

Service Training



Commercial  
Vehicles

Self-study Programme 372

# The Shiftmatic Gearbox 0B81

Design and Function

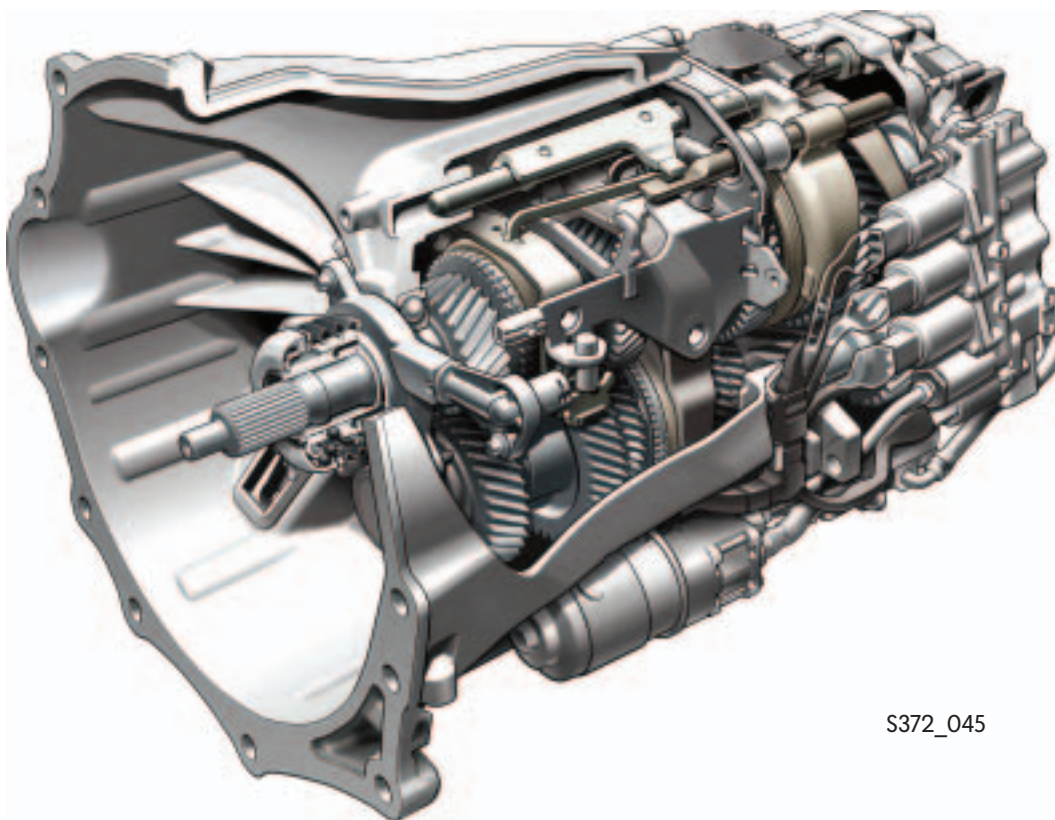


In addition to the two variants of the mechanical manual gearbox, the Crafter is also available with an automated manual gearbox – the Shiftmatic gearbox.

This gearbox is basically the same as a manual gearbox on the inside. However, additional hydraulic components combined with control technology allow gear changes to be automated.

You can use both an automatic shift program and a manual shift program.

The Shiftmatic gearbox is a both practical and low-cost alternative to an automatic gearbox.



**NEW**



**Important  
Note**



**The self-study programme shows the design and function of new developments.  
The contents will not be updated.**

For current testing, adjustment and repair instructions, refer to the relevant service literature.

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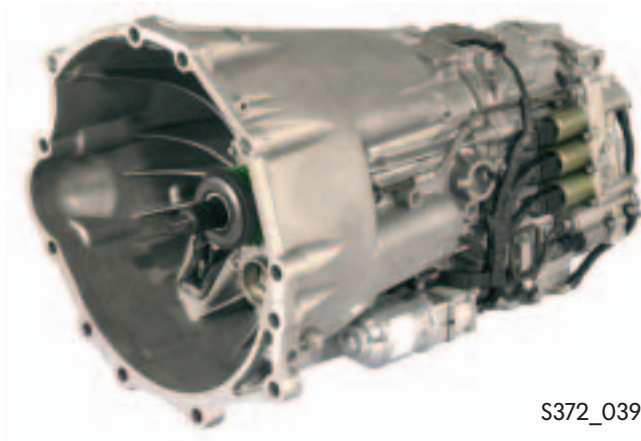




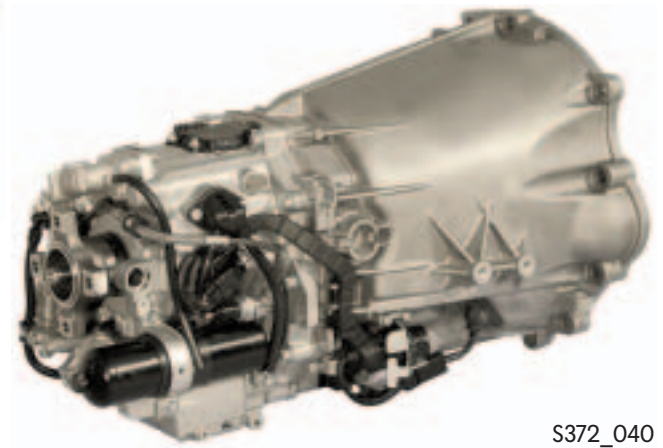
## Introduction

The Shiftmatic gearbox with the code OB81 belongs to the group of fully-automatic gearboxes. This gearbox is based on the manual gearbox OB7 - 330 Nm that is also used in the Crafter.

Gear changes in the Shiftmatic gearbox are either completely automatic or carried out as selected by the driver. Even though the Shiftmatic gearbox has a clutch for power transmission, there is no clutch pedal like with automatic gearboxes. The clutch is operated by a hydraulic system.



S372\_039



S372\_040

The advantages of this gearbox are:

- Cheaper price and lower fuel consumption than an automatic gearbox
- Lower exhaust emissions than an automatic gearbox
- Lower weight compared with an automatic gearbox
- Less work for driver thanks to simple operation
- Short traction interruptions
- Low-wear, smooth and comfortable gearshifts
- Hill start assist as standard

## Technical data



<b>Developer/manufacturer</b>	DaimlerChrysler AG
<b>Name</b>	Shiftmatic OB81
<b>Gearbox type</b>	Automated 6-speed manual
<b>Mounting</b>	Front/longitudinal mounting
<b>Gearbox control</b>	Electro-hydraulic system, consisting of sensors/actuators and gearbox control unit
<b>Number of shafts</b>	3 shafts Drive shaft, layshaft, output shaft
<b>Torque transfer</b>	Max. 330Nm
<b>Clutch</b>	Single-plate, self-adjusting dry clutch SAC "Self Adjusting Clutch"
<b>Clutch operation</b>	Electro-hydraulic
<b>Gearbox oil specification</b>	G 009 317 A2
<b>Gearbox oil capacity</b>	1.5 l
<b>Change interval</b>	320 000 km/10 years
<b>Hydraulic oil specification</b>	G 004 000 M2 PENTOSIN CHF 202
<b>Hydraulic oil capacity</b>	0.5 l lifetime filling
<b>Length (distance from clutch bell housing – output flange)</b>	572.8 mm
<b>Weight</b>	52.5 kg



## Ratios

2.5l TDI engine			
Engine code <b>BJK 80 kW</b> and engine code <b>BJL 100 kW</b>			
	Ratio: i	Gear pair	Gear jumps
Constant mesh	$i_k = 1,56$	$\frac{39}{25}$	
1st gear	$i_1 = 5,014$	$\frac{39 \times 45}{25 \times 14}$	
2nd gear	$i_2 = 2,831$	$\frac{39 \times 49}{25 \times 27}$	$\frac{i_1}{i_2} = 1,771$
3rd gear	$i_3 = 1,789$	$\frac{39 \times 39}{25 \times 34}$	$\frac{i_2}{i_3} = 1,582$
4th gear	$i_4 = 1,256$	$\frac{39 \times 33}{25 \times 41}$	$\frac{i_3}{i_4} = 1,425$
5th gear	$i_5 = 1,0$		$\frac{i_4}{i_5} = 1,256$
6th gear	$i_6 = 0,797$	$\frac{39 \times 24}{25 \times 47}$	$\frac{i_5}{i_6} = 1,255$
Reverse	$i_R = 4,569$	$\frac{39 \times 23 \times 41}{25 \times 23 \times 14}$	
Spread $\varphi$		$\frac{i_1}{i_6} = 6,291$	

The gear jump is the transmission ratio of two neighbouring gears.

This ratio is given as a decimal value or as a percentage.

Example of decimal value:  $\frac{i_1}{i_2} = 1,771$

Example of percentage:  $\left(\frac{i_1}{i_2} - 1\right) \cdot 100 \% = 77,1 \%$

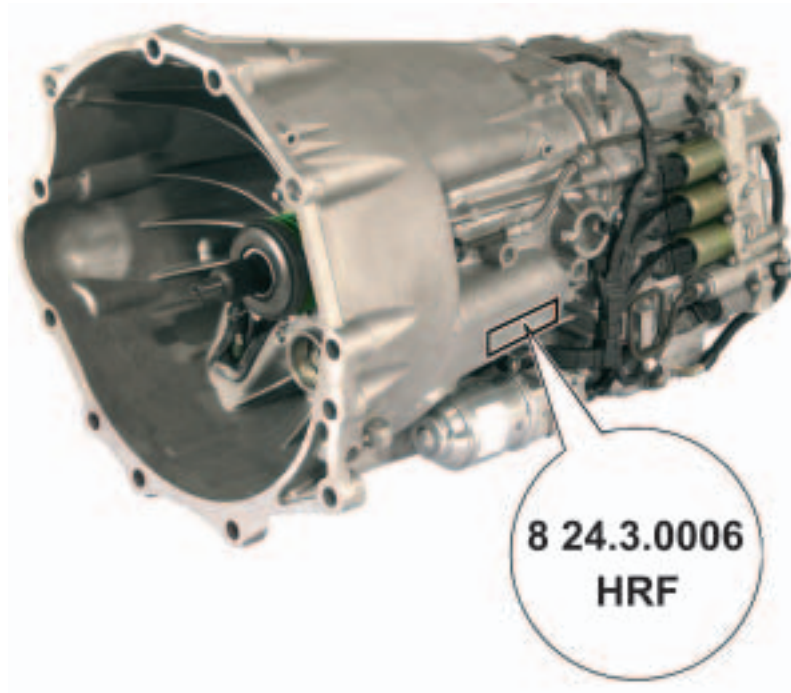


Progressive gear-ratio steps were chosen for the Shiftmatic gearbox. The gear jumps become smaller as the gear number gets higher with this type of gearing. As a result, the gear ratios between the higher gears are closer compared with the lower gears. The Shiftmatic gearbox has therefore been specially configured for driving in higher gears.

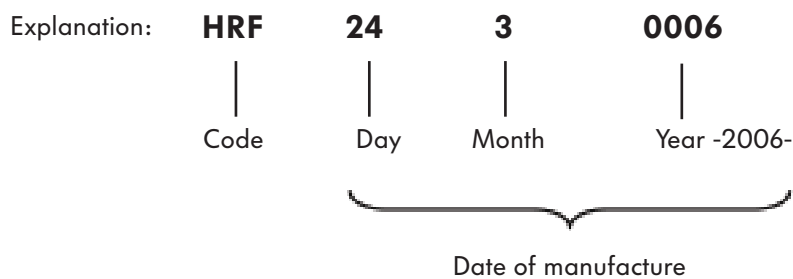
Furthermore the Shiftmatic gearbox has a spread of 6.291, which is particularly useful when the Crafter is used as a transport vehicle. This adjustment allows a high starting ratio ( $i_1$ ) with good acceleration and a low minimum ratio ( $i_6$ ) for low engine speeds at high speeds. This also reduces the fuel consumption.

## Gearbox code

The gearbox code and the design data are located on the left-hand side of the front gearbox casing.



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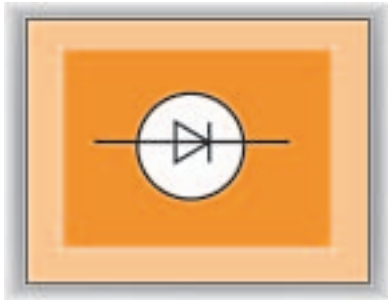


# In Brief



## Function areas

### Electronics

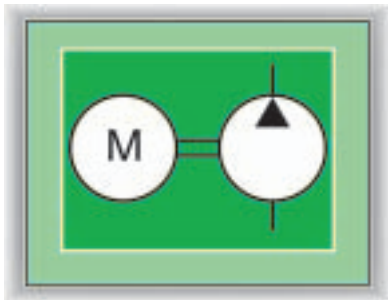


S372\_061

consisting of ...

- Sensors
- Actuators
- Gearbox control unit

### Hydraulics



S372\_062

consisting of ...

- Hydraulic pump
- Accumulator
- Slave cylinder with clutch release bearing
- Shift actuator
- Solenoid valves

### Mechanics



S372\_063

consisting of ...

- Housing
- Shafts with gears and bearings
- Shift unit





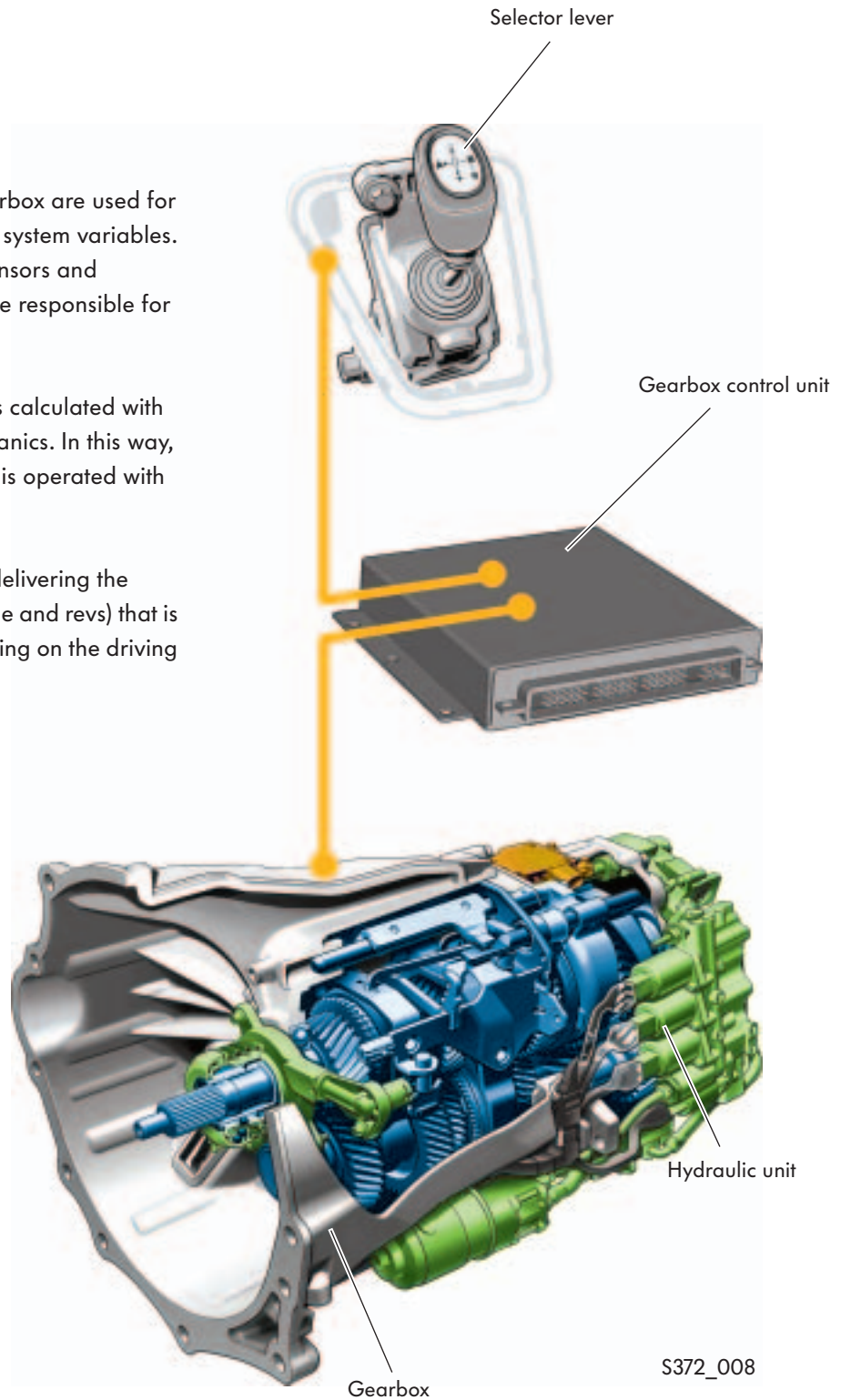
The Shiftmatic gearbox can be subdivided into the following functional areas on the basis of its design and operation:

- Electronics
- Hydraulics
- Mechanics

The electronics in the Shiftmatic gearbox are used for evaluating and monitoring different system variables. The gearbox control unit with the sensors and actuators that are connected to it are responsible for this in particular.

The hydraulics transfer the variables calculated with the electronics to the gearbox mechanics. In this way, the gears are shifted and the clutch is operated with the hydraulics.

The mechanics are responsible for delivering the necessary power transmission (torque and revs) that is calculated in the electronics depending on the driving conditions.



# Gearbox Mechanics

## Gearbox design

The Shiftmatic gearbox is based on a manual gearbox.

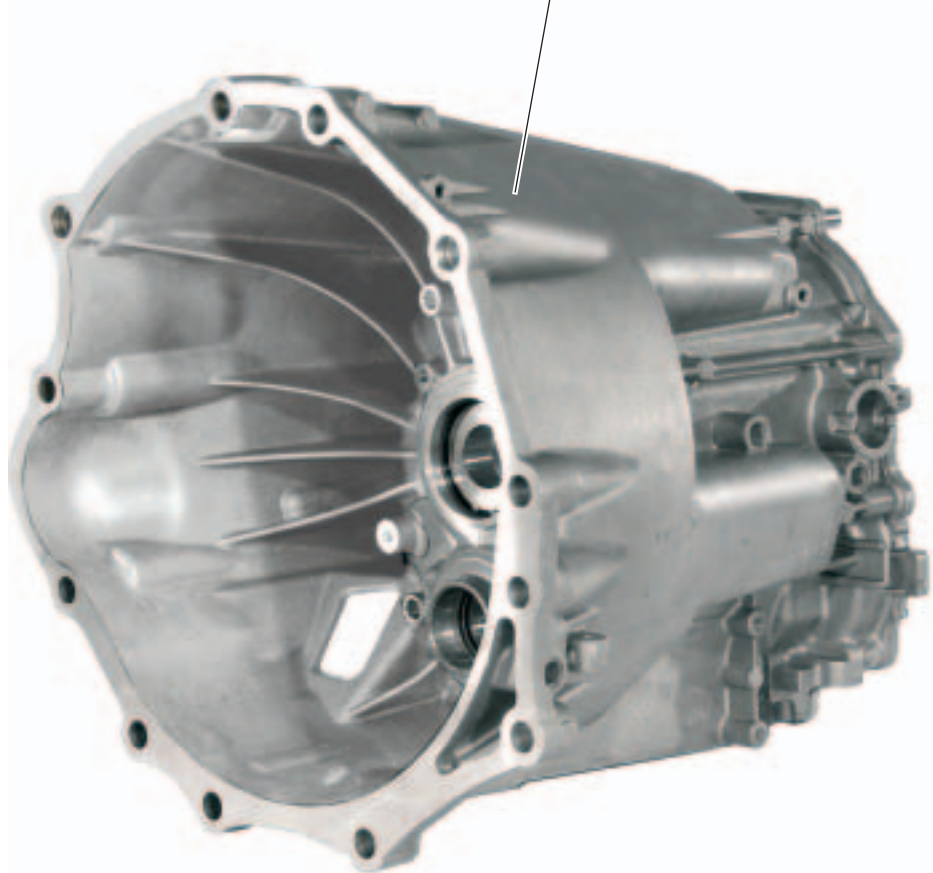
It uses components from the OB7 - 330 Nm manual gearbox.

The three main components are:

- the front and
- the rear gearbox case,
- the gearbox shafts with shift unit.

The two cases are made from a cast aluminium alloy.

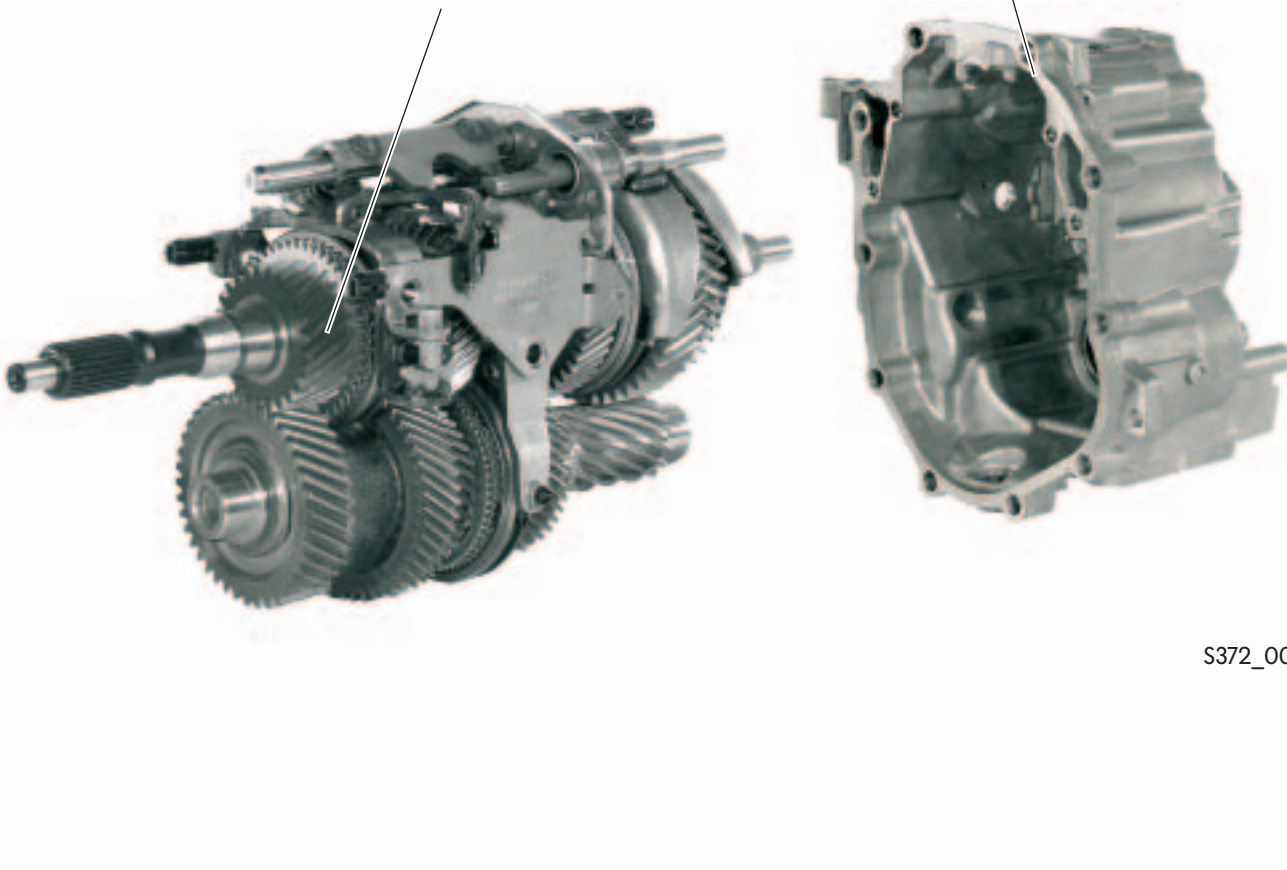
Front gearbox case  
(with clutch bell housing)





Gearbox shafts with  
shift unit

Rear gearbox case



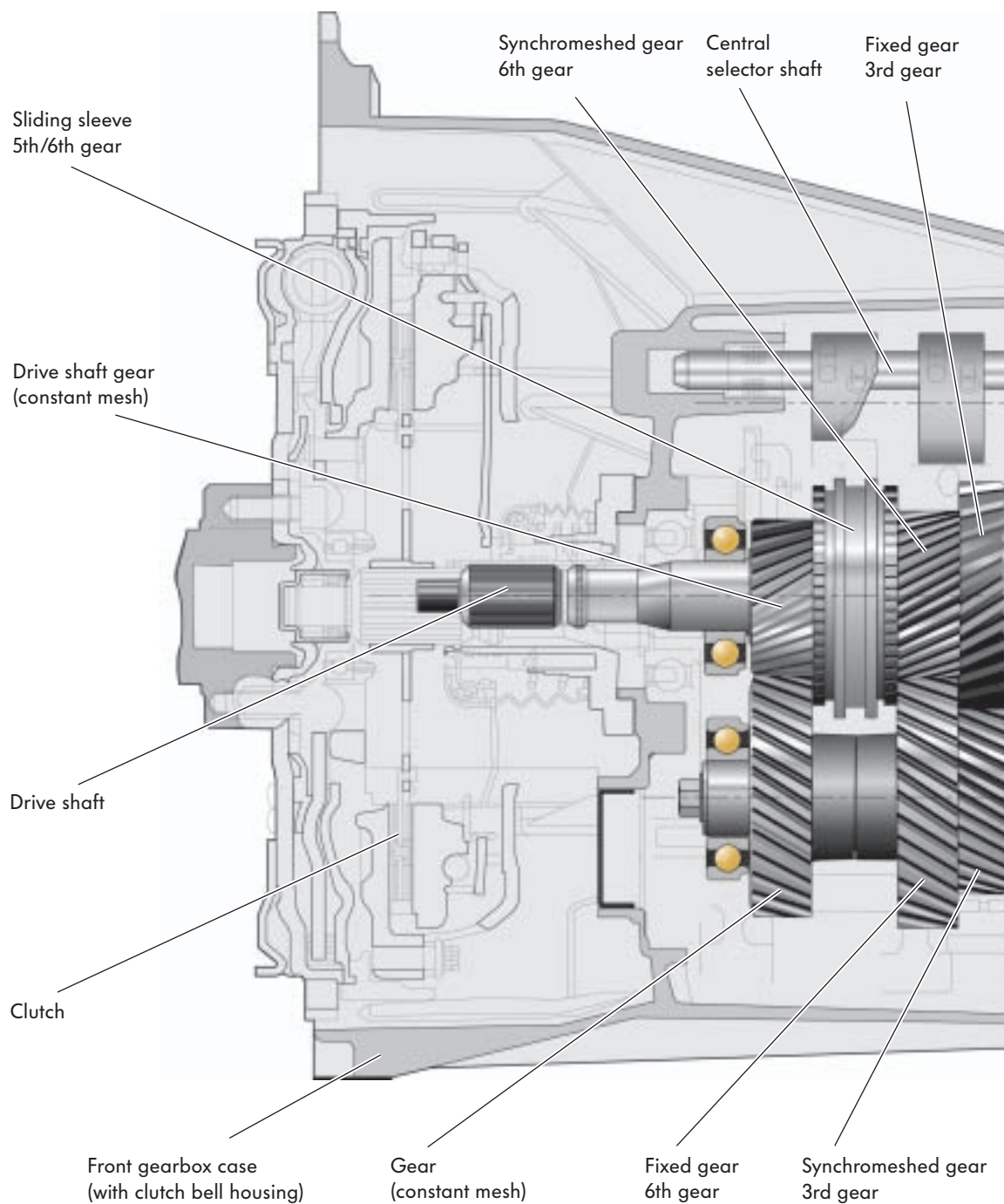
S372\_002

# Gearbox Mechanics

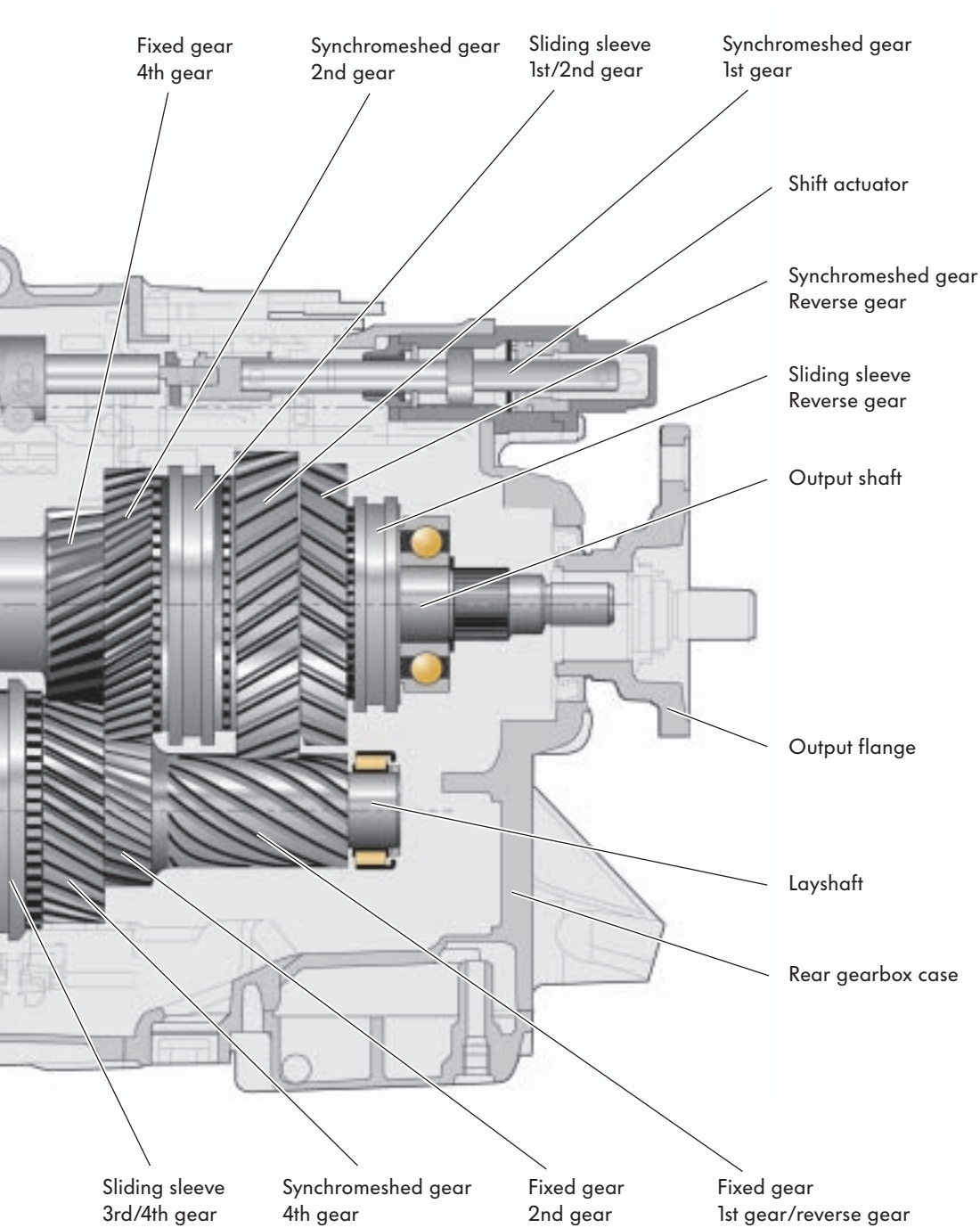
## Gearbox cross-section

The OB81 Shiftmatic gearbox is a 2-step gearbox with fully synchronized gears. It has a drive shaft, a layshaft and an output shaft.

All synchroneshed gears use needle bearings and are distributed on the layshaft and the output shaft. The 5th gear is selected directly by the sliding sleeve shifting to the drive shaft gear.



The gears are selected by the central selector shaft either moving longitudinally or moving longitudinally and rotating. The selector finger of the central selector shaft then engages in the respective selector fork.



S372\_001

# Gearbox Mechanics

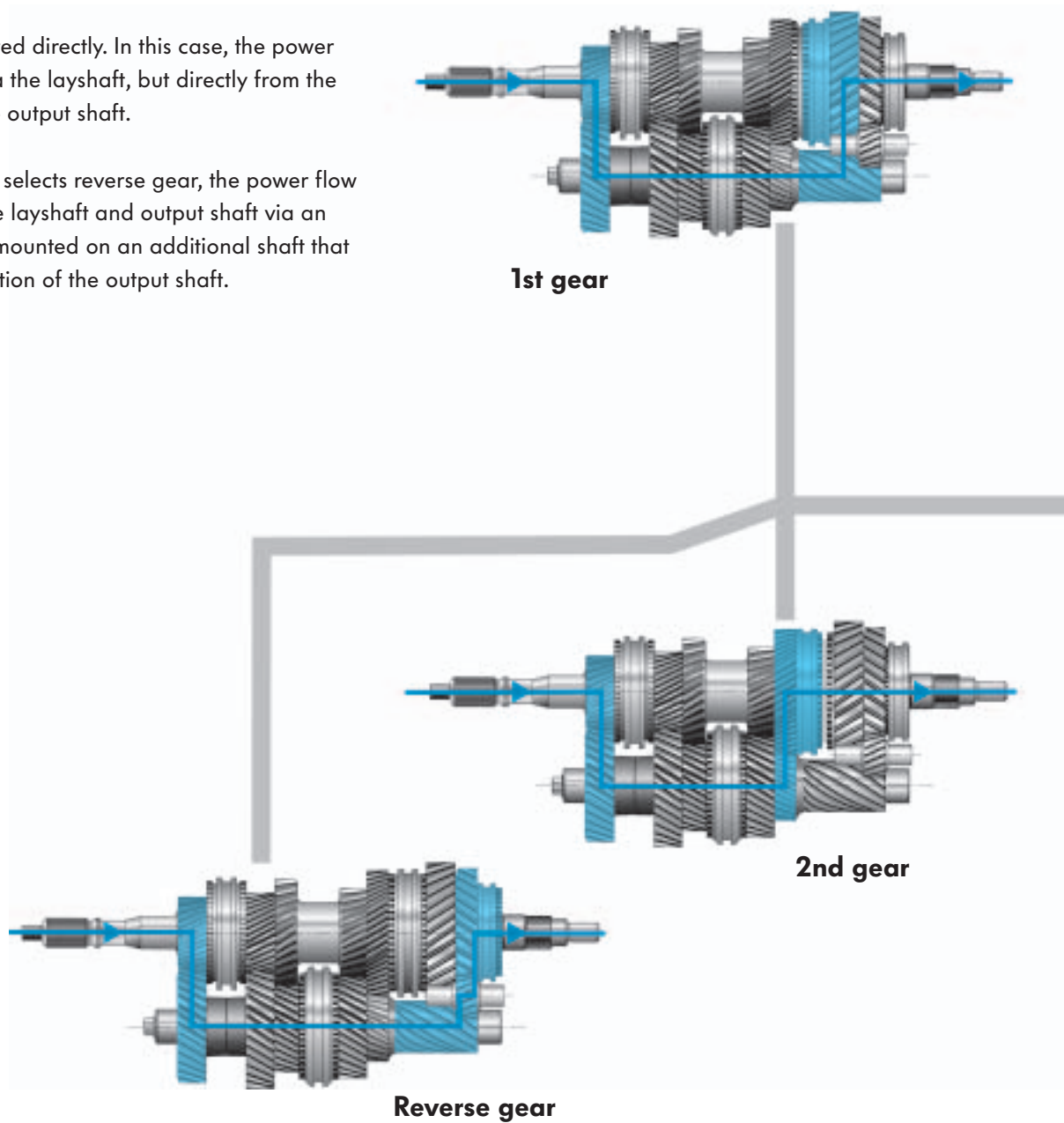
## Power transmission

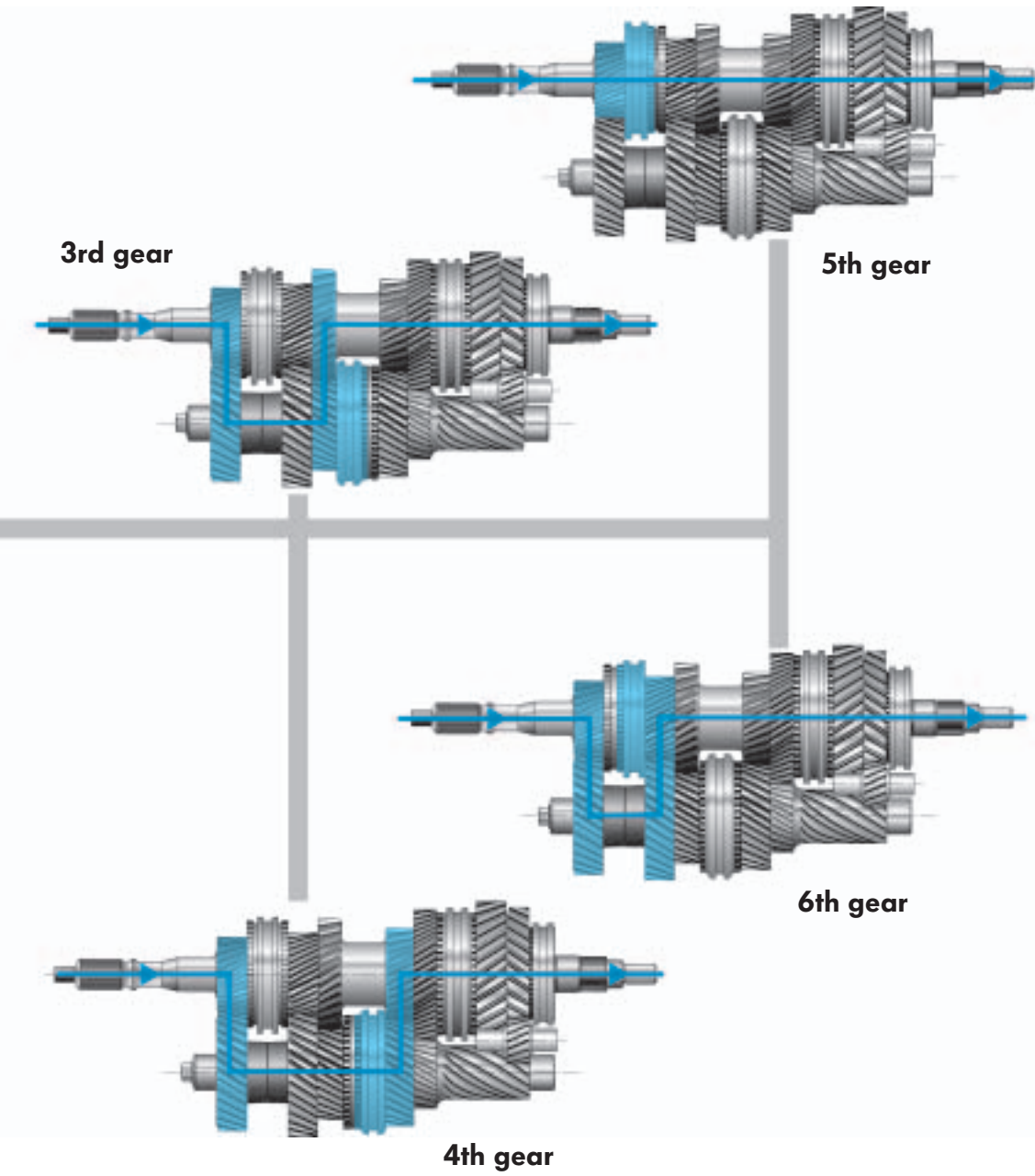
The engine torque is transmitted to the gearbox via the drive shaft. The gear pair for the constant mesh, which is always in use, transfers the power flow to the layshaft.

In all gears except for 5th gear, the power flow is transferred from the layshaft to the output shaft via the respective gear pair for the selected gear.

5th gear is selected directly. In this case, the power does not flow via the layshaft, but directly from the drive shaft to the output shaft.

When the driver selects reverse gear, the power flow runs between the layshaft and output shaft via an individual gear mounted on an additional shaft that reverses the rotation of the output shaft.





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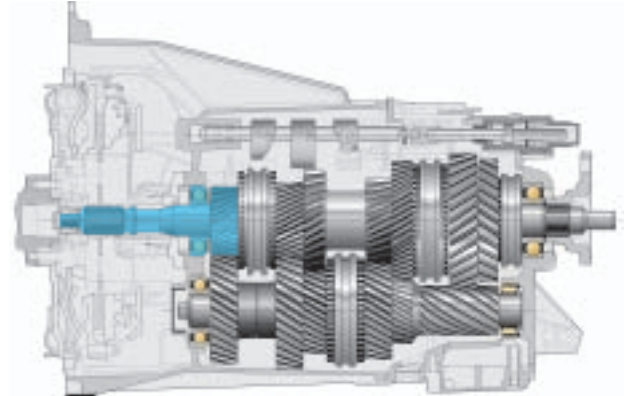
# Gearbox Mechanics

## Drive shaft

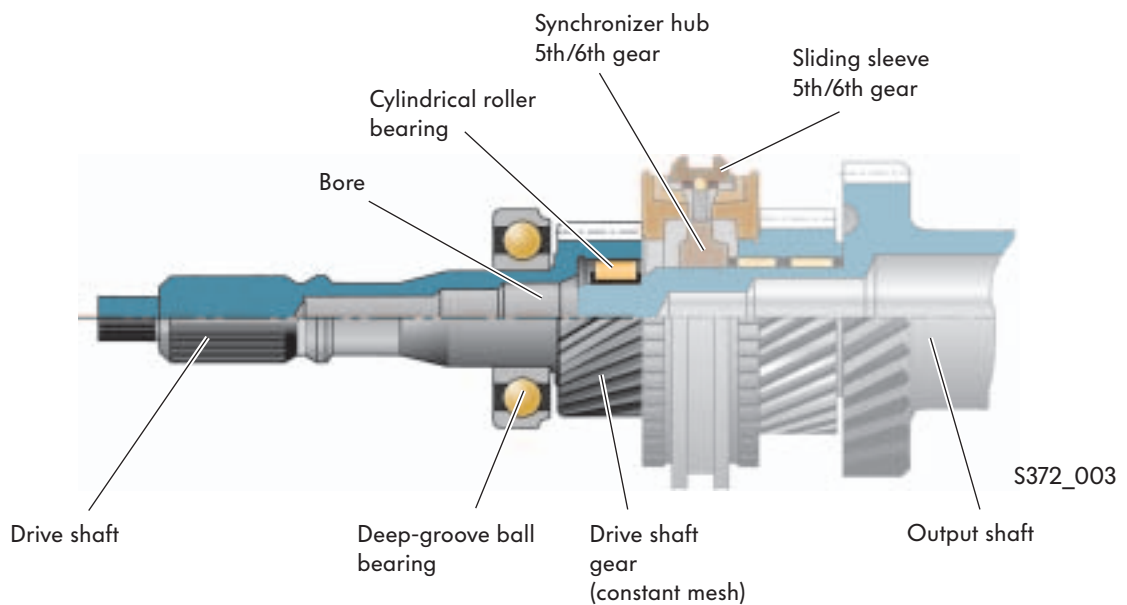
The drive shaft is mounted in the front gearbox case with a fixed deep-groove ball bearing.

The cylindrical roller bearing works as a moveable bearing between the drive shaft and output shaft. It is in the drive shaft bore hole.

The drive shaft gear for the constant mesh is part of the drive shaft.



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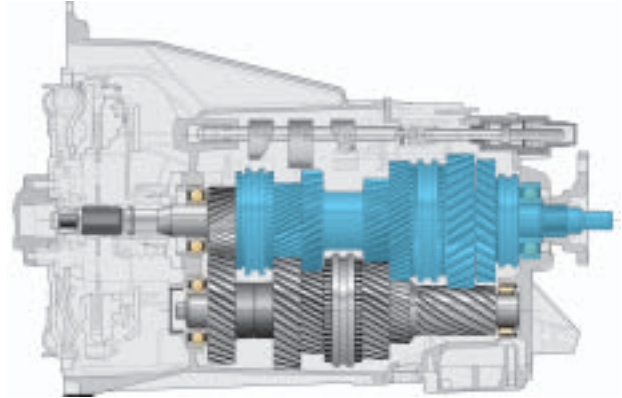


## Output shaft

The output shaft uses a deep-groove ball bearing that is fitted in the rear gearbox casing as a fixed bearing. The cylindrical roller bearing works as a moveable bearing between the drive shaft and output shaft.

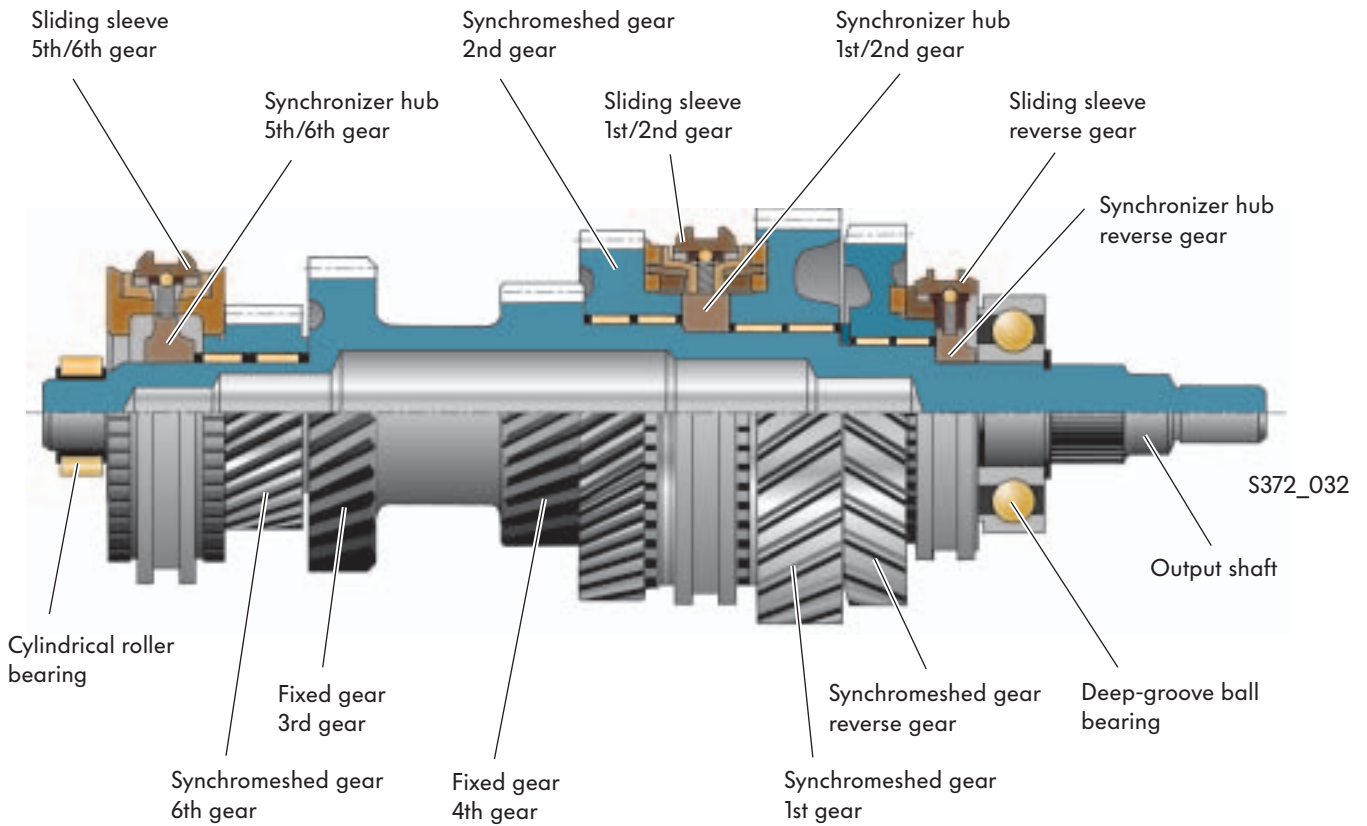
The fixed gears for 3rd and 4th gear are part of the output shaft. The synchroneshed gears for 1st, 2nd, 6th and reverse gear have needle bearings and thus rotate freely. These synchroneshed gears are also called idler gears and they rotate constantly with the corresponding fixed gears.

The synchroneshed gears only connect to the output shaft via the respective sliding sleeve and the accompanying synchronizer hub to transfer the torque once a gear has been selected.



S372\_069

The synchronizer hubs for 1st/2nd gear, 5th/6th gear and reverse gear are permanently connected to the output shaft via splines.



# Gearbox Mechanics

## Layshaft

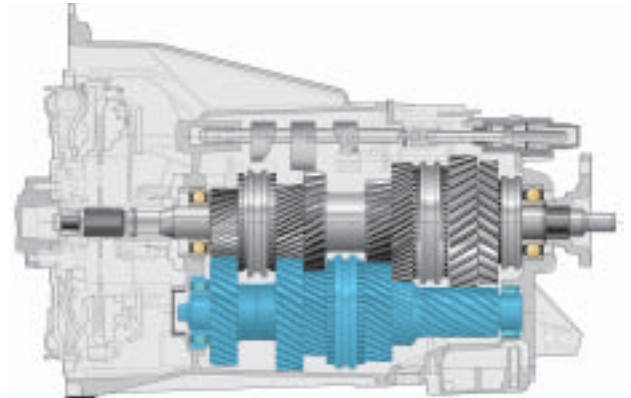
One fixed and one moveable bearing are also used as bearings for the layshaft.

The deep-groove ball bearing is fitted in the front gearbox case as a fixed bearing and the cylindrical roller bearing as a moveable bearing in the rear gearbox case.

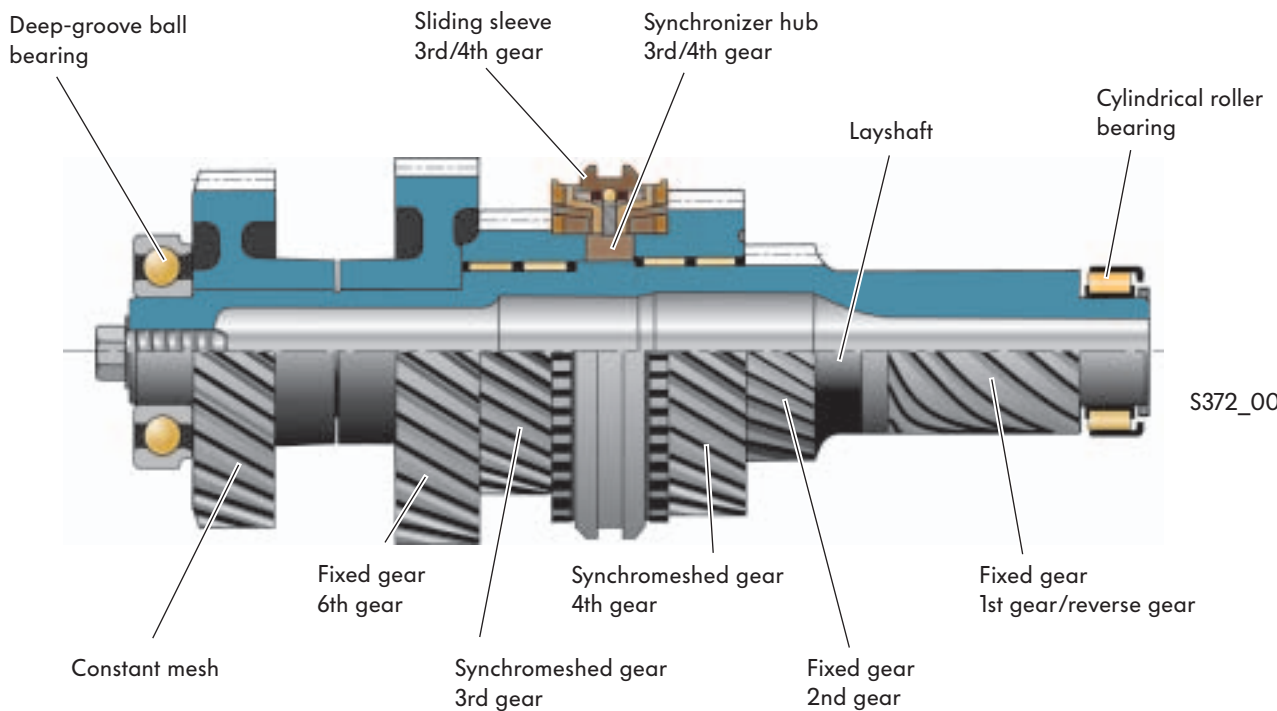
The fixed gears for 1st and 2nd gear are part of the layshaft.

The synchroneshed gears for 3rd and 4th gear are idler gears on needle bearings. The fixed gear for 6th gear as well as the constant mesh are press-fitted onto the layshaft.

The synchronizer hub for 3rd/4th gear also meshes with the layshaft via a gear.



S372\_070



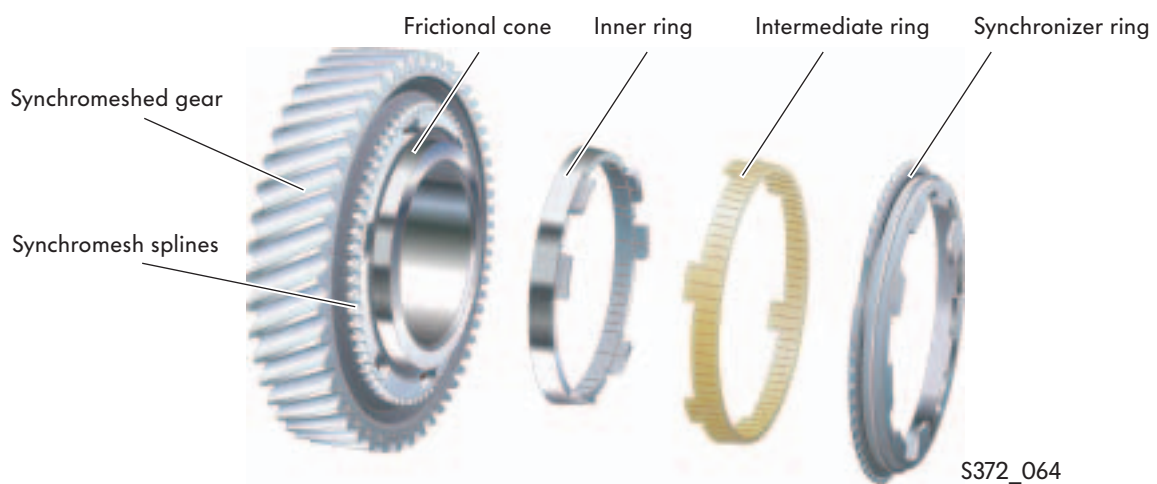
S372\_004

## Synchromesh

Different synchromeshes are used for the individual gears in one gearbox to allow adjustment to different speeds.

### 1st/2nd gear – triple synchromesh

The engine speed differences are greatest in 1st and 2nd gear. Therefore triple synchromesh is used here. In the synchromesh, a frictional surface is formed between the frictional cone on the synchromeshed gear and the inner ring, a second one between the inner ring and intermediate ring and a third one between the synchronizer ring and intermediate ring.

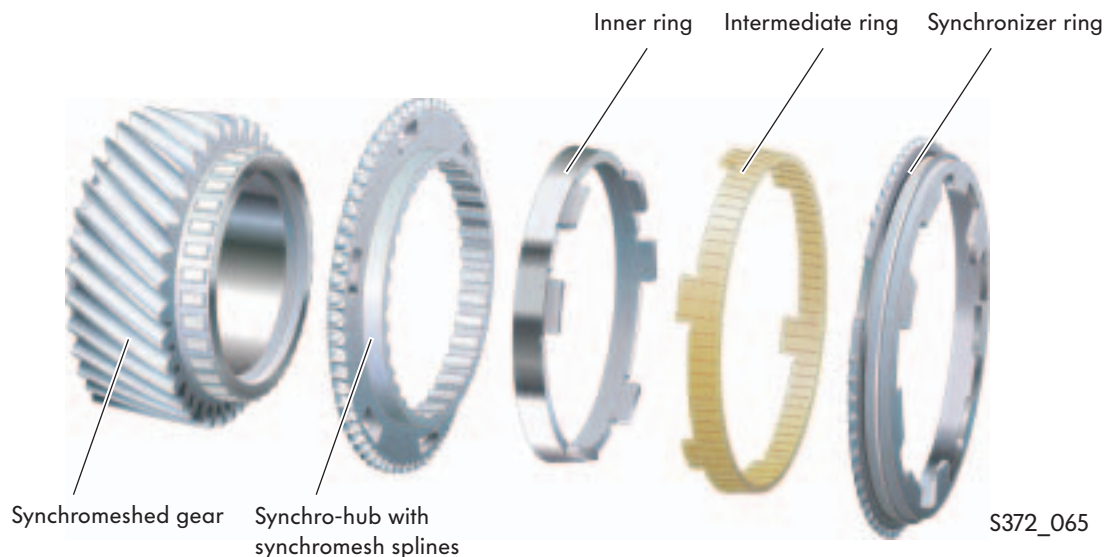


### 3rd/4th gear – double synchromesh

The double synchromesh in 3rd and 4th gear has a special feature on the Shiftmatic gearbox OB81.

It consists of a synchro-hub with synchromesh splines that can be replaced separately and fits onto the synchromeshed gear.

The friction surfaces for the double synchromesh are between the inner ring and intermediate ring as well as between the synchronizer ring and intermediate ring.

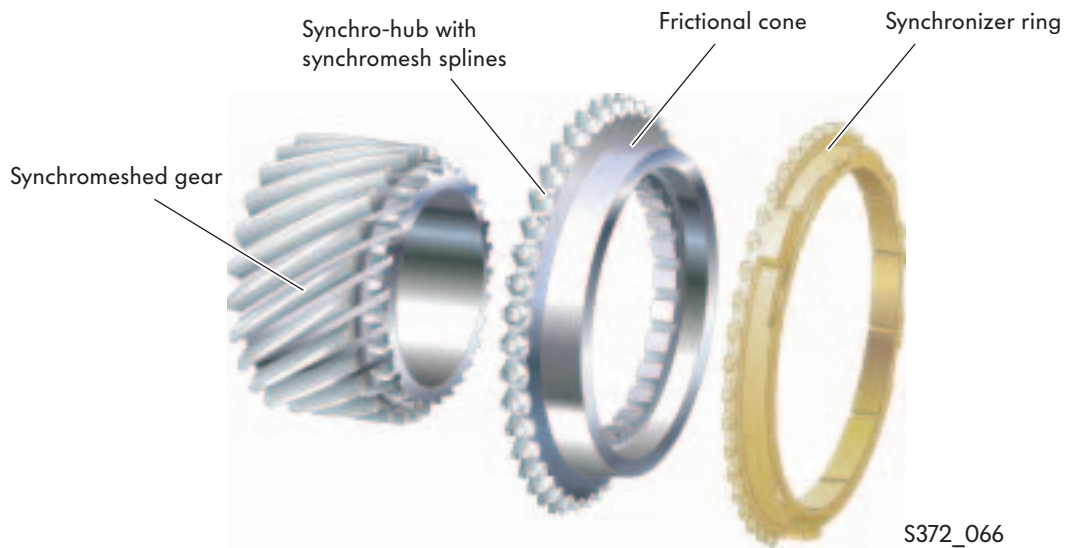


# Gearbox Mechanics

## 5th/6th gear – single synchronesh

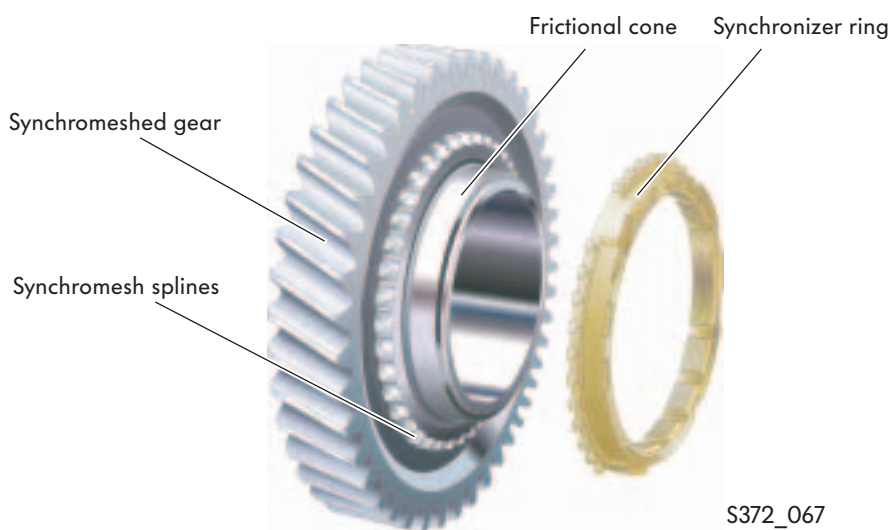
In 5th/6th gear, single synchronesh is used due to the small engine speed differences. The separate synchro-hub with synchronesh splines is the special feature in this case.

The single synchronesh has just one frictional surface between the frictional cone on the synchro-hub and the synchronizer ring.



## Reverse gear – single synchronesh

The reverse gear in the Shiftmatic gearbox is single synchronesh. The only frictional surface here is between the frictional cone on the synchromeshed gear and the synchronizer ring.

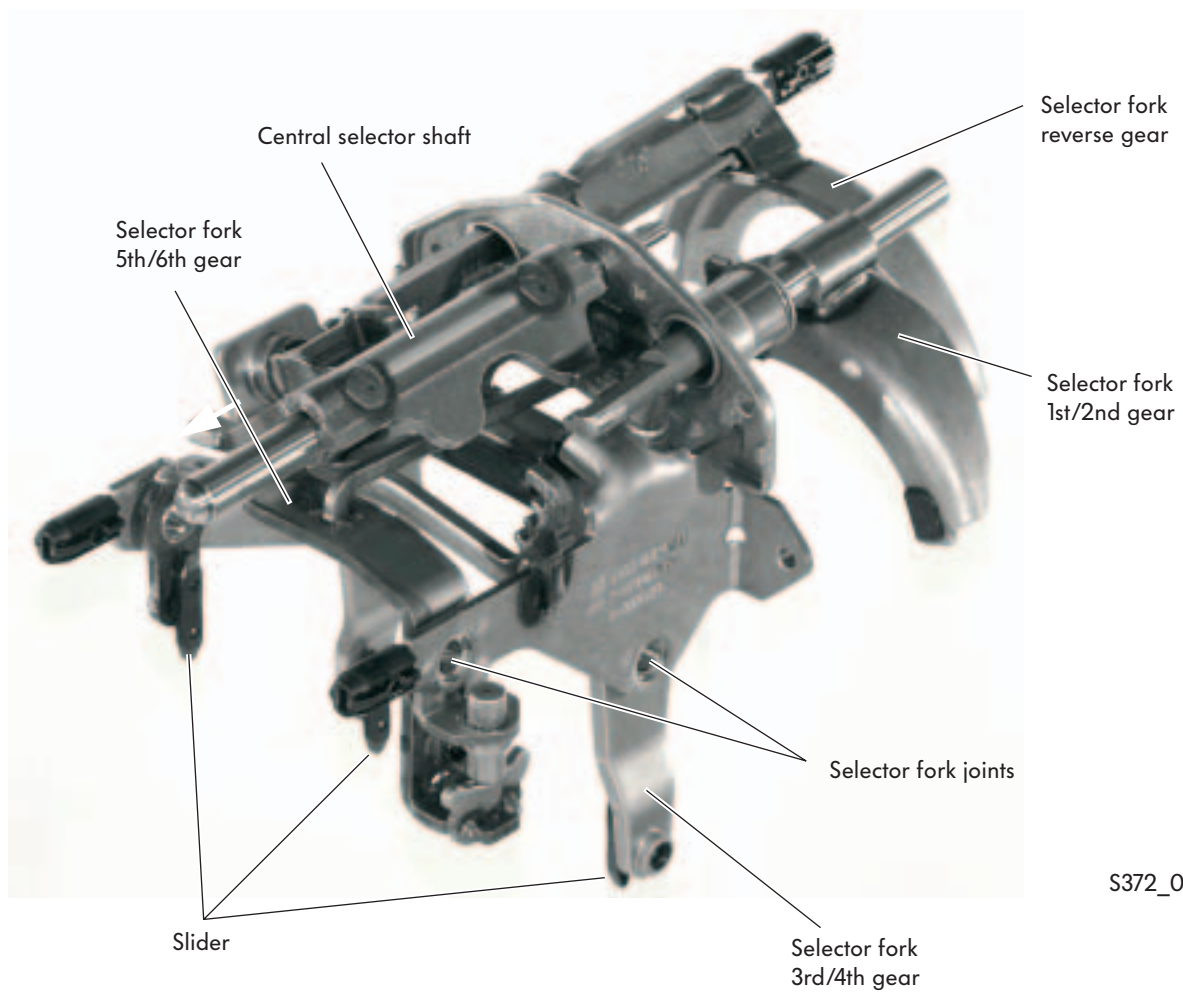


You will find more information on synchronesh in self-study programme 320 "6-Speed Manual Gearbox 0A5".

## Shifter unit

The shift unit is used to engage the selected gear with its shifter rails and selector forks. The central selector shaft is the central part of this shifter unit. It has the task of transferring the movement to the selector forks. The movement is transferred to the sliding sleeves by the selector forks for the respective gear pair.

As the selector fork for the 5th/6th gear and the selector fork of the 3rd/4th gear carry out a rotary movement instead of a longitudinal movement, rotating sliders are mounted on the selector forks to transfer the movement onto the sliding sleeve.

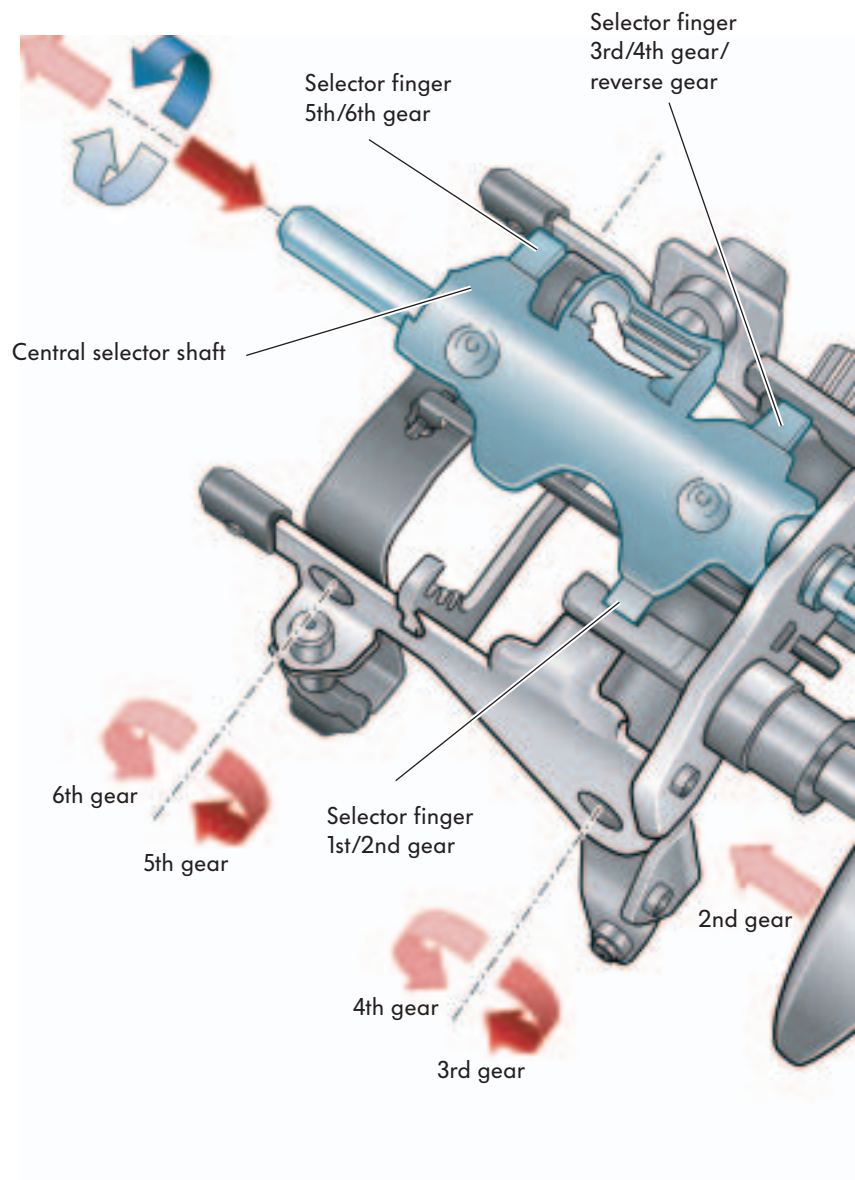


S372\_009

# Gearbox Mechanics

## Shifter unit with shift actuator

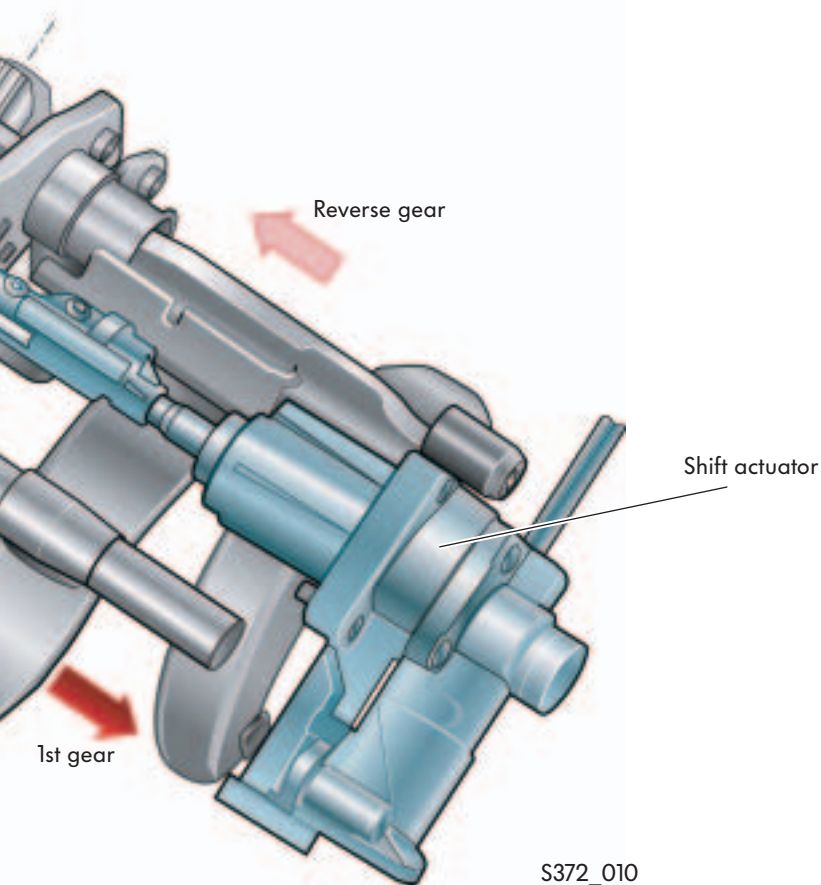
The central selector shaft has three selector fingers. These selector fingers are pushed to the respective position to operate a selector fork by the rotary movement of the central selector shaft. Rotary movement of the central selector shaft to the left causes a downwards gate change and rotary movement to the right causes an upwards gate change. The central selector shaft causes a longitudinal movement for a gear change within the gate.



The gearshifts are calculated in the electronic manual gearbox control unit J514 on the basis the driver's shift selection or the driving situation and applied by the hydraulic system.

The central selector shaft is bolted to the shift actuator on the hydraulic system for this reason.

Due to pressure build-up or reduction in the various chambers of the shift actuator, the central selector shaft is set in a rotary movement with longitudinal displacement or only in a longitudinal movement.



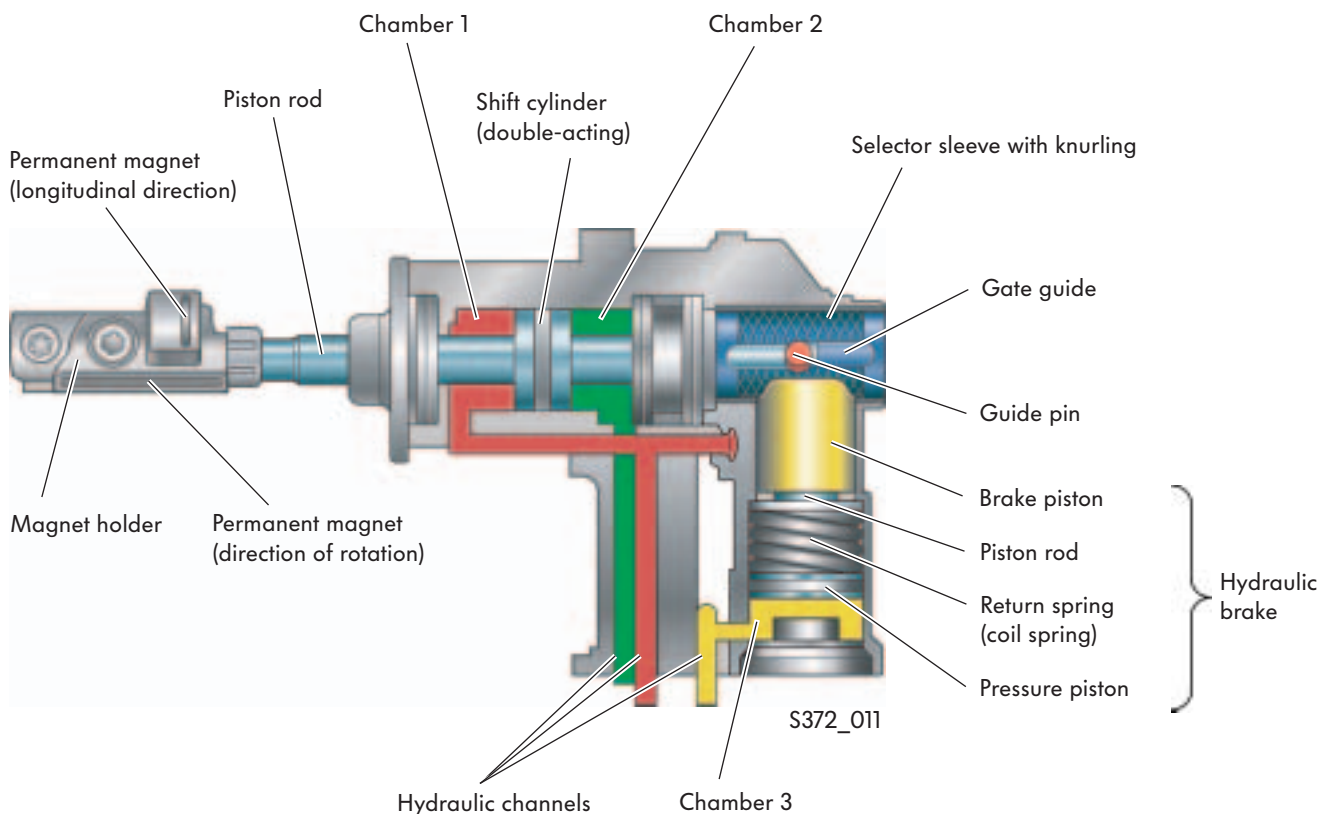
S372\_010

# Gearbox Mechanics

## Shift actuator

The shift actuator forms the interface between the mechanics and hydraulics. It consists of two hydraulic cylinders. The double-acting hydraulic cylinder is the shift cylinder. It is connected to the central selector shaft on the left via the piston rod. The selector sleeve with gate guide is fitted on the piston rod of the shift cylinder on the right-hand side. The guide pin that is press-fitted onto the piston rod is located inside the gate guide.

The second hydraulic cylinder is the hydraulic brake. This cylinder is a single-acting hydraulic cylinder that has a coil spring to return it into position. The pressure piston is mounted on the underside and the brake piston on the upside. The upper part of the brake piston has a cylindrical shape like the outer contour of the selector sleeve. To improve the friction effect between the selector sleeve and the brake piston, the selector sleeve has a knurled surface.







There is a solenoid valve for each hydraulic channel (chamber) in the shift actuator. The solenoid valves are used to build up or reduce pressure.

The piston rod of the shift cylinder is moved to the right by pressure being built up in chamber 1 or to the left by pressure being built up in chamber 2.

However, if pressure is also applied in chamber 3 of the hydraulic brake, then the selector sleeve cannot be rotated by the brake piston. The piston rod of the shift cylinder is rotated in addition to being moved longitudinally. The rotary movement is caused by the positive drive of the guide pin in the “stepped” gate guide.

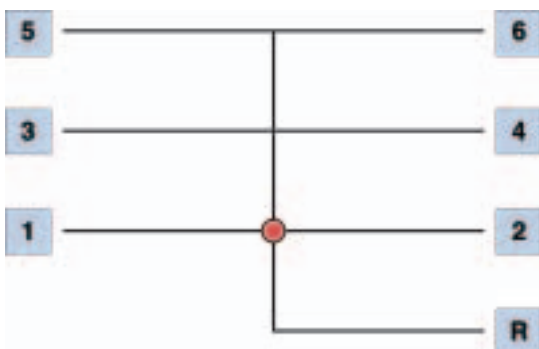
If the gear is changed within a gate, pressure is only applied to chamber 1 or chamber 2. This causes the piston rod of the shifter cylinder to be moved lengthways.

If the gear is changed together with a shifting gate, pressure is applied to chamber 3 as well as chamber 1 or chamber 2. This in turn causes the piston rod of the shifter cylinder to be moved lengthways and rotated.

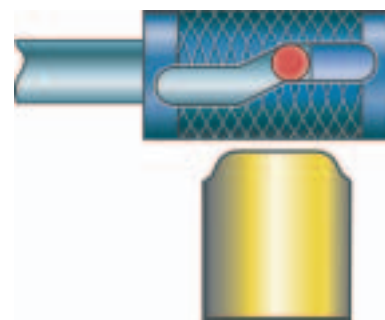
Two permanent magnets are mounted on the piston rod using a magnet holder to recognise the longitudinal movement and the rotary movement.

## Neutral position of the gearbox/shift actuator

The neutral position on the Shiftmatic gearbox is not just available in the 3rd and 4th gear shifting gate as on a manual gearbox, but also in each shift gate. The gearbox always switches to neutral in the respective shifting gate depending on the speed. The neutral position in the shifting gate of the 1st and 2nd gear starting from 1st gear is shown as an example. In this position, the guide pin is on the left in the upper step of the gate guide.



S372\_072

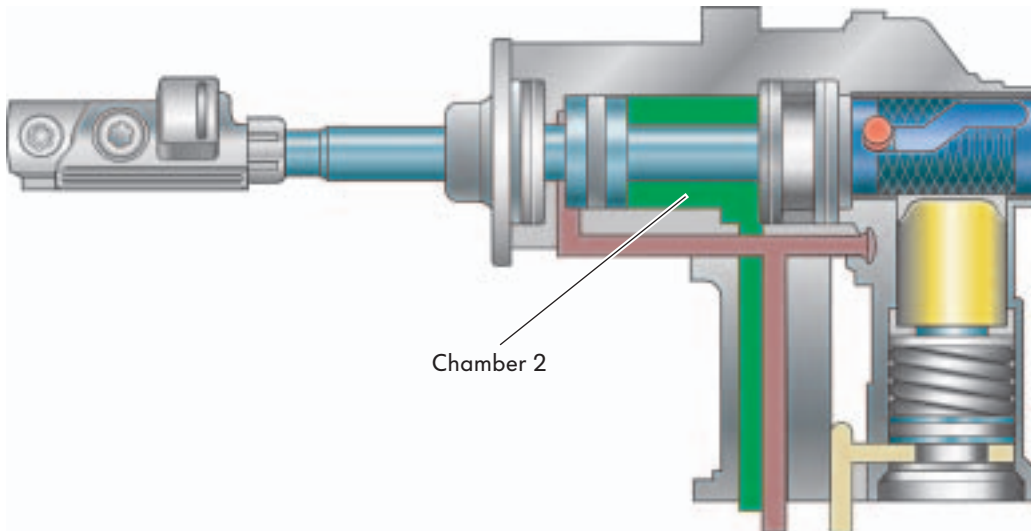


S372\_073

# Gearbox Mechanics

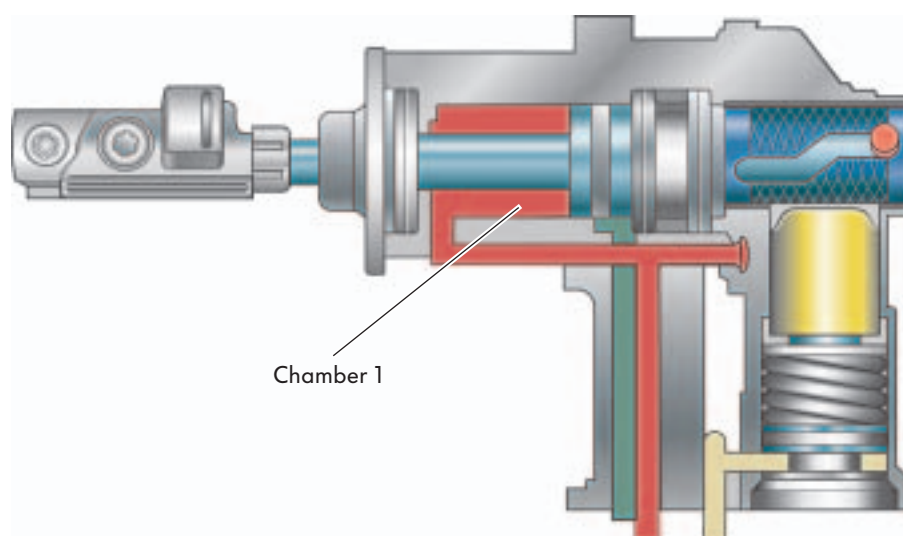
## Changing gear without changing shifting gate

Shifting up gears 1 → 2; 3 → 4; 5 → 6



S372\_085

Shifting down gears 2 → 1; 4 → 3; 6 → 5

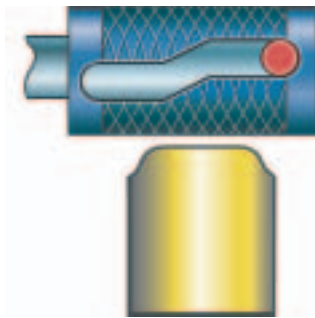


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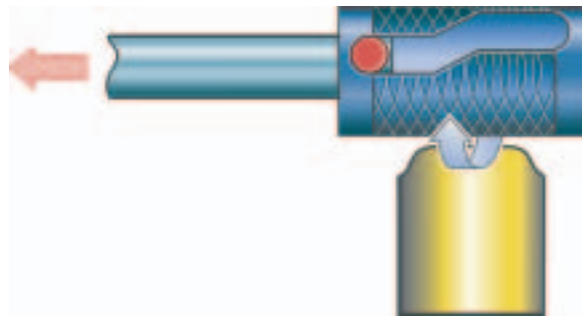
## Starting position

## Final position

When shifting up to an even gear, pressure is built up in chamber 2 of the shift cylinder. This causes the piston rod to move longitudinally to the left. The selector sleeve then rotates to the right because of the positive drive.

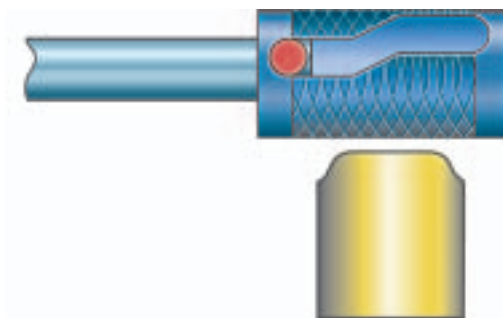


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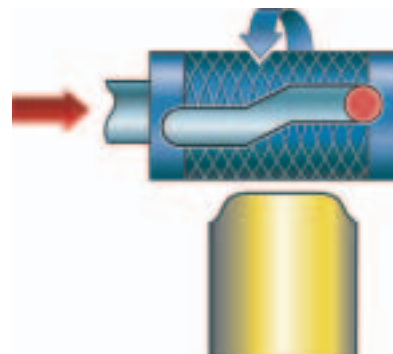


S372\_013

When shifting down to an odd gear, pressure is built up in chamber 1 of the shift cylinder. This causes the piston rod to move longitudinally to the right. The selector sleeve then rotates to the left because of the positive drive.



S372\_014



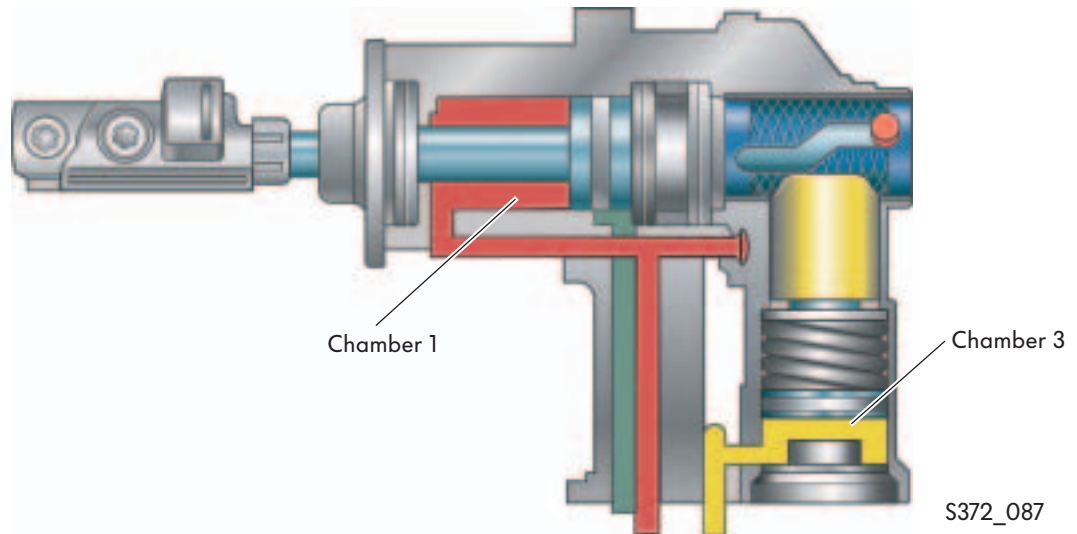
S372\_015

# Gearbox Mechanics

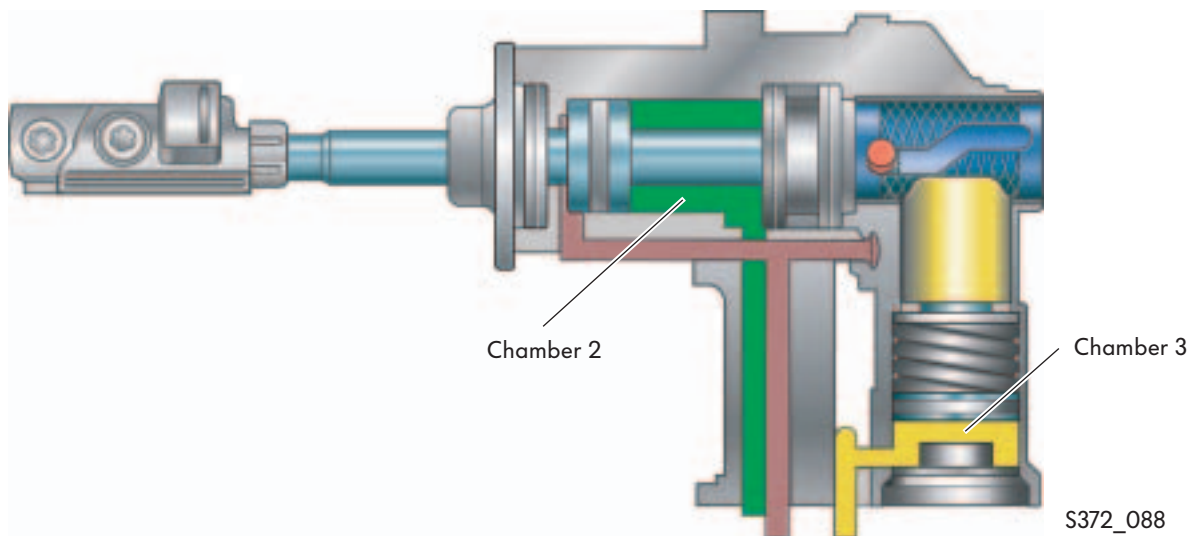
## Gear change with shifting gate change



Shift up gears 2 → 3; 4 → 5 and shift R → 1



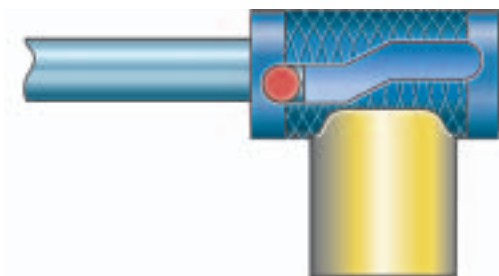
Shift down gears 3 → 2; 5 → 4 and shift 1 → R



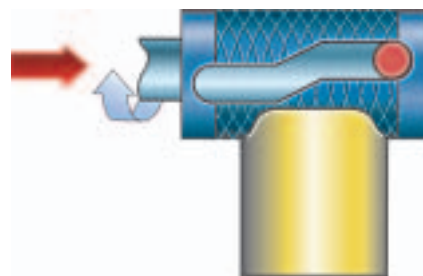
## Starting position

## Final position

When the gearbox shifts up to an odd gear, pressure is first built up in chamber 3 of the hydraulic brake and then in chamber 1 of the shift cylinder. The pressure built-up in chamber 3 causes the selector sleeve to be locked and the pressure built-up in chamber 1 also causes rotation to the right due to the positive drive in the blocked selector sleeve in addition to the longitudinal movement of the piston rod to the right.

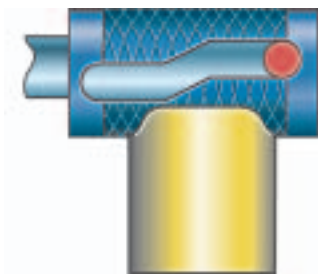


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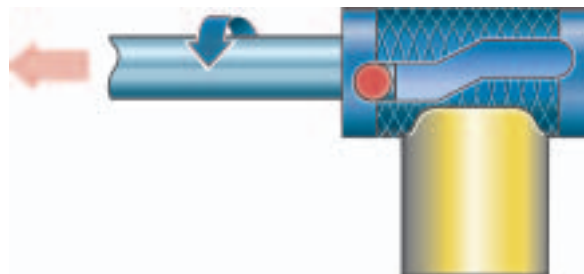


S372\_017

When the gearbox shifts down to an even gear, pressure is first built up in chamber 3 of the hydraulic brake and then in chamber 2 of the shift cylinder. The pressure built-up in chamber 3 locks the selector sleeve and the pressure built-up in chamber 2 of the selector cylinder also causes rotation to the left, in addition to the longitudinal movement of the piston rod, due to the positive drive in the locked selector sleeve.



S372\_018



S372\_019

# Hydraulics

## Hydraulic system

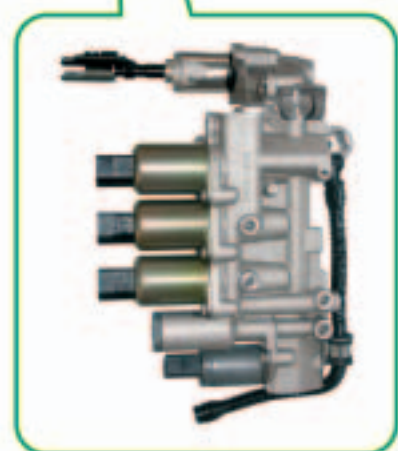
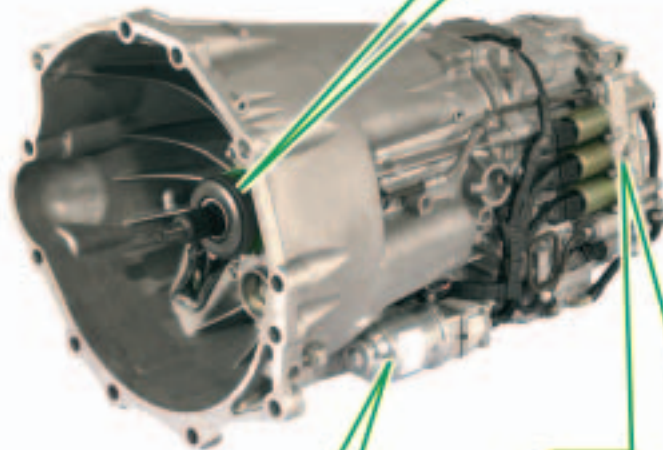
All components in the hydraulic system are fitted directly on the gearbox or inside it. This saves on hoses and thus space.

The hydraulic system consists of the following main components:

- Hydraulic oil tank
- Breather
- Slave cylinder with clutch release bearing
- Accumulator
- Hydraulic control unit with shift actuator
- Hydraulic pump for gearbox V387



Slave cylinder with clutch release bearing



Hydraulic control unit with shift actuator

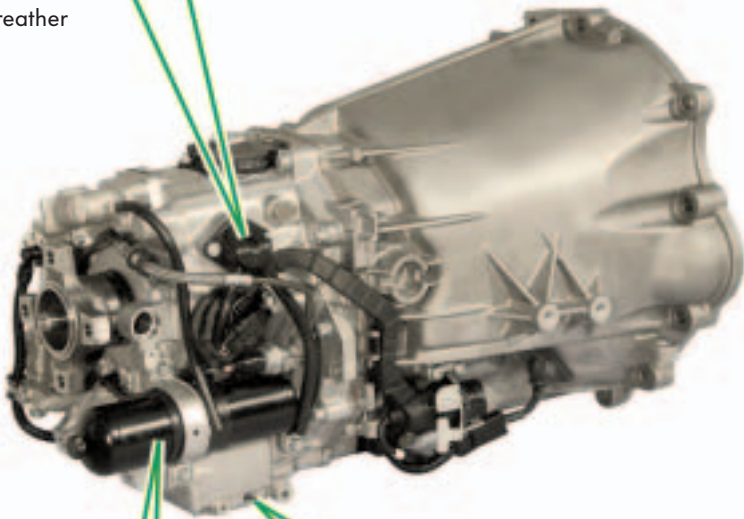


Hydraulic pump for gearbox V387

S372\_020



Breather



Hydraulic oil tank

S372\_021



Accumulator

# Hydraulics

## Hydraulic oil system

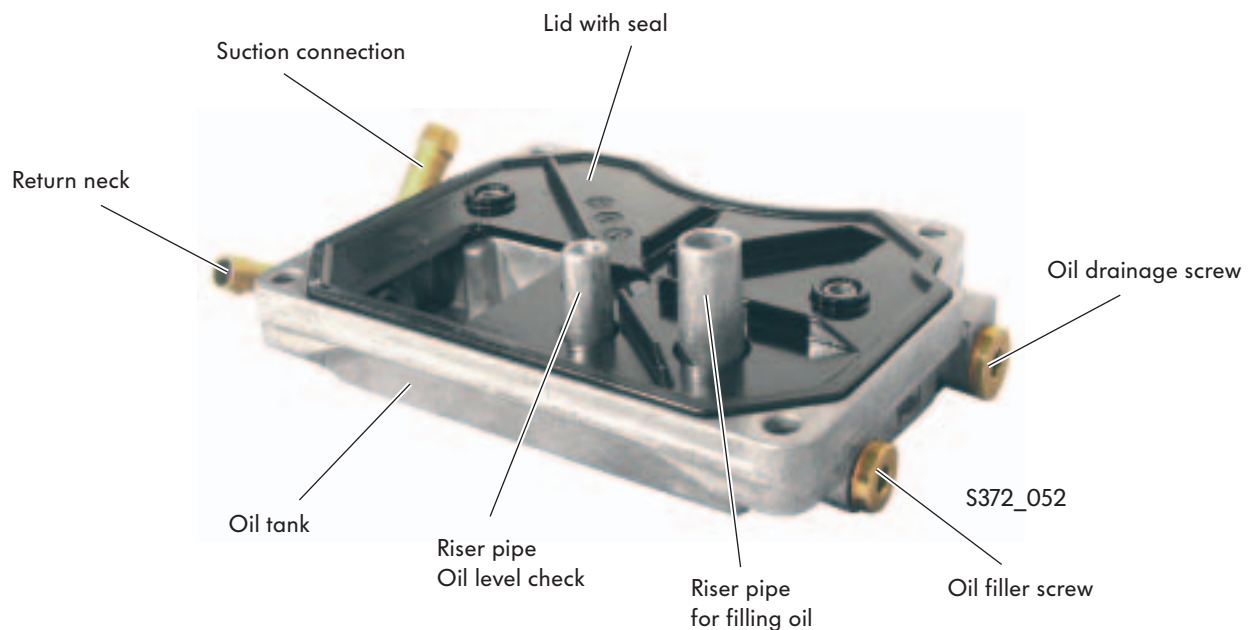
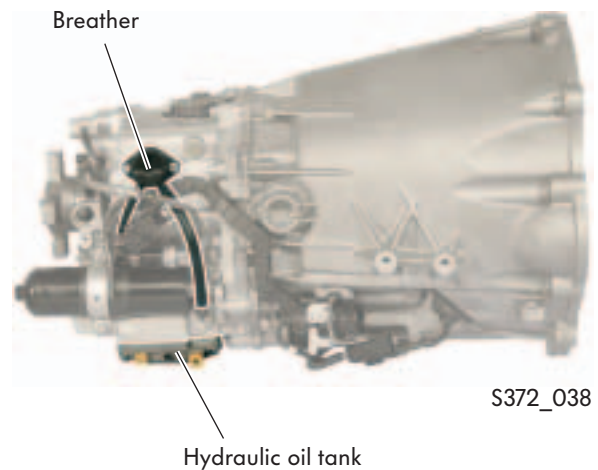
The mechanics of the automated manual gearbox are controlled by an electro-hydraulic system. There is a separate hydraulic oil system in addition to the gearbox oil system. 0.5l of G 004 000 M2 (PENTOSIN CHF 202) is used as the hydraulic oil. It is filled for life.

## Hydraulic oil tank

The hydraulic oil tank is bolted to the underside of the rear gearbox case. It is used as a reservoir for the hydraulic oil. In addition to supplying the hydraulic oil, it also has the task of settling and defoaming the oil.

The oil filler screw and the oil drainage screw are located on one side and the suction and return neck on the other.

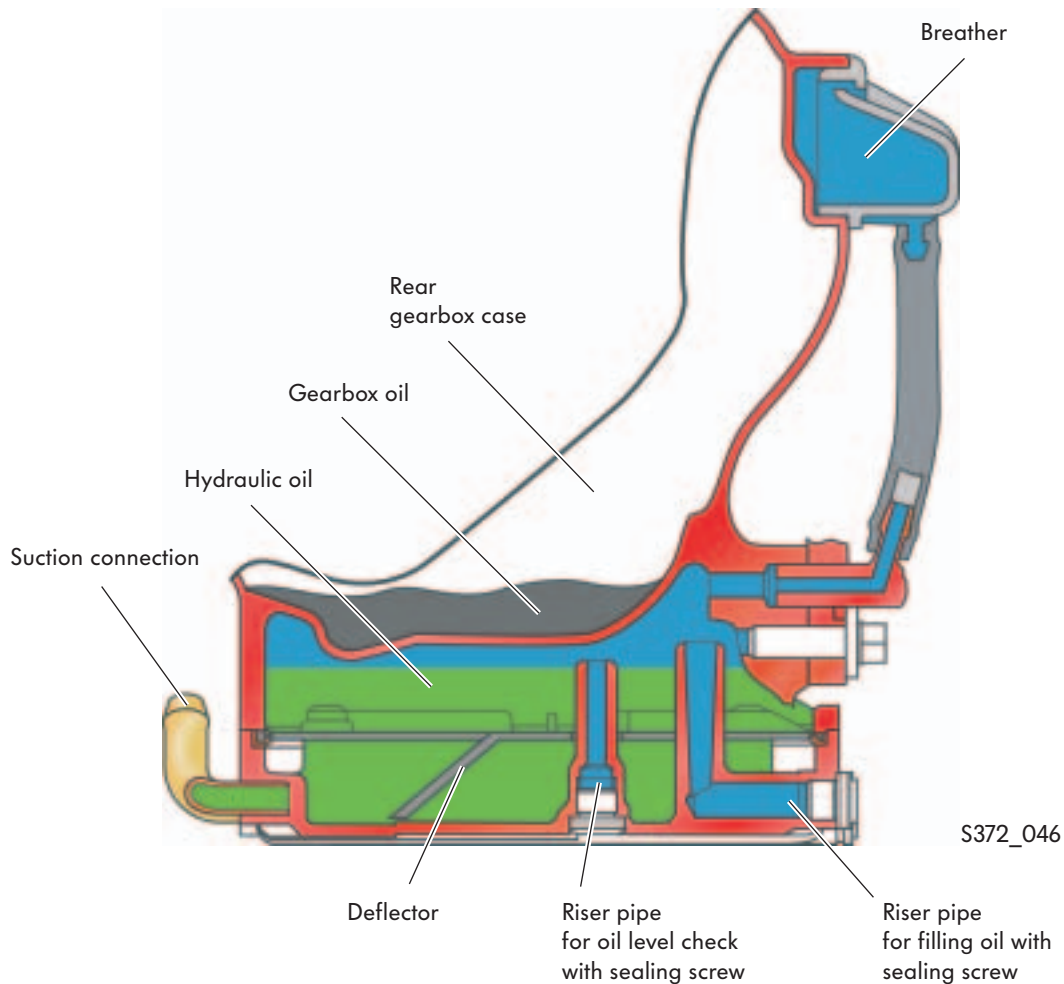
The riser pipes for checking the oil level and filling oil are located on the top. The hydraulic oil tank is covered by a sealed lid.





The cross-section of the rear gearbox case shows the separate oil systems in the gearbox, the gearbox oil system and the hydraulic oil system.

Breathing and thus pressure compensation of the hydraulic system is ensured by a breather cap. This is fitted on the left of the gearbox housing and connected to the hydraulic system by hoses.



See the repair guide for how to fill hydraulic oil.

# Hydraulics

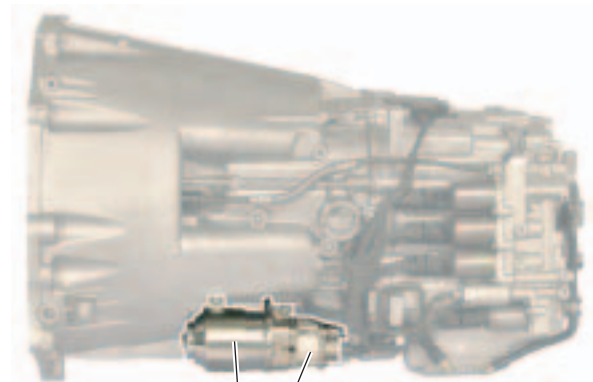
## Hydraulic pump for gearbox V387

The hydraulic pump for gearbox V387 is mounted as a unit on the front left-hand side of the gearbox case together with a 12 V electric motor.

The hydraulic pump maintains the working pressure that is required for precise clutch operation and gearshifts. A pressure sensor constantly sends the hydraulic pressure to the electronic manual gearbox control unit J514. If the pressure falls below 39 bar after several shift processes, the electric motor is activated and switched off again at a pressure of 55 bar.

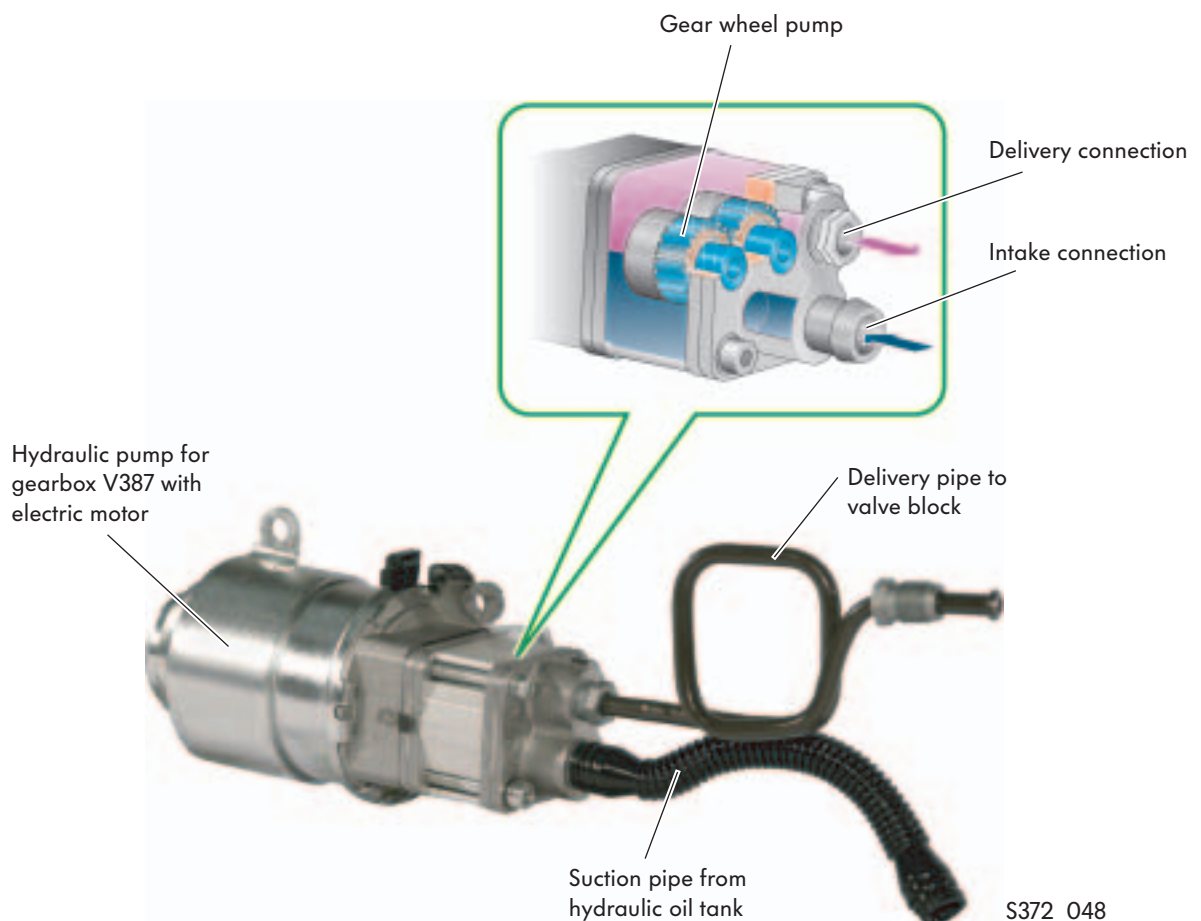
A gear wheel pump is used as the hydraulic pump. The hydraulic oil is drawn in from the hydraulic oil tank via the suction neck and transferred to the accumulator and valve block via a steel pipe.

The oil is returned to the hydraulic oil tank through the return line on the valve block.



S372\_037

Hydraulic pump for gearbox V387 with electric motor



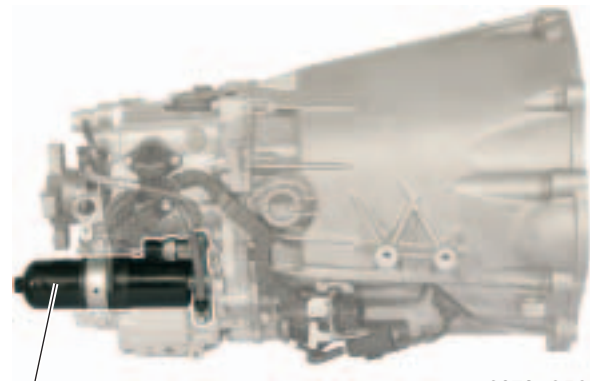
S372\_048

## Accumulator

The accumulator is mounted on the right-hand side of the rear gearbox case. The accumulator is connected to the valve block by a steel pipe. The gearbox hydraulic pressure sender G270 is mounted between the delivery pipe connection and accumulator.

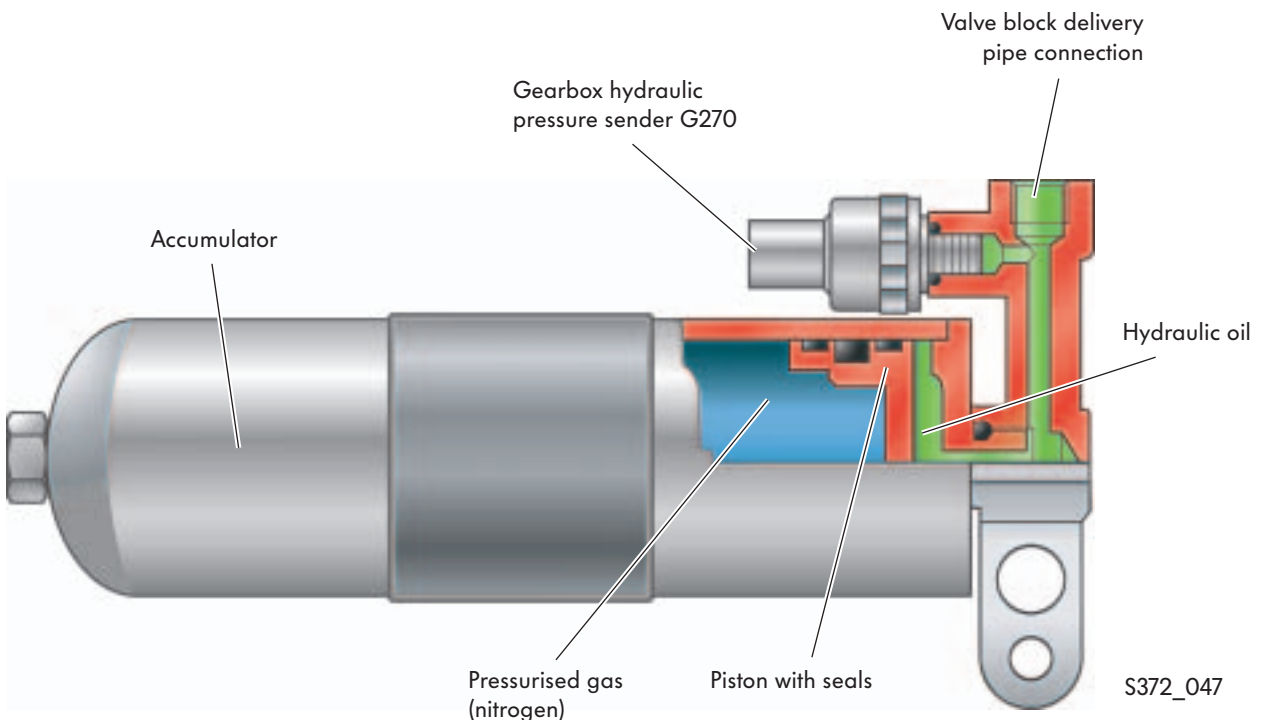
Whenever necessary, the accumulator passes on the stored pressure to the hydraulic system.

On the inside, the accumulator consists of a piston and a pressurised gas filling. When hydraulic pressure starts to build up, the piston is pressed against the gas and compresses it. If the hydraulic pressure suddenly falls, the gas expands again and the working pressure is maintained. The filled pressure accumulator can bridge up to three shift procedures without the hydraulic pump being run. Nitrogen is used as the pressurised gas.



Accumulator

S372\_050



Pressurised gas (nitrogen)

Piston with seals

S372\_047



# Hydraulics

## Hydraulic control unit

The hydraulic control unit is mounted on the rear left-hand side of the gearbox.

It consists of the valve block, the shift actuator, a fine filter and four solenoid valves. Selector lever valve 1 N284, selector lever valve 2 N285 and the clutch actuator valve N255 are control valves. The solenoid for hydraulic brake, Shiftmatic N431 is a switching valve with pressure limitation.

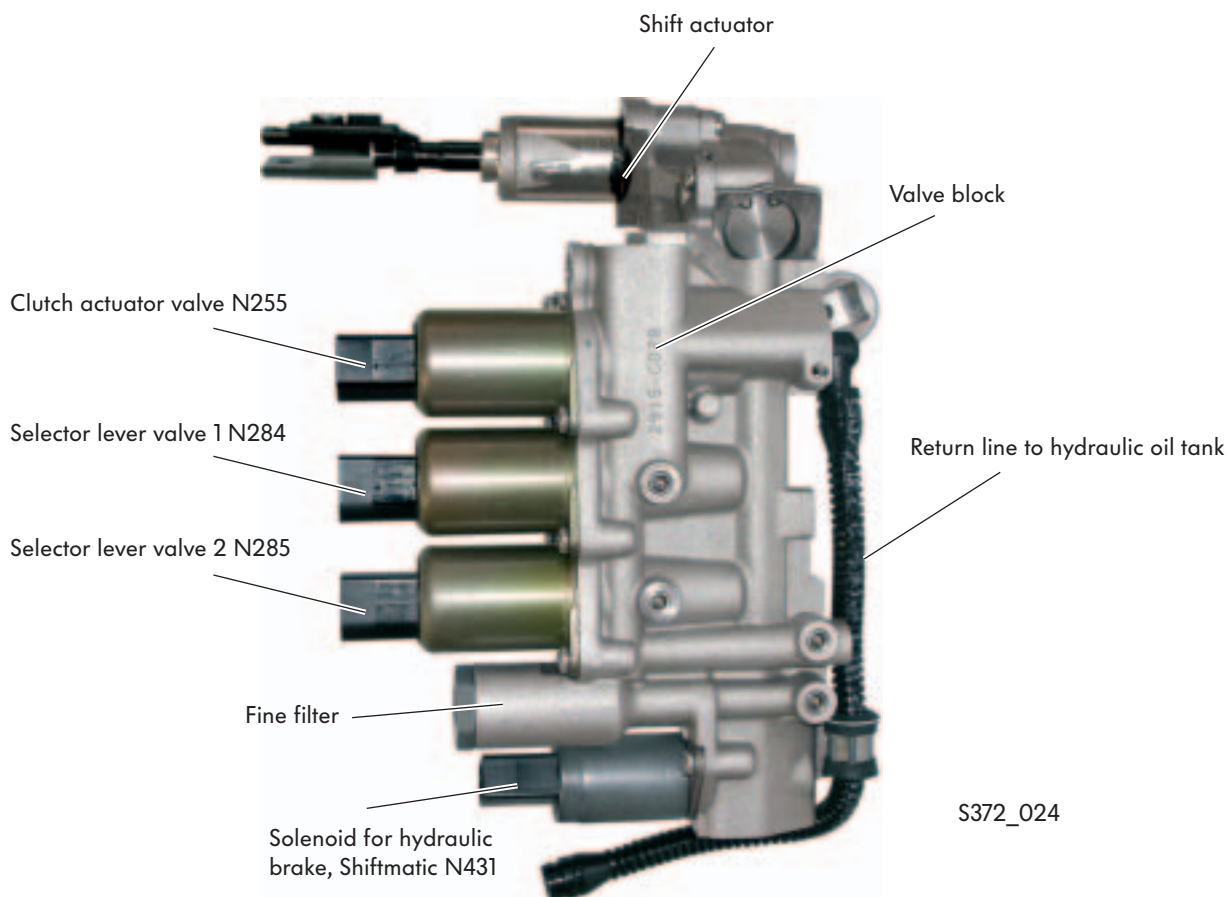
The advantage of the valve block is its compact and space-saving design. The need for pipes has been reduced and fewer seals are required.

It is important that you reduce the hydraulic pressure before carrying out repair work as the valve block is under constant pressure.



S372\_036

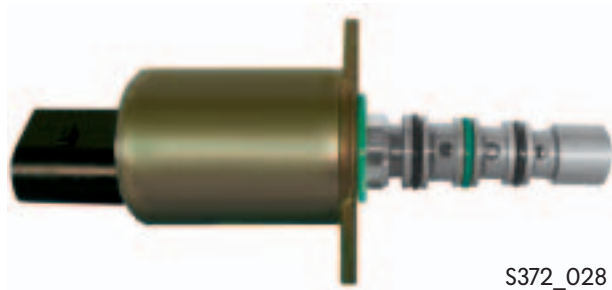
Hydraulic control unit



S372\_024

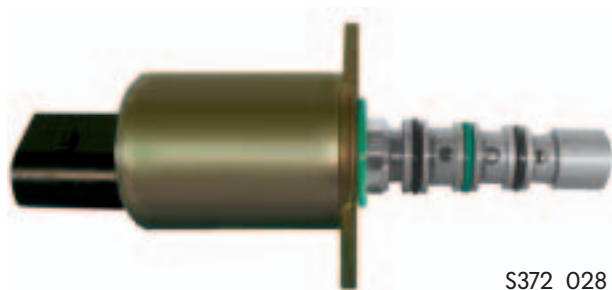
## Clutch actuator valve N255

The clutch actuator valve N255 is used to activate the slave cylinder with clutch release bearing and thus operate the clutch via the hydraulic oil system.



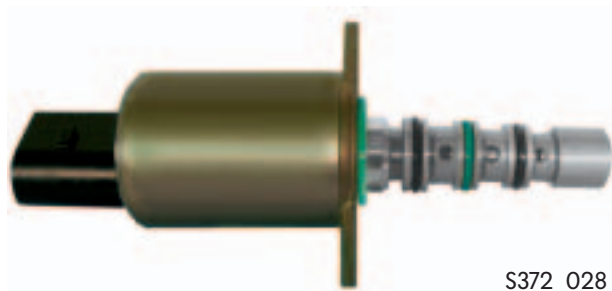
## Selector lever valve 1 N284

Selector lever valve 1 N284 is used for longitudinal movement of the central selector shaft to the right and thus to shift to 1st, 3rd and 5th gear.



## Selector lever valve 2 N285

Selector lever valve 2 N285 is used for longitudinal movement of the central selector shaft to the left and thus to shift to 2nd, 4th and 6th gear.



## Solenoid for hydraulic brake, Shiftmatic N431

The solenoid for hydraulic brake, Shiftmatic N431 is used to control the hydraulic brake in the shift actuator. The selector sleeve in the shift actuator is blocked and the central selector shaft rotates due to the positive drive of the guide pin in the selector sleeve.



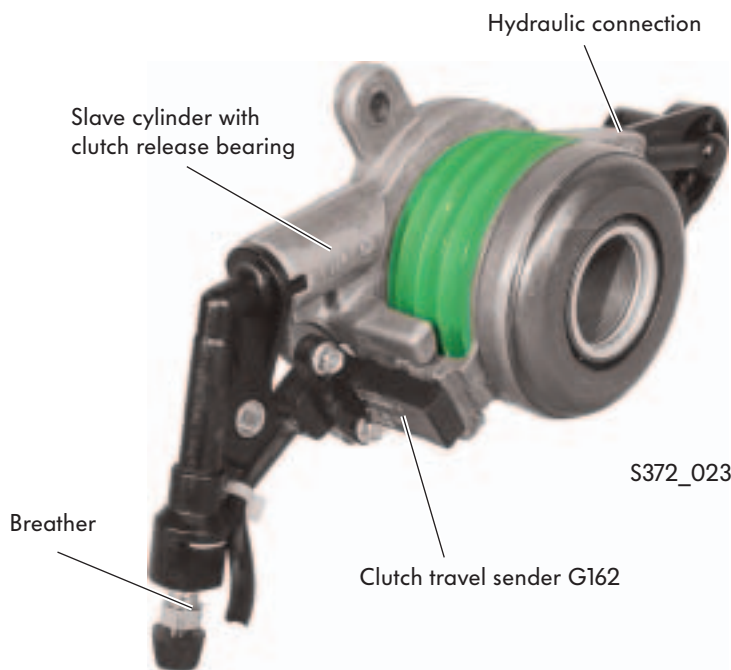
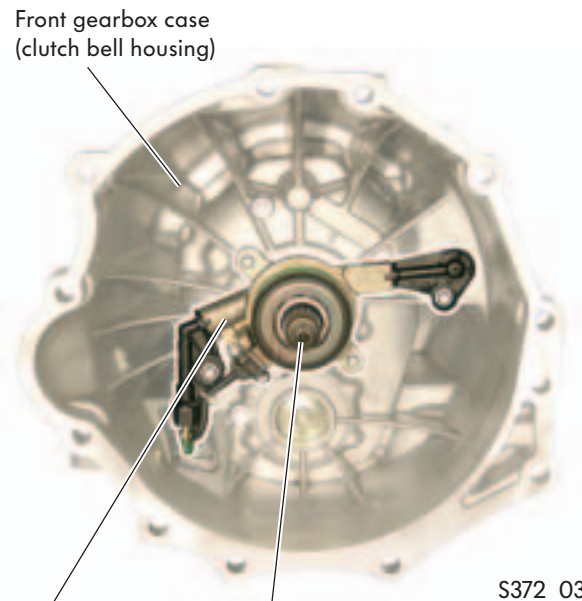
# Hydraulics

## Slave cylinder with clutch release bearing

The slave cylinder with clutch release bearing is a module on the drive shaft. Activation of the clutch actuator valve N255 builds up pressure in the slave cylinder and presses the clutch diaphragm spring tongues over the clutch release bearing. The clutch is then disengaged.

Despite there being a breather valve on the slave cylinder with clutch release bearing, ventilation is not necessary as the whole gearbox hydraulic system including the clutch is vented.

A clutch travel sender G162 fitted to the slave cylinder with clutch release bearing measures the disengagement travel and sends the information to electronic manual gearbox control unit J514.

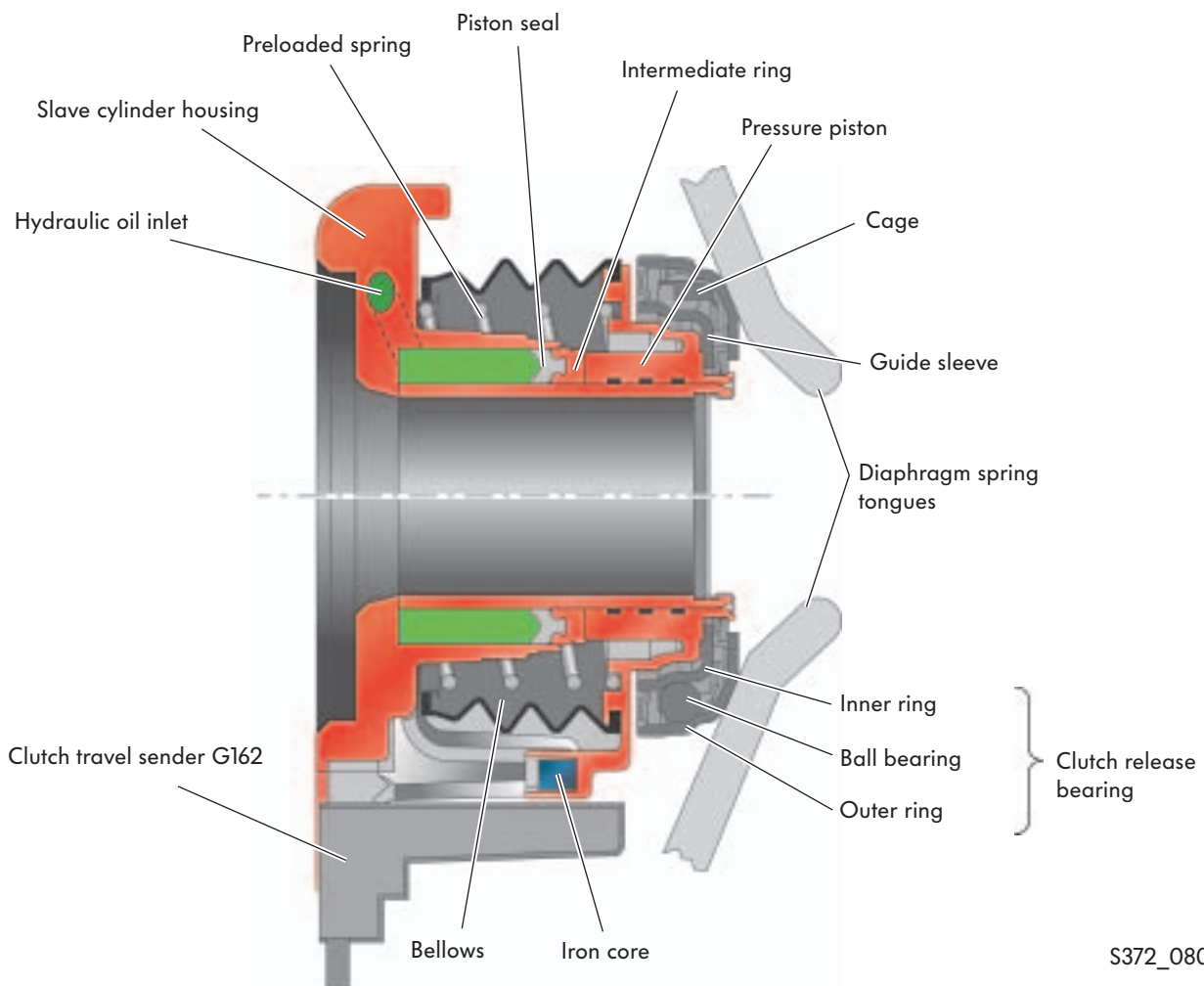


**Important**  
Hydraulic system is vented and may not be ventilated separately.

## Arrangement and operation

The clutch actuator valve N255 is activated to engage the clutch allowing the hydraulic pressure to build up against the slave cylinder. In the slave cylinder, the hydraulic pressure is transferred to the pressure piston via the piston seal and an intermediate ring. This moves the pressure piston towards the diaphragm spring tongues. The piston thus presses against the outer ring, inner ring and the clutch release bearing consisting of ball bearings in a cage. The longitudinal movement of the clutch release bearing pushes the diaphragm spring tongues and thus disengages the clutch.

The preload spring presses against the clutch release bearing when the clutch is not engaged. For this reason, the outer ring runs constantly at the clutch speed. This reduces bearing noise. The speed compensation between the inner and outer ring is achieved with the ball bearings that run in a cage. The clutch release bearing has a lifetime grease filling as lubrication. To protect the slave cylinder with clutch release bearing from dirt, bellows have been fitted between the two parts.











Upon longitudinal movement, the iron core fitted to the slave cylinder causes changes to the magnetic field in the coils of the clutch travel sender G162 that are used to determine the disengagement travel.

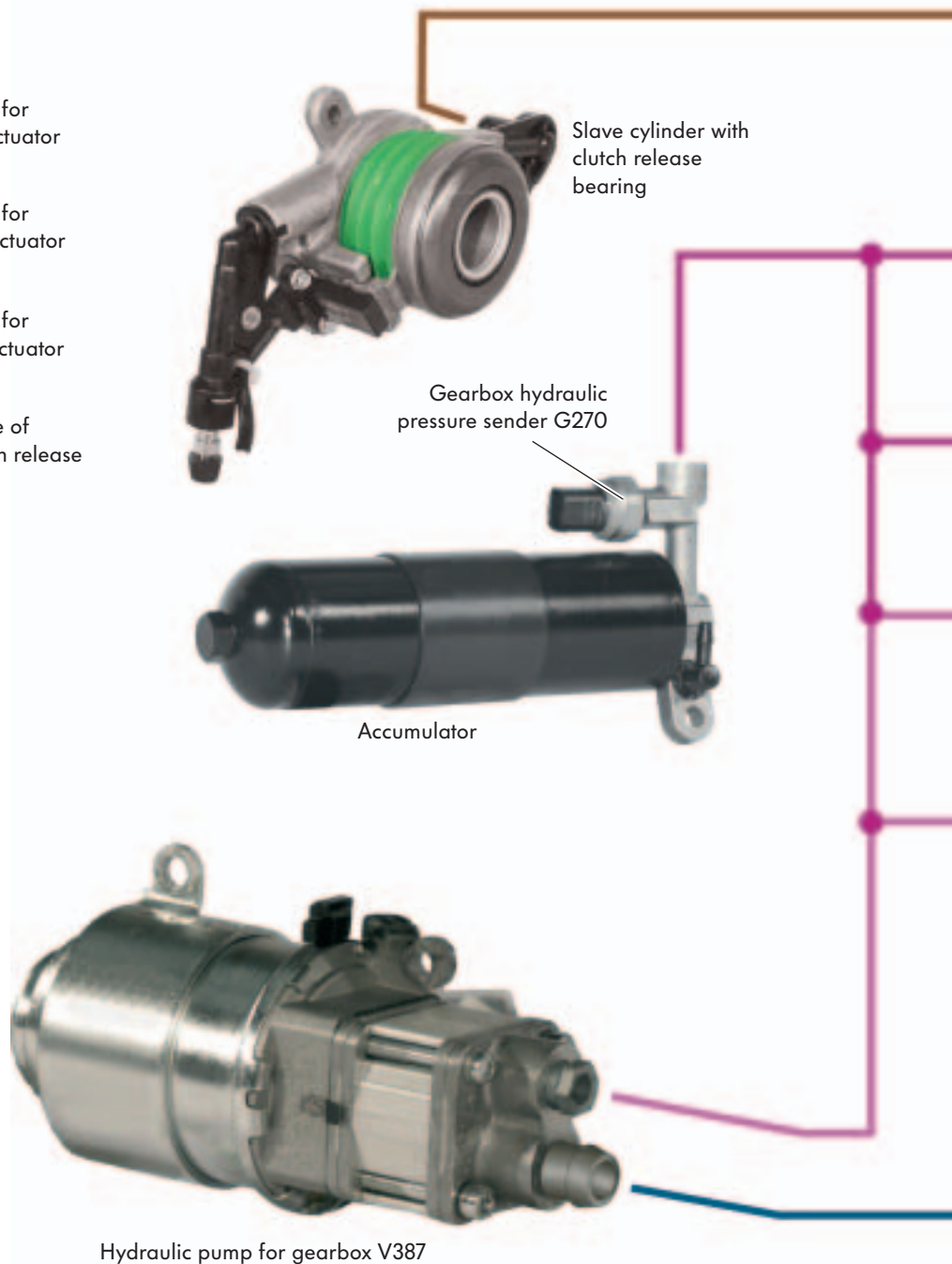
# Hydraulics

## Hydraulic diagram

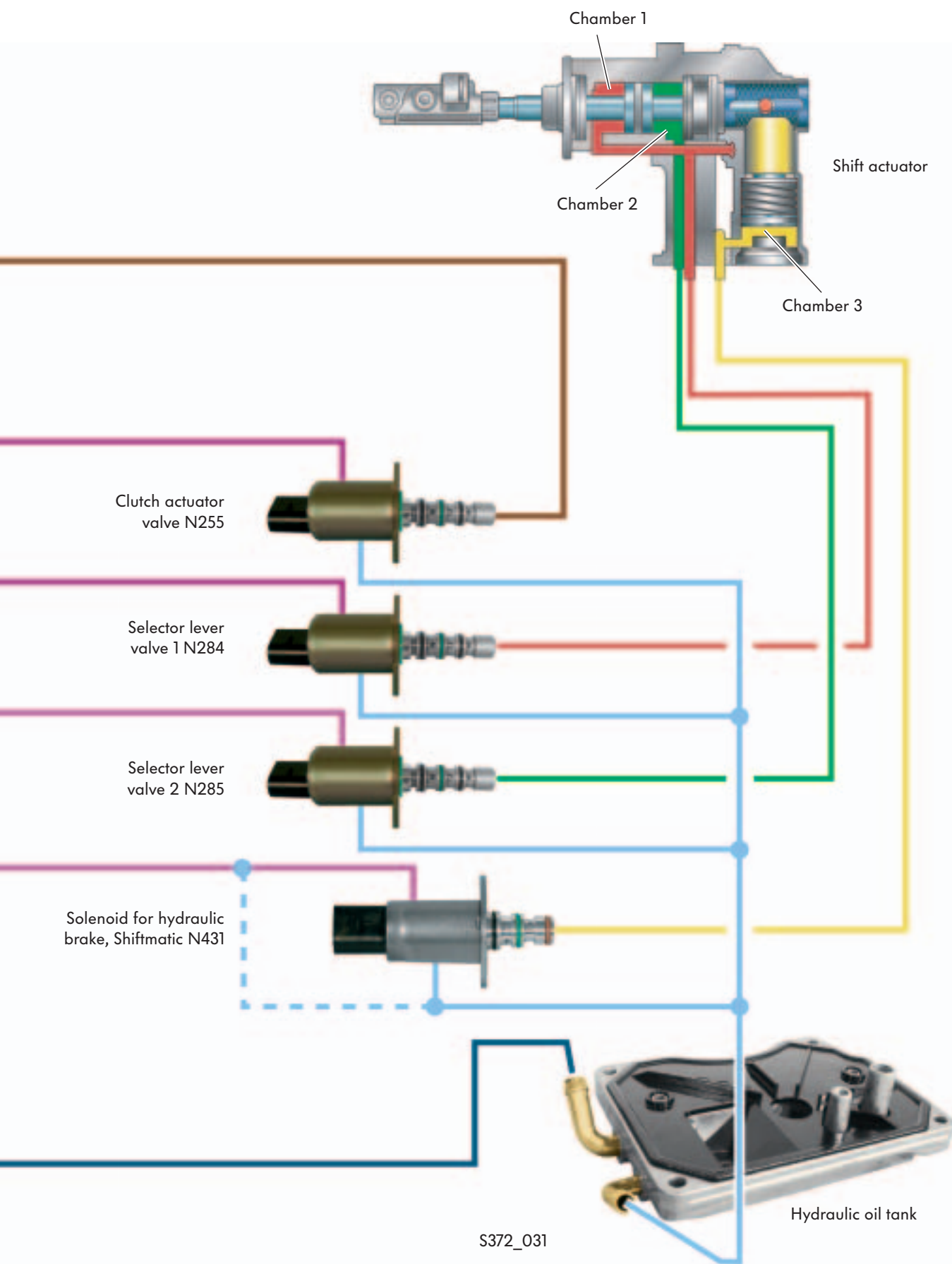
The hydraulic diagram provides an overview of the components interacting in the hydraulic system.



-  Delivery pipe to valves and accumulator
-  Delivery and return line for chamber 1 of the shift actuator
-  Delivery and return line for chamber 2 of the shift actuator
-  Delivery and return line for chamber 3 of the shift actuator
-  Delivery and return pipe of slave cylinder with clutch release bearing
-  Intake pipe
-  Return pipe
-  Control line for overpressure limitation





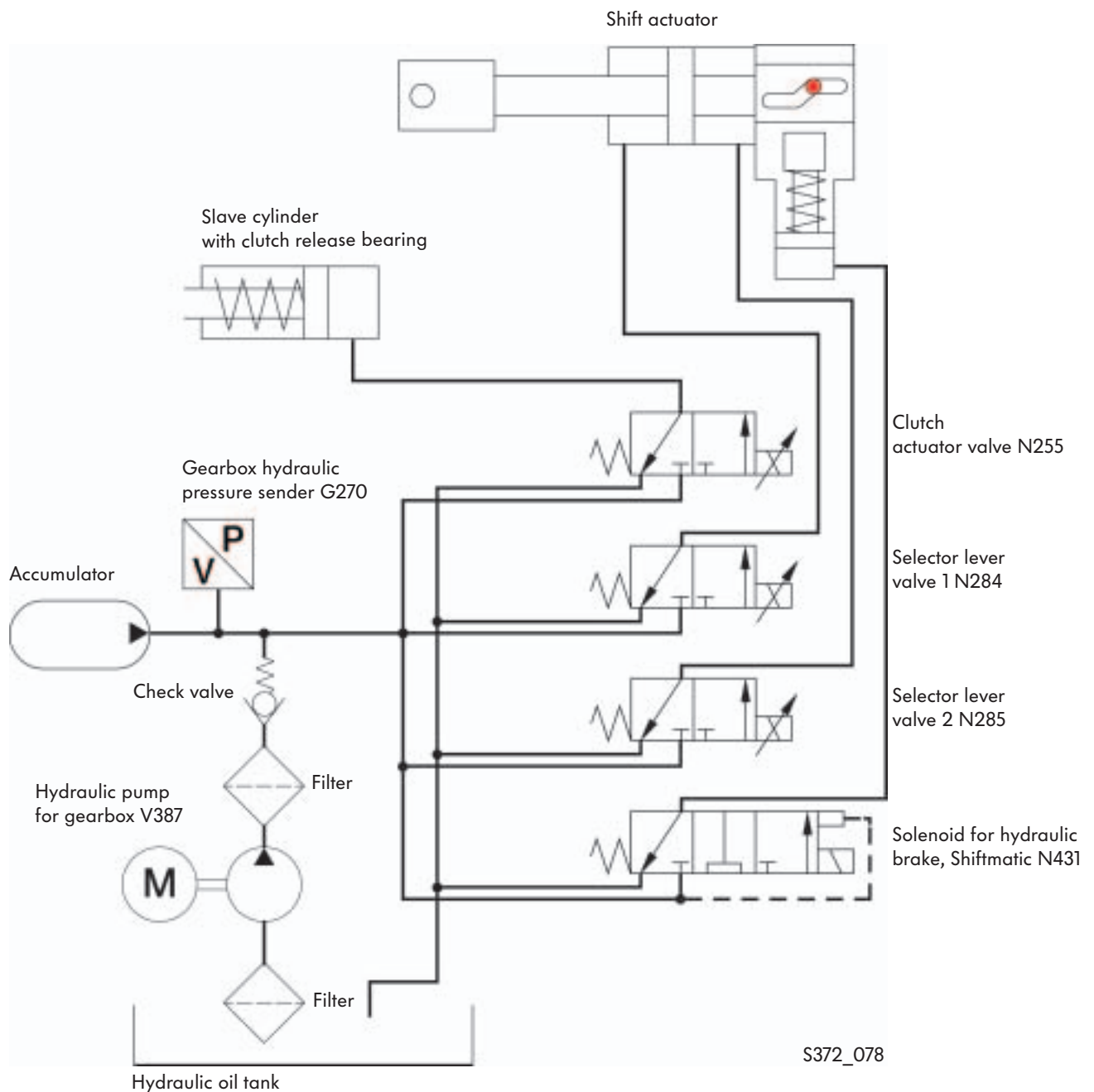


# Hydraulics

## Hydraulic circuit diagram

### Components

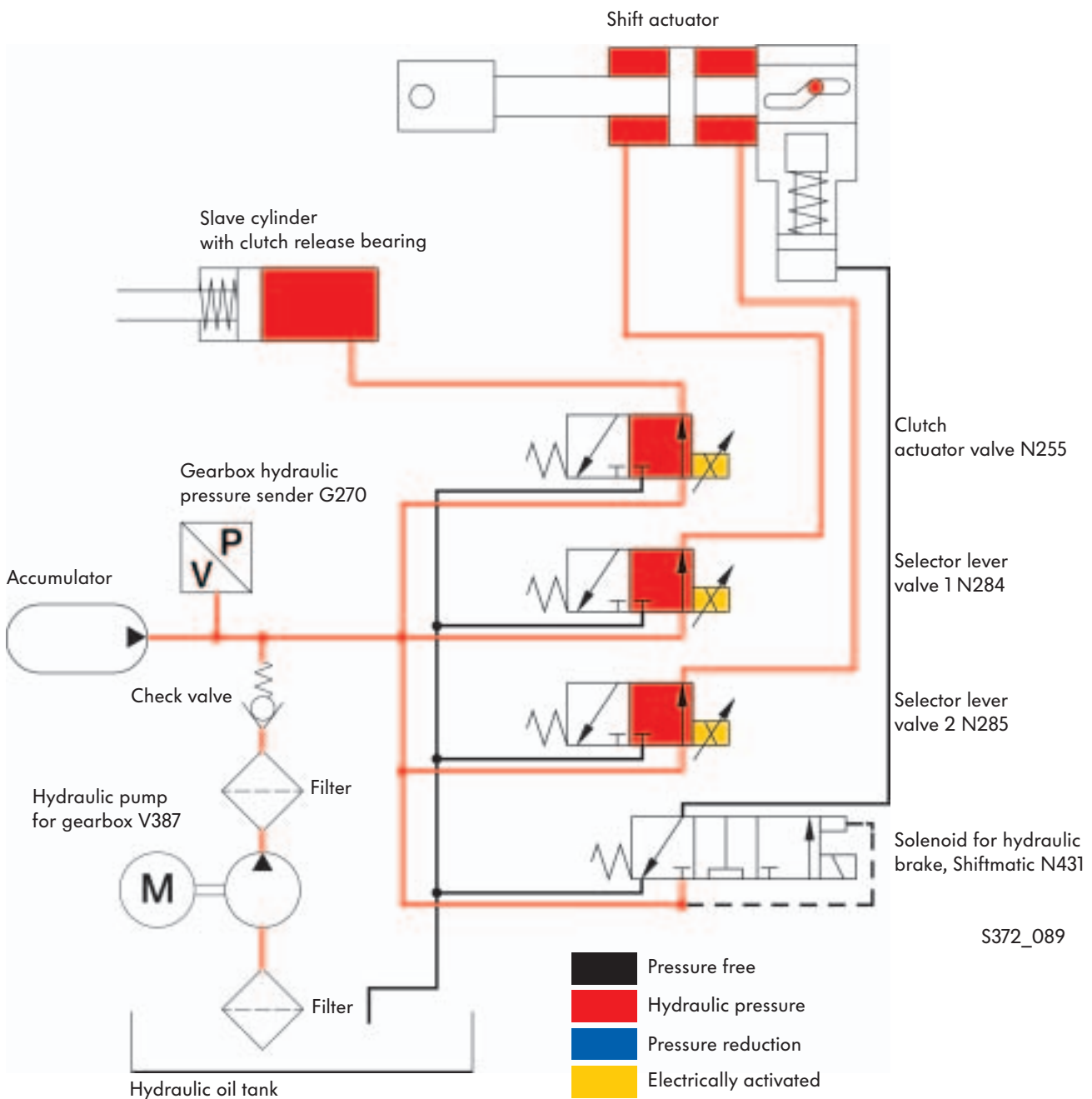
This circuit diagram shows the hydraulic oil circuit for the Shiftmatic gearbox using hydraulic circuit symbols for the individual hydraulic components. The following hydraulic circuit diagrams should illustrate various switching positions of the solenoid valves for the individual shift processes with and without gate changes.



## Neutral position

At the start of each shift procedure, the power flow between the engine and gearbox has to be interrupted by disengaging the clutch. To allow this, the clutch actuator valve N255 is activated electrically during the whole shift procedure and the hydraulic pressure can be applied to the slave cylinder with release bearing. As the Shiftmatic gearbox switches to neutral in the respective shift gate depending on the speed, it is shown here in the example starting with 1st gear (shift gate 1st/2nd gear).

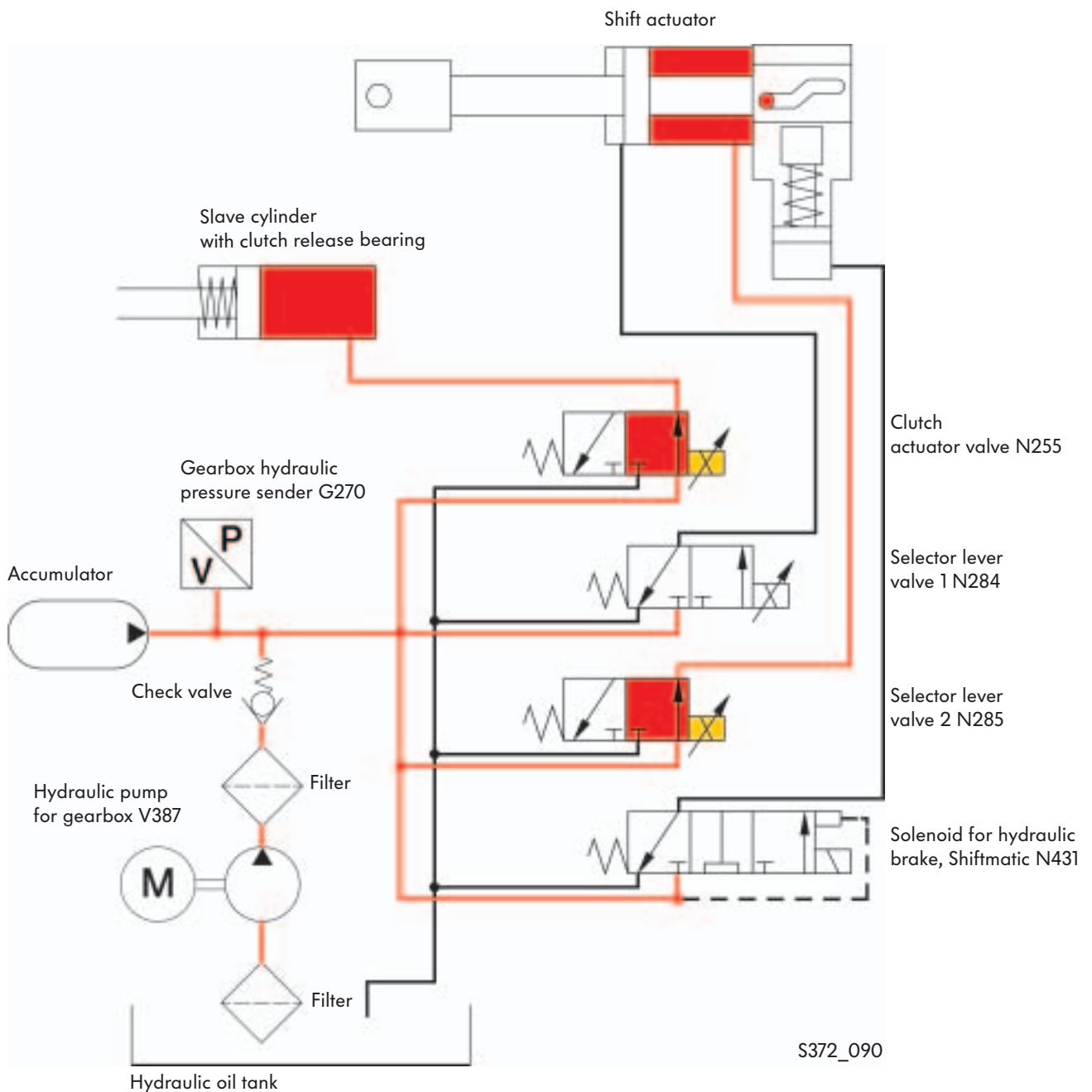
Once the clutch has been disengaged, selector lever valve 2 N285 is activated electrically to accelerate the piston. The piston is then slowed down again by the electrical activation of selector lever valve 1 N284 so that it reaches its centre position in the shift cylinder. The guide pin is then on the left in the upper step of the gate guide.



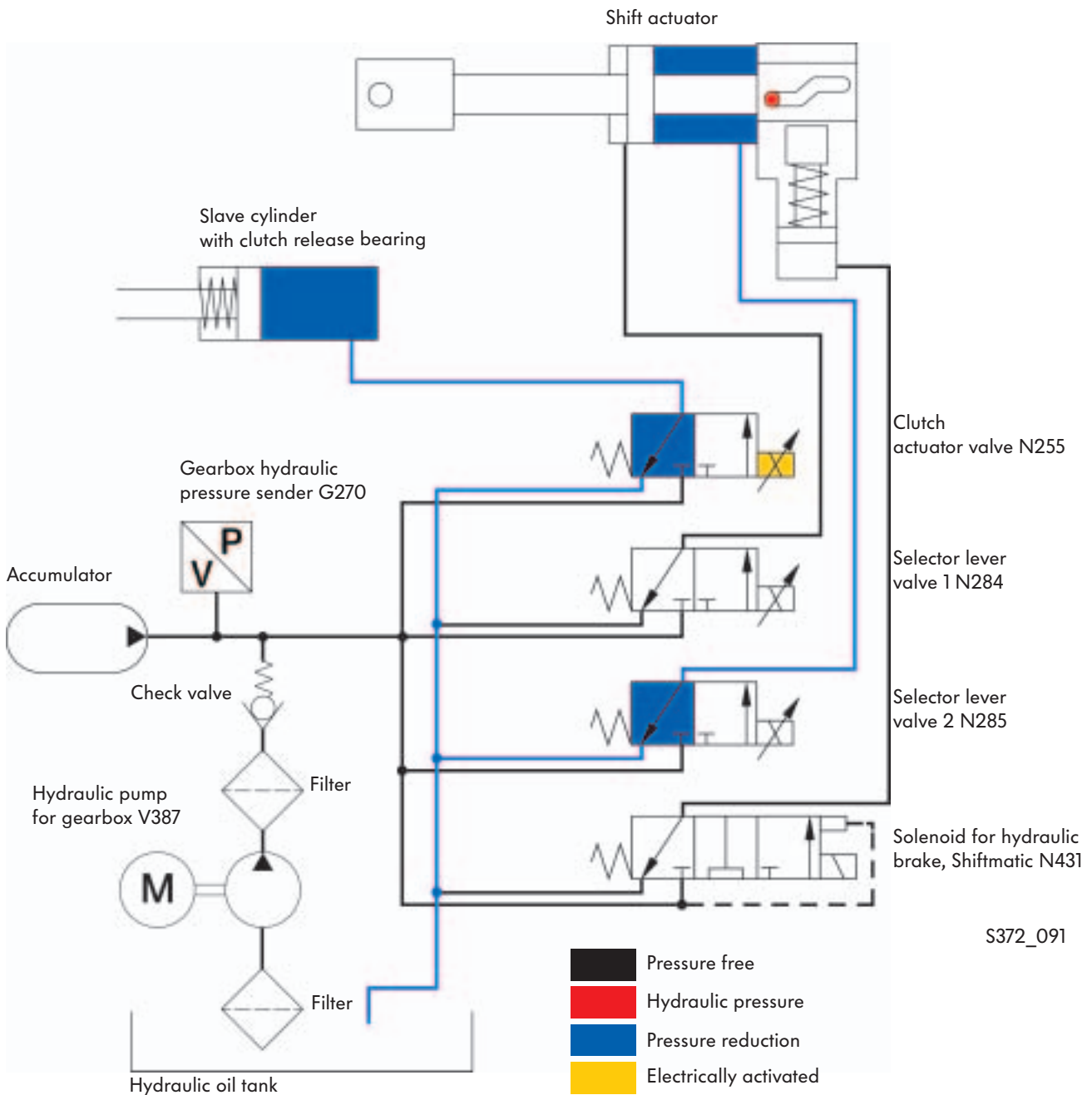
# Hydraulics

## Changing gear without changing shifting gate

A gear change without gate change is shown as a gear being shifted up within a gate. Firstly, pressure is built up in the slave cylinder with clutch release bearing due to the clutch actuator valve N255 being activated. This disengages the clutch. The selector lever valve 2 N285 is then activated moving the piston in the shift cylinder to the left until the guide pin is positioned on the left of the gate guide. As the solenoid for hydraulic brake, Shiftmatic N431 blocks the pressure, there is also no pressure on the hydraulic brake pressure piston so that the selector sleeve in the shift actuator can rotate freely.



The pressure reduction during the shift procedure is the reverse of the pressure build-up. First, selector lever valve 2 N285 is returned to its rest position by the spring force. The pressure is then built-up in the shift actuator. The pressure reduction in the slave cylinder with clutch release bearing is then carried out in such a way using the clutch actuator valve N255 that the clutch can be engaged easily again. This is controlled by the current for the clutch actuator valve N255. Once the pressure has been reduced in the chambers of the shift actuator and in the slave cylinder with clutch release bearing, the shift process is complete.

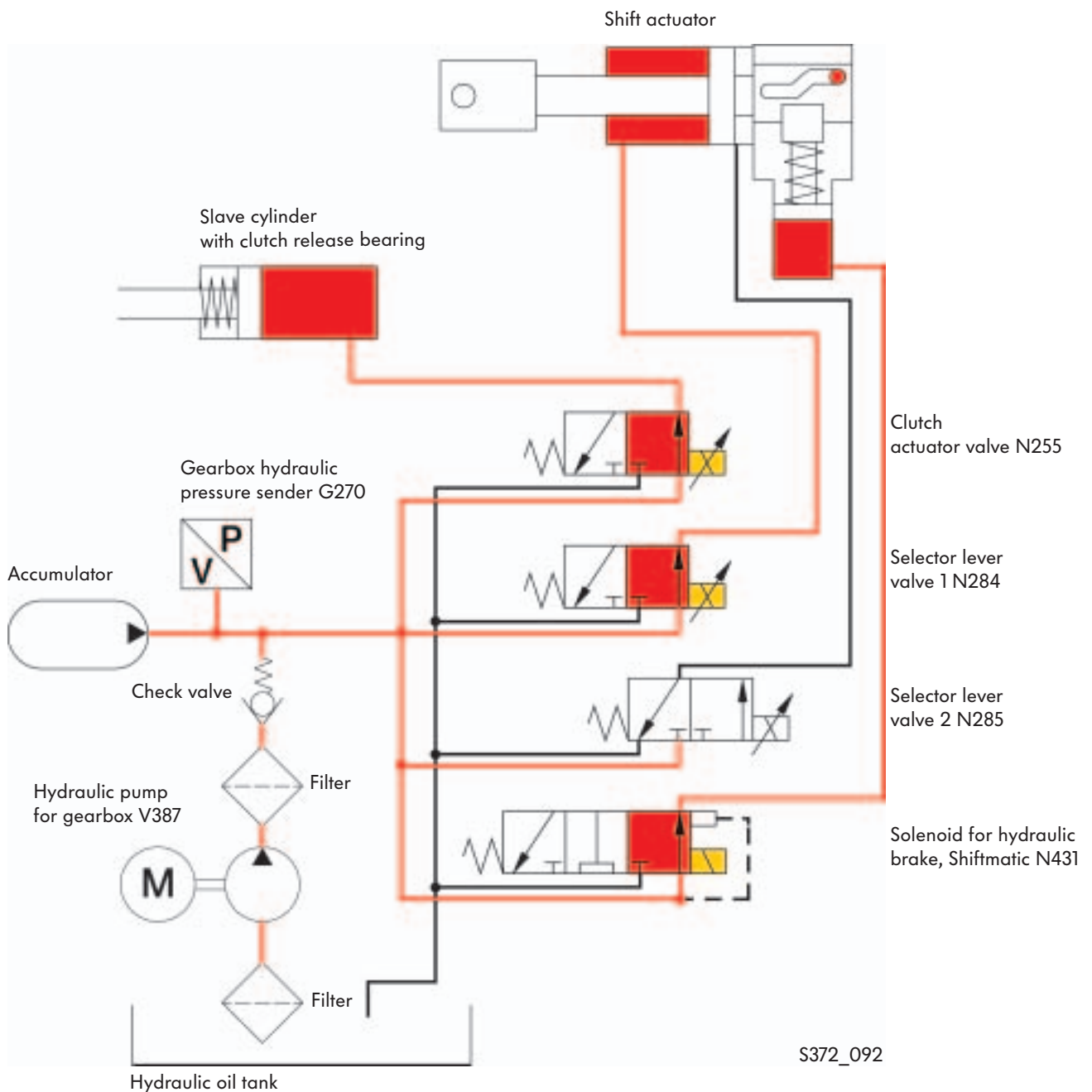


S372\_091

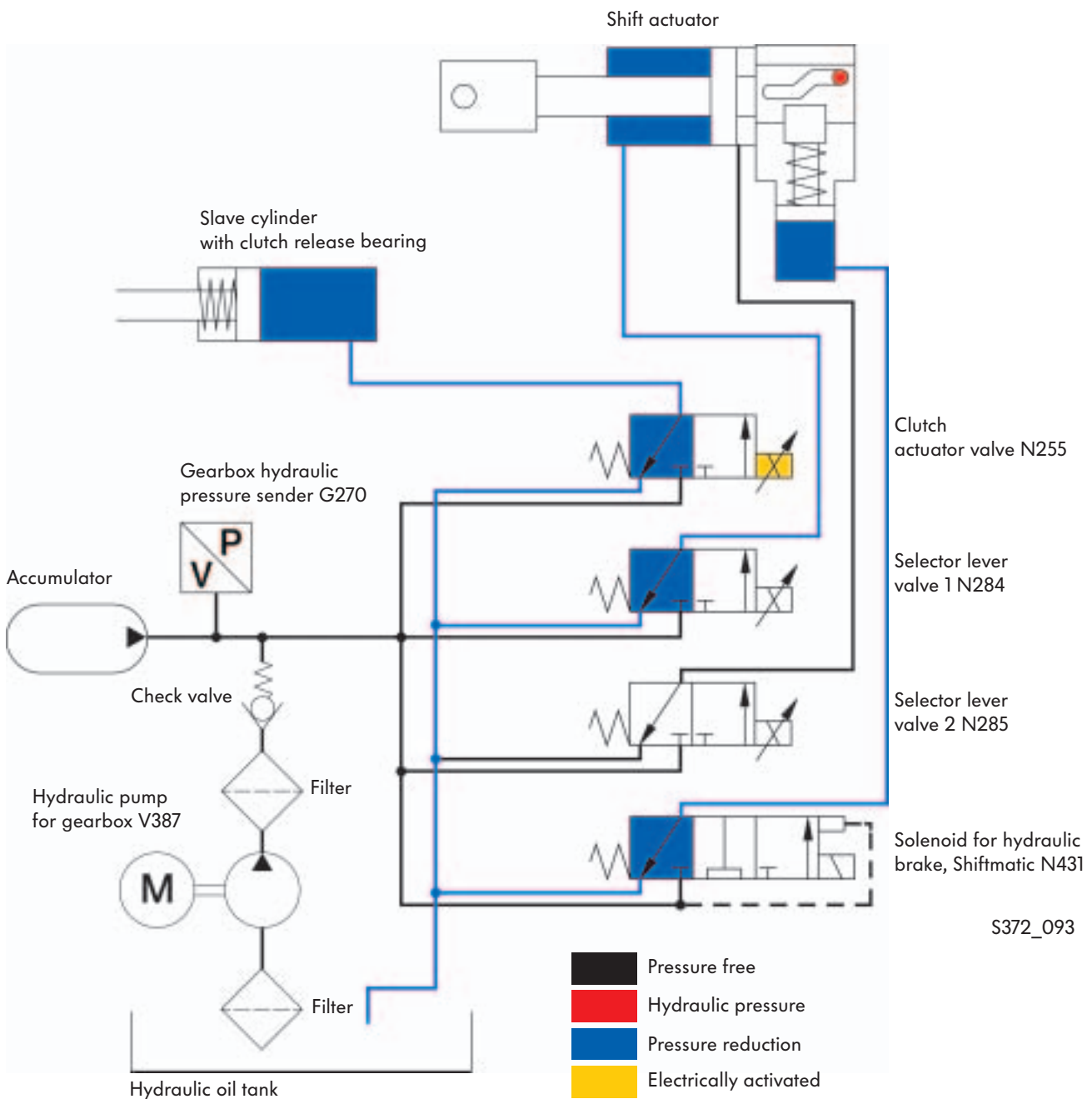
# Hydraulics

## Gear change with shifting gate change

A gear change with gate change is shown as a gear being shifted up with gate change. Firstly, the clutch is disengaged by activating the clutch actuator valve N255 and thus pressure is built up in the slave cylinder with clutch release bearing. The solenoid for hydraulic brake, Shiftmatic N431 is then switched to flow through so that the hydraulic brake is activated and the selector is prevented from rotating. The selector lever valve 1 N284 is then opened and pressure starts to build up against the shift cylinder piston in the shift actuator. Since the selector sleeve is now locked, the piston rod rotates to the right in addition to moving lengthways. This occurs due to the positive drive of the guide pin in the gate guide.



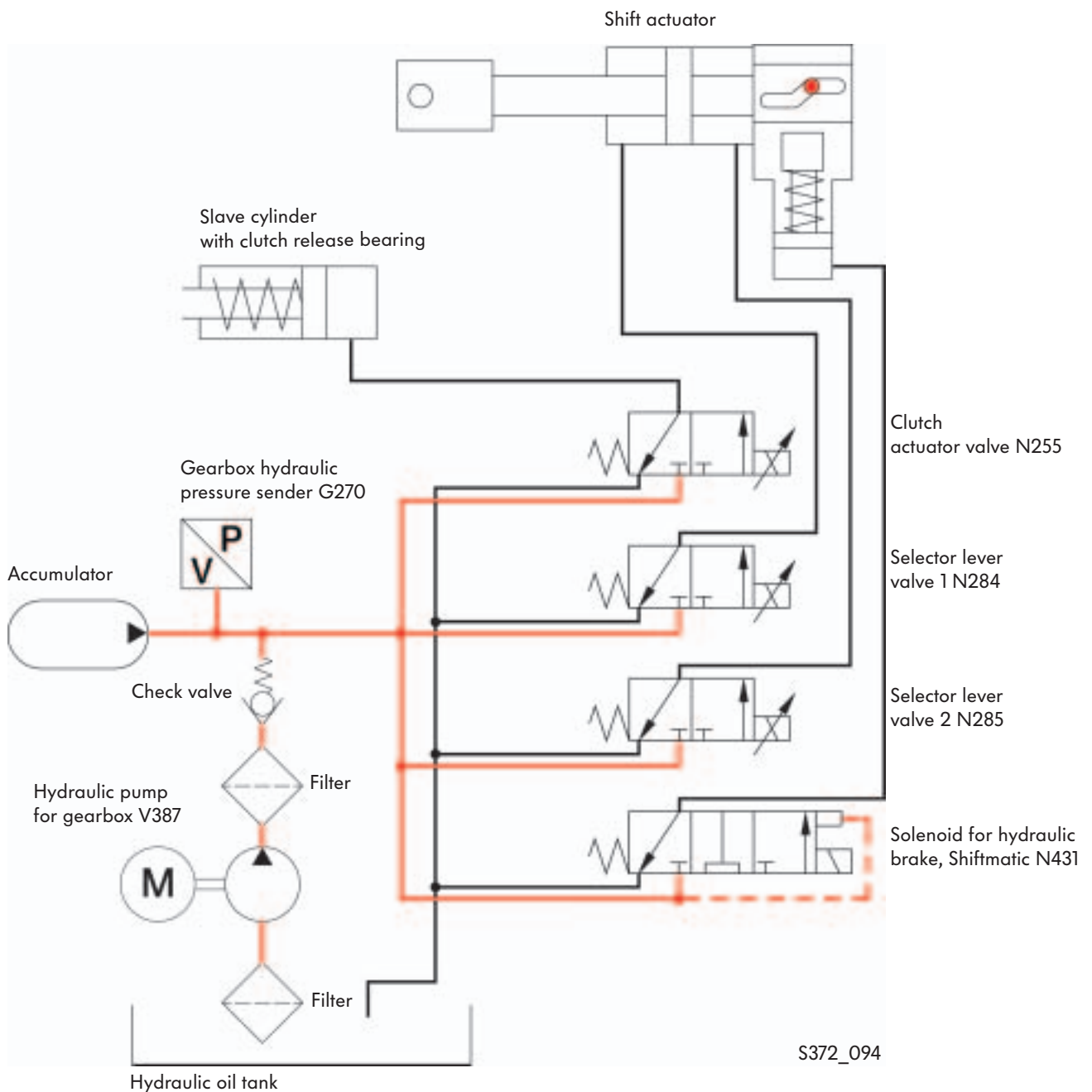
Once the gear has been selected, the pressure is reduced again. For this, both valves N284 and N431 are moved back to the rest position by a spring. This allows the pressure in the shift actuator chambers to be reduced again. Next, the pressure in the slave cylinder with clutch release bearing is reduced in a controlled manner by activating the clutch actuator valve N255. This allows the clutch to engage smoothly and easily. Once the pressure in the shift actuator chambers and in the slave cylinder with clutch release bearing has been reduced, the shift process is complete.



# Hydraulics

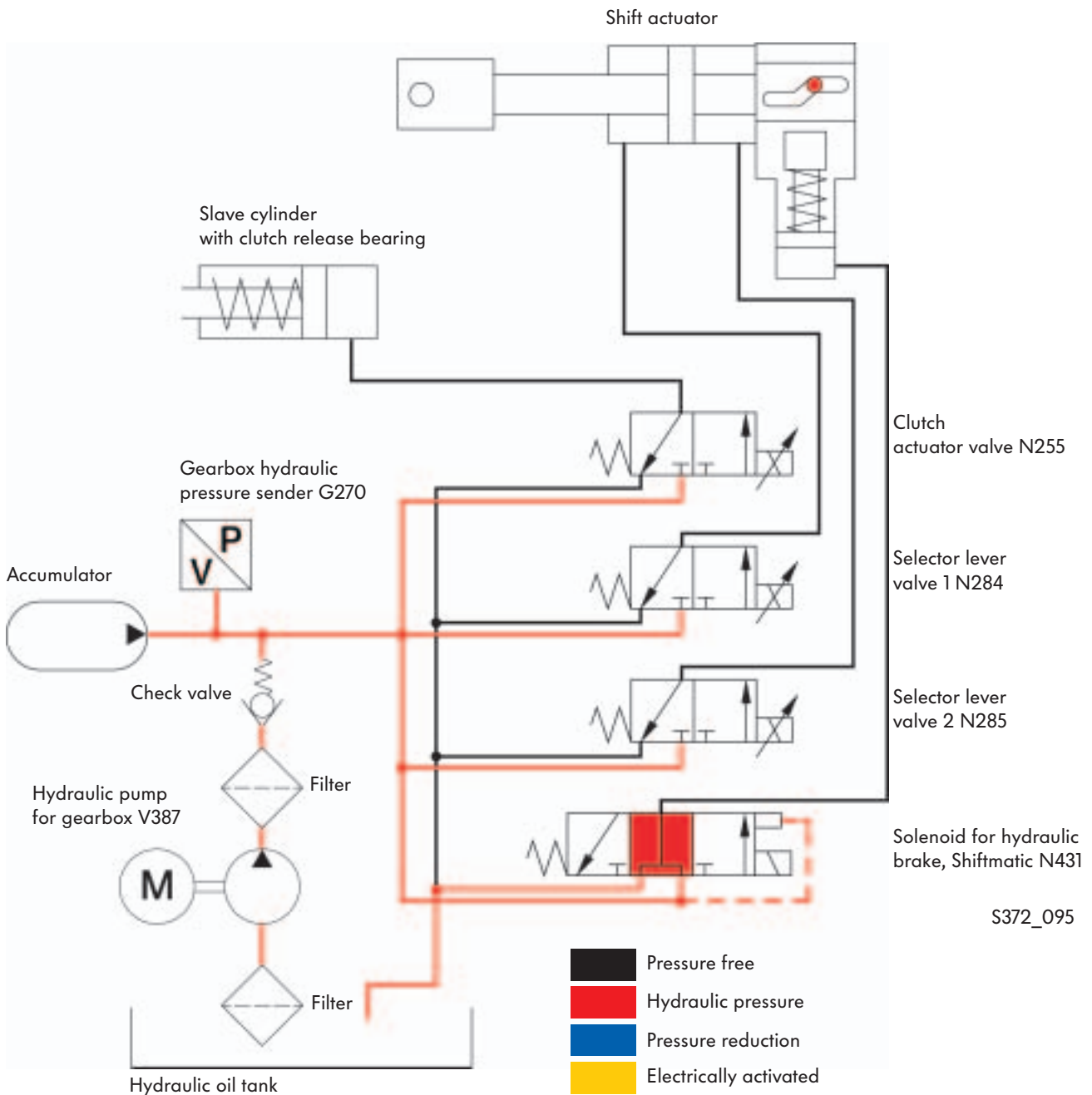
## Pressure relief system

A pressure relief system has been integrated in the hydraulic oil system of the Shiftmatic gearbox to protect components from overloading. The pressure relief is performed by the solenoid for hydraulic brake, Shiftmatic N431. During all shift procedures, the hydraulic pressure is applied constantly via a control line on valve N431. This means that the valve can also be controlled with the hydraulic pressure in addition to electrical activation. The valve stays in its rest position at a system pressure of 55 bar.





If the hydraulic pressure rises above 75 bar, however, the spring force of the clutch actuator valve N431 is counteracted and the valve is pushed to its centre position. This short-circuits the hydraulic oil system so that the pressure cannot rise any further.



# Electronics

## System overview



Selector lever E313

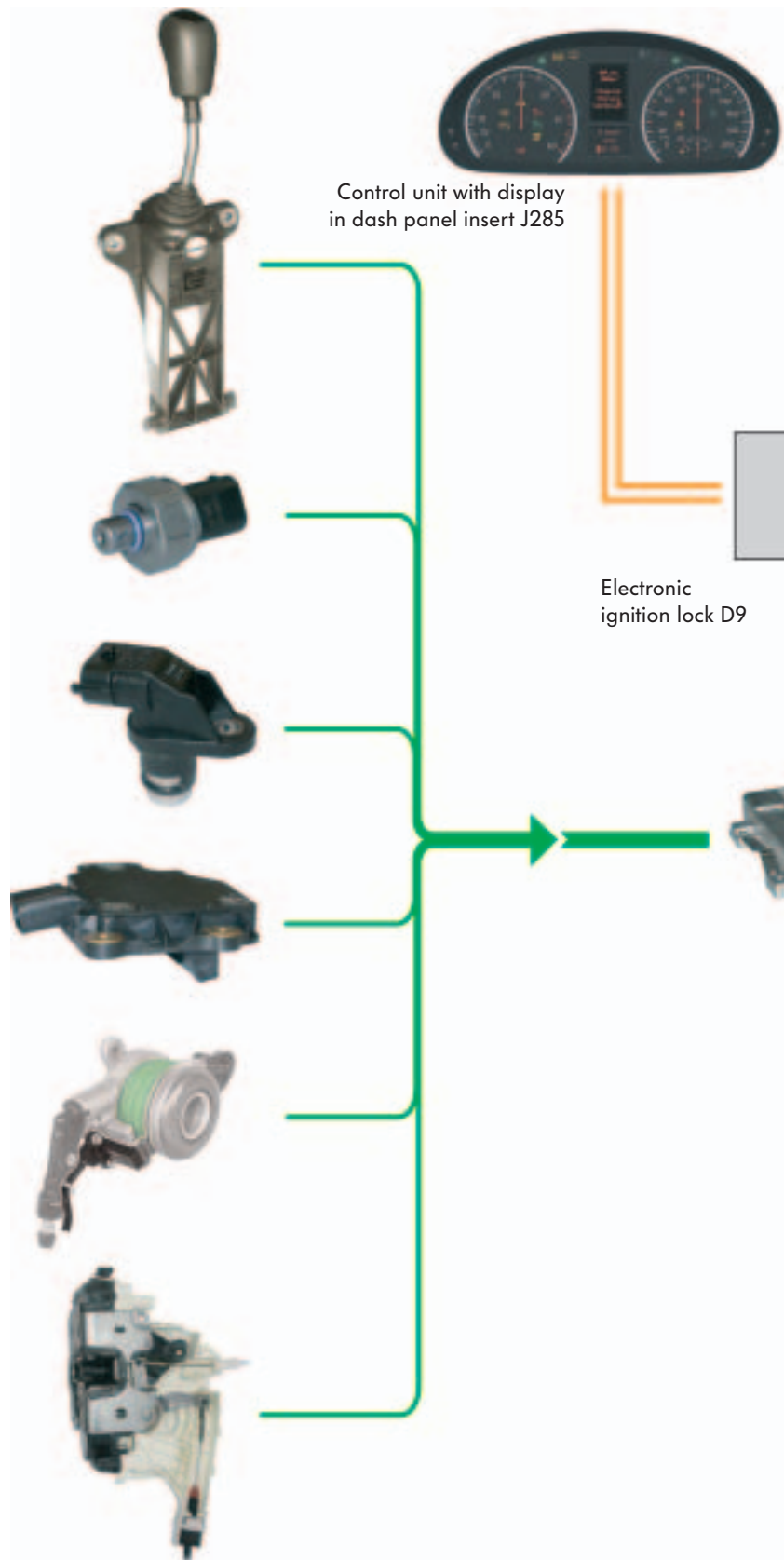
Gearbox hydraulic pressure sender G270

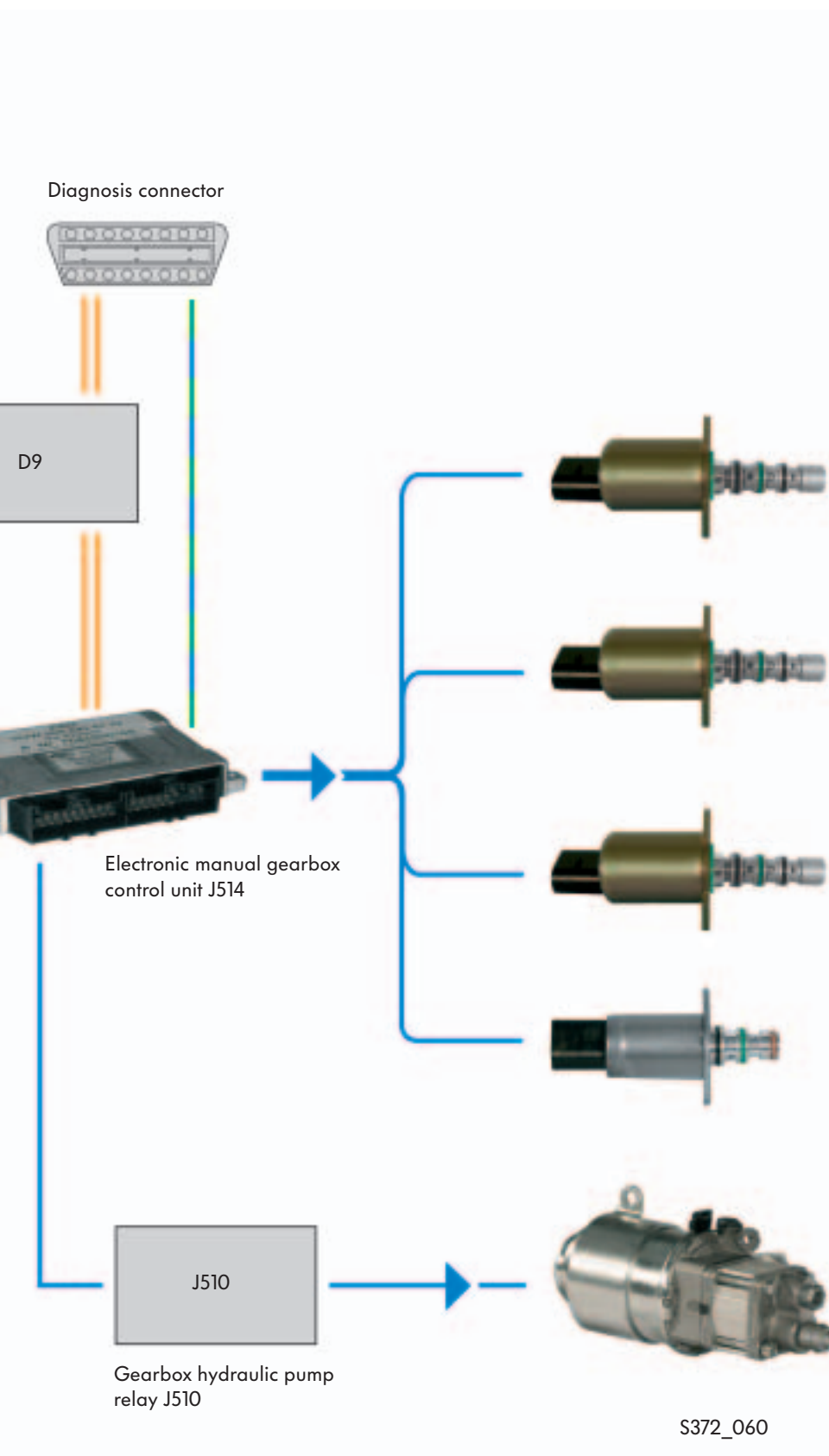
Gearbox speed sender G38

Gear detection sensor G604

Clutch travel sender G162

Driver door contact switch F2





## Sensors

### Gearbox speed sender G38

The gearbox speed sender G38 is mounted on the right-hand side of the rear gearbox case.

The sensor measures the speed on the synchromeshed gear for the reverse gear on the output shaft.

### Signal use

The signal from the gearbox speed sender G38 is used to determine the clutch speed and thus also the gearbox input speed from the transmission ratio.

The electronic manual gearbox control unit J514 needs these speeds to calculate the biting point of the clutch as well as to control the clutch procedures.

### Function

The gearbox speed sender G38 is a differential Hall sensor that measures the tooth backlash on a ferromagnetic sender wheel. Two Hall elements are used that measure the left and right sides of a tooth. The output signal that is also converted into a rectangular signal is formed from the difference of both signals.

This sensor type measures very accurately and is not sensitive to disturbance, like, for example, temperature fluctuations in the gearbox.

### Effects of signal failure

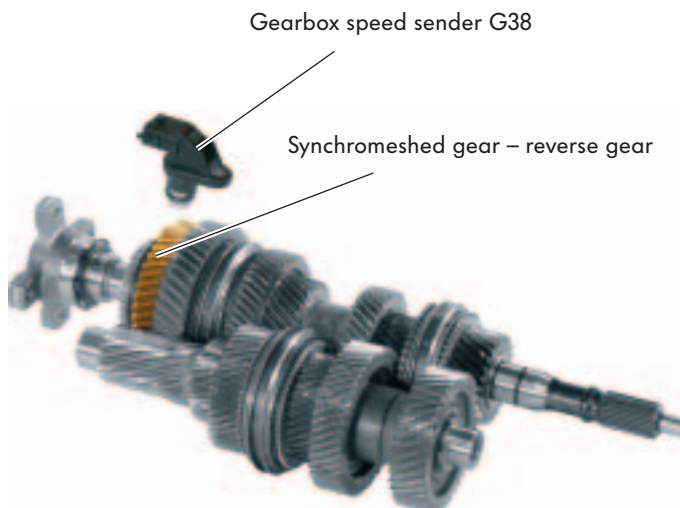
If the signal fails, the gearbox emergency mode will be activated. Gear changes are then only possible in manual mode up to 3rd gear.

Automatic mode is deactivated.



Gearbox speed sender G38

S372\_044



S372\_051

## Gearbox hydraulic pressure sender G270

The gearbox hydraulic pressure sender G270 is mounted directly on the accumulator on the right-hand side of the rear gearbox case.

### Signal use

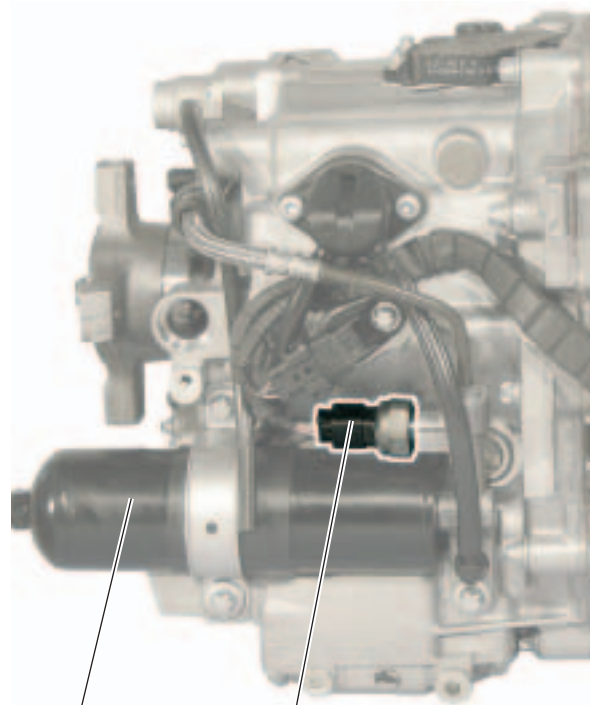
The gearbox hydraulic pressure sender G270 determines the current pressure in the hydraulic system and transfers it to the electronic manual gearbox control unit J514. If the working pressure falls below 39 bar, the gearbox hydraulic pump relay J510 is triggered by the electronic manual gearbox control unit and the hydraulic pump for gearbox V387 is thus activated. At a pressure of 55 bar, the hydraulic pump for gearbox is switched off again.

### Function

A diaphragm with strain resistors is fitted inside the pressure sensor. As soon as pressure is applied to the diaphragm, the resistances change due to the stretching. The resulting drop in voltage is converted into a pressure value by the electronic manual gearbox control unit J514.

### Effects of signal failure

If the signal fails, the gearbox emergency mode will be activated. Gear changes are then only possible in manual mode up to 3rd gear. Automatic mode is deactivated.



S372\_059

Accumulator

Gearbox hydraulic pressure sender G270



## Selector lever E313

The selector lever for the Shiftmatic gearbox E313 uses a so-called “shift by wire” system. This means that there is no mechanical connection between the selector lever and gearbox.

The selector lever E313 has three stable positions:

- Forwards gear “O”
- Neutral “N”
- Reverse gear “R”

and 3 unstable positions:

- Shift up “+”
- Shift down “-”
- Automatic mode (auto shift) “A”

The positions for forwards “O”, neutral “N” and reverse “R” are held horizontally by the holding roller locking in the housing lid. There are 2 further locking positions in the guide housing for vertical locking. One of the locking positions is for vertical locking of the “forwards” and “neutral” driving positions and the other for locking the reverse gear.

The unstable positions are preset by the gate guide in the lid and in the guide housing.

After tapping an unstable position, a spring returns the selector lever E313 to the starting position for forwards “O”.

The selector lever E313 has contact-free sensors. This avoids wear and ensures safe operation.

## Signal use

The electronic manual gearbox control unit J514 uses the selector lever position to calculate the driver’s gear shift requirement.

## Function

A permanent magnet is mounted on the underside of the selector lever, which causes changes in the magnetic field within the sensor range of the housing lid.

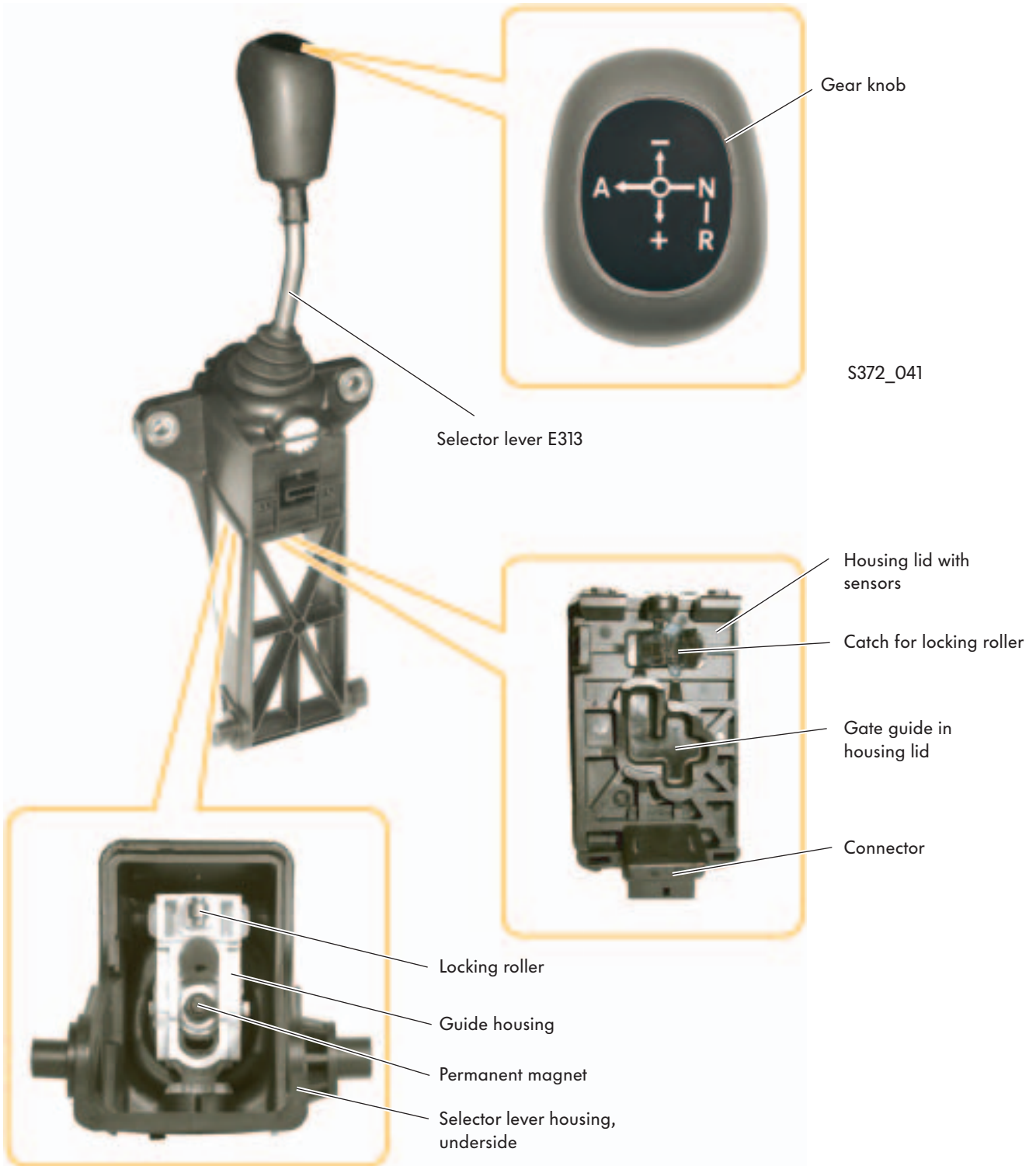
The 6 selector lever positions are encoded in a shift logic of 4 signals. This logic is used by the electronic manual gearbox control unit J514 to evaluate the selector lever position and thus the driver’s gear shift requirement.

## Effects of signal failure

If the signal fails, only automatic mode will be available.

If two or more signals fail, gear selection and thus the gearbox will be disabled and an “F” will appear in the combi instrument gear indicator. It will also not be possible to start the engine.





## Clutch travel sender G162

The clutch travel sender G162 is a contact-free position sensor that measures the disengagement travel directly on the slave cylinder with clutch release bearing. The sensor is bolted directly to the slave cylinder with clutch release bearing.

### Signal use

The signal from the clutch travel sender G162 is used together with the gearbox speed sender G38 to control the clutch position and to determine the following three operating modes in the electronic manual gearbox control unit J514:

- clutch biting point,
- clutch engaging point and
- clutch wear.

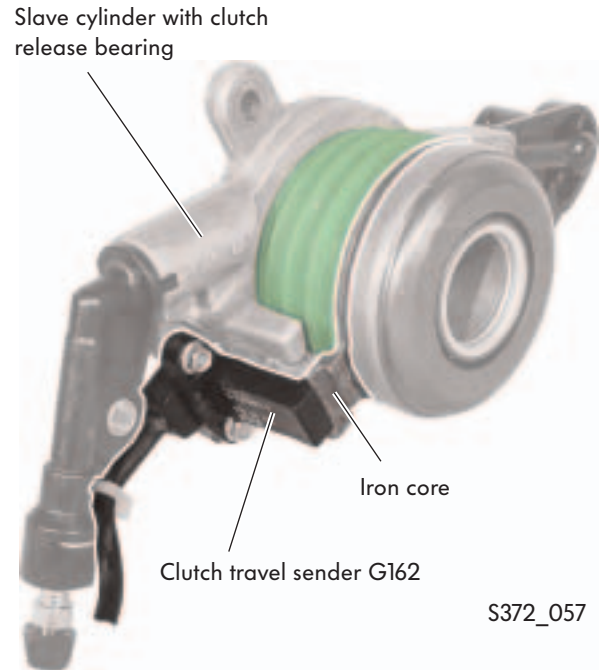
This allows the clutch to be controlled smoothly and safely.

The clutch used in the Crafter is a self-adjusting single-plate dry clutch, which means the disengagement travel always stays constant.

The “clutch biting point” indicates at which disengagement travel the clutch biting point occurs between the engine and gearbox. At this moment, the clutch starts to slip and the synchromeshed gears in the gearbox start to turn.

At the “clutch engaging point”, full power transmission occurs between the engine and gearbox when a gear is selected. The clutch is fully closed and does not slip.

The “clutch wear” is a value stored in the control unit that takes the wear of the friction lining into consideration. A new friction lining with a high frictional value requires a slower pressure build-up in the clutch actuator valve N255 compared with a worn lining. The scale of the necessary pressure reduction is determined using the clutch wear. The activation time of the valve is varied so that smooth clutch operation is always possible.



For this reason, it is necessary to teach in the clutch biting point again when a new clutch is fitted or if there is a malfunction.

### Function

A ring with iron core mounted on the slave cylinder with clutch release bearing causes the magnetic field in the 2 coils of the clutch travel sender G162 to change. Evaluation electronics convert this change into the position signal.

### Effects of signal failure

If the signal fails, the gearbox emergency mode will be activated. Gear changes in manual mode are then only possible up to 3rd gear and an “F” appears in combi instrument gear indicator.



You will find more information in the Guided fault finding – Learn new clutch biting point.



## Driver door contact switch F2

The driver door contact switch F2 is fitted in the driver door lock unit and is not directly visible from the outside.

It is a mechanical switch that is reset by a spring.

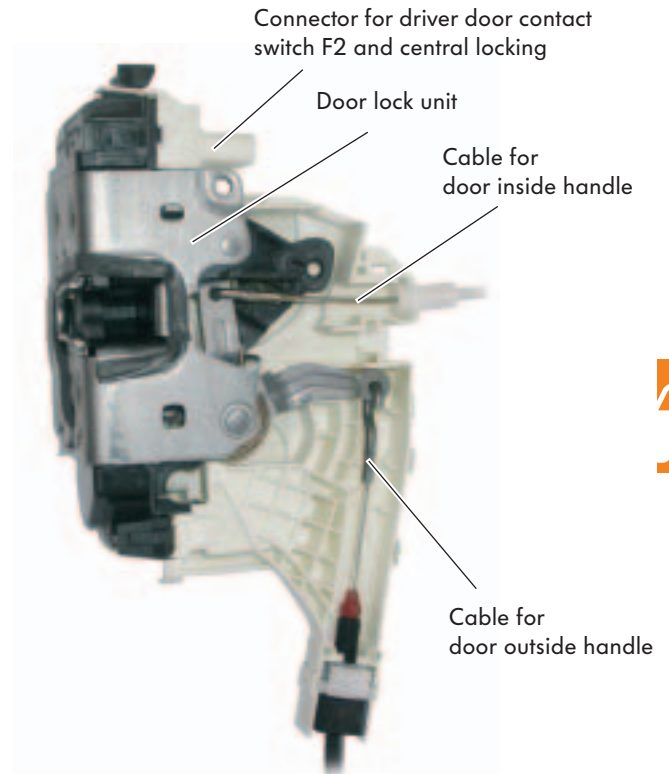
### Signal use

The signal from the driver door contact switch F2 is used together with the signal from the gearbox hydraulic pressure sender G270 and the ambient temperature sensor G17 to determine whether and when the hydraulic pump for gearbox V387 needs to be activated.

If the gearbox hydraulic pressure sender G270 measures a pressure below 39 bar, the hydraulic pump will need to be run before the engine is started to provide the necessary hydraulic system pressure.

If the ambient temperature sensor records a temperature below  $-20\text{ }^{\circ}\text{C}$ , the hydraulic pump will run as soon as the driver's door is opened due to the viscosity of the hydraulic oil. If the temperature is above that, this will not happen until the driver's door is closed.

The signal from the door contact switch F2 is also used for the roll away warning in the Crafter. A warning signal will sound as soon as the driver's door is opened and the handbrake is not engaged.



S372\_054

Another function that is controlled with the signal from the door contact switch F2 is the gearbox neutral switching. Before the gearbox is switched to neutral, a warning signal sounds under the following conditions:

- engine running
- gear selected
- no pedal pressed
- driver's door open

The gearbox is only switched to neutral after another three seconds.

### Effects of signal failure

The gearbox continues normal operation and there is no emergency mode.

## Gear detection sensor G604

The gear detection sensor G604 is located on the top of the rear gearbox housing. It is used for contact-free detection of the longitudinal movement and rotary movement of the central selector shaft that is connected to the piston rod.

### Signal use

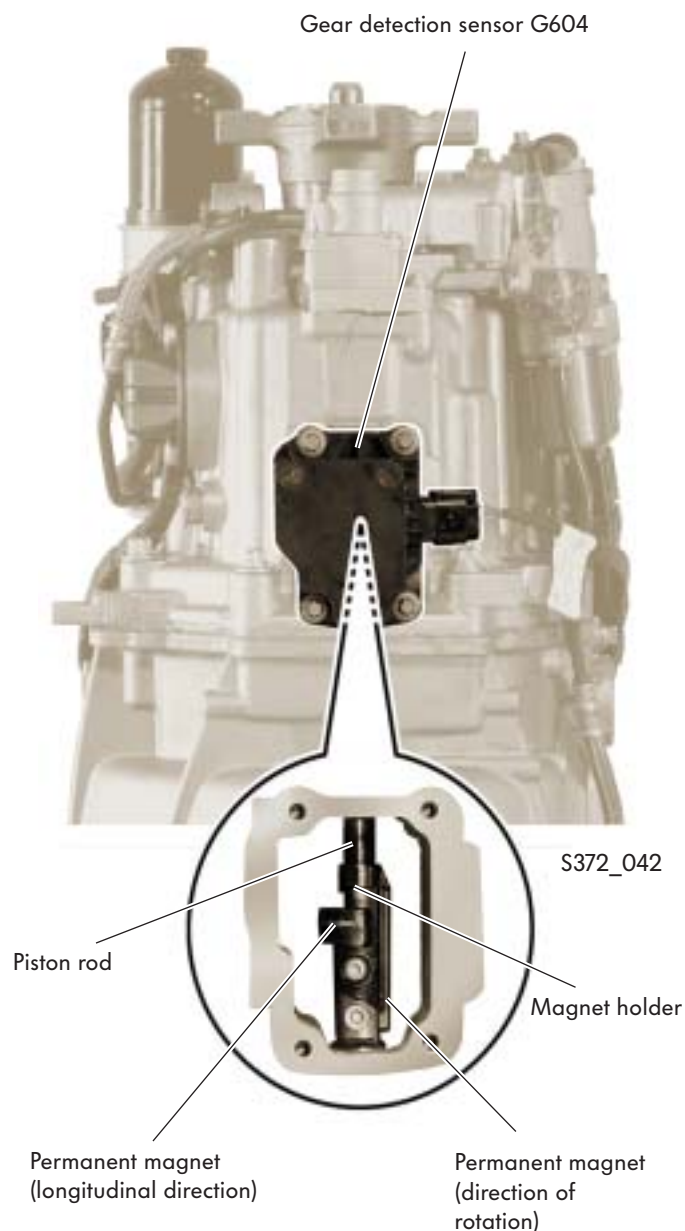
The electronic manual gearbox control unit J514 uses the position signals from the gear detection sensor G604 to determine the selected gear and thus also the gear gate.

### Function

One permanent magnet for detecting the longitudinal movement and one for the rotation direction is fitted on the piston rod of the shift actuator. When the piston rod is moved or rotated, the permanent magnets change the magnetic field in the coils of the gear detection sensor G604. The electronic manual gearbox control unit J514 calculates the position of the central selector shaft from these signals.

### Effects of signal failure

If the signal fails, gear selection and thus the gearbox will be disabled and an "F" will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



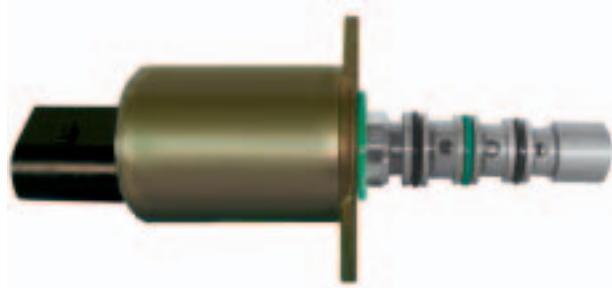
## Actuators

### Clutch actuator valve N255

The clutch actuator valve N255 is a control valve. This solenoid valve can control the volume flow and thus the hydraulic pressure by regulating the flow. Intermediate positions are possible in addition to “open” and “closed”. This property is necessary to make the clutch procedure safe and precise. The valve is opened with an electrical current and is returned to the closed position by the spring force.

#### Effects of signal failure

If the signal fails, gear selection and thus the gearbox will be disabled and an “F” will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



S372\_028

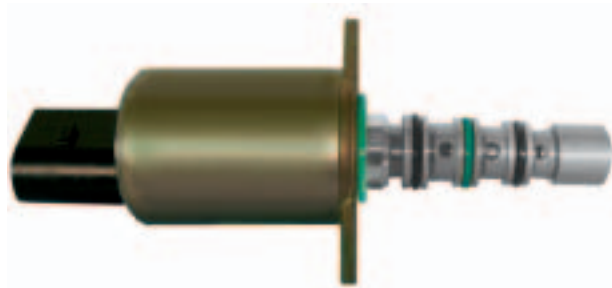


### Selector lever valve 1 N284

The selector lever valve 1 N284 is a control valve. It is used to shift gears 1, 3 and 5. The valve is opened with an electric current. It is returned to the closed position by a spring.

#### Effects of signal failure

If the signal fails, gear selection and thus the gearbox will be disabled and an “F” will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



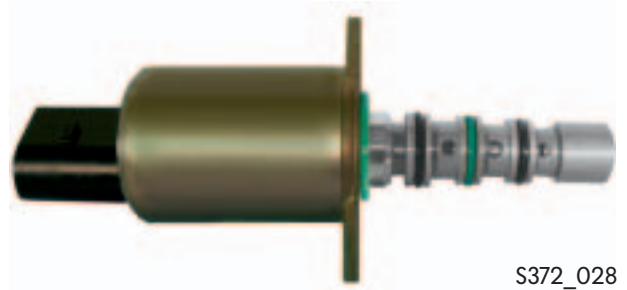
S372\_028

## Selector lever valve 2 N285

The selector lever valve 2 N285 is a control valve. It is used to shift gears 2, 4 and 6 as well as reverse gear. The valve is opened with an electric current. It is returned to the closed position by a spring.

### Effects of signal failure

If the signal fails, gear selection and thus the gearbox will be disabled and an "F" will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



S372\_028

## Solenoid for hydraulic brake, Shiftmatic N431

The solenoid for hydraulic brake, Shiftmatic N431 is used to control the hydraulic brake in the shift actuator. This solenoid valve is black/white or binary operated valve, but with 3 positions. The valve is open when fully powered. It is returned to the closed position by a spring. The middle position has a pressure limitation function in which the hydraulic oil system is short-circuited and the pressure cannot rise any further.

### Effects of signal failure

If the signal fails, gear selection and thus the gearbox will be disabled and an "F" will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



S372\_029



## Hydraulic pump for gearbox V387

The hydraulic pump for gearbox V387 is a module consisting of a 12 V electric motor and a hydraulic pump. A gear wheel pump is used as a hydraulic pump.

The hydraulic pump is switched on and off by the gearbox hydraulic pump relay J510.

### Effects of signal failure

If the signal fails (gearbox hydraulic pump relay J510 or hydraulic pump for gearbox V387), gear selection and thus the gearbox will be disabled and an "F" will appear in the combi instrument gear indicator. It will also not be possible to start the engine.



S372\_022

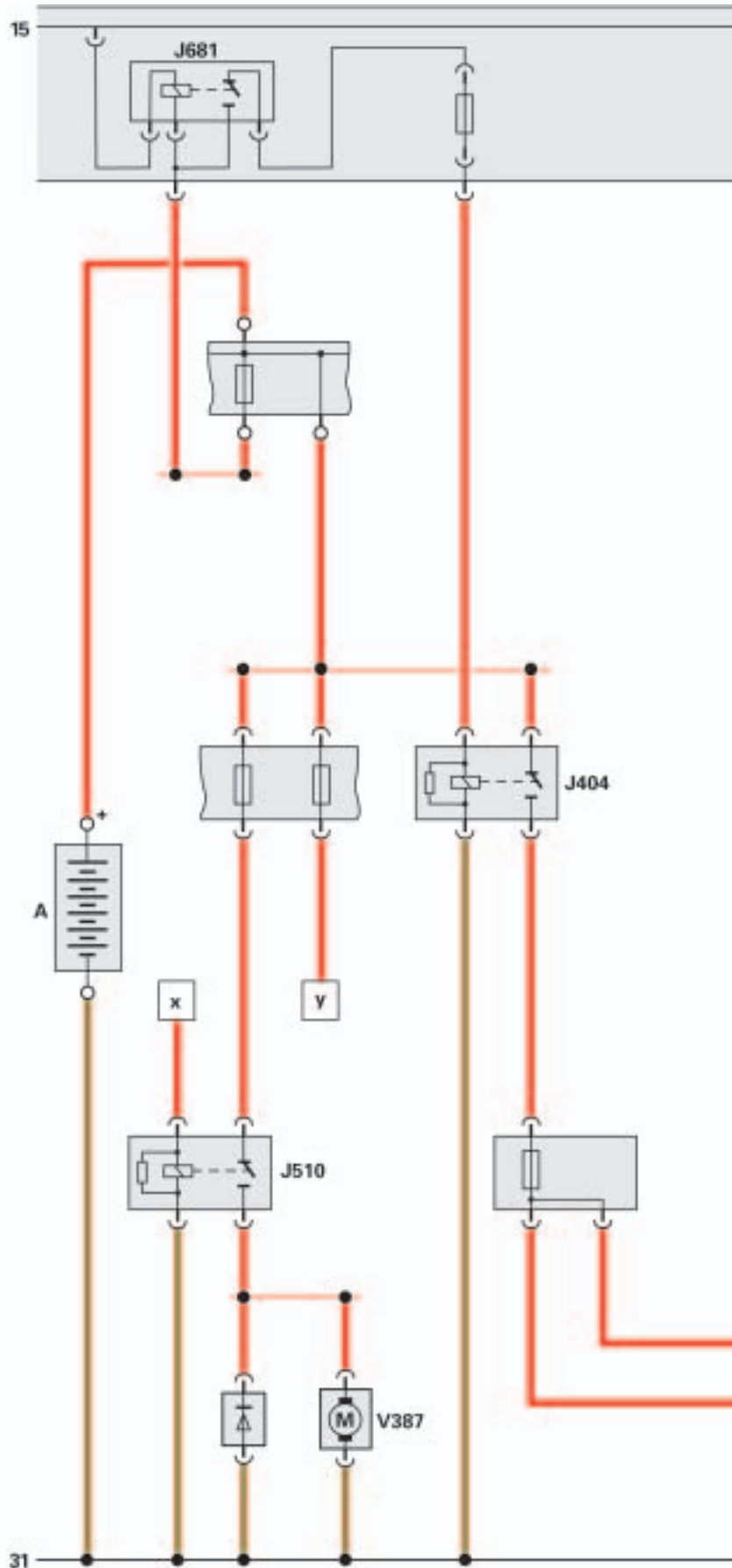


# Electronics

## Functional Diagram

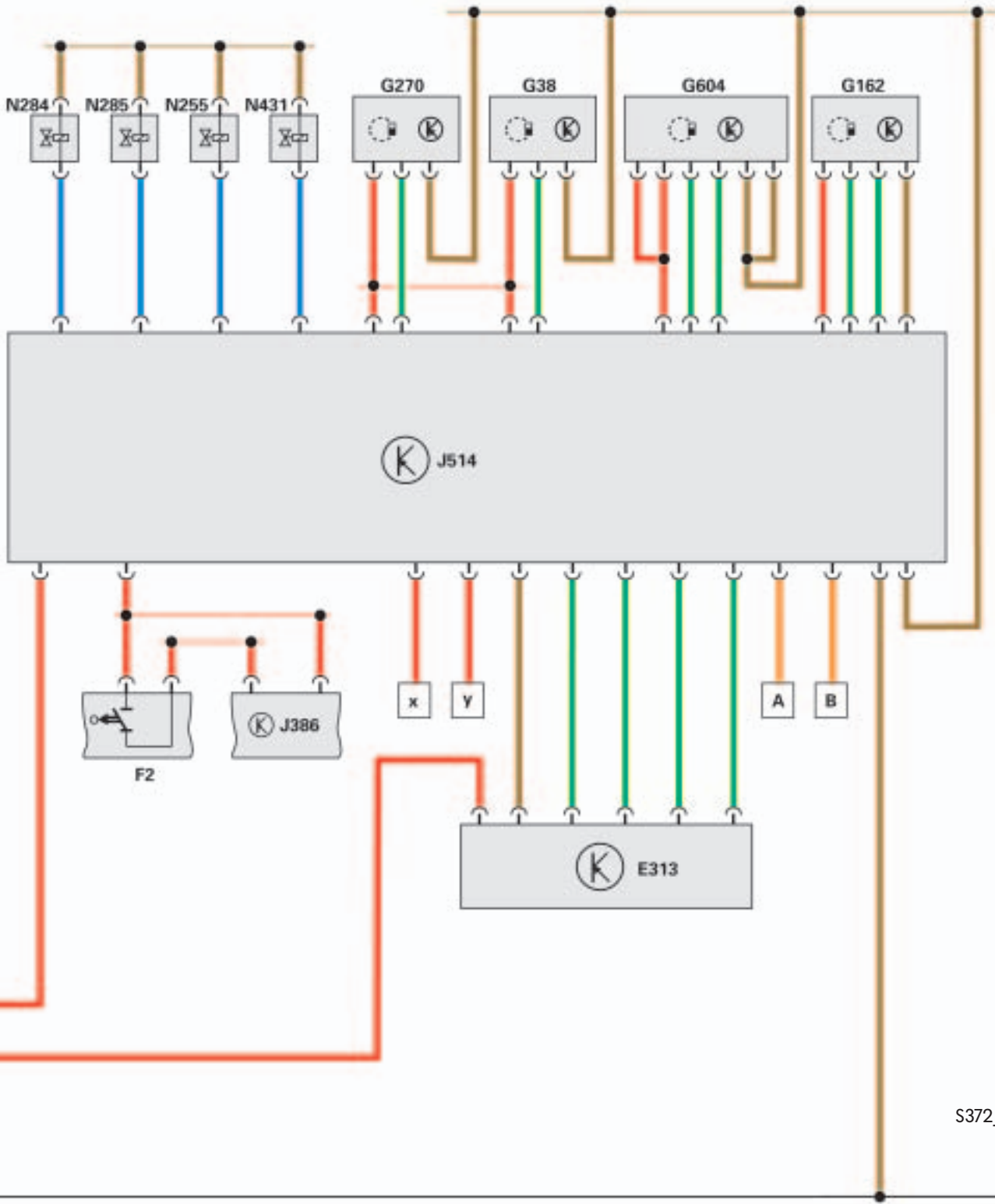
- E313** Selector lever
- F2** Driver door contact switch
- G38** Gearbox speed sender
- G162** Clutch travel sender
- G270** Gearbox hydraulic pressure sender
- G604** Gear detection sensor
- J386** Driver door control unit
- J404** Terminal 15 relief relay
- J510** Gearbox hydraulic pump relay
- J514** Electronic manual gearbox control unit
- J519** Onboard supply control unit
- J681** Terminal 15 voltage supply relay 2
- N255** Clutch actuator valve
- N284** Selector lever valve 1
- N285** Selector lever valve 2
- N431** Solenoid for hydraulic brake, Shiftmatic
- V387** Hydraulic pump for gearbox

- Input signal
- Output signal
- Positive
- Earth
- CAN data bus





(K) J519



S372\_079

31

## Location of electronic manual gearbox control unit J514

The electronic manual gearbox control unit J514 is mounted inside the console under the seat on the left-hand side of the vehicle.

Electronic manual gearbox control unit J514



S372\_082







# Test Yourself

---

## Which answers are correct?

One or several of the answers could be correct.

### 1. Which statement about the Shiftmatic gearbox is correct?

- a) It is a semi-automatic gearbox.
- a) It is a fully automatic gearbox.
- c) It is an automated manual gearbox.

### 2. Which statement about the triple synchromesh is correct?

- a) It can shift gears faster than double synchromesh.
- b) In triple synchromesh, a frictional surface occurs less than in double synchromesh.
- c) Greater speed differences are compensated in the triple synchromesh than with double synchronization.

### 3. Which component is the central element of the shift unit?

- a) 1st/2nd gear selector fork
- a) 3rd/4th gear selector fork
- a) 5th/6th gear selector fork
- d) Reverse gear selector fork
- e) Shift actuator
- f) Central selector shaft



**4. Which statement about the shift actuator is correct?**

- a) It is activated electrically.
- b) It is activated hydraulically via solenoid valves.
- c) It is used for the horizontal movement and rotation of the central selector shaft.

**5. What kind of hydraulic pump is used for the Shiftmatic gearbox?**

- a) Axial piston pump
- b) Radial piston pump
- c) Gear wheel pump

**6. What characterises the selector lever E313 on the Shiftmatic gearbox?**

- a) It uses a "shift by wire" system.
- b) It is connected mechanically to the Shiftmatic gearbox.
- c) It has contact-free sensors.

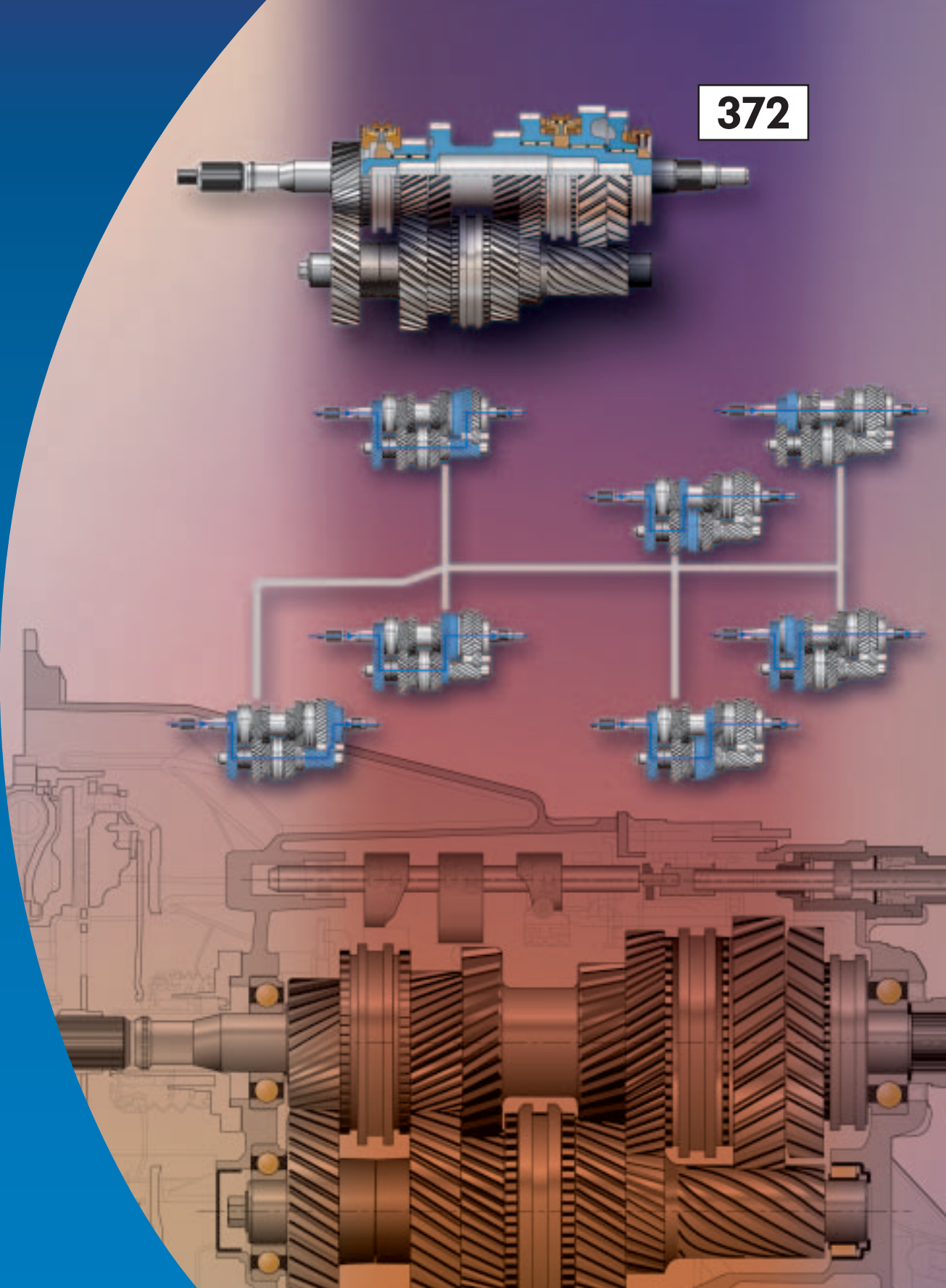
**7. How many signals does the electronic manual gearbox control unit J514 use to evaluate the 6 selector lever positions?**

- a) 4
- b) 5
- c) 6



1. b, c; 2. c; 3. f; 4. b, c; 5. c; 6. a, c; 7. a

**Answers**



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