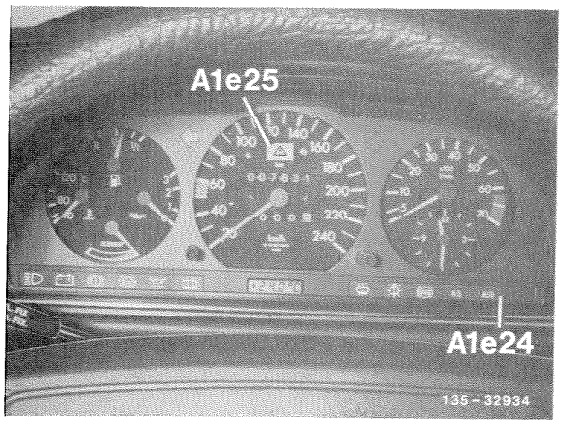
A. General

Vehicles with conventional differentials have a significant traction disadvantage when one of the driven wheels starts to spin due to ice, gravel or sand on one side.

In this case the torque from the engine is transferred by the differential without limited slip to the spinning wheel and the other wheel remains stationary making it impossible to start the vehicle moving. Although limited slip differentials with an extremely high locking effect eliminate this problem, they also lead to significant losses in the vehicle stability, especially in curves or during braking, because the differences in the wheel speeds resulting from direction changes cannot be compensated sufficiently.

The **automatic locking differential (ASD)** eliminates the disadvantages of a conventional differential without the disadvantages of a permanent differential lock.

The automatic system activates the lock only when required on the basis of objective measurements eliminating the human error factor. The electronic control operates with virtually no delay. Activation of the lock up to approx. 38 km/h (up to 04/87), 30 km/h (from 05/87 to 02/89) or 26 km/h (starting 03/89) and an increased slip of the drive wheels is indicated optically on the ASD warning lamp (A1e25) in the speedometer over the entire speed range.



135–32934

A1e24 ASD Malfunction Indicator Lamp
A1e25 ASD warning lamp

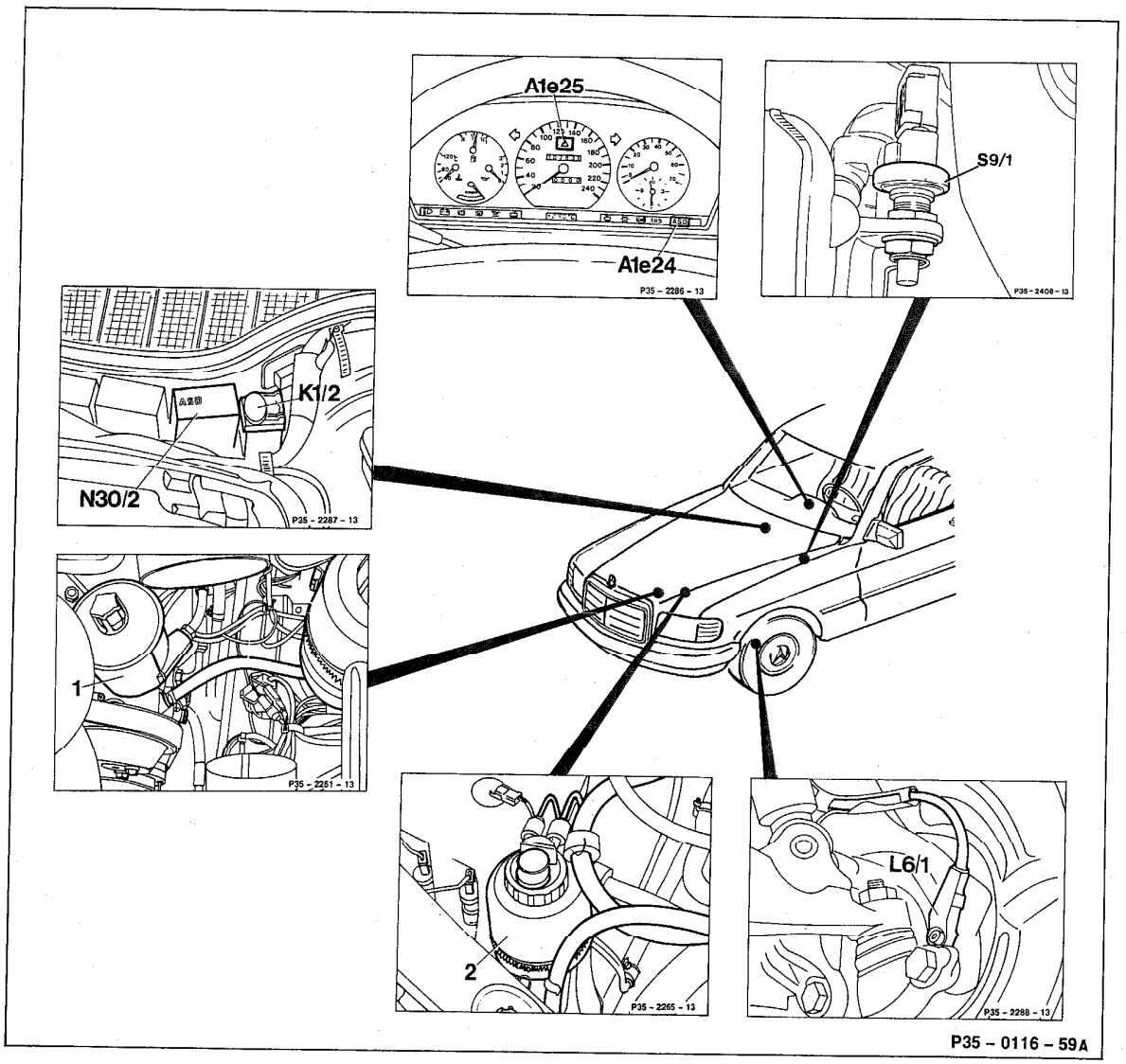
This signals to the driver that the vehicle is approaching its dynamic limits giving the driver an opportunity to better adapt his driving to the road conditions. This is a significant contribution to increasing active safety.

Characteristics:

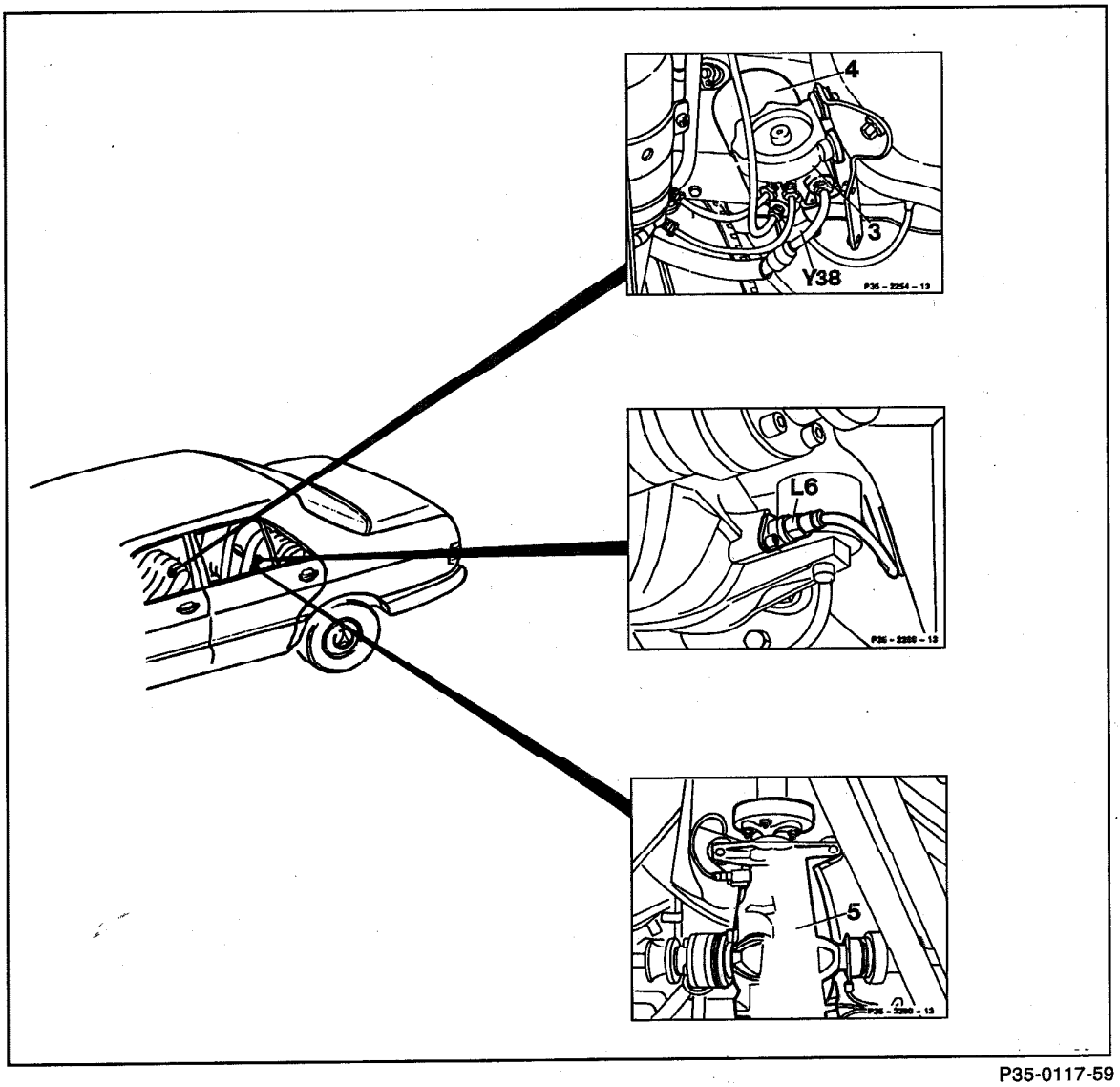
- Basic function same as limited slip differential (locking effect approx. 35 %).
- Hydraulically actuated auxiliary lock switches automatically.
  This provides a 100 % locking effect as long as the locking moment is higher than the moment which can be transferred to the road.
- Switching conditions for lock-up are measured electronically.
- Activation of lock and increased wheel slip are indicated optically.
- The directional stability during braking is maintained by switching off the auxiliary lock thereby assuring full effect of the anti-lock braking system (ABS).

The automatic locking differential consists of the following components:

Electronic components	Hydraulic system	Mechanical system
3 vehicle speed signal sensors	Oil reservoir	Rear axle differential housing with limited slip differential
Control module	Pressure oil pump	
Brake light switch	Hydraulic unit	
ASD warning lamp	Ring cylinder	
ASD Malfunction Indicator Lamp		


A1e25
A1e24
P35 – 2286 – 13
S9/1
P35 – 2408 – 13
K1/2
N30/2
P35 – 2287 – 13
1
P35 – 2281 – 13
2
P35 – 2265 – 13
L6/1
P35 – 2288 – 13
P35 – 0116 – 59A

P35-0116-59A



P35-0117-59

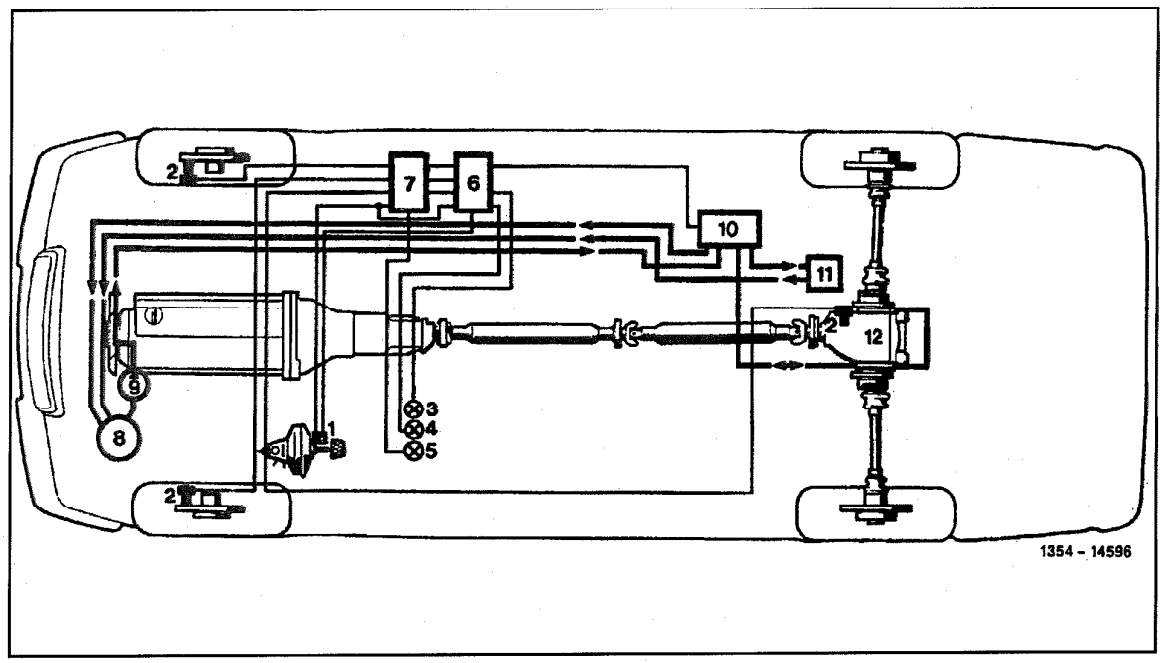
Overall function

The signals from the vehicle speed signal (VSS) sensors on the front wheels and on the rear axle differential housing are transferred to the control module where they are processed to obtain the average speed of the front wheels and rear wheels. Differences in the speeds between the front and rear wheels are recognized as slip by the control module, which sends a switching signal to the solenoid valve in the hydraulic unit when a certain limit is exceeded.

Within a fraction of a second the pressurized hydraulic oil travels from the reservoir to the rear axle differential housing. The compensation effect between the two rear wheels is limited by the initial hydraulic pressure on the multi disc clutches. The torque from the spinning wheel, which can no longer be transferred to the road, is then transferred to the wheel with traction.

The ASD switching logic unit is designed according to the following principles:

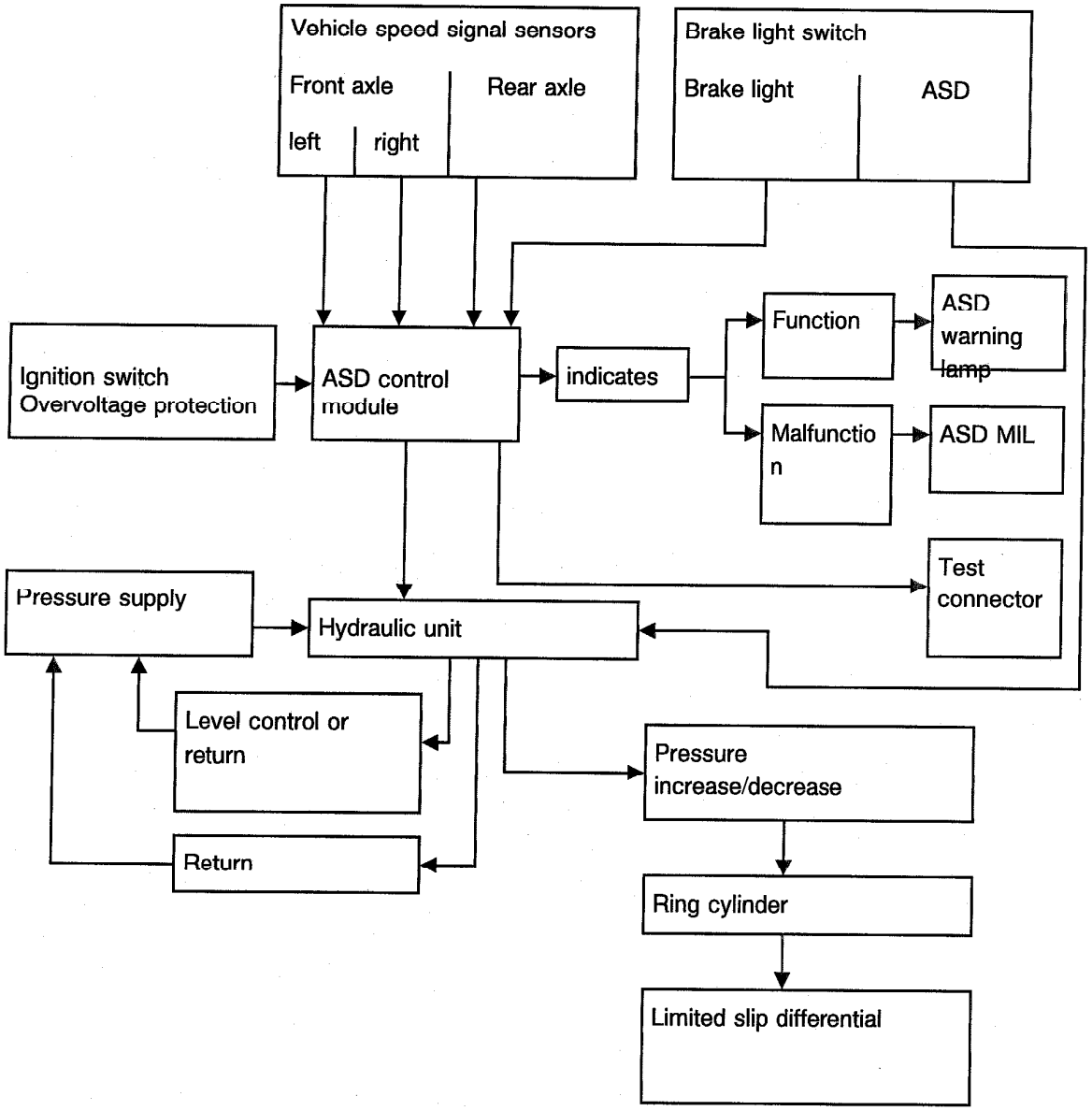
- During acceleration at speeds below 23 km/h the lock is actuated hydraulically (see "Function schematic" for modified actuation speeds). During deceleration the lock is not engaged for reasons of driving stability.
- At higher speeds a significant improvement in the traction is not to be expected. For this reason the lock is released above 26 km/h in favour of the higher driving stability (see "Function schematic" for modified release speeds).
- The basic self-locking function of the differential (limited slip) provides improved traction even at higher speeds.
- At speeds below 23 km/h the hydraulic lock is released when the actuation criteria are not fulfilled (speed difference between front/rear wheels less than 2 km/h).
- The ASD function is switched off immediately when the vehicle starts to decelerate and/or when the brakes are applied. This assures maximum driving stability and full effect of the ABS system.
- A "repeat effect" is programmed into the control module for starting up. This means that the computer recognizes an unsuccessful attempt to put the vehicle into motion and keeps the lock actuated for the next startup attempt.
- A diagnosis program is integrated into the control module for monitoring the vehicle speed signal sensors, the solenoid valve and the brake light switch as well as the computer. If an error is detected, the ASD Malfunction Indicator Lamp in the instrument cluster illuminates. The hydraulic lock is then no longer actuated for safety reasons.



1354-14596

1	Brake light switch	7	ABS control module
2	Vehicle speed signal sensors, front and rear wheels	8	Oil reservoir
3	ASD Malfunction Indicator Lamp	9	Pressure oil pump on engine
4	ASD warning lamp	10	Hydraulic unit
5	ABS control	11	Level control
6	ASD control module	12	Rear axle differential housing

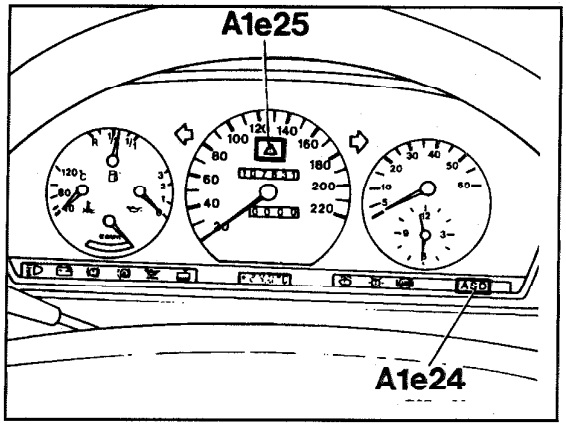
Overall function, electronic – hydraulic – mechanical systems



Driving with ASD, ASD Malfunction Indicator Lamp and ASD warning lamp

Two indicators with various symbols are located in the instrument cluster.

When the ignition switch is switched to position 2 the ASD warning lamp (A1e25) and yellow ASD Malfunction Indicator Lamp (A1e24) on the instrument cluster illuminate and then extinguish when the engine is running.



P35-2251-13

If the ASD Malfunction Indicator Lamp (A1e24) illuminates with the engine running, a malfunction is present in the circuit. This fault is stored in the ASD control module for later recovery. It can be retrieved via the ASD Malfunction Indicator Lamp (A1e24) with the aid of the test connector in the units compartment. The number of flash impulses indicates the source of the fault (see test program).

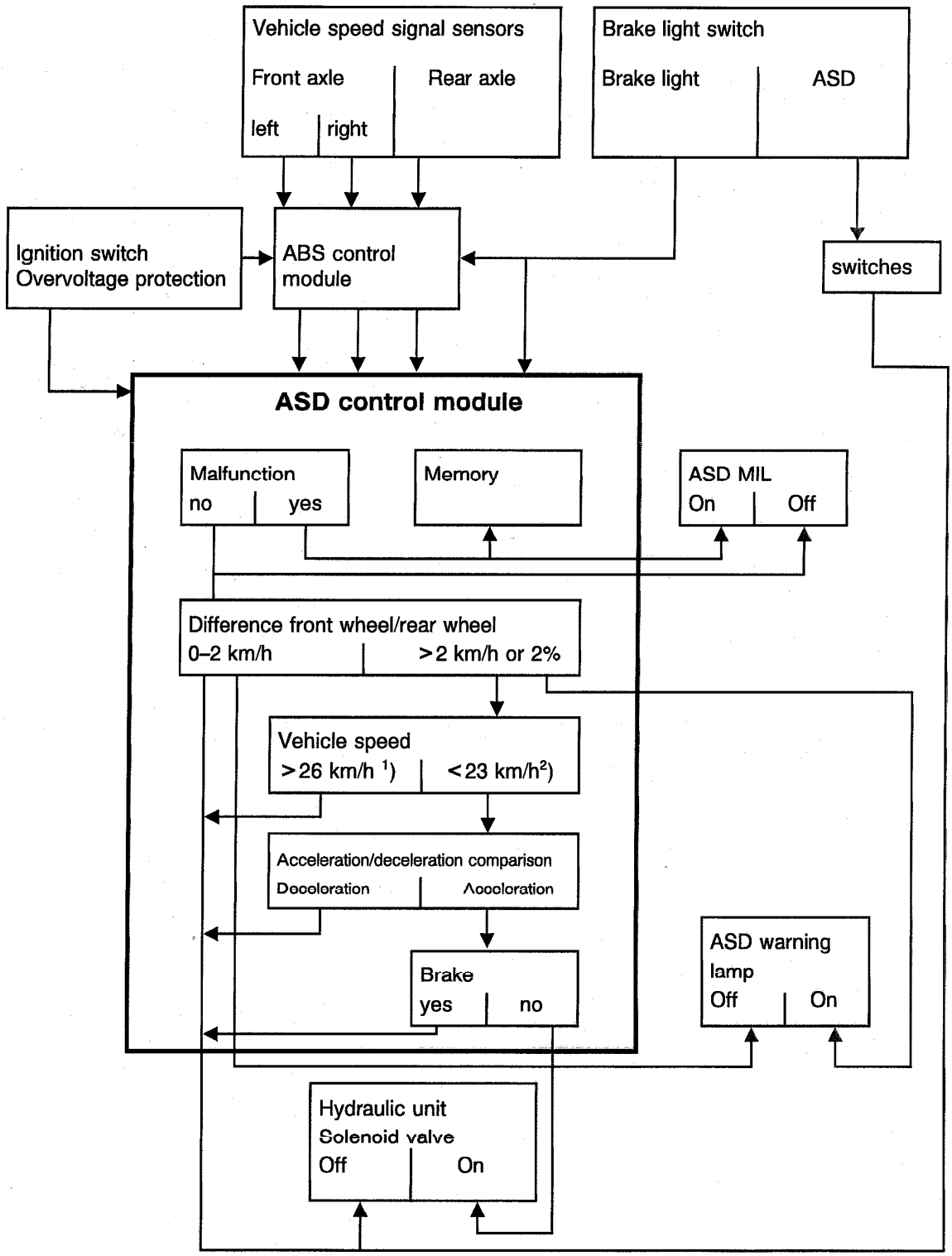
The ASD warning lamp (A1e25) is controlled via a plug connector on the rear of the instrument cluster with 4 pins (up to approx. middle 1989) or 3 pins. The brightness of the ASD warning lamp (A1e25) is reduced when the lights are switched on so that it does not disturb the driver when driving at night.

Vehicles with winter tires

On vehicles with winter tires the ASD warning lamp (A1e25) may illuminate momentarily at outdoor temperatures above 20 °C when the vehicle is accelerated sharply or the transmission is shifted down. This is caused by the higher slip of the winter tires in comparison to summer tires resulting from the tread pattern and mixture. This phenomenon is normal. Modification on the ASD control module is not possible.

B. Electrical/Electronic systems

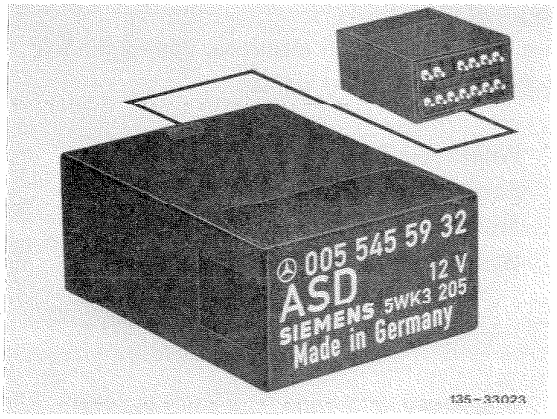
Function schematic, electrical system with ABS



1) Modified release speed: > 38 km/h up to 04/87, > 30 km/h from 05/87 to 02/89 and > 26 km/h starting 03/89.
2) Modified actuation speed: < 35 km/h up to 04/87, < 25 km/h from 05/87 to 02/89 and < 23 km/h starting 03/89.

ASD electronic control module

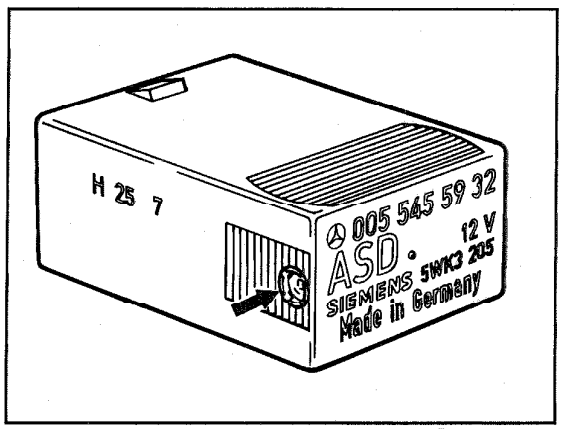
Up to 02/89 the electronic ASD control module consists of two circuit boards with printed conductors on both sides and components such as resistors, diodes, transistors and one microprocessor on one side. The two circuit boards are located above one another in the control module and are surrounded by a plastic housing.



135-33023

Starting 03/89 the 2nd generation control modules were introduced and all electronic components integrated on one circuit board.

Starting 05/87 a diaphragm was installed on the side of the housing to provide sufficient ventilation for the control module (arrow).



P35-2226-13

The control module processes the signals from the vehicle speed signal sensors and controls the solenoid valve in the hydraulic unit.

The electronic control module can be subdivided functionally into:

- Signal processing stage
- Logic stage
- Safety circuit

Signal processing stage

The signal processing stage converts the signals from the vehicle speed signal sensors or from the ABS control module to a form which can be used by the logic stage.

Before processing the input signals are filtered to eliminate errors in the wheel speed measurement resulting from production tolerances and motion at the steering knuckle. The wheel speed signals are converted to acceleration and deceleration signals for processing in the logic stage.

Logic stage

The logic stage of the electronic control module receives the following signals:

- Wheel speeds
- Speed difference Front/rear wheels (slip)
- Speed difference front right/front left

ASD is actuated only:

- at a speed difference > 2 km/h between the front and rear wheels (slip) during acceleration up to 26 km/h, or when the speed drops below 23 km/h (see function schematic).

ASD is not in function or is switched off when:

- the actuation threshold (slip) is less than 2 km/h
- the speed is higher than 26 km/h (see function schematic)
- during deceleration
- when brakes are applied

If the actuation threshold is exceeded for min. 0.5 seconds during startup and a speed of 5 km/h is not reached, the lock without slip remains actuated. This startup program is deactivated when the speed is higher than 10 km/h or after 7.6 seconds.

Deviations are recognized and corrected by the ASD control module:

- In curves without slip resulting from different curve radii for the front and rear wheels.
- Different tire circumferences resulting from tolerances and changes in the tire pressure.

The ASD warning lamp switches on when the switching criterion is present continuously for min. 0.4 seconds. In contrast to the solenoid valve the ASD warning lamp remains switched on over the entire speed range even during deceleration when the actuation threshold is exceeded. The switching criterion for the ASD warning lamp is still present up to a speed of 100 km/h when a difference of 2 km/h or 2% is present. The ASD warning lamp extinguishes only when the retention time has expired (as on solenoid valve), however only after illuminating for at least 1.5 seconds. The ASD warning lamp is also switched on when starting up with lock.

Safety circuit

The function of the safety circuit is to recognize erroneous signals in the electronic ASD control module and faults in the circuit outside of the electronic ASD control module. If a fault is recognized the system is switched off. This is indicated to the driver by the ASD Malfunction Indicator Lamp.

The control module recognizes the following faults:

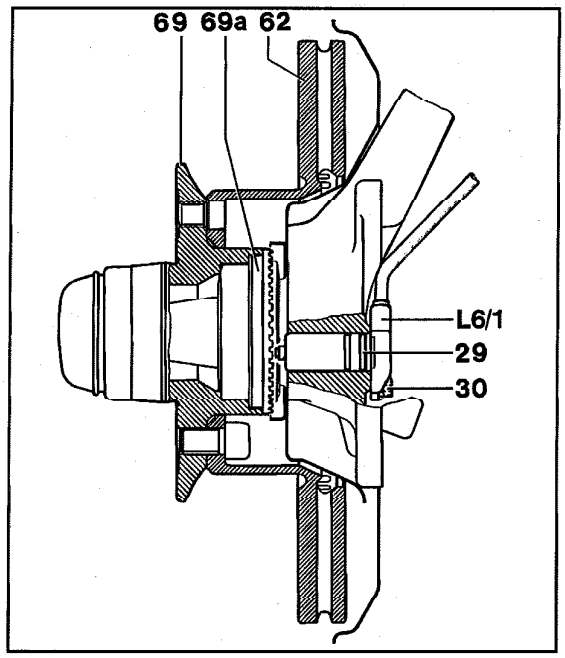
- Control module defective.
- Brake light switch, ASD switching function defective.
- Speed signal from front left or front right not present; contact interruption.
- Speed signal from rear not present; contact interruption.
- All three speed signals not present.
- Solenoid valve or brake light switch; brake light switching function defective.

Moreover the safety circuit continuously monitors the battery voltage. If the voltage drops below the specified voltage the system is switched off until the voltage returns to the specified range.

Vehicle speed signal sensors

The vehicle speed signal sensors also used for ABS consist of a magnetic core and a coil. They sense the wheel speed at the toothed rotors (69a on front axle or 49 on rear axle). The vehicle speed signal sensors and rotors must be positioned at a defined distance to one another. If the rotor turns, the magnetic field changes inducing an AC voltage in the coil. The frequency depends on the rotor speed.

The vehicle speed signal sensors on the front wheels (L6/1, left and L6/2, right) are located in the steering knuckles, the toothed rotor is integrated into the front wheel hubs (69).

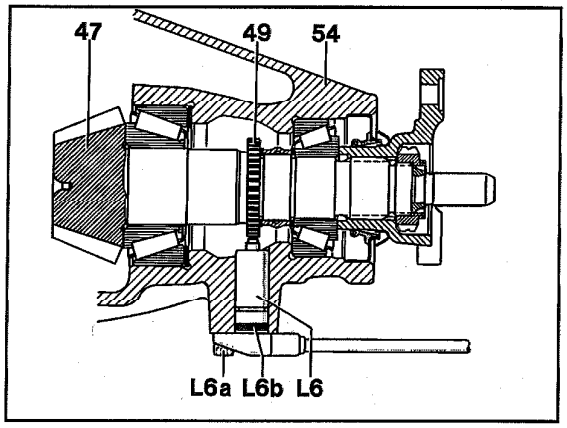


P33-0053-15

L6/1 Speed sensor, left front wheel
29 O-ring
30 Allen screw
62 Brake disc
69 Front wheel hub
69a Toothed rotor

The rear axle speed sensor (L6) is located in the rear axle housing (54) and the rotor (49) is pressed onto the drive pinion (47).

A special rotor with the appropriate number of teeth is required for each rear axle ratio. The average speed of both rear wheels is measured via the drive pinion.

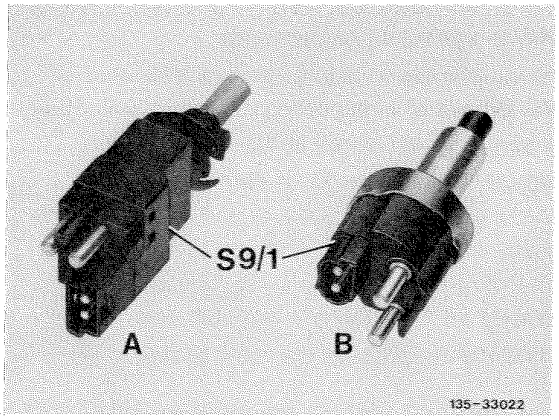


P42-0237-13

L6 Speed sensor, rear axle
L6a Allen screw
L6b O-ring
47 Drive pinion
49 Gear (rotor)
54 Rear axle housing

Brake light switch

The brake light switch (S9/1) has an additional contact for the ASD system.

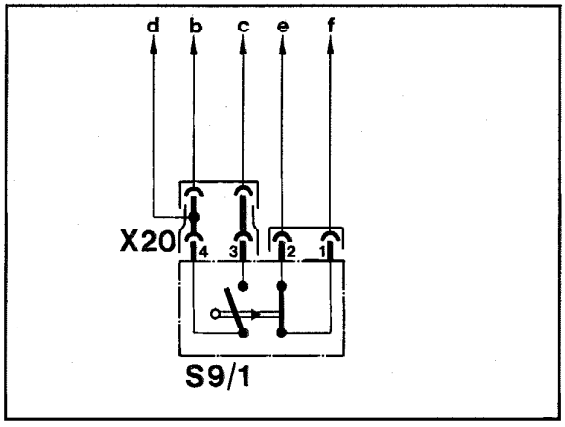


135-33022

S9/1 Brake light switch
A Model 124/201/129
B Model 126

A line leads from plug connector (X20) 4 mm pin dia. (brake light) to fuse 5, terminal 15 (c), a second to the brake light (b) and parallel (d) to the ASD control module (operating circuit).

The plug connector with 2.5 mm pin dia. (ASD) provides the power supply from the overvoltage protection relay (e) to the solenoid valve (f, rest circuit).



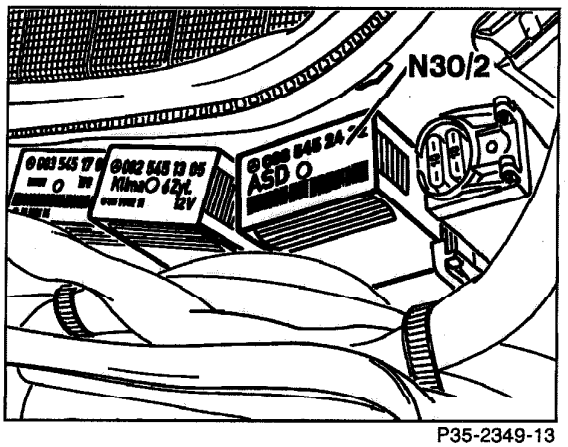
P35-0205-13

Cable harness and overvoltage protection relay

A separate cable harness is present for ASD with ABS.

To assure the function of the ASD system under all operating conditions the power is supplied via an overvoltage protection relay (K1/1 or K1/2). This relay is controlled via terminal 15 (ignition switch) and terminal 30. The integrated overvoltage protection is fused with 10 A to protect the electronic ASD control module from excessive voltage.

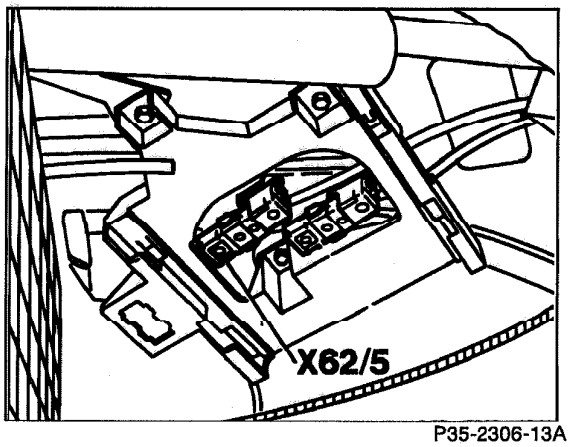
The cable harness is connected to the electronic ASD control module (N47 or N30/2) via the 14-pole plug connector.



P35-2349-13

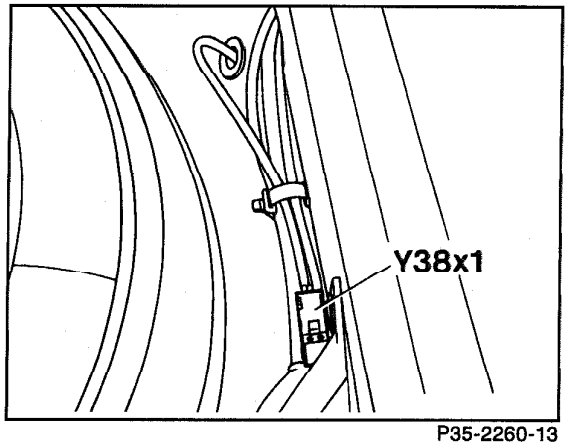
The cable harness with 2-pole plug connector (X62/5) leads from the control module to the solenoid valve in the hydraulic unit.

The first plug connector (X62/5) is located on the right side of the A pillar.



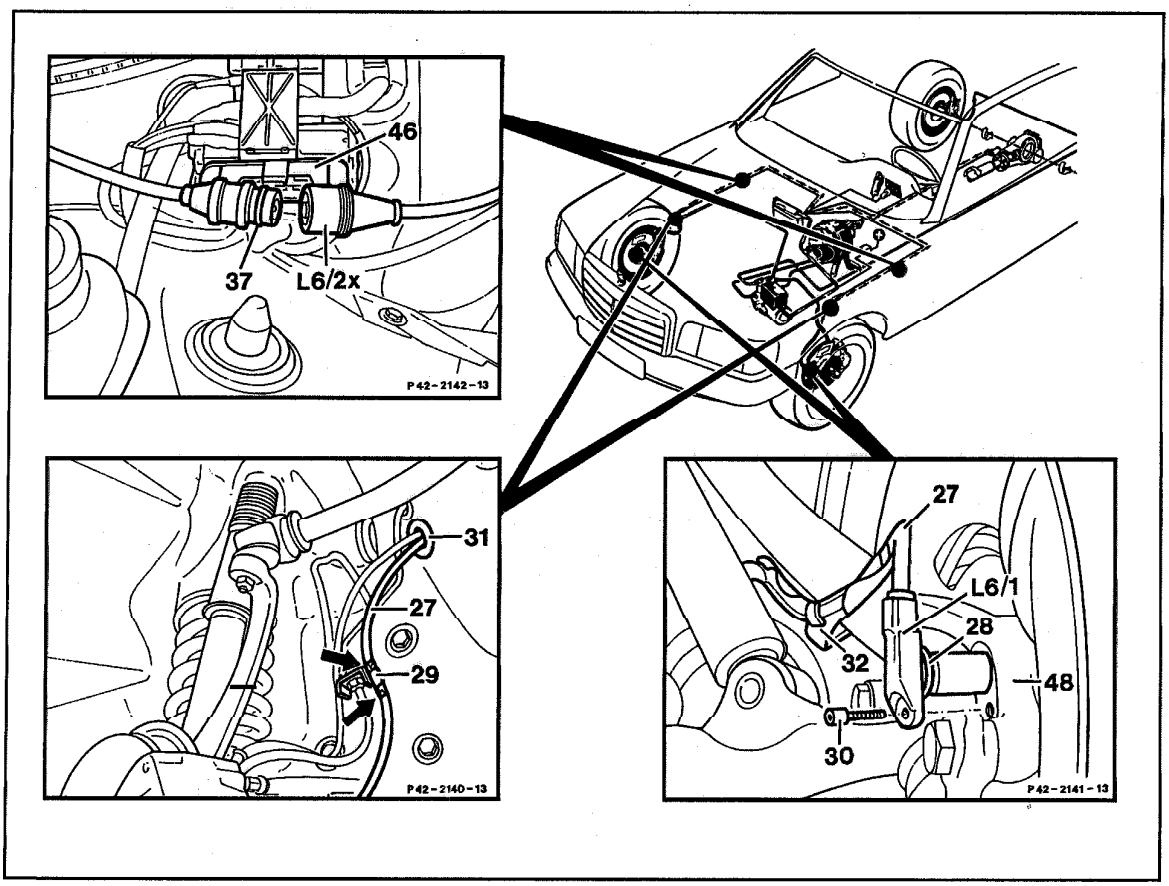
P35-2306-13A

The second plug connector (Y38/x1) is located on the right side in the spare tire recess.



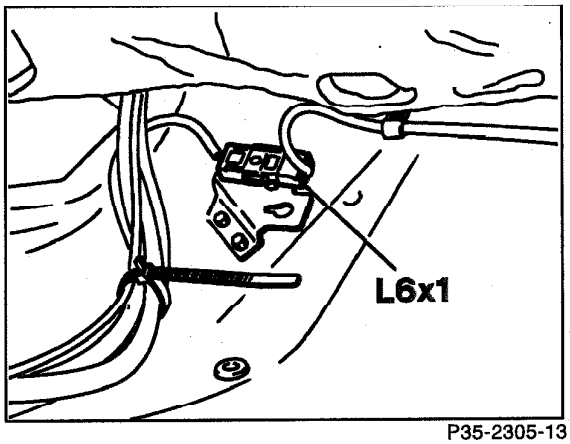
P35-2260-13

The vehicle speed signal sensors for the front wheels are connected to the cable harness with coaxial plugs (L6/2x). The line (27) from the speed sensor in the steering knuckle leads to the coaxial plug (L6/2x) in the engine compartment and is held by holders (29 and 32) on the steering knuckle and holders in the wheelhouse.



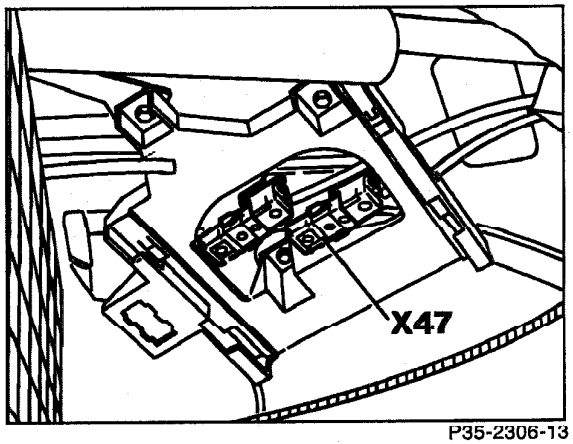
P42-0232-57

The line connector (L6x1) for the rear axle speed sensor (same as ABS) is located behind the rear seat backrest and connected to the cable harness.



P35-2305-13

An additional plug connector (X47) is located on the right side in the A pillar.

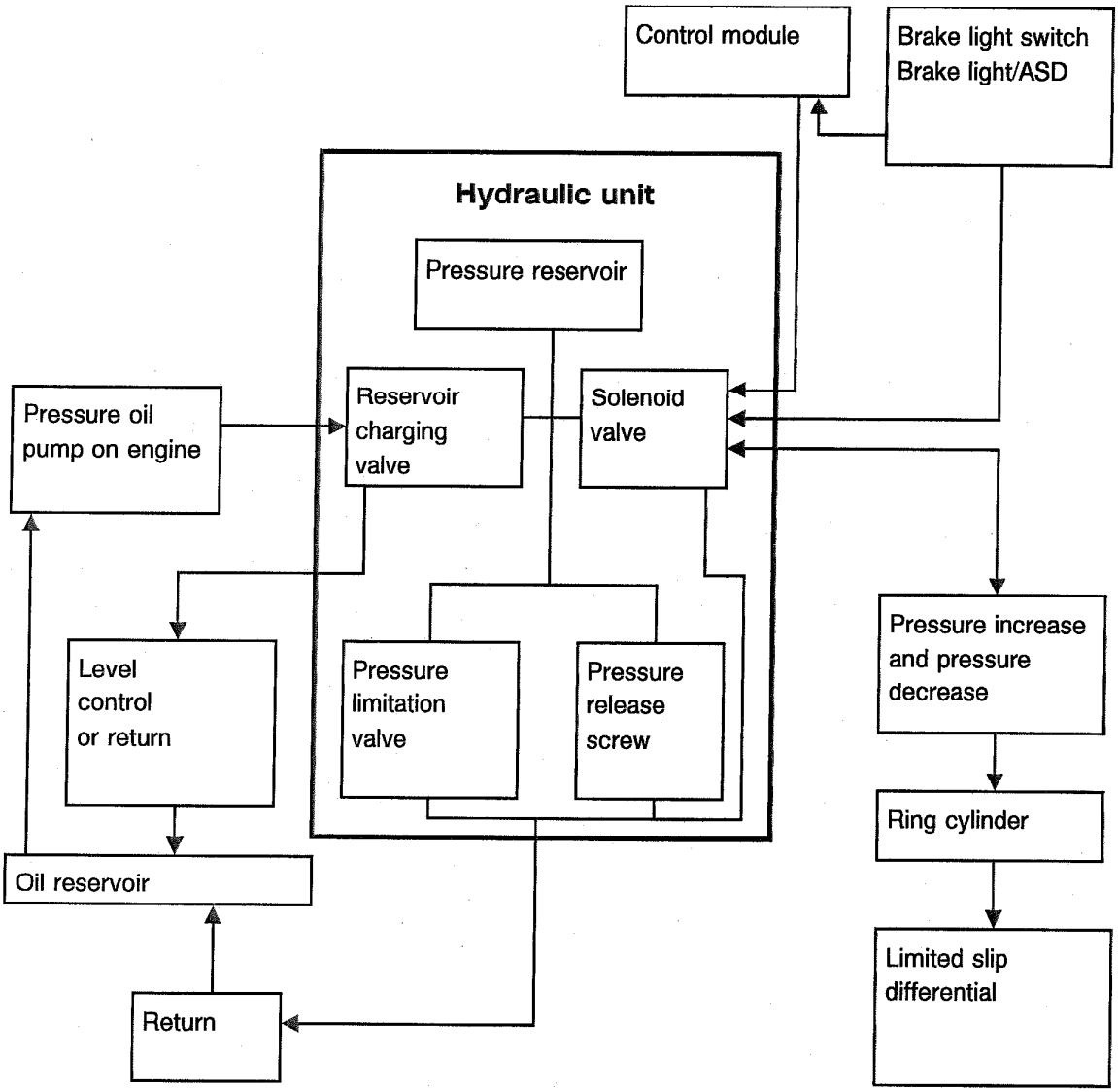


P35-2306-13

Electrical circuit diagrams
See ETM Model 126

C. Hydraulic system

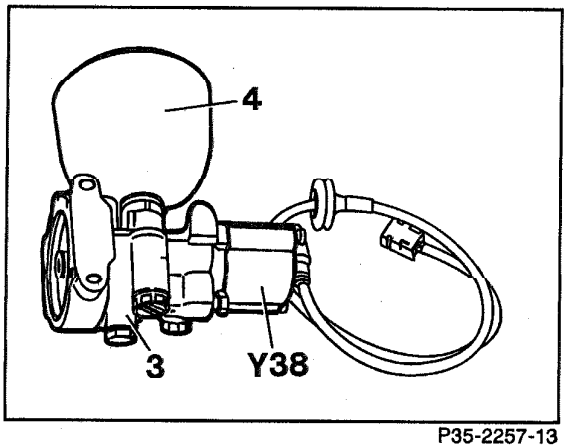
Function schematic, hydraulic system



Hydraulic unit

The hydraulic unit consists of the following components:

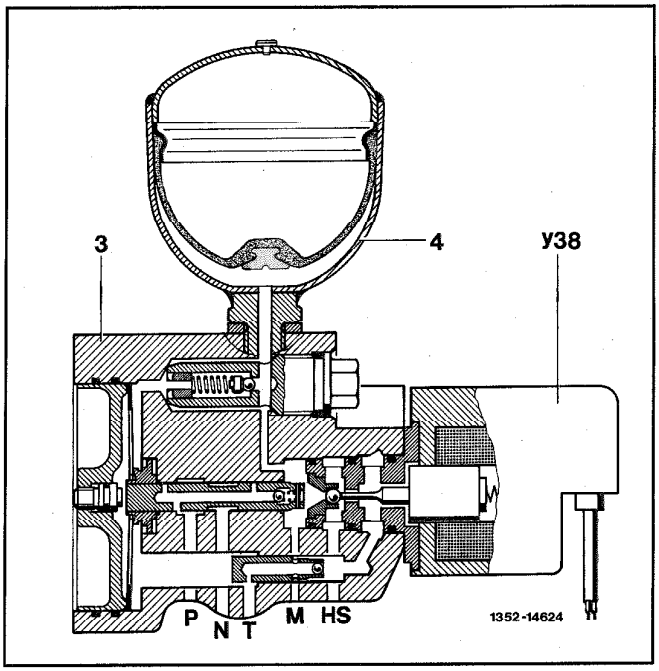
- Pressure reservoir (4)
- Reservoir charging valve (3) with pressure limitation valve and pressure release screw
- Solenoid valve (Y38)



P35-2257-13

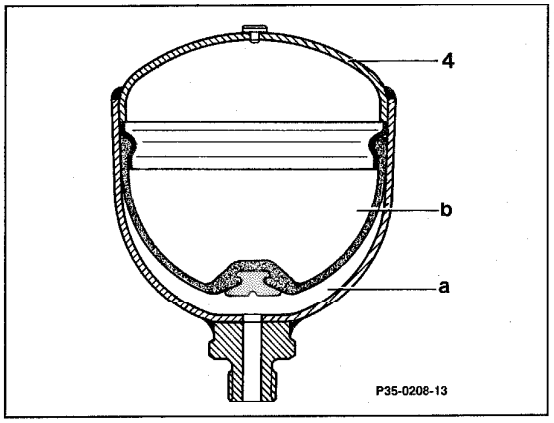
Pressure reservoir (4)

The spherical pressure reservoir (4) with the ASD lettering is screwed to the reservoir charging valve (3).



1352-14624

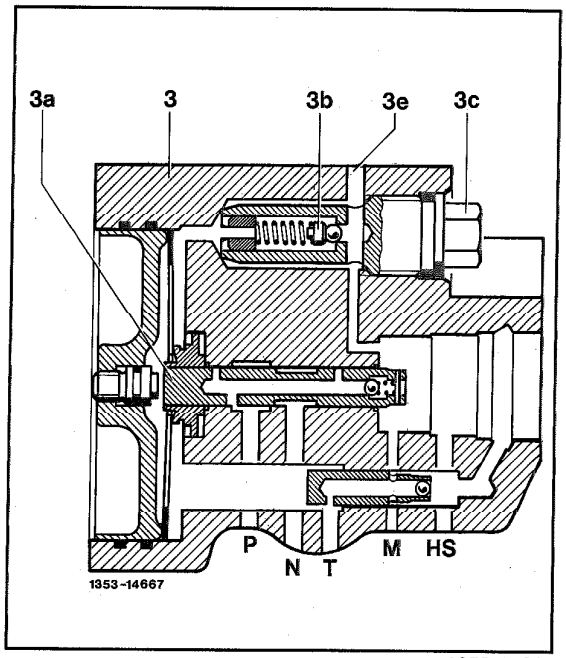
The inner design of the pressure reservoir corresponds basically to that of the spring-loaded diaphragm cylinder for the level control. The oil chamber (a) and gas chamber (b) are separated by a diaphragm. The gas pressure (nitrogen) is approx. 21 bar.



P35-0208-13

Reservoir charging valve (3) with pressure limitation valve and pressure release screw

The pressure charging valve (3) in the hydraulic unit regulates the pressure in the pressure reservoir (4) to a value between 27 and 33 bar. Upon reaching the maximum pressure of 33 bar the control valve (3a) in the reservoir charging valve switches and the oil flows through connection (N) and the return line back to the oil reservoir. On vehicles with level control the oil flows through the connection (N) and pressure line to the level control.



1353-14667

3	Reservoir charging valve
3a	Control valve
3b	Pressure limitation valve (integrated into pressure release screw)
3c	Pressure release screw
3e	Pressure reservoir connection
P/N/T/HS	Line connections
M	Test connection

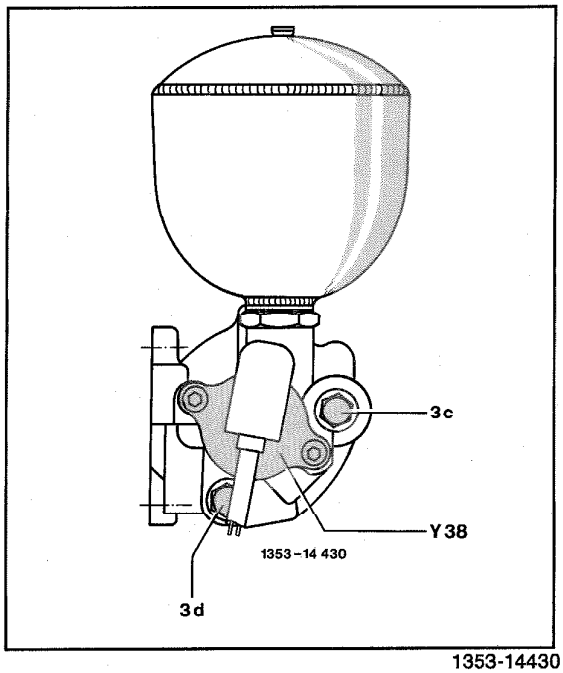
Pressure limitation valve (3b) integrated into pressure release screw

The hydraulic unit is protected against a system overload by a pressure limitation valve (3b). If the control valve (3a) malfunctions the pressure limitation valve prevents the pressure from increasing to beyond approx. 38 bar and the oil flows back to the oil reservoir through the reservoir charging valve connection (T) and the return line.

Pressure release screw (3c)

The pressure must be released before performing any type of work on the hydraulic system. For this purpose screw out the pressure release screw (3c) approx. 1/2 turn. The oil flows back into the oil reservoir through the reservoir charging valve connection (T) and the return line.

Tightening torque 20 Nm.

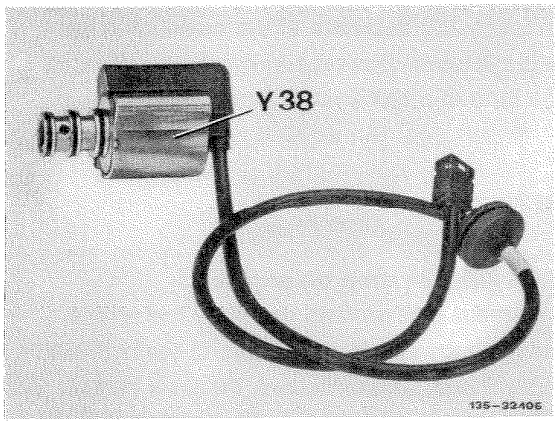


1353-14430

3c	Pressure release screw
3d	Plug for test connection (M)
Y38	Solenoid valve

Solenoid valve (Y38)

The automatic locking differential (ASD) is actuated or released hydraulically within a few milliseconds by the ASD control module via the rapidly switching solenoid valve (Y38).

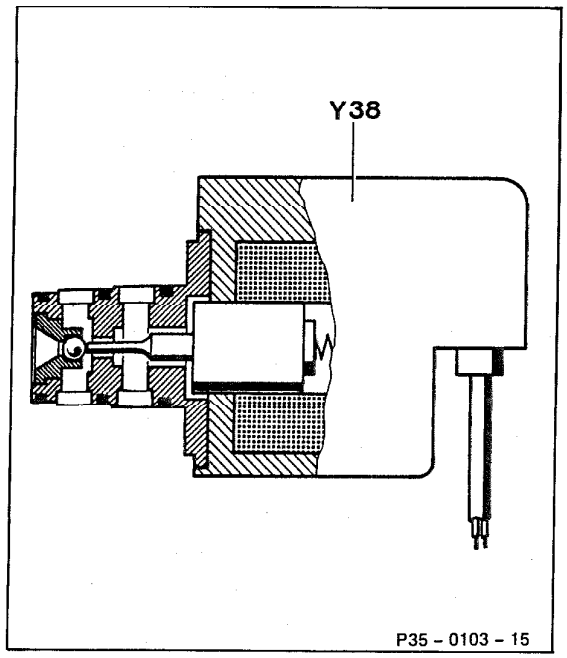


135-33495

When the solenoid valve (Y38) opens pressure is applied to both ring cylinders on the rear axle housing actuating the automatic locking differential (ASD). When the solenoid valve closes the oil flows back to the oil reservoir through the solenoid valve, reservoir charging valve connection (T) and the return line. The two ring cylinders are no longer under pressure and the automatic locking differential (ASD) is released.

When the operating brake is actuated the solenoid valve closes as a matter of principle and the pressure in the ring cylinders is released. The automatic locking differential (ASD) is released assuring the stability of the vehicle.

When the engine is started the solenoid valve is actuated momentarily resulting in a momentary increase and decrease of the pressure in the ring cylinders. This procedure can be heard in the form of a soft knocking noise.

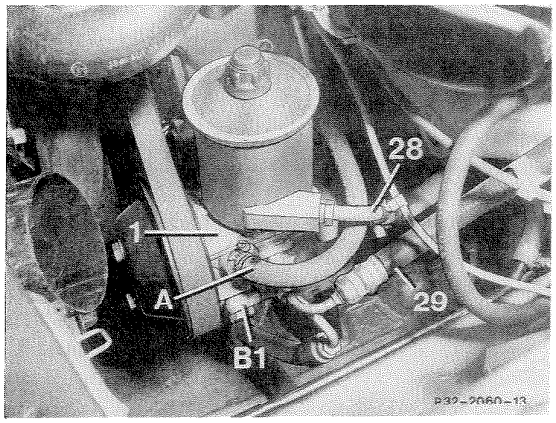


P35-0103-15

Pressure oil pump on engine

The radial piston pump driven by the engine provides the required pressure to the hydraulic system and, when installed, the level control. The pressure oil supply is designed so that the ASD hydraulic unit is supplied on a priority basis. When additional pressure is no longer required to fill the ASD pressure reservoir and the level control (when present), the oil flows back to the oil reservoir through reservoir charging valve connection (N) and the return line.

When the engine is running the pressure oil pump sucks hydraulic oil out of the oil reservoir through the intake line (A) and fills the hydraulic unit pressure reservoir via the high-pressure expansion hose, the pressure line (B1) and the reservoir charging valve connection (P). On vehicles with level control the level control module is supplied with pressure via the reservoir charging valve connection (N) and the pressure line.



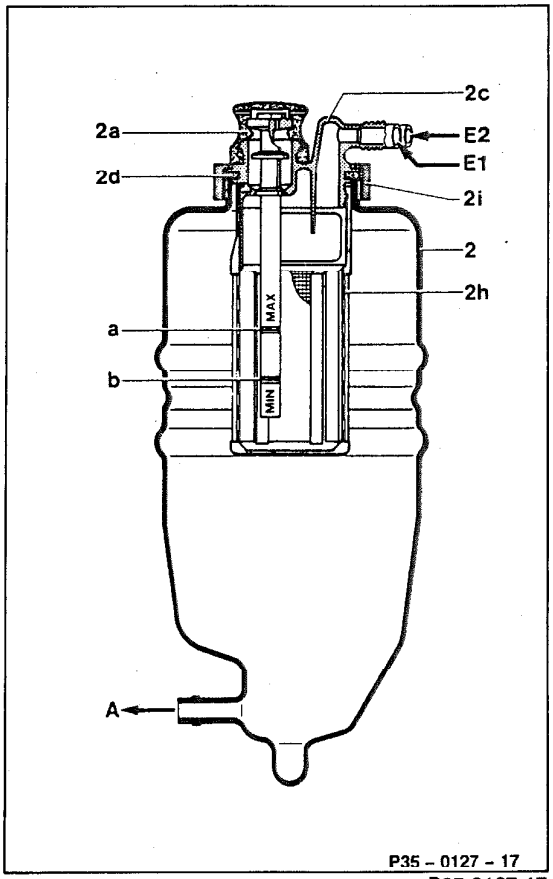
P32-2060-13

1 Dual pump VTP162 (power steering and radial piston pump)

Oil reservoir (2)

The plastic oil reservoir (2) located in the engine compartment is fastened resiliently on the mount. It is connected to the pressure oil pump via intake line (A) and to the ASD hydraulic unit and the control module for the level control (when present) via return lines (E1 and E2).

The hydraulic oil flowing back is filtered by a filter cartridge (2h) put onto the connection fitting for the return lines (E1 and E2).



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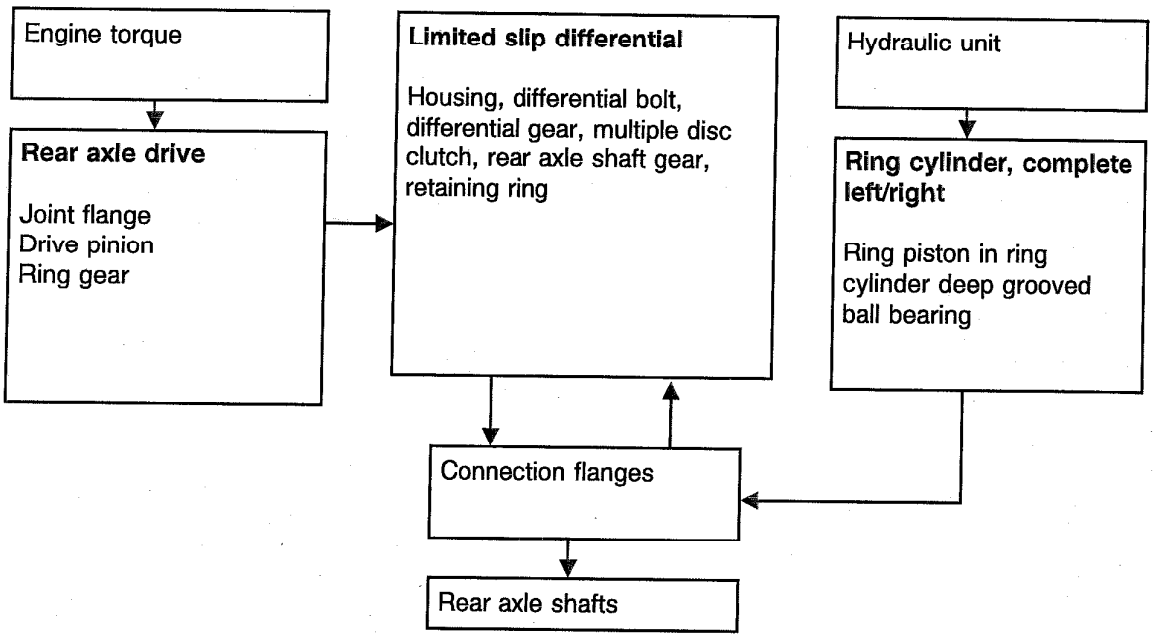
2	Oil reservoir
2a	Plug with oil dipstick
2c	Connection fitting
2d	Rubber gasket
2h	Filter cartridge
2i	Plug nut
a	Maximum mark
b	Minimum mark
A	Intake line, oil reservoir – pressure oil pump
E1	Return line, reservoir charging valve (connection T) – oil reservoir
E2	Vehicles without level control: return line Reservoir charging valve (connection N) – oil reservoir Vehicles with level control: return line Level control – oil reservoir

D. Mechanical system

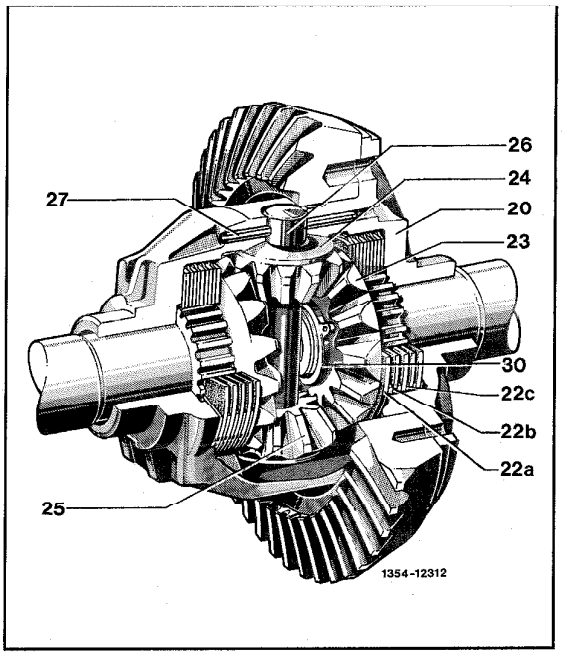
Function schematic, mechanical system



Rear axle differential housing

In addition the following components or modified components are located in the rear axle differential housing for the automatic locking differential:

- Rear axle housing with additional threaded bores at sides
- Connection flanges
- Deep grooved ball bearing
- Ring cylinders with ring pistons and seals
- Smaller radial shaft seals for connection flanges
- Oil baffle plate
- Hydraulic connection line
- Shorter rear axle shafts



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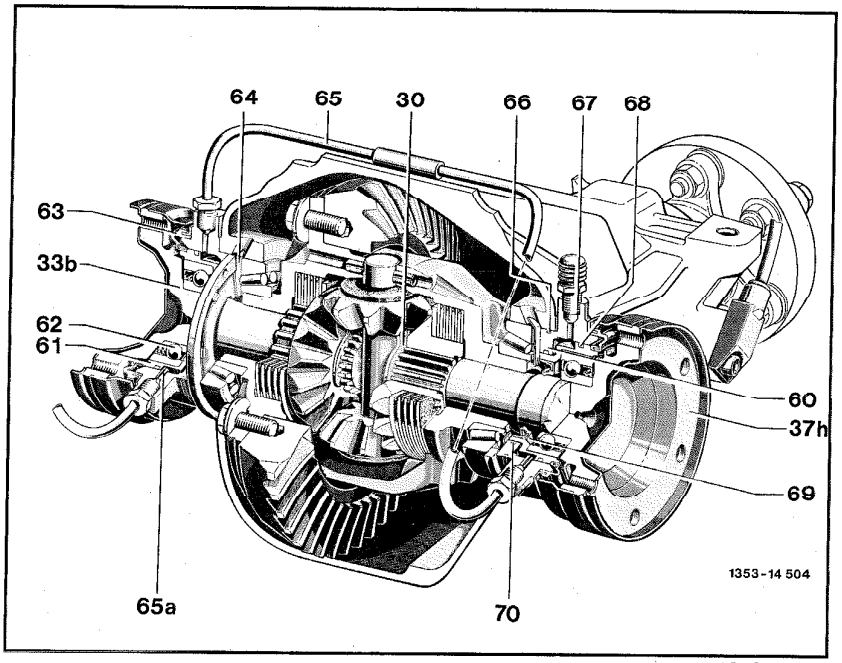
20 Differential housing
22a Friction disc with lining on one side
22b Friction disc without lining
22c Friction disc with lining on both sides
23 Rear axle shaft gear
24 Spherical disc
25 Differential bezel gear
26 Differential bolt
27 Clamping sleeve
30 Retaining ring



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30 Retaining ring
33b Connection flange
37h Cover for rear shaft
60 Ring cylinder
61 Ring piston
62 Deep grooved ball bearing
63 Cuff
64 Oil baffle plate
65 Hydraulic line
65a Clamping sleeve
66 O-ring (80×2)
67 Vent
68 O-ring (72×3)
69 Radial shaft seal
70 O-ring (63×2.5)

O-rings (66) provide the seal between the rear axle housing and ring cylinder. The connection flanges are sealed in the ring cylinders with the radial shaft seal (69). The deep grooved ball bearings (62) in the ring pistons (61) are sealed laterally and filled with long term lubricant.

An oil baffle plate (64) is installed on each side to assure oil supply to the tapered roller bearings for the differential as well as the connection flanges in the differential housing.

Ring cylinders

The ring cylinders are fastened on the side of the rear axle housing with two M8 Allen screws. The ring piston is sealed to the ring cylinder housing by two O-rings (68 and 70). The ring pistons are connected to the ring cylinder housing with a pressed-on cuff (63) for protection against dust and moisture.

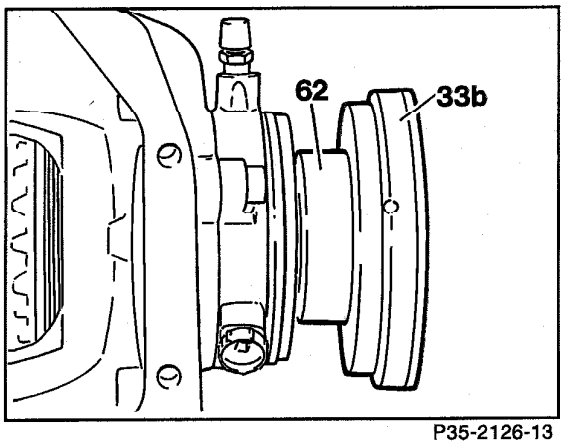
Function of ring cylinders

When the ring pistons in the ring cylinders are subjected to a hydraulic pressure of approx. 27–33 bar the two ring pistons move outward simultaneously. The resulting force is transferred to the rear axle shaft gears via the deep grooved ball bearings, connection flanges and retaining rings pressing the multi disc clutches together.

The resulting friction prevents compensation of the speed between the left and right rear wheels until the friction limit is exceeded.

Connection flange

Installation of the deep grooved ball bearing (62) in the ring cylinder made it necessary to increase the length of the connection flange (33b). The deep grooved ball bearing is pressed onto the connection flange.



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Rear axle shaft

The rear axle shaft is approx. 20 mm shorter than on vehicles without ASD due to the location of the ring cylinder including connection flange.