Construction and function

CI Fuel Injection System 240/260 1976—

Section 2 Group 24

CI Fuel Injection System 240/260

VOLVO

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Introduction

The CI-Fuel Injection System is used on both the B21F, B21FT, B23E, B27F and B28F engines (240—260 series vehicles).

To help simplify the presentation of information, this manual illustrates and outlines the basic system for the B21F. References are made to the B27F and B28F in those areas where components and/or operation differs significantly from that of the B21F engine.

NOTE: All reference to 240 and 260 models in the manual also apply to DL, GL, GLE, GT, GLT and Coupe as appropriate.

Indicates changes in text and/or specification in this manual.

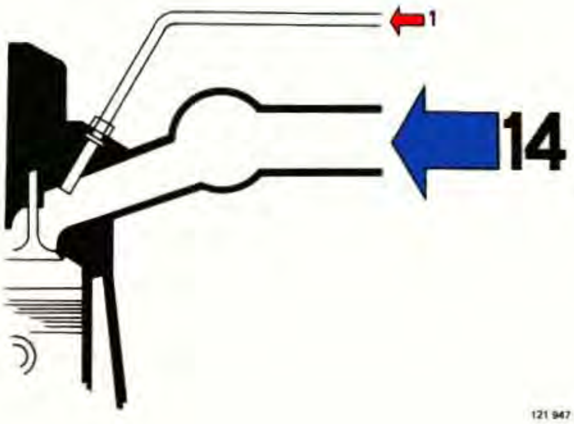
General

The B21F, B21FT, B23E, B27F and B28F engines are equipped with the CI-Fuel Injection System (CI stands for Continuous Injection). This system is basically mechanical and contains one injection valve (injector) per engine cylinder.

The "CI" is derived from the fact that the injectors continuously inject fuel into the engine while it is running.

Fuel supplied to the engine is controlled by varying the flow to the injectors.

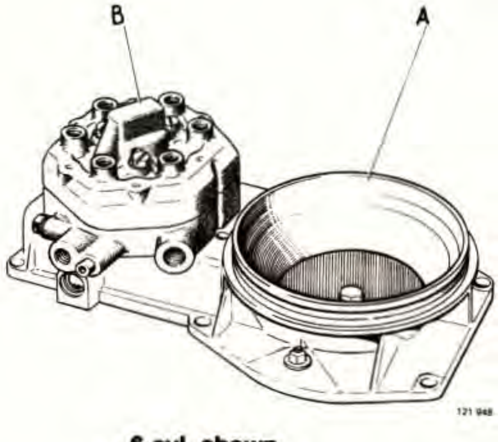
The purpose of the CI-System is similar to that for all other type fuel systems, that is, to store, transfer and supply fuel to each cylinder in the proper amount. This fuel is mixed with the incoming air in the ratios needed for various engine operating conditions.



A number of components, all working together, are used to enable the operation described above. (See illustration of CI-Fuel System Components on next page.)

To understand the operating principles of the CI-System the following must be known:

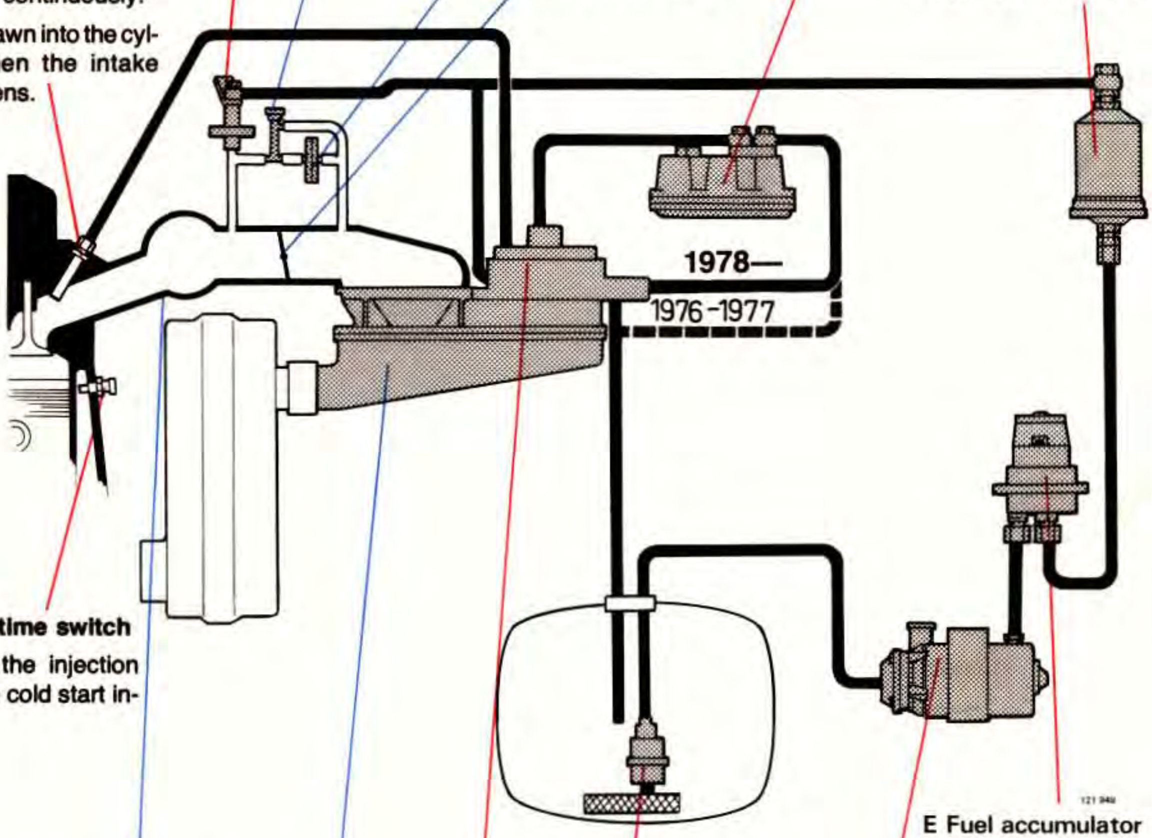
- Fuel combustion requires air. Proper burning of the fuel/air mixture is dependent on the mixture ratio.
- Nominal mixture ratio is 1 part fuel to 14 parts air by weight.
- Measuring the volume of air being supplied to the engine can be used to determine the amount of fuel needed.



6 cyl. shown

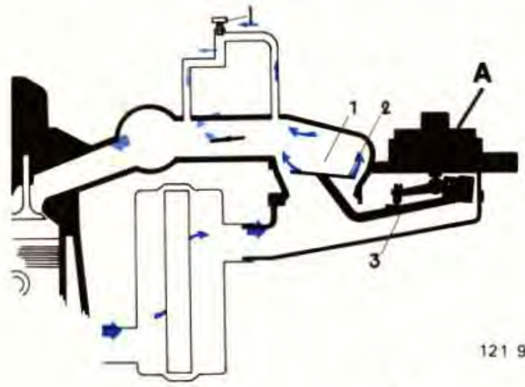
The basic principle of the CI-System is to continuously measure the air flow into the engine and use this information to control the amount of fuel provided to the engine. Incoming air and fuel flow are in fact regulated by the airflow control unit, which is the "brain" for the CI-System. This unit consists of the air flow sensor (A) and fuel distributor (B).

CI-Fuel System Components – B21F



Description of the CI-System

Refer also to "CI-System – Fuel Flow Diagram" at rear of this manual. Individual components are described in greater detail in the Section titled "CI-System Components".

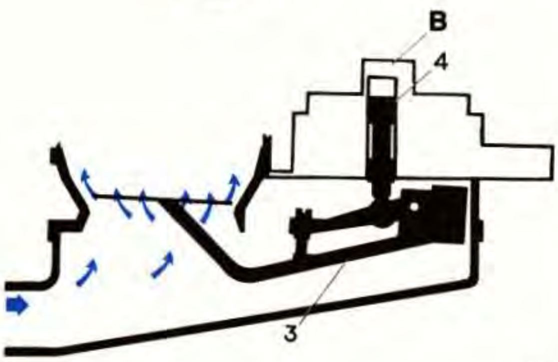


121 950

Air flow to the engine is controlled by throttle (butterfly valve) position, engine speed and load.

During idle, air flow is regulated by the *idle adjustment screw (I).*

Incoming air flows through the *air flow sensor (A)* consisting of air flow sensor plate (2) moving within the air venturi (1). The air flow sensor plate is attached to lever (3).

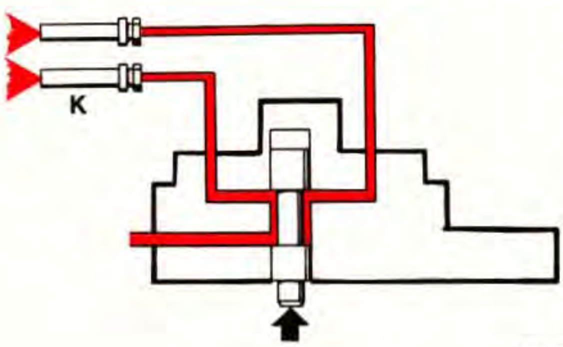


121 951

Air flowing through the venturi moves the air flow sensor plate in direct proportion to the air volume. (The greater the amount of air flowing through, the more the plate is moved.)

Amount of plate movement is transferred through lever (3) to control plunger (4) in the *fuel distributor (B).*

Therefore, when the air flow sensor plate moves, the control plunger also moves.

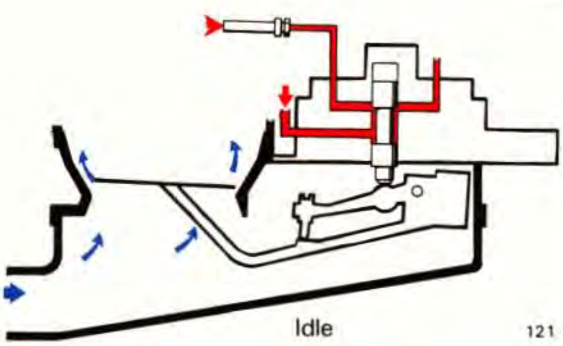


121 952

The control plunger moves within a cylinder (barrel) containing metering slots (one slot per engine cylinder).

Plunger and cylinder together are referred to as *control valve.*

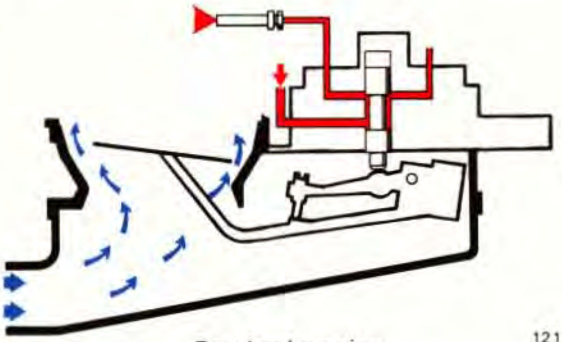
When the control plunger lifts in relation to air flow, it exposes the metering slots and fuel flows through them to the *injectors (K).*



Idle

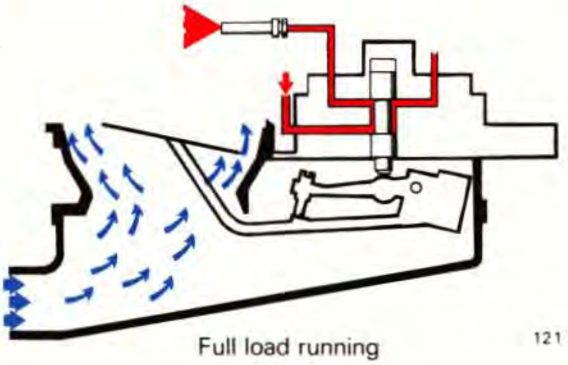
121 953

Restricted air flow to engine: Air flow sensor plate and control plunger move slightly. This exposes only a small portion of the metering slots, and thus a small amount of fuel passes through.



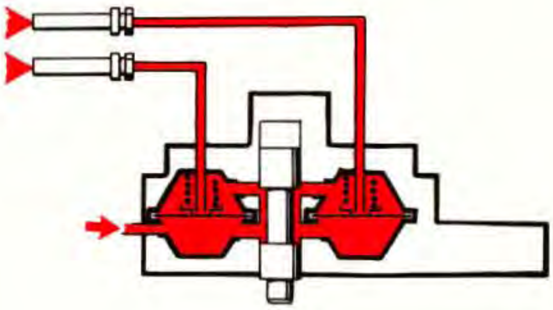
Part load running 121 954

Increased air flow to engine: Air flow sensor plate and control plunger move a greater distance. This exposes a larger portion of the metering slots, and thus more fuel passes through the openings.



Full load running 121 955

Fuel supplied to the engine depends entirely on the amount of slot opening. This provides the fuel regulation for the CI-System.



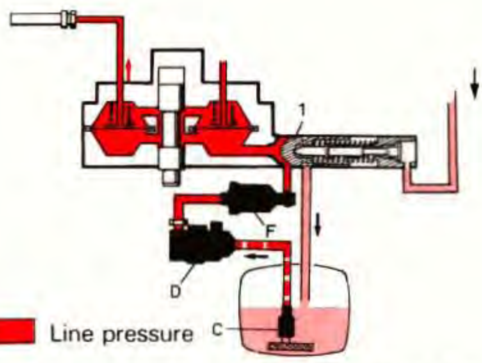
121 956

Adjacent to each metering slot is a diaphragm valve called the *pressure regulator.*

These pressure regulators maintain a constant pressure difference between the inlet and outlet sides of the metering slots.

With this pressure differential, fuel flowing through the slots is influenced only by the amount of slot opening.

Thus the fuel is distributed evenly between all injectors (engine cylinders).



Line pressure

(0.2 kp/cm² = 3.0 psi)

Return fuel

C Tank pump
D Fuel pump
F Fuel filter

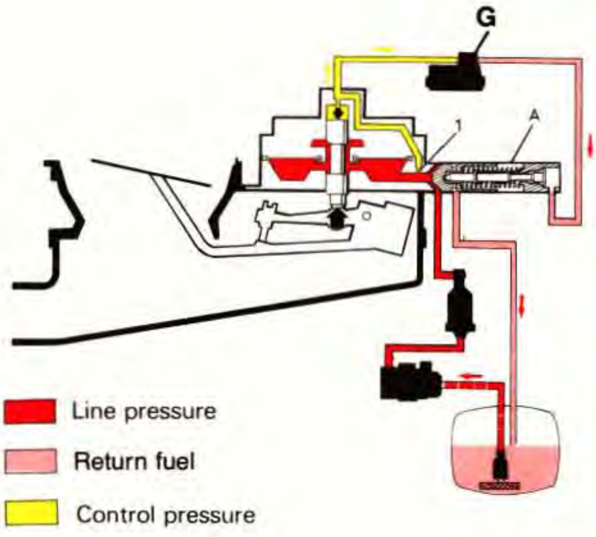
1 = Line pressure regulator/ check valve

121 957

The fuel distributor also contains a *line pressure regulator/check valve (1)* which maintains line feed pressure at approximately 4.9 kp/cm² = 70 psi.

Fuel pump (D) provides considerably more fuel than the engine may need. Pump capacity is approximately 100 liters (26 US gals.) per hour. Excess fuel is re-directed through the line pressure regulator (1) back to the tank.

Some 1976 car models and all models 77 and later are provided with a *tank pump (C)* situated in the fuel tank. This pump maintains fuel pressure in the fuel line from the tank to the main pump. Fuel pressure is approximately 20 kPa (0.2 kp/cm² = 3.0 psi). Vapor pockets in the line are thus eliminated.



A = Line pressure regulator/check valve
1978 models

125 900

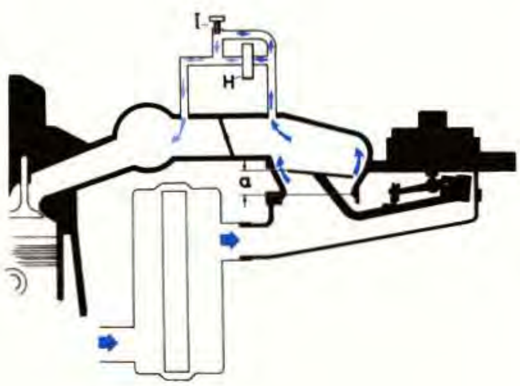
A portion of the fuel under pressure is re-directed through a narrow passage (1) to the top of the control plunger. This "control pressure" acts against the force moving the air flow sensor plate.

Control pressure is regulated by the *control pressure regulator (G)* and normally goes up to 3.7 kp/cm² = 53 psi. Surplus fuel is channeled (at atmospheric pressure) back to the fuel tank.

If the control pressure regulator becomes clogged, line pressure will be present in the control pressure circuit. This restricts upward movement of the control plunger and the fuel/air mixture will become lean.

Components described thus far have been the main ones in the CI-System. Other components in the system are used to adapt for various operating conditions.

Function of the CI-System



Cold engine

121 961

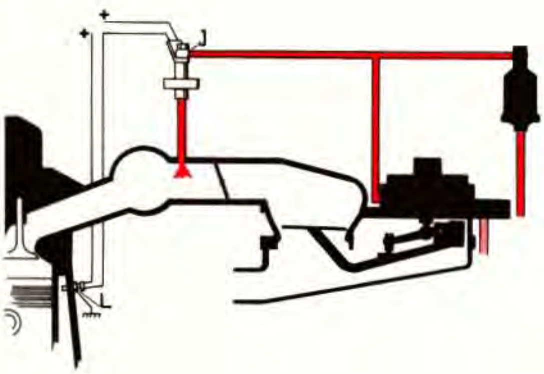
Cold engine starting

When the ignition switch is set to START position the tank pump and main fuel pump start operating immediately to make fuel available to the system at line pressure of 4.9 kp/cm² = 70 psi. Pressure pulses caused by the pumps are smoothed out by the fuel accumulator.

Fuel filtration is provided by the fuel tank filter and the line fuel filter.

After filtering, the fuel is channeled to the fuel distributor, control pressure regulator and the cold start injector.

While cranking, the engine cylinders develop a vacuum which causes air at atmospheric pressure to flow through the intake system. This air passes through the air flow sensor and continues through the intake manifold, passed the auxiliary air valve/throttle valve and to the intake port.

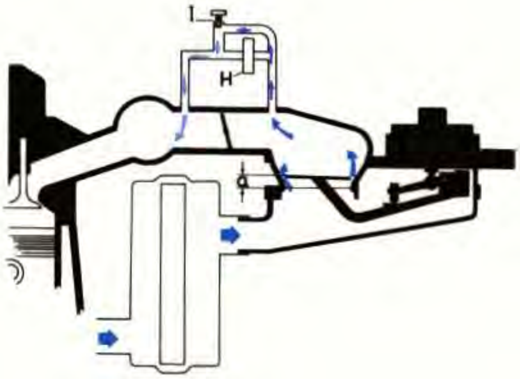


121 960

Simultaneously, the movement of the airflow sensor plate is transmitted via connecting arm to the control plunger. Movement of the plunger exposes a portion of the metering slots and allows a quantity of fuel to travel towards the cylinder injectors. All injectors are opened by fuel pressure and fuel is continuously sprayed into the intake port areas.

Turbulent air and fuel both present at the intake port areas mix to form the air/fuel mixture which is drawn into the cylinder during each intake stroke of the pistons (intake valves open).

The *cold start injector (J)* supplies additional fuel to enrichen the fuel/air mixture for easier starting. This injector is electrically operated and injection time is regulated by the *thermal time switch (L)*. At −20° C (−4° F) or colder, fuel is supplied for approximately 7.5 seconds. At higher temperatures the injection period gradually decreases and ends **completely at +35°C (95°F) for the B21F engine and at +15°C (60°F) for the B27F and B28F engines. The injector operates only when the starter motor is engaged.**



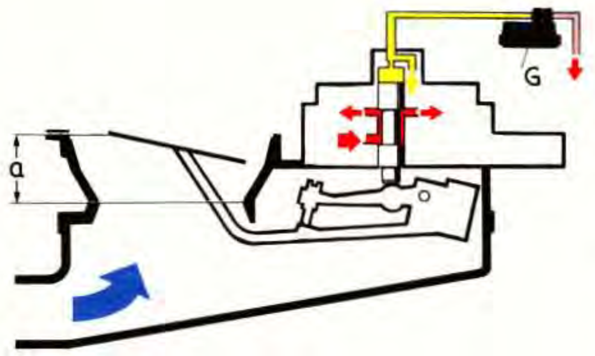
Warm engine

121 962

Engine warm-up

A cold engine has greater friction than one at operating temperature and thus requires increased idle rpm to prevent stalling. *The auxiliary air valve (H)* automatically provides increased air and fuel flow for fast idle with the throttle valve closed.

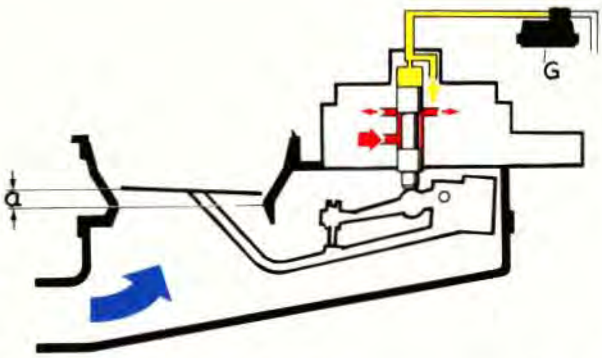
The air valve opening is controlled by a bimetallic spring which is heated by an electrical coil. The valve gradually closes as the spring warms up and is fully closed at +70° C (158° F).



Control pressure, cold engine 121 963

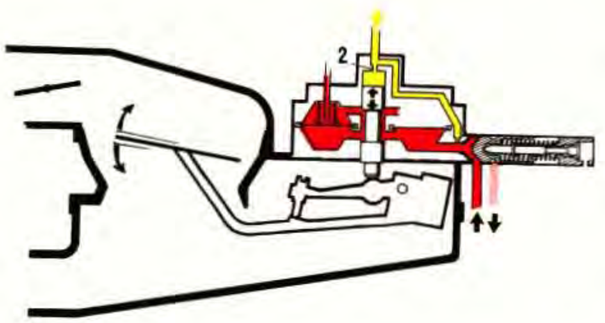
During cold engine operation some of the fuel may condense and adhere to the inlet port and cylinder walls. This causes a leaner mixture than desired.

To compensate for leaner than desired mixture, the *control pressure regulator (G)*, lowers the control pressure during engine warm-up. Thus the movement of the control plunger becomes less restricted and additional fuel is allowed to flow through the distribution slots and enrichens the mixture.



Control pressure, warm engine 121 964

As the engine warms up the control pressure regulator gradually increases the control pressure and causes the fuel/air mixture to become normal.

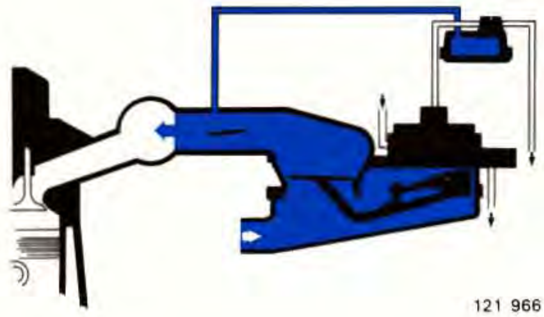


121 965

Maximum load/acceleration

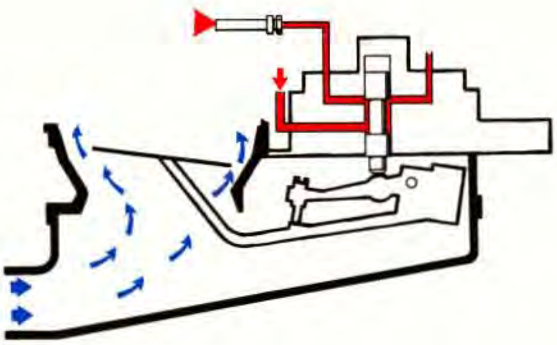
At maximum load (throttle fully open and low vehicle speed) air flow pulses into the inlet duct. This causes the air flow sensor plate to move beyond the "normal" position and thus moves the control plunger even higher. Additional fuel passes through the exposed slots and enriches the mixture to obtain maximum output.

The narrow passage (2) above the control plunger dampens air flow sensor plate movement caused by the air flow pulsations. Movement of the sensor plate during abrupt throttle changes is determined by the size of the constriction.


121 966

Because the intake strokes occur more frequently per revolution in a six cylinder engine, the pulsating air flow in the B27F is not strong enough to enable mixture enrichment.

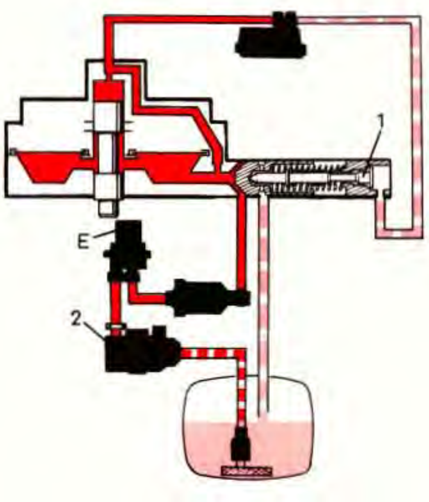
The B27F and B28F control pressure regulator is designed to sense the vacuum in the engine intake manifold. (Exception: models with Oxygen Sensor Feedback System, "California" and "High Altitude" specifications). At maximum load, the vacuum in the manifold decreases and causes the control pressure regulator to lower the control pressure. This causes the control plunger to move further upward, enrichening the mixture and thus enabling maximum engine output.


121 954

Cruising – part throttle

At cruising speed (throttle partly open and steady vehicle speed), air passing the air flow sensor plate causes it to move and hold at a given position. This results in the control plunger assuming a position relative to air flow and allows fuel to pass through the slots in amounts necessary to provide "normal" mixture.

Any small changes in throttle valve setting causes a corresponding change in the air flow sensor plate and control plunger position. Thus the volume of fuel/air mixture is changed without appreciably affecting the mixture ratio.



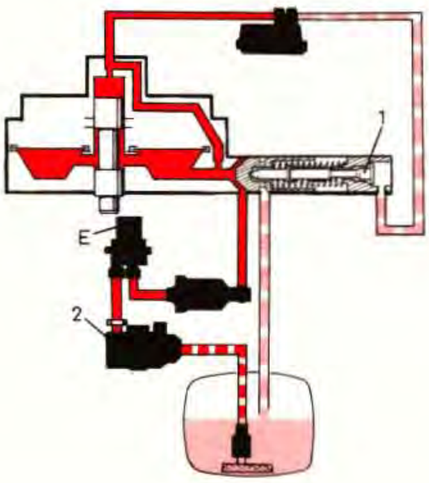
121 959

Engine shutdown

When the engine is shut down the fuel pumps stop operating and the line pressure drops rapidly to below injector opening pressure. The line pressure regulator then closes completely. Fuel is prevented from flowing back to the fuel tank by a check valve (1) in the line pressure regulator ('78 models) and non-return valve (2) on the main pump (and tank pump).

Fuel, at rest pressure, is stored in the system for an indefinite period. This pressure prevents vapor pockets from forming in the lines and facilitates restarting of a warm engine and operation under various extreme environmental conditions.

The *accumulator (E)* stores fuel under pressure and assures that fuel pressure will be maintained over a longer period.



121 959

Warm engine starting

Operation of the fuel system for warm starts is similar to that for cold starts except:

1. **Fuel, at rest pressure, exists in the lines to provide instant fuel availability to the engine.**
2. The cold start injector operates for a shorter period or does not operate if engine temperature exceeds +35 °C (95° F).
3. The auxiliary air valve is only partially open or is fully closed and inoperative if engine temperature exceeds +70° C (158° F).
4. The control pressure remains at "normal" thus restricting additional movement of the control plunger and maintaining normal fuel/air mixture.

Function of CI-System Components

Refer also to "CI-System Fuel Flow Diagram" at rear of this manual.

The CI-System is composed of two subsystems; air system and fuel system.

Operation of each component is explained below in detail in the order of air and fuel flow through the system.

Explanation of CI-System electrical circuit operation can be found in section titled "CI-System Electrical Circuits".

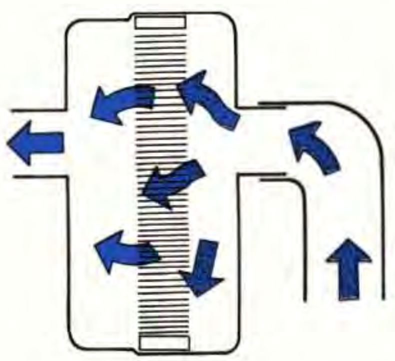


Illustration shows the air cleaner for the B21F

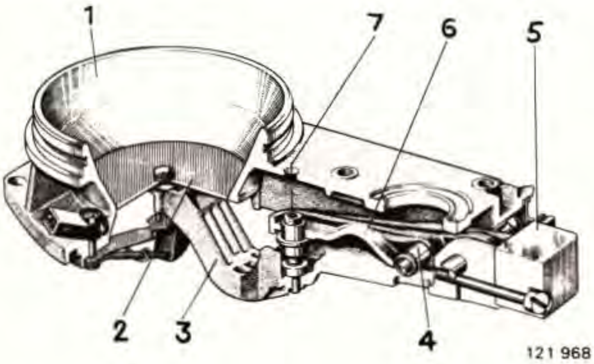
121 967

Air System

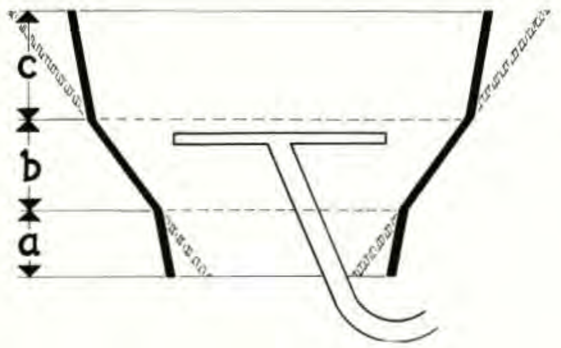
The air system contains those components necessary for cleaning, measuring, regulating and directing air into the engine cylinders. This includes air cleaner, *air flow sensor (A)*, throttle, intake manifold, *idle adjustment screw (I)* and an *auxiliary air valve (H)*.

Air cleaner

The air cleaner removes particles from the air which can damage the engine and contains a replaceable paper element filter.



121 968



a = idle b = part load c = full load

121 969

Air flow sensor

The air flow sensor continuously measures air flowing into the engine and transmits this information to the fuel distributor.

This unit consists of an air venturi (1) and an air flow sensor plate (2) which moves in the venturi. The plate is attached to lever (3) which transmits the movement of the plate via flange (4) to the control plunger in the fuel distributor.

Weight of the sensor plate and lever is counterbalanced by counterweight (5).

Adjustment screw (7), attached to lever (6), can be used to adjust the CO content. The adjustment screw regulates the basic setting of the control plunger (CO-adjustment).

Differences in engine loads require appropriate changes to the mixture ratio. Design of the air flow sensor venturi (see illustration) provides the means for automatic mixture ratio compensation.

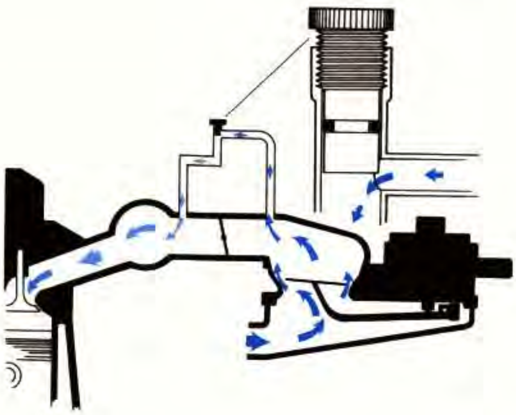
In the area where the venturi walls are steeper than the mid portion, the air flow sensor plate will lift higher per a given volume of air flow. This causes a richer mixture to occur during idling and at full load.

121 970

Throttle

Air flow to the engine is regulated by the throttle to control engine speed. Increased air flow results in higher speed. Throttle movement is controlled directly by the accelerator pedal position.

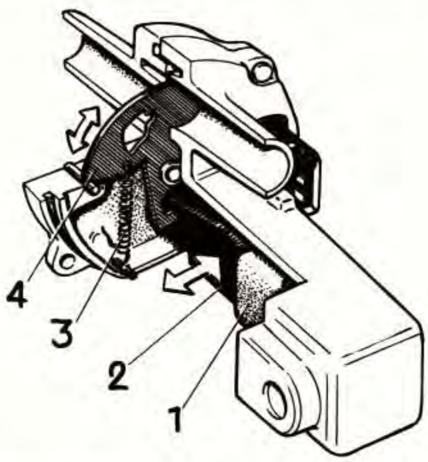
NOTE: There is no direct mechanical link between the throttle valve and the air flow sensor plate.



121 971

Idle adjustment screw (I)

This screw located in a bypass line above the throttle regulates air flow to the engine when the throttle is closed (idle). Restricting the air flow in the bypass line causes lower idling speed while increased air flow raises the idle rpm.

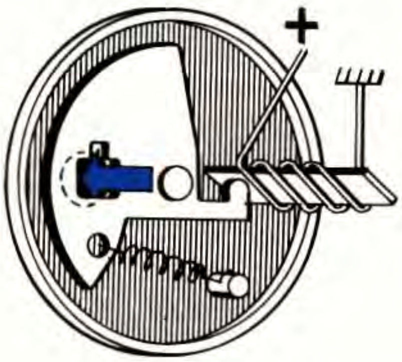


1 Electrical cable
2 Bimetal spring
3 Return spring
4 Valve

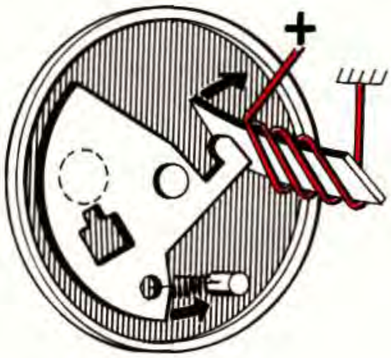
121 972

Auxiliary air valve

This valve is mounted on the engine and is used to provide fast idle during engine warm-up. It consists of an air duct, valve and bimetallic spring.



When the engine is cold, the bimetallic spring forces the valve open and allows air to pass through the duct (fully opened at −30°C (−22°F)).

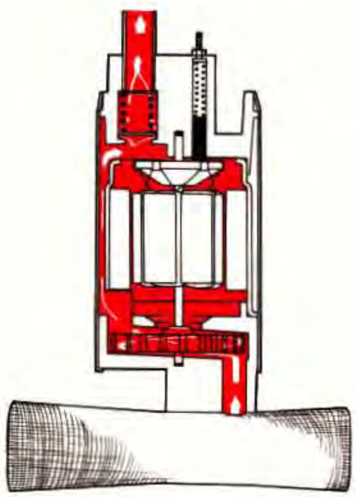


After the engine has started, current flows through the electric wire wrapped around the bimetallic spring. Heat from the wire causes the spring to bend away from the valve. The return spring acts on the valve and closes off the air duct.

The valve becomes fully closed at +70° C (158° F) which is equivalent to running the engine for 5 minutes at an ambient temperature of 20° C (68° F.).

Fuel system

The fuel system contains those components necessary for measuring, cleaning, regulating and distributing fuel to the engine cylinders. This includes; tank pump (C), fuel pump (D), pressure accumulator (E), fuel filter (F), fuel distributor (B), control pressure regulator/ check valve (G), injectors (K), cold start valve (J), as well as fuel line and fuel tank.



121 974

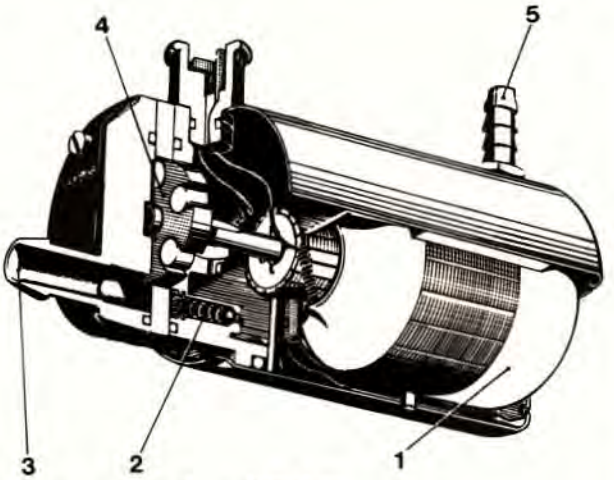
Tank pump

Installed on some 1976 models and all models from 1977 on.

The tank pump containing a winged impeller is electrically operated and is used to maintain pressure in the line from the fuel tank to the main pump. This prevents potential vapor lock from forming in the line.

This pump operates at all times that the ignition switch is set to the ON or START position. Fuel is drawn into the chambers between the impeller wings that rotate within the stepped chamber. It is then forced into the line to the main pump.

A non-return (check) valve at the pump outlet prevents fuel from returning to the tank when the pump is not operating.

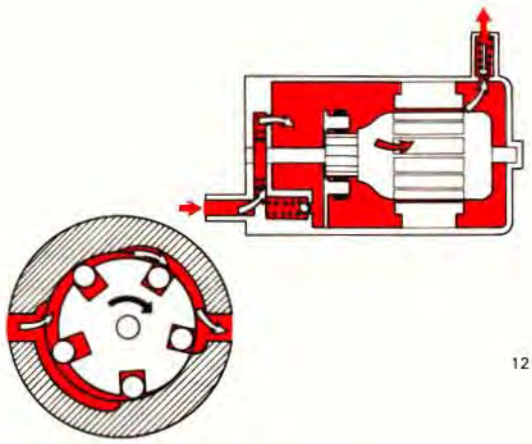


1 Armature
2 Relief valve
3 Inlet
4 Roller pump
5 Outlet

108 197

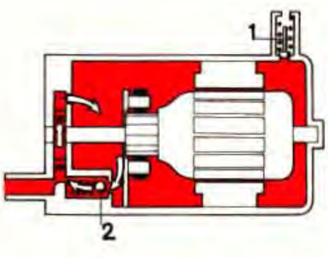
Fuel pump

This electrically driven roller-type pump feeds fuel under pressure to the CI-system. Pump operation begins when the starter motor engages or the engine is running.



121 975

As the pump motor spins, the rollers are forced outward by centrifugal force and ride against the eccentrically shaped pump chambers. Fuel is drawn into the cavities between the rollers and forced outward to the line under pressure.

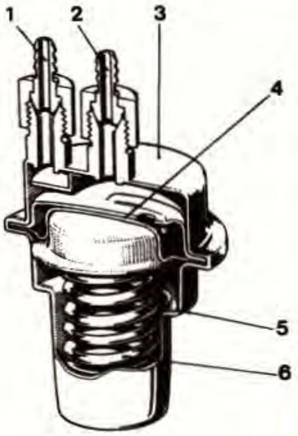


121 976

If pump output is greater than the system need (pressure rises above a pre-determined value), built-in relief valve (2) opens. This allows the fuel to be circulated around the pump without a further increase in pressure.

The non-return (check) valve (1) on the outlet side prevents fuel from flowing back when the pump stops operating.

1 Inlet
2 Outlet
3 Accumulator housing
4 Diaphragm
5 Stop
6 Spring

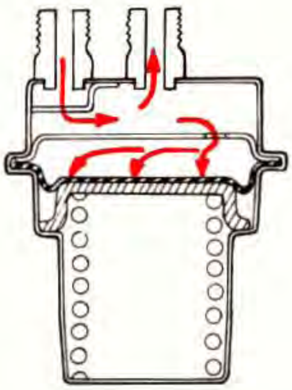


108 198

Fuel accumulator

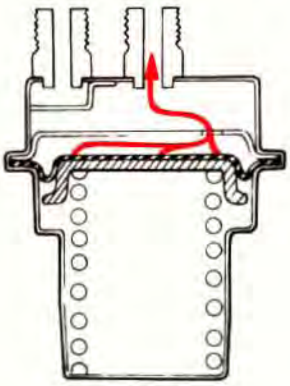
The accumulator dampens pump pulses and maintains rest pressure in the system for a prolonged period after the engine is shut down. (It also acts to quiet the pulsing sounds emitted from the pump.) Essentially the accumulator is a spring loaded diaphragm.

When a cold engine is started, a delay in pressure buildup is compensated for by the fuel stored under pressure in the accumulator chamber. During release of this fuel the diaphragm briefly returns to the unloaded position.



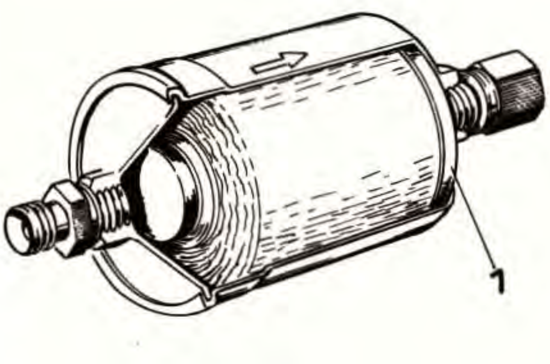
108 989

As the fuel pumps operate, pressure builds thus pumping fuel into the accumulator chamber and compressing the diaphragm and spring.



108 988

When the engine is shut down and the fuel pumps stop operating, fuel is maintained at "rest pressure". This pressure is held for an extended period due to accumulator spring pressure in combination with fuel stored in the chamber.



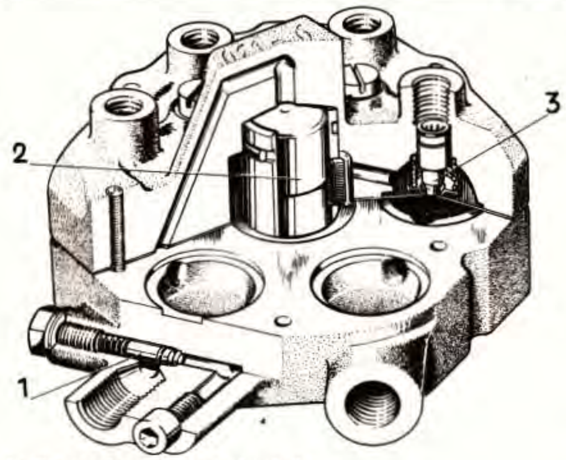
121 977

Fuel filter

The fuel filter traps most foreign particles before they reach components that could become clogged or damaged.

A paper element is used to filter the fine particles and a special mesh (I) traps any paper particles that may have broken loose from the filter itself. This is why the fuel filter is directional and must be properly installed in the line. An arrow is used to indicate direction of fuel flow.

1976–1977



This illustration shows a fuel distributor for the 6 cylinder 1976-1977. The only difference between this and the fuel distributor for the 4-cylinder B21F is the number of outputs for the injectors.

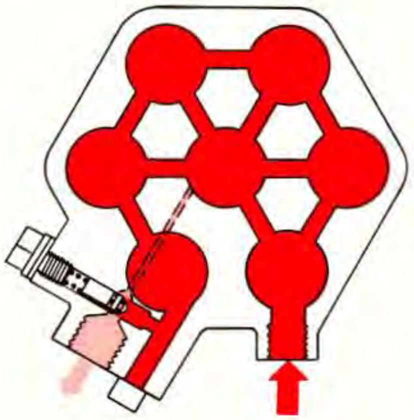
121 978

Fuel distributor

The distributor regulates and distributes fuel to the injector in direct proportion to the air entering the engine.

Major components in the distributor are:

1. *Line pressure regulator* – regulates line and rest pressure.
2. *Fuel control unit* – regulates and distributes fuel to the injectors.
3. *Pressure regulator valves (one for each injector)* – maintain a constant pressure differential (1 kp/cm² = 14 psi) between the fuel control unit input and output sections.



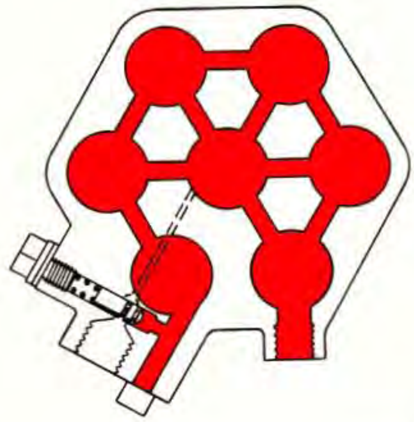
121 979

Line pressure regulator, 1976–1977

Functionally the regulator is a spring-loaded plunger.

Pressure is held constant (approximately 4.9 kp/cm² = 70 psi) by controlling the amount of fuel passing throught the returnline.

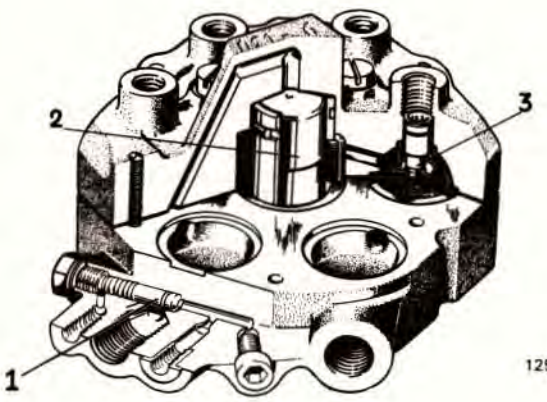
The dotted lines represent a passageway which allows fuel to pass that has leaked from between the control plunger and its cylinder in the fuel control unit.



121 980

When the engine is shut down (the pumps stop operating), line pressure drops to below opening pressure for the injectors. The line pressure regulator valve closes fully and maintains rest pressure of 1.7 kp/cm² = 24 psi minimum in the system.

1978—



125 901

Line pressure regulator / check valve

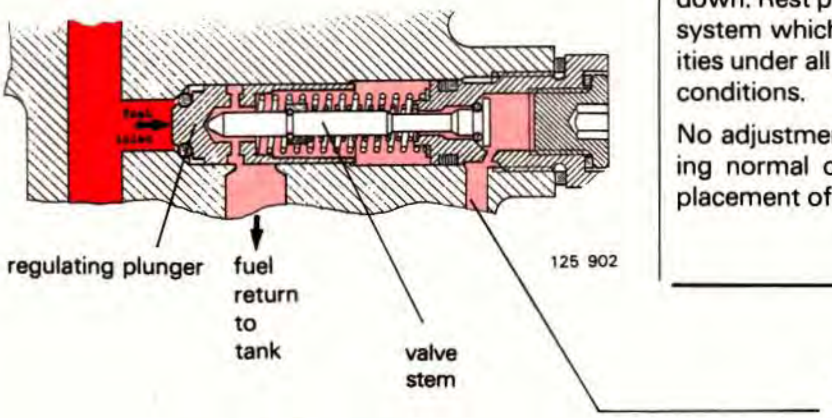
The CI system fuel distributor includes a two function regulator / check valve assembly(1).

Operation of fuel control unit (2) and pressure regulator valves (3) are not affected.

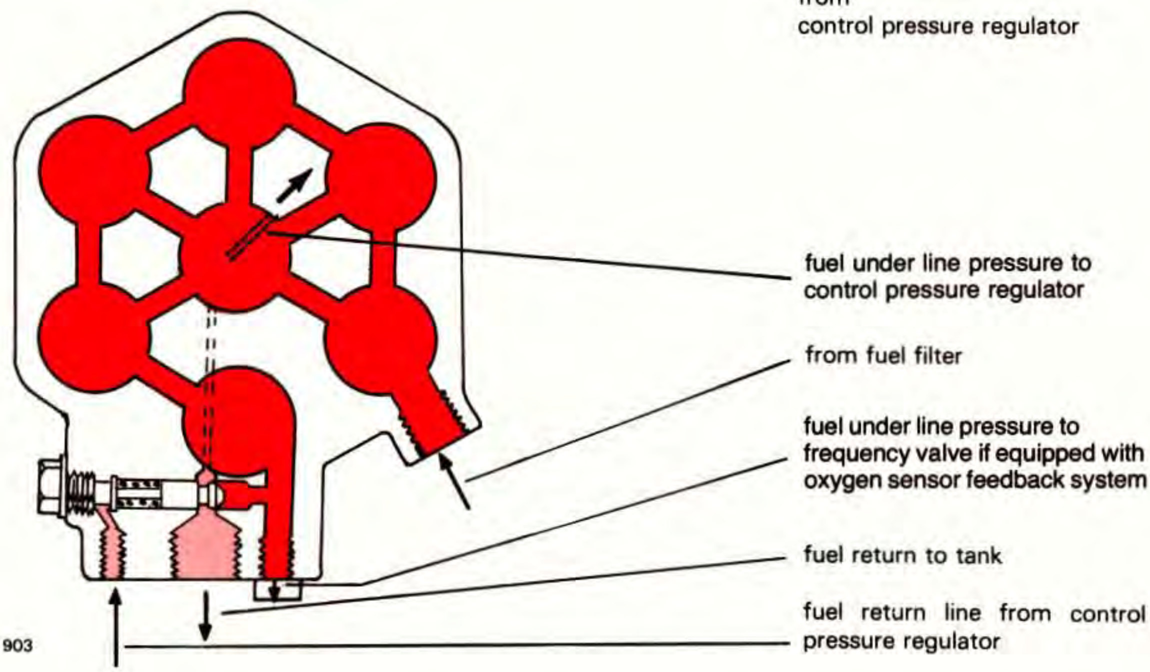
Illustration shows a fuel distributor for the 6 cylinder. 1978—

The assembly regulates line pressure and also prevents fuel from returning to the tank from the charged lines after the engine has been shut down. Rest pressure is thus maintained in the fuel system which provides positive starting capabilities under all environmental / engine temperature conditions.

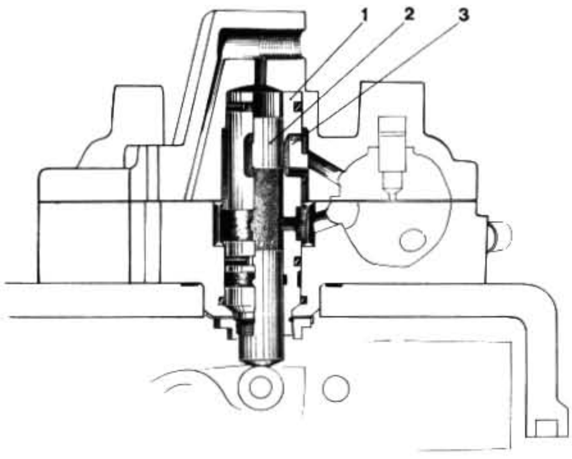
No adjustments or maintenance is required during normal operation. Malfunction requires replacement of the entire fuel distributor as before.



125 902



125 903



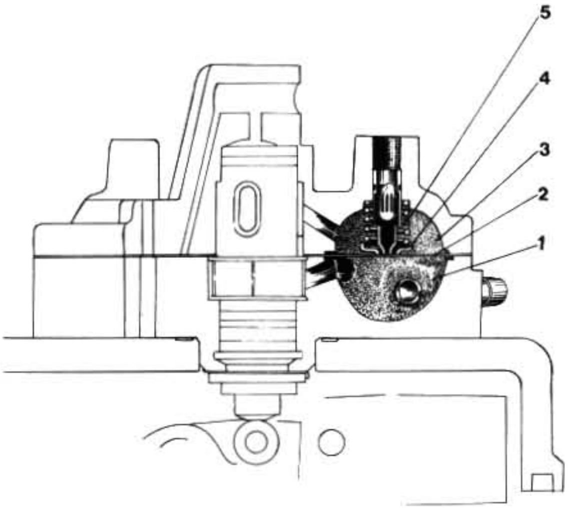
Fuel control unit

This unit consists of a cylinder (1) with one metering slot (3) per injector. Control plunger (2) moves within the cylinder and is controlled by air flow sensor movement.

As the control plunger lifts, more of the metering slot(s) area is left exposed thereby allowing additional fuel to flow to the injectors.

Fuel under control pressure acts on the top of the control plunger to partially counteract the upward movement of the plunger.

Control pressure is regulated by the *control pressure regulator (G).*

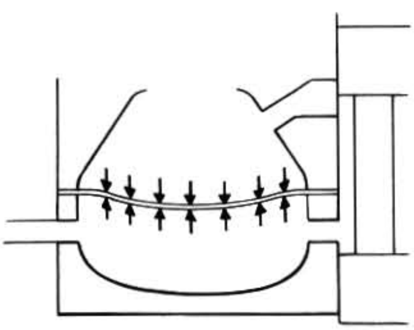


Pressure regulator valves

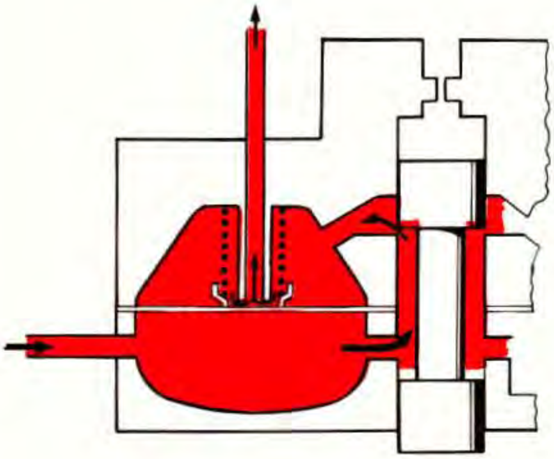
These valves maintain a constant pressure difference between the inlet and outlet sides of the slots regardless of the amount of fuel passing through the slots. This assures that the slot openings alone determine fuel flow to the engine injectors. Thus, fuel flow control is not influenced by pressure variations or by deviations in required opening pressure between each injector.

Each pressure regulator valve consists of two chambers separated by a diaphragm. The lower chambers (1) are linked to each other by means of channels and the inlet on the slots (see line pressure regulator illustration on previous page).

The upper chambers (3) are connected to the outlets on the slots and house a valve whose inlet area varies with the position of the diaphragm (2). Spring (5) is used to exert force on the diaphragm.



The forces above and below the flexible diaphragm act on it causing a shift in position according to the differential pressure. This shift occurs until a state of balance is achieved.



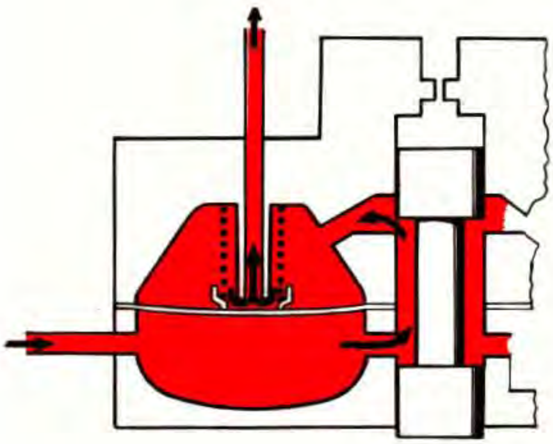
108 208

The pressure in the lower chamber is always equal to line pressure, that is approximately 4.9 kp/cm² = 70 psi.

Pressure in the upper chamber is the sum of the fuel pressure plus spring pressure and when in balance with the lower chamber equals 4.9 kp/cm² = 70 psi.

Because spring pressure is equal to 0.1 kp/cm² = 1.4 psi, the fuel pressure must be 4.8 kp/cm² = 68.6 psi.

Thus the fuel pressure difference between upper and lower chambers (inlet and outlet on the slot) is 0.1 kp/cm² = 1.4 psi.

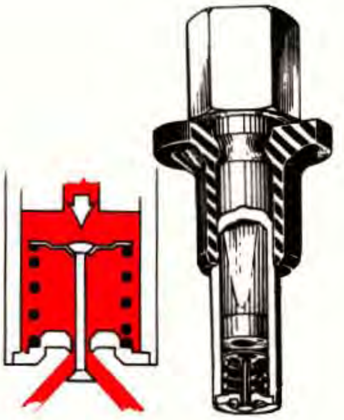


108 916

When the control plunger rises, the fuel flow through the slots increases. Pressure in the upper chamber thus increases forcing the diaphragm downward. This increases the fuel control unit opening to the injectors to maintain the pressure difference of 0.1 kp/cm² = 1.4 psi.

The diaphragm regulates the opening in the fuel control unit to assure that the amount of fuel flowing from the upper chamber is equal to that flowing into the chamber.

Diaphragm movement is only a fraction of an inch.



121 981

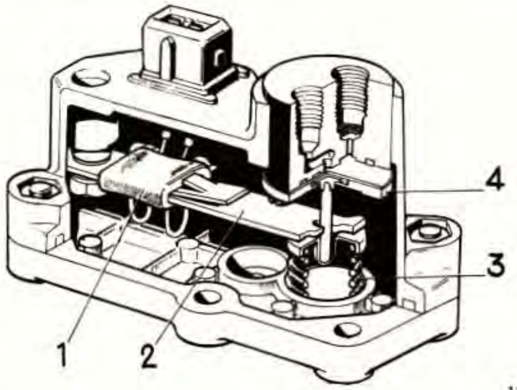
Injectors

Fuel is injected continuously into the intake manifold while the engine is running. When the intake valves open the fuel is drawn into the cylinders.

Injectors contain a spring-loaded disc type valve that opens at fuel pressures of approximately 2.1-2.3 kp/cm² = 37-51 psi. Check specifications for engine application.

Fuel is atomized as it exits the injectors.

The amount of fuel injected is controlled by the *fuel distributor (B)* as the injectors perform no regulating function.

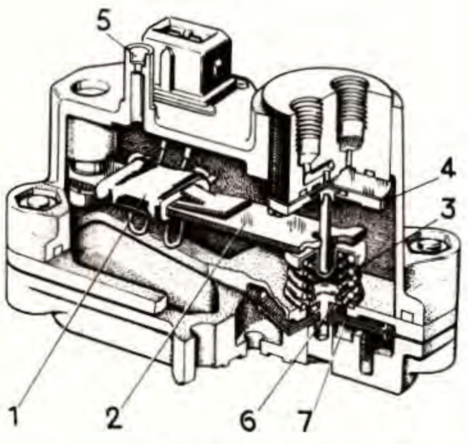


121 982

Control pressure regulator B21F, B23E, B27F, 1976-1980

1	Electrical coil	5	Connection for hose to inlet duct
2	Bimetal spring		
3	Spring	6	Spring
4	Diaphragm valve	7	Diaphragm

Control pressure regulator diaphragm valve movement is regulated by a bi-metal spring.



Control pressure regulator B27F only

121 983

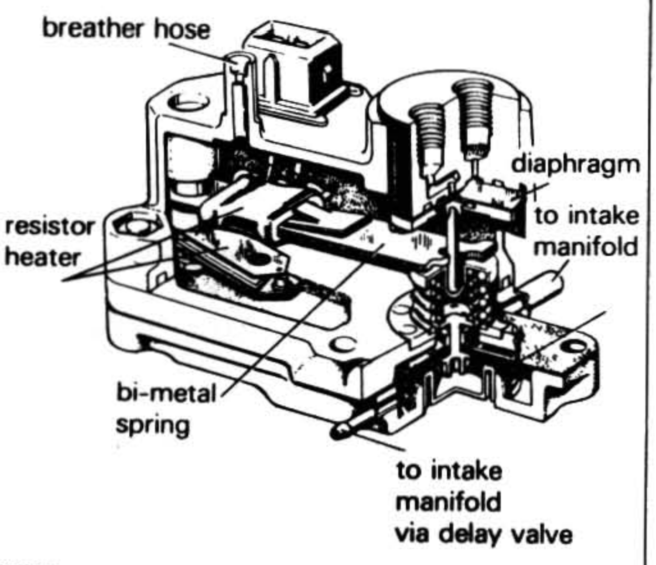
Control pressure regulator

This unit is mounted on the engine and is used to adjust the fuel-air mixture for cold and warm engine operation.

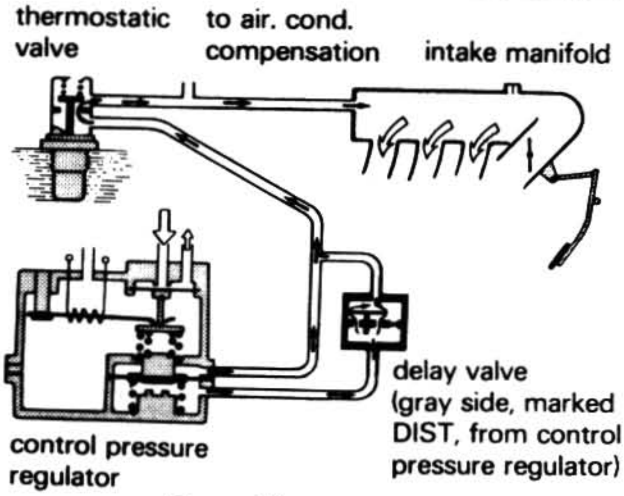
During cold starts and while the engine is warming up, the regulator lowers the control pressure and causes the fuel-air mixture to become richer.

NOTE: For certain B27F engines, the control pressure also drops under maximum engine load (controlled by engine vacuum).

Exception:
Models with Oxygen Sensor Feedback System, "California" and "High Altitude" specifications.

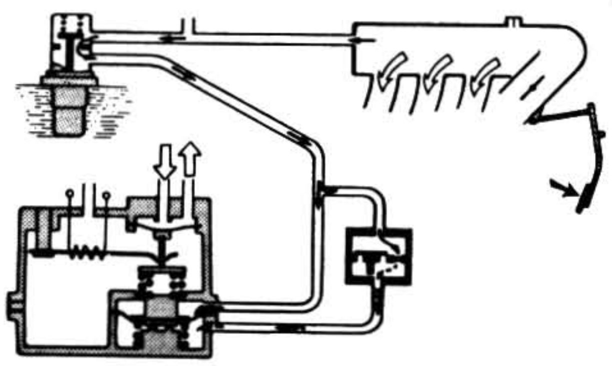


129075



Operation, cruising at steady speed

129073



Operation, acceleration

129074

Control Pressure Regulator

B21F, B21F-MPG, B21FT, B28F

Richer air/fuel mixture during acceleration.

The engine requires a richer air/fuel mixture during acceleration with a cold engine.

Control pressure regulator utilizes a diaphragm valve to accomplish this action. Both sides are connected to the intake manifold, the underside via a delay valve. The pressure difference will cause the valve to momentarily reduce the control pressure and make the air/fuel mixture richer.

Lambda-sond System works against this enrichment but is positioned downstream and has to register the enrichment as an accomplished fact.

System is switched off by a thermostat valve when engine temperature reaches approx. 53° = 12°.

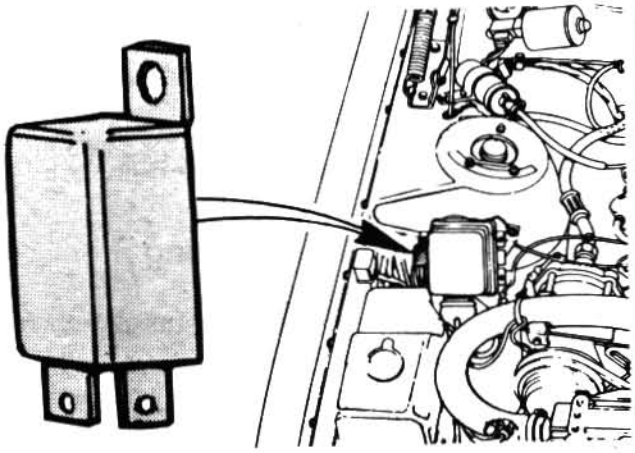
Operation, cold engine.

At cruising speed and no throttle movements, a steady vacuum exists in the intake manifold. This vacuum is applied on both sides of the diaphragm valve which is in a rest position.

Increased throttle opening = acceleration, decreases the vacuum in the intake manifold and the top side of the diaphragm.

Because of the delay valve it will take approx. 1 second before the vacuum on the bottom side of the diaphragm valve has equalized.

This will create a higher pressure on the top side of the diaphragm valve. The diaphragm valve moves downward, causing the control pressure regulator to open, lowering the control pressure. The air-fuel mixture is thus made richer.



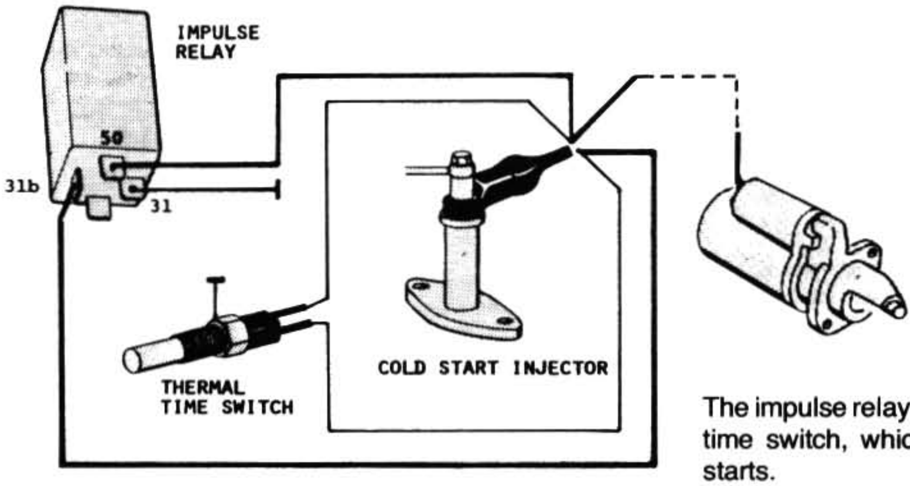
130557

B28F, B21FT

Enrichment at warm starts.

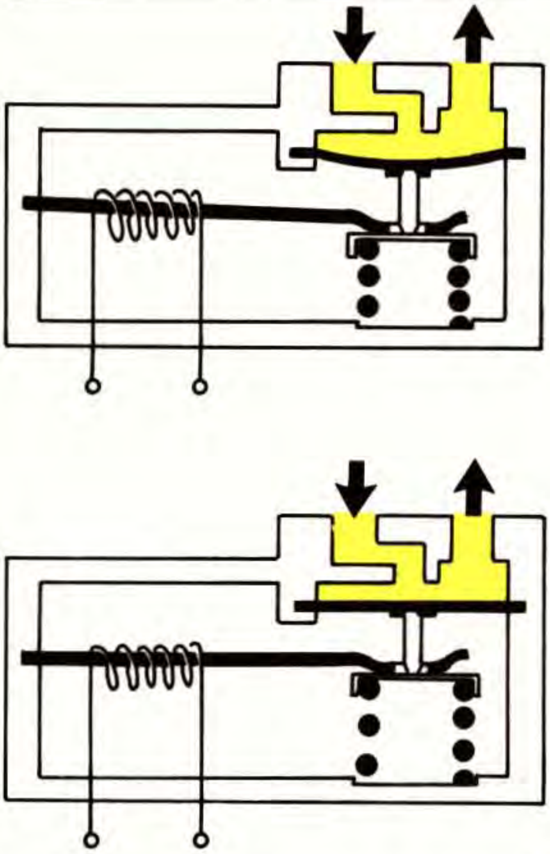
This system utilizes an impulse relay and the cold start injector to provide enrichment when starting an engine after it has been shut down for a while. This is especially effective after the vehicle has been parked for a couple of hours.

At warm starts, the impulse relay is engaged after approx. 1.5 seconds. It then starts to give 0.1 second of injection with 0.3 second interval.



130558

The impulse relay is wired in parallel to the thermal time switch, which provides enrichment at cold starts.



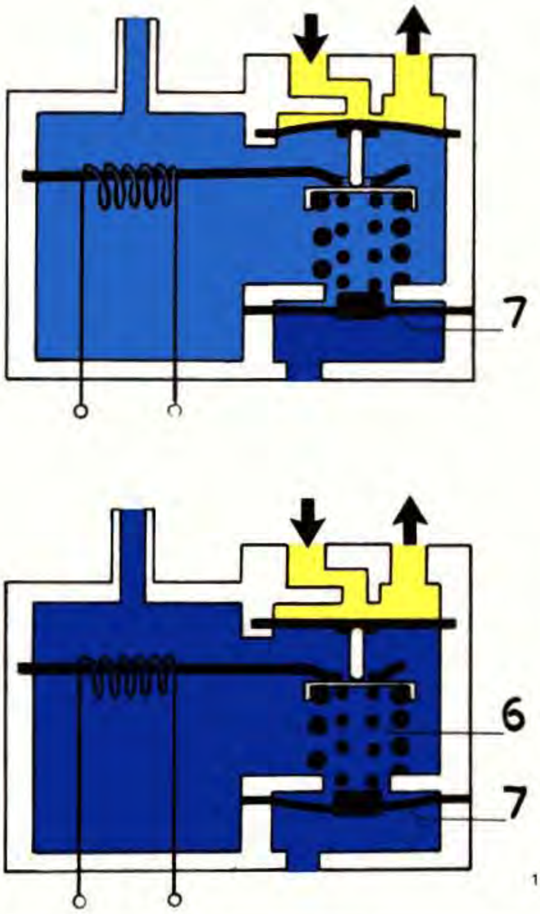
121 984

B21F and B27F engines:
When the engine is cold, the bi-metal spring bends downward and acts against the coil spring. The colder the engine the more the spring is compressed resulting in additional valve opening. This allows additional fuel to flow back to the tank and lowers the control pressure.

Lower control pressure allows increased movement of the air flow sensor plate and the control plunger resulting in a richer fuel-air mixture.

When the starter motor is energized and during engine operation, current flows through the heating coil wrapped around the bi-metal spring. The resulting heat buildup in the spring causes it to warp away from the coil spring and thus exert less pressure on it. Coil spring pressure is now allowed to act on the diaphragm, pushing the valve upward and causing the control pressure to increase.

From 1977, vehicles sold in high altitude areas are equipped with a control pressure regulator incorporating an altitude compensating device.



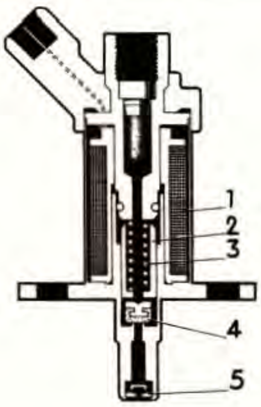
121 985

B27F engines only:
The control pressure regulator is connected to the engine intake manifold via a vacuum hose. At normal engine speed, intake manifold vacuum is greater, thereby assisting diaphragm upward movement. Diaphragm valve (7) is forced upward by atmospheric pressure and acts against the spring.

1977 B27F vehicles manufactured to "California" specifications should have the control pressure regulator connected to open air.

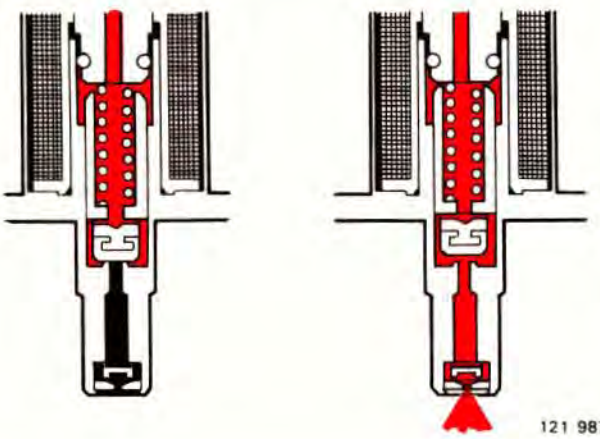
At maximum engine load (throttle fully open at low rpm), the intake manifold vacuum drops. This causes diaphragm valve (7) to move downward away from the spring allowing the fuel valve to open further. The resultant control pressure drop enriches the fuel-air mixture which is needed for maximum engine output.

As engine output decreases (reduced throttle) intake manifold vacuum increases and again allows the diaphragm valve to press against the spring (6). The diaphragm valve opening becomes smaller and the control pressure increases.



1 Solenoid
2 Return spring
3 Actuator
4 Seal
5 Nozzle insert

121 986



121 987

Cold start injector

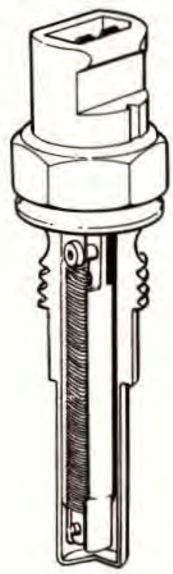
The cold start injector is electrically operated and is used to supply additional fuel to the engine for cold starts. Injection time is controlled by a *thermal timer (L)*. When starting at −20° C (−4° F) or colder, fuel is injected for approximately 7.5 seconds. At higher temperatures the injection period decreases and ends completely at +35° C (95° F).

The injector operates only when the starter is energized and will function at each attempt to start the engine.

When current passes through the coil, magnetic action causes the actuator to be pulled upward and fuel is injected through the injector opening and into the intake manifold.

When the coil is no longer energized, the return spring forces the actuator against the seat and fuel is prevented from exiting the injector.

NOTE: Check specifications for model year and engine application.



121 988

Thermal time switch

The timer regulates cold start injector operation by varying circuit make/brake time according to engine temperature and length of starting cycle.

Electrical contact action is controlled by a bi-metal spring surrounded with a heating coil. Because the unit is located in the engine block it is also affected by engine coolant temperature.

When the engine is cold, below +35° (95° F), the contacts are closed and current can then flow to the cold start injector when starting the engine.

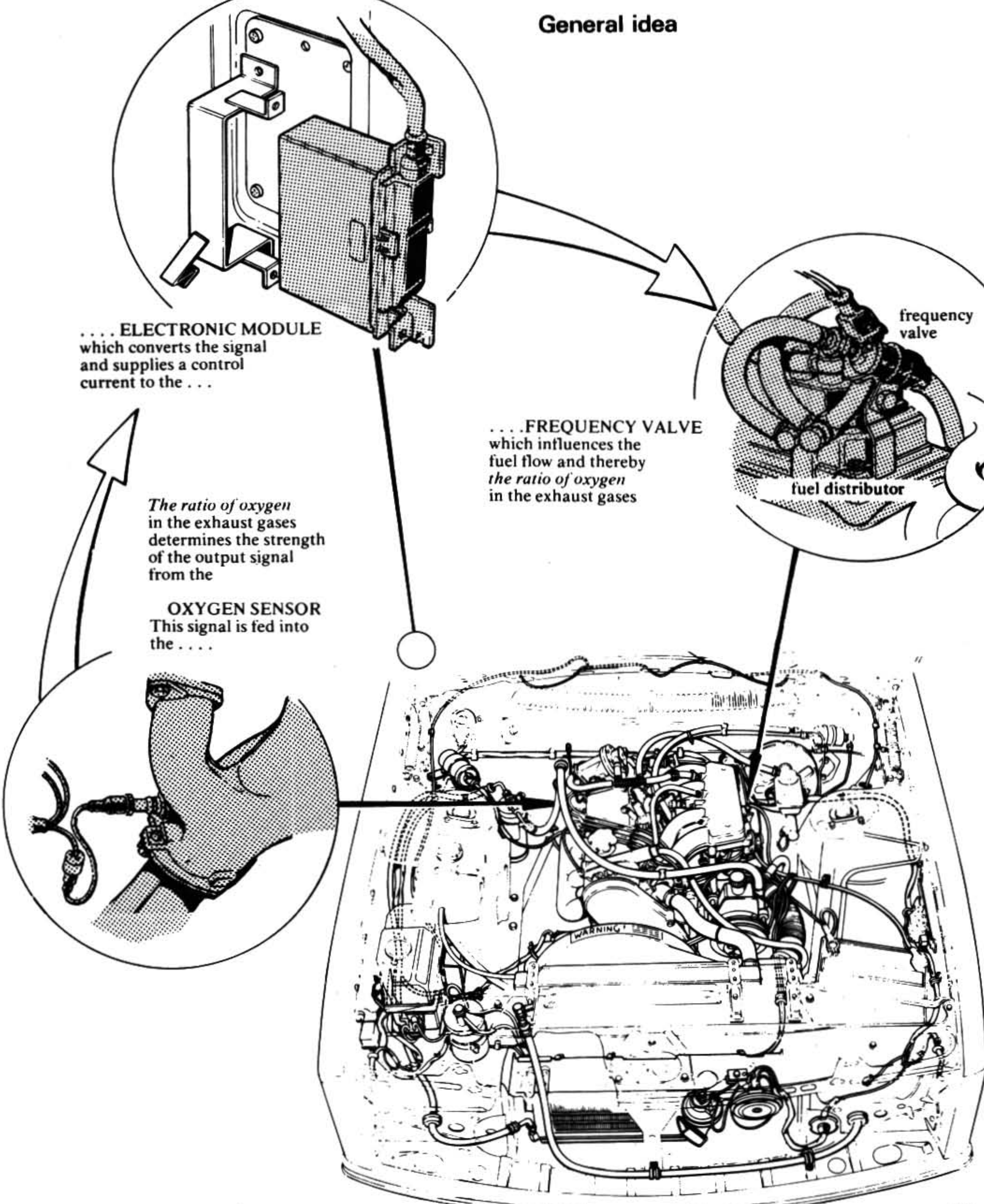
Current flow through the heating coil causes the bi-metal spring to heat and bend, thus opening the points and deactivating the injector.

Cycle time for this operation is directly related to engine temperature. The warmer the coolant the shorter the injection time.

NOTE: Check specification for model year and engine application.

Oxygen Sensor Feedback System

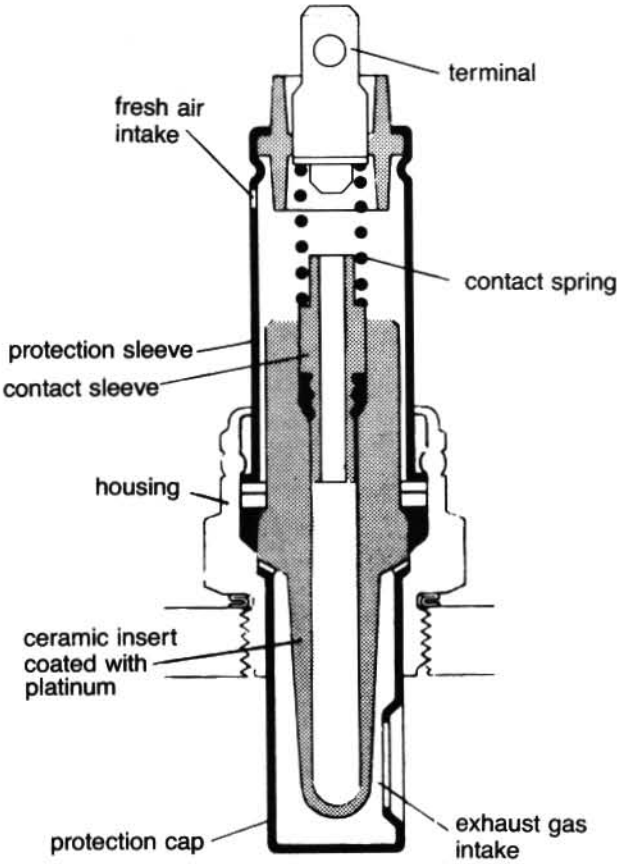
General idea



120 953

Oxygen Sensor Feedback System

This is a self-tuning engine control system designed to reduce emissions and improve fuel economy. An **exhaust gas sensor,** (oxygen sensor, also called lambda sensor) monitors the composition of the exhaust gases leaving the engine. The exhaust gas analysis is fed into a closed loop feedback system. This continuously adjusts the air-fuel ratio to provide optimum conditions for combustion and efficient destruction of all three of the major pollutants (hydrocarbons, carbon monoxide and nitrous gases) by a 3-way catalytic converter.



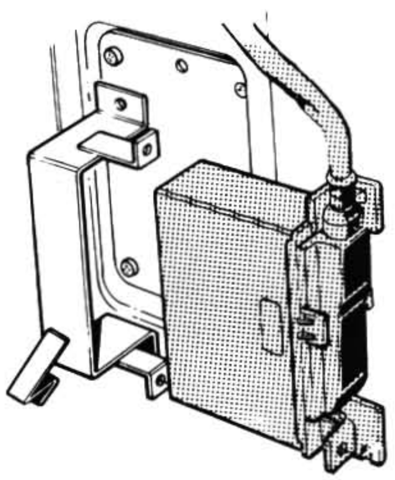
Oxygen sensor

The exhaust gas sensor, called **oxygen sensor,** is located in the exhaust manifold. It consists of a platinum coated ceramic tube. The inside is connected to free atmosphere, while the outside extends into the exhaust gases.

At higher temperatures (the oxygen sensor does not function when cold) an electrical potential is built up.

This is a function of the air-fuel ratio. There is a steep transition just at the point where the air-fuel ratio is ideal.

The electrical potential is high (approx. 1 volt) with low content of oxygen in the exhaust gases (= rich mixture) and low (approaching 0 volt) when the mixture is lean (= oxygen surplus).



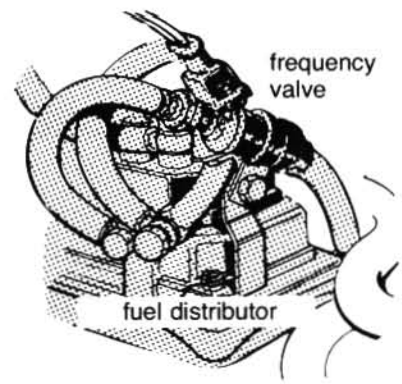
Electronic module

The output from the oxygen sensor is fed into an electronic unit, called the **electronic module.**

This device supplies a control current to the **frequency valve.** The control current has a set frequency and operates by varying the **duty cycle.**

When the oxygen sensor is cold, or defective, a fixed control is switched in after approximately 5-10 seconds. This fixed control resembles a duty cycle of 54° (see "Instrument" next page).

The electronic module is located inside the vehicle, at the right side in front of the right door. In this position it is protected and is close to the oxygen sensor and the electrical system.

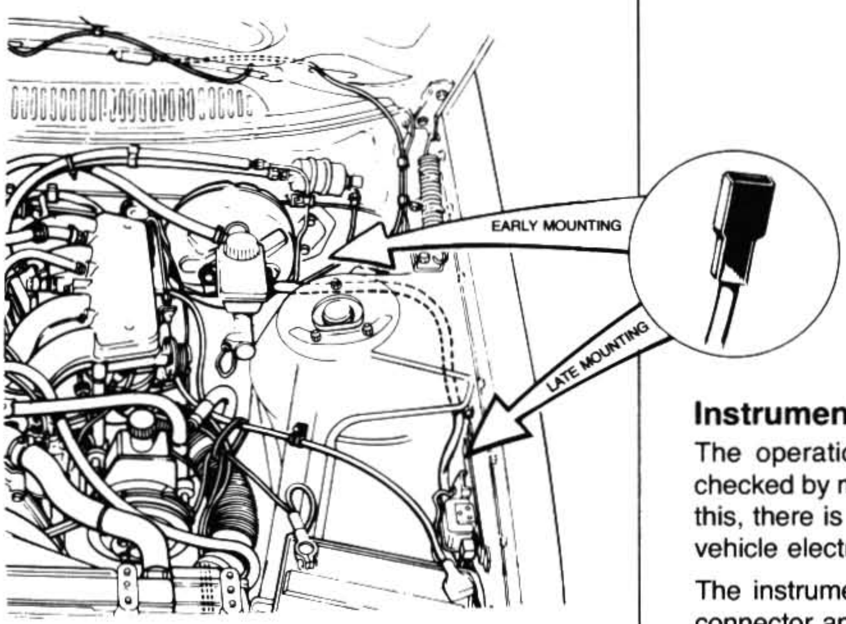


Frequency valve

This device influences the fuel flow by influencing the pressure on the underside of the diaphragm in the pressure regulating valves in the CI System.

It is located on a bracket behind the fuel distributor on the left side of the engine.

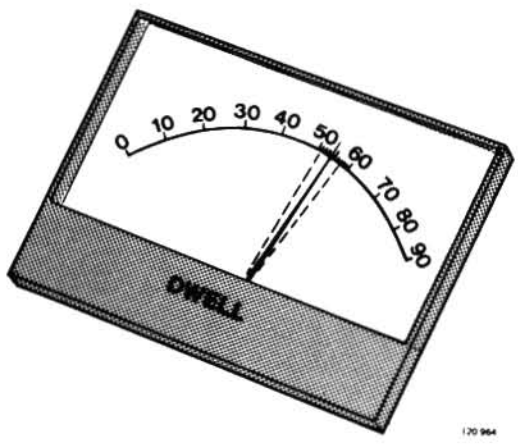
The frequency valve operates on a set frequency and by varying the duty cycle (ratio of closed/open circuit).



Instrument pick-up point

The operation of the frequency valve can be checked by measuring the duty cycle. To achieve this, there is a pick-up connector provided in the vehicle electrical system.

The instrument should be connected to pick-up connector and ground.



Instrument

The instrument used should be a Volvo Monotester or a high quality dwell meter (with very high internal resistance) and a reading extending to 70° or more.

The setting should be for **4 cylinders.**

NOTE:
This instrument actually measures the **duty cycle** of the frequency valve. It just happens that a dwell meter is best suited for this purpose.

Oxygen Sensor Feedback System for B27F, B28F

B27F, B28F system:

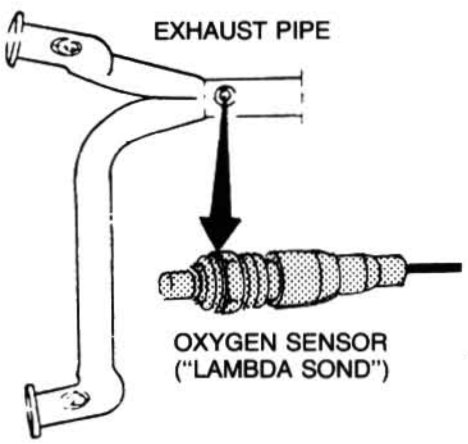
The system is in most respects similar to the system already used on the B21F engine.

The information available in this manual can be applied to the B27F, B28F with appropriate adaptations as follows.

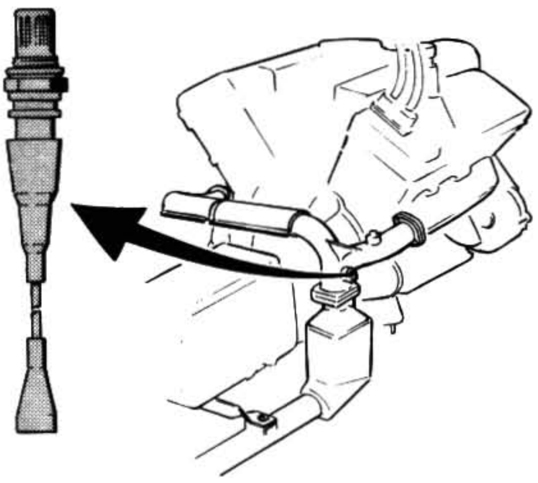
The fixed control which switches in, if the oxygen sensor becomes inoperative and has a duty cycle of 40-50°.

The oxygen sensor for the B27F is equipped with a protective cap. On B28F the protective cap was deleted.

The frequency valve is located on the left bank valve cover.

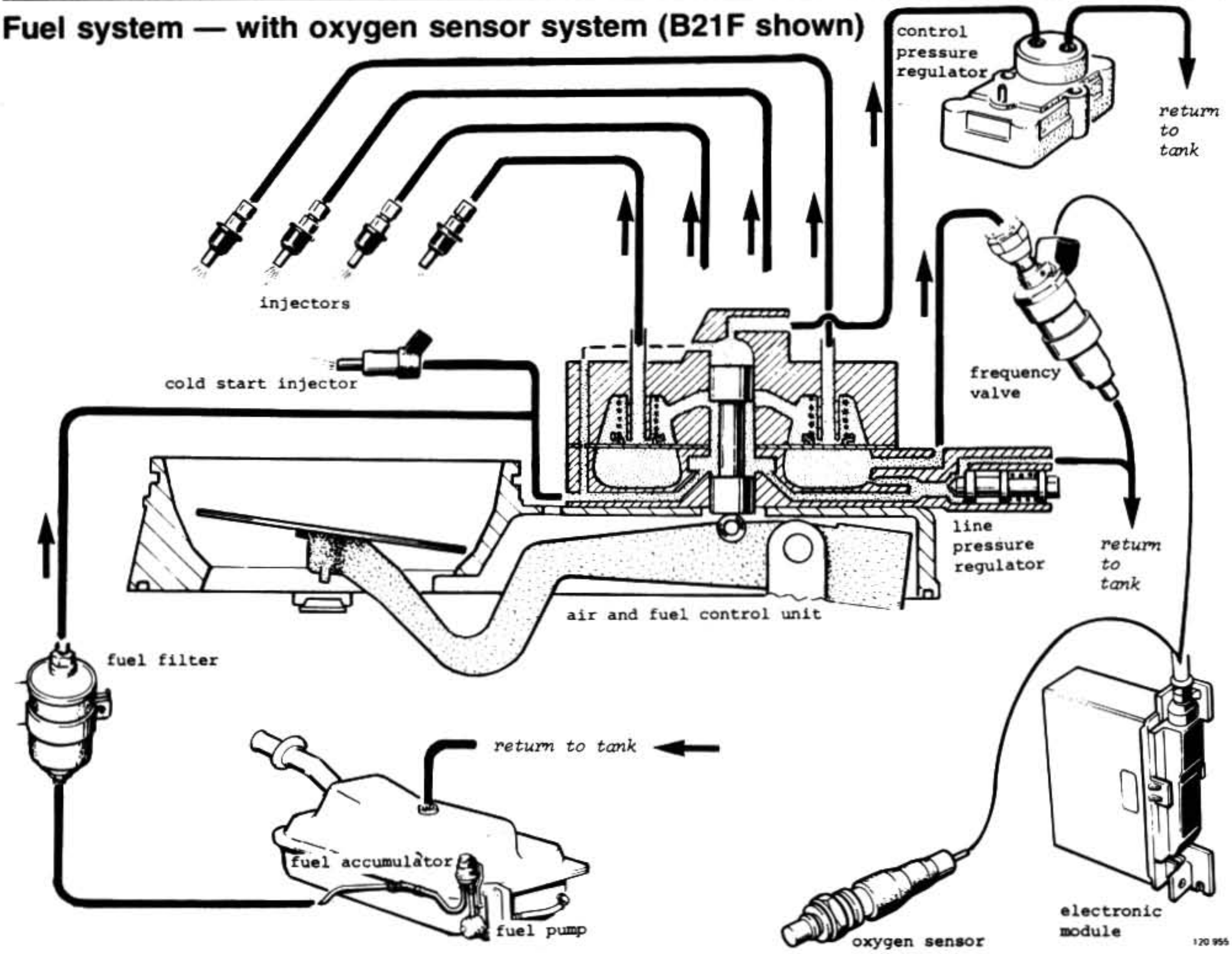


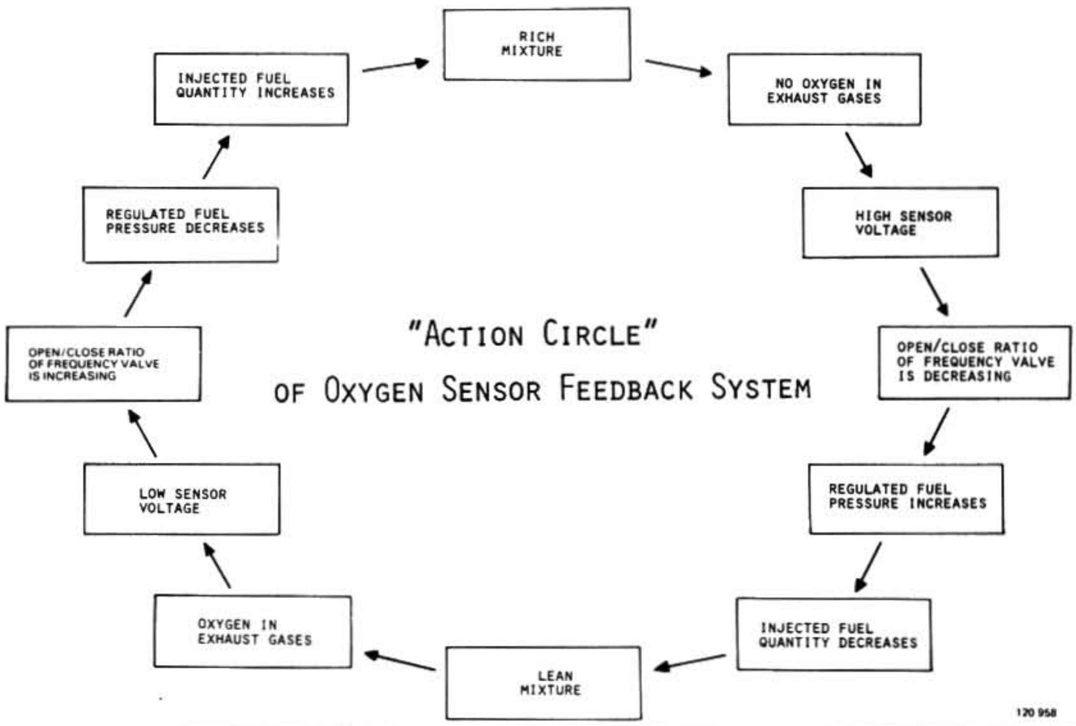
SENSOR LOCATION (B27F)



SENSOR LOCATION (B28F)

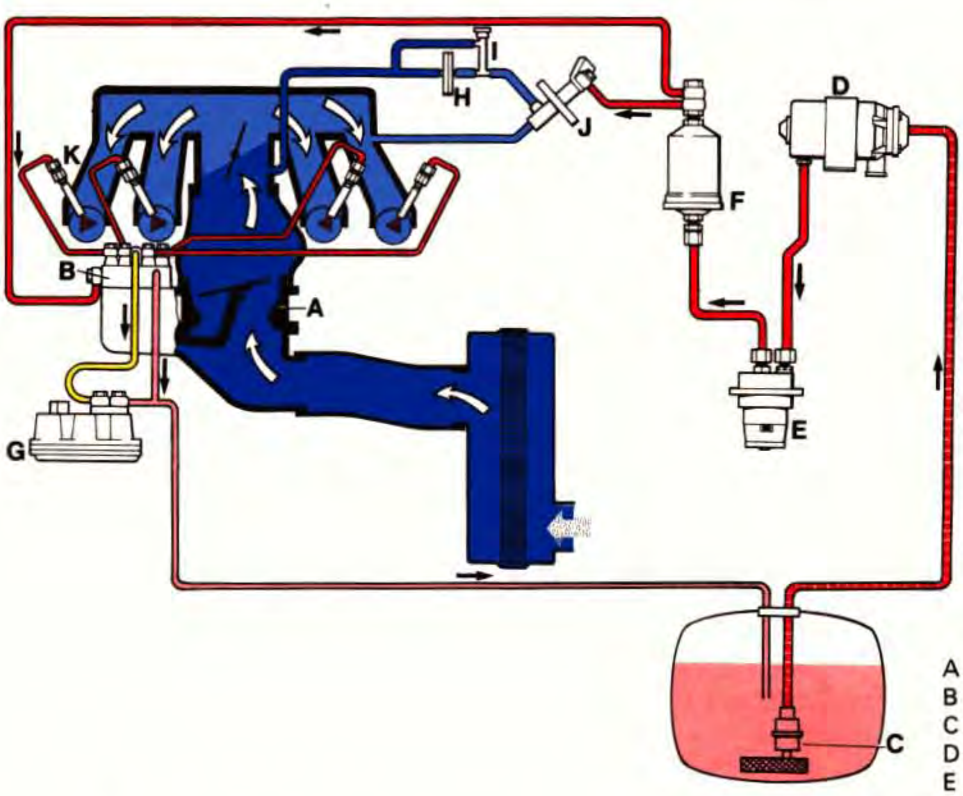
Fuel system — with oxygen sensor system (B21F shown)





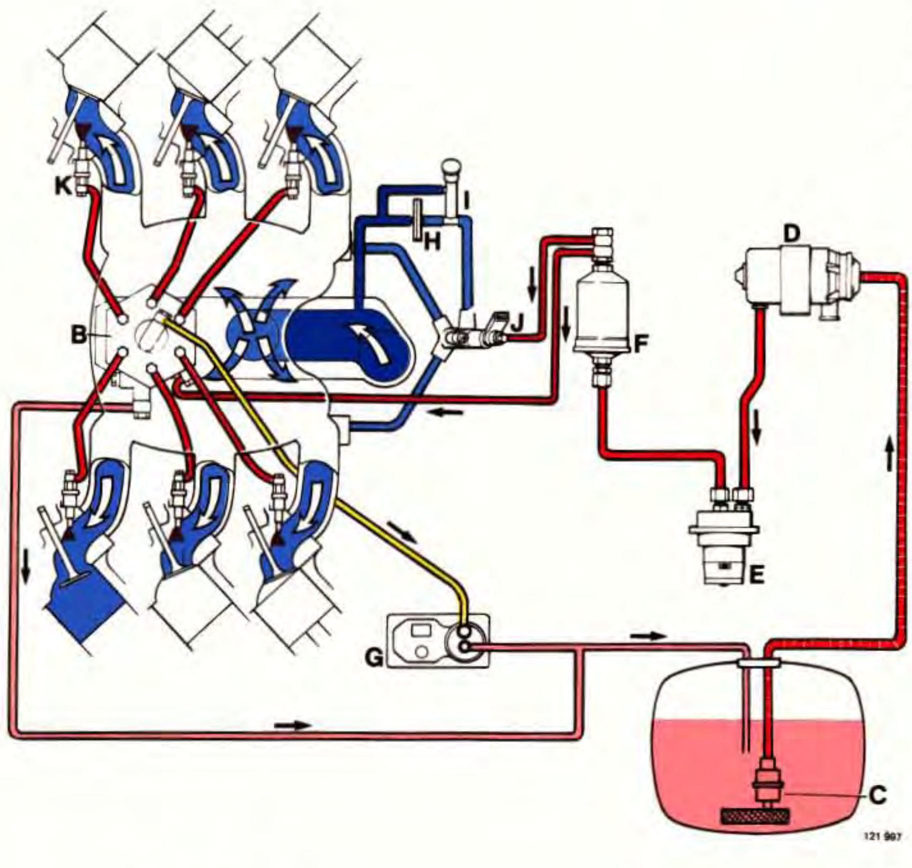
CI-System
Fuel Flow Diagram
1976–1977

B21F 1976–1977



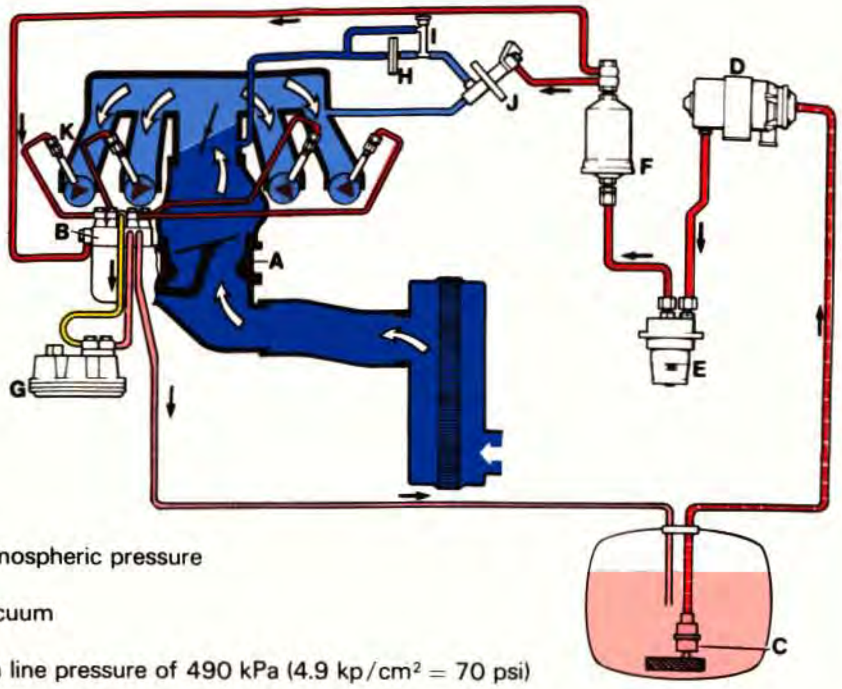
A Air flow sensor
B Fuel distributor
C Tank pump (1977–)
D Fuel pump
E Fuel accumulator
F Fuel filter
G Control pressure regulator
H Auxiliary air valve
I Idle adjustment screw
J Cold start injector
K Injector

B27F 1976–1977



CI-System Fuel Flow Diagram 1978—

4 Cyl. 1978—



Air at atmospheric pressure

Air at vacuum

Fuel with line pressure of 490 kPa (4.9 kp/cm² = 70 psi)

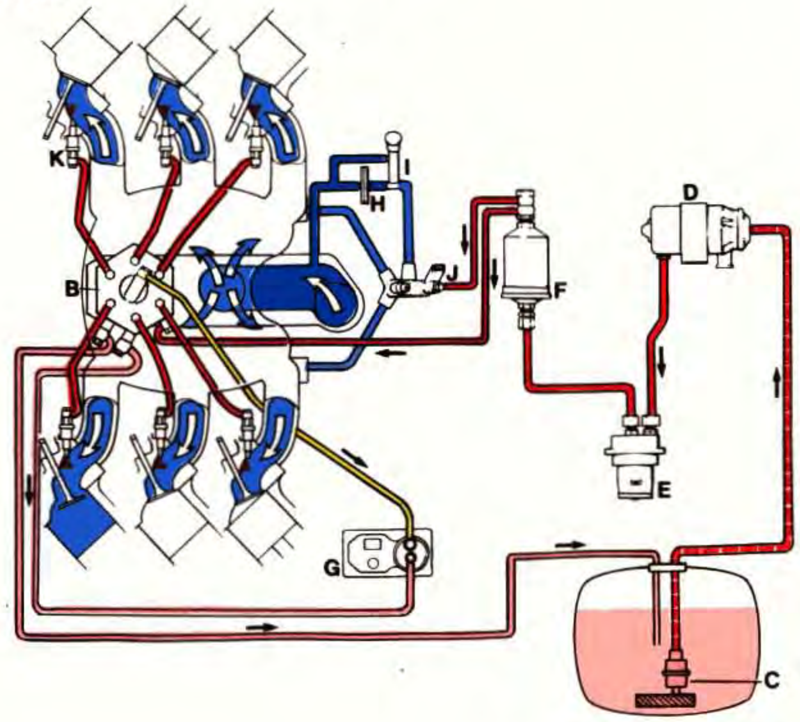
Fuel at pressure of approx. 20 kPa (0.2 kp/cm² = 3 psi)

Fuel at injection pressure of approx. 330 kPa (3.3 kp/cm² = 47 psi)

Pressureless fuel

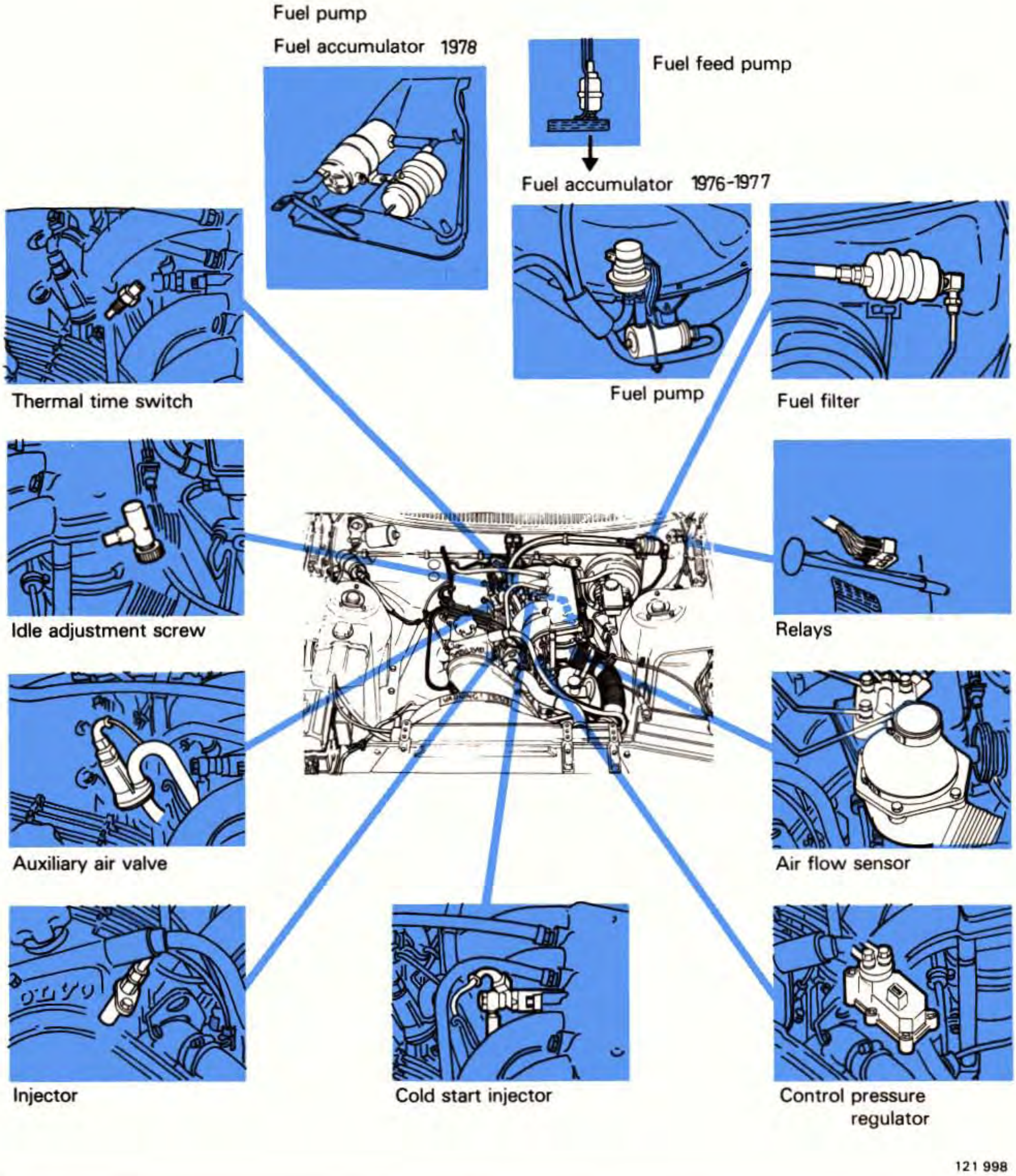
Fuel with control pressure at approx. 370 kPa (3.7 kp/cm² = 53 psi)

6 Cyl. 1978—

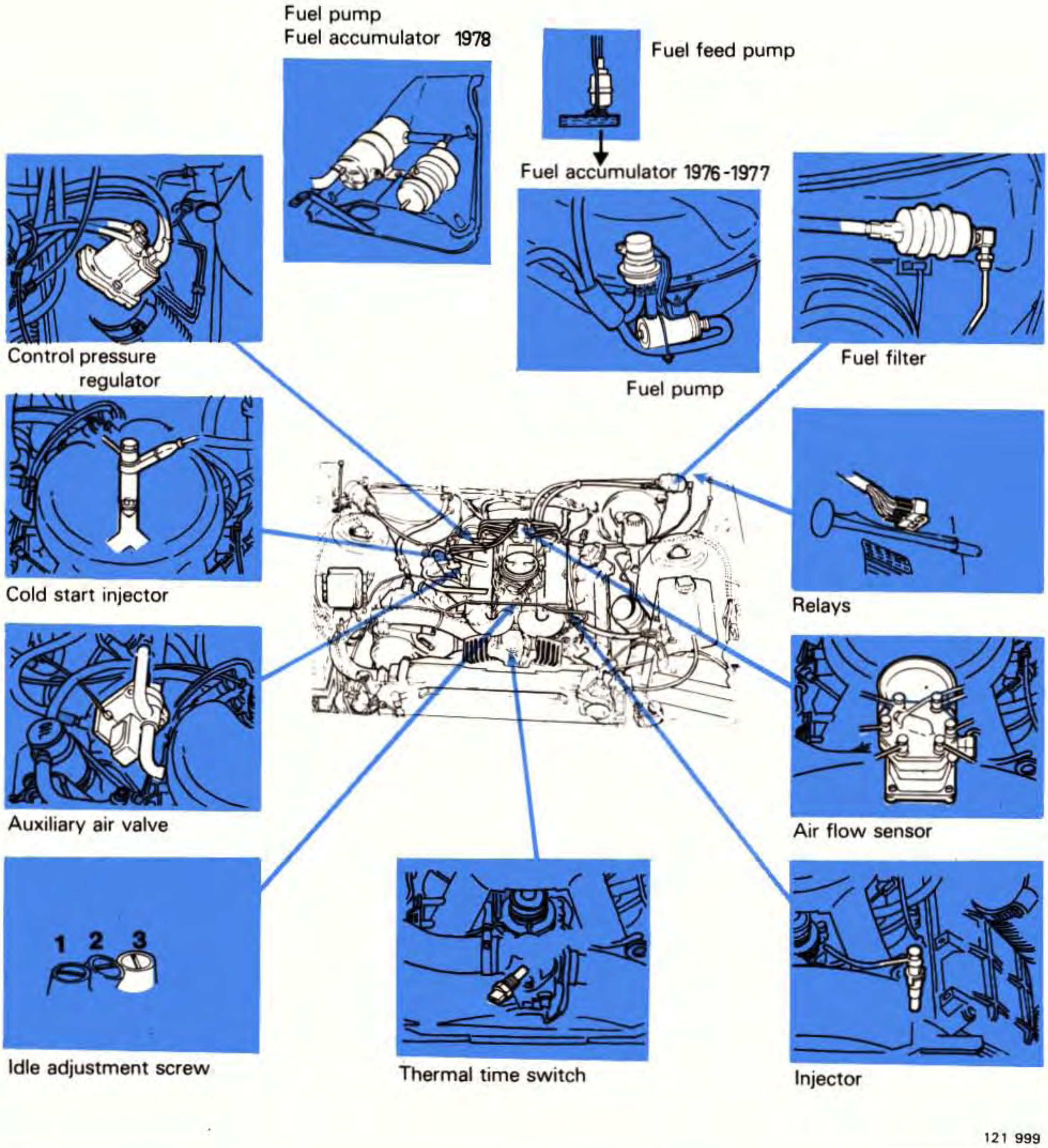


125 904

B21F, B23E CI-System—Component Location Guide



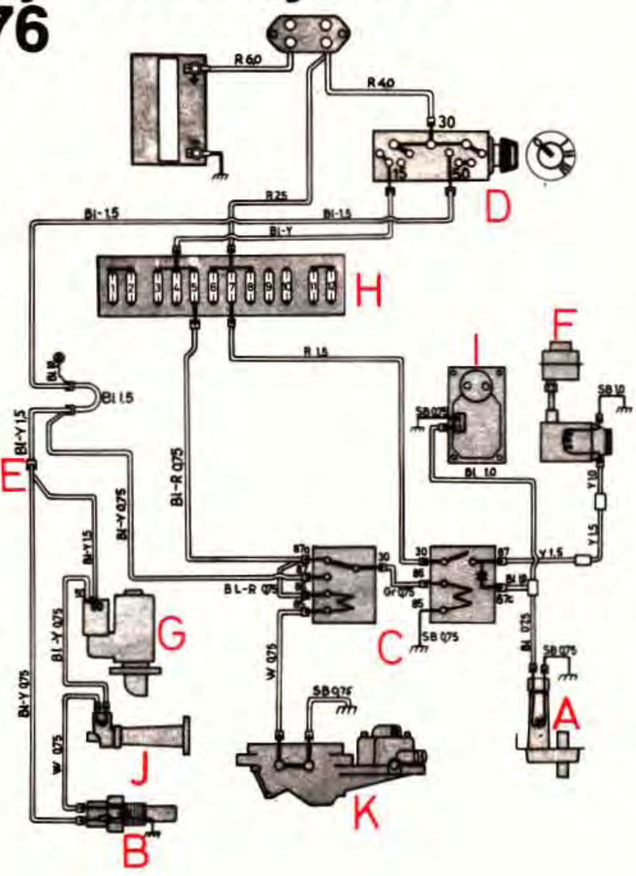
B27F, B28F CI-System—Component Location Guide



The wiring diagrams below provide component identification and interconnection information for the CI-Fuel System electrical circuits.

Wiring diagrams shown on the following pages are for information only. Consult appropriate manual for additional technical specifications.

CI fuel injection system 4-cyl 1976



Wire colors:	
SB	– black
GR	– gray
W	– white
R	– red
BR	– brown
Y	– yellow
BL	– blue
GN	– green

Approx wire sizes:	
0.75 mm^2	– 18 gauge
1.5	– 16
2.5	– 14
6.0	– 10
10.0	– 8
16.0	– 6

Fuse No. 5:

Relay, CI system

Bulb failure warning system

Turn signals
Instrument cluster

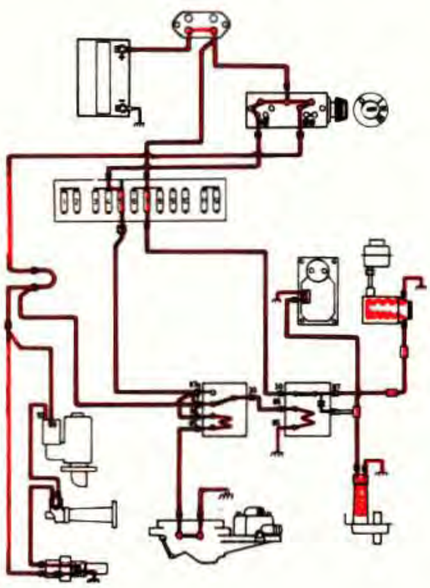
Fuse No. 7:

Fuel pump, CI system
Clock

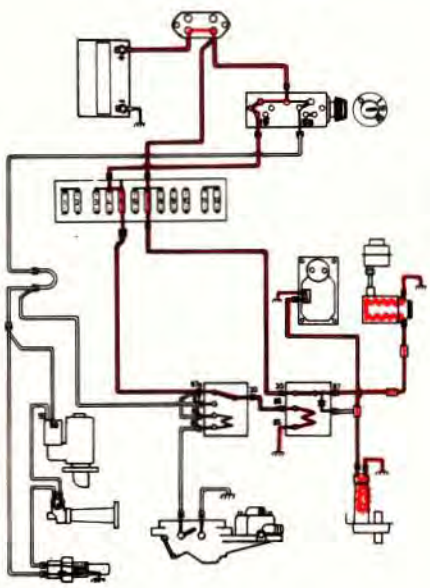
Legend:

A Auxiliary air valve
B Thermal time switch
C Relays
D Ignition switch
E Connector
F Fuel pump
G Starter motor
H Fuse box
I Control pressure regulator
J Cold start injector
K Air/fuel control unit

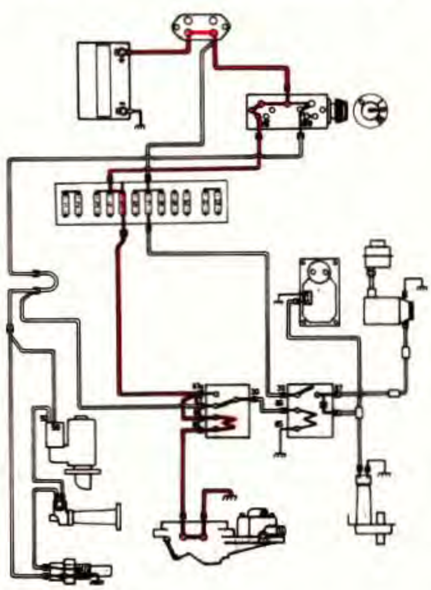
Starting engine



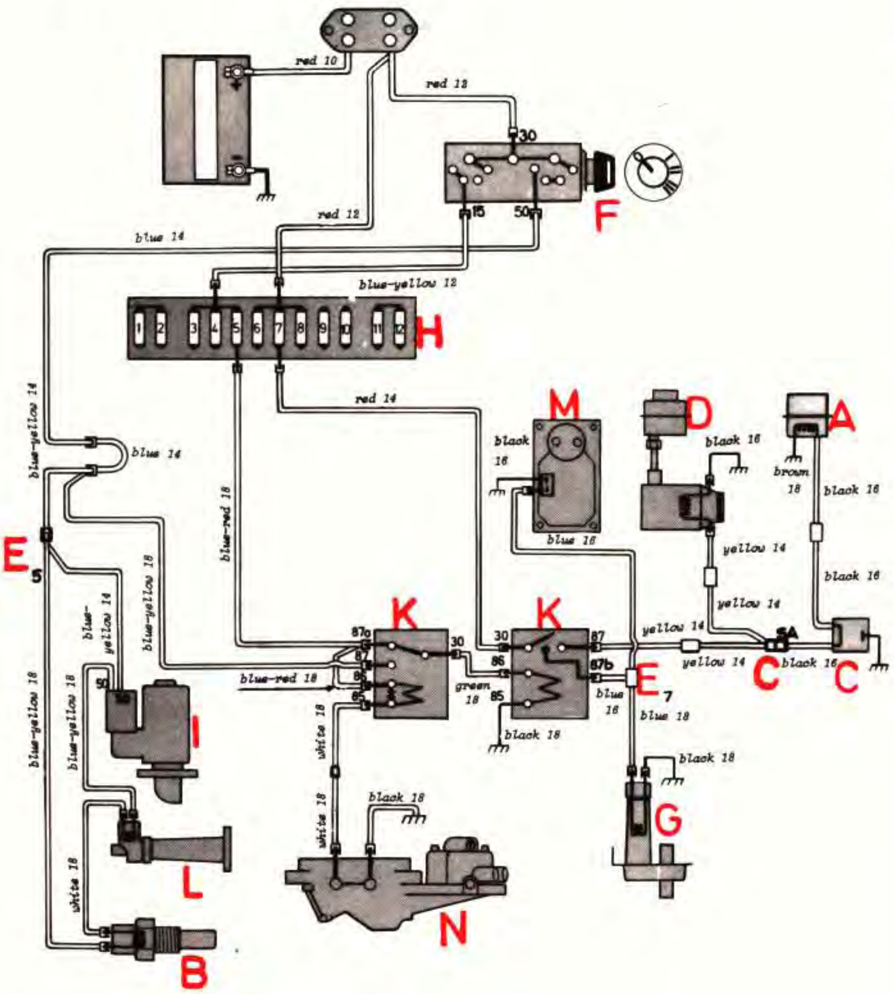
Engine running



Engine stalled (ignition on, but engine not running)



CI fuel injection system 4-cyl 1977



Fuse No. 5

Instrument cluster
Turn signals
Relay, CI system

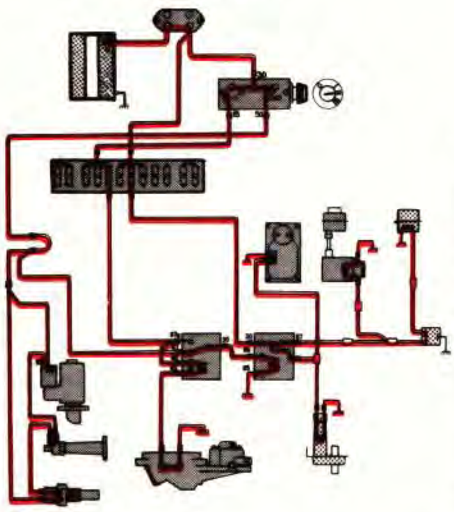
Fuse No. 7

Clock
Fuel pump

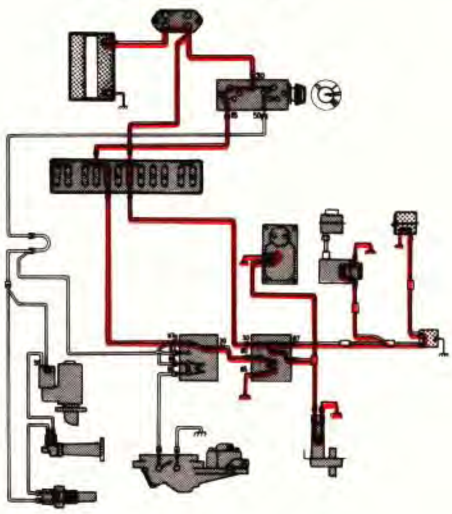
Legend:

A Fuel feed pump
B Thermal time switch
C Fuse
D Fuel pump
E Connector
F Ignition lock
G Auxiliary air valve
H Fuse box
I Starter motor
K Relays
L Cold start injector
M Control pressure regulator
N Air/fuel control unit

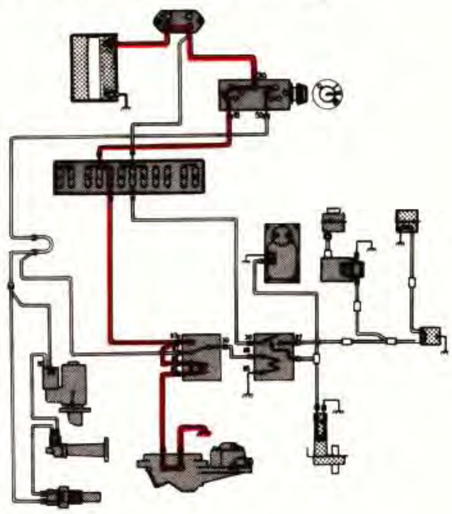
Starting engine



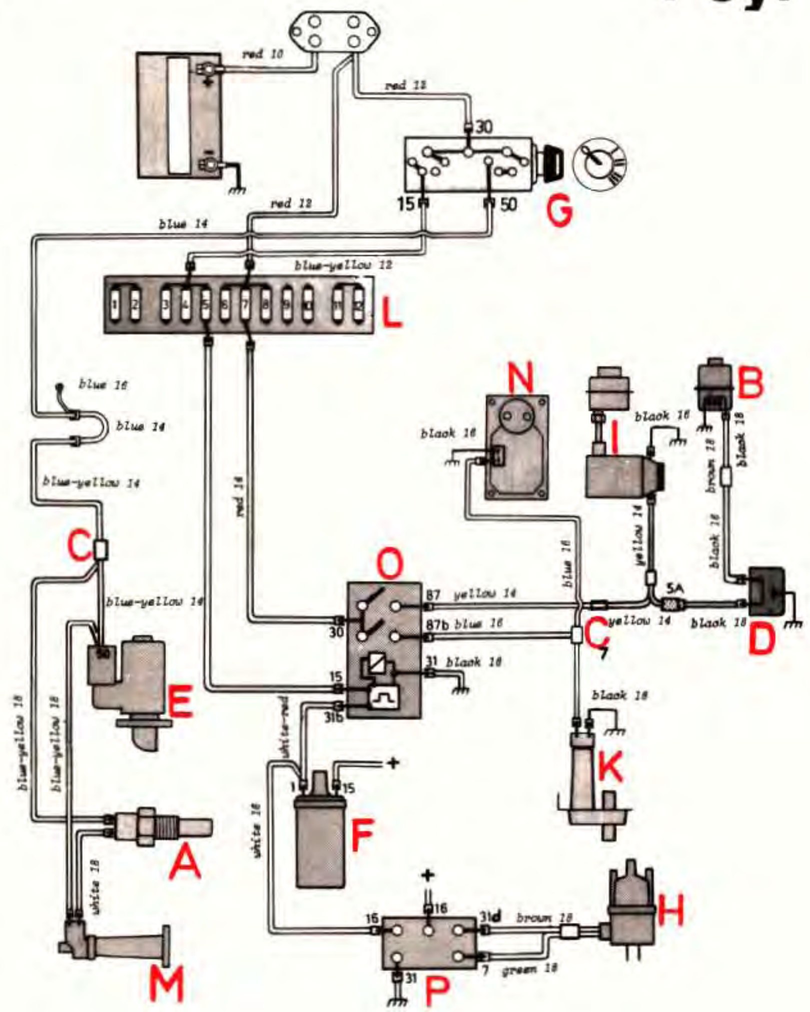
Engine running



Engine stalled (ignition on, but engine not running)



CI fuel injection system 4-cyl 1978



Fuse No. 5

Instrument cluster
Turn signals
Relay, CI system

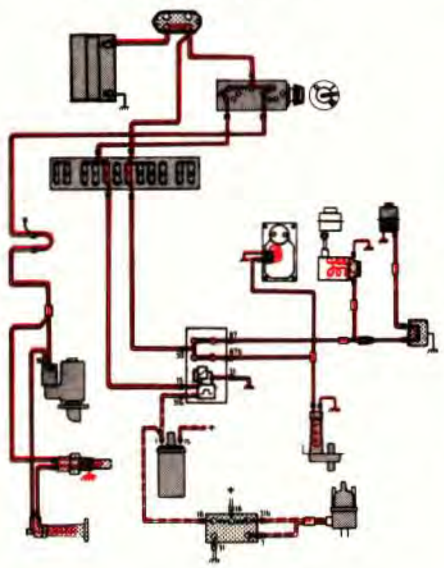
Fuse No. 7

Fuel pump

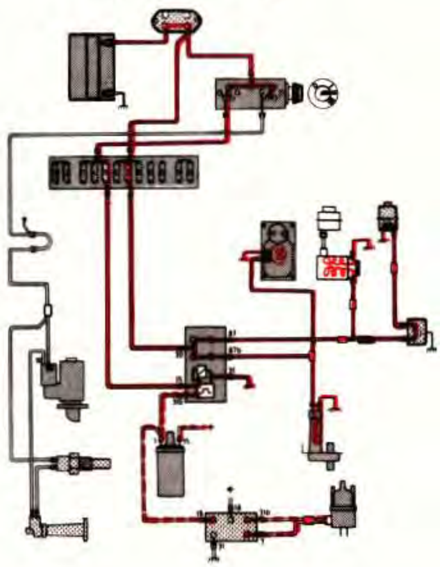
Legend:

A Thermal time switch
B Fuel feed pump
C Connector
D Fuse
E Starter motor
F Ignition coil
G Igniton lock
H Distributor
I Fuel pump
K Auxiliary air valve
L Fuse box
M Cold start injector
N Control pressure regulator
O Electronic fuel pump relay
P Ignition electronic module

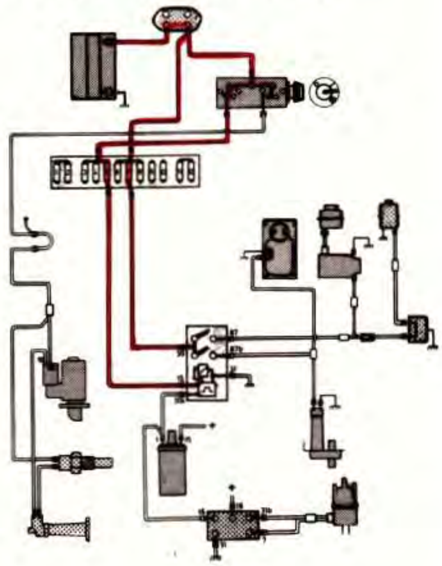
Starting engine



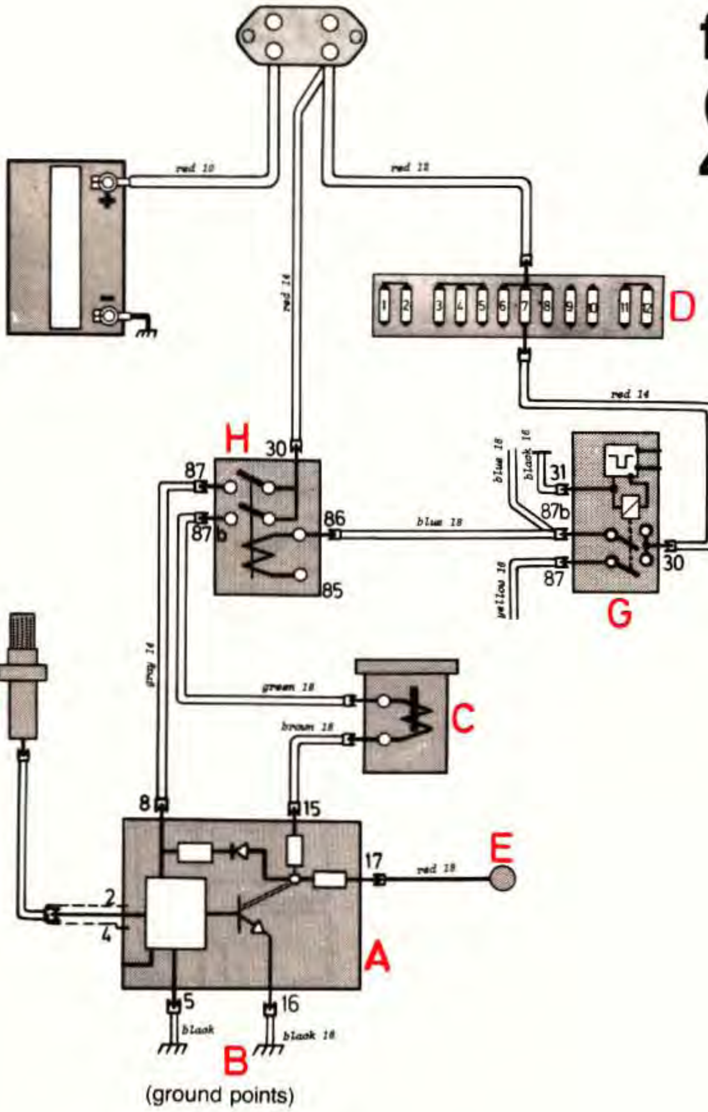
Engine running



Engine stalled (ignition on, but engine not running)



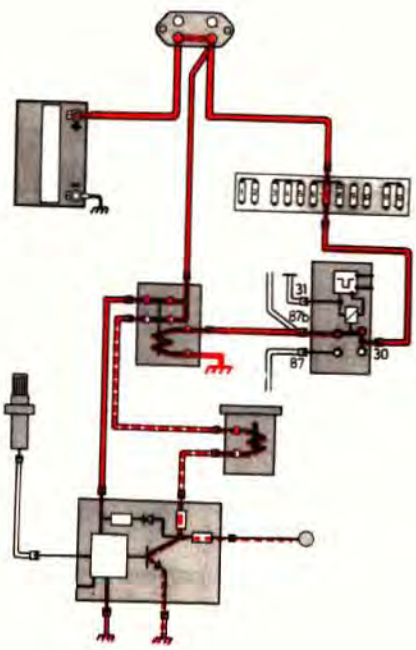
Oxygen sensor feedback system ("Lambda-sond") 4-cyl 1978



Fuse No. 7
Fuel pumps
Oxygen sensor system

Legend:

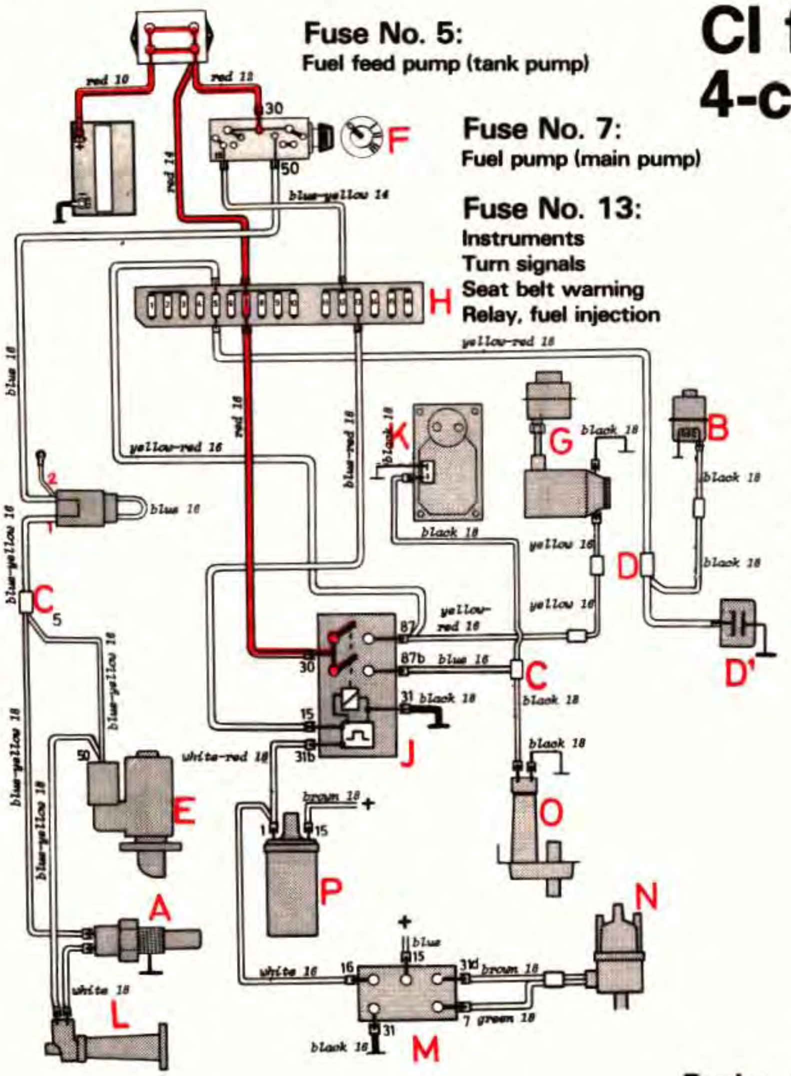
A Electronic module
B Ground points
C Frequency valve
D Fuse box
E Test instrument pick-up point
F Oxygen sensor
G Electronic pump relay
H System relay



Frequency valve operating

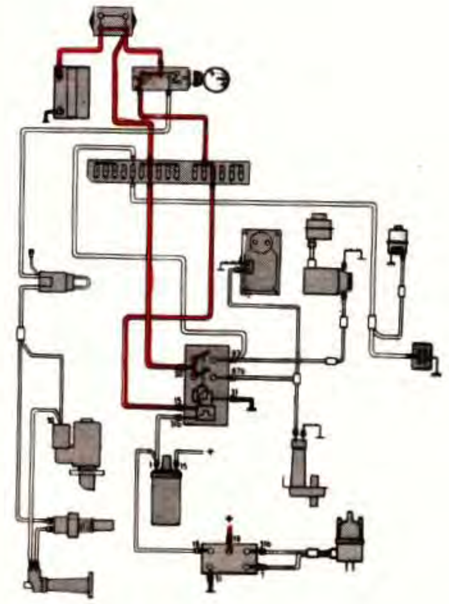
Dotted line
indicates
frequency valve
current

CI fuel injection system 4-cyl 1979



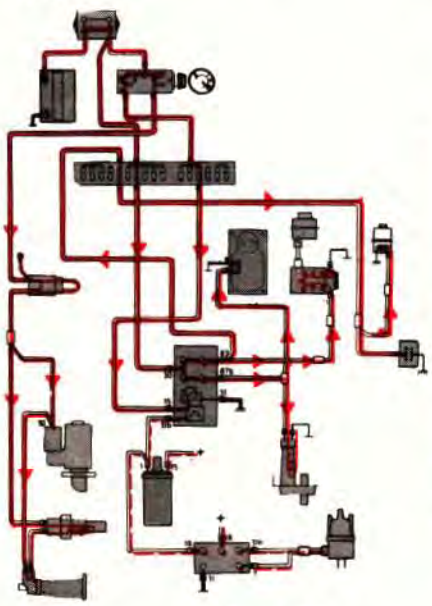
Legend:

- **A** Thermal time switch
- **B** Fuel feed pump (tank pump)
- **C** Connector
- **D** Connector
- **D1** Capacitor
- **E** Starter motor
- **F** Ignition switch
- **G** Fuel pump (main pump)
- **H** Fuse box
- **J** Electronic pump relay
- **K** Control pressure regulator
- **L** Cold start injector
- **M** Ignition electronic module
- **N** Distributor
- **O** Auxiliary air valve
- **P** Ignition coil

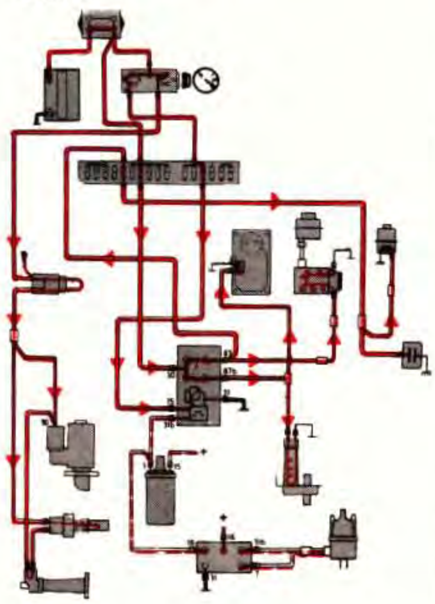


Engine stalled (ignition on, but engine not running)

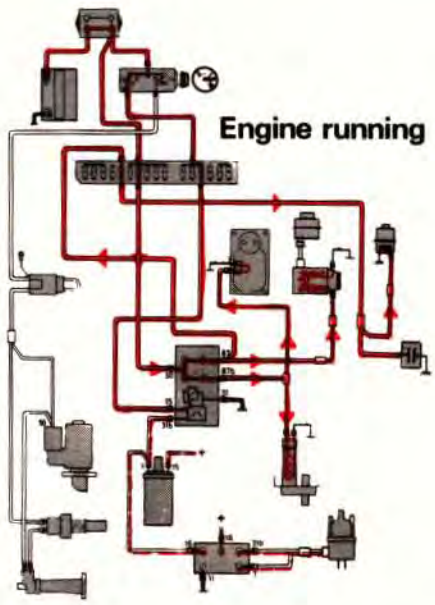
Starting engine cold



Starting engine warm



Engine running



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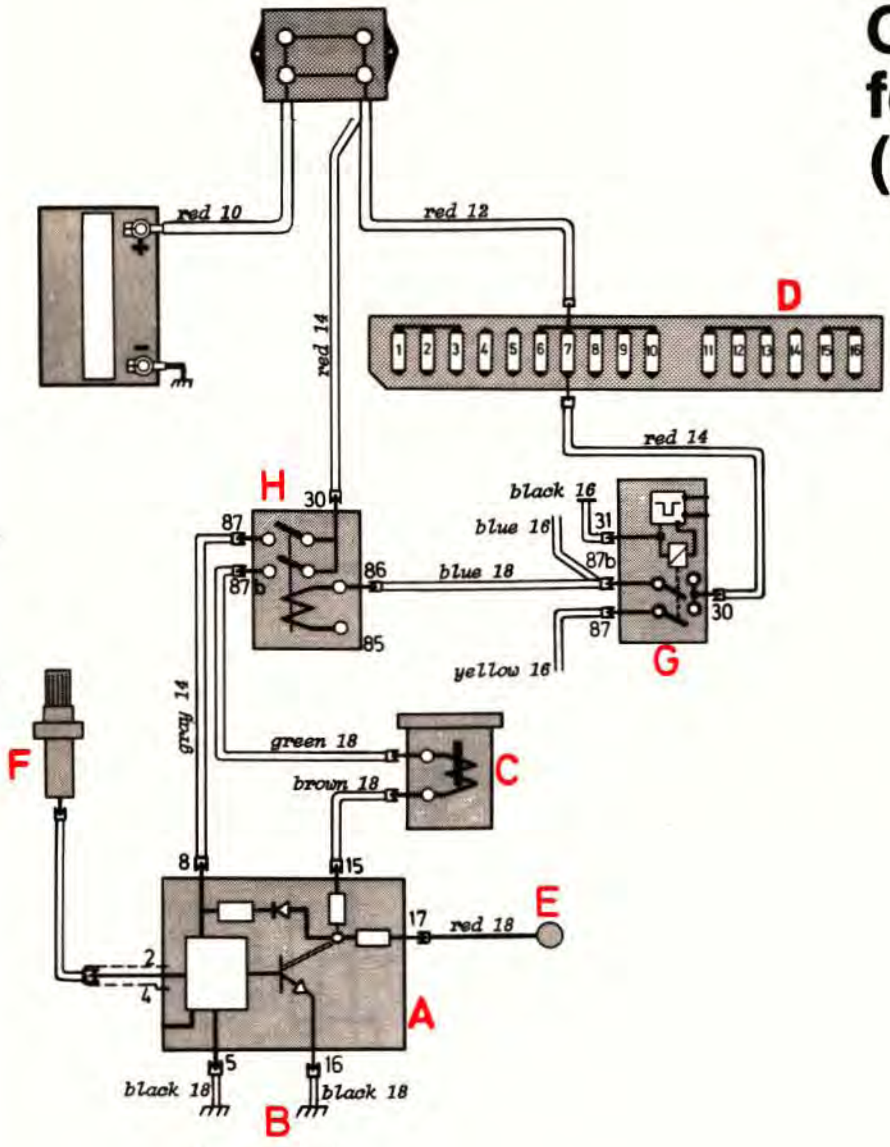
Oxygen sensor feedback system (Lambda-sond)

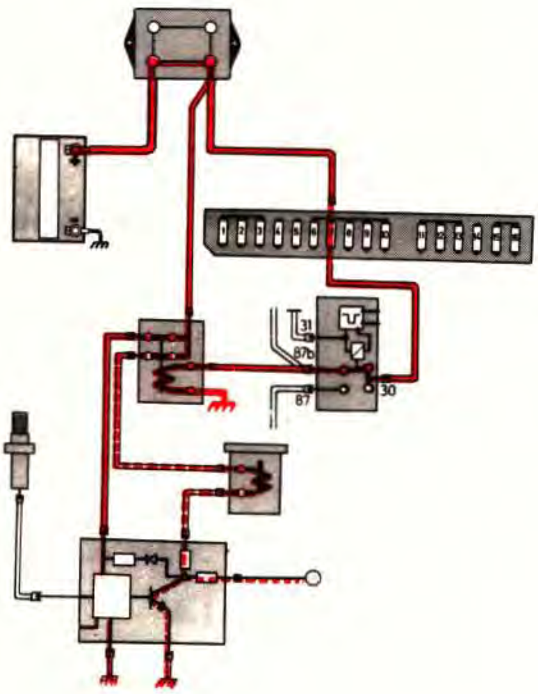


(ground points)

Fuse No. 7:
Fuel pump (main pump)

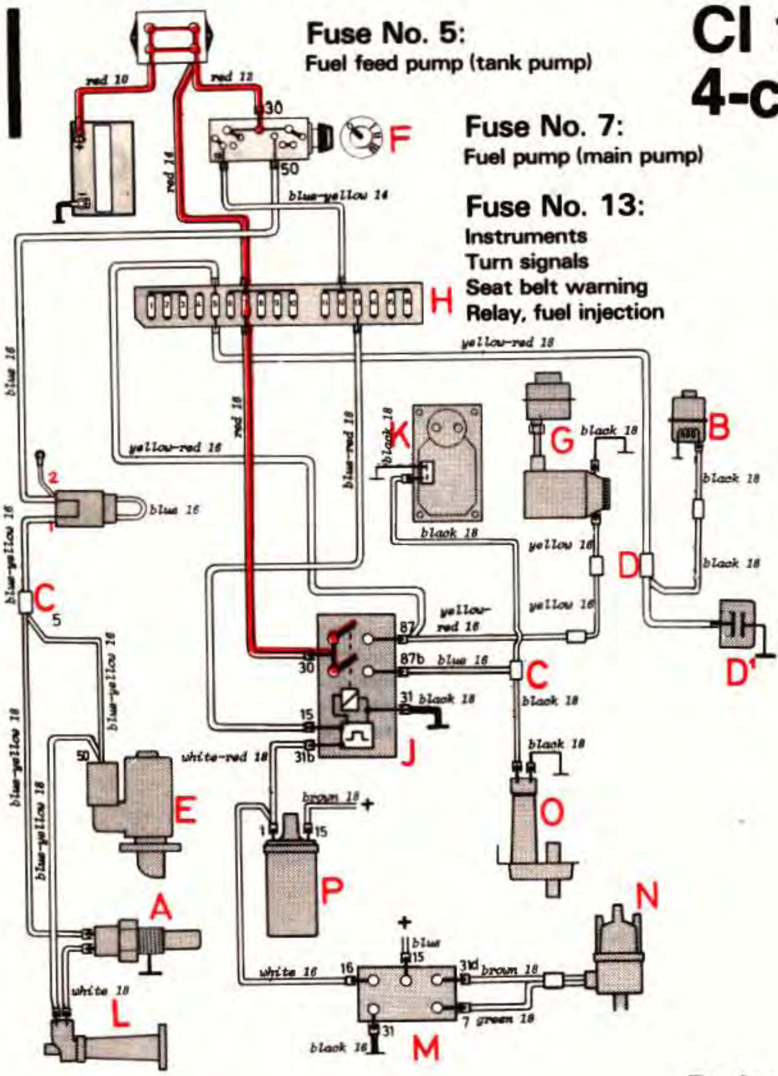
Legend:

- **A** Electronic module
- **B** Ground points
- **C** Frequency valve
- **D** Fuse box
- **E** Test instrument pick-up point
- **F** Oxygen sensor
- **G** Electronic pump relay
- **H** System relay



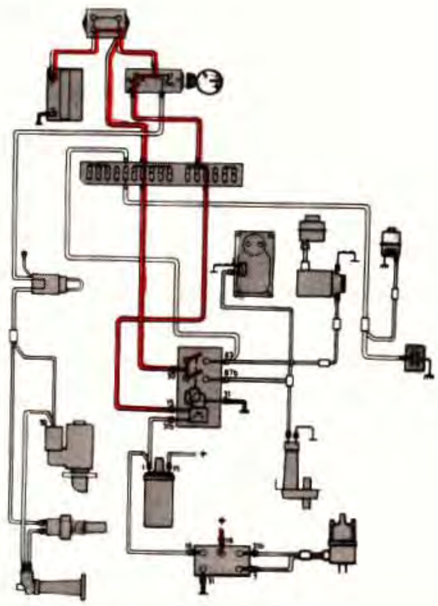
Frequency valve operating
Dotted line indicates frequency valve current

CI fuel injection system 4-cyl 1980-



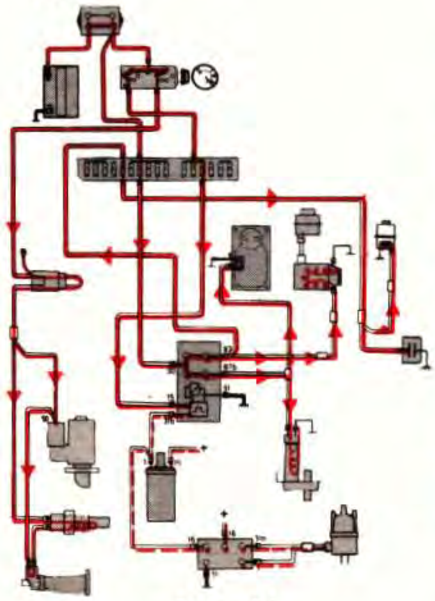
Legend:

- **A** Thermal time switch
- **B** Fuel feed pump (tank pump)
- **C** Connector
- **D** Connector
- **D[1]** Capacitor
- **E** Starter motor
- **F** Ignition switch
- **G** Fuel pump (main pump)
- **H** Fuse box
- **J** Electronic pump relay
- **K** Control pressure regulator
- **L** Cold start injector
- **M** Ignition electronic module
- **N** Distributor
- **O** Auxiliary air valve
- **P** Ignition coil

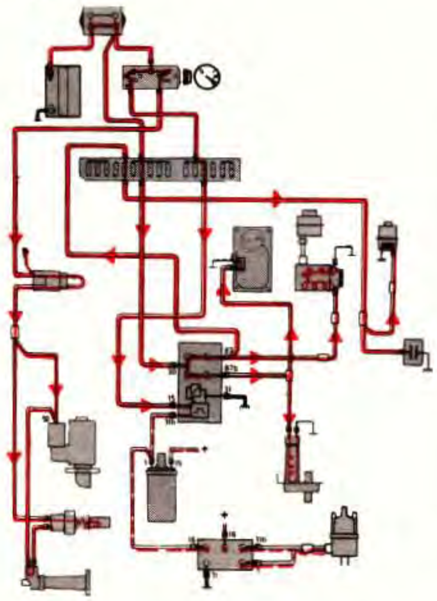


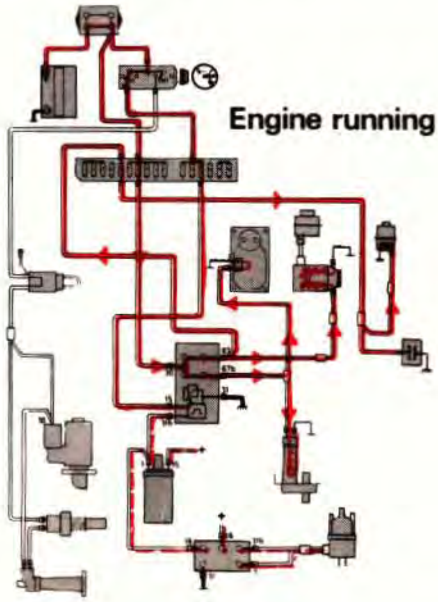
Engine stalled (ignition on, but engine not running)

Starting engine cold



Starting engine warm





Engine running

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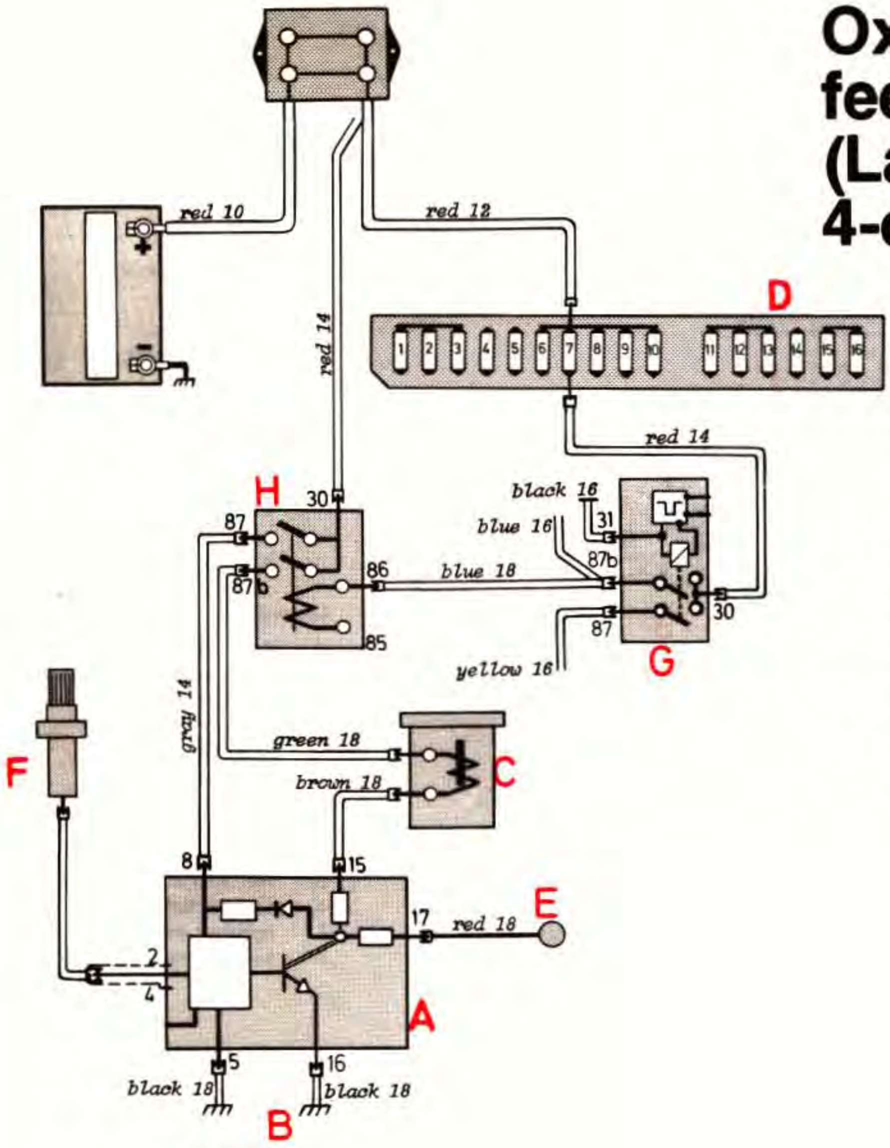
Oxygen sensor feedback system (Lambda-sond) 4-cyl 1980-

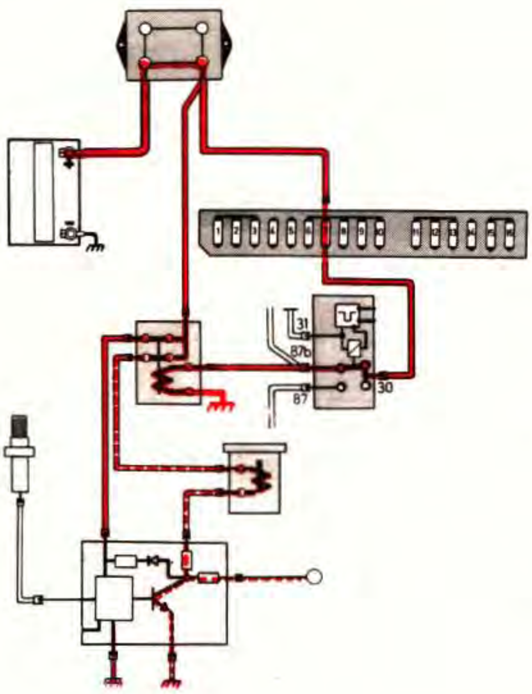


(ground points)

Fuse No. 7:
Fuel pump (main pump)

Legend:

- **A** Electronic module
- **B** Ground points
- **C** Frequency valve
- **D** Fuse box
- **E** Test instrument pick-up point
- **F** Oxygen sensor
- **G** Electronic pump relay
- **H** System relay



Frequency valve operating
Dotted line indicates frequency valve current

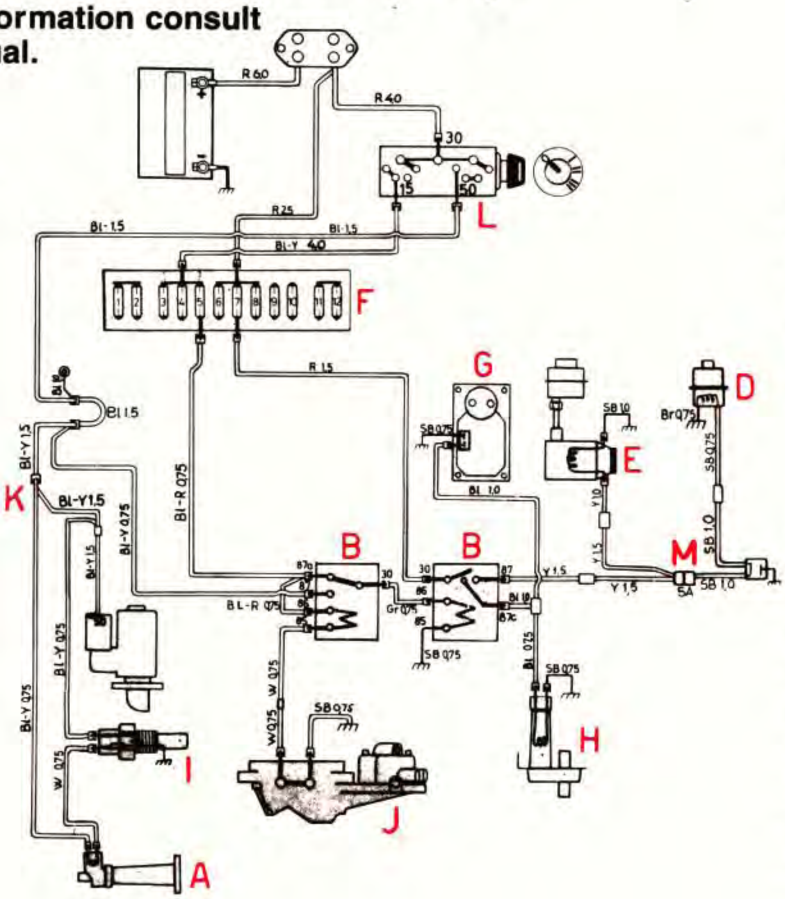
CI fuel injection system 6-cyl (typical installation)

For additional information consult appropriate manual.

Wire colors:	
SB	– black
GR	– gray
W	– white
R	– red
BR	– brown
Y	– yellow
BL	– blue
GN	– green

Approx wire sizes:

mm²		gauge
0.75	=	18
1.5	=	16
2.5	=	14
6.0	=	10
10.0	=	8
16.0	=	6



Fuse No. 5:

Relay, CI system
Bulb failure warning system.
Turn signals
Instrument cluster

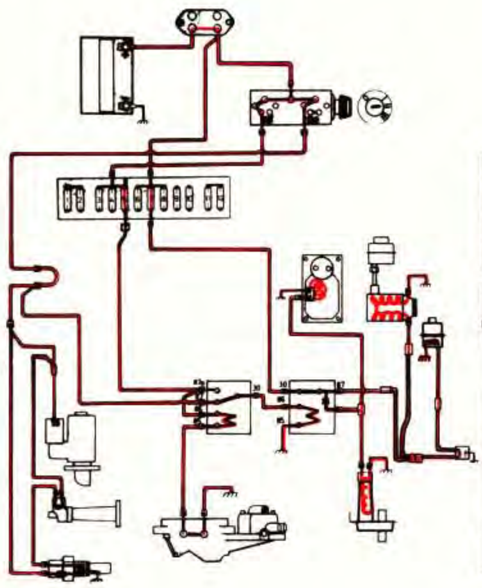
Fuse No. 7:

Fuel pump, CI system
Clock

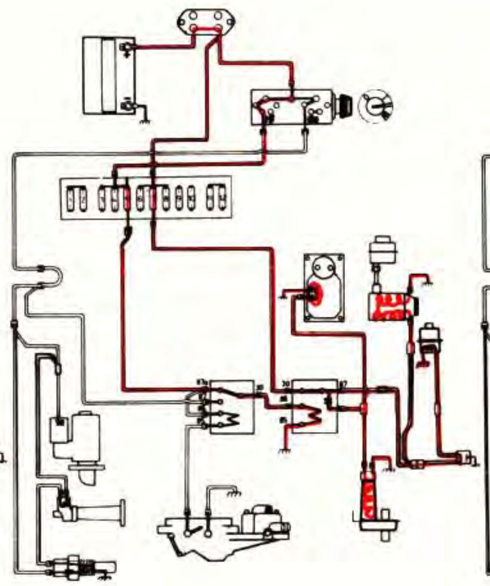
Legend:

- **A** Cold start injector
- **B** Main and pump relays
- **C** Starter motor
- **D** Tank pump
- **E** Fuel pump
- **F** Fuse box
- **G** Control pressure regulator
- **H** Auxiliary air valve
- **I** Thermal time switch
- **J** Air/fuel control unit
- **K** Connector
- **L** Ignition switch
- **M** In-line fuse

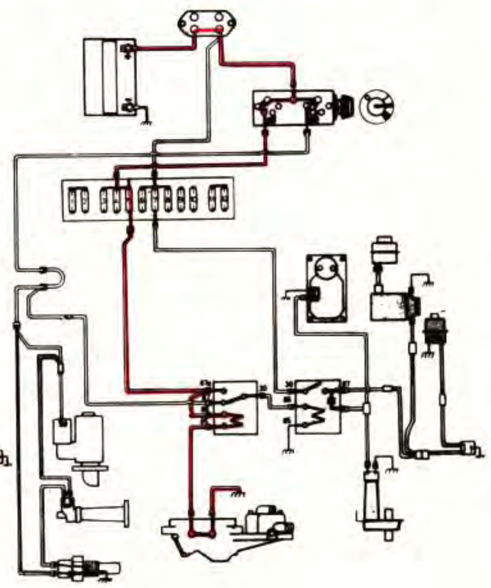
Starting engine



Engine running



Engine stalled (ignition on, but engine not running)



CI fuel injection system and oxygen sensor system 6-cyl (typical installation)

For additional information consult appropriate manual.

Legend:

- **A** Connector, Electronic Control Unit
- **B** Oxygen sensor (Lambda-sond)
- **C** Capacitor, fuel tank pump
- **D** Fuel pump relay
- **E** Frequency valve
- **F** Fuel tank pump
- **G** Fuel pump
- **H** Throttle switch
- **I** Temperature switch
- **J** Test instrument pick-up
- **K** Relay, oxygen sensor system
- **L** Pressure differential switch
- **M** Thermal time switch
- **N** Cold start injector
- **O** Control pressure regulator
- **P** Starter motor
- **R** Ignition system Electronic Control Unit
- **T** Impulse relay
- **U** Ignition coil
- **V** Distributor