Chapter 4 Part B: Fuel and exhaust systems – diesel engines

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

System type	
All engines	Bosch EDC 16C9 high-pressure direct injection 'common-rail' system, electronically controlled
Fuel system data	
Firing order	1–3–4–2 (No 1 at timing belt end of engine)
Fuel system operating pressure	1600 bar at 2200 rpm
Idle speed	Controlled by ECM
Maximum speed	Controlled by ECM
High-pressure fuel pump:	
Type	Bosch CP1H
Fuel supply pump:	
Type	Electric, mounted in fuel tank
Delivery pressure	3.3 bar (maximum)
Injectors:	
Type	Bosch CRIP 1-MI
Injection holes (per injector)	6
Resistance	0.255 ± 0.04 ohms

Torque wrench settings

	Nm	lbf ft
Alternator and high-pressure fuel pump bracket bolts	25	18
Camshaft sensor retaining bolt(s)	9	7
Catalytic converter clamp bolt	20	15
Crankshaft sensor retaining bolt	9	7
EGR valve pipe to exhaust manifold	25	18
Exhaust manifold nuts*	20	15
Exhaust front pipe-to-catalytic converter nuts*	20	15
Fuel injector clamp bracket nuts	25	18
Fuel pressure regulator to fuel rail	60	44
Fuel pressure sensor to fuel rail	70	52
Fuel rail retaining nuts/bolts	25	18
High-pressure fuel pipe unions:		
M12 union nuts	25	18
M14 union nuts	30	22
High-pressure fuel pump mounting bolts	25	18
Intake air sensor retaining bolt	9	7
Intake manifold nuts	25	18
Injector clamp bracket nut	32	24
Throttle body/housing bolts	9	7
Turbocharger oil return pipe bolts:		
M6 bolts	9	7
M8 bolts	25	18
Turbocharger oil supply pipe banjo union bolt	15	11

* *Do not re-use*

1 General information and precautions

1 These engines are fitted with a high-pressure direct injection system that incorporates the very latest in diesel injection technology. On this system, a high-pressure fuel pump is used purely to provide the pressure required for the injection system and has no control over the injection timing (unlike conventional diesel injection systems). The injection timing is controlled by the electronic control module (ECM), via the electrically-operated injectors. The system operates as follows.

2 The fuel system consists of a fuel tank (which is mounted under the rear of the car, with an electric fuel supply pump immersed in it), a fuel filter with integral water separator, a high-pressure fuel pump, injectors and associated components.

3 Fuel is supplied to the fuel filter housing which is located in the engine compartment. The fuel filter removes all foreign matter and water, and ensures that the fuel supplied to the pump is clean. Excess fuel is returned from the outlet on the filter housing lid to the tank via the fuel cooler. The fuel cooler is fitted to the underside of the vehicle and is cooled by the passing airflow to ensure the fuel is cool before it enters the fuel tank.

4 The fuel is heated to ensure no problems occur when the ambient temperature is very low. This is achieved by an electrically-operated fuel heater incorporated in the filter housing; the heater is controlled by the ECM.

5 The high-pressure fuel pump is driven at half crankshaft speed by the timing belt. The high pressure required in the system (up to 1600 bar) is produced by the three pistons in the pump. The high-pressure pump supplies high-pressure fuel to the fuel rail, which acts as a reservoir for the four injectors. Since the pump has no control over the injection timing (unlike conventional diesel injection systems), this means that there is no need to time the pump when installing the timing belt.

6 The electrical control system consists of the ECM, along with the following sensors:

a) ***Accelerator pedal position sensor*** – *informs the ECM of the accelerator pedal position, and the rate of throttle opening/closing.*

b) ***Coolant temperature sensor*** – *informs the ECM of engine temperature.*

c) ***Airflow meter*** – *informs the ECM of the amount of air passing through the intake duct.*

d) ***Crankshaft sensor*** – *informs the ECM of the crankshaft position and speed of rotation.*

e) ***Camshaft sensor*** – *informs the ECM of the positions of the pistons.*

f) ***Intake air sensor*** – *informs ECM of the intake air temperature and (boost) pressure in the intake manifold.*

g) ***Fuel pressure sensor*** – *informs the ECM of the fuel pressure present in the fuel rail.*

h) ***ABS control unit*** – *informs the ECM of the vehicle speed.*

i) ***Particle trap sensor*** – *measures the differential pressure across the particulate filter, and informs the ECM when the filter is full.*

j) ***Exhaust temperature sensor*** – *informs the ECM of the exhaust gas temperature before and after the catalytic converters.*

7 All the above signals are analysed by the ECM, which selects the fuelling response appropriate to those values. The ECM controls the fuel injectors (varying the pulse width – the length of time the injectors are held open – to provide a richer or weaker mixture, as appropriate). The mixture is constantly varied by the ECM to provide the best setting for cranking, idle (with either a hot or cold engine), warm-up, cruising and acceleration.

8 The ECM also has full control over the fuel pressure present in the fuel rail via the high-pressure fuel regulator and third piston deactivator solenoid valve, which are fitted to the high-pressure pump. To reduce the pressure, the ECM opens the high-pressure fuel regulator, which allows the excess fuel to return direct to the tank from the pump. The third piston deactivator is used mainly to reduce the noise of the engine, but can also be used to lower the fuel pressure. The deactivator solenoid valve relieves the fuel pressure from the third piston of the pump, which results in only two of the pistons pressurising the fuel system.

9 The ECM also controls the exhaust gas recirculation (EGR) system, described in detail in Part C of this Chapter, the pre/post-heating system (see Chapter 5A), and the engine cooling fan.

10 The intake manifold is fitted with a butterfly valve arrangement to improve efficiency at low engine speeds. Each cylinder has two inlet tracts in the manifold, one of which is fitted with a valve; the operation of the valve is controlled by the ECM via an electric motor and drive arrangement. At low engine speeds (below approximately 1500 rpm) the valves remain closed, meaning that air entering each cylinder is passing through only one of the manifold tracts. At higher engine speeds the ECM opens up each of the four valves allowing the air passing through the manifold to flow through both intake tracts.

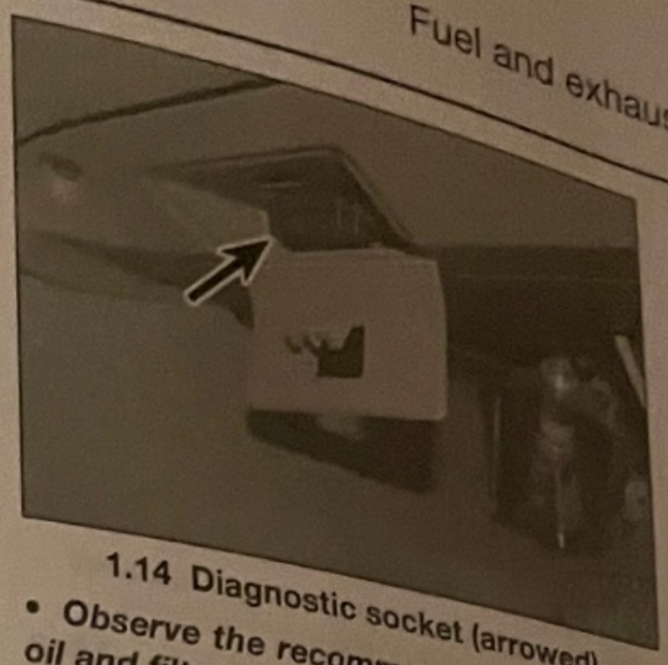
11 A variable-vane turbocharger is fitted to increase engine efficiency. It does this by raising the pressure in the intake manifold above atmospheric pressure. Instead of the air simply being sucked into the cylinders

it is forced in. Note that the turbocharger is integral with the exhaust manifold.

12 Between the turbocharger and the intake manifold, the compressed air passes through an intercooler. This is an air-to-air heat exchanger mounted next to the radiator, and supplied with cooling air from the front of the vehicle. The purpose of the intercooler is to remove some of the heat gained in being compressed from the intake air. Because cooler air is denser, removal of this heat further increases engine efficiency.

13 Energy for the operation of the turbocharger comes from the exhaust gas. The gas flows through a specially-shaped housing (the turbine housing) and in so doing, spins the turbine wheel. The turbine wheel is attached to a shaft, at the end of which is another vaned wheel known as the compressor wheel. The compressor wheel spins in its own housing, and compresses the intake air on the way to the intake manifold. The turbo shaft is pressure-lubricated by an oil feed pipe from the main oil gallery. The shaft 'floats' on a cushion of oil. A drain pipe returns the oil to the sump. Boost pressure (the pressure in the intake manifold) is limited by a wastegate, which diverts the exhaust gas away from the turbine wheel in response to a pressure-sensitive actuator.

14 If certain sensors fail, and send abnormal signals to the ECM, the ECM has a back-up programme. In this event, the abnormal signals are ignored, and a pre-programmed value is substituted for the sensor signal, allowing the engine to continue running, albeit at reduced efficiency. If the ECM enters its back-up mode, a warning light on the instrument panel will illuminate, and a fault code will be stored in the ECM memory. This fault code can be read using suitable specialist test equipment plugged into the system's diagnostic socket. The diagnostic socket is located beneath the driver's side of the facia, above the pedals (see illustration).



1.14 Diagnostic socket (arrowed)

⚠ *Warning: It is necessary to take certain precautions when working on the fuel system components, particularly the high-pressure side of the system. Before carrying out any operations on the fuel system, refer to the precautions given in 'Safety first!' at the beginning of this manual, and to any additional warning notes at the start of the relevant Sections. Also refer to the additional information contained in Section 2.*

- ***Do not operate the engine if any of air intake ducts are disconnected or the filter element is removed. Any debris entering the engine will cause severe damage to the turbocharger.***
- ***To prevent damage to the turbocharger, do not race the engine immediately after start-up, especially if it is cold. Allow it to idle smoothly to give the oil a few seconds to circulate around the turbocharger bearings. Always allow the engine to return to idle speed before switching it off – do not blip the throttle and switch off, as this will leave the turbo spinning without lubrication.***
- **Observe the recommended intervals for oil and filter changing, and use a reputable oil of the specified quality. Neglect of oil changing, or use of inferior oil, can cause carbon formation on the turbo shaft, leading to subsequent failure.**

2 High-pressure diesel injection system – special information

Warnings and precautions

1 It is essential to observe strict precautions when working on the fuel system components, particularly the high pressure side of the system. Before carrying out any operations on the fuel system, refer to the precautions given in *Safety first!* at the beginning of this manual, and to the following additional information.

- Do not carry out any repair work on the high-pressure fuel system unless you are competent to do so, have all the necessary tools and equipment required, and are aware of the safety implications involved.
- Before starting any repair work on the fuel system, wait at least 30 seconds after switching off the engine to allow the fuel circuit to return to atmospheric pressure.
- Never work on the high-pressure fuel system with the engine running.
- Keep well clear of any possible source of fuel leakage, particularly when starting the engine after carrying out repair work. A leak in the system could cause an extremely high-pressure jet of fuel to escape, which could result in severe personal injury.
- Never place your hands or any part of your body near to a leak in the high-pressure fuel system.
- Do not use steam cleaning equipment or compressed air to clean the engine or any of the fuel system components.

Repair procedures and general information

2 Strict cleanliness must be observed at all times when working on any part of the fuel system. This applies to the working area in general, the person doing the work, and the components being worked on.

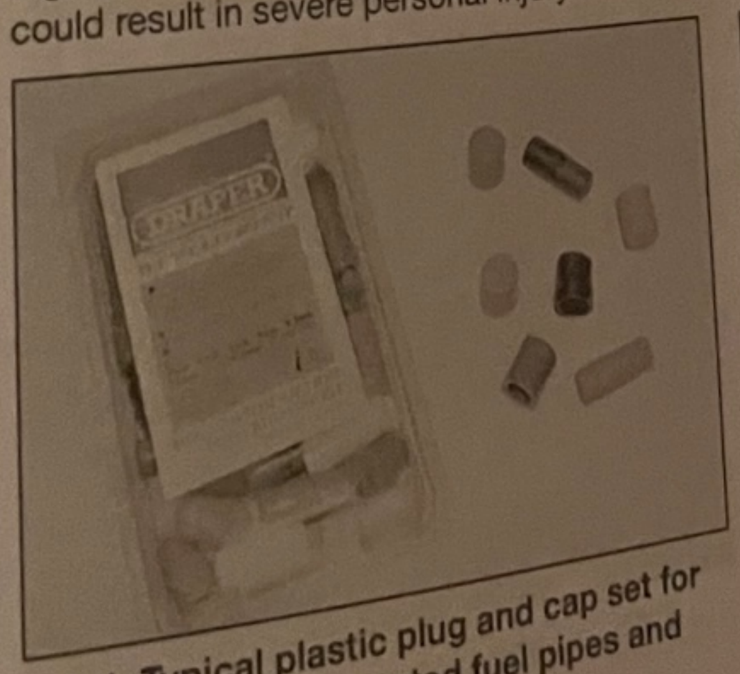
3 Before working on the fuel system components, they must be thoroughly cleaned with a suitable degreasing fluid. Cleanliness is particularly important when working on the fuel system connections at the following components:

a) *Fuel filter.*
b) *High-pressure fuel pump.*
c) *Fuel rail.*
d) *Fuel injectors.*
e) *High-pressure fuel pipes.*

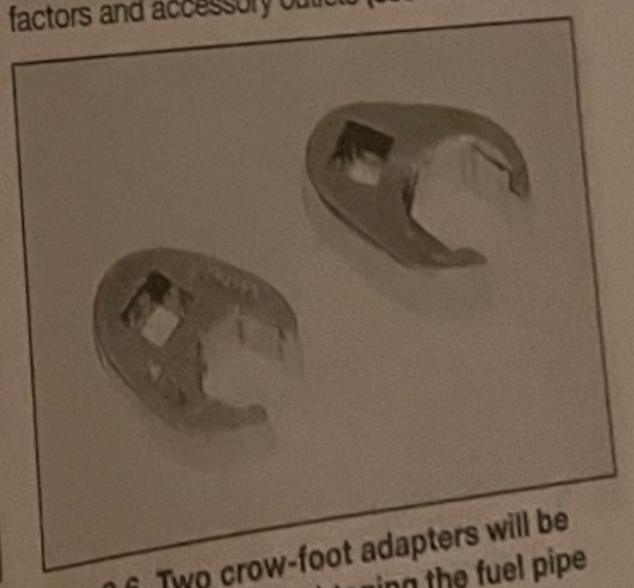
4 After disconnecting any fuel pipes or components, the open union or orifice must be immediately sealed to prevent the entry of dirt or foreign material. Plastic plugs and caps in various sizes are available in packs from motor factors and accessory outlets, and are particularly suitable for this application (see illustration). Fingers cut from disposable rubber gloves should be used to protect components such as fuel pipes, fuel injectors and wiring connectors, and can be secured in place using elastic bands. Suitable gloves of this type are available at no cost from most petrol station forecourts.

5 Whenever any of the high-pressure fuel pipes are disconnected or removed, a new pipe(s) must be obtained for refitting.

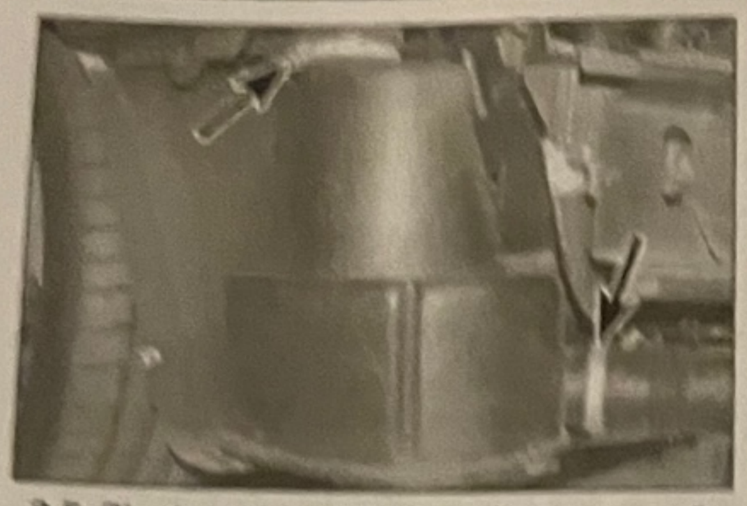
6 The torque wrench settings given in the Specifications must be strictly observed when tightening component mountings and connections. This is particularly important when tightening the high-pressure fuel pipe unions. To enable a torque wrench to be used on the fuel pipe unions, two crow-foot adapters are required. Suitable types are available from motor factors and accessory outlets (see illustration).



2.4 Typical plastic plug and cap set for sealing disconnected fuel pipes and components



2.6 Two crow-foot adapters will be necessary for tightening the fuel pipe unions



3.5 Slacken the retaining clips (arrowed) and disconnect the intake pipes

3 Air cleaner assembly – removal and refitting

Removal

1 Remove the front grille (see Chapter 11).
2 Remove the right-hand headlight unit as described in Chapter 12.
3 Slacken the retaining clip, and disconnect the intake pipe from the top of the air cleaner assembly **(see illustration 3.5)**.
4 Apply the handbrake, then jack up the front of the car and support on axle stands (see *Jacking and vehicle support*). Remove the right-hand front wheel, undo the retaining screws and remove the wheel arch liner.
5 From under the vehicle, slacken the retaining clip, and disconnect the intake pipe from the bottom of the air cleaner assembly **(see illustration)**.
6 Unscrew the lower mounting nuts **(see illustration)**, and lower the air cleaner assembly from under the inner wing. **Note:** *It may be necessary to remove a couple of retaining screws from the right-hand side of the front bumper to allow removal of the air cleaner assembly.*
7 If required, undo the retaining bolt(s) and remove the bracket for the air intake pipe **(see illustration)**, then withdraw the air intake pipe from across the front of the radiator.

⚠ ***Warning: Do not run the engine with the air cleaner housing and/or ducting removed – the depression at the turbocharger intake may increase very suddenly if the engine speed is raised above idle.***

3.6 Remove the lower mounting nuts (arrowed) and withdraw the air cleaner housing

Refitting

8 Refitting is a reversal of the removal procedure. **Note:** *Make sure the peg at the top of the air cleaner assembly, locates in the hole in the inner wing panel.*

4 Accelerator pedal/ position sensor – removal and refitting

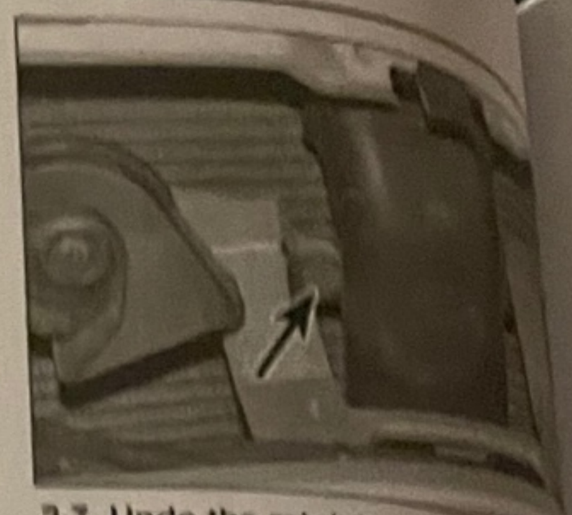
Refer to Chapter 4A, Section 4.

5 Fuel system – priming and bleeding

1 After disconnecting the fuel supply system or running out of fuel, it is necessary to prime the fuel system and bleed off any air, which may have entered the system components, as follows.
2 Operate the fuel supply pump by switching on the ignition three times for approximately 15 seconds. The engine should now start. If it doesn't, wait a few minutes and repeat the procedure.

6 Fuel gauge sender unit – removal and refitting

On all models, the fuel gauge sender unit is integral with the fuel pump and can only be



3.7 Undo the retaining bolt (arrowed) and withdraw the air intake pipe

purchased as a complete assembly. Refer to Chapter 4A, Section 9, for fuel pump removal and refitting.

7 Fuel pump – removal and refitting

The diesel fuel supply pump is located in the same position as the fuel pump on petrol engine models, and the removal and refitting procedures are virtually identical **(see illustrations)**. Refer to Chapter 4A, Section 9. On completion, bleed the fuel system as described in Section 5.

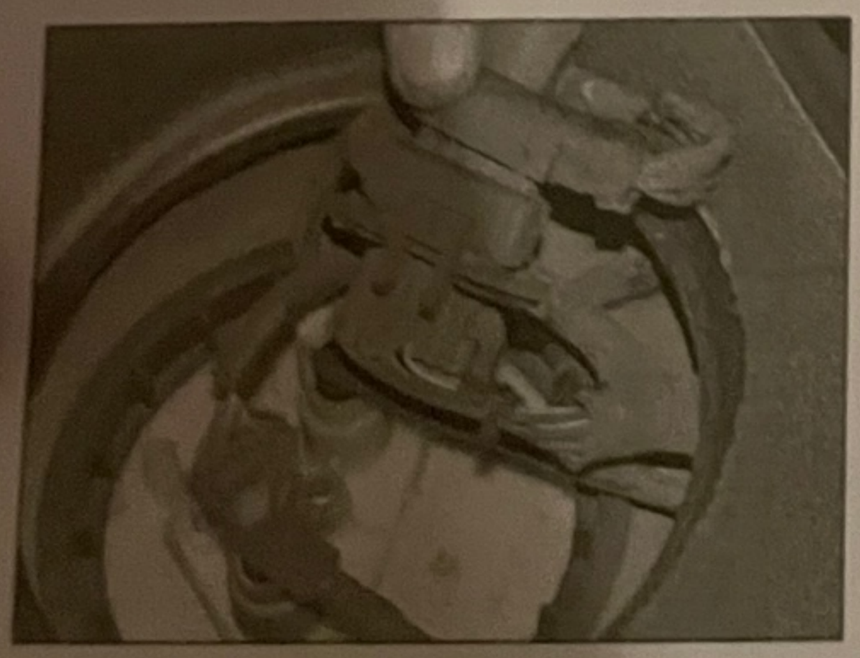
8 Fuel tank – removal and refitting

Refer to Chapter 4A, Section 12. On completion, bleed the fuel system as described in Section 5.

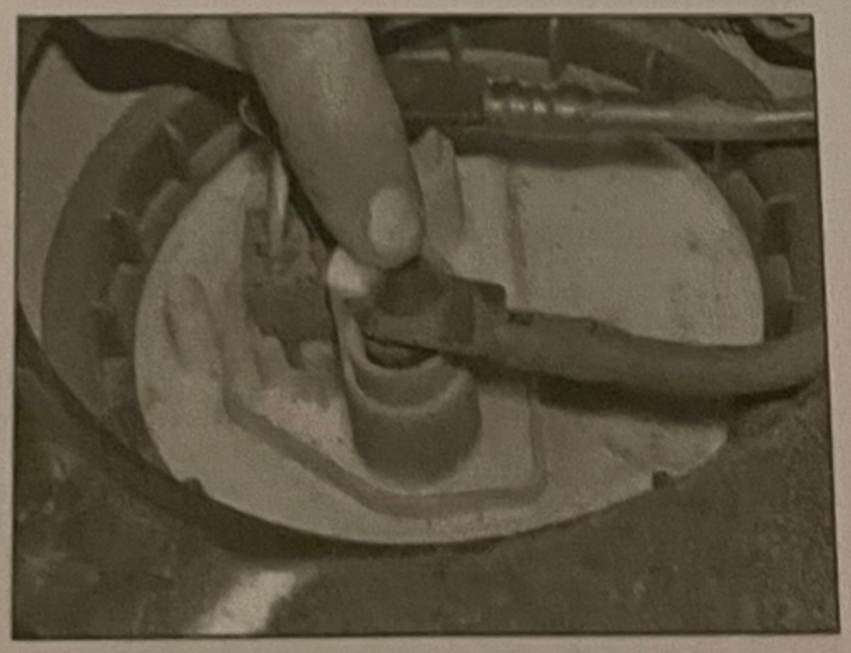
9 Injection system electrical components – removal and refitting

Airflow meter

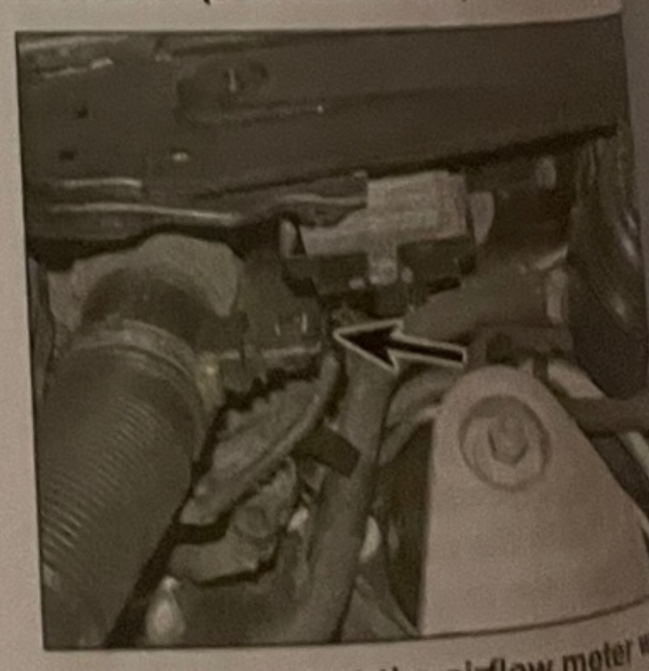
1 Slacken the retaining clip securing the intake duct to the airflow meter and disconnect the duct.
2 Disconnect the airflow meter wiring connector **(see illustration)**.



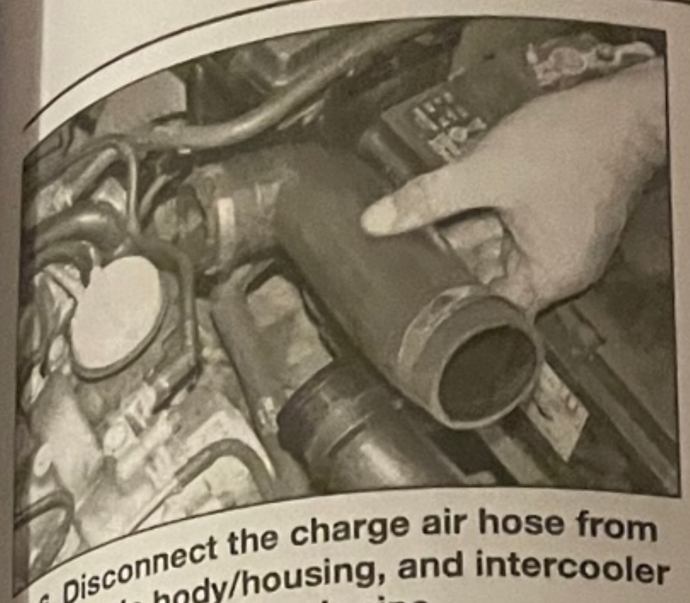
7.1a Disconnect the wiring connector . . .



7.1b . . . and release the fuel pipes



9.2 Disconnect the airflow meter wiring connector



9.6 Disconnect the charge air hose from the throttle body/housing, and intercooler charge air pipe

3 Slacken the retaining clip and remove the airflow meter from the air cleaner housing lid.
4 Refitting is a reversal of removal, but ensure that the arrow on the airflow meter points toward the throttle body/housing when fitted.

Throttle body/housing

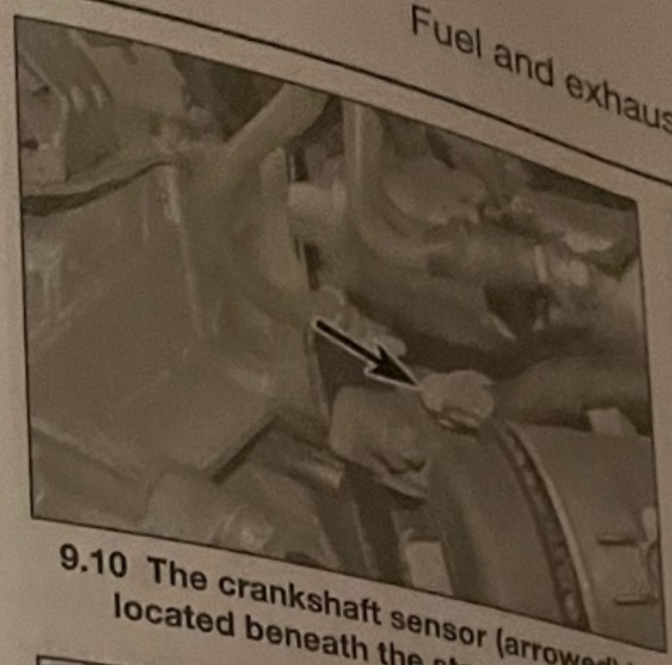
5 Remove the plastic cover from the top of the engine.
6 Release the retaining clip and disconnect the charge air hose from the throttle body/housing **(see illustration)**.
7 Disconnect the throttle body wiring plug.
8 Undo the three retaining bolts and remove the throttle body/housing from the intake manifold. Note the location of any wiring harness support brackets also secured by the retaining bolts.
9 Refitting is a reversal of removal, but thoroughly clean the mating faces and use a new gasket/seal. Tighten the retaining bolts to the specified torque.

Crankshaft sensor

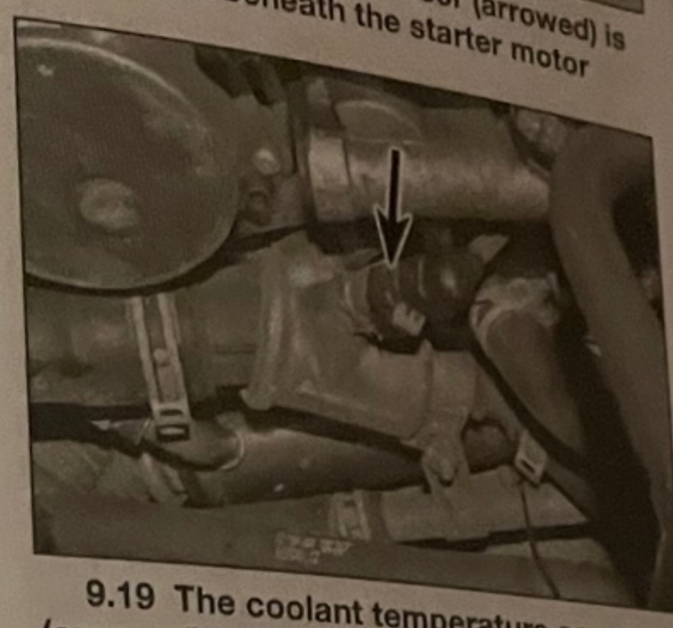
10 The sensor is located at the rear of the cylinder block, below the starter motor **(see illustration)**. To gain access, firmly apply the handbrake, and then jack up the front of the car and support it securely on axle stands (see *Jacking and vehicle support*).
11 Undo the retaining bolts and remove the undershield from beneath the engine/transmission unit.
12 Wipe clean the area around the crankshaft sensor then disconnect the wiring connector.
13 Slacken and remove the retaining bolt and remove the sensor from the cylinder block. Recover the sealing ring.
14 Refitting is the reverse of removal, using a new sealing ring. Tighten the sensor retaining bolt to the specified torque.

Camshaft sensor

15 The camshaft sensor is located at the right-hand end of the camshaft housing **(see illustration)**. To gain access, remove the plastic cover from the top of the engine.
16 Wipe the area clean around the camshaft sensor, and then disconnect the wiring connector.



9.10 The crankshaft sensor (arrowed) is located beneath the starter motor



9.19 The coolant temperature sensor (arrowed) is located at the left-hand end of the cylinder head

17 Slacken and remove the retaining bolt and remove the sensor from the camshaft cover. Recover the sealing ring.
18 Refitting is the reverse of removal, using a new sealing ring. Tighten the sensor retaining bolt to the specified torque.

Coolant temperature sensor

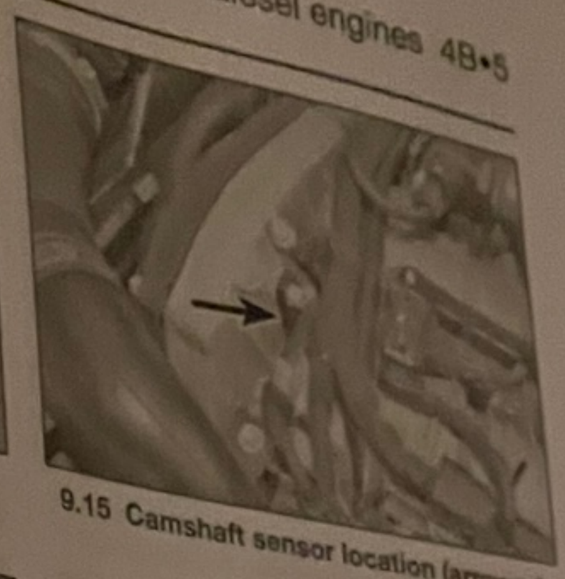
19 The coolant temperature sensor is located on the thermostat housing on the left-hand end of the cylinder head. Partially drain the cooling system, disconnect the wiring plug and unscrew the sensor **(see illustration)**.
20 Refitting is a reversal of removal. Top-up the cooling system as described in Chapter 1B.

Intake air pressure/ temperature sensor

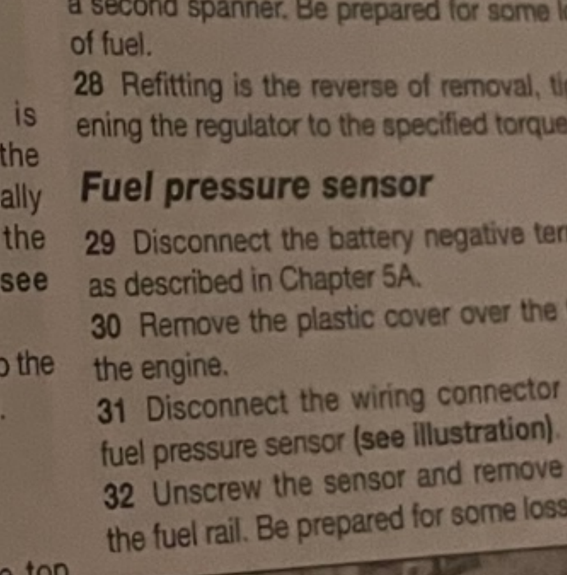
21 Remove the plastic cover from the top of the engine, then disconnect the wiring connector from the charge pressure sensor located in the centre of the intake manifold **(see illustration)**.
22 Slacken and remove the retaining bolt and remove the sensor from the manifold. Recover the sealing ring.
23 Refitting is the reverse of removal, using a new sealing ring. Tighten the sensor retaining bolt to the specified torque.

Fuel pressure regulator

24 Disconnect the battery negative terminal as described in Chapter 5A.
25 Remove the plastic cover over the top of the engine.



9.15 Camshaft sensor location (arrowed)

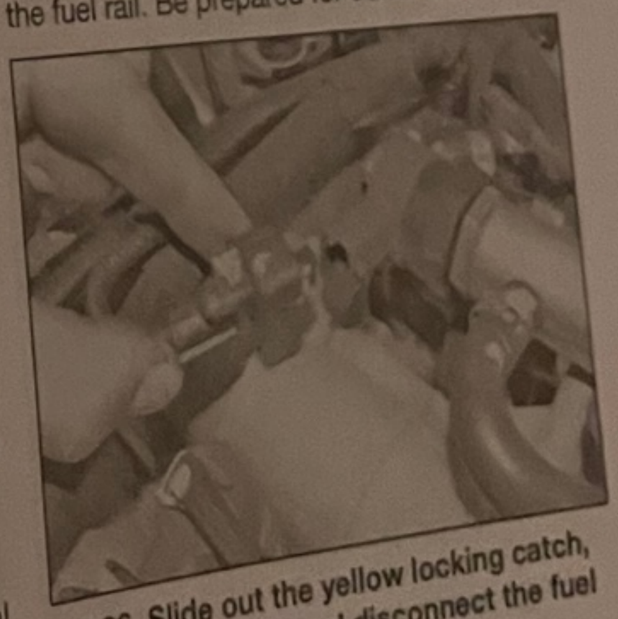


9.21 Disconnect the charge air pressure sensor wiring plug (arrowed)

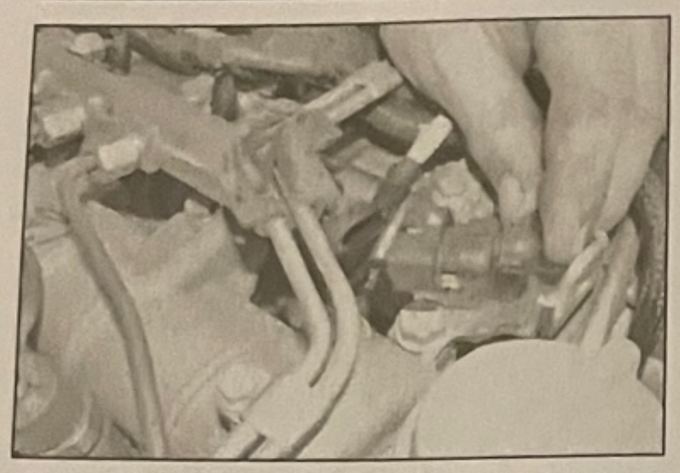
26 Disconnect the wiring connector from the fuel pressure regulator **(see illustration)**.
27 Remove the regulator from the fuel rail by unscrewing the inner nut (nearest the fuel rail) while counter-holding the regulator body with a second spanner. Be prepared for some loss of fuel.
28 Refitting is the reverse of removal, tightening the regulator to the specified torque.

Fuel pressure sensor

29 Disconnect the battery negative terminal as described in Chapter 5A.
30 Remove the plastic cover over the top of the engine.
31 Disconnect the wiring connector at the fuel pressure sensor **(see illustration)**.
32 Unscrew the sensor and remove it from the fuel rail. Be prepared for some loss of fuel.



9.26 Slide out the yellow locking catch, depress the clip and disconnect the fuel pressure regulator wiring plug



9.31 Disconnect the fuel pressure sensor wiring plug

33 Refitting is the reverse of removal, tightening the sensor to the specified torque.

Electronic control module (ECM)

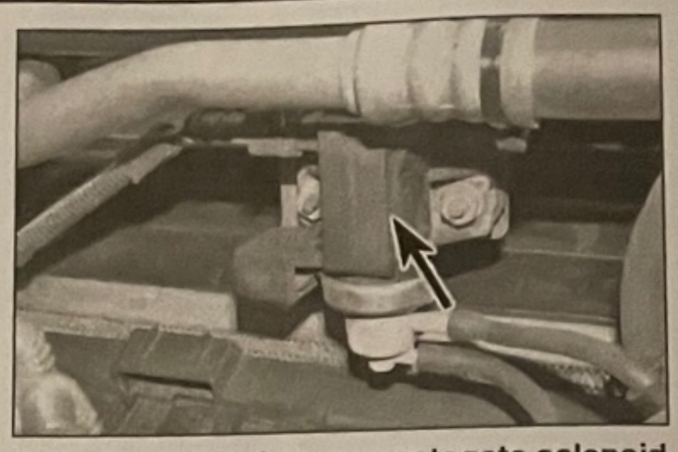
Note: *If a new ECM is to be fitted, this work must be entrusted to a Saab dealer or suitably-equipped specialist, as it is necessary to programme the new ECM after installation. This work requires the use of dedicated Saab diagnostic equipment or a compatible alternative.*

34 On all models, the electronic control module (ECM) is located in the same position. Refer to Chapter 4A, Section 14, for the electronic control module removal and refitting.

Turbocharger wastegate solenoid

35 The wastegate (charge pressure) solenoid valve is located at the front of the engine compartment **(see illustration)**.

36 Disconnect the wiring connector and the



9.35 The turbocharger wastegate solenoid is located at the front of the engine compartment

two vacuum hoses from the valve then undo the retaining nuts and remove the valve from its mounting bracket.

37 Refitting is the reverse of removal.

10 High-pressure fuel pump – removal and refitting

Warning: Refer to the information contained in Section 2 before proceeding.

Note: *A new fuel pump-to-fuel rail high-pressure fuel pipe will be required for refitting.*

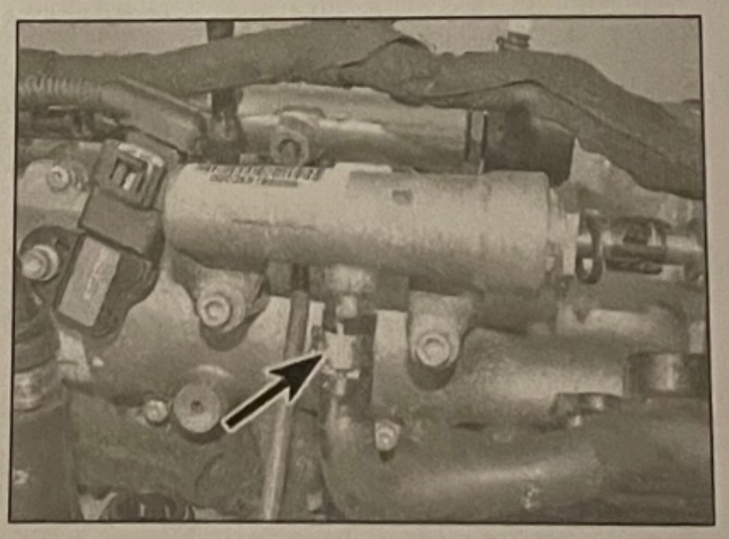
Removal

1 Disconnect the battery negative terminal as described in Chapter 5A.

2 Remove the plastic cover over the top of the engine.

3 Remove the timing belt and the high-

10.4a Release the clips and disconnect the upper (arrowed) . . .



10.4b . . . and lower (arrowed) fuel return hoses at the damping chamber

pressure fuel pump sprocket as described in Chapter 2B.

4 Release the retaining clips and disconnect the two fuel return hoses at the fuel damping chamber **(see illustration)**. Suitably plug or cover the open unions to prevent dirt entry.

5 Disconnect the injector leak-off pipe and fuel return quick-release fitting, then unscrew the two bolts and remove the damping chamber. Suitably plug or cover the open unions to prevent dirt entry.

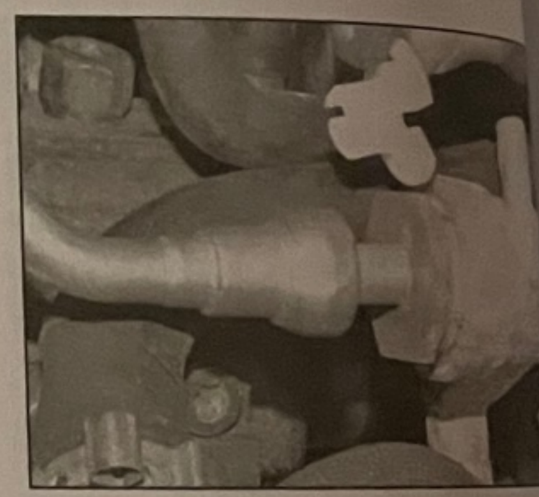
6 Disconnect the fuel supply hose from the quick-release fitting to the high-pressure fuel pump. Suitably plug or cover the open unions to prevent dirt entry **(see illustration)**.

7 Disconnect the wiring connector from the high-pressure fuel pump.

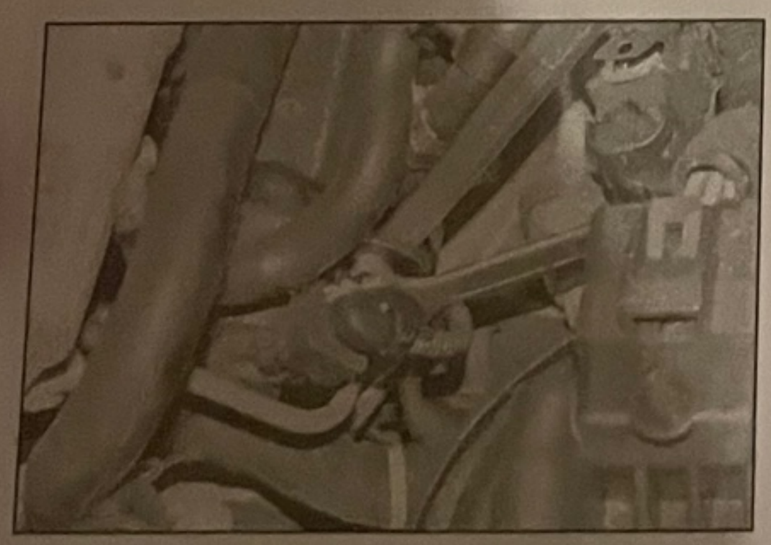
8 Thoroughly clean the fuel pipe unions on the fuel pump and fuel rail. Using an open-ended spanner, unscrew the union nuts securing the high-pressure fuel pipe to the fuel pump and fuel rail. Counter-hold the union on the fuel rail with a second spanner, while unscrewing the union nut **(see illustration)**. Withdraw the high-pressure fuel pipe and plug or cover the open unions to prevent dirt entry.

9 Unscrew the three retaining nuts and remove the pump from the engine bracket **(see illustrations)**.

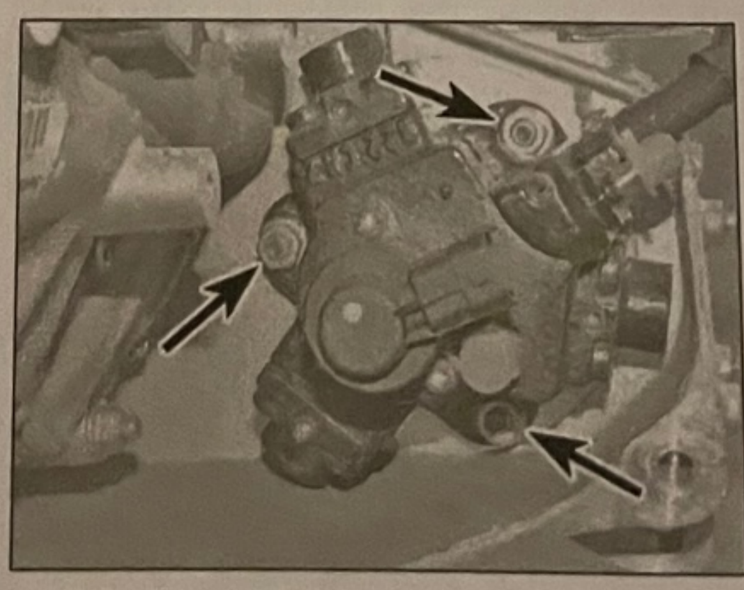
Caution: The high-pressure fuel pump is manufactured to extremely close tolerances and must not be dismantled in any way. No parts for the pump are available separately and if the unit is in any way suspect, it must be renewed.



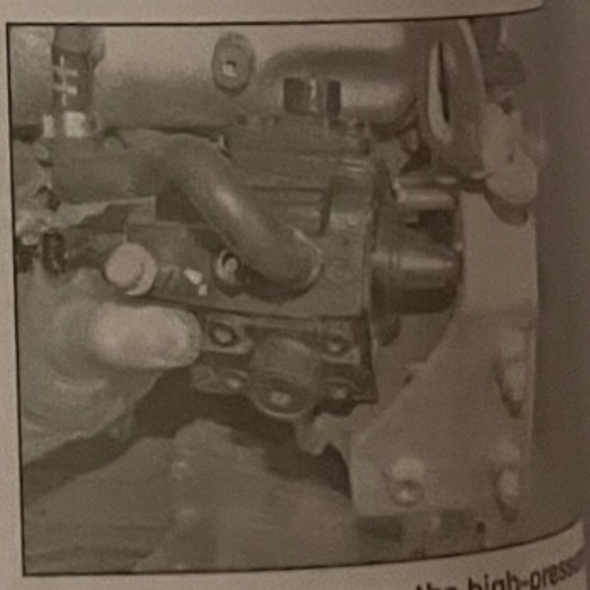
10.6 Insert a generic release tool around the fuel pipe, and push it into the coupling to release the clips and disconnect the pipe



10.8 Unscrew the union nuts securing the high-pressure fuel pipe to the fuel pump and fuel rail



10.9a Unscrew the three retaining nuts (arrowed) . . .



10.9b . . . and remove the high-pressure fuel pump from the engine bracket

Refitting

10 Refit the pump to the engine bracket and tighten the retaining bolts to the specified torque.

11 Remove the blanking plugs from the fuel rail and the unions on the pump and fuel rail. Locate a new high-pressure fuel pipe over the unions and screw on the union nuts finger-tight at this stage.

12 Using a torque wrench and crow-foot adapter, tighten the fuel pipe union nuts to the specified torque. Counter-hold the unions on the pump with an open-ended spanner, while tightening the union nuts.

13 Reconnect the pump wiring connector and the fuel return hose quick-release fitting.

14 Refit the damping chamber and tighten the retaining bolts securely. Reconnect the injector leak-off pipe, and the two remaining fuel return hoses.

15 Refit the high-pressure fuel pump sprocket and the timing belt as described in Chapter 2B.

16 Reconnect the battery negative terminal as described in Chapter 5A.

17 Observing the precautions listed in Section 2, prime the fuel system as described in Section 5, then start the engine and allow it to idle. Check for leaks at the high-pressure fuel pipe unions with the engine idling. If satisfactory, increase the engine speed to 4000 rpm and check again for leaks. Take the car for a short road test and check for leaks once again on return. If any leaks are detected, obtain and fit a new high-pressure fuel pipe.

18 Refit the engine cover on completion.

11 Fuel rail – removal and refitting

Warning: Refer to the information contained in Section 2 before proceeding.

Note: *A complete new set of high-pressure fuel pipes will be required for refitting.*

Removal

1 Disconnect the battery negative terminal as described in Chapter 5A.

2 Remove the plastic cover over the top of the engine.

3 Thoroughly clean all the high-pressure fuel pipe unions on the fuel rail, fuel pump and injectors. Using two spanners, hold the unions and unscrew the union nuts securing the high-pressure fuel pipes to the fuel injectors. Unscrew the union nuts securing the high-pressure fuel pipes to the fuel rail, withdraw the pipes and plug or cover the open unions to prevent dirt entry **(see illustration)**.

4 Using an open-ended spanner, unscrew the union nuts securing the high-pressure fuel pipe to the fuel pump and fuel rail **(see illustration)**. Counter-hold the unions on the pump with a second spanner, while unscrewing the union nuts. Withdraw the high-pressure fuel pipe and plug or cover the open unions to prevent dirt entry.

5 Disconnect the wiring connectors at the fuel pressure regulator and fuel pressure sensor, then release the clip and disconnect the fuel return hose. Undo the two bolts and remove the fuel rail **(see illustrations)**.

Refitting

6 Refit the fuel rail and tighten the retaining bolts to the specified torque. Reconnect the fuel pressure regulator and fuel pressure sensor wiring connectors, and reconnect the fuel return hose.

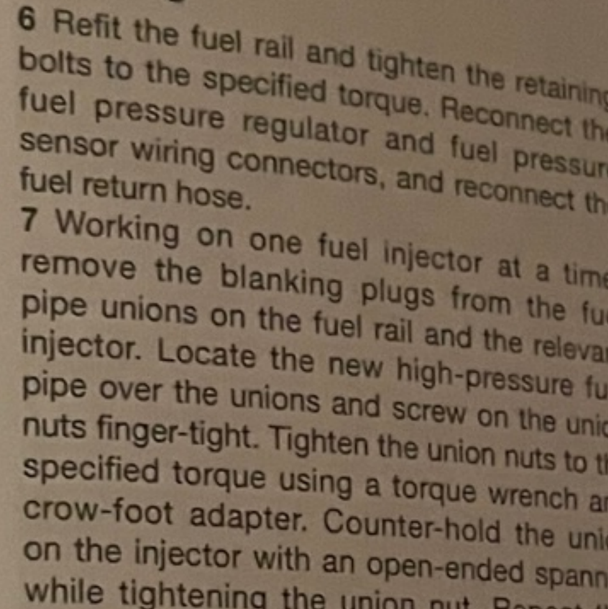
7 Working on one fuel injector at a time, remove the blanking plugs from the fuel pipe unions on the fuel rail and the relevant injector. Locate the new high-pressure fuel pipe over the unions and screw on the union nuts finger-tight. Tighten the union nuts to the specified torque using a torque wrench and crow-foot adapter. Counter-hold the union on the injector with an open-ended spanner, while tightening the union nut. Repeat this operation for the remaining three injectors.

8 Similarly, fit the new high-pressure fuel pipe to the fuel pump and fuel rail, and tighten the union nuts to the specified torque. Counter-hold the union on the pump with an open-ended spanner, while tightening the union nut.

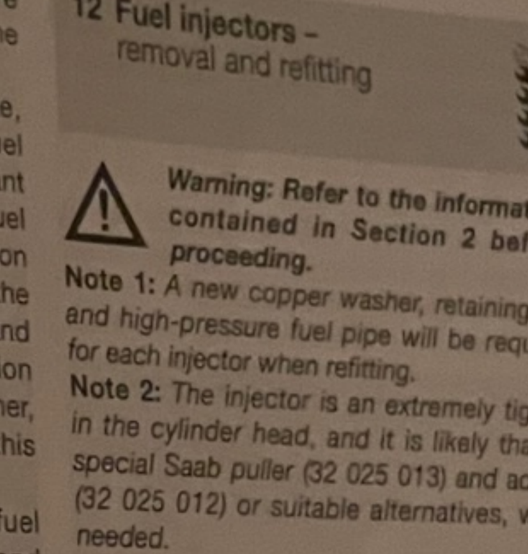
9 Reconnect the battery negative terminal as described in Chapter 5A.

10 Observing the precautions listed in Section 2, prime the fuel system as described in Section 5, then start the engine and allow it to idle. Check for leaks at the high-pressure fuel pipe unions with the engine idling. If satisfactory, increase the engine speed to 4000 rpm and check again for leaks. Take the car for a short road test and check for leaks once again on return. If any leaks are detected, obtain and fit a new high-pressure fuel pipe.

11 Refit the engine cover on completion.



11.3 Unscrew the union nuts securing the high-pressure fuel pipes to the fuel rail and injectors



11.4 Unscrew the union nuts securing the high-pressure fuel pipe to the pump and fuel rail

12 Fuel injectors – removal and refitting

Warning: Refer to the information contained in Section 2 before proceeding.

Note 1: *A new copper washer, retaining nut and high-pressure fuel pipe will be required for each injector when refitting.*

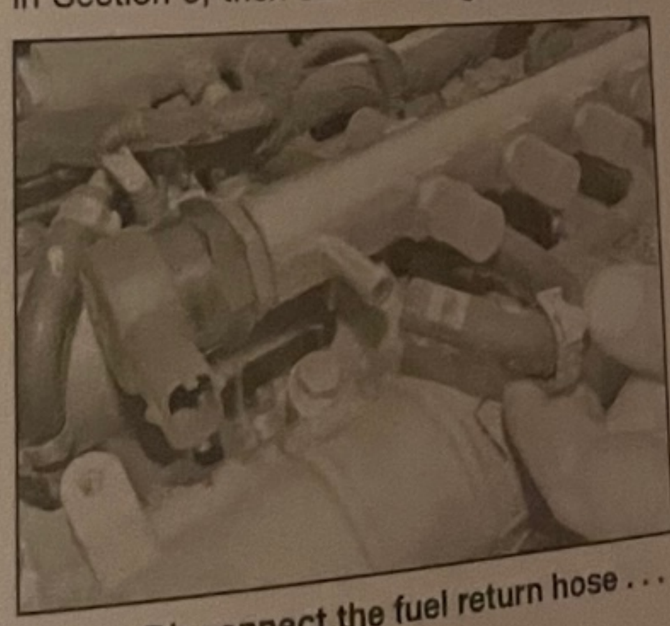
Note 2: *The injector is an extremely tight fit in the cylinder head, and it is likely that the special Saab puller (32 025 013) and adapter (32 025 012) or suitable alternatives, will be needed.*

Removal

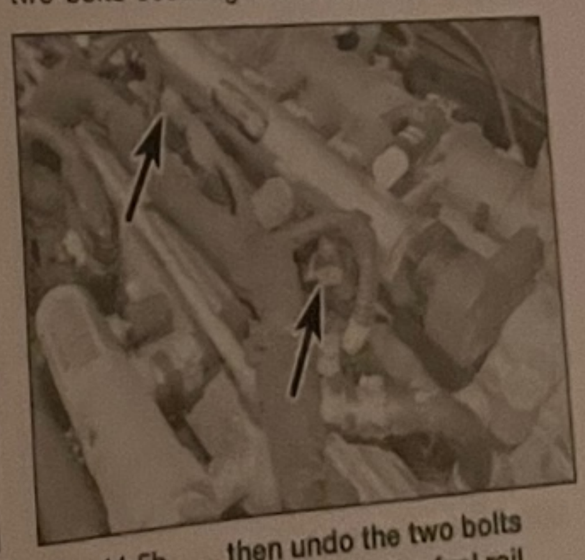
1 Disconnect the battery negative terminal as described in Chapter 5A.

2 Remove the plastic cover over the top of the engine.

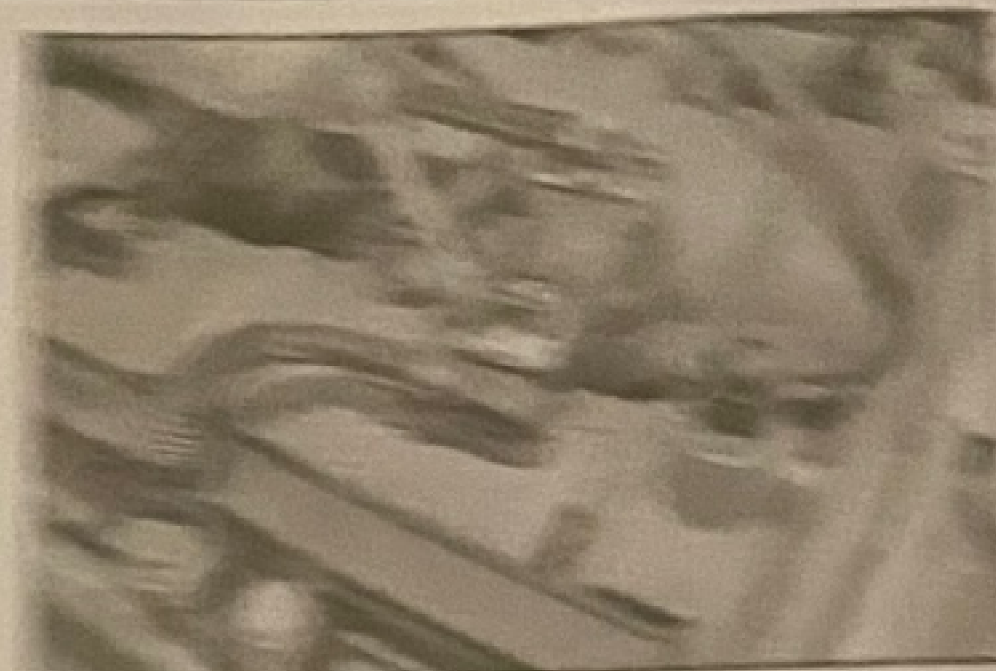
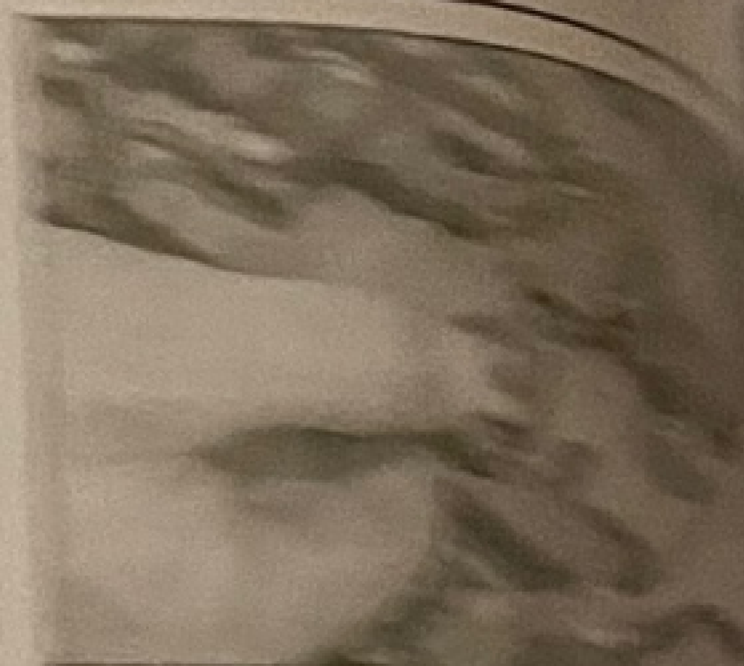
3 Release the retaining clip securing the engine breather hose to the breather pipe adjacent to the engine oil dipstick. Undo the two bolts securing the breather pipe to the



11.5a Disconnect the fuel return hose . . .

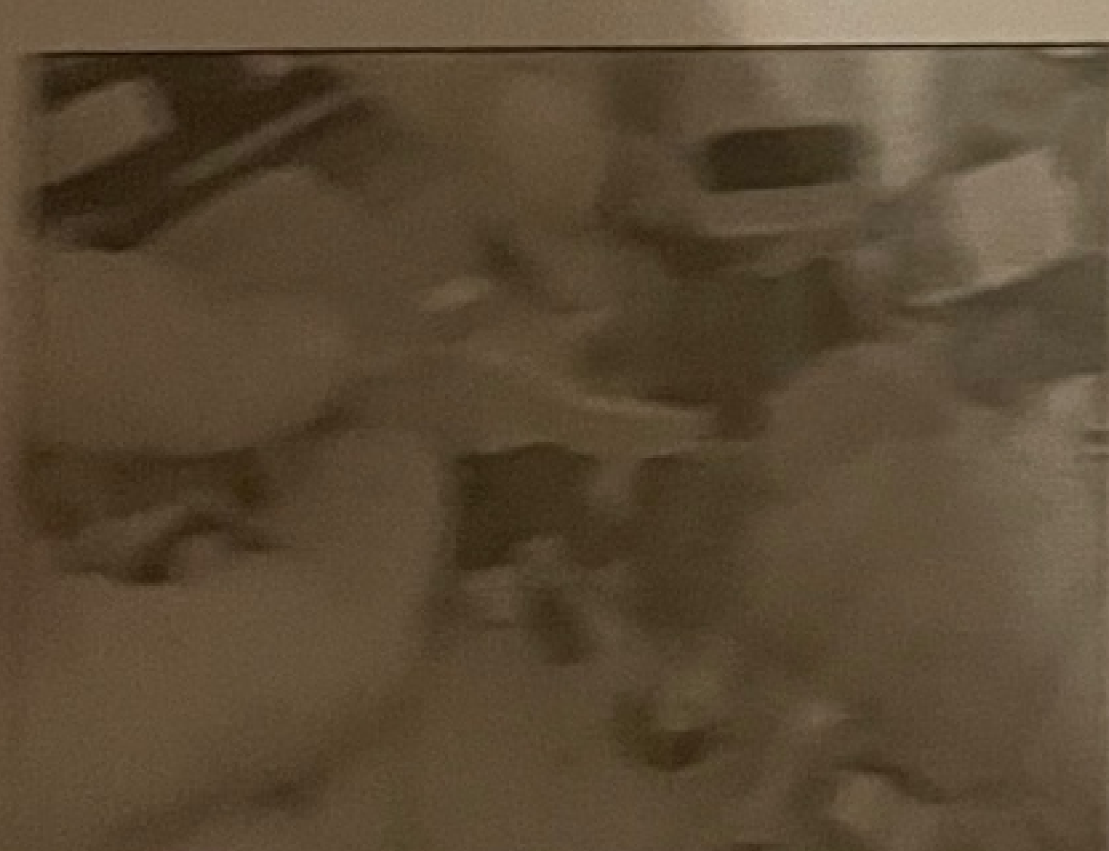
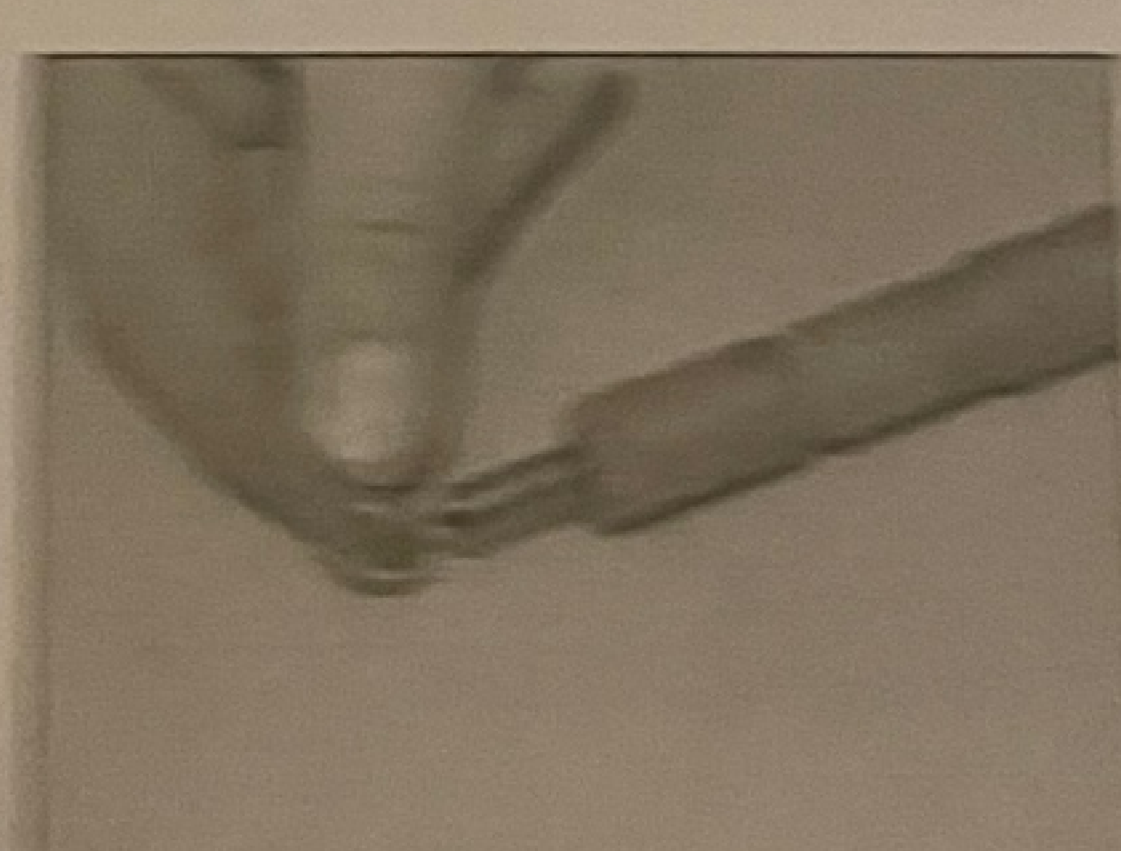


11.5b . . . then undo the two bolts (arrowed) and remove the fuel rail





e clip and disconnect
wiring plugs

injector union when
-pressure fuel pipe
ns

Using two spanners,
screw the union nut
sure fuel pipe to the
ation). Unscrew the
gh-pressure fuel pipe
the pipe and plug or
prevent dirt entry.
No 1, unscrew the
the washer from the
ee illustration).
r together with the
e cylinder head. If
emoving the injector,
oil to the base of the
the oil to penetrate.
ctant to free, it will
mall slide hammer
ge of the injector
y tap it free (see
use Saab special
012 and 83 90 270
t it is not possible
side-to-side to free
he clamp bracket.
s been removed,
racket and remove
injector base (see
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ase of the injector
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g injectors in the

ually for any signs
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the injector.
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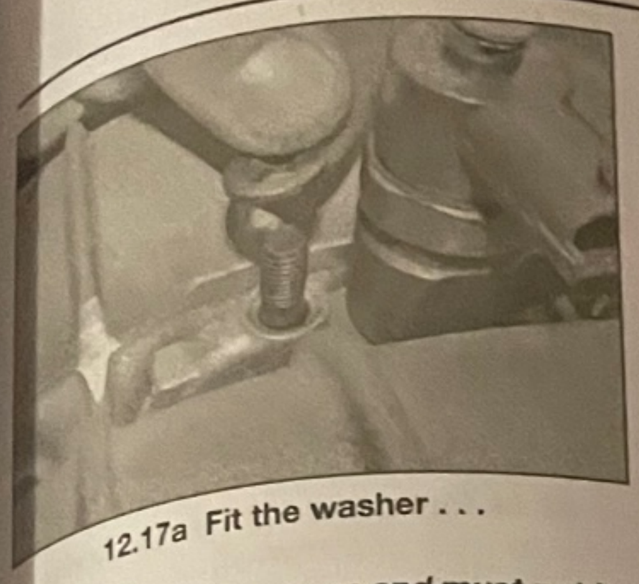
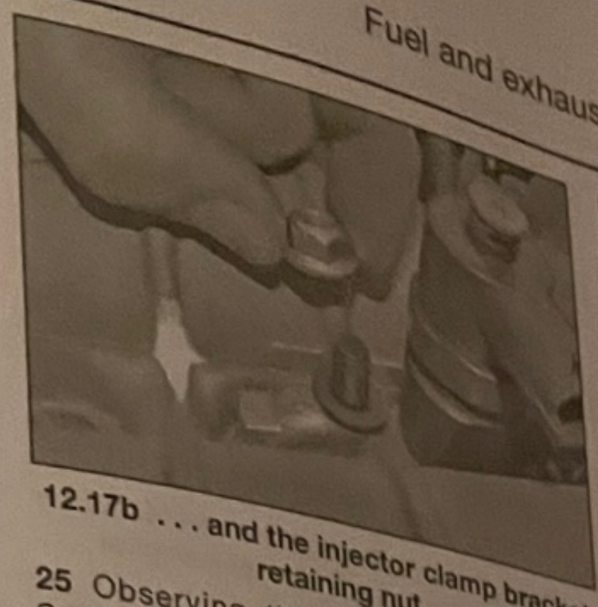
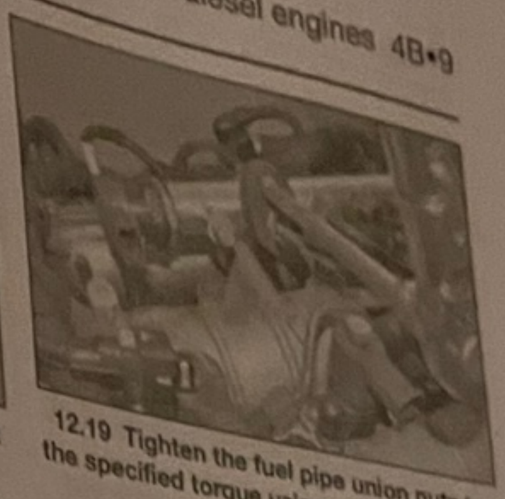


12.17a Fit the washer . . .



12.17b . . . and the injector clamp bracket retaining nut



12.19 Tighten the fuel pipe union nuts to the specified torque using a torque wrench and crow-foot adapter

extremely close tolerances and must not be dismantled in any way. Do not unscrew the fuel pipe union on the side of the injector, or separate any parts of the injector body. Do not attempt to clean carbon deposits from the injector nozzle or carry out any form of ultrasonic or pressure testing.

12 If the injectors are in a satisfactory condition, plug the fuel pipe union (if not already done) and suitably cover the electrical element and the injector nozzle.

13 Prior to refitting, obtain a new set of copper washers, retaining nuts and high-pressure fuel pipes.

Refitting

14 Thoroughly clean the injector seat in the cylinder head, ensuring all traces of carbon and other deposits are removed.

15 Starting with injector No 4, locate a new copper washer on the base of the injector.

16 Place the injector clamp bracket in the slot on the injector body and refit the injector to the cylinder head.

17 Fit the washer and the injector clamp bracket retaining nut and tighten the nut to the specified torque **(see illustrations)**.

18 Remove the blanking plug from the fuel pipe union on the fuel rail and the injector. Locate the new high-pressure fuel pipe over the unions and screw on the union nuts. Take care not to cross-thread the nuts or strain the fuel pipe as it is fitted.

19 Tighten the fuel pipe union nuts to the specified torque using a torque wrench and crow-foot adapter **(see illustration)**. Counter-hold the union on the injector with an open-ended spanner, while tightening the union nut.

20 Repeat this procedure for the remaining injectors.

21 Reconnect the leak-off hose fittings to the injectors by pushing in the locking clip, attaching the fitting, then releasing the locking clip. Ensure that each fitting is securely connected and retained by the clip.

22 Reconnect the wiring connectors to the fuel injectors.

23 Attach the engine breather hose to the breather pipe and secure with the retaining clip. Secure the breather pipe to the cylinder head with the two bolts securely tightened.

24 Reconnect the battery negative terminal as described in Chapter 5A.

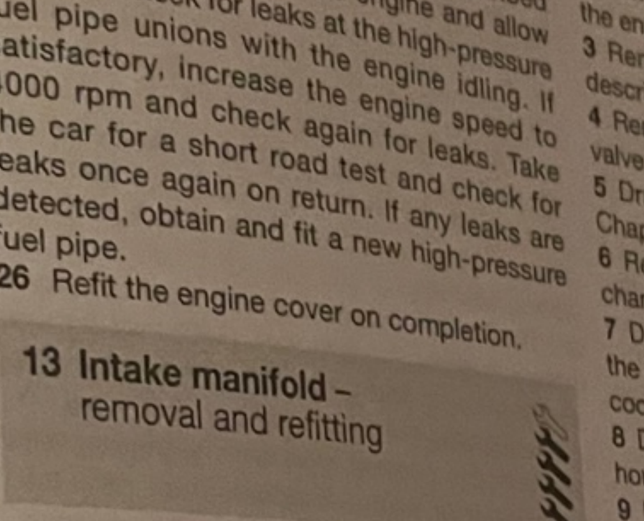
25 Observing the precautions listed in Section 2, prime the fuel system as described in Section 5, then start the engine and allow it to idle. Check for leaks at the high-pressure fuel pipe unions with the engine idling. If satisfactory, increase the engine speed to 4000 rpm and check again for leaks. Take the car for a short road test and check for leaks once again on return. If any leaks are detected, obtain and fit a new high-pressure fuel pipe.

26 Refit the engine cover on completion.

13 Intake manifold – removal and refitting

Removal

1 Disconnect the battery negative terminal as described in Chapter 5A.



13.9 Unscrew the nuts and free the wiring harness and coolant pipe from the starter motor bracket

2 Remove the plastic cover over the top of the engine.

3 Remove the high-pressure fuel pump as described in Section 10.

4 Remove the exhaust gas recirculation (EGR) valve as described in Chapter 4C.

5 Drain the cooling system as described in Chapter 1B.

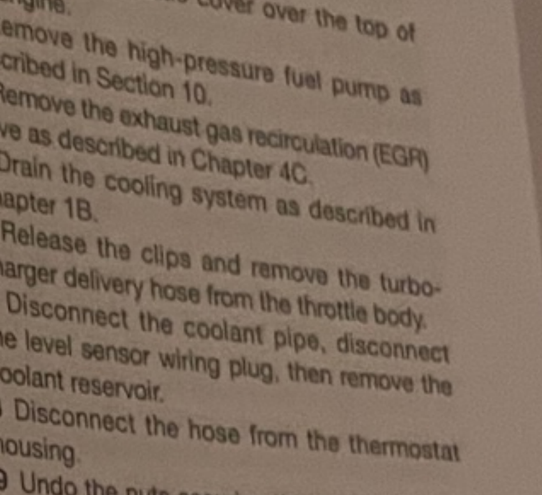
6 Release the clips and remove the turbo-charger delivery hose from the throttle body.

7 Disconnect the coolant pipe, disconnect the level sensor wiring plug, then remove the coolant reservoir.

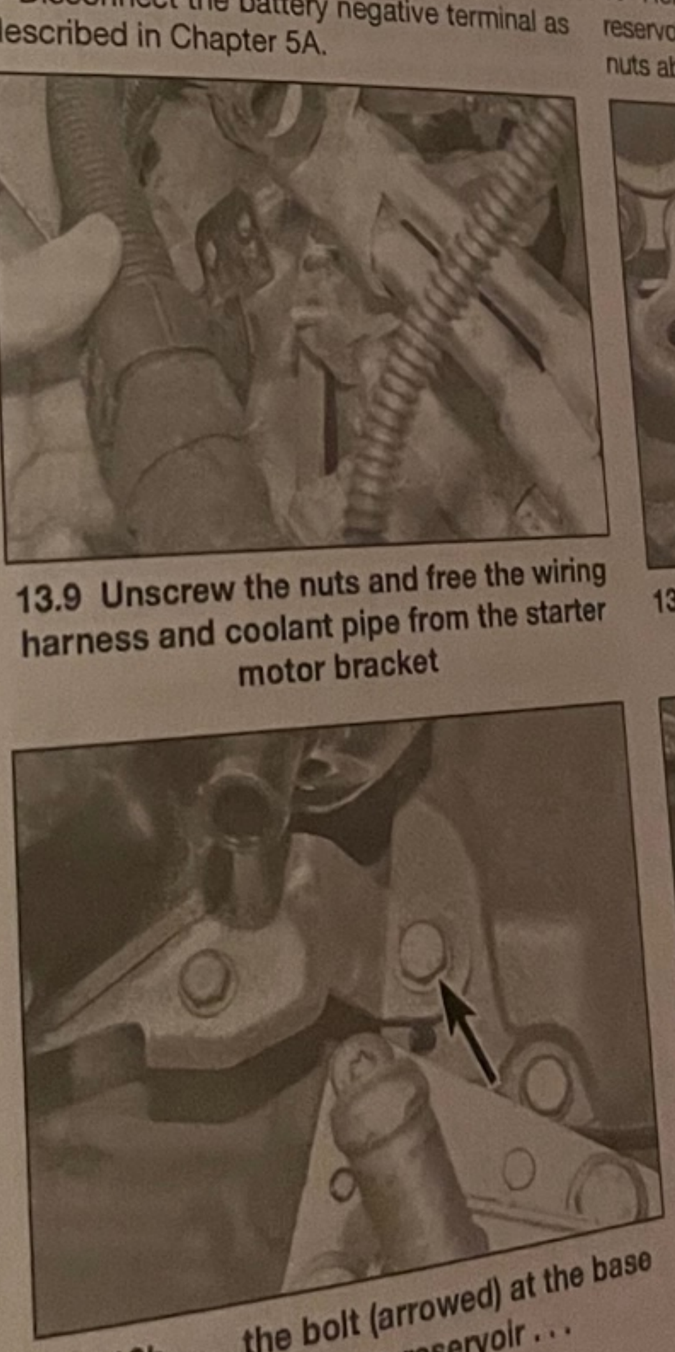
8 Disconnect the hose from the thermostat housing.

9 Undo the nuts securing the coolant pipe to the starter motor bracket, and bend the pipe away slightly **(see illustration)**.

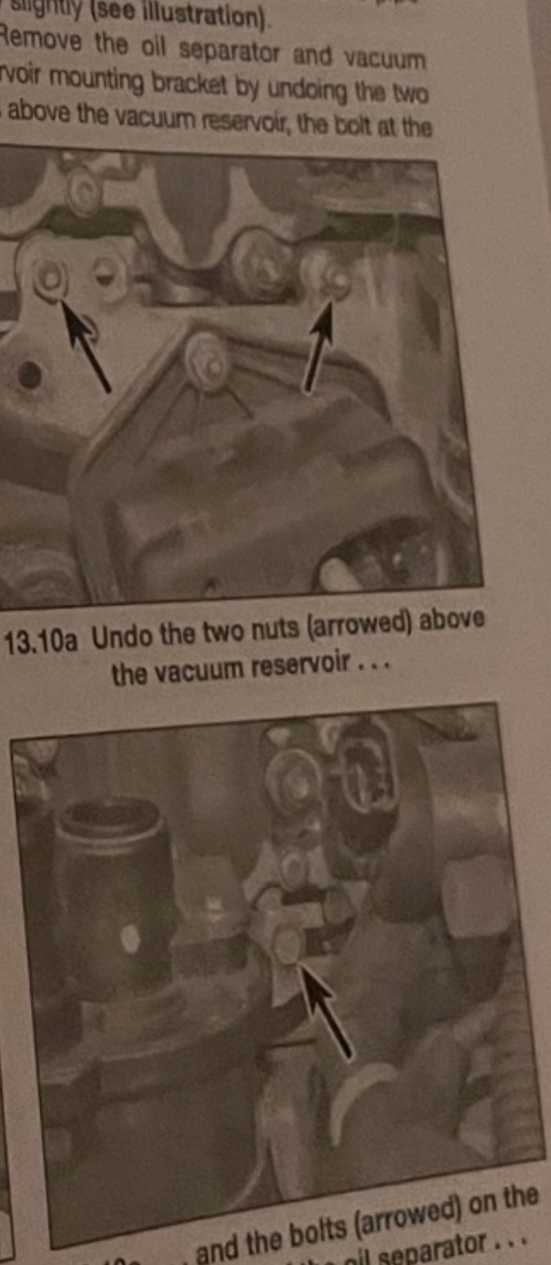
10 Remove the oil separator and vacuum reservoir mounting bracket by undoing the two nuts above the vacuum reservoir, the bolt at the



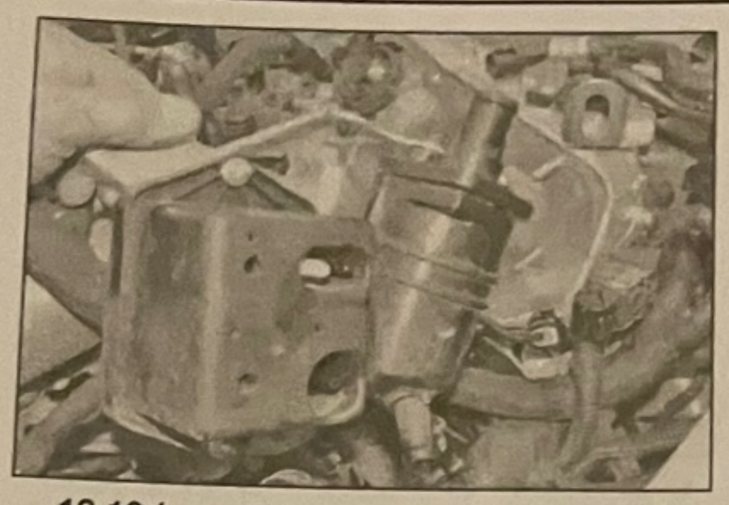
13.10a Undo the two nuts (arrowed) above the vacuum reservoir . . .



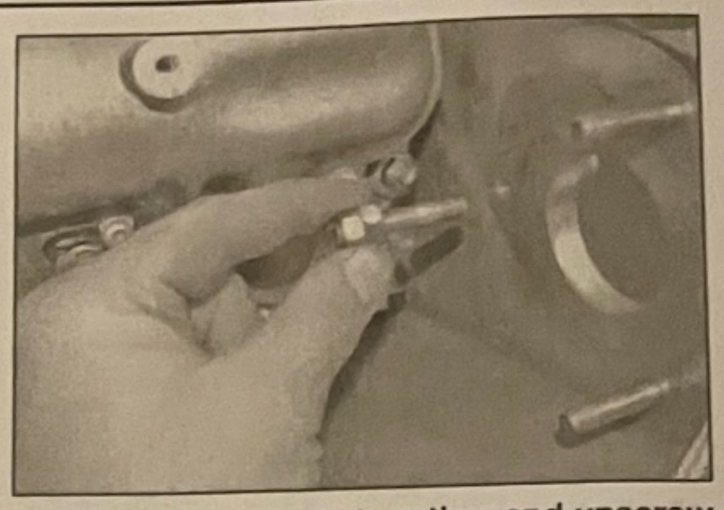
13.10b . . . the bolt (arrowed) at the base of the vacuum reservoir . . .



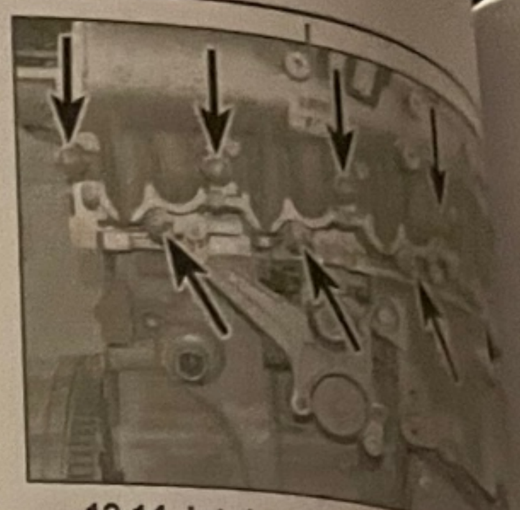
13.10c . . . and the bolts (arrowed) on the right-hand side of the oil separator . . .



13.10d . . . then remove the mounting bracket complete with oil separator and vacuum reservoir



13.12 Lock two nuts together and unscrew the fuel pump stud from the engine bracket



13.14 Intake manifold retaining nuts (arrowed)

base of the vacuum reservoir, and the bolt at the right-hand side of the oil separator. Remove the mounting bracket complete with oil separator and vacuum reservoir **(see illustrations)**.

11 Undo the three bolts, release the hose clip, free the wiring harness and detach the coolant pipe from the intake manifold.

12 Screw two nuts onto the inner high-pressure fuel pump mounting stud. Lock the two nuts together and unscrew the stud from the engine bracket **(see illustration)**.

13 Disconnect the wiring connectors at the throttle body/housing, coolant temperature sensor, intake air sensor, fuel pressure sensor, and fuel pressure control valve.

14 Undo the nine retaining nuts and remove the intake manifold from the cylinder head studs **(see illustration)**. Recover the gasket.

15 With the manifold removed, if required, remove the throttle body/housing with reference to Section 9.

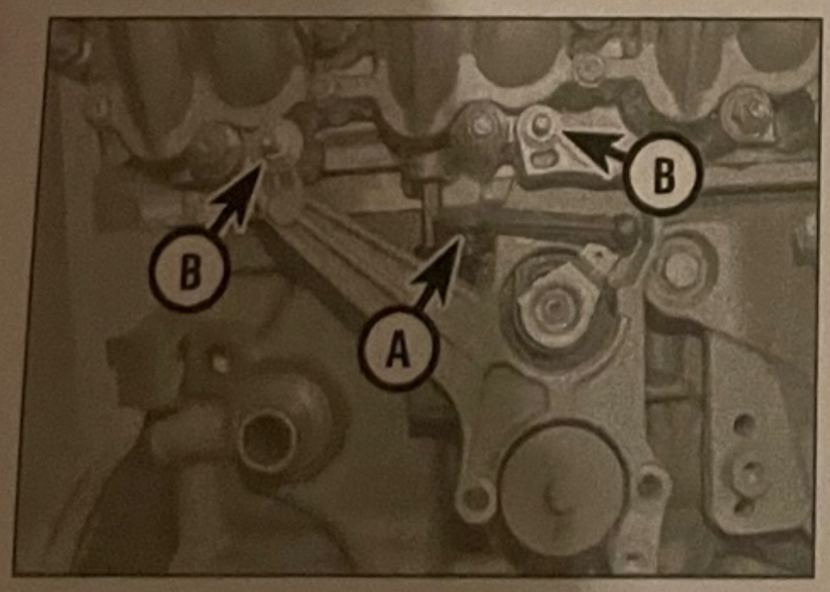
16 The changeover flap actuator drive can be removed by disconnecting the drive motor actuating rod ball socket, and undoing the two stud bolts.

Refitting

17 If removed, refit the throttle body/housing with reference to Section 9, then refit the changeover flap actuator drive.

18 Thoroughly clean the intake manifold and cylinder head mating faces, and then locate a new gasket on the intake manifold flange.

19 Locate the manifold in position and refit the retaining nuts. Diagonally and progressively, tighten the nuts to the specified torque.



14.11 Disconnect the actuating rod ball socket (A), undo the two stud bolts (B) and remove the actuator drive

20 Reconnect the wiring connectors at the throttle body/housing and charge (boost) pressure sensor.

21 Refit the high-pressure fuel pump mounting stud, then remove the two nuts used to remove/refit the stud.

22 Refit the coolant pipe to the manifold, and secure with the three bolts tightened securely. Reconnect the coolant pipe and attach the wiring harness.

23 Refit the oil separator and vacuum reservoir mounting bracket. Refit and tighten the two bolts and two nuts, then reconnect the crankcase breather hoses.

24 Refit the coolant pipe and wiring harness to the starter motor bracket, then refit and tighten the two nuts.

25 Refit the exhaust gas recirculation (EGR) valve as described in Chapter 4C.

26 Refit the high-pressure fuel pump as described in Section 10.

27 Reconnect the battery negative terminal as described in Chapter 5A.

28 Observing the precautions listed in Section 2, prime the fuel system as described in Section 5, then start the engine and allow it to idle. Check for leaks at the high-pressure fuel pipe unions with the engine idling. If satisfactory, increase the engine speed to 4000 rpm and check again for leaks. Take the car for a short road test and check for leaks once again on return. If any leaks are detected, obtain and fit a new high-pressure fuel pipe.

29 Refit the engine cover on completion.

14 Intake manifold changeover flap actuator drive – removal and refitting

Removal

1 Disconnect the battery negative terminal as described in Chapter 5A.

2 Remove the plastic cover over the top of the engine.

3 Remove the high-pressure fuel pump as described in Section 10.

4 Remove the exhaust gas recirculation (EGR) valve as described in Chapter 4C.

5 Drain the cooling system as described in Chapter 1B.

6 Release the clips and remove the [illegible] charger delivery hose from the [illegible]

7 Disconnect the coolant pipe, disc[illegible] the level sensor wiring plug, then rem[illegible] coolant reservoir.

8 Disconnect the hose from the [illegible] housing.

9 Undo the nuts securing the coolant [illegible] the starter motor bracket, and bend the [illegible] away slightly **(see illustration 13.9)**.

10 Remove the oil separator and va[illegible] reservoir mounting bracket by undoin[illegible] two nuts above the vacuum reservoir, the[illegible] at the base of the vacuum reservoir, an[illegible] bolt at the right-hand side of the oil sepa[illegible] Remove the mounting bracket com[illegible] with oil separator and vacuum reservo[illegible] **illustrations 13.10a to 13.10d)**.

11 Disconnect the drive motor actuati[illegible] ball socket, and undo the 2 stud bolts [illegible] **illustration)**.

12 Withdraw the assembly from the [illegible] manifold and disconnect the wiring plug.

Refitting

13 Refitting is the reverse of removal.

15 Intercooler – removal and refitting

Refer to Chapter 4A, Section 17.

16 Turbocharger – description and precautions

Description

1 The turbocharger increases engine ef[illegible] by raising the pressure in the intake [illegible] above atmospheric pressure. Instea[illegible] air simply being sucked into the cylin[illegible] forced in.

2 Energy for the operation of the turb[illegible] comes from the exhaust gas. The [illegible] through a specially-shaped hou[illegible] turbine housing) and, in so doing, [illegible] turbine wheel. The turbine wheel is [illegible] a shaft, at the end of which is ano[illegible]

wheel known as the compressor wheel. The compressor wheel spins in its own housing, and compresses the intake air on the way to the intake manifold.

3 The turbocharger operates on the principle of variable vane geometry. At low engine speed the vanes close to give less flow cross-section, then as the speed increases the vanes open to give an increased flow cross-section. This helps improve the efficiency of the turbocharger.

4 Boost pressure (the pressure in the intake manifold) is limited by a wastegate, which diverts the exhaust gas away from the turbine wheel in response to a pressure-sensitive actuator.

5 The turbo shaft is pressure-lubricated by an oil feed pipe from the main oil gallery. The shaft 'floats' on a cushion of oil. A drain pipe returns the oil to the sump.

Precautions

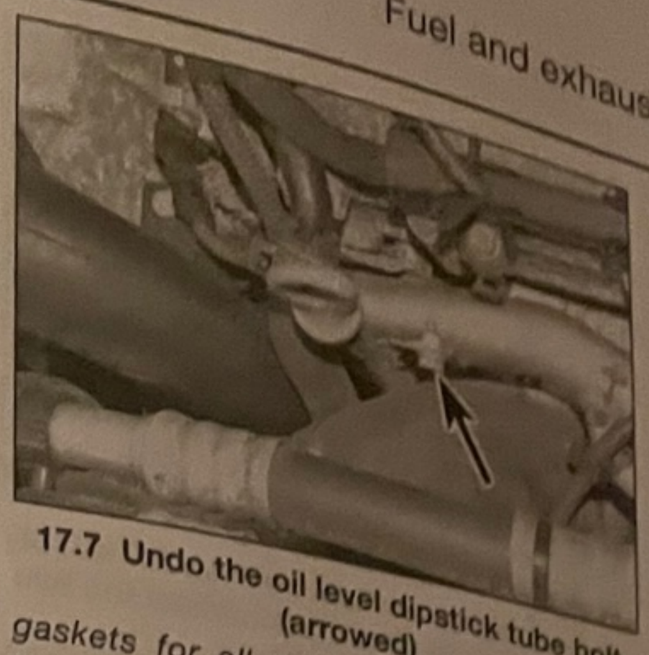
6 The turbocharger operates at extremely high speeds and temperatures. Certain precautions must be observed, to avoid premature failure of the turbo, or injury to the operator.

- Do not operate the turbo with any of its parts exposed, or with any of its hoses removed. Foreign objects falling onto the rotating vanes could cause excessive damage, and (if ejected) personal injury.
- Do not race the engine immediately after start-up, especially if it is cold. Give the oil a few seconds to circulate.
- Always allow the engine to return to idle speed before switching it off – do not blip the throttle and switch off, as this will leave the turbo spinning without lubrication.
- Allow the engine to idle for several minutes before switching off after a high-speed run.
- Observe the recommended intervals for oil and filter changing, and use a reputable oil of the specified quality. Neglect of oil changing, or use of inferior oil, can cause carbon formation on the turbo shaft, leading to subsequent failure.

17 Exhaust manifold and turbocharger – removal and refitting

Note: *New manifold retaining nuts, new gaskets for all disturbed joints, and new copper washers for the turbocharger oil supply pipe banjo union will be required for refitting.*

17.18 Unscrew the sensor from the catalytic converter



17.7 Undo the oil level dipstick tube bolt (arrowed)

Removal

1 Disconnect the battery negative terminal as described in Chapter 5A.

2 Remove the plastic cover from the top of the engine.

3 Firmly apply the handbrake, and then jack up the front of the car and support it securely on axle stands (see *Jacking and vehicle support*). Undo the bolts and remove the engine undershield.

4 Drain the cooling system as described in Chapter 1B.

5 Undo the fasteners and remove the front section of the exhaust pipe.

6 Undo the 2 nuts and remove the heat shield over the catalytic converter.

7 Undo the bolt securing the oil level dipstick tube **(see illustration)**.

8 Release the retaining clip securing the engine breather hose to the breather pipe adjacent to the engine oil dipstick. Undo the two bolts securing the breather pipe to the cylinder head, and disconnect the pipe from the hose.

9 Remove the air cleaner assembly and air intake duct as described in Section 3.

10 Remove the turbocharger intake hose.

11 Remove the turbocharger delivery pipe from the throttle body, and turbocharger.

12 Release the clip and disconnect the radiator top hose from the thermostat housing.

13 Disconnect the coolant hose between the reservoir and the manifold. Undo the mounting and remove the hose.

14 Disconnect the coolant hoses from the coolant pipe at the left-hand end of the engine, then remove the lower coolant hose from the coolant pipe.

15 Undo the 3 front bolts and wedge the upper timing cover away from the engine slightly.

16 Undo the 3 fasteners and remove the coolant pipe from the front of the engine.

17 Remove the heat shield at the front of the turbocharger **(see illustration)**.

18 Working underneath the vehicle, unscrew the temperature sensor from the catalytic converter (where fitted) **(see illustration)**.

19 Undo the catalytic converter lower mounting bolts, and then bend the lower bracket down a little.

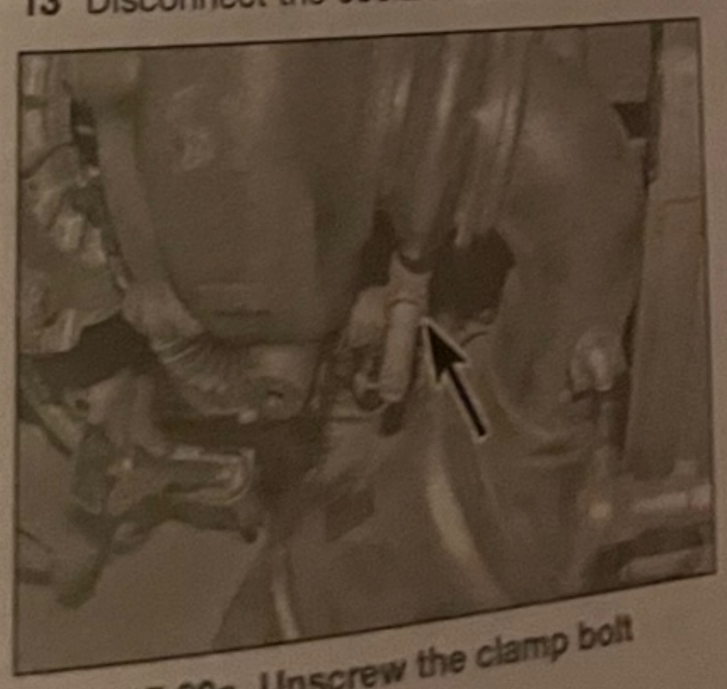
20 Undo the upper clamp securing the catalytic converter to the turbocharger, and lower the catalytic converter from place **(see illustrations)**.

21 Disconnect the vacuum hose from the turbocharger wastegate actuator.

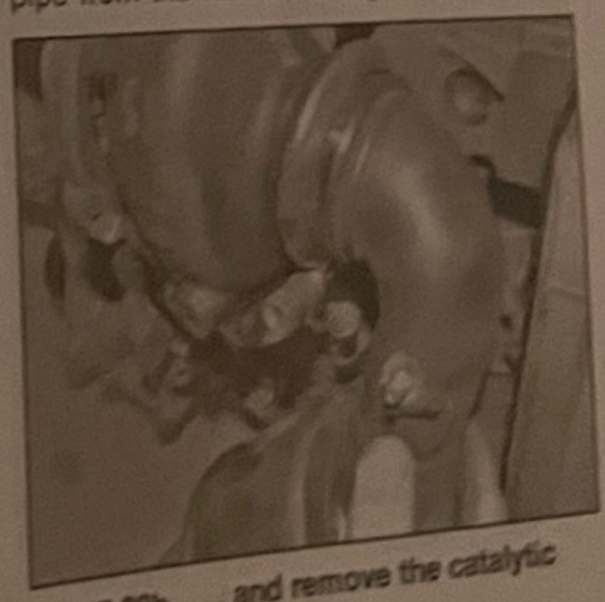
22 Unscrew the four bolts securing the oil return pipe to the turbocharger and cylinder block **(see illustration)**. Remove the pipe and recover the gaskets.

23 Unscrew the turbocharger oil supply pipe banjo union from the cylinder block and collect the two copper washers **(see illustration)**.

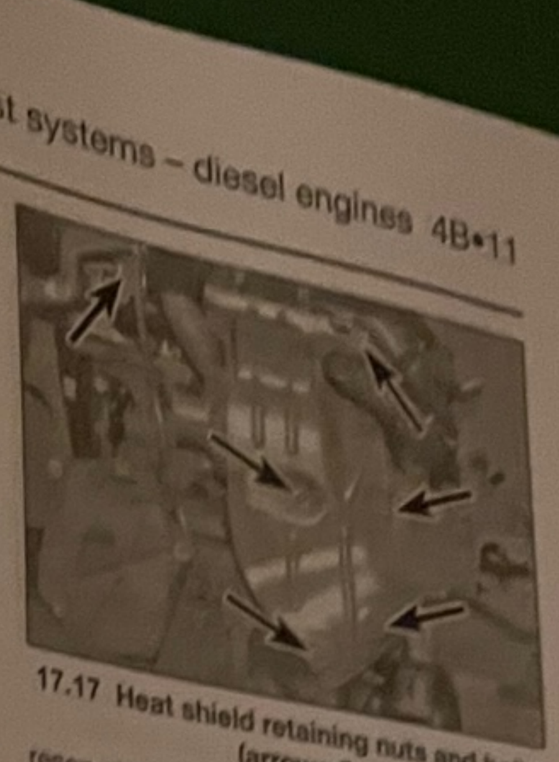
24 Undo the retaining nut and bolt and release the metal EGR pipe clamp from the EGR valve heat exchanger. Separate the pipe from the heat exchanger and recover



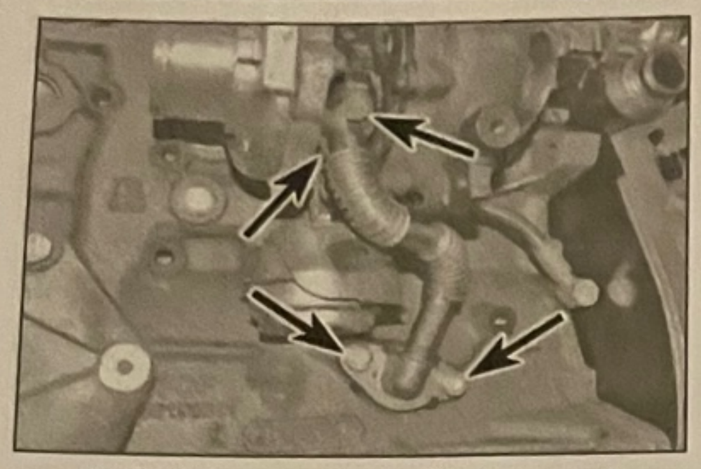
17.20a Unscrew the clamp bolt (arrowed) . . .



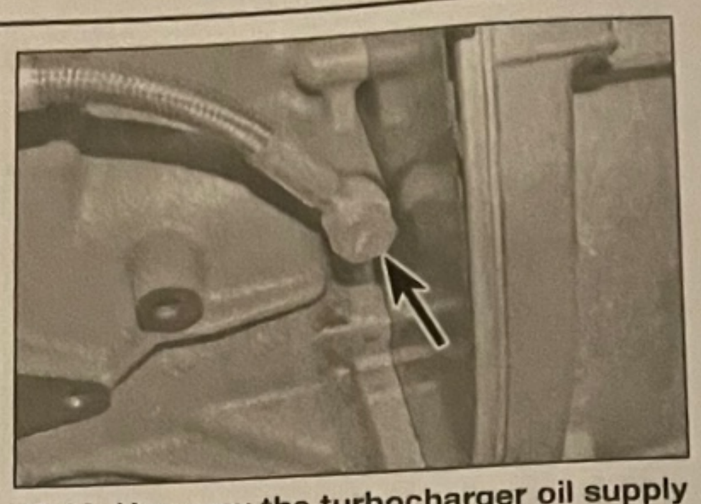
17.20b . . . and remove the catalytic converter



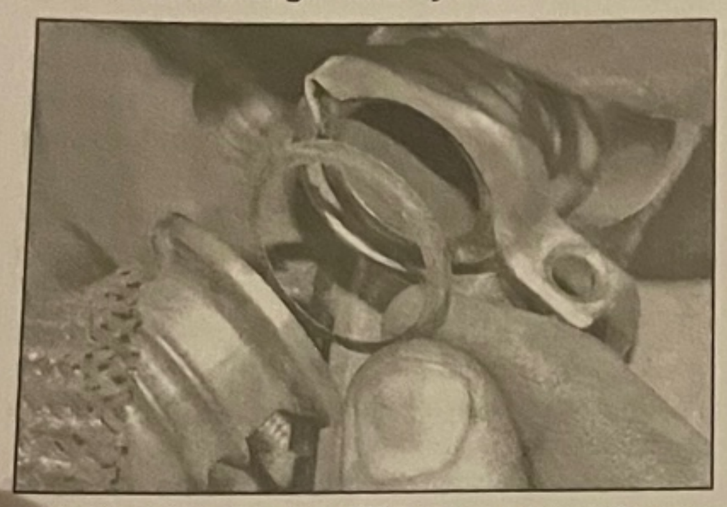
17.17 Heat shield retaining nuts and bolts (arrowed)



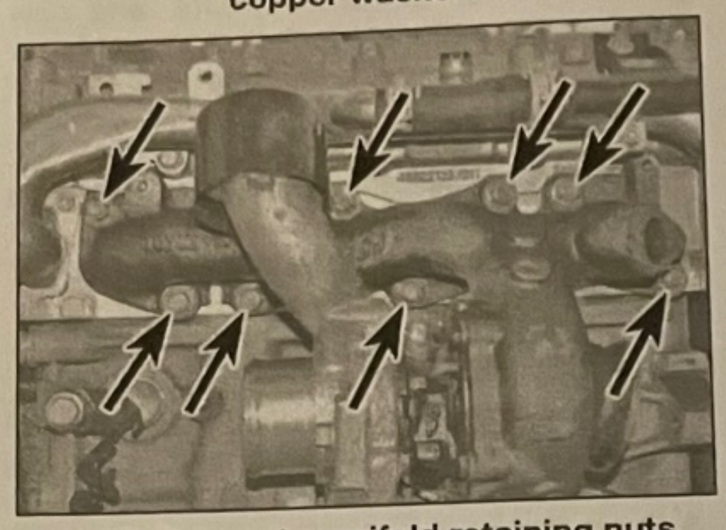
17.22 Unscrew the bolts (arrowed) securing the oil return pipe to the turbocharger and cylinder block



17.23 Unscrew the turbocharger oil supply banjo union (arrowed) and collect the two copper washers



17.24 Release the EGR pipe clamp from the heat exchanger, separate the pipe and recover the gasket



17.25 Exhaust manifold retaining nuts (arrowed)

the gasket from the pipe connection **(see illustration)**.

25 Unscrew the eight nuts securing the exhaust manifold to the cylinder head **(see illustration)**. Note that new nuts will be required for refitting. Withdraw the manifold and turbocharger assembly from the mounting studs, manipulate it sideways, and remove from under the car. Recover the gasket.

Refitting

26 Refitting is the reverse of removal, noting the following points.

a) Ensure all mating surfaces are clean and dry and renew all gaskets, seals and copper washers.

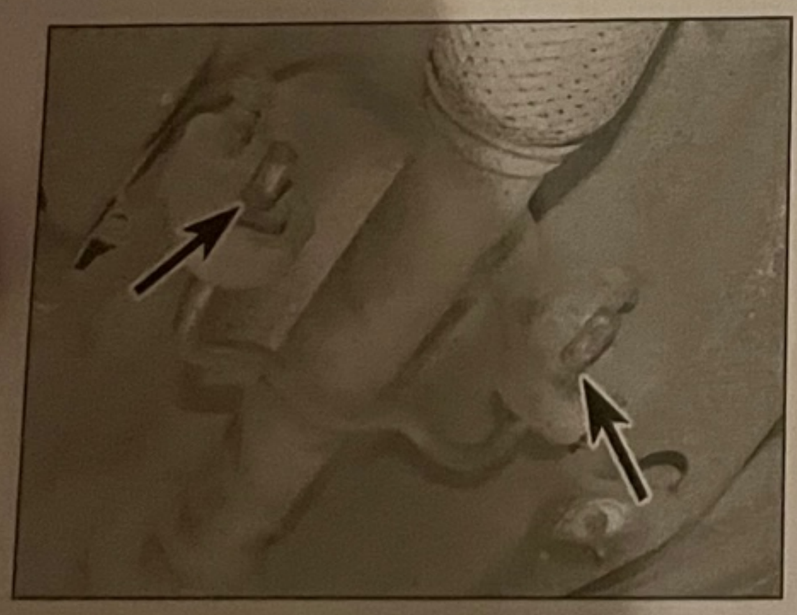
b) Fit the new manifold nuts and tighten them evenly and progressively to the specified torque, working in a diagonal sequence.

c) Tighten all other retaining nuts and bolts to the specified torque (where given).

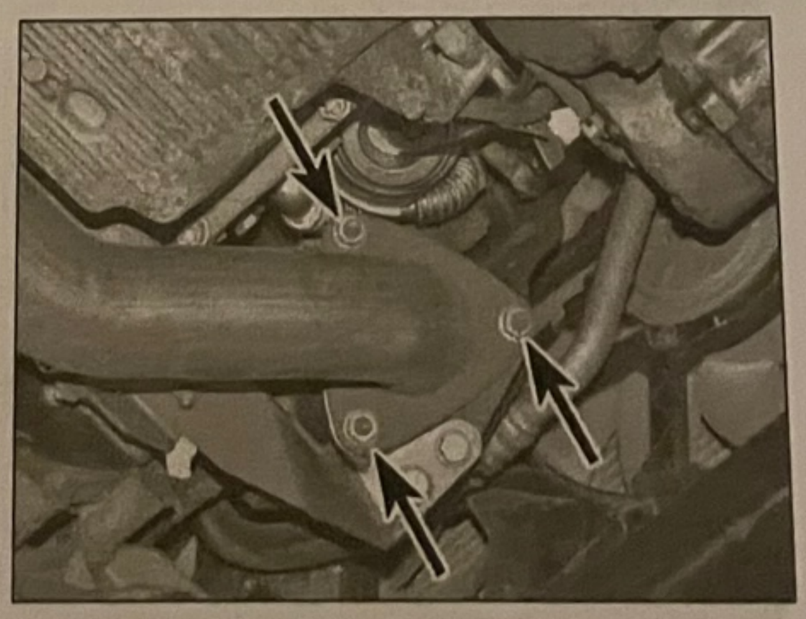
d) Refit the exhaust system as described in Section 18.

e) On completion refill the cooling system as described in Chapter 1B and, if necessary, top-up the oil level as described in 'Weekly checks'.

f) On starting the engine for the first time, allow the engine to idle for a few minutes before increasing the engine speed; this will allow oil to be circulated around the turbocharger bearings.



18.5 Spray penetrating oil over the exhaust rubber mounting blocks in the area arrowed



18.7 Undo the 3 nuts (arrowed) and detach the front exhaust pipe from the catalytic converter

18 Exhaust system – general information, removal and refitting

General information

1 Two different exhaust systems are fitted dependent on model, market and engine. On some models a four-piece system is fitted, comprising a front catalytic converter/front pipe, particulate filter, and a rear section with silencer. On others, a second catalytic converter/silencer is fitted in place of the particulate filter.

2 The front pipe is attached to the exhaust manifold/catalytic converter by a flange, secured by nuts. The other exhaust sections are joined by overlap joints, which are sealed by clamps, or flange joints secured by nuts. The system is suspended throughout its length by rubber mountings.

3 The manufacturers specify that if any of the exhaust sections are separated, the clamps must be renewed. As the clamps are attached to the exhaust sections by means of a spot weld at manufacture, it will be necessary to use a suitable grinder to remove the spot weld.

Removal

Complete system

4 To remove the system, first jack up the front and rear of the car and support it securely on axle stands. Alternatively, position the car over an inspection pit or on car ramps. The help of an assistant will be needed. Undo the fasteners and remove the engine undershield.

5 Spray some penetrating oil over the exhaust rubber mounting blocks so that the mounting blocks will slide easily on the exhaust underbody hangers **(see illustration)**.

6 Undo the two bolts securing the front support bracket to the transmission bracket/sump.

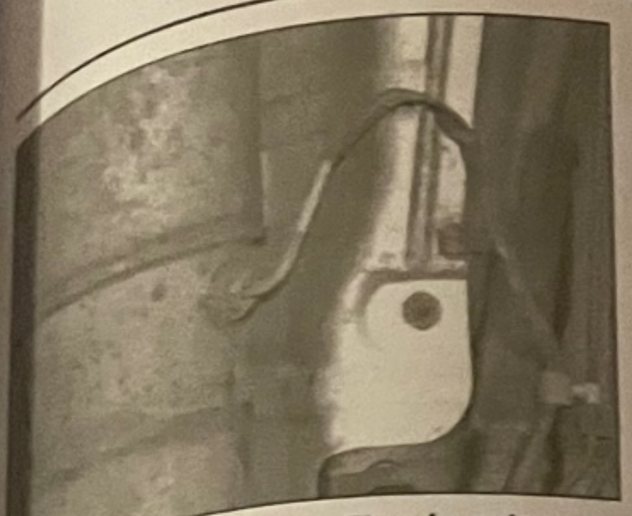
7 Undo the three retaining nuts and separate the exhaust front pipe from the exhaust manifold/catalytic converter, taking care to support the flexible section. **Note:** *Angular movement in excess of 10° can cause permanent damage to the flexible section.* Recover the gasket **(see illustration)**. Note that new nuts will be required for refitting.

8 Slide the front pipe rubber mounting blocks as far forward as possible. Move the exhaust system to the rear and disengage the front pipe hangers from the mounting blocks.

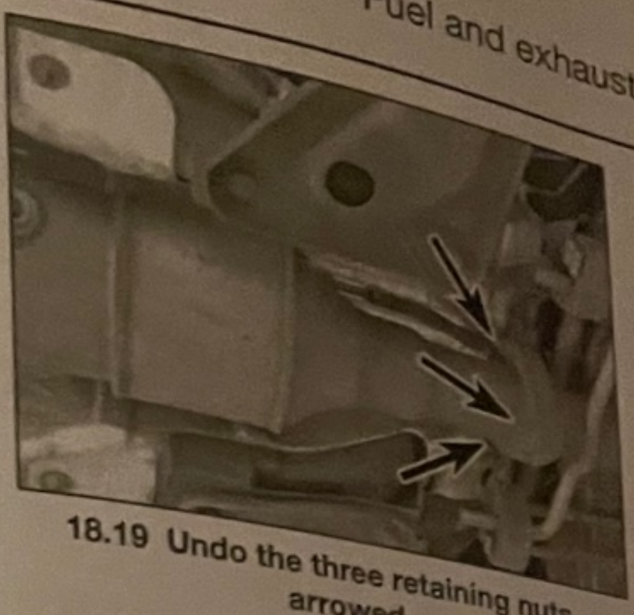
9 Move the exhaust system forward to disengage the intermediate pipe and tail pipe hangers from the rubber mounting blocks. Lower the system to the ground and withdraw it out from under the car.

Individual section

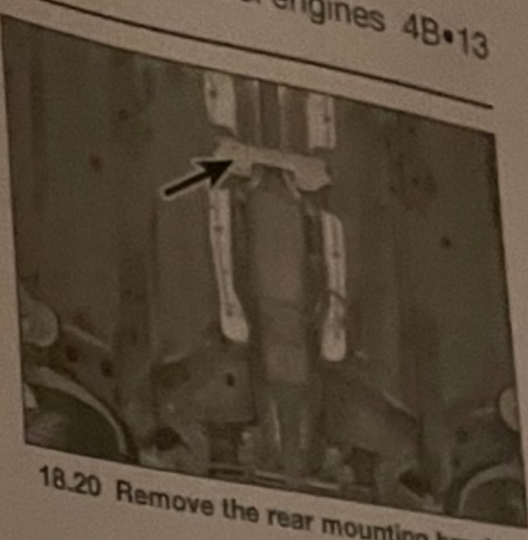
10 Individual sections of the exhaust system can be removed by slackening the relevant clamp and releasing the exhaust from the rubber mountings.



18.17 Pipe to particulate filter in exhaust



18.19 Undo the three retaining nuts – arrowed



18.20 Remove the rear mounting bracket

11 Slacken and remove the nut from the relevant exhaust clamp retaining bolt. Apply liberal amounts of penetrating oil to the joint and tap around the joint and clamp with a hammer to free it. Twist the pipe to be removed in both directions while holding the adjacent pipe. Once the joint is free, pull the pipes apart.

12 Mark the position of the clamp on the pipe, so the new clamp can be fitted in the same position, then grind off the clamp retaining spot weld. Remove the clamp.

Catalytic converter

13 There maybe one or two catalytic converters, dependent on model, market, etc – one fitted between the exhaust manifold and the exhaust front pipe, and a second unit, integral with the exhaust front pipe. Refer to Section 17 for removal and refitting details for the converter fitted between the front pipe and manifold.

14 Where no second catalytic converter in fitted, a particulate filter is installed.

Heat shield(s)

15 The heat shields are secured to the underside of the body by various nuts and threaded caps. Each shield can be removed once the relevant exhaust section has been removed. If a shield is being removed to gain access to a component located behind it, it may prove sufficient in some cases to remove the retaining nuts/caps, and simply lower the shield, without disturbing the exhaust system. If any of the threaded caps are damaged during removal, a suitable nut and washer can be used when refitting.

Particulate filter

16 Raise the vehicle and support it securely on axle stands (see *Jacking and vehicle support*).

17 Note their fitted positions, and disconnect the exhaust gas temperature sensor pipe(s) from the particulate filter **(see illustration)**.

18 If required, unscrew the temperature sensor from the filter.

19 Undo the 3 nuts securing the filter to the front pipe **(see illustration)**. Note that new nuts will be required for refitting.

20 Undo the bolts securing the filter rear mounting bracket to the vehicle body **(see illustration)**.

21 Slacken the clamp and separate the rear exhaust pipe from the filter.

22 Release the filter from the rubber mountings and withdrawn it from under the vehicle.

23 Upon refitting, apply a little high-temperature anti-seize grease to the temperature sensor threads. Note that if a new particle filter has been fitted, Saab diagnostic equipment must be connected to the vehicle's diagnostic plug to reset adaptation values in the engine management ECM. Entrust this task to a Saab dealer or suitably-equipped specialist.

Refitting

24 Refitting is a reversal of the removal sequence, noting the following points:

a) *Ensure that all traces of corrosion have been removed from the system joints and renew all disturbed clamps.*

b) *Inspect the rubber mountings for signs of damage or deterioration, and renew as necessary.*

c) *When refitting the front pipe to the manifold/catalytic converter, use a new gasket and new retaining nuts, and tighten the nuts to the specified torque.*

d) *Prior to tightening the exhaust system clamps, ensure that all rubber mountings are correctly located, and that there is adequate clearance between the exhaust system and vehicle underbody. Tighten the clamp bolt retaining nuts securely.*