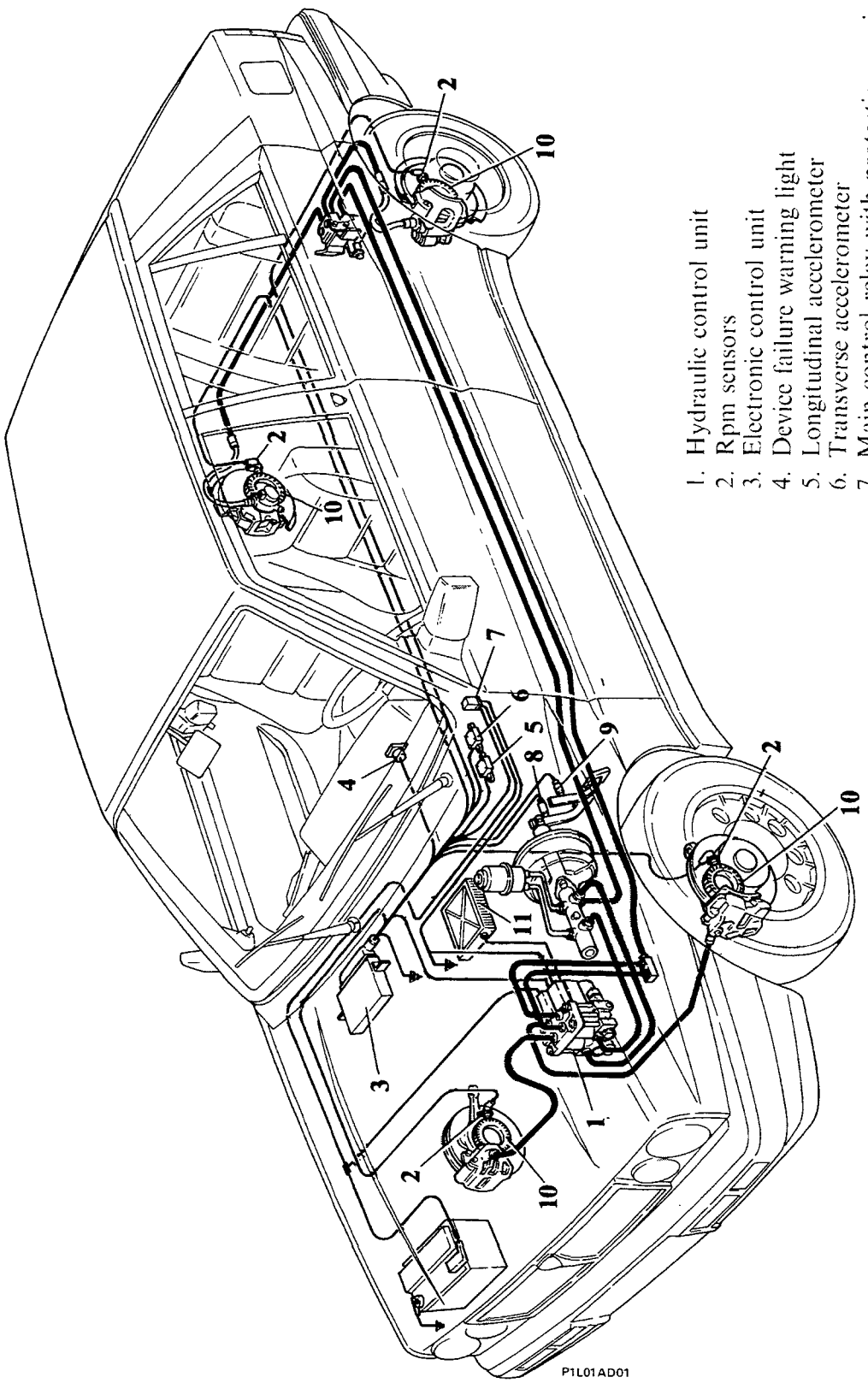
page

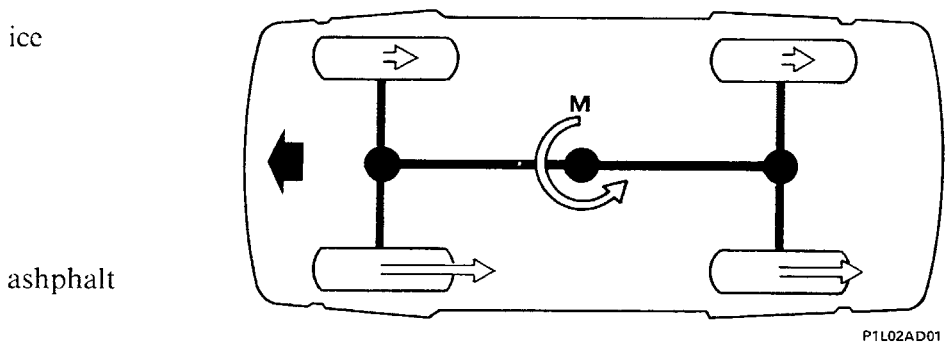
BOSCH (ABS) 4 CHANNEL 2ND GENERATION ANTI-LOCK BRAKING SYSTEM

DIAGRAM SHOWING ANTI-LOCK BRAKING SYSTEM



1. Hydraulic control unit
2. Rpm sensors
3. Electronic control unit
4. Device failure warning light
5. Longitudinal accelerometer
6. Transverse accelerometer
7. Main control relay with protection against excess voltage
8. Brake lights switch
9. Switch on clutch pedal
10. Flywheels
11. Injection control unit

The Bosch (ABS) 4 channel, 2nd generation anti-lock braking system, until now used on 2 wheel drive vehicles, has been modified and used on the Delta Integrale 16 V to guarantee improved safety, reliability and performance on 4 wheel drive vehicles.
In this type of vehicle the front axle is connected to the rear axle by means of a rigid connection, whilst the rear axle wheels are connected to each other by the differential (in this case Torsen).
As a result there is increased slewing when braking on a different road surface where the right and left wheels adhere.
The phenomenon is further aggravated by the increased moment of inertia, caused by the movement of the masses, and by the engine braking torque acting on the four wheels.



In order to combat this the anti-skid system used on the Delta Integrale 16 V has the following devices which intervene to ensure maximum operating efficiency:
. a logic which allows further attenuation of the slewing moments (GMA)
. a fast idle device

SLEWING MOMENTS ATTENUATION DEVICE (GMA)

As is already known the ABS electronic control unit produces successive "brake releasing" cycles on the wheels which adhere least (which are sliding).
In order to reduce the slewing moment, firstly the braking torque must be modulated even for the wheels with greatest adhesion, as long as they are not sliding, so that the braking torque for all the wheels is more even.
This logic which is indicated by the GMA, is already used on 2 wheel drive vehicles equipped with the latest generation ABS systems; this, however, takes place for an extremely short length of time (one single modulation cycle).
In the case of the Delta Integrale 16 V, the GMA is activated for successive modulation cycles.
On balance with the advantage of preventing slewing, this logic system produces disadvantages in terms of the adhesion when braking on bends.
In order to prevent this problem the GMA must be excluded; to do this the Delta Integrale 16 V electronic control unit uses the information supplied by a transverse accelerometer.

Fast idle

If the accelerator is released during braking two braking torques build in: engine torque and braking torque.

On a front wheel drive vehicle with 2 driving wheels the engine torque only acts on the front wheels and its intensity is constant and can therefore be managed by the ABS control units.

On a vehicle with 4 driving wheels, however, the engine braking torque is also distributed to the rear wheels with the tendency to brake the rear axle which is the more critical one more than necessary; the ABS control unit succeeds in managing this phenomenon by activating the fast idle device, via a signal, to reduce the engine braking torque. In order to do this the ABS electronic control unit is interfaced with the injection control unit.

The anti-lock braking system on the Delta Integrale 16 V has been designed to:

a. guarantee the direction stability of the vehicle during braking, preventing the one or more wheels from locking for any reason which could cause this (for example, poor adhesion due to the road surface, ice, unmade road). This feature allows improved steering or steerability, preventing the vehicle from skidding. However, skidding cannot be avoided if the speed limit is exceeded.
b. guarantee the directional stability of the vehicle during braking on surfaces which have different adhesion coefficients (e.g : right wheels on ashphalt, left wheels on ice).
c. optimize the braking distance making maximum use of the adhesion available.
d. maintain the driveability of the vehicle during braking.

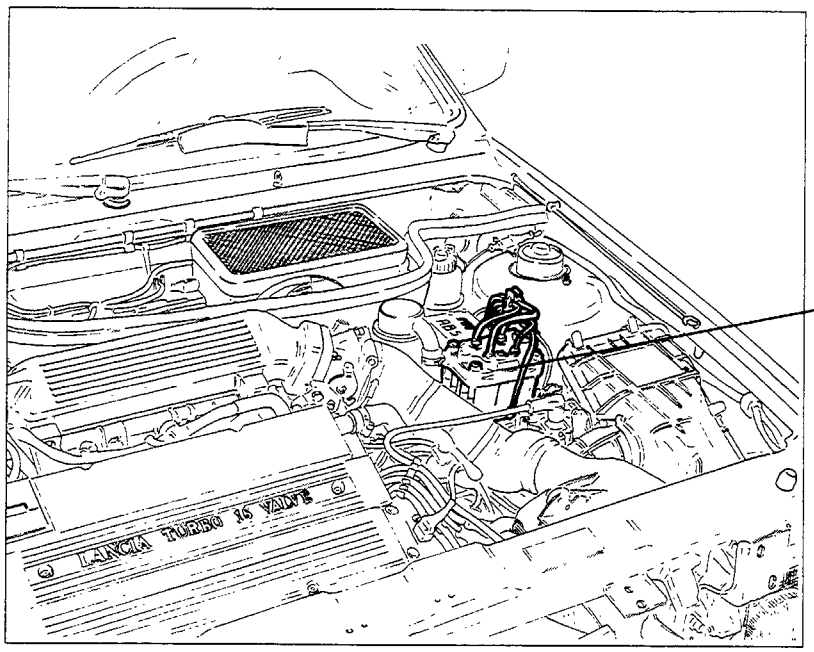
Composition

The anti-lock braking system is composed of the conventional servo-assisted braking system plus the following components:

1. electronic control unit
2. hydraulic control unit
3. 4 rpm sensors (1 for each wheel)
4. control relay with protection against excess voltage
5. red system failure warning light in the instrument panel
6. longitudinal accelerometer
7. transverse accelerometer
8. brake lights switch
9. switch on clutch pedal

33.

LAYOUT OF COMPONENTS ON VEHICLE



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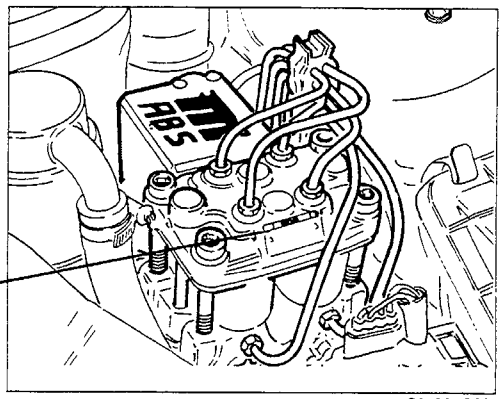

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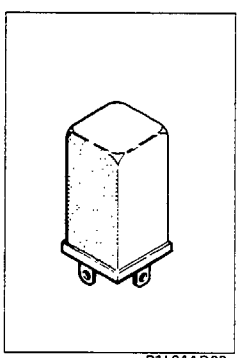
Hydraulic control unit



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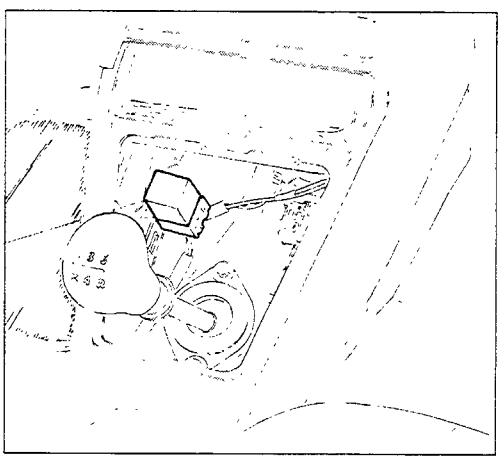
Main control relay with protection against excess voltage



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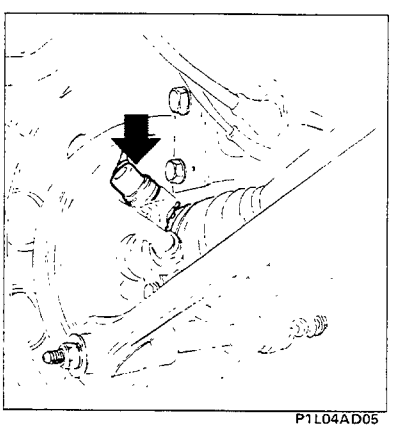

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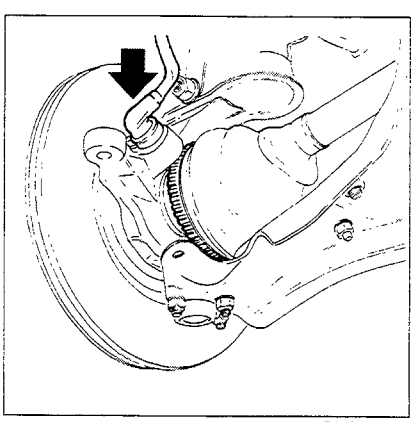
Rpm sensor for rear wheel



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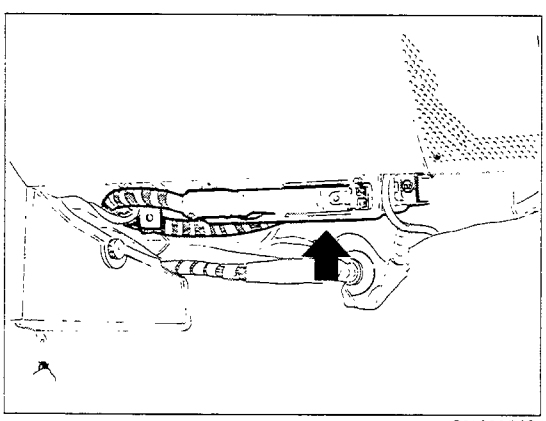
Rpm sensor for front wheel



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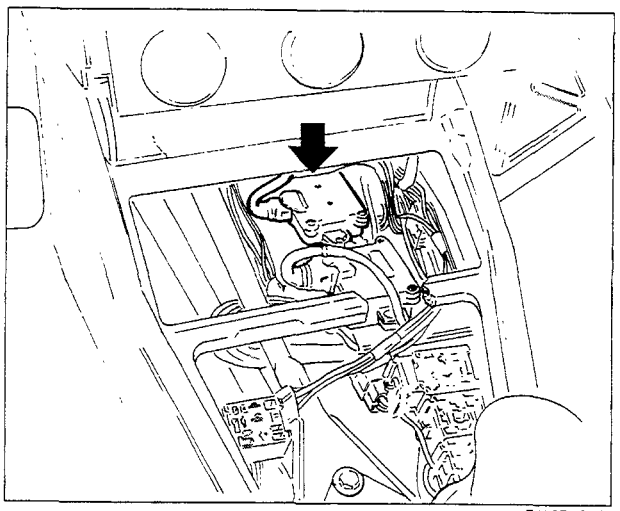
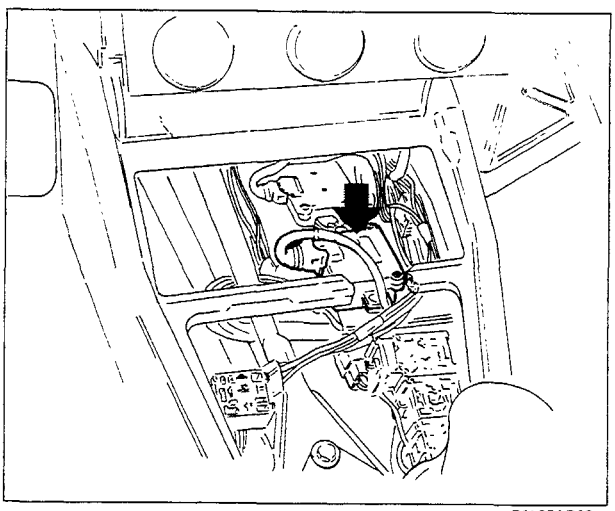
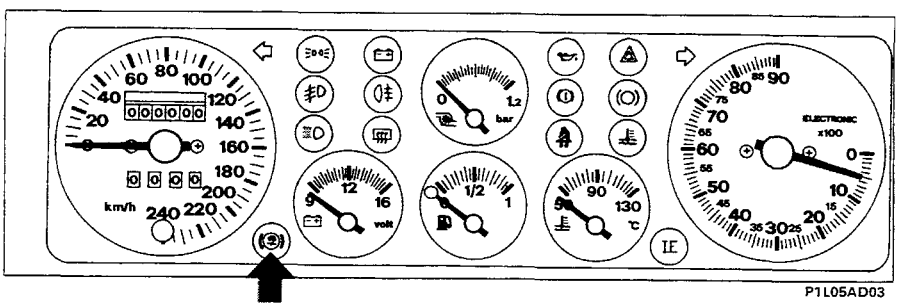
Electronic control unit



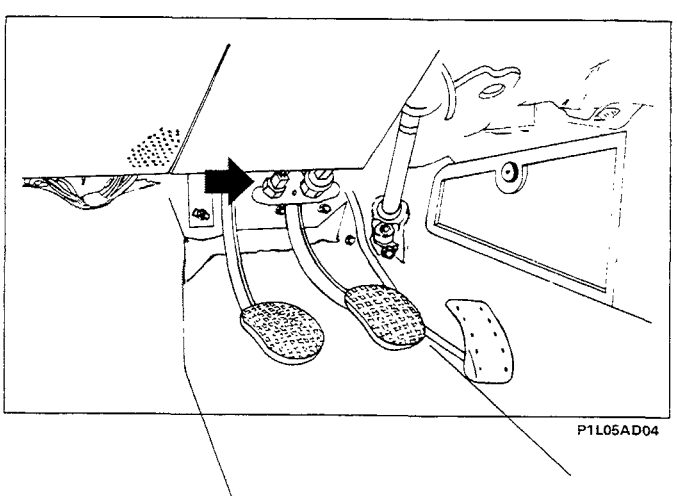
Longitudinal accelerometer



Transverse accelerometer



Anti-lock braking system failure warning light



Switch on clutch pedal

Brake lights switch

33.

ELECTRONIC CONTROL UNIT

The electronic control unit comprises printed circuits with resistances, diodes, transistors and integrated logic circuits.
It is connected to the anti-lock braking system by means of a multiple connector and can operate divided into two parts which are in practice two separate but strictly identical computers:
1. signal and logic processing sections
2. safety circuits

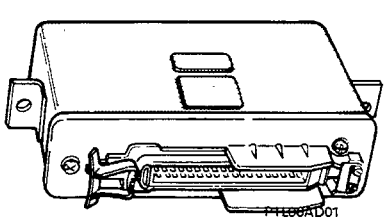
Both receive the same input signals which each processes individually and only when the results obtained are identical does the electronic control unit send the operational signal to the hydraulic unit.
If this is not the case, there is obviously a fault in the processing system and therefore **the processor switches off and braking takes place in the conventional manner.**
In the processing section, the signals sent by the rpm sensors are transformed into signals which can be used by the logic section so that it recognizes the values for acceleration, deceleration and "slidingo" for the wheels.

NOTE *The peripheral speed for a braking wheel decreases to a greater extent than that of the vehicle, so that with the wheels completely locked through braking action (peripheral speed of wheel = 0) and the vehicle still moving, the maximum difference between these two speeds exists.*
This difference is known as creeping or sliding coefficient when it is expressed as a percentage.

Creeping 0% = wheel free
Creeping 100% = wheel locked and vehicle moving

During braking the friction coeffecient has an increasing trend when the braking takes place with contained creeping (rolling) and a decreasing trend when the crawling of the tyre is accentuated until it locks.
As a result of a considerable number of practial tests and experiments it is generally possible to achieve maximum braking force with creeping values contained between 5% and 15% with a maximum value of 20%. This is within the optinum values for which anti-lock braking systems tend to operate for all types of vehicle.

The logical section compares the signals received and transmits the adjustment commands to four solenoid valves located in the hydraulic control unit. In the absence of braking, the electronic control unit recognizes the speed of the vehicle from the signals from the sensors.
When the drive presses the brake pedal, the wheels decelerate at a different rate from one another; from the combination of the individual speeds of the wheels a reference speed is processed and is memorized and constantly updated; it can give the approximate speed of the vehicle at any time during braking.
Comparing the speeds of the individual wheels with the reference speed provides a constant check on the creeping signals for each wheel.



Electronic control unit

The braking force may increase until one wheel is creeping more than the others; when this condition known as split is reached, the control unit commands the hydraulic unit solenoid valve to stop the braking force on the wheel which has a pronounced loss of adhesion. The wheel concerned can accelerate once again.
The electronic control unit also stores the deceleration and acceleration thresholds in its memory which each individual wheel should never exceed. Therefore, by means of a systematic, continuous and extremely rapid comparison of the creeping values, the rolling of the braking wheel is kept in check. As soon as the threshold values for acceleration/deceleration, creeping acceleration/deceleration and combined split are exceeded, the electronic control unit intervenes and commands the hydraulic control unit for three adjustment phases: increasing pressure-decreasing pressure-maintaining pressure.

These phases make up an intermittent but extremely fast adjustment cycle which is repeated until the vehicle is stopped.
The electronic control unit governs the different stages, supplying the solenoid valve with impulses of varying current intensity.

It also applies the same braking force to both the rear wheels as the processor provides to the rear wheel more likely to lock, i.e. the one with poorer adhesion to the road surface.
Usually the device no longer comes into operation at speeds of below 5 kph to allow the wheel to come to a complete halt when the vehicle is stationary.

NOTE *Since the parameters which the control unit governs (wheel speed and acceleration) are influenced by the inertia of the rim/tyre assembly, vehicles equipped with anti-lock braking systems* ***must also have the wheel rims and tyres recommended by the Manufacturer.***

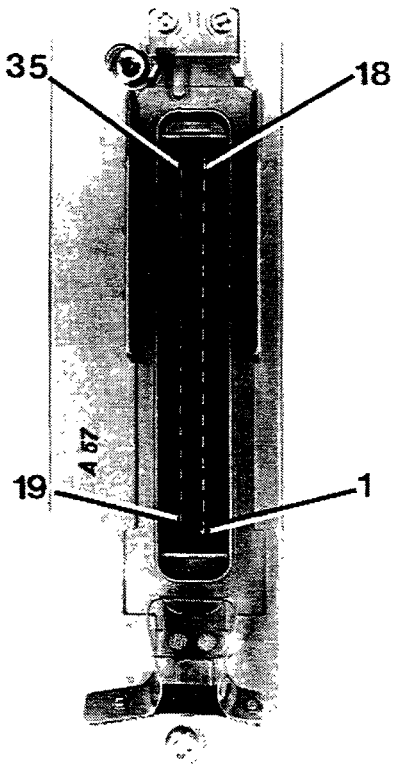
The electronic control unit also has a safety circuit which has the task of checking the efficiency of the system before the vehicle sets off each time and when it is running.
If a fault is detected, the safety circuit cuts off the operation of the device, guaranteeing braking, however, through the conventional braking system.
A warning light in the instrument panel signals to the driver that the device is switched off.
The safety circuit also constantly checks the battery voltage, switching off the device is the voltage is too high or too low.

Another integral part of the safety circuit is the test cycle or BITE (built in test equipment) which is activated by the voltage produced from the wheel sensors and checks the correct operation of the electronic control unit including the safety circuit by means of a test programme and signal.

At speeds of around 6 kph, the BITE circuit checks the rpm sensors, the operation of the hydraulic control unit recovery pump motor and the accelerometers. The accelerometers are electrically checked by the BITE circuit if they remain in an open circuit position for more than a certain length of time: 20 seconds for the longitudinal accelerometer and 60 seconds for the transverse accelerometer.
If the anti-lock braking system failure warning light comes on at this speed, with the device switched off, the fault may lie in one of the above mentioned components. However, this is not binding and before carrying out any repair operations, the device should be subjected to the tests described in the Fault Diagnosis Cards.

33.

Identification of terminals for electronic control unit and relevant connector



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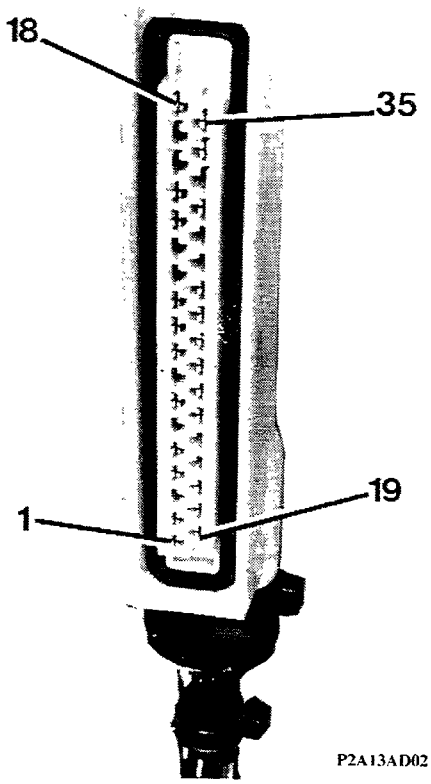


P2A13AD02

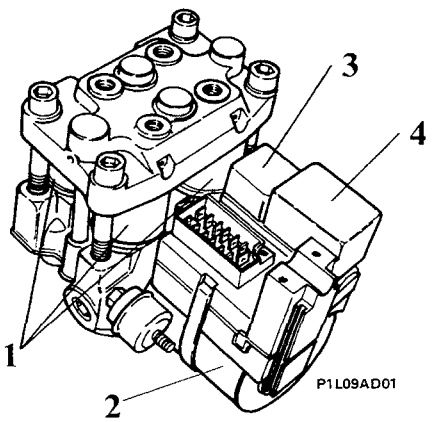
N°	cable colour	Destination	N°	cable colour	Destination
1	GN	To terminal 87 for the relay	19	RV	To terminal 7 for the hydraulic control unit
2	BR	To terminal 1 for the hydraulic control unit	20	N	Earth (luggage compartment right side 80A)
3	-	Spare	21	V	To the right front rpm sensor
4	B	To the left front rpm sensor	22	-	Spare
5	B	To the left front rpm sensor	23	-	Spare
6	-	Spare	24	R	To the right rear rpm sensor
7	G	To the left rear rpm sensor	25	RN	To the brake lights switch
8	-	Spare	26	R	To the right rear rpm sensor
9	G	To the left rear rpm sensor	27	CB	To terminal 6 for the hydraulic control unit
10	NZ	Earth (luggage compartment right side 80A)	28	GR	To terminal 11 for the hydraulic control unit
11	V	To the right front rpm sensor	29	VG	To the device failure warning light
12	-	Spare			
13	-	Spare	30	-	Spare
14	AN	To terminal 9 for the hydraulic control unit	31	-	Spare
15	H	To terminal + D for the alternator	32	HR	To terminal 12 for the hydraulic control unit
16	-	Spare	33	-	Spare
17	-	Spare	34	N	Earth (luggage compartment right side 80A)
18	GV	To terminal 5 for the hydraulic control unit	35	VB	To terminal 3 for the hydraulic control unit

HYDRAULIC CONTROL UNIT

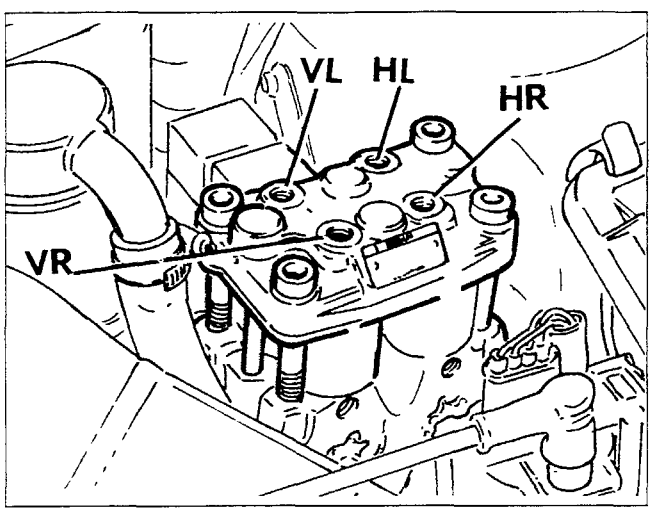
The hydraulic control unit has the task of varying the pressure of the brake fluid in the caliper pistons according to the signals coming from the electronic control unit.
It comprises:

1. 4 solenoid valves, the rear 2 of which are connected to each other
2. a dual circuit recovery pump
3. a relay for the solenoid valves; the energization of the 2 front valves is separate, whilst that of the rear 2 is common
4. a relay for the recovery pump

NOTE *The pressure for the rear brakes is adjusted by the wheel which locks first.*

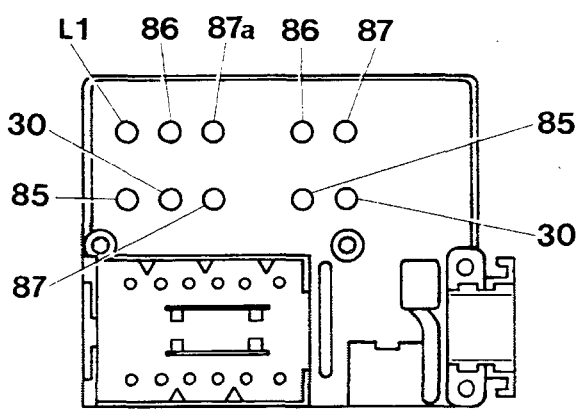


Hydraulic control unit

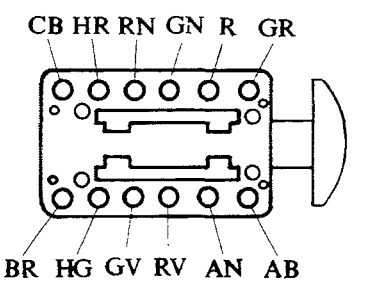


Identification of hydraulic control unit outlets (marked on the cover near each outlet)

HR = to the right rear caliper
HL = to the left rear caliper
VR = to the right front caliper
VL = to the left front caliper



Identification of terminals on the hydraulic control unit



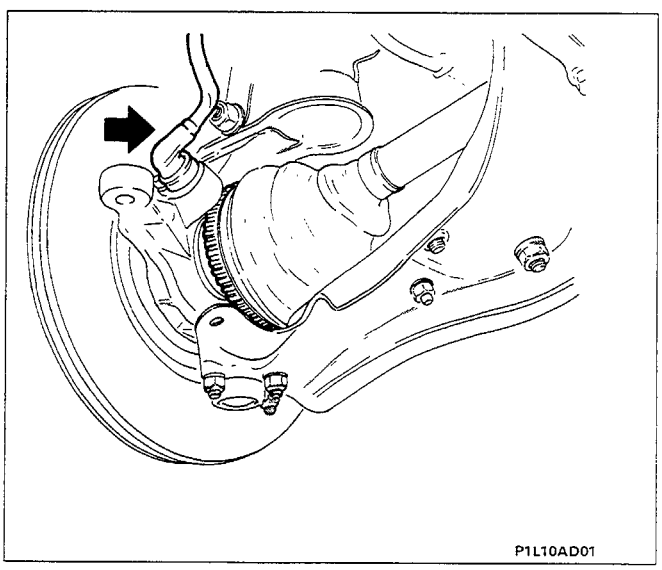
Identification of terminals on hydraulic control unit connector (the symbols for the cable colour are indicated: see wiring diagram on page 19)

33.

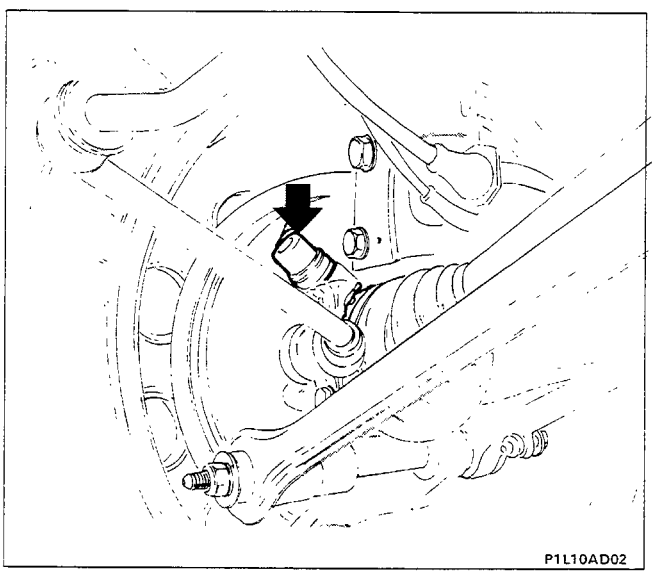
The hydraulic control unit cannot be overhauled and if there is a fault it must be replaced in one piece. Only the two relays can be replaced.
It is available as spares filled with brake fluid and with the solenoid valves in an open position and therefore the bleeding and refilling of the braking system is the same as that for a conventional system.

RPM SENSORS

The rpm sensors provide the electronic control unit with all the information required so that the hydraulic control unit can be correctly controlled.
They measure the speed of the vehicle, acceleration, deceleration and wheel creeping.
The sensors are of the inductive type and are fitted in special housings, on the front wheel dampers and on the rear wheel brake back plates.
The lines of magnetic flux close through the teeth of a flywheel facing the sensor which rotates with the wheel. The flow from full to empty, due to the presence or absence of teeth, caruses a variation in the magnetic flux sufficient to create an electro-motive force transmitted to the sensor terminals and therefore an alternating electric signal to the electronic control unit.

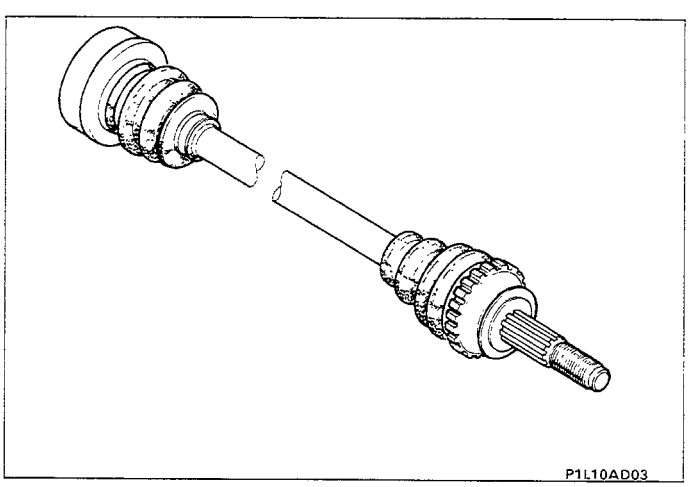


Positioning front wheel rpm sensor



Positioning rear wheel rpm sensor

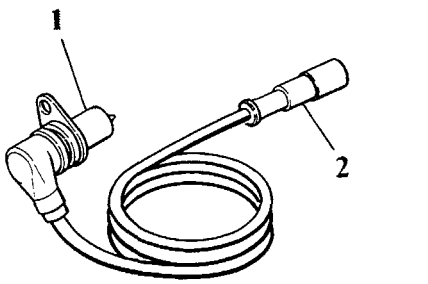
The flywheels are in the wheel side constant velocity joints and are highlighted by yellow epoxide paint.



Positioning flywheel for front and rear wheel

The distance between the end of the sensor and the flywheel (gap) to obtain correct signals should be between 0.3 and 1.05 mm.

Keep the sensors in their packaging until fitting, away from any possible sources of de-magnetization.

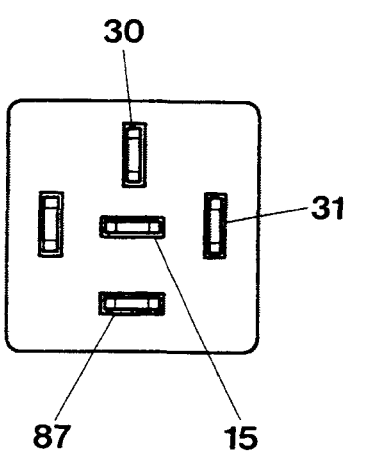


1. Rpm sensor
2. Electrical connection

MAIN CONTROL RELAY AND PROTECTION AGAINST EXCESS VOLTAGE

The main control relay has the task of supplying both the electronic control unit and the hydraulic control unit relays.
It contains a protective fuse for the device with a zener diode with protection against excess voltage.

Relay terminal	cable colour	Destination
87	GN	To terminal 2 for the hydraulic control unit
	GN	To terminal 1 for the electronic control unit
15	C	Throush connection 105 to the ignition switch
31	N	Earth (luggage compartment right side 80A)
30	R	To the 10 A protective fuse (104) for the device



33.

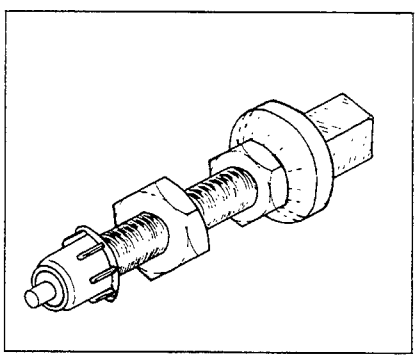
DEVICE FAILURE WARNING LIGHT

With the ignition switch in the ON position, the red warning light signalling a failure with the device, should come on; as soon as the engine is started up the warning light should go out.
The signal that the engine is running reaches the electronic control unit from the alternator.

If all the sensors were broken, the control unit could not, however, recognize the problem and therefore the warning light would not come on. The same would happen if one front sensor and the rear diagonal sensor were broken.

BRAKE LIGHTS SWITCH

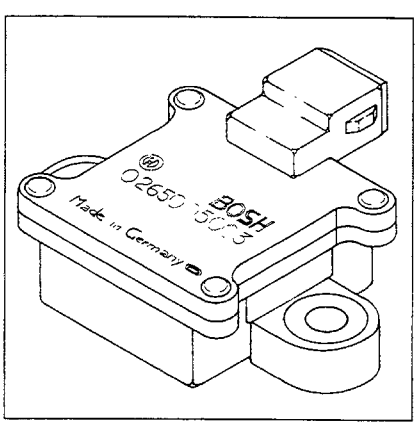
When the vehicle is running and the brake pedal is pressed, the signal reaches the electronic control unit and informs it that the driver is braking.
This information is particularly useful in the case of uneven road surfaces (potholes, cobblestones) which can cause variations in speed of the wheels for causes not linked to braking, thereby avoiding erroneous signals to the electronic control unit.



Brake lights switch

LONGITUDINAL ACCELEROMETER

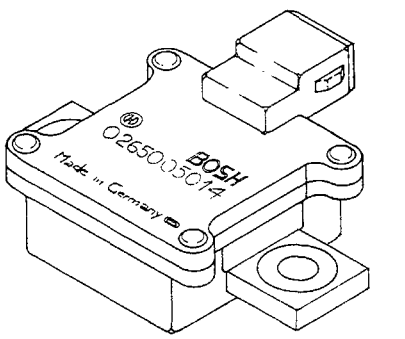
This sensor detects poor adhesion conditions (low deceleration during braking) or good adhesion conditions (high deceleration) and allows the electronic control unit to adopt the appropriate control logic.



Longitudinal accelerometer

TRANSVERSE ACCELEROMETER

This sensor detects acceleration of the bodyshell in a transverse direction.
When a bend is being taken there is a centrifugal acceleration; the moment in which this parameter exceeds the intervention threshold, the transverse accelerometer sends a signal to the electronic control unit de-activating the GMA.



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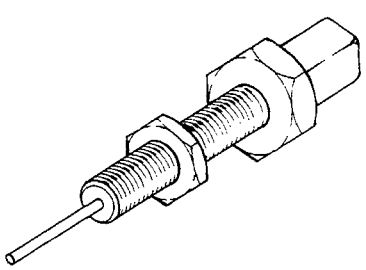
Transverse accelerometer

SWITCH ON CLUTCH PEDAL

When the clutch pedal is pressed, a switch, on the upper end of it, cuts off the operation of the ABS system, at the same time, keeping the conventional braking system working. When the pedal is completely released, the switch allows the ABS device to be re-activated by excluding the signal previously sent to the electronic control unit.



P1L13AD02

Switch on clutch pedal

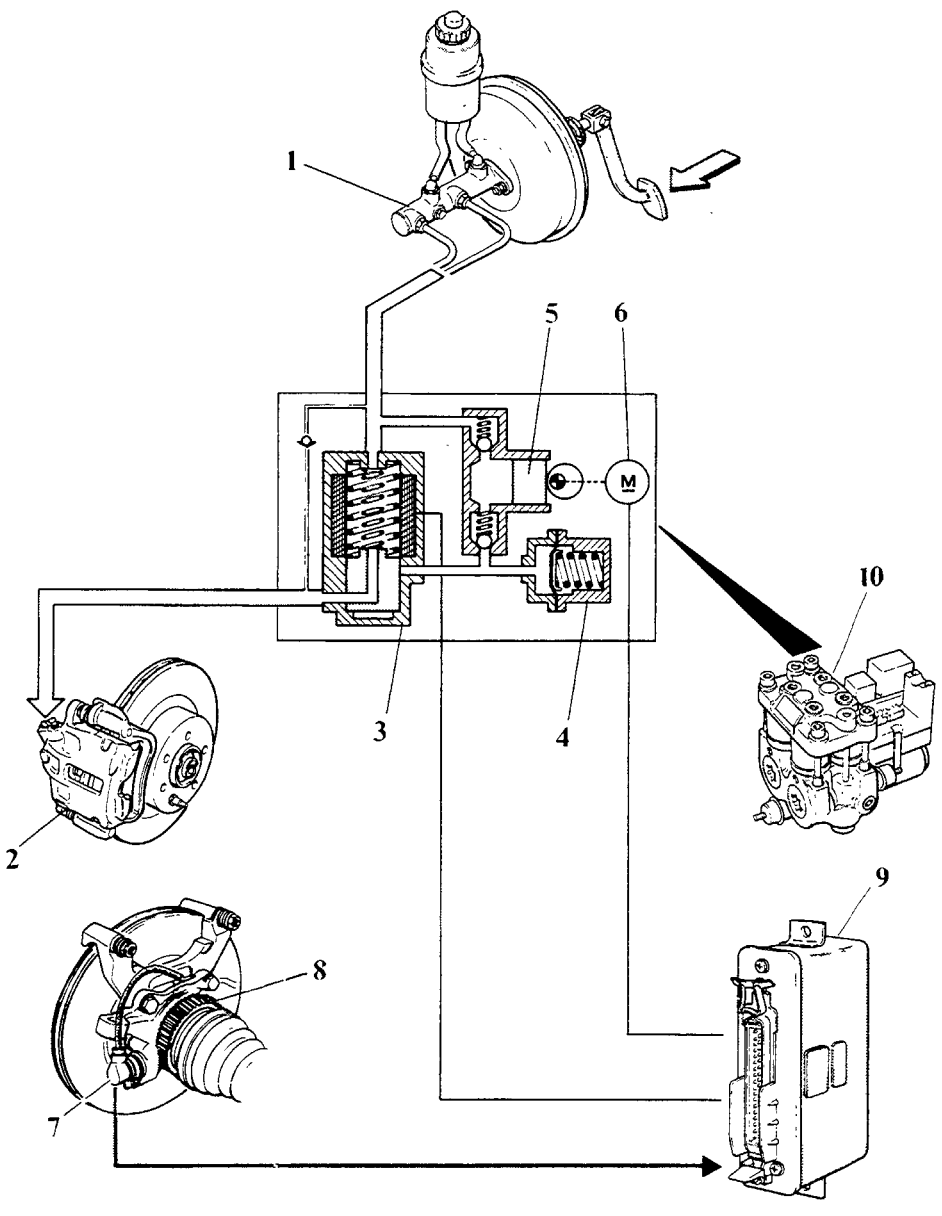
33.

DESCRIPTION OF OPERATION OF ANTI-LOCK BRAKING SYSTEM

According to the impulses received by the electronic control unit, the hydraulic control unit varies the pressure of the brake fluid to the calipers according to three phases:

Increasing pressure stage

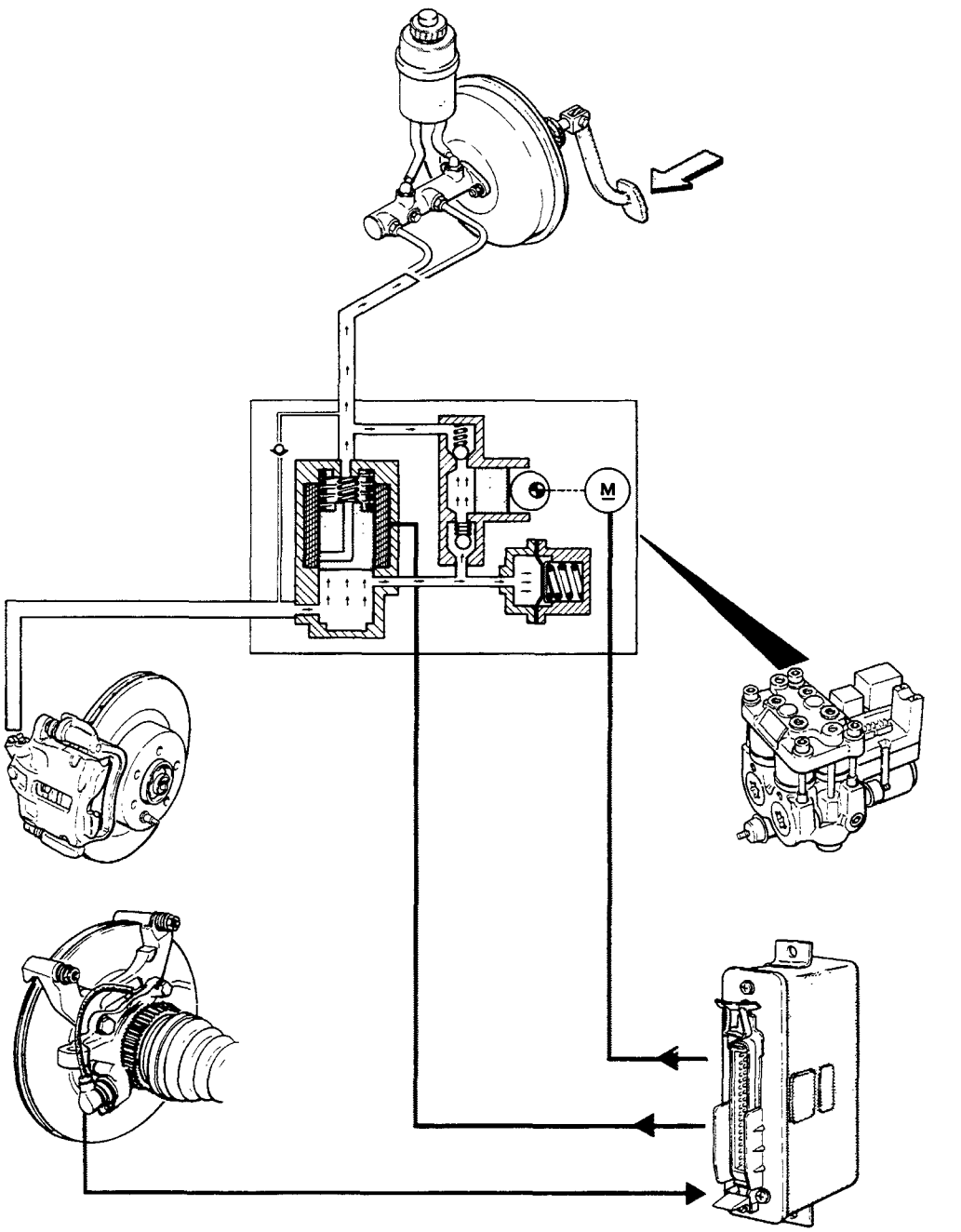
During this stage the hydraulic unit solenoid valves are not energized and the pressure in the brake calipers is that created by the pressure exerted on the brake pedal by the driver.
The braking force increases and consequently the wheel decelerates and its speed is reduced in relation to that of the vehicle (increase in creeping). The acceleration and speed are reduced until the values are such as would adversely affect the adhesion of the vehicle to the ground; at this point the braking force must be reduced to allow the wheel to increase speed and regain adhesion.



1. Pedal-brake pump assembly
2. Brake
3. Solenoid valve
4. Pump accumulator
5. Recovery pump
6. Pump motor
7. Rpm sensor
8. Flywheel
9. Electronic control unit
10. Hydraulic control unit

Decreasing pressure stage

The electronic control unit detects the tendency of the wheel to lock and the anti-lock braking device comes into operation.
The solenoid valve is energized by a current of around 5 A and the connection between the brake pump and the brake caliper is interrupted, whilst the connection between the brake caliper and the recovery pump is opened. In this way the brake fluid is removed from the brake caliper and reintroduced into circulation in the main circuit via the recovery pump circuit (also known as the secondary circuit). This originates from the intermittent hydraulic thrusts on the brake pedal, which can be felt by the driver, during the braking stage, which are normal during the operation of the device.
The accumulator in the circuit has the function of storing part of the brake fluid in the secondary circuit, allowing the pump to be designed to deal with an economical average capcity.
During this stage the wheel starts to accelerate.



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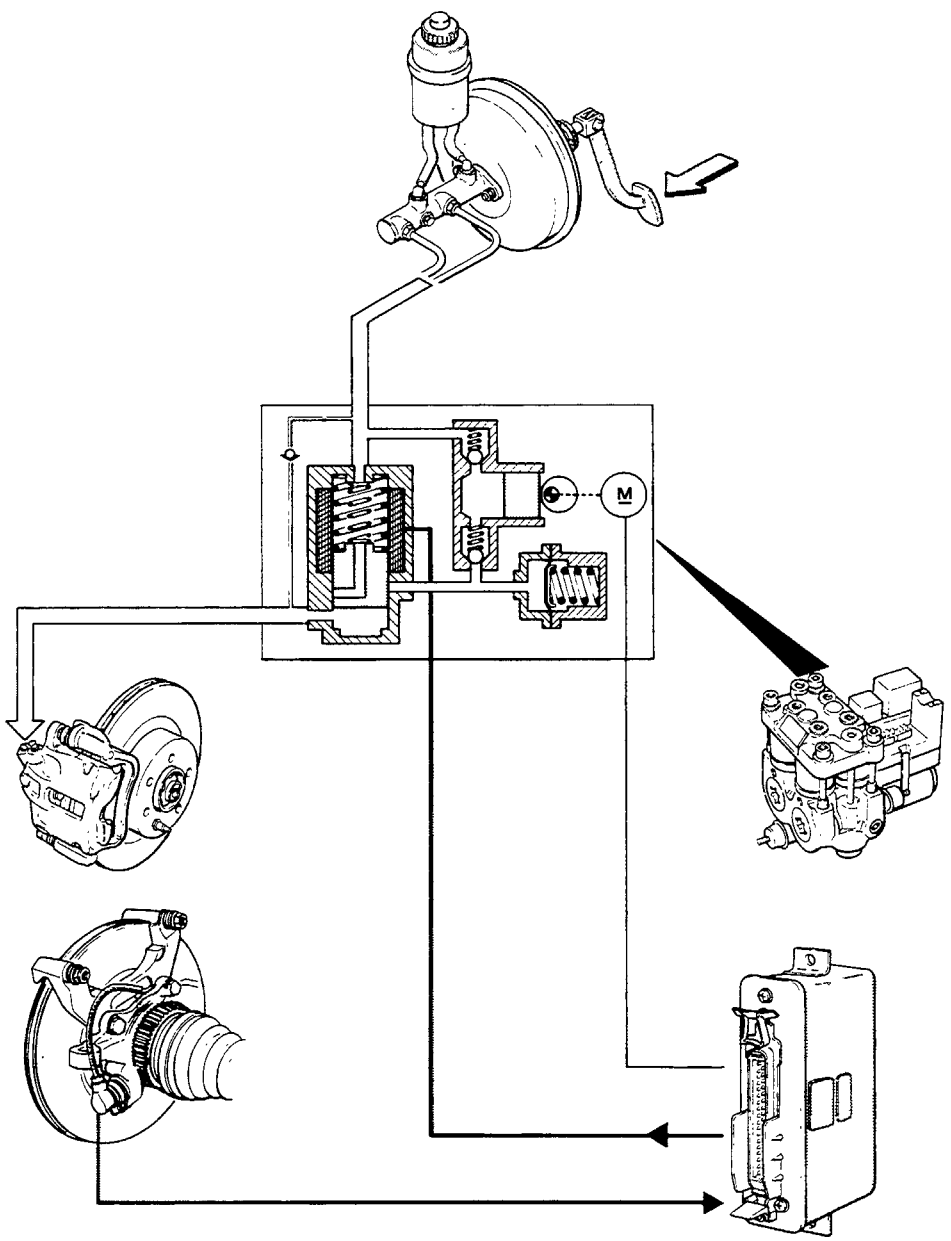
33.

Pressure maintenance stage

During this stage both the speed and the acceleration of wheel are increasing
The solenoid valve is energized by a 2 A current; the connection between the brake pump and the brake caliper is still interrupted (waiting position) and the pressure in the brake caliper is maintained constant at the value reached previously, whatever the pressure on the brake pedal.



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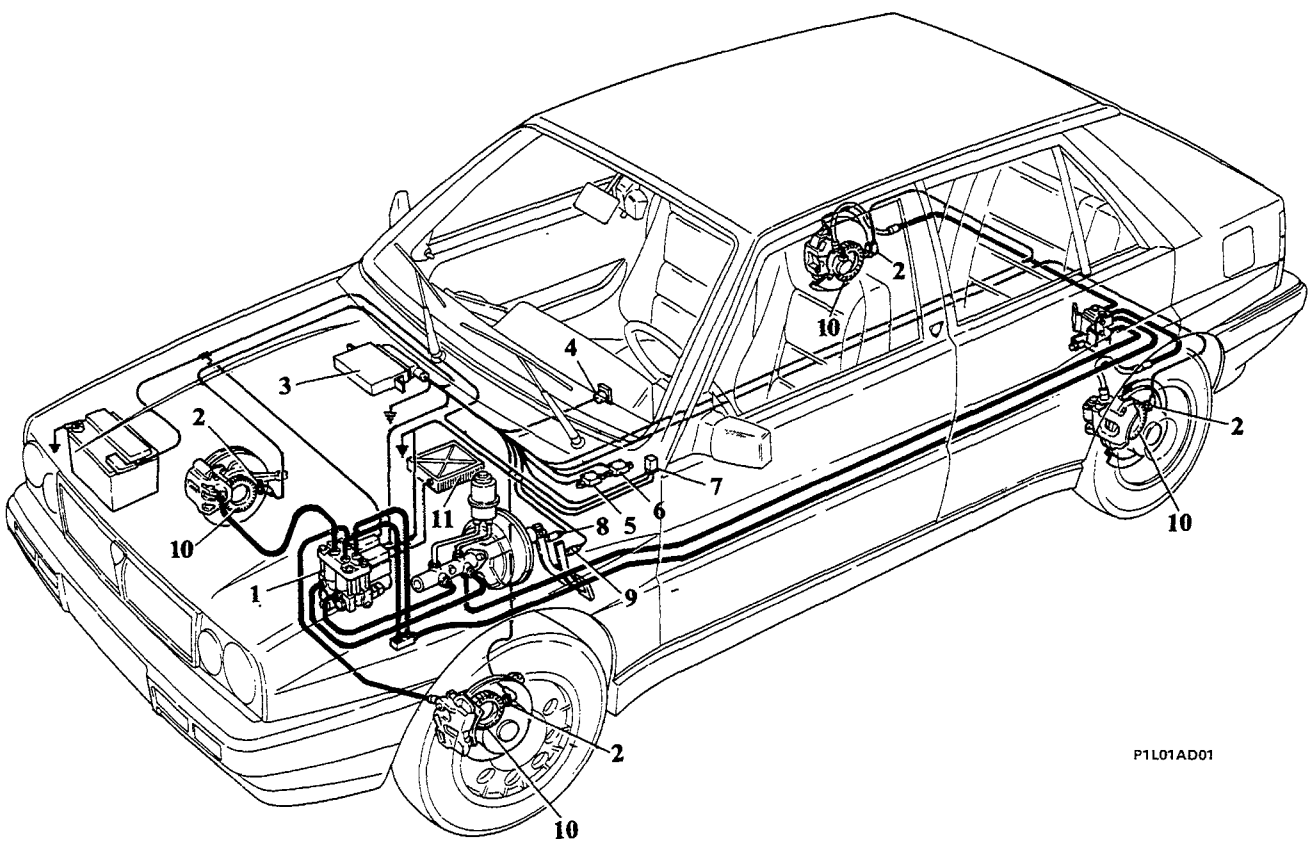
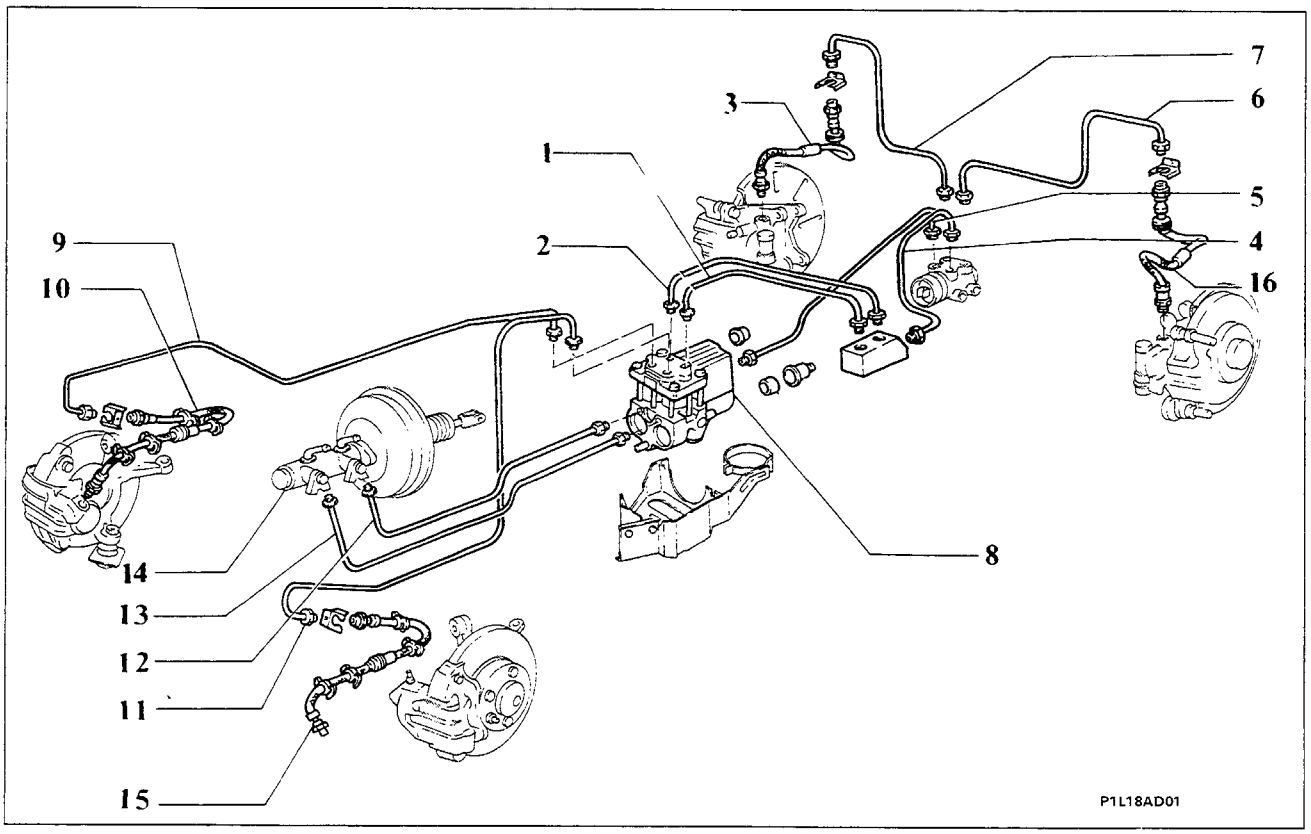
Anti-lock braking system components



1. Hydraulic control unit
2. Rpm snesors
3. Electronic control unit
4. Device failure warning light
5. Longitudinal accelerometer
6. Transverse accelerometer
7. Main control relay with protection against excess voltage
8. Brake lights switch
9. Switch on clutch pedal
10. Flywheels
11. Injection control unit

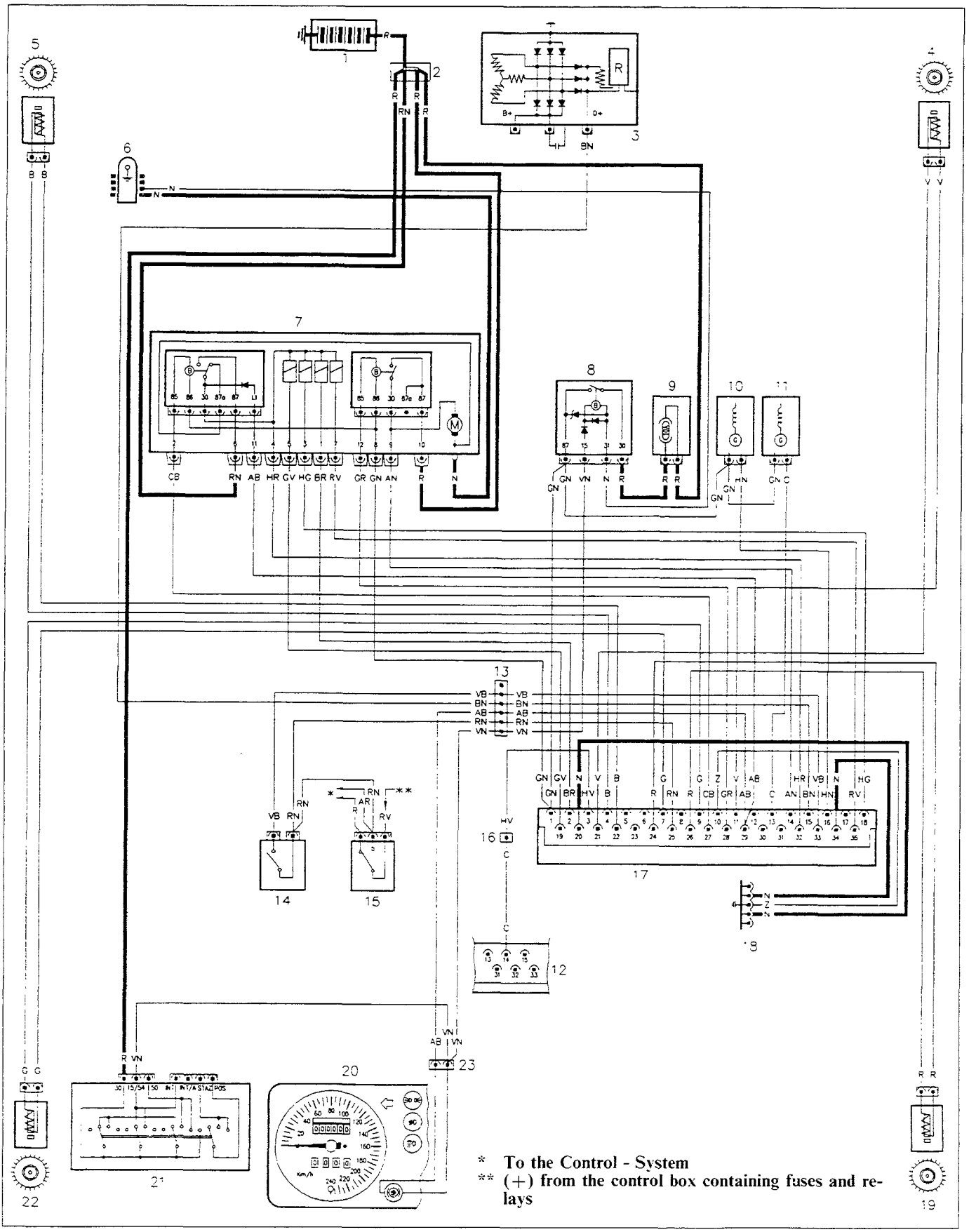
33.

Anti-lock braking system components available as spares



1. Brake pipe after ABS control unit
2. Brake pipe after ABS control unit
3. Right rear brake pipe
4. Left rear brake pipe
5. Right rear brake pipe
6. Left rear brake pipe
7. Right rear brake pipe
8. ABS hydraulic control unit
9. Left front brake pipe
10. Right front flexible pipe
11. Left front brake pipe
12. Brake pipe between master cylinder and ABS
13. Brake pipe between master cylinder and ABS
14. Master cylinder
15. Left front brake pipe
16. Left rear brake pipe

Bosch type 4 channel, 2nd generation, anti-lock braking system



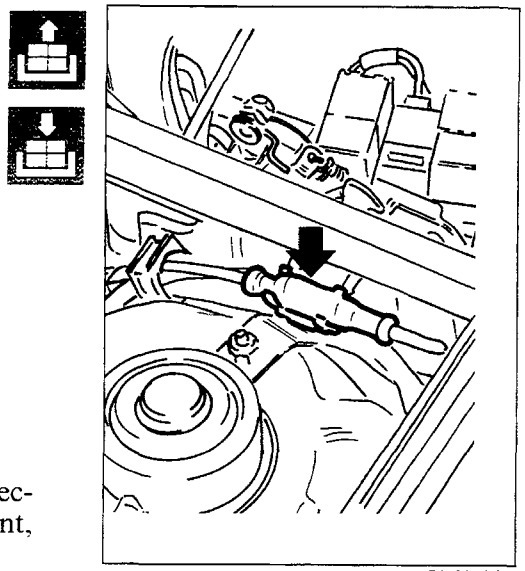
ABS wiring diagram key

1. Battery
2. Connector block
3. Alternator
4. Right front rpm sensor
5. Left front rpm sensor
7. Hydraulic control unit
8. ABS relay
9. Fuse carrier block
10. Longitudinal accelerometer
11. Transverse accelerometer
12. Injection/ignition electronic control unit (I.A.W)
13. Join for anti-lock braking system
14. Switch on clutch pedal
15. Brake lights switch
16. Join between injection/ignition electronic control unit (I.A.W.) and ABS control unit
17. ABS control unit
18. Earth cable loom under dashboard
19. Right rear rpm sensor
20. Instrument panel
21. Ignition switch
22. Left rear rpm sensor
23. Instrument panel connection

Cable colour code

A	Light blue	**GL**	Yellow Blue
B	White	**GR**	Yellow Red
C	Orange	**GV**	Yellow Green
G	Yellow	**HG**	Grey Yellow
H	Grey	**HN**	Grey Black
L	Blue	**HR**	Grey Red
M	Brown	**HV**	Grey Green
N	Black	**LB**	Blue White
R	Red	**LG**	Blue Yellow
S	Pink	**LN**	Blue Black
V	Green	**LR**	Blue Red
Z	Violet	**LV**	Blue Green
AB	Light blue White	**MB**	Brown White
AG	Light blue Yellow	**MN**	Brown Black
AN	Light blue Black	**NZ**	Black Violet
AR	Light blue Red	**RB**	Red White
AV	Light blue Green	**RG**	Red Yellow
BG	White Yellow	**RN**	Red Black
BL	White Blue	**RV**	Red Green
BN	White Black	**SN**	Pink Black
BR	White Red	**VB**	Green White
BV	White Green	**VN**	Green Black
BZ	White Violet	**VR**	Green Red
CA	Orange Light blue	**ZB**	Violet White
CB	Orange White		
CN	Orange Black		
GN	Yellow Black		

RPM SENSOR FOR FRONT WHEEL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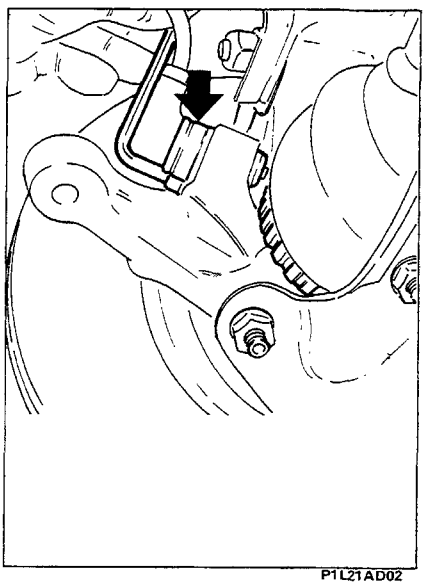
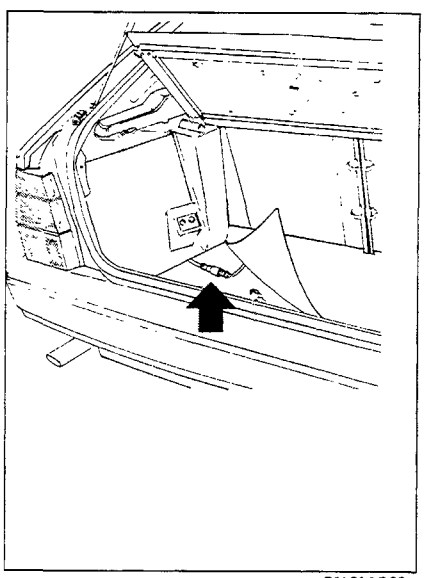

P1L21AD02

Removing-refitting sensor

Disconnect the electrical connection, in the engine compartment, shown by the arrow.

RPM SENSOR FOR REAR WHEEL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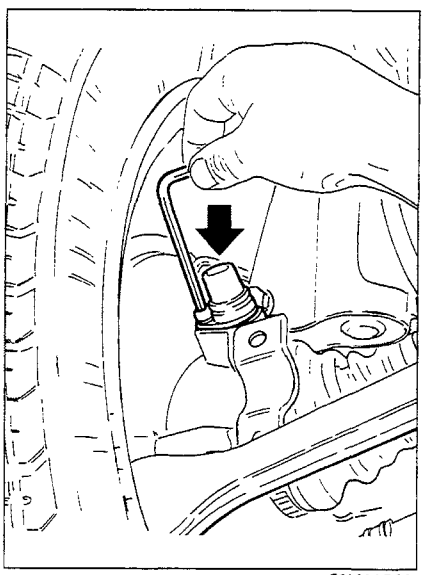

P1L21AD04

Removing-refiting sensor

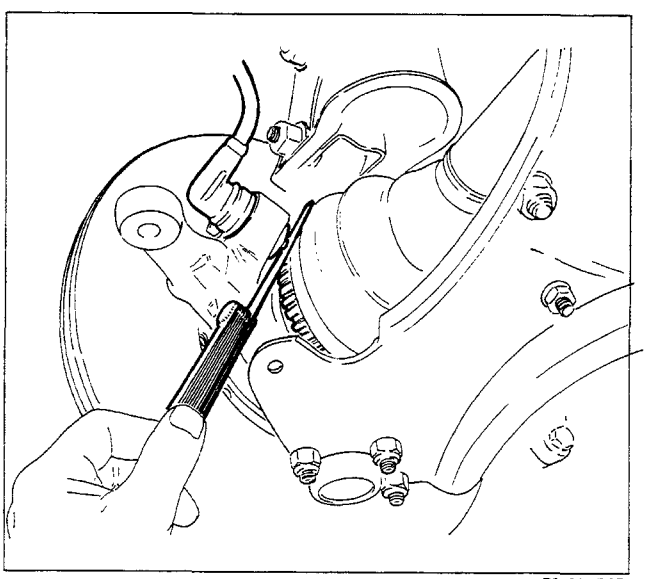
Disconnect the electrical connection, shown by the arrow, at the bottom of the luggage compartment.

CHECKING GAP BETWEEN RPM SENSOR AND FLYWHEEL TEETH

The gap (0.3 - 1.05 mm) should be checked each time the sensor or the wheel side constant velocity joint is replaced or when work is carried out on the supporting components.

The gap cannot be adjusted as shims are not supplied for this purpose. However, if the gap is outside of the prescribed tolerance, check the condition of the sensor and the flywheel teeth.

Checking gap between rpm sensor and flywheel on front wheel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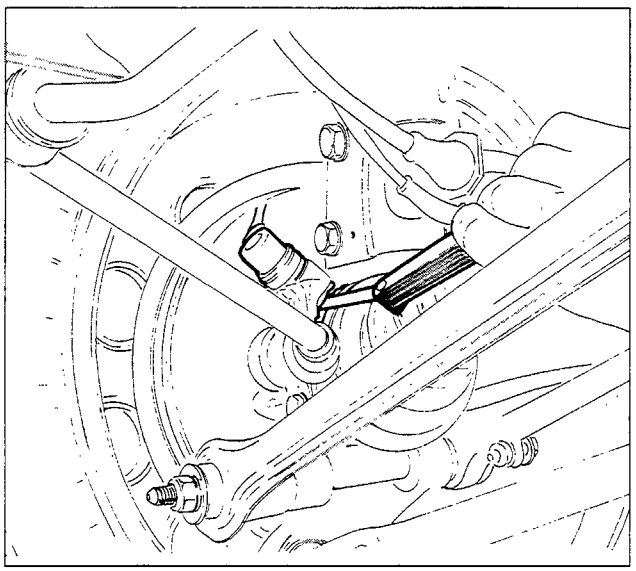
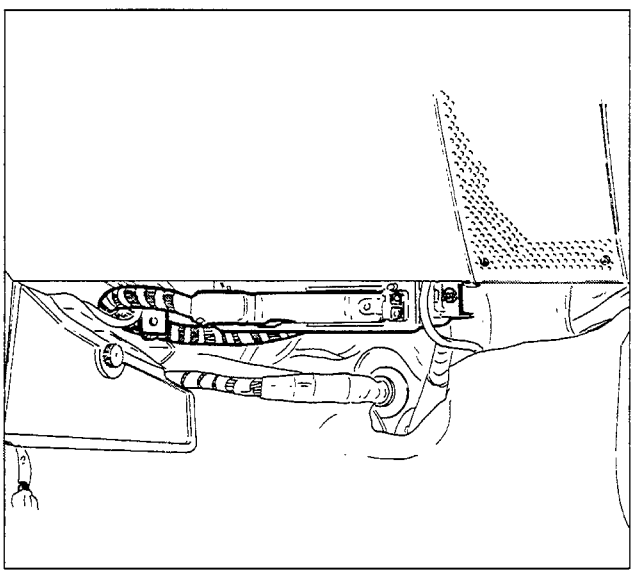


P1L22AD01

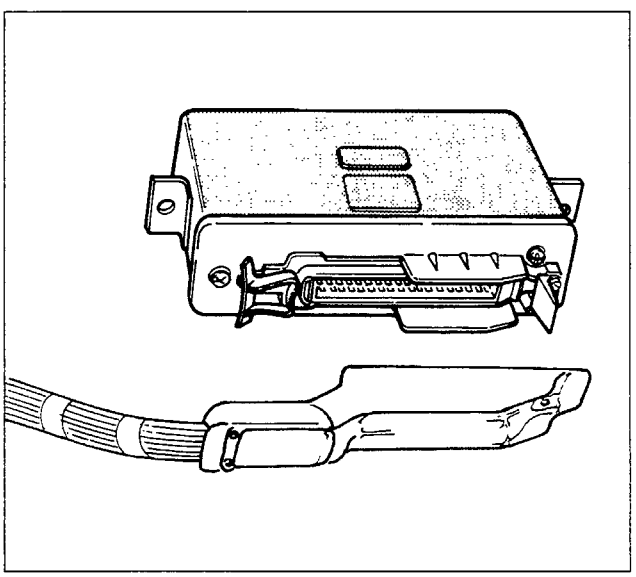
Checking gap between rpm sensor and flywheel on rear wheel



P1L22AD02

ELECTRONIC CONTROL UNIT

Removing-refitting electronic control unit



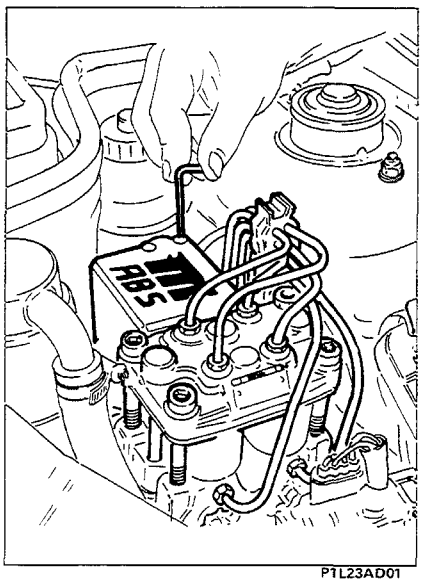
P1L22AD03

Disconnect-connect the electical connector from the electronic control unit

HYDRAULIC CONTROL UNIT

Before removing the hydraulic control unit, disconnect the negative lead from the battery.

Removing-refitting relay cover and electrical connection



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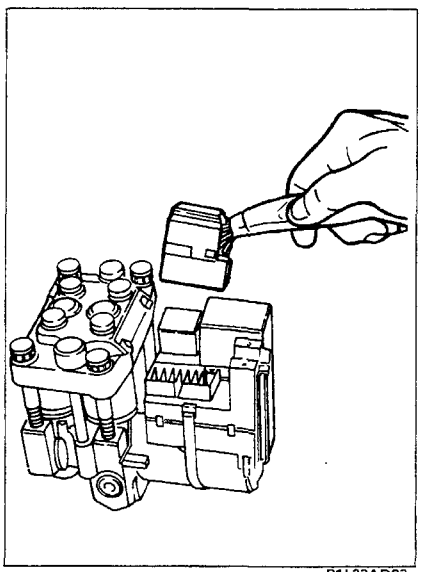

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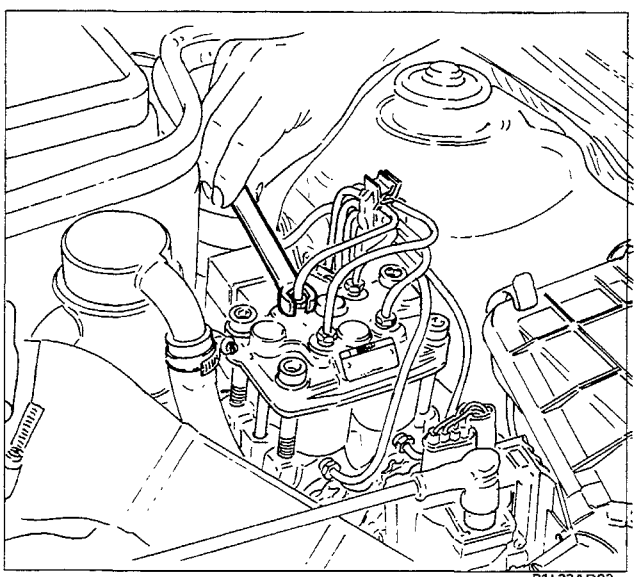
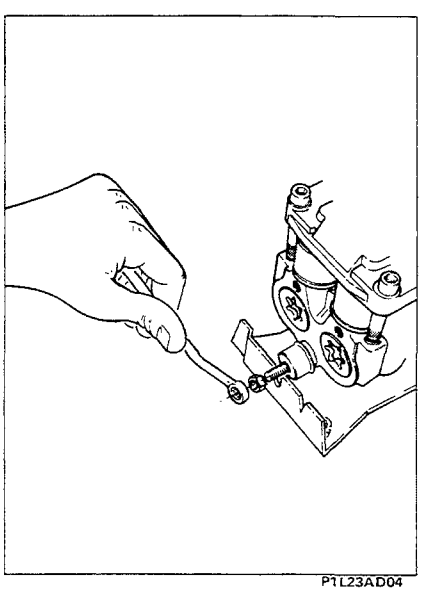


P1L23AD03

Removing-refitting brake pipes from hydraulic control unit

Removing-refitting hydraulic control unit and earth wire

Bleed air from hydraulic system



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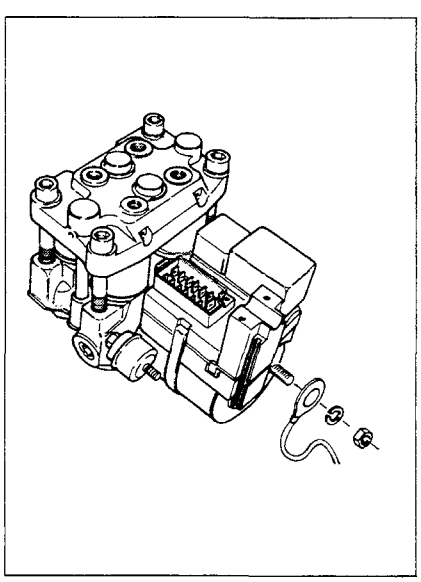

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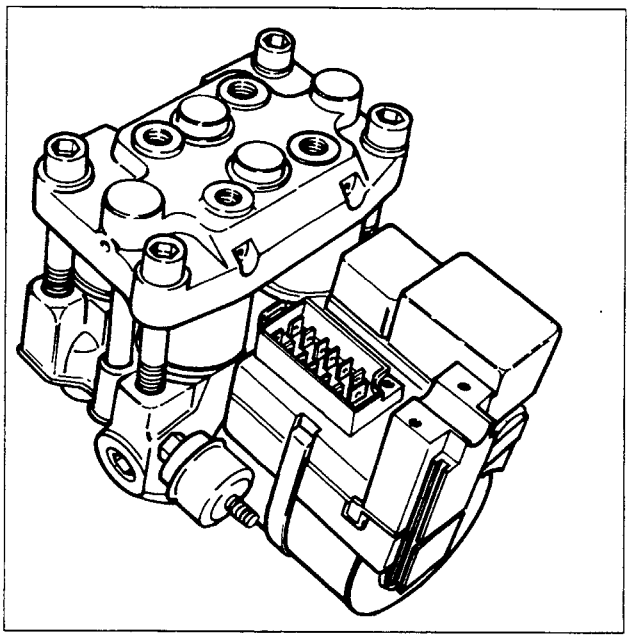
P124AD01

View of hydraulic control unit

PRECAUTIONS TO BE OBSERVED ON A VEHICLE EQUIPPED WITH ANTI-LOCK BRAKES

Before carrying out any welding using electric welding equipment, the connector must be disconnected from the electronic control unit.
During any paint spraying operations, the electronic control unit can only be exposed for a brief period to temperatures of 95°C and, for a longer period (around 2 hours) to a maximum temperature of 85°C.

When the battery is removed, after refitting it, the terminals must be securely tightened.
Before removing the hydraulic control unit, the negative lead must be disconnected from the battery.

SPECIAL TOOLS

1856132000 Spanner for brake fluid pipe unions

TIGHTENING TORQUES

DESCRIPTION	Thread size	Tightening torques
		daNm
Unions connecting rigid pipe on hydraulic control unit	M 10 x 1	1,2
Bolts fixing rpm sensors on all four wheels	M 6 x 1	0,8