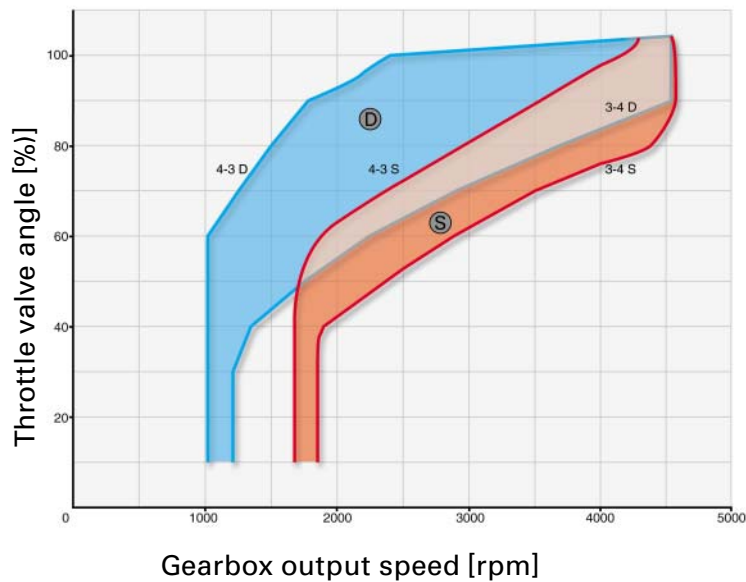
- Moving the selector lever to "S" whilst driving with the accelerator pedal held constantly in the same position results in change-down within defined limits.
- To achieve more direct vehicle reaction to accelerator pedal movement, the torque converter clutch is kept closed wherever possible whilst driving.
- If 6th gear is designed for overdrive in the overall transmission ratio, only gears 1-5 are selected.



Note on ***N** and ***P** for vehicles with entry and start authorisation button E408 (with advanced key system)

For safety reasons, the engine can only be switched off using button E408 (stop button) in selector lever position N or P.

Comparison of D/S characteristic shift curves

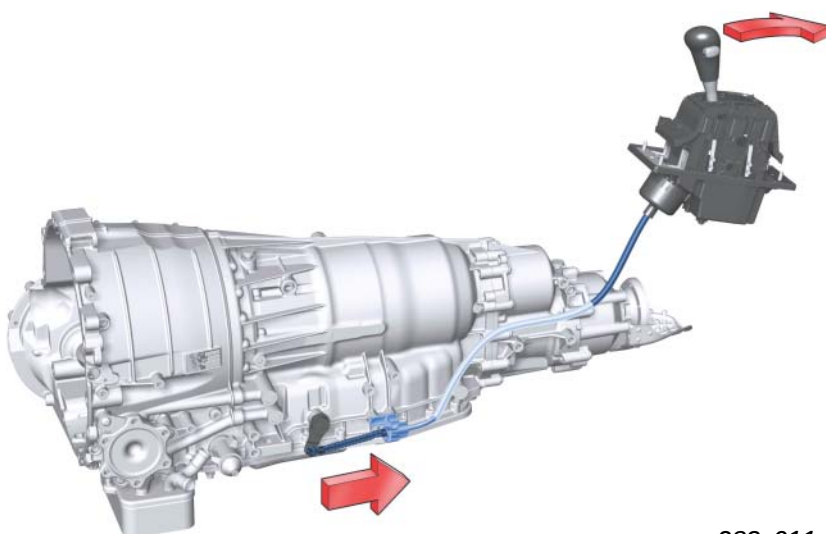


The sports program significantly extends the effective shift range between economical and sporty (for more details refer to Part 2 SSP 284, Page 39 onwards).

283_152

In terms of the following functions, there are interesting new aspects to the selector mechanism in the new Audi A8:

- Selector mechanism kinematics
- Selector lever/lock button kinematics
- Selector lever lock
- Ignition key removal lock
- Selector lever lock emergency release



283_011



283_115

Gearbox Periphery

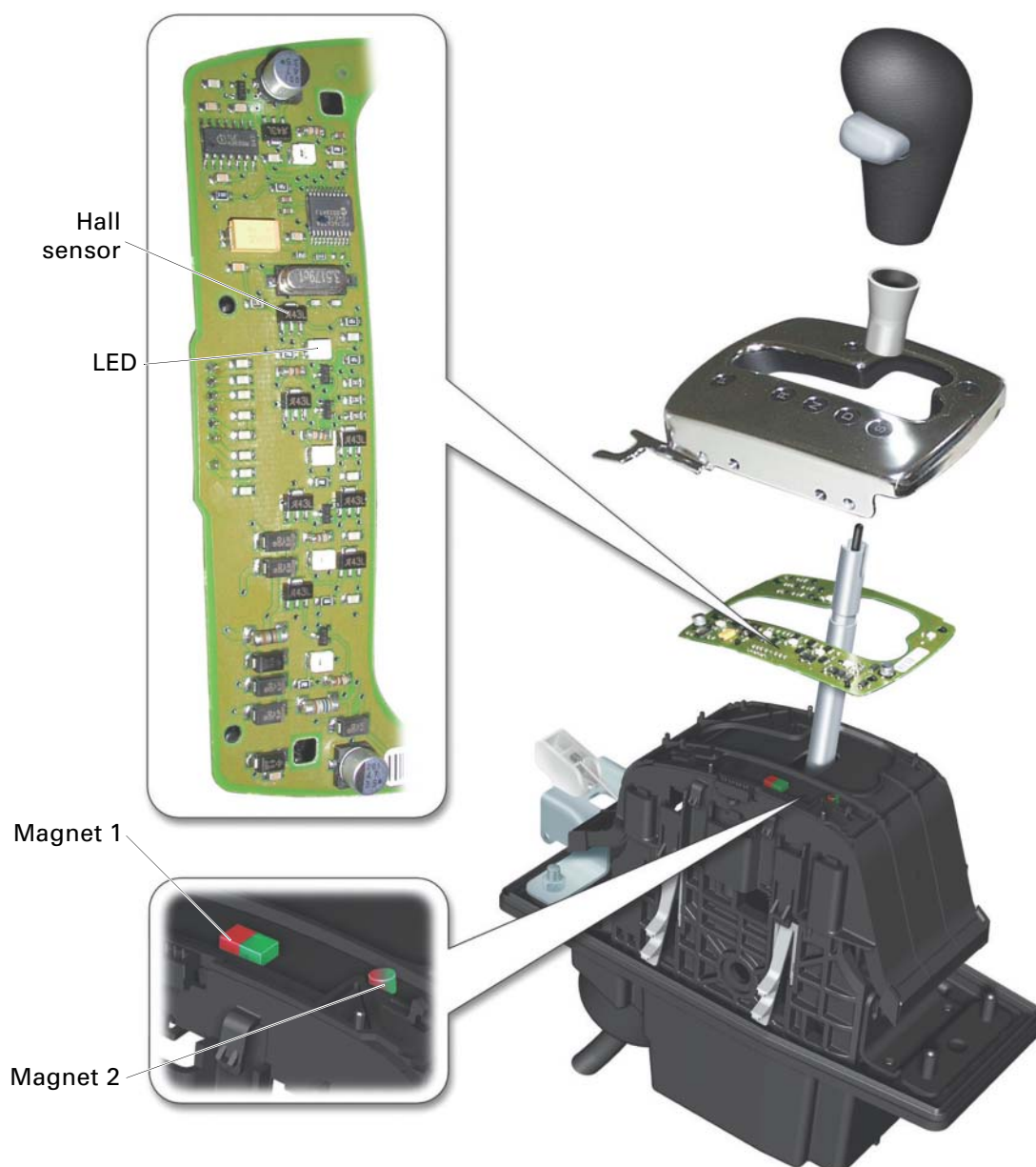
Selector lever gate

The selector lever gate is illuminated by means of correspondingly controlled LEDs.

The PC board of the selector lever gate is provided with 7 LEDs, one for each selector lever position as well as for the + and - symbols of the tiptronic gate.

One separate Hall sensor each controls the corresponding selector lever position LED.

The appropriate Hall sensors are switched by way of the permanent magnet 1 positioned on the masking panel (for more details refer to tiptronic switch F189 in Part 2 SSP 284, Page 18 onwards).



283_009

Selector mechanism kinematics

The installation situation in the new Audi A8 makes it possible to achieve selector mechanism kinematics involving pulling rather than pushing of the selector lever cable on "Shifting out of position P". This permits a highly flexible selector lever cable design, thus reducing the transmission of vibration to the passenger compartment and at the same time improving noise levels.

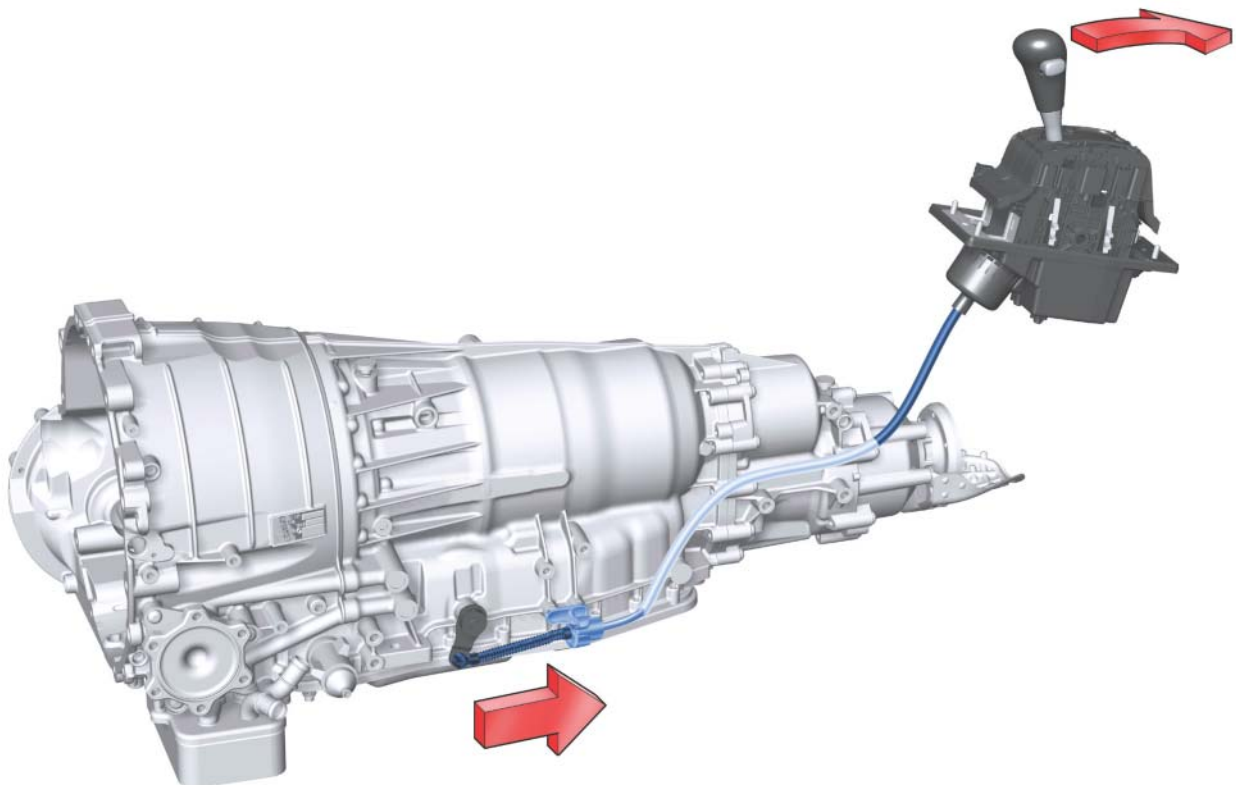
Cables are capable of withstanding high tensile force. In the opposite direction however (thrust) they are highly susceptible to kinking for physical reasons.

To be able to transmit the required level of thrust, selector lever cables therefore had to be sufficiently thick and thus rigid in design.

A rigid selector lever cable transmits vibrations to a far greater extent than a flexible one.

If the selector lever cable is subject to tension in its installation position, vibration from the drive system is transmitted to the passenger compartment and often leads to a noise nuisance.

Tension-free routing of the cable is of great importance in terms of passenger compartment noise levels.



283_011

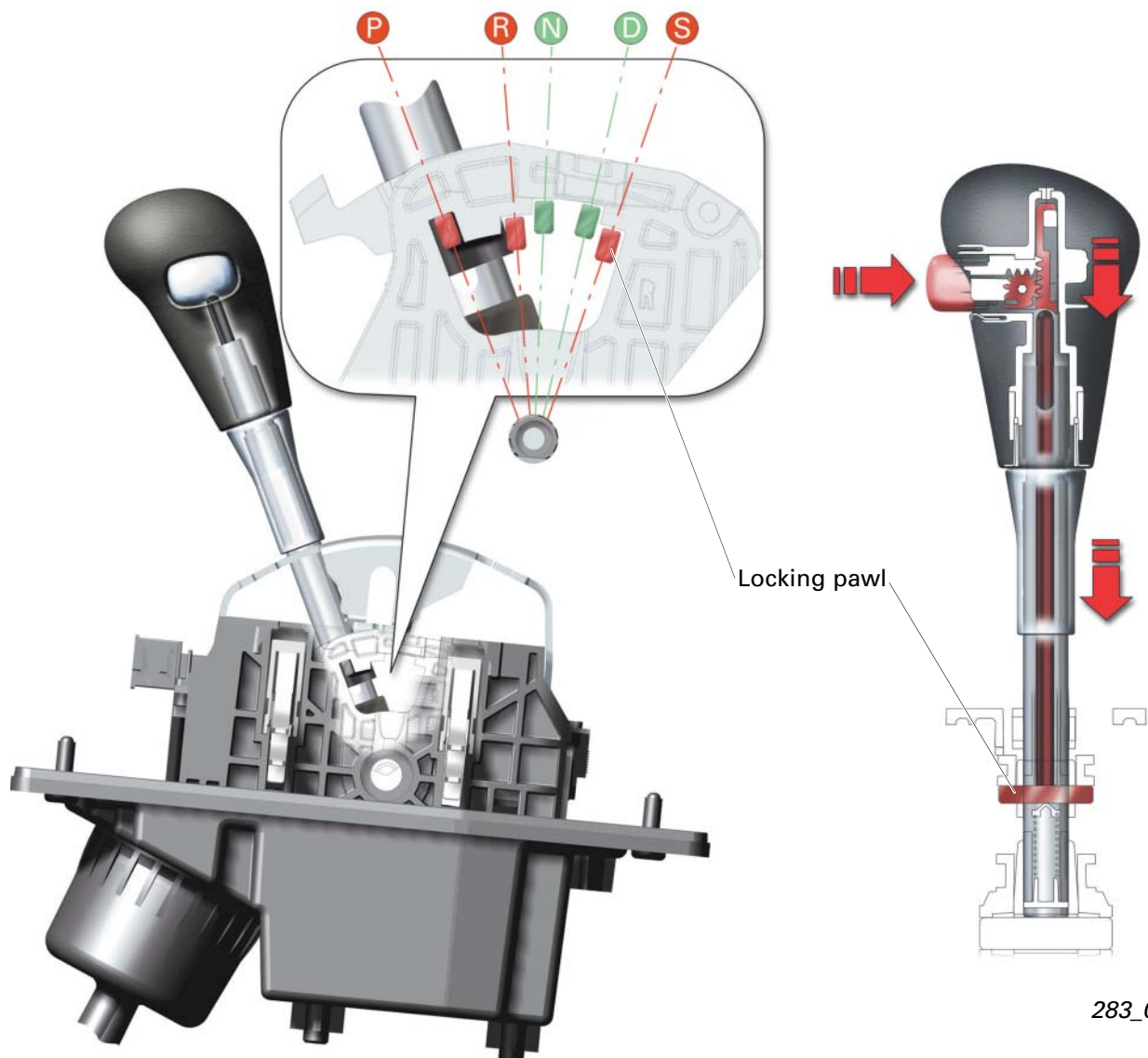
Gearbox Periphery

Selector lever/button kinematics

To prevent inadvertent shifting into selector lever position "S", a change has been made to the selector lever kinematics such that switching to "S" involves pressing the button in the gearstick knob.

A small gear mechanism is provided in the gearstick knob to reduce the required button operating force.

The locking rod is actuated by the application of pressure, which means changes have also been made to kinematics and gearstick knob assembly (refer to Workshop Manual).



283_018

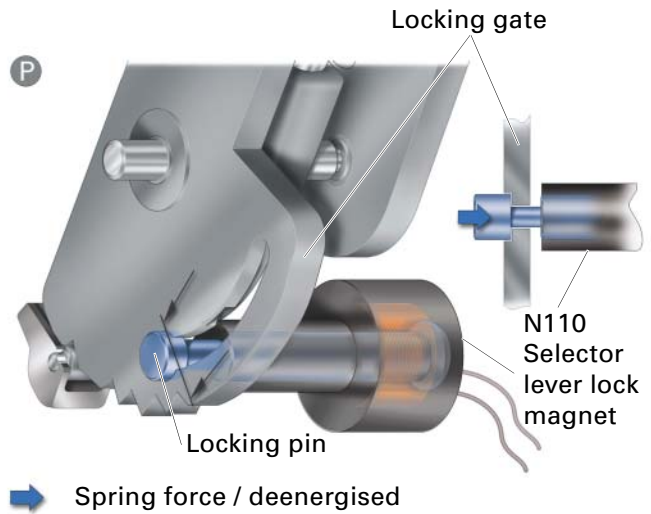
283_017

Selector lever locks (P lock + P/N lock)

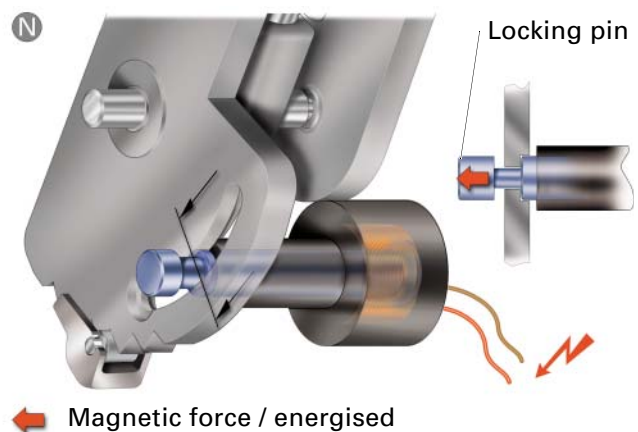
A basic distinction is made between the P/N lock whilst driving/with ignition switched on and locking of the selector lever in position P with the ignition key removed (P lock).

In the past, the P lock function was implemented by the steering column lock by means of a cable to the selector mechanism. On account of the new "electronic ignition/ starter switch" (entry and start authorisation switch E415) and the electrical steering column lock control element N360, there is now no cable and thus also no mechanical link.

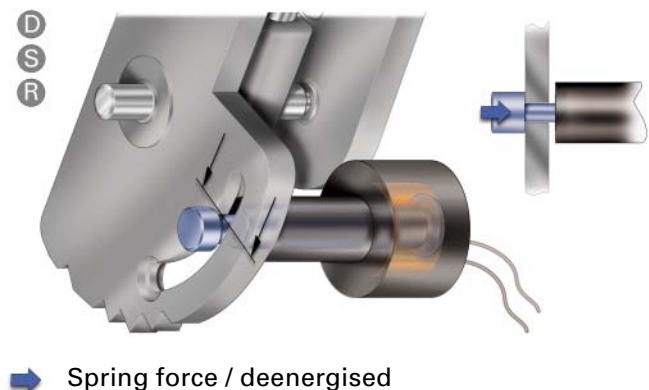
On the A8'03, the P lock function is assumed by the locking pin of N110. To achieve this, the locking gate of the selector lever and the locking pin of N110 are designed such that locking is possible both with N110 deenergised (P) and energised (N).



283_051



283_052



283_053

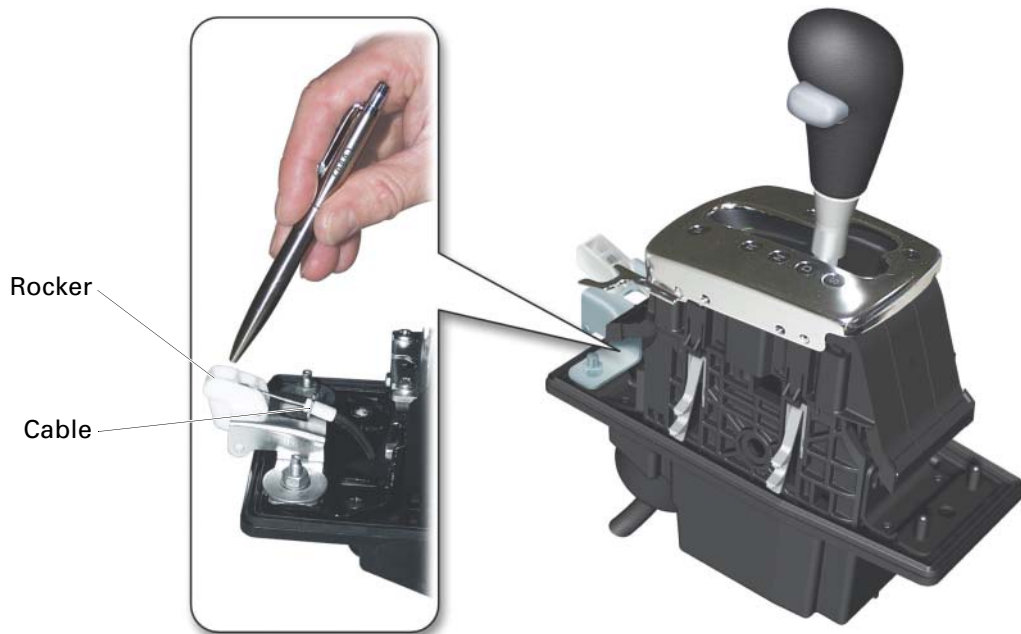
Gearbox Periphery

Selector lever lock emergency release

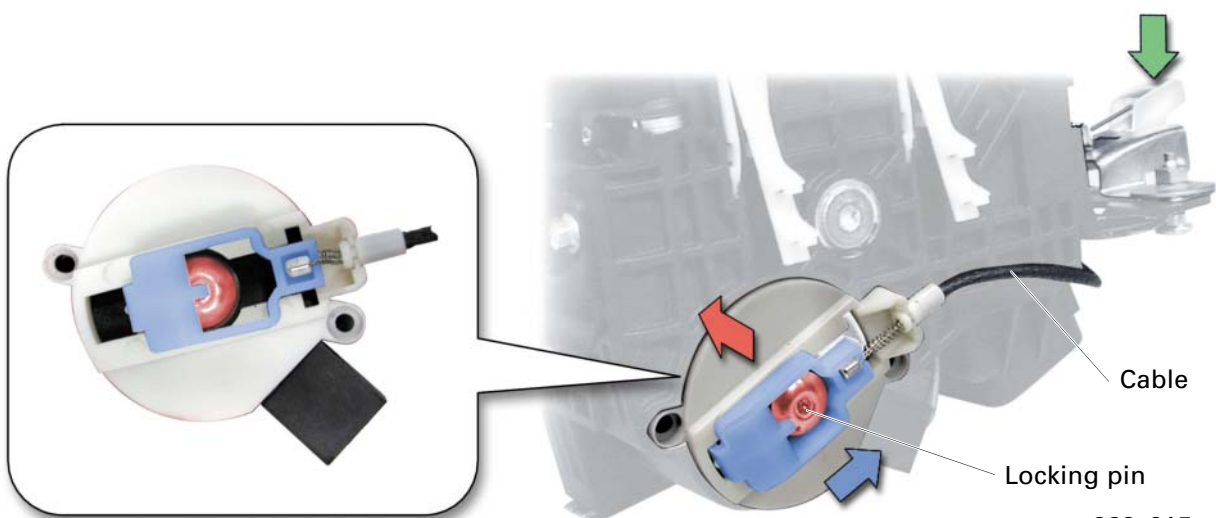
As a result of this modified function, the selector lever remains locked in position "P" in the event of problems with or failure of the power supply (e.g. battery flat). An emergency release mechanism is provided for the selector lever lock to enable the vehicle to be moved in such circumstances (e.g. towing).

Access to the emergency release mechanism is provided by removing the ashtray insert.

Actuation of the rocker causes a small cable mechanism to pull the locking pin of N110 out of the P lock, overcoming the spring force.



283_016



283_015

tiptronic steering wheel

The tiptronic steering wheel controls have been re-designed. One paddle each for change-up (+ right) and change-down (- left) is provided on the back of the steering wheel on either side.

In combination with the tiptronic steering wheel, the "tiptronic" function is also available in selector lever position "D" or "S".

The tiptronic function is selected by actuating one of the two one-touch paddles on the steering wheel (selector lever in position "D" or "S"). The system then switches to the tiptronic function for roughly 8 seconds. Any gear can be selected in the permissible engine speed ranges.

Gears can be skipped by tapping several times, e.g. to change down from 6th to 3rd gear.

Return to normal automatic gearbox operation takes place approx. 8 seconds after the last one-touch shift request.

Special feature:

The approx. 8 second countdown before returning to normal automatic gearbox operation is interrupted while ever cornering is detected or if the vehicle is in overrun mode.

The period is extended as a function of vehicle dynamics. Switching from one-touch function to automatic mode is however implemented after 40 seconds at the latest.



The steering wheel tiptronic function in selector lever position D or S is not authorised for the USA.



283_020

tiptronic/selection strategy

The automatic gearbox selects the next gear up before the maximum engine speed is exceeded.

Change-down to the next lowest gear is implemented on dropping below a minimum engine speed.

Kick-down results in change-down to the lowest possible gear.

Driving off always takes place in 1st gear.

In addition to permitting manual gearshift, the tiptronic function offers a further application:

As positions 4, 3, 2 no longer exist (new selector lever gate with positions D and S), prevention of change-up must be selected if required using the tiptronic function (by shifting selector lever to "tip" gate).

For more details, refer to tiptronic switch F189 in Part 2 SSP 284, Page 18 onwards.

Selector lever position and gear indicator in dash panel insert

Most gearbox control faults and malfunctions are covered by the comprehensive self-diagnosis function.

Depending on their effect on the gearbox and road safety, faults are indicated to the driver by means of an inverted segment display in the selector lever position indicator.

The vehicle should be taken to an Audi Service workshop without delay to have the fault rectified.



Automatic mode

283_117



tiptronic mode

283_118



Fault display

283_119

Gearbox Periphery

Ignition key removal lock

Major modifications have been made to operation of the ignition key removal lock and selector lever lock (shiftlock). On account of the new "electronic ignition/starter switch" (entry and start authorisation switch E415) and the electrical steering column lock control element N360, there is now no mechanical link between the selector mechanism and the steering column lock (cable).

Release of the ignition key removal lock is controlled by the entry and start authorisation control unit J518 and implemented by the ignition key withdrawal lock magnet N376 integrated into the entry and start authorisation switch E415.

The selector lever position "P" information is supplied by the gear selector position P switch F305 (mechanical microswitch).

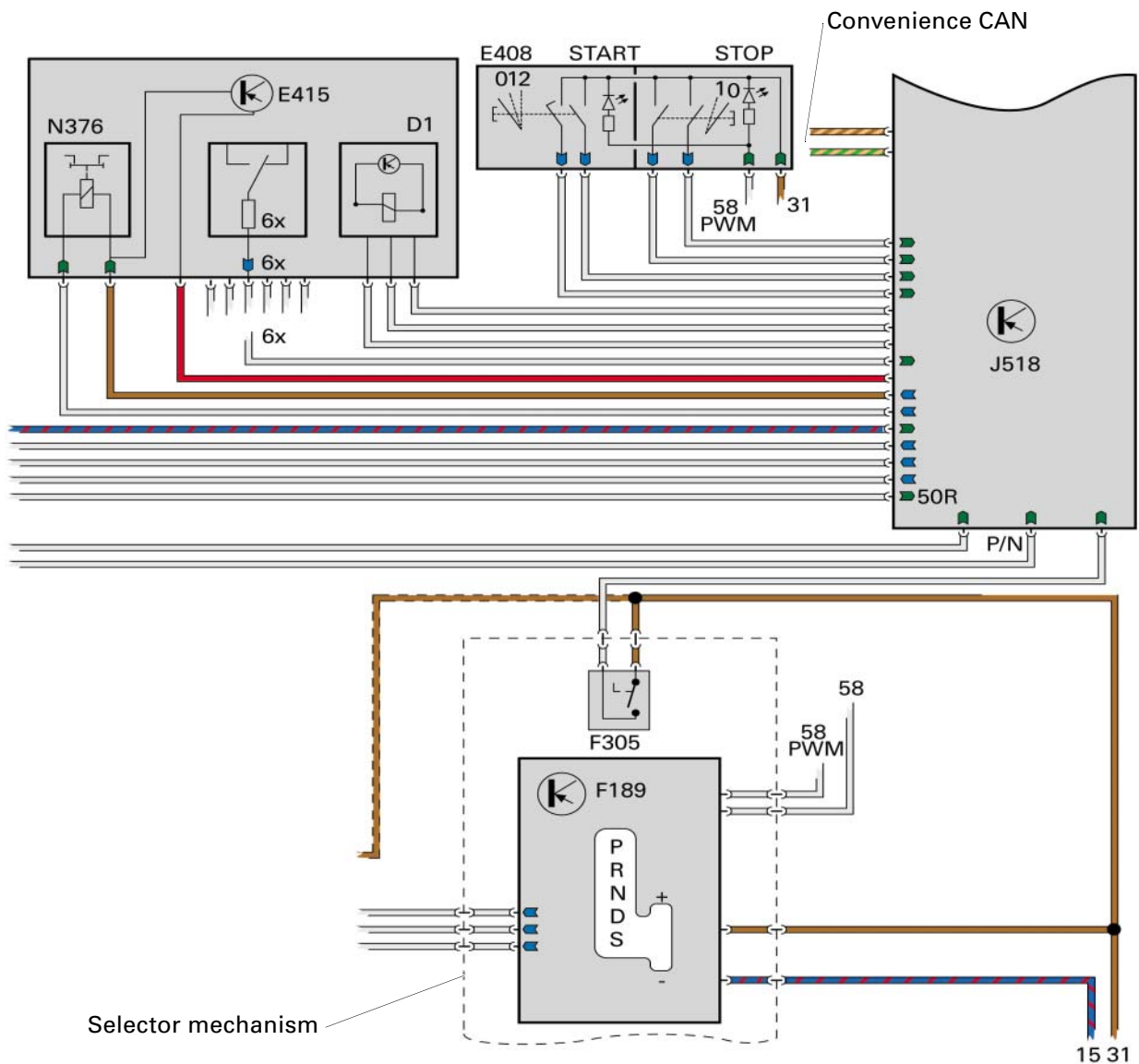
In parallel to this, the shift position is transmitted from the gear sensor F125 by way of CAN data exchange and from the automatic gearbox control unit J217 to the control unit J518.

In selector lever position P, the control unit J518 switches voltage to E415, as a result of which the ignition key withdrawal lock magnet N376 cancels key locking.

If the selector lever is not set to "P" in switch position "OFF", the driver is informed of this situation on opening the driver's door by way of an acoustic signal and a visual display in the dash panel insert.



283_121



283_120

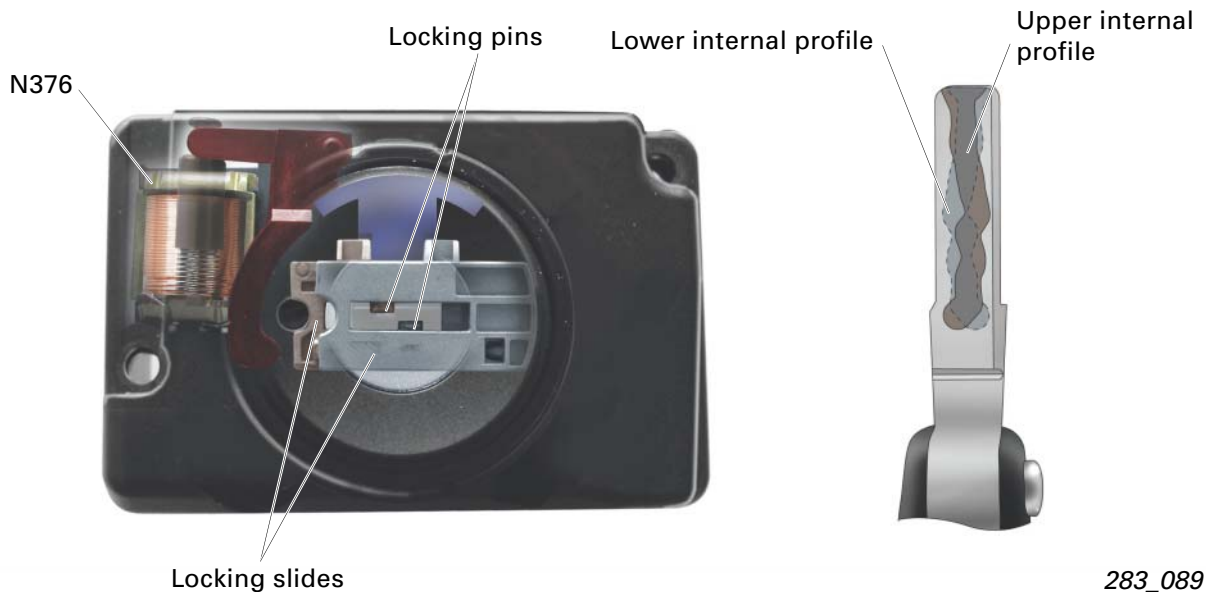
- D1 Inhibitor reading unit
- E408 Entry and start authorisation button
- E415 Entry and start authorisation switch
- F305 Gear selector position P switch
- J217 Automatic gearbox control unit
- J518 Entry and start authorisation control unit
- N110 Selector lever lock magnet
- N376 Ignition key withdrawal lock magnet (in E415)

Gearbox Periphery

Ignition key removal lock function

There are two spring-loaded locking slides with one locking pin each behind the opening for the ignition key. On inserting and removing the ignition key, the locking pins slide through the internal profile of the ignition key on both sides. In this process the two locking slides move axially in opposite directions.

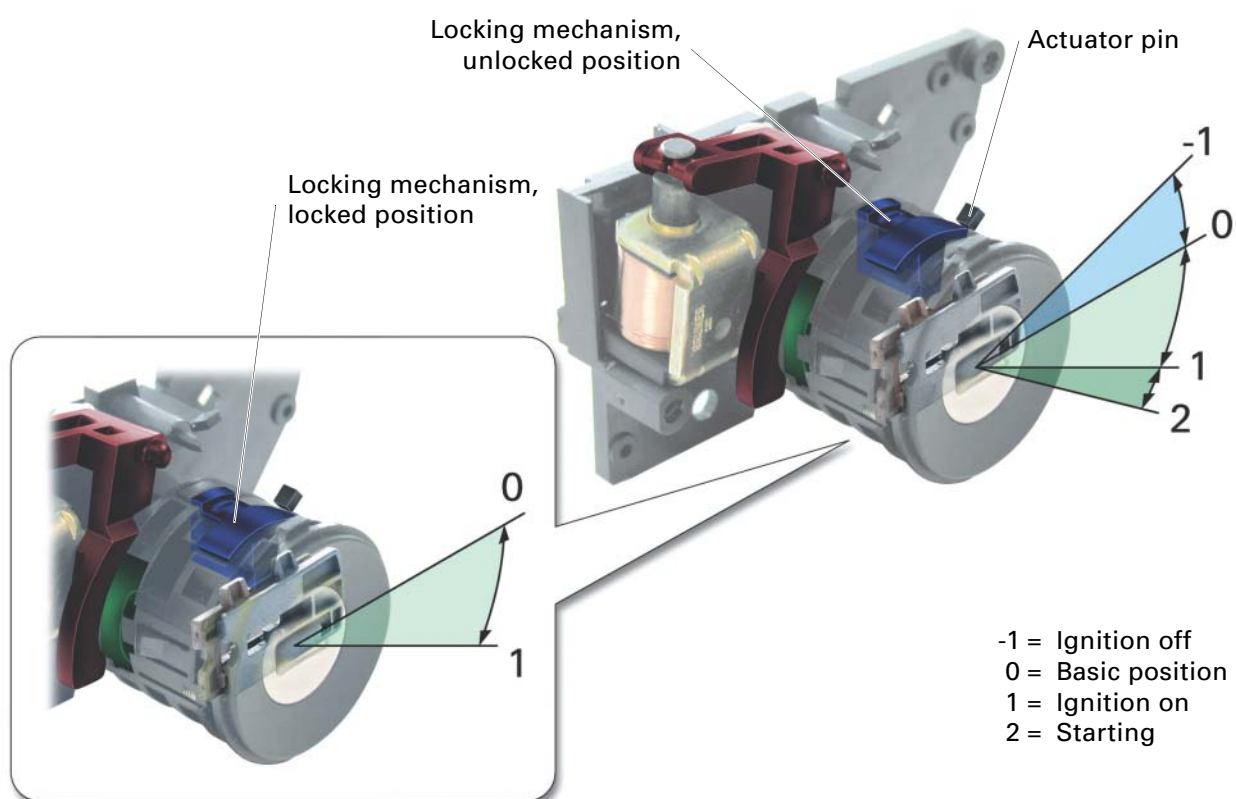
If the ignition key is fully inserted, the locking slides/locking pins are in basic position (as when key is not inserted).



Engaging removal lock:

When the ignition is switched on (clockwise turn to pos. 1), a mechanical locking mechanism prevents axial movement of the locking plates.

The locking pins are blocked and cannot follow the contour of the internal profile. The ignition key is thus locked and cannot be removed.



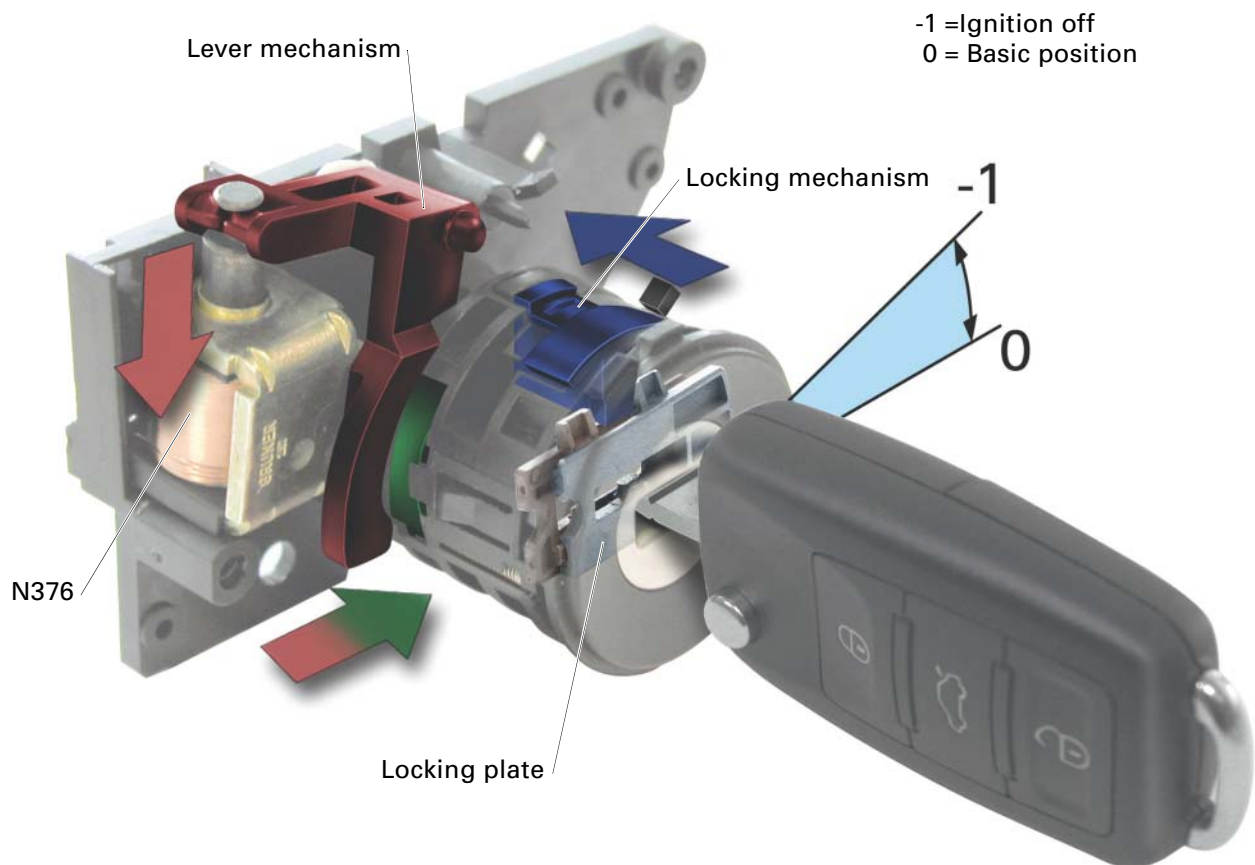
283_090

Gearbox Periphery

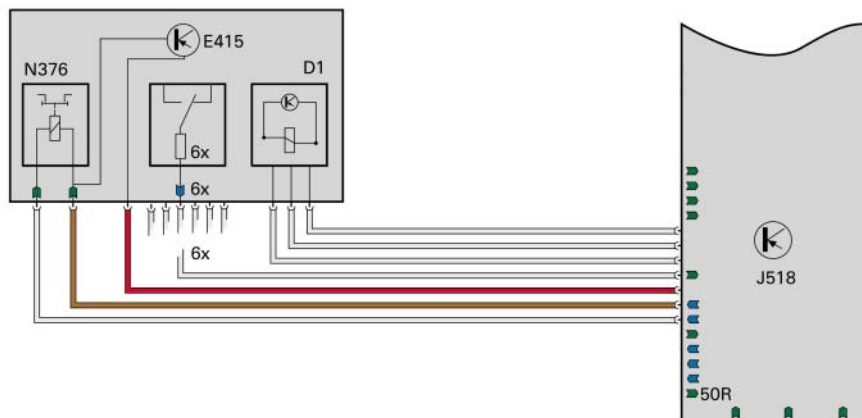
Releasing removal lock:

When ignition is switched off and selector lever is set to position "P", the entry and start authorisation control unit J518 energises the ignition key withdrawal lock magnet N376 briefly.

The lever mechanism of N376 then releases the locking mechanism of the locking plates and the ignition key can be removed.



283_095



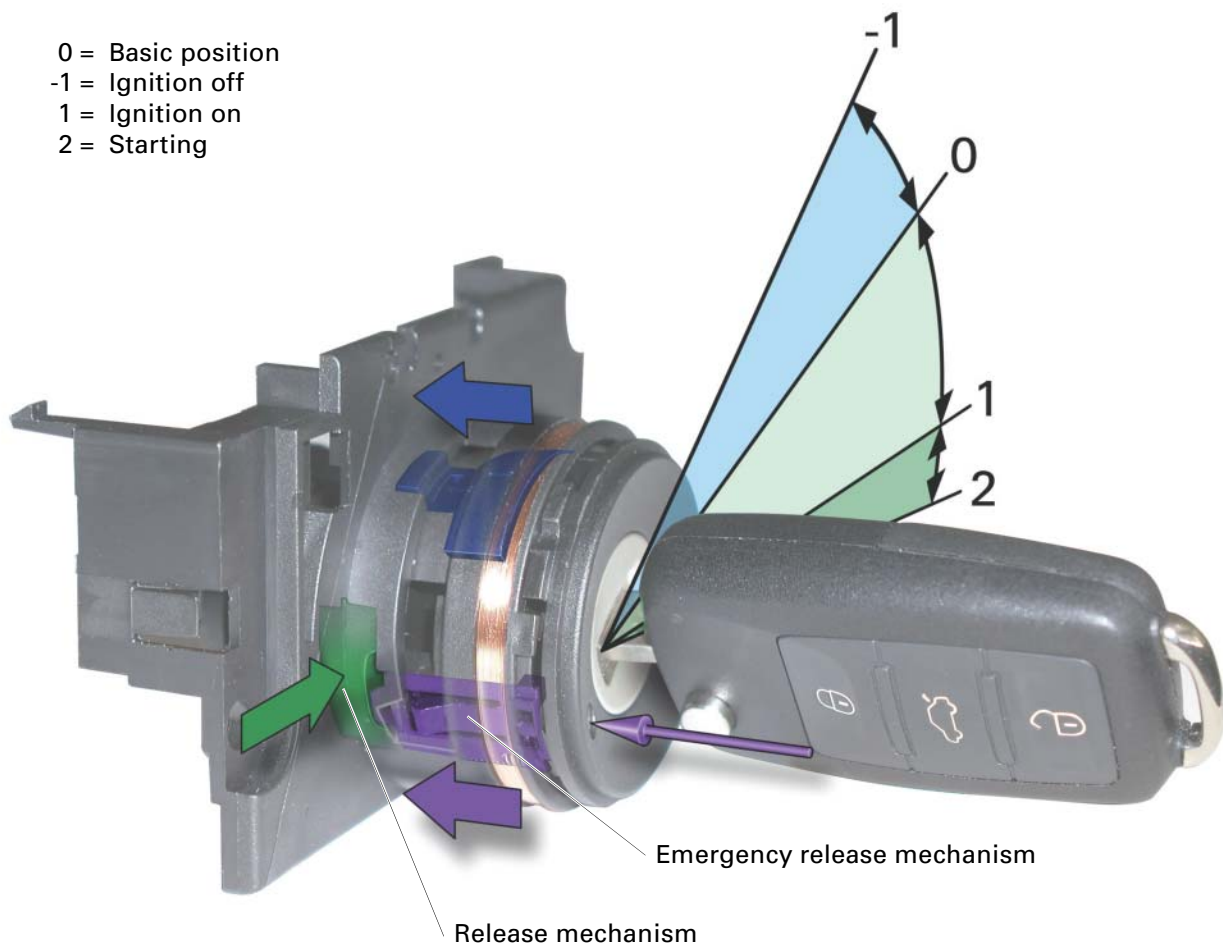
283_156

Removal lock emergency release

In the absence of electrical system voltage or in the event of malfunction, an emergency release mechanism permits removal of the key from the switch E415. This involves pressing the release knob with a ballpoint pen, for example, in "OFF" position.

The locking mechanism is thus released and the key can be removed.

- 0 = Basic position
- 1 = Ignition off
- 1 = Ignition on
- 2 = Starting



283_096



The entry and start authorisation switch E415 is not assigned to any particular key. In other words, E415 can be actuated by inserting various keys.

An authorised key is recognised electronically by means of reader coil and transponder.

Gearbox Periphery

Starting lock/starter control

(Audi A8 '03)

As has always been the case, the starting lock function only permits starter operation in selector lever position P or N.

A new feature is automatic implementation of starter control (actuation of term. 50) by the engine control unit J623.

Release for starter actuation is always transmitted by the entry and start authorisation control unit J518 to the engine control unit J623. One of the release requirements is that control unit J217 transmits the selector slide position information P or N to the control units J623 and J518.

A further requirement when starting with button E408 is that the brake pedal is pressed (brake light switch F signal via separate interface to J518). **The ignition key must not be inserted in E415.**

The gear sensor F125 detects the positions of the selector slide and relays this information to the gearbox control unit J217.

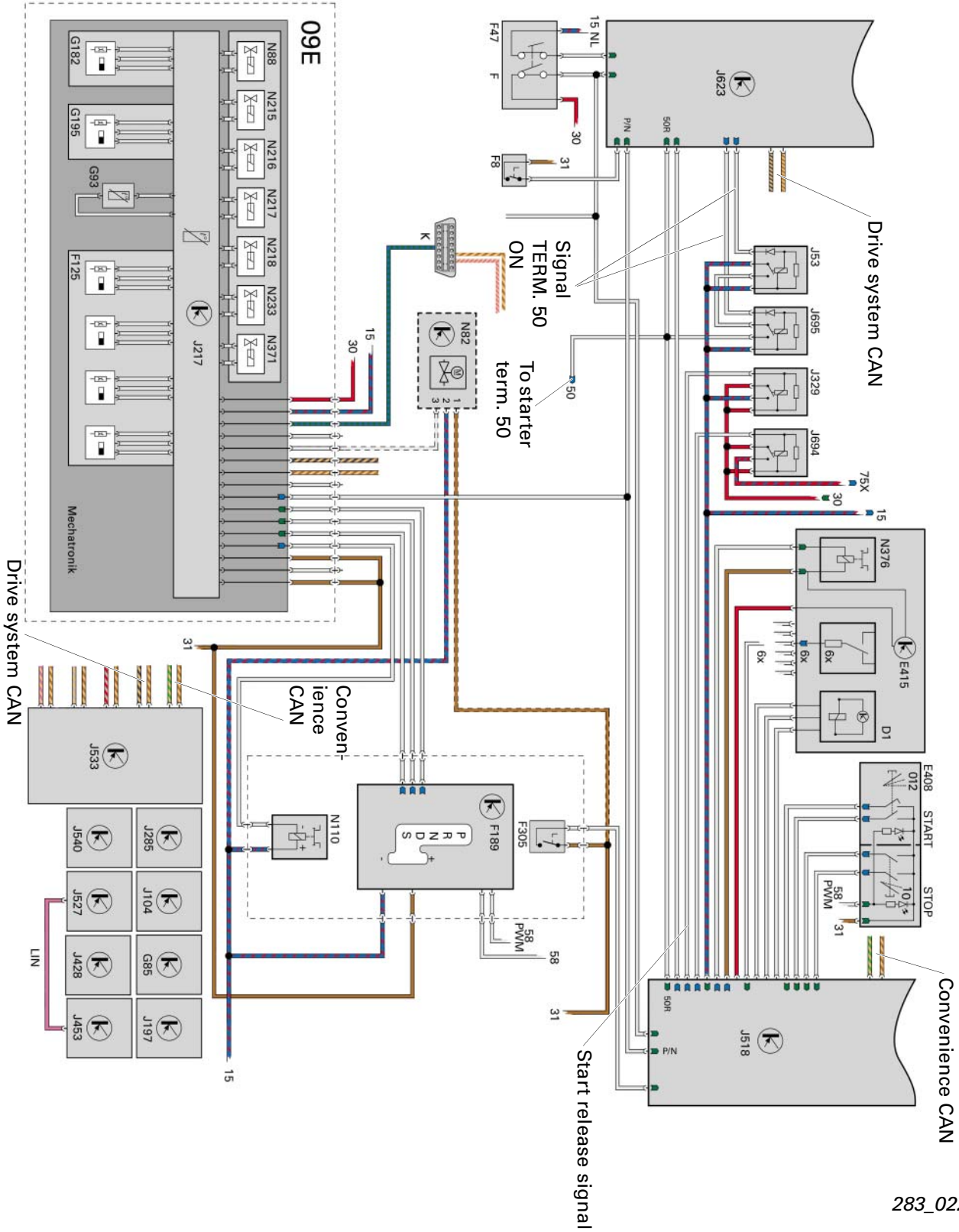
The information P/N is transmitted by J217 via separate interfaces to J623 and J518 (earth signal with P/N).

J217 also transmits the selector slide position information via the drive system CAN.

The information is passed by means of the data bus diagnostic interface J533 to the entry and start authorisation control unit J518. This permits plausibility checking and thus diagnosis of the separate interfaces.

Refer also to block diagram in Part 2 SSP 284, Page 26 onwards (general view).

E408	Entry and start authorisation button
E415	Entry and start authorisation switch (electronic ignition switch)
F	Brake light switch
F125	Gear sensor
J217	Automatic gearbox control unit
J518	Entry and start authorisation control unit
J533	Data bus diagnostic interface (gateway)
J623	Engine control unit



Gearbox Assemblies

Torque converter

Torque converter clutch

Torque converters operate on the basic fluid coupling principle. This automatically leads to a difference in speed between pump and turbine impellers. This is referred to as converter slip, which causes a reduction in efficiency.

The torque converter clutch (TCC) eliminates converter slip and thus contributes towards achieving optimum consumption. Modern torque converters have therefore been fitted with a TCC for many years.

Closing and opening of the TCC is regulated in the interests of ride comfort.

A basic distinction is made between three operating statuses:

- TCC open
- TCC control mode
- TCC closed

Power transmission via the TCC used to be subject to relatively tight limits. For this reason, the TCC was only closed in the higher gears and operated on a controlled basis at low engine torques.

The permissible friction power of the TCC was increased with the 09E automatic gearbox, thus considerably extending the operating range and enhancing the overall efficiency of the drive system.

The TCC ...

- ... can be engaged in all gears
- ... can be engaged with any engine torque
- ... is engaged as of 40°C ATF temperature

To achieve constant transmission of the high torque levels, the TCC has two friction surfaces.

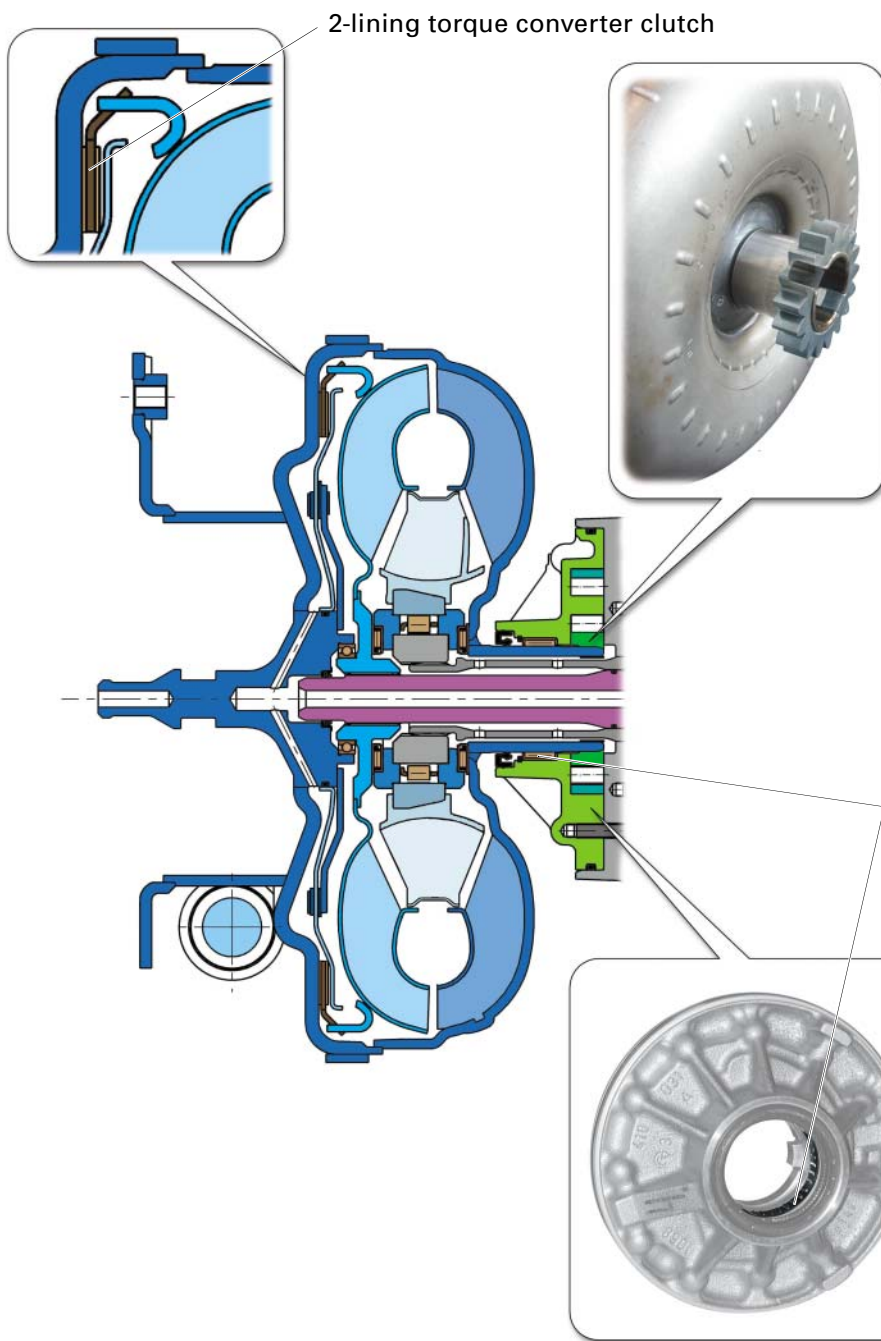
The TCC has a separate lining plate. This plate is provided on both sides with a clutch lining, thus creating two friction surfaces.

The lining plate is located between the torque converter cover (converter housing) and the TCC piston. These two components are mutually friction locked. The lining plate is positively connected to the turbine impeller. On closing the TCC, the torque is transmitted from both sides to the lining plate and thus to the turbine impeller.

In line with physical principles, doubling the number of friction surfaces also doubles the amount of force which can be transmitted.

To ensure TCC durability and a long service life, the new ATF G 055 005 A2 was specially developed to suit the exacting requirements involved.

The torque converter is matched to the power output and characteristics of the engine. In the event of complaints and when replacing the torque converter, particular attention should be paid to correct assignment to the engine/gearbox. The torque converter multiplication can be read out by way of self-diagnosis function 08 "Reading measured value block".



When installing the torque converter, particular care is to be taken to ensure that the grooves of the converter hub engage in the oil pump drivers (refer to Workshop Manual).

Roller bearing mounting

The mounting of the torque converter in the oil pump housing takes the form of a wear-resistant roller bearing. This design ensures a long mounting service life, particularly under operating conditions with restricted oil supply (on cold initial starting).

283_013



The basic mode of operation of the torque converter is explained in the Multimedia Training Programme "Power Transmission 2" (000.2700.21.20).

Gearbox Assemblies

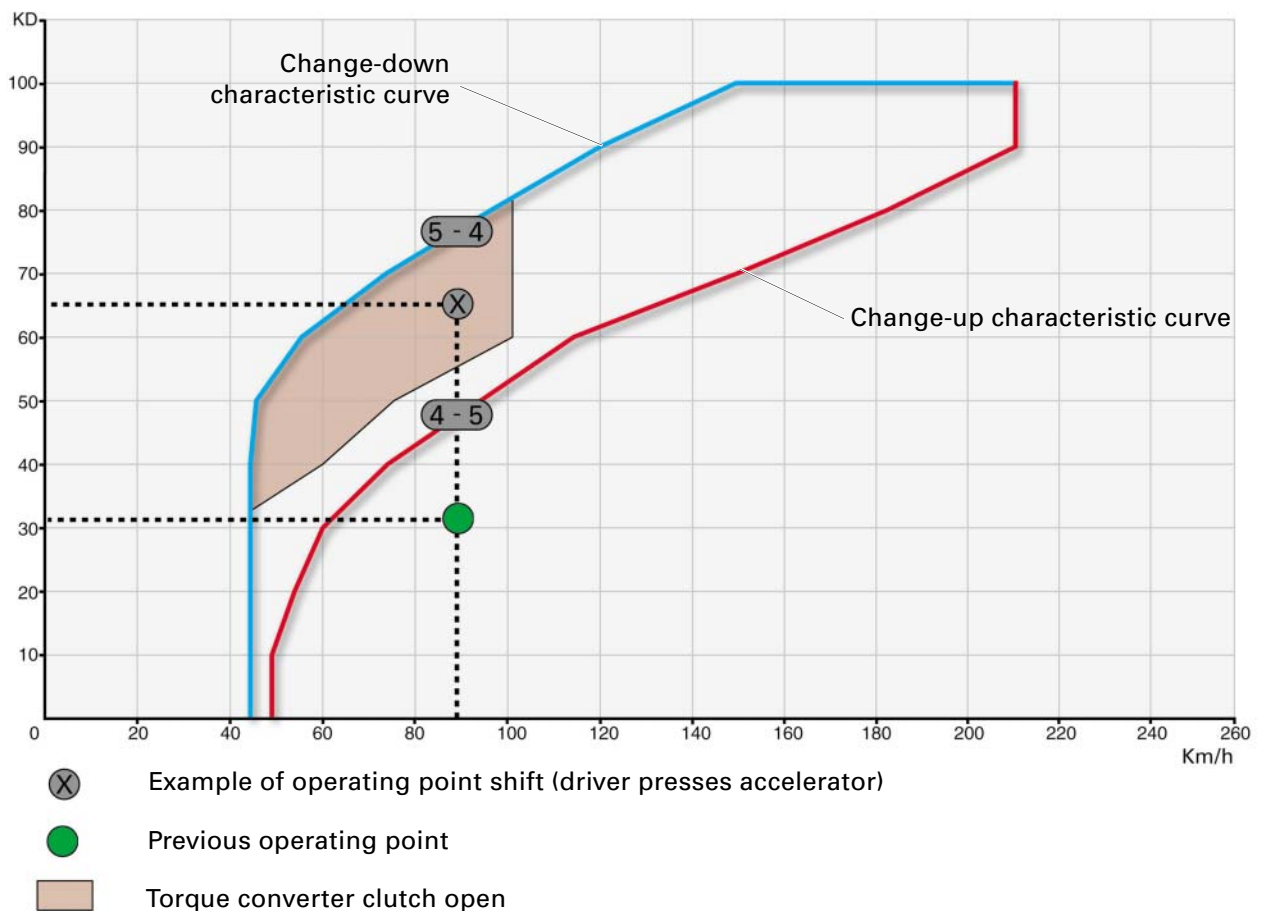
Torque converter shift operations

The torque converter multiplication is not only used for driving off, but also as a substitute for the gearshift operation under specific loads and at certain operating points. Thus for example on accelerating in certain load situations, the torque converter clutch is opened instead of change-down taking place, resulting in an increase in engine speed in a similar manner to change-down. The difference in speed between the pump and turbine impellers produces an increase in torque by the converter, corresponding to a gearshift operation, and at the same time the increase in speed causes the engine to be operated in a higher power range.

The advantage of this "strategy" is that "torque converter shifting" is smoother than shifting between gears on account of the damping effect of the torque converter and the relatively simple torque converter clutch control action.

In conjunction with the 6-speed gearing, the additional "torque converter shift operations" provide corresponding intermediate stages and thus a level of handling approaching that attained with continuously variable transmission.

Example of torque converter shift operation



283_106

Torque converter oil supply

The torque converter is constantly supplied with oil by means of a separate hydraulically controlled circuit. The heat (produced by the hydrodynamic torque transmission and the friction power of the TCC) is dissipated by the continuous supply of ATF.

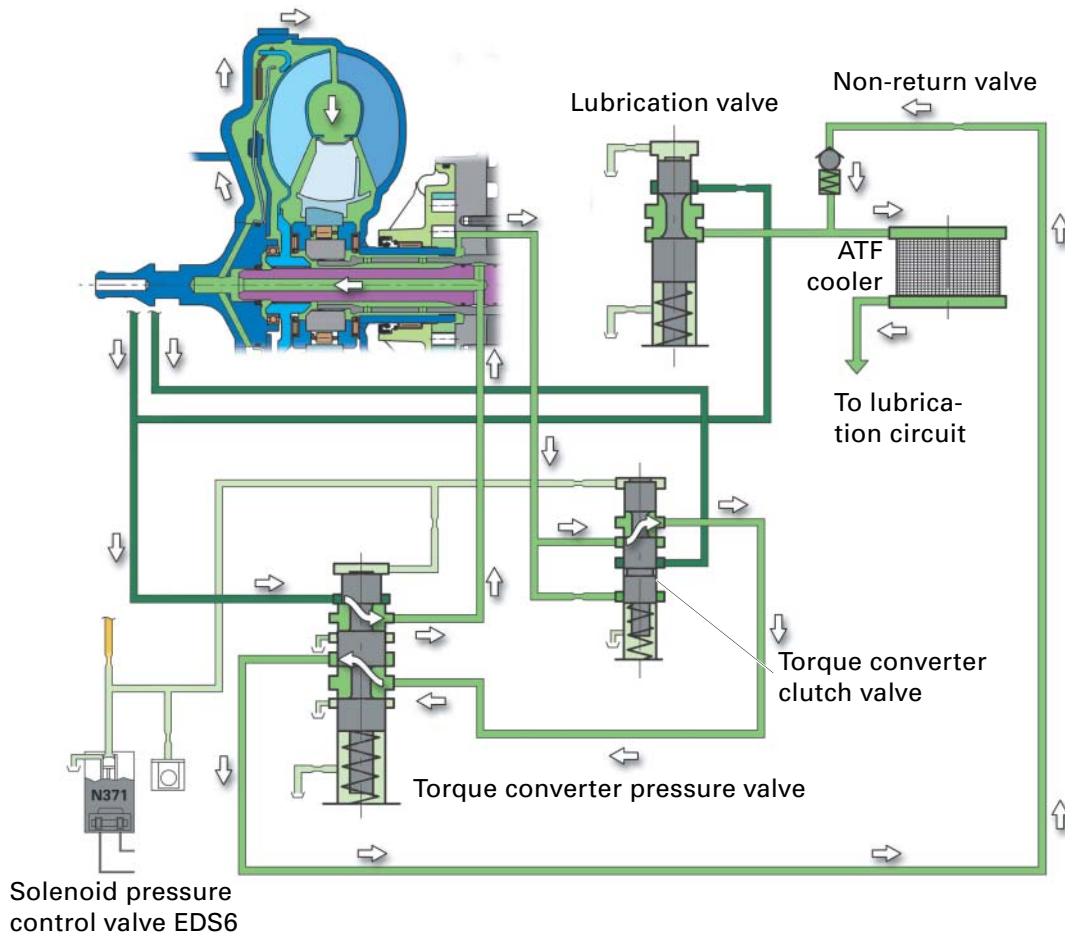
The TCC is controlled electrohydraulically by regulating the direction of flow and the pressure applied to each side of the TCC piston.

TCC control is based on the following parameters:

- Engine speed
- Engine torque
- Turbine speed
- Current gear
- Output speed
- ATF temperature

The gearbox control unit uses these to calculate the specified TCC status and establishes a corresponding control current for the pressure regulating valve N371. N371 converts an electrical control current into a defined proportional hydraulic control pressure.

This control pressure regulates the torque converter pressure valve and the torque converter clutch valve, which determine the direction of flow and the pressure for the TCC.



283_100

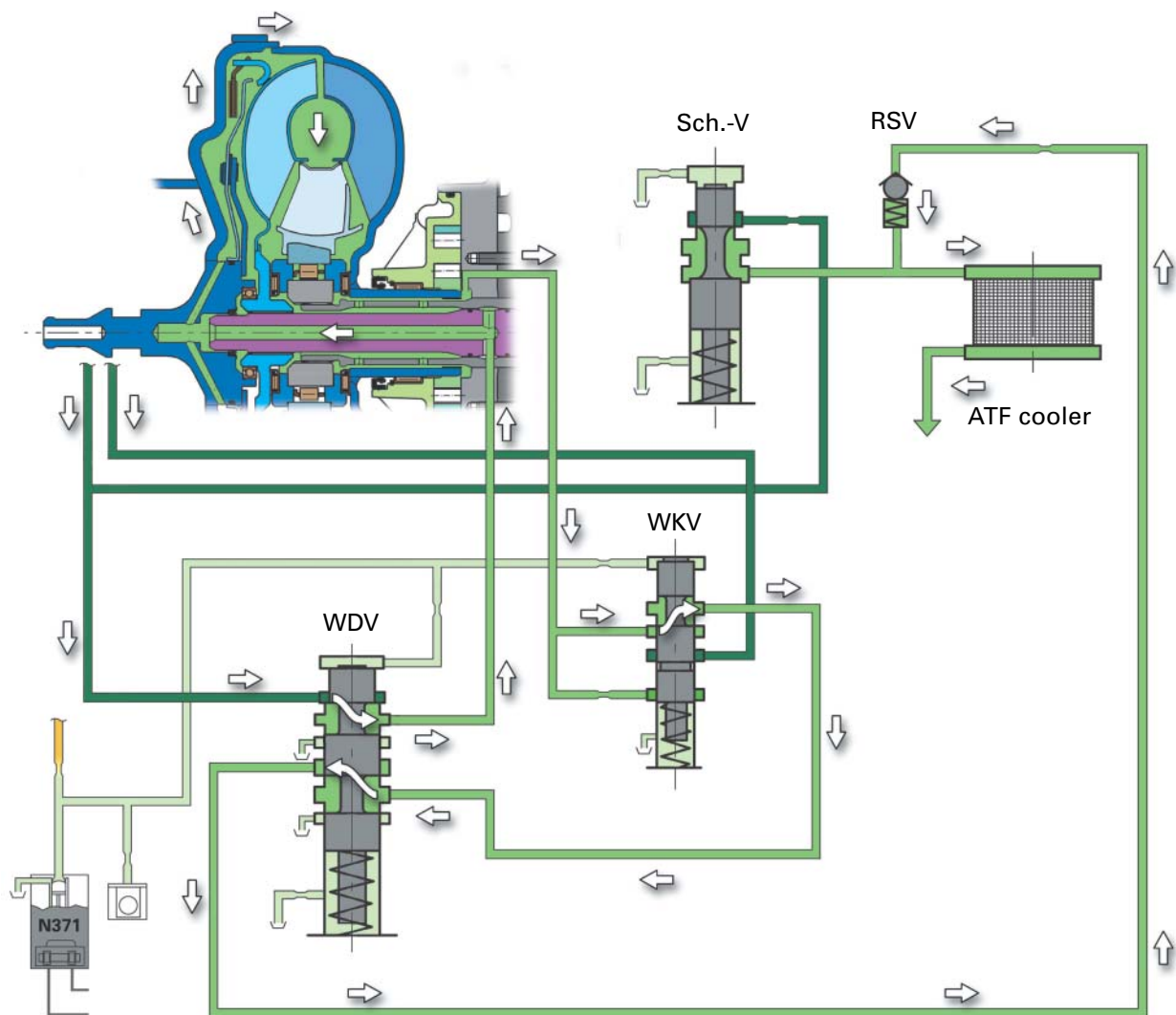
Gearbox Assemblies

Torque converter clutch operation

TCC_open

When open, the oil pressure is equal on both sides of the TCC piston. The ATF flows from the piston chamber past the lining plate and friction surfaces to the turbine chamber. The warm ATF is routed by means of the torque converter clutch to the ATF cooler for cooling.

This design ensures adequate component and ATF cooling both during torque converter operation and with torque converter clutch control action.



Sch.-V = Lubrication valve
RSV = Non-return valve
WKV = Torque converter clutch valve
WDV = Torque converter pressure valve

Depressurised
Torque converter pressure
System pressure
Pilot pressure

TCC_control mode/_closed

To close the TCC, the direction of ATF flow is reversed by actuating the torque converter pressure valve and torque converter clutch valve. The oil pressure in the piston chamber is dissipated. The pressure in the torque converter then acts on the turbine end of the TCC piston, thus causing the TCC to close.

The clutch torque is increased or decreased in line with actuation of the valves.

The following applies:

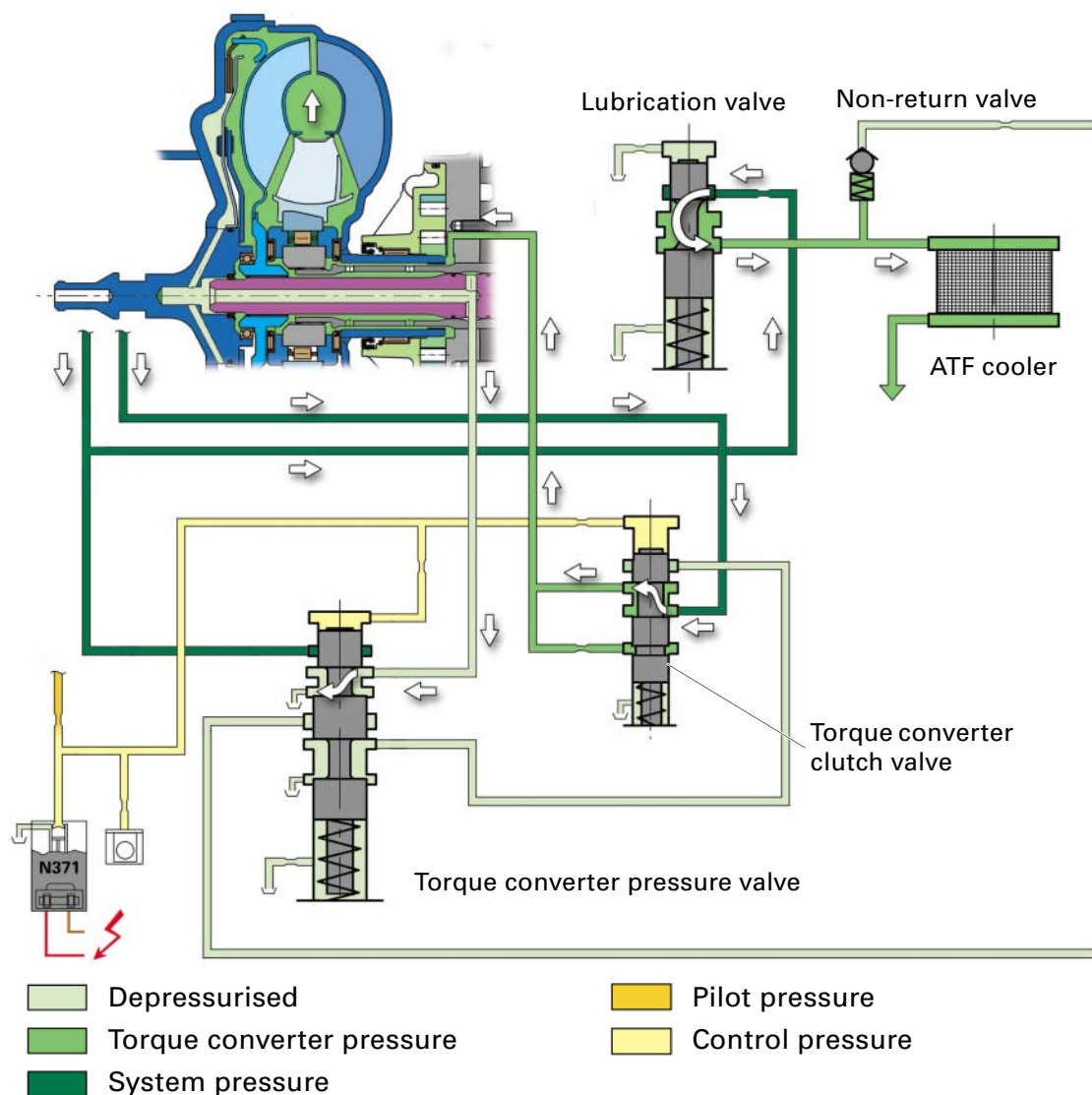
- Low N371 control current corresponds to low clutch torque
- High N371 control current produces a high clutch torque

Adequate attenuation is provided in TCC control mode for engine torsional vibration, thus obviating the need for additional torsion dampers.

Safety/substitute function in the event of failure:

On exceeding a certain TCC specified pressure (control current), use is made of transmission capacity curves to check whether there is a difference between turbine and engine speed. If this is the case, a fault is stored and the torque converter clutch no longer closed.

Fault display: None



Gearbox Assemblies

ATF pump

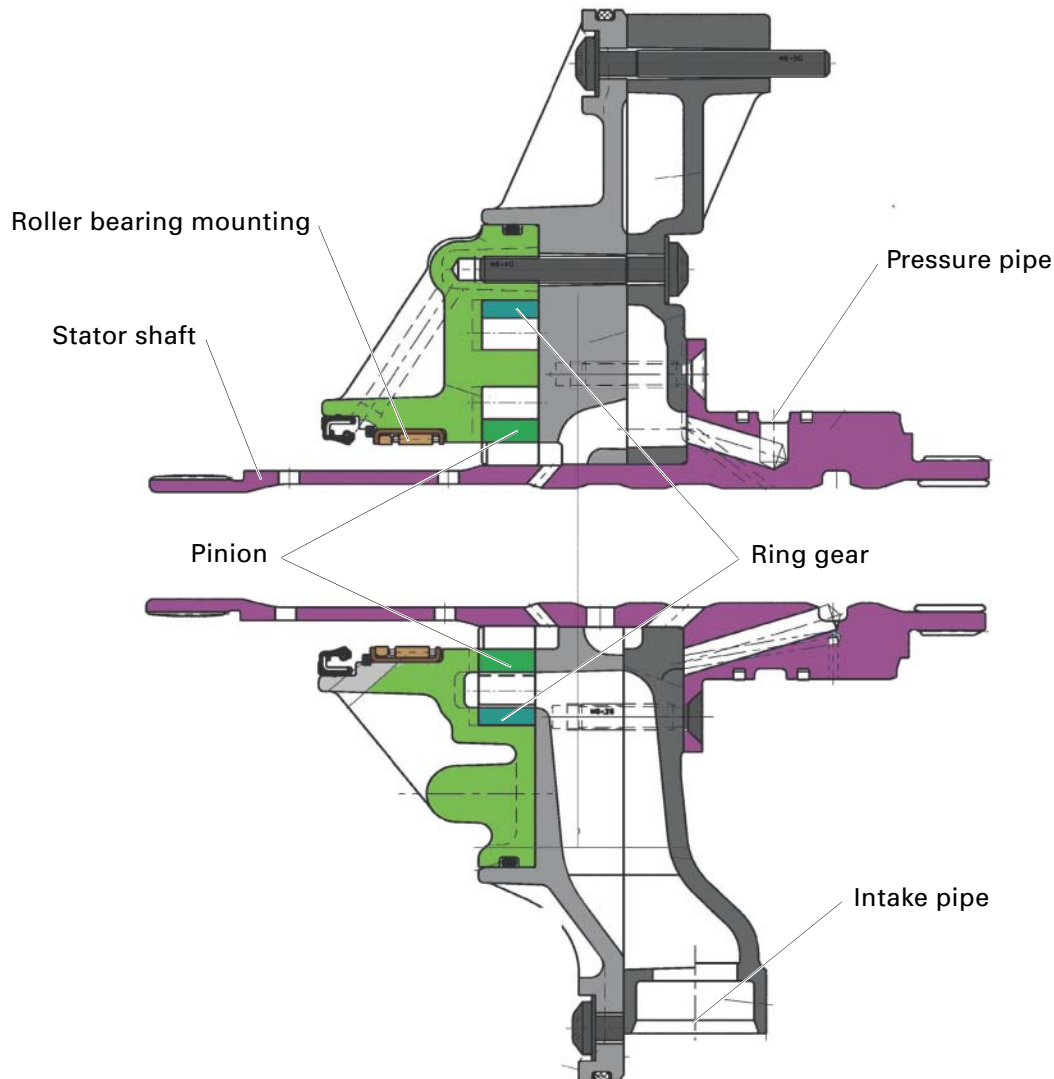
One of the most important components of an automatic gearbox is the oil pump.

An adequate oil supply is absolutely essential for proper operation.

The oil pump takes the form of an internally geared (crescent) pump.

Optimisation of the oil supply and the reduction of leakage throughout the entire hydraulic control system as well as in the gearbox meant that it was possible to have a lower oil pump delivery volume.

Both internal pump leakage and oil supply system losses were thus significantly reduced.



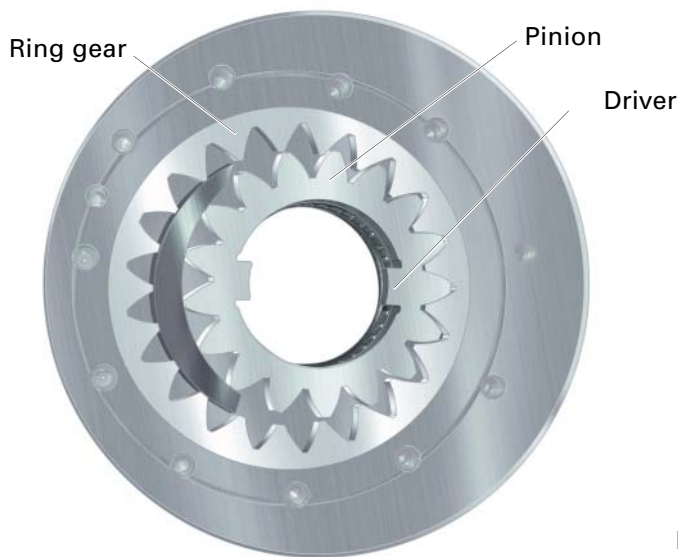
283_122

The oil pump is driven directly by the engine via the torque converter housing and hub. The mounting of the torque converter in the oil pump housing takes the form of a wear-resistant roller bearing.

The oil pump draws in the ATF through the filter and conveys the pressurised fluid into the hydraulic control unit, where the system pressure valve (Sys. Dr.V) regulates the required fluid pressure.

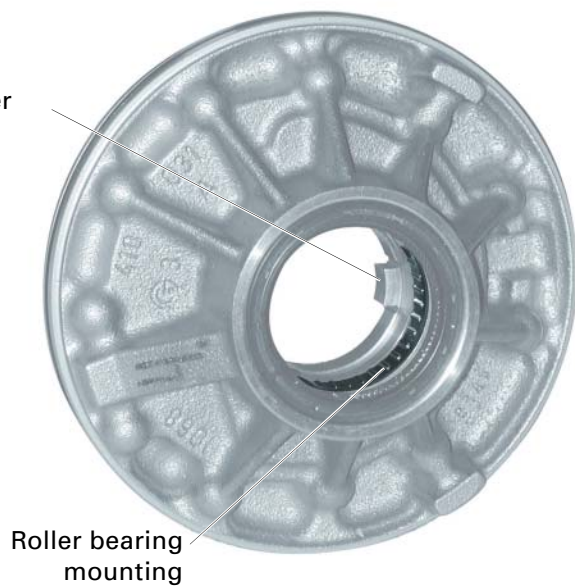
The surplus ATF is returned to the intake duct of the oil pump and the energy liberated used to charge the intake side. In addition to increasing efficiency, the noise level is reduced by avoiding cavitation.

Oil pump/gearbox end



283_137

Oil pump/engine end



283_138



When installing the torque converter, particular care is to be taken to ensure that the oil pump drivers engage in the grooves of the converter hub (refer to Workshop Manual).

Gearbox Assemblies

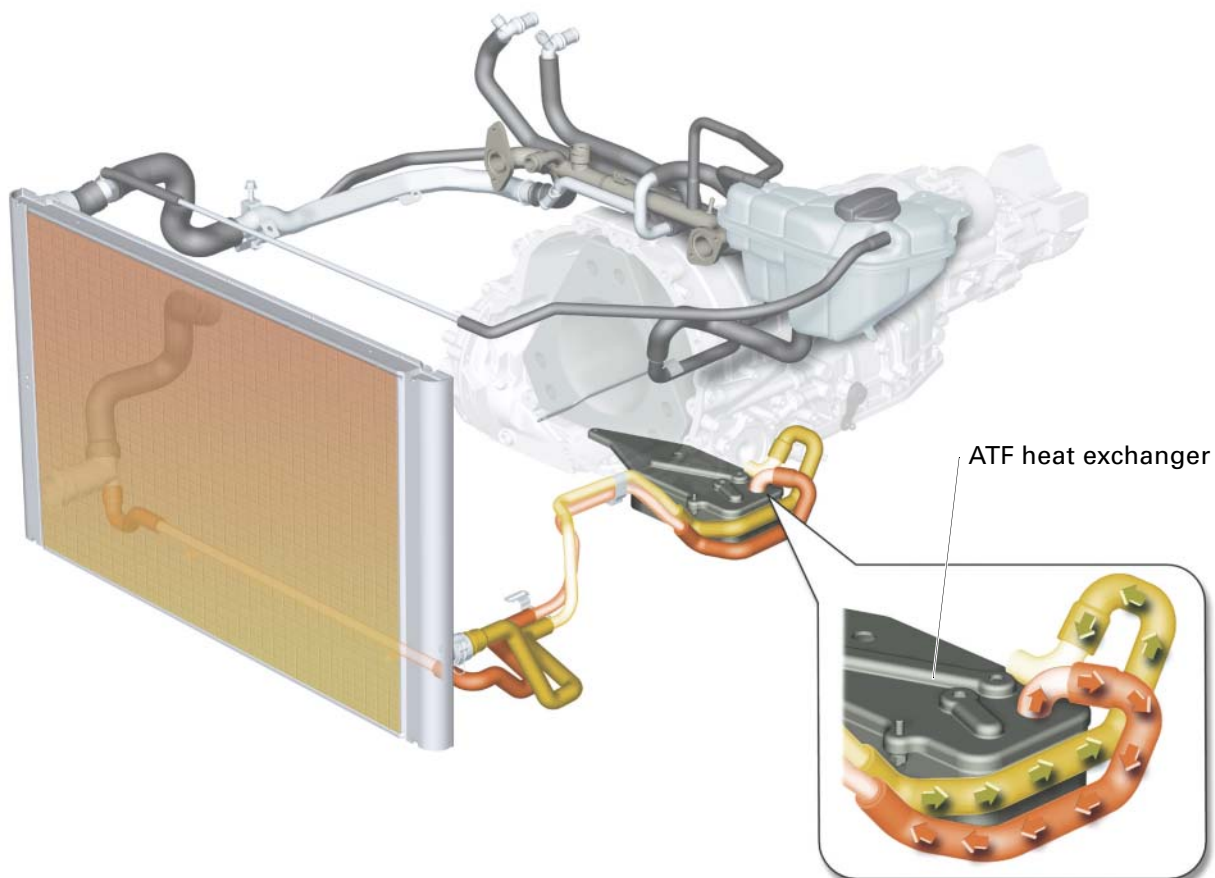
ATF cooling

The ATF is cooled by means of a coolant/oil heat exchanger flanged directly to the gearbox and incorporated into the engine cooling circuit.

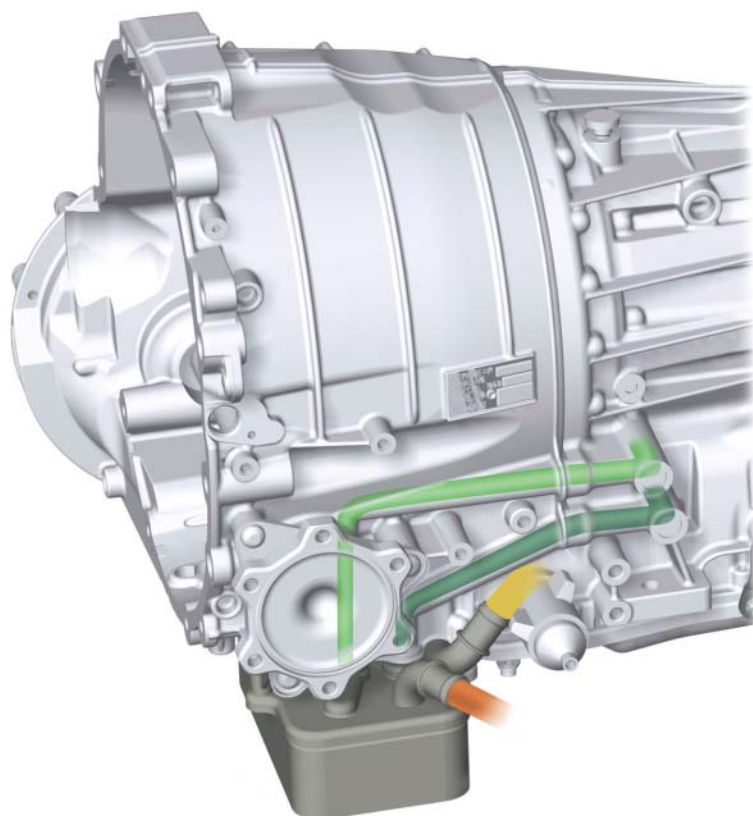
Direct attachment of the ATF cooler to the gearbox permits more flexible adjustment of the cooling output. As there are no ATF pipes, this greatly reduces the number of possible sources of leakage.

The "closed system" facilitates filling with ATF and checking of the fluid level. Operations arising due to the disconnection of ATF pipes when removing and installing the gearbox no longer apply. The ingress of dirt into the gearbox is thus minimised.

The ATF cooler forms part of the scope of delivery of the gearbox. Cleaning of the cooler and oil pipes to remove contamination caused by gearbox damage is no longer necessary on replacing the gearbox.

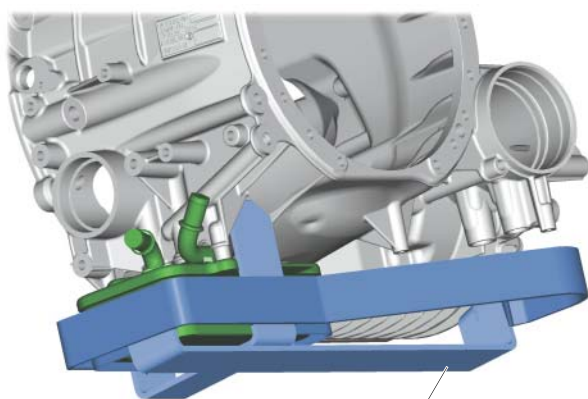


283_049



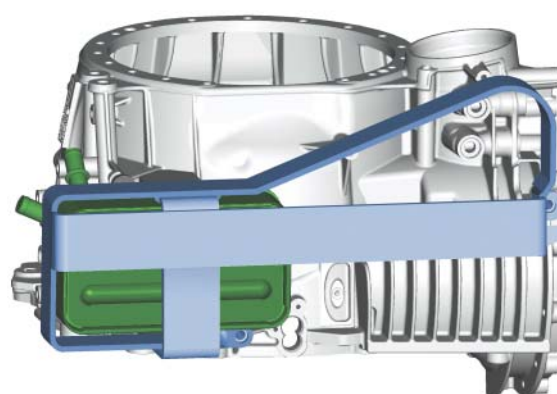
- Coolant supply
- Coolant return
- ATF return
- ATF supply

283_047



Transportation safeguard

283_081



283_082



A transportation safeguard is required to protect the ATF heat exchanger on account of its location on the underside of the gearbox.

The transportation safeguard is always to be used when handling and setting down the gearbox following removal.

The gearbox is never to be set down on the ATF heat exchanger.

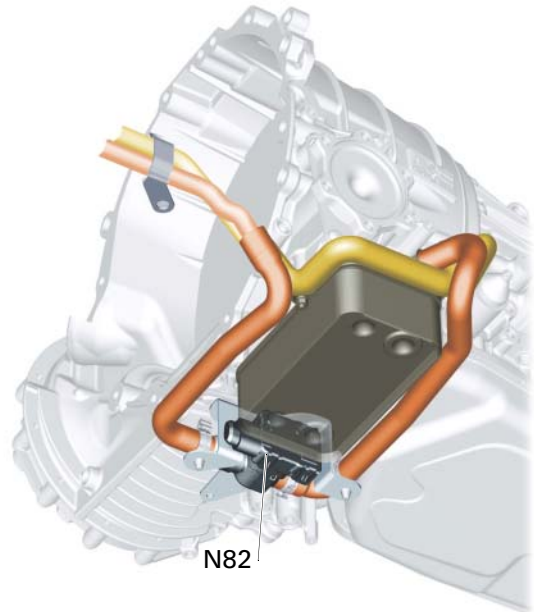
Gearbox Assemblies

ATF cooling with shutoff valve

Use is made of the shutoff valve N82 to warm the engine more quickly after a cold start.

N82 is a rotary slide valve driven by an electric motor and actuated by the gearbox control unit J217 as a function of ATF temperature. Up to an ATF temperature of 80°C, the valve is closed and blocks the flow of coolant from the engine to the ATF heat exchanger. The engine heat is thus not dissipated to the ATF and the engine attains its operating temperature more quickly.

In addition to heating the engine more quickly, the use of N82 enhances the heat output after a cold start.

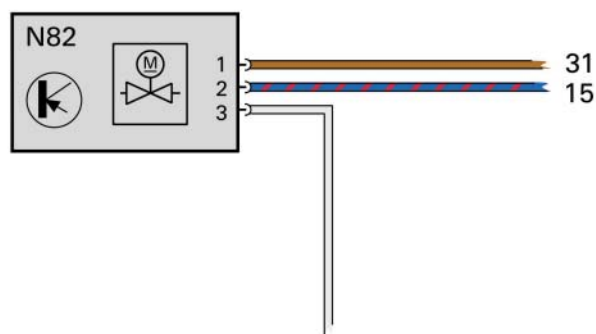


Installation location on V8 TDI

283_108

Operating settings:

<80°C	actuated (earth)	closed
>80°C	not actuated	open
<75°C	actuated (earth)	closed



PIN 8 on connector to gearbox

283_151



ATF cooling with the shutoff valve N82 is initially only available for the V8 4.0l TDI and W12 engines.

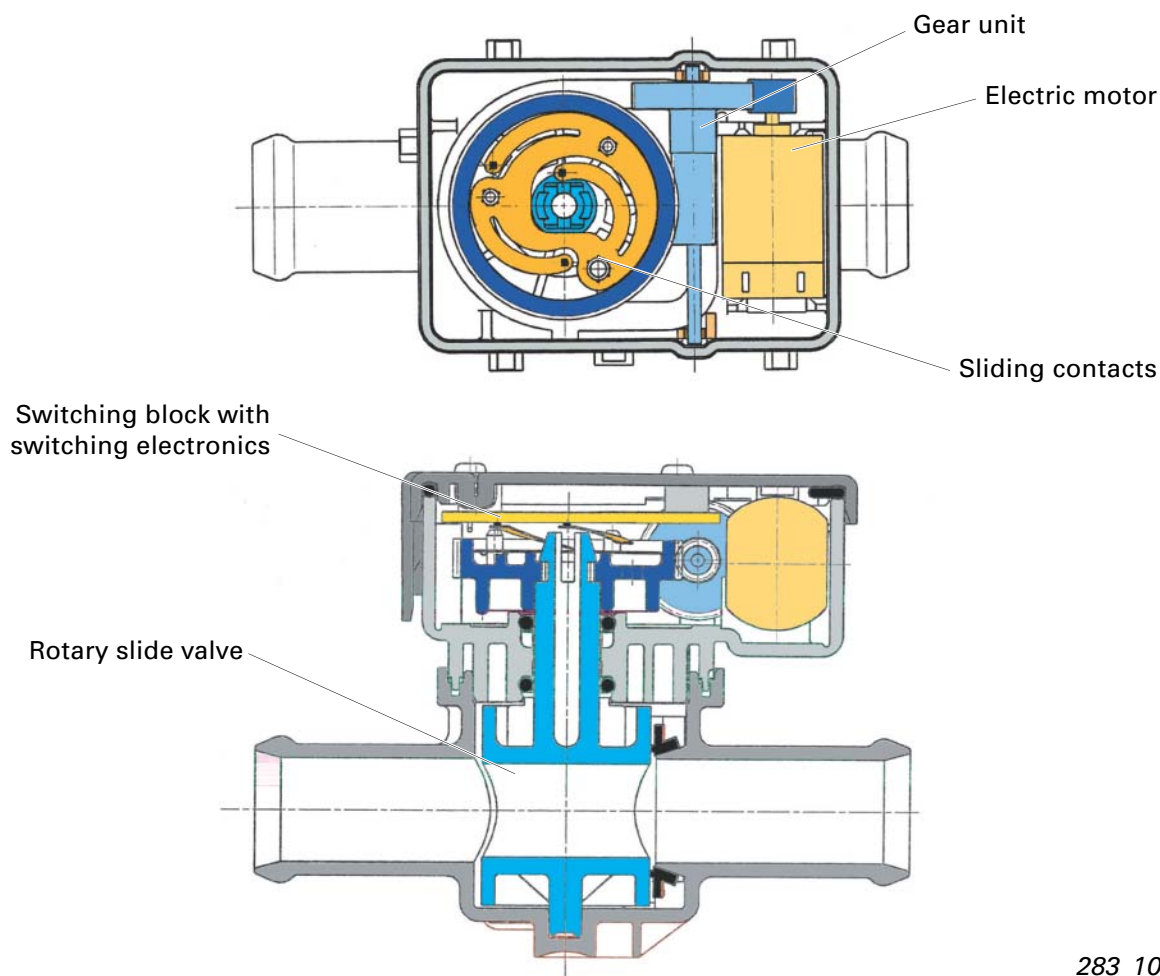
Design and operation

N82 is supplied with voltage by term. 15 and term. 31. Sliding contacts and a small switching block with integrated switching electronics control the electric motor, which turns the rotary slide valve by means of a small gear unit.

In the initial position (power being supplied, no actuation), the rotary slide is open. Application of earth to the signal input of N82 (pin 3) causes the motor (controlled by the sliding contacts and switching electronics) to turn the rotary slide through 90° into closed position.

If earth is no longer applied, the motor turns the rotary slide through a further 90°, returning it to open position. The rotary slide always moves by 90° in the same direction.

In the event of an open circuit in the signal wire, the shutoff valve remains open. ATF cooling is ensured should this fault occur. The shutoff valve is always closed in the event of short to earth. There is no ATF cooling and the gearbox overheats as a result.



283_107



The valve remains closed if the power supply fails during the warm-up phase (valve closed). There is no ATF cooling and the gearbox overheats as a result.

Gearbox Assemblies

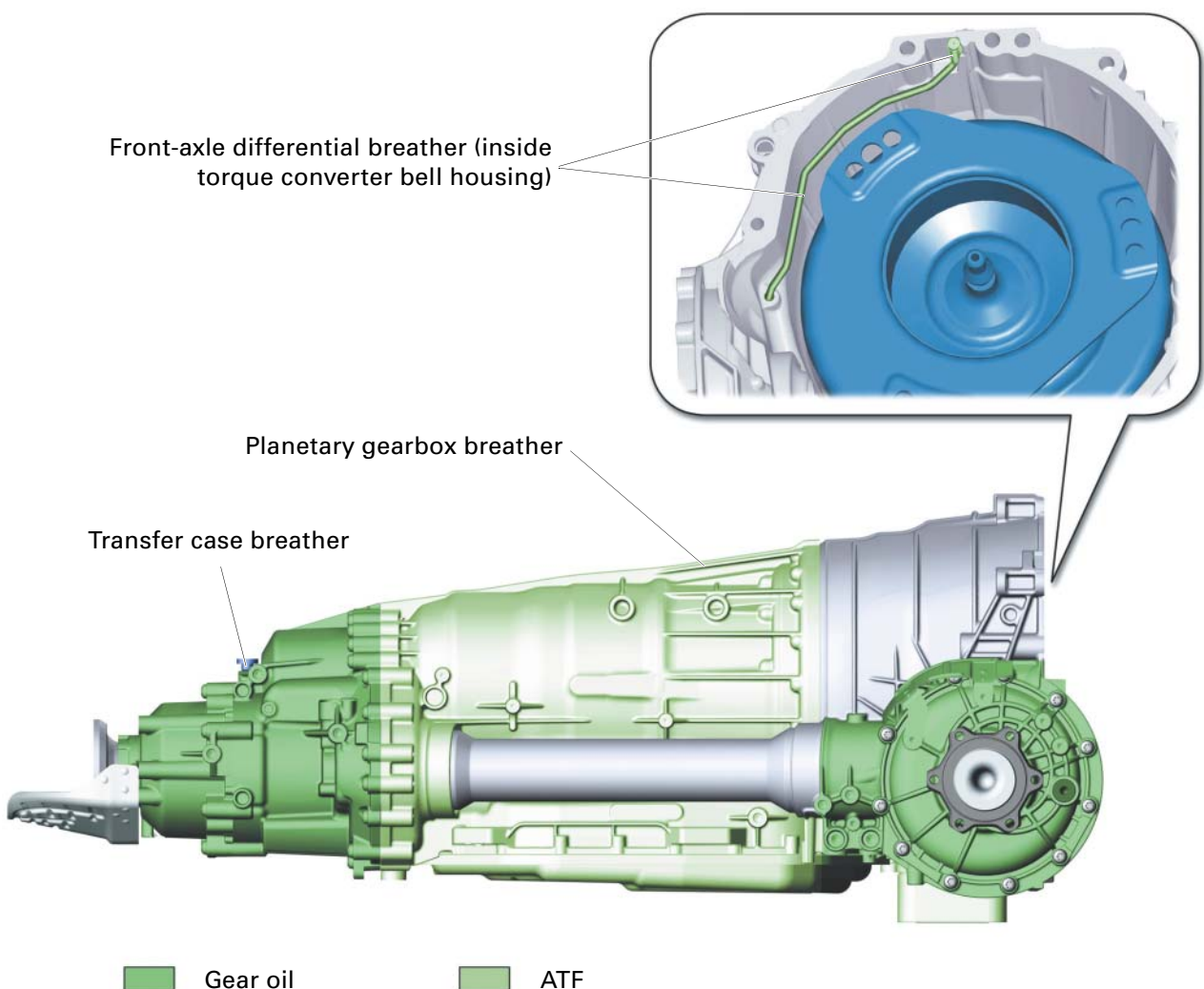
Oil and lubrication system

The 09E has three separate oil systems. Separation between the ATF section for the front-axle drive/differential and the transfer case is achieved by way of double radial shaft seals. In the event of double radial shaft seal leakage, the oil escapes from the corresponding leakage oil bore. This rules out intermixing of the oils from the adjacent systems.

ATF has to meet with the highest requirements in terms of gearshift quality and reliability and has a crucial influence on the coefficient of friction of a clutch/brake.

In addition to lining quality and friction materials, the following factors govern the coefficient of friction:

- Gear oil (grade, ageing, wear)
- Gear oil temperature
- Clutch temperature
- Clutch slip



283_127

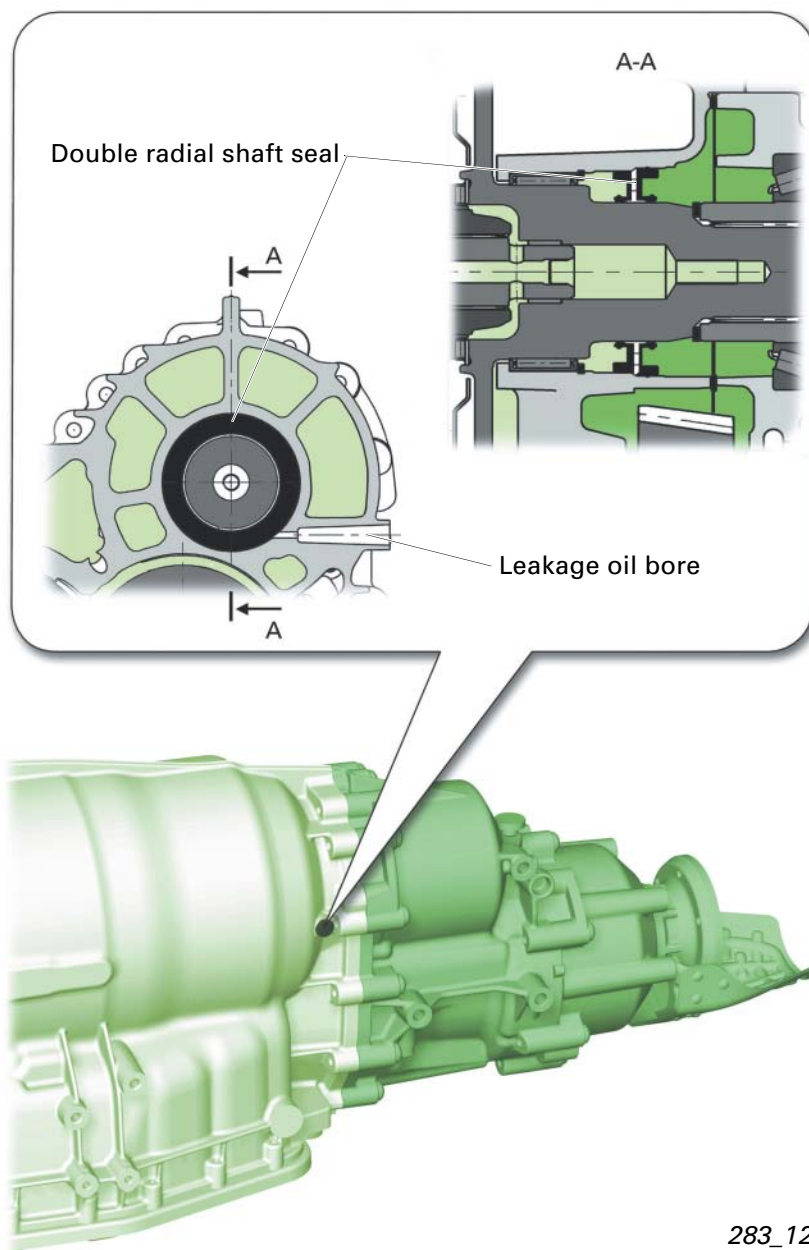
The effect of the ATF on the coefficient of friction of the clutches and brakes is incorporated into development at the design and trial stages.

It is thus logical that a special, improved ATF has been developed for the 09E.

Use of the prescribed ATF is therefore a prerequisite for proper operation.

The approved oils are designed to be a lifetime fill.

For further information on this topic, refer to Part 2 SSP 284, Page 14 "Monitoring of oil temperature population".



283_128

Gearbox Assemblies

Selector elements

The selector elements (clutches/brakes) are designed to implement power shift operations under load.

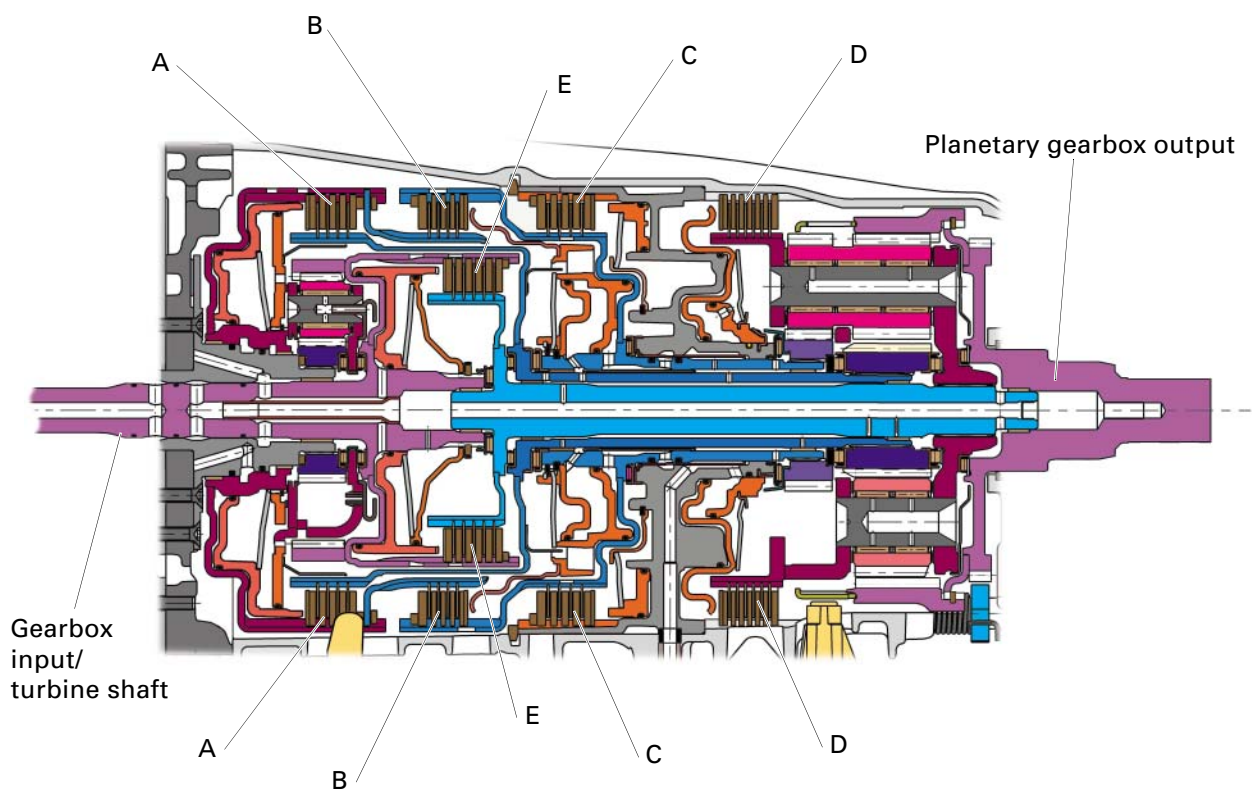
Thanks to the special configuration of the Lepelletier planetary gear train, shifting of the 6 forward gears and reverse gear only requires 5 selector elements.

- Three rotary multi-plate clutches A, B and E
- Two fixed multi-disc brakes C and D

All selector elements are actuated indirectly by the solenoid pressure control valves (for further information refer to Part 2 SSP 284, Page 7 onwards).

The planetary gearbox has no free-wheel. Engine braking action is provided in all gears.

The multi-plate clutches A, B and E channel the engine torque into the planetary gearbox. In this process, the engine torque is supported at the gearbox housing by the multi-disc brakes C and D.

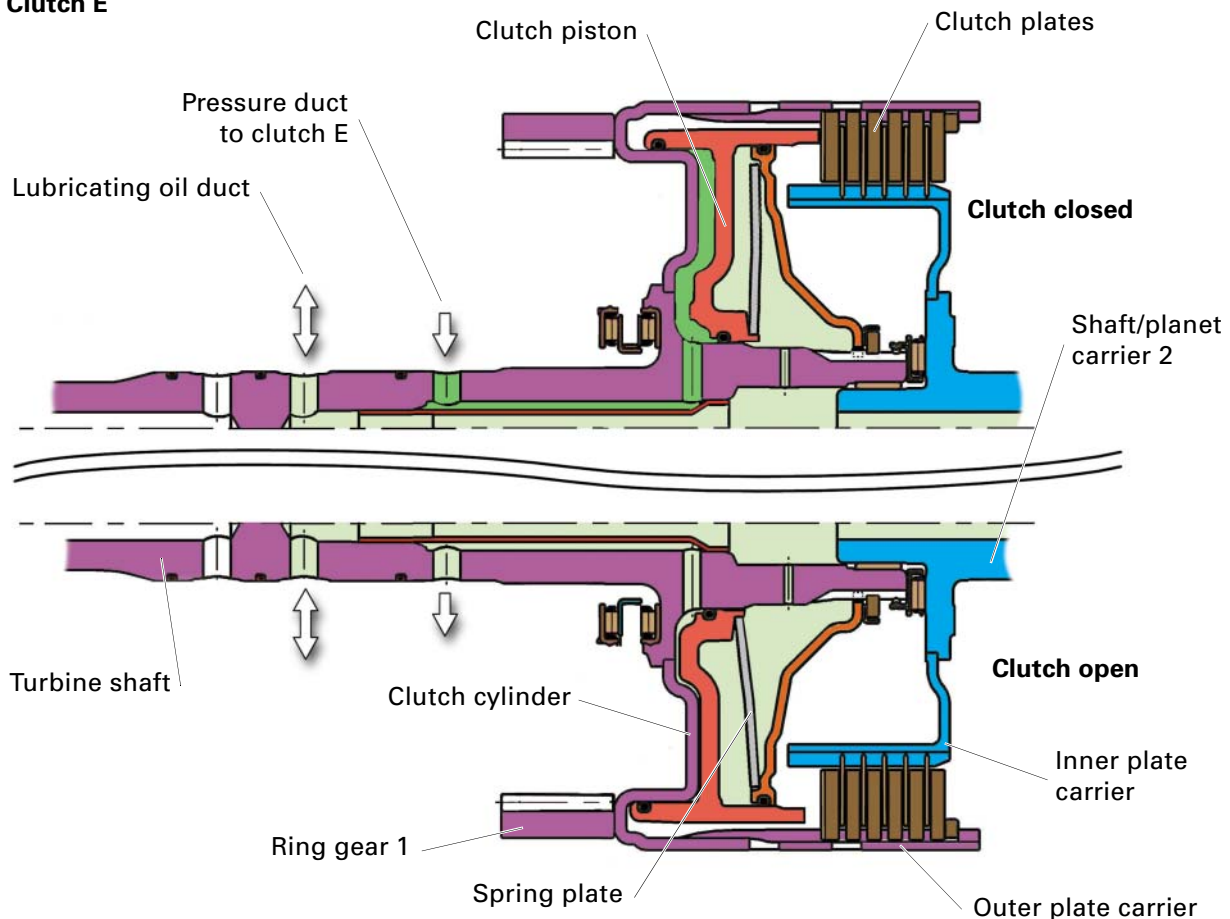


283_014

The selector elements are closed hydraulically. This is achieved by applying oil pressure to the cylinder of the appropriate clutch/brake, thus causing the piston to compress the set of plates/discs. As the oil pressure subsides, the spring plate resting on the piston forces the piston back into its initial position.

For optimum matching of gearbox efficiency to the engine, the number of clutch plates is adapted to the engine output, thus minimising the friction losses of open clutches.

Clutch E



283_123

Gearbox Assemblies

Dynamic pressure equalisation

Due to the rotation at high speeds, the ATF in the clutch cylinder is subjected to considerable centrifugal force. This results in an increase in pressure in the clutch cylinder towards the largest radius. This is referred to as "dynamic pressure build-up".

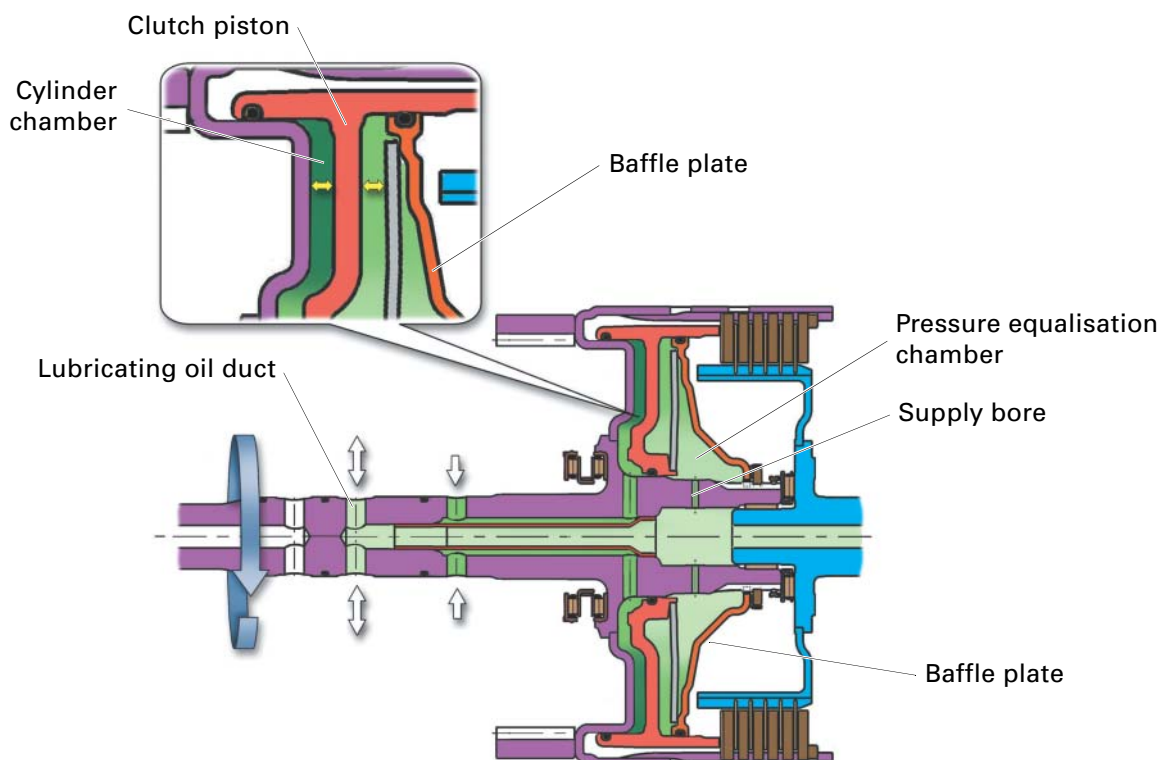
Dynamic pressure build-up is undesirable, as it increases the contact pressure unnecessarily and impedes defined pressure build-up and reduction in the clutch cylinder.

Clutches A, B and E feature pressure equalisation to ensure reliable opening and closing of the clutches in all speed ranges. The gearshift operation can thus be precisely regulated, considerably enhancing gearshift comfort.

Mode of operation taking multi-plate clutch E as an example

Oil is applied to both sides of the clutch piston. This is achieved by the baffle plate, which forms a sealed chamber with respect to the piston for dynamic pressure equalisation purposes. Only low pressure from the lubricating oil duct is applied to the pressure equalisation chamber.

The oil contained in the pressure equalisation chamber is subjected to the same forces (dynamic pressure build-up) as in the clutch cylinder, thus equalising the contact pressure of the clutch piston.



283_124

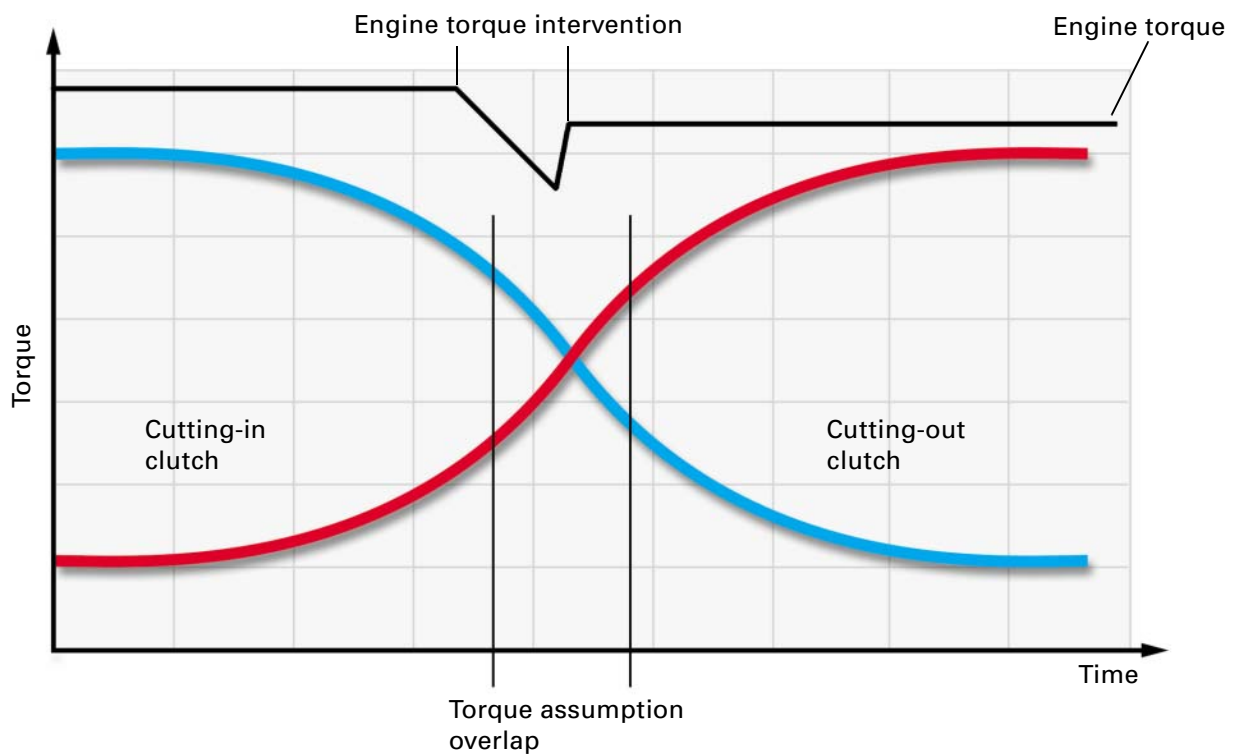
	Notes	

Gearbox Assemblies

Overlapping gearshift operations/control

All gearshift operations (from 1st to 6th gear and from 6th to 1st gear) are so-called overlapping gearshift operations. In other words: During gearshift, the clutch in the process of transmitting power retains its transmission capacity with reduced pressure until the corresponding clutch cutting in assumes the torque being applied.

The gearshift operation is assisted by a brief reduction in engine torque on changing up or an increase in engine torque on changing down (with effect from new control unit generation, refer to Part 2 SSP 284, Page 15).



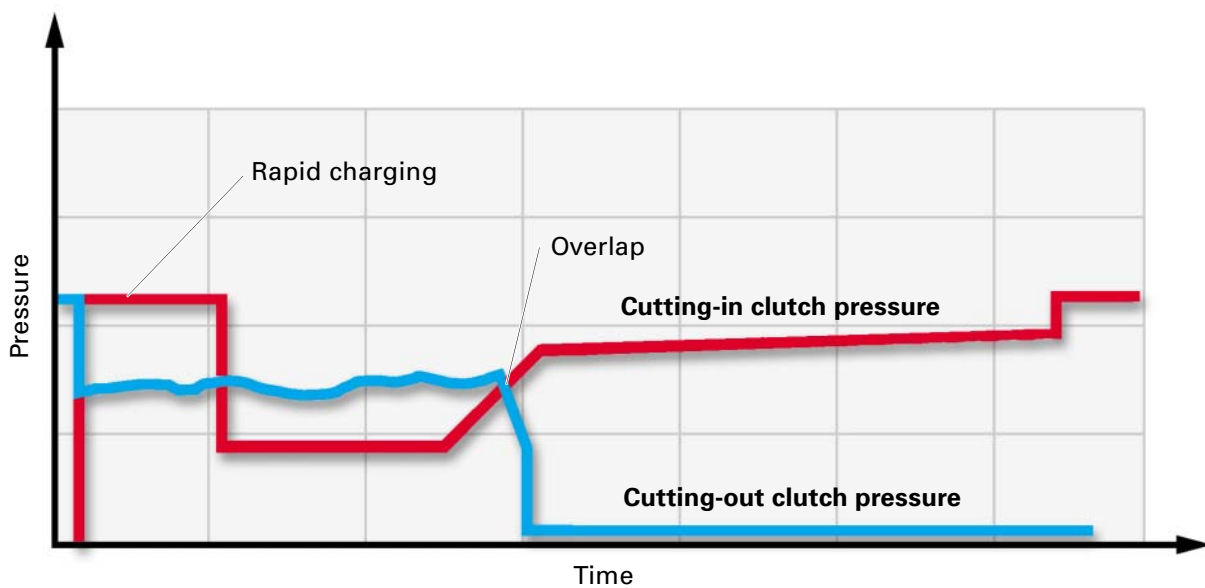
283_032

By using overlapping gearshift operations, it is possible to effectively replace free-wheeling by electrohydraulic clutch control, leading to great savings in terms of weight and space.

The gearshift operations are monitored by evaluating the gearbox input speed profile (G182), enabling appropriate action to be taken as necessary (e.g. shift pressure increase, gear retention or implementation of emergency operation).

Evaluation of the speed profile during the gearshift operation permits continuous adaption of the overlap control. Charging and the pressure build-up process in the clutch are influenced by appropriately adapting the control current of the pressure regulating valves.

For further information, refer to Part 2 SSP 284, Page 7 onwards.



283_055

Gearbox Assemblies

Planetary gearbox

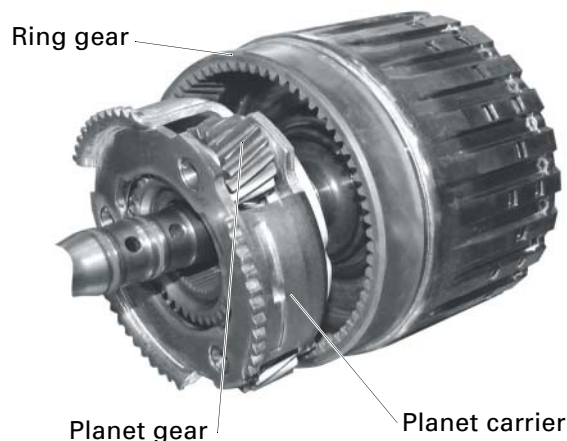
A new feature is the use of the so-called Lepelletier planetary gear train. This permits the implementation of six forward gears and one reverse gear employing only five selector elements (three clutches and two brakes).

Principle:

A single planetary gear train is fitted upstream of the Ravigneaux double planetary gear train and provides 2-speed drive for the Ravigneaux gear train.

Output is always via the ring gear of the Ravigneaux gear train. A further feature is multiple utilisation of brakes and clutches.

Primary planetary gear train, single planetary gear train



283_036

Secondary planetary gear train, Ravigneaux gear train



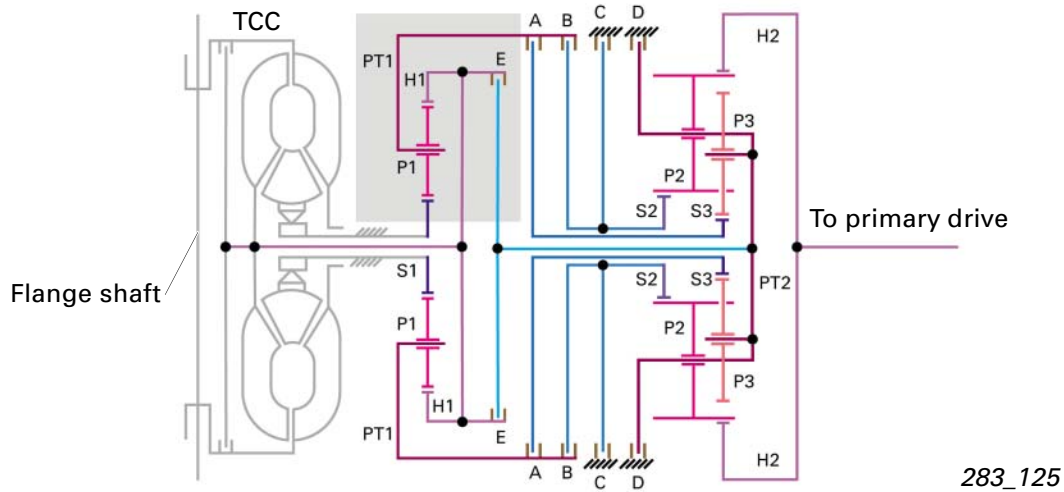
283_126

Advantages of Lepelletier planetary gear train:

- The extremely compact design allows for a reduction in overall length despite a greater spread, more gear ratio steps and high torque transmission.
- The use of far fewer components not only significantly reduces weight but also lowers manufacturing costs.

Power flow and the different ratios of the individual gears are achieved by torque being channelled via various elements of the planetary gear trains with the other elements in each case being held stationary or two elements of a gear train being connected with one another.

Block diagram of Lepelletier planetary gear train in the 09E gearbox



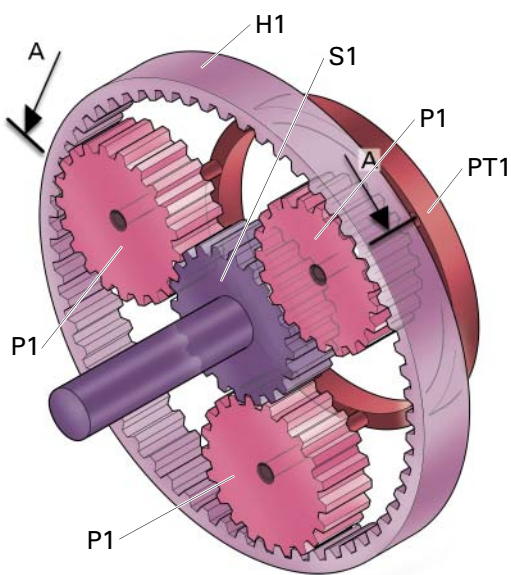
Single planetary gear train:

Sun gear (S1) = Stationary
 Planet carrier (PT1) = Clutch A/B
 Ring gear (H1) = Turbine shaft/
 clutch E
 Input

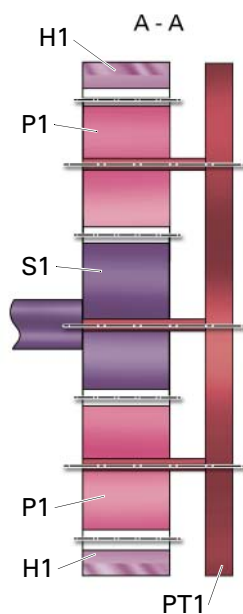
Ravigneaux gear train:

Large sun gear (S2) = Clutch B
 Brake C
 Small sun gear (S3) = Clutch A
 Planet carrier (PT2) = Clutch E
 Brake D
 Ring gear (H2) = Output

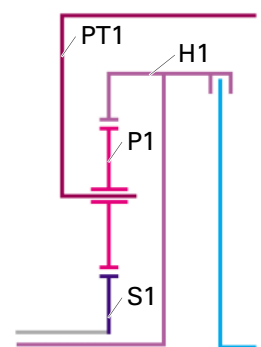
Explanation of block diagram 283_125 based on section with grey background



283_057



283_059



283_087

Gearbox Assemblies

Gear description/torque profile

Power flow in 1st gear

Selector elements: Clutch A
Brake D

The turbine shaft drives the ring gear H1 of the primary planetary gear train.

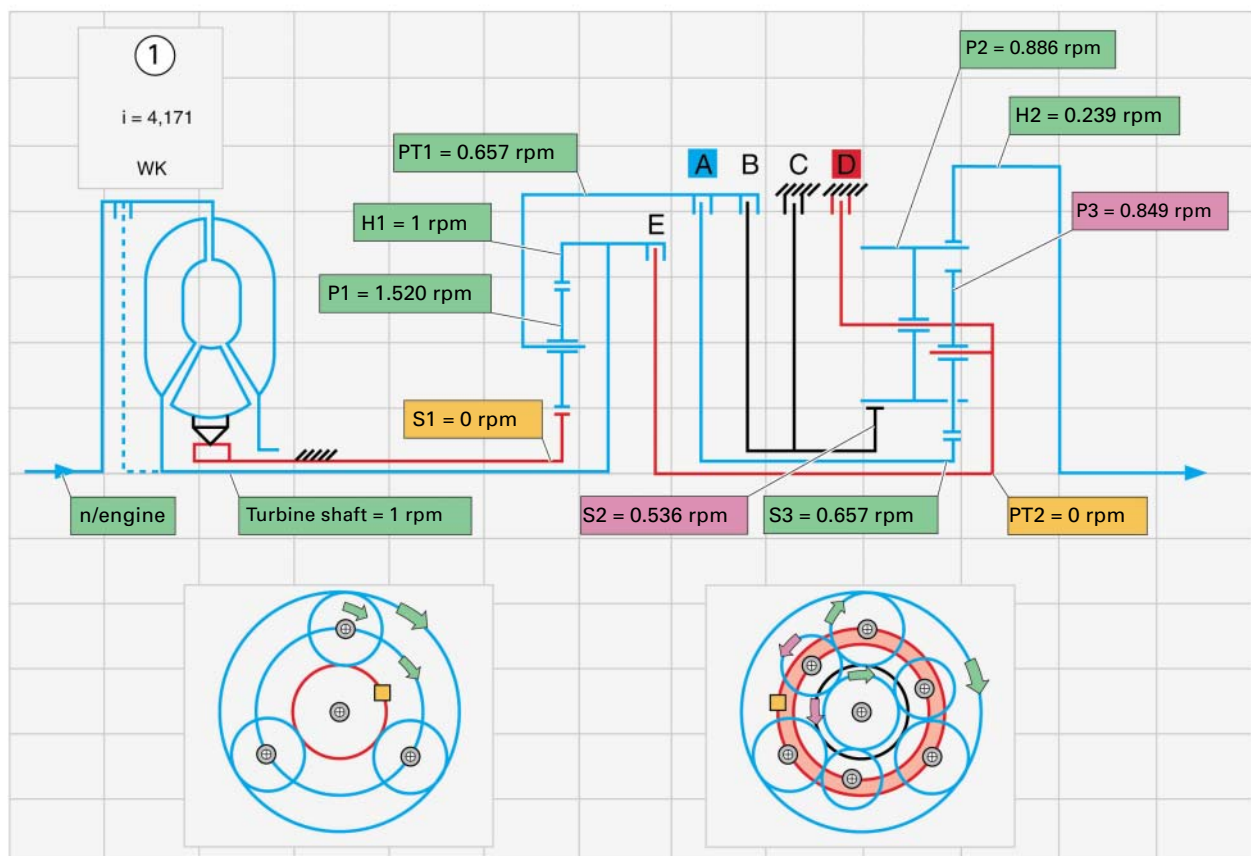
The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch A connects PT1 to the sun gear S3 and thus channels the torque into the secondary planetary gear train.

The brake D blocks the planet carrier PT2. The torque is transmitted from the sun gear S3 to the short planet gears P3 and from there to the long planet gears P2. Supported by the planet carrier PT2, the torque is transmitted to the ring gear H2, which is connected to the output shaft.



In the interests of clarity, the torque profile is shown in the form of a block diagram. The following illustrations only show the upper half of the planetary gearbox in each case.



283_070

Power flow in 2nd gear

Selector elements: Clutch A
Brake C

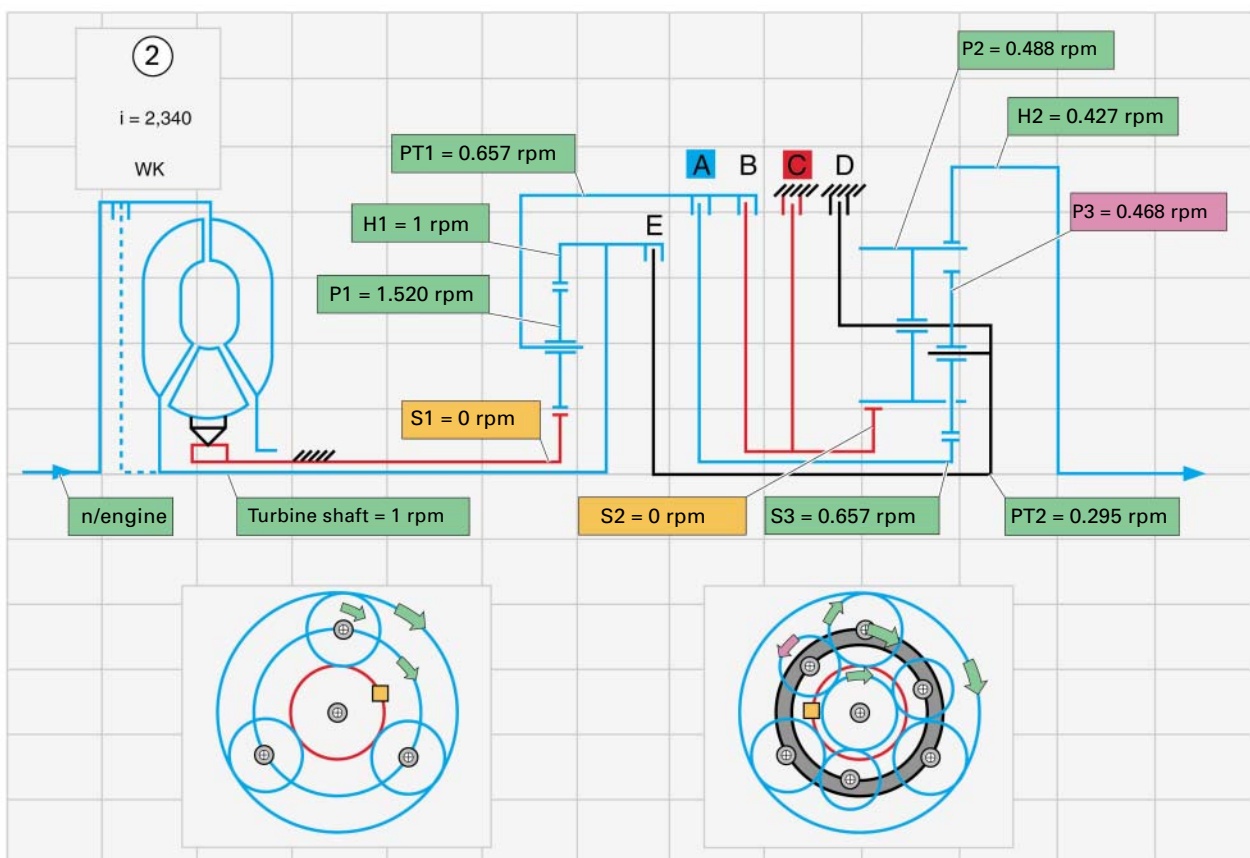
The turbine shaft drives the ring gear H1 of the primary planetary gear train.

The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch A connects PT1 to the sun gear S3 and thus channels the torque into the secondary planetary gear train.

The brake C blocks the large sun gear S2. The torque is transmitted from the sun gear S3 to the short planet gears P3 and from there to the long planet gears P2.

The long planet gears P2 roll around the stationary sun gear S2 and drive the ring gear H2.



283_071

Gearbox Assemblies

Power flow in 3rd gear

Selector elements: Clutch A
Clutch B

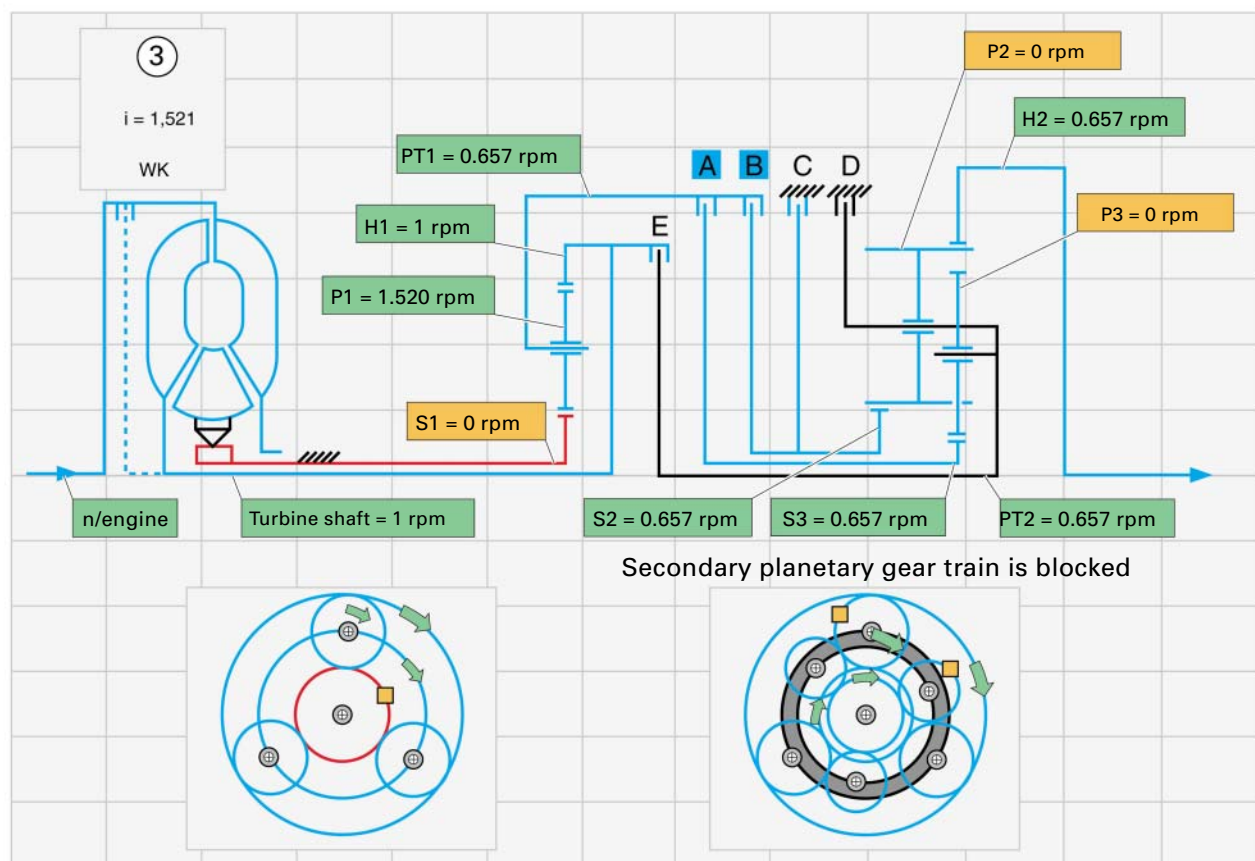
The turbine shaft drives the ring gear H1 of the primary planetary gear train.

The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch A connects PT1 to the sun gear S3 and thus channels the torque into the secondary planetary gear train.

The clutch B also channels the torque to sun gear S2 in the secondary planetary gear train.

Closing of the two clutches A and B blocks the secondary planetary gear train. The torque is then transmitted directly from the primary planetary gear train to the output shaft.



283_072

Power flow in 4th gear

Selector elements: Clutch A
Clutch E

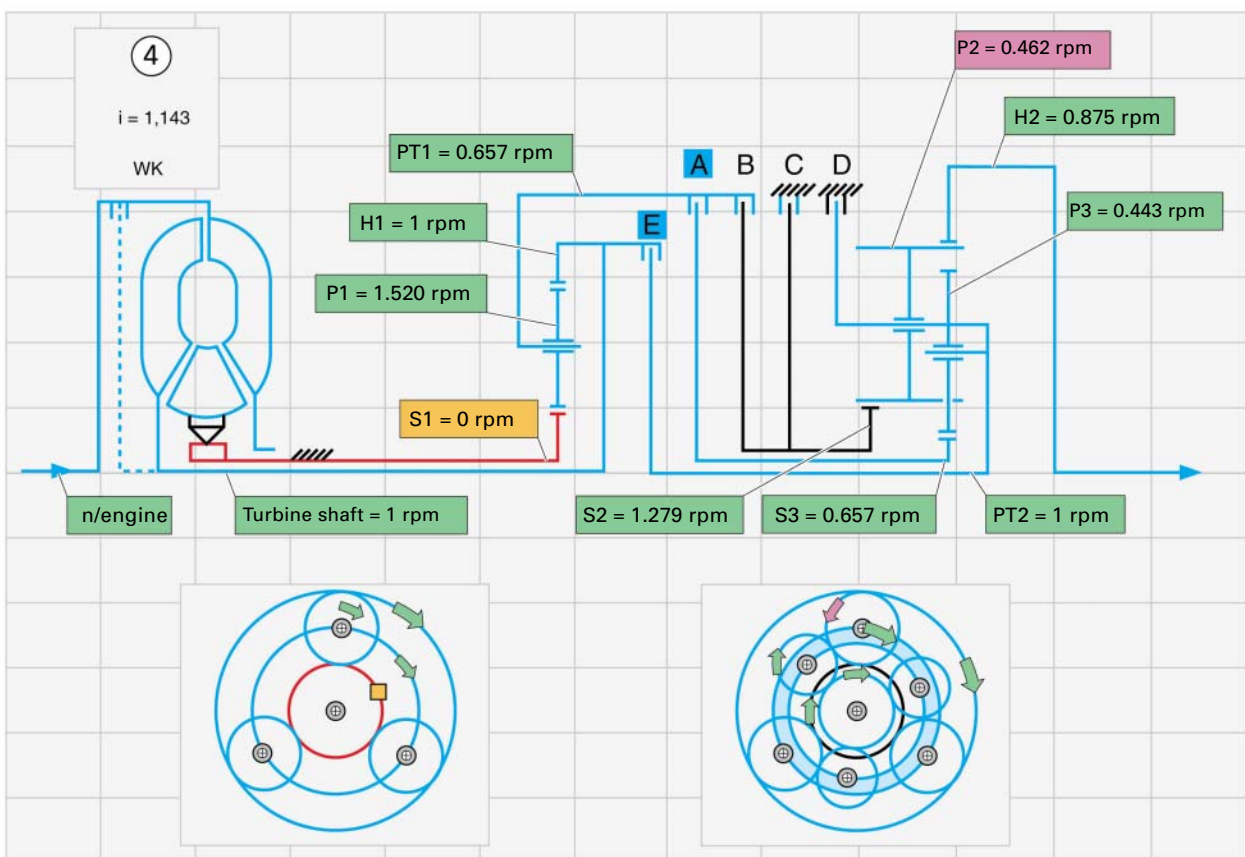
The turbine shaft drives the ring gear H1 of the primary planetary gear train and the outer plate carrier of clutch E.

The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch A connects PT1 to the sun gear S3 and thus channels the torque into the secondary planetary gear train.

The clutch E connects the turbine shaft to the planet carrier of the secondary planetary gear train PT2 and thus also channels the torque into the secondary planetary gear train.

The long planet gears P2, meshed with the short planet gears P3, drive the ring gear H2 together with the planet carrier PT2.



283_073

Gearbox Assemblies

Power flow in 5th gear

Selector elements: Clutch B
Clutch E

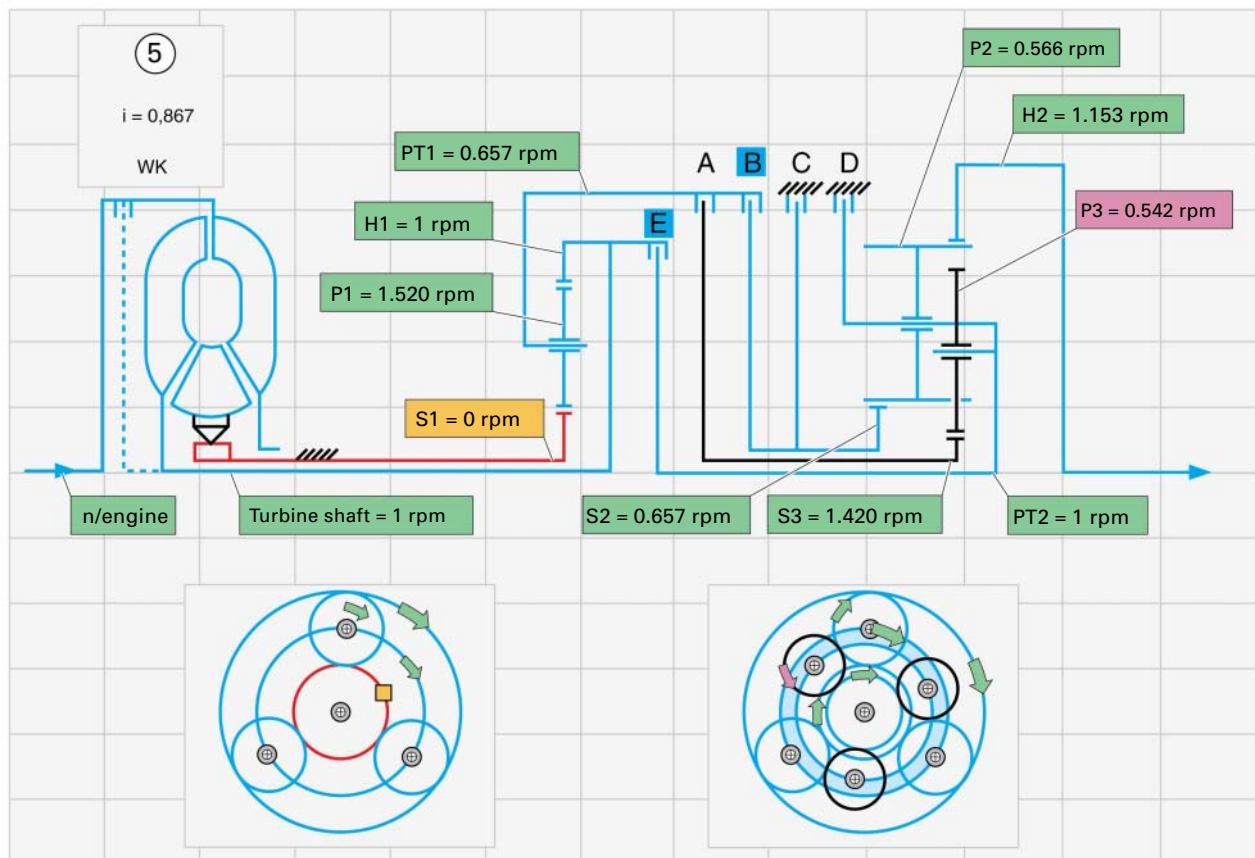
The turbine shaft drives the ring gear H1 of the primary planetary gear train and the outer plate carrier of clutch E.

The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch B connects PT1 to the sun gear S2 and thus channels the torque into the secondary planetary gear train.

The clutch E connects the turbine shaft to the planet carrier of the secondary planetary gear train PT2 and thus also channels the torque into the secondary planetary gear train.

The long planet gears P2 drive the ring gear H2 together with the planet carrier P2 and the sun gear S2.



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	t gears P2 roll around the gear S2 and drive the ring		
			B are open. The primary train is not involved in power

The long planet gears P2 roll around the stationary sun gear S2 and drive the ring gear H2.

Clutches A and B are open. The primary planetary gear train is not involved in power transmission.

Diagram illustrating a planetary gear train configuration. The input shafts are labeled n/engine and $\text{Turbine shaft} = 1 \text{ rpm}$. The output shafts are labeled $P2 = 1.652 \text{ rpm}$, $H2 = 1.447 \text{ rpm}$, and $P3 = 1.583 \text{ rpm}$. The gear train includes a primary planetary gear train (labeled 6) with a gear ratio $i = 0.691$ and a WK component. The gear train is connected to a turbine shaft (labeled 1 rpm) and a primary planetary gear train (labeled 6) with a gear ratio $i = 0.691$. The gear train is connected to a turbine shaft (labeled 1 rpm) and a primary planetary gear train (labeled 6) with a gear ratio $i = 0.691$. The gear train is connected to a turbine shaft (labeled 1 rpm) and a primary planetary gear train (labeled 6) with a gear ratio $i = 0.691$.

283_075

Gearbox Assemblies

Power flow in reverse gear

Selector elements: Clutch B
Brake D

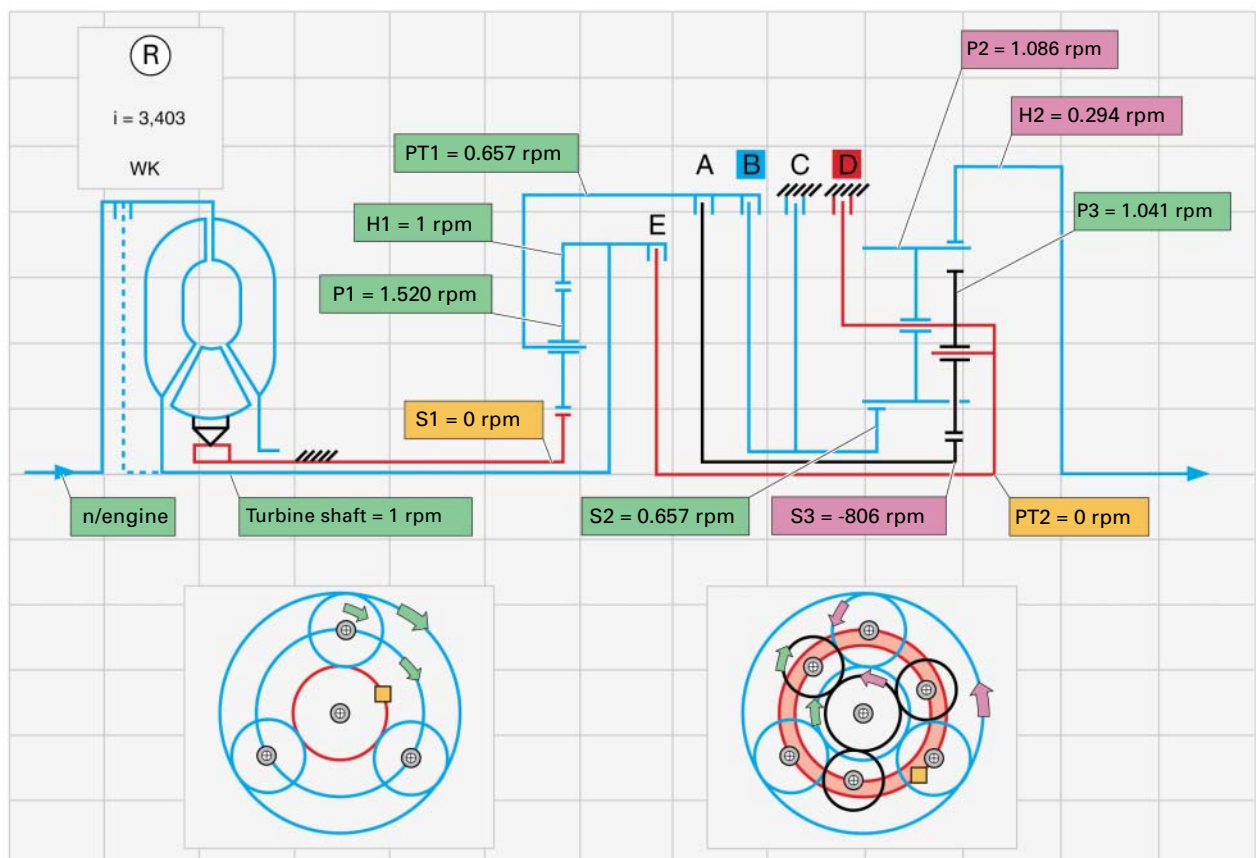
The turbine shaft drives the ring gear H1 of the primary planetary gear train.

The ring gear H1 drives the planet gears P1, which roll around the stationary sun gear S1, thus driving the planet carrier PT1.

The clutch B connects PT1 to the sun gear S2 and thus channels the torque into the secondary planetary gear train.

The brake D blocks the planet carrier PT2. The torque is transmitted from the sun gear S2 to the long planet gears P2. Supported by PT2, the torque is transmitted to the ring gear H2, which is connected to the output shaft.

The ring gear H2 is driven in the direction opposite to that of engine rotation.



283_076

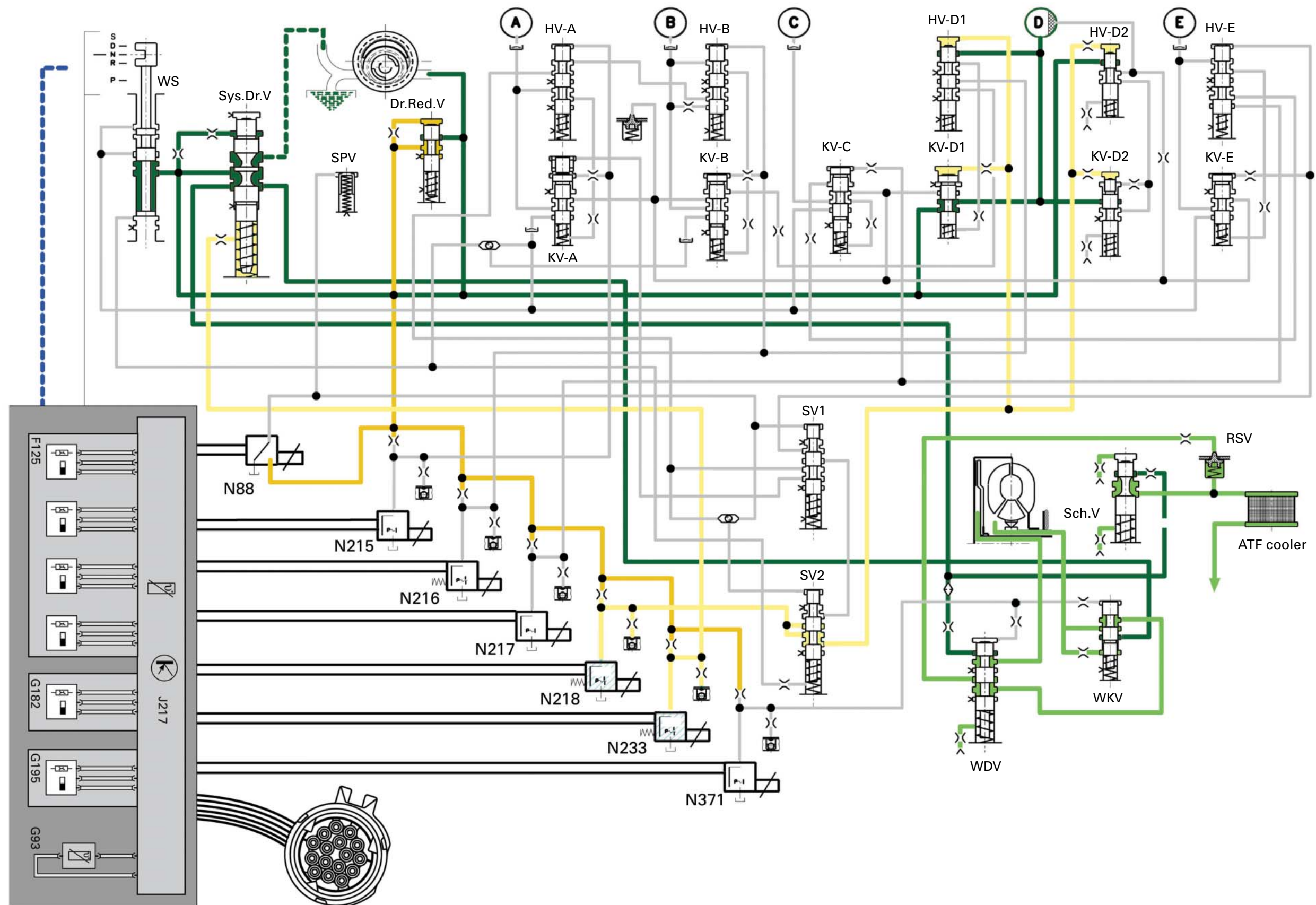
Gearshift matrix

Gear	Solenoid valve logic							Clutch logic				
	N88	N215	N216	N217	N218	N233	N371	A	B	C	D	E
P/N												
Reverse gear												
1st gear												
2nd gear												
3rdgear												
4thgear												
5thgear												
6thgear												
	Selector valve 1	Clutch A	Clutch B	Brake C	Brake/clutch D/E	System pressure	Torque converter clutch					

Actuation governed by operating status






Actuated

283_149



Hydraulic system diagram

Dr.Red.V	Pressure reduction valve
EDS1 (N215)	Solenoid pressure control valve 1
EDS2 (N216)	Solenoid pressure control valve 2
EDS3 (N217)	Solenoid pressure control valve 3
EDS4 (N218)	Solenoid pressure control valve 4
EDS5 (N233)	Solenoid pressure control valve 5
EDS6 (N371)	Solenoid pressure control valve 6
HV - A	Holding valve - Clutch A
HV - B	Holding valve - Clutch B
HV - D1	Holding valve - Brake D
HV - D2	Holding valve - Brake D2
HV - E	Holding valve - Clutch E
KV - A	Clutch valve - Clutch A
KV - B	Clutch valve - Clutch B
KV - C	Clutch valve - Brake C
KV - D1	Clutch valve - Brake D1
KV - D2	Clutch valve - Brake D2
KV - E	Clutch valve - Clutch E
MV1 (N88)	Solenoid valve 1
RSV	Non-return valve
Sch.V	Lubrication valve
SPV	Compensation valve
SV1	Selector valve 1
SV2	Selector valve 2
Sys. Dr.V	System pressure valve
WDV	Torque converter pressure valve
WKV	Torque converter clutch valve
WS	Selector slide

	Depressurised
	Torque converter pressure
	System pressure
	Control pressure
	Pilot pressure

Gearbox Assemblies

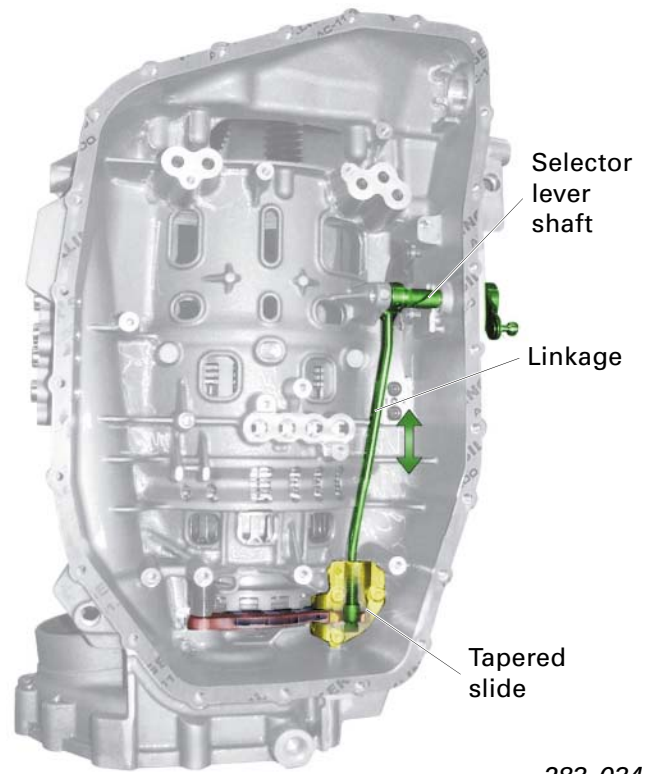
Parking lock

The parking lock is designed to stop the vehicle rolling away.

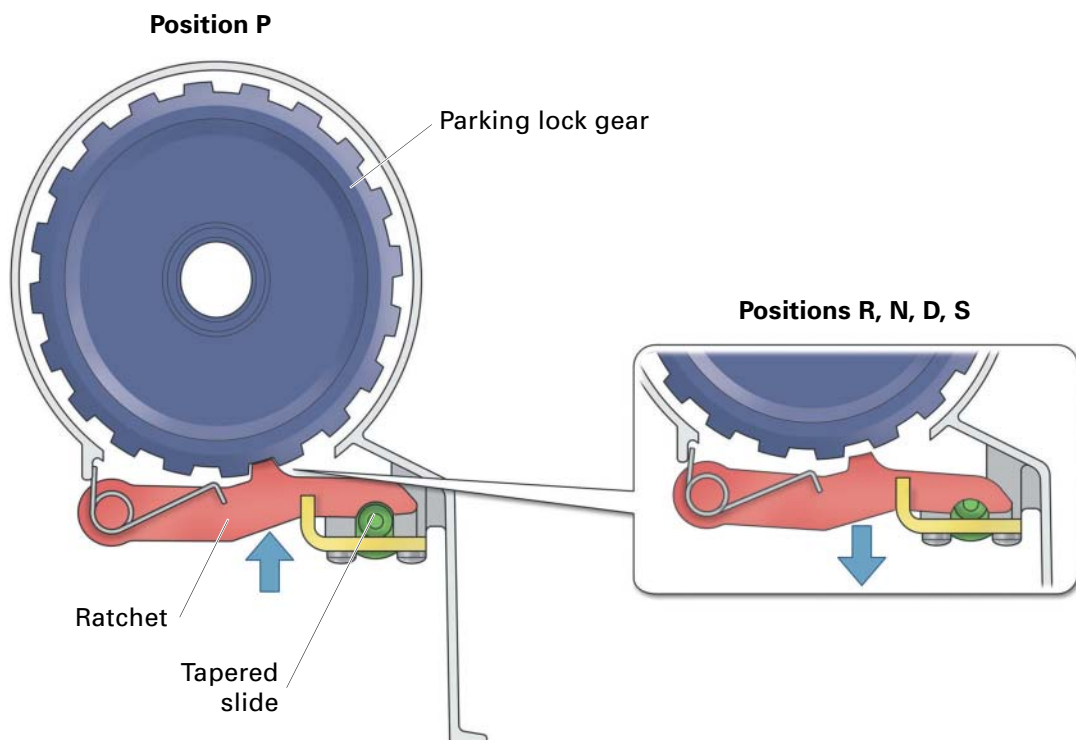
It is of conventional design, i.e. it is actuated (purely mechanically) by the selector lever with a Bowden cable. The parking lock gear is connected to the ring gear 2 and the output shaft.

The ratchet which engages in the toothing of the parking lock gear thus blocks output to the transfer case. Front and rear axle are locked. If one axle is raised, compensation can be achieved via the Torsen differential if the raised wheels are free to turn. This does however result in destruction of the Torsen differential when towing the vehicle, for example.

To facilitate release of the parking lock, the handbrake should be applied before engaging the parking lock.

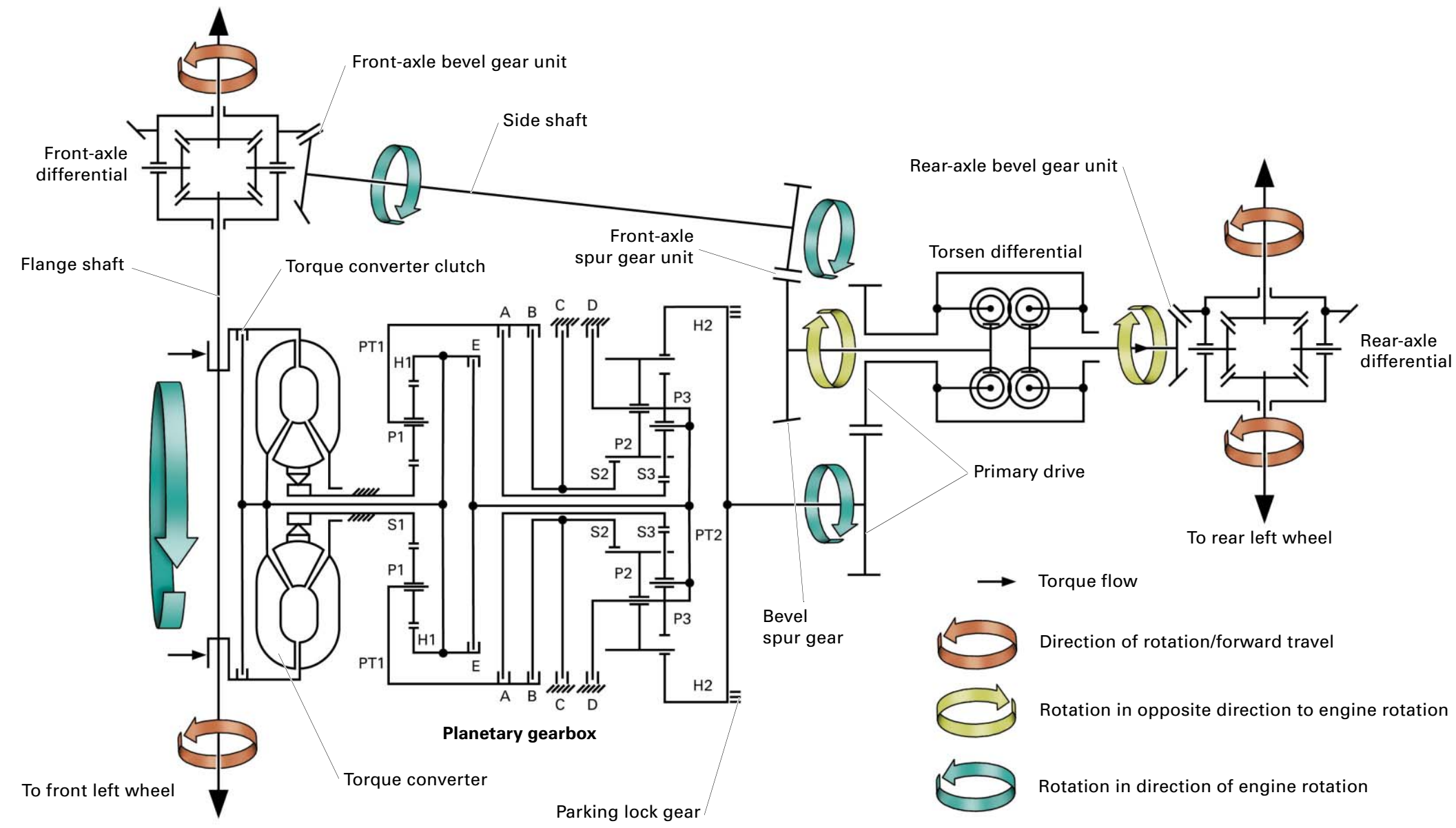


283_034

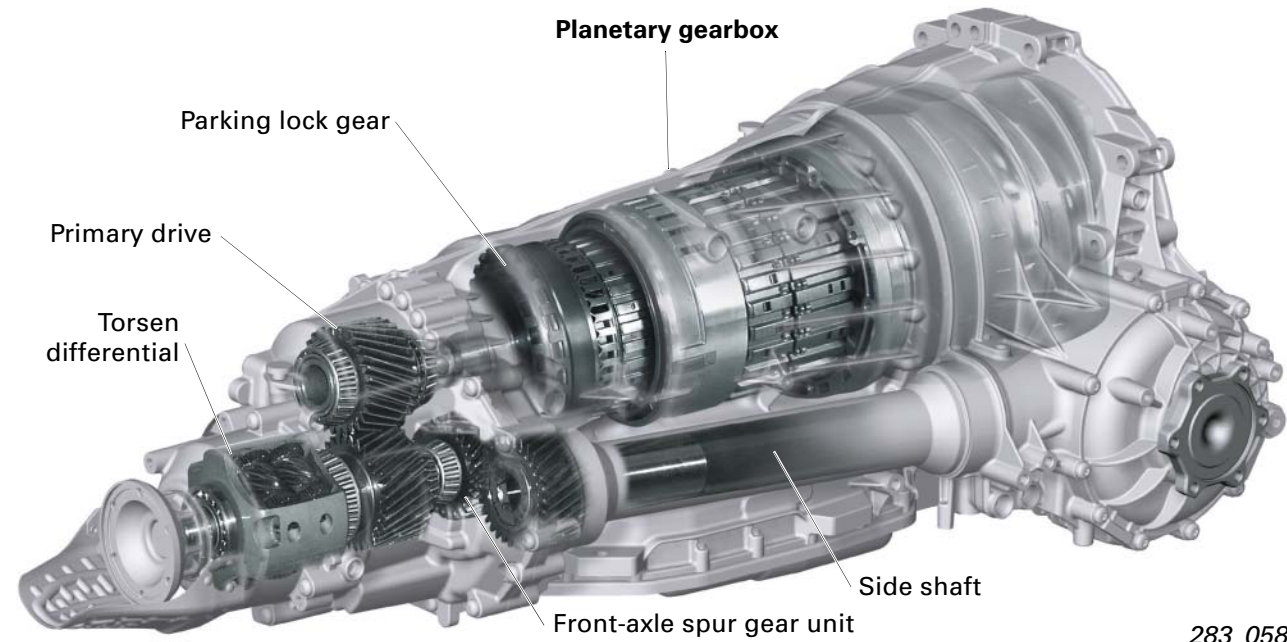


283_085

Torque profile / Four-wheel drive



283_038



283_058

A special feature of the 09E gearbox is the angled position of the input shaft (side shaft) with respect to the front axle.

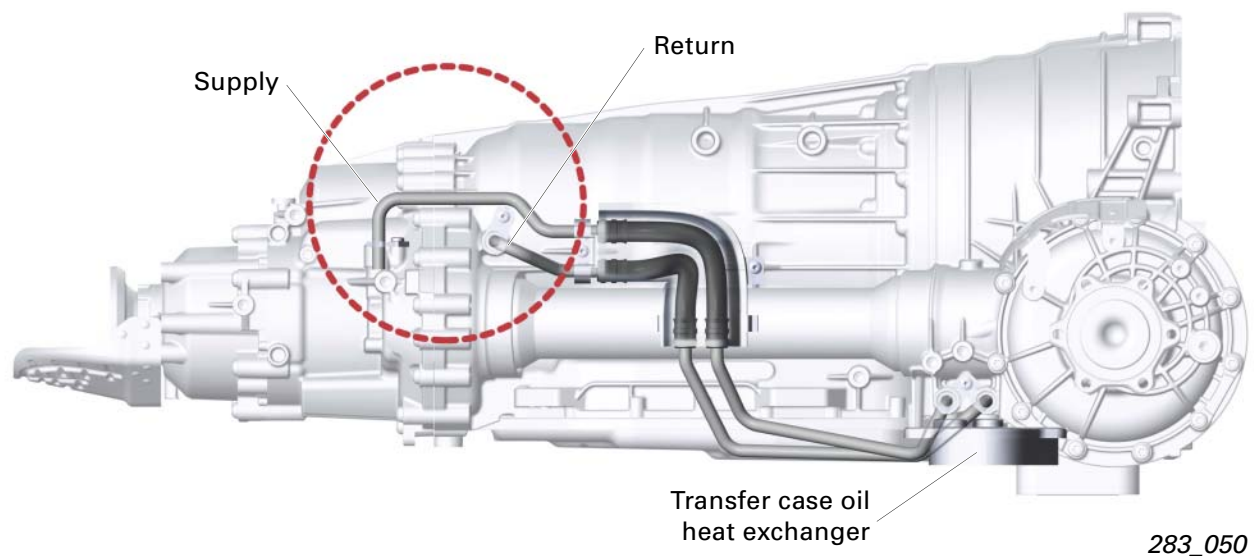
The torque is transmitted by a bevel spur gear (beveloid teeth) at an angle of 8° to the side shaft spur gear.

Gearbox Assemblies

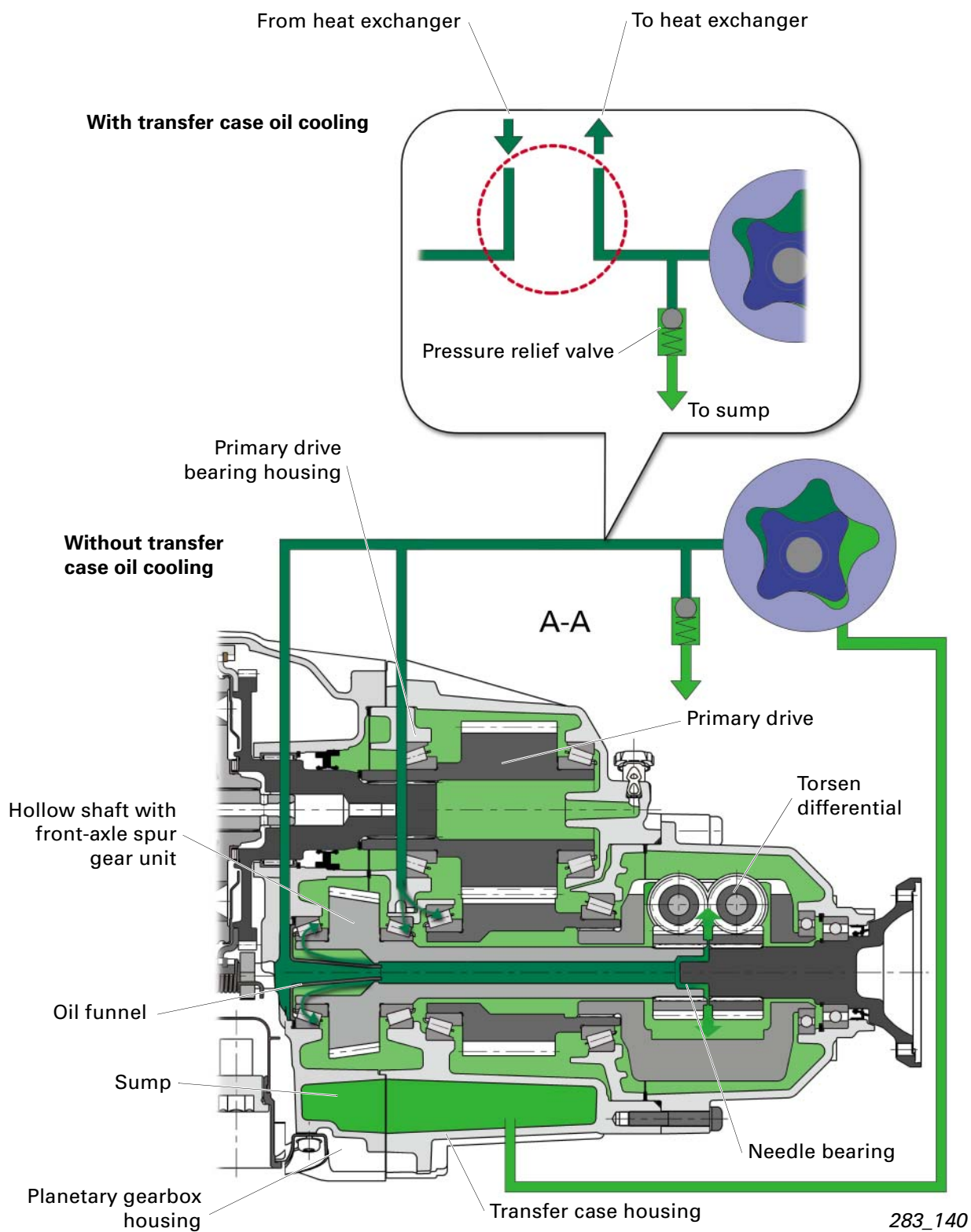
Transfer case cooling

To accommodate future versions, the 09E is already designed with connections for transfer case oil cooling.

For such purposes, the transfer case oil pump is not only responsible for lubricating the transfer case but also for the flow through an optional heat exchanger.

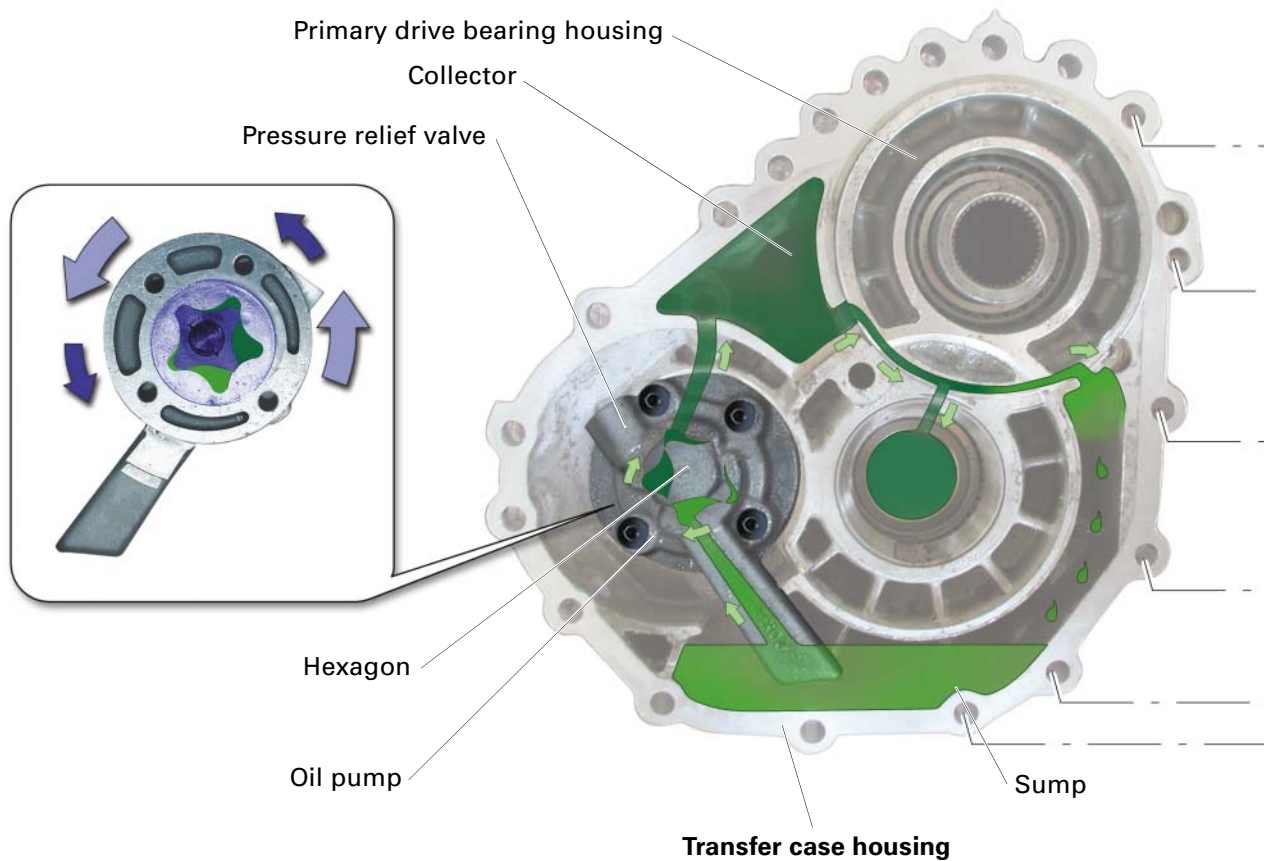


The transfer case oil cooling diagram shown does not correspond to the final series status, as the design had still to be finalised at the time of compilation of this SSP.



Gearbox Assemblies

Transfer case oil pump



The oil pump (rotor-type pump) provides efficient lubrication of all transfer case components.

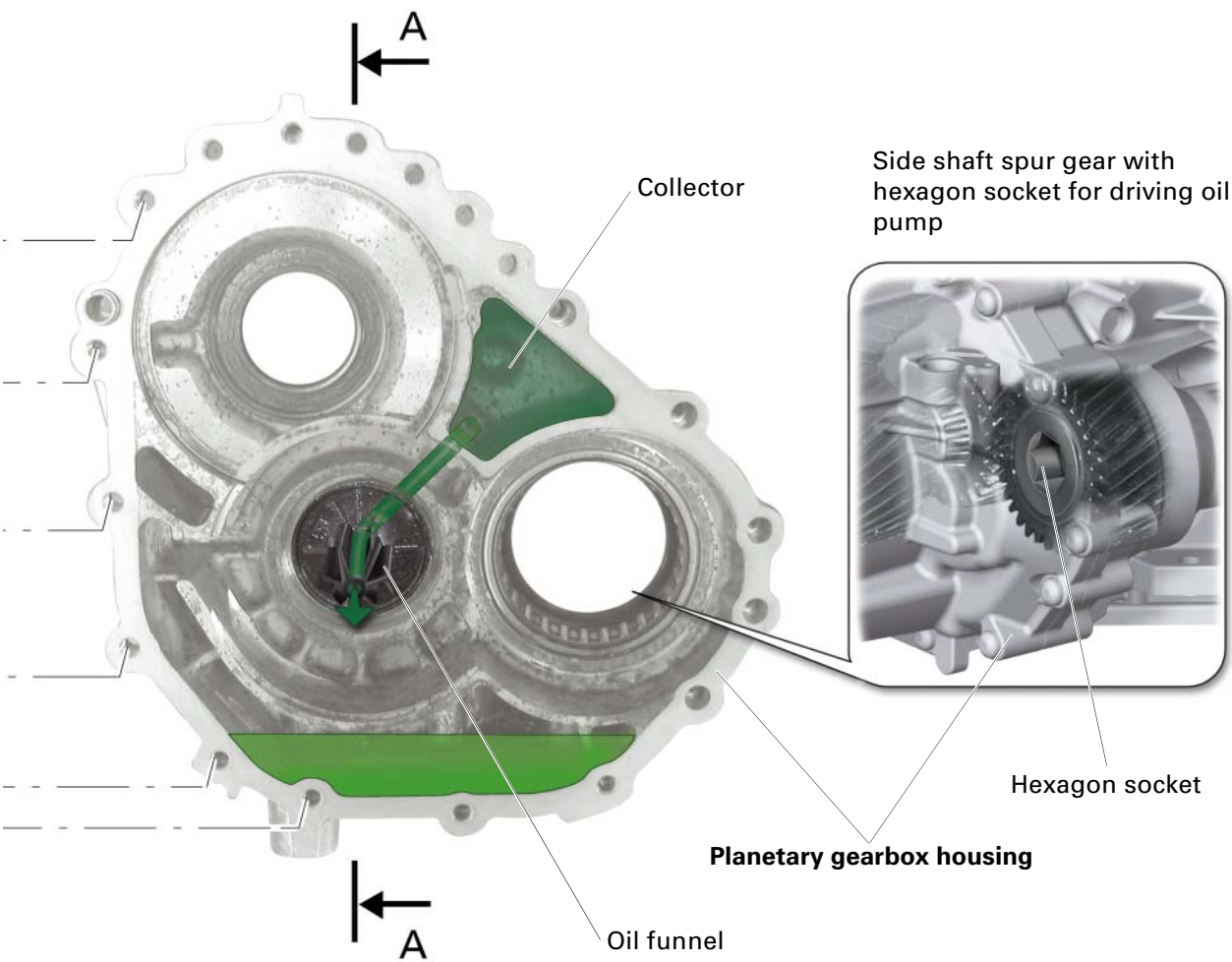
The pump is located in the front housing section of the transfer case and is driven by the side shaft by means of a hexagon connection.

From the sump, the pump conveys the oil into a collector. The oil is routed via a duct in the primary drive bearing housing to the lower primary drive mount and some of the oil is returned to the sump.

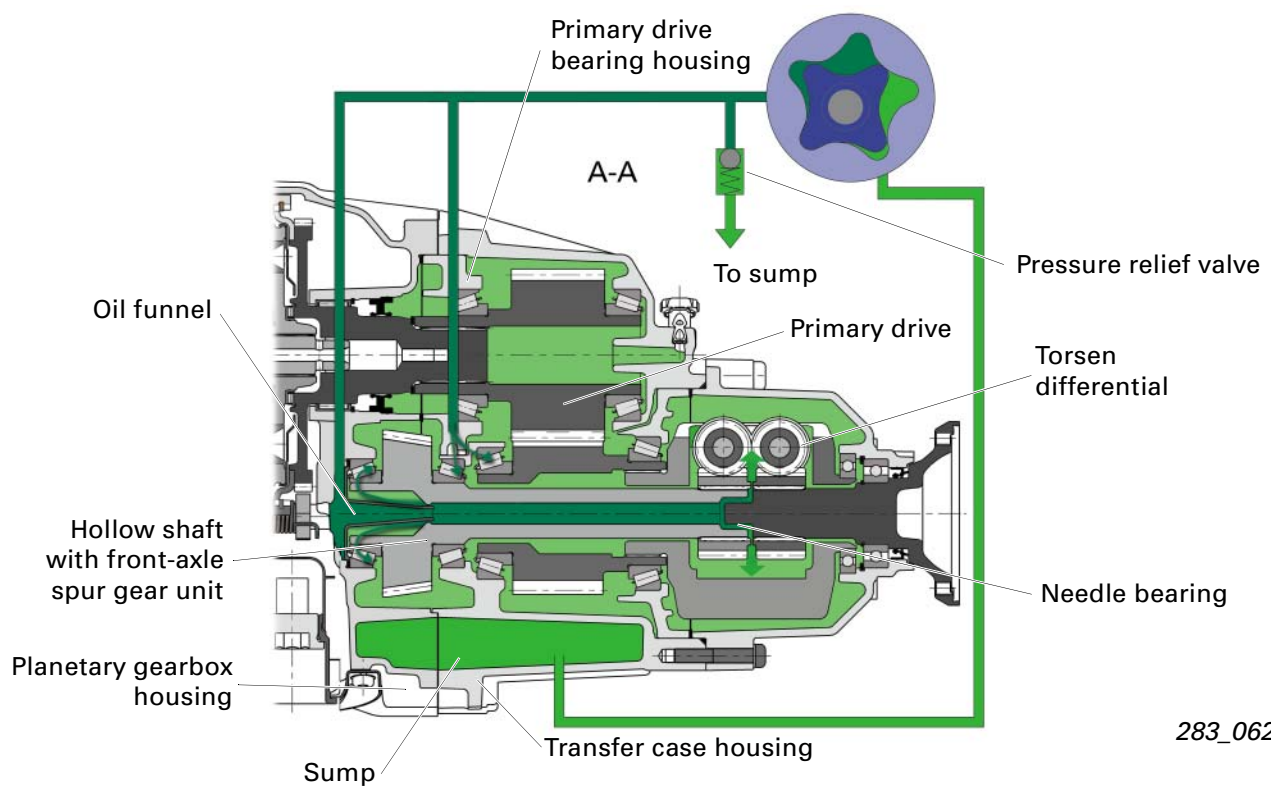
The pressure relief valve in the oil pump protects the components against excessive pressure.

From the collector, the oil is conveyed in a further duct to the oil funnel, which routes the oil into the hollow shaft of the front-axle spur gear unit. From there, it is transferred to the front shaft bearing and via the needle bearing of the rear-axle flange shaft into the Torsen differential.

Such a design permits reliable lubrication with a low oil level, which in turn minimises hydraulic losses and foaming.



283_060



283_062

