

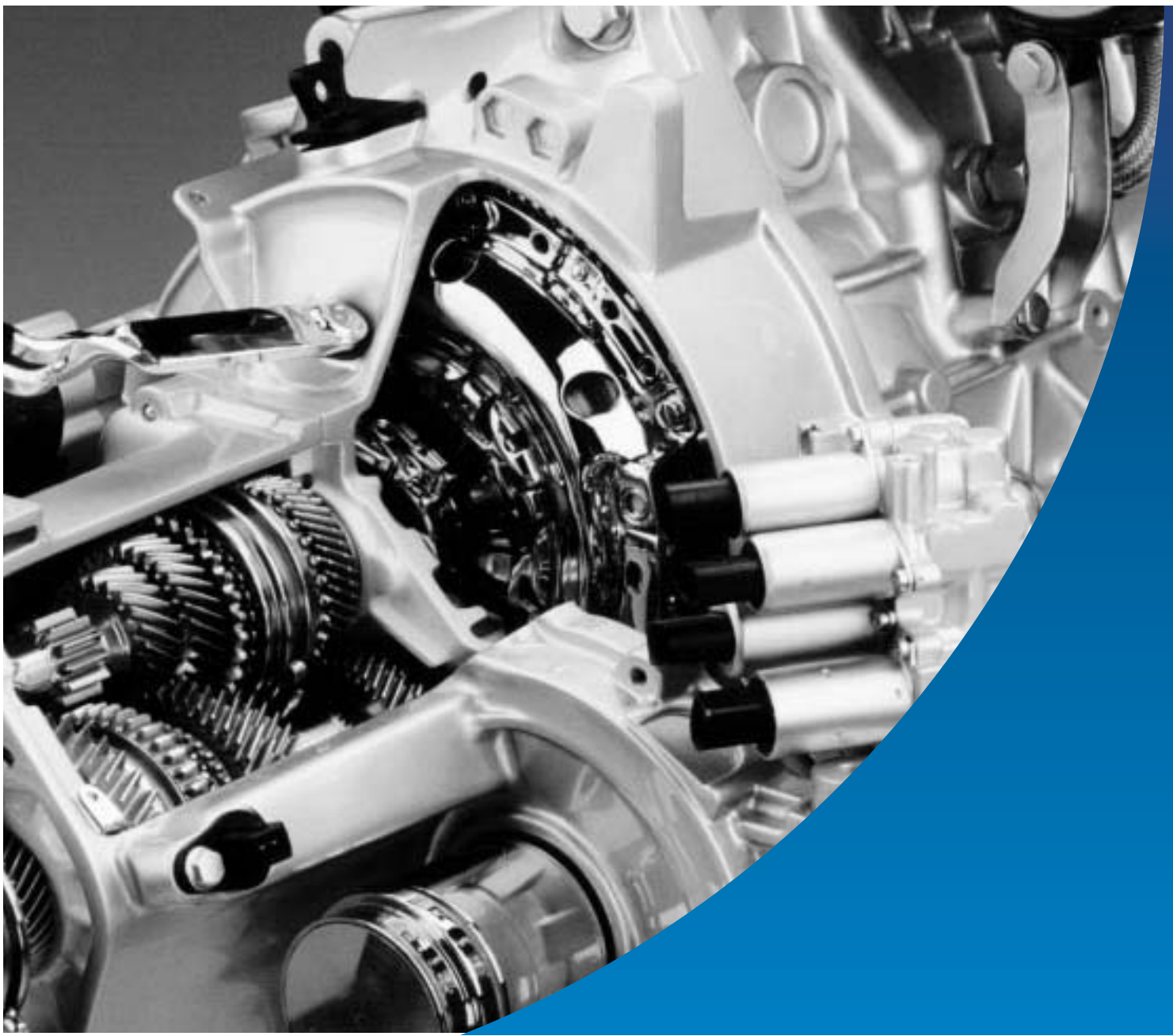
Service.



Self-Study Programme 221

Electronic Manual Gearbox

Design and Function



Taking the Lupo as the basis, Volkswagen has developed the world's first 3 L car that will also go into volume production.

Designing a vehicle which covers 100 km on 3 litres of fuel involved a great deal of detail work.

Factors influencing fuel consumption - such as aerodynamics, rolling resistance, engine concept, gearbox tuning and kerb weight - have been revised systematically.

The goal was achieved by using new technologies, weight-saving materials and new production processes.

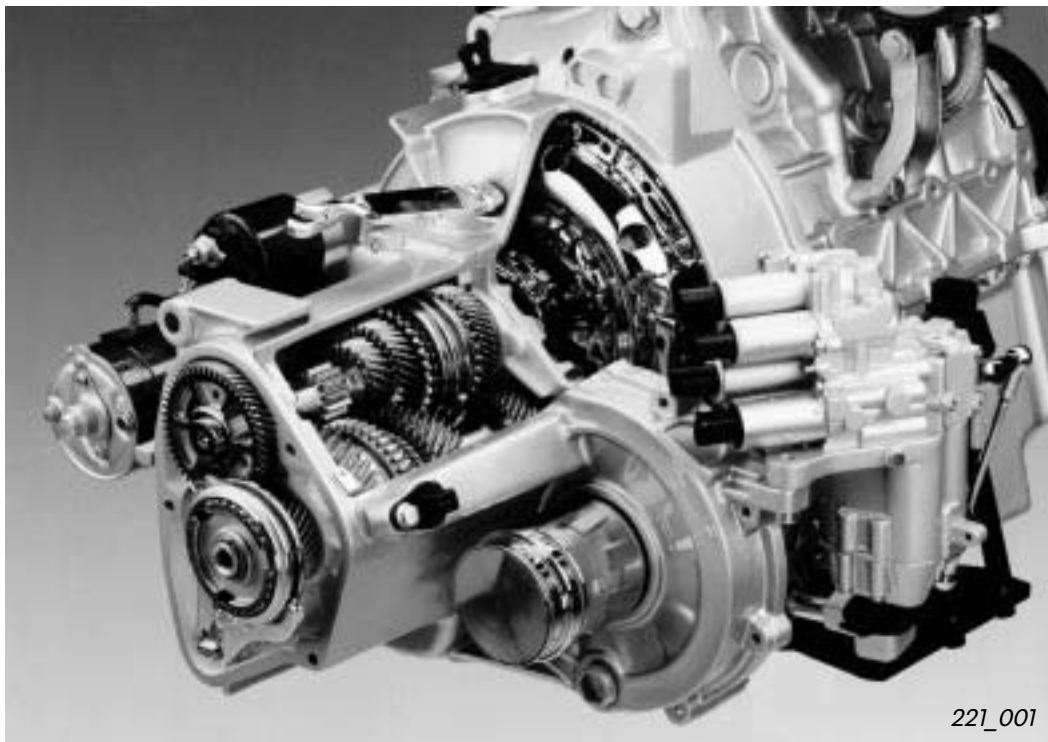
However, the driver also plays a key role with regard to fuel economy.

A great many drivers are not aware of this fact, though.

The new electronic manual gearbox eliminates gear shift errors. Gear shifts are executed automatically and in such a way as to optimise fuel consumption.

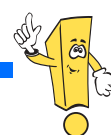


The advantages of an electronic manual gearbox over an automatic gearbox are lower weight and higher efficiency.



New

**Important
Note**



**The Self-Study Programme
is not a Workshop Manual.**

Please always refer to the relevant Service Literature for all inspection, adjustment and repair instructions.

Table of contents



General information	4
The electronic manual gearbox	4
Mechanicals	6
General information	6
The selector lever	8
Hydraulics	10
System representation	10
The hydraulic clutch control	12
The selector gate selection	14
The gear selection	18
The pressure control	22
The hydraulic pump	24
The clutch slave cylinder	25
Electronics	26
System overview	26
The sensors	28
The actuators	37
The gearbox control unit	44
The stop/start function	46
Function diagram	48
The self-diagnosis	50
Test your knowledge	52

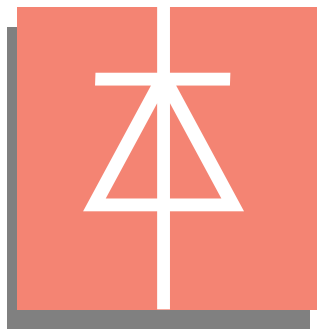


General information



The electronic manual gearbox

comprises three main elements:



The electronics comprise:

- the electronic selector lever
- the electronic accelerator pedal
- the gearbox control unit
- the electro-hydraulic valves
- the potentiometer and the micro-switches

The hydraulics comprise:

- the hydraulic unit with hydraulic pump and pressure accumulator
- the clutch slave cylinder
- the selector lever
- the pressure valves

The mechanics comprise:

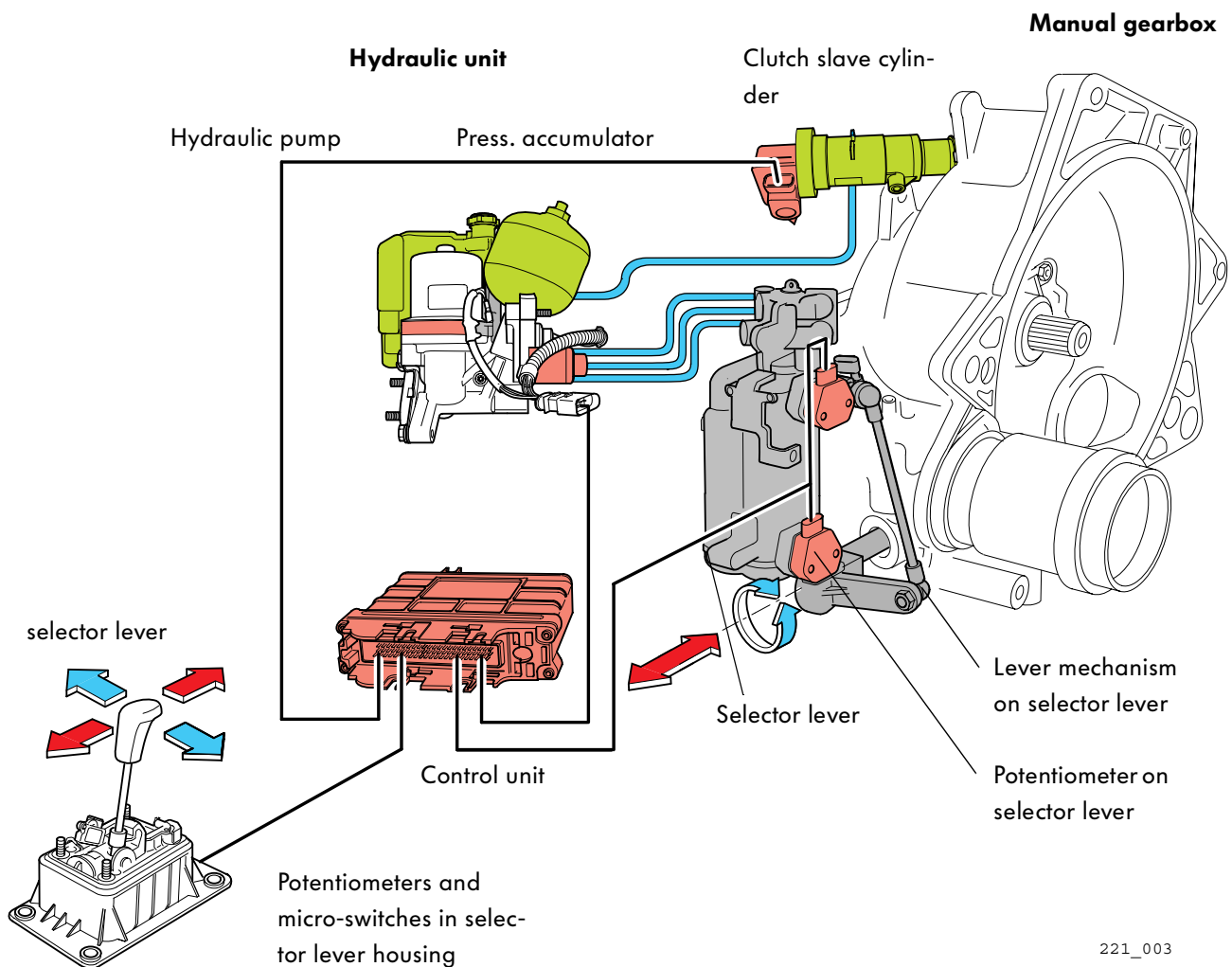
- manual gearbox 085
- the selector shaft and the lever mechanism of the selector lever



In the electronic manual gearbox,

movements of the gear lever are registered by a potentiometer and four micro-switches and signalled to the control unit.

The actual gear change is initiated by the gearbox control unit and executed via hydraulic valves and selector levers.



221_003

Mechanicals

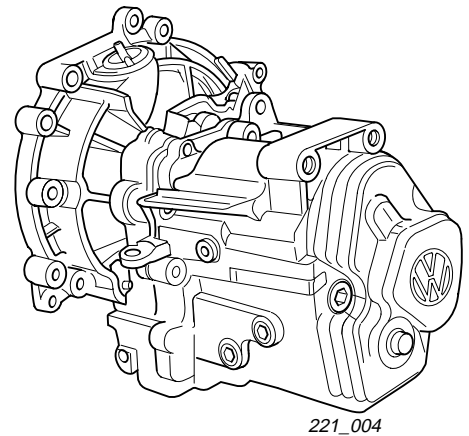
General information

The electronic manual gearbox mechanism is based on the 5-speed manual gearbox fitted in the VW Polo and Lupo.

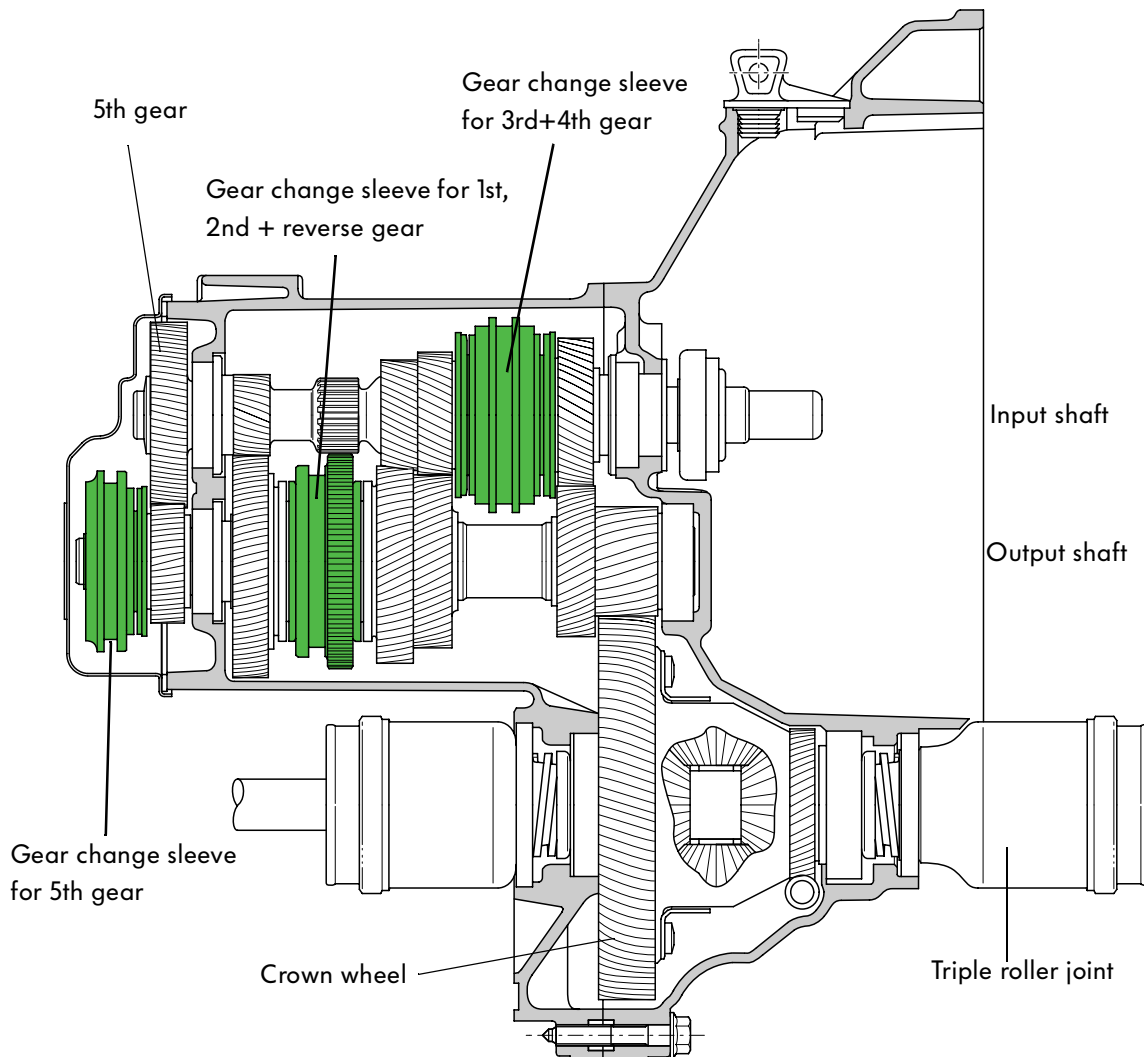
The manual gearbox has been made lighter and revised to make it suitable for use in the Lupo 3 L.

Weight was reduced as follows:

- Openings were included in the crown wheel
- The input and output shafts were hollow drilled
- The 5th gear has been designed as a spoked gear wheel
- The remaining gear wheels have been made lighter by machining recesses in the side faces
- By moving the oil filler screw, oil capacity has been reduced by 0.2 litres but the oil level is still the same as before



221_004

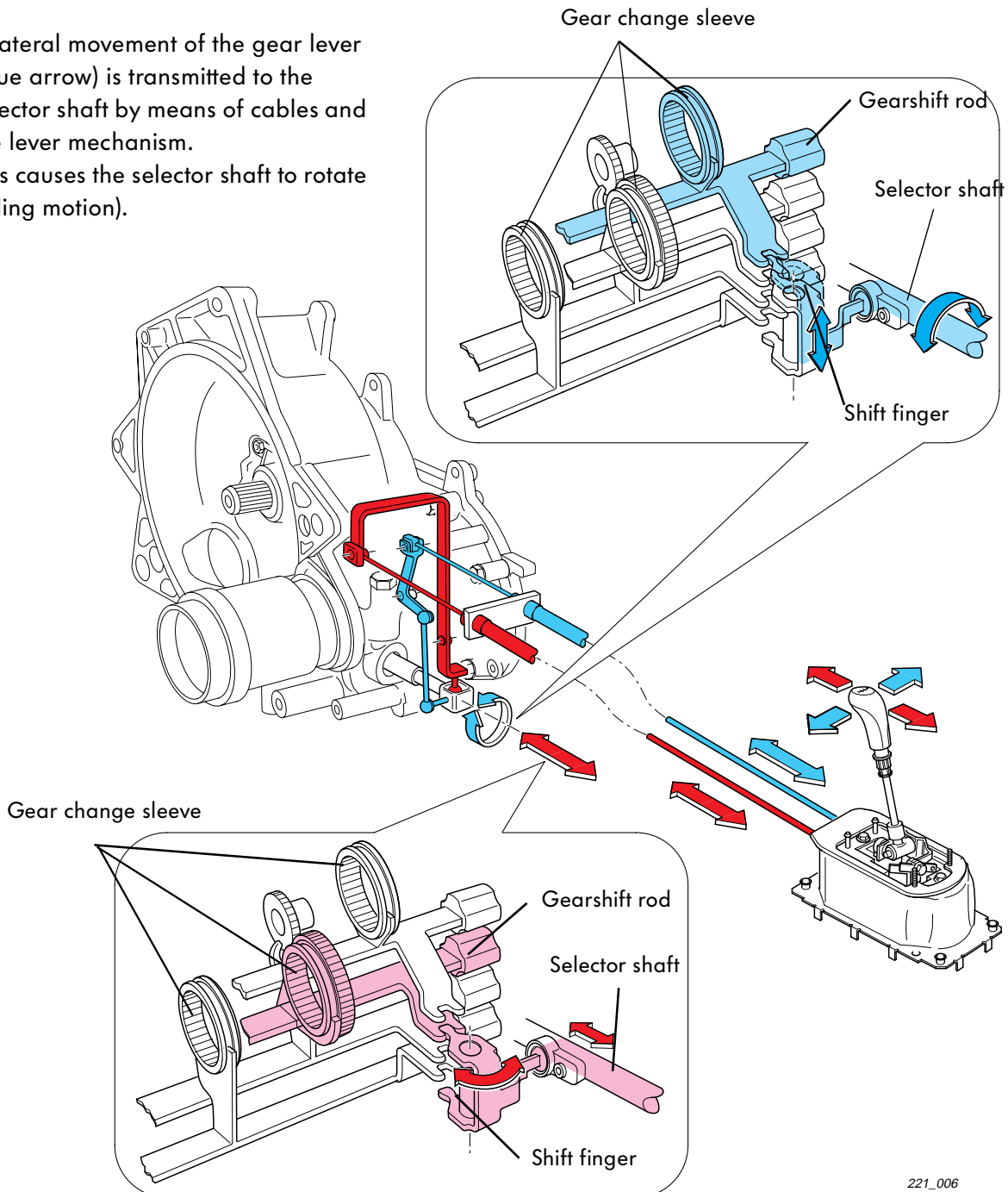


221_005

Gear shifts

of the standard manual gearbox are initiated via the gear lever and transferred to the selector shaft on the gearbox by means of cables and reversing levers.

A lateral movement of the gear lever (blue arrow) is transmitted to the selector shaft by means of cables and the lever mechanism. This causes the selector shaft to rotate (idling motion).



Forward and reverse movements of the gear lever (red arrow) are transformed to forward and reverse movements of the selector shaft (gearshifts).



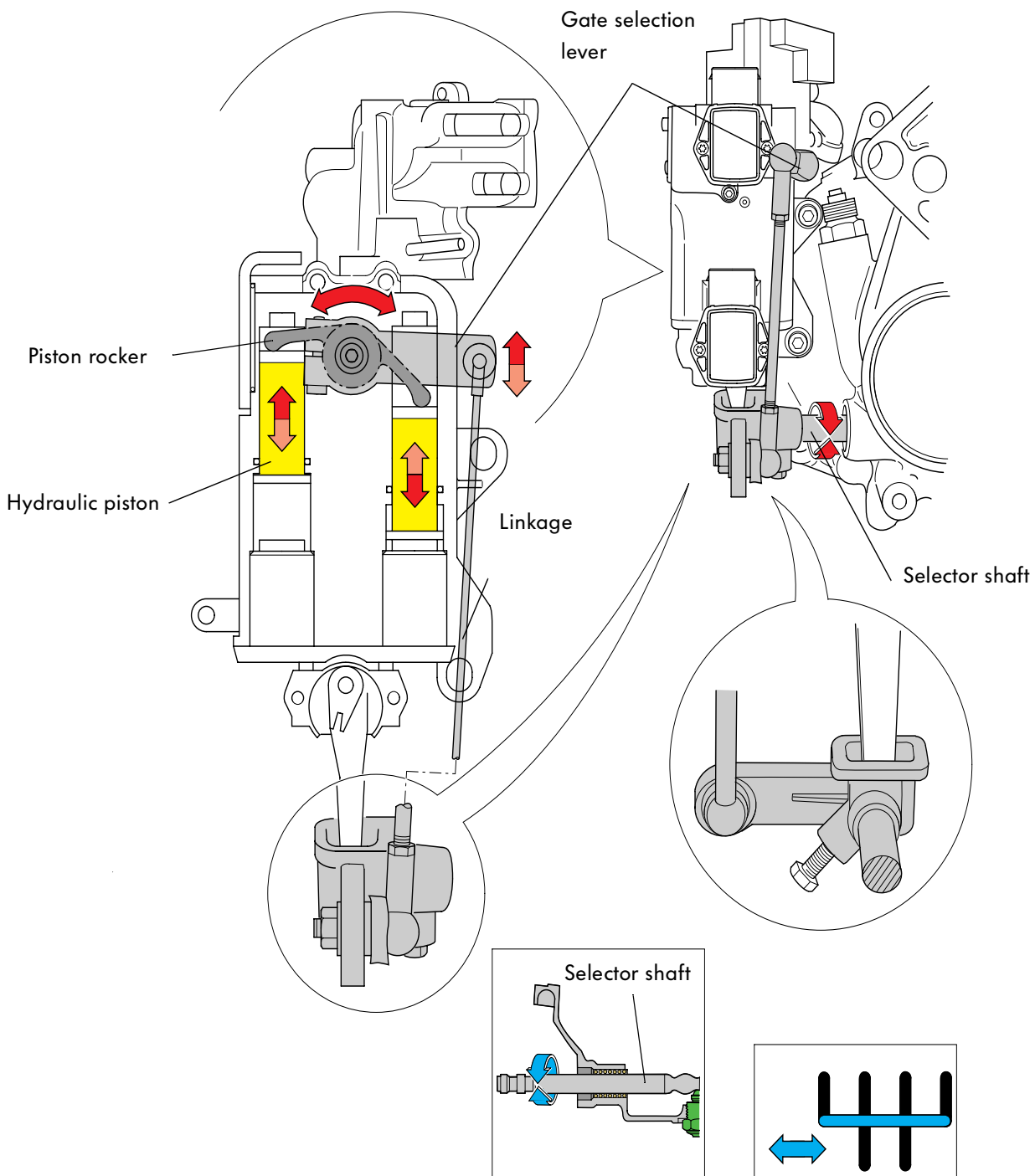
In the electronic manual gearbox, external mechanical actuation is performed by the selector lever.

Mechanicals

The selector lever

transfers the shift operations initiated by the control unit to the selector shaft on the manual gearbox.

Hydraulic pistons in the selector lever housing are actuated with hydraulic fluid via solenoid valves. The piston applies pressure to the piston rocker to whose arbor the gate selection lever is attached. A linkage transfers the movement to a lever located on the selector shaft. This causes the selector shaft to rotate.

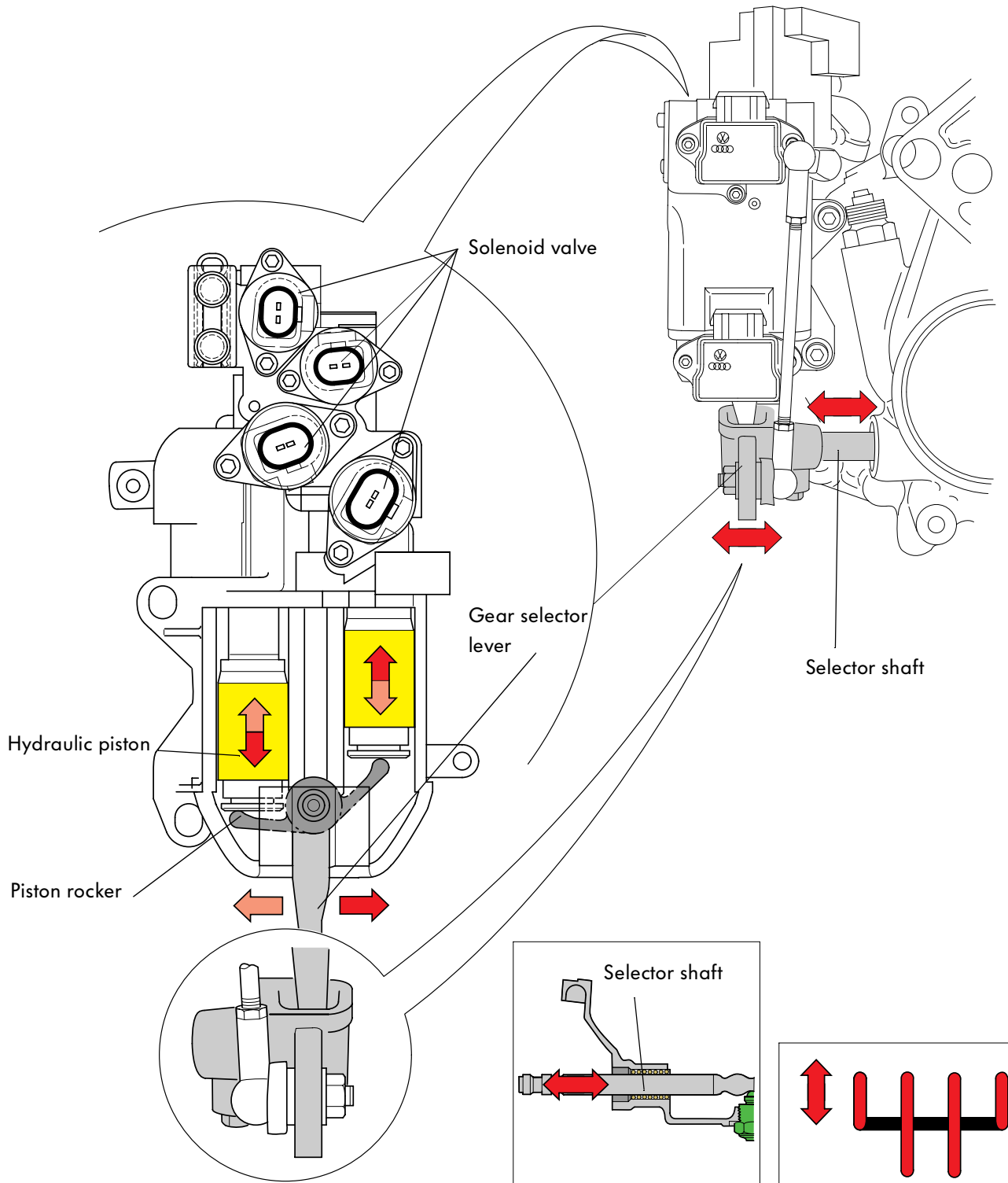


221_007

When a gear is selected, two additional pistons in the selector lever housing are actuated with oil pressure via solenoid valves.

A piston applies pressure to a piston to whose arbor the gear selector lever is attached.

The selector shaft is moved forward or backward.



Hydraulics

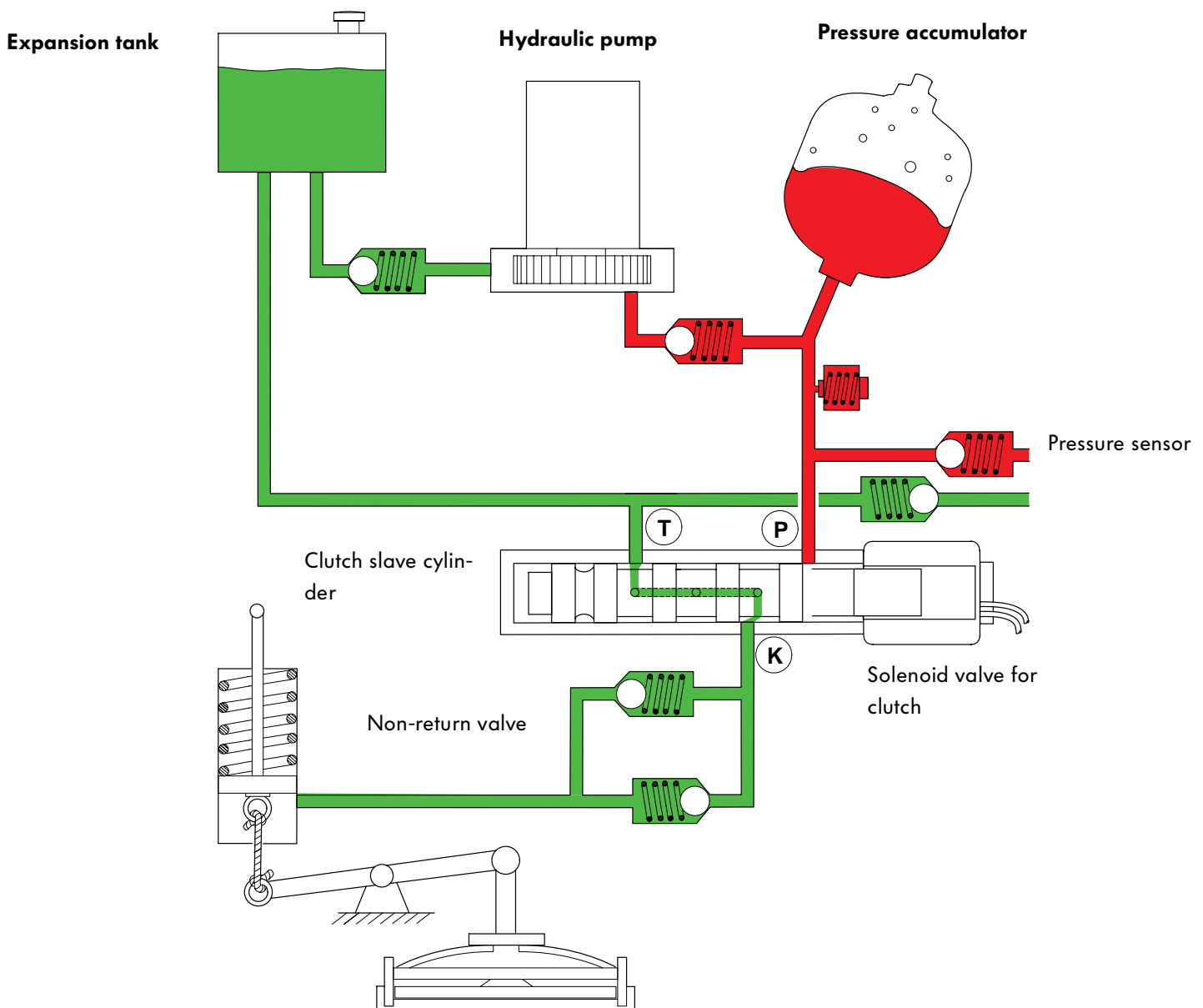
System representation

The hydraulics enable the system to execute shift movement sequences.


An electrical hydraulic pump generates for the required pressure.

Thanks to the pressure accumulator, the system has an oil and pressure reserve which enables it to execute instantaneous shift operations.

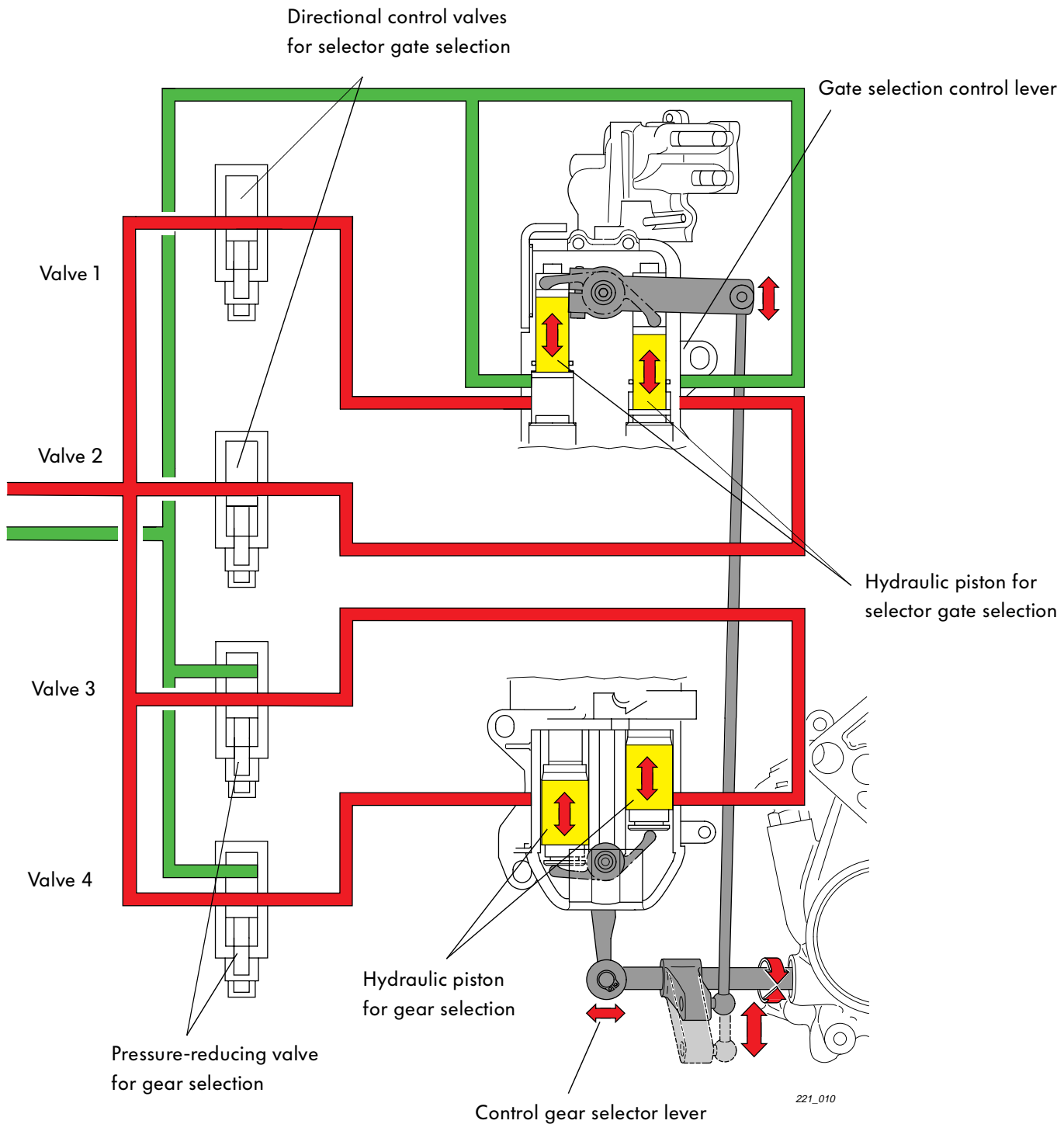
A pressure accumulator signals the momentary system pressure to the control unit.



221_009

- 
- K** = pressure pipe connection to clutch
 - P** = pressure pipe connection to pump (pressure side)
 - T** = pressure pipe connection to expansion tank

During a gear change, solenoid valves admit pressure to both the clutch slave cylinder and the pistons in the selector lever corresponding to the correct position in the selector gate and the gear selected.



Hydraulics

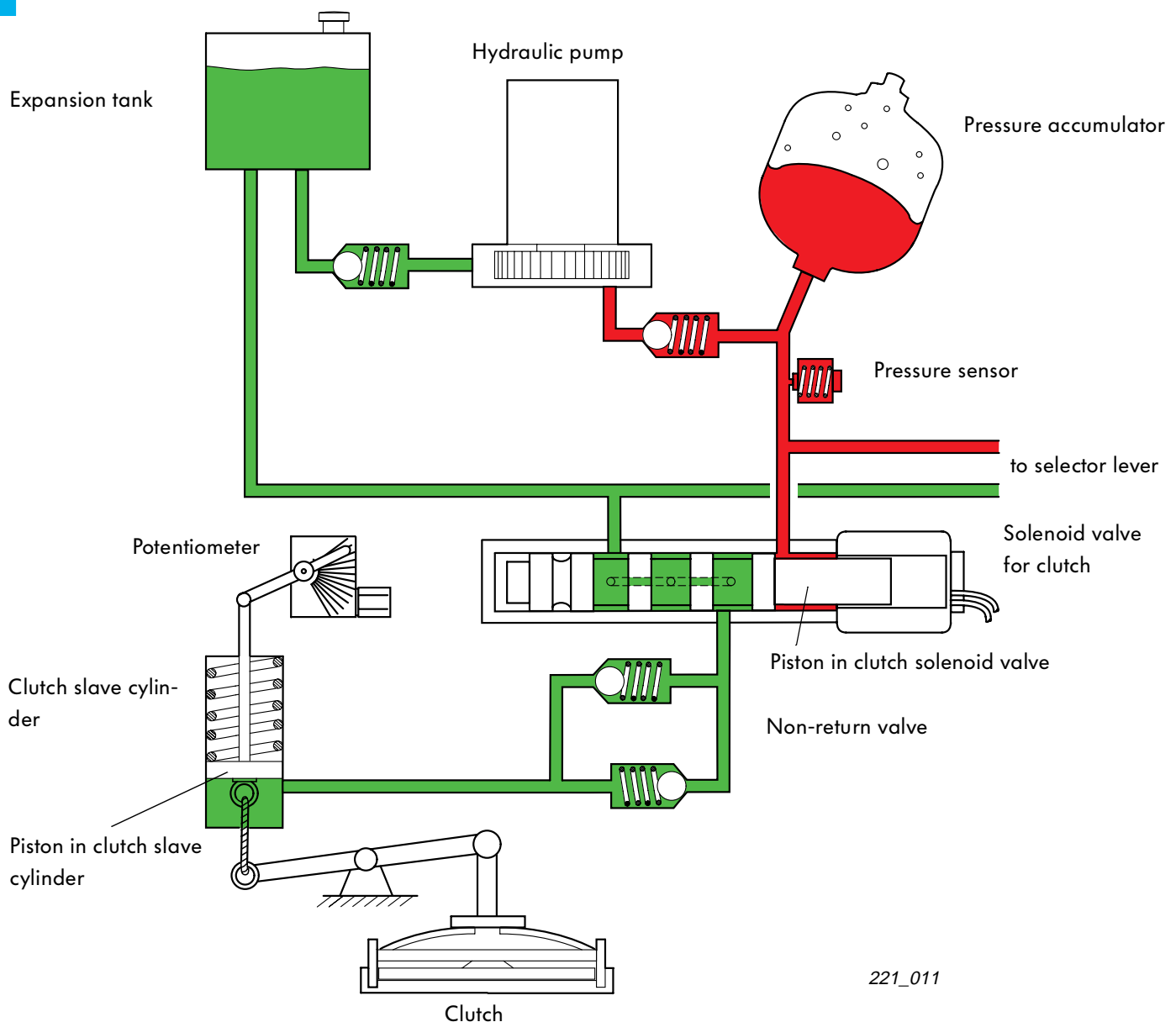
The hydraulic clutch control

During a gear change, the clutch solenoid valve is also activated by the gearbox control unit. The solenoid valve is used to control clutch opening or clutch closing.

Located on the end of the clutch slave cylinder is a potentiometer which enables the control unit to detect the exact position of the clutch slave cylinder and also the position of the clutch.

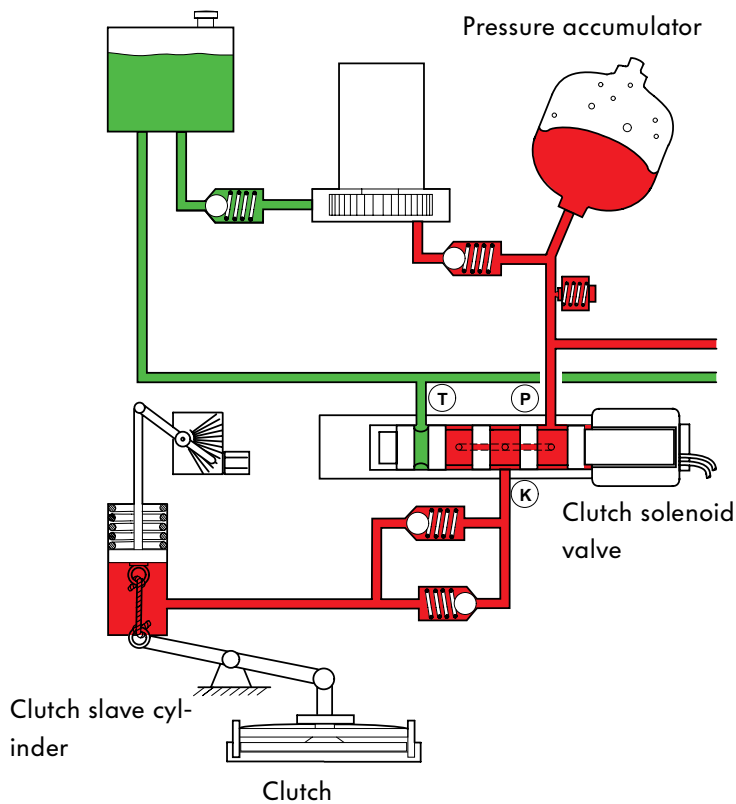


Clutch closed



221_011

Clutch opened



To open the clutch, the piston of the solenoid valve is displaced in such a way that the oil pressure can flow from the pressure accumulator to the clutch slave cylinder.

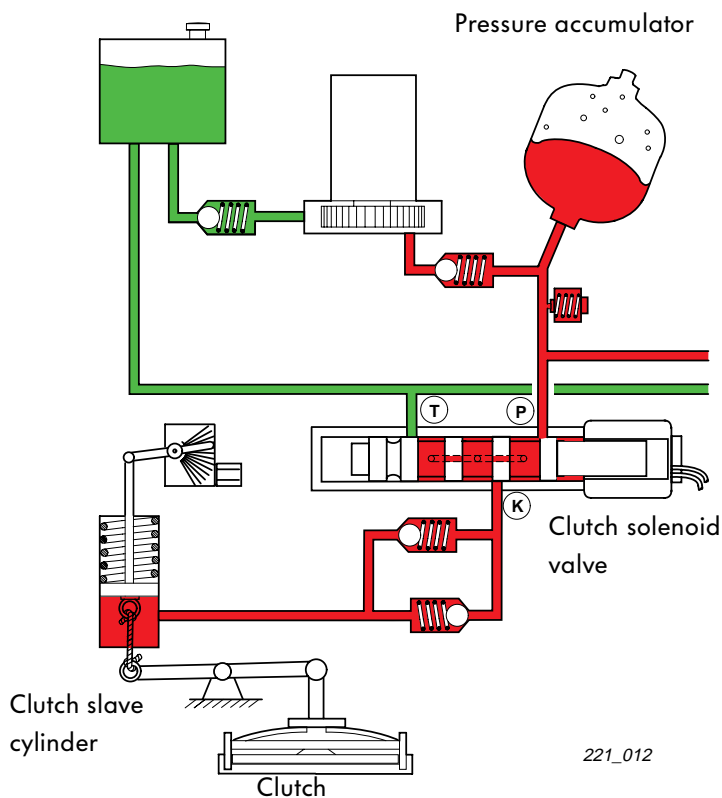
Pressure is applied to the clutch slave cylinder piston; the latter then pulls the clutch lever via a cable.

The clutch is actuated and opens.

The potentiometer registers the position of the clutch and sends a corresponding signal to the control unit.



Clutch 20% opened



The clutch is kept approx. 20% open in order to ensure good response during gear change operations and to reduce transition times.

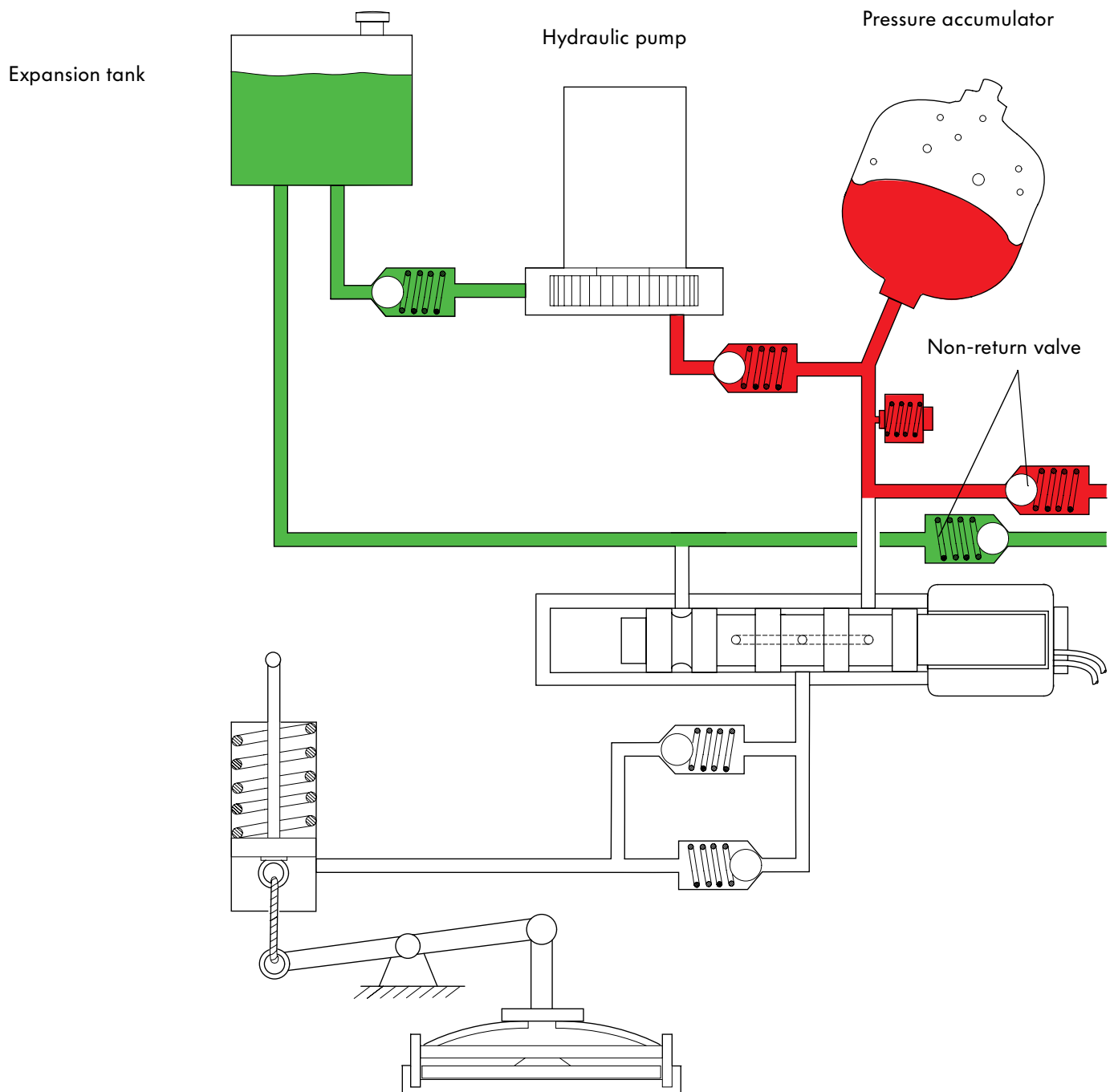
The piston in the solenoid valve maintains a residual pressure of approx. 20% of the maximum pressure in the clutch slave cylinder after the clutch is opened.

The piston is positioned in such a way that it blocks all hydraulic connections.

Hydraulics

Selector gate selection from right to left

Solenoid valves 1 and 2 are activated by the gearbox control unit when a selector gate movement is executed on the gearbox selector shaft.

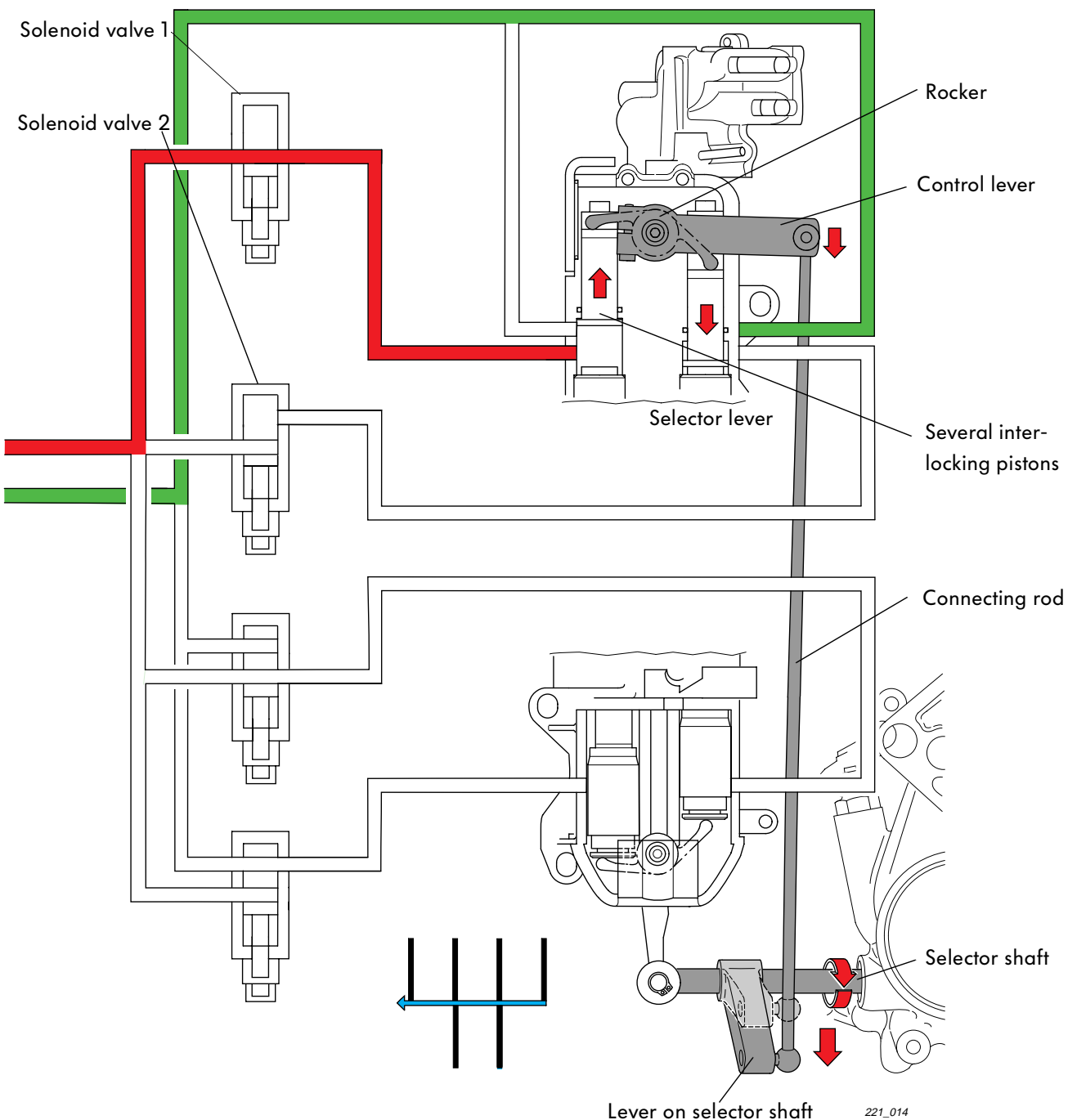


For selector gate movement from right to left, solenoid valve 1 is activated and oil pressure is admitted to the left piston in the selector lever.

The piston moves a rocker to whose arbor the selector gate control lever is attached.

The control lever moves a lever on the selector shaft via a connecting rod. This causes the selector shaft to rotate.

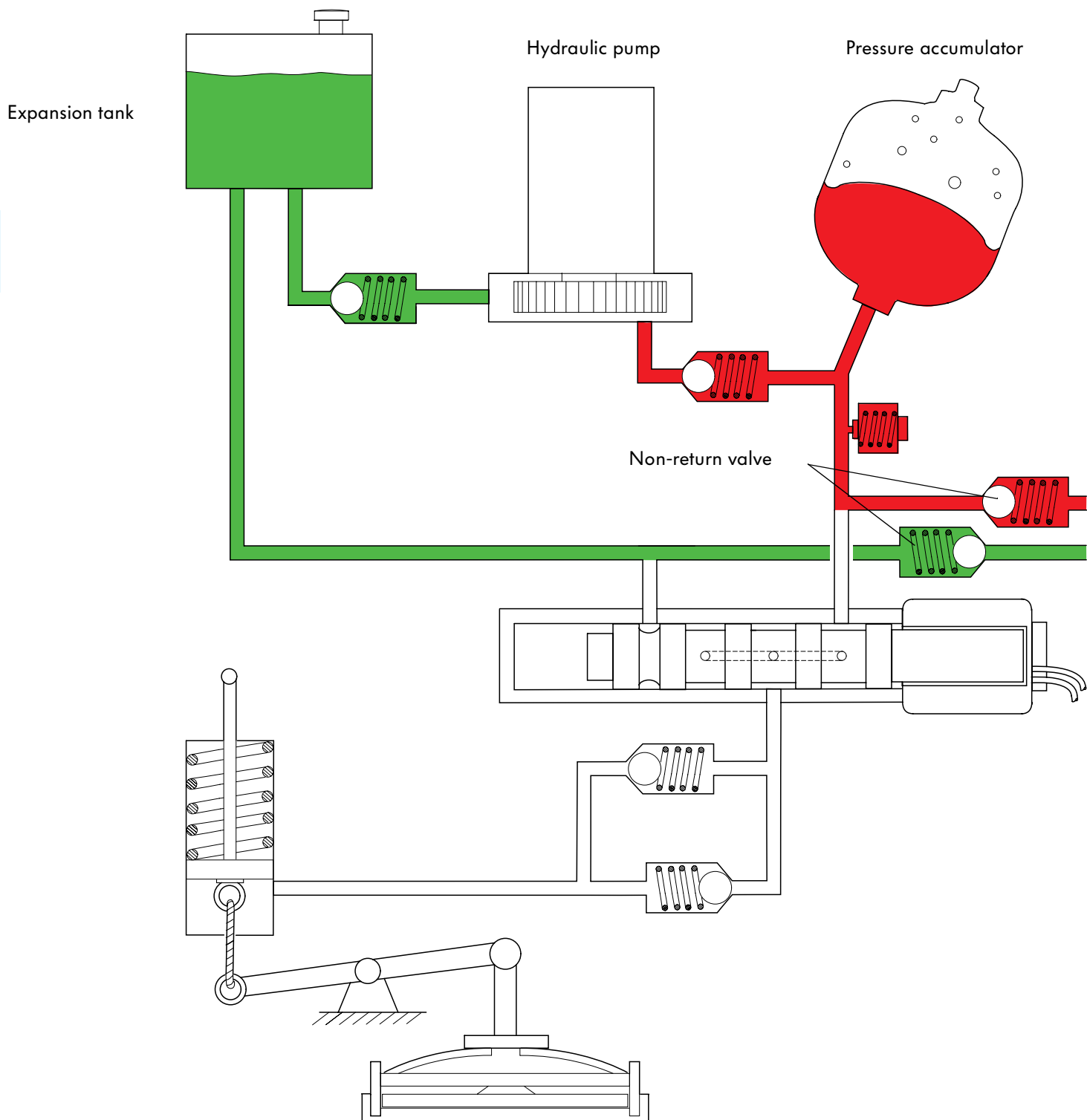
There are several interlocking pistons with different surface areas in the selector lever. They react to the inflowing volume of oil in such a way that the selector shaft can also be rotated into the positions for the 3rd - 4th gear gates or 1st - 2nd gear gates.



Hydraulics

Selector gate selection from left to right

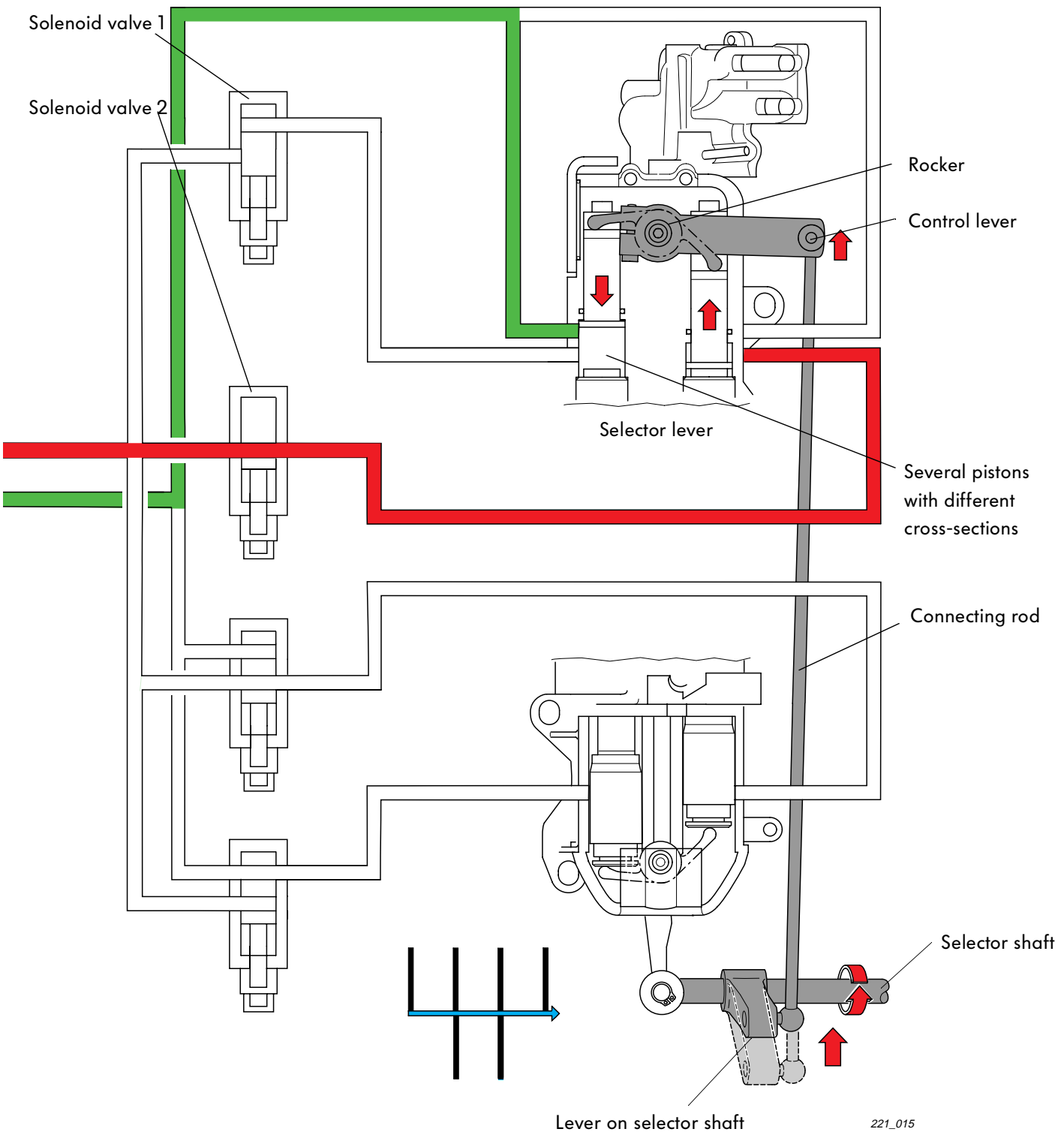
Solenoid valves 1 and 2 are reactivated.



For movement of the selector gate from left to right, solenoid valve 2 is activated and the oil pressure is admitted to the right piston in the selector lever.

The piston moves the lever on the selector shaft by means of the rocker and the connecting rod.

The selector shaft is rotated.

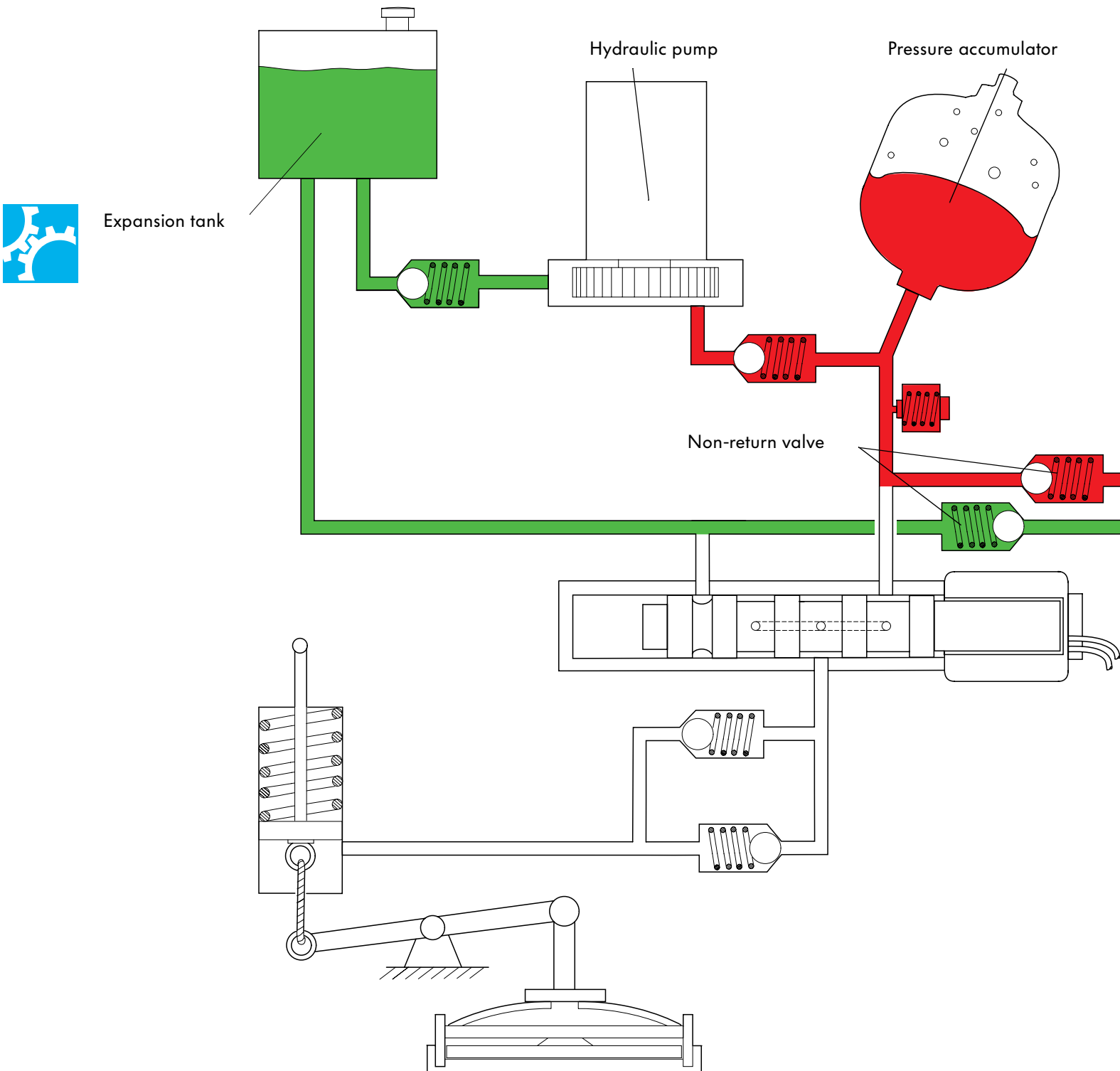


221_015

Hydraulics

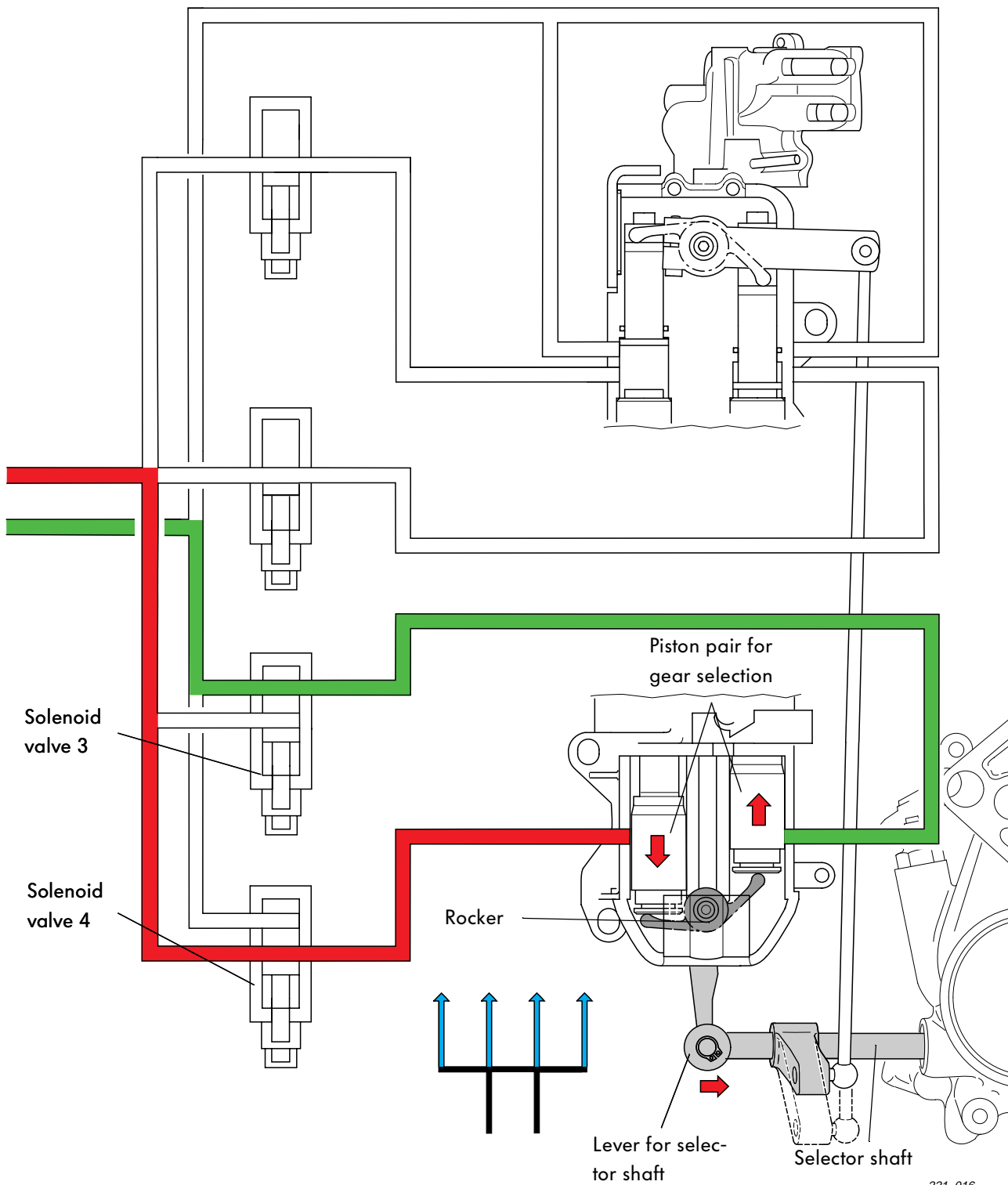
Gear selection

Solenoid valve 3 and 4 are activated by the gearbox control unit when a gear is selected.



To perform an upshift in the direction of travel, solenoid valve 4 is activated. The oil pressure flows to the left piston in the selector lever.

The piston applies pressure to the rocker. The lever for the selector shaft is connected to the rocker. The selector shaft is pushed forward and a gear is selected.



221_016

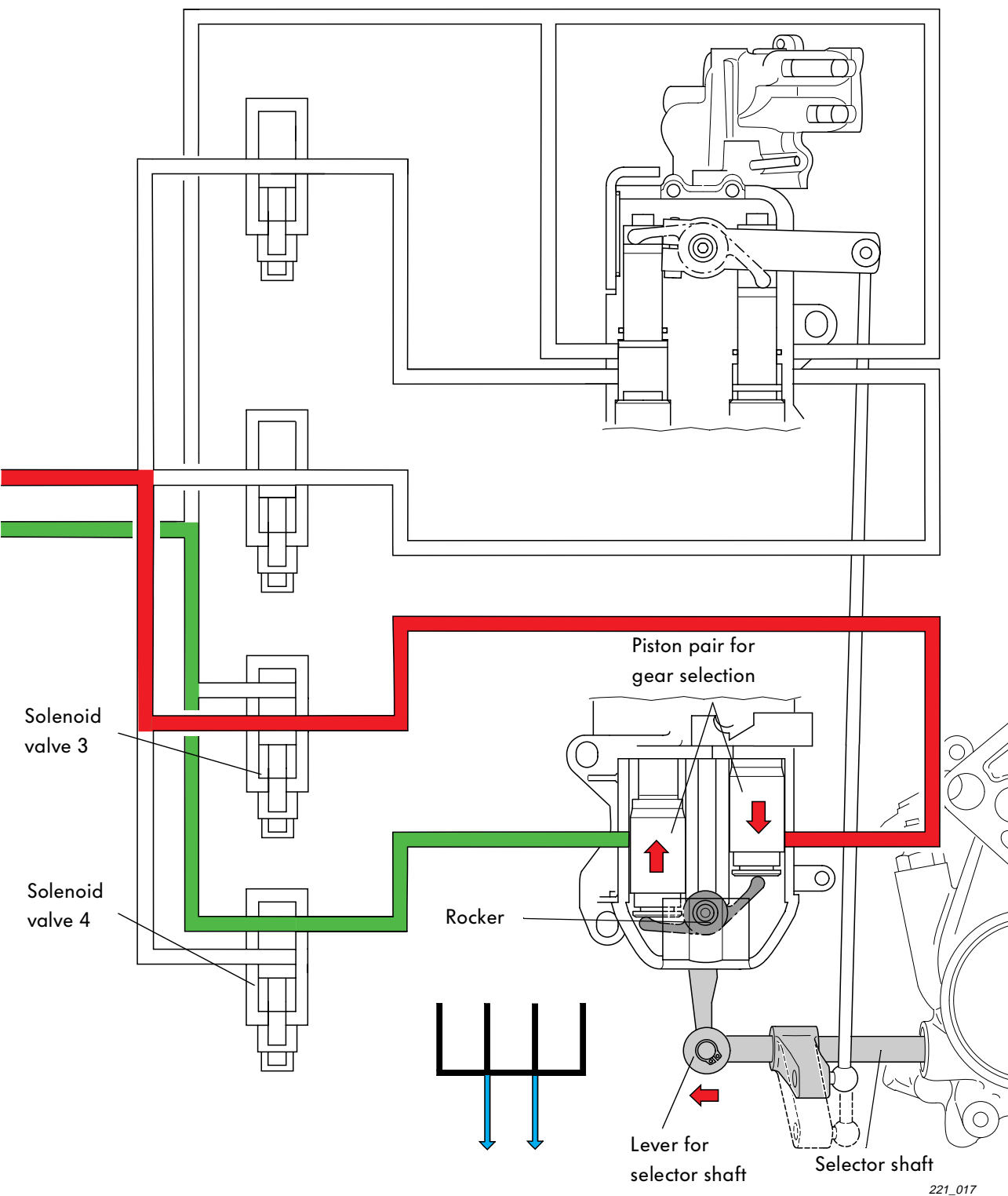
Gear selection

Solenoid valves 3 and 4 are activated by the gearbox control unit when a gear is selected.



To perform a downshift in the direction of travel, solenoid valve 3 is activated. The oil pressure flows to the right piston in the selector lever.

The piston applies pressure to the rocker. The lever for the selector shaft is connected to the rocker. The selector shaft is pulled back and a gear is selected.

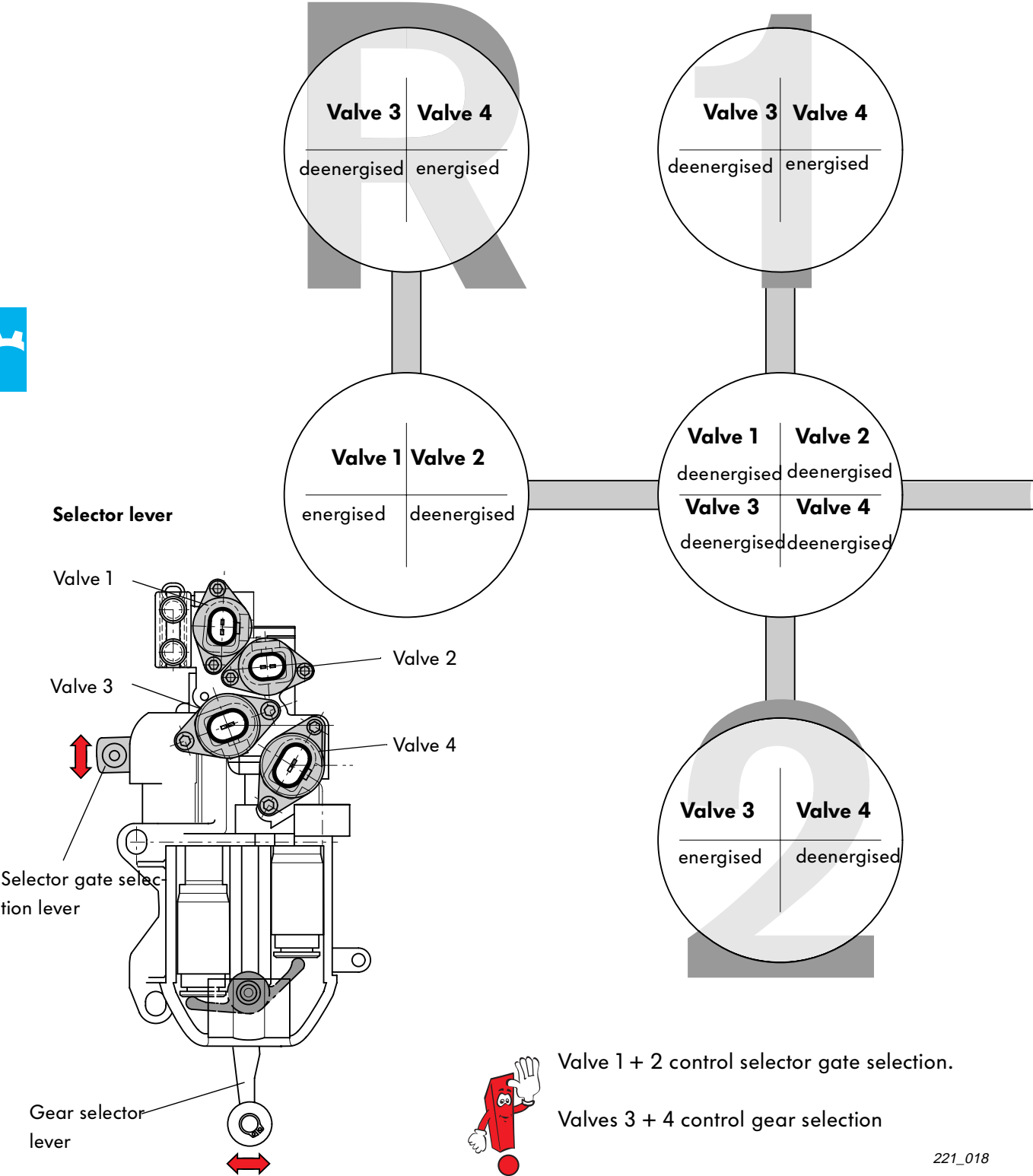


221_017

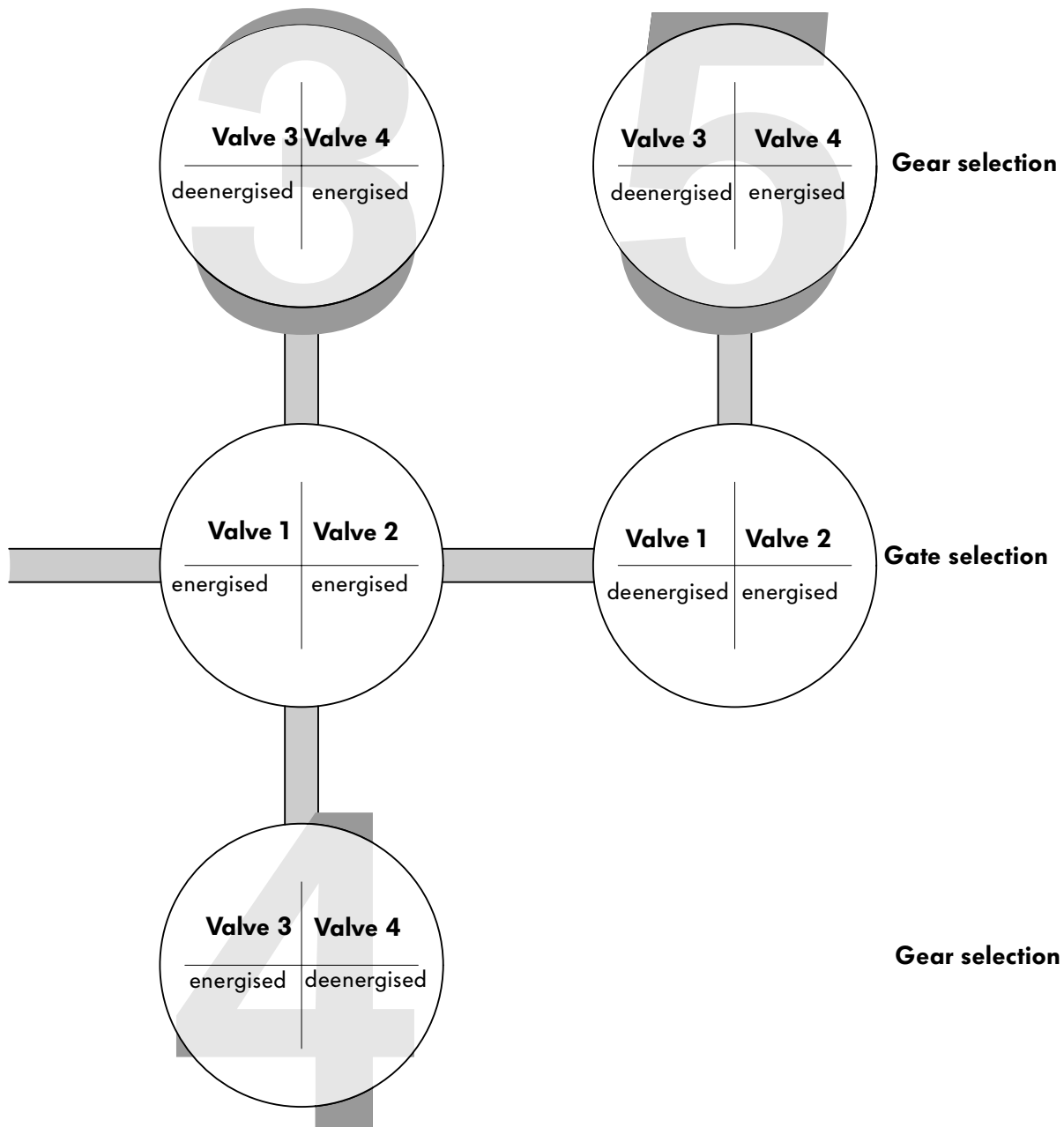


Hydraulics

The pressure control



221_018



All valves are deenergised in the selector gate positions for 1st and 2nd gear.

221_019

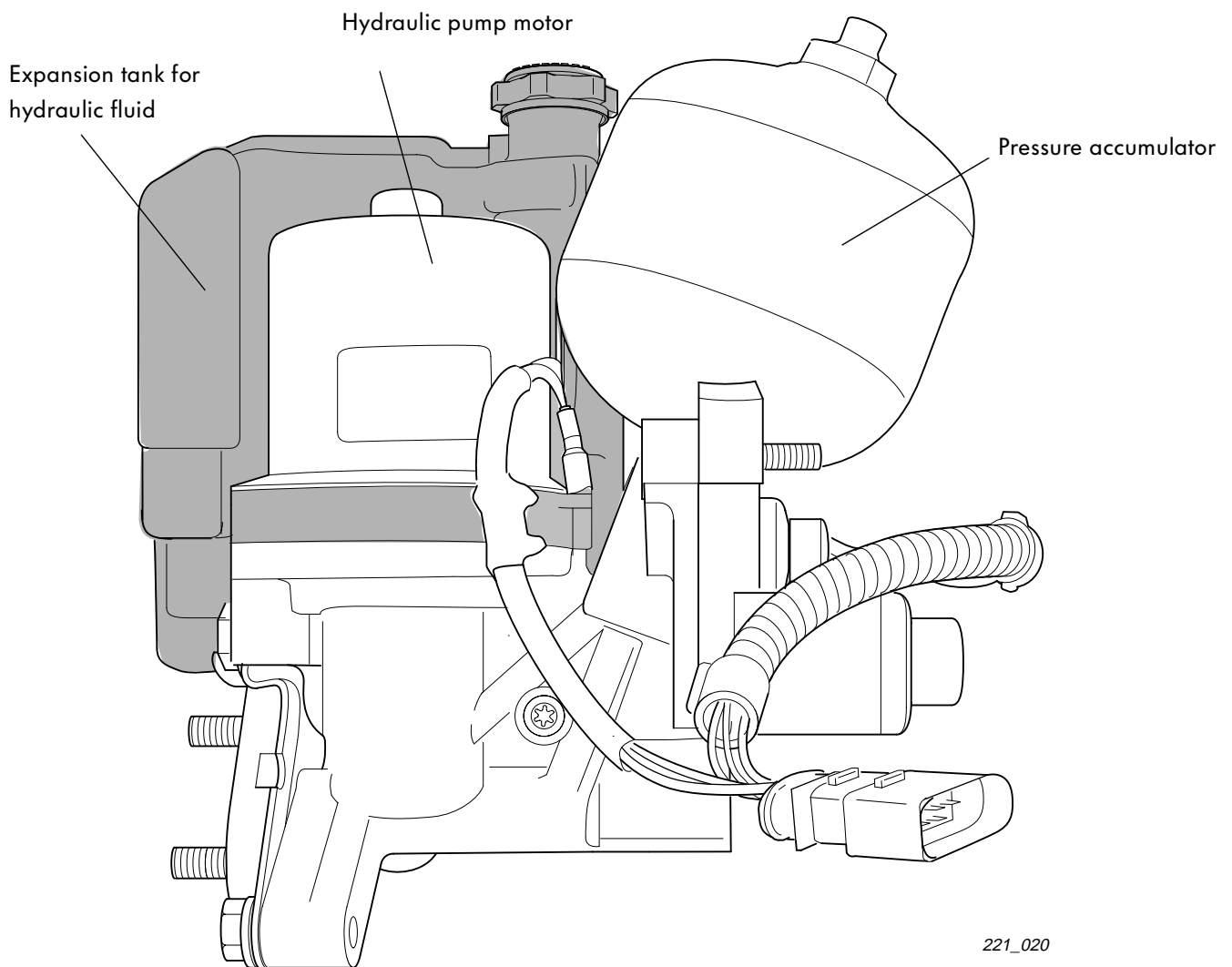
Hydraulics

The hydraulic pump,

together with the pressure accumulator, generates the system pressure of 39 - 55 bar required to actuate the clutch and perform gear changes.

The hydraulic pump is activated when opening the driver's door.

The pressure accumulator holds a certain oil and pressure reserve for quicker response.



221_020

The clutch slave cylinder

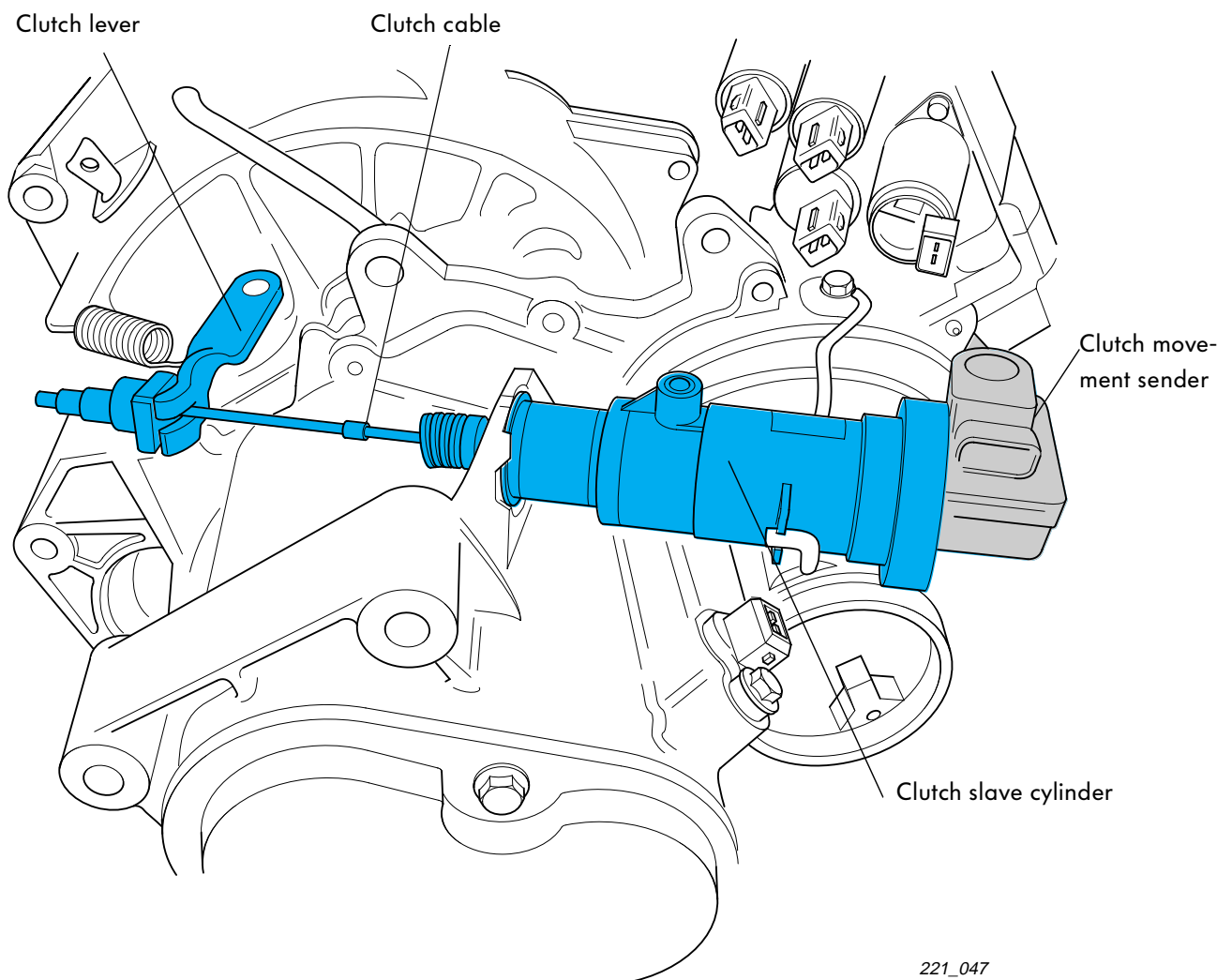
is supplied with oil pressure via a solenoid valve during a clutch engagement operation.

The pressure build-up causes a piston in the clutch slave cylinder to move; the clutch cable is attached to the end of this piston.

The clutch lever is now actuated.

The clutch lever is returned to its initial position by a spring in the clutch slave cylinder or by the clutch plate spring.

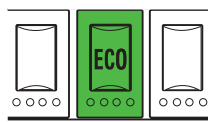
The position of the clutch slave cylinder is registered via the clutch movement sender and signalled to the gearbox control unit.



Electronics

System over- view

Switch for electronic manual gearbox
E262



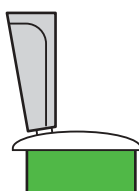
Potentiometer for selector lever for-
wards/reverse G272

Switch for gate recognition, selector
lever F257

Switch for N recognition, selector
lever F258

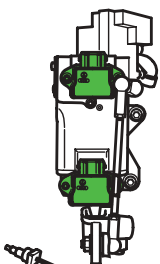
Switch for stop position F259

Switch for E recognition F271

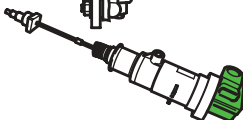


Potentiometer 2 for
gear recognition G240
(gate selection)

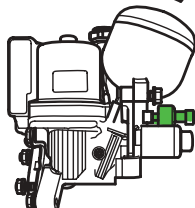
Potentiometer 1 for
gear recognition G239
(gear selection)



Clutch movement sender G162



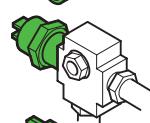
Sender for hydraulic pressure G270



Gearbox speed sender G38



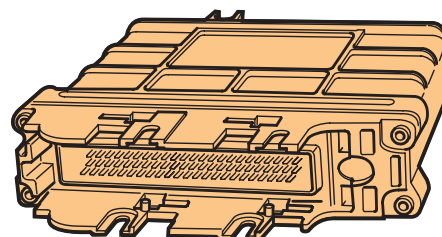
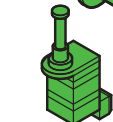
Brake pressure sender F270



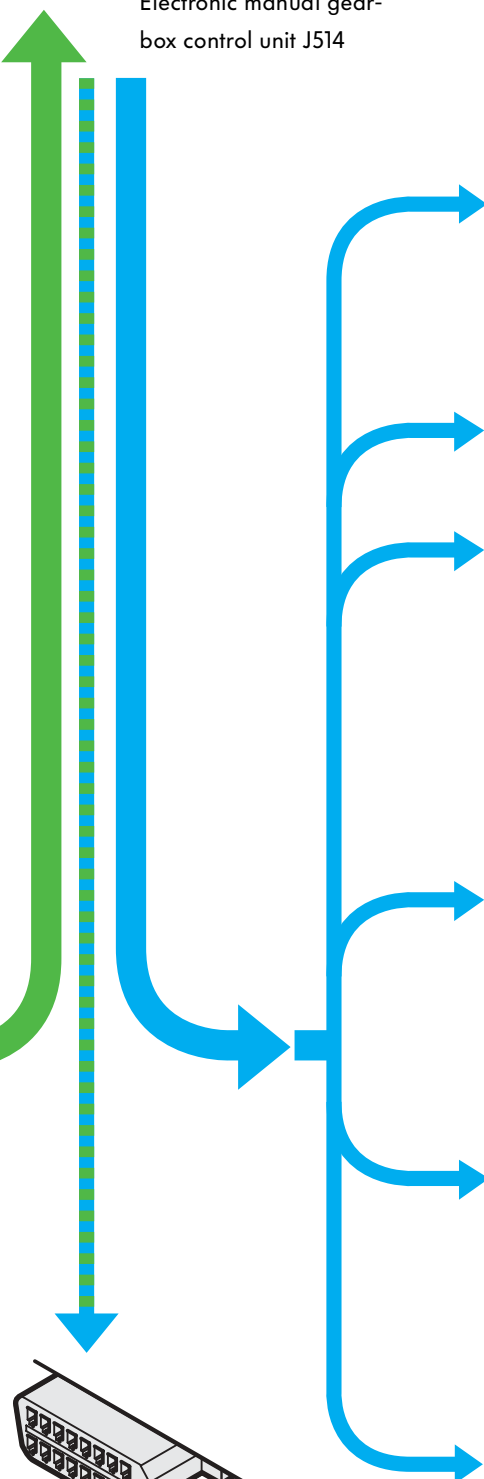
Door contact switch, driver's side F2

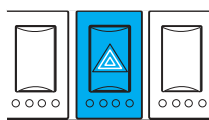


Bonnet switch F207

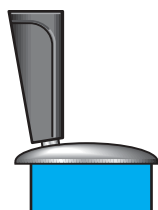


Electronic manual gear-
box control unit J514

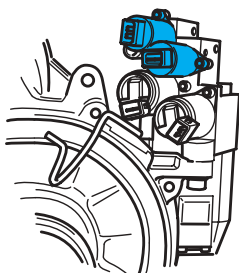




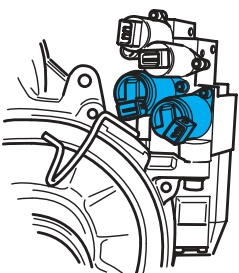
Handbrake warning lamp K14



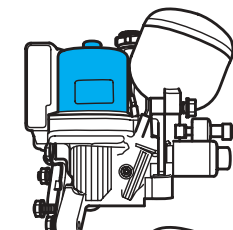
Selector lever lock solenoid N110



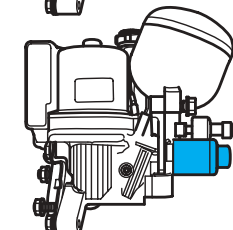
Valves 1 + 2 for selector lever N286, N287
(gate selection)



Valves 3 + 4 for selector lever N284, N285
(gear selection)

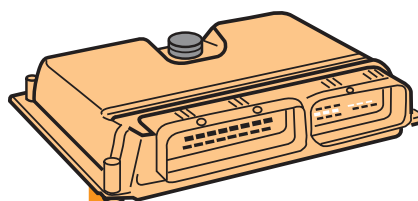


Hydraulic pump



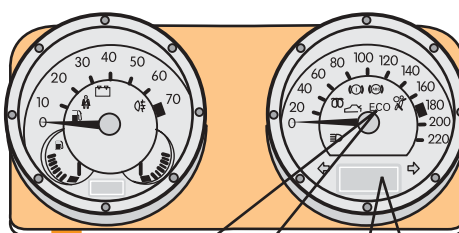
Solenoid valve for clutch slave cylinder N255

Engine control unit



e.g.
coolant temperature signal
accelerator pedal position
signal

Control unit for display unit in dash
panel insert J285



Warning lamp for
Economy mode



Gearshift indica-
tor



ABS control
unit



The sensors

The selector lever

The electronic selector lever offers a choice between automatic gear selection and manual gear selection.

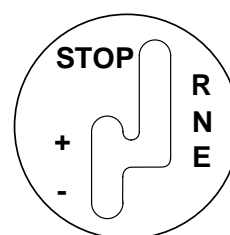
Pushing the the electronic selector lever into the left selector gate allows gear changes to be performed individually like on the tiptronic.

In the right selector gate and in position E, the forward gears are selected automatically depending on engine speed, vehicle road speed, etc.

The movements of the selector lever are registered by 4 micro-switches and a potentiometer, and are signalled to the control unit.

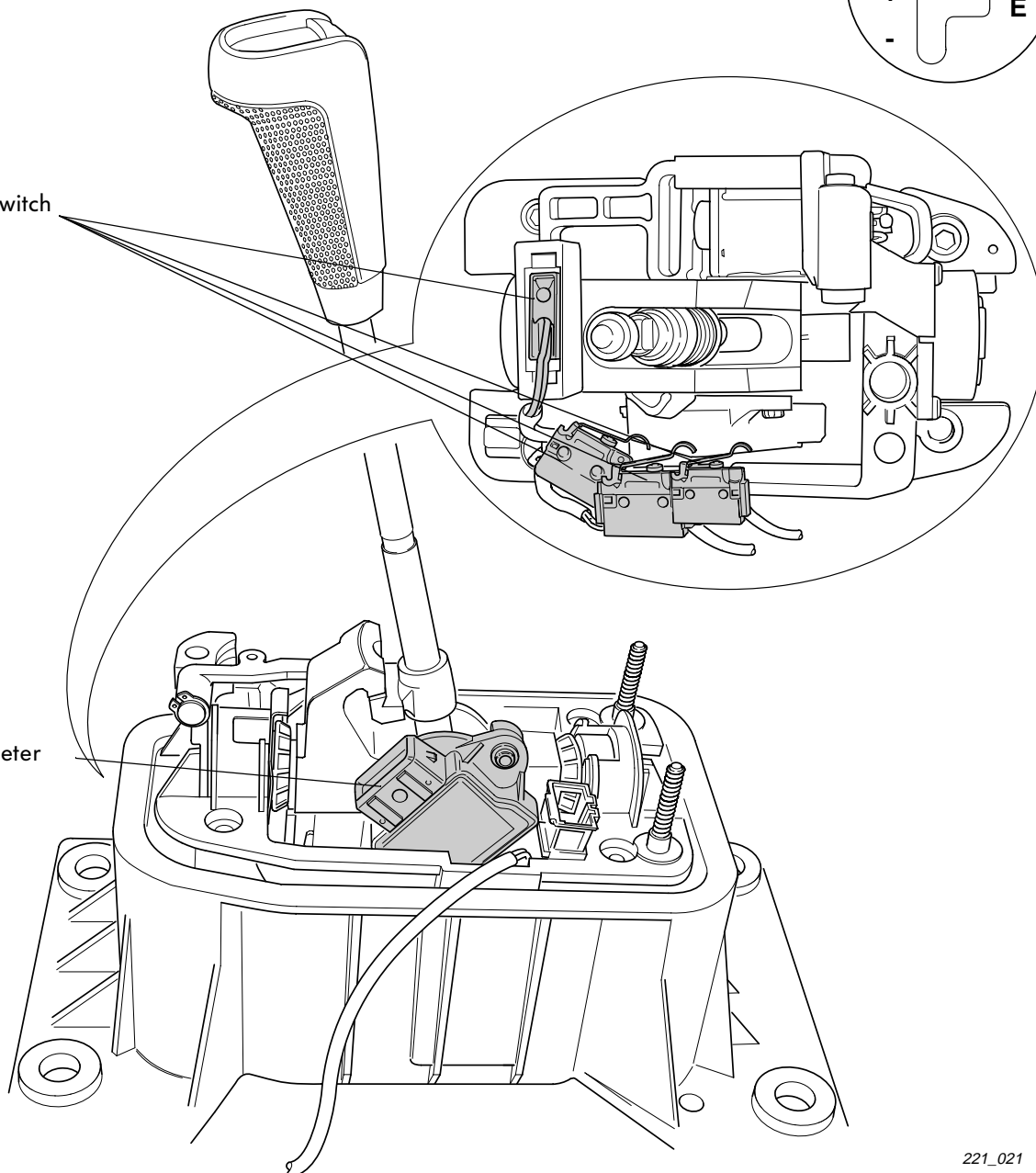
+ = Upshifts

- = Downshifts



Micro-switch

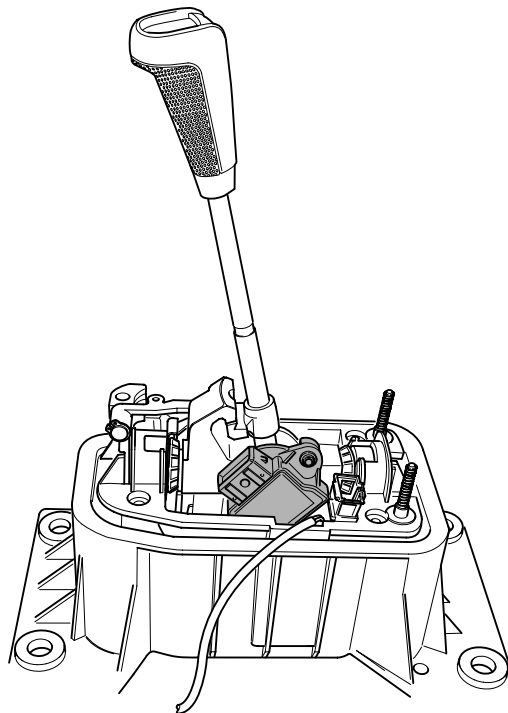
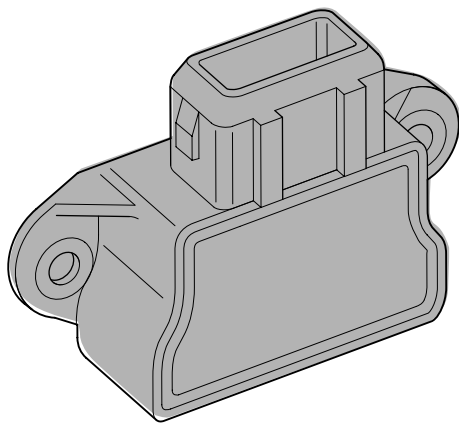
Potentiometer



221_021

The potentiometer for selector lever forwards/reverse -G272-

is located on the rotational axis for the backwards and forwards movements of the selector lever.



221_022



Function

The potentiometer registers the exact position during the reverse and forward movements of the selector lever.

It also sends the tip signals in the tiptronic gate to the control unit.

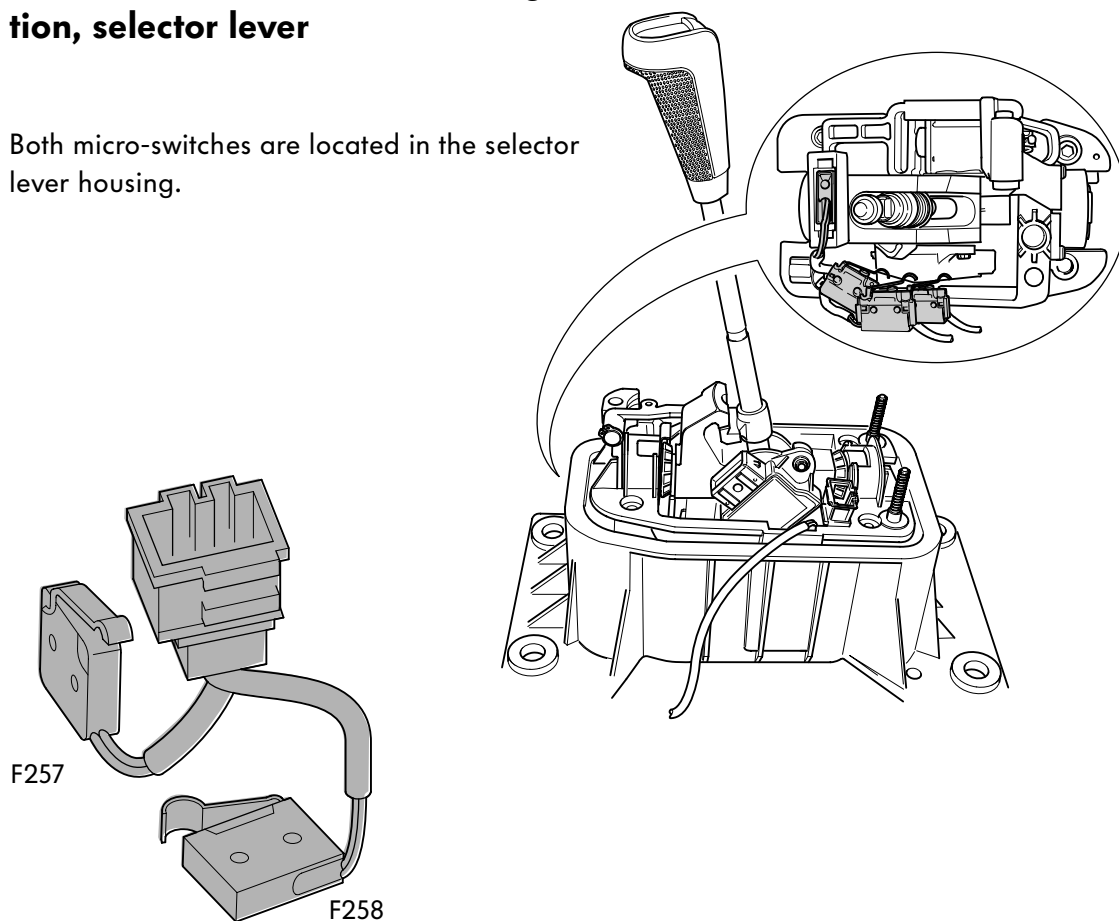
Signal utilisation

For determining the exact position of the selector lever during the reverse and forward movements.

**Micro-switch -F257- for gate recog-
nition, selector lever**

**Micro-switch -F258- for N recogni-
tion, selector lever**

Both micro-switches are located in the selector lever housing.



Function

Both micro-switches are actuated mechanically by the selector lever in the corresponding positions.

Signal utilisation

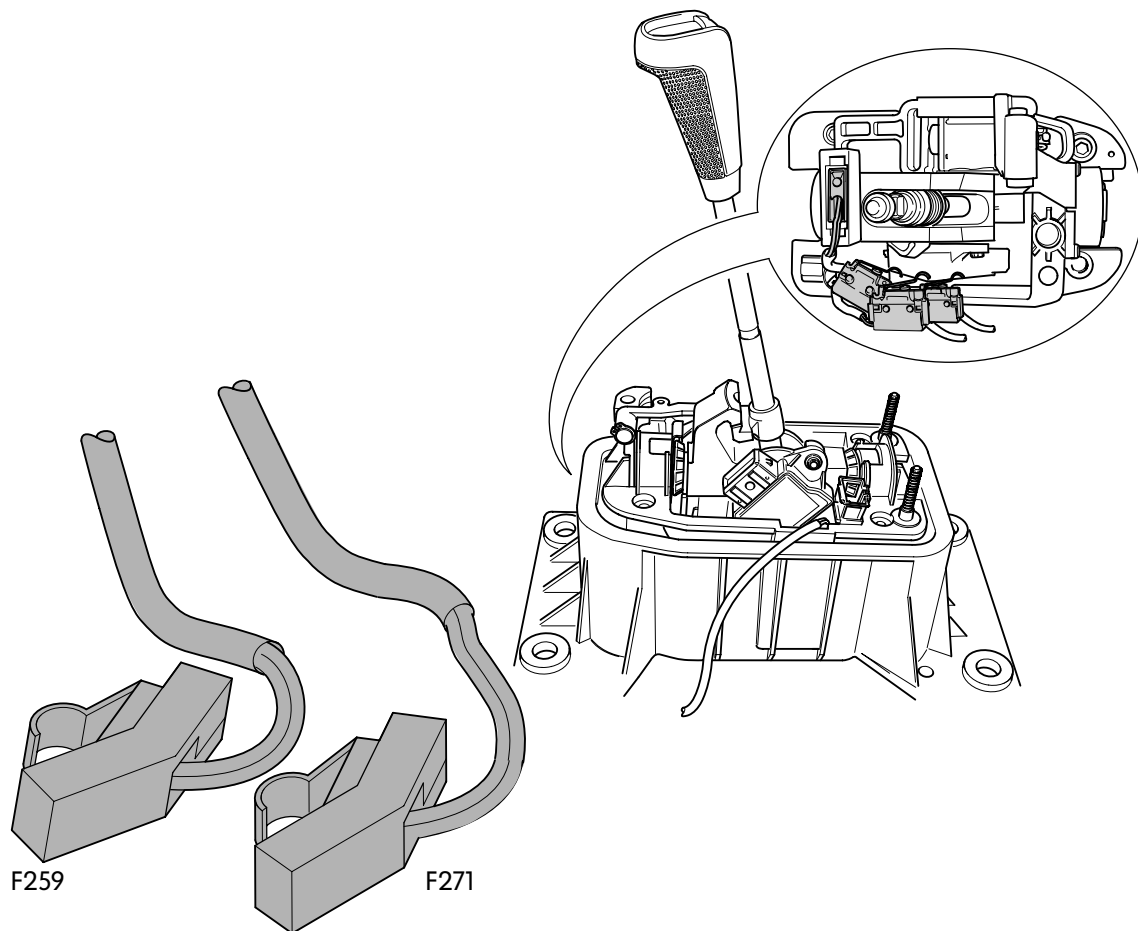
Micro-switch -F257- for gate recognition in the selector lever housing informs the gearbox control unit about whether the selector lever is located in the tiptronic gate.

Micro-switch -F258- for N recognition informs gearbox control unit -J514- about whether the selector lever is in the neutral position.

221_023

Micro-switch -F259- for stop recognition Micro-switch -F271- for E recognition

Both micro-switches are located in the housing of the selector lever.



Function

Both micro-switches are actuated mechanically by the selector lever in the corresponding positions.

Signal utilisation

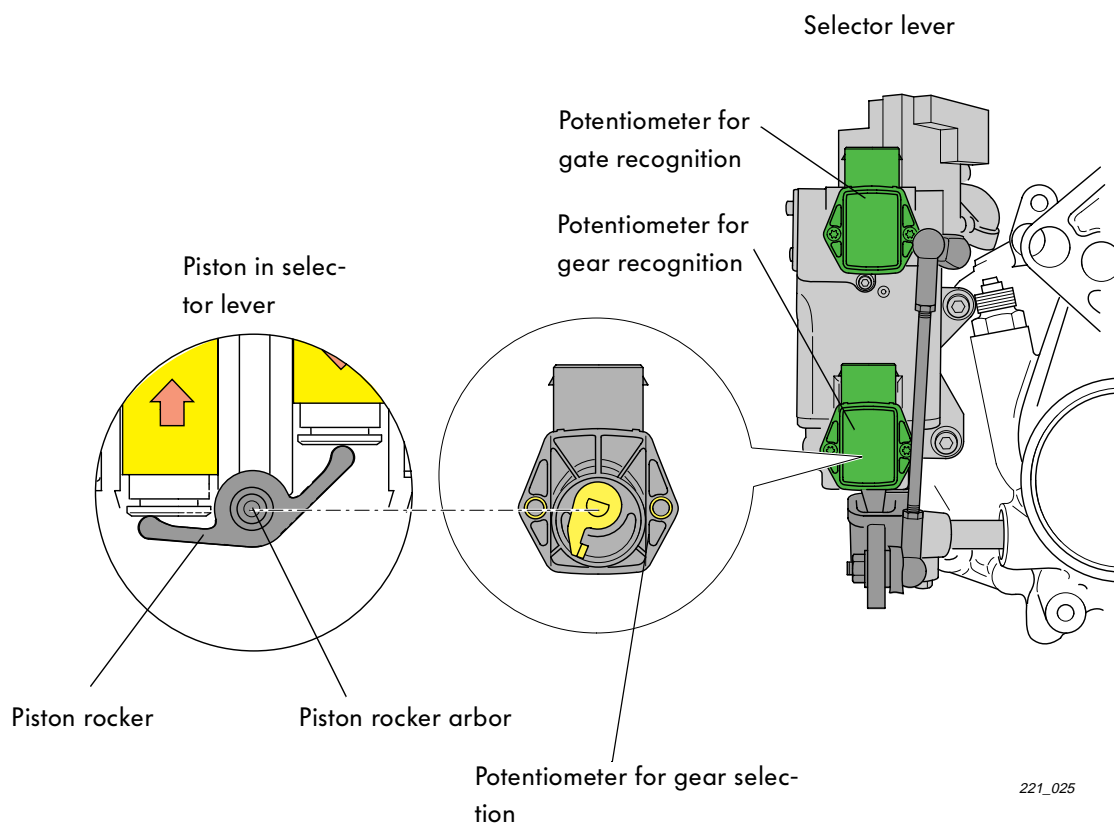
Micro-switch -F259- for stop recognition and micro-switch -F271- for E recognition inform gearbox control unit -J514- about whether the selector lever is in the stop position or E position.

221_024



Potentiometer -G240- for gate recognition and potentiometer -G239- for gear recognition

The potentiometers are located on the selector lever and are actuated by the piston rocker lever and are actuated by the piston rocker arbor.

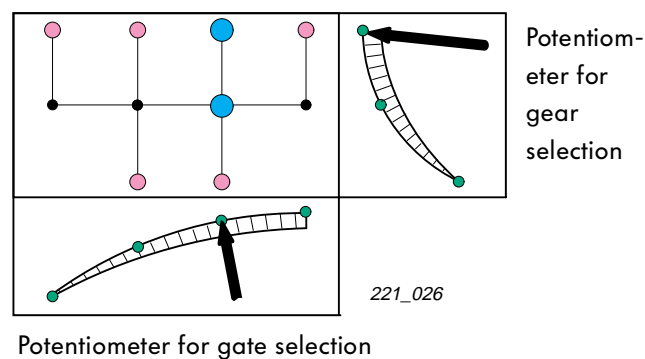


Design and function

Potentiometer -G239- for gear recognition registers backward and forwards movement of the selector shaft.

Potentiometer -G240- for gate recognition registers the individual positions during the gate movement of the selector shaft.

Example for 3rd gear



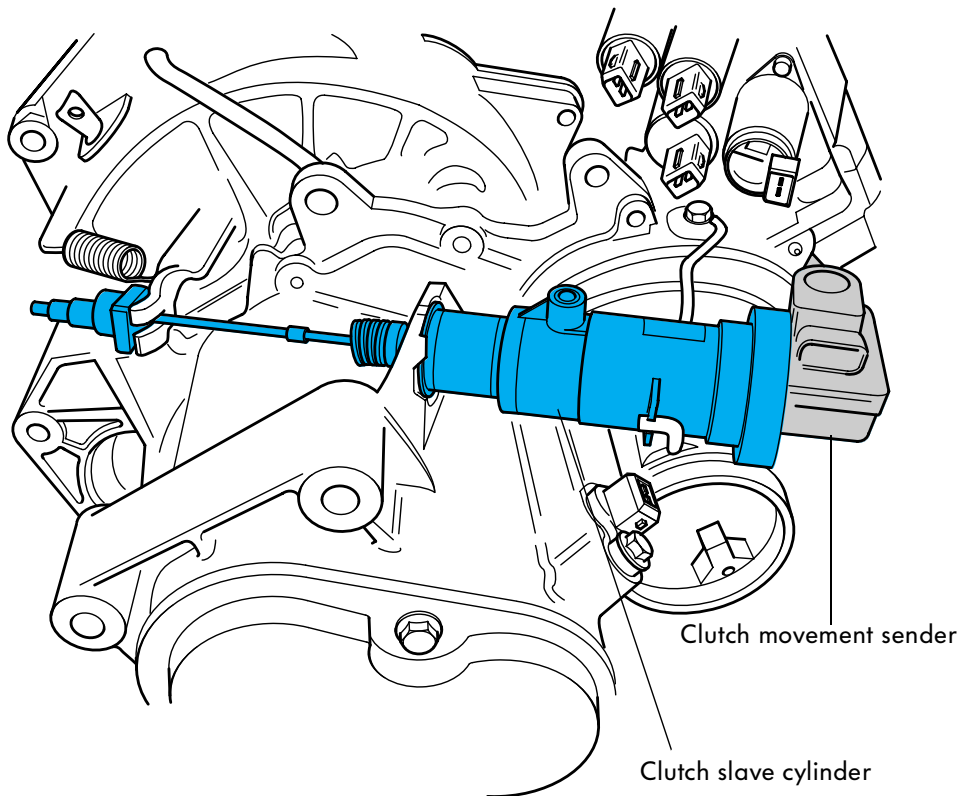
Both potentiometers send the registered positions to gearbox control unit -J514-.

Clutch movement sender -G162-

The clutch movement sender is located on the clutch slave cylinder.

Design and function

The position of the clutch is registered via the senders and signalled to the gearbox control unit.



221_27

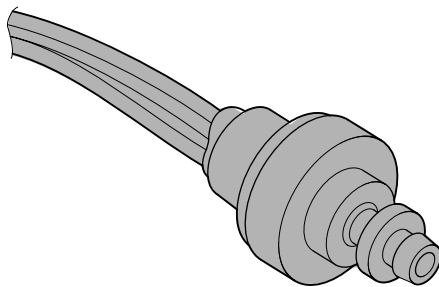


The clutch limit positions are measured and registered at regular intervals. This enables the system to allow for clutch wear.



Sender -G270- for hydraulic pressure

The sender for hydraulic pressure is located on the hydraulic unit.



221_028

Function

The sender for hydraulic pressure measures the pressure produced in the system by the hydraulic pump.

Signal utilisation

The shift points are at 39 and 55 bar.

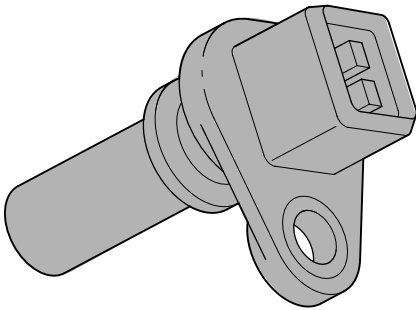
If the measured pressure is less than 39 bar, the hydraulic pump will start.

When the shut-off pressure of 55 bar is reached, the pump is again switched off.



Gearbox speed sender -G38-

The gearbox speed sender is located on the gearbox housing.



221_029

Design and function

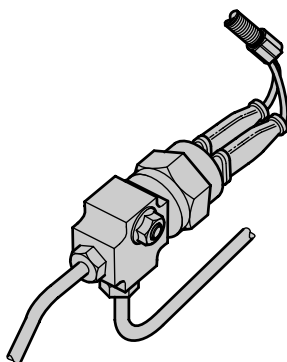
The gearbox speed sender measures the rotational speed of the gearbox input shaft.

Using this Information and the road speed signal, the gearbox control unit can determine what gear is selected and the extent of clutch slip.



Brake pressure sender -G270-

The brake pressure sender is located on the engine bulkhead in the engine compartment on the right.



221_030

Design and function

The excess pressure in the brake pipe is measured.

The response pressure lies between 4 and 6 bar.

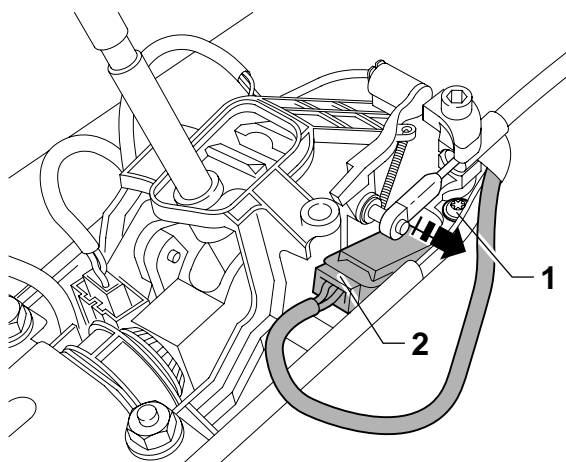
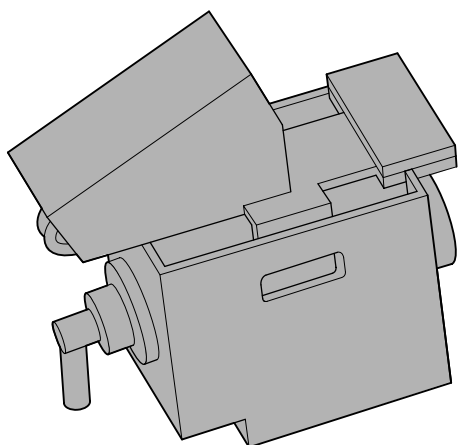
The gearbox control unit recognises from this pressure reading how heavily the vehicle is being braked.

Signal utilisation

If the brake pressure is in excess of 4 - 6 bar in ECO mode, the engine is, for example, shut off via the stop/start function after 3 s braking time and after the vehicle comes to a standstill.

Selector lever lock solenoid -N110-

The selector lever lock solenoid is located on the selector lever.



221_031

Design and function

The selector lever lock solenoid locks the selector lever in the STOP position when the ignition is switched on.

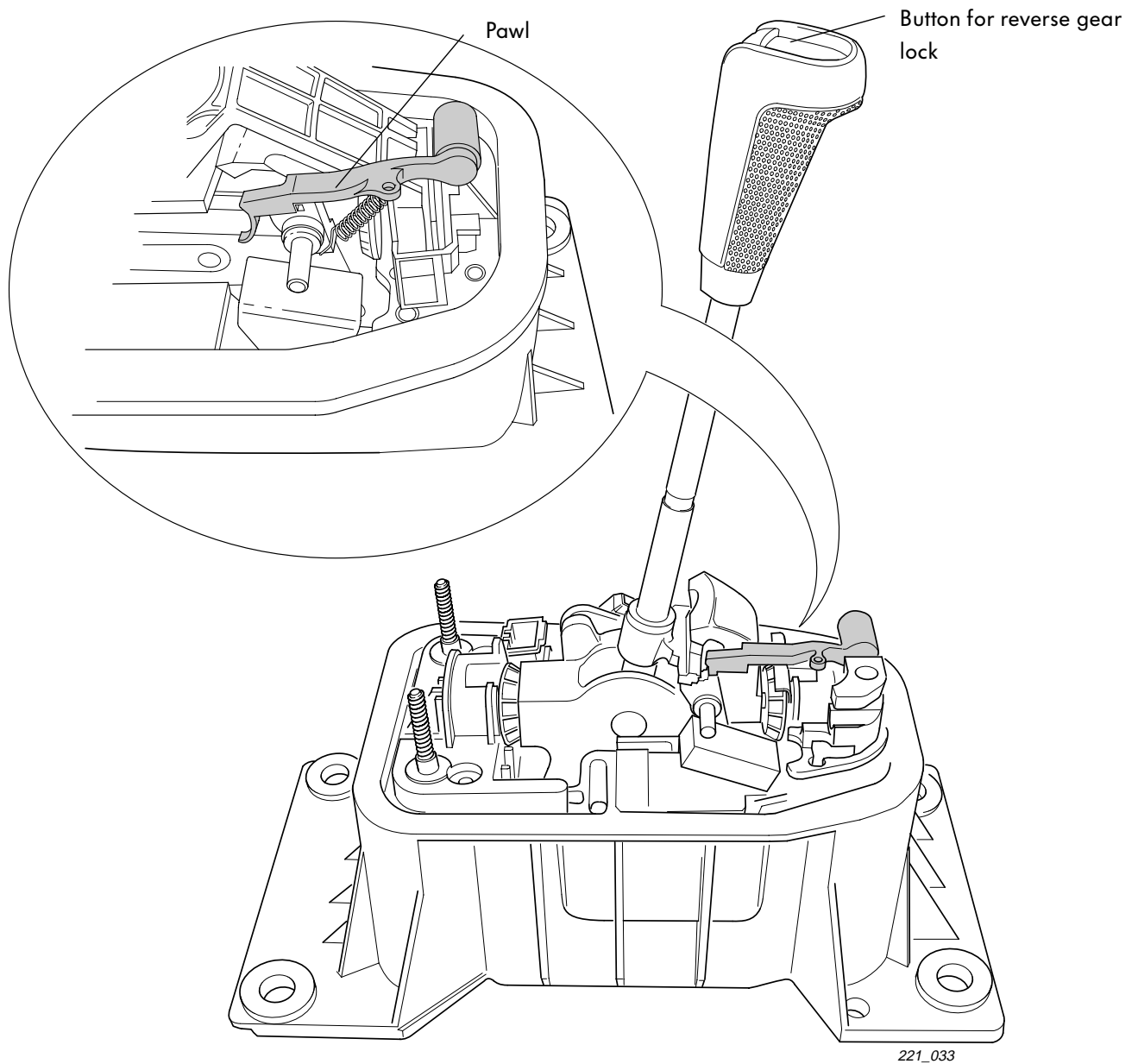
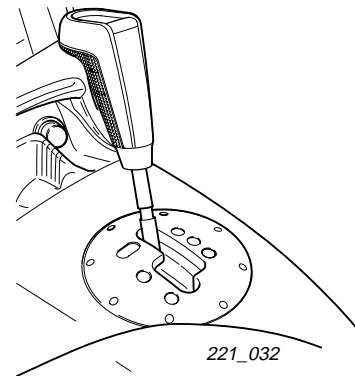
The selector lever cannot be moved out of this position until the brake pedal is pressed.

Electronics

Reverse gear

To engage reverse gear, a mechanical lock (pawl) must be released.

To do this, the button on the selector lever must be pressed.



Valves -N286- and -N287- for the selector gate selection

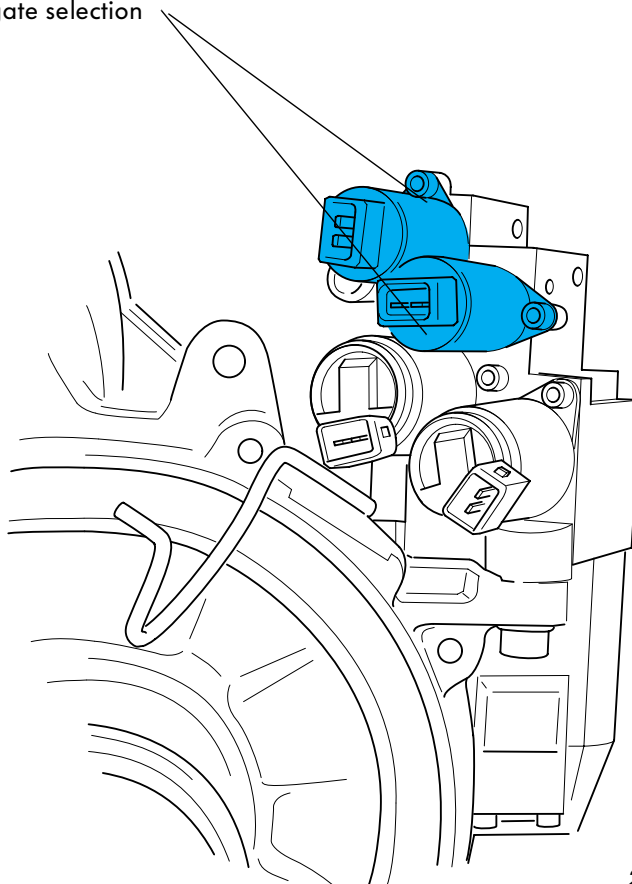
The valves for the selector gate selection are located on the selector lever.

Design and function

The valves are actuated by the gearbox control unit and control the selector gate positions in relation to the individual gears.

These valves are control valves, i.e. only two switched positions are possible: depressurised or pressurised.

Valve for selector gate selection



221_034



Valves -N284- and -N285- for gear selection

The valves for gear selection are located on the selector lever.

Design and function

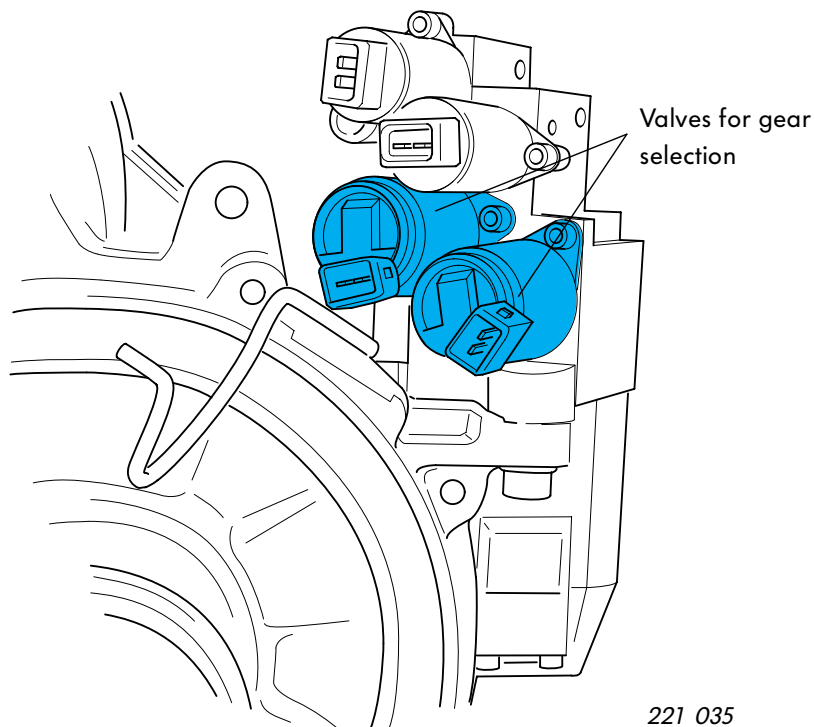
The valves are actuated by the gearbox control unit after the selector shaft has reached the correct position in the selector gate and when a gear needs to be selected.

Each valve is responsible for a gear change direction.

These valves are control valves, i.e. the pressure is regulated depending on the applied current.



This is a requirement for synchronising the gears during the gear change operation.



221_035

The electric motor for the hydraulic pump,

together with the pressure accumulator, the hydraulic fluid reservoir, the clutch solenoid valve and the pressure sensor, make up a hydraulic unit.

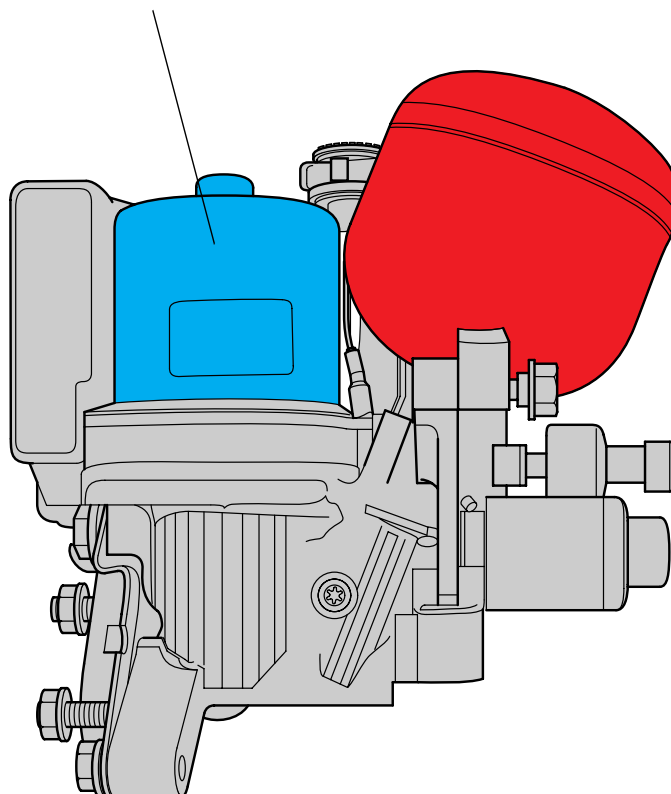
Design and function

When opening the driver's door or in the event of a pressure drop, the electric motor for the hydraulic pump runs until the shut-off pressure is reached, and then it is switched off again.



In the event of a defect, e.g. in the pressure sensor, the electric motor runs on for up to 5 minutes.

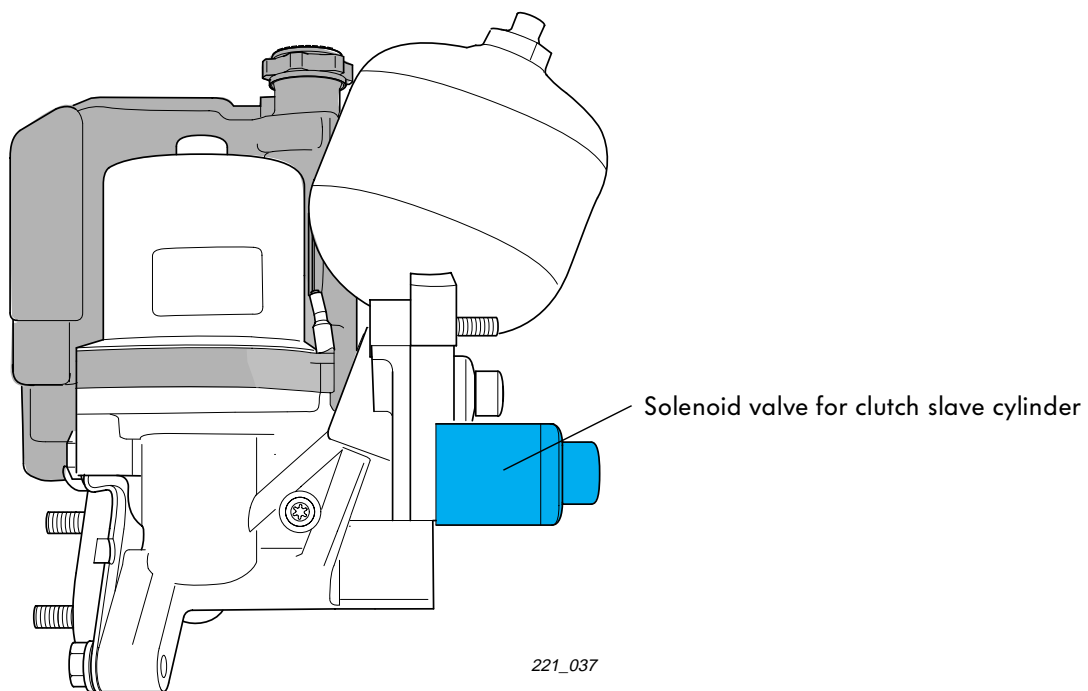
Motor for hydraulic pump



221_036

The solenoid valve for clutch slave cylinder -N255-

is attached to the hydraulic unit.



Design and function

The solenoid valve for the clutch slave cylinder is activated when the clutch is to be opened, closed or partially opened.



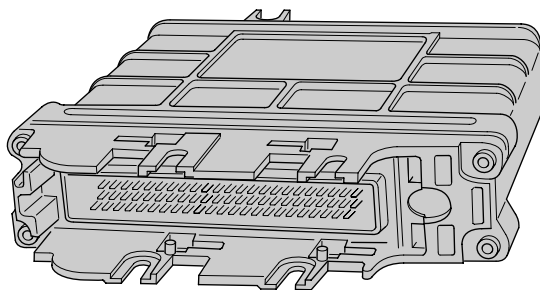
The gearbox control unit

is connected to the control units for

- diesel direct injection
 - ABS
 - dash panel insert
- via the CAN databus.

The control units interchange information via the CAN databus. This way it is possible for several control units to process the information from a sensor and activate their actuators accordingly.

The gearbox control unit controls the shift operations in dependence on the data acquired, e.g. engine speed, speed, engine load, brake actuation, etc.



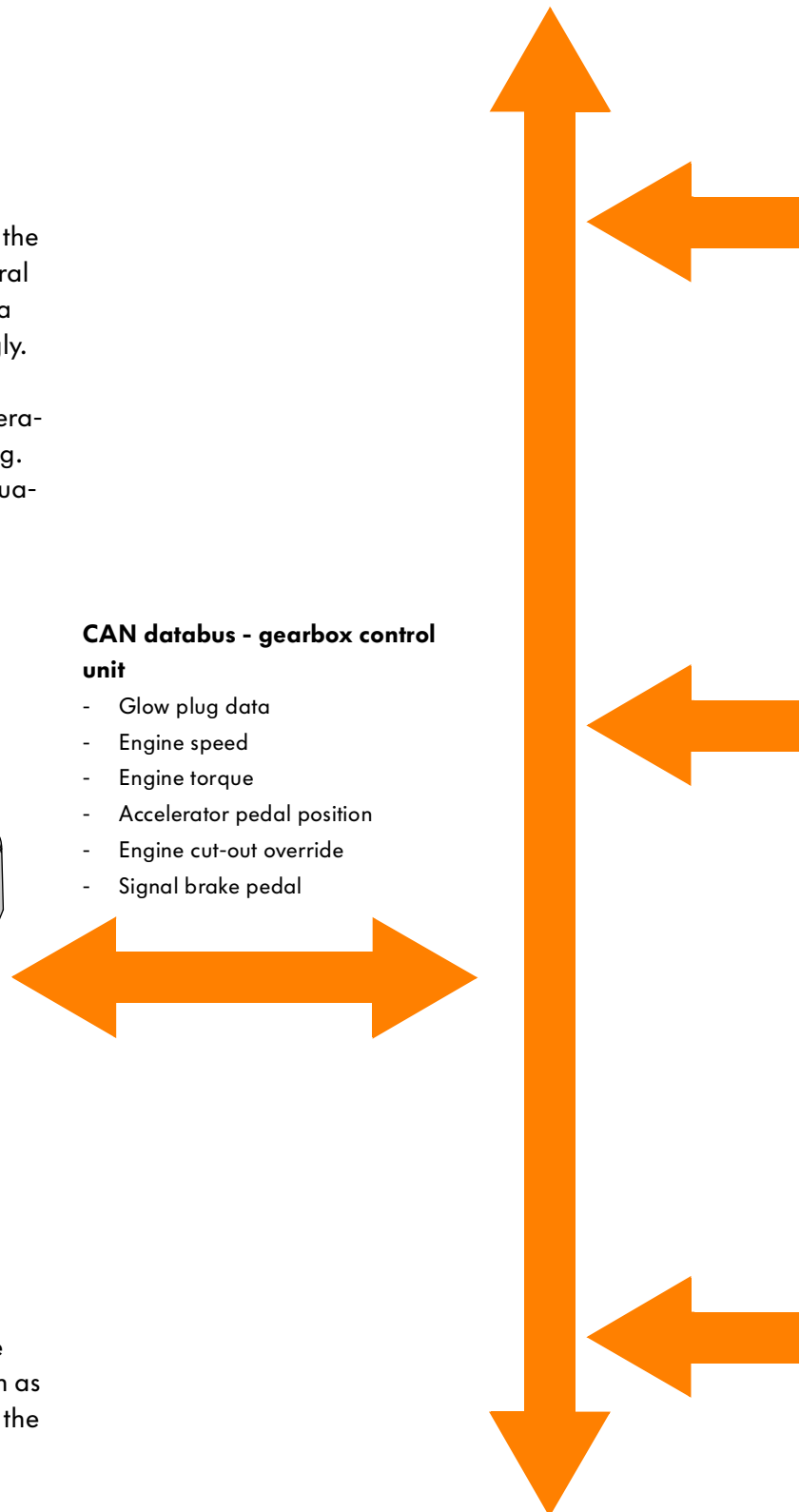
221_038

CAN databus - gearbox control unit

- Glow plug data
- Engine speed
- Engine torque
- Accelerator pedal position
- Engine cut-out override
- Signal brake pedal

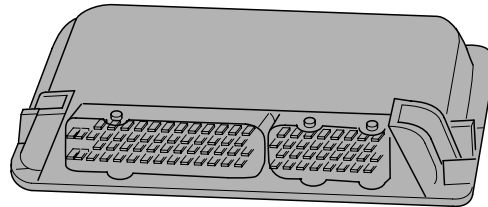


The gearbox control unit informs the engine control unit about events such as a reduction in engine torque during the clutch engagement/disengagement operation.



CAN databus - engine control unit

- Engine torque control
- Engine shut-off
- Accelerator pedal position

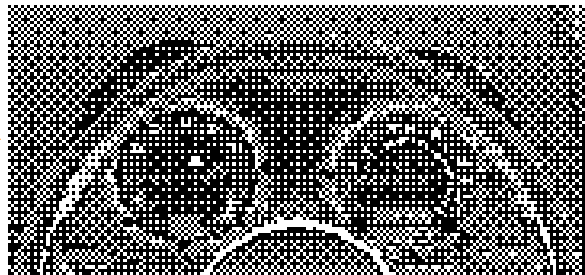


221_039

Diesel direct injection
system control unit

CAN databus control unit for display unit in dash panel insert

- Signal from switch for electronic manual gearbox
- Display of ECO mode, consumption, shift indicator, etc.



Control unit with display unit in dash panel insert



CAN databus ABS control unit

- Signal wheel speed sensor



221_041

ABS control unit



CAN means:
Controller Area Network
(control unit network)

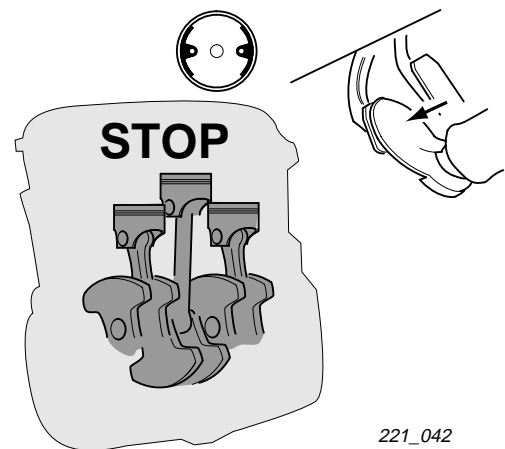
The stop/start function



In Economy mode, the 3L Lupo has a stop/start function which eliminates fuel wastage. When the vehicle is stationary, the engine is shut off if the foot brake is pressed and held down for longer than 3 s.

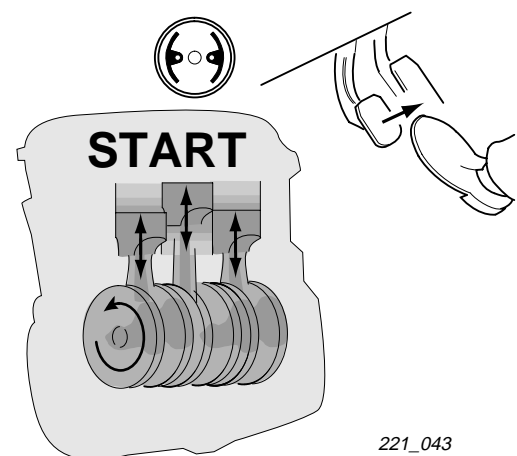
The conditions for automatic shut-off of the engine are:

- Selector lever is in position E
- ECO mode is active
- Brake is held down for 3 s.
- Brake pressure above 4-6 bar
- ABS wheel speed sensors indicate that vehicle is stationary
- Coolant temperature is above 17°C
- Intake air temperature is above 0°C
- Alternator load factor below 55%



The conditions for resumption of vehicle operation are:

- The driver releases the brake pedal
- The gearbox control unit starts the engine
- The gearbox control unit switches the starter off as soon as the engine begins to run
- The gearbox control unit activates the clutch and engages first gear
- The driver presses the accelerator pedal and the vehicle accelerates



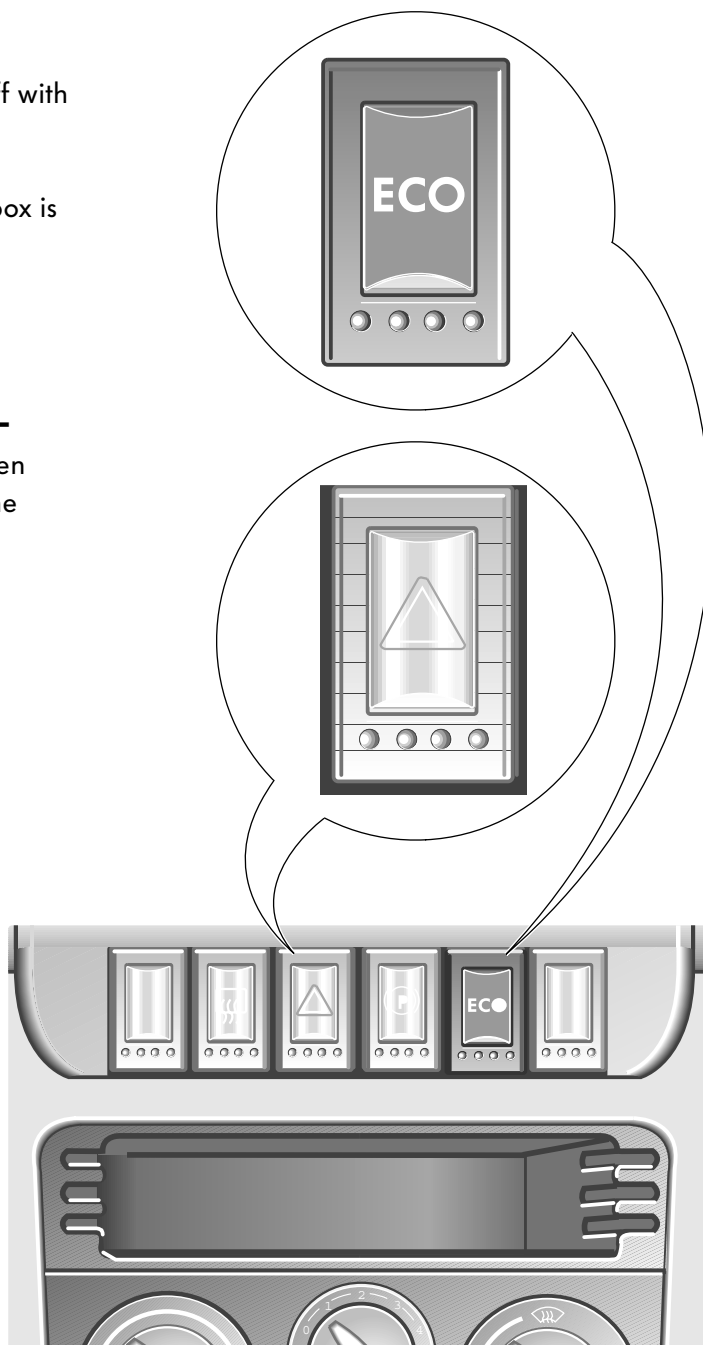
Switch -E262- for electronic manual gearbox

The ECO mode can be switched on and off with this switch.

The switch for the electronic manual gearbox is located in the middle of the dash panel.

Handbrake warning lamp -K14-

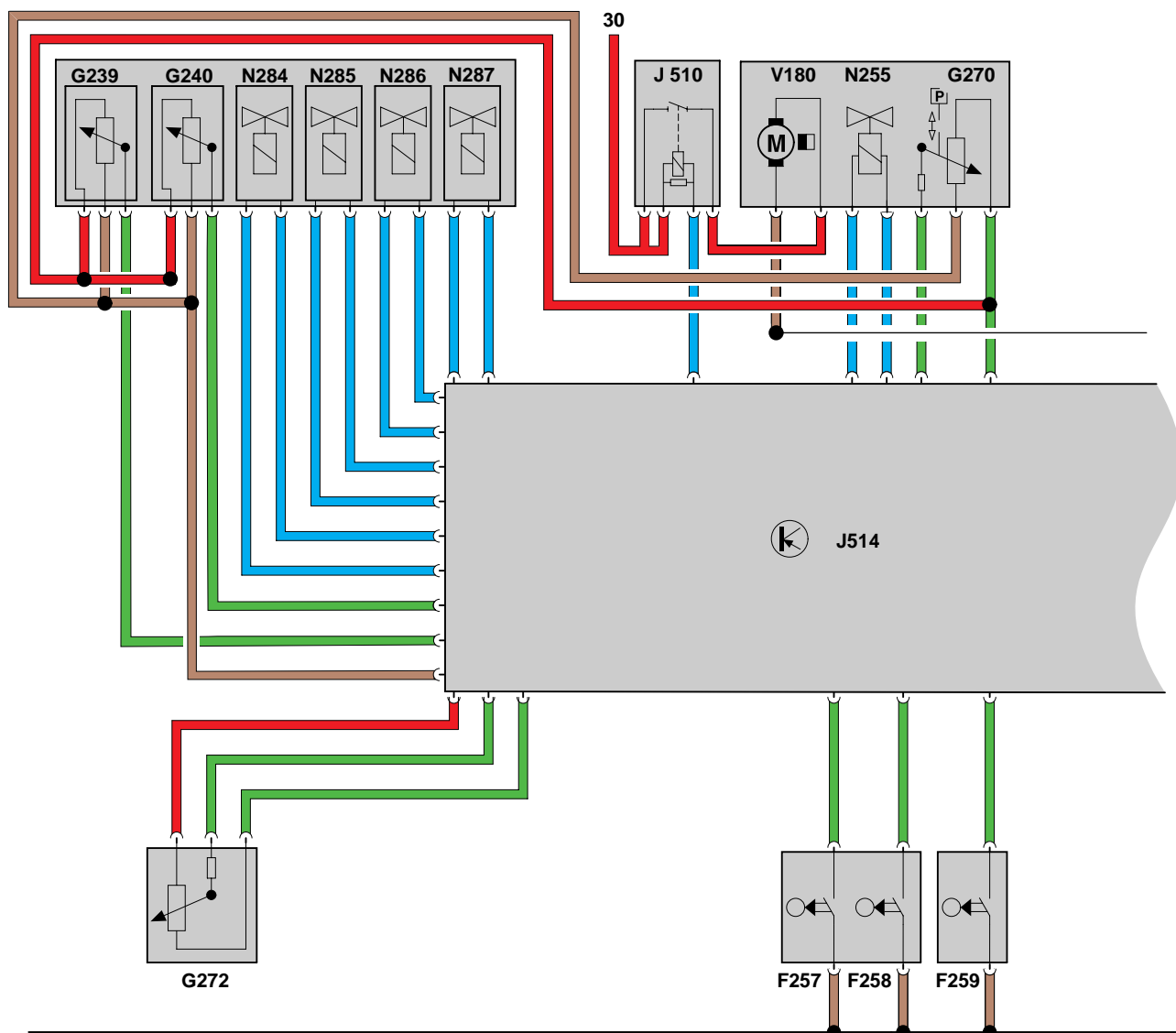
flashes if the handbrake is not applied when parking the vehicle with selector lever in the STOP position.



221_044

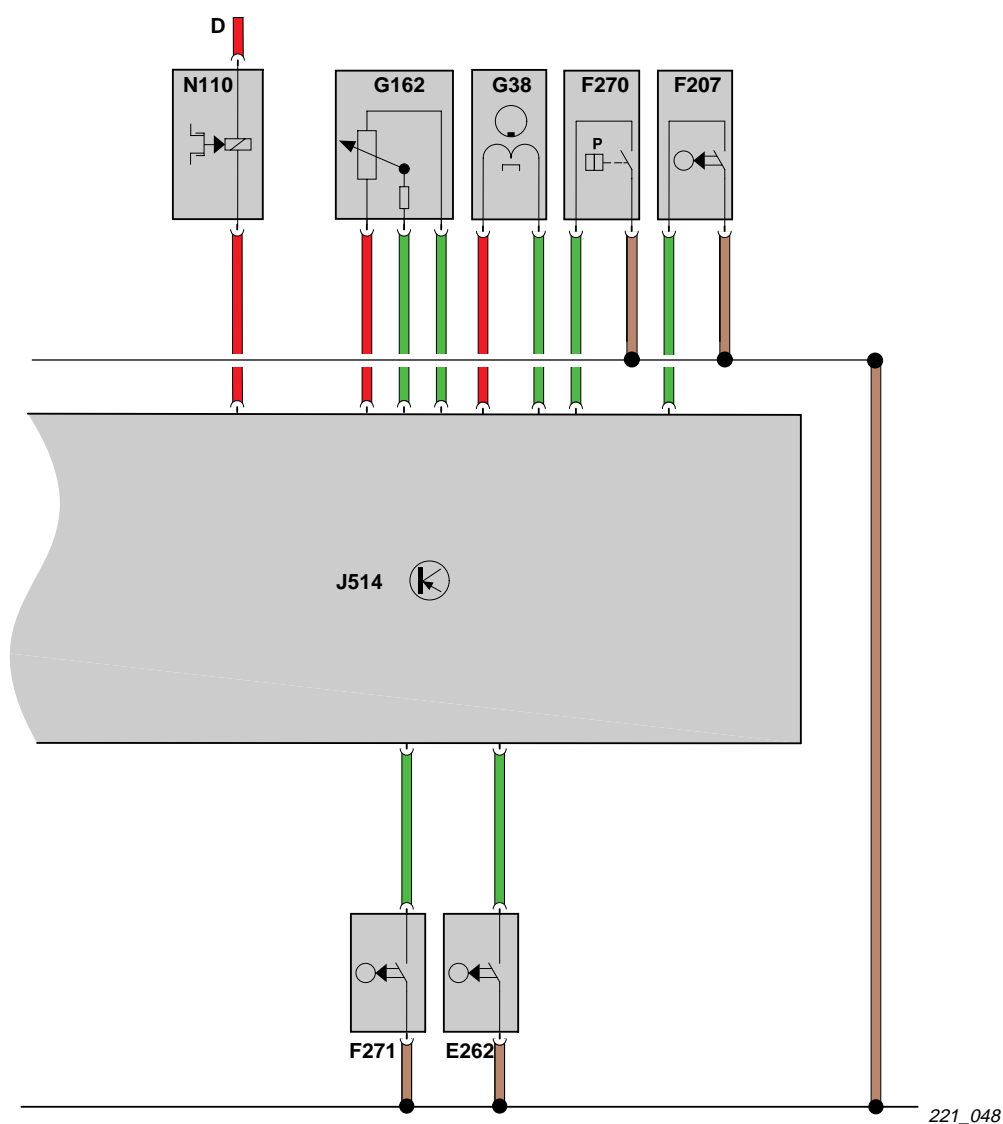


Function diagram



E262	Switch for electronic manual gearbox
F207	Bonnet switch
F257	Switch for gate recognition, selector lever
F258	Switch for N recognition, selector lever
F259	Switch for stop recognition
F270	Brake pressure sender
F271	Switch for E recognition

G38	Gearbox speed sender
G162	Clutch movement sender
G239	Potentiometer for gate recognition
G240	Potentiometer for gear recognition
G270	Sender for hydraulic pressure
G272	Potentiometer for selector lever forward/reverse



221_048

- J510 Relay for gearbox hydraulic pump
- J514 Electronic manual gearbox control unit
- N110 Selector lever lock solenoid
- N255 Valve for selector lever
- N284..287 Valves for gear selection
- V180 Hydraulic pump motor

- Input signal
- Output signal
- Positive
- Earth

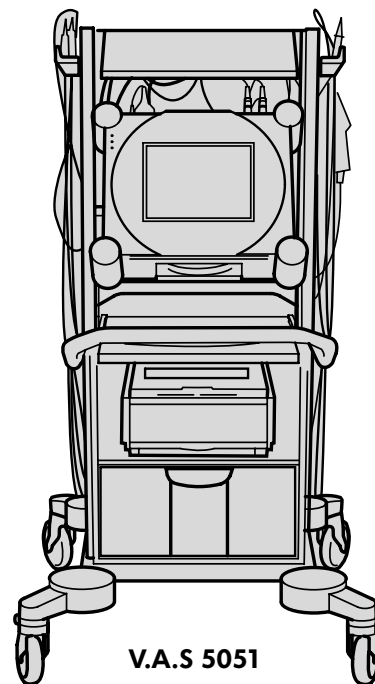


Self-diagnosis

Self-diagnosis

The following functions can be read out using the vehicle Diagnostic Testing and Information System V.A.S 5051:

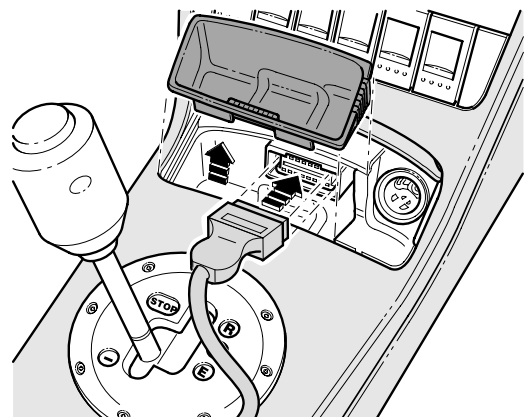
- 01 Interrogate control unit version
- 02 Interrogate fault memory
- 03 Actuator diagnosis
- 04 Basic adjustment
- 05 Erase fault memory
- 06 End of output
- 07 Encode control unit
- 08 Read measured value block



V.A.S 5051

221_045

The diagnostic connector is located in the central console behind the ashtray.

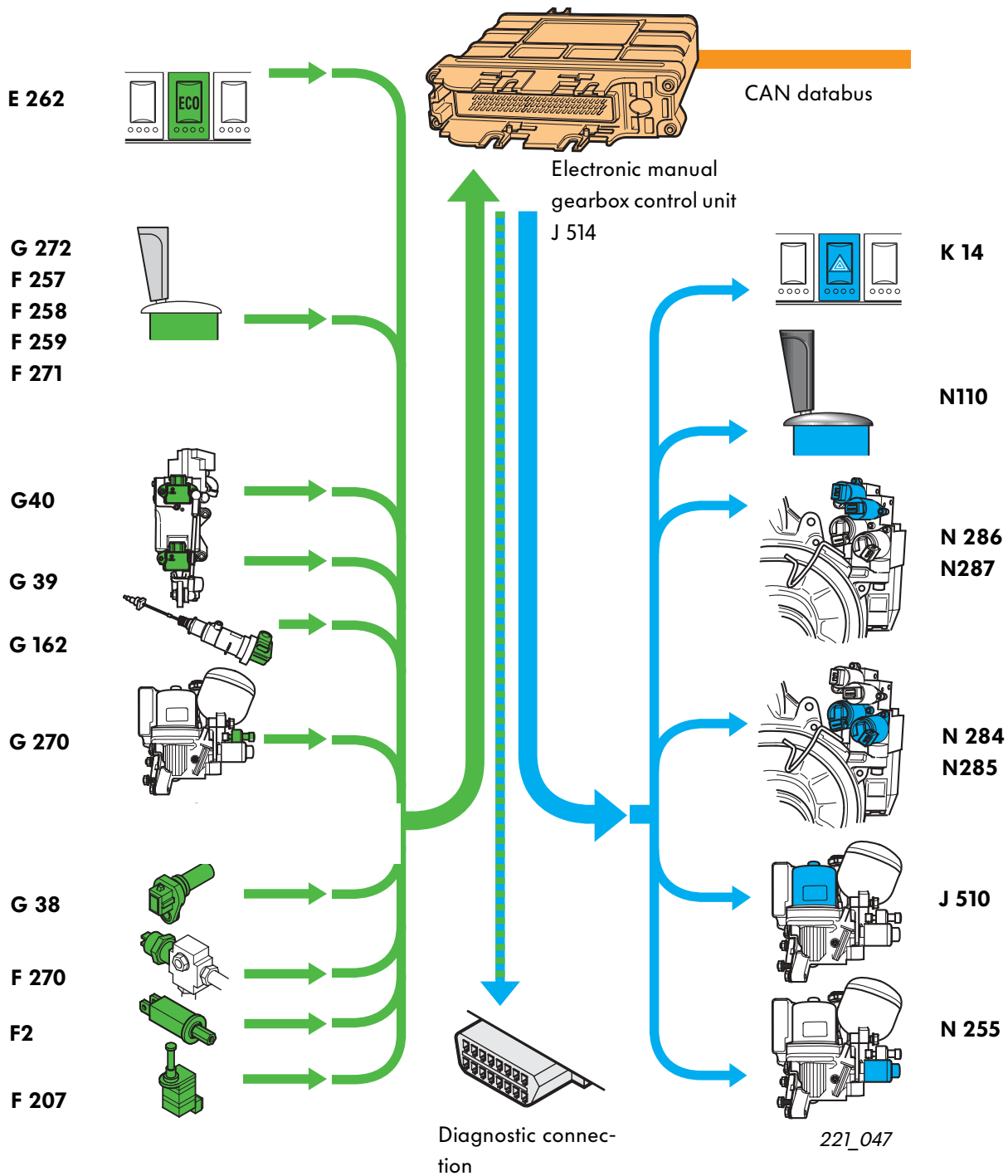


221_046



Function 02 Interrogate fault memory

Faults in the components listed below are registered by the self-diagnosis function and stored in the fault memory.



Test your knowledge

1. What gearbox serves as the basis for the electronic manual gearbox?

- ☐ a) 002
- ☐ b) 085
- ☐ c) 02J

2. How is the selector lever movement transferred to the selector shaft?

- ☐ a) by a linkage
- ☐ b) by the selector lever
- ☐ c) by selector cables

3. In what selector gate position are all valves deenergised?

- ☐ a) R
- ☐ b) 3+4
- ☐ c) 1+2

4. Which of these components belongs to hydraulic unit?

- ☐ a) Pressure accumulator
- ☐ b) Valves for selector lever
- ☐ c) Clutch movement sender
- ☐ d) Pressure sensor
- ☐ e) Clutch solenoid valve

5. In total, how many valves in the selector lever control gear and gate selection?

- ☐ a) 2
- ☐ b) 6
- ☐ c) 4



6. Which of these components are networked with the electronic manual gearbox control unit through the CAN databus?

- ☐ a) Control unit for display unit in dash panel insert
- ☐ b) ABS control unit
- ☐ c) Engine control unit

7. When is the engine shut off in ECO mode?

- ☐ a) when releasing the accelerator pedal
- ☐ b) after 60 s braking time and when the vehicle is stationary
- ☐ c) after 3 s braking time and when the vehicle is stationary

8. What condition must be met before the selector lever can be moved out of the STOP position?

- ☐ a) The brake pedal must be pressed
- ☐ b) The steering wheel must be in the straight-ahead position
- ☐ c) The handbrake must be applied

9. Which of these conditions must be met before the engine is shut off automatically?

- ☐ a) Coolant temperature over 17°C
- ☐ b) ECO mode is active
- ☐ c) Alternator load factor below 55%

10. When does the handbrake warning lamp flash?

- ☐ a) when the brake linings are worn
- ☐ b) when the brake fluid level in the reservoir is too low
- ☐ c) when the handbrake for parking the vehicle is not applied when the selector lever is in the STOP position

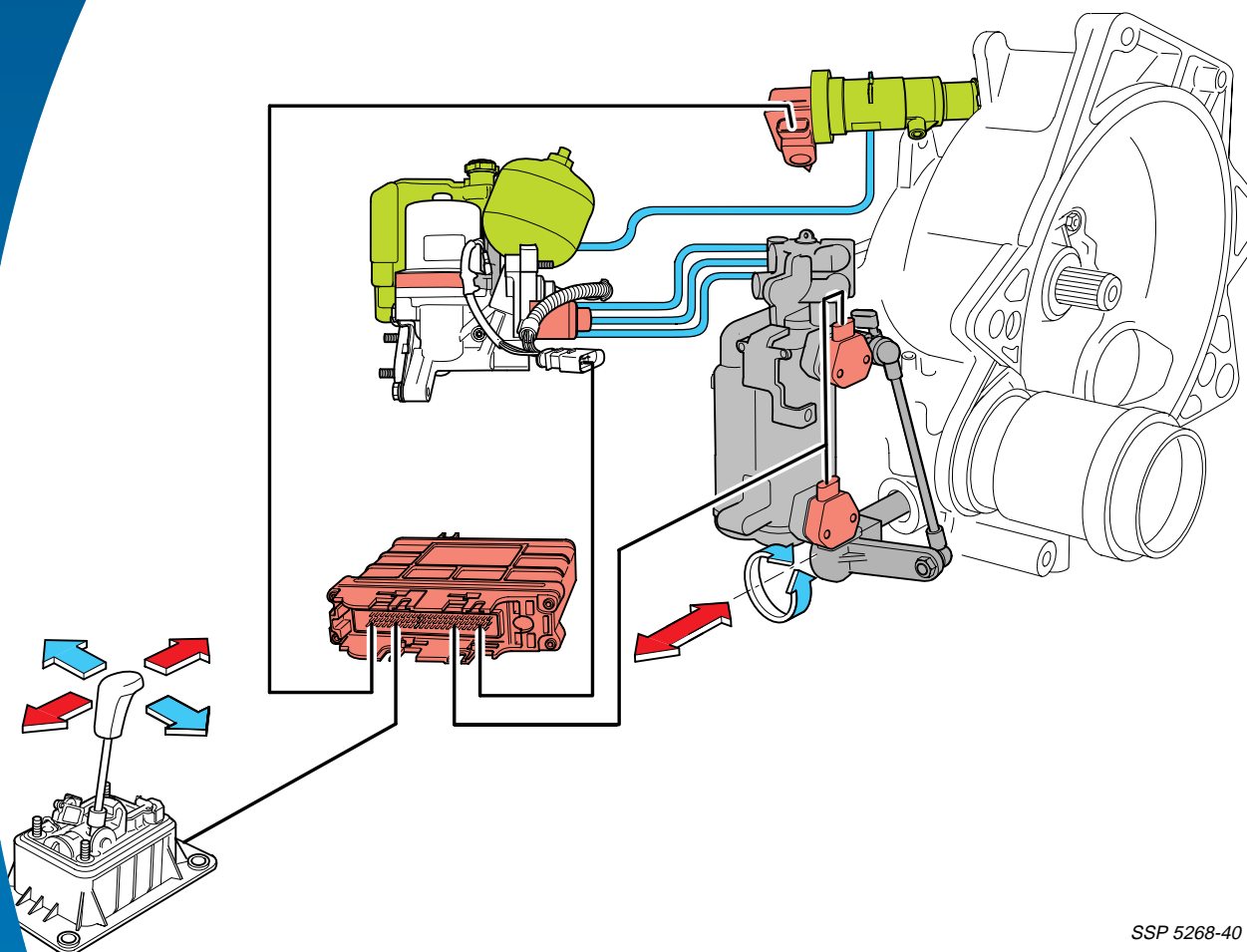
Solutions:

- 1. b
- 2. b
- 3. c
- 4. a, d, e
- 5. c
- 6. a, b, c
- 7. c
- 8. a
- 9. a, b, c
- 10. c



Notes





SSP 5268-40

For internal use only © VOLKSWAGEN AG, Wolfsburg

All rights reserved. Technical specifications subject to change without notice.

940.2810.40.00 Technical status: 05/99

♻️ This paper is produced from
non-chlorine-bleached pulp.