INTEGRATED INJECTION-IGNITION SYSTEM - M.MARELLI-WEBER I.A.W.-49F

Introduction

The I.A.W.-49F fitted to the 1581 i.e. 16v engine belongs to the category of digital electronic ignition systems with static advance and timing, integrated with a phased, multipoint, intermittent electronic fuel injection system.

System identification codes change according to the version:
- I.A.W.-49F.B6 for version with manual gearbox
- I.A.W.-49F.L3 for version with automatic transmission

This system therefore adopts a single ECU, single wiring system and a set of sensors common to both systems.

Its function is therefore to inject an exact quantity of fuel into the engine intake duct upstream of the intake valves in order to obtain the correct mixture concentration.

The I.A.W.-49F system ensures efficient operation and optimisation of performance and fuel consumption. Harmful emission levels are reduced through real time response to the various engine operating conditions.

The system may be divided schematically into the following subsystems:
- Electric/electronic circuit
- Air intake circuit
- Fuel feed circuit
- Emission control devices

The system is able to monitor the following parameters by means of dedicated sensors:
1. instantaneous engine rpm;
2. position of each piston pair in relation to TDC of cylinder 1;
3. intake air temperature;
4. throttle valve angular position;
5. coolant temperature;
6. actual mixture concentration (by means of lambda probe signal);
7. intake manifold pressure;
8. vehicle speed;
9. battery voltage;
10. air conditioner compressor activation (if fitted).
11. presence of knock

This data, generally analogue, is converted into digital signals by analogue/digital (A/D) converters so that it may be used by the ECU.
Note that this I.A.W.-49 injection-ignition sytem does not require adjustment because it is self-adjusting and self-adaptive.

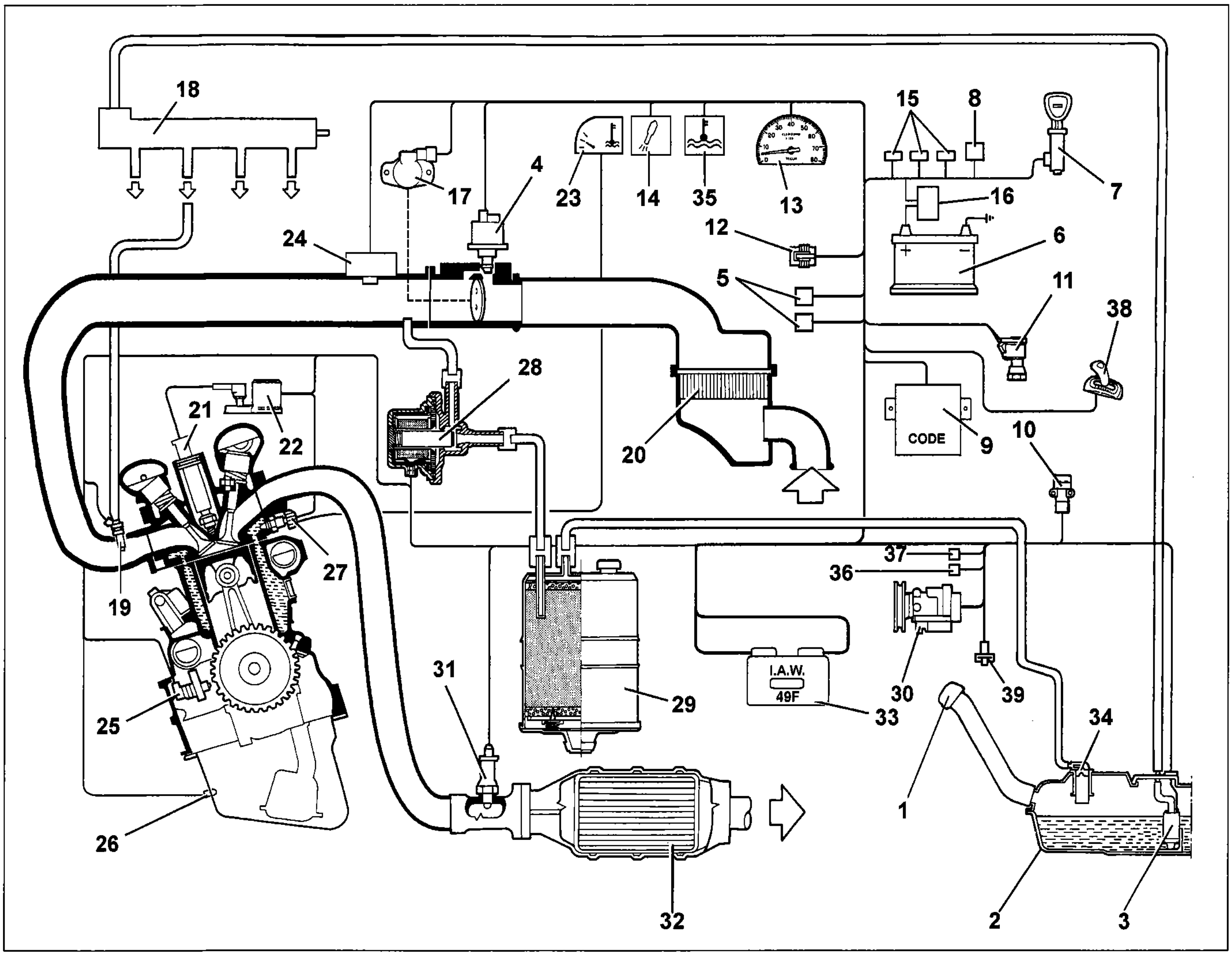
SYSTEM OPERATING STRATEGIES

The management software resident in the ECU memory comprises a set of strategies. Each of these controls a specific system control function.
Each strategy uses the various inputs listed above to process a set of parameters, using data maps saved in specific areas of the ECU. The resulting data output is used to control system actuators, in other words the devices used to operate the engine, namely:

1. injectors;
2. ignition coils;
3. solenoids of various types;
4. electric fuel pump;
5. engine idle speed actuator;
6. control relays.

10.

INJECTION-IGNITION SYSTEM OPERATING DIAGRAM



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1. Safety and ventilation valve
2. Fuel tank
3. Electric fuel pump
4. Idle speed actuator
5. Radiator fan high and low speed control relays
6. Battery
7. Ignition switch
8. Injection system relay
9. FIAT CODE control unit
10. Inertia switch
11. Vehicle speed sensor
12. Tester socket
13. Rev counter
14. Injection system warning light
15. Injection - ignition system fuses
16. Master fuse box
17. Throttle valve position sensor
18. Fuel supply manifold
19. Injectors
20. Air cleaner
21. Spark plugs
22. Ignition coils
23. Coolant temperature gauge
24. Pressure and air temperature sensor
25. Rpm and TDC sensor.
26. Knock sensor
27. Coolant temperature sensor
28. Fuel vapour cut-off solenoid
29. Active carbon trap filter
30. Air conditioner compressor
31. Lambda probe
32. Catalytic converter
33. Injection - ignition control unit
34. Multifunction valve
35. Excessive engine coolant temperature warning light
36. Air conditioner compressor relay
37. Heating/ventilation system relay
38. Automatic transmission
39. Pressure switch

The management strategies control ignition advance and fuel supply as effectively as possible to ensure mixture concentration is constantly corrected as engine load and environmental conditions change.

System operating strategies are essentially as follows:

- -injection management;
- -ignition management;
- -Fiat CODE immobiliser function management;
- -radiator fan management
- -engine idle control;
- -fuel vapour recirculation management;
- -test management
- -heating/ventilation system management

INJECTION MANAGEMENT

The ignition management strategies are designed to provide the engine with the correct amount of fuel at the right moment in accordance with engine service conditions.

The injection-ignition system uses an indirect measurement system known as «SPEED DENSITY - LAMBDA», i.e. angular speed of rotation, intake air density, retro-active concentration check.

In practice this system uses ENGINE SPEED (revs per minute) and AIR DENSITY (pressure and temperature) to measure the amount of air taken in by the engine.

The amount of air taken in by each cylinder upon each engine stroke depends on intake air density and also on standard displacement and volumetric efficiency.

Air density is taken to be the density of air taken in by the engine and calculated as a function of absolute pressure and temperature - both measured in the inlet manifold.

Volumetric efficiency is a parameter relating to the cylinder filling coefficient. It is calculated on the basis of experimental tests carried out on the engine throughout its service range and then memorized in the ECU.

Once the amount of air taken in has been established, the system must provide sufficient fuel to make up the required fuel mixture concentration.

The injection trigger pulse or time at which fuel delivery begins is mapped in a control unit and alters according to engine speed and intake manifold pressure. In practice, the the ECU performs calculations in order to control sequential, phased opening of the four injectors, one per cylinder for the length of time strictly necessary to form an air-fuel mixture as close as possible to a stoichiometric ratio.

Fuel is injected directly into the manifold close to the intake valves at a differential pressure of some 3 bar.

Speed (no. of revolutions per minute) and air density (pressure and temperature) are used to measure intake air quantity, which is used in turn to calculate the amount of fuel needed to achieve the required mixture proportions. The other sensors in the system (coolant temperature, throttle valve position, battery voltage, etc.) allow the ECU to correct the baseline strategy for each specific engine service condition.

In order to keep the catalytic converter working efficiently and reduce polluting emissions, it is essential to ensure the air-fuel ratio is maintained at near stoichiometric levels.

A stoichiometric ratio is achieved by using a hot lambda probe. This probe continually monitors the amount of oxygen in the exhaust gas and then informs the ECU. This unit in turn uses mapped data to correct the fuel air mixture on-line if proportions are no longer stoichiometric.

Idle speed, exhaust gas CO level and throttle valve sensor position cannot adjusted on this system.

Control of mixture concentration (retro-active control)

NOTE *Mixture ratio is defined and indicated by the Greek letter α (alpha) as follows:*

$$\alpha = \frac{\textbf{quantity of air taken in by engine}}{\textbf{quantity of fuel injected}}$$

The following ratio is said to be stoichiometric and indicated by αst:

$$\alpha st = \frac{\textbf{theoretical quantity of air required to burn all the fuel injected}}{\textbf{quantity of fuel injected}}$$

The following ratio defines mixture concentration and is indicated by the Greek letter λ (lambda):

$$\lambda = \frac{\textbf{quantity of air taken in by engine}}{\textbf{theoretical quantity of air required to burn all the fuel injected}}$$

Thus we easily find that $\alpha/\alpha st=\lambda$.

Stoichiometric ratio depends on fuel type. For unleaded fuels in current use, this figure is 14.7 - 14.8, which corresponds to lambda = 1. (a ratio of 14.8:1 means that 14.8 parts of air are required to burn 1 part of fuel).

The mixture is termed rich (or heavy) when the quantity if air is less than the stoichiometric level. In this case, lambda equals ≤ 1;

the mixture is termed lean (or light) when the quantity of air exceeds the stoichiometric level. In this case, lambda equals ≥ 1;

The strategy is designed to correct base pulse constants so that mixture concentration oscillates continually and at a high rate between 0.98 and 1.02.

This oscillation rate varies according to engine load and speed. It is in the order of a few Hertz (0.5 - 4 Hertz).

NOTE

1 Hz = 1 oscillation per second

Under conditions of:

- cut-off,
- throttle opening about 60% (lower at low speeds)
- engine temperature lower than 25 °C

the strategy is de-activated.

Self-adaptability

The control unit features a self-adaptive function able to memorise deviations between basic maps and corrections imposed by the lambda probe that occur persistently during operation. Such deviations (due to system and engine component ageing) are saved permanently so that system operation can be adapted to gradual changes in engine and components with regard to original specifications. The corrections are **NOT** lost even when the batter or control unit is disconnected

The strategy is de-activated while the carbon filter flushing solenoid is open. If the ECU is replaced, it is advisable to leave the engine to idle for a few minutes until warm to allow the ECU to store the correction again. Corrections at higher speeds are stored under normal driving conditions.

The control unit is also equipped with a self-adaptive function which corrects idle speed actuator opening when idling on the basis of changes due to throttle body leaks or natural engine ageing. This specific correction is lost by disconnecting the battery or control unit.

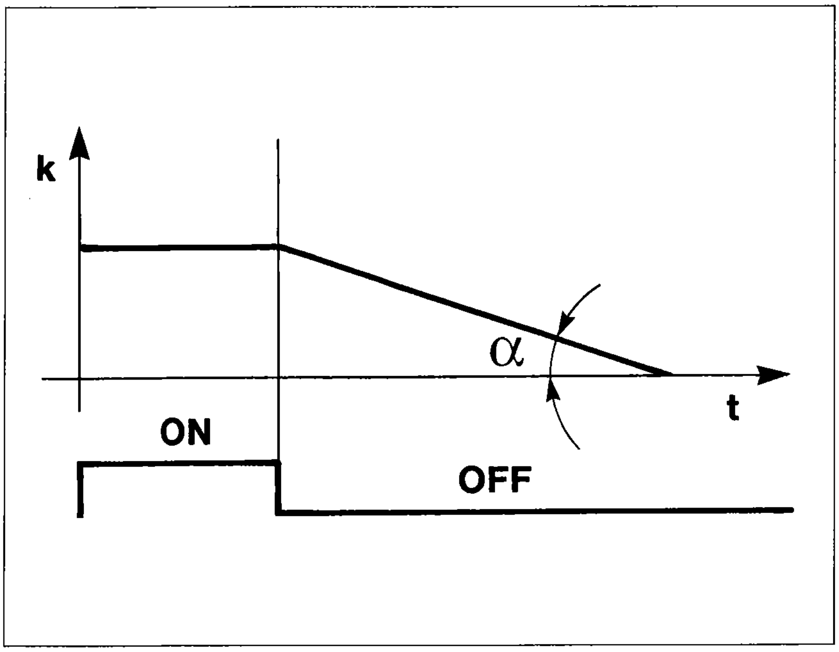
Starting and post-starting

During start-up, engine phase cannot be instantly identified and phased injection cannot therefore be implemented for the first injection in each cylinder.

An initial simultaneous injection is carried out during the first few engine revolutions (full group) because the considerable fluctuations in rotation speed do not permit injection time to be calculated correctly. Only subsequently does injection becomes phased.

The base pulse constant is increased by a certain factor throughout the period when the engine is cranked by the starter motor.

Once start-up has taken place, the factor is gradually reduced to zero within a given time period, which is in inverse proportion to engine temperature.



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k : enrichment factor

t : time

α : decrease proportional to engine temperature

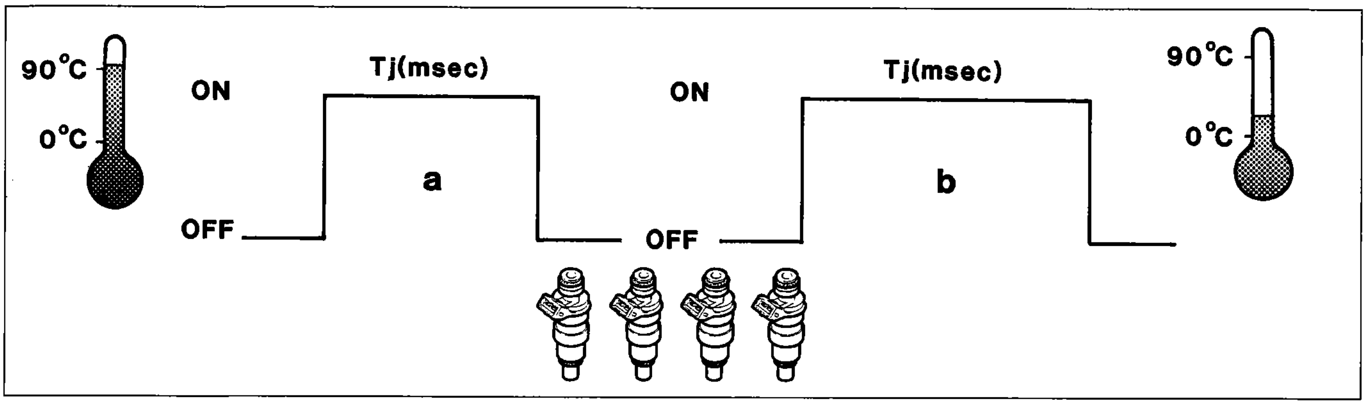
ON: engine cranked

OFF: engine running

When cold

Under these conditions, the mixture becomes naturally leaner due to reduced evaporation and heavy fuel condensation on the intake manifold internal walls. The greater viscosity of the lubrication oil also brings about an increase in the rolling resistance of internal engine components which also serves to exacerbate matters.

The electronic control unit recognises this condition and corrects injection time on the basis of the coolant temperature signal.



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Consequently:

- At very low temperatures the injector stays open longer Tj) graph (b) for a low air fuel ratio (rich mixtures);
- As engine temperature increases, injector opening time becomes shorter (tj) graph (a) and the air/fuel ratio becomes correspondingly higher (lean mixture).

While the engine is warming up, the ECU also governs a step motor which is responsible for calculating the amount of air necessary to ensure the engine does not stall.

Rpm is decreased as the temperature rises until the rated level is reached (850 ± 30 Rpm) when the engine is warm. The ECU governs the step motor to maintain idle speed constant even if electrical and mechanical loads vary.

Connection to automatic transmission

The ECU adjusts engine idle speed on the basis of the load input when the selector lever is moved to a given position and transmits information to the automatic transmission ECU on torque reduction (pin 36), engine coolant temperature (pin 5) and throttle valve position (pin 16).

The control unit reduces the level of torque produced by the engine (mainly by altering ignition advance) during gear changes, when it receives a signal from the automatic transmission control unit (pin 49).

Full-load

Under full load conditions, base pulse constant must be increased to obtain maximum engine power output.

The ECU detects a full load condition as a result of parameters supplied by the throttle position and absolute pressure sensors.

On the basis of this information, the ECU implements the appropriate correction strategy by increasing base pulse constant.

Over-run

Two strategies are superimposed during this stage:

1. Transient negative strategy to reduce the amount of fuel required by the engine (lower emissions). This stage is recognized by the ECU when the potentiometer signal changes from a higher voltage level to a lower value.
2. A dash-pot strategy to lessen changes in torque delivery (lower engine brake). This strategy is implemented when the potentiometer signal indicates that the throttle is closed and rpm is high. The step motor gradually decreases the flow of air through the by-pass.

Barometric correction

Atmospheric pressure varies with altitude to bring about changes in volumetric efficiency of sufficient entity to require a correction to baseline concentration (injection time).

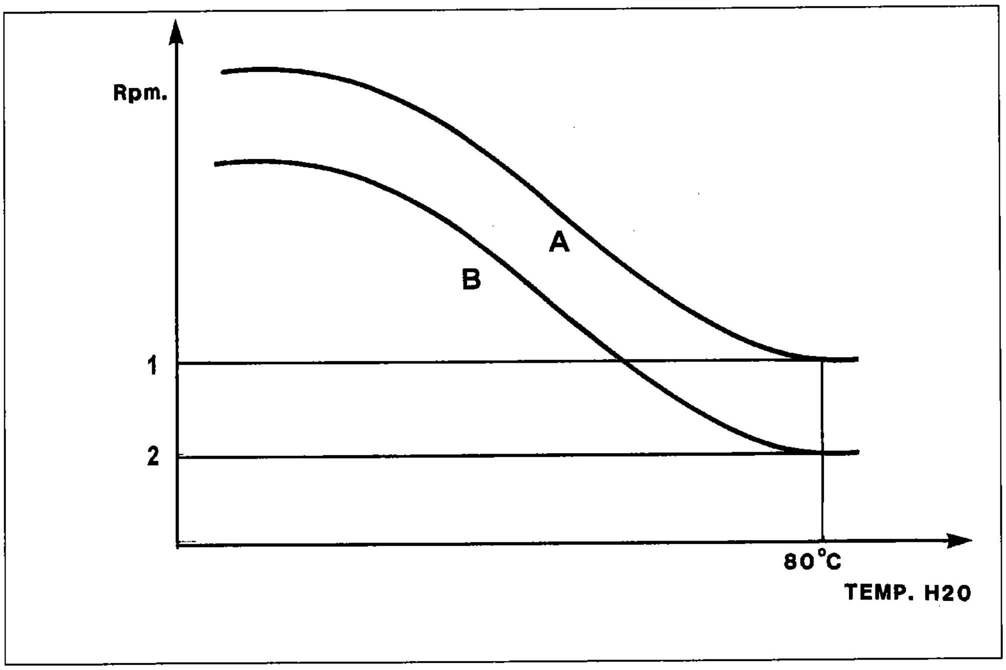
Injection time is corrected according to changes in altitude and updated automatically by the ECU whenever the engine is started up and under certain conditions of throttle position and rpm (dynamic adjustment of barometric correction)

Cut-off

The fuel cut-off strategy is activated when the ECU recognises that the throttle is in closed position (throttle potentiometer signal) and engine speed exceeds 1350 rpm (1750 rpm for automatic transmission versions). The ECU activates cut-off only when engine temperature exceeds 0° C.

The fuel supply is restored when the throttle is no longer closed or the engine speed is lower than 1270 rpm (1650 rpm for version with automatic transmission).

At very high speeds, cut-off takes place even when the throttle valve is not fully closed but pressure in the intake manifold is particularly low (partial cut-off).



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Version with manual gearbox

1. 1350 rpm
2. 1270 rpm

Version with automatic transmission

1. 1750 rpm
2. 1650 rpm

A. entering cut-off

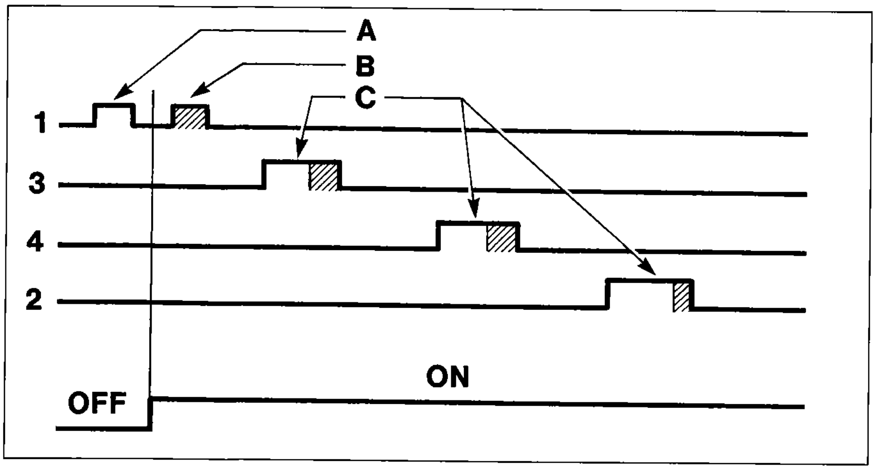
B. leaving cut-off

Acceleration

During this stage, the ECU increases the amount of fuel required by the engine (to achieve maximum torque) on the basis of signals from the following sensors:
- throttle potentiometer;
- absolute pressure sensor;
- rpm and TDC sensor.

The base pulse constant is multiplied by a factor according to coolant temperature and accelerator throttle opening speed.

If an abrupt change in injection time is calculated when the injector is already closed, the ECU reopens the injector (extra pulse), in order to make the concentration up to the required level as quickly as possible. Subsequent injections are automatically increased as described previously.



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A. normal injection time
B. injector re-opening (extra pulse)
C. injection time including enrichment
OFF. engine under steady-state conditions
ON. engine under transient conditions

Protection against excess rpm

When engine rpm exceeds a level of 6700 rpm for longer than 10 seconds or an upper threshold of 6900 rpm imposed by the manufacturer for any length of time, engine operating conditions are said to be critical.

When the ECU recognises that this threshold rpm level has been exceeded, it reduces injector control time.

When rpm drops to non-critical levels, control is restored.

Electric fuel pump drive

The fuel pump is governed by the ECU through a relay.
The pump stops when:

- engine speed drops below 50 rpm;
- after a certain time (5 seconds) with the ignition turned to MAR without start-up taking place (timed enablement).
- if the inertia switch is activated.

Injector control

Injectors are controlled in sequential, phased manner. During start-up, however, all injectors are initially all controlled in parallel (full-group).

Injector control timing varies according to engine speed and intake air pressure in order to improve cylinder filling because this makes for better fuel economy, good handling and lower emission levels.

IGNITION MANAGEMENT

The ignition circuit is static inductive discharge type, i.e. a high tension distributor with power modules located inside the injection-ignition control unit.

The system comprises two high tension twin outlet coils combined in a single container and connected directly to the spark plugs.

The primary winding of each coil is connected to the power relay (i.e. supplied by battery voltage) and pins of the ECU for connection to earth.

Once the start-up stage is over, the ECU implements a base pulse constant taken from a specific map in accordance with the following input parameters:

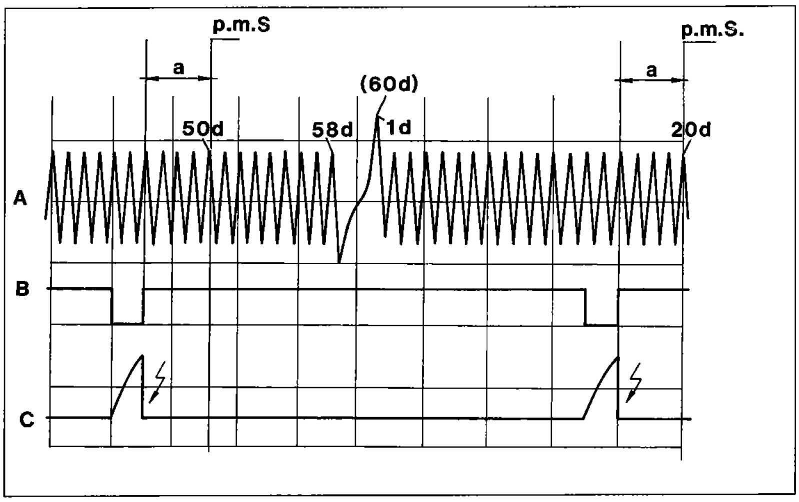
- engine rotating speed (rpm),
- absolute pressure reading (mmhg) obtained in intake manifold.

This advance setting is corrected according to temperature.

The advance angle is also subject to correction under the following conditions:

- during start-up;
- during transient stages of acceleration and over-run.
- during cut-off.
- to stabilise idle speed
- when knock is present
- when required by the automatic transmission ECU (speed change).

For the ignition system to work efficiently, the ECU must recognise the signal configuration.



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A. Rpm sensor signal

B. Power control

C. Current running through coil primary winding

a. Ignition advance with reference to cylinder TDC

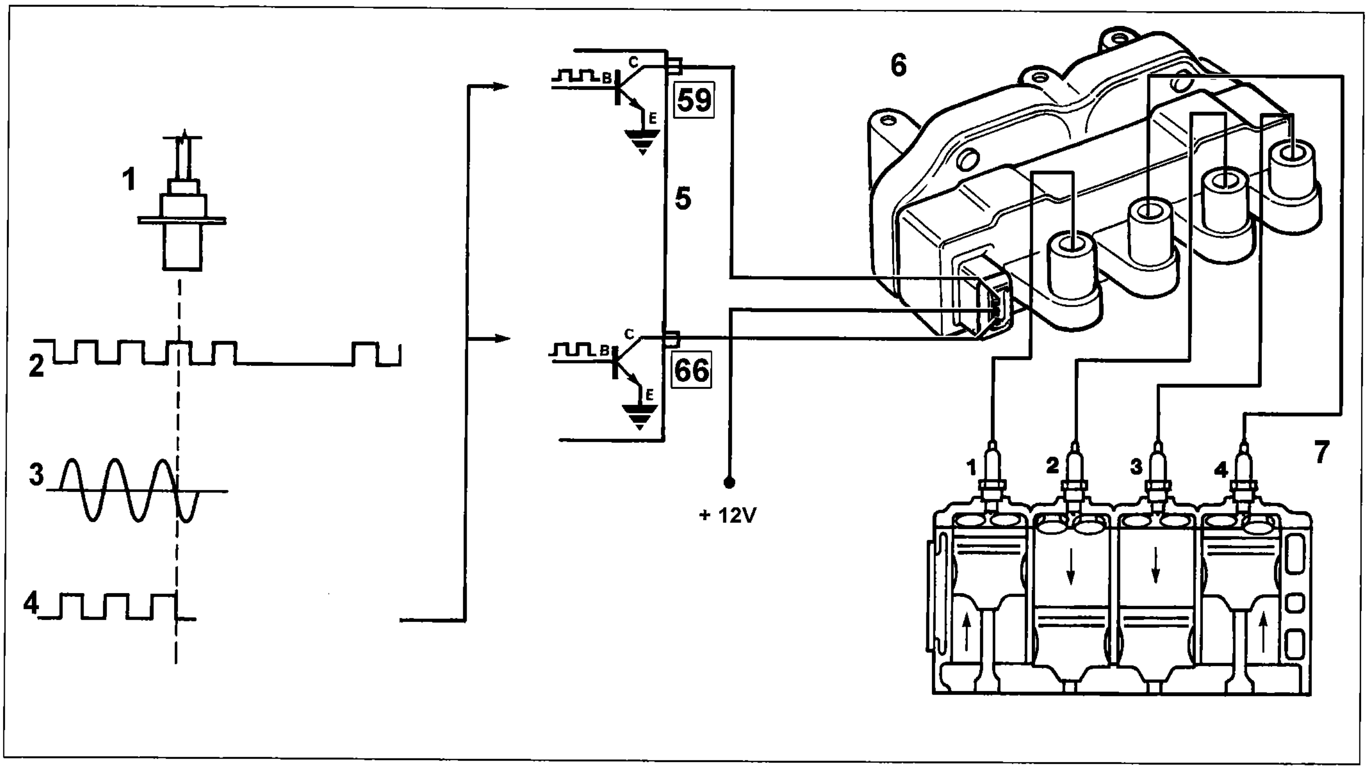
The gap or change in signal generated by the lack of two teeth on the phonic wheel, more specifically between the 58th and 1st tooth (known also as the synchronism tooth) which occurs each time the crankshaft pulley turns is a reference signal which allows the ECU recognition 114° in advance of TDC of piston pair 1-4 in correspondence to falling front of 20th tooth.

Once the ECU (see following page) has received the correct T.D.C. signal configuration, it establishes the point at which conduction (supply) to primary circuits of coils (6) begins through internal power module (5).

The rising side of signal (graph B in figure on previous page) therefore represents a moment within which alternative primary winding conduction could take place. This point can be established only by the control unit power module. The conduction time the H.T. coil needs in order to store sufficient energy is also defined by DWELL management strategies. This depends on the time taken by the current to reach about 6A in the coil primary winding and also on the calculation algorithm run by the microprocessor which uses factors saved in a special memory, obviously based on engine rpm

With reference to the figure on the previous page, the falling side of the signal, (B) conduction end point (or current drop to zero), is a categorical order to cut-off the current flowing in the primary winding and represents the ignition advance point (a) processed by the computer (advance - (a) - varies according to rpm).

The control unit (ECU) then controls spark advance in the different cylinders in relation to top dead centre and conduction time necessary for the coil to store energy by controlling the two power stages (corresponding to ECU pins 59 and 66). These in turn permit current to flow through primary windings of coils (6) for long enough to ensure the specified 6A current rating.



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Ignition operating diagram

1. RPM and TDC sensor.
2. Phonic wheel.
3. Signal pattern taken from phonic wheel (60-2) teeth.

   TDCs correspond to teeth 20 and 50.

4. Succession of rectangular square wave signals of constant amplitude
5. Ignition power module ()inside control unit.
6. Ignition coils.
7. Spark plugs

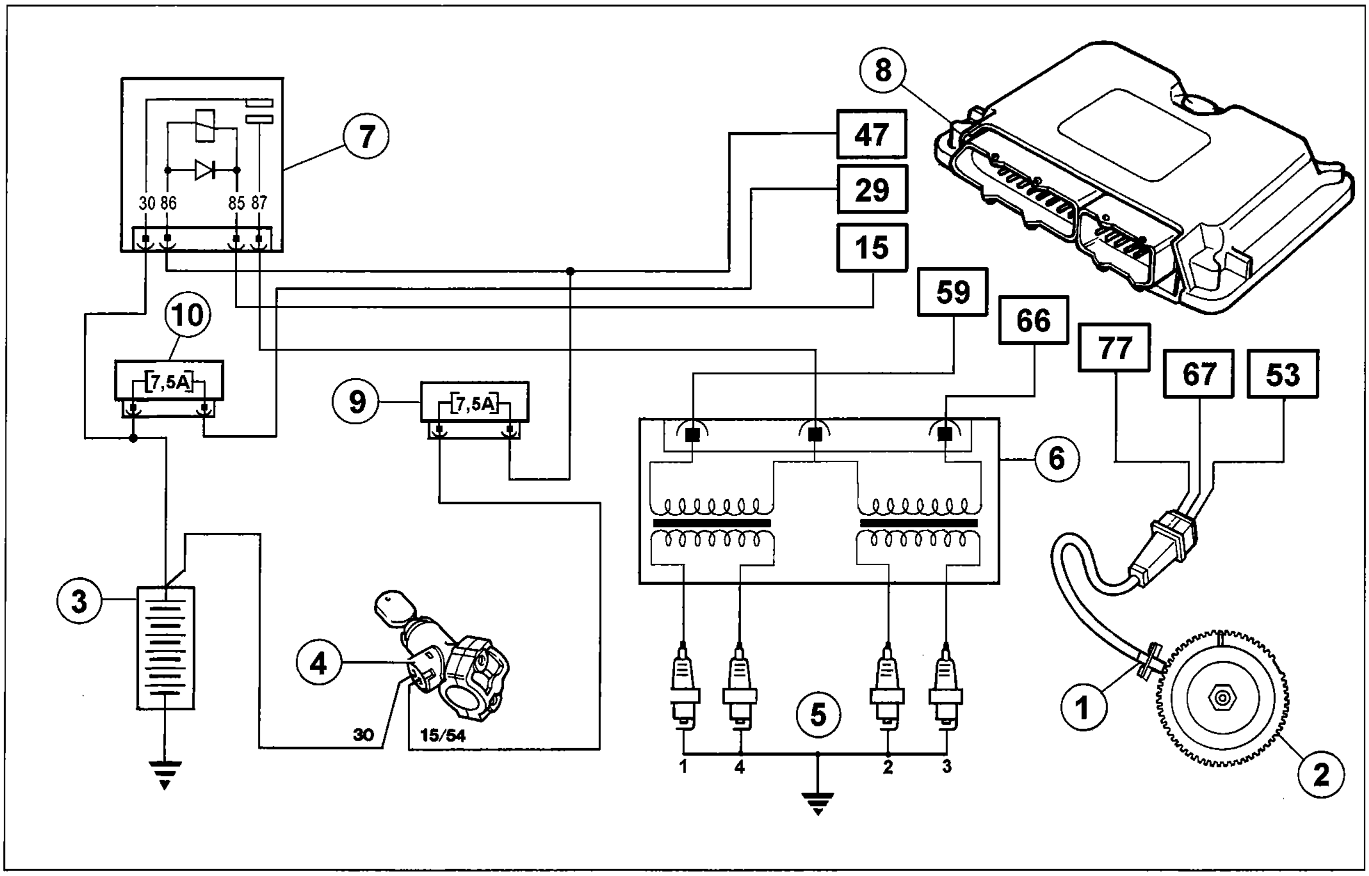
NOTE *The numbers in boxes indicate the corresponding control unit pins*

At the moment when the ECU de-activates one of the two power stages, current flow is cut off. This generates a voltage by induction (up to 30kV without loads) in the secondary winding.

When the voltage required for triggering an arc between the spark plug electrodes is examined, we note that voltage is high in the cylinder undergoing compression (about 10kV) while it is reduced (about 5kV) in the cylinder undergoing exhaust.

High tension distribution is static, i.e. takes place without a rotary brush and cap. This system effectively does away with a distributor. This gives the system a considerable advantage because it is known that brush and cap insulation properties play an important role. Any loss of insulation to earth may impair ignition: particularly during winter or periods of heavy rain.

The spark plugs of cylinders 1-4 and 2-3 are connected directly (in pairs) by means of high tension leads to coil secondary winding terminals and may be considered to be connected in series, because the cylinder head joins them all. This solution is also known as a "lost spark" system because the energy built up by the coil discharges almost exclusively on the electrodes of the spark plug located in the cylinder under compression to allow mixture ignition. The other spark is obviously unused because the cylinder does not contain mixture for ignition - solely exhaust gas ready for venting.



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1. Rpm and TDC sensor
2. Crankshaft pulley with phonic wheel
3. Battery
4. Ignition switch
5. Spark plugs
6. Ignition coils
7. Injection system relay
8. Electronic injection-ignition control unit
9. Injection-ignition system fuse
10. Injection-ignition control unit fuse

Controlling knock

This function detects the presence of knock by processing signals from relevant sensors. The ECU continually compares signals from sensors with a threshold level which is continually updated in turn to take into account background noise and engine age.

If the system detects the presence of knock, the strategy reduces the ignition advance until the phenomenon disappears. The advance is then gradually restored to the base setting or until knock recurs. Advance increases are implemented gradually, whereas reductions take place immediately.

When accelerating, a higher threshold is used to take into account increased engine noise in these circumstances.

The knock control strategy is also self-adaptive. This means that advance reductions repeated regularly are memorised in order to adjust mapping to the range of conditions experienced by the engine (use of low-octane fuel, for example). The strategy is able to restore the advance setting to the mapped level when the conditions that gave rise to the reduction cease.

FIAT CODE IGNITION IMMOBILISER MANAGEMENT

The system features an anti-theft function. This is implemented through a special FIAT CODE control unit able to dialogue with the engine control unit, and an electronic key with a specific sender unit designed for sending an identification code.

Once the key has been turned to STOP, the FIAT CODE system de-activates the engine control unit completely.

When the key is turned to MAR, the following operations take place in sequence:

1 - the engine control unit (whose memory contains a secret code) sends the FIAT CODE a request demanding that a secret code be sent to de-activate the function lock:

2 - the FIAT CODE control unit responds by sending the secret code only after receiving a recognition code sent by the ignition key;

3 - recognition of the secret code allows the engine control unit lock to be de-activated and normal operation to proceed.

NOTE *Due to the presence of the FIAT CODE immobiliser,* **DO NOT TEST** *the vehicle using another engine control unit. In this case, the FIAT CODE control unit would transfer the recognition code (unknown) to the test control unit, which would thus be rendered completely unserviceable on other vehicles.*

RADIATOR FAN MANAGEMENT

The ECU controls radiator fan operation directly according to coolant temperature and whether the air conditioning system is activated or not.

The fan comes on when the temperature exceeds 97 °C (1st speed) and 102 °C (2nd speed). The fan goes off with a hysteresis of 3 °C lower than the activation threshold.

High and low speed functions are controlled by specific relays located in the air conditioner control unit and controlled by the control unit.

ENGINE IDLE CONTROL

The main aim of this strategy is to maintain engine speed at around the mapped setting (warm engine: 850 rpm): the position assumed by the actuator is dependent on engine conditions/rpm and vehicle speed.

Start-up stage

When the key is inserted, the actuator takes up a position dependent on engine temperature and battery voltage (open-loop position).

Warming-up stage

The rpm is mainly corrected on the basis of coolant temperature.

With the engine warm, idle management is dependent upon the signal from the rpm sensor. The ECU introduces sustained idle when external loads are activated.

Over-run

When the accelerator is released when the car is not idling, the ECU governs the actuator (step motor) by measn of special delivery curve (dash-pot curve), i.e. delays the return of the plunger to its housing to optimise the engine braking effect.

FUEL VAPOUR RECIRCULATION MANAGEMENT

The strategy controls vapour cut-off solenoid position as follows:

- during start-up, the solenoid remains closed to prevent fuel vapours enriching the mixture excessively. This condition persists until coolant temperature reaches 65° C;
- with the engine warm, the ECU sends the solenoid a square wave signal (duty-cycle control) which modulates opening.

In this way, the ECU controls the amount of fuel vapour directed to the intake, thus avoiding substantial changes in mixture concentration.

Under the following operation conditions:

- throttle valve closed
- speed less than 1500 rpm
- intake manifold pressure less than a lower threshold calculated by the ECU on the basis of rpm level

solenoid control is inhibited with the same closure position maintained. This makes engine operation more efficient.

TEST MANAGEMENT

Full injection-ignition system electronic testing can be achieved by connecting an appropriate device (EXAMINER or SDC station) to the test socket.

The system is also equipped with a self-diagnostic function which recognises, memorises and indicates any faults.

If sensors or actuators are found to be faulty, signal reconstruction strategies are immediately activated (recovery) so that the engine is able to operate at an acceptable level without affecting function. The car can then be driven to a service point for the necessary repairs.

HEATING/VENTILATION SYSTEM MANAGEMENT

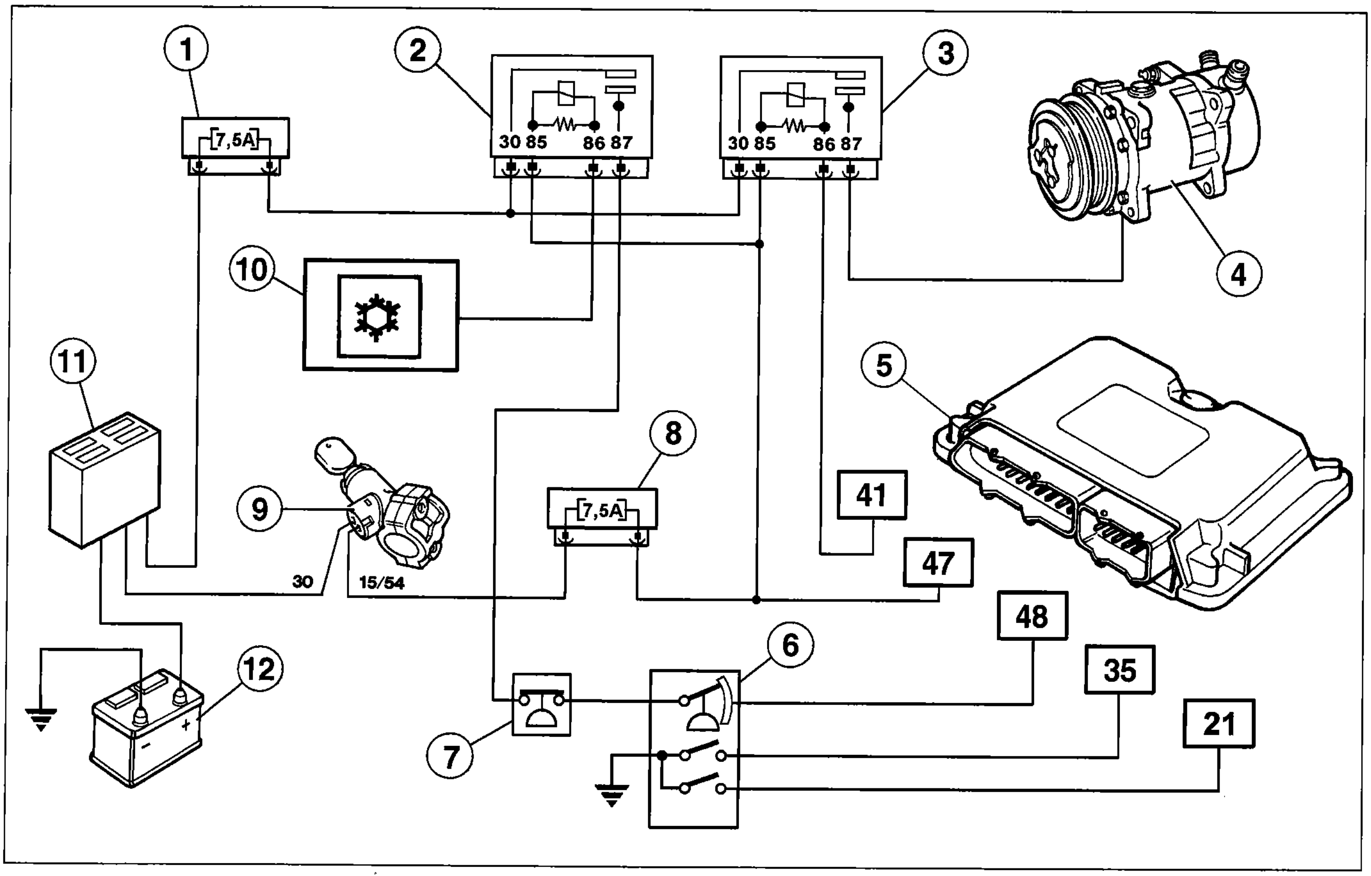
The injection-ignition control unit is connected operationally to the air conditioning system because:

1. a compressor activation request is received and appropriate action is taken (supplementary air);
2. compressor activation is enabled via pin 41, when certain pre-established conditions are satisfied;
3. information on 4-level thermostat status is received through pins 21, 35, 48 and appropriate action is taken (radiator fan activation).

With regard to point 1, if the engine is idling, the ECU increases the flow of air from the idle actuator ahead of compressor activation while the actuator is restored to normal position with a delay in relation to compressor de-activation.

With regard to point 2, the ECU automatically controls compressor de-activation:

- for a few seconds (timed de-activation):
  - during high power demands on the engine (strong acceleration)
  - engine take-off;
- as long as the following critical conditions persist:
  - for coolant temperatures in excess of a set threshold
  - for engine speeds less than 750 rpm.



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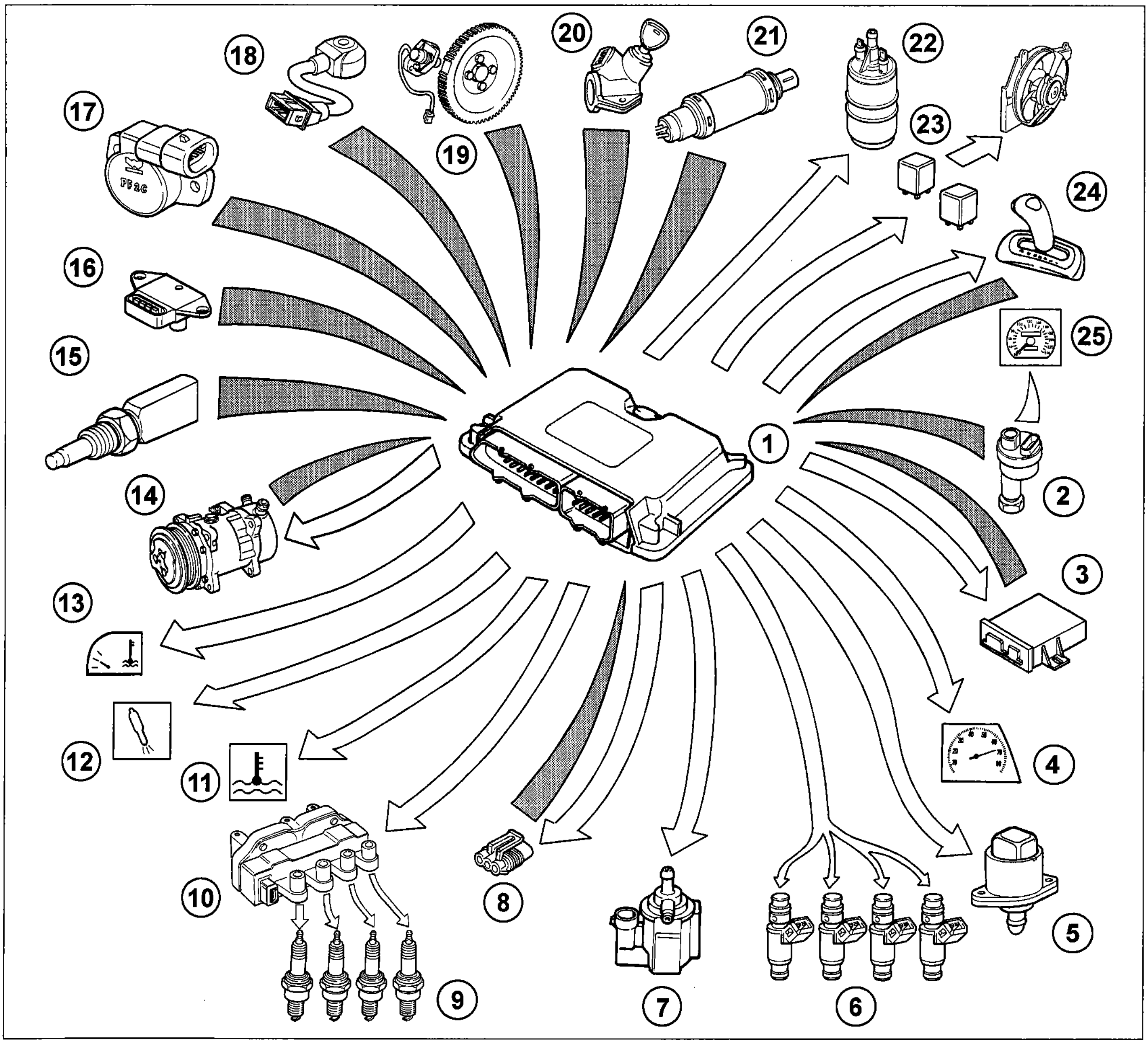
1. Climate control system fuse
2. Heating/ventilation system relay
3. Compressor electromagnetic coupling supply relay
4. Compressor
5. Injection-ignition ECU
6. Pressure switch
7. Defrosting sensor
8. Injection-ignition control unit fuse
9. Ignition switch
10. Climate control system control unit
11. Power fuse box
12. Battery

DIAGRAM SHOWING INFORMATION INPUT/OUTPUT FLOWS BETWEEN CONTROL UNIT AND INJECTION-IGNITION SYSTEM SENSORS/ACTUATORS



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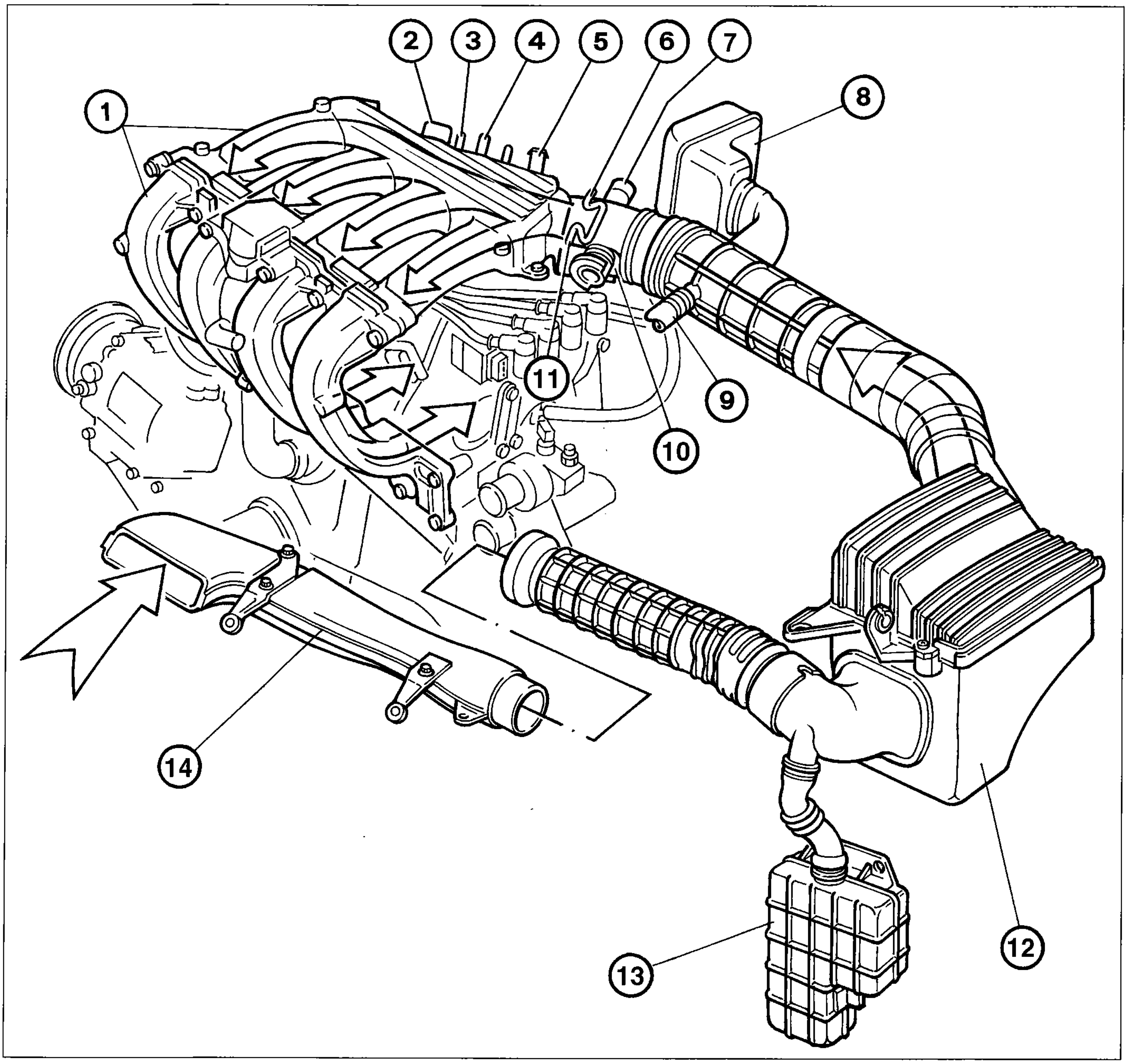
1. Electronic control unit
2. Speedometer sensor
3. FIAT CODE control unit
4. Rev counter
5. Engine idle speed actuator
6. Injectors
7. Fuel vapour solenoid
8. Diagnostic socket
9. Spark plugs
10. Ignition coils
11. Excessive coolant temperature warning light
12. Injection warning light
13. Coolant temperature gauge
14. Heating/ventilation system
15. Engine coolant temperature sensor
16. Intake air pressure and temperature sensor
17. Butterfly valve position sensor
18. Knock sensor
19. Rpm and TDC sensor
20. Ignition switch
21. Lambda probe
22. Electric fuel pump
23. Radiator fan high and low speed control relays
24. Automatic transmission
25. Speedometer / mileometer

AIR INTAKE CIRCUIT MANAGEMENT



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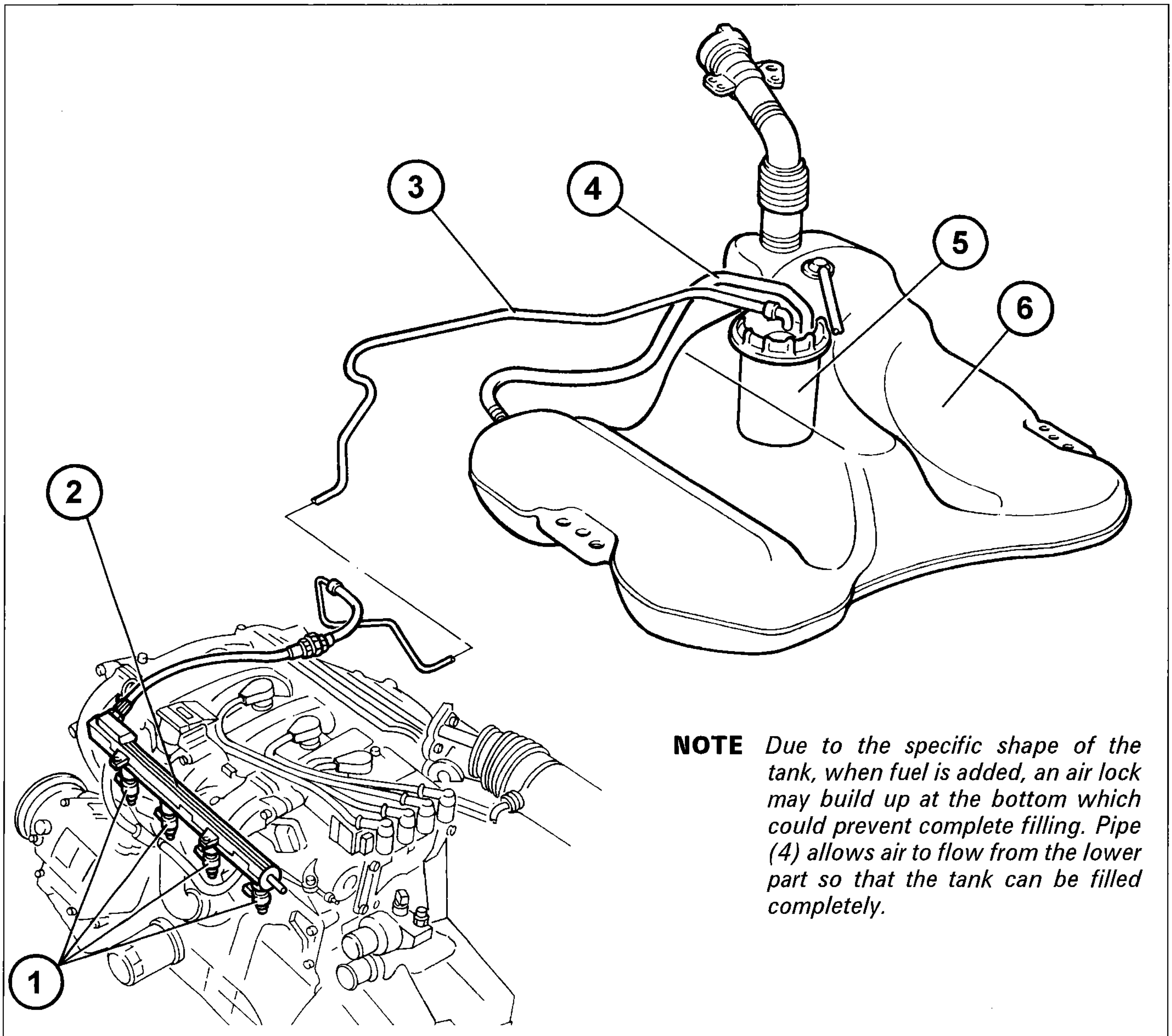
The air intake circuit consists of various parts which are responsible for carrying the amount of air required by the engine under various service conditions.

1. Inlet manifold
2. Intake air temperature and pressure sensor
3. Fuel evaporation control system point
4. Engine block gas (blow-by gas) intake for recirculation of idling exhaust gases
5. Brake servo intake
6. Attachment for engine coolant outlet pipe
7. Engine idle speed actuator
8. Upper resonator
9. Main crankcase gas intake
10. Throttle body
11. Attachment for coolant intake for heating throttle body
12. Air cleaner
13. Lower resonator
14. Inlet fitting

FUEL SUPPLY CIRCUIT DIAGRAM



NOTE *Due to the specific shape of the tank, when fuel is added, an air lock may build up at the bottom which could prevent complete filling. Pipe (4) allows air to flow from the lower part so that the tank can be filled completely.*

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1. Injectors
2. Fuel supply manifold
3. Fuel delivery line to injectors
4. Vent pipe
5. Electric fuel pump with filter and pressure regulator
6. Reservoir

Fuel is supplied to the system via an electrical pump submerged in the tank. This takes up fuel and sends it to the injectors.

The fuel feed system is returnless, i.e. only one pipe connects fuel tank and engine.

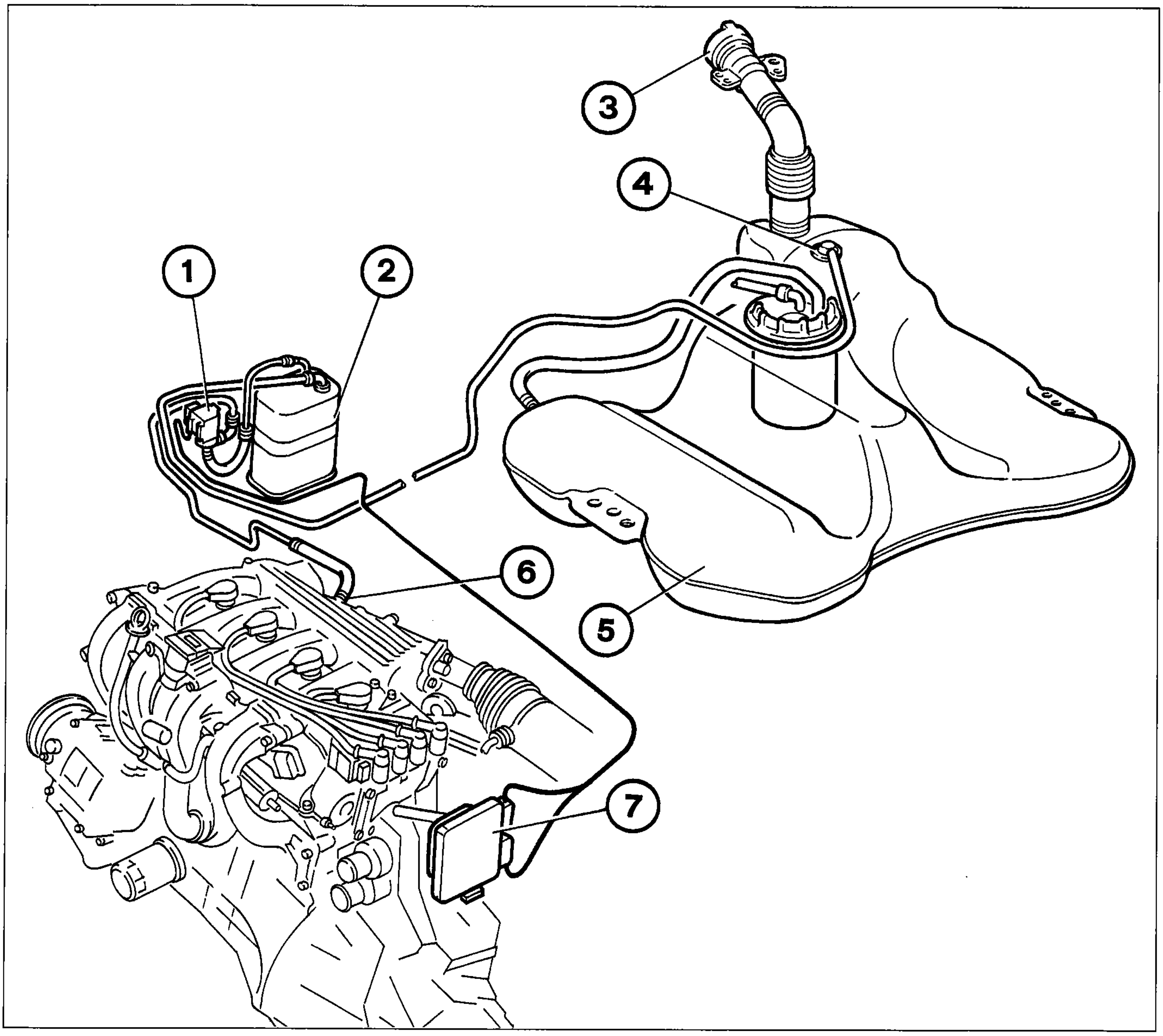
This system:

- minimises the possibility of vehicle fires in the case of an accident;
- reduces fuel vapour emissions into the atmosphere;

The electric fuel pump is enclosed in a basket. This also houses the fuel pressure regulator, fuel level gauge and fuel filter.

The system is also fitted with an inertia switch. This cuts off fuel flow from the electric fuel pump in the case of vehicle impact.

FUEL EVAPORATION CONTROL CIRCUIT DIAGRAM

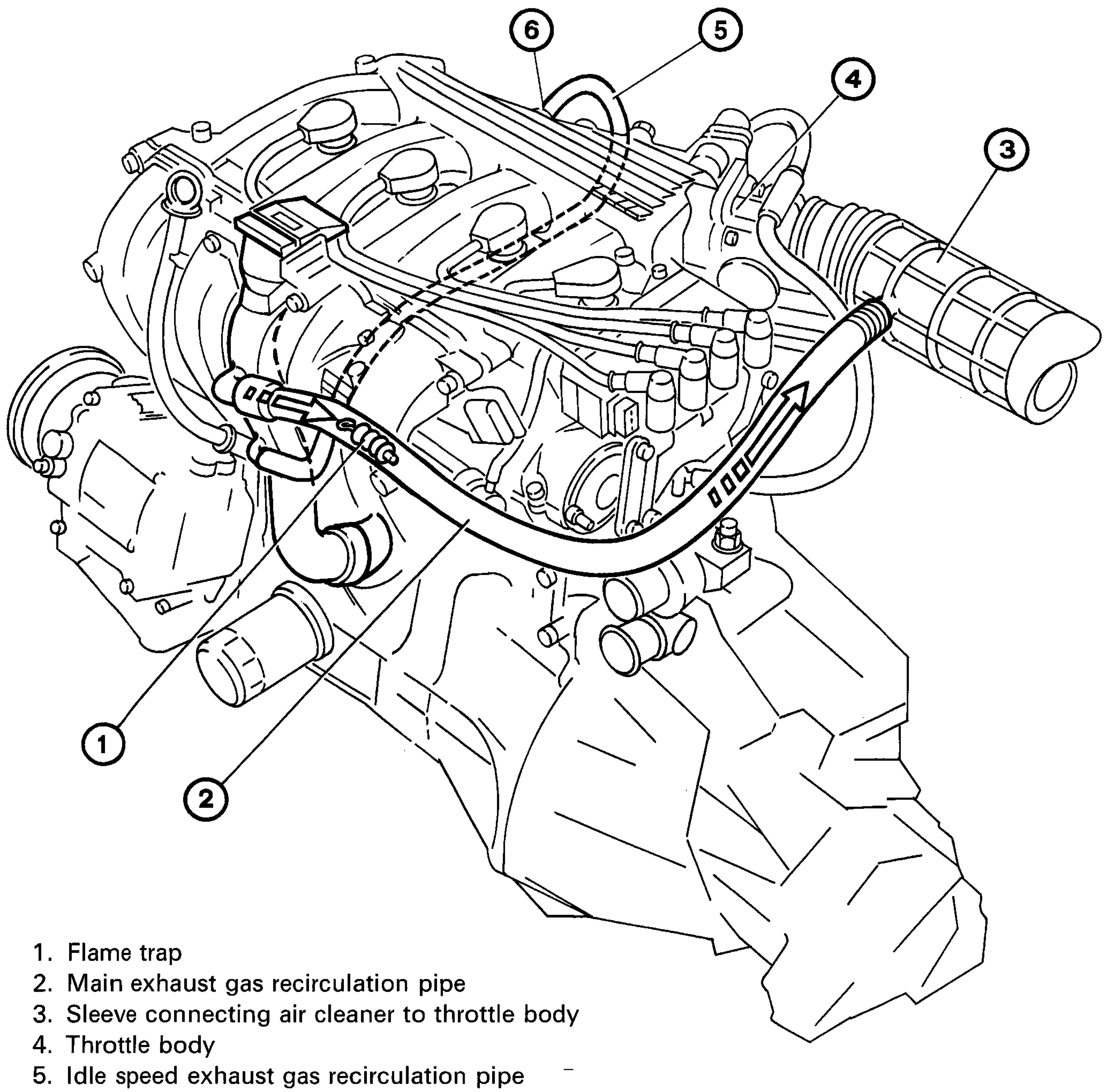


P4F18IJ01

1. Fuel vapour cut-off valve
2. Active carbon trap filter
3. Safety and ventilation valve
4. Multifunction valve
5. Reservoir
6. Fuel vapour intake fitting in intake manifold
7. Injection-ignition ECU

The tank ventilation system is closed-loop type.
This system prevents fuel vapours formed in the tank and fuel system from escaping into the atmosphere and releasing their load of polluting light hydrocarbons (HC).
The system consists of a tank (5), multifunction valve (4) for controlling vapour flow, a two-way safety and ventilation valve (3) located on the fuel filler fitting, an active carbon filter (2) and a fuel vapour cut-off valve (1) controlled by control unit (7).

BLOW-BY GAS RECIRCULATION DIAGRAM



1. Flame trap
2. Main exhaust gas recirculation pipe
3. Sleeve connecting air cleaner to throttle body
4. Throttle body
5. Idle speed exhaust gas recirculation pipe
6. Calibrated hole

P4F19IJ01

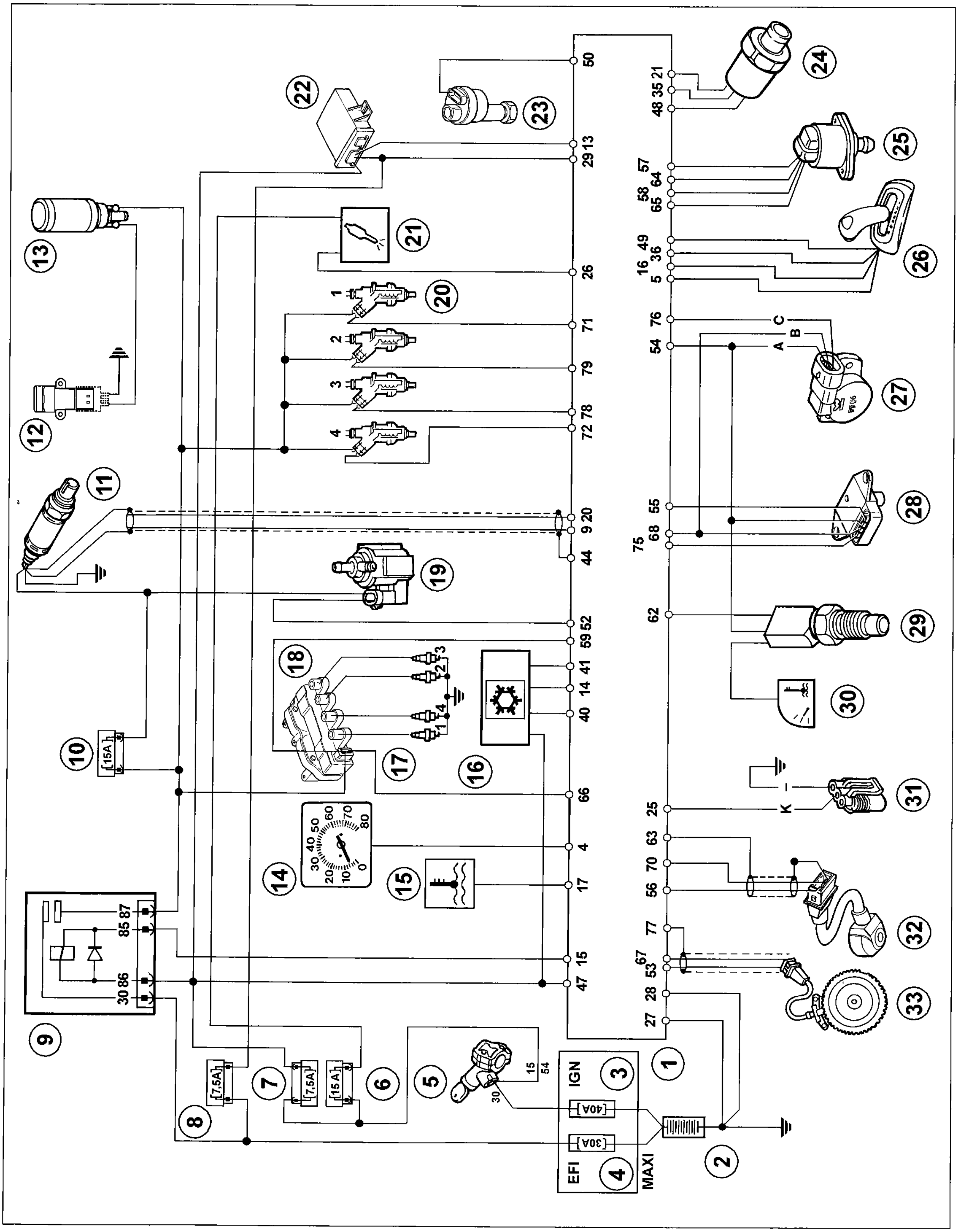
The system controls emission, from the engine block, of vent gases made up of air-fuel mixtures, burnt gases which leak through piston rings and lubricant oil vapours by recirculating them to the intake.

With the accelerator throttle open, vent gases from the engine block reach the sleeve connecting the air cleaner-throttle body (3) through pipe (2). This contains a flame trap (1) which prevents combustion caused by flame flashing back from throttle body (4).

With the throttle closed (engine idling), the vacuum in the intake manifold takes up gas (in limited quantities) directly through pipe (5) and calibrated hole (6).

10.

INJECTION-IGNITION SYSTEM WIRING DIAGRAM

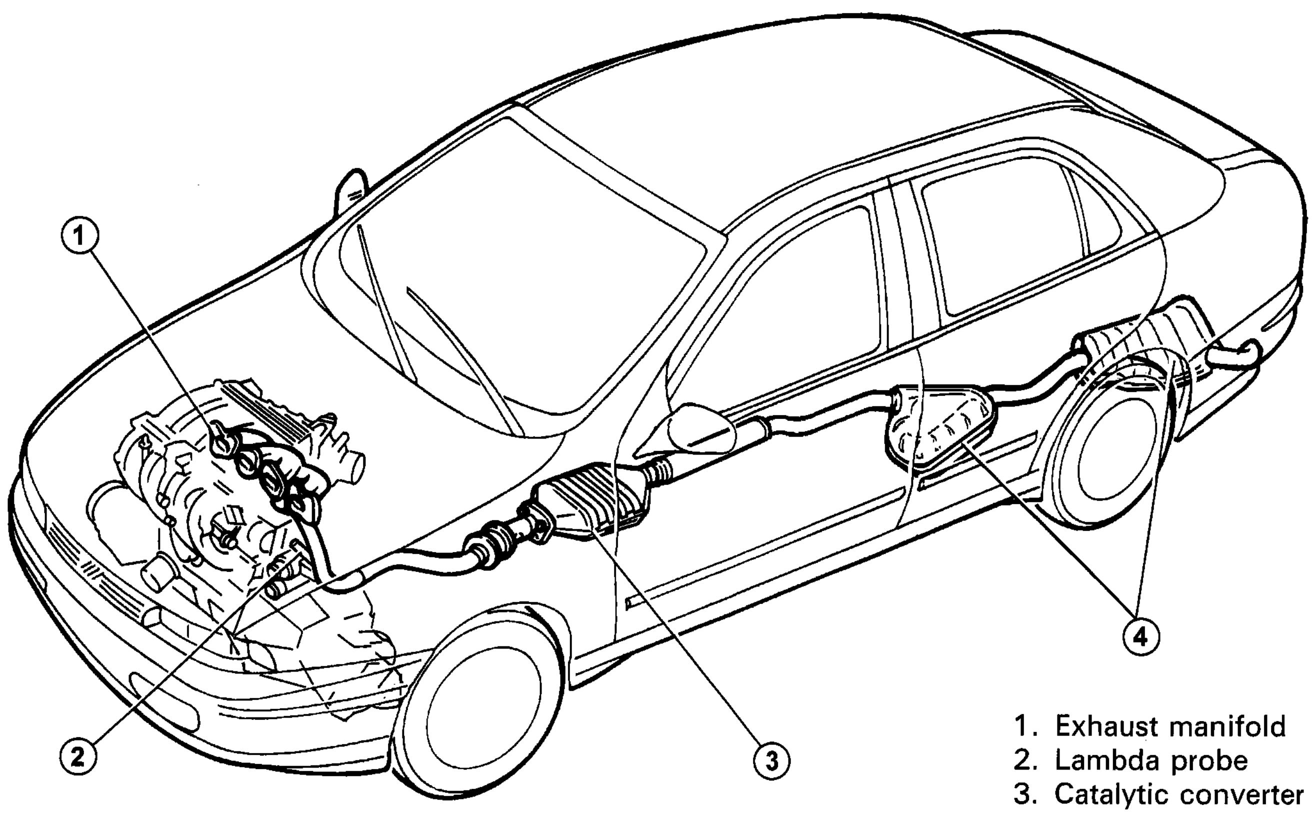


P4F20IJ01

Key to injection - ignition system wiring diagram components

1. Electronic injection-ignition control unit
2. Battery
3. 40A master fuse for services activated by ignition key
4. 30A master fuse for injection - ignition system
5. Ignition switch
6. 15A fuse for injection system warning light
7. 7.5A fuse for various injection system components and injection ECU +15 supply
8. Injection control unit (+30
9. Fuel pump relay, lambda probe, fuel vapour cut-off solenoid, ignition coils and injectors
10. 15A fuse protecting lambda probe and fuel vapour cut-off solenoid
11. Lambda probe
12. Inertia switch
13. Electric fuel pump
14. Rev counter
15. Excessive coolant temperature warning light
16. Heating/ventilation control unit and radiator fan high and low speed control relays
17. Spark plugs
18. Ignition coils
19. Fuel vapour cut-off solenoid
20. Injectors
21. Injection - ignition system failure warning light
22. FIAT CODE control unit
23. Speedometer sensor (vehicle speed)
24. Pressure switch (four stage)
25. Engine idle speed actuator (step motor)
26. Automatic transmission ECU
27. Throttle valve position sensor
28. Intake air pressure and temperature sensor
29. Coolant temperature sensor
30. Coolant temperature gauge
31. Diagnostic socket
32. Detonation sensor
33. Rpm and TDC sensor

ENGINE EXHAUST ASSEMBLY DIAGRAM



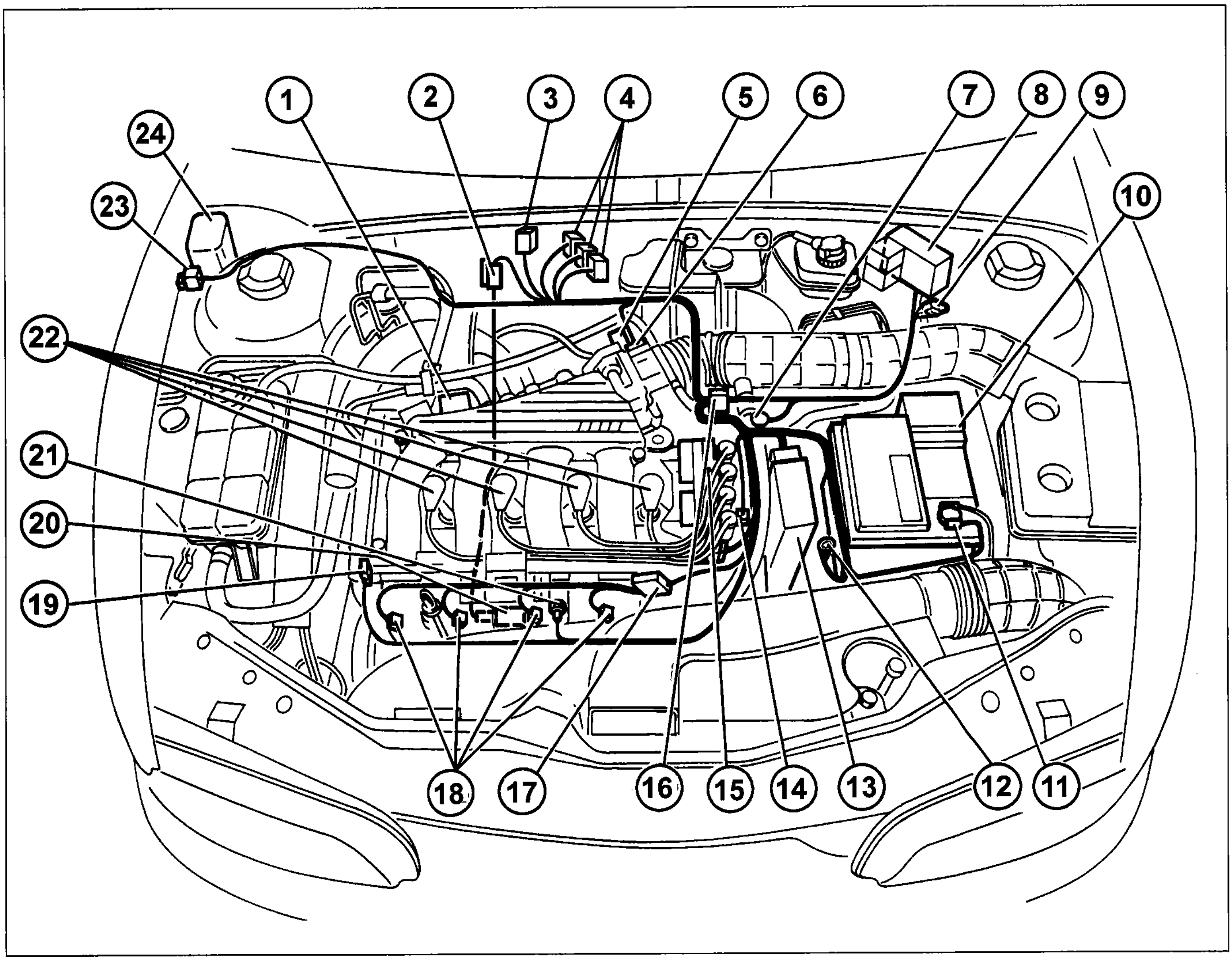
1. Exhaust manifold
2. Lambda probe
3. Catalytic converter
4. Silencers

P4F22IJ01

In the I.A.W. system, closed-loop mixture concentration control is activated by a lambda probe sensor. This measures the amount of oxygen in exhaust gas upstream of the catalytic converter.
The lambda probe readings allow the electronic control unit to correct the concentration continually to maintain the air/fuel ratio constant.
Harmful exhaust emissions are controlled in this way. This control is complemented by a trivalent catalytic converter.
Efficient catalytic converter operation and the ability to contain exhaust gas toxicity are dependent on the air/fuel ratio supplied to the engine.
The trivalent catalytic converter reduces the three pollutant gases present in exhaust gases simultaneously: uncombused hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx).
Two types of chemical reaction take place inside the catalytic converter:
- oxidation of CO and HC to carbon hydroxide (CO_2) and water (H_2O)
- reduction of NOx, to nitrogen (N_2).

The catalytic converter is put rapidly and irreparably out of action by the following:
- presence of lead in fuel. This lowers the level of conversion to levels that render the catalyst ineffective;
- presence of uncombusted fuel in the converter. A fuel flow lasting 30s in an environment at 800 °C (temperature insde the catalytic converter) is sufficient to cause melting and breakdown of the catalytic converter. It is absolutely necessary to ensure the ignition system is working properly. Therefore **the spark plugs should never be disconnected for for any reason with the engine running. When tests are carried out, the catalytic converter should be replaced with an equivalent length of piping.**

LOCATION OF INJECTION-IGNITION SYSTEM COMPONENTS



P4F23IJ01

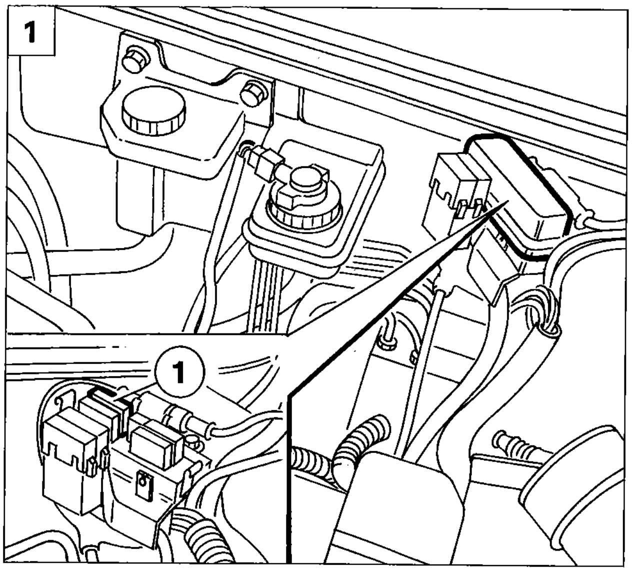
Key to components

1 Intake air temperature and pressure sensor
2 Lambda probe coupling
3 Injection system relay
4 Protective fuses
5 Engine idle speed actuator
6 Throttle position sensor
7 Vehicle speed sensor
8 General 30A system fuse
9 Diagnostic socket
10 Battery
11 Earth on negative battery lead
12 Connection between injection earth and car body earth
13 Injection-ignition ECU
14 Coolant temperature sensor
15 Ignition coils
16 Joint between injection lead and front lead
17 Injector lead coupling
18 Injectors
19 Rpm and TDC sensor
20 Lambda probe
21 Detonation sensor
22 Spark plugs
23 Fuel vapour cut-off solenoid
24 Carbon filter

INJECTION - IGNITION SYSTEM FUSES AND RELAYS

General system protection fuse (fig. 1)

The general fuse (30A) protecting the injection-ignition system (1) is housed inside a container; to gain access to the fuse, undo side clips and lift lid.

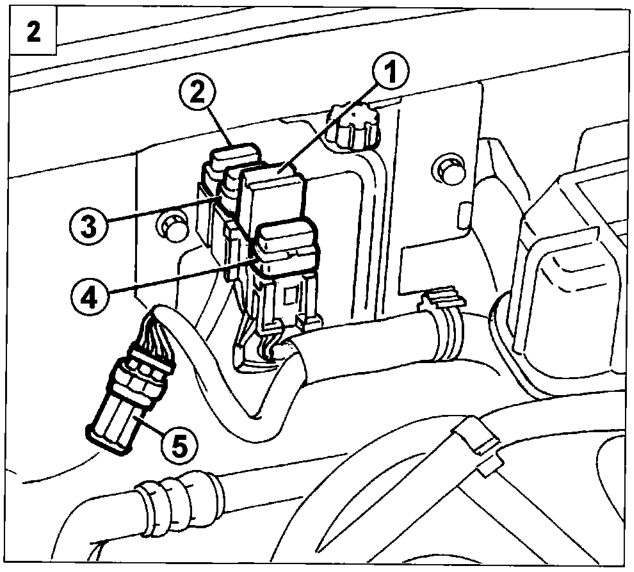


P4F24IJ01

Fuses and relay (fig. 2)

The following components are housed on a bracket located against the rear wall of the engine bay:

1. System relay
2. 7.5A fuse protecting +15/54 power source
3. 7.5A fuse protecting +30 power source
4. 15A fuse protecting lambda probe and fuel vapour solenoid
5. Lambda probe lead junction

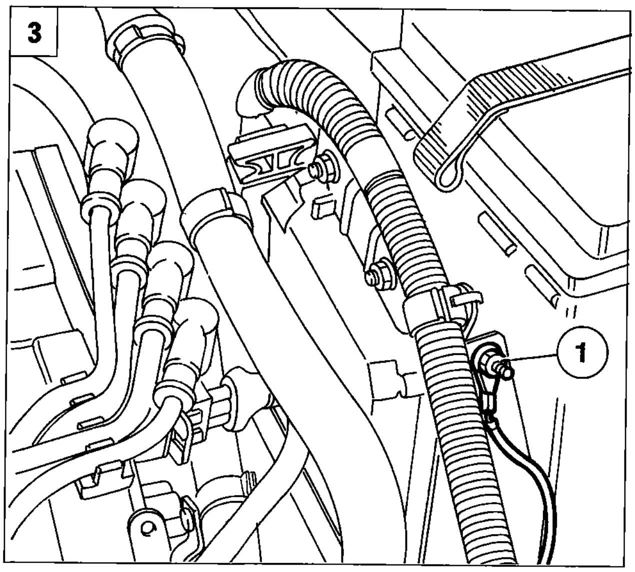


P4F24IJ02

EARTH POINTS (fig. 3)

To increse electromagnetic compatibility and functional reliability, the earth points are arranged as follows:

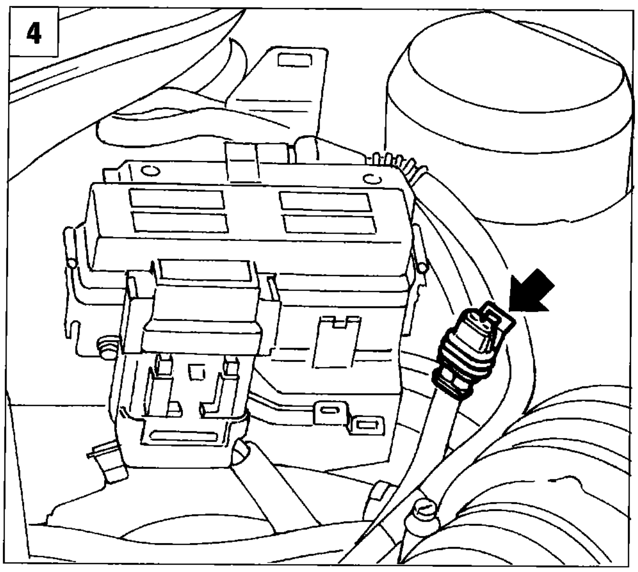
- The main injection-ignition system earth is directly connected to the battery negative terminal.
- The earth of the injection-ignition ECU container (1) is connected to the car body earth on the control unit bracket.



P4F24IJ03

TESTER SOCKET (fig. 4)

The test socket for connection of an SDC station or EXAMINER is located alongside the power fuse box.



P4F24IJ04

COMPONENTS OF INJECTION-IGNITION SYSTEM

The injection-ignition system consists mainly of wiring, an electronic control unit (ECU) and the following sensors and actuators:

Sensors

- Rpm and TDC sensor
- Knock sensor
- Throttle position sensor
- Coolant temperature sensor
- Intake air temperature and pressure sensor
- Vehicle speed sensor
- Lambda probe

Actuators

- Engine idle speed actuator
- Electric fuel pump
- Fuel vapour cut-off valve
- Injectors
- Ignition coils

INJECTION-IGNITION SYSTEM WIRING

The various system components are connected by a single wiring system fitted with connectors of various types. These are grouped in special ducts fitted to the engine (prewiring).

INJECTION-IGNITION ECU

The injection - ignition system control unit adopted is specific to this version. It is connected to the electrical wiring by two connectors. These are 52 pin (upper connector) and 28 pin (lower connector) respectively.

This digital, microprocessor unit features high computing capacity and is accurate, reliable and versatile. It consumes little energy and is maintenance-free.

The ECU's task is to process signals from the various sensors through the application of software algorithms and control the actuators in order to achieve optimal engine performance.

Essential features of the electronic control unit are as follows:

- Data acquisition and coding section
- Microprocessor
- ROM memory
- RAM memory
- EEPROM memory
- Drivers

a. Data acquisition and coding section

This consists of a set of electronic components (A/D converters) designed to receive data in the form of analogue electrical signals. Inside, the signals are converted into digital signals, processed and stored.

b. Microprocessor

This electronic component is responsible for computing and managing acquired data. It is thus a true computer and its main tasks include: consulting memories, comparing data input with sample data, managing actuator control circuits.

c. ROM memory (Read Only Memory)

This contains all programs necessary for microprocessor operation. Because the unit is programmed permanently prior to installation, data may be read but not modified.

The ROM memory is conservative; commands are saved even when the battery leads are disconnected.

d. RAM memory (Random Access Memory)

The RAM memory is a transitional memory where data can be read and saved.

This memory is actually used to save input data temporarily so that they are available for processing and also to memorize signals for coding operating anomalies that may occur within sensors, actuators or ECU functions.

The RAM memory is divided into sections: the first volatile part, for data memorization, is enabled with ignition key in MARCIA position and deleted in STOP position.

The second non-volatile part, (RAM STAND-BY) is used to store self-adaptive corrections made to idle speed opening, idle speed actuator and throttle valve angular position when the throttle is fully closed. It also saves engine parameters and adapts them in time. In other words, the ECU uses the Lambda probe signal to modify and store an injection time correction factor that influences mixture concentration.

For self-adaptive idle speed actuator corrections to be maintained, they require a continuous supply from the battery.

If the battery, dual relay or terminals are disconnected, the parameters are zeroed. Normal vehicle use resets the adaptation process and new parameters are memorized.

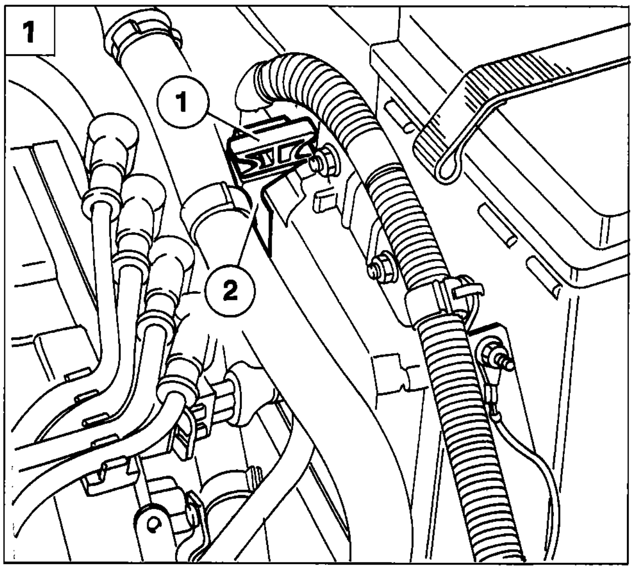
e. EEPROM memory (Electrical Erasable Programmable Read Only Memory)

his is a special type of memory that can be deleted electrically and reprogrammed again and again. One of its functions is to receive from the RAM STAND-BY recordings of anomalies that have arisen during engine operation and send these through the diagnostic socket to a Fiat-Lancia Tester. A Fiat-Lancia Tester must be used in active diagnosis in order to delete the anomalies.

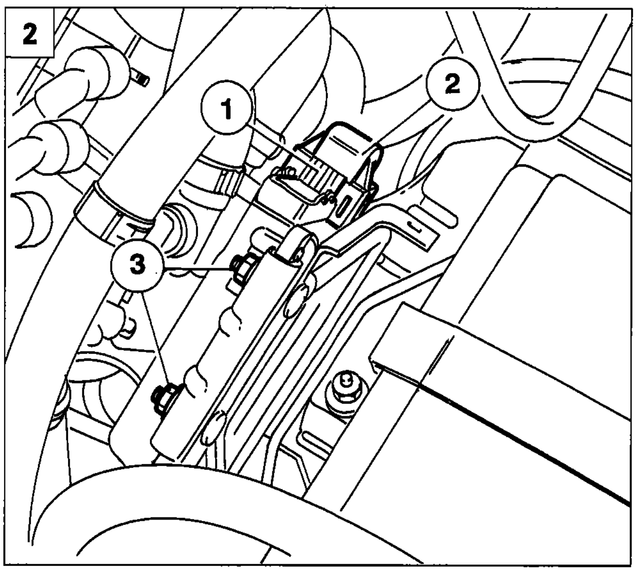
The presence of a non volatile memory allows data relating to system anomalies to be saved even if the battery is disconnected and anomalies to be indicated even once they have been disappeared.

f. Drivers (final power stages for actuator control)

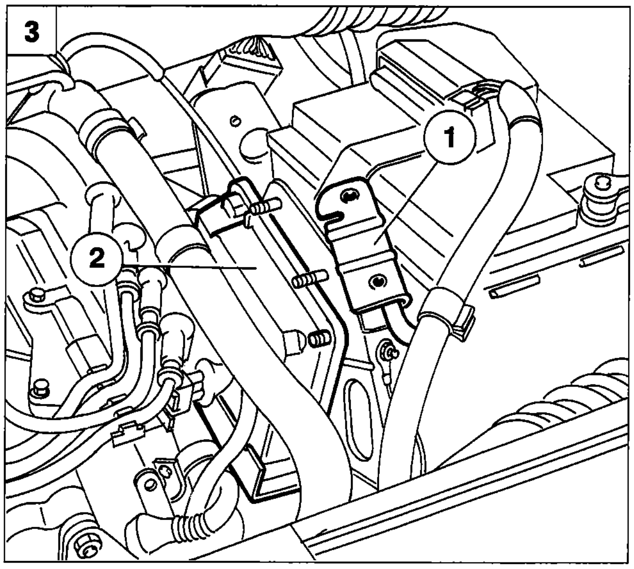
These circuits are driven directly by the microprocessor and the relevant integrated circuit. They are used to supply actuators such as: injectors, motor for idle control, fuel vapour cut-off valve and fuel pump relay.



P4F27IJ01



P4F27IJ02



P4F27IJ03

Removing-refitting

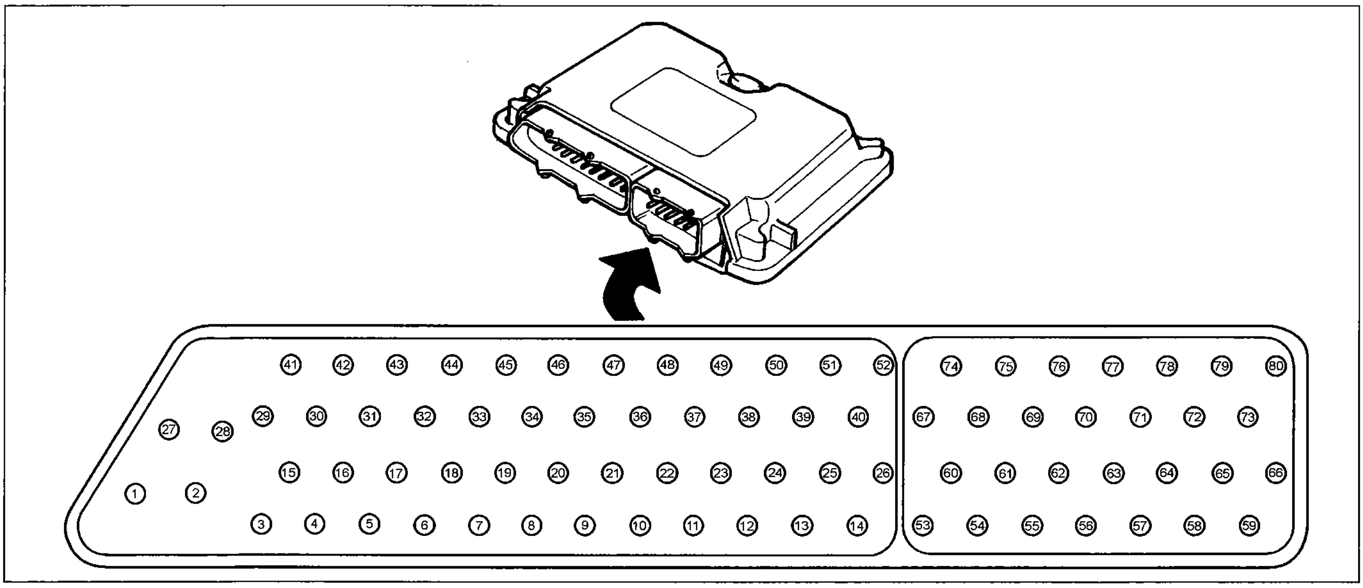
1. Lift up lock (1) and disconnect upper connector (2).
2. Pull down lock device (1) and disconnect lower connector (2) then undo retaining nuts (3).
3. Disconnect bracket (1) and remove, then remove the injection-ignition control unit (2).

It is absolutely prohibited to exchange injection control units between different vehicles in order to check their efficiency.

Before replacing an ECU as a result of testing, ensure it is really faulty because when a new ECU is activated, the secret Fiat CODE system code is memorised and this makes the unit completely unusable on other vehicles.

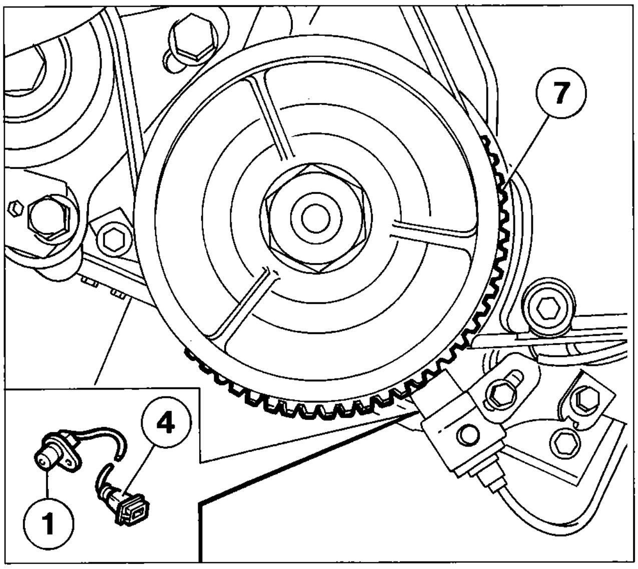
Unconnected pins may be live. Do not connect anything because this could lead to short-circuits and damage to the control unit.
Fit and remove the multiple connector with the ignition key removed.

Identifying connections on injection-ignition control unit (pin-out)



P4F28IJ01

1-3. Not connected
4. Rev counter signal
5. Automatic transmission ECU (coolant temperature signal)
6-8. Not connected
9. Lambda probe (negative)
10-12. Not connected
13. FIAT CODE control unit
14. Radiator fan high speed control (versions with air conditioner)
15. Injection system relay enablement
16. Automatic transmission ECU (throttle valve angle)
17. Excessive coolant temperature warning light
18-19. Not connected
20. Lambda probe (positive)
21. 4-stage pressure switch
22-24. Not connected
25. Diagnostic socket (K line)
26. Injection system warning light
27-28. Earth
29. Fused power source (+30)
30-34. Not connected
35. Radiator fan low speed activation request signal
36. Automatic transmission ECU (torque reduction signal)
37-39. Not connected
40. Radiator fan low speed control (versions with air conditioner)
41. Air conditioner compressor relay
42-43. Not connected
44. Lambda probe lead shielding
45-46. Not connected
47. Power source (+15)
48. Air conditioner activation request
49. Automatic transmission ECU (gear change signal)
50. Vehicle speed signal
51. Not connected
52. Fuel vapour solenoid
53. Rpm sensor (positive)
54. Earth for coolant temperature, air pressure/temperature and throttle valve position sensors.
55. Inlet air temperature
56. Knock sensor (positive)
57. Engine idle speed actuator
58. Engine idle speed actuator
59. Ignition coils (cylinders 1-4)
60. Throttle valve position sensor power source
61. Not connected
62. Coolant temperature sensor (positive)
63. Knock sensor lead shielding
64. Engine idle speed actuator
65. Engine idle speed actuator
66. Ignition coils (cylinders 2-3)
67. Rpm sensor (negative)
68. Intake air pressure/temperature sensor power source
69. Not connected
70. Knock sensor (negative)
71. Cylinder no. 1 injector
72. Cylinder no. 4 injector
73-74. Not connected
75. Intake air pressure signal
76. Throttle valve position sensor
77. Rpm sensor lead shielding
78. Cylinder no. 3 injector
79. Cylinder no. 2 injector
80. Not connected



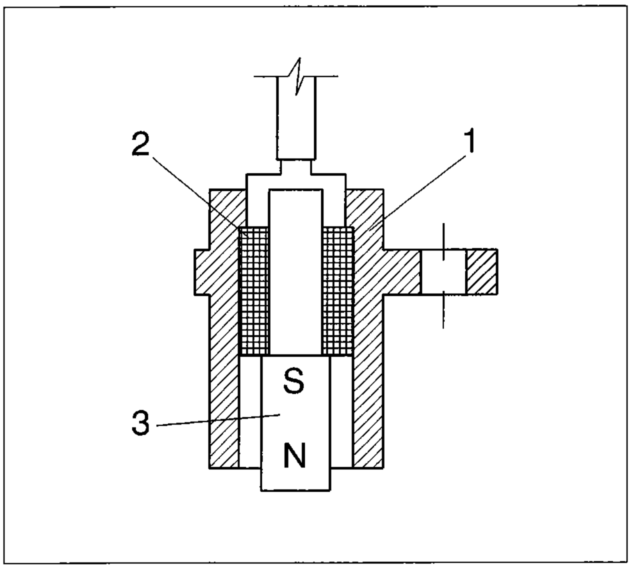
P4F291J01

RPM AND TDC SENSOR (Jaeger CVM02)

RPM and crankshaft angular position reference (TDC indicator) sensor (1) is secured to the engine block facing phonic wheel (7) located on the crankshaft pulley.

Principle of operation

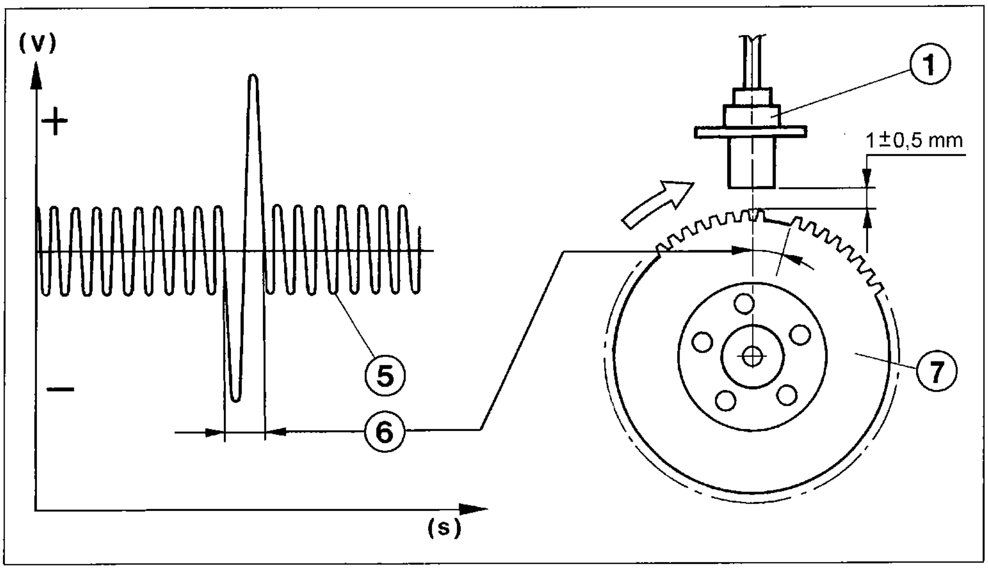
This consists of a tubular case (1) containing a permanent magnet (3) and an electrical coil (2).The magnetic flux set up by magnet (3) undergoes fluctuations due to changes in the gap as the teeth pass in front of the phonic wheel.



P4F291J02

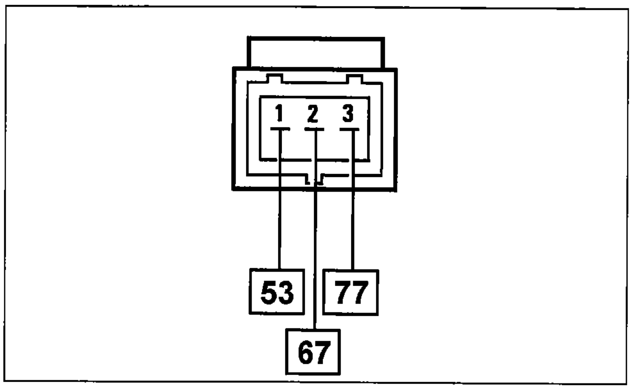
These magnetic flux changes set up an electromotive force in coil (2). An alternating positive (teeth facing sensor) and negative (gap facing sensor) voltage is set up at coil terminals. The sensor output voltage peak value depends on the gap beteween sensor and phonic wheel teeth if all other factors are equal.

Two of the sixty teeth on the phonic wheel are removed to create a reference gap. Gear pitch therefore corresponds to an angle of 6° (360° divided by 60 teeth). The synchronism point is recognised at the end of the first tooth following the space left by the two missing teeth. When this gap passes beneath the sensor, engine piston pair 1-4 is located at 114° before TDC.



P4F291J03

1. Sensor
2. Winding
3. Permanent magnet
4. Sensor connector
5. Output signal
6. Signal corresonding to the two missing teeth
7. Crankshaft pulley with phonic wheel



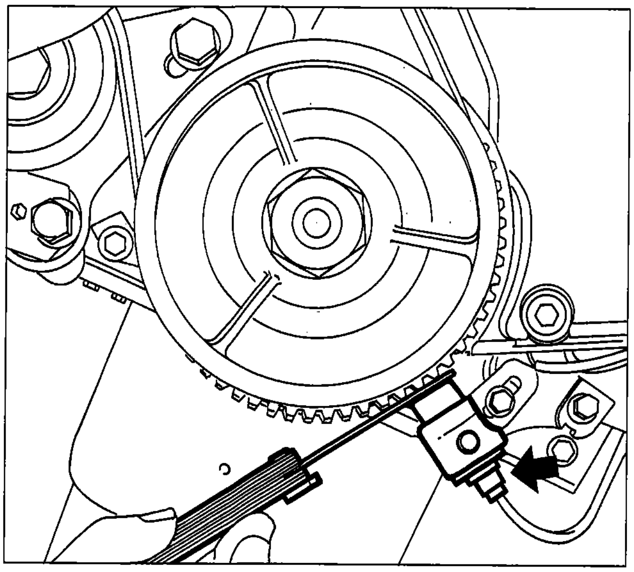
P4F30IJ01

Wiring connector

The sensor is connected to the ECU by means of twisted wires covered by a shielded, interference-proof sheath.

Pin 1 - Signal
Pin 2 - Earth
Pin 3 - Shielding

NOTE *The numbers in boxes indicate corresponding control unit pins.*



P4F30IJ02

Removing-refitting

Disconnect electrical connection.

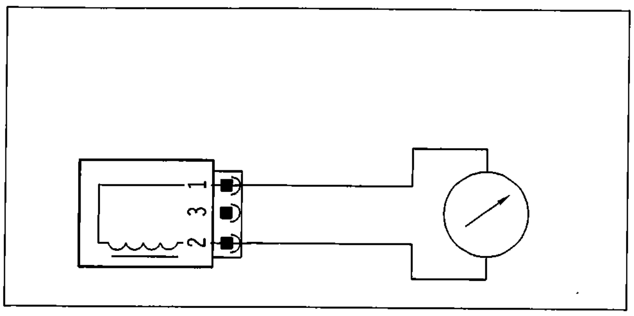
Unscrew the screw indicated and remove the sensor.

Checking gap

Check gap between sensor and phonic wheel teeth.

Gap: 0.5 - 1.5 mm

NOTE *Whenever repairs to the rpm and TDC sensor mount are necessary (e.g. gap not as specified, sensor not aligned etc.), the sensor must be positioned and aligned with the mount as described in the engine service manual (publication no. 504.589/20).*

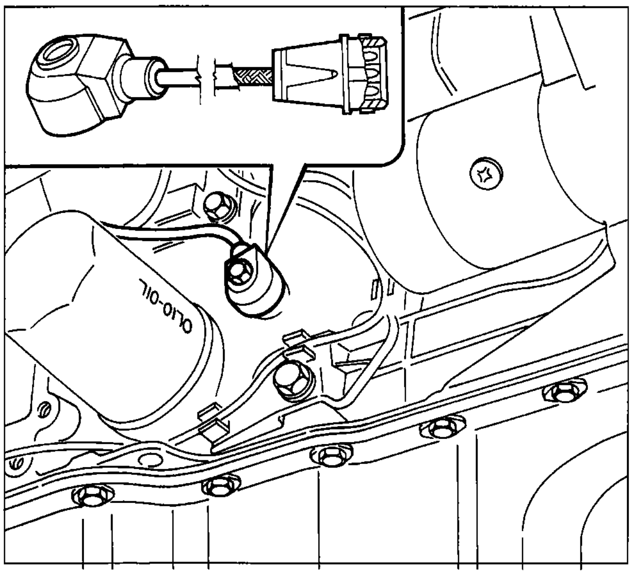


P4F30IJ03

Checking resistance

Sensor resistance may be measured by disconnecting the connector and connecting an ohmmeter to the sensor terminals.

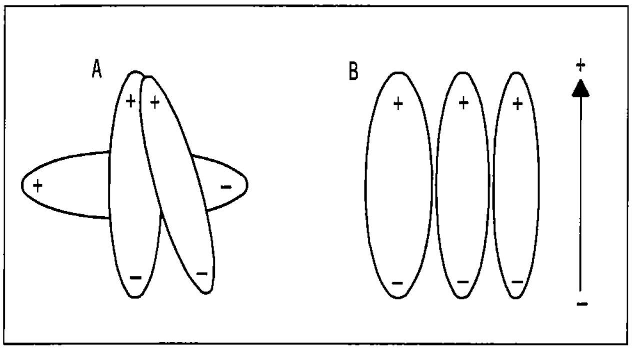
Resistance 1134 - 1386 ohm at 20 °C



P4F31IJ01

KNOCK SENSOR (KNE-03)

This piezo-electric sensor is fitted to the engine block in a symmetrical position in relation to cylinder pairs 1-2 and 3-4.
This positioning is necessary in order to detect the onset of knock in all cylinders equally.
When the engine knocks, vibrations of a specific frequency are set up in the engine block. This effect has a mechanical effect on a piezo-electric crystal, which sends a signal to the control unit. The control unit processes the signal and reduces ignition advance until the phenomenon disappears. Advance is then gradually restored to original values.



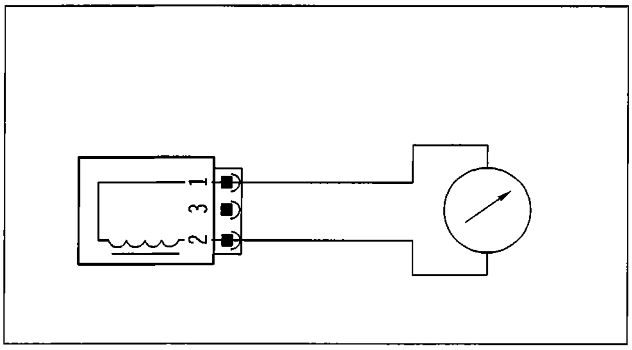
P4F31IJ02

Principle of operation

Quartz crystal molecules possess electrical polarity.
The molecules are not oriented in any particular direction when at rest (A).
When the crystal is subject to pressure or impact (B), it takes up a different position. The entity of the change is proportional to the pressure to which the crystal is subjected. The positioning induces a voltage at the crystal terminals.

A. Rest position

B. Position when under pressure

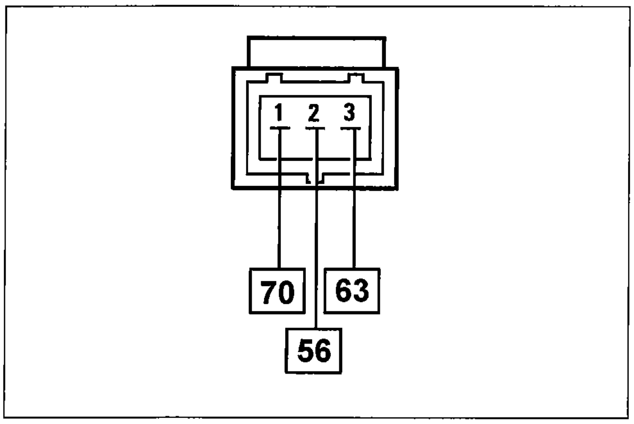


P4F30IJ03

Checking resistance

Sensor resistance may be measured by disconnecting the connector and connecting an ohmmeter across the sensor terminals.

Resistance 532 - 588 ohm at 20 °C



P4F31IJ03

Wiring connector

The sensor is connected to the control unit by mean of twisted wires and covered with a shielded anti-interference sheath.

Pin 1 - Earth
Pin 2 - Signal
Pin 3 - Shielding

The numbers in boxes indicate the corresponding control unit pins.

Removing - refitting

Disconnect electrical connection, unscrew screw retaining the knock sensor and remove.

THROTTLE BODY (46 SXF 2)

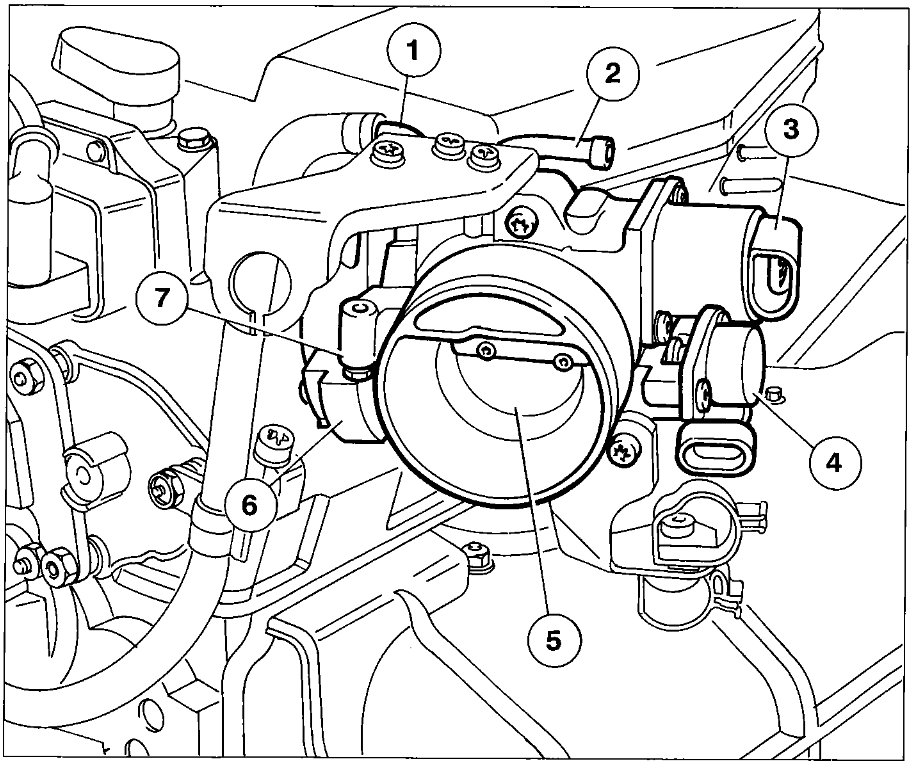
The throttle body is responsible for metering the quantity of air supplied to the engine (and thus controlling engine power output) according to accelerator position determined by the driver.

The throttle body is fastened to the intake manifold by four screws. The throttle is opened by a linkage with configuration designed to open the throttle by a small amount when the pedal is hardly pressed (provided pedal travel remains the same) and open it by large amounts when the pedal is pressed down further.

With the pedal fully released (engine in over-run or idling), the additional air required is supplied by an engine idle adjustment solenoid. Under these conditions, the throttle opening lever comes into contact with an anti-bind screw, which prevents the throttle becoming locked in closed position.

To prevent the build-up of ice around the throttle and the hole leading to the PCV valve, the throttle body is heated by directing a small amount of coolant from the engine thermostat around a chamber inside the case.

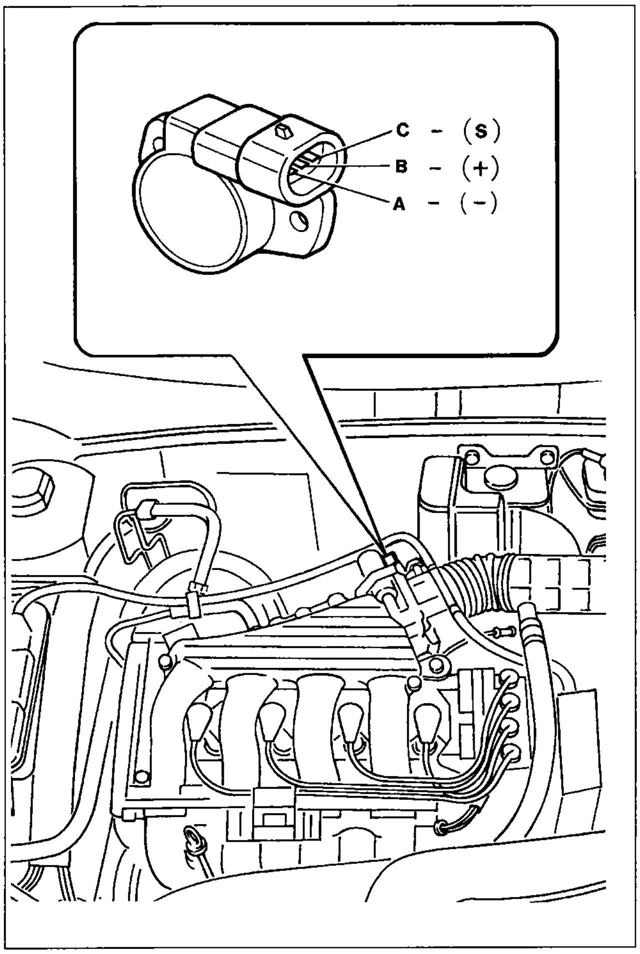
The throttle position sensor and engine idle speed actuator are also fitted on the butterfly valve case.



P4F32IJ01

The anti-bind screw is set by flushing in the factory and should never be tampered with.

1. Attachment for engine coolant delivery hose
2. Attachment for engine coolant return hose
3. Engine idle speed actuator
4. Throttle position sensor
5. Throttle valve
6. Throttle linkage
7. Throttle valve adjustment and antibind screw (do not touch)



P4F33IJ01

THROTTLE VALVE POSITION SENSOR (IPF-2C)

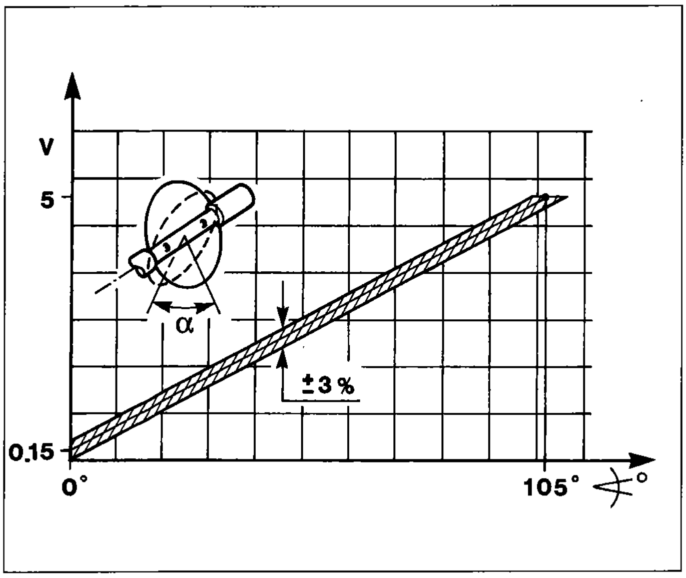
This takes the form of a potentiometer whose mobile part is controlled by the butterfly valve spindle.

The potentiometer is fitted inside a plastic container equipped with two tabs containing two UNSLOTTED holes. These anchor the sensor and ensure it is positioned correctly in relation to the throttle valve. A three-pin socket (ABC) on the container provides an electrical connection with the injection-ignition ECU.

During operation, the ECU supplies the potentiometer at a voltage of 5 Volt. The parameter measured is throttle position from idle to full opening for injection control management.

The ECU recognises throttle valve opening status on the basis of outlet voltage and corrects mixture concentration accordingly.
When the throttle is closed, an electric voltage signal is sent to the ECU, which recognises idle and cut-off status (discerning between them on the basis of rpm level).

The following graph indicates the voltage level supplied by the sensor as a function of throttle opening angle.



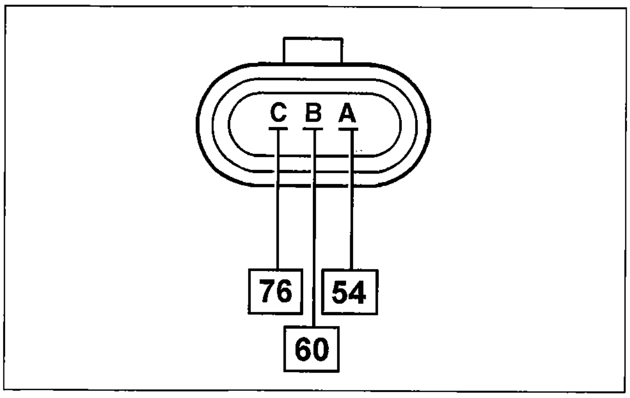
P4F33IJ02

The potentiometer is linear (single-ramp): its main specifications are as follows:

Effective electrical angle: 90° ± 2°

Total mechanical travel: 110° ± 8°

Temperature service range: –30°C - +125°C



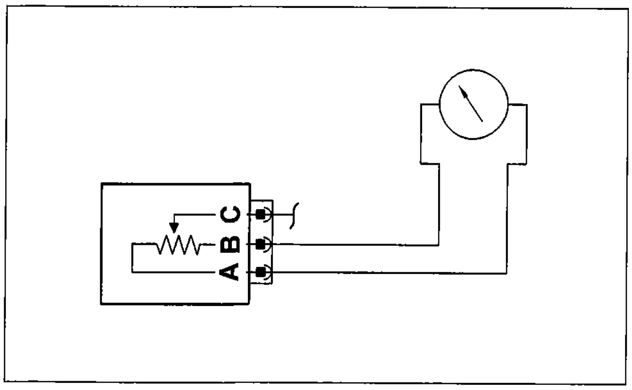
P4F34IJ01

Wiring connector

The numbers in boxes indicate the corresponding control unit pins.
Pin A - Earth
Pin B - Positive
Pin C - Signal

Checking resistance

Sensor resistance may be measured as follows
- by connecting an ohmmeter across sensor pins A and B to check fixed resistance is 1200 ohms;
- by connecting an ohmmeter across sensor pins A and C and checking that resistance changes from 0 to 1200 ohm ±20%. when the throttle valve is moved.



P4F34IJ02

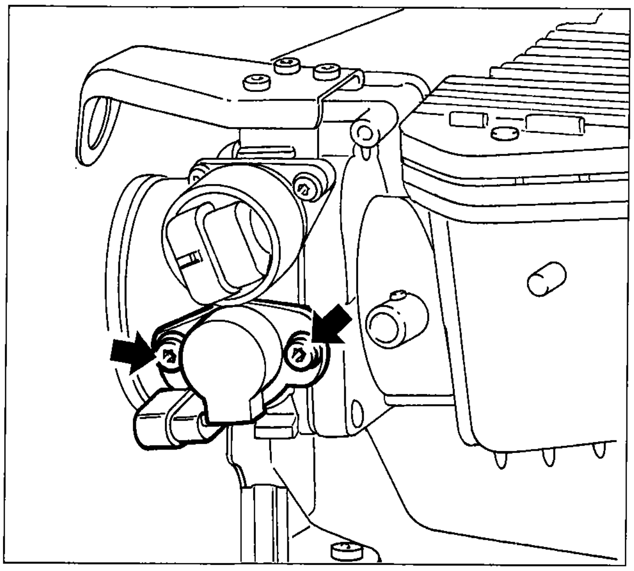
Recovery

A value calculated on the basis of rpm and inake manifold pressure is assumed. If the pressure sensor also fails, a throttle opening angle of 50° is adopted as a fixed value.

The strategy of gradually decreasing rpm when idling (dashpot) is blocked.

Idle self-adaptation is blocked.

Mixture concentration self-adaptation is blocked.



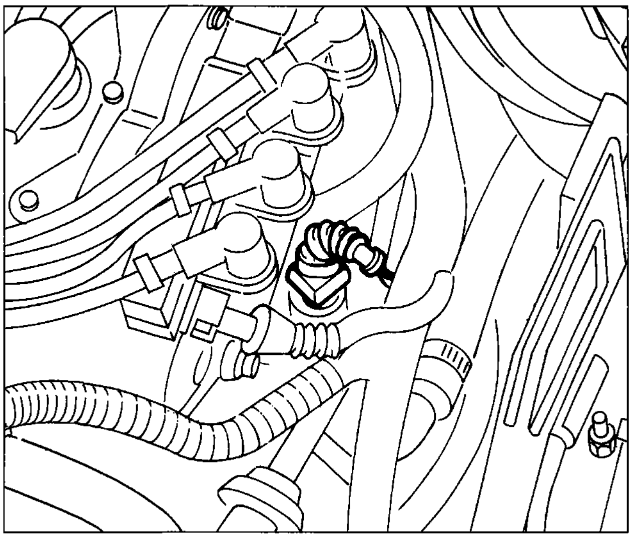
P4F34IJ03

Removing-refitting

Disconnect electrical connection, unscrew both retaining screws and remove the sensor.

NOTE *The potentiometer is fitted to the throttle body by two tabs containing two unslotted holes. No angular position adjustment is therefore necessary because the control unit uses its own self-adaption software to detect whether the throttle is fully open or fully closed.*

NOTE *Fit new potentiometer retaining screws each time they are removed because the thread is covered by a light coat of loctyte. This ensures a seal once only.*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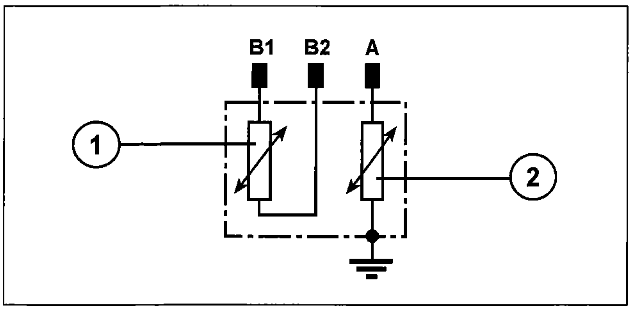


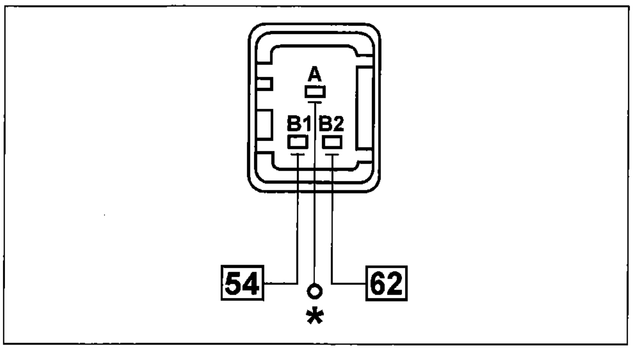
P4F35IJ02

NTC INJECTION

°C	Ω	°C	Ω
-20	15970	40	1150
-10	9620	50	807
0	5975	60	576
10	3816	70	418
20	2500	80	309
25	2044	90	231
30	1679	100	176

INSTRUMENT NTC

°C	Ω
60	512-602
90	184-208
120	76-88



P4F35IJ03

* Connection to coolant temperature gauge on instrument panel

ENGINE COOLANT TEMPERATURE SENSOR
(Jaeger 402.183.01)
(Elth 2690350)

The sensor is fitted to the thermostat case. It consists of a brass case, which protects the actual resistance element: two NTC thermistors (standing for Negative Temperature Coefficient because sensor electrical resistance decreases in inverse proportion to temperature).

The two NTC unuts are separate and send temperature information to a special indicator on the instrument panel and to the injection-ignition control unit.

The reference voltage is 5V for the injection system NTC element; since this circuit is designed as a voltage divider, the voltage is distributed between a resistance present in the ECU and the sensor N.T.C. resistance. The ECU is therefore able at any moment to assess sensor resistance changes through voltage changes and thus obtain information on intake air temperature.

1. NTC for injection system
2. NTC for indicator on instrument panel

Recovery

The last reading is adopted or a fixed value of 80 °C if intake air temperature exceeds a certain value

Mixture concentration self-adaption is inhibited.
The radiator fan is activated.
Idle self-adaption is inhibited.

Checking resistance

The table alongside shows sensor resistance values at different temperatures. These may be measured by disconnecting the connector and connecting an ohmmeter to the sensor terminals.

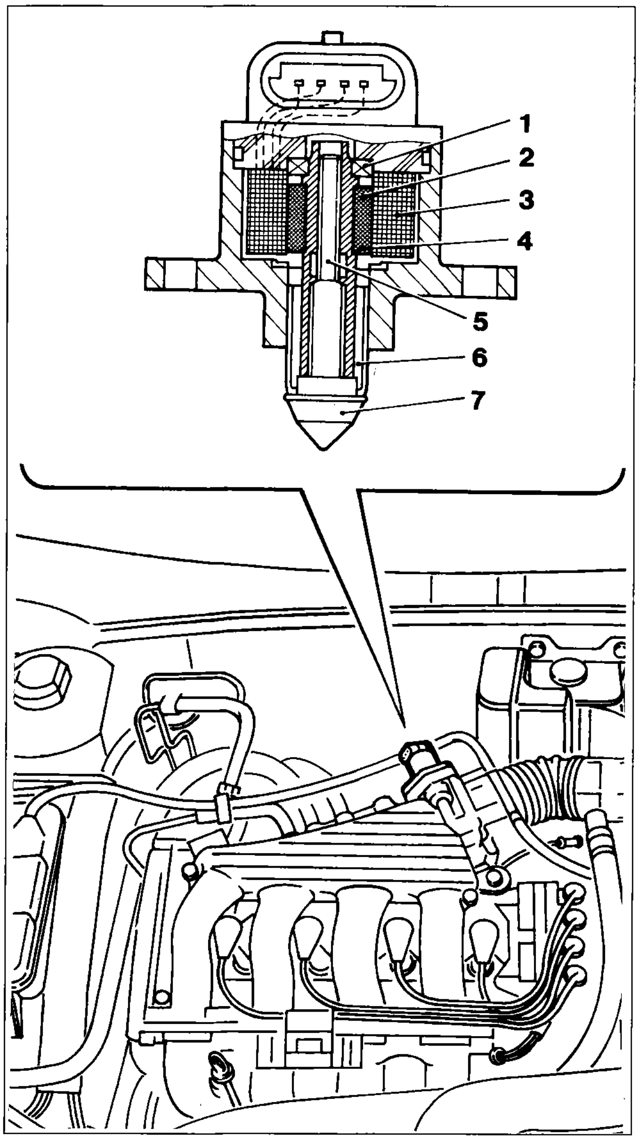
Removing-refitting

Disconnect electrical connection and remove the sensor.

Tightening torque 2.2 daNm.

Wiring connector

The numbers in boxes indicate the corresponding control unit pins.



P4F36IJ01

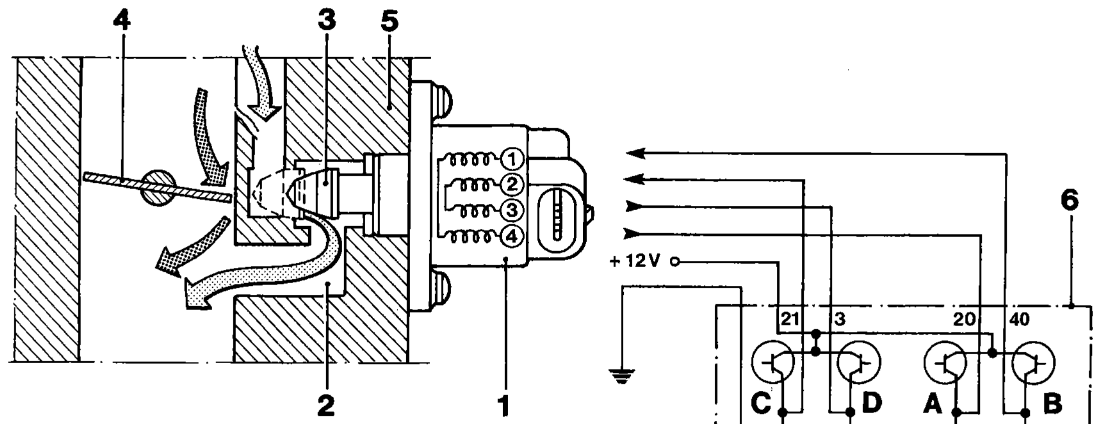
ENGINE IDLE SPEED ACTUATOR (step motor) (IB02)

1. Bearing
2. Lead screw
3. Coils
4. Magnets
5. Screw
6. Anti-rotation grooves
7. Plunger

The actuator is fitted to the throttle body and consists of:

- An electric step motor with two windings in the stator and a rotor that contains a certain number of permanent magnet pairs.
- A worm and screw reduction unit that converts rotatory motion into linear motion.

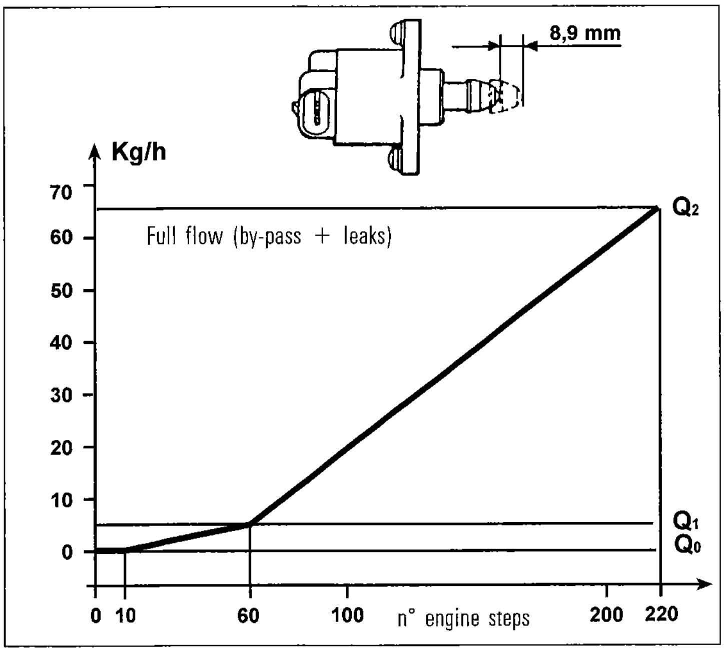
In order to idle, i.e. with throttle (4) fully closed, the engine needs a certain amount of air (Qo) and fuel to overcome internal friction and maintain rpm levels.
To the quantity of air Qo that leaks through the closed throttle valve (4) during idling, an additional quantity of air Q must be added to allow the engine to maintain rpm levels constant, particularly during warm up and when electrical users or external loads are activated (air conditioner, automatic transmission, etc).
To achieve this result, the system uses a step motor (1) fastened to butterfly valve case (5) controlled by ECU (6) which moves a rod fitted with a plunger (3) during operation. This alters the cross-section of by-pass duct (2) and thus the amount of air (Qo + Q) taken in by the engine.
In order to govern this type of action, the ECU uses angular engine speed and coolant temperature input from the relevant sensors.



Q. Air flow regulated by plunger (variable)

Qo. Air flow leaking through throttle (constant)

P4F36IJ02



P4F37IJ01

The electric step motor features extremely high accuracy and resolution (about 220 steps per second). Pulses sent from the ECU to the engine are converted from rotary motion into straight-line motion (about 0.04 mm/step) through a worm and screw mechanism. This operates a plunger which in turn moves to alter the by-pass duct cross-section.

The constant idle air flow Qo arises as a result of leakage through the butterfly valve. This is regulated during production and protected by a cap. Maximum flow Q2 arises when the plunger is fully retracted (about 200 steps corresponding to 8.9 mm). Between these two levels, air flow follows the graph shown alongside.

Motor strategy

The number of working steps is dependent upon engine conditions:

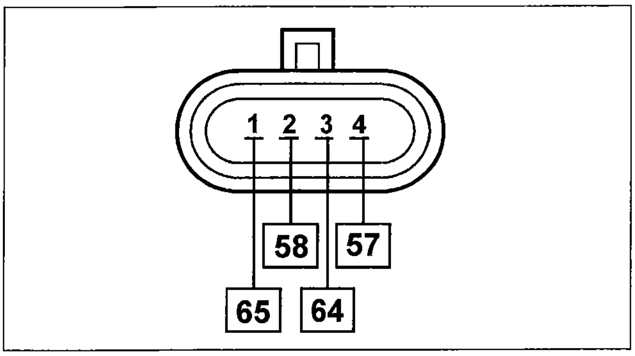
- Start-up stage
  When the key is inserted, the ECU controls step motor position according to engine coolant temperature and battery voltage.
- Warming-up stage
  Rpm levels are corrected according to engine coolant temperature.
- With engine warm:
  Idle control is dependent on a signal from the rpm sensor. When external users are activated, the ECU governs sustained idle.
- Over-run:
  The ECU recognises over-run status from the throttle potentiometer position.
  It controls step motor position by means of the idle flow law (DASH-POT laws). In other words, it slows the return of pluger (3) to its seat so that a quantity of air by-passing hole (2) reaches the engine and reduces levels of pollutants in the exhaust gas.

Recovery

Actuator operation disenabled, self-adaption of idling fuel mixture level blocked and speed limited to 1200 rpm.

Removing-refitting engine idle control actuator (step motor)

- disconnect the battery negative terminal;
- unscrew both retaining screws and withdraw the actuator;
- check condition of thoroid seal and remove any impurities from the case seat;
- refit the actuator, checking that the plunger fits easily without forcing.

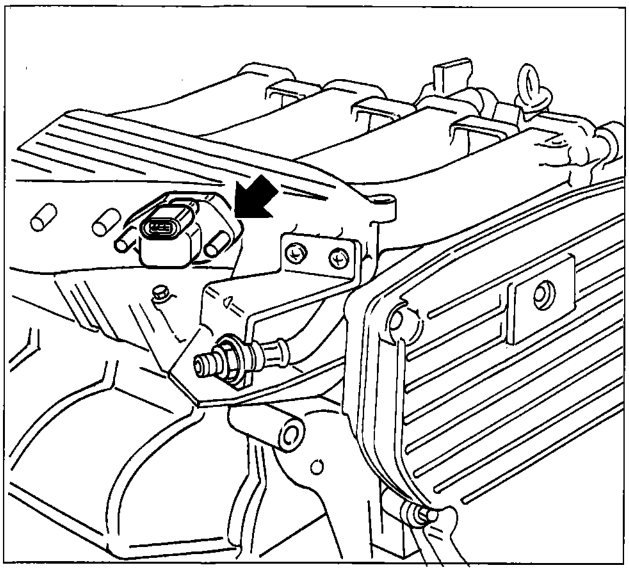


P4F37IJ02

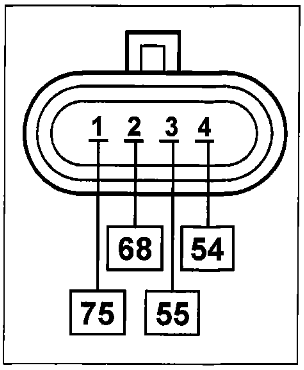
Tightening torque of step motor screws 0.35 - 0.45 da Nm.

Wiring connector

The numbers in boxes indicate the corresponding control unit pins



P4F38IJ01



P4F38IJ02

Pin 1-Air pressure signal

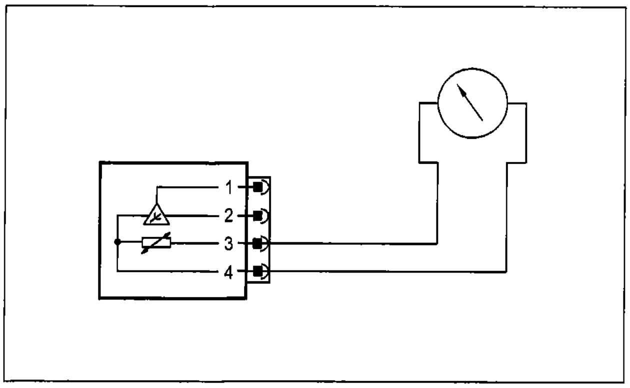
Pin 2-Positive

Pin 3-Air temperature signal

Pin 4-Negative

Wiring connector

The numbers in boxes indicate the corresponding control unit pins.



P4F38IJ03

Checking resistance

The table alongside shows resistance values that the temperature sensor (NTC thermistor) may assume at different temperatures. These values may be measured by connecting an ohmmeter to the terminals of sensor pins 3 and 4.

INTAKE AIR PRESSURE AND TEMPERATURE SENSOR (T-PRT 03)

The intake air pressure and temperature sensor is an integral component. It measures air pressure and temperature inside the intake manifold. The injection control unit needs both items of information to establish the amount of air taken up by the engine. This information is then used to compute injection time and ignition point. The sensor is fitted to the intake manifold.

Automatic diagnosis and recovery

The self-diagnostic function monitors the two sensor output signals.

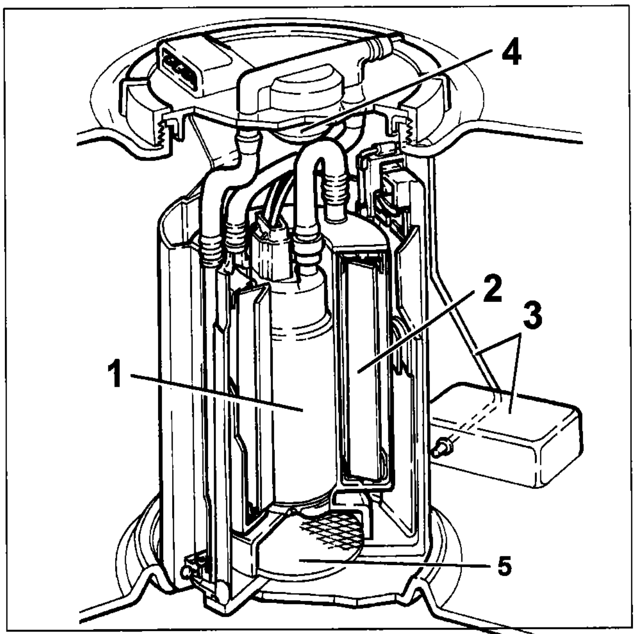
This detects the following for both signals:

- Short-circuit to earth.
- Short circuit to positive and reference voltage.
- Circuit open / interrupted

When the sensor pressure signal required to calculate injection time and ignition point is not present, the throttle potentiometer signal and engine rpm signal are used instead. These are processed by the electronic control unit to reconstruct the missing signal. If the air temperature sensor breaks, the injection control unit uses the last reading as the recovery temperature. If the fault occurs upon start-up, it assumes a fixed value of 45 °C and mixture self-adaption is disabled.

If the pressure sensor fails, a fixed value of 1024 mBar is used.

Temperature (°C)	Resistance (Ω)
-40	49933 ± 13.6%
-20	15701 ± 10.8%
0	5959 ± 8.5%
10	3820 ± 7.4%
20	2509 ± 6.5%
25	2051 ± 6.0%
30	1686 ± 6.0%
40	1157 ± 5.9%
50	810 ± 5.8%
60	578 ± 5.7%
80	309 ± 5.5%
100	176 ± 5.4%

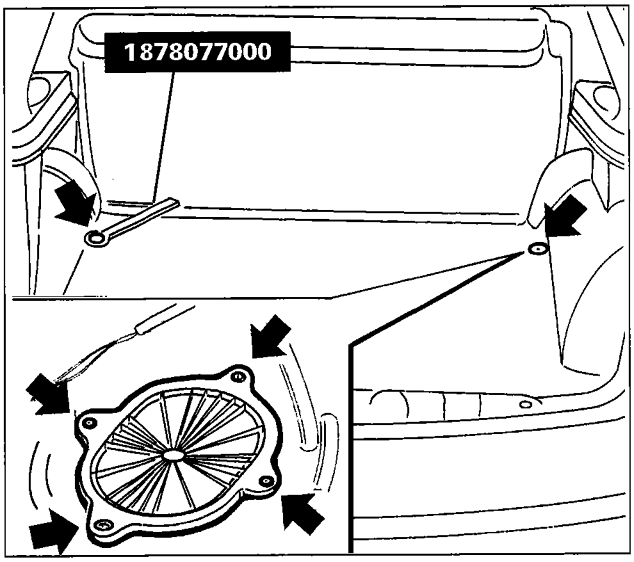


P4F39IJ01

ELECTRIC FUEL PUMP (ESS 291)

The pump assembly consists mainly of:
- an electric fuel pump (1);
- a fuel filter (2);
- a float-type level gauge (3);
- a membrane-type pressure regulator (4);
- a mesh prefilter (5).

The electric pump is single-stage peripheral flow type wit high performance under low voltage and temperature conditions. It offers the following advantages over electric pumps which work on the volumetric principle: low weight and reduced size.



P4F39IJ02

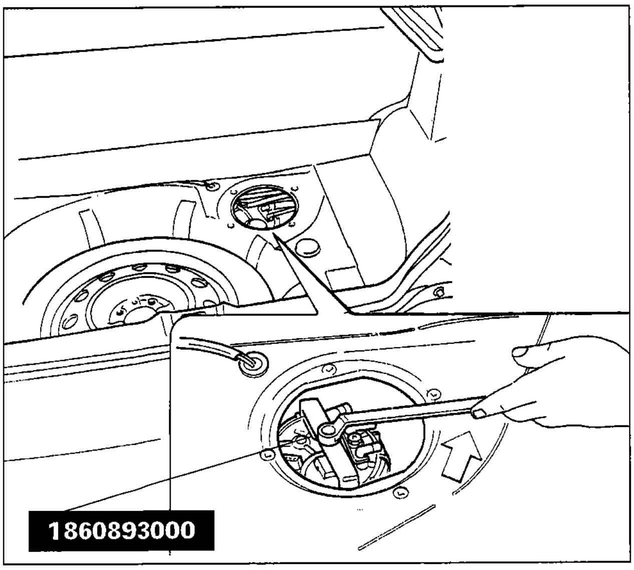
Removing-refitting electric fuel pump

The pump is located in the tank. Proceed as follows to remove:

Undo the fastening studs indicated using tool 1878077000.

Lift the luggage compartment mat.

Unscrew the bolts indicated and remove the dust cover.



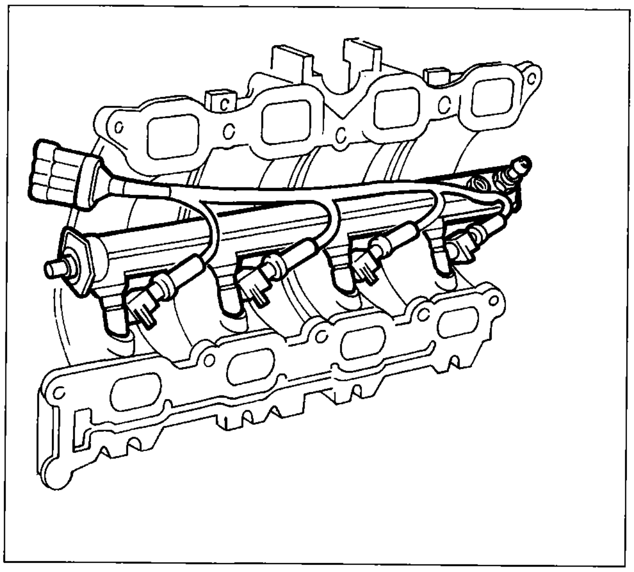
P4F39IJ03

Disconnect electrical connection to the pump and fuel level sender unit.

Disconnect the fuel delivery line.

Unscrew the lock-ring retaining the electric pump to the tank using tool 1860893000 and one box wrench.

Disconnect fuel pump assembly.



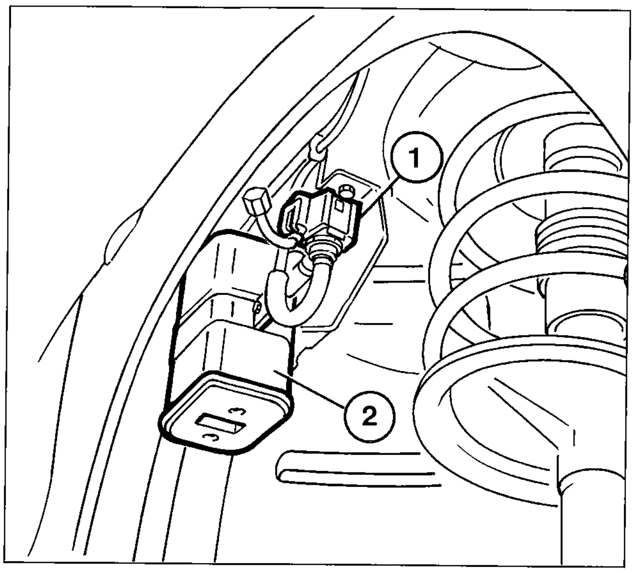
P4F40IJ01

FUEL MANIFOLD (CB 168)

The fuel manifold is fastened to the inner part of the intake manifold. Its function is to direct fuel to the injectors.

The fuel manifold is pressure cast in aluminium and incorporates injector seats.

The fuel intake is fastened using bolts with tapered seals.



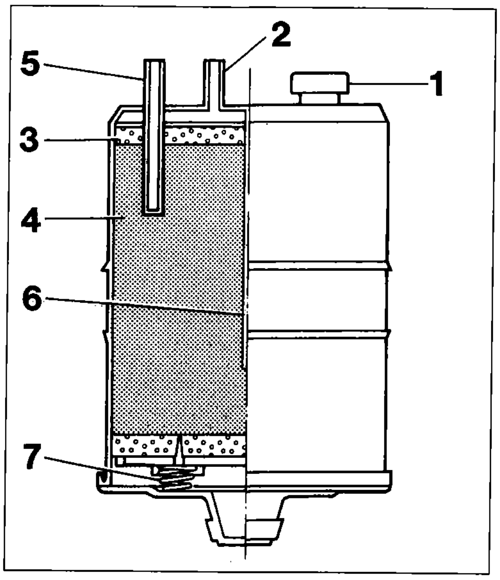
P4F40IJ02

CARBON FILTER AND FUEL VAPOUR CUT-OFF VALVE

These components form part of the fuel evaporation control and vapour recovery system. They are located in the right wheel arch compartment and can be reached by removing the rear part of the right front wheel arch compartment trim.

1. Fuel vapour cut-off solenoid

2. Carbon filter



P4F40IJ03

Carbon filter

This consists of carbon granules (4) that trap fuel vapour entering intake (5).

Warm flushing air enters intake (1), through paper filter (3) and flows over the carbon granules to remove fuel vapours and carry them toward the outlet (2) and then on toward the cut-off valve.

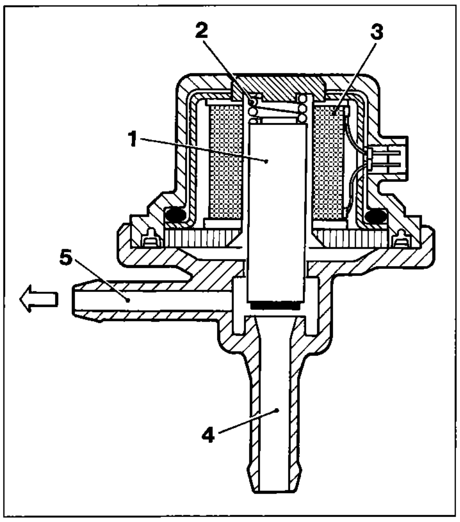
Air entering through intake (5) may also be pulled back by a vacuum in the tank, when it serves to ventilate the tank. Partition (6) ensures that the flushing air flows over all the carbon granules and promotes the release of fuel vapour toward the inlet manifold.

Two springs (7) allow the mass of granules to expand when the pressure increases.

Fuel vapour cut-off solenoid (EC1)

The function of this valve is to control the quantity of fuel taken up by the active carbon filter and directed to the intake manifold (via the injection-ignition control unit).
The valve is closed when de-activated to prevent fuel vapours enriching the mixture excessively.
The injection-ignition control unit controls operation as follows:
- during start-up, the solenoid remains closed to prevent fuel vapour from enriching the mixture excessively. This condition persists until the coolant temperature reaches a pre-established threshold (about 60°C).
- with engine warm, the ECU sends the solenoid a square wave signal, which modulates opening in accordance with the signal empty/full pattern.

  In this way, the ECU controls the quantity of fuel vapour sent to the intake to prevent significant changes in mixture concentration.



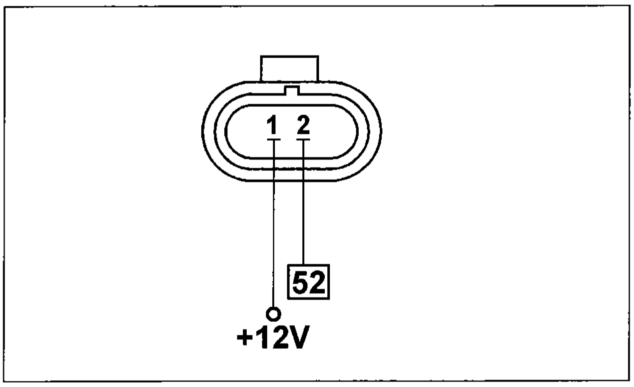
P4F41IJ01

Under the service conditions listed below:
- throttle in idle position
- speed less than 1500 rpm
- intake manifold pressure less than a limit setting computed by the ECU according to rpm level

solenoid activation is inhibited to maintain the unit closed in order to improve engine operation.

Longitudinal section through fuel vapour cut-off valve

1. Valve core.
2. Reaction spring.
3. Magnetic winding.
4. Pipe connected to air intake manifold
5. Pipe connected to active carbon filter.



P4F41IJ02

Wiring connector

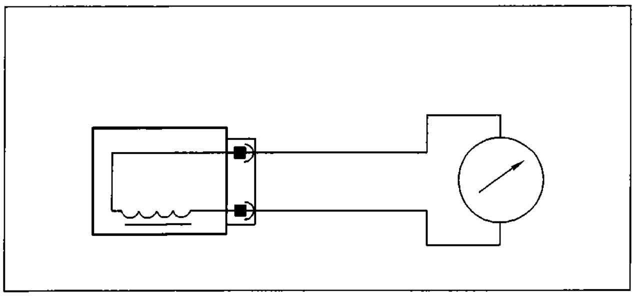
The numbers in boxes indicate the corresponding control unit pins

Recovery

Solenoid control is inhibited

Fuel vapour recirculation self-adaption is inhibited.

Mixture self-adaption is inhibited.



P4F41IJ03

Checking resistance

Solenoid resistance may be measured by disconnecting the connector and connecting an ohmmeter as shown in the figure.

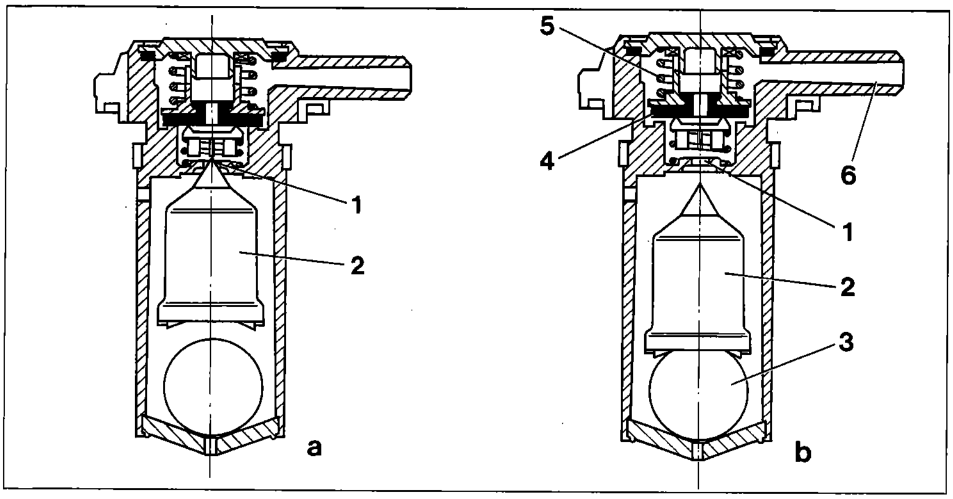
Resistance: 17.5 - 23.5 ohm at 20 °C

MULTIFUNCTION VALVE (SIRIO 0175.00)

This valve performs the following functions:
- prevents fuel flowing out when tank is over-filled or in case the vehicle overturns in an accident;
- vents fuel vapours from tank to the active carbon trap filter;
- ventilates the tank if a vacuum builds up inside.

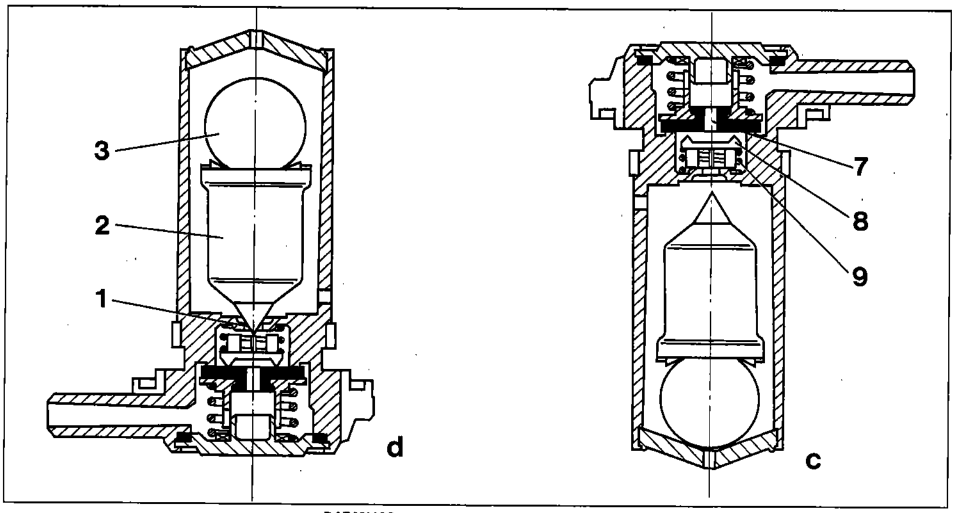
This valve consists of: a float (2); a heavy ball (3); a plate (4), pushed against valve case of spring (5) and plate (8), pushed against plate (4) of spring (9). Multifunctional valve operation may be summarised as follows and depends on fuel tank level:

a. if the tank is full float (2) blocks hole (1) to prevent liquid fuel from reaching active carbon filter and hence damage to the filter;
b. the tank fuel level drops, float (2) is lowered and rests upon ball (3) to open hole (1). When the pressure exercised by fuel vapours on plate (4) overcomes load of spring (5), a ring opening between plate and valve case opens to allow fuel vapours to emerge from the duct (6) and reach the active carbon filter.

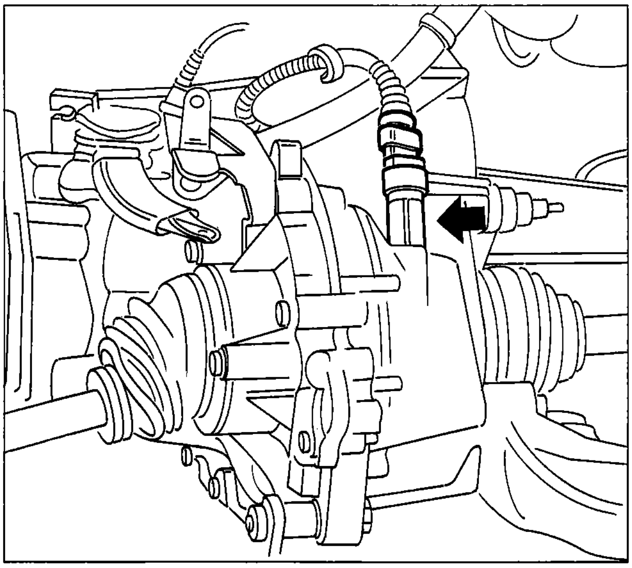


P4F42IJ01 P4F42IJ02

c. if the drop in tank fuel level is sufficient to set up a vacuum, this acts on plate (8) and overcomes load of spring (9) so that this moves down to allow tank ventilation through hole (7).
d. if the vehicle overturns, however full the tank, the weight of ball (3) acts on float (2) to push the float against hole (1) and prevent a dangerous flow of fuel to the intake manifold with the attendant risk of the vehicle catching fire.



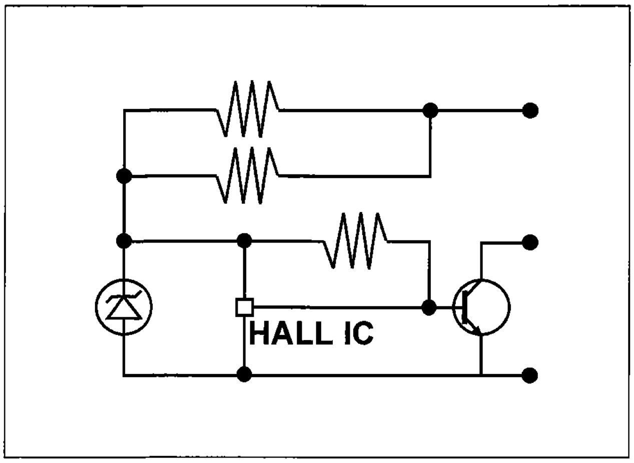
P4F42IJ03 P4F42IJ04


P4F43IJ01

VEHICLE SPEED SENSOR (SOGECO)

The sensor is located on the differential output, near the left half-axle joint. It sends information on vehicle speed to the control unit: the signal is also used to operate the speedometer.

The sensor operates on the principle of the Hall effect (see section on "engine timing sensor") and transmits 16 pulses/revolution. Vehicle speed can therefore be calculated from pulse frequency.



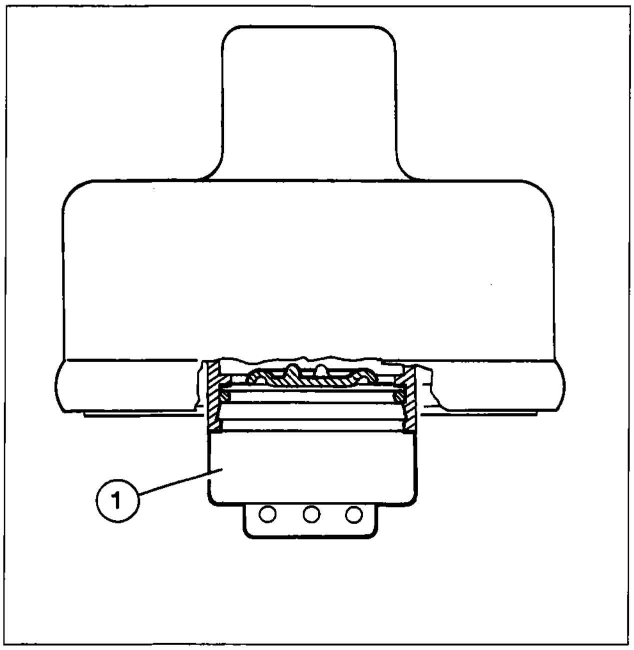
P4F43IJ02

Removing - refitting

Disconnect electrical connection and remove the sensor.

Tightening torque 0.8 daNm

Wiring diagram



P4F43IJ03

SAFETY AND VENTILATION VALVE

This valve is located in the fuel filler cap and performs the following functions according to the pressure level in the tank:

- When the pressure inside the tank exceeds 0.13 - 0.18 bar, excess fuel vapours are vented to the outside (pressure-relief function).

- If, on the other hand, a vacuum builds up inside the tank, equivalent to 0.020 - 0.030 bar, air is taken into the tank (ventilation function).

INJECTORS (IWP 064)

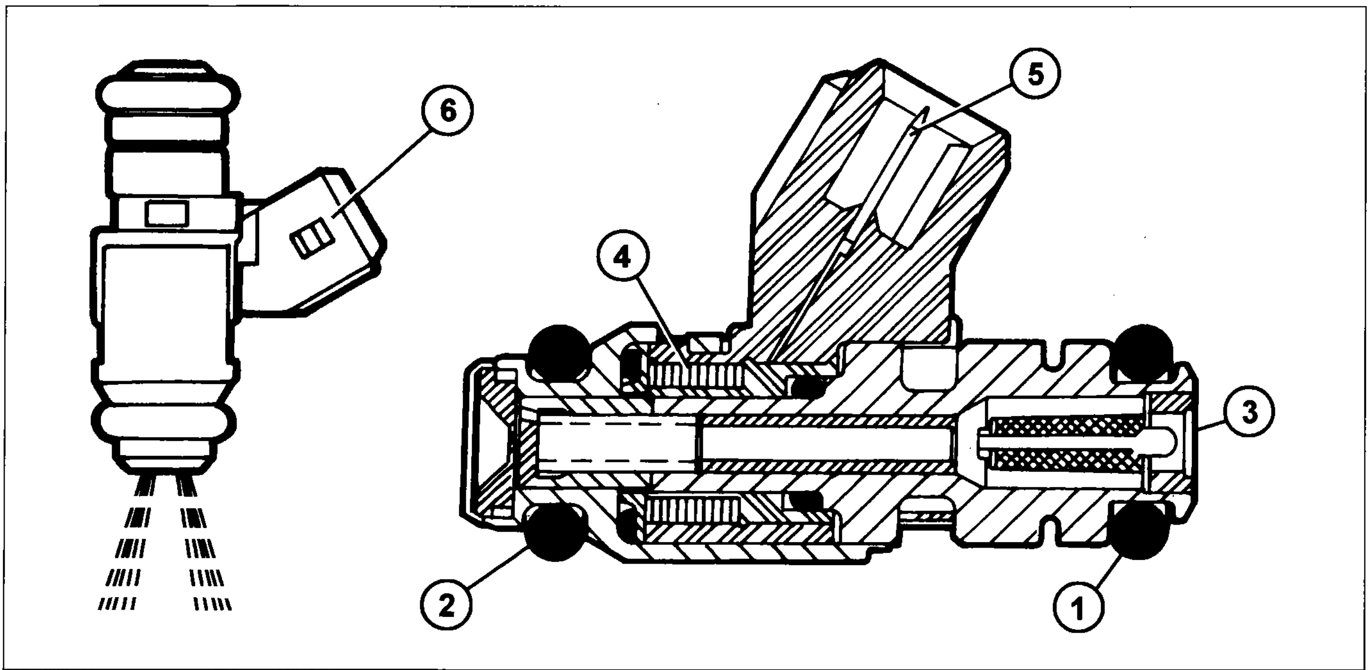
The twin-jet top-feed injectors (spray is inclined in relation to the injector centre-line) are specific for four valve per cylinder engines. They allow the jets to be directed toward the two intake valves.
Fuel jets at a differential pressure of 3 bars leave the injector and are immediately nebulised to form two propogation cones.

The injector control system is «timed, sequential» type, i.e. the four injectors are controlled in accordance with the engine cylinder intake sequence. Fuel delivery for each cylinder may begin during the expansion stage and last through to the a point when the intake stage has already begun.

The injectors are held in place by the fuel manifold, which presses them into their seats on the intake ducts. They are also anchored to the fuel manifold by safety clips. Two viton rings (1) and (2) form a seal on the intake duct and fuel manifold.

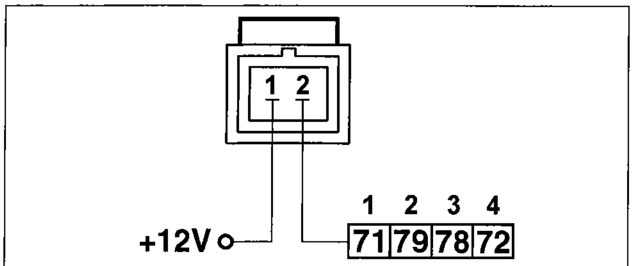
Fuel is supplied from the top part (3) of the injector. Th case contains winding (4) connected to terminals (5) of electrical connector (6).

NOTE *When removing-refitting, do not apply stresses higher than 120 N to injection connector (6) or it may be damaged..*



P4F44IJ01

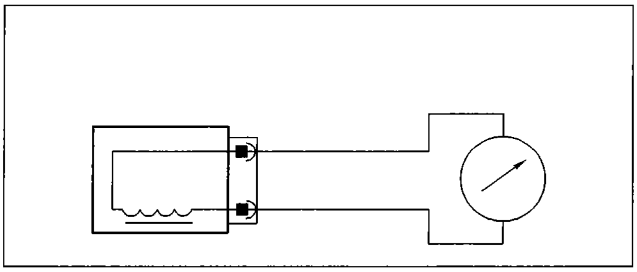
Wiring connector



P4F44IJ02

NOTE *The numbers in boxes indicate ECU pin no. in order of cylinder number.*

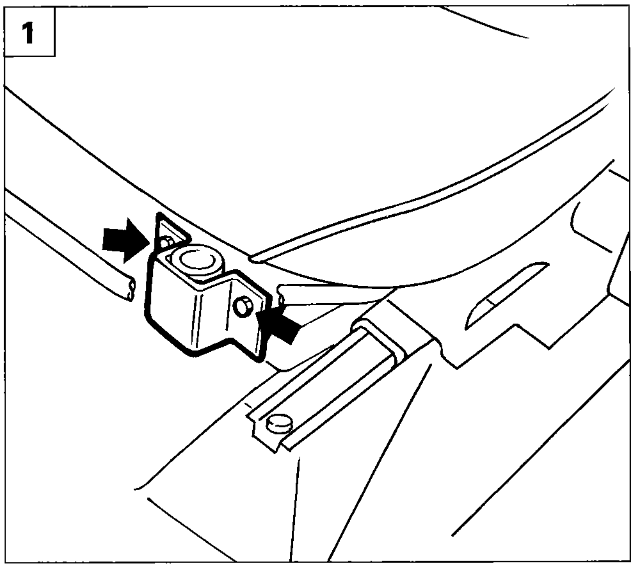
Checking resistance



P4F41IJ03

The injector resistance may be measured by disconnecting connector and connecting an ohmmeter as shown in the figure.

Resistance: 13.7 - 15.2 ohm at 20 °C



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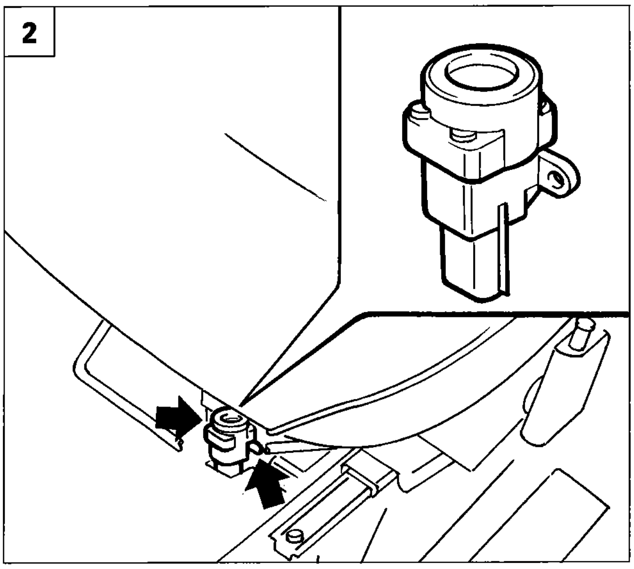

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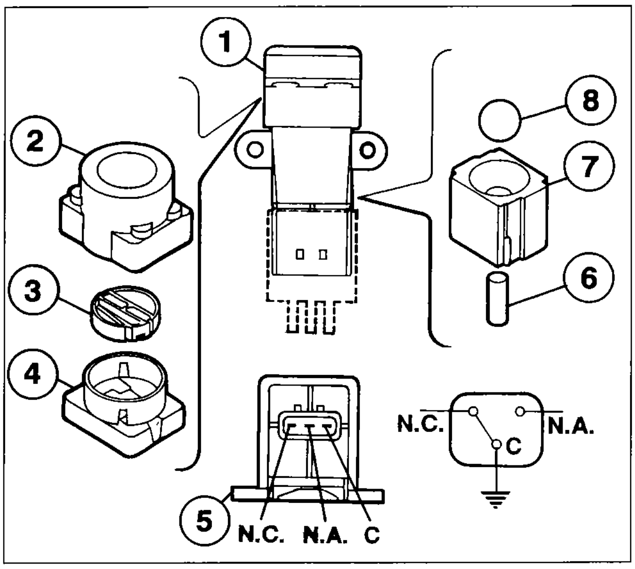


P4F451J03

INERTIA SAFETY SWITCH

The vehicle is equipped with an inertia switch located inside the passenger compartment beneath the driver's seat to increase passenger safety in the case of impact.
This sensor reduces the possibility of fire (caused by fuel emerging from the injection system) by de-activating the fuel feed pump.
The switch consists of a steel ball fitted inside a tapered housing. It is held in position through the attractive force of an permanent magnet.
The ball is released from the magnetic force in the case of violent impact, when it opens the normally closed (NC) electrical circuit to cut off the fuel pump earth connection and thus the fuel supply to the injection system.
To restore the pump earth connection, push the seat back and press the switch until it clicks on.

Removing-refitting

1. Move driver's seat back fully, unscrew the bolts indicated and remove the plastic protection.
2. Unscrew the bolts, disconnect electrical connection and remove the switch.

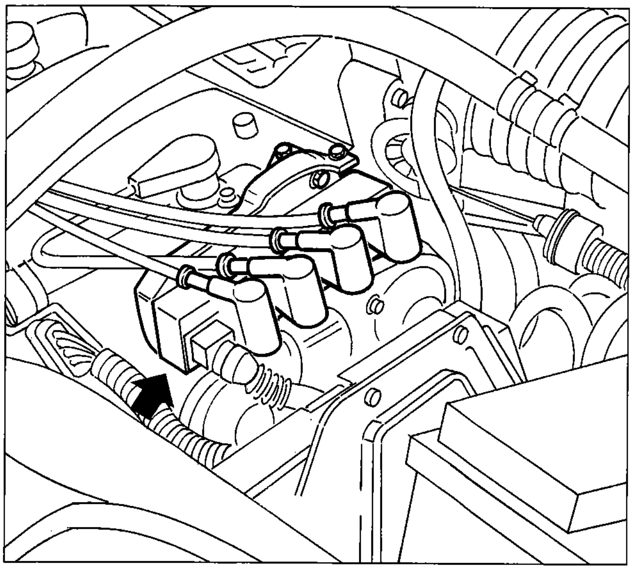
After even an apparently slight collision, if a smell of petrol is noted or fuel leaks are seen, do not activate the switch again until the fault has been found and corrected in order to avoid the risk of fire.

Components of inertia switch

1. Inertia switch assembly
2. Sheath
3. Button
4. Upper end
5. Fitting end
6. Permanent magnet
7. Permanent magnet seat
8. Steel ball

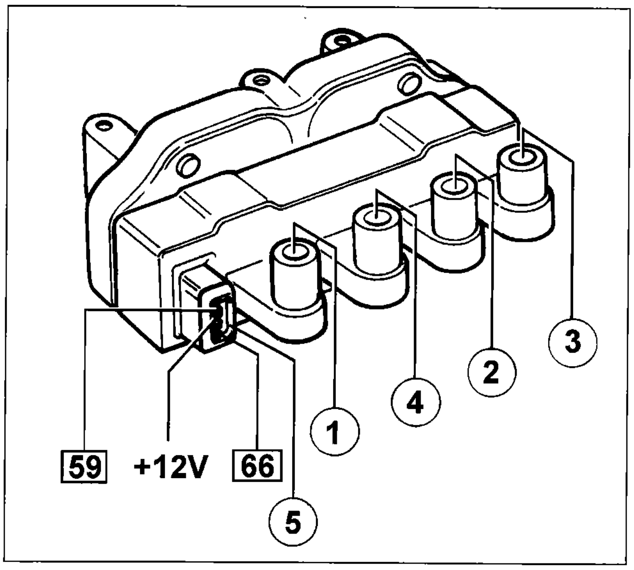
C= Common terminal
N.C. Normally closed
N.A. Normally open

IGNITION COILS
(Bae 920A)
(Beru 0.040.100.029)


P4F46IJ01

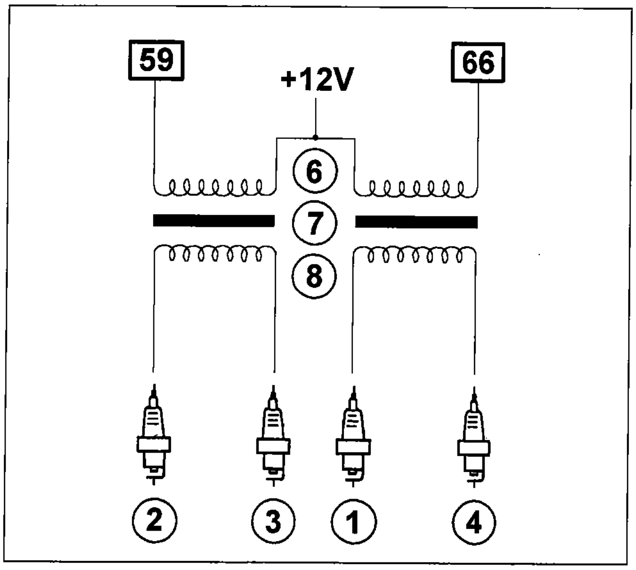
The coils are fastened by means of a bracket to the camshaft covers and are closed magnetic loop type. They are formed from a layered pack, whose central core (broken by a narrow gap) carries both windings.

The windings are placed in a moulded plastic container embedded in epoxy resin, which gives them exceptional dielectric properties. Because the primary winding is so close to the magnetic core, little magnetic flux is lost and coupling with the secondary winding is maximised.



P4F46IJ02

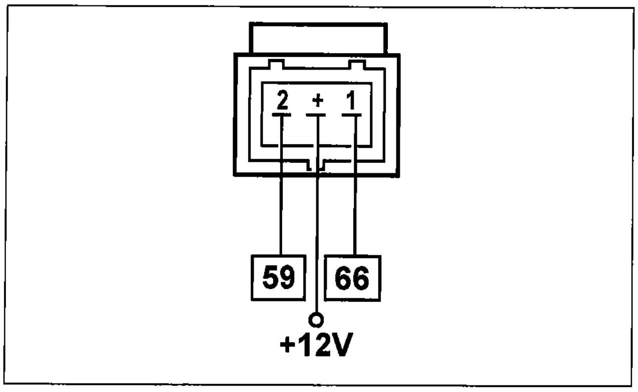
1. HT socket for cylinder no. 1 spark plug
2. HT socket for cylinder no. 2 spark plug
3. HT socket for cylinder no. 3 spark plug
4. HT socket for cylinder no. 4 spark plug
5. LT socket for ECU connection
6. Primary circuit
7. Gap
8. Secondary circuit



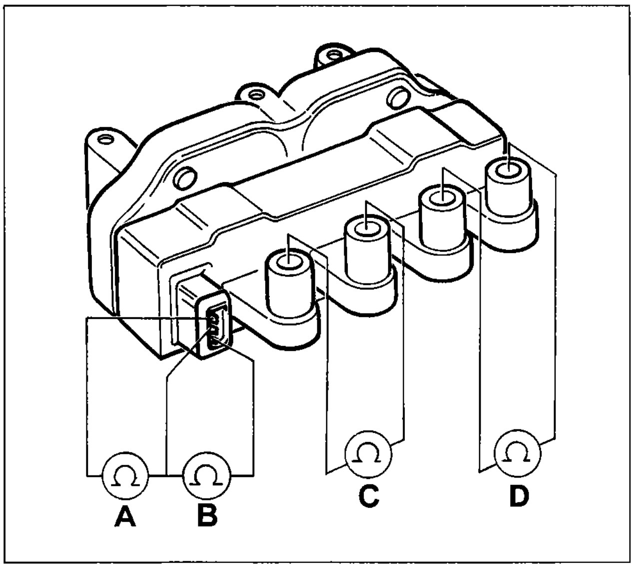
P4F46IJ03

Wiring connector

NOTE *The numbers in boxes indicate the corresponding control unit pins.*



P4F46IJ04



P4F47IJ01

Checking winding resistance

Primary circuit (A cylinders 1-4, B cylinders 2-3)

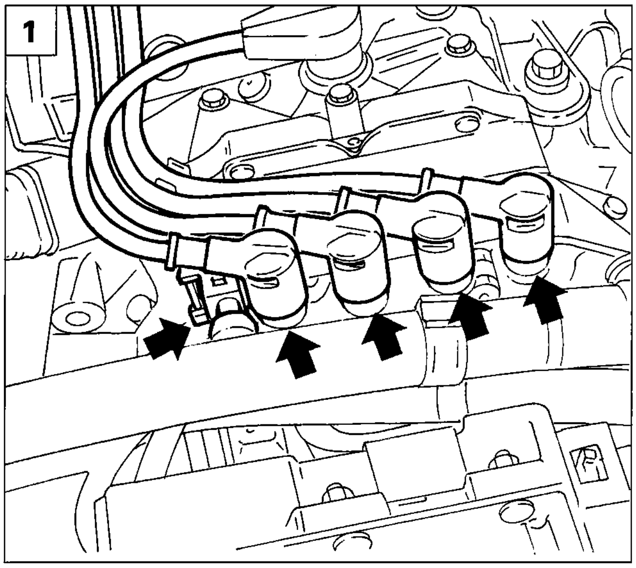
Bring the probes of an ohmmeter into contact with the postive strip (central pin) and the negative strip (pin 1 for circuit A and pin 2 for circuit B).

The primary circuit resistance reading on the guage should be between 0.44 and 0.53 ohm at 23 °C.

Secondary circuit (C cylinders 1-4, D cylinders 2-3)

Bring the probes of an ohmmeter into contact between the two high tension outlet terminals.

The secondary winding resistance reading on the gauge must be between 4500 and 5500 ohm at 23 °C.



P4F47IJ02

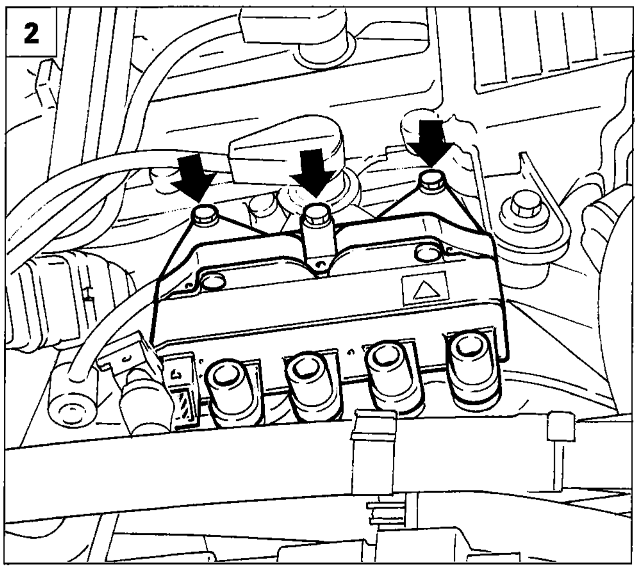
Recovery

Inhibition of injectors for cylinders in which ingnition is not taking place.

Open-loop mixture control

Current command is de-activated in case of short circuit to positive in order to try again later.

If circuit is broken, or short-circuit to earth, charge time is assumed to be dependent upon battery voltage.



P4F47IJ03

Removing refitting

1. Disconnect HT leads from spark plugs.

2. Unscrew the bolts indicated and remove the ignition coils

LAMBDA PROBE (NTK 0ZA334-A1)

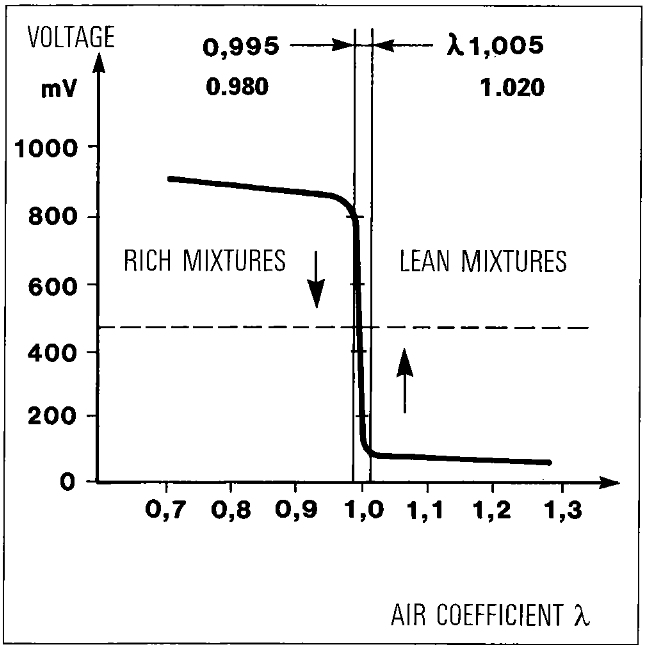
This sensor measures exhaust gas oxygen content.

The sensor output signal is sent to the electronic control unit to adjust the air-fuel mixture in order to maintain the ratio as close as possible to theoretical levels.

To obtain an optimum mixture, the quantity of fuel injected must be as close as possible to a theoretical quantity that could be fully burnt for a given amount of air taken in by the engine.

In this case, Lambda factor (λ) is said to be equal to 1;in fact:

$$\lambda = \frac{\text{INTAKE AIR QUANTITY}}{\text{THEORETICAL QUANTITY OF AIR NECESSARY TO BURN ALL THE FUEL INJECTED}}$$



P4F48IJ01

λ= 1 Ideal mixture
CO levels are within legal limits

λ⩾ 1 Lean mixture
Excess air; CO levels tend to be low

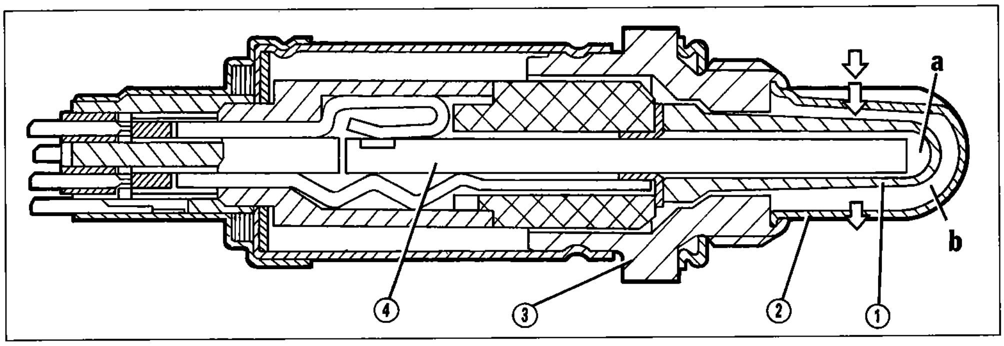
λ⩽ 1 Rich mixture
Lack of air; CO levels tend to be high

NOTE *While the coefficient λ expresses an excess or lack of air supplied to the engine in relation to the theoretical required level, the air-fuel mixture is a ratio between these two substances that react chemically when combined. Present-day engines require 14.7-14.8 parts of air to burn 1 part of petrol fully.*

The probe is fastened upstream of the converter.

It consists of a ceramic case (1) made up of a zirconium dioxide base covered by a light layer of platinum. It is sealed at one end, enclosed in protective pipe (2), and housed in metal case (3) that provides further protection and permits installation to the exhaust manifold. The outer part (B) of the ceramic case is exposed to the exhaust gas flow while inner part (A) communicates with the outside air.

The probe works on the principle that when the temperature exceeds 300 °C, the ceramic material used begins to conduct oxygen ions. Under these conditions, if the levels of oxygen at both ends (a and b) of the probe are different, a voltage variation is set up between the two ends. This signal notifies the ECU that the oxygen residues in the exhaust gas are not in proportions that will ensure lean burning of harmful residues.



P4F491J01

a. (+) electrode in contact with outside air
b. (-) electrode in contact with exhaust gas
1. Ceramic case
2. Protective pipe
3. Metal case
4. Electrical resistant

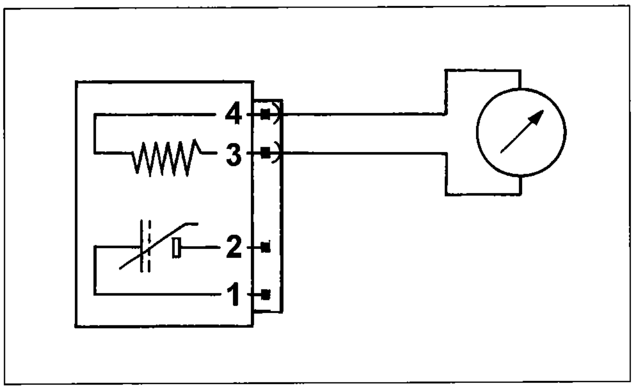
When the probe supplies a low voltage level (less than 200 mV) the ECU recognises that the mixture is lean (lambda » 1) and takes steps to increase the amount of fuel injected. When the probe supplies a high voltage level (greater than 800 mV) the control unti recognises that the mixture is rich (lambda « 1) and decreases the quantity of fuel injected.

The lambda probe therefore alters injection times to ensure that the engine operates with a lambda factor continually fluctuating between 0.980 and 1.020.

Below 300 °C the ceramic material is not active and the probe does not send usable signals. A special circuit in the control unit blocks loop mixture regulation while the probe is warming up.

To ensure service temperature is reached quickly, the probe is equipped with electrical resistance (4) supplied by the battery

⚠ *The probe may be swiftly put out of service by even slight traces of lead in the fuel.*

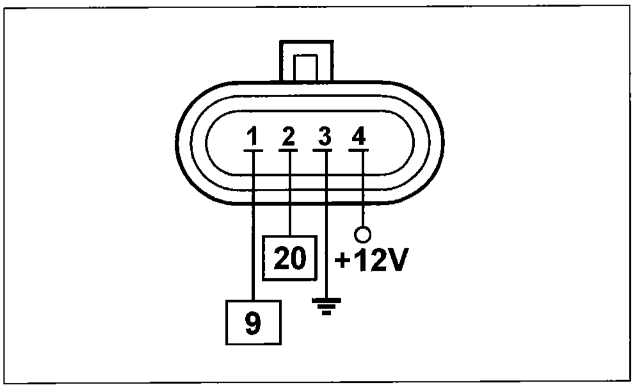


P4F491J02

Checking resistance

The heater and probe resistance may be measured by disconnecting the connector and connecting an ohmmeter as indicated in the figure.

Heater resistance = 4.3 - 4.7 ohm



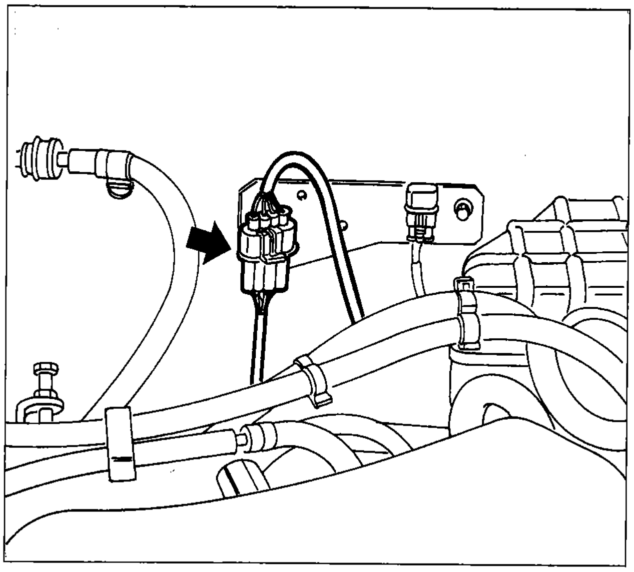
P4F491J03

Recovery

Lambda data are ignored (open loop).

Wiring connector

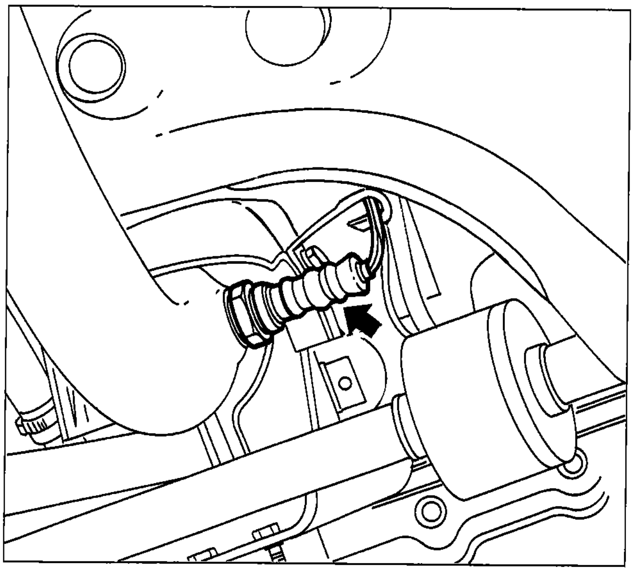
The numbers in boxes indicate corresponding control unit pins.



P4F50IJ01

Removing - refitting lambda probe

- Place the vehicle on a lift
- Disconnect battery negative lead
- Disconnect electrical connection located against the rear wall of the engine bay.



P4F50IJ02

Remove the lambda probe from its seat on the exhaust pipe.

When refitting, spread the threaded part with ANTISEIZE MATERI-A-BORON NITRIDE N.G.K. grease from SPARK PLUG CO-LTD.

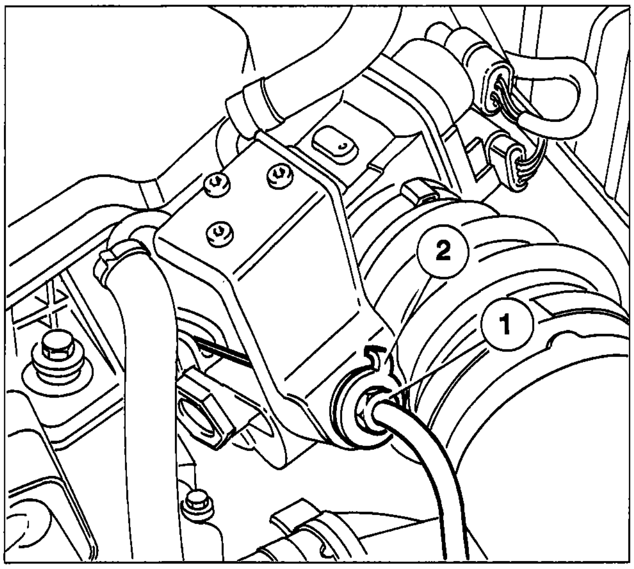
Tightening torque 3.5 - 4.5 daNm

CHECKS, ADJUSTMENTS AND REPAIRS TO INJECTION-IGNITION SYSTEM

OBSERVE THE FOLLOWING PRECAUTIONS WHEN WORKING ON VEHICLES WITH IAW INJECTION-IGNITION SYSTEMS:

- *never start the engine when the electrical terminals are poorly connected or loose on the battery poles;*
- *never use a quick battery charger to start the engine;*
- *never disconnect the battery from the car circuit with the engine running;*
- *when charging the battery quickly, first disconnect the battery from the vehicle circuit;*
- *if the vehicle is placed in a drying oven after painting at a temperature of more than 80º C, first remove the injection/ignition ECU;*
- *never connect or disconnect the ECU multiple connector with the ignition key in MARCIA position;*
- *always disconnect battery negative lead before carrying out electrical welding on vehicle.*

Note that the memory of this system is active at all times and contains all learnt self-adaptive parameters. Because all this information would be lost if the battery were disconnected, this operation should only be carried out when absolutely essential.

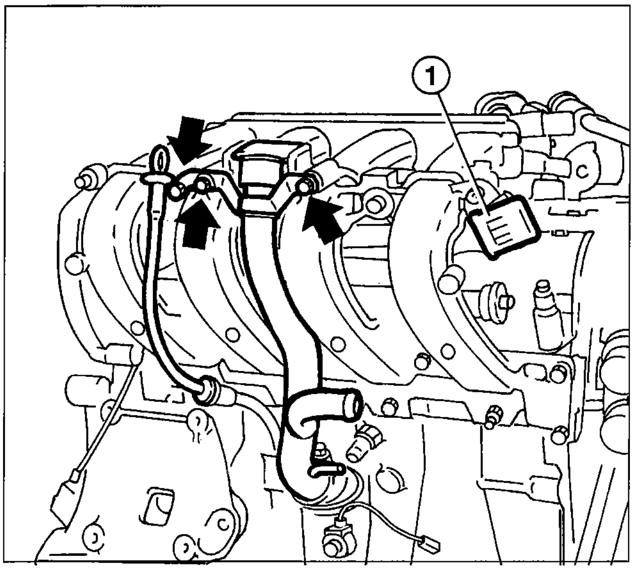


P4F51IJ01

ADJUSTING THROTTLE CABLE

The accelerator cable is adjusted by loosening nut (1) and moving clip (2).

Position clip (2) so that the head of the accelerator cable enters the slot freely without altering idle speed. Then tighten nut (1) to lock.

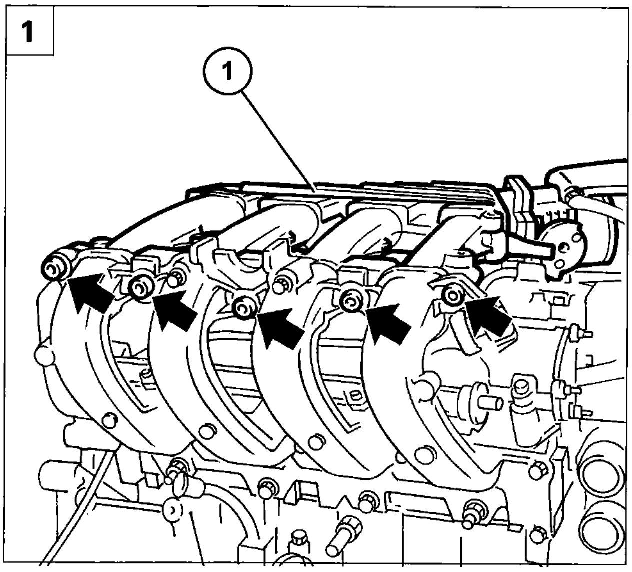


P4F51IJ02

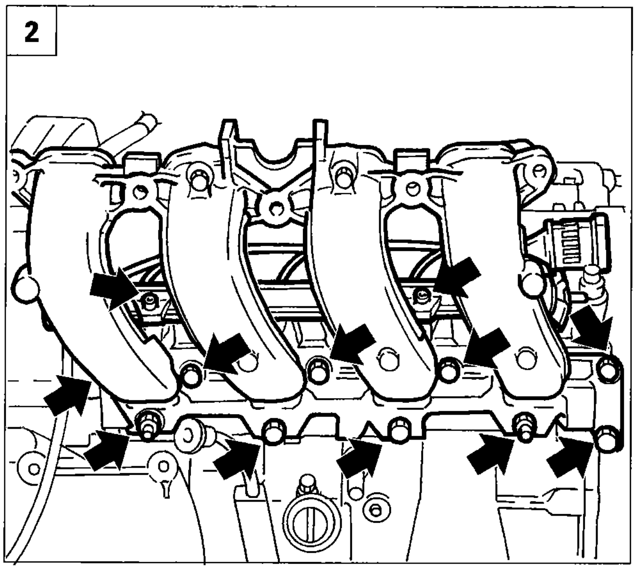
REMOVING-REFITTING FUEL MANIFOLD AND INJECTORS

Disconnect the first section of the oil dipstick mount and the oil filler pipe, then disconnect the injector lead coupling (1).

10.



P4F521J01



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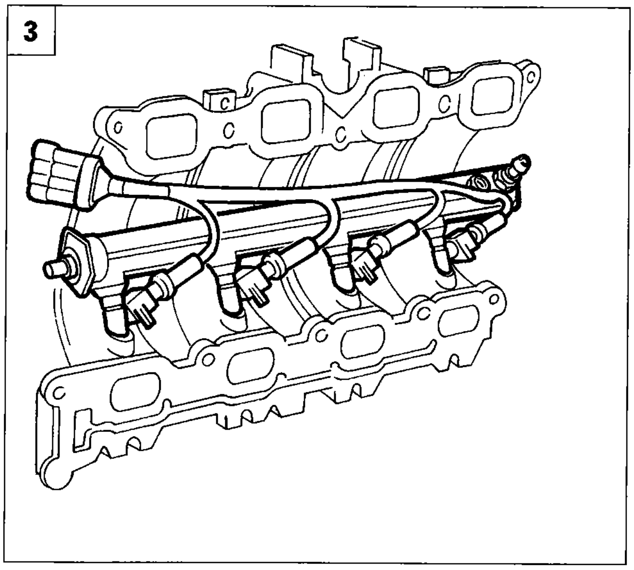

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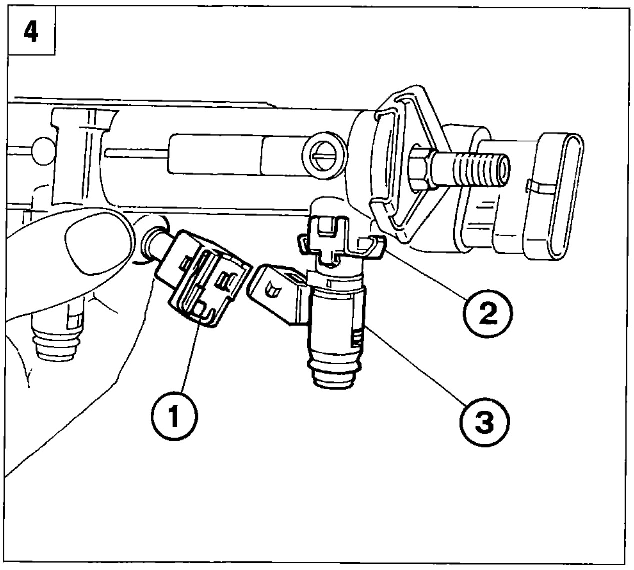


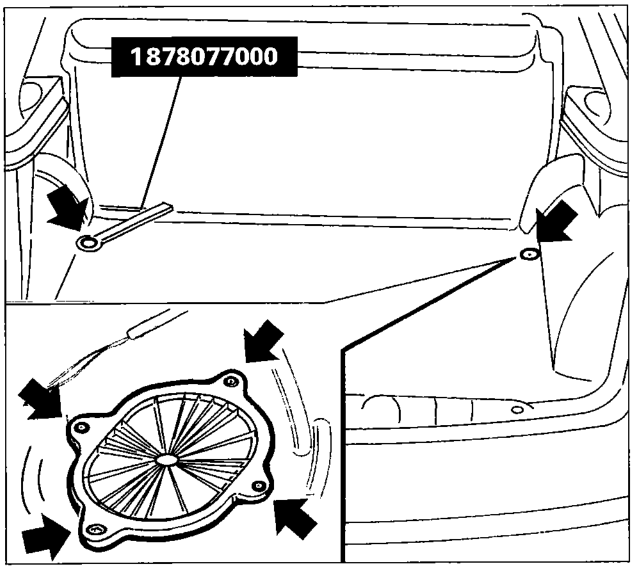
P4F521J03

1. Unscrew the bolts fastening both sections of the fuel supply manifold and remove the first section (1).
2. Unscrew the fuel manifold retaining bolts and the bolts fastening the second section of the intake manifold to the engine block and remove.
3. Disconnect the fuel lines and remove the manifold together with injectors.
4. Then remove the injectors as follows:

   - Disconnect electrical connection (1).
   - Remove the safety clip (2).
   - Remove press-fitted injector (3).

Never pull the electrical connection to remove the injector.

Before refitting, check the seal is undamaged.

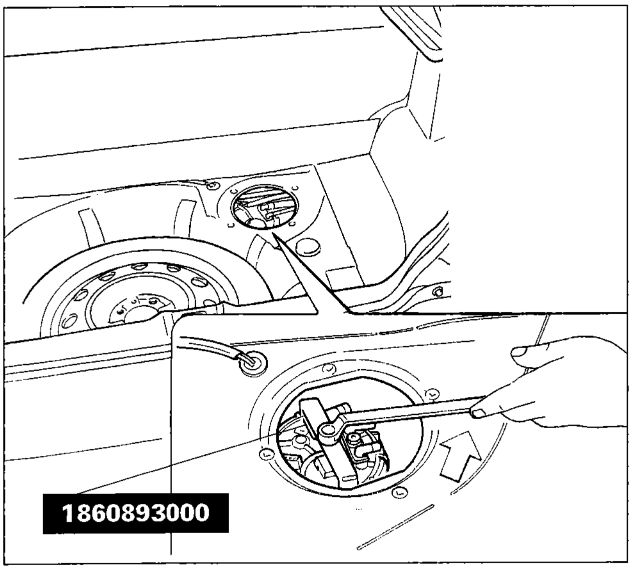


P4F39IJ02

REMOVING-REFITTING FUEL TANK

Before proceeding with the removing-refitting of the tank, drain the fuel, position the vehicle on a lift and disconnect the negative battery lead. Then proceed as follows:

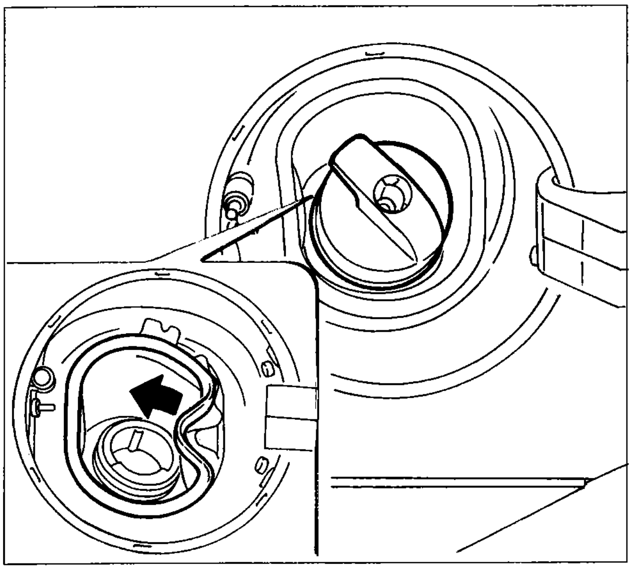
- Lift up the lining in the luggage compartment after having removed the retaining buttons using spanner 1878077000. Remove the protective cover shown in the inset, acting on the fixing bolts.



P4F39IJ03

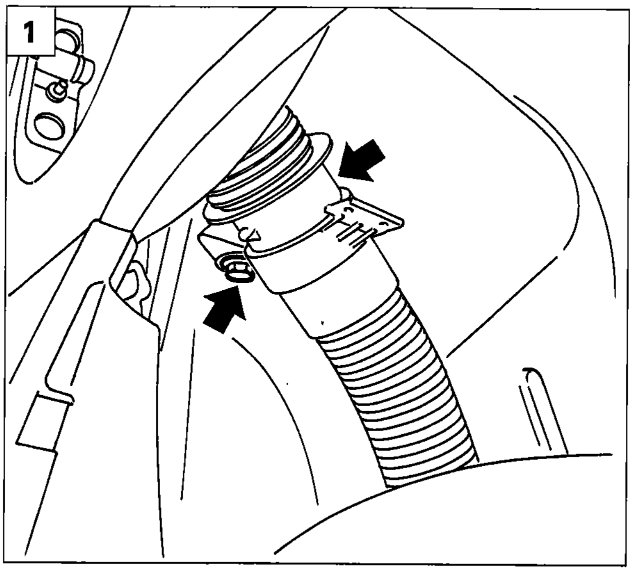
- Disconnect the electrical connections from the pump and the fuel gauge sender unit. Disconnect the breather pipe (1) acting on the retaining nut and pipes (2) and (3), the fuel return and supply pipes, respectively, acting on the retaining tabs.

- Undo the ring nut fixing the electric pump to the tank using tool 1860893000 together with a polygonal spanner.

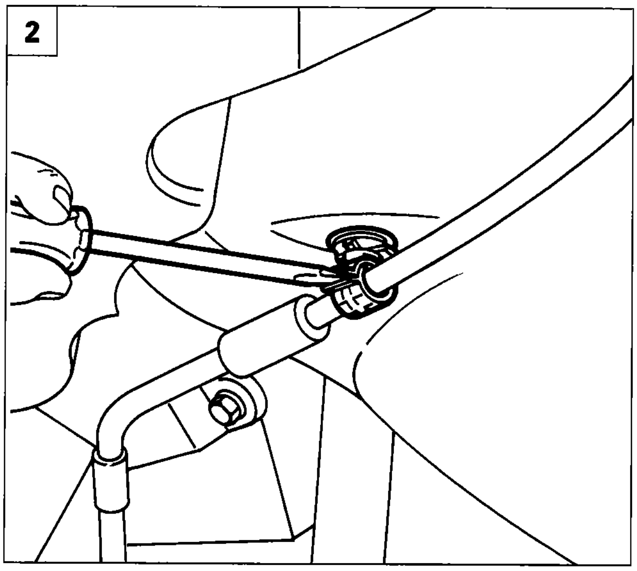

P4F53IJ01

- Undo the plug and remove the boot for the fuel filler from its housing.

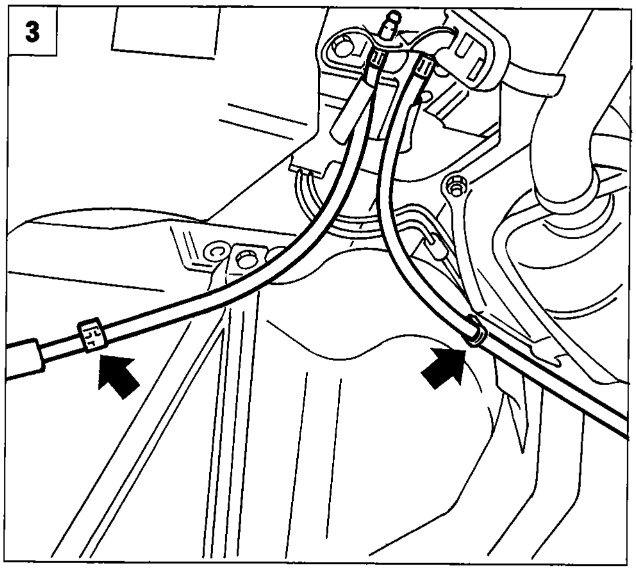
10.



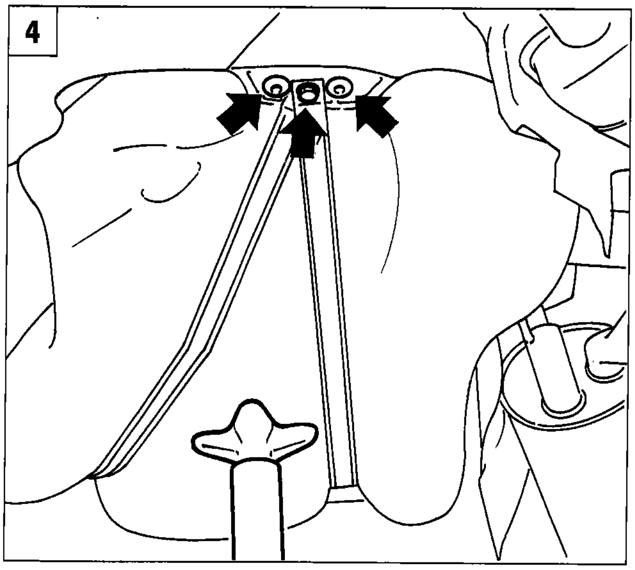
P4F541J01



P4F541J02



P4F541J03

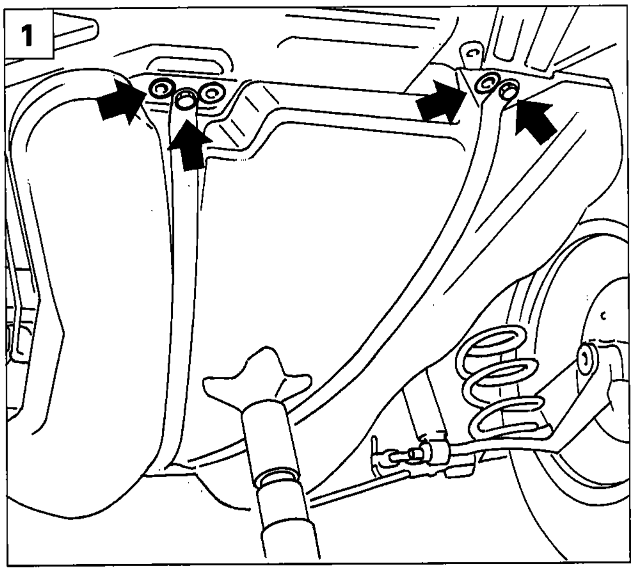


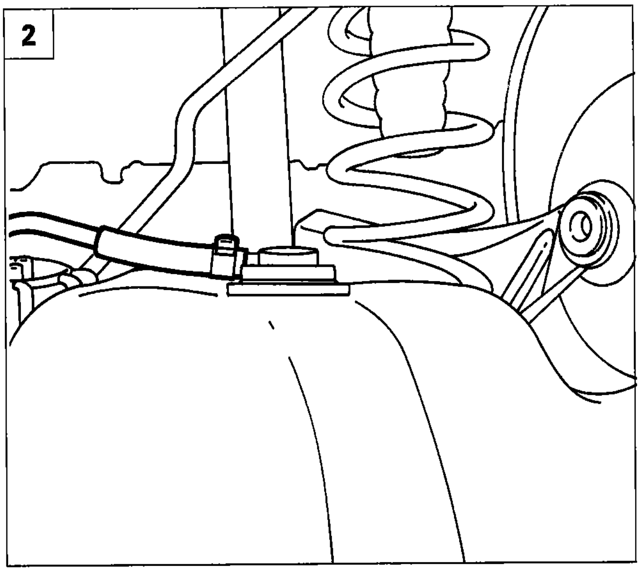
P4F541J04

1. Remove the bolt shown and the plug retaining the fuel filler fitting to the body.

2-3. Open the collars arrowed and release the parking brake control cables from their anchorages on the fuel tank.

4. Arrange a hydraulic jack beneath the tank in order to support it during removing-refitting operations. Then remove the front bolt and plugs securing the tank to the body.


P4F55IJ01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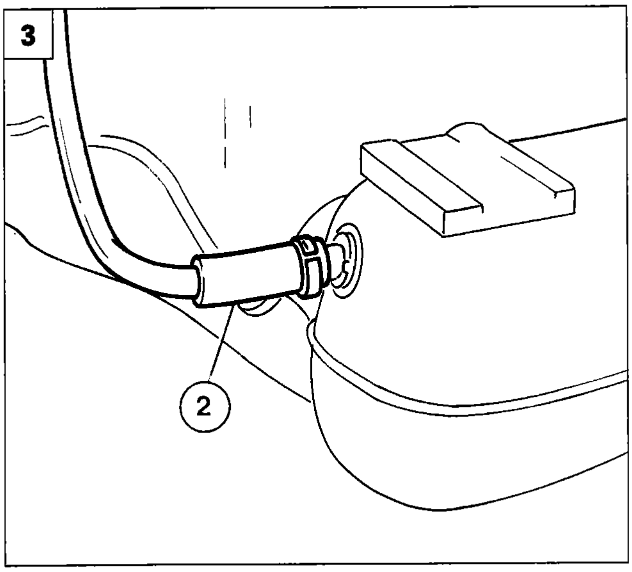
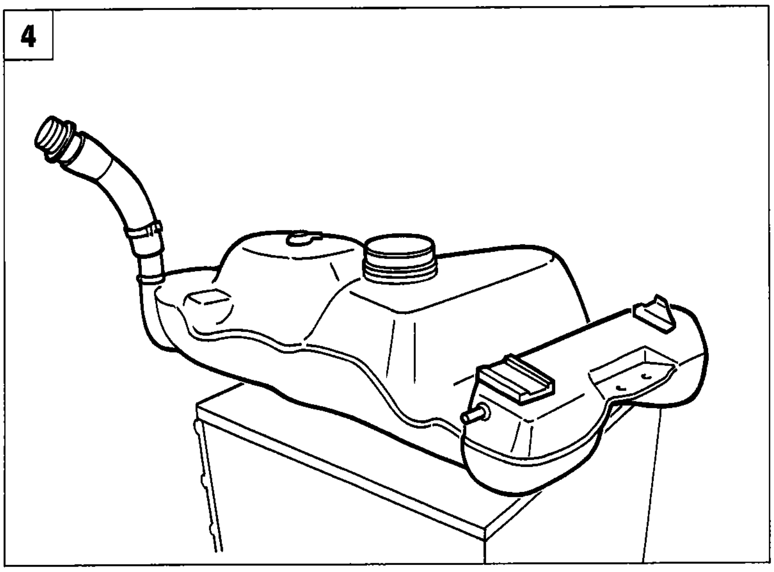


P4F55IJ03

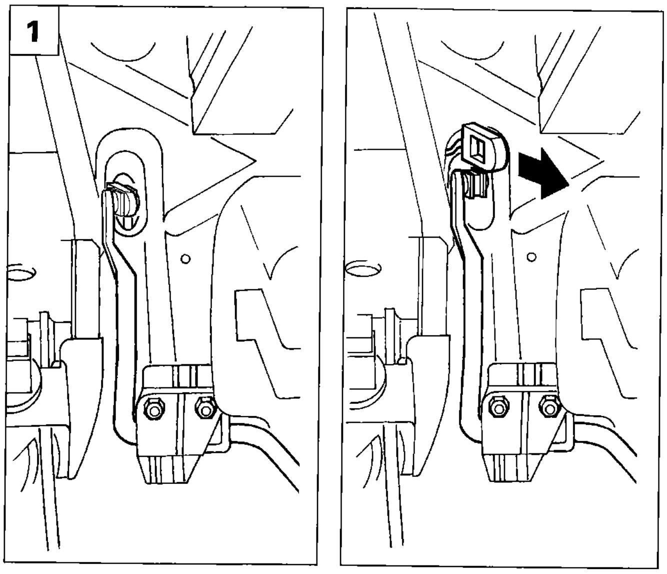
1. Remove the rear bolts and plugs securing the tank to the body.

2. Gradually lower the hydraulic jack. Check that the tank is properly balanced, then disconnect the fuel vapour recovery pipe.

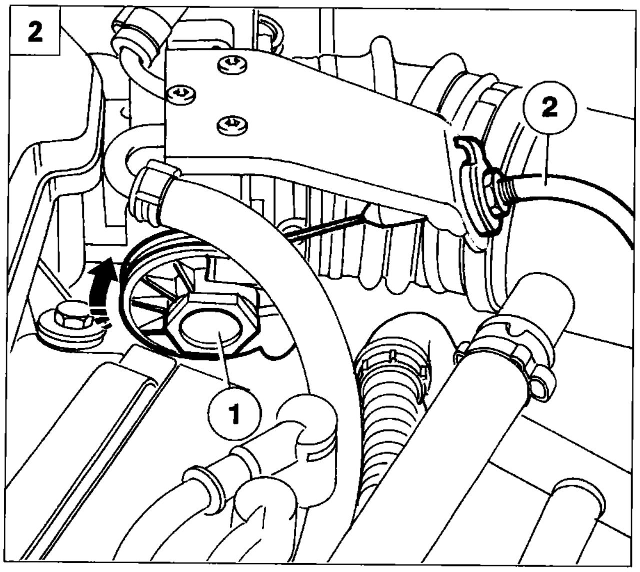
3. If necessary, also disconnect breather pipe (2) on the tank.


P4F55IJ04

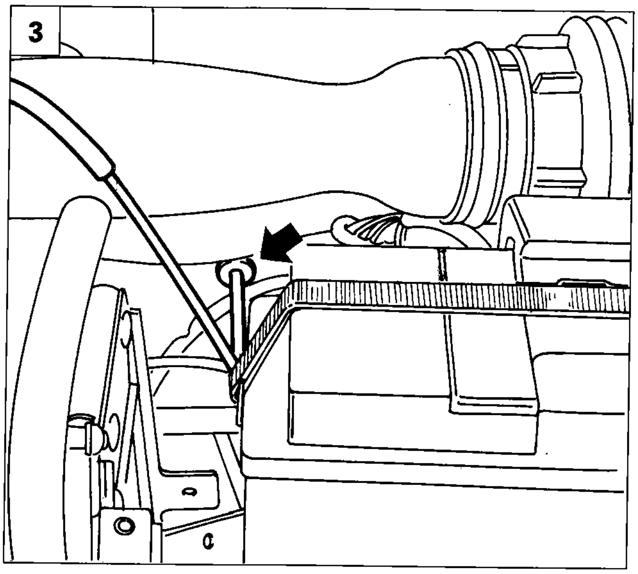
4. Fuel tank.



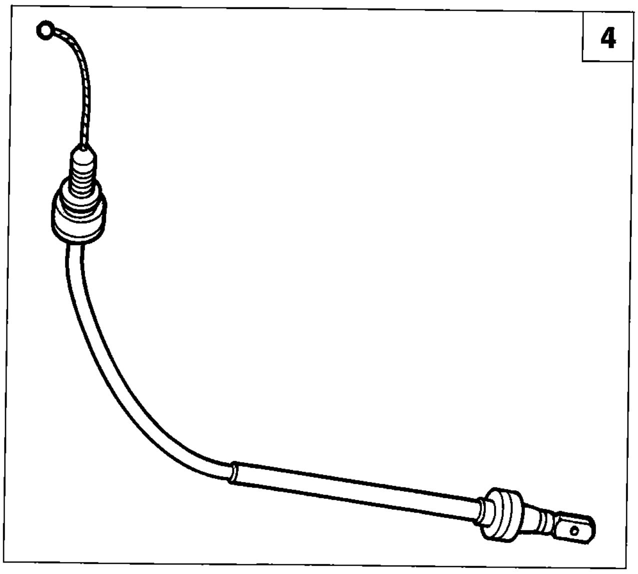
P4F561J01 P4F561J02



P4F561J03



P4F561J04



P4F561J05

REMOVING-REFITTING ACCELERATOR CABLE

Disconnect the battery lead, then proceed as follows:

1. Working from inside the vehicle, disconnect the control cable from its anchorage on the accelerator pedal.
2. In the engine bay, turn the throttle valve control lever (1) and disconnect the accelerator control cable. Then withdraw cable (2) from its support bracket.
3. Withdraw the flexible block from its anchorage hole on the dashboard bulkhead and remove the accelerator cable assembly.
4. Accelerator cable assembly.

After assembly, adjust the accelerator cable as described i the paragraph "Adjusting throttle cable".

CHECKING ENGINE IDLE SPEED

If the engine idle speed is not 850 ± 50 rpm and the injection-ignition control unit is the self-regulating type, then it is not possible to carry out the adjustment, therefore it is necessary to check that the accelerator linkage is correctly adjusted and the fault should be sought through a complate fault diagnosis using the diagnostic equipment.

CHECKING CONCENTRATION OF POLLUTANT EMISSIONS

Thanks to the auto-adjustment of the injection/ignition system, the idle speed and the CO percentage are continuously checked, thereby making any external adjustment operations superfluous (there are no longer any adjustment screws). However, a check on the content of the exhaust gases upstream and downstream of the catalyzer can provide precious indications on the operating conditions of the injection/ignition system and the catalyzer and engine parameters.

Checking idle concentration of CO and HC upstream of the catalytic silencer

To check the concentration of carbon monoxide (CO) and unburnt hydrocarbons (HC) upstream of the catalyzer, proceed as follows:

1. Undo the cap or the nut on the exhaust pipe, upstream of the catalyzer, and tighten the tool in its place.
2. Connect a suitably calibrated CO tester probe to the tool.
3. Start up the engine and let it reach operating temperature.
4. Check that engine speed is correct.
5. Check that the idle CO concentration is within the limits in the table overleaf; if this is not the case, it is necessary to check:
   - that the Lambda sensor is working properly, using the diagnostic equipment;
   - the presence of air penetration in the area surrounding the Lambda sensor housing;
   - the injection and ignition system (**in particular the state of wear of the spark plugs**).
6. Under the same circumstances, check that the HC concentration is less than 600 p.p.m.
7. If these figures are not found, proceed with tuning the engine, in particular checking:
   - the ignition advance angle;
   - the valve clearances;
   - the valve gear timing;
   - the engine compression

Pollutant emissions tolerance figures table

	CO (%)	HC (p.p.m.)	CO_2 (%)
Upstream of the catalyzer	0,4 ÷ 1	600	⩾ 12
Downstream of the catalyzer	⩽ 0,35	⩽ 90	⩾ 13

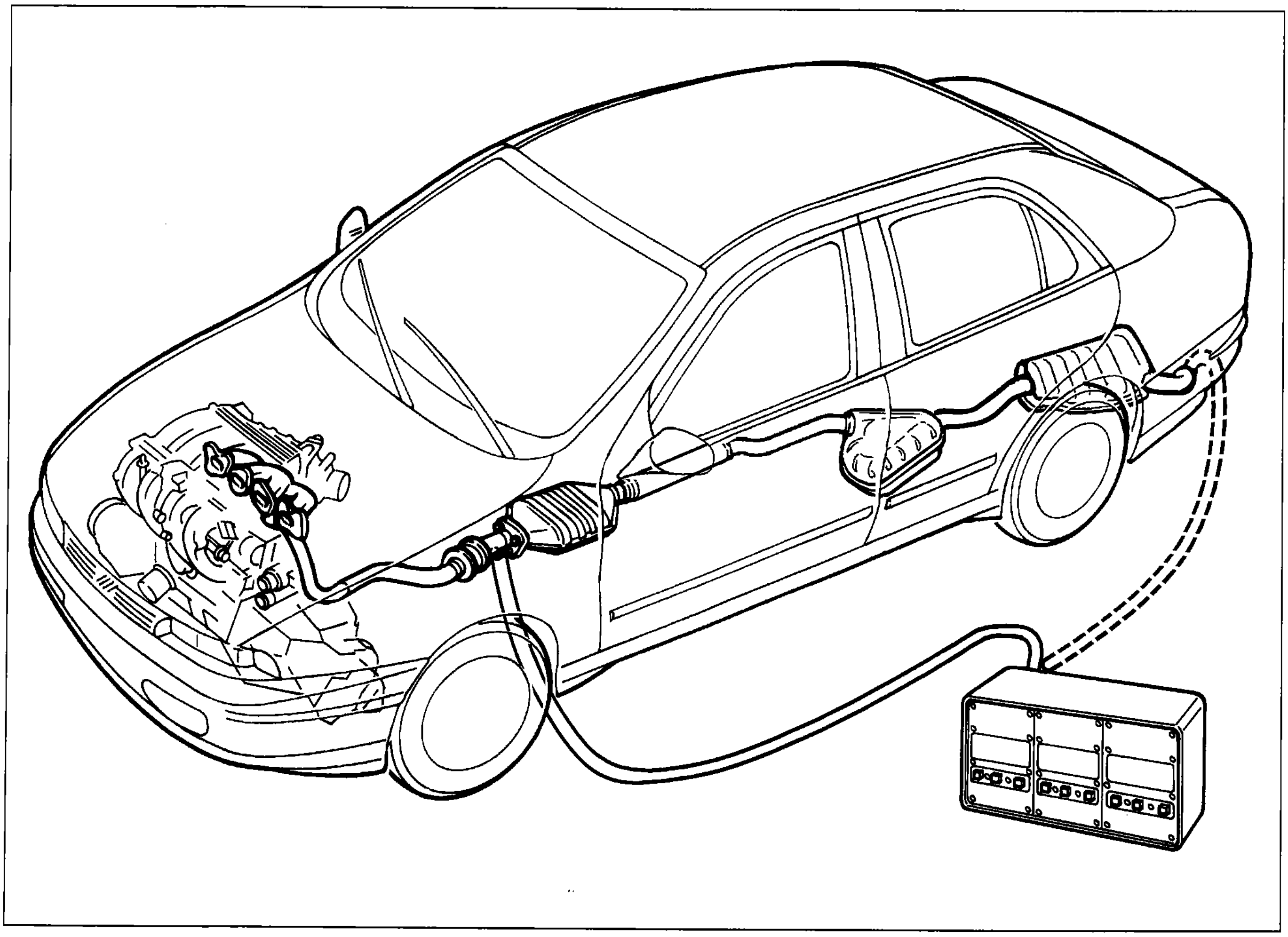
Checking CO and HC levels at exhaust

To measure levels of carbon monoxide (CO) and unburnt hydorcarbons (HC) in exhaust emissions, insert the probe of an appropriately calibrated tester until at least 30 cm inside tail pipe.

If exhaust tail-pipe shape will not allow the probe to be fully introduced, add an extension pipe to ensure a seal in the joint area.

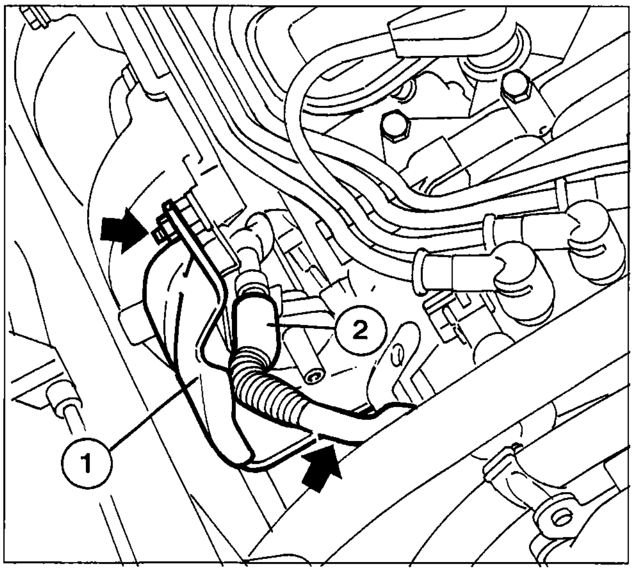
1. Check that idling CO and HC levels are as specified (see table)

2. If HC level is not as specified but level measured upstream of the catalytic converter was correct, it may be assumed that engine is correctly tuned and the fault lies in catalytic converter inefficiency.



P4F58IJ01

CHECKS ON FUEL FEED CIRCUIT



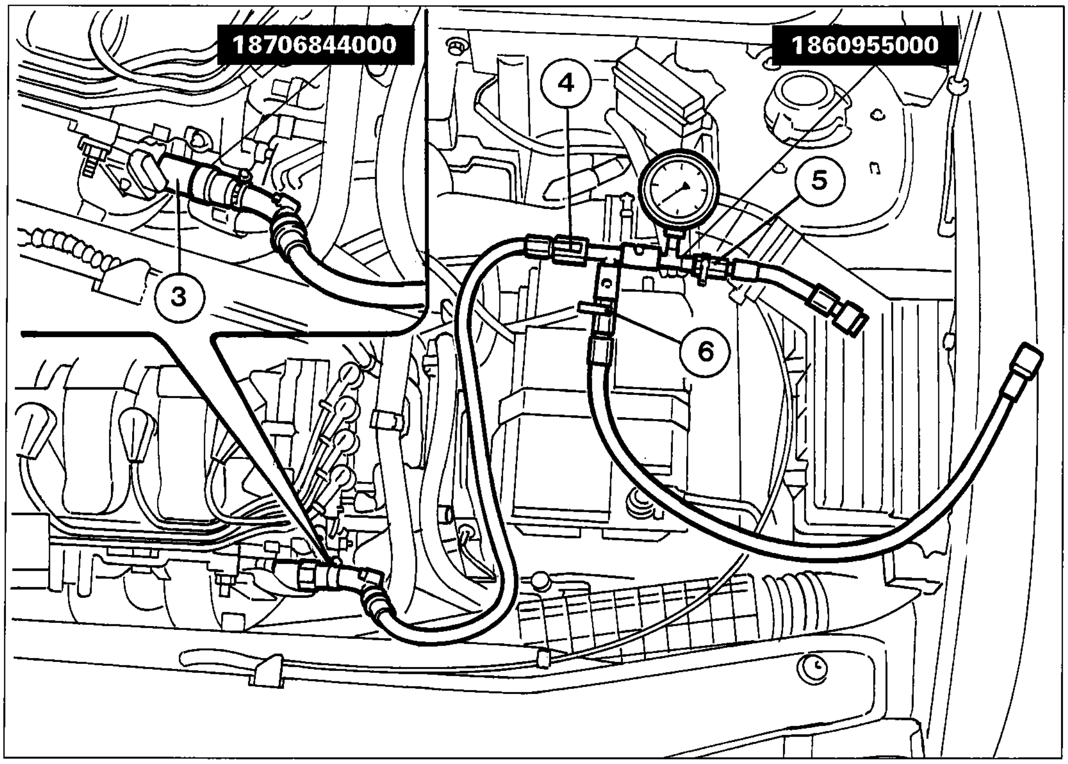
P4F59IJ01

Checking fuel feed pressure

Proceed as follows to check fuel feed pressure:
- undo retaining nuts indicated by arrows and remove bracket (1);
- disconnect injector supply connector (2);
- arrange cock (4) of tool 1860955000 in open position and cocks (5) and (6) in closed position;
- position device 1860955000 and connect to the fuel manifold by means of special adaptor 18706844000 (3) then reconnect injector supply connector (2);

NOTE *Device 1860955000 is fitted with adaptors for connection to different types of injection system. Fit the appropriate adaptors before making the connections.*

- start the engine and check that the pressure gauge reading is stable at 3 bar ± 0.2 bar when idling, then turn off the engine;
- operate the fuel pump with the engine off using a tester. Select fuel pump test when in active test mode;
- the pressure gauge should show a pressure increase of up to 4 bars.
- disconnect device 1860955000 from fuel manifold and refit bracket (1).



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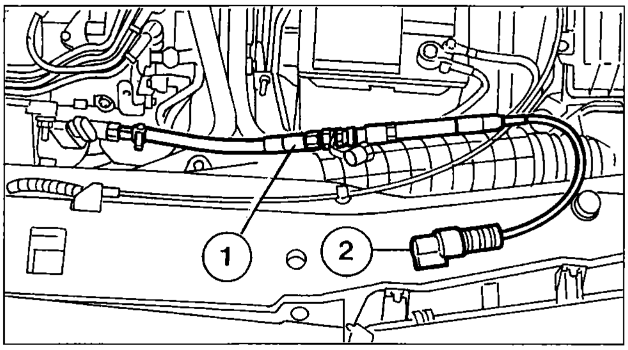


P4F60IJ01

Checkign fuel feed pressure using a tester

Fuel feed pressure can also be checked using an EXAMINER or SDC station. In this case, firstly remove the protective bracket as described in the previous paragraph, connect the tester to transducer (2), which must be connected to the fuel manifold via fitting (1).

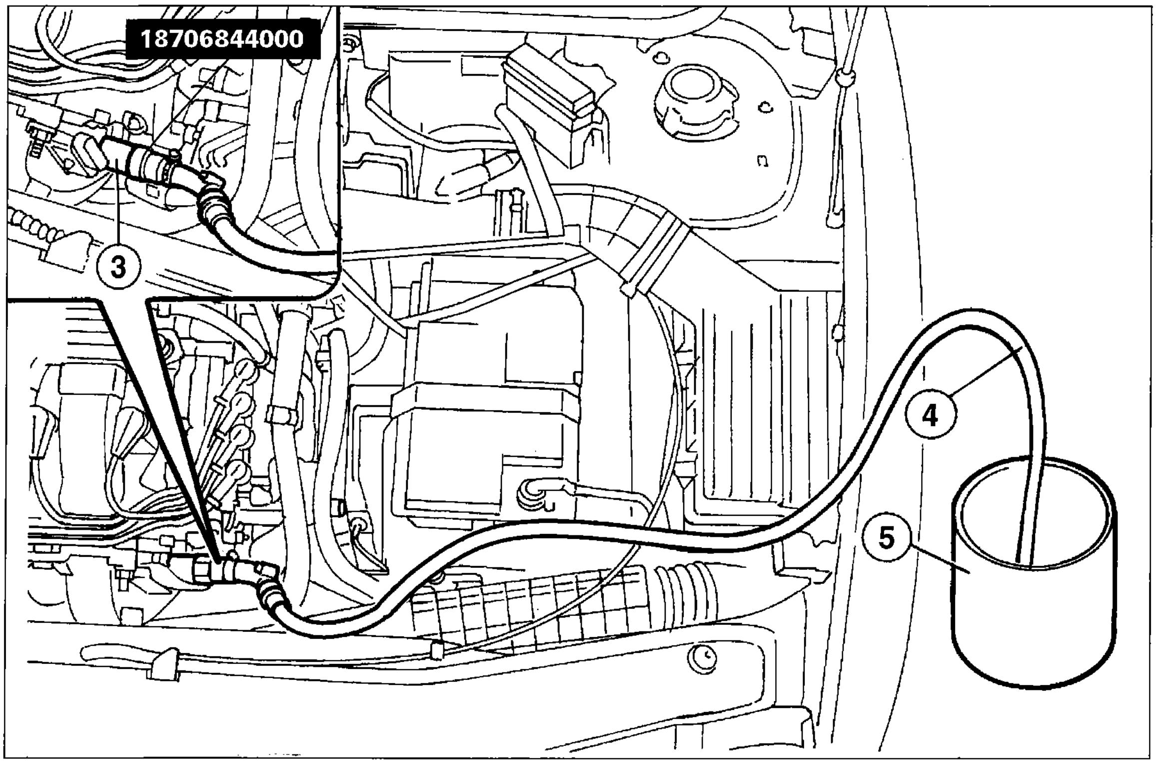
Checking fuel consumption

Check fuel consumption as follows:

- remove the protective bracket and disconnect injector supply connector as described in the previous paragraph on checking fuel feed pressure;

⚠ The fuel supply circuit is maintined at a constant pressure of 3 bar even when the engine is off. Before disconnecting the delivery pipe, therefore, drain off fuel under pressure as described below.

- obtain a suitable container (5) and place pipe (4) inside;
- connect the other end of line (4) to the fuel manifold using a special adaptor 18706844000 (3);
- drain fuel under pressure into container (5);
- disconnect adaptor (3) and fuel manifold pipe (4), then reconnect the injector supply connector;



P4F60IJ02

- disconnect the fuel delivery pipe from the quick-release fitting against the rear engine bay bulkhead and use fittings of tester 1860955000 to connect to a Flowtronic device (1806149001) as follows:
  1. Cut and withdraw end (A) of fitting (2), then connect end (B) to the fitting of rigid pipe (3) and end (A) to the Flowtronic inlet pipe (4).
  2. Insert fitting (5) into pipe section (6) and secure usinga steel collar. Then connect end (A) to pipe (1) disconnected previously and end (B) to the outlet pipe of Flowtronic device (4).
- carry out a fuel consumption road test in accordance with EU directive 93/116/CE (litres x 100 km):

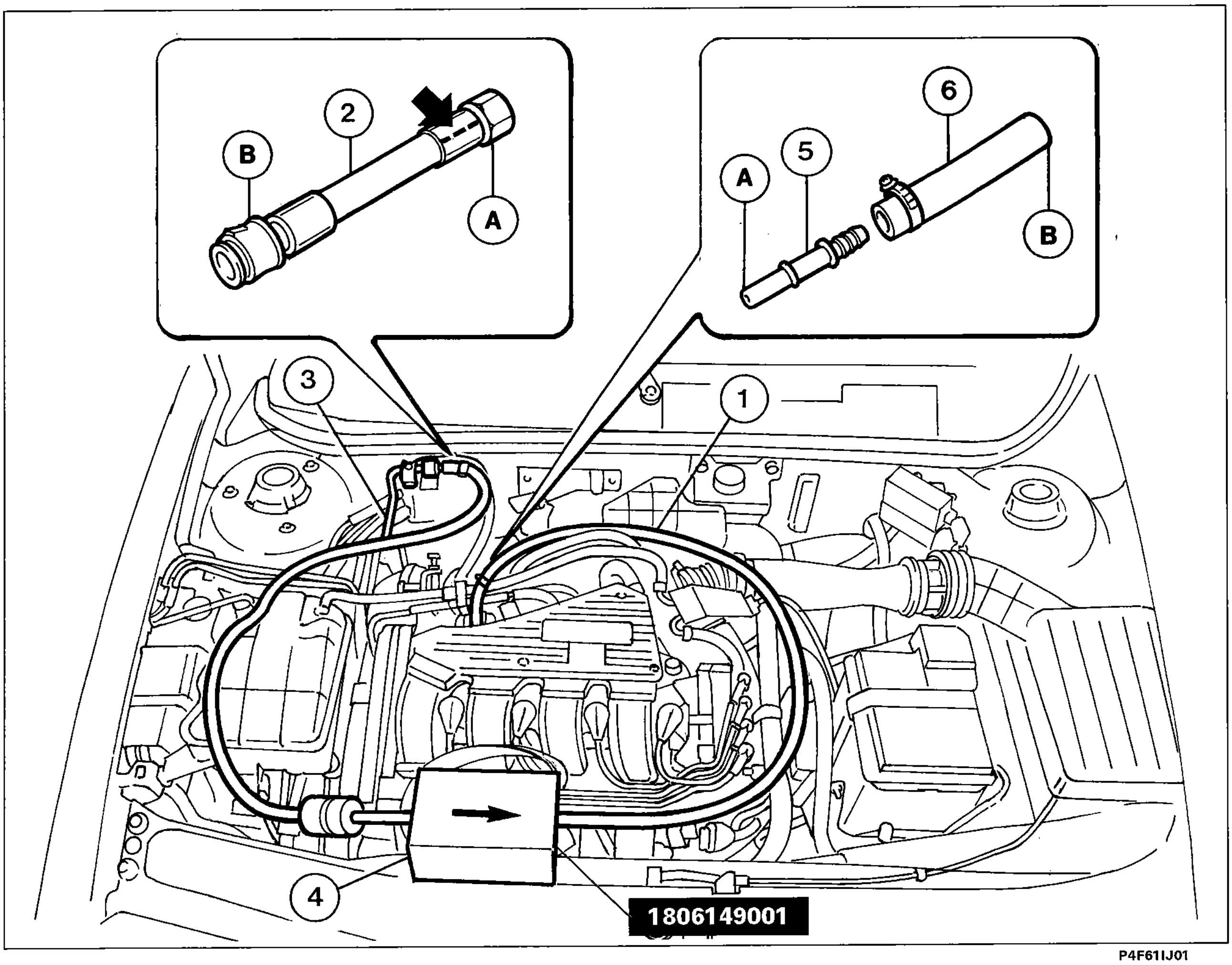
  URBAN CYCLE - includes a cold start followed by a simulated varied urban route.

  OUT-OF-TOWN CYCLE - includes frequent acelerations in all gears to simulate normal out-of-town vehicle use; speed ranges from 0 to 120 km/h.

  AVERAGE COMBINED FUEL CONSUMPTION - 37% of the urban cycle and 63% of the extraurban cycle.

NOTE *Type of route, traffic situations, driving style, weather conditions, version/equipment/accessory level, presence of a roof rack, presence of special equipment and vehicle condition in general, may lead to fuel consumption figures other than those measured as above.*

- check that the readings correspond to specifications in the "Introduction and technical data" section.



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FAULT DIAGNOSIS

Full fault diagnosis can be carried out on the injection-ignition system through active dialogue with an Examiner or SDC station.

If the sensors are found to be faulty, the electronic control unit replaces the faulty data output with a stored signal **(recovery)** so that the engine can continue to operate.

When a fault is detected, it is stored permanently and the sensor is cut off from the system until the signal is again compatible.

The same procedure is applied if the fault affects an actuator or actuator control port. When a fault is detected and replaced with a recovery value, the fault is indicated by means of a warning light on the instrument panel.

The following devices may be managed using the electronic control unit recovery system:

- Idle speed actuator
- Ignition coils
- Fuel vapour recirculation solenoid
- Pressure and air temperature sensor
- Coolant temperature sensor
- Knock sensor
- Throttle position sensor
- Lambda probe

In the case of control unit or rpm sensor faults, the system detects the fault but cannot replace it with a recovery value and the vehicle stalls. Anomalies may be detected in the control unit memory using an Examiner or SDC station.

Error recognition and storage

An error is detected by means of a validation system, which works as follows:

When an error is detected, it is monitored for a time to rule out the possibilty of interference on the tester line. Once this stage is over, the error is considered to be present and stored in the RAM memory (filtered error). A check is then carried to ensure the error continues to be present for a further period of time. Once this stage is over, the error is stored permanently (validated error) and the fault warning light comes on. The error is written into the EEPROM memory after the ignition key has been turned back to STOP.

Error frequency counter

A frequency counter is allocated to each error. This is used to determine the moment at which a fault which is no longer present was first stored. The first time a validated error is recorded, the counter is set at a fixed calibration value.

The counter is decreased whenever the vehicle is started up without the fault reappearing. If the counter goes down to zero, the fault is automatically deleted from the EEPROM memory.

Error deletion

Errors may be deleted from the EEPROM memory in one of two ways:

- using a tester device (Examiner or SDC station), in active test mode
- by zeroing the error frequency counter.

NOTE *Data recorded in the EEPROM memory are not deleted when the control unit is disconnected from the system, even for long periods.*

System fault warning light management

The control unit turns on the warning light to check it is working and keeps it on for 4 seconds whenever the ignition key is turned to MAR. The warning light is also lit whenever a validated error occurs - i.e. as long as the fault persists - and is turned off when the fault disappears.

Communication between control unit and tester

A socket in the engine bay is used for connection of a tester device.
Information is exchanged between control unit and tester by means of a two-way tester line (K line) and the communicaiton protocol is to Key Word 2000 standards. Data are transmitted in NRZ positive logic at a rate of 10400 Bauds.
The tester can provide the following information:

- Engine parameter display;
- Error display;
- Active diagnosis.

Displayed parameters

Engine rpm
Injection time
Absolute pressure to inlet manifold
Inlet air temperature
Coolant temperature
Butterfly valve opening angle
Battery voltage
Number of engine idle speed actuator open/-close steps
Advance
Mixture correction (Lambda probe)
Vehicle speed
Self-adaptability
Error counter
Ignition coil load time (Dwell)
Petrol vapour solenoid
Start-up counter
Engine load
Fiat CODE

List of errors

RPM sensor	Signal absent
Throttle potentiometer	A.C.-D.C.
Absolute pressure sensor	A.C.-D.C.
Air temperature sensor	A.C.-D.C.
Coolant temperature sensor	A.C.-D.C.
Battery	Power supply> 16.2V Power supply< 6V
Lambda probe	Implausible signal D.C.
Injectors	A.C.-D.C.
Ignition coils	A.C.-D.C.
Idle speed actuator	A.C.-D.C.
Fuel vapour solenoid	A.C.-D.C.
Actuator relays	A.C.-D.C.
Control unit	Microprocessor or ECU memory faults are indicated.
Self-adaptive parameters	Indication displayed when ECU self-adaptive limits reached. This indicates that engine parameters are too far removed from specified values. It is therefore advisable to look for mechanical and other faults.
Speed sensor	Implausible signal Speed greater than top speed
Knock sensor	A.C.-D.C.
Fiat CODE	Code not recognised or not received

Active diagnosis

When in active diagnosis mode, some components can be activated and certain specific functions can be carried out, e.g. the error deletion command described in the following table.

During active diagnosis, the ignition key must be turned to MAR and the engine must be running for certain functions.

Function/Actuator	Activation mode
Electric fuel pump	Relay activation for 30 s
Injectors	Activation for 4 ms in each s for 5 times
Ignition coils	Activation for 2 ms in each s for 5 times
Error deletion command	Validated error deletion
Fuel vapour solenoid	Activation for 20 ms in each s for 7 times
Rev counter	Activation at 125 Hz for 2 s
Air conditioner relay	Relay activation for 30 s
Injection system failure warning light	Warning light activation for 30 s
Excessive coolant temperature warning light	Warning light activation for 10 s
Engine idle speed actuator	Activation for 32 forward/backward steps
Fiat CODE	Recovery procedure to allow engine start-up
Radiator fan	Activation for 10 s at both high and low speed

page

FUEL SYSTEM

The information in this publication is intended as a guide and could be superseded as a result of modifications adopted by the Manufacturer at any time due to technical and commercial reasons and in accordance with local regulations.

Fiat Auto S.p.A.

D.M.C. - M.P.S.
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INTRODUCTION

From chassis no. 205884, a new hot-film flowmeter has been adopted instead of the vane-type flowmeter.

The hot-film flowmeter is more precise and, as it has no moving parts, it is more reliable than the previous version.

With the introduction of the new flowmeter, other parts have also been affected by the modification; in addition to the hot-film flowmeter the new parts (added or modified) relating to the fuel system are as follows:

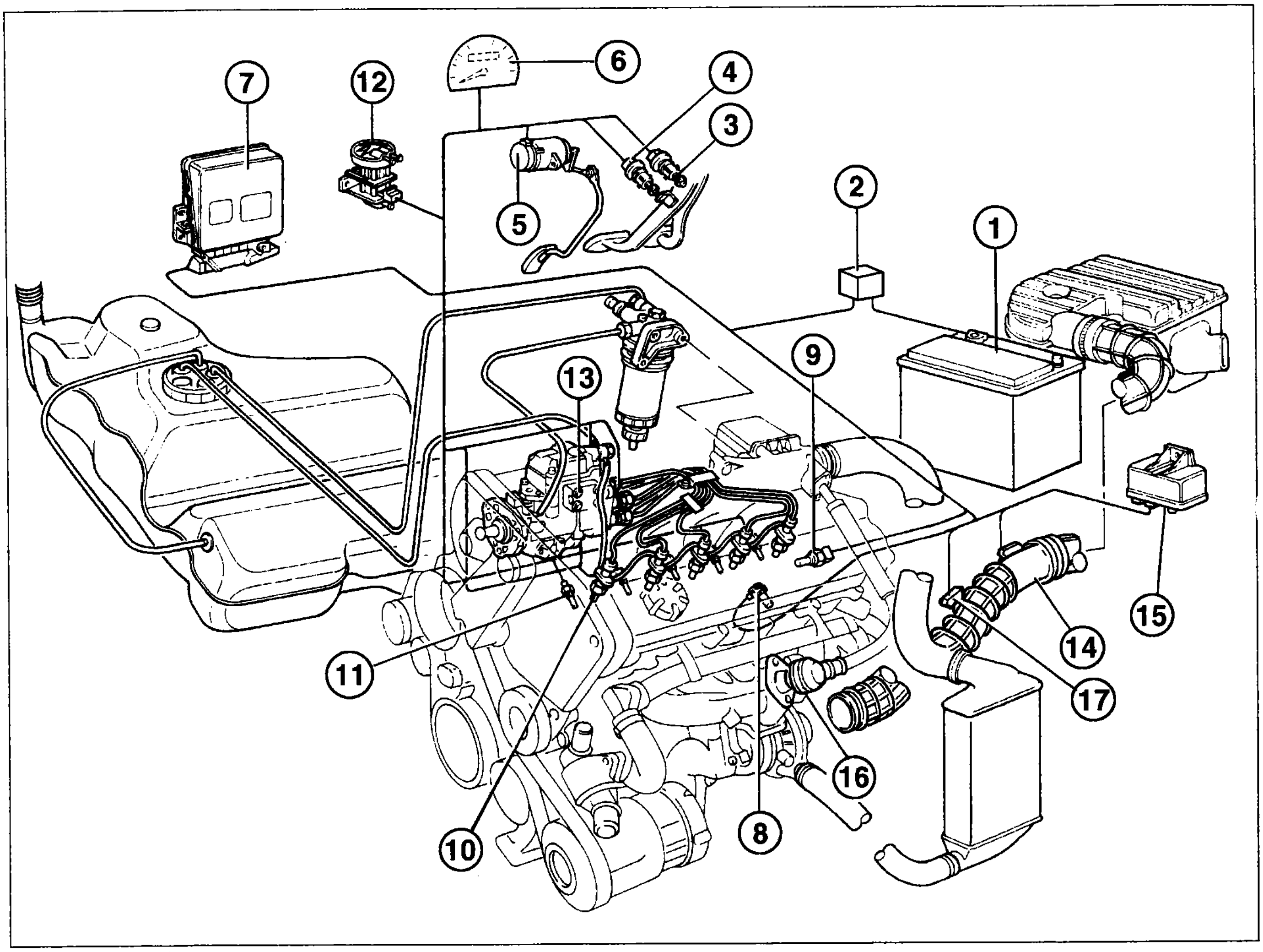
- Modified air duct connecting air cleaner to flowmeter.
- Modified air duct connecting flowmeter to turbine.
- Modified flowmeter mounting bracket.
- Replaced engine coolant temperature sender unit with a new sender unit which comprises two separate sensors: one for the fuel injection and one for the instrument panel gauge.
- Added intake air temperature sender unit which is no longer built into the flowmeter, but is a single component located upstream of the new hot-film flowmeter.
- Modified fuel injection pump: on the fuel outlet connection for the return to the tank, the 0.75 mm calibrated hole has been replaced with a valve calibrated at the pressure of about 4 bar; this allows the pump not to empty and to keep fuel under pressure in it, thus ensuring better engine starting.
- New Bosch 0.432.217.297 fuel injectors.
- New Bosch 0.432.217.296 instrumented fuel injector.
- New MSA 11 Bosch 0.281.001.741 fuel injection electronic control unit.
- New fuel injection wiring for connection to the new sensors.

This section only covers the parts of the 2387 TD engine fuel system which are different in relation to the previous version.

For aspects not covered in the following pages, see the descriptions give in the "Fuel system of 2387 TD" in the basic edition, contained in volume 1.

10.

GENERAL DIAGRAM OF FUEL SYSTEM



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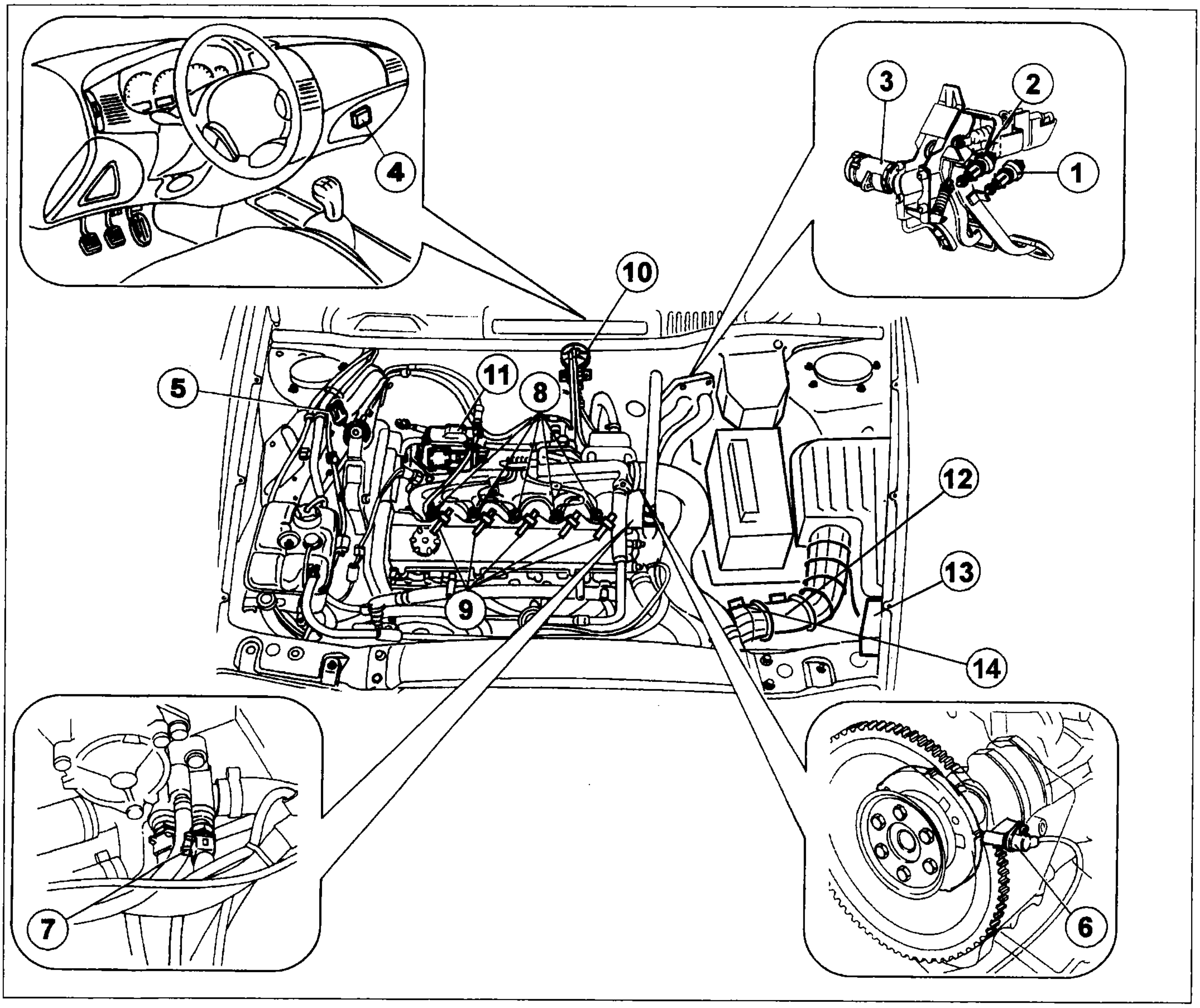
1. Battery
2. Relay
3. Clutch pedal switch
4. Brake pedal switch
5. Accelerator potentiometer
6. Speedometer
7. Electronic control unit
8. Engine rpm sensor
9. Coolant temperature sensor
10. Instrumented fuel injector
11. Heater plugs
12. Borg-Warner modulating valve
13. Bosch fuel injection pump
14. Flowmeter
15. Plug preheating control unit
16. E.G.R. valve
17. Intake air temperature sensor

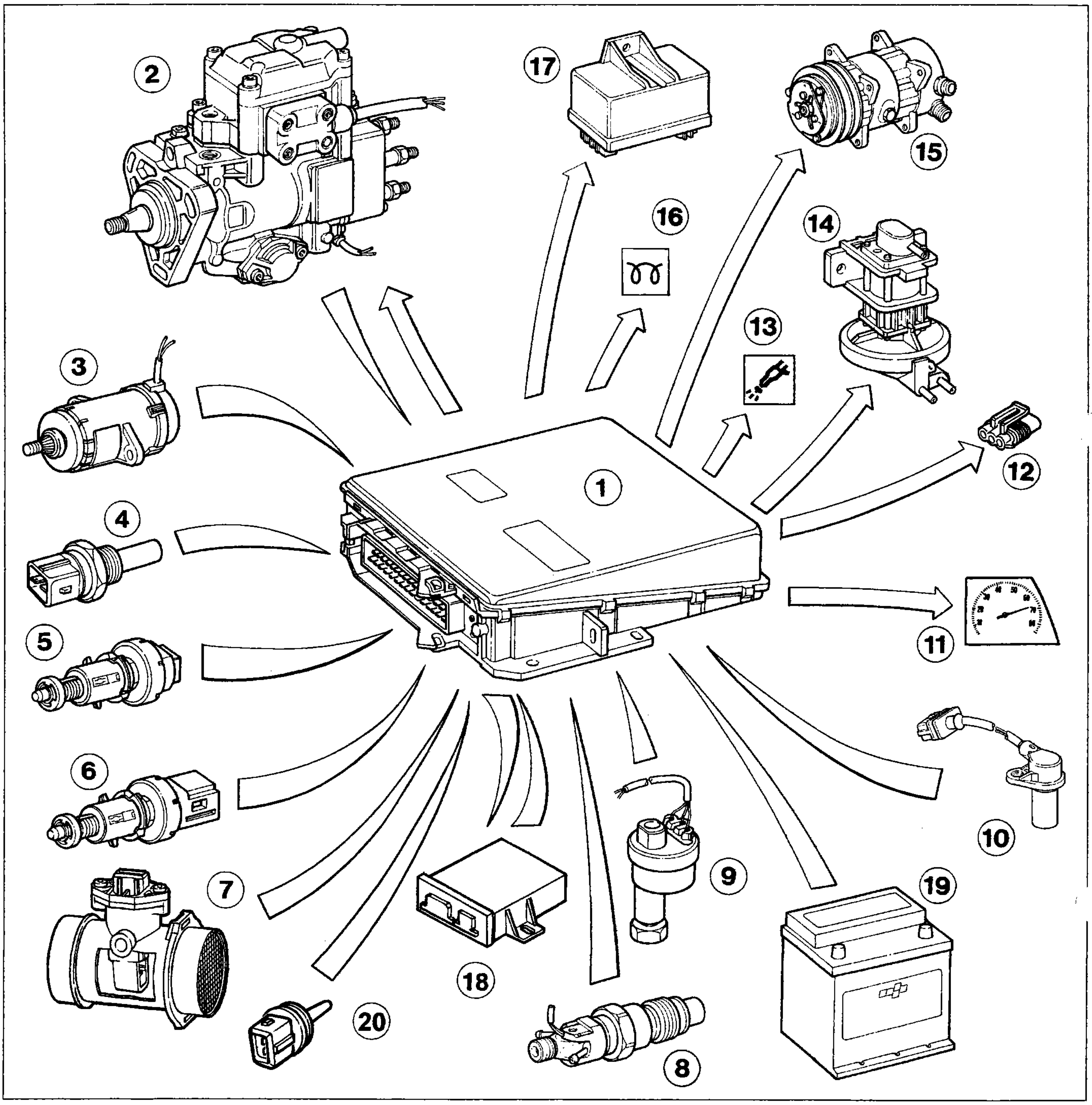
LOCATION OF FUEL SYSTEM COMPONENTS



1. Clutch pedal switch
2. Brake pedal switch
3. Accelerator potentiometer
4. Electronic control unit
5. Diagnostic socket
6. Engine rpm sensor
7. Coolant temperature sensor
8. Fuel injectors
9. Heater plugs
10. Borg Warner modulating valve
11. Bosch fuel injection pump
12. Flowmeter
13. Plug preheating control unit
14. Intake air temperature sensor

10.

INPUT/OUTPUT SIGNALS BETWEEN CONTROL UNIT AND SENSORS/ACTUATORS



1. Electronic control unit
2. Injection pump
3. Accelerator pedal potentiometer
4. Engine coolant temperature sensor
5. Clutch pedal switch
6. Brake pedal switch
7. Air flowmeter
8. Instrumented fuel injector
9. Speedometer sensor
10. Engine rpm sensor
11. Rev counter
12. Diagnostic socket
13. Fuel injection fault warning light
14. Borg Warner solenoid
15. Air conditioner
16. Heater plugs warning light
17. Plug preheating control unit
18. Fiat CODE control unit
19. Battery
20. Intake air temperature sensor

The BOSCH MSA11 electronic control unit (1) receives the following information:

- accelerator pedal position from the potentiometer connected to it (3);
- engine rpm from the sensor mounted on the engine block (10);
- intake air quantity from the flowmeter (7);
- quantity of fuel injected from the sensor mounted on the actuator contained in the fuel injection pump (2);
- intake air temperature from the relevant sensor (20);
- diesel temperature from the sensor located in the fuel injection pump (2);
- coolant temperature from the sensor (4);
- actual start of injection (opening of fuel injector pintle) from the instrumented fuel injector (8), located on cylinder 1;
- car speed from speedometer sensor (9) located on the gearbox;
- brake operation information from the switch (6) located on the brake pedal;
- clutch operation from the switch (5) located on the clutch pedal;
- atmospheric pressure from the sensor located inside the control unit (1);
- signal requesting the switching on of the air conditioner compressor from the air conditioning system (15).

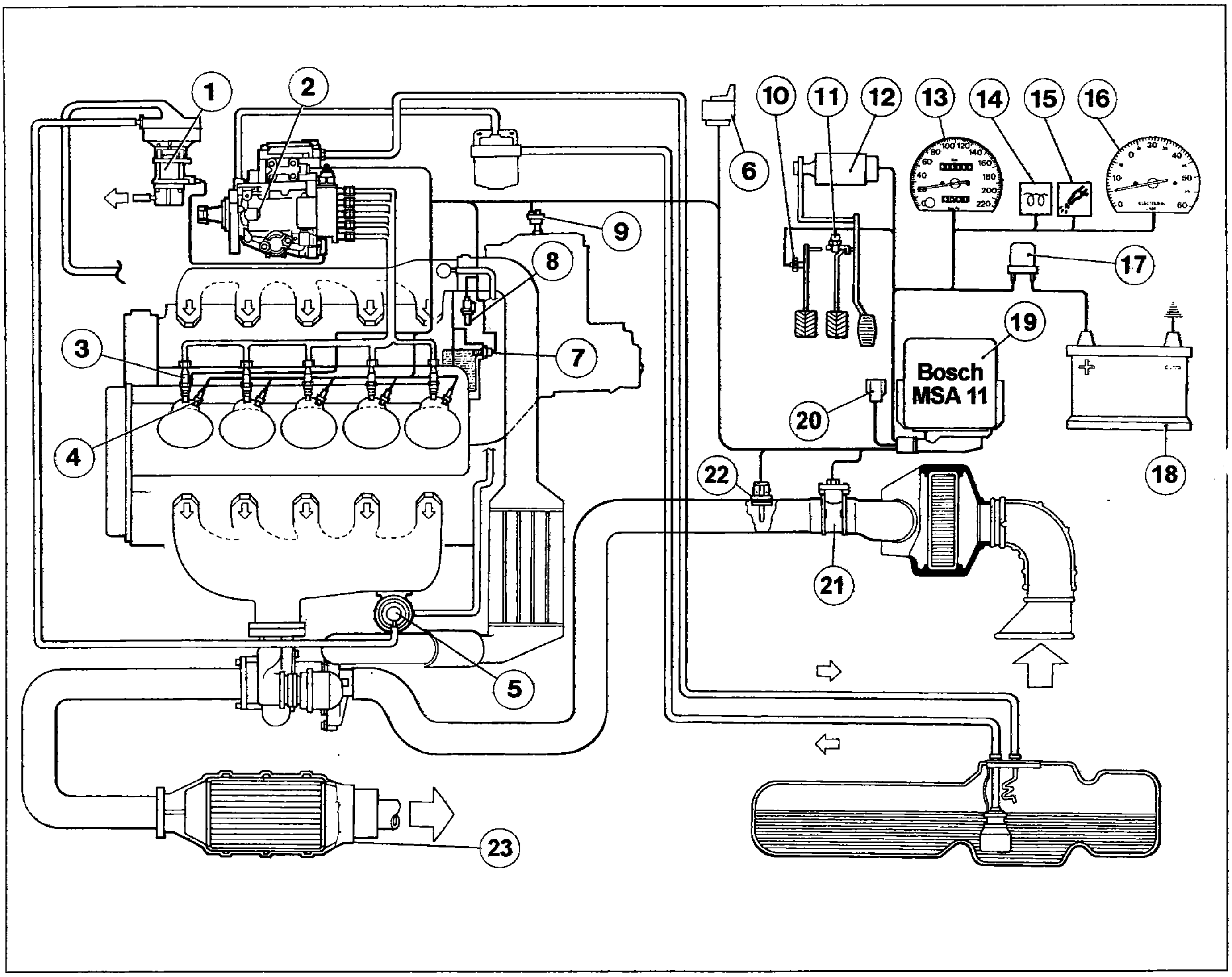
Depending on the input values, the electronic control unit (1) consults the mapped values in its memory and corrects the output values accordingly, thus managing:

- the actuator controlling the quantity of fuel contained in the fuel injection pump (2);
- the fuel injection advance regulation solenoid contained in the fuel injection pump (2);
- the engine stop solenoid contained in the fuel injection pump (2);
- the heater plug control unit (17);
- the Borg Warner (14) vacuum modulating solenoid controlling the E.G.R. valve;
- the heater plugs warning light (16);
- the fuel injection fault warning light (13);
- the rev counter (11);
- the engagement of the air conditioner compressor electromagnetic clutch (15);
- the diagnostic socket (12).

The control unit also has the function of blocking engine starting (Fiat CODE).
This function is carried out by a specific control unit (Fiat CODE) (18), which can dialogue with the electronic control unit (1), and an electronic key with a special transmitter for sending a recognition code.

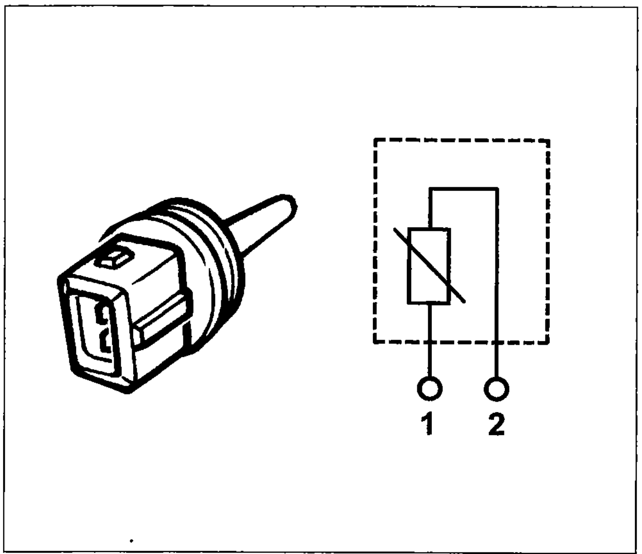
10.

FUNCTIONAL DIAGRAM OF THE FUEL SYSTEM



P4F06LJ01

1. Borg Warner modulating valve
2. Bosch fuel injection pump
3. Instrumented fuel injector
4. Heater plug
5. EGR valve
6. Plug preheating control unit
7. Coolant temperature sensor
8. Engine rpm sensor
9. Speed sensor
10. Clutch pedal sensor
11. Brake pedal sensor
12. Accelerator potentiometer
13. Speedometer
14. Heater plug warning lamp
15. Fuel injection fault warning light
16. Rev counter
17. Relay
18. Battery
19. Fuel injection control unit
20. Diagnostic socket
21. Air flowmeter
22. Intake air temperature sensor
23. Catalytic converter



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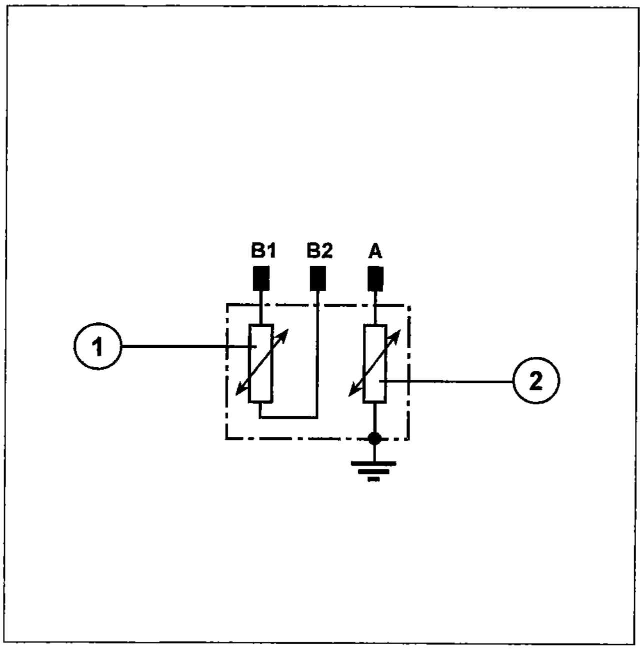
AIR TEMPERATURE SENSOR

On this version, the intake air temperature sensor is separate from the air flowmeter; it is an ordinary NTC (Negative Temperature Coefficient) sensor, whose electrical resistance decreases as temperature increases.

As the input circuit into the control unit is designed as a voltage divider, this voltage is divided between a resistor present in the control unit and the sensor's NTC resistor. The control unit can therefore assess the changes in the sensor's resistance from the changes in voltage, and thus obtain the temperature information.



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COOLANT TEMPERATURE SENSOR

The sensor consists of a brass casing which houses the actual resistive elements, which are two NTC (Negative Temperature Coefficient) thermistors; the electrical resistance of the sensor decreases as the temperature increases.
The two NTC thermistors are separate, and they supply the temperature information to the specific gauge on the instrument panel and the fuel injection-ignition control unit.
For the NTC element relating to the fuel injection, the reference voltage is 5 Volt; as the input circuit into the control unit is designed as a voltage divider, this voltage is divided between a resistor present in the control unit and the sensor's NTC resistor. The control unit can therefore assess the changes in resistance of the sensor through the changes in temperature.

1. NTC for fuel injection
2. NTC for instrument panel gauge

The tables opposite give the resistance values which the NTC elements can assume in accordance with the coolant temperature.

INJECTION NTC

°C	Ω
-20	15970
-10	9620
0	5975
10	3816
20	2500
25	2044
30	1679

°C	Ω
40	1150
50	807
60	576
70	418
80	309
90	231
100	176

GAUGE NTC

°C	Ω
60	512-602
90	184-208
120	76-88

HOT-FILM AIR FLOWMETER

This component measures the quantity of air drawn in by the engine. The electrical signal (proportional to the air flow) which the flowmeter gives as an output is sent to the engine control unit. This is used to:
- calculate the quantity of fuel to be injected, so as to obtain the maximum fuel flow rate while maintaining an acceptible level of smoke in the exhaust;
- check the quantity of gases recirculating through the EGR valve.

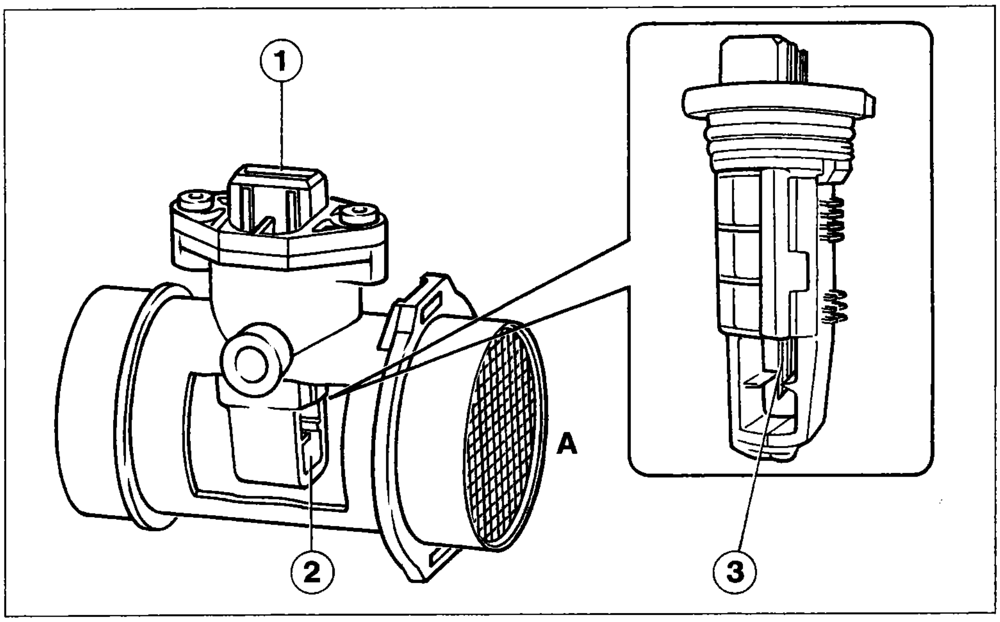
The check on the quantity of recirculating gases is based on the following equation:

Qam - Qar = Qgr

Qam = quantity of theoretical air mapped in the control unit in a particular point of engine operation;
Qar = quantity of air which really passes through the flowmeter (and is drawn in by the engine) at the same point of engine operation;
Qgr = the imbalance, compared with the theoretical value, of the quantity of recirculating gases.

If the quantity of recirculating gases is correct for a particular point of engine operation, the quantity of air drawn in by the engine must be the same as the mapped quantity. Thus Qgr must be zero. If Qam is greater than Qar, this means that the quantity of air passing through the flowmeter is less than the theoretical quantity, i.e. the quantity of recirculating gases is higher than the specified value (Qgr > 0). In this case the control system intervenes on the EGR valve to reduce the flow rate, so that the Qgr value is cancelled.

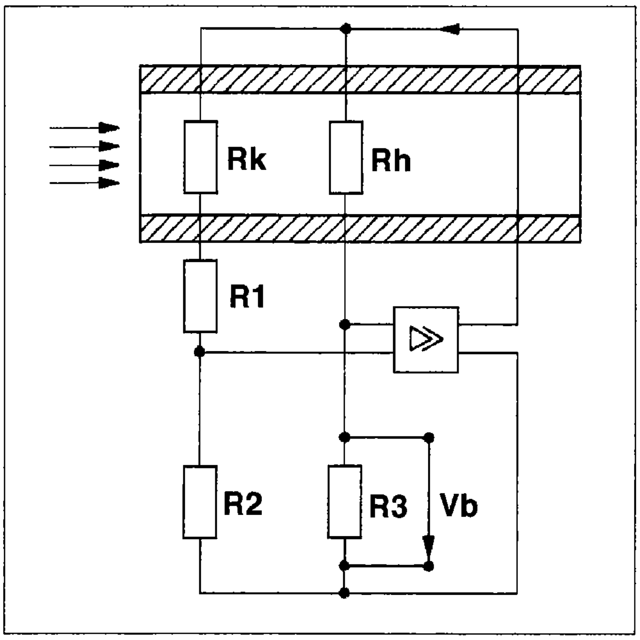
The system behaves in the same way if Qar > Qam.



1. Connector
2. Measuring channel
3. Hot-film sensor
A = Air input

The "hot-film" air flowmeter.
The operating principle of these sensors is based on the heat exchange between a "hot" element and the air flow enveloping it.
The heat exchanged is given by the electrical power supplied by the power supply to the hot element, to keep its temperature constant.

The principle of operation of the flowmeter may be observed from the following wiring diagram of the electrical circuit which drives the sensor:



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Wiring diagram

Rh = hot film

Rk = temperature compensation sensor

R1, R2, R3 = bridge resistors

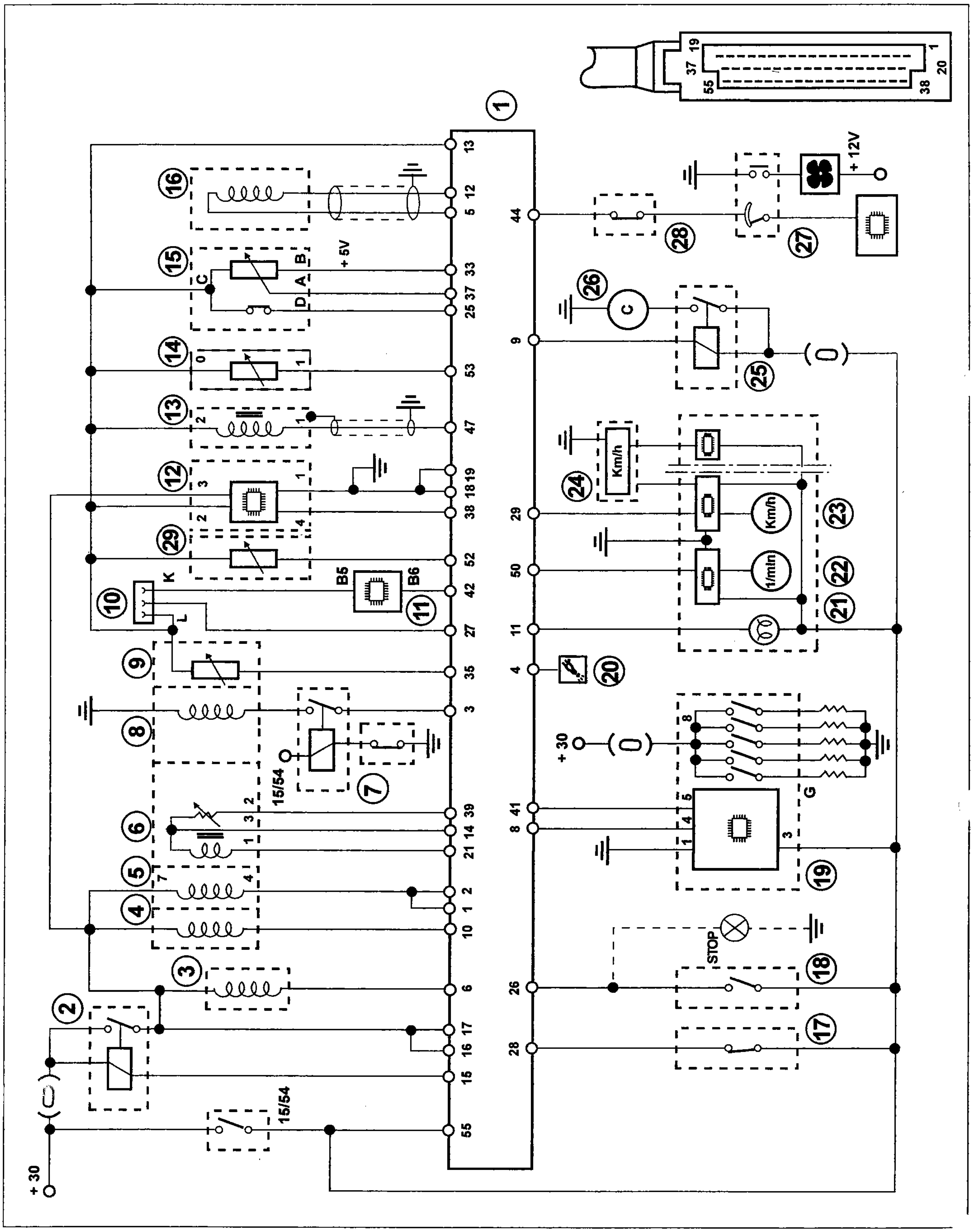
In the diagram, the component Rh represents the hot sensor, which is kept at constant temperature in relation to the air temperature.
An increase in the quantity of air enveloping the hot element causes it to cool down, and so reduces its resistance, unbalancing the bridge.
The circuit restores the balance of the bridge by increasing the current supplied to the hot element until its resistance (and so its temperature) assumes the original balanced value.
The increase in current which passes through the hot element is proportional to the air flow passing through the flowmeter. This value thus gives the air flow: to measure precisely the current passing through the hot film, the voltage at the ends of the fixed resistor R3 is measured; this voltage thus provides the information on the mass of air passing through the flowmeter.

To compensate for the measurement error due to the variation in air temperature, the resistor Rk is in parallel to the hot film. Its high value only changes when the air temperature changes, compensating for the increase in resistance of the hot sensor, so the bridge does not undergo unbalancing due to the variation in the air temperature.

The hot element consists of platinum. For the same area, film technology offers shorter response times than hot wire. In addition, having a larger area than wire, it has greater immunity to inorganic contamination.

10.

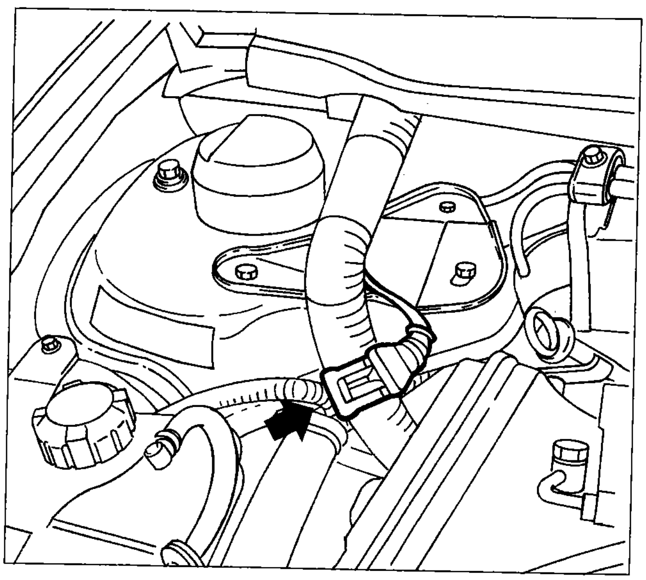
WIRING DIAGRAM



P4F10LJ01

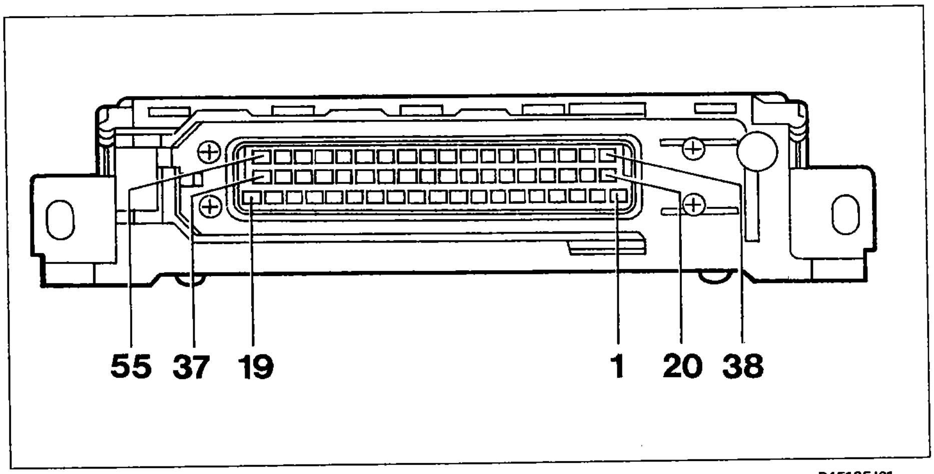
Key to wiring diagram

1. Electronic control unit
2. System protection relay
3. Borg-Warner modulating solenoid
4. Fuel injection advance actuator
5. Fuel quantity actuator
6. Fuel quantity actuator position control
7. Inertial switch
8. Engine cut-out solenoid
9. Fuel temperature sensor
10. Diagnostic socket
11. Immobilizer
12. Flowmeter
13. Engine rpm sensor
14. Engine coolant temperature sensor
15. Accelerator pedal potentiometer with idle switch
16. Instrumented fuel injector
17. Clutch pedal switch
18. Brake pedal switch
19. Plug preheating electronic control unit
20. System fault warning light
21. Plug preheating warning light
22. Rev counter
23. Speedometer
24. Speedometer sensor
25. Air conditioner compressor relay
26. Air conditioner compressor
27. Three-stage pressure switch
28. Anti-frost thermostat
29. Air temperature sensor



Location of diagnostic socket

CONTROL UNIT PINS



1. Fuel flow actuator
2. Fuel flow actuator
3. Engine cut-out solenoid
4. Infocenter
5. Instrumented fuel injector
6. E.G.R. solenoid
7. Not connected
8. Activation of plug preheating control unit
9. A.C. compressor
10. Fuel injection advance actuator
11. Heater plugs "on" warning light
12. Earth for instrumented fuel injector
13. Sensors' shared earth
14. Cursor position sensor
15. Main relay
16. Control unit supply through relay
17. Control unit supply through relay
18. Earth
19. Earth
20. Not connected
21. Cursor position sensor (reference winding)
22. Not connected
23. Not connected
24. Not connected
25. Idle switch on accelerator pedal
26. Stop lights switch
27. Not connected
28. Clutch pedal switch
29. Vehicle speed signal
30. Not connected
31. Not connected
32. Not connected
33. 5V accelerator pedal position sensor
34. Not connected
35. Fuel temperature signal
36. Not connected
37. Accelerator pedal position signal
38. Flowmeter signal
39. Cursor position sensor signal
40. Not connected
41. Heater plug operation signal
42. Line K and immobilizer
43. Not connected
44. Signal required for switching on compressor
45. Not connected
46. Not connected
47. Engine rpm sensor
48. Not connected
49. Not connected
50. Rev counter signal
51. Not connected
52. Air temperature signal
53. Engine coolant temperature signal
54. Not connected
55. Ignition key positive