



P 120

Part 4 (44)

AUTOMATIC  
TRANSMISSION  
(BW - 35)

**CARS**

**SERVICE  
MANUAL**

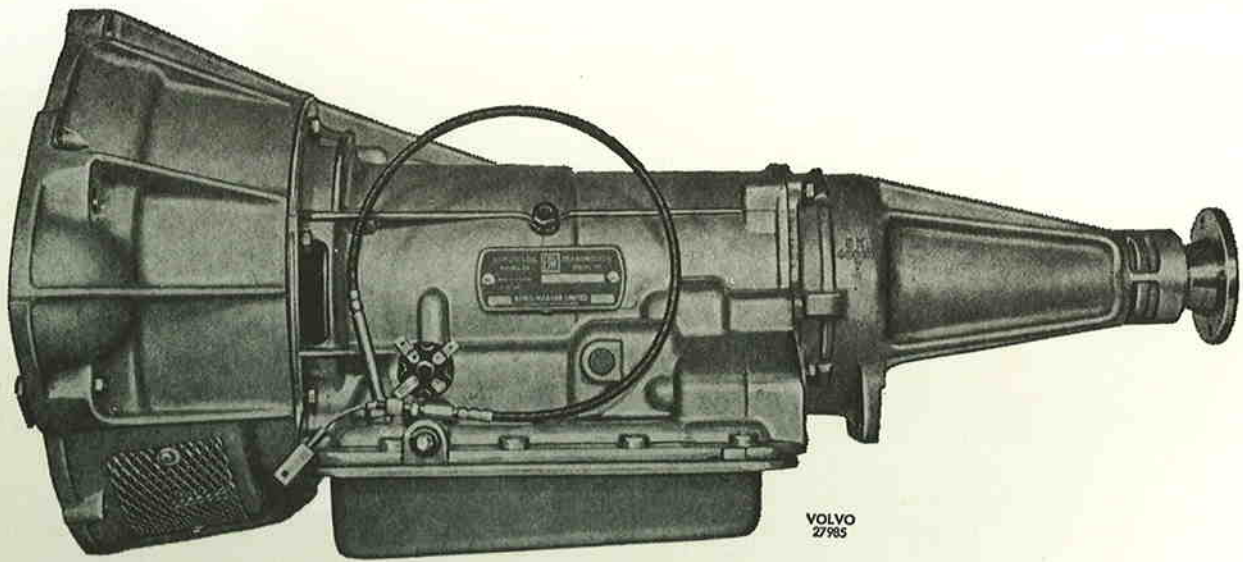


Fig. 1. The Borg-Warner Automatic Transmission type 35.

### List of contents

Description .....	4-1
Maintenance and repair instructions .....	4-15
Checking fluid level .....	4-15
Adjusting selector controls .....	4-15
Adjusting downshift valve cable .....	4-15
Adjusting starter inhibitor switch .....	4-17
Adjusting front brake band .....	4-17
Adjusting rear brake band .....	4-17
Air pressure checks .....	4-18
Removing .....	4-19
Dismantling .....	4-19
Inspecting .....	4-24
Assembling .....	4-24
Selector controls .....	4-30
Fault-tracing .....	4-31
Special tools .....	4-34
Specifications .....	4-35
Fault-tracing chart .....	4-37

In all correspondence with AB Volvo concerning the guarantee, servicing and spare parts the serial number of the transmission must always be stated. This also applies to the converter, which does not have a manufacturing serial number.

Note that all questions concerning the guarantee servicing, spare parts, etc., are dealt with by AB Volvo. No correspondence should be sent to the manufacturer.

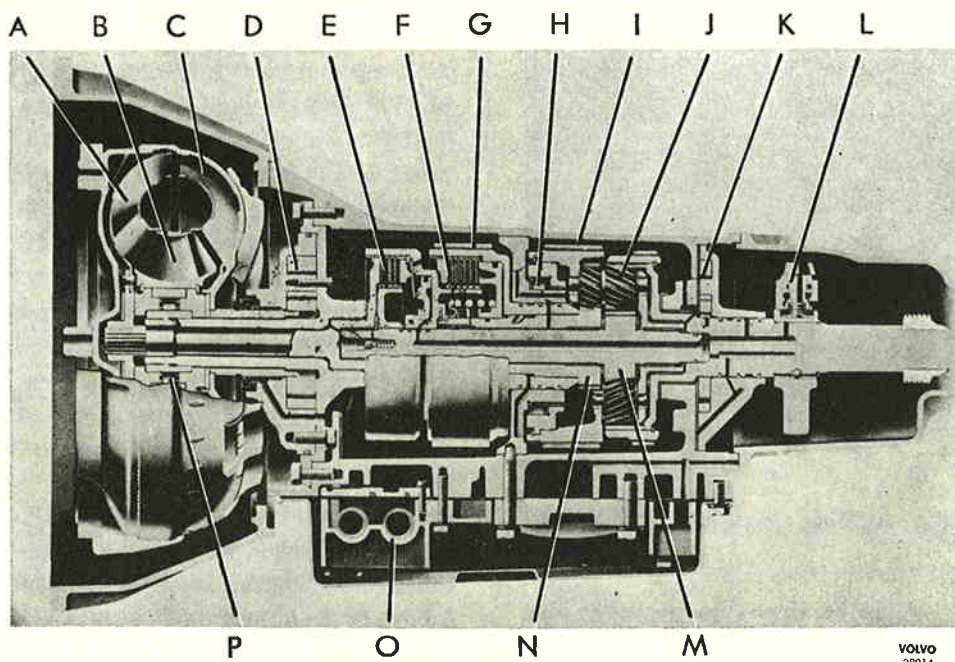


Fig. 2. Sectioned view of the transmission.

- |                       |                              |                                |
|-----------------------|------------------------------|--------------------------------|
| A. Turbine            | G. Front brake band          | M. Forward sun gear            |
| B. Stator             | H. One-way clutch in gearbox | N. Reverse sun gear            |
| C. Impeller and cover | I. Rear brake band           | O. Control system              |
| D. Front pump         | J. Planetary gear set        | P. One-way clutch in converter |
| E. Front clutch       | K. Rear pump                 |                                |
| F. Rear clutch        | L. Governor                  |                                |

## DESCRIPTION

The Volvo automatic transmission for cars is of Borg-Warner manufacture, type 35. It consists of two main components:

1. A three-element hydrokinetic torque converter coupling capable of torque multiplication at an infinitely variable rate between 2:1 and 1:1.
2. A hydraulically operated gearbox comprising a planetary gear set with a valve system which automatically selects a suitable gear in relation to the speed of the car and position of the accelerator pedal.

There is also a selector control with positions "L", "D", "N", "R" and "P", see Fig. 3.

### THE TORQUE CONVERTER

The torque converter serves both as a clutch and as an extra (hydraulic) gear between the engine and gearbox. It provides a means of obtaining smooth application of engine power to the driving wheels and additional engine torque multiplication to the 1st

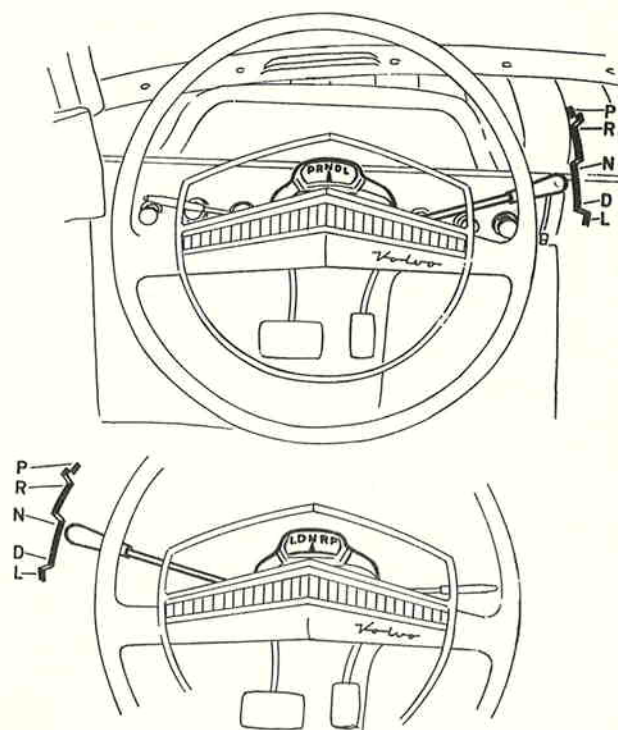
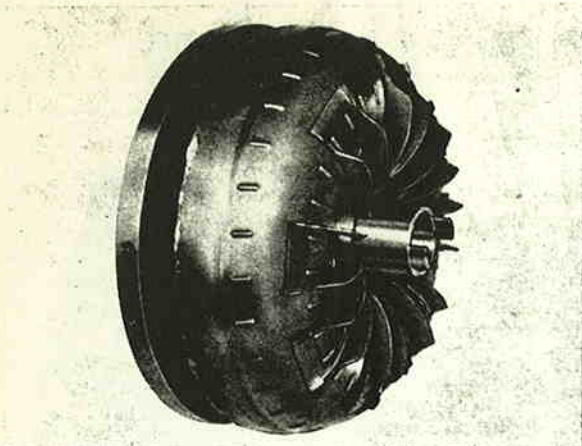


Fig. 3. Selector lever positions.

VOLVO  
27986



VOLVO  
27667

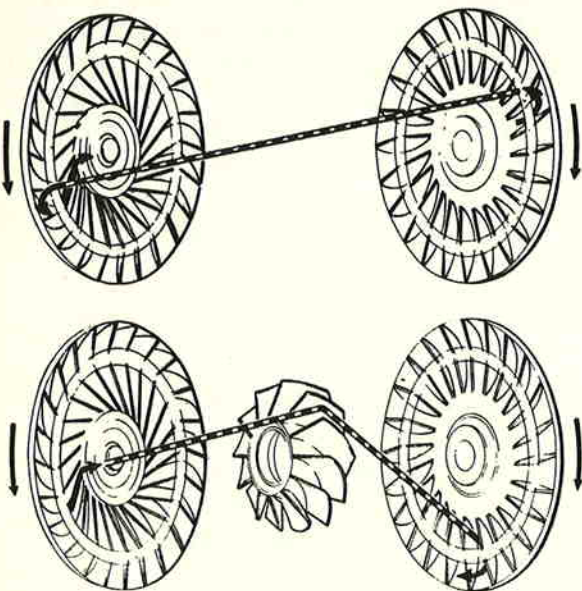
Fig. 4. The converter.

and 2nd gears of the gearbox. The converter also provides extreme low-speed flexibility when the gearbox is in 3rd gear and, due to the ability of multiplying engine torque, it provides good acceleration from very low road speed without having to resort to a downshift in the gearbox.

The converter consists of three main components — an impeller connected to the engine crankshaft, a turbine connected to the input shaft of the gearbox, and a stator mounted on a sprag-type one-way clutch supported on a fixed hub projecting from the gearbox case.

The converter functions as follows:

The impeller is rotated by the engine and converts the engine power into hydrokinetic energy. The fluid flows from the impeller vanes to the turbine vanes and returns to the impeller through the stator vanes,



VOLVO  
27978

Fig. 5. Function of converter.

see Fig. 5. The curvature of the various vanes is so designed that when a speed differential exists between the impeller and the turbine, the angle of the fluid flow from the turbine is changed by the stator vanes in such a way that the discharge of fluid from the stator assists in driving the impeller. Under such conditions, torque multiplication occurs and varies from 2:1 when the turbine is stalled (i.e. when, with any of the driving ranges selected, the vehicle is held stationary and the engine is operating at maximum throttle opening) to 1:1 when the turbine reaches a speed approximately 90 % of that of the impeller. When this speed differential between the impeller and turbine is achieved, the fluid flow angle from the turbine is such that the stator is driven in the same direction as the turbine and the impeller. Under these circumstances, the converter becomes a fluid flywheel or coupling and there is no torque multiplication.

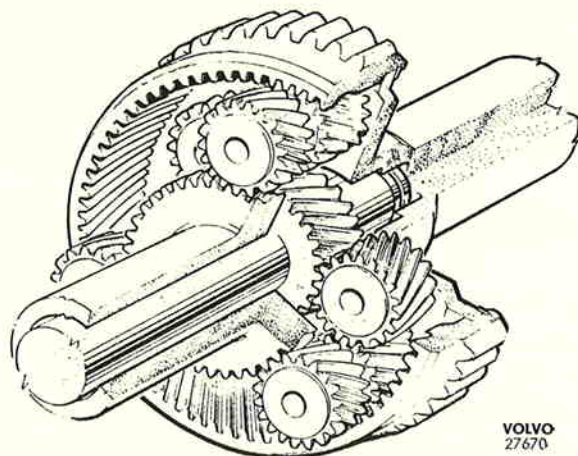
## GEARBOX

The gearbox consists of a mechanical power transmission system — planetary gear, two clutches, two brake bands and a one-way clutch — and a hydraulic system — front and rear pump, centrifugal governor and a control valve system which regulates the fluid pressure and directs the fluid to the various gearbox components.

### Mechanical power transmission system

#### PLANETARY GEAR

The planetary gear set consists of two sun gears, two sets of pinions, a pinion carrier and a ring gear, see Fig. 6. Helical involute tooth forms are used throughout. In all forward gears, power enters through the forward sun gear; in reverse, power enters through the reverse sun gear. Power leaves the gear set by the ring gear. The pinions are used to transmit power



VOLVO  
27670

Fig. 6. Planetary gear.

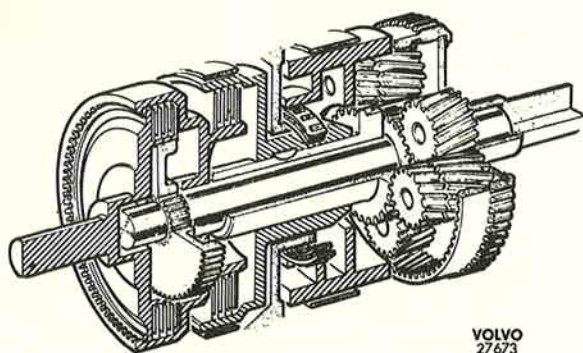


Fig. 7. Planetary gear, clutches and brake bands.

from the sun gears to the ring gear. In reverse, a single set of pinions is used which causes the ring gear to rotate in the opposite direction to the sun gear. In forward gears, a double set of pinions is used to cause the ring gear to rotate in the same direction as the sun gear. The carrier locates the pinions in their correct positions relative to the two sun gears and the ring gear (and also forms a reaction member in certain conditions). The various mechanical ratios of the gear set are obtained by the engagement of hydraulically operated multi-disc clutches and brake bands.

**CLUTCHES**

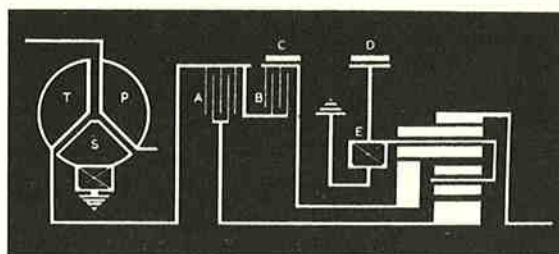
The clutches, see Fig. 7, consist of multi-disc units operated by hydraulic pistons. In all forward gears the front clutch connects the converter to the forward sun gear; for reverse, the rear clutch connects the converter to the reverse sun gear.

**BRAKE BANDS**

Brake bands, operated by hydraulic servos, hold elements of the gear set stationary to effect an output speed reduction and a torque increase. In "lock-up", the rear band holds the pinion carrier stationary and provides the 1st gear ratio of 2.39:1 and, in reverse, a ratio of 2.09:1. The front band holds the reverse sun gear stationary to provide the 2nd gear ratio of 1.45:1.

**ONE-WAY CLUTCH**

In the drive position "D", a one-way clutch is used in place of the rear band to prevent the pinion carrier from turning opposite to engine rotation, thus also providing a 1st gear ratio of 2.39:1. This one-way clutch, allowing the gearbox to freewheel in 1st gear, provides smooth ratio changes from 1st to 2nd and vice versa.



VOLVO 27979

	A	B	C	D	E
1st gear, L	●			●	
1st gear, D	●				●
2nd gear	●		●		
3rd gear	●	●			
Neutral					
Reverse		●		●	
Park					

Fig. 8. Diagram of power flow.

- A. Front clutch
- B. Rear clutch
- C. Front brake band
- D. Rear brake band
- E. One-way clutch
- P. Impeller
- S. Stator
- T. Turbine

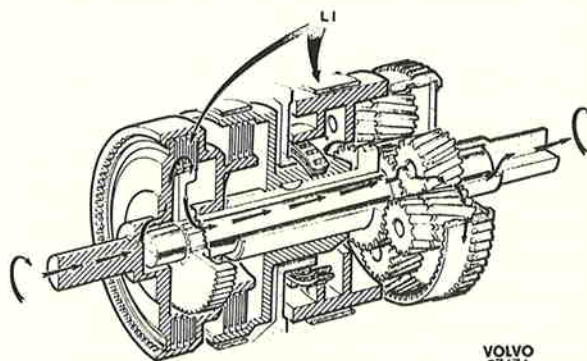
**POWER FLOW**

**1st gear ("lock-up" selected)**

The front clutch is applied, connecting the converter to the forward sun gear, see Fig. 9. The rear brake band is applied, holding the pinion carrier stationary; the gear set provides the reduction of 2.39:1. The reverse sun gear rotates freely in the opposite direction to the forward sun gear.

**1st gear, (drive selected)**

The front clutch is applied, connecting the converter to the forward sun gear, see Fig. 10. The one-way clutch is in operation preventing the pinion carrier from turning opposite to engine rotation; the gear set provides the reduction of 2.39:1. On the overrun, the one-way clutch, and thus the gearbox, freewheels.



VOLVO 27674

Fig. 9. Power flow, 1st gear, position "L".

**2nd gear ("Lock-up" or "drive" selected)**

Again the front clutch is applied, connecting the converter to the forward sun gear, see Fig. 11. The front brake band is applied holding the reverse gear stationary; the gear set provides a reduction of 1.45: 1.

**3rd gear**

Again the front clutch is applied, connecting the converter to the forward sun gear, see Fig. 12. The rear clutch is applied, connecting the converter also to the reverse sun gear; thus both sun gears are locked together and the gear set rotates as a unit providing a ratio of 1: 1.

**Neutral and park**

The front and rear clutches are off and no power is transmitted from the converter to the gear set. The front and rear brake bands are also released, except in "park", where for constructional reasons the rear brake band is applied as long as the engine is running.

**Reverse**

The rear clutch is applied, connecting the converter to the reverse sun gear, see Fig. 13. The rear brake band is applied, holding the pinion carrier stationary; the gear set provides the reduction of 2.09: 1 in the reverse direction.

**Hydraulic system**

**FRONT PUMP**

The front pump, which is driven by two fingers on the converter impeller hub, is in operation whenever the engine is running. This pump supplies the hydraulic requirements of the transmission with the engine running when the vehicle is stationary, as well as at low vehicle speeds before the rear pump becomes effective. When the rear pump is effective, the front pump check valve closes but a by-pass permits the pump still to supply the converter and lubrication requirements. The front pump then operates at reduced pressure in order to minimize pumping losses.

**REAR PUMP**

The rear pump is rotated by the driven shaft of the transmission. It is fully effective at speeds above 20 m.p.h. (30 km.p.h.) and then supplies the hydraulic requirements of the transmission. If the engine cannot be started with the car battery, i.e. the front pump is inoperative, the rear pump can, above 20 m.p.h. (30 km.p.h.) provide all hydraulic requirements thus enabling the engine to be started through the transmission by towing.

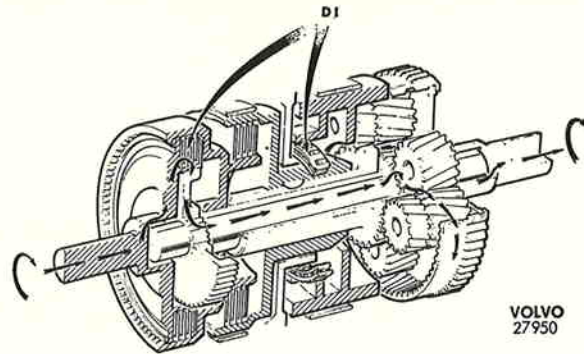


Fig. 10. Power flow, 1st gear, position "D".

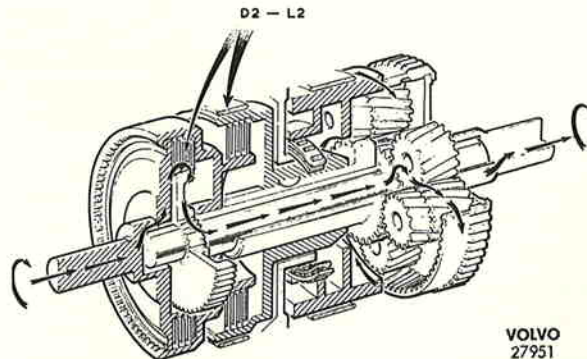


Fig. 11. Power flow, 2nd gear.

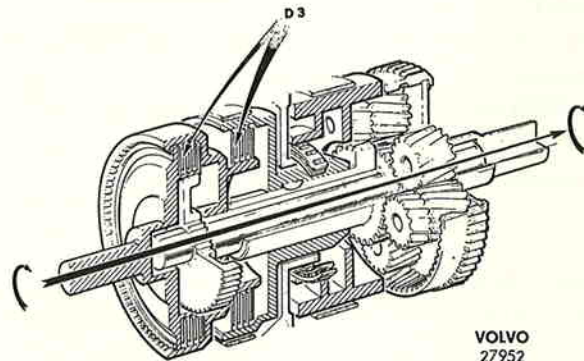


Fig. 12. Power flow, 3rd gear.

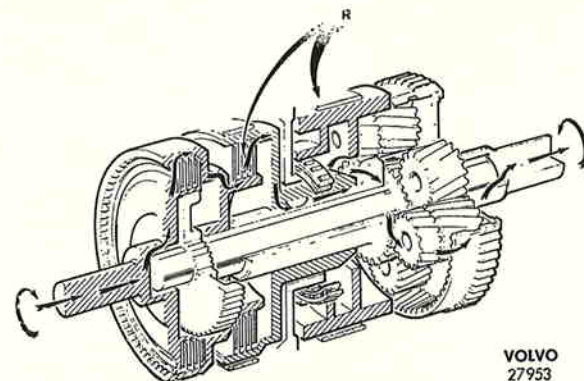


Fig. 13. Power flow, reverse.

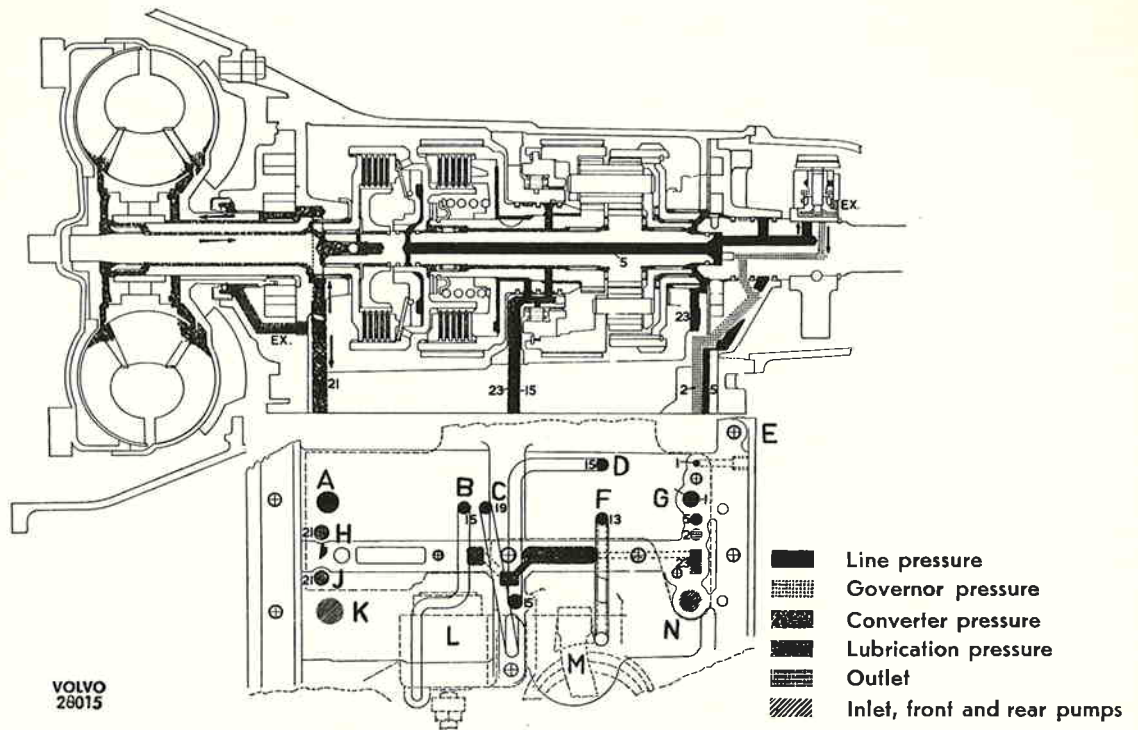


Fig. 14. Fluid passages, transmission and gearbox case.

- |                              |                          |
|------------------------------|--------------------------|
| A. Front pump pressure line  | H. Converter feed        |
| B. Front servo release       | J. Converter return line |
| C. Front servo application   | K. Front pump inlet      |
| D. Rear clutch               | L. Front servo           |
| E. Outlet for pressure gauge | M. Rear servo            |
| F. Rear servo                | N. Rear pump inlet       |
| G. Rear pump pressure line   |                          |

**GOVERNOR**

The governor, revolving with the driven shaft, is basically a pressure regulating valve which reduces line pressure to a value that varies with output shaft (i.e. vehicle) speed. This variable pressure, known as governor pressure, is utilized in the control system to effect up and downshifts through the 1—2 and 2—3 shift valves. The rotation of the governor causes the governor weight (C) and valve (B) to produce a centrifugal force, tending to open the valve. This outward force is opposed by an equal and opposite hydraulic force produced by governor pressure acting upon a small area of the governor valve. Due to this, the governor pressure will rise in proportion to the increased centrifugal force caused by increased rotational speed.

As speed increases, the governor weight moves outwards centrifugally to a stop in the governor body, when it can move no further. When this occurs, a spring (A) located between the weight and the governor valve becomes effective. The constant force of this spring then combines, with the centrifugal force of the governor valve, the total then being

opposed by governor pressure, thus rendering this pressure less sensitive to output shaft speed variations.

The governor thus provides two distinct phases of regulation, the first being used for accurate control of the low speed shift points.

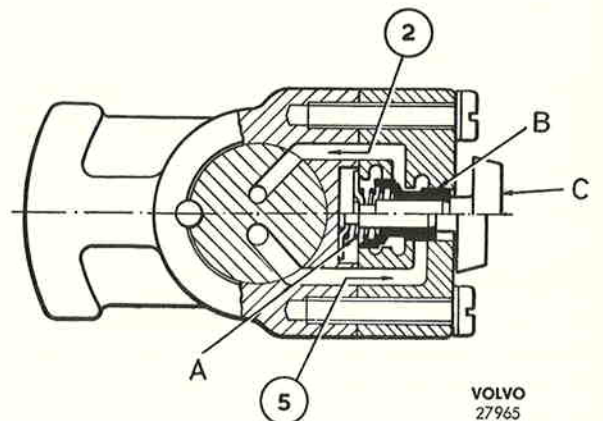


Fig. 15. Governor.

- |           |                    |
|-----------|--------------------|
| A. Spring | C. Governor weight |
| B. Valve  |                    |

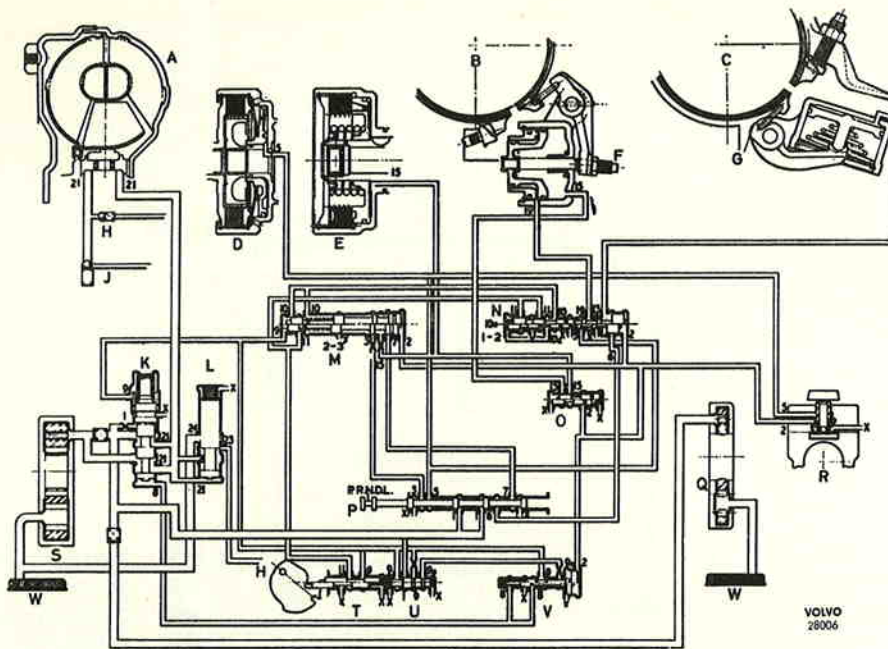


Fig. 16. Hydraulic circuits.

- |                           |                                |                    |
|---------------------------|--------------------------------|--------------------|
| A. Converter              | J. Return line                 | R. Governor        |
| B. Front brake band       | K. Primary regulator valve     | S. Front pump      |
| C. Rear brake band        | L. Secondary regulator valve   | T. Downshift valve |
| D. Front clutch           | M. 2—3 shift valve             | U. Throttle valve  |
| E. Rear clutch            | N. 1—2 shift valve             | V. Modulator valve |
| F. Front servo            | O. Servo orifice control valve | W. Strainer        |
| G. Rear servo             | P. Manual control valve        |                    |
| H. Lubrication ball valve | Q. Rear pump                   |                    |

**CONTROL SYSTEM**

The line and converter pressures are controlled by the primary and secondary regulator valves, the former operating in conjunction with throttle pressure acting upon the spring end, and modulated throttle pressure acting on the opposite end.

Shift control is provided by the 1—2 and 2—3 shift valves, which are operated by governor pressure, throttle pressure and line pressure.

Manual control is provided by the manual control valve which, according to the position of the selector, directs fluid to or provides an exhaust for the clutch and servo pistons.

For ease of reference, all hydraulic circuits are identified by numbers. The numbers in brackets in the following description refer to the line numbers, see Figs. 14—23.

**Primary regulator valve**

This valve regulates front pump pressure during idling, reversing and at low vehicle speeds, and rear pump pressure when, as a result of increased vehicle speed, the rear pump becomes effective. Rear pump regulation occurs when rear pump pressure exceeds front pump regulated pressure. This pressure differential opens the rear pump check valve allowing

rear pump fluid to flow to the primary regulator valve and supply the line pressure requirements. Front pump pressure is then no longer regulated by the primary regulator valve but flows through this to the secondary regulator valve.

Line pressure (1), operating on a small area of the valve, can be decreased by modulated throttle pressure (8) operating on one end of the valve. These forces are opposed by the primary regulator valve spring and throttle pressure (9) operating on the spring end of the valve. The line pressure thus produced varies with the accelerator position as well as vehicle speed and provides the correct clutch and brake capacity under all operating conditions. This line pressure (1) is directed to the manual valve and throttle valve.

**Secondary regulator valve**

This is a regulating valve which controls the values of converter pressure (21) and lubrication (23) for the components in the rear of the transmission case. Converter pressure operating on one end of the valve is opposed by spring force on the other end. When the front pump capacity is increased due to increased engine speed, the valve moves to open a port giving access to the suction side of the front

pump. Thus at high speed excess front pump output is directed back to minimize pumping losses.

#### **Downshift valve and throttle valve**

The downshift valve is connected to the carburetor linkage via a cable-actuated cam. Movement of the downshift valve compresses the throttle valve spring located between the downshift valve and the throttle valve. This spring is opposed by the throttle return spring, combined with throttle pressure (9) acting at low vehicle speed on one area of this regulating valve, and at higher vehicle speeds on two areas (9 and 9a). Thus a throttle pressure is produced that is related to both engine torque and vehicle speed. This pressure (9) is directed to the spring end of the primary regulator valve. The line pressure thus depends on the throttle pressure, providing correct clutch and brake band capacities and appropriate shift quality under all operating conditions.

Full movement of the downshift valve directs throttle pressure (11) to certain areas on the shift valves whereby upshifts or downshifts 3—2 and 3—1 respectively are obtained at pre-set maximum vehicle speeds.

Throttle pressure (9) is also directed to the 2—3 shift valve plunger which at part throttle opening reduces the value of throttle pressure by a fixed amount. This reduced pressure is directed to the 1—2 and 2—3 shift valves to render the low speed shift points less sensitive to throttle pressure and, therefore, accelerator position.

#### **Modulator plug and valve**

The modulator plug is a regulating valve that reduces throttle pressure (9) by a fixed amount. This modulated pressure (8) operating on the spring end of the plug and assisted by the modulator valve spring, is opposed by throttle pressure (9) operating on the opposite end. Modulated throttle pressure (8) is directed to the primary regulator valves to vary the rate of increase of line pressure relative to throttle pressure.

The modulator valve is a shuttle valve. Governor pressure operating on the large end is opposed by the modulator valve spring. As governor pressure rises, the valve moves, preventing the plug from regulating, and modulated throttle pressure (8) then becomes equal to throttle pressure (9). Moreover this movement directs throttle pressure to a second area of the throttle valve opposing throttle valve spring force. This arrangement permits high throttle and line pressures under full and partial throttle conditions, with a reduction in these pressures after "cut-back".

#### **Servo orifice control valve**

A common line (15) supplies fluid to, or exhaust fluid from, the rear clutch and the release area of the front servo to effect the 2—3 and 3—2 shift.

The servo orifice control valve is interposed in the front servo release circuit. Governor pressure (2) operating on an area of the valve is opposed by the valve spring. At a 2—3 shift with low governor pressure (i.e. low vehicle speed), fluid passes without restriction to the release side of the front servo system. At higher speeds, however, the valve moves and fluid is directed through an orifice to this side of the piston. During upshifts, with the servo orifice in circuit, the front band releases more slowly relative to rear clutch engagement, thus avoiding "run-up" during the transition from 2 to 3. During downshifts, the orifice in circuit ensures that the front band does not engage before the rear clutch releases, thus avoiding "tie-up" on the 3—2 shift.

The servo orifice control valve, therefore, affects the relationship between the rear clutch and front brake band and provides correct shift timing under all operating conditions.

#### **1—2 shift valve**

This operates when the selector lever is in "D". In 1st gear, governor pressure (2) operates on the large end of the valve. The governor pressure is opposed by the line pressure (5), the spring and reduced throttle pressure (10—10a). When governor pressure exceeds these opposing forces, the valve moves to the 2nd gear position and line pressure (5) is directed to the apply side of the front servo piston (19). The movement also results in an area of the valve being no longer subjected to line pressure (5). This allows the 2—1 downshift to occur at a lower speed than the 1—2 upshift. When the governor pressure is lower than the spring force combined with the throttle pressure, the valve moves to the 1st gear position and the apply side of the front servo (19) is opened to exhaust.

In "L" position also with low governor pressure, the valve moves to the 1st gear position; line pressure (6) thus directed to the rear servo (13) latches the valve hydraulically in the 1st gear position, preventing an upshift.

#### **2—3 shift valve**

The plunger in this shift valve reduces the value of throttle pressure (9) by a fixed amount and is therefore inoperative when throttle pressure is below this fixed amount. Throttle pressure (9), operating on one end of the plunger, is opposed by this reduced throttle pressure (10) and the 2—3 shift valve spring

located between the plunger and valve. This reduced pressure is directed to the 2—3 shift valve and the 1—2 shift plunger as described under "Downshift and throttle valve".

The 2—3 shift valve is a shuttle valve. In the 2nd gear position, and before the plunger begins regulating, governor pressure (2) operating on the large end of the valve is opposed by line pressure (3) operating on an area of this valve, as well as the 2—3 shift valve spring. Once the plunger begins regulating, the governor pressure (2) is opposed by the line pressure (3), the reduced throttle pressure (10) and the throttle pressure (9). This last force is relayed to the 2—3 shift valve by the valve spring.

Movement of the shift valve to the 3rd gear position directs fluid via the circuit (15) to the rear clutch and, via the servo orifice control valve, to the release side of the front servo. This pressure causes the rear clutch to be applied. Moreover, because the release area of the front servo is larger than the apply area, it causes the front band to be released. The movement also results in an area of the valve being no longer subjected to line pressure (3), and that the plunger in the valve, which is forced to the end of the valve bore by the spring, is not affected by any pressure. In this way reduced throttle pressure (10) is replaced by throttle pressure (9). This change in forces causes the 3—2 shift point to occur at a lower governor pressure (i.e. lower vehicle speed) than the 2—3 upshift.

When the manual control valve is moved to "L", line pressure (15) is exhausted since the line (3) has access to the oil pan. The circuit (7) at the opposite end of the manual control valve is also open. This inevitably results in an immediate downshift to 2nd gear regardless of the position of the 2—3 shift valve. In reverse, line pressure (7) is directed to the rear clutch and front servo release (15).

#### Manual control valve

This valve, which is actuated by the movement of the selector lever, directs line pressure to, or exhausts it from, the appropriate valves or components in accordance with control requirements.

#### Park

When the selector lever is moved to "P" the parking pawl is mechanically engaged with the externally toothed ring gear on the driven shaft, effectively immobilizing the vehicle. In this position no fluid is directed to the front clutch or 2—3 shift valve for the rear clutch, so that the gear set is disconnected from the converter and no engine power is transmitted to

the rear wheels. Due to the arrangement of the manual control valve lands, line pressure (6) is directed to the rear servo (13), which from a functional point of view has no significance.

#### Reverse

Line pressure (6) is directed to the rear servo (13) via the 1—2 shift valve and also (7) to the rear clutch (15) via the 2—3 shift valve. No pressure is directed to the governor.

#### Neutral

Line pressure is cut off from the clutches and servos which are also exhausted since the circuits (3) and (5) have access to the oil sump via the manual control valve (x). The gear set is therefore disconnected from the converter and no engine power is transmitted to the rear wheels.

#### Drive

Line pressure (5) is directed to the front clutch, governor and 1—2 shift valve. Line pressure is also directed to the 2—3 shift valve.

#### Lock-up

Line pressure (5) is directed to the front clutch, governor and 1—2 shift valve, but not to the 2—3 shift valve. In this position, therefore, upshifts to 3rd gear are excluded.

When in 1st gear, line pressure (6) is directed to a differential area of the 1—2 shift valve to lock it in 1st position, and thence to the rear servo.

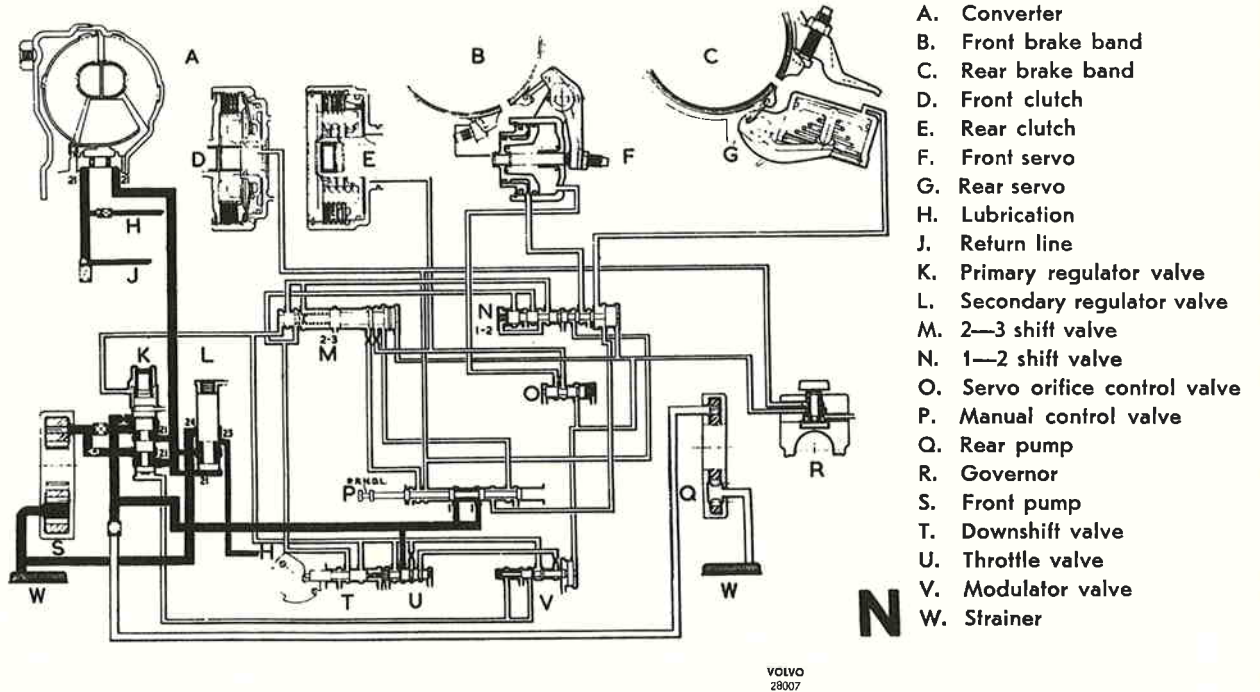
#### FUNCTION

Since the control system is affected by both the selector lever position, the speed of the car and the position of the accelerator pedal, many different operating conditions occur. In order to make it easier to understand how the control system operates, we describe below a working cycle in each gear position and gear.

#### Operation in "N", see Fig. 17

With the engine running, the front pump check valve is open and the rear pump check valve closes due to absence of rear pump pressure.

The primary regulator valve regulates line pressure (1) which is directed to the manual valve and throttle valve. It also permits fluid to reach the secondary regulator valve.



- A. Converter
- B. Front brake band
- C. Rear brake band
- D. Front clutch
- E. Rear clutch
- F. Front servo
- G. Rear servo
- H. Lubrication
- J. Return line
- K. Primary regulator valve
- L. Secondary regulator valve
- M. 2—3 shift valve
- N. 1—2 shift valve
- O. Servo orifice control valve
- P. Manual control valve
- Q. Rear pump
- R. Governor
- S. Front pump
- T. Downshift valve
- U. Throttle valve
- V. Modulator valve
- W. Strainer

VOLVO  
28007

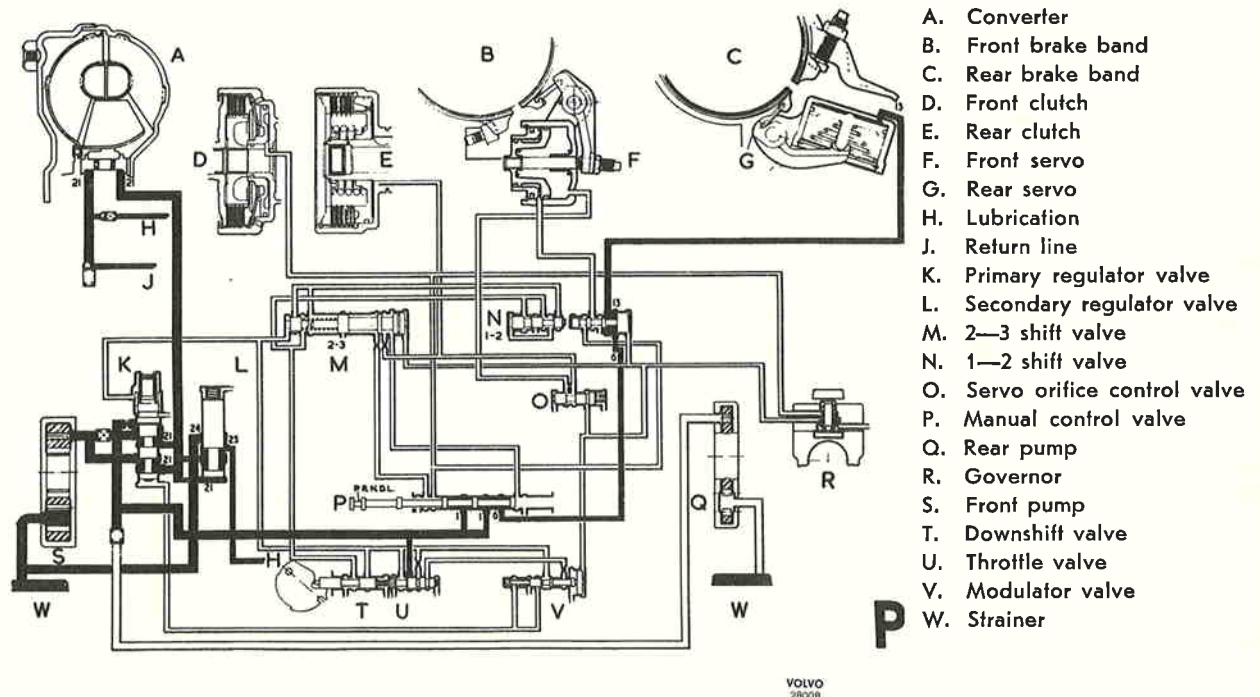
Fig. 17. Operation in "N".

The secondary regulator valve regulates pressure to the converter and lubrication of the front end of the gear train (21). Identical pressure (23) is directed to the rear end of the gear train for lubricating this. The surplus flow (24) is directed back to the inlet of the front pump.

**Operation in "P", see Fig. 18**

An internal linkage from the manual control valve detent lever engages the parking pawl with teeth formed on the driven shaft ring gear.

With the engine running, the operation of the hydraulic system is identical to "N" except that the



- A. Converter
- B. Front brake band
- C. Rear brake band
- D. Front clutch
- E. Rear clutch
- F. Front servo
- G. Rear servo
- H. Lubrication
- J. Return line
- K. Primary regulator valve
- L. Secondary regulator valve
- M. 2—3 shift valve
- N. 1—2 shift valve
- O. Servo orifice control valve
- P. Manual control valve
- Q. Rear pump
- R. Governor
- S. Front pump
- T. Downshift valve
- U. Throttle valve
- V. Modulator valve
- W. Strainer

VOLVO  
28008

Fig. 18. Operation in "P".

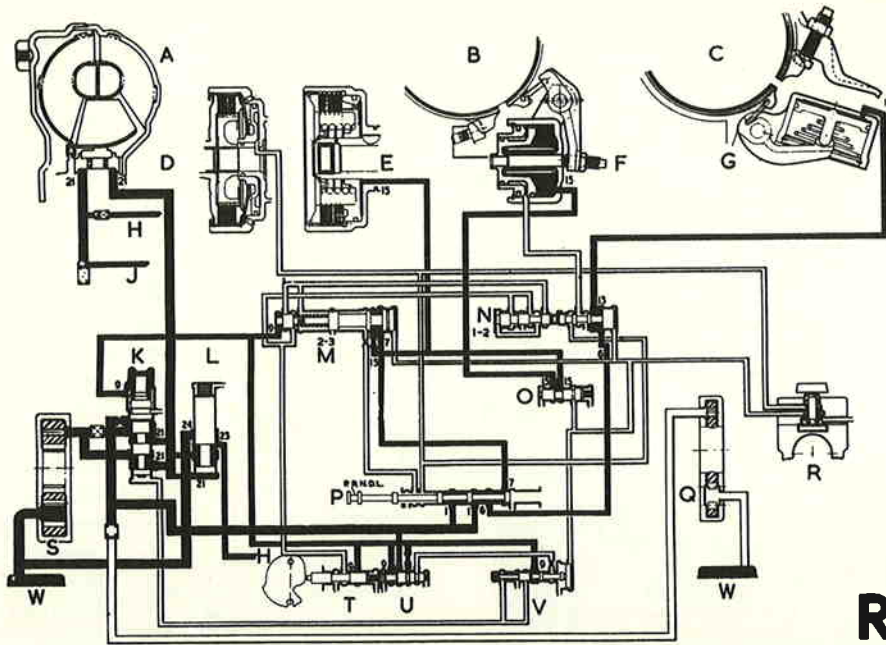


Fig. 19. Operation in "R".

manual valve directs line pressure (6) to the rear servo (13). This arrangement originates in the design of the manual control valve on which, for simplicity, three of the lands serve to control both the "L" and "P" selector positions. The application of the rear brake band does not perform any function in "P".

**Operation in "R", see Fig. 19**

Control of the line pressure takes place as in "P" or "N", but when the accelerator pedal is depressed, throttle pressure (9) is directed to the spring end of the primary regulator valve, thus increasing line pressure (1) in accordance with torque capacity requirements. The manual valve directs line pressure (6) through the 1—2 shift valve to the rear servo (13) and line pressure (7) through the 2—3 shift valve to the rear clutch and front servo release (15). Due to absence of governor pressure, the shift valves and servo orifice control valve perform no function in this selector position. The fluid passages (13) and (15) of the other manual valve positions are utilized in "R" to simplify the hydraulic circuit.

**Operation in "D 1", see Fig. 20**

Fluid pressure from the front and/or rear pump is controlled as in "R", but with the throttle valve in the full throttle position as shown in Fig. 20, a modulator throttle pressure regulated by the valve plunger will be obtained. This pressure acts upon the primary

regulator valve opposing throttle pressure (9), thus modulating line pressure in order to give reliable and smooth shifting under all driving conditions. The manual valve directs line pressure (5) to the front clutch, governor feed and 1—2 shift valve for the subsequent 1—2 shift. Line pressure (3) reaches the 2—3 shift valve for the subsequent 2—3 shift. The front clutch applied in conjunction with the one-way clutch permits the car to move off from rest in 1st gear.

**Operation in "D 2", see Fig. 21**

The primary regulator valve regulates the pressure from the rear pump, the front pump providing torque converter (21) and gearbox (21, 23) lubrication requirements. Throttle pressure (8, 9) acts upon the primary regulator valve as in "D 1". Shift control is provided by the 1—2 shift valve moving under the influence of governor pressure (2), opposed by spring force and throttle pressure (11). When the governor pressure (2) is high enough, the valve will move to 2nd gear position and line pressure (5) will flow to the apply side of the front servo (19). The front band is thus applied and, in conjunction with the front clutch, provides 2nd gear. With the downshift valve in the forced throttle position as illustrated, forced throttle pressure (11) acts upon the 1—2 shift valves, thus further delaying upshifts or providing a 2—1 downshift at speeds where there is little governor pressure (2).

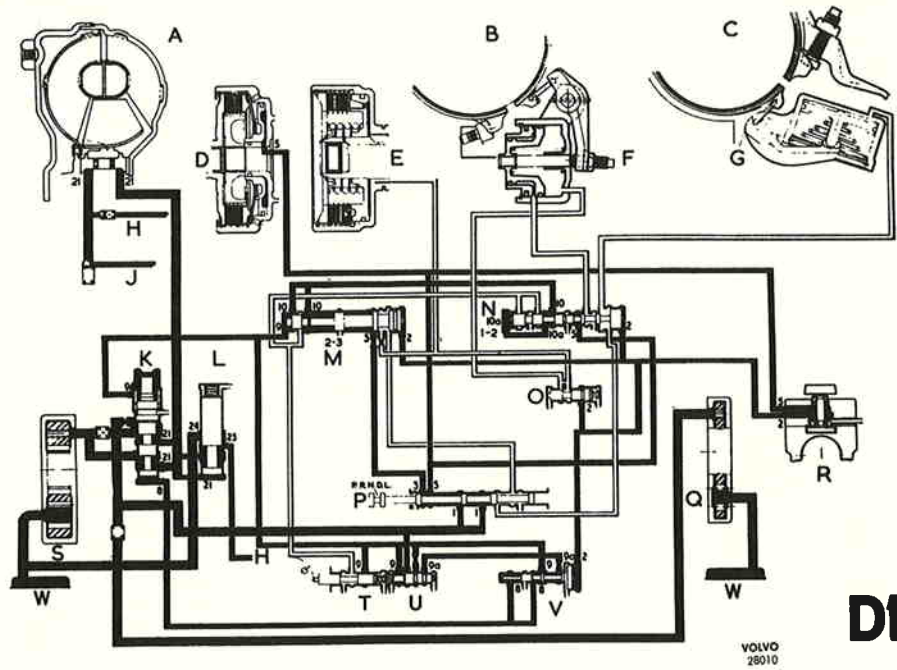


Fig. 20. Operation in 1st gear, position "D".

- |                     |                                |                    |
|---------------------|--------------------------------|--------------------|
| A. Converter        | J. Return line                 | R. Governor        |
| B. Front brake band | K. Primary regulator valve     | S. Front pump      |
| C. Rear brake band  | L. Secondary regulator valve   | T. Downshift valve |
| D. Front clutch     | M. 2—3 shift valve             | U. Throttle valve  |
| E. Rear clutch      | N. 1—2 shift valve             | V. Modulator valve |
| F. Front servo      | O. Servo orifice control valve | W. Strainer        |
| G. Rear servo       | P. Manual control valve        |                    |
| H. Lubrication      | Q. Rear pump                   |                    |

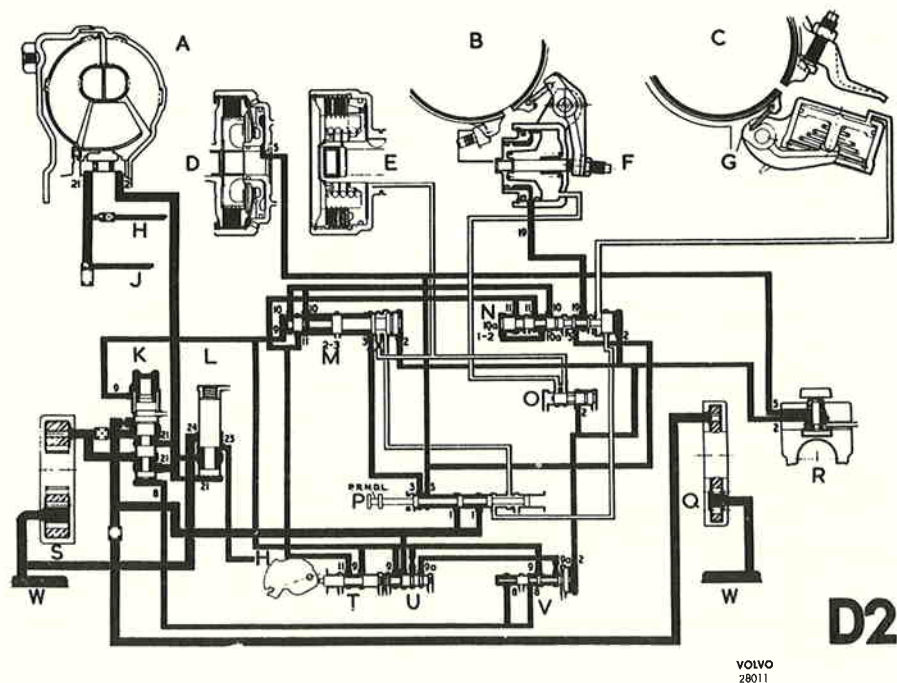
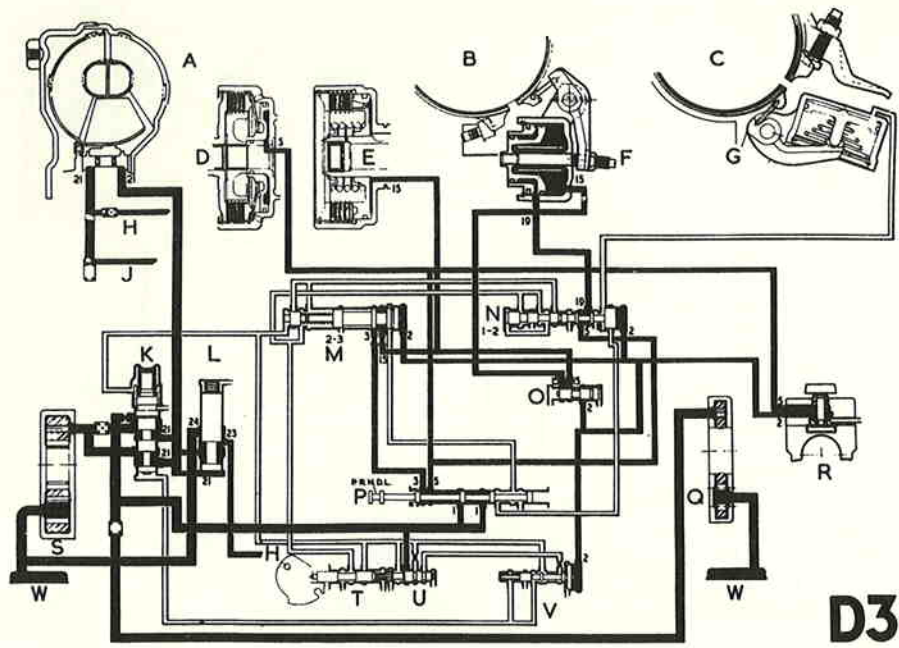


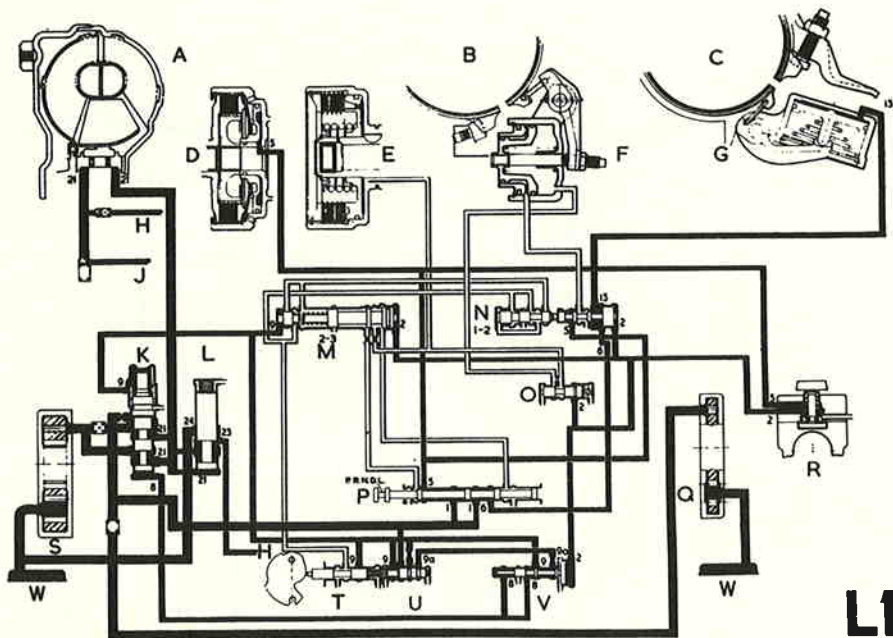
Fig. 21. Operation in 2nd gear, position "D".



VOLVO  
28012

Fig. 22. Operation in 3rd gear, position "D".

- |                     |                                |                    |
|---------------------|--------------------------------|--------------------|
| A. Converter        | J. Return line                 | R. Governor        |
| B. Front brake band | K. Primary regulator valve     | S. Front pump      |
| C. Rear brake band  | L. Secondary regulator valve   | T. Downshift valve |
| D. Front clutch     | M. 2-3 shift valve             | U. Throttle valve  |
| E. Rear clutch      | N. 1-2 shift valve             | V. Modulator valve |
| F. Front servo      | O. Servo orifice control valve | W. Strainer        |
| G. Rear servo       | P. Manual control valve        |                    |
| H. Lubrication      | Q. Rear pump                   |                    |



VOLVO  
28013

Fig. 23. Operation in 1st gear, position "L".

**Operation in "D 3", see Fig. 22**

Pressure control is as in "D 2" except that in the throttle valve position shown (minimum throttle) no throttle pressure or modulated throttle pressure acts upon the two ends of the primary regulator valve. Shift control is provided by the 2—3 shift valve moving against spring force under the influence of governor pressure (2). This permits line pressure (3) to reach the rear clutch (15), and the release side of the front servo through the servo orifice control valve. When governor pressure (2) is apparent, the servo orifice valve closes, forcing line pressure through a 0.052" (1.3 mm) orifice which thus affects the relationship between rear clutch apply and front servo release in accordance with road speed.

Because the release side of the front servo has a larger area than the apply side, the front servo will disengage the band. The rear clutch now engaged in conjunction with the front clutch provides 3rd gear.

The absence of throttle pressure as mentioned above will cause the 2—3 shift valve to move early under influence of governor pressure, thus providing a low-speed 2—3 shift.

**Operation in "L", see Fig. 23**

Pressure control of the front and/or rear pump will be as in "D 1" at the same throttle valve position (full throttle) as illustrated.

The manual valve directs line pressure (5) to the front clutch, governor feed and 1—2 shift valve; it also directs line pressure (6) to the 1—2 shift valve. In the 1st gear condition illustrated, the 1—2 shift valve is latched hydraulically by line pressure (6) operating on so great an area. This is certainly opposed by the governor pressure (2) but this pressure is lower than the line pressure. The result is that line pressure (6) is open to the rear servo (13) and no upshift can occur. In the "L" position the manual control valve opens the circuit (7) to the sump thus exhausting the rear clutch and front servo release circuit (15) via the 2—3 shift valve. This causes a 3—2 downshift at whatever road speed the car has when the selector is moved to "L". In this condition governor pressure (2) will have moved the 1—2 shift valve to 2nd position; the result is that line pressure (6) is then blocked from the rear servo (13) but (5) is open to the apply side of the front servo (19) as in "D 2".

TABLE OF HYDRAULIC CIRCUITS

Circuit No.	Name of pressure	From	To	Theoretical pressure range		Remarks
				lb/sq.in.	kg/cm <sup>2</sup>	
1*	Line pressure	Front and rear pump	Primary regulator valve Manual control valve Throttle valve	55—160—75	3.9—11.3—5.3	The only pressure that can be measured
2	Governor pressure	Governor	Modulator valve 1—2 shift valve 2—3 shift valve Servo orifice control valve	0—70	0—4.9	According to road speed
3	Directed line pressure	Manual control valve	2—3 shift valve	55—160—75	3.9—11.3—5.3	In "D"
5	Directed line pressure	Manual control valve	Front clutch and governor feed 1—2 shift valve	55—160—75	3.9—11.3—5.3	In "L" and "D"
6	Directed line pressure	Manual control valve	1—2 shift valve	55—160—75	3.9—11.3—5.3	In "L", "D", "R" and "P"
7	Directed line pressure	Manual control valve	2—3 shift valve	55—160—75	3.9—11.3—5.3	In "R" and "P"
8	Modulated throttle pressure	Modulator valve	Primary regulator valve	0—135—68	0—9.5—4.7	
9	Throttle pressure	Throttle valve	Modulator valve Primary regulator valve (spring end) 2—3 shift valve and shift valve plug	0—135—68	0—9.5—4.7	
9a	Throttle pressure controlled by modulator valve	Modulator valve	Throttle valve	0—135	0—9.5	Doubles throttle pressure before cut-back and increases line pressure under part-throttle acceleration
10	Shift valve plunger pressure	Shift valve plunger	2—3 shift valve 1—2 shift valve	0—68	0—4.7	
10a	Shift valve plunger pressure	Shift valve plunger	1—2 shift valve	0—68	0—4.7	In 1st gear only
11	Forced throttle pressure	Downshift valve	1—2 shift valve 2—3 shift valve	135	9.5	
13	Line pressure	1—2 shift valve	Rear servo apply	55—160—75	3.9—11.3—5.3	
15	Line pressure	2—3 shift valve	Rear clutch and front servo release	55—160—75	3.9—11.3—5.3	Front servo release through servo orifice or valve
19	Line pressure	1—2 shift valve	Front servo apply	55—160—75	3.9—11.3—5.3	
21	Converter pressure	Primary regulator valve	Secondary regulator valve and converter	18—25	1.25—1.75	
23	Lubrication pressure	Secondary regulator valve	Front pump suction	18—25	1.25—1.75	
24	Exhaust	Secondary regulator valve	Front pump suction			

NOTE: Where a pressure range consists of three figures, the first value represents idling speed, the second forced throttle before cut-back, and the third forced throttle after cut-back.

## MAINTENANCE AND REPAIR INSTRUCTIONS

When carrying out any work on the vehicle, the selector lever should be in position "P".

Provided the transmission is operating satisfactorily, the car may be towed in position "N". The fluid level must be correct. If the transmission is inoperative, the propeller shaft should be disconnected before starting towing.

The control system of the automatic transmission is manufactured with the same degree of precision and accurate fits as the injection equipment of a Diesel engine. Fluid circulates through the converter, transmission gearbox and control system. It is therefore necessary to observe the utmost cleanliness when carrying out any work on the transmission.

### WORK WHICH CAN BE CARRIED OUT WITHOUT REMOVING THE TRANSMISSION

#### Checking the fluid level

The fluid level should be checked every 3000 miles (5000 km).

The filling pipe with dipstick is located in front of the bulkhead on the right-hand side of the engine.

When checking, the transmission should be at normal operating temperature which is obtained after driving for about 5 miles (8—10 km). The car should be on a level surface. Move the selector lever to "P" and allow the engine to idle for two minutes. With the engine still idling in "P", wipe the dipstick with a non-fluffy rag, clean paper or chamios leather. Push down the dipstick, pull it up and read off the fluid level, see Fig. 24 if necessary, add fluid to bring the level to the "max." mark. Do not fill up over the "max." mark as otherwise the transmission can overheat. The difference between the "min." and "max." marks on the dipstick is 1 Imp. pint (0.5 litre). Use an approved Type A Suffix A Automatic Transmission Fluid for filling up.

When filling up with oil during cold weather, for example, after having carried out repairs, the level should come 10 mm ( $\frac{3}{8}$ " ) below the "max." mark. The gearbox should then be run warm, after which the oil level is checked as described above.

If it is necessary to fill up with fluid frequently, this indicates leakage, which must be put right immediately.

#### Adjusting the selector controls

1. Disconnect the pull rod from the lever on the selector shaft. Set the selector lever to "N", see Fig. 25.

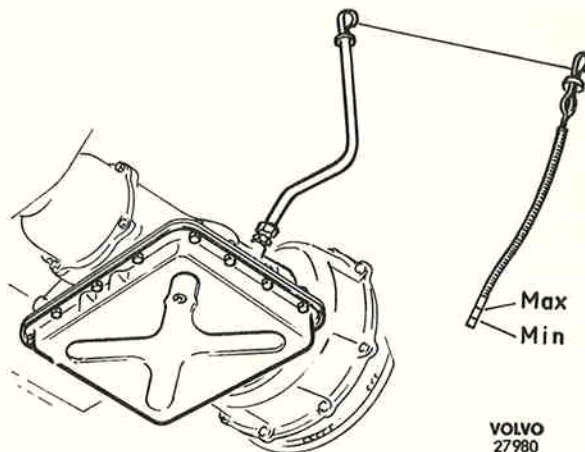


Fig. 24. Checking fluid level.

2. Set the lever on the transmission to the central position. Adjust the length of the pull rod so that the pin can be pushed easily through the yoke and lever.
3. Check the adjustment by moving the selector lever to the other positions.
4. Check that the pointer for the gear positions points correctly on the scale. If not, slacken the screws for the scale and move it sideways until the pointer indicates correctly.
5. Check that the output shaft is locked with the control lever in position "P".

#### Adjusting the downshift valve cable

Correct adjustment of this cable is most important for satisfactory operation of the transmission. There are three different methods. Adjust first in accordance with A, see Fig. 26.

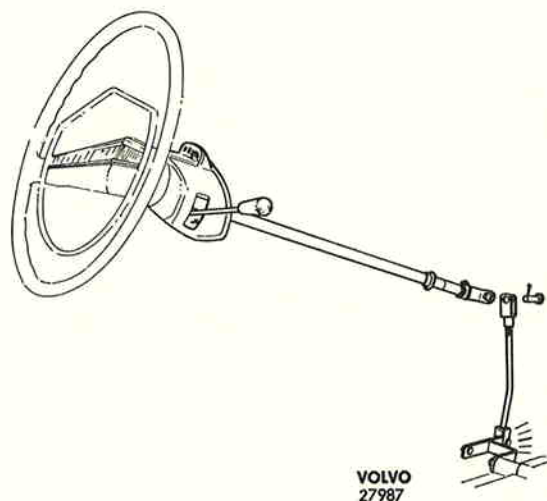


Fig. 25. Adjusting selector controls.