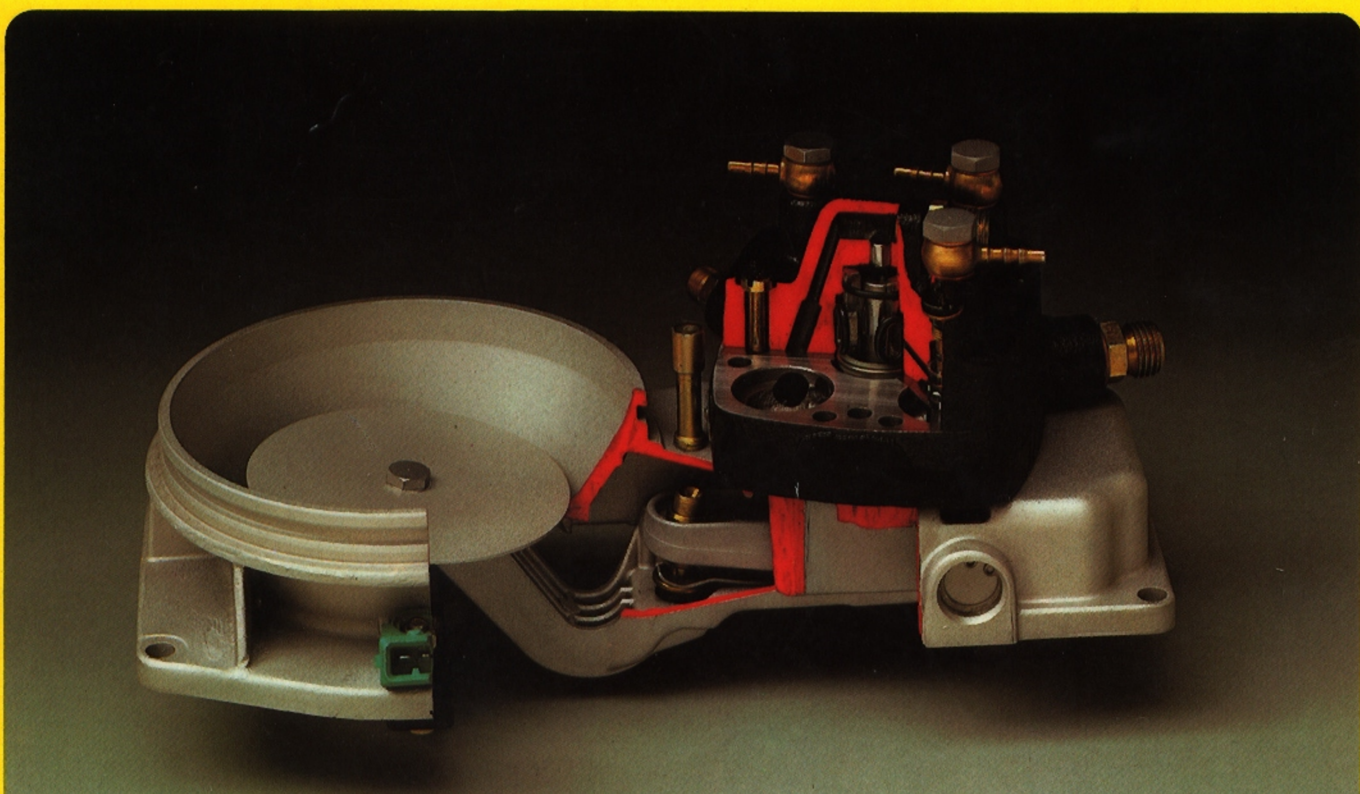
BOSCH

Technical Instruction



K-Jetronic

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Editor in chief: Ulrich Adler
Editor: Holger H. Schweizer
Translation (1979) Peter W. Girling, Douglas J. Smith
In consultation with the technical departments of our organisation.
Composition, graphics, layout:
Dept. KH/VDT

Printed in the Federal Republic of Germany.
Imprimé en République Fédérale d'Allemagne par Robert Bosch GmbH.

2nd edition
September 1978

K-Jetronic
A Fuel-Injection System from Bosch

Bosch K-Jetronic

It's unbelievable:

An engine that delivers MORE power but at the same time uses LESS fuel!

A few years ago this claim would have been laughed at and regarded as "wishful thinking" or "a magic formula – after all everybody knows that you can't get something for nothing". That though was a few years ago.

In the meantime, things have changed. We have realized that in the first place it's a question of fuel metering. Once this has been solved, the engine uses noticeably less fuel, its performance increases noticeably and at the same time pollutant emissions are reduced.

These are all facts that we know and accept today. After all, Bosch has developed and marketed the Jetronic. And what's more, there are millions of Jetronic-equipped vehicles in everyday use.

This manual will show you how the K-Jetronic works.

How it controls the air-fuel mixture, both mechanically and hydraulically. And how it injects continuously.

That's where the "K" comes from. "K" stands for the German word for continuously. Bosch K-Jetronic*)

*) Bosch has other Jetronic systems on the market. Another manual in this series informs you about the "Bosch L-Jetronic".

The Engine's Fuel Requirements

A spark-ignition engine needs a particular air-fuel ratio in order to operate. The ideal air-fuel ratio is 14:1. Certain operating conditions make it necessary to correct the mixture accordingly.

The air-fuel ratio

Essentially, the power, the fuel consumption and the exhaust-gas composition of a spark-ignition engine depend upon the air-fuel ratio. Perfect ignition and perfect combustion only take place within particular air-fuel ratios. In the case of gasoline (petrol), the ideal air-fuel ratio is about 14:1. In other words, 14 kg of air are required for complete combustion of 1 kg of gasoline (stoichiometric ratio). Deviations from this ratio affect engine operation.

The amount of fuel to be injected depends upon load, engine speed and the particular exhaust-gas regulations in force at the time. Depending upon the mode of operation, i.e. idle, part load or full load, a different air-fuel ratio is optimal in each case. Of decisive importance is the strict adherence to the particular most favorable air-fuel ratio at any one time.

The excess-air factor

The excess-air factor is identified by the symbol λ (Lambda).

$$\lambda = \frac{\text{amount of air supplied}}{\text{theoretical air requirement}}$$

$\lambda = 1$
This means that the amount of air supplied to the engine corresponds to the theoretical amount of air required (stoichiometric air-fuel ratio).

$\lambda <= 1$
This means air deficiency, or a rich mixture, and increased power.

$\lambda >= 1$
This means air excess, or lean mixture, lower fuel consumption, less power.

$\lambda => 1.2$
This means that the mixture will no longer ignite, the lean misfire limit (LML) has been exceeded.

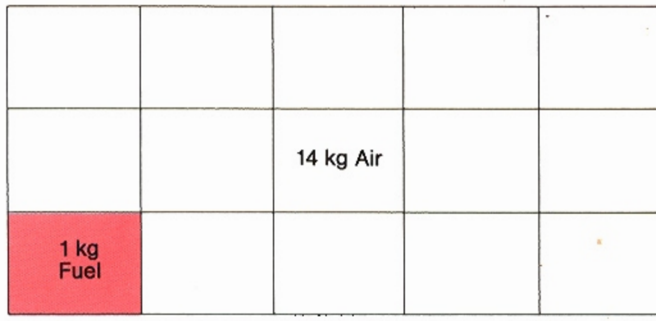


Fig. 1
Theoretical air-fuel ratio for complete combustion.

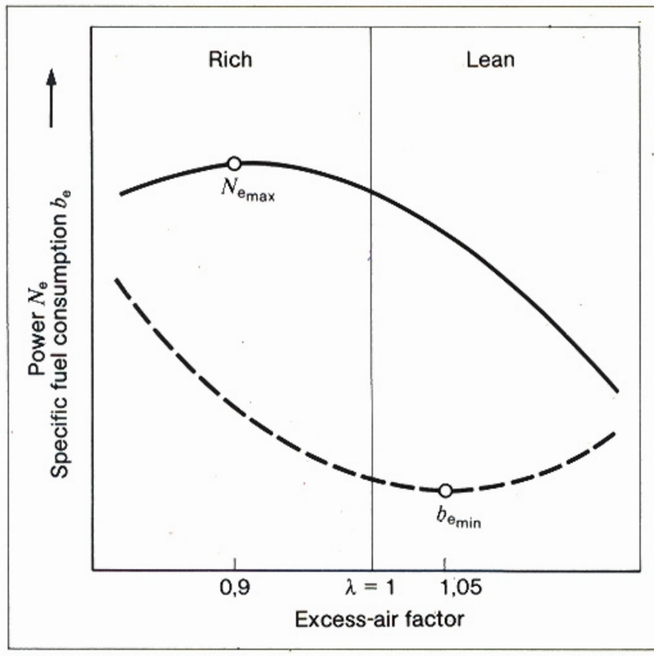


Fig. 2
Influence of the excess-air ratio λ on the power and the specific fuel consumption.

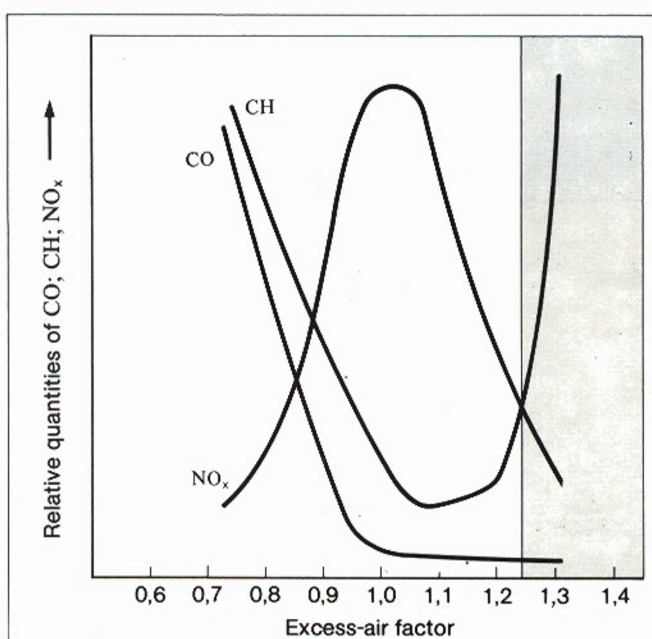


Fig. 3
Influence of the excess-air factor λ on the composition of the exhaust gases from a spark-ignition engine at full load.

CH:
Hydrocarbons

CO:
Carbon monoxide

NO_x:
Nitrogen monoxide

The illustrations demonstrate the manner in which power, specific fuel-consumption and exhaust-gas composition are all affected by the excess-air factor. It can be seen that there is no single ideal excess-air factor at which all these factors are at an optimum value. In practice, excess-air factors of $\lambda = 0.9 ... 1.1$ have proved to be the most appropriate. If, however, the excess-air factor is to be maintained within strict limits, the amount of air sucked in by the engine must be precisely measured and a finely-dosed amount of fuel precisely metered to the engine.

Fuel-Induction Systems

Fuel-induction systems, whether of the carburetor or injection types, have the task of preparing an optimum air-fuel mixture. Fuel induction by means of manifold injection permits the optimum adaptation of the air-fuel mixture to every operating phase of the engine. It also ensures a lower pollutant level in the exhaust gas.

In spark-ignition engines, fuel induction is by means of either a carburetor or fuel-injection system. Although, up to now, the carburetor has been the most commonly used method, there has been a distinct trend in the last couple of years towards fuel induction by means of manifold injection.

This trend has been caused by the advantages offered by fuel injection as regards the demands for fuel economy, high performance and, last but not least, less pollutants in the exhaust gas.

These advantages are based on the fact that manifold fuel injection permits extremely precise metering of the fuel depending upon the operating conditions of the engine and its load and taking into account environmental effects. With manifold fuel injection, the correct air-fuel ratio is maintained so precisely that the pollutant content in the exhaust gas is considerably lower. Since with this system the carburetor is no longer required, the intake paths can be optimally designed and laid out. This results in better cylinder charge which in turn leads to a more favorable torque characteristic.

What types of mixture formation by means of fuel injection are available?

There are both electronically controlled systems available as well as mechanical ones.
The K-Jetronic is a mechanical continuous fuel-injection system which does not require any form of drive whatsoever.

Electronically controlled systems

The fuel is supplied by an electrically driven fuel pump which develops the pressure necessary for injection. The fuel is injected by solenoid-operated injection valves into the cylinder intake tubes. The injection valves are controlled by an electronic control unit (ECU) and the amount of fuel injected depends on the length of time that they stay open. The ECU is provided with information about the operating conditions of the engine and about the ambient conditions around the vehicle. This information is provided by means of sensors. The basis for assessing the amount of fuel to be injected is the amount of air sucked in by the engine.

The L-Jetronic is an electronically controlled fuel-injection system.

In the case of the L-Jetronic, the amount of air sucked in by the engine is directly measured by an air-flow sensor.

Electronically controlled fuel-injection systems are dealt with in detail in the Publication "Electronically Controlled Fuel Injection, D-Jetronic and L-Jetronic" VDT-UBP 751/1 En, in the Bosch Technical Instruction series.

Mechanical systems

With mechanical fuel-injection systems, one differentiates between those requiring a drive from the engine and those not.

The engine-driven systems comprise a fuel-injection pump with an integrated governor. Their principle of operation is the same as that of the fuel-injection systems for Diesel engines.

The other variation of the mechanical system is one which needs no drive and which injects continuously. This system, the K-Jetronic, is described in the following.

The K-Jetronic

The K-Jetronic is a mechanical fuel-injection system from Bosch.

It is divided into three main functional areas:

- Air-flow measurement
- Fuel supply
- Fuel induction

Air-flow measurement

The amount of air sucked in by the engine is controlled by a throttle valve and measured by an air-flow sensor.

Fuel supply

An electrically driven fuel pump delivers the fuel to the fuel distributor via a fuel accumulator and a filter. The fuel distributor allocates this fuel to the injection valves in the cylinder intake tubes.

Fuel induction

The amount of air, corresponding to the position of the throttle plate, sucked in by the engine serves as the criterium for the metering of the fuel to the individual cylinders. The amount of air sucked in by the engine is measured by the air-flow sensor which, in turn, controls the fuel distributor.

The air-flow sensor and the fuel distributor are assemblies which form part of the mixture control unit. Injection takes place continuously, that is, without regard to the position of the intake valve. During the intake-valve closed phase, the fuel is "stored" in the intake tubes.

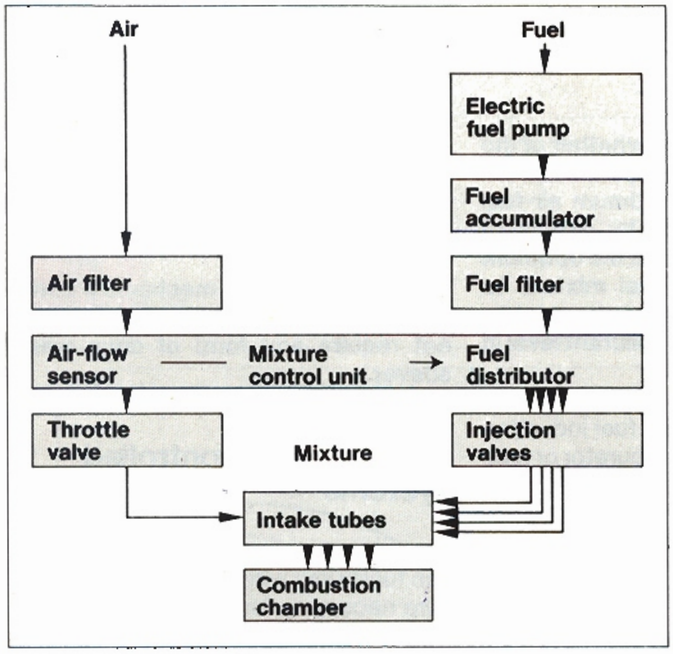


Fig. 4
Basic schematic of the K-Jetronic.
Functional areas:
Air flow measurement
Fuel supply
Fuel induction

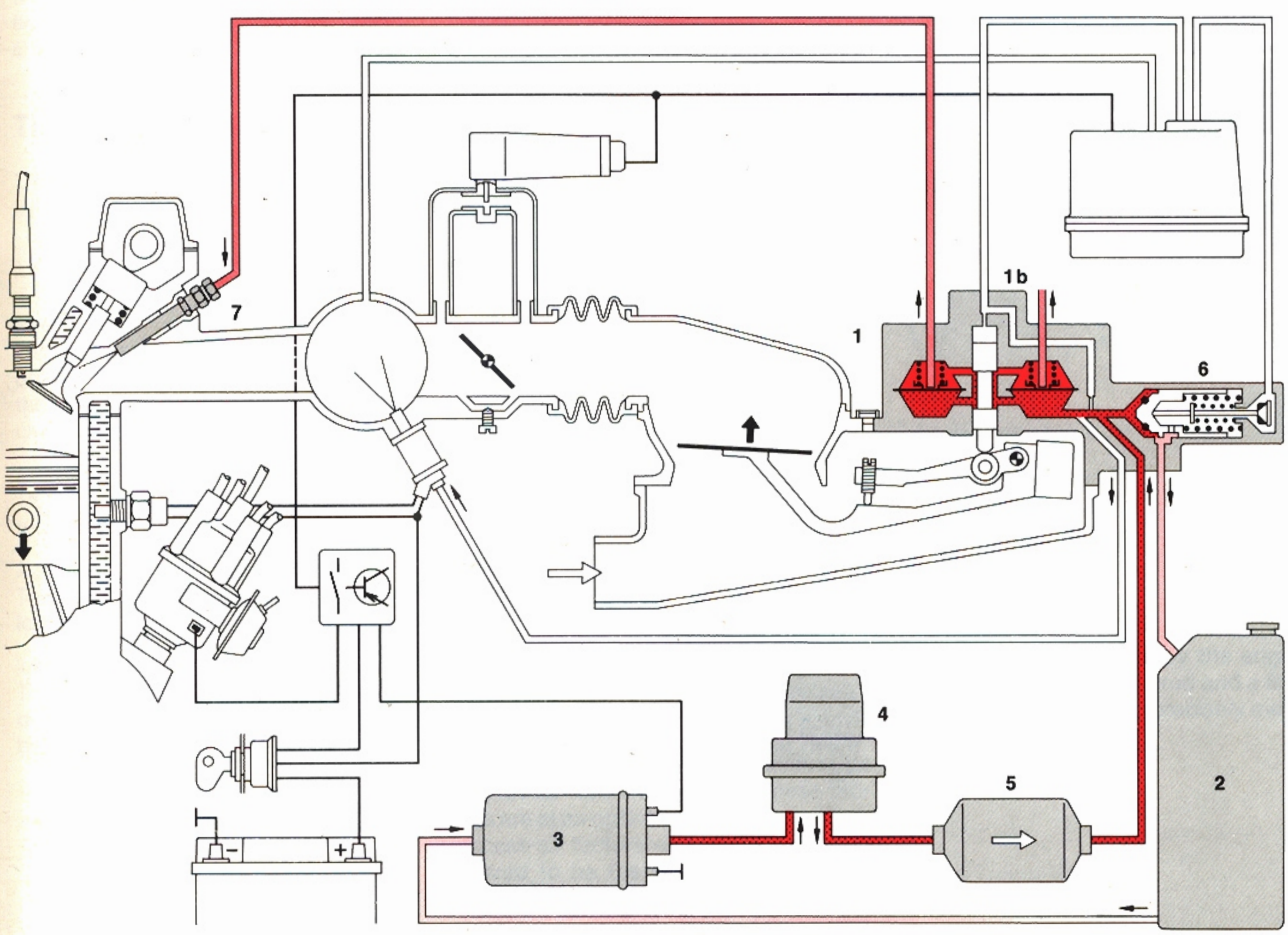


Fig. 5
Schematic diagram of the K-Jetronic.
Functional area:
Fuel supply

1 Mixture control unit
1b Fuel distributor
2 Fuel tank
3 Electric fuel pump
4 Fuel accumulator
5 Fuel filter
6 Pressure regulator
7 Fuel-injection valve

Fuel supply

Outline of system

The fuel is sucked out of the fuel tank by an electrically driven fuel pump. It is then forced, under pressure, through a pressure accumulator and a fine filter to the fuel distributor which is located in the mixture control unit. The pressure is held constant by a pressure regulator in the mixture control unit from where it flows to the fuel-injection valves.

The injection valves inject fuel continuously into the intake tubes of the engine cylinders. The designation K-Jetronic stems from this fact ("K" stands for the German word for "continuous"). When the intake valves open, the air-fuel mixture is drawn into the cylinders.

The individual subassemblies of the fuel-supply system are described in the following.

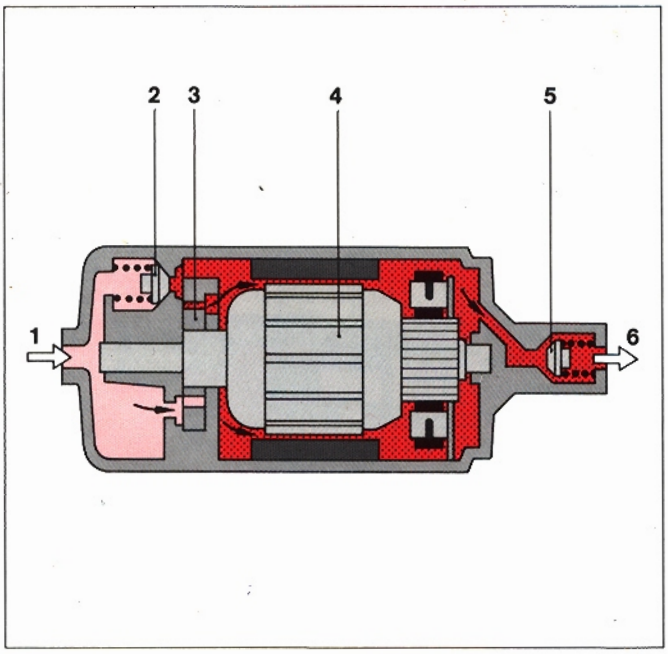


Fig. 6
Electric fuel pump
1 Intake side
2 Excess-pressure valve
3 Roller-cell pump
4 Electric-motor armature
5 Non-return valve
6 Pressure side

Electric fuel pump

The electric fuel pump is a roller-cell pump the electric motor of which is permanently surrounded by fuel.

The fuel pump is driven by a permanent-magnet electric motor.

The rotor disc which is eccentrically mounted in the pump housing is fitted with metal rollers in notches around its circumference which are pressed against the thrust ring of the pump housing by centrifugal force and act as seals. The fuel is carried in the cavities which form between the rollers. The fuel flows directly around the electric motor. There is no danger of explosion, however, because there is never an ignitable mixture in the pump housing. The pump delivers more fuel than the maximum requirement of the engine so that the pressure in the fuel system can be maintained under all operating conditions.

During starting, the pump runs as long as the ignition key is operated. The pump continues to run when the engine has started. A safety circuit is incorporated to stop the pump running and fuel being delivered if the ignition is switched on but the engine has stopped turning (for instance in the case of an accident).

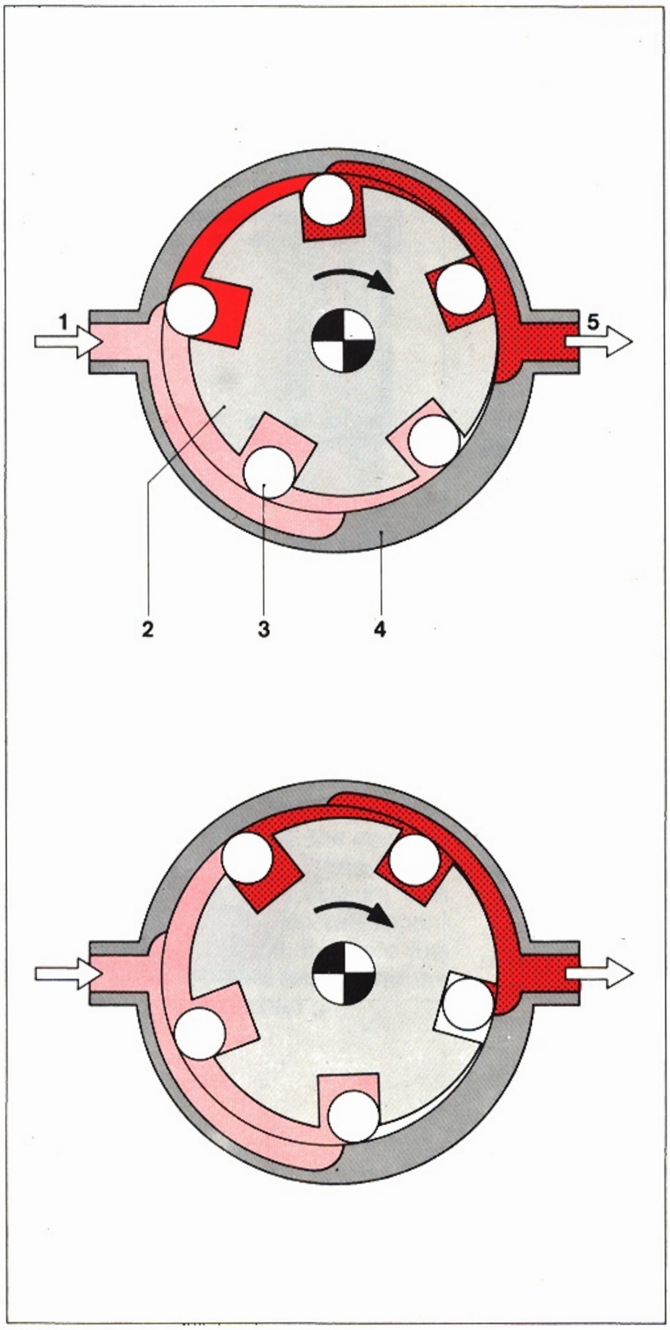


Fig. 6
Roller-cell pump
Pumping process
1 Intake side
2 Rotor disc
3 Roller
4 Pump housing
5 Pressure side

Fuel, pressureless
Fuel, being conveyed
Fuel, pressurized

Fuel accumulator

The fuel accumulator maintains the pressure in the fuel system for a certain time after the engine has been switched off. When the engine is running it serves to deaden the noise of the electric fuel pump.

After the engine has been switched off, the fuel accumulator maintains the pressure in the fuel system in order to facilitate re-starting, particularly when the engine is hot. The design of the accumulator housing is such that it deadens the noise from the fuel pump when the engine is running.

The interior of the fuel accumulator is divided into two chambers by means of a diaphragm. One chamber serves as the accumulator volume for the fuel, the other chamber contains a spring.

During operation the accumulator chamber is filled with fuel. This causes the diaphragm to bend back against the force of the spring until it is halted by the stops in the spring chamber. The diaphragm remains in this position, which corresponds to the maximum accumulator volume, as long as the engine is running.

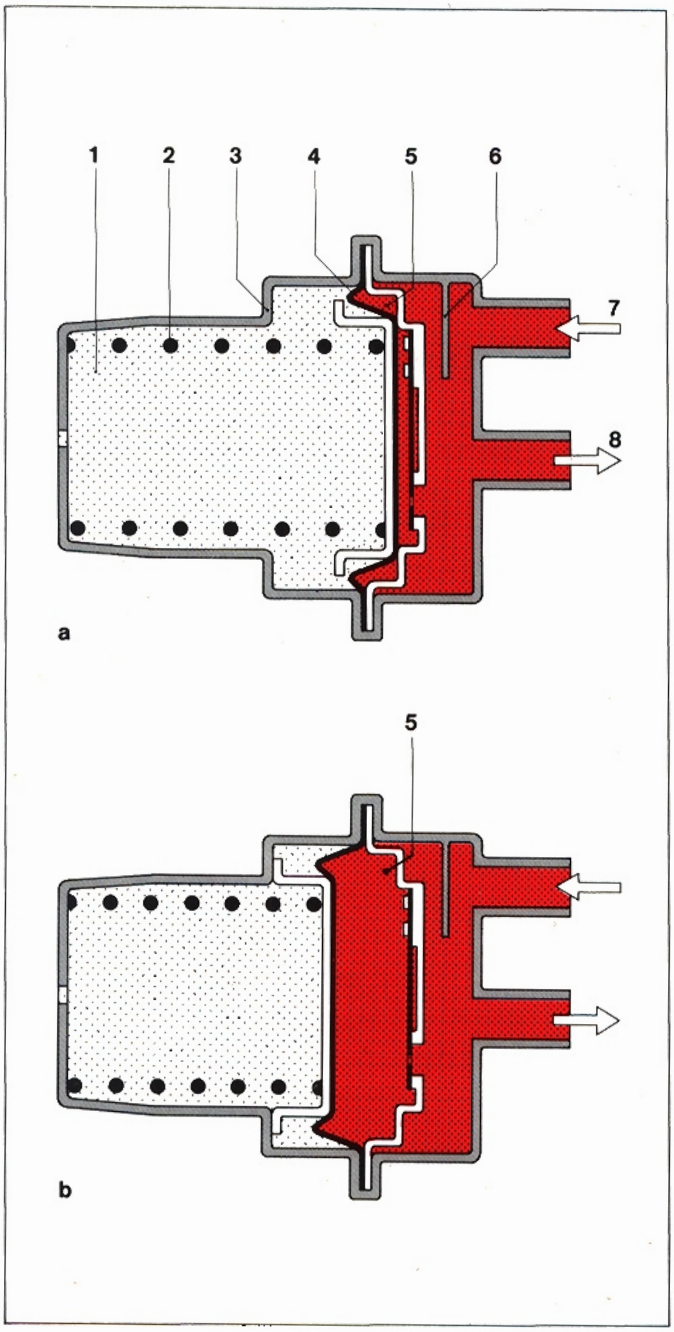


Fig. 8
Fuel accumulator
a empty
b full
1 Spring chamber
2 Spring
3 Stop
4 Diaphragm
5 Accumulator volume
6 Baffle plate
7 Fuel entry
8 Fuel exit

Fuel filter

Due to the extremely close tolerances of various components in the system, it is necessary to fit a special fine filter for the fuel in order to guarantee faultless performance of the K-Jetronic.

The fuel filter retains particles of dirt which are present in the fuel and which would otherwise adversely affect the functioning of the injection system.

The fuel filter contains a paper filter element which is backed up by a strainer. This combination results in a high degree of cleaning being achieved. A supporting plate is used to hold the filtering elements in place in the filter housing. It is of utmost importance that the direction of flow indicated on the housing is complied with. The filter is fitted in the fuel line downstream of the fuel accumulator.

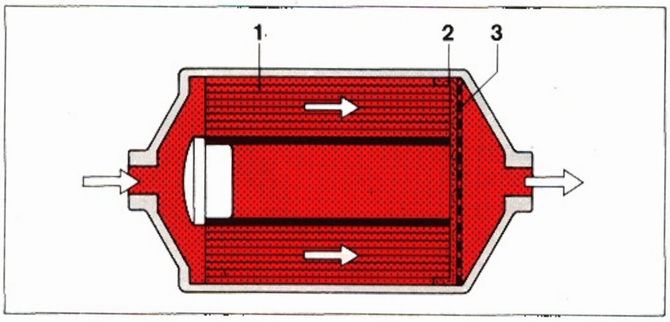


Fig. 9
Fuel filter
1 Paper element
2 Strainer
3 Supporting plate

Primary-pressure regulator

The primary-pressure regulator maintains the pressure in the fuel system constant.

The pressure regulator incorporated in the fuel-distributor housing maintains the delivery pressure (= primary pressure) at about 5 bar. Due to the fact that the fuel pump delivers more fuel than the engine needs, a plunger shifts in the pressure regulator and opens a port through which excess fuel can return to the fuel tank.

The pressure in the fuel system and the force exerted by the spring on the plunger in the pressure regulator balance each other out. If for instance, the fuel pump delivers slightly less fuel, the plunger is shifted by the spring into the corresponding new position and in doing so reduces the open section of the port through which excess fuel flows back to the tank. This means that less fuel leaves the system at this point, and as a result the primary pressure in the system increases to the specified value.

When the engine is switched off, the fuel pump also stops running. The primary pressure drops to below the injection-valve opening pressure. The pressure regulator closes the return-flow port and prevents further pressure reduction in the fuel system.

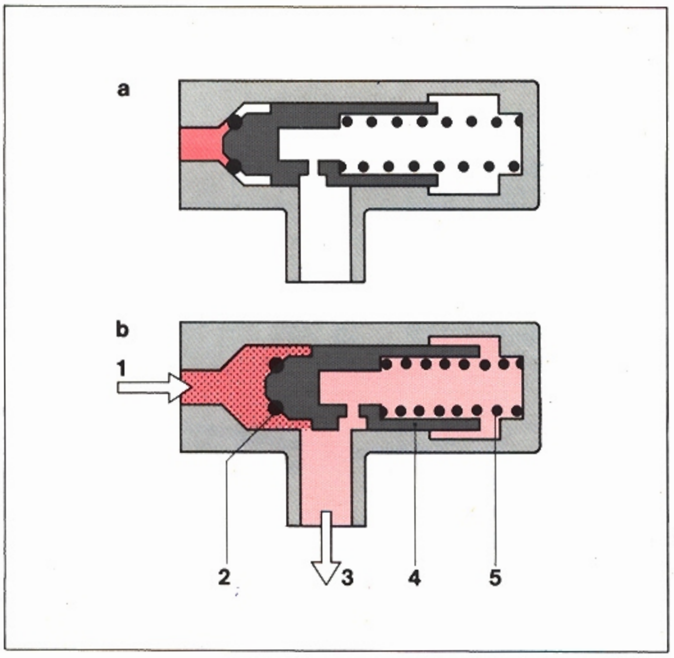


Fig. 10
Primary-pressure regulator in the fuel distributor
a Inoperative
b During operation
1 Primary-pressure input
2 Seal
3 Return to fuel tank
4 Plunger
5 Regulator spring

Fuel-injection valve

The fuel-injection valves open at a certain pressure and inject fuel into the intake tubes. The fuel is atomized by the oscillation of the valve needle.

The injection valves inject the fuel allocated by the fuel distributor into the intake tubes directly in front of the intake valves of the cylinders.

The injection valves are secured in a special holder in order to insulate them from engine heat. The insulation prevents vapor bubbles forming in the fuel-injection lines which would lead to poor starting behaviour when the engine is hot.

The injection valves have no metering function. They open of their own accord when the opening pressure of 3.3 bar is exceeded. They are fitted with a valve needle which vibrates ("chatters") audibly at high frequency when fuel is injected. This means that excellent fuel atomization is achieved, even with the smallest of injected quantities. When the engine is switched off, the injection valve closes tightly and forms a seal when the fuel-system pressure has dropped below the injection-valve opening pressure. As a result, no more fuel can drip into the intake tubes after the engine has been switched off.

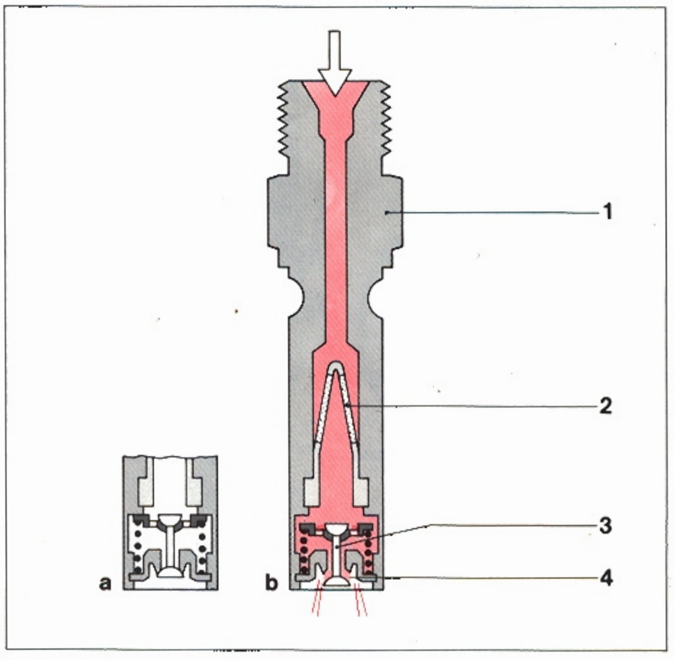


Fig. 11
Fuel-injection valve
a Inoperative
b During injection
1 Valve housing
2 Filter
3 Valve needle
4 Valve seat

Fuel Induction

Mixture control unit

The task of fuel induction is to meter, or allocate, the correct quantity of fuel which corresponds to the amount of air drawn in by the engine.
Fuel induction is carried out by the mixture control unit. This comprises the air-flow sensor and the fuel distributor.

Air-flow sensor

The air-flow sensor operates according to the suspended-body principle and measures the amount of air drawn in by the engine.

All the air drawn in by the engine flows through an air-flow sensor which is connected upstream of the throttle plate. The air-flow sensor is fitted with an air funnel in which is located a movable sensor plate (the suspended body).

The air drawn in through the air funnel shifts the sensor plate by a certain amount out of its zero position. The movement of the sensor plate is transmitted to a control plunger by a lever system. This plunger determines the quantity of fuel required.

Considerable pressure shocks can occur in the intake system if backfiring takes place in the intake manifold. For this reason, the airflow sensor is so designed that the sensor plate can swing back in the opposite direction, past its zero position, and thus open a relief cross-section in the funnel. A rubber buffer limits the swing-back in the downward direction (in the case of the updraft air-flow sensor, the swing-back in the upwards direction is also limited by a rubber buffer). A leaf spring ensures that the sensor plate assumes the correct zero position when the engine is stationary. The sensor-plate movements are transmitted to the control plunger in the fuel distributor by means of a lever system. The weight of the sensor plate and the lever system are balanced by a counterweight.

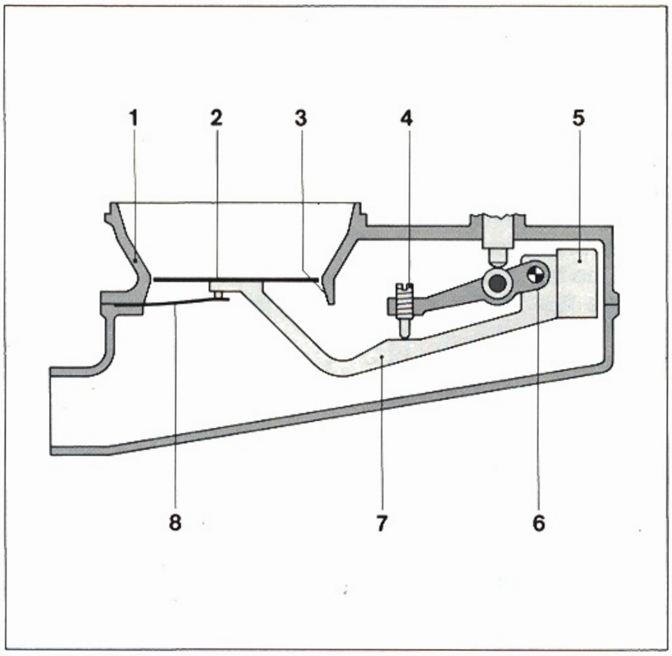


Fig. 12
Updraft air-flow sensor in zero position
1 Air funnel
2 Sensor plate
3 Relief cross-section
4 Idle mixture adjusting screw
5 Counterweight
6 Fulcrum
7 Main lever
8 Leaf spring

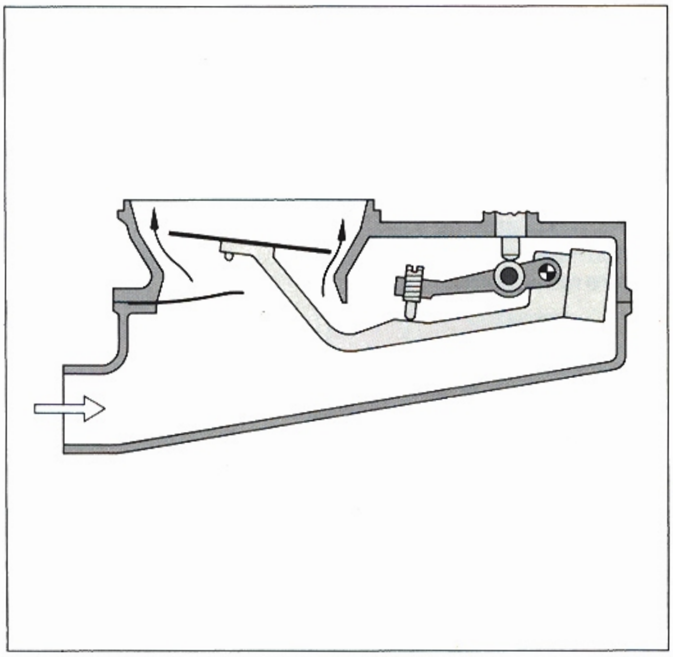


Fig. 13
Updraft air-flow sensor in operation, simplified representation.

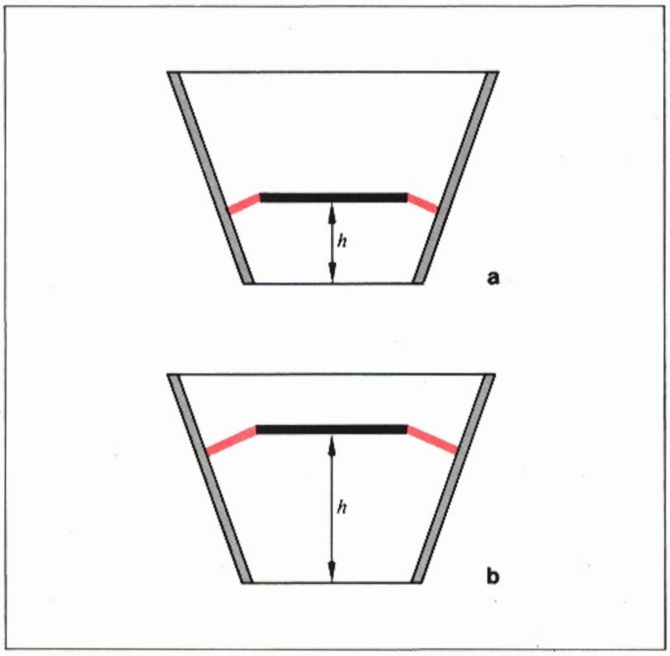


Fig. 14
Principle of the air-flow sensor
a Small amount of air drawn in: sensor plate is only lifted slightly
b Larger amount of air drawn in: sensor plate is lifted much further

Fuel distributor

The fuel distributor meters (allocates) the correct amount of fuel to the individual cylinders in accordance with the position of the air-flow sensor plate.

As already mentioned, the position of the sensor plate is a measure of the amount of air drawn in by the engine. The position of the plate is transmitted to the control plunger by a lever. The control plunger controls the amount of fuel which is to be injected.

Depending upon its position in the barrel with metering slits, the control plunger opens or closes the slits to a greater or lesser degree. The fuel flows through the open section of these slits to the differential pressure valves and then to the fuel-injection valves.

If sensor-plate travel is only small, then the control plunger is only lifted slightly and as a result only a small section of the slot is opened for the passage of fuel. With larger plunger travel, the plunger opens a larger section of the slits and more fuel can flow.

There is, therefore, a linear relationship between sensor-plate travel and the slit section in the barrel which is opened for fuel flow.

The force applied to the control plunger by the sensor plate travel is opposed by another force which comes from the so-called control pressure. One of the functions of this control pressure is to ensure that the control plunger follows the movements of the sensor plate immediately and does not, for instance, stay in the (upper) end position when the sensor plate moves back down again. Further important functions of the control pressure are discussed in the chapters dealing with warm-up and full-load enrichment.

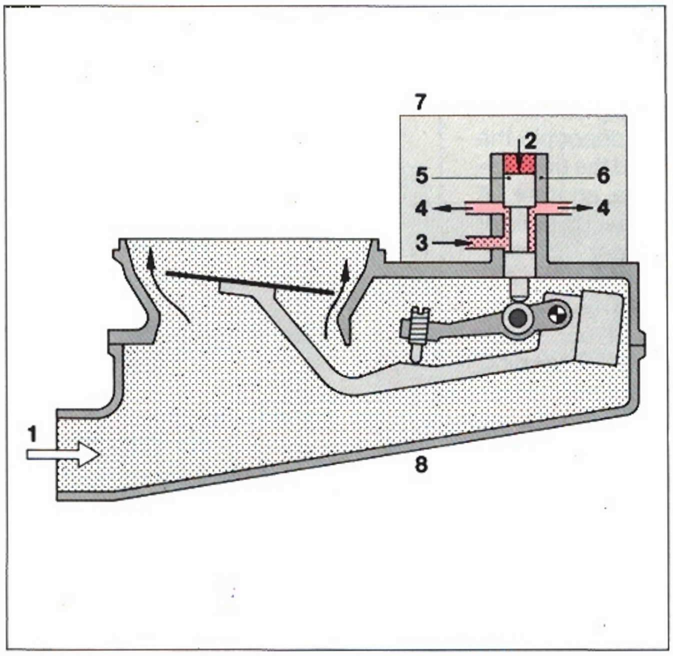


Fig. 15
Barrel with metering slits.
1 Intake air
2 Control pressure
3 Fuel intake
4 Fuel metered to cylinders
5 Control plunger
6 Barrel with metering slits
7 Fuel distributor
8 Air-flow sensor

Fig. 16
Barrel with metering slits. The slits are shown enlarged.
(The actual slit is about 0.2 mm wide.)

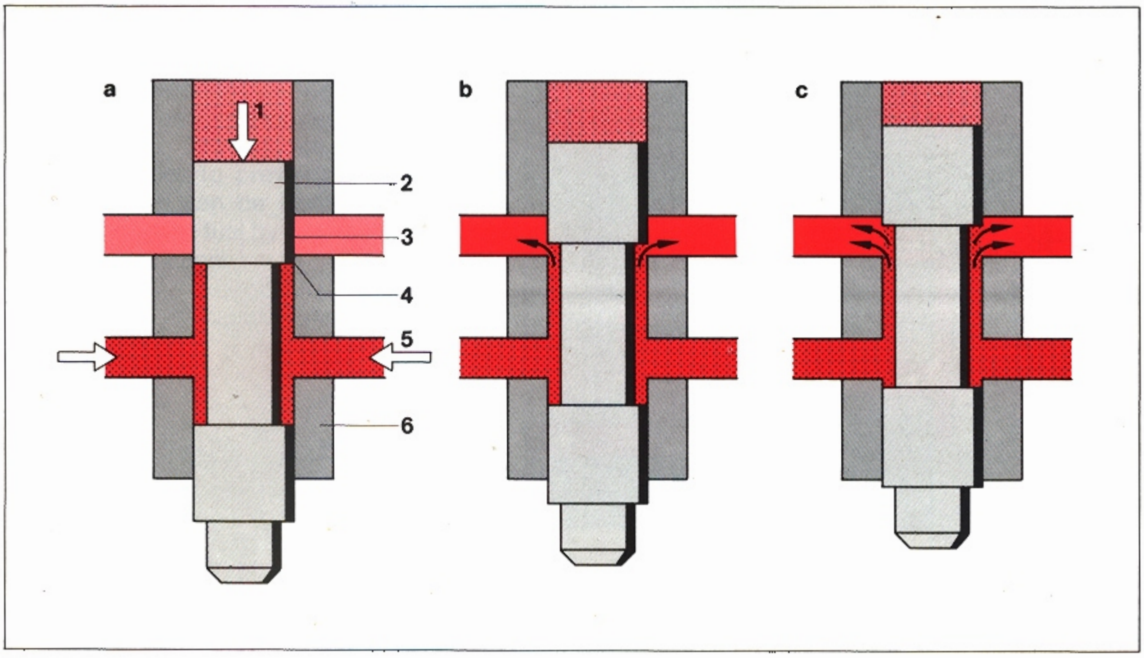


Fig. 17
Barrel with metering slits and control plunger.
a Zero (inoperated) position
b Part load
c Full load
1 Control pressure
2 Control plunger
3 Metering slit in the barrel
4 Control edge
5 Fuel intake
6 Barrel with metering slits

Control pressure

The control pressure is tapped off from the primary pressure through a restriction bore which serves to decouple the control-pressure circuit and the primary-pressure circuit from one another. A connection line joins the fuel distributor and the warm-up regulator (control-pressure regulator).

When starting the cold engine the control pressure is about 0.5 bar. As the engine warms up, the warm-up regulator increases the control pressure to about 3.7 bar.

The control pressure acts through a damping restriction on the control plunger and thereby develops the force which opposes the force of the air in the air-flow sensor. In doing so, the restriction dampens a possible oscillation of the sensor plate which could result due to pulsating air-intake flow.

The control pressure influences the fuel distribution. If the control pressure is low, the air drawn in by the engine can deflect the sensor plate further. This results in the control plunger opening the metering slits further and the engine being allocated more fuel. On the other hand, if the control pressure is high the air drawn in by the engine cannot deflect the sensor plate so far and, as a result, the engine receives less fuel.

In order to fully seal off the control-pressure circuit with absolute certainty when the engine has been switched off, and at the same time to maintain the pressure in the fuel circuit, the return line of the warm-up regulator is fitted with a non-return valve. This (push-up) valve is actually in the primary-pressure regulator and is held open during operation by the pressure-regulator plunger.

When the engine is switched off and the plunger of the primary-pressure regulator returns to its zero position, the non-return valve is closed by a spring.

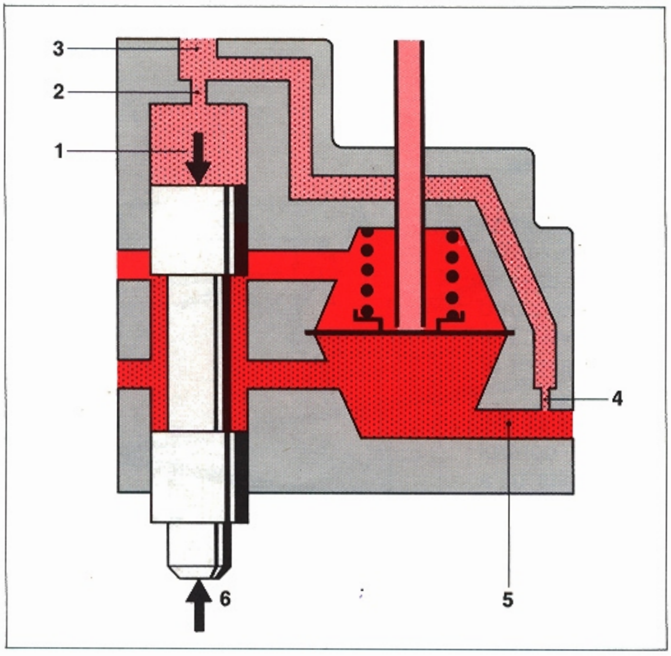


Fig. 18
Primary pressure and control pressure
1 Control-pressure effect (hydraulic force)
2 Damping restriction
3 Line to warm-up regulator
4 Decoupling restriction bore
5 Primary pressure (delivery pressure)
6 Effect of air pressure

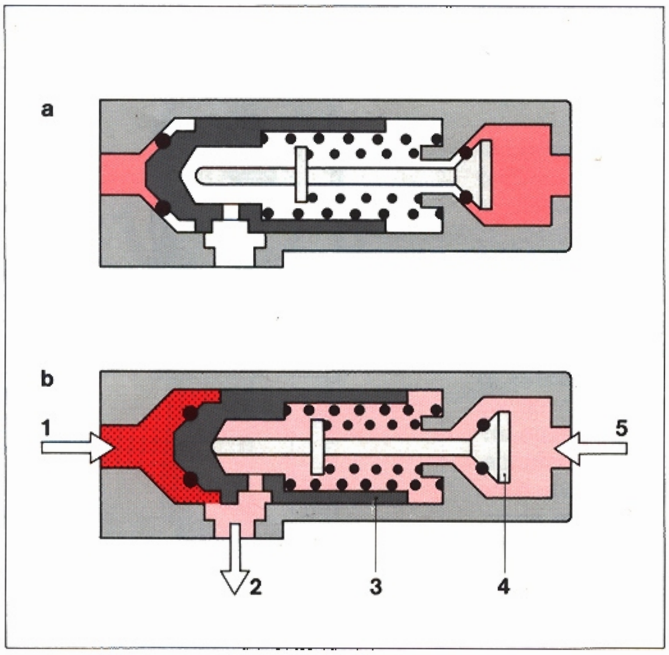


Fig. 19
Primary-pressure regulator with push-up valve in the control-pressure circuit.
a In zero (inoperated) position
b In operating position
1 Primary-pressure intake
2 Return (to fuel tank)
3 Plunger of the primary-pressure regulator
4 Push-up valve
5 Control-pressure intake (from warm-up regulator)

Differential-pressure valves

The differential-pressure valves in the fuel distributor serve to hold the drop in pressure at the metering slits constant.

The air-flow sensor has a linear characteristic. This means that if double the quantity of air is drawn in, the sensor-plate travel is also doubled. If this (linear) travel is to result in a change of delivered fuel in the same relationship, in this case double the travel = double the quantity, then a constant drop in pressure must be guaranteed at the metering slits independent of the amount of fuel flowing through them.

The differential-pressure valves maintain the drop in pressure at the metering slits constant independent of fuel throughflow. The difference in pressure is 0.1 bar, this facilitates a high degree of control accuracy.

The differential-pressure valves are of the flat-seat type. They are fitted in the fuel distributor and one such valve is allocated to each metering slit. The upper and lower chambers of the valve are separated by a steel diaphragm. The lower chambers of all the valves are connected with one another by a ring main and are subjected to the primary pressure (delivery pressure from fuel-supply pump). The valve seat is located in the upper chamber. Each upper chamber is connected to a metering slit and its corresponding fuel-injection line. The upper chambers are completely sealed off from each other. The diaphragms are spring-loaded and it is this helical spring that produces the pressure differential.

If more fuel flows into the upper chamber, through the metering slit, the steel diaphragm is bent downwards and enlarges the valve cross-section at the outlet line leading to the injection valve until the differential pressure of 0.1 bar set by the spring again prevails. If less fuel flows, the diaphragm bends back towards its original position and decreases the valve cross-section at the outlet line until the differential pressure of 0.1 bar is again present. This causes an equilibrium of forces to prevail at the diaphragm which can be maintained for every quantity of fuel by controlling the valve cross-section.

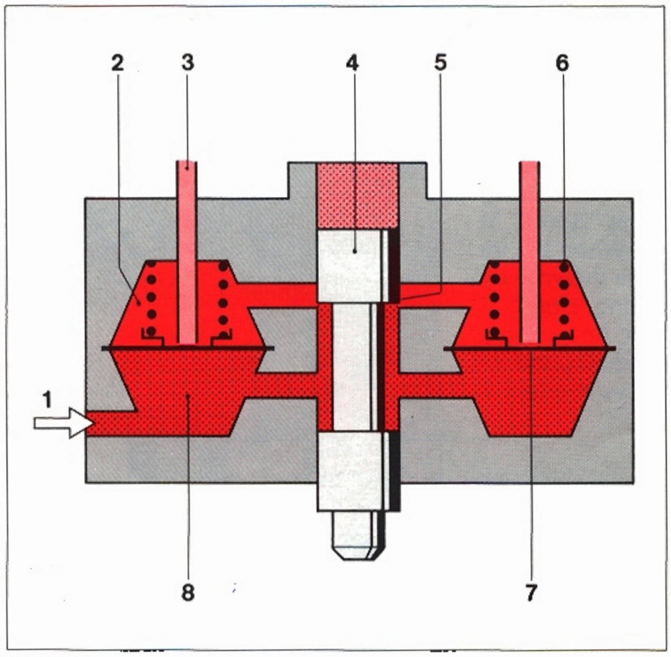


Fig. 20
Fuel distributor with differential pressure valves.
1 Fuel intake (primary pressure)
2 Upper chamber of the differential-pressure valve
3 Line to the fuel-injection valve (injection pressure)
4 Control plunger
5 Control edge and metering slit
6 Valve spring
7 Valve diaphragm
8 Lower chamber of the differential pressure valve

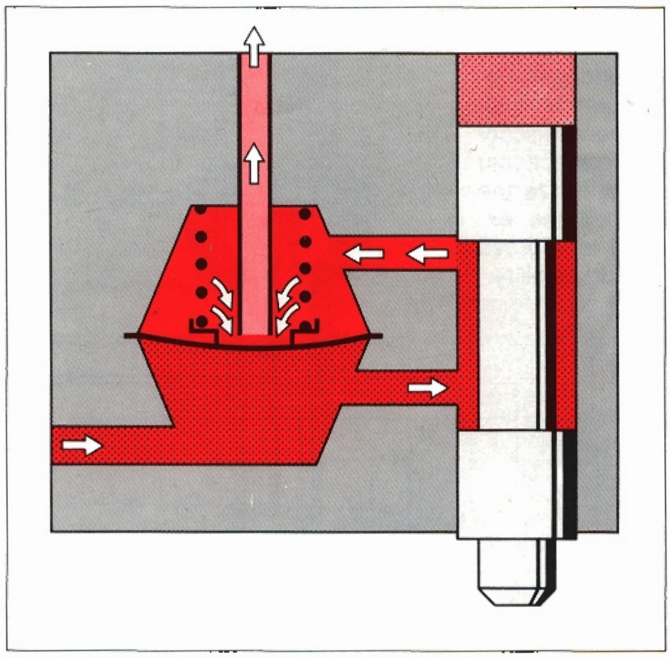


Fig. 21
Differential-pressure valve, diaphragm position with a large injected fuel quantity.

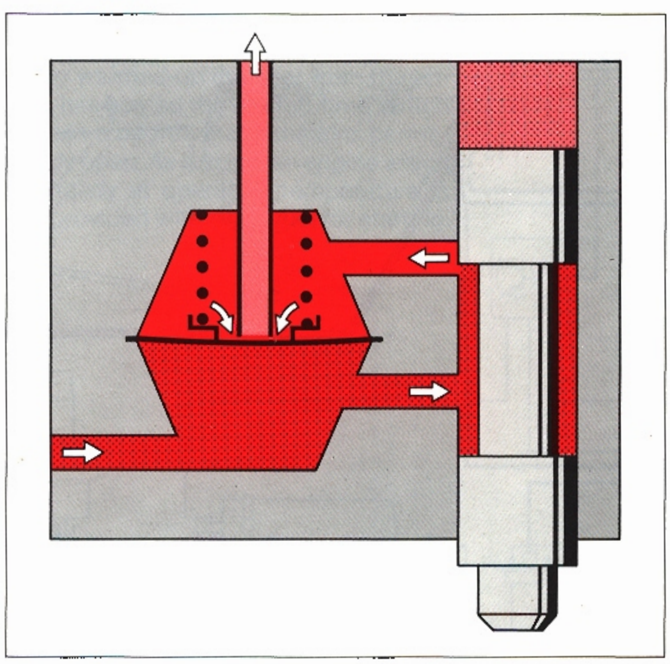


Fig. 22
Differential-pressure valve, diaphragm position with a low injected fuel quantity.

Mixture formation

The formation of the air-fuel mixture takes place in the intake manifold (tubes) and cylinders of the engine.

The continually injected fuel coming from the injection valves is "stored" in front of the intake valves. When the intake valve is opened, the air drawn in by the engine carries the waiting "cloud" of fuel with it into the cylinder. An ignitable air-fuel mixture is formed during the induction stroke due to the swirl effect.

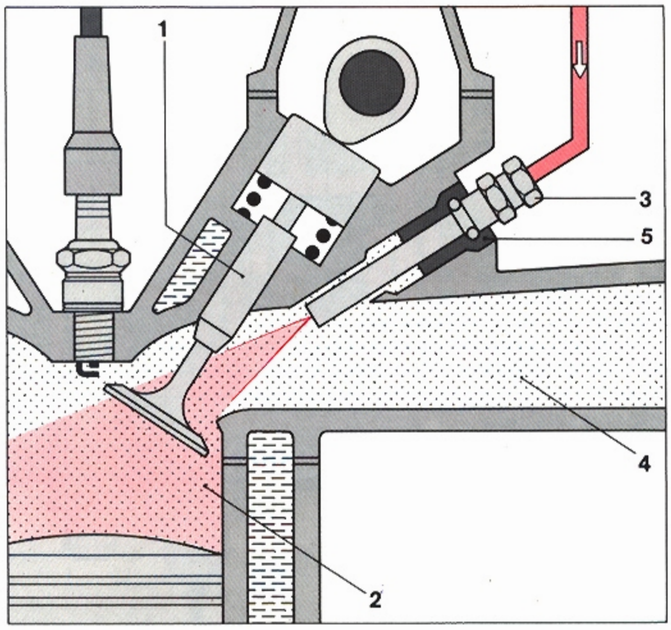


Fig. 23
Mixture formation
1 Intake valve
2 Combustion chamber
3 Fuel-injection valve
4 Intake manifold (tube)
5 Heat-isolating mount

Mixture Adaptation

In addition to the basic functions described up to now, the mixture has to be adapted during particular operating conditions. These adaptations (corrections) are necessary in order to optimize the power delivered, to improve the exhaust-gas composition and to improve the starting behaviour and driveability.

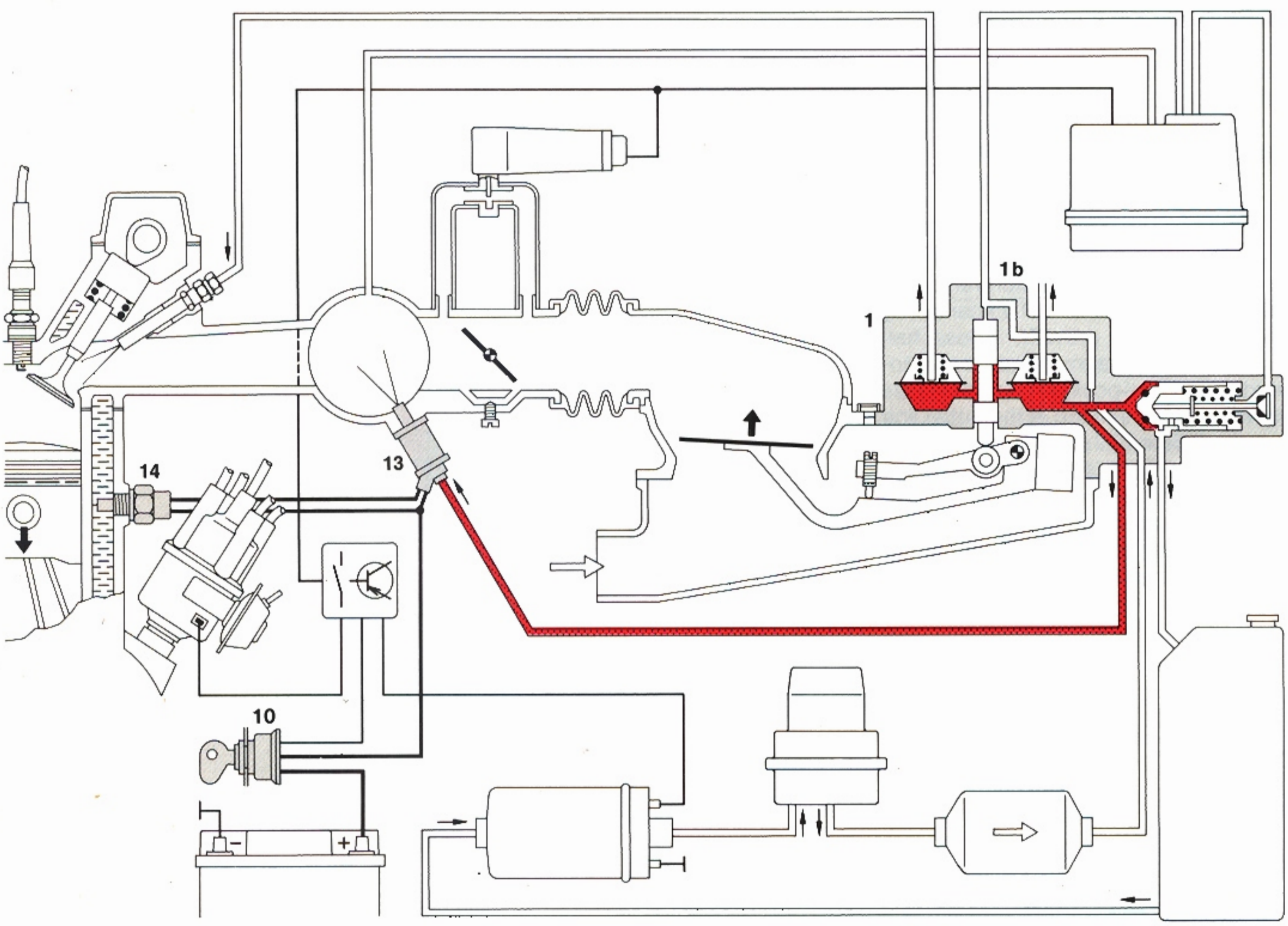


Fig. 24
Cold-start enrichment
1 Mixture-control unit
1 b Fuel distributor
10 Ignition/starting switch
13 Start valve
14 Thermo-time switch

Cold start

Depending upon the engine temperature, the start valve injects extra fuel into the intake manifold for a limited period during the starting process.

During cold starting, part of the fuel in the mixture drawn in is lost due to condensation on the cold cylinder walls.

In order to compensate for this loss and to facilitate starting the cold engine, extra fuel must be injected at the instant of start-up.

This extra fuel is injected by the start valve into the intake manifold. The injection period of the start valve is limited by a thermo-time switch depending upon the engine temperature.

This process is known as cold-start enrichment and results in a "richer" air-fuel mixture, i.e. the excess-air factor is temporarily less than 1.

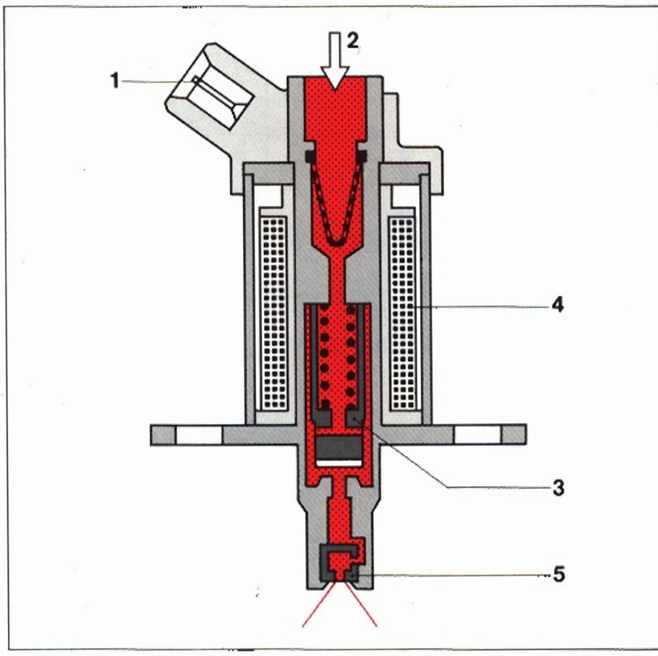


Fig. 25
Start valve in operated state.
1 Electrical connection
2 Fuel supply with strainer
3 Valve (electromagnet armature)
4 Solenoid winding
5 Swirl nozzle

Start valve

The start valve is of the solenoid-operated type. The winding of an electromagnet is fitted inside the valve. In the inoperated state, the movable armature of the electromagnet is forced against a seal by means of a spring and thus closes the valve. When the electromagnet is energized, the armature which as a result has lifted from the valve seat opens the passage for the flow of fuel through the valve. From here, the fuel enters a special nozzle at a tangent and is caused to rotate. The fuel is particularly well atomized by this specially shaped nozzle – the so-called "swirl nozzle" – and enriches the air in the intake manifold, downstream of the throttle valve, with fuel.

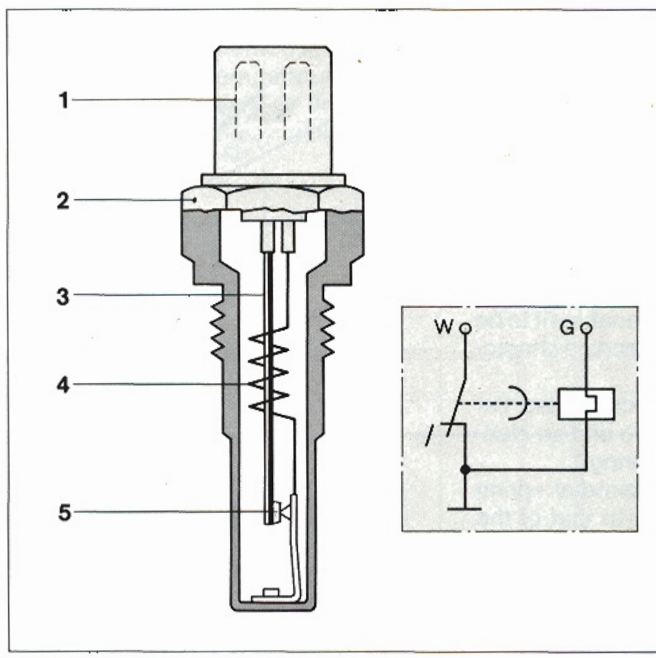


Fig. 26
Thermo-time switch
1 Electrical connection
2 Threaded pin
3 Bimetal
4 Heating filament
5 Switching contact

Thermo-time switch

The thermo-time switch limits the injection period of the start valve dependent upon engine temperature.

It is comprised of an electrically heated bimetal strip which depending upon its temperature either opens or closes an electric contact. The complete device is fitted into a hollow threaded pin which in turn is located at a position where typical engine temperature prevails.

The thermo-time switch determines the injection period of the start valve. In doing so, the warming-up of the switch due both to the engine heat and to the surrounding temperature, as well as its inbuilt electrical heating filament are the determining factors. The inbuilt heating facility is necessary in order to limit the maximum start-valve injection period. The mixture would otherwise become too rich and the engine would not start due to "flooding". During cold start the injection period depends mainly upon the electrical heating facility. (Switch off at −20 °C after approx. 8 seconds). On the other hand, when the engine is already warmed-up the heat from the engine has heated the thermo-time switch to such a degree that it remains permanently open. As a result, an engine which is already at operating temperature is not provided with extra fuel for starting.

Warm-up

Warm-up enrichment is controlled by the warm-up regulator. When the engine is cold the warm-up regulator reduces the control pressure to a degree dependent upon engine temperature and thus causes the metering slits to open further.

At the beginning of the warm-up period which directly follows the cold start, some of the injected fuel still condenses on the cylinder walls and in the intake tubes. This can cause combustion miss to occur. For this reason, the air-fuel mixture must be enriched during the warm-up phase ($\lambda < 1.0$). This enrichment must be continuously reduced along with the rise in engine temperature in order to prevent the mixture being over-rich when higher engine temperatures have been reached. The warm-up regulator (control-pressure regulator) is the component which carries out this mixture control for the warm-up period by changing the control pressure.

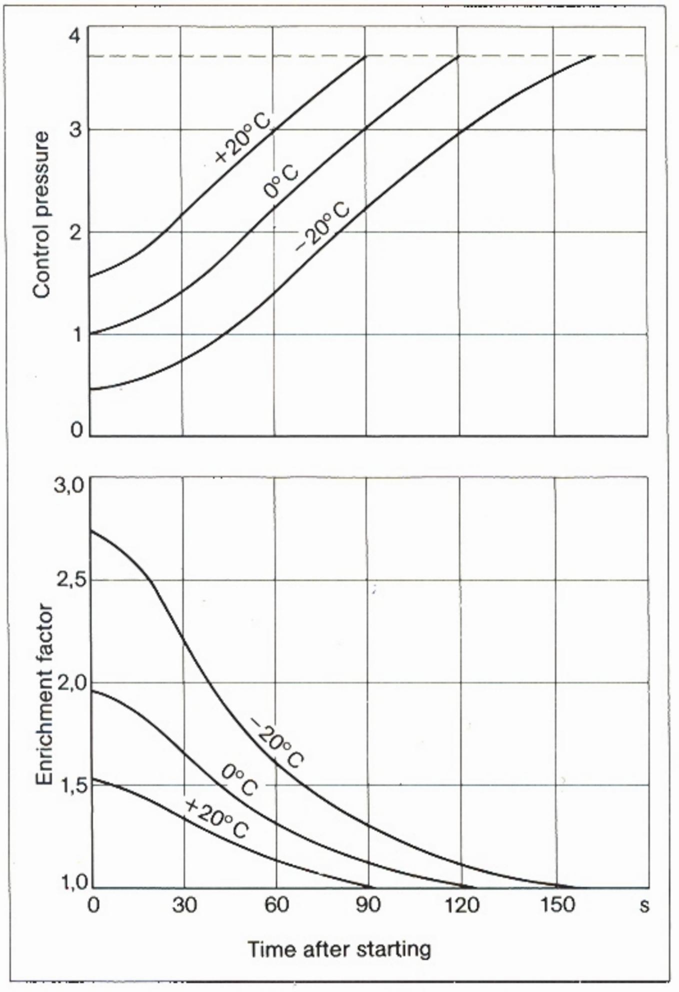


Fig. 27
Warm-up regulator characteristics at various engine temperatures. Enrichment factor 1.0 corresponds to fuel metering with the engine at operating temperature.

Warm-up regulator
The change of the control pressure is effected by the warm-up regulator which is so fitted to the engine that it ultimately adopts the engine temperature. In addition, the warm-up regulator is electrically heated which enables it to be precisely matched to the engine characteristic.

It comprises a spring-controlled flat seat diaphragm-type valve and an electrically heated bimetal spring.

In the cold state the bimetal spring exerts an opposing force to that of the valve spring and, as a result, reduces the effective pressure applied to the underside of the valve diaphragm. This means that the valve outlet cross section is slightly increased at this point and more fuel is diverted out of the control-pressure circuit in order to achieve a low control pressure.

As soon as the engine is cranked the bimetal spring is heated electrically and after starting it is also heated by the engine. The spring bends, and in doing so reduces the force opposing the valve spring which, as a result, pushes up the diaphragm of the flat-seat valve. The valve outlet cross section is reduced and the pressure in the control-pressure circuit rises.

Warm-up enrichment is completed when the bimetal spring has lifted fully from the valve spring. The control pressure is now solely controlled by the valve spring and maintained at its normal level. The control pressure is about 0.5 bar at cold start and about 3.7 bar with the engine at operating temperature.

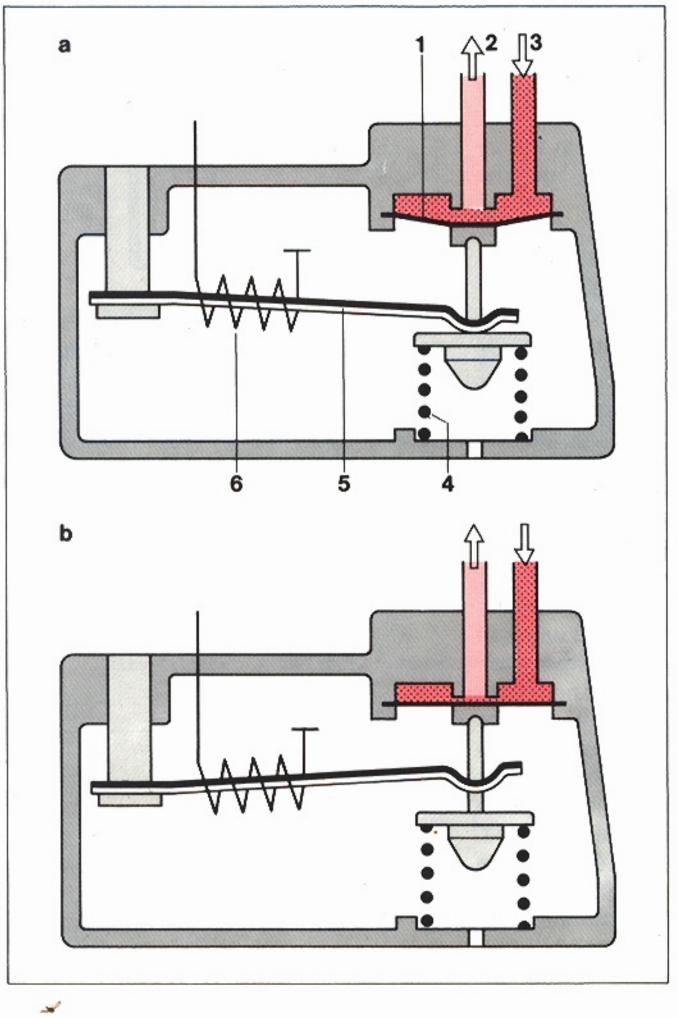


Fig. 28
Warm-up regulator
a with the engine cold
b with the engine at operating temperature
1 Valve diaphragm
2 Return
3 Control pressure (from the mixture-control unit)
4 Valve spring
5 Bimetal spring
6 Electrical heating

Auxiliary-air device

In order to overcome the increased friction in the cold state and to guarantee smooth idling, the engine receives more air-fuel mixture during the warm-up phase due to the action of the auxiliary-air device.

When the engine is cold, the frictional resistances are higher than when it is at operating temperature. These must also be overcome by the engine during idle. For this reason, the engine is allowed to draw in more air by means of the auxiliary-air device which by-passes the throttle valve. Due to the fact that this auxiliary air is measured by the air-flow sensor and taken into account for fuel metering, the engine is provided with more air-fuel mixture. This results in idle stabilization when the engine is cold.

In the auxiliary-air device a specially shaped plate is pivoted by means of a bimetal spring and changes the open cross section of the bypass line. Dependent upon temperature the plate assumes a different position, so that in the case of a cold engine a correspondingly larger cross section of the bypass line is opened. As the temperature increases the open area is decreased until, finally, it is closed completely. The bimetal is heated electrically. This means that the opening time can be limited according to engine type. The auxiliary-air device is so located that it is heated up by the engine to the engine temperature. This ensures that the auxiliary-air device does not respond when the engine is warm.

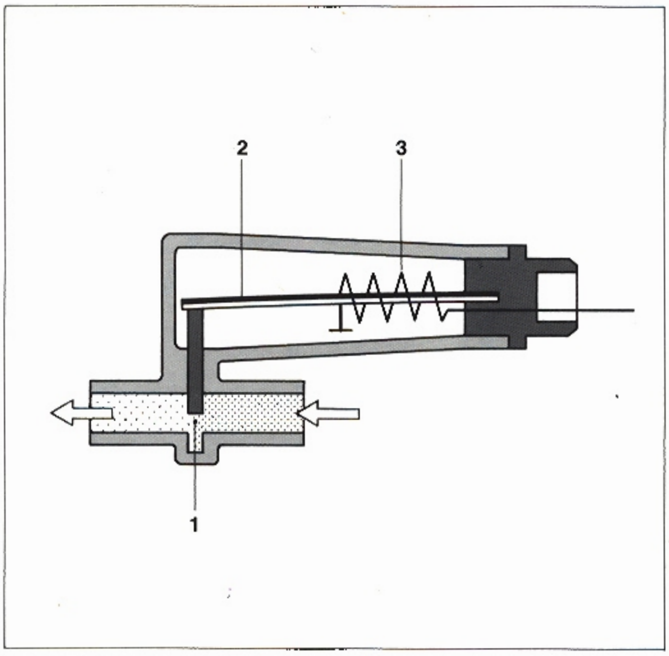
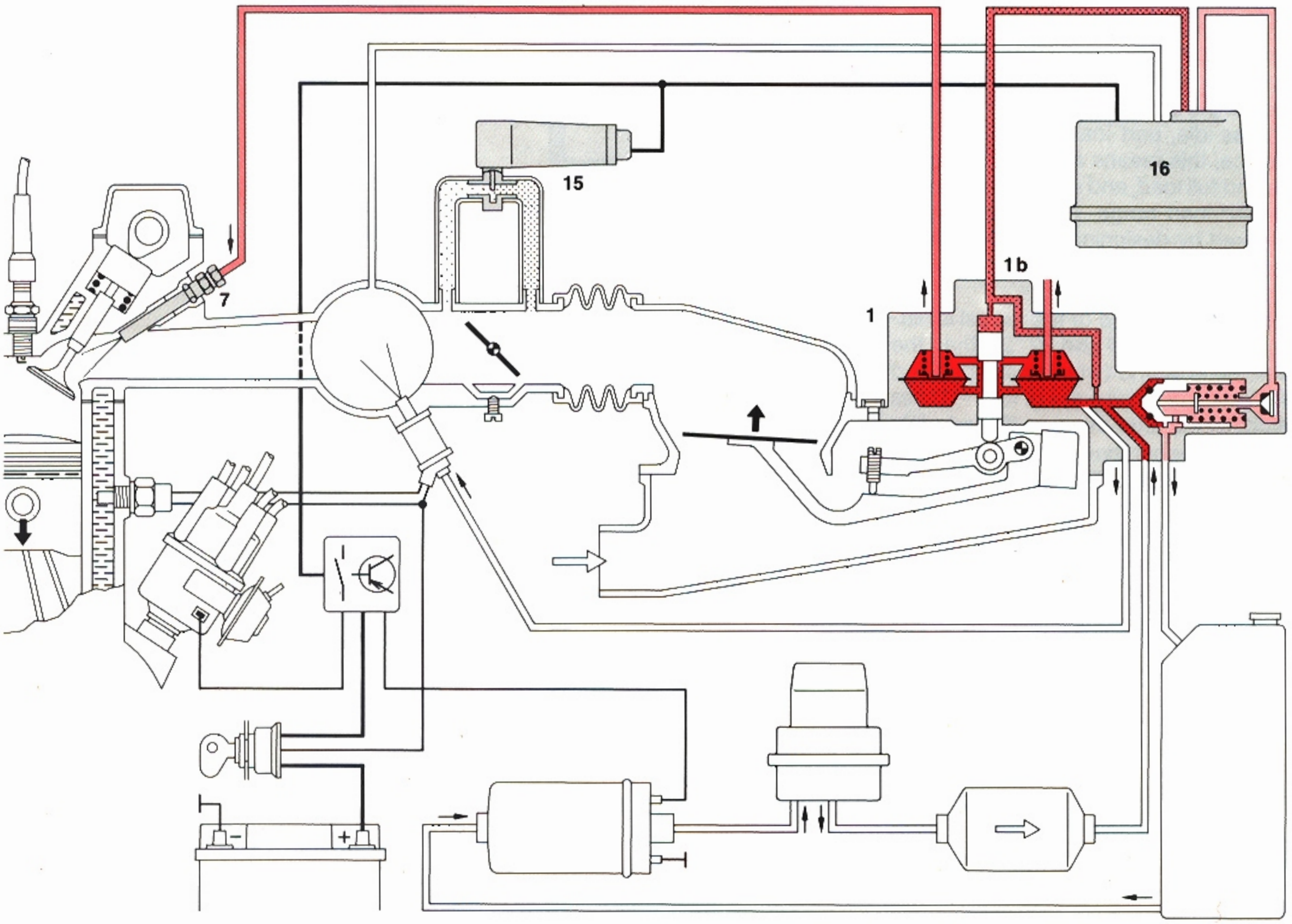


Fig. 29
Auxiliary-air device
1 Bypass line with pivoting plate
2 Bimetal
3 Electrical heating

Fig. 30
Warm-up enrichment
1 Mixture-control unit
1b Fuel distributor
7 Fuel-injection valve
15 Auxiliary-air device
16 Warm-up regulator



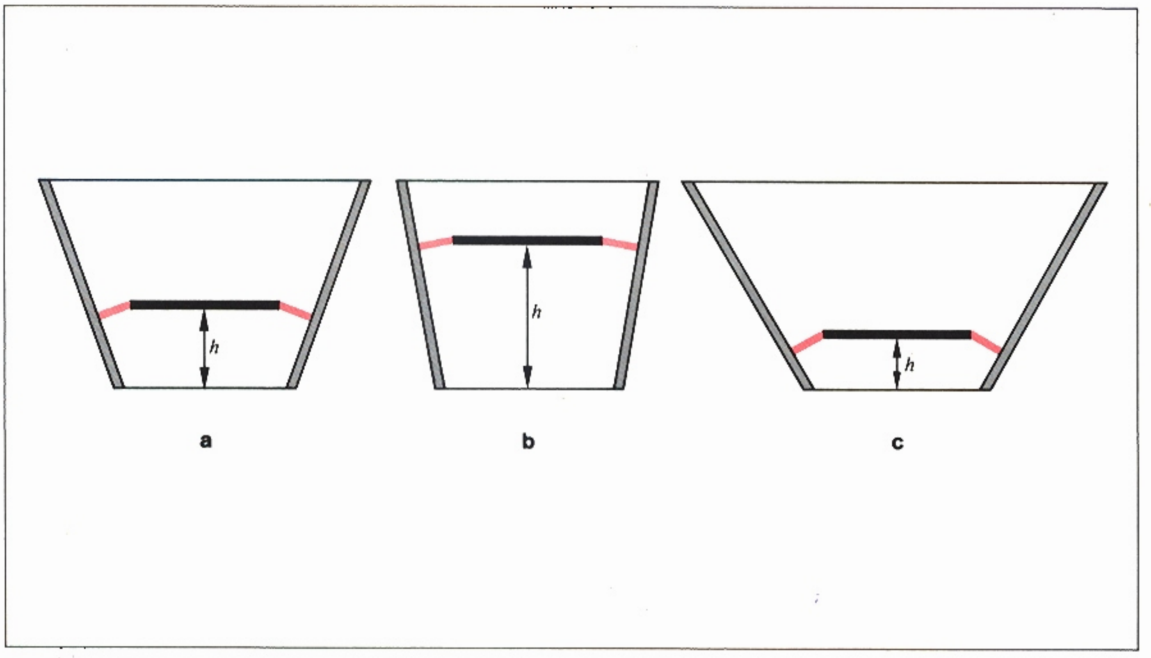


Fig. 31
Influence of the angle of the funnel walls on the deflection of the sensor plate for the same air throughput.
a Basic shape of the air funnel results in sensor-plate deflection "h"
b Steep funnel walls result in increased deflection "h" for the same air throughput
c Flatter funnel shape results in reduced deflection "h" for the same air throughput

Annular area opened by the sensor plate remains the same in a, b and c.

Load conditions

The adaptation, or correction, of the air-fuel mixture to the operating conditions of idle, part load and full load is carried out by means of appropriately shaping the air funnel in the air-flow sensor.

If the funnel had a purely conical shape (as in Fig. 31), the result would be a mixture with a constant air-fuel ratio throughout the whole of the sensor plate range of travel (metering range).

As has already been mentioned though, it is necessary to meter to the engine an air-fuel mixture which is optimal for particular operating conditions such as idle, part load and full load. In practice, this means a richer mixture at idle and full load, and a leaner mixture in the part-load range. This adaptation is achieved by designing the air funnel so that it becomes wider in stages (see Fig. 32).

If the cone shape of the funnel is flatter (as in Fig. 31 "c" and 32 "2") than the basic cone shape (which was specified for a particular mixture, e.g. for $\lambda = 1$) this results in a leaner mixture. If the funnel walls are steeper than in the basic model the sensor plate is lifted further for the same air throughput, more fuel is therefore metered and the mixture is richer.

Hence, the funnel is so shaped that a richer mixture is produced at idle and full load, and a leaner mixture at part load (full-load and idle enrichment).

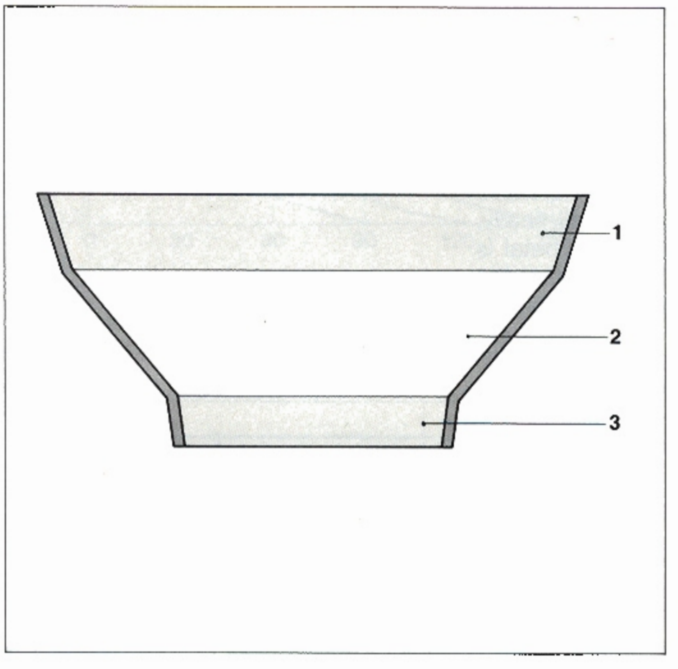


Fig. 32
Adaptation of the funnel shape on the air-flow sensor
1 For full-load
2 For part-load
3 For idle

Mixture enrichment by means of control-pressure reduction

In those cases where engines are operated with a very lean mixture in the part-load range, an extra mixture enrichment must be provided at full load in addition to the mixture adaptation resulting from the shape of the air funnel.

This extra enrichment is carried out by a specially designed warm-up regulator. This regulates the control pressure depending upon the manifold pressure.

In this model of the warm-up regulator, two valve springs are used instead of one. The outer of the two springs is supported on the housing as is the case with the normal-model warm-up regulator. The inner spring though, is supported on a diaphragm which divides the regulator into an upper and a lower chamber. The manifold pressure is effective in the upper chamber which is connected to the intake manifold, behind the throttle valve, by means of a hose. Depending upon the model, the lower chamber is subjected to atmospheric pressure either directly or by means of a second hose leading to the air filter.

Due to the low manifold pressure in the idle and part-load ranges, which is also present in the upper chamber, the diaphragm lifts to its upper stop. The inner spring is now at maximum pretension. The pretension of both springs, as a result, determines the particular control pressure for these two ranges. When the throttle valve is opened further at full load, the pressure in the intake manifold increases, the diaphragm leaves the upper stops and is pressed against the lower stops.

The inner spring is relieved of tension and the control pressure reduced by the specified amount as a result. In this manner, mixture enrichment is achieved.

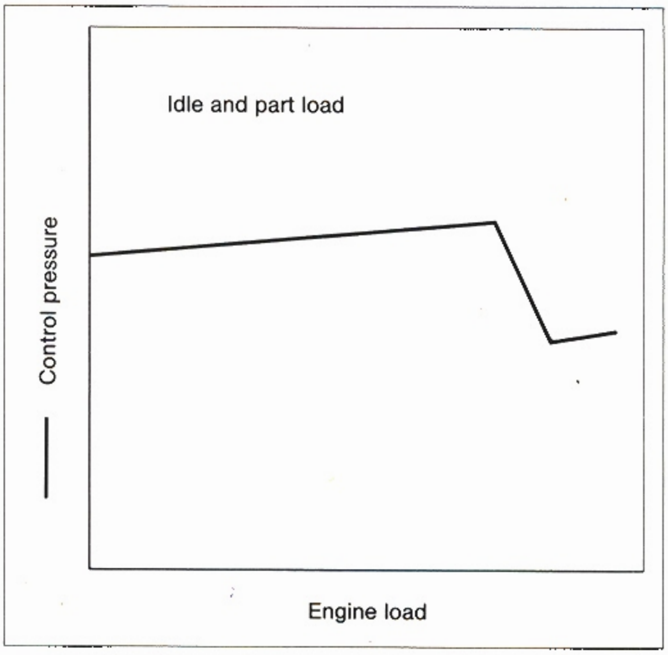


Fig. 33
Dependence of the control pressure on engine load.

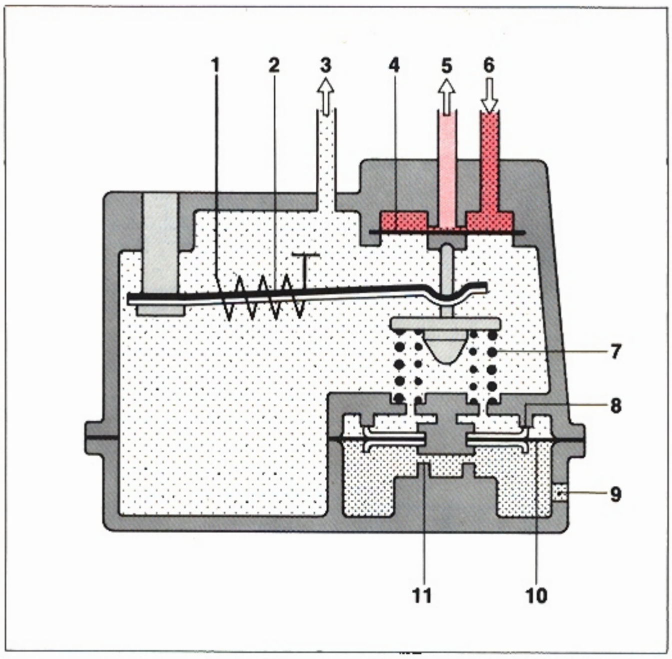


Fig. 34
Warm-up regulator with the full-load diaphragm in the idle and part-load position.
1 Electrical heating
2 Bimetal spring
3 Vacuum connection (from intake manifold)
4 Valve diaphragm
5 Return to fuel tank
6 Control pressure (from fuel distributor)
7 Valve springs
8 Upper stops
9 to atmospheric pressure
10 Diaphragm
11 Lower stops

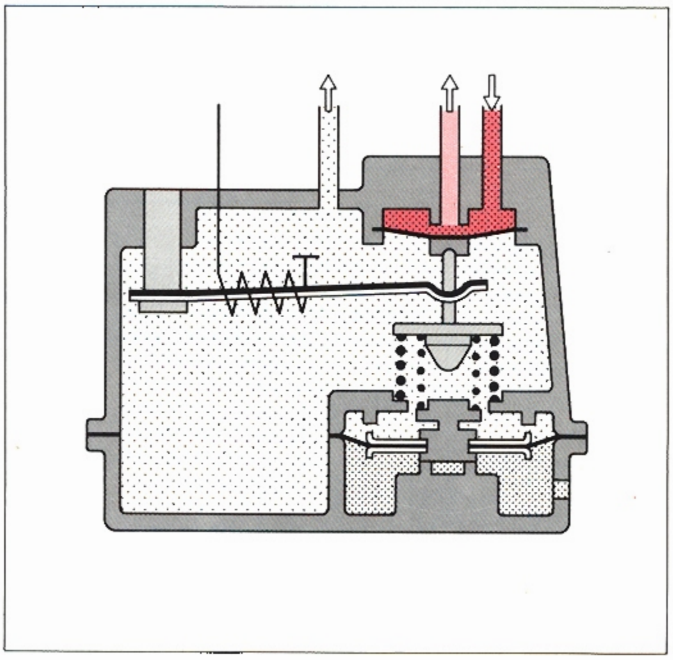


Fig. 35
Warm-up regulator with the full-load diaphragm in the full-load position.

Acceleration response

The good acceleration response is a result of the sensor plate "overswing".

Acceleration

During the transition from one operating condition to the other, changes in the mixture ratio occur which are utilized to improve the driveability.

If at constant engine speed the throttle valve is suddenly opened, the amount of air which enters the combustion chamber, plus the amount of air which is needed to bring the manifold pressure up to the new level, flow through the air-flow sensor. This causes the sensor plate to briefly "overswing" past the fully opened throttle point. This "overswing" results in more fuel being metered to the engine (acceleration enrichment) and ensures good acceleration response.

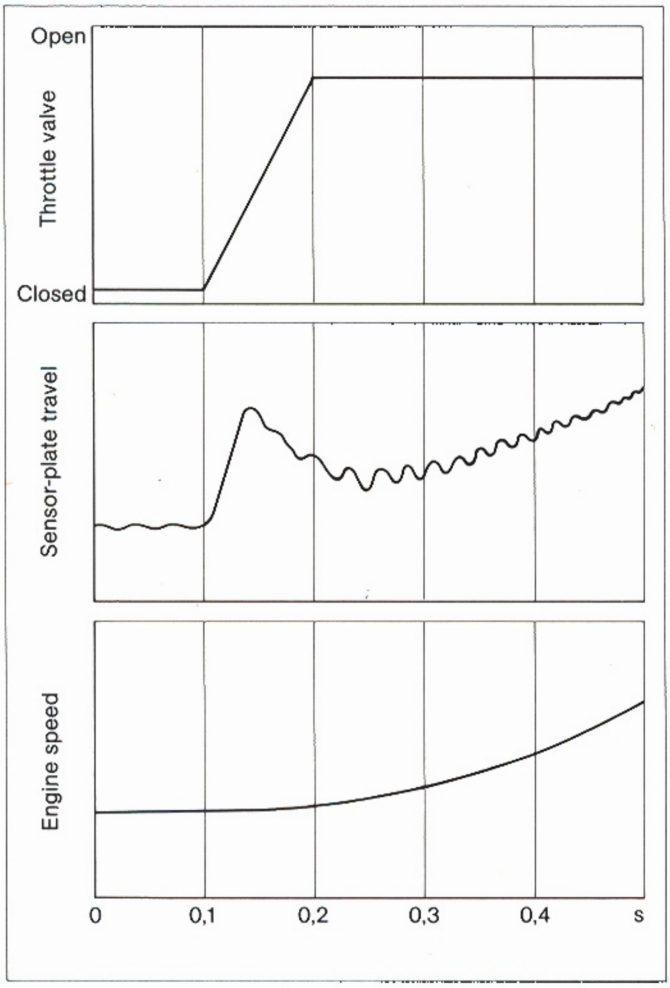


Fig. 36
Acceleration response. Behaviour of the K-Jetronic when the throttle valve is suddenly opened.

Electrical Circuitry

If the engine stops but the ignition remains switched on, the electric fuel pump is switched off.

The K-Jetronic system is equipped with a number of electrical components, such as electric fuel pump, warm-up regulator, auxiliary-air device, start valve and thermo-time switch. The electrical supply to all of these components is controlled by the control relay which itself is switched by the ignition-start switch.

Apart from its switching functions, the control relay also has a safety function. A commonly used circuit is described in the following.

Function

When cold-starting the engine, voltage is applied to the start valve and the thermo-time switch through terminal 50 of the ignition-start switch. If the cranking process takes longer than between 8 and 15 s, the thermo-time switch switches off the start valve in order that the engine does not "flood". In this case the thermo-time switch performs a time-switch function.

If the temperature of the engine is above about +35 °C when the starting process is commenced, the thermo-time switch will have already open-circuited the connection to the start valve which as a result does not inject extra fuel. In this case the thermo-time switch performs as a temperature switch.

Voltage from the start-ignition switch is still present at the control relay which switches on as soon as the engine runs. The rotational speed reached when the starting motor cranks the engine is high enough to generate the "engine running" signal which is taken from the ignition pulses coming from terminal 1 of the ignition coil.

These pulses are processed by an electronic circuit in the control relay which switches on after the first pulse and applies voltage to the electric fuel pump, the auxiliary-air device and the warm-up regulator. The control relay remains switched on as long as the ignition is switched on and the engine is running. If the pulses from terminal 1 of the ignition coil stop because the engine has stopped turning, for instance in the case of an accident, the control relay switches off about 1 s after the last pulse is received. This safety circuit prevents the fuel pump from pumping fuel when the ignition is switched on but the engine is not turning.

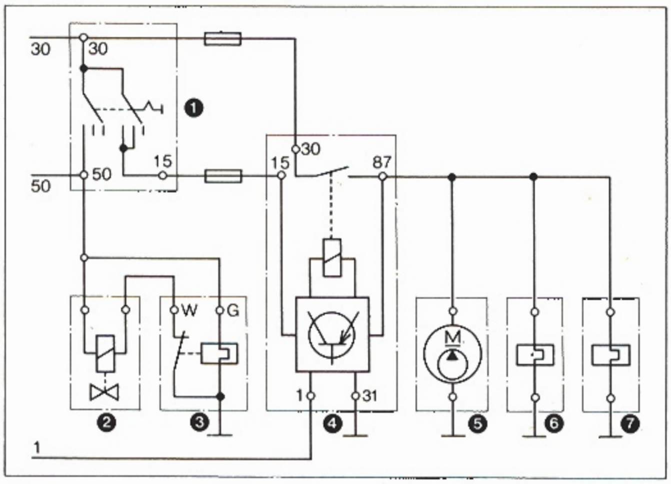


Fig. 37
Circuit without voltage applied
❶ Ignition-start switch
❷ Start valve
❸ Thermo-time switch
❹ Control relay
❺ Electric fuel pump
❻ Warm-up regulator
❼ Auxiliary-air device

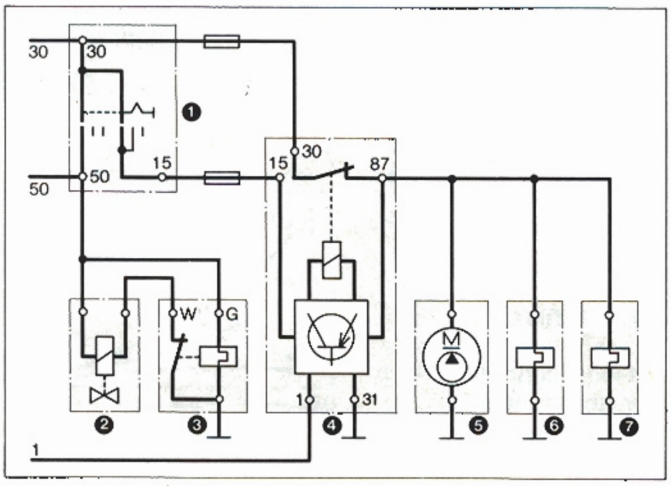


Fig. 38
Starting with the engine cold. Start valve and thermo-time switch are switched on. The engine turns (pulses are taken from terminal 1 of the ignition coil). The control relay, electric fuel pump, auxiliary-air device and warm-up regulator are switched on.

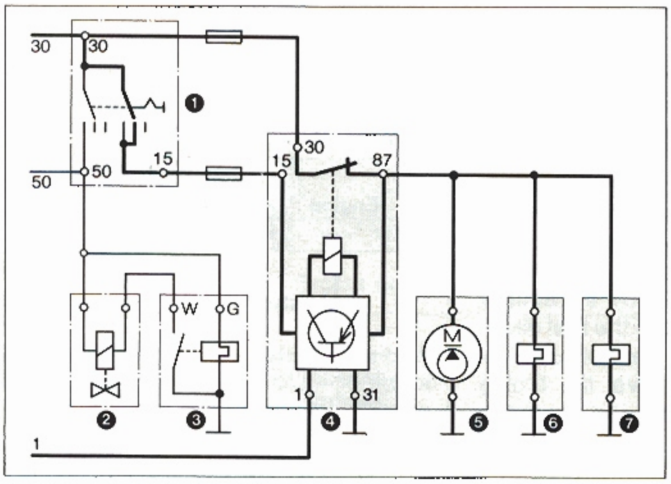


Fig. 39
Operation
Ignition on and engine running. Control relay, electric fuel pump, auxiliary-air device and warm-up regulator are switched on.

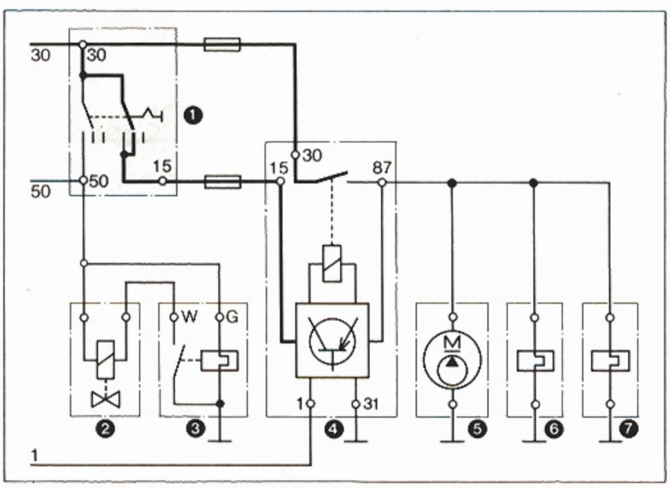


Fig. 40
Ignition on but engine stopped. No pulses can be taken from terminal 1 of the ignition coil. The control relay, electric fuel pump, auxiliary-air device and warm-up regulator are switched off.

Reduction of Pollutant Emissions

Combined with an exhaust-gas catalyst, the K-Jetronic provides the optimum prerequisites for fulfilling all legislation concerning the noxious content of exhaust gases. This even applies when these laws become more stringent in the future – as will be the case in some States in the USA.

Using one particular catalyst, the so-called "single-bed catalyst", together with the K-Jetronic it is possible to sufficiently reduce the level of all three noxious components, carbon monoxide CO, the unburnt hydrocarbons CH and nitrogen oxide NO_x. The decisive precondition though, is that the composition of the air-fuel mixture must be controlled to a high degree of accuracy. Here, the operating point with an excess-air factor of $\lambda = 1$ is situated in the vicinity of the figure for minimum fuel consumption while at the same time good driveability is still ensured.

Lambda closed-loop control

By means of the closed-loop control using the Lambda sensor, the air-fuel ratio can be controlled very accurately.

The principle of control is based upon the fact that the Lambda sensor continuously measures the amount of excess oxygen in the exhaust gas. This excess oxygen is a measure for the composition of the air-fuel mixture fed to the engine. The Lambda sensor fitted as a detecting element in the exhaust pipe provides information as to whether the mixture is richer or leaner than $\lambda = 1$. If the mixture deviates from this figure, the sensor output voltage jumps suddenly. This voltage jump is processed by a Lambda control unit and passed to the fuel distributor in the mixture-control unit by means of a solenoid valve, the timing valve, in order to correct the composition of the air-fuel mixture.

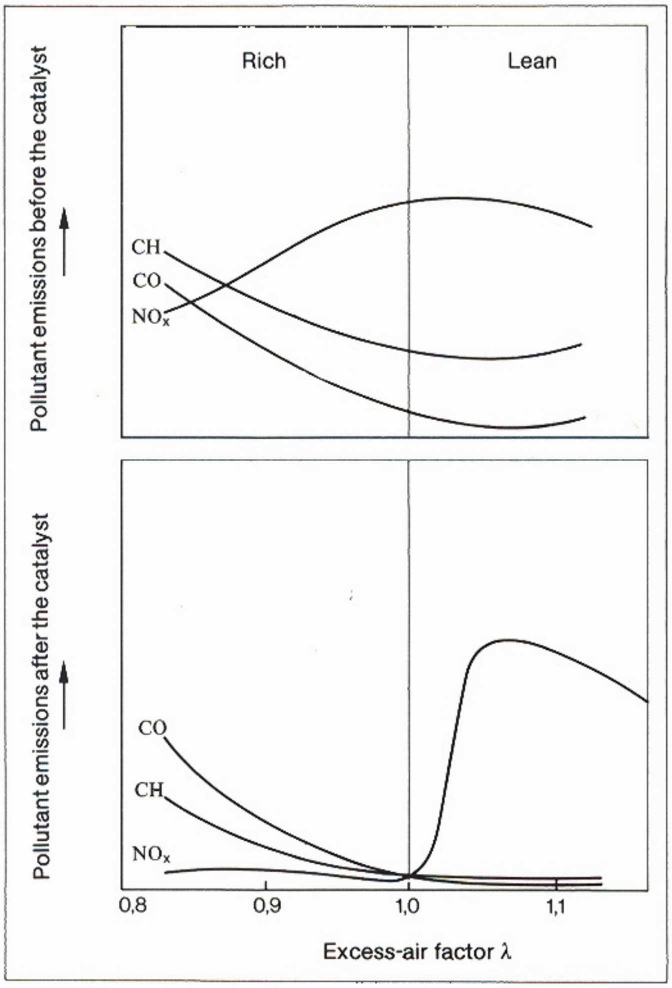


Fig. 41
Pollutant emissions of a spark-ignition engine before and after a single-bed catalyst.
CH Unburnt hydrocarbons
CO Carbon monoxide
NO_x Nitrogen oxide

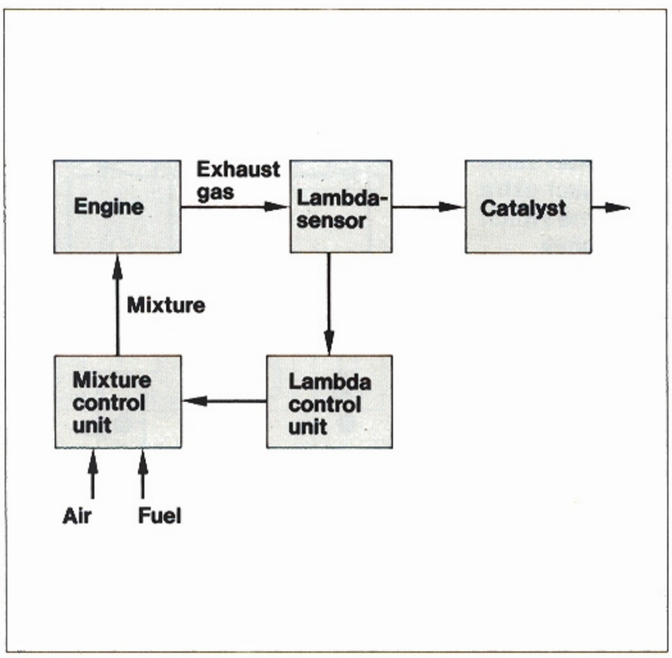


Fig. 42
Lambda closed-loop control

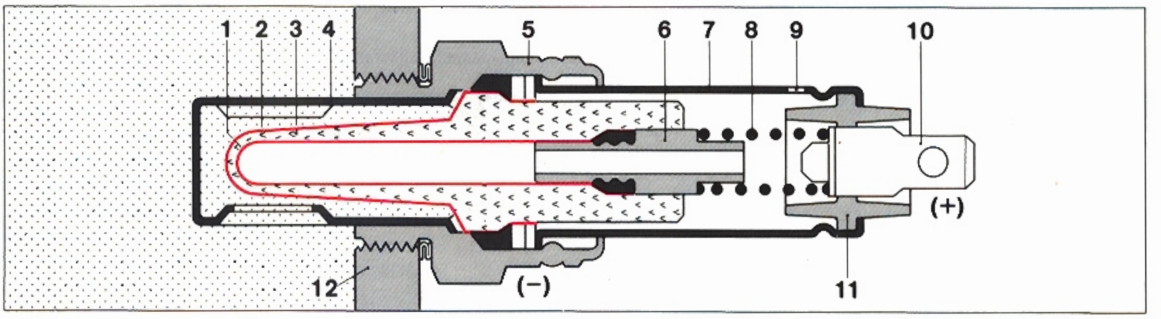


Fig. 43
Section drawing of the Lambda sensor
1 Electrode (+)
2 Electrode (−)
3 Sensor ceramic
4 Protective tube (exhaust-gas side)
5 Housing (−)
6 Contact bushing
7 Protective tube (atmosphere)
8 Contact spring
9 Opening to atmosphere
10 Electrical terminal (+)
11 Insulator
12 Exhaust-pipe or manifold wall
Left: Exhaust-gas side

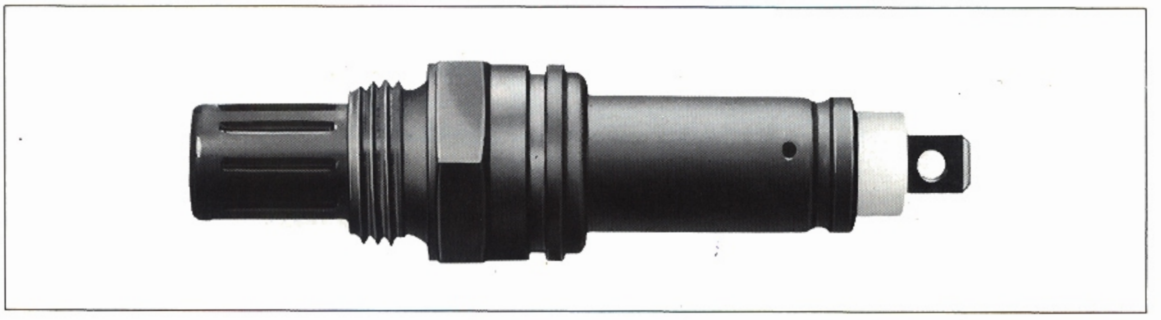


Fig. 44
The Bosch Lambda sensor shown in natural size.

Principle of operation of the Lambda sensor

The Lambda sensor measures the excess air content of the exhaust gas. The amount of excess air depends upon the air-fuel mixture. The Lambda sensor is characterized by the fact that deviations from the excess-air factor $\lambda = 1$ result in a sudden voltage change in its output signal.

The sensor is fitted as near as possible to the engine in the exhaust pipe or manifold. It is incorporated in a housing which protects it against mechanical damage whilst at the same time facilitating its fitting in the exhaust manifold or pipe. (Detailed information is to be found in the Publication VDT-U 1/1 En "Automotive Electronics" from the Bosch Technical Instruction series.)

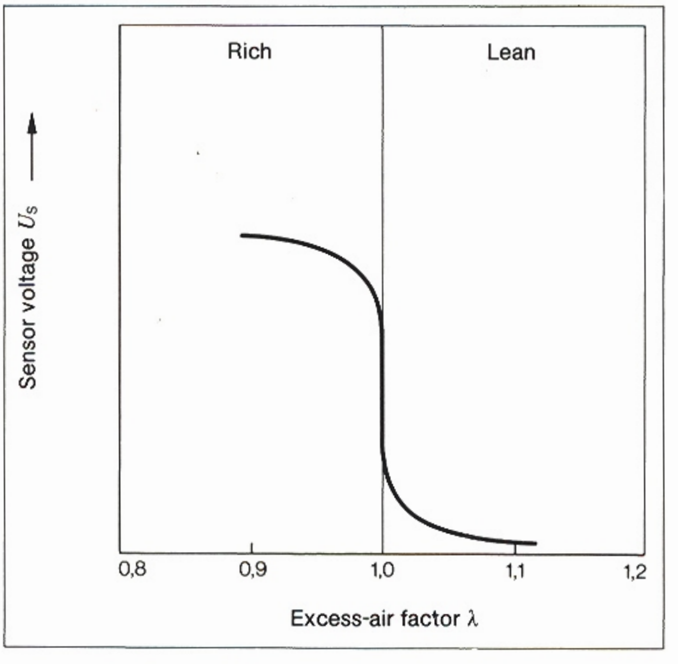


Fig. 45
Relationship between the sensor voltage and the excess-air factor.

Lambda control unit

An electronic control unit processes the signal coming from the Lambda sensor. It generates constant-frequency control pulses for the timing valve. The pulse width, i.e. the on/off ratio of the pulses, is changed depending upon the signal from the sensor. Apart from this basic function, the control unit carries out additional control and adaptation tasks. Until the sensor has reached its operating temperature (a matter of seconds), closed-loop control cannot come into operation and the system is switched to the open-loop mode. During operation, the control unit monitors the function of the Lambda sensor. If a defect should arise, the timing valve is provided with pulses having a fixed on/off ratio.

Controlling the air-fuel mixture

In order to adapt the injected fuel quantity to the ideal air-fuel ratio of $\lambda = 1$, the pressure in the lower chambers of the fuel distributor is varied. If for instance the pressure is reduced, the differential pressure at the metering slots climbs accordingly with the result that the injected fuel quantity is also increased. In order to be able to vary the pressure in the lower chambers, these are decoupled (in contrast to the conventional K-Jetronic fuel distributor) from the primary pressure. Decoupling is by means of a fixed throttle. A further throttle connects the lower chambers with the fuel return.

This throttle is variable. If it is open, the pressure in the lower chambers can reduce. If it is closed, the primary pressure is present in the lower chambers. If this throttle is opened and closed rapidly, it is possible to vary the pressure in the lower chambers to correspond to the ratio between open time and close time. An electromagnetic valve, the timing valve, is used as the variable throttle. It is controlled by electrical pulses from the Lambda control unit.

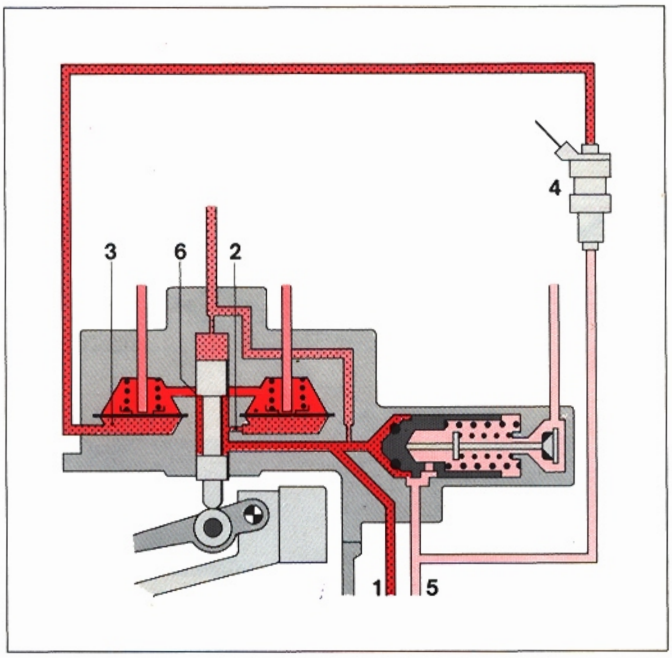


Fig. 46
Fuel distributor model for Lambda closed-loop control.
1 Fuel inlet
2 Decoupling throttle (fixed throttle)
3 Lower chambers of the differential pressure valves
4 Timing valve (variable throttle)
5 Fuel return
6 Metering slits

Summary

1. In order to operate correctly, a spark-ignition engine requires a specific air-fuel ratio. The theoretically ideal air-fuel ratio is 14:1. Certain driving conditions necessitate an adaptation of the air-fuel mixture.

2. Fuel induction by means of manifold injection permits optimum mixture adaptation to all phases of operation and guarantees less pollutants in the exhaust gas.

3. There are both electronically controlled and mechanically controlled fuel-injection systems available. The K-Jetronic is a mechanical system which does not require a drive, and which injects continuously into the intake tubes.

4. The electric fuel-supply pump is of the roller-cell type and is permanently flooded with fuel.

5. After the engine has been switched off, the fuel accumulator maintains the pressure in the fuel system for a given period. During operation it dampens the noise from the fuel-supply pump.

6. A special fine filter must be incorporated in the system in order that the K-Jetronic can operate reliably and efficiently.

7. A primary-pressure regulator maintains the pressure in the fuel system constant.

8. At a certain opening pressure, the fuel-injection valves open and atomize the fuel by means of the oscillation of the valve needle.

9. The task of fuel induction is to meter, or allocate, the correct quantity of fuel which corresponds to the amount of air drawn in by the engine. The mixture control unit comprises the air-flow sensor and the fuel distributor.

10. The air-flow sensor operates according to the suspended-body principle and measures the amount of air drawn in by the engine.

11. The movement of the air-flow sensor flap is transmitted directly to the control plunger in the fuel distributor.

12. The fuel distributor meters, or allocates, the correct amount of fuel to the individual cylinders in accordance with the position of the air-flow sensor plate.

13. Depending upon its position in the fuel distributor, the control plunger opens or closes the metering slits to a greater or lesser degree.

14. The differential-pressure valves serve to hold the drop in pressure at the metering slits constant.

15. At constant differential pressure, the amount of fuel metered to the injection valves is proportional to the opened section of the metering slits.

16. The metered, allocated, fuel is injected continuously into the intake tubes by the injection valves which at the same time atomize it finely.

17. The mixture formation takes place in the individual intake tubes and cylinders of the engine.

18. Depending upon the engine temperature, the start valve injects extra fuel into the intake manifold for a limited period during the starting process.

19. The start valve is controlled by the thermo-time switch.

20. Warm-up enrichment is controlled by the warm-up regulator. When the engine is cold the warm-up regulator reduces the control pressure to a degree dependent upon engine temperature and thus causes the metering slits to open further.

21. Mixture adaptation for the operating conditions idle, part-load and full-load is carried out by appropriately shaping the air funnel.

22. In order to overcome the increased friction in the cold state, the engine receives more air-fuel mixture during the warm-up phase due to the action of the auxiliary-air device.

23. Due to the fact that the sensor plate "overswings", satisfactory transition response (acceleration, deceleration) is achieved.

24. If the engine stops whilst the ignition is still switched on, the electric fuel pump is switched off.

Technical Terms

Air-flow sensor
Component for measuring the quantity of air drawn in by the engine.

Air funnel
The funnel-shaped opening in which the sensor plate deflects to measure the rate of air flow through the air-flow sensor.

Air-fuel ratio
The ratio of the quantity of air to the quantity of fuel in the mixture drawn in by the engine.

bar
Unit of pressure.
1 bar corresponds to approx.
1 kgf/cm^2.

Barrel with metering slits
Tubular-shaped component in the fuel distributor. It is provided with the metering slits. The control plunger moves up and down inside the barrel.

Bimetallic strip
A strip formed of two dissimilar metals which have different temperature coefficients of expansion. The strip bends to one side when the temperature increases, as a result of heating by a heating wire for instance.

Catalyst
A material which affects a chemical reaction without itself being changed. For instance, the acceleration of the decomposition of pollutants in the exhaust gas.

Cold start
Starting the engine when it is cold.

Condensation losses
"Leaning" of the air-fuel mixture as a result of the fuel condensing on the cold walls of the cylinder(s) and intake manifold.

Control plunger
Plunger in the fuel distributor which is moved by means of the lever in the air-flow sensor. Depending upon its position, the control plunger opens or closes the slits to a greater or lesser degree and as a result determines the injected fuel quantity.

Control pressure
The control pressure is the pressure controlled by the warm-up regulator and applied to the control plunger in the fuel distributor. It generates the opposing force to that originating from the air-flow sensor.

Damping restriction (K-Jetronic)
Bore of small cross-section in the fuel distributor of the K-Jetronic. It damps sensor-plate movement in the air-flow sensor at low rotational speeds and high loads.

Diaphragm valve
A valve with a spring-loaded diaphragm which lifts from the valve seat when a set pressure is exceeded and opens the flow passage.

Differential pressure valve
Each cylinder is allocated a diaphragm-controlled flat-seat valve in the fuel distributor. The valves are situated downstream of the metering slits and serve to maintain the pressure drop at the metering slits constant irrespective of through-flow quantity and primary pressure. As a result, the through-flow quantity is only dependent upon the area of the metering slit opened up by the control plunger.

D-Jetronic
Electronically controlled fuel induction by means of gasoline injection dependent upon the pressure measured in the intake manifold.

Downdraft air-flow sensor
In the downdraft air-flow sensor the intake air flows down past the sensor plate from above.

Excess-air factor (λ)
Trapped air-fuel ratio divided by stoichiometric ratio (see stoichiometric ratio).

Fuel accumulator
A container which is divided by an elastic diaphragm into an accumulator chamber and a spring chamber. It serves to dampen the noise of the fuel-supply pump and to maintain pressure in the system after the engine has been switched off.

Fuel distributor
The component which feeds fuel to the individual engine cylinders corresponding to the air-flow rate metered by the air-flow sensor.

Fuel filter
A filter fitted in the fuel line which removes impurities from the fuel passing through it.

Fuel-injection valve
Injects the pressurized fuel into the intake tubes directly before the intake valve of the engine cylinder.

Gasoline injection
Adding and metering of gasoline to the intake-air quantity by means of a fuel-injection system.

Intake manifold
A pipe or casting which serves to direct the intake air or the air-fuel mixture into the engine cylinders.

K-Jetronic
Fuel induction by means of continuous fuel injection dependent upon the measured intake-air quantity.

Lambda (λ), air factor
See "Excess-air factor".

Lambda sensor
A sensor located in the exhaust-gas stream. Its output signal is dependent upon the air-fuel ratio of the mixture supplied to the engine.

L-Jetronic
Electronically controlled fuel induction by means of intermittent fuel injection depending upon the measured intake-air quantity.

Metering slit
Metering slits are narrow rectangular slits in the tubular barrel of the fuel distributor. The number of metering slits corresponds to the number of engine cylinders. The cross-sectional area of these slits open to the flow of fuel can be varied by the control edge of the movable control plunger according to fuel requirements.

Mixture control unit
Comprises the air-flow sensor, the fuel distributor and the primary pressure regulator. Its function is to meter the proper amount of fuel to match the rate of air flow.

Push-up valve
The valve which prevents the control pressure dropping rapidly when the fuel-supply pump is switched off. When the fuel pump is switched on, it is pushed open by the primary-pressure regulator plunger.

Roller-cell pump
A pump whose rotor disc is positioned eccentric to the pump housing. There are slits in the circumference of the rotor disc, in which metal rollers are located which are pressed against the pump housing by centrifugal force and act as seals when the rotor rotates. Fuel is carried in the cavities between the rollers and forced into the pressure lines.

Spark-ignition engine
An engine in which combustion of the compressed air-fuel mixture is initiated at the correct instant in time by means of externally supplied ignition.

Start valve
A solenoid-operated injection nozzle which, during starting with a cold engine, injects extra fuel in finely atomized form into the intake manifold.

Stoichiometric ratio
The ratio of the mass of air theoretically required for the complete combustion of a given mass of fuel to this mass of fuel. For gasoline it is an average of 14:1 (= 14 kg air for 1 kg gasoline).

Swirl nozzle
An injection nozzle with tangential entry passages which force the fuel into rotation so that it leaves the nozzle as a finely atomized spray.

Thermo-time switch
A switch which interrupts the electric circuit to the start valve as a function of temperature, and thus limits the switch-on time of the start valve.

Timing valve
A valve, the switching rhythm of which can be used to determine the pressure in the lower chamber of the fuel distributor.

Updraft air-flow sensor
In the updraft air-flow sensor the intake air flows up past the sensor plate from below.

Warm start
Starting the engine when it is warm.

Warm-up
The period of time between starting a cold engine and it reaching operating temperature.

Warm-up regulator
Controls the control pressure dependent upon engine temperature.

Bibliography

R. Schwartz, G. Stumpp, H. Knapp: K-Jetronic – Continuous Gasoline Injection from Bosch (K-Jetronic – kontinuierliche Benzineinspritzung von Bosch), ATZ 11 (1973), pp. 393 to 398 and ATZ 12 (1973), pp. 453 to 459.

R. Schwartz, G. Stumpp, H. Knapp: The K-Jetronic – A Mechanical System for Continuous Gasoline Injection (Die K-Jetronic – eine mechanisch arbeitende Anlage zur kontinuierlichen Benzineinspritzung), Bosch Technische Berichte 4 (1973) Heft 5, pp. 200 to 214.

H. Scholl: Electronic Gasoline Injection controlled by Air-Flow Quantity and Engine Speed (Elektronische Benzineinspritzung mit Steuerung durch Luftmenge und Motordrehzahl), Bosch Technische Berichte 4 (1973) Heft 5, pp. 190 to 199.

Key Words

Test questions

A The K-Jetronic operates
☐ a Electrically
☐ b Mechanically

B The fuel-supply pump is
☐ a Driven by the vehicle engine
☐ b Driven by an electric motor

C With the engine switched off and the ignition switched on
☐ a The fuel-supply pump is switched off
☐ b The fuel-supply pump continues to run

D The fuel accumulator maintains the pressure in the fuel system
☐ a During operation
☐ b After switch-off

E The fuel filter is necessary for trouble-free operation
☐ a Unnecessary
☐ b Absolutely necessary

F The unit 1 bar
☐ a Corresponds to 1 psi
☐ b Corresponds to approx. 1 kp/cm^2

G The primary-pressure regulator controls
☐ a The primary pressure
☐ b The primary pressure and the control pressure

H The mixture-control unit
☐ a Controls the air-fuel ratio
☐ b Comprises the air-flow sensor, fuel distributor and primary-pressure regulator

I The air-flow sensor
☐ a Measures the excess-air factor
☐ b Measures the quantity of air drawn in by the engine

K The excess-air factor is defined as
☐ a The amount of air-fuel mixture supplied to the engine
☐ b The ratio of the amount of air supplied to the engine to that actually required by the engine

L In the fuel distributor
☐ a The metering of the injected fuel quantity is carried out
☐ b The metered fuel quantity is distributed to the individual engine cylinders

M The primary pressure
☐ a Has an effect upon the control plunger
☐ b Has an effect upon the differential-pressure valves

N The differential-pressure valves
☐ a Measure the primary pressure
☐ b Hold the drop in pressure at the metering slits constant

O The fuel-injection valves spray the fuel
☐ a Into the intake passages
☐ b Directly into the combustion chamber

P The gasoline is injected
☐ a Continuously
☐ b Intermittently

Q The start valve has the function of
☐ a Providing more air-fuel mixture
☐ b Injecting more fuel

R The thermo-start valve
☐ a Switches off the start valve
☐ b Is electrically heated

S The warm-up regulator is
☐ a Only heated by the engine
☐ b Heated electrically and by the engine

T The warm-up regulator controls
☐ a The primary pressure
☐ b The control pressure

U If the control pressure is low
☐ a More fuel is allocated to the cylinders
☐ b Less fuel is allocated to the cylinders

V The auxiliary-air device has the function of
☐ a Increasing the air-fuel-mixture quantity
☐ b Increasing the injected fuel quantity

W A reduction in the control pressure results in
☐ a Enrichment of the air-fuel mixture
☐ b Allocation of less fuel to the cylinders

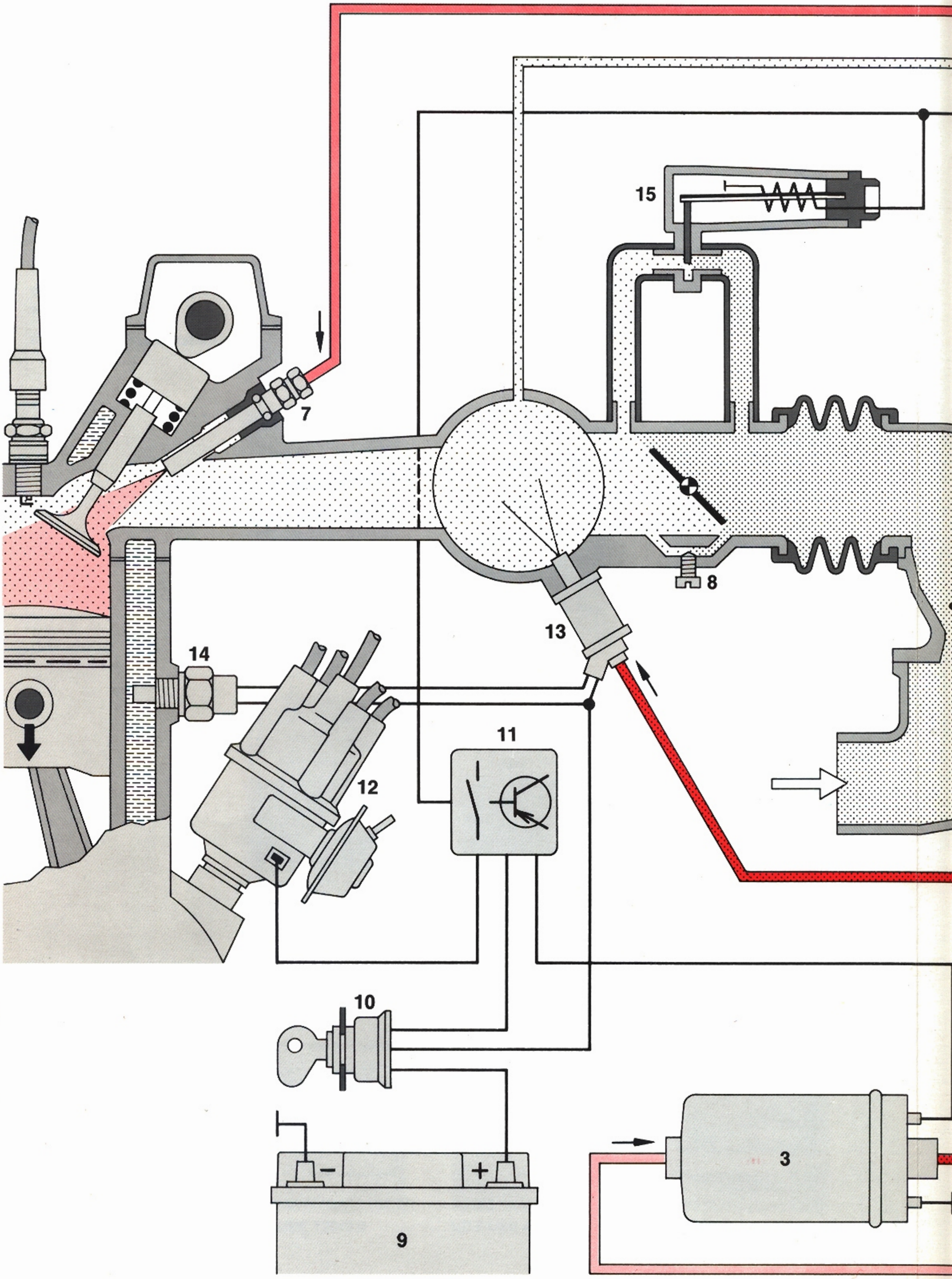
You will find the correct answers to these questions on the following pages:

A 6, B 7, C 7/21, D 8, E 8, F 26, G 9, H 10,
I 10, K 4, L 4, M 13, N 13, O 14, P 9/14, Q 15,
R 15, S 16, T 16, U 12, V 17, W 19.

Installation Schematic

1 Mixture-control unit
1a Air-flow sensor
1b Fuel distributor
1c Idle-mixture adjusting screw
2 Fuel tank
3 Electric fuel pump
4 Fuel accumulator
5 Fuel filter
6 Primary-pressure regulator
6a Push-up valve
7 Fuel-injection valve
8 Idle-speed adjusting screw
9 Battery
10 Ignition-and-starting switch
11 Control relay
12 Ignition distributor
13 Start valve
14 Thermo-time switch
15 Auxiliary-air device
16 Warm-up regulator
16a Full-load diaphragm

- Delivery pressure (primary pressure).
- Pressure in the upper chamber 4.7 bar
- Injection pressure 3.3 bar
- Control pressure 0.5 ... 3.7 bar
- Suction or return
- Atmospheric pressure
- Manifold pressure
- Coolant



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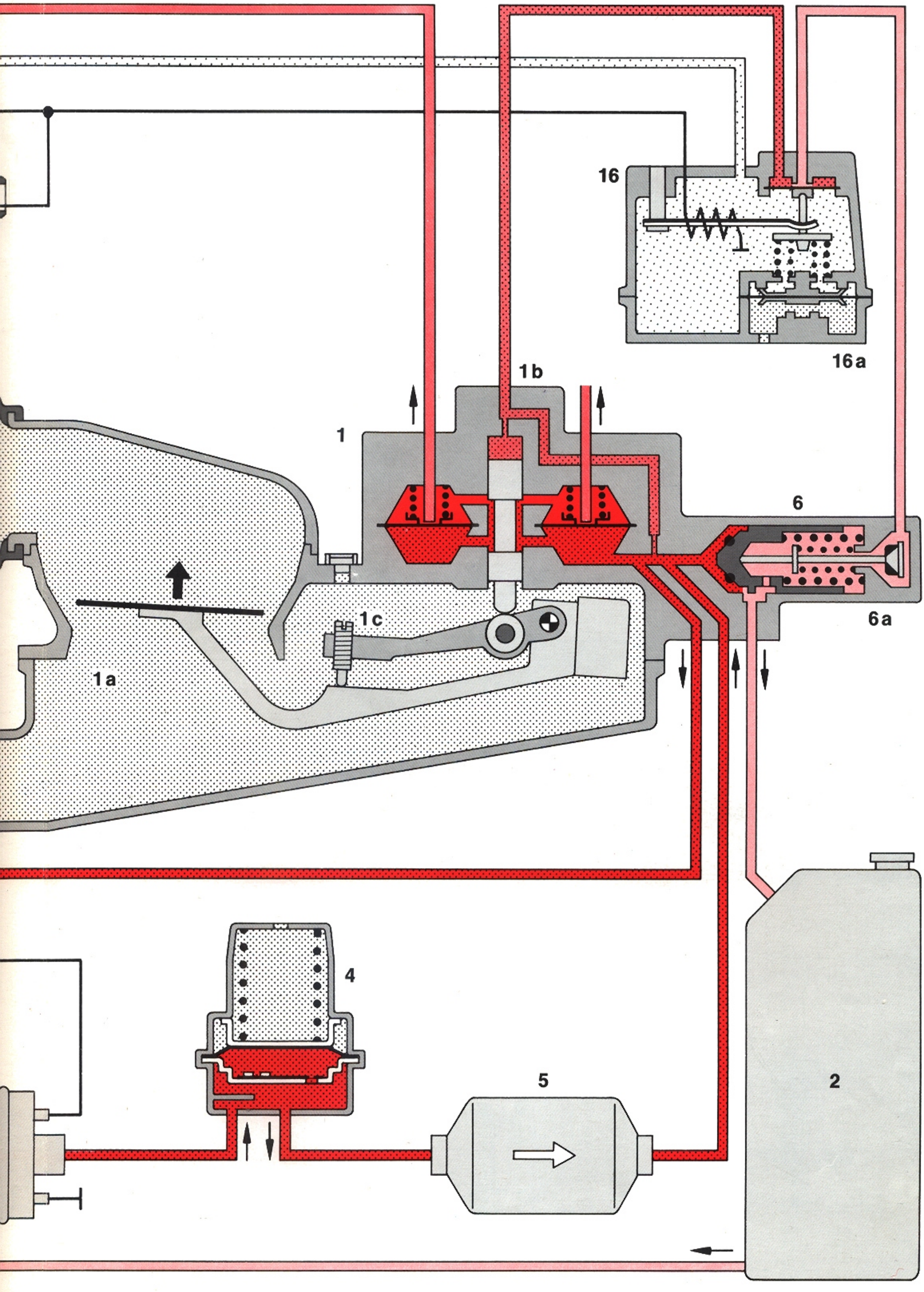
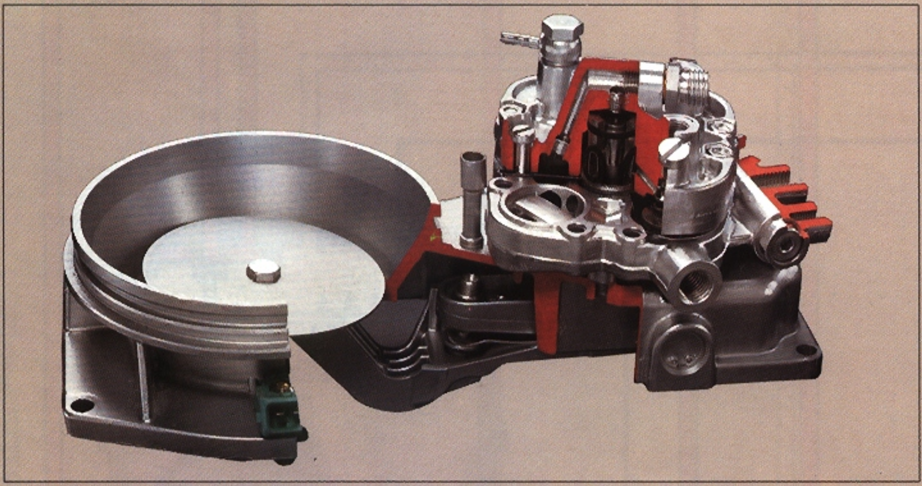
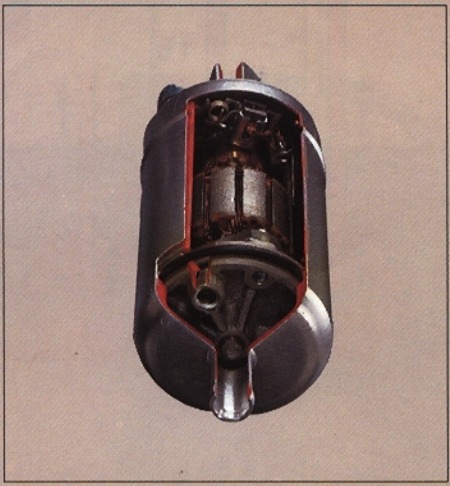
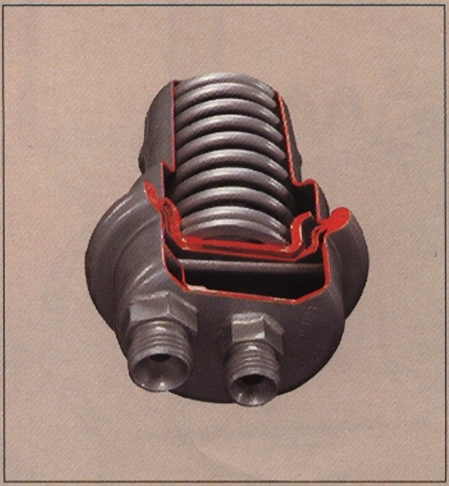
9

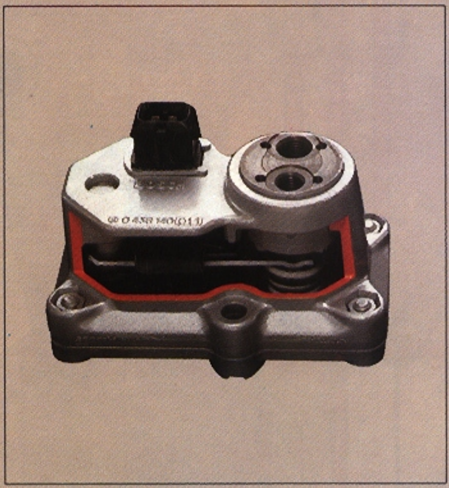

16
16a
1b
1
6
6a
1c
1a
4
5
2

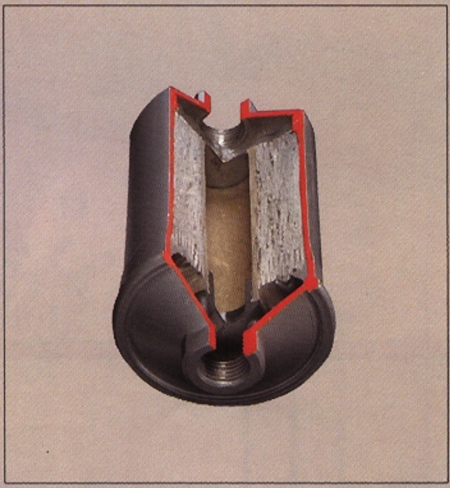


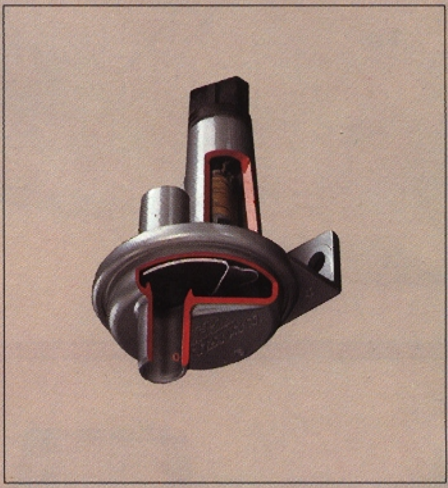
The K-Jetronic Components

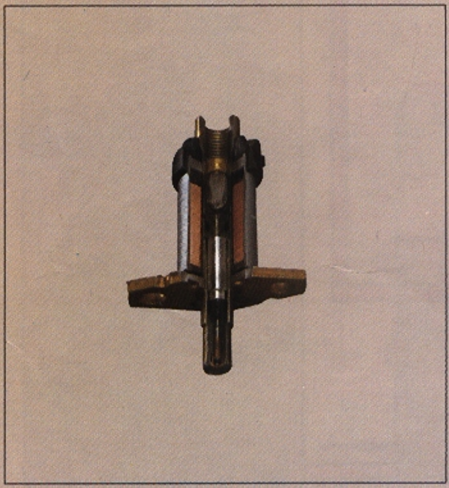


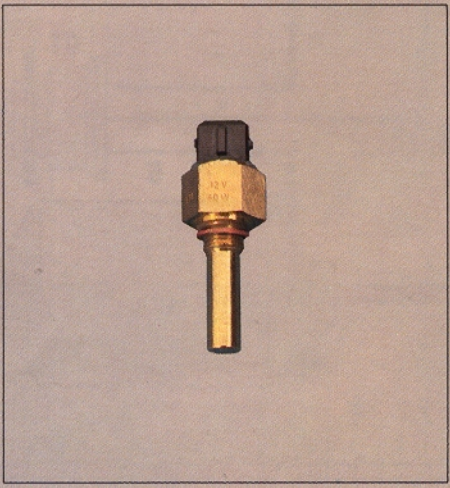


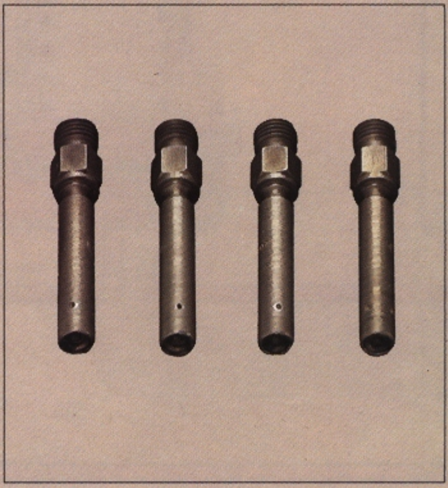












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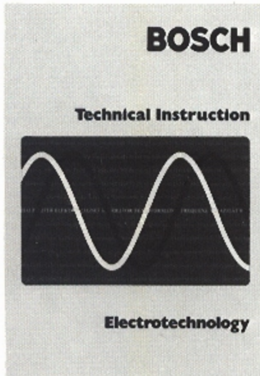

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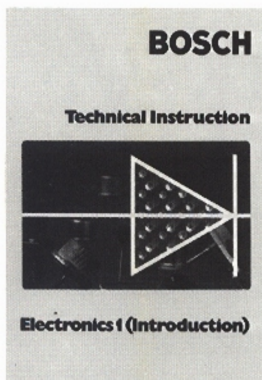

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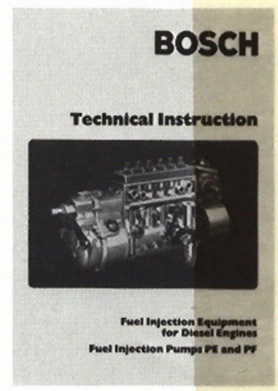

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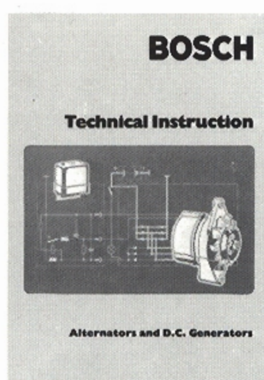

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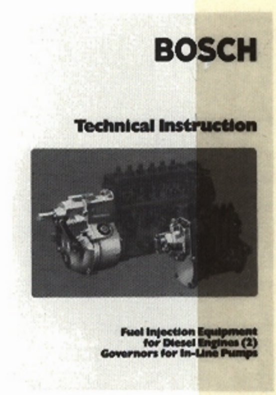

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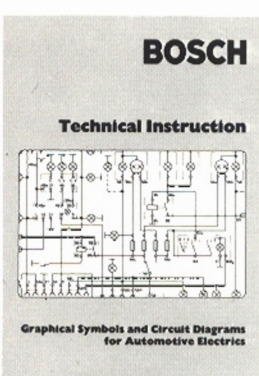

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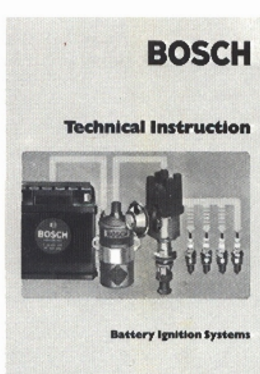

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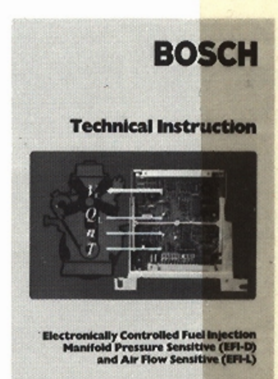

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