C.A.V. DIESEL INJECTION SYSTEM 23B

GENERAL DESCRIPTION

The C.A.V. injection system fitted on the 2,4 litre York diesel engine consists of a single acting injection pump, fuel lift pump, sediment and main fuel filters, injectors and a glow plug starting system. Basic idle speed is adjustable and should be checked and if necessary adjusted at the specified service intervals. Glow plugs should be changed at the specified intervals as detailed in the Service Voucher Book.

Pump timing is adjustable and a service procedure for this is detailed in Operation 23 414. The full throttle stop is set during engine final test and sealed to ensure unqualified persons do not overload the system.

To ensure that optimum performance, economy and exhaust emission-levels are maintained it is essential that the correct service repair and setting procedures are used in conjunction with the relevant specifications contained in the Technical Data Section.

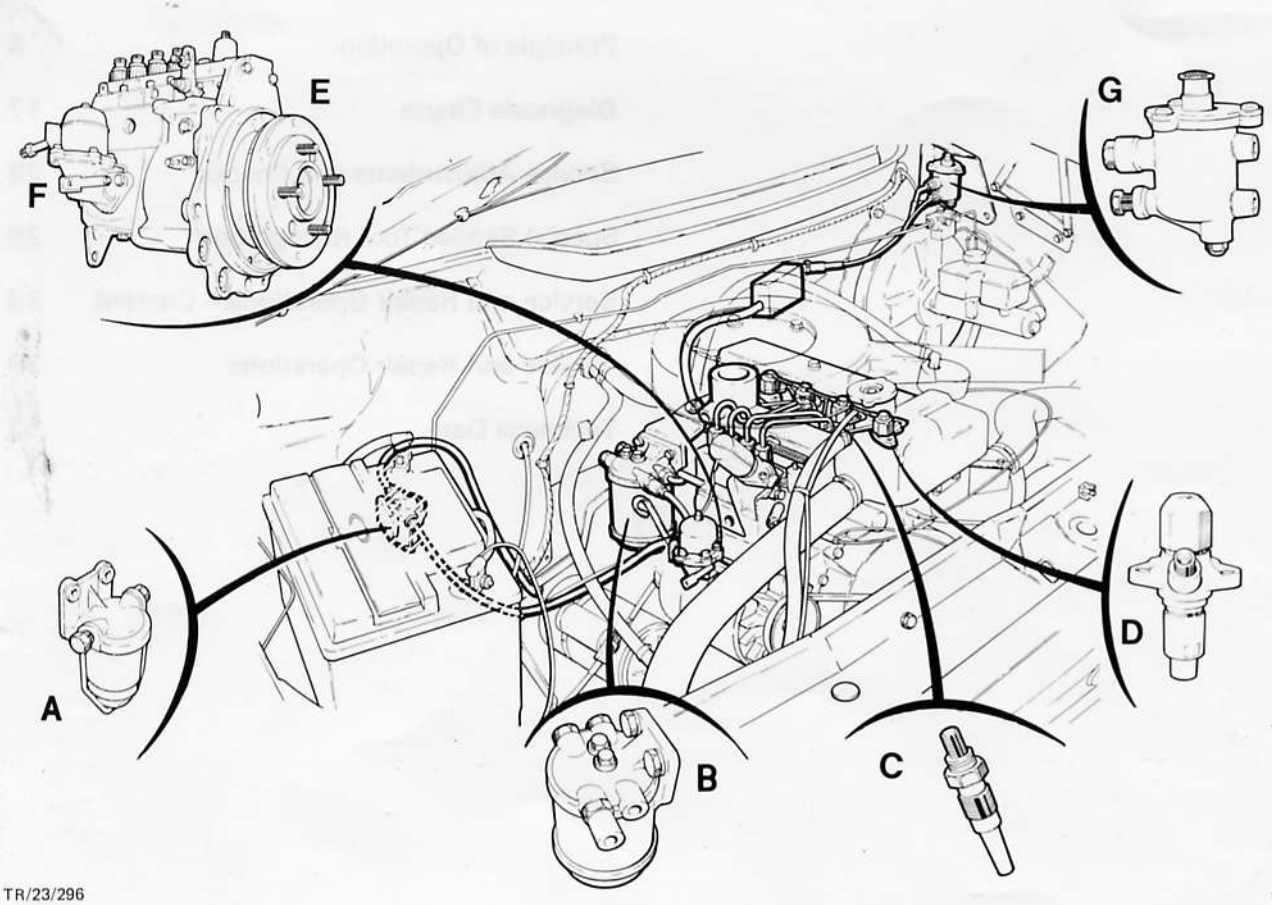


Fig. 1. C.A.V. Diesel injection system
Components that make up the diesel injection system are described individually on the following pages

A – Sediment filter
B – Main fuel filter
C – Glow plugs
D – Injectors
E – C.A.V. Injection pump
F – Fuel lift pump
G – Reservoir

GENERAL DESCRIPTION (cont'd)

Diesel Injection Pump. Fig. 2.

Two types of injection pumps are fitted on the Transit diesel variant, a Bosch rotary pump, which is covered in section 23C, and a C.A.V. Minimec pump which is described in this section (23B). The C.A.V. pump is of a jerk type design utilising a camshaft and four pumping elements.

The pump is located on the right hand side of the engine and is driven at half engine speed by a toothed drive belt, located behind the front cover of the engine. A governor located at the front of the pump is of a mechanical design utilising centrifugal weights. Fuel pressure is supplied from a lift pump mounted externally on the injection pump and driven by an eccentric cam on the pump camshaft. Stop control is by means of a cable connected to the stop lever which when operated moves the control rod into the no fuel position.

An excess fuel plunger is included in the pump and operated, when the engine is cold, by an externally mounted control solenoid.

Full details of how these individual systems operate are shown in the principle of operation section on page 4 onwards.

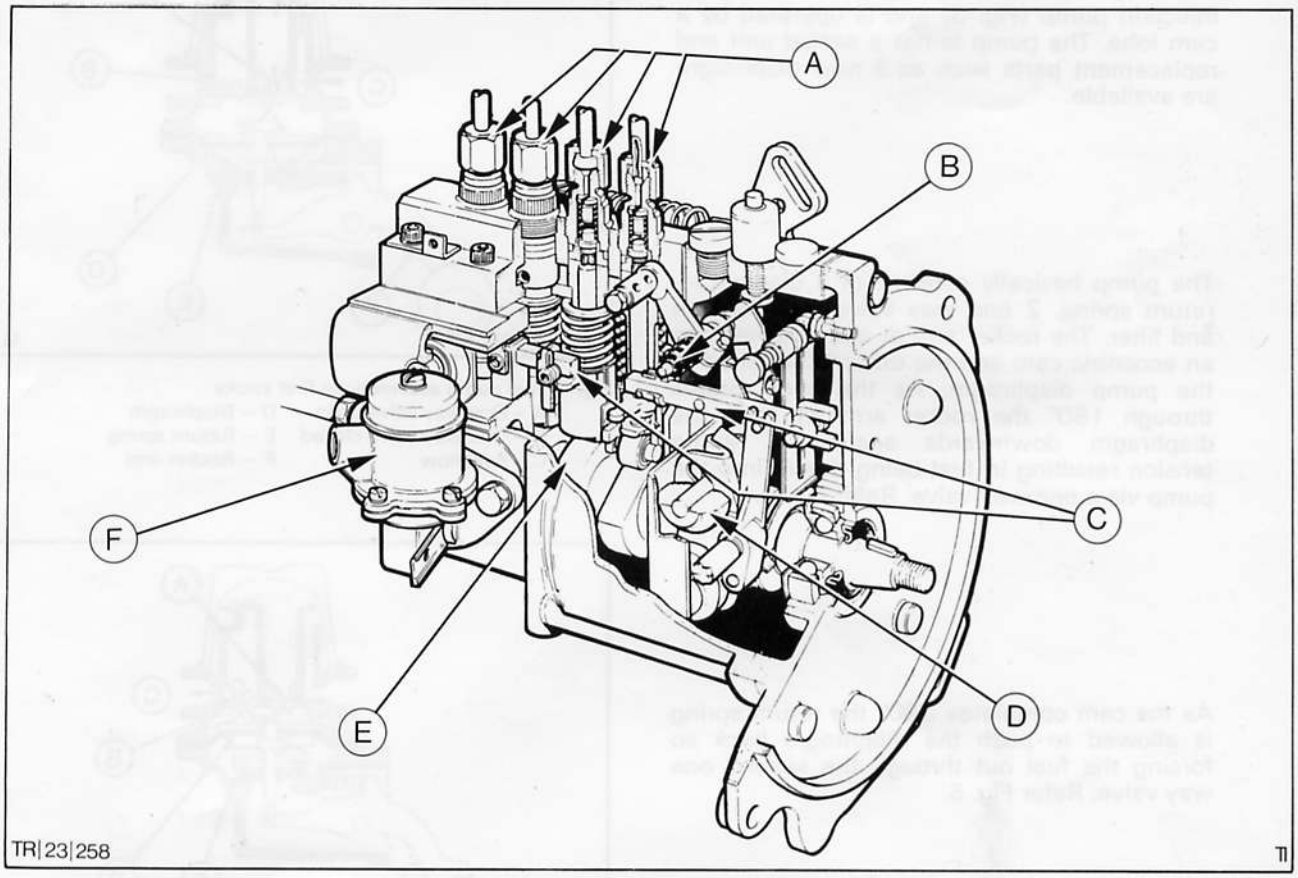


Fig. 2. C.A.V. Minimec diesel injection pump

A – Pumping elements
B – Excess fuel plunger
C – Control rod
D – Centrifugal weights
E – Camshaft
F – Fuel lift pump

PRINCIPLE OF OPERATION

Diesel Injection Pump

The injection pump is the heart of the diesel injection system and its most complicated component. For this reason the principle of operation of this unit is split into five sections:

A. Fuel lift pump

B. Pumping elements and camshaft

C. Excess fuel device

D. Governor

E. Auto-advance unit.

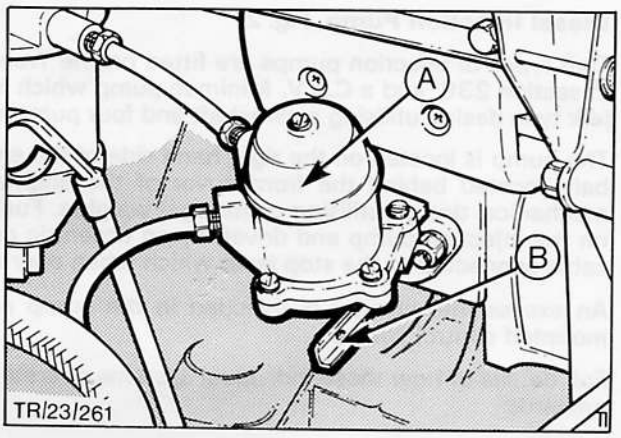


Fig. 3. Fuel pump assembly
A – Lift pump
B – Hand prime lever

A. Fuel Lift Pump, Fig. 3.

The lift pump is mounted on the side of the injection pump (Fig. 3) and is operated by a cam lobe. The pump is not a sealed unit and replacement parts such as a new diaphragm are available.

The pump basically consists of a diaphragm, return spring, 2 one way valves, rocker arm and filter. The rocker arm at one end rests on an eccentric cam and the other is attached to the pump diaphragm. As the cam rotates through 180° the rocker arm will pull the diaphragm downwards against a spring tension resulting in fuel being drawn into the pump via a one way valve. Refer Fig. 4.

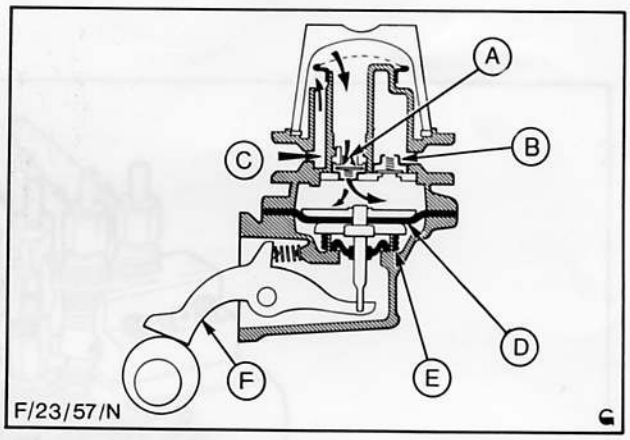


Fig. 4. Fuel pump assembly on first stroke
A – One way valve open
B – One way valve closed
C – Fuel flow
D – Diaphragm
E – Return spring
F – Rocker arm

As the cam completes 360° the return spring is allowed to push the diaphragm back so forcing the fuel out through the second one way valve. Refer Fig. 5.

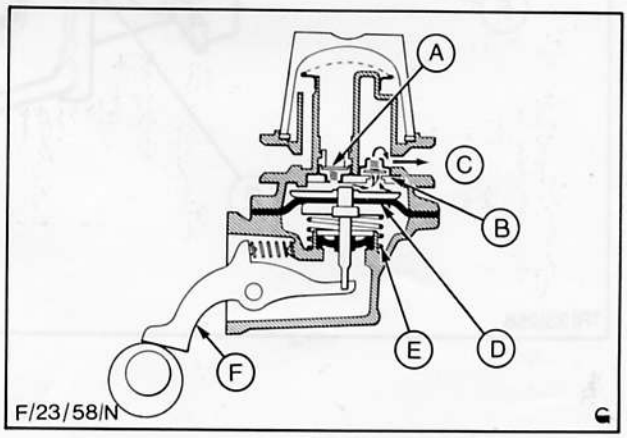


Fig. 5. Fuel pump assembly on second stroke
A – One way valve closed
B – One way valve open
C – Fuel flow
D – Diaphragm
E – Return spring
F – Rocker arm

An additional feature of the lift pump is a hand priming lever (Refer Fig. 3) which should be used when initially bleeding the fuel system.

PRINCIPLE OF OPERATION (cont'd)

B. Pumping Elements

The elements, one for each cylinder are mounted in the upper half of the pump, and are operated by the pump camshaft. Each element consists of a plunger and barrel assembly, delivery valve and a pressure control spring. There are four stages of element operation which are shown in Fig. 6.

Stage 'A' The plunger (E) is positioned on the back of the cam and is in its lowest position. The delivery valve (H) is held closed by the pressure control spring (G) and the inlet port (F) is open allowing fuel to enter and charge the element.

Stage 'B' As the cam turns the plunger is lifted which blocks the inlet port and pressurises the fuel charge. At this stage the fuel charge has not reached the required pressure to open the delivery valve against the control pressure spring.

Stage 'C' As the cam continues to turn, the fuel pressure in the element increases until at a pre-determined level, the pressure acting on the delivery valve overcomes the spring tension. At this point the fuel charge passes, at a high pressure from the element to the injector.

Stage 'D' When the plunger reaches the top of its stroke a helical slot which is connected to a central gallery in the plunger lines up with the return port and discharges the remaining fuel. Pressure immediately drops to lift pump pressure, the delivery valve closes and ends the injection cycle.

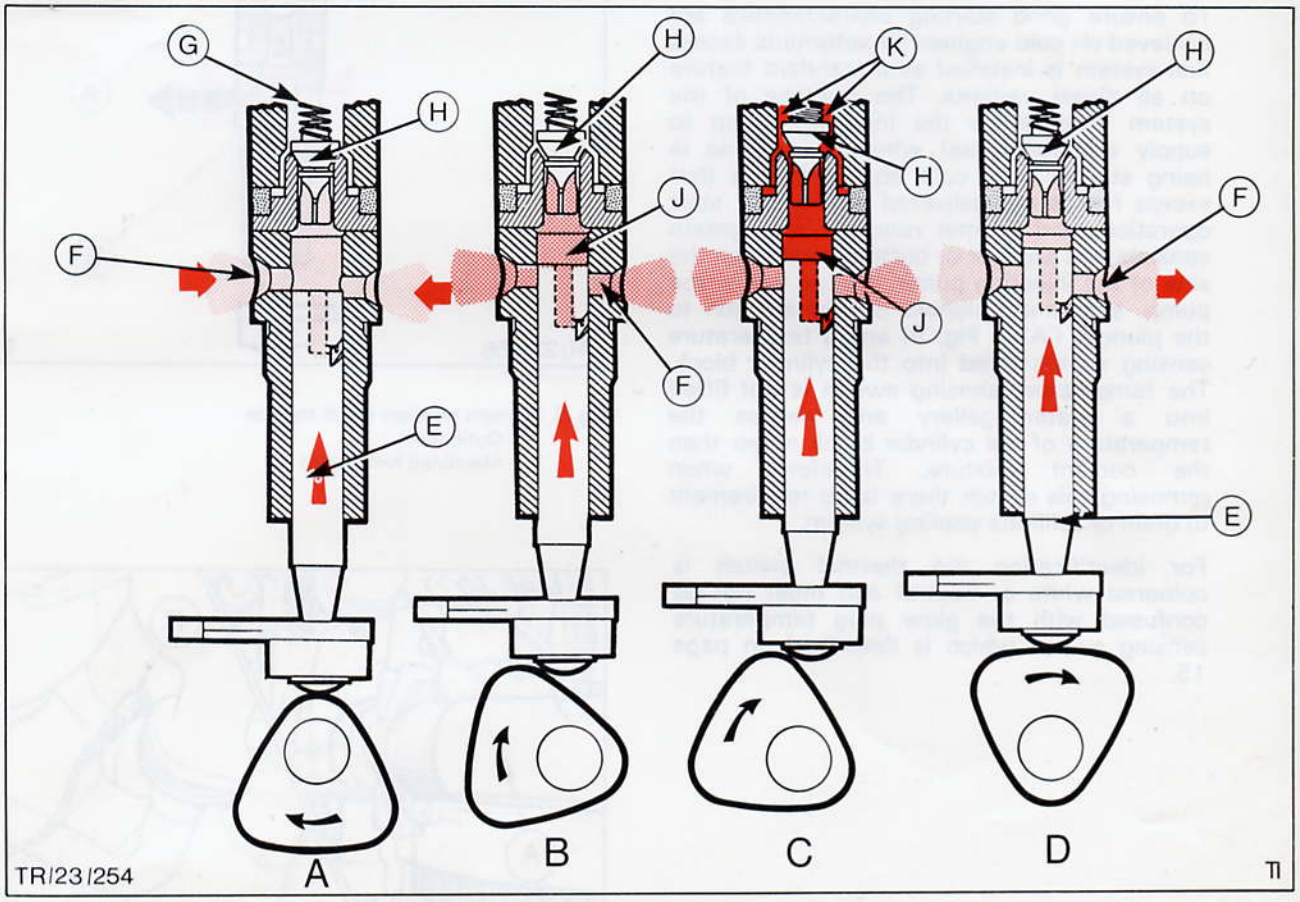


Fig. 6. Four stages of pumping element operation

Stage 'A'
- E – Plunger at start of stroke
- F – Inlet port open
- G – Pressure control spring
- H – Delivery valve closed

Stage 'B'
- F – Inlet port closed
- H – Delivery valve closed
- J – Fuel charge

Stage 'C'
- H – Delivery valve open
- J – Fuel charge at injection pressure
- K – Outlet port to injector open

Stage 'D'
- E – Plunger at top of stroke
- F – Return port open
- H – Delivery valve closed

PRINCIPLE OF OPERATION (cont'd)

As shown on the previous page the effective end of the injection stroke is when the helical slot machined into the plunger reaches the return port, and discharges the remaining fuel charge.

The element in Fig. 7 shows the position of the plunger when the engine is idling. Note that the end of the effective stroke is achieved with only a small amount of upward movement of the plunger. This results in a small amount of fuel being passed to the injector.

By rotating the plunger the effective end of the stroke can be altered. Fig. 8 shows the element at full throttle with the helical slot shortened, resulting an a longer effective plunger stroke and an increased fuel supply to the injector.

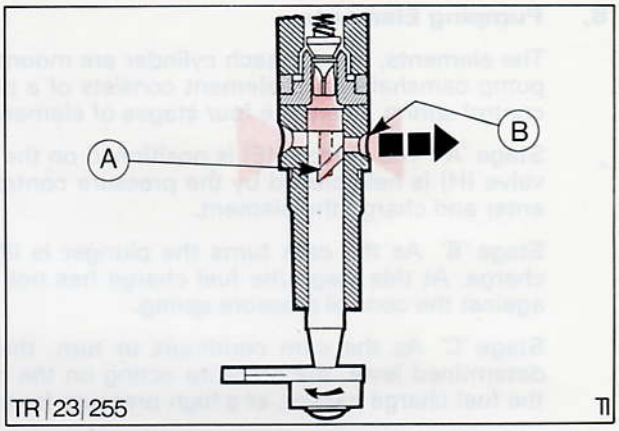


Fig. 7. Element positioned during engine idling
A – Machined helical slot
B – Outlet port

C. Excess Fuel System Fig. 9

To ensure good starting characteristics are achieved on cold engines an automatic excess fuel system is installed as a standard feature on all diesel variants. The purpose of the system is to allow the injection pump to supply additional fuel when the engine is being started from cold and to ensure that excess fuel is not delivered during 'hot' start operation, and normal running. The system consists of a plunger or button, located on the side of the injection pump, linkage within the pump, a control solenoid positioned next to the plunger ('A' in Fig. 9) and a temperature sensing switch fitted into the cylinder block. The temperature sensing switch is not fitted into a water gallery and senses the temperature of the cylinder block rather than the coolant mixture. Therefore, when removing this switch there is no requirement to drain or refill the cooling system.

For identification the thermal switch is coloured white or neutral and must not be confused with the glow plug temperature sensing switch which is described on page 15.

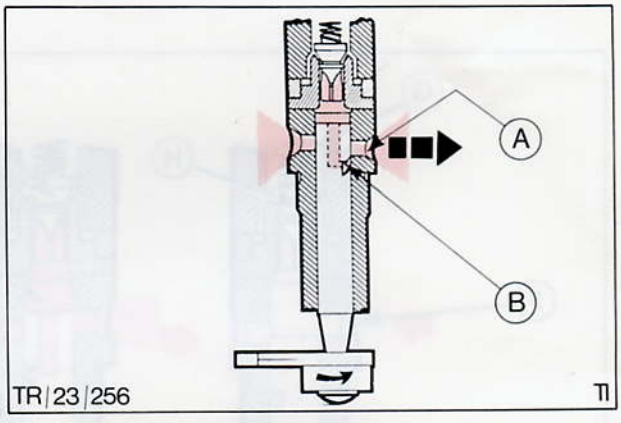


Fig. 8. Element position at full throttle
A – Outlet port
B – Machined helical slot

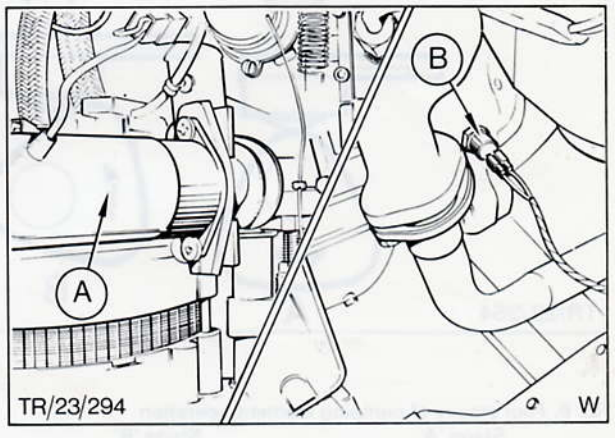


Fig. 9. Excess fuel system
A – Operating solenoid
B – Temperature sensing switch

PRINCIPLE OF OPERATION (cont'd)

Excess Fuel Plunger and Operating Linkage.

As already explained during normal operation fuel supply to the engine is increased by rotating the four injection pump elements. The elements are turned simultaneously by a control rod which moves backwards and forwards in response to either the governor or to the throttle pedal position.

During normal operation maximum movement of the control rod and therefore maximum fuel delivery to the engine is controlled by a stop bracket mounted at the end of the rod. Fig. 10, shows the situation when the engine is operating at full throttle with the control rod stop abutting the excess fuel stop. With the control rod in this position the air/fuel ratio will be correct to give maximum power from the engine.

During extreme cold start operations (at temperatures below 0 °C) the fuel supplied at full throttle will not be sufficient to readily start the engine. Under these conditions the excess fuel button is pushed inwards moving the shaft and excess stop bracket sideways, Fig. 11. This allows the control rod to override the normal stop position and results in the pump elements being turned past the full throttle position, supplying the engine with the increased amount of fuel required for cold start operation.

Control Components

Two control components are used in the excess fuel system, these are a operating solenoid, Fig. 12, and a temperature sensing switch. The solenoid operates the fuel button and the switch is designed to cut out the system during 'hot' start operation. The solenoid operates in two stages, firstly to push the excess fuel button into position and secondly to hold the button 'in' when the engine is being started. It is important to note that the solenoid is adjustable and if the unit is mal-adjusted it will quickly burn out. Full adjustment procedure is shown on the following page.

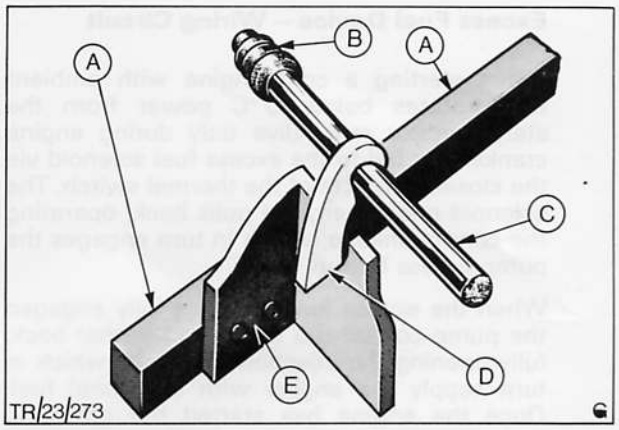


Fig. 10. Excess fuel device during normal full throttle operation
A – Control rod
B – Excess fuel button
C – Excess fuel shaft
D – Excess stop
E – Control rod stop

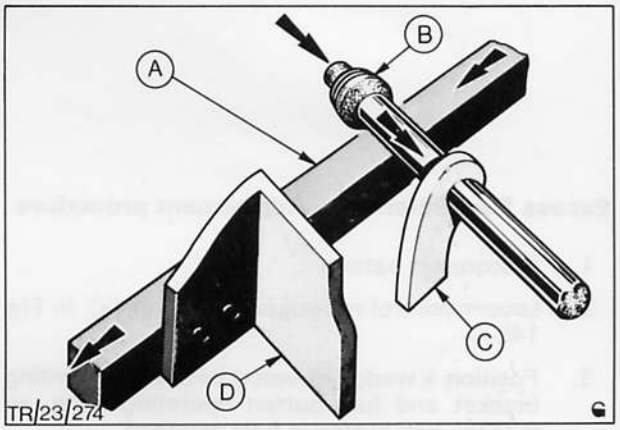


Fig. 11. Excess fuel device during cold start operation
A – Control rod moved back past normal stop
B – Excess button pushed in
C – Excess stop moved sideways
D – Control rod stop

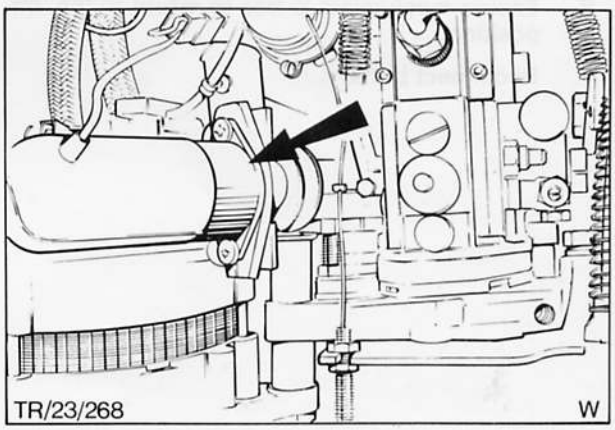


Fig. 12. Excess fuel operating solenoid

PRINCIPLE OF OPERATION (cont'd)

Excess Fuel Device – Wiring Circuit

When starting a cold engine with ambient temperatures below 0 °C power from the starter motor relay (live only during engine cranking) is fed to the excess fuel solenoid via the closed contacts of the thermal switch. The solenoid once energised pulls back, operating the control linkage, which in turn engages the pump excess button.

When the excess fuel button is fully engaged the pump control rod is allowed further back, fully opening the injection elements, which in turn supply the engine with additional fuel. Once the engine has started the governor, acting on the control rod, disengages the excess fuel device and so allows normal engine operation.

If the button fails to dis-engage the engine will run very roughly and at a low idle speed.

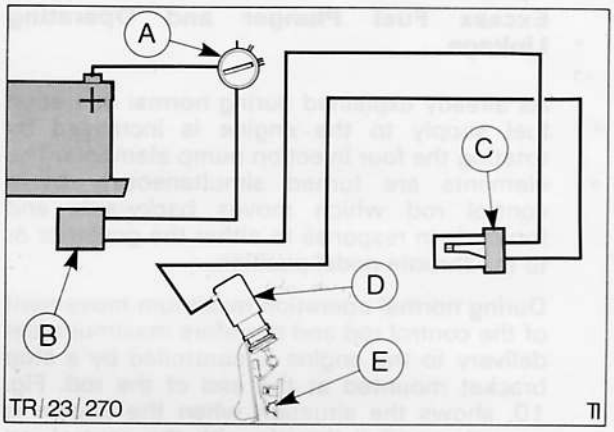


Fig. 13. Excess fuel System wiring circuit in operation (Simplified)
A – Ignition switch in start position
B – Starter motor relay energised
C – Thermal switch points closed
D – Fuel solenoid
E – Excess fuel button fully pushed in

Excess Fuel Solenoid – Adjustment procedure

1. Disconnect battery.
2. Loosen control rod adjusting clamp, ('C' in Fig. 14).
3. Position a wedge of wood between mounting bracket and fuel button operating lever, so that the fuel button is fully engaged.
4. Fully engage solenoid by pushing control rod (B) upwards as far as possible.
5. Secure control rod adjusting clamp and release wedge.
6. Ensure mechanism is free to return to the 'off' position.
7. Reconnect battery.

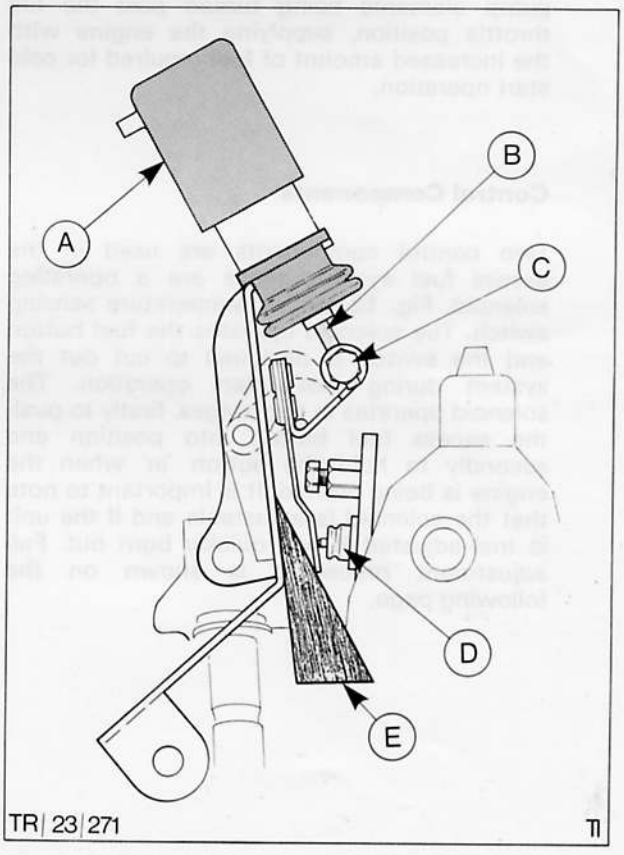


Fig. 14. Excess fuel solenoid adjustment
A – Solenoid
B – Control rod
C – Adjusting clamp
D – Excess fuel button
E – Adjustment wedge

PRINCIPLE OF OPERATION (cont'd)

D. Governor Control

In the diesel engine, idle adjustment by a stop screw to directly control the fuel delivery is not possible as the quantity of fuel required is very small and varies with ambient conditions and engine temperature. Any slight over adjustment or a change in ambient conditions would result in too much fuel being injected and the speed would rise. Also pumping efficiency improves as the speed rises so more fuel will be delivered and the engine speed could rise uncontrolably. Under adjustment would have the opposite effect and the engine would stall.

Limitations on maximum speed are imposed on the engine due to its heavy construction and also by the time required to deliver the fuel quickly enough to the engine for complete combustion. Incomplete combustion causes a smoky exhaust.

A Governor is incorporated to control both these extremes of speed, it also has a controlling effect on all intermediate speeds as well. This is termed a Variable Speed Governor and on the C.A.V. injection system is of the mechanical type.

The governor assembly is located at the front of the injection pump between the camshaft and auto-advance unit. It consists of two centrifugal weights, a weight carrier assembly, operating linkage and a control sleeve. The centrifugal weight carrier is bolted to the camshaft and the complete assembly including the two weights revolve at injection pump speed.

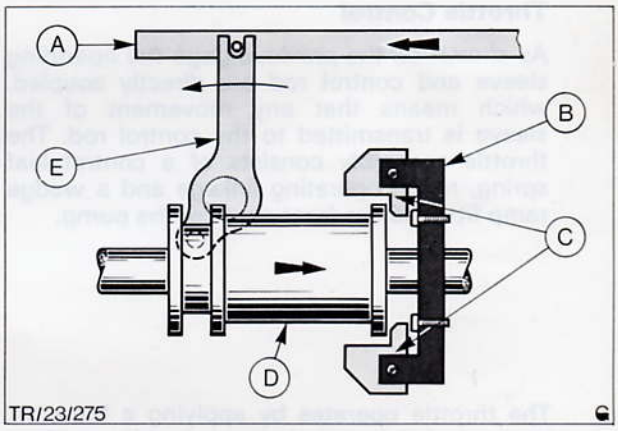


Fig. 15. Governor Assembly at full throttle and a low engine rpm (Side elevation)
A – Control rod
B – Weight carrier
C – Centrifugal weights
D – Control sleeve
E – Operating linkage

Fig. 15, shows the relative position of the governor components when the engine is at full throttle with a low engine speed. In this situation the two centrifugal weights are in their rest position applying a low force onto the control sleeve.

This allows the control sleeve and therefore the control rod to be positioned, by the throttle, in any location up to full throttle. (Throttle operation shown on the following page) Note that the control sleeve ('D' in Fig. 15) is located in its extreme right hand position.

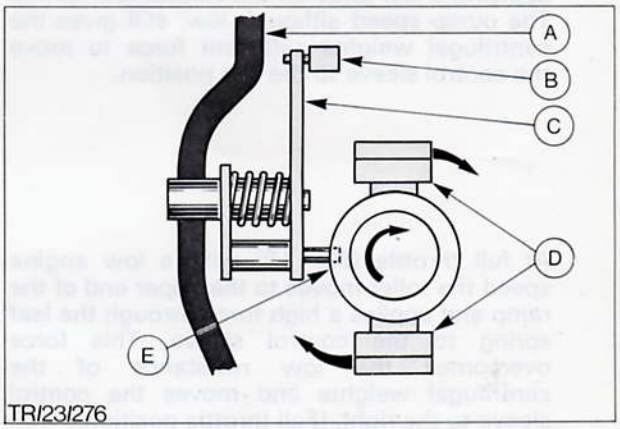


Fig. 16. Governor assembly (End elevation)
A – Pump casing
B – Control rod
C – Operating link
D – Centrifugal weights
E – Control sleeve

PRINCIPLE OF OPERATION (cont'd)

As engine speed increases the centrifugal weights are thrown outwards (refer to Fig. 17) and due to their shape, force the control sleeve to the left. This movement is transferred, via the operating link, to the control rod which closes the four pumping elements.

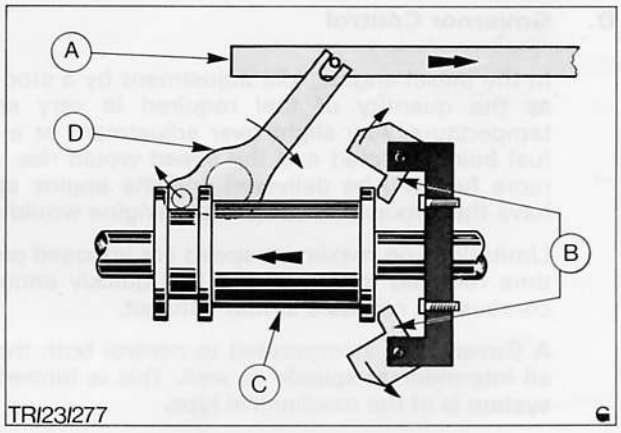


Fig. 17. Governor assembly at high engine rpm
A – Control rod
B – Centrifugal weights
C – Control sleeve
D – Operating linkage

Throttle Control

As shown on the previous page the operating sleeve and control rod are directly coupled, which means that any movement of the sleeve is transmitted to the control rod. The throttle assembly consists of a control leaf spring, roller, operating linkage and a wedge ramp fitted to the front cover of the pump.

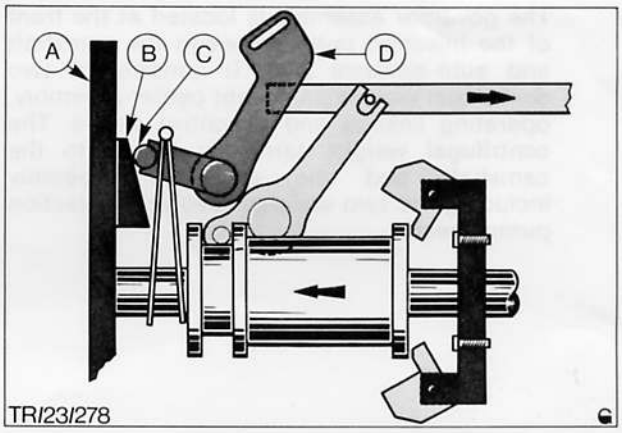


Fig. 18. Throttle and governor assembly during engine idling
A – Pump front cover
B – Wedge ramp
C – Roller
D – Throttle lever

The throttle operates by applying a force on the end of the control sleeve pushing against the action of the centrifugal weights. Fig. 18, shows the condition when the engine is at a low speed and the throttle pedal released (Engine idling). In this situation the roller is positioned at the lower end of the ramp applying a low force on the control leaf spring. The pump speed although low, still gives the centrifugal weights sufficient force to move the control sleeve to the idle position.

At full throttle (Fig. 19) with a low engine speed the roller moves to the upper end of the ramp and applies a high force through the leaf spring to the control sleeve. This force overcomes the low resistance of the centrifugal weights and moves the control sleeve to the right. (Full throttle position).

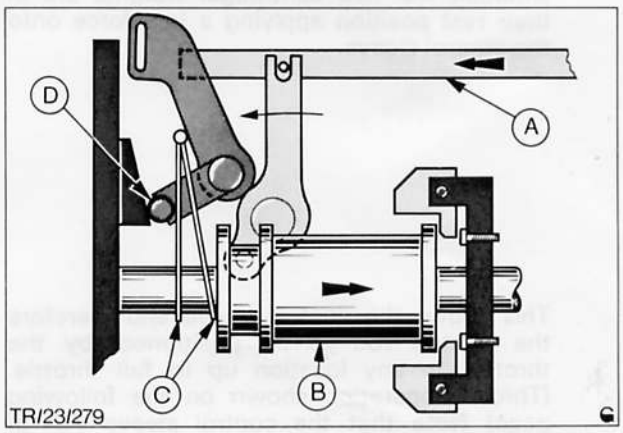


Fig. 19. Throttle and governor assembly during full throttle with a low engine rpm
A – Control rod (Full throttle)
B – Control sleeve
C – Leaf spring
D – Roller

PRINCIPLE OF OPERATION (cont'd)

As engine speed increases to a pre-determined maximum speed, the force of the two centrifugal weights moves the control sleeve to the left closing the two leaf springs together. This results in the control rod being moved to the right and closing down the four pump elements.

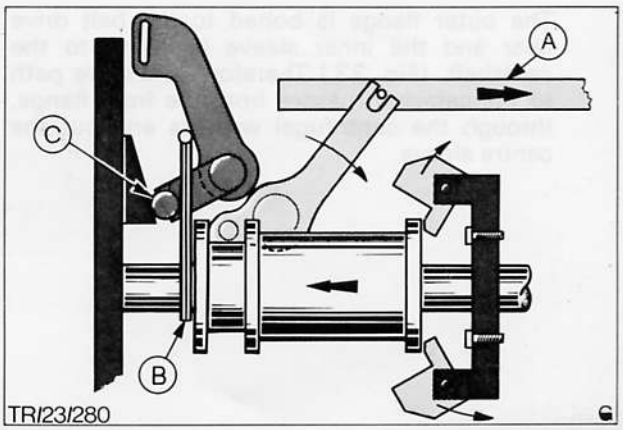


Fig. 20. Throttle and governor assembly during full throttle and high engine revs
A – Control rod
B – Leaf spring (Closed up)
C – Roller

E. Auto-Advance Unit

At low and medium engine speed the time allowed to inject the fuel into the cylinder is sufficient to ensure that fuel injection finishes at the correct point in the engine firing cycle. At high speed the time allowed to inject the fuel is radically reduced and if left un-controlled could lead to an incomplete burn resulting in loss of power and a smokey exhaust.

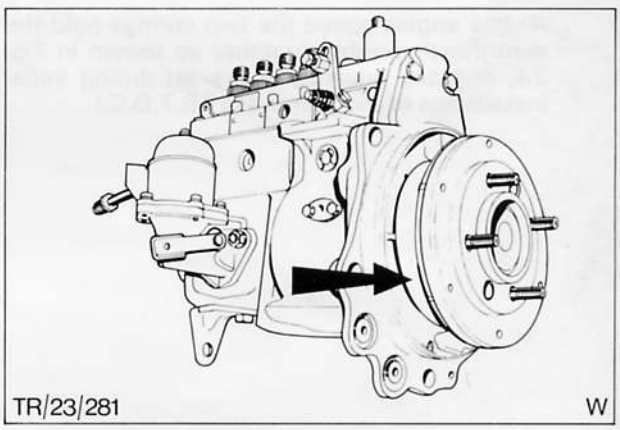


Fig. 21. Location of pump auto-advance unit

To overcome these problems an auto-advance unit is included in the pump to advance the start of injection delivery at high engine revs, thus ensuring that fuel injection is completed at the correct point in the firing cycle.

Located at the front of the injection pump (Fig. 21) the unit consists of 2 centrifugal weights ('C' in Fig. 22) control springs ('E') and advance sliders ('B').

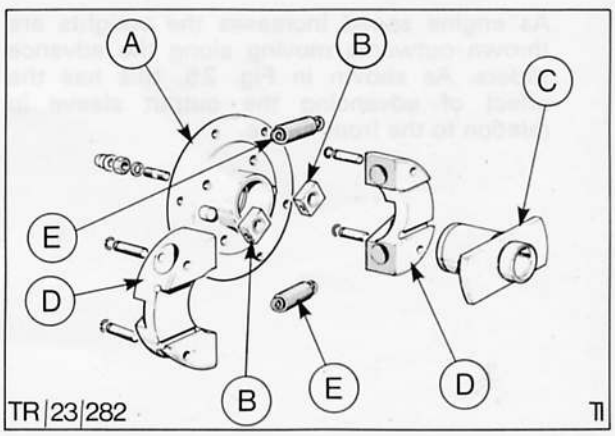


Fig. 22. Auto-advance unit (Exploded)
A – Drive flange
B – Advance slider
C – Centre sleeve
D – Centrifugal weights
E – Control springs

PRINCIPLE OF OPERATION (cont'd)

The outer flange is bolted to the belt drive gear and the inner sleeve is keyed to the camshaft. (Fig. 23.) Therefore, the drive path to the camshaft passes from the front flange, through the centrifugal weights and out the centre sleeve.

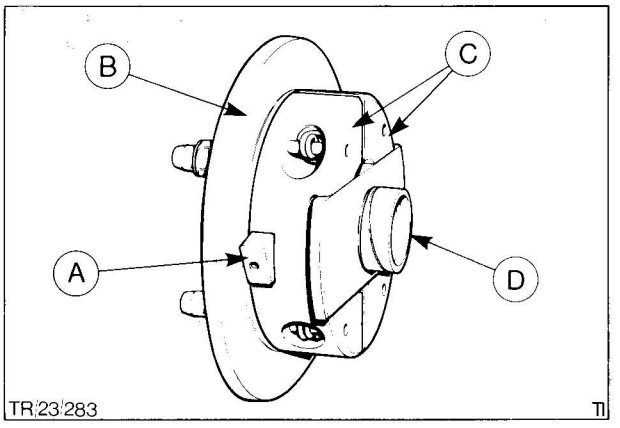


Fig. 23. Auto-advance unit
A – Advance slider
B – Front flange
C – Centrifugal weights
D – Centre output sleeve

At low engine speed the two springs hold the centrifugal weights together as shown in Fig. 24, and any advance is pre-set during initial installation of the pump. (11° B.T.D.C.)

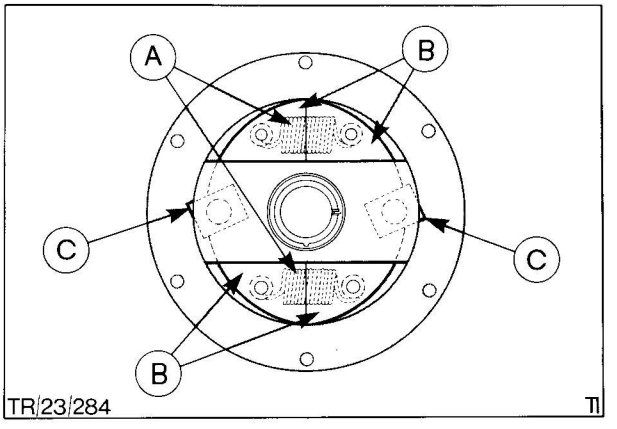


Fig. 24. Advance unit at low rpm (Zero advance)
A – Control springs
B – Centrifugal weights (held together)
C – Advance slider

As engine speed increases the weights are thrown outwards moving along the advance sliders. As shown in Fig. 25, this has the effect of advancing the output sleeve in relation to the front flange.

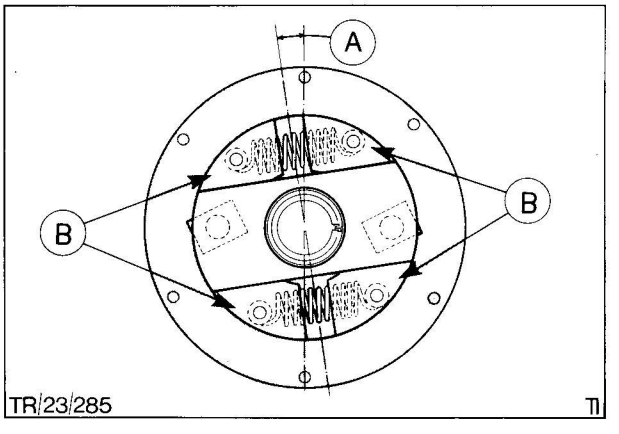


Fig. 25. Advance unit at high rpm (Maximum advance)
A – Degrees advance
B – Centrifugal weights thrown outwards

PRINCIPLE OF OPERATION (cont'd)

Sediment or Line Filter (Fig. 26)

The sediment or line filter is located on the right-hand wing panel beneath the battery. The purpose of the filter is to trap any large pieces of sediment before being passed to the main filter. The glass bowl should be removed and cleaned at the specified service interval.

Fig. 26. Sediment or line filter

Main Fuel Filter

The main filter is bolted onto the engine in the location shown in Fig. 27, and includes a bleed bolt fitted into the upper housing. The filter is of a cartridge type which has to be renewed at the specified service interval. Details of this procedure are covered in Operation 23–545. The filter has a very fine mesh to ensure that all dirt and grit are removed from the fuel before it enters the pump where the dirt would cause damage to the accurately machined surfaces.

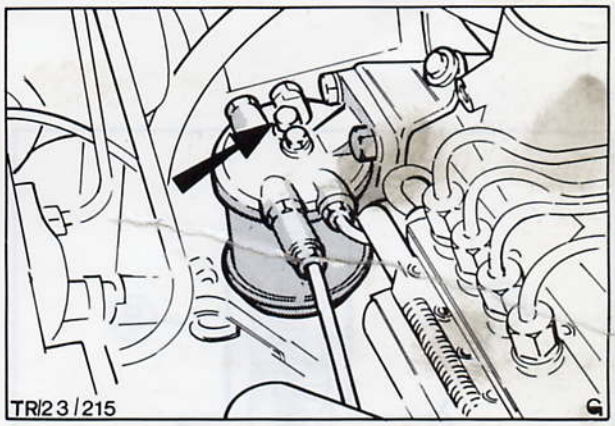


Fig. 27. Main fuel filter
Bleed bolt arrowed
(Air cleaner removed for clarity)

Injectors (Fig. 28)

The injectors are located down the left-hand side of the cylinder head and are held in position by 2 bolts. The type of injectors used are of the Pintle design (described overleaf) and operated by fuel pressure supplied from the pump.

The injectors carry out two functions, firstly to atomise the fuel into a fine mist during the power stroke, and secondly to ensure that fuel does not seep or drip into the cylinder during the other three strokes in the engine firing cycle. This type of injector does not carry out any metering or timing function, these operations being carried out by the injection pump.

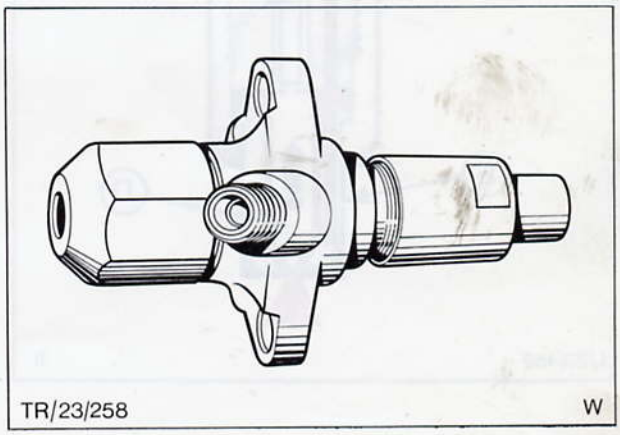


Fig. 28. Injector assembly

PRINCIPLE OF OPERATION (cont'd)

The basic components that make up the injectors, are a control spring, spindle, needle and nozzle body. (Refer Fig. 29, which shows the injector on its power stroke).

As already shown on previous pages the pump will supply the injectors at the correct time with the correct amount of fuel at a high pressure. This fuel enters the injector at point 'A' in Fig. 29, and due to its high pressure will lift the needle, and discharge into the cylinder. It is a combination of the shape and position of the needle and the high pressures that ensure the full atomization of the fuel. After the metered amount of fuel has been delivered the pressure will drop allowing the return spring to close the needle. The pressure figure when the valve starts to inject is called the needle opening pressure, which can be adjusted. This requires specialist tools and equipment which are usually only available in a fully equipped diesel pump room.

To disconnect injector pipes an open ring spanner should be used to ensure connections are not damaged.

Injector leak off system (See Fig. 30).

To ensure that the needle does not seize in its guide, these two components are lubricated by a controlled back leak of fuel up the needle guide, up past the spindle and return spring, and out through the leak off pipe back to the tank.

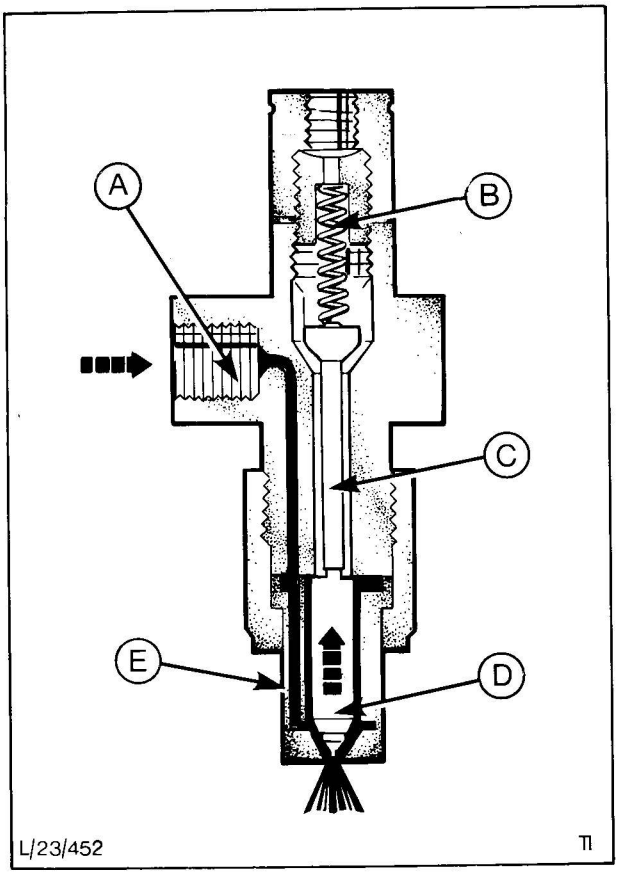


Fig. 29. Injector on the power stroke
A – Fuel inlet (high pressure)
B – Return spring
C – Spindle
D – Needle (raised)
E – Nozzle body

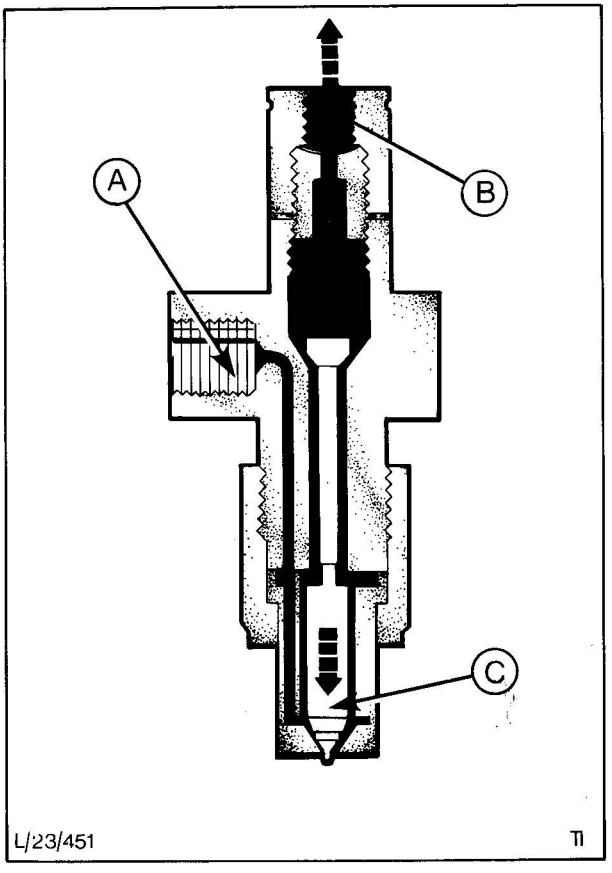


Fig. 30. Injector leak off system
A – Fuel inlet (low pressure)
B – Leak off connection
C – Needle (closed)

PRINCIPLE OF OPERATION (cont'd)

Glow Plug Starting Aid System

In addition to the excess fuel device a glow plug starting aid is fitted. The purpose of the plugs is to pre-heat the air in the pre-combination chamber before the engine is started. The heated air helps to atomize the fuel into a fine mist to ensure good starting characteristics are achieved. The Service life of the plugs are 45,000 km (30,000 miles) when they should be replaced. The procedures for this is detailed in Operation No. 23 772.

The glow plugs one for each cylinder are simple heater elements located in the cylinder head adjacent to each injector.

The No. 1 glow plug can be seen by inspecting the head, adjacent to the No. 1 injector, (Fig. 31), however the remaining 3 plugs are not visible unless the inlet manifold is removed.

Additional control components used in the system are a temperature sensing switch fitted into the cylinder head ('C' in Fig. 32) a time control unit 'A', and power relay 'B' fitted on the right-hand battery support panel, and a warning lamp. The time control unit controls the length of time that the plugs are allowed to operate and the switch cuts out plug operation on a hot engine.

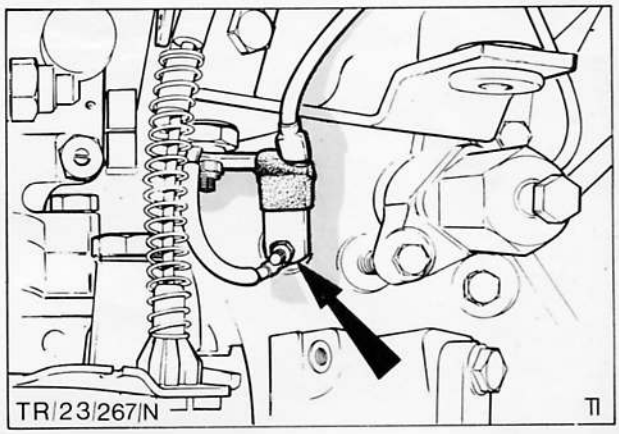


Fig. 31. No. 1 Glow plug positioned in cylinder head

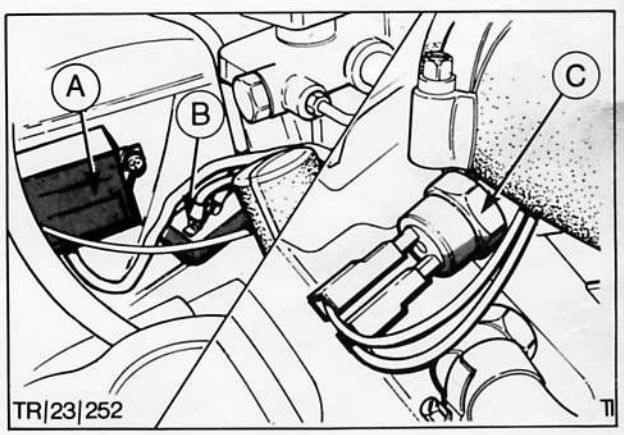


Fig. 32. Glow plug control components
A – Time control relay
B – Power relay
C – Coolant temperature sensor

Principle of Operation Refer Fig. 33

On a cold engine (at below approximately 40 °C) power from the ignition switch is fed to the time control unit and up through the warning lamp which lights up. The time control unit energises the relay via the closed contacts of the temperature switch, which in turn allows a heavy current to pass from the battery to the four glow plugs. After approximately 10 seconds at +10 °C or 20 seconds at −10 °C the time unit breaks part of the circuit, cutting off power to the warning lamp. At this point the engine can be started. During cranking the time control unit will still energise the relay enabling the plugs to pre-heat the air intake during the starting procedure. A safety feature of this system is that if the ignition is left in the 'ON' position and the engine is not cranked, the time control unit will cut off power to the relay after approximately 30 seconds.

If the engine fails to start the relay will be re-energised when the ignition is turned 'off' and then back 'on' again.

On a hot engine the contracts within the temperature switch will be open breaking any flow of current from the control unit to the relay.

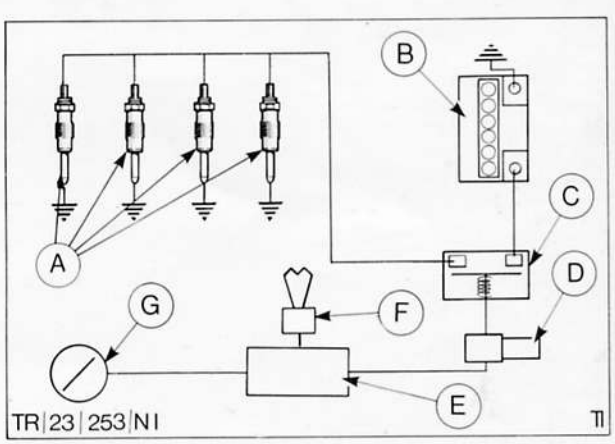


Fig. 33. Glow plugs wiring (Simplified)
A – Glow plugs
B – Battery
C – Power relay
D – Temperature sensing switch
E – Time control relay
F – Warning lamp
G – Ignition switch

DIAGNOSIS PROCEDURES

INTRODUCTION

The following procedures have been devised to assist in making the most accurate diagnosis of any fuel system problem with the least amount of trial and error work.

It will be found that, the diagnosis procedures detail the items to be checked and the manner of checking.

It is not intended to incorporate all the repair methods within the text, and whenever necessary, reference should be made to the appropriate section to establish the technical data and the method of carrying out each repair.

The fault diagnosis procedures are divided into seven categories which represent the most common categories of concern.

These are:

I. Engine will not start or is difficult to start.

II. Excessive exhaust smoke.

III. Engine starts and then stops.

IV. Uneven running/misfiring.

V. Lack of power/poor fuel consumption.

VI. Engine Surge (with throttle in fixed position).

VII. Engine 'Knock' (with incorrect fuel metering).

To make the most effective use of these diagnosis procedures, first test the vehicle to establish which category or categories you have to contend with. Having defined it as one of the general terms listed above simply refer to the relevant diagnosis chart and supplementary notes which follow each chart to establish the cause and the relevant remedy.

GENERAL NOTES

Requirements for Easy Starting:

An adequate quantity of properly atomised fuel delivered at the correct pressure, at the correct time, into the combustion chamber in which the compression of air has increased the temperature to readily ignite the fuel.

Requirements for Good Performance:

The most efficient generation of power is attained by the best possible combination of fuel and oxygen in the combustion chamber. Frictional losses throughout the vehicle must be kept to a minimum.

Requirements for Correct Speed Settings:

The specified idling and maximum no load speeds should be readily attained and held when the fuel pump control lever is in contact with the appropriate correctly set adjusting screw.

Requirements for Even Running:

All engine cylinders should give equal power output at evenly spaced intervals of the engine cycle at any given throttle opening and acceptable load. Engine mountings should hold the engine steady yet be sufficiently resilient to dampen normal engine vibration.

Requirements for Clean Exhaust:

If all the fuel and all the air in the combustion chamber were to be burnt this would be complete combustion. This ideal condition is approached but never realised in practice. However, no engine, if properly maintained and at its normal operating temperature, should emit more than a faint haze from the exhaust pipe.

Smoke is generated when combustion is unsatisfactory and therefore a proportion of the fuel is not doing useful work.

In the following notes it is assumed that the engine is in good condition and is therefore not burning excessive amounts of lubricating oil.

Black Smoke:

This consists of a large number of carbon particles which are produced when fuel is heated in 'oxygen lean regions' of the combustion chamber.

Blue Smoke:

This consists of large numbers of fuel oil particles of about 0,5 microns diameter or less.

These particles are condensed droplets of partially burnt or unburnt fuel which have passed through 'low temperature regions' of the combustion chamber, and may also be caused by burning lubricating oil caused by some mechanical defects.

White Smoke:

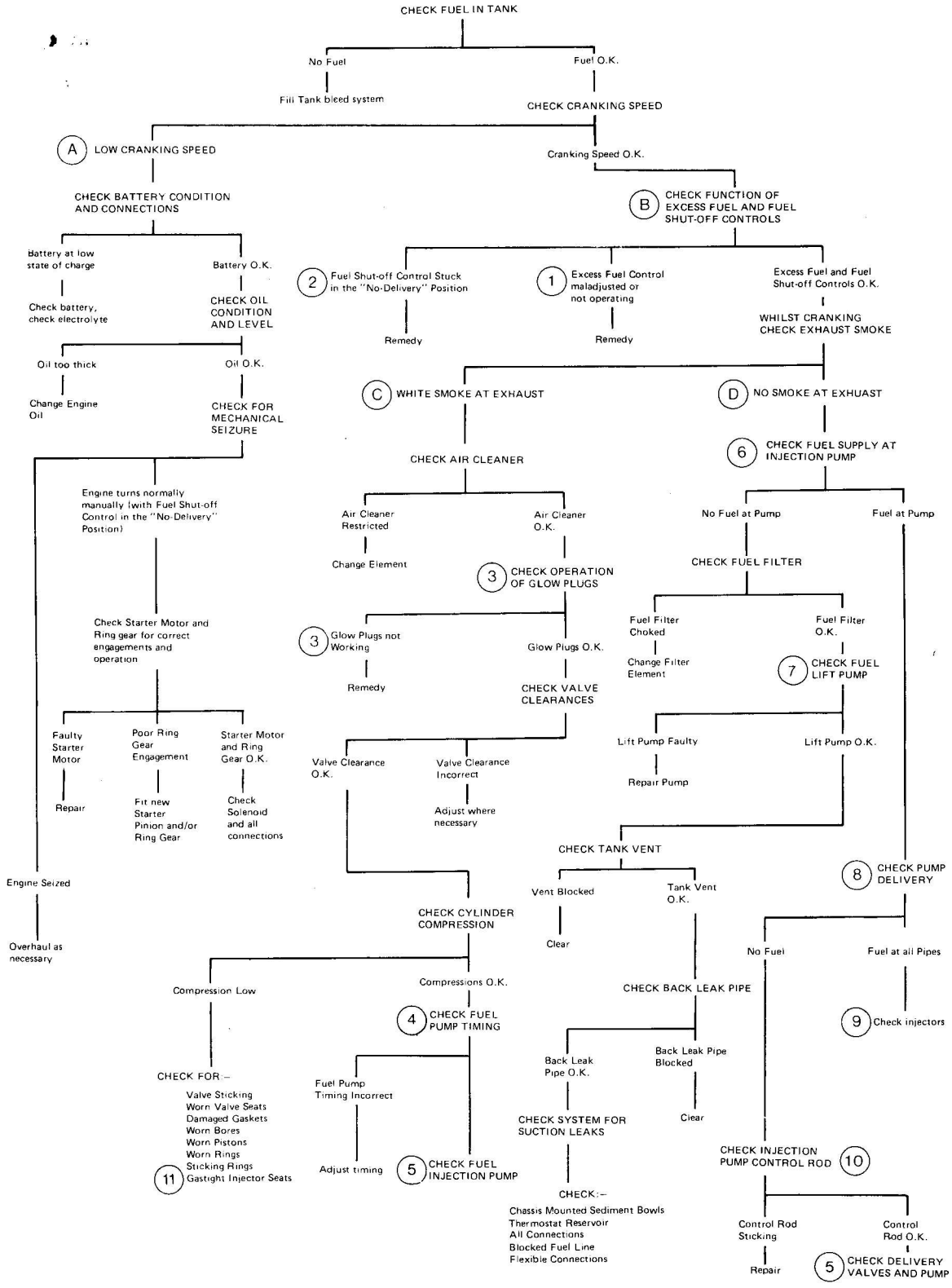
This consists of a large number of condensed droplets of partially burnt or unburnt fuel larger than about 1,0 micron diameter. To produce white smoke the fuel will have had more time to condense than for blue smoke, e.g. a cold engine running at light load and low speed could produce white smoke. Retarded injection timing would not give the fuel suitable conditions to burn correctly, and this can also produce white smoke.

It is important to realise that the majority of the items listed would not arise if the correct maintenance operations were carried out at the specified intervals.

Before any part of the fuel supply system is dismantled the surrounding area must be thoroughly cleaned. When the fuel system has been reassembled and all nuts tightened to the specified torque, it will be advisable to bleed the system to assist the self purge system.

DIAGNOSIS PROCEDURES (cont'd)

I ENGINE WILL NOT START OR IS DIFFICULT TO START



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DIAGNOSIS PROCEDURES (cont'd)

I. ENGINE WILL NOT START OR DIFFICULT TO START

Sympton 'A' Engine will not turn over at a sufficiently high speed.

For diagnosis information on this sympton reference should be made to either Section 36 (Batteries and Cables) Section 26 (Starter Motors) or Section 21 (Engines).

Item 'B' Excess fuel and fuel shut-off systems faulty.

1. Excess fuel control mal-adjusted – Full adjustment procedure shown on page 8.

   Excess fuel control inoperative – Operation of the excess fuel system can be checked by inspecting the solenoid, located on the excess pump button, which will be energised when the ignition is turned 'ON' at a cylinder temperature below 0 °C.

   At cylinder temperatures above 0 °C disconnect the cut out switch loom and fit a bridge between the two connections. Principle of Operation of the system is shown on page 6.

2. Fuel shut-off control. Check that when the ignition is turned 'ON' the shut-off motor and cable allows the stop control lever, on the pump, to return to the 'OFF' position.

Sympton 'C' White smoke at exhaust when the engine is being cranked – The white smoke proves that a fuel supply is being delivered to the engine.

3. Glow plug check procedure fully detailed in Operation 23 771. If all plugs fail to operate a voltmeter should be connected at the No. 1 glow plug terminal to ascertain if a voltage is available at the plug. If voltage is not available the wiring connections should be first checked and then the time control unit and relay checked by substitution. Principle of operation of the glow plug system is shown on page 15.

4. Check fuel pump timing – Full details of pump timing are shown in Operation 23 414.

5. If the injection pump is suspect the pump should be removed and overhauled by either C.A.V. or one of their authorised Agents.

Sympton 'D' No smoke at exhaust when the engine is being cranked – This would indicate that fuel is not being injected into the cylinder.

6. To check fuel delivery at the injection pump, disconnect the inlet pipe and crank engine.

7. To check lift pump disconnect the delivery connection and crank engine. If no fuel is delivered at this point the pump should be removed, dismantled and the diaphragm, lever and return spring checked for serviceability.

8. Check pump delivery by disconnecting the four injector pipes at the injectors and cranking engine.

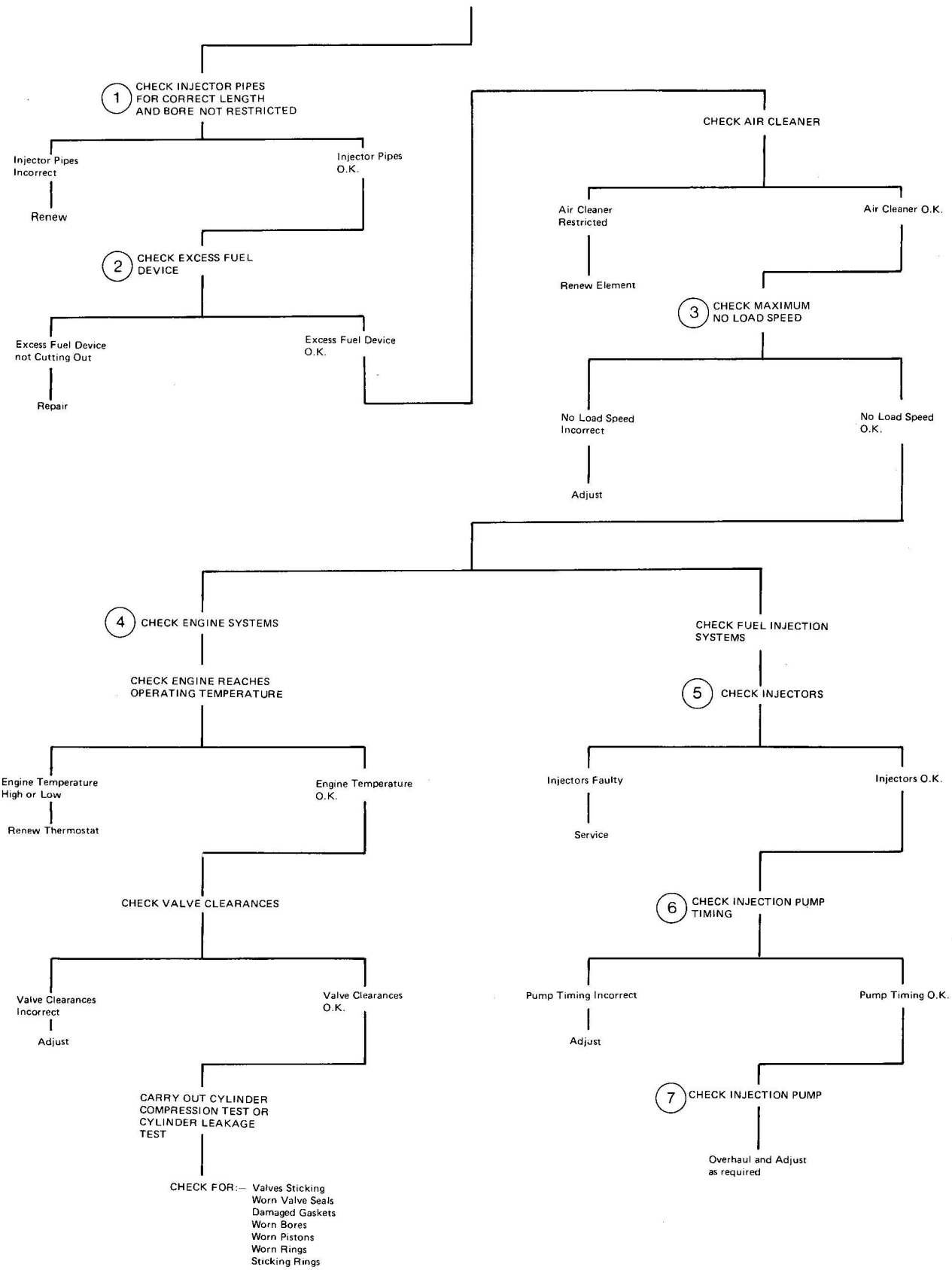
9. Injector check – Full details for checking and overhauling injectors are shown in Operation 23 454 8 on page 38.

10. Check injection pump control rod by removing the pump side cover, and moving the control rod backwards and forwards checking that the rod does not stick or bind.

11. Check that the injectors are a gas tight fit by inspecting the seals and replacing if required (Refer Operation 23 454) and ensuring the securing bolts are tightened to the specified torque.

DIAGNOSIS PROCEDURES (cont'd)

II EXCESSIVE EXHAUST SMOKE



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DIAGNOSIS PROCEDURES (cont'd)

II. EXCESSIVE EXHAUST SMOKE

CHART REFERENCE

1. Incorrect or damaged injection pipes can result in incorrect and unbalanced fuel distribution to the injectors. Check can be made visually.

2. Excess fuel device not cutting out – Visual inspection of the excess fuel button on the pump should confirm that the button has returned to its 'OFF' position. Also, if the button remains engaged the injection pump will baulk resulting in the engine running very rough and at a low idle speed. Principle of Operation for this system is shown on page 6.

3. Maximum no load speed – Procedure for this Operation is fully covered in Operation No. 23 413 on page 31.

   NOTE: The no load speed adjustment is sealed during pump manufacture and further adjustment must only be carried out by a C.A.V. Authorised Agent.

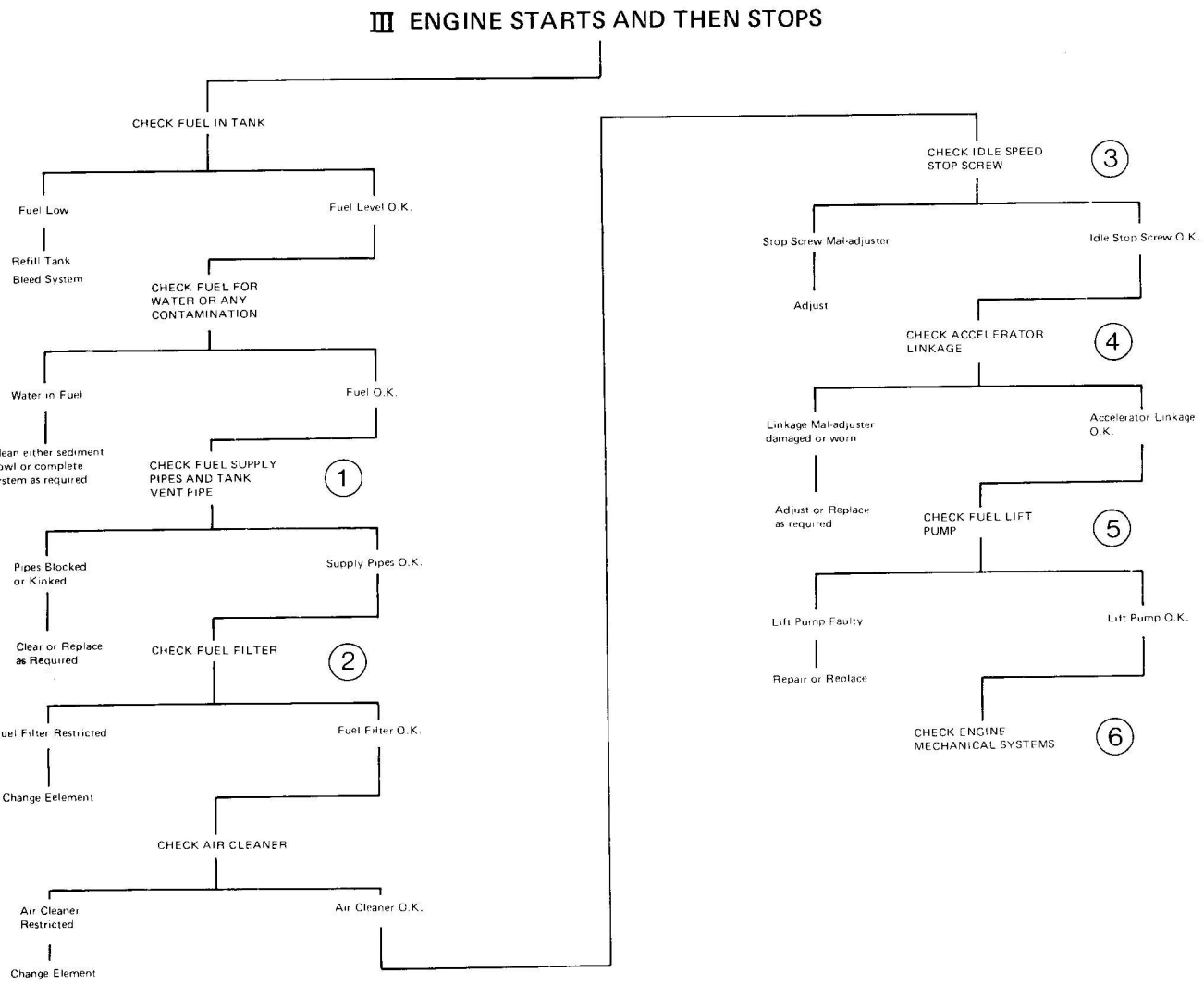
4. Engine systems – For further information and technical data for the engine operations reference should be made to the appropriate section in this Workshop Manual.

5. Injectors – Faulty injectors is one of the main causes of smoking exhausts and it is essential that they are serviced at regular intervals as laid out in the Service Voucher Book. The injectors should be checked for correct type, serviceable components and correct adjustment. Also, when injectors are removed ensure that the sealing washers are correctly fitted. Refer Operation No. 23 454 (Injector Remove and Install) and Operation No. 23 454 8 (Injector Overhaul).

6. Injection pump timing – Full details of pump timing check and adjustment are shown in Operation No. 23 414.

7. Injection pump – If the injection pump is faulty the pump should be removed and overhauled by either C.A.V. or one of their Authorised Agents.

DIAGNOSIS PROCEDURES (cont'd)



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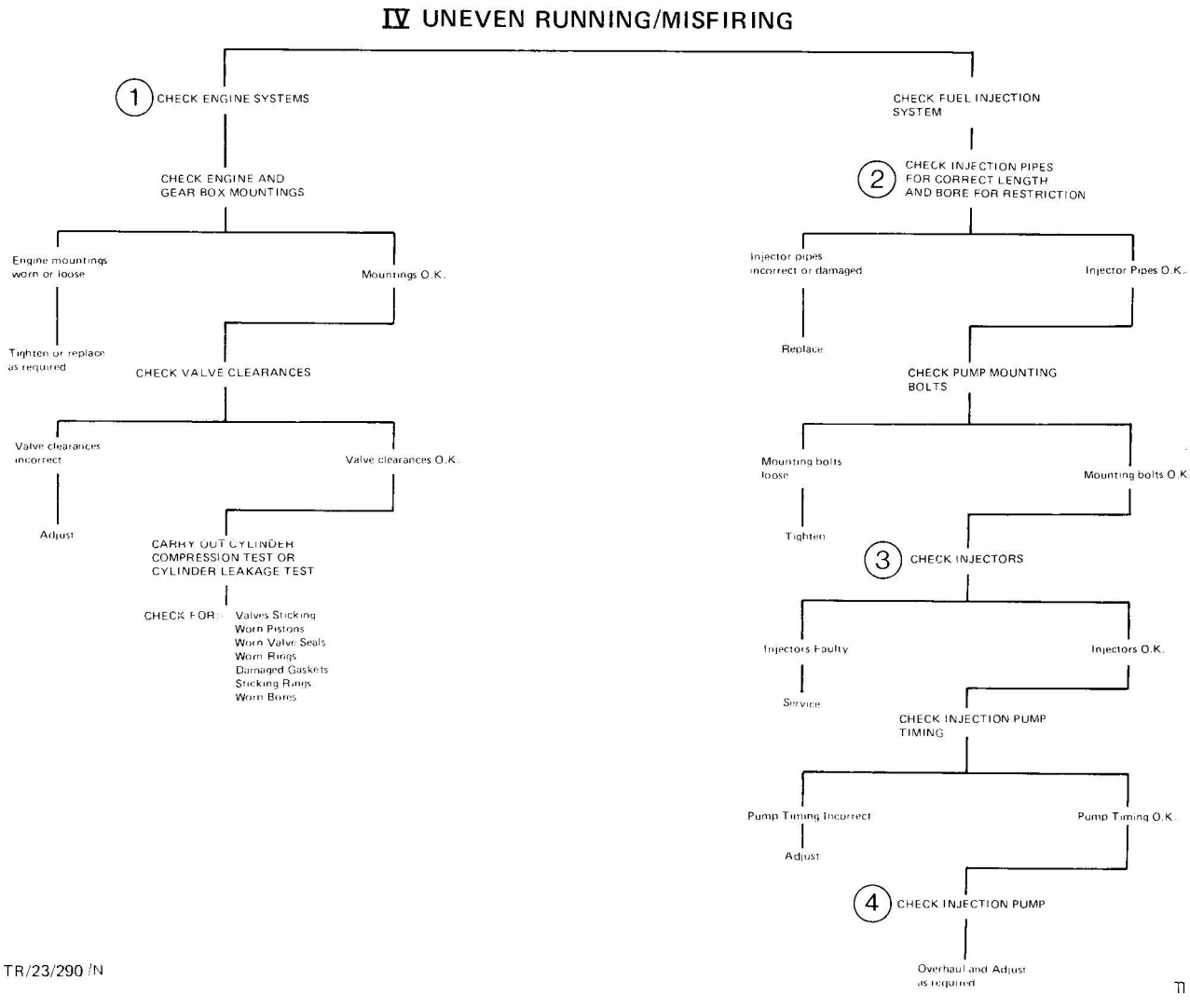
III. ENGINE STARTS AND THEN STOPS

This is usually caused by fuel starvation as shown on above illustration.

CHART REFERENCE

1. Fuel supply and vent pipes – All pipes should be visually checked for damage or kinking and if still suspect the fuel supply pipe should be disconnected and blown through using an air line. If the tank vent pipe is blocked the engine will normally run for a considerable time before stopping and if at this time the filler cap was to be removed this would cure the problem. Also, check pipe unions for correct torque.
2. Fuel Filter – The fuel filter should be renewed at regular intervals as detailed in the Service Voucher Book. Refer Operation No. 23 545.
3. Idle Speed Stop Screw – This adjustment, should be checked to ensure that the idle speed is not to low as to cause a stall condition.
4. Accelerator Linkage – Linkage should be checked for correct adjustment, damage or worn components. Adjust or replace as required.
5. Fuel Lift Pump – To check pump disconnect delivery connection and crank engine. If no fuel is delivered the pump must be removed, dismantled and the components checked for serviceability. Overhaul or renew as required.
6. Check engine mechanical system – For further information reference should be made to the appropriate section in this Manual.

DIAGNOSIS PROCEDURES (cont'd)



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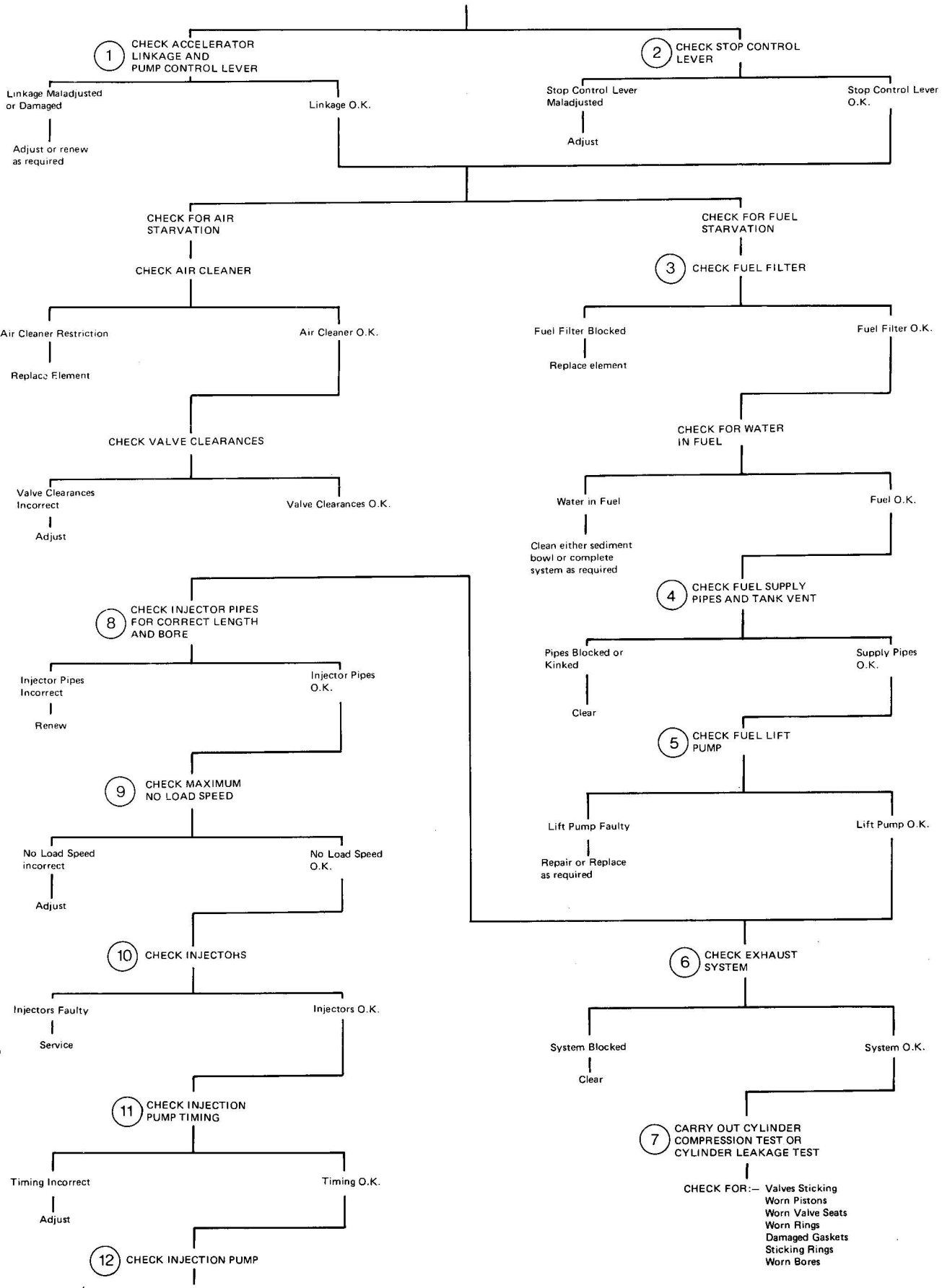
IV. UNEVEN RUNNING/MISFIRING

CHART REFERENCE

1. Check engine mechanical systems – For further information reference should be made to the appropriate section in this Manual.
2. Injector Pipes – Incorrect or damaged injection pipes can result in incorrect and unbalanced fuel distribution to the injectors. Checks can be made visually.
3. Injectors – To ensure a smooth drive is achieved it is essential that injectors are serviced at specified intervals as laid out in the Service Voucher Book. The injectors should be checked for correct type, serviceable components, and correct adjustment also when injectors are removed ensure that the sealing washers are correctly fitted. Refer Operation 23 454 (Injector Remove and Install) and Operation 23 454 8 (Injector Overhaul).
4. Injection Pump timing – Full procedure for pump timing check and adjustment are shown in Operation 23 414.
5. Injection Pump – If the injection pump is faulty the pump should be removed and overhauled by either C.A.V. or one of their Agents.

DIAGNOSIS PROCEDURES (cont'd)

V LACK OF POWER/POOR FUEL CONSUMPTION



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DIAGNOSIS PROCEDURES (cont'd)

V. LACK OF POWER/POOR FUEL CONSUMPTION

CHART REFERENCE

1. Accelerator Linkage – Linkage should be checked for correct adjustment damage or worn components.

   Pump lever should be checked for correct operation and secure fit.

2. Stop Control Lever – With the ignition 'ON' the lever should be checked to ensure it has fully returned and does not affect pump control rod operation.

3. Fuel Filter – It is essential for correct operation to ensure that the fuel filter is renewed at the specified service intervals, as outlined in the service voucher book.

4. Fuel supply and vent pipes – All pipes should be checked for damage or kinking and if still suspect the supply pipes should be disconnected, and blown through using an air line.

5. Fuel lift pump – To check pump disconnect the delivery connection and crank engine. If no fuel is delivered the pump must be removed, dismantled, and the components checked for serviceability. Overhaul or renew as required.

6. Check exhaust system – Check exhaust system for internal obstruction, as any obstruction will create a high back pressure and reduce power output.

7. Check engine compression – For further information on engine operation and technical data, reference should be made to Section 21, (Engines).

8. Injector pipes – Incorrect or damaged pipes can result in incorrect and unbalanced fuel distribution to the injectors. Checks can be made visually.

9. Check maximum no-load speed – Procedure for the check is shown in Operation 25 413 on page 31.

   NOTE: The no-load speed adjustment is sealed during pump manufacture and further adjustment must only be carried out by C.A.V. or one of their authorised agents.

10. Injectors – To ensure peak performance and economy the injectors must be serviced at the specified intervals laid down in the Service Voucher Book.

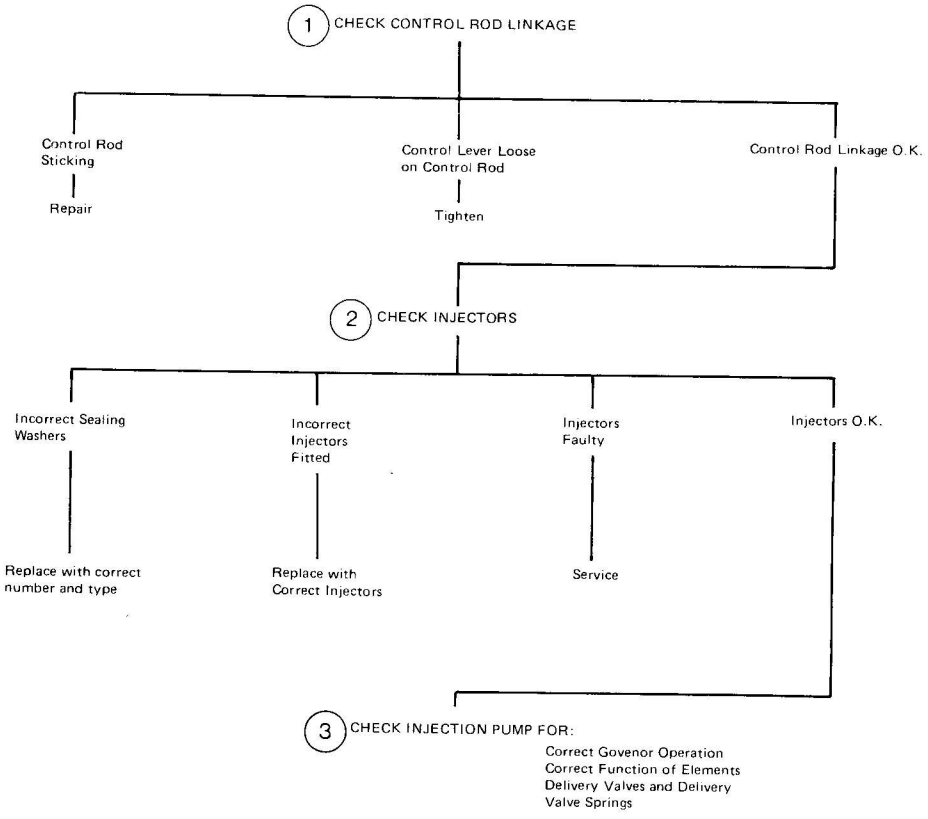
    The injectors should be checked for correct type, serviceable components and correct adjustment. Also when injectors are removed ensure that the sealing washers are correctly fitted. (Refer Operation 23 454 (Injector remove and install) and Operation No. 23 454 8 (Injector overhaul).

11. Injection pump timing – Full details of pump timing check and adjustment are shown in Operation 23 414.

12. Injection pump – If the injection pump is faulty the pump should be removed and overhauled by either C.A.V. or one of their authorised agents.

DIAGNOSIS PROCEDURES (cont'd)

VI ENGINE SURGE (WITH THROTTLE IN FIXED POSITION)



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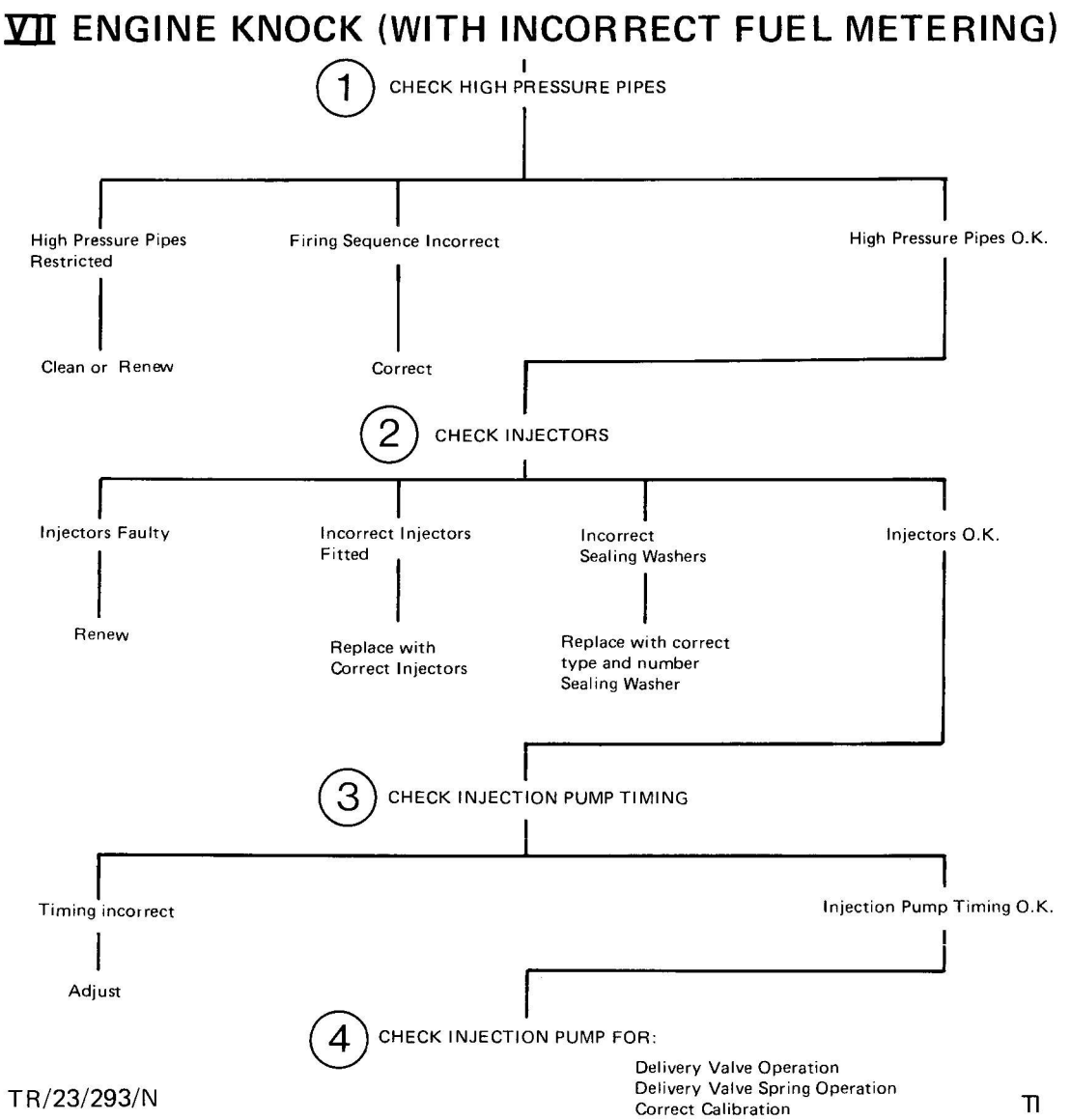
VI. ENGINE SURGE (WITH THROTTLE IN FIXED POSITION)

CHART REFERENCE

1. Check injection pump control rod by removing the pump side cover and moving the control rod backwards and forwards, checking that the rod does not stick or bind. Also ensure that the control lever is secure to the control rod.
2. Injectors – The injectors should be checked for correct type, serviceable components and correct adjustment. Also, when injectors are removed ensure that the sealing washers are correctly fitted. Refer Operation 23 454 (Injector Remove and Install) and Operation No. 23 454 8 (Injector overhaul).
3. Injection pump – If the injection pump is faulty the pump should be removed and overhauled by either C.A.V. or one of their Authorised agents.

DIAGNOSIS PROCEDURES (cont'd)



VII. ENGINE KNOCK (WITH INCORRECT FUEL METERING)

CHART REFERENCE

1. Check Injector Pipes – Incorrect or damaged injection pipes can result in incorrect and unbalanced fuel distribution to the injectors. Check can be made visually.
2. Injectors – The injectors should be checked for correct type, serviceable components and correct adjustment. Also when injectors are removed ensure that the correct number and type of sealing washers are fitted. Refer Operation 23 454 (Injector remove and install), and Operation 23 454 8 (Injector overhaul).
3. Injection pump timing – Full details of pump timing check and adjustment is shown in Operation 23 414.
4. Injection Pump – If the injection pump is faulty the pump should be removed and overhauled by either C.A.V. or one of their Authorised Agents.

SERVICE ADJUSTMENTS AND CHECKS

At specified service intervals the following items should be checked.

(a) Check and adjust idle speed.
Detailed in Operation 23 413.

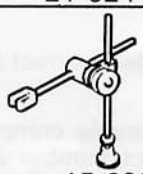
(b) Renew air filter element.
Detailed in Operation 23 184.

(c) Renew Diesel fuel filter.
Detailed in Operation 23 546.

(d) Check entire fuel system for evidence of leaks. If any are found they should be rectified immediately.

(e) Renew all four glow plugs.
Detailed in Operation 23 773.

SPECIAL SERVICE TOOL RECOGNITION

Tool	Tool Name
 21-016	Camshaft gear alignment pin
 21-024	Valve spring compressor
 21-024-01	Valve spring compressor
 21-024-02	Valve spring compressor adaptor
 15-022	Dial gauge holding fixture
 15-046	Metric dial gauge

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SERVICE AND REPAIR OPERATIONS – CONTENT

DIESEL FUEL SYSTEM		Described in this publication	Contained in operation
23 142	Fuel system bleed	X	
23 174	Air cleaner assembly – remove and install	X	
23 184	Element – air cleaner – replace	X	
23 411	Injection pump – adjust timing		23 414
23 413	Engine idle speed – adjust	X	
23 414	Injection pump – remove and install	X	
23 414 4	Injection pump – remove and install (engine removed)		23 414
23 451 1	Injector – check (one) (injector removed)		23 454 8
23 454	Injector – remove and install (one)	X	
23 454 8	Injector – overhaul (one) (injector removed)	X	
23 455	Injectors – remove and install (all)		23 454
23 455	Injectors – remove and install (all) (air cleaner removed)		23 454
23 482	Pipe – injector delivery – remove and install (one)		23 483
23 483	Pipes – injector delivery – remove and install (all)	X	
23 485	Pipe – injector leak off – remove and install	X	
23 532	Fuel pump – clean	X	
23 534	Fuel pump – remove and install	X	
23 543	Filter – fuel line – clean	X	
23 544	Filter – fuel line – remove and install	X	
23 545	Fuel filter – remove and install	X	
23 546	Element – fuel filter – replace	X	
23 548	Fuel reservoir – remove and install	X	
23 588	Fuel line – fuel pump to fuel filter – remove and install	X	
23 592	Fuel line – fuel filter to injection pump – remove and install		23 588
23 594	Fuel line – fuel reservoir to fuel tank – remove and install		23 588
23 595	Fuel line – fuel reservoir to injection pump – remove and install		23 588
23 771	Glow plugs – check operation	X	
23 772	Glow plug – remove and install (one)		23 773
23 773	Glow plugs – remove and install (all)	X	
23 842	Cable – stop control – remove and install	X	

23 142 FUEL SYSTEM – BLEED

Special Service Tools Required: None

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Position drain tray beneath fuel filter and loosen filter bleed bolt by approximately half a turn, Fig. 34.
4. Using the hand priming lever (located on the lower half of the fuel lift pump, Fig. 35) bleed filter by pumping fuel through the bleed bolt until all air is removed. Tighten bleed bolt.
5. Bleed injection pump assembly by loosening bleed bolt on pump, Fig. 35, and manually pumping fuel through bleed bolt.
6. Tighten pump bleed bolt, and remove drain tray.
7. Reconnect battery.
8. Remove fender covers and close hood.

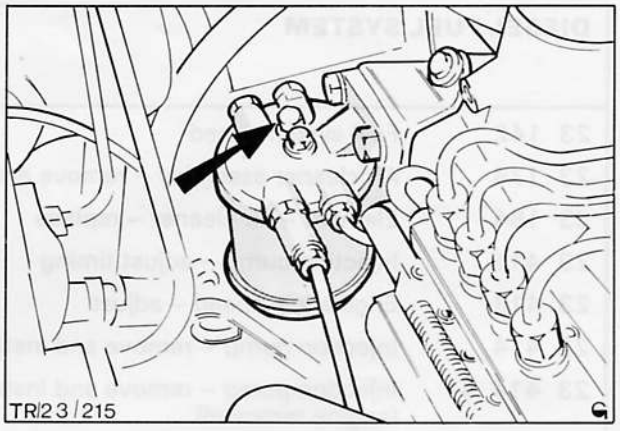


Fig. 34. Fuel filter bleed bolt
Air cleaner removed for clarity

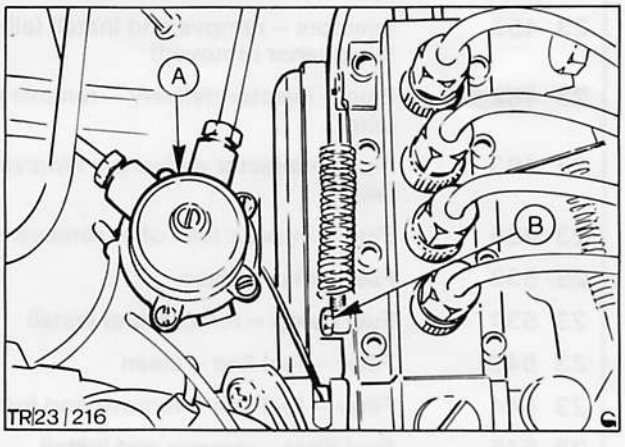


Fig. 35. Fuel injection pump
A – Fuel lift pump
B – Pump bleed bolt

23 174 AIR CLEANER – REMOVE AND INSTALL

Special Service Tools Required: None

To Remove

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Remove centre wing bolt, one mounting stay bolt and detach cleaner assembly, Fig. 36.

To Install

4. Position cleaner assembly and secure with 2 bolts.
5. Reconnect battery.
6. Remove fender covers and close hood.

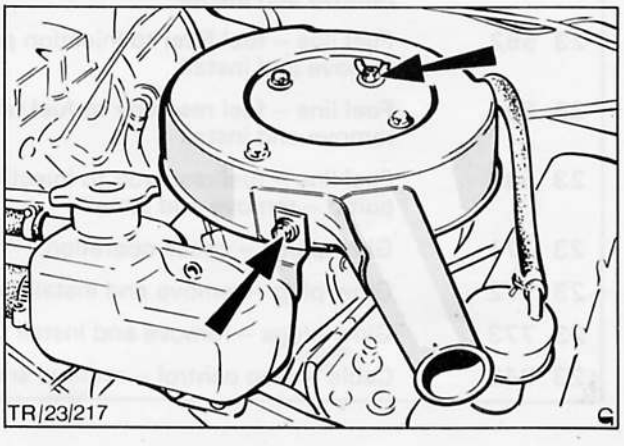
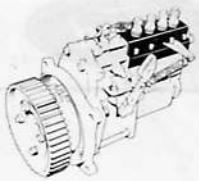


Fig. 36. Air cleaner securing bolts



23 184 ELEMENT – AIR CLEANER – REPLACE

Special Service Tools Required: None

To Remove

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly. Detailed in Operation 23 174.
4. Remove three bolts, split cleaner into two sections, and remove element, Fig. 37.

To Install

5. Using a new element re-assembly cleaner, and secure three bolts.
6. Refit air cleaner assembly.
7. Reconnect battery.
8. Remove fender covers and close hood.

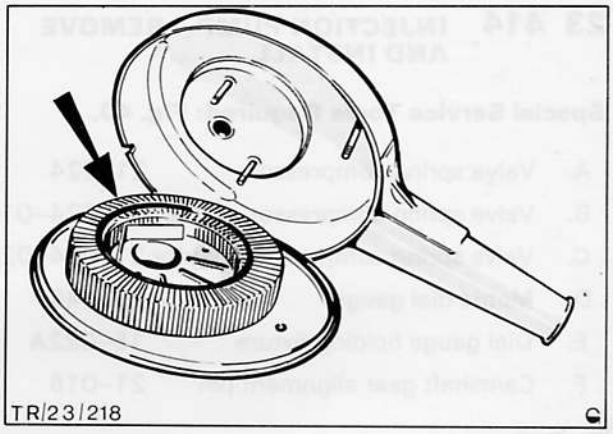


Fig. 37. Air cleaner element removal

23 413 ENGINE IDLE SPEED – ADJUST

Special Equipment Required: Tachometer

1. Open hood, and fit fender covers.
2. Run engine at full throttle and check maximum no-load speed. Do not hold throttle for longer than 5 seconds. An ideal type of tachometer is the strobe type, Fig. 38.
   NOTE: The maximum no-load adjustment is sealed and must only be adjusted by C.A.V. or one of their agents.

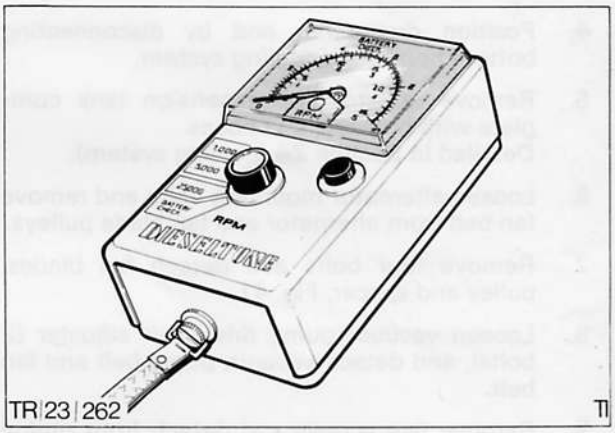


Fig. 38. Strobe type tachometer

3. Check and adjust idle speed by loosening the lock nut shown in Fig. 39, and screwing in or out the adjusting screw.
4. Remove fender covers and close hood.

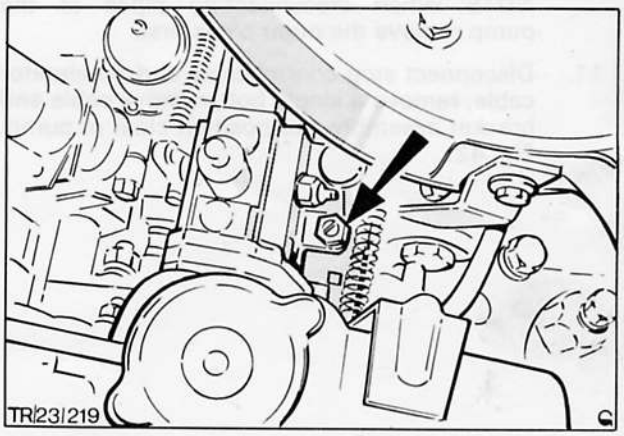
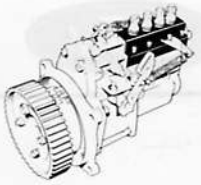


Fig. 39. Idle speed adjuster



23 414 INJECTION PUMP – REMOVE AND INSTALL

Special Service Tools Required: Fig. 40.

A.	Valve spring compressor	21–024
B.	Valve spring compressor adaptor	21–024–01
C.	Valve spring compressor adaptor	21–024–02
D.	Metric dial gauge	15–046
E.	Dial gauge holding fixture	15–022A
F.	Camshaft gear alignment pin	21–016

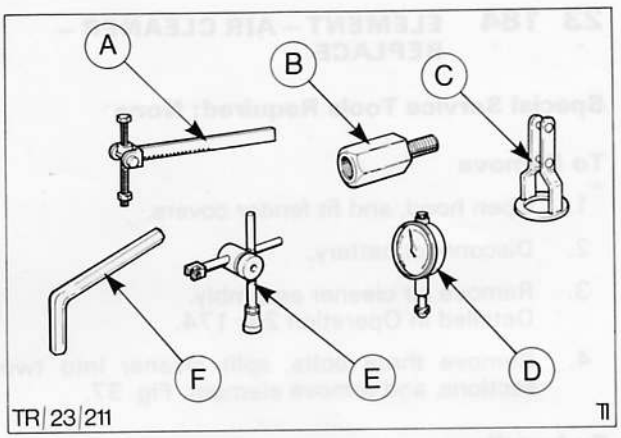


Fig. 40. Special tools requirement

To Remove

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly.
   Detailed in Operation 23 174.
4. Position drain tray and by disconnecting bottom hose drain cooling system.
5. Remove radiator and expansion tank complete with brackets and hoses.
   Detailed in Section 24 (cooling system).
6. Loosen alternator mounting bolts and remove fan belt from alternator and fan blade pulleys.
7. Remove four bolts and detach fan blades, pulley and spacer, Fig. 41.
8. Loosen vacuum pump drive belt adjuster (2 bolts), and detach vacuum pump belt and fan belt.
9. Remove five screws and detach front timing belt cover.
   A right angled cross-head screwdriver is a useful tool to remove screws.
10. Remove four injector supply pipes and fit dust caps to injectors and pump connections.
    NOTE: When disconnecting pipes at the pump remove the outer pipes first.
11. Disconnect stop control cable and accelerator cable, remove a single bolt, remove cable and bracket assembly and position clear of pump, Fig. 42.

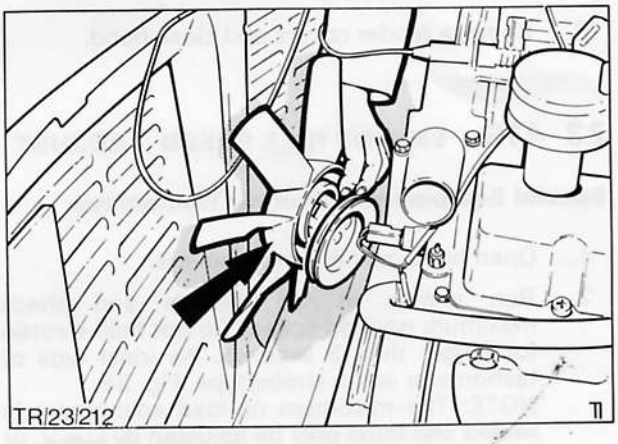


Fig. 41. Fan blade and pulley removed

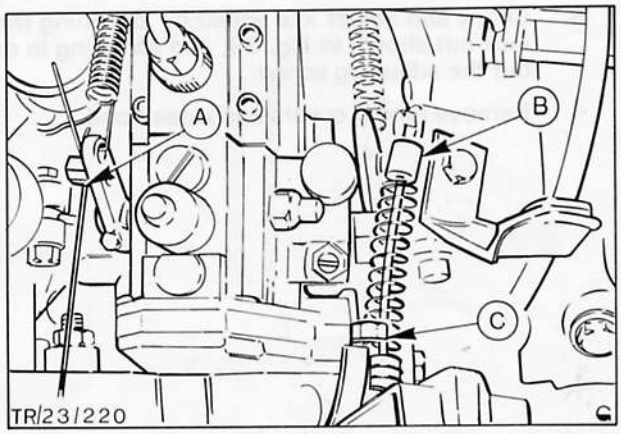
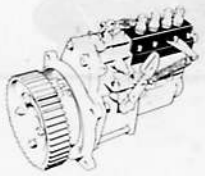


Fig. 42. Pump cable connections
A – Stop control cable
B – Accelerator cable
C – Cable bracket securing bolt



12. Disconnect fuel lift pump inlet and outlet pipes, and injection pump to filter pipe, Fig. 43.

13. Remove 2 bolts and detach fuel filter assembly, Fig. 43.

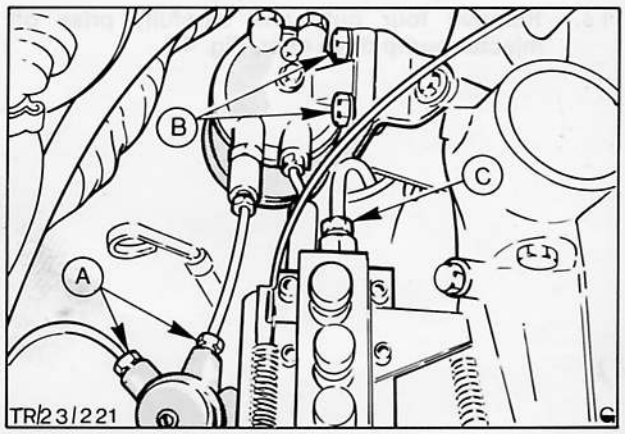


Fig. 43. Fuel filter assembly
A – Lift pump fuel connections
B – Filter securing bolts
C – Pump inlet connection

14. Using the timing marks on the crankshaft pulley and peg in the camshaft gear turn engine to T.D.C. No. 1, Fig. 44.

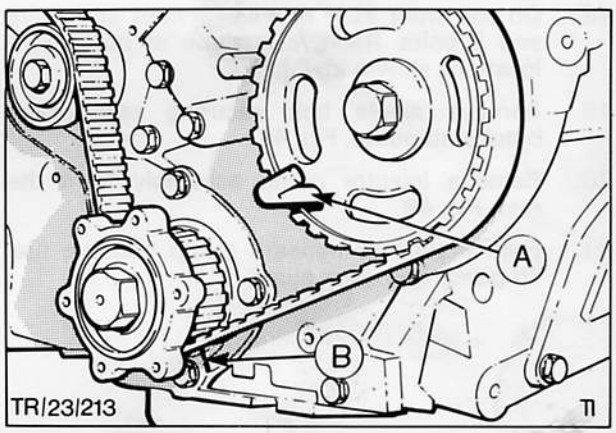


Fig. 44. Engine set on T.D.C. No. 1
(Crankshaft pulley removed for clarity)
A – Camshaft peg
B – Crankshaft T.D.C. marks

15. Loosen drive belt tensioner bolts swing tensioner away from belt and lock in this position, (Refer 'A' in Fig. 45).

NOTE: The centre bolt does not have a captive nut and it may be necessary to hold the nut with a ring spanner from the rear (Refer 'B' in Fig. 45, which shows the nut when the pump is removed).

16. Remove drive belt from gears.

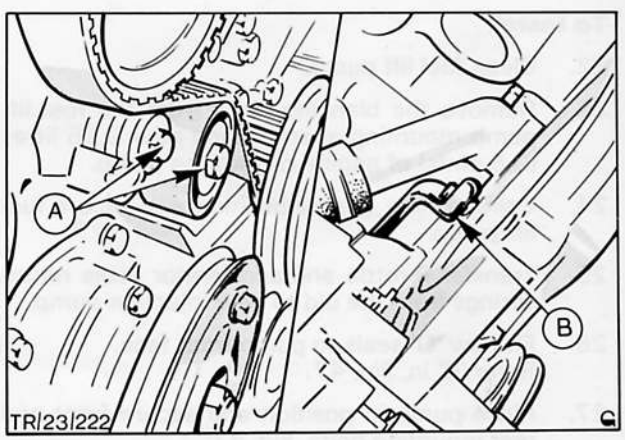
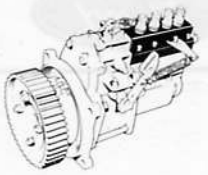


Fig. 45. Drive belt tensioner
A – Securing bolts viewed from the front
B – Securing nut viewed from the rear



17. Remove four nuts and carefully prise off injector pump drive gear, Fig. 46.

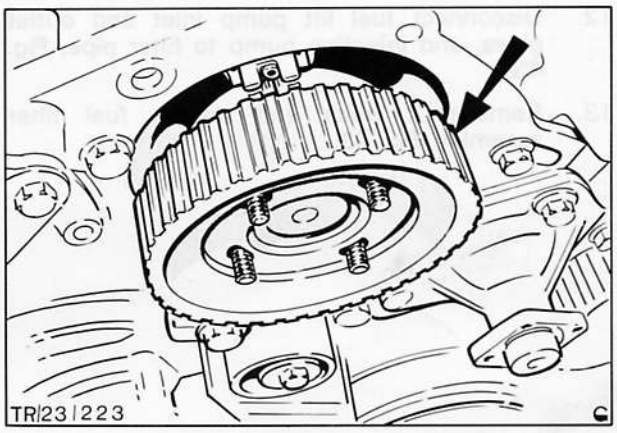


Fig. 46. Injection pump drive gear

18. On the front face remove 3 nuts and bolts and 2 bolts. Relative position of pump bolt locations shown in, Fig. 47.
19. Remove single bolt securing rear pump bracket to pump, Fig. 47.
20. Remove injector pump assembly from the rear, Fig. 48.
21. Hold drain tray beneath pump, remove fuel lift pump and drain pump.

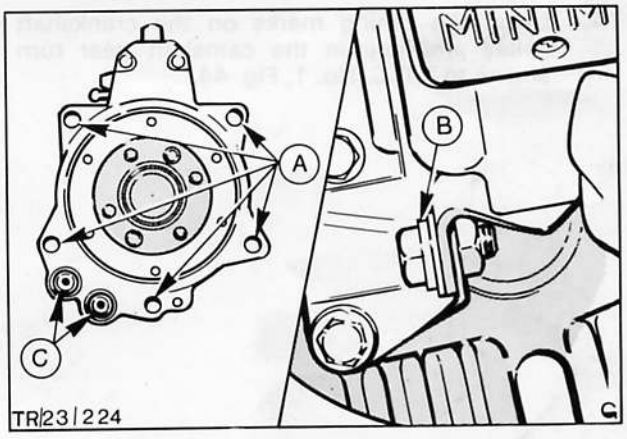


Fig. 47. Injection pump mounting point
A – Pump front face securing bolt holes
B – Pump rear mounting bolt
C – Injection pump oil seals

To Install

22. Clean fuel lift pump.
23. Remove the blanking plate from the fuel lift pump mounting aperture and pour 0,25 litres (0,5 pints) of engine oil into the pump.
24. Using a new gasket position and secure fuel lift pump.
25. Transfer throttle and accelerator cable return springs from the old to new injection pump.
26. Fit new 'O' seals to pump front face. Refer 'C' in, Fig. 47.
27. Place pump in position and secure front and rear mounting bolts, Fig. 47.

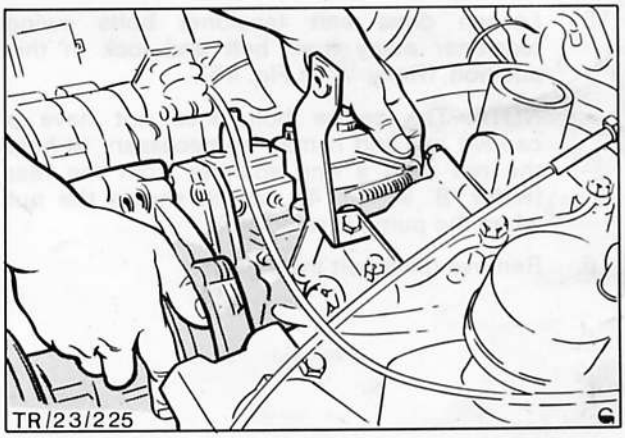
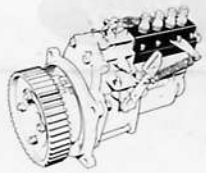


Fig. 48. Injection pump removal



28. Refit drive gear ensuring studs are in the centre of the elongated slots and loosely fit plate and four securing nuts, Fig. 49.

29. Ensure camshaft peg is still fitted and crankshaft lined up at T.D.C. Turn pump to the T.D.C. position as shown in Fig. 49, and refit drive belt.

30. Slacken belt tensioner actuate tensioner mechanism by sharply depressing the longest span of the belt and tighten retaining bolts, Fig. 45. Remove camshaft peg and rotate engine 2 revolutions to settle belt, refit T.D.C. peg.

31. Set engine to spill timing position as follows:

    A. Remove six screws and detach rocker cover.

    B. Loosen No. 1. exhaust valve adjuster screw clear of push rod. Slide rocker arm sideways, detach push rod and turn rocker arm through 90°, Fig. 50.

    C. Remove valve stem cap and using the valve spring compressor with suitable adaptors detach No. 1 exhaust valve spring, and valve stem seal. Allow valve to drop down onto piston.

    D. Mount dial gauge and adaptors using the rocker cover securing screw location and position gauge onto the valve stem, Fig. 51.

    E. Remove camshaft peg and using the gauge accurately set engine to T.D.C. Zero gauge. Turn engine backwards (anti-clockwise at the camshaft pulley) to a position where the piston has dropped 7 mm (seven complete revolutions on gauge).

    NOTE: Do not turn engine 360° as valve would drop into cylinder bore.

    F. Turn engine forward (clockwise at crankshaft) 6,01 mm and hold. At this position the front piston will be positioned 0,99 mm before top dead centre.

    IMPORTANT NOTE: If the final 0,99 mm position is passed the engine should be turned back to the 7 mm position sub operation (e) and sub operation (f) then repeated.

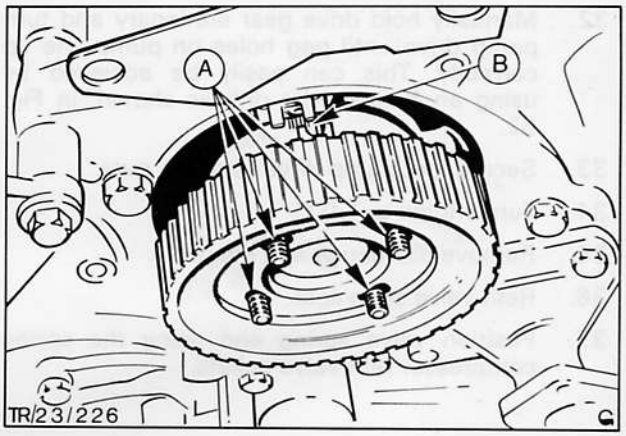


Fig. 49. Injection pump drive gear
A – Studs positioned in the centre of the slots
B – Pump set at approximately T.D.C.

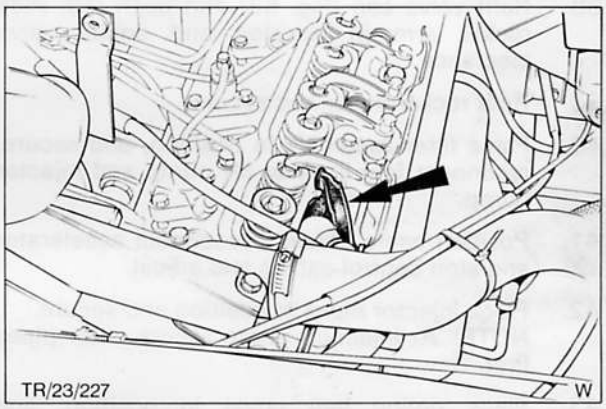


Fig. 50. Push rod removed and rocker arm turned through 90°

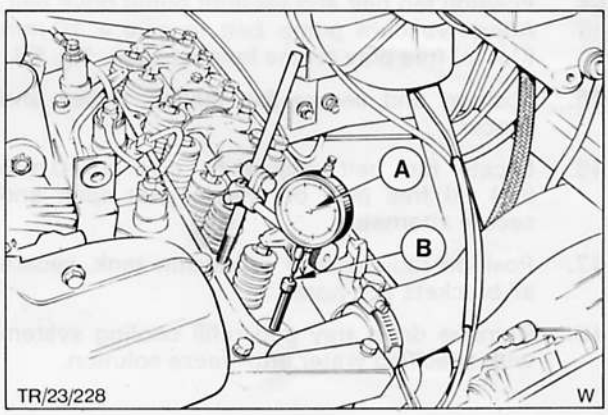
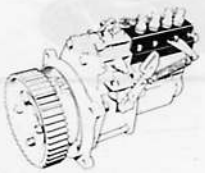


Fig. 51. Engine set at spill timing position
A – Metric dial gauge
B – Exhaust valve stem



32. Manually hold drive gear stationary and turn pump drive until peg holes on pump line up correctly. This can easily be achieved by using an 8 mm twist drill as shown, in Fig. 52.
33. Secure four pump drive securing nuts.
34. Turn engine to T.D.C.
35. Remove dial gauge and adaptors.
36. Refit valve stem seal.
37. Position valve spring and using the spring compressor refit valve collets.

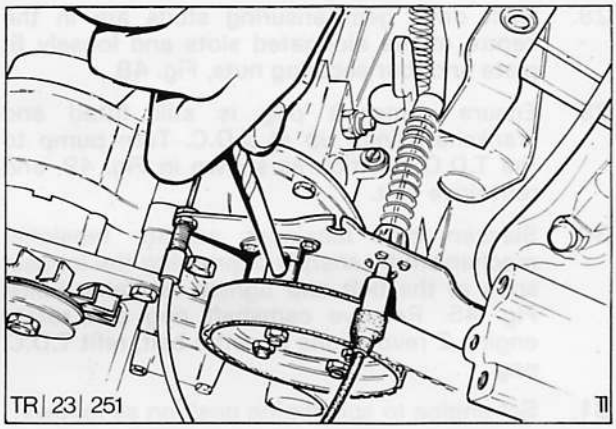


Fig. 52. Injector pump set at spill timing using an 8 mm twist drill to line-up hole

38. Refit valve cap (Fig. 53) and push rod, slide rocker arm in position and adjust valve clearance.
39. Refit rocker cover and secure.
40. Place filter assembly in position, and secure, reconnect fuel lines to lift pump and injector pump.
41. Position cable bracket, reconnect accelerator and stop control cables and adjust.
42. Place injector pipes in position and secure. NOTE: At injection pump secure outer pipes first.
43. Place timing belt cover in position, and secure cross-head screws.

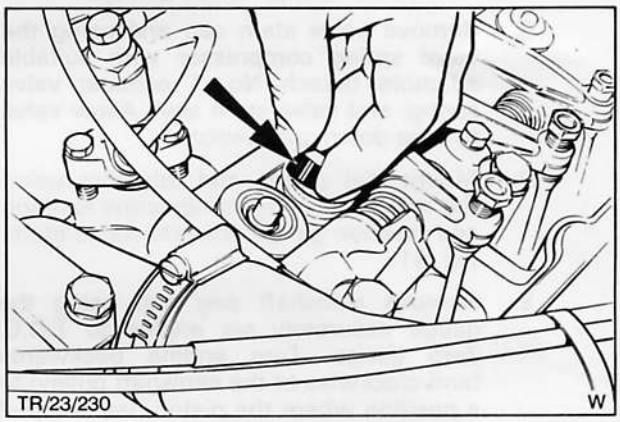


Fig. 53. Installation of valve stem cap

44. Position fan belt and vacuum pump drive belt. Adjust vacuum pump belt to give a 10 mm (0,4 in) free play on the longest span, Fig. 54.
45. Position and secure fan blades, pulley and spacer.
46. Locate fan belt, adjust to give a 10 mm (0,4 in) free play on the longest span and secure alternator.
47. Position radiator and expansion tank, secure all brackets and hoses.
48. Remove drain tray and refill cooling system with specified water anti-freeze solution.

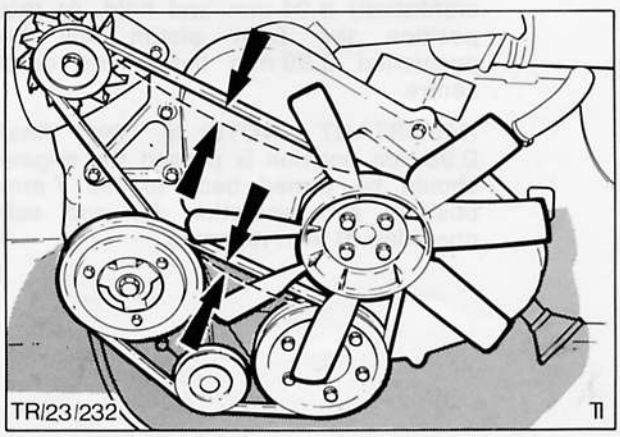


Fig. 54. Fan and drive belt adjustment

49. Bleed fuel filter and injection pump, Fig. 55. Detailed in Operation 23 142.
50. Refit air cleaner assembly.
51. Reconnect battery.
52. Start engine check for leaks and top up cooling system.
53. Remove fender covers and close hood.

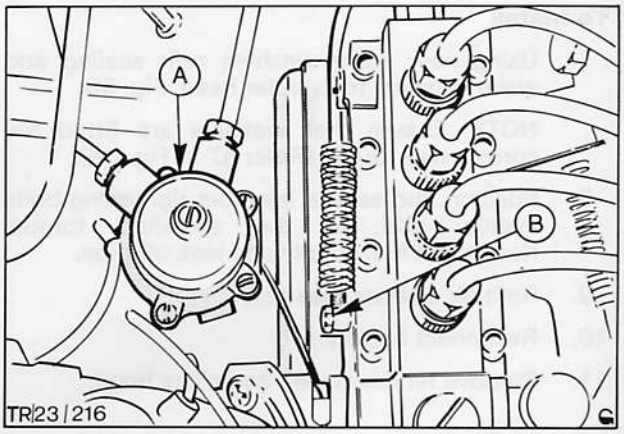


Fig. 55. Fuel injection pump
A – Fuel lift pump
B – Pump bleed bolt

23 454 INJECTOR – REMOVE AND INSTALL (ONE)

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly.
4. Disconnect leak off pipe and fuel supply pipe, remove 2 bolts and detach injector, Fig. 56.

   NOTE: In some cases the heatshield 'D' in, Fig. 58. will come out with the injector. If this happens a new sealing washer 'E' must be fitted.

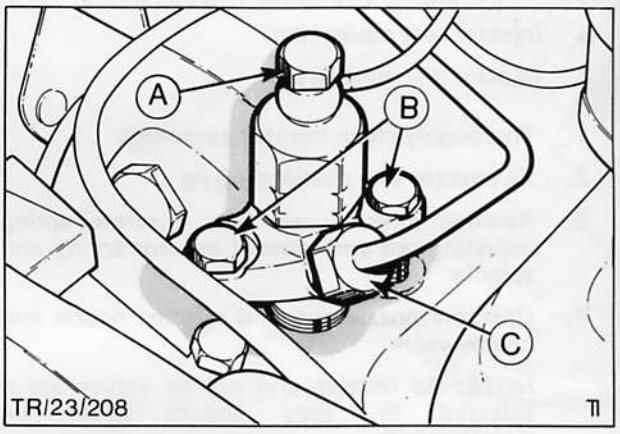


Fig. 56. No. 1 injector assembly
A – Injector leak off pipe
B – Securing bolts
C – Fuel supply pipe

5. Using an electricians screwdriver or scriber remove wave washer, Fig. 57.
6. Throughly clean, check, overhaul or renew injector as required.

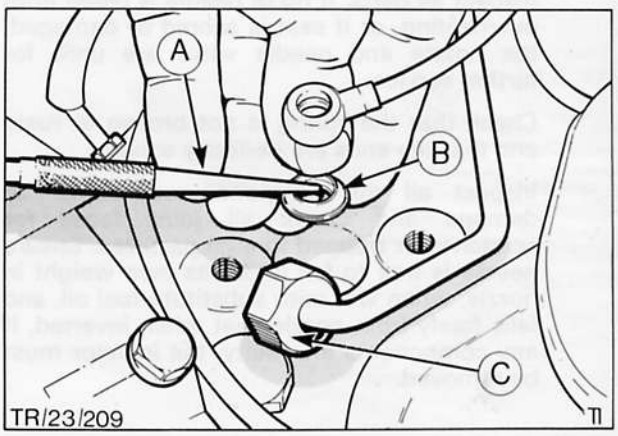


Fig. 57. Injector wave washer removal
A – Scriber
B – Wave washer
C – Injector union

To Install

7. Using new wave washers refit sealing and wave washers to cylinder head, Fig. 58.

   NOTE: Ensure that washers are fitted the correct way round, (Refer 'C' in Fig. 58).

8. Position and secure injectors tightening bolts evenly, and to the specified torque. Reconnect fuel supply and leak off pipe.
9. Refit air cleaner assembly.
10. Reconnect battery.
11. Remove fender covers and close hood.

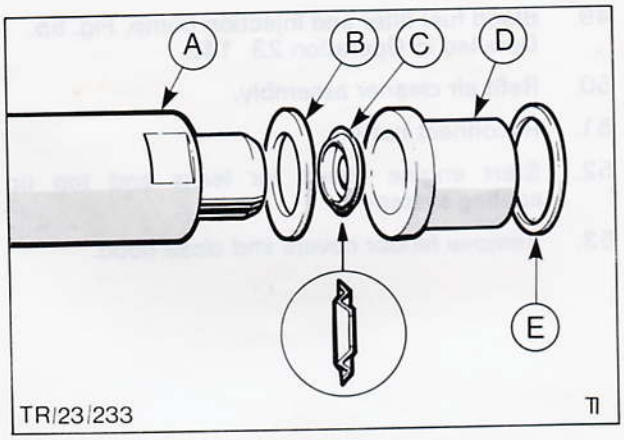


Fig. 58. Injector to head sealing washers
A – Injector
B – Sealing washer
C – Wavy washer
D – Heat shield
E – Sealing washer

23 454 8 INJECTOR – OVERHAUL (ONE) (Injector removed)

Special Service Equipment Required:

Injector test equipment.

Injector dismantling jig.

1. Thoroughly clean injector assembly.
2. Fit injector to a dismantling jig.
3. Remove injector cap nut, unscrew spring adjusting nut and remove injector spring and spindle.
4. Unscrew nozzle nut, and remove nozzle and needle valve.

   NOTE: As nozzles and needle valves are a selected fit, they should never be interchanged.

5. Wash all injector parts in clean fuel oil or substitute fuel oil and, using a soft brass wire brush, remove all carbon from nozzle and needle valve.

   Inspect all parts. If tip of needle is blued from overheating, or if seat is scored or damaged, the nozzle and needle valve are unfit for further service.

   Check that the spring is not broken or rusty and that the ends are perfectly square.

   Inspect all the components for wear or damage and check all joint faces for scratches or trapped foreign particles. Ensure needle is free to fall under its own weight in nozzle, when wet with substitute fuel oil, and falls freely from nozzle seat when inverted. If any components are faulty, the injector must be removed.

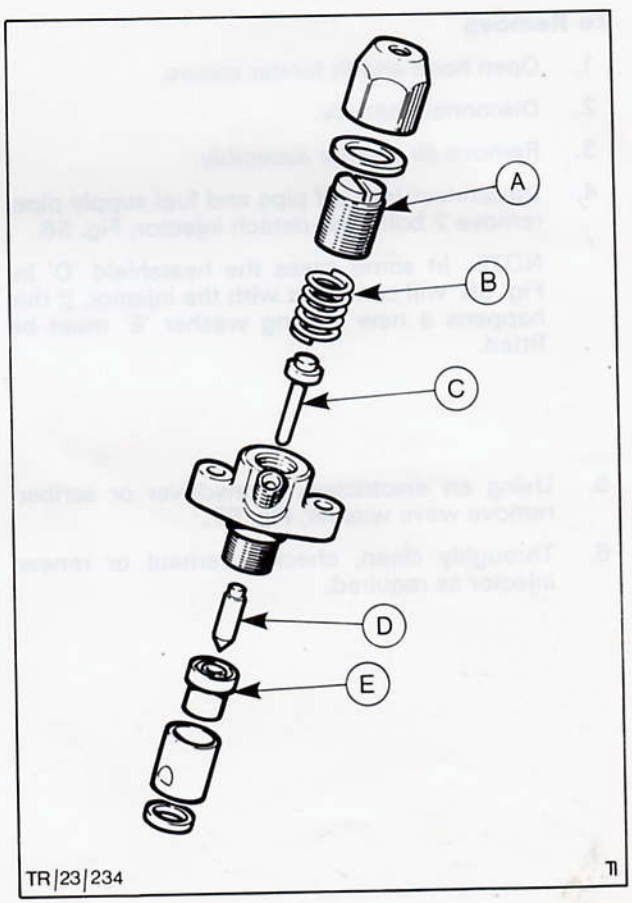
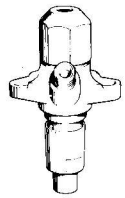


Fig. 59. Injector dismantled
A – Spring adjusting nut
B – Injector spring
C – Spindle
D – Needle valve
E – Nozzle



6. Using an injector cleaning kit remove all carbon from interior of nozzle.

   When a hard carbon deposit is formed, it may be softened by immersing nozzle in 'Acetone' for a short period. Up to half an hour is normally sufficient.

   WARNING: 'Acetone' is highly inflammable liquid it must not be brought near a naked flame and should be subject to the same handling precautions as petroleum spirit.

   IMPORTANT: Immediately the nozzle is removed from the fluid, it must be rinsed in clean fuel oil or substitute fuel oil to prevent corrosion on the finely-finished surfaces.

   Alternatively, the nozzle may be treated as follows:

   A. Dissolve 55 gm (2 oz) of caustic soda in 0,6 litre (1 pint) of water. Also add 14 gm ($\frac{1}{4}$ oz) of detergent.

   B. Place nozzle in the liquid and boil for a minimum period of 1 hour and not more than 1$\frac{1}{2}$ hours.

      NOTE: The concentration of caustic soda must not exceed 15% and water should be added to replace that lost by evaporation.

      Should the concentration of caustic soda exceed 15% then the needle valve bore and joint face on the nozzle body may be roughened, making the injector unserviceable.

   C. Remove nozzles, after treatment, and wash in running water to remove all traces of caustic soda. After washing, immerse nozzles in a de-watering oil, then remove surplus oil by draining.

7. The carbon can now be easily removed with a wire brush and a standard pricker wire.

8. Flush out interior of the nozzle using a suitable reverse wash adaptor fitted to the injector testing machine. When all particles of carbon have been removed, enter needle valve into nozzle and ensure that it is quite free.

9. Re-assemble injector as follows: Fig. 59.

   NOTE: All injector parts should be assembled wet after rinsing in clean fuel or substitute fuel oil. Do not use rag to clean any of the internal parts.

   Fit nozzle and needle valve to the injector body. Screw on nozzle nut and tighten securely to specified torque.

   NOTE: It is essential that this figure is not exceeded otherwise serious distortion of the nozzle assembly may occur.

   Fit injector spindle, spring and spring adjusting nut. Screw down adjusting nut until pressure can be felt on spring.

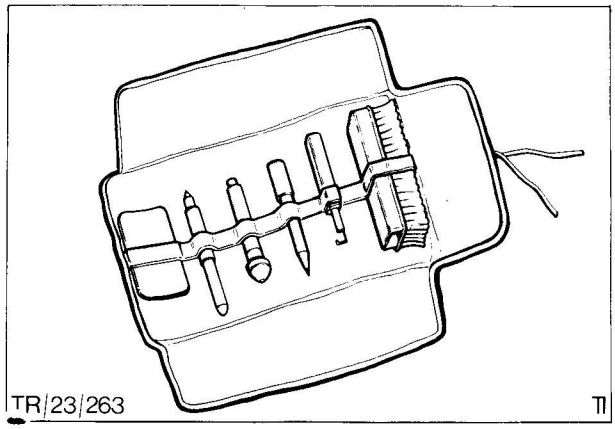


Fig. 60. Typical injector cleaning kit

10. Connect injector to test equipment.
11. Adjust opening pressure to 145 kg/cm² (145 atm) by screwing in or out adjuster nut, Fig. 61.
12. Fit injector cap, tighten and recheck nozzle opening pressure.
13. Fully test injector.

    NOTE: If, after cleaning, the injector fails to pass these tests it should be replaced by a serviceable injector and the faulty one re-conditioned. On no account should attempts be made to reclaim injector nozzles, and valves through hand-lapping with metal polish or any other abrasive.

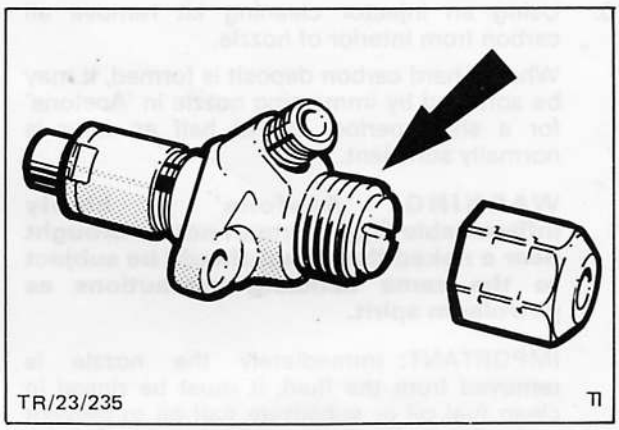


Fig. 61. Injector adjusting nut

Injector Testing

Care should be taken when testing injectors to ensure that the fuel spray does not come into contact with the hands of personnel operating the test equipment.

The characteristics of this pintle nozzle differ from the normal type in that the spray, with slow hand pumping, presents rather an inefficient appearance in comparison, and is inclined to be more 'ragged', 'wet' or 'soft' than with the normal four hole injector.

The nozzle can only be completely and satisfactorily tested with expensive and special stroboscopic equipment, but a good general test can be applied with a nozzle testing machine as follows:

A. Depress the Nozzle Testing Machine lever at about 20 strokes per minute, when a serviceable nozzle should emit a soft 'buzzing' noise, (possibly intermittent). Atomization will, however, appear to be streaky and generally unsatisfactory although, at the same time there should be no appreciable wetness at the orifice, Fig. 62.

B. Raise and maintain the pressure at 10 atmospheres below opening pressure for 10 seconds, when no fuel leakage should occur at the orifice.

C. It is difficult to obtain fuel 'atomization' with these nozzles on a normal testing machine, and the spray will always appear to be streaky. Fast operation of the lever (about 100 strokes per minute) should give a reasonable spray.

D. Check injector back leakage as follows:

   Raise pressure to 100 atmospheres and measure the time taken for the pressure to drop to 75 atmospheres.

   Refer Technical Data.

14. Remove injector from test equipment.

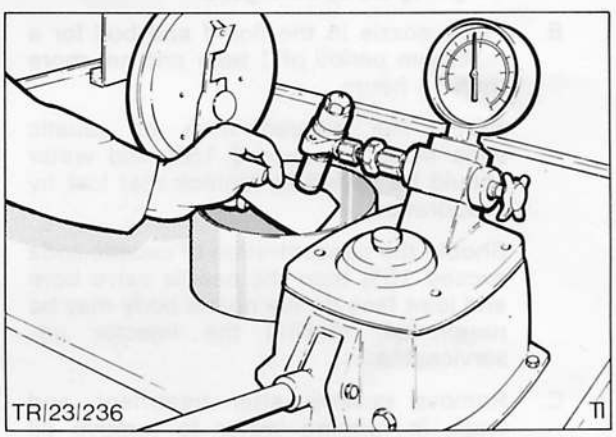


Fig. 62. Checking injector for leakage by using a piece of absorbent paper

23 483 PIPES INJECTOR DELIVERY – REMOVE AND INSTALL (All)

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly.

   Detailed in Operation 23 174.
4. Disconnect pipes at injector and pump and remove pipe assemblies.

   NOTE: When disconnect pipes at the pump remove outer pipes first, Fig. 63.
5. Remove clamps from pipe.

To Install

6. Loosely refit clamps to new pipes, place pipe assemblies in position and secure.

   Fully tighten pipe clamps.
7. Reconnect battery.
8. Start engine and check for leaks.
9. Refit air cleaner assembly.
10. Remove fender covers and close hood.

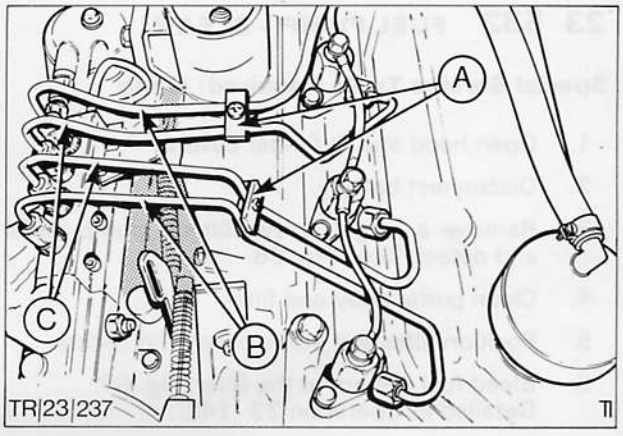


Fig. 63. Injection pipes in position
A – Pipe clamps
B – Outer injection pipes
C – Inner injection pipes

23 485 PIPE INJECTOR – LEAK OFF – REMOVE AND INSTALL

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly.
   Detailed in Operation 23 174.
4. Disconnect leak off return pipe and pipe to injector connections. Remove pipe, Fig. 64.

   NOTE: Do not lose sealing washers.

To Install

5. Place pipe in position and reconnect to return pipe and injectors.

   NOTE: Ensure sealing washers are fitted to injector connection, Fig. 65.
6. Reconnect battery.
7. Start engine and check for leaks.
8. Refit air cleaner assembly.
9. Remove fender covers and close hood.

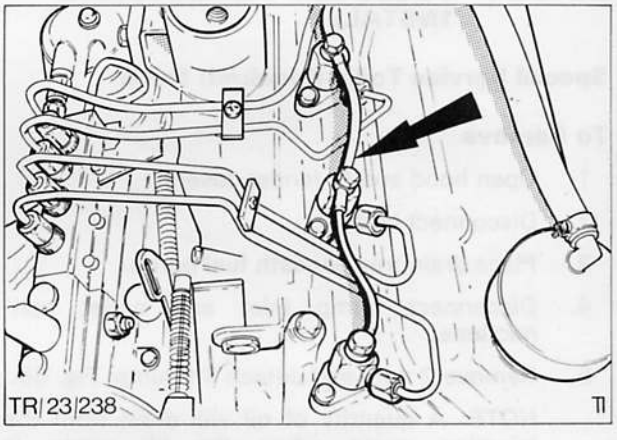


Fig. 64. Injector leak off pipe

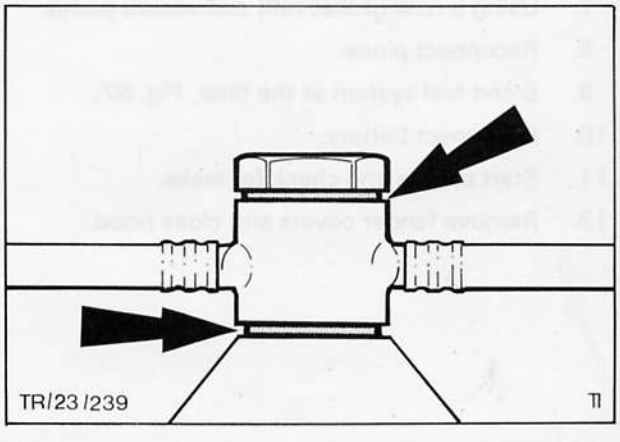
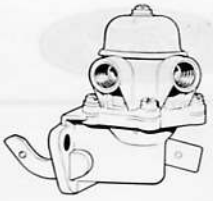


Fig. 65. Leak off pipe sealing washers



23 532 FUEL PUMP – CLEAN

Special Service Tools Required: None

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove a single screw, lift off pump cover and detach filter, Fig. 66.
4. Clean pump body and filter.
5. Position filter and pump cover and secure.
6. Bleed fuel system at the filter, Fig. 67. Detailed in Operation 23 142.
7. Reconnect battery.
8. Remove fender covers and close hood.

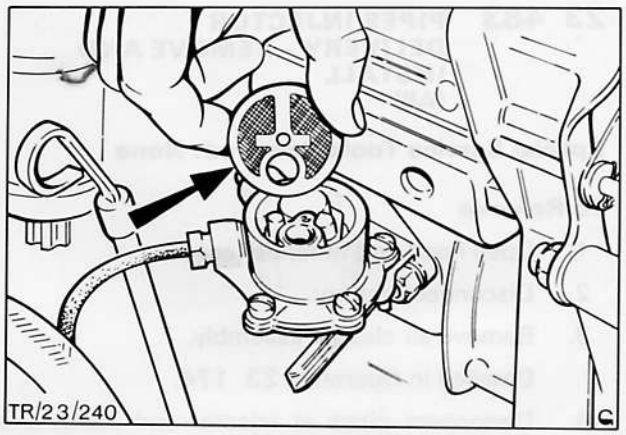


Fig. 66. Removal of pump filter

23 534 FUEL PUMP – REMOVE AND INSTALL

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Place drain tray beneath fuel pump.
4. Disconnect pump inlet and outlet connections.
5. Remove 2 nuts and detach lift pump, Fig. 68.

   NOTE: A quantity of oil will drain from the injection pump when the lift pump is removed.

To Install

6. Clean pump gasket mating surfaces.
7. Using a new gasket refit and secure pump.
8. Reconnect pipes.
9. Bleed fuel system at the filter, Fig. 67.
10. Reconnect battery.
11. Start engine and check for leaks.
12. Remove fender covers and close hood.

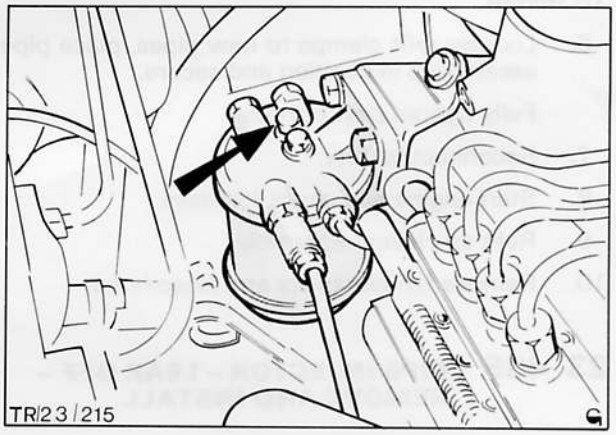


Fig. 67. Fuel filter bleed bolt
(Air cleaner removed for clarity)

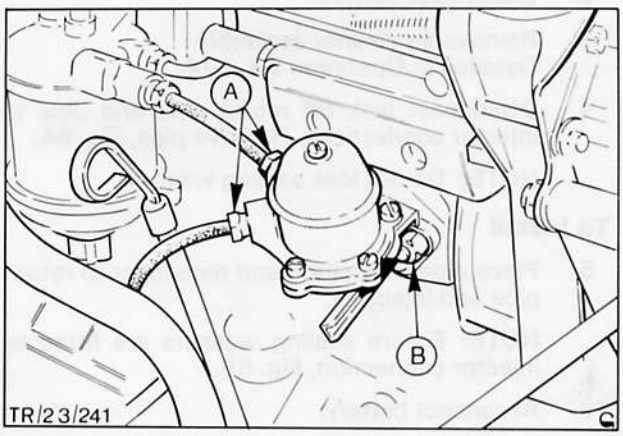
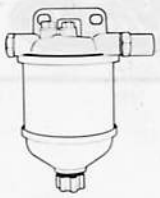


Fig. 68. Fuel lift pump
A – Pump fuel connection
B – Pump securing nut



FUEL FILTER

23 543 FILTER – FUEL LINE – CLEAN

Special Service Tools Required: None

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Remove filter bowl, Fig. 69, drain and clean.
4. Check seal is correctly fitted and refit bowl.
5. Bleed fuel system at the filter. Detailed in Operation 23 142.
6. Reconnect battery.
7. Remove fender covers and close hood.

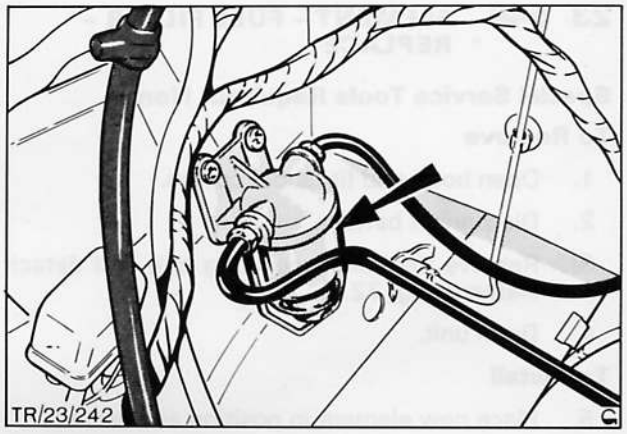


Fig. 69. Fuel line filter bowl

23 544 FILTER – FUEL LINE – REPLACE

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect filter inlet and outlet pipe connections, Fig. 70.
4. Remove 2 screws and detach filter assembly.
5. Drain unit.

To Install

6. Place filter in position and secure.
7. Reconnect fuel pipes.
8. Bleed fuel system at the filter. Detailed in Operation 23 142.
9. Reconnect battery.
10. Remove fender covers and close hood.

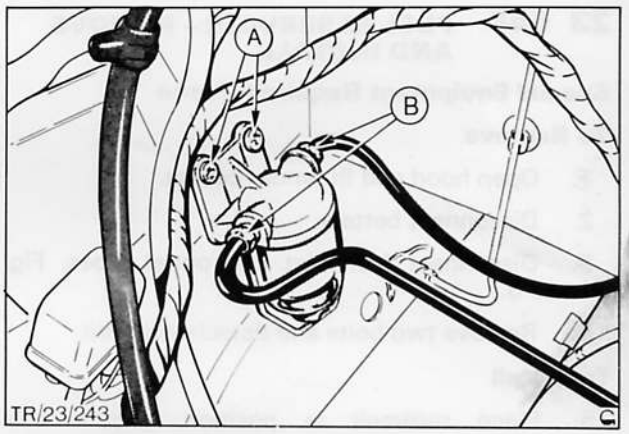


Fig. 70. Fuel line filter assembly
A – Filter securing screws
B – Filter fuel connections

23 545 FUEL FILTER – REMOVE AND INSTALL

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect filter inlet and outlet pipes.
4. Remove 2 bolts and detach filter assembly, Fig. 71.
5. Drain unit.

To Install

6. Place filter assembly into position and secure 2 bolts.
7. Reconnect fuel lines.
8. Bleed fuel system at the filter. Detailed in Operation 23 142.
9. Reconnect battery.
10. Remove fender covers and close hood.

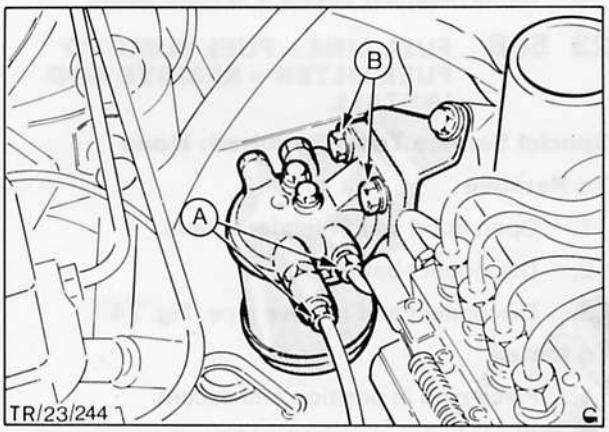
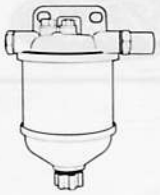


Fig. 71. Fuel filter assembly
(Air cleaner removed for clarity)
A – Filter fuel connections
B – Filter securing bolts



FUEL FILTER

23 546 ELEMENT – FUEL FILTER – REPLACE

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove the centre securing bolt and detach element, Fig. 72.
4. Drain unit.

To Install

5. Place new element in position and secure.
6. Bleed fuel system at filter. Detailed in Operation 23 142.
7. Reconnect battery.
8. Remove fender covers and close hood.

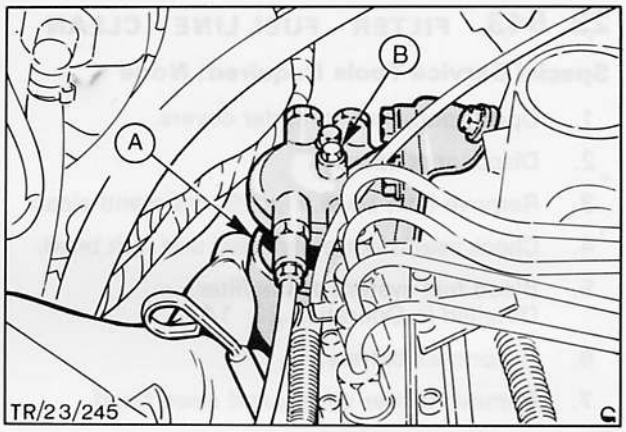


Fig. 72. Filter element removal
A – Filter element
B – Element securing bolt
(Air cleaner removed for clarity)

23 548 FUEL RESERVOIR – REMOVE AND INSTALL

Special Equipment Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect fuel inlet and outlet pipes, Fig. 73.
4. Remove two bolts and detach reservoir.

To Install

5. Place reservoir in position, secure and reconnect fuel pipes.

   NOTE: There is no requirement to bleed system.
6. Reconnect battery.
7. Remove fender covers and close hood.

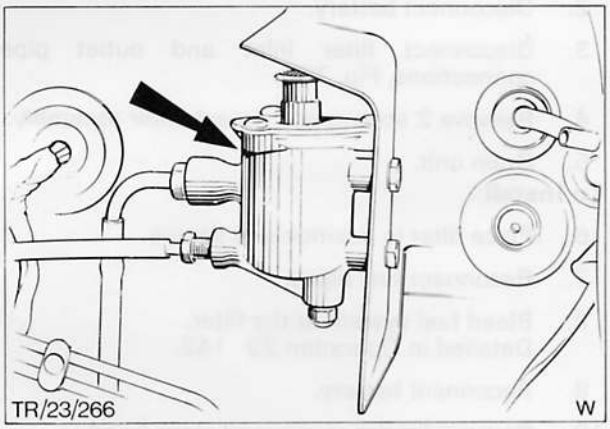


Fig. 73. Fuel reservoir assembly

23 588 FUEL LINE – FUEL PUMP TO FUEL FILTER – REMOVE AND INSTALL

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect and remove pipe, Fig. 74.

To Install

4. Place pipe in position and secure.
5. Bleed fuel system at fuel filter. Detailed in Operation 23 142.
6. Reconnect battery.
7. Remove fender covers and close hood.

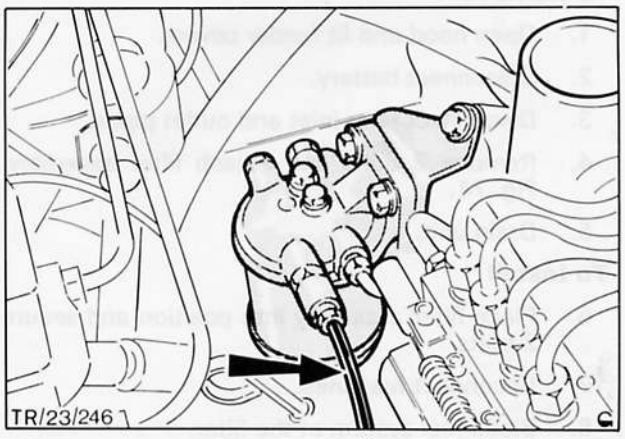


Fig. 74. Fuel pump to filter fuel line

23 771 GLOW PLUGS – CHECK OPERATION

Special Service Tools Required: None

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly. Detailed in Operation 23 174.
4. Disconnect leak off pipe fuel supply pipe, remove 2 bolts and detach injector, Fig. 75.

   NOTE: In some cases the heat shield, 'D' in Fig. 77, will come out with the injector. If this happens a new sealing washer 'E' must be fitted.
5. Remove remaining three injectors.
6. Using an electricians screwdriver or scriber remove four injector wave washers, Fig. 76.
7. Reconnect battery.
8. Ensure engine is below 40 °C. If not disconnect wire from thermal switch (Fig. 32) and connect a bridge between the two connections.

   Turn ignition on and using a mirror look down each injector location. If the glow plugs are operating the plugs will light up the injector hole in the cylinder head.

   NOTE: The plugs will only heat up for approximately 30 seconds, after this the plugs should be allowed to cool and the check repeated.
9. Disconnect battery.
10. Using new wave washers refit sealing and wave washers to cylinder head, Fig. 77.

    NOTE: Ensure that washers are fitted the correct way round ('E' in Fig. 77).
11. Position and secure injectors, reconnect fuel and leak off pipes.

    Ensure sealing washers are fitted to leak off pipe.
12. Refit air cleaner assembly.
13. Reconnect battery.
14. Remove fender covers and close hood.

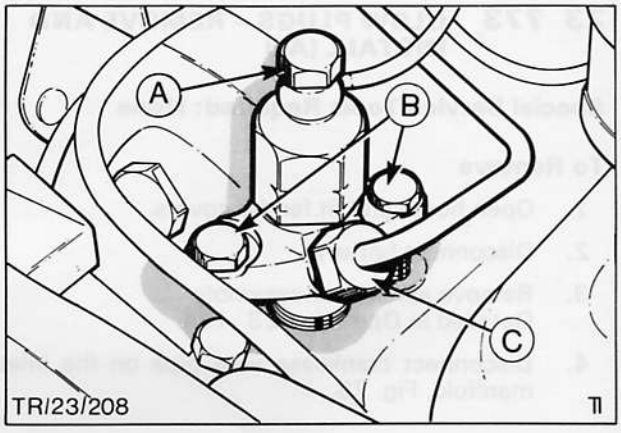


Fig. 75. No. 1 Injector assembly
A – Injector leak off pipe
B – Securing bolts
C – Fuel supply pipe

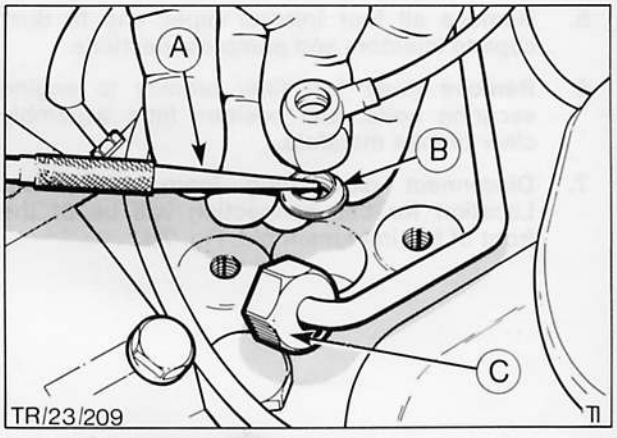


Fig. 76. Injector wave washer removal
A – Scriber
B – Wavy washer
C – Injector union

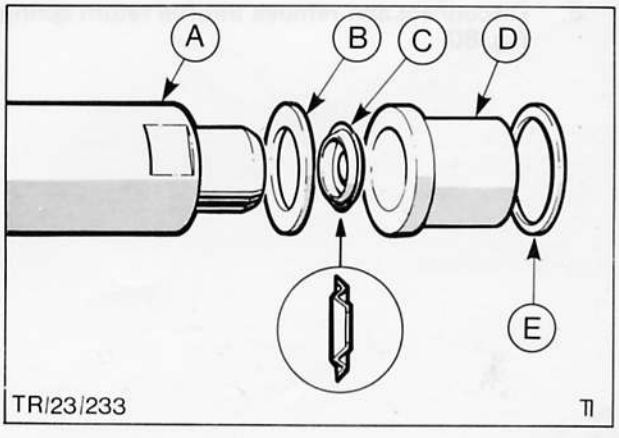


Fig. 77. Injector to head sealing washers
A – Injector
B – Sealing washer
C – Wave washer
D – Heat shield
E – Sealing washer

23 773 GLOW PLUGS – REMOVE AND INSTALL (All)

Special Service Tools Required: None

To Remove

1. Open hood, and fit fender covers.
2. Disconnect battery.
3. Remove air cleaner assembly. Detailed in Operation 23 174.
4. Disconnect crankcase vent pipe on the inlet manifold, Fig. 78.

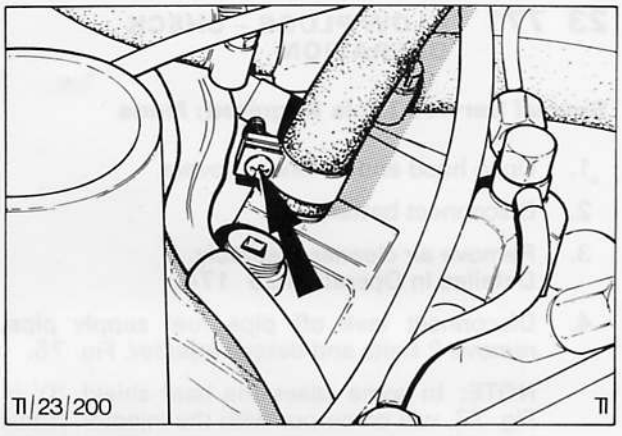


Fig. 78. Crankcase vent pipe on inlet manifold

5. Remove all four injector pipes and fit dust caps to injectors and pump connections.
6. Remove three fuel filter bracket to engine securing bolts, and position filter assembly clear of inlet manifold.
7. Disconnect glow plug loom connection. Location for this connection will be at the front of the inlet manifold, Fig. 79.

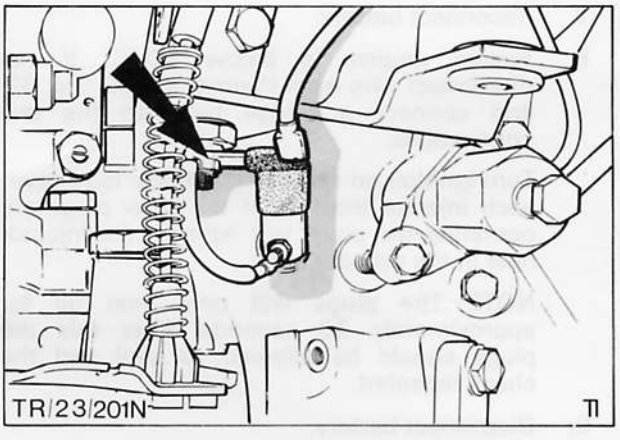


Fig. 79. Glow plug loom connection

8. Disconnect and remove throttle return spring, Fig. 80.

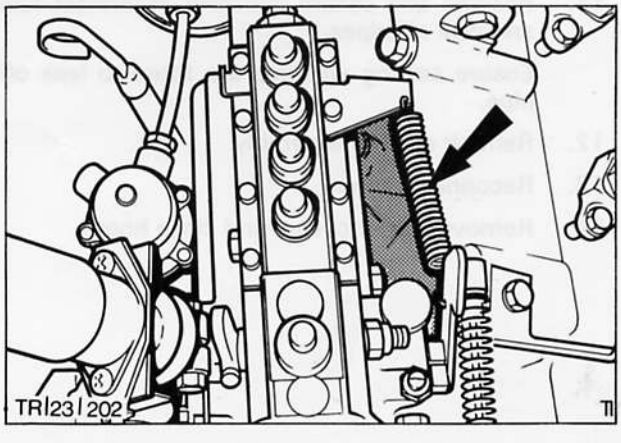


Fig. 80. Throttle return spring

9. Remove eight bolts securing inlet manifold to engine.

   NOTE: To remove the front lower securing bolts a long 13 mm ring spanner should be used as shown in Fig. 81.

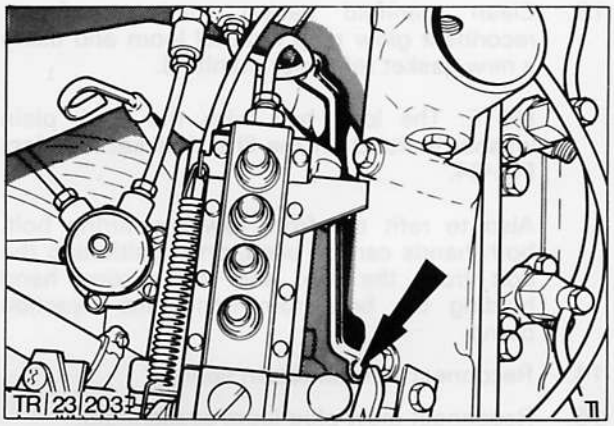


Fig. 81. Removal of front lower manifold securing bolt

10. Lift manifold clear of engine, disconnect glow plugs internal loom connection and remove manifold, Fig. 82.

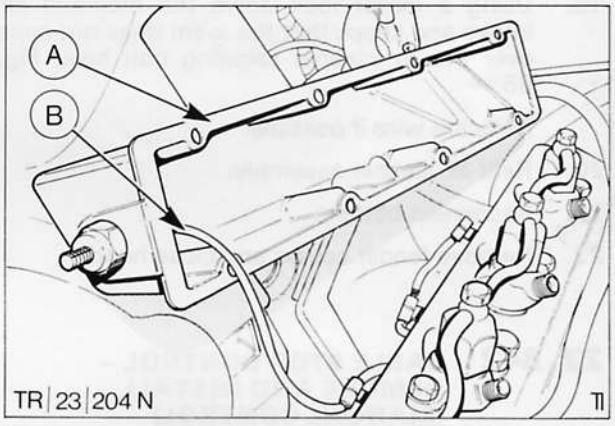


Fig. 82. Removal of inlet manifold
A – Inlet manifold
B – Glow plug loom connection

11. Using sockets disconnect and remove four glow plugs from cylinder head, Fig. 83.

To Install

12. Place plugs in position, secure and reconnect loom.

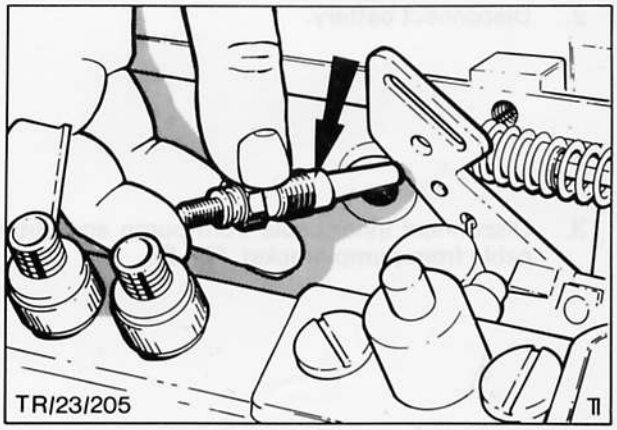


Fig. 83. Glow plug removal

13. Clean manifold gasket mating surfaces, reconnect glow plug internal loom and using a new gasket refit inlet manifold.

    NOTE: The long bolt with the thick plain washer is fitted on the filter bracket location, Fig. 84.

    Also to refit the front lower securing bolt, both hands can be used, one positioning the bolt from the top, and the second hand holding the bolt from under the injection pump.

14. Reconnect throttle return spring.
15. Reconnect glow plug loom at manifold.
16. Position and secure filter assembly.
17. Remove dust caps and refit injector supply pipes.
18. Reconnect crankcase vent pipe.
19. Using a mirror look down the manifold air intake and check that the loom does not pass over the air cleaner securing bolt hole, Fig. 85.

    Relocate wire if possible.

20. Refit air cleaner assembly.
21. Reconnect battery.
22. Remove fender covers and close hood.

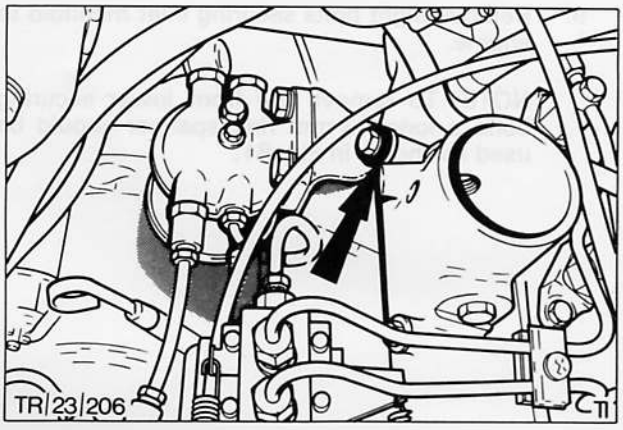


Fig. 84. Filter bracket securing bolt

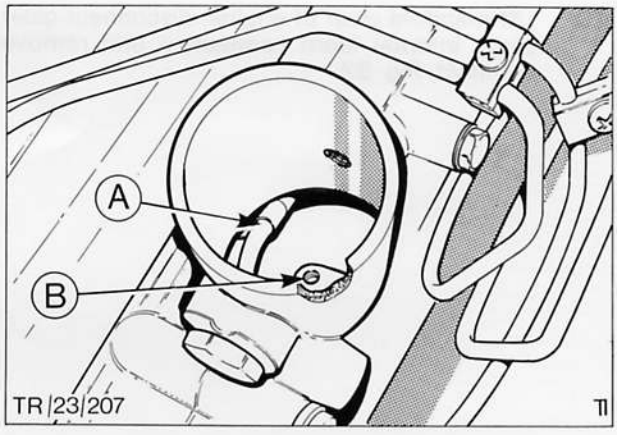


Fig. 85. Inlet manifold air intake
A – Glow plug internal loom
B – Air cleaner bolt hole

23 842 CABLE STOP CONTROL – REMOVE AND INSTALL (MANUAL CONTROL)

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect inner cable from pump and outer cable from pump bracket, Fig. 86.

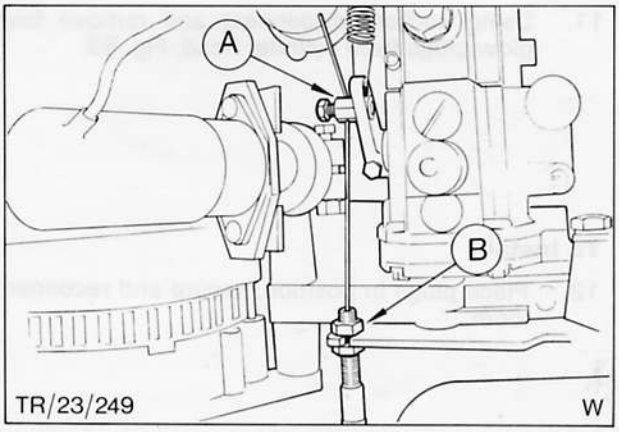


Fig. 86. Stop control cable
A – Inner cable clamp
B – Outer cable securing and adjusting position

4. Detach bulkhead to cable grommet.
5. Remove two screws and detach heater control panel, Fig. 87.
6. Remove outer cable to dash securing nut (17 mm).
7. Attach draw cord to cable and remove from inside vehicle.

To Install

8. Postion cable and remove draw cord.
9. Screw outer cable to dash.
10. Refit heater control panel, Fig. 87.
11. Reconnect cable to injection pump and adjust.

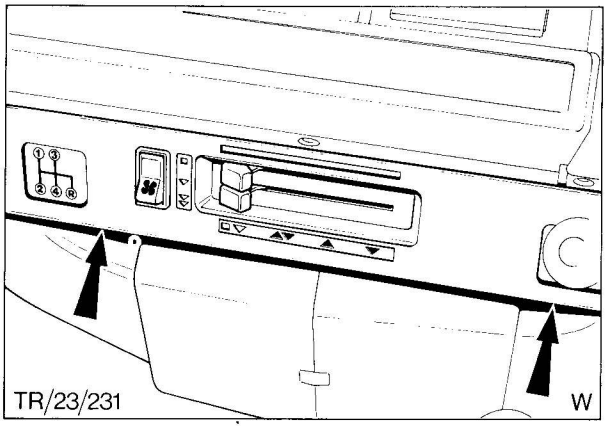


Fig. 87. Heater panel securing screws

23 842 CABLE STOP CONTROL – REMOVE AND INSTALL (AUTOMATIC CONTROL) '78 Model Year

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect inner cable from stop control motor by removing split pin.
4. Disconnect outer cable from motor bracket by prising out circlip, Fig. 88.
5. Disconnect inner cable from pump and outer cable from pump bracket, Fig. 89.
6. Detach cable assembly.

To Install

7. Place cable in position and loosely reconnect to pump.
8. Reconnect outer cable to stop motor bracket and refit retaining circlip, Fig. 88.

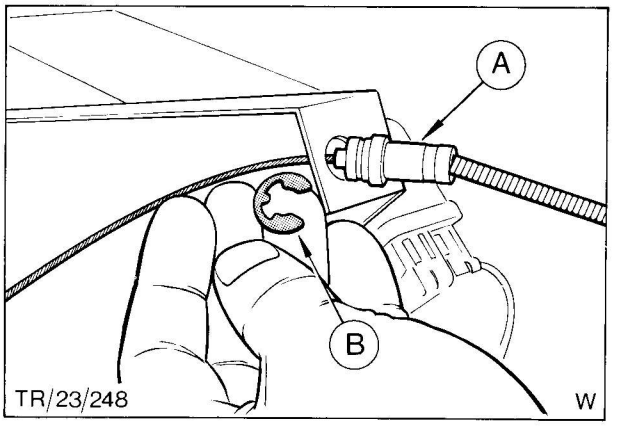


Fig. 88. Stop control cable removal
A – Outer cable
B – Securing circlip

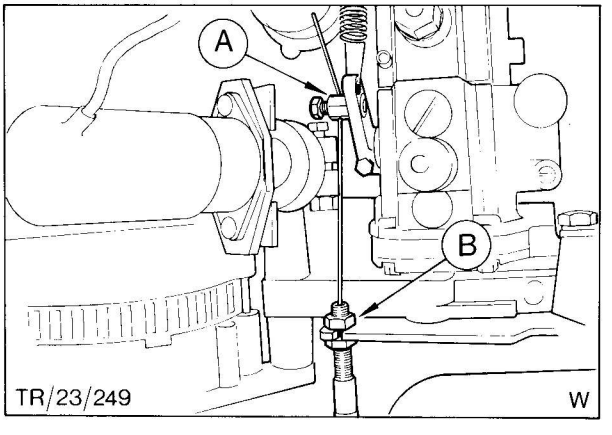
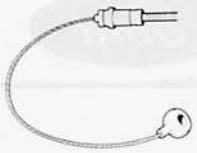


Fig. 89. Stop control cable
A – Inner cable clamp
B – Outer cable securing and adjusting position



STOP CONTROL CABLE

9. Reconnect inner cable to stop motor lever.

   NOTE: When connecting inner cable ensure plastic spacer washer is fitted, as shown in Fig. 90.

10. Reconnect battery and turn ignition 'ON'.
11. Adjust cable at the pump end so that no slack exists in the cable.
    Ensure pump stop lever is in the position shown in Fig. 89.
12. Check operation of stop control motor.
13. Remove fender covers and close hood.

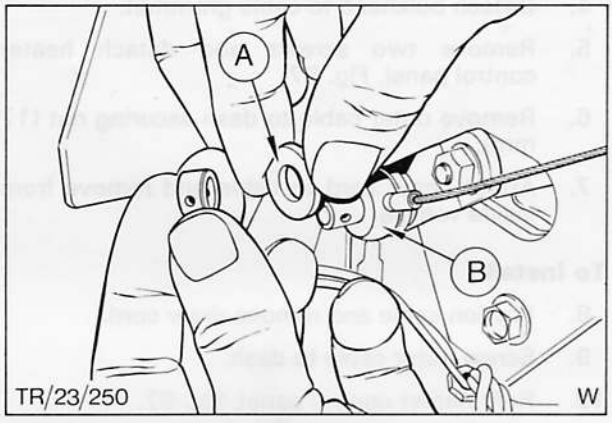


Fig. 90. Stop control cable
A – Plastic spacer washer
B – Inner cable

23 842 CABLE STOP CONTROL – REMOVE AND INSTALL (AUTOMATIC CONTROL) '79 Model Year

Special Service Tools Required: None

To Remove

1. Open hood and fit fender covers.
2. Disconnect battery.
3. Disconnect inner cable from stop control motor by removing a single cross head screw, Fig. 91.
4. Disconnect outer cable from motor bracket by compressing jaws of connector with a pair of pliers.
5. Disconnect inner cable from pump and outer cable from pump bracket, Fig. 92.
6. Detach cable assembly.

To Install

7. Place cable in position and connect to pump.
8. Clip outer cable to motor bracket and secure inner cable to stop control lever, Fig. 91.
9. Reconnect battery.
10. Check operation of stop control motor.
11. Remove fender cover and close hood.

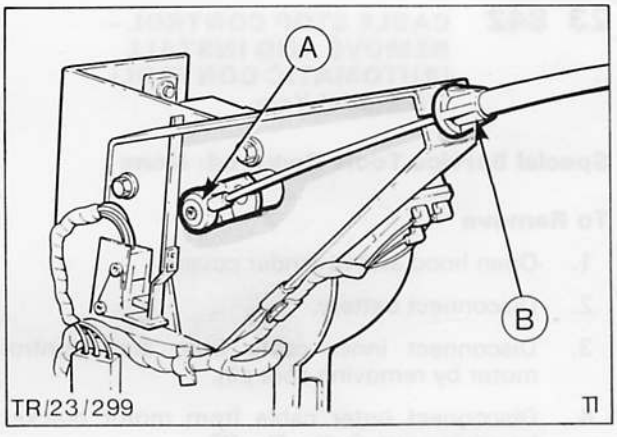


Fig. 91. Stop control cable. ('79 model year)
A – Inner cable connection
B – Outer cable connection

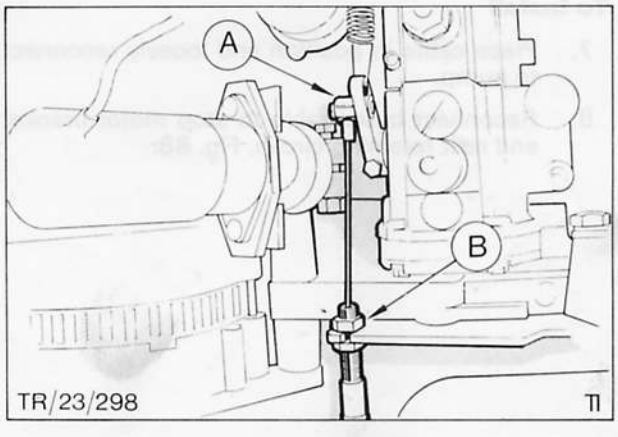


Fig. 92. Stop control cable
A – Inner cable clamp
B – Outer cable securing point and cable adjustment

TECHNICAL DATA

Fuel Injection Pump

Type	4 Element Jerk
Rotation (Viewed from the front)	Clockwise
Governor Type	Mechanical
Idle Speed	625 rpm ±25
Maximum 'No load' speed	4000 rpm ±30
Pump Timing	0,99 mm (11°) B.T.D.C.

Fuel Injectors

Type	Pintle
Plunger opening pressure	175 atmospheres
Back Leakage (time for pressure to drop from 100 to 75 atmospheres)	6 to 22 seconds
Needle seat leakage	Nozzle to be dry after operating the injector and after holding the pressure at 20 atmospheres below opening pressure for 10 seconds

Tightening Torques

Injector assembly securing bolts	1·5 to 2·0 kg.m (11 to 14·5 lb.ft.)
Injector Nozzle	6 to 8 kg.m (43 to 58 lb.ft.)