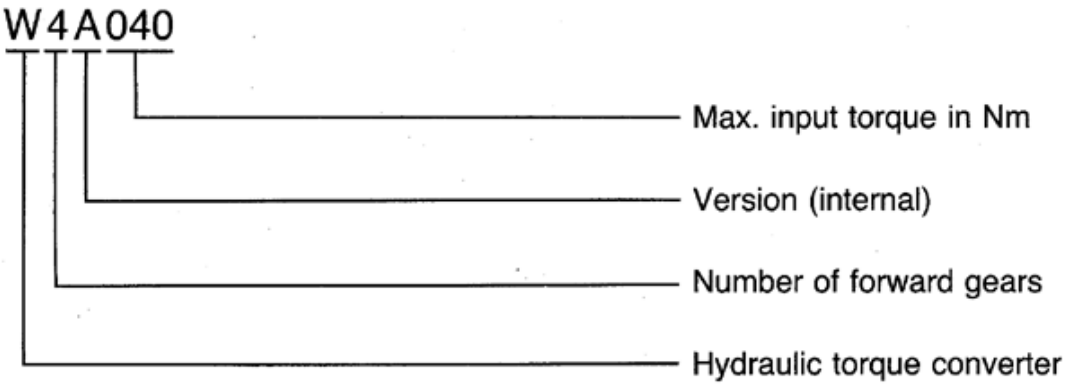
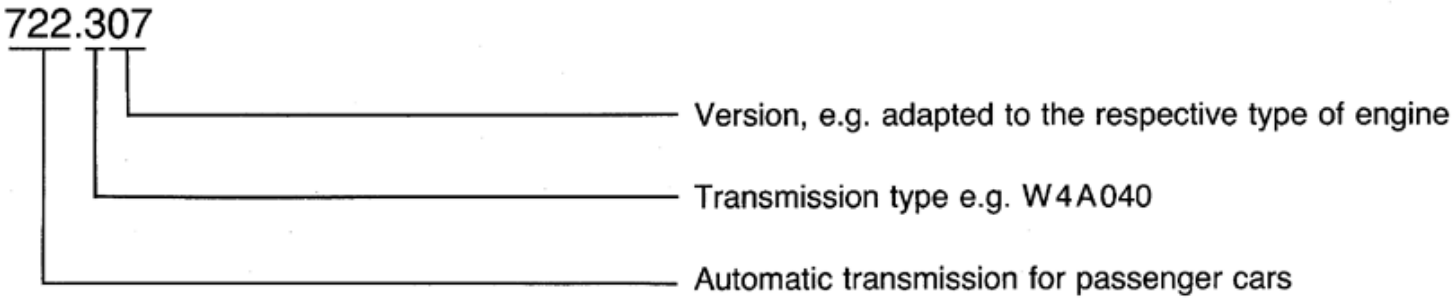
Transmission type

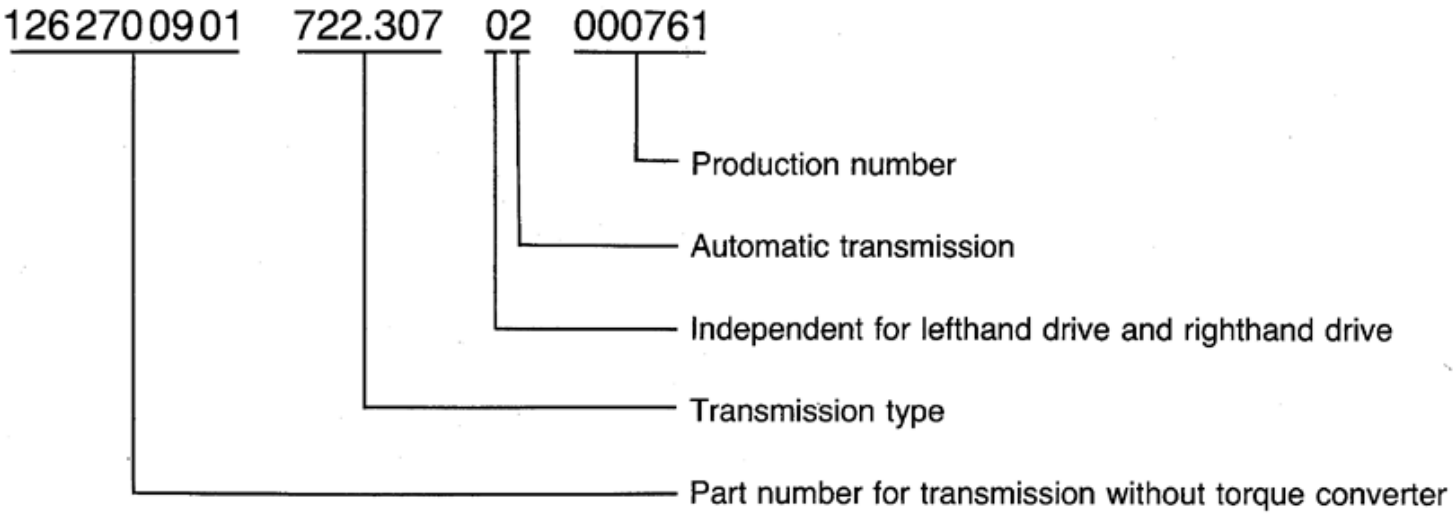


Transmission



Identification of new transmission

Number stamped into transmission housing



General

The automatic transmissions 722.3 (W4A040) and 722.4 (W4A020) are fully automatic 4-speed planetary gear transmissions not requiring conventional clutch application and shifting of gears.

The forward gears are shifted automatically depending on selector lever position, driving speed and accelerator pedal position.

The selector lever permits adapting the automatic shifting process to special operating conditions.

Construction of transmissions

Transmission housing

The transmission housing and the converter housing are a one-piece casting and are made of a light metal alloy. This one-piece casting is extremely rigid and is therefore insensitive to vibrations.

The oil distribution plate of the shift valve housing is cast in the lower side of the transmission housing. This results in an additional reinforcement of the transmission housing.

Front cover

The front cover is also made of light alloy and holds the primary pump and the stator shaft. The clutch K1 is mounted on the transmission-side extension of the stator shaft. The pressure oil for clutch K1 flows via passages in front cover.

Rear cover

The rear cover is made of light alloy and houses the output shaft of the transmission.

Planetary transmission

The planetary transmission comprises two planetary gear sets with input and output shaft, as well as a one-way clutch.

Primary and secondary pump

With engine running, the primary pump supplies the hydraulic system with oil. It is driven by the engine via the torque converter.

The secondary pump, operative only with stationary engine and when the vehicle has been stopped first. The pump supplies the transmission with oil during tow-starting and when towing off.

The secondary pump is driven by the input shaft via worm drive by the shaft of the centrifugal governor.

Shift valve housing

The shift valve housing is the control center of the hydraulic control system. It consists of two housing parts and is bolted from the bottom to the oil distribution plate and the transmission housing.

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The selector lever permits adapting the automatic shifting process to special operating conditions.

Centrifugal governor

The centrifugal governor is installed in the rear part of the transmission housing. It is driven by the drive shaft via a worm drive.

Oil cooler

Vehicles with automatic transmission are provided with a transmission oil cooler.

With engine running, lubricating oil continuously circulates through this cooler.

Electrical system

The electrical equipment comprises the starter lockout and backup lamp switch, as well as the kickdown solenoid valve.

The starter lockout and backup lamp switch controls the following functions:

- In positions "D", "3", "2" and "R" the electrical circuit to the starter is interrupted.
- In position "R" the electrical circuit to the backup lamp switch is closed.
- Other functions such as idle speed stabilization, moving-off, 1st gear etc. are controlled depending on vehicle model.

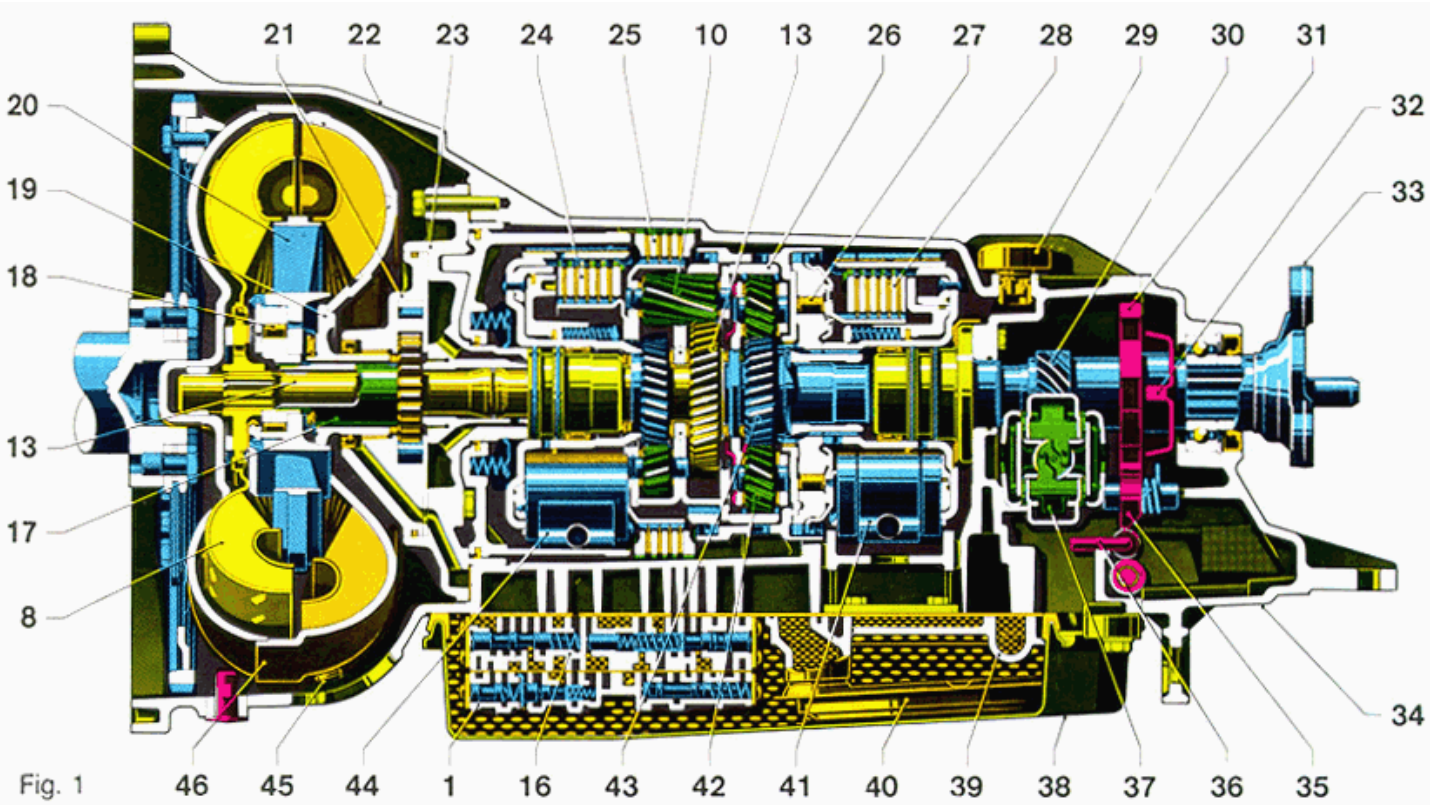

Fig. 1

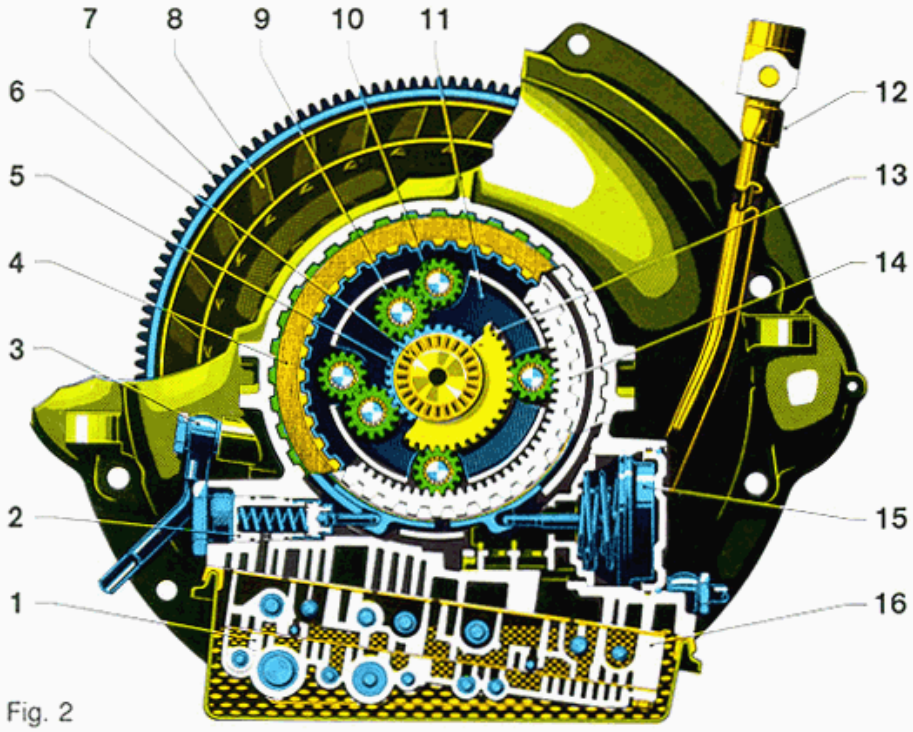

Fig. 2

1 Accumulator housing
2 Thrust bearing (brake band B1)
3 Oil drain (to cooler)
4 Inside plate (brake B3)
5 Sun gear (front)
6 Axial bearing
7 Starter ring gear
8 Turbine wheel
9 Turbine wheel (short front)
10 Turbine wheel (long front)
11 Planetary gear carrier
12 Oil dipstick
13 Input shaft with sun gear
14 Internal gear (front)
15 Brake band plunger (brake band B1)
16 Shift valve housing
17 Stator shaft
18 Free-wheeling unit (converter)
19 Drive flange primary pump
20 Guide wheel
21 Primary pump
22 Transmission housing
23 Front cover
24 Clutch K1
25 Brake B3
26 Internal gear (rear)
27 Free-wheeling shift unit
28 Clutch K2
29 Vent
30 Helical gear (driving)
31 Parking lock gear
32 Impulse star (speedometer drive)
33 Three-arm flange
34 Rear transmission housing
35 Locking pawl
36 Parking lock linkage
37 Centrifugal governor
38 Oil pan
39 Lower cover
40 Oil filter
41 Brake band B2
42 Planetary gear (rear)
43 Sun gear (rear)
44 Brake band B1
45 Oil drain plug
46 Pump gear

Selector lever positions

The selector lever permits adaptation of automatic shift sequence to special operating conditions. For this purpose, the lever can be shifted into 6 or 7 different positions.

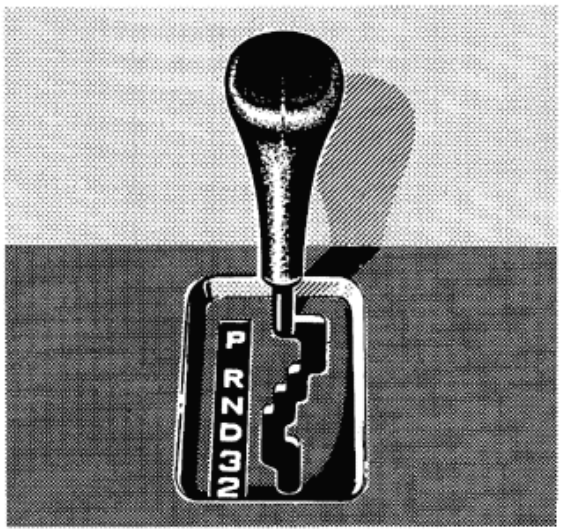

Fig. 3
Without position "B"

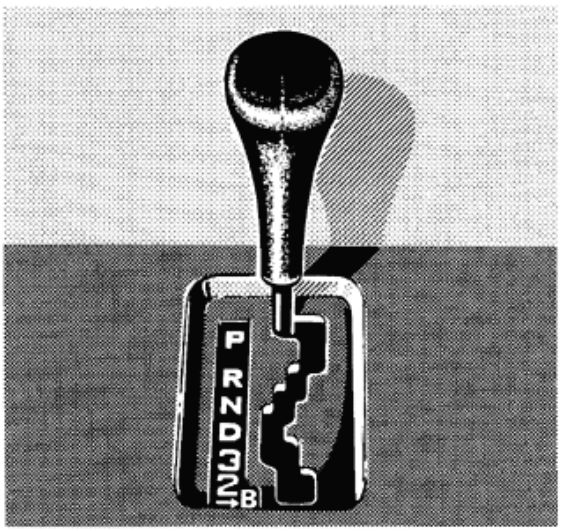

Fig. 4
With position "B"

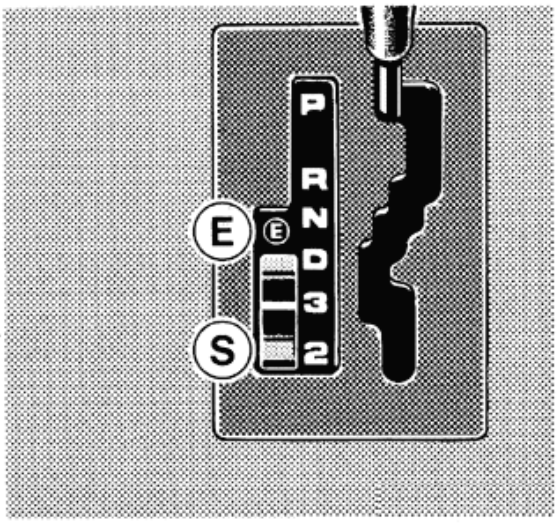

Fig. 5
With program selector switch

Significance of selector lever positions:

"P" Parking lock and starting position

The output shaft is blocked by a parking lock pawl to prevent the vehicle from rolling downhill. The parking lock is mechanically blocked when driving forward at more than 10 km/h and may be engaged only with the vehicle stationary. The engine can be started.

"R" Reverse gear

Selector lever position "R" is mechanically blocked when driving forward at more than 10 km/h and may be engaged only with the vehicle stationary.

"N" Neutral gear and starting position

There is no power transmission from engine to rear axle. With the brakes released, the vehicle can be freely moved (pushing, tow-starting and towing off). Do not engage "N" while driving. Engine can be started.

"D" Direct (normal driving)

All gears are available. Optimum driving in all normal operating conditions.

"3" Gradients

Shifting up to 3rd gear only. Correct when driving up and down long, medium gradients. The braking effect of the engine can be utilized in 3rd gear.

"2" Load

Upshifts up to 2nd gear only. Correct for driving on steep mountain passes, with trailer in the mountains and under aggravated operating conditions.

"B" Braking position

Upshifts up to 2nd gear. Correct when driving down extreme gradients and for driving on long mountain passes, in particular with trailer. Below approx. 40 km/h the transmission shifts into 1st gear and will remain engaged up to approx. 60 km/h. The braking effect of the engine is utilized in 1st and 2nd gear.

On program selector switch the switch positions are as follows:

"S" Standard program

"E" Economy program

Comfortable driving with less shifting.

Instrument cluster

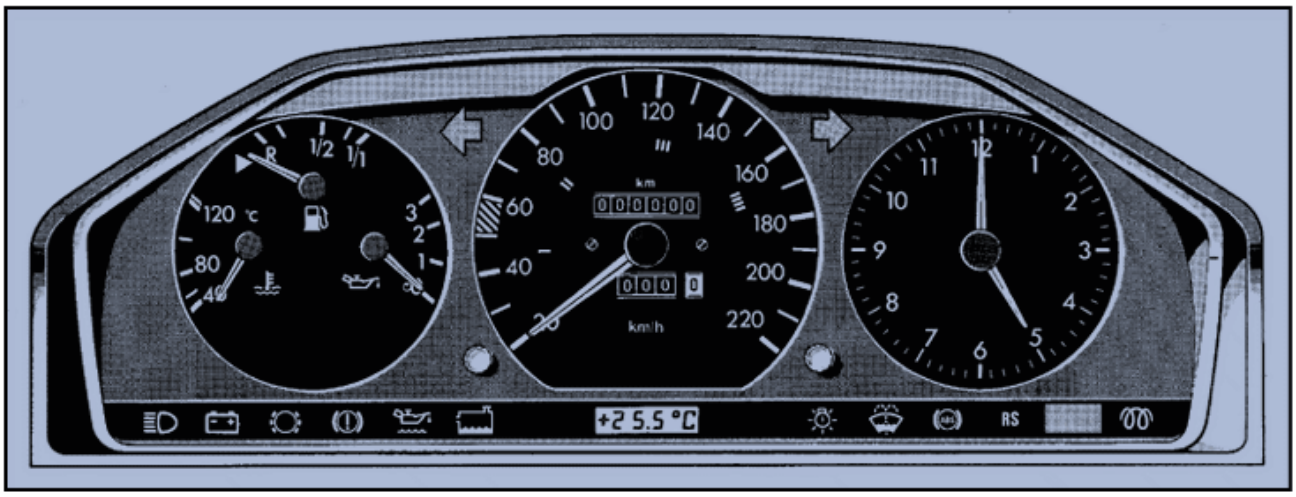

Fig. 6

Attentions! Do not exceed max. speed in individual selector lever positions. Refer to graduated marks on speedometer.

Shift back only (braking shift) when the speed of the vehicle is not higher than the max. permissible speed in the desired selector lever position. Excessive revolutions are detrimental to engine.

No unnecessary selector lever downshifts (braking shifts) on smooth roads, e.g. from "D" to "3" or "3" to "2".

Forward speeds are automatically shifted, depending on vehicle speed and position of accelerator pedal.

Accelerator pedal position: Little gas = early upshift
Much gas = late upshift

Kickdown reverse shifts can be made in speed range provided for this purpose only.

The shift points within the individual vehicle models or transmission versions are different. For shift point values refer to technical literature.

1. Driving off

Only with the engine idling, place selector lever in the desired driving position while applying the service brake.

2. Stopping

With brief stops, e.g. at a traffic light, keep the selector lever in the respective driving position and hold the vehicle with the service brake.

3. Towing the vehicle

Only in driving position "N". The towing speed should not exceed 50 km/h.

When towing over distances in excess of 120 km and after medium to serious accidents, the vehicle should only be towed with the rear axle raised or with propeller shaft disconnected on flange. The best solution is to transport the vehicle on a truck or train.

4. Emergency engine start (by towing)

A few examples of model-specific details for towing off are shown in respective operating instructions. Below are a few examples:

Selector lever at "N", key in steering lock in position "2", then tow-start vehicle. At 30 km/h (with very cold transmission) or up to 50 km/h (with warm transmission) maintain speed for approx. one minute so that an adequate oil pressure is established in transmission.

Move selector lever to position "2" for starting the engine. Touch accelerator pedal only after the engine is rotating along. Release the accelerator pedal after the engine fires and move selector lever again immediately to position "N".

If the engine does not fire after a few seconds, move selector lever immediately back to position "N" to eliminate any possibility of damaging the transmission.

For another attempt at starting, tow vehicle again for some time in selector lever position "N" and repeat starting procedure.

Proceed likewise during an emergency start of engine by rolling down a gradient.

Note: The secondary pump is taken along by shaft of centrifugal governor only after previously stopping the vehicle.

Layout

The most important components of a torque converter are:

1. Pump wheel (1), also called primary wheel, this is firmly bolted to the crankshaft of the engine via the cover shell (7).

2. Turbine wheel (2), also called secondary wheel, connected to drive shaft (9) of transmission.

3. Guide wheel (3), also called stator, is connected to transmission housing via free-wheeling unit (8) and stator shaft (4).

The torque converter is a closed unit. The turbine wheel (2) freely runs in cover shell (7), which is connected to pump wheel (1). The guide wheel (3) is mounted on a free-wheeling unit (8) and locks in the direction contrary to the direction of rotation of the engine.

The blades of pump, turbine and guide wheels are provided with certain coordinated inlet and outlet angles and are appropriately curved.

Layout of a torque converter

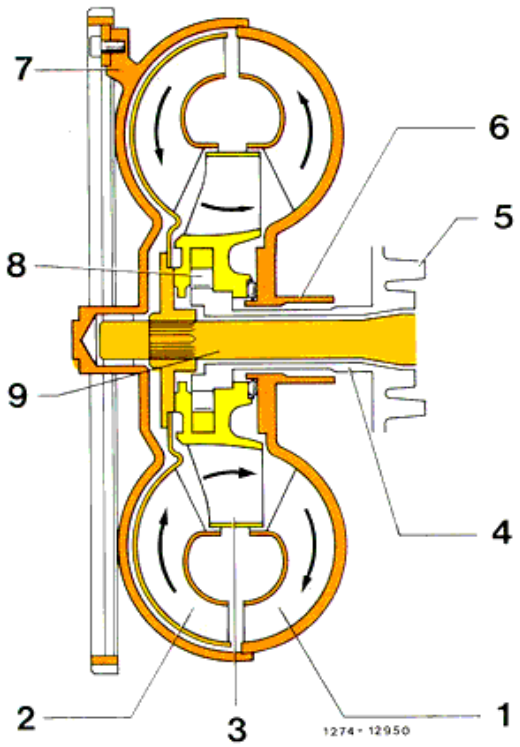

Fig. 9

1 Pump wheel
2 Turbine wheel
3 Guide wheel
4 Stator shaft
5 Front cover
6 Primary pump drive flange
7 Cover shell
8 Free-wheeling unit
9 Drive shaft

Current flow in torque converter when moving off

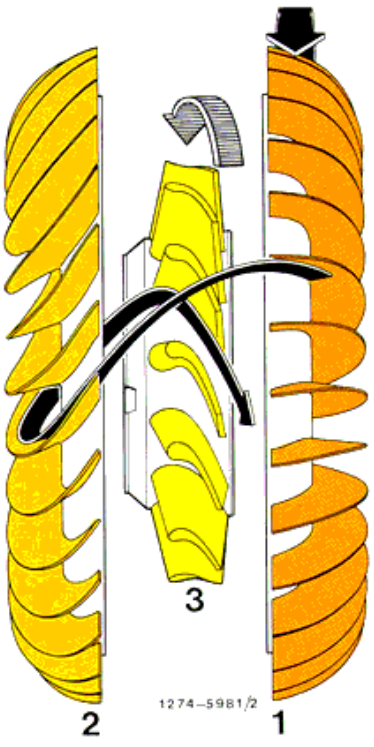

Fig. 10

1 Pump wheel
2 Turbine wheel
3 Guide wheel

Operation

The torque converter is filled with oil. For heat dissipation this oil is continuously supplied between the stator shaft (4) and the primary pump drive flange (6) and discharged in-between the stator shaft (4) and the drive shaft.

When the pump wheel (1) rotates, the oil between the pump wheel blades is forced by the centrifugal action in outward direction into the turbine wheel (2).

The mechanical energy provided by the engine is transmitted to the turbine wheel in the shape of flow energy.

Within the turbine wheel (2) the flow energy of the oil is again converted to mechanical energy (torque and speed) by deflection in the curved blade channels.

The oil issuing from the turbine wheel (2) contrary to the direction of rotation now hits the guide wheel (3), which is locked via the free-wheeling unit in the direction of rotation indicated by the interrupted-line arrow (see Fig. 10). It is again deflected by the guide wheel blades, i.e. in the direction of rotation of the pump wheel.

This deflection produces a torque in guide wheel which is backed-up via free-wheeling unit (8) and stator shaft (4) by the housing and transferred to the pump wheel by the oil.

The sum of the two torques, i.e. the driving torque transmitted from the engine to the pump wheel and the torque passed on from the guide wheel via the oil to the pump wheel is finally equal to the torque transmitted from the turbine wheel to the transmission.

The ratio of the output torque to the driving torque at the moment of driving off (driving-off conversion) is 1.8–2.0. The conversion continually drops with increasing turbine speed, while the flow direction to the guide wheel and the deflection in the guide wheel is also subjected to a continuous change.

If the oil flow hits the rear of the guide wheel blades, deflection no longer takes place in the guide wheel. The guide wheel starts to rotate in the same direction as the pump and the turbine wheel, the torque conversion reaches the value 1.

This operating point is attained at a speed ratio of 0.87–0.9 and is called clutch point. Above the clutch point the torque converter operates as hydraulic clutch and reaches a maximum efficiency of approx. 98 %.

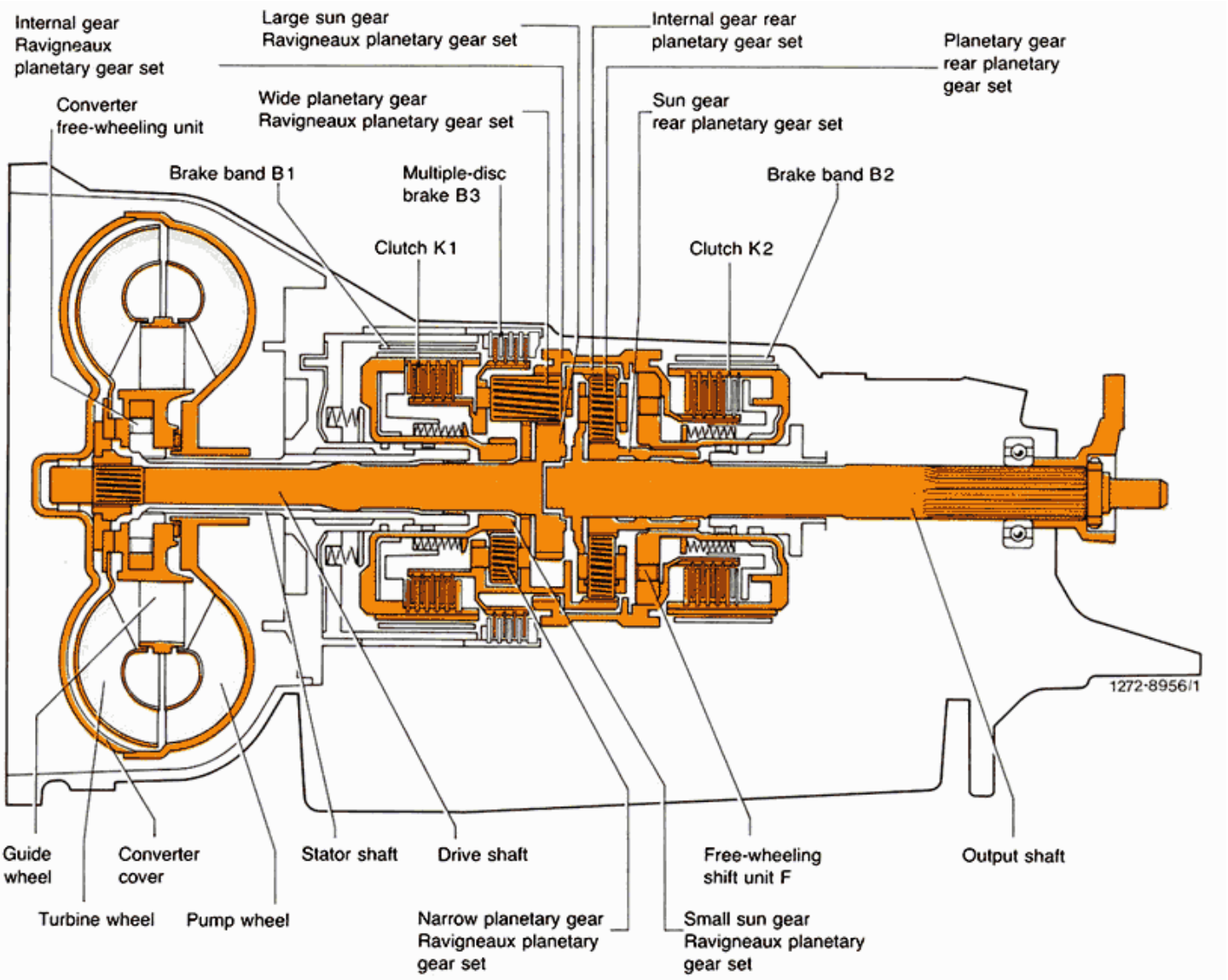

Figure 11

The mechanical part of the automatic transmission is equipped with planetary gears in two-group construction.

A Ravigneaux planetary gear set is employed as front group and a simple planetary gear set as rear group.

The individual transmission components are interconnected as follows:

1. Turbine wheel of the torque converter with the large sun gear of the Ravigneaux planetary gear set via the drive shaft.
2. Planetary gear carrier of the Ravigneaux planetary gear set with internal disc carrier K2, internal disc carrier B3 and internal gear of the rear planetary gear set.
3. Brake band drum B1 and external disc carrier K1 with small sun gear of the Ravigneaux planetary gear set.
4. Internal gear of the Ravigneaux planetary gear set via the connecting carrier with outer race of the free-wheeling shift unit F and internal disc carrier K2.
5. Brake band drum B2, external disc carrier K2 and inner race of the shift free-wheeling unit F with sun gear of the rear planetary gear set.
6. Planetary gear carrier of rear planetary gear set with the output shaft.

General

Planetary gear trains are used in automatic vehicle drives as variable speed transmissions. Their advantages are:

coaxial position of drive and output
compact construction
high efficiency
good shiftability of the individual transmission components.

By holding individual elements of a planetary gear set (sun gear, planetary gear carrier, internal gear) it is possible to produce various transmission ratios without having to move gears or sliding sleeves.

The gears are always engaged and shifting processes consist of hydraulic actuation of clutches and brake bands, depending on which gear is shifted.

Simple planetary gear set

A simple planetary gear set consists of the internal gear (1), the planetary gears (2) which run in the planetary gear carrier (4) and the sun gear (3).

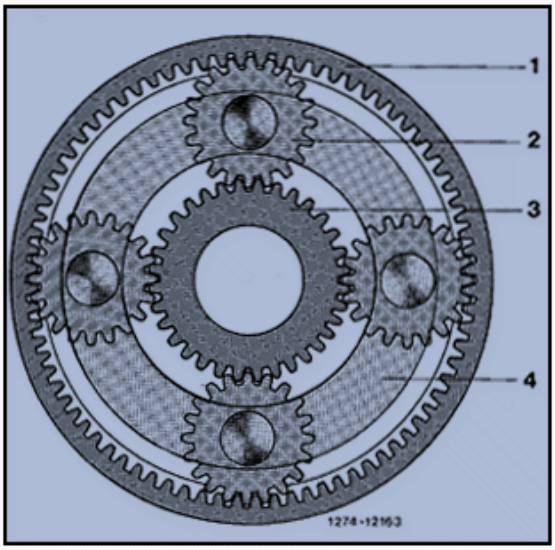

Fig. 12

1 Internal gear
2 Planetary gear
3 Sun gear
4 Planetary gear carrier

In order that a planetary gear set is able to transmit a torque it is necessary to lock the internal gear, the planetary gear carrier or the sun gear to the transmission housing. A brake (brake band or multiple-disc brake) is actuated here.

A torque is also transmitted if the planetary gear set is blocked in itself. A clutch (multiple-disc clutch) must be actuated here.

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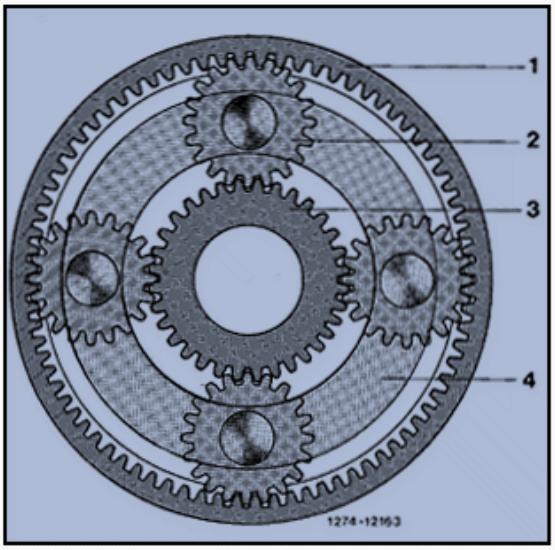

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The following transmission possibilities are applied with automatic transmissions:

1. Internal gear held
   sun gear driving
   planetary gear carrier driven
   produces
   relatively great speed
   reduction

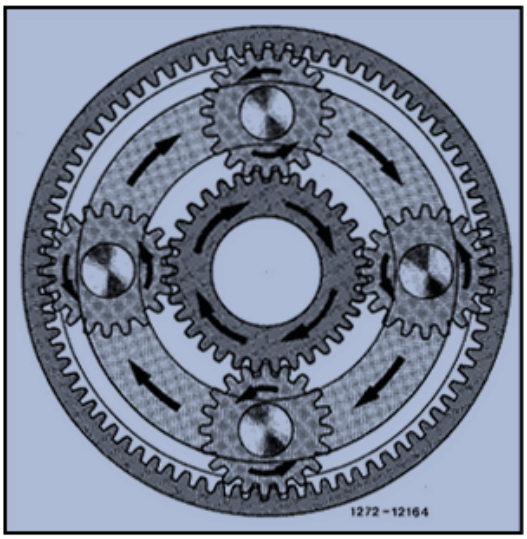

Fig. 13

2. Sun gear held
   internal gear driving
   planetary gear carrier driven
   produces
   relatively small speed
   reduction

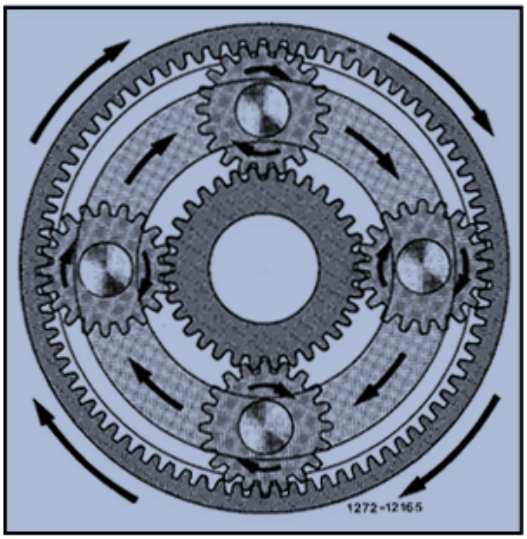

Fig. 14

3. Planetary gear carrier held
   sun gear driving
   internal gear driven
   produces
   change of direction
   or rotation and
   a speed reduction.
   This combination is applied
   for the reverse gear.

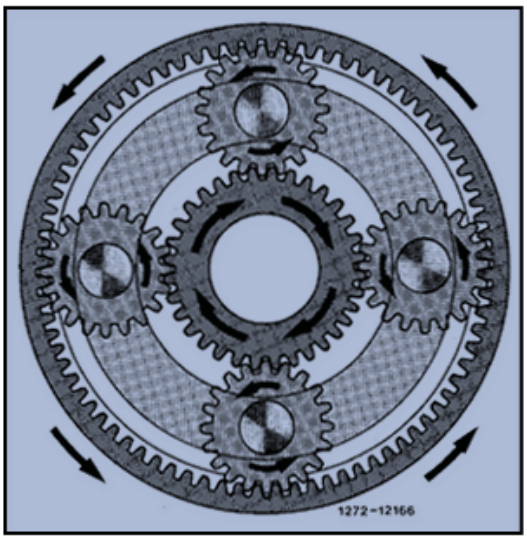

Fig. 15

4. Interlocking of two elements so that the planetary gear set rotates as a whole resulting in a direct power transmission.

The Ravigneaux planetary gear set, in principle, is a compound planetary gear train consisting of two simple planetary gear sets.

Special features are the reduced construction expenditure with only one internal gear and one common planetary gear carrier.

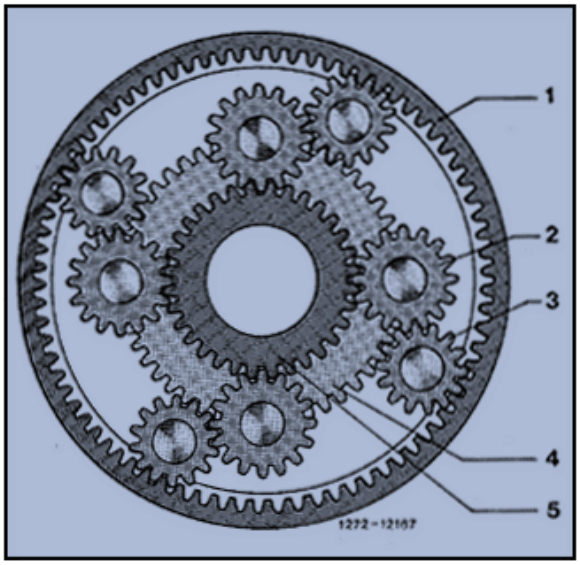

Fig. 16

1 Internal gear
2 Narrow planetary gear
3 Wide planetary gear
4 Large sun gear
5 Small sun gear

The Ravigneaux planetary gear set (see Fig. 16) is equipped with two sun gears of different size, four narrow and four wide planetary gears, a common planetary gear carrier and an internal gear.

In the type employed in the transmission, the drive is effected via the large sun gear. The output in the forward gears takes place via the planetary gear carrier to the internal gear of the planetary gear set.

In the 1st gear the torque is backed up by the band brake B2 via the internal gear and the free-wheeling shift unit F.

In the 2nd gear the small sun gear is held by the band brake B1.

In the 3rd and 4th gears the multiple-disc clutch K1 is engaged. The Ravigneaux planetary gear set runs interlocked without the transmission ratio 1:1.

In the reverse gear the planetary gear carrier is held by the multiple-disc brake B3. Drive takes place also via the large sun gear. The output is now effected via the internal gear to the rear planetary gear set.

Transmission 722.3

Gear	Transmission	Actuated or effective shift elements	Transmission ratios i =
1st	In front (Ravigneaux) and rear planetary gear set	Brake band B2 Free-wheeling unit[1])	3.68
2nd	In front (Ravigneaux) and rear planetary gear set	Brake band B1 Brake band B2	2.41
3rd	In rear planetary gear set	Clutch K1 Brake band B2	1.44
4th	No transmission	Clutch K1 Clutch K2	1
Reverse	In front (Ravigneaux) and rear planetary gear set	Disc brake B3 Free-wheeling unit F + K2	5.14

Transmission 722.4

Gear	Transmission	Actuated or effective shift elements	Transmission ratios i =
1st	In front (Ravigneaux) and rear planetary gear set	Brake band B2 Free-wheeling unit F[1])	4.25
2nd	In front (Ravigneaux) and rear planetary gear set	Breke band B1 Brake band B2	2.40
3rd	In rear planetary gear set	Klutch K1 Brake band B2	1.48
4th	No transmission	Clutch K1 Clutch K2	1
Reverse	In front (Ravigneaux) and rear planetary gear set	Disc brake B3 Free-wheeling unit F + K2	5.14

[1]) In driving positions „2“ and „B“ clutch K2 is additionally engaged.

1st gear

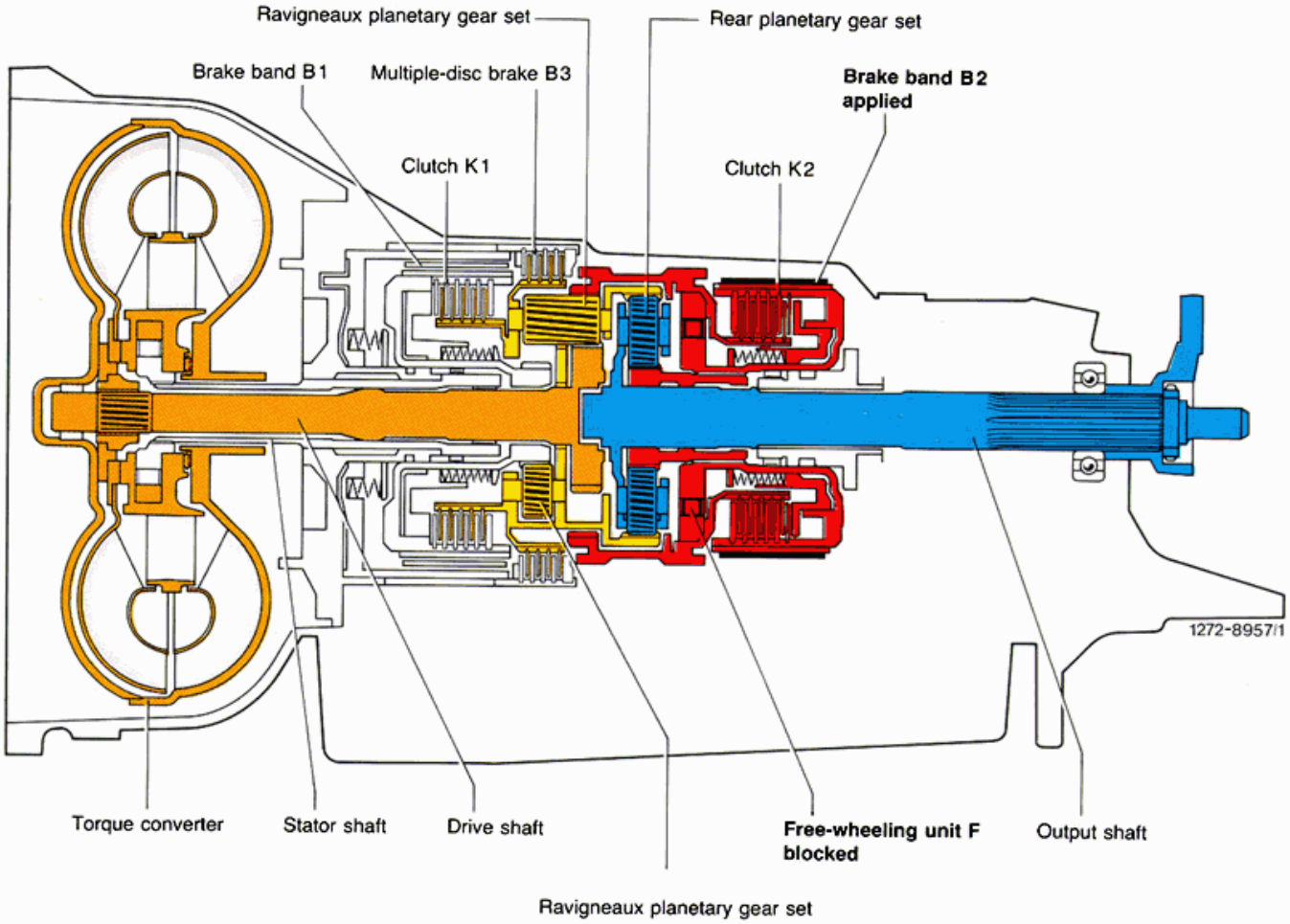

Fig. 17

- Engine speed
- Stationary parts
- Reduced speed
- Speed reduced once more

Actuated: **Brake band B2 and free-wheeling shift unit F,** in selector lever position "2", additionally clutch K2.

Both groups of the planetary gear train are involved in forming the transmission ratio.

i_{11} = 1st part reduction of the front group
i_{21} = 1st part reduction of the rear group

Front group: Ravigneaux planetary gear set

The internal gear of the Ravigneaux planetary gear set is locked in position by brake band B2 via the shift free-wheeling unit F, which locks in reverse direction of rotation.

Via the large sun gear, the drive shaft drives the two wide planetary gears of the Ravigneaux planetary gear set. This causes the planetary gears to roll in the fixed internal gear, driving the planetary gear carrier in the same direction of rotation.

Part reduction i_{11} = 2.56

Rear group: Simple planetary gear set

The sun gear of the rear planetary gear set is held with brake band B2. The planetary gear carrier of the Ravigneaux planetary gear set is firmly connected with the internal gear of the rear planetary gear set.

The internal gear of the rear planetary gear set is driven with the output speed of the front group. This results in the planetary gears rolling in the fixed sun gear, driving the planetary gear carrier of the rear planetary gear set and the output shaft in the same direction of rotation.

Part reduction $i_{21} = 1.44$

Total reuction in 1st gear $i_1 = i_{11} \times i_{21} = 2.56 \times 1.44 = 3.68$

The free-wheeling shift unit F is bridged by engaging clutch K2. The braking action of the engine is then also utilized in 1st gear with the selector lever in position "2".

2nd gear

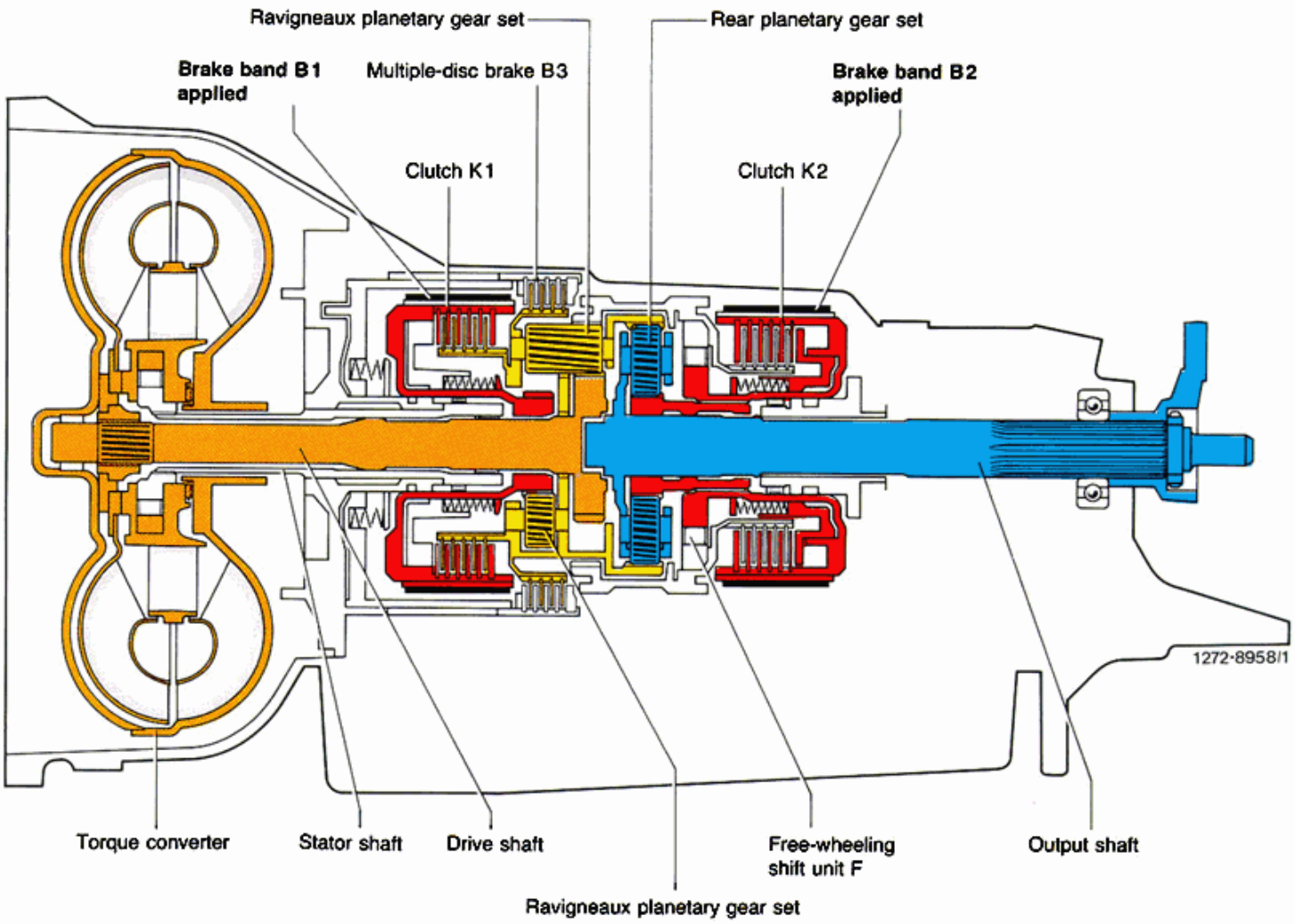

Fig. 18

- Engine speed
- Fixed parts
- Reduced speed
- Speed reduced once more

Actuated: **Brake band B1 and brake band B2**

Both groups of the planetary gear train are involved in forming the transmission ratio.

i_{12} = 2nd part reduction of front group
i_{21} = 1st part reduction of rear group

Front group: Ravigneaux planetary gear set

The brake band B1 holds the small sun gear of the Ravigneaux planetary gear set.

The drive shaft drives the wide planetary gears of the Ravigneaux planetary gear set via the large sun gear.

Driven by the wide planetary gears, the narrow planetary gears roll on fixed small sun gear, driving the planetary gear carrier of Ravigneaux planetary gear set in driving direction of rotation.

The internal gear of the Ravigneaux planetary gear set runs without load contrary to the direction of rotation without non-positive connection to the free-wheeling shift unit F (state of free-wheeling)

Part reduction $i_{21} = 1.68$

Ravigneaux planetary gear set:
Direction of rotation of the transmission components in the 2nd gear

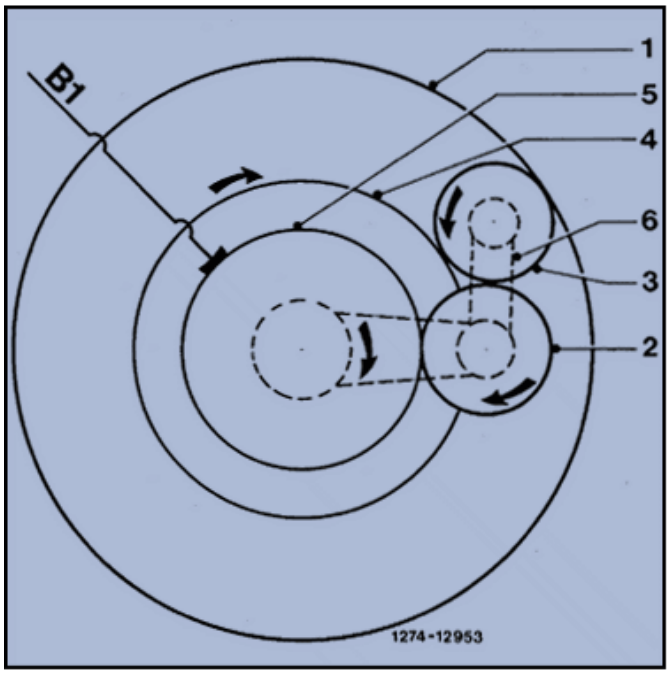

Fig. 19

1 Internal gear (without load)
2 Narrow planetary gear
3 Wide planetary gear
4 Large sun gear (drive)
5 Small sun gear (supporting member)
6 Planetary gear carrier (output)

Rear group: Simple planetary gear set

The power train in the rear planetary gear set corresponds to that obtained in the 1st gear.
Part reduction $i_{21} = 1.44$
Total reduction in 2nd gear $i_2 = i_{12} \times i_{21} = 1.68 \times 1.44 = 2.41$

3rd gear

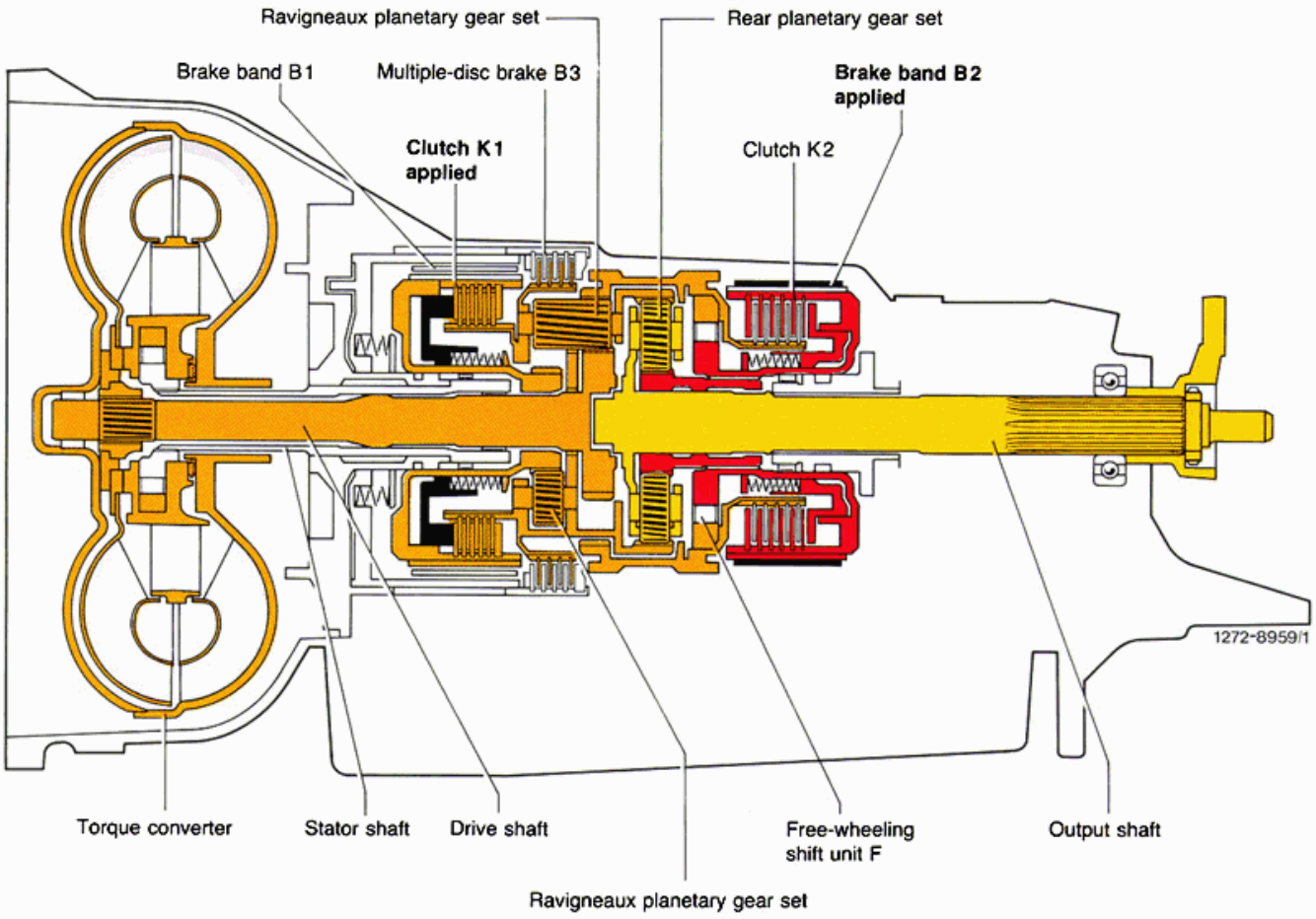

Fig. 20

Engine speed
Fixed parts
Reduced speed

Actuated: **Clutch K1 and brake band B2**

Only the rear group is involved in forming the total transmission ratio.

i_{13} = 3rd part reduction of the front group

i_{21} = 1st part reduction of the rear group

Front group: Ravigneaux planetary gear set

By engaging the clutch K1, the small sun gear of the Ravigneaux planetary gear set is non-positively connected with the planetary gear carrier. This results at the same time in the other components of the Ravigneaux planetary gear set being interlocked.

Part reduction $i_{13} = 1$

Rear group: Simple planetary gear set

The internal gear of the rear planetary gear set is driven with driving speed.

The power train in the rear planetary gear set corresponds to that obtained in the 1st and 2nd gears.

Part reduction $i_{21} = 1.44$

Total reduction of 3rd gear $i_3 = i_{13} \times i_{21} = 1 \times 1.44 = 1.44$

4th gear

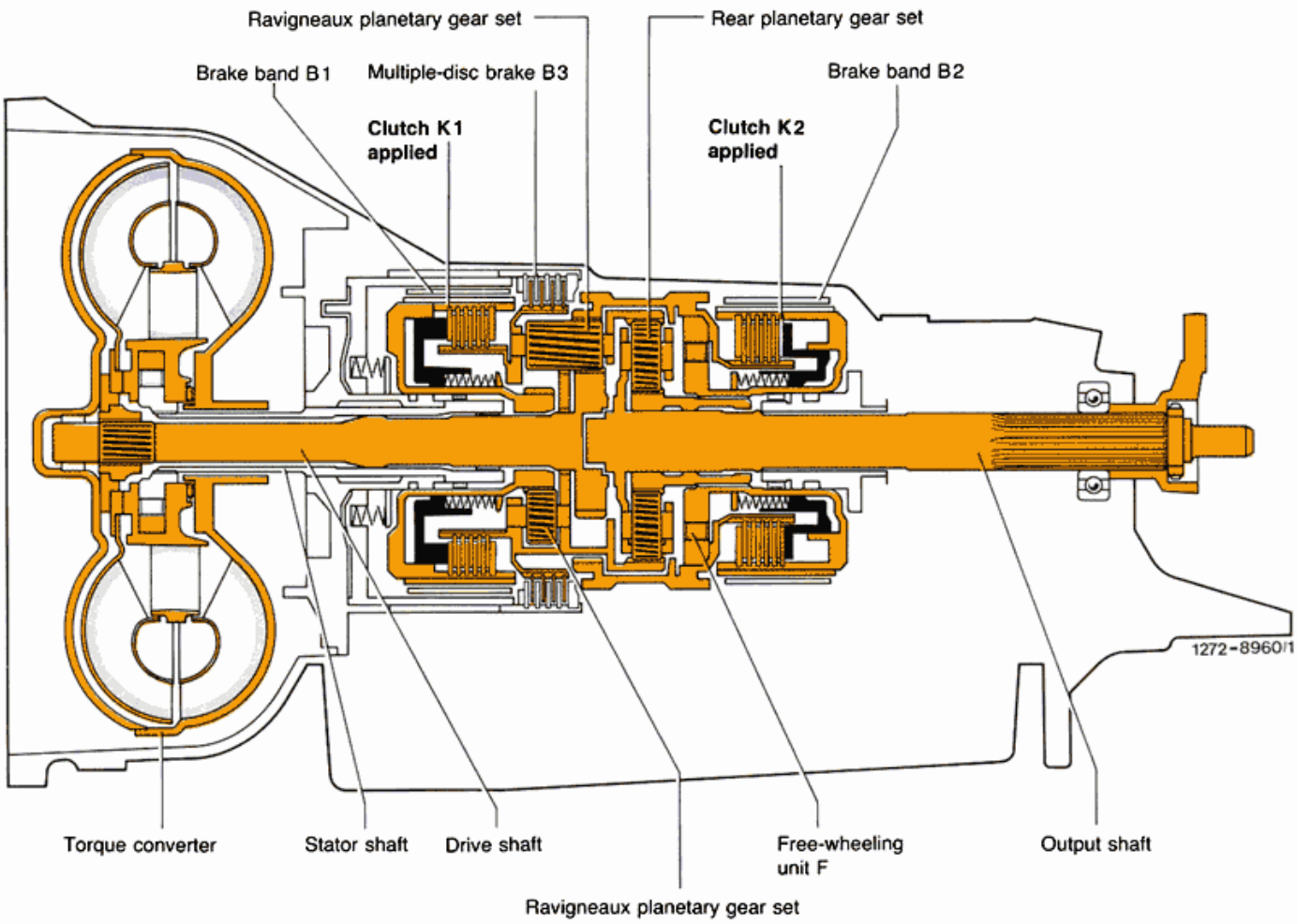

Fig. 21 Engine speed

Actuated: **Clutch K1 and clutch K2**

Both groups of the planetary gear train rotate interlocked.

i_{13} = 3rd part reduction of the front group
i_{22} = 2nd part reduction of the rear group

Front group: Ravigneaux planetary gear set

The Ravigneaux planetary gear set is interlocked by clutch K1 and rotates at transmission ratio $i_{13} = 1$.

Rear group: Simple planetary gear set

By engaging clutch K2, the sun gear of the rear planetary gear set is connected to internal gear of rear planetary gear set via Ravigneaux planetary gear set.

This results in the rear planetary gear set being interlocked and rotating with the transmission ratio $1_{22} = 1$.
Total transmission ratio in the 4th gear $i_4 = i_{13} \times i_{22} = 1 \times 1 = 1$

Reverse gear

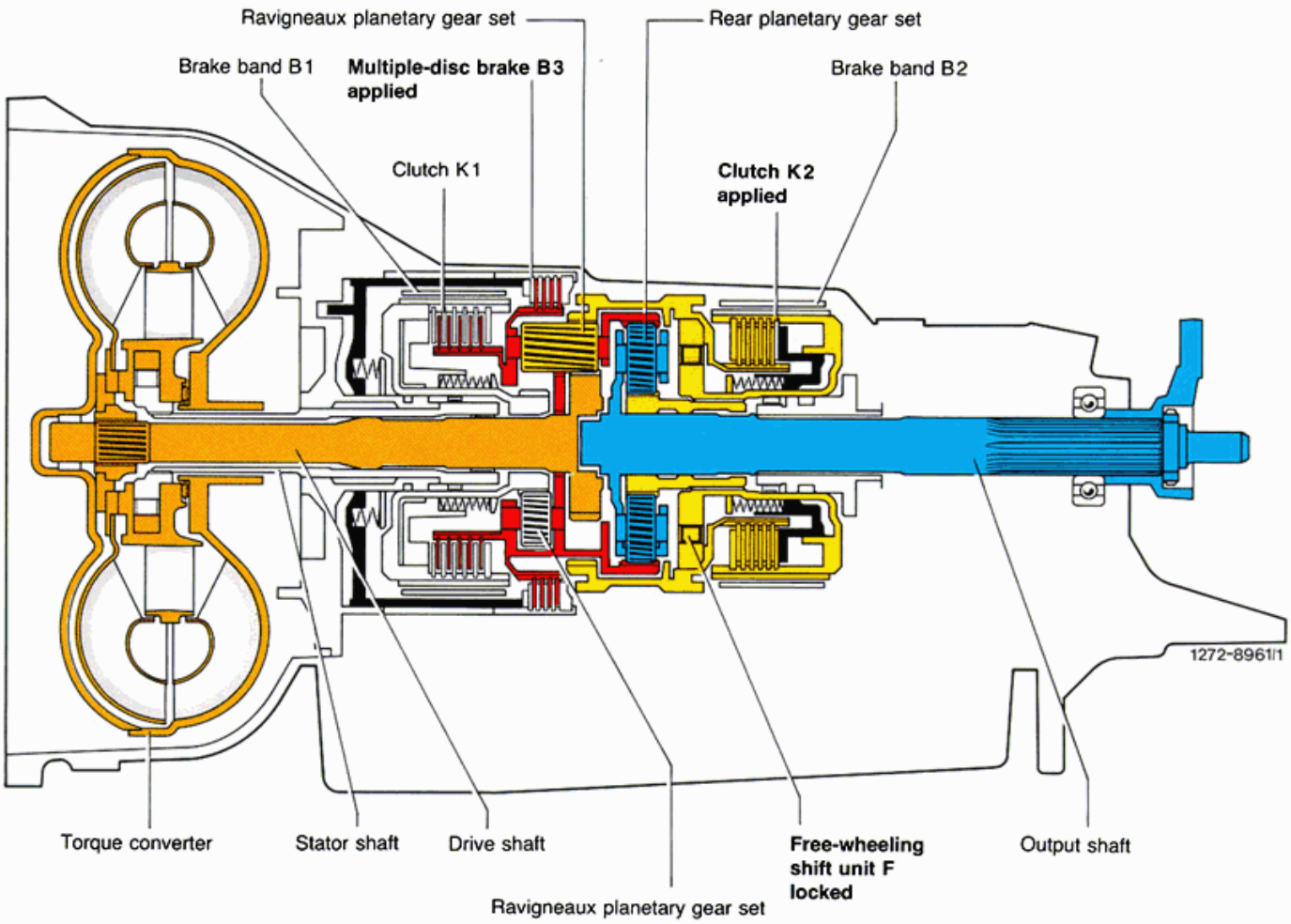

Fig. 22

- Engine speed
- Fixed parts
- Reduced speed with reversal of direction of rotation
- Speed reduced once more

Actuated: **Multiple disc brake B3, free-wheeling shift unit F and clutch 2**

Both groups of the planetary gear train are involved in forming the transmission ratio.

i_{1R} = Part reduction of the front group in reverse gear
i_{23} = 3rd part reduction of the rear group

Front group: Ravigneaux planetary gear set

The planetary gear carrier of the Ravigneaux planetary gear set and the connected internal gear of the rear planetary gear set are held via the multiple-disc brake B3.

The drive shaft drives the wide planetary gears of the Ravigneaux planetary gear set via the large sun gear. With fixed planetary gear carrier this results in a reversal of direction of rotation of the internal gear.

Part reduction i_{1R} = 1.56

Rear group: Simple planetary gear set

The internal gear of the Ravigneaux planetary gear set operating in reverse drives the sun gear of the rear planetary gear set via the shift free-wheeling unit F, which locks in counterdirection of rotation.

The planetary gears of rear planetary gear set are rolling in held internal gear and are driving the planetary gear carrier and thereby the output shaft in reverse direction of rotation.

Part reduction $i_{23} = 3.29$

Total reduction in reverse gears: $i_R = i_{1R} \times i_{23} = -1.56 \times 3.29 = -5.14$

Clutch K2 bridges the free-wheeling shift unit F. In this way the non-positive connection is maintained even when coasting.

The automatic transmission requires hydraulic energy.

This energy, a pressurized oil flow, is generated by the oil pumps installed in transmission and is delivered to shift valve housing.

The shift valve housing is additionally provided with information fed from outside into the transmission:

1 Selector lever position
2 Program selector switch
3 Accelerator pedal position (control pressure)
4 Engine torque (via vacuum in intake manifold)
5 Kickdown
6 Vehicle speed

The oil flow is routed to the different points in transmission and adapted to requirements with regard to quantity and pressure.

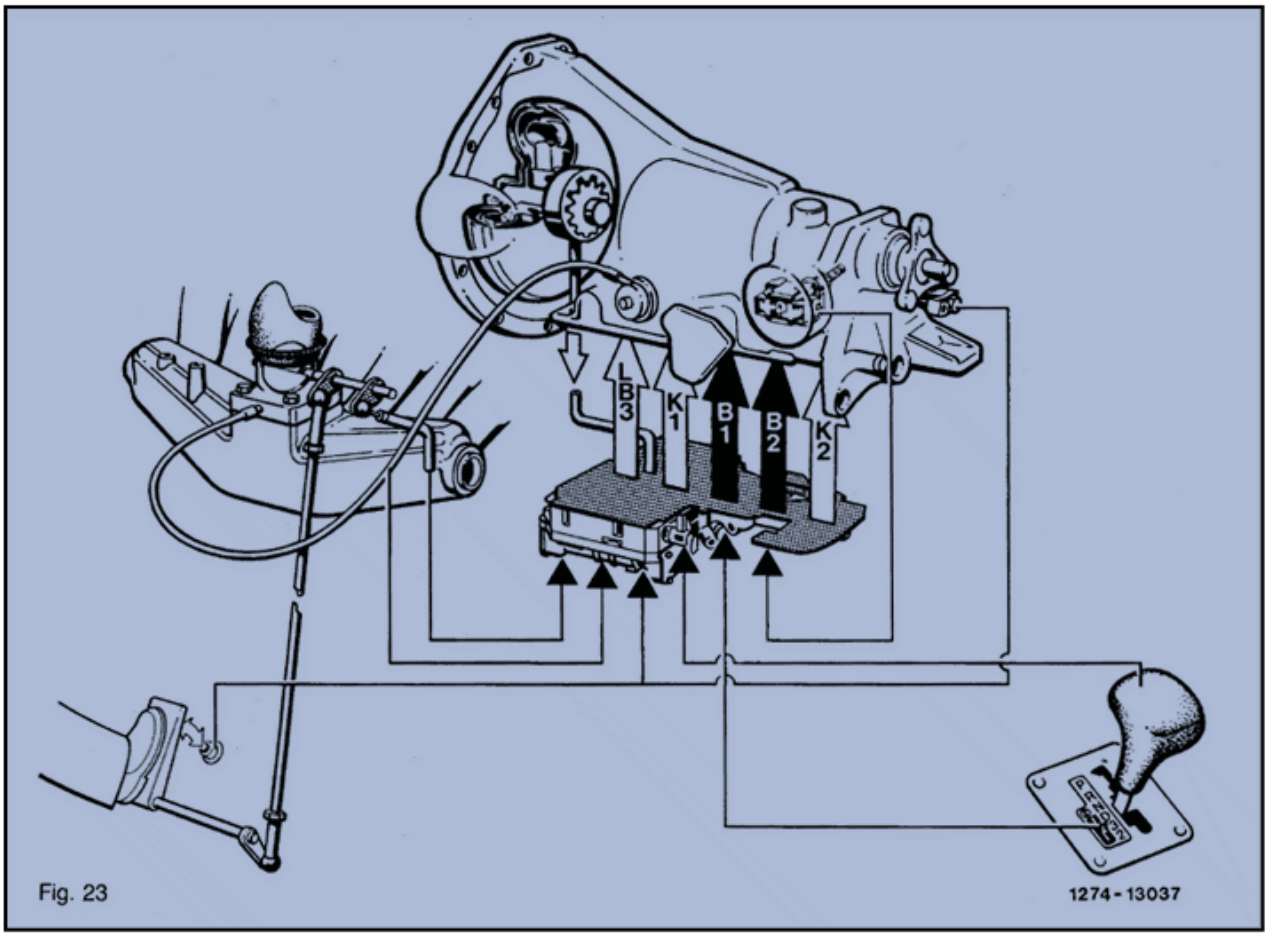

Fig. 23 1274-13037

The following individual views refer to the shift valve housing of the 2nd version as from production breakpoint 1.1982. Minor deviations on shift valve housing of the 1st version are not included.

The primary pump (70) is a gear wheel or half-moon shaped (sickle-shaped) pump which is located in front housing (cover). It is driven by the engine via drive flange of torque converter.

As long as the engine rotates, the primary pump (70) operates and supplies the entire hydraulic system with oil.

Drive (f) of the secondary pump (75) is switched off via shutoff piston (76) by the pressure of the primary pump (70).

Primary pump in operating condition, that is, with engine running and drive (f) of secondary pump switched off.

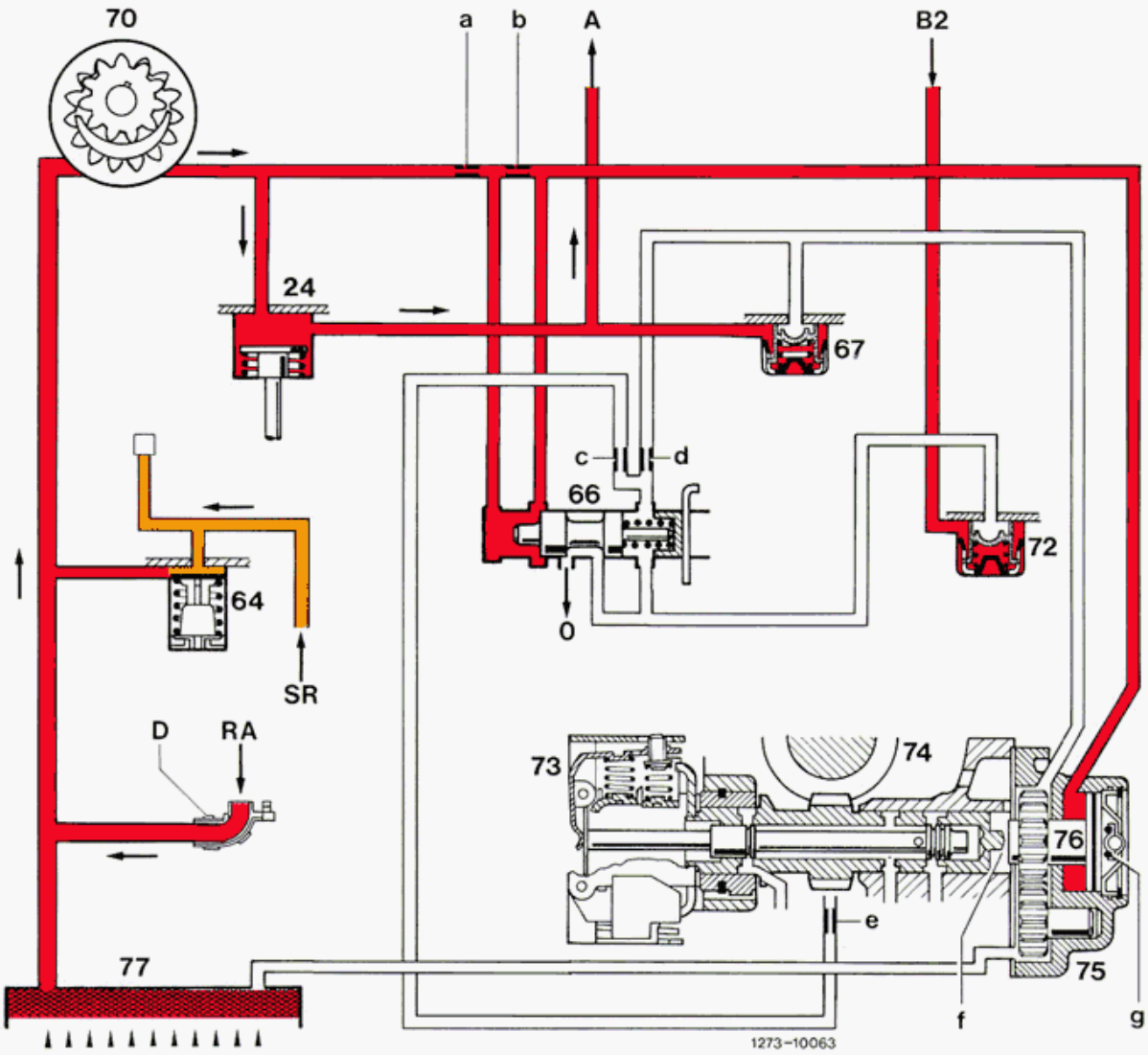

Fig. 24

24	Check valve, primary pump
64	Lubricating pressure valve
66	Shift valve, secondary pump
67	Check valve
70	Primary pump
72	Check valve
73	Centrifugal governor
74	Drive for governor and secondary pump
75	Secondary pump
76	Shutoff plunger, secondary pump
77	Oil filter

A	Working pressure
SR	Lubricating pressure
B2	Connection to shift side B2
RA	Excess oil flows through nozzle (D) of regulating valve-working pressure (26) back into intake duct or primary pump
D	Nozzle
a, b, c, d, e	Throttles
f	Drive, secondary pump
g	Compression spring
o	Drain, oil sump

□ For additional line progress refer to complete hydraulic diagram

The secondary pump (75) ist required only for tow starting and towing-off of vehicle. It is designed as an external gear pump and is located in rear section of transmission.

If required, the secondary pump is driven by the shaft of the centrifugal governor. If the engine has fired while tow-starting the vehicle, the secondary pump will be disconnected again only after either the vehicle has come to a stop or the transmission has shifted to 4th gear.

When the system is pressureless, the drive of the secondary pump will be reengaged only after the vehicle has come to a stop (deflecting surfaces on drive teeth).

Secondary pump in operative condition, that is, with engine stopped and vehicle rolling (tow-start), brake band B2 begins to grip.

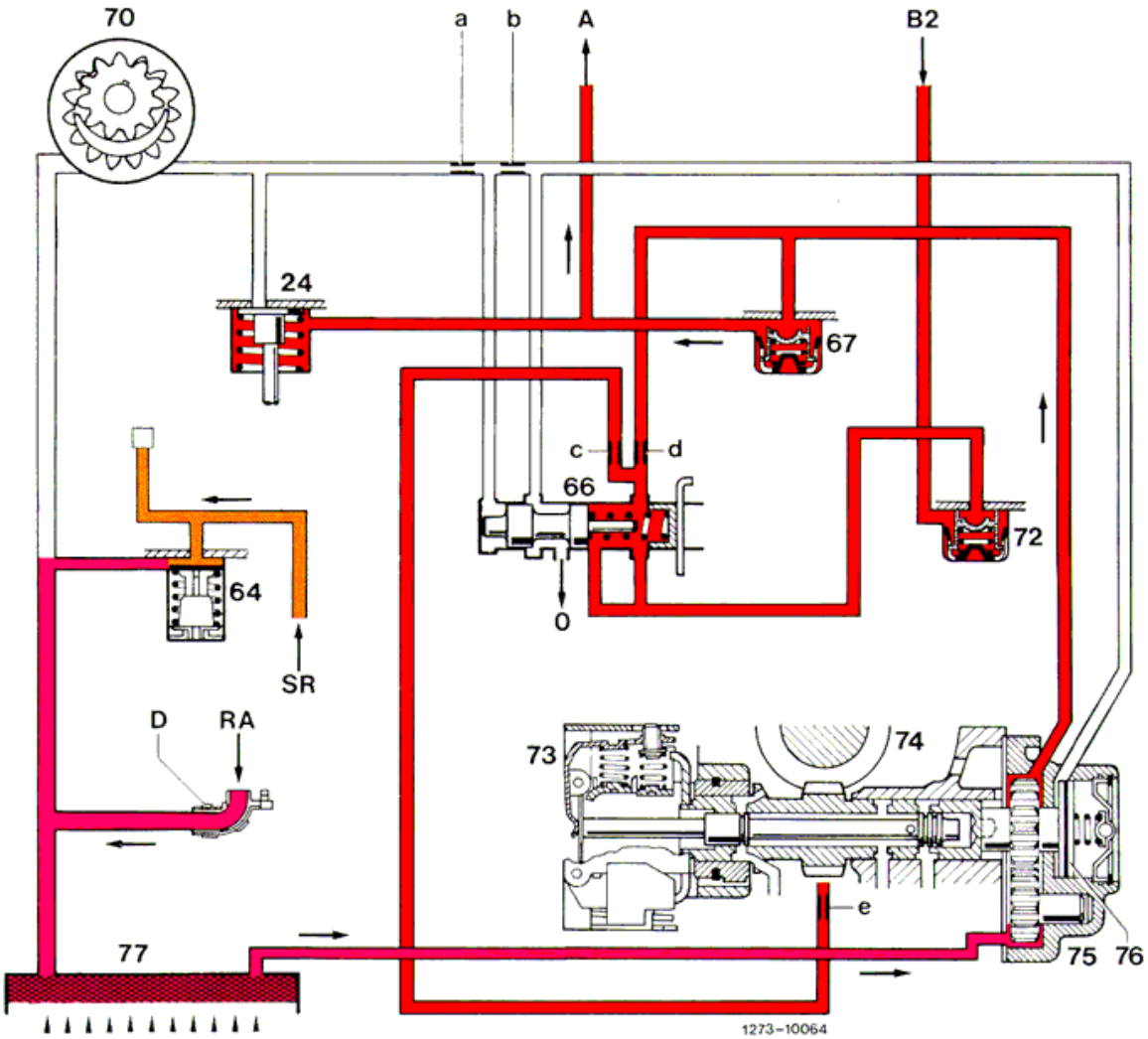

Fig. 25

24 Check valve, primary pump
64 Lubricating pressure valve
66 Shift valve, secondary pump
67 Check valve
70 Primary pump
72 Check valve
73 Centrifugal governor
74 Drive for governor and secondary pump
75 Secondary pump
76 Switch-off plunger, secondary pump
77 Oil filter

□ For additional line progress refer to complete hydraulic diagram

A Working pressure
SR Lubricating pressure
B2 Connection to shift side B2
O Drain of oil sump
RA Excess oil flows through nozzle (D) of regulating valve-working pressure (26) back into intake duct of primary pump
D Nozzle
a, b, c, d, e Throttles

The following pressures are regulated to control the hydraulic system and to actuate the shift elements:

A	Working pressure
RA	Reduced pressure or flown-through by oil
SR	Lubricating pressure
M1	Modulating pressure (vacuum-dependent)
M2	Modulating pressure (speed-dependent)
S1	Full throttle-control pressure (constant)
S2	Control pressure (load-dependent)
S3	Kickdown-control pressure (control pressure S2-dependent)
R	Governor pressure
VR	Amplified governor pressure
SD	Shift pressure

1274 – 12 066

The working pressure actuates the multiple-disc brake B3, the brake bands and the clutches.

This pressure is regulated by the working pressure. Independent of the oil coming out of the primary or secondary pump, the pressure level is adapted to the respective operating condition. As a result, the primary pump capacity can be held as small as possible, so that the efficiency of the transmission will be high. The working pressure is always the highest pressure in the hydraulic system. All the other pressures are derived from this max. pressure and reduced to a lesser pressure by means of regulating valves.

The following operating conditions are included:

- Regulation in basic pressure range (deceleration)
- Regulation under engine load

The working pressure system is influenced by

- Position of accelerator pedal
- Driving speed
- Position of selector lever
- Shifted gear

The following elements are included in working pressure system (Fig. 28)

- Control valve working pressure (26)
- Control valve basic pressure (16)
- Two-way ball valve (14)
- Two-way ball valve (15)
- Pressure relief valve modulating pressure (25)
- Throttle check valve (81)

The control valve-working pressure (26) determines the amount of working pressure. This pressure varies or

- rises above force of pressure in spring chamber, which acts to the right together with spring force,
- is reduced via forces acting against control surfaces (f), (g), (l) and (m) to the left.

The working pressure actuates the multiple-disc brake B3, the brake bands and the clutches.

This pressure is regulated by the working pressure. Independent of the oil coming out of the primary or secondary pump, the pressure level is adapted to the respective operating condition. As a result, the primary pump capacity can be held as small as possible, so that the efficiency of the transmission will be high. The working pressure is always the highest pressure in the hydraulic system. All the other pressures are derived from this max. pressure and reduced to a lesser pressure by means of regulating valves.

The following operating conditions are included:

- Regulation in basic pressure range (deceleration)
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The working pressure system is influenced by

- Position of accelerator pedal
- Driving speed
- Position of selector lever
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The following elements are included in working pressure system (Fig. 28)

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The control valve-working pressure (26) determines the amount of working pressure. This pressure varies or

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The following pressures are regulated to control the hydraulic system and to actuate the shift elements:

A	Working pressure
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M1	Modulating pressure (vacuum-dependent)
M2	Modulating pressure (speed-dependent)
S1	Full throttle-control pressure (constant)
S2	Control pressure (load-dependent)
S3	Kickdown-control pressure (control pressure S2-dependent)
R	Governor pressure
VR	Amplified governor pressure
SD	Shift pressure

1274 - 12 066

Regulation proceeds via flow-off edges (h) and (j). As soon as the control valve (26) deflects to the left, the excessive oil quantity is preferably fed to the lubricating system via flow-off edge (h). The remaining excess oil, depending on pump speed and oil temperature, flows via flow-off edge (j) and nozzle (D) back to suction end of primary pump.

The control valve basic pressure (16) regulates a basic pressure at a low modulating pressure M2. In basic pressure range this pressure is derived from working pressure A1/AR or governor pressure R and is taken to the spring chamber of valve (26).

Basic pressure range is the name for an operating condition of the transmission, in which the modulating pressure amounts to zero or is very low.

Regulation in basic pressure range (deceleration)

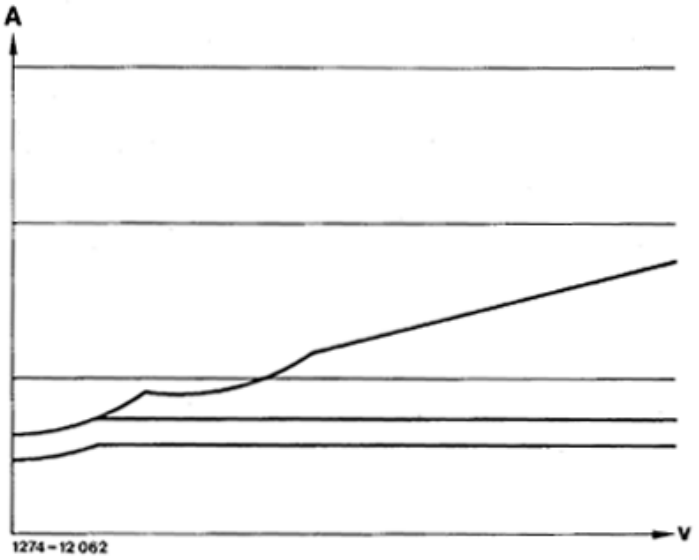


Fig. 26

A Working pressure
V Speed

Basic pressure reverse speed

The working pressure AR arrives via two-way ball valve (15), regulating edge (e) and two-way ball valve (14) in spring chamber of regulating valve – working pressure (26). This pressure acts also against annular surface (c) of control valve – basic pressure (16) and presses the latter against the force of its spring to the left into control position. As a result, the infeed for working pressure AR at control edge (e) is closed. The valve (16) controls a high pressure, since the face (d) is pressureless during reverse speed. The annular surface (f) and face (m) on valve (26) are also pressureless. A high and constant working pressure is regulated.

Basic pressure 1st speed, position "2"

Regulation as described under basic pressure-reverse speed.
Deviating therefrom is:

- Inflow is working pressure A1
- Face (m) of valve (26) is pressurized in addition to annular surface (l). As a result, a lower working pressure than in reverse speed is controlled.

Basic pressure 2nd speed, position "2"

The regulator pressure (R) increases with the driving speed and flows toward spring chamber of valve (26). The force of regulator pressure at annular surface (c) is without working pressure and at face (d) not high enough to push valve (16) to the left into regulating position. Valve (26) controls a working pressure which is increasing with the working pressure.

Basic pressure 1st and 2nd speed, position "D" and "3"

Regulator pressure (R) flows up to spring chamber of valve (26). Working pressure AD-3 is switched to face (d) of valve (16). The increasing regulator pressure at annular surface (c) forces, supported by working pressure at face (d), the valve (16) to the left into regulating position.

The pressure is regulated initially increasing with regulator pressure and will then become a constantly progressing working pressure.

Basic pressure 3rd and 4th speed, position "D"

Regulation as described under basic pressure 1st and 2nd speed, position "D" and "3". In addition, the annular surface (g) on valve (26) is pressurized. The resulting working pressure is less than in 1st and 2nd speed.

Basic pressure in position "N"

On regulating valve-working pressure (26), a constant working pressure is regulated via force of pressure on annular surface (1), which acts against the spring force. All the other control surfaces are pressureless.

Control under engine load

Diagram "control at full throttle" (max. modulating pressure). At lesser modulating pressures the curves are displaced downward, but not deeper than with basic pressure control.

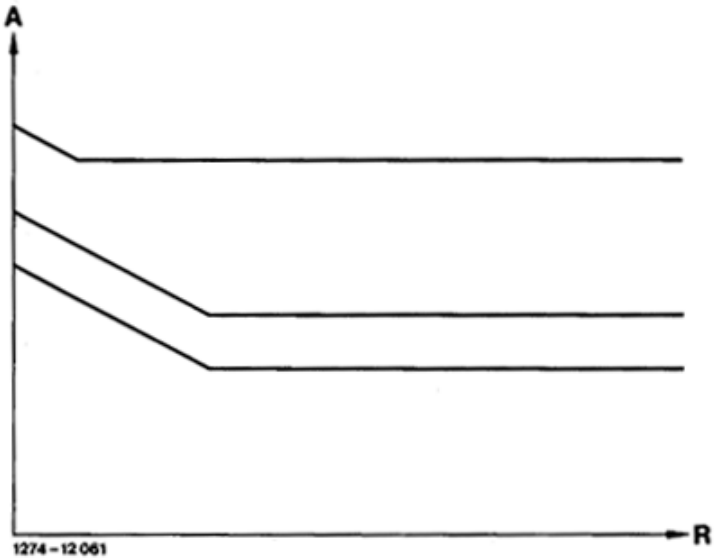


Fig. 27

A Working pressure
R Governor pressure

During acceleration, modulating pressure M2 will be under control. This pressure flows toward two-way ball valve (14) and via throttle (b) to annular surface (f). As soon as the modulating pressure M2 becomes higher than the pressure controlled by valve (16), the ball valve (14) will control in upward direction and the modulating pressure M2 flows toward spring chamber of valve (26). The pressure at annular surface (f) acts in direction of low working pressure.

Working pressure reverse speed

On valve (26) only the annular surface (1) is pressurized. A high working pressure is controlled. At low speed or at low governor pressure the working pressure is increased according to pressure development of modulating pressure M2.

Working pressure in 1st and 2nd speed

On valve (26) the annular surface (1) and the face (m) are connected with the working pressure. The controlled working pressure is less than the pressure at reverse speed. This pressure is increased in lower speed range according to converter adaptation.

Working pressure in 3rd and 4th speed

On valve (26) the annular surface (g) is additionally pressurized. The result is a lower pressure than at 1st and 2nd speed. The pressure development is the same.

Working pressure system

shown in driving position "D" 2nd speed and part throttle

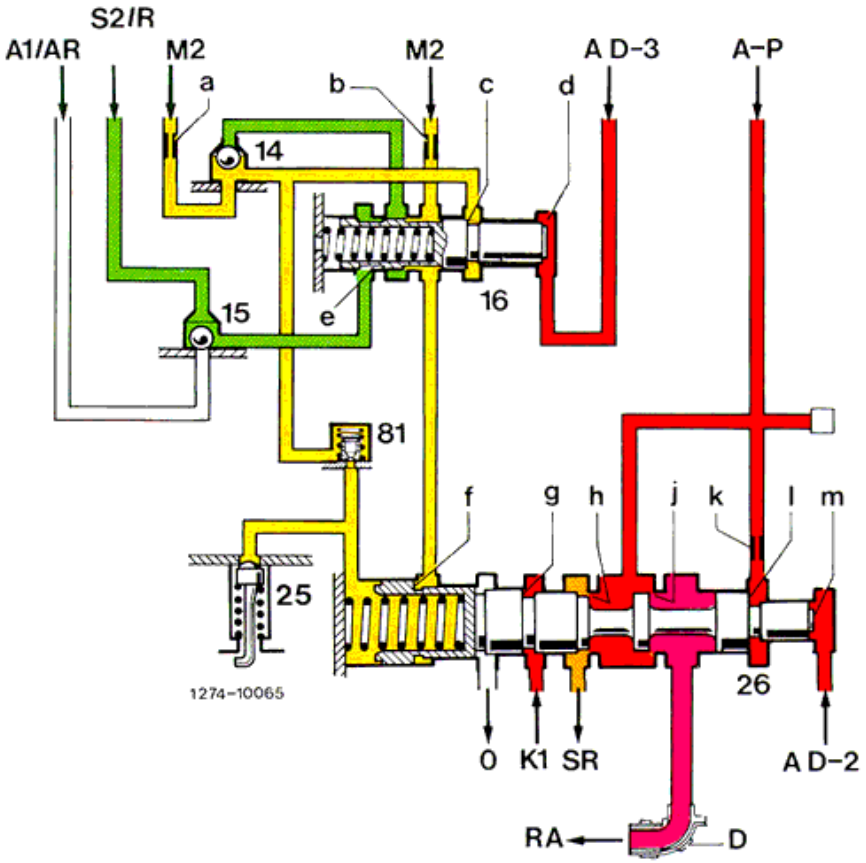


Fig. 28

14	Two-way ball valve
15	Two-way ball valve
16	Control valve-basic pressure
25	Pressure relief valve-modulating pressure
26	Control valve-working pressure
81	Throttle check valve
A-P	Working pressure from primary pump
A1/AR	Working pressure in 1st speed and reverse
AD-3	Working pressure in positions "D" and "3"
AD-2	Working pressure in positions "D" up to "2"
RA	Excess oil flows via nozzle "D" back to suction duct of primary pump
SR	Lubricating pressure
M2	Modulating pressure (increased dependent on speed)
S2/R	Control pressure (load-dependent) at idle throttle or governor pressure under load
O	Outlet oil sump
D	Nozzle on large intermediate plate (injector)
K1	Connection from clutch K1, working pressure with K1 actuated
a,b	Throttles
c	Annular surface
d	Face
e	Control edge
f,g	Annular surfaces
h,j	Control edges
k	Throttle
l	Annular surface
□	For additional progress of line refer to complete hydraulic diagram

The modulating pressure influences the height of the working pressure from part to full throttle or of control pressure.

The modulating pressure is derived from working pressure and controlled at two separate control valves:

- on control valve (69) modulating pressure M1 (vacuum-dependent)
- on control valve (5) modulating pressure M2 (increased depending on speed)

The torque increase of the torque converter in starting range requires this increase of the modulating pressure M2.

Modulating pressure M1

The modulating pressure system M1 comprises the control valve (69) and a vacuum control unit (68). The spring chamber of the vacuum control unit is connected with the intake manifold of the engine. At increasing vacuum the force of spring (b) against control valve (69) is reduced.

The modulating pressure M1 is controlled at control edges (d) and (f), in dependence of the force of spring (b) and the pressure put in at face (e).

This means:

Throttle valve closed

- low engine load
- high vacuum

provides

- low modulating pressure
- low working pressure

Throttle valve opened

- high engine load
- low vacuum

provides

- high modulating pressure
- high working pressure

Modulating pressure M2

The modulating pressure M1 is increased at control valve converter adaptation (5) in dependence of the speed and provides modulating pressure M2.

In starting position the control valve (5) is at the right, forced against stop by the spring force. As soon as modulating pressure M1 is established, this pressure moves into the modulating pressure system M2. Simultaneously, modulating pressure M1 acts against face (k) and pushes valve (5) to the left against the prevailing spring force. This will close the connection toward modulating pressure M1 and the working pressure inflow is opened at control edge (j). The modulating pressure M2 increases and forces valve (5) into control position via annular surface (h).

While the vehicle is rolling along, control pressure flows to face (g). The force of the pressures at face (g) and annular surface (h) as well as the force of the spring oppose the modulating pressure M1 at surface (k).

At increasing governor pressure the modulating pressure M2 drops continuously until valve (5) is forced out of the control position up to righthand stop. Modulating pressure M1 will flow directly into modulating pressure system M2, both modulating pressures have the same level.

Modulating pressure M1

The modulating pressure system M1 comprises the control valve (69) and a vacuum control unit (68). The spring chamber of the vacuum control unit is connected with the intake manifold of the engine. At increasing vacuum the force of spring (b) against control valve (69) is reduced.

The modulating pressure M1 is controlled at control edges (d) and (f), in dependence of the force of spring (b) and the pressure put in at face (e).

This means:

Throttle valve closed

- low engine load
- high vacuum

provides

- low modulating pressure
- low working pressure

Throttle valve opened

- high engine load
- low vacuum

provides

- high modulating pressure
- high working pressure

Modulating pressure M2

The modulating pressure M1 is increased at control valve converter adaptation (5) in dependence of the speed and provides modulating pressure M2.

In starting position the control valve (5) is at the right, forced against stop by the spring force. As soon as modulating pressure M1 is established, this pressure moves into the modulating pressure system M2. Simultaneously, modulating pressure M1 acts against face (k) and pushes valve (5) to the left against the prevailing spring force. This will close the connection toward modulating pressure M1 and the working pressure inflow is opened at control edge (j). The modulating pressure M2 increases and forces valve (5) into control position via annular surface (h).

While the vehicle is rolling along, control pressure flows to face (g). The force of the pressures at face (g) and annular surface (h) as well as the force of the spring oppose the modulating pressure M1 at surface (k).

At increasing governor pressure the modulating pressure M2 drops continuously until valve (5) is forced out of the control position up to righthand stop. Modulating pressure M1 will flow directly into modulating pressure system M2, both modulating pressures have the same level.

Modulating pressure system

shown in lower speed range. Both valves (69) and (5) are in control position.

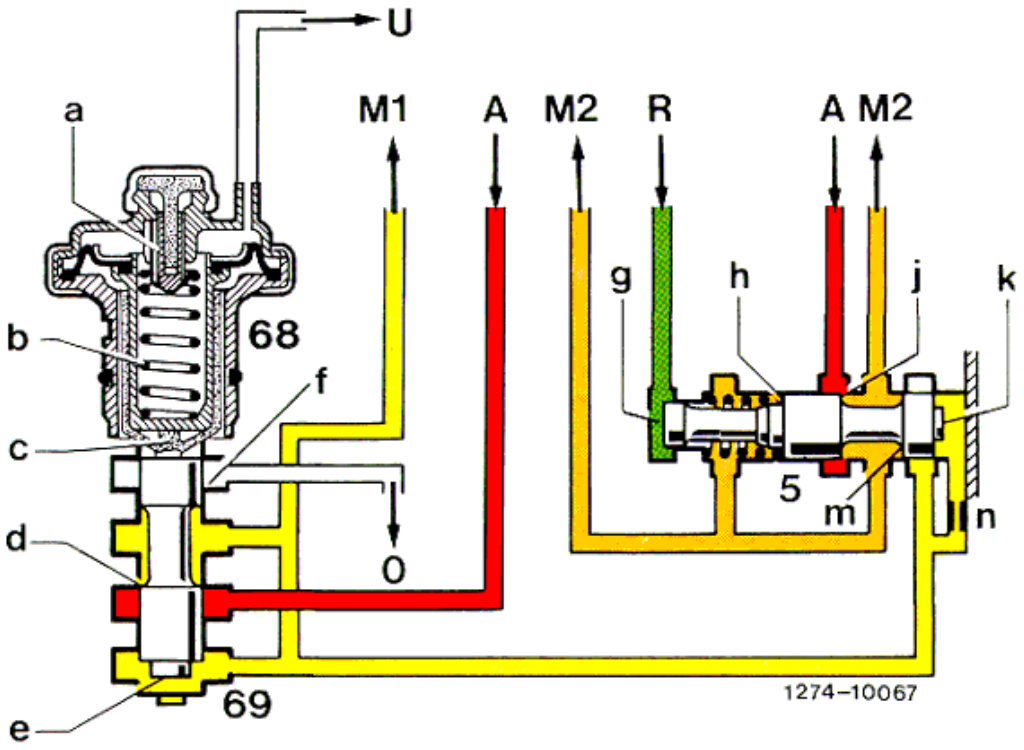


Fig. 29

5	Control valve-converter adaptation
68	Vacuum control unit
69	Control valve-modulating pressure
A	Working pressure
M1	Modulating pressure (vacuum-dependent)
M2	Modulating pressure (increased depending on speed)
R	Governor pressure
O	Outlet, oil sump
U	Connection to intake manifold of engine (vacuum)
a	Adjusting screw
b	Compression spring
c	Plastic pin
d	Control edge
e	Face
f	Control edge
g	Face
h	Annular surface
j	Control edge
k	Face
m	Control edge
n	Throttle

The pressurized lube oil flows through the torque converter and the oil cooler and is routed to the mechanical part of the transmission in cooled down condition. This will keep the transmission temperature in permissible limits.

The lube oil flows from the flow-off edge (h) of control valve-working pressure (26) to torque converter, from there to oil cooler and back again to transmission. It is guided through the ducts and bores in the housings, shafts and wheels to the point where it is required for cooling and lubrication.

The lubricating pressure is limited by the lubricating pressure valve (64). The excess oil flows back into suction duct of primary pump. In upper speed range of engine the lubricating pressure varies between 3.5 and 5.0 bar.

In the 4th gear the spring chamber of the control pin (35) will be pressureless upon release of brake band B2. The lubricating pressure at opposite face raises the control pin (35) against the spring force and a part of the lube oil flows directly back into suction duct of primary pump. The oil quantity for the lube points in the transmission is reduced, since the planetary gear sets rotating as a block require only a low quantity of lube oil.

Lubricating pressure system

shown with brake band B2 actuated.

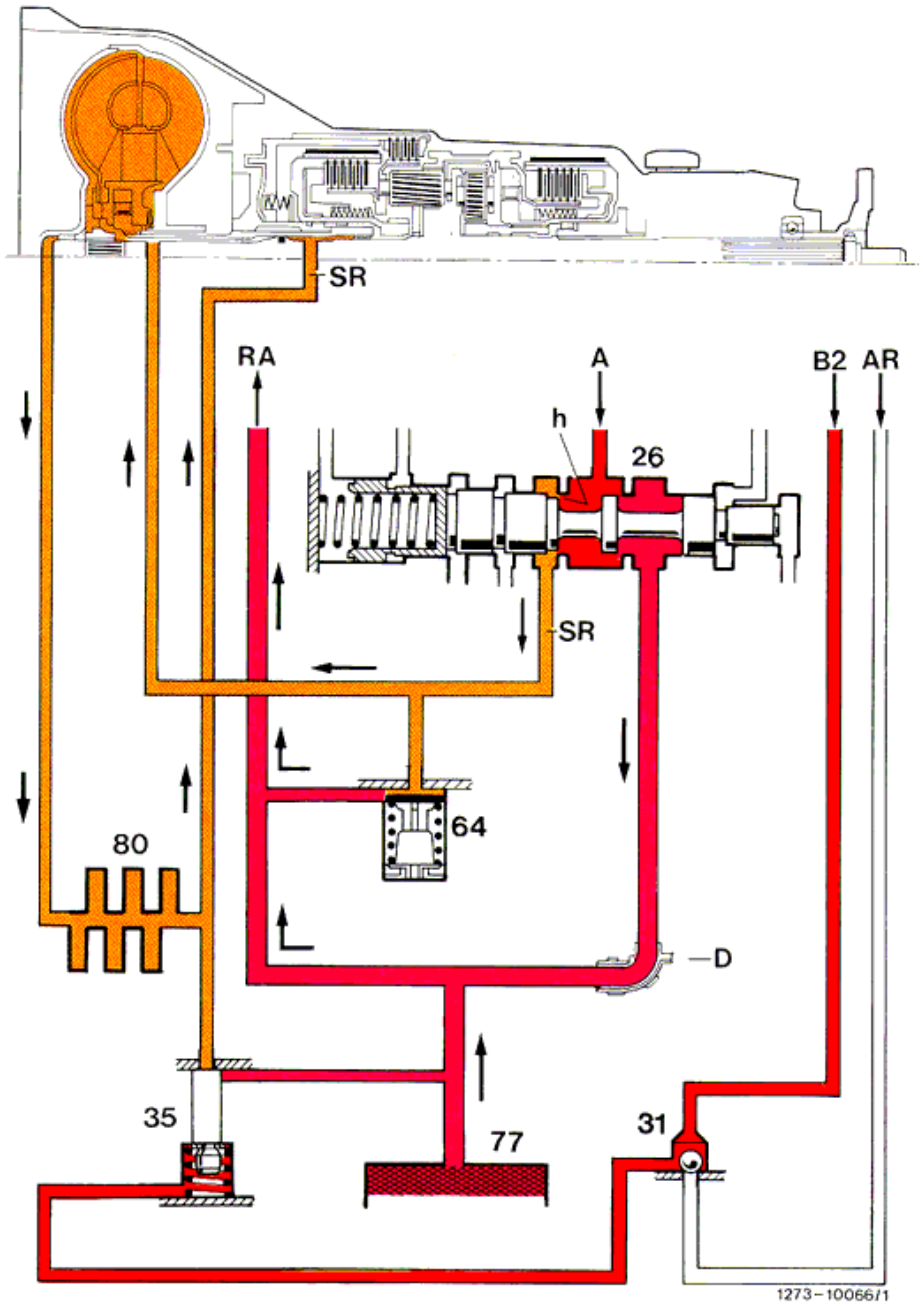


Fig. 30

26	Control valve-working pressure
31	Two-way ball-valve
35	Control pin lubricating pressure
64	Lubricating pressure valve
77	Oil filter
80	Oil cooler
A	Working pressure
AR	Working pressure with reverse speed engaged
RA	Excess oil flows via nozzle (D) back into suction duct of primary pump
SR	Lubricating pressure
B2	Connection to control side B2
D	Nozzle on large intermediate plate (injector)
h	Flow-off edge

Control pressures S1 and S2

The control pressure system controls a pressure which varies under influence of the position of accelerator pedal. This pressure or the pressures S1, S2 and S3 are acting on the command valves against the governor pressure and thereby determine the shift points.

The control pressure system for the control pressures S1 and S2 comprises:

- Control valve-full throttle (32) for control pressure S1
- Control valve-control-pressure (45) for control pressure S2
- Plunger control valve-control pressure (46) opens or closes the flow-off cross sections VL1 and VL2, as well as S2-V.

Control pressure S1 (constant or approximately constant)

The control pressure S1 determines the shift points at full throttle and kickdown. It is derived from the working pressure and controlled at control valve-full throttle (32).

The level of the control pressure S1 is influenced by the spring force, which can be steplessly adjusted by means of adjusting screw (d). The control pressure at the annular surface (b) and at the face (c) operates against the spring force and pushes valve (32) to the left into control position. This will throttle the working pressure inflow or, during pressure reduction, will open the zero outlet. The annular surface (b) is connected with control pressure (S2). This will slightly change the amount of control pressure S1, refer to diagram.

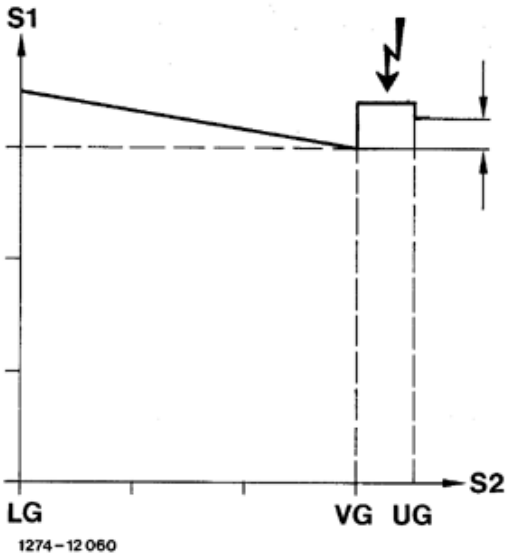


Fig. 31

S1 Control pressure S1
S2 Control pressure S2
LG Idle throttle
VG Full throttle
UG Kickdown

S1	
at VG	= S2VG
at LG	> S2VG
at UG	= S2UG and > S2VG

Control pressure S2 (load-dependent)

The control pressure S1 flows as an infeed pressure toward control valve-control pressure (45).

The control pressure S2 determines the shift points at idle throttle and part throttle. This pressure is derived from control pressure S1 and is controlled at control valve-control pressure (45).

At idle throttle the height of the control pressure S2 is determined by the force of spring (j). After stepping down on accelerator pedal the plunger-control valve-control pressure (46) is pushed to the left via control pressure cable control (102) and guide lever (78). After covering a given distance, the spring (m) acts additionally against control valve (45). The control pressure S2 reacts against the spring forces at left face and forces the control valve (45) to the right into control position. This will throttle the inflow for control pressure S1 or will open the zero outlet when the pressure is reduced.

This means, at

idle throttle = low spring force = low control pressure S2

part throttle = higher spring force = higher control pressure S2

full throttle and kickdown, the control valve (45) is forced completely to the left via spring guide (n). The control edge (h) opens and the control pressure S2 increases up to the pressure of control pressure S1. Both pressure values are the same.

The control pressure cable control is actuated by the engine throttle control system. The movements of throttle valve and plunger-control valve-control pressure (46) are therefore accurately coordinated and adapted to the engine-transmission combination. For this reason, correct adjustment of control pressure cable control is of high importance.

The force for actuating the plunger-control valve-control pressure (46) is determined by spring (k). After stepping down on accelerator pedal, the increasing hydraulic force on lefthand face is balanced by the control pressure S2 on annular surface (p). This will reduce the required foot pressure against accelerator pedal.

To prevent pressure peaks of control pressure S2 during spontaneous actuation of accelerator pedal, the control valve (45) is provided at the left with a damping plunger (g) with a spring, which slows down the control movements of the control valve (45).

The plunger-control valve-control pressure (46) controls the following signals:

- after approx. 1.5 mm stroke the outflow cross sections VL2 will be closed
- after approx. 4.5 mm stroke the outflow cross section VL1 will be closed
- after approx. 15 mm stroke the connection S2 to S2-V will be opened.

Control pressure system

shown with engine running and idle throttle

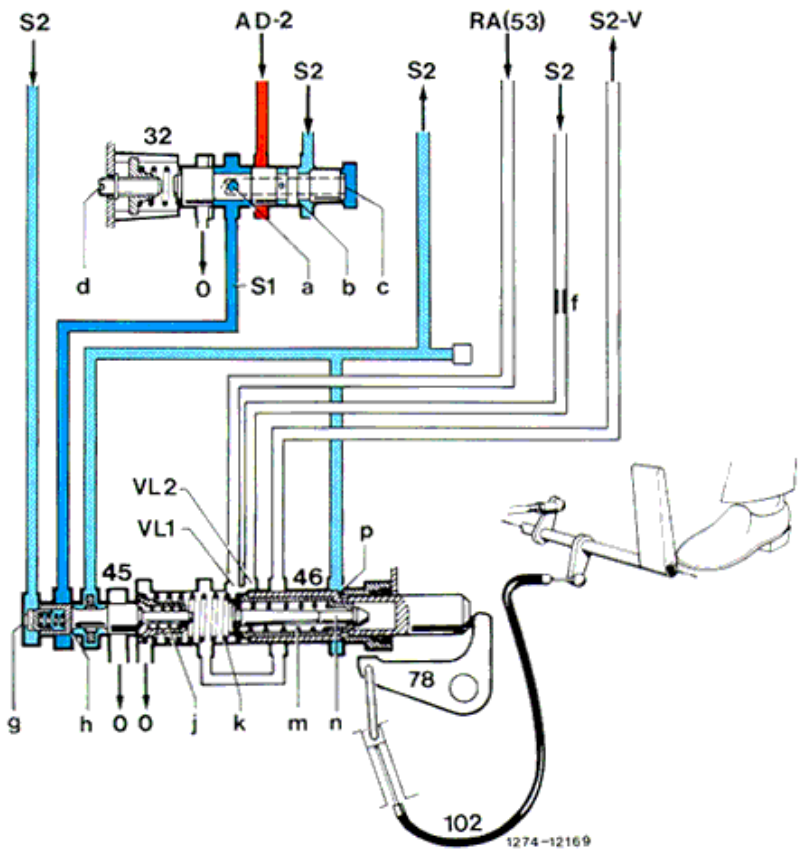


Fig. 32

32	Control valve – full throttle
45	Control valve – control pressure
46	Plunger control valve – control pressure
78	Reverse transfer
102	Control pressure cable control
AD-2	Working pressure in positions "D" to "2"
RA(53)	Connection from accumulator (53)
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S2-V	Control pressure at full throttle
VL1	Flow-off cross section for oil quantity from spring chamber of accumulator (53)
VL2	Flow-off cross section for control pressure S2, open at idle throttle
a	Radial bore
b	Annual surface
c	Face
d	Adjusting screw
f	Throttle
g	Damping plunger
h	Control edge
j	Idle throttle spring
k	Compression spring
m	Full throttle spring
n	Spring guide
p	Annular surface
O	Outlet, oil sump
□	For additional line progress refer to complete hydraulic diagram

Kickdown-control pressure S3

The kickdown-control pressure S3 is established in kickdown system. This pressure acts on command valves against the governor pressure and thereby determines the kickdown-shiftpoints. On transmissions with 19 balls in shift valve housing this pressure permits in addition earlier downshifts at part up to full throttle.

The kickdown system comprises:

- control valve-full throttle (32)
- shift valve-kickdown (40)
- accumulator-kickdown (63)
- solenoid valve-kickdown (71)
- kickdown switch (100)
- throttle check valve (82)

Shift valve housing with 19 balls

The kickdown control pressure S3 is controlled at part up to full throttle, refer to diagram. The characteristic curve shows that as from approx. 1.3 bar control pressure S2 the kickdown-control pressure S3 is increasingly controlled. At kickdown, the control pressure S3 jumps suddenly to height of control pressure S2 at kickdown.

Control pressure S2 flows via throttle check valve (82) and throttle (a) in accumulator-kickdown (63) to solenoid valve (71) and to left face (g) on control valve-control pressure (45).

Without kickdown, the needle valve of the solenoid valve (71) is closed. The control pressure S2 closes the ball check valve (83) in downward direction and acts against lefthand face of valve (40). At approx. 1.3 bar control pressure S2 the force at lefthand face exceeds, and valve (40) is forced to the right against the prevailing spring force. Control edge (f) opens and control pressure S3 flows to command valves. This pressure acts via throttle (c) on spring chamber and supports the spring force. Valve (40) moves to the left into control position. This will throttle the infeed control pressure S2 and the zero outlet will be opened to reduce the pressure. At increasing control pressure S2 the control pressure S3 will also increase.

At kickdown, the kickdown switch (100) will be actuated and the solenoid valve (71) will be energized. The needle valve opens and the line system connected to this valve will become pressureless.

- An intermediate pressure, in accordance with throttle diameter, will be established between the throttles (a) and (b), which will have an effect on the annular surface (d) and the accumulator (63). The control pressure S1 will then increase above its full throttle value. In addition, a time-limited increase of the control pressure S1 is obtained during the operating time of the accumulator (63) for the spontaneous initiation of kickdown-downshifts.

- The ball valve (83) opens in upward direction and the pressure in direction of throttle (c) is reduced. Valve (40) switches up to stop to the right and the kickdown-control pressure jumps suddenly to level of control pressure S2 during kickdown.

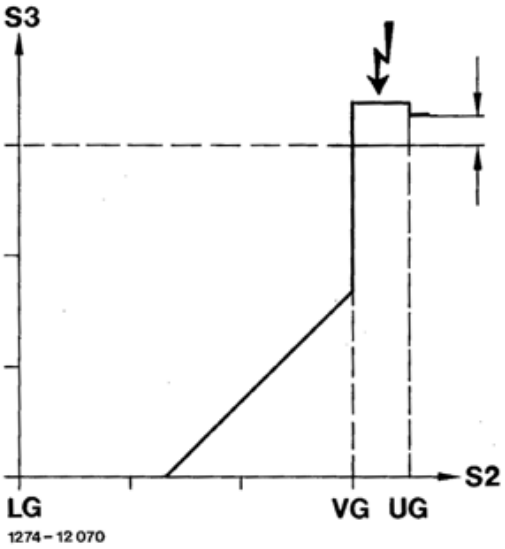
Shift valve housing without ball check valve (83)

On some shift valve housing versions the ball check valve (83) is eliminated. The connecting line with throttle (c) between faces of shift valve-kickdown (40) is not installed.

This shift valve housing controls no control pressure-dependent kickdown pressure S3.

However, the function of kickdown remains unchanged.

Diagram for pressure path of kickdown-control pressure S3 for shift valve housing with 19 balls.

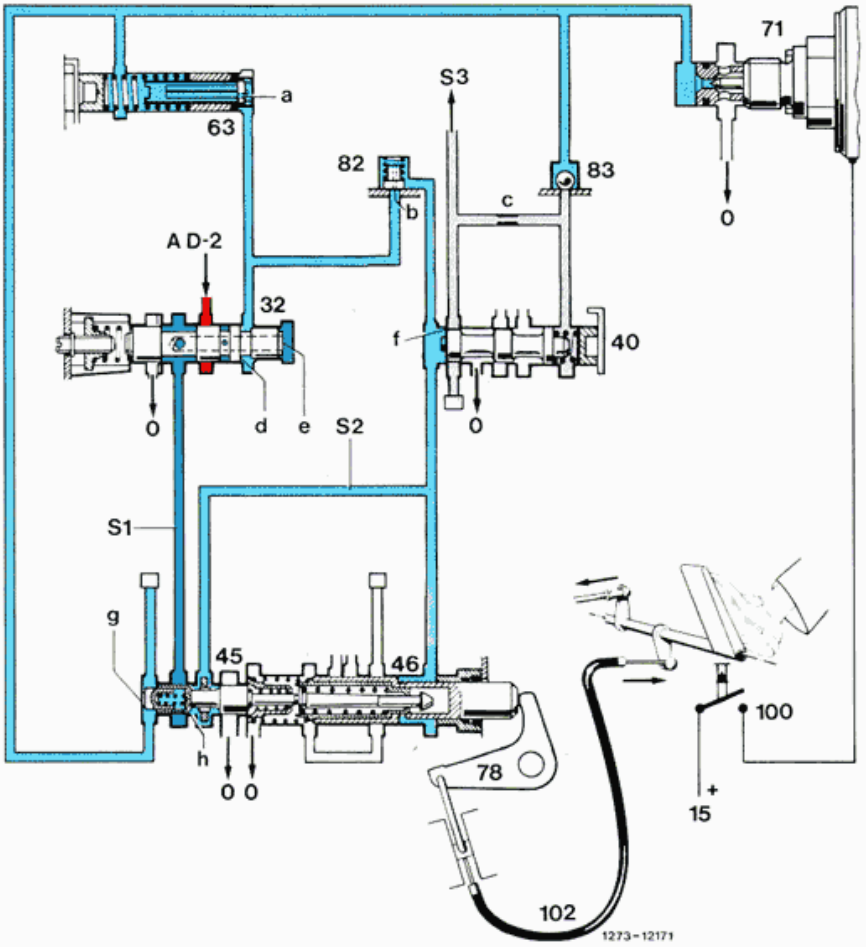


S3 = S2
at VG

UG-increase

Fig. 33

S2 Control pressure S2
S3 Kickdown-control pressure S3
LG Idle throttle
VG Full throttle
UG Kickdown

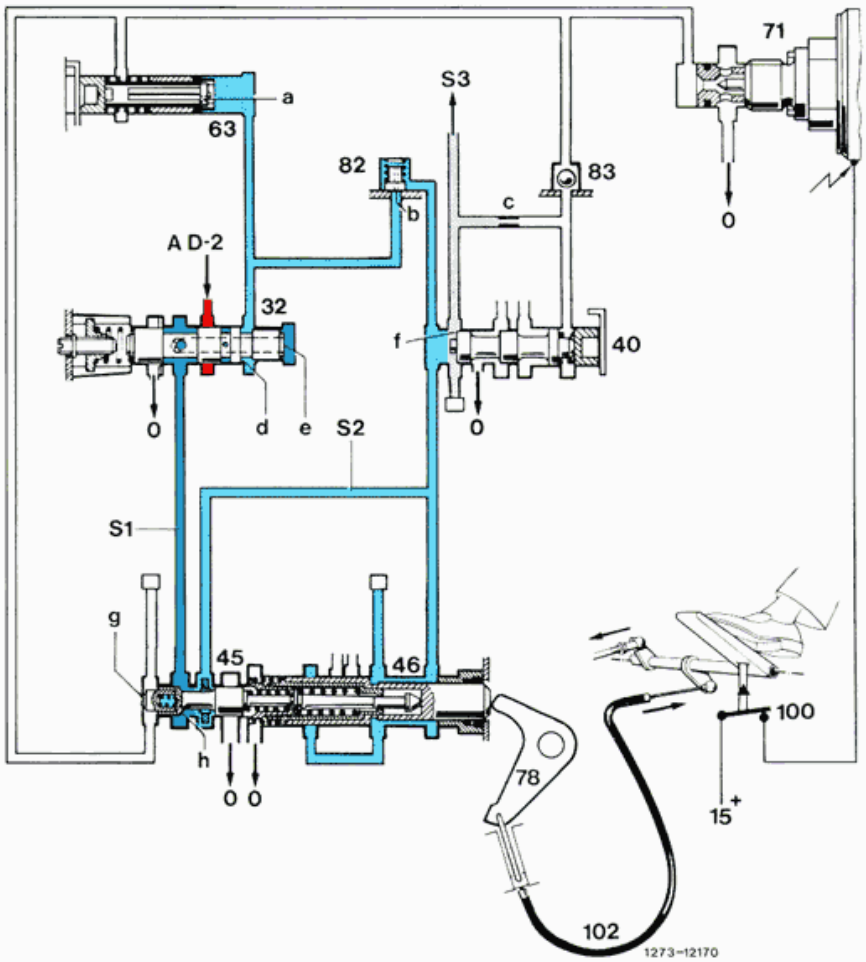


Kickdown system

at part throttle, kickdown-control pressure S3 is controlled

Fig. 34

32	Control valve-full throttle
40	Shift valve-kickdown
45	Control valve-control pressure
46	Plunger control valve-control pressure
63	Accumulator-kickdown
71	Solenoid valve-kickdown
78	Reverse transfer lever
82	Throttle check valve
83	Ball check valve
100	Kickdown switch
102	Control pressure cable control
AD-2	Working pressure at "D" to "2"
S1	Control pressure S1 (constant)
S2	Control pressure S2 (load-dependent)
S3	Kickdown-control pressure
O	Outlet, oil sump
a	Throttle cross section
b	Throttle cross section
c	Throttle
d	Annular surface
e	Face
f	Control edge
g	Damping plunger
h	Control edge
□	For additional line progress refer to complete hydraulic diagram



at kickdown, kickdown-control pressure S3 increases to its full value

Fig. 35

32	Control valve-full throttle
40	Shift valve-kickdown
45	Control valve-control pressure
46	Piston control valve-control pressure
63	Accumulator-kickdown
71	Solenoid valve-kickdown
78	Reverse transfer lever
82	Throttle check valve
83	Ball check valve
100	Kickdown switch
102	Control pressure cable control
AD-2	Working pressure at "D" to "2"
S1	Control pressure S1 (constant)
S2	Control pressure S2 (load-dependent)
S3	Kickdown-control pressure
O	Outlet, oil sump
a	Throttle cross section
b	Throttle cross section
c	Throttle
d	Annular surface
e	Face
f	Control edge
g	Damping plunger
h	Control edge
□	For additional line progress refer to complete hydraulic diagram

The governor pressure is derived from working pressure and established by the governor pressure system.

The pressure acts at command valve against the control pressure or kickdown-control pressure and determines the shift points (upshifts).

The governor pressure system comprises:

- governor drive via helical gear (74)
- centrifugal governor (73) with control valve (a) and 3 flyweights each (F1, F2 and F3).

With vehicle stopped, the flyweights are swivelled inwards and thereby force the control valve (a) to the left. The working pressure inlet is closed and the zero outlet is open.

With the vehicle rolling along, the output shaft will drive the centrifugal governor. The flyweights swivel outwards and will force the control valve (a) to the right.

As from approx. 10 km/h the zero outlet is closed and the working pressure inlet at control edge (c) is opened. The governor pressure is established by flowing through radial bore (b) toward face (d). The governor pressure forces the control valve (a) against force of flyweights to the left into control position. The working pressure inlet is thereby throttled at control edge (c) and the zero outlet is opened to reduce the pressure.

The centrifugal force increases with increasing speed and thereby also the governor pressure.

This means:

low speed	= low governor pressure
high speed	= high governor pressure

The pressure increases in 3 stages, refer to diagram. The flyweights F1 and F2 are supported against governor housing in dependence of speed and will thereby become ineffective for additional pressure increase.

Note: **without governor pressure = no upshifts**

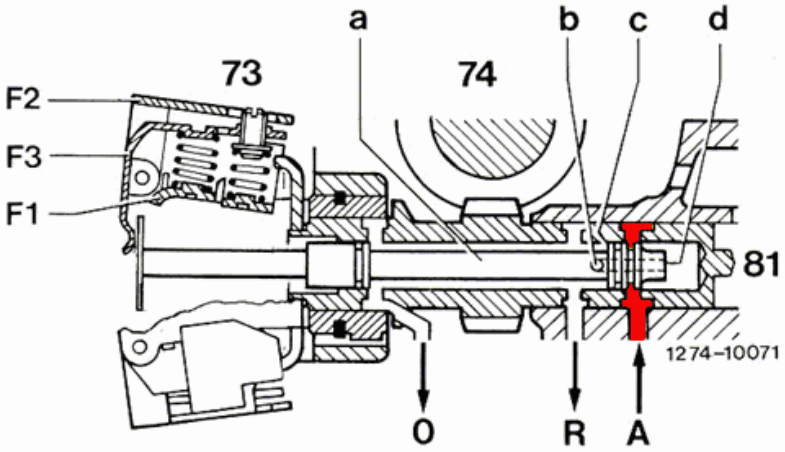


Fig. 36

with engine running and vehicle stopped

73 Centrifugal governor
74 Drive for governor and secondary pump
81 Driver for secondary pump
F1 Flyweight no. 1
F2 Flyweight no. 2
F3 Flyweight no. 3

A Working pressure
R Governor pressure
O Oil sump outlet

a Control valve
b Radial bore with connection to face (d)
c Control edge
d Face

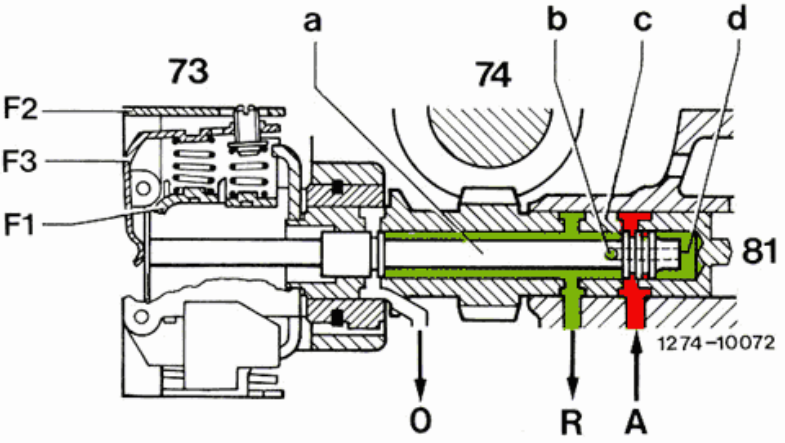
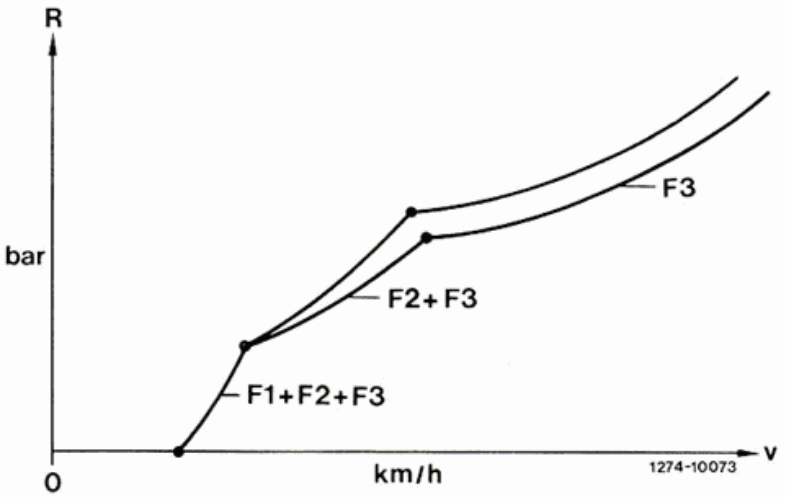


Fig. 37

with engine running and vehicle rolling



v Speed
R Governor pressure

F1 Flyweight no. 1
F2 Flyweight no. 2
F3 Flyweight no. 3

Fig. 38

Pressure progress of governor pressure

The amplified governor pressure determines shift points 1-2-1 only.

This pressure is derived depending on version of shift valve housing from working pressure AD-3 or from control pressure S1D-2 and is controlled at accumulator valve-governor pressure (44).

With the accelerator pedal in idle throttle position, control pressure S2 and governor pressure at part to full throttle or kickdown will flow to face (a). The pressures at annular surfaces (b) and (d), as well as at face (e) act against the pressure at face (a) and will force valve (44) into control position. Control proceeds at control edge (10) and at zero outlet. The increased governor pressure VR increases with increasing governor pressure R and flows via two-way valve (42) to command valve 1-2.

Depending on shift valve housing version, shape and dimensions of accumulator-governor pressure (44) vary. A spring is partially installed at the left or right. The shift program 1-2-1 is thereby balanced.

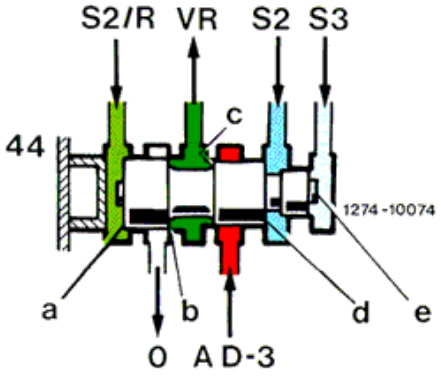


Fig. 39

Version with shift valve housings without driving position "B"

44	Accumulator valve-governor pressure
AD-3	Working pressure in driving positions "D" and "3"
S2	Control pressure S2
S2/R	Control pressure S2 at idle throttle and governor pressure at part to full throttle and kickdown
S3	Kickdown control pressure
VR	Amplified governor pressure
O	Oil sump outlet
a	Face
b	Annular surface
c	Control edge
d	Annular surface
e	Face

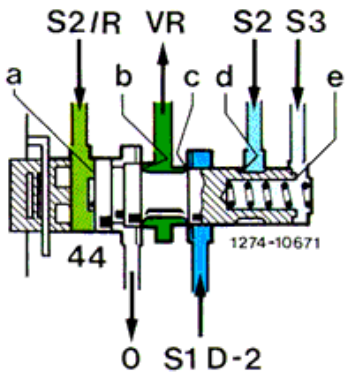


Fig. 40

Version with shift valve housings with driving position "B"

44	Accumulator valve-governor pressure
S1D-2	Control pressure S1 in driving positions "D", "3" and "2"
S2	Control pressure S2 at part to full throttle
S2/R	Control pressure S2 at idle throttle and governor pressure at part to full throttle and kickdown
S3	Kickdown control pressure
VR	Amplified governor pressure
O	Oil sump outlet
a	Face
b	Annular surface
c	Control edge
d	Recess on valve
e	Face

The shifting pressure influences the shift quality when engaging and disengaging clutches K1 and K2 and brake band B1.

The shifting pressure acts in spring chambers of accumulators K1 (48), K2 (49) and accumulator B1 (52).

The shifting pressure is derived from working pressure and controlled at control valve-shifting pressure (47).

The shifting pressure acts on face (c) and forces the control valve (47) against modulating pressure M1 into control position. This will throttle the working pressure inflow at control edge (a) and open the zero outlet to reduce the pressure.

The height of the shifting pressure is determined by the modulating pressure M1 and by spring force.

This means:

low modulating pressure = low shifting pressure
high modulating pressure = high shifting pressure

Shifting pressure system; the valve is in control position

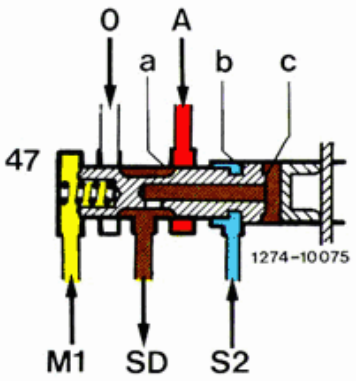


Fig. 41

47 Control valve-shifting pressure

A Working pressure
M1 Modulating pressure M1 or
SD Shifting pressure
S2 Control pressure S2
O Oil sump outlet
a Control edge
b Control surface
c Face

General

The command valves in shift valve housing determine the shift points and are starting the shifting steps:

Command valve no.	(17), (18) and (19)	for shift 1-2-1
	(3) and (4)	for shift 2-3-2
	(11) and (12)	for shift 3-4-3

Apart from minor deviations, the operation of the command valve is the same. Below is a description of command valve control in connection with shifting sequence.

Special characteristics on command valve 1-2

Downshift 2-1 when moving off.

Without pressure in hydraulic system the command valve 1-2 (17) is pushed by the spring force to the right into position 1st speed. The shift valve-governor pressure (41) is also against righthand stop.

With the engine running and the vehicle stopped, in driving positions "D", "3" or "2" and idle throttle, the control pressure S2 flows via valve (41) and two-way ball valve (43) to face (e) of amplifier valve-governor pressure (44). An increased governor pressure VR is established and flows via two-way ball valve (42) to face of plunger (19). The command valve 1-2 is forced against the spring force and the control pressure S1 acting against annular surface (c) to the left. The transmission shifts into 2nd speed.

During acceleration and whenever the idle travel on linkage-engine regulation is exceeded, plunger (46) closes outflow VL2. Shift pressure SD or control pressure S2, depending on version of shift valve housing, is established behind throttle (d). Shift valve (41) is pushed to the left. As a result, the face (e) of valve (44) is connected with governor pressure system. With the vehicle stopped, no governor pressure will be established. Valve (44) moves to the left and opens the zero outflow on annular surface (f). The reinforced governor pressure VR is reduced and the command valve 1-2 (17) shifts to the right into 1st speed position.

Upon release of idle path, with zero outflow VL2 opened, an upshift into 2nd speed follows.

In driving position "2" the inflow AD-3 to valve (44) is pressureless. Therefore, no increased governor pressure is established and the command valve shifts to 1st speed. In some versions of the shift valve housing, control pressure S2 is additionally flowing to annular surface (b) of sleeve (18). This will influence shift point 2-1.

During kickdown, kickdown-control pressure S3 flows to annular surface (a) of sleeve (18) and to face (h) of valve (44). The control pressure S3 at annular surface (a) influences shift 2-1. The control pressure S3 at face (h) causes within kickdown-backshift limits that valve (44) is pushed completely to the left and that the reinforced governor pressure is reduced or set back depending on speed. The transmission shifts back to 1st speed.

Special characteristics on command valve 1-2

Downshift 2-1 when moving off.

Without pressure in hydraulic system the command valve 1-2 (17) is pushed by the spring force to the right into position 1st speed. The shift valve-governor pressure (41) is also against righthand stop.

With the engine running and the vehicle stopped, in driving positions "D", "3" or "2" and idle throttle, the control pressure S2 flows via valve (41) and two-way ball valve (43) to face (e) of amplifier valve-governor pressure (44). An increased governor pressure VR is established and flows via two-way ball valve (42) to face of plunger (19). The command valve 1-2 is forced against the spring force and the control pressure S1 acting against annular surface (c) to the left. The transmission shifts into 2nd speed.

During acceleration and whenever the idle travel on linkage-engine regulation is exceeded, plunger (46) closes outflow VL2. Shift pressure SD or control pressure S2, depending on version of shift valve housing, is established behind throttle (d). Shift valve (41) is pushed to the left. As a result, the face (e) of valve (44) is connected with governor pressure system. With the vehicle stopped, no governor pressure will be established. Valve (44) moves to the left and opens the zero outflow on annular surface (f). The reinforced governor pressure VR is reduced and the command valve 1-2 (17) shifts to the right into 1st speed position.

Upon release of idle path, with zero outflow VL2 opened, an upshift into 2nd speed follows.

In driving position "2" the inflow AD-3 to valve (44) is pressureless. Therefore, no increased governor pressure is established and the command valve shifts to 1st speed. In some versions of the shift valve housing, control pressure S2 is additionally flowing to annular surface (b) of sleeve (18). This will influence shift point 2-1.

During kickdown, kickdown-control pressure S3 flows to annular surface (a) of sleeve (18) and to face (h) of valve (44). The control pressure S3 at annular surface (a) influences shift 2-1. The control pressure S3 at face (h) causes within kickdown-backshift limits that valve (44) is pushed completely to the left and that the reinforced governor pressure is reduced or set back depending on speed. The transmission shifts back to 1st speed.

General

The command valves in shift valve housing determine the shift points and are starting the shifting steps:

Command valve no.	(17), (18) and (19)	for shift 1-2-1
	(3) and (4)	for shift 2-3-2
	(11) and (12)	for shift 3-4-3

Apart from minor deviations, the operation of the command valve is the same. Below is a description of command valve control in connection with shifting sequence.

Shift valve housing in transmissions for engines 117 with starting 2nd speed in position "D".

On these shift valve housings:

- the connection to face of valve (41) is interrupted. Control via outflow cross section VL2 is without effect.
- The shift valve-governor pressure (41) is designed as a control valve-control pressure (41 a). Control pressure S2 flows through cross bore and longitudinal bore in valve (41 a) to face and makes sure that valve (41 a) is pushed against the spring force to the left into control position. The pressure regulated in this manner moves continuously toward face (e) of valve (44). A reinforced governor pressure VR will be established, and prevents shifting back into 1st speed.

Moving off in 1st speed, vehicles with engine 117.

In driving positions "3" and "2", as well as during kickdown, the kickdown-solenoid valve (71) is energized. As a result, kickdown control pressure S3 will be established, and act against face (h) of valve (44), which will then shift it to the left. Increased governor pressure VR will then be connected to zero outlet and will thereby become pressureless. Below 12 km/h the command valve 1-2 will shift to 1st speed.

On automatic transmission with driving position "B" the shift valve housings are modified in such a manner that instead af AD-3, S1 will flow to valve (44). The inflow control pressure S1 results in establishing increased governor pressure VR in driving position "2", with the command valve 1-2 in position of 2nd speed, as long as the solenoid valve-kickdown (71) is not energized.

For moving off at 1st speed in driving position "B" electric current is switched to solenoid valve-kickdown (71) via switch on guide block (refer to Fig. 61).

Special features on command valve 1-2

shown in driving position "D" or "3" and **idle throttle**

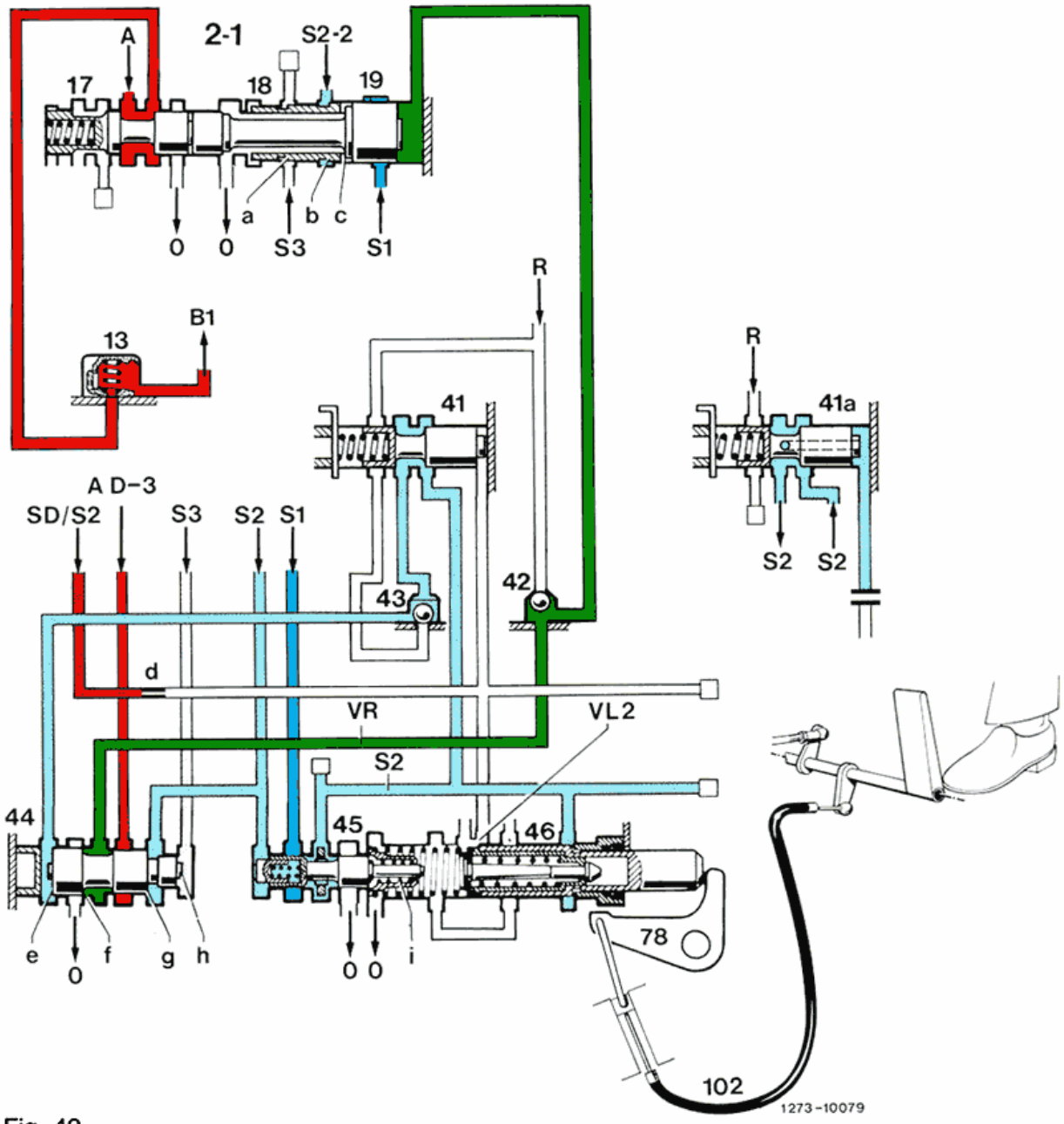


Fig. 42

13	Plate check valve
17	Command valve 1-2
18	Sleeve command valve 1-2
19	Plunger command valve 1-2
41	Shift valve-governor pressure
41a	Control valve-governor pressure
42	Two-way ball valve
43	Two-way ball valve
44	Amplifier valve-governor pressure
45	Control valve-governor pressure
46	Plunger governor valve-control pressure
78	Reverse transfer lever for control pressure cable
102	Control pressure cable
a, b, c	Annular surfaces
d	Throttle
e, h	Faces
i	Idle throttle spring
f, g	Annular surfaces
A	Working pressure
AD–3	Working pressure in positions "D" and "3"
S1	Full throttle-control pressure
S2	Control pressure S2
S2–2	Control pressure S2 in position "2"
S3	Kickdown-control pressure
SD/S2	Shift pressure or control pressure S2
R	Governor pressure
VR	Increased governor pressure
O	Oil sump outlet
B1	Connection to brake band plunger B1
VL2	Flow-off cross section, with idle throttle open
□	For additional line progress refer to complete hydraulic diagram

Special features on command valve 1-2

shown in driving position "D" or "3" and **part throttle**

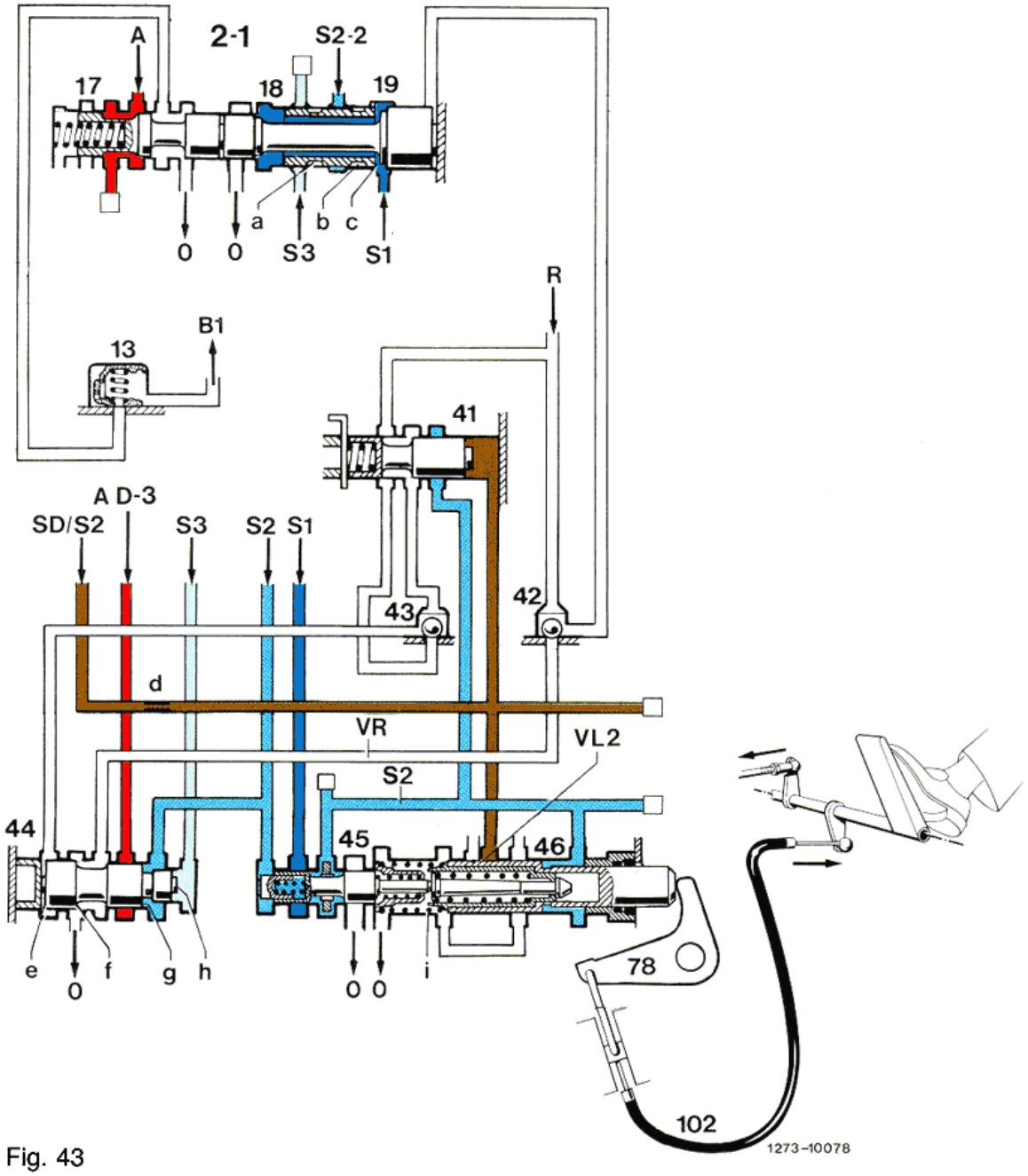


Fig. 43

13	Plate check valve
17	Command valve 1-2
18	Sleeve-command valve 1-2
19	Plunger-command valve 1-2
41	Shift valve-governor pressure
42	Two-way ball valve
43	Two-way ball valve
44	Amplifier valve-governor pressure
45	Control valve-governor pressure
46	Plunger governor valve-vontrol pressure
78	Reverse transfer lever for control pressure cable
102	Control pressure cable
a, b, c	Annular surfaces
d	Throttle
e, h	Faces
i	Idle throttle spring
f, g	Annular surfaces
A	Working pressure
AD-3	Working pressure in positions "D" and "3"
S1	Full throttle-control pressure
S2	Control pressure S2
S2-2	Control pressure S2 in position "2"
S3	Kickdown-control pressure
SD/S2	Shift pressure or control pressure S2
R	Governor pressure
VR	Increased governor pressure
O	Oil sump outlet
B1	Connection to brake band plunger B1
VL2	Flow-off cross section, with idle throttle open
□	For additional line progress refer to complete hydraulic diagram

Special features on command valve 1-2

hydraulic control for moving off in 2nd speed at part throttle; shown in driving position "D" or "3" and **idle throttle,** speed below 12 km/h.

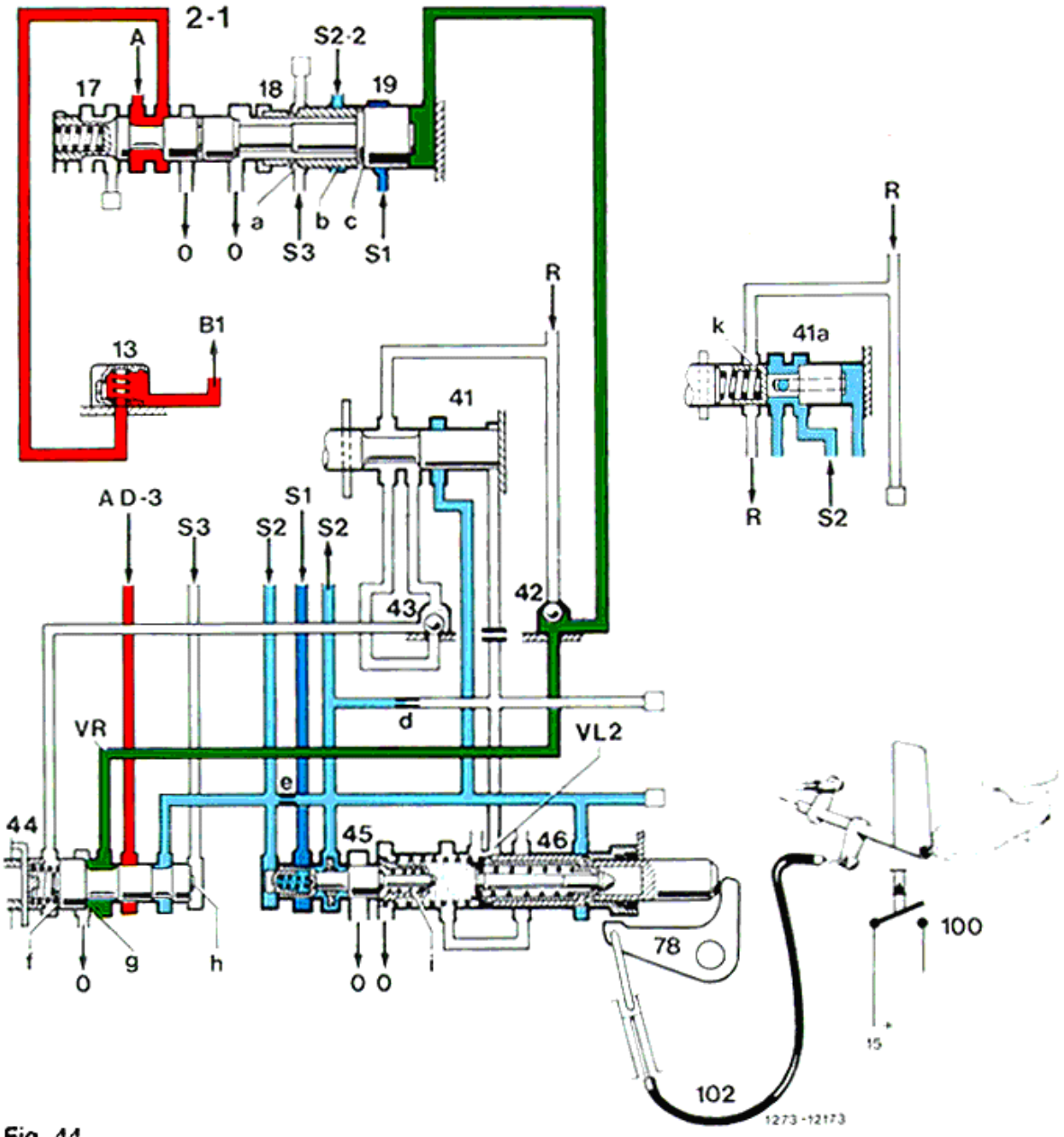


Fig. 44

13	Plate check valve
17	Command valve 1-2
18	Sleeve command valve 1-2
19	Plunger command valve 1-2
41	Shift valve-governor pressure
42a	Shift valve-governor pressure
42	Two-way ball valve
43	Two-way ball valve
44	Amplifier valve-governor pressure
45	Control valve-governor pressure
46	Plunger governor valve-control pressure
78	Reverse transfer lever for control pressure cable
100	Kickdown switch
102	Control pressure cable
□	For additional line progress refer to complete hydraulic diagram

A	Working pressure
AD-3	Working pressure in positions "D" and "3"
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S3	Kickdown-control pressure
S2-2	Control pressure S2 in position "2"
R	Governor pressure
VR	Amplified governor pressure
0	Oil sump outlet
VL2	Flow-off cross section, with idle throttle open
a, b, c	Annular surfaces
d, e	Throttles
f, h	Faces
g	Annular surface
i	Idle throttle spring
k	Radial bore

Hydraulic control for moving off at 2nd speed with part throttle

With the vehicle stopped, the engine running and at idle throttle the transmission will shift to 2nd speed upon engaging driving positions "D" or "3".

- When moving off with little gas the 2nd speed remains engaged.
- When moving off with much gas a downshift into 1st speed follows.

Operation:

The amplifier valve-governor pressure (44) is pushed toward the right by the spring acting at the left. Valve (44) will close the 0-outlet while simultaneously opening the inflow for working pressure AD–3. Amplified governor pressure VR is established, which acts against face of plunger (19) and forces the command valve (17) into position of 2nd speed.

Control pressure S3 is established during acceleration or in upper partial load range and will continue to increase independent of position of accelerator pedal up to full throttle or kickdown. This pressure acts at face (h) of valve (44) against the spring force. The amplified governor pressure is reduced. The spring on command valve (17) overcomes the force of the reinforced governor pressure on valve (19). Downshift 2-1 is initiated.

Governor pressure R will be established as from approx. 12 km/h, and acts at spring chamber of valve (44) against control pressure S3 and against the amplified governor pressure VR at annular surface (g). The increase of the amplified governor pressure VR continues. A downshift 2-1 without kickdown is now no longer possible.

The control pressure S3 continues to increase under kickdown. As a result, a downshift 2-1 within shift limit is possible.

In a former version (production 1983/84) valve (41 a) was installed instead of plug (41). Taking a few minor deviations into account, this system functioned in a similar manner.

Special features on command valve 1-2

hydraulic control for moving off in 2nd speed at part throttle;
shown in driving position "D" or "3" and **full throttle,** speed below 12 km/h.

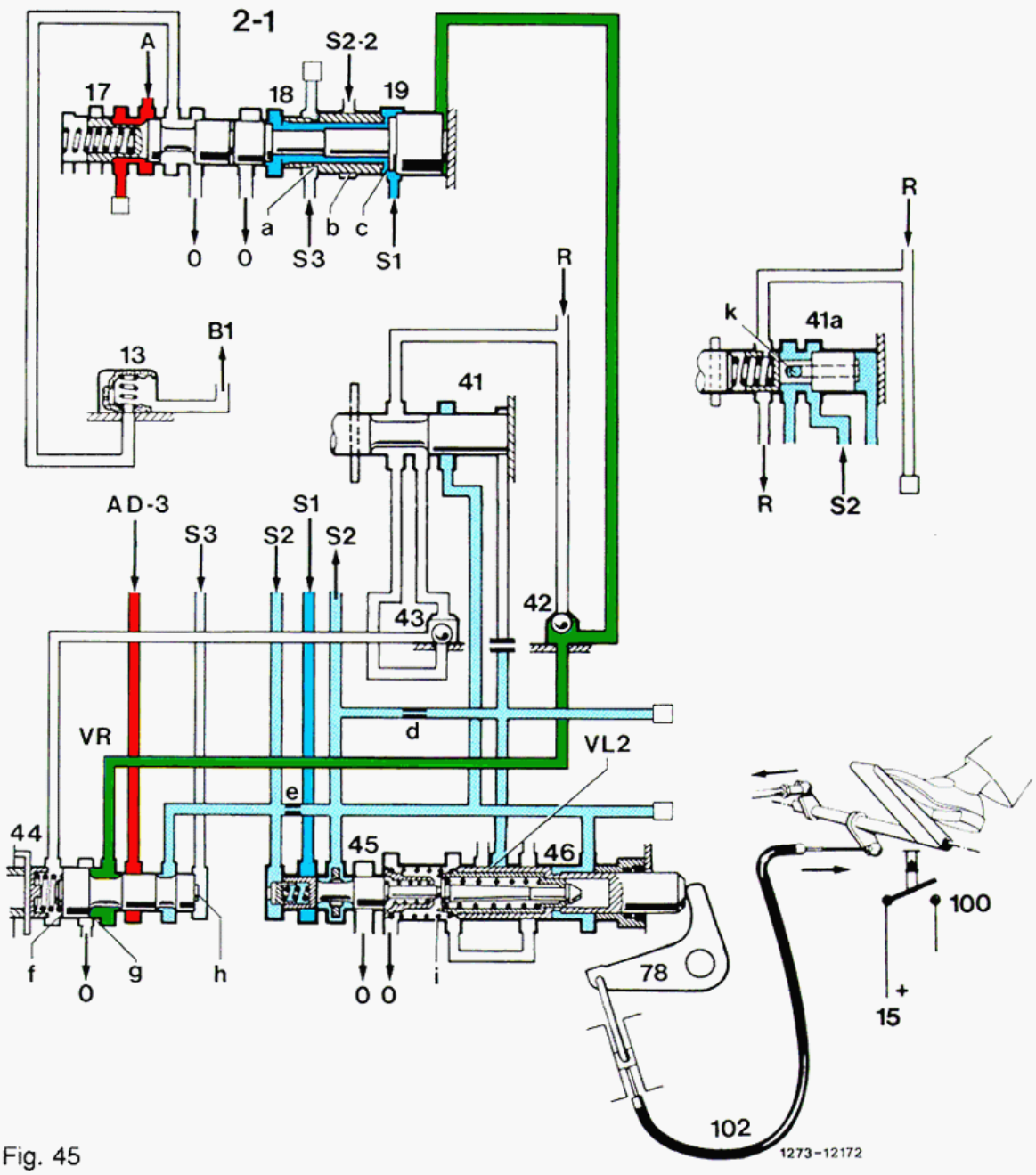


Fig. 45

13	Plate check valve
17	Command valve 1-2
18	Sleeve command valve 1-2
19	Plunger command valve 1-2
41	Shift valve-governor pressure
41a	Shift valve-governor pressure
42	Two-way ball valve
43	Two-way ball valve
44	Amplifier valve-governor pressure
45	Control valve-governor pressure
46	Plunger-governor valve-control pressure
78	Reverse transfer lever for control pressure cable
100	Kickdown switch
102	Control pressure cable
□	For additional line progress refer to complete hydraulic diagram

A	Working pressure
AD–3	Working pressure in positions "D" and "3"
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S3	Kickdown-control pressure
S2–2	Control pressure S2 in position "2"
R	Governor pressure
VR	Amplified governor pressure
O	Oil sump outlet
VL2	Flow-off cross section, with idle throttle open
a, b, c	Annular surfaces
d, e	Throttles
f, h	Faces
g	Annular surface
i	Idle throttle spring
k	Radial bore

Special features on command valve 2-3

Upshifts and downshifts 2-3-2

Upshift

Clutch K1 must be engaged and brake band B1 disengaged.

The transmission is in 2nd speed. The command valve (4) and the plunger command valve (3) are at the left. Control pressure S2 on righthand face and on annular surfaces (d) and (e), as well as the spring force are pushing the command valve with the plunger to the left. The governor pressure RD–3 on lefthand face of plunger (3) opposes these forces.

With increasing governor pressure (increasing speed) or/and dropping control pressure (deceleration) the command valve moves at first slowly to the right. As soon as the control edge (b) opens the connection to zero outflow via valve (85), the force of the control pressure on annular surface (e) is reduced. The force of the governor pressure predominates suddenly, and the command valve (4) snaps to the right up to stop.

Shift 2-3 is initiated. Clutch K1 is connected to inflow-working pressure AD–3 via command valve (4). As soon as clutch K1 is appropriately filled and positively connected, the shift valve B1 (10) is forced by the filling pressure of K1 against the spring force and against the working pressure on annular surface (g) to the right. This will connect brake band B1 to zero outlet. The transmission is in 3rd speed.

For shifts 2-3-2 without kickdown the pressure difference between the control pressures S2 and S3 is also used for snapping action of command valve (4), controlled via control edges (f).

Downshift

Brake band B1 must be engaged and clutch K1 disengaged.

During a downshift the procedure on command valve is in a reverse sequence.

The introductory movement to the left against governor pressure RD–3 up to the snapping point is effected depending on driving condition at

- part throttle by the spring or by the spring and control pressure S3 (part throttle value)
- full throttle by the spring or by the spring and control pressure S3 (full throttle value) and control pressure S2–V.

Upshifts and downshifts 2-3-2

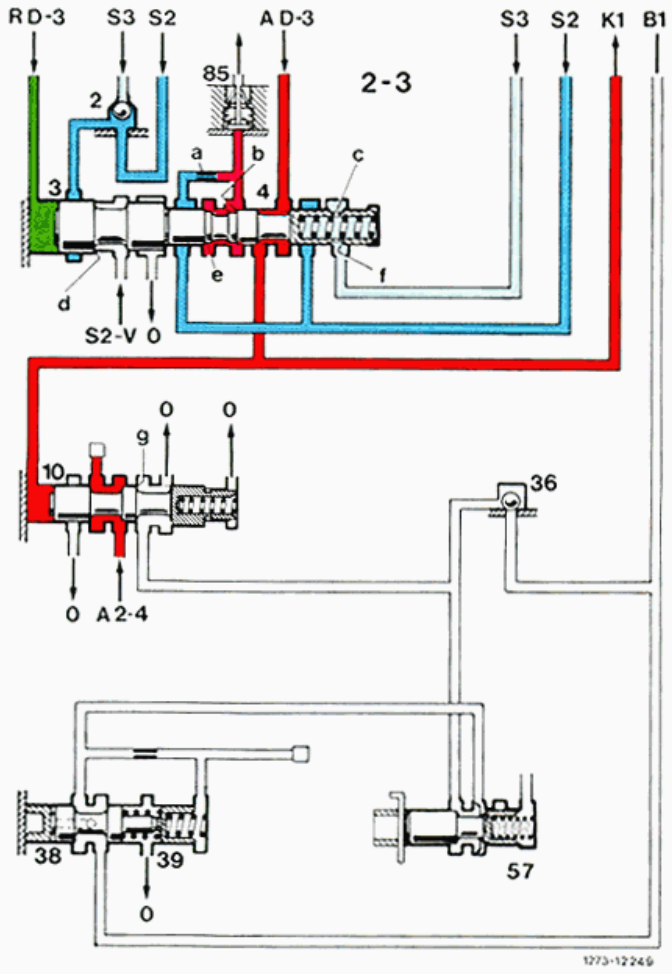


Fig. 46 Shift sequence 2-3 at end of sequence

2	Two-way ball valve
3	Plunger-command switch 2-3
4	Command valve 2-3
10	Shift valve B1
36	Ball check valve
38	Control valve B1
39	Plunger control valve B1
57	Control valve-accumulator B1
85	Pressure limiting valve
A2–4	Working pressure in 2nd to 4th speed
AD–3	Working pressure in positions "D" and "3"
S2	Control pressure (load-dependent)
S2–V	Control pressure at full throttle
S3	Kickdown-control pressure
RD–3	Control pressure in positions "D" and "3"
O	Oil sump outlet
B1	Connection to plunger B1
K1	Connection for clutch K1
a	Throttle
b	Control edge
c	Radial bore
d	Annular surface
e	Annular surface
f	Control edges on both sides of recess
g	Annular surface
□	For additional line progress refer to complete hydraulic diagram

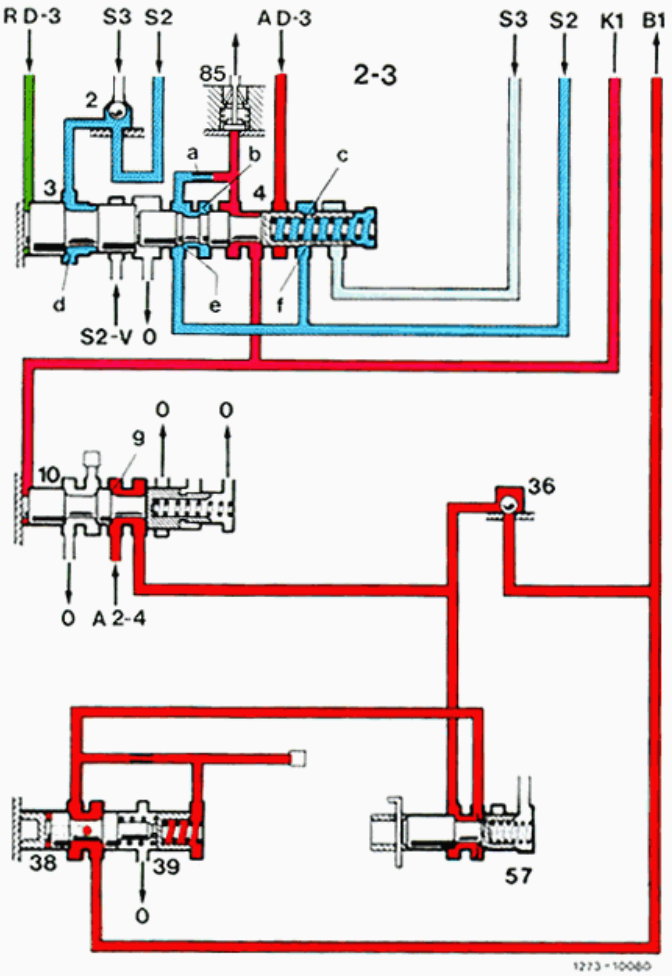


Fig. 47 Shift sequence 3-2 at end of sequence

2	Two-way ball valve
3	Plunger command switch 2-3
4	Command valve 2-3
10	Shift valve B1
36	Ball check valve
38	Control valve B1
39	Plunger control valve B1
57	Control valve-accumulator B1
85	Pressure limiting valve
A2–4	Working pressure in 2nd to 4th speed
AD–3	Working pressure in position "D" and "3"
S2	Control pressure (load-dependent)
S2–V	Control pressure at full throttle
S3	Kickdown-control pressure
RD–3	Control pressure in positions "D" and "3"
O	Oil sump outlet
B1	Connection to plunger B1
K1	Connection for clutch K1
a	Throttle
b	Control edge
c	Radial bore
d	Annular surface
e	Annular surface
f	Control edges on both sides of recess
g	Annular surface
□	For additional line progress refer to complete hydraulic diagram

Special features on command valve 3-4

Upshifts and downshifts 3-4-3

Upshift

Clutch K2 must be engaged and brake band B2 disengaged.

The transmission is in 3rd speed. The command valve (12) is at the right. Control pressure S2 on annular surface (d) and lefthand face, as well as the force of spring (b) push the command valve (12) to the right. The governor pressure R–D at righthand face of command valve opposes these forces.

With increasing governor pressure (increasing speed) or/and falling control pressure (deceleration) the command valve moves to the left. As soon as the control edge (f) opens the connection toward zero, the force of the control pressure at the annular surface (d) goes down. The force of the governor pressure dominates suddenly, and the command valve snaps back against stop to the left.

The 3-4 shift is initiated. Clutch K2 is connected via command valve with the inflow working pressure A3–4. As soon as clutch K2 is filled and positively connected, the control valve B2 (33) is forced to the left by the filling pressure of clutch K2 against the spring force and against the working pressure on annular surface (h). At the same time the controlling side of the brake band plunger B2S and the spring chamber of the releasing valve (60) are connected to zero. Valve (60) is forced by the control pressure S1 to the right against the spring force, and the releasing side of the brake band plunger B2L is connected to inflow-working pressure AD–3/B1. The transmission is in 4th speed.

For shifts 3-4-3 without kickdown the pressure difference between the control pressures S2 and S3 is also used for the snapping of the command valve controlled via control edges (e).

Downshift

Brake band B2 must be engaged and clutch 2 disengaged.

For a downshift the procedure on command valve runs off in vice versa sequence. The initiating movement to the right against the governor pressure R–D up to snapping point is effected, depending on driving condition, at

- part throttle by spring or spring and control pressure S3 (part throttle value)
- full throttle of control pressure S2–V at face (a) of plunger command valve (11)
- kickdown by spring and control pressure S3 (kickdown value).

After the snapping effect of the command valve, the face of valve (33) is connected directly and clutch K2 via throttle check valve (84) to zero outlet.

The valve (33) is pressed by its spring to the right. The shift side of the brake band piston B2S is connected to inflow operating pressure AD–2. Simultaneously, clutch K2 empties itself slowly through throttle (g). As soon as the detent valve (60) is pushed to the left by the pressure in spring chamber, the released side of the brake band plunger B2L and of clutch K2 are emptied in unthrottled condition. The transmission has shifted to 3rd speed.

In the event of a selector lever downshift to "3" the governor pressure R–D is connected to "zero". The command valve snaps into position of 3rd speed independent of the speed.

Upshifts and downshifts 3-4-3

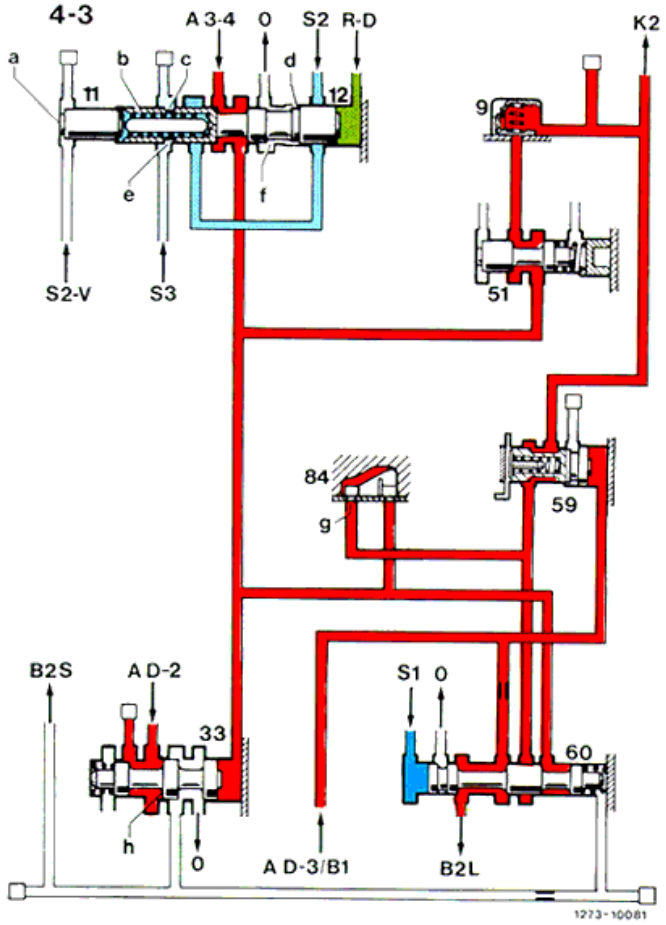


Fig. 48 **Shift sequence 3-4** at end of sequence

9	Plate-type check valve
11	Plunger command valve 3-4
12	Command valve 3-4
33	Shift valve B2
51	Control valve-accumulator K2
59	Shift valve K2
60	Release valve B2
84	Throttle check valve
A3–4	Working pressure in 3rd and 4th speed
AD–3	Working pressure in positions "D" and "3"
B1	As well as with brake band B1 connected
AD–2	Working pressure in positions "D" to "2"
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S2–V	Control pressure S2 at full throttle
S3	Kickdown-control pressure
R–D	Governor pressure in position "D"
0	Oil sump outlet
B2S	To brake band plunger B2 shift side
B2L	To brake band plunger B2 release side
K2	To clutch K2
a	Face
b	Compression spring
c	Radial bore
d, h	Annular surface
e	Control edges on both sides of recess
f	Control edge
g	Throttle
□	For additional line progress refer to complete hydraulic diagram

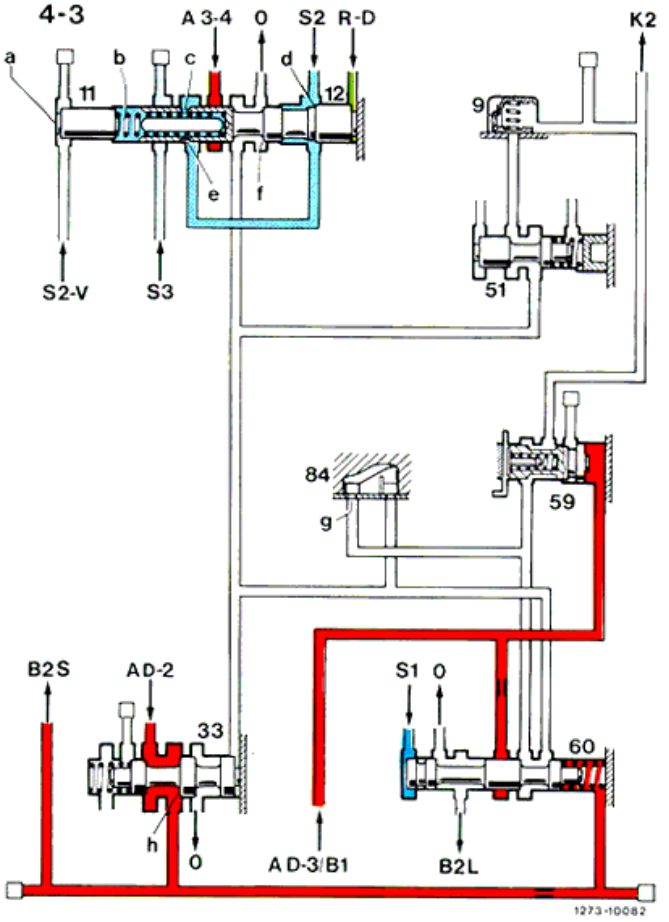


Fig. 49 **Shift sequence 4-3** at end of sequence

9	Plate-type check valve
11	Plunger command valve 3-4
12	Command valve 3-4
33	Shift valve B2
51	Control valve-accumulator K2
59	Shift valve K2
60	Release valve B2
84	Throttle check valve
A3–4	Working pressure in 3rd and 4th speed
AD–3	Working pressure in positions "D" and "3"
B1	As well as with brake band B1 connected
AD–2	Working pressure in positions "D" to "2"
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S2–V	Control pressure S2 at full throttle
S3	Kickdown-control pressure
R–D	Governor pressure in position "D"
O	Oil sump outlet
B2S	To brake band plunger B2 shift side
B2L	To brake band plunger B2 release side
K2	To clutch K2
a	Face
b	Compression spring
c	Radial bore
d, h	Annular surface
e	Control edges on both sides of recess
f	Control edge
g	Throttle
□	For additional line progress refer to complete hydraulic diagram

General

Following a downshift under acceleration the engine speed has to be increased in accordance with gear ratio. During the shifting procedure the shift element of the higher speed releases itself slowly, so that the engine can rev up. The brake band drum will then change its direction of rotation. This reversal of the direction of rotation is sensed by means of the brake band. When the reversing point is attained, the shift element firmly connects the lower speed.

The brake band is connected in two steps. These are:

- a contact position to feel the direction of rotation of the brake band drum, with the brake band in contact,
- a shifting position, with the brake band firmly connected.

During deceleration and while the engine is increasing its speed, the brake band supports itself, in accordance with direction of rotation of brake band drum, against the brake band plunger.

Under acceleration, the brake band drum supports itself against brake band B1 on reaction valve RV1.

Downshift 3-2 under acceleration

Brake band B1 in contact condition

After the command valve 2-3 (4) has snapped over, the lefthand face of the control valve (10) and the connection toward clutch K1 is set to "zero". The shut-off valve (7) is pushed down by the pressure in spring chamber, and clutch K1 is slowly drained via throttle (a). The control valve (10) is pushed to the left by its spring and working pressure A2–4 flows through plate-type check valve (13) via valve (10), (57) and (38) to brake band piston B1.

In control valve-valve (38) pressure flows through throttle (f) to lefthand face and forces the valve against the spring force to the right into control position. The pressure flowing to brake band plunger B1 is simultaneously reduced at control edge (e).

Brake band B1 is applied with this reduced pressure. The high-revving engine will delay drum B1, which is still rotating against brake band plunger B1, up to a stop (reversing point).

A low quantity of oil flows through throttle (d) via shut-off valve (62) to reaction valve RV1. As long as brake band B1 is in applied condition and supports itself against brake band piston, the zero flow-off at reaction valve remains open. No pressure can be built up in line system between throttle (d) and reaction valve.

Downshift 3-2 under acceleration

Brake band B1 in contact condition

After the command valve 2-3 (4) has snapped over, the lefthand face of the control valve (10) and the connection toward clutch K1 is set to "zero". The shut-off valve (7) is pushed down by the pressure in spring chamber, and clutch K1 is slowly drained via throttle (a). The control valve (10) is pushed to the left by its spring and working pressure A2–4 flows through plate-type check valve (13) via valve (10), (57) and (38) to brake band piston B1.

In control valve-valve (38) pressure flows through throttle (f) to lefthand face and forces the valve against the spring force to the right into control position. The pressure flowing to brake band plunger B1 is simultaneously reduced at control edge (e).

Brake band B1 is applied with this reduced pressure. The high-revving engine will delay drum B1, which is still rotating against brake band plunger B1, up to a stop (reversing point).

A low quantity of oil flows through throttle (d) via shut-off valve (62) to reaction valve RV1. As long as brake band B1 is in applied condition and supports itself against brake band piston, the zero flow-off at reaction valve remains open. No pressure can be built up in line system between throttle (d) and reaction valve.

General

Following a downshift under acceleration the engine speed has to be increased in accordance with gear ratio. During the shifting procedure the shift element of the higher speed releases itself slowly, so that the engine can rev up. The brake band drum will then change its direction of rotation. This reversal of the direction of rotation is sensed by means of the brake band. When the reversing point is attained, the shift element firmly connects the lower speed.

The brake band is connected in two steps. These are:

- a contact position to feel the direction of rotation of the brake band drum, with the brake band in contact,
- a shifting position, with the brake band firmly connected.

During deceleration and while the engine is increasing its speed, the brake band supports itself, in accordance with direction of rotation of brake band drum, against the brake band plunger.

Under acceleration, the brake band drum supports itself against brake band B1 on reaction valve RV1.

Downshift 3-2 under acceleration

Brake band B 1 in applied condition

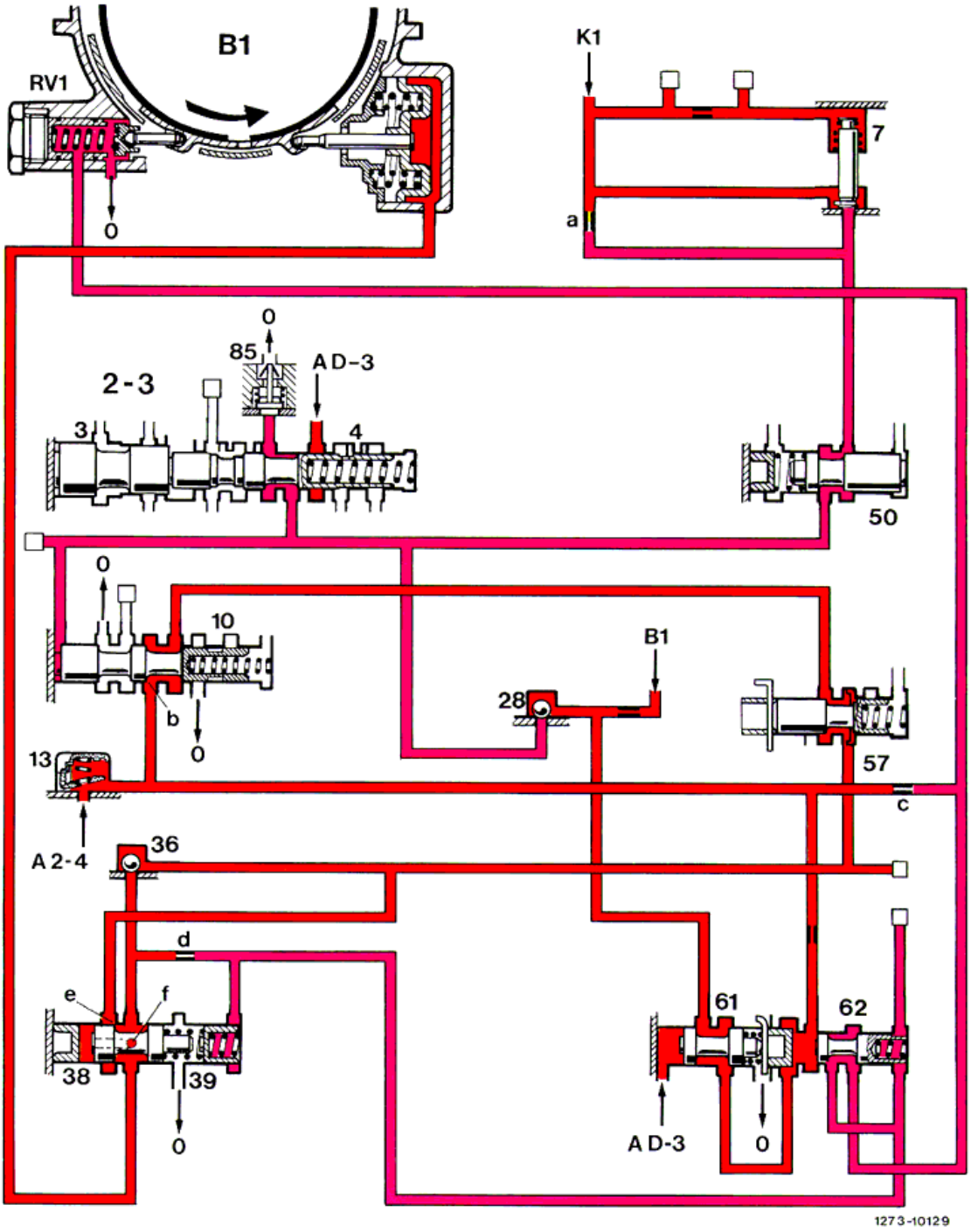


Fig. 50

3	Plunger command valve 2-3	AD–3	Working pressure in positions "D" and "3"	a	Throttle
4	Command valve 2-3	A2–4	Working pressure in 2nd to 4th speed	b	Annular surface
7	Shut-off valve K1	O	Oil sump drain	c	Throttle
10	Shift valve B1			d	Throttle
13	Plate-type check valve with throttle	RV1	Reaction valve for brake band B1	e	Control edge
28	Ball check valve	B1	Connection to shift side of brake band plunger B1	f	Throttle (radial bore)
36	Ball check valve				
38	Control valve B1	K1	Connection to plunger clutch K1	□	For additional line progress refer to complete hydraulic diagram
39	Plunger control valve B1				
50	Control valve-accumulator K1				
57	Control valve-accumulator B1				
61	Shut-off valve-brake shift				
62	Shut-off valve RV1				
85	Pressure limiting valve				

Connecting brake band B1

When the reversing point is attained, drum B1 attempts to rotate in the opposite direction, while supporting the force of the brake band against reaction valve RV1. The zero outflow is closed against the spring force.

Pressure will build up in line system between the throttle (d) and the reaction valve. This pressure acts in spring chamber of plunger (39) and forces valve (38) completely to the left. Full pressure flows to brake band piston B1, the brake band is connected. When the reaction valve closes, the shut-off valve (62) moves into its lefthand position.

In 3rd and 4th speed, with brake band B1 not applied, oil will flow continuously in slight quantities through throttle (c) to reaction valve RV1. The line system remains therefore filled with oil and operational.

Downshift 3-2 under acceleration

Brake band B1 is applied

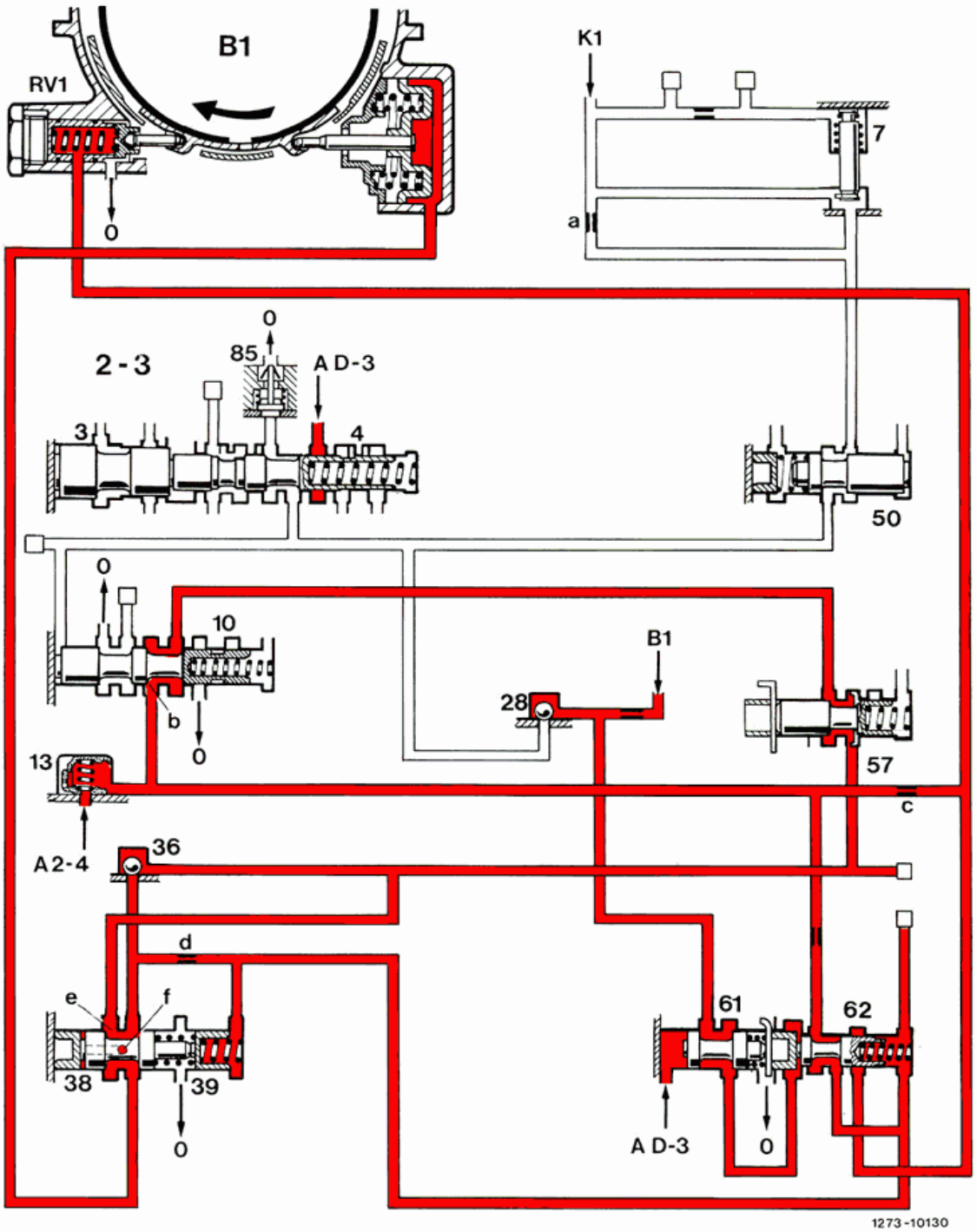


Fig. 51

3	Plunger-command valve 2-3
4	Command valve 2-3
7	Shut-off valve K1
10	Shift valve B1
13	Plate-type check valve with throttle
28	Ball check valve
36	Ball check valve
38	Control valve B1
39	Plunger control valve B1
50	Control valve-accumulator K1
57	Control valve-accumulator B1
61	Shut-off valve-brake shift
62	Shut-off valve RV1
85	Pressure limiting valve
AD–3	Working pressure in positions "D" and "3"
A2–4	Working pressure in 2nd to 4th speed
O	Oil sump drain
RV1	Reaction valve for brake band B1
B1	Connection to shift side of brake band plunger B1
K1	Connection to plunger clutch K1
a	Throttle
b	Annular surface
c	Throttle
d	Throttle
e	Control edge
f	Throttle (radial bore)
□	For additional line progress refer to complete hydraulic diagram

Downshift 4-3 under acceleration

Brake band B2 in applied position

After the command valve (12) snaps over, the righthand face of the shift valve (33) and the connection to clutch K2 is switched to "zero". Clutch K2 slowly starts emptying via shift valve K2 (59) and throttle (e) in check valve (84). Simultaneously, valve (33) switches under spring force to the right and opens the connection AD–2 to shift side of brake band plunger B2.

As soon as the pressure on shift side has adequately increased, the bypass valve (c) is pushed to the left against the force of its spring. The connection (d) between shift and release side is opened. Oil flows from release side to shift side until a uniform pressure has been established, while the brake band plunger (a) is moving to the left and forces the brake band B2 into applied position.

The applying force results from the differential area of the brake band plunger and pressure AD–2.

The brake band is applied against the drum at this applying force. The high-revving engine will slowly delay the drum, which is still rotating against brake band piston B2, up to stop (reversing point).

Oil flows through throttle (f) via shut-off valve (55) to reaction valve RV2. As long as the brake band is in applied position, the zero outflow on reaction valve remains open. No pressure can be built up in line to reaction valve.

Downshift 4-3 under acceleration

Brake band B2 in applied position

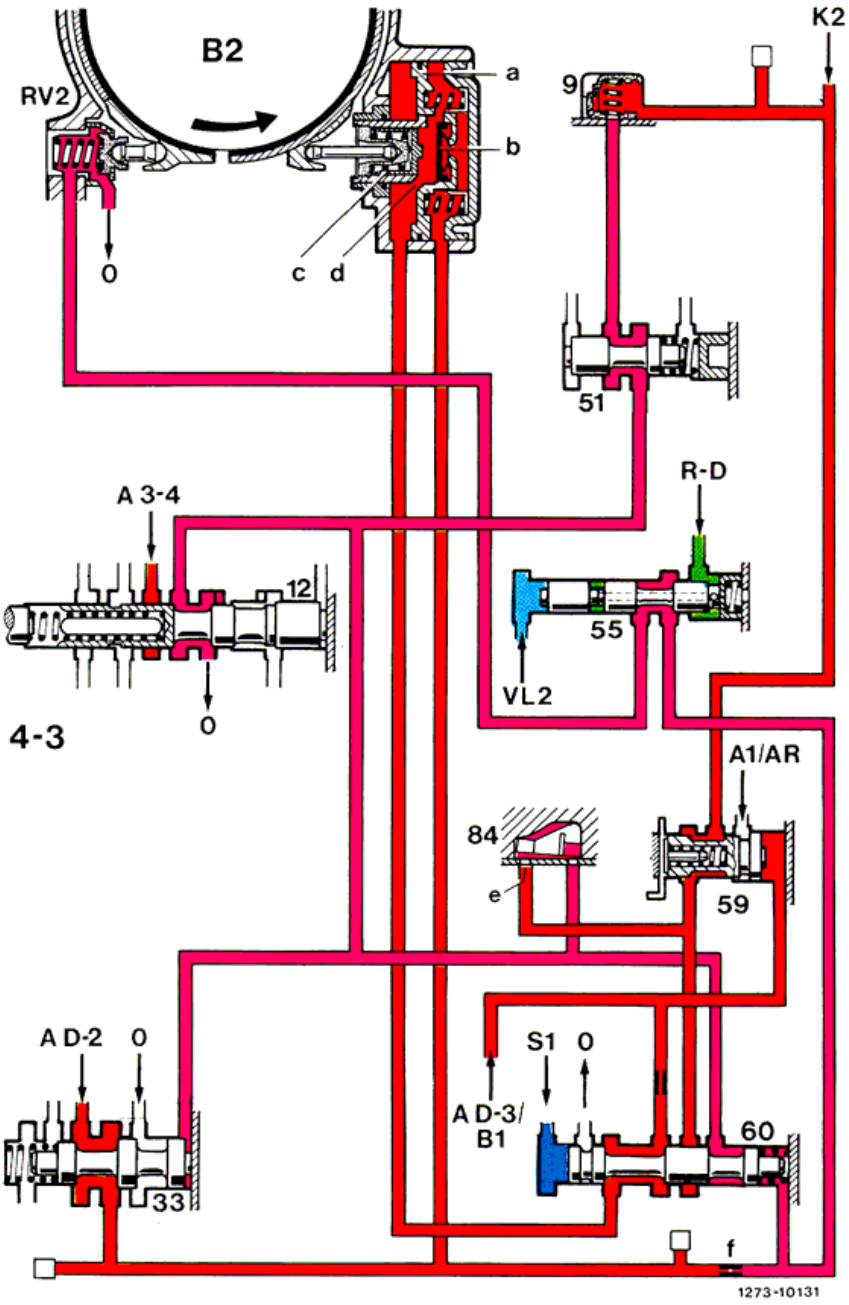


Fig. 52

9	Plate-type check valve
12	Command valve 3-4
33	Shift valve B2
51	Control valve-accumulator K2
55	Shut-off valve RV2
59	Shift valve K2
60	Detent valve B2
84	Check valve
A3–4	Working pressure in 3rd and 4th speed
AD–2	Working pressure in positions "D" to "2"
A1–AR	Working pressure in 1st speed and reverse
AD–3/ B1	Working pressure in positions "D" and "3" as well as with brake band B1 actuated
R–D	Governor pressure in position "D"
S1	Control pressure S1
O	Oil sump drain
RV2	Reaction valve RV2
K2	Connection to plunger clutch K2
VL2	Connection to outflow cross section on plunger-control pressure (46)
a	Brake band plunger B2
b	Plate-type valve
c	Bypass valve
d	Connection between shift and release side
e	Throttle bore
f	Throttle
❑	For additional line progress refer to complete hydraulic diagram

Connecting brake band B2

When the reversing point is attained, the drum B2 tries to rotate in the opposite direction, while supporting the force of brake band B2 against reaction valve RV2. The zero outflow is closed against spring force. Pressure is established in the line to reaction valve. This pressure acts in spring chamber of valve (60), which shifts to the left against force of control pressure S1. As a result:

- the release side of brake band piston is switched to "zero". The plate-type valve (b) closes with its spring toward the left and separates the connection (d) toward release side. The oil pressure now acts only on shift side. The brake band is applied.
- The still available residual pressure in clutch K2 is discharged unthrottled via valve (60) on command valve (12).

Downshift 4-3 under acceleration

Brake band B2 is switched

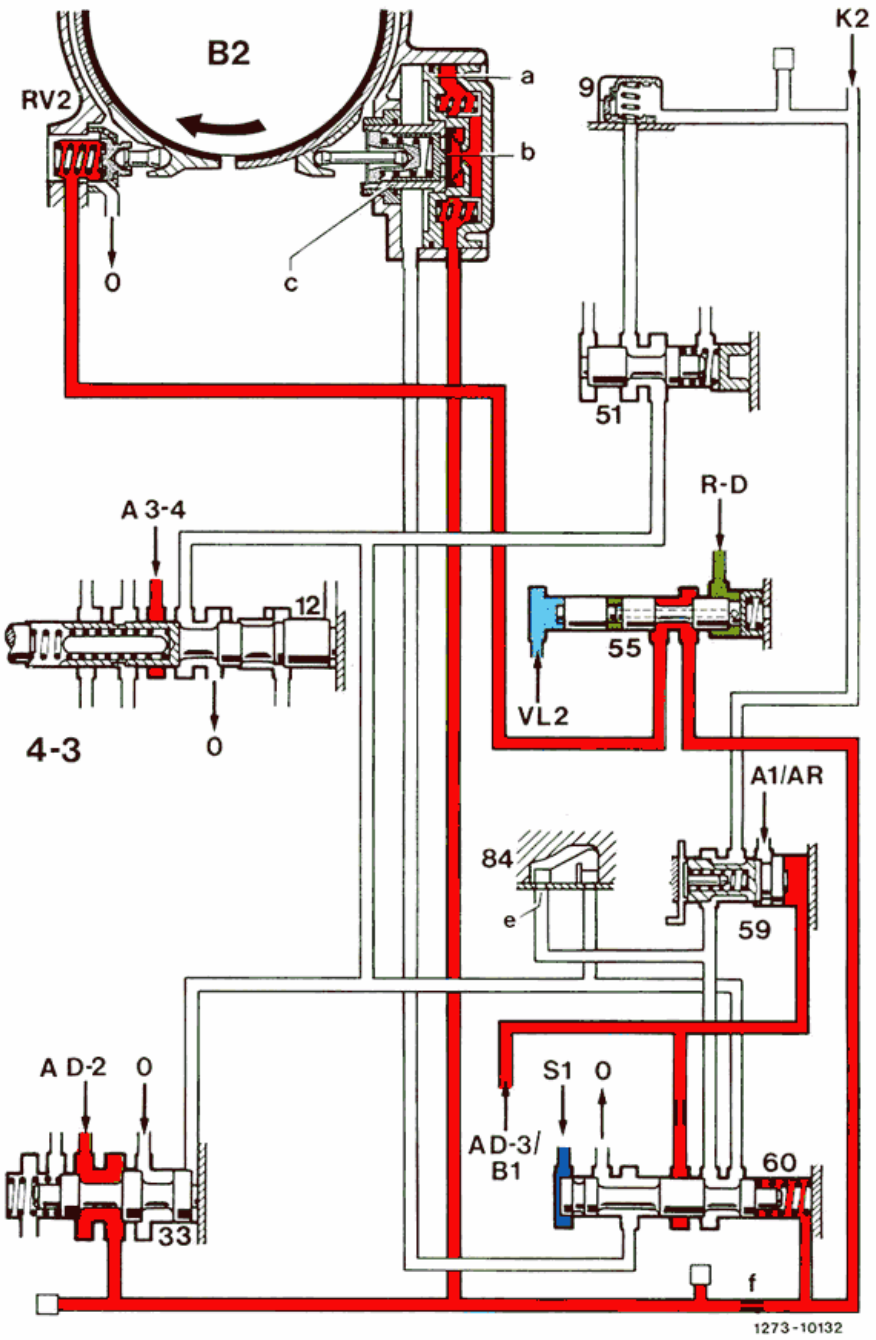


Fig. 53

9	Plate-type check valve
12	Command valve 3-4
33	Shift valve B2
51	Control valve accumulator K2
55	Shut-off valve RV2
59	Shift valve K2
60	Detent valve B2
84	Check valve
A3–4	Working pressure in 3rd and 4th speed
AD–2	Working pressure in positions "D" to "2"
A1–AR	Working pressure in 1st speed and reverse
AD–3/ B1	Working pressure in positions "D" and "3" as well as with brake band B1 actuated
R–D	Governor pressure in position "D"
S1	Control pressure S1
O	Oil sump drain
RV2	Reaction valve RV2
K2	Connection to plunger clutch K2
VL2	Connection to outflow cross section on plunger-control pressure (46)
a	Brake band plunger B2
b	Plate-type valve
c	Bypass valve
e	Throttle bore
f	Throttle
❑	For additional line progress refer to complete hydraulic diagram

Selector lever downshift from "D" to "3" at idle throttle-brake shift

When shifting from selector lever position "D" to "3" the governor pressure R–D on selector valve (1) is switched to "zero". The command valve (12) snaps to the right independent of vehicle speed. The downshift 4-3 is initiated.

Simultaneously, the shut-off valve RV2 (55) is pushed to the left by spring (d), after

- the governor pressure R–D on face (b) and annular surface (c) has been switched to "zero" via selector valve (1) and
- face (a) is without pressure. In idle throttle position with outflow cross section VL2 opened, no pressure can be established behind throttle (e).

In its lefthand position valve (55) locks the line to reaction valve RV2. A closed reaction valve is thereby simulated.

As soon as the return shift is initiated and working pressure arrives at shift side B2S, the detent valve (60) connects the release side of brake band plunger to zero. In this connection refer to "Downshift 4-3 under acceleration"

Brake band B2 is fully connected, independent of the driving speed and the engine speed.

Selector lever downshift from "D" to "3" at idle throttle-brake shift

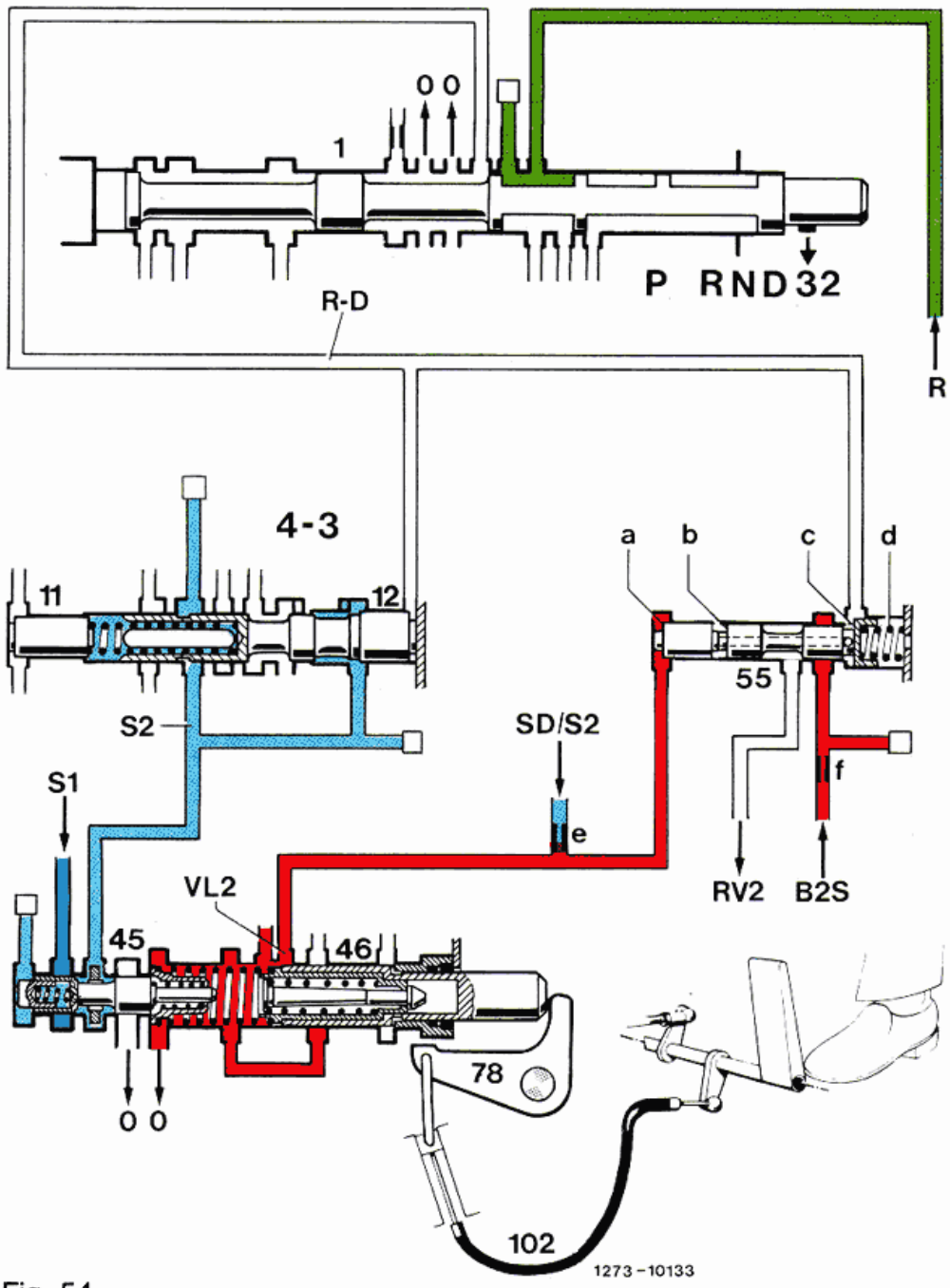


Fig. 54

1	Selector valve
11	Plunger command valve 3-4
12	Command valve 3-4
45	Regulating valve-control pressure
46	Plunger regulating valve-control pressure
55	Shut-off valve RV2
78	Reverse transfer lever
102	Control pressure cable
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
R	Governor pressure
R–D	Governor pressure in position "D"
SD/	Depending on shift valve housing version
S2	*Inflow shift pressure or control pressure*
O	Oil sump drain
RV2	Reaction valve RV2
B2S	Connection to brake band plunger B2
VL2	Outflow cross section, with idle throttle open
a	Face
b	Face
c	Annular surface
d	Compression spring
e	Throttle
f	Throttle
□	For additional line progress refer to complete hydraulic diagram

Selector lever downshift from "3" to "2" at idle throttle-brake shift

When shifting from selector lever position "3" to "2" the governor pressure RD–3, which acts at face of command valve, is switched to "zero" on selector valve (1). Command valve (4) snaps to the left, independent of vehicle speed. Downshift 3-2 is initiated.

Simultaneously, the shut-off valve-brake shift (61) has switched to the left under influence of spring force, after

- the working pressure AD–3 has been connected to zero outflow on selector valve (1) and additionally
- the pressure VL2 on plunger control pressure (46) has been switched to "zero". In idle throttle position or with outflow cross section VL2 opened, no pressure can be built up behind throttle (a) and therefore on face of valve (61).

In lefthand position of valve (61), the lefthand face of shut-off valve RV1 (62) is connected to zero outflow. Valve (62) shifts to the left and locks the connection to reaction valve RV1. A closed reaction valve is thereby simulated.

Working pressure flows to plunger-control valve B1 (39) and forces this valve together with control valve B1 (38) to the left. Control valve (38) can no longer control any contact pressure for brake band plunger B1, but lets the working pressure A2–4 act immediately and directly against plunger B1. In this connection, refer to downshift 3-2 under acceleration.

Brake band B1 is fully connected, independent of driving speed and engine speed.

Selector lever downshift from "3" to "2" at idle throttle-brake shift

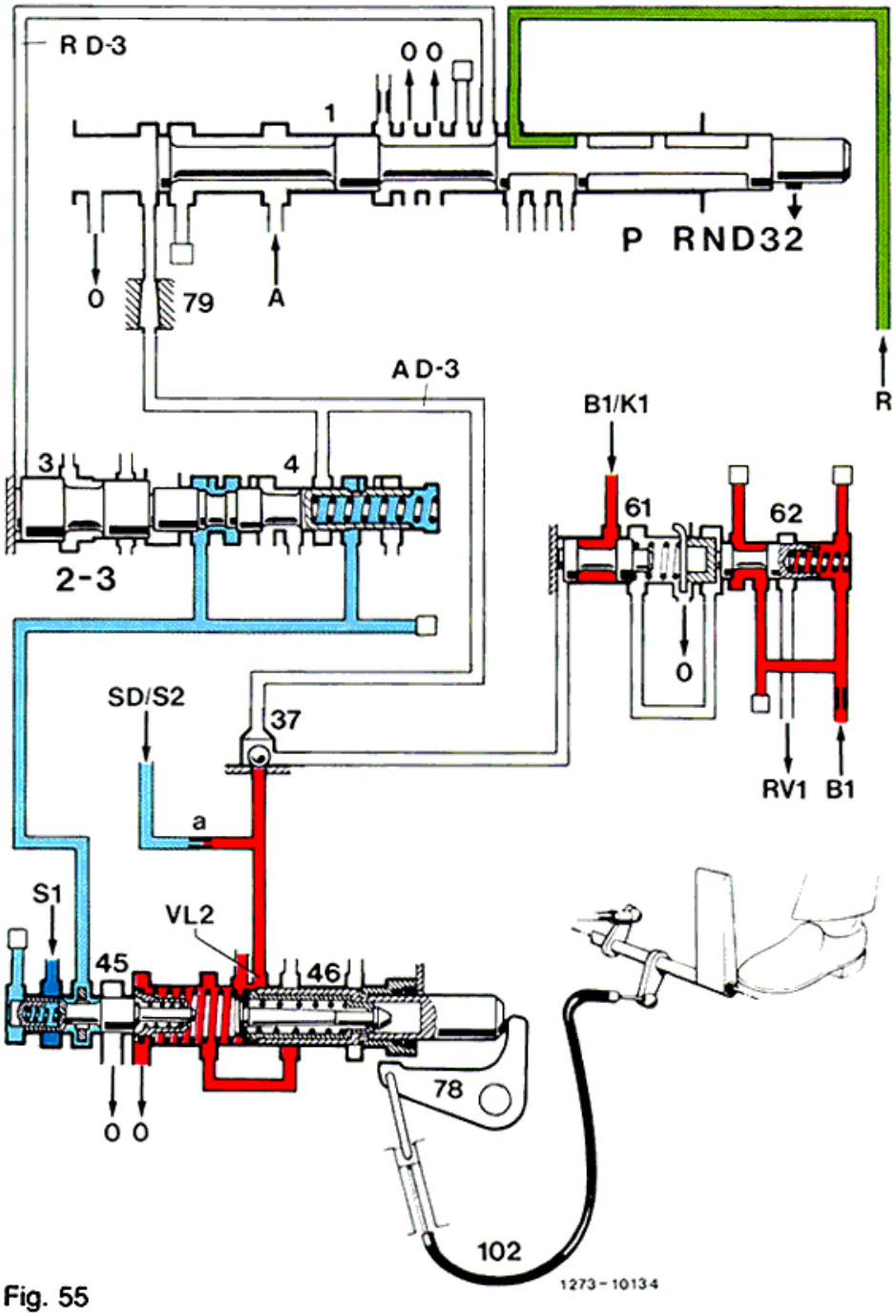


Fig. 55

1	Selector valve
3	Plunger-command valve 2-3
4	Command valve 2-3
37	Two-way ball valve
45	Control valve-control pressure
46	Plunger control valve-control pressure
61	Shut-off valve-brake circuit
62	Shut-off valve RV1
78	Reverse transfer lever
79	Temperature throttle K1
102	Control pressure cable
a	Working pressure
AD-3/	Working pressure in positions "D" and "3"
R	Governor pressure
RD-3	Governor pressure in positions "D" and "3"
SD/	Depending on shift valve housing version
S2	Inflow shift pressure or control pressure
S1	Control pressure (constant)
O	Oil sump drain
B1	Connection to brake band plunger B1
B1/K1	Depending on gear step shifted, inflow working pressure from B1 or K1
RV1	Connection to reaction valve RV1
VL2	Outflow cross section with idle throttle open
a	Throttle
□	For additional line progress refer to complete hydraulic diagram

General

An essential task of the hydraulic system comprises control of working pressure flow during a gear change. This means that within the time (shifting time) set up for each shift, the traction force of the vehicle must be continuously transferred from the condition of the engaged (shifted) gear step into the condition of the follow-up gear step. During this process, the engine speed increases by the respective difference in reduction (during a downshift) or decreases (during an upshift). The same goes for the cut-in procedure.

For this purpose, accumulator systems which are independent of each other, are available for the following purpose:

Accumulator	Purpose
Accumulator K1	Control of K1 for shifts 2-3-2
Accumulator K2	Control of K2 for shifts 3-4-3
Accumulator B1	Control of B1 for shifts 1-2-1
Accumulator cutting-in	Control of cutting-in procedure Selector lever from N in D shift elements B1 and B2 N in 3 shift elements B1 and B2 N in 2 shift elements K2 and B2 N in R shift elements K2 and B3

Pressure flow when connecting a shift element

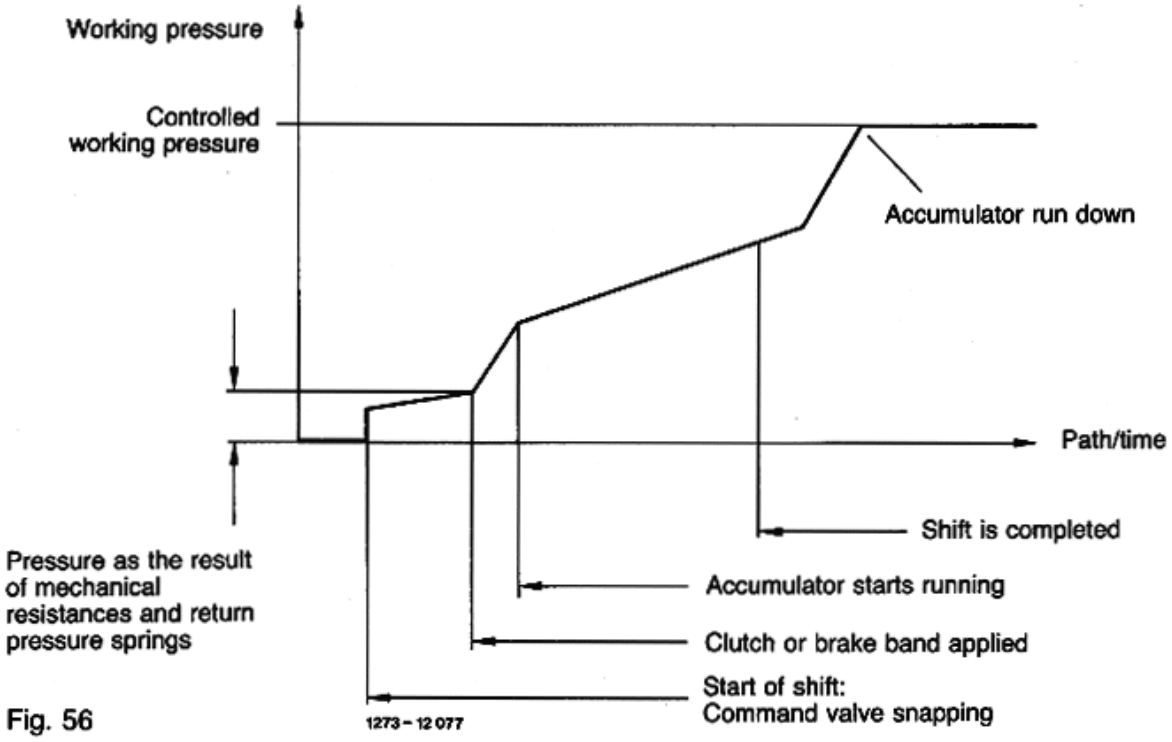


Fig. 56

Pressure flow when connecting a shift element

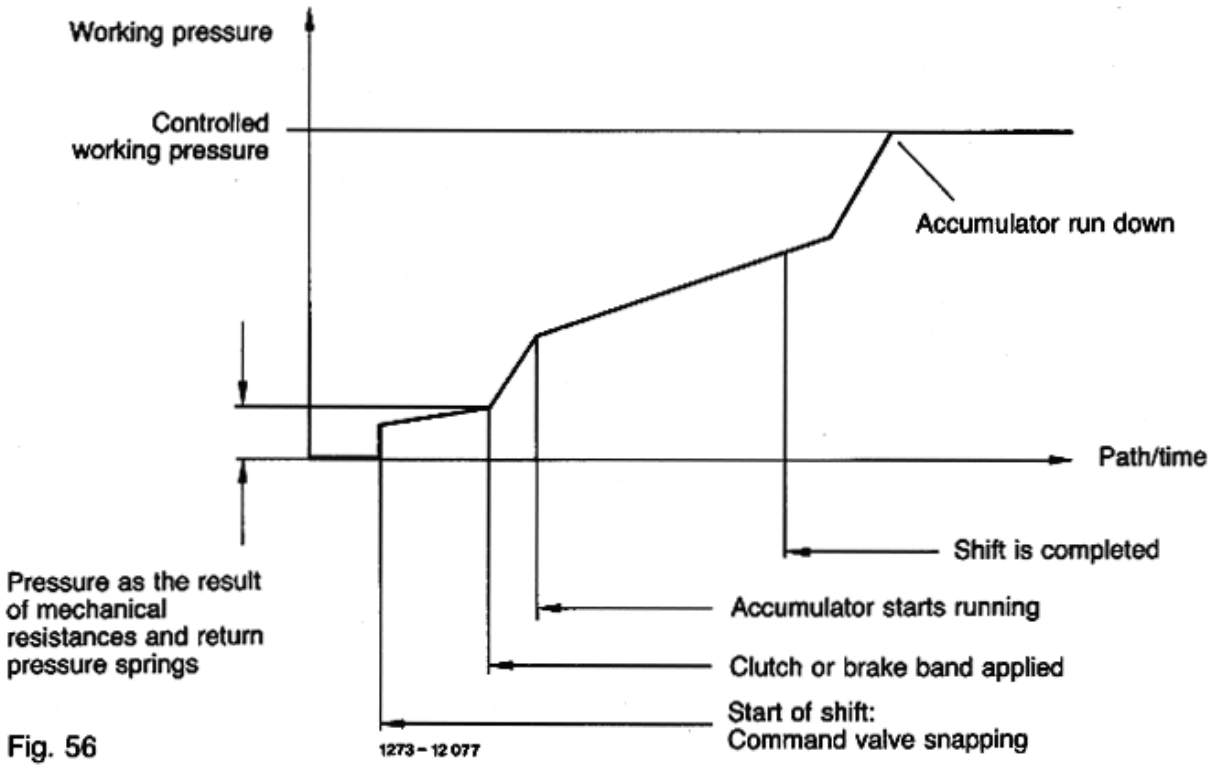


Fig. 56

An accumulator system comprises:

- accumulator plunger with spring pack
- control valve – accumulator with spring
- running time throttle

Below is an explanation of the accumulator system K1. Operation of accumulator systems K2 and B1 is in principle the same. Special characteristics of accumulator system B1 are separately explained.

Accumulator system K1

Control pressure SD is effective in spring chamber of accumulator (48) and on faces of control valve-accumulator (50). Valve (50) is at the right in opened position. Valve (7) is connected at the top.

Working pressure flows from command valve via control valve (50) and shut-off valve (7) to clutch K1 and via ball-check valve (6) to face of accumulator (48).

The working pressure overcomes at first the force of the return springs on clutch K1 and attains thereby the level of the apply pressure. As soon as the clutch discs are resting free of play against each other, the working pressure continues to rise and attains a level at which it moves the accumulator plunger against the force of its spring and the momentary prevailing shift pressure SD to the right. This will displace the oil quantity out of spring chamber of accumulator plunger, with the oil flowing off via timing throttle (a) to control valve for shift pressure. Different pressures "Before" and "Behind" throttle (a) will result and flow through lines toward control valve (50). The higher pressure "Before" throttle (a) overcomes the lower pressure "Behind" the throttle and moves the valve against the force of the spring to the left into control position. The inflow working pressure toward clutch K1 is throttled at control edge (d) while the operating speed of the accumulator plunger (48) is simultaneously reduced. As a result, the pressure increase in clutch K1 is suitably influenced and the specified accumulator time is maintained.

The moment the accumulator (48) attains the rightside stop, the working pressure on clutch K1 increases to its full value. There will be pressure equilibrium at the faces of the control valve (50), which is pushed back into its starting position.

When switching off, the command valve opens a zero outflow. The connection toward throttle (c) becomes pressureless. The shut-off valve (7) and the ball check valve (6) are closing in downward direction. Clutch K1 drains slowly via throttle (c). The oil in front of face of accumulator (48) flows off via throttle (b). The draining process is influenced via cross section of the throttles (b) and (c).

During a braking shift without gas, the shift pressure acting against spring side of accumulator plunger is very low, so that the shut-off valve (7) can be forced upwards by its spring. As a result, clutch K1 will not be gradually drained via throttle (c), but spontaneously through the large opening under shut-off valve (7).

Accumulator system K1

Control pressure SD is effective in spring chamber of accumulator (48) and on faces of control valve-accumulator (50). Valve (50) is at the right in opened position. Valve (7) is connected at the top.

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An accumulator system comprises:

- accumulator plunger with spring pack
- control valve – accumulator with spring
- running time throttle

Below is an explanation of the accumulator system K1. Operation of accumulator systems K2 and B1 is in principle the same. Special characteristics of accumulator system B1 are separately explained.

Accumulator system for clutch K1

Shown while connecting clutch

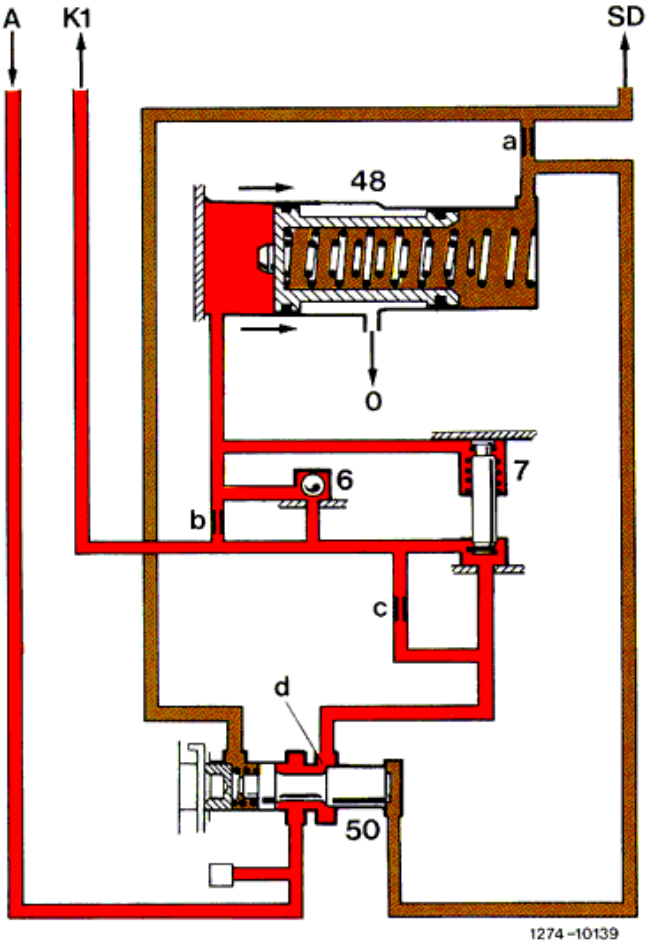


Fig. 57

6	Ball check valve
7	Shut-off valve K1
48	Accumulator K1
50	Control valve-accumulator K1
A	Working pressure
SD	Shift pressure
O	Oil sump drain
K1	Connection to clutch K1
a	Timing throttle
b	Throttle
c	Throttle
d	Control edge
□	For additional line progress refer to complete hydraulic diagram

Shown while disconnecting clutch

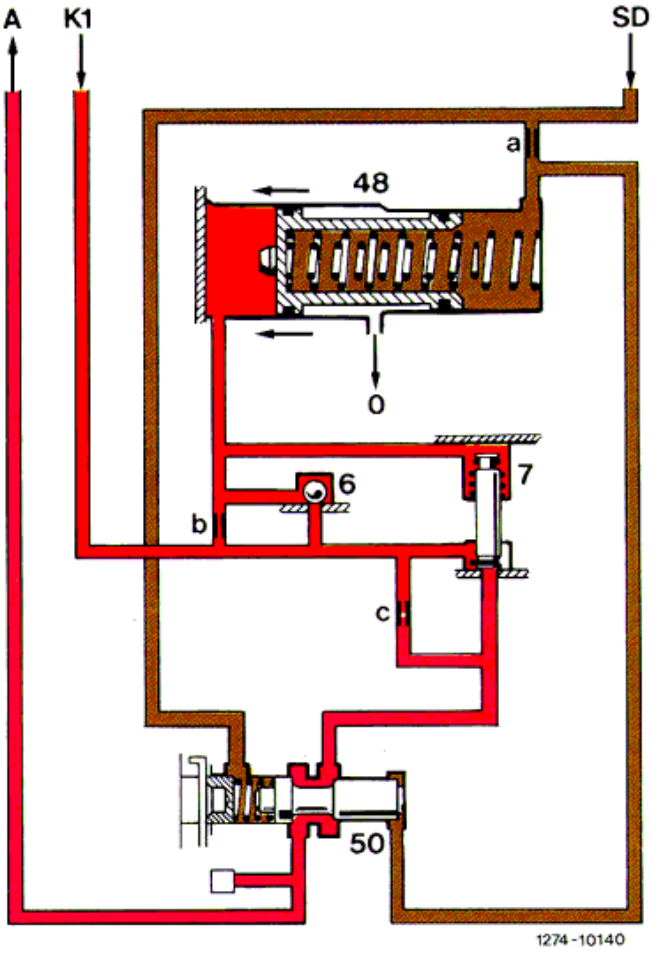


Fig. 58

6	Ball check valve
7	Shut-off valve K1
48	Accumulator K1
50	Control valve-accumulator K1
A	Working pressure
SD	Shift pressure
O	Oil sump drain
K1	Connection to clutch K1
a	Timing throttle
b	Throttle
c	Throttle
d	Control edge
□	For additional line progress refer to complete hydraulic diagram

Switching on accumulator system

The accumulator switch (53) controls the working pressure sequence after engaging driving positions "R", "D", "3" and "2".

Operation after engaging driving position "R"

In starting position the accumulator (53) is at the left. The spring chamber is filled with oil. In position "R" the selector valve (1) opens the inflow working pressure, which then flows toward brake B3 and via shift valve-kickdown (40), ball valve (21) and throttle (d) to face of accumulator (53).

The filling pressure on disc brake B3 forces the accumulator (53) to the right. At idle throttle the oil in spring chamber flows off pressureless via VL1. At part throttle, this oil is discharged into shift pressure system against shift pressure SD via ball-check valve (23).

During the filling process, there will be varying pressures before and behind the throttle (d), which act against the faces of the control valve (58). As a result, valve (58) is forced toward the left into control position. The inflow-working pressure is throttled at control edge (f) and the operating speed of the accumulator (53) is simultaneously reduced.

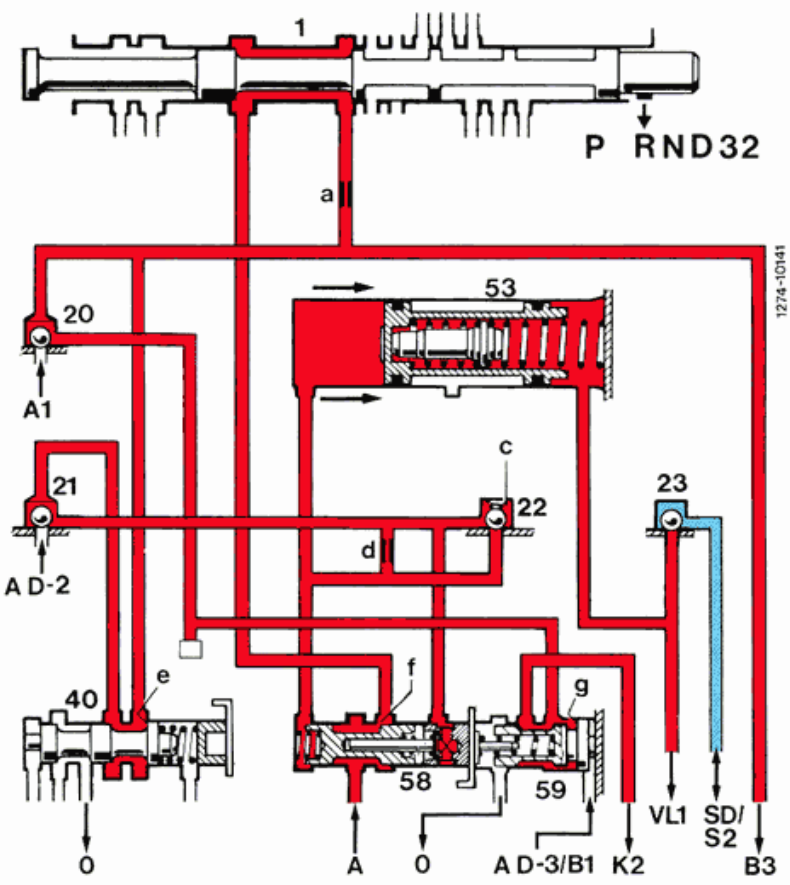
When the pressure at the disc brake B3 has attained approx. 5 bar, the working pressure against annular surface (e) pushes the shift valve-kickdown (40) to the right. The oil in front of accumulator face drains via ball valve (22) on zero outflow of valve (40), and the accumulator switches to the left into outlet position. In parallel with operation of B3, working pressure will flow via ball valve (20) to annular surface (g) of shift valve K2 (59) and forces this valve against the spring force to the right. Clutch K2 is switched. The accumulator (53) is operational for a forward driving position.

Function after engaging driving positions "D", "3" or "2"

When a forward driving position is engaged, the accumulator (53) operates about the same as when driving position "R" is engaged.

Differences are:

- The inflow working pressure now proceeds via AD–2 on two-way ball valve (21). Valve (21) closes in upward direction and separates the connection to shift valve-kickdown (40). The accumulator remains at righthand stop, also after switching on has been completed.
- In 1st speed, working pressure A1 on ball valve (20) flows toward annular surface (g) on valve (59). In driving position "2" 1st speed, the spring chamber of the shift valve K2 (59) is getting pressureless. Valve (59) switches to the right and clutch K2 is engaged.

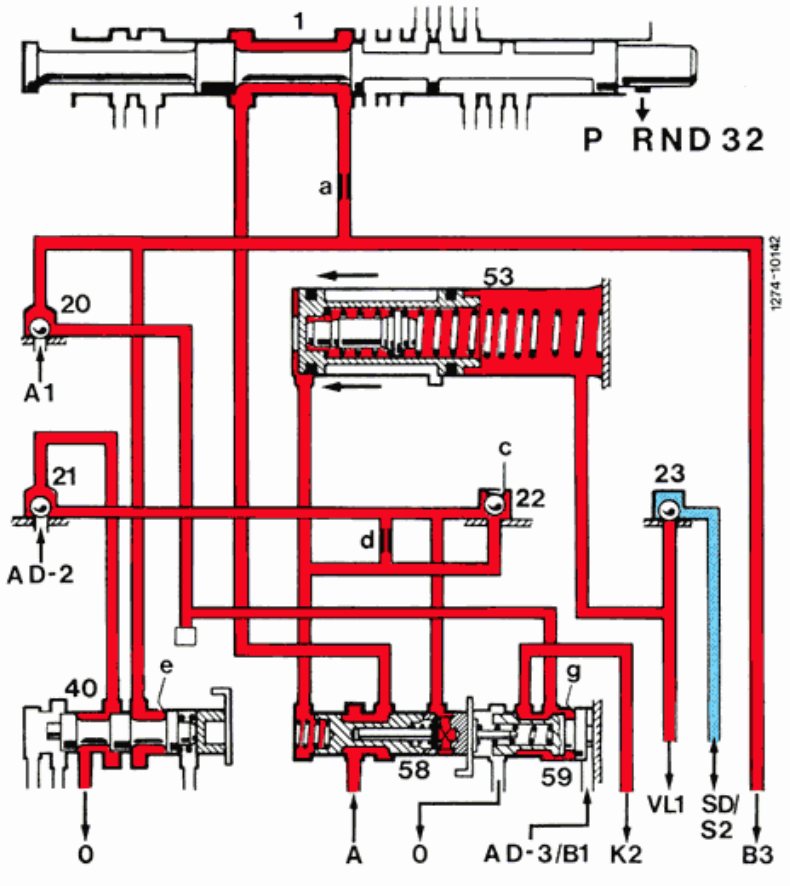


Switching on accumulator system

shown shortly after engaging driving position "R"

Fig. 59

1	Selector valve
20	Two-way ball valve
21	Two-way ball valve
22	Ball check valve
23	Ball check valve
40	Shift valve-kickdown
53	Accumulator-switching on
58	Control valve-accumulator switching on
59	Shift valve K2
A	Working pressure
A1	Working pressure in 1st speed
AD-2	Working pressure in positions "D" to "2"
AD-3/ B1	Working pressure in positions "D" to "3" and with brake band B1 actuated
SD/S2	Shift pressure or control pressure S2 depending on version of shift valve housing
O	Oil sump drain
B3	Connection to plunger brake B3
K2	Connection to plunger clutch K2
VL1	Connection to outflow cross section on plunger-control pressure (46)
a	Throttle
c	Compression spring
d	Throttle
e	Annular surface
f	Control edge
g	Annular surface
□	For additional line progress refer to complete hydraulic diagram



shown in driving position "R" at end of sequence

Fig. 60

1	Selector valve
20	Two-way ball valve
21	Two-way ball valve
22	Ball check valve
23	Ball check valve
40	Shift valve-kickdown
53	Accumulator-switching on
58	Control valve-accumulator-switching on
59	Shift valve K2
A	Working pressure
A1	Working pressure in 1st speed
AD-2	Working pressure in positions "D" to "2"
AD-3/ B1	Working pressure in positions "D" to "3" and with brake band B1 actuated
SD/S2	Shift pressure or control pressure S2 depending on version of shift valve housing
O	Oil sump drain
B3	Connection to plunger brake B3
K2	Connection to plunger clutch K2
VL1	Connection to outflow cross section on plunger-control pressure (46)
a	Throttle
c	Compression spring
d	Throttle
e	Annular surface
f	Control edge
g	Annular surface
□	For additional line progress refer to complete hydraulic diagram

Depending on vehicle model or equipment, the following functions are controlled by the control pressure and kickdown system:

- Driving position "B" (selector lever position "B")
- Kickdown-shutoff

Driving position "B"

Selector lever position "B" permits an earlier braking shift 2-1 (selector lever downshift 2-1). As a result, a better utilization of the engine brake torque is made possible also for vehicles with long rear axle ratios.

When selector lever position "B" is engaged, a switch in selector lever gate switches current to kickdown-solenoid valve (71). Solenoid valve (71) opens and the pressure on face (r) of control valve-control pressure (45) drops. The idle throttle spring (t) forces the valve to the left.

The control pressure S2 increases and acts on annular surface (u) of piston-control valve-control pressure (46), which is pushed against the force of spring (s) to the left toward control valve (45). The control pressure S2 attains its full height. There is a kickdown condition, even though the accelerator pedal is not in kickdown position.

Kickdown-shutoff

To utilize the engine output up to max. speed during kickdown shifts, the kickdown upshift is placed hydraulically above the max. engine speed. To make sure that the transmission shifts to the next speed shortly before attaining maximum speed, the current for the kickdown-solenoid valve is interrupted by the fuel pump relay.

Driving position "B" and kickdown-shutoff

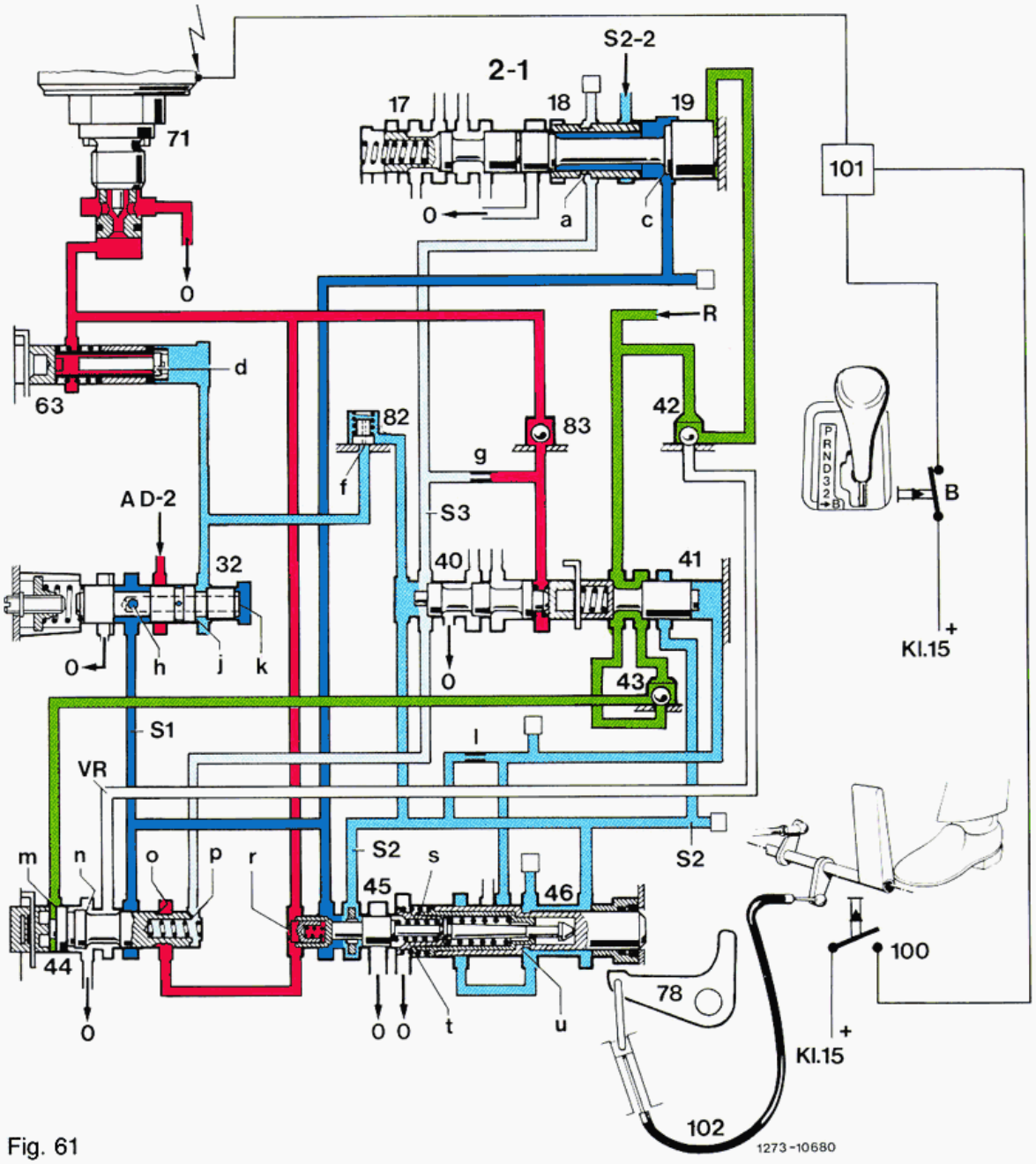


Fig. 61

17	Command valve 1-2
18	Sleeve command valve 1-2
19	Plunger command valve 1-2
32	Control valve-full throttle
40	Shift valve-kickdown
41	Shift valve-governor pressure
42	Two-way ball valve
43	Two-way ball valve
44	Amplifier valve-governor pressure
45	Control valve-control pressure
46	Plunger control valve-control pressure
63	Accumulator-kickdown
71	Solenoid valve-kickdown
78	Reverse-transfer lever for control pressure cable
82	Throttle check valve
83	Ball check valve
100	Kickdown switch
101	Electric control
102	Control pressure cable

AD-2	Working pressure in positions "D" to "2"
S1	Control pressure (constant)
S2	Control pressure (load-dependent)
S2-2	Control pressure in position "2"
S3	Kickdown-control pressure
R	Governor pressure
VR	Amplified governor pressure
O	Oil sump drain
a,c	Annular surfaces
d,f	Throttles
h	Radial bore
j	Annular surface
k	Face
l	Throttle
m,p,r	Faces
n,o	Annular surfaces
s	Compression spring for plunger (46)
t	Idle throttle spring
u	Annular surface
□	For additional line progress refer to complete hydraulic diagram

The program selector switch is integrated in gear-shifting gate. The letter shown in each case indicates the preselected gear-shifting program.

Switch position:

S = standard program
E = economy program

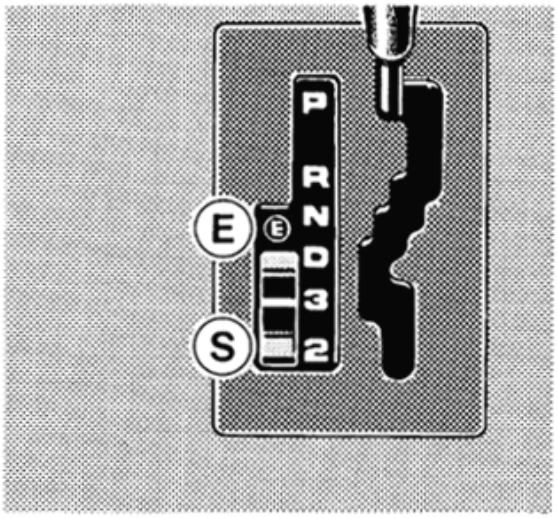


Fig. 63

S-program

In switch position "S" in selector lever positions "D" and "3", 2nd speed will be shifted when moving off in lower partial load range. When moving off in upper partial load range up to full load, kickdown is applied to shift back to 1st speed. Maximum driving performances will then be attained.

E-program

The E-program serves to select a quiet, comfort-oriented driving style with less shifting steps.

In switch position "E" moving off proceeds in 2nd speed in selector lever positions "D" and "3" without kickdown. Upshifts and downshifts in upper partial load and full load range are made at lower driving speeds and engine speeds.

The E-program is automatically interrupted when kickdown is applied. As a result, even with the E-program preselected, the full power reserve of the engine is available whenever required, and thereby the max. driving performance similar to S-program. As soon as the accelerator pedal position is back below the "E"-limit values, the transmission again follows the "E"-program.

Operation

The electric switchover valve (5) is activated via program selector switch (Fig. 64, item 4) and connects the vacuum element (7) integrated in control pressure cable with the intake manifold (3) and the vacuum supply tank (9). The pin of vacuum element is slipped over the vertically located rod connected to reverse-transfer lever (78). This will limit the travel of control pressure valve (46) and the spring on reverse-transfer lever (78) will be pulled out when the engine is further accelerated.

If kickdown is applied with the E-program engaged, the kickdown switch (97) will interrupt the current supply to electric switchover valve (5). This will vent the vacuum element (7), and the E-program remains switched off as long as the kickdown switch is actuated.

Function diagram

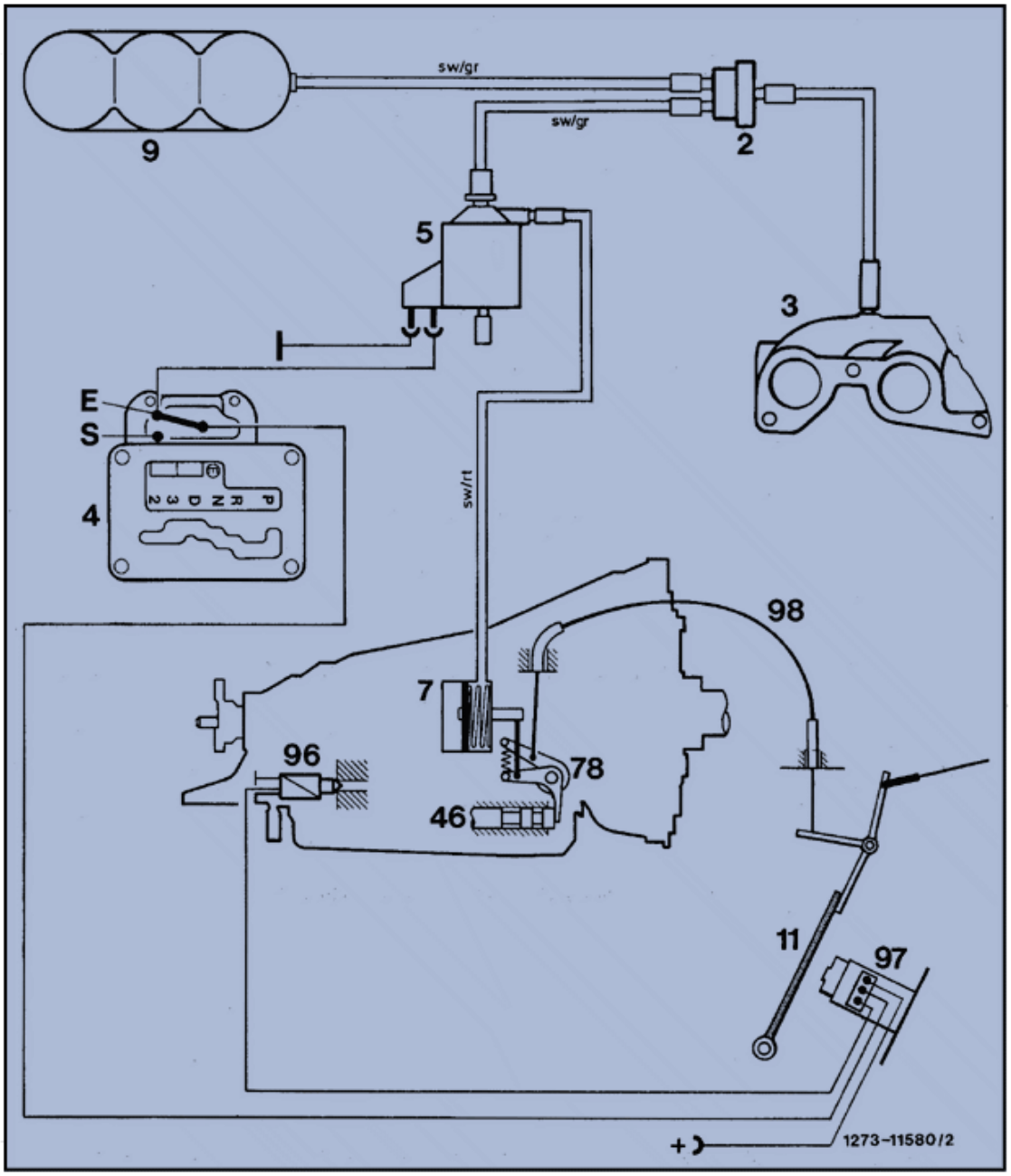


Fig. 62

2 Check valve
3 Intake manifold
4 Program selector switch
5 Electric switchover valve
7 Vacuum element
9 Vacuum supply tank
11 Accelerator pedal
46 Control pressure valve
78 Reverse transfer lever
96 Kickdown-solenoid valve
97 Kickdown switch
98 Control pressure cable