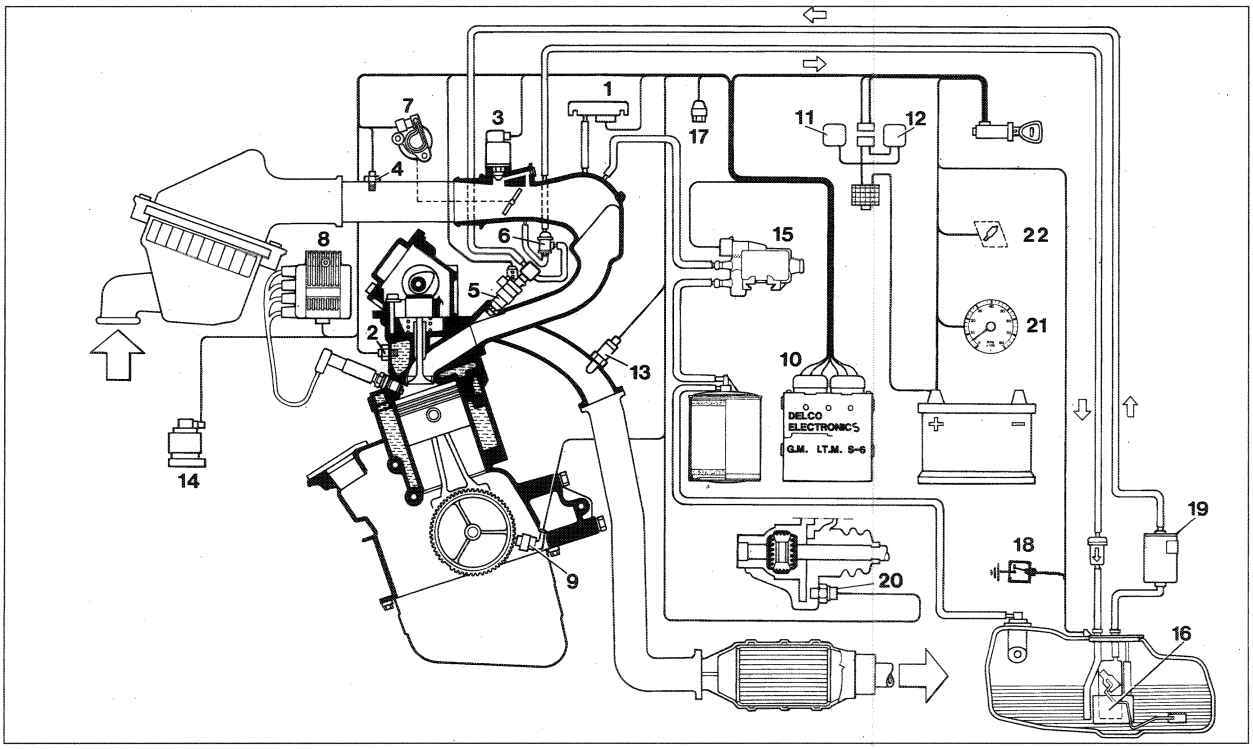
G.M. ACG MULTEC - XM M.P.I. INTEGRATED INJECTION-IGNITION SYSTEM

Introduction

The G.M. system fitted to the Punto 1581 engine belongs to the category of digital electronic integrated ignition systems with solid-state advance and distribution and an electronic intermittent, multipoint semi-sequential petrol injection system.
This device ensures efficient operation and good fuel economy while minimising noxious exhaust emissions because the system complies with USA '83 emission control regulations.
Lastly, this type of system does not require adjustments of any type, for example to engine idle speed, butterfly valve position sensor or exhaust gas CO level.

INJECTION-IGNITION SYSTEM DIAGRAM



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1. Absolute pressure sensor
2. Engine coolant temperature sensor
3. Engine idle speed adjustment step motor
4. Intake air temperature sensor
5. Injectors
6. Fuel pressure regulator
7. Throttle position sensor
8. Ignition coil (with incorporated power modules)
9. Rpm and TDC sensor.
10. Electronic control unit
11-12. Injection/ignition system relays
13. Lambda probe
14. E.G.R. solenoid.
15. Vapour recirculation solenoid
16. Electric fuel pump
17. Diagnostic socket
18. Inertia switch
19. Fuel filter
20. Speedometer sensor on gearbox
21. Rev counter
22. Injection-ignition system failure warning light

PRINCIPLE OF OPERATION OF INJECTION SYSTEM

Two essential conditions must be satisfied during air-fuel mixture preparation for efficient operation of controlled ignition engines:

1) metering (air/fuel ratio) must be maintained as close as possible to a stoichiometric level in order to ensure swift combusion and avoid pointless waste;

2) the mixture must be made up of petrol vapour distributed through the air as finely and evenly as possible.

In the ACG MULTEC-XM system, the injector nozzles distribute the petrol by nebulising it into tiny droplets. Because the absolute pressure of intake air may vary, the amount of fuel to be injected must be adjusted in order not to alter the air-fuel weight ratio. This ratio is maintained constant by altering the fuel feed pressure by means of a regulator according to inlet manifold vacuum level. In this way, the difference between the two pressures is maintained constant under all engine service conditions.

Optimal **metering** is calculated on the basis of the following measurements:

- Absolute pressure in inlet manifold
- Coolant temperature
- Inlet air temperature
- Level of oxygen in exhaust gas
- EGR percentage

Base pulse width is calculated through indirect measurement of engine load, achieved by measuring absolute pressure in the inlet manifold and rpm (Speed Density).

The following main parameters are considered when calculating injection time:

- Base pulse constant
- Absolute pressure
- Air temperature
- Metering (A/F)
- Volumetric efficiency
- Battery voltage
- Self-adaptive factor
- Lean-burn factor during over-run
- Closed-loop correction"
- Enrichment during acceleration.

The part of the equation directly concerned with the Speed Density measurement is given by the **product of base pulse constant** (BPC) **and absolute pressure and volumetric efficiency divided by the product of air temperature and metering** (A/F) **carried out by the microprocessor every 15.6 ms.**

The ECU governs the injectors electrically. These are **connected in pairs in parallel**, and **inject two by two in asynchronous fashion** , with injection start instant, **mappable up to 180° after the 7th tooth** (cylinders 2-3) **and the 37th tooth** (cylinders 1-4) **of the phonic wheel**.

Injection delay depends on engine speed and throttle angle.

PRINCIPLE OF OPERATION OF SOLID STATE IGNITION SYSTEM

The ECU contains a memory map with a set of advance settings to be adopted by the engine according to engine speed and load.

The ECU selects the best advance setting for the engine on the basis of engine speed and absolute pressure in the inlet manifold. It then drives the power module associated with the cylinder in combustion phase.

The resulting advance setting is corrected mainly on the basis of;
- Coolant temperature
- Inlet air temperature
- E.G.R. percentage.
- Altitude (barometric pressure)
- Transitory acceleration phase.

The ignition system consists of:

a) **An ignition coil** with four High Tension terminals, made up of two primary windings (supplied at battery voltage) and two secondary windings (High tension) whose outputs are connected directly to the spark plugs of cylinders 1-4 and 3-2. These are supplied with High Tension each time the primary winding is supplied by the power module.

Because of the nature of the secondary circuit (spark plugs in series), the High Tension that supplies the two spark plugs simultaneously is of different intensity. This is due to the fact that periodically one of the two spark plugs is under greater pressure (compression) compared to the othrs (exhaust phase). The current must therefore overcome a greater dielectric potential in the spark plug that is in compression and will give rise to a more powerful spark in this plug. The power of the second spark is negligible to reduce fuel consumption (lost spark)

b) **A power module** (incorporated in the ignition coil) supplies the primary winding of the ignition coil with sufficient current to energise it completely and thus cut off the current instantly so that high tension is set up in the coil secondary winding and a spark is triggered to the spark plug.

The information required by the ECU for controlling ignition is provided by the following sensors:

- **Rpm/T.D.C. sensor.**: indicates engine speed and identifies T.D.C. of cylinders 1-4 and 3-2 by means of a facing phonic wheel.

- **Absolute pressure sensor**: by means of an electrical signal proportional to absolute pressure in the inlet manifold, directly linked to engine load.

SYSTEM COMPONENTS

The G.M. ACG MULTEC-XM injection-ignition system is made up of four interdependent circuits:

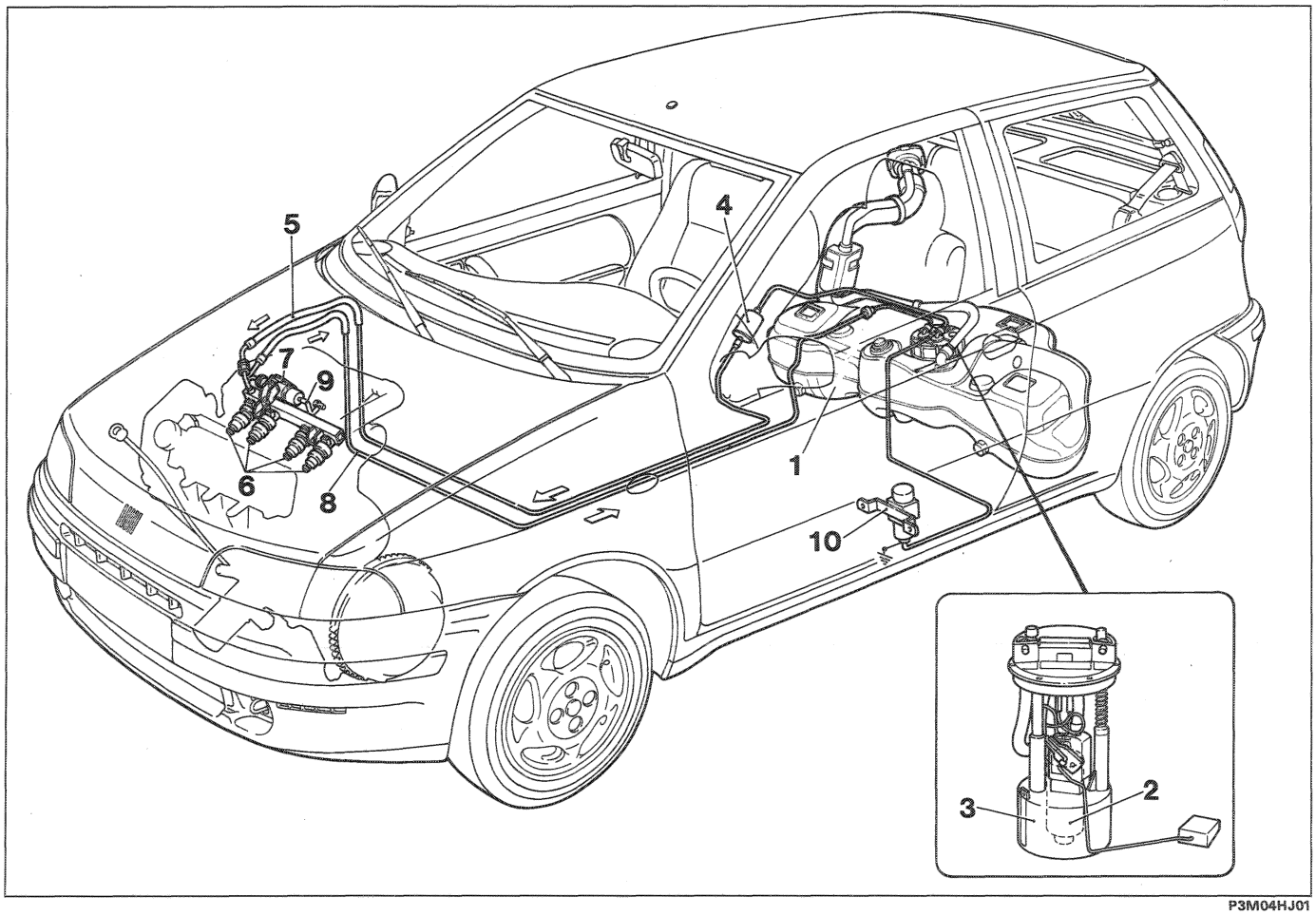
A Fuel supply circuit
B Air intake circuit
C Electric/electronic circuit
D Circuit for checking harmful exhaust emissions

Devices and associated circuits strictly connected to the injection-ignition system are also present. These are also designed to reduce noxious vehicle emissions in line with USA '83 standards and are as follows: **fuel evaporation control and vapour recovery circuit; crankcase vapour recirculation and recovery circuit; exhaust gas recirculation system (E.G.R.).**

A. FUEL SUPPLY CIRCUIT

This consists of the following parts:

1. reservoir
2. pump submerged in tank
3. mesh prefilter on pump intake
4. paper main fuel filter
5. outlet line
6. four injectors
7. fuel pressure regulator
8. return line with one-way recirculation valve or anti-reflux valve
9. vacuum point for fuel pressure regulator
10. inertia safety switch



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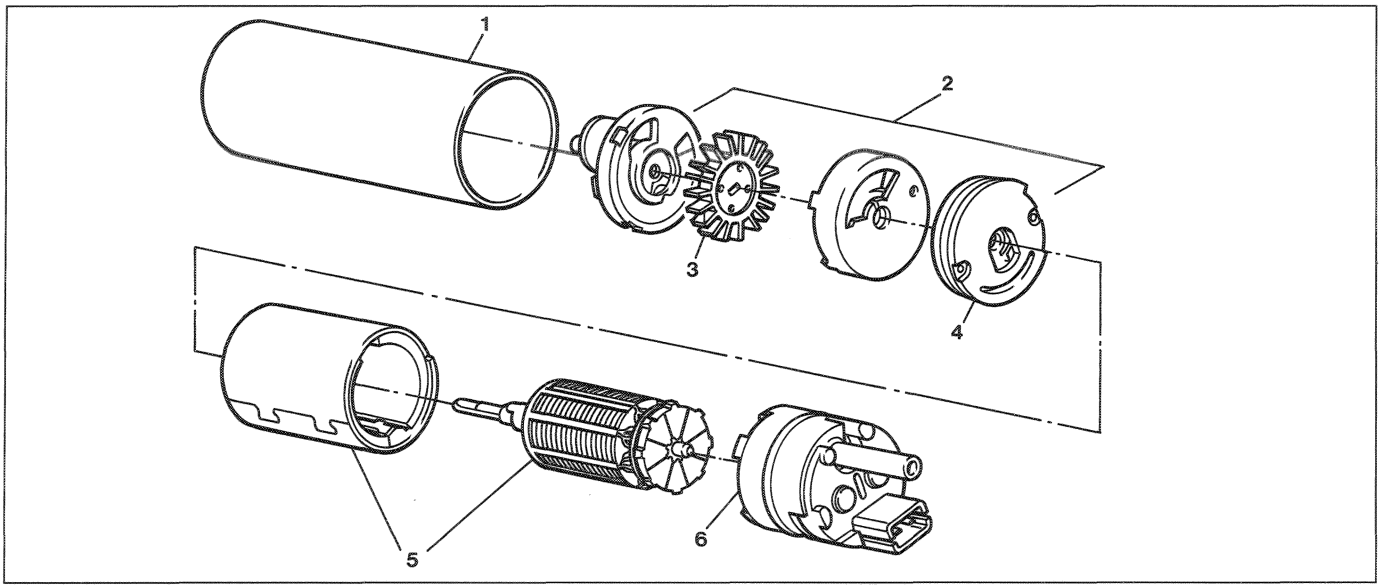
ELECTRIC FUEL PUMP

The mixed, two-stage electric fuel pump is fitted with a turbine for low pressures and rollers for high pressures. Fuel is taken up from the tank under low pressure and sent to the engine at high pressure.

Because it is fitted in the fuel tank, this pump performs the initial function of vapour separation. An impeller separates vapour from fuel inside the pump by means of centrifugal force. A vapour separator optimises output of heated fuel and forces it back to the fuel tank. Fuel then flows from the vapour separation assembly to the pump high pressure module. This module is designed expressly to ensure fuel delivery from tank to injection system at the required pressure.

Fuel is then forced towards the engine through the terminal assembly (cover) of the pump and the outlet pipe. The terminal assembly comprises a valve and an RPI (radio frequency interference) suppression module. The valve maintains fuel feed pressure when the engine stops running. The RFI circuit prevents noise due to pump operation that interferes with radio frequencies.

Output is about 90 l/h with pump pressure relief valve setting of **4.5-6.5 bar**.



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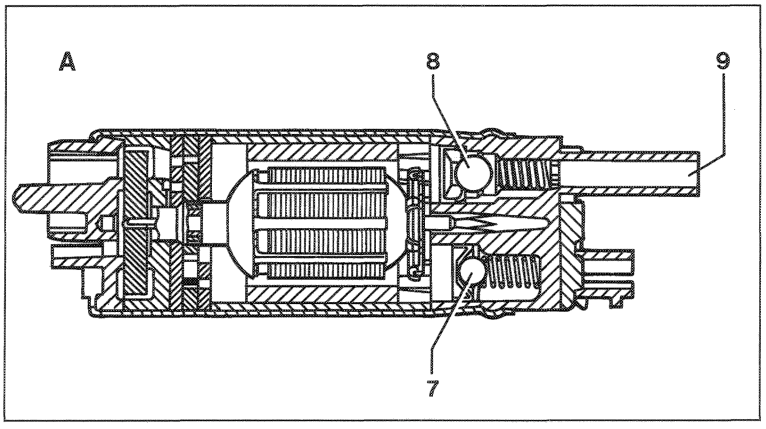
The electric pump consists of:

1. Case
2. Two-stage pumping section
3. Low-pressure turbine
4. High pressure roller
5. Pump motor
6. Cover assembly
7. Safety valve
8. Retaining valve
9. Fuel outlet
10. Fuel intake
11. Vapour exhaust



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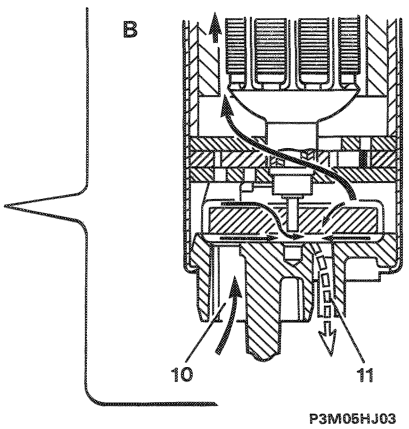

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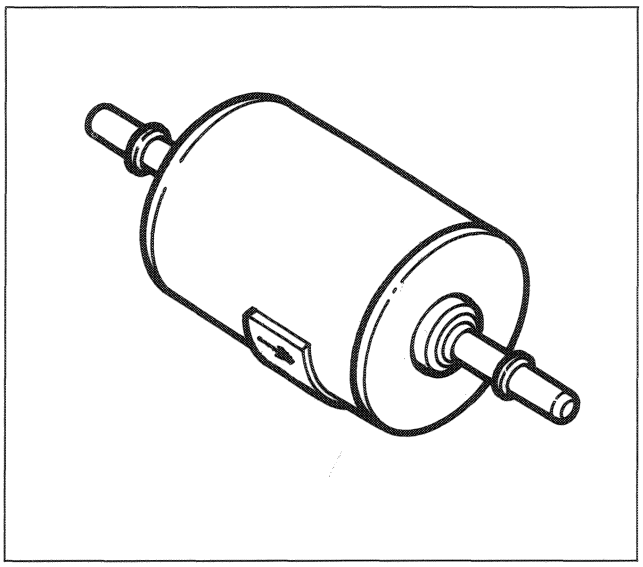

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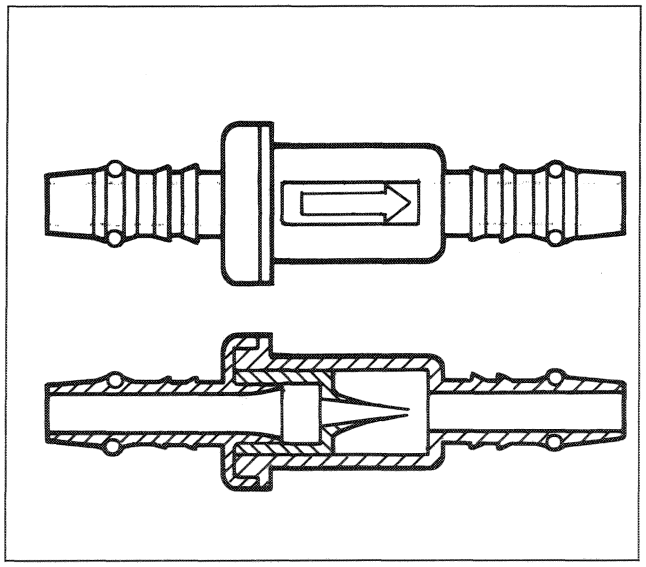
FUEL FILTER

The filter is fitted under the body near the fuel tank along the pipe carrying fuel to the throttle case.
It is made up of an outer case and an internal mount that holds a paper element with high filtering capacity.
This is essential for ensuring injector operation because the injector is extremely sensitive to foreign bodies in the supply circuit.

It is therefore advisable to replace the unit at the recommended intervals.



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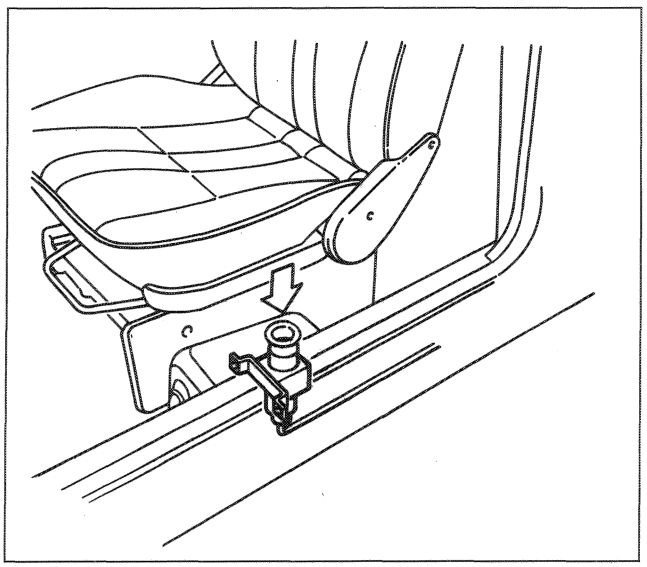
FUEL RECIRCULATION ONE-WAY OR ANTI-REFLUX VALVE

This is a safety valve fitted in the fuel return line near the tank. It allows fuel to return to the tank and prevents reflux in the case of an accident with consequent pipe breakage.



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INERTIA SAFETY SWITCH

This switch is located alongside the driver's seat on the left hand side and triggered in the case of vehicle collision to cut off the earth connection to the fuel pump and thus the supply to the injection system.

The same switch is fitted to all versions.

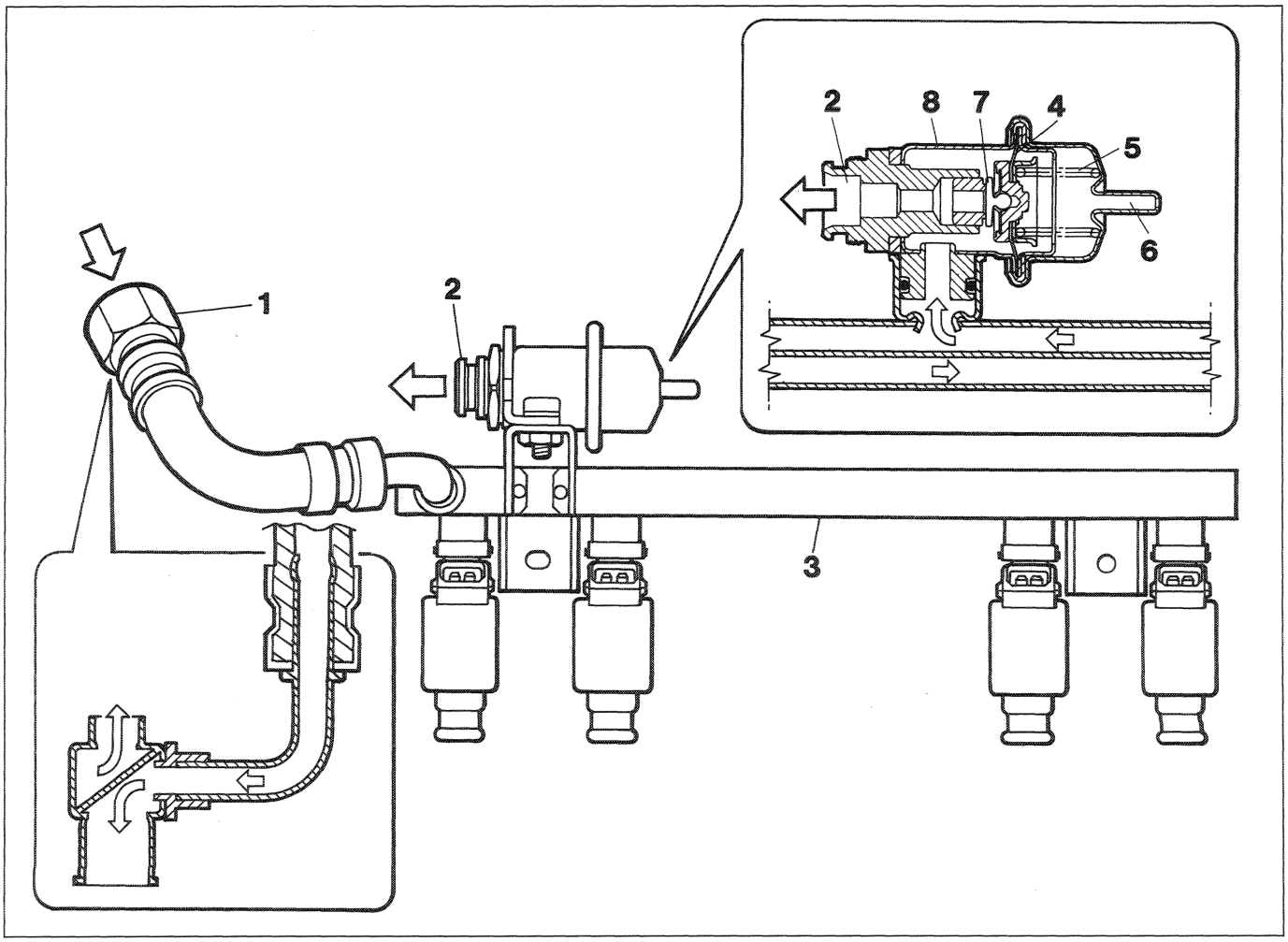
PRESSURE REGULATOR AND FUEL MANIFOLD

The mechanical, membrane type pressure regulator is fitted to the fuel manifold and is not adjustable. The one-piece fuel manifold supports both injectors and pressure regulator.

The pressure regulator consists of a metal case that houses a mobile unit and membrane (4) loaded by spring (5). Once a pre-established force made up of the vacuum present on the opposite side of the membrane and load of spring (5) has been overcome, fuel forced out by the pump brings about opening of valve (7) that permits excess fuel to flow back through pipe (2) to the tank.

The spring housing chamber communicates with the intake duct of engine (6) (vacuum signal). This arrangement maintains a constant difference between fuel pressure and intake duct pressure under all engine service conditions.

Pressure regulator setting: 3±0.2 bar
With engine idling 2.5±0.2 bar (vacuum about 0.5 bar).



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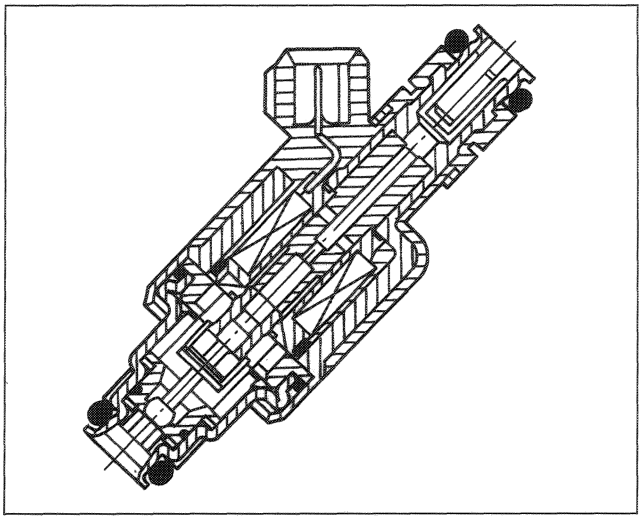
1. Fitting connected to fuel inlet line
2. Fitting connected to fuel return line
3. Injector and fuel manifold support
4. Membrane with reflux valve
5. Regulating spring
6. Pipe connected to vacuum in intake manifold
7. Reflux valve
8. Metal case



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INJECTOR

The injectors are fitted to the inlet ducts immediately before the inlet valve.

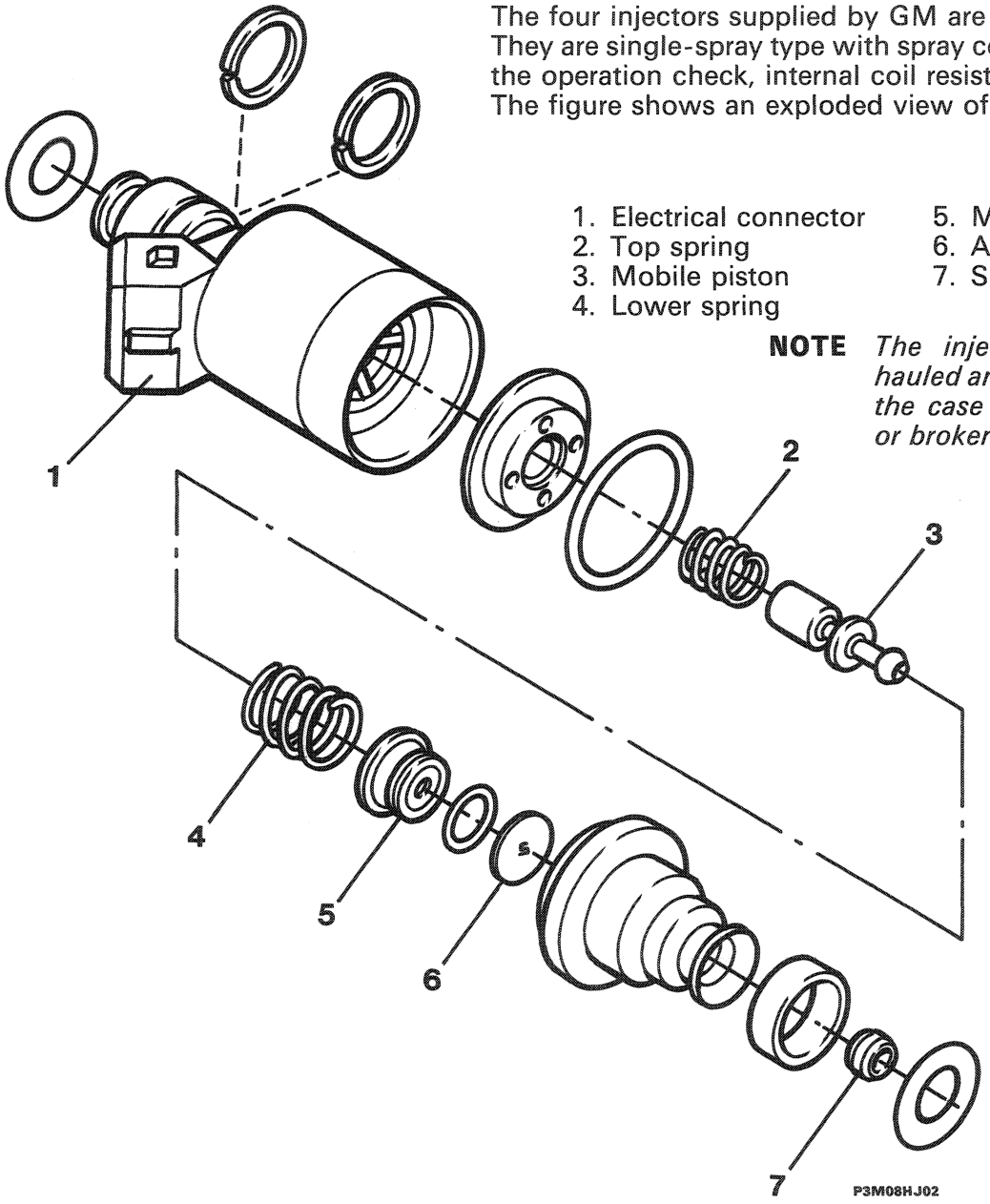
The injector nozzle is positioned so that the fuel jet strikes the intake valve directly.

The injectors are held in place by the fuel manifold, which presses the injectors into their seats in the inlet ducts. They are also anchored to the fuel manifold by safety clips. Two rubber rings seal the inlet duct and fuel manifold.

The four injectors supplied by GM are supplied at 12V. They are single-spray type with spray cone amplitude of 8°. For the operation check, internal coil resistance is 12 ± 0.4Ω. The figure shows an exploded view of an injector where:

1. Electrical connector
2. Top spring
3. Mobile piston
4. Lower spring
5. Mobile piston seat
6. Adjustable hole
7. Spray orifice

NOTE *The injector cannot be overhauled and should be replaced in the case of noise, short-circuits or broken circuits.*



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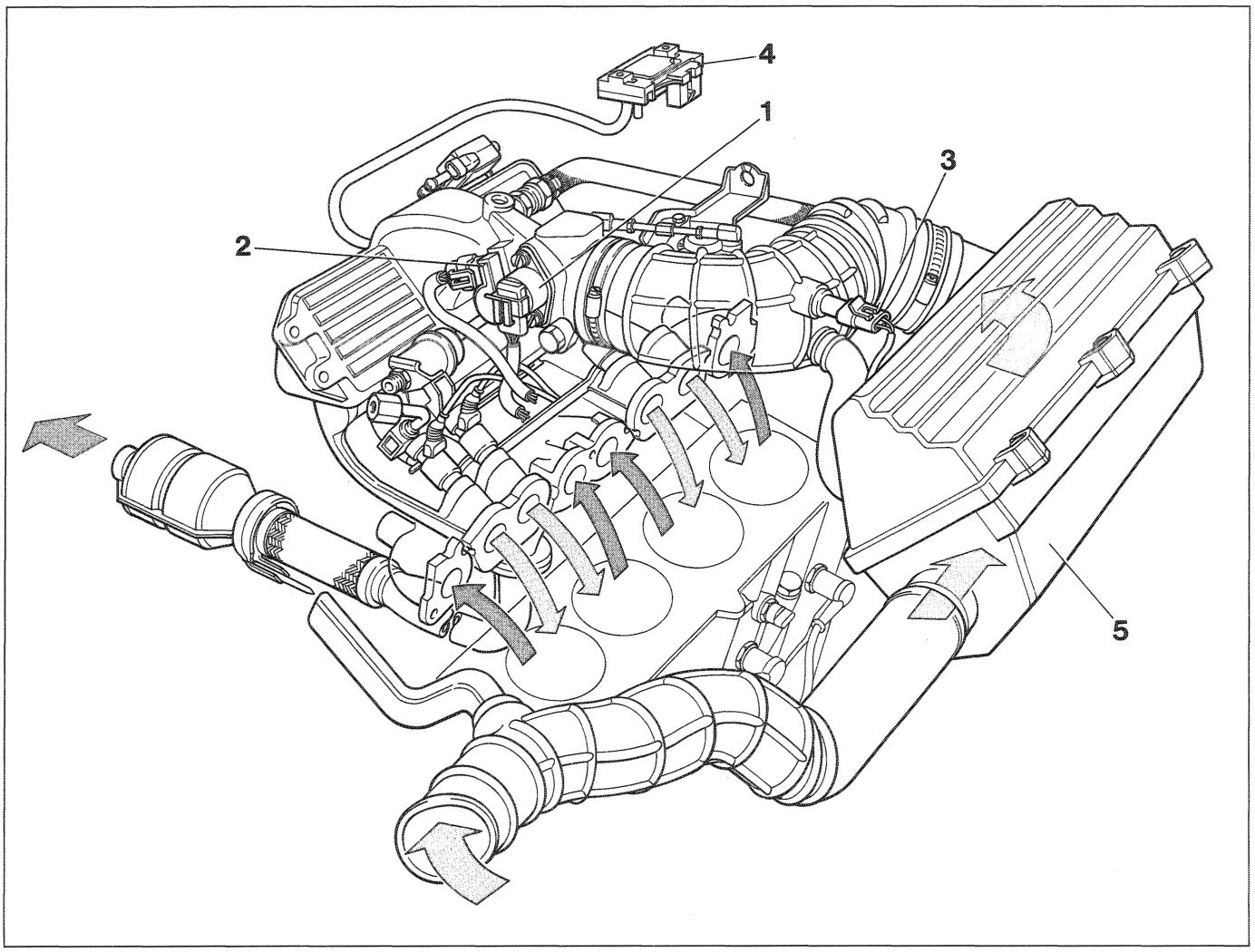
B - AIR INTAKE CIRCUIT

This consists of the following components:
A throttle case containing the **engine idle speed regulation step motor, throttle valve position potentiometer and inlet air temperature sensor.**

- An absolute pressure sensor with vacuum socket connected to the inlet manifold.
- Air cleaner.



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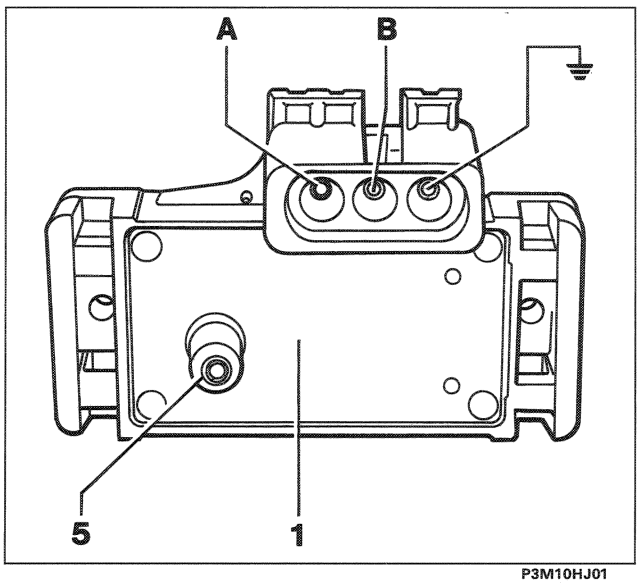
1. Engine idle speed regulation actuator (step motor)
2. Throttle valve position potentiometer
3. Intake air temperature sensor
4. Absolute pressure sensor
5. Air cleaner

ABSOLUTE PRESSURE SENSOR



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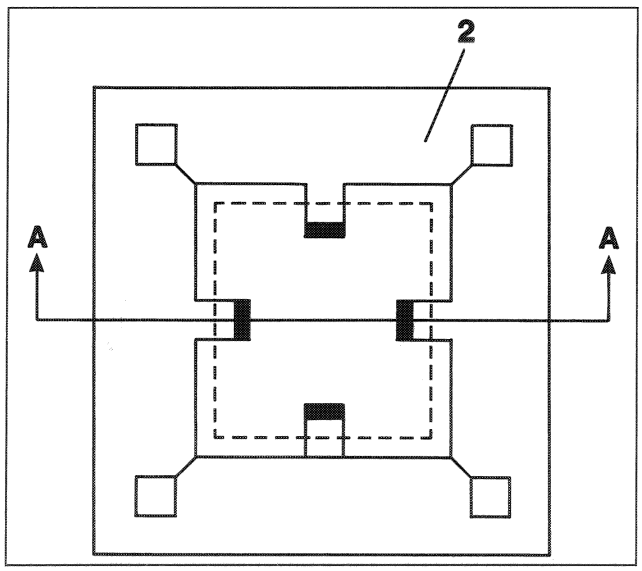

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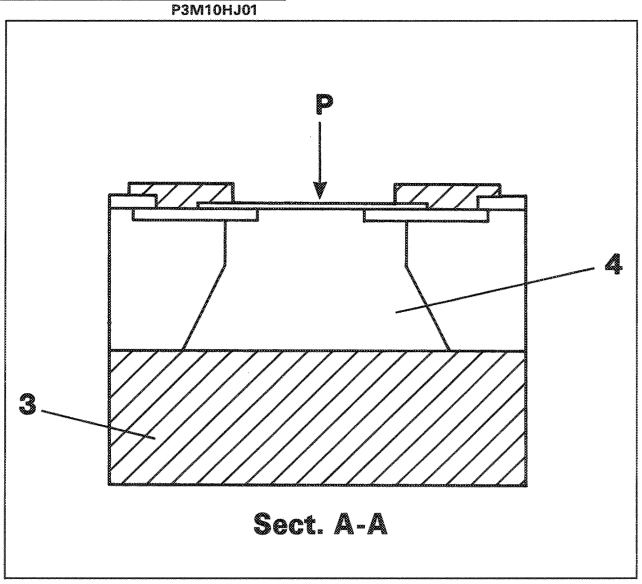

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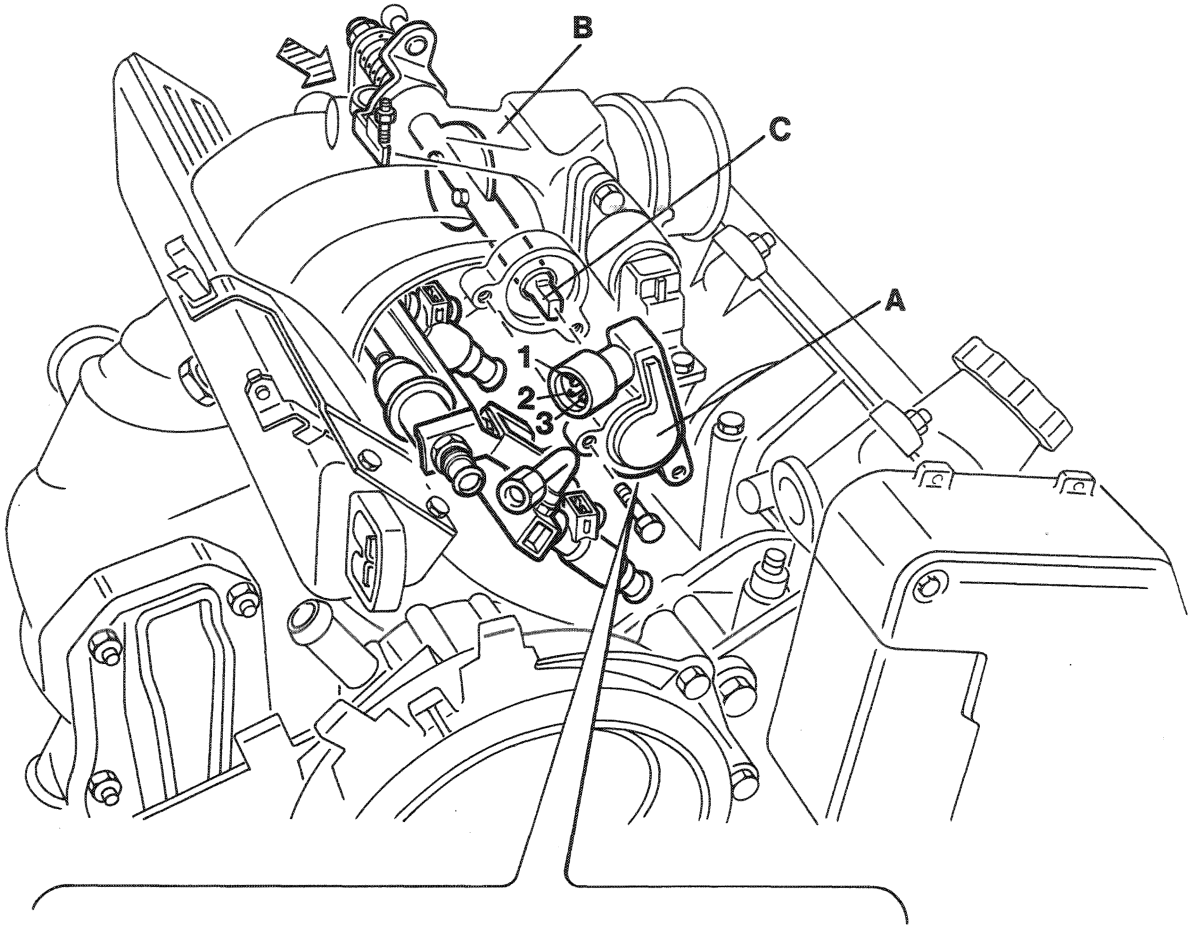
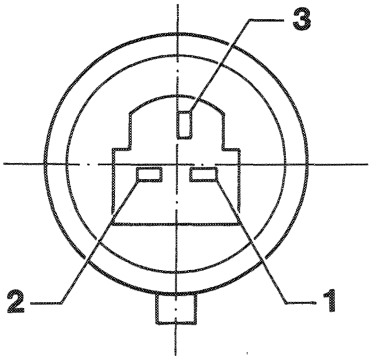
Absolute pressure sensor (1) measures changes inside the inlet manifold due to changes in engine load and rpm through vacuum point (5).

It consists of a diaphragm made out of insulating material in which are embedded resistances connected to form a bridge mesh (2).
The edge of the diaphragm is sealed to pyrex plate (3). A vacuum is set up in this in order to obtain reference cavity (4).
As soon as pressure P is applied to the part of the diaphragm that communicates with the inlet manifold, the diaphragm bends to bring about a change in the bridge resistance proportional to the applied pressure.
The ECU supplies pressure sensor (1) with a reference voltage of 5 Volts through terminal A and is able to record voltage changes brought about by pressure changes: the resistance change brings about a voltage change that the ECU uses to calculate absolute pressure in the intake manifold on a parametric basis. If pressure recorded in the intake manifold is 0.60 bar, therefore, voltage measured by the ECU is 2.75 Volt.

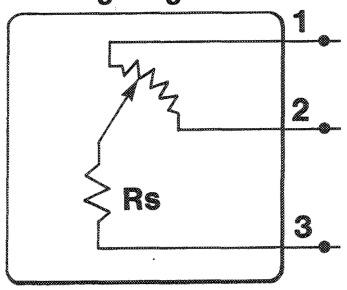
The ECU also uses the pressure value measured before the engine starts: this value measured with no vacuum in the inlet manifold represents the atmospheric pressure level.

BUTTERFLY VALVE POSITION POTENTIOMETER





Wiring diagram



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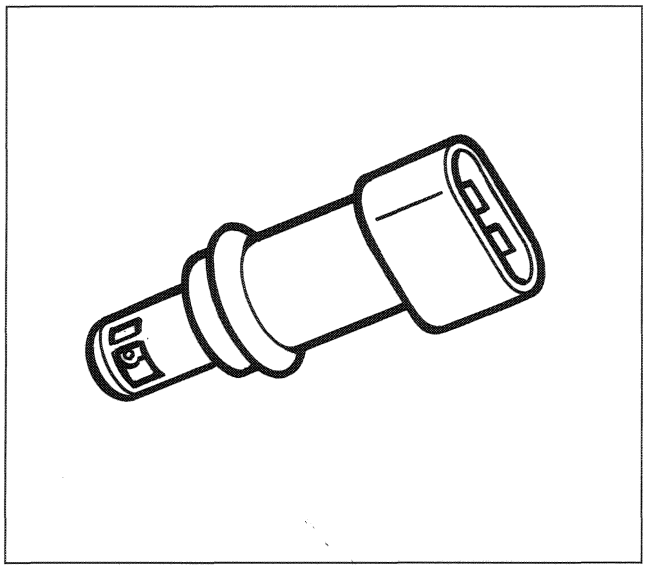
The arrowed screw is used to adjust throttle closure to prevent fouling against the surrounding duct; **this screw must not be used to adjust idle speed because it is set by flushing during manufacture and should never be tampered with under any circumstances.**
The resistance value measured across terminals 1 and 2 must be > 3KΩ

Butterfly valve percentage opening sensor (A) is fitted on butterfly valve case (B) and connected directly to the butterfly valve spindle.
Butterfly valve angular position is determined by measuring the resistance of the potentiometer that constitutes the sensor (resistance varies as throttle opening angle changes).
The ECU provides the butterfly valve position sensor with a reference voltage of 5 Volt.

As rotation of the butterfly valve about its spindle changes, electric circuit resistance alters: by measuring the voltage between one resistance terminal and variable connection of potentiometer (3) connected to terminal F5, the ECU is able to determine percentage throttle opening on a parametric basis.

If throttle opening is 30°, therefore, the ECU measures a voltage of 1.70 Volt.
Pin 1 is connected to pin F8 of the control unit and receives a signal, while pin 2 is connected to pin F15 of the ECU and to earth.



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INTAKE AIR TEMPERATURE SENSOR

Air temperature is measured by a sensor fitted to the air intake duct. The air temperature sensor consists of an NTC resistance able to alter its own resistance in inverse proportion to temperature
The ECU provides the sensor with a 5 Volt reference voltage through terminal B-4 and F-15 and is able to record air temperature by measuring the current in the circuit (the current change is determined by the resistance value that changes according to temperature). If the temperature of air in the intake manifold is about 0°C, sensor resistance is some 8,000Ω.

ENGINE IDLE SPEED CONTROL ACTUATOR (Step motor)

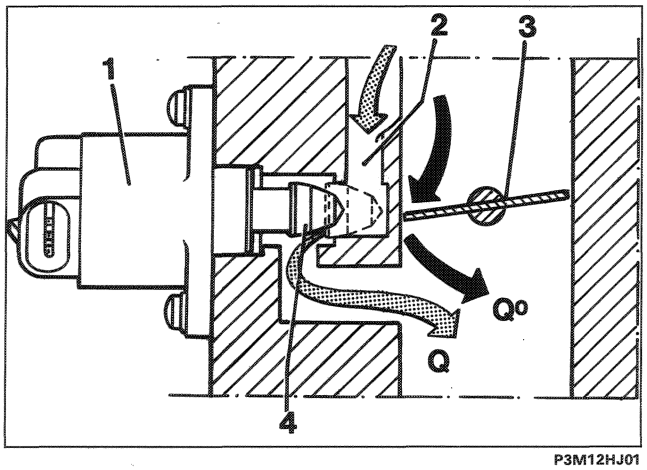
In order to idle (i.e. with throttle valve fully closed), the engine requires a certain amount of air and fuel to maintain its speed of rotation and overcome any internal engine friction. This quantity of air must increase if the engine is subjected to an additional load due to activation of an appliance.

Until the engine warms up, the amount of fuel injected must be increased in addition to the extra air flow. The ECU arranges this on the basis of signals from the coolant temperature sensor.

The amount of air that leaks through the closed throttle valve when the engine is idling is supplemented by a further quantity of air when the engine is warming up or when electrical appliances are activated in order to maintain engine rpm at the same level. This result is achieved through the modulated opening of an air by-pass duct connected in parallel with the throttle valve.

In order to achieve this result, the system uses a step motor (1) fastened to the ECU. During operation, this moves a rod equipped with a plunger that adjusts the cross section of the by-pass duct and, consequently, the amount of air (Qo + Q) taken up by the engine.

The ECU uses engine angular speed and coolant temperature parameters obtained from specific sensors in order to regulate this type of action.



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Air flow leaking through throttle (constant)

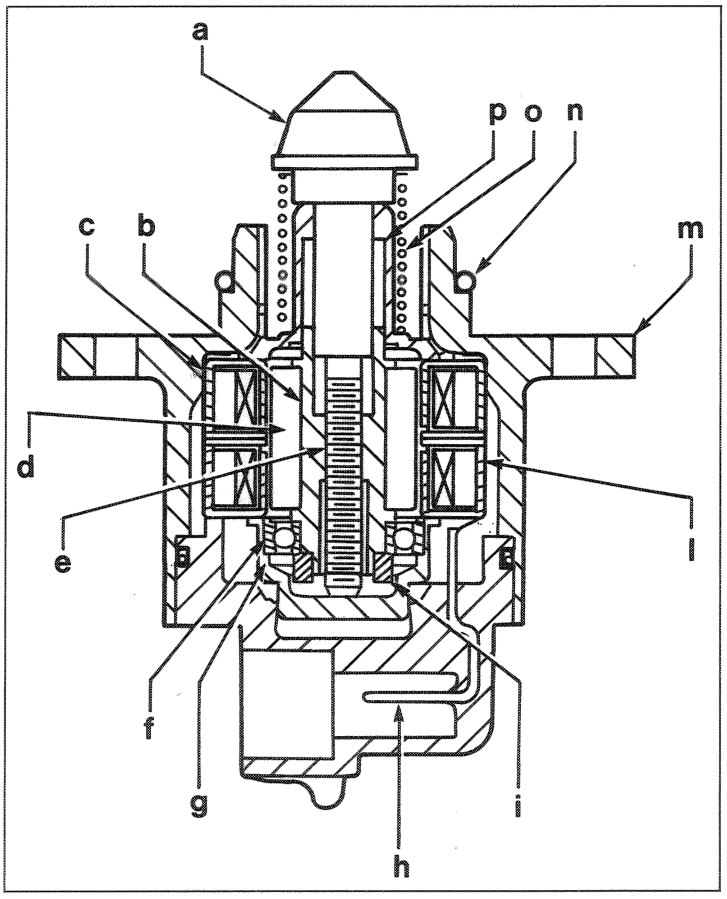
Air flow regulated by actuator (variable)

Cross section through additional air and idle adjustment actuator

1. Control step motor
2. By-pass duct
3. Throttle valve
4. Plunger

The ECU controls pin movements through 4 electrical lines and memorises the positions taken up. Reference position 0 is achieved when the actuator pin is fully extended and no supplementary air flow is present.
When the engine is off, the ECU positions the actuator pin in accordance with a value recorded in the memory so it is ready for the subsequent start-up stage.
While the engine is idling, optimal air control motor position is computed by the ECU on the basis of coolant temperature and any external loads.

The ECU also monitors battery terminal voltage continually. If for any reason terminal voltage is <9 Volt, or >17 Volt, the ECU will not allow the air control motor to move because efficient operation cannot be assured under these conditions.



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The cross section shows all components of the step motor, namely:

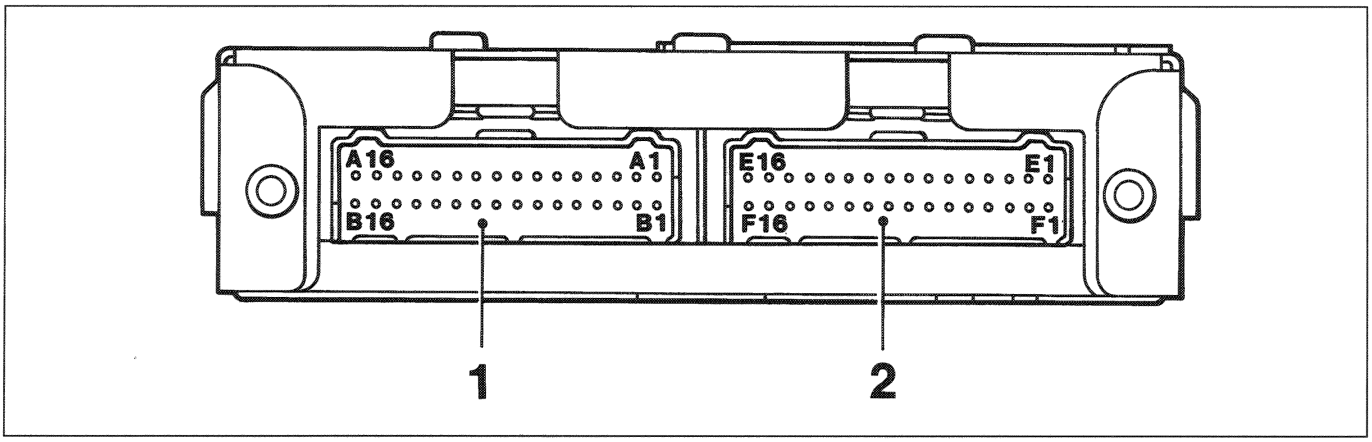
a) Plunger or plunger pin
b) Rotor assembly
c) Insulating layer
d) Magnetic core
e) Worm screw
f) Bearing seat
g) Ball bearing
h) Electrical connector
i) Rotor sleeve
l) Stator assembly made up of: winding, polar expansions and coil
m) Outer case
n) O-ring
o) Compression spring
p) Plunger guide support

C - ELECTRIC/ELECTRONIC CIRCUIT

Connects all injection/ignition system components and provides them with electricity. It consists mainly of an ECU and the following components.

- Two system supply relays
- Throttle valve position sensor
- Coolant temperature sensor
- Fuel pump submerged in tank
- Four injectors
- Absolute pressure sensor
- Intake air temperature sensor
- Engine idle speed regulation actuator (step motor)
- Rpm and TDC sensor
- Ignition coil with four high tension outlets and power module incorporated
- Lambda probe
- Fuel vapour control solenoid
- Four spark plugs
- Inertia safety switch
- Diagnostic socket for Fiat/Lancia Tester
- Injection-ignition system failure warning light

INJECTION-IGNITION ECU (CONTROL UNIT)



Reference numbering of terminals (pin) on control unit

1. 32-way connector, red
2 32-way connector, dark yellow

CONTROL UNIT FUNCTIONS

Starting and cold starting

During start-up, the injectors are controlled in two main stages:

- **Prime Pulse** (Prime pulse)
- **Simultaneous Double Fire Crank**

A prime pulse is administered as quickly as possible in order to minimise starting times. Pulse size depends on coolant temperature.

Simultaneous double fire crank occurs twice upon each crankshaft revolution in correspondence with teeth 22 and 52 of the phonic wheel and persists until 450 rpm is exceeded.

During cold starts, the mixture is enriched on the basis of mapped values according to temperature and absolute pressure.
Special anti-flood functions reduce enrichment if starting takes a long time.

Engine warm-up

The heating stage begins when the post-starting stage is over and lasts until conditions are suitable for entry into closed loop operation (lambda probe operating range). During this stage, the fuel mixture is enriched in inverse proportion to coolant temperature.

Enrichment during acceleration

Enrichment is implemented during acceleration in asynchronous manner according to information on butterfly valve angular changes and absolute pressure.
Requirement for/size of these factors is computed every 7.81 ms.

Heavy load

During operation under full load, the fuel mixture is enriched to allow the engine to deliver full power (achieved without a stoichiometric ratio) and prevent the catalyser overheating.
The lambda probe reading is disenabled.

Fuel cut-off

When the accelerator pedal is released, engine temperature > 40 °C, vehicle speed > 20 Km/h and rpm > 1750, the control unit cuts off injection (CUT-OFF). It is restored when speed drops below 18 Km/h and rpm below 1500.

Idle speed control

The ECU controls idle speed in three ways:
- by means of a stepper motor that moves a plunger to act on the throttle by-pass;
- by changes in ignition advance;
- via asynchronous fuel injections.

Idle speed control is implemented to compensate for power taken up by the various appliances in order to ensure speed is maintained as constant as possible.
The ECU is able to take vehicle speed into account in order to control restoration of idle speed in different ways according to whether vehicle is stationary or moving.

Restriction of maximum rpm

Injection is cut off when 6600 rpm is exceeded.

Control of combusted gas - Lambda probe

The ECU ensures air-fuel ratio is maintained close to stoichiometric levels for as long as possible in order to permit efficient, long-lasting operation of the catalytic converter.

Fuel vapour recovery

Fuel vapours from the tank and subsequently collected in the active carbon filter are taken up again so that they can be burnt.
Vapour take-up and intake activation are governed by the ECU by means of a solenoid controlled with Duty Cycle proportional to rpm, engine load and base pulse constant.

Air conditioner compressor connection

The ECU is interfaced with the air conditioning system (where fitted) in order to stabilise idle speed fluctuations due to power absorption caused by compressor activation.
By controlling information such as engine load, coolant temperature and throttle angle, the ECU is able to de-activate the compressor if necessary.

Connection with anti-theft system

The anti-theft device can alter the logical status of one ECU pin to de-activate the engine.

Controlling ignition advance

The ECU also processes a control strategy for the solid-state electronic ignition.

The optimal advance angle is computed as follows:

1. A baseline advance angle is computed using a memory map whose input parameters are engine angular speed of rotation and absolute pressure measured in the inlet manifold. Two different one-dimensional tables are used when idling and under full load on the basis of engine speed.

2. The resulting values are added to the correction for coolant temperature during the engine warm-up period.

3. The idle table value is further corrected in the case of sudden drops in idle speed (e.g. due to activation of an appliance).

4. Speed is used in the case of over-run and subsequent cut-off.

5. The advance angle setting is also corrected under the following conditions:
   – transitory throttle positions;
   – return from cut-off due to changed throttle position;
   – return from cut-off due to minium rpm threshold.

System self-diagnosis

ECU input/output may be subjected to diagnosis whereby signal characteristics are checked cyclically. In the case of malfunction, errors are memorised in two tables: "current" and "history", the former associated with the volatile memory (RAM) and the other to the non-volatile memory (RAM STAND-BY).

When an error is recorded, it is saved in the "current" table and then input into the "history" table following a validation period.
When the error disappears, it is eliminated from the volatile memory but remains present in RAM STAND-BY.
For errors to be deleted from the non-volatile memory, one of the following conditions must be satisfied:
- the number of error-free engine ignitions must exceed 20;
- a special command is sent from the Fiat/Lancia Tester.

The RAM STAND-BY is cleared completely by the diagnostic instrument.

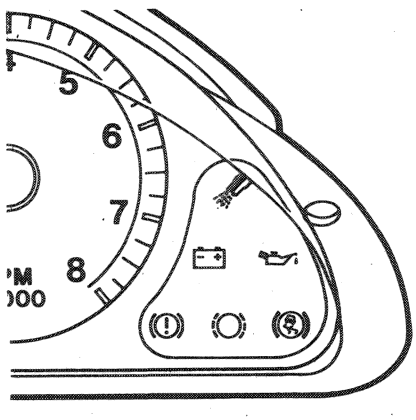
This strategy is usually applicable; the only exception occurs in the case of faults in injectors, phonic wheel and coils that are identified only when activated.
The diagnostic instrument can activate individual components in order to check their efficiency.
The presence of a sensor/actuator operating anomaly is indicated to the user by **the lighting up of a warning light** as soon as the fault occurs and this is simultaneously validated by the ECU itself (simultaneous memorisation in RAM and RAM STAND-BY);
The light goes off when the repair is carried out or if the fault is not permanent.
In the case of a fault, the ECU controls alternative functions in order to keep the engine working as far as possible so that the vehicle can be taken back to a service centre **(recovery).**

NOTE *When the ignition is turned to "MAR" the warning light is on; it goes off some 0.5 sec. after a successful starting attempt if no significant faults are recorded.*

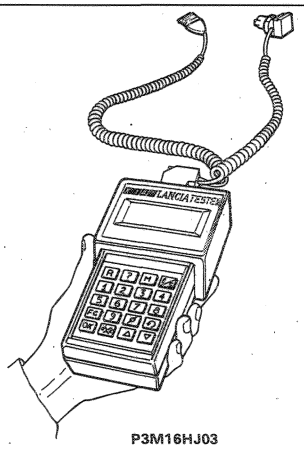
Diagnosis using Fiat/Lancia tester

The F.L.T. should be connected to a bidirectional diagnostic socket in the engine bay on the relay cover

The TESTER should be connected to the electronic control unit as follows:



P3M16HJ01 P3M16HJ02



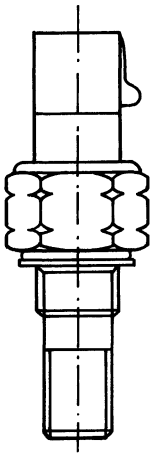
P3M16HJ03

1. Connect the Fiat-Lancia Tester using «ADAPTER ADT 101 A»
2. Activate the TESTER through the cigar lighter socket or by connecting directly to the battery (a special lead is provided for this purpose).
3. Connect the TESTER socket to the ECU socket

The instrument is able to provide the following information:

- Display engine parameters
- Display errors
- Active diagnosis
- Memory to be used M 33-A

TYPICAL CURVE (rest points)	
°C	Ω
- 40	100707.0
- 30	52684.6
- 20	28677.4
- 10	16176.9
0	9423.1
10	5671.8
20	3515.4
30	2237.6
40	1459.2
50	972.8
60	667.2
70	466.7
80	332.3
90	240.6
100	177.0
110	131.9
120	99.9
122	94.6
124	89.7
126	85.1
128	80.8
130	76.8
140	59.8
150	47.2



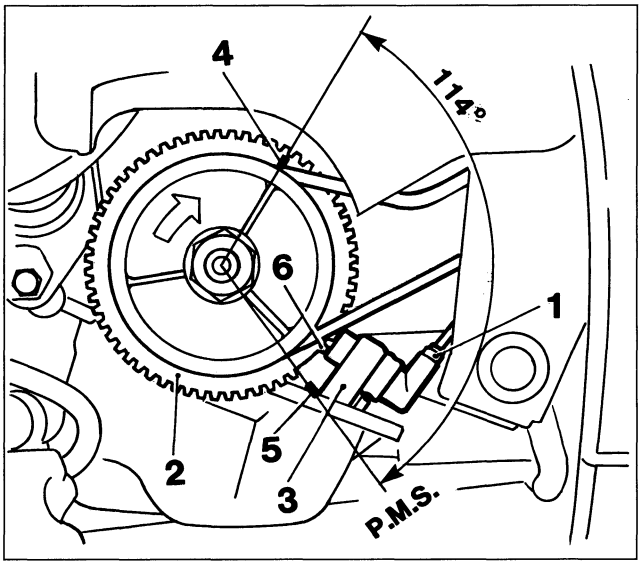
P3M17HJ01

COOLANT TEMPERATURE SENSOR

The sensor is fitted with its sensitive part in contact with the coolant. It provides the ECU with a voltage that varies according to engine temperature in order to correct air output information.

When a signal is received by the sensor, the ECU lengthens fuel injection time to ensure the enrichment necessary for compensating for fuel loss due to the condensation of fuel particles in the inlet ducts while the engine is warming up.

This sensor therefore ensures safe engine operation in the stage following start-up by enriching the mixture. Intensity and duration of enrichment depend on coolant temperature; this facility also allows the engine to work properly during acceleration with the engine cold.



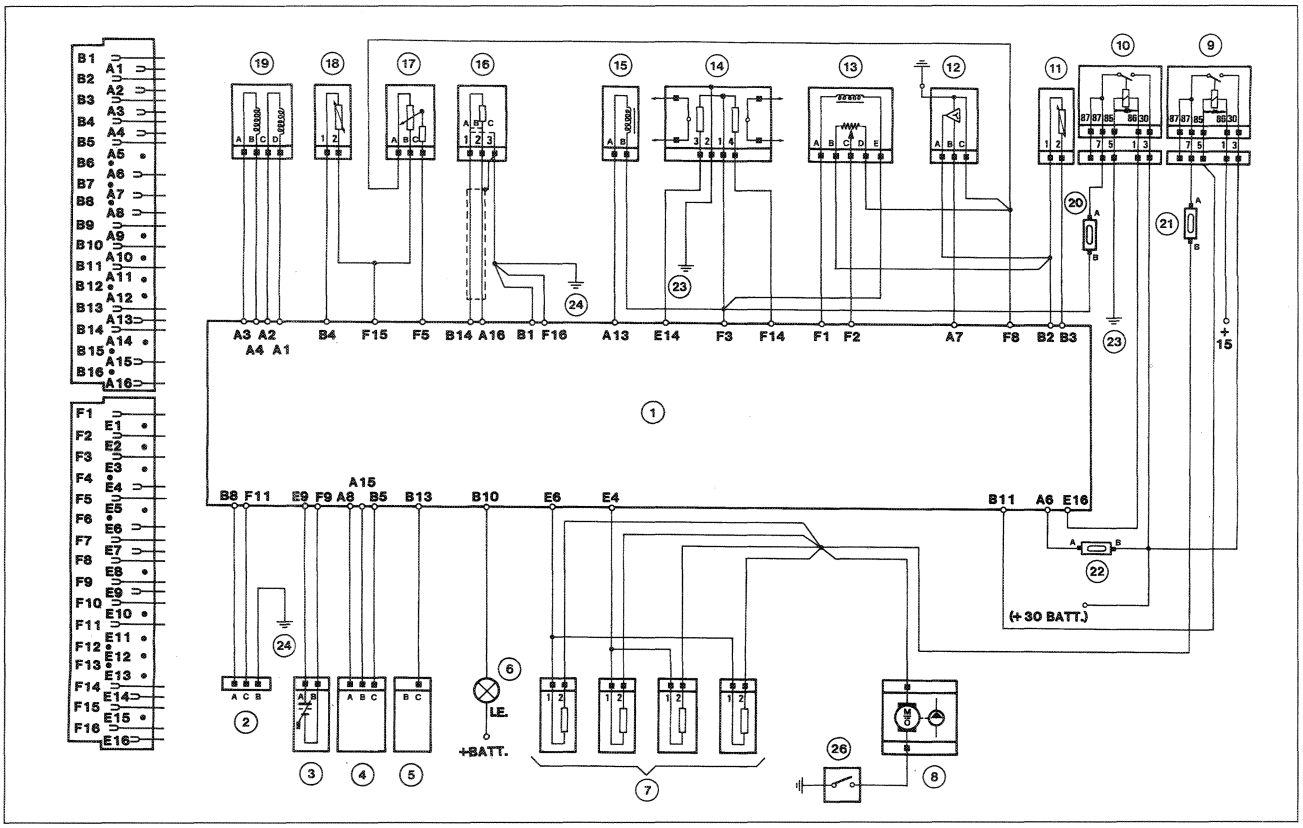
P3M17HJ02

1. Sensor
2. Phonic wheel
3. Sensor mount
4. TDC reference notch on phonic wheel
5. TDC reference notch on sensor mount
6. Synchronism tooth

RPM AND TDC SENSOR

The phonic wheel consists of 58 teeth plus a space equivalent to the bulk occupied by two suppressed teeth.
The reference defined by the space occupied by the two missing teeth is used as a basis for measuring the synchronism point (TDC).
The synchronism point is delimited by tooth (6). When this passes beneath the sensor, the crankshaft is located with piston pair 1-4 at 14° before TDC.
This signal is used by the ECU to compute the ignition advance angles.

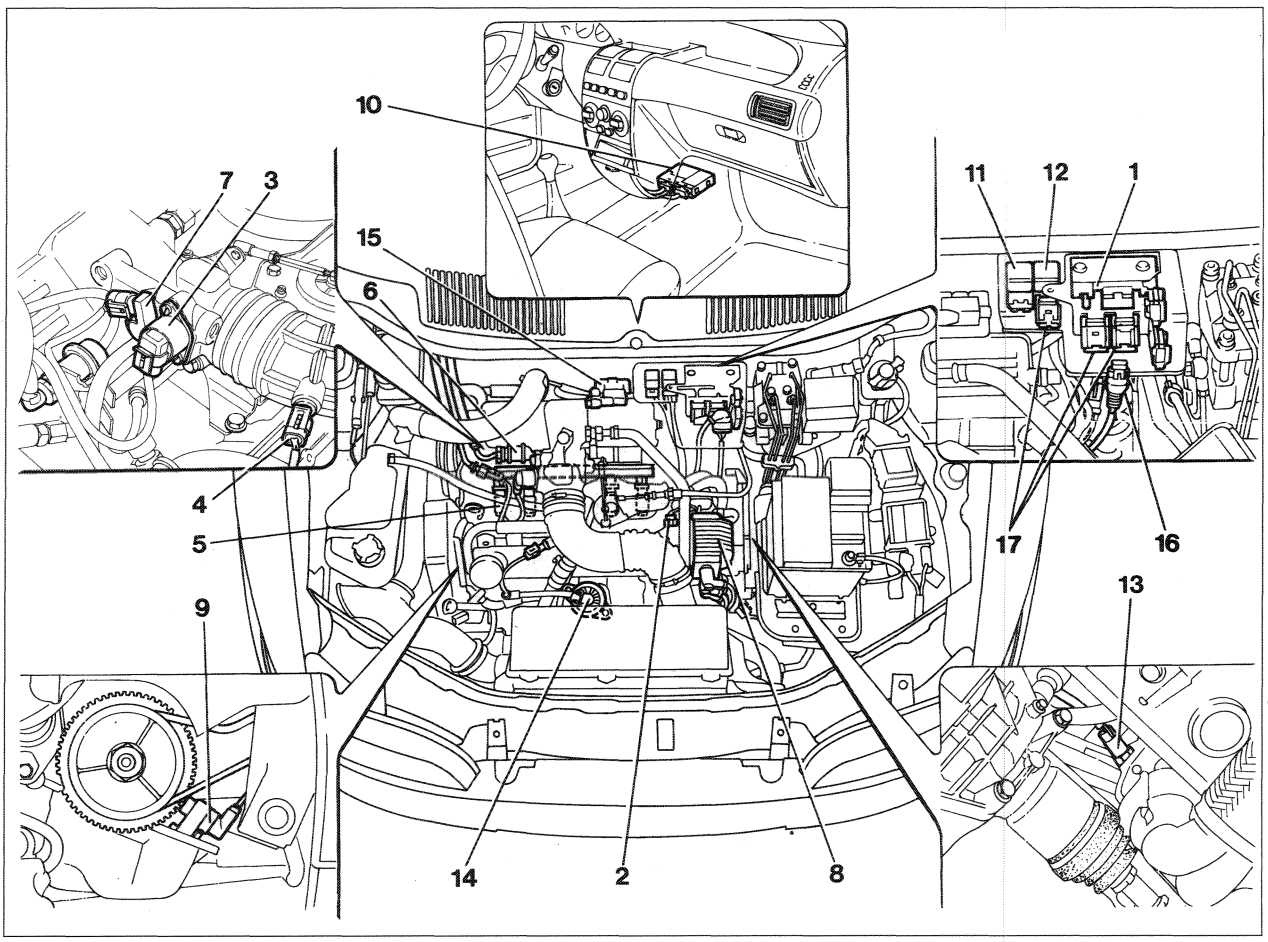
DIAGRAM SHOWING ELECTRICAL CONNECTIONS BETWEEN ECU-SENSORS-ACTUATORS



P3M018HJ01

1. Electronic control unit
2. Diagnostic socket for the F/L TESTER
3. Lambda probe
4. Air conditioner control unit
5. Signal for tachometer
6. Panel warning light bulb
7. Injectors
8. Electric fuel lift pump
9. Pump supply relay
10. System relay
11. Water temperature sensor
12. Absolute pressure sensor
13. E.G.R.
14. Ignition coil with power module
15. Vapour intake solenoid
16. Rpm sensor
17. Throttle potentiometer
18. Air temperature sender unit
19. Idle adjustment step motor
20. Fuse protecting injection/ignition system (15-A)
21. Fuse protecting electric pump (10-A)
22. Fuse protecting control unit (3-A)
23. Electronic earth connection
24. Power earth connection
25. Speedometer sensor
26. Inertia switch

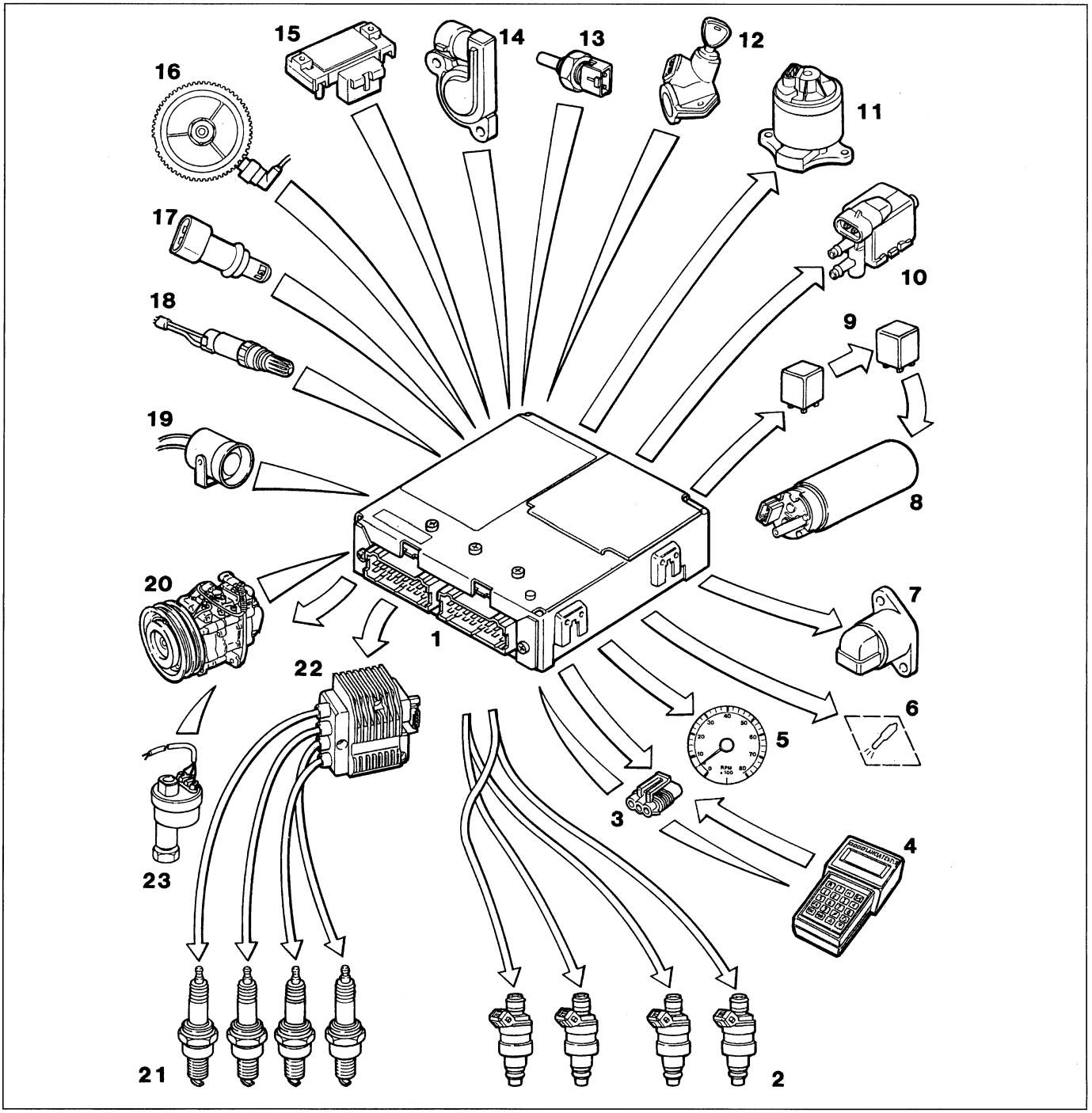
LOCATION OF G.M. M.P.I. INJECTION-IGNITION SYSTEM COMPONENTS IN ENGINE BAY



P3M19HJ01

1. Absolute pressure sensor
2. Coolant temperature sensor
3. Electric step motor for idle speed adjustment
4. Inlet manifold air temperature sensor
5. Injectors
6. Fuel pressure regulator
7. Throttle valve opening sensor
8. Ignition coil with electronic power module incorporated
9. Rpm and TDC sensor.
10. Electronic control unit located in central console
11. Relay for control unit supply
12. Relay for fuel pump supply
13. Lambda probe
14. E.G.R. valve.
15. Vapour intake valve
16. Diagnostic socket
17. System fuse

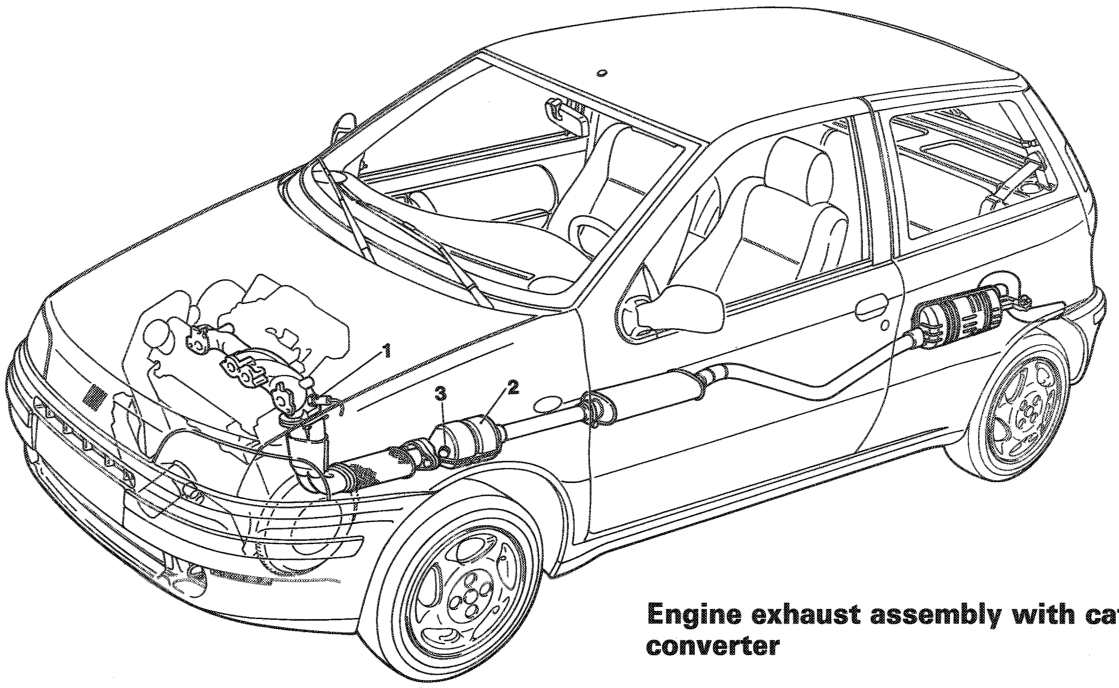
DIAGRAM OF INPUT AND OUTPUT BETWEEN ECU AND DELCO ELECTRONICS ITMS-6 M.P.I. SYSTEM SENSORS AND ACTUATORS



P3M20HJ01

1. Electronic control unit
2. Injectors
3. Diagnostic socket
4. Fiat/Lancia Tester
5. Rev counter
6. Failure warning light
7. Idle speed adjustment step motor
8. Electric fuel pump
9. Contactors
10. Vapour intake solenoid
11. Electronic EGR valve
12. Ignition switch
13. Coolant temperature sensor
14. Throttle position sensor
15. Absolute pressure sensor
16. Rpm and TDC sensor.
17. Air temperature sensor
18. Lambda probe
19. Antitheft device
20. Air conditioner compressor
21. Spark plugs
22. Ignition coil with power module
23. Speedometer sensor

D. SYSTEM FOR CONTROLLING NOXIOUS EXHAUST EMISSIONS



Engine exhaust assembly with catalytic converter

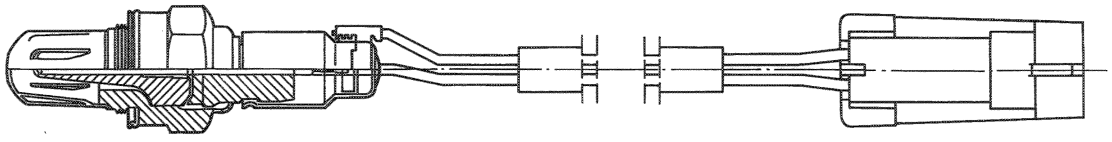
P3M21HJ01

1. Lambda probe
2. Catalytic converter
3. Point for measuring CO upstream of catalytic converter

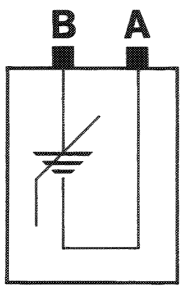
Lambda probe

This sensor measures exhaust gas oxygen content.
The sensor output signal is sent to the electronic control unit to adjust the air-fuel mixture in order to maintain the stoichiometric ratio as close as possible to theoretical levels.

The type of probe used is not heated and therefore has only two wires.



P3M21HJ02



Wiring diagram

A - to PIN E9 control unit (earth)
B - to PIN E9 control unit (signal)

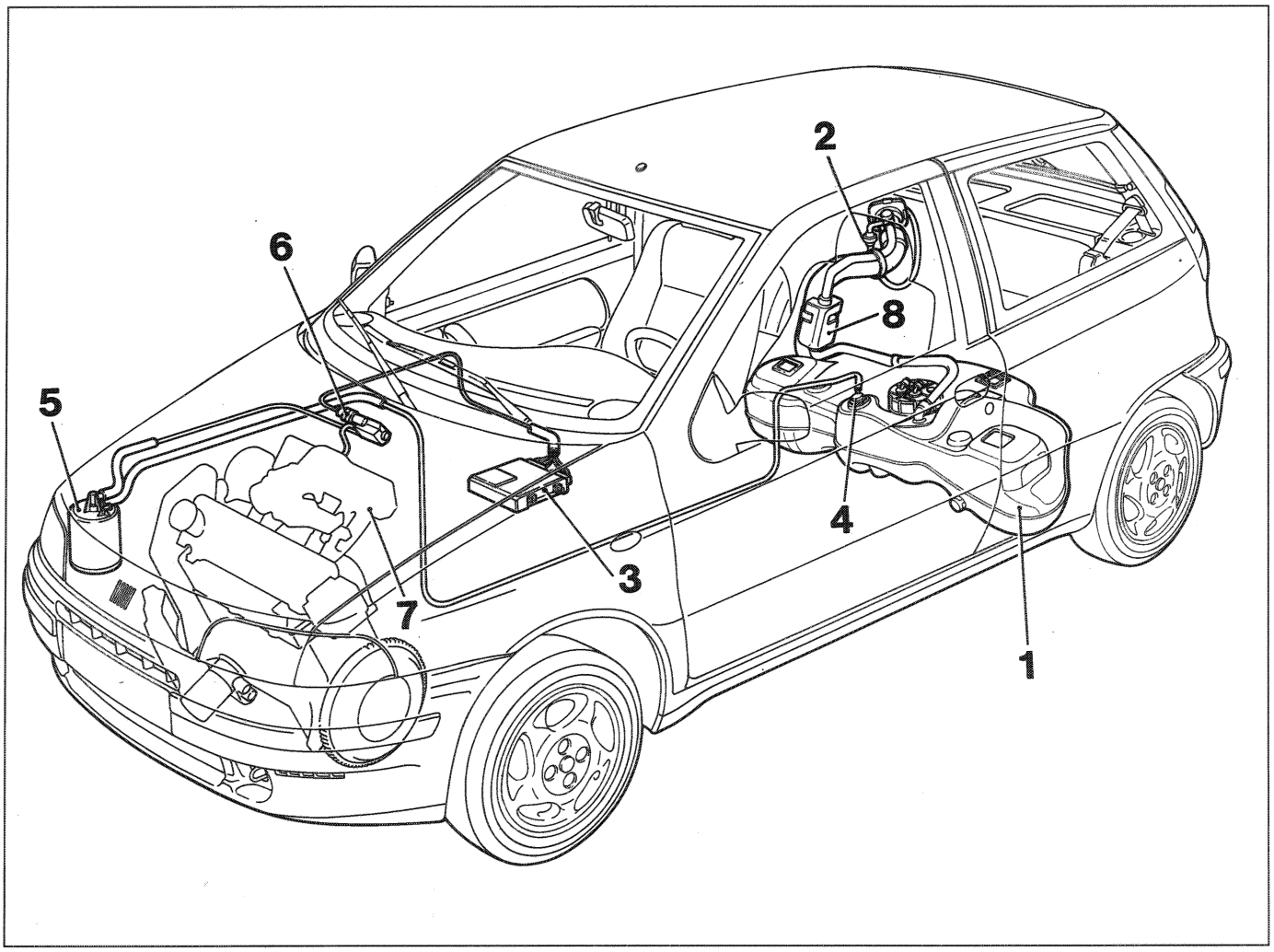
voltage output	800 mV min rich at 370 °C 200 mV max lean at 370 °C
internal resistance	40 Kohm max at 370 °C

FUEL EVAPORATION CONTROL AND VAPOUR RECOVERY CIRCUIT

The system adopted for tank ventilation is "closed" type.
This system prevents fuel vapours formed within the tank and fuel system from entering the atmosphere It also prevents the release of their load of polluting light hydrocarbons (HC).

The system consists of: tank (1) with plug on filler fitting without ventilation hole; a two-way safety valve (2); multifunctional valve (4) for controlling the flow of fuel vapours into the tank; an active carbon filter (or trap) (5); solenoid (Delco Remy) for cutting off fuel vapours (6), controlled by ECU (3) of IAW injection-ignition system, and lastly inlet manifold (7).

The system operates when, with high outdoor temperatures, after the vehicle has been at a standstill for a long time, the fuel temperature increases (because the tank is no longer cooled by the car's motion) and brings about a pressure increase inside the tank. This increase may occur with medium-low fuel levels or with the tank full - in particular:



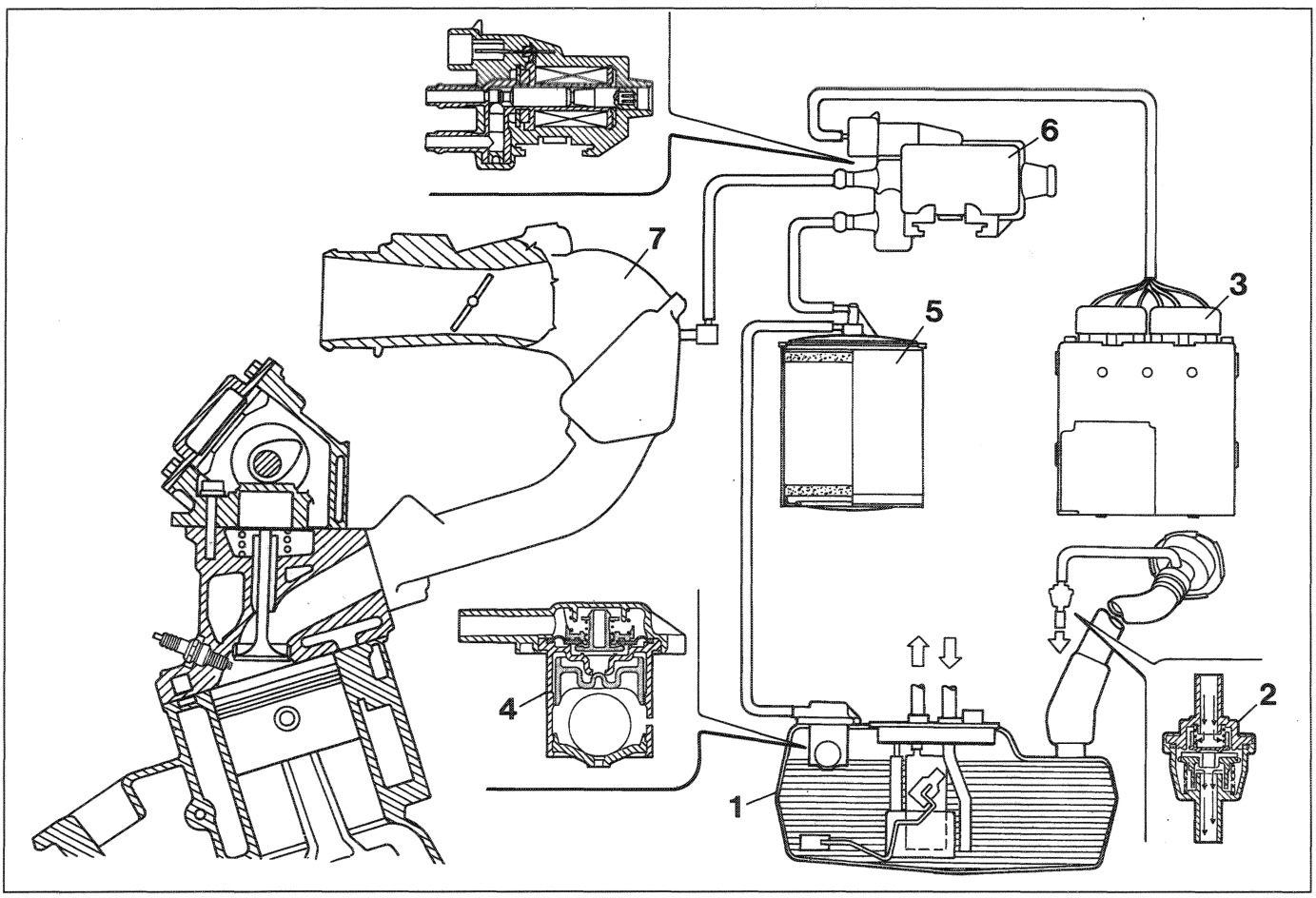
P3M22HJ01

1. Fuel tank (with unventilated filler cap)
2. Two-way safety valve
3. Injection/ignition control unit
4. Multifunction valve
5. Active carbon trap filter (located under front right wheel arch)
6. Petrol vapour cut-off solenoid
7. Inlet manifold
8. Expansion tank

– During tank filling, the pressure inside is more or less the same as atmospheric pressure. Because the multifunctional valve only allows fuel to pass through at excess pressures of 30-45 mbar this remains closed. Even when completely full, the tank still contains a pocket of air (about 7 litres) necessary for efficient operation of the evaporation control system when the vehicle is running.

– When the cap is closed and seals the system, the vapours generated inside the tank (with vehicle moving or while parked) build up due to fuel volatility and tank internal pressure also builds up until the valve opening level is exceeded. Under these conditions the vapours flow to the active carbon trap where they are absorbed. These vapours then reach the inlet manifold, when the injection/ignition system brings about opening of the vapour cut-off solenoid. While the vehicle is in motion, when the amount of fuel consumed is greater than the vapours produced, the multifunctional valve allows air back into the tank through the active carbon filter.

If the system is not working properly, a two-way safety valve on the fuel filler is able to drain off excess pressure and allow air into the tank.



P3M23HJ01

Diagram of evaporation control and fuel vapour recovery circuit

1. Fuel tank
2. Two-way safety valve
3. Injection/ignition control unit
4. Multifunction valve
5. Active carbon trap filter
6. Vapour cut-off solenoid (Delco Remy)
7. Inlet manifold

EXHAUST GAS RECIRCULATION SYSTEM E.G.R.

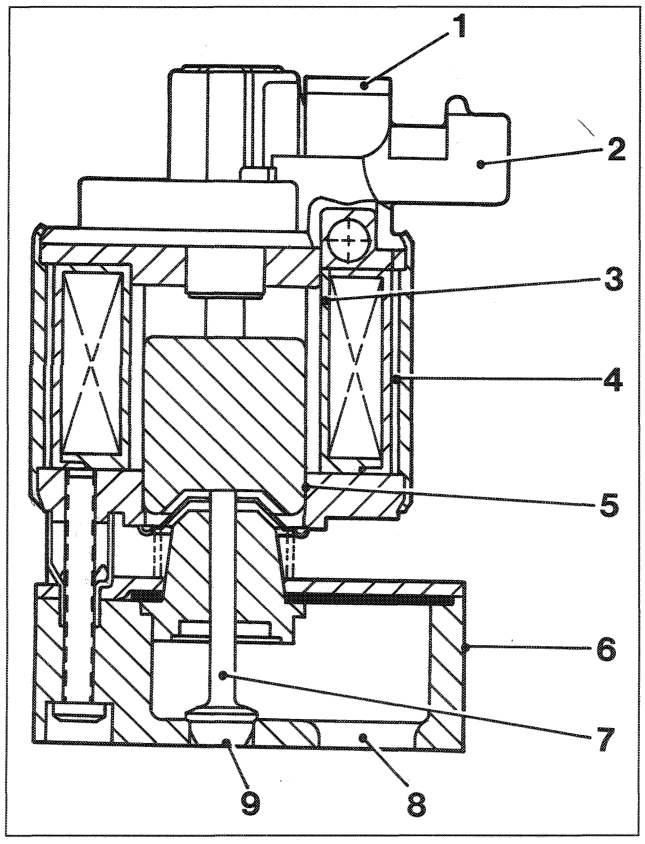
Introduction

This system allows a proportion of exhaust gases **(5 - 15%)** to be sent to the exhaust under certain engine service conditions.
This strategy dilutes the fuel mixture: the temperature peak in the combustion chamber is lowered to keep nitrogen oxide (NOx) production down.

The EGR (Exhaust Gas Recirculation) valve adopted on this system is electronic and fitted on the outlet duct of cylinder no. 3 (on head).
Cuts in with coolant temperature >55°C, inlet air temperature >17°C and rpm between 1550-5600.

The Linear EGR valve is a control device operated by a solenoid that ensures a continually variable flow by moving a conical pin inside a hole.
The solenoid is not affected by the vacuum and can therefore open with any engine load or manifold vacuum. The ECU maintains a flow sufficient for engine requirements by measuring engine parameters such as speed, load and temperature according to input from sensors. The required EGR flow and pin position are then calculated on the basis of the setting program required for each specific application. The ECU now sends the Linear EGR a command in the form of a modulated pulse and amplitude current signal.

To ensure precision, a pin position sensor forming part of the valve sends the ECU a non-return signal. The ECU continually compares this signal with another signal relating to required pin position. Any necessary adjustments are made automatically in order to ensure flow precision.



P3M24HJ01

The valve consists of:

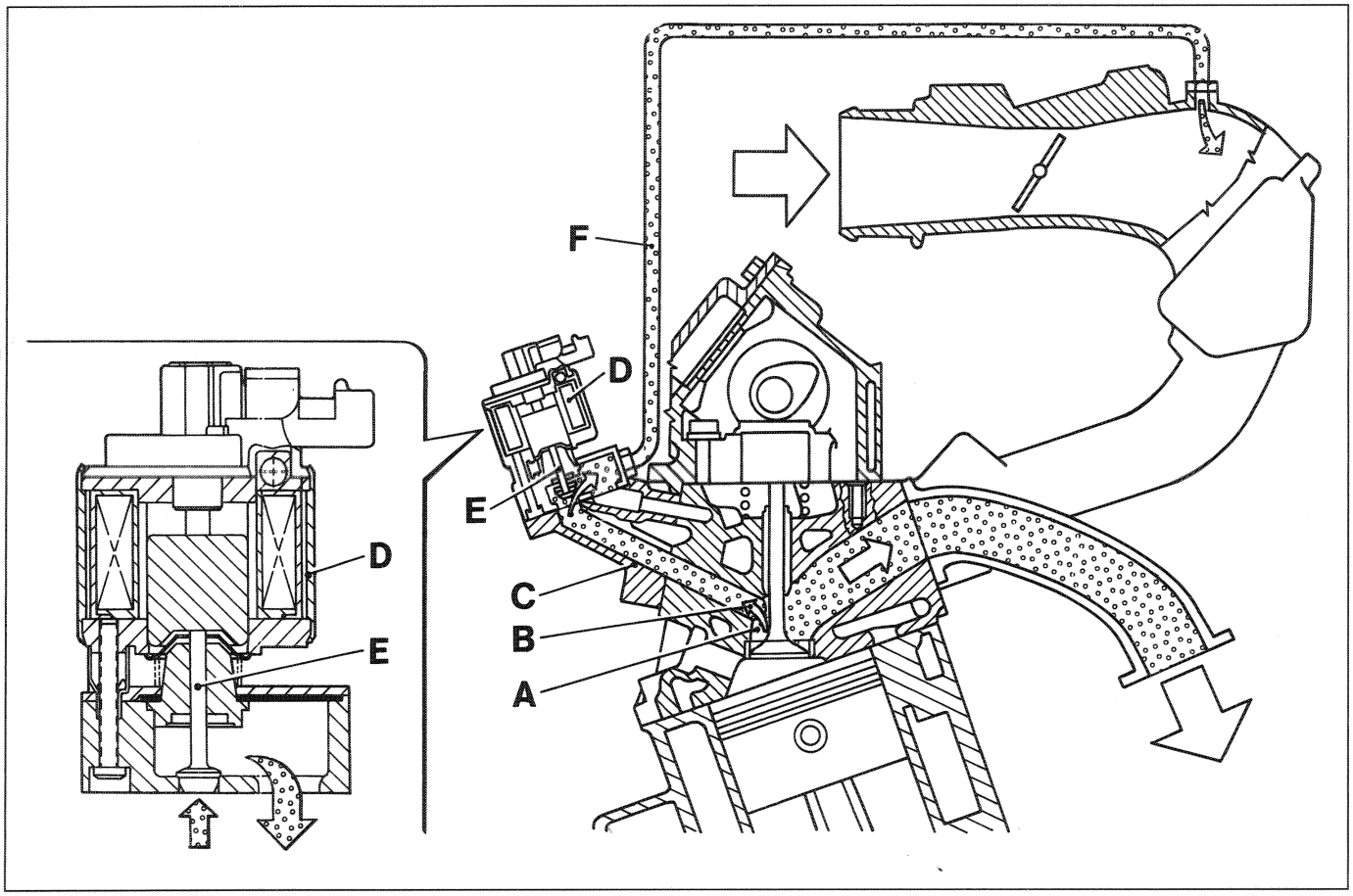
1. Sensor cover
2. EGR sensor assembly
3. Primary pole element
4. Winding assembly with encapsulated coil

5. Armature sleeve
6. Armature assembly and base
7. Tapered pin
8. Checking exhaust gas outlet
9. Checking exhaust gas intake

Electrical specifications

Coil resistance	8.2 (ohm)
Position sensor	5 KΩ

The diagram shows the EGR valve operating diagram
As already described, the valve is fitted on the exhaust duct (A) of cylinder number 3.
When the EGR is working, exhaust gases (B) are intercepted and conveyed through duct (C) toward valve (D). Activated by the ECU, this lifts actuator piston (E) to allow exhaust gas to be conveyed through duct (F) to the intake.



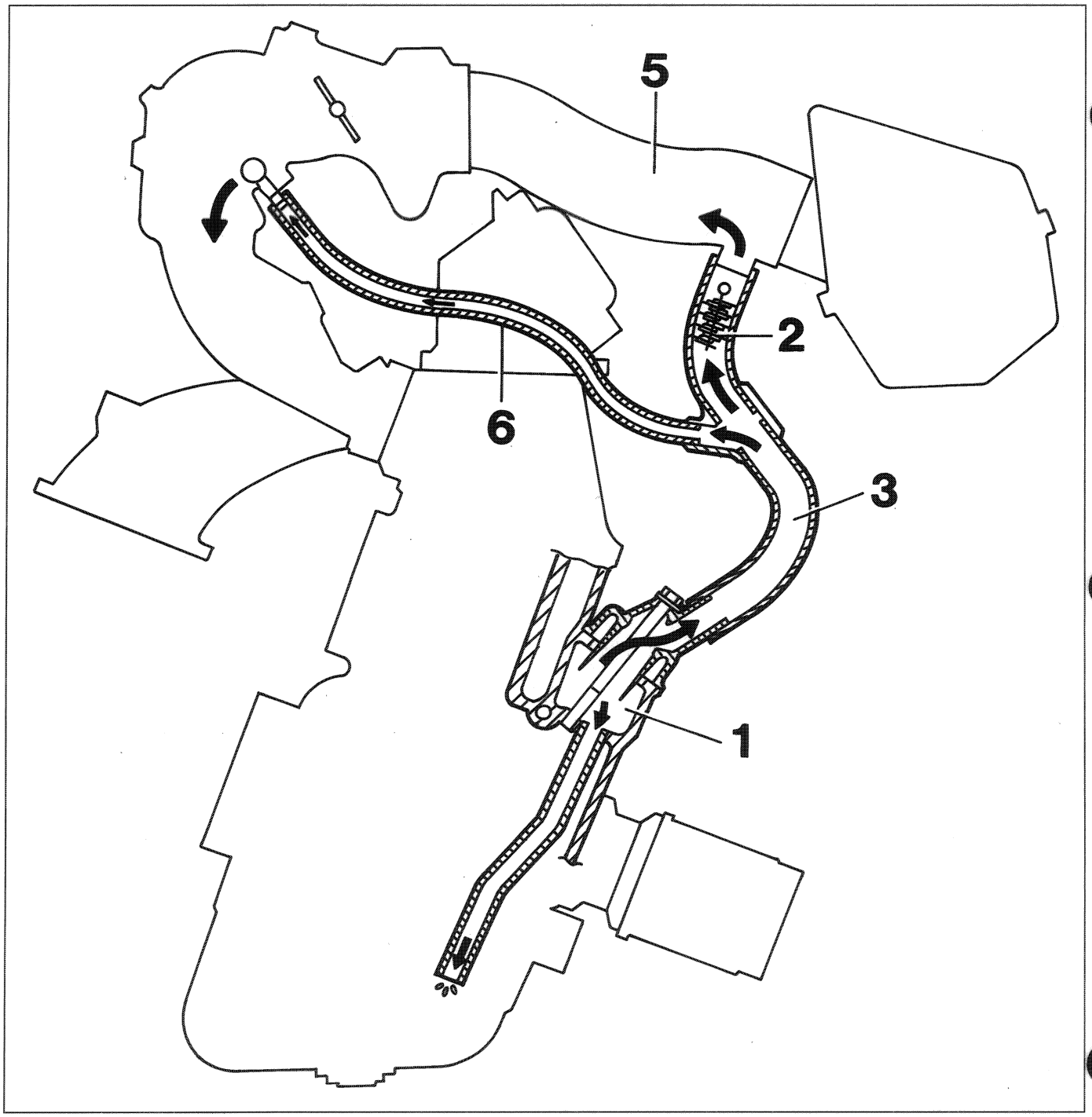
P3M25HJ01

CRANKCASE GAS RECYCLING SYSTEM

The system controls crankcase emissions made up air, fuel and burnt gas mixtures that leak through piston ring seals in addition to lubricant oil vapours by recirculating them to the intake.

Vent gases flow through cycle separator (1) and lose part of their dissolved oil content. This drops back down into the sump in the form of droplets. The remaining gases reach intake sleeve (5) through pipe (3). This contains a flame trap (2) to prevent flame flashing back and setting light to the crankcase.

A second pipe (6) connected to inlet manifold downstream of the throttle valve ensures that when the engine is idling, crankcase vapours are drawn up by the vacuum in the intake manifold.



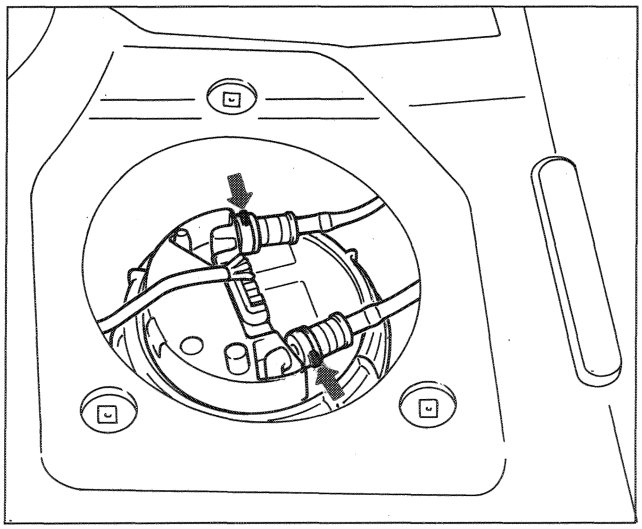
P3M26HJ01

CHECKS - ADJUSTMENTS AND REPAIRS TO MAIN COMPONENTS OF G.M. ACG MULTEC-XM INJECTION/IGNITION SYSTEM ADDITIONAL TO DIAGNOSES WITH FIAT/LANCIA TESTER

OBSERVE THE FOLLOWING PRECAUTIONS WHEN WORKING ON VEHICLES WITH G.M. INJECTION-IGNITION SYSTEMS:

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

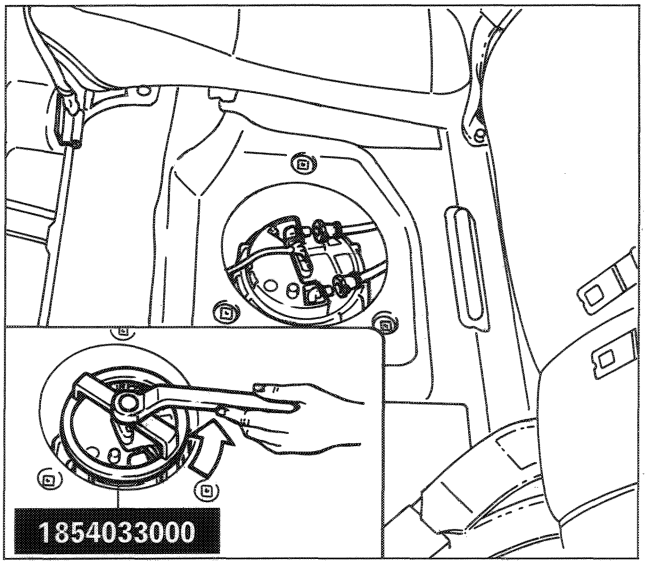
Note that system contains one memory that is always active (stand-by memory) that stores learnt self-adaptive values. Because this data is lost when the battery is disconnected, this operation should be carried out as infrequently as possible.



P3M27HJ01 P3M27HJ02

REMOVING-REFITTING ELECTRIC FUEL PUMP

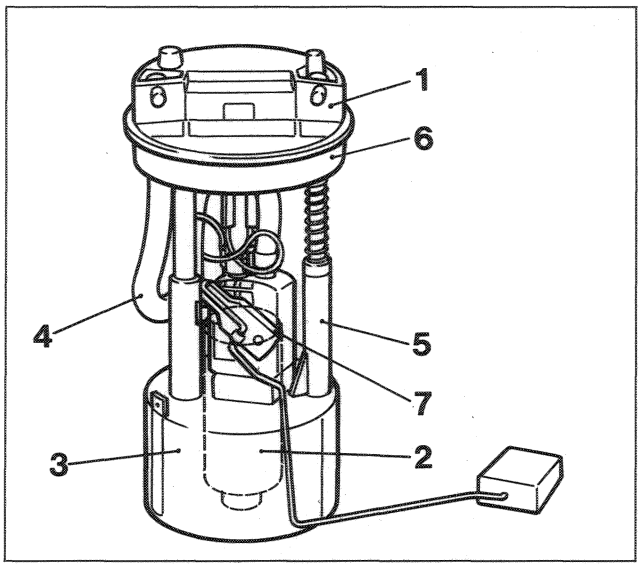
The electric pump is located inside the fuel tank.
In order to remove:
- raise rear seat;
- remove protective cover;
- disconnect electrical connection;
- disconnect fuel delivery and return line quick-release fittings by pressing the two tabs indicated by the arrows;



P3M27HJ03

- unscrew lock-ring connecting pump to tank using tool 1854033000 and a polygonal wrench;
- remove pump.

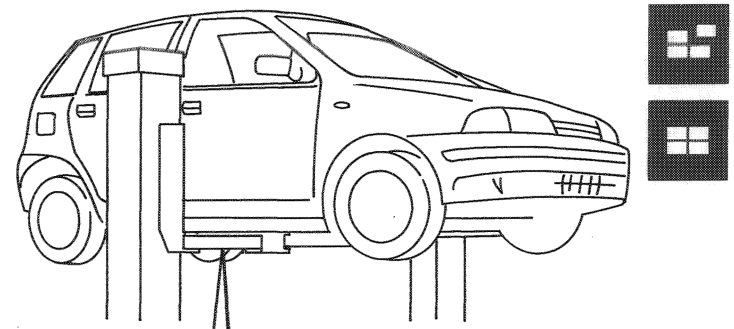
Ensure that quick-release fuel line fittings are fitted properly onto pump fittings.



P3M28HJ01

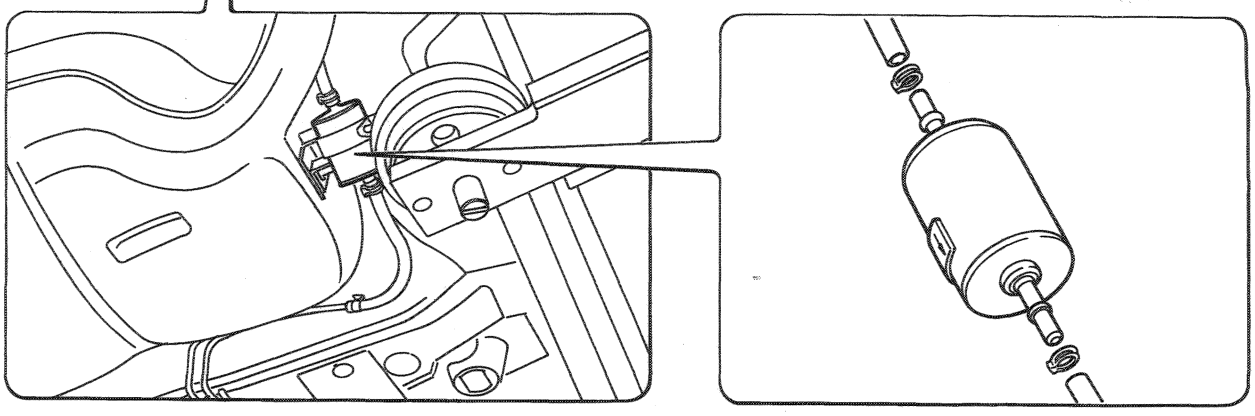
Components of fuel pump assembly

1. Retaining plate
2. Electric fuel pump
3. Mesh prefilter
4. Delivery line
5. Return line
6. Gasket
7. Fuel level gauge sender unit



REMOVING-REFITTING FUEL FILTER

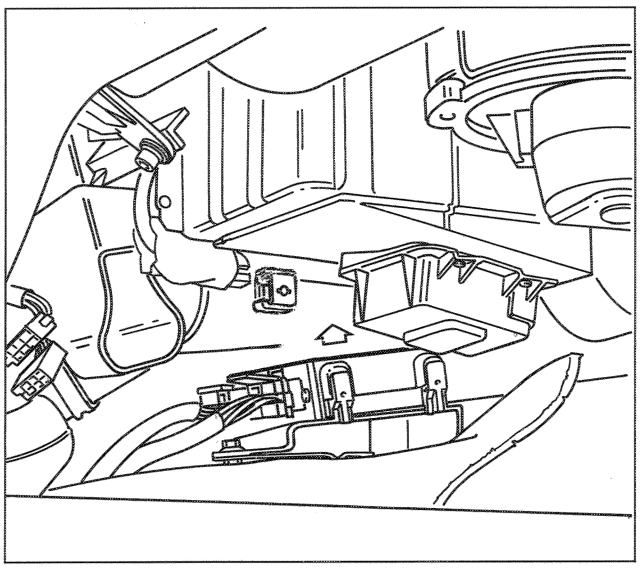
- Raise the vehicle
- Unscrew screw retaining filter to support bracket
- Remove clips holding fuel hoses to filter
- Collect fuel emerging during the operation in a suitable container



P3M28HJ02

The fuel filter must be replaced at intervals of 30,000 km.

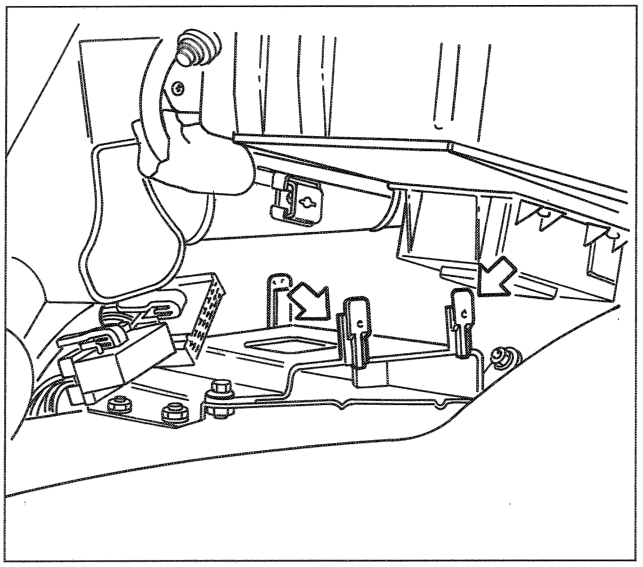
NOTE *The filter MUST NEVER BE FITTED THE WRONG WAY ROUND, otherwise it must be replaced (even after only a short period of use). The arrow stamped on the outer case indicates the fuel flow direction.*



P3M29HJ01

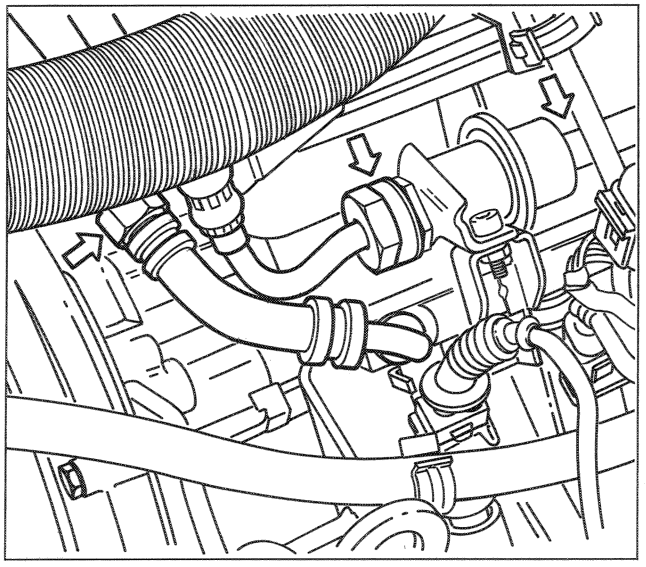
REMOVING-REFITTING ELECTRONIC CONTROL UNIT (CONTROL UNIT)

- Remove underfacia trim on the left hand passenger side
- Release the control unit from its mounts by inserting a screwdriver between mount bracket and control unit and prising gently
- Disconnect the two electrical connections



P3M29HJ02

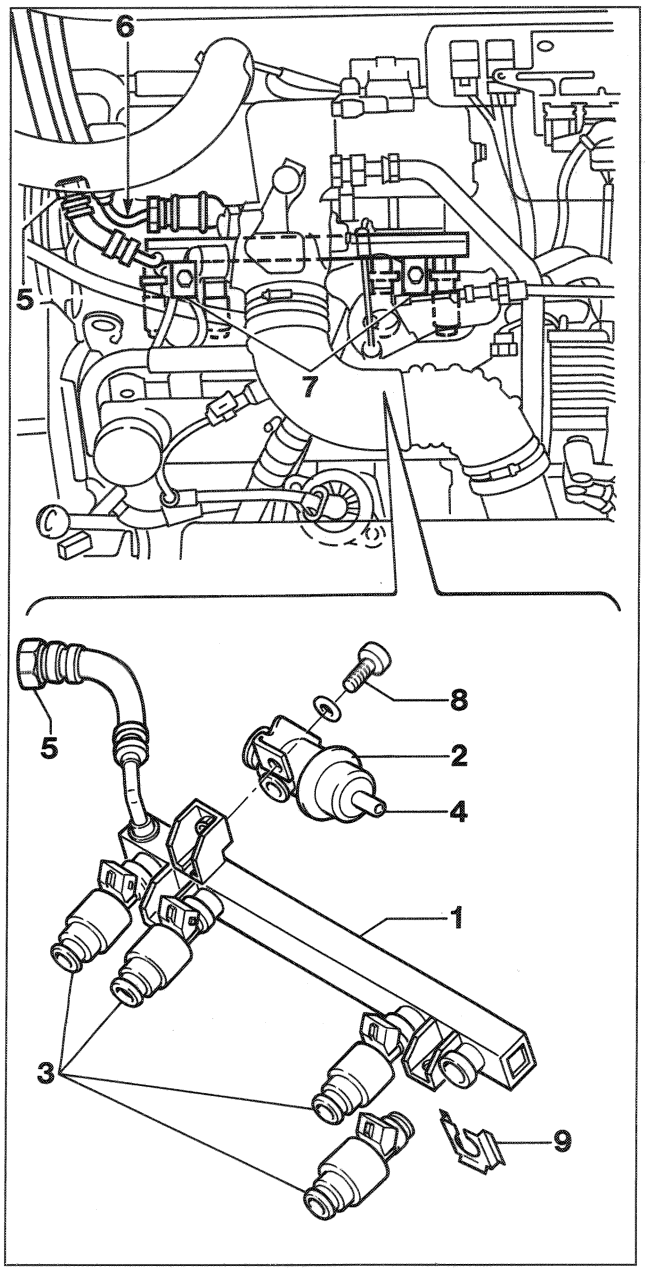
The ECU is anchored to the support bracket by four clips



P3M29HJ03

REMOVING-REFITTING FUEL MANIFOLD WITH INJECTORS AND PRESSURE REGULATOR

- Disconnect the fuel inlet and outlet hoses
- Disconnect the vacuum intake pipe from the regulator
- Disconnect electrical connectors from injectors



P3M30HJ01

1. Fuel manifold
2. Fuel pressure regulator
3. Injectors
4. Vacuum socket from engine inlet manifold
5. Fuel inlet pipe from pump
6. Fuel return lines to tank
7. Screws retaining fuel manifold and injectors
8. Screw retaining pressure regulator to fuel manifold
9. Clip retaining injector to fuel manifold

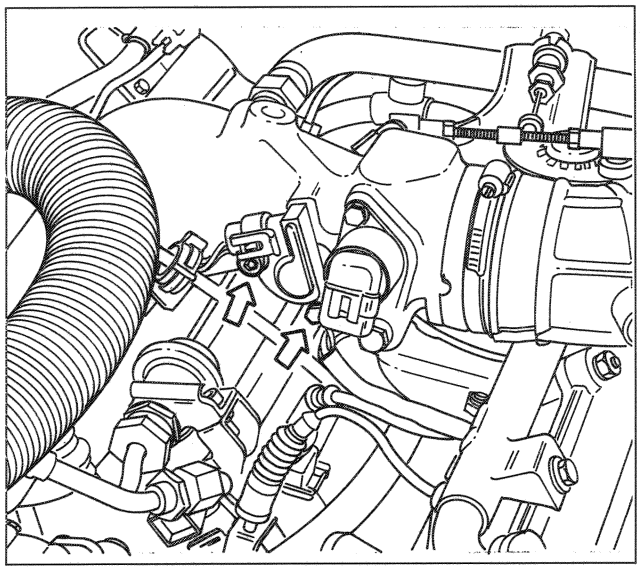
- Unscrew the two screws (7) retaining the fuel manifold to the inlet manifold
- Take out the injector manifold assembly
- To remove the injectors from the manifold, remove clip (9)
- To remove the pressure regulator from the fuel manifold, unscrew retaining screw (8).

Fuel manifold: Never wash the manifold by submerging in strong fluids. Clean only on the outside using a brush. Otherwise the o-rings may be damaged.

NOTE *Lubricate injector and pressure regulator o-rings with pure vaseline (use as little as possible in order not to affect functional areas) before fitting.*

Tightening torques

Screw retaining pressure regulator to fuel manifold **0.8-1 daNm**
Screw retaining fuel inlet line to manifold **2-2.2 daNm**
Screw retaining fuel return line to regulator **2 daNm**



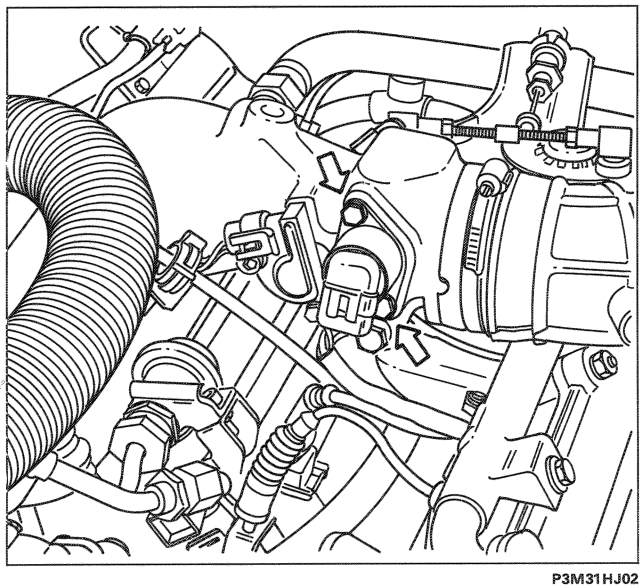
P3M31HJ01

DISMANTLING-FITTING THROTTLE VALVE OPENING POSITION SENSOR (POTENTIOMETER)

- disconnect electrical connector from potentiometer;
- unscrew screws retaining potentiometer to injector turret;
- refit the potentiometer, taking care to fit throttle pin correctly into mobile part;
- screw in and tighten potentiometer retaining screws **(0.2-0.3 daNm)**

NOTE *When specified throttle opening angle cannot be obtained, replace the potentiometer because it is defective and potentiometer retaining screw holes cannot be adjusted.*

Whenever potentiometer screws are loosened or removed they should be changed, because the thread is covered with a light layer of loctyte and this is able to ensure a tight fit only once.

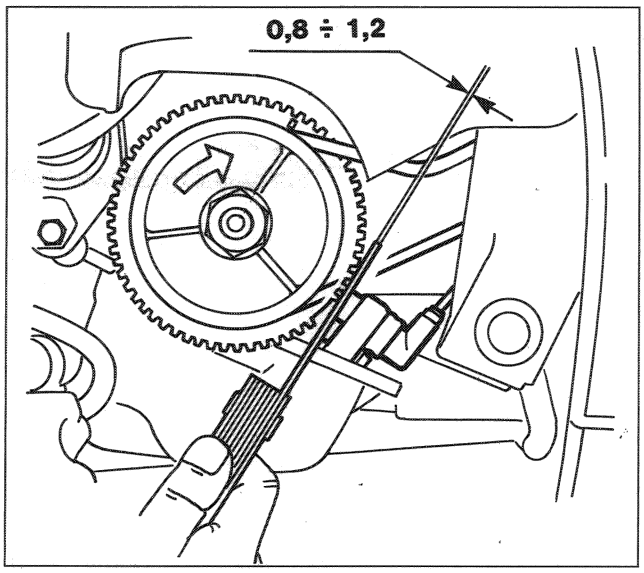


P3M31HJ02

DISMANTLING-FITTING ADDITIONAL AIR AND IDLE SPEED ACTUATOR (STEP MOTOR)

- disconnect battery negative terminal;
- unscrew both screws and remove actuator;
- check condition of thoroid seal and remove any contamination from seat on case;
- refit the actuator, checking that the plunger is inserted properly without forcing it in its seat. To do this, with the actuator fitted and the retaining screws in place but not tightened, operate the step motor using a Fiat/Lancia/Tester so that it moves through its entire range of travel. After checking plunger is properly aligned in its seat and electrical connector is positioned, tighten screws to a torque of **0.36-0.44 daNm**

NOTE *Whenever the step motor screws are loosened or removed they should be changed because the thread is covered with a light layer of loctyte and this is able to ensure tightening once only.*

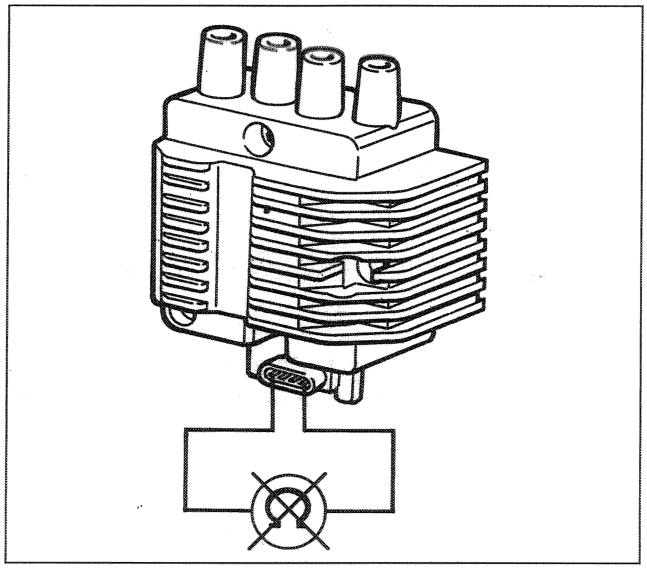


P3M32HJ01

CHECKS ON RPM AND TDC SENSOR

Because correct angular positioning of the rpm and TDC sensor is achieved by means of a rigid mount, this adjustment is not possible.

The gap may be checked and must be 0.8-1.2 mm.
If the gap is not as specified, the cause must be due to inaccurate machining.
The resistance measured with a digital multimeter must be between 486 - 594 Ω at 25 °C.



P3M32HJ02

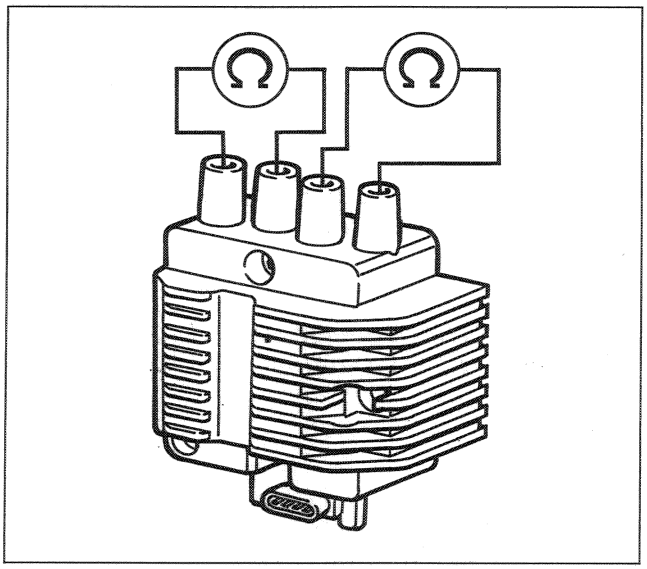
IGNITION COIL WITH POWER MODULE INCORPORATED (AC - ROCHESTER)

Checking ignition coil primary winding resistance

Due to the specific nature of the internal connections of the ignition coil primary winding with the power module, the resistance of these coils cannot be measured using a digital multimeter.

Any A.C. or D.C. circuit errors may be recorded by the Fiat/Lancia tester during diagnosis.

The resistance of the ignition coil secondary winding can be measured using a digital multimeter.

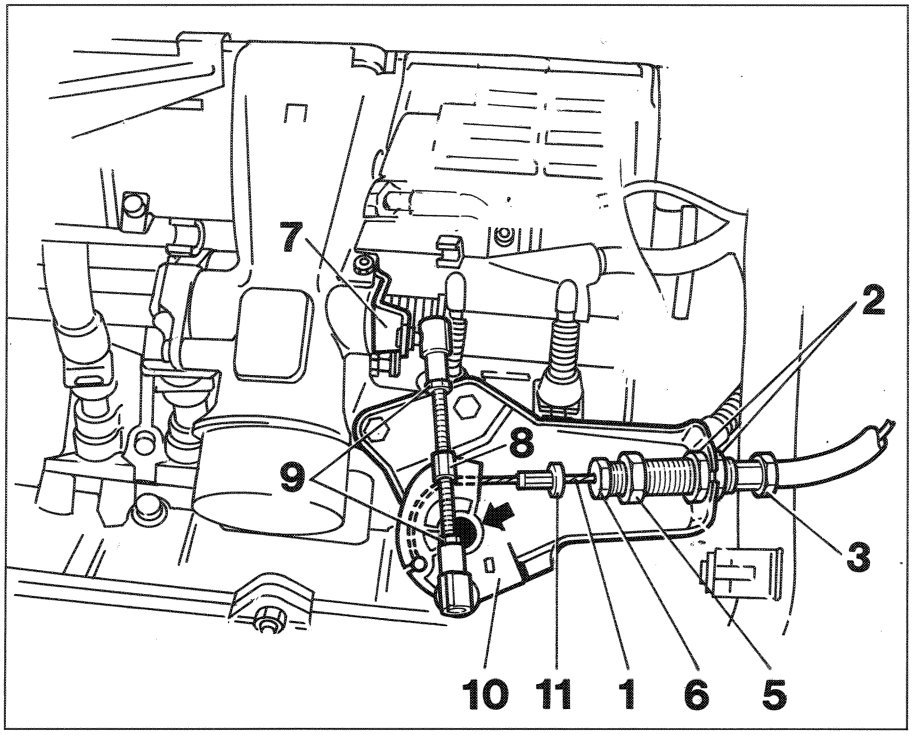


P3M32HJ03

Checking resistance of ignition coil secondary winding

Bring the probes of a multimeter into contact with the two high tension outlet terminals respectively 1-4 and 2-3.

The resistance reading should be between 4.500 Ω and 6.400 Ω at 22 - 25°C.



P3M33HJ01

ADJUSTING ACCELERATOR CONTROL

Before adjusting accelerator control cable, lubricate arrowed pin throughly using "TUTELA MRM2" grease.

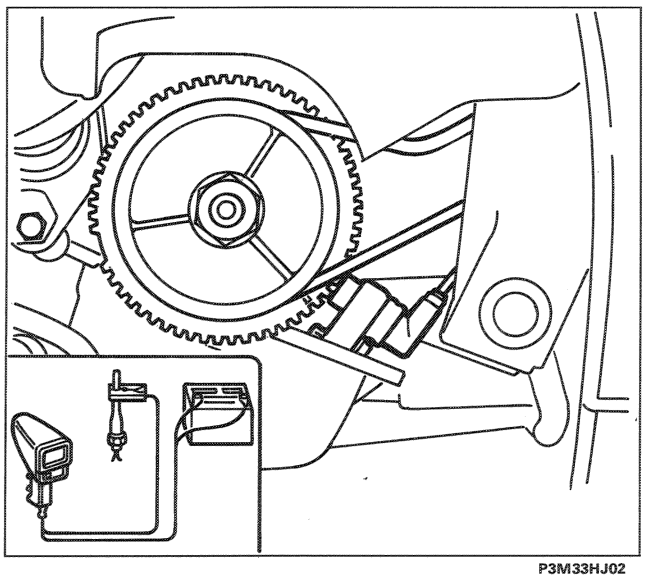
To adjust the accelerator control cable, proceed as follows;

Check that with link (8) disconnected from head of throttle control lever (7), block (10) is at the end of its travel.

Under these conditions, accelerator cable (1) must not be too tight or slack so that no free accelerator pedal is present.
If this is not the case, loosen locknuts (2) and undo hexagonal nut (3).
Connect link (8) to head of lever (7) removed previously. The link seat must be level with the head. If not, loosen locknuts (9) and adjust link (8), tighten the locknuts.

Once adjustment is complete, press down accelerator pedal to floor and check that with throttle fully open, bush (11) fitted to the accelerator cable is flush against bush (6). If not, loosen locknut (5) and adjust bush (6) to tighten the locknut.

APPROXIMATE CHECK ON IDLING IGNITION ADVANCE WITH STROBOSCOPIC LAMP



P3M33HJ02

Connect inductive clip stroboscopic lamp with graduated scale

To check the ignition advance angles at different engine speeds, use a Fiat/ Lancia Tester.

Advance with engine idling is (850±30/min) 8°

CHECKING IDLE SPEED

If idle speed is not 850±30/min, because injection-ignition ECU is self-regulating, ***the adjustment cannot be carried out****. The position of the accelerator linkage must therefore be checked and then the fault detected by means of full diagnosis using a Fiat/Lancia Tester.*

CHECKING LEVELS OF POLLUTING EMISSIONS

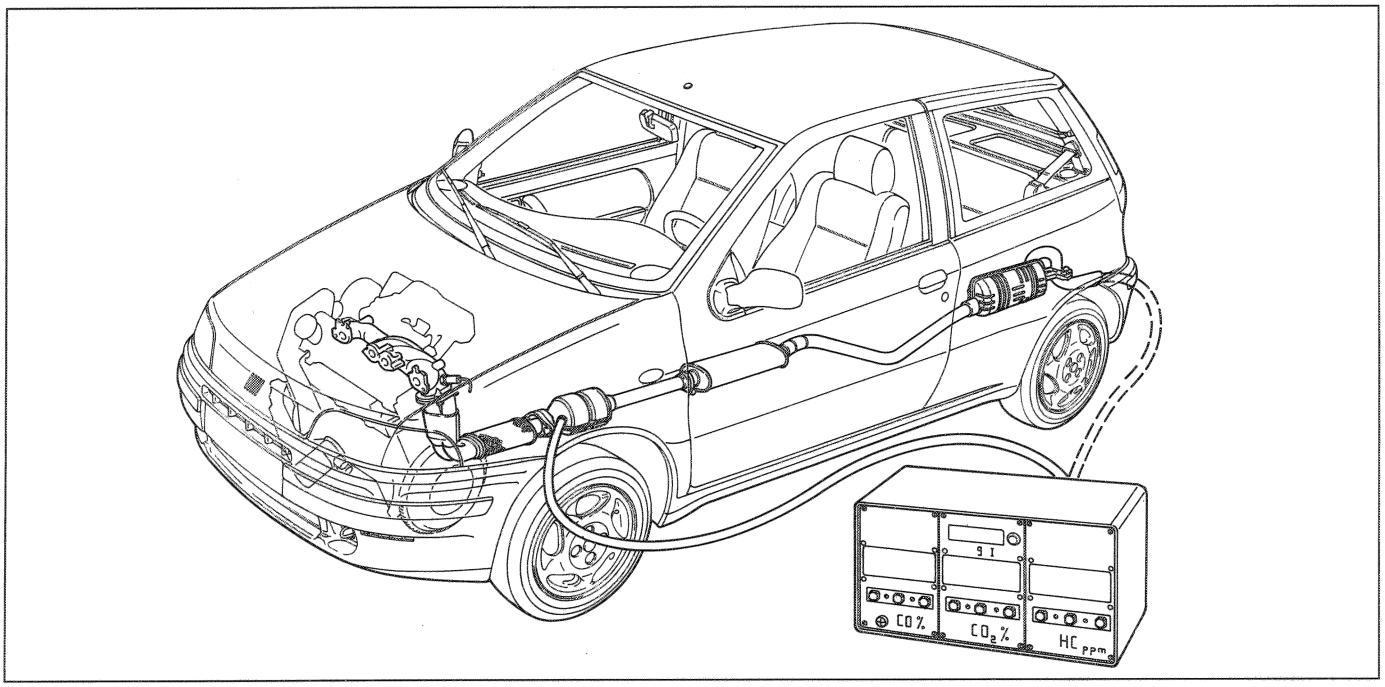
Foreword

Because the G.M. system is self-adaptive and ensures continual control of idle speed and CO level, no external regulation is necessary (adjustment screws are no longer fitted). A check on exhaust emissions upstream and downstream from the catalytic converter can nevertheless provide valuable information on the condition of the injection-ignition system and engine or catalytic converter parameters.

Checking idling CO and HC levels upstream of catalytic converter

To check the levels of carbon monoxide (CO) and uncombusted hydrocarbons (HC) upstream of the converter, proceed as follows:

1. Unscrew the plug or nut located on the exhaust pipe upstream of the converter and tighten the tool in its place.
2. Connect the probe of a specially calibrated CO-tester in its place.
3. Start up the engine and allow to warm up.
4. Check that the rpm is as specified.
5. Check that idling CO level is as specified (see table); otherwise check:
   - Lambda probe operation, using a Fiat/Lancia Tester;
   - for air leaks in the area around the Lambda probe seat;
   - the injection system **(particularly the condition of the spark plugs).**
6. Check, under the same conditions, that HC level is lower than 500 p.p.m.
7. If these level are not as specified, adjust the engine and check the following in particular:
   - ignition advance angle
   - valve clearance
   - timing
   - engine compression



P3M34HJ01

Summary table of polluting emission tolerances

	CO (%)	HC (p.p.m.)	CO_2 (%)
Upstream of catalytic converter	0.4 - 1	⩽600	⩾ 12
Downstream of catalytic converter	⩽0.35	⩽90	⩾ 13

Checking CO and HC levels at exhaust

Measure carbon monoxide (CO) and uncombusted hydrocarbon (HC) at the exhaust by inserting the probe of a calibrated tester into the end of the exhaust pipe by at least 30 cm as indicated in the figure.

If the shape of the exhaust tail pipe will not allow the probe to be fitted fully, add an extension pipe and ensure the joint area is well sealed.

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

2. If the HC level is not as specified whereas level measured upstream of converter is correct, engine parameters should be considered correct and the cause of the anomaly must lie in reduced converter efficiency.