SCANIA

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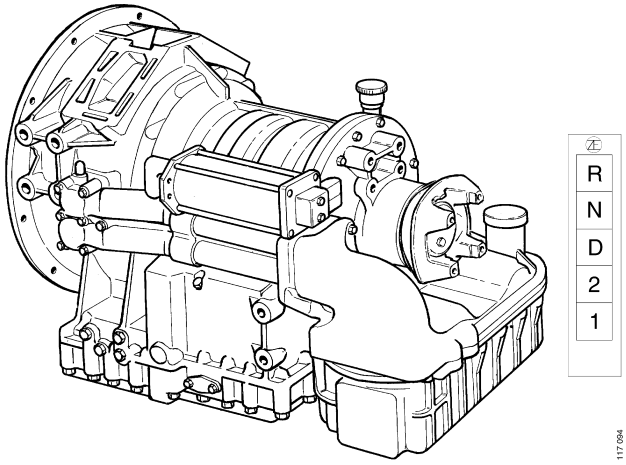
Issue 2 **en**

ZF automatic gearbox

ZF 4/5HP500, 590 and 600

Function description



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Contents

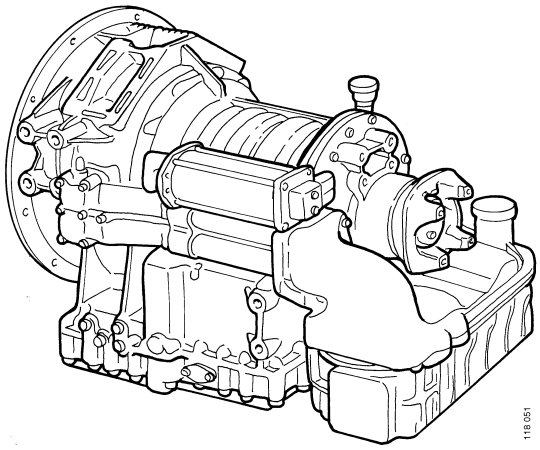
General

Introduction

This description applies to automatic gearboxes with the designations ZF 4/5HP500, 590 and 600. The gearboxes are manufactured by ZF.

The gearboxes have retarders as standard.

The gearboxes are four or five-speed and are fitted with torque converters. An electronically controlled hydraulic system performs the gear changes. The gear boxes are constructed with a combination of mechanical and hydraulic gears.



An integrated pump supplies pressurised fluid both to the hydraulic system and to the gearbox lubrication system. The fluid is cleaned by passing through a filter. This filter must be renewed at regular intervals. Refer to Workshop Manual section 0.

As this description deals with several closely-related models of gearboxes, the appearance of components may differ slightly from what is shown in the illustrations. The location of the components may also vary.

There are several generations of gearboxes. In order to know which generation the gearbox belongs to, see the section 'Gearbox type plate'.

To reduce the effects of any discrepancies due to different variants, the Work and Function Descriptions are as general as possible.

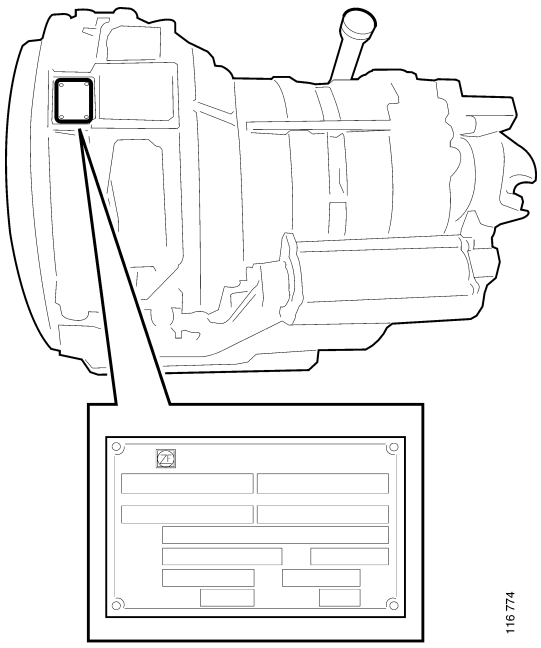
Gearbox type plate

When contacting ZF representatives, please refer to the ZF designation indicated on the gearbox type plate. The type plate is located on the upper side of the gearbox.

The type plate indicates the type, serial number, part number, model designation, gear ratio and speedometer ratio.

Example:

Type number	Description
4HP500N	4-speed with NBS
5HP600	5-speed without NBS
4HP500/80	4-speed with NBS and angle gear
4HP590/80D	4-speed with NBS and angle gear with drop

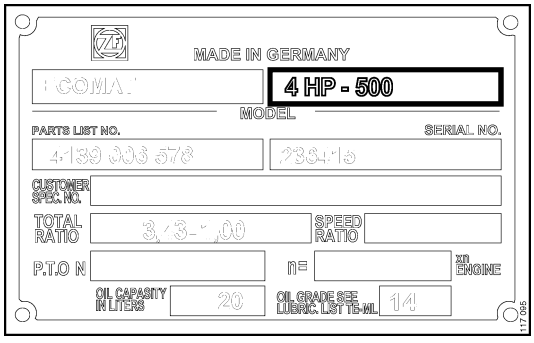


The type plate is located on the upper side of the gearbox.

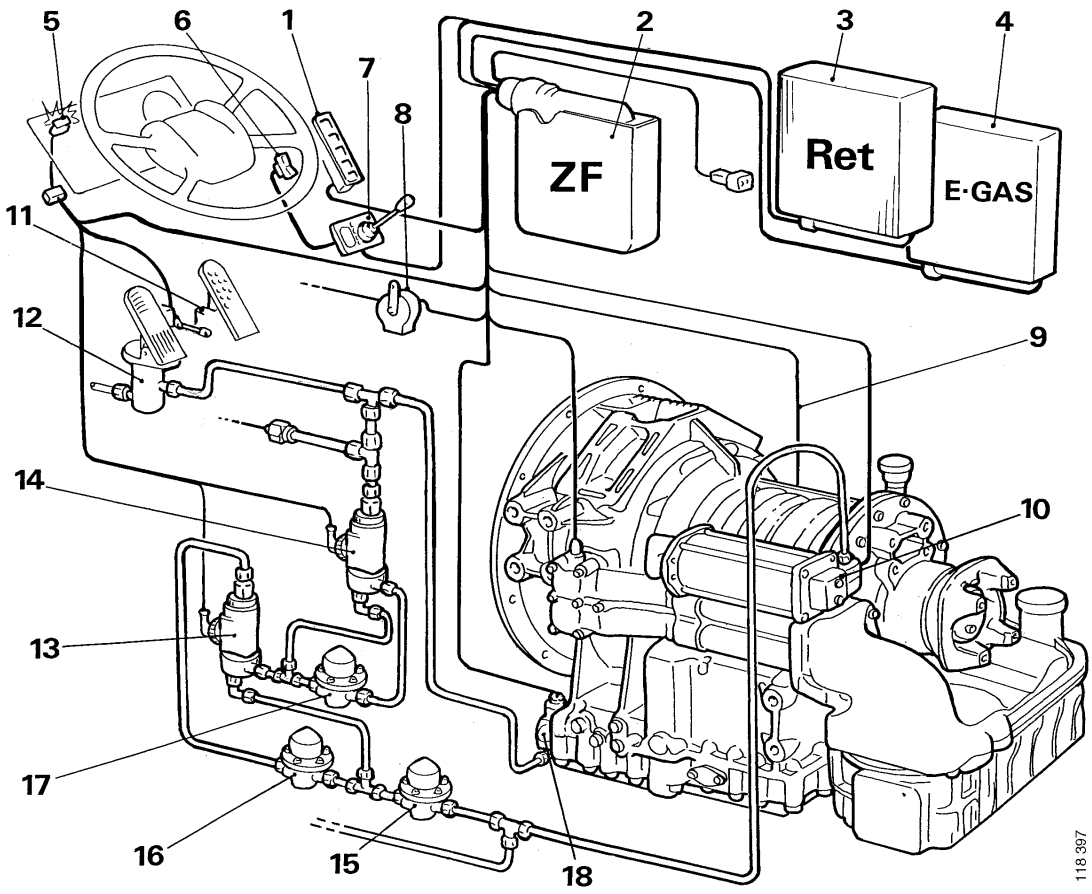
The type number also indicates which generation the gearbox belongs to.

4 HP-500	Generation 1
4 HP-502	Generation 2

Generation 2 is described in separate booklets.

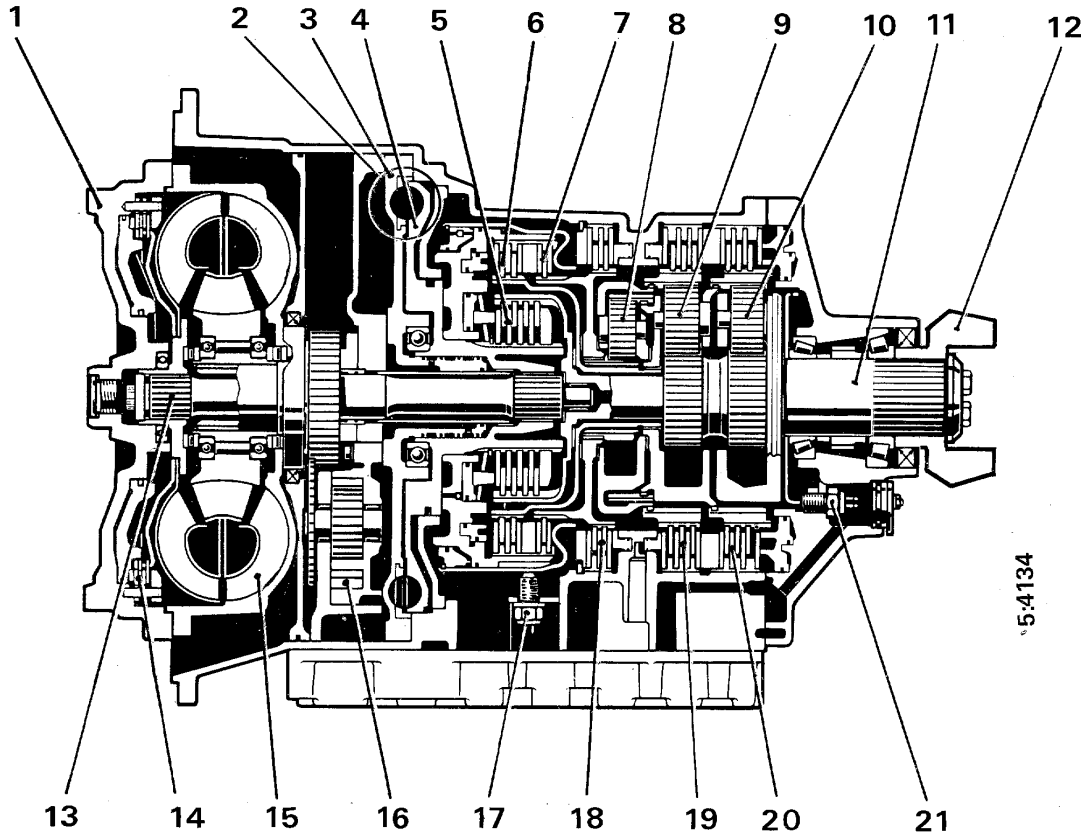


System design



1 *Drive mode selector*
2 *Gearbox control unit*
3 *Retarder control unit*
4 *Electric throttle control unit*
5 *Oil temperature warning lamp*
6 *Retarder switch. The switch may alternatively be located in the central electric unit.*
7 *Retarder lever*
8 *Throttle actuation sensor on engine, in case of mechanical throttle control.*
9 *Electrical connection for solenoid valves and frequency sensor in gearbox. (Cannon connector).*
10 *Accumulator solenoid valve V502*
11 *Accelerator pedal sensor D35 with kickdown switch*
12 *Service brake valve with potentiometer D37*
13 *Retarder solenoid valve V503*
14 *Retarder solenoid valve V504*
15 *Pressure regulator, stage 1*
16 *Pressure regulator, stage 2*
17 *Pressure regulator, stage 3*
18 *Retarder solenoid valve V501*

Gearbox design



1 *Input shaft*
2 *Retarder*
3 *Stator*
4 *Rotor*
5 *Coupling A*
6 *Coupling B*
7 *Coupling C*
8 *Planetary gear 1*
9 *Planetary gear 2*
10 *Planetary gear 3*
11 *Output shaft*
12 *Driver*
13 *Turbine shaft*
14 *Lock-up coupling*
15 *Torque converter*
16 *Oil pump*
17 *Turbine frequency sensor*
18 *Coupling D*
19 *Coupling E*
20 *Coupling F*
21 *Output shaft frequency sensor*

Torque converter

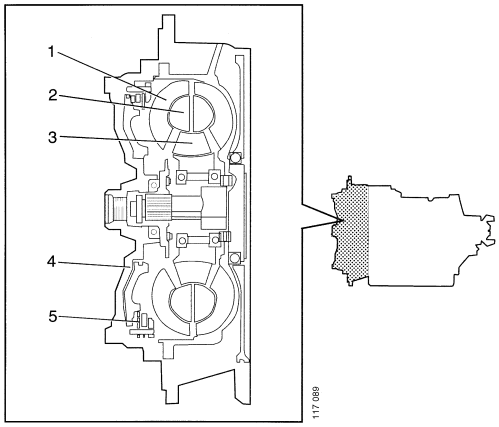
A hydraulic torque converter transmits engine torque to the gearbox. The torque converter amplifies engine torque when starting and assures smooth transmission of power.

A hydraulic torque converter is less efficient than a mechanical transmission. Therefore there is a coupling that locks-up the torque converter turbine shaft with the pump wheel shaft as soon as a certain engine speed has been reached in first, second and reverse gears. Torque is then transmitted entirely mechanically. This is known as the lock-up position. In higher gears, this coupling is always engaged, meaning that the torque is transmitted in the same manner as in a mechanical gearbox.

The torque converter consists of three parts, the pump wheel, stator and turbine wheel. The pump wheel is situated on the input shaft and acts as one half of a clutch. The pump wheel is cup-shaped and consists of a number of curved vanes.

The turbine wheel has the same design as the pump wheel, but is situated on the output shaft. Both the cup-shaped wheels are placed with the openings towards each other. In the space between them is the stator, which is also a wheel with curved vanes.

When the pump wheel rotates, the fluid is set in motion between the pump and turbine wheels. The centrifugal force of the fluid transmits the torque from the pump wheel to the turbine wheel. If there is a large difference in rotation speed between the pump wheel and the turbine wheel, the stator wheel, which is mounted on a freewheel, produces a torque boost to the turbine shaft.



1 *Pump wheel*

2 *Turbine wheel*

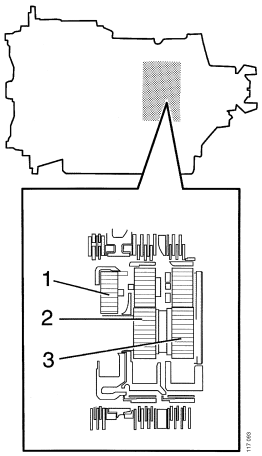
3 *Stator wheel*

4 *Input shaft*

5 *Lock-up clutch*

Planetary gears

The gearbox contains three planetary gears. These are connected via disc couplings to the gearbox shafts and to each other. By engaging or disengaging different combinations of disc couplings, engine torque is transmitted via the planetary gears in different ways, resulting in different gear ratios.



1 *Planetary gear 1*
2 *Planetary gear 2*
3 *Planetary gear 3*

Retarder

The gearbox is equipped with an integrated retarder.

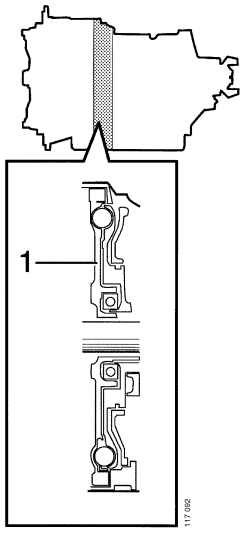
The retarder consists of a stator and a rotor and functions according to the same principle as the torque converter. The rotor always rotates at engine speed. The retarder brakes by hydraulic oil being forced into the retarder. This has the effect of braking the rotor and output shaft. When retarder braking is requested, via the brake pedal or retarder lever, the accumulator solenoid valve opens and a pneumatic piston forces the oil into the retarder. In order to regulate the braking action of the retarder, there is a control valve to control the pressure in the retarder.

Braking with the retarder generates a great deal of heat. The heat is cooled off by a heat exchanger connected to the engine cooling system.

When the retarder is not used, it is emptied of hydraulic oil. The hydraulic oil is stored in an accumulator.

The retarder can produce very high braking torque. In order to avoid awkward braking or wheel locking, the gearbox control unit reduces the retarder power to retarder setting 1 when in first and second gear.

If the vehicle is equipped with ABS and one wheel is about to lock, the ABS control unit will send a signal to the retarder control unit, which will then stop sending brake signals to the retarder. This will happen even if the brake pedal or retarder lever is activated.

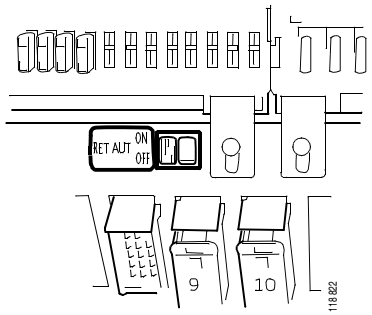


1 Retarder

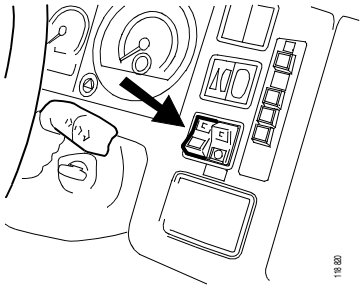
Activating the retarder

The brake pedal activates the retarder when the switch is on.

The switch may alternatively be located in either the central electric unit S525 or on the instrument panel S526.



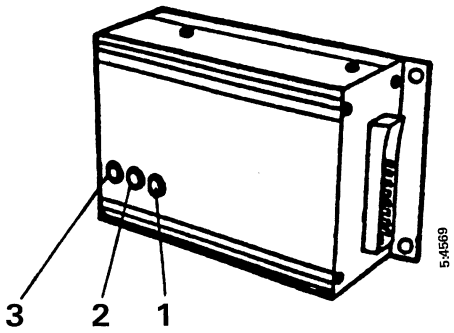
Switch S525



Switch S526

The retarder has a separate control unit located in the central electric unit. The retarder control unit receives an analogue signal from the brake valve potentiometer D37 when the brake pedal is depressed. This signal is converted by the control unit into 3 digital signals that are passed to the gearbox control unit E502 and then to the retarder solenoid valves V501, stage 1, V503, stage 2 and V504, stage 3.

The braking action increases the harder the brake pedal is depressed. As soon as the wheel brakes are applied, the retarder provides full braking power.

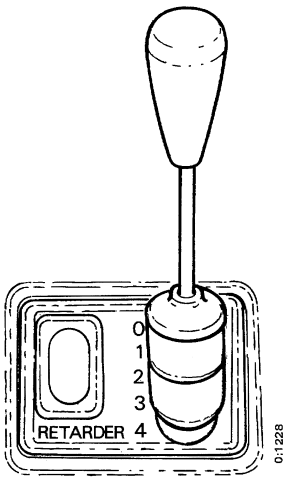


1 Trim potentiometer for B1 + B2
2 Trim potentiometer for B4
3 Trim potentiometer for B3

The vehicle may also have a combination of manual and automatic operation. The maximum requested braking power would be obtained, e.g. with the retarder lever in position 1 and by simultaneously depressing the brake pedal with full force, causing the retarder to brake fully.

Retarder lever positions 3 and 4 both produce the braking power of position 3, i.e. the braking power in the two positions is identical.

The auxiliary brake is powerful and only brakes the drive wheels. In vehicles without ABS, it may be unsuitable and in certain cases extremely dangerous to use this brake on slippery road surfaces.

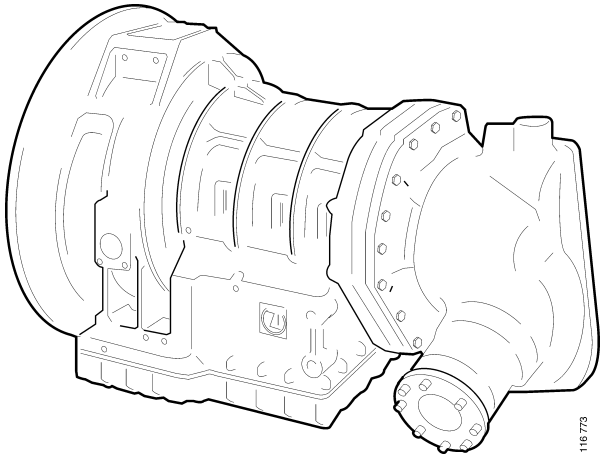


Angle gears

In order to save the maximum amount of space when installing engines and gearboxes, there are various designs of angle gears. The drop gear allows the propeller shaft to be lowered by approximately 200 mm.

Angle gear

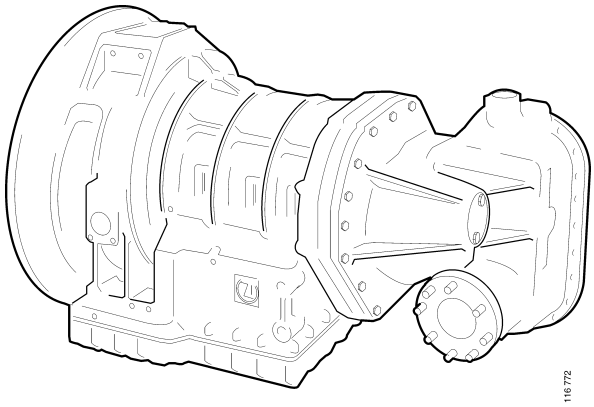
The angle gear changes the angle by 80° in case of a transversely mounted engine and gearbox.



Angle gear, 80°

Angle gear with drop

The drop gear changes the angle by 80°, allowing the propeller shaft to be lowered by around 200 mm in case of a transversely mounted engine and gearbox.



Angle gear with drop, 80°

Control unit

The gearbox control unit E502 consists of a microprocessor programmed to monitor and control the gearbox to ensure correct gear change timing.

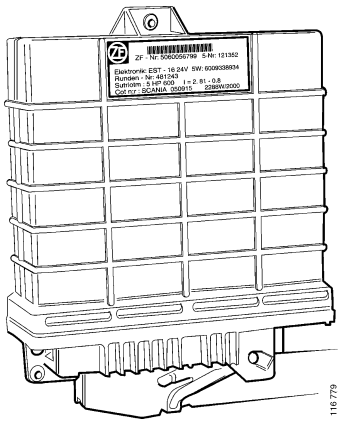
In vehicles equipped with electric throttle, the gearbox control unit communicates with the electric throttle control unit.

By compiling information from sensors on the gearbox, drive mode selector, engine speed and current throttle actuation, the control unit determines which gear should be selected. It also assists when braking with the retarder. The control unit also controls the entire gear change process and monitors the gearbox control system.

The control unit continuously monitors rotation speed changes by means of various sensors and then compensate in order to obtain good gear change quality.

Note: Connect all wires to a new control unit before turning on the voltage with the starter key.

When contacting ZF representatives, please refer to the control unit as EST 18, as stated on the label on the control unit.



Gear changing

Gears are changed up and down by engaging or disengaging the couplings by means of hydraulic pressure. The control unit sends signals to the solenoid valves in the gearbox hydraulic system for gear changing or retarder braking.

The control unit also monitors that the slip time is correct, i.e. the how long the discs slip against each other during the gear change. If the slip time is too short, this results in hard gear changes, and if it is too long the discs wear out quickly. The slip time is regulated by the so-called modulation pressure.

If the slip time is too long, e.g. due to insufficient fluid level in the gearbox, the depressed button in the drive mode selector will flash.

Gear changing programs

There are two gear changing programs, one for performance and one for economy driving. The control unit operates according to the performance program if pin 34 is connected to +24V.

In vehicles manufactured from April 1998, the performance program is set as standard. By connecting or disconnecting the two connections in the front central electric unit connector C874, the gear changing program can be changed

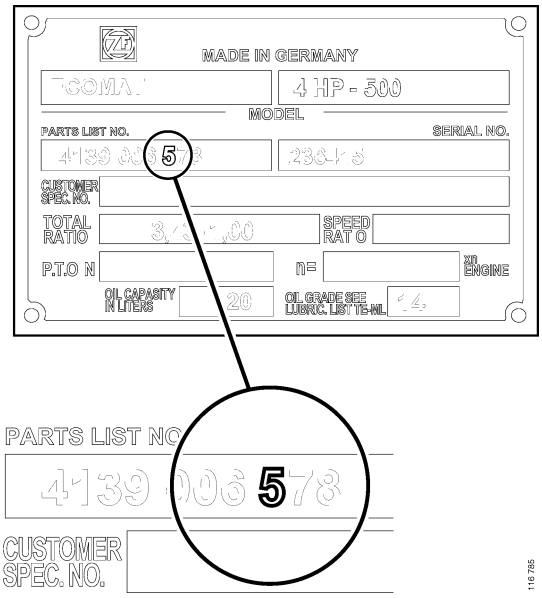
NBS

Certain variants of ZF automatic gearboxes have a function known as NBS (Neutral Bei Stillstand, i.e. neutral when stationary). This function disengages the rotating gearbox parts from the output shaft provided that:

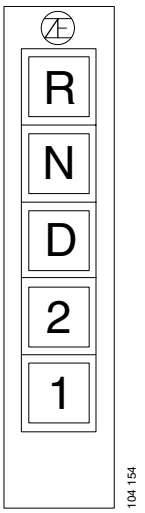
- first gear is selected
- the accelerator pedal is in idling position
- the foot brake or bus stop brake is applied
- the speed of the bus is less than 3 km/h.

The service brake only needs to be applied with light pressure, 0.8 bar, in order to activate NBS.

The NBS function yields lower fuel consumption, especially in city traffic with repeated stopping and starting. Gearboxes with NBS can be identified by looking at the 10-digit code on the gearbox type plate. If the third digit from the end is a 5 (xxxx xxx 5xx), the gearbox has the NBS function.



Drive mode selector



The drive mode selector S520 informs the gearbox control unit of which gear or which gear changing program the driver has selected.

- R = Reverse gear.

Note: Reverse gear can only be selected if the vehicle is stationary

- N = Neutral. Used when starting the engine, for long stops and parking.

Note: Do not select neutral when the vehicle is in motion. This may damage the gearbox.

- D = Normal forward drive mode. All gears are used.
- 2 = Forward drive mode. All gears except top gear are used.
- 1 = Forward drive mode. Only the lowest gear is used.

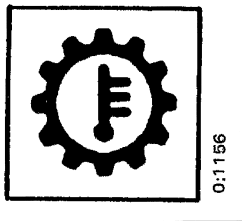
If you press button 1 or 2 when driving, the gearbox changes down as normal when you reduce vehicle speed. It will not change up when accelerating.

Certain types of drive mode selectors only have the R, N and D buttons.

Warning and indicator lamps

Warning lamp, high gearbox oil temperature

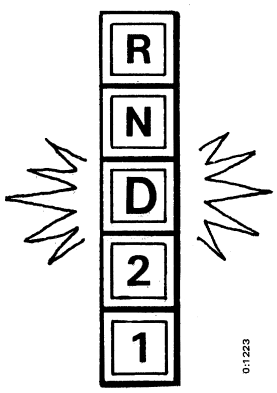
Braking with the retarder generates a great deal of heat. If the temperature becomes too high, a red warning lamp lights in the instrument cluster after a delay of 30 seconds produced by a timer relay, R516.



Flashing lamps in the drive mode selector

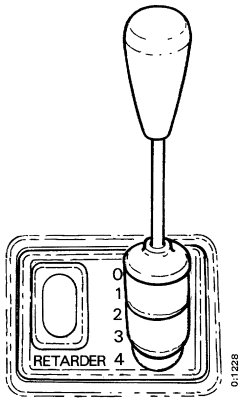
The gearbox has a warning system that warns of serious faults in the gearbox and its control system.

If a fault occurs, the diagnostic lamp and the depressed button on the drive mode selector S520 will flash.



Activated retarder lamp

Next to the retarder lever is an indicator lamp W505. The lamp lights when the retarder is engaged.



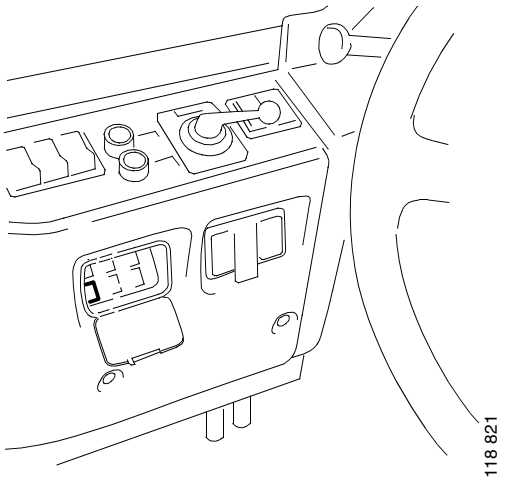
Diagnostics switch with lamp

The diagnostics switch is used to read fault codes that may be stored in the control unit memory. The fault codes are flashed out by the lamp. The switch is also used to erase fault codes.

The diagnostics lamp is connected in parallel with the drive mode selector. Therefore the diagnostic lamp is constantly on as soon as the power has been turned on with the starter key.

In the event of an active fault, the depressed button on the drive mode selector flashes to warn the driver and consequently the diagnostic lamp also flashes.

The fault code memory can store a maximum of ten fault codes

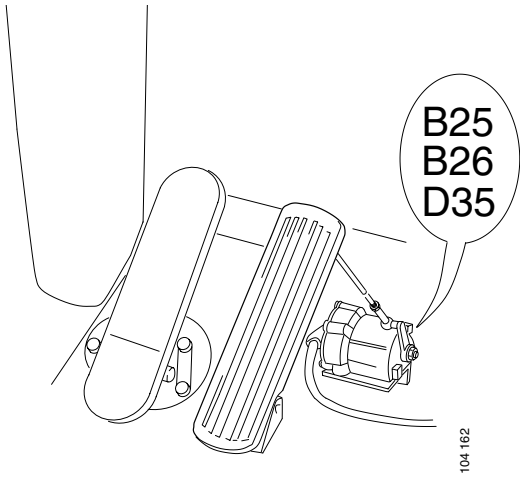


Diagnostics switch

Kick-down

The kick-down switch is closed near full throttle actuation. The kick-down signal passes directly from the accelerator pedal sensor to the gearbox control unit. This occurs without the intervention of the throttle actuation sensor, D503, or the electric throttle control unit. The kick-down switch is always located in the accelerator pedal sensor, whether the vehicle has mechanical throttle control or electric throttle. Refer to Workshop Manual section 14.

Kick-down is used to change down a gear, e.g. when overtaking. Kick-down can also be used to delay changing up. Holding the accelerator pedal in kickdown position avoids letting the engine lose power by changing up on an upward slope.



B25 Throttle actuation switch (idling)
B26 Kick-down switch
D35 Potentiometer

Mechanical throttle control

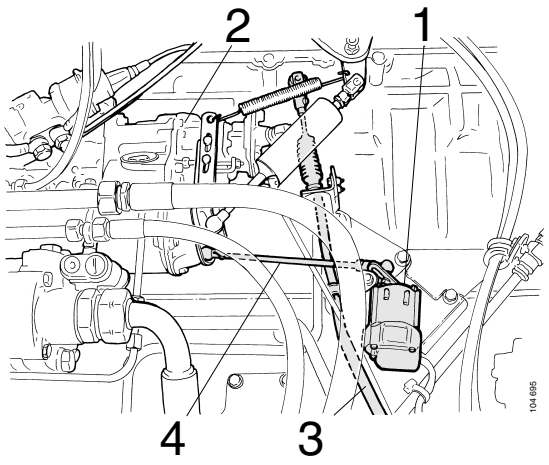
If the vehicle is equipped with mechanical throttle control, it will have a throttle actuation sensor D503. This is located on the engine and is linked to the injection pump control lever. It informs the control unit of throttle actuation and therefore of the degree of engine is load. The sensor sends an analogue signal to the control unit, which the control unit then converts this to a digital signal.

The throttle actuation sensor setting must be checked:

- following servicing or repair work to the engine or gearbox.
- in the event of hard gear changing or too long slip times.

IMPORTANT! If the throttle actuation sensor is set incorrectly, the gearbox may be damaged.

Note: For setting the kick-down switch, see *W*orkshop Manual section 14.



1 Throttle actuation sensor
2 Injection pump
3 Throttle cable
4 Link

Electric throttle:

If the bus is equipped with electric throttle, the electric throttle control unit sends a PWM signal to the gearbox control unit. PWM = Pulse Width Modulation. This means that the pulse width of the signal is proportional to the throttle actuation. An analogue value is transmitted by a digital signal. See also Workshop manual, section 14.