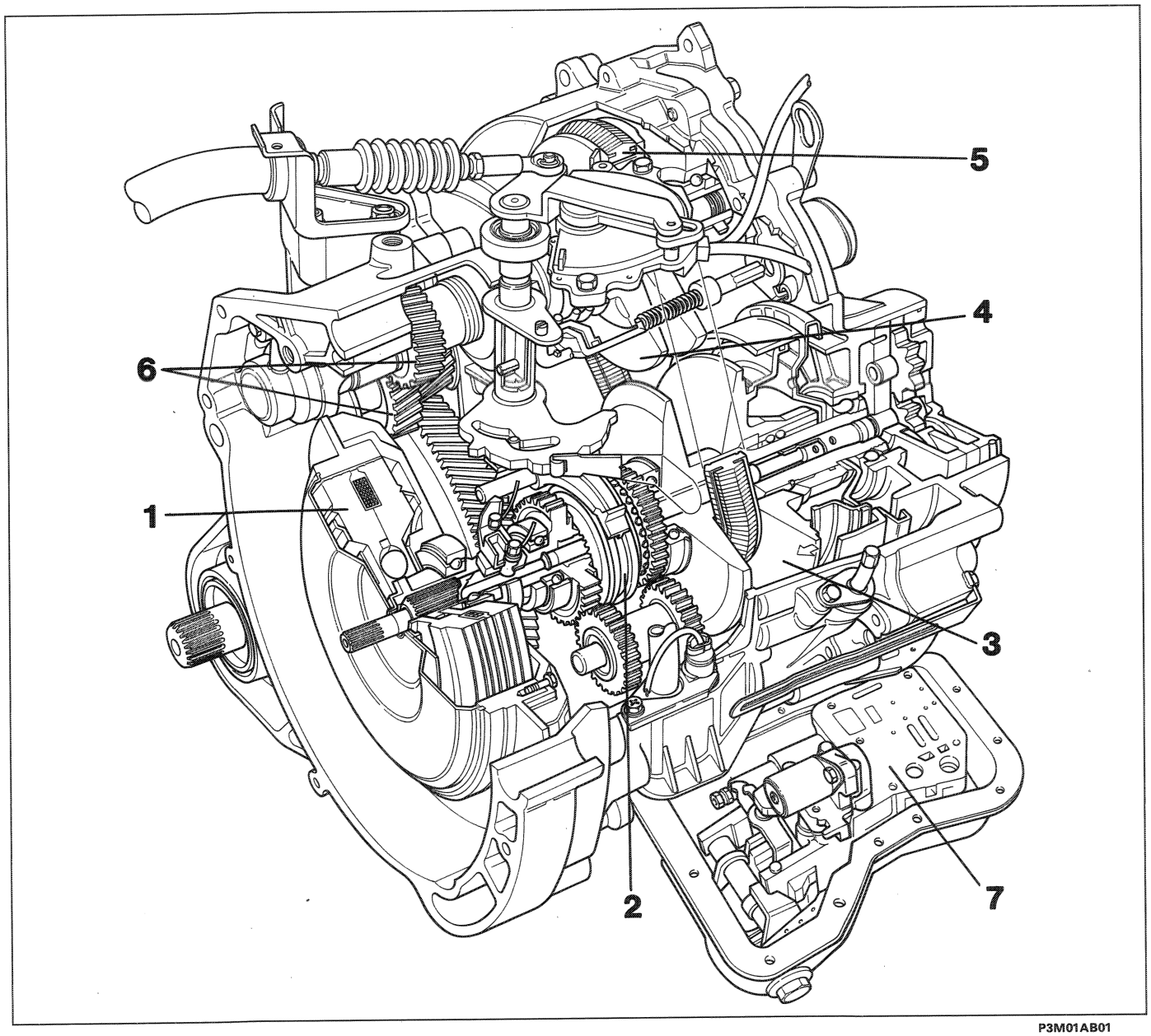
INTRODUCTION

The Punto ECVT (Electronic Continuously Variable Transmission) is part of a new generation of transmissions which allow the vehicle speed to be varied continuously without the necessity of gearchanges (from standstill to top speed), thereby ensuring a lively and smooth ride, and better overall vehicle performance with reduced fuel consumption.



P3M01AB01

ECVT automatic transmission shown partially sectioned

1. Electromagnetic clutch
2. Mechanism to engage and disengage forward and reverse ratios
3. Primary pulley
4. Secondary pulley
5. Metal drive belt
6. Final drive reduction gearset
7. Hydraulic control unit

GENERAL INFORMATION

The ECVT combines an electronically controlled magnetic clutch with a variable transmission (pulleys driven by a metal belt), to allow high performance coupled with low fuel consumption and ease of use.

The pressure of the hydraulic control system can modify the transmission from "high" to "low" and vice-versa in relation to the engine load and power demanded by the driver. To guarantee the best transmission efficiency and torque, the clutch is optimally controlled by a microcomputer.

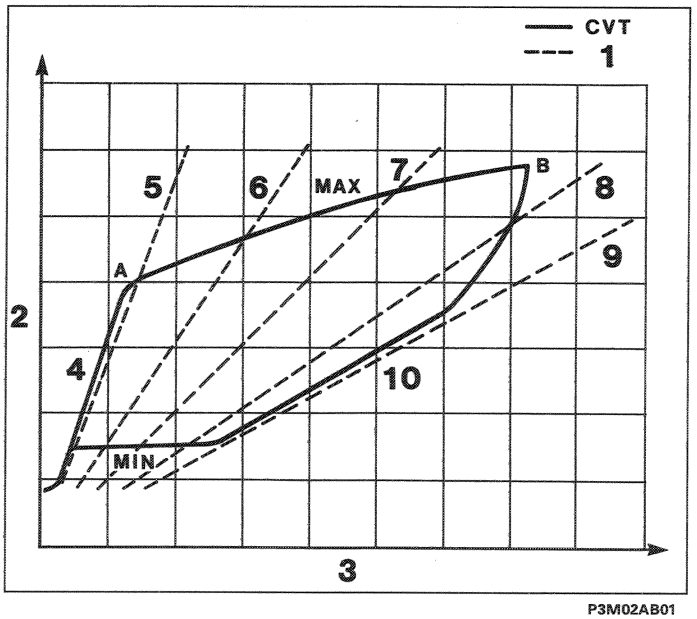
The electromagnetic clutch has been exclusively designed for the ECVT. It is of the "closed at standstill" type, and contains magnetic powder. An electronic control unit continuously calculates the engine rpm, the vehicle speed and the throttle valve position.

The variable transmission is driven by a metal belt and a set of special pulleys. The effective diameter of the pulleys is gradually changed by the variation of hydraulic pressure. This ensures a continuous increase of the transmission ratio, from standstill up to the vehicle top speed. This is identical to that of a conventional gearbox, but has the advantage of always selecting the most efficient ratio for the operating conditions.
To assist servicing, the ECVT is equipped with a warning light that alerts the driver of transmission faults.

SPECIFICATIONS

Change of transmission velocity

The rate of change of velocity is not linear as in conventional manual gearboxes. It can be expressed as an area between the minimum and maximum transmission ratios allowed by the pulleys.



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1. Manual transmission
2. Engine RPM
3. Vehicle speed
4. Low transmission ratio
5. 1st gear
6. 2nd gear
7. 3rd gear
8. 4th gear
9. 5th gear
10. High transmission ratio (Overdrive)

In the figure above, the MAX line indicates the ratio between the vehicle speed and the engine RPM under hard acceleration conditions. The MIN line indicates this ratio when the acceleration is light.

When travelling on a flat road at a constant velocity, the engine RPM stays on the MIN line, but can respond rapidly to accelerator pedal pressure by moving upwards into the enclosed CVT area.

Under maximum acceleration conditions, i.e. between start point (A) and end point (B), the engine RPM increases gradually as the vehicle speed increases.

SELECTOR LEVER OPERATION

Lever position	Function	Engine started
P	Parking	0
R	Reverse	X
N	Neutral	0
D	Drive	X
L	Uphill, engine braking and sporty driving	X

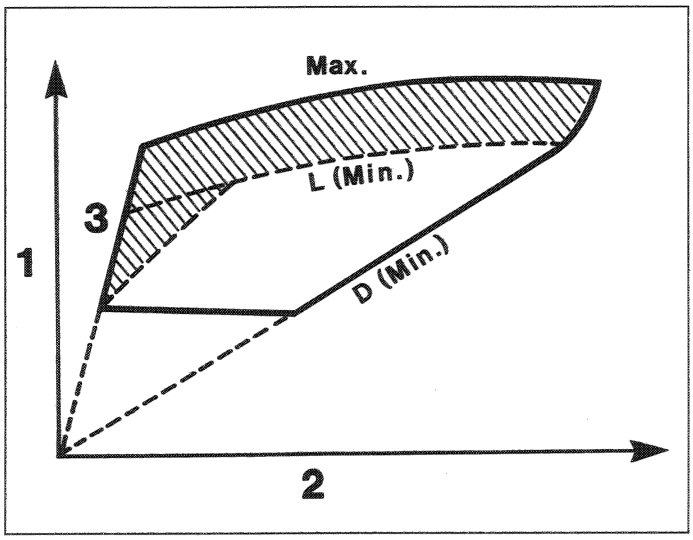
Position "D" (Normal driving mode)

Light acceleration

Pushing the accelerator pedal causes the vehicle speed to increase, following the low transmission ratio line. When the engine speed is approximately 1600 RPM the transmission ratio begins to increase and the vehicle speed increases correspondingly along the MIN line.

Hard acceleration

The vehicle speed increases along the low transmission ratio line until the engine reaches 4000 RPM. Here it starts to produce maximum power and acceleration.
When the engine exceeds 4000 RPM, The transmission ratio changes along the MAX line. This keeps the engine in the maximum performance RPM band.



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1. RPM
2. Vehicle speed
3. Low transmission ratio line

From hard acceleration to cruising mode.

At some point, the accelerator pedal pressure will be reduced since the desired velocity has been reached using hard acceleration. The transmission ratio, which was lowest on the MAX line, increases to a long cruising ratio on the MIN line.
As soon as the engine RPM reduces, the ratio gradually changes to overdrive, to ensure economical operation of the engine.

From cruising mode to hard acceleration

If the accelerator pedal is pushed whilst the vehicle is cruising and the transmission ratio is on the MIN line, then the ratio of the pulleys automatically changes to the lowest transmission ratio (on the MAX line) and the vehicle speed rapidly increases.

"L" position (Uphill and sporty driving, engine braking)

The transmission ratio variation in position "L" is limited to within the high engine RPM zone of the total range that was available in the "D" position. When the vehicle moves at more than 30 km/h the engine speed remains over 3000 RPM (always above the "L" MIN line), where the engine power and torque are greatest. The Punto ECVT can be used in "L" mode for the entire vehicle speed range. This is an advantage when compared to the "1" and "2" selector positions of conventional automatic transmissions which are limited to low vehicle speeds only. "L" mode allows increased vehicle acceleration response and engine braking at all speeds.

"R" position

Reversing mode. The transmission ratio is kept on the low ratio line by the pulley control system, so no vehicle speed changes take place.

"P" position

In the "P" position, the secondary shaft of the transmission is mechanically blocked.

"N" position

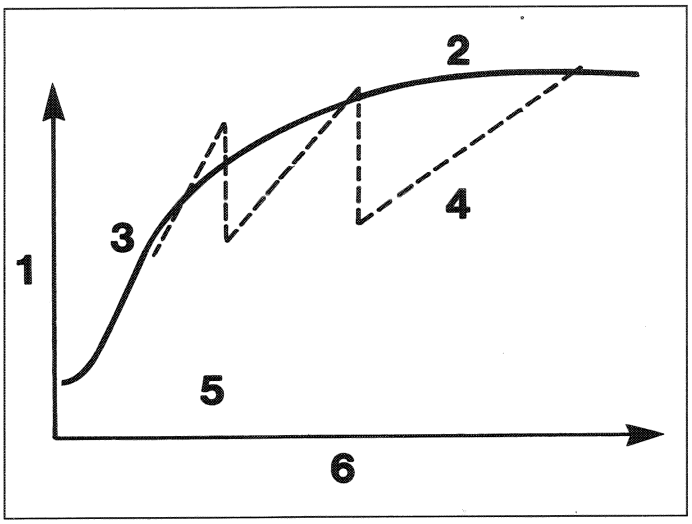
In the "N" position, the controlling mechanism for the forward and reverse gears is held in a neutral position.

USING ENGINE POWER TO THE FULL

The transmission ratio can change continuously from low to high and vice-versa, without breaks or steps. The maximum power curve is also, therefore, a continuous line. The curve is very different from that of a conventional transmission.

The following figure shows curves for an ECVT transmission and a standard, three-ratio automatic transmission. It can be seen that the power available from the ECVT is superior to that from the automatic transmission in the areas bordered by the two curves.

In the "L" position, it is possible to keep the engine in the maximum powerband (3000 RPM and above) by simply keeping the accelerator pressed, no gearchanges take place and the advantages of the ECVT are exploited.



P3M05AB01

1. Engine RPM
2. 1st, 2nd, 3rd gear
3. Maximum transmission ratio
4. Conventional automatic transmission
5. Full throttle acceleration
6. Vehicle speed

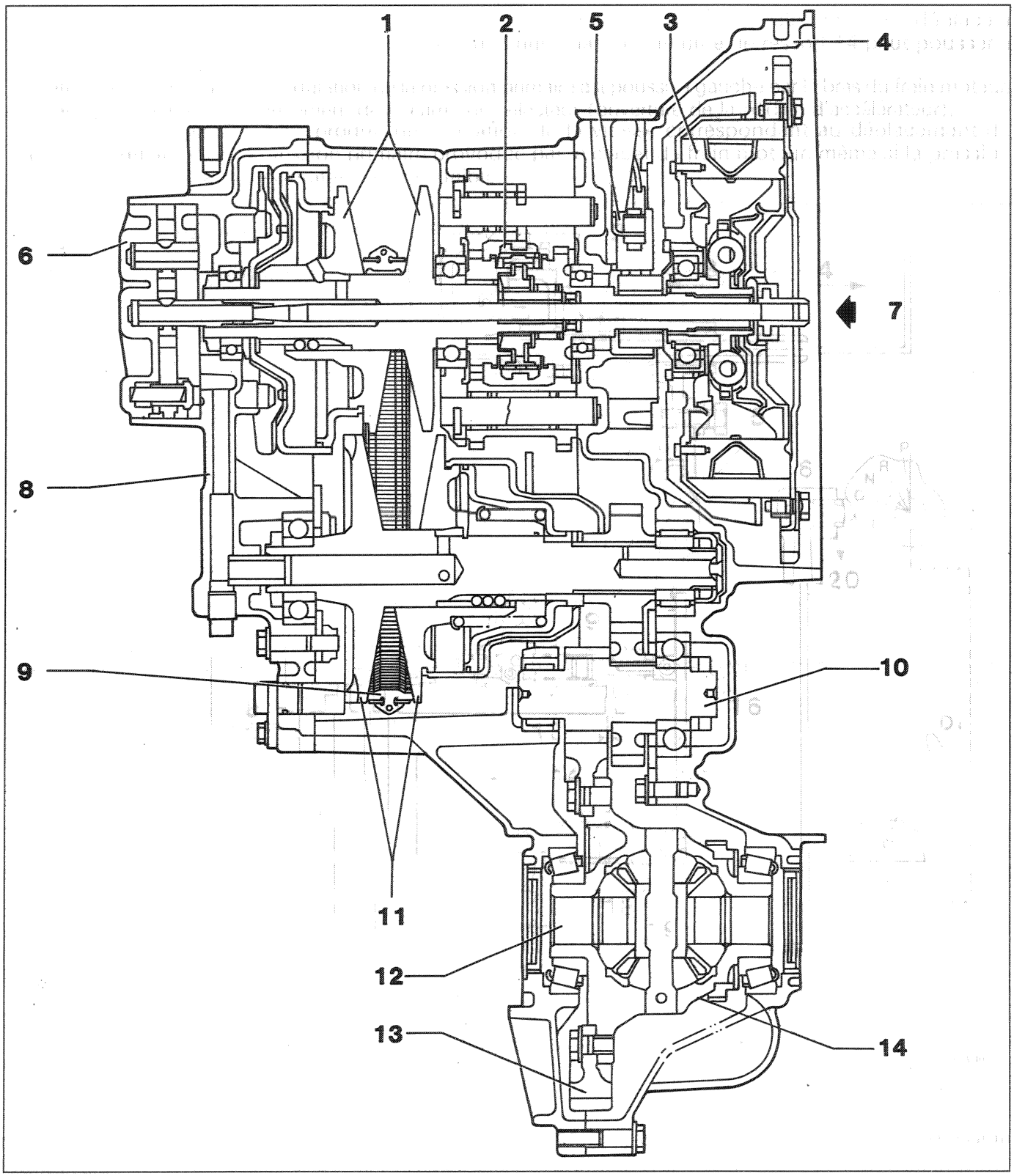
OBSERVATIONS

- The continuous changing of the transmission ratio automatically from vehicle standstill to top speed ensures optimum acceleration for all drivers.
- The engine can be held in the high power range at all vehicle speeds (from standstill to top speed) by using the "L" driving mode. This allows higher performance than would be obtained from a conventional automatic transmission, where "1" and "2" ratios can only be used to obtain similar results at low speeds.
  The "L" mode also improves engine braking and allows sporty driving.
- The electromagnetic clutch eliminates the efficiency loss typical of conventional torque converters. This leads to a fuel consumption reduction.
- The electromagnetic clutch remains disengaged when the vehicle is stationary, so no creeping will occur when the brakes are released and the selection lever is in the "D", "L" or "R" position.
- The vehicle speed changes without jerkiness and long ratios are frequently used to ensure quiet and smooth operation.

SYSTEM COMPOSITION

The ECVT consists of the following five elements: electromagnetic clutch, mechanism to select forward and reverse gears, belt and pulleys, hydraulic control unit and final reduction gearset.
The electromagnetic clutch allows the engagement or disengagementof the engine to the transmission. The clutch action is controlled by a microcomputer which uses various input signals; vehicle speed, engine RPM, accelerator pedal position, etc.
The mechanism for selecting forward and reverse gears uses a synchronising mechanism with straight gearteeth engagement. It is connected to the selector lever via a cable.

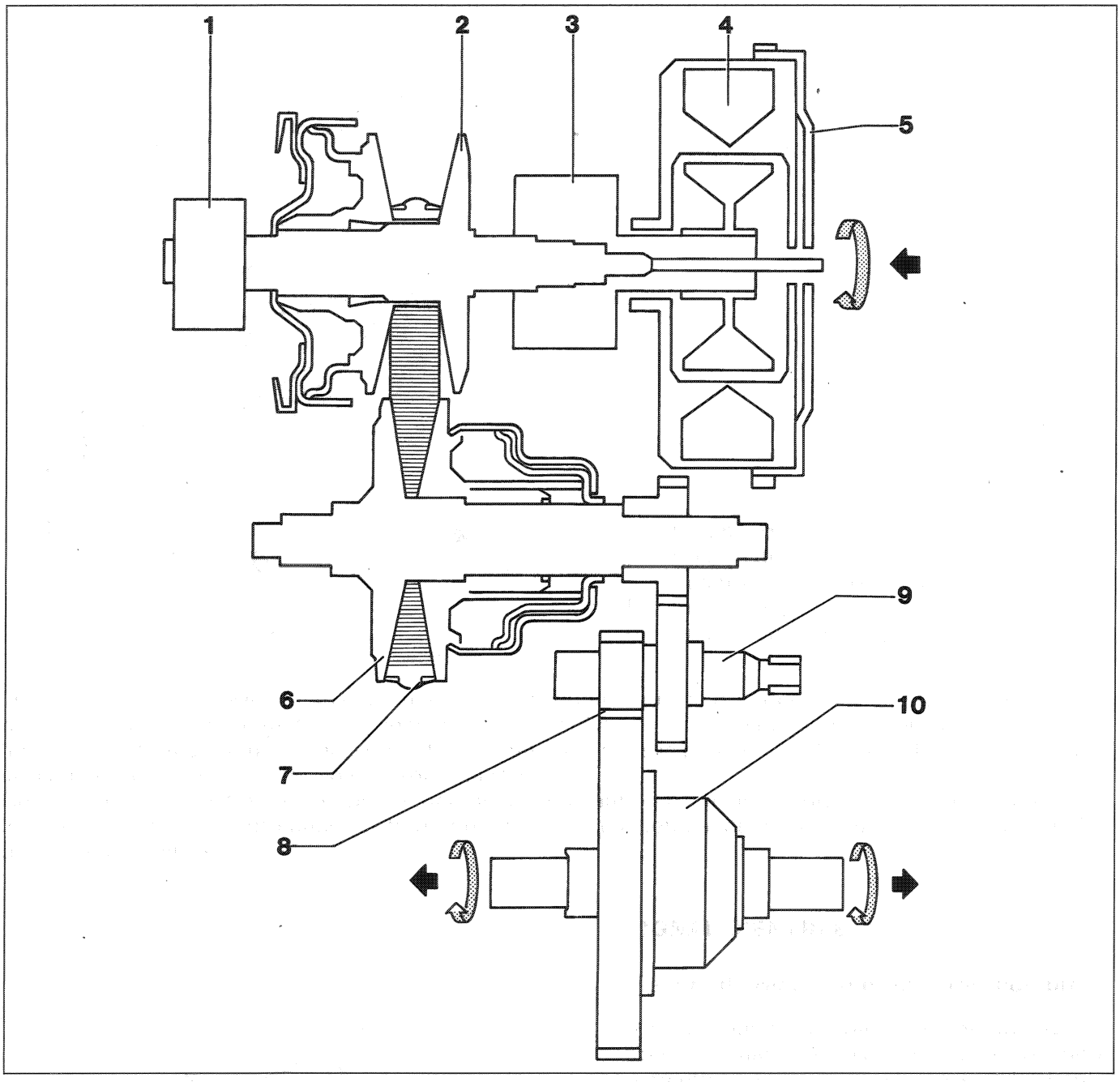
The belt-pulley group allows automatic smooth ratio changing. It rotates the final reduction gearset at continuously variable speeds, as a response to the engine power supplied to the electromagnetic clutch. The oil pressure supplied to the input and output shafts of this system is governed by the torque and the engine RPM, the accelerator pedal position, the pulley ratio, etc.



Sectional view

P3M07AB01

1. Primary pulley
2. Mechanism to select forward and reverse gears
3. Electromagnetic clutch
4. Clutch housing
5. Brush holder
6. Oil pump
7. Drive shaft (from engine)
8. Side housing
9. Metal belt
10. Intermediate shaft
11. Secondary pulley
12. Half-shaft
13. Final drive reduction gearset
14. Differential



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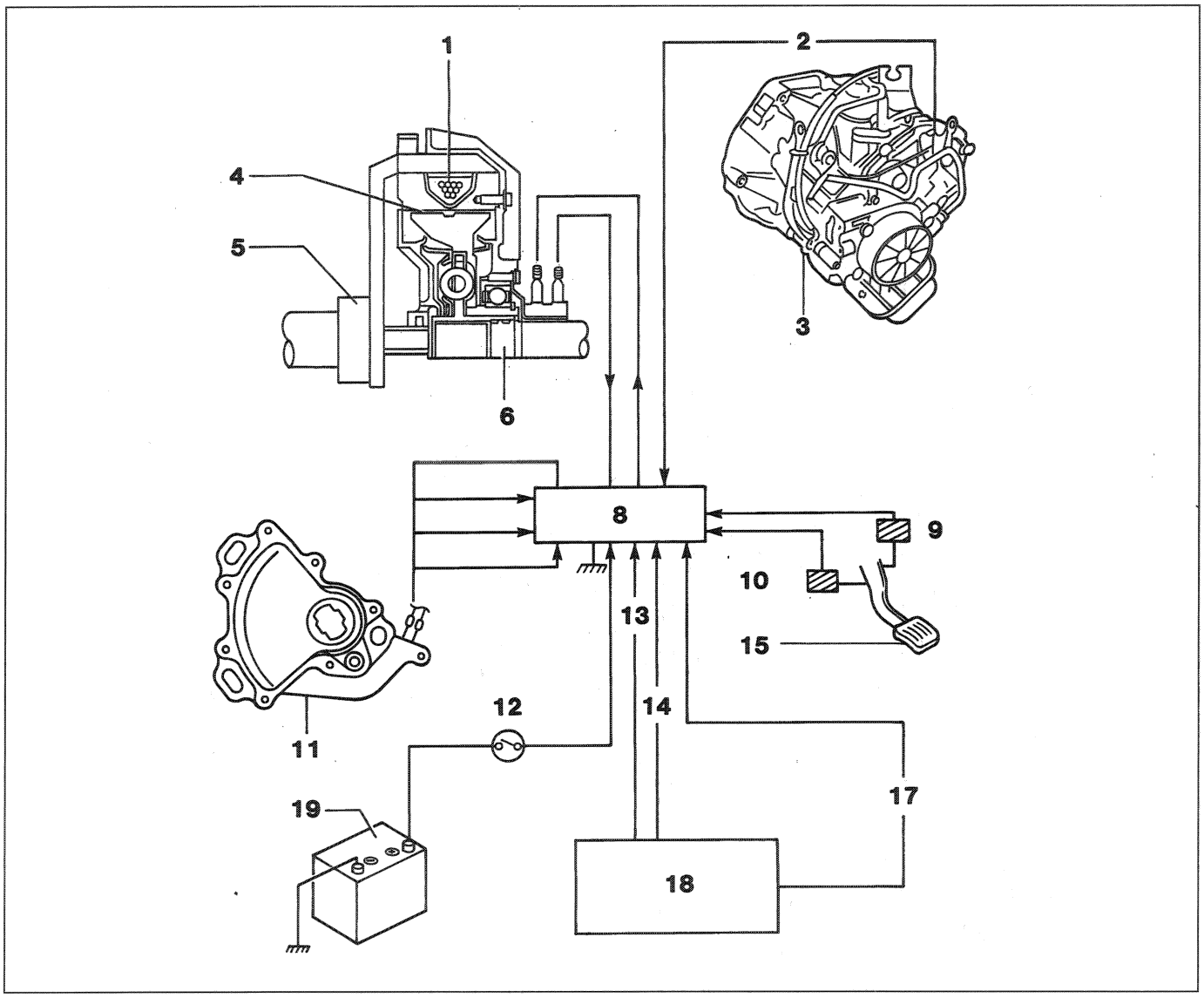
Functional elements of the ECVT

1. Oil pump
2. Primary pulley
3. Mechanism to select forward and reverse gears
4. Electromagnetic clutch
5. Driven plate
6. Secondary pulley
7. Metal belt
8. Final drive reduction gearset
9. Intermediate shaft
10. Differential

ELECTROMAGNETIC CLUTCH

The system consists of an electromagnetic clutch and a control unit, which picks up the signals shown in the figure below.



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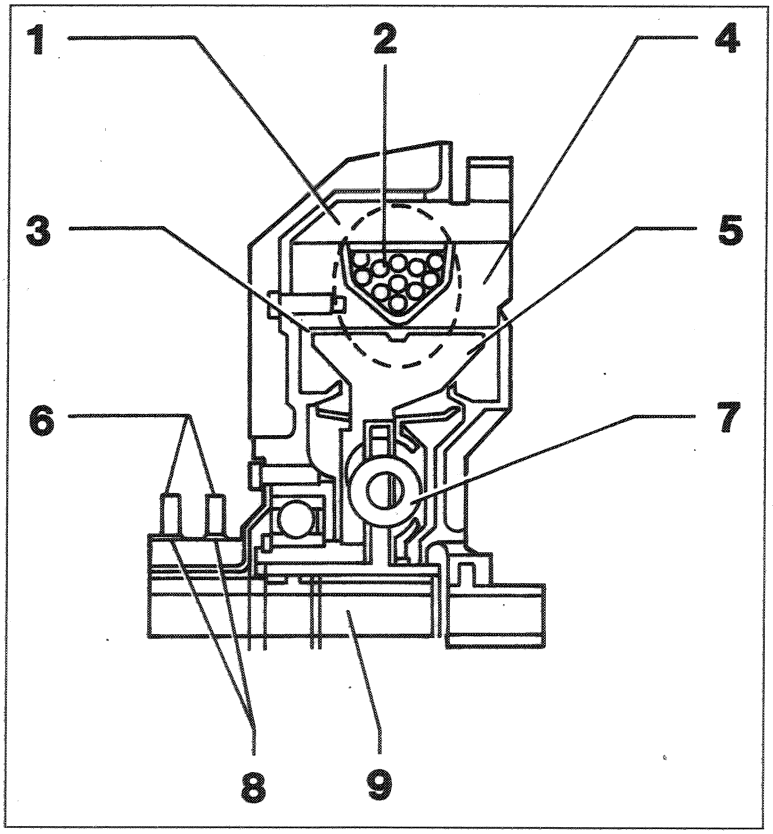
1. Coil
2. Signal from vehicle speed sensor
3. Vehicle speed sensor
4. Electromagnetic powder
5. Drive shaft (from engine)
6. Input shaft to the transmission
8. ECVT control unit
9. Accelerator pedal switch
10. Throttle valve opening position potentiometer
11. Multifunction switch
12. Ignition switch
13. Air conditioning signal
14. Engine RPM signal.
15. Accelerator pedal
17. Water temperature signal
18. Injection/ignition control unit
19. Battery

THEORY OF OPERATION

When metallic powder is moved towards a magnet, the particles of metal unite to form a chain. This extended magnetised chain can be used to transmit a force. The electromagnetic clutch uses this transmission principle.
Between the internal surface of the driver and the external surface of the driven plate there is a small gap, filled with magnetic powder. When an electromagnetic force is applied to this powder, the driver attracts the plate and they connect.
The electromagnetic force is generated by passing an electric current through the coil located in the driver, causing it to become an electromagnet.
The magnetic powder made into a solid chain allows the transmission of power from the driver to the driven plate.
The transmitted torque is proportional to the current. When the current is decreased the torque also reduces.

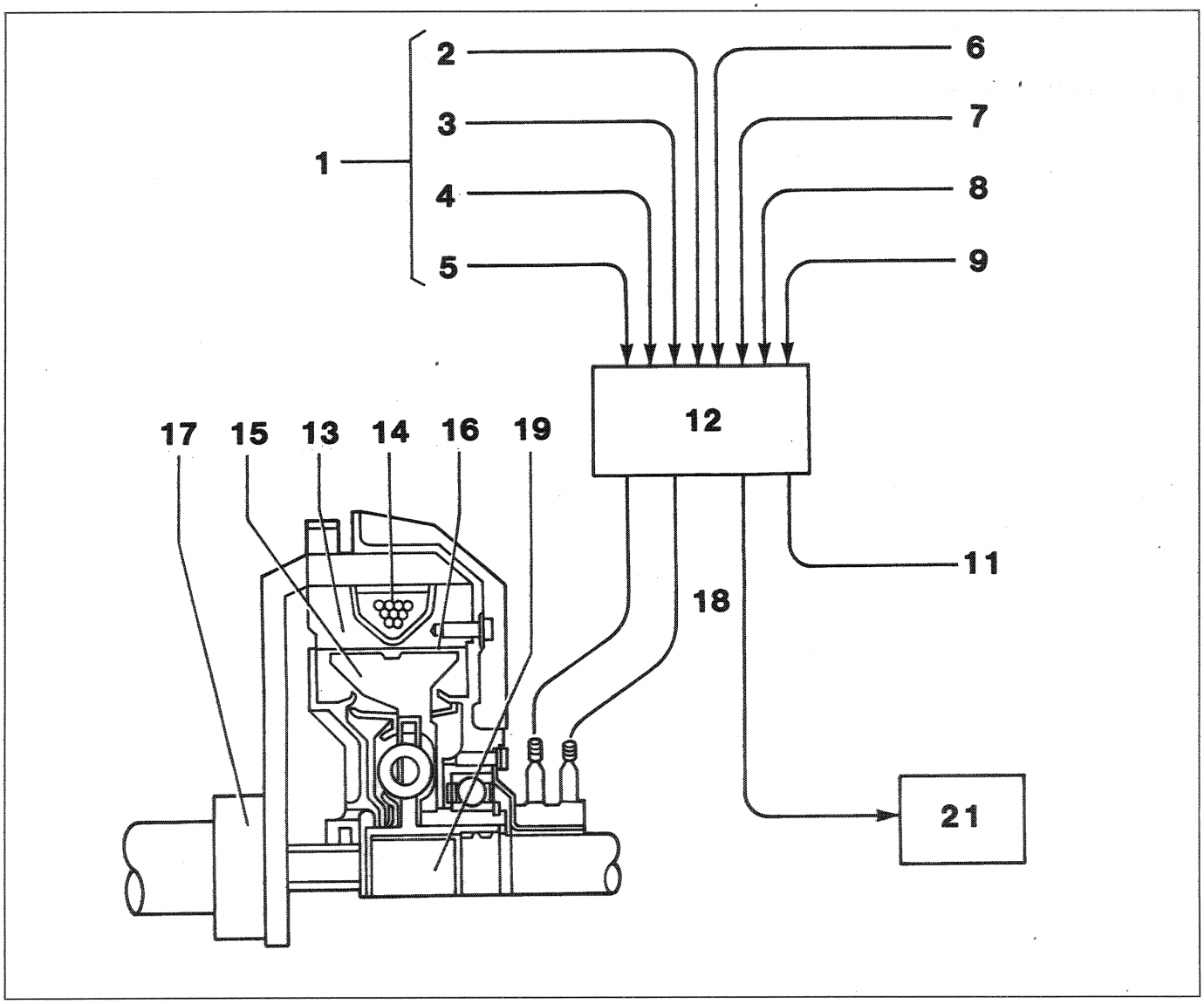


P3M10AB01

1. Magnetic field line
2. Coil
3. Electromagnetic powder
4. Driver
5. Driven plate
6. Electric current
7. Antivibration elements
8. Slip-ring
9. Transmission input shaft

CONTROL SIGNALS

Engagement and disengagement of the clutch, hence engine-power transmission, are controlled by the current applied to the electromagnetic clutch coil.
Several signals are transmitted to the control unit. These determine control strategies for various vehicle operating modes; starting, stopping, ratio changing.
The clutch also prevents shudders or jerks, which may occur when it is directly engaged or disengaged or when the engine is used to provide braking in the "L" position.



P3M11AB01

1. Input signals
2. Engine RPM signal
3. Accelerator pedal switch
4. Vehicle speed sensor signal
5. R,D,L,P,N position switch
6. Water temperature signal
7. Throttle opening position sensor
8. Air conditioning switch
9. Brake switch
11. Torque signal (2nd accelerator pedal switch)
12. ECVT control unit
13. Driver
14. Coil
15. Driven plate
16. Electromagnetic powder
17. Crankshaft
18. Clutch current
19. Input shaft
21. Pressure control solenoid valve

Engine RPM signal

This is supplied from the injection/ignition control unit. The engine torque is calculated from the RPM signal.
The same signal is used to prevent engine starting when the vehicle is pushed or towed.

Accelerator pedal switch

This sends an alert signal indicating that the driver wants to move the vehicle, before the throttle valve starts to open.
The vehicle moves only after this signal has been supplied.

Throttle valve position sensor

This potentiometer sends a signal to regulate the clutch torque variation as a function of the engine RPM and throttle opening.

"D" "L" and "R" position sensing switches

These switches allow the clutch control unit to sense the selected driving mode and then engage or disengage the clutch.

Vehicle speed sensor

As a result of this signal, the clutch is completely engaged when the vehicle speed reaches 20 km/h in "L" or "R" and 35 km/h in "D".
The sensor reads the rotation speed of the parking gear.

Water temperature sensor signal

When this signal indicates that the engine is "cold", the control unit increases the current sent to the clutch to raise the lockup point.
If the clutch rotates below the lockup point then slippage occurs. If it rotates at above the lockup point then it is locked solid.

Air conditioner sensor signal

This signal indicates that the air conditioner is operating. The control unit then compensates the clutch current. (The clutch torque is reduced when the engine torque is reduced).

Brake switch

Braking is signalled for the following reasons:
1) To disengage the clutch, hence preventing engine stalling if the wheels lock.

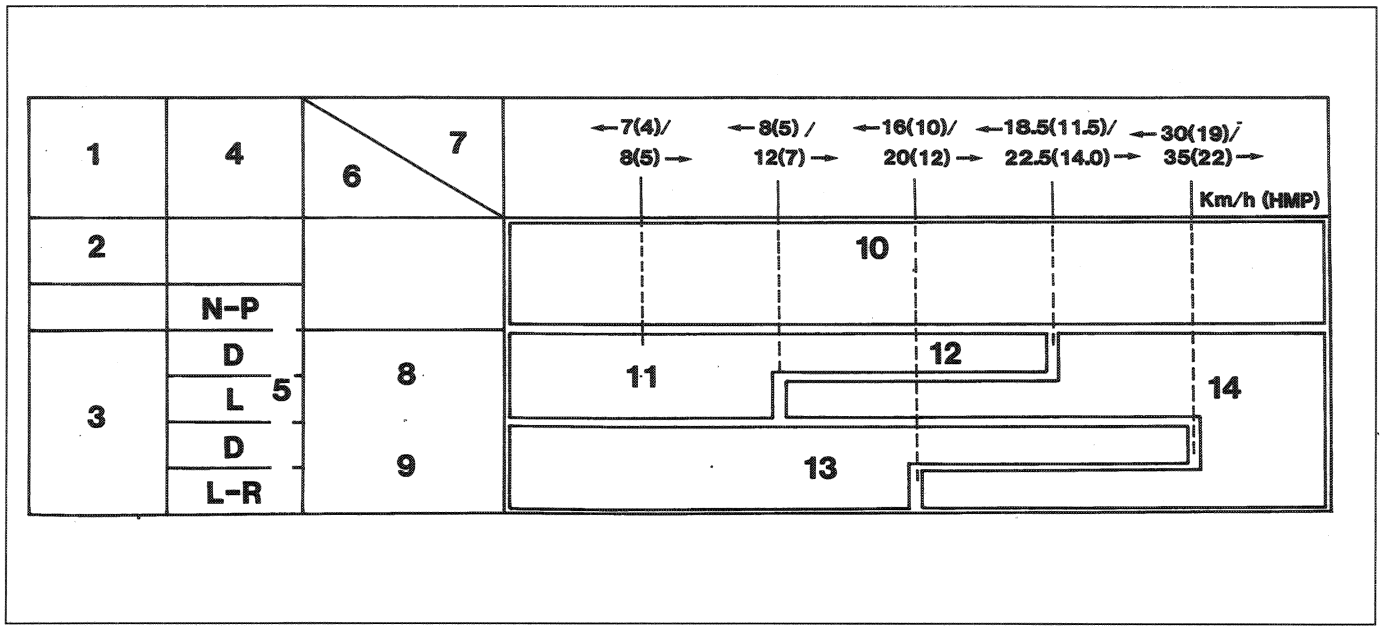
2) To increase the hydraulic pulley closing pressure to prevent damage to the belt following wheel locking.

Torque signal (2nd accelerator pedal switch)

This signal is used to increase or decrease the hydraulic circuit pressure, depending on the engine torque.
The engine torque is calculated by the transmission control unit as a function of the engine RPM, the air flow rate, the water temperature, etc.

OPERATING MODES OF THE OUTPUT SIGNALS

The signal modes shown in the table ensure correct clutch operation.



P3M13AB01

1. Engine RPM
2. Under 200 RPM
3. 200 RPM or over
4. Transmission mode selected
5. Positions N, P/ Position D/ Positions L, R/ Position D/ Positions L, R
6. Accelerator
7. Vehicle speed
8. Released
9. Pressed
10. Reverse enable mode
11. Rapid acceleration mode
12. Zero mode
13. Moving-off mode
14. Direct coupling mode

«- 7 (4)/8 (5) -» means that in deceleration the change point is 7 km/h (4MPH) and in acceleration it is 8 km/h (5 MPH) due to magnetic hysteresis

1. Moving-off mode

This operating mode adjusts the clutch force during moving-off by increasing the current in proportion to the engine RPM and also sensing the rate of increase of this RPM when the accelerator pedal is pressed.
If the accelerator pedal is pushed or released after moving-off when the vehicle speed is still 20 km/h or less, the clutch will slip. The slippage will continue until the driven plate RPM (mounted on the primary pulley shaft) almost matches that of the engine.

2. Direct coupling mode

This operating mode directly couples the clutch using a rated current when the vehicle has reached the prescribed velocity.
The rated current has three values depending on how hard the accelerator pedal is pressed.

Accelerator pedal released	0.6-1.8 A	
Accelerator pedal pressed lightly	3.2 A	(Only the accelerator pedal switch operates)
Accelerator pedal fully depressed	4.0 A	(The accelerator pedal switch and the throttle valve position sensor operate.)

3. Pick-up

To maintain good pick-up characteristics from stationary and low speed driving (up to 7 km/h), including stops during driving in the "D", "L" and "R" modes, a pick-up torque is used to eliminate play. It is created by passing a current (approximately 0.2 A) through the clutch when the accelerator pedal is released.
This pick-up torque is very small compared to that applied in conventional automatic transmissions.
To avoid engine slowing when in neutral due to the pick-up torque and also to avoid vehicle creep, the idle speed signal is read by the control unit.

4. Reverse excitation mode

To demagnetise the clutch reverse excitation is used in the following four situations:

a. Selector lever in "N" or "P" position: reverse excitation mode is activated to disengage the clutch.
b. Engine RPM less or equal to 200 RPM. Reverse excitation mode is activated to prevent the engine being started by pushing or towing.
c. For 0.4 - 0.8 seconds after "D" or "P" are selected, reverse excitation mode is activated to facilitate selector lever movement.
d. For approximately 1 second after the accelerator pedal is released during low speed driving the reverse excitation mode is activated to eliminate residual magnetism.

5. Zero mode

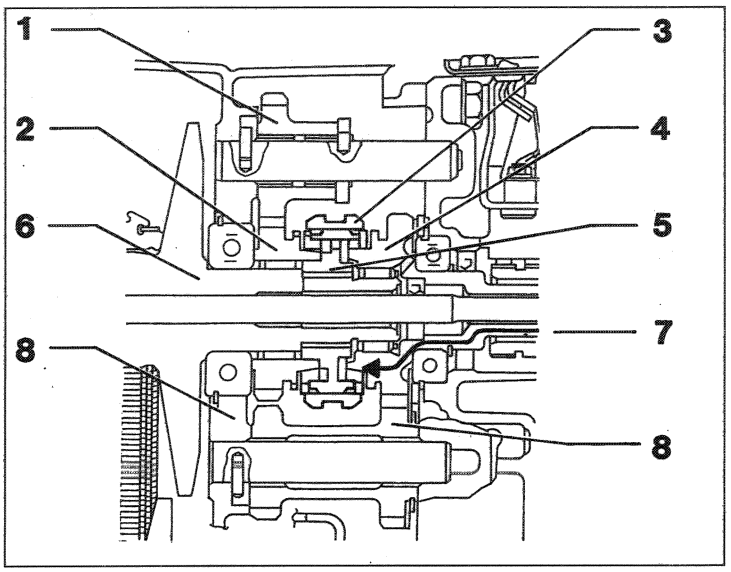
If the accelerator is released and the selector lever is in the "D", "L" or "R" position, then the transmission mode changes from "direct coupling" to "pick-up".
During changeover, current to the electromagnetic clutch is cut off.

6. Control of ratio-changing (changeover mode)

This mode allows clutch control to smooth the direct coupling operation, when the selector lever is moved to the "L" position or when it is necessary to accelerate or decelerate from a very low speed, as follows:
- changing from "D" to "L" the clutch control current is reduced momentarily;
- when the accelerator pedal is pressed or released the current is reduced momentarily;
- changing from "starting" to "direct coupling" mode, the variation of the current is controlled so that there is no jerking as the clutch is engaged slowly.

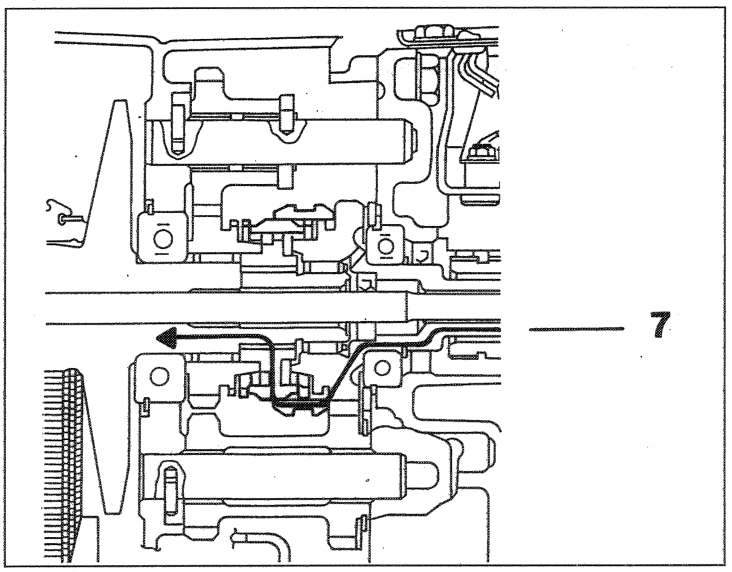
AUTO-DIAGNOSIS AND FAIL-SAFE MODE

The ECVT has auto-diagnosis function. If inappropriate signals are received then the ECVT warning light will light up.
It should be noted, however, that even if a fault occurs in the various electrical circuits the vehicle can still be driven due to a fail-safe mode; LIMP-HOME.



P3M15AB01

1. Reverse idler gear
2. Reverse drive gear
3. Selector rod
4. Primary drive gear
5. Hub
6. Primary pulley
7. Torque
8. Idler gear



P3M15AB02

7. Torque

RATIO SELECTOR MECHANISM

The synchronised mechanism for changing between forward and reverse ratios is located between the primary pulley and the electromagnetic clutch.
This mechanism allows selection of the "N" position from the "D" drive position and vice-versa during vehicle operation.

"N" position

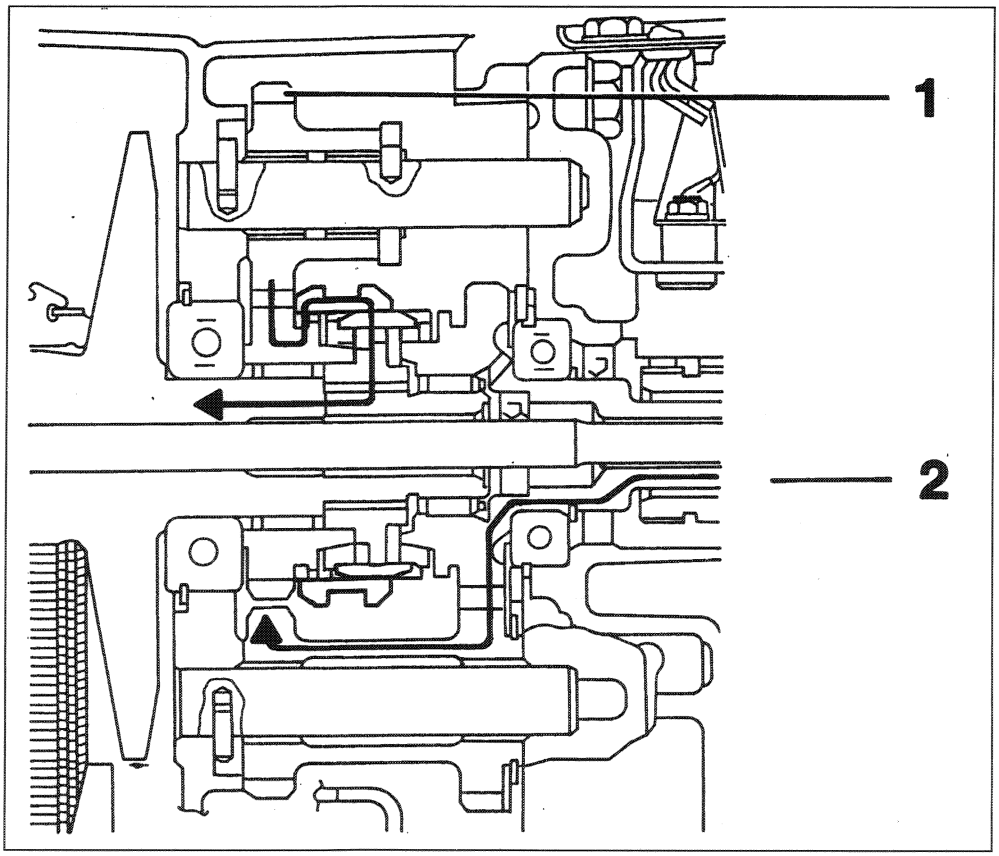
This is the neutral position. The selector rod is in the central position, hence power cannot be transmitted from the principal gear to the gearhub.

"D" position

When the selector lever is in this position the selector rod is displaced to the right to operate the forward ratio.
In this condition the selector rod transmits power from the principle gear to the primary pulley via the gearhub.

"R" position

In this position the selector rod moves to the left to engage reverse. In this condition the power from the principle gear is transmitted via the idler gear to the primary pulley via the reverse gearset



P3M16AB01

1. Reverse gearset

2. Torque

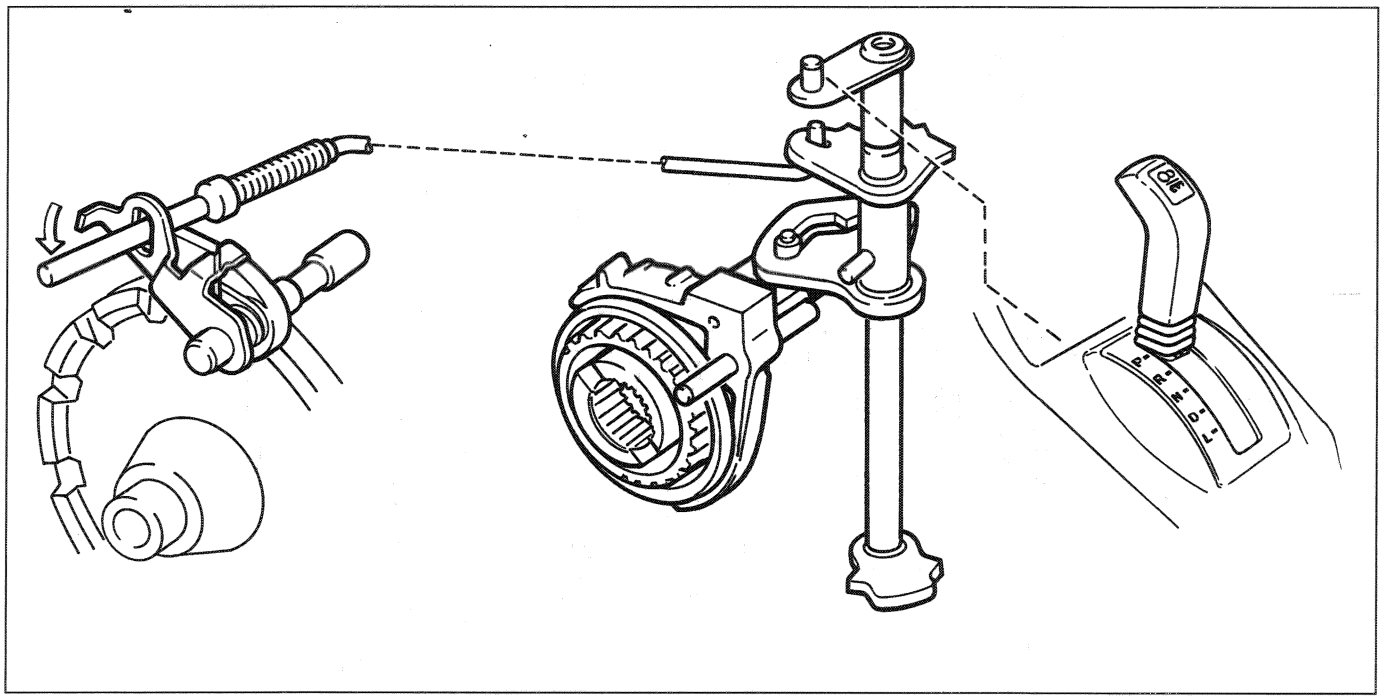
NOTE: *When performing the R «--» N «--» D changes, the accelerator pedal must be completely released, even if the vehicle is stationary.*

"L" position

In this position the selector rod is as for the "D" position, but when the selector lever is in the "L" position engine braking is transmitted via the hydraulic control unit. The vehicle speed reduction is therefore controlled as required for the "L" driving mode.

"P" position

In this position the parking pawl control rod is operated by the pin inside the selector lever cam. The control rod pushes the pawl in the direction shown by the arrow.
The pawl is forced into a tooth of the parking gear mounted on a secondary pulley face which is then locked. The attached halfshafts are also locked.
The selector rod is concurrently moved to reverse.



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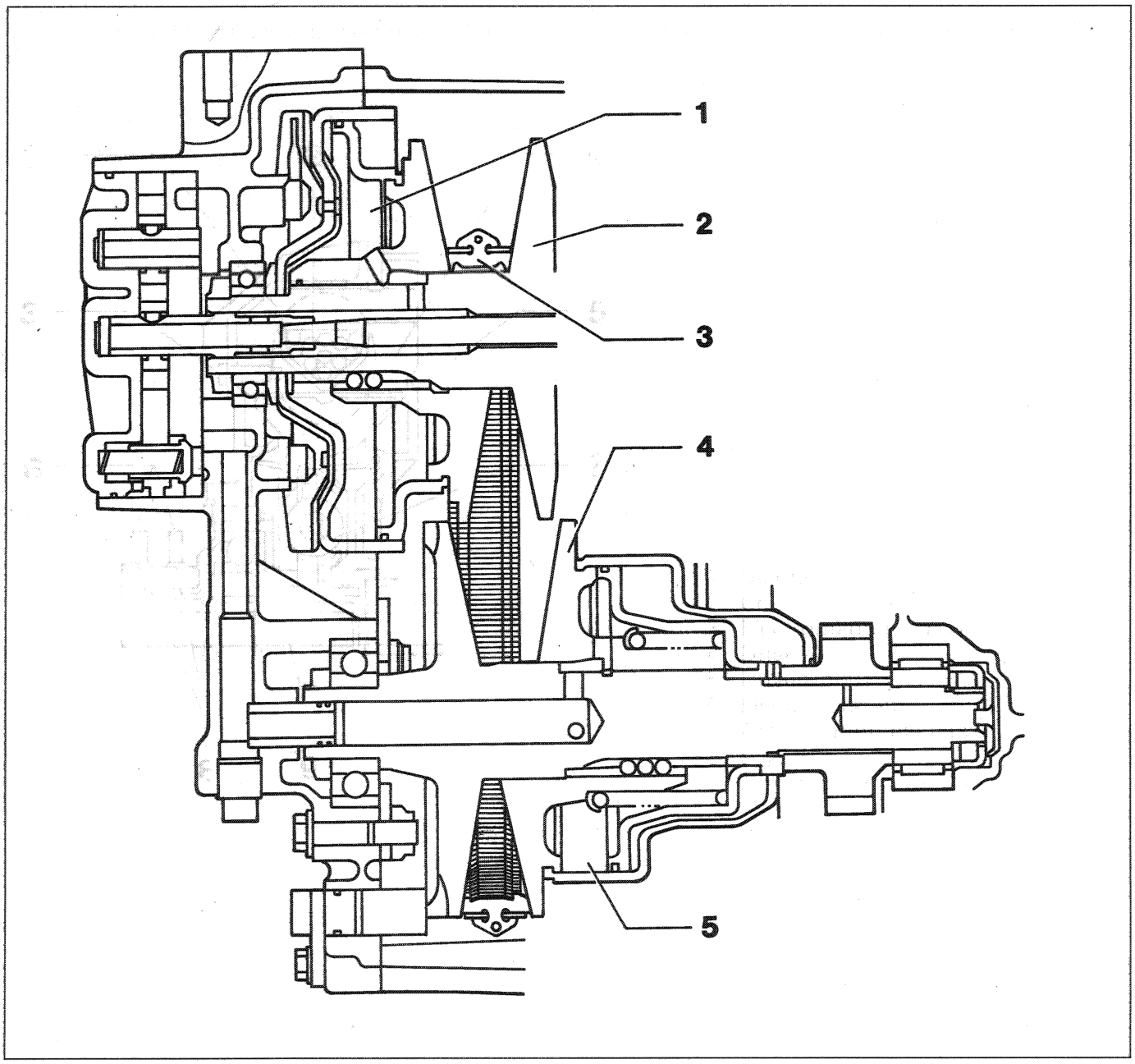
Gearchange mechanism

BELT AND PULLEYS

Belt and pulley mechanism

The assembly consists of a pair of pulleys, which can expand or contract in an axial sense, and a metal belt that consists of steel blocks mounted on a steel band.

The transmission ratio can vary continuously from a minimum (ratio = 2.503) to a maximum (ratio = 0.497), depending on the pulley/belt contact diameter ratio.
The pulley width is regulated by hydraulic pressure acting on the pulley-centres where they are mounted on the input and output shafts.



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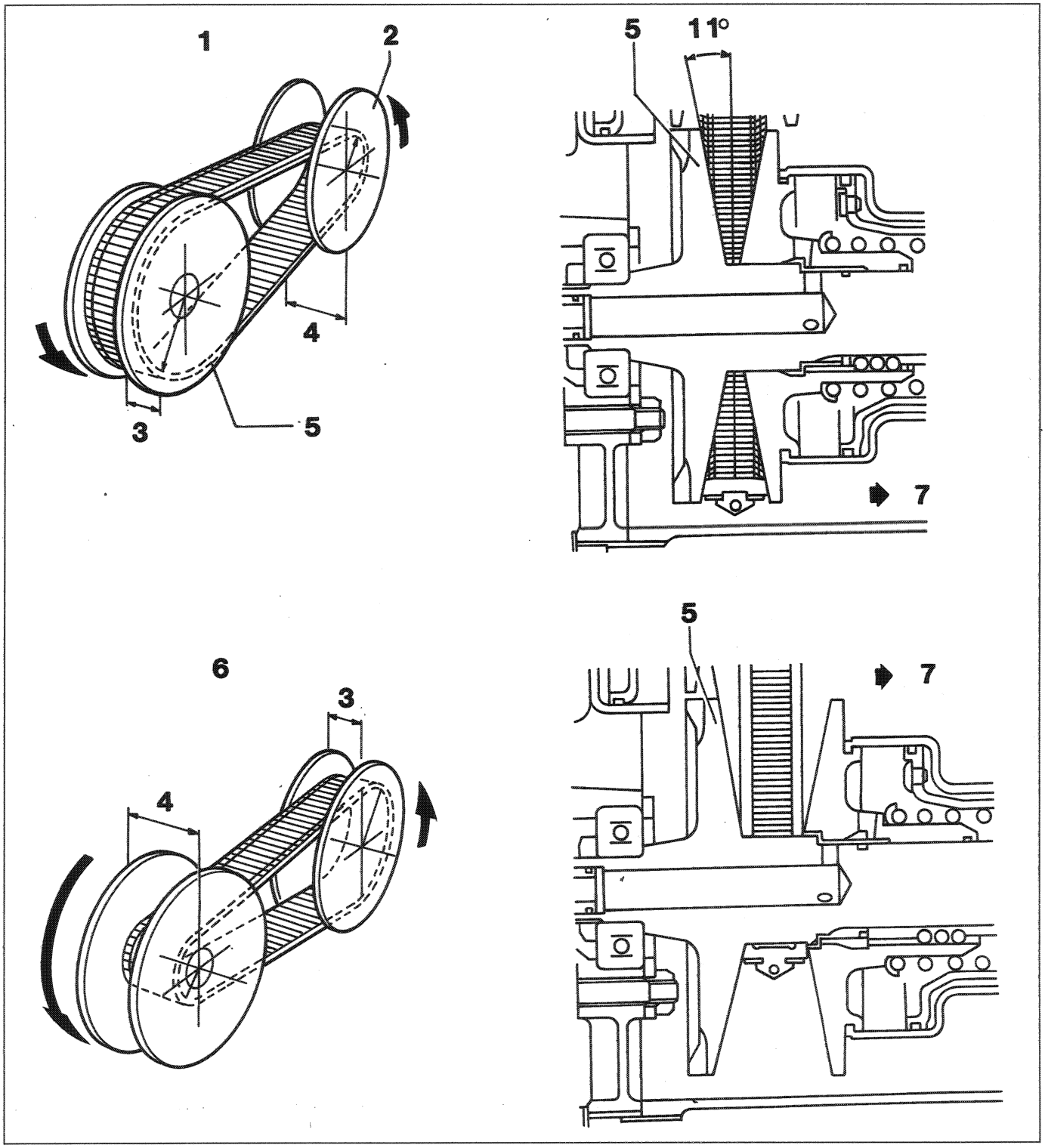
1. Primary chamber
2. Primary pulley
3. Metal belt
4. Secondary pulley
5. Secondary chamber



P3M19AB01

1. Low vehicle speed operating condition: ratio between the pulleys r2/r1 = 2.503
2. Primary pulley
3. Narrow
4. Wide
5. Secondary pulley
6. High vehicle speed operating condition (overdrive): ratio between the pulleys r2/r1 = 0.497
7. Sliding bearing ring

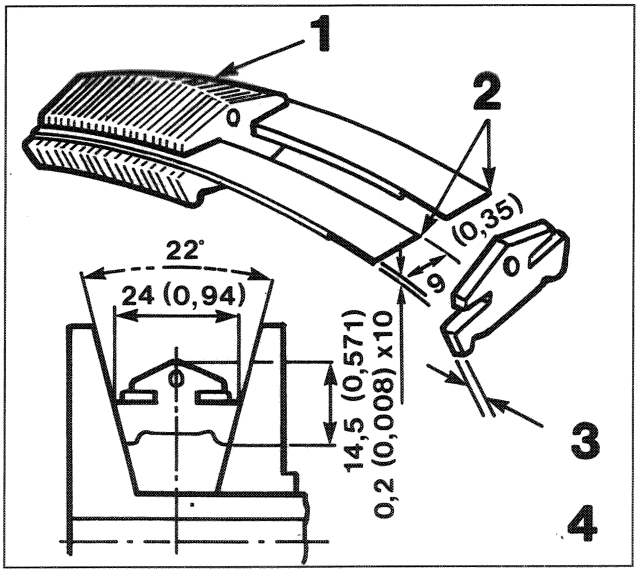
21-27.

METAL DRIVE BELT

The metal drive belt consists of approximately 280 blocks mounted on two steel bands each made from 10 laminated strips.
The belt transmits power via the compression of these blocks; it "pushes" the torque. This is contrary to the operation of traditional rubber belts which are in tension and "pull" the torque.
The metal bands consist of thin strips of laminated steel (thickness 0.2 mm) which are capable of withstanding the compression loading. The steel blocks differ in thickness (2.0 and 2.2 mm) to reduce noise.

To transmit power, friction is necessary between the blocks and the pulley internal faces.

This friction is produced by applying a closing pressure to the secondary pulley, compressing the blocks. This force also causes the belt to move outwards (increasing its diameter).
The increased operating diameter causes tension and this creates friction between the blocks and the primary pulley.
In other words, the steel blocks transmit power by compression, the steel bands then ensure that the necessary tension to create driving friction is maintained



P3M20AB01

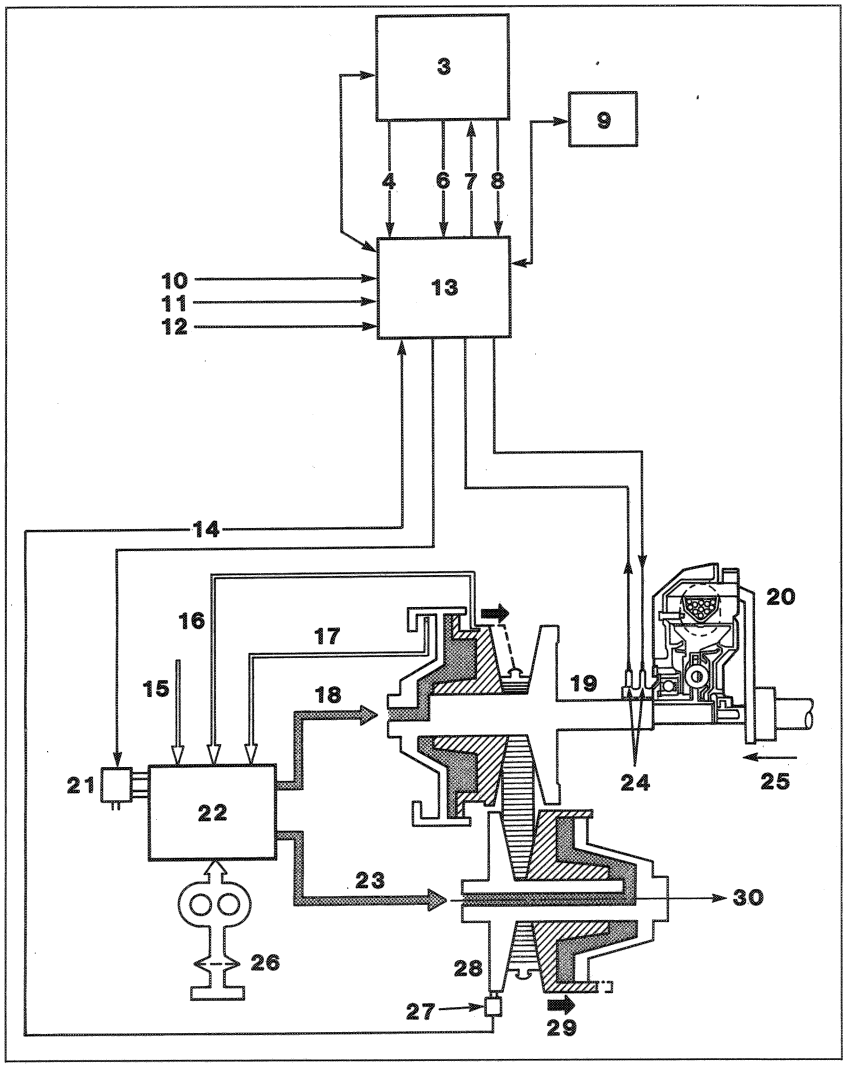
1. Steel blocks: Approximately 280
2. Steel belt (length approximately 600)
3. Approximately 2
4. Unit of measurement: mm

PULLEYS

Both the primary pulley and secondary pulley have sliding bearing rings on their rotation axes. The sealing faces are inclined at 11°.
Both pulleys have pressure chambers surrounding the rings.
The pulley width (hence its operating diameter and ratio) is modified by forcing the rings to move along the rotation axis on roller bearings.

HYDRAULIC CONTROL SYSTEM

The hydraulic control system consists of a motor driven pump and hydraulic pressure regulation valve which serve to change the ratio.
The system receives several input signals; the speed of the input shaft, the position of the accelerator pedal and the pulley ratio. These signals determine the control strategy.



Hydraulic control system

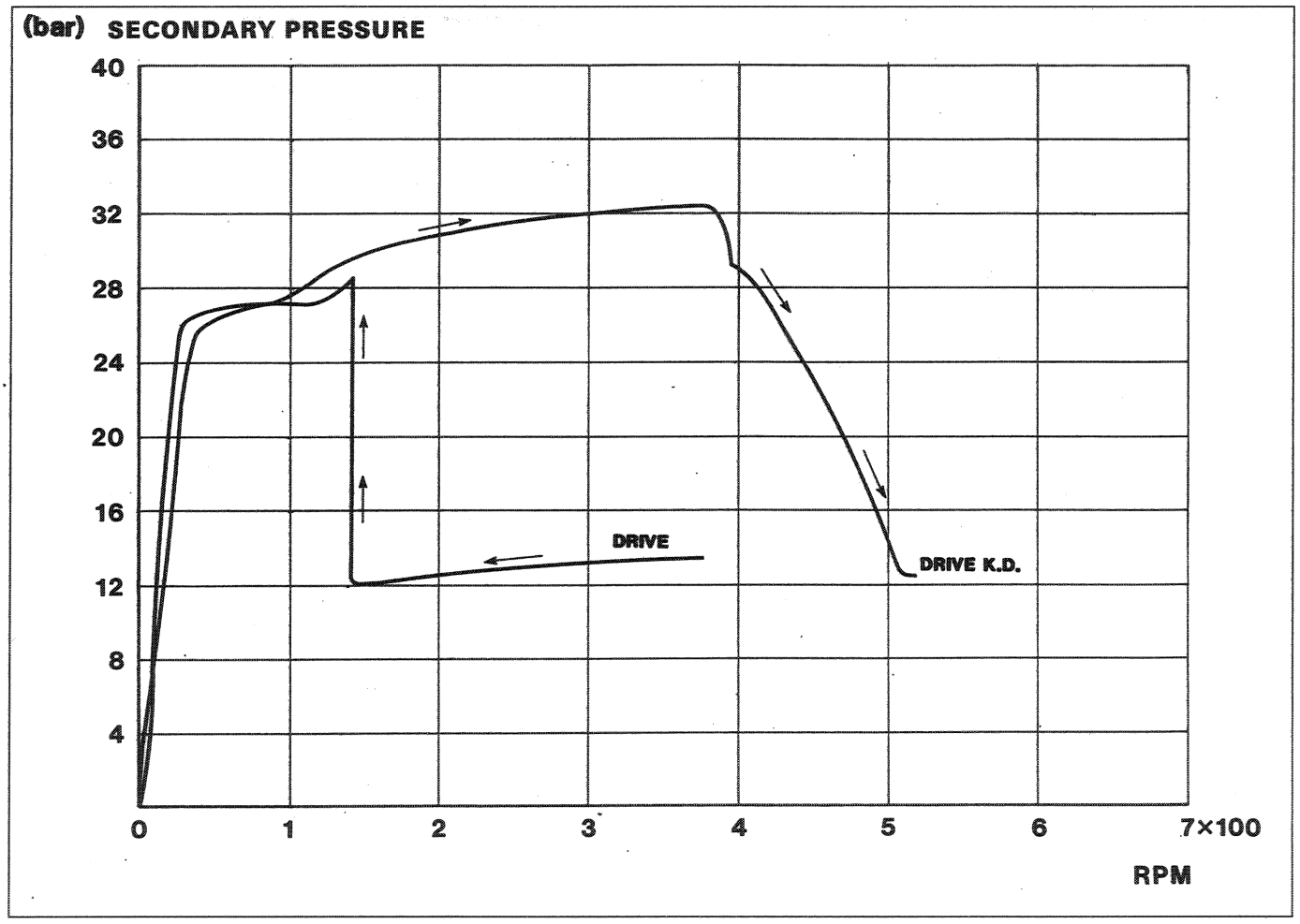
3. Injection/ignition control unit
4. Air conditioner sensor signal
6. Water temperature signal
7. Clutch signal
8. Engine RPM signal
9. ECVT warning light
10. Selector lever position
11. Accelerator pedal switch/throttle valve potentiometer/Torque signal
12. Brake switch
13. ECVT control unit
14. Signal from vehicle speed sensor
15. Accelerator pedal position switch
16. Pulley ratio
17. Input shaft RPM
18. Primary oil pressure
19. Primary pulley
20. Electromagnetic clutch
21. Pressure regulating solenoid valve
22. Oil pressure control valve
23. Secondary oil pressure
24. Slip ring
25. From engine
26. Oil pump
27. Vehicle speed sensor
28. Secondary pulley
29. Belt and pulley
30. To halfshafts

21-27.

OIL PUMP

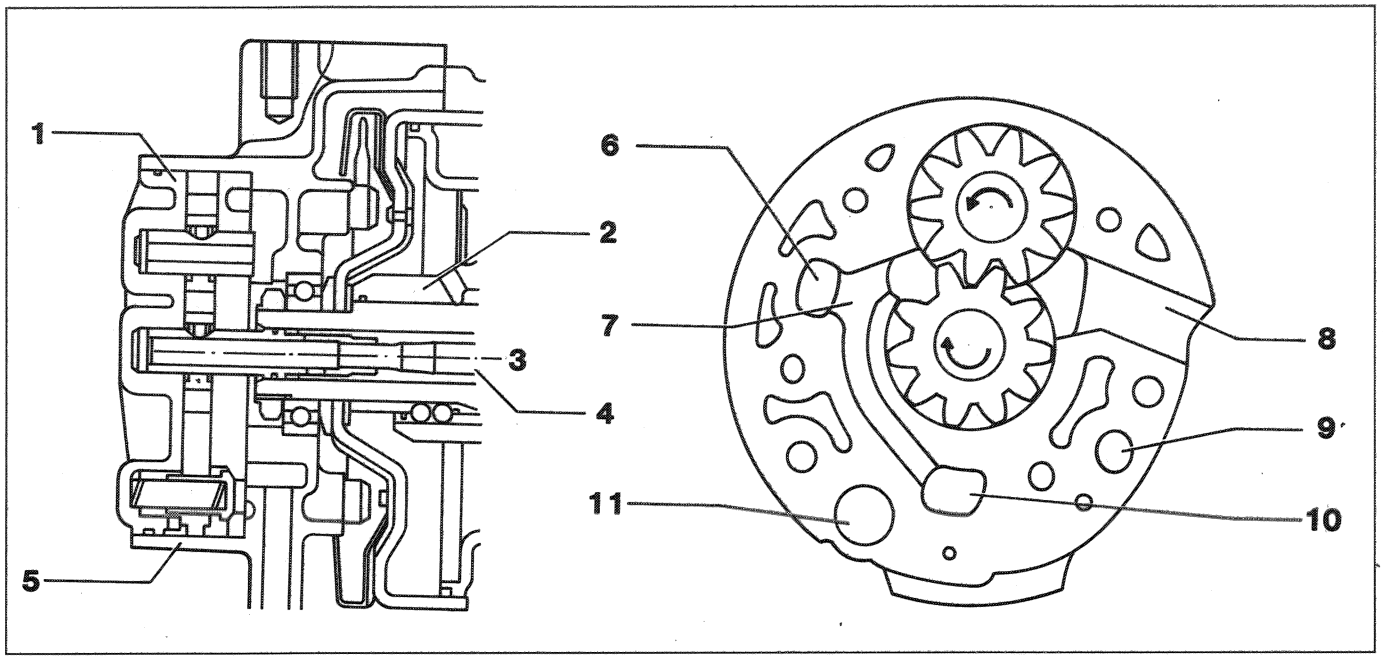
The oil pump is driven by a motor via a transmission shaft from the primary pulley.

The pump is an external gearpump. The oil flow is delivered from the pump and regulated by the hydraulic valve. This serves to control the primary and secondary pulley positions and to lubricate all components.
The oil pressure varies depending on the driving conditions, from 12 to 35 kg/cm², as shown in the graph below.



P3M22AB01

The belt lubrication system functions by passing oil through a tube and spraying it directly onto the belt through a nozzle.
The pulley face that houses the transmission ratio sensor is also oil lubricated.

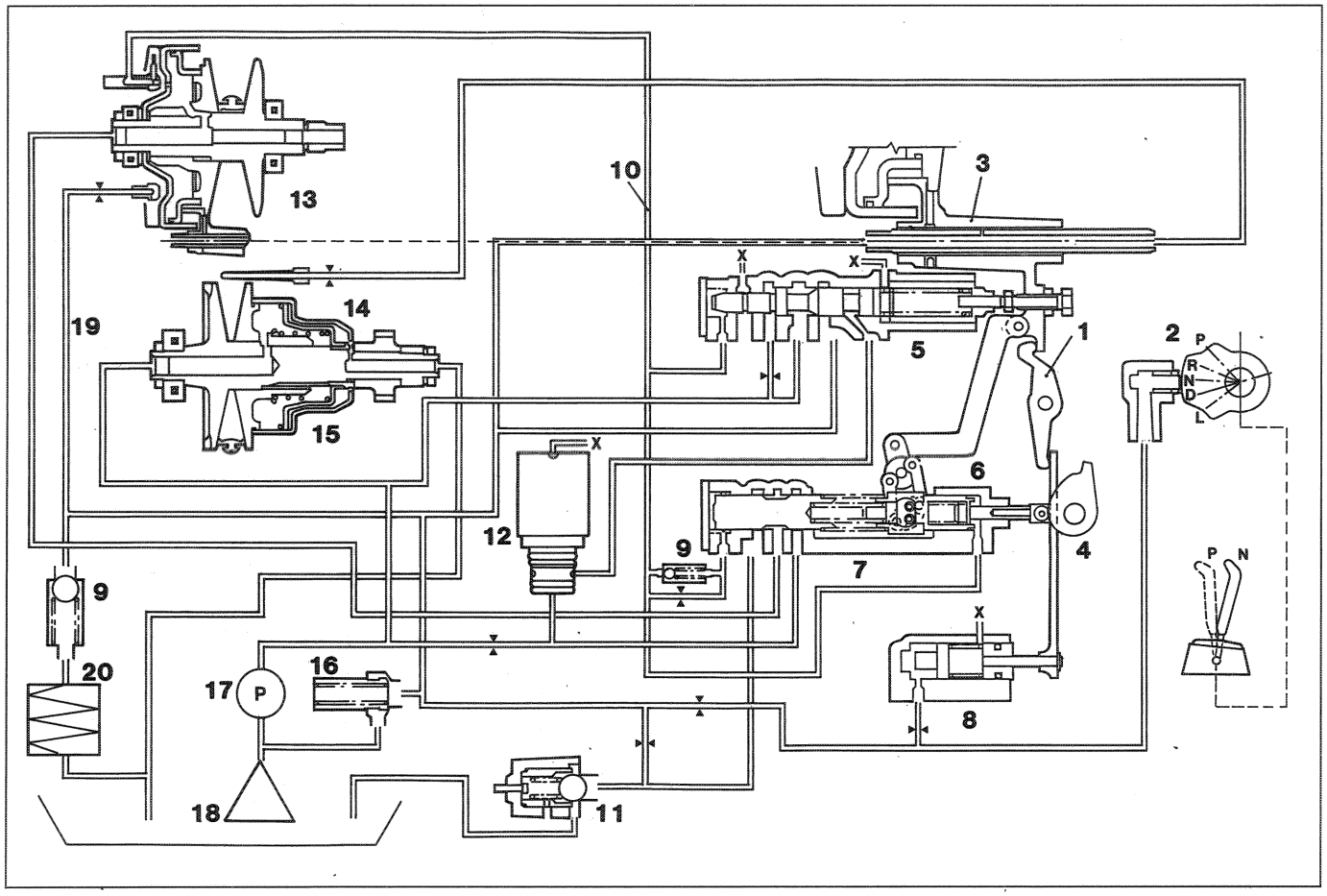


P3M23AB01

1. Oil pump
2. Primary pulley
3. (Engine side)
4. Drive shaft
5. Transmission casing
6. To secondary pulley
7. Oil exit
8. Oil suction intake
9. To primary pulley
10. Pressure regulation valve
11. Lubrication oil valve hole

HYDRAULIC CONTROL VALVES

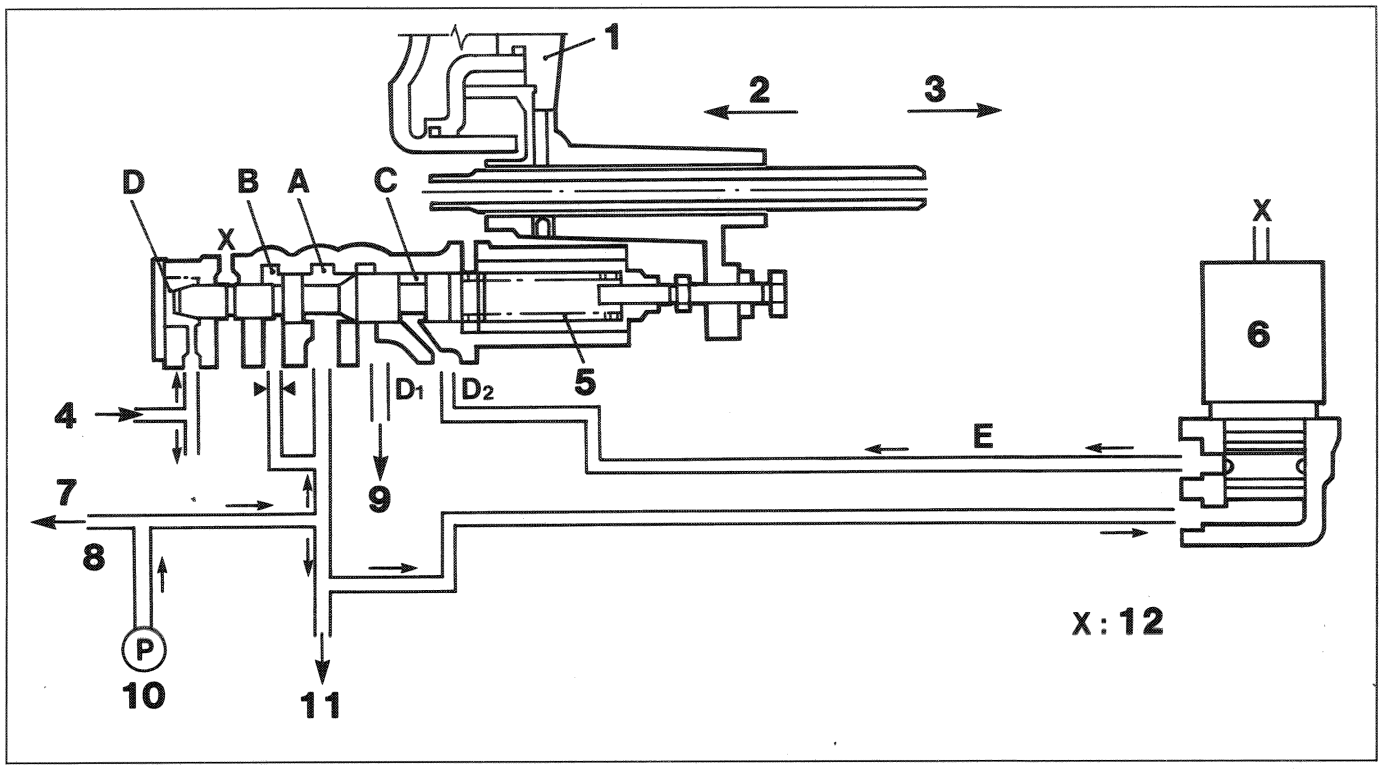
There are three hydraulic control valves:
- secondary pressure regulating valve;
- primary pressure regulating valve (ratio variation);
- engine braking valve.



P3M24AB01

1. "L" driving mode activation lever
2. Push rod (engine braking)
3. Sliding sensor
4. Selector cam
5. Secondary pressure regulation valve
6. Modulating pushrod
7. Primary pressure regulation valve
8. Engine braking valve
9. Safety valve
10. Pitot pressure
11. Transmission pressure retaining valve
12. Pressure regulating solenoid valve
13. Primary pulley
14. Belt lubrication
15. Secondary pulley
16. Lubricating valve
17. Oil pump
18. Oil filter
19. Pitot supply line
20. Oil cooler

SECONDARY PRESSURE REGULATING VALVE



P3M25AB01

1. Sliding bearing ring (Primary pulley)
2. Ratio between the pulleys: high (low speed)
3. Ratio between the pulleys: low (top speed)
4. Pitot pressure
5. Spring
6. Pressure control solenoid valve
7. Circuit pressure
8. Secondary pulley
9. Lubricating oil pressure
10. Oil pump
11. Transmission control valve
12. X: Outlet

The regulator valve ensures that the correct quantity of pressurised oil is sent to the secondary pulley when the pulley is forced to rotate by the belt. Oil supply to the primary pulley is controlled by the transmission control valve.
The oil exiting the pump is directed into circuits (A) and (B) in such a way that the circuits and spring (5) pressure remain in equilibrium.
The circuit oil pressure varies as a function of the transmission ratio and the primary pulley speed, as follows:
The position of the primary pulley slide ring is read from the sliding sensor and provokes a change in the imposed length of the pressure regulating valve spring.
In pratice, when the pulley ratio is high (low speed) the pressure regulating spring is pushed towards the left, reducing the outlet size.
In this way the pressure remains high and the pulley is forced to increase diameter.
When the transmission ratio is low (Overdrive), the circuit pressure is held low, so the secondary pulley decreases in diameter.
The oil pressure (Pitot pressure) is proportional to the primary pulley RPM and acts on the circuit at (X) on the opposite side to spring (5).
The pressure regulating valve is consequently pushed towards the right, which limits the oil pressure increase (circuit pressure) provoked by the increased engine speed.

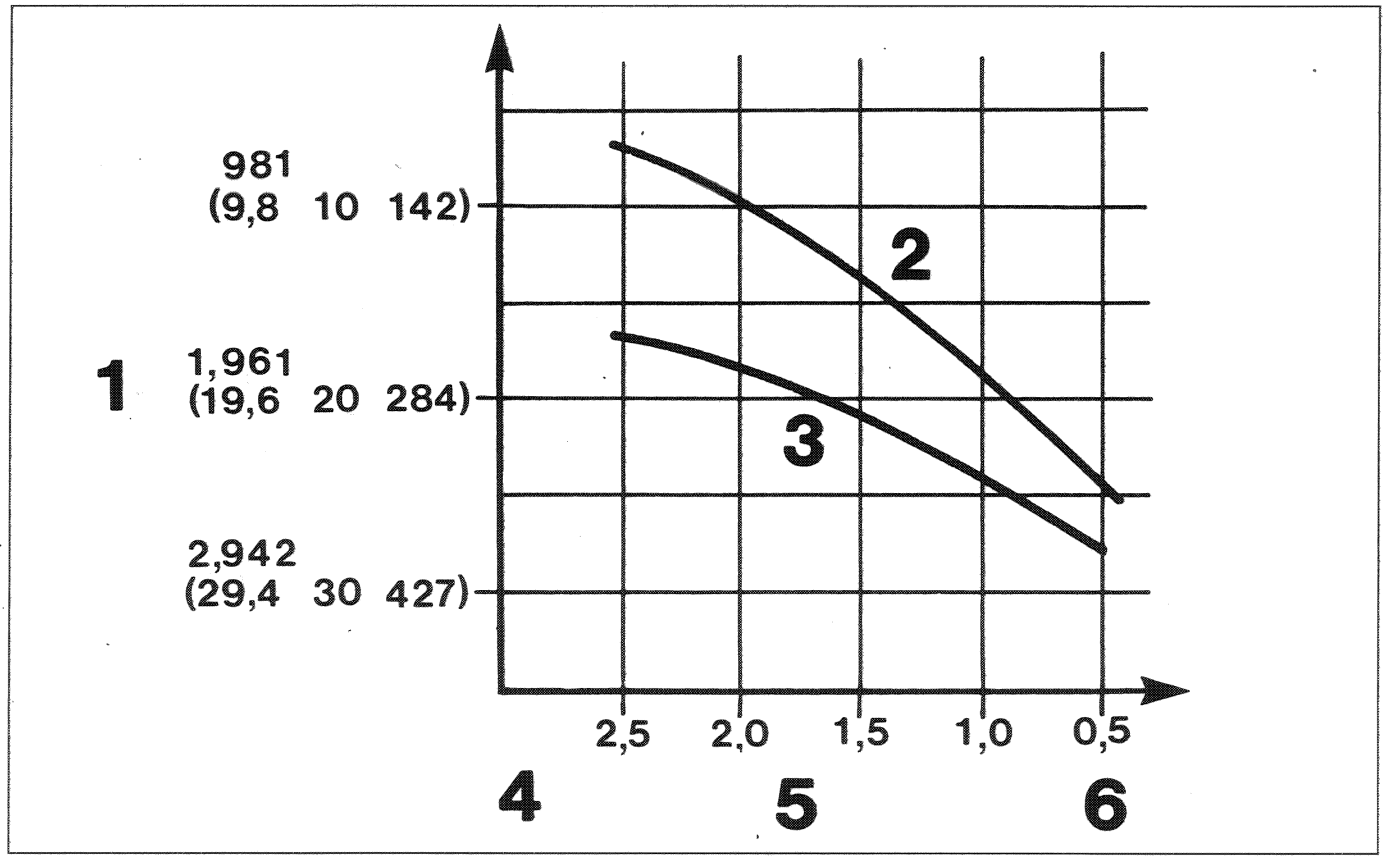
21-27.

When the engine is operating under partial load conditions (approximately 60% of max power), the pressure control solenoid valve (6) acts, and hydraulic pressure is redirected from circuit (C) into chamber (D) via passage (E).
Since diameter D2 is greater than diameter D1, there is an increase of contact area that pushes the pressure regulating valve towards the right, therefore the circuit pressure is reduced.
Alternatively, when the engine load is high, the solenoid valve (6) closes, excluding circuit (C) and chamber (D). The oil outlet is then connected, again via the solenoid valve (6).

This eliminates the force acting on the right side of the pressure regulating valve.
The contact area to push the regulating valve to the right is reduced, hence the circuit pressure increases.

The oil pressure is regulated as explained above.
In this way the optimum belt tension is ensured whilst minimising the power loss at the oil pump.

This control system gives better performance at low/medium engine loads and reduces fuel consumption.

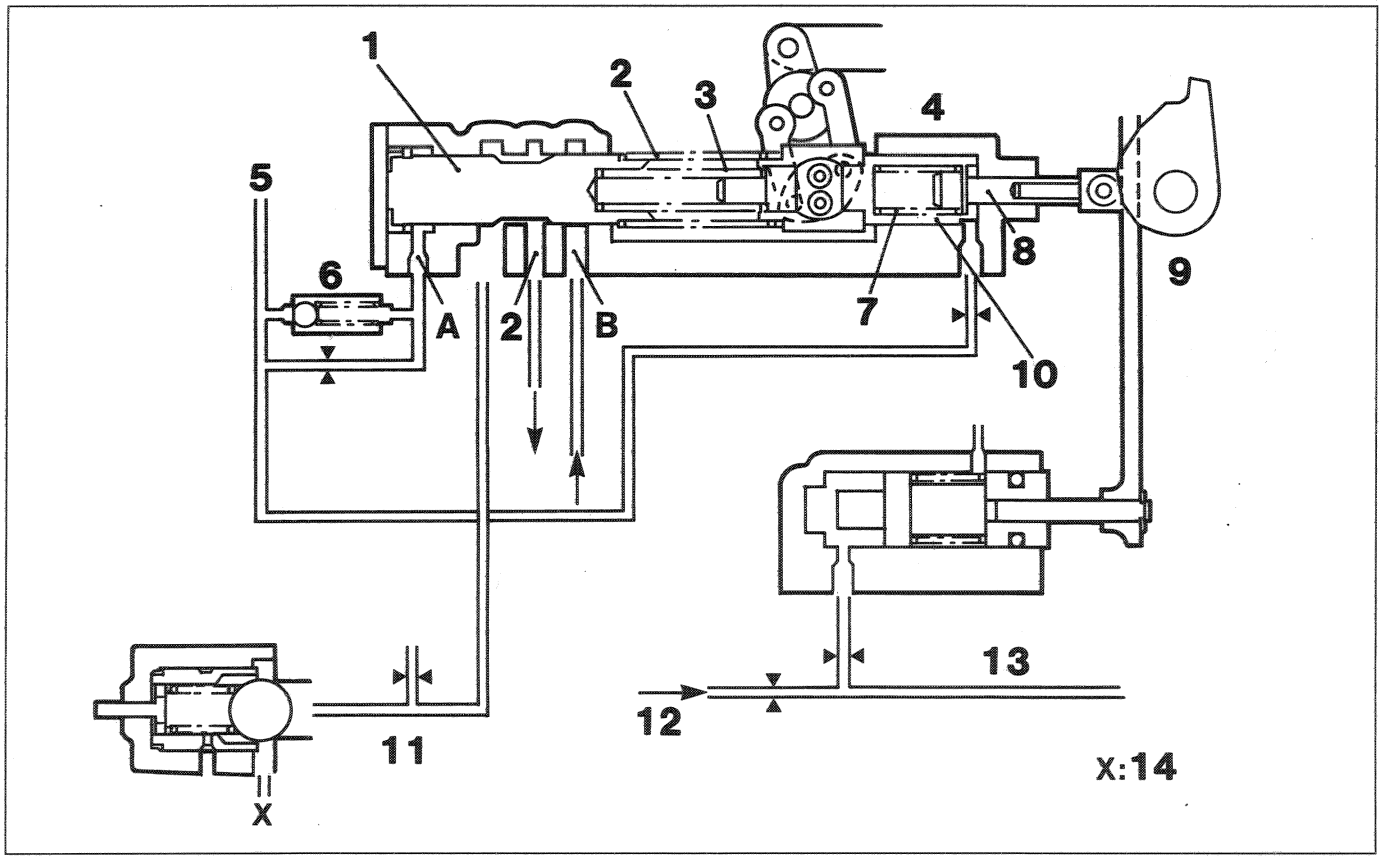


P3M26AB01

1. Circuit pressure, kPa (bar, kg/cm², psi)
2. High pressure (solenoid valve inactive)
3. Low pressure (solenoid valve active)
4. Low speed
5. Pulley ratio
6. Overdrive

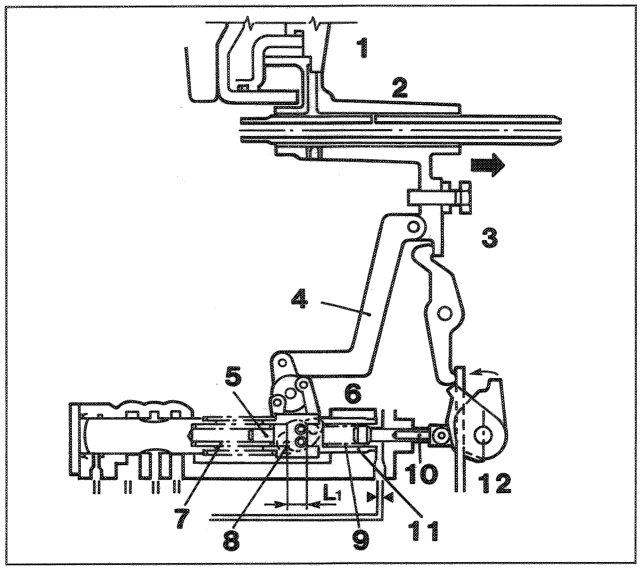
PRIMARY PRESSURE REGULATION VALVE

This valve continuously controls the transmission output speed, from minimum to maximum, whilst "D" or "L" are selected.
The pulley ratio is changed by varying the pressure in circuit (A), acting on the primary pulley, via the sliding bearing. The control inputs are the accelerator pedal position (read from the movement of the transmission control cam) and the engine RPM (calculated from the Pitot pressure).
At low speed, spring (2) pushes the transmission control valve towards the left. As the engine RPM increases the Pitot pressure (4) also increases; the transmission control valve moves towards the right and the pressure in circuit (B) is allowed to pass through the solenoid valve to be directed to the primary pulley.
At this point the transmission speed starts to change. The initial variation of the engine between N1 and N2 is calculated from the accelerator pedal position, connected to the transmission control cam.
When the accelerator pedal is pressed, the transmission control valve moves towards the left. The pressure in circuit (B) cannot pass to the solenoid valve circuit until the Pitot pressure (which is proportional to the engine RPM) begins to increase. In this way the vehicle speed starts to increase from low speeds.



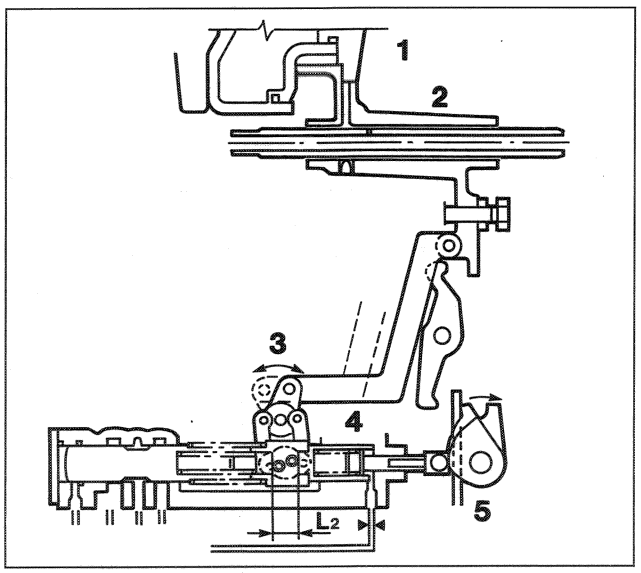
P3M27AB01

1. Primary pressure regulation valve
2. Spring
3. Spring
4. Modulator linkage
5. Pitot pressure
6. Safety valve
7. Spring
8. Plunger pin
9. Selector cam (connected to the accelerator pedal)
10. Compensating piston
11. Transmission retaining valve
12. Lubrication pressure
13. Engine braking valve
14. X: to outlet



P3M28AB01

1. Low transmission speed
2. Sliding sensor
3. "L" mode actuation lever
4. Connecting lever
5. Support
6. Modulator linkage
7. Spring
8. Roller bearing element
9. Spring
10. Plunger pin
11. Compensating piston
12. Selector cam

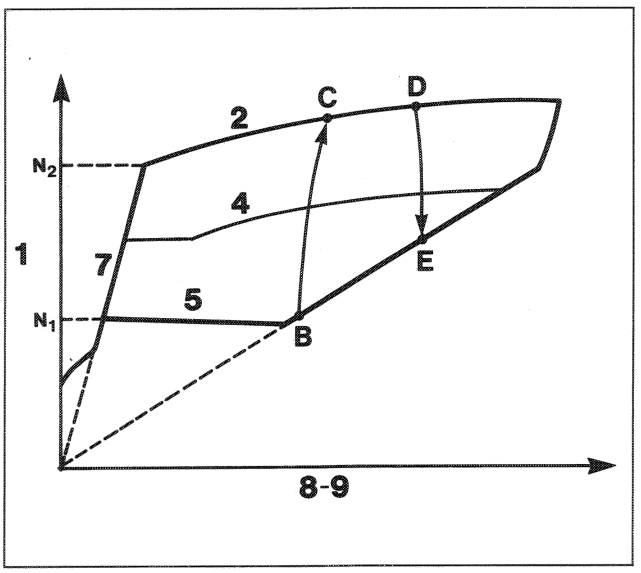


P3M28AB02

If the accelerator pedal is pushed whilst travelling at top speed, the force pushing the transmission ratio control valve towards the left increases. The engine RPM increases from point B to point C on the velocity map (Kick-Down).

If, instead, the accelerator pedal pressure is reduced whilst travelling at top speed then the engine RPM decreases, from point D to point E on the same map (Upshift).

1. O/D Overdrive
2. Sliding sensor
3. LOW speed/minimum velocity
4. Modulator linkage
5. Selector cam

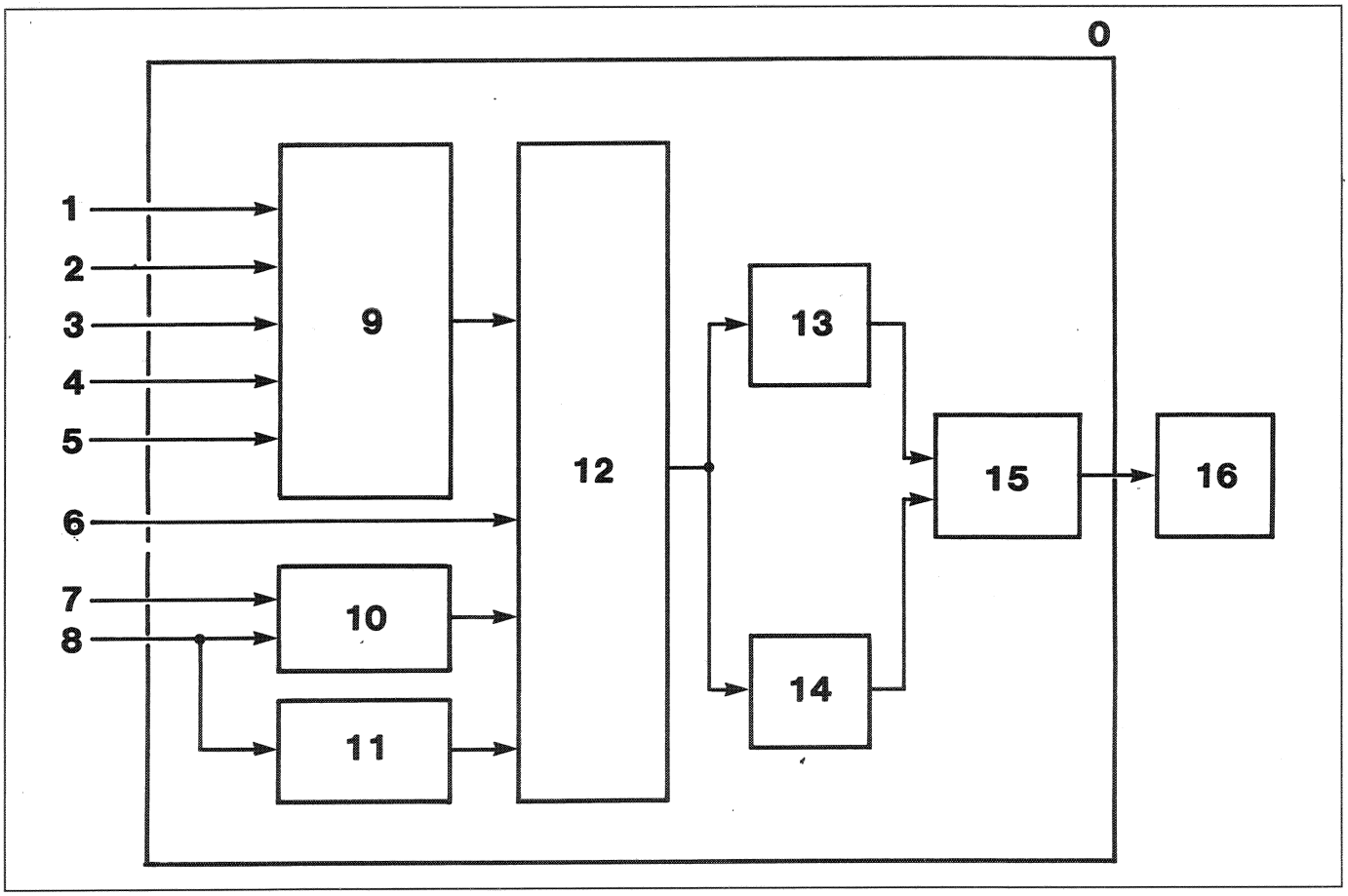


P3M28AB03

When the sliding sensor moves from the "low speed" to the "top speed" position, the reading position on the map moves to the right, corresponding to an increase in the engine RPM.
This occurs because the roller bearing element, connected to the sliding sensor via a rod, rotates clockwise and compresses spring (7) so that the distance between the support and the compensating piston increases (L1--»L2).

1. Engine speed
2. Throttle valve opening: wide open
4. Throttle valve opening: medium
5. Throttle valve opening: small
6. Top speed (Overdrive)
7. Low vehicle speed
8. Vehicle speed
9. Velocity change characteristic curve map

This strategy has been developed to satisfy the driver who normally expects the vehicle speed to increase when engine RPM increases.
To achieve this sensation, a plunger pushed by the selector cam (connects to the accelerator pedal) acts on the compensating piston via spring (9).
This mechanism inhibits immediate release of the oil pressure retaining the primary pulley (towards the retaining valve) when the accelerator pedal is suddenly pressed. Without this mechanism, the pressure release would instantaneously move the transmission control valve to the left.
If the primary chamber is empty of oil then the velocity change is also delayed. This allows the lubricating oil to achieve a constant flow rate into the chamber.
There is also a pressure retaining valve (ball type) in the outlet circuit of the transmission control valve , this prevents complete oil drainage of the primary pulley circuit.



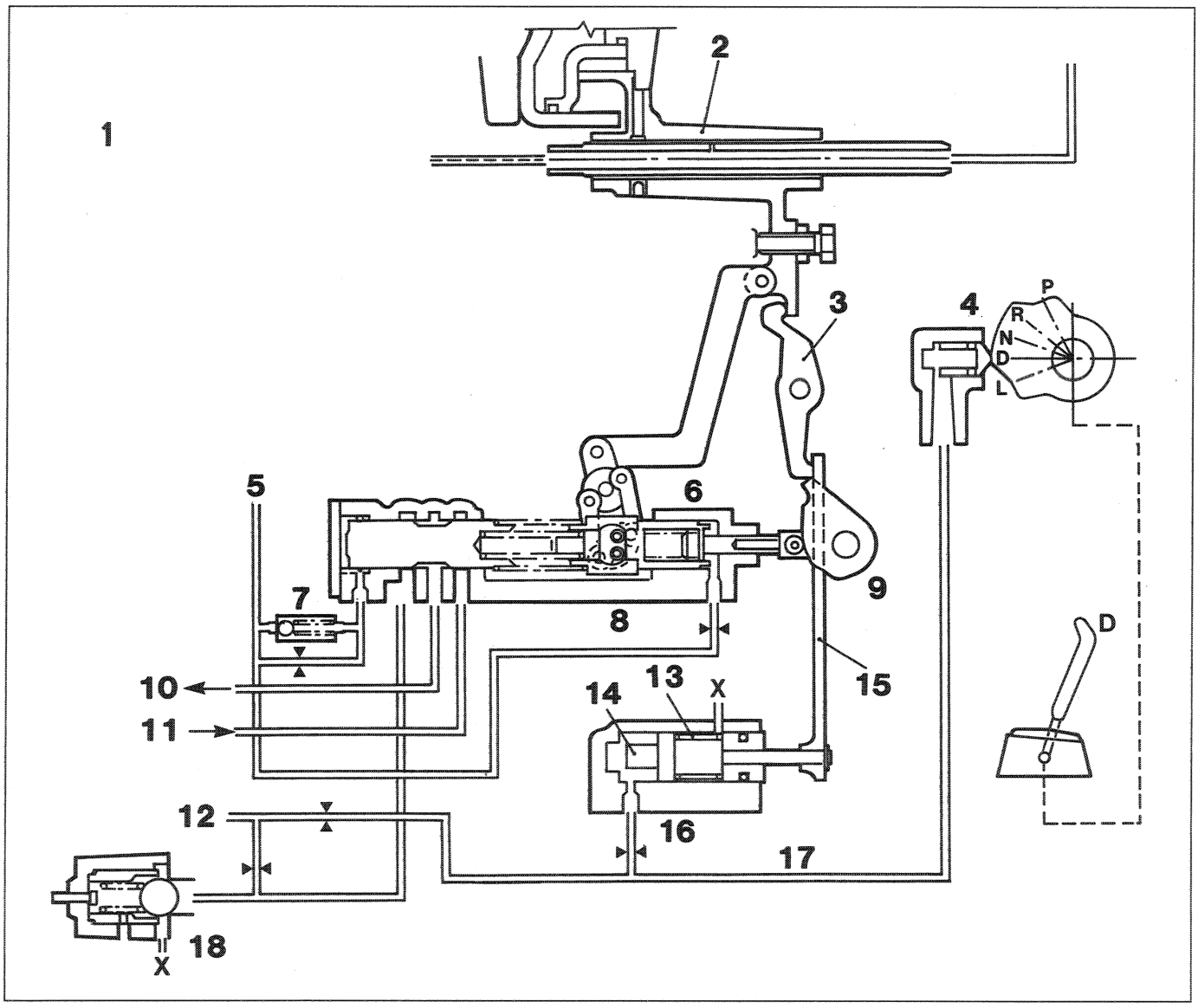
P3M29AB01

0. ECVT control unit
1. Accelerator pedal switch
2. Throttle valve opening potentiometer
3. Switch, "D" position
4. Switch, "L" position
5. Switch, "R" position
6. Torque signal
7. Brake switch
8. Vehicle speed signal
9. Calculation during ratio changing
10. Calculation during rapid deceleration
11. Calculation during rapid acceleration
12. High and low pressure separation stage
13. Activation command for high pressure
14. Activation command for low pressure
15. Outlet control
16. Circuit pressure regulation solenoid--valve

21-27.

ENGINE BRAKING VALVE

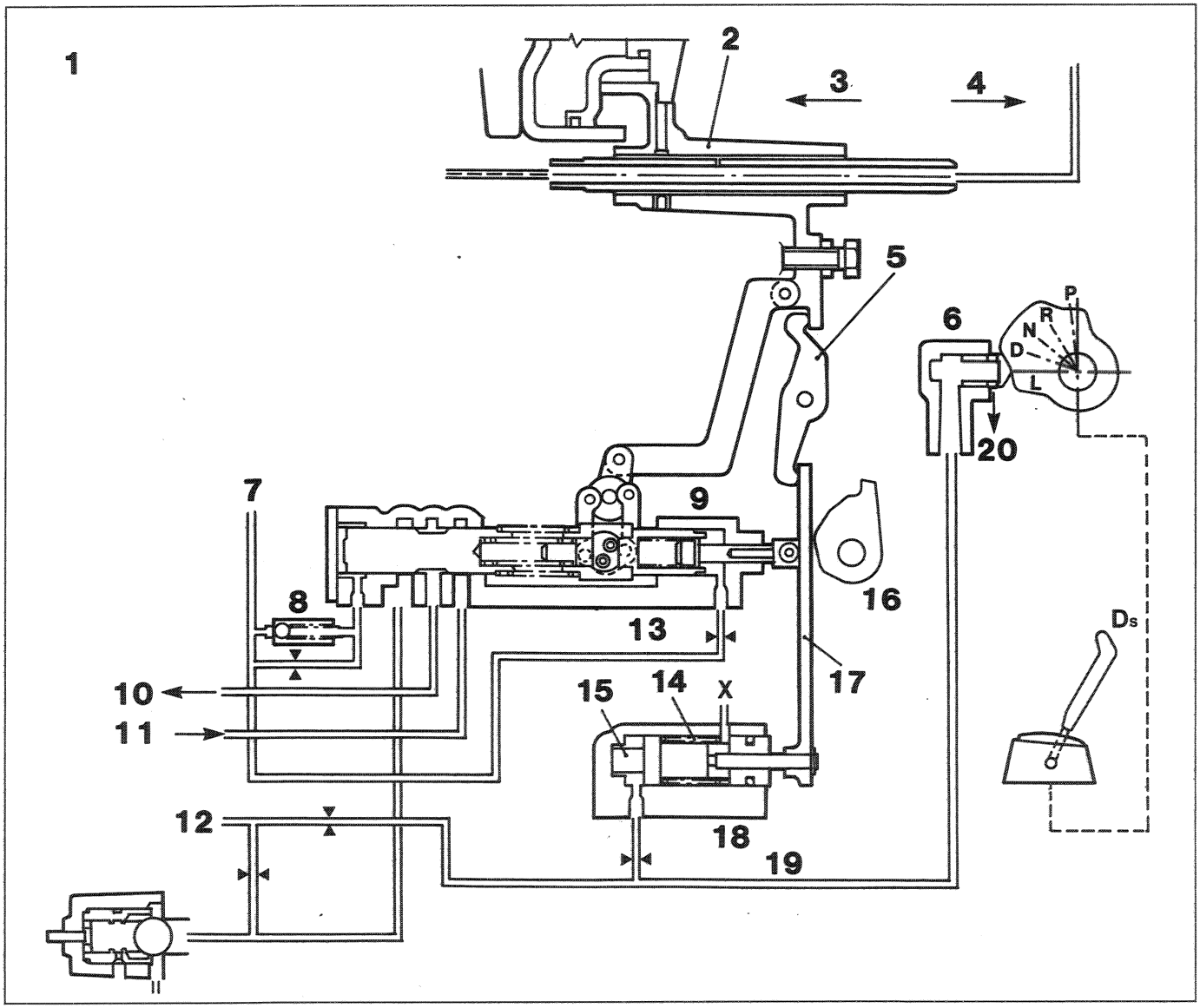
The engine braking valve allows the engine RPM to maintained relatively high, when it is necessary to have good engine braking (e.g. on steep descents or mountain roads).
When the selector lever is in position "D", the engine braking piston blocks the lubricating oil (17) and pressure is maintained at the engine braking valve. The pressure forces spring (13) to compress and pushes coil (14) towards the right.



P3M30AB01

1. "D" position
2. Sliding sensor
3. Engine braking lever
4. Engine braking piston
5. Pitot pressure
6. Modulation linkage
7. Safety valve
8. Transmission control valve
9. Transmission control cam
10. To primary pulley
11. Circuit pressure
12. Lubrication circuit valve
13. Spring
14. Coil
15. Engine braking actuation rod
16. Engine braking valve
17. Lubricating pressure
18. Pressure retaining valve

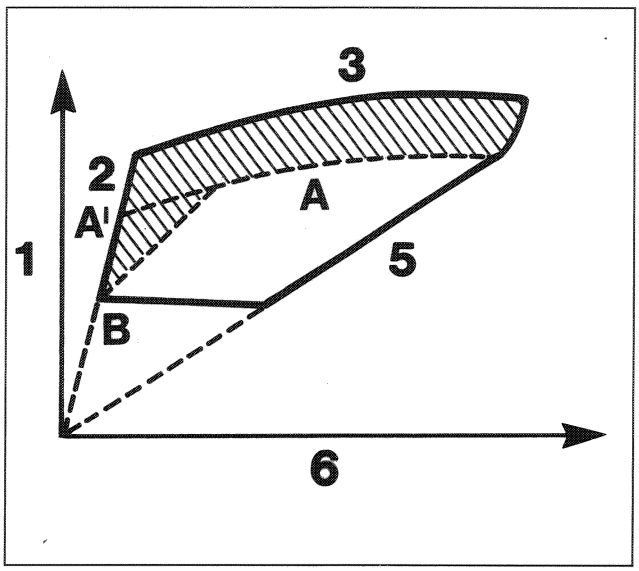
When the selector lever is moved to the "L" position, the engine braking piston moves towards the right, and the lubricating oil drains out of the circuit. The spring (14) can push the coil (15) of the engine braking valve towards the left.
The primary pressure regulation valve is then pushed to the left by the engine braking actuation rod, without the help of the selector cam (which follows the depression of the accelerator pedal).
In the "L" position a minimal pedal pressure will cause a change in the transmission speed, since the engine braking valve immediately acts on the primary pressure regulating valve.



P3M31AB01

1. "L" position
2. Sliding sensor
3. Pulley ratio (low)
4. Pulley ratio (high)
5. Engine braking lever
6. Engine braking piston
7. Pitot pressure
8. Safety valve
9. Modulation linkage
10. To primary pulley
11. Circuit pressure
12. Lubricating valve
13. Primary pressure regulation valve
14. Spring
15. Coil
16. Selector cam
17. Engine braking actuation rod
18. Engine braking valve
19. Lubrication pressure
20. To outlet

The position of the primary pulley sliding bearing is sensed by the engine braking lever. When the vehicle speed is under the line A in the figure below, the coil (14) moves to the right. This action in itself forces a reduction of the engine RPM when the vehicle speed decreases, as can be seen in the same figure (A-B).
Since the pulley ratio is high (low velocity), the effect of the engine braking bècomes too pronounced if the vehicle speed reduces along line A-A'.



P3M32AB01

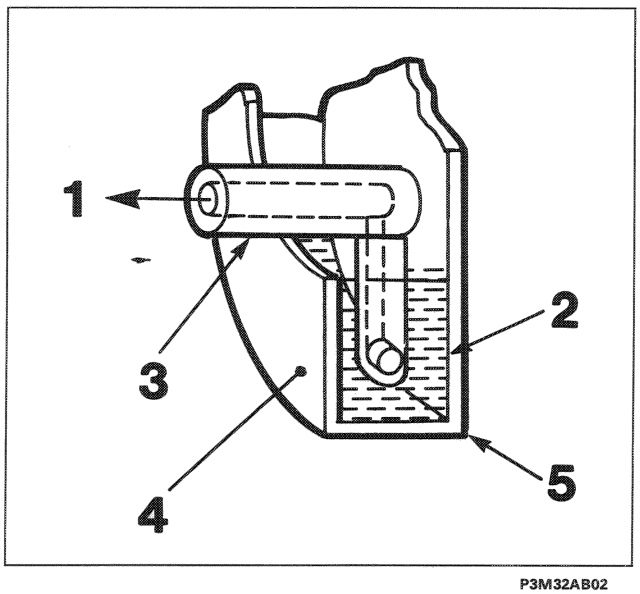
1. Engine speed
2. Low vehicle speed
3. "D" position with maximum throttle opening
5. Top vehicle speed
6. Vehicle speed

Moreover, if the selector cam moves the transmission control valve in excess of the displacement caused by the engine braking actuation rod, then the vehicle can move at a speed above that shown by the dotted line in the figure. The result is that, in the "L" position, the vehicle speed can vary within the hatched area of the velocity map.
This velocity range cannot be achieved by a conventional automatic transmission, and allows top speed to be reached whilst allowing engine braking similar to a manual gearbox at all vehicle operating speeds.

INPUT SIGNALS

Engine RPM sensing (Pitot pressure)

A Pitot tube is contained within a chamber that rotates with the primary pulley. It consents measurement of the hydraulic pressure head, which is proportional to the square of the engine RPM (in this transmission the engine is connected directly to the primary pulley).
In the "R" position, oil cannot enter the Pitot tube, since the primary pulley rotates in reverse and the tube nozzle is L-shaped, preventing oil from entering it. The pulley ratio therefore remains unchanged.



P3M32AB02

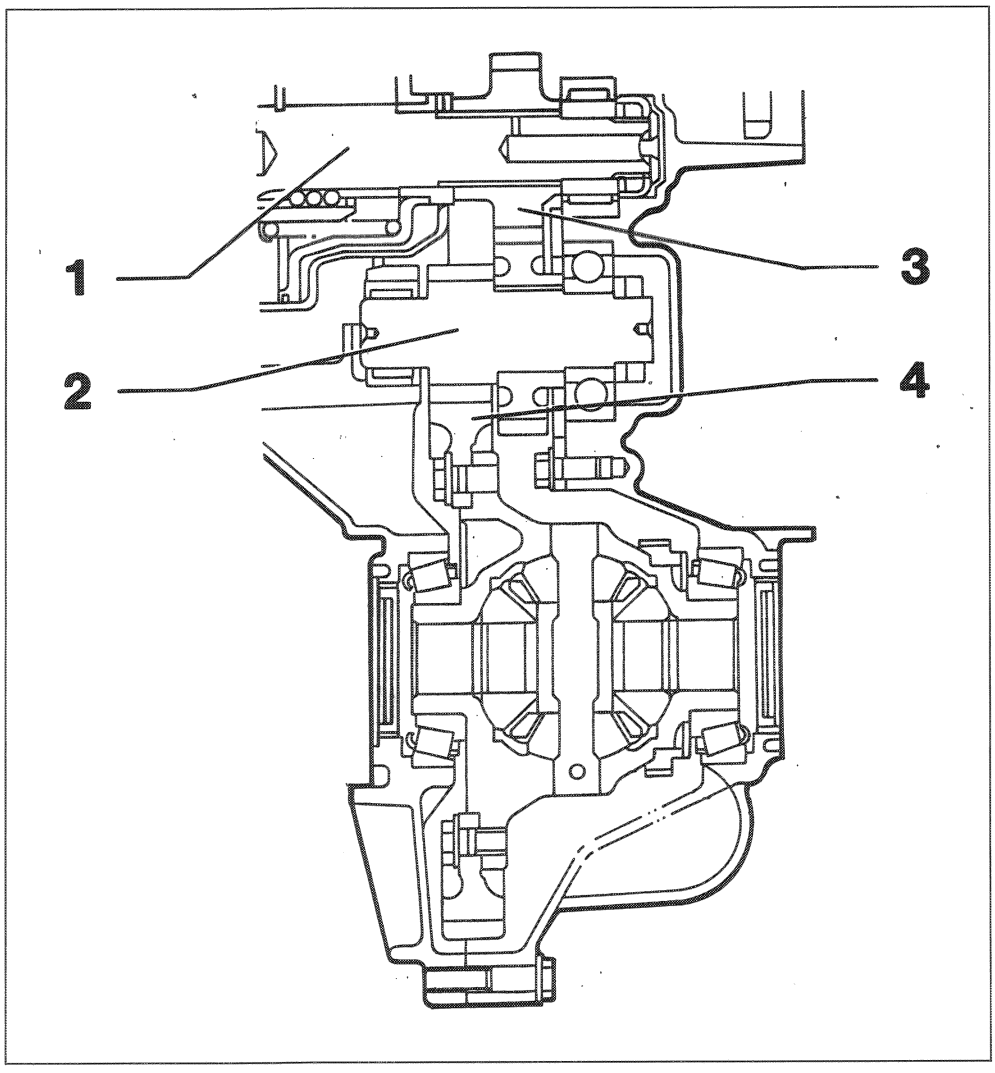
1. Pitot pressure
2. Oil rotating with the pulley
3. Fixed to the transmission casing
4. Chamber attached to pulley
5. Primary pulley external face

TRANSMISSION PRESSURE RETAINING VALVE

If the wheels lock under braking then the Pitot pressure cannot be generated and the transmission control valve moves to the left. The oil drains out and the pulley ratio changes.
To resolve this problem, the pressure retaining valve stabilises the pulley ratio before and after releasing the brake to avoid the jerk caused by a ratio change. The pressure retaining valve impedes oil discharge, and hence maintains constant oil pressure at the primary pulley.

ECVT REDUCTION GEAR SYSTEM AND COOLING SYSTEM

The reduction gear system has two stages: primary reduction and secondary reduction. Both stages use helical gear pairs.
The differential is identical to that of a manual transmission.



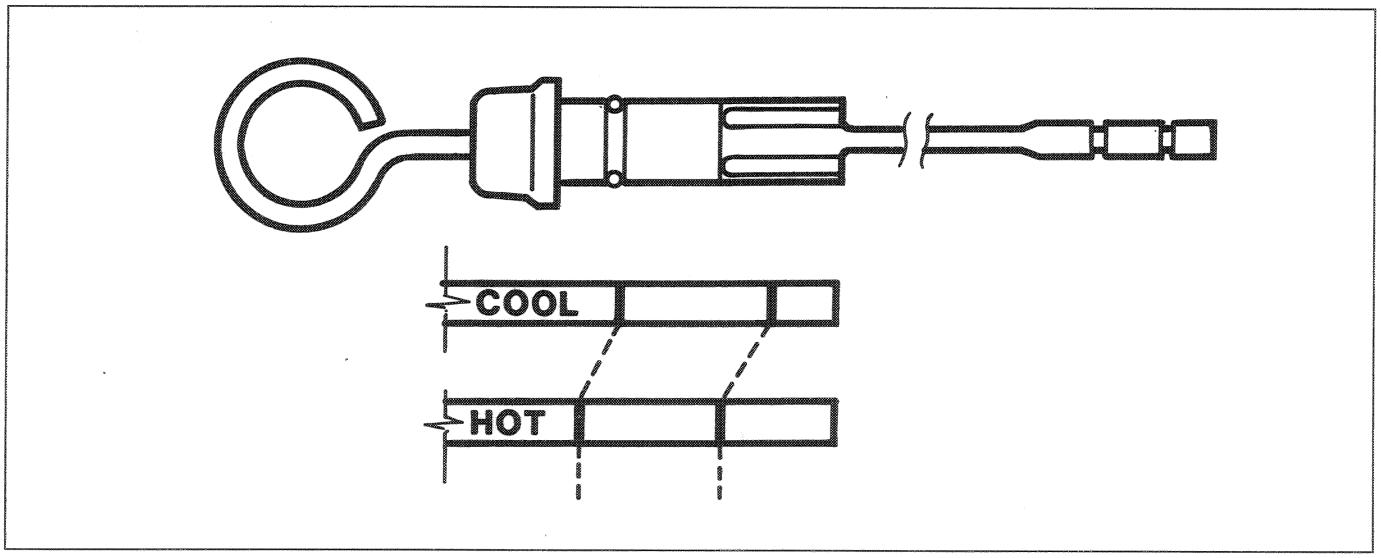
P3M33AB01

1. Secondary pulley
2. Idler pinion (drop gear)
3. Primary reduction
4. Secondary reduction

The cooling system consists of a separate oil cooler, rigid pipes and flexible tubes. The lubricating oil recirculates in the cooling circuit and passes through the cooler.

NOTES AND RECOMMENDATIONS

1. Due to the nature of the transmission, the engine cannot be started by pushing or towing the vehicle
2. When stationary on an incline, do not attempt to hold the vehicle by revving the engine. This practice overheats the electromagnetic clutch, resulting in possible component damage.
3. When stall-testing the engine, do not hold maximum throttle for more than 5 seconds.
4. The transmission fluid must be periodically replaced, as detailed in the service manual. Always use the correct oil type, do not mix it with other products.
5. The valves contain high tolerance components, when cleaning them use a clean, lint-free cloth.
6. When reassembling the metal belt ensure that the arrow on the bevelled side of the steel blocks lines up with the rotation direction.
7. Checking oil level.
   Oil level checks must be performed with the engine idling, the vehicle on level ground and the selector lever in "P" or "N". Use the dipstick provided.
   The minimum and maximum oil levels are shown on one dipstick face for hot oil, the other face is for cold oil:
   - Use the COOL face when the transmission is at 20-40 °C
   - Use the HOT face when the transmission is at 60-80 °C



P3M34AB01

NOTE *Use only Fiat TUTELA CVT oil*