A. General information

The ABS anti-locking brake system (or electronic brake slip control) is one of the active safety elements of a vehicle for the purpose of decisively reducing the risk of becoming involved in an accident.

For this reason, the ABS is expected to meet the following demands:

1. The driving stability of the vehicle should be assured while braking both when the braking force is slowly increased up to locking limit and when suddenly increasing the braking force in the event of a panic stop.

2. As long as the vehicle speed is adequately below the curve limit speed, braking in a curve should be possible without impairing driving stability while maintaining full steerability (the curve speed is the speed at which a vehicle can be driven around a bend without engine power and just fast enough that it will not leave the road unter influence of centrifugal forces).

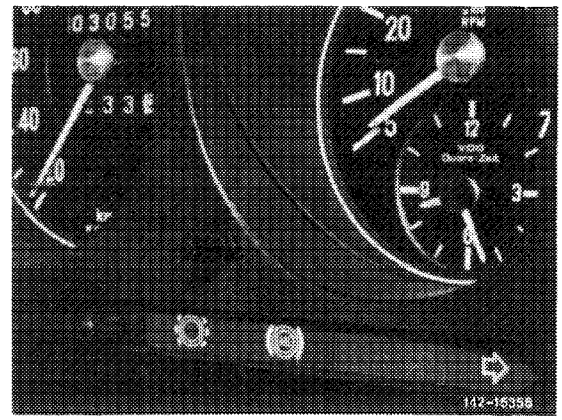
3. When the brake pedal is excessively operated to the extent that an uncontrolled braking system will result in locking of the wheels, the ABS will modify the braking pressure of the wheel brakes to the extent that the wheels are not locking and that instead the adhesion between the wheels and the road is optimally exploited.

Consequently, vehicles with ABS as compared with uncontrolled brake systems provide the following advantages when the brakes are fully applied:

- Higher driving stability.
- Better steerability.

B. Driving with ABS

When the ignition is switched on, the yellow indicator lamp with the symbols ABS in instrument cluster lights up and will go out when the engine is running. (Just like the charge indicator lamp). If the lamp does not go out, the electric on-board power supply may be subject to undervoltage or the power supply to the electronic control unit is interrupted. At approx. 5 km/h after starting, a self-testing routine will be started by ABS (bite). If a fault is found, the indicator lamp will again light up.



In the event of a permanent fault, e.g. a broken cable, the fault is stored in electronic control unit until the ignition is switched off. A timely restricted undervoltage in vehicle mains is not stored. That is, if the battery voltage is below 10.5 V when the ignition is switched on and the test speed is exceeded, the ABS will remain switched off until the charge from alternator increases the voltage to above 10.5 V. The warning lamp will go out then only.

Any braking in locking range initiated above 12 km/h can be controlled down to a speed of 5–7 km/h. This means that controlled braking begins only after the so-called control speed of 12 km/h has been exceeded. A modified electronic control unit is installed as of February 1984. The ABS is now operational as of 8 km/h and will control down to a speed of 3 km/h.

Attention!
When the warning lamp in instrument cluster lights up, the ABS is switched off and the vehicle can be braked without ABS control only. The conventional brake system remains operational. The vehicle should be checked and reconditioned in a Mercedes-Benz service station as soon as possible.

C. Layout

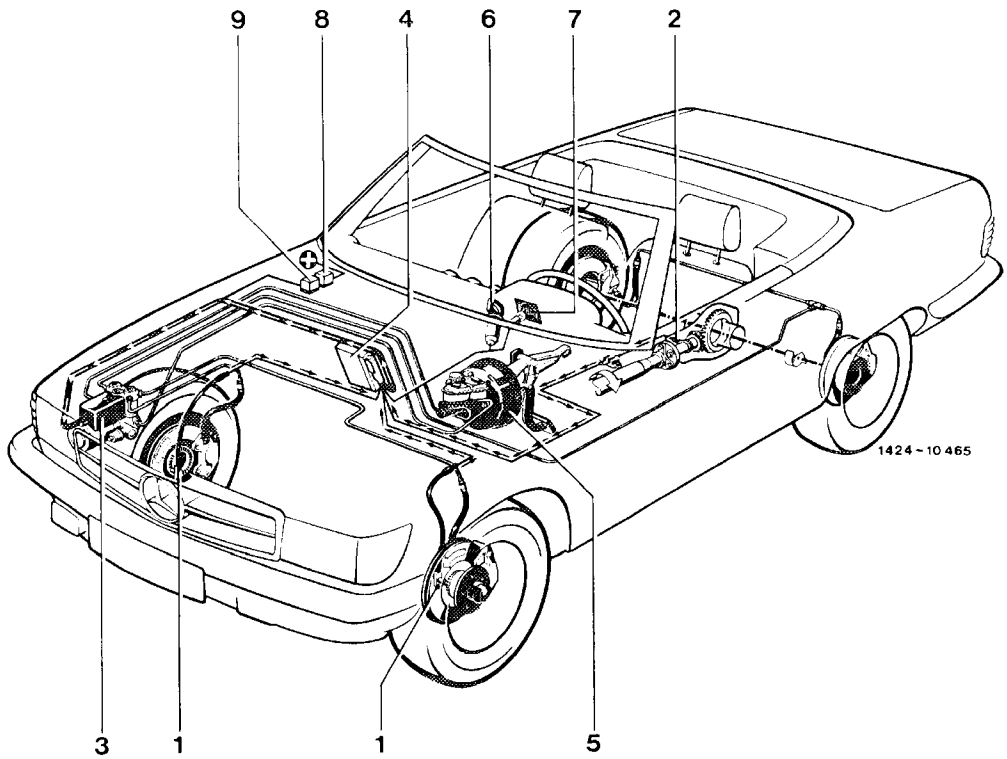
The ABS system comprises the conventional braking system known up to now and the following additional components:

a) Hydraulic unit

b) Speed sensor

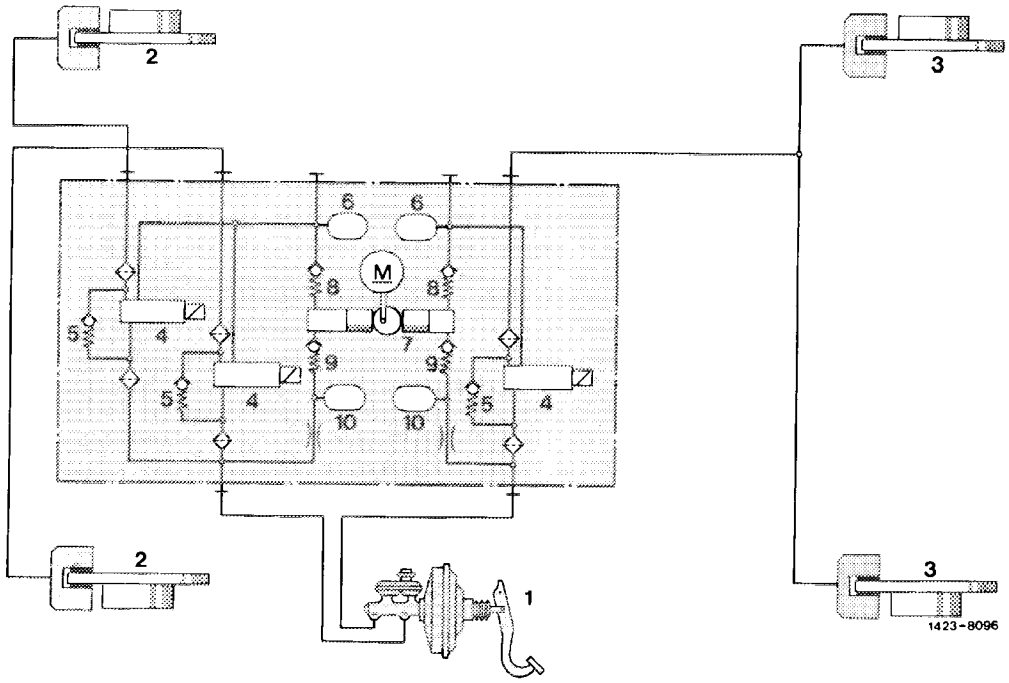
c) Electronic control unit

d) Harness with relay and overvoltage protection



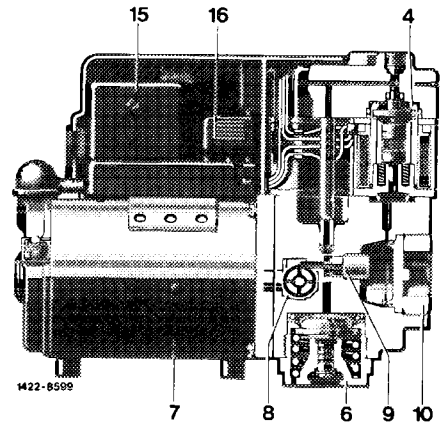
1 Speed sensor front axle
2 Speed sensor rear axle
3 Hydraulic unit
4 Electronic control unit
5 Brake unit with tandem main cylinder
6 Steering lock
7 Warning lamp in instrument cluster
8 Overvoltage protection
9 Relay for voltage supply of electronic control unit

a) Hydraulic unit



1 Brake unit with tandem main cylinder
2 Front wheel brake
3 Rear wheel brake
4 Solenoid valve
5 Check valve
6 Pump reservoir
7 Return pump
8 Pump input valve
9 Pump output valve
10 Silencer

Independent of the pressure in tandem main cylinder the hydraulic unit can change the fluid pressure to the brake calipers during control. However, the pressure increase with regard to the pressure introduced by the main cylinder is not possible.



4 Solenoid valve
6 Pump reservoir
7 Return pump
8 Pump input valve
9 Pump output valve
10 Silencer
15 Relay for return pump
16 Relay for solenoid valve

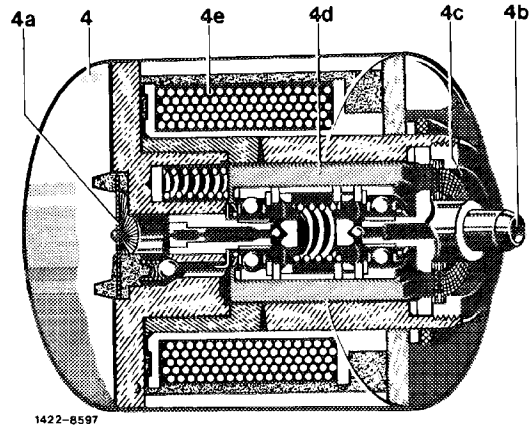
The hydraulic unit comprises three fast-switching solenoid valves. Of these valves, one each is associated with the lefthand or righthand front wheel brake and the third with the rear wheel brake.

By activating the valves with current of varying amperage, the brake fluid pressure in the individual calipers can be

increased = pressure build-up stage (no current)

held = pressure holding stage (half max. current)

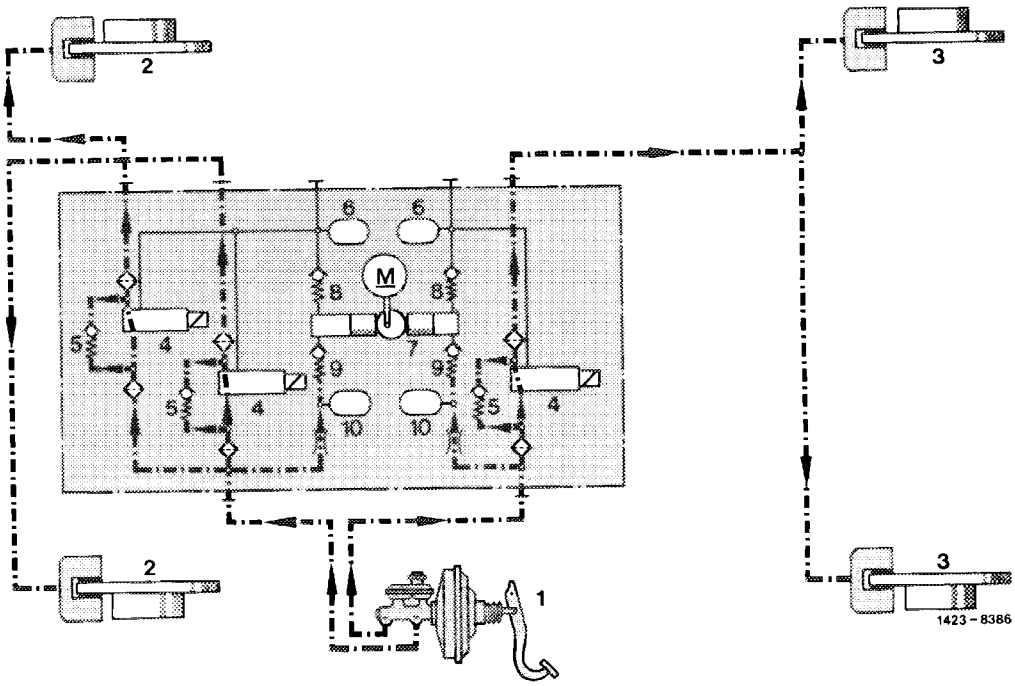
or reduced = pressure reduction stage (max. current).



4 Solenoid valve
4a Connection brake line from main cylinder
4b Output return pump
4c Connection brake line to wheel brake
4d Armature
4e Coil

Pressure build-up stage

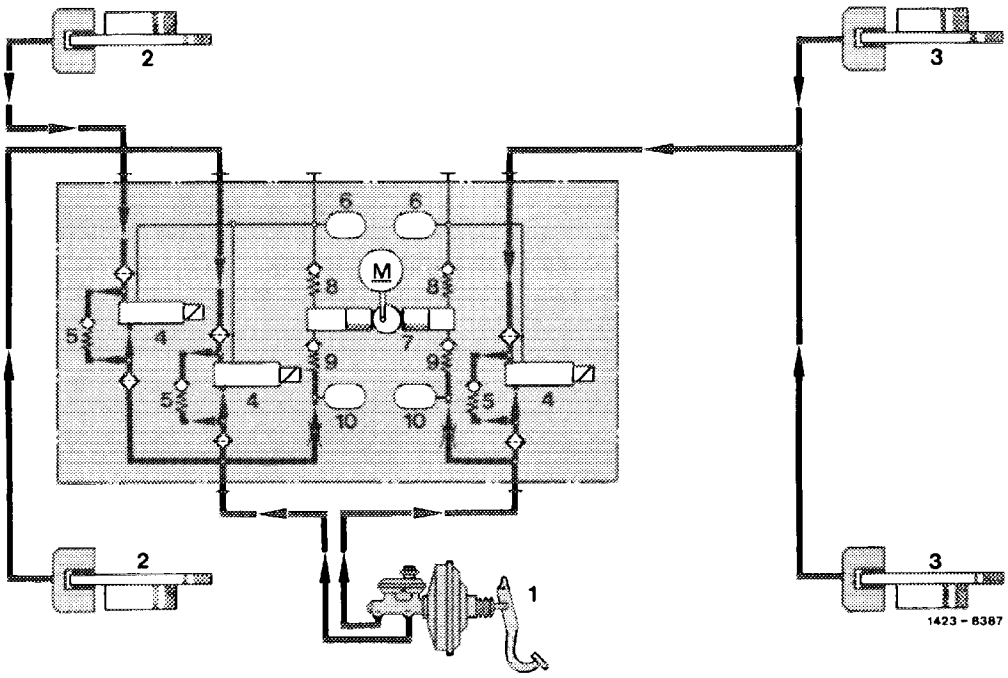
During the pressure build-up stage the pressure can be increased via the opened intake valve in solenoid valve up to the pressure activated by the tandem main cylinder.



1 Brake unit with tandem main cylinder
2 Front wheel brake
3 Rear wheel brake
4 Solenoid valve
5 Check valve
6 Pump reservoir
7 Return pump
8 Pump input valve
9 Pump output valve
10 Silencer

Pressure-holding stage

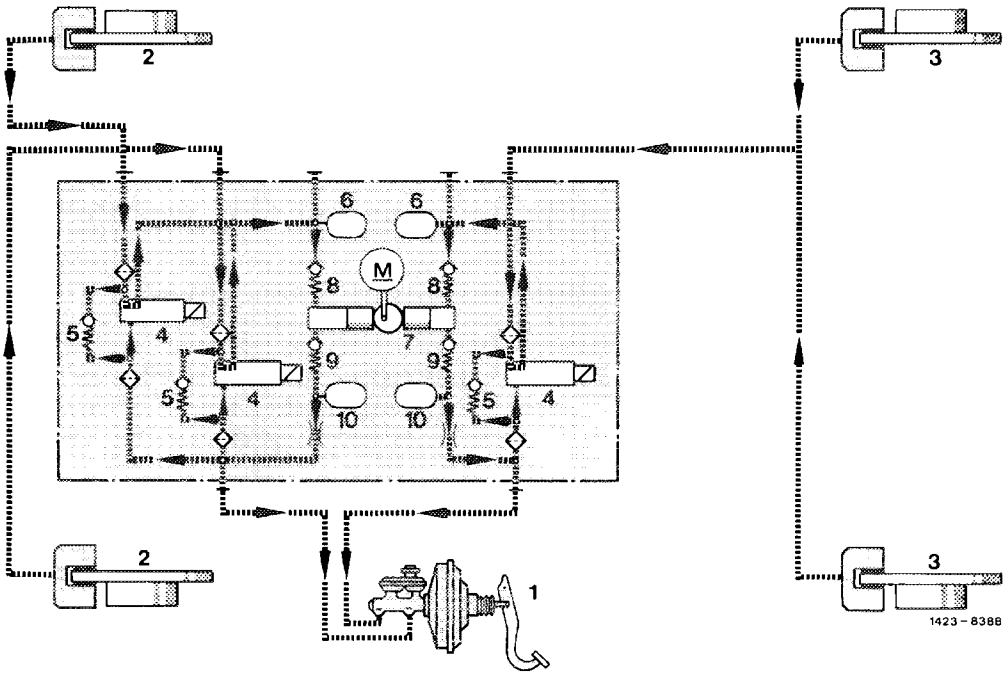
In the pressure-holding stage which precedes each pressure reduction stage the fluid pressure from hydraulic unit to wheel brakes is held constant because the output and input in solenoid valve is closed.



1 Brake unit with tandem main cylinder
2 Front wheel brake
3 Rear wheel brake
4 Solenoid valve
5 Check valve
6 Pump reservoir
7 Return pump
8 Pump input valve
9 Pump output valve
10 Silencer

Pressure reduction stage

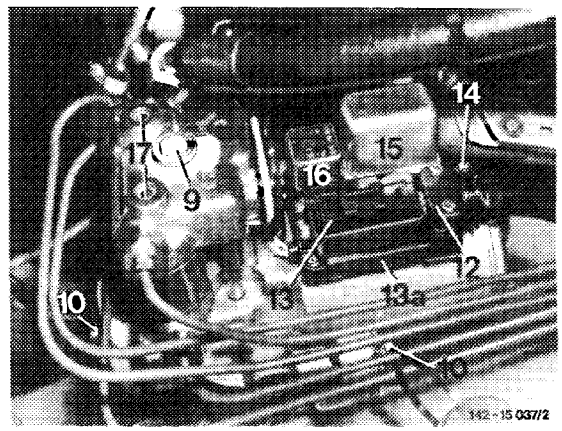
During the pressure reduction stage the brake fluid flows via a reservoir (6) into return pump (7). To maintain the fluid volume of main cylinder, the return pump returns the brake fluid into the main cylinder against the prevailing pressure. To dampen the delivery noise, each circuit is provided with a silencer (10).



1 Brake unit with tandem main cylinder
2 Front wheel brake
3 Rear wheel brake
4 Solenoid valve
5 Check valve
6 Pump reservoir
7 Return pump
8 Pump input valve
9 Pump output valve
10 Silencer

On plug socket (13a) of hydraulic unit is relay (16) for solenoid valves and relay (15) for return pump. A diode is additionally soldered into socket. The hydraulic unit is connected to the vehicle ground connection by means of grounding cable (14).

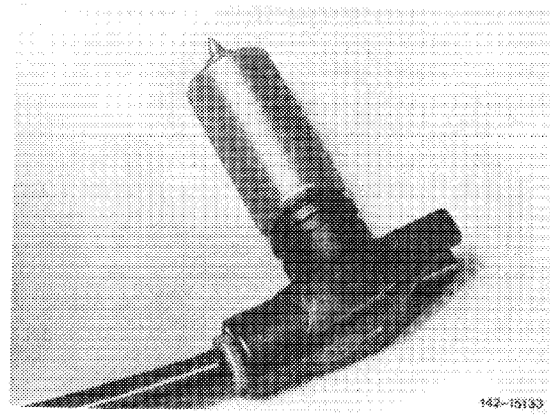
Note: Phased-in early 1986 a modified hydraulic unit will be installed. The valve relay (16) has 6 contact pins (previously 5) and contains the diode previously located in plug socket of hydraulic unit.



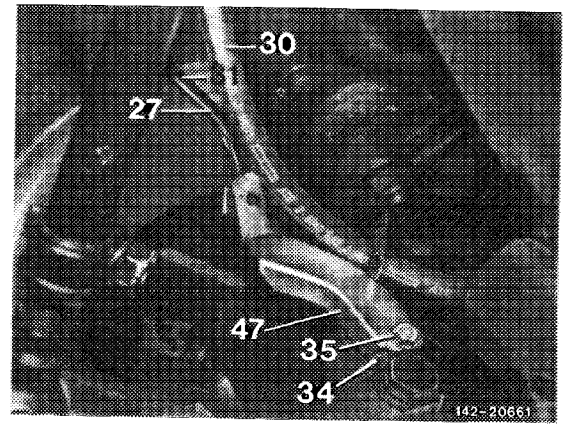
9 Center bolt
10 Hex. nut
12 Harness stress relief
13 Socket
13a Plug socket
14 Grounding cable
15 Relay for return pump
16 Relay for solenoid valve
17 Hex. socket screws

b) Speed sensor

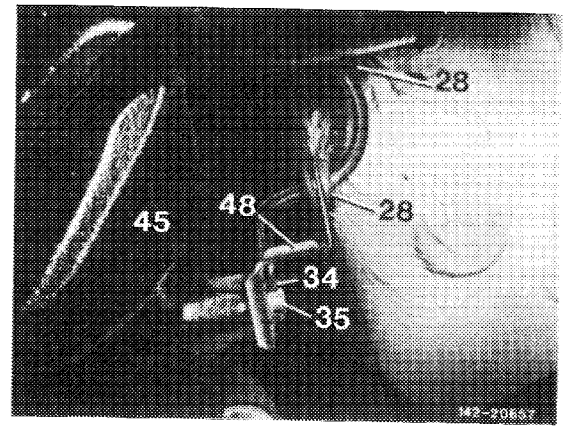
Rod-shaped speed sensors or impulse transmitters are used for measuring wheel speeds. The three-channel system with three-speed sensors installed in our vehicles serves for separately measuring the wheel speed of each wheel on front axle.



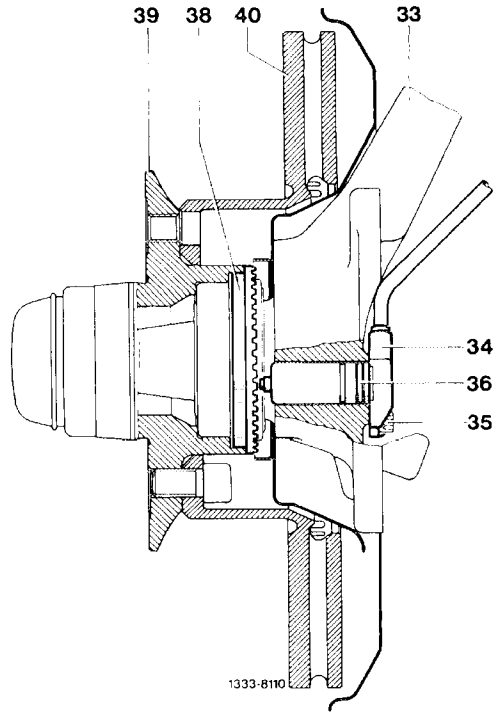
The speed sensors (34) for front axle are installed in steering knuckles.



The speed sensor (34) for rear axle is mounted on rear axle housing (45). The drive pinion serves to measure the mean speed of both rear wheels.

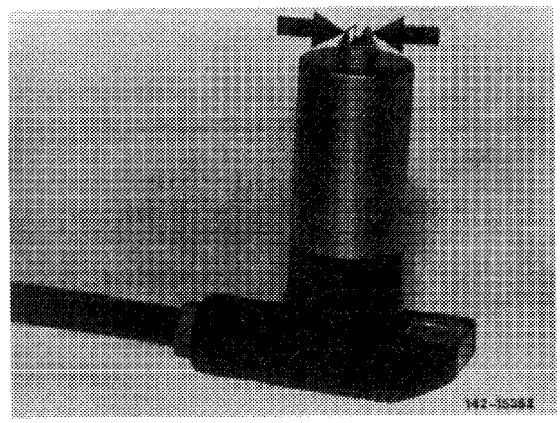


The speed sensors are probing the wheel speeds by way of the rotor teeth. On front axle, the rotor teeth (38) are machined into front wheel hub (39).

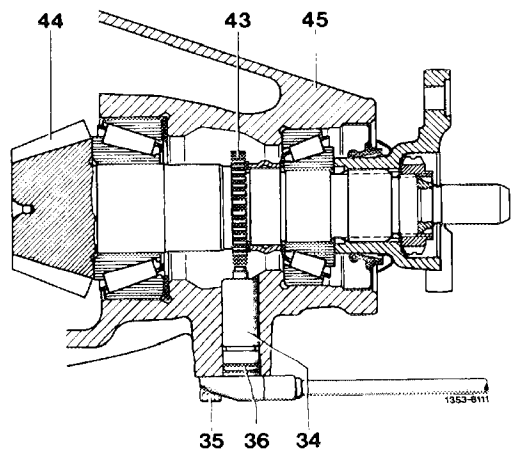


33 Steering knuckle
34 Speed sensor
35 Hex. socket screws
36 O-ring
38 Teeth (rotor)
39 Front wheel hub
40 Brake disk

The speed sensors for the front axle have two edges (arrows), starting September 1985 they have one edge and a diameter of 18 mm.

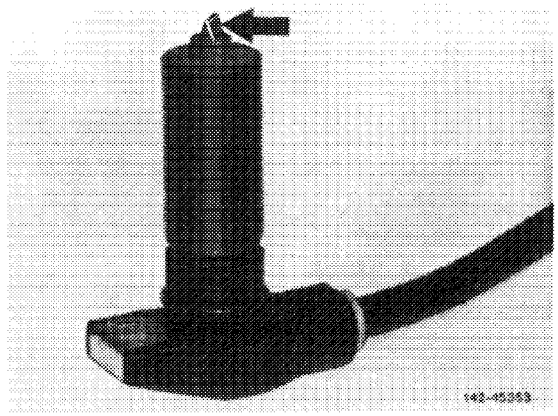


On rear axle, the rotor is a toothed wheel (43) and pressed on drive pinion (44). Each rear axle ratio is associated with a pertinent gear wheel having a different number of teeth.

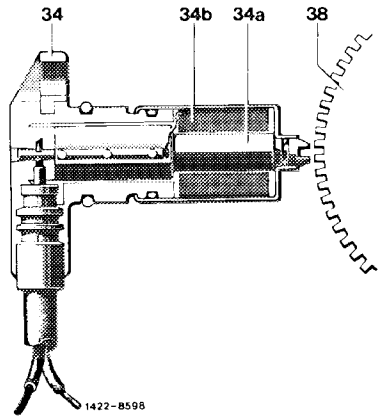


34 Speed sensor
35 Hex. socket screw
36 O-ring
43 Toothed wheel (rotor)
44 Drive pinion
45 Rear axle housing

The speed sensor for the rear axle is single-edged (arrow) and has a diameter of 15 mm.

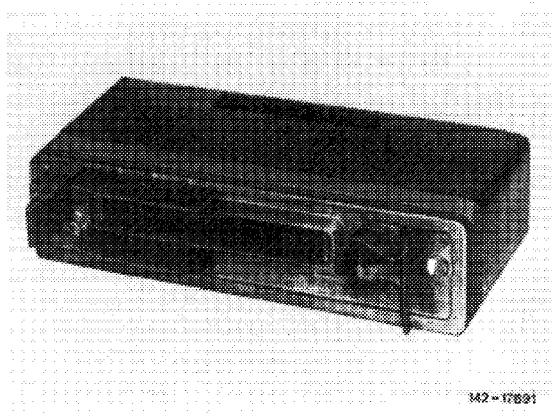


The speed sensors consist of a magnetic core and a coil. Rotation of toothed wheel or rotor, which is located at a given distance in relation to speed sensor, will change the magnetic field, so that an alternating voltage is induced in coil. This alternating voltage changes its frequency in accordance with the wheel speed and the number of teeth, i.e. the frequency is proportional to wheel speed.



34 Speed sensor
34a Magnetic core
34b Coil
38 Gear wheel (rotor)

c) Electronic control unit



The electronic control unit is laid out as a board version. The boards are provided with conductors on both sides and on one side with components such as resistors, diodes, transistors and so-called large-scale circuits. The boards are always one above the other inside the control unit and are enclosed by a light-alloy housing.

The control unit processes the signals of the speed sensors and contacts the valves in hydraulic unit.

The entire signal conditioning and signal processing is digital.

The electronic control unit is functionally subdivided into:

- the signal conditioning section
- the logic section and
- the safety circuit.

Signal-conditioning section

In the signal-conditioning section the signals supplied by the speed sensors are converted into a suitable shape for the logic section.

To prevent trouble while measuring the wheel speed, which may be caused by production tolerances and by movements in steering knuckle, the input signals are filtered prior to use. Deceleration and acceleration signals obtained from the wheel speed signals are processed in logic section.

Logic section

The logic section of the electronic control unit employs the following input signals for each controlled wheel or the controlled rear wheels:

Wheel slip

Wheel speed acceleration

Wheel deceleration

Output signals of logic section are controlling the solenoid valves of the hydraulic unit. The following hydraulic functions can be obtained in wheel brake calipers:

Pressure maintenance

Pressure reduction

Pressure build-up

Safety circuit

The safety circuit serves the purpose of recognizing faulty signals in electronic control unit and faults outside electronic control unit in the electric installation. In addition, the safety circuit intervenes in control sequence during extreme driving conditions such as aquaplaning. When a fault is recognized, the system should be switched off, a condition which is indicated to the driver by the warning lamp lighting up.

The safety circuit is also continuously monitoring the battery voltage. If the voltage is below specified requirements, the system is also switched off until the voltage is back again in specified range.

In addition to this monitored function the safety switch also includes an active section, the test cycle or Bite (built-in test equipment).

Test cycle (Bite)

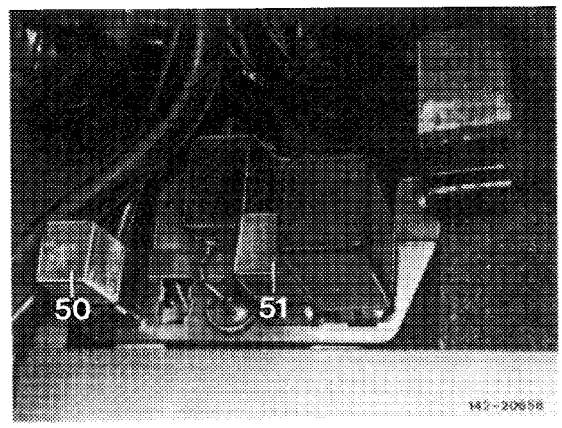
Upon starting, the test cycle begins as soon as the wheel speed in all three speed channels is higher than 5–7 km/h. The cycle is activated by the speed sensor voltage, which is simultaneously also automatically monitored. The test cycle itself checks compoments of monitoring circuit as well as the logic section. For this purpose, the electronic control unit is fed with given test sample signals to check whether the correct output signals are available.

d) Harness with relay and overvoltage protection

A supplementary harness for the ABS anti-locking brake system is installed.

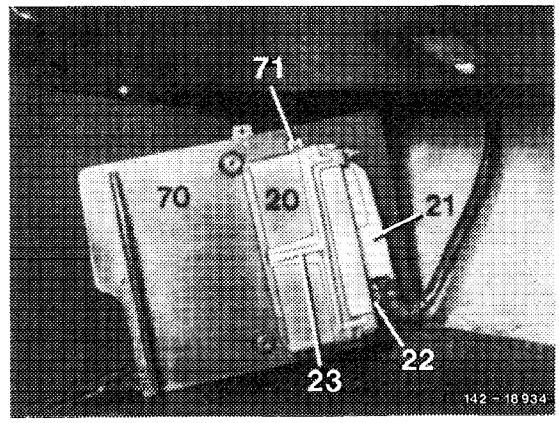
To guarantee the function of the ABS system under all operating conditions, the electric power is supplied via the electronic relay (50) which is activated by terminal 15 (ignition lock).

The overvoltage protection (51) is located between battery and relay (50) and protects the electronic control unit against excess voltage.



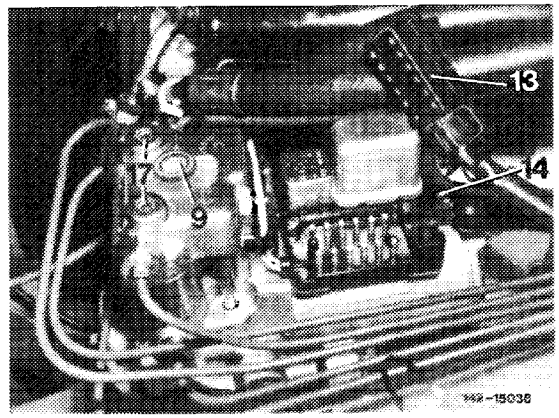
An overvoltage protection with integrated relay for voltage supply of electronic control unit and an exchangeable fuse are installed since September 1981.

The harness is connected to the electronic control unit (20) by means of a 35-pole plug connection (21).

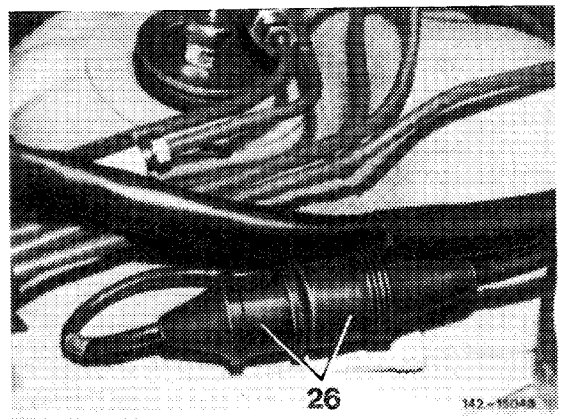


The harness with the 12-pole plug connection (13) leads to hydraulic unit.

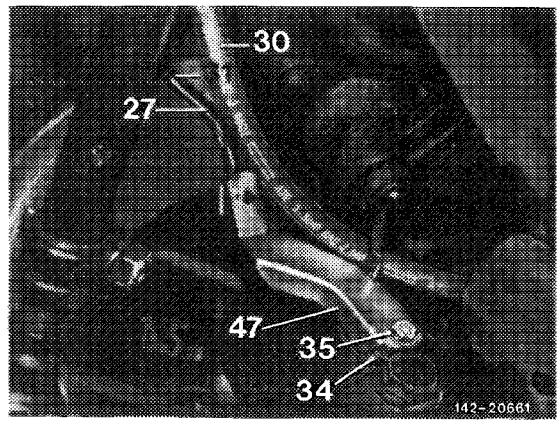
The grounding strap (14) for hydraulic unit is connected to side member (wheel house).

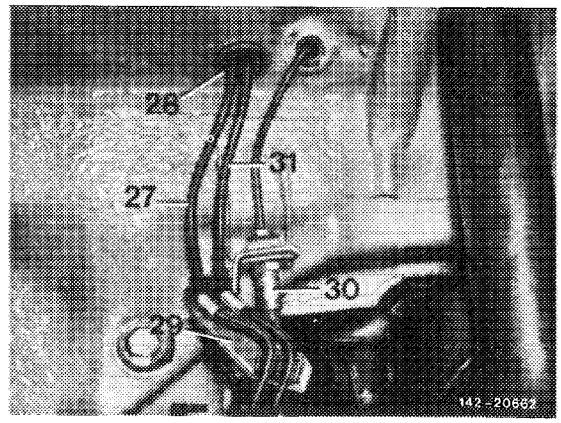


The speed sensors of the front axle are connected to harness by means of coaxial plug (26).



Cable (27) of speed sensor from steering knuckle to coaxial plug is guided through a holder (29) in wheel house.

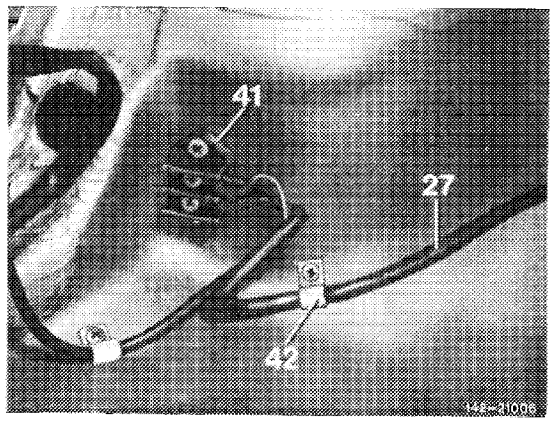




Layout front axle

27 Speed sensor cable
28 Rubber grommet
29 Holder
30 Brake hose
31 Wear indicator cable

The speed sensor of the rear axle is connected to harness under rear seat bench by means of cable connector (41).



Layout of rear axle

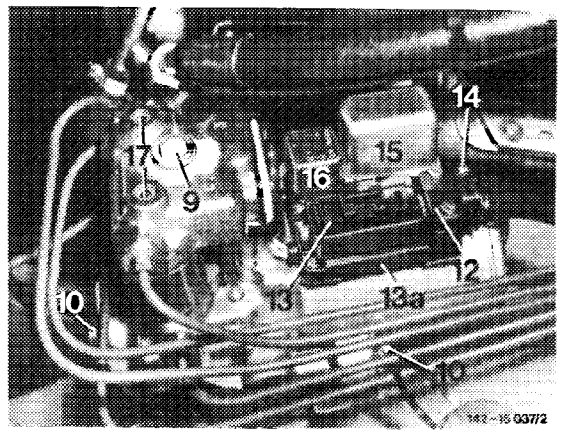
27 Speed sensor cable
41 Cable connector
42 Clamp

Two relays are located under cover of hydraulic unit. Relay (15) contacts return pump and the current flows to solenoid valves via relay (16).

A diode soldered into plug socket (13a) activates the warning lamp in instrument cluster when the multi-point plug on electronic control unit is pulled off.

Phased-in early 1986 the diode is no longer in plug socket, but in valve relay.

The new relay has 6 contact pins (previously 5).



D. Operation of ABS

The ABS is operational after the ignition has been switched on and as soon as a speed of 5–7 km/h is attained. All the braking steps in locking range are controlled as of the so-called control speed of 12 km/h. On the modified control unit, starting February 1984, the control speed is 8 km/h.

The following is a description of the control cycle on one wheel. The control sequence on the other wheels is the same. The wheel speed measured by the speed sensor provides the wheel deceleration and wheel acceleration signals for the electronic control unit. Linking of the individual wheel speeds provides the so-called reference speed, which is the approximate vehicle speed. A comparison of the wheel speed with the reference speed supplies the slip signals.

If a wheel shows a tendency toward locking as a result of too much brake fluid pressure in caliper, a condition which is recognized by means of the wheel speed sequence (wheel slip), the fluid pressure will be held constant, i.e. an additional pressure increase is not possible.

If there is still a tendency toward locking, because the constant pressure is still too high, the fluid pressure will be lowered by opening the outlet valve in solenoid valve. Simultaneously the brake fluid still in accumulator is pumped back to the tandem main cylinder by the return pump. If the pressure is at such a low level that the wheel wants to accelerate again, there will be no additional pressure reduction, and the fluid pressure will again be held constant.

When the re-acceleration of the wheel passes a threshold value, the pressure is again increased in-between by opening the input valve in solenoid valve.

By means of pertinent signals of the electronic control unit, the hydraulic unit can actuate the three following control stages of

pressure build-up

pressure maintenance and

pressure reduction.

The control sequence is continuously repeated during controlled braking until the brake pedal is released or shortly before vehicle stops.