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The information contained in this publication is provided as a guide and may no longer be up to date as a result of modifications made by the Manufacturer, at any time, for reasons of a technical or marketing nature in addition to adaptations to meet legal requirements in various countries.

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BOSCH M1.5.5 INTEGRATED INJECTION/IGNITION SYSTEM

Introduction

The BOSCH M1.5.5 system fitted on the 1242 16v engine belongs to the category of static advance digital electronic ignition systems integrated with phased multiple intermittent type electronic fuel injection systems.
The integrated system can be summarized in the following sub-systems:

ELECTRICAL/ELECTRONIC CIRCUIT
AIR INTAKE CIRCUIT
FUEL SUPPLY CIRCUIT
EMISSION CONTROL DEVICES

- The system is capable of detecting the following parameters by means of suitable sensors:
- the engine rotation speed;
- the correct sequence of TDC for the explosion stroke in the cylinders (injection timing);
- the absolute pressure in the inlet manifold;
- the temperature of the intake air;
- the position and the variation speed of the accelerator butterfly position;
- the temperature of the engine coolant;
- the possible presence of detonation;
- the speed of the vehicle;
- the battery voltage;
- whether the air conditioning is switched on;
- whether the power steering is in the end of travel position;

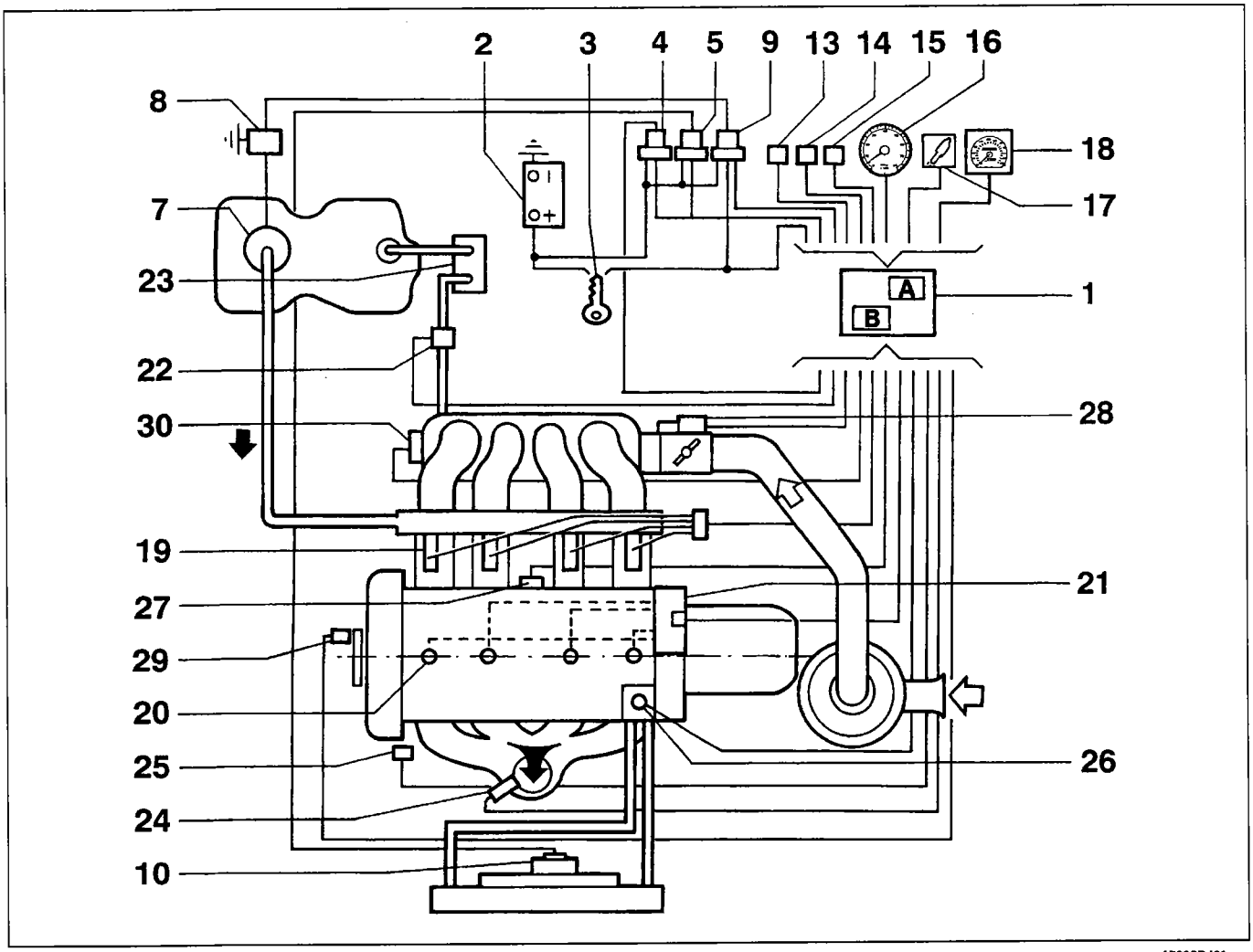
This information, usually in analogue format, is converted into digital signals by analogue/digital converters (A/D) in order to be able to be used by the control unit.
The control unit memory contains the management programme (software) which consists of a series of strategies, each of which manages a precise system control function.
Using the information (input) listed previously, each strategy processes a series of parameters using data maps stored in special areas of the control unit memory and then controls the system actuators (output) which consist of devices which allow the engine to operate, namely:
injectors;
relay feeds;
implementation fan;
interface with the vehicle (diagnostic warning light, diagnostic instrument, etc.).

NOTE *The BOSCH M1.5.5 injection/ignition system does not require any adjustments as it is the self-regulating type.*

NOTE *The numbers in the drawings and the diagrams indicate the corresponding pins for the engine control unit (number/A for connector A, number/B for connector B).*

10.

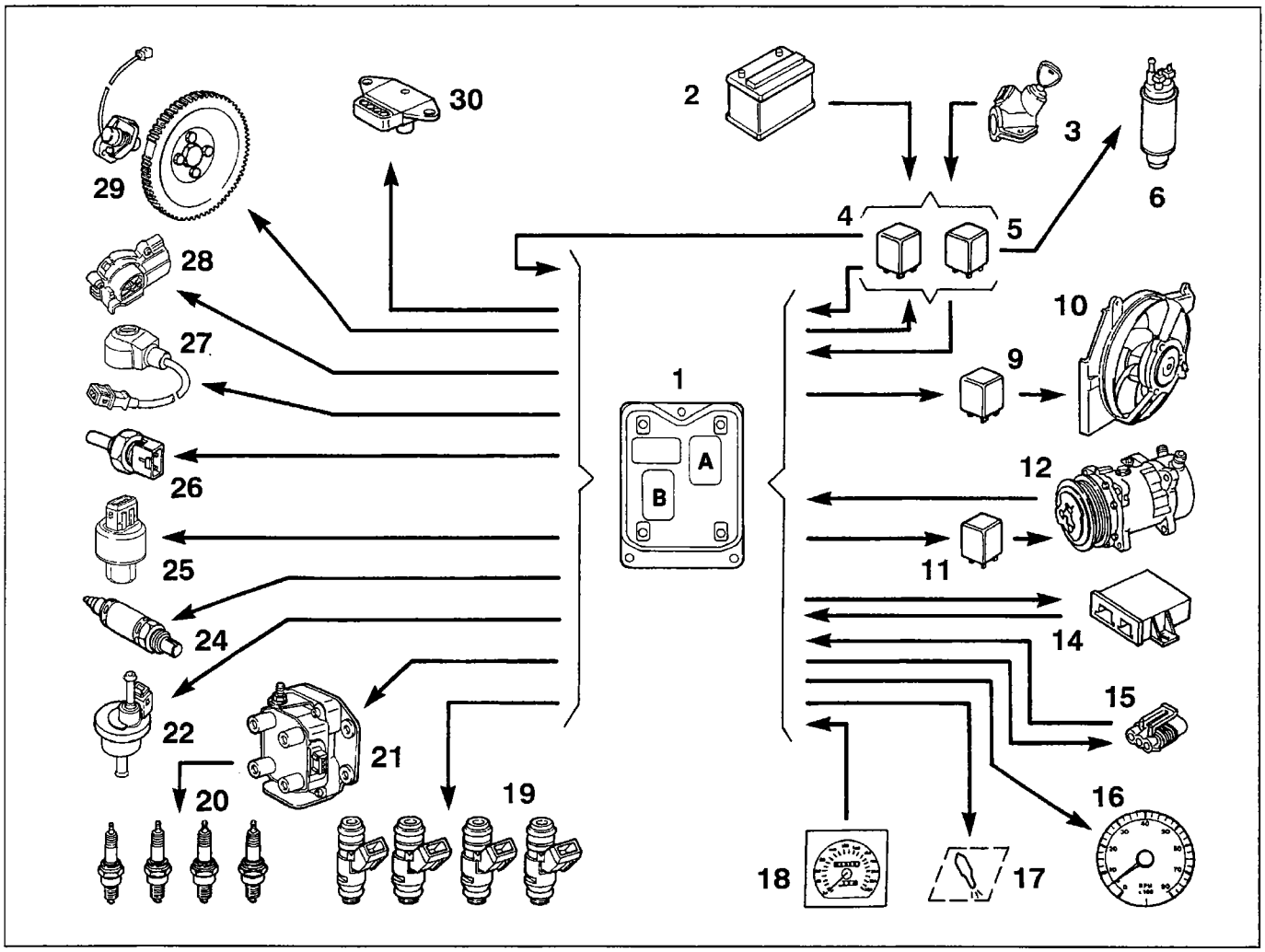
BOSCH M1.5.5 INJECTION/IGNITION SYSTEM FUNCTIONAL DIAGRAM



4F002PJ01

1. Engine control unit
2. Battery
3. Ignition switch
4. Engine control system relay
5. Electric fuel pump relay
7. Drip tray (including: electric pump, pressure regulator, filter, gauge)
8. Inertia switch
9. Radiator fan relay(s)
10. Radiator fan
13. Climate control connection
14. CODE connection
15. Diagnostic equipment connection
16. Rev counter
17. System failure bulb
18. Speedometer
19. Injectors
20. Spark plugs
21. Ignition coil
22. Charcoal filter scavenging solenoid valve
24. Lambda sensor
25. Power assisted steering sensor
26. Coolant temperature sensor
27. Detonation sensor
28. Engine idle adjustment actuator and butterfly position sensor
29. Engine rpm and TDC sensor
30. Absolute pressure and air temperature sensor

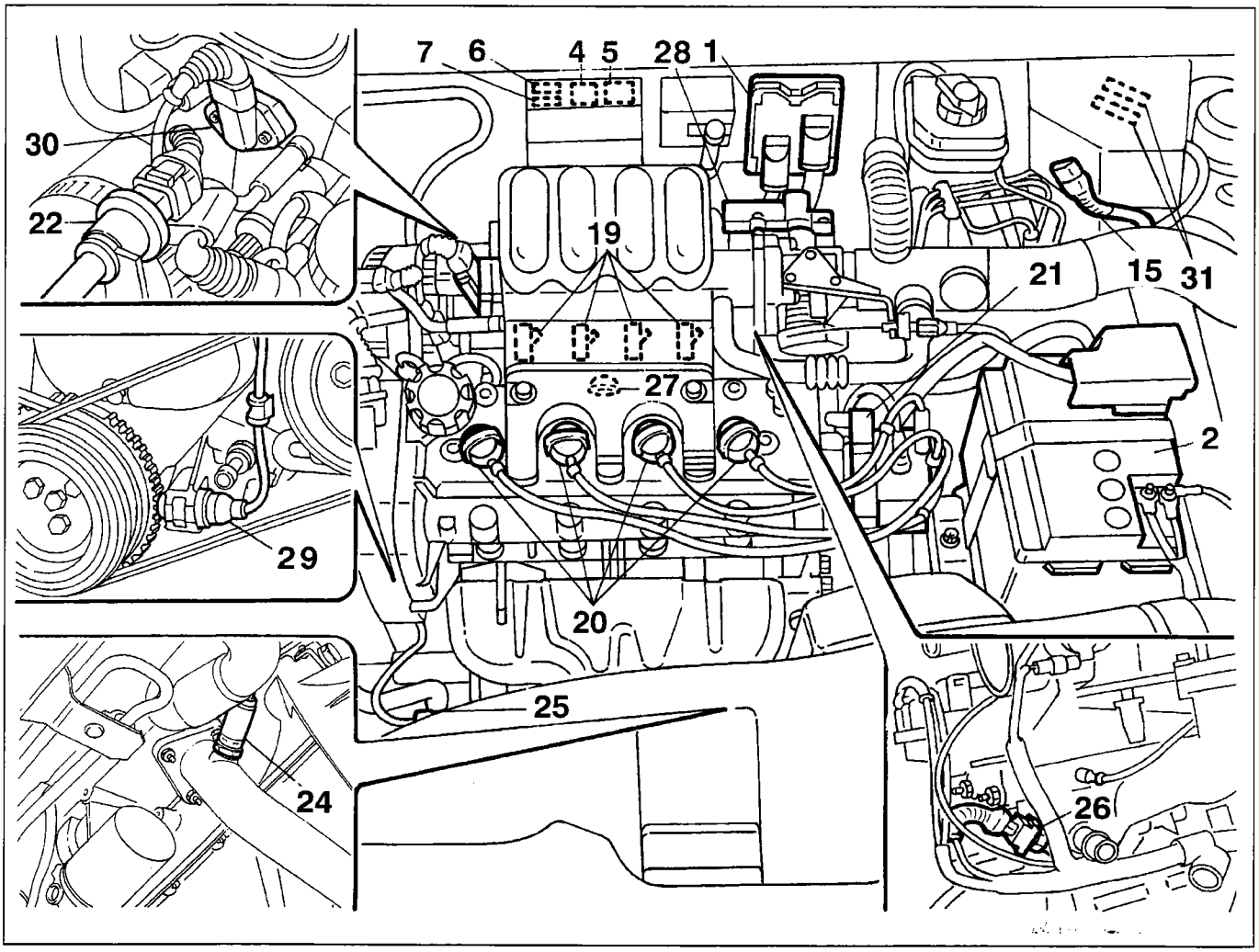
DIAGRAM SHOWING INFORMATION ENTERING/LEAVING THE CONTROL UNIT AND SENSORS/ACTUATORS FOR THE BOSCH M1.5.5 INJECTION/IGNITION SYSTEM



4F003PJ01

1. Engine control unit
2. Battery
3. Ignition switch
4. Engine control system relay
5. Electric fuel pump relay
6. Electric fuel pump
9. Radiaor fan relay(s)
10. Radiator fan
11. Compressor engagement relay
12. Compressor
14. CODE control unit
15. Diagnostic equipment connection
16. Rev counter
17. System failure light
18. Speedometer
19. Injectors
20. Spark plugs
21. Ignition coil
22. Charcoal filter scavenging solenoid valve
24. Lambda sensor
25. Power assisted steering sensor
26. Coolant temperature sensor
27. Detonation sensor
28. Engine idle adjustment actuator and butterfly position sensor
29. Engine rpm and TDC sensor
30. Absolute pressure and air temperature sensor

LOCATION OF BOSCH M1.5.5 INJECTION/IGNITION SYSTEM COMPONENTS IN THE ENGINE COMPARTMENT



4F004PJ01

1. Engine control unit
2. Battery
4. Engine control system relay
5. Electric fuel pump relay
6. System fuse
7. Electric pump fuse
15. Diagnostic equipment connection
19. Injectors
20. Spark plugs
21. Ignition oil
22. Charcoal filter solenoid valve
24. Lambda sensor
25. Power assisted steering sensor
26. Coolant temperature sensor
27. Detonation sensor
28. Engine idle speed adjustment actuator and butterfly position sensor
29. Engine rpm and TDC sensor
30. Absolute pressure and air temperature sensor
31. Main fuses (maxi-fuse)

SYSTEM MANAGEMENT STRATEGIES

Operating principle

Any engine operating point is identified by two parameters:

- rotation speed;
- engine load.

If these parameters are known through suitable processing it is possible to calculate and then implement the injection (quantity of fuel supplied and timing with TDC in explosion stroke), the ignition (correct ignition advance) and any other functions for each engine operating point.

In the BOSCH M1.5.5 system the rotation speed is measured directly through the sensor whilst the engine load is determined indirectly by calculating a "tl factor" (representing the actual engine load) according to the absolute pressure and temperture of the air, both measured in the inlet manifold.
During experiments on the engine and the vehicle special maps are produced for the injection and the ignition which contain the injection and ignition advance timing for the correct operation of the engine (for a certain number of pairs of speed/load parameters).
For any engine operating point not included exactly amongst the values stored in the memory, the figures are determined by mathematical interpolation.

The injection times calculated are also corrected according to the signal coming from the Lambda sensor which, according to suitable operating strategies, determines a continuous fluctuation of the mixture strength around the stoichiometric value.
The system is therefore defined as the speed-density-Lambda type because the injection is basically determined by these three parameters.

All the particular operating situations which require special adjustments to the injection timing and ignition advance values calculated are managed by the engine control unit according to the signals coming from the various system senors.

Management of the signals

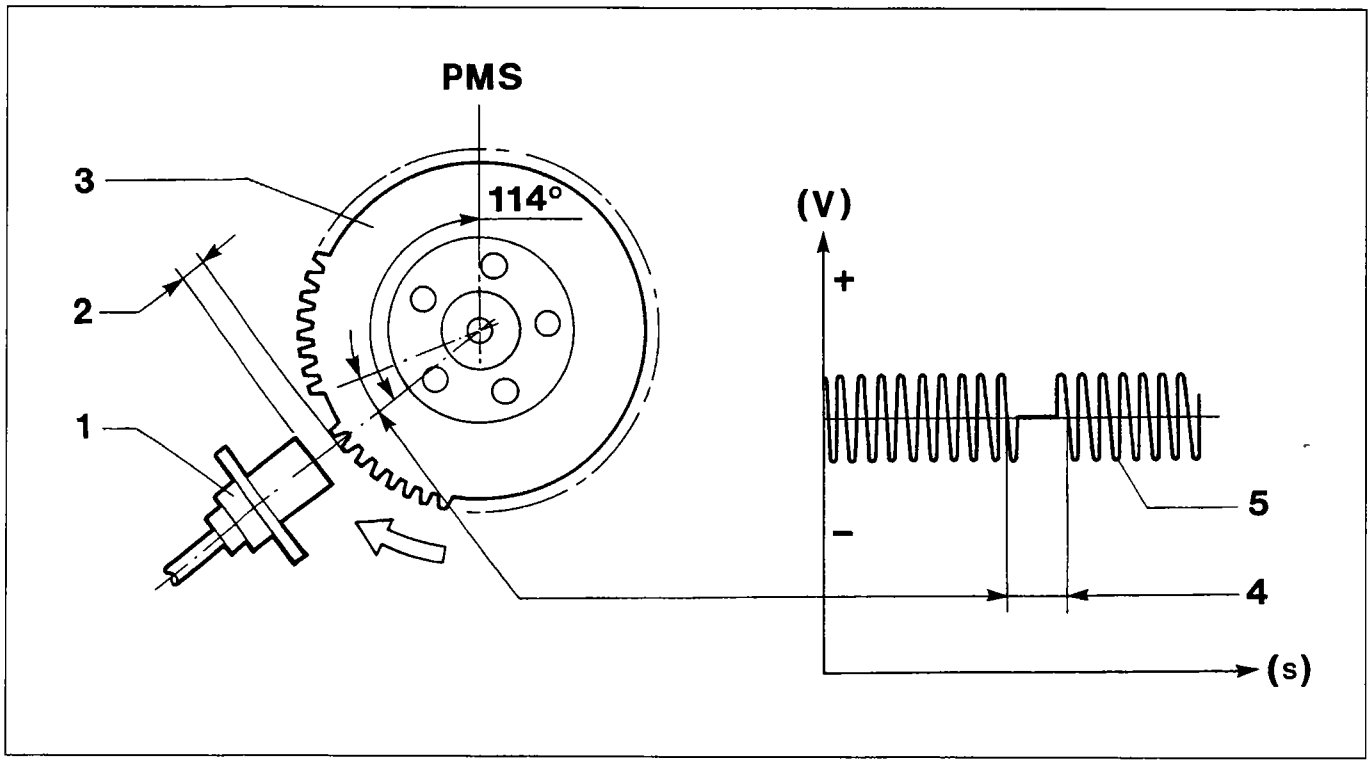
NOTE *The term "signals" refers to the collection of signals coming from the sensor on the crankshaft which feature a precise sequence which the control unit is capable of recognizing.*

During starting, the control unit recognizes the injection and ignition timing which is fundamental for the subsequent operation of all the strategies.
This recognition takes place in two successive stages:

- by interpreting the succession of signals coming from the flywheel sensor, on the crankshaft, the control unit recognizes TDC for the pair of cylinders 1-4.
- using a particular strategy, the control unit is capable, by failing to operate a certain injector, of evaluating the consequent variation in speed (not noticeable by the driver), of recognizing to which cylinder the injector not operated belongs and, consequently, of determining the correct cylinder sequencing (software timing).

10.

In particular, the signals are made up as follows.
There are sixty teeth on the flywheel, two of which have been removed to create a space: the angle between two consecutive teeth is therefore 6 degrees:
The point of synchronism is recognized at the end of the first tooth following the two missing teeth: the flywheel is fitted so that as this tooth passes the pair of cylinders 1-4 is 17 teeth before TDC.



4F006PJ01

1. Engine rpm and TDC sensor
2. Gap
3. Flywheel 60-2 teeth
4. Signal corresponding to the two missing teeth
5. Flywheel signal (engine rpm sensor)

MANAGEMENT OF THE INJECTION

The injection management strategies are designed to provide the engine with the correct quantity of fuel and at the correct time according to the engine operating conditions.

The management of the injection basically consists of calculating the injection time, determining the injection timing and then implementing it by operating the injector.
The "basic" injection time is calculated by means of mathematical interpolation of the speed/load maps: the experimentally obtained values contained in the maps also depend on the specifications of the injector.
The "final" injection time is determined through a calculation algorhythm in which the "basic" time is corrected by a series of coefficients which take into account the different engine operating conditions which are highlighted by the various sensors in the system.

Controlling the mixture strength (feed back control)

NOTE *The mixture ratio is defined and denoted by the Greek letter α (alfa).*

$$\frac{\text{quantity of air drawn in by the engine}}{\text{quantity of fuel injected}}$$

This is defined as the stoichiometric ratio and is denoted by α st.

$$\frac{\text{theoretical quantity of air required to burn all the fuel injected}}{\text{Quantity of fuel injected}}$$

This is defined as the mixture strength and is denoted by the Greek letter α (Lambda):

$$\frac{\text{quantity of air drawn in by the engine}}{\text{theoretical quantity of air required to burn all the fuel injected}}$$

It can easily be deduced that $\alpha st = \lambda$.
The stoichiometric ratio depends on the type of fuel: for current unleaded petrol this value is around 14.7 - 14.8 which corresponds to a Lambda of 1:
A mixture is called rich when the quantity of air is lower than the stoichiometric value and in this case the Lambda $\lambda < 1$:
A mixture is called poor (or lean) when the quantity of air is higher than the stoichiometric value and in this case the Lambda $\lambda > 1$.

The strategy is designed to correctthe "basic" injection times so that the mixture strength continuously fluctuates at a high Hertz frequency:

NOTE *1 Hz = 1 oscillation per second*

In the following conditions:
- cut-off,

or
- engine fully laden,

or
- engine cold (coolant and air temperature below about 20 °C)

the strategy is disabled.

Self-adjustment

The control unit is equipped with a self-adjustment function which has the task of memorizing any differences between the basic map and corrections made by the Lambda sensor which may occur persistently during operation. These differences (due to the ageing of the system and engine components) are permanently memorized allowing the adaptation of the system operation to the gradual alterations in the engine and components compared with when they were new.
The strategy is disabled whilt the charcoal filter solenoid valve is open.
If the control unit is replaced, a road test must be carried out where the engine is allowed to reach operating temperature and the control unit intervenes in the self-adjustment mode (especially during idling stops).

10.

Starting and operation when cold

During cold starting the injection is managed simultaneously (full-group), i.e. not phased: this situation persists until a certain coolant temperature is reached (about 0°C), after which the management becomes phased.

The injection time whilst the engine is being driven by the starter motor is determined by a special map according to the temperature of the coolant: when the engine is started up, the calculation returns to the normal speed/load map.

During operation when cold, since there is a natural weakening of the mixture as a result of the reduced evaporation and the strong condensation of the fuel on the internal walls of the inlet manifold, the "basic" injection time is increased by a multiplication coefficient which depends on the temperature and speed of the engine.

Operation in full load conditions

This strategy is enabled when the butterfly exceeds a certain threshold which depends, in turn, on the engine speed.

The injection time in this situation is determined by a special map which depends on the engine load and speed conditions.

Operation in acceleration and deceleration conditions

The acceleration or deceleration situation is interpreted by the system as a transition stage between two conditions, departure and arrival: this transition can be positive (acceleration) or negative (deceleration).

The transition management strategy is very complex, having to take a large number of factors into account.

In general, the injection time is increased for positive transitions and reduced for negative ones.

The extent of the correction basically depends on the variation in the engine load: however, the movement speed of the butterfly, the engine speed, the gear engaged (taken from the ratio between the engine speed and the vehicle speed) and the temperature of the engine (coolant and intake air) all have an effect and are interconnected in different ways.

The "basic" injection time is multiplied by a coefficient, in turn the sum of two coefficients: the first takes into account the temperature of the engine and the opening speed of the accelerator butterfly; the second depends on the engine rotation speed.

In particular, if the increase in the injection time is feasible at an injector which has just closed, the control unit reopens the injector (extra pulse) in order to compensate the mixture strength extremely quickly: the subsequent injections are, on the other hand, already increased on the basis of the coefficients mentioned previously.

Operation in cut-off conditions

The control unit enables the cut-off strategies when the temperature of the engine exceeds a certain level.

The cut-off strategy is implemented when the control unit recognizes that the butterfly is in the minimum position (butterfly potentiometer signal): it is disabled when the engine is cold to prevent driveability problems.

The engine supply is enabled again when the butterfly is no longer closed or when the engine speed goes below a level which depends on the coolant temperature.

Rotation speed restricter

This strategy restricts the maximum speed which can be reached by the engine enabling the cut-off. There are two different cut-off levels:

- static restricter (the engine speed approaches the level slowly): maximum speed = 6670 rpm;
- dynamic restricter (the speed approaches the level rapidly): maximum speed = 6500 rpm;

Electric fuel pump operation

The electric fuel pump is operated by the engine control unit by means of a relay.
The pump cuts out:

- if the engine speed goes below 50 rpm
- after a certain period (about 5 seconds) with the ignition key in the ON position without the engine being started up (timed go ahead);
- if the inertia switch has been operated.

Operation of the injectors

The operation of the injectors is the phased sequential type. However, during cold starting the injectors are operated in parallel up to a certain temperature.
The phasing of the injectors can vary according to the engine speed.

MANAGEMENT OF THE FIAT CODE ANT-THEFT FUNCTION

The system is equipped with an anti-theft function. This function is achieved thanks to the presence of a special control unit (FIAT CODE) capable of conversing with the engine control unit and an electronic key, with a special transmitter for sending a recognition code.

Each time the key is turned to the OFF position, the FIAT CODE system completely deactivates the engine control unit.

When the key is turned to the ON position, the following operations take place in the order given:

1. the engine control unit (whose memory contains a secret code) sends the FIAT CODE control unit a request to send the secret code to deactivate the immobilizer function;
2. the FIAT CODE control unit responds by only sending the secret code after having, in turn, received the recognition code transmitted by the ignition key;
3. the recognition of the secret code allows the deactivation of the engine control unit immobilizer function and normal operation is resumed.

NOTE *If the FIAT CODE anti-theft system is fitted, DO NOT CARRY OUT the test, during the fault diagnosis, using another engine control unit. In effect, in such circumstances, the FIAT CODE control unit would transfer the (unrecognized) code to the test control unit which could then no longer be used on other vehicles.*

10.

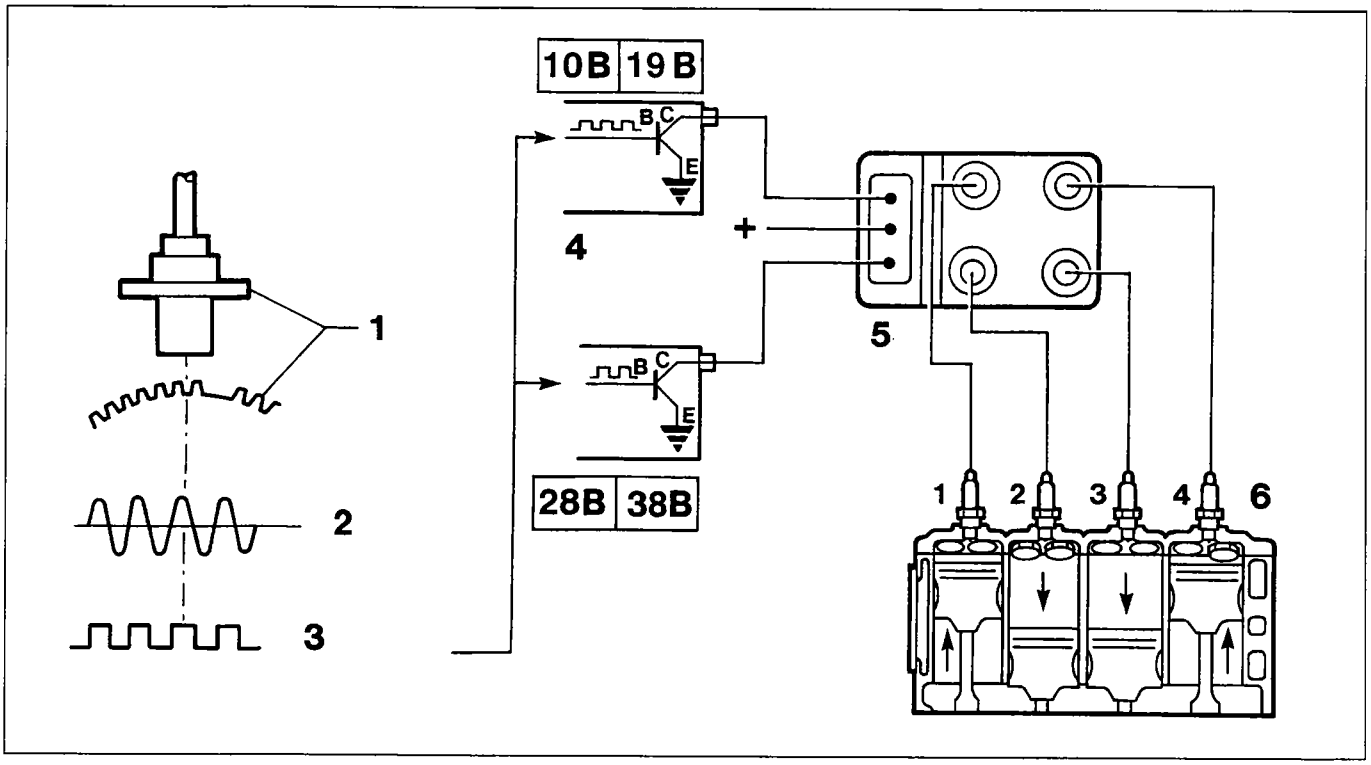
MANAGEMENT OF THE IGNITION

The management of the ignition mainly consists of determining the desired ignition advance according to the engine operating conditions and implementing it by operating the power transistor, located inside the control unit.
The "basic" advance value, calculated according to the engine load and speed conditions, is then corrected on the basis of the different engine operating conditions.
The primary winding for each coil is supplied by the battery voltage via the relay and is connected to the power transistor manifold incorporated in the engine control unit whose emitter is connected to earth, whilst the base receives the operating voltage from the control unit.

According to the engine rotation speed and the ignition advance to be implemented, the engine control unit establishes the moment for the start of the conduction for the primary winding so that the desired current intensity (saturation) is reached in the primary winding just before this current is cut off.

This moment obviously varies in terms of the angle in relation to TDC for the explosion stroke of each cylinder and the greater the engine rotation speed, the greater the advance, since the time required to saturate the current in the coil primary winding is virtually constant: it is determined using appropriate coefficients stored in the memory during the mapping stage (dwell management).

The moment for the start of conduction is also corrected according to the battery voltage.
The engine control unit therefore determines the moment the current in the primary winding is cut off, transforming the advance degrees into the time needd for the engine to travel through this angle: this time constitutes the advance in relation to TDC for the explosion stroke with which the current at the base of the transistor is interrupted.
The moment at which the current at the base of the power transistor is interrupted, the connection to earth of the primary winding is interrupted and, as a result, the high tension is discharged at the secondary winding.



4F010PJ01

1. Engine rpm and TDC sensor and flywheel
2. Control unit input signal
3. Signal converted in control unit (square wave)
4. Internal power module
5. Coil
6. Spark plugs

Starting

During starting, it is not possible to carry out the normal management of the advance because the considerable fluctuations in the rotation speed do not allow the correct calculation of the dwell and the advance. The control unit implements a fixed advance for the entire time the engine is driven by the starter motor.

Operation at high temperatures

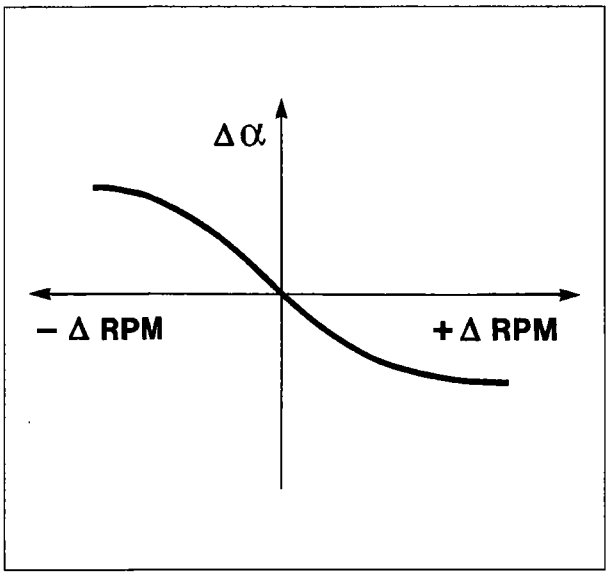
The strategy is enabled when the temperature of the intake air exceeds a certain level.
The "basic" advance value is reduced according to this temperature.

Operation in cut off conditions

The injection advance is reduced on entry into cut-off conditions: from the moment the fuel supply is restored, the advance is gradually returned to the "basic" value.

Operation in take-off conditions

This strategy reduces the advance when the vehicle sets off from stationary.



4F011PJ01

Δ α: idle ignition advance correction
+ΔRPM: idle speed above the nominal value
-ΔRPM: idle speed below the nominal value

Operation with the engine idling

When the engine is idling, the management of the advance is implemented independently of the "basic" advance.

The idle advance is correctly in a manner inversely proportional to the variation in the speed in relation to the pre-set speed, in turn, dependent on the temperature of the coolant.

In particular, the advance is increased if the speed decreases and descreases if the speed increases in order to guarantee the stability of the actual speed.

Control of the detonation

This strategy has the task of detecting the presence of detonation, by processing the signal coming from the sensor. The strategy continuously compares the signal coming from the sensor with a level which is, in turn, continuously updated to take into account background noise and the ageing of the engine.

If the system recognizes the presence of detonation, the strategy reduces the ignition advance, proceeding in steps of 3° up to a maximum of 9° until the phenomenon has disappeared. Later, the advance is gradually restored to the basic value or until the phenomenon starts again.

The strategy also has a self-adjustment function which memorizes the reductions in the advance which are continuously repeated, adapting the advance to the different conditions in which the engine finds itself (for example, the use of a low octane rating fuel). The strategy is capable of restoring the advance to the value memorized if the conditions which caused the reduction disappear.

10.

MANAGEMENT OF THE ENGINE IDLE SPEED CONTROL

The general objective of the strategy is to keep the engine speed around the value memorized (engine warm: 800 rpm); the position of the butterfly depends on the engine conditions and speed and the vehicle speed.

- Starting.

When the key is inserted, the butterfly assumes a position which depends on the temperature of the engine and the battery voltage (open loop position).

- Engine running and accelerator pedal released.

The engine speed varies according to the temperature of the engine and is kept constant close to this value by altering the position of the butterfly to compensate for any fluctuations in the speed.
This takes place, in particular, when external loads are applied (power steering, heated rear windscreen, etc.).

If the fans and the air conditioning is switched on, both managed by the control unit and the power assisted steering reaches the end of travel position, signalled by a switch, the strategy manages the butterfly in advance of the load being applied.

- Normal driving.

Under these circumstances the actuator is in the open loop position.

- Deceleration.

In release conditions outside of idling, the control unit controls the position of the butterfly through a particular flow rate curve (dash-pot curve), i.e. it slows down the return of the butterfly to the closed position thereby producing a reduction in the braking effect of the engine.

In addition, if the vehicle is decelerating, the information concerning its speed, correlated to that of the engine speed, allows the optimum management of the dash-pot effect adapting it to the gear engaged.

MANAGEMENT OF THE ACTIVE CHARCOAL FILTER

This strategy controls the position of the charcoal solenoid valve in the following way:

- during starting the solenoid valve remains closed, preventing the fuel vapours from enriching the mixture;

- after cold starting, the solenoid valve remains closed for the entire time the engine is warming up;

- with the engine warm, the control unit operates the solenoid valve in duty-cycle to control the quantity of fuel vapours sent to the inlet (scavenging of the charcoal filter) according to the engine speed and load. In particular, the system alternates periods of scavenging with periods free from scavenging: during the latter, the self-adjustment strategy, which is disabled during the scavenging, finds itself enabled;

the solenoid valve remains closed in cut-off conditions.

MANAGEMENT OF THE CLIMATE CONTROL SYSTEM

The injection/ignition control unit is functionally connected to the climate control system, as follows:

1. it receives the request to switch on the compressor and operates the various interventions (additional air);

2. it gives the go ahead to switch on the compressor when the strategy conditions are verified;

3. it receives information on the state of the four stage pressure switch and operates the various interventions (operation of the radiator fan).

As far as point 1 is concerned, if the engine is idling, the control unit increases the air flow rate, altering the position of the butterfly in advance of the compressor being switched on and conversely returns the butterfly to its normal position after the compressor is switched off.
The engine idle speed is also increased for the entire time the compressor is activated (engine warm: 900 rpm).

As far as point 2 is concerned, the control unit automatically controls the switching off of the compressor:

- for several seconds (timed disengagement):
  - in high engine power requirement conditions (fierce acceleration);
  - during vehicle take-off;

- as long as the following critical conditions exist:
  - temperature of the engine coolant above a pre-set level (engine overheated);
  - engine speed below 700 rpm

10.

MANAGEMENT OF THE RADIATOR FAN

NOTE *Since the temperature of the coolant is measured by the sensor there is no longer a thermal contact on the radiator.*

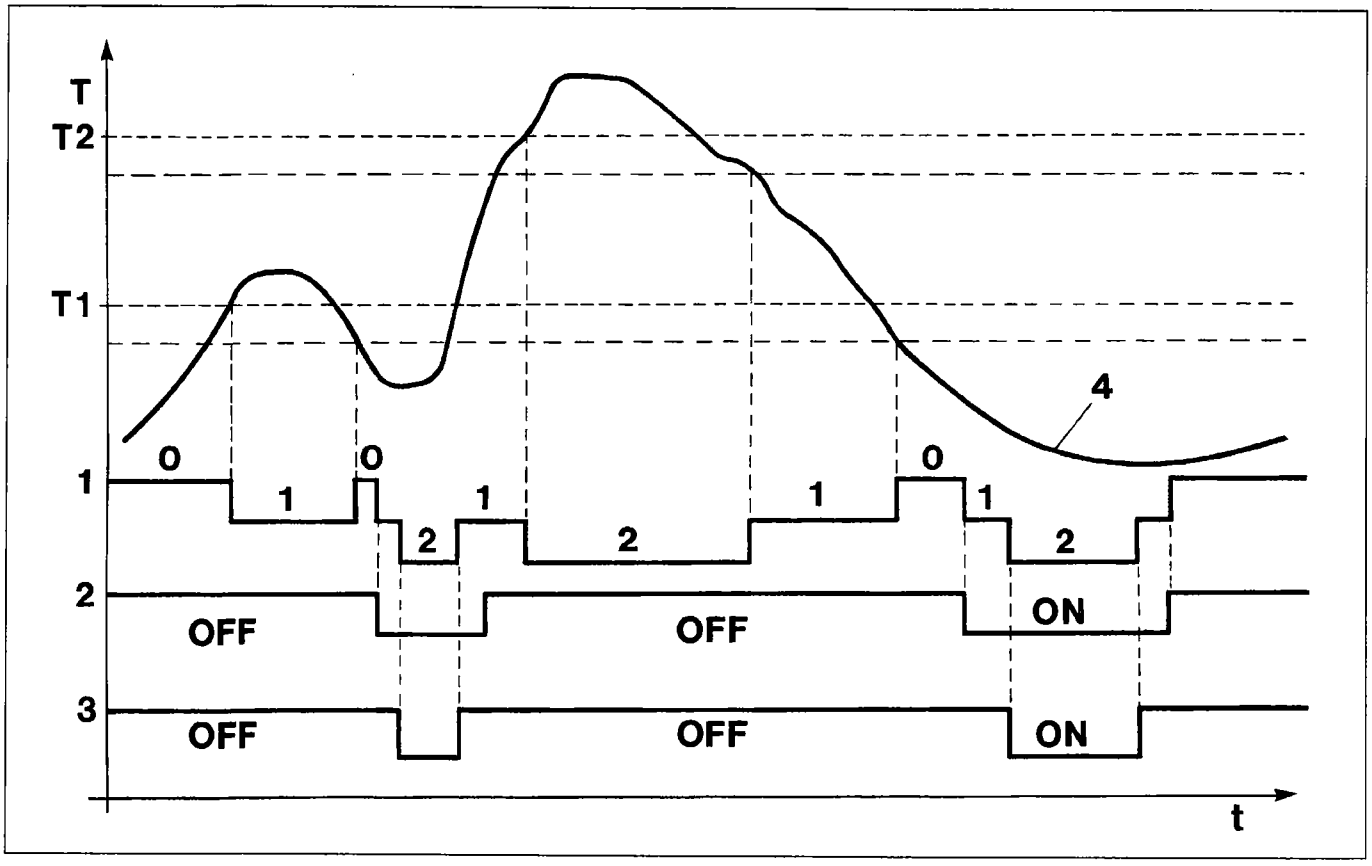
The engine control unit controls the engagement of the radiator fan according to the temperature of the coolant and whether or not there is a climate control system.

In the case of versions with climate control, there are two fan operating speeds, managed according to two different, completely independent logics.
- According to the temperature of the coolant.

Low speed: it comes on when the temperature of the coolant reaches T 1 = 96.5 °C;
High speed: it comes on when the temperature of the coolant reaches T 2 = 102 °C.

It switches off with a hysteresis of around 3 °C.
- According to the four stage pressure switch condition.

Low speed: it switches on when level II of the pressure switch is engaged;
High speed: it switches on when level III of the pressure switch is engaged.



4F014PJ01

T 1 = 96.5 °C
T 2 = 102 °C

ON: pressure switch activated

OFF: pressure switch deactivated

1. Solenoid valve status
   0 = off
   1 = low speed
   2 = high speed
2. level II of four stage pressure switch
3. level III of four stage pressure switch
4. Progress of engine coolant temperature

DIAGNOSTICS

The system is equipped with an autodiagnostic function which is designed to check for irregularities with the following components:

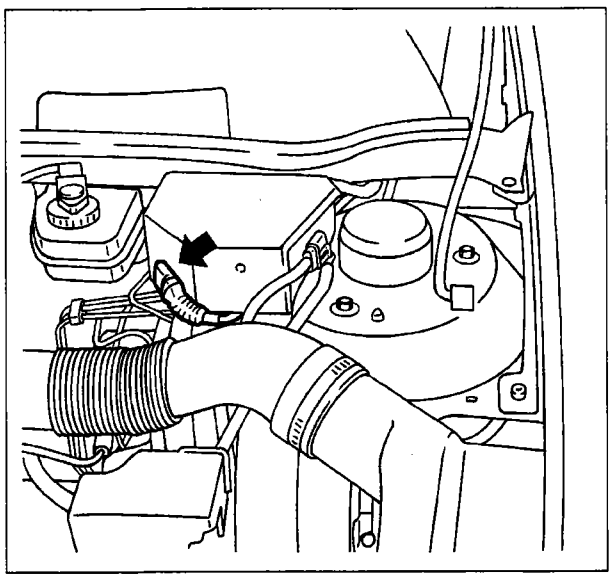
Actuators

injectors
coils
charcoal filter soleniod valve
engine idle adjustment actuator
electric fuel pump relay
climate control relays (if fitted)

Sensors

engine speed sensor
vehicle speed sensor
Lambda sensor
butterfly position sensor
coolant temperature sensor
detonation sensor

Location of diagnostic connector



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The detection of a fault, if confirmed, involves it being permanently memorized, in addition to the exclusion of the sensor from the system until it is restored.

The detection of a confirmed fault usually involves: the warning light in the dashboard coming on: the light goes out when the fault conditions disappear.

NOTE *During starting, the bulb:*
- *comes on for about 4 seconds;*
- *goes out for 0.1 secnods;*
- *remains on/off definitively according to whether or not there are "permanent" errors.*

When working with the diagnostic equipment it is possible to carry out the complete fault diagnosis of the system, which consists of three stages:

- display of a series of functional parameters (with the engine switched off or running);

- display of the errors and their cancellation;

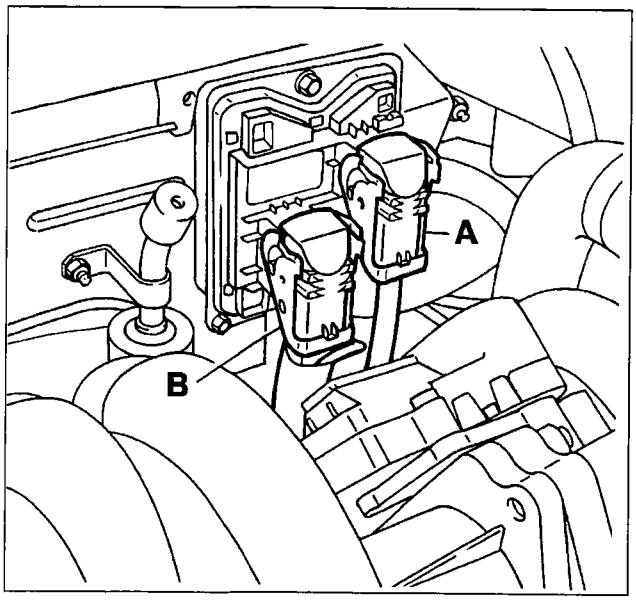
- activation of some actuators (active diagnosis).

Recovery strategy

If a fault is detected with the sensors/actuators, the control unit, where possible, replaces the missing data, reconstructing it using software (recovery) to allow the operation of the engine.

10.

ELECTRICAL/ELECTRONIC CIRCUIT



4F016PJ01

Wiring

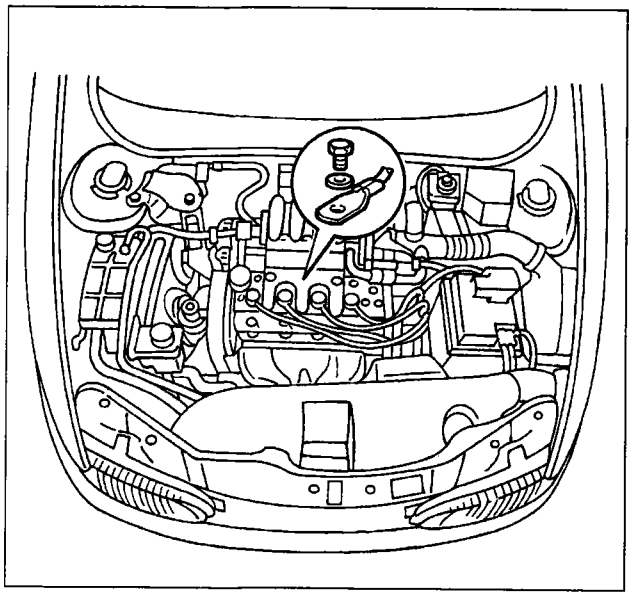
The system has two distinct sets of wiring for the control unit connectors: the engine side wiring (B) connects the components fitted on the engine to the engine control unit, the vehicle side wiring (A), on the other hand, connects the other components to the control unit and constitutes the interface with the vehicle wiring.

vehicle side wiring (A)

supply from battery
supply from ignition switch
fuses
system relay feeds
radiator fan relay(s)
climate control compressor relay (if fitted)
CODE control unit connection
on board panel connection
diagnostic equipment

engine side wiring (B)

engine rpm sensor
absolute pressure and air temperature sensor
coolant temperature sensor
detonation sensor
Lambda sensor
power assisted steering end of travel sensor
injectors
idle speed actuator/butterfly position sensor
ignition coil
charcoal filter solenoid valve



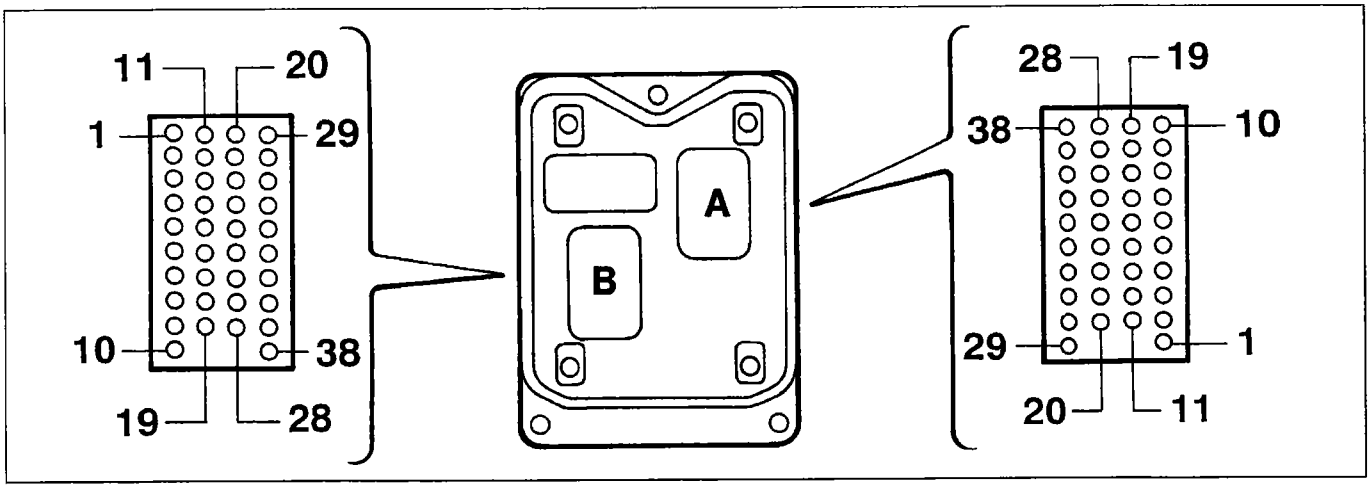
4F016PJ02

Layout of system earth points

In order to improve the electro-magnet compatibility and functional reliability, special care has been taken over the number and location of the earth points, as illustrated in the diagram below:

- main earth directly on battery negative;
- engine control system earth on cylinder block/crankcase near the detonation sensor.

BOSCH M1.5.5 SYSTEM CONTROL UNIT PIN OUT



4F017PJ01

Connector B (engine side)

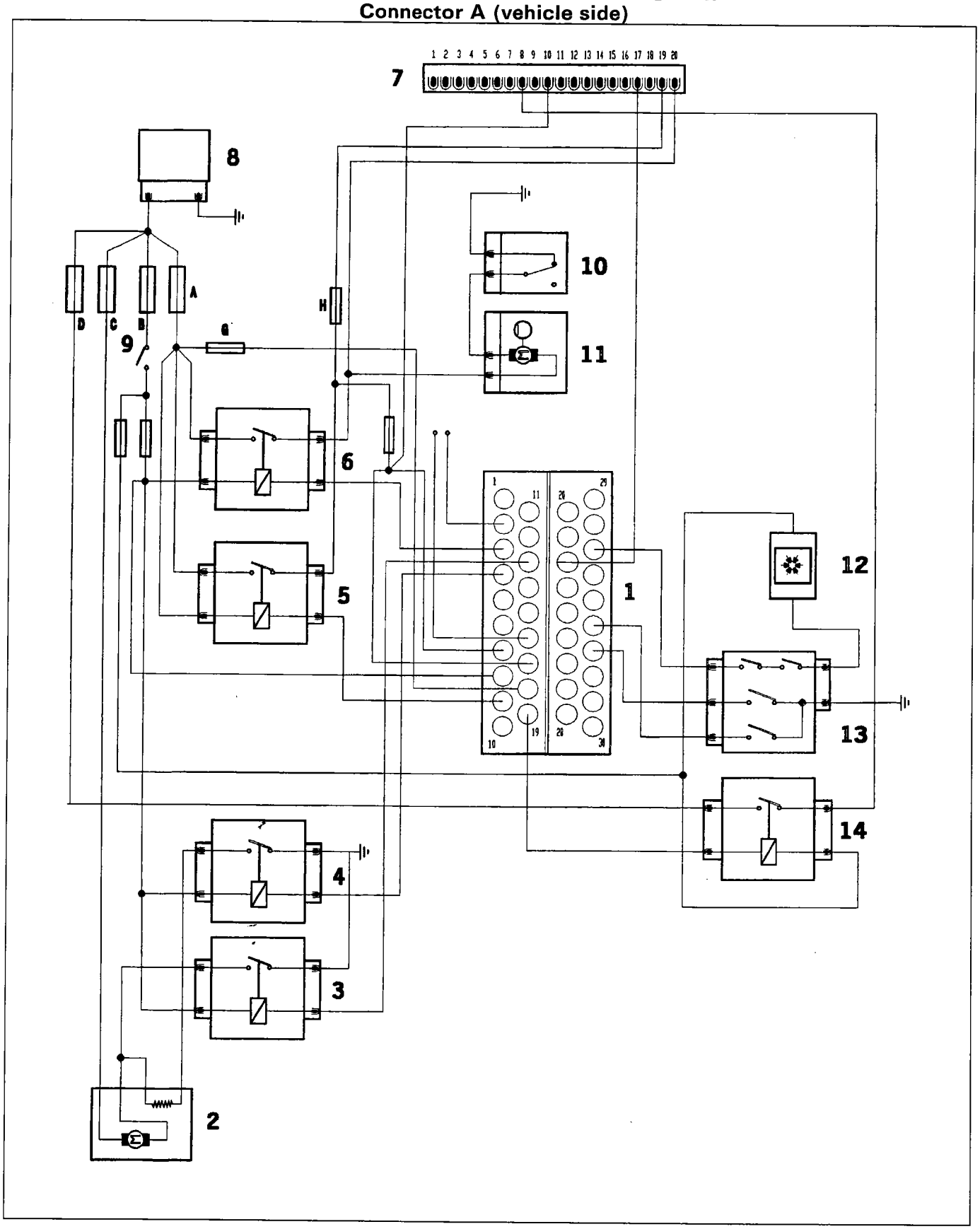
1. Sensors earth
2. Detonation sensor signal
3. Intake air temperature sensor signal
4. Butterfly position senor signal
5. Coolant temperature sensor signal
6. Operation of injector for cylinder 1
7. Operatin of injector for cylinder 4
8. Lamba sensor heater operation
9. N.c.
10. Operation of coil for cylinder 2-3
11. Detonation sensor earth
12. Absolute pressure sensor signal
13. Butterfly position sensor signal
14. N.c.
15. N.c.
16. Operation of injector for cylinder 3
17. Operation of injector for cylinder 2
18. N.c.
19. Operation of coil for cylinders 2-3
20. N.c.
21. Lambda sensor earth
22. Engine rpm sensor positive
23. N.c.
24. N.c.
25. N.c.
26. Idle speed actuator operation
27. N.c.
28. Operation of coil for cylinders 1-4
29. Sensors supply
30. Lambda sensor signal
31. N.c.
32. Engine rpm sensor negative
33. N.c.
34. Operation of charcoal filter solenoid valve
35. Operation of idle speed actuator
36. N.c.
37. N.c.
38. Operation of coil for cylinders 1-4

Connector A (vehicle side)

1. N.C
2. Operation of rev counter
3. Operation of fuel pump relay
4. Operation of high speed fan relay
5. N.c.
6. N.c.
7. Control unit supply from relay (+30)
8. Engine started signal (from ignition switch)
9. Engine control system relay feed
10. N.c.
11. Line K
12. Operation of system failure light
13. Operation of low fan speed relay
14. N.c.
15. N.c.
16. CODE connection
17. Control unit supply from relay (+30)
18. Control unit supply (+30)
19. Operation of compressor relay (if fitted)
20. N.c.
21. N.c.
22. Power assisted steering sensor signal
23. N.c.
24. N.c.
25. N.c.
26. N.c.
27. Vehicle speed sensor signal
28. N.c.
29. N.c.
30. N.c.
31. Compressor engagement operation
32. N.c.
33. N.c.
34. Four stage thermostat signal (if fitted)
35. Four stage thermostat signal (if fitted)
36. N.c.
37. N.c.
38. N.c.

10.

BOSCH M1.5.5 SYSTEM WIRING DIAGRAM
Connector A (vehicle side)



4f018PJ01

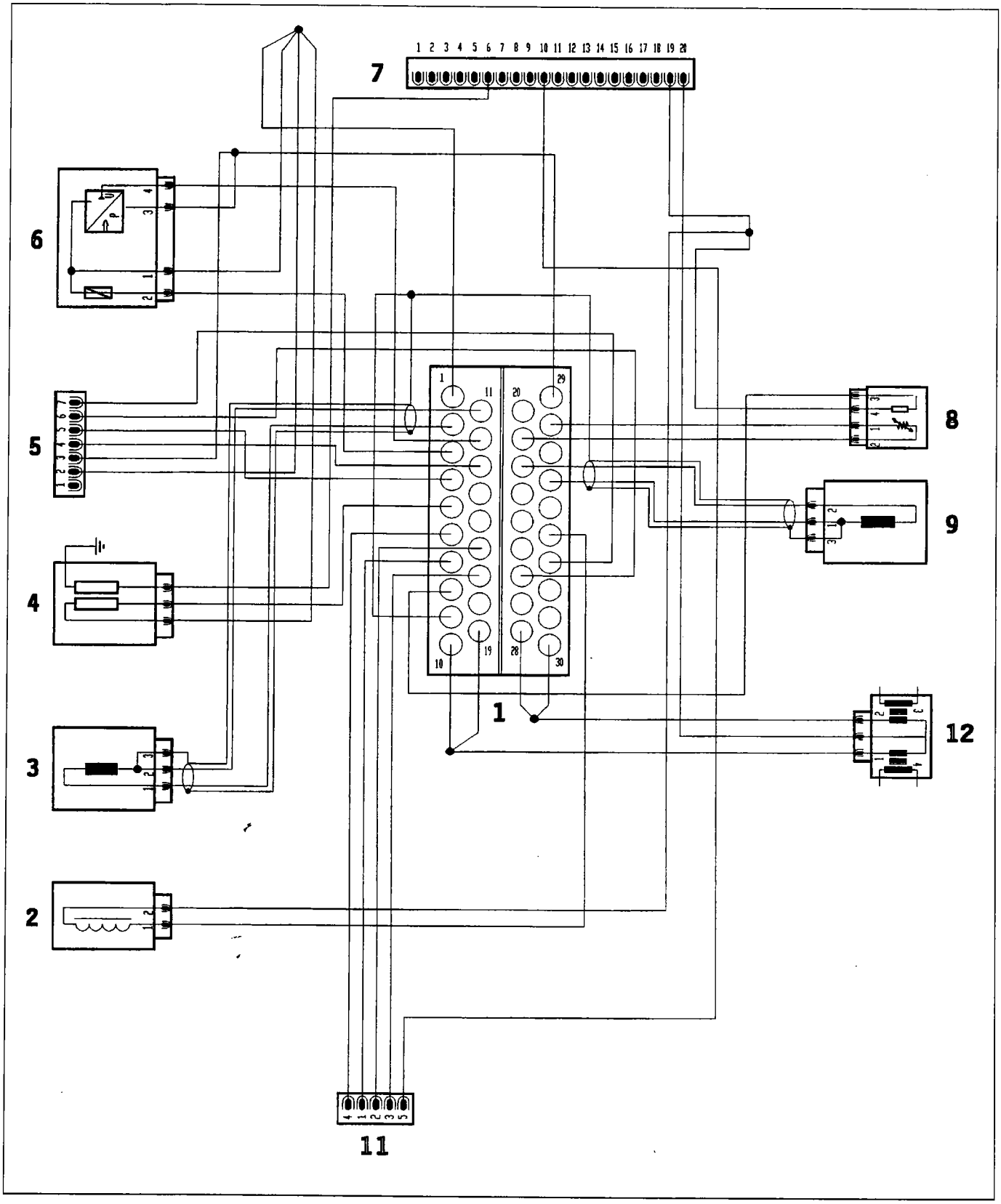
Bosch M1.5.5 system wiring diagram key
Connector A (vehicle side)

1. Control unit
2. Radiator fan
3. Fan high speed relay
4. Fan low speed relay
5. Engine control system relay
6. Fuel pump relay
7. Front cable connection
8. Battery
9. Ignition switch
10. Inertia switch
11. Electric fuel pump
12. Air conditioning control unit (on button)
13. Four stage pressure switch
14. Compressor relay

A. 30A fuse
B. 40A fuse
C. 40A fuse
D. 7.5A fuse
E. 7.5A fuse
F. 7.5A fuse
G. 7.5A fuse
H. 15A fuse
L. 15A fuse

10.

BOSCH M1.5.5 SYSTEM WIRING DIAGRAM
Connector B (engine side)

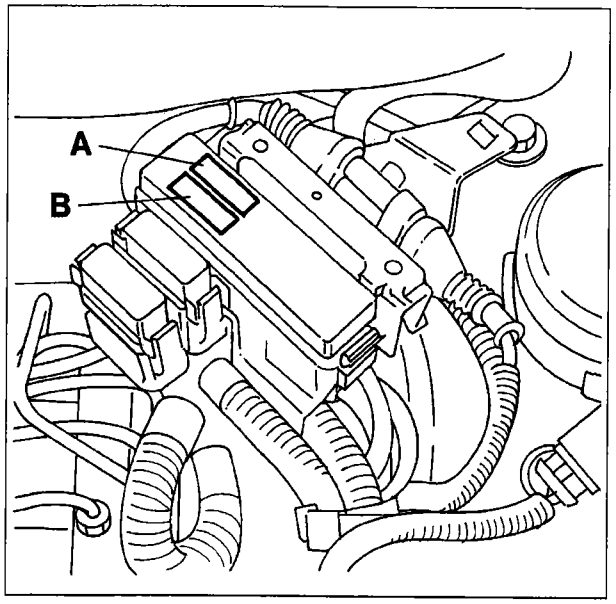


4f020PJ01

Bosch M1.5.5 system wiring diagram key
Connector B (engine side)

1. Control unit
2. Active charcoal filter solenoid valve
3. Detonation sensor
4. Coolant temperature sensor
5. Engine idle adjustment actuator/butterfly position sensor
6. Absolute pressure and air temperature sensor
7. Front cable connection
8. Lambda sensor
9. Engine rpm sensor
10. Coil
11. Injector section

10.



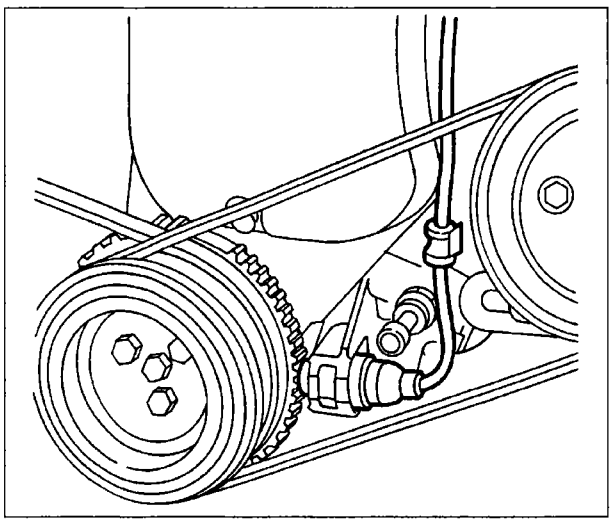
4F022PJ01

LOCATION OF FUSES AND RELAYS

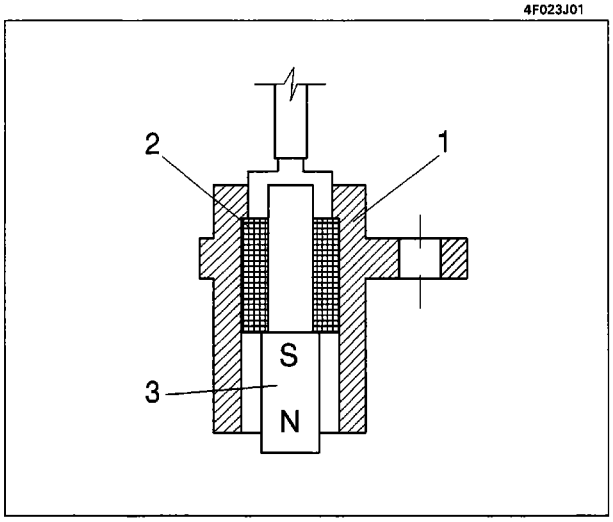
NOTE *For more information, see Group 55-Electrical equipment*

Main fuses (maxi-fuse)

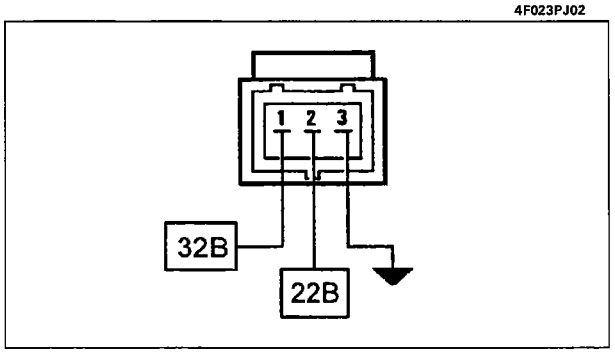
A. System fuse
B. Ignition switch fuse



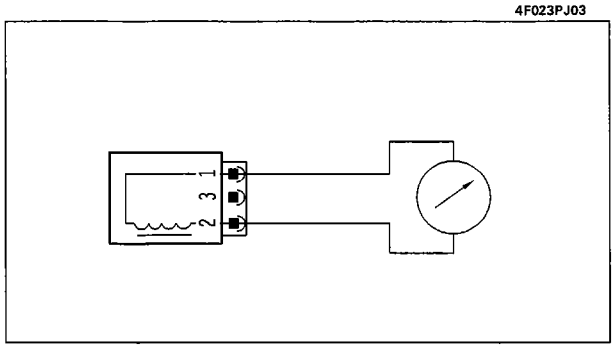
4F023J01



4F023PJ02



4F023PJ03



4F023PJ04

ENGINE RPM AND TDC SENSOR

The engine rpm and TDC sensor (1) is fixed on the cylinder block/crankcase and is facing the flywheel on the crankshaft pulley.

Operating principle

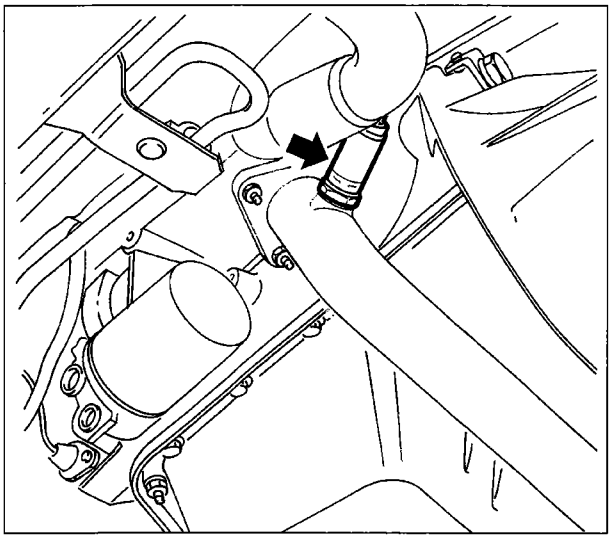
The sensor consists of a tubular casing (1) which contains a permanent magnet (3) and an electrical winding (2). The magnetic flow produced by the magnet (3) undergoes fluctuations as a result of the alteration in the gap as the flywheel teeth pass.

These fluctuations produce an electro-motive force in the winding (2) where an alternately positive (tooth facing the sensor) and negative (gap facing the sensor) voltage is produced. The peak sensor output voltage depends, all things being equal, on the distance between the sensor and the tooth (gap).

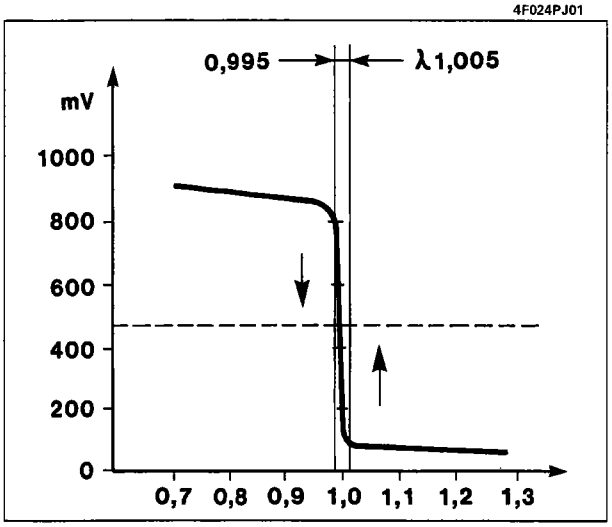
Wiring connector

The sensor resistance can be measured by disconnecting the connector and connecting an ohmmeter to the sensor

Resistance: 9600+10% ohm at 20°C



4F024PJ01



4F024PJ02

λ=1 Ideal mixture (stoichiometric)
λ 1 Lean mixture

Excess air; the CO values tend to be low
λ 1 Rich mixture

Lack of air; the CO values tend to be high

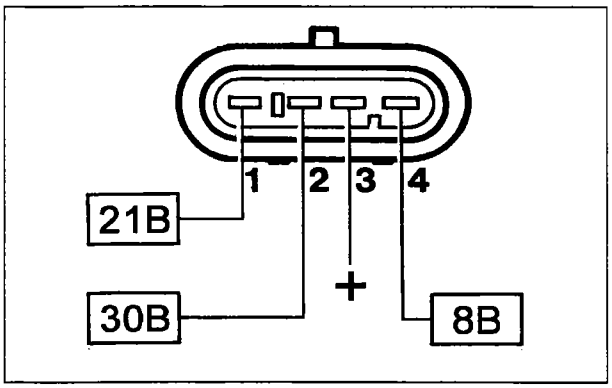
LAMBDA SENSOR

The Lambda sensor measures the oxygen content of the exhaust gases: it is fitted on the exhaust pipe upstream of the catalytic silencer.
The sensor output signal is sent to the control unit for feed back correction of the mixture strength.
When the sensor provides a low signal (voltage below 200 mV) the control unit recognizes a weak mixture and increases the injection time; later, when the sensor signal is high (voltage above 800 mV), the control unit recognizes a rich mixture and decreases the injection time.
This sequence of interventions is repeated with a frequency in the order of tens of Hertz so that the engine operates with a mixture strength constantly fluctuating around the stoichiometric ratio.
At temperatures below 300 °C the ceramic material is not activated, therefore the sensor does not send reliable signals: to ensure rapid heating during starting and maintain its temperature during idling, the sensor is equipped with a heater with the electrical resistance on permanently.

The sensor can be rapidly put out of action by the presence of even slight amounts of lead in the fuel.

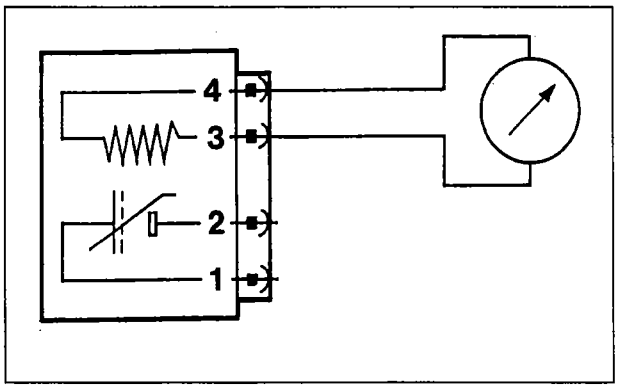
The sensor heating resistance can be measured by disconnecting the connector and connecting an ohmmeter as illustrated in the figure.

Connector wiring

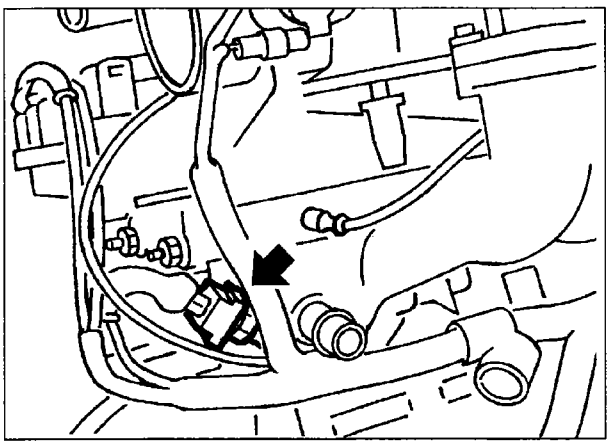


4F023PJ03

Resistance: 4.5+0.5 ohm at 20 °C



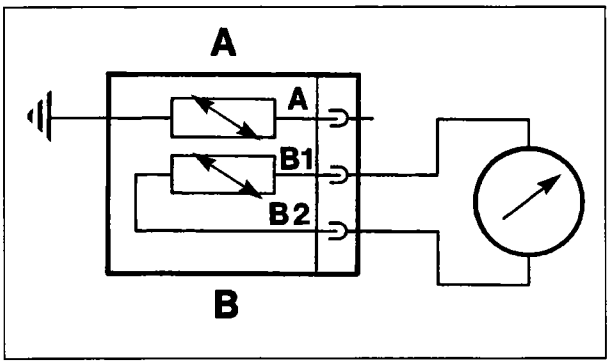
4F023PJ04



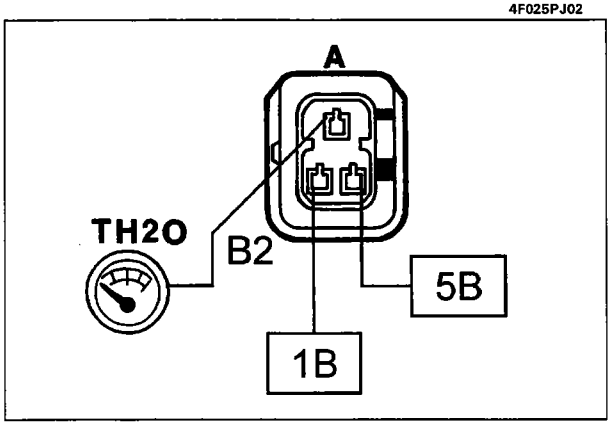
4F025J01

INJECTION NTC

°C	M	°C	M
-20	16900-15000	40	1200-1100
-10	10100-9100	50	830-780
0	6300-5700	60	590-560
10	4000-3600	70	430-400
20	2600-2400	80	315-300
25	2100-1950	90	235-225
30	1750-1600	100	137-133



4F025PJ02



4F025PJ03

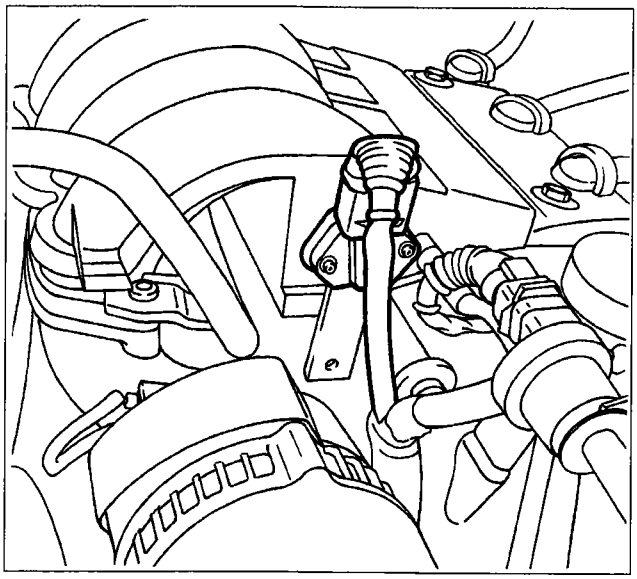
ENGINE COOLANT TEMPERATURE SENSOR

This sensor is fitted on the thermostat.
It is made up of a brass casing which affords protection to the actual resistive elements, consisting of two NTC (Negative Temperature Coefficient) thermistors whose electrical resistance decreases as the temperature increases.
The two thermistors are distinct and provide information concerning the temperature to the instrument in the panel (A) and to the engine control unit (B).

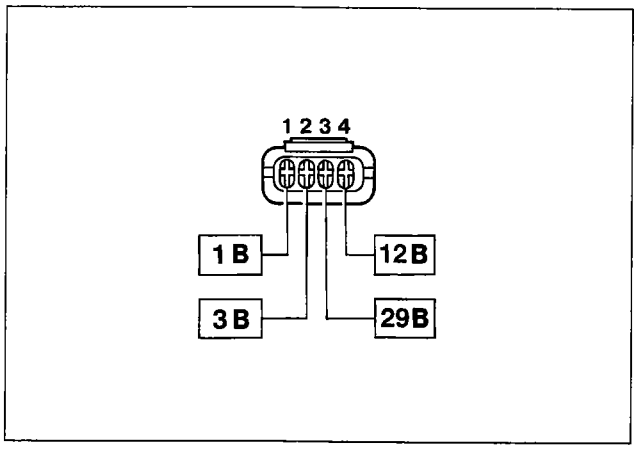
The reference voltage for the latter is 5 Volt: since the intake circuit in the control unit is designed as a voltage divider, the reference voltage is divided between a resistance in the control unit and the actual sensor.
As a result, the control unit is capable of evaluating the variations in the sensor resistance through the changes in voltage, thereby obtaining temperature information

The table illustrates the sensor specifications which can be measured by disconnecting the connector and connecting an ohmmeter as illustrated.

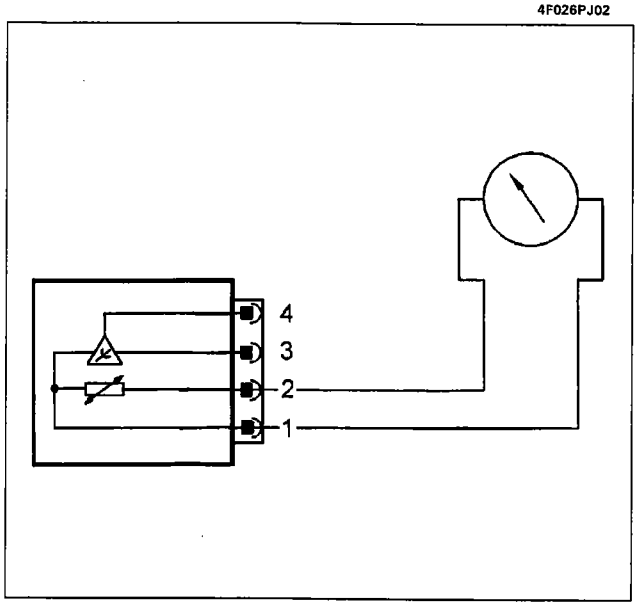
Connector wiring



4F026PJ01



4F026PJ02



4F026PJ03

INTAKE AIR TEMPERATURE AND PRESSURE SENSOR

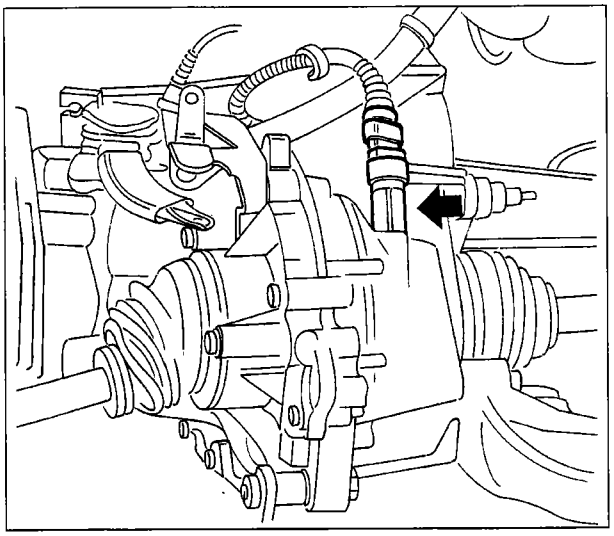
The intake air temperature and pressure sensor is an integrated component which has the task of measuring the pressure and the temperature of the air inside the inlet manifold. Both pieces of information are used by the injection control unit in defining the quantity of air drawn in by the engine; this information is then used for calculating the injection time and the point of ignition. The sensor is fitted on the inlet manifold.

Temperature (°C)	Resistance (M)
-40	52600-38700
-20	17500-13500
0	6500-5300
10	4200-3400
20	2700-2300
30	1850-1550
40	1300-1050
50	920-750
60	650-530
80	360-290
100	210-160

Connector wiring

Checking resistance

The table at the side contains the resistance values which the temperature sensor (NTC type thermistor) can assume according to the temperature. These values can be measured by connecting an ohmmeter as illustrated in the diagram.

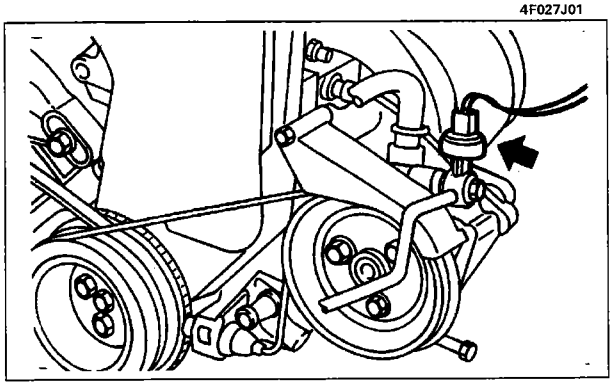


4F027J01

VEHICLE SPEED SENSOR

This sensor is positioned at the differential output, by the left driveshaft coupling and transmits information concerning the vehicle speed to the speedometer: the signal is then sent to the engine control unit.

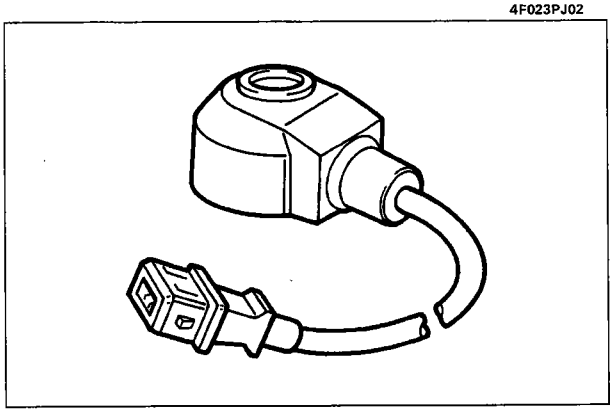
The sensor is the Hall effect type and is calibrated so that a given distance corresponds to each impulse: it is therefore possible to calculate the vehicle speed according to the frequency of the impulses.



4F023PJ02

POWER ASSISTED STEERING SENSOR

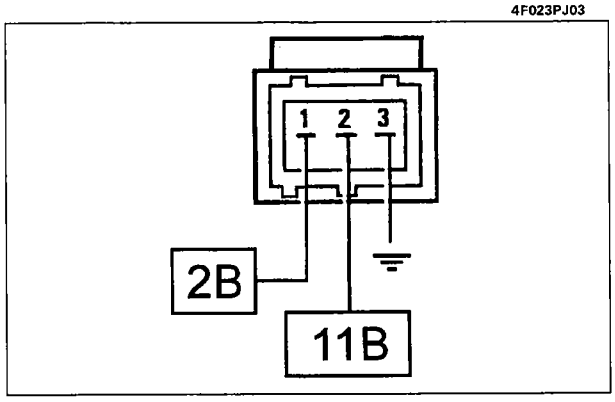
This sensor, fitted on the pump high pressure outlet pipe, consists of a pressure switch which closes when the hydraulic pressure exceeds a level corresponding to the steering close to the end of travel position: the information is used to manage the idle speed control actuator in advance of the absorption of power due to steering.



4F023PJ03

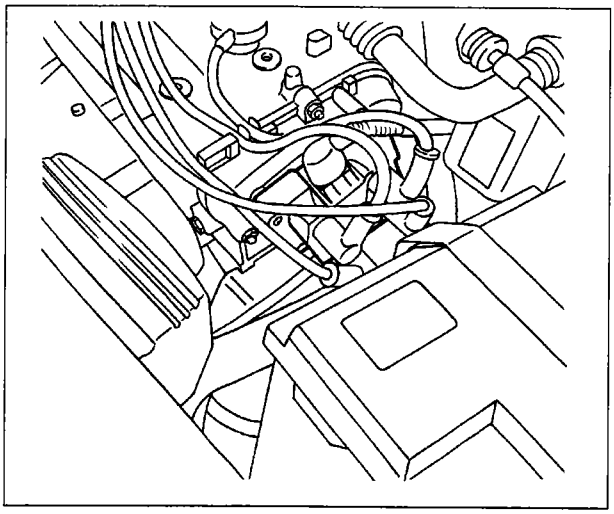
DETONATION SENSOR

This is a piezoelectric type sensor fitted on the cylinder block/crankcase, symmetrical in relation to the pairs of cylinders 1-2 and 3-4.
This position is determined by the need to detect the onset of detonation in the same way in all cylinders.
When the engine is knocking, cylinder block/crankcase vibrations of a particular frequency are produced and they are transformed by the sensor into a voltage signal proportional to their intensity.

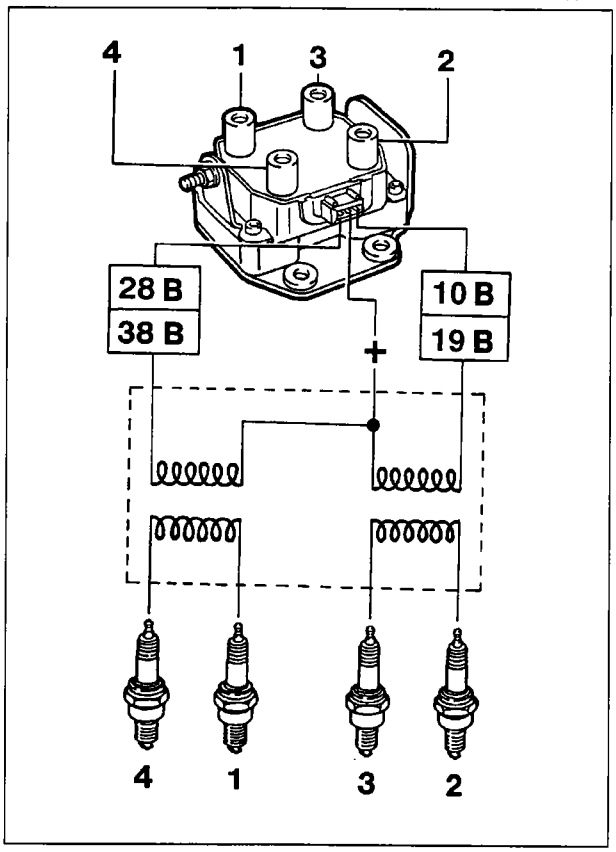


4F023PJ04

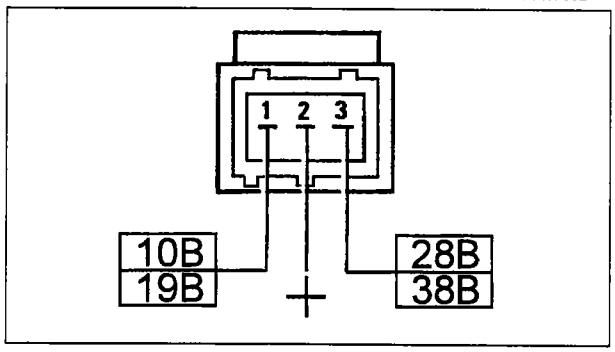
Connector wiring



4F028PJ01



4F028PJ02



4F028PJ03

IGNITION COILS

The ignition circuit is the inductive discharge static advance type, where the high tension is supplied by two twin outlet coils fitted laterally to the cylinder head.

The coils used are the closed magnetic circuit type, with windings in a plastic container immersed in epoxide resin. Each coil is connected to the two spark plugs by means of high tension leads with high dielectric properties.

In this type of coil the current in the secondary winding (discharge current) always has the same polarity: therefore one terminal of the circuit is positive and the other negative.

This fact implies that the discharge current in the secondary winding is always flowing in the same direction and therefore the sparks for the two cylinders connected to the coil strike in the opposite way:

- in the spark plug with the positive centre electrode, the spark strikes from the earth electrode to the centre one;
- in the spark plug with the negative centre electrode, the spark strikes from the centre electrode to the earth one;

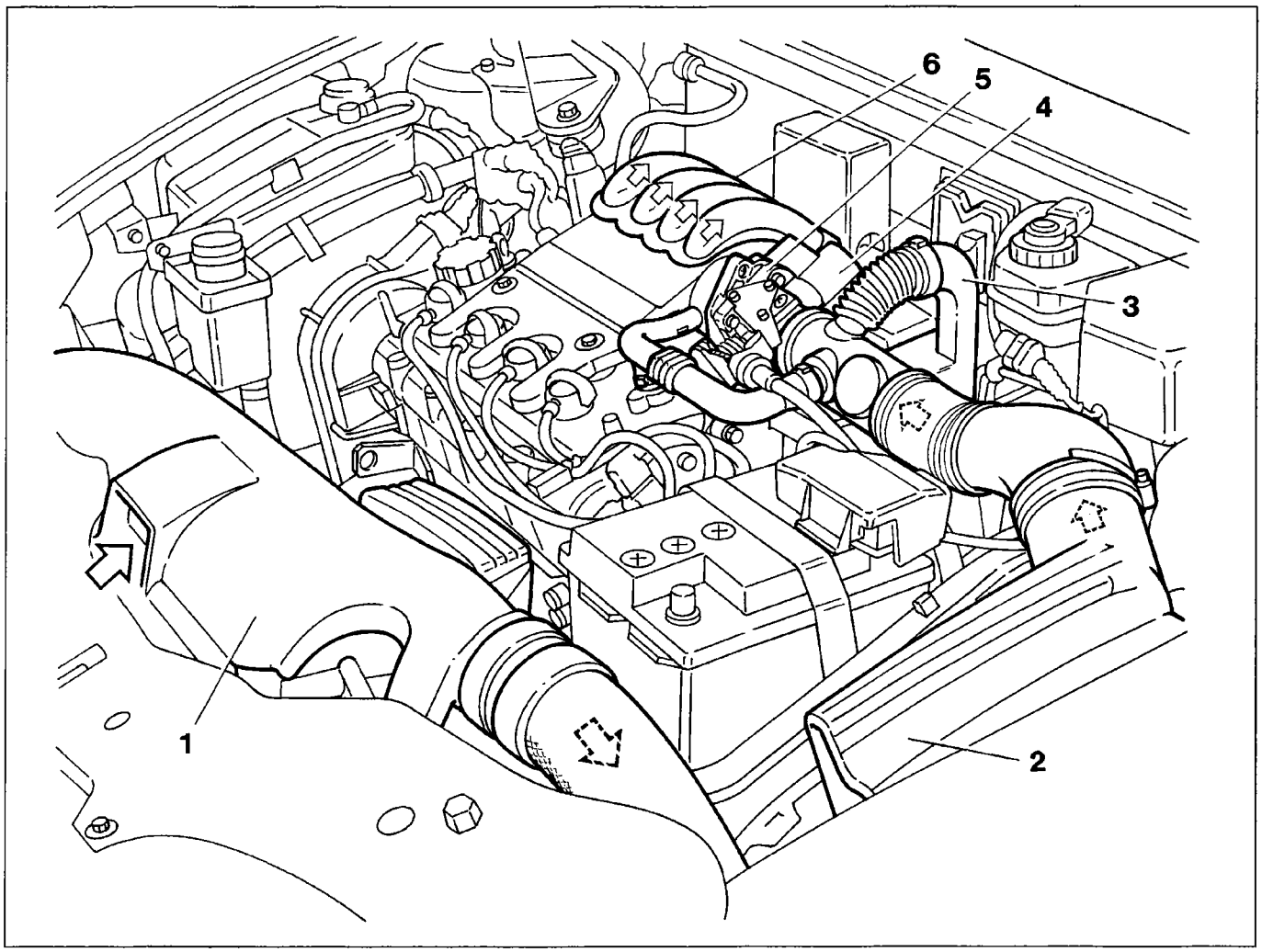
As a result, the wear of the electrodes between the two spark plugs is different.

Since the intensity of the spark depends on the resistance between the electrodes (dielectric), whilst the spark in the cylinder in the cross-over stage is weak (lost spark) on account of the almost atmospheric pressure in the chamber, the spark in the cylinder at the end of the compression stroke is intense (working spark) on account of the high pressure in the chamber.

Connector wiring

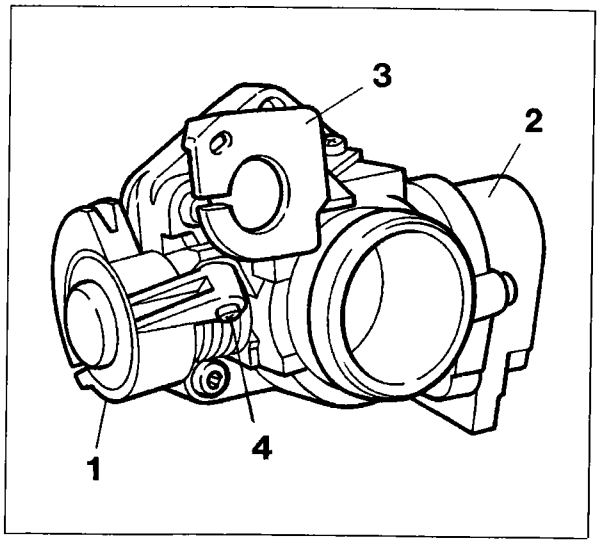
INTAKE CIRCUIT

This consists of various components which ensure the air flow rate required by the engine in the various operating conditions.



4F029PJ01

1. Intake vent
2. Air filter
3. Resonator
4. Engine idle speed adjustment actuator and butterfly position sensor
5. Butterfly casing
6. Inlet manifold



4F030PJ01

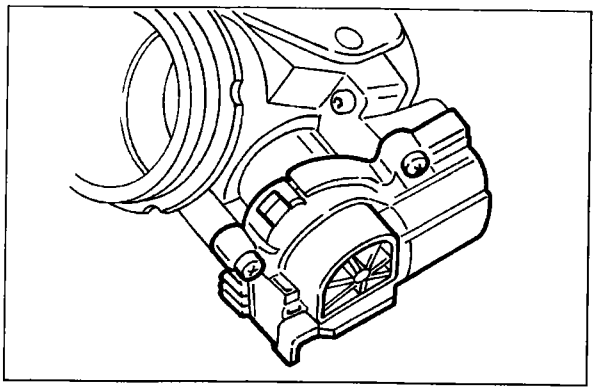
1. accelerator control lever
2. idle speed adjustment actuator and butterfly position sensor
3. accelerator cable adjustment bracket
4. anti-tamper screw

BUTTERFLY CASING

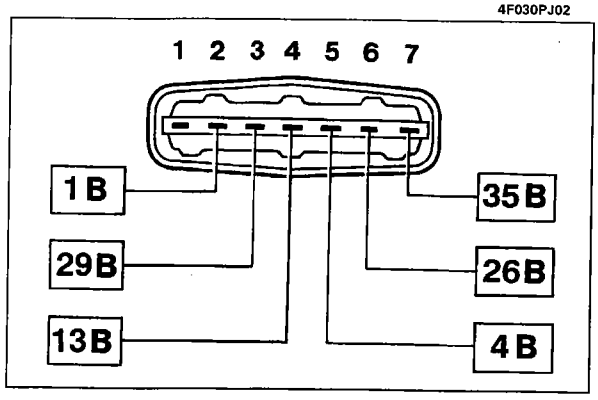
The butterfly casing has the task of metering the quantity of air drawn in by the engine (and therefore the power developed) according to the driver's request via the accelerator.

The butterfly casing is fixed to the inlet manifold: the butterfly is opened via a lever through a gradual opening law (small butterfly opening angles for a large part of the accelerator pedal stroke and large angles in the last part of the stroke).

With the pedal completely released (engine decelerating or idling) the position of the butterfly is regulated by the engine idle adjustment actuator in order to be able to supply the additional air required according to the engine conditions. The actuator also includes the butterfly position sensor.



4F030PJ02



4F030PJ03

ENGINE IDLE SPEED ADJUSTMENT ACTUATOR AND BUTTERFLY POSITION SENSOR

The actuator, fitted on the butterfly casing, consists of a direct current motor operated by a circuit inside the engine control unit which regulates the position of the butterfly: it has the task of ensuring the additional air for the engine with the accelerator pedal released, in all conditions where this is necessary (idling, deceleration, external loads applied).

The maximum angular opening which can be achieved by the actuator is around 30°.

- the first track goes from the closed position up to 30° and is used for the operation of the butterfly with the accelerator pedal released;
- the second track goes from the closed position up to the maximum butterfly opening and is used for the normal management of the engine.

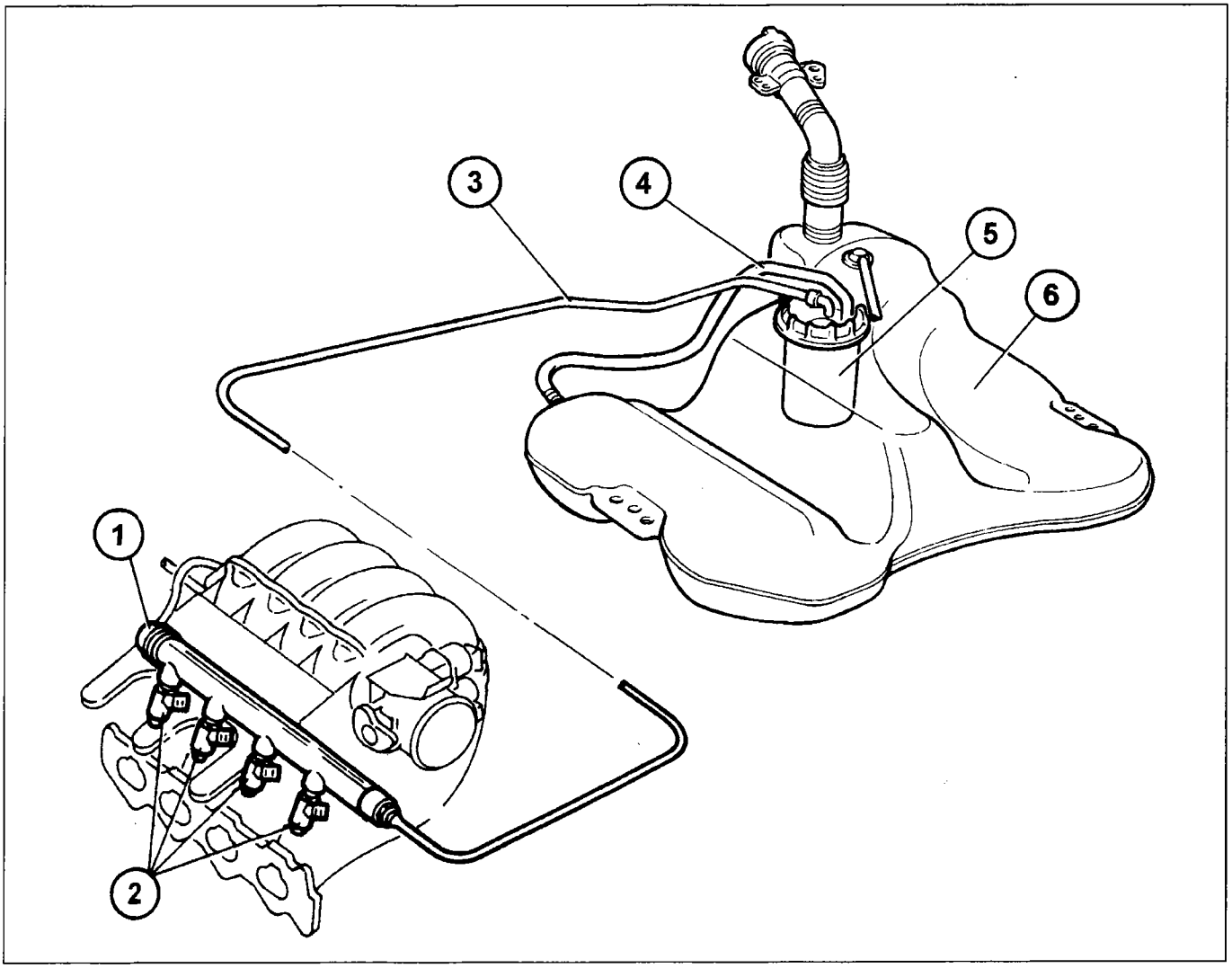
Connector wiring

FUEL SUPPLY CIRCUIT

This circuit consists of the following components:

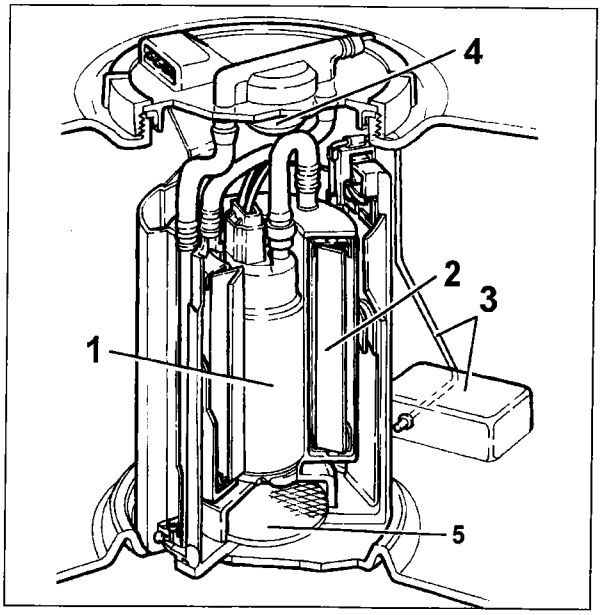
- Fuel tank
- Drip tray complete with pump, filter, pressure regulator and gauge
- Supply pipe
- Returnless type fuel manifold complete with injectors

FUEL CIRCUIT DIAGRAM



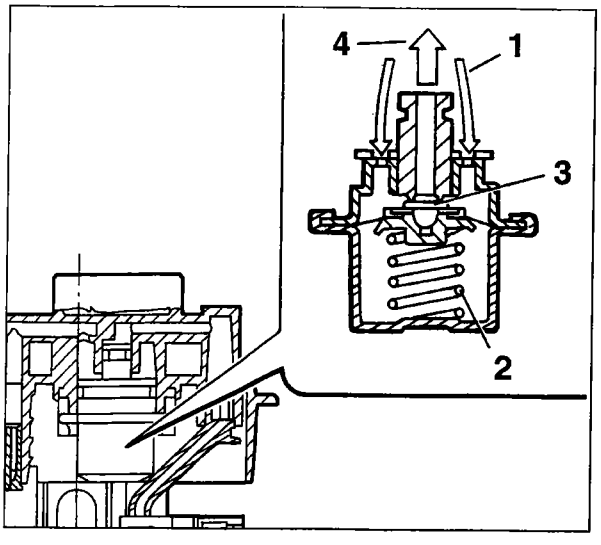
4F031PJ01

1. Air bleed connector
2. Injector manifold
3. Supply pipe
4. Tank filler pipe
5. Drip tray complete with pump, filter, pressure regulator and gauge
6. Fuel tank



4F032PJ01

1. Electric fuel pump
2. Fuel filter
3. Gauge with float
4. Pressure regulator
5. Gauze pre-filter



4F032PJ02

FUEL DRIP TRAY ASSEMBLY

Electric fuel pump

The pump is housed inside the fuel tank on a special drip tray which also supports the gauge and is equipped with a filter on the pump inlet. The pressure regulator is also fitted on the pump supply.
The pump is the single stage peripheral flow type and is designed to run on unleaded fuel.
- The rotor is driven by a direct current electric motor supplied by a relay, operated by the control unit to ensure:
- that the pump cuts out if the engine speed goes below a minimum level;
- the timed operation (about 5 seconds) each time the ignition is switched ON, even if the engine is not started up;
- operation when the engine is started up.

The pump is equipped with an excess pressure valve which short circuits the supply with the inlet if the pressure in the supply circuit exceeds about 5 bar, to prevent the electric motor from overheating.

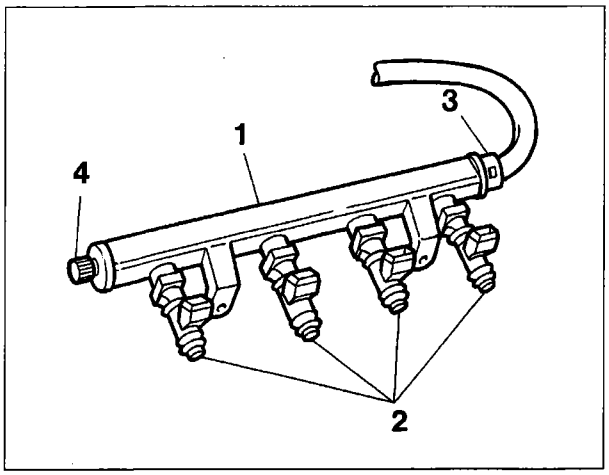
In addition, a single-acting valve, fitted on the supply, prevents the entire fuel circuit from draining when the pump is not working.

Fuel filter

The fuel filter is housed in the casing surrounding the pump and does not need to be replaced periodically.

Fuel pressure regulaor

This is a differential diaphragm device, adjusted during manufacture, to a pressure of 3.50±0.05 bar and it is located in the top part of the drip tray.
The fuel under pressure (1), coming from the pump, exerts a force on the flow valve (3) opposed by the calibrated spring (2). When the calibration pressure is exceeded, the flow valve opens and the excess fuel (4) returns to the tank, thereby stabilizing the pressure in the circuit.



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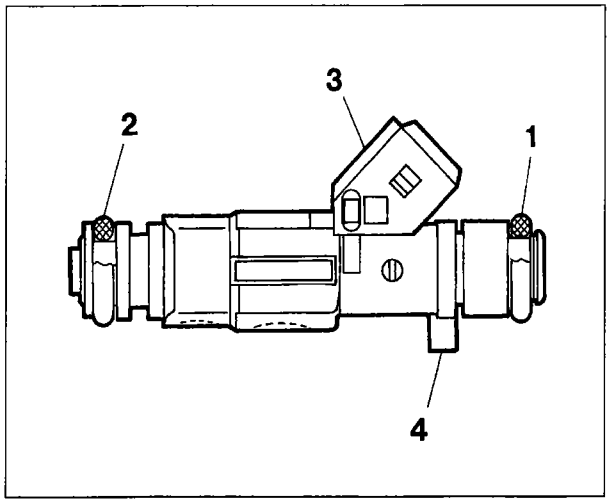

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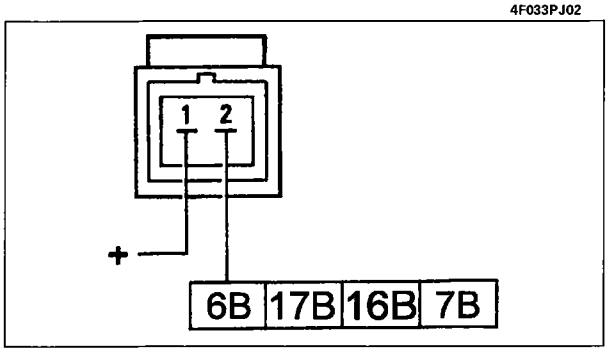

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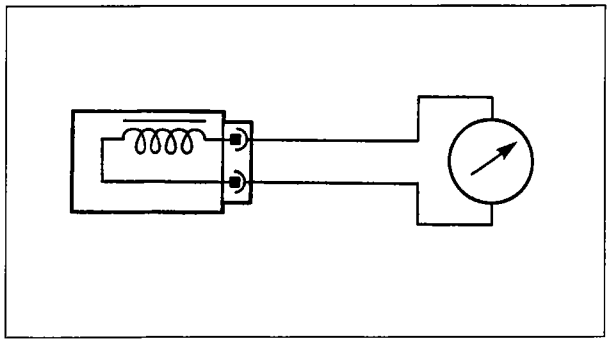


4F033PJ04

FUEL MANIFOLD

The fuel manifold, which has the task of distributing the fuel to the injectors, is made from die-cast aluminium and incorporates the seats for the injectors and the air bleed valve.
The fuel intake is achieved by means of a rapid attachment. Since the system is the returnless type, there is no recirculation pipe.

1. Fuel manifold
2. Injectors
3. Fuel arrival connector
4. Bleed valve

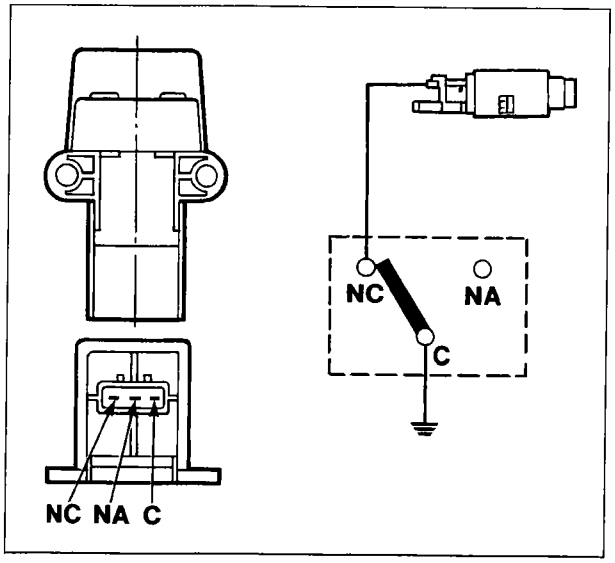
INJECTORS

The injector is designed to provide the quantity of fuel needed for the operation of the engine: the fuel is injected into the inlet manifold, immediately upstream of the inlet valves.
The injector is the top-feed type, with the supply of fuel from the top part of the body where the electrical winding connected to the connector (3) terminals is also housed.
When the current flows through the winding, the magnetic field which is created attracts the shutter causing the opening of the injector and the flow of fuel.
Two seals ensure the fuel manifold (1) side seal and the inlet manifold side (2).
A reference (4) determines the angular position of the injector and the correct direction of the jets in relation to the inlet valves.

Connector wiring

The injector resistance can be measured by disconnecting the connector and connecting an ohmmeter as illustrated in the diagram.

Resistance value: 14.5 5%±ohm.



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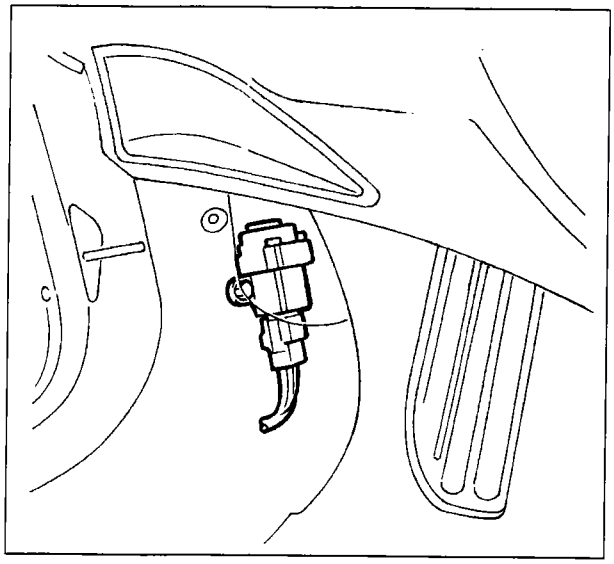


4F034PJ02

INERTIA SAFETY SWITCH

The inertia switch has the task of cutting off the electrical supply for the electric fuel pump if the vehicle suffers violent deceleration (impacts) to prevent the escape of fuel in case the fuel manifold or the supply pipe is damaged with a consequent risk of fire.

The switch consists of a steel ball fitted in a conical shaped housing kept in position by the attraction force of a permanent magnet.

Under the action of the acceleration due to inertia forces, the ball may be released from the magnetic clip and gradually come out of the conical housing with an upwards movement which depends on the angle of the cone.

There is a rapid release mechanism located above the ball which forms a normally closed (NC) circuit. When the mechanism is struck by the ball, it changes position into a normally open (NA) circuit, thereby interrupting the electrical supply to the electric pump and causing it to cut out.

The calibration of the switch causes it to intervene at acceleration above 1.2 g (approx 11.7 m/s2, corresponding to an impact at a speed of around 25 km/h).

To restore the connection to earth for the auxiliary electric pump, the seat must be moved backwards and the switch pressed until a click is heard.

After even an apparently slight impact, if there is a smell of fuel or there are leaks from the fuel system, do not turn the switch back on, but search for the cause of the problem and remedy it to avoid the risk of fire.

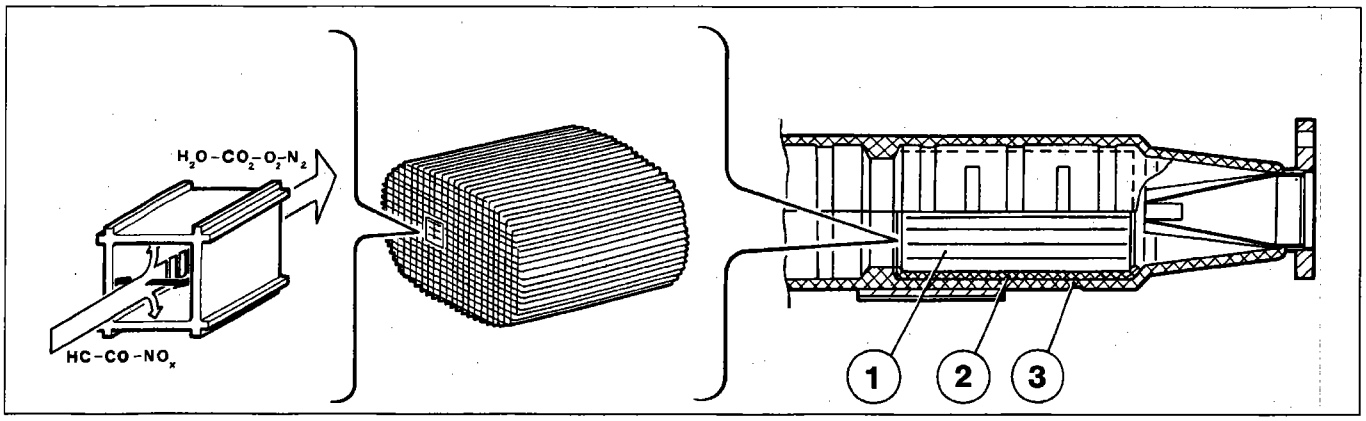
If there are no leaks and the vehicle is ready to depart once again, press the button to reactivate the electric pump.

EMISSION CONTROL DEVICES

The devices used for this purpose have two objectives;
- to keep down the levels of the pollutant substances in the exhaust, through the catalytic silencer;
- to eliminate the outwards dispersion of unburnt hydrocarbons, through the (fuel) anti-evaporation system and the (lubricant) oil vapour recirculation system.

CATALYTIC SILENCER

The catalytic silencer is a device which makes it possible to simultaneously keep down the levels of the three main pollutant compounds present in the exhaust: unburnt hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx).
Two types of chemical reaction take place inside the catalyzer:
oxidation of the CO and HC, converted into carbon dioxide (CO_2) and water (H_2O);
reduction of the NOx, converted into nitrogen (N_2).
These reactions can take place in extremely short periods of time thanks to the presence, inside the catalyzer structure (ceramic support), of a layer of active substances (platinum and rhodium) which enormously accelerate the conversion speed of the harmful substances.
The efficiency of this conversion process is, however, conditioned by the fact that the mixture strength for the engine must be continuously fluctuating around the stoichiometric value which is achieved thanks to the feed back control which is carried out by the control unit on the basis of the Lambda sensor signals.
Lastly, the conversion processes are activated at temperatures above 300-350 °C: it is therefore vital for the catalyzer to reach this temperature as quickly as possible in order to be able to operate correctly.



4F035PJ01

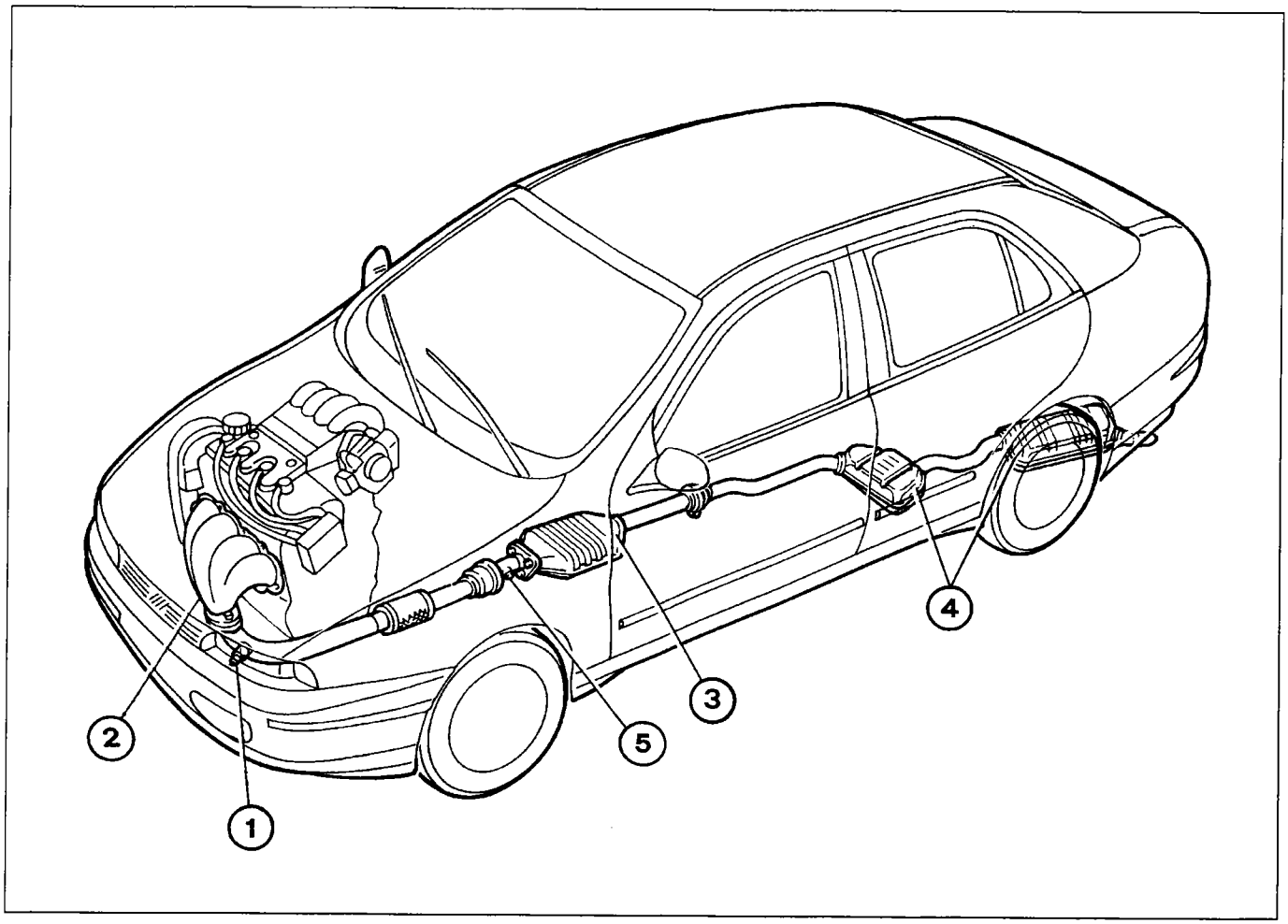
1. Ceramic monolith
2. Metal support
3. Steel outer casing

When operations have to be carried out near the catalytic silencer, the vehicle must be left to rest for some time because the operating temperature inside the catalyer is between 500 and 850 °C.

There are basically two things which cause the destruction of the inside of the catalyzer, namely:
- *the presence of lead in the fuel, which lowers the degree of conversion to levels which are practically nil ("lead poisoning") and also irreparably damages the Lambda sensor;*
- *the presence of totally unburnt fuel in the exhaust gases, due to failed ignition, which causes an increase in temperature which leads to the ceramic support melting. As a result, the high tension leads should not be disconnected, under any circumstances, with the engine running: when carrying out tests, the silencer must be replaced with a suitable length of pipe.*

10.

ENGINE EXHAUST ASSEMBLY DIAGRAM

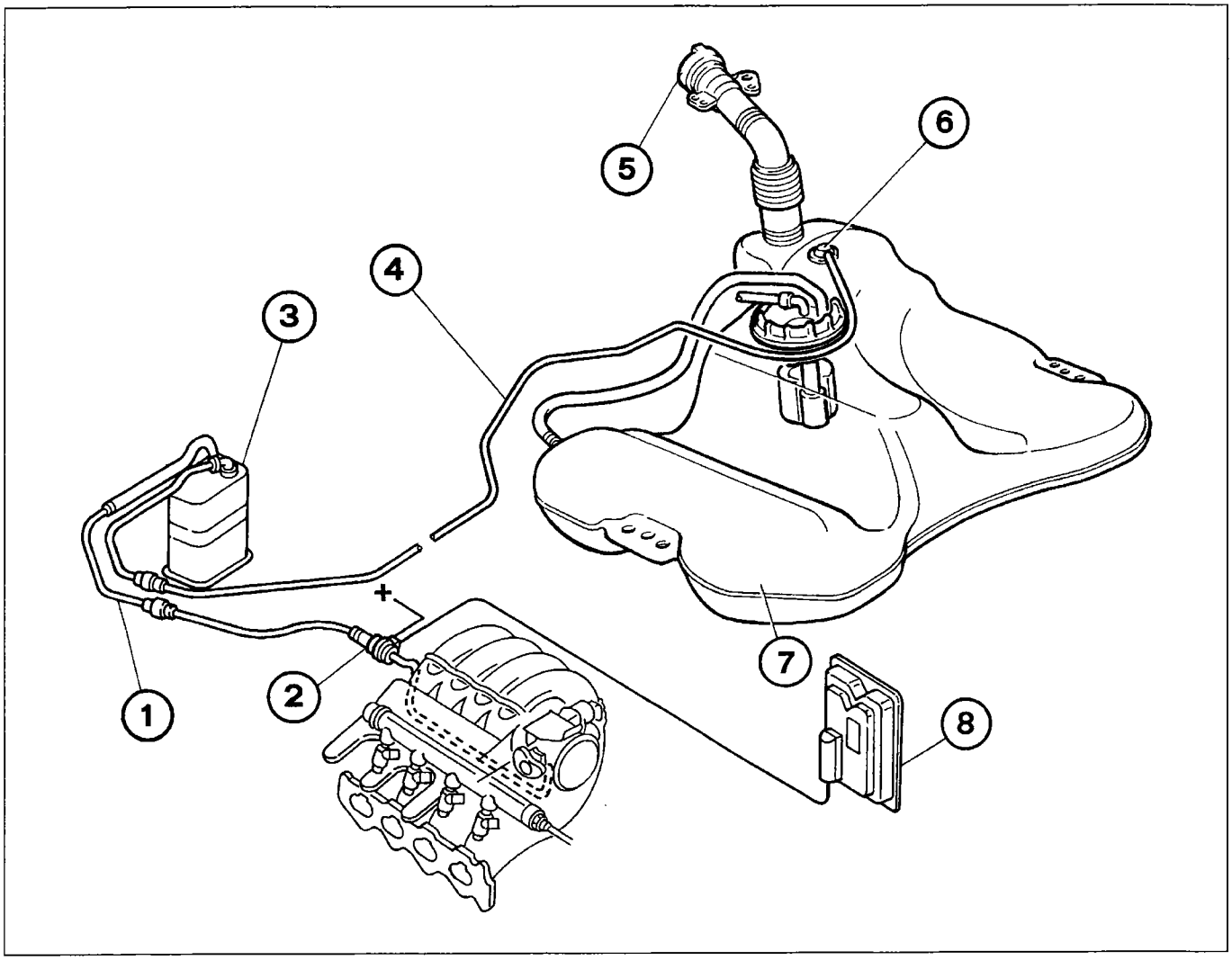


4F036PJ01

Key

1. Lambda sensor
2. Exhaust manifold
3. Catalytic silencer
4. Silencer
5. CO socket

ANTI-EVAPORATION CIRCUIT DIAGRAM



4F037PJ01

The anti-evaporation system is designed to prevent the fuel vapours, consisting of the lightest fractions of hydrocarbons which basically form in the tank, from being discharged into the atmosphere.

1. Vapour supply pipe to the butterfly casing
2. Charcoal filter solenoid valve
3. Charcoal filter
4. Vapour supply pipe from the tank to the charcoal filter
5. Safety and ventilation valve
6. Multi-purpose valve
7. Tank
8. Injection/ignition control unit

10.

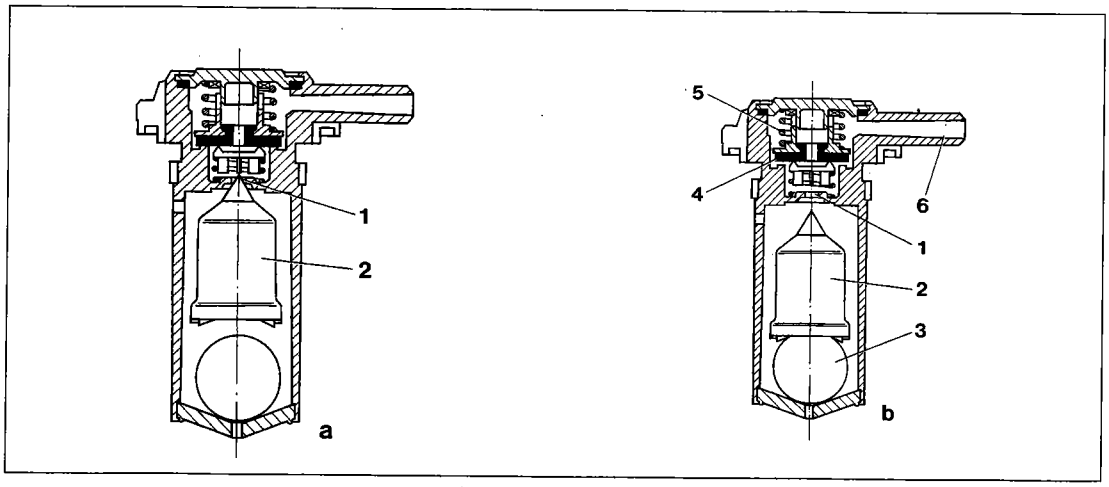
ANTI-EVAPORATION SYSTEM COMPONENTS

Multi-purpose valve

This valve is used to carry out various functions, namely:
- preventing the flow of liquid fuel, if the tank is too full or if there is an accident during which the vehicle overturns.
- allowing the breathing of fuel vapours toward the active charcoal filter;
- allowing the ventilation of the tank if there is a vacuum in it.

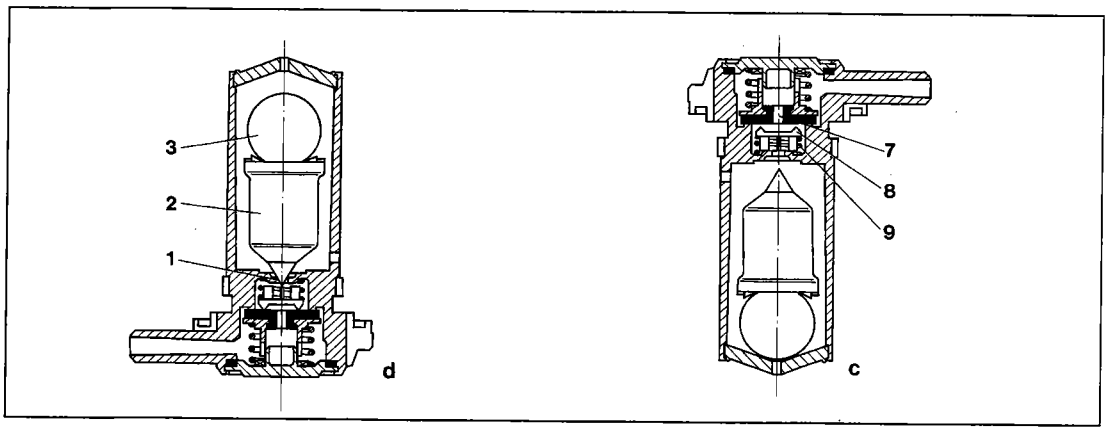
The valve consists of a float casing (2), a heavy ball (3), a plate thrust against the valve body by the spring (5) and a plate (8) thrust against the plate (4) by the spring (9). The operation of the multi-purpose valve can be summarized in the following cases, depending on how full the fuel tank is:

a. if the tank is full, the float (2) shutters the port (1) preventing the liquid fuel from reaching the active charcoal filter thereby avoiding damaging it;
b. if the level of the fuel in the tank decreases, the float (2) descends and rests on the ball (3), opening the port (1); when the pressure exerted by the fuel vapours on the plate (4) exceeds the loading of the spring (5), a ring section opens between the actual plate and the valve body, which allows the fuel vapours to flow out from the duct (6) and reach the active charcoal filter;

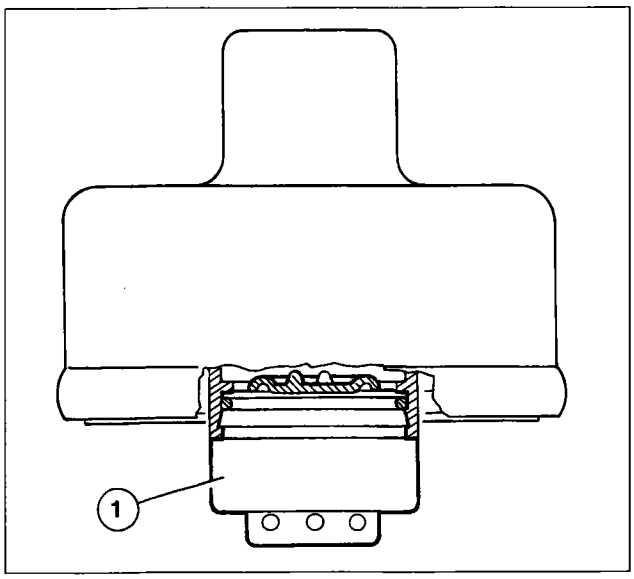


4F038PJ01 4F038PJ02

a. if the level of the fuel in the tank decreases to the extent that a vacuum is produced inside the tank, this vacuum acts on the plate (8) and, overcoming the spring (9) loading, recalls it downwards, allowing the ventilation of the tank through the port (7).
b. if the vehicle overturns, irrespective of how full the tank is, the ball (3), weighing on the float (2), pushes it against the port (1) preventing the dangerous escape of fuel and the consequent risk of fire.



4F038PJ03 4F038PJ04

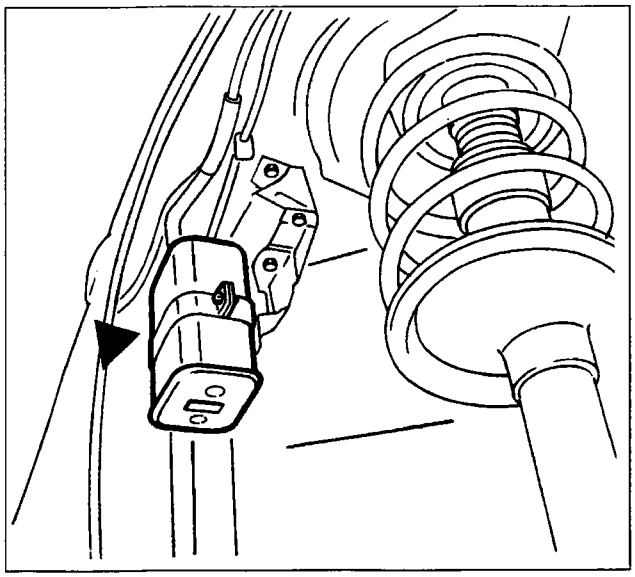


4F039PJ01

Safety and ventilation valve

This valve is located in the fuel filler cap and, according to the pressure in the tank, carries out the following functions:

- When the pressure inside the fuel tank exceeds 0.13 - 0.18 bar, it allow the excess vapours to be discharged outwards (safety function).
- If, conversely, a vacuum forms inside the tank equal to 0.020 - 0.030 bar, it allows the introduction of air (ventilation function).



4F039PJ02

Charcoal filter

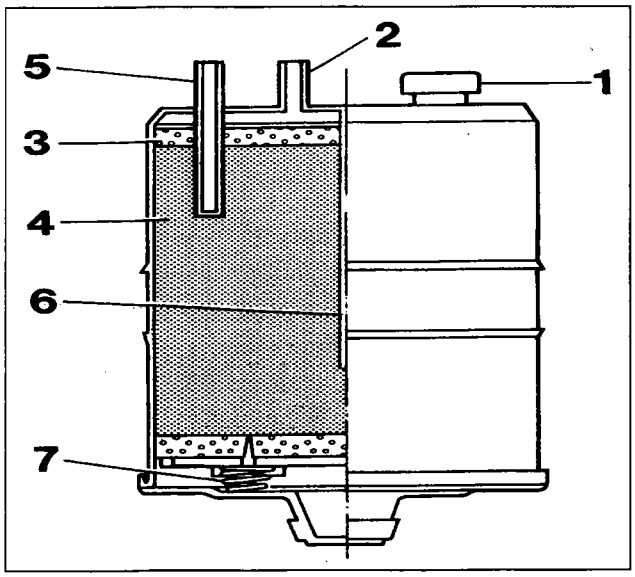
The charcoal filter is located in the right wheel arch; to gain access to it the rear part of the right front wheel arch liner has to be removed.

It consists of granules of charcoal (4) which trap the petrol vapours entering through the intake (5).

The air which enters through the intake (1) and the paper filter (3) comes into contact with the granules and directs them to the outlet (2) and from there to the cut out valve.

The air, having entered through the intake (5), can also be recalled by the vacuum in the tank for ventilation purposes. The partition (6) ensures that the intake air comes into contact with all the granules of charcoal, enhancing the release of petrol vapours to the inlet manifold.

There are also two springs (7) which allow the expansion of the mass of granules when the pressure increases.



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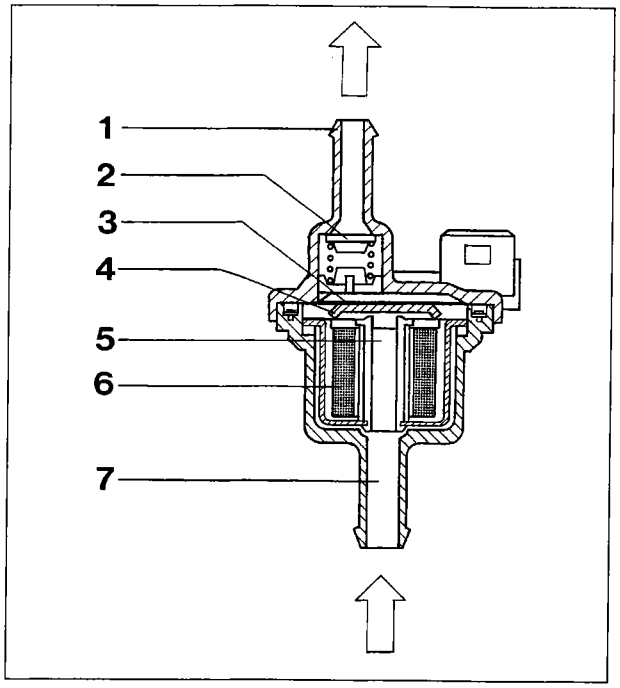


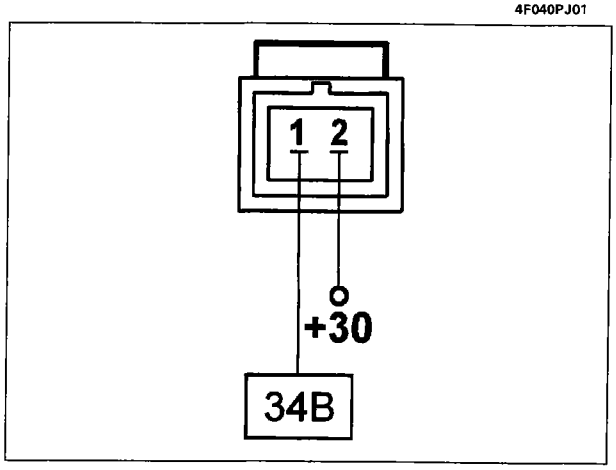
4F040PJ01

Charcoal filter solenoid valve

The function of this valve is to control the quantity of fuel vapours drawn in by the active charcoal filtr and directed to the inlet manifold which is achieved by means of the injection/ignition electronic control unit.

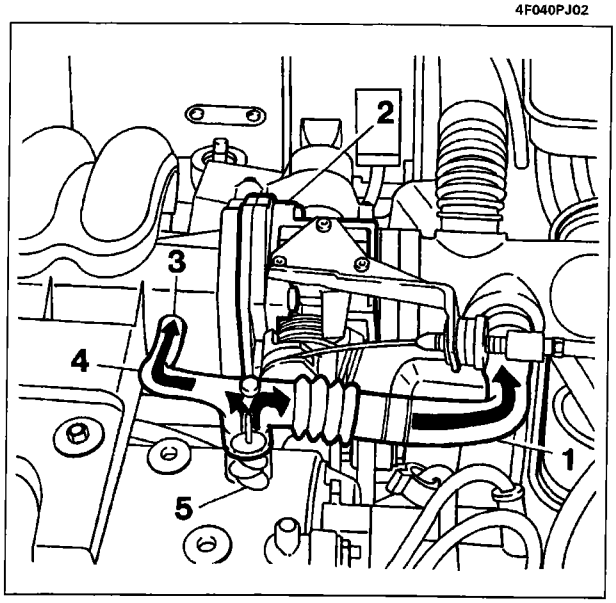
If this valve is not supplied, it is closed, preventing the fuel vapours from excessively enriching the mixture.

1. Inlet connector
2. Single-acting valve
3. Spring
4. Shutter
5. Outlet port
6. Electro-magnet
7. Outlet connector



4F040PJ02

Connector wiring



4F040PJ03

DIAGRAM SHOWING EXCHANGE OF GASES COMING FROM THE CYLINDER BLOCK/CRANKCASE (BLOW-BY)

This system controls the emission, from the cylinder block/crankcase, of breather gases consisting of air/petrol mixtures and burnt gases which escape from the piston seals, in addition to lubricant oil vapours, recirculating them to the inlet.
With the accelerator butterfly open, the gases from the upper cover reach the main air inlet pipe through the pipe (1) which contains a flame damper (5) to prevent combustion due to flame returns from the butterfly casing (2).
With the accelerator butterfly closed (engine idling), the vacuum in the inlet manifold draws in the gases (in limited quantities) directly through the small pipe (4) and the calibrated port (3).

CHECKS, ADJUSTMENTS AND REPAIR OPERATIONS ON THE BOSCH M1.5.5 SYSTEM

When working on a vehicle equipped with a Bosch M1.5.5 system, observe the following precautions:
- *do not start up the engine with the electrical connection terminals not properly connected or slack at the battery poles;*
- *do not use a rapid battery charger for starting up the engine;*
- *never disconnect the battery from the electrical system with the engine running;*
- *to charge the battery, disconnect it first from the electrical system;*
- *if the vehicle has to go in a drying oven after painting at temperatures in excess of 80 °C, then the engine control unit must be removed from the vehicle;*
- *do not connect/disconnect the control unit multiple connectors with the ignition switch in the ON position;*
- *always disconnect the negative battery lead before carrying out electrical welding on the vehicle.*

The system has a memory which is directly supplied by the battery, even when the ignition is switched off, which contains the values obtained during self-adjustment. Disconnecting the battery will mean that this information is lost and can only be acquired again after a certain length of time: this operation should therefore be restricted as far as possible.

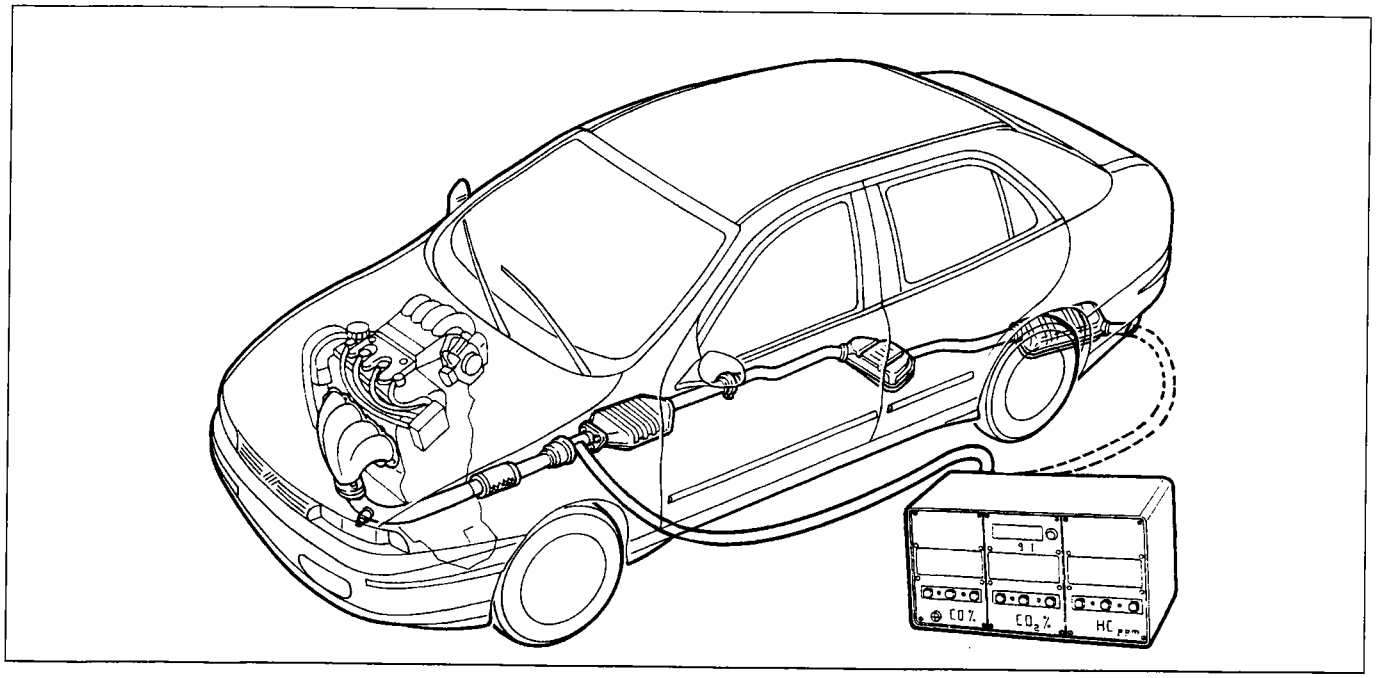
CHECKING THE CONCENTRATION OF THE EMISSIONS

The system manages the advance, the carbon monoxide (CO) content and the idle air flow rate without the possibility for adjustments, threfore no manual regulations are required. However, a check on the content of th exhaust gases, upstream and downstream of the catalyzer can provide precious indications on the injection/ignition system operating conditions, the engine parameters and the catalyzer.

Checking the idle CO and HC concentration 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 plug 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 the engine speed is correct.
5. Check that the idle CO concentration is within the recommended limits (see table); if this is not the case, it is necessary to check:
   - that the Lambda sensor is working properly, using the diagnostic equipment;
   - for the presence of air penetration in the area surrounding the Lambda sensor housing;
   - the injection and ignition system **(in particular the state of the spark plugs)**.
6. In the same conditions, check that the HC concentration is below 500 p.p.m.
7. If these figures are not obtained, proceed with tuning the engine, in particular checking the:
   - valve gear timing;
   - engine compression.



4F042PJ01

Table summarizing pollutant emission tolerance values

	CO (%)	HC (p.p.m.)	CO_2 (%)
Upstream of the catalyzer	0.4 - 1	⩽ 500	⩾ 12
Downstream of the catalyzer	⩽ 0,35	⩽ 90	⩾ 13

Checking exhaust concentration of CO and HC

The concentration of carbon monoxide (CO) and unburnt hydrocarbons (HC) at the exhaust is measured by inserting a suitably calibrated tester probe at least 30 cm into the end of the exhaust pipe.

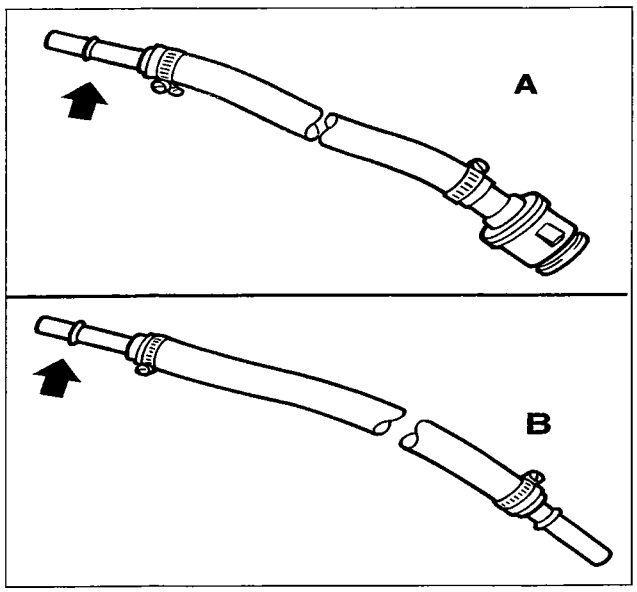
1. Check that the idle CO and HC concentration values are those recommended in the table.
2. If the HC value is outside of the recommended limit, whilst that measured previously upstream of the catalyzer was correct, the engine parameters are correct and therefore the cause of the problem should be sought in the decreased efficiency of the catalyzer.

ENGINE IDLE SPEED CHECK

If the engine idle speed does not correspond to the recommended value and the system is the self-regulating type then no adjustment can be carried out. It is therefore necessary to check that the accelerator linkage is correctly adjusted and then the cause of the problem should be sought by carrying out a complete fault diagnosis using the diagnostic equipment.

IGNITION ADVANCE CHECK

The diagnostic equipment must be used to check the ignition advance angles at the various speeds.



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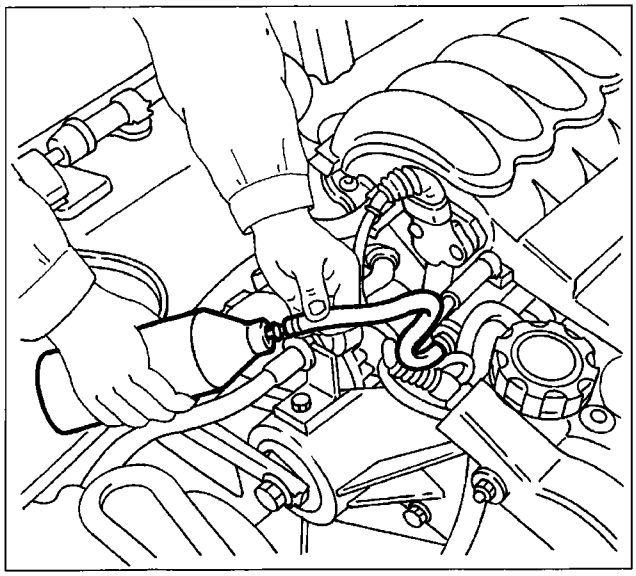


4F043PJ02

CHECKS ON FUEL SUPPLY CIRCUIT

CARRY OUT THESE OPERATIONS IN THE PRESENCE OF A SUITABLE VAPOUR PURIFICATION AND EXHAUST SYSTEM

Fuel supply circuit pressure check

Check the fuel supply pressure and the fuel system seal following the instructions given below using the equipment 1860955000 with two adaptors to be constructed as described below:

- adaptor (A): use a new type female terminal for rapid attachment and a length of pipe contained in Kit No. 186095503 and an old type male terminal for rapid attachment contained in Kit No. 1860955001;
- adaptor (B): use a new type male terminal for rapid attachment and a length of pipe contained in Kit No. 1860955003 and an old type male terminal for rapid attachment contained in Kit No. 1860955001;

Configure the adaptors as illustrated in the diagram.

The arrow shows the side to insert in the test equipment 1860955000 (pressure gauge)

Draining supply circuit fuel pressure

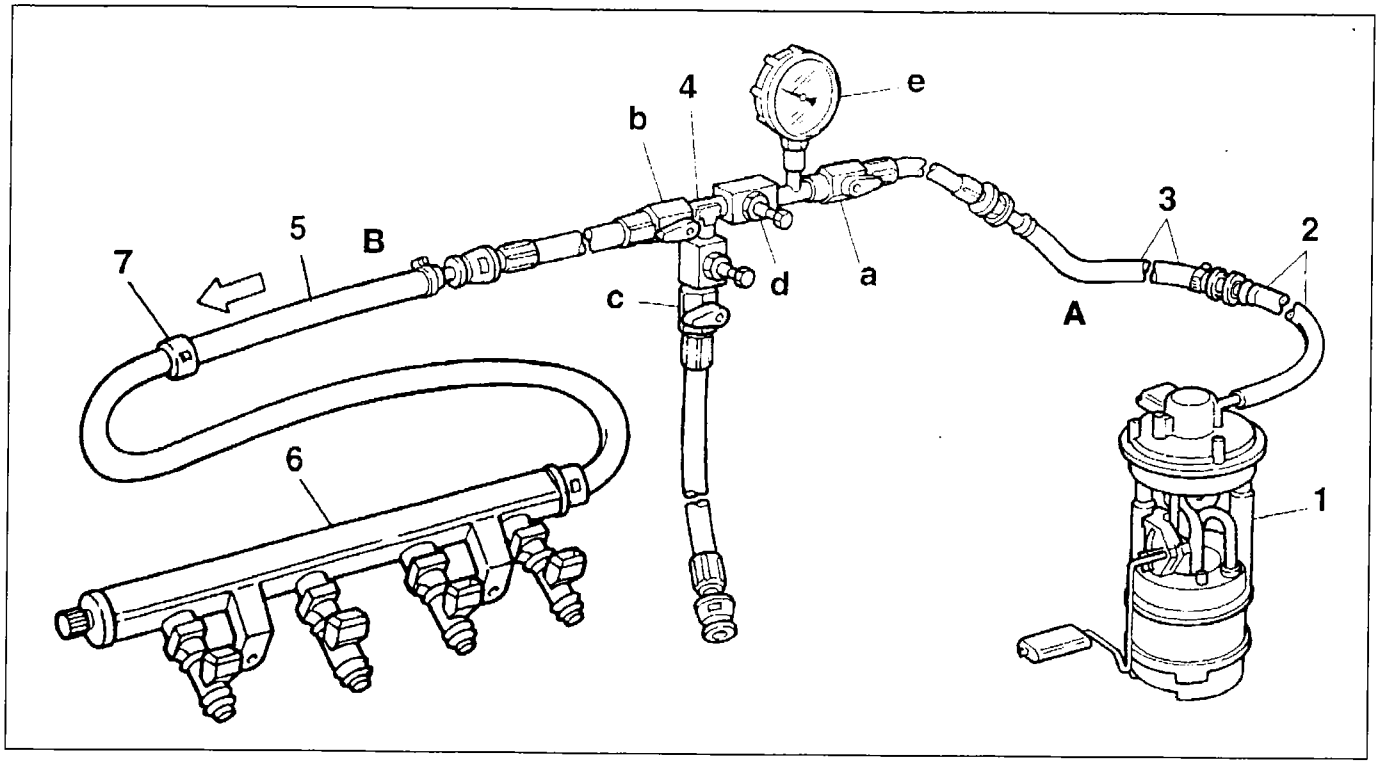
The fuel supply circuit is kept at a constant pressure of about 3.2 bar even when the engine is switched off; therefore, before carrying out any operations to the supply pipe it is necessary to drain the pressure in the system using the adaptor no. 1870684000 and a special container into which to drain the excess fuel. Proceed as described below:

- Remove the protective cover from the attachment on the fuel manifold;
- introduce the male terminal for the adaptor inside the container and insert the rapid connector on the attachment on the fuel manifold, as illustrated in the diagram; in this way the small amount of excess fuel, which creates pressure, is drained into the container and the test procedures can then be carried out on th fuel supply system;
- disconnect the adaptor from the attachment and refit the protective cover.

10.

Fuel supply circuit pressure check

Prepare the test equipment 1860955000 using the adaptors produced previously and fitted as illustrated in the diagram below using the valves (a), (b) and (d) in the maximum opening position and valve (c) in the closed position.



4F044PJ01

1. Complete electric pump
2. Fuel supply pipe
3. Adaptor (A)
4. Test equipment No. 1860955000
5. Adaptor (B)
6. Fuel manifold
7. Rapid attachment connector

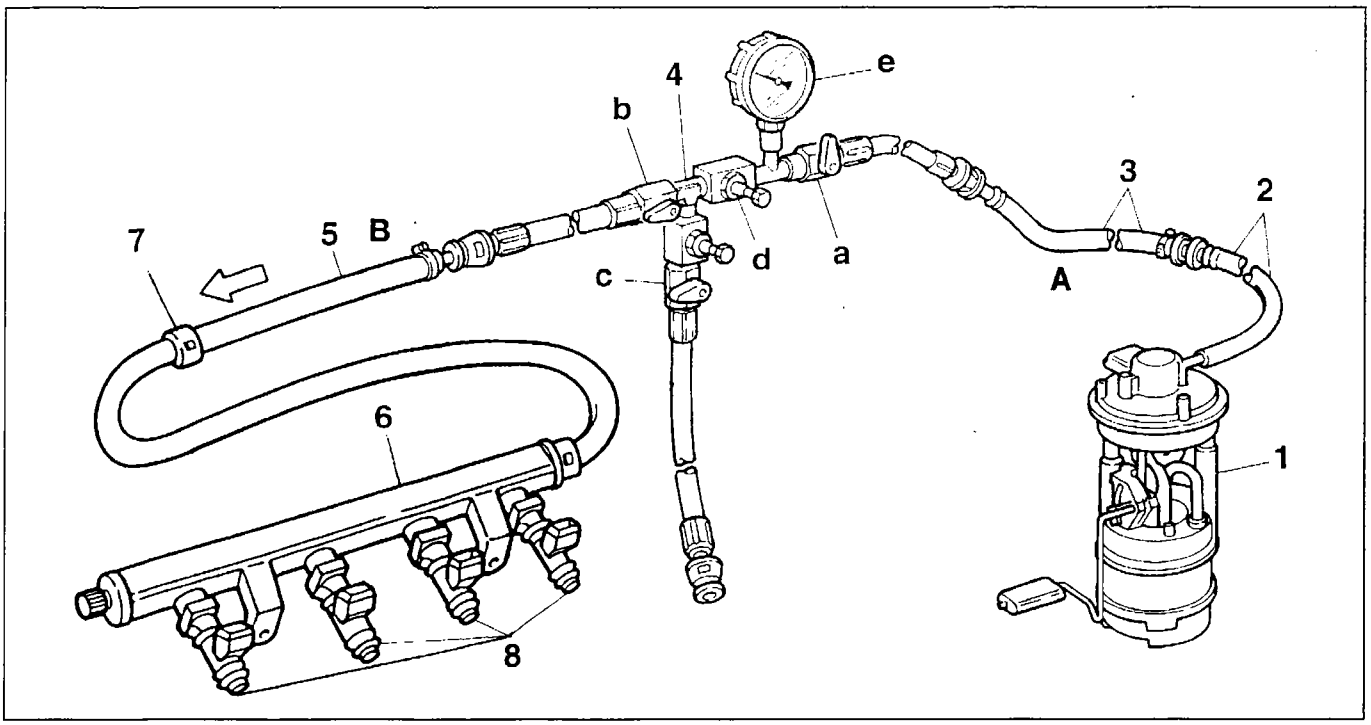
After having discharged the pressure, remove the terminal for the fuel supply pipe (2) from the rapid connector (7) following the instructions given on the previous pages, connect it to the female connector for the adaptor (A), connect the new male terminal for the adaptor (B) to the rapid connector (7) and check that the connectors are properly fitted.
Turn the ignition key to the ON position and check on the pressure gauge (e) that after having increased to a value of about 3.5 bar, the pressure settles down at around 3.2 bar (the decrease in pressure is due to the fact that after operating for several seconds the pump cuts out if the engine is not started up).
If there is a decrease in pressure greater than the figures given above, check the seal of the system in the section upstream of the fuel manifold and check the seal of the injectors following the instructions given below.

Checking fuel supply pipe seal

Keep the test equipment prepared as described in the previous paragraph, close valve (b), keeping valve (c) closed and valve (a) in the fully open position.
Turn the ignition key to the ON position and check on the pressure gauge (e) that the pressure, after rising to around 3.5 bar, settles down to around 3.2 bar (the decrease in pressure is due to the fact that the pump cuts out after operating for several seconds if the engine is not started up).

If there is a decrease in pressure greater than the figures given above, check the seal of the system in the section upstream of the manifold and, if there are no leaks or damage to the fuel supply pipe, replace the electric fuel pump drip tray assembly because the pressure regulator is housed in this unit and CANNOT be replaced.
If the pressure, after having repeated the test, exceeds the recommended figure and is considerably higher, replace the electric fuel pump because there iare operating faults in the pressure regulator.
If the pressure corresponds to the recommended figure, check the seal of the fuel manifold and the injectors, following the procedure described in the next paragraph.

Injector seal check



4F045PJ01

1. Complete electric pump
2. Fuel supply pipe
3. Adaptor (A)
4. Test equipment No. 1860955000
5. Adaptor (B)
6. Fuel manifold
7. Rapid attachment connector
8. Injectors

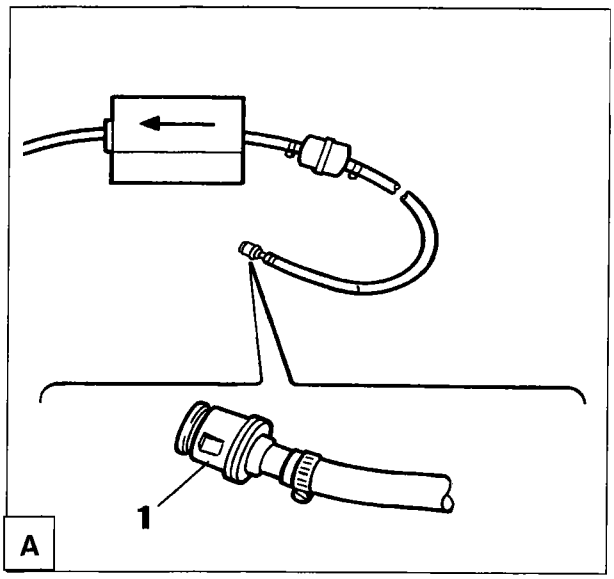
Keep the test equipment configured as described in the previous paragaph, close valve (b), keeping valve (c) closed and valve (a) in the fully open position.

Turn the ignition key to the ON position and check on the pressure gauge (e) that, after having increased to a value of around 3.5 bar, the pressure settles down at around 3.2 bar, then close the valve (a) and check that the pressure remains constant for at least one minute; if this is not the case, there is a leak from one or more of the injectors.

10.

Removing test equipment

Remove the test equipment 1860955000 with the ignition key in the OFF position proceeding as follows:
- introduce the end of the pipe connected to the valve (c) in a suitable container;
- open the valve (c) and drain the excess fuel into the container;
- keep the pipe in the container and disconnect the end of the supply pipe from the female connector for adaptor (A) holding the connector upwards;
- let the fuel in the pipes flow into the container;
- disconnect the end of the adapator (B) from the rapid connector and let the fuel flow from the pipes into the container;
- reconnect the fuel supply pipe.



4F046PJ01

Check the fuel consumption using the FLOWTRONIC equipment 1866149001

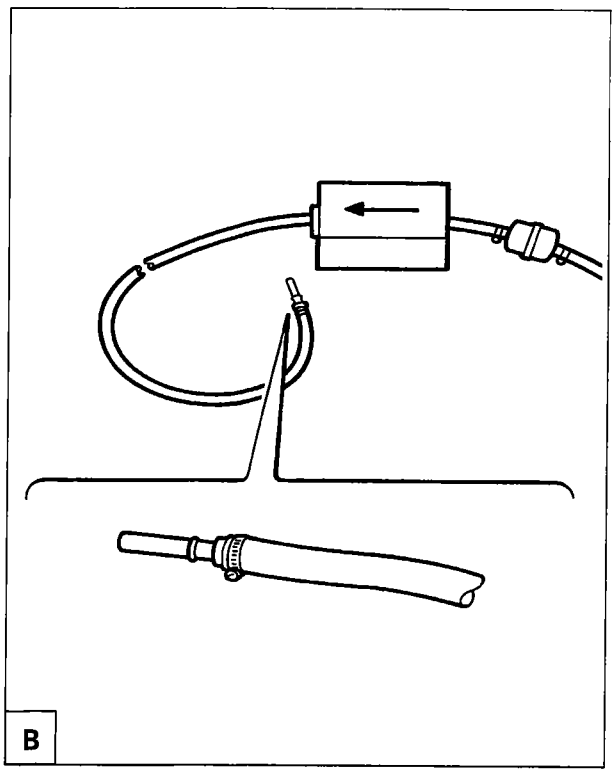
To carry out the test the equipment must be configured with the connectors as illustrated in the diagrams:

A. supply pipe side

B. fuel manifold side

If this is not the case, carry out the adjustment, following the instructions given below:

– cut the end of the inlet pipe for the FLOW-TRONIC equipment and replace it with a femal rapid connector (1), contained in Kit No. 186095503, as illustrated in figure A;

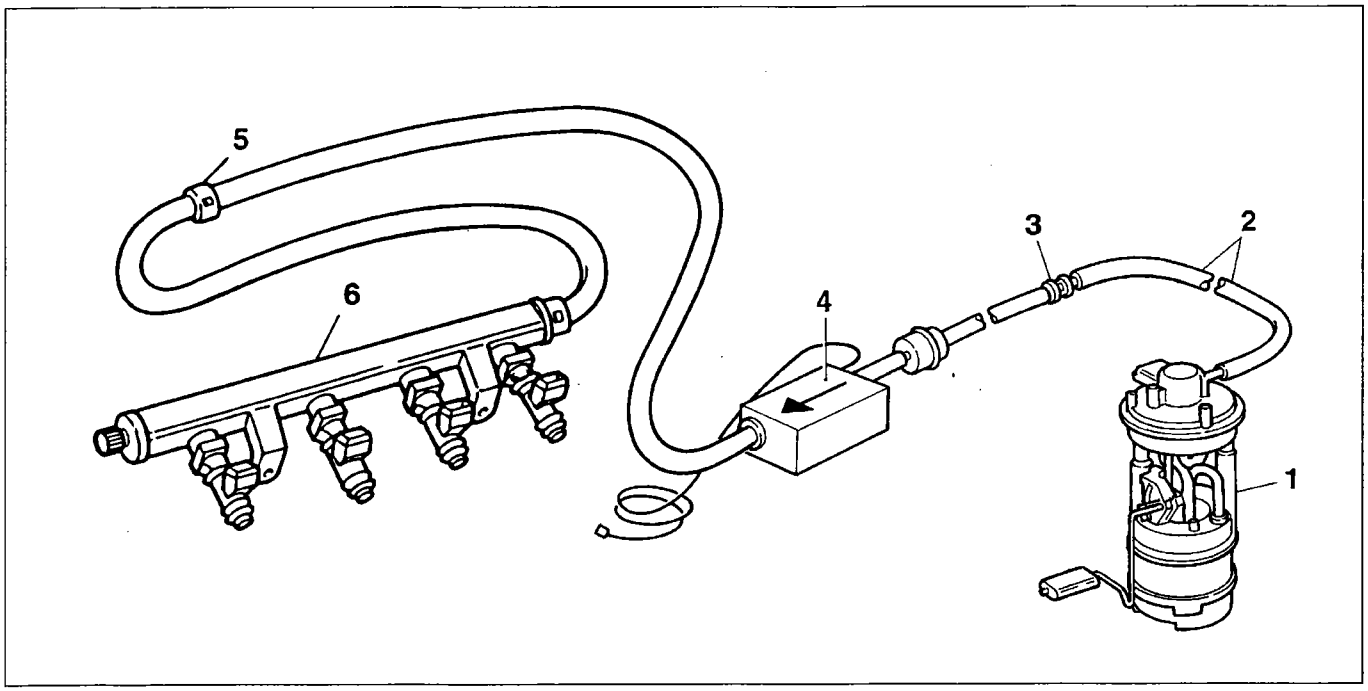


4F046PJ01

– cut the end of the outlet pipe for the FLOWTRONIC equipment and replace it with a male connector (2), contained in Kit No. 1860955003, as illustrated in figure B.

The connectors which have been removed should be recovered and kept for future connections.

- discharge the fuel prssure inside the supply pipe and disconnect the pipe from the rapid connector, following the instructions given in the previous paragraphs;
- connect the end of the supply pipe to the female rapid connector for the FLOWTRONIC equipment and the male connector to the rapid connector;
- position the equipment in the engine compartment, place the electrical connecting cable inside the vehicle and connect the actual equipment as described in the instructions which come with the equipment;
- proceed with checking the fuel consumption in accordance with regulation 93/116 CE and check that the figures correspond to those in section 00 - Technical Data.

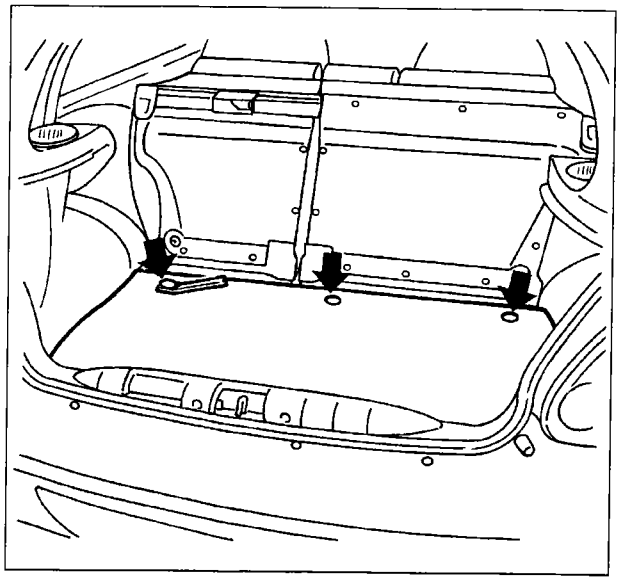


4F047PJ01

1. Complete electric pump
2. Fuel supply pipe
3. Female rapid connector
4. FLOWTRONIC equipment
5. Rapid connector
6. Fuel manifold

- carry out the fuel consumption road test in accordance with directive 93/116 CE (litres per 100 km)
  URBAN CYCLE - includes a cold start, followed by a varied simulated urban journey;
  EXTRA-URBAN CYCLE - includes frequent acceleration, in all gears, simulating normal out of town usage of the vehicle; the speed varies between 0 and 120 km/h;
  AVERAGE COMBINED CONSUMPTION - includes 33% of the urban cycle and 67% of the extra-urban cycle;
  check that the values measured correspond to those in the section "Introduction and Technical Data".

NOTE *Traffic conditions, driving styles, atmospheric conditions, trim levels/accessories, the presence of a roof rack, special equipment and the state of the vehicle in general can lead to fuel consumption figures which differ from those obtained using the procedures described above.*



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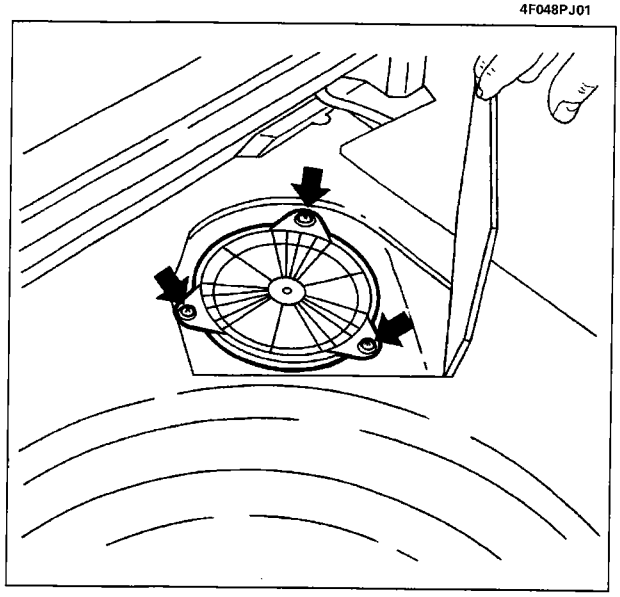

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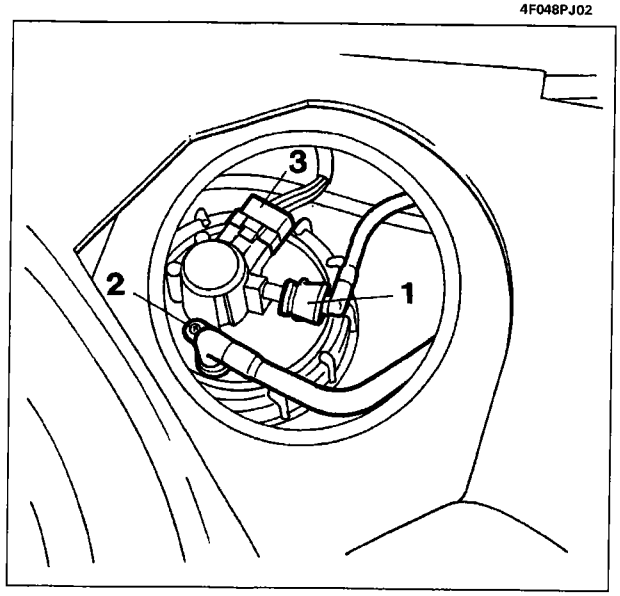


4F048PJ03

FUEL DRIP TRAY ASSEMBLY

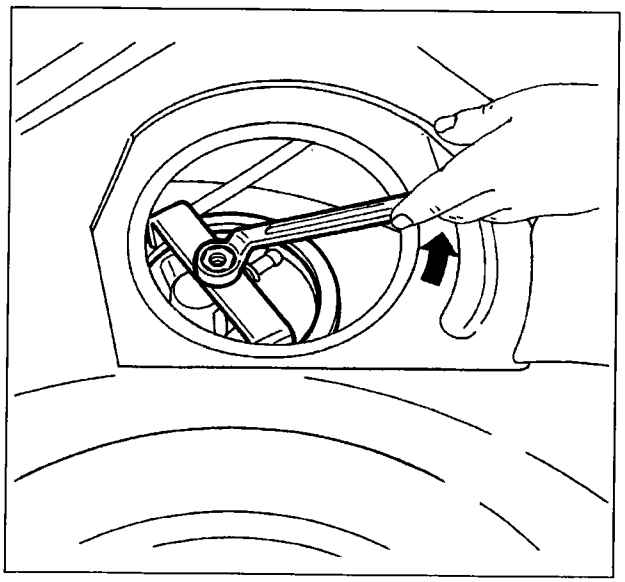
NOTE *In order to extract the unit from the tank, the fuel should not come above the maximum level.*

Removing-refitting

Proceed with the removal of the fuel drip tray assembly as follows:

- using tool 187807700, remove the buttons (arrow) fixing the luggage compartment lining and remove it, then lift up the cover to gain access to the dust cover;
- undo the bolts (arrow) and remove the dust cover; _ disconnect the supply pipe (1), the breather pipe (2) and the electrical connector (3);
- using the tool 1860893000, remove the ring nut securing the drip tray amd extract the drip tray from the tank, taking care not to damage the seal.

When refitting, reverse the order of the operations carried out for the removal; at the end, make sure that there are no fuel leaks.



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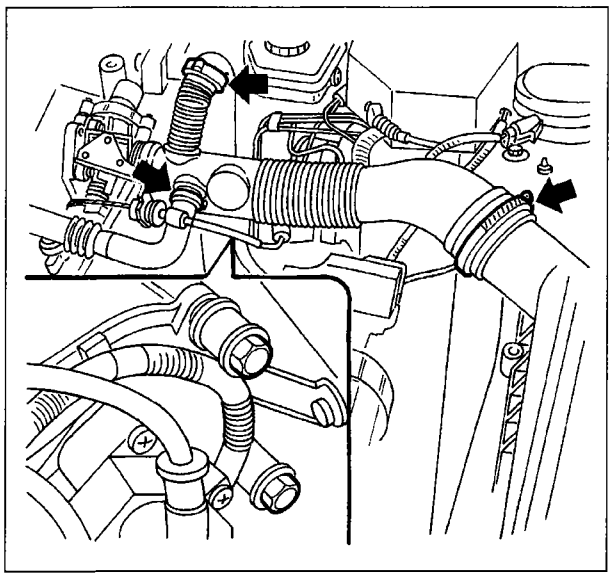


4F049PJ01

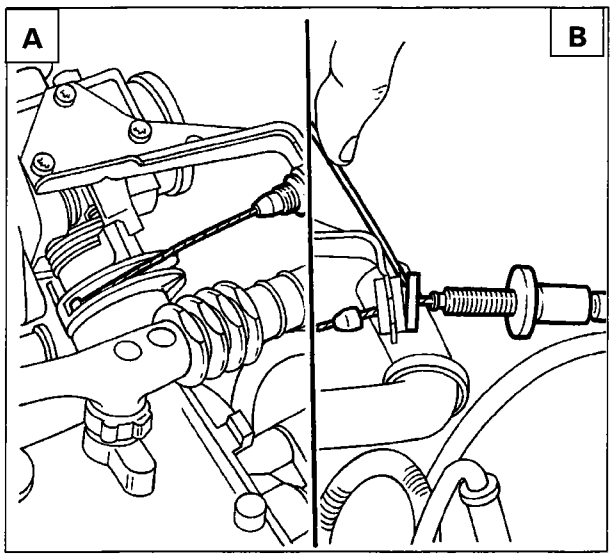
FUEL MANIFOLD AND INJECTORS

NOTE *Before removing the manifold, discharge the pressure inside, following the instructions given at the start of this chapter.*

Removing-refitting fuel manifold

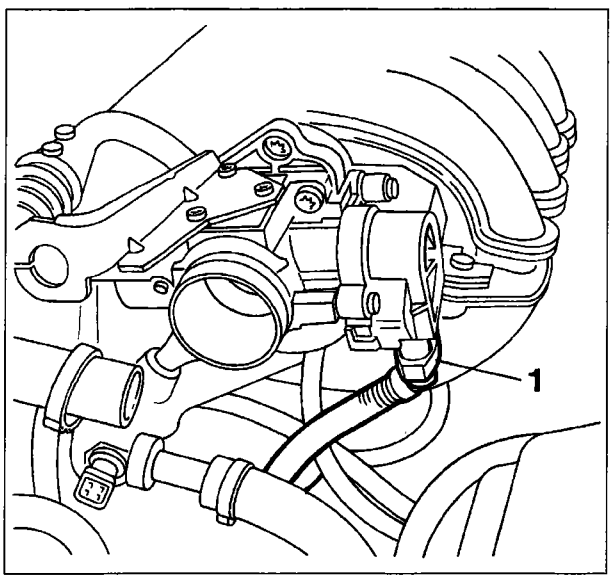
Proceed with the removal of the manifold as follows:

- remove the bands shown (arrow); then undo the two bolts (detail) and rmeove the inlet hose complete with resonator;



4F0499J02

- turn the accelerator lever and release the end of the accelerator cable from the lever (A), then remove the adjustment plate from the bracket (B) and move the accelerator cable away;
- disconnect the engine idle speed actuator connector (1);
- undo the bolts (arrow) fixing the upper half manifold and remove the vapour recirculation pipe (2).



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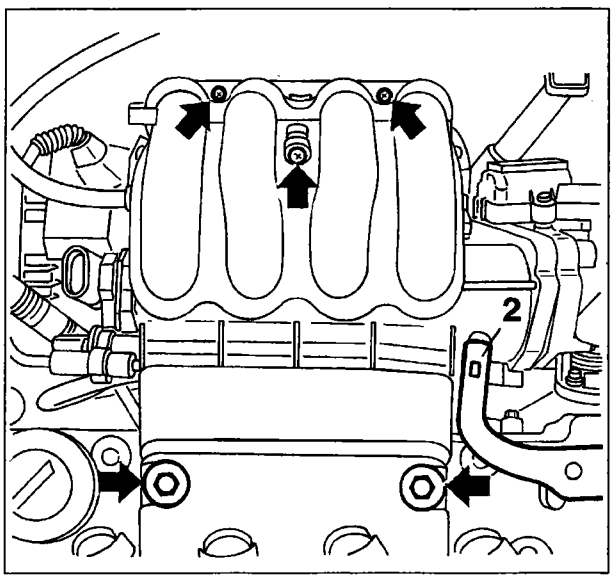

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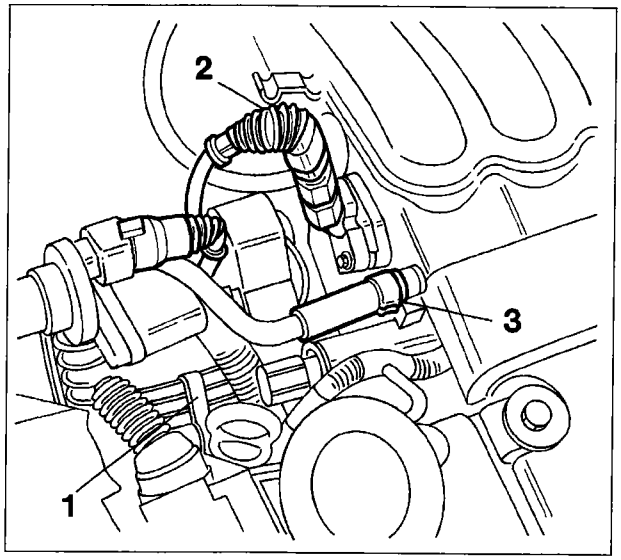

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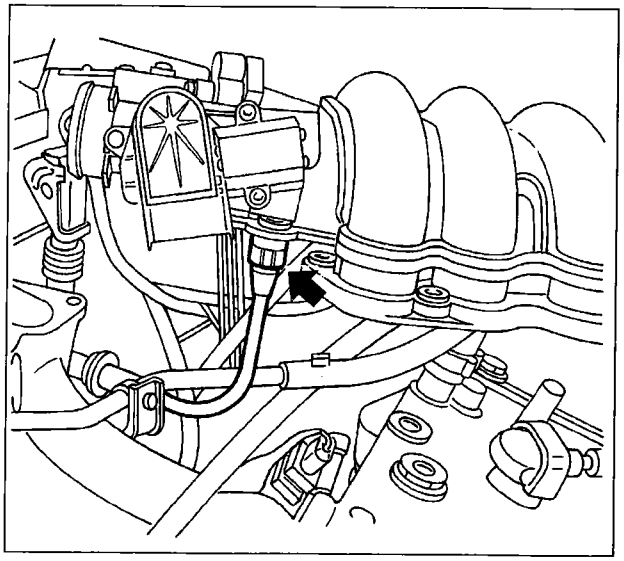
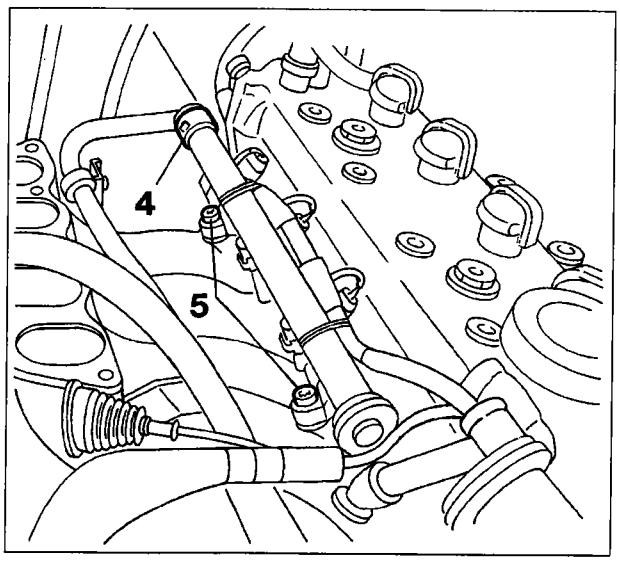


4F050PJ02

- disconnect the pressure and air temperature sensor connector (2), the injector cable connector (1) and remove the charcoal filter intake pipe (3);
- partly raise the half manifold and remove the brake servo vacuum intake pipe (arrow);
- disconnect the rapid connector (4), undo the fixing bolts (5) then remove the complete fuel manifold.

When refitting, reverse the order of the operations carried out for the removal.



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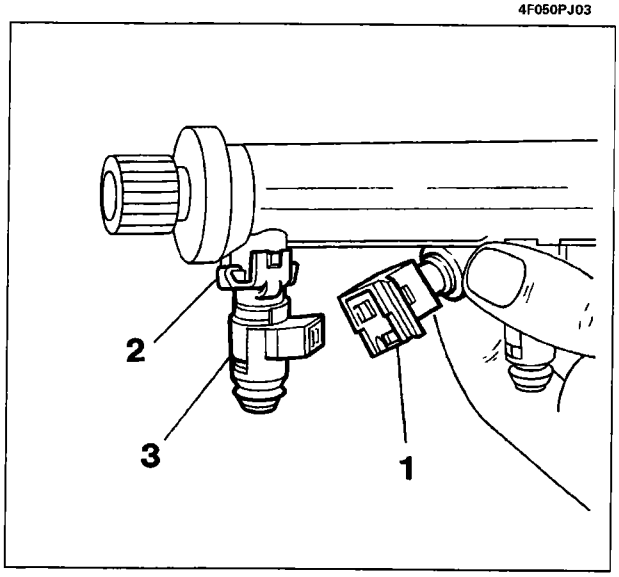

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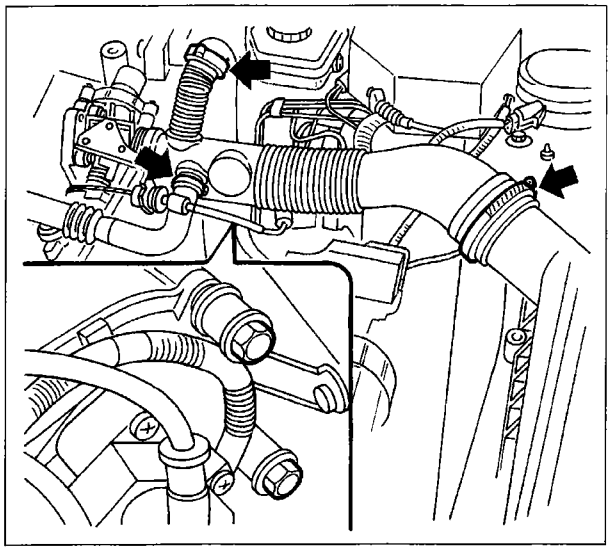
Removing-refitting injectors

To remove the injectors, proceed as follows:
- Disconnect the electrical connection (1).
- Remove the safety clip (2).
- Remove the injecor (3) which is a press fit.

Never act on the electrical connector to remove the injector.
Before refitting, check the condition of the seals.



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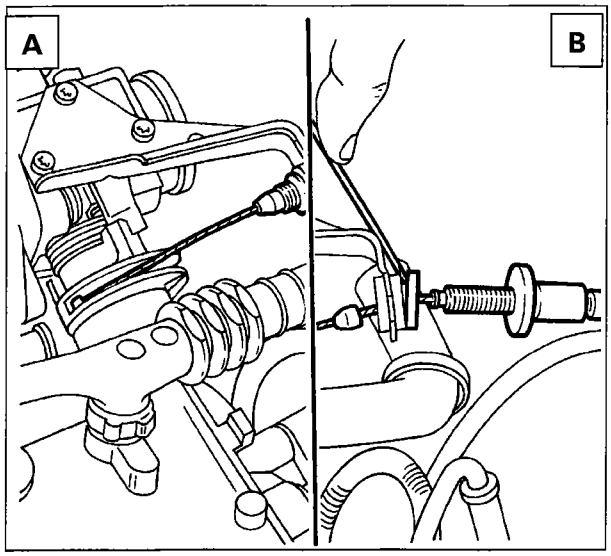

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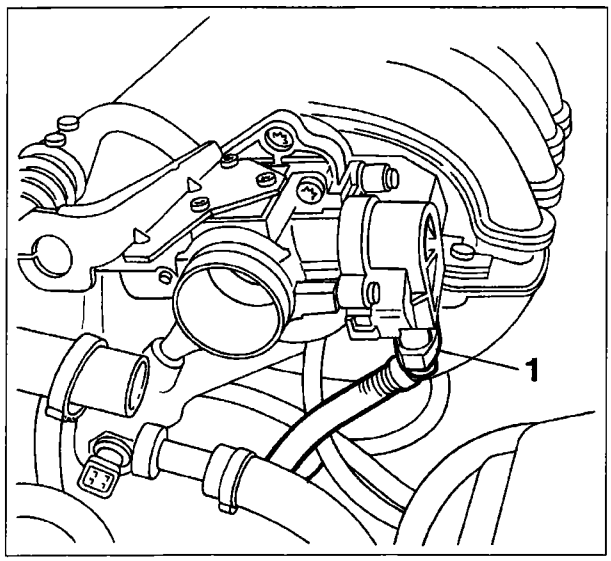


4F049PJ03

BUTTERFLY CASING

Removing-refitting

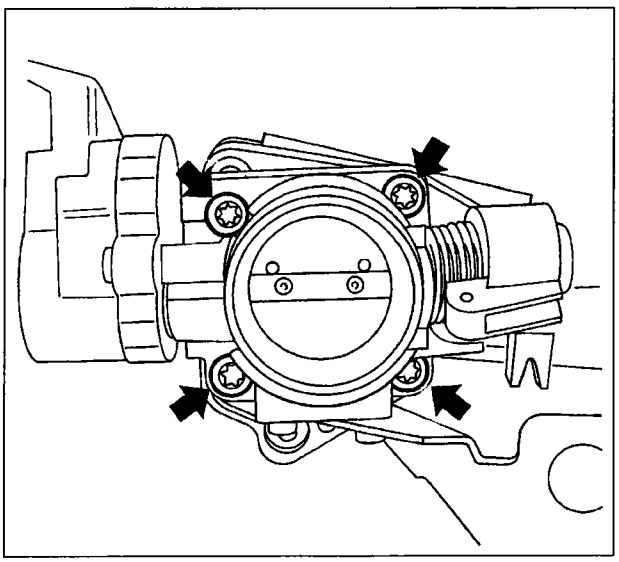
Proceed with the removal of the butterfly casing as follows:

- remove the bands illustrated (arrow); then undo the two bolts (detail) and remove the inlet hose complete with resonator;
- release the end of the accelerator cable from the lever (A) then remove the adjustment plate from the bracket (B) and move the accelerator cable away;
- disconnect the engine idle speed actuator connector (1);
- undo the four fixing bolts (arrow) and remove the butterfly casing.

When refitting, reverse the order of the operations carried out for the removal.

Adjust the accelerator control cable as described in the paragraph below.

NOTE *If the butterfly casing is being replaced, connect the diagnostic equipment (Examiner) to the diagnostic socket and carry out the zeroing and self-learning procedures for the engine idle adjustment actuator data (M.D.S.)*



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10.

Zeroing

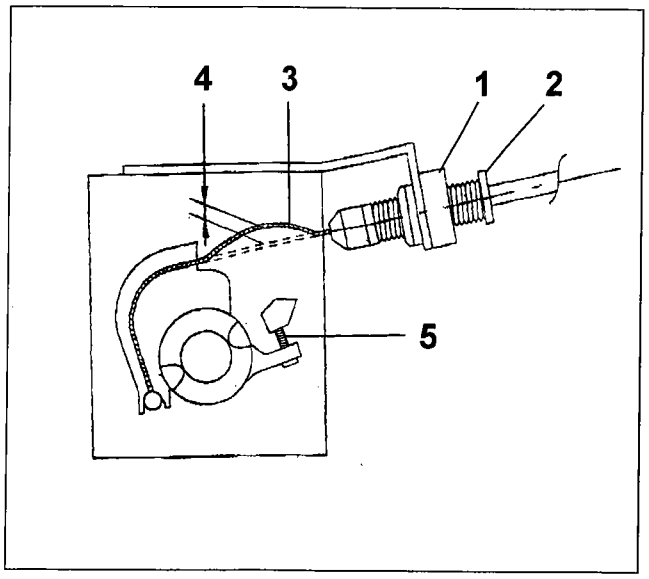
- Make sure that the ignition switch is in the OFF position.
- Check that the climate control is switched off, that the accelerator pedal is not pressed and the accelerator control cable is correctly adjusted (see paragraph below).
- Connect switch MPX 97 (tool 1806365000) to the diagnostic socket and place the knob in position 3.
- Connect the diagnostic equipment (Examiner).
- Using the Examiner, enter into the "Control Unit Test" ambient.
- Place the ignition switch in the ON position.
- Using the Examiner, enter the "Active Diagnosis" ambient, then select "Self-adjustment Parameters Reset" and "Idle Actuator".
- Confirm Reset and wait for the message "Carried Out".
- Turn the ignition switch to the OFF position and wait for 30 seconds.

Self-learning

- Turn the ignition switch to the ON position and wait for 30 seconds.
- Using the Examiner, re-establish the dialogue with the engine control system.
- Using the Examiner, enter the "Parameters" ambient and in the "Select" menu select the "Idle recognition Test– carried out" and "Idle recognition signals – synchronized" checks.

NOTE *If at least one of the parameters does not conform, turn the ignition OFF and repeat the procedure. If the non conformity persists, check that the diagnostic cable is correctly connected and that the instrument is working properly.*

- Turn the ignition to the OFF position and wait for 30 seconds.
- Start up the engine without pressing the accelerator pedal and wait for the fan to come on.
- Disconnect the diagnostic equipment.
- Road test the vehicle for several kilometres then, with the engine warmed up, check that the idle is working properly.



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ACCELERATOR CABLE

Adjustment

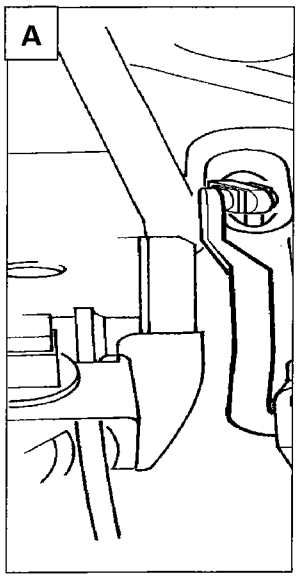
- loosen the lock nut (1);
- working on the adjustment nut (2), adjust the accelerator cable (3) clearance so that, with the pedal released, the butterfly is completely closed (adjustment screw 5 in end of travel position) and the cable clearance (4) is about 5 mm.

Proceed as described below:

tighten to reduce the clearance
loosen to increase the clearance;

- when the adjustment has been completed, lock the lock nut.

At the end of the adjustment of the cable during idling, connect the diagnostic equipment to the special intake and check that, with the pedal fully depressed, the opening angle of the butterfly is at least 80°.



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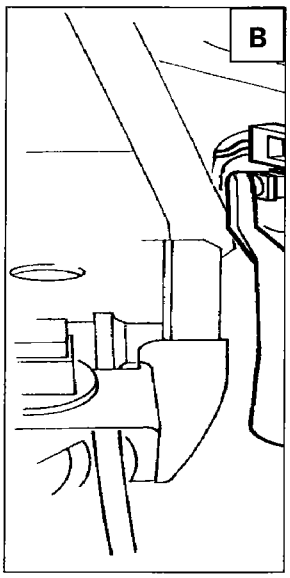


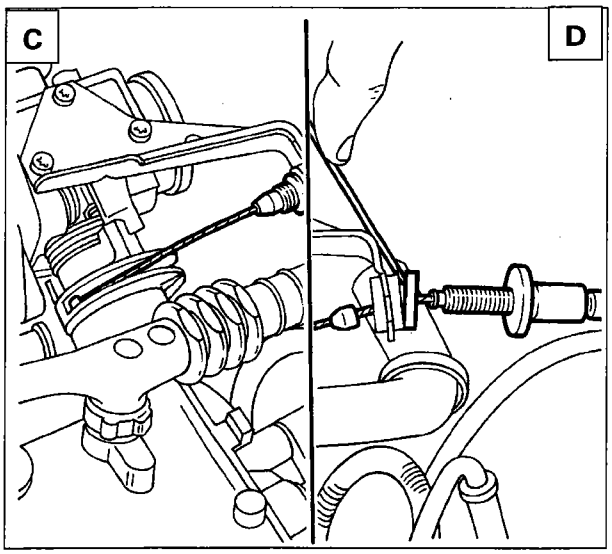
4F052PJ03

Removing-refitting

Proceed with the removal of the accelerator cable as follows:

- working from inside the vehicle (A), disconnect the control cable from the mounting on the accelerator pedal (B);
- turn the accelerator lever to release the end of the accelerator cable from the lever (C), then remove the adjustment plate from the bracket (D) and move the accelerator cable away.

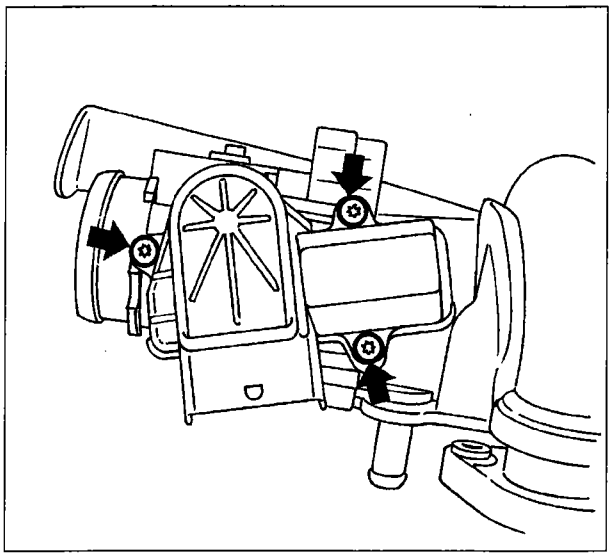
When refitting, reverse the order of the operations carried out for the removal.



4F049PJ02

ENGINE IDLE ADJUSTMENT ACTUATOR/BUTTERFLY POSITION SENSOR

NOTE *The engine idle adjustment actuator/butterfly position sensor should only be disconnected from the butterfly casing if it is being replaced, because the removing-refitting causes the deterioration of some components (e.g. internal seals) which then do not guarantee the correct operation of the component once it is refitted.*



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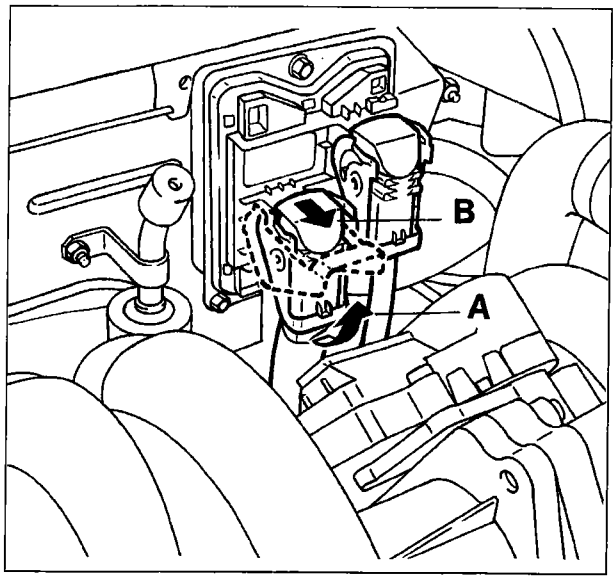
Removing-refitting

To remove the actuator, disconnect the connector and undo the fixing bolts (arrow).

NOTE *When refitting, the zeroing and self-learning procedures for the engine idle adjustment actuator data (M.D.S.) must be carried out as described in the "BUTTERFLY CASING" paragraph.*

10.



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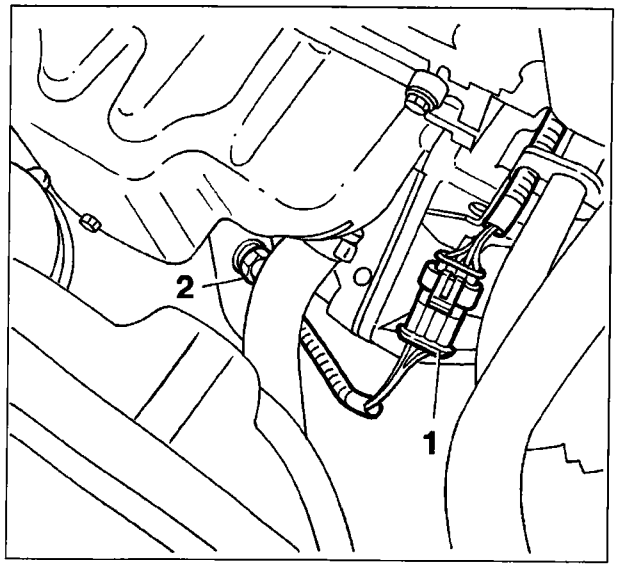

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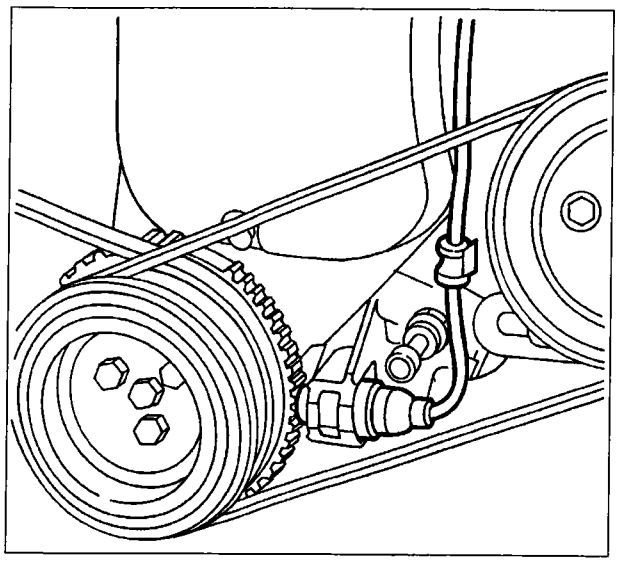

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ENGINE CONTROL UNIT

Removing - refitting

Proceed with the removal of the control unit as follows:

- disconnect both connectors, working in two stages:
  A) turn the metal hook upwards to release the connection;
  B) move the connector away;
- undo the bolts fixing the control unit and remove it.

When refitting the connector, proceed as follows:

- place the connector in contact with the control unit;
- rotate the metal hook until it is completely closed.

NOE *If replacing the engine control unit, connect the diagnostic equipment (Examiner) to the diagnostic socket and carry out the self-learning procedure for the engine idle adjustment actuator (M.D.S.), as described in the "BUTTERFLY CASING" paragraph.*

LAMBDA SENSOR

Removing - refitting

Disconnect the electrical connection (1) and remove the sensor (2) from the housing on the exhaust manifold.
When refitting, apply lubricating grease, resistant to high temperatures, to the thread.

ENGINE RPM AND TDC SENSOR

Removing-refitting

Disconnect the electrical connection.
Undo the fixing bolt and remove the senor.

Checking the gap

Check the distance between the sensor and the flywheel teeth (gap).

Gap: 0.5 - 1.5 mm

NOTE *If necessary, work on the sensor support (e.g. if the gap is outside of the tolerance, the sensor is not aligned, etc.); the procedure for correctly positioning the sensor and support and the timing should be carried out following the instructions given in the engine overhaul manual.*

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The information contained in this publication is supplied as a guide and may no longer be up to date as a result of modifications made by the Manufacturer, at any time, for reasons of a technical or commercial nature in addition to meet legal requirements in different countries.

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HITACHI INTEGRATED INJECTION/IGNITION SYSTEM

INTRODUCTION

The Hitachi system fitted on the Marea-Marea Weekend versions with the 1747 i.e. 16v engine belongs to the category of static advance, digital electronic ignitino systems integrated with phased, multiple, intermittent type electronic fuel injection systems.
The system can be divided into the following sub-systems:

ELECTRICAL/ELECTRONIC CIRCUIT
AIR INTAKE CIRCUIT
FUEL SUPPLY CIRCUIT
EMISSION CONTROL DEVICES

The system is capable of detecting the following parameters via special sensors:

1. the engine rotation speed;
2. the position of each pair of cylinders in relation to TDC for cylinder 1;
3. the engine intake air flow rate;
4. the position and variation speed of the position of the accelerator butterfly;
5. the temperature of the engine coolant;
6. the effecive mixture strength (through the Lambda sensor signal);
7. the possible presence of detonation;
8. the speed of the vehicle;
9. the battery voltage;
10. whether or not the climate control compressor is switched on.

This information, usually in analogue format, is converted into digital signals by the analogue/digital converters (A/D) for use by the control unit.
In particular, any engine operating point is identified by two parameters:

- the engine rotation speed, measured in revs per minute (rpm);
- the engine load, which consists of the quantity of air drawn in by each cylinder.
- This quantity is calculated on the basis of the intake air flow rate and is represented by the parameter TP, measured in milliseconds (ms).

The control unit memory contains the management programme (software) which consists of a series of strategies, each of which manages a precise system control function.
By using the information (input) listed previously, each strategy processes a series of parameters, using the data maps stored in special areas of the control unit memory, and then controls the system actuators (output), which are the devices which allow the engine to operate, namely:

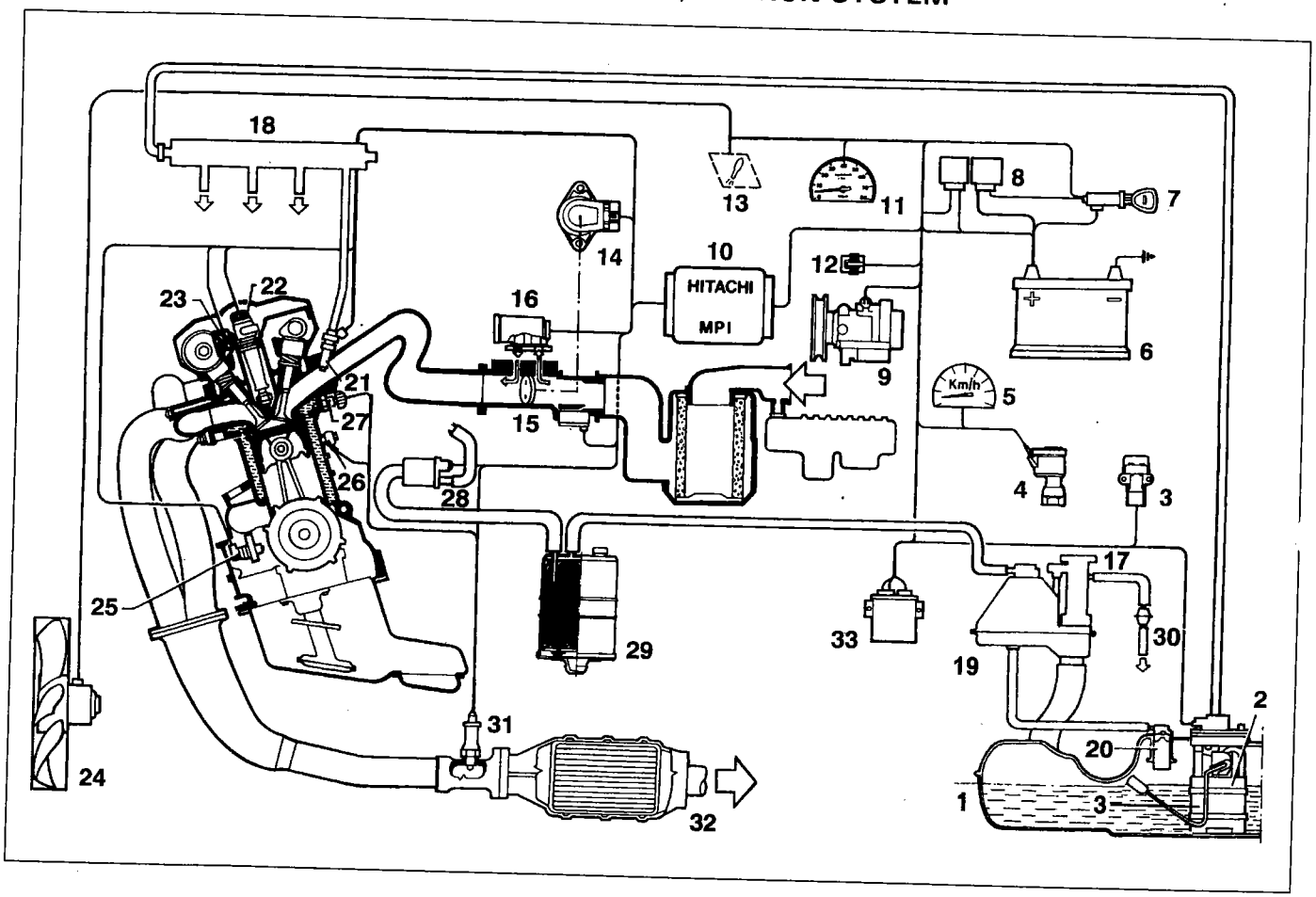
1. injectors;
2. ignition coils;
3. various type solenoid valves;
4. fuel pump;
5. relays.

NOTE *The HITACHI injection/ignition system does not require any adjustments as it is the self-adjusting and self-adapting type.*

NOTE *The numbers in the boxes in the drawings and the wiring diagrams denote the corresponding HITACHI engine management control unit pins (a number followed by A, indicates connector A, a number followed by B, indicates connector B).*

10.

FUNCTIONAL DIAGRAM SHOWING INJECTION/IGNITION SYSTEM



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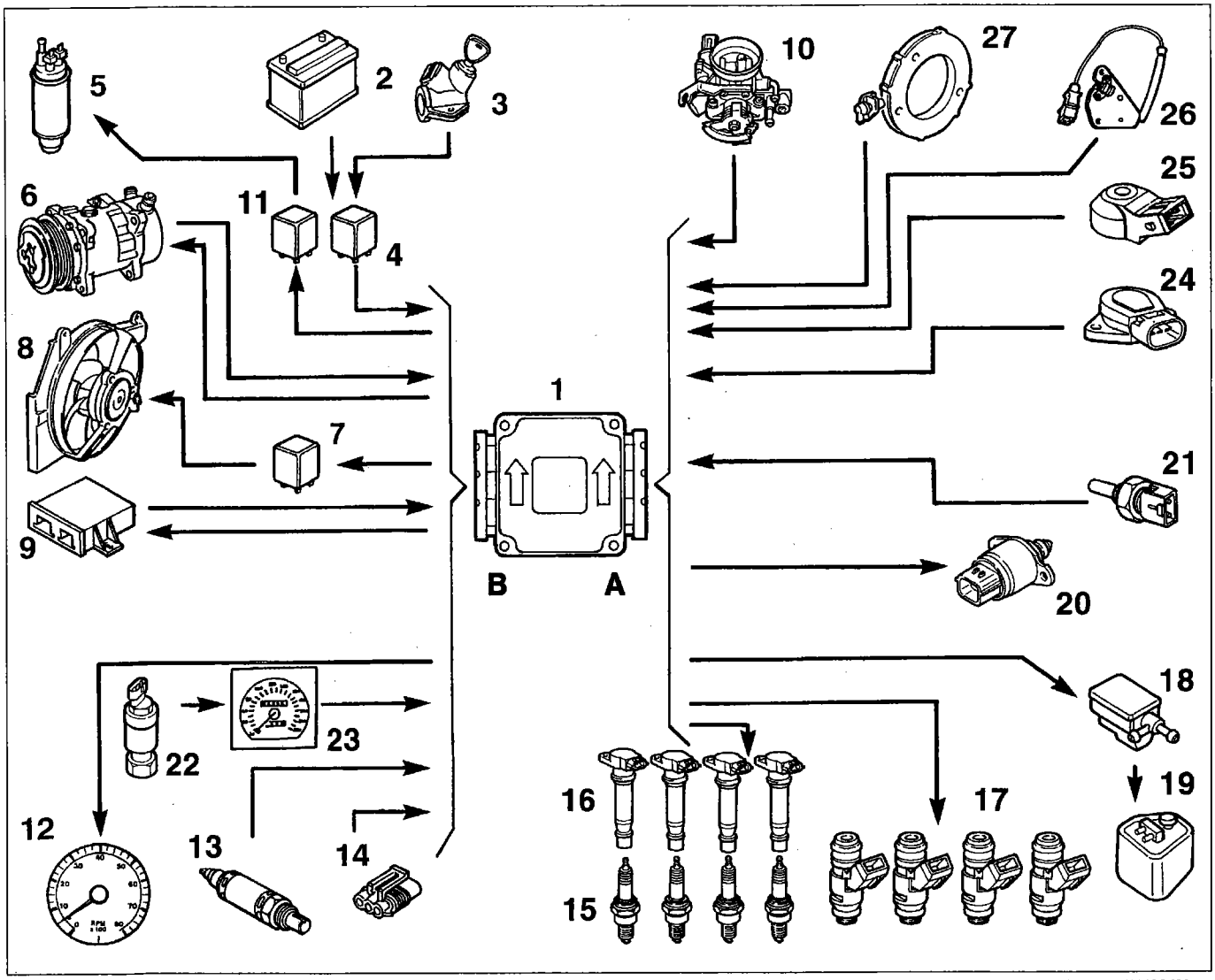
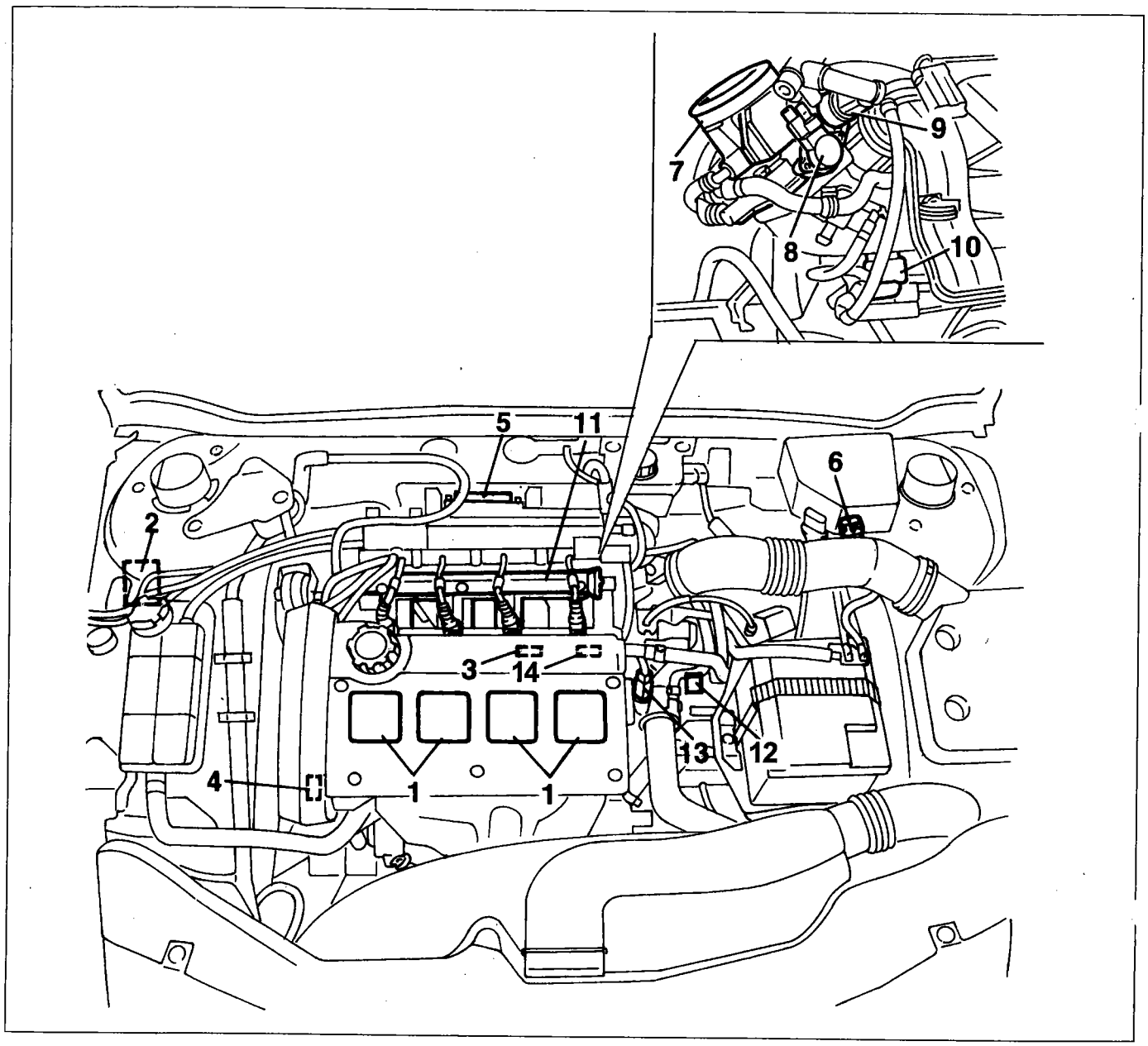
1. Fuel tank
2. Drip tray including: electric fuel pump, pressure regulator, filter, gauge
3. Inertia switch
4. Vehicle speed sensor
5. Speedometer
6. Battery
7. Ignition key
8. I.E. system relays
9. Climate control compressor
10. HITACHI engine management control unit
11. Rev counter
12. Diagnostic equipment connector
13. System failure light
14. Butterfly position sensor
15. Butterfly casing with air flow meter incorporated
16. Engine idle adjustment actuator
17. Filler cap with safety valve
18. Fuel manifold
19. Fuel vapour separator
20. Overturn valve
21. Injector
22. Coil
23. Engine timing sensor
24. Radiator fan
25. Engine rpm sensor
26. Detonation sensor
27. Coolant temperature sensor
28. Charcoal filter solenoid valve
29. Charcoal filter
30. Safety and ventilation valve
31. Lambda probe
32. Catalytic silencer
33. FIAT CODE control unit

DIAGRAM SHOWING INFORMATION ENTERING/LEAVING HITACHI INJECTION/IGNITION SYSTEM CONTROL UNIT AND SENSORS/ACTUATORS



1. HITACHI engine management control unit
2. Battery
3. Ignition switch
4. System relay
5. Electric fuel pump
6. Climate control system
7. Radiator fan relay
8. Radiator fan
9. FIAT-CODE control unit
10. Air flow meter
11. Fuel pump relay
12. Rev counter
13. Lambda probe
14. Diagnostic equipment connector
15. Spark plugs
16. Coils
17. Injectors
18. Charcoal filter solenoid valve
19. Charcoal filter
20. Idle speed adjustment stepping motor
21. Coolant temperature sensor
22. Vehicle speed sensor
23. Speedometer
24. Butterfly position sensor
25. Detonation sensor
26. Engine timing sensor
27. Engine rpm sensor

LOCATION OF HITACHI INJECTION/IGNITION SYSTEM COMPONENTS IN ENGINE COMPARTMENT



P3N04GJ01

1. Ignition coils
2. Charcoal filter
3. Detonation sensor
4. Engine timing sensor
5. Hitachi engine management control unit
6. Diagnostic socket
7. Butterfly casing with air flow meter
8. Butterfly valve position sensor
9. Idle speed adjustment actuator
10. Charcoal filter solenoid valve
11. Fuel manifold with injectors
12. Vehicle speed sensor
13. Coolant temperature sensor
14. Engine rpm sensor

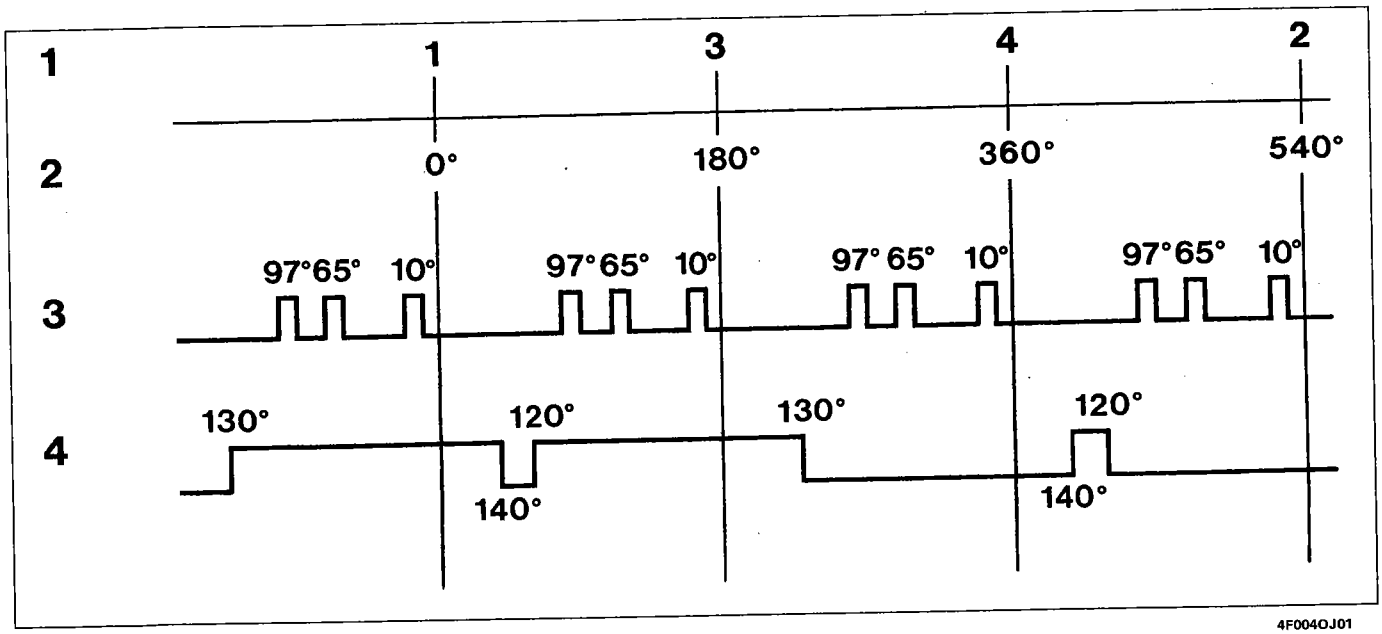
SYSTEM MANAGEMENT STRATEGIES

MANAGEMENT OF THE SIGNALS

During starting, the control unit recognizes the phasing of the injection and the ignition which are vital for the subsequent operation of all strategies.
This recognition is based on interpreting the succession of signals coming from the flywheel sensor, on the crankshaft and the engine timing sensor, on the camshaft.

NOTE *The term "square signals" refers to the collection of signals coming from the sensor on the crankshaft and those from the sensor on the camshaft which, due to the precise reciprocal position, provide the control unti with a synchronized sequence of signals which the control unit is capable of recognizing.*

These signals are composed as follows:
- flywheel on the crankshaft: it has two symmetriacl sets of teeth, arranged respectively at 10°, 65° and 97° in advance of each TDC;
- wheel on the camshaft: it has two long inspection windows and a short one, whose size and position allow the signal to be supplied as illustrated.



4F004OJ01

1. cylinder TDC
2. Crankshaft angles
3. Crankshaft flywheel signal (engine rpm sensor)
4. Camshaft wheel signal (engine timing sensor)

NOTE *The numbers relating to the signals indicate the crankshaft angles in advance of the next TDC.*

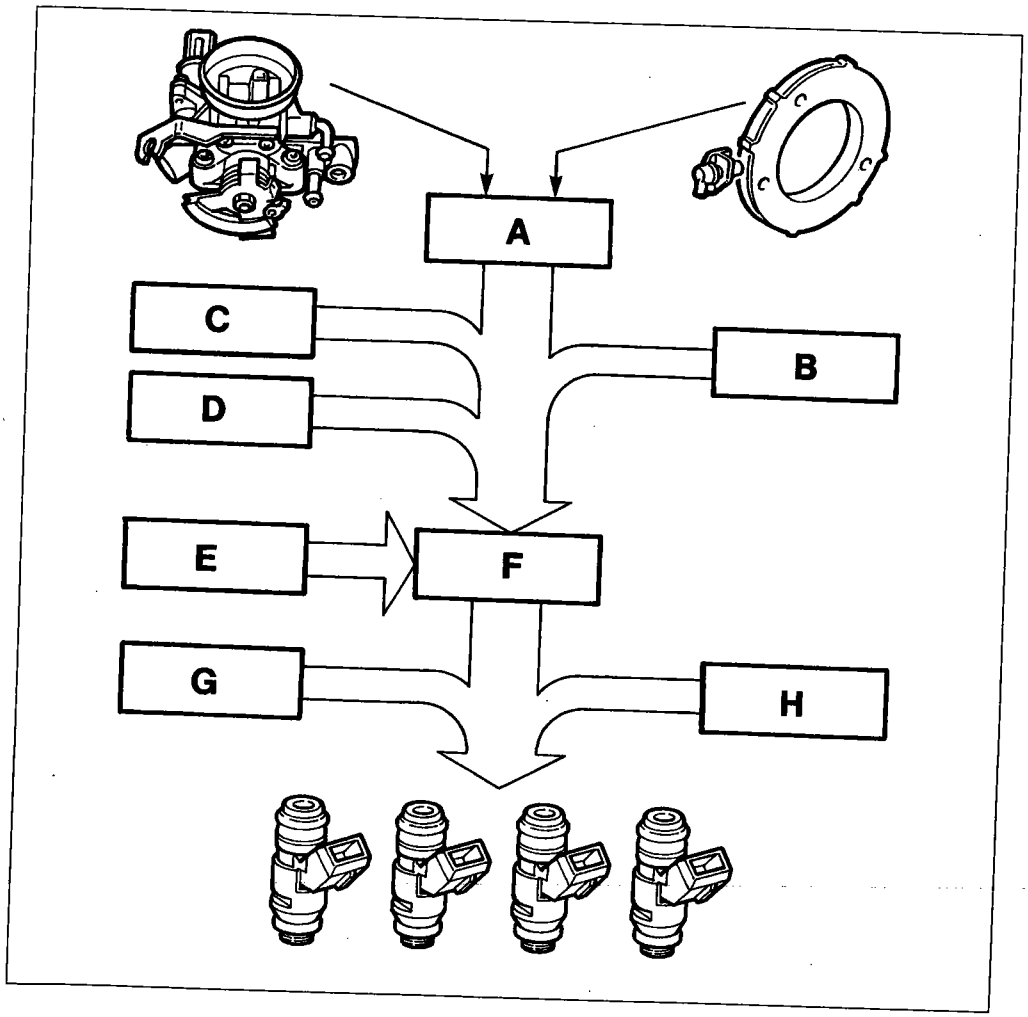
10.

MANAGEMENT OF THE INJECTION

The injection management strategies are designed to provide the engine with the correct amount of fuel at the desired time according to the engine operating conditions.

NOTE *The presence of the flow meter allows the intake air mass to be measured directly making the presence of the intake air temperature sensor superfluous.*

The management of the injection basically consists of calculating the injection time, determining and then implementing the injection timing via the operation of the injector.
The "basic" injection time depends on the specifications of the injector and corresponds to the quantity of fuel to be injected into each cylinder. The latter is, in turn, determined by multiplying the quantity of air drawn in by each cylinder (calculated according to the quantity of intake air and the engine rotation speed) by the desired mixture strength for the engine operating point.
The final injection time is determined by means of a calculation algorhythm in which the "basic" time is corrected by a series of coefficients which take into account the different engine operating conditions which are highlighted by the various sensors in the system.



4F005OJ01

A: "basic" injection time
B: correction coefficients:
- low engine temperature
- high engine temperature
- starting and post-starting
- butterfly fully open
- deceleration
- acceleration

C: feed-back mixture control
D: self-adjustment
E: cut-off
F: intermediate injection time
G: extra-pulse
H: non phased injection management

Control of the mixture strength (feed-back control)

NOTE *The mixture strength is defined by the following ratio and is denoted by the greek letter α (alfa):*

$$\frac{\text{quantity of air drawn in by the engine}}{\text{quantity of fuel injected}}$$

The stoichiometric ratio is defined by the following ratio and is denoted by α st:

$$\frac{\text{theoretical quantity of air required to burn all the fuel njected}}{\text{quantity of fuel injected}}$$

The following ratio defines the mixture strength which is denoted by the greek letter λ (lambda):

$$\frac{\text{quantity of air drawn in by the engine}}{\text{theoretical quantity of air required to burn all the fuel injected}}$$

Consequently $\alpha / \alpha st = \lambda$.
The stoichiometric ratio depends on the type of fuel: for current unleaded petrol this value is around 14.7 - 14.8 which corresponds to a Lambda of 1.
A mixture is spoken of as being *rich* () when the quantity of air is lower than that in the stoichiometric ratio and in this case the Lambda < 1:
a mixture is described as *poor* (*or lean*) when the quantity of air is greater than that in the stoichiometric ratio and in this case the Lambda > 1.

The strategy is designed to correct the "basic" injection times so that the mixture strength continuously fluctuates at high frequency between 0.98 and 1.02.
The fluctuation frequency varies according to the engine load and speed: it is in the order of tens of Hertz.

NOTE *1 Hz = 1 fluctuation per second*

In the following conditions:

- cut-off,
- butterfly opening above 70° and high engine load,
- engine temperature below 25°C,

the strategy is disabled.

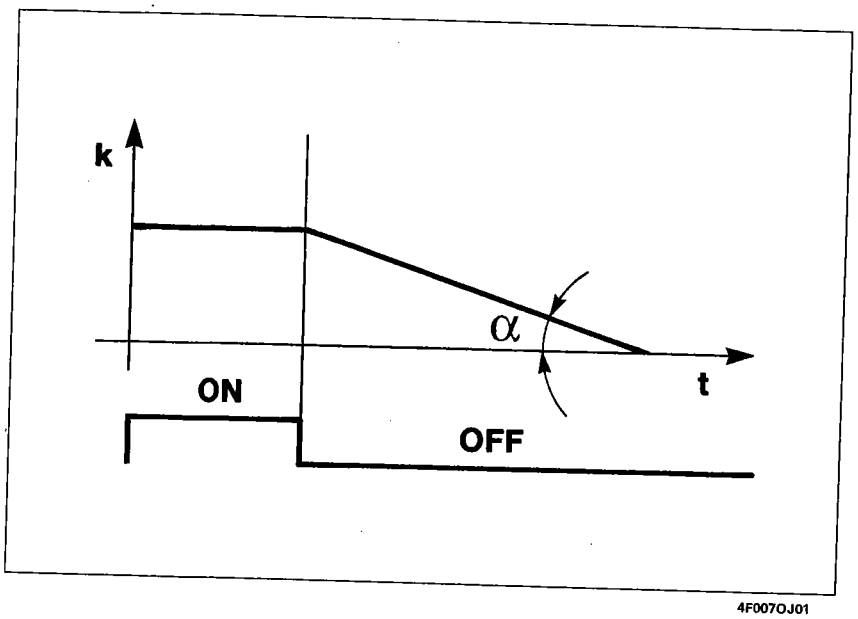
Self-adjustment

The control unit is equipped with a self-adjustment function which has the task of memorizing any possible differences between the basic map and the corrections imposed by the Lambda sensor which may take place during operation. These differences (due to the ageing of the system and engine components) are permanently memorized, allowing the operation of the system to be adapted to the gradual alterations in the engine and the components compared with when they were new.
The strategy is disabled whilst the charcoal filter solenoid valve is open.
If the control unit is replaced, the vehicle must be road tested allowing the engine to reach operating temperature and the control unit self-adjustment function to intervene (especially during idling stops).

10.

Starting and post-starting

During starting, the engine timing cannot be recognized therefore the phased injection cannot be implemented.
Whilst the engine is first running, an initial simultaneous injection is carried out (also because the considerable fluctuations in the rotation speed do not allow the injection timing to be calculated correctly) and later on the injection becomes the phased type.
The "basic" injection time is increased by a multiplication coefficient for the entire time the engine is driven by the starter motor.
Once the engine is started up, the coefficient is gradually reduced until it disappears after a certain length of time, the lower the temperature of the engine, the longer this time.



K: enrichment coefficient
t: time
α: engine temperature function decrease
ON: engine driven (crank)
OFF: engine started (run)

Operation when cold

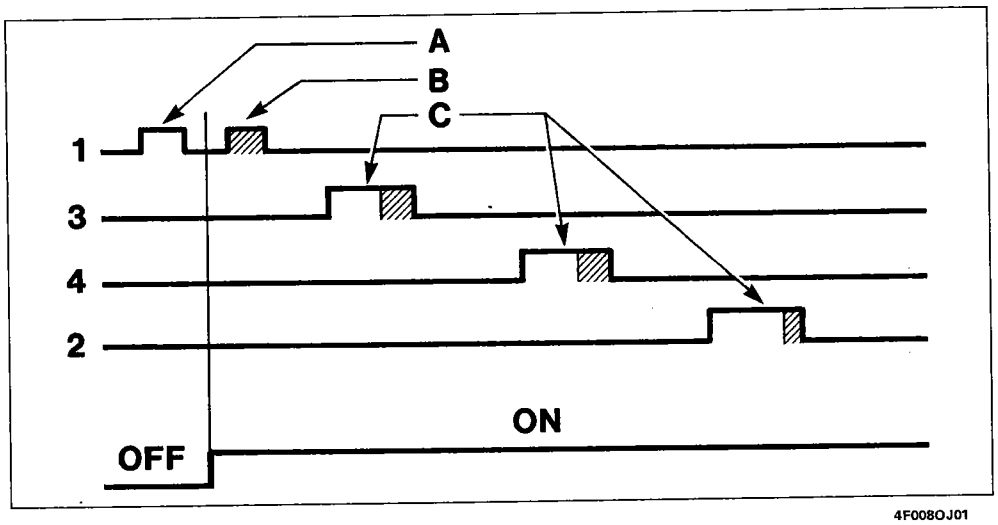
Under these circumstances the mixture is naturally weakened as a result of the reduced evaporation and strong condensation of the fuel on the inner walls of the intake manifold: in addition, the increased viscosity of the lubricant oil causes an increase in the passive resistance of the engine.
The "basic" injection time is corrected by a multiplication coefficient which depends on the temperature and speed of the engine.

Operation in full load conditions

The strategy is enabled when the butterfly opening exceeds 70°.
The "basic" injection time is multiplied by a coefficient (function of the engine speed) equal to about 1.1.

Operation in acceleration conditions

During this stage, the control unit increases the quantity of fuel supplied.
The "basic" injection time is multiplied by a coefficient which depends on the temperature of the engine and the opening speed of the accelerator butterfly (average vaule 1.2).
If the sharp variation in the injection time is calculated when the injector is already closed, the control unit reopens the injector (extra pulse) to compensate the mixture strength as quickly as possible: the subsequent injection are, however, already increased according to the previously mentioned coefficients.



A: normal injection time
B: extra-pulse
C: injection time including enrichment
OFF: engine at stationary speed
ON: engine in transition

Operation in deceleration conditions

During this stage a negative transition strategy is implemented to decrease the quantity of fuel supplied: the "basic" injection time is multiplied by a coefficient which depends on the temperature of the engine and the engine speed and load conditions in the moment immediately preceding the start of the deceleration.

Operation in cut-off conditions

The cut-off strategy is implemented when the control unit recognizes that the butterfly is in the idle position (signal from the butterfly potentiometer) and the engine speed is above 1600 rpm (with the engine warm).
The supply to the engine is re-enabled when the butterfly is recognized not to be in the closed position or when the engine speed goes below 1200 rpm (with the engine warm).

Rotation speed limiter

This strategy limits the maximum speed which can be reached by the engine, gradually enabling the cut-off, as illustrated in the table.
Maximum speed: 7150 rpm

mode \ Cylinders	1	2	3	4
1 cylinder	O			
2 cylinders	O			O
3 cylinders	O		O	O
4 cylinders	O	O	O	o

Fuel pump operation

The fuel pump is operated by the engine management control unit via a relay.
The pump cuts out:
- if the engine speed goes below 50 rpm;
- after a certain length of time (about 5 seconds) if the ignition is switched ON and the engine is not started up (timed go ahead);
- if the inertia switch has been operated.

Operation of the injectors

The operation of the injectors is the phased, sequential type. However, during starting the injectors are operated once initially in parallel.
The phasing of the injector operation varies according to the engine speed.

MANAGEMENT OF THE FIAT·CODE ANTI-THEFT FUNCTION

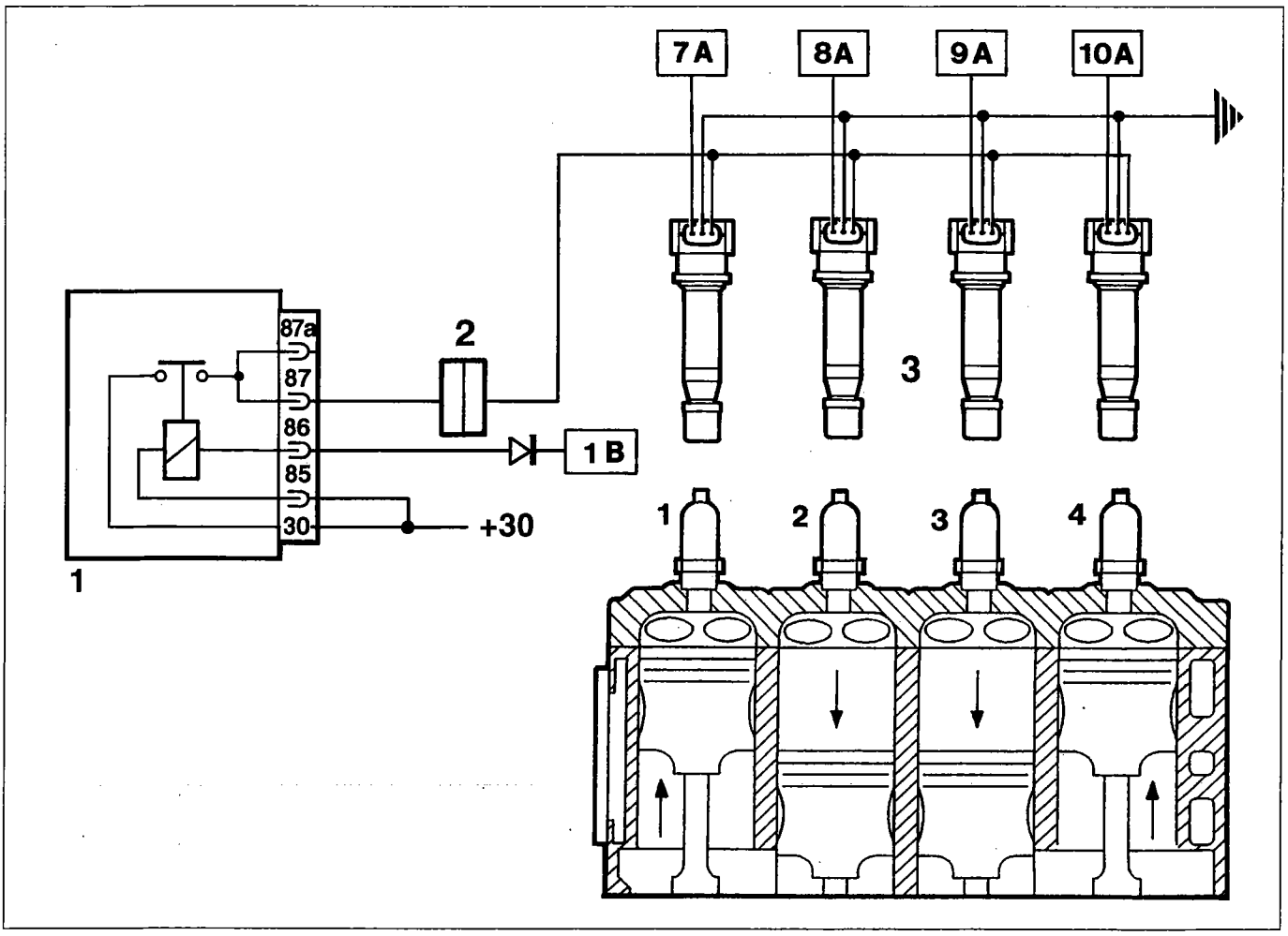
The system is equipped with an anti-theft function. This function is achieved thanks to the presence of a specific (FIAT CODE) control unit capable of dialogue with the engine management control unit and an electronic key with a special transmitter for sending a recognition code.
Each time the key is switched OFF, the FIAT CODE system completely deactivates the engine management control unit.
When the key is turned to the ON position, the following operations take place, in order:
1. the engine management control unit (whose memory contains a secret code) sends the FIAT CODE control unit a request to send the secret code for deactivating the immobilizer function;
2. the FIAT CODE control unit responds by only sending the secret code after having, in turn, received the recognition code transmitted by the ignition key;
3. the recognition of the secret code allows the deactivation of the immobilizer function for the engine management control unit and normal operation can be resumed.

NOTE *The presence of the FIAT CODE anti-theft system means that it is not advisable to use another engine management control unit during fault diagnosis. In such a case, the FIAT CODE control unit would transfer the (unrecognized) code to the test control unit which could then no longer be used on any other vehicle.*

MANAGMENT OF THE IGNITION

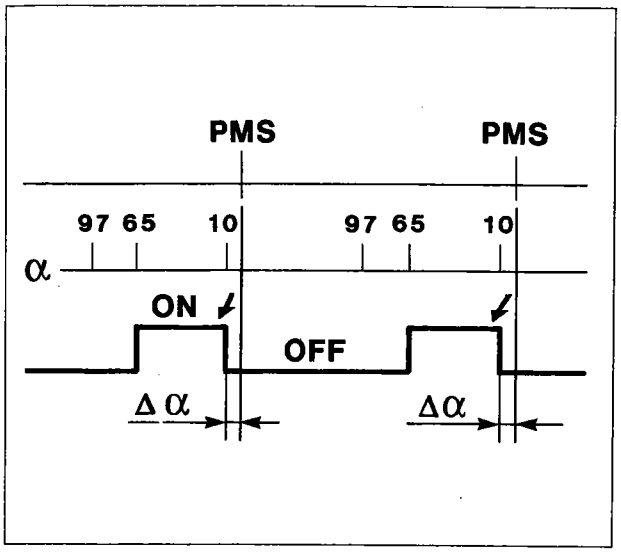
The ignition management strategies are designed to strike the spark with the desired advance according to the engine operating conditions.

The management of the ignition basically consists of determining the ignition advance and implementing it through the operation of the power transistor incorporated in each coil.
The "basic" advance value, calculated according to the intake air flow rate and the engine speed, is then corrected on the basis of the different engine operating conditions.
The control unit determines the moment of the start of the conduction of the current in the coil primary winding according to the engine rotation speed.
The angle of this moment obviously varies, in relation to TDC for the explosion stroke of each cylinder and, the greater the engine rotation speed, the greater the advance, because the (dwell) time required to saturate the current in the coil primary winding is more or less constant.
The moment of the start of conduction is corrected according to the battery voltage.



4F010OJ01

1. System relay
2. Interface connector
3. Single ignition coil (pencil-coil)



4F011OJ01

α: crankshaft flywheel signals
Δα: fixed ignition advance (10° engine)
ON: coil conduction activated
OFF: coil conduction deactivated

Starting

During starting, the normal management of the advance cannot be carried out because the considerable fluctuations in the rotation speed do not allow the dwell and the advance to be calculated correctly.
The advance is therefore managed taking the following references:
- for the start of conduction, the tooth at 65°;
- for the ignition advance, the tooth at 10°.

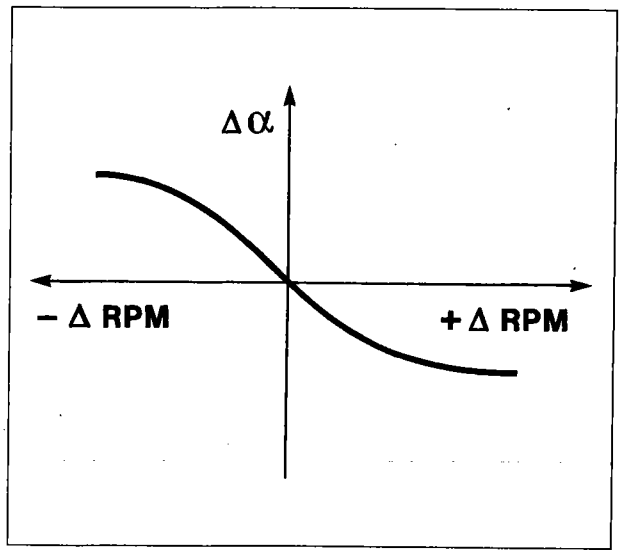
There is a fixed advance of 10° for the entire time the engine is driven by the starter motor.

Operation when cold

Whilst the engine is running when cold, an additional advance correction is implemented: the increase in the advance in relation to the value in the map is inversely proporational to the temperature of the engine.

Operation in cut-off conditions

The ignition advance is increased on entry into cut-off: from the moment the supply of fuel is restored, the advance is gradually returned to the "basic" value.



4F011OJ02

Δα: correction of idle ignition advance
+Δ RPM: the idle speed is higher than the nominal speed
-Δ RPM: the idle speed is below the nominal speed

Operation with engine idling

When the engine is idling, the management of the advance is implemented independently of the "basic" advance.
The idle advance value, which varies according to the temperature of the coolant (10° with the engine warm) is corrected according to the variation in the speed in relation to a pre-set speed, also dependent on the temperature.
The advance is increased if the speed decreases and is reduced if the speed decreases in order to guarantee the stability of the actual speed.

Control of detonation

This strategy has the task of detecting the presence of detonation by processing the signal coming from the appropriate sensor. The strategy continuously compares the signal coming from the sensor with a level which is, in turn, constantly updated to take into account background noise and the ageing of the engine.
If the system recognizes the presence of detonation, the strategy reduces the ignition advance, in steps of 2° up to a maximum of 7°, until the phenomenon disappears. Later, the advance is gradually restored to the basic value or until the onset of the phenomenon again. The advance increases are implemented gradually, whilst the reductions are implemented immediately.
In acceleration conditions, the strategy uses a higher threshold to take into account the increased noise of the engine under these circumstances.
The strategy is also equipped with a self-adjustment function which temporarily memorizes the reductions in the advance which are continuously repeated in order to adapt the advance to the different conditions in which the engine finds itselllf (for example, the use of a low octane rating fuel). The strategy is capable of restoring the advance to the map vaule if the conditions which caused the reduction no longer exist.

10.

MANAGEMENT OF THE ENGINE IDLE

The general aim of this strategy is to keep the engine speed around the value memorized (engine warm: 850 rpm): the position assumed by the actuator depends on the speed of the engine and the speed of the vehicle.

Starting stage

When the key is inserted, the position assumed by the actuator depends on the temperature of the engine and the voltage of the battery (open-loop position).

Engine started with accelerator pedal released

The engine speed varies according to the temperature of the engine and is constantly kept close to this value by altering the position of the shutter in order to compensate for any fluctuations in the speed.
This especially takes place when external loads are switched on (power assisted steering, heated rear windscreen, etc.).
If the air conditioning and the fans are switched on, both managed by the control unit, the strategy manages the actuator in advance of the switching on.

Normal driving

In these conditions the actuator is in the open-loop position.

In deceleration conditions

In deceleration conditions outside of idling, the control unit controls the position of the actuator by means of a special flow rate curve (dash-pot curve), in other words it slows down the return of the shutter to its housing, reducing the braking effect of the engine.

MANAGEMENT OF THE CHARCOAL FILTER

This strategy controls the position of the charcoal filter solenoid valve as follows:
- during starting, the solenoid valve remains closed, preventing the fuel vapours from enriching the mixture; this condition persists until the engine coolant reaches 25°C;
- with the engine at operating temperature, the control unit operates the solenoid valve in duty-cycle in order to control the quantity of fuel vapours sent to the intake, according to the engine speed and load conditions.

In the following operating conditions:
- butterfly in closed position,
- engine speed below 1250 rpm,
- engine load below a pre-set level

the operation of the solenoid valve is disabled, keeping it in the closed position.

MANAGEMENT OF THE CLIMATE CONTROL SYSTEM

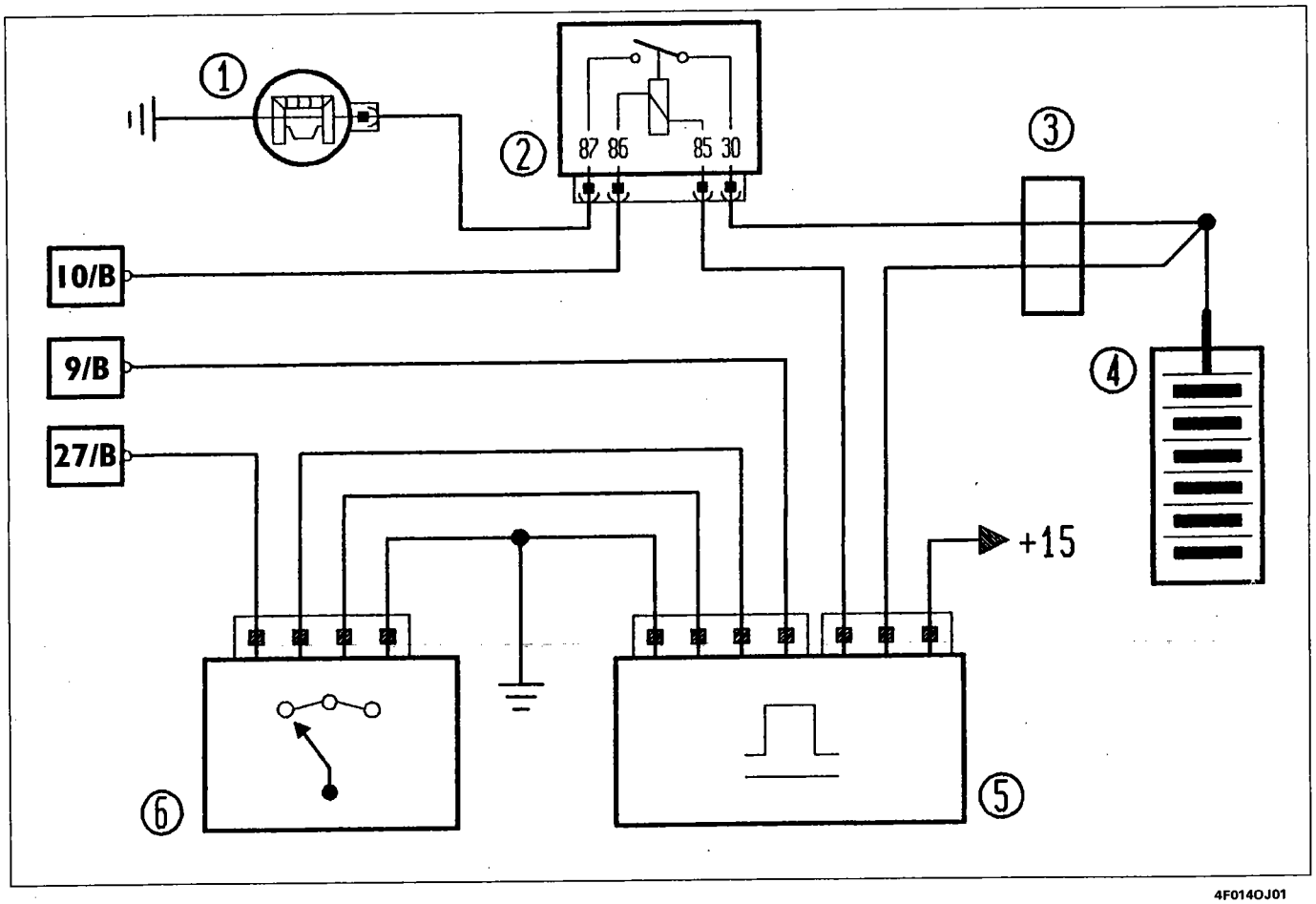
The Hitachi engine management control unit is functionally connected to the climate control system in as far as:

1. it receives the request to switch on the compressor via pin 9/B and operates the interventions (additional air);
2. it gives the go ahead to switch on the compressor via pin 10/B when the strategy conditions are verified;
3. it receives information concerning the state of the three stage pressure switch from pin 27/B and operates the interventions (radiator fan operation).

As far as point 1 is concerned, if the engine is idling, the control unit increases the air flow rate passing from the idle actuator in advance of the compressor being switched on and, conversely, it returns the actuator to its normal position after the compressor is switched off.
As far, on the other hand, as point 2 is concerned, the control unit automatically switches off the compressor:

- for 6 secs (timed disengagement):
  - in butterfly opening conditions above 70°,
  - during vehicle take-off;

- as long as the critical conditions persist:
  - at engine coolant temperatures above 114°C,
  - at engine speeds below 750 rpm.



4F014OJ01

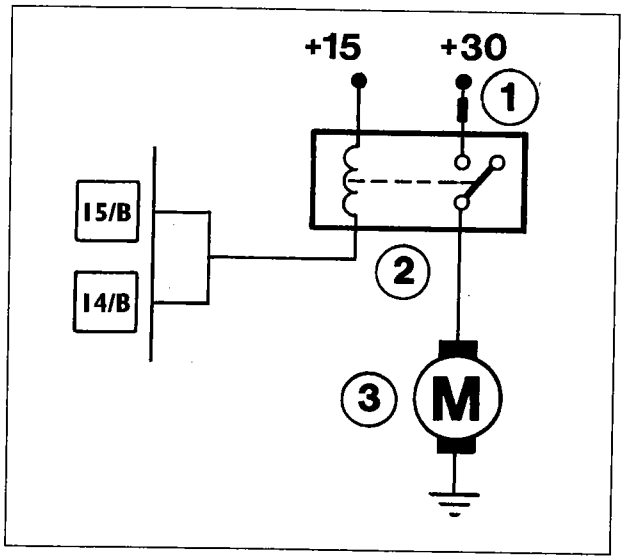
1. Compressor
2. Compressor relay feed
3. Fuse box
4. Battery
5. Climate control unit
6. Three stage pressure switch

10.

MANAGEMENT OF THE RADIATOR FANS

The control unit directly controls the operation of the radiator fans according to the temperature of the engine coolant and whether or not there is a climate control system.

NOTE *Since the temperature of the engine is detected by the appropriate sensor, there is no longer a thermal contact on the radiator.*

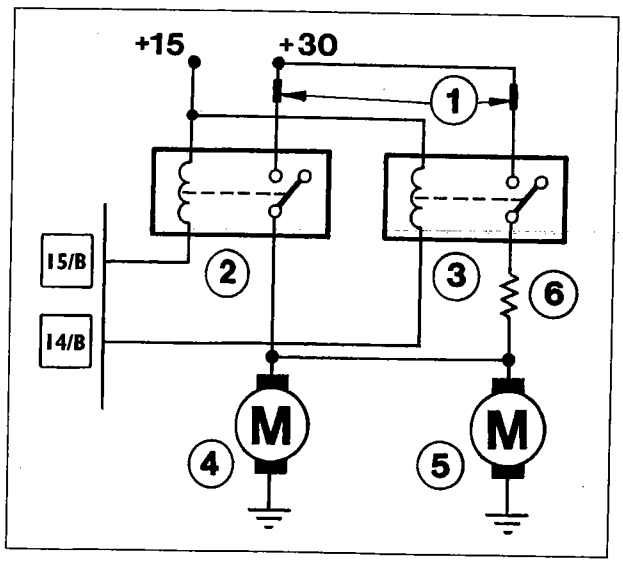


4F015OJ01

Version without climate control

There is a single fan which comes on when the temperature of the coolant exceeds 95°C.
The fan is switched off with a hysteresis of 2°C at the temperature level.

1. Fuse
2. Fan relay
3. Fan



4F015OJ02

Version with climate control

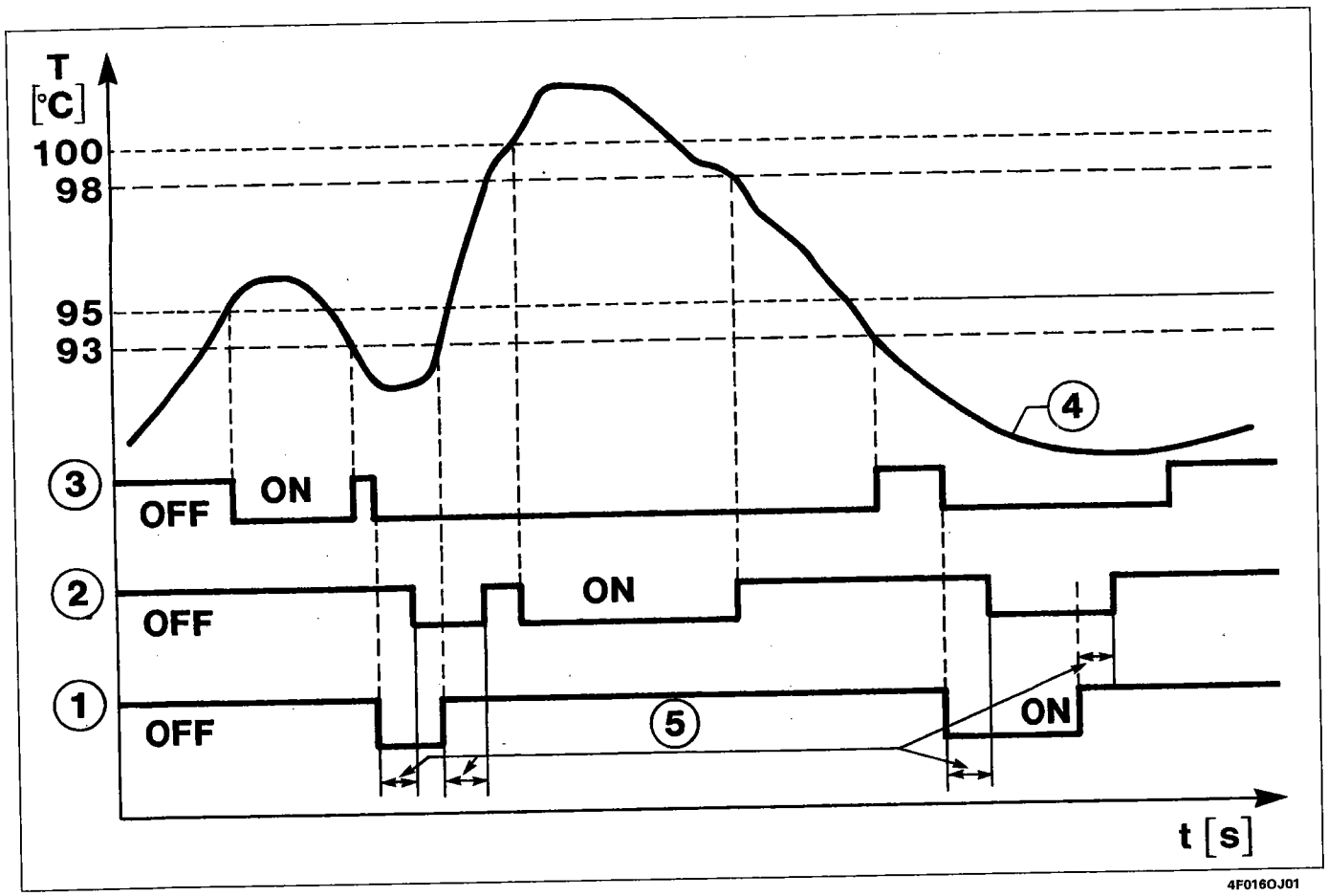
There are two fans: one low speed one and one high speed one.

NOTE *If this high speed fan comes on then the low speed fan comes on at the same time.*

1. Fuse
2. High speed fan relay
3. Low speed fan relay
4. High speed fan
5. Low speed fan
6. Load resistance

Diagram showing engagement of fans for version with air conditioning

Low speed fan: it comes on when the temperature of the coolant reaches 95°C.
High speed fan: it comes on when the temperature of the coolant reaches 100°C: the first fan is only switched off after the second one.
The engagement of the fans also depends on the state of the climate control system three stage pressure switch which determines the switching on of the first fan and then, with a certain delay, that of the second and the subsequent switching off.



1. Condition of three stage pressure switch
2. Condition of high speed fan
3. Condition of low speed fan
4. Engine coolant temperature progress
5. Three stage pressure switch engagement/disenagement delay

ON: fan/pressure switch activated
OFF: fan/pressure switch deactivated

10.
DIAGNOSTICS

The system has an autodiagnostic function which is designed to check for any irregularities in the following components:

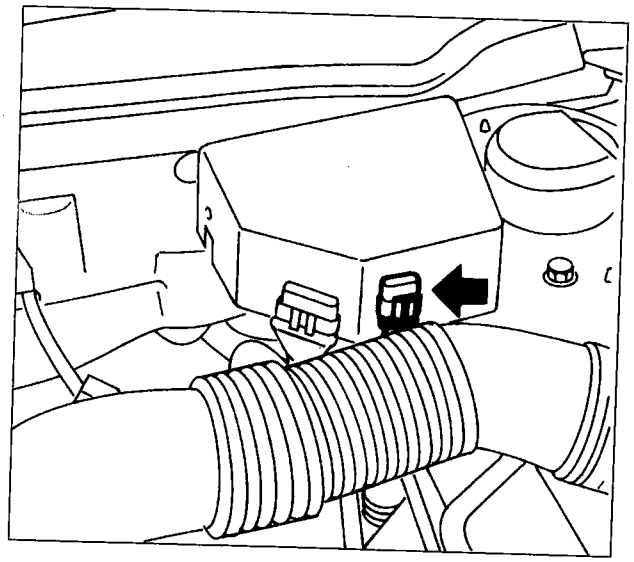
Actuators

injectors
coils
charcoal filter solenoid valve
engine idle adjustment
stepping motor
fuel pump relay
climate control compressor relay

Sensors

engine rpm sensor
engine timing sensor
air flow meter
Lambda sensor
coolant temperature sensor
detonation sensor
butterfly position sensor
vehicle speed sensor

Location of diagnostic connector


P3N18GJ01

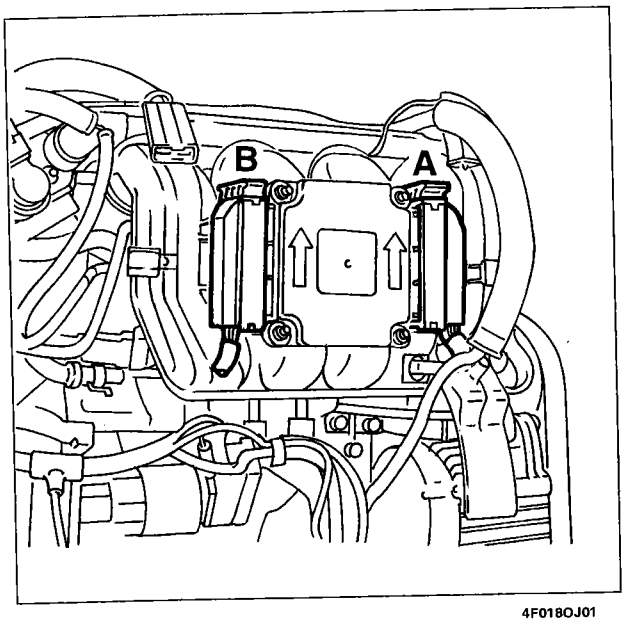
The detection of a fault, if confirmed, means that it is permanently memorized in addition to the relevant sensor being excluded from the system until it is repaired.
The detection of a confirmed fault usually involves, the warning light in the dashboard coming on; the light goes out when the fault conditions no longer exist.

NOTE *During starting, the light is:*
- *on for 1 second*
- *off for 0.1 seconds*
- *on for 0.5 seconds*
- *kept on/off definitively according to whether or not there are "permanent" errors present.*

Working with the diagnostic equipment it is possible to carry out a complete fault diagnosis of the system, which consists of three stages:
display of a series of functional parameters (with the engine switched off or running);
display of the errors and their cancellation;
activation of some actuators (active diagnosis).

Recovery strategy

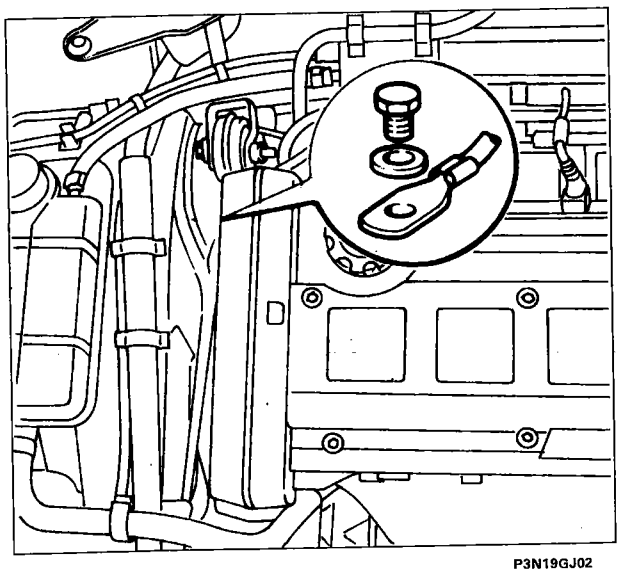
If a failure is detected in the sensors/actuators, the control unit, where possible, replaces the missing data, reconstructing it using software (recovery) to allow the operation of the engine.



4F018OJ01

engine side wiring (A)

butterfly position sensor
coolant temperature sensor
air flow meter
engine rpm sensor
engine timing sensor
vehicle speed sensor
detonation sensor
injectors
coils
idle speed stepping motor
charcoal filter solenoid valve



P3N19GJ02

ELECTRICAL/ELECTRONIC CIRCUIT

Wiring

The system has two distinct sets of wiring. The engine side wiring (A) connects the components fitted on the engine to the engine management control unit and the vehicle side wiring (B) which conects the other components to the control unit and acts an an interface with the vehicle wiring.

NOTE *The two connectors are the same, therefore if the control unit is dismantled the fitting position (arrow) must be followed to prevent them from being mixed up.*

vehicle side wiring (B)

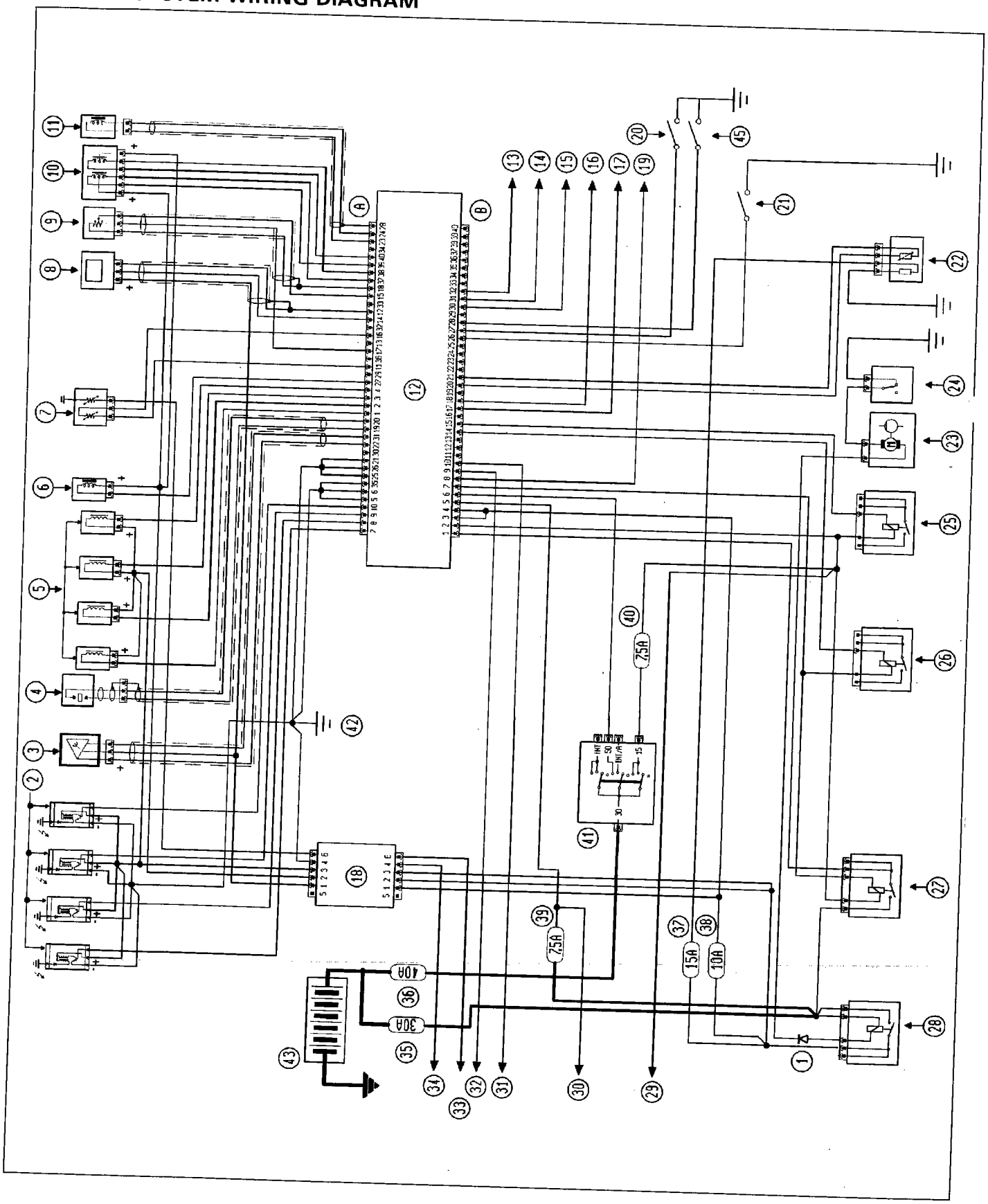
electric fuel pump
twin relay
radiator fan relay
climate control compressor relay (if fitted)
fuses
Lambda sensor
diagnostic equipment
FIAT CODE control unti
instrument panel connection
supply from battery
supply from ignition switch

Location of system earth points

In order to increase electro-magnetic compatibility and operational reliability, special care has been taken over the number and the location of the earth points, as illustrated below:
main earth directly on the battery negative;
engine control system earth on the timing side power unit mounting.

10.

HITACHI SYSTEM WIRING DIAGRAM



3N21GJ01

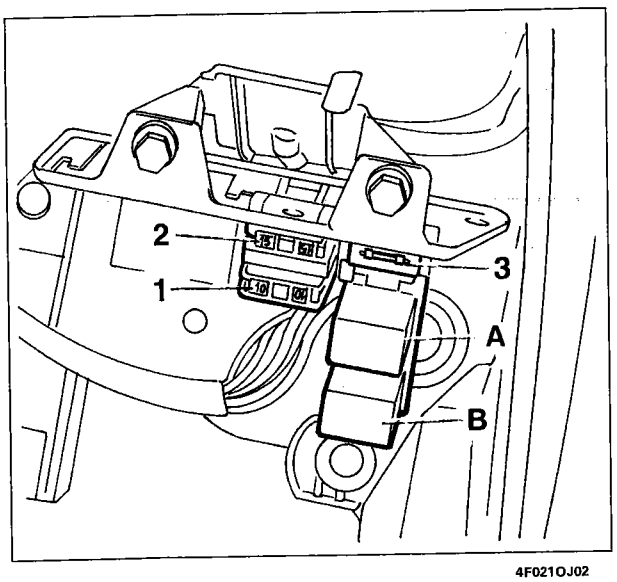
Hitachi system wiring diagram key

1. Anti-inversion diode
2. Single coils
3. Engine timing sensor
4. Detonation sensor
5. Injectors
6. Charcoal filter solenoid valve
7. Engine coolant temperature sensor
8. Air flow meter
9. Butterfly position sensor
10. Idle speed adjustment actuator
11. Engine rpm sensor
12. Engine management control unit
13. Line K
14. Memory reprogramming
15. FIAT CODE control unit connection
16. Vehicle speed intake
17. Rev counter operation
18. Interface connector
19. System failure light control
20. Intake from climate control three stage thermosta (if fitted)
21. Trim level selection (only connected to earth for versions without climae control)
22. Lambda probe
23. Electric fuel pump
24. Inertia switch
25. High speed fan relay feed (if fitted)
26. Low speed fan relay feed
27. Fuel pump relay
28. I.E. relay
29. Supply (+15) for FIAT CODE
30. Supply (+30) for FIAT CODE
31. Climate control compressor relay feed (if fitted)
32. Climate control compressor engagement intake (if fitted)
33. Engine coolant temperature gauge signal
34. Engine earth for FIAT CODE
35. Fuse A (30 A)
36. Fuse B (50 A)
37. Fuse C (15 A)
38. Fuse D (10 A)
39. Fuse E (7.5 A)
40. Fuse F (7.5 A)
41. Ignition switch
42. Engine earth
43. Battery
44. Intake from climate control 4 stage thermostat (if fitted)

SYSTEM RELAYS

With the ignition key in the ON position (+15), the energizing coils for both relays are supplied and the power contacts are closed.
The relay (A) supplies the fuel pump, receiving voltage directly from the battery.
The relay (B) ensures the multiple supply of the control unit and the various system sensors and actuators both directly and through the connector blocks.

NOTE *The arrangement of the relays (A) and (B) and the fuses (1) and (2) can vary according to production requirements. The recognition depends on the electrical connections.*



4F021OJ02

A. Fuel pump relay

B. System relay

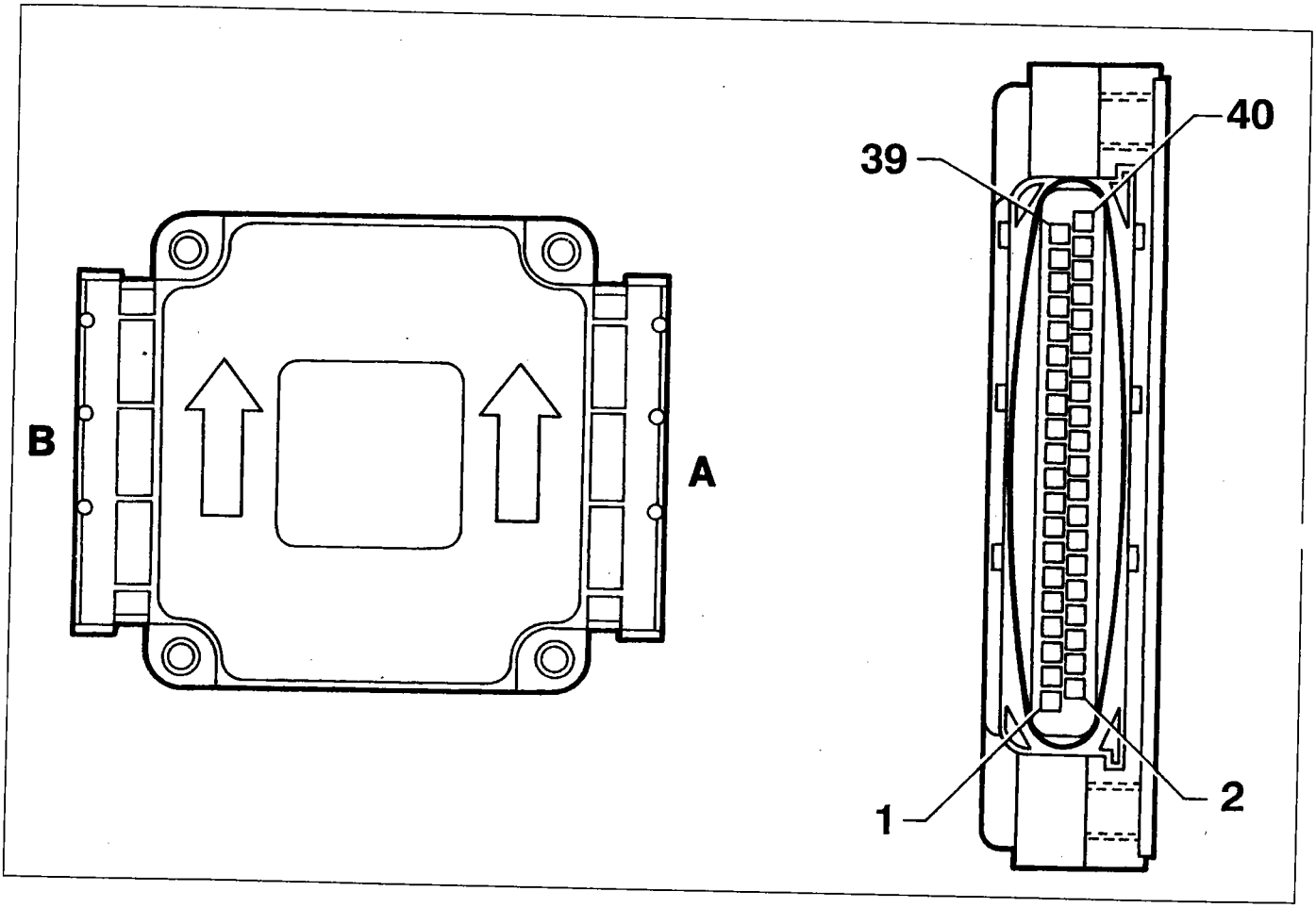
1. 10A fuse

2. 15A fuse

3. Anti-inversion diode

10.

HITACHI SYSTEM CONTROL UNIT PIN-OUT

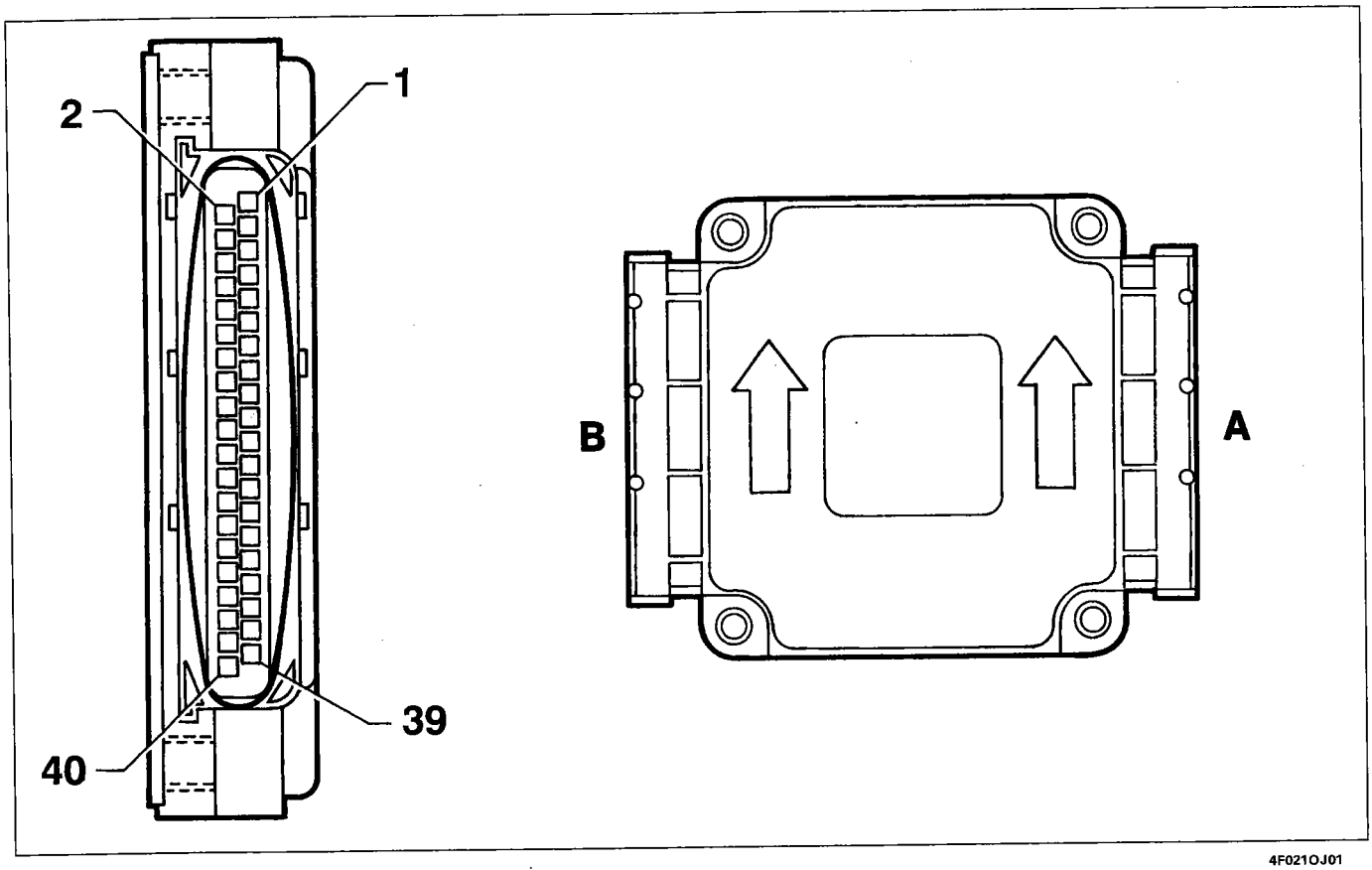


4F020OJ01

Connector A

1. Operation of injector for cylinder 1
2. Operation of injector for cylinder 2
3. Operation of injector for cylinder 3
4. Operation of injector for cylinder 4
5. Ignition earth
6. Power module (1)
7. Operation of coil for cylinder 1
8. Operation of coil for cylinder 2
9. Operation of coil for cylinder 3
10. Operation of coil for cylinder 4
11. Engine coolant temperature earth
12. Air flow meter earth
13. N.C.
14. Air flow meter signal
15. Butterfly position sensor signal
16. Coolant temperature sensor signal
17. Butterfly position sensor supply
18. Butterfly position signal earth
19. Detonation sensor signal
20. Detonation sensor earth
21. Container earth
22. Engine timing sensor signal
23. Engine rpm sensor positive
24. Engine rpm sensor negative
25. A/D converter earth
26. Coil earth
27. Charcoal filter solenoid valve operation
28. Engine rpm sensor screening
29. N.C.
30. N.C.
31. Engine timing sensor earth
32. N.C.
33. N.C.
34. N.C.
35. Power earth (2)
36. N.C.
37. Phase 1 idle speed actuator operation
38. Phase 2 idle speed actuator operation
39. Phase 3 idle speed actuator operation
40. Phase 4 idle speed actuator operation

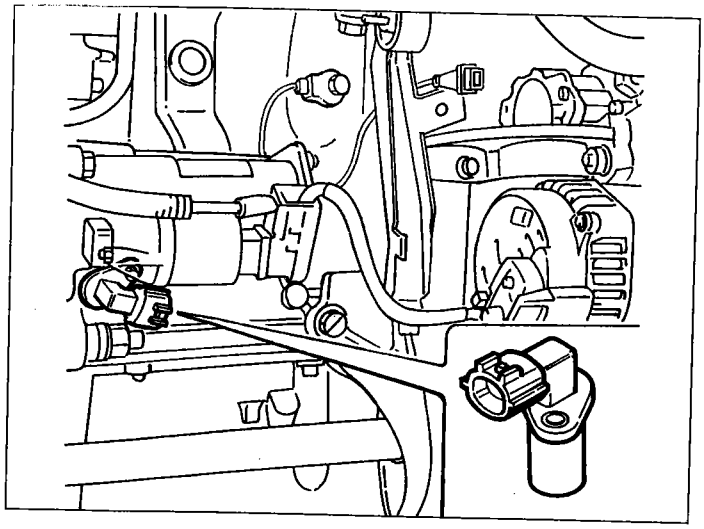
HITACHI SYSTEM CONTROL UNIT PIN-OUT



4F021OJ01

Connector B

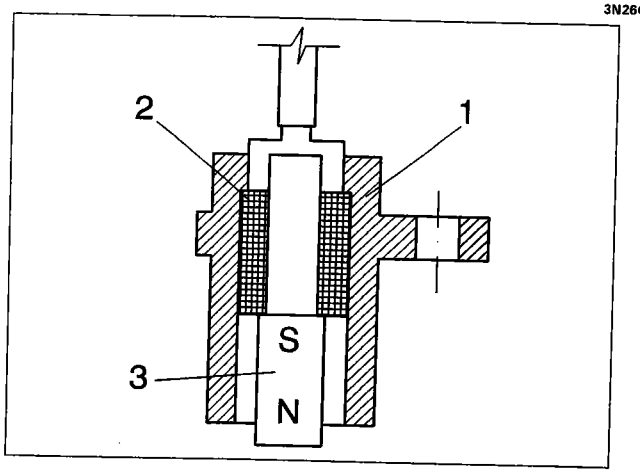
1. System relay operation
2. Control unit supply (+15)
3. Power supply 1
4. Power supply 2
5. Control unt supply (+30)
6. Engine started signal from ignitino key +50
7. Fuel pump relay operation
8. System failure light operation
9. Air conditioning compressor engagement signal (if fitted)
10. Air conditioning compressor relay operation (if fitted)
11. N.C.
12. N.C.
13. N.C.
14. Low speed fan relay operation
15. High speed fan relay operation
16. N.C.
17. Rev counter operation
18. Vehicle speed sensor signal
19. N.C
20. Lambda probe signal
21. Lambda sensor negative
22. N.C.
23. N.C.
24. N.C.
25. N.C.
26. Trim level selection (to earth only for versions without climate control)
27. Three stage thermostat signal (only for versions with climate control)
28. N.C.
29. N.C.
30. Connection with FIAT CODE
31. Reprogramming
32. Line K
33. N.C.
34. N.C.
35. N.C.
36. N.C.
37. N.C.
38. N.C.
39. N.C.
40. N.C.



3N26GJ01

ENGINE RPM SENSOR

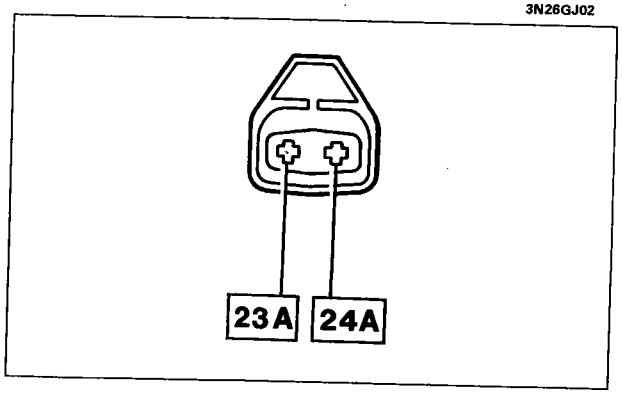
This sensor is fixed to the cylinder block/crankcase: the flywheel is in one piece with the crankshaft crank.



3N26GJ02

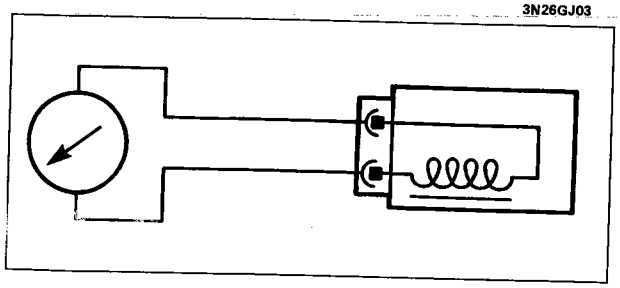
Operating principle

The sensor consists of a tubular casing (1) which contains a permanent magnet (3) and an electrical winding (2):
As a result of the flywheel teething passing, the magnetic flow produced by the magnet (3) undergoes the fluctuations produced by the variation in the gap.
These fluctuations produce an electro-motive force in the winding (2) where there is an alternately positive voltage (tooth facing the sensor) and negative voltage (gap facing the sensor: see paragraph on "signal management"). The peak sensor output voltage value, all things being equal, depends on the distance between the sensor and the tooth (gap).



3N26GJ03

Wiring connector

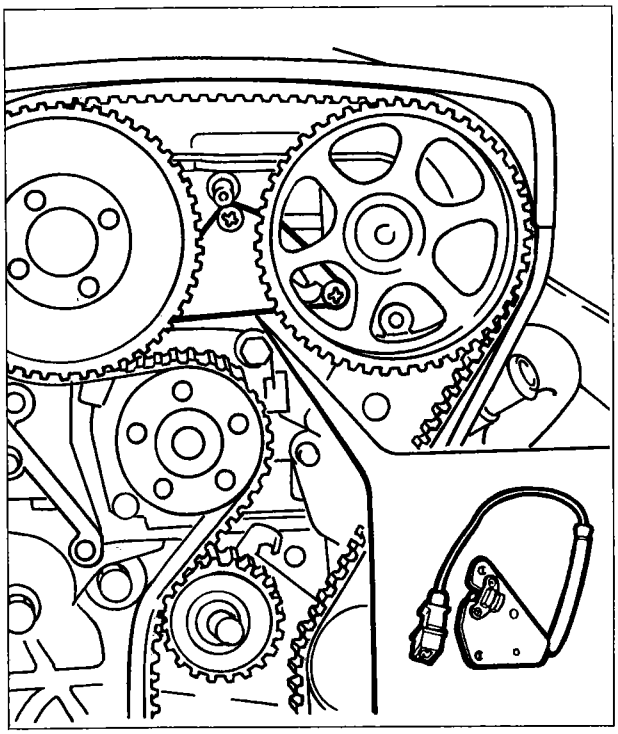


3N26GJ04

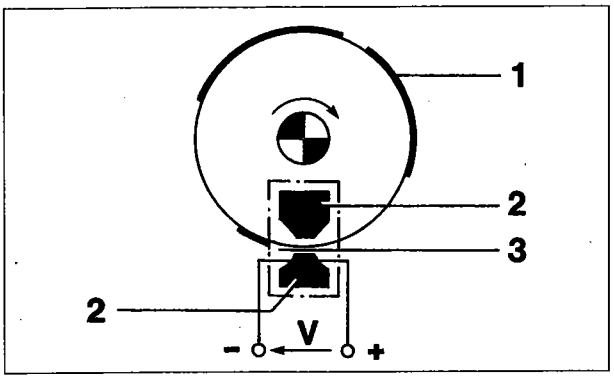
The sensor resistance can be measured by disconnecting the connector and connecting an ohmmeter to the sensor terminals

Resistance: 570±57 ohm at 20°C

ENGINE TIMING SENSOR



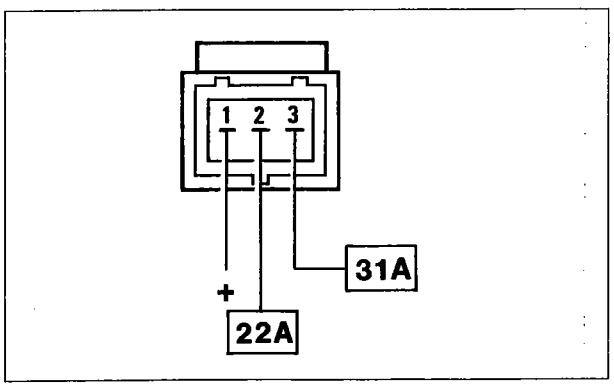
3N27GJ01



3N27GJ02

1. Deflector
2. Mangetic material
3. Gap

Wiring connector



3N27GJ03

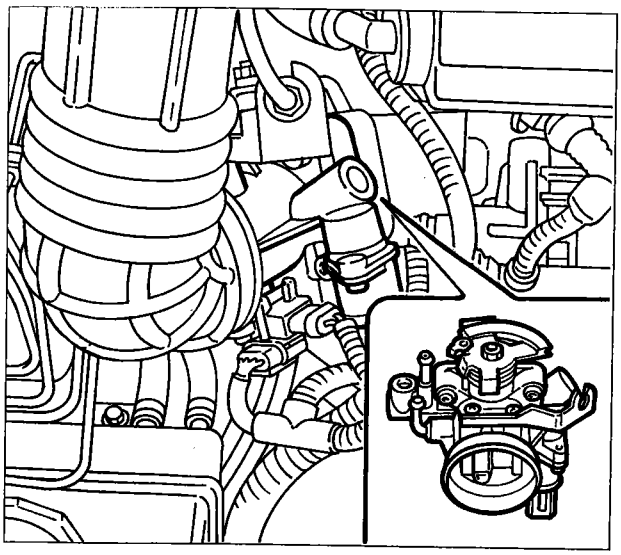
The engine timing signal, in conjunction with the engine rpm and TDC signal, allows the control unit to recognize the succession of cylinders to implement the phased injection.
This signal is produced by a Hall effect sensor, fitted by the exhaust camshaft drive pulley.

NOTE *It is not possible to carry out any adjustments to the angular position of the sensor.*

Operating principle

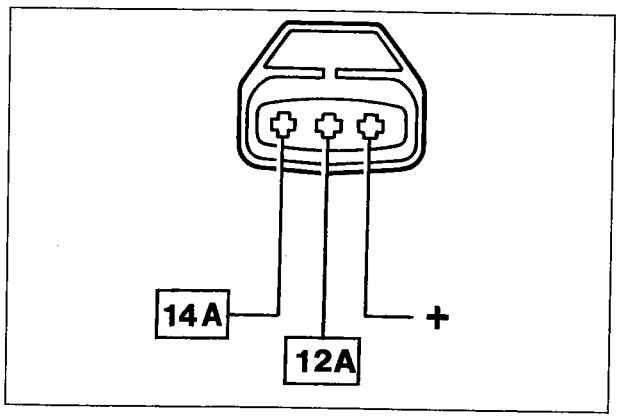
A semi-conductor layer, through which the current passes, immersed in a normal magnetic field (lines of force perpendicular to the direction of the current) produces a difference in power, known as Hall voltage.
If the intensity of the current remains constant, then the voltage produced only depends on the intensity of the magnetic field. It is therefore simply necessary to alter the intensity of the field perodically in order to produce a modulated electrical signal.
In practice, to achieve this change, the sensor passes through a metal ring (fixed to the inner part of the timing pulley) which has a series of openings: as it moves, when the ring covers the sensor it blocks the magnetic field and the signal remains low, whilst corresponding to the openings, the field is enclosed and the signal becomes high
The alternating of the signals therefore depends on the succession of the openings (see chapter on "signal management").

10.



3N28GJ01

Wiring connector

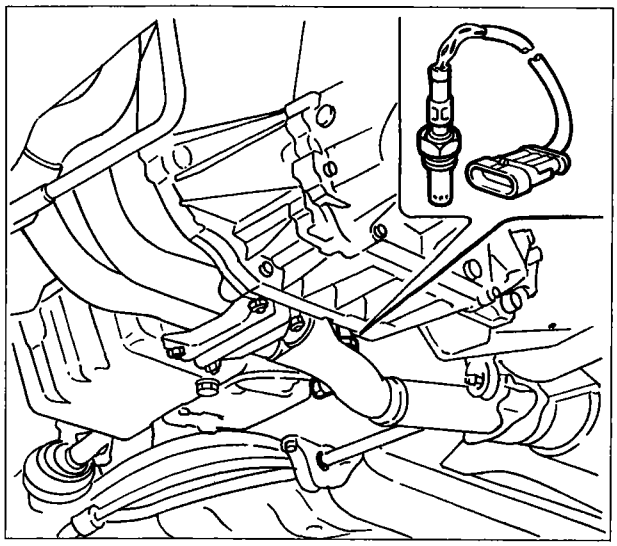


3N28GJ02

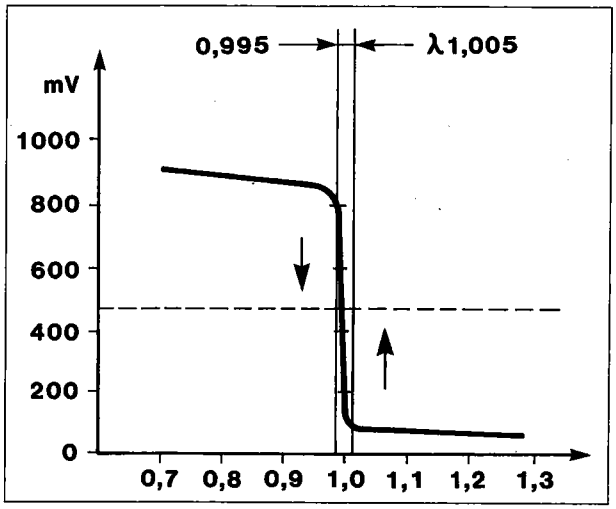
AIR FLOW METER

The air flow meter is the hot wire type and is incorporated in the butterfly casing.
The upper part contains a duct parallel to the main flow in which the heated filament is located.
Part of the flow of intake air is introduced into the duct and, after having passed through it, it comes out of the opposite side, rejoining the main flow.
As a result, only part of the mass of air which passes through the flow meter is measured: this quantity is, however, proportional to the overall mass passing through the flow meter.
The flow meter electrical output voltage is therefore representative of the total flow rate.
This type of flow meter has two advantages compared with the full flow type:

- considerable insensitivity to the pulsing effect of the columns of air, present especially at lwo speeds and heavy loads;
- less fouling of the filament, thanks to the reduced mass of air coming into contact with it; as a result the control unit has no wire cleaning strategy (burn-in).



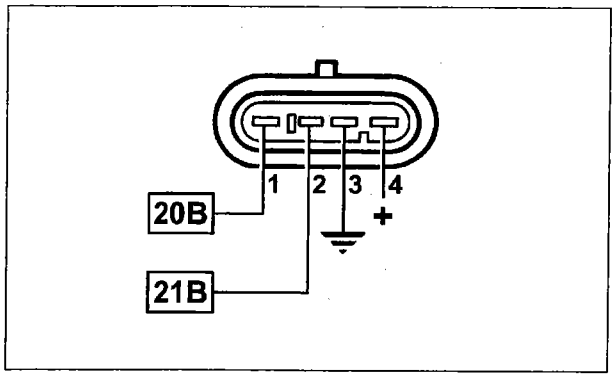
3N29GJ01



3N29GJ02

λ = 1 Ideal mixture (stoichiometric)
λ > 1 Lean mixture
Excess air, the CO values tend to be low
λ < 1 Rich mixture
Lack of air; the CO values tend to be high

Wiring connector



3N29GJ04

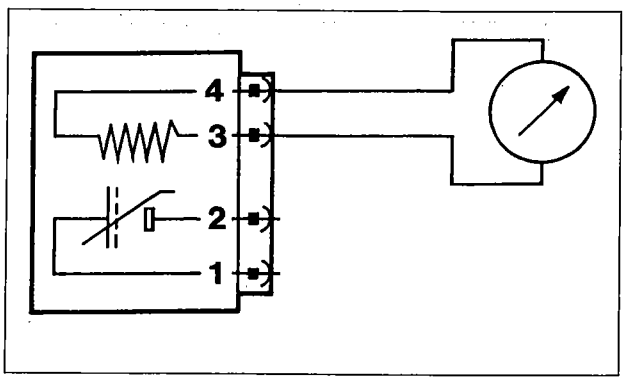
LAMBDA SENSOR

The Lambda sensor measures the oxygen content in the exhaust gases: it is fitted on the exhaust pipe, upstream of the catalytic silencer.
The sensor output signal is sent to the control unit for feed-back correction of the mixture strength.
When the sensor provides a low signal (voltage below 200 mV) the control unit recognizes a poor mixture and increases the injection time; later on, when the sensor signal is high (voltage above 800 mV), the control unit recognizes a rich mixture and decreases the injection time.
This sequence is repeated at a frequency in the order of tens of Hertz so that the engine runs with a mixture strength continuously fluctuating around the stoichiometric level.
At temperatures below 300°C the ceramic material is not activated, therefore the sensor does not send reliable signals: to make sure that it heats up quickly during starting and the temperature is maintained whilst idling, the sensor is fitted with a heater with an electrical resistance which is always on.

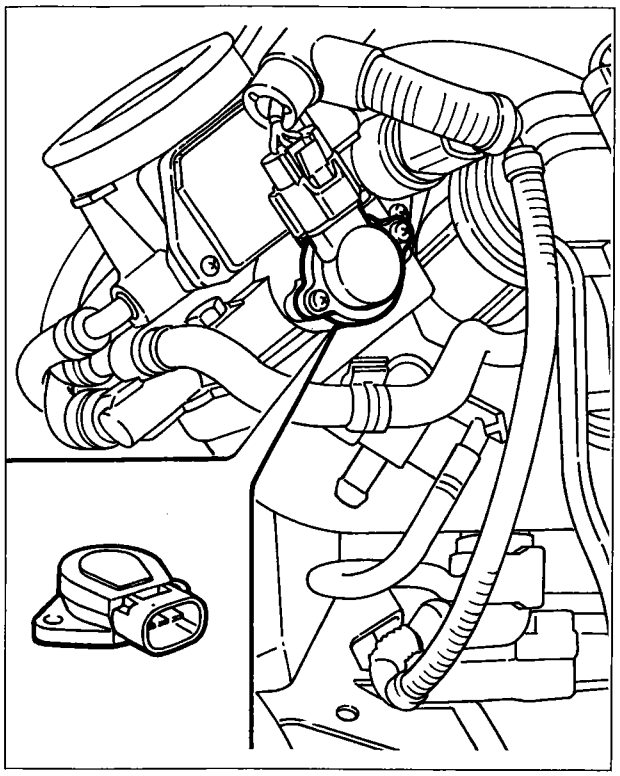
The sensor can be rapidly put out of action by the presence of even slight amounts of lead in the fuel.

The sensor heating resistance can be measured by disconnecting the connector and connector an ohmmeter as illustrated in the diagram.

Resistance: 4.5 ± 0.5 ohm at 20°C



3N29GJ03

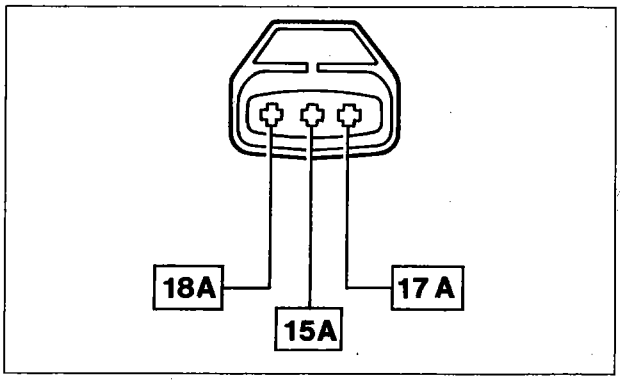


3N30GJ01

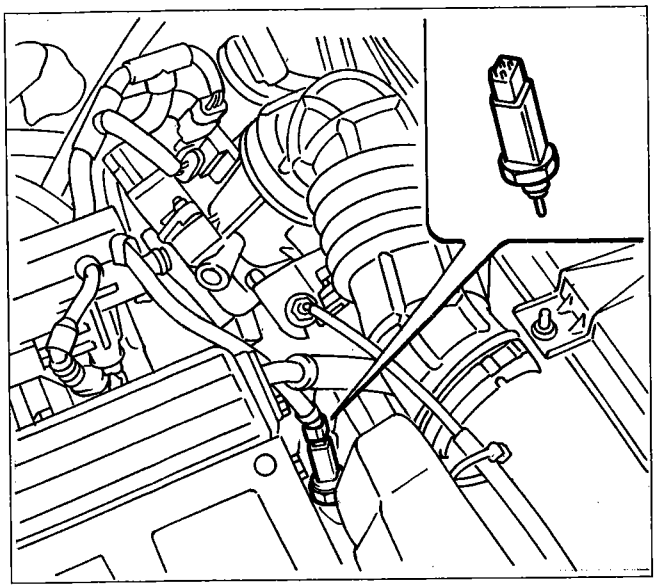
BUTTERFLY POSITION SENSOR

This consists of a single track potentiometer where the moving part is rotated by the accelerator butterfly shaft.

Wiring connector



3N30GJ02



3N32GJ01

ENGINE COOLANT TEMPERATURE SENSOR

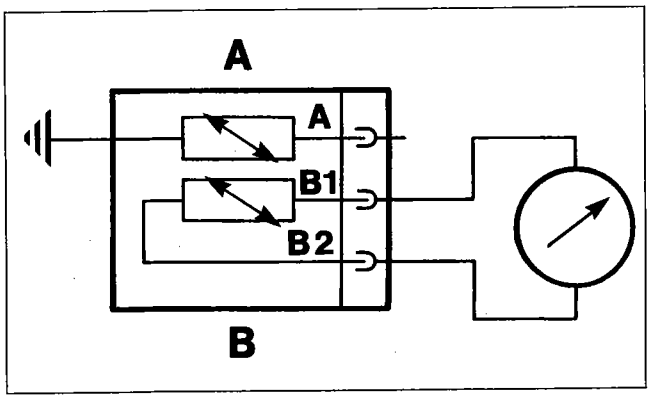
This sensor is fitted on the thermostat.
It consists of a brass casing which affords protection for the resistive elements, comprising two NTC type thermistors (Negative Temperature Coefficient, where the electrical resistance decreases as the temperature increases).
The two thermistors are distinctive and provide information for the instrument panel (A) and the engine management control unit (B), respectively.
The reference voltage for the latter is 5 Volt: since the control unit input circuit is designed as a voltage divider, the reference voltage is shared between a resistance in the control unit and the actual sensor.
As a result, the control unit is capable of evaluating the variations in the sensor resistance through the changes in the voltage, thereby obtaining information concerning the temperature.

INJECTION NTC

°C	Ω	°C	Ω
-20	15971	40	1152
-10	9620	50	807
0	5975	60	576
10	3816	70	418
20	2502	80	309
25	2044	90	231
30	1679	100	176

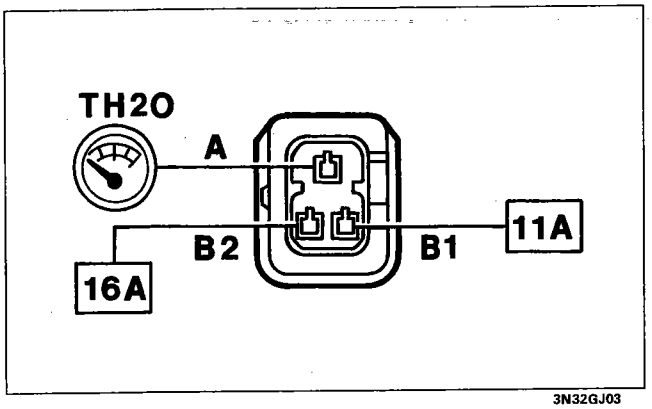
INSTRUMENT NTC

°C	Ω
60	512-602
90	184-208
120	76-88



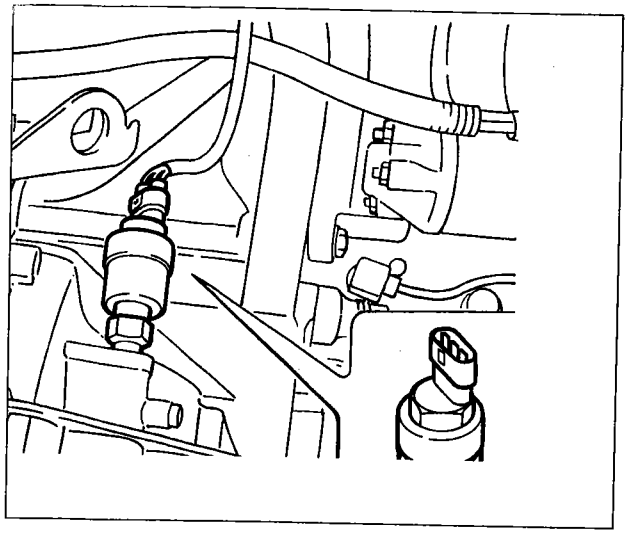
3N32GJ02

The table illustrates the sensor progress, which can be measured by disconnecting the connector and connecting an ohmmeter as shown in the diagram.



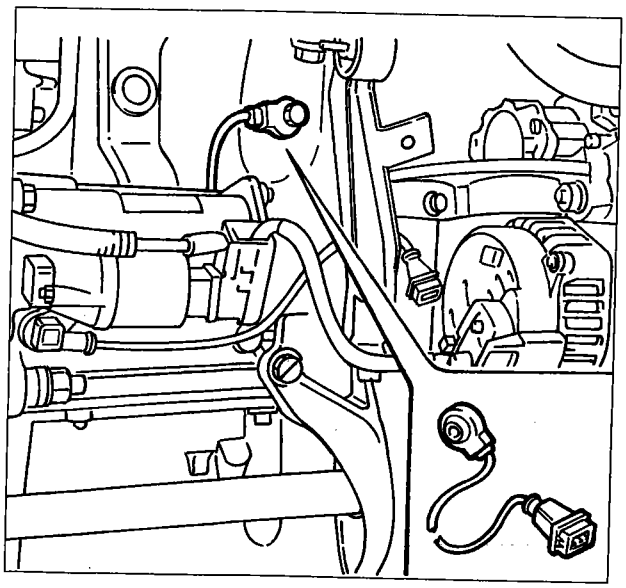
3N32GJ03

Wiring connector



3N33GJ05

Wiring connector

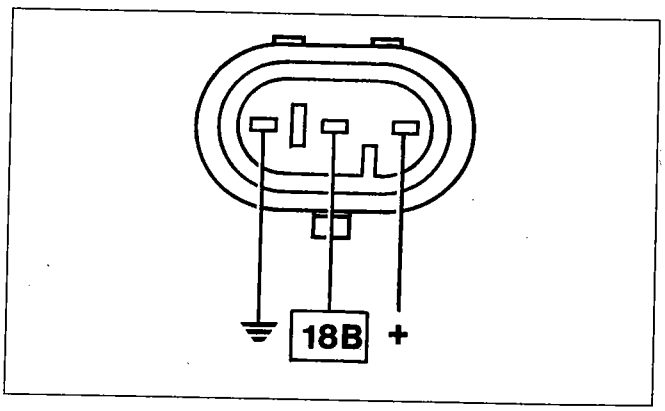


3N33GJ04

Wiring connector

VEHICLE SPEED SENSOR

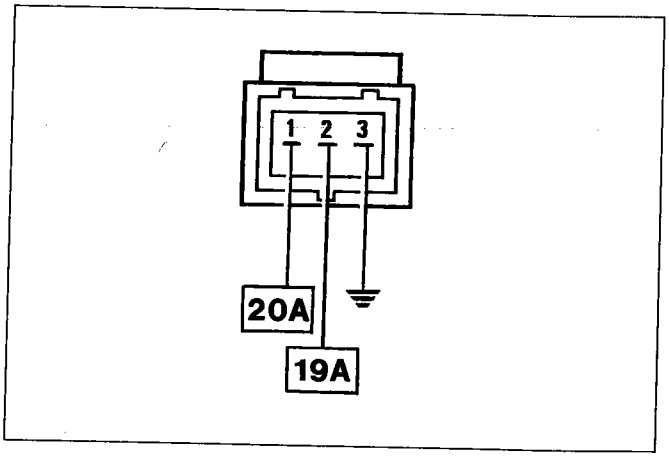
This sensor is positioned at the differential output, by the left driveshaft coupling and it transmits information to the control unit concerning the vehicle speed: the signal is also used for the operation of the speedometer.
The sensor is the Hall effect type (see paragraph on "engine timing sensor") and is calibrated so that each impulse corresponds to a distance of one metre: it is therefore possible to ascertain the speed of the vehicle from the frequency of the impulses.



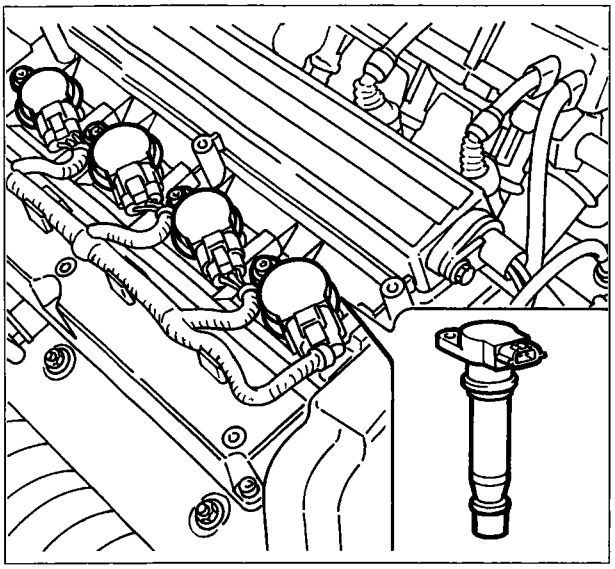
3N33GJ01

DETONATION SENSOR

This is a piezoelectric type sensor fitted on the cylinder block/crankcase in a symmetrical position in relation to the pairs of cylinders 1-2 and 3-4.
This position is determined by the need to detect the onset of detonation in the same way for all cylinders.
When the engine is knocking, crankcase vibrations of a particular frequency are produced which are transformed by the sensor into a voltage signal proportional to their intensity.



3N33GJ02

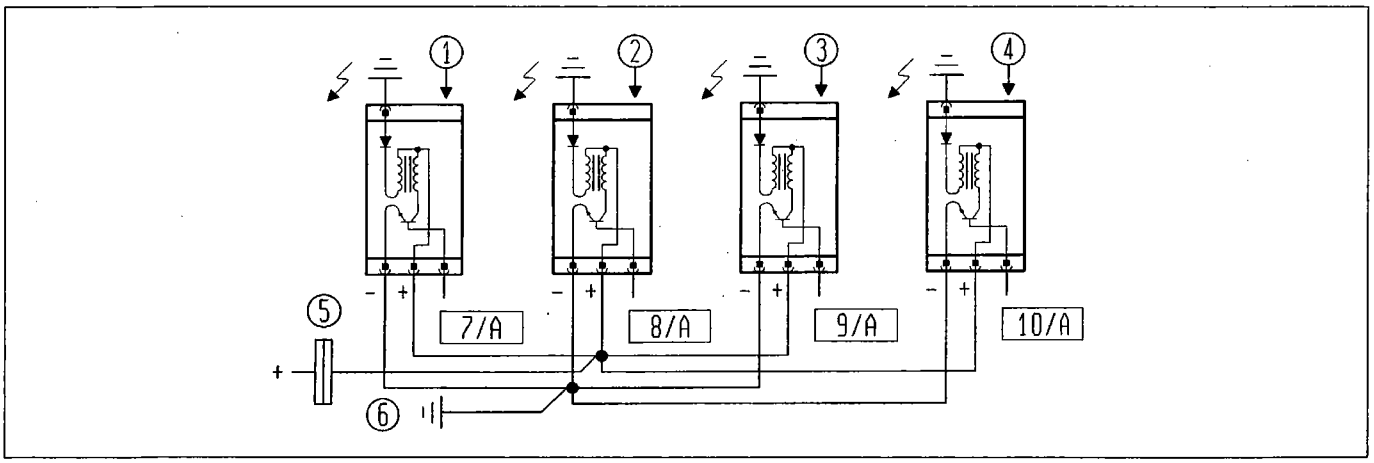


3N34GJ01

IGNITION COIL

The ignition circuit is the inductive discharge, static advance type where the high voltage is supplied by four coils fitted directly on the spark plugs (pencil-coils).
The coil used is the closed magnetic circuit type, with the windings in a plastic container immersed in epoxide resin. The coil is connected directly to the spark plug by means of a silicon extension which has good dielectric properties.
The coil incorporates a power transistor for interrupting the primary winding.
The primary winding of each coil is supplied by the battery voltage (+30) by means of the twin relay and is connected to earth via the built in power transistor whose base is connected to the control unit pin.

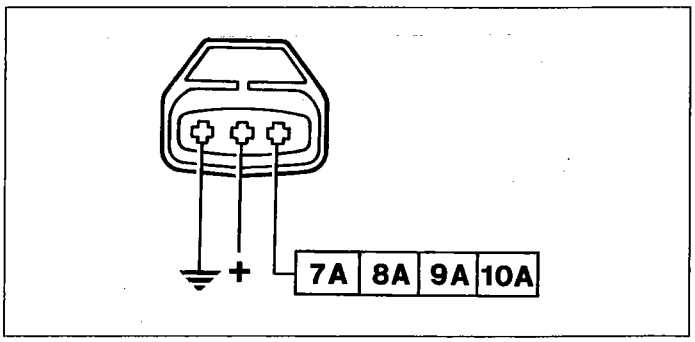
Interrupting the current to the base of the transistor interrupts the connection to earth of the primary winding and, as a result, causes the high tension discharge at the secondary winding.
The optimum ignition advance is calculated by the control unit according to the engine speed and load conditions and is implemented in the form of time between the TDC for the explosion stroke and the moment the supply in the coil primary winding is interrupted.



3N34GJ02

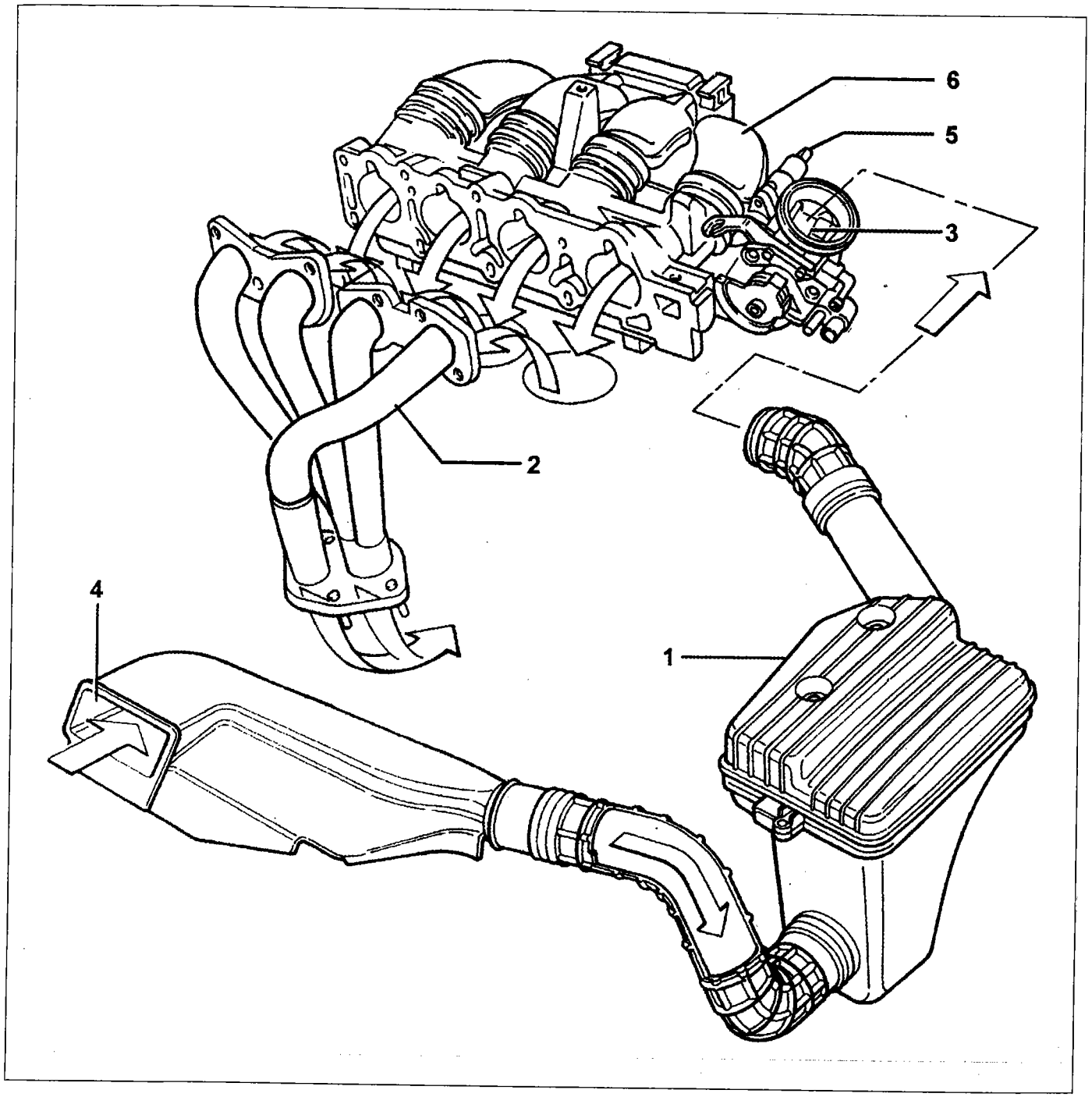
1. Cylinder 1 ignition coil
2. Cylinder 2 ignition coil
3. Cylinder 3 ignition coil
4. Cylinder 4 ignition coil
5. Interface connector
6. Engine earth

Wiring connector



3N34GJ03

DIAGRAM SHOWING AIR INTAKE CIRCUIT



4F032OJ01

1. Air filter
2. Exhaust manifold
3. Butterfly casing with air flow meter
4. Intake vent
5. Engine speed adjustment actuator
6. Intake manifold

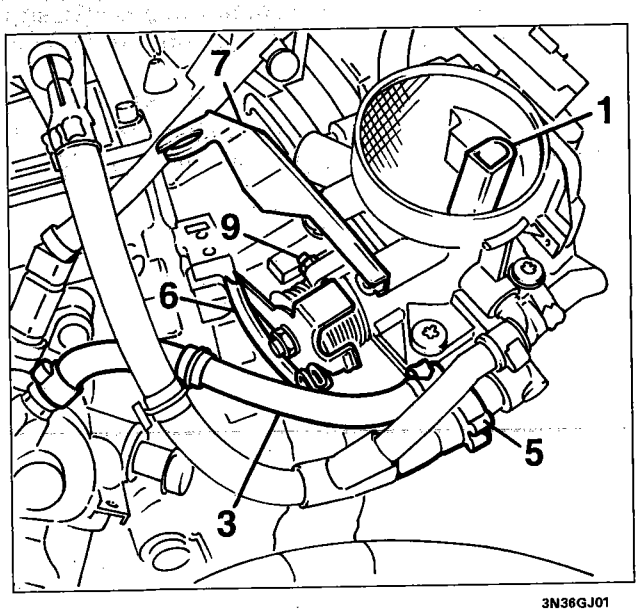
INTAKE CIRCUIT

The intake circuit consists of the following components:
- air filter and hoses;
- acoustic resonators fitted in parallel to the intake hose (two upstream and two downstream of the filter);
- intake manifold on which the fuel manifold, complete with injectors, the engine management control unit and the charcoal filter solenoid valve are fitted
- butterfly casing, incorporated with the air flow meter, on which the butterfly position sensor, the oil vapour recirculation circuit PCV valve and the engine idle speed adjustment actuator are fitted.

BUTTERFLY CASING

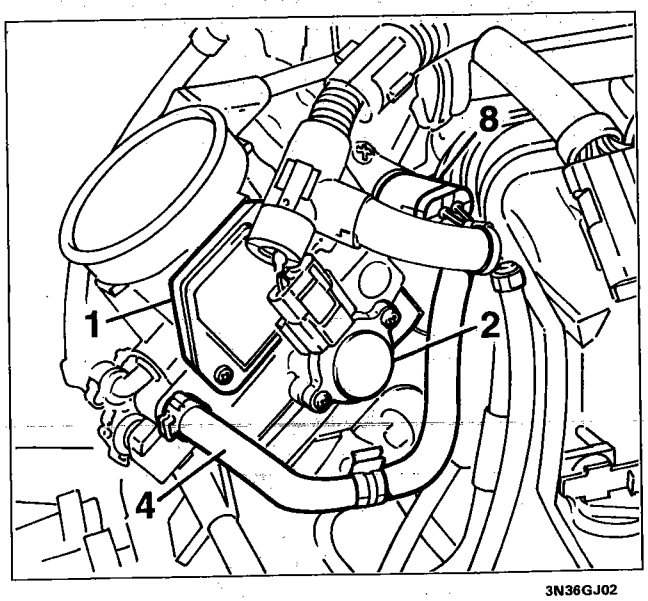
The butterfly casing has the task of metering the quantity of air drawn in by the engine (and consequently the power developed) according to the request from the driver via the accelerator and it is incorporated with the air flow meter.
The butterfly casing is fixed to the intake manifold by four bolts: the butterfly is opened by means of linkage with small butterfly opening angles corresponding to the pedal slightly pressed and large angles corresponding to when it is very depressed.
With the pedal completely released (engine decelerating or idling), the additional air required is supplied by the engine idle adjustment actuator: under these circumstances, the butterfly opening lever is in the end of travel position against an anti-tamper screw which prevents the butterfly from getting stuck in the closed position.
To prevent ice forming near the butterfly and the port connected to the PCV valve, the butterfly casing is heated by a small amount of coolant, coming from the engine thermostat, circulating in a chamber inside the actual casing.
The oil vapour recirculation system PCV valve and the butterfly position sensor are also fitted on the butterfly casing.

The anti-tamper screw is adjusted during the fluxing operation in the factory and should never be tampered with.



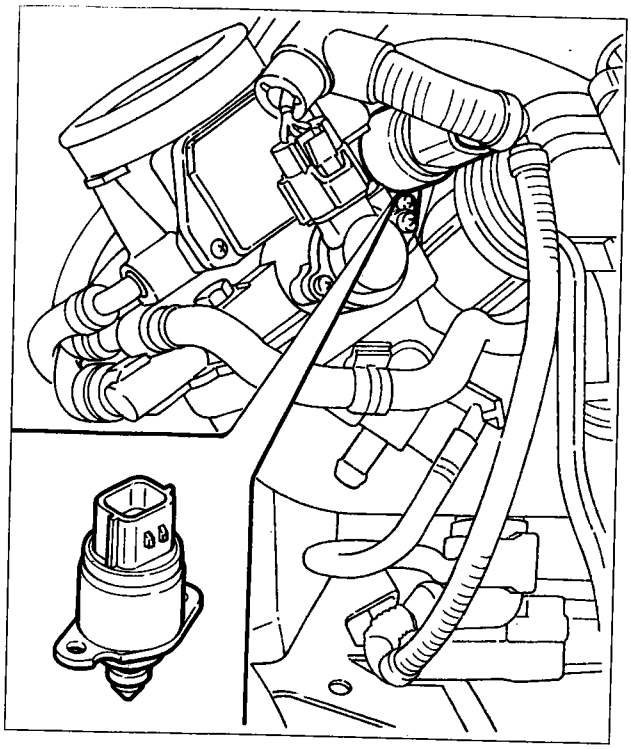
3N36GJ01

1. Air flow meter
2. Butterfly position sensor
3. Engine coolant inlet
4. Engine coolant outlet
5. PCV valve



3N36GJ02

6. Accelerator control lever
7. Accelerator cable adjustment bracket
8. Idle speed adjustment actuator
9. Anti-tamper screw



3N37GJ01

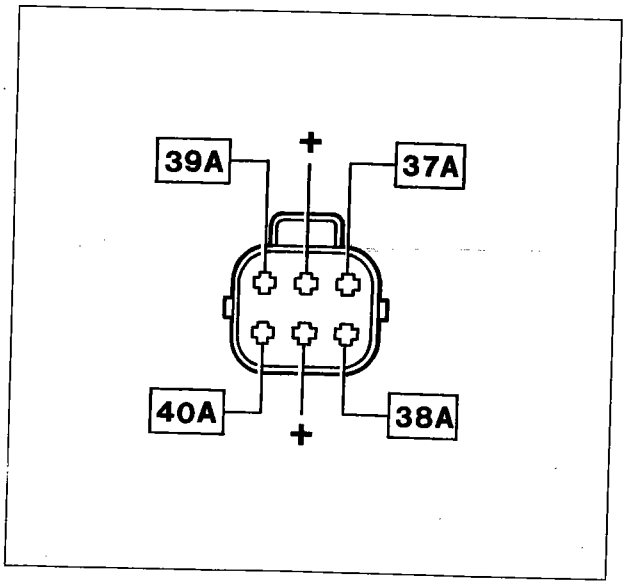
ENGINE IDLE SPEED ADJUSTMENT ACTUATOR

The actuator, fitted on the butterfly casing, intercepts a flow of air which, taken from upstream of the butterfly, returns it downstream: it has the task of guaranteeing the additional air for the engine with the butterfly closed in all conditions where it is required (idling, deceleration).
A stepping motor is used to achieve the latter and it is fixed to the butterfly casing and operated by a circuit inside the engine management control unit.

Operating principle

The actuator consists of:
- an electric stepping motor which has two windings in the stator and a rotor which includes a certain number of pairs of permanent magnet poles;
- a screw-female screw type reduction gear which transforms the rotary motion into rectilinear motion.

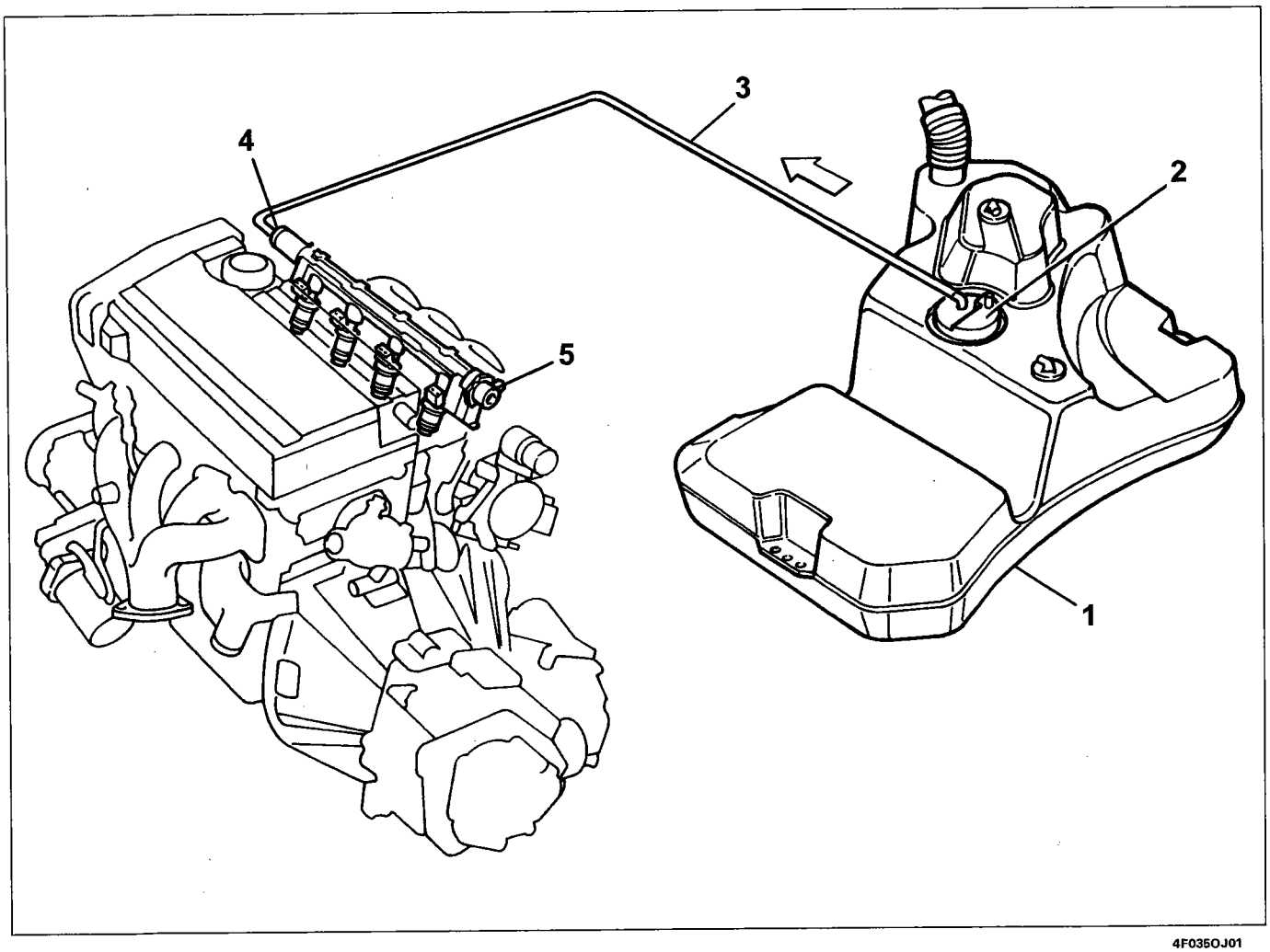
The stepping motor is operated by the engine management control unit which, combining the offset and the direction in which the current flows through the windings, causes the rotor to rotate in both directions through a given number of steps.
The screw-female screw coupling causes the movement of stem, fitted with a tapered shutter, which varies the passage of the by-pass duct and, as a result, the quantity of air drawn in by the engine to obtain the desired speed even when external loads are applied (air conditioning, fans, power assisted steering, etc.).



3N37GJ02

Wiring connector

DIAGRAM SHOWING FUEL CIRCUIT



4F035OJ01

1. Fuel tank
2. Drip tray complete with pump, filter, pressure regulator and gauge float
3. Supply pipe
4. Returnless type fuel manifold
5. Air bleed connector

FUEL SUPPLY CIRCUIT

This circuit consists of the following components:

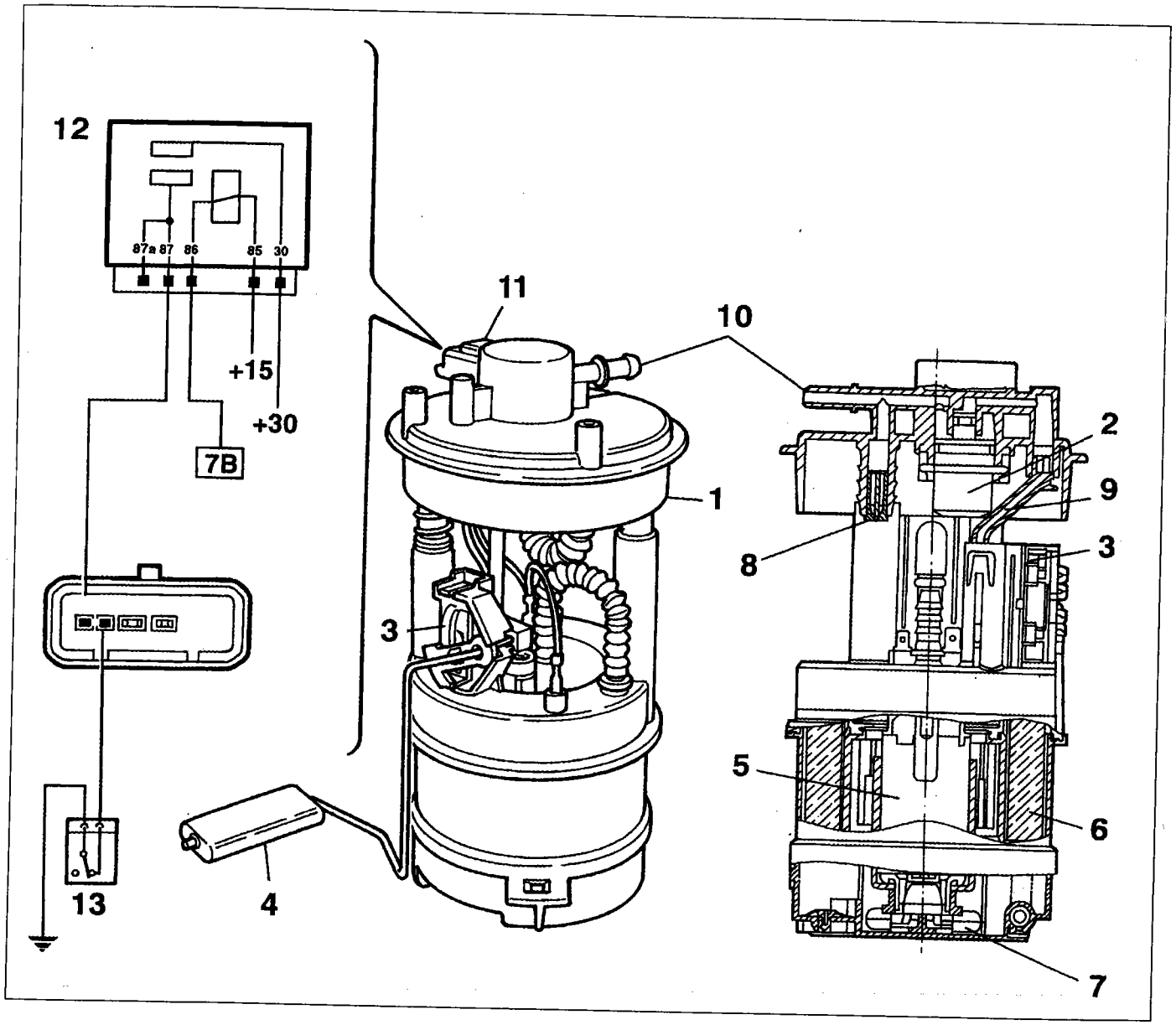
- Fuel tank
- Drip tray complete with pump, filter, pressure regulator and gauge float
- Supply pipe
- Returnless type fuel manifold complete with injectors

10.

FUEL DRIP TRAY

Electric fuel pump

The pump is housed inside the fuel tank on a special drip tray which also supports the gauge and is fitted with a gauze filter on the pump intake. The pressure regulator is also fitted on the pump supply.

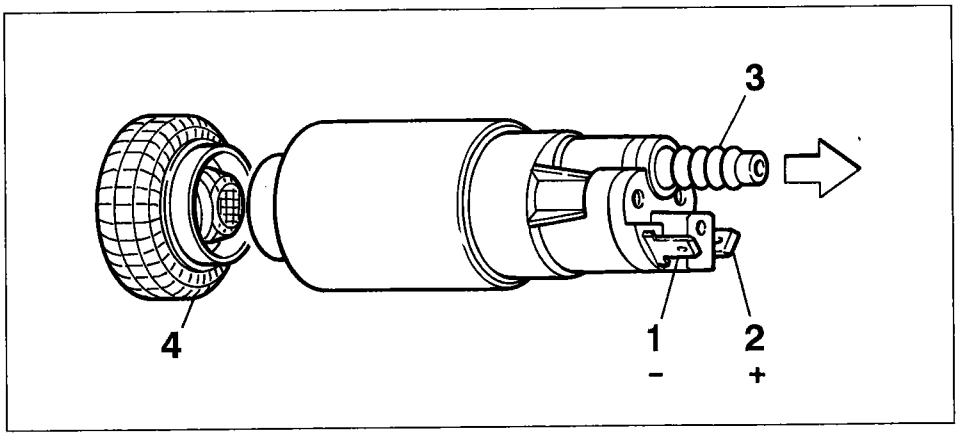


3N40GJ01

1. Complete drip tray
2. Pressure regulator
3. Gauge
4. Float
5. Electric pump
6. Fuel filter
7. Pre-filter
8. Single-acting valve
9. Internal fuel return
10. Fuel supply
11. Electrical connector
12. Relay
13. Inertia switch

The pump is the volumetric type and is designed to run on unleaded fuel. The rotor is driven by a d.c. electric motor supplied with the battery voltage directly by the twin relay operated by the control unit in order to ensure:

- that the pump cuts out if the engine speed goes below a minimum level (around 450 rpm);
- the timed operation (around 15 seconds) each time the ignition is turned to the ON position and the engine is not started up;
- operation when the engine has been started.



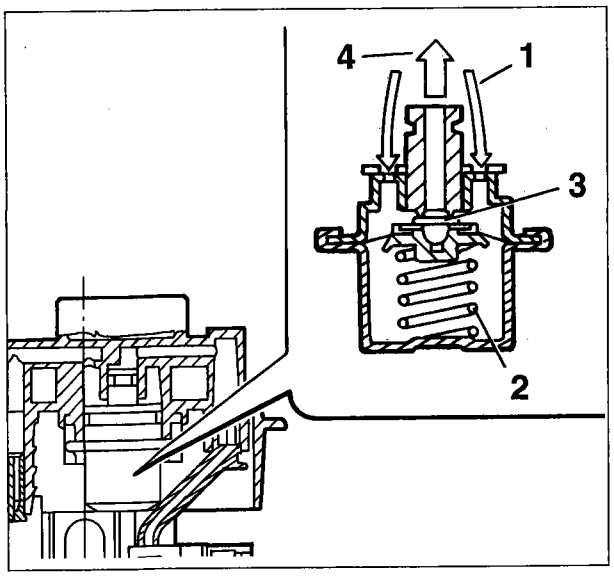
3N41GJ01

1. Negative
2. Fuel system
3. Supply
4. Pre-filter

The pump is equipped with an excess pressure valve which short circuits the supply with the inlet if the pressure in the supply circuit exceeds 5 bar to prevent the electric motor from overheating.
In addition, a one-way valve fitted on the supply prevents the entire fuel circuit from being drained when the pump is not working.
The nominal flow rate of the pump varies according to the speed of the rotor and consequently the supply voltage.

Fuel filter

The fuel filter is contained in the pump housing and does not require periodic replacement



3N41GJ02

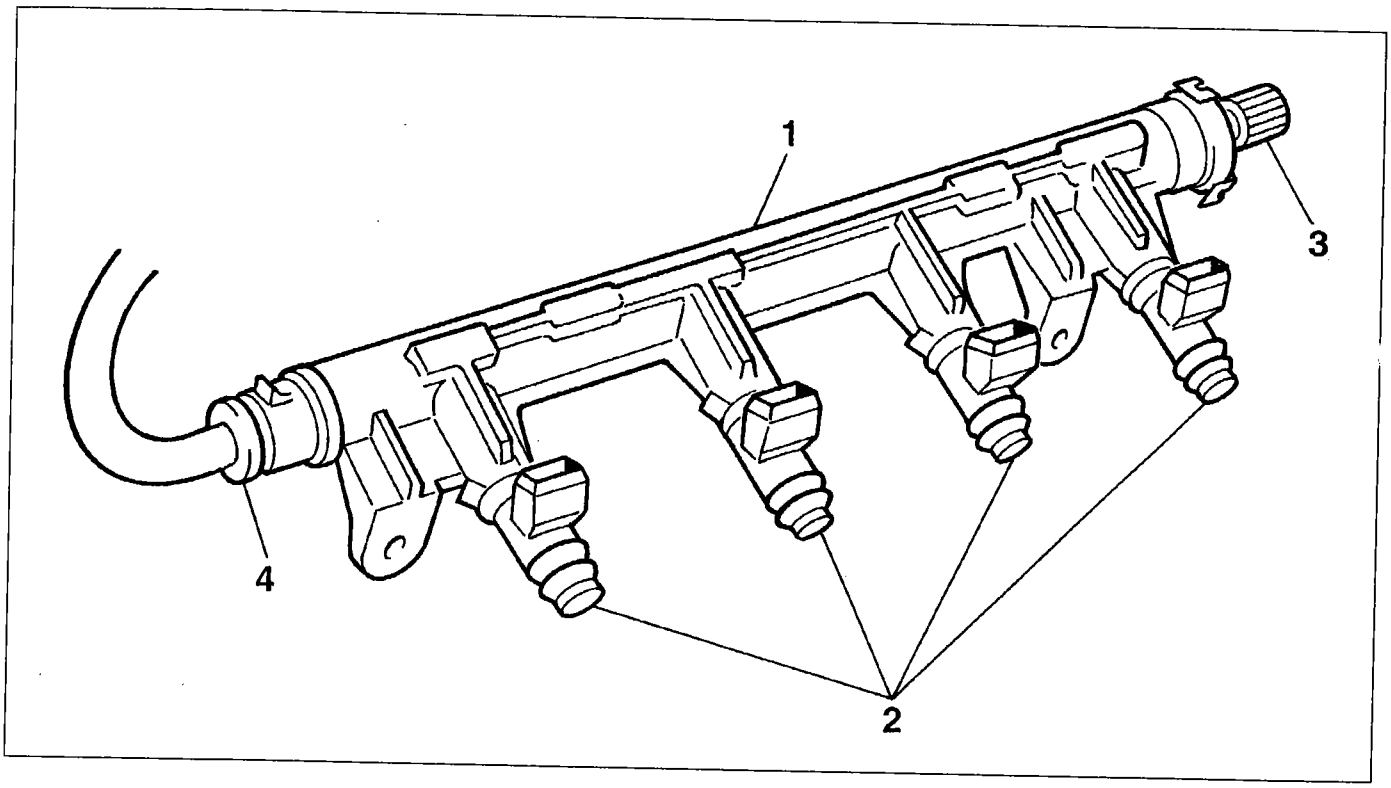
Fuel pressure regulator

This is a differential diaphragm device, regulated during manufacture to a pressure of 3.50±0.05 bar and located in the top part of the drip tray.
The pressurized fuel (1), coming from the pump, exerts a force on the flow valve (3) opposted by the calibrated spring (2). When the calibration pressure is exceeded, the valve opens and the excess fuel (4) returns to the tank, thereby stabilizing the pressure in the circuit.

10.

FUEL MANIFOLD

The fuel manifold, which has the task of distributing the fuel to the injectors, is produced by aluminium die-casting and incorporates the seats for the injectors and the bleed valve.
The fuel intake is fixed by a tapered bolt. Since the system is the returnless type, there is no recirculation pipe.

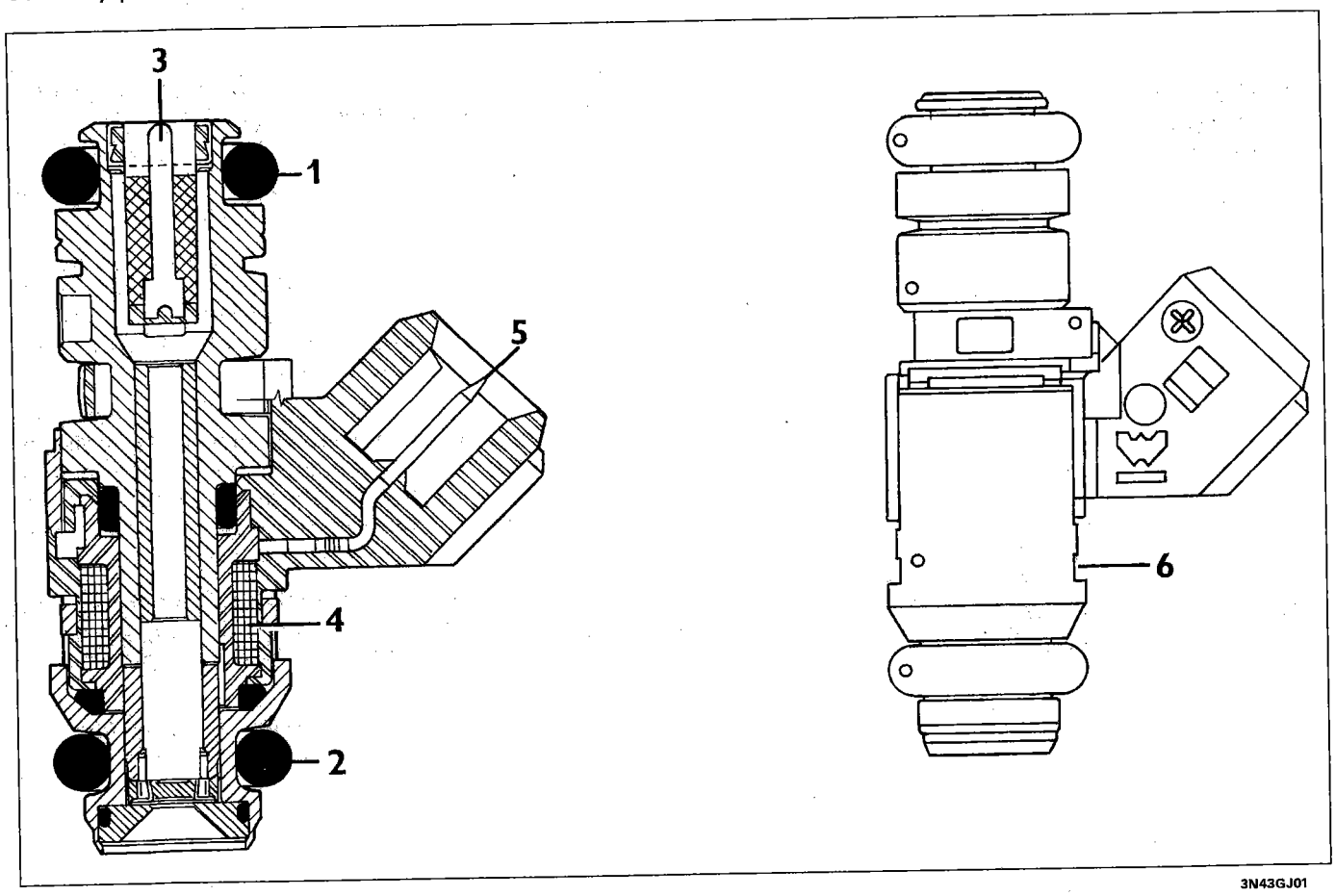


3N42GJ02

1. Fuel manifold
2. Injectors
3. Bleed valve
4. Fuel supply connector

INJECTORS

The injector has the task of supplying the quantity of fuel needed for the engine to run: the fuel is injected into the intake manifold, immediately upstream of the inlet valves.
The injectors are the top-feed, twin jet type with the supply (3) of fuel at the top of the casing where the electrical winding (4), connected to the connector terminals (5) is also housed.
When the current passes through the winding, the magnetic field which is created attracts the shutter, causing the opening of the injector and the flow of fuel.
Two seals provide the seal on the fuel manifold side (1) and the intake manifold side (2). A reference (6) determines the angular position of the injector in relation to the intake manifold to ensure that the jets are correctly positioned in relation to the inlet valves.

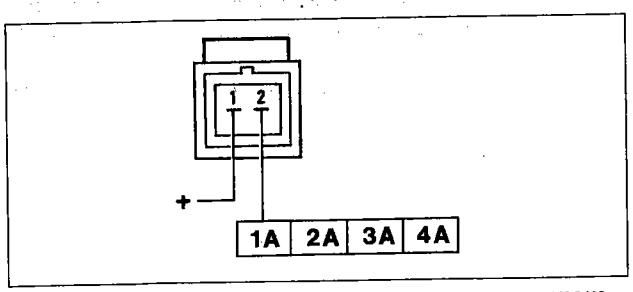


3N43GJ01

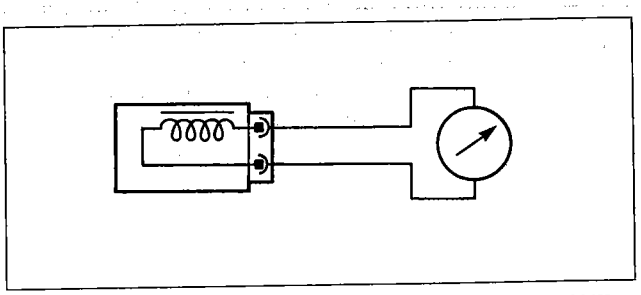
The injector resistance can be measured by disconnecting the connector and connecting an ohmmeter as illustrated in the diagram.

Resistance value: 14.5 ± 5% ohm.

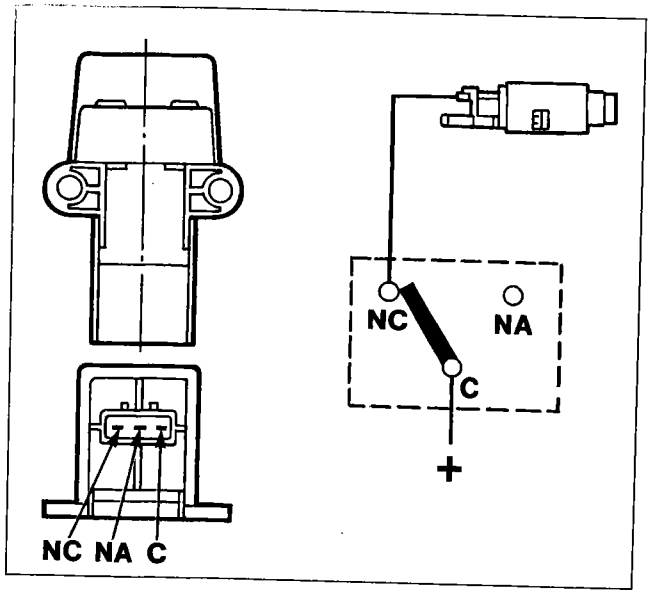
Wiring connector



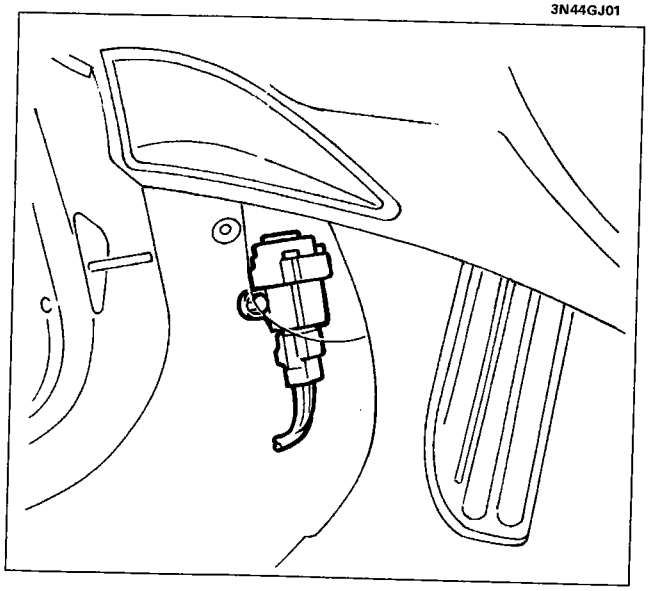
3N43GJ02



3N43GJ03



3N44GJ01



4A34JJ02

1. Inertia sensor
2. Button for restoring operation of electric fuel pump

INERTIA SAFETY SWITCH

In order to improve the safety of the occupants of the vehicle in the case of an impact, the vehicle is equipped with an inertia switch, located under the dashboard on the driver's side, fastened to the left side panel, near the bonnet release.

The inertia switch has the task of interrupting the electrical supply for the fuel pump if the vehicle undergoes violent deceleration (impact) to prevent fuel from being able to escape, if the fuel manifold or the supply pipes are damaged, and create a fire hazard.

The switch consists of a steel ball, fitted in a conical shaped housing and kept in positino by the attraction force of a permanent magnet.

As a result of the acceleration due to the inertia forces, the ball can be released from the magnetic clip and gradually come out of the tapered housing with an upwards movements which depends on the angle of the cone.

There is a rapid release mechanism, above the ball, which forms a normally closed (NC) circuit. When the mechanism is struck by the ball, it changes position into a normally open (NA) circuit, thereby interrupting the electric supply to the pump and causing it to cut out.

The calibration of the switch causes it to intervene at accelerations of above 1.2 g (about 11.7 m/s^2, corresponding to an impact at a speed of about 25 Km/h).

The switch can be turned back on by pressing the top button with the protective cover.

Even after an apparently slight impact, if there is a smell of fuel or there are leaks from the fuel system, the switch should not be turned back on, but the cause of the problem sought and remedied to prevent the risk of fire.
If this is not the case and there are no leaks, the vehicle can be driven again and the button should be pressed to reactivate the pump.

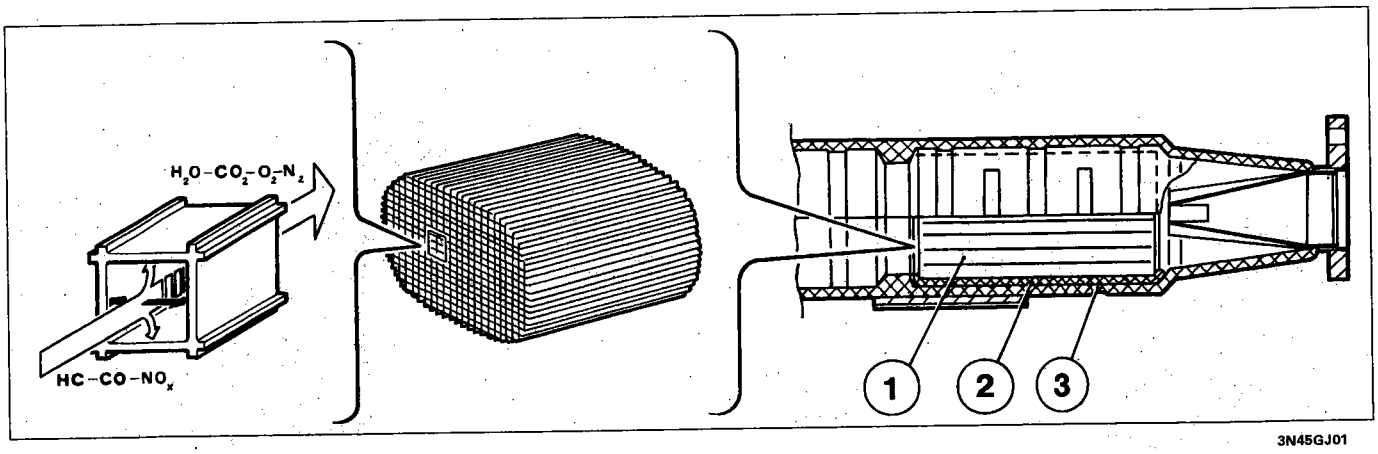
EMISSION CONTROL DEVICES

These devices have two aims:
- to keep down the levels of pollutant substances present in the exhaust, by means of the catalytic silencer;
- to eliminate the dispersion into the atmosphere of the unburnt hydrocarbons, through the (fuel) anti-evaporation system and the (lubricant) oil vapour recirculation system.

CATALYTIC SILENCER

The catalytic silencer is a device which makes it possible to keep down the levels of the three main pollutant compounds present in the exhaust simultaneously: unburnt hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx).
Two types of chemical reactions take place inside the catalyzer:
- oxidation of the CO and HC, converted into carbon dioxide (CO_2) and water (H_2O);
- reduction of the NOx, converted into nitrogen (N_2).

These reactions can take place extremely quickly thanks to the presence, inside the structure (ceramic support) of the catalyzer, of a layer of active substances (platinum and rhodium) which greatly accelerate the conversion speed of the harmful substances.
The effectiveness of this conversion process is conditioned by the fact that the mixture strength on which the engine is running is continuously fluctuating around the stoichiometric value, which is achieved thanks to the feed-back control carried out by the control unit on the basis of the Lambda sensor signals.
Lastly, the conversion processes are activated at temperatures in excess of 300 - 350°C: it is therefore vital for the catalyzer to reach this temperature as quickly as possible in order to be able to work properly.



3N45GJ01

1. Ceramic structure
2. Metal support
3. Outer steel casing

when work hs to be carried out in the vicinity of the catalytic silencer, the vehicle must be left for a certain length of time because the operating temperature inside the catalyzer is between 500 and 850°C.

There are basically two causes which can destroy the inside of the catalyzer:
- *the presence of lead in the fuel which lowers the degree of conversion to practially zero (lead poisoning) and irreparably damages the Lambda sensor as well;*
- *the presence of completely unburnt fuel in the exhaust gases, due to failed ignition, which causes an increase in temperature which leads to the ceramic support melting. As a result, the connector for the coils must never, under any circumstances, be disconnected with the engine running: in the case of tests, the silencer must be replaced with an equivalent length of pipe.*

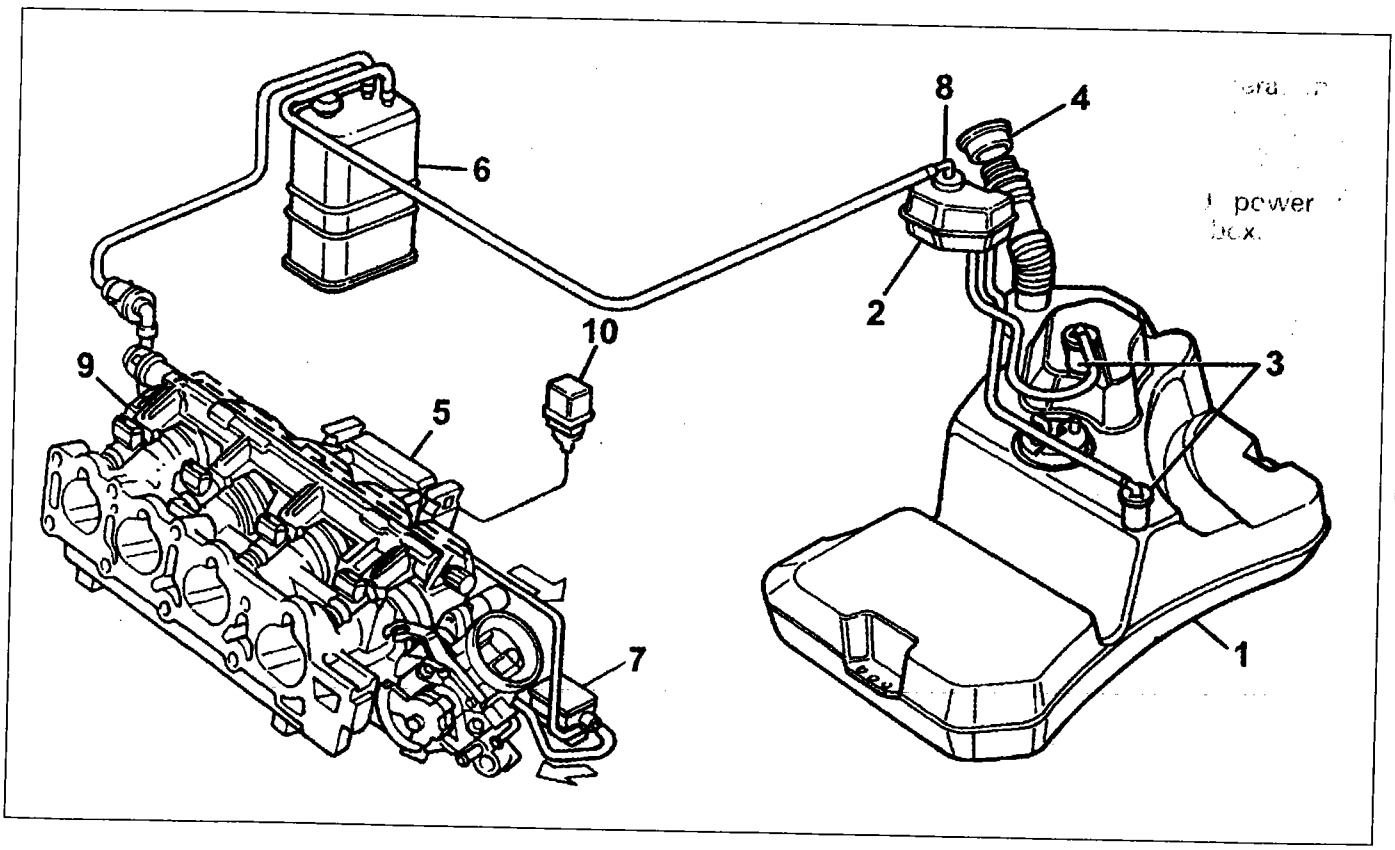
10.

FUEL ANTI-EVAPORATION SYSTEM

The anti-evaporation system is designed to prevent the fuel vapours, composed of the lightest fractions of hydrocarbons which basically form in the tank, from being discharged into the atmosphere.
The system consists of the tank, the vapour separator, two float valves, a two-way ventilation valve, the charcoal filter and a charcoal filter solenoid valve controlled by the control unit. The cap contains a two-way safety valve.

Operating principle

The system operates, above all, at high outside temperatures when the temperature of the fuel increases and, consequently, the tendency to evaporation increases: in this situation there is an increase in pressure inside the tank.
In particular, even when the tank (1) is full, the two float valves (3) remain open, as they are located higher than the breather pipe and therefore always allow the fuel vapours to reach the separator (2), thereby preventing fuel from escaping.
The fuel vapours reach the charcoal filter (6) when the pressure inside the tank causes the opening of the ventilation valve (8). This valves also allows an intake of air into the tank through the charcoal filter, if necessary, when the level of the fuel decreases.
When the engine is running, the control unit operates the charcoal filter solenoid valve which allows the intake of vapours by the engine and the consequent scavening of the charcoal filter.
If, as a result of a malfunction with any of the components, the pressure inside the tank increases to dangerous levels, the safety valve, located in the cap (4), allows the pressure to be discharged outwards. If necessary, this valve can open in the opposite direction to ventilate the tank and prevent the vacuum levels from becoming excessive.

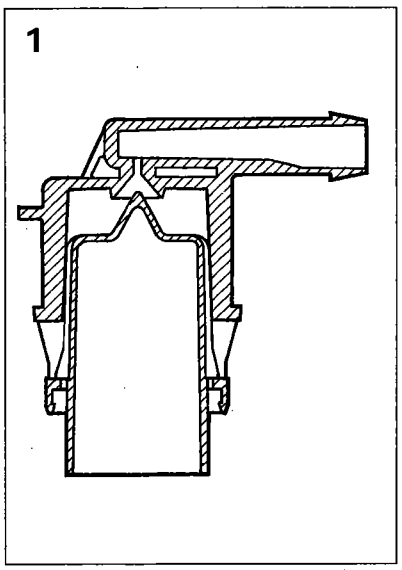


4F042OJ01

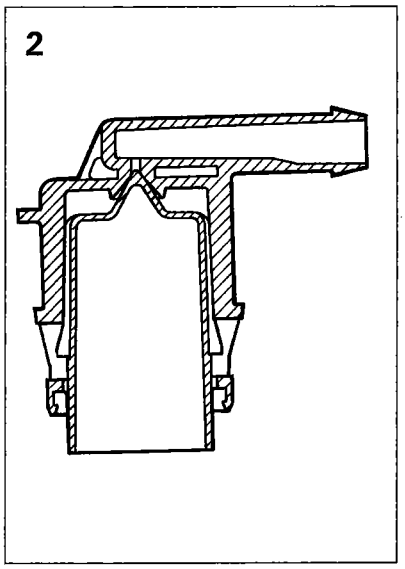
1. Fuel tank
2. Vapour separator
3. Float valve
4. Cap with safety valve
5. Engine management control unit
6. Charcoal filter
7. Charcoal filter solenoid valve
8. Safety and ventilation valve
9. Inlet manifold
10. System relay

Float valve

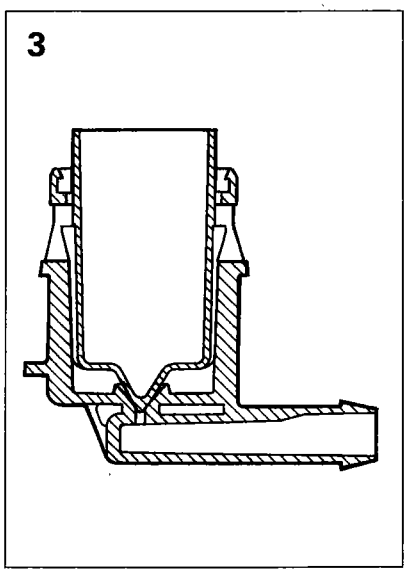
The float valve has the task of allowing the flow of vapours to the separator, without, however, allowing the escape of liquid fuel.
The valve contains a float, the end of which closes the actual valve outlet port in the following conditions:
strong lateral acceleration (vehicle driving round a bend) or longitudinal acceleration (vehicle braking) with the relevant movement of the mass of fuel as a result of the inertia force;
vehicle overturning.



3N48GJ01

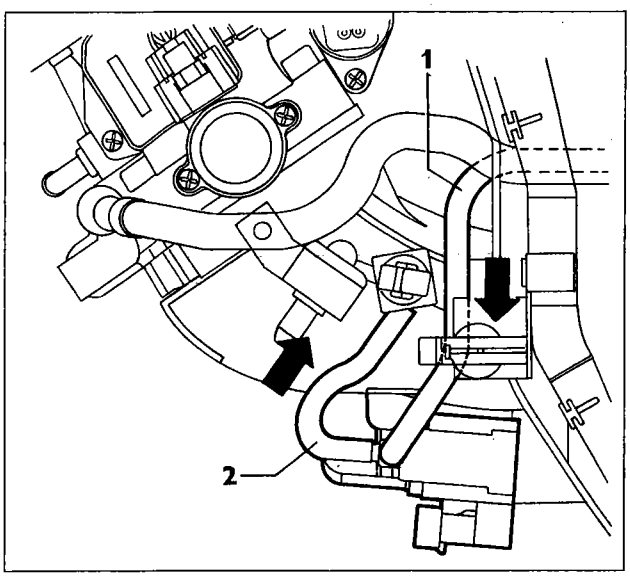


3N48GJ02



3N48GJ03

1. Normal operating conditions: valve open
2. The fuel pushes the float upwards as a result of strong acceleration: valve closed;
3. Vehicle overturned: valve closed.



3N49GJ03

Charcoal folter solenoid valve

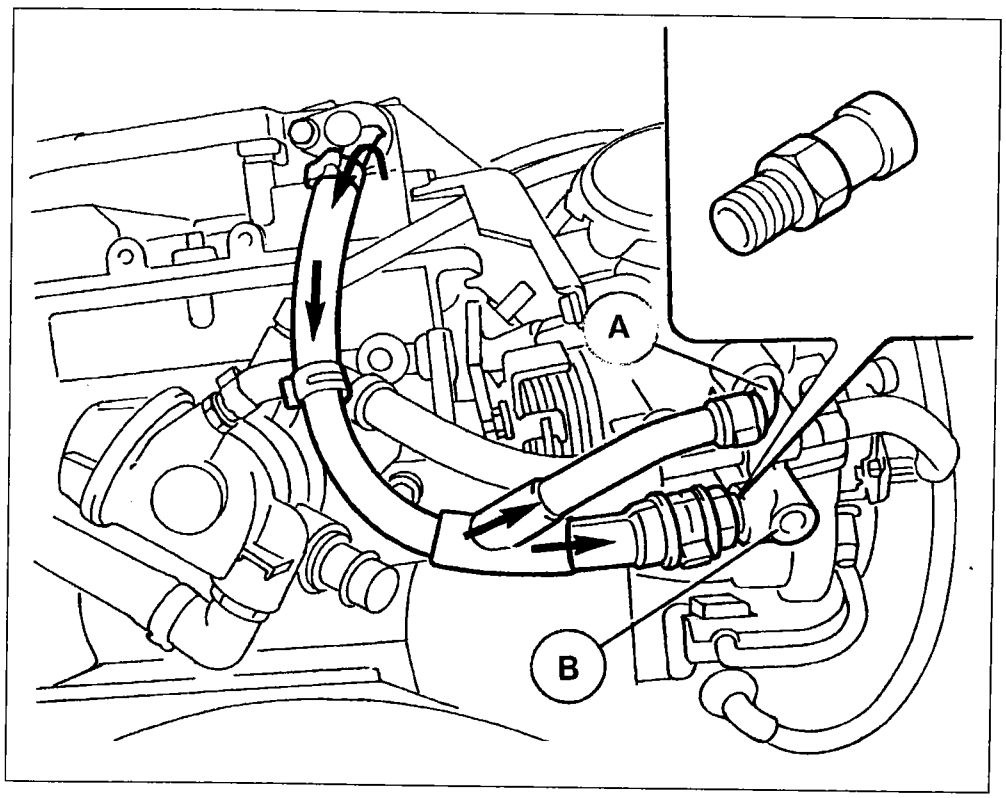
This normally closed type valve, controls the flow of vapours reaching the intake manifold, being operated by the control unit in a duty-cycle.

1. From the charcoal filter
2. To the intake manifold

10.

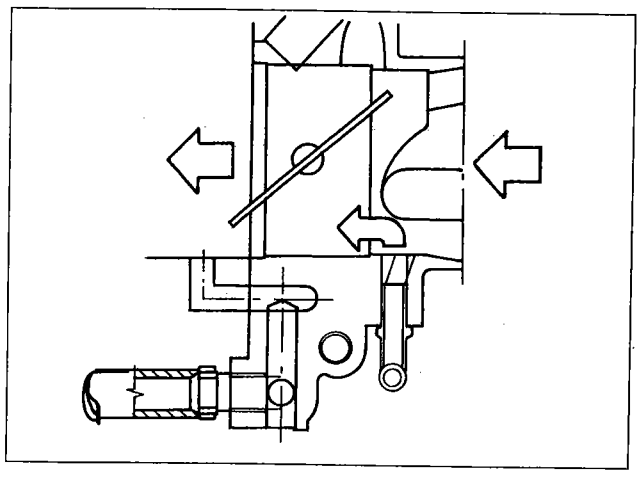
EXHAUST GAS RECIRCULATION SYSTEM (BLOW-BY)

This system controls the emission of breather gases from the crankcase which consist of mixtures of air, fuel vapours and burnt gases which escape from the piston seals and lubricant oil vapours, causing them to be recirculated and burnt in the engine.
The breather gases coming from the crankcase rise as far as the cylinder head and are directed into two different intakes:
- at medium-high accelerator butterfly openings, the gases are drawn in by the duct immediately downstream of the air flow meter (detail A);
- at small butterfly openings (and, in particular, with the engine idling or decelerating), the gases are drawn ni through the PCV valve (Positive Crank Ventilation) fitted on the butterfly casing downstream of the actual butterfly (detail B).



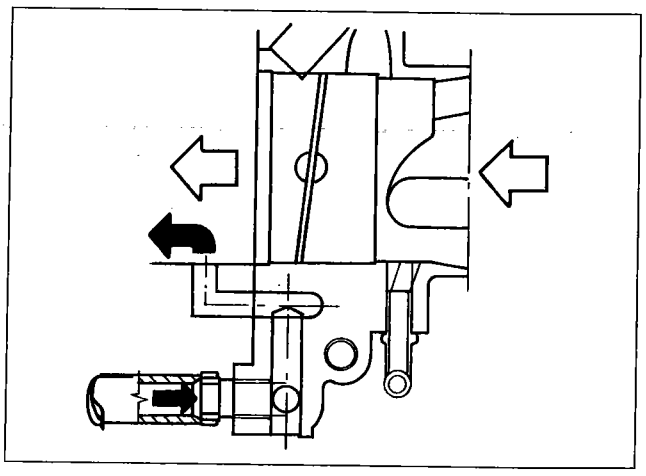
3N50GJ01

Detail A



3N50GJ02

Detail B



3N50GJ03

CHECKS, ADJUSTMENTS AND REPAIR OPERATIONS ON THE HITACHI MPI SYSTEM

The following precautions must be observed when working on a vehicle equipped with a Hitachi MPI system:
do not start the engine when the electrical leads are not properly connected or are slack at the battery terminals;
- *do not use a rapid battery charger to start the engine;*
- *never disconnect the battery from the electrical system with the engine running;*
- *when recharging the battery, it must be disconnecte first from the electrical system;*
- *if the vehicle is going into a drying oven after painting at temperatures above 80°C, then the engine management control unit must be removed from the vehicle first;*
- *do not connect/disconnect the control unit multiple connector with the ignition switched ON;*
- *always disconnect the negative battery lead before carrying out electrical welding on the vehicle.*

The system has a memory which is supplied directly by the battery, even when the ignition is switched off, where the values acquired during the self-adjustment are stored. The operation of disconnecting the battery means that this data is lost and can only be acquired again after a certain length of time: this operation should therefore be carried out as infrequently as possible.

NOTE *If the Hitachi MPI sysetm components are replaced:*
- *Butterfly casing and flow meter*
- *Engine idle speed actuator*
- *Butterfly position sensor*
- *Engine management control unit*
- *Lambda probe*

The negative battery terminal must be disconnected in order to reset the self-adjustment memory which could, with new components, involve the failure of the engine to start or the irregular behaviour of the engine when first started.

CHECKING CONCENTRATION OF EMISSIONS

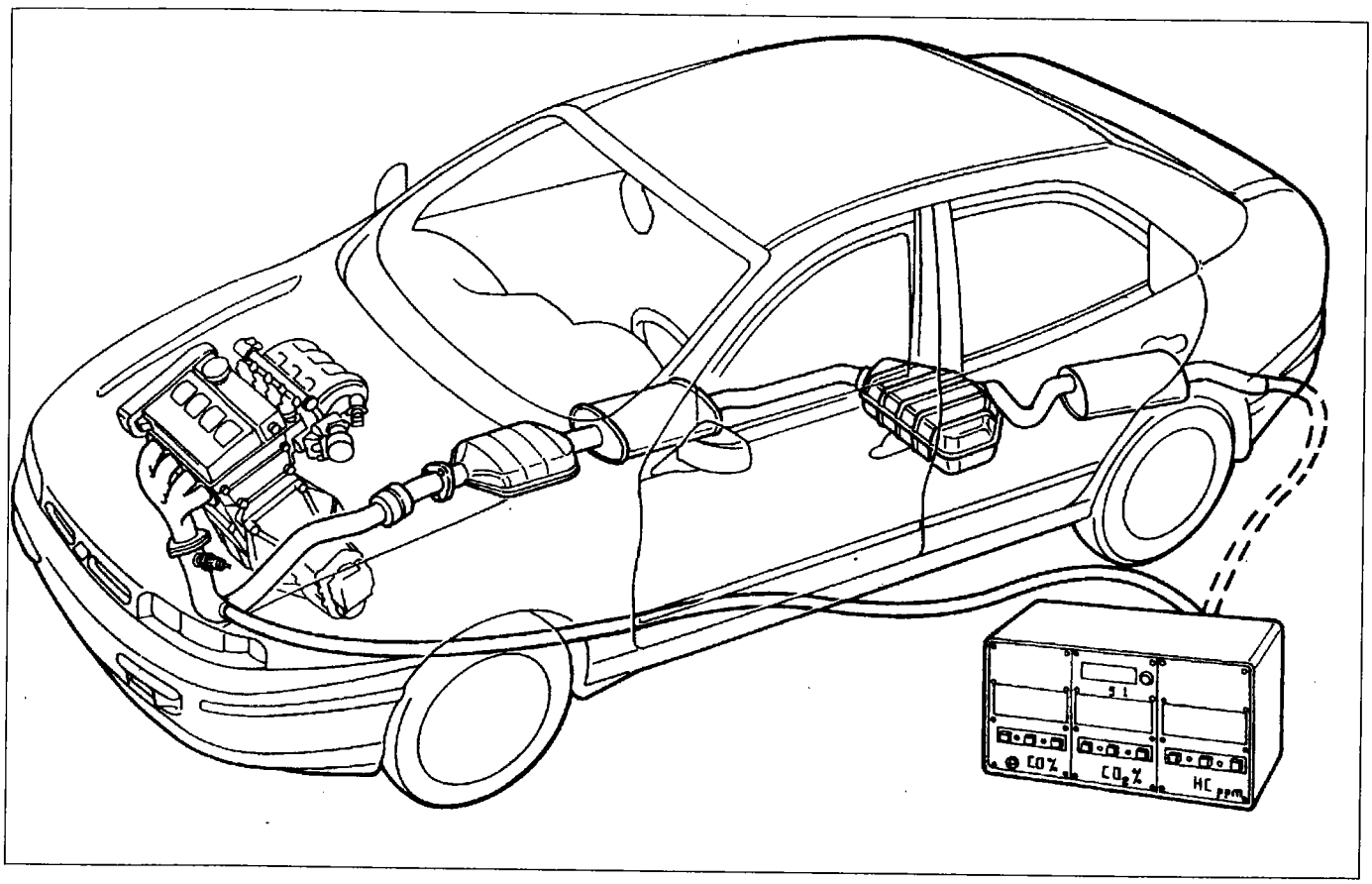
The system manages the advance, the carbon monoxide (CO) content and the idle air flow rate without any possibility of manual adjustment.
However, a check on the content of the exhaust gases, upstream and downstream of the catalyzer, can provide useful information on the injection/ignition system operating conditions, the engine parameters and the catalyzer.

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

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

1. Undo the cap located 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 the idle speed is correct.
5. Check that the idle CO concentration is within the recommended limits (see table); if this is not the case, it is necessary to check:
   - that the Lambda sensor is working properly, using the diagnostic equipment;
   - for 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. In the same conditions, check that the concentration of HC is below 500 p.p.m.
7. If the values do not correspond, tune the engine, checking, in particular:
   - the valve gear timing;
   - the engine compression.

10.



4F046OJ01

Table summarizing pollutant emission tolerance figures

	CO (%)	HC (p.p.m.)	CO_2 (%)
Upstream of the catalyzer	04 - 1	< 500	> 12
Downstream of the catalyzer	< 0.35	< 90°	> 13

Checking exhaust concentration of CO and HC

The concentration of carbon monoxide (CO) and unburnt hydrocarbons (HC) at the exhaust is measured by inserting a suitably calibrated tester sensor at least 30 cm into the end of the exhaust pipe.

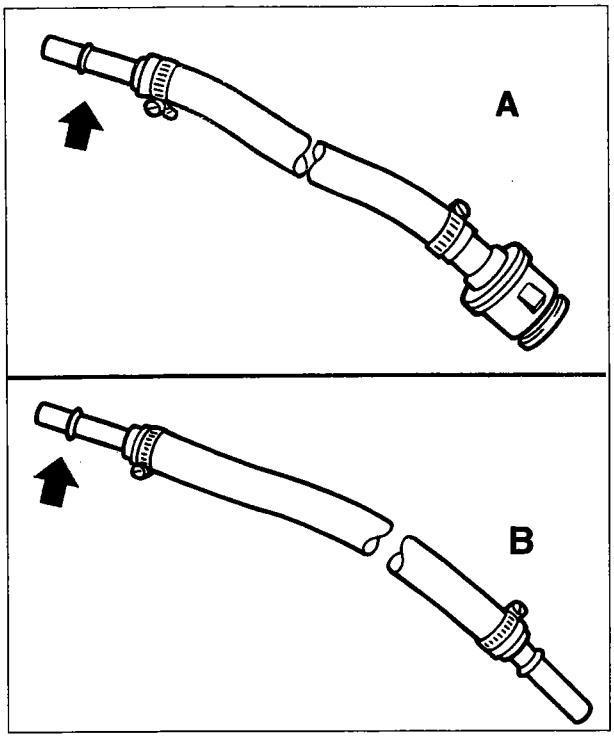
1. Check that the idle CO and HC concentrations correspond to the recommended figures (see table).
2. If the HC value is outside of the recommended limit, whilst that measured previously upstream of the catalyzer was correct, then the engine parameters are correct the cause of the problem should be sought in the decreased efficiency of the catalyzer.

CHECKING ENGINE IDLE SPEED

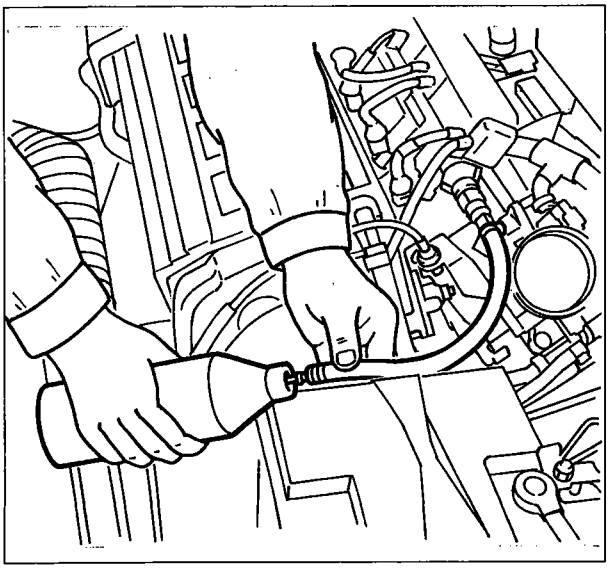
If the engine idle speed does not correspond to the recommended figure and the system is the self-regulating type, then no adjustment can be carried out: it is therefore necessary to check that the accelerator linkage is correctly adjusted and the cause of the problem should be sought by carrying out a complete fault diagnosis using the diagnostic equipment.

CHECKING IGNITION ADVANCE

The diagnostic equipment must be used to check the ignition advance angles at the different speeds.



3N53GJ01



3N53GJ02

CHECKS ON FUEL SUPPLY CIRCUIT

THESE OPERATIONS SHOULD BE CARRIED OUT IN THE PRESENCE OF A SUITABLE VAPOUR PURIFICATION AND EXHAUST SYSTEM

Fuel supply circuit pressure check

Check the pressure of the system and the seal of the fuel system, as described below, using equipment 1860955000, fitted with two adapators which should be constructed as described below:

- adapator (A) use a new type rapid attachment female terminal and a length of pipe contained in Kit no. 1860955003 and an old type rapid attachment male terminal contained in Kit no. 1860955001;
- adapator (B) use a new type rapid attachment male terminal and a length of pipe contained in Kit no. 1860955003 and an old type rapid attachment male terminal contained in Kit no. 1860955001;

Configure the adapators as illustrated in the diagram.

The arrow indicates the side to be inserted in the test equipment 1860955000 (pressure gauge)

Draining supply system fuel pressure

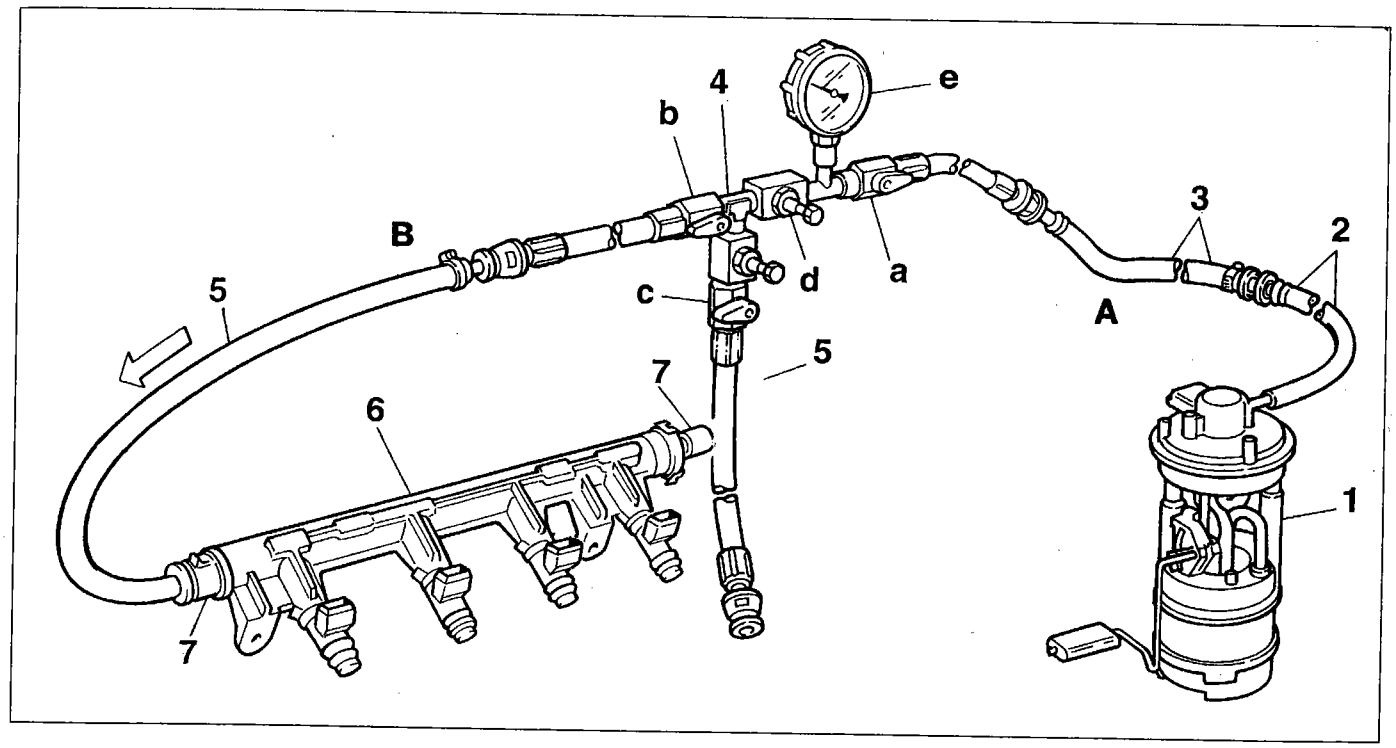
The fuel supply circuit is kept at a constant pressure of around 3.2 bar, even with the engine switched off; therefore, before carrying out operations on the supply pipe the pressure must be drained from the system, using adaptor no. 1870684000 and a special container to collect the excess fuel in.
Proceed as described below:

- Remove the inlet hose from the butterfly casing;
- Remove the protective cover from the attachment on the fuel manifold;
- introduce the male terminal of the adapator inside the container and fit the rapid connector to the attachment on the fuel manifold, as illustrated in the diagram; in this way, the small amount of excess fuel, which produces pressure, will be drained into the container and it will be possible to carry out the procedure for checking the fuel supply system.
- disconnect the adaptor and refit the protective cover.

10.

Checking fuel supply circuit pressure

Prepare the test equipment 1860955000, using the adapators constructed previously and fitted as illustrated in the diagram below, with ball valves (a), (b) and (d) in the fully open position and valve (c) in the closed position.



3N54GJ01

1. Complete electric pump
2. Fuel supply pipe
3. Adapator (A)
4. Test equipment No. 1860955000
5. Adapator (B)
6. Fuel manifold
7. Rapid attachment connector on manifold

After having discharged the pressure, remove the end of the fuel supply pipe (2) from the rapid connector (7) on the manifold, following the instructions on the previous pages, connect it to the adapator (A) female connector, connect the new male end of the adapator (B) to the rapid connector on the fuel manifold (7) and check that the connectors are correctly engaged.
Turn the ignition key to the ON position and check, on the gauge (e), that, after increasing to around 3.5 bar, the pressure then settles down at round 3.2 bar (the fall in pressure is due to the fact that if the engine is not started up, after the pump has been running for several seconds, it cuts out).
If the decrease in pressure is more than the values mentioned above, check the seal of the section of the system upstream of the fuel manifold and check the seal of the injectors, proceeding as described below.

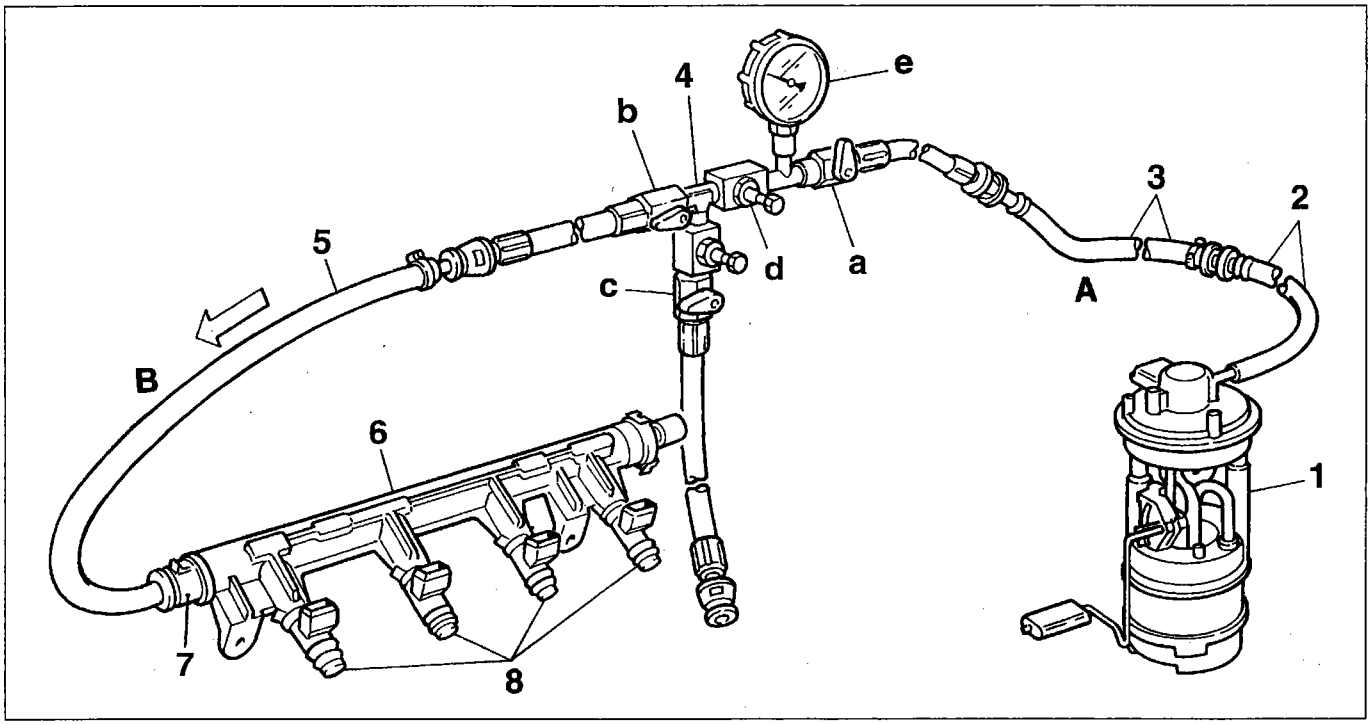
Checking fuel supply pipe seal

Keep the test equipment as described in the previous paragraph, close valve (b), keeping valve (c) closed and valve (a) in the fully open position.
Turn the ignition key to the ON position and check, on the pressure gauge (e) that, after having increased to around 3.5 bar, the pressure settles down at around 3.2 bar (this decrease in pressure is due to the fact that if the engine is not started up, after operating for several seconds, the pump cuts out).

Checking the injector seal

If there is a decrease in pressure beyond the figures given above, check the seal of the section of the system upstream of the manifold and, if there are no leaks or damage to the fuel supply pipe, replace the electric fuel pump assembly because, as described in the paragraph dealing with the fuel pump, the pressure regulator is housed in the same unit and CANNOT be replaced.
If, after having repeated the check, the pressure exceeds the recommended figure and is considerably higher, replace the electric fuel pump because there are operating faults with the pressure regulator which is housed inside it.

Checking the seal of the injectors



3N55GJ01

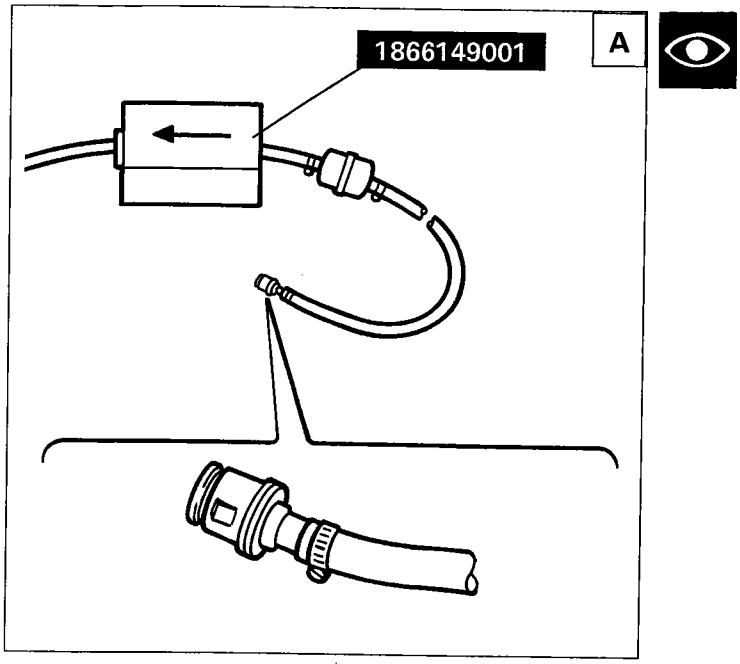
1. Complete electric pump
2. Fuel supply pipe
3. Adaptor (A)
4. Test equipment No. 1860955000
5. Adapator (B)
6. Fuel manifold
7. Rapid connector on the manifold
8. Injectors

Keep the test equipment as described in the previous paragraph, place valve (b) in the fully open position, keeping valve (c) closed and valve (a) in the fully open position.
Turn the ignition key to the ON position and observe on the pressure gauge (e), that the pressure, after having increased to around 3.5 bar, settles down at a pressure of around 3.2 bar, then close valve (a) and check that the pressure remains constant for at least a minute; if this is not the case, then one or more of the injectors is leaking.

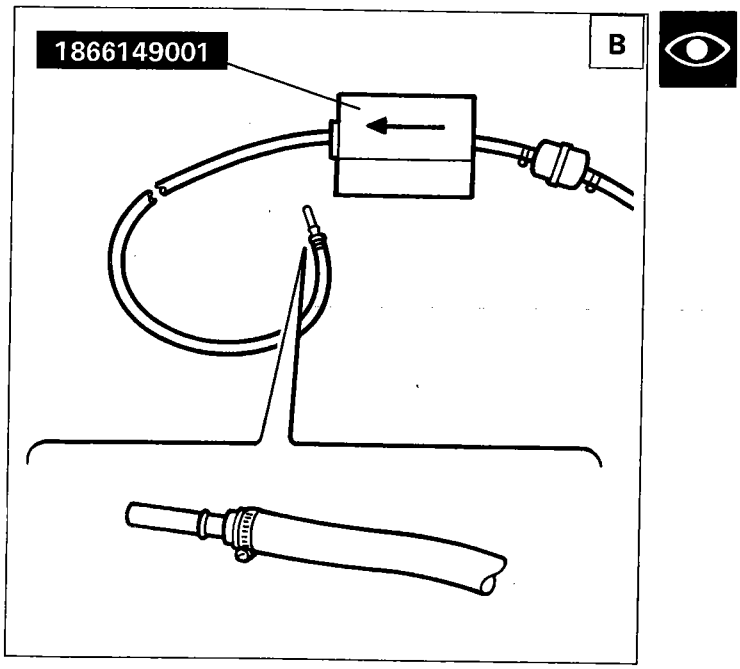
10.

Removing test equipment

Remove the test equipment 1860955000 with the ignition key in the OFF position, proceeding as described below:
- introduce the end of the pipe connected to the valve (c) into a suitable container;
- open the valve (c) and drain the excess fuel into the container;
- keep the pipe in the container and disconnect the end of the supply pipe from the female connector for adapator (A) keeping the connector upwards;
- let the fuel in the pipes flow into the container;
- disconnect the terminal of adapator (B) from the connector on the fuel manifold and let the residual fuel flow from the pipes into the container;
- reconnect the fuel supply pipe to the fuel manifold.



3N56GJ01



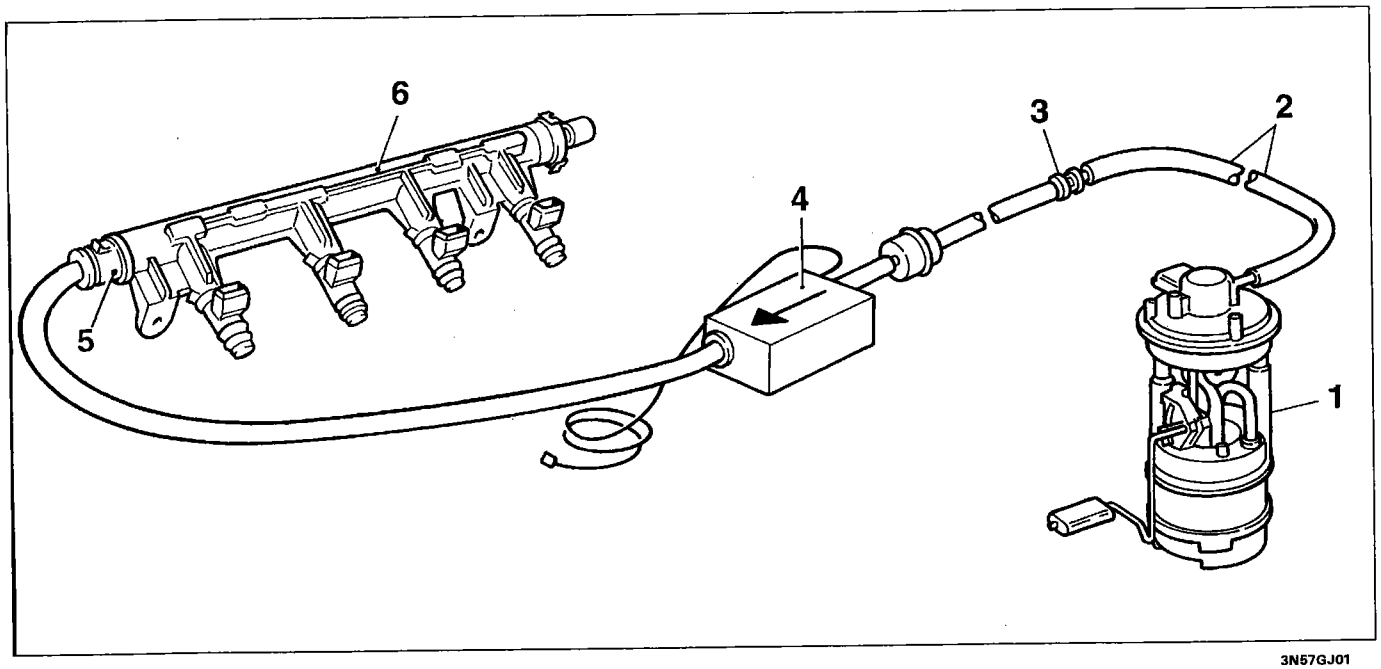
3N56GJ02

Check the fuel consumption using the FLOWTRONIC equipment 1866149001

To carry out the test, the equipment should be configured with the connectors shown in the diagrams:
A. supply pipe side
B. fuel manifold side
If this is not the case, make the adjustment, proceeding as described below:
- cut the terminal on the inlet pipe for the FLOWTRONIC equipment and replace it with a female rapid connector (1) contained in Kit No. 1860955003, as illustrated in figure A;
- cut the terminal on the outlet pipe for the FLOWTRONIC equipment and replace it with a male connecto (2) contained in Kit No. 1860955003, as illustrated in figure B.

The connectors removed should be recovered and kept for any future connections

- drain the fuel pressure inside the supply pipe and disconnect the pipe from the fuel manifold, acting as described in the previous paragraphs;
- attach the end of the supply pipe to the female rapid connector for the FLOWTRONIC equipment and the male connector to the rapid connector on the fuel manifold;
- position the equipment in the engine compartment, place the connecting electrical cable inside the vehicle and connect the actual equipment as described in the instructions which come with the tool.
- proceed with checking the consumption following he 93/116 CE standards and check that the figures correspond with those in section 00 - Technical Data.

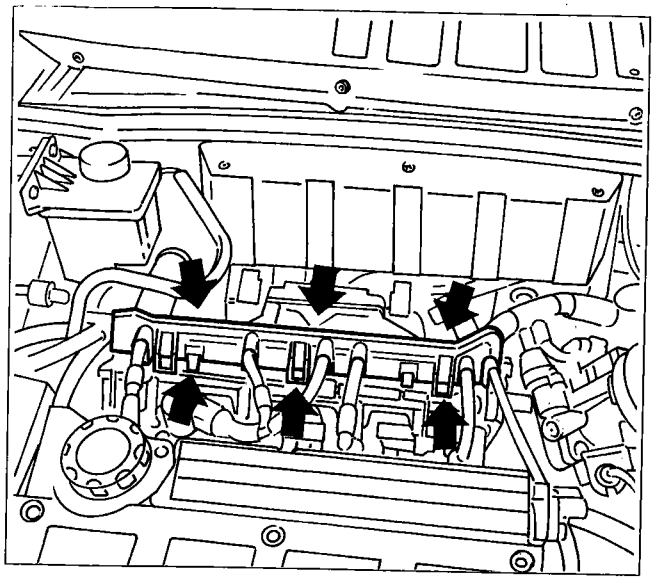


3N57GJ01

1. Complete electric pump
2. Fuel supply pipe
3. Female rapid connector
4. FLOWTRONIC equipment
5. Male terminal
6. Fuel manifold

- carry out the road fuel consumption test in accordance with directive 93/116 CE (litres per 100 km):
- URBAN CYCLE - this includes a cold start followed by a varied, simulated urban cycle;
  EXTRA-URBAN CYCLE - this includes frequent acceleration, in all gears, simulating the normal out of town usage of the vehicle; the speed varies between 0 and 120 km/h;
  AVERAGE COMBINED CONSUMPTION - this incudes 33% of the urban cycle and 67% of the extra-urban cycle;
- check that the figures measured correspond to those in the section "Introduction and Technical Data".

NOTE *The type of route, traffic cnditions, driving style, weather conditions, trim level/accessories, presence of a roof rack, presece of special equipment and the state of the vehicle in general, can lead to different fuel consumption figures from those established during the above mentioned procedures.*



3N61GJ01

FUEL MANIFOLD AND INJECTORS

Before removing the manifold, drain the internal pressure following the instructions at the beginning of this chapter.

Proceed with removing the manifold, as follows:

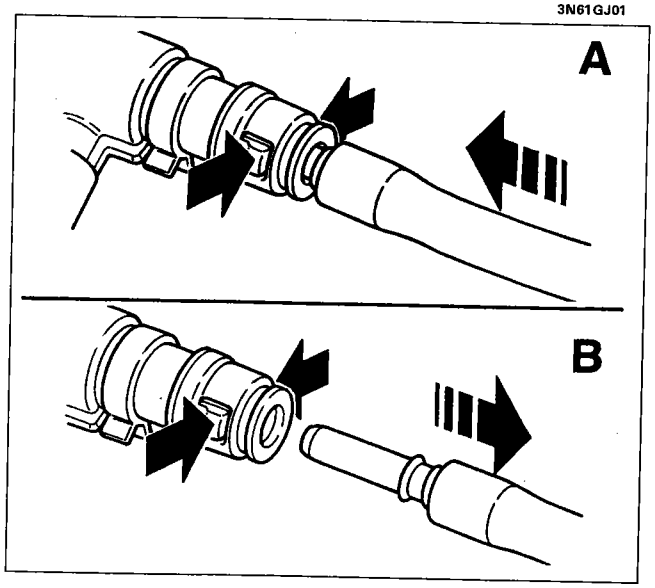
- release the front and rear springs (arrow) attaching the cable duct to the manifold;
- disconnect the electrical connections from the injectors and from the phase transformer and move the duct, released previously, aside;
- disconnect the fuel supply pipe (1) from the manifold, working in two stages:

A. press the retaining springs, at the same time pushing the end of the pipe in the direction shown to release the casing;

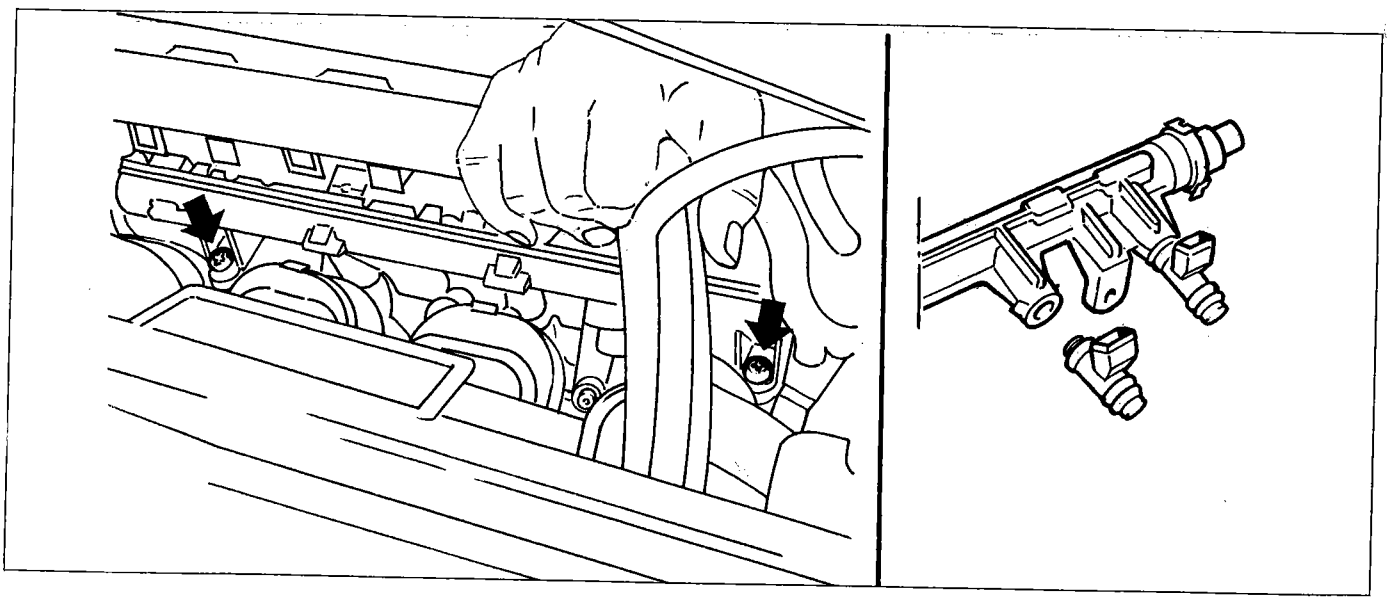
B. keep the springs pressed and extract the end from the manifold;

- undo the two bolts (arrow) fixing the manifold and remove it.

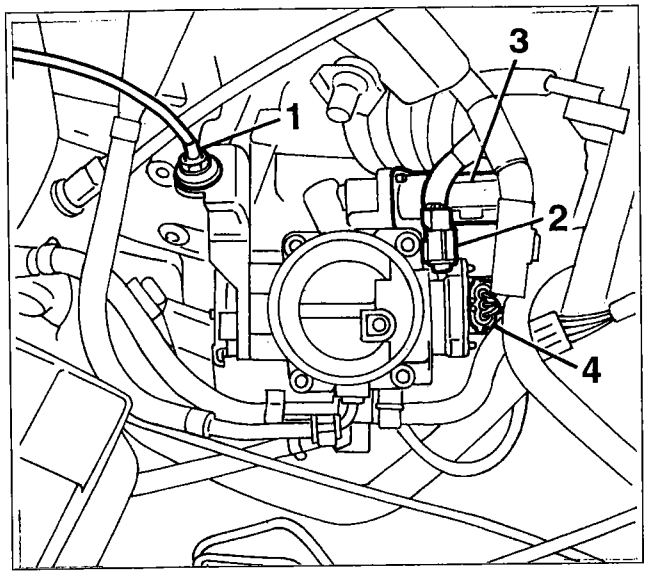
The injectors do not have clips: to detach them simply remove them from their housing (see detail).



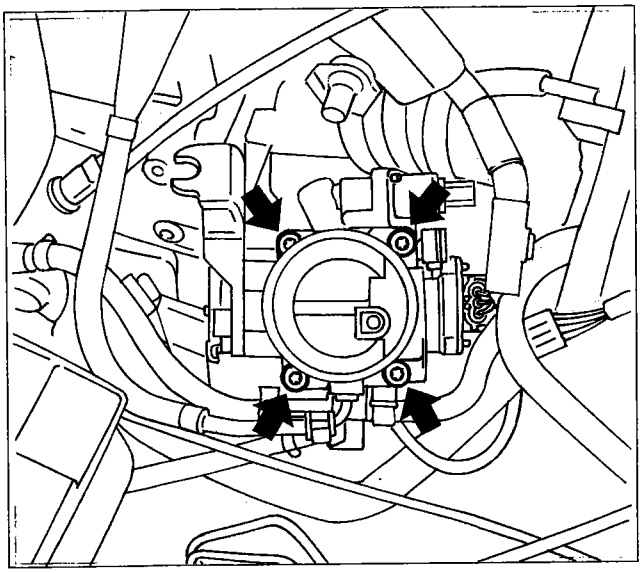
3N61GJ02



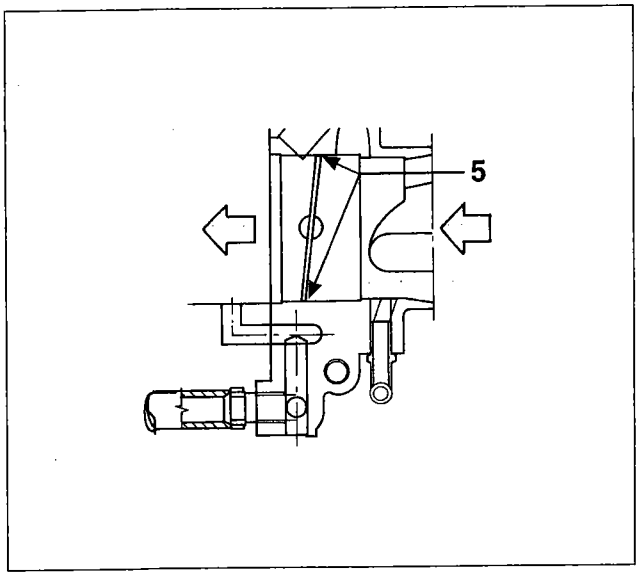
3N61GJ03



3N62GJ01



3N62GJ02



3N62GJ04

BUTTERFLY CASING

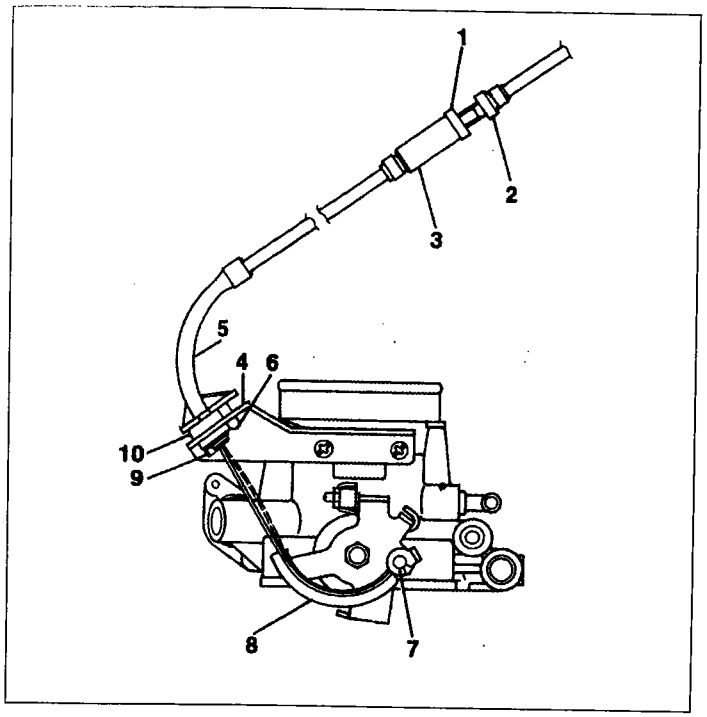
NOTE *The butterfly casing and the flow meter are incorporated in a single unit.*

Removing-refitting

Proceed with the removal of the butterfly casing, as follows:

- remove the inlet hose from the butterfly casing, loosening the retaining bands;
- remove the accelerator cable (1), completely undoing the connector on the adjustment bracket and releasing the cable from the lever on the butterfly casing;
- disconnect the electrical connectors from the butterfly position sensor (2), the idle adjustment solenoid valve (3) and the air flow meter (4);
- remove both connecting pipes from the PCV valve;
- undo the four bolts (arrow) fixing the butterfly casing to the inlet manifold;
- remove the coolant connecting pipes from the inlet and outlet pipes, sealing them suitably.

NOTE *Do not remove the layer of molybdenum disulphide applied to the edge of the butterfly.*



4F054OJ01

ACCELERATOR CONTROL CABLE

Removing

- Working from inside the vehicle, disconnect the accelerator cable from the attachment on the pedal.
- Loosen the accelerator cable, acting on the adjustment screw (2), then release the end of the cable (7) from the pulley (8).
- Remove the clip (9) and remove the cable from the mounting bracket, then remove the accelerator cable.

Refitting

- Fit the rubber mounting (10) in the special housing in the bracket (4).
- Insert the flexible cable (5) in the rubber mounting (10), positioning it so that the reference pin (6) on the cable engages in the special opening in the bracket (4).
- Wind the accelerator cable around the pulley (8) and insert the terminal (7) in the special housing.
- Insert the clip (9) into the groove at the end of the cable (5).
- Reconnect the accelerator cable to the attachment on the pedal.

Adjustment

- Working on the adjustment nut (2), adjust the accelerator cable clearance so that, with the pedal released, the butterfly is completed closed (pulley in end of travel position against the adjustment screw) and the clearance (4) at the cable is about 5 mm. At the end of the adjustment, tighten the ring nut (1) against the dust cover (3), by hand.
- If the accelerator cable is being replaced, connect the diagnostic equipment to the special socket and check that, with the pedal fully depressed, the butterfly opening angle is between 80° and 84° (98-99%). If the value measured does not correspond to the recommended figures, regulate the adjustment screw on the accelerator pedal to adjust the travel.