

#### BOSCH MOTRONIC M 2.10.4 M.P.I. INTEGRATED INJECTION/IGNITION SYSTEM

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**BOSCH MOTRONIC M 2.10.4 M.P.I. INTEGRATED INJECTION/IGNITION SYSTEM****Introduction**

The Bosch Motronic system fitted on the 1998 5 cylinder 20valve engine belongs to the category of digital, inductive discharge, static advance electronic ignition systems integrated with sequential, timed type electronic injection.

This system has only one electronic control unit, a single set of wiring and one set of common sensors. Its function is to inject the exact quantity of petrol into the engine inlet manifold, upstream of the inlet valves, to mix with the air introduced into the cylinder so that the correct mixture strength is obtained.

The Motronic M 2.10.4 system ensures efficient operation making it possible to achieve optimum performance and fuel consumption and to reduce harmful emissions through a response to the different engine operating conditions.

**General description of the injection system**

The essential conditions which always have to be satisfied in the preparation of the air/fuel mixture for the smooth running of ignition engines are basically two:

1. the metering (air/fuel ratio) should be kept as constant as possible and close to the stoichiometric value, in order to ensure the rapid combustion required to prevent unnecessary fuel consumption;
2. the mixture should be composed of petrol vapours atomized as finely and as uniformly as possible in the air.

In the Bosch Motronic M 2.10.4 system the injector nozzles carry out the task of atomizing the petrol into minute droplets.

Since the absolute pressure of the air drawn may vary, it is necessary to adjust the quantity of petrol to be injected so as not to alter the weight ratio between the air and the petrol.

The constancy of this ratio is obtained by varying the supply pressure of the fuel, by means of a regulator, according to the value of the vacuum of the air in the inlet manifold, so that the difference between the two pressures is constant at all engine operating conditions.

As far as the optimum metering, on the other hand, is concerned, it is calculated according to the following measurements:

- exact quantity of air drawn in by the flow meter (air flow meter);
- engine rotation speed by means of the rpm sensor;
- acceleration required by means of the butterfly valve position sensor;
- temperature of the engine coolant by means of the sensor on the thermostat mounting;
- measuring the oxygen content of the exhaust gases via the Lambda sensor.

This information is processed by a micro-processor in the injection/ignition electronic control unit which determines the basic injection time using values, obtained experimentally, which are stored in a special memory in the above mentioned control unit.

**General description of the ignition system**

The ignition system is the static advance, inductive discharge type (i.e. without a high tension distributor) with power modules inside the electronic control unit.

The system has a single coil for each spark plug; the advantages of this solution are:

- less electrical overloading
- guarantee of constant discharge at each spark plug

The electronic control unit memory contains the entire series of optimum advance values which the engine can adopt for its operating range according to the engine speed and load conditions.

## 10.

These values have been obtained experimentally, by means of a long series of practical tests carried out on prototypes at the engine test bench to identify the advances at which it is possible to achieve the best compromise between the conflicting requirements of maximum power and low consumption and harmful exhaust emissions.

The optimum advance values have then been memorized in the system control unit. During the operation of the engine, the control unit is constantly informed of the engine speed and load conditions and, on this basis, it "selects" the advance value from its memory to strike the spark at the spark plug for the cylinder during the explosion stroke with the optimum advance.

In addition the control unit corrects this value depending on further factors such as engine coolant temperature, intake air temperature, detonation and position of the butterfly valve, so that the ignition point is always optimum.

The information required by the control unit to operate the single coils is transmitted by means of electrical signals emitted by the following sensors:

- a. **An rpm sensor** which generates a single phase alternating signal, whose frequency indicates the engine rpm.
- b. **An air flow meter** which, on the basis of the quantity of air drawn in by the engine, transforms this value into an electrical signal, sending it to the electronic control unit.
- c. **An air temperature sensor** which transforms the value of the intake air temperature into an electrical signal, sending it to the electronic control unit.
- d. **Two detonation sensors** which are positioned in the upper part of the crankcase, one between cylinders 1 and 2 and the other between cylinders 4 and 5, allowing the control unit to recognize the cylinder which is detonating (or is in the early stages of detonation) and to correct the ignition advance for the spark plug for the cylinder involved only.
- e. **A butterfly valve position sensor** which transforms the angular value of the actual butterfly into an electrical signal allowing the control unit to recognize the conditions of minimum, partial or full load.

### Functions of the system

In addition to electronically controlling the moment of ignition and the air flow rate during idling in order to allow the engine to run smoothly when the environment parameters and the load conditions vary, the control unit must also control and manage the injection in such a way that the stoichiometric ratio (air/fuel) is always within the optimum values.

The electronic control unit establishes the «time» for the injectors following a relatively simple rule which can be summed up as follows.

Taking the physical characteristics of the fuel (viscosity and density) and the difference in pressure between the fuel and the pressure in the inlet manifold as constant, the quantity of fuel injected depends only on the «opening time» of the injector.

The functions carried out by the injection/ignition system are basically as follows:

- |  |  |
|--|--|
| - adjusting the injection times;               | - fuel vapour recovery;  |
| - adjusting ignition advances;                 | - checking detonation  |
| - checking cold starting;                      | - checking the phase transformer                                       |
| - checking the enrichment during acceleration; | - connection with the climate control system (where fitted);           |
| - fuel cut off during deceleration (Cut-off);  | - self-adjustment of the system  |
| - checking and managing engine idle speed;     | - connection with the engine starting immobilizing device (Fiat CODE); |
| - limiting the maximum number of revs;         | - autodiagnosis.   |
| - checking combustion via the Lambda sensor;   |  |

## SYSTEM MANAGEMENT STRATEGIES

### Adjustment of the injection times

Digital technology has made it possible to obtain optimum fuel consumption and performance by using programmed maps, stored inside the electronic control unit memory, dependent on the engine speed and load conditions.

The control unit controls the injectors with extreme speed and precision, calculating the opening time on the basis of the load on the engine (number of revs and air flow rate) also taking into account the battery voltage and the temperature of the engine coolant.

The injection is sequential and timed for each cylinder (the moment of injection is not simultaneous for all the cylinders) and takes place corresponding to the optimum injection point.

### Adjustment of ignition advances

Thanks to a map memorized inside the electronic control unit it is capable of calculating the advance according to the engine load (minimum, partial, full, on the basis of the number of revs and air flow rate), the temperature of the intake air and the temperature of the engine coolant.

It is possible to delay the ignition selectively for the cylinder requiring it, which can be recognized via the combination of the values recorded by the detonation and cam angle sensors.

### Checking cold starting

Under these circumstances there is a natural weakening of the mixture as a result of the poor turbulence of the particles of fuel at low temperatures, reduced evaporation and condensation on the inner walls of the inlet manifold, all of it exacerbated by the increased viscosity of the lubrication oil.

The electronic control unit recognizes this condition and corrects the injection time on the basis of the coolant temperature signal, the temperature of the intake air, the battery voltage and the engine speed.

The ignition advance is only dependent on the number of revs and the temperature of the engine coolant.

During starting the control unit controls an initial simultaneous injection for all the injectors (full-group injection) and after the reference on the flywheel is recognized, it switches to the normal sequential timed operation.

Whilst the engine is warming up, the electronic control unit controls the idle speed actuator which determines the quantity of air required to ensure that the engine does not cut out.

The rotation speed is made to decrease proportionally as the temperature increases until the nominal value is obtained when the engine has reached operating temperature.

### Checking acceleration enrichment

When there is a request for acceleration, if the air flow meter signal variation exceeds a pre-set increase, the control unit not only adjusts the injection to the new requirements, but also increases it further through rapidly reaching the speed required.

When approaching the pre-set speed, the injection increase is gradually eliminated.

**NOTE** *The request for acceleration is also detected by the potentiometer on the butterfly; this makes it possible to ensure optimum running if there is a failure in the air flow meter until a Service Dealer can be reached.*

### Fuel cut off during deceleration

The fuel cut off during deceleration is the modified type.

When the closed butterfly condition is recognized and the engine speed is greater than 1700 rpm (for engine speeds below 1700 rpm the cut off function is not operational to maintain optimum "driveability") the injection of fuel is deactivated.

With no fuel supply, the engine speed starts to decrease more or less quickly depending on the vehicle driving conditions.

# 10.

Before the idle speed is reached the dynamics of the engine speed decrease are checked.

If they exceed a certain value, the fuel supply is partly reactivated on the basis of a logic which involves the "soft accompaniment" of the engine at idle speed.

When this condition is reached the normal idle functions are reactivated and the cut off during deceleration is only reactivated if the fuel cut off level is exceeded to ensure that the engine runs smoothly. The levels at which the fuel supply is restored and the cut off activated depend on the temperature of the engine.

Another fuel cut off logic is developed in the engine which intervenes during partial deceleration, i.e. when lower engine loads are required.

The function is only activated if the new condition persists for a pre-set time and after the ignition advance angle has been adjusted to the new situation.

### Checking and managing engine idle speed

The adjustment of the idle speed is controlled in all operating conditions by means of the idle speed actuator which acts on the butterfly by-pass.

In addition to controlling the actual idle speed it also carries out the functions of a supplementary air valve and regulator for switching on the various consumers (e.g. the climate control compressor); with the butterfly in the end of travel position, in effect the actuator regulates the by-pass opening compensating for the power required by the consumers to ensure an engine idle speed of 750 rpm.

The actuator fitted on this version guarantees great responsiveness to adjustment because the opening and the closing of the by-pass are both operated by magnetic windings.

The correction of the idle is carried out not only by the actuator but also by the adjustment of the ignition (advance) angle because it has a more rapid effect.

**NOTE** *The self-adjustment function makes it possible to dispense with all idle speed adjustments with the butterfly casing sensor recognizing the "butterfly in the end of travel" position and correcting any wear which occurs in time and is detected by the butterfly closure position.*

### Limiting maximum number of revs (protection outside of revs)

When the engine speed exceeds 6,800 rpm, the electronic control unit reduces the injector operating times so that this value is not exceeded.

If the engine speed exceeds 7,013 rpm, the control unit activates the "fuel cut off" strategy restoring the operation of the injectors when the speed goes below 6,800 rpm.

### Checking combustion via the Lambda sensor

The Lambda sensor informs the control unit of the quantity of oxygen present at the exhaust and therefore the correct air/fuel metering.

The optimum mixture is obtained with a Lambda coefficient of 1 (optimum stoichiometric mixture). The electrical signal which the sensor sends to the control unit undergoes a sharp variation when the composition of the mixture differs from  $\text{Lambda} = 1$ . When the mixture is "lean" ( $\lambda > 1$ ) the control unit increases the quantity of fuel, when the mixture is "rich" ( $\lambda < 1$ ) it decreases it: in this way the engine operates as close as possible to the ideal Lambda value.

The Lambda sensor signal is processed, inside the control unit, by a special integrator which prevents sharp variations in the injection times to correct the mixture strength.

The sensor is heated by an electrical resistance in order to be able to reach the correct operating temperature of around 300 °C rapidly.

By using this sensor it is possible to regulate the engine carburation with precision. This makes it possible, amongst other things, to operate at the limits laid down for emissions.

### **Fuel vapour recovery**

The (pollutant in terms of the regulations) fuel vapours are sent to an active charcoal filter and from there towards the engine where they are burnt; this takes place by means of a solenoid valve which is operated by the control unit only when the engine is in a load condition which allows the correct combustion without the operation of the engine being "disturbed": in effect, the control unit compensates for this quantity of petrol entering with a reduction of the supply to the injectors.

### **Checking detonation**

The function has the task of detecting the presence of the phenomenon of detonation (engine knocking) by processing the signal coming from the relevant sensors. The control unit constantly compares the signals coming from the sensors with a threshold value which, in turn, is continuously updated, to take into account background noise and the ageing of the engine.

The control unit is therefore capable of detecting detonation (or the early stages of detonation) and makes provisions to reduce the ignition advance (from 3° up to maximum of 9.7°), until the phenomenon disappears. Afterwards the advance is gradually restored until the basic value is reached.

In acceleration conditions, a higher threshold is used, to take into account the greater noise produced by the engine in these circumstances. The detonation control strategy is also equipped with a self-adjustment function which ensures the memorizing of the advance reductions which should be constantly repeated to adapt to the different conditions in which the engine finds itself.

### **Checking phase transformer**

The control unit controls the solenoid valve which controls the phase transformer depending on the engine load conditions. When the temperature of the coolant exceeds 40 °C and when the engine speed is higher than the idle speed and lower than 4,800 rpm with the butterfly angle greater than about 8°, the control unit sends a signal to the solenoid valve which is activated and allows the transformer to decrease the timing diagram for the inlet stage by 18° (torque operation).

When the engine is idling or the speed exceeds 4,800 rpm, the control unit deactivates the solenoid valve and the transformer restores the inlet timing to the previous basic values.

Obviously the control of the phase transformer operates with a hysteresis field, i.e. the activating level for the solenoid valve is always higher than the deactivating level; this is designed to prevent balance conditions and a consequent too rapid succession passing from one timing diagram to another with obvious operating problems.

### **Connection with the climate control system**

When the climate control is switched on the compressor absorbs power from the engine which, when idling, tends to cut out. To prevent this problem the control unit adjusts the air flow rate to the new power requirements, controlled by the appropriate actuator (this adjustment also takes place during usage conditions to maintain optimum "driveability"). Another function of the system is that of momentarily interrupting the supply to the compressor in the case of high power requirements by the engine (strong acceleration).

### **System self-adjustment**

The control unit is equipped with a self-adjustment function which has the task of recognizing the changes which take place in the engine due to the settling processes which take place over a period of time and the ageing of both the components and the engine itself.

These changes are stored in the memory in the form of modifications to the basic map and have the task of adapting the operation of the system to the gradual alterations to the engine and the components in relation to the characteristics when new.

## 10.

This self-adjustment function also makes it possible to compensate for the inevitable differences (due to production tolerances) of any components which may have been replaced. This allows the best possible results for all vehicles with special adjustment or checking operations.

The self-adjustment parameters are lost if the control unit is disconnected.

### Connection with engine starting immobilizing device (Fiat CODE)

To increase protection against theft attempts, the vehicle has been equipped with an engine immobilizing device (Fiat CODE) which only allows the activation of the injection/ignition control unit by means of an electronic code.

Each time the key is turned to the OFF position, the Fiat CODE system completely deactivates the injection/ignition control unit.

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

1. The injection/ignition control unit sends the Fiat CODE control unit a request for the secret code in order to deactivate the functions lock.
2. The Fiat CODE control unit responds by sending the secret code only after it, in turn, has received the recognition code transmitted by the ignition key, which contains a special transponder inside.
3. The recognition of the secret code allows the de-activation of the functions lock and the injection/ignition control unit can activate the normal system management programme.

A special two directional serial line allows the exchange of information between the injection/ignition control unit and the Fiat CODE control unit.

If there is a failure in the Fiat CODE system it is, however, still possible to start the engine via an emergency procedure.



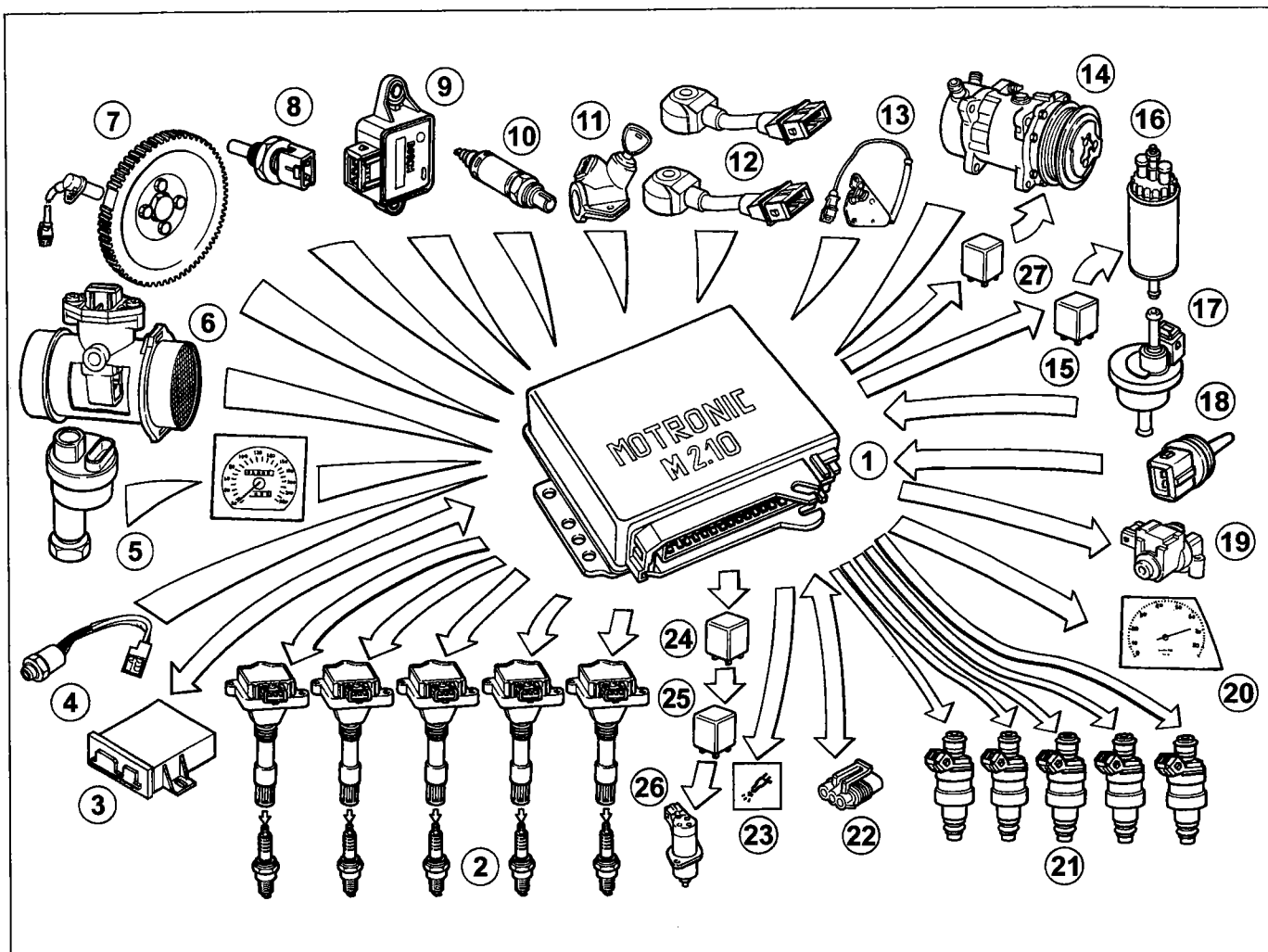
*Control units must not, under any circumstances, be exchanged between different vehicles to check if they are working properly.*

*During the fault diagnosis, before replacing the control unit, make sure that it really is not working properly, because when a new control unit is supplied the secret code is memorized making it completely unusable on other vehicles.*

### Autodiagnosis

The Motronic M 2.10.4 injection/ignition system is also equipped with an “**autodiagnosis**” function which memorizes any problems with the sensors and actuators, making it easier to detect and correct them. Any problem is signalled by the appropriate warning light in the instrument panel.

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



P4A07FJ02

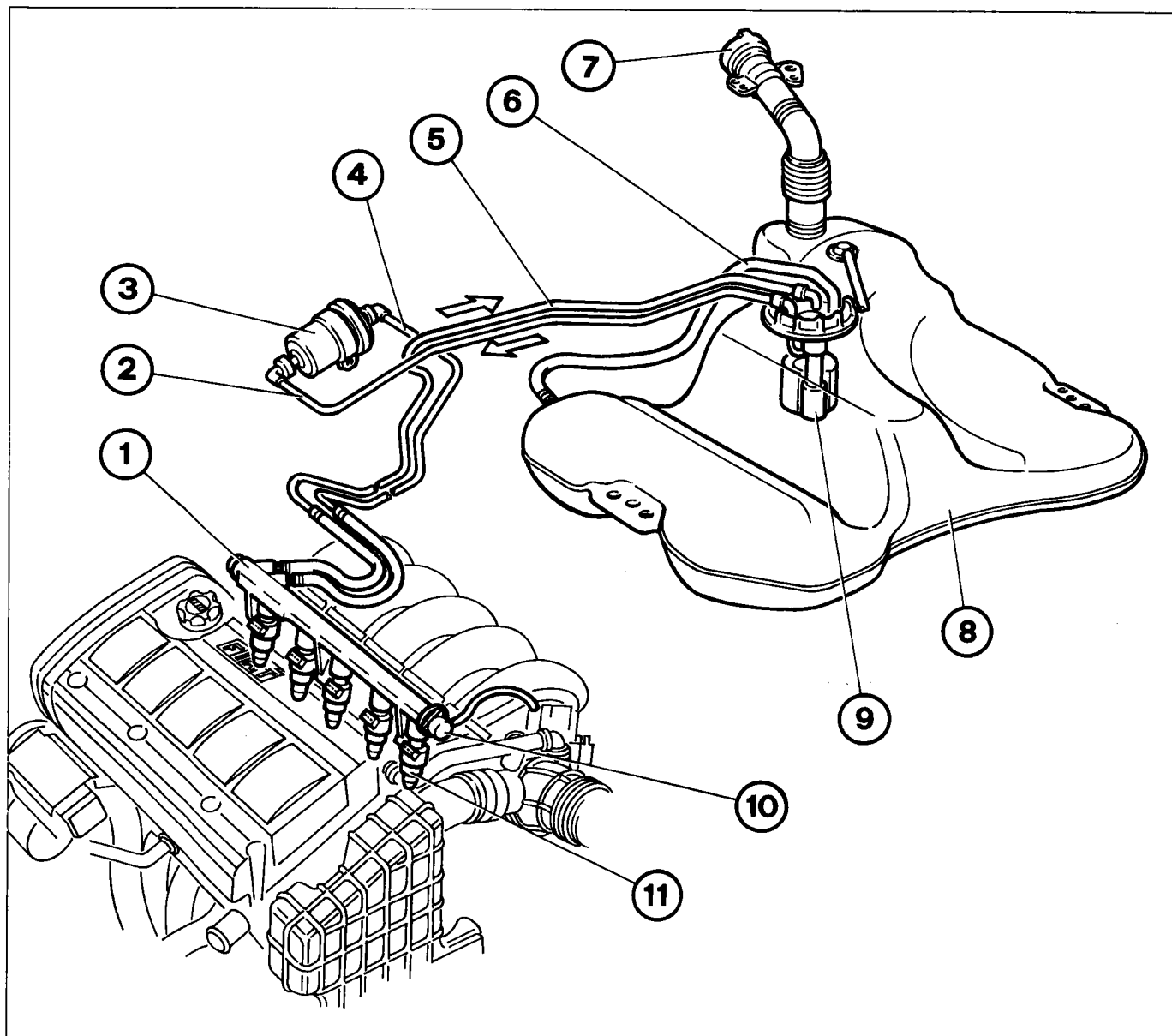
**Components key**

- |                                   |  |
|-----------------------------------|--|
| 1. Electronic control unit        | 15. Electric fuel pump and Lambda sensor relay |
| 2. Coils and spark plugs          | 16. Electric fuel pump                         |
| 3. Fiat CODE control unit         | 17. Petrol vapour inlet solenoid valve         |
| 4. Three stage pressure switch    | 18. Intake air temperature sensor              |
| 5. Speedometer sensor             | 19. Engine idle speed actuator                 |
| 6. Flow meter                     | 20. Rev counter signal                         |
| 7. Rpm sensor                     | 21. Injectors                                  |
| 8. Coolant temperature sensor     | 22. Diagnostic socket                          |
| 9. Butterfly potentiometer        | 23. I.E. system failure warning light          |
| 10. Lambda sensor                 | 24. I.E. system relay.                         |
| 11. Ignition switch               | 25. Relay for phase transformer                |
| 12. Detonation sensors            | 26. Phase transformer solenoid valve           |
| 13. Timing sensor                 | 27. Air conditioning relay feed                |
| 14. Climate control system signal |  |



# 10.

**DIAGRAM SHOWING FUEL SUPPLY CIRCUIT**

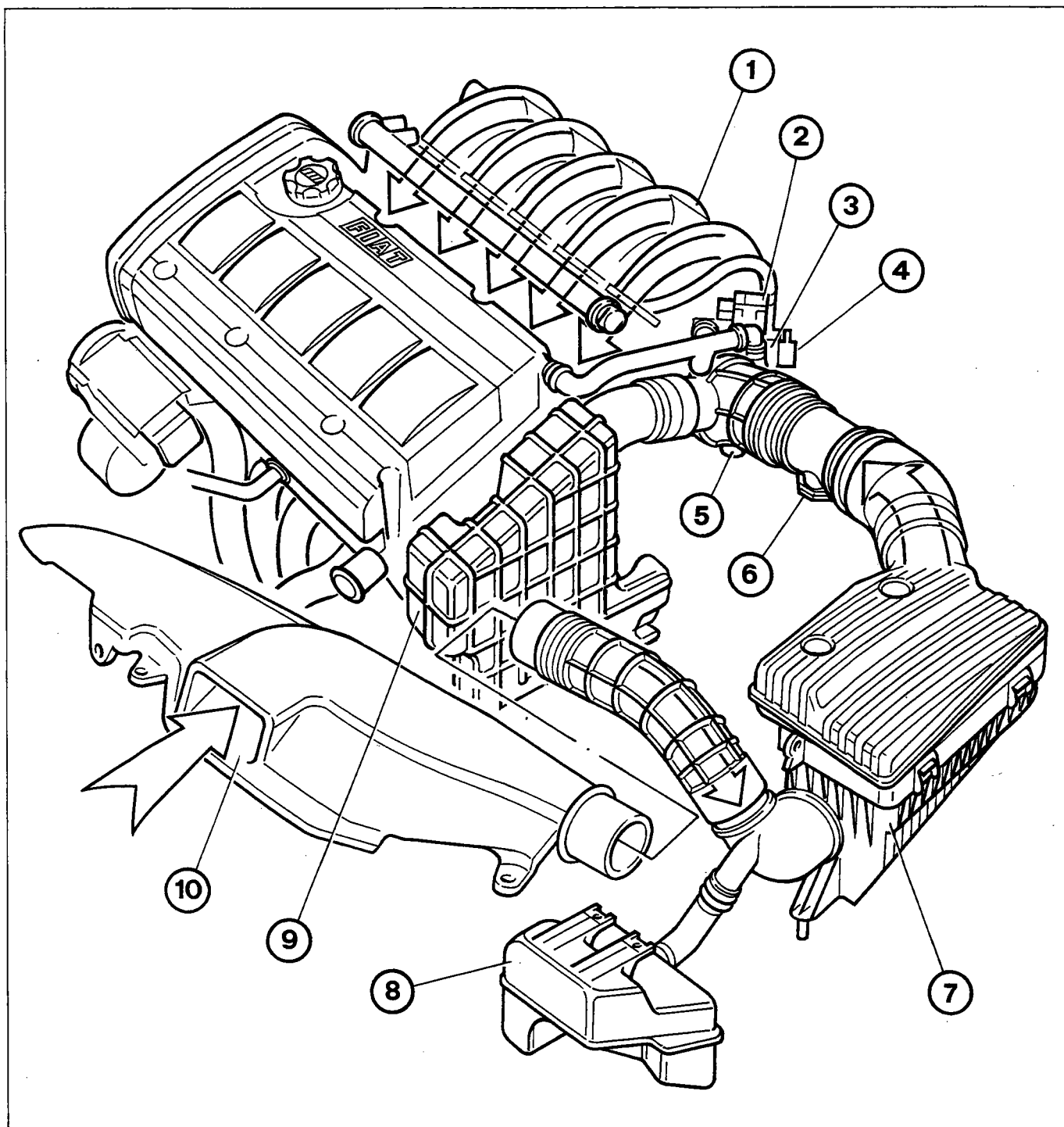


P4A08FJ01

1. Fuel supply manifold
2. Supply pipe from the tank to the filter
3. Filter
4. Supply pipe from filter to injectors
5. Return pipe
6. Breather pipe
7. Filler with ventilation and safety valve
8. Tank
9. Electric pump
10. Pressure regulator
11. Injectors

**NOTE** *Given the special shape of the tank, when fuel is being introduced an air pocket tends to form in the lower part preventing it from being filled completely; the pipe (6) allows the air to flow from the bottom thereby enabling the tank to be filled completely.*

**DIAGRAM SHOWING AIR INTAKE CIRCUIT**



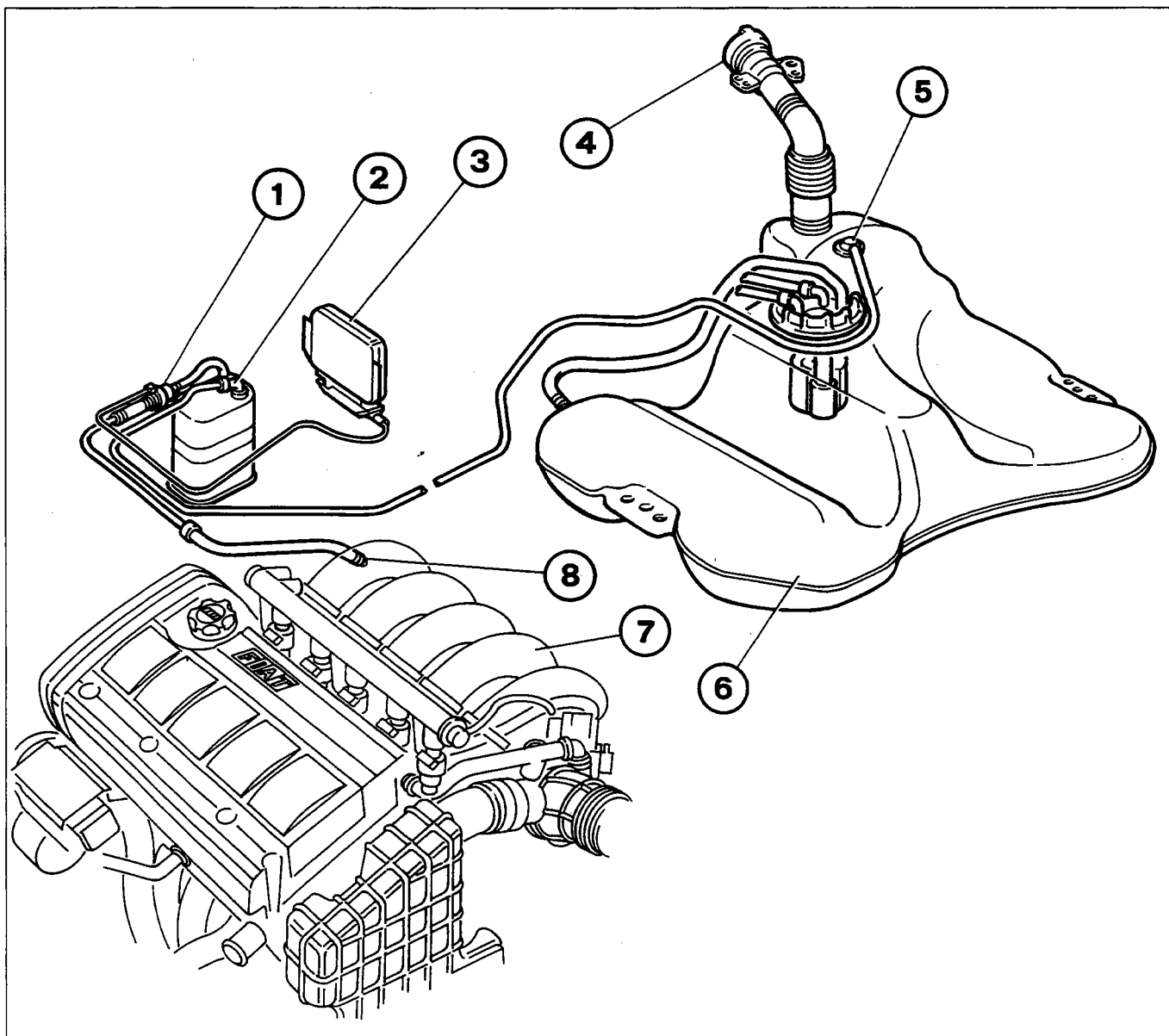
P4A09FJ01

- 1. Inlet manifold
- 2. Engine idle speed actuator
- 3. Butterfly casing
- 4. Butterfly valve position sensor
- 5. Air temperature sensor

- 6. Flow meter
- 7. Air filter
- 8. Lower resonator
- 9. Upper resonator
- 10. Inlet opening

# 10.

## DIAGRAM SHOWING FUEL ANTI-EVAPORATION CIRCUIT



P4A10FJ01

The anti-evaporation system has the task of preventing the fuel vapours, made up of the lightest sections of hydrocarbons which form in the tank, from being discharged into the atmosphere.

1. Fuel vapour cut out valve
2. Charcoal filter
3. Injection/ignition control unit
4. Safety and ventilation valve
5. Multi-purpose valve
6. Tank
7. Inlet manifold
8. Fuel vapour intake

# **SYSTEM FOR RECIRCULATING GASES COMING FROM THE ENGINE CRANKCASE**

This system controls the emissions, from the engine crankcase, of breather gases made up of air/petrol mixtures and burnt gases which escape from the piston seals, in addition to lubricant oil vapours, recirculating them to the inlet.

The breather gases, directed by special walls, rise by the engine oil filler and then pass through the labyrinth (7), under the tappet cover, where they lose part of the oil which they contain, in the form of droplets, falling on the camshafts through the pipe (6).

The siphon shape of the pipe (6) prevents the breather gases from escaping and only allows the recirculation of the droplets of oil.

The remaining gases escape from the intake (5) inside of which there is a spark out (4) (to prevent the phenomenon of combustion due to flame returns from the butterfly casing).

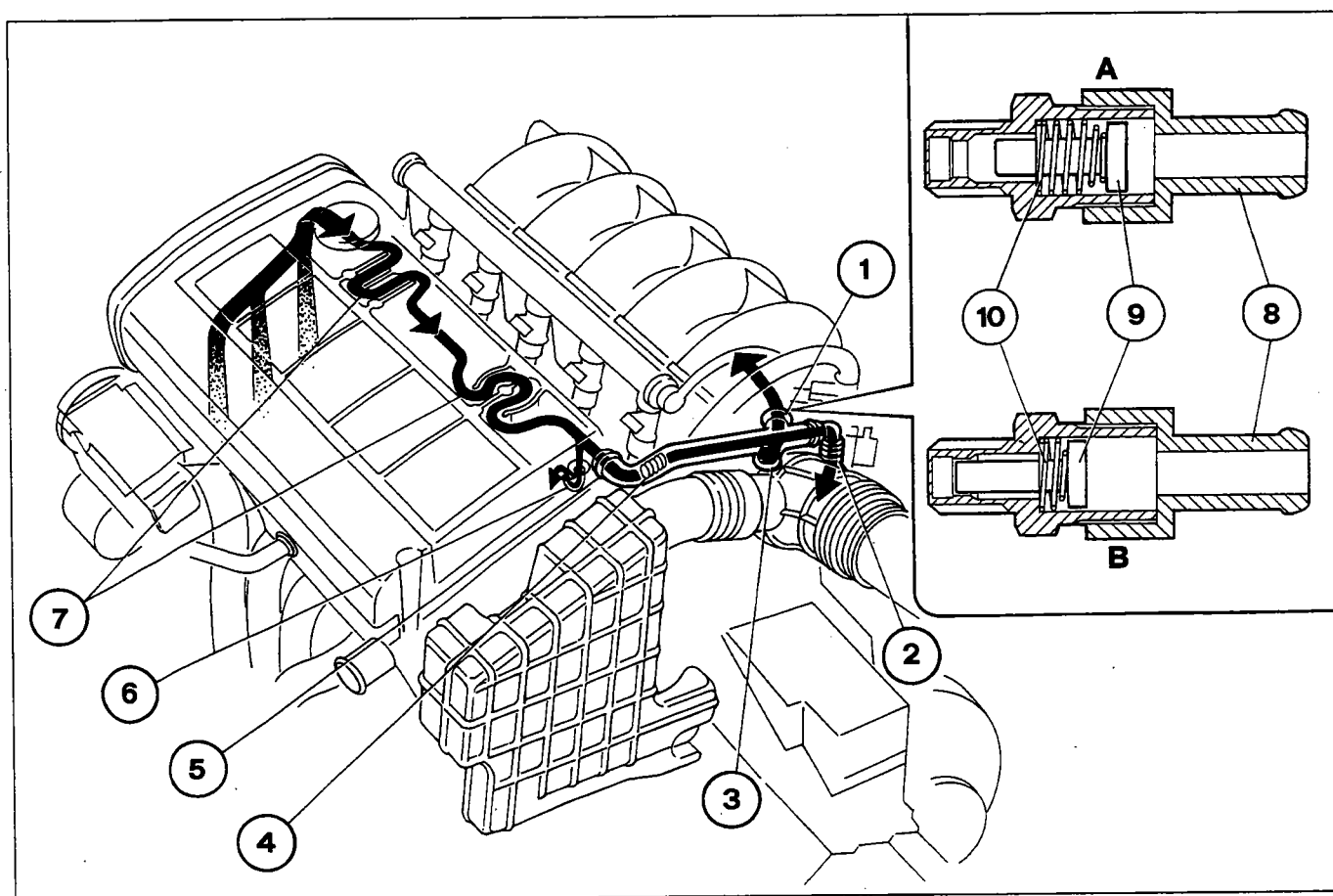
From the intake (5) the breather gases reach the T union (3).

With the butterfly open, the gases flow through the intakes (1) and (2) to be drawn into the manifold.

With the butterfly closed, the vacuum in the inlet manifold draws in the gases through the intake (1) which contains a PVC restricting valve (8) (Positive Crank Ventilation) which shutters the intake.

The PCV valve can, in effect, be modulated and the quantity of gas which passes through is proportional to the vacuum in the inlet manifold.

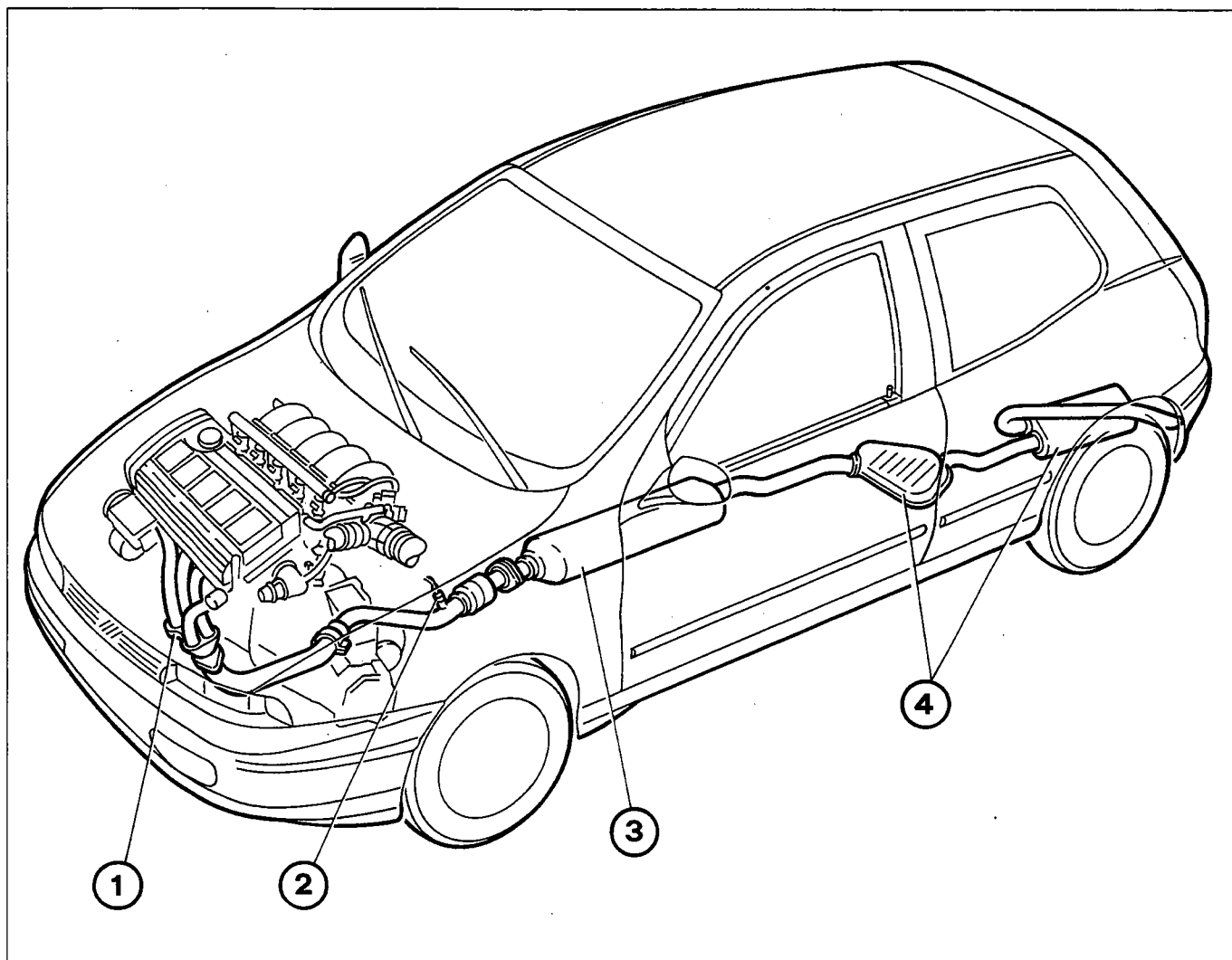
When the butterfly valve is completely open (condition A), the vacuum inside the inlet manifold is minimal, the spring (10) is fully extended and the PCV valve allows the maximum flow of breather gases. Viceversa, with the butterfly completely closed (condition B), the vacuum inside the manifold is maximum, this causes the movement of the piston (9) which shutters the section through which the breather gases flow inside the PCV valve thereby restricting the intake of the actual gases in the manifold.



P4A11FJ01

## 10.

### DIAGRAM SHOWING ENGINE EXHAUST ASSEMBLY

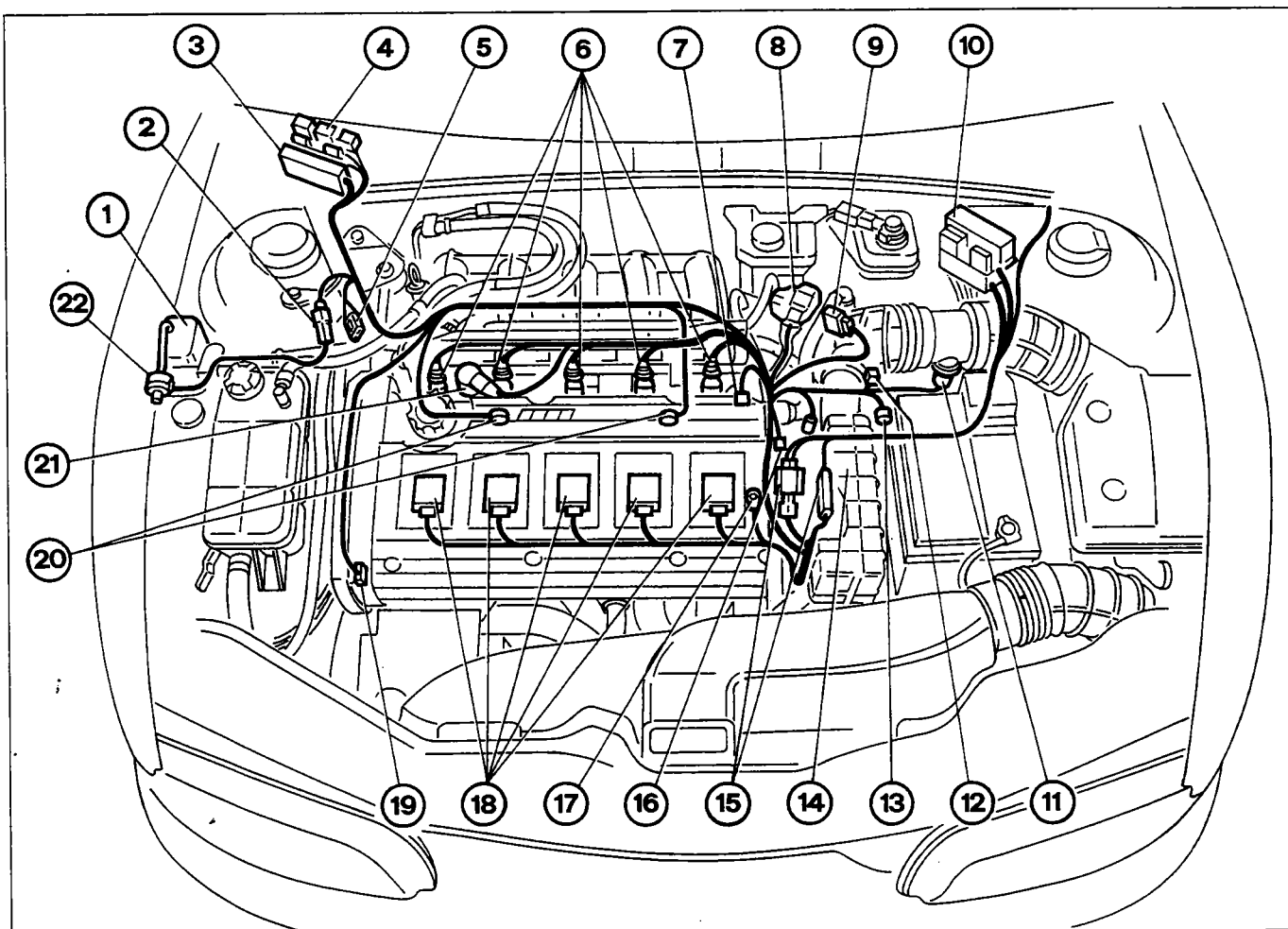


P4A12FJ01

#### Key

1. Exhaust manifold
2. Lambda sensor
3. Catalytic silencer
4. Silencers

**LOCATION OF INJECTION/IGNITION SYSTEM COMPONENTS**



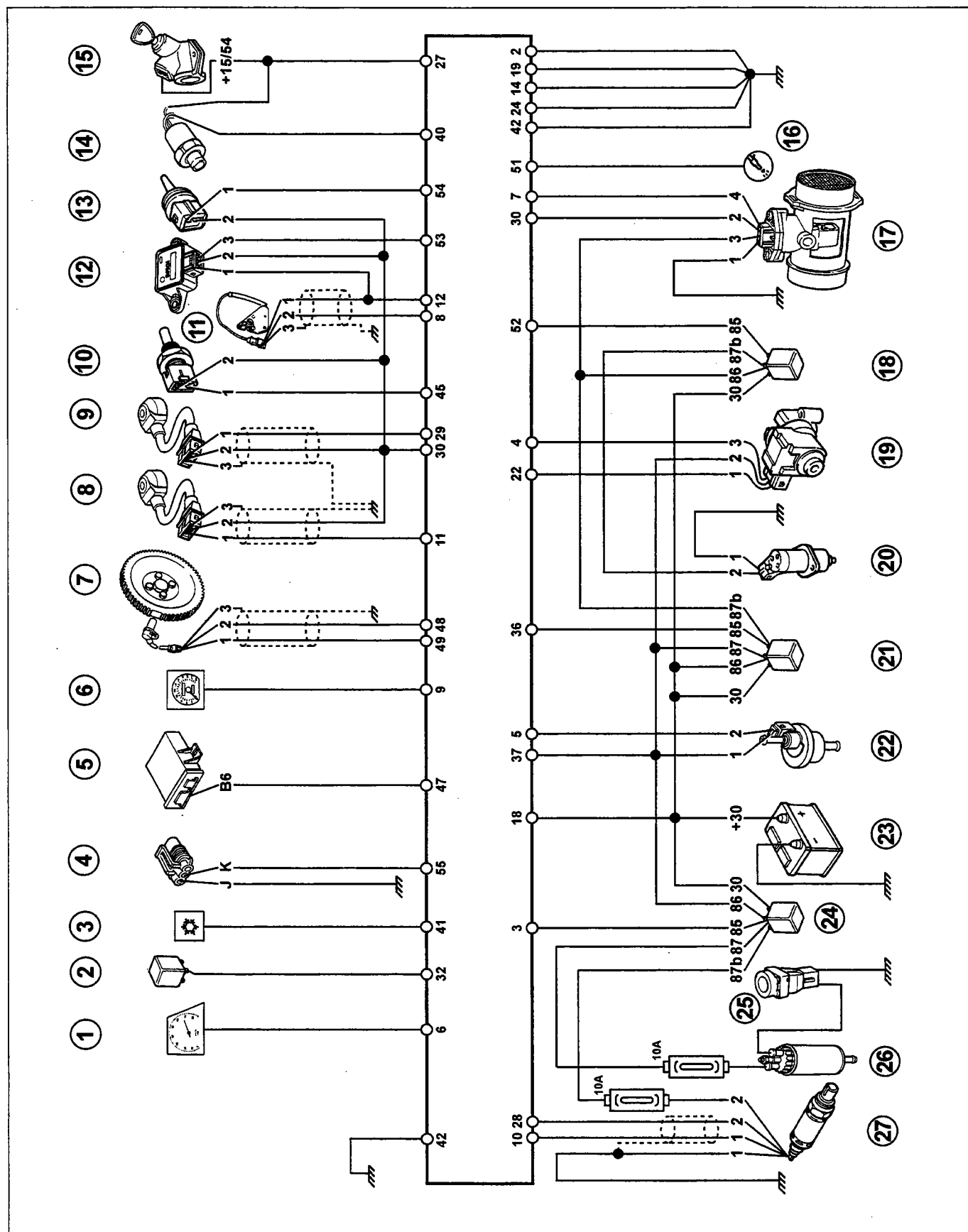
P4A13FJ01

**Key**

- |  |  |
|--|--|
| 1. Charcoal filter                       | 12. Air temperature sensor                       |
| 2. Fuel vapour solenoid valve connection | 13. Vehicle speed sensor                         |
| 3. Injection/ignition control unit       | 14. Lambda sensor                                |
| 4. Fuses and relays                      | 15. Join between front cable and injection cable |
| 5. Diagnostic socket                     | 16. Coolant temperature sensor                   |
| 6. Injectors                             | 17. Earth connection                             |
| 7. Rpm sensor                            | 18. Ignition coils                               |
| 8. Engine idle speed actuator            | 19. Timing sensor                                |
| 9. Butterfly valve position sensor       | 20. Detonation sensor                            |
| 10. General system protective fuse       | 21. Phase transformer solenoid valve             |
| 11. Flow meter                           | 22. Fuel vapour solenoid valve                   |

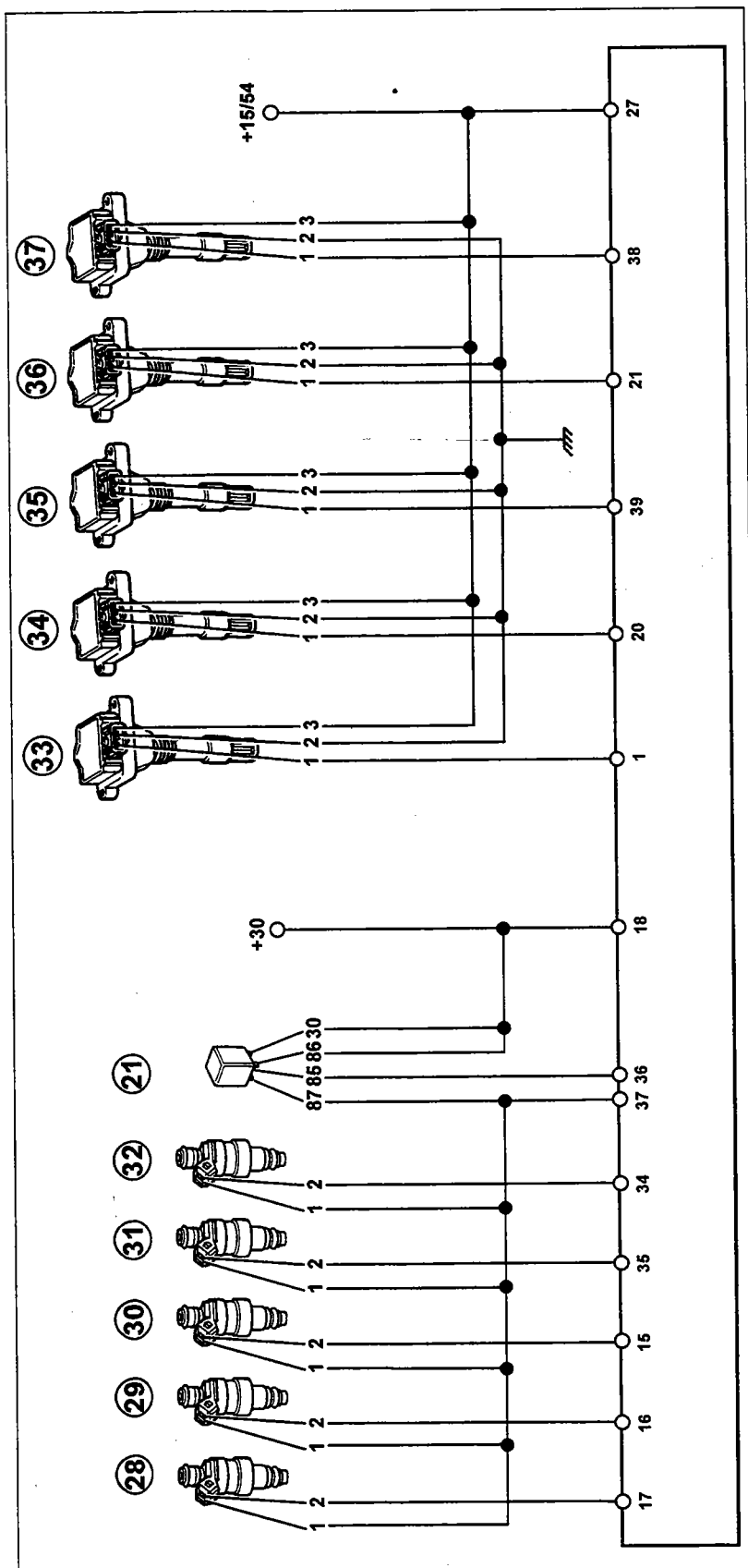
# 10.

## WIRING DIAGRAM SHOWING INJECTION/IGNITION SYSTEM



P4A14FJ01

Connection of control unit/ignition coils and injectors



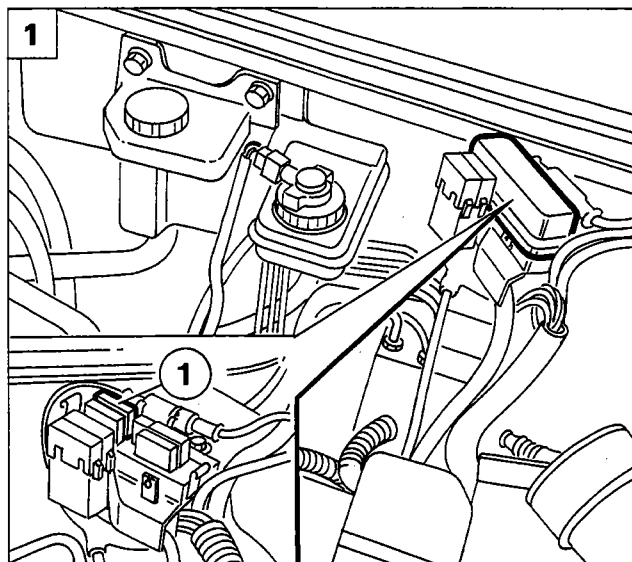
Key:

1. Rev counter signal
2. Climate control relay
3. Climate control on button
4. Fiat/Lancia Tester diagnostic socket
5. Fiat CODE control unit
6. Speedometer signal
7. Rpm and TDC sensor
8. Detonation sensor 1
9. Detonation sensor 2
10. Water temperature sensor
11. Timing sensor
12. Butterfly valve position sensor
13. Intake air temperature sensor
14. Three stage pressure switch
15. Ignition switch
16. I.E. system failure warning light
17. Flow meter
18. Phase transformer solenoid valve relay
19. Engine idle speed actuator
20. Phase transformer solenoid valve
21. I.E. system relay feed
22. Fuel vapour solenoid valve
23. Battery
24. Electric fuel pump relay and Lambda sensor
25. Inertia switch
26. Electric fuel pump
27. Lambda sensor
28. Injector for cylinder N°1
29. Injector for cylinder N°2
30. Injector for cylinder N°3
31. Injector for cylinder N°4
32. Injector for cylinder N°5
33. Ignition coil for cylinder N°1
34. Ignition coil for cylinder N°2
35. Ignition coil for cylinder N°3
36. Ignition coil for cylinder N°4
37. Ignition coil for cylinder N°5

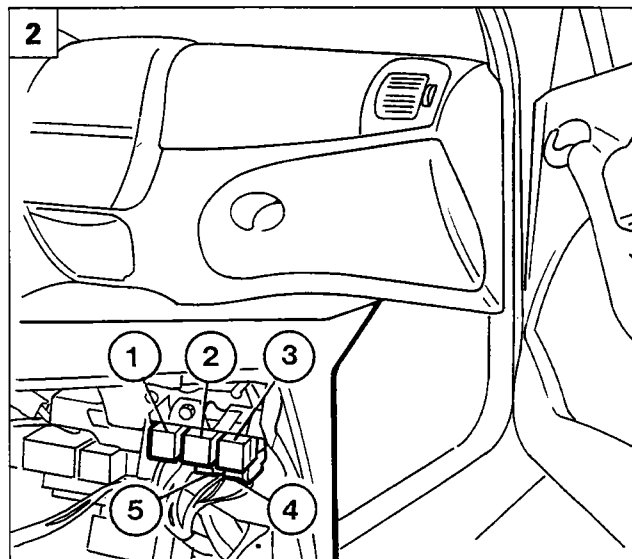
P4A15FJ01



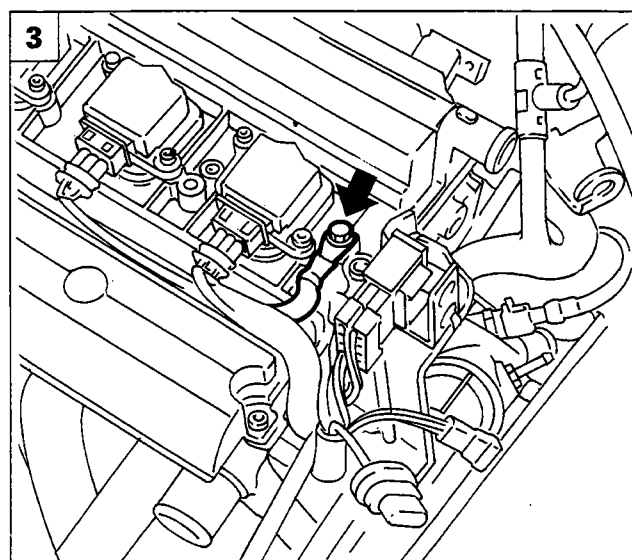
# 10.



P4A23CJ01



P4A16FJ02



P4A16FJ03

## FUSES, RELAYS AND EARTH POINTS

### 1. General protective fuse

The general protective fuse (EFI-30A) for the injection/ignition system (1) is housed inside a container; to gain access to it, remove the cover releasing the side clips.

### 2. Fuses and relays

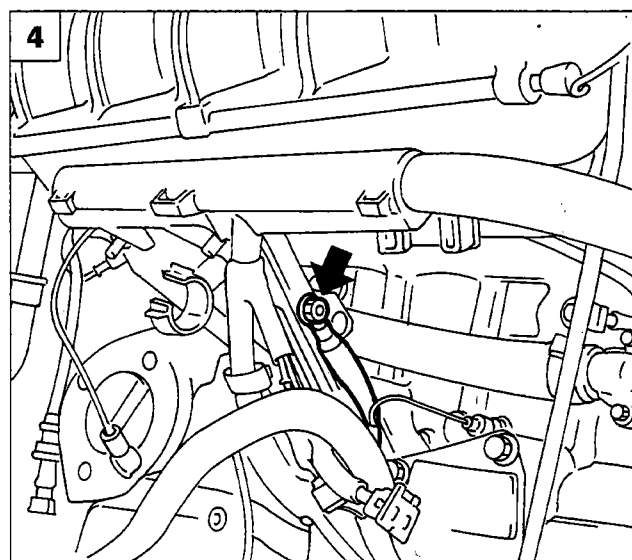
These are located under the glove compartment, in front of the electronic control unit.

1. Phase transformer solenoid valve relay
2. Injection system relay
3. Electric fuel pump relay
4. Lambda sensor fuse (10A)
5. Electric fuel pump fuse (10A)

### 3-4 Earth points

In order to improve electro-magnetic compatibility and operational reliability special care has been taken over the number and location of the earth points:

3. secondary coils connected below the cylinder head cover;
4. earth control unit (pin 2, 14, 19, 24,42), Lambda sensor heater, flow meter and phase transformer solenoid valve connected to the inlet manifold mounting bracket.



P4A16FJ04

## INJECTION/IGNITION SYSTEM COMPONENTS

The injection/ignition system is basically made up of wiring, an electronic control unit (I.E. control unit) and the following sensors/actuators:

### Sensors

- Speedometer sensor
- Rpm and T.D.C. sensor
- Detonation sensors
- Coolant temperature sensor
- Timing sensor
- Butterfly valve position sensor
- Intake air temperature sensor
- Intake air flow rate sensor (flow meter)
- Lambda sensor

### Actuators

- Engine idle speed actuator
- Phase transformer solenoid valve
- Fuel vapour cut out solenoid valve
- Electric fuel pump
- Injectors
- Ignition coils
- Spark plugs

## INJECTION/IGNITION SYSTEM WIRING

The connection between the different system components is achieved by means of a single set of wiring with various type connectors grouped together in special conduits fitted on the engine.

## INJECTION/IGNITION ELECTRONIC CONTROL UNIT

It is made up of thick film hybrid circuits and is connected to the electrical wiring by means of a **55 way** (or pole) multiple connector.

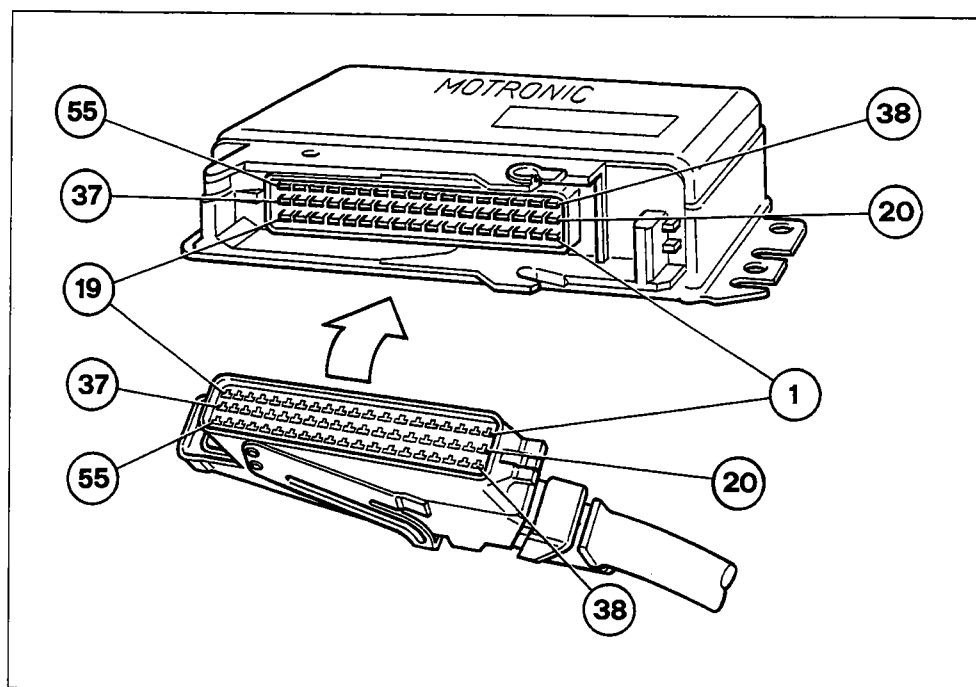
All the information on the engine operating conditions transmitted by the various sensors flows into the control unit.

By means of this data and with the aid of characteristic programmes written indelibly in its memory, the control unit is capable of achieving the following objectives:

1. Managing the injection time and frequency; in other words, it provides the quantity of fuel calculated for each cylinder with a sequential, timed operation (1-2-4-5-3).  
In practice, the air/fuel ratio should always remain within the optimum value, defined during setting up, in order to limit fuel consumption, reduce harmful exhaust emissions and ensure optimum thermodynamic efficiency for the engine.
2. Electronically controlling the moment of ignition (ignition advance)
3. Controlling the air flow rate at the rotation speed through the specific sensor in order to allow the smooth running of the engine as the environmental parameters and loads applied vary.
4. Detecting, by carrying out the programmes, any operating defects for the different sensors recorded in the RAM and replacing the incorrect data or data not received with replacement values to ensure the operation of the engine even in emergency conditions (RECOVERY).
5. Supplying the Fiat/Lancia Tester, if connected, via the serial line (diagnostic socket) with the data relating to the operating defects detected and memorized.

# 10.

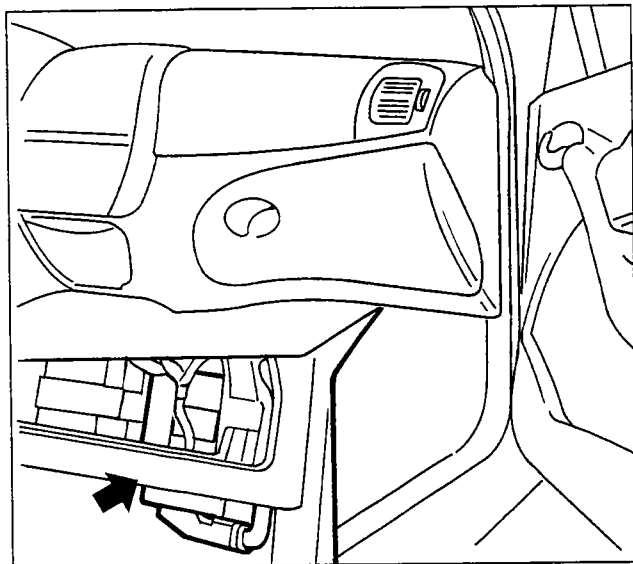
## IDENTIFICATION OF CONTROL UNIT CONNECTIONS (PIN-OUT)



P4A18FJ01

- |  |  |
|--|--|
| 1. Ignition coil for cylinder N°1                  | 29. Detonation sensor                        |
| 2. Engine earth                                    | 30. Supply for various sensors               |
| 3. Electric fuel pump relay feed and Lambda sensor | 31. Not connected                            |
| 4. Engine idle speed actuator                      | 32. Climate control go ahead relay           |
| 5. Fuel vapour solenoid valve                      | 33. Not connected                            |
| 6. Rev counter signal                              | 34. Injector for cylinder N°5                |
| 7. Intake air flow meter                           | 35. Injector for cylinder N°4                |
| 8. Timing sensor                                   | 36. I.E. system relay                        |
| 9. Speedometer sensor                              | 37. Supply (+)                               |
| 10. Lambda sensor                                  | 38. Ignition coil for cylinder N°5           |
| 11. Detonation sensor                              | 39. Ignition coil for cylinder N°3           |
| 12. Timing sensor                                  | 40. Three stage pressure switch              |
| 13. Not connected                                  | 41. Air conditioning on signal               |
| 14. Engine earth                                   | 42. Engine earth                             |
| 15. Injector for cylinder N°3                      | 43. Not connected                            |
| 16. Injector for cylinder N°2                      | 44. Not connected                            |
| 17. Injector for cylinder N°1                      | 45. Coolant temperature sensor               |
| 18. Supply (+30)                                   | 46. Not connected                            |
| 19. Engine earth                                   | 47. Fiat CODE control unit                   |
| 20. Ignition coil for cylinder N°2                 | 48. Rpm and TDC sensor                       |
| 21. Ignition coil for cylinder N°4                 | 49. Rpm and TDC sensor                       |
| 22. Engine idle speed actuator                     | 50. Not connected                            |
| 23. Not connected                                  | 51. I.E. system failure warning light        |
| 24. Engine earth                                   | 52. Phase transformer solenoid valve relay   |
| 25. Not connected                                  | 53. Butterfly valve position sensor          |
| 26. Not connected                                  | 54. Intake air temperature sensor            |
| 27. Supply (+15/54)                                | 55. Diagnostic socket for Fiat/Lancia Tester |
| 28. Lambda sensor                                  |  |

# 10.



P4A19FJ01



## REMOVING-REFITTING ELECTRONIC CONTROL UNIT

The electronic control unit is located under the glove compartment (right hand side). To remove the control unit proceed as follows:

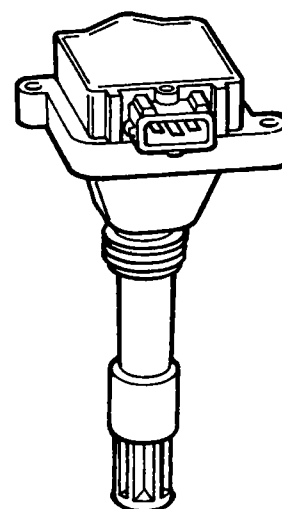
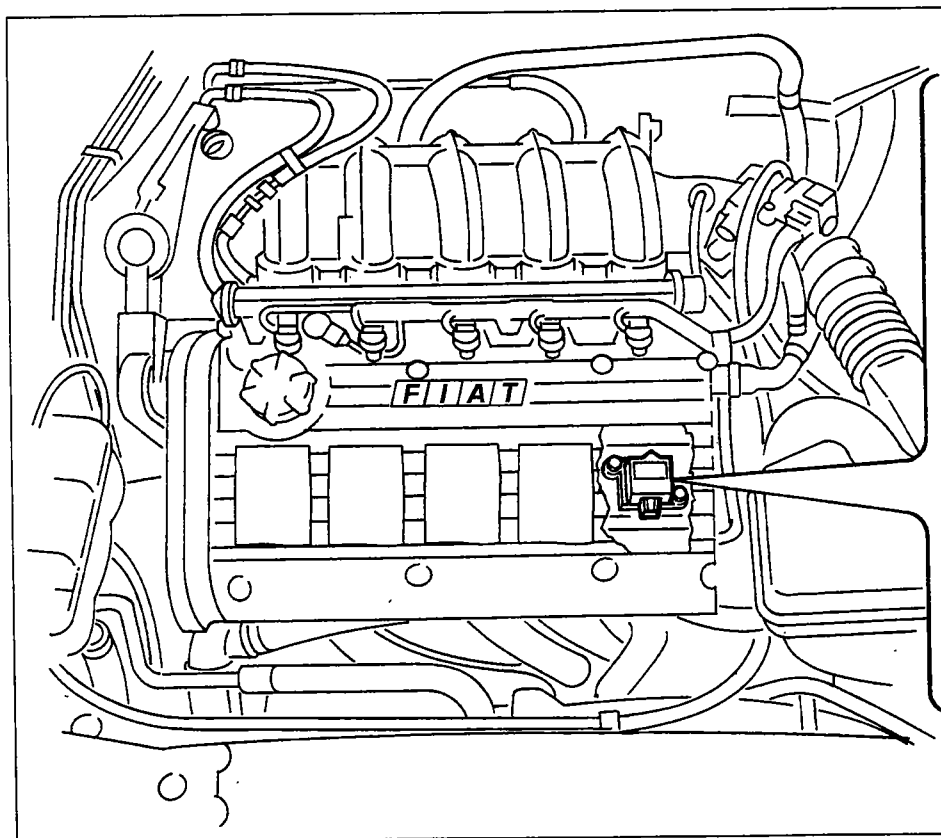
- Undo the bolts fixing the control unit to the mounting bracket.
- To remove the multiple connector, pull the connector clip upwards.



*There could be tension at the terminals not connected therefore no connections should ever be made because there is the risk of a short circuit with damage to the control unit.*

*The operations of fitting and removing the multiple connector should be carried out with the ignition switched off.*

## IGNITION COILS (0 221 504 006)

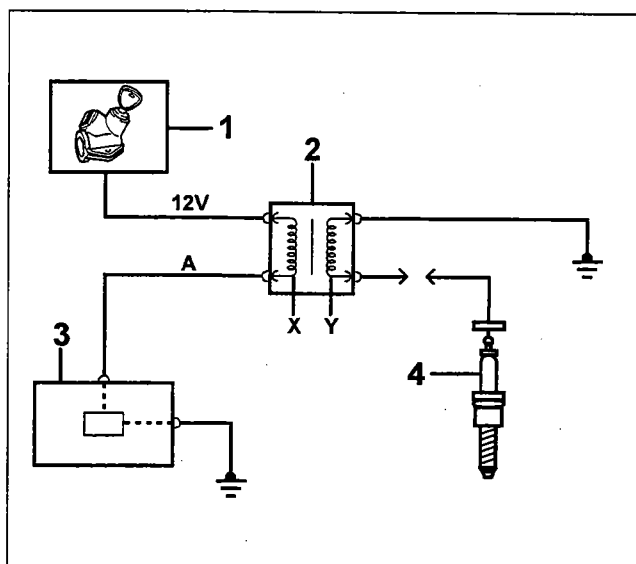


P4A19FJ02

The "static advance" electronic ignition has been improved with a single coil for each spark plug (SINGLE COIL); in addition, the power modules are contained inside the control unit; in practice this solution eliminates the H.T. circuit, further increasing reliability and safety and decreasing the risk of interference due to the high tension leads and connections.

They are normal coils which increase the tension of the impulse sent to the spark plugs: each individual coil, located on the cylinder head, directly supplies a spark plug without intermediate H.T. leads.

### 10.



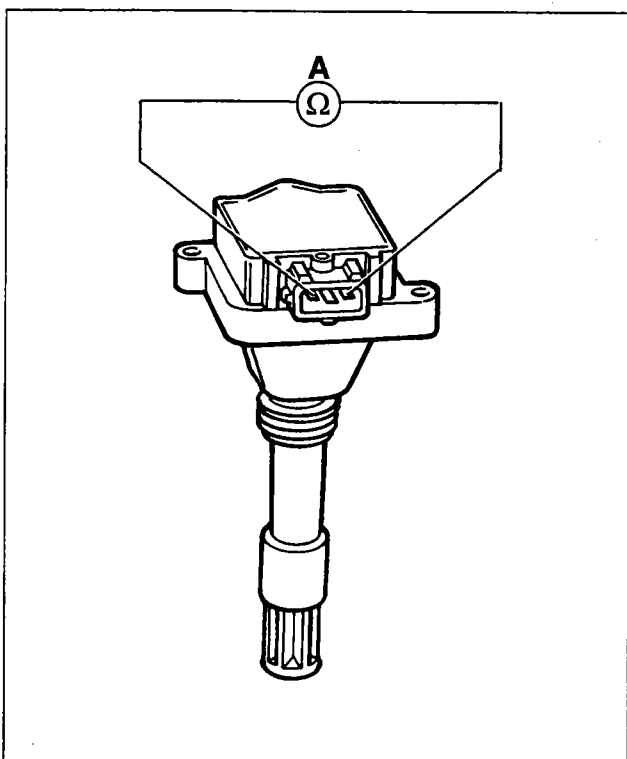
P4A20FJ01

#### Electrical features

Primary winding inductance..... 3 mH  
 Primary winding resistance..... 0,4  $\Omega$   
 Interference resistance..... 1 K $\Omega$

#### Diagram showing electrical connections

- A. Operating signal
- X. Primary winding
- Y. Secondary winding
- 1. Supply via ignition switch
- 2. Single coil
- 3. Electronic control unit
- 4. Spark plug



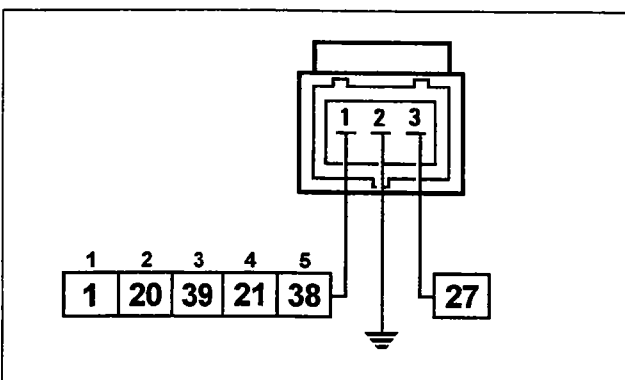
P4A20FJ02

#### Checking coil circuit resistance

##### A. Primary circuit

The resistance is checked by connecting an ohmmeter to the connector outer pins, as shown in the diagram.

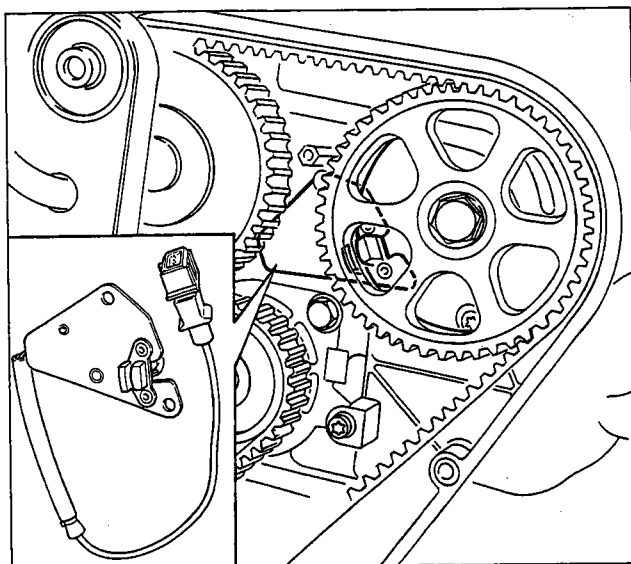
**Primary resistance: 0.4 ohm**



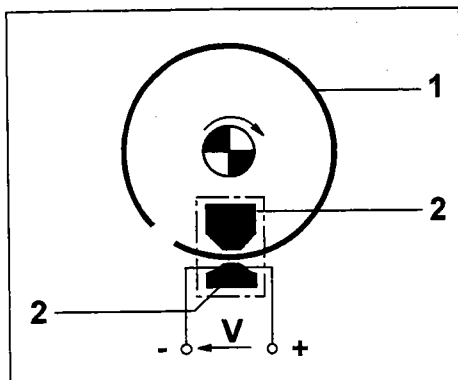
P4A20FJ03

#### Wiring connector

*The numbers indicate the corresponding pins for the control unit arranged in the order of the number of cylinders.*



P4A21FJ01



P4A21FJ02

1. Deflector (pulley seal)
2. Magnetic material

A semi-conductor layer with current passing through, immersed in a normal magnetic field (lines of force perpendicular to the direction of the current) generates a difference in power, known as "HALL" tension.

If the intensity of the current remains constant, the tension generated depends only on the intensity of the magnetic field; it is therefore sufficient for the intensity of the magnetic field to be varied periodically to obtain a modulated electrical signal where the frequency is proportional to the speed with which the magnetic field changes.

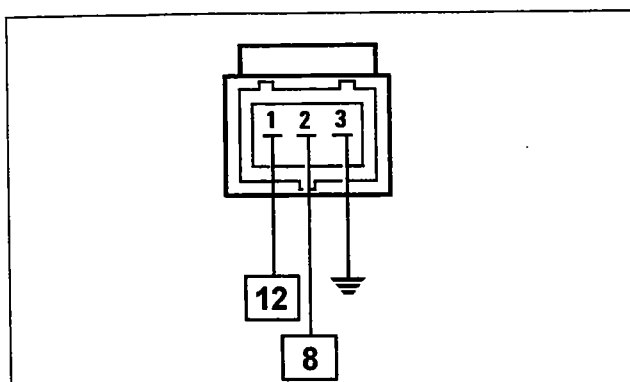
To obtain this change, a metal ring (inner part of the pulley) with an opening is made to pass through the sensor. When it moves the metal part of the ring covers the sensor blocking the magnetic field with the consequent low output signal; viceversa, by the opening and therefore where the magnetic field is present, the sensor generates a high signal.

As a result the high signal alternates with the low signal once every two revolutions of the engine and precisely when cylinder N°1 is 78° before TDC.

This signal, together with the rpm and TDC signal, allows the control unit to recognize the cylinders and determine the injection point. For each revolution of the engine the control unit checks that the timing signal is present; if this signal is lacking for two consecutive revolutions, the control unit signals the failure (warning light in the instrument panel comes on) and the engine cannot be started up.

### Wiring connector

The numbers indicate the corresponding pins for the control unit



P4A21FJ03

### TIMING SENSOR (0.232.101.036)

The Bosch Motronic M 2.10.4 system uses a sequential timed system, i.e. the injection of the fuel takes place in sequence for each cylinder during the inlet stroke.

To achieve this, the electronic control unit also uses a timing signal to determine the injection point in addition to the rpm and TDC signal.

The signal sent to the control unit is produced by a Hall effect sensor fitted by the camshaft drive pulley, exhaust side.

### Operating principle

### Removing-refitting

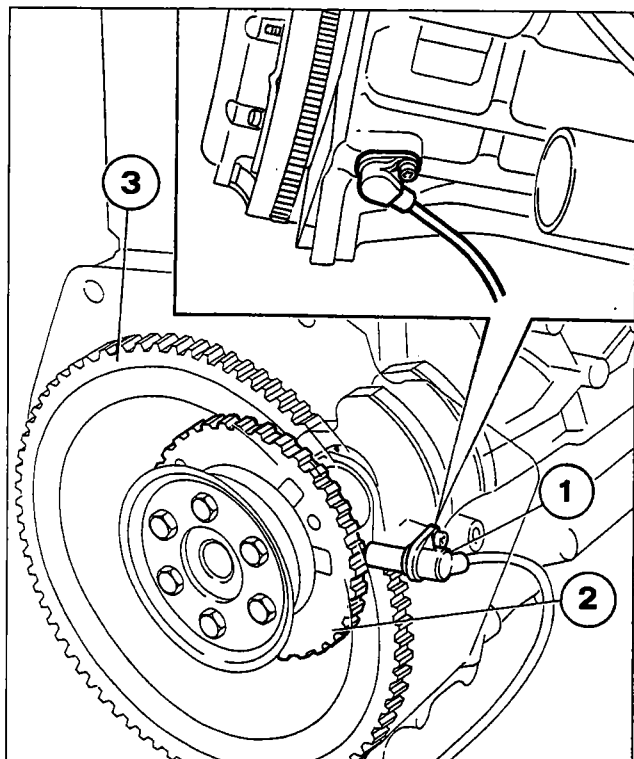
This operation involves removing the timing belt and the camshaft pulley, exhaust side. When these operations have been carried out it is necessary to:

- disconnect the electrical connector;
- Undo the fixing bolts and remove the sensor.

When refitting carry out the procedure in the reverse order, following the instructions for fitting and tensioning the toothed belt.

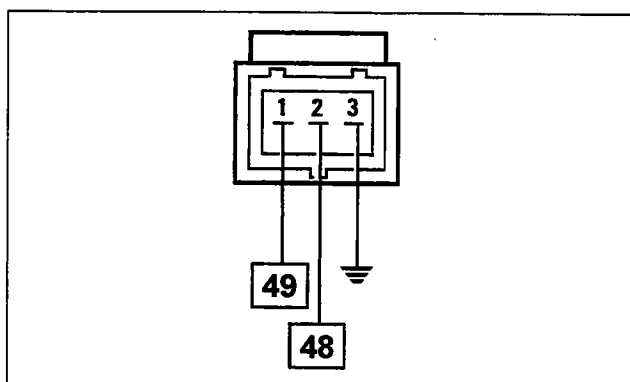
**NOTE** The sensor does not require any type of adjustment.

### 10.

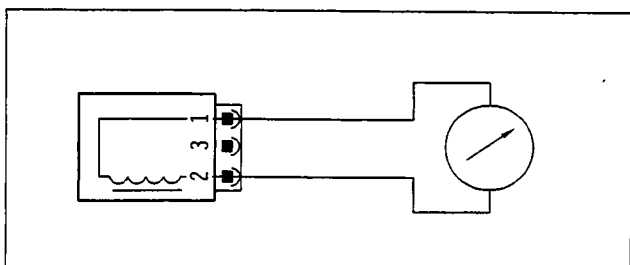


P4A22FJ01

1. Rpm sensor
2. Toothed pulley
3. Engine flywheel



P4A22FJ02



P4A22FJ03

### RPM AND TDC SENSOR (0.281.002.102)

The sensor designed to detect the rpm and TDC is the inductive type, i.e. it operates by varying the magnetic field created by the teeth on a toothed pulley (flywheel) inside the crankcase and fixed to the rear counter-weight for the crankshaft. In this way the sensor is fixed to the crankcase and the checks and adjustments of the gap and the angular position are no longer necessary.

The teeth which pass in front of the sensor, alter the gap between the pulley and the sensor; the flow dispersed, which consequently varies, produces an alternating voltage which depends on the number of revs.

The flywheel has 58 teeth plus a space equivalent to the two missing teeth.

The reference defined by the space for the two missing teeth constitutes the basis for detecting the synchronism point (TDC).

For a more detailed description of the operating principle, refer to the Fuel System section for the 1581 16v engine.

### Removing-refitting

Position the vehicle on a lift, then working from underneath the vehicle:

- Disconnect the electrical connector;
- undo the bolt fixing the sensor and remove it from its housing.

### Wiring connector

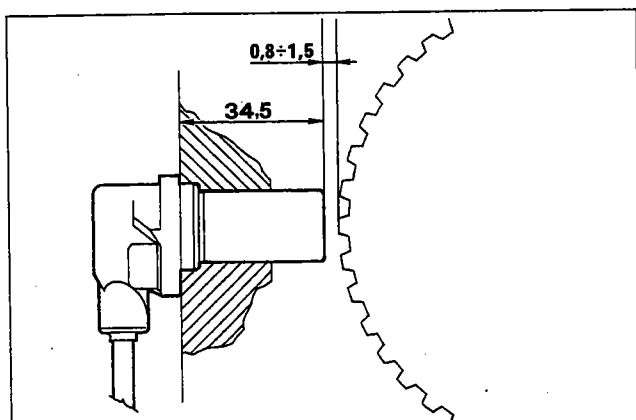
The sensor is connected to the electronic control unit (pins 48 and 49) by means of twisted cables covered by a screened anti-interference outer casing connected to earth.

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

### Checking the resistance

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

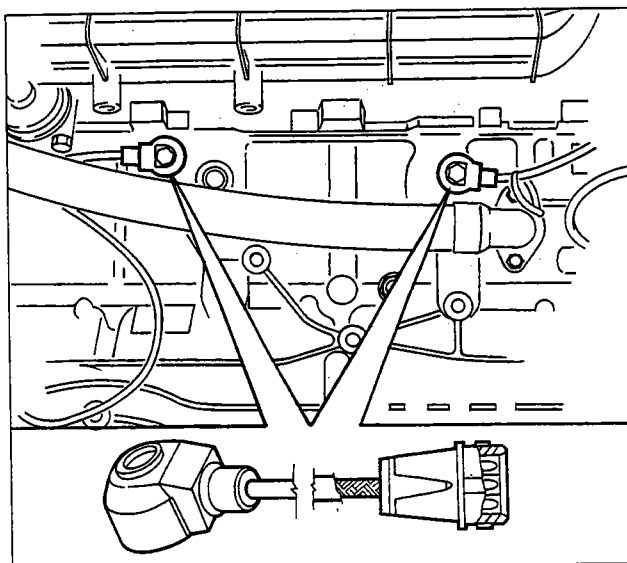
**Resistance: 774-946 ohm at 20°C**



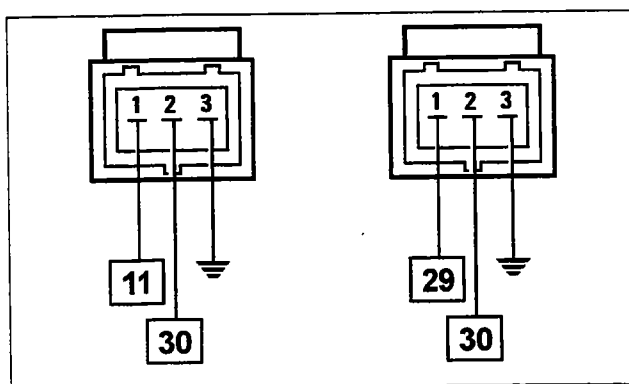
P4A23FJ01



*When measuring the distance it is necessary to be sure that you are at right angles with the flywheel and by a tooth and not a hollow.*



P4A23FJ02



P4A23FJ03

### Checking the gap

The rpm and TDC sensor is fixed directly to the engine crankcase and therefore no adjustments of the gap or the angular position are required. If a problem is suspected it is possible to check the gap, proceeding as follows:

- remove the rpm and TDC sensor;
- check that the distance between the surface of the sensor and the flywheel tooth corresponds to the sum of the length of the sensor probe (34.5 mm) with the gap (0.8 - 1.5 mm).

### DETONATION SENSORS (0.261.231.095)

The detonation sensors are located in the monobloc below the inlet manifolds and between cylinders 1-2 and 4-5, respectively.

These sensors have a bush to prevent incorrect torque wrench tightening. **If they are replaced, do not place washers or shims between the engine crankcase and sensor contact surfaces.**

When there is engine knocking (detonation) vibrations of a certain frequency are created in the cylinder block/crankcase.

The phenomenon creates mechanical repercussions on a piezoelectric crystal which sends a signal to the control unit which, on the basis of this signal, makes provisions to reduce the ignition advance (from 3° to a maximum of 9.7°) until the phenomenon disappears. Afterwards the advance is gradually restored to the basic value.

### Wiring connector

The numbers indicate the corresponding control unit pins.

### Recovery

The ignition advance is calculated according to the temperature of the engine coolant and the temperature of the intake air.



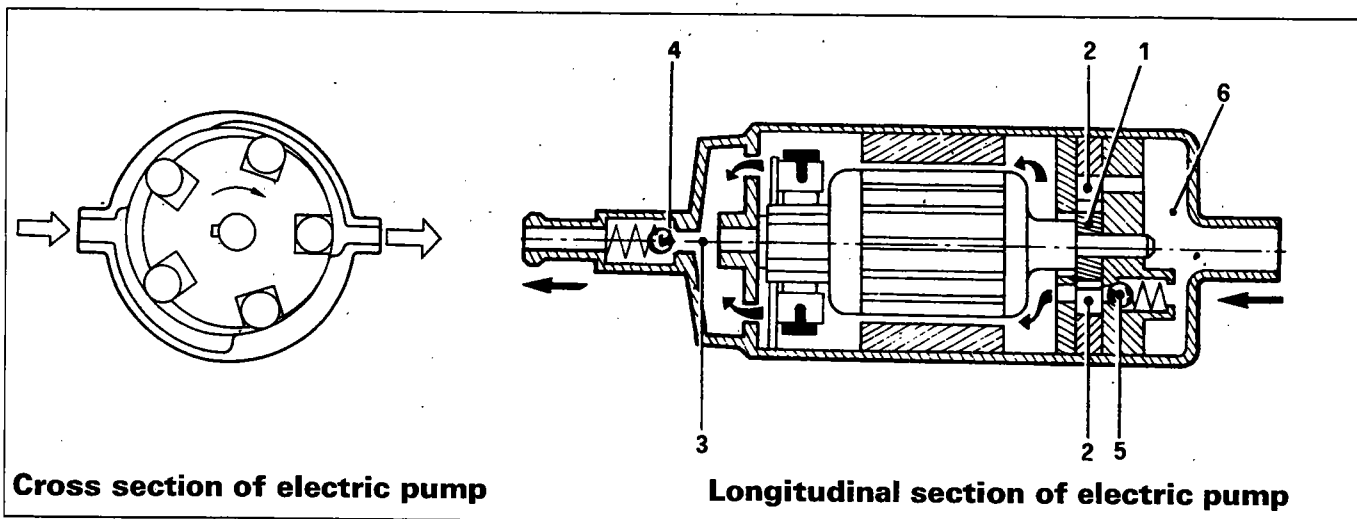
# 10.

## ELECTRIC FUEL PUMP (0.580.453.408)

The submerged electric fuel pump is located inside the tank, housed in a mounting also containing the fuel gauge.

The electric pump is the cell type with rollers, operated by an electric motor with permanent magnet windings, immersed in the fuel.

A disc rotor (1) situated eccentrically in the pump casing contains the cells arranged along its circumference and metal rollers (2) which are thrust by centrifugal force against the outer race with the effect of ensuring the hydraulic seal.

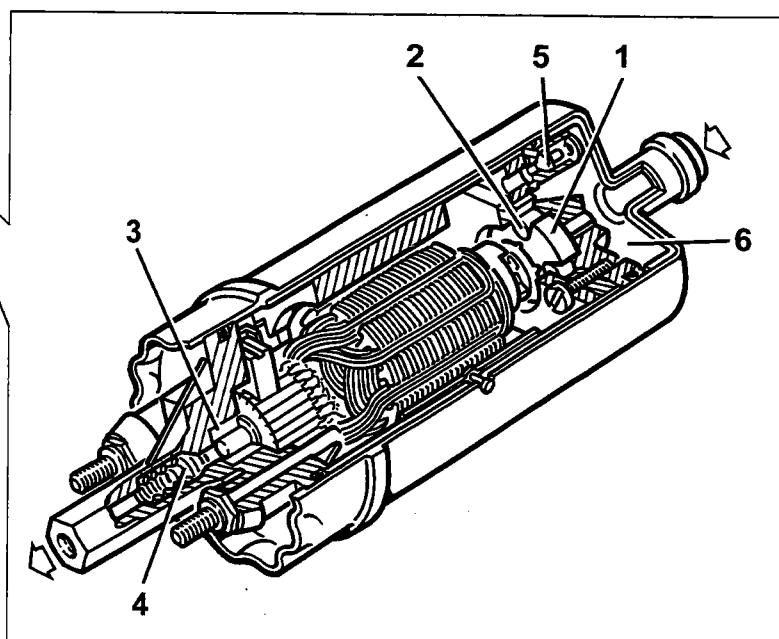
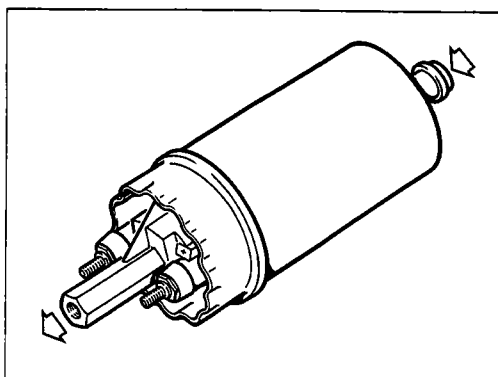


The fuel flows in the empty housings and is compressed in the supply duct (3). A one-way valve (4) prevents the supply pipe from being drained with the engine switched off. An excess pressure valve (5) short circuits the supply in the inlet chamber (6) when the pressure exceeds 7.5 bar.

The electric pump starts to work when the ignition switch is turned to the starting position. When the starting stage is over, the electric pump continues to operate with the switch in the ON position, unless the engine speed goes below 225 rpm or the ignition switch is turned to the OFF position.

If the engine cuts out for any reason, with the ignition switch in the ON position, the operation of the pump is automatically interrupted, thereby creating a safety condition.

### Diagram showing longitudinal cross section and external view of electric fuel pump



**NOTE** For the positioning and the re-moving-refitting procedures, refer to the fuel system section for the 1581 16v engine.

#### FUEL FILTER (A.450.024.262)

The fuel filter is fitted under the floor panel, on the fuel supply pipe. For the removing-refitting procedure, refer to the fuel system section for the 1581 16v engine.

#### FUEL SUPPLY MANIFOLD AND PRESSURE REGULATOR

The fuel supply manifold, which has the function of distributing the fuel to the injectors, is made from steel and is equipped with housings for the injectors and for the pressure regulator and the fuel inlet and outlet unions.

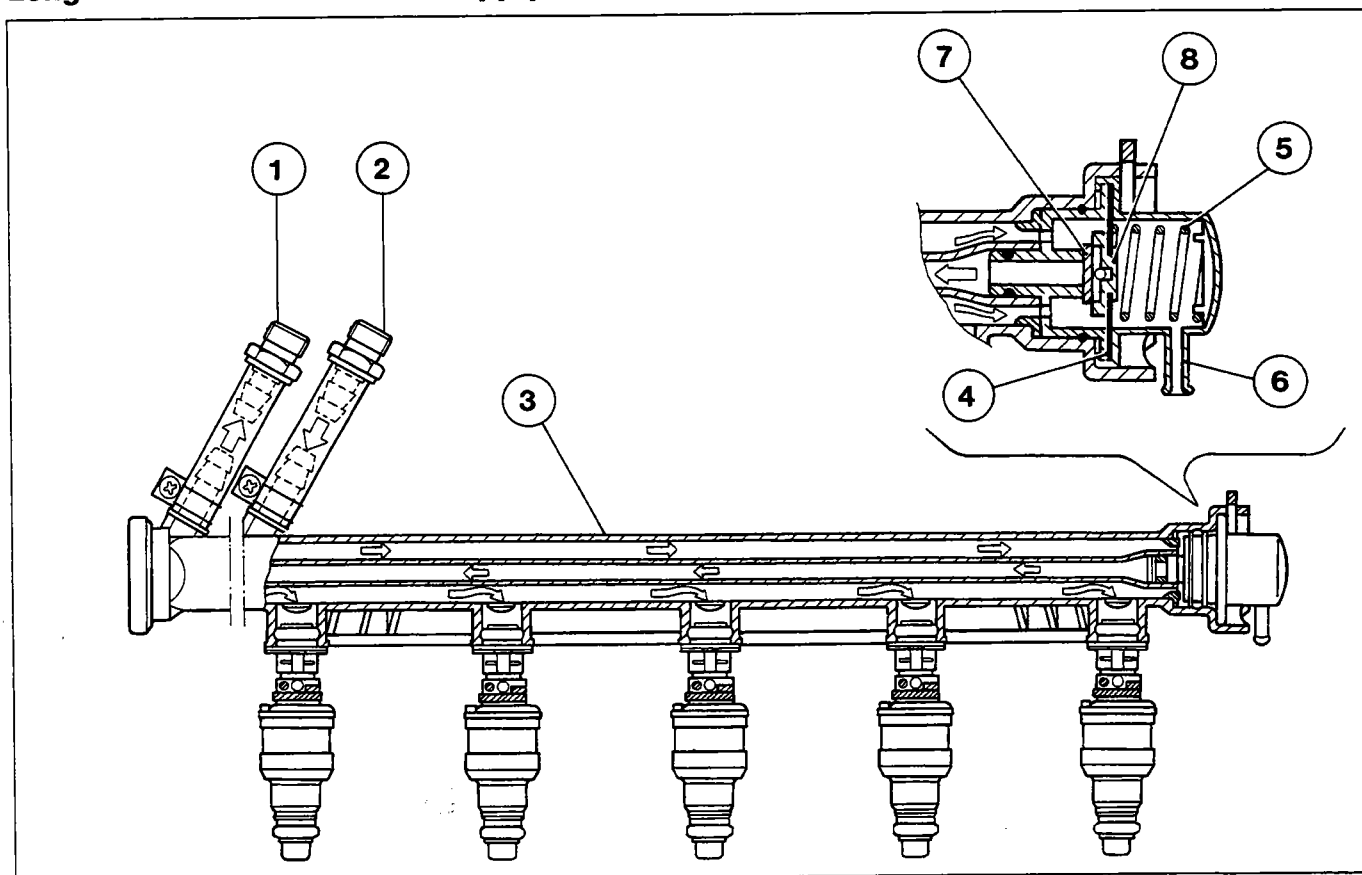
The fuel manifold is fixed to the inlet manifold by four brackets.

The pressure regulator is a necessary element in keeping the rise in pressure at the injectors constant. It is a differential diaphragm type device, regulated at a pressure of around 3 bar.

The pressure regulator is made up of a metal casing which houses a moving element comprising a metal casing (8) and a diaphragm (4) loaded by a spring (5). When the pre-set force, made up of the vacuum in the opposite part of the diaphragm and the spring (5) loading, is exceeded, the fuel thrust by the pump causes the opening of a valve (7) which allows the excess fuel to flow through the pipe to the tank (2).

The chamber housing the spring is in contact with the engine inlet manifold (6) (vacuum signal). The difference between the pressure of the fuel and the vacuum in the inlet manifold is kept constant for all engine operating conditions.

#### Longitudinal section of fuel supply manifold and pressure regulator



P4A25FJ01

1. Fuel return union
2. Fuel arrival union
3. Injectors mounting and fuel manifold
4. Diaphragm with flow valve

5. Adjustment spring
6. Connection to inlet manifold
7. Flow valve
8. Metal casing

# 10.

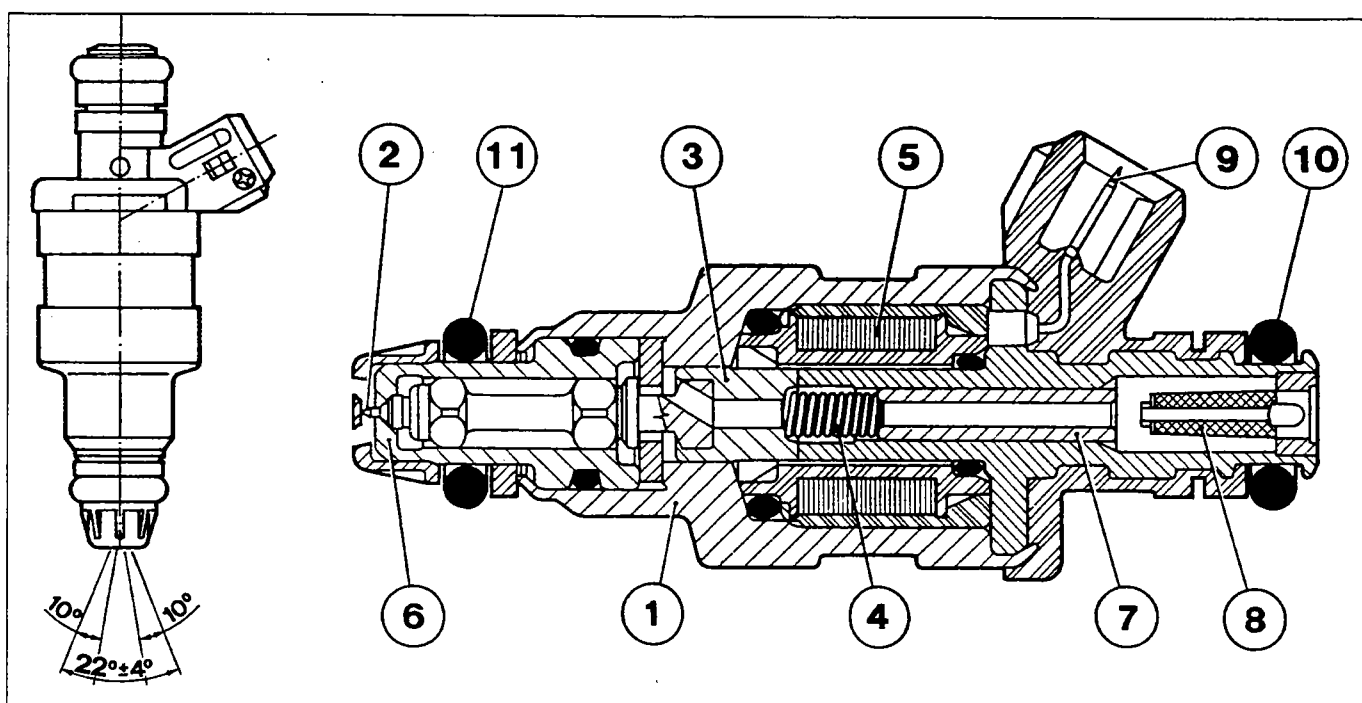
## INJECTORS (0.280.150.443)

The double jet type injectors are fitted on the inlet manifolds, immediately before the inlet valve. These injectors are specifically for engines with 4 valves per cylinder, making it possible to direct the jets towards the two inlet valves.

The jets of fuel at a differential pressure of 3 bar which leave the injector are instantly atomized forming two cones of about  $10^\circ$  each.

The operation of the injectors is the «sequential timed» type, i.e. the five injectors are operated according to the engine cylinder inlet sequence, whilst the supply can already start for each cylinder during the expansion stroke until the inlet stroke has already begun.

The injectors are fixed by the fuel manifold which presses them into their housings in the inlet manifolds. In addition they are anchored to the fuel manifold by means of «safety clips». Two rubber seals (10) and (11) ensure the seal for the inlet manifold and the fuel manifold.

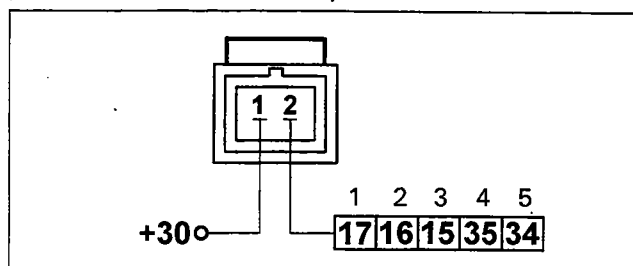


P4A26FJ01

- |                    |                             |                                 |
|--------------------|-----------------------------|---------------------------------|
| 1. Injector casing | 5. Winding                  | 9. Electrical connection socket |
| 2. Needle          | 6. Injector nose            | 10. Fuel seal                   |
| 3. Magnetic core   | 7. Adjustable spring pusher | 11. Vacuum seal                 |
| 4. Coil spring     | 8. Fuel filter              |                                 |

### Wiring connector

**NOTE** The numbers indicate the corresponding control unit pins arranged in the order of the number of cylinders.

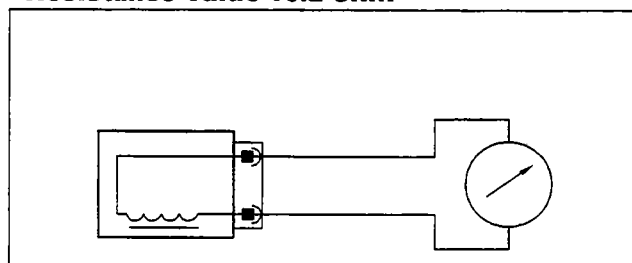


P4A26FJ02

### Checking the resistance

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

**Resistance value 16.2 ohm**



P4A26FJ03

**BUTTERFLY CASING**

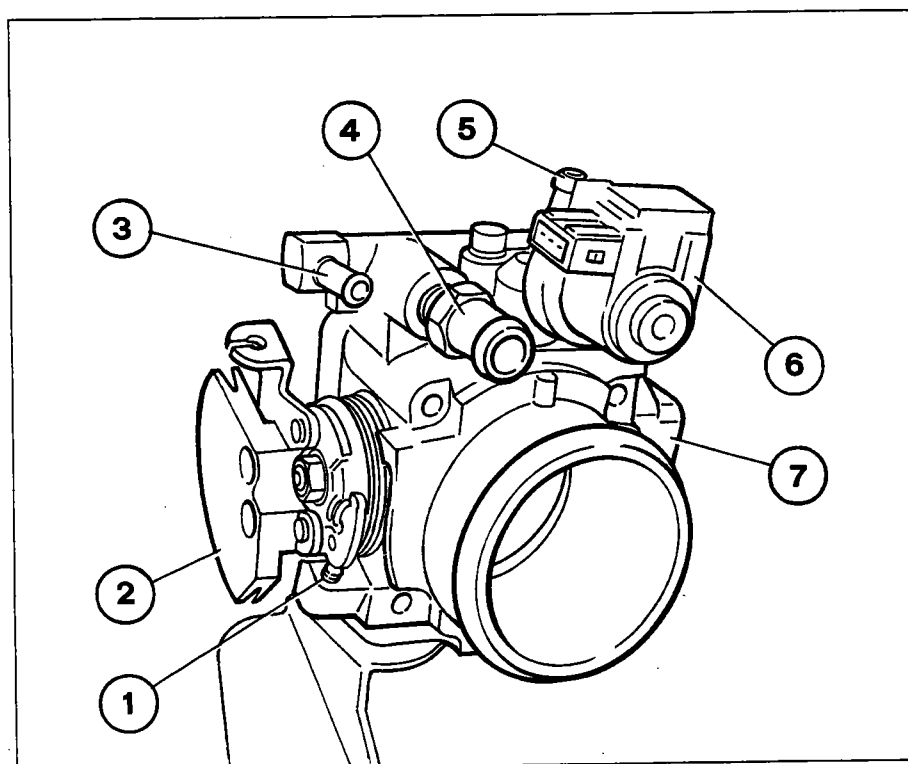
The quantity of air drawn in is determined by the opening of the butterfly located at the start of the inlet manifold. The butterfly casing is fixed to the inlet manifold by four bolts; the butterfly is operated by the accelerator pedal by means of linkage which produces an opening system where in relation to the pedal travel, small butterfly opening angles are produced with the pedal slightly pressed and greater opening angles are produced with the pedal more depressed.

The air required to support the engine during idling and in load conditions with the butterfly valve closed is regulated and by-passed exclusively by the engine idle speed actuator.

A special screw (1), makes it possible to adjust the butterfly closure to prevent interference with the surrounding duct; this screw is not used for adjusting the idle as it is adjusted by fluxing in production and should not be tampered with under any circumstances.

The flow of engine coolant arriving from the thermostat flows through the inlet and outlet ducts (3) and (5) in the area of the butterfly valve has the aim of preventing condensation and the formation of ice which could be produced in particular low external temperature and/or high humidity conditions.

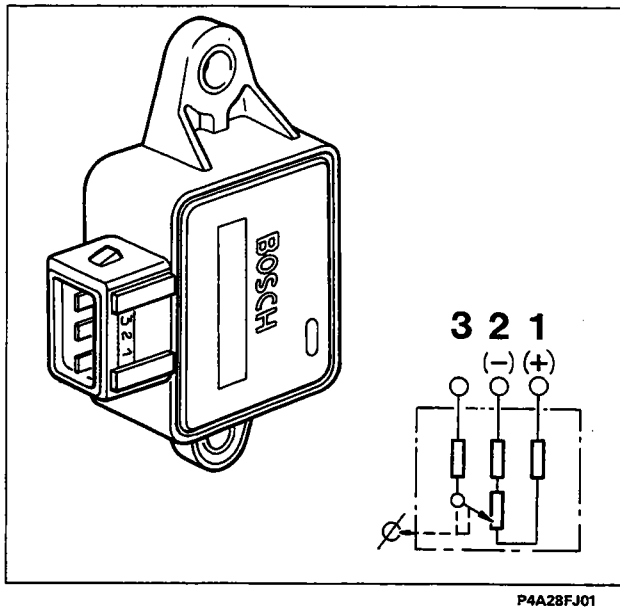
The gases which flow from the engine crankcase are drawn into the inlet manifold downstream of the butterfly through the PCV valve (4).



P4A27FJ01

1. Butterfly valve adjustment and anti-tamper screw (**not to be tampered with**)
2. Butterfly opening control levers
3. Attachment for engine coolant supply pipe
4. Attachment for engine crankcase vapour recovery and recirculation pipe
5. Attachment for engine coolant return pipe
6. Engine idle speed actuator
7. Butterfly valve position sensor

### 10.



#### BUTTERFLY VALVE POSITION SENSOR (0.280.122.001)

The sensor is made up of a potentiometer inserted in a plastic container which has two fins, in which there are two openings WITHOUT SLOTS which have the function of ensuring the anchorage and the positioning of the sensor in relation to the butterfly valve. A three pin socket in the container guarantees the electrical connection with the electronic control unit.

During operation, the injection/ignition control unit provides the potentiometer with a supply of 5 Volts at pins (1) and (2).

There is a voltage at pin 3 which is inversely proportional to the opening position of the butterfly valve. According to the voltage sent by pin 3 the control unit recognizes the opening condition for the butterfly valve and suitably corrects the mixture strength.

With the butterfly closed an electrical voltage signal of around 0.5 Volts reaches the control unit which recognizes the idle and cut off conditions (distinguishing them on the basis of the engine speed).

The potentiometer automatically recognizes the butterfly idle position by means of a "self-adjustment" function. This eliminates the adjustment operations and makes it possible to allow for any wear which may occur for the butterfly closure position.

#### Recovery

If the sensor fails, the control unit establishes the following parameters:

Butterfly opening angle = 10°

idle state: air flow rate < 12.8 m<sup>3</sup>/h;

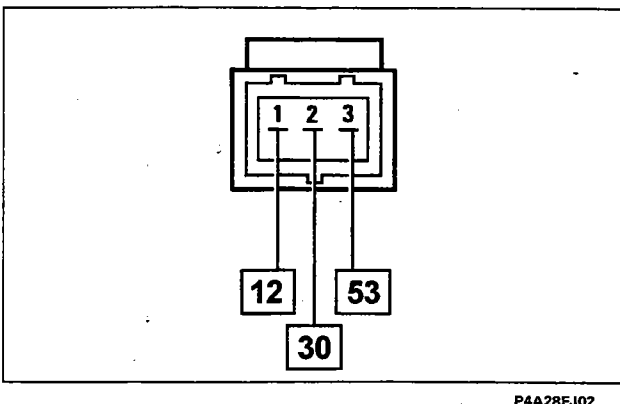
exit from idle state: air flow rate > 8 m<sup>3</sup>/h;

full load state: engine load > 6,5 ms and simultaneous speed > 2000 RPM;

exit from full load state: engine load < 6,5 ms or speed < 2000 RPM.

#### Additional provisions

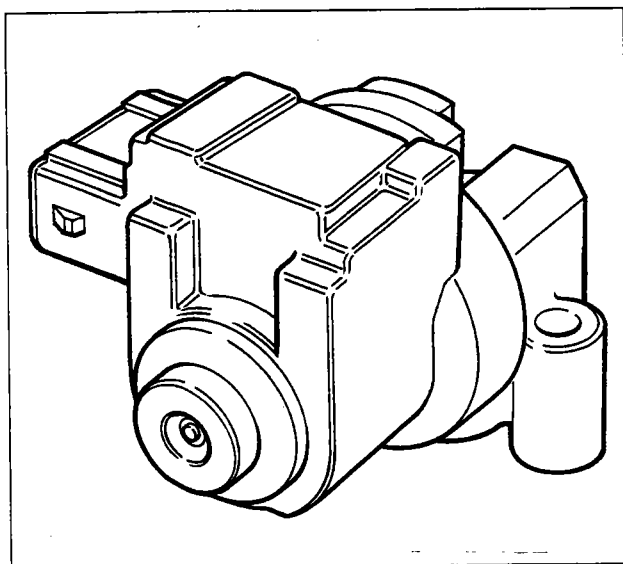
The engine idle speed gradual decrease (dashpot) and idle self-adjustment strategies are stopped.



#### Wiring connector

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

**ENGINE IDLE SPEED ACTUATOR  
(0.280.140.553)**



P4A29FJ01

It is composed of an electric motor which, by opening the flow of supplementary air (in parallel to the flow from the butterfly with the accelerator released) in the butterfly casing more or less, automatically keeps the engine idle speed constant, irrespective of the load conditions (additional consumers switched on or not, engine hot or cold, etc.).

The opening caused by the rotation of the distributor is controlled by electrical impulses processed by a special section in the injection control unit which causes the distributor to rotate in one direction or the other depending on the speed at which the engine is rotating.

**Recovery**

If the actuator fails, the control unit activates different recovery strategies depending on the butterfly valve opening angle.

*Recovery 1:* valve in recovery position, near the idle air flow rate for:

- short circuit battery V at opening or closing winding or opening and closing winding;
- open circuit at opening or closing winding or at opening and closing winding
- short circuit battery V at opening winding and open circuit at opening winding
- short circuit battery V at closing winding and open circuit at opening winding.

*Recovery 2:* valve open 0% for:

- short circuit battery V at opening winding and short circuit to earth at closing winding;
- open circuit at opening winding and short circuit to earth at closing winding.

*Recovery 3:* valve open 50% for:

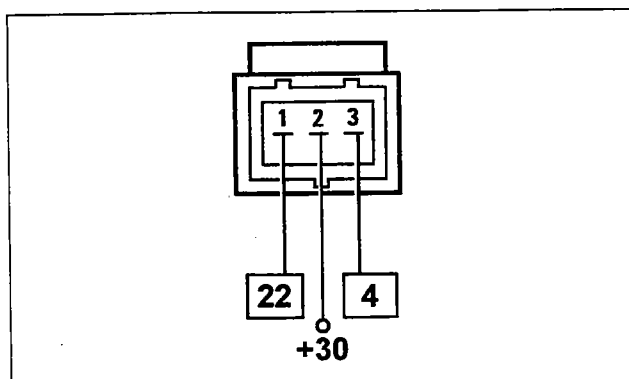
- short circuit to earth at opening winding or closing winding or opening and closing

*Recovery 4:* valve open 100% for:

- short circuit battery V at closing winding and short circuit to earth at opening winding;
- open circuit at closing winding and short circuit to earth at opening winding.

**Additional provisions**

Locking the idle self-adjustment at the current values and locking the idle control.

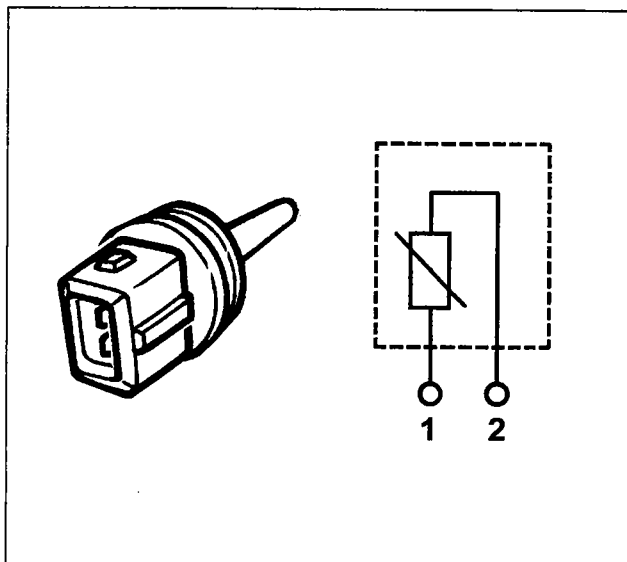


P4A29FJ02

**Wiring connector**

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

# 10.

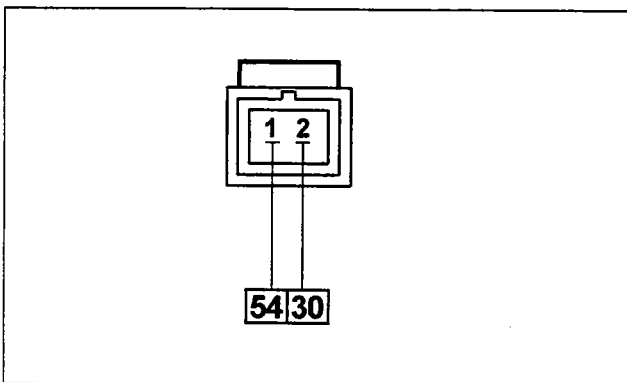


P4A30FJ01

## AIR TEMPERATURE SENSOR (0.280.130.073)

The intake air temperature sensor is, in this version, separate from the air flow meter: it is made up of an NTC sensor (Negative Temperature Coefficient) where the electrical resistance decreases as the temperature increases.

Since the control unit input circuit is designed as a tension divider, this tension is divided between a resistance in the control unit and the sensor NTC resistance. As a result the control unit is capable of evaluating the variations in the resistance of the sensor through the changes in voltage and of thereby obtaining the temperature information.



P4A30FJ02

### Recovery

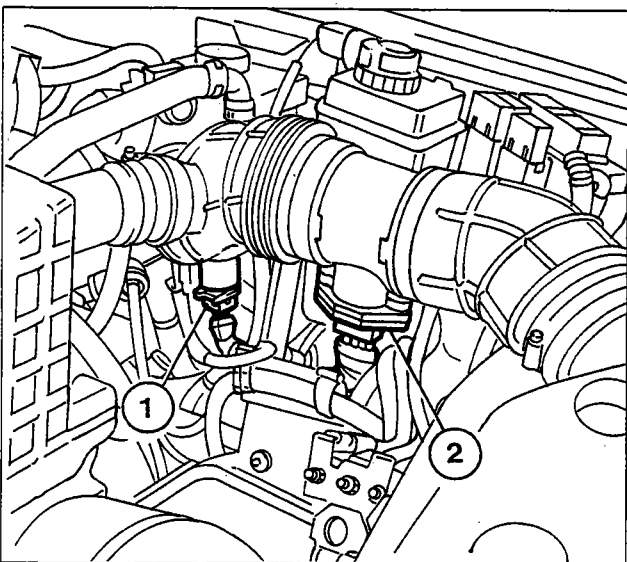
If, 3 minutes after starting, the control unit detects a temperature (air T) < -35 °C or > 130 °C for 30 seconds, it assumes air T=20.4 °C as a fixed parameter

### Additional provisions

Locking the self-adjustment of the mixture strength at current values

### Wiring connector

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



P4A30FJ03

1. Air temperature sensor

2. Flow meter

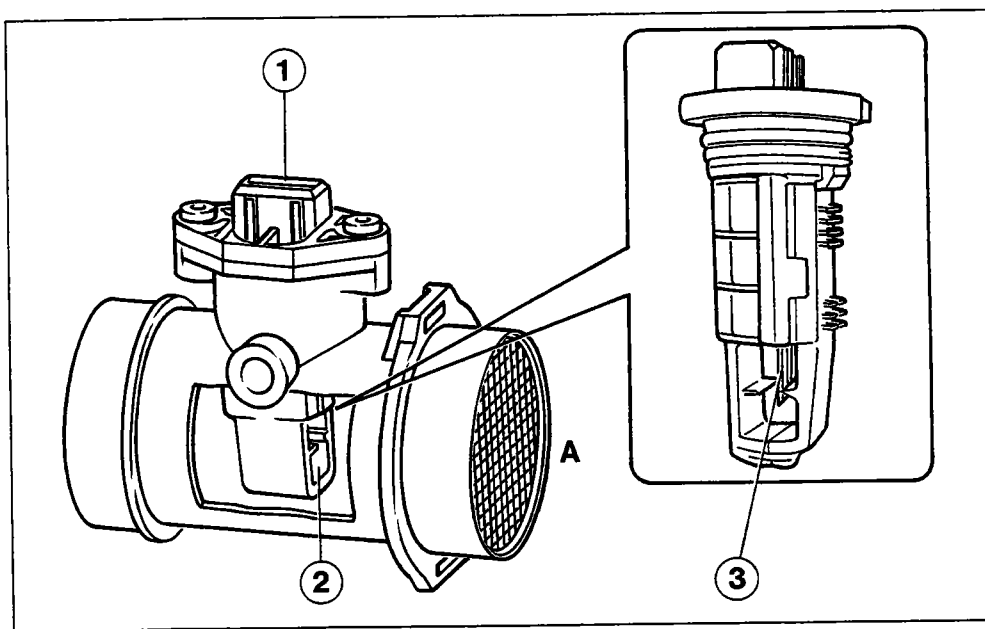
## FLOW METER (0.280.217.111)

The air flow meter is the "heated film" type; the operating principle is based on a heated diaphragm which is placed in a measuring duct through which the intake air entering the engine flows.

The film diaphragm is kept at a constant temperature (~120 °C above the temperature of the air) by the heating resistance in contact with it.

The mass of air which passes through the measuring duct tends to remove heat from the diaphragm therefore, to maintain the latter at a constant temperature, a current must flow through the heating resistance; this current is measured by a suitable Wheatstone bridge.

The current measured is therefore proportional to the mass of air flow.



P4A31FJ01

- 1. Connector
- 2. Measuring duct
- 3. Hot film sensor
- A= Air intake

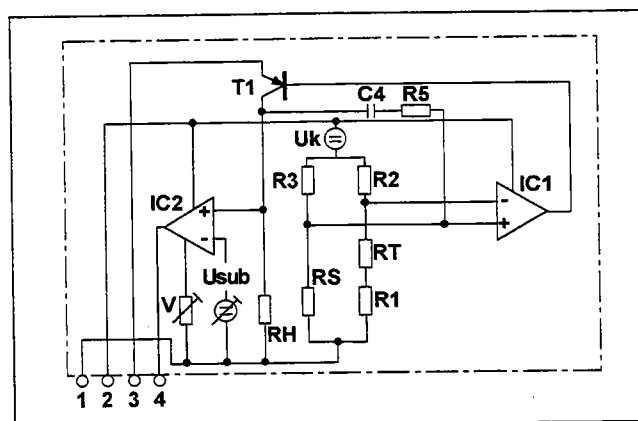
**NOTE** This flow meter directly measures the mass of air (and not the volume as on previous versions) thereby dispensing with the problems of temperature, altitude, pressure, etc.

### Description of the operation

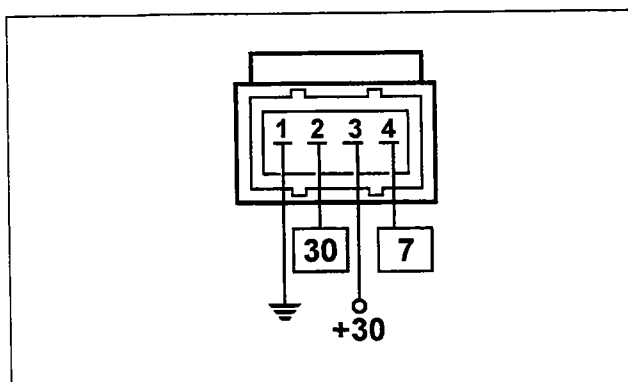
The Wheatstone bridge (made up of  $R_3$ ,  $R_2$ ,  $R_s$ ,  $R_t+R_1$ ) is balanced when the  $R_s$  is at about  $120^\circ\text{C}$  above the temperature of the air. The air which passes through the diaphragm removes heat from the  $R_s$ , therefore the bridge is unbalanced. This situation is detected by the circuit at IC1 which controls the transistor T1 in a manner which is proportional to the bridge imbalance and as a result more current is passed through  $R_h$  to heat  $R_s$  and therefore restore the balance for the bridge. The circuit IC2 measures the current which passes through  $R_h$ . This current makes it possible to keep the bridge balanced and therefore proportional to the mass of air which passes through the air flow meter.

### Recovery

In the absence of a simultaneous error at the butterfly potentiometer, the idle engine load is calculated according to the speed if the engine is idling, otherwise a fixed engine load is allocated. If there is a simultaneous error at the butterfly potentiometer, the engine load and advance values are allocated according to a table depending on the number of revs.



P4A31FJ02



P4A31FJ03

### Additional provisions

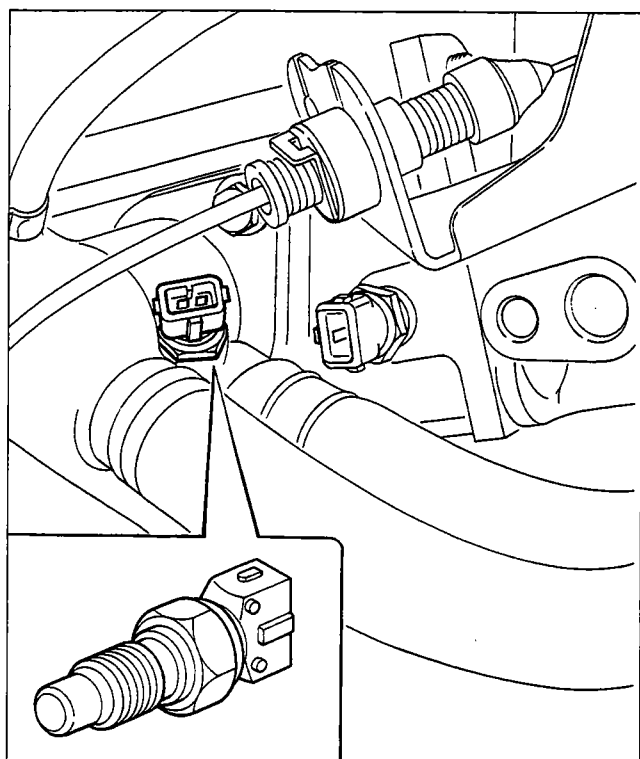
Locking the self-adjustment of the mixture strength and idle at current values.

### Wiring connector

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

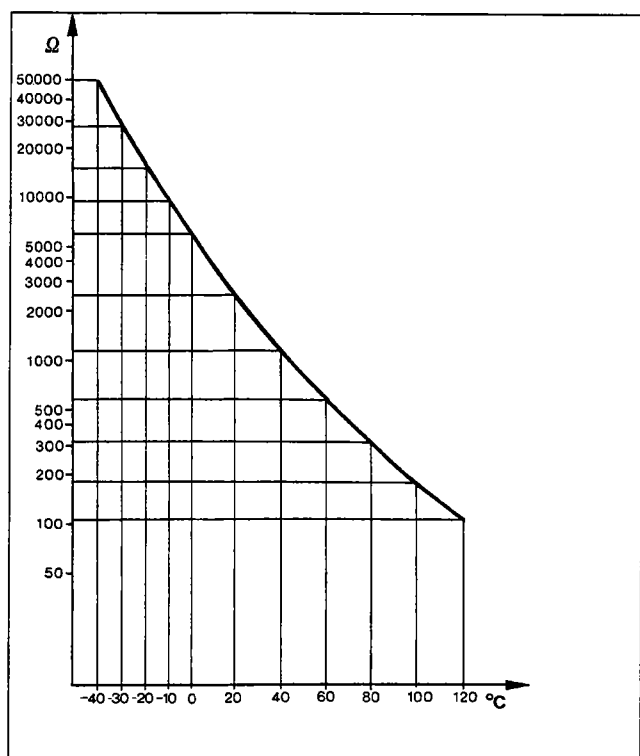


# 10.



P4A32FJ01

The graph below shows the sensor characteristics which can be measured by disconnecting the connector and connecting an ohmmeter as shown in the diagram at the side.

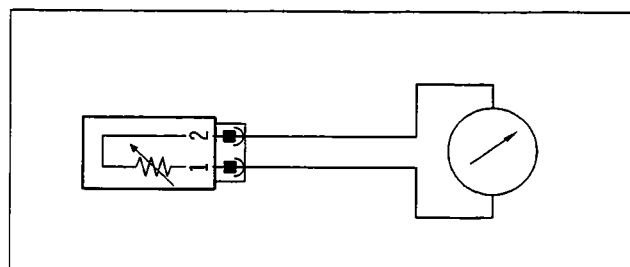


P4A32FJ03

## COOLANT TEMPERATURE SENSOR (0.280.130.026)

The sensor is fitted near the thermostat casing with the sensitive part in contact with the coolant. It is made up of a brass casing which protects the actual resistive element comprising an NTC (Negative Temperature Coefficient) «thermistor», where the electrical resistance of the sensor decreases as the temperature increases).

It provides the control unit with a voltage which varies according to the temperature of the engine in order to correct the information concerning the air flow rate from the flow meter so that according to the signal received by the sensor the control unit can control the injection of the fuel for a greater length of time, providing the necessary enrichment when the engine is operating at temperatures below operating temperature.



P4A32FJ02

## Recovery

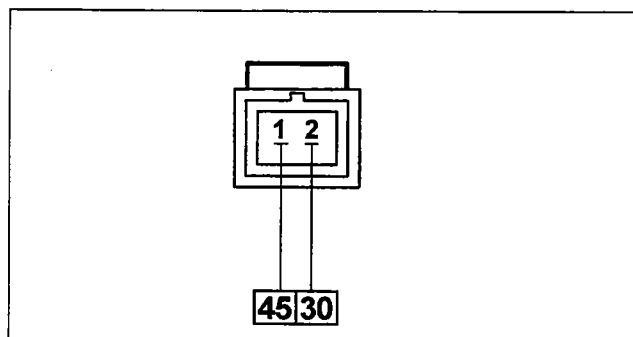
If air  $T \leq 19.9^\circ\text{C}$ , it is assumed that engine  $T = \text{air } T$  for three minutes, then it is assumed that engine  $T = 80^\circ\text{C}$ . If air  $T \geq 19.9^\circ\text{C}$ , it is assumed that engine  $T = 80^\circ\text{C}$  immediately.

## Additional provisions

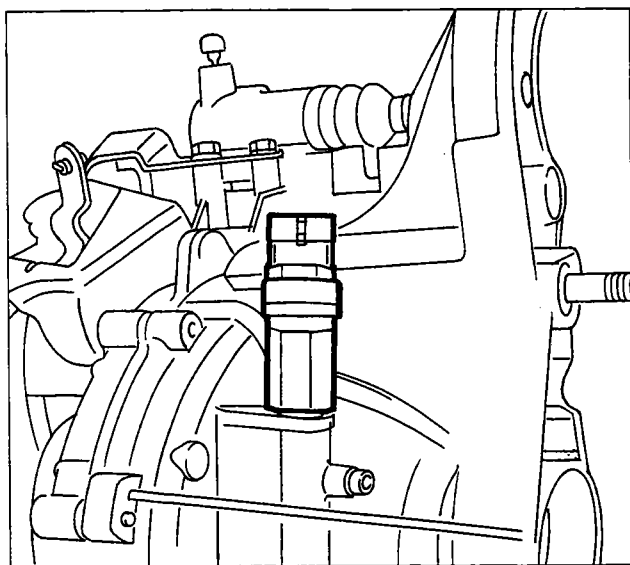
Locking the self-adjustment of the mixture strength and idling at current values.

## Wiring connector

The numbers indicate the corresponding control unit pins



P4A32FJ04



P4A33FJ01

## PHASE TRANSFORMER

In order to achieve a good compromise between the high performance in terms of power at high speeds and good torque at low speeds, a phase transformer (electronically and hydraulically operated) is fitted for the inlet camshaft.

This device makes it possible to alter the timing diagram (inlet phase) according to the engine load conditions; this parameter is processed by the MOTRONIC control unit on the basis of the electrical signals received by the air flow meter and the rpm sensor and sent to the phase transformer solenoid valve.

The construction of the device involves a main assembly fitted on the inlet camshaft which has the task of altering the angular position of the actual shaft in relation to the drive pulley.

In addition there is a valve, operated by an electro-magnet, both of which are on the inlet manifold and connected hydraulically to the main assembly by appropriate ducts.

The operating principle is as follows:

- with the temperature of the coolant below 40 °C and when the engine is idling or the speed exceeds 4800 rpm, the electro-magnet (1) is de-energized, therefore the valve (2) thrust by the opposing spring (3) remains raised not allowing the oil which is arriving from the duct (A) to reach the transformer.

In this case the timing of the inlet valves remains unaltered.

With the temperature of the coolant above 40 °C and with the engine speed above idle and below 4800 rpm with the butterfly angle greater than about 8°, the electro-magnet (1) is energized, thereby thrusting the valve (2) downwards. In this position the oil, coming from the duct (A), enters the piston chamber (B) and from here flows via a special opening into the duct (C) inside the latter.

The oil can only leave the above mentioned duct via the upper port (in contact with duct (D) supplying oil to the transformer) because with the valve (2) lowered, the lower port is not in contact with the discharge duct (E).

The oil reaches the chamber (G) through ducts (D) and (F) moving the piston (4) axially towards the engine; because this piston has helical teeth on the outside this axial movement causes it to rotate in a clockwise direction (as seen from the timing side).

This rotation is transmitted, by means of a straight toothed splined profile, to the pinion (5) which, bolted onto the threaded end of the camshaft (6), transmits the rotation to the shaft, thereby varying the timing of the inlet valves by an advance of 9°.

When the electro-magnet is de-energized, the valve (2) returns to the original position, interrupting the flow of oil under pressure to the chamber (G), but allowing the return of the oil to the exhaust, thanks to the force of the opposing spring (7).

## SPEEDOMETER SENSOR

The speedometer sensor (vehicle speed sensor) it is composed of a Hall effect sensor and is located at the differential outlet.

The sensor transmits a signal to the control unit where the frequency varies according to the speed of the vehicle.

The control unit uses this information to improve the management of the engine idle adjustment actuator and for the CUT-OFF strategy.



*The speedometer sensor signal is also processed to calculate and memorize the mileage travelled in the control unit; this information can be read using the Fiat/Lancia Tester.*

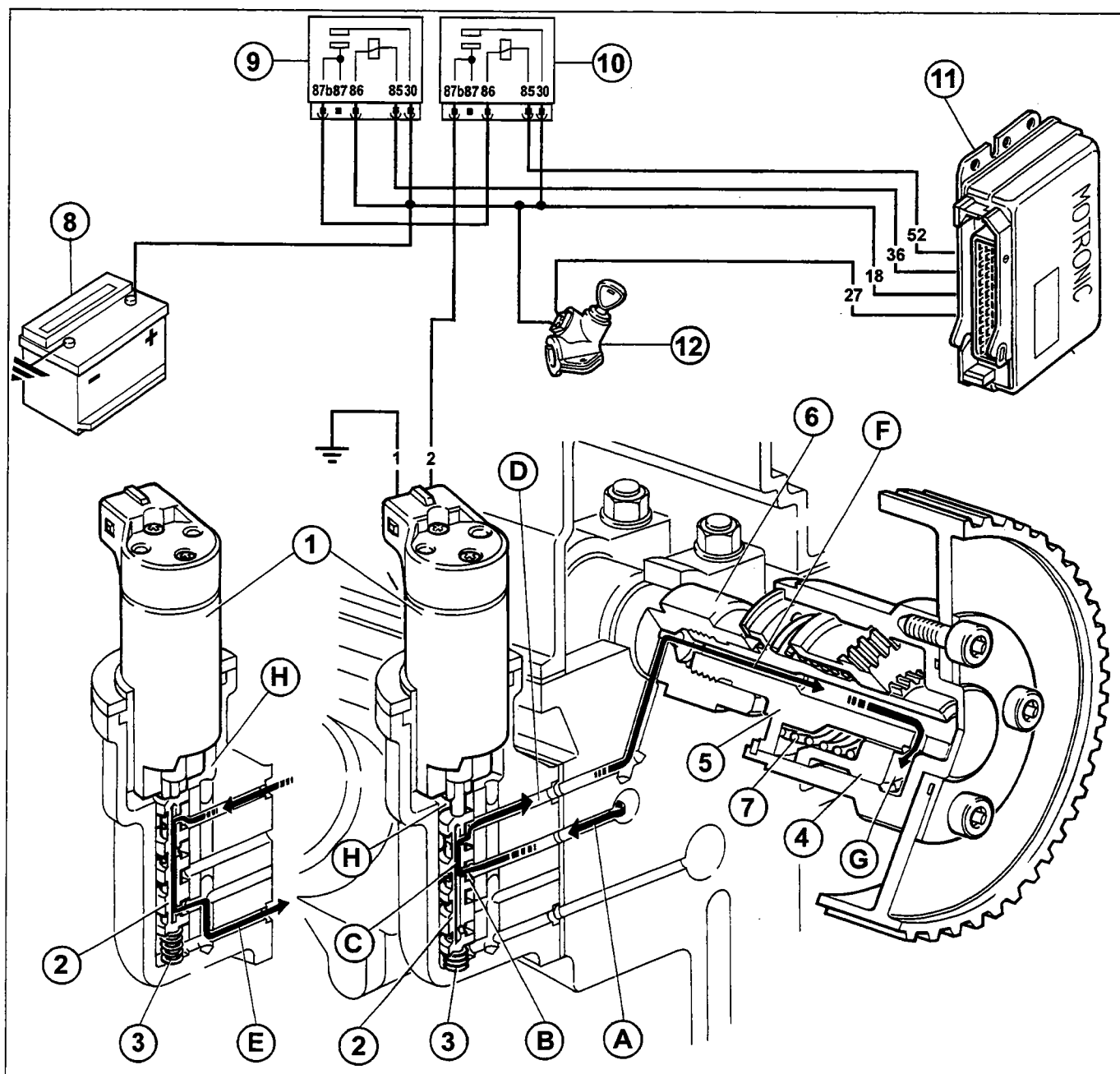
### 10.

An additional duct ensures the lubrication of the bearing on the camshaft even when the device is not activated.

The oil which reaches the chamber (H) for the electro-magnet is discharged through the drainage duct (E).

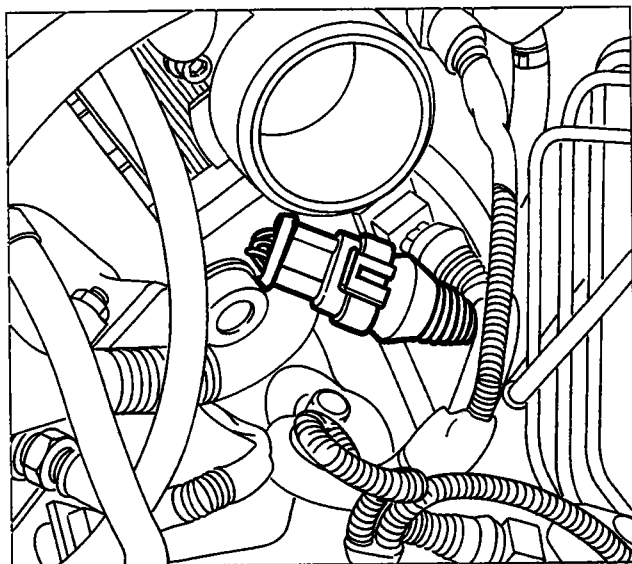
#### Recovery

If the solenoid valve fails, the final stage (driver) in the control unit is deactivated.



P4A34FJ01

- |                         |   |
|-------------------------|---|
| 1. Solenoid valve       | 8. Battery                                      |
| 2. Valve                | 9. Injection/ignition system relay              |
| 3. Valve spring         | 10. Phase transformer solenoid valve relay feed |
| 4. Piston               | 11. Injection/ignition control unit             |
| 5. Pinion               | 12. Ignition switch                             |
| 6. Camshaft end section |   |
| 7. Piston spring        |   |



P4A05DX04



### LAMBDA SENSOR (0.258.003.466)

To meet the strict legislation governing the emission of harmful residues from internal combustion engines which require increasingly more precise metering of the air/fuel mixture, the vehicle has been equipped with a heated Lambda sensor with four wires which measures the oxygen content of the exhaust gases. For a complete description of the Lambda sensor, refer to the Fuel System section for the 1581 16V engine.



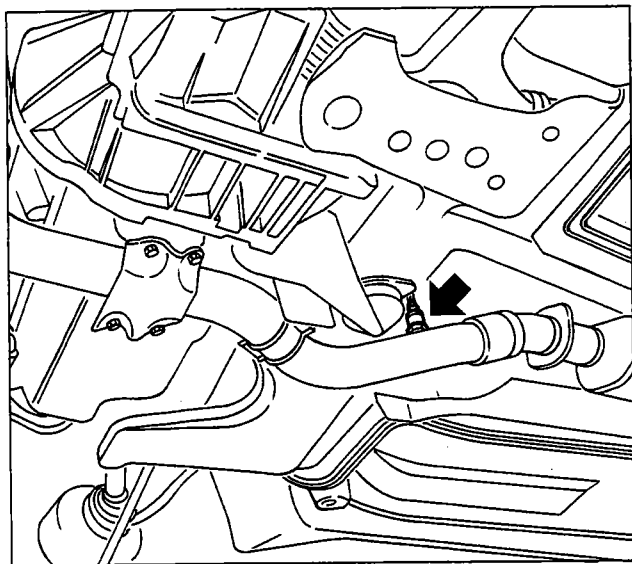
*The sensor can be rapidly put out of action by even the slightest amounts of lead in the fuel.*

### Removing-refitting

- Position the vehicle on a lift.
- Disconnect the negative lead from the battery.
- Disconnect the electrical connection under the butterfly casing.
- Raise the vehicle.
- Remove the Lambda sensor from its housing.
- When tightening, do not exert force on the component or it will be irreparably damaged.



*If the Lambda sensor is being replaced, when refitting smear anti-seize grease on the threaded part (e.g. Bosch VS 14016- FT).*



P4A35FJ02



**Tightening torque 5 - 6 daNm**

### Recovery

The Lambda data is ignored (open loop) if the sensor voltage is  $> 1,099$  V or between  $0.400$  and  $0.518$  V for more than  $2.55$  s.

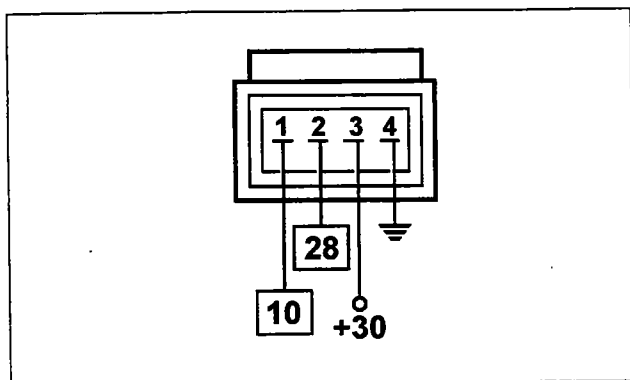
Locking of self-adjustment of mixture strength for sensor voltage  $< 0,0879$  V for more than  $2.55$  s.

Open loop is considered the maximum Lambda integrator value (FR) for the last good sensor voltage reading  $< 0.0879$  V and simultaneously  $FR=1.4$ .

Locking of FR at limit value reached for  $FR > 1.25$  or  $< 0.75$  for at least  $15$  s.

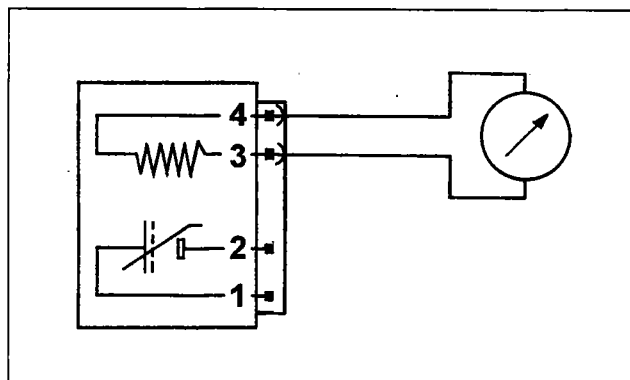
### Wiring connector

The numbers indicate the corresponding control unit pins.



P4A35FJ03

### 10.



P4A36FJ01



#### Checking the resistance

The resistance of the sensor heater can be measured by disconnecting the connector and connecting an ohmmeter as shown in the diagram.

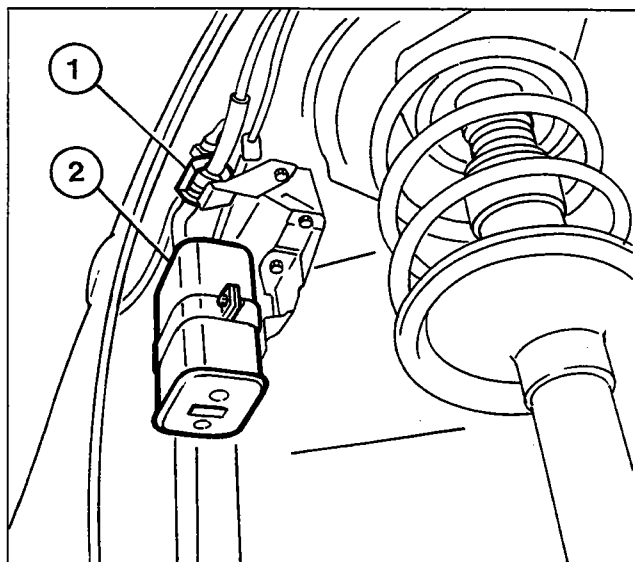
**Resistance:  $4.5 \pm 0.5$  ohm at  $20^\circ\text{C}$**

#### CHARCOAL FILTER AND FUEL VAPOUR CUT OUT SOLENOID VALVE

The charcoal filter and the solenoid valve are located in the right wheel arch.

For the description of the charcoal filter refer to the Fuel System section for the 1581 16V engine.

1. Vapour cut out solenoid valve
2. Charcoal filter



P4A36FJ02

#### Vapour cut out solenoid valve (0.280.142.300)

The function of this valve is to control the quantity of petrol vapours drawn in by the active charcoal filter and directed to the inlet manifold by means of the electronic control unit.

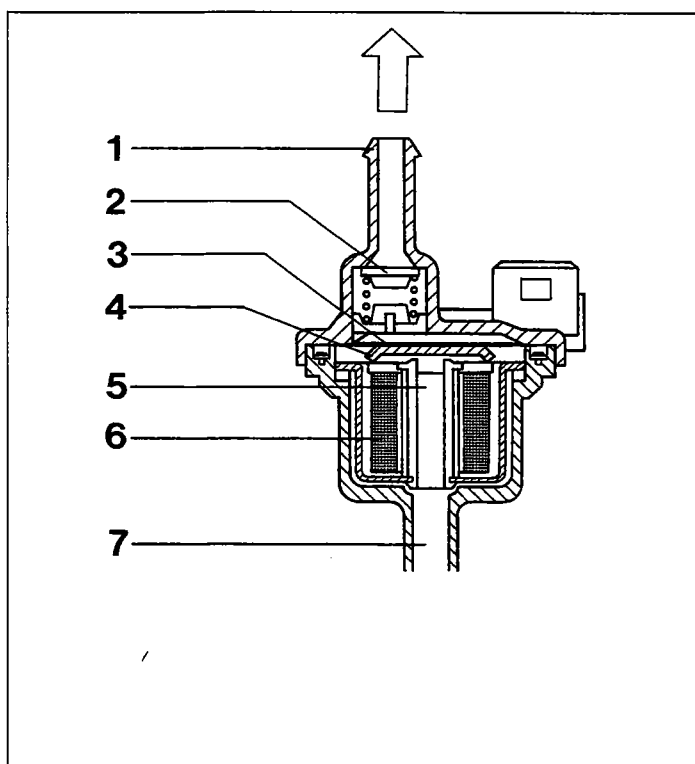
If this valve is not supplied it is in the open position; if the key is turned to the ON position, it closes preparing for operation. In effect, if energized the solenoid valve (6) attracts the shutter (4) which, overcoming the spring (3) loading, closes the port (5) preventing the flow of petrol vapours.

The operation is controlled by the electronic control unit as follows:

- during starting the solenoid valve remains closed, preventing the petrol vapours from excessively enriching the mixture;
- when the engine has been started up, the electronic control unit sends a signal to the solenoid valve which modulates the opening.

In this way the control unit controls the quantity of petrol vapours sent to the inlet, thereby preventing considerable variations (above all during idling) in the mixture strength.

**NOTE** *The solenoid valve must be fitted correctly: the arrow on its casing should be facing the vacuum inlet on the inlet manifold.*



P4A36FJ03

1. Inlet union
2. One-way valve
3. Spring
4. Shutter
5. Outlet port
6. Solenoid valve
7. Outlet union

## Removing-refitting

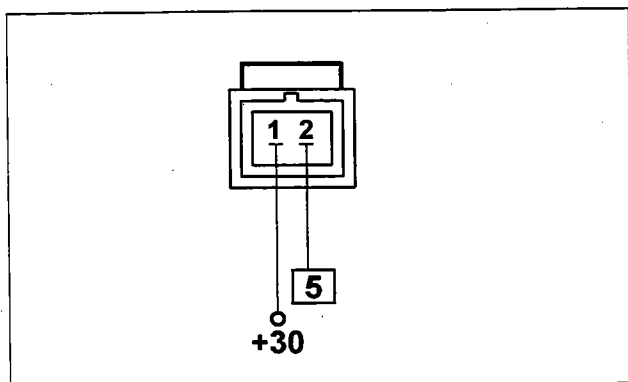
The procedure is valid for both the charcoal filter and the vapour cut out solenoid valve.

- Raise the vehicle;
- remove the right front wheel;
- remove the rear liner for the right front wheel arch;
- undo the bolt which fixes the component concerned to the mounting bracket;
- remove the electrical connection and the pipes connected;
- remove the component concerned.

## Recovery

Locking self-adjustment of mixture strength.

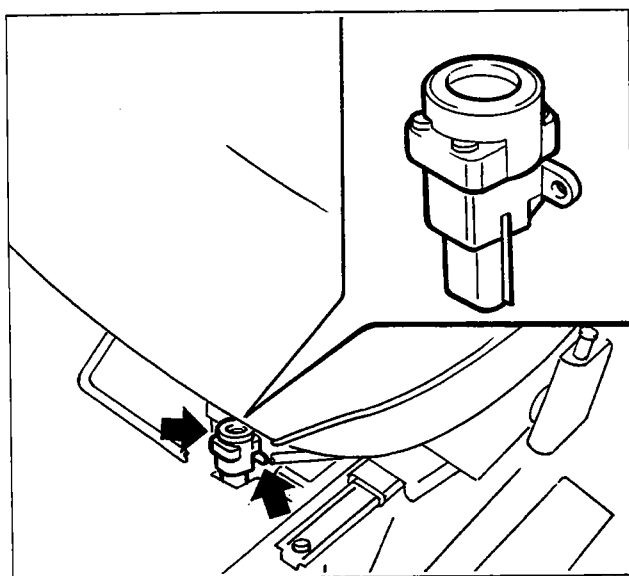
Locking the self-adjustment of the fuel anti-evaporation system.



P4A37FJ01

## Wiring connector

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



P4A48CJ02

## INERTIA SWITCH

In order to increase the degree of safety for the occupants of the vehicle in the case of an impact, the vehicle is equipped with an inertia switch located inside the passenger compartment, under the driver's seat.

This sensor reduces the possibility of fire (as a result of fuel escaping from the injection system) by de-activating the electric pump which supplies the injection circuit.

For the complete description and the removing-refitting procedure, refer to the Fuel System section for the 1581 16V engine.



*After even a 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 problem and correct it to prevent the risk of fire.*

# 10.

## MULTI-PURPOSE VALVE AND SAFETY AND VENTILATION VALVE

These valves belong to the fuel vapour anti-evaporation and recirculation system. For their description refer to the Fuel System section for the 1581 16V engine.

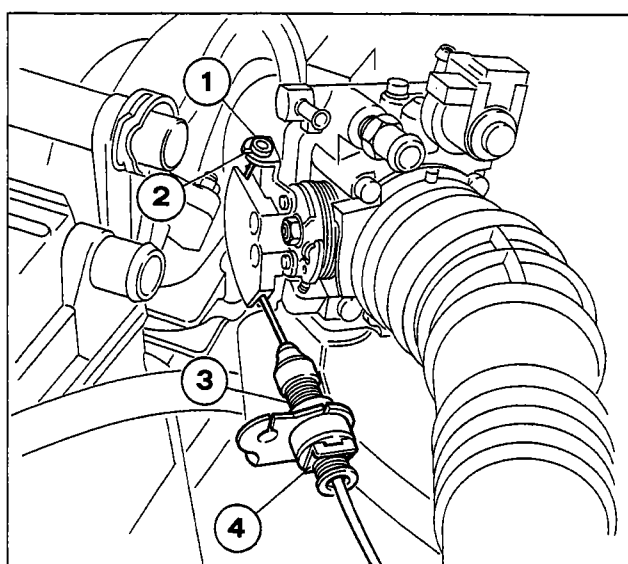
## CHECKS/ADJUSTMENTS AND REPAIR OPERATIONS TO BOSCH MOTRONIC M 2.10.4 INJECTION/IGNITION SYSTEM APART FROM FAULT DIAGNOSIS WITH THE FI-AT/LANCIA TESTER



**WHEN WORKING ON A VEHICLE EQUIPPED WITH A MOTRONIC INJECTION/IGNITION SYSTEM THE FOLLOWING PRECAUTIONS MUST BE OBSERVED:**

- do not start up the engine with the electrical connection terminals not properly connected or slack at the battery poles;
- never use a rapid battery charger to start the engine;
- never disconnect the battery with the engine running;
- to rapidly charge the battery it must be disconnected first from the vehicle's electrical system;
- if the vehicle is going in a drying oven after painting where the temperatures are in excess of 80 °C, it is necessary to remove the injection/ignition electronic control unit;
- never attach or disconnect the electronic control unit multiple connector with the ignition switch in the ON position;
- always disconnect the negative battery lead before carrying out electrical welding on the vehicle.

*Remember that this system has a memory which is always supplied (stand-by memory) where the self-adjustment values are memorized. The operation of disconnecting the battery results in this information being lost but it can be acquired again after a certain mileage; this operation should therefore be restricted.*



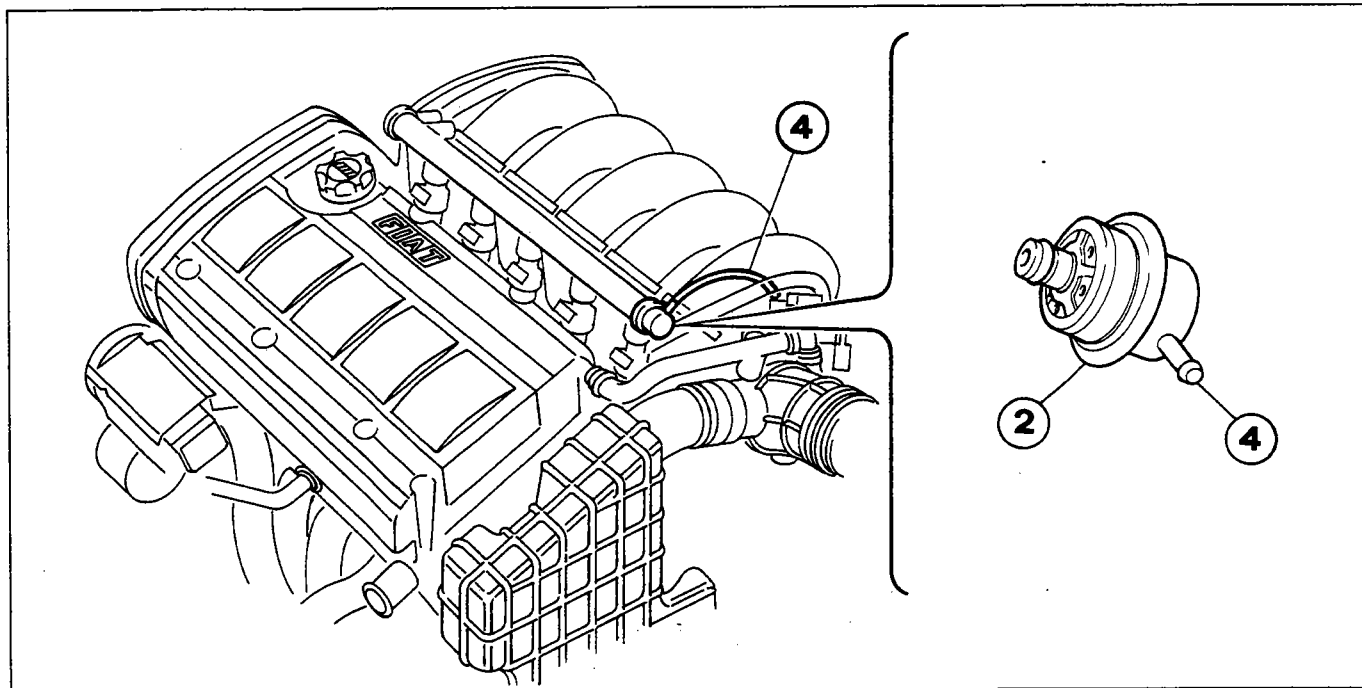
## ADJUSTMENT OF ACCELERATOR CONTROL CABLE

The adjustment of the accelerator cable is obtained by moving the clip (4) in the different bush (3) splines.

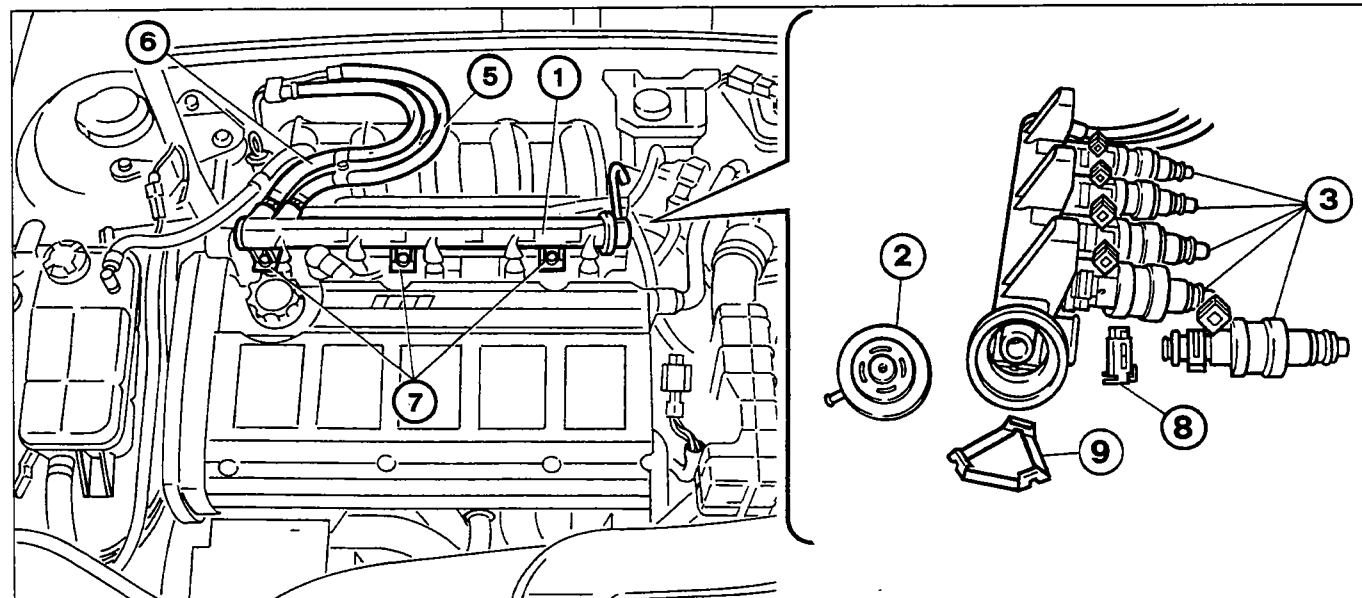
Position the clip in such a way that the head (1) of the accelerator cable freely enters the slot (2) without altering the engine idle speed.

# 10.

## REMOVING-REFITTING FUEL MANIFOLD COMPLETE WITH INJECTORS AND PRESSURE REGULATOR



P4A39FJ01



P4A39FJ02

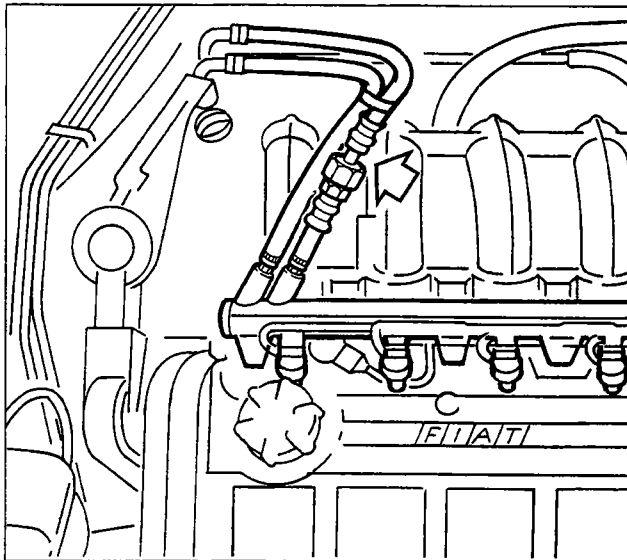
Proceed as follows:

- Disconnect the fuel supply pipe (5) from the union.
- Loosen the band for the return pipe and disconnect the flexible rubber pipe from the rigid pipe.
- Disconnect the electrical connectors from the injectors.
- Undo the fixing bolts (7).
- Extract the injector manifold assembly..
- To remove the injectors from the fuel manifold, remove the clip (9).

1. Fuel manifold
2. Fuel pressure regulator
3. Injectors
4. Vacuum pick up from engine inlet manifold
5. Fuel supply pipe from the electric pump
6. Fuel return pipe to the tank
7. Bolts fixing fuel manifold and injectors
8. Pressure regulator clip on fuel manifold
9. Injector clip on fuel manifold



## 10.



P4A40FJ01

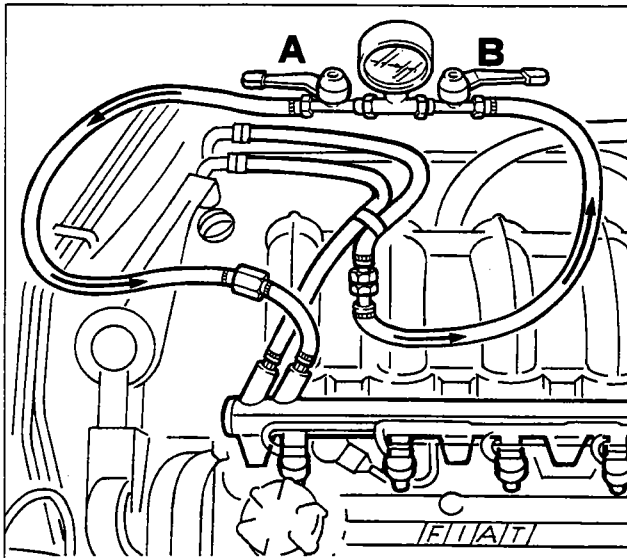


### CHECKS ON FUEL SUPPLY CIRCUIT

#### 1st Test

##### Checking fuel regulation pressure

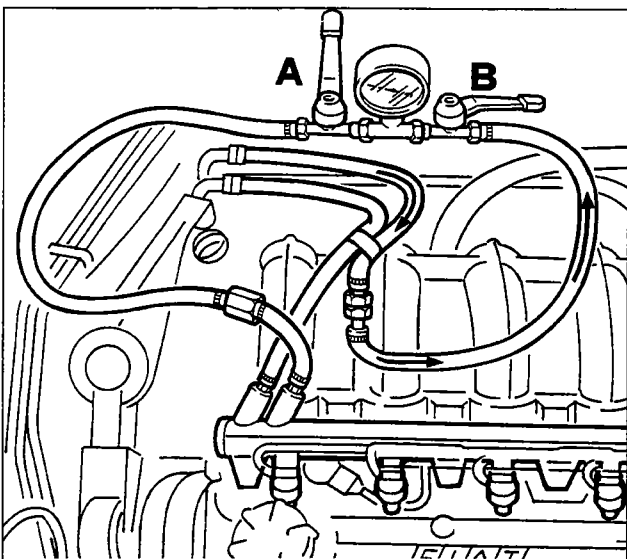
- Disconnect the fuel supply pipe to the manifold from the union shown by the arrow;
- Place pressure gauge 189589000 with both taps A and B in the open position between the end of the pipe disconnected and the fuel manifold;



P4A40FJ02



- operate the electric fuel pump with the engine switched off with the help of the Fiat/Lancia Tester activating the "fuel pump" test;
- the pressure reading on the pressure gauge should stabilize in these test conditions at around 3 bar. If the pressure is insufficient, carry out the 2nd test.



P4A40FJ03

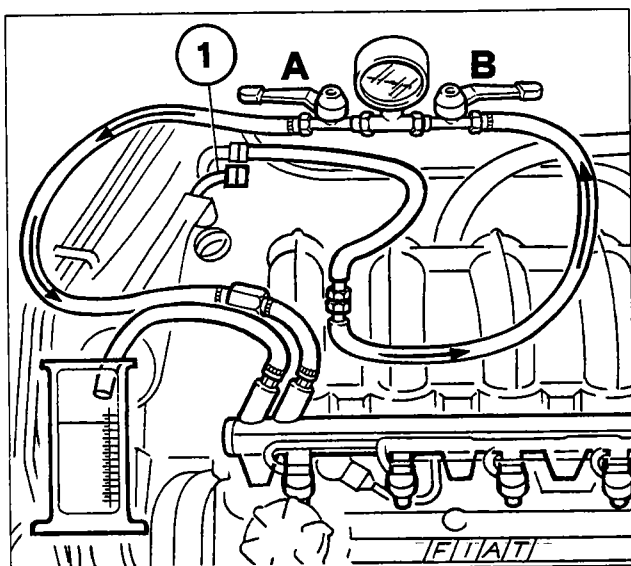


#### 2nd Test

##### Checking maximum fuel supply pressure (or electric pump efficiency)

The same connections as for the previous test apply.

- Close lever A for the fuel tap (downstream of the pressure gauge);
- operate the electric pump with the engine switched off, as described in the previous test: the pressure should reach 6 bar and not exceed 7.5 bar (pump safety valve calibration). If this is not the case, replace the electric pump because it is defective.

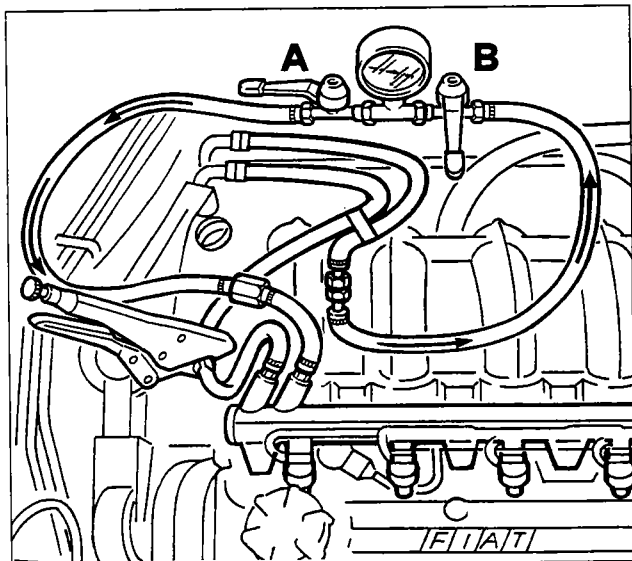


P4A41FJ01



If in the 1st test (see previous page) the pressure value was more than three bar it is necessary to:

- disconnect the fuel return pipe (at the connection point (1) with the rigid fuel return pipe to the electric pump) and place it in a suitable container for collecting the fuel.
- place both taps A and B in the open position;
- operate the electric pump with the engine switched off, as described on the previous page, then read off the value reached on the pressure gauge:
  - a. if it reaches 3 bar, check the fuel return pipe to the tank because it is obstructed or bent;
  - b. if it exceeds 3 bar, then the pressure regulator must be replaced because it is defective.



P4A41FJ02



### 3rd Test

#### Checking injectors seal

To check whether the injectors are dripping, simply implement the connections for the 1st test (checking regulation pressure), then operate the electric pump with the engine switched off. When the regulation pressure is reached, close the control lever B and, at the same time, restrict the fuel return pipe to the tank; a pair of pliers should be used so as not to damage the pipe.

This operation is necessary to distinguish between a real leak from the injectors and the imperfect seal of the fuel pressure regulator flow valve.

Then:

- switch off the electric pump;
- observe whether the pressure remains constant for around 60 seconds as soon as it stabilizes (i.e. decreases slightly).

If this is not the case, there is a leak from one or more injector or from a union.

- If this is the case, remove the fuel manifold from the inlet manifold, keeping the connection with the pressure gauge.
- Repeat the previous test leaving the pressure gauge tap open.
- After having operated the electric pump with the engine switched off, visually inspect for drips from the injectors or from any connecting sections.

Replace any injector which is dripping and/or renew the defective seal which is leaking.

# 10.

## CHECKING ENGINE IDLE SPEED

If the engine idle speed is not  $750 \pm 50$  rpm and the injection/ignition control unit is the self-adjusting type, it is not possible to adjust it, therefore it is necessary to check that the accelerator linkage is correctly adjusted and to then search for the cause of the problem by carrying out a complete fault diagnosis using the Fiat/Lancia Tester.

## CHECKING CONCENTRATION OF POLLUTANT EMISSIONS

The Motronic M 2.10.4 system ensures a constant check on the idle speed and the CO percentage through the self-adjustment of the system, thereby making any outside adjustments superfluous (there are no adjustment screws). However, a check on the content of the exhaust gases downstream of the catalyzer can provide precious indications on the operation of the injection/ignition system, the engine parameters and the catalyzer.

### Checking idle concentration of CO and HC

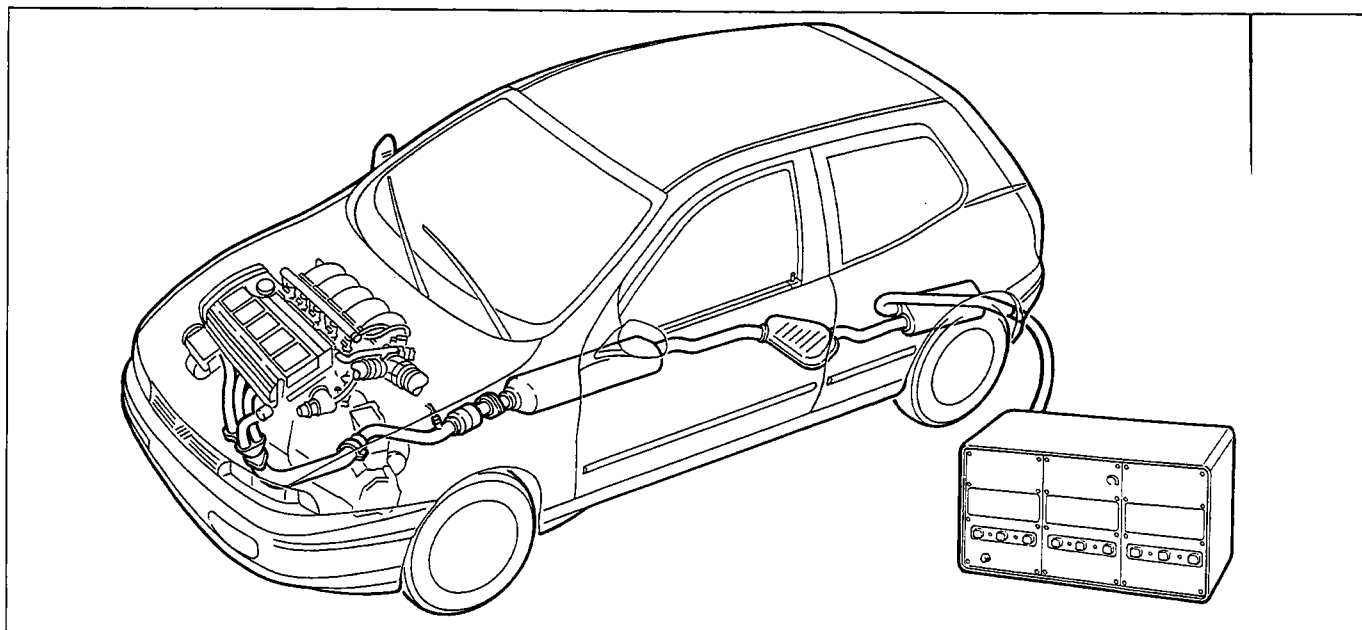
The concentration of carbon monoxide (CO) and unburnt hydrocarbons (HC) is measured with the catalyzer at operating temperature ( $300 - 350^{\circ}\text{C}$ ) (it is advisable to drive "hard" for around 5 - 10 minutes to make sure that the catalyzer reaches operating temperature), then insert the suitably tester probe at least 30 cm into the end of the exhaust pipe as shown in the diagram.

If the shape of the end section of the exhaust pipe is such that the sensor cannot be completely introduced, a special extension pipe must be added which ensures the seal in the join area.

1. Check that the CO and HC concentrations are within the values given in the table;
2. If the CO value is not within the recommended figures, it is necessary to check:
  - the correct operation of the Lambda sensor, using the Fiat/Lancia Tester;
  - 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**).
3. If the HC value is outside of the recommended limits, the cause of the problem should be sought in the incorrect engine timing or the decreased efficiency of the catalyzer.

CO (%)	HC (p.p.m.)	CO <sub>2</sub> (%)
$\leq 0,35$	$\leq 90$	$\geq 13$

**Table summarizing pollutant emission tolerances downstream of the catalyzer**



P4A42FJ01

## DIAGNOSIS

The complete diagnosis of the system is possible through active dialogue with the Fiat/Lancia Tester.

If a failure is detected for the sensors the electronic control unit replaces the information coming from the faulty sensor with information memorized (**recovery**) so that the engine can still operate. The detection of the problem involves it being memorized permanently and the exclusion of the sensor from the system until the signal is compatible once again.

The same procedure is applied if the problem involves an actuator or its control holder. The detection of the problem and the replacement with recovery data involves signalling the problem by the special warning light in the instrument panel coming on.

The parameters which can, in the case of a breakdown, be managed by the control unit are: flow meter, idle adjustment actuator, coolant temperature sensor, butterfly valve position sensor, Lambda sensor, air temperature sensor, battery voltage and detonation sensors. If there are problems with the control unit, the timing sensor or the injectors, the system does not detect the problem and the vehicle breaks down. The problems can be read by an operator on the control unit using the Fiat/Lancia Tester.

### Detecting problems

This is carried out during the basic function which manages the sensor/actuator.

### Memorizing the error and the structure of the errors memory

The errors are memorized in the control unit in the order in which they occur in the RAMS. For each of them the location and type of error, 2 environmental conditions (specific to each type of problem) measured the moment in which the problem is detected and a frequency counter is memorized.

### Classification of the defect

If a defect is recognized for the first time and the error state persists for a time  $t > 0.5s$ , the defect is memorized as "permanent". If this defect then disappears, it is memorized as "intermittent" and "not present". If it then reappears, it remains memorized as "intermittent", but becomes "present".

The classification of a problem as "permanent" activates the recovery functions; when the problem disappears the normal function of reading or implementation is restored.

Certain types of problem are classified as "important", i.e. in terms of anti-pollution regulations. The presence of these problems is signalled to the user by means of the failure warning light in the instrument panel coming on.

### Frequency counter

For each error there is a frequency counter, which is used to determine the moment in which a problem which is no longer present has been memorized. The first time the problem is detected, the counter is set at 10. If the fault disappears, the counter remains at the current value. If it reappears, it is increased by 1 (to an upper limit of 50).

The counter is decreased each time the engine is started up without the fault reappearing. If the counter reaches zero then the fault is automatically cancelled from the memory.

If after having decreased the counter the fault should reappear, the counter returns to a value of 10 (if, however, it is greater than 10, it is not altered).

### Signalling failures

The failure warning light comes on when there is a defect memorized as "present" and "important". The delay time between detecting the problem and the warning light coming on is 0.1 seconds; the delay time between the disappearance of the problem in the memory and the warning light going out is 4 seconds.

The warning light comes on each time the ignition key is turned to the ON position. If there are "important" problems already present, the warning light goes out after 4 seconds.

# 10.

## Cancelling the error

When the frequency counter reaches the value 0, the error is cancelled and so are the parameters associated with it.

The immediate cancelling of the entire errors memory takes place in the following cases:

- by means of the "cancel errors memory" command sent by the tester;
- by interrupting the supply to the injectors control unit (disconnecting the battery or the connector for the control unit).

## Fault diagnosis with the Fiat/Lancia Tester

On the right hand side of the engine compartment (near the engine oil dip stick) is the diagnostic socket to which the Fiat/Lancia Tester is connected.

The exchange of data between the control unit and the Tester takes place via a two direction serial line (line K) using the standard Bosch communication protocol.

The Tester can supply the following information:

- display of the errors;
- display of engine parameters;
- active diagnosis.

## List of errors

Rpm sensor	Loss of signal
Butterfly potentiometer	C.C.
Air temperature sensor	C.C.
Coolant temperature sensor	C.A-C.C.
Battery	Supply > 16,01V.
	Supply < 10V.
Lambda sensor	C.A-C.C.- Incorrect CO value
Injector	C.C.
Idle speed actuator	C.C.
Petrol vapour solenoid valve	C.C.
Actuator relays	C.C.
Control unit	Operating problems for the micro-processor or control unit memories are signalled.
Flow meter	C.C.
Timing sensor	Signal missing or not plausible
Detonation sensor	Signal missing or not plausible
Speedometer sensor	Signal missing or not plausible
Phase transformer	C.C.
Electric fuel pump	C.C.
Fiat CODE	Code not recognized or not received

**Parameters displayed**

Engine rpm  
Injection time  
Advance  
Intake air temperature  
Coolant temperature  
Butterfly valve opening angle  
Battery voltage  
Lambda sensor  
Self-adjustment  
Flow meter  
Engine knocking (detonation)  
Vehicle speed  
Petrol vapour cut out solenoid valve  
Fiat CODE  
Mileage travelled

**Active diagnosis**

The following active tests can be carried out using the Fiat/Lancia Tester:

- Phase transformer
- Injector
- Failure warning light
- Petrol vapour solenoid valve
- Air conditioning
- Idle speed actuator
- Cancelling errors.

**Recovery**

If there are problems with the sensors, the control unit replaces the value transmitted by the sensor with a so called Recovery value which, depending on the different problems, is stored in the control unit memory or is specially reconstructed from the other information available, in order to allow the vehicle to reach a service centre.

This value is also transmitted to the Fiat/Lancia Tester, therefore, during the fault diagnosis it is worth bearing in mind that in the case of problems the Fiat/Lancia Tester will signal the error for the sensor concerned and the Recovery value will be displayed.

**Permanent memory**

The control unit is equipped with a «permanent» type errors memory (EEPROM), i.e. the error indication is preserved even if the cause of the problem no longer exists and the key has been turned to the OFF position; it also has a «volatile» type memory (RAM) which, on the other hand, loses the error information as soon as the cause disappears.

This also allows the more effective detection of errors of an occasional nature.

Before ending the fault diagnosis the contents of the «permanent» memory should be cancelled using the Fiat/Lancia Tester in Active Diagnosis.

The contents of the «permanent» errors memory can be cancelled in the following ways:

- 1 - Using the Fiat/Lancia Tester in active diagnosis.

If this is not the case, when the Fiat/Lancia Tester is reconnected the errors already examined are signalled.

- 2 - If the cause of the error is no longer present and the engine has been started up 5 times (working for at least 20 minutes) with a gap of at least 2 minutes between one starting and the next.



*Disconnecting the control unit from the system, even for long periods of time, does not cancel the contents of the «permanent» memory.*

