Chapter 6 Emissions control systems

Contents

Degrees of difficulty

Easy, suitable for novice with little experience	**Fairly easy,** suitable for beginner with some experience	**Fairly difficult,** suitable for competent DIY mechanic	**Difficult,** suitable for experienced DIY mechanic	**Very difficult,** suitable for expert DIY or professional

Specifications

Crankshaft speed/position sensor

Resistance	200 to 450 ohms

Camshaft position sensor

Resistance	200 to 900 ohms

Inlet air temperature sensor

Resistance:	
At 0ºC	89 to 102 kilohms
At 20ºC	35 to 40 kilohms
At 100ºC	1.9 to 2.5 kilohms
At 120ºC	1.0 to 1.4 kilohms

Throttle position sensor

Resistance - see text	400 to 6000 ohms

Power steering pressure switch

Resistance:	
Contacts open	Infinite resistance
Contacts closed	0 to 2.5 ohms

Charcoal canister-purge solenoid valve

Resistance	50 to 120 ohms

Pulse-air solenoid valve

Resistance	50 to 120 ohms

Torque wrench settings

Torque wrench settings	Nm	lbf ft
Camshaft position sensor screw	18 to 23	13 to 17
Inlet air temperature sensor	23	17
Oxygen sensor	60	44
Pulse-air system piping-to-exhaust manifold sleeve nuts	32	24

1 General information

To minimise pollution of the atmosphere from incompletely-burned and evaporating gases, and to maintain good driveability and fuel economy, a number of emissions control systems are used on these vehicles. They include the following:

a) The engine management system (comprising both fuel and ignition sub-systems) itself.
b) Positive Crankcase Ventilation (PCV) system.
c) Evaporative Emissions Control (EVAP) system.
d) Pulse-air system.
e) Catalytic converter.

The Sections of this Chapter include general descriptions, checking procedures within the scope of the home mechanic, and component renewal procedures (when possible) for each of the systems listed above.

Before assuming an emissions control system is malfunctioning, check the fuel and ignition systems carefully (see Chapters 4 and 5). The diagnosis of some emissions control devices requires specialised tools, equipment and training. If checking and servicing become too difficult, or if a procedure is beyond the scope of your skills, consult your dealer service department or other specialist.

This doesn't mean, however, that emissions control systems are particularly difficult to maintain and repair. You can quickly and easily perform many checks, and do most of the regular maintenance, at home with common tune-up and hand tools. **Note:** *The most frequent cause of emissions problems is simply a loose or broken electrical connector or vacuum hose, so always check the electrical connectors and vacuum hoses first.*

Pay close attention to any special precautions outlined in this Chapter. It should be noted that the illustrations of the various systems may not exactly match the system installed on your vehicle, due to changes made by the manufacturer during production or from year-to-year.

Vehicles sold in some areas will carry a Vehicle Emissions Control Information (VECI) label, and a vacuum hose diagram located in the engine compartment. These contain important specifications and setting procedures for the various emissions control systems, with the vacuum hose diagram identifying emissions control components. When servicing the engine or emissions systems, the VECI label in your particular vehicle should always be checked for the latest information for your vehicle.

2 Electronic control systems - description and precautions

Description

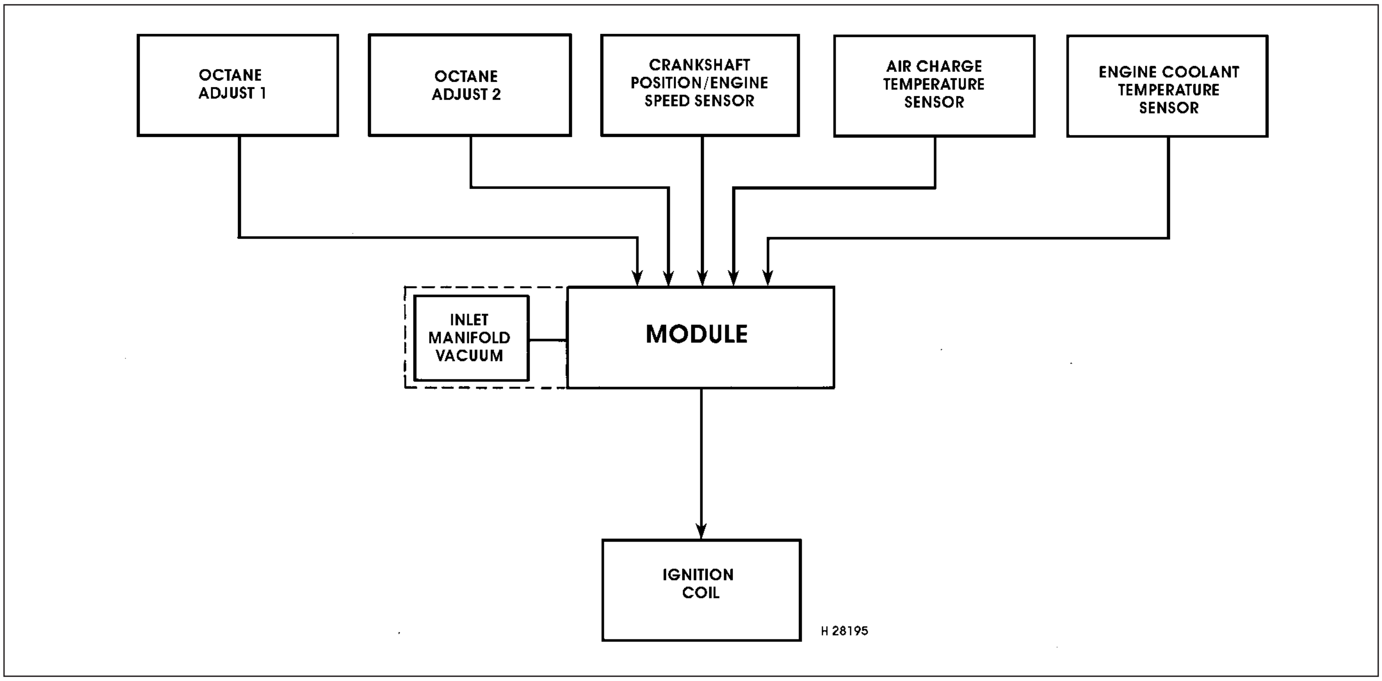
The sophistication of the emissions control systems fitted, and hence their method of electronic control, is dependant on the emissions level that the engine has been designed to meet. The engines covered in this manual are all designed to meet one of the three current emissions levels, namely, 15.04, NEEC 5th, and US '83. The European 15.04 is the least stringent of the three, and its requirements are met by carburettor engines having engine management systems controlling the ignition-related components only. Some of the additional emissions systems described in this Chapter may also be fitted. The US '83 regulations are the most stringent. To meet these, an engine will need a full engine management system, electronic fuel injection (to allow precise control of the air/fuel mixture ratio) a regulated catalytic converter, and one or more of the additional emissions systems described in this Chapter.

On carburettor engines, the exhaust emissions requirements are met mainly by precise control of the ignition timing, by means of an ignition module receiving inputs from sensors monitoring various engine parameters, and additionally by the use of a pulse-air system and unregulated catalytic converter **(see illustrations)**. The ignition module fitted varies according to engine type, but all operate in a similar fashion. Further information on ignition module types and their functions will be found in Chapter 5.

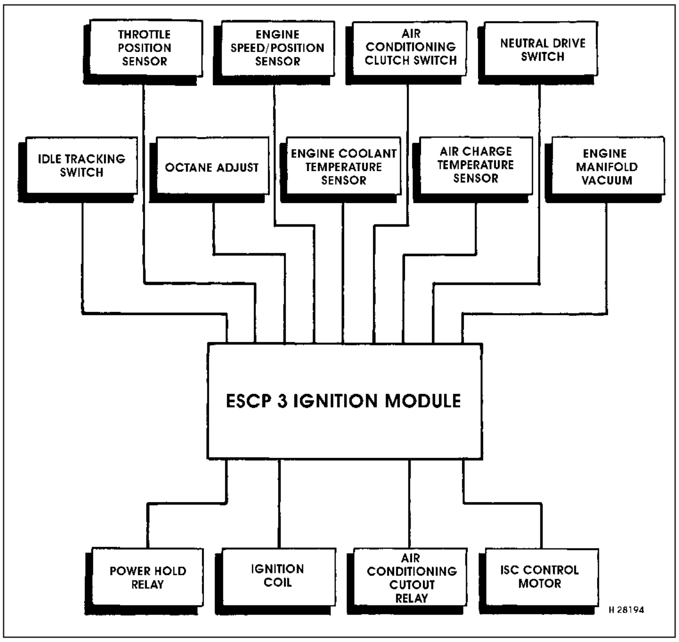
On fuel-injected engines, a highly-sophisticated engine management system is fitted, controlled by the EEC-IV microcomputer in conjunction with an ignition module.

The EEC-IV (Electronic Engine Control, fourth-generation) engine management system controls fuel injection by means of a microcomputer or ECU (Electronic Control Unit) **(see illustrations)**.

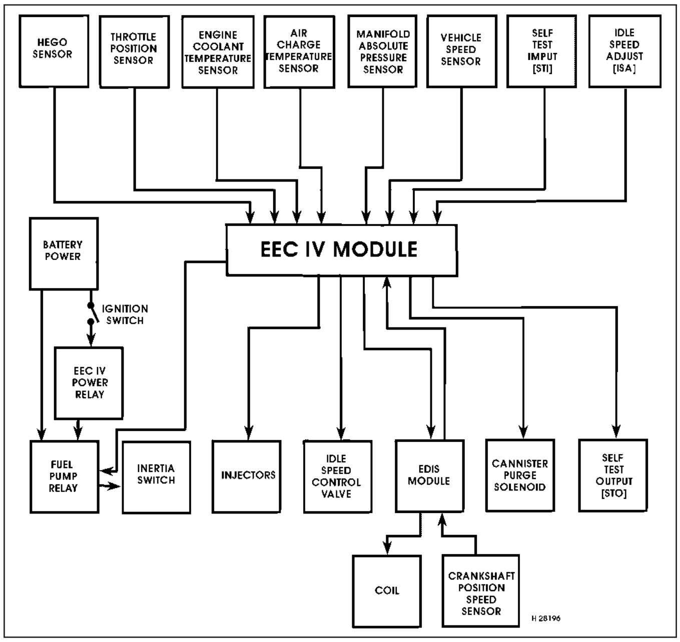
The ECU receives signals from various sensors, which monitor changing engine



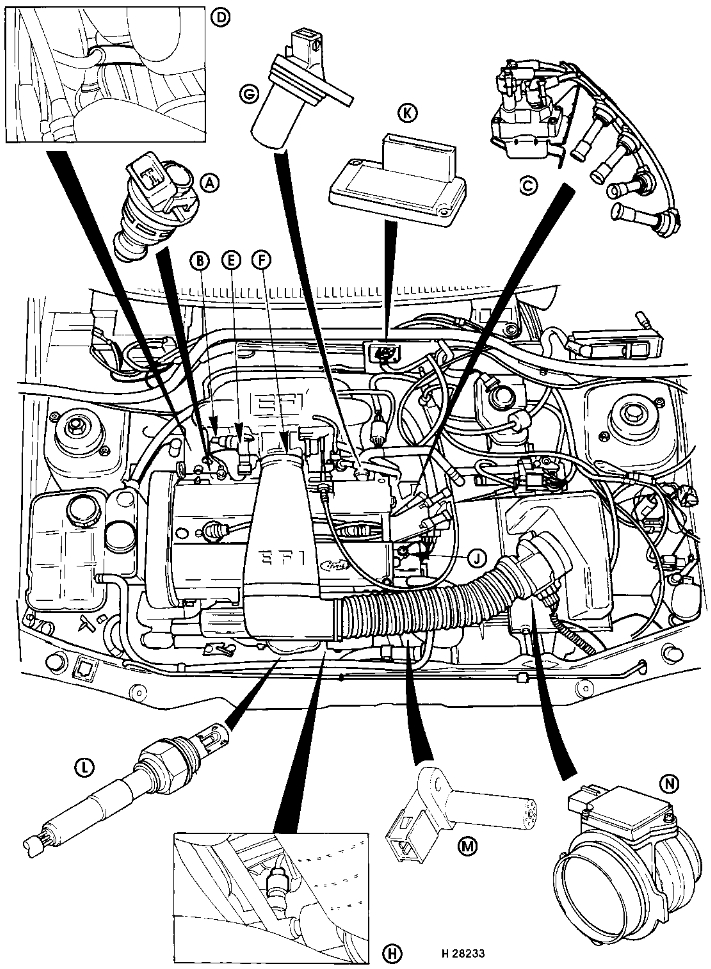
2.2A Diagram of engine monitoring sensors and actuators used on 1.3 litre carburettor engine models



2.2B Diagram of engine monitoring sensors and actuators used on 1.4 and 1.6 litre carburettor engine models



2.4A Diagram of engine monitoring sensors and actuators used on 1.6 litre EFi fuel injected engine models to US '83 emission standard



2.4B Layout of engine management system components and sensors on Zetec engine models

A *Fuel injector (1 of 4)*
B *Idle speed control valve*
C *Ignition coil and HT leads*
D *Charcoal canister-purge solenoid valve*
E *Throttle position sensor*
F *Inlet air temperature sensor*
G *Camshaft position sensor*
H *Vehicle speed sensor*
J *Coolant temperature sensor*
K *E-DIS ignition module/electronic vacuum regulator*
L *Oxygen sensor*
M *Crankshaft position sensor*
N *Air mass meter*

operating conditions such as inlet air mass (ie, inlet air volume and temperature), coolant temperature, engine speed, acceleration/ deceleration, exhaust oxygen content, etc. These signals are used by the ECU to determine the correct injection duration.

The system is analogous to the central nervous system in the human body - the sensors (nerve endings) constantly relay signals to the ECU (brain), which processes the data and, if necessary, sends out a command to change the operating parameters of the engine (body) by means of the actuators (muscles).

Here's a specific example of how one portion of this system operates. An oxygen sensor, located in the exhaust downpipe, constantly monitors the oxygen content of the exhaust gas. If the percentage of oxygen in the exhaust gas is incorrect, an electrical signal is sent to the ECU. The ECU processes this information, and then sends a command to the fuel injection system, telling it to change the air/fuel mixture; the end result is an air/fuel mixture ratio which is constantly maintained at a predetermined ratio, regardless of driving conditions. This happens in a fraction of a second, and goes on almost all the time while the engine is running - the exceptions are that the ECU cuts out the system and runs the engine on values pre-programmed ("mapped") into its memory both while the oxygen sensor is reaching its normal operating temperature after the engine has been started from cold, and when the throttle is fully open for full acceleration.

In the event of a sensor malfunction, a back-up circuit will take over, to provide driveability until the problem is identified and fixed.

Precautions

a) *Always disconnect the battery terminals - see Section 1 of Chapter 5 - before removing any of the electronic control system's electrical connectors.*

b) *When reconnecting the battery, be particularly careful to avoid reversing the positive and negative battery leads.*

c) *Do not subject any components of the system (especially the ECU) to severe impact during removal or installation.*

d) *Take care when carrying out fault diagnosis. Even slight terminal contact can invalidate a testing procedure, and may damage one of the numerous transistor circuits.*

e) *Never attempt to work on the ECU - don't test it (with any kind of test equipment), or open its cover.*

f) *If you are inspecting electronic control system components during rainy weather, make sure that water does not enter any part. When washing the engine compartment, do not spray these parts or their electrical connectors with water - strong plastic bags should be wrapped around these components to prevent water ingress.*

3 Self-diagnosis system - general information

General

On fuel-injected engines with full engine management systems, the various components of the fuel, ignition and emissions control systems (not forgetting the same ECU's control of sub-systems such as the air conditioning and automatic transmission, where appropriate) are so closely interlinked that diagnosis of a fault in any one component is virtually impossible using traditional methods. Working on simpler systems in the past, the experienced mechanic may well have been able to use personal skill and knowledge immediately to pinpoint the cause of a fault, or quickly to isolate the fault, by elimination; however, with an engine management system integrated to this degree, this is not likely to be possible in most instances, because of the number of symptoms that could arise from even a minor fault.

So that the causes of faults can be quickly and accurately traced and rectified, the ECU is provided with a built-in self-diagnosis facility, which detects malfunctions in the system's components. When a fault occurs, three things happen: the ECU identifies the fault, stores a corresponding code in its memory, and (in most cases) runs the system using back-up values pre-programmed ("mapped") into its memory; some form of driveability is thus maintained, to enable the vehicle to be driven to a garage for attention.

Any faults that may have occurred are indicated in the form of two- or three-digit codes when the system is connected (via the built-in diagnosis or self-test connectors, as appropriate) to special diagnostic equipment - this points the user in the direction of the faulty circuit, so that further tests can pinpoint the exact location of the fault. Obviously, to be able to interpret these fault codes accurately requires special diagnostic test equipment and an understanding of its use, which puts this phase of the diagnostic procedure outside the scope of the DIY enthusiast. There are, however, a number of checks that can be performed without sophisticated equipment, and in many cases these alone will find the cause of the trouble.

Given below is a procedure that should be followed to trace an engine management system fault from scratch. Most of the operations described apply equally to carburettor models with minimal emissions control, right through to fuel-injected models with full engine management. Read through the procedure and decide how much you can attempt, depending on your skill and experience and the equipment available to you, or whether it would be simpler to have the vehicle attended to by your local Ford dealer. If you are concerned about the apparent complexity of the system, however, remember that the following system checks require nothing but care, patience and a few minor items of equipment, and may well eliminate the majority of faults.

Initial system checks

Note: *When carrying out these checks to trace a fault, remember that if the fault has appeared only a short time after any part of the vehicle has been serviced or overhauled, the first place to check is where that work was carried out, however unrelated it may appear, to ensure that no carelessly-refitted components are causing the problem.*

If you are tracing the cause of a "partial" engine fault, such as lack of performance, in addition to the checks outlined below, check the compression pressures (see Parts A, B or C of Chapter 2, as applicable) and bear in mind the possibility that one of the hydraulic tappets (where applicable) might be faulty, producing an incorrect valve clearance. Check also that the fuel filter has been renewed at the recommended intervals.

If the system appears completely dead, remember the possibility that the alarm/immobiliser system may be responsible.

1 On fuel-injected models, the first check for anyone without special test equipment is to switch on the ignition, and to listen for the fuel pump (the sound of an electric motor running, audible from beneath the rear seats); assuming there is sufficient fuel in the tank, the pump should start and run for approximately one or two seconds, then stop, each time the ignition is switched on. If the pump runs continuously all the time the ignition is switched on, the electronic control system is running in the back-up (or "limp-home") mode, referred to by Ford as "Limited Operation Strategy" (LOS). This almost certainly indicates a fault in the ECU itself, and the vehicle should therefore be taken to a Ford dealer for a full test of the complete system using the correct diagnostic equipment; do not waste time trying to test the system without such facilities.

2 If the fuel pump is working correctly (or not at all), a considerable amount of fault diagnosis is still possible without special test equipment. Start the checking procedure as follows.

3 Open the bonnet and check the condition of the battery connections - remake the connections or renew the leads if a fault is found (see Chapter 5, Section 1 before disconnecting the battery). Use the same techniques to ensure that all earth points in the engine compartment provide good electrical contact through clean, metal-to-metal joints, and that all are securely fastened. Many of these earth points will be on the inner wings, and on most models, there is an earth strap from the engine or transmission to the vehicle body. Note that certain components have their earth connection made directly through the back of the component onto its mounting surface, in which case, the component should be removed, and the mating surfaces cleaned. A smear of petroleum jelly, or some water-dispersant spray, will help to ensure a continued good connection between the cleaned surfaces.

4 Referring to the information given in Chapter 12 and in the wiring diagrams at the back of this manual, check that all fuses protecting the circuits related to the engine management system are in good condition. Fit new fuses if required; while you are there, check that all relays are securely plugged into their sockets.

5 Next work methodically around the engine compartment, checking all visible wiring, and the connections between sections of the wiring loom. What you are looking for at this stage is wiring that is obviously damaged by chafing against sharp edges, or against moving suspension/transmission components and/or the auxiliary drivebelt, by being trapped or crushed between carelessly-refitted components, or melted by being forced into contact with hot engine castings, coolant pipes, etc. In almost all cases, damage of this sort is caused in the first instance by incorrect routing on reassembly after previous work has been carried out (see the note at the beginning of this sub-Section).

6 Obviously wires can break or short together inside the insulation so that no visible evidence betrays the fault, but this usually only occurs where the wiring loom has been incorrectly routed so that it is stretched taut or kinked sharply; either of these conditions should be obvious on even a casual inspection. If this is thought to have happened and the fault proves elusive, the suspect section of wiring should be checked very carefully during the more detailed checks which follow.

7 Depending on the extent of the problem, damaged wiring may be repaired by rejoining the break or splicing-in a new length of wire, using solder to ensure a good connection, and remaking the insulation with adhesive insulating tape or heat-shrink tubing, as desired. If the damage is extensive, given the implications for the vehicle's future reliability, the best long-term answer may well be to renew that entire section of the loom, however expensive this may appear.

8 When the actual damage has been repaired, ensure that the wiring loom is re-routed correctly, so that it is clear of other components, is not stretched or kinked, and is secured out of harm's way using the plastic clips, guides and ties provided.

9 Check all electrical connectors, ensuring that they are clean, securely fastened, and that each is locked by its plastic tabs or wire clip, as appropriate. If any connector shows external signs of corrosion (accumulations of white or green deposits, or streaks of "rust"), or if any is thought to be dirty, it must be unplugged and cleaned using electrical contact cleaner. If the connector pins are severely corroded, the connector must be renewed; note that this may mean the renewal of that entire section of the loom - see your local Ford dealer for details.

10 If the cleaner completely removes the corrosion to leave the connector in a satisfactory condition, it would be wise to pack the connector with a suitable material which will exclude dirt and moisture, and prevent the corrosion from occurring again; a Ford dealer may be able to recommend a suitable product. **Note:** *The system's connectors use gold-plated pins, which must not be mixed with the older tin-plated types (readily identifiable from the different colour) if a component is renewed, nor must the lithium grease previously used to protect tin-plated pins be used on gold-plated connectors.*

11 Following the accompanying schematic diagrams, and working methodically around the engine compartment, check carefully that all vacuum hoses and pipes are securely fastened and correctly routed, with no signs of cracks, splits or deterioration to cause air leaks, or of hoses that are trapped, kinked, or bent sharply enough to restrict air flow. Check with particular care at all connections and sharp bends, and renew any damaged or deformed lengths of hose.

12 Working from the fuel tank, via the filter, to the carburettor or fuel rail (and including the feed and return), check the fuel lines, and renew any that are found to be leaking, trapped or kinked.

13 Check that the accelerator cable is correctly secured and adjusted; renew the cable if there is any doubt about its condition, or if it appears to be stiff or jerky in operation. Refer to the relevant Sections of Chapter 4 for further information, if required.

14 Unclip the air cleaner cover, and check that the air filter element and the crankcase ventilation system filter (where applicable) are not clogged or soaked. (A clogged air filter will obstruct the inlet air flow, causing a noticeable effect on engine performance; a clogged crankcase ventilation system filter will inhibit crankcase "breathing"). Renew or clean the filter(s) as appropriate; refer to the relevant Sections of Chapter 1 for further information, if required.

15 Start the engine and allow it to idle. **Note:** Working in the engine compartment while the engine is running requires great care if the risk of personal injury is to be avoided; among the dangers are burns from contact with hot components, or contact with moving components such as the radiator cooling fan or the auxiliary drivebelt. Refer to "Safety first!" at the front of this manual before starting, and ensure that your hands, and long hair or loose clothing, are kept well clear of hot or moving components at all times.

16 Working from the air inlet, via the air cleaner assembly and carburettor, or on fuel-injected models, the air mass meter to the throttle housing and inlet manifold (and including the various vacuum hoses and pipes connected to these), check for air leaks. Usually, these will be revealed by sucking or hissing noises, but minor leaks may be traced by spraying a solution of soapy water on to the suspect joint; if a leak exists, it will be shown by the change in engine note and the accompanying air bubbles (or sucking-in of the liquid, depending on the pressure difference at that point). If a leak is found at any point, tighten the fastening clamp and/or renew the faulty components, as applicable.

17 Similarly, work from the cylinder head, via the manifold to the tailpipe, to check that the exhaust system is free from leaks. The simplest way of doing this, if the vehicle can be raised and supported safely and with complete security while the check is made, is to temporarily block the tailpipe while listening for the sound of escaping exhaust gases; any leak should be evident. If a leak is found at any point, tighten the fastening clamp bolts and/or nuts, renew the gasket, and/or renew the faulty section of the system, as necessary, to seal the leak.

18 It is possible to make a further check of the electrical connections by wiggling each electrical connector of the system in turn as the engine is idling; a faulty connector will be immediately evident from the engine's response as contact is broken and remade. It may be possible with some connectors to carefully bend the connector pins to improve the contact being made. However, a faulty connector should really be renewed, to ensure the future reliability of the system (note that this may mean the renewal of that entire section of the loom - see your local Ford dealer for details).

19 Switch off the engine. If the fault is not yet identified, the next step is to check the ignition voltages, using an engine analyser with an oscilloscope - without such equipment, the only tests possible are to remove and check each spark plug in turn, to check the spark plug (HT) lead connections and resistances, and to check the connections and resistances of the ignition coil. Refer to the relevant Sections of Chapters 1 and 5.

20 The final step in these initial checks would be to use an exhaust gas analyser to measure the CO level at the exhaust tailpipe. This check cannot be made without special test equipment - see your local Ford dealer for details.

6

4 Information sensors - general information, testing, removal and refitting

Note: *This Section is concerned principally with the sensors which give the ECU the information it needs to control the various engine management sub-systems - for further details of those systems and their other components, refer to the relevant Chapter of this manual. Not all of the sensors listed below are fitted to all engines.*

General

ECU (Electronic Control Unit)

1 This component is the heart of the entire engine management system, controlling the fuel injection, ignition and emissions control systems. It also controls sub-systems such as the air conditioning and automatic transmission, where appropriate. Refer to Section 2 of this Chapter for an illustration of how it works.

Air mass meter

2 The air mass meter fitted to models equipped with Sequential Electronic Fuel Injection (SEFI) is based on a "hot-wire" system, sending the ECU a constantly-varying (analogue) voltage signal corresponding to the mass of air passing into the engine. Since air mass varies with temperature (cold air being denser than warm), measuring air mass provides the ECU with a very accurate means of determining the correct amount of fuel required to achieve the ideal air/fuel mixture ratio.

Crankshaft speed/position sensor

3 This is an inductive pulse generator bolted (in a separate bracket) to the cylinder block/crankcase, to scan the ridges between 36 holes machined in the inboard (right-hand) face of the flywheel/driveplate. As each ridge passes the sensor tip, a signal is generated, which is used by the ECU to determine engine speed.

4 The ridge between the 35th and 36th holes (corresponding to 90º BTDC) is missing - this step in the incoming signals is used by the ECU to determine crankshaft (ie, piston) position.

Camshaft position sensor

5 This is bolted to the rear left-hand end of the cylinder head on Zetec engines, to register with a lobe on the inlet camshaft. It functions in the same way as the crankshaft speed/position sensor, producing a series of pulses (corresponding to No 1 cylinder at 46º ATDC); this gives the ECU a reference point, to enable it to determine the firing order, and operate the injectors in the appropriate sequence.

Coolant temperature sensor

6 This component is an NTC (Negative Temperature Coefficient) thermistor - that is, a semi-conductor whose electrical resistance decreases as its temperature increases. It provides the ECU with a constantly-varying (analogue) voltage signal, corresponding to the temperature of the engine coolant. This is used to refine the calculations made by the ECU, when determining the correct amount of fuel required to achieve the ideal air/fuel mixture ratio.

Inlet air temperature sensor

7 This component is also an NTC thermistor - see the previous paragraph - providing the ECU with a signal corresponding to the temperature of air passing into the engine. This is used to refine the calculations made by the ECU, when determining the correct amount of fuel required to achieve the ideal air/fuel mixture ratio.

Throttle position sensor

8 This is mounted on the end of the throttle valve spindle, to provide the ECU with a constantly-varying (analogue) voltage signal corresponding to the throttle opening. This allows the ECU to register the driver's input when determining the amount of fuel required by the engine.

Vehicle speed sensor

9 This component is a Hall-effect generator, mounted on the transmission's speedometer drive. It supplies the ECU with a series of pulses corresponding to the vehicle's road speed, enabling the ECU to control features such as the fuel shut-off on the overrun, and to provide information for the trip computer, adaptive damping and cruise control systems (where fitted).

Manifold absolute pressure (MAP) sensor

10 The manifold absolute pressure sensor measures inlet manifold vacuum, and supplies this information to the ECU for calculation of engine load at any given throttle position.

Power steering pressure switch

11 This is a pressure-operated switch, screwed into the power steering system's high-pressure pipe. Its contacts are normally closed, opening when the system reaches the specified pressure - on receiving this signal, the ECU increases the idle speed, to compensate for the additional load on the engine.

Oxygen sensor

12 The oxygen sensor in the exhaust system provides the ECU with constant feedback - "closed-loop" control - which enables it to adjust the mixture to provide the best possible conditions for the catalytic converter to operate.

13 The sensor has a built-in heating element which is controlled by the ECU, in order to bring the sensor's tip to an efficient operating temperature as rapidly as possible. The sensor's tip is sensitive to oxygen, and sends the ECU a varying voltage depending on the amount of oxygen in the exhaust gases; if the intake air/fuel mixture is too rich, the sensor sends a high-voltage signal. The voltage falls as the mixture weakens. Peak conversion efficiency of all major pollutants occurs if the intake air/fuel mixture is maintained at the chemically-correct ratio for the complete combustion of petrol - 14.7 parts (by weight) of air to 1 part of fuel (the `stoichiometric' ratio). The sensor output voltage alters in a large step at this point, the ECU using the signal change as a reference point, and correcting the intake air/fuel mixture accordingly by altering the fuel injector pulse width (injector opening time).

Air conditioning system

14 A pressure-operated switch and compressor clutch solenoid are connected to the ECU, to enable it to determine how the system is operating. The ECU can increase idle speed or switch off the system, as necessary, so that normal vehicle operation and driveability are not impaired. See Chapter 3 for further details, but note that diagnosis and repair should be left to a dealer service department or air conditioning specialist.

Testing

ECU (Electronic Control Unit)

15 Do not attempt to "test" the ECU with any kind of equipment. If it is thought to be faulty, take the vehicle to a Ford dealer for the entire electronic control system to be checked using the proper diagnostic equipment. Only if all other possibilities have been eliminated should the ECU be considered at fault, and replaced.

Air mass meter

16 Testing of this component is beyond the scope of the DIY mechanic, and should be left to a Ford dealer.

Crankshaft speed/position sensor

17 Unplug the electrical connector from the sensor.

18 Using an ohmmeter, measure the resistance between the sensor terminals. Compare this reading to the one listed in the Specifications Section at the beginning of this Chapter. If the indicated resistance is not within the specified range, renew the sensor.

19 Plug in the sensor's electrical connector on completion.

Camshaft position sensor

20 The procedure is as described in paragraphs 17 to 19 above.

Coolant temperature sensor

21 Refer to Chapter 3, Section 6.

Inlet air temperature sensor

22 Unplug the electrical connector from the sensor which is located either in the air cleaner (carburettor engines) or in the CFi unit or inlet manifold (fuel-injected engines).

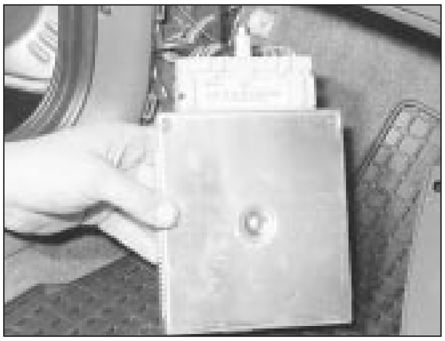
23 Using an ohmmeter, measure the resistance between the sensor terminals. Depending on the temperature of the sensor tip, the resistance measured will vary, but it should be within the broad limits given in the Specifications Section of this Chapter. If the sensor's temperature is varied - by placing it in a freezer for a while, or by warming it gently - its resistance should alter accordingly.

24 If the results obtained show the sensor to be faulty, renew it.

Throttle position sensor

25 Remove the air cleaner assembly or plenum chamber as necessary for access (see Chapter 4) then unplug the sensor's electrical connector.

4.35 ECU location behind the side cowl kick panel in the passenger's footwell



4.36 Release the ECU from its retaining bracket, then unscrew the retaining bolt and remove the wiring multi-plug

4.38 Disconnecting the air mass meter electrical connector

26 Using an ohmmeter, measure the resistance between the unit's terminals - first between the centre terminal and one of the outer two, then from the centre to the remaining outer terminal. The resistance should be within the limits given in the Specifications Section of this Chapter, and should alter *smoothly* as the throttle valve is moved from the fully-closed (idle speed) position to fully open and back again.

27 If the resistance measured is significantly different from the specified value, if there are any breaks in continuity, or if the reading fluctuates erratically as the throttle is operated, the potentiometer is faulty, and must be renewed.

Vehicle speed sensor

28 Testing of this component is beyond the scope of the DIY mechanic, and should be left to a Ford dealer.

Manifold absolute pressure (MAP) sensor

29 Testing of this component is beyond the scope of the DIY mechanic, and should be left to a Ford dealer.

Power steering pressure switch

30 Unplug the electrical connector from the sensor.

31 Using an ohmmeter, measure the resistance between the switch terminals. With the engine switched off, or idling with the roadwheels in the straight-ahead position, little or no resistance should be measured. With the engine running and the steering on full-lock, the pressure increase in the system should open the switch contacts, so that infinite resistance is now measured.

32 If the results obtained show the switch to be faulty, renew it.

Oxygen sensor

33 Testing of this component can be done only by attaching special diagnostic equipment to the sensor wiring, and checking that the voltage varies from low to high values when the engine is running; *do not* attempt to "test" any part of the system with anything other than the correct test equipment. This is beyond the scope of the DIY mechanic, and should be left to a Ford dealer.

Removal and refitting

General

34 Before disconnecting any of these components, always disconnect the battery terminals, negative (earth) lead first - see Section 1 of Chapter 5.

ECU (Electronic Control Unit)

Note: *The ECU is fragile. Take care not to drop it, or subject it to any other kind of impact. Do not subject it to extremes of temperature, or allow it to get wet.*

35 Working inside the vehicle, remove the side cowl kick panel from the front passenger's footwell to gain access to the ECU **(see illustration)**.

36 Release the ECU from its retaining bracket **(see illustration)**, then unscrew the retaining bolt and remove the wiring multi-plug.

37 Refitting is the reverse of the removal procedure.

Air mass meter

38 Releasing its wire clip, unplug the meter's electrical connector **(see illustration)**.

39 Release the clips and lift the air cleaner cover, then release the two smaller clips and detach the meter from the cover.

40 Slacken the clamp securing the meter to the inlet hose, and withdraw the meter.

41 Refitting is the reverse of the removal procedure. Ensure that the meter and air cleaner cover are seated correctly and securely fastened, so that there are no air leaks.

Crankshaft speed/position sensor

42 Refer to Chapter 5.

Camshaft position sensor

43 Release the fuel feed and return hoses from their clip.

44 Releasing its wire clip, unplug the sensor's electrical connector. Remove the retaining screw, and withdraw the sensor from the cylinder head; be prepared for slight oil loss **(see illustration).**

45 Refitting is the reverse of the removal procedure, noting the following points:

a) Apply petroleum jelly or clean engine oil to the sensor's sealing O-ring.

b) Locate the sensor fully in the cylinder head, and wipe off any surplus lubricant before securing it.

c) Tighten the screw to the specified torque wrench setting.

Coolant temperature sensor

46 Refer to Chapter 3, Section 6.

Inlet air temperature sensor

47 Remove the air cleaner assembly or air inlet ducting as necessary (refer to Chapter 4) to gain access to the sensor.

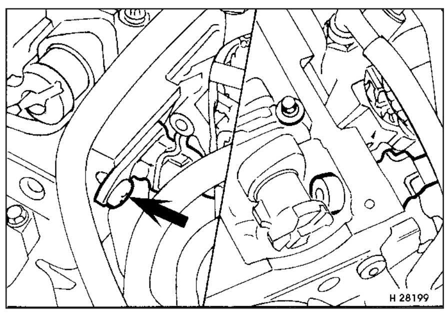
48 Releasing its clip, unplug the sensor's electrical connector, then unscrew the sensor from the CFi unit, inlet manifold, or resonator, as applicable.

49 Refitting is the reverse of the removal procedure. Tighten the sensor to the specified torque wrench setting; if it is overtightened, its tapered thread may crack the resonator.

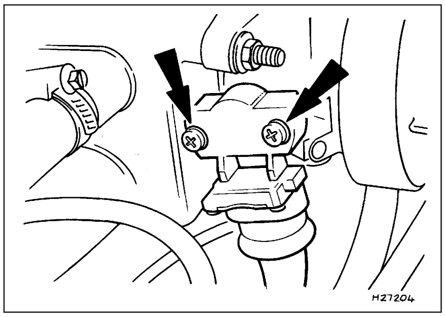
Throttle position sensor

50 Remove the air cleaner assembly, where necessary, for access (see Chapter 4).

51 Releasing its wire clip, unplug the potentiometer's electrical connector. Remove the retaining screws, and withdraw the unit



4.44 Camshaft position sensor location in cylinder head with retaining screw (arrowed) - cylinder head cover shown removed for clarity



4.51 Throttle position sensor securing screws (arrowed)

from the throttle housing **(see illustration)**. *Do not* force the sensor's centre to rotate past its normal operating sweep; the unit will be seriously damaged.

52 Refitting is the reverse of the removal procedure, noting the following points:

a) *Ensure that the potentiometer is correctly orientated **(see illustration)**, by locating its centre on the D-shaped throttle shaft (throttle closed), and aligning the potentiometer body so that the bolts pass easily into the throttle housing.*

b) *Tighten the screws evenly and securely (but do not overtighten them, or the potentiometer body will be cracked).*

Vehicle speed sensor

53 The sensor is mounted at the base of the speedometer drive cable, and is removed with the speedometer drive pinion. Refer to the relevant Section of Chapter 7, Part A or B, as applicable.

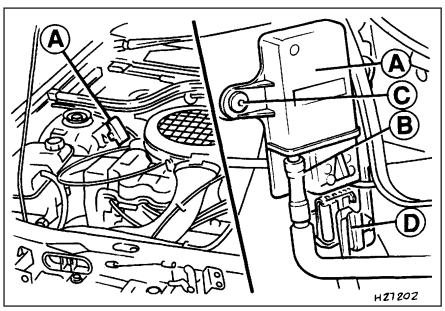
Manifold absolute pressure (MAP) sensor

54 The sensor is located at the rear of the engine compartment, on the right-hand side **(see illustration)**.

55 Disconnect the wiring multi-plug, and detach the vacuum hose from the base of the sensor.

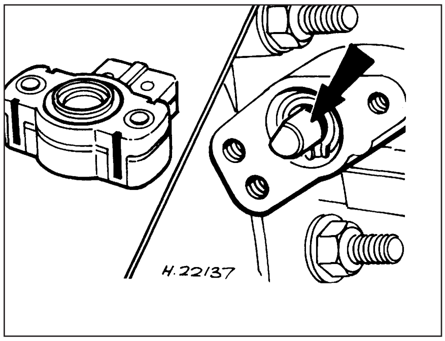
56 Undo the two retaining screws, and withdraw the sensor from its location.

57 Refitting is the reverse of the removal procedure.



4.54 Manifold absolute pressure (MAP) sensor location and connections

A MAP sensor
B Vacuum hose
C Retaining screw(s)
D Wiring multi-plug



4.52 Align the throttle position sensor "D" section on throttle shaft (arrowed) when refitting

Power steering pressure switch

58 Releasing its clip, unplug the switch's electrical connector, then unscrew the switch **(see illustration)**. Place a wad of rag underneath, to catch any spilt fluid. If a sealing washer is fitted, renew it if it is worn or damaged.

59 Refitting is the reverse of the removal procedure; tighten the switch securely, then top-up the fluid reservoir (see Chapter 1) to replace any fluid lost from the system, and bleed out any trapped air (see Chapter 10).

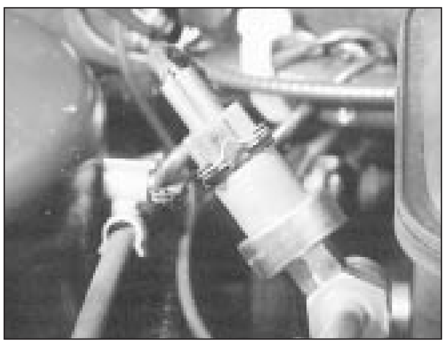
Oxygen sensor

Note: *The sensor is delicate, and will not work if it is dropped or knocked, if its power supply is disrupted, or if any cleaning materials are used on it.*

60 Release the sensor's electrical connector from its bracket on the engine/transmission front mounting, and unplug it to disconnect the sensor.

61 Raising and supporting the front of the vehicle if required to remove the sensor from underneath, unscrew the sensor from the exhaust system front downpipe; collect the sealing washer (where fitted).

62 On refitting, clean the sealing washer (where fitted) and renew it if it is damaged or worn. Apply a smear of anti-seize compound to the sensor's threads, to prevent them from welding themselves to the downpipe in service. Refit the sensor, tightening it to its specified torque wrench setting; a slotted socket will be required to do this. Reconnect the wiring, and refit the connector plug.



4.58 Power steering pressure switch location at right-hand rear of engine

5 Evaporative emissions control (EVAP) system

General description

1 This system is fitted to minimise the escape of unburned hydrocarbons into the atmosphere. Fuel evaporative emissions control systems are limited on vehicles meeting 15.04 regulations; carburettor float chambers are vented internally, whilst fuel tanks vent to atmosphere through a combined roll-over/anti-trickle-fill valve. On vehicles meeting the more stringent emissions regulations, the fuel tank filler cap is sealed, and a charcoal canister is used to collect and store petrol vapours generated in the tank when the vehicle is parked. When the engine is running, the vapours are cleared from the canister (under the control of the ECU via the canister-purge solenoid valve) into the inlet tract, to be burned by the engine during normal combustion.

2 To ensure that the engine runs correctly when it is cold and/or idling, and to protect the catalytic converter from the effects of an over-rich mixture, the canister-purge solenoid valve is not opened by the ECU until the engine is fully warmed-up and running under part-load; the solenoid valve is then switched on and off, to allow the stored vapour to pass into the inlet.

Checking

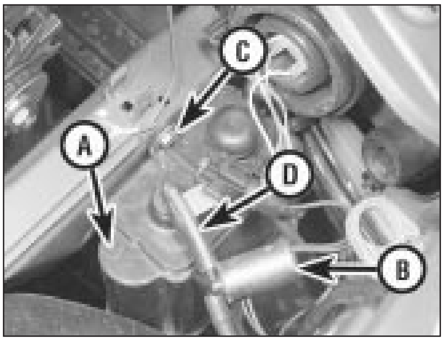
3 Poor idle, stalling and poor driveability can be caused by an inoperative canister-purge solenoid valve, a damaged canister, split or cracked hoses, or hoses connected to the wrong fittings. Check the fuel filler cap for a damaged or deformed gasket.

4 Fuel loss or fuel odour can be caused by liquid fuel leaking from fuel lines, a cracked or damaged canister, an inoperative canister-purge solenoid valve, or disconnected, misrouted, kinked or damaged vapour or control hoses.

5 Inspect each hose attached to the canister for kinks, leaks and cracks along its entire length. Repair or renew as necessary.

6 Inspect the canister. If it is cracked or damaged, renew it. Look for fuel leaking from the bottom of the canister. If fuel is leaking, renew the canister, and check the hoses and hose routing.

7 If the canister-purge solenoid valve is thought to be faulty, unplug its electrical connector and disconnect its vacuum hoses. Connect a battery directly across the valve terminals. Check that air can flow through the valve passages when the solenoid is thus energised, and that nothing can pass when the solenoid is not energised. Alternatively, connect an ohmmeter to measure the resistance across the solenoid terminals, and compare this reading to the one listed in the Specifications Section at the beginning of this



5.9 Charcoal canister-purge solenoid valve and associated components located at the front right-hand side of the engine compartment near the headlight unit on HCS and CVH engines

A Charcoal canister
B Purge solenoid valve
C Canister retaining bolt
D Canister vapour hose

Chapter. Renew the solenoid valve if it is faulty.

8 Further testing should be left to a dealer service department.

Component renewal

Charcoal canister-purge solenoid valve

9 The solenoid is located at the front right-hand side of the engine compartment, near the headlight unit, on HCS and CVH engines **(see illustration)**. On Zetec engines, the valve is clipped to the bulkhead, behind the engine on the right-hand side. Locate the solenoid, then remove any components as necessary to improve access.

10 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1), then unplug the valve's electrical connector. Unclip the valve from its location, then disconnect its vacuum hoses and withdraw it.

11 Refitting is the reverse of the removal procedure.

Charcoal canister

12 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).

13 The canister is located in the forward section of the right-hand wheel arch (beneath the coolant expansion reservoir). Access to the top of the unit is made by removing the coolant expansion reservoir. Access to the underside of the unit is gained by raising the vehicle at the front and removing the roadwheel on the right-hand side. Ensure that the vehicle is securely supported on axle stands before working under the wheel arch.

14 Disconnect the hose from the unit, and plug it to prevent the ingress of dirt.

15 Undo the retaining screws, and withdraw the unit from under the wheel arch.

16 Refit in the reverse order of removal. Unplug the hose before reconnecting it, and ensure that it is clean and securely connected.

6 Pulse-air system - general information, checking and component renewal

General information

1 This system consists of the pulse-air solenoid valve (fuel-injected models), the pulse-air valve itself, the delivery tubing, a pulse-air filter, and on some models, a check valve. The system injects filtered air directly into the exhaust ports, using the pressure variations in the exhaust gases to draw air through from the filter housing; air will flow into the exhaust only when its pressure is below atmospheric. The pulse-air valve can allow gases to flow only one way, so there is no risk of hot exhaust gases flowing back into the filter.

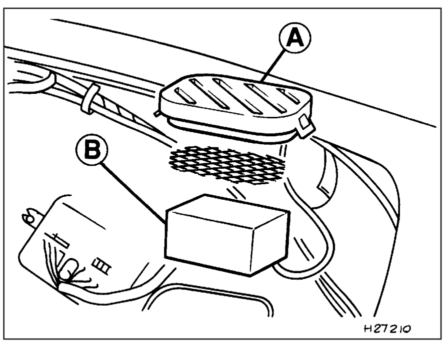
2 The system's primary function is raise exhaust gas temperatures on start-up, thus reducing the amount of time taken for the catalytic converter to reach operating temperature. Until this happens, the system reduces emissions of unburned hydrocarbon particles (HC) and carbon monoxide (CO) by ensuring that a considerable proportion of these substances remaining in the exhaust gases after combustion are burned up, either in the manifold itself or in the catalytic converter.

3 To ensure that the system does not upset the smooth running of the engine under normal driving conditions, it is linked by the pulse-air solenoid valve to the ECU on fuel-injected models, so that it only functions during engine warm-up, when the oxygen sensor is not influencing the fuel/air mixture ratio. On carburettor models, a temperature-sensitive ported vacuum switch shuts the system off when normal engine operating temperature is reached.

Checking

4 Poor idle, stalling, backfiring and poor driveability can be caused by a fault in the pulse-air system.

5 Inspect the vacuum pipe/hose for kinks, leaks and cracks along its entire length. Repair or renew as necessary.



6.9 Pulse-air system filter components on CVH engines

A Filter housing lid *B Filter element*

6 Inspect the filter housing and piping. If either is cracked or damaged, renew it.

7 If the pulse-air solenoid valve is thought to be faulty, unplug its electrical connector and disconnect its vacuum hoses. Connect a battery directly across the valve terminals, and check that air can flow through the valve passages when the solenoid is thus energised, and that nothing can pass when the solenoid is not energised. Alternatively, connect an ohmmeter to measure the resistance across the valve terminals, and compare this reading to the one listed in the Specifications at the beginning of this Chapter. Renew the solenoid valve if it is faulty.

8 Further testing should be left to a dealer service department.

Component renewal

Pulse-air filter and housing (CVH engines)

9 Detach the lid from the filter body, and lift out the filter element from the housing **(see illustration)**. If required, the housing can be removed by detaching the air hoses from the base of the unit and withdrawing the unit from the vehicle.

10 Refit in the reverse order of removal.

Pulse-air valve (CVH engines)

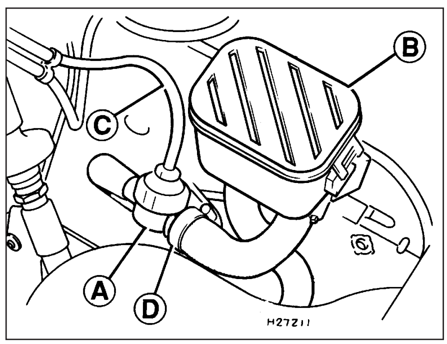
11 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).

12 Detach the vacuum hoses from the valve **(see illustration)**.

13 Loosen off the air hose clamp, and detach the air hose from the valve.

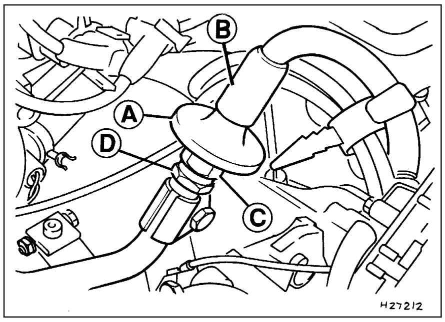
14 Detach the remaining air hose. Note the orientation of the valve, and remove it from the vehicle.

15 When refitting the valve, ensure that it is fitted the correct way round. Refitting is otherwise a reversal of removal the removal procedure.



6.12 Pulse-air valve and connections on CVH engines

A Pulse-air valve
B Pulse-air filter housing
C Vacuum hose
D Air hose securing clamp



6.17 Pulse-air check valve and connections on CVH engines

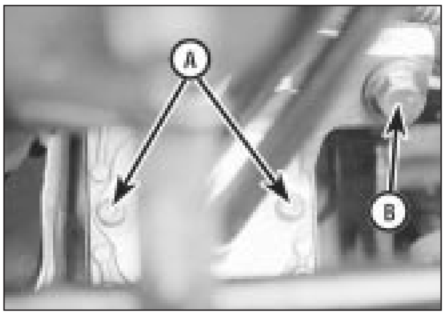
A Check valve   *C Check valve upper nut*
B Air hose   *D Lower tube nut*

Pulse-air check valve (CVH engines)

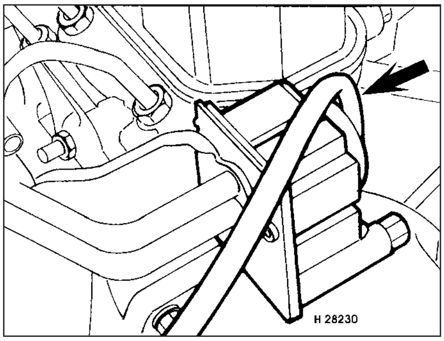
16 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).
17 Detach the air hoses from the check valve **(see illustration)**.
18 Hold the lower tube nut at the base of the valve firm with a suitable spanner, and unscrew the valve using a spanner fitted on the upper nut.
19 Refit in the reverse order of removal. Ensure that the valve is correctly positioned before fully tightening the tube nut against the valve nut.

Pulse-air valve, filter and housing (HCS engines)

20 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).



6.29 . . . then undo screws “A” to disconnect the piping and mounting bolt “B” to release the housing



6.21 Vacuum hose connection (arrowed) to pulse-air valve on HCS engines

21 Disconnect the vacuum hose from the rear of the pulse-air valve assembly **(see illustration)**.
22 Undo the retaining screws, and withdraw the air-valve, filter and housing assembly from the mounting bracket.
23 To dismantle the filter housing, undo the four screws and separate the top from the base of the housing; extract the foam filter, and clean it in a suitable solvent. If any of the housing’s components are worn or damaged, the assembly must be renewed.
24 Refitting is the reverse of the removal procedure.

Pulse-air valve, filter and housing (Zetec engines)

25 Apply the handbrake, then raise the front of the vehicle, and support it securely on axle stands.
26 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).
27 Disconnect the vacuum hose from the base of the filter housing **(see illustration)**.
28 Remove the air cleaner air inlet ducting for access (refer to Chapter 4).
29 Remove the screws securing the filter housing to the piping, unscrew the mounting bolt, then withdraw the housing **(see illustration)**.
30 To dismantle the filter housing, undo the four screws and separate the top from the base of the housing. Extract the foam filter, and clean it in a suitable solvent **(see illustrations)**. If any of the housing’s components are worn or damaged, the assembly must be renewed.
31 Refitting is the reverse of the removal procedure.

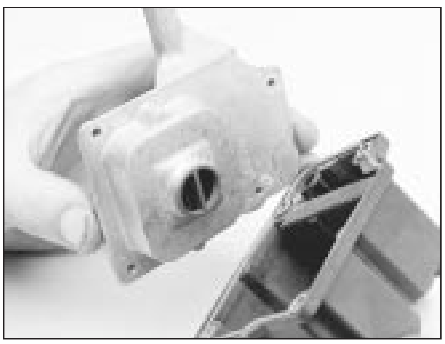
6.27 Disconnect the vacuum hose from the base of the filter housing . . .

Pulse-air solenoid valve

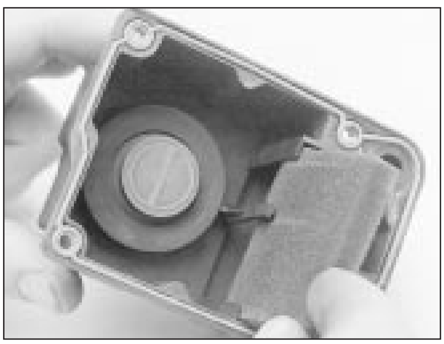
32 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).
33 Releasing its wire clip, unplug the electrical connector, then release the valve from its mounting bracket. Withdraw the valve, then label and disconnect the two vacuum hoses.
34 Refitting is the reverse of the removal procedure; ensure that the hoses are correctly reconnected.

Pulse-air piping (HCS and CVH engines)

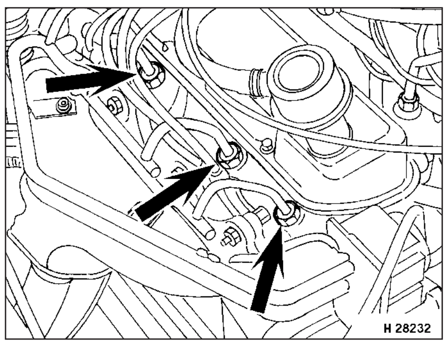
35 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).
36 Remove the air cleaner if necessary for improved access (refer to Chapter 4).
37 Disconnect the vacuum hose from the pulse-air valve.
38 Unbolt and detach the air tube from its fixing to the exhaust manifold, cylinder head and transmission, according to engine type.
39 Loosen off the four nuts securing the air delivery tubes to the cylinder head exhaust ports, then carefully withdraw the delivery tubes as a unit **(see illustration)**. Do not apply undue force to the tubes as they are detached.
40 Carefully clean the piping, particularly its



6.30A Remove the four screws to release the filter housing top from the base . . .



6.30B . . . and withdraw the foam filter for cleaning, if required



6.39 Pulse-air piping retaining nuts (arrowed) on HCS engines

6.46 Removing the pulse-air piping on Zetec engines

threads and those of the manifold. Remove all traces of corrosion, which might prevent the pipes seating properly, causing air leaks when the engine is restarted.

41 On refitting, insert the piping carefully into the cylinder head ports, taking care not to bend or distort it. Apply anti-seize compound to the threads, and tighten the retaining sleeve nuts while holding each pipe firmly in its port.

42 The remainder of the refitting procedure is the reverse of removal.

Pulse-air piping (Zetec engines)

43 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).

44 Remove the air cleaner air inlet ducting for access (refer to Chapter 4).

45 Unbolt the exhaust manifold heat shield; unclip the coolant hose to allow the upper part to be withdrawn.

46 Remove the screws securing the filter housing to the piping. Unscrew the four nuts securing the pipes into the exhaust manifold, and remove the piping as an assembly, taking care not to distort it **(see illustration)**.

47 Carefully clean the piping, particularly its threads and those of the manifold. Remove all traces of corrosion, which might prevent the pipes seating properly, causing air leaks when the engine is restarted.

48 On refitting, insert the piping carefully into the cylinder head ports, taking care not to bend or distort it. Apply anti-seize compound to the threads, and tighten the retaining sleeve nuts while holding each pipe firmly in its port; if a suitable spanner is available, tighten the sleeve nuts to the specified torque wrench setting.

49 The remainder of the refitting procedure is the reverse of removal.

7 Positive Crankcase Ventilation (PCV) system

General information

1 The function of the crankcase ventilation system is to reduce the emissions of unburned hydrocarbons from the crankcase, and to minimise the formation of oil sludge. By ensuring that a depression is created in the crankcase under most operating conditions, particularly at idle, and by positively inducing fresh air into the system, the oil vapours and "blow-by" gases collected in the crankcase are drawn from the crankcase, through the air cleaner or oil separator, into the inlet tract, to be burned by the engine during normal combustion.

2 On HCS engines, the system consists of a vented oil filler cap (with an integral mesh filter) and a hose connecting it to a connector on the underside of the air cleaner housing. A further hose leads from the adapter/filter to the inlet manifold. Under conditions of idle and part-load, the emissions gases are directed into the inlet manifold, and dispensed with in the combustion process. Additional air is supplied through two small orifices next to the mushroom valve in the air cleaner housing, the object of which is to prevent high vacuum build-up. Under full-load conditions, when the inlet manifold vacuum is weak, the mushroom valve opens, and the emissions are directed through the air cleaner housing into the engine induction system and thence into the combustion chambers. This arrangement eliminates any fuel mixture control problems.

3 On CVH engines, a closed-circuit type crankcase ventilation system is used, the function of which is basically the same as that described for the HCS engine type, but the breather hose connects directly to the rocker cover. The oil filler cap incorporates a separate filter in certain applications.

4 On Zetec engines, the crankcase ventilation system main components are the oil separator mounted on the front (radiator) side of the cylinder block/crankcase, and the Positive Crankcase Ventilation (PCV) valve set in a rubber grommet in the separator's left-hand upper end. The associated pipework consists of a crankcase breather pipe and two flexible hoses connecting the PCV valve to a union on the left-hand end of the inlet manifold, and a crankcase breather hose connecting the cylinder head cover to the air cleaner assembly **(see illustration)**. A small foam filter in the air cleaner prevents dirt from being drawn directly into the engine.

Checking

5 Checking procedures for the system components are included in Chapter 1.

Component renewal

Air cleaner components

6 See Chapter 1.

Positive Crankcase Ventilation (PCV) valve

7 The valve is plugged into the oil separator on Zetec engines. Depending on the tools available, access to the valve may be possible once the pulse-air assembly has been removed (see Section 6). If this is not feasible, proceed as outlined in paragraph 8 below.

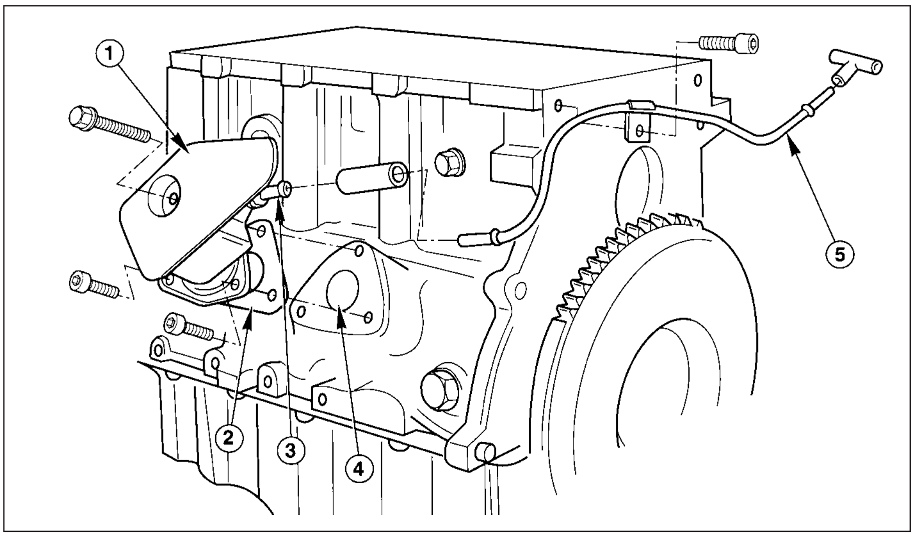
Oil separator

8 Remove the exhaust manifold (see Chapter 2C). The Positive Crankcase Ventilation (PCV) valve can now be unplugged and flushed, or renewed, as required, as described in Chapter 1.

9 Unbolt the oil separator from the cylinder block/crankcase, and withdraw it; remove and discard the gasket.

10 Flush out or renew the oil separator, as required (see Chapter 1).

11 Refitting is the reverse of the removal procedure, but use a new gasket between the oil separator and cylinder block. Refill the cooling system (see Chapter 1). Run the engine, check for exhaust leaks, and check the coolant level when it is fully warmed-up.



7.4 Crankcase ventilation system oil separator and related components on Zetec engines

1 Oil separator
2 Gasket
3 PCV valve
4 Cylinder block/crankcase opening
5 Breather pipe and hose

8 Catalytic converter - general information, checking and component renewal

General information

1 The exhaust gases of any petrol engine (however efficient or well-tuned) consist largely (approximately 99%) of nitrogen (N_2), carbon dioxide (CO_2), oxygen (O_2), other inert gases and water vapour (H_2O). The remaining 1% is made up of the noxious materials which are currently seen (CO_2 apart) as the major polluters of the environment: carbon monoxide (CO), unburned hydrocarbons (HC), oxides of nitrogen (NO_x) and some solid matter, including a small lead content.

2 Left to themselves, most of these pollutants are thought eventually to break down naturally (CO and NO_x, for example, break down in the upper atmosphere to release CO_2) having first caused ground-level environmental problems. The massive increase world-wide in the use of motor vehicles, and the current popular concern for the environment has caused the introduction in most countries of legislation, in varying degrees of severity, to combat the problem.

3 The device most commonly used to clean up vehicle exhausts is the catalytic converter. It is fitted into the vehicle's exhaust system, and uses precious metals (platinum and palladium or rhodium) as catalysts to speed up the reaction between the pollutants and the oxygen in the vehicle's exhaust gases, CO and HC being oxidised to form H_2O and CO_2 and (in the three-way type of catalytic converter) NO_x being reduced to N_2. Note: *The catalytic converter is not a filter in the physical sense; its function is to promote a chemical reaction, but it is not itself affected by that reaction.*

4 The converter consists of an element (or "substrate") of ceramic honeycomb, coated with a combination of precious metals in such a way as to produce a vast surface area over which the exhaust gases must flow; the whole being mounted in a stainless-steel box. A simple "oxidation" (or "two-way") catalytic converter can deal with CO and HC only, while a "reduction" (or "three-way") catalytic converter can deal with CO, HC and NO_x. Three-way catalytic converters are further sub-divided into "open-loop" (or "unregulated") converters, which can remove 50 to 70% of pollutants and "closed-loop" (also known as "controlled" or "regulated") converters, which can remove over 90% of pollutants.

5 The catalytic converters fitted to models covered in this manual are of the three-way open- or closed-loop type.

6 The catalytic converter is a reliable and simple device, which needs no maintenance in itself, but there are some facts of which an owner should be aware if the converter is to function properly for its full service life:

a) *DO NOT use leaded petrol in a vehicle equipped with a catalytic converter - the lead will coat the precious metals, reducing their converting efficiency, and will eventually destroy the converter; it will also affect the operation of the oxygen sensor, requiring its renewal if lead-fouled. Opinions vary as to how much leaded fuel is necessary to affect the converter's performance, and whether it can recover even if only unleaded petrol is used afterwards; the best course of action is, therefore, to assume the worst, and to ensure that NO leaded petrol is used at any time.*

b) *Always keep the ignition and fuel systems well-maintained in accordance with the manufacturer's schedule (Chapter 1) - particularly, ensure that the air filter element, the fuel filter and the spark plugs are renewed at the correct intervals. If the inlet air/fuel mixture is allowed to become too rich due to neglect, the unburned surplus will enter and burn in the catalytic converter, overheating the element and eventually destroying the converter.*

c) *If the engine develops a misfire, do not drive the vehicle at all or at least as little as possible) until the fault is cured - the misfire will allow unburned fuel to enter the converter, which will result in its overheating, as noted above. For the same reason, do not persist if the engine refuses to start - either trace the problem and cure it yourself, or have the vehicle checked immediately by a qualified mechanic.*

d) *Avoid allowing the vehicle to run out of petrol.*

e) *DO NOT push- or tow-start the vehicle unless no other alternative exists, especially if the engine and exhaust are at normal operating temperature. Starting the engine in this way may soak the catalytic converter in unburned fuel, causing it to overheat when the engine does start - see (b) above.*

f) *DO NOT switch off the ignition at high engine speeds; in particular, do not "blip" the throttle immediately before switching off. If the ignition is switched off at anything above idle speed, unburned fuel will enter the (very hot) catalytic converter, with the possible risk of its igniting on the element and damaging the converter.*

g) *Avoid repeated successive cold starts followed by short journeys. If the converter is never allowed to reach its proper working temperature, it will gather unburned fuel, allowing some to pass into the atmosphere and the rest to soak in the element, causing it to overheat when a long journey is made - see (b) above.*

h) *DO NOT use fuel or engine oil additives - these may contain substances harmful to the catalytic converter. Similarly, DO NOT use silicone-based sealants on any part of the engine or fuel system, and do not use exhaust sealants on any part of the exhaust system upstream of the catalytic converter. Even if the sealant itself does not contain additives harmful to the converter, pieces of it may break off and foul the element, causing local overheating.*

i) *DO NOT continue to use the vehicle if the engine burns oil to the extent of leaving a visible trail of blue smoke. Unburned carbon deposits will clog the converter passages and reduce its efficiency; in severe cases, the element will overheat.*

j) *Remember that the catalytic converter operates at very high temperatures - hence the heat shields on the vehicle underbody - and the casing will become hot enough to ignite combustible materials which brush against it. DO NOT, therefore, park the vehicle in dry undergrowth, over long grass or piles of dead leaves.*

k) *Remember that the catalytic converter is FRAGILE. Do not strike it with tools during servicing work, and take great care when working on the exhaust system (see Chapter 4). Ensure that the converter is well clear of any jacks or other lifting gear used to raise the vehicle. Do not drive the vehicle over rough ground, road humps, etc, in such a way as to "ground" the exhaust system.*

l) *In some cases, particularly when the vehicle is new and/or is used for stop/start driving, a sulphurous smell (like that of rotten eggs) may be noticed from the exhaust. This is common to many catalytic converter-equipped vehicles, and seems to be due to the small amount of sulphur found in some petrols reacting with hydrogen in the exhaust, to produce hydrogen sulphide (H_2S) gas; while this gas is toxic, it is not produced in sufficient amounts to be a problem. Once the vehicle has covered a few thousand miles, the problem should disappear - in the meanwhile, a change of driving style, or of the brand of petrol used, may effect a solution.*

m) *The catalytic converter on a well-maintained and well-driven vehicle should last for between 50 000 and 100 000 miles. From this point on, careful checks should be made at regular intervals to ensure that the converter is still operating efficiently. If the converter is no longer effective, it must be renewed.*

Checking

7 Checking the operation of a catalytic converter requires expensive and sophisticated diagnostic equipment, starting with a high-quality exhaust gas analyser. If the level of CO in the exhaust gases is too high, a full check of the engine management system must be carried out (see Section 3 of this Chapter) to eliminate all other possibilities before the converter is suspected of being faulty.

8 The vehicle should be taken to a Ford dealer for this work to be carried out using the correct diagnostic equipment; do not waste time trying to test the system without such facilities.

Component renewal

9 The catalytic converter is part of the exhaust system - see Chapter 4 for details of removal and refitting.