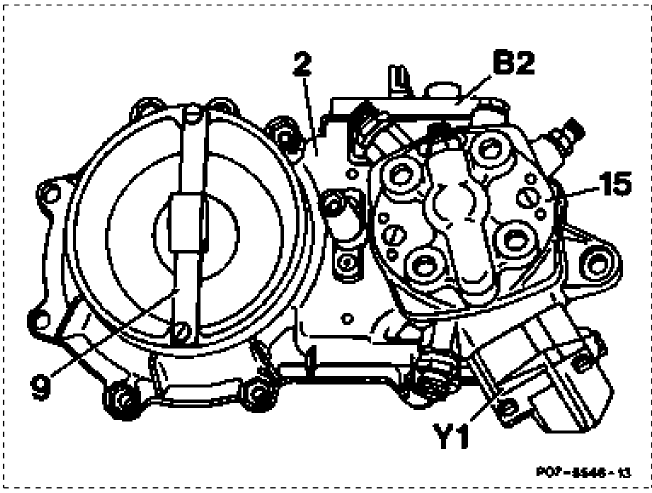
C. Mixture formation

a) Mixture control unit



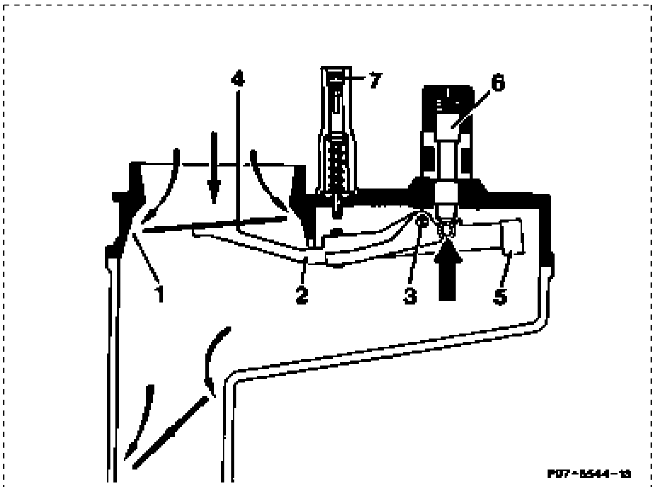
The mixture control unit consists of

- air flow sensor with control lever and air flow sensor position indicator.
- fuel distributor and electrohydraulic actuator.

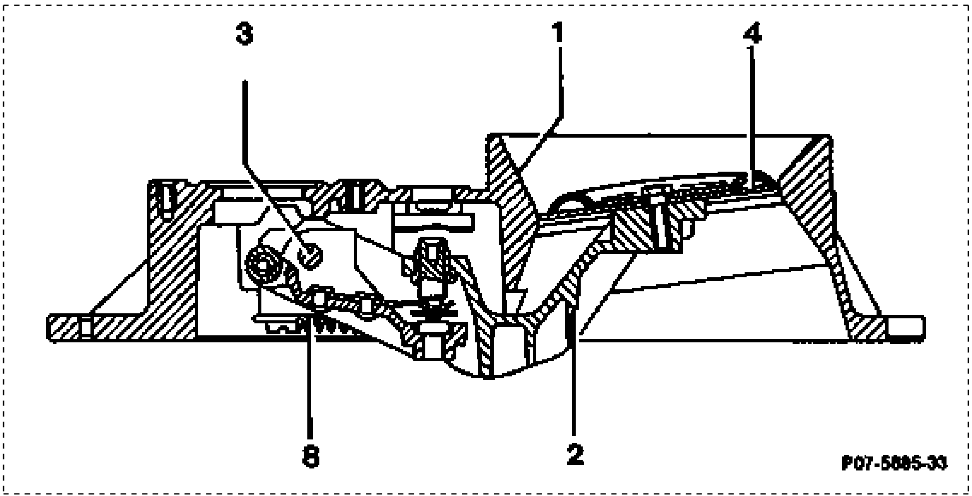
B2 Air flow sensor position indicator
Y1 Electrohydraulic actuator
2 Air flow sensor
9 Stop bar
15 Fuel distributor

b) Air flow sensor

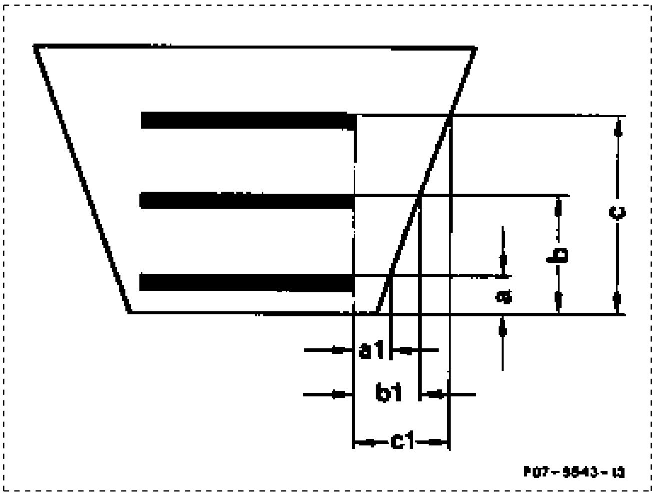
The air flow sensor is installed in the induction flow upstream of the throttle valve and measures the total quantity of air inducted by the engine. This quantity of air is the principal control parameter of the mechanical mixture basic adaptation.
The air flow sensor consists of an air funnel (1), the control lever (2) with counterweight (5) or return spring (only on engine 102) and air flow sensor plate (4). The control lever (2) pivots around the pivot point (3).
The deadweight of air flow sensor plate (4) and control lever (2) is compensated by the counterweight (5) or by a return spring (only on engine 102).



1 Air funnel
2 Control lever
3 Pivot point
4 Air flow sensor plate
5 Counterweight
6 Control piston
7 Mixture regulating screw



1 Air funnel
2 Control lever
3 Pivot point
4 Air flow sensor plate
8 Return spring



Measurement of the quantity of air is based on the suspended body principle which states that a suspended body moves in a uniform cone in proportion to the air throughput.

The suspended body shown in the illustration permits an air throughput equivalent to the annular surface (a1) in the case of lift (a) and equivalent to the annular surface (b1) in the case of lift (b). Hence: the greater the air throughput, the greater is the lift of the suspended body.

In the air flow sensor of the mixture control unit, the air flow sensor plate is the suspended body, the air funnel is the cone.

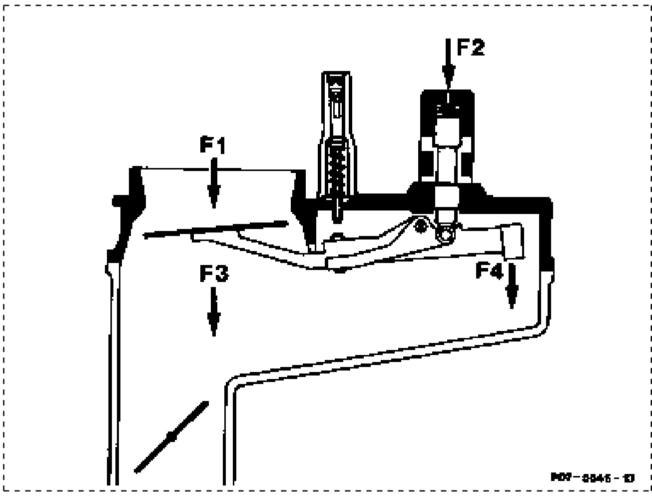
In accordance with the quantity of air inducted by the engine, the air flow sensor plate adopts its position in the air funnel of the air flow sensor. The movement of the air flow sensor plate is transmitted to the control piston by the control lever. The control piston alters the cross-section of the opening at the control slots. Consequently, a large quantity of fuel is metered to a large quantity of air and vice versa.

The following forces are active at the air flow sensor: The intake air acts on the air flow sensor plate as an air force (F1). Opposed to it is the hydraulic force (F2) of the system pressure which acts from above on the control piston.

The deadweight of air flow sensor plate and control lever, the force (F3), is compensated by the counterweight (F4) or by a return spring (only on engine 102).

The position of the sensor plate alters until the air force (F1) and the hydraulic force (F2) are in equilibrium.

Thus, the deflection of the air flow sensor plate and thus the position of the control piston in the case of the basic function are determined only by the air throughput.

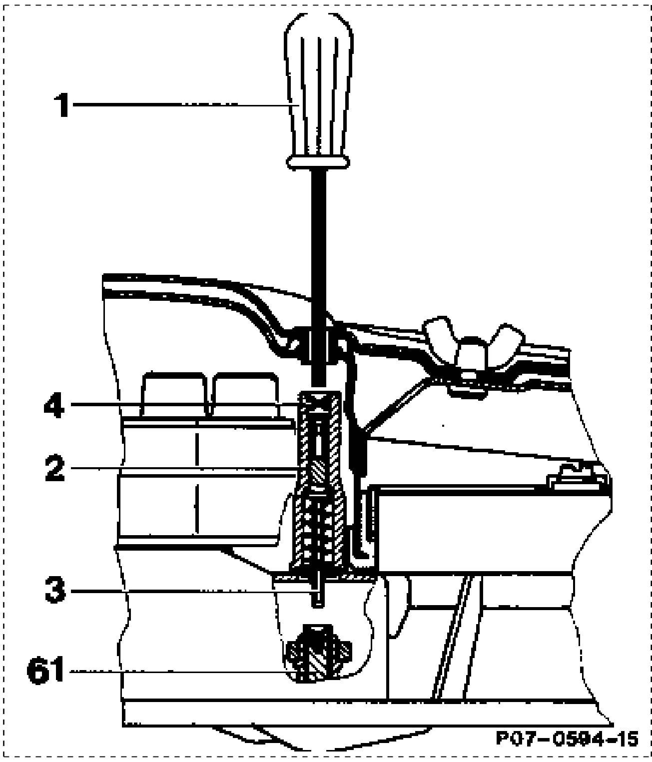


F1 Intake air force
F2 System pressure force
F3 Force, deadweight of control lever/air flow sensor plate
F4 Force, counterweight or return spring

When the engine is switched off, the air flow sensor plate is in the zero position, resting against a resilient stop. The zero position of the sensor plate is adjustable.

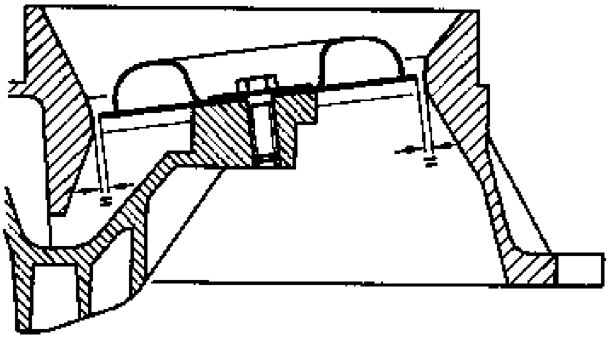
In the case of misfiring ("backfiring") the resilient stop is overcome, the air flow sensor plate moves up and opens a relief cross-section at the air funnel. The pressure in intake manifold is reduced and damage to the air flow sensor plate is prevented. The upward travel of the sensor plate is limited by the stop bar.
Matching of air flow sensor plate and control piston or mixture adjustment is performed with the mixture regulating screw.

1 Screwdriver
2 Adjusting device
3 Hexagon
4 Anti-tamper plug
61 Mixture regulating screw



Air flow sensor with shaped air flow sensor plate

The shaped air flow sensor plate permits a higher air throughput compared to the flat sensor plate at the same deflection.

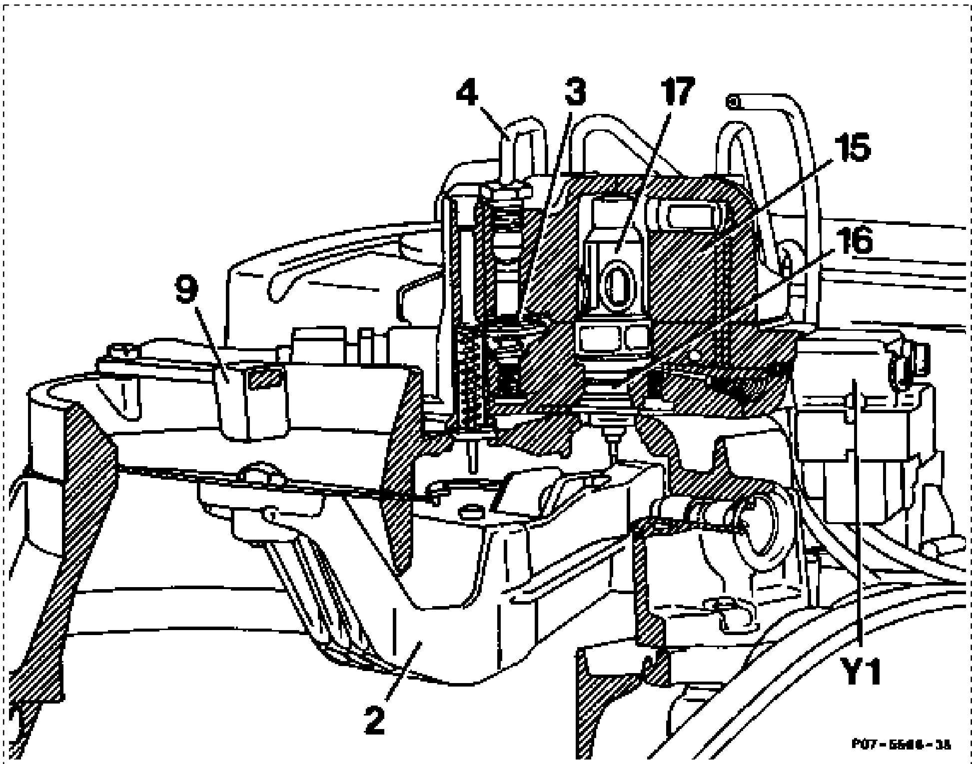


c) Fuel distributor

The fuel distributor meters the quantity of fuel to the individual cylinders depending on the position of the sensor plate in the air flow sensor.

Mixture control unit

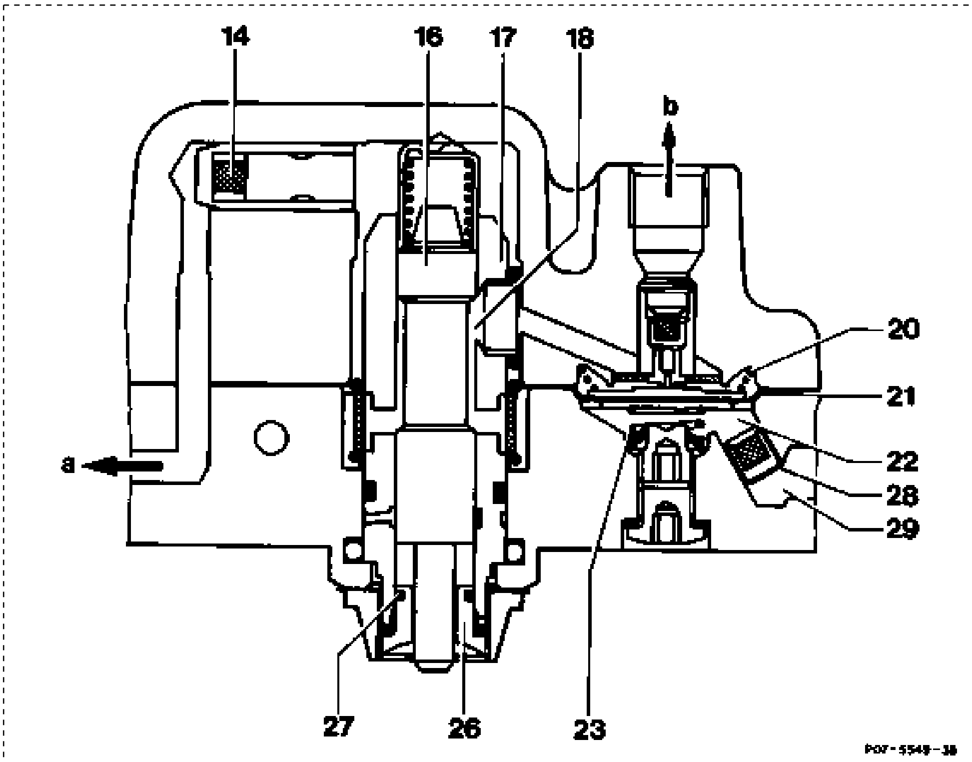
Y1 Electrohydraulic actuator
2 Air flow sensor with air funnel, air flow sensor plate and control lever
3 Differential pressure valve
4 Injection line to an injection valve
9 Stop bar
15 Fuel distributor
16 Control piston
17 Metering slot body

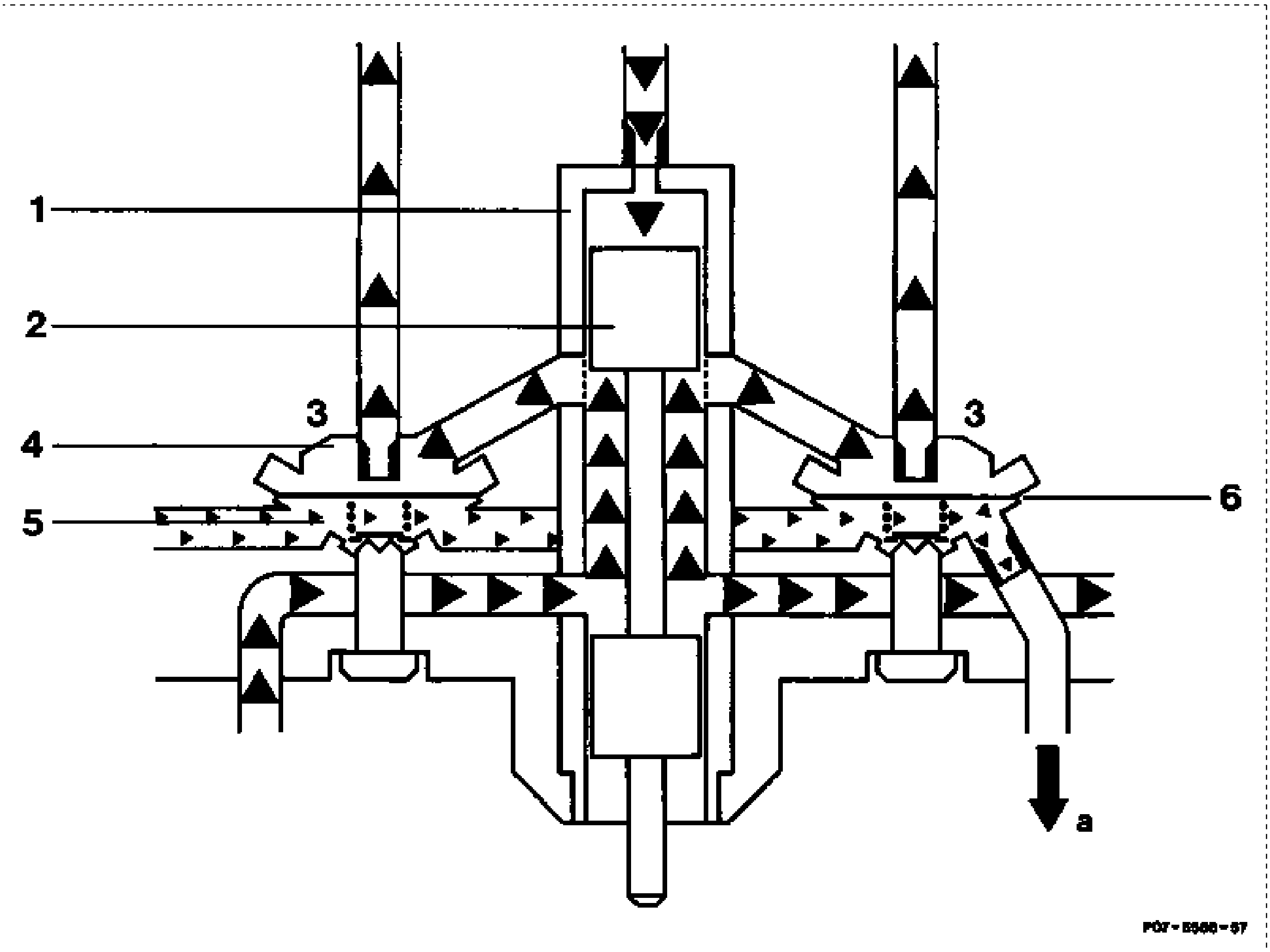


Fuel distributor

14 Strainer with permanent magnet
16 Control piston
17 Metering slot body
18 Control orifice
20 Upper chamber
21 Diaphragm
22 Lower chamber
23 Compression spring
26 Screw plug (control piston)
27 Shaped ring
28 Restriction
29 Connection Connecting line to diaphragm pressure regulator (control and leak quantity)

a to electrohydraulic actuator
b to injection valve





System pressure/upper chamber pressure
Lower chamber pressure
Injection pressure
pressureless

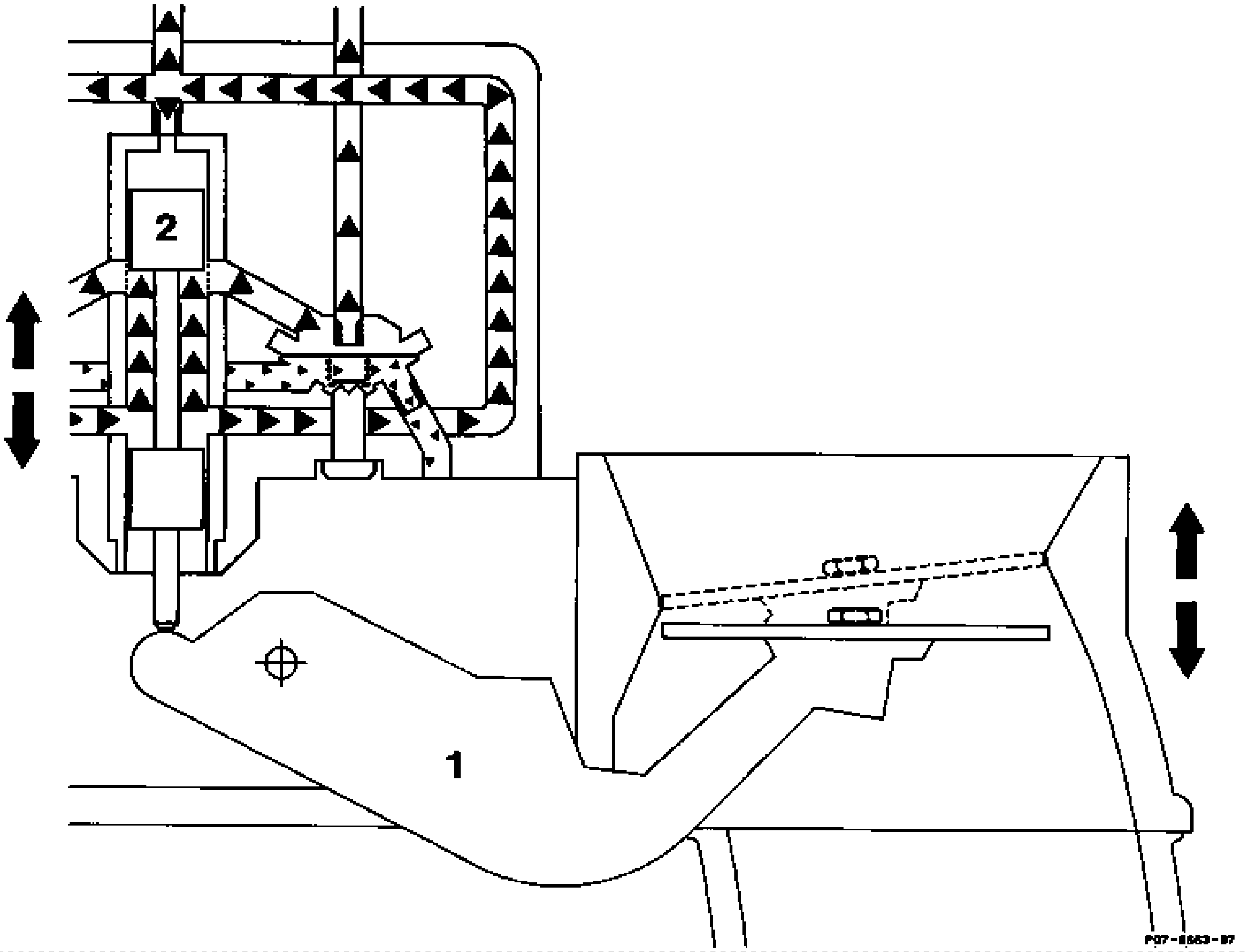
Fuel distributor

1	Metering slot body	5	Lower chamber
2	Control piston	6	Diaphragm
3	Differential pressure valve	a	Control/leak quantity to diaphragm pressure regulator
4	Upper chamber		

The metering slot body with the metering slots (1) and the control piston (2) is positioned in the center of the fuel distributor. A differential pressure valve (3) is allocated to each metering slot. The number of differential pressure valves corresponds to the number of cylinders in the engine. Each differential pressure valve is divided into an upper chamber (4) and a lower chamber (5).

The two chambers are separated by a diaphragm (6). The upper chambers are sealed off to each other. An injection line runs from each upper chamber to the respective injection valve. All the lower chambers, in contrast, are connected to each other.

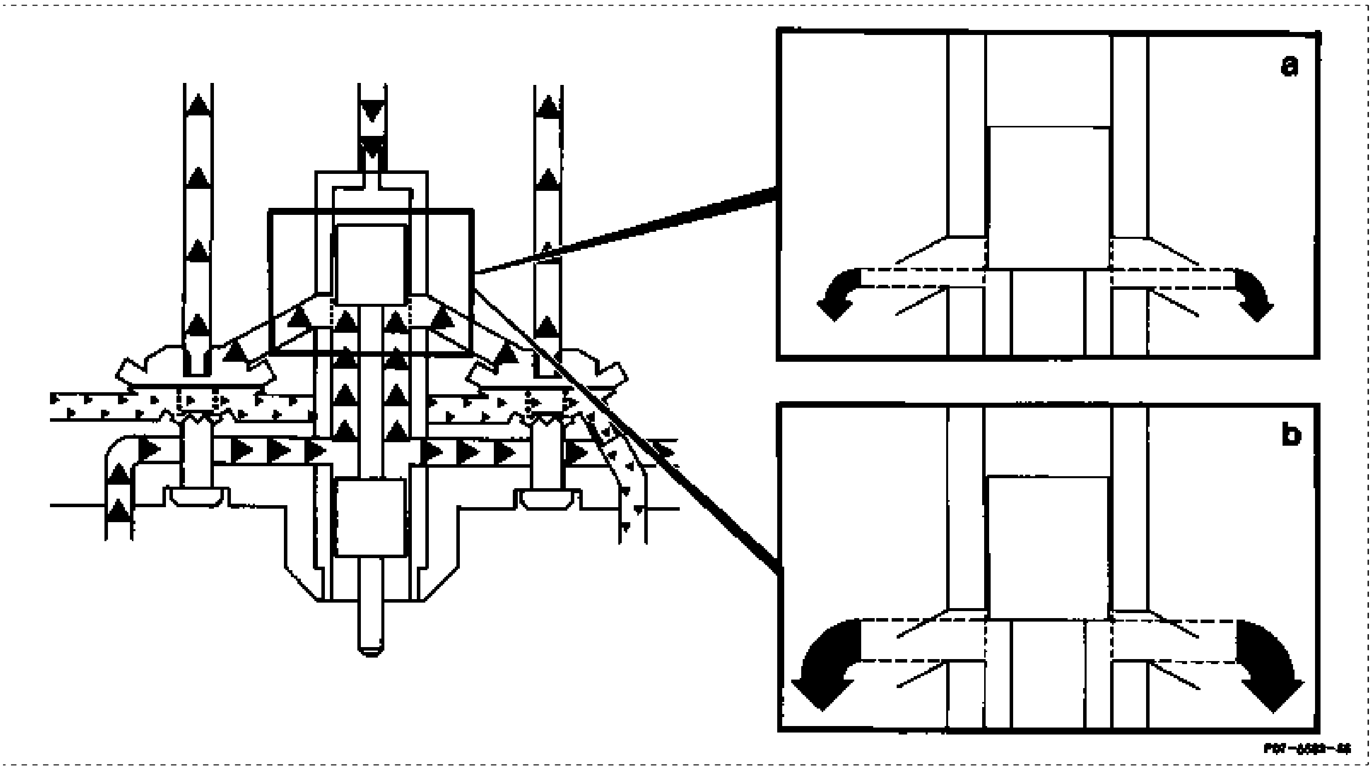
d) Mechanical mixture adaptation



Mixture control unit

1	Control lever
2	Control piston

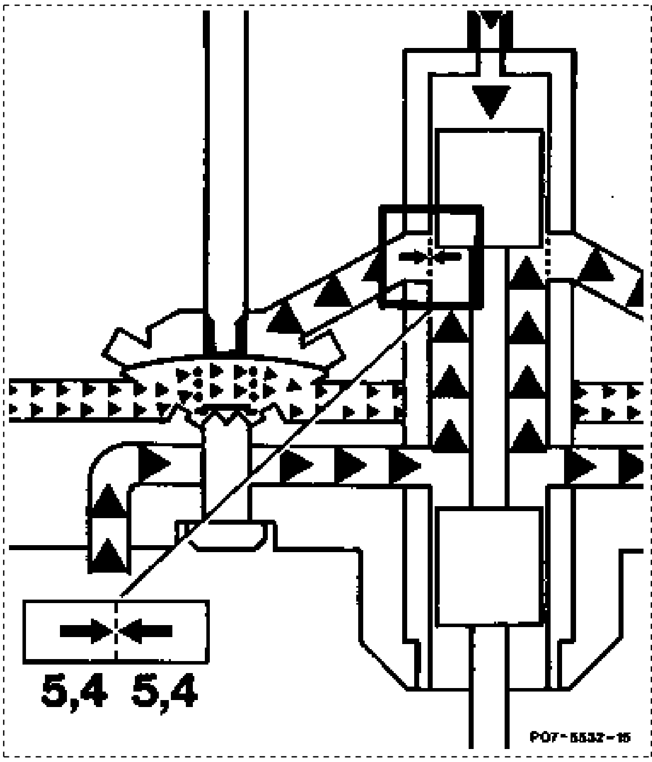
The mixture basic adaptation is performed mechanically. In accordance with the quantity of air inducted by the engine the air flow sensor plate adopts its position in the air funnel of the air flow sensor. The movement of the air flow sensor plate is transmitted to the control piston (2) by the control lever (1). The control piston alters the cross-section of the opening at the metering slots. Thus, a large quantity of fuel is metered to a large quantity of air and vice versa.

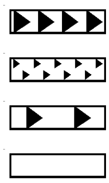


System pressure/upper chamber pressure
Lower chamber pressure
Injection pressure

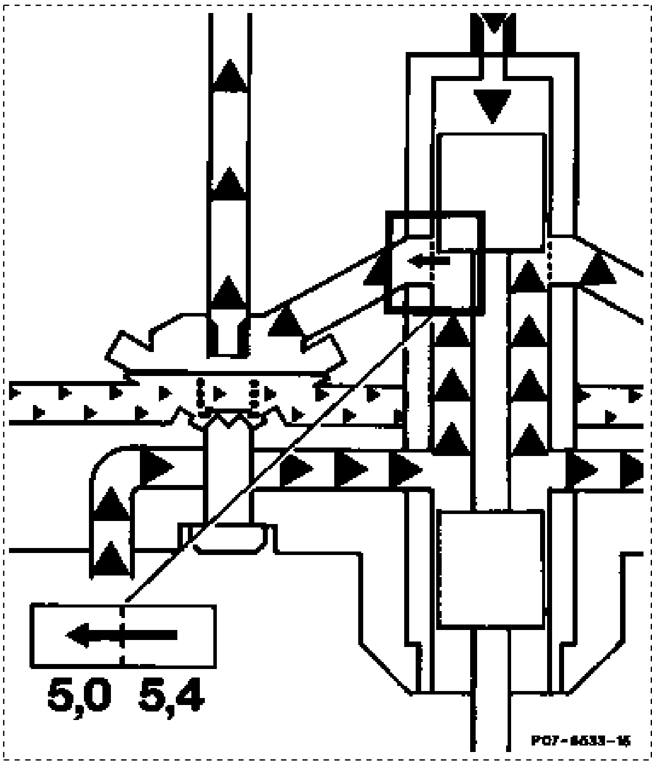
Fuel metering in the case of mixture basic adaptation is performed by altering the cross-sections of the openings at the metering slots. The fuel flows through the metering slots into the upper chambers and then to the injection valves. The illustration (a) shows a slight opening cross-section of the metering slot. The engine is running at low load with a small quantity of fuel. In the illustration (b) the opening cross-section of the slots is large. The engine is running at a higher load with a greater quantity of fuel.

A pressure difference is necessary to enable the fuel to flow through the metering slots. This means, no fuel would flow if the pressure upstream and downstream of the metering slots were the same, irrespective of the position of the control piston.





The pressure difference for the mechanical basic function of the fuel distributor is fixed by the design. It is approx. 0.4 bar. Fuel metering is performed mechanically with a constant pressure difference. In this case, the control piston alters the opening cross-section at the metering slots in accordance with the quantity of air inducted by the engine.



System pressure/upper chamber pressure
Lower chamber pressure
Injection pressure
pressureless

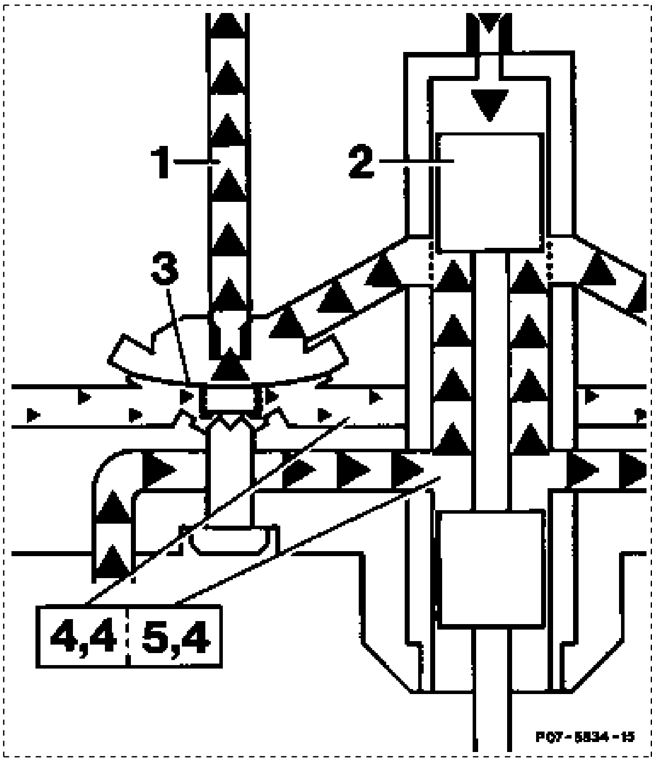
e) Electronic mixture adaptation

In addition to the mechanical basic adaptation, there is a further possibility of adapting the fuel/ air mixture to the different operating states of the engine. It is possible to alter the pressure difference at the metering slots - and thus the quantity of fuel - by altering the pressure in the lower chambers with the electrohydraulic actuator. A basic rule in this procedure is that the upper chamber pressure alters in the same ratio to the lower chamber pressure.

If the lower chamber pressure is low, this produces a large pressure difference at the metering slots and thus an enrichment of the mixture.

Example for mixture enrichment by means of electronic mixture adaptation (position of control piston (2) constant):

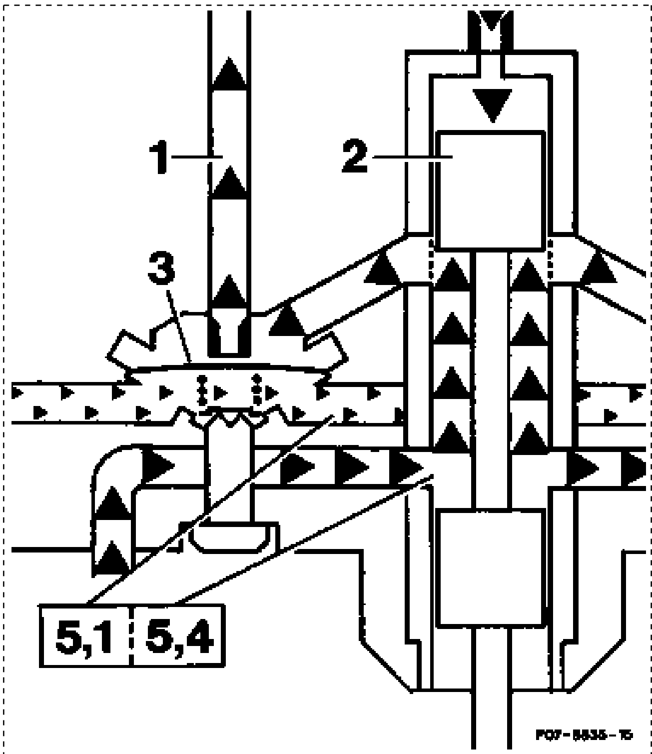
- Lower chamber pressure low (4.4 bar).
- Differential pressure large (1.0 bar).
- Diaphragm (3) in the differential pressure valve curves down and opens a larger outlet cross-section to the injection line (1).
- Mixture enrichment.

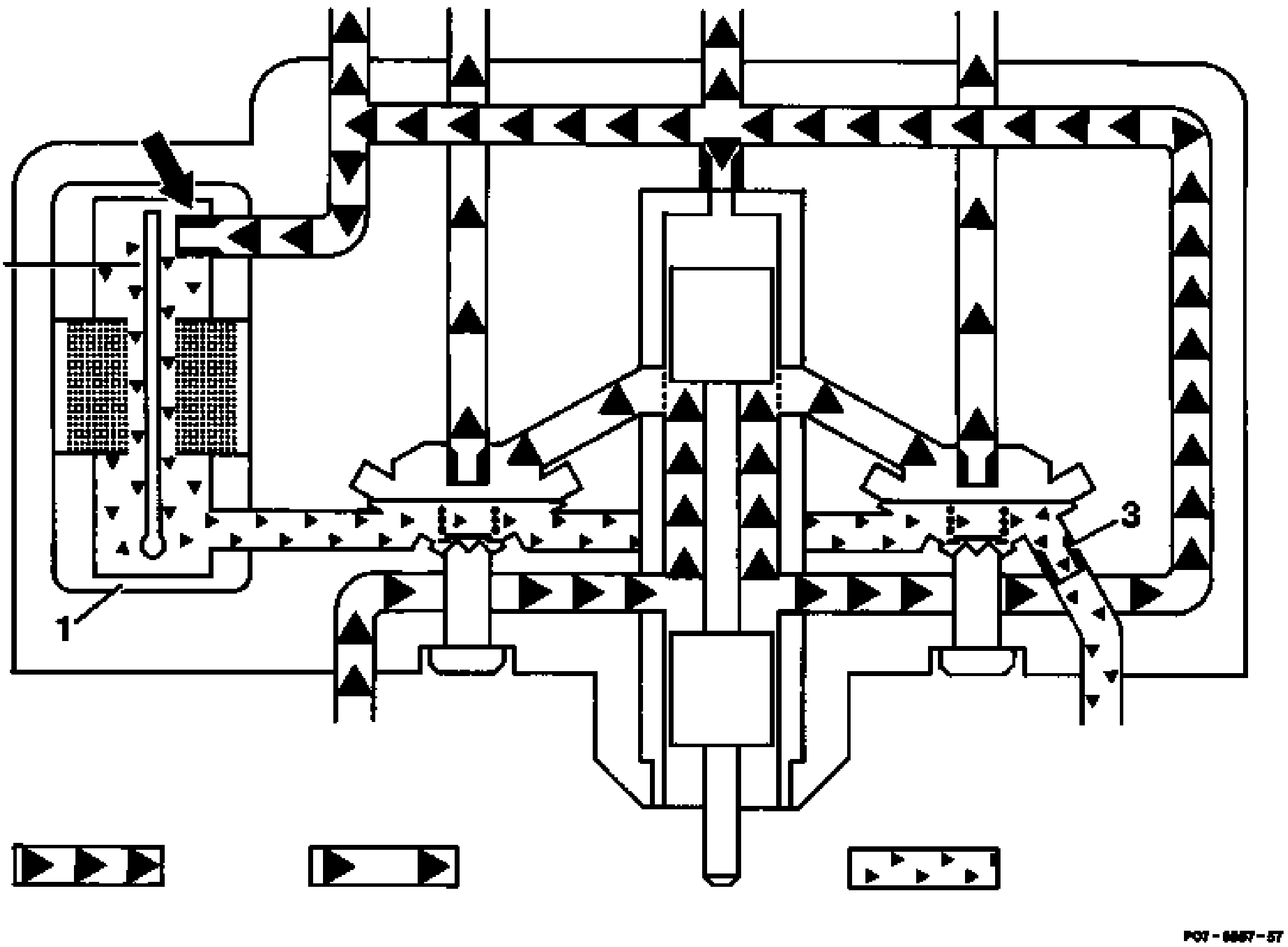


If the lower chamber pressure is high, this produces a lower pressure difference at the metering slots and thus a leaner mixture.

Example for leaner mixture by means of electronic mixture adaptation (position of control piston (2) constant):

- Lower chamber pressure high (5.1 bar).
- Differential pressure small (0.3 bar) (only 0.1 bar less than the design-related value of 0.4 bar).
- Diaphragm (3) in the differential pressure valve curves upward and narrows the outlet cross-section to the injection line (1).
- Leaner mixture.



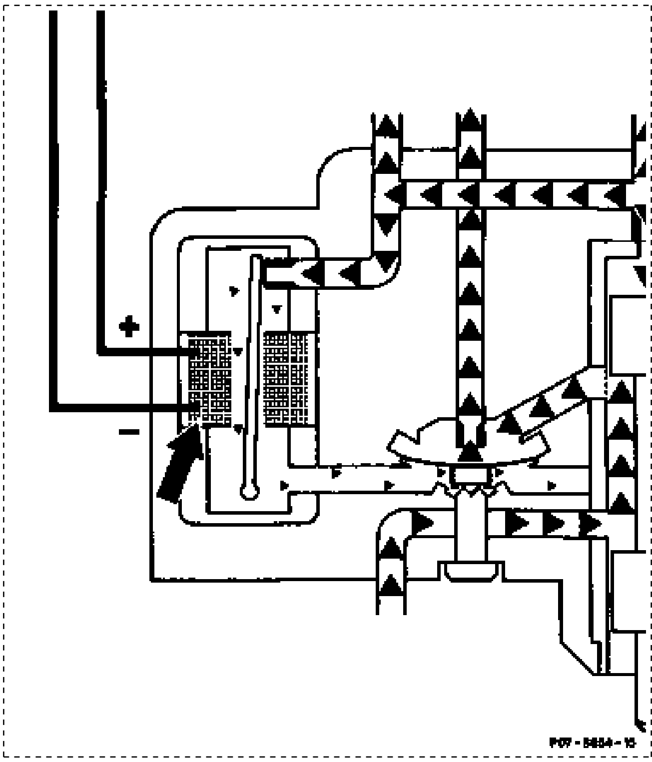


System pressure/upper chamber pressure	1 Electrohydraulic actuator
Lower chamber pressure	2 Valve plate
Injection pressure	3 Fixed restriction

An electrohydraulic actuator (1) which controls the fuel feed (arrow) to the lower chambers and thus the lower chamber pressure is necessary in order to alter the lower chamber pressure. The fuel feed can be opened more or less by moving the valve plate (2). A fixed restriction (3) which together with the lower chamber pressure determines the quantity of return fuel is located at the outlet of the inter-connected lower chambers.

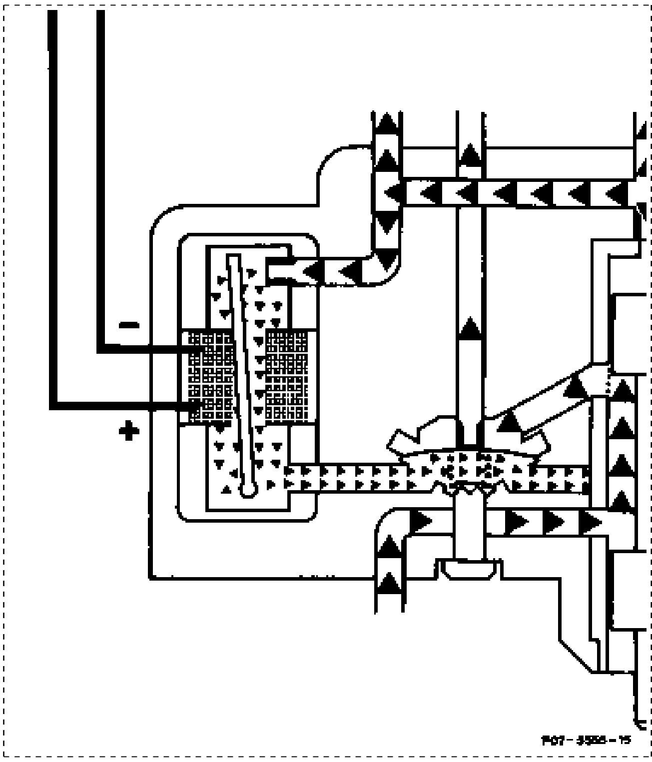
The valve plate in the electrohydraulic actuator can be moved into directions from its base position with the help of a solenoid (arrow).

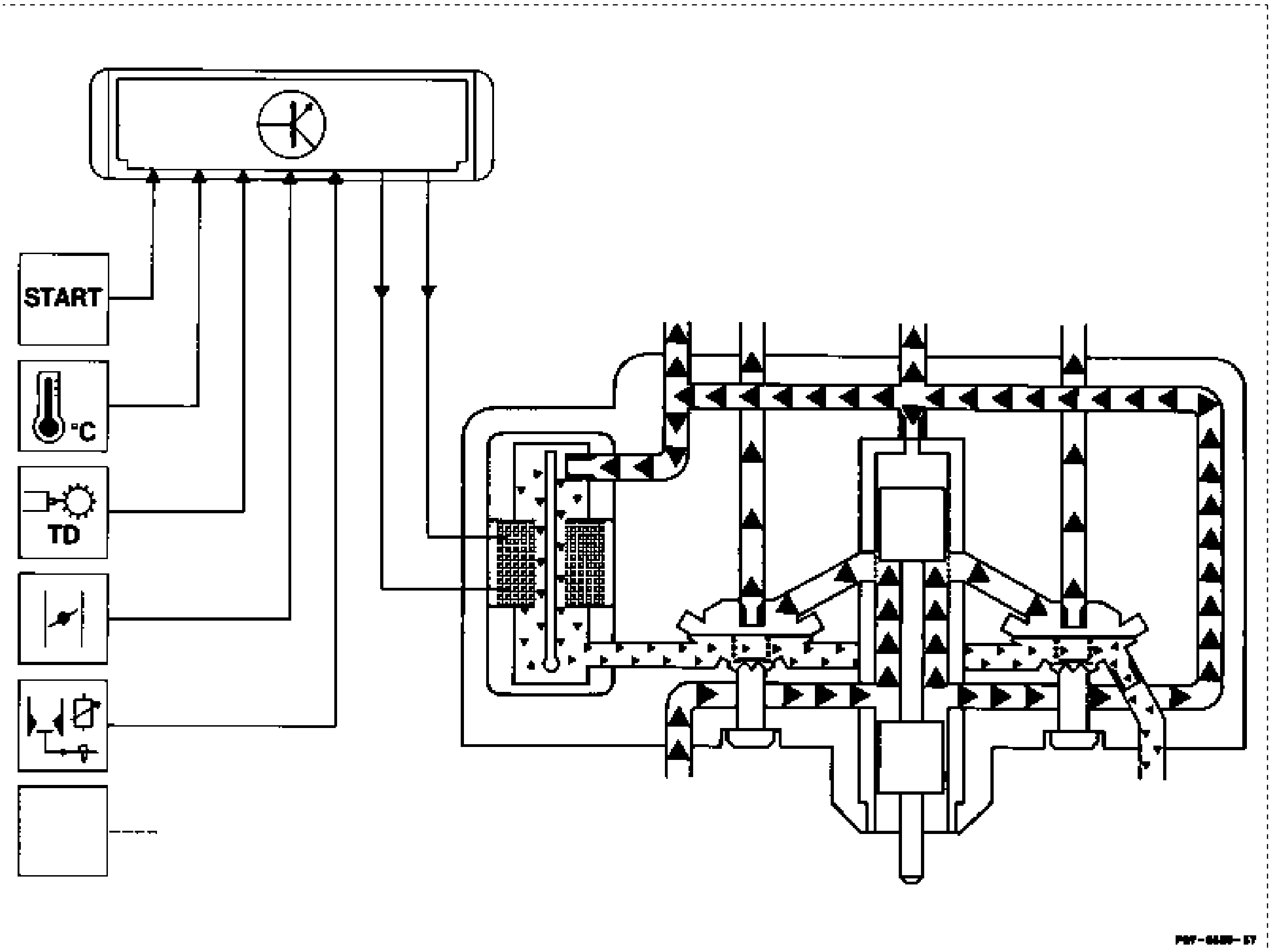
If current flows through the solenoid, the valve plate moves in the direction of fuel feed. The lower chamber pressure is reduced and the pressure difference at metering slots is thus greater.



By altering the direction of the current at the solenoid, the valve plate is moved away from the fuel feed. The lower chamber pressure rises and the pressure difference at the metering slots is thus less.

The pressure difference at the metering slots is always altered when the lower chamber pressure is altered. Altering the pressure difference enables the composition of the mixture to be rapidly controlled for all operating states of the engine. This applies both in the sense of enriching the mixture as well as in the sense of achieving a leaner mixture up to deceleration fuel cutoff.



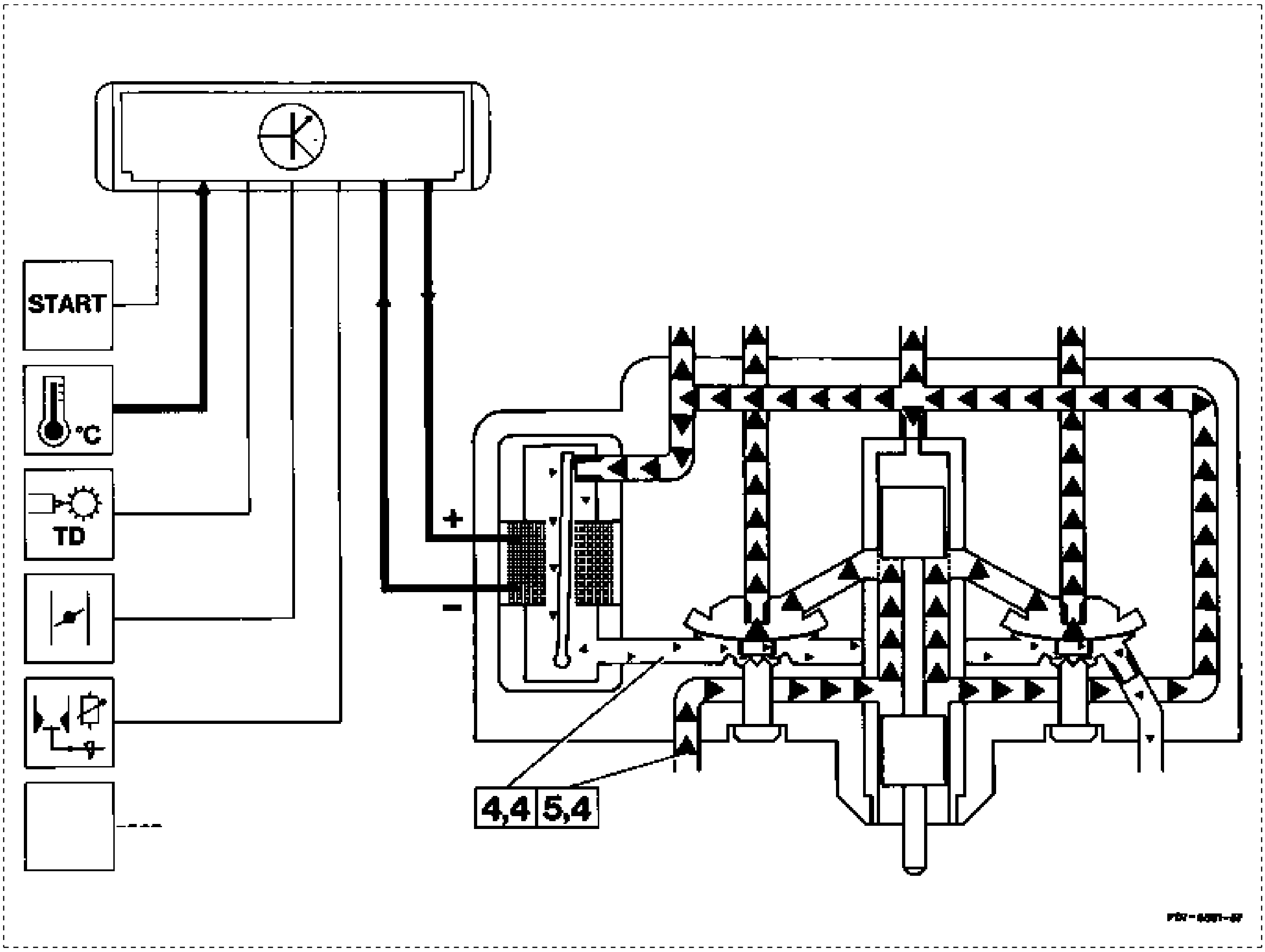


System pressure/upper chamber pressure
Lower chamber pressure
Injection pressure

The electrohydraulic actuator is energized by the KE control unit. The KE control unit determines the control current from various influencing parameters.

Influencing parameters may be for example:

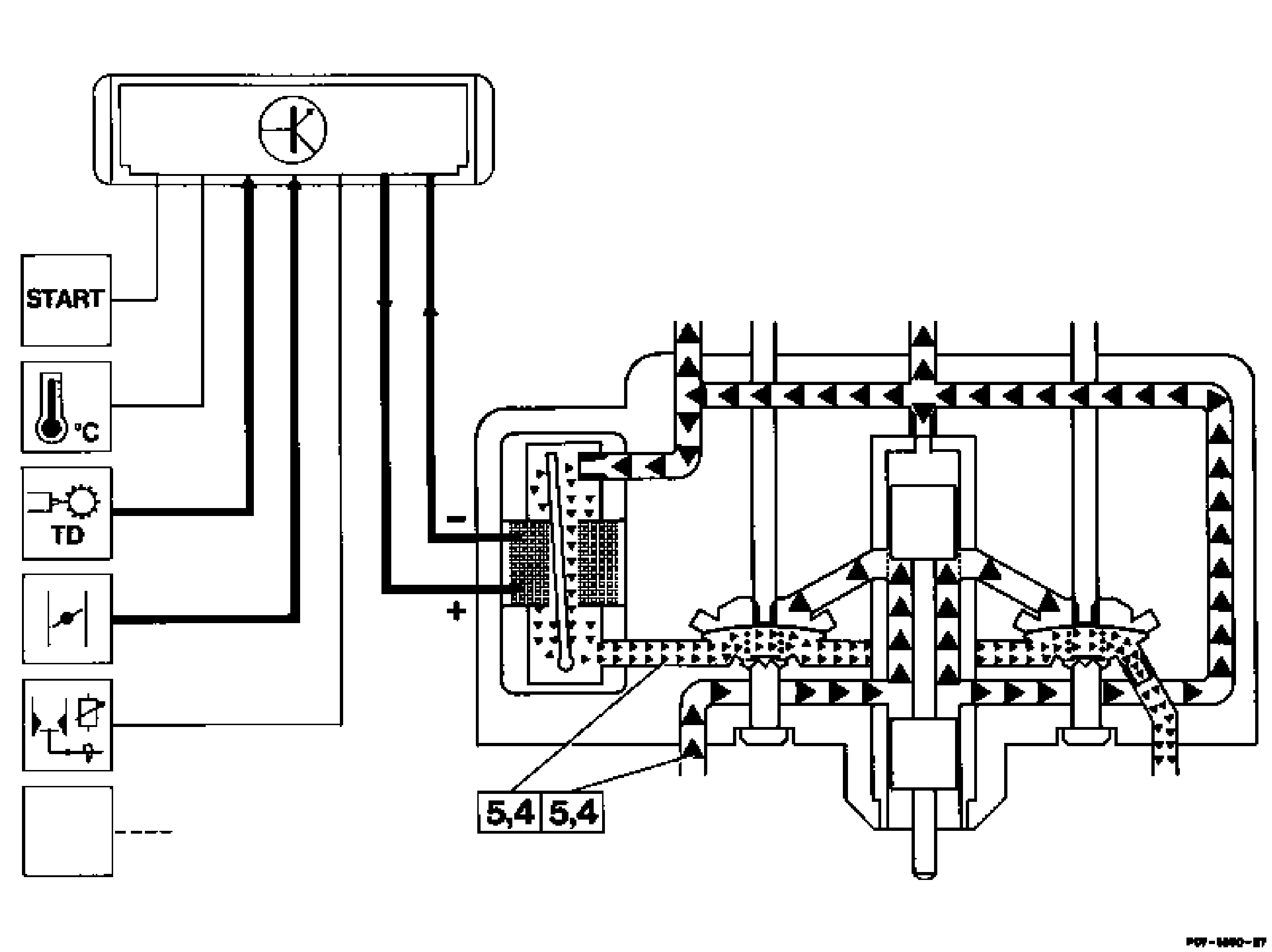
- start signal
- engine temperature
- engine speed signal (TD signal)
- load state of engine
- air flow sensor position indicator signal (position and movement of air flow sensor plate, opening rate)
- Lambda signal in the case of KAT



System pressure/upper chamber pressure
Lower chamber pressure
Injection pressure

Mixture enrichment

If it is necessary to enrich the mixture for operation of the engine, for example in the warming-up phase, the engine temperature is signalled to the KE control unit by the coolant temperature sensor. The corresponding control current is now supplied by the KE control unit to the electrohydraulic actuator. The valve plate in the electrohydraulic actuator is moved in the direction of fuel feed. As a result of this, the feed quantity is reduced and the lower chamber pressure drops (e. g. 4.4 bar). The pressure difference at the metering slots is increased and thus also the quantity of fuel injected.



▶▶▶▶	System pressure/upper chamber pressure
▸▸▸▸	Lower chamber pressure
▶ ▶	Injection pressure
(blank box)	pressureless

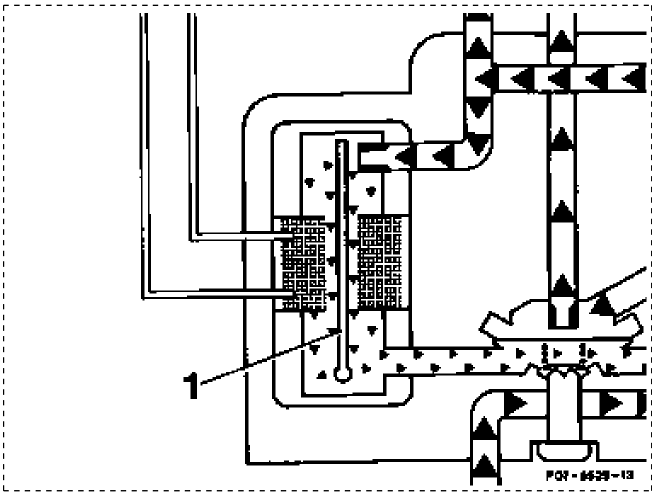
Deceleration mode

If no fuel is required in engine deceleration mode, the KE control unit is supplied with the information "throttle valve closed" by the decel fuel cutoff microswitch or the idle speed contact in the throttle valve switch and from terminal TD with the information that the momentary engine speed is above idling speed.
The KE control unit alters the polarity of the control current to the electrohydraulic actuator for this operating state.

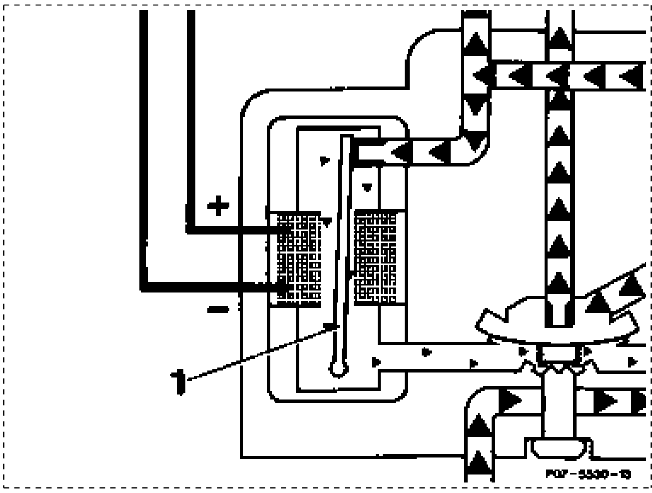
The valve plate is now moved away from the fuel feed. As a result, the lower chamber pressure rises (e. g. 5.4 bar) up to the level of the system pressure (e. g. 5.4 bar). The diaphragm is deflected further up with the aid of the spring force and stops the fuel feed to the injection valves. No pressure difference exists at the metering slots. Deceleration fuel cutoff is cancelled again by the KE control unit before idling speed is reached.

Engine at normal operating temperature

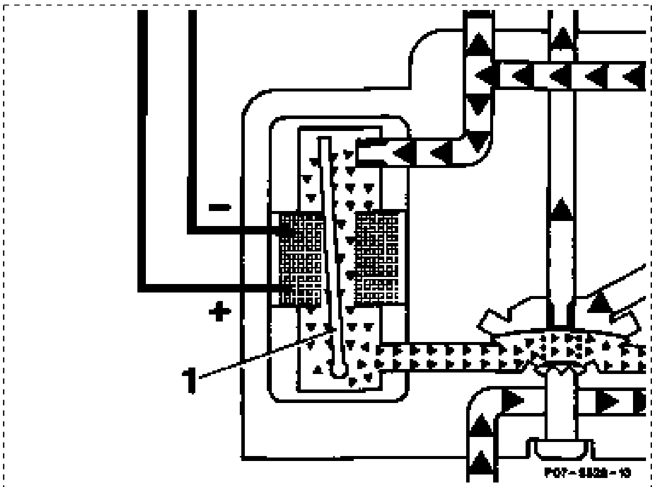
If no additional mixture adaptation is required once the engine is at normal operating temperature, the valve plate (1) adopts a certain middle position, depending on the engine version. This middle position of the valve plate produces the design-specified pressure difference of approx. 0.4 bar at the metering slots.



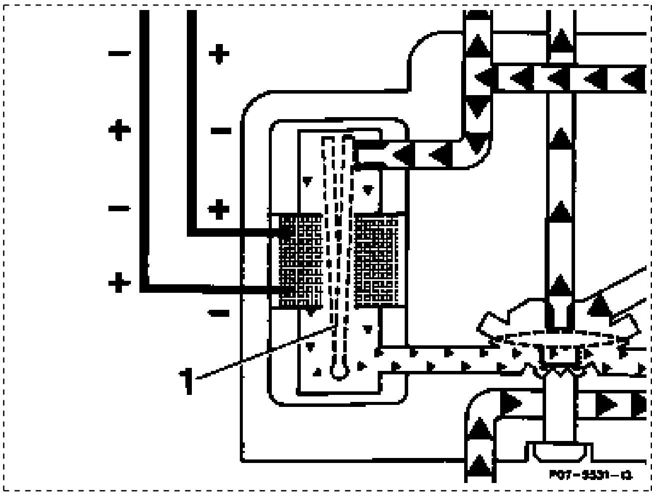
If the valve plate (1) is moved out of the middle position in the direction of fuel feed by a control current, the mixture is enriched.

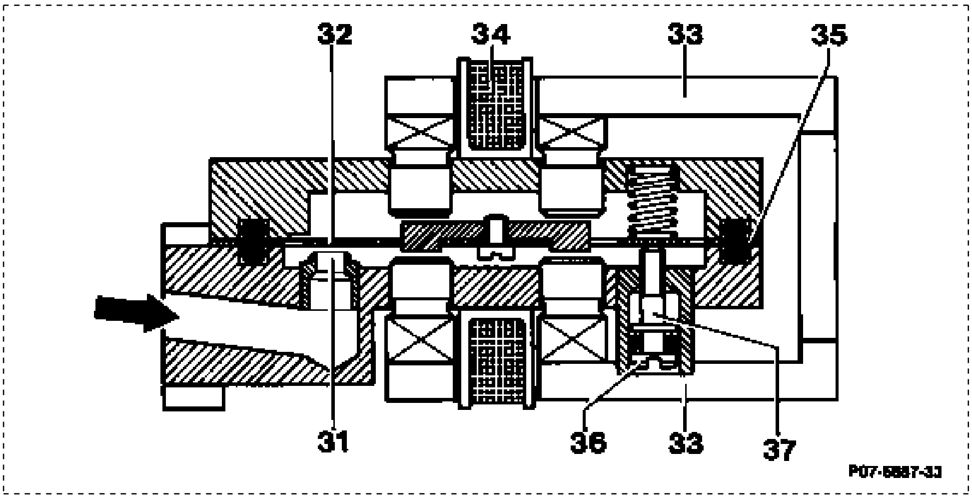


If the direction of the control current is altered, i. e. a change in polarity is performed at the solenoid, the valve plate (1) is moved out of the middle position toward the fuel feed. This produces a leaner mixture.



On vehicles fitted with catalytic converter and lambda control, the valve plate (1) constantly moves around its middle position in order to produce the necessary richer or leaner mixture. The KE control unit constantly alters the direction of the current for this purpose.



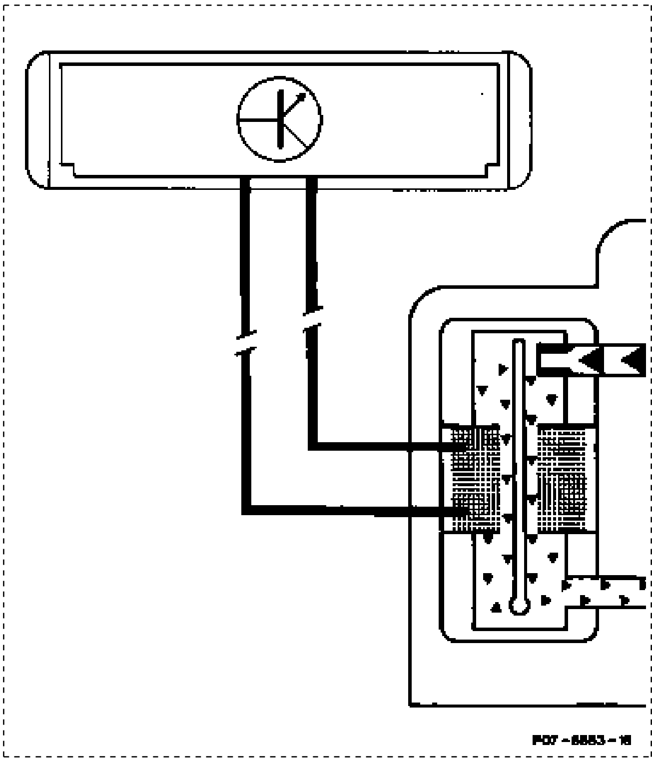


Electrohydraulic actuator

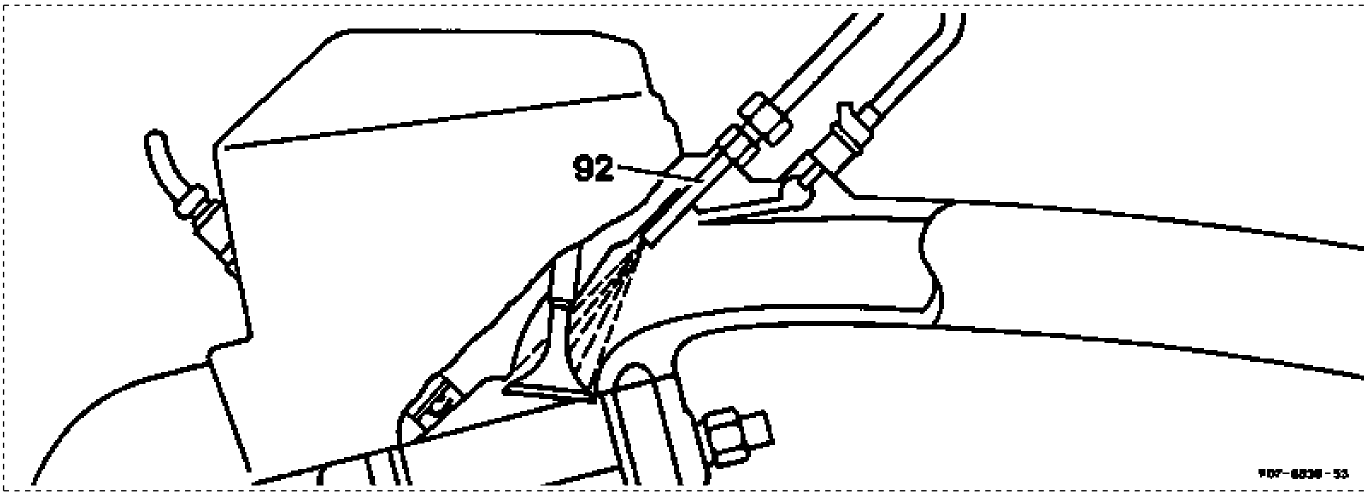
31 Feed (nozzle)
32 Valve plate
33 Permanent magnet
34 Solenoid
35 Rocker
36 Screw plug
37 Adjusting screw (operating point)

Emergency running properties

The KE injection system possesses good emergency running properties. In the event that the electrohydraulic actuator is de-energized, e. g. as a result of an open circuit in the wiring, the pressure difference is set to the design-specified level of approx. 0.4 bar. The mechanical mixture basic adaptation remains operational. The engine can continued to be operated in the normal operating temperature state. Warming-up is restricted, however. It is no longer possible to adapt the mixture to lean or rich.



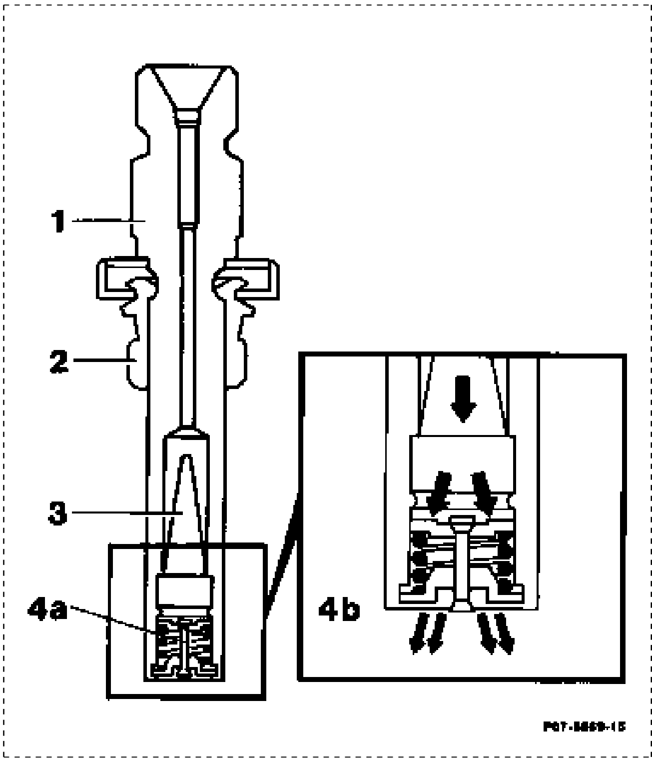
f) Injection valves



An injection valve (92) is positioned in the intake manifold for each cylinder of the engine. The injection valves spray the fuel metered by the fuel distributor continuously into the intake ports downstream of the injection valves. The injection valves do not perform any metering function.

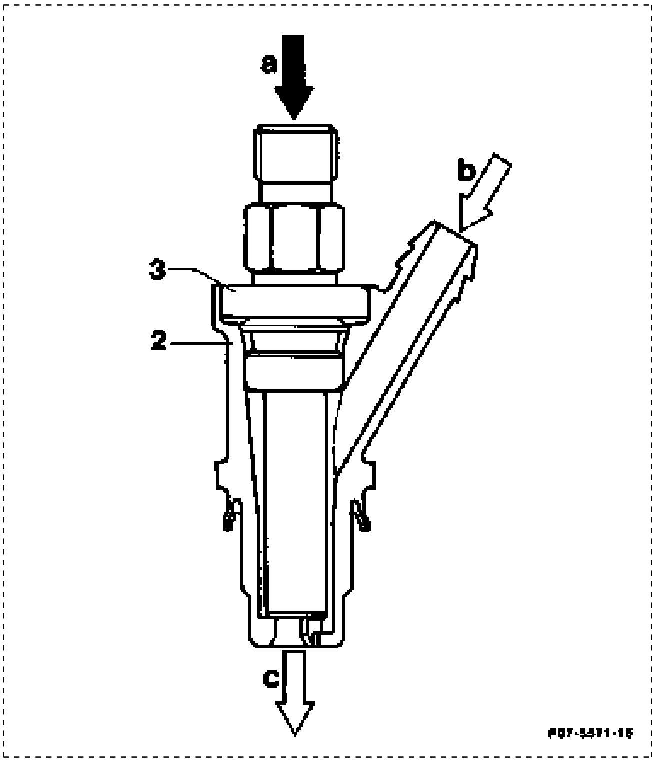
The injection valves open when a certain pressure exists in the fuel system and atomize the fuel as a result of the vibration movements of the valve needle (chatter valve).

After the engine is switched off, the injection valves close leaktight as soon as the pressure in fuel system has dropped below their opening pressure. The holding pressure is retained in the injection lines to ensure good hot starting characteristics.



1	Injection valve
2	Seal
3	Filter
4a	Valve needle in rest position
4b	Valve needle in operating position

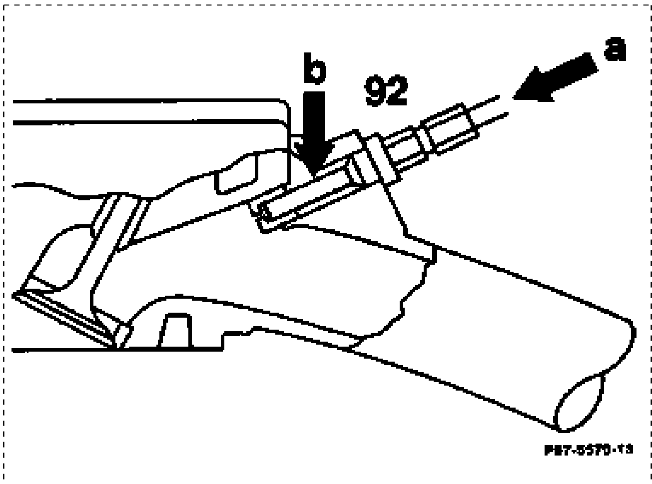
Air-shrouded or air-enveloped injection valves
To improve mixture formation at idling speed, the required quantity of idle speed air is supplied directly to the fuel outlet of the injection valves through insulating sleeves in which the injection valves are attached, or through ducts in the intake manifold (M103, M104). This ensures better atomization of the fuel.



Air-shrouded injection valve
Engines 102.983/102.99/116/117/119

2 Insulating sleeve
3 Plastic support
a Fuel
b Air
c Fuel/air mixture

Notes regarding version
All 6- and 8-cylinder engines have air-shrouded or air-enveloped injection valves. In the case of the 4-cylinder engine, they are installed in engines with
4 valves per cylinder.



Air-enveloped injection valve
Engines 103/104

a Fuel
b Air from idle air duct in intake manifold

Ejection and opening pressure of injection valves in bar (examples)

Engine		System pressure	Opening pressure of new injection valves	Opening pressure at least
102, 103	up to 08/88	5.3 - 5.4	3.5 - 4.1	3.0
	as of 09/88	5.3 - 5.4	3.7 - 4.3	3.2
104, 116, 117, 119		6.2 - 6.4	4.3 - 4.6	3.7[1])

[1]) Injection valve with Viton needle seat as of 09/90