7.02
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5-Speed Automatic Gearbox 09A/09B

Trainer Information (GB)

Trainer Information, 5-Speed Automatic Gearbox 09A/09B, 7.02 (GB)

Contents

1. General Information

The newly developed automatic gearbox 09A/09B with 5 gears and torque converter lock-up clutch ensures smooth and rapid gearshift and is intended for installation in vehicles with transverse engine: Golf, Bora, Audi TT, Audi A3, Sharan.

1.1 Technical data

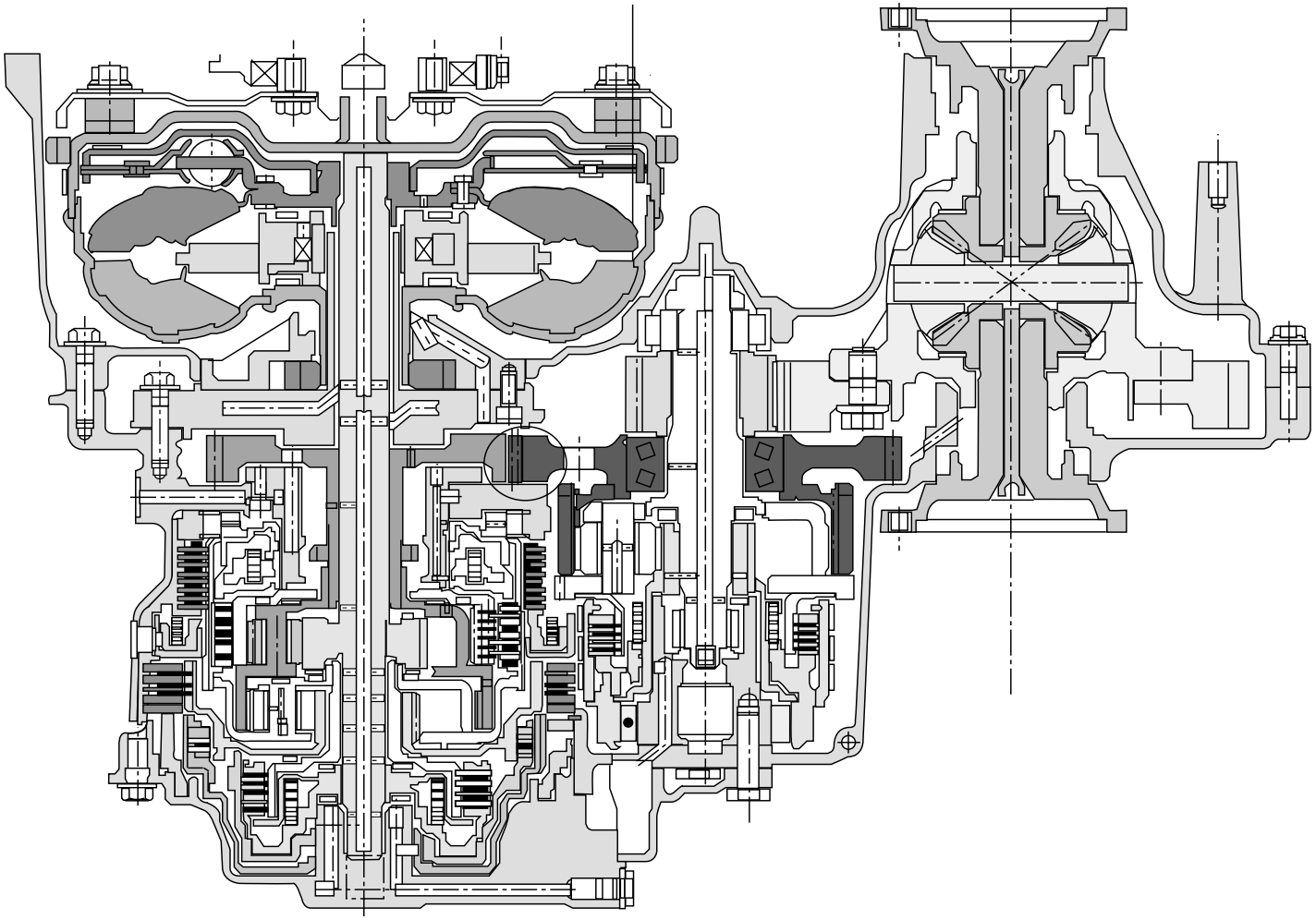
Automatic gearbox model		5 forward gears and 1 reverse gear
Torque converter	**Starting conversion**	Symmetrical with 3 elements, with torque converter lock-up clutch 1.77 (1.9 TDI), 1.96 (1.8T, VR5)
Control system		Electronic control (by means of fuzzy logic driving programs based on driving situation and motion resistance)

Transmission ratios	From	To
1st gear	3.801	4.130
2nd gear	2.131	2.233
3rd gear	1.364	1.364
4th gear	0.935	0.935
5th gear	0.685	0.685
Reverse	2.970	2.970

Final drive ratio	**Two-wheel drive**	4.17 [1.8L-T (132 kW)], 3.48 [1.9TDI (85 kW)]

Lubrication system	Forced lubrication using oil pump
Cooling system	Built-in water cooler, connected to engine cooling circuit
ATF	G052990

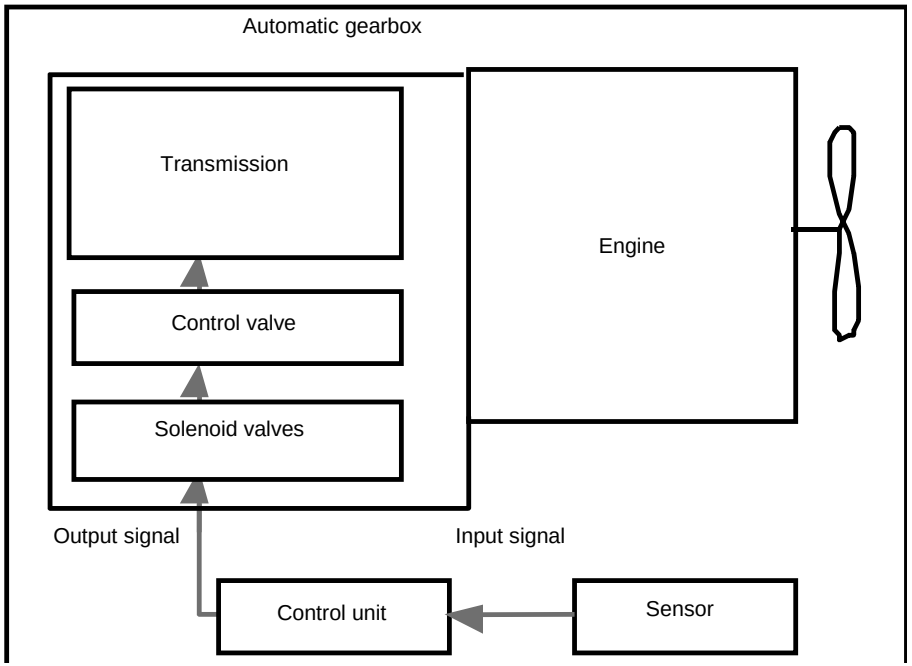
1.2 Sectional view of 09A/09B



1.3 Control system

The automatic gearbox 09A/09B features electronic control of gearshift, fluid pressure and lock-up clutch actuation. The control unit receives electrical signals from sensors used to monitor road speed and engine torque. The control unit selects the appropriate gear on the basis of these signals and regulates other associated factors.

The actual gearbox control changes are implemented by control elements (solenoids) which respond to signals from the control unit. There are 9 solenoids, on which the entire transmission control system is based and which regulate the operation of the control valves. These effect changes in the fluid ducts, which in turn result in changes in fluid pressure within the gearbox. The gearbox function is controlled by the changes in fluid pressure. The illustration shows the drive train and control system for the gearbox 09A/09B. The input and output signal paths for the control unit are explained on the following pages.



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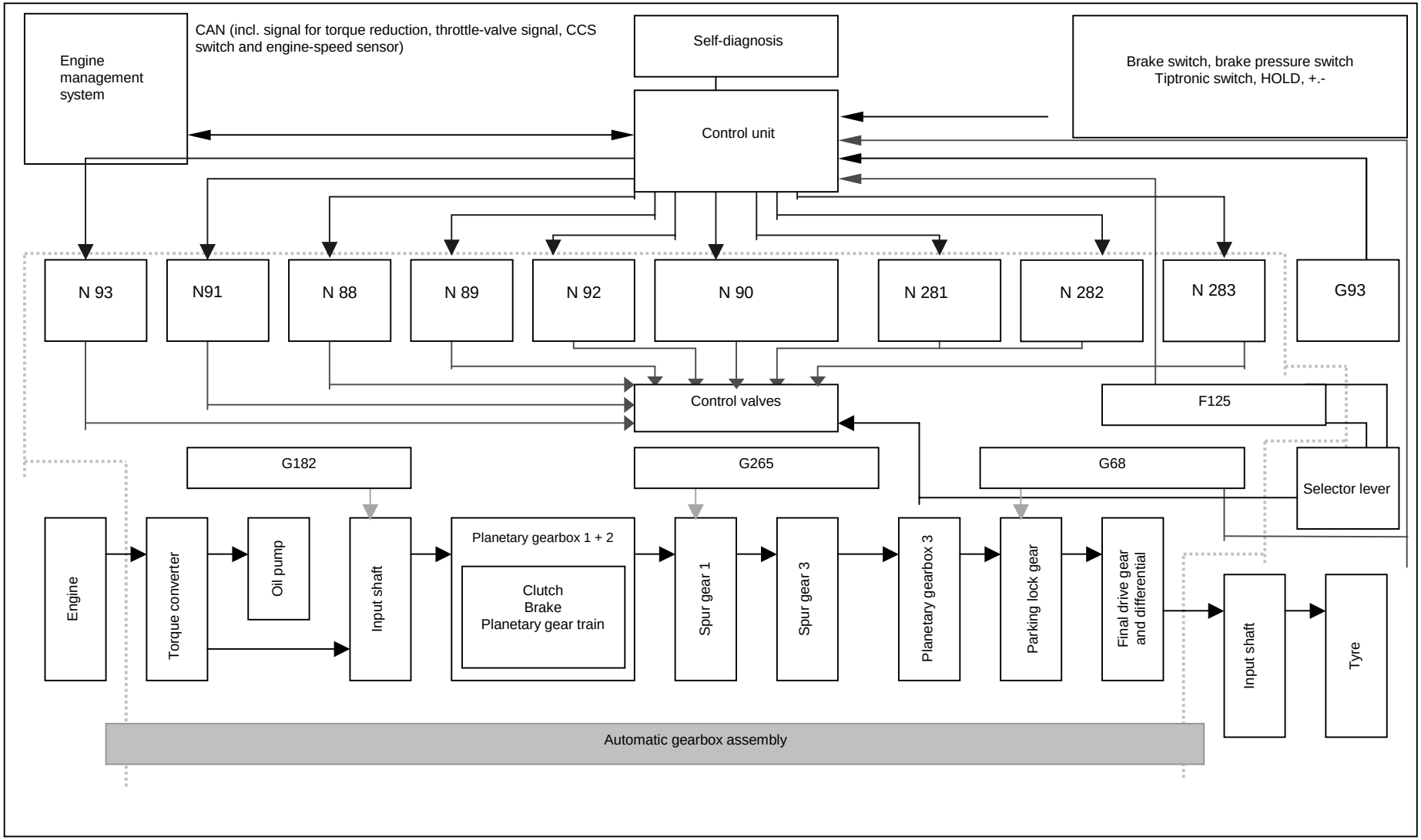


1.4 Input and output signals

		Function
Input signals	**G 68**	Detects rotational speed of parking lock gear for determining road speed.
	G 182	Detects rotational speed of turbine shaft for determining automatic gearbox input speed.
	G 265	Detects rotational speed of input spur gear of planetary gearboxes I and II
	Multi-function switch F 125	Detects position (range) of selector lever.
	G 93	Detects temperature of automatic transmission fluid (ATF).
	Brake pressure switch F, F 270	Detects foot brake actuation. Supplies signal as a function of brake pressure.
	Tip HOLD switch **Tip + switch** **Tip – switch**	Detects Tiptronic position.

Output signal	**N 88**	Solenoid valve
	N 89	Solenoid valve
	N 92	Solenoid valve
	N 93	Provides adaption of engine torque as part of pipe pressure control.
	N 90	Provides adaption of clutch pressure K1 as part of gearshift and pipe pressure control.
	N 91	Actuates lock-up control valve in valve body for lock-up control.
	N 281	Maintains ATF pressure at brake B3 in 1st to 4th gears and reverse gear, whereas fluid pressure is reduced at the other clutches and brakes.
	N 282	Controls brake B2.
	N 283	Regulates ATF pressure of brakes B2 and B3.

2. Control System Details

2.1 General information

The control functions of the automatic gearbox 09A/09B can be classified in accordance with the following tables, which provide a general outline of these functions.

	Function
2.2 Gearshift control	Regulates gearshift in the range between 1st and 5th gear as specified by automatic gearbox control unit for the individual gears and permits selection of engine brake mode depending on range. 1st gear Tip.
2.3 Main pressure control	The fluid pressure required to actuate clutch and brake differs depending on the gear selected. The pipe pressure control regulates these changing pressures. Provides precise control of fluid pressure changes on gearshift and thus ensures a smooth, comfortable ride.

2.4 Lock-up clutch control

The torque converter and lock-up clutch are directly connected. The lock-up control regulates operation of the lock-up clutch. Lock-up can be implemented in 2nd, 3rd, 4th and 5th gear of ranges D, 4 and 3. Provides lock-up control for long journeys in a certain road speed range to achieve greater economy and minimal driving noise.

2.5 Solenoid-controlled time coordination

1. N 281
2. N 90
3. N 283

Controls coordination of clutch and brake actuation times when driving off or changing gear for quicker and smooth gearshift. Also stops vehicle reversing if R range is inadvertently selected whilst vehicle is travelling forwards. Idle control effects switching to "stationary vehicle decoupling" with engine idling in D range.

2.6	**Engine torque reduction control**	Engine torque reduction on gearshift to ensure smoother gear change. This involves the gearbox control unit transmitting a control signal to the engine control unit.
2.7	**Gearshift time coordination with the aid of G 182 and G 38**	Precise monitoring of internal operating conditions of automatic gearbox with the aid of G 182 and G 38. Optimisation of lock-up control and coordination of brake and clutch actuation times on gearshift. Smoother gear change.
2.8	**Reverse prevention control**	Selection of R range at speeds as of 10 km/h causes control unit to switch N 90 to "ON", thus resulting in idle status "N" instead of selected range "R".
2.9	**Stationary vehicle decoupling "N" at idling speed (Currently only available for diesel vehicles)**	Detection of an active brake pressure switch F 270 with vehicle stationary results in transition to idle control mode. Solenoid valve N 283 is energised and 2nd gear is engaged to stop the vehicle rolling backwards. Selector lever position "N" is retained as long as the brake is pressed.

3 Gearshift Control

• Gearshift control is based on the fuzzy logic with which the engine control unit is operated. The control system effects automatic shifting through all gear ranges from 1st to 5th.
• The gearshift procedure is determined separately for each individual gear. Gearshift is controlled directly by the solenoid valves.
• In addition to the basic control procedures, gearshift control includes gearshift pattern recognition control, disabling of 5th gear and solenoid control.

3.1 Basic control functions

• On the basis of the fuzzy logic, the solenoid valves N 88, N 89 and N 92 are designed to control gear changes during vehicle operation.

• The fuzzy logic controls the shift point and engaging of the lock-up clutch in line with torque, engine speed and road speed.

• The gear position is determined by N 88, N 89 and N 92. The gearshift (change in engine speed) is also controlled by the solenoids.

	Solenoid valve		
Gear	N88	N89	N92
1st	+	+	+
1st Tip	-	+	+
2nd	+	+	-
3rd	-	+	-
4th	-	-	+
5th	+	-	+
R	+	+	+

(+) = Actuated
(-) = Not actuated

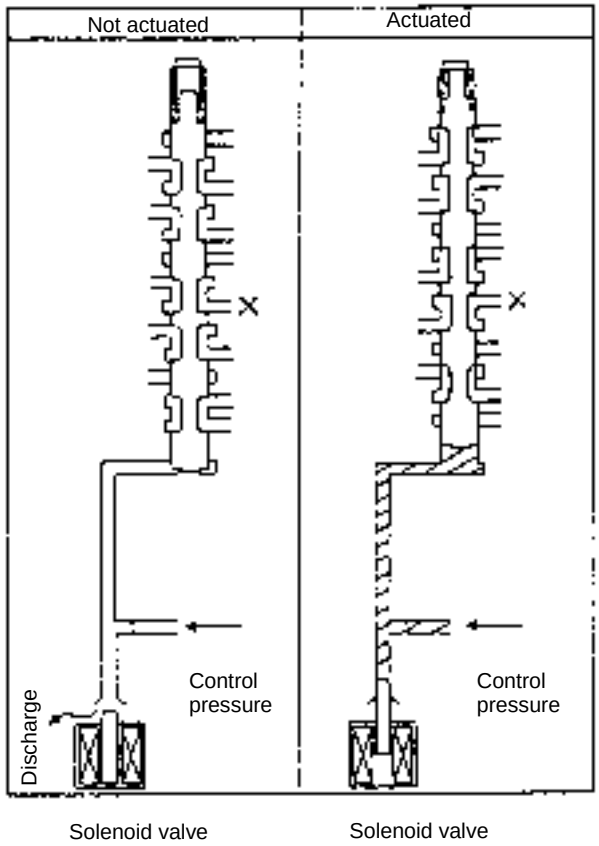
The table shows the sensor and actuator involved in the various types of control process.

		Gearshift control	Pipe pressure control (shift quality)	Lock-up control	Torque reduction control	"Signal incorrect" control (self-diagnosis)
Input signal	G68	⊗	⊗	⊗	⊗	⊗
	G182		⊗	⊗	⊗	⊗
	G38		⊗		⊗	⊗
	MSFF125	⊗	⊗	⊗	⊗	⊗
	F189	⊗		⊗		⊗
	G93	⊗	⊗	⊗	⊗	⊗
	F	⊗				⊗
Output signal	Solenoid valve N88	⊗	⊗			⊗
	N89	⊗	⊗			⊗
	N92	⊗	⊗			⊗
	N93		⊗			⊗
	N91			⊗		⊗
	Torque signal				⊗	⊗
	N281		⊗			⊗
	N90		⊗			⊗
	N282		⊗			⊗
	N283		⊗			⊗
Data transfer	CAN	⊗			⊗	⊗
	K-LINE	_	_	_	_	⊗

3.2	**Drive pattern assessment control**	The automatic gearbox 09A/09B provides the three driving modes "Tip Hold", "Tip+" and "Tip-". In FAILURE mode, i.e. if the ATF temperature exceeds a certain level (124 °C) or the fluid temperature sensor is not functioning, the failure mode pattern is automatically adopted to maintain vehicle mobility at a high temperature.
3.3	**5th gear prevention control**	Selection of 5th gear is prevented at an ATF temperature of less than –10 °C to allow the engine to warm up more quickly.
4	**Gearshift Mechanism**	Gearshift is regulated by the control unit on the basis of the fuzzy logic. The control unit activates the solenoids, each of which is connected to a selector valve inside the control valve assembly. The control and selector valve action changes the fluid duct configuration in the gearbox. The resultant change in pipe pressure produces the clutch action required for changing gear.

4.1 Solenoid valve action

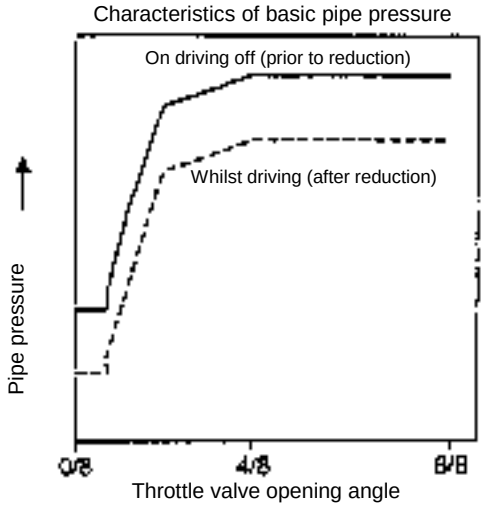
There are three ON/OFF solenoid valves, designated N 88, N 89 and N 92. There are also three selector valves inside the valve body, which are referred to as A, B and C.
The illustrations outline the mode of operation of solenoid valve A. There is no flow of current when solenoid valve A is set to OFF. The discharge port is open. The control pressure is not routed to selector valve A. Selector valve A is pressed downwards by spring force.
Current flows when the solenoid valve A is set to ON. The discharge port is closed. The control pressure is routed to selector valve A. The control pressure is greater than the spring force. Selector valve A moves upwards. The mode of operation of solenoid valves B and C and selector valves B and C is identical to that of N 88 and selector valve A.



5 ATF Pressure Control

5.1 ATF main pressure control

Controls pipe pressure on driving off and during normal driving in part-throttle operation. Optimum pipe pressure is ensured by way of control of the solenoid valve N 93 in response to engine torque. As shown by the pressure characteristics in the illustration, the pressure is kept at a lower level when driving normally in part-throttle operation than on driving off. This is referred to as pipe pressure reduction (only used when travelling forwards). Reduction control is selected for each individual drive pattern. In emergency operation, constant use is made of the pressure characteristics prevailing prior to reduction (i.e. higher pressure than with normal driving in part-throttle operation).



5.2 Pipe pressure control during gearshift (change in engine speed)

Precise pipe pressure control is implemented on gearshift (change of engine speed). Control is effected in response to the engine torque and driving conditions detected. The appropriate pipe pressure is ensured for all gear changes, thus making gearshifts and vehicle operation far smoother.

5.3 Control at extremely low temperature

If its temperature is very low, ATF has an extremely high viscosity, which results in delayed clutch action. This is counteracted by the application of maximum pipe pressure if the temperature of the ATF is less than -30°C. This is implemented irrespective of accelerator pedal position and engine torque.

5.4 Pipe pressure control during gear selection

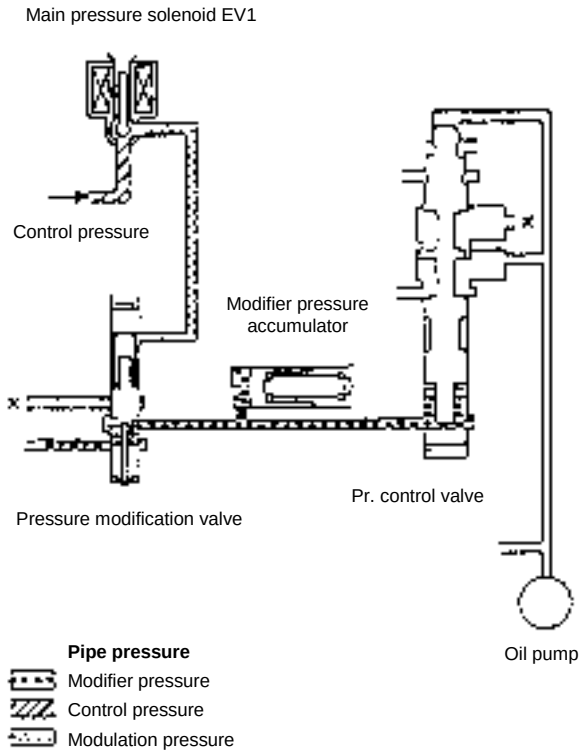
D-N-R gearshifts are only implemented if certain time and engine-speed prerequisites are met. This reduces the jolt on actuating the selector lever beyond the "N" range.

5.6 Stop control for main pressure solenoid valve

If the temperature of the ATF is less than -30°C with the vehicle stationary and the accelerator pedal not pressed, the action of the main pressure solenoid valve N 93 (load control) is brought to a halt. This applies to all gears and ensures smooth operation when the vehicle is stationary at low temperatures.

5.7 Main pressure regulation mechanism

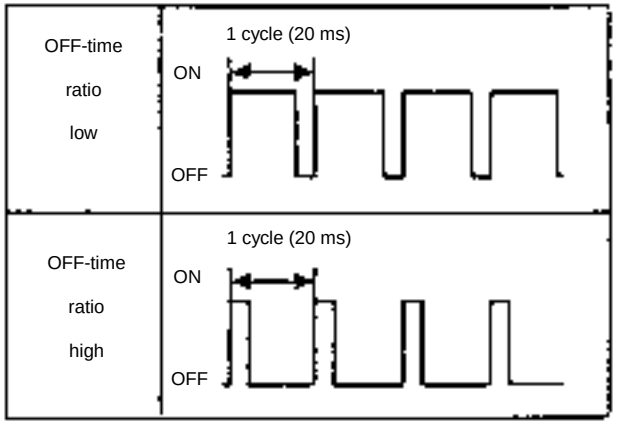
5.7.1 Regulator mechanism



• The pipe pressure is regulated directly by the pressure control valve, the function of which is based on the response to changes in engine torque.
• The pressure specified by the engine torque is determined by the pressure modification valve, the function of which is based on the response to changes in modulation pressure.
• The modulation pressure is determined by the output signal of the main pressure solenoid.
• Changes in modulation pressure accordingly influence the following process changes in the sequence indicated below:
Modulation pressure → Pressure modifier pressure → Pipe pressure. The pipe pressure, on the other hand, is regulated by the main pressure solenoid.

5.7.2

50 Hz pulse signal



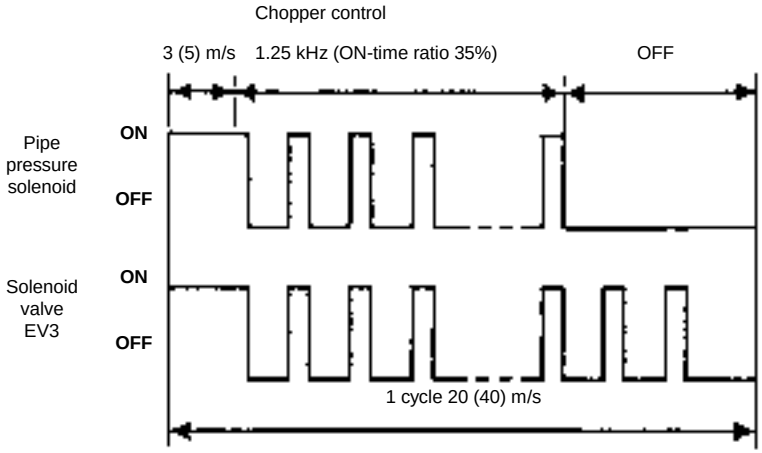
Main pressure and solenoid valve N 93 control

• The modulation pressure is controlled by the output signal of the main pressure solenoid. This solenoid control provides the necessary modulation pressure.
• The main pressure solenoid valve is actuated with an ON/OFF pulse frequency of 50 Hz (1 cycle in 20 ms), thus varying the main pressure.

Note: The value is 25 Hz at an ATF temperature of less than –18 °C.

5.7.3

Schematic view of chopper control



Value in ( ) applies to ATF temperature of less than –18 °C.

Chopper control

The chopper control provides efficient current regulation by fixing the ON/OFF time distribution and operating cycle of the solenoid to reduce the current consumption of the main pressure solenoid and the solenoid valve N 281.

6 Control of Lock-up Clutch Lock-up Control

To ensure quiet operation and a low fuel consumption level, the automatic gearbox 09A/09B is equipped with a lock-up mechanism connected directly to the torque converter. The lock-up mechanism actuates the lock-up clutch integrated into the torque converter. The lock-up control enables the clutch to be engaged and released in line with the lock-up specifications. It acts in response to the prevailing clutch operating conditions.
The lock-up control is also responsible for smooth lock-up control, control of overrun lock-up and control of lock-up prevention.

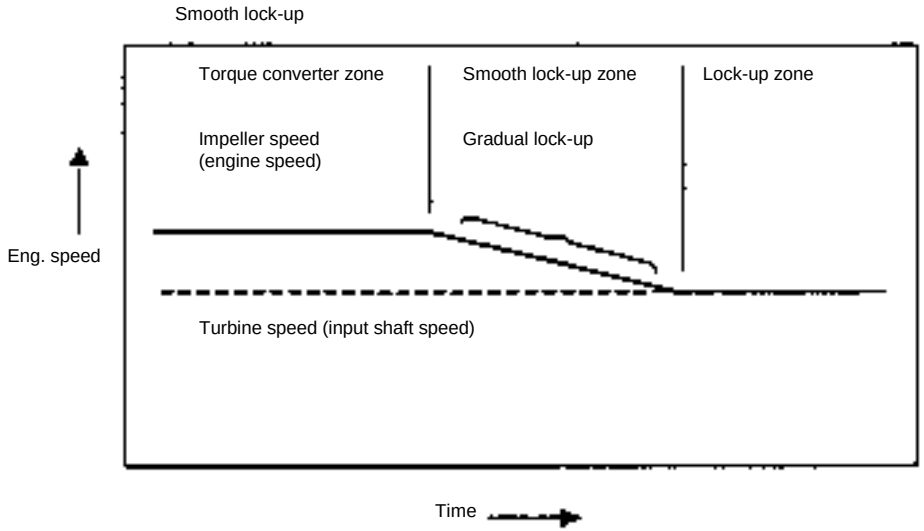
6.1 Basic control

Control of switching between implementation and cancellation of lock-up in (2nd, 3rd), 4th and 5th in line with the respective gear and the lock-up specifications stipulated for the driving mode concerned. The lock-up mechanism can be used in gears D, 4, (3 and 2).

Note: The lock-up mechanism normally only functions in 4th and 5th gear. In exceptional situations (high temperature) it does however also work in 2nd and 3rd gears.

6.2 Smooth lock-up control

Smooth lock-up control reduces the lock-up jolt to a minimum by engaging the lock-up clutch gently and gradually.



6.3 Control of overrun lock-up

Designed to maintain lock-up status even after releasing accelerator pedal in lock-up range when driving at a specific high speed. This precludes the unpleasant sensation which would be caused by repeated switching due to accelerator pedal ON/OFF between implementation and cancellation of lock-up.

6.4 Control of lock-up prevention

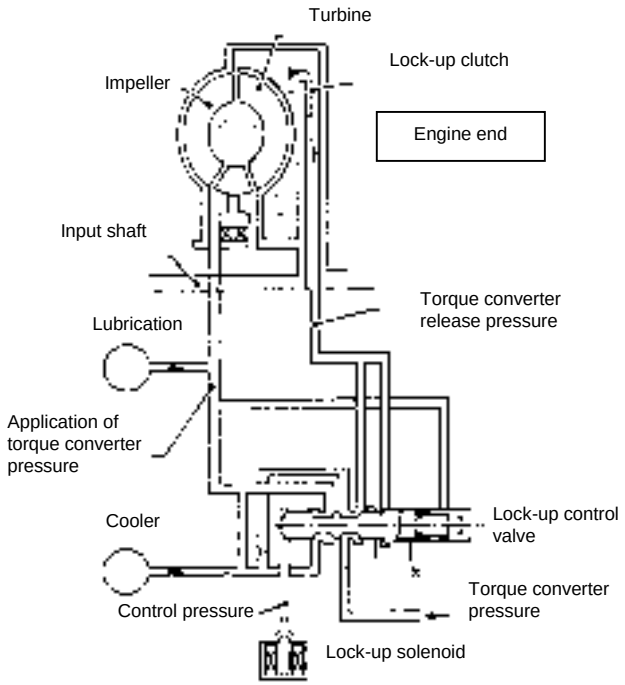
If the temperature of the ATF is less than 40 °C, the lock-up mechanism is disabled even within the lock-up range. Lock-up in ranges 1, P, R and N is also disabled.

7 Lock-up Mechanism

There are three lock-up mechanism statuses (lock-up, no lock-up and smooth lock-up), each of which is described in detail below.

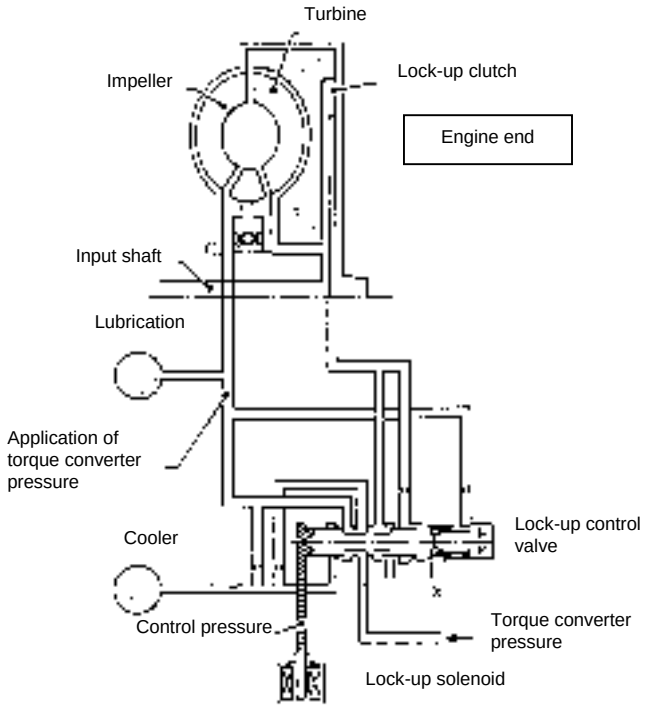
7.1 No lock-up status

The lock-up solenoid is OFF (OFF load ratio approx. 95 %). The status of the fluid pressure ducts is as shown on the right. In this condition, the torque converter release pressure moves the right side of the lock-up clutch away from the torque converter for disengagement. This represents the no lock-up status.



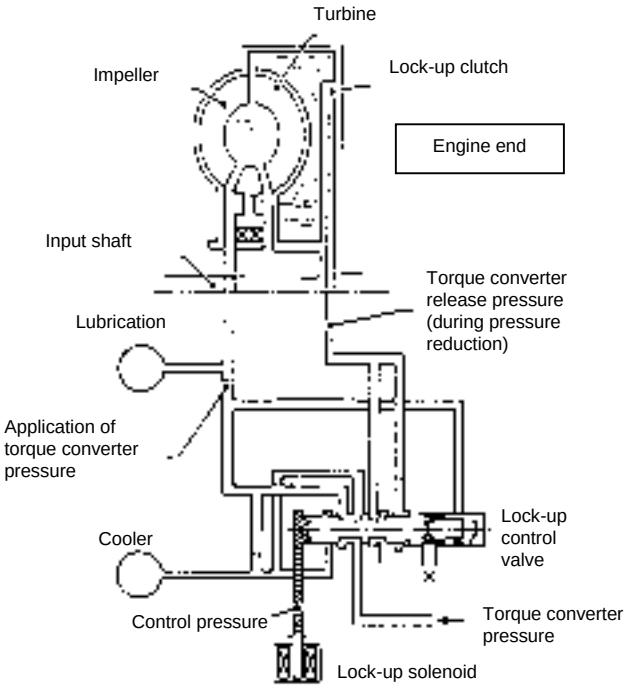
7.2 Lock-up status

The lock-up solenoid is ON (OFF load ratio approx. 5 %). The status of the fluid pressure ducts is as shown on the right. In this condition, the torque converter release pressure can be ignored. The right side of the lock-up clutch moves towards the torque converter and engages. This represents the lock-up status.



7.3 Smooth lock-up status

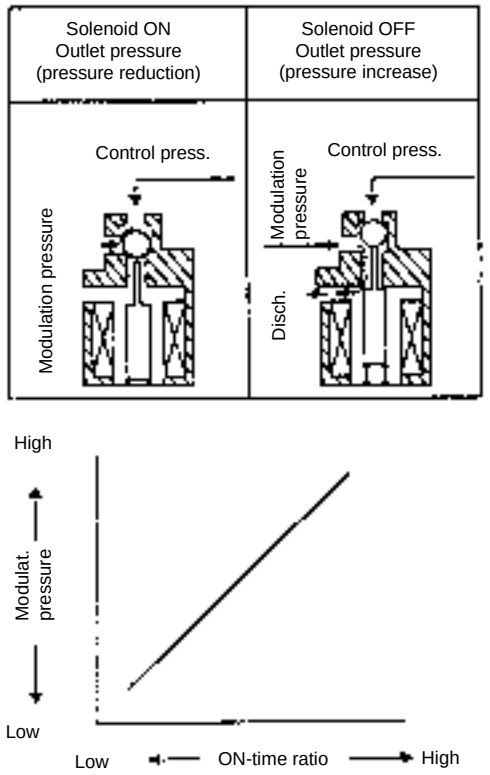
Smooth lock-up refers to the status when the mechanism switches from no lock-up to lock-up. The torque converter release pressure is reduced gradually instead of abruptly to stop the lock-up clutch engaging suddenly. Gentle, gradual clutch engagement reduces the lock-up jolt to a minimum. Gradual reduction of the torque converter release pressure involves the use of a load solenoid in addition to the lock-up solenoid. The lock-up control valve features a pressure regulator, which responds to the release pressure of the torque converter and the solenoid outlet pressure. This leads to a gradual reduction in solenoid outlet pressure. The decreasing OFF load ratio of the solenoid is accompanied by a corresponding drop in torque converter release pressure, thus ensuring smooth engagement of the lock-up clutch.



7.4 Lock-up solenoid valve N 91 drive mechanism

• The lock-up solenoid is a driven power solenoid which is identical to the 50 Hz main pressure solenoid valve N 93.
• The fluid circuit for the solenoid outlet pressure is connected to the through-openings of the main fluid circuit. The outlet pressure increases as soon as the valve in the lock-up solenoid closes the outlet pressure circuit.
• The outlet pressure decreases, on the other hand, if the valve in the lock-up solenoid opens the outlet pressure circuit.
• If the lock-up solenoid is OFF (no flow of current), the circuit is opened. The outlet pressure increases if the solenoid OFF time is greater than the ON time.

Mode of operation of lock-up solenoid

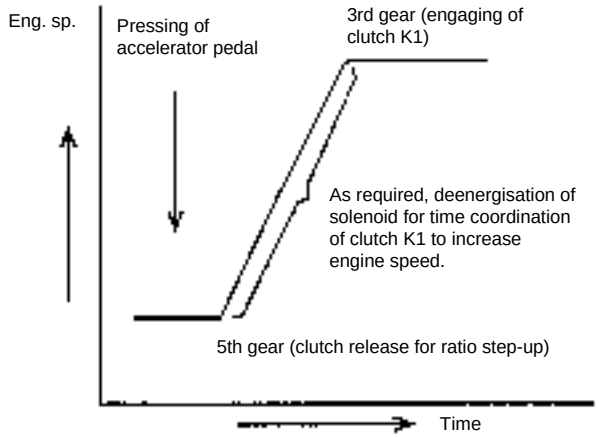


8 Solenoid-controlled Time Coordination for Clutch K1 (N 90)

The solenoid valve for time coordination of the clutch K1 (N 90) has four functions:

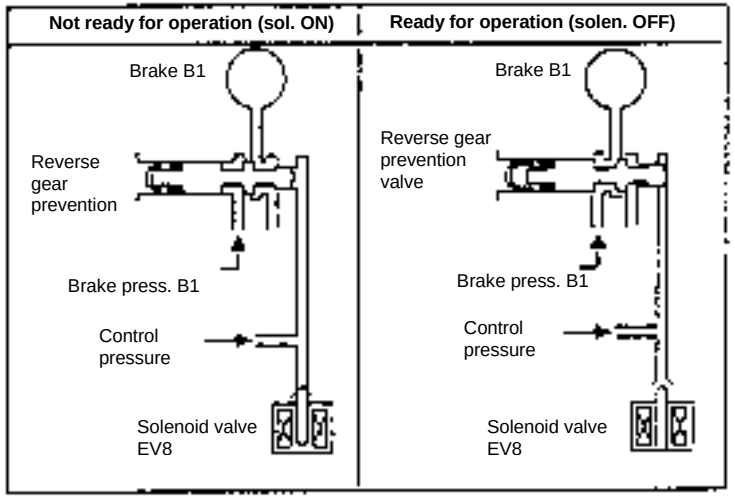
8.1 Gearshift time coordination control

The solenoid valve controls clutch switching (coordination of engage and release times) for every gear change as a function of driving conditions. Example: On shifting down from 5th to 3rd gear in response to pressing of accelerator pedal, brake B2 must be released and the clutch engaged at the same time. Failure to properly coordinate the timing of the two operations will lead to a greater jolt. The pipe pressure is thus controlled by switching the solenoid valve to OFF to delay clutch K1 engagement time with a view to achieving a smooth gear change. The individual time coordination solenoids have a similar function.



8.2 Control of pipe pressure reduction

The reduction process is described in the preceding section on basic pipe pressure control. Control of the fluid pressure before and after reduction is effected by switching the solenoid ON/OFF to coordinate the timing of the clutch K1 (N 90).



8.3 Reverse gear prevention control

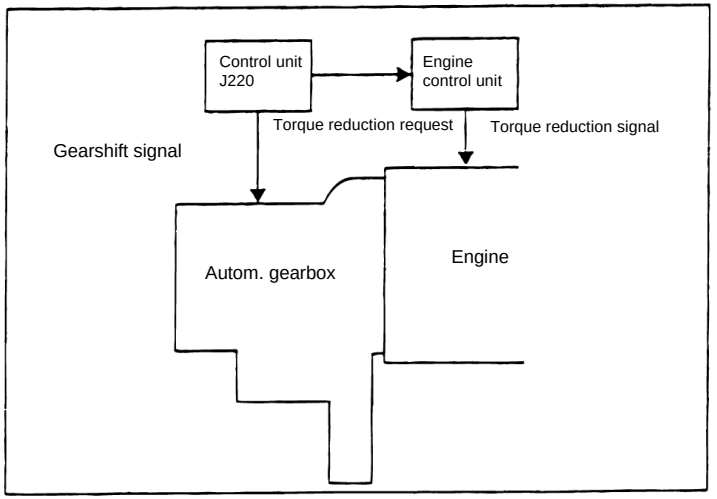
If "R" is selected when travelling forwards, the clutch K1 time coordination solenoid is actuated (status ON) to stop the reverse gear clutch being engaged.

8.4 Idle control ("N") at idling speed

Idle control at idling speed is provided by the clutch K1 time coordination solenoid valve (N 90) and the brake B2 time coordination solenoid valve (N 282).

8.5 Torque reduction control

On changing gear, the engine torque is briefly reduced by this control function to reduce gearshift jolts to a minimum. On gearshift, the control unit simultaneously transmits a message via the CAN to the engine control unit requesting torque reduction. The engine control unit responds by reducing the engine torque. Torque reduction control is implemented on shifting up and shifting down in the ranges D, 4, 3 and 2 as a function of accelerator pedal position and engine torque.



9 Coordination of Gearshift Timing using Gearbox Input Speed Sender G182 and Intermediate Shaft Speed Sender G 265

With the automatic gearbox 09A/09B, not only the intermediate shaft speed (G 265), but also the input shaft speed (G 182 - parking lock gear) inside the automatic gearbox and the spur gear speed of planetary gearbox 3 are measured and entered into the control unit. As both transmission ratios can be calculated with the aid of these three speed sensors, the control unit always recognises the corresponding statuses.

Transmission ratio for planetary gearboxes 1+2 =

Input shaft speed G182	→ Input signal from G 182
Input gear/planetary gearbox 3 speed G68	→ Input signal from G 68

Transmission ratio for planetary gearbox 3 =

Input gear/planetary gearbox 3 speed G68	→ Input signal from G 68
Intermediate shaft speed G265	→ Input signal from road speed sender G 68

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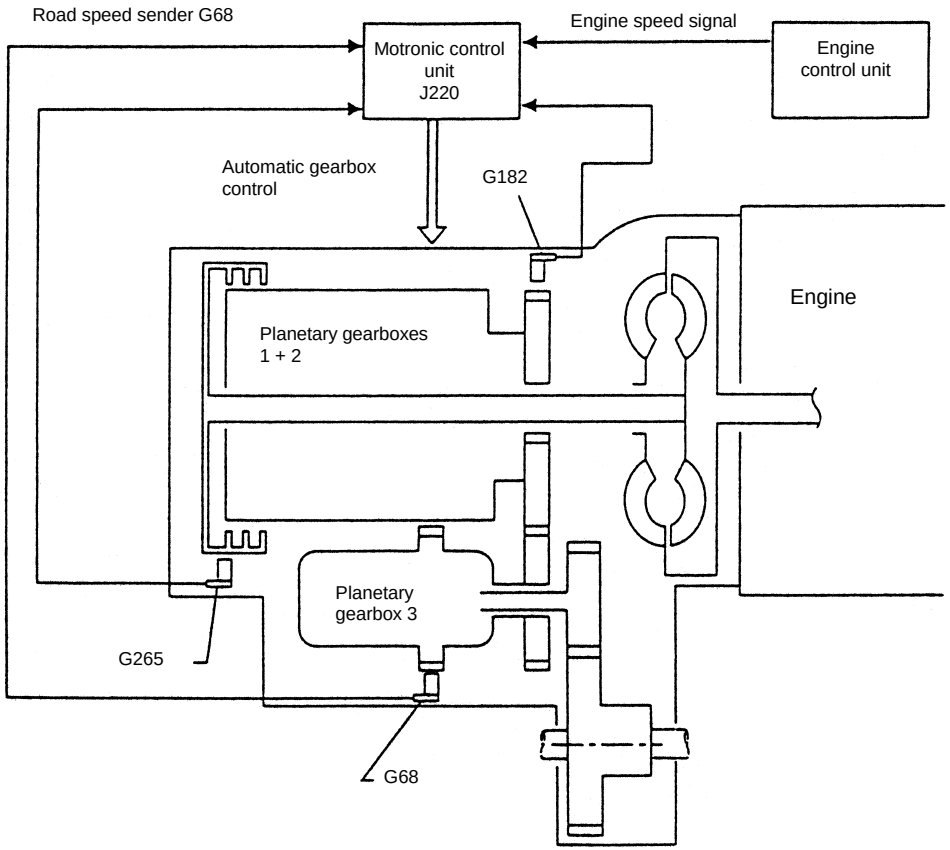


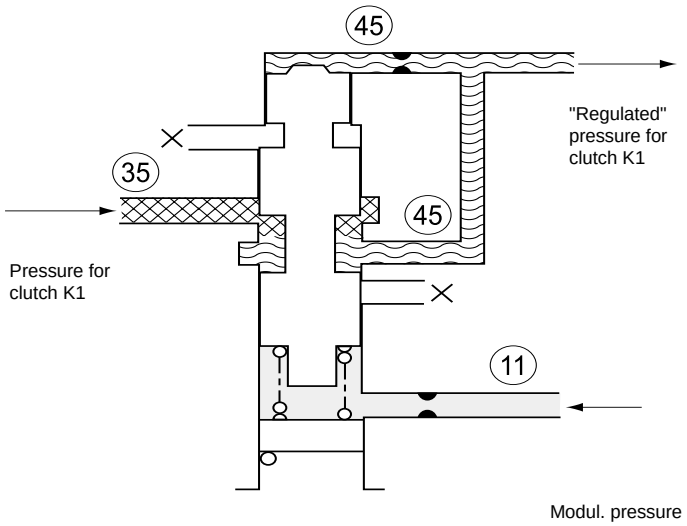
9.1 Idle control valve

General

The idle control valve (which operates in conjunction with the idle selector valve) regulates the pressure of clutch K1 to set the automatic gearbox to neutral if the vehicle comes to a halt with a forward gear engaged (currently only available for vehicles with diesel engine).

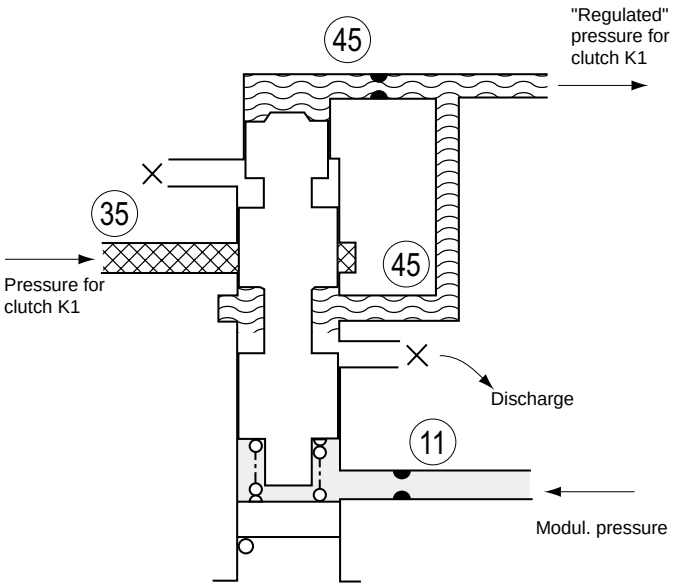
Mode of operation Clutch pressure for ratio reduction

The idle control valve is moved upwards by way of spring force while modulation pressure (11) is applied to the bottom end of the idle control valve.
"Regulated" pressure for clutch K1 (45) is applied to the top end of the idle control valve so that it moves downwards.
The "regulated" pressure for clutch K1 (45) and the modulation pressure are equalised by reducing the pressure for clutch K1.
If the "regulated" pressure for clutch K1 (45) is less than the modulation pressure (11), the idle control valve moves upwards and opens the pressure circuit for clutch K1 (35) as shown in the adjacent illustration. The "regulated" pressure for ratio reduction (45) is then increased by pressure for the clutch K1.
The increase in "regulated" pressure for ratio reduction (45) causes the idle control valve to move downwards, thus closing the pressure circuit for clutch K1 (35) and terminating the application of pressure to the idle control valve.



Clutch pressure for ratio reduction

As soon as the "regulated" pressure for the clutch K1 (45) exceeds the modulation pressure (11), the idle control valve moves downwards and opens the discharge circuit (X) as shown in the adjacent illustration. The "regulated" pressure for the clutch K1 (45) is then dissipated and reduced.
As soon as the "regulated" pressure for the clutch K1 (45) has been reduced, the idle control valve moves upwards and closes the discharge circuit (X).
This then terminates the reduction of the "regulated" pressure for the clutch K1. This process of pressure increase and reduction is repeated to control the "regulated" pressure for the clutch K1 (45) as a function of modulation pressure (11).



9.2 Selector valves A, B and C

General

The selector valves A, B and C act as switching valves. In accordance with the solenoid valve function, these three valves supply pipe pressure to the necessary clutch and brake circuits.
The selector valves A, B and C are employed as a set and regulate the fluid circuits for 1st to 5th gear.

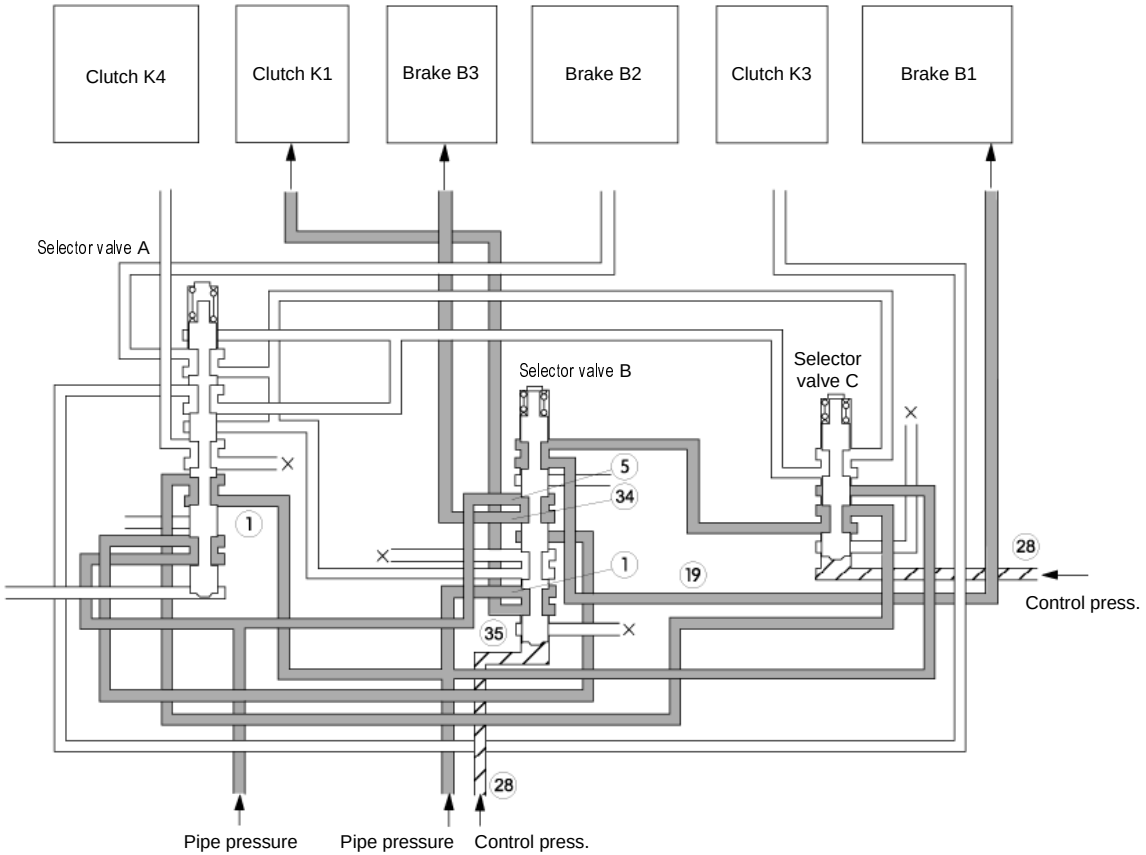
Mode of operation

Spring force is employed for downward movement of the selector valves A, B and C.

9.2.1 1st gear (engine brake in operation)

The solenoid valves are kept in mode for 1st gear (with engine brake).
Control pressure is applied to the bottom end of the selector valves B and C, thus holding selector valves B and C in their upper position.
Selector valve A on the other hand is held in its lower position by means of spring force.
In this status, pipe pressure (1) is routed through selector valve B and applied to clutch K1 (35). Pipe pressure (5) is routed through selector valve B and applied to brake B3 (34).
The pipe pressure (1) acting on selector valve A is also routed via selector valve C through selector valve B and then acts on the reverse gear prevention valve (19).
If selector lever is set to range 2, the pipe pressure (19) being applied to the reverse gear prevention valve is routed through the valve and subsequently acts on the brake for ratio reduction and reverse gear.

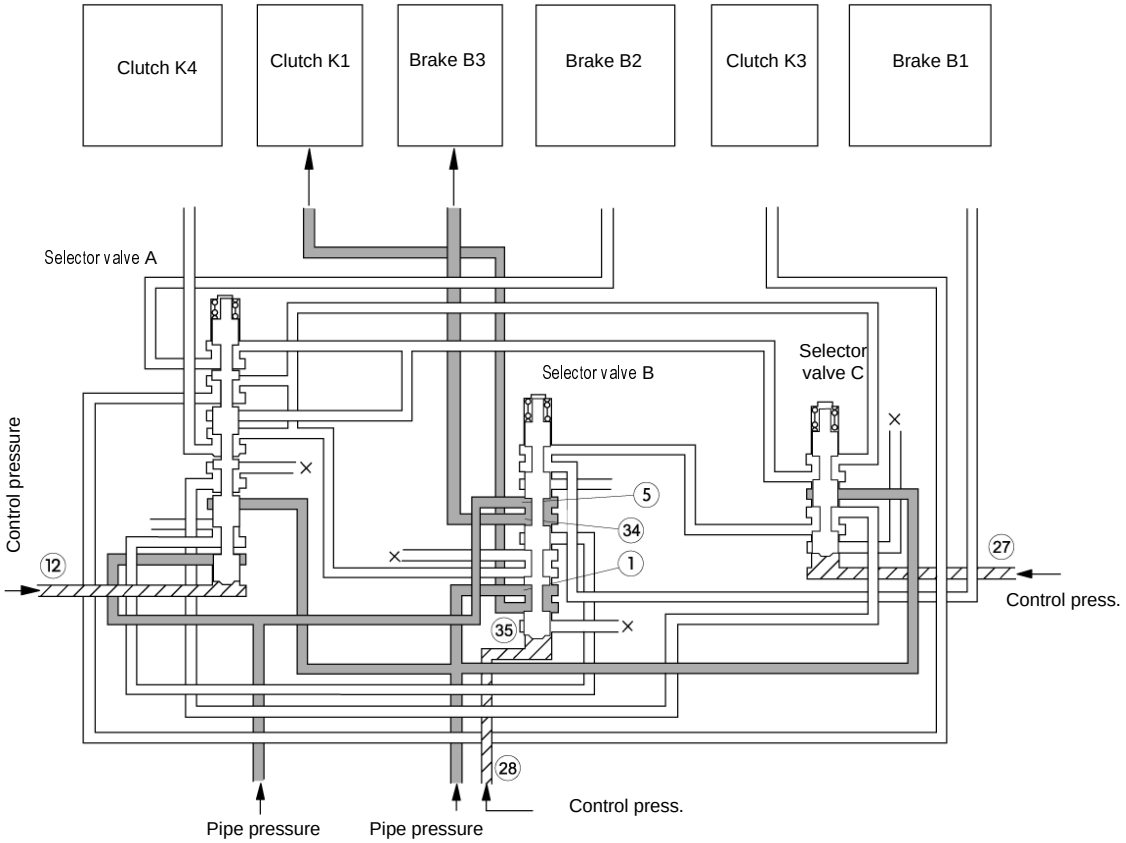
1st gear (engine brake in operation)



9.2.2 1st gear (engine brake not in operation)

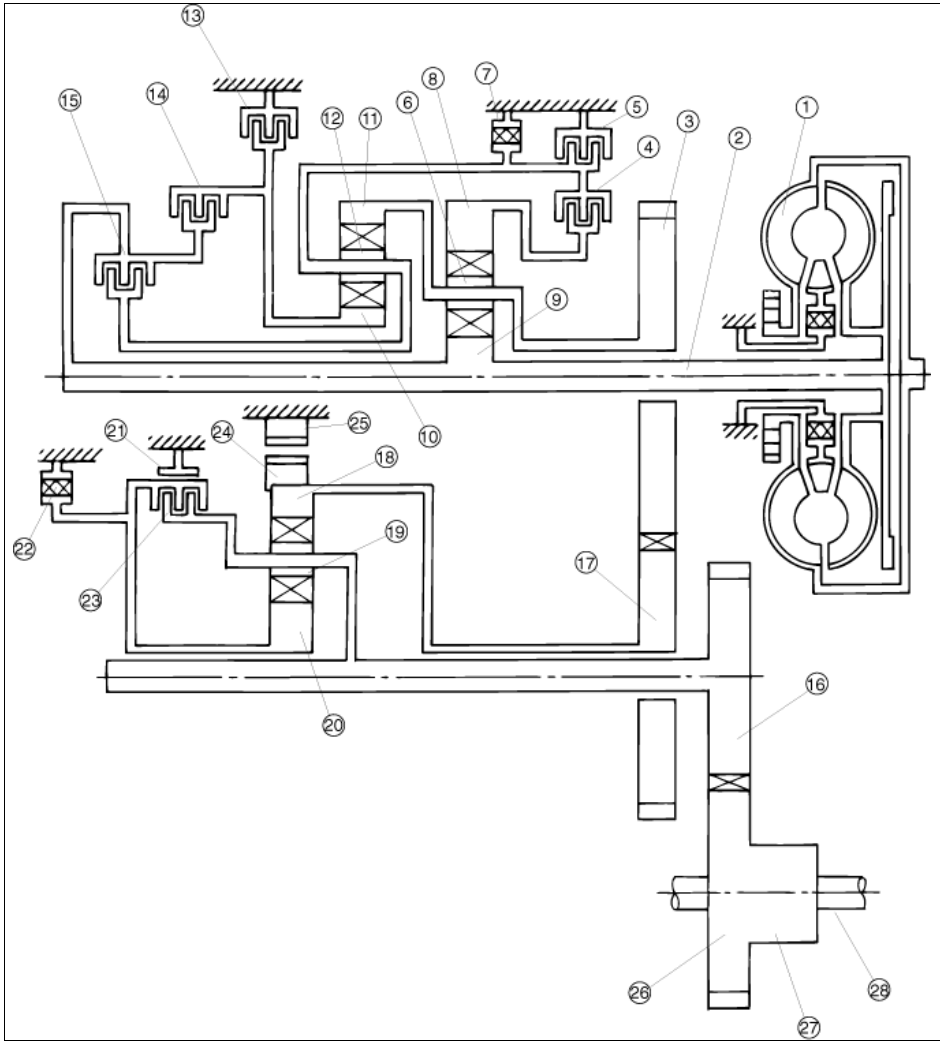
The solenoid valves are kept in mode for 1st gear (without engine brake).
Control pressure is applied to the bottom end of all the selector valves (A, B and C), thus holding the selector valves A, B and C in their upper position.
In this status, pipe pressure (1) is routed through selector valve B and applied to clutch K1 (35). Pipe pressure (5) is routed through selector valve B and applied to the auxiliary gear brake (34).

1st gear (engine brake not in operation)



10 Basic Design

Cross-sectional view of automatic gearbox 09A/09B



(1) Torque converter
(2) Input shaft
(3) Spur gear
(4) Clutch K1
(5) Brake B2
(6) Rear planetary gear
(7) Free-wheel/ratio reduction
(8) Rear ring gear
(9) Rear sun gear
(10) Front sun gear
(11) Front ring gear
(12) Front planetary gear
(13) Brake B2
(14) Clutch K2
(15) Clutch K3
(16) PL 3
(17) Input/planetary gearbox 3
(18) Input/ring gear/planetary gearbox 3
(19) Input/planetary gear train/planetary gearbox 3
(20) Input/sun gear/planetary gearbox 3
(21) Input/brake band B 3/planetary gearbox 3
(22) Input/free-wheel/planetary gearbox 3
(23) Clutch K4
(24) Parking lock gear
(25) Parking lock ratchet
(26) Final drive gear
(27) Differential
(28) Input shaft

11 Clutch and Brake Functions

Clutch K2	Engages in range R. Connected to input shaft and front sun gear.
Clutch K3	Engages in 3rd, 4th and 5th gear. Connected to input shaft and front planet carrier.
Clutch K1	Engages in 1st, 2nd and 3rd gear. Connected to PL 1 planet carrier and rear ring gear.
Clutch K4	Engages in 5th gear. Connected to PL 3 planet carrier and PL 3 sun gear.
Brake B1	Engages in 1st gear and range R. Prevents rotation of front planet carrier.
Brake B2	Engages in 2nd, 4th and 5th gear. Prevents rotation of front sun gear.
Brake B3	Engages in 1st, 2nd, 3rd and 4th gear, as well as range R. Prevents rotation of PL 3 sun gear.
Free-wheel/Coupled planetary gearbox	Engages in 1st gear. Prevents rotation of PL 1 planet carrier as vehicle starts to move forwards. Rotates in free-wheel with decreasing road speed.
Free-wheel/ Reduction	Engages in 1st, 2nd, 3rd and 4th gear. Prevents rotation of PL 3 sun gear as vehicle starts to move forwards. Rotates in free-wheel with decreasing road speed.

Trainer Information, 5-Speed Automatic Gearbox 09A/09B, 7.02 (GB)

Clutch and brake action in range

o = In operation Δ = In operation in 2nd gear

Range			K2	K3	K1	K4	B1	B2	B3	Free-wheel 1	Free-wheel 3	Vehicle status
P									o			Parked
R			o				o		o			Reversing
N									o			Neutral
2WD	D 4 3 2	1st			o		Δ		o	o	o	D:1↔2↔3↔4↔5 4: 1↔2↔3↔4←5 3: 1↔2↔3←4←5 2: 1↔2←3←4←5
		2nd			o			o	o		o	
		3rd		o	o				o		o	
		4th		o				o	o		o	
		5th		o		o		o				

12 Transmission Functions

Range P

• Neither clutches nor brakes are engaged in range P. No drive power is transmitted to the gearbox. In range P the parking lock ratchet engages in the teeth of the parking lock gear. The parking lock gear is mechanically connected to the idler, thus blocking the drive train.

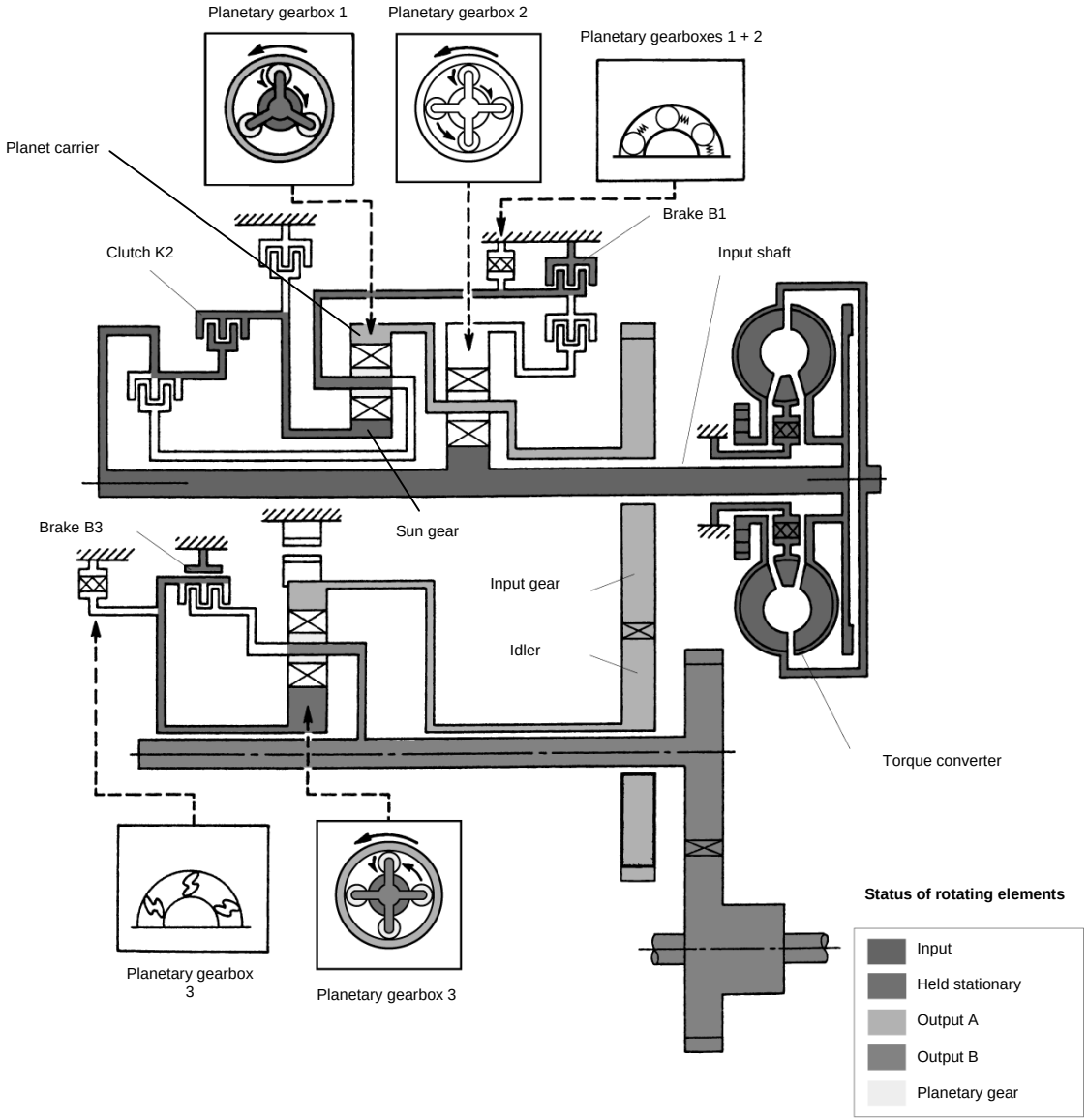
Range N

• Neither clutches nor brakes are engaged in range N. No drive power is transmitted to the gearbox. The configuration in range N is however not the same as that in range P. In range N the parking lock gear is free to turn and the drive train is thus not blocked.

Range R

• Clutch K2, brake B1, reverse gear and brake B3 are engaged in range R. The drive power is conveyed from the input shaft to the reverse gear clutch and the PL 1 sun gear. Planet carrier 1 is locked as brake B1 is engaged. This means that planet carrier 1 is held stationary when the PL 1 sun gear rotates in clockwise direction. However the PL 1 planetary gears then turn anti-clockwise. This forces the front ring gear to turn anti-clockwise as well. The same applies to the spur gear A. The rotation of the spur gear is transmitted via the idler to the PL 3 ring gear. As the brake locks the PL 3 sun gear, the planet carrier rotates in the opposite direction to that for the forward gear ranges and thus transmits the drive power to the input gears.

Range R

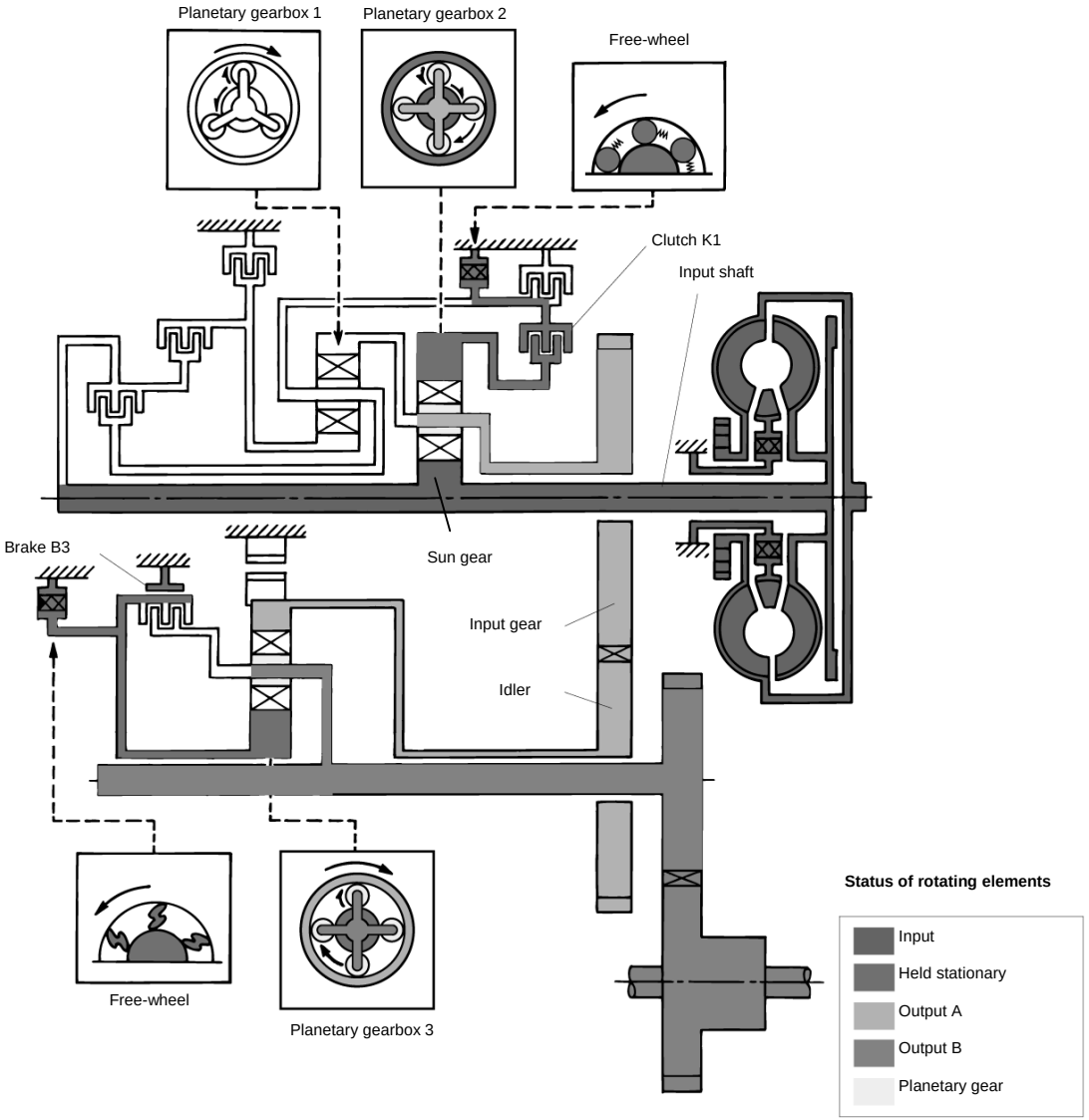

Planetary gearbox 1
Planetary gearbox 2
Planetary gearboxes 1 + 2
Planet carrier
Brake B1
Clutch K2
Input shaft
Brake B3
Sun gear
Input gear
Idler
Torque converter
Planetary gearbox 3
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

1st gear

• Clutch K1 and brake B3 are engaged when 1st gear is active. Free-wheel 1 and the PL 3 free-wheel are locked on accelerating in 1st gear. The drive power is transmitted by the input shaft, the PL 2 sun gear turns clockwise and the PL 2 planetary gear train turns anti-clockwise. The ring gear thus attempts to turn anti-clockwise. However, as the ring gear is connected via the clutch K1 for ratio reduction to the free-wheel 1, the PL 2 ring gear cannot turn. Accordingly, the PL 2 planet carrier and the spur gear turn clockwise. The rotation of the spur gear is then transmitted via the idler to the PL 3 ring gear. As the PL 3 sun gear is locked by the B3 brake, the
PL 3 planetary gear train turns clockwise, allowing the PL 3 planet carrier to turn clockwise at the same time. Consequently, PL 3 turns clockwise and transmits the drive power to the input gears.

PL 1 = Planetary gearbox 1 • PL 2 = Planetary gearbox 2 • PL 3 = Planetary gearbox 3

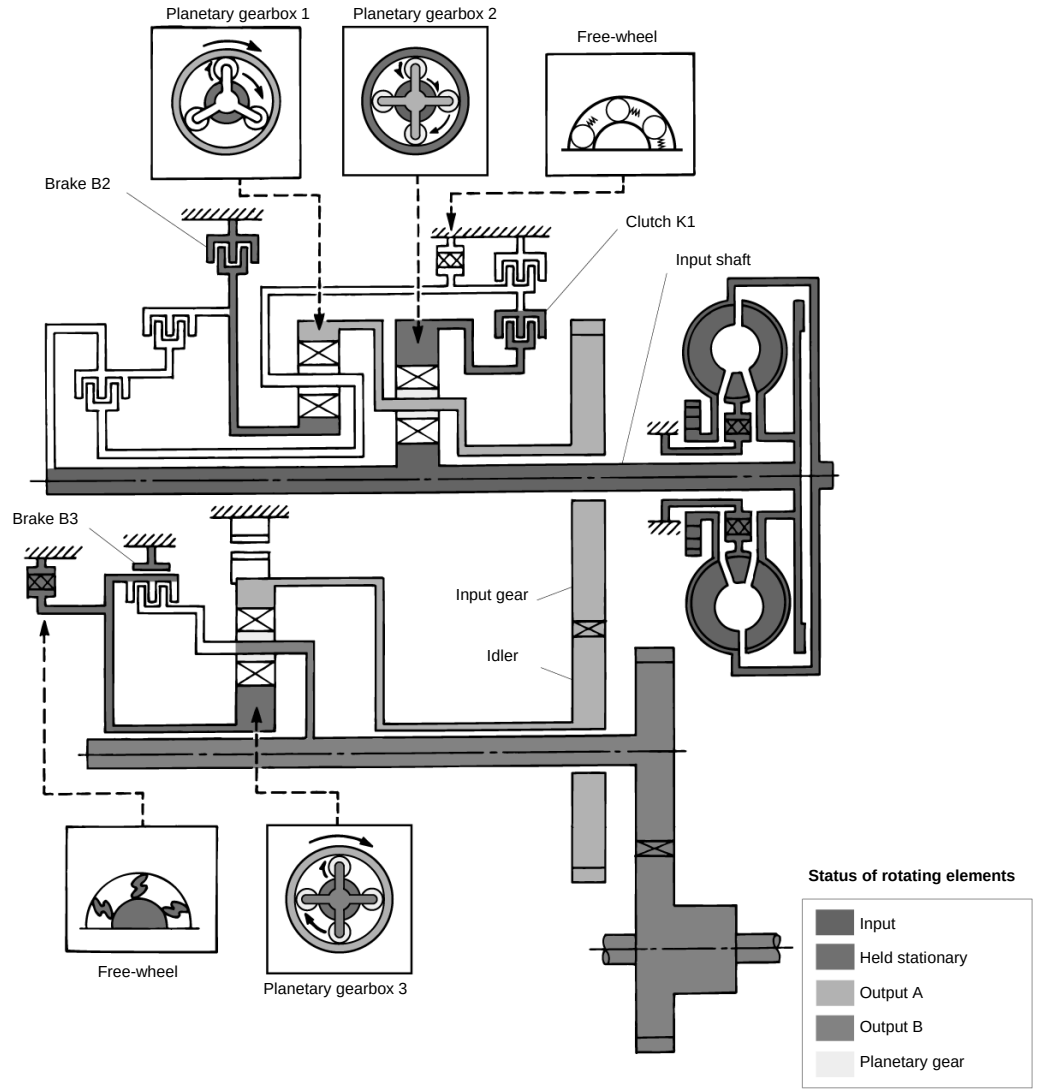
1st gear


Planetary gearbox 1
Planetary gearbox 2
Free-wheel
Clutch K1
Input shaft
Brake B3
Sun gear
Input gear
Idler
Free-wheel
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

2nd gear

• Clutch K1, brake B2 and brake B3 are engaged when 2nd gear is active in forward gear ranges. PL 3 free-wheel is locked on accelerating in 2nd gear. The drive power is transmitted by the input shaft, the PL 2 sun gear turns clockwise and the PL 2 planetary gear train turns anti-clockwise. As with 1st gear, the PL 1 planet carrier thus turns clockwise. The PL 1 sun gear is locked by brake B2 when 1st gear is active. This means that the PL 1 planetary gear train turns clockwise so that the PL 1 planet carrier rotates in clockwise direction. This drive power turns the PL 1 ring gear clockwise and the spur gear turns more quickly on account of the rotation of the PL 1 ring gear. The rotation of the spur gear A is transmitted to PL 3 and then to the input gears.

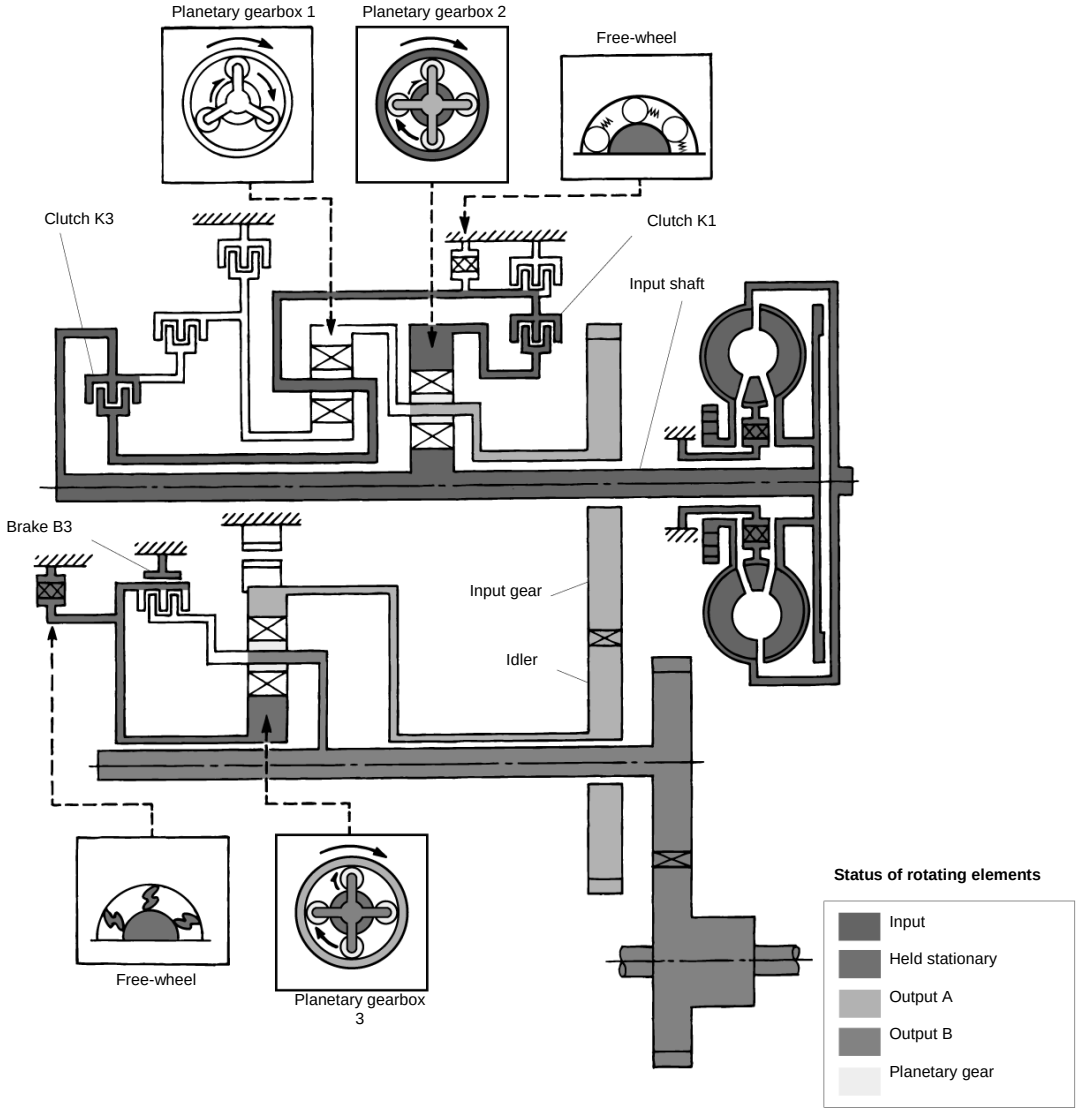
2nd gear


Planetary gearbox 1
Planetary gearbox 2
Free-wheel
Brake B2
Clutch K1
Input shaft
Brake B3
Input gear
Idler
Free-wheel
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

3rd gear

• Clutch K3, clutch K1 and brake B3 are engaged when 3rd gear is active in forward gear ranges. The free-wheel is locked on accelerating in 3rd gear. The drive power is conveyed by the input shaft and transmitted via the clutch K3 to the PL 1 planet carrier, which turns clockwise. As the PL 1 planet carrier is connected by means of the clutch K1 to the PL 2 ring gear, the PL 2 ring gear rotates at the same speed as the input shaft.
On the other hand, the PL 2 sun gear turns clockwise, as it is connected to the input shaft. In other words, the PL 2 sun gear and PL 2 ring gear rotate in clockwise direction at the same speed, the PL 2 planetary gear train does not turn and the PL 2 planet carrier rotates in the same direction (clockwise) and at the same speed as the input shaft.
The rotation of the PL 2 planet carrier is transmitted by way of spur gear, idler, PL 3 ring gear and PL 3 planet carrier to the PL 3 and then to the input gears in the same manner as for 1st and 2nd gear.

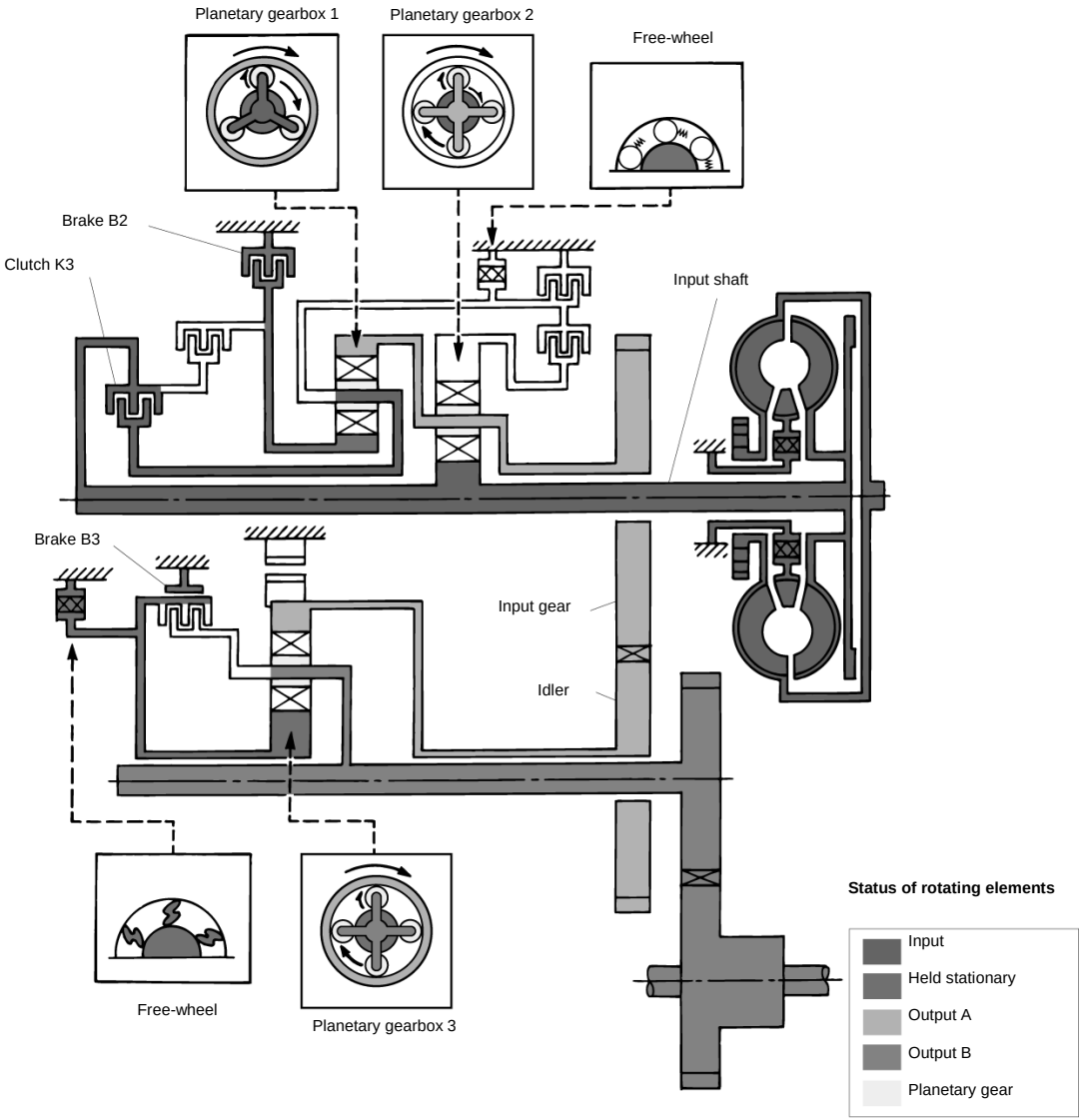
3rd gear


Planetary gearbox 1
Planetary gearbox 2
Free-wheel
Clutch K3
Clutch K1
Input shaft
Brake B3
Input gear
Idler
Free-wheel
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

4th gear

• Clutch K3, brake B2 and brake B3 are engaged when 4th gear is active in forward gear ranges. The PL 3 free-wheel is locked on accelerating in 4th gear. The drive power is conveyed by the input shaft and transmitted via the clutch K3 to the PL 1 planet carrier, which turns clockwise. As the PL 1 sun gear is locked by the brake B2, the PL 1 planetary gear train turns clockwise, thus allowing the PL 1 planet carrier to rotate in clockwise direction at the same time. This drive power turns the PL 1 ring gear clockwise and is transmitted by way of the spur gear and idler to the PL 3 ring gear. Due to the rotation of the PL 2 ring gear, the speed (drive power) of the PL 1 planet carrier is higher than in 3rd gear. It is transmitted to the input gears in the same manner as for 1st gear.

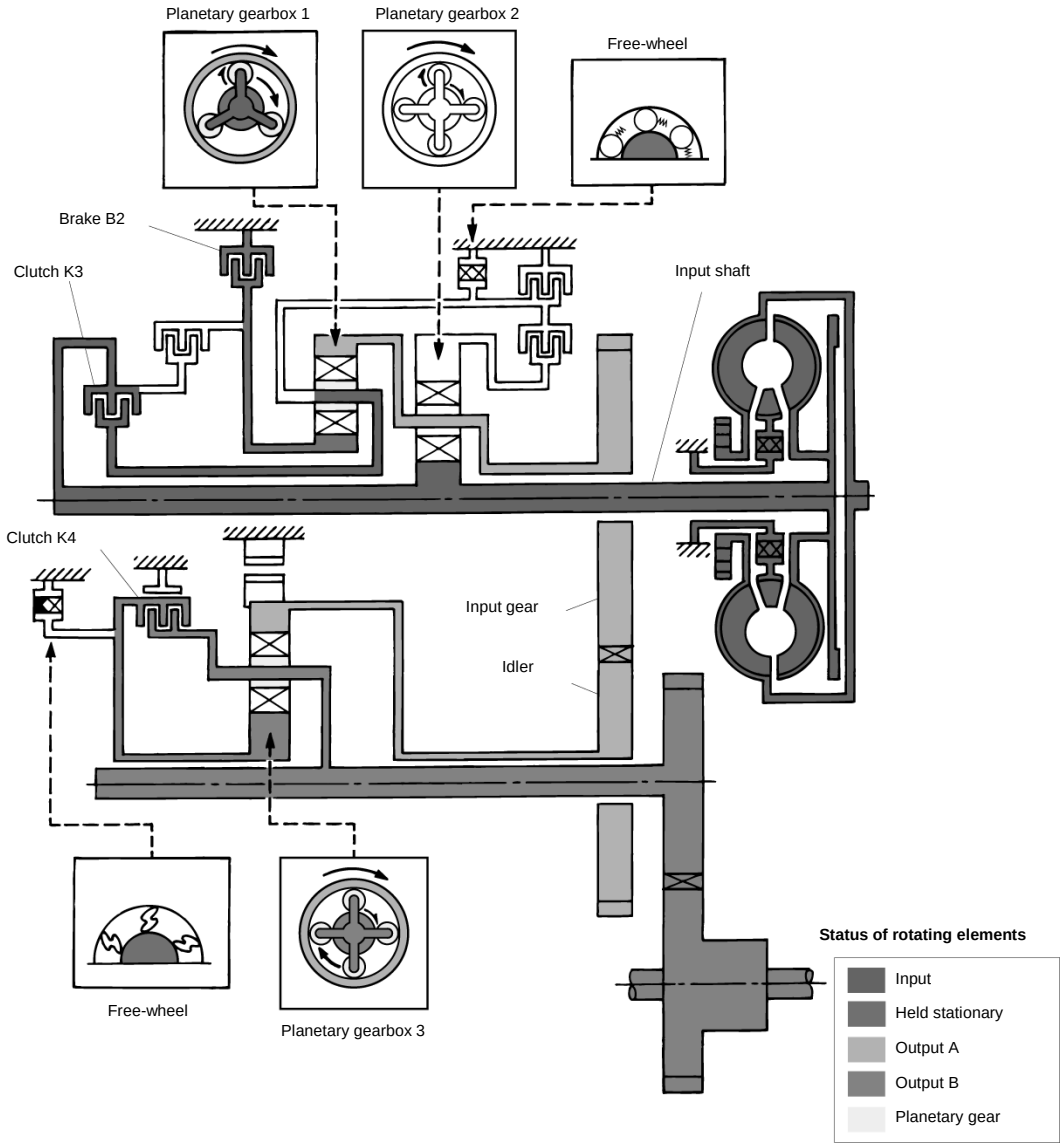
4th gear


Planetary gearbox 1
Planetary gearbox 2
Free-wheel
Brake B2
Clutch K3
Input shaft
Brake B3
Input gear
Idler
Free-wheel
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

5th gear

• Clutch K3, clutch K4 and brake B2 are engaged when 5th gear is active in forward gear ranges. The drive power is conveyed by the input shaft and transmitted via the clutch K3 to the PL 3 ring gear in the same manner as for 4th gear. This drive power is transmitted via the clutch K4 to the PL 3 sun gear and then to the input gears.

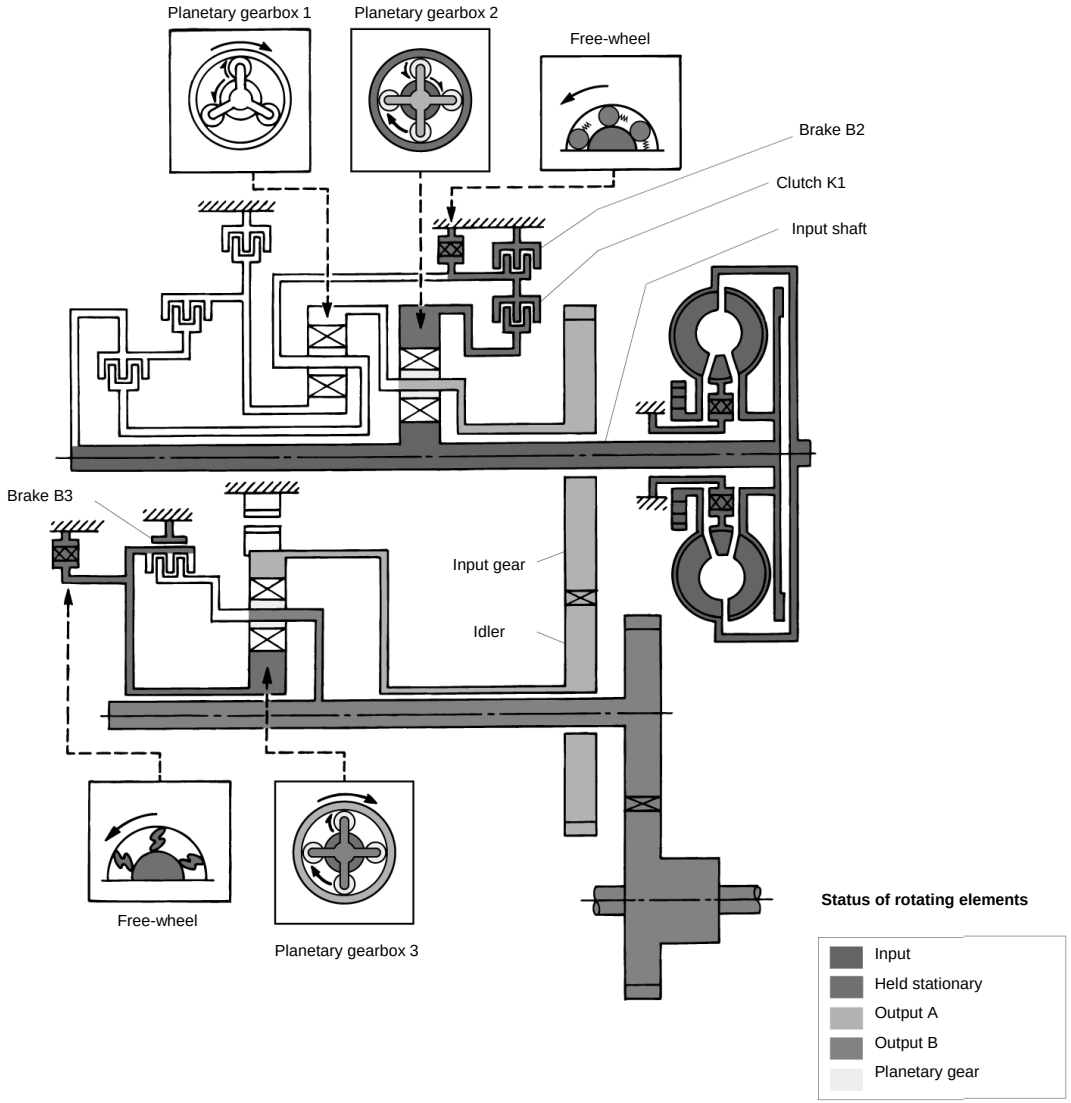
5th gear


Planetary gearbox 1
Planetary gearbox 2
Free-wheel
Brake B2
Clutch K3
Input shaft
Clutch K4
Input gear
Idler
Free-wheel
Planetary gearbox 3
Status of rotating elements
Input
Held stationary
Output A
Output B
Planetary gear

1st gear (range 2) with engine brake

• Clutch K1, brake B2 and brake B3 are engaged when 1st gear is active. Both free-wheels operate in locking direction on accelerating in 1st gear.
The drive power is transmitted in the same manner as for 1st gear in range D.
Engine braking is however implemented in overrun mode as brake B2 and reverse gear are active.

1st gear (range 2) with engine brake



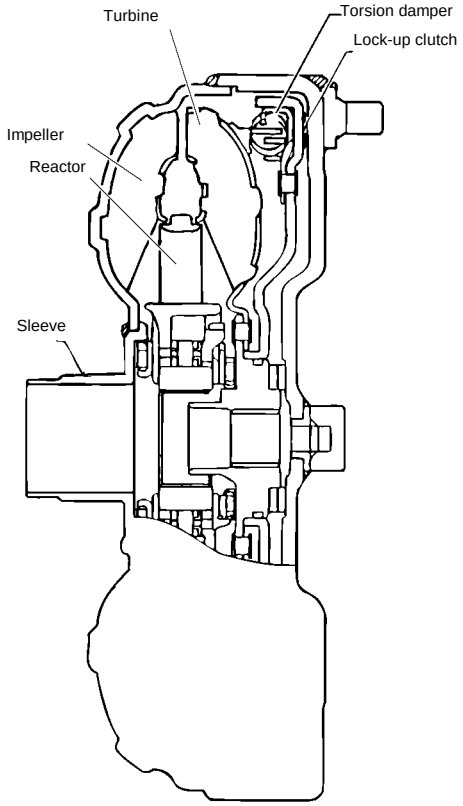
13. Main Components

The following sections deal with the main components of the automatic gearbox and the electronic control system and their interaction.

13.1. Automatic gearbox unit

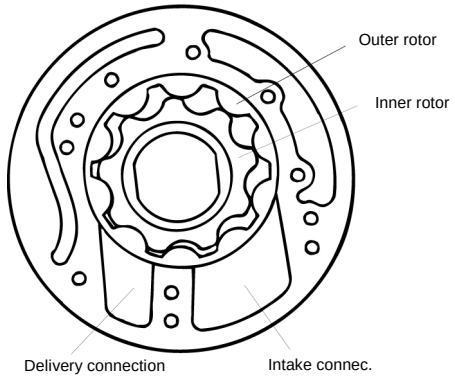
13.1.1 Torque converter with lock-up mechanism

• The torque converter transmits the engine drive power to the gearbox. If the lock-up clutch is not engaged, power output takes place by way of the ATF. If it is engaged, the engine power is transmitted to the gearbox through the lock-up clutch.
• The automatic gearbox 09A/09B makes use of a single-stage two-phase torque converter with symmetrical elements.
• The 3 symmetrical elements (impeller, turbine and reactor) are shown in the adjacent illustration. This clearly shows the symmetrical layout of the 3 elements.
• The term "single-stage" refers to the fact there is only one turbine assembly.
• The term "two-phase" refers to the turbine speed in relation to the impeller speed. If the turbine speed is lower than the impeller speed, the mechanism acts as a simple torque converter. If, on the other hand, the turbine speed is greater than the impeller speed, the mechanism operates like a fluid coupling.



13.1.2 Oil pump

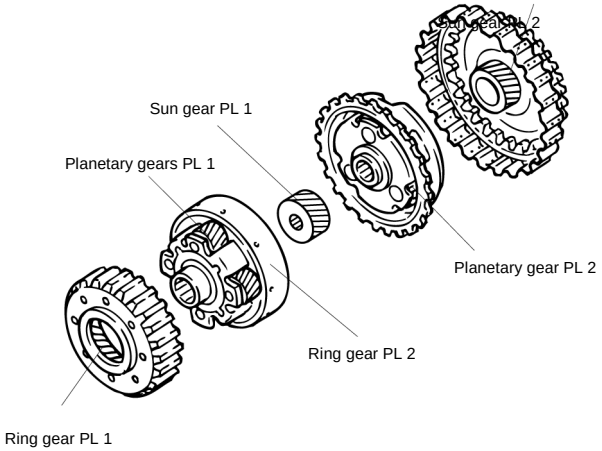
• A rotary-type oil pump is used for the automatic gearbox 09A/09. The advantage of such a pump is that there is very little loss of efficiency.
• The pump is driven by the engine. The inner rotor is connected to the torque converter sleeve.



13.1.3 Planetary gearbox

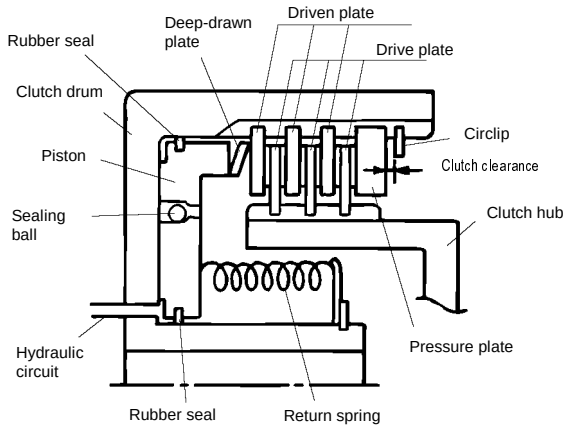
The planetary gearbox consists of sun gear, planetary gears, planet carrier and ring gear.
Definition of components

- Sun gear: The sun gear is located in the centre.
- Planetary gear: The rotating planetary gear is meshed with the sun gear and rolls around it.
- Planet carrier: The planet carrier rotates in order to guide the planetary gears.
- Ring gear: The ring gear is located on the outside of the planetary gears and is always meshed with them. It rotates on the same axis as the sun gear.



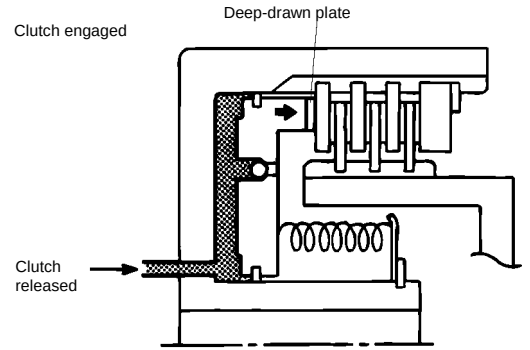
13.1.4 Clutch

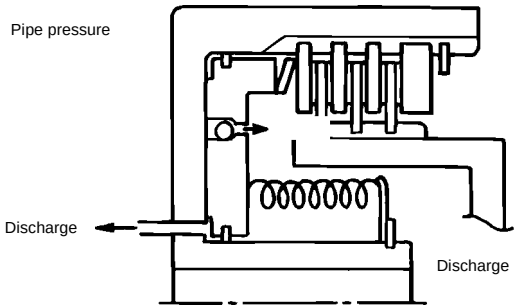
• The automatic gearbox 09A/09B has 4 integrated multi-plate wet-type clutches (clutch K1, clutch K2, clutch K3 and clutch K4). The design and mode of operation of the clutch are outlined in the adjacent illustration.
• Each clutch has two rotating primary elements (clutch drum and clutch hub). Transmission is effected and controlled by these two components.
The clutch drum and clutch hub are connected to a clutch plate. Pressure acting on the clutch plate produces transmission. Without pressure application, a clutch plate is not able to provide transmission.
• The main clutch components are shown in the adjacent illustration. The clutch plates on the clutch drum end are driven plates, whereas those on the clutch hub end are drive plates. The edges of the clutch plates are provided with friction materials. The pressure plate is attached to the driven plate and also acts as a spacer when the clutch is not engaged. It ensures compliance with the prescribed clutch clearance.



• The clutch is engaged as soon as fluid pressure is applied to the piston in the clutch drum. The deep-drawn plate acts as a cushion designed to prevent the sudden intense application of force to the clutch plates and thus the possibility of rough clutch engagement.
• The force of the return spring moves the piston back to its normal position on relieving the fluid pressure via the discharge port. The clutch is released in this manner.

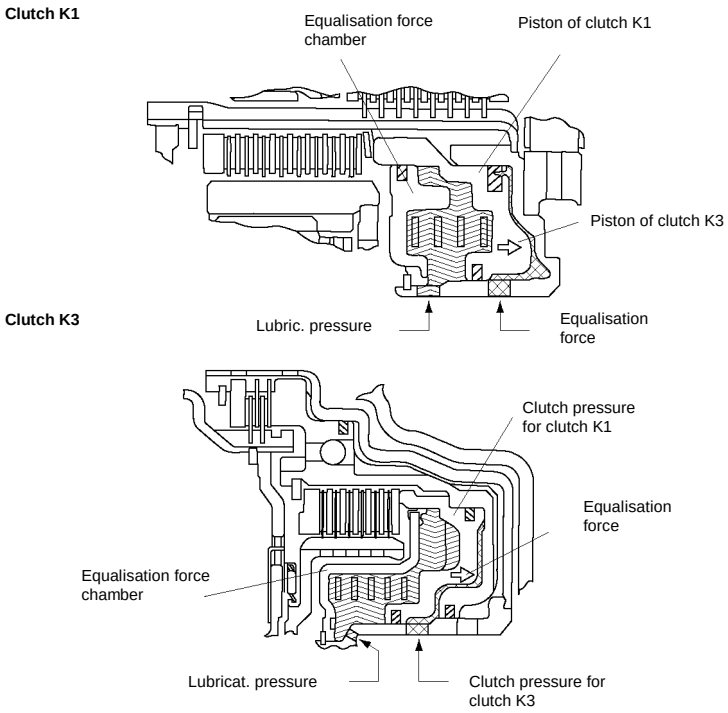
• When the clutch is engaged, the fluid circuit is automatically sealed off by the sealing ball through the fluid pressure acting against the fluid inlet bore. As soon as the clutch is released, the sealing ball at the inlet bore is retracted and opens up the circuit, thus enabling air to enter the fluid chamber. This stops residual fluid pressure forming in the clutch drum.
• The clutch drum and clutch hub are each connected to a planetary gear train. The rotation of the planetary gear trains acts as a clutch control function.
• Further details on the operation of the individual clutches can be found in the "Gearshift Mechanism" section.





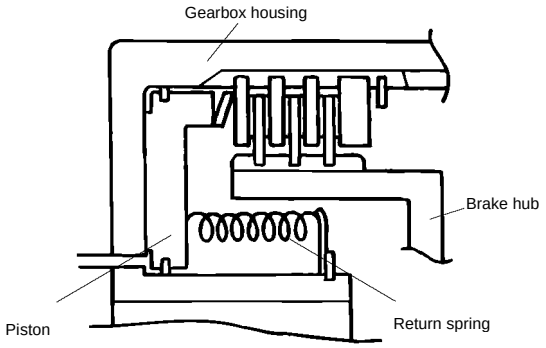
Clutches with centrifugal-force pressure equalisation

• Clutches K1 and K3 of the automatic gearbox 09A/09B are provided with a centrifugal equalisation chamber for the fluid pressure.
This chamber improves the clutch release time by applying force to clutches K1 and K3.
• As opposed to the sealing ball method, this system enhances the operating behaviour of the piston.
Centrifugal force from the pressure chamber on the other side of the piston cylinder causes the piston to return to its original position.
This improves the response behaviour of the clutch release process and results in rapid gear change.



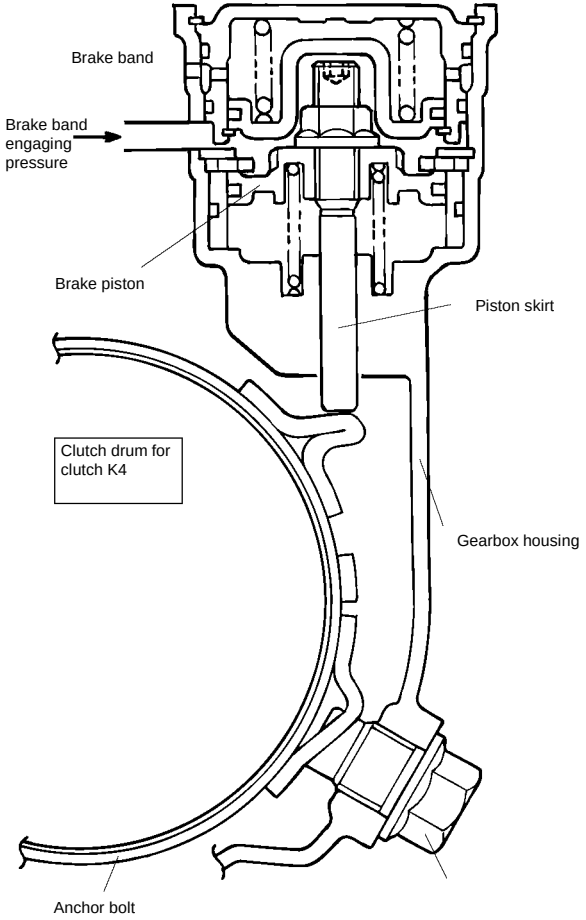
13.1.6 Brakes B1 and B2

• Brakes B1 and B2 are multiple-disc brakes, the basic operating principle of which is similar to that of the multi-plate clutches. The clutch drum is installed at a suitable location at the gearbox housing. The function of the brakes is to stop the clutch hub rotating when the clutch plate is engaged.



13.1.7 Brake B3

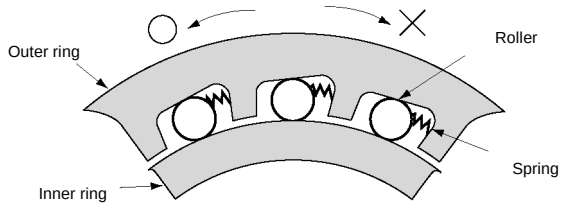
• The brake band responds to the servo actuator and stops the clutch drum for K3 rotating.
• The servo actuator is provided with a piston, which operates as a function of changes in fluid pressure. The piston extends in ranges P and N in 1st, 2nd, 3rd, 4th and reverse gear and thus stops the clutch drum for K3 rotating.
• The servo piston starts to operate as soon as the pipe pressure reaches the band servo actuator. The downward piston stroke causes the piston skirt to tension the brake band.
Clutch K3 stops rotating.
• The function of the anchor bolt is to maintain the necessary clearance between brake band and clutch drum as soon as the brake band is released. This clearance can be set by way of the adjusting nut at the anchor bolt.



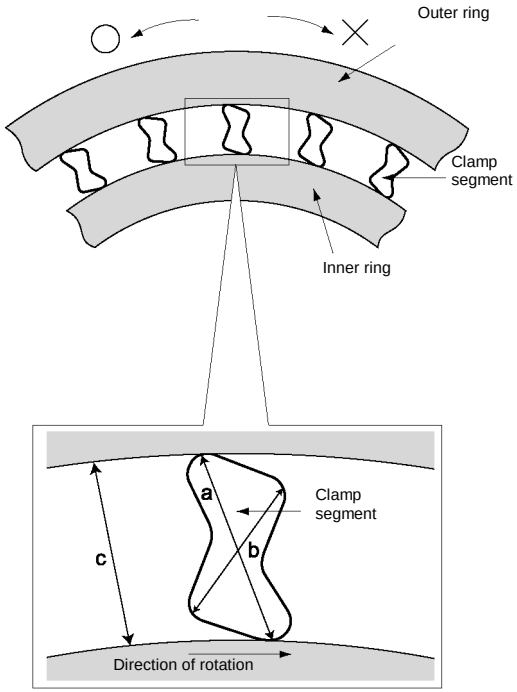
13.1.7 Free-wheel/planetary gearboxes I and III

• Use is made on the automatic gearbox 09A/09B of a clamp-roller free-wheel for the clutch K1 and a clamp-segment free-wheel for the brake B3.
• Free-wheel/planetary gearbox I
The PL 1 planet carrier is fixed in position by the inner ring which is idling in 1st gear.
• Free-wheel/planetary gearbox III
The PL 3 sun gear is fixed in position by the inner ring which is idling is 1st, 2nd, 3rd and 4th gear.
[Clamp-roller free-wheel]
• Energy is normally applied towards the narrower side of the rollers by a spring. In the direction in which they are engaged between the cam and inner ring, the rollers thus form a unit for torque transmission together with these two components. As in the opposite direction the rollers move towards the larger gap, clearance develops between the inner and outer rings, which can thus rotate in opposite directions.
[Clamp-segment free-wheel]
• The difference between the clamp segment diameters "a" and "b" is apparent. If the inner ring attempts to turn to the right, diameter "a" (which is longer than the gap "c") causes the segment to be clamped and prevented from moving to the left.

Clamp-roller free-wheel

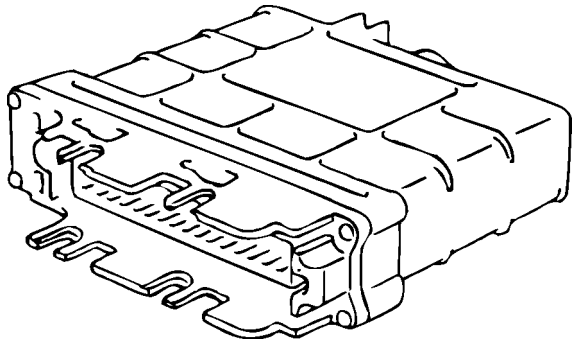


Clamp-segment free-wheel



13.1.8 Automatic gearbox control unit

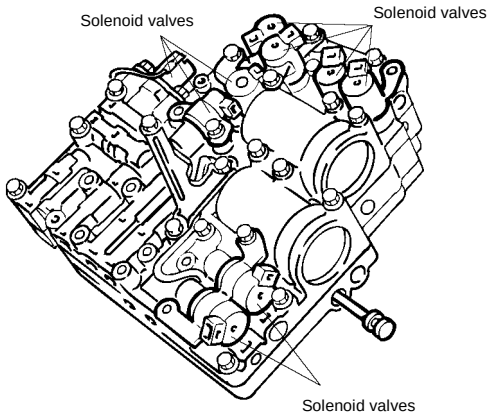
• The control unit regulates the solenoid valves on the basis of the input signals and operates the automatic gearbox.

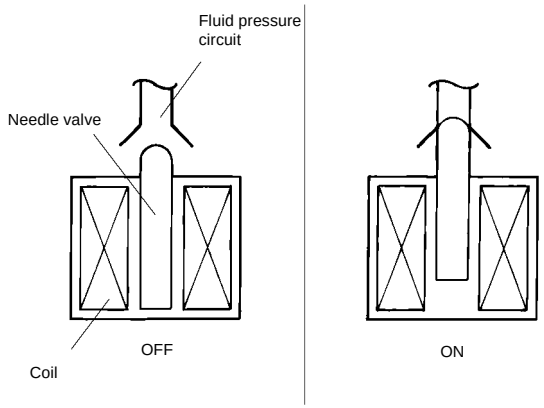


13.1.9 Solenoid

• The automatic gearbox 09A/09B has 9 solenoids (control elements) which are actuated by control-unit output signals. The solenoids control the gearbox.
• In accordance with their method of actuation, all 9 solenoids can be classified in two types (three load solenoids and six ON/OFF solenoids).
• All the solenoids have an internal coil. A flow of current through the coil actuates the needle valve, which opens and closes the fluid pressure circuits.
• An ON/OFF solenoid closes a fluid pressure circuit as a function of current flow.

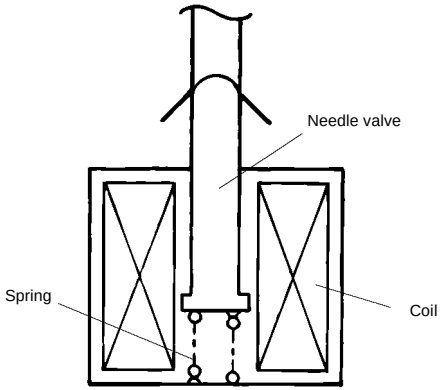
ON/OFF solenoids:
N 88, N 89, N 92, N 90, N 282, N 281





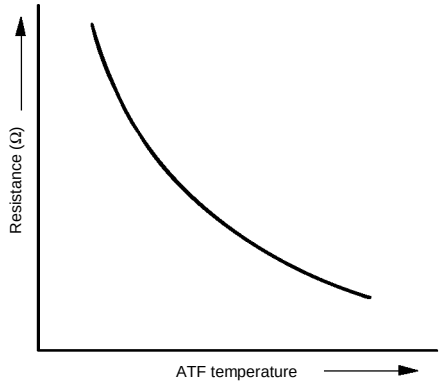
13.1.9

• The modulation valves are repeatedly switched ON and OFF at a frequency of 50 Hz, thus opening and closing the fluid pressure circuits.
• A spring is fitted in each of the modulation valves. The spring force opposes the needle valve. The needle valve operates as a function of current flow (ON). The spring force is overcome as soon as the flow of current stops (OFF) and the spring force returns the needle valve to its original position.
Modulation valve: Pipe pressure solenoid, lock-up solenoid, 2-4 brake load solenoids



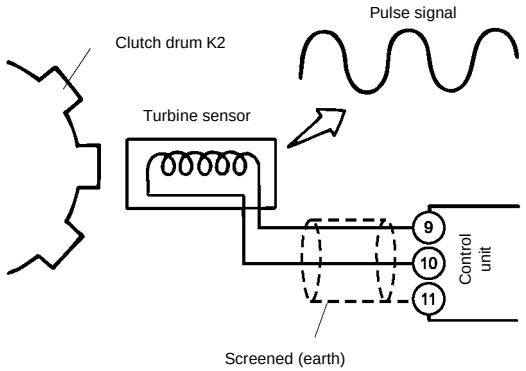
13.1.10 ATF temperature sensor

• The ATF temperature sensor is installed in the gearbox housing and is used to constantly monitor the temperature of the ATF.
• The internal operating resistance varies depending on ATF temperature. The control unit detects the ATF temperature on the basis of the voltage generated by the ATF temperature sensor.



13.1.11 Gearbox input speed sender G 182

• G 182 is installed at the automatic gearbox and is used to detect the speed of the clutch drum K2. The clutch drum K2 is connected to the input shaft and rotates at the same speed. The control unit calculates the speed of the input shaft to determine the turbine speed.
• G 182 uses a solenoid. As the input shaft rotates, the sender detects a pulse signal corresponding to the teeth on the outside of the reverse gear clutch drum and transmits this signal to the control unit.



13.1.12 Road speed sender G 68

• The road speed sender is installed at the automatic gearbox and detects the speed of the parking lock gear. The control unit calculates the road speed on the basis of the parking lock gear speed.
• The road speed sender uses a solenoid. As the parking lock gear rotates, the sender detects a pulse signal corresponding to the teeth at the parking lock gear and transmits this signal to the control unit.

13.1.13 Intermediate shaft speed sender G 265

• G 265 is installed at the automatic gearbox and detects the speed of the spur gear. The control unit calculates the speed of the spur gear.
• G 265 uses a solenoid. As the spur gear rotates, the sender detects a pulse signal corresponding to the teeth at the input gear and transmits this signal to the control unit.