VOLVO SERVICE

CARS

P 120

Part 4 (44)

AUTOMATIC TRANSMISSION (BW - 35)

SERVICE MANUAL

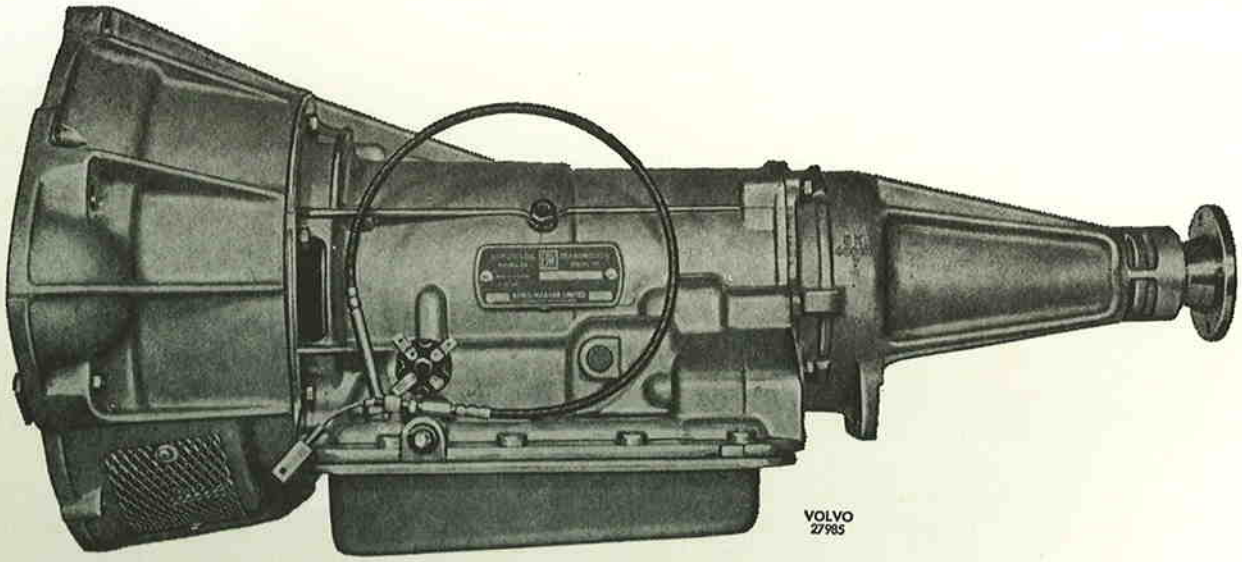

Fig. 1. The Borg-Warner Automatic Transmission type 35.

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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.

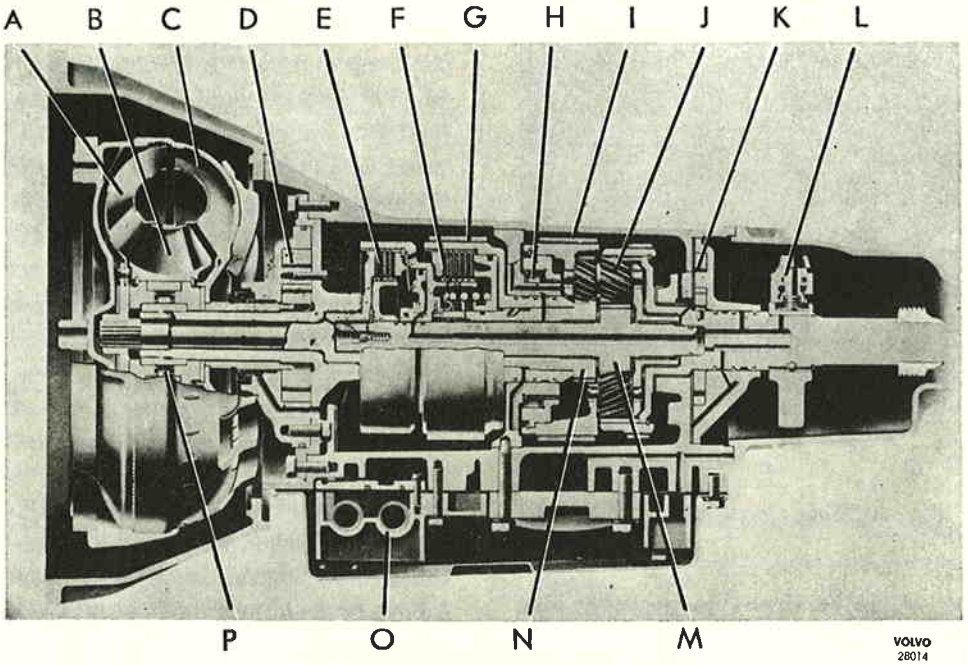


Fig. 2. Sectioned view of the transmission.

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

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.

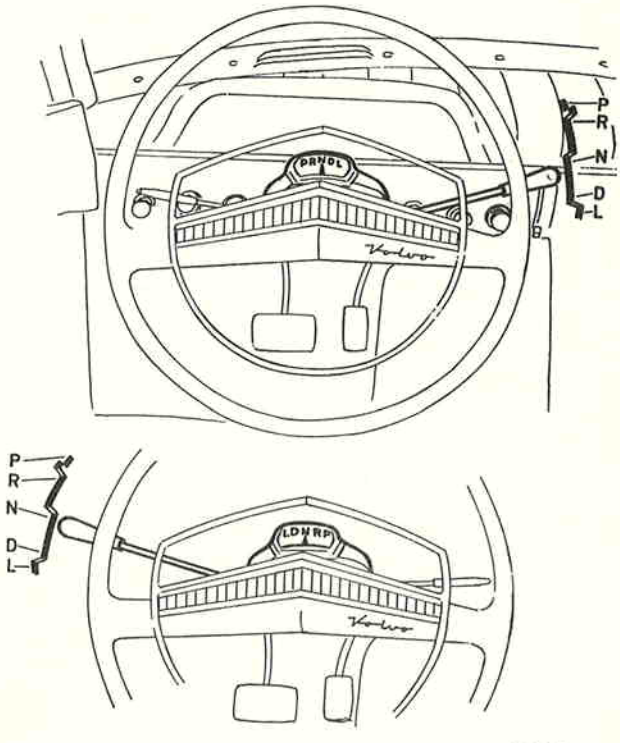


Fig. 3. Selector lever positions.

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

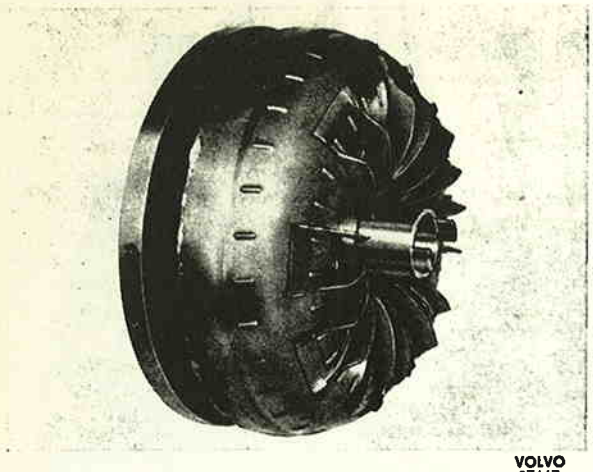


Fig. 4. The converter.

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, 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.

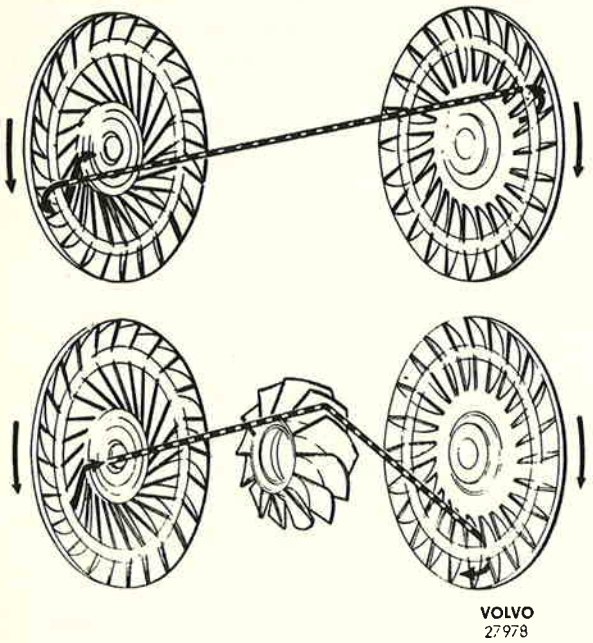


Fig. 5. Function of converter.

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

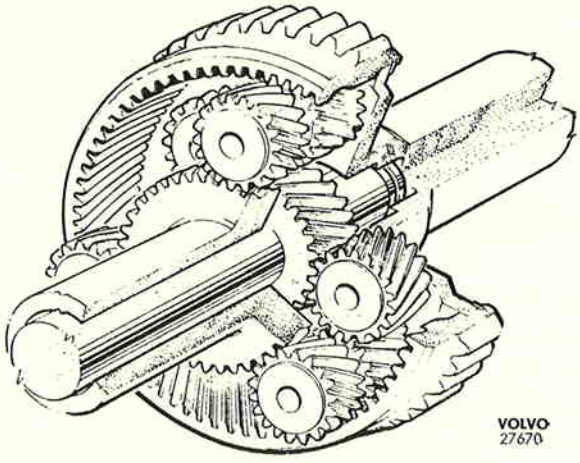


Fig. 6. Planetary gear.

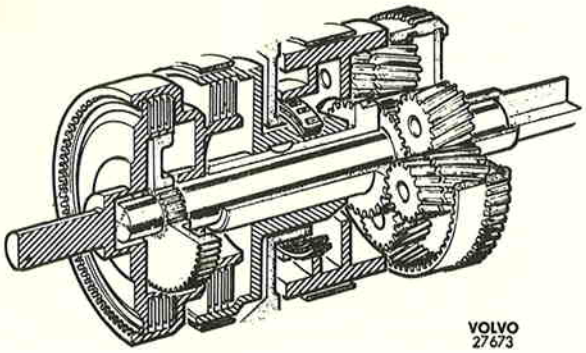


Fig. 7. Planetary gear, clutches and brake bands.

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

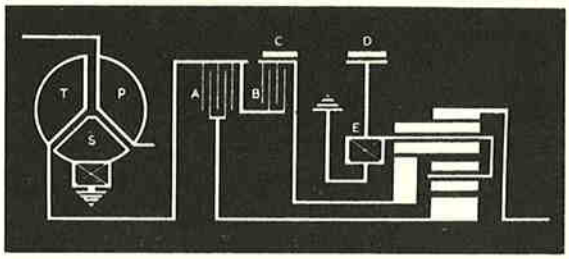
The clutches, see Fig. 7, consist of multi-disc units operated by hydraulic pistons. In all forward gears the front clutch connects the converter to the forward sun gear; for reverse, the rear clutch connects the converter to the reverse sun gear.

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.



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	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.

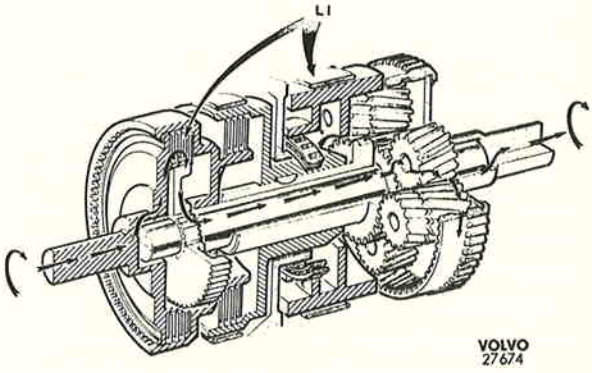

Fig. 9. Power flow, 1st gear, position "L".

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.

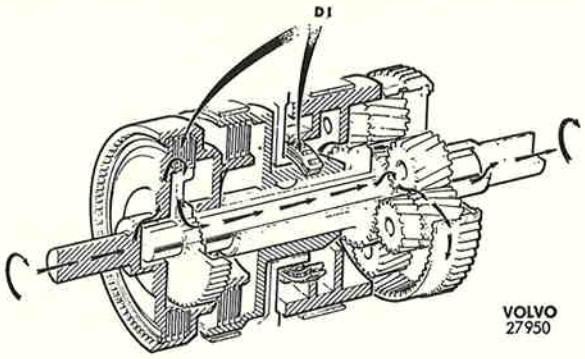

Fig. 10. Power flow, 1st gear, position "D".

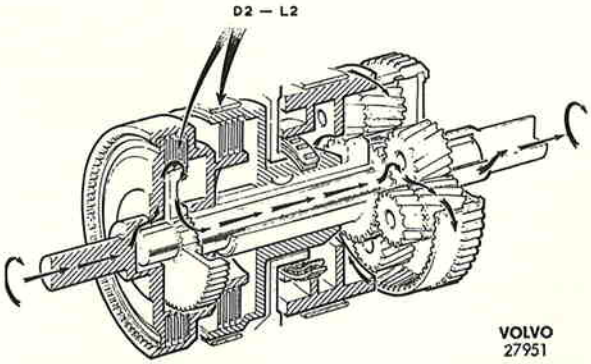

Fig. 11. Power flow, 2nd gear.

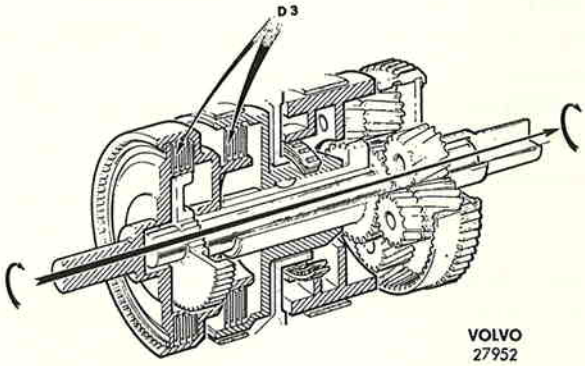

Fig. 12. Power flow, 3rd gear.

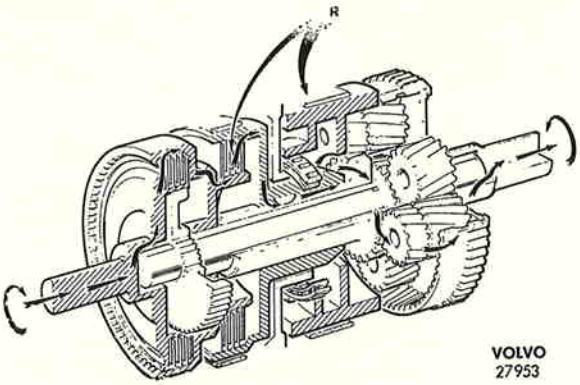

Fig. 13. Power flow, reverse.

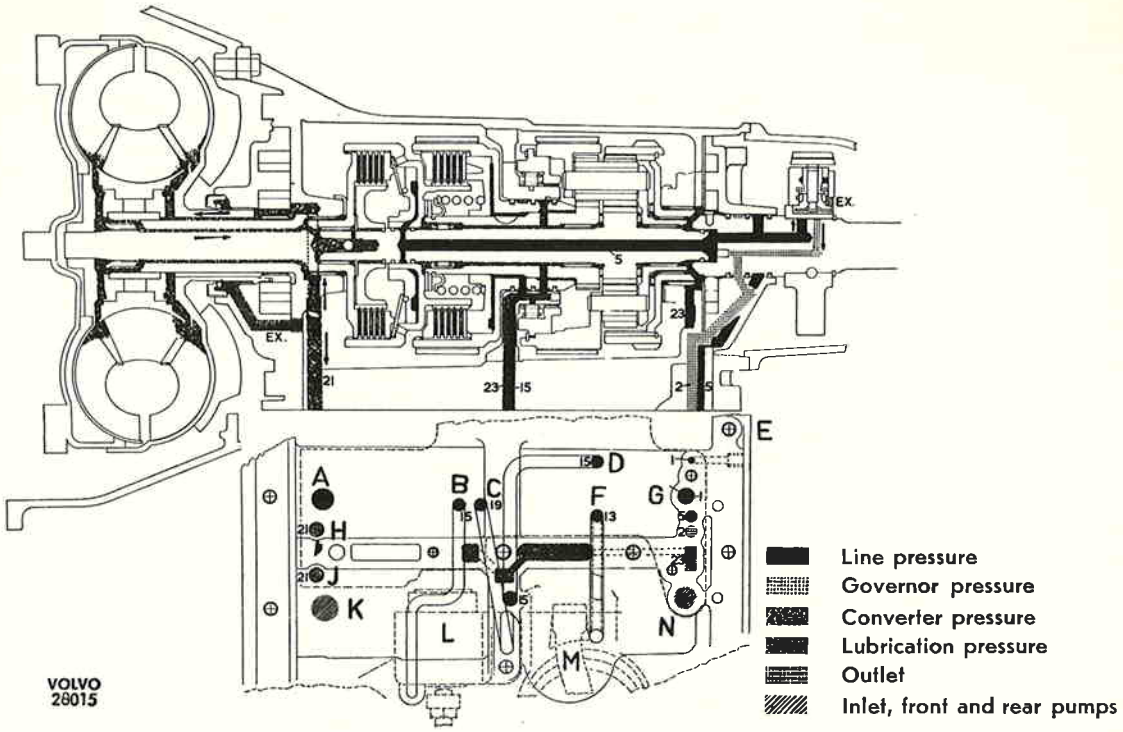

Fig. 14. Fluid passages, transmission and gearbox case.

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

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.

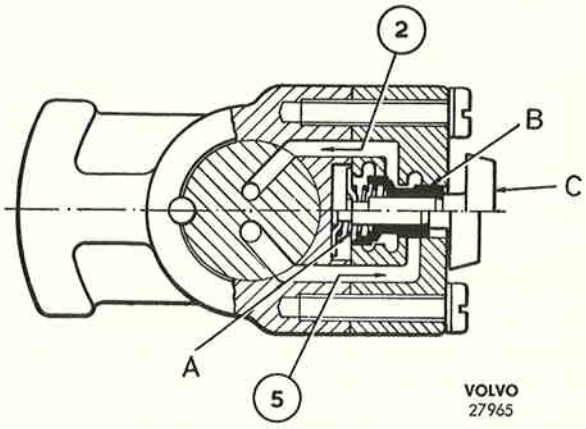

Fig. 15. Governor.

A. Spring
B. Valve
C. Governor weight

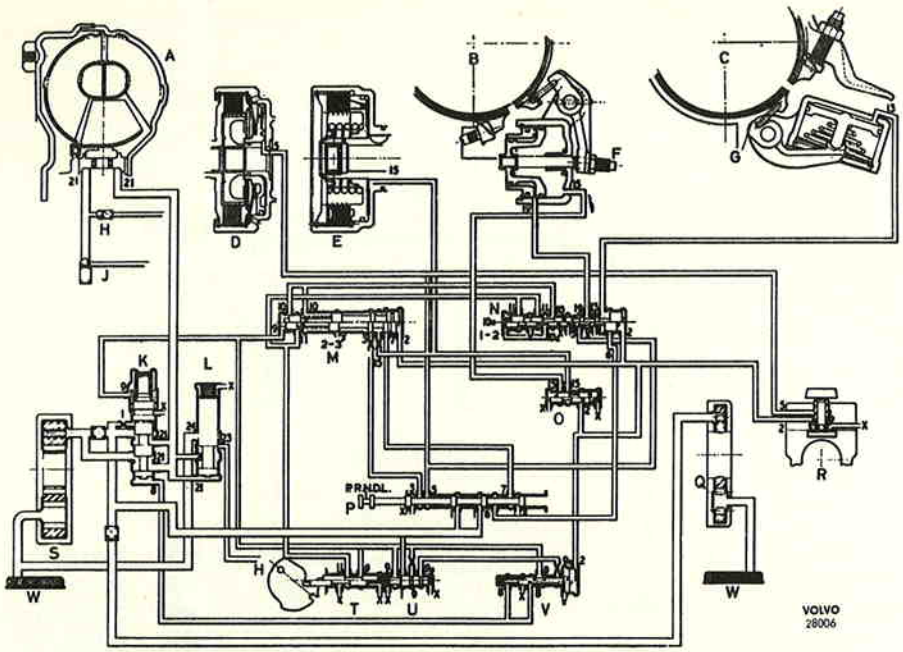

Fig. 16. Hydraulic circuits.

A. Converter
B. Front brake band
C. Rear brake band
D. Front clutch
E. Rear clutch
F. Front servo
G. Rear servo
H. Lubrication ball valve
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

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 in increased due to increased engine speed, the valve moves to open a port giving access to the suction side of the front