



SERVICE MANUAL

TRUCKS

L 385

Export Service Department

AKTIEBOLAGET

VOLVO

GÖTEBORG, SWEDEN

3. Loosen the bands retaining the fuel tank on the frame. Lift off the fuel tank.
4. Fit in reverse order to that used when removing.

When fitting make sure that the felt strips come into their right position and that the fuel pipeline screw unions are thoroughly tightened before the retainer bands are complete tightened.

Repair of Fuel Tank

Great care should be taken when working with the fuel tank. The gas that forms in a tank is extremely inflammable and sparks or an open flame can easily cause an explosion. If it is necessary to use an open flame on or near the fuel tank, the tank should first be cleaned in an alkali bath for at least one hour and then be rinsed out with hot water and blown dry with compressed air.

If there are any leaks in the fuel tank it should be repaired by soldering but the tank should be removed and flushed with warm water for at least ten minutes before soldering work is commenced. The point to be soldered should first be thoroughly cleaned and tinned. An electric soldering iron should preferably be used.

Keep the tank flushed with compressed air while soldering is being carried out to prevent the accumulation of gases and the possibility of an explosion.

Feed Pump with Hand Primer Pump

Removing

1. Clean the fuel injection pump, the feed pump and the fuel lines thoroughly externally.
2. Disconnect the pipeline to the fuel filters and the pipe connection to the pre-filter.
3. Remove the four nuts retaining the feed pump on the fuel injection pump and then lift off the feed pump.

Disassembly

1. Set up the pump in a suitable way in a vise.
2. Remove the six nuts holding the cover and pump housing together. Remove the cover (Fig. 1-101).
3. Remove the pressure valve housing (4) and take out the ball (3). Fig 1-102.
4. Unscrew the connection tube nipple (4), the seal ring (3), the valve disk (2) and the valve spring (1). See Fig. 1-103.
5. Remove the nut from the push rod and then take off the nut washer, the plunger, the support washer diaphragm and the inner support washer. When removing the push rod

nut another wrench (thin, flat adjuster wrench) must be held on the hex under the diaphragm. (Fig. 1-104).

6. Remove the lock wire for the rocker arm shaft and then screw out the shaft and remove the rocker arm and return spring (Fig. 1-105. 1-106). This is carried out in the following way: Fix the rocker arm in a vise in such a way that the contact plate is not clamped and with the pump attaching flange at right angles to the vise. In order to facilitate disassembly, the hand primer pump handle is turned into such a position that the diaphragm spring is compressed. When this has been done, the rocker arm and spring can be removed from the housing by turning the housing at the same time as it is pulled away from the rocker arm which is firmly held in a vise.

This procedure is also carried out even if only the rocker arm is to be replaced without disassembling the other parts.

7. Remove the screw retaining the hand primer pump handle and remove the handle.
8. Remove the screws retaining the check flange and remove this together with its spring.
9. Remove the feed shaft which is facilitated if the diaphragm spring is compressed by using suitable tools.
10. Remove the push rod and diaphragm spring.
11. Remove all dirt by carefully washing in clean fuel oil.

Inspection

Check the ball and seat on the pressure valve. The contact surface on the seat can be adjusted by lapping with lapping compound but it should be replaced if it is damaged. The same applies to the ball.

If the suction valve spring, valve disk or seal ring are damaged in any way they should be replaced.

Check the tightness of the plunger by inserting it in the cover. There should be a good seal all round. Should the plunger or the cylinder in the cover or both be so worn that a good seal is not obtained, the parts concerned should be replaced.

The diaphragm should be replaced each time reconditioning is carried out since it becomes subject to fatigue after having been used for some time. The diaphragm spring should have the right tension. The maximum length of the compressed spring should be 19 mm (3/4").

The push rod should be straight and there should be no signs of wear on the contact surface towards the rocker arm. The rocker arm should be checked for wear on the bearing points, on the contact surface towards the camshaft and the push rod. The contact surface towards the push rod should be a clean undamaged curve. If the rocker arm is worn or damaged it

should be replaced.

Other component parts should be examined and worn or damaged parts replaced.

Assembling

The best way to assemble the feed pump is in the reverse way to that adopted when disassembling with the following exception:

The diaphragm spring and the push rod are fitted in position first. The hand primer shaft is then fitted as a support after the spring is being compressed whereupon the rocker arm and return spring are fitted in a reverse way to that used when disassembling.

Make sure that all the parts are kept clean and then rinse them in clean fuel oil before assembling. If the feed pump is not to be refitted immediately, all pipe units should be fitted with protector caps.

Fitting

1. Fit a new gasket and bolt the feed pump onto the fuel injection pump.
2. Tighten the pipe connections to the fuel filters and the pre-filter.
3. Fill the fuel injection pump with engine oil up to the correct level.
4. Air-vent the complete injection system.
 - a. Open the air-venting screw on the upper fuel filter.
 - b. Operate the feed pump hand primer to force fuel up into the filter container and continue to pump until the fuel passing out is free from air bubbles. Then tighten the air-venting screw again.
 - c. Open the air-venting screw on a fuel injection pump and continue to operate the hand primer pump until the fuel passing out is free from air bubbles. Then tighten the screw again.

Testing the Fuel Feed Pump

1. Fit a low pressure gauge on the fuel injection pump at the point where the air-venting screw is fitted.
2. Start the engine and read off the pressure which should be at least 0.6 kg/cm^2 (8.5 p.s.i.) if the feed pump is in good condition. This value applies on condition that the fuel filters are not blocked.
3. Should the feed pressure obtained be below this figure, the pump should be removed, fitted in a test bench and examined with respect to the test values concerned provided by the manufacturer.

Pre-filter

Cleaning

The pre-filter should be cleaned regularly in order to avoid running interruptions. During normal operation, cleaning should be carried out once a week as follows:

1. Loosen the tensioner screw on the container bail, move the bail to one side and remove the filter and bowl. (Fig. 1-108).
2. Rinse and brush the filter and bowl in clean fuel oil.
3. Replace the filter and fit a new gasket. Fit the bowl and tighten the screw on the bowl making sure that the gasket seals properly.
4. Air-vent the fuel system in accordance with the instructions on page 1-75 "Air-venting of Fuel System".

Fuel Filters

Replacement of Filter Elements

The time when the filter element should be replaced is decided by the feed pressure. For this reason the feed pressure should be checked before replacement is carried out. When the feed pressure has decreased to 0.50 kg/cm^2 (7 p.s.i.) the elements should be replaced, both at the same time. Under normal conditions the vehicle is run from 40,000 - 60,000 km (25,000 - 40,000 miles) between element replacements.

The fuel filter elements (Fig. 1-19) are replaced in the following way:

1. Clean the filters and the connection pipes very thoroughly. Make sure that all dirt under the projecting edges of the covers is removed. Blow clean with compressed air. Remove the drain plug and let the fuel run out.
2. Loosen the nut on the center of the cover and remove the filter container and the filter element on both filters.
3. Remove the filter element and screw out the plugs for sludge drainage in the bottom of the containers.

Clean the containers thoroughly and blow them dry with compressed air.
4. Remove the cover gaskets, clean the covers thoroughly internally and blow them dry with compressed air.
5. Screw the plugs back into the containers and fit the new filter elements. Fit new cover gaskets and then reassemble filters and tighten the nuts on the covers.

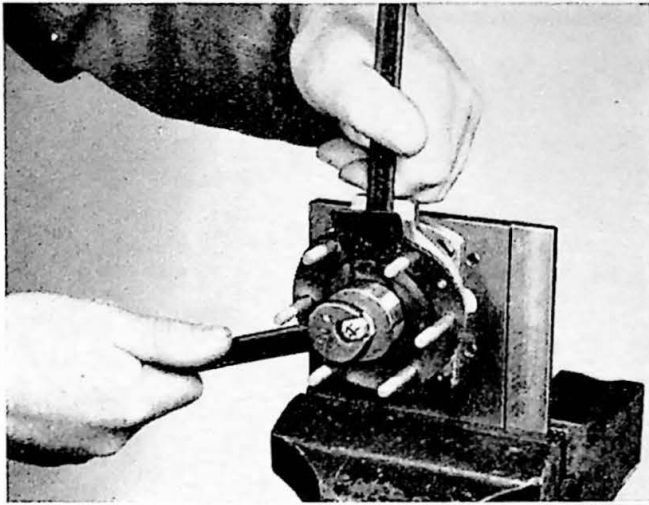


Fig. 1—104. Removing plunger and diaphragm.

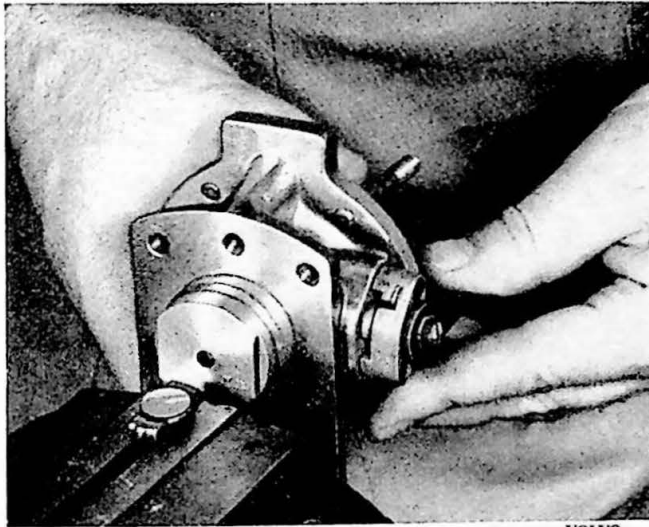


Fig. 1—105. Removing rocker arm.

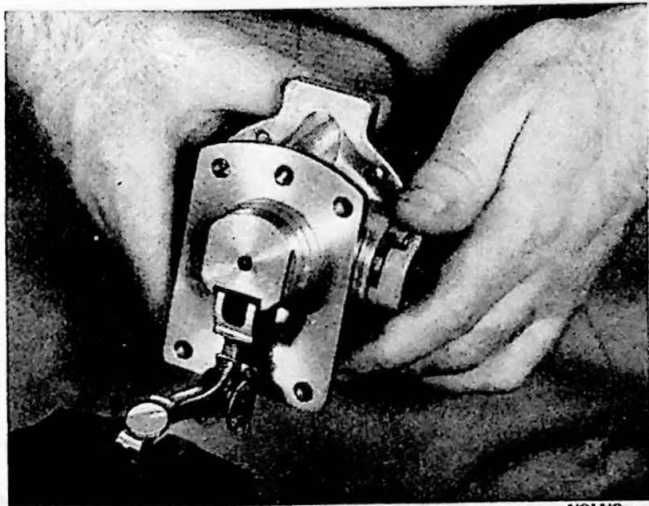


Fig 1—106. Removing rocker arm.

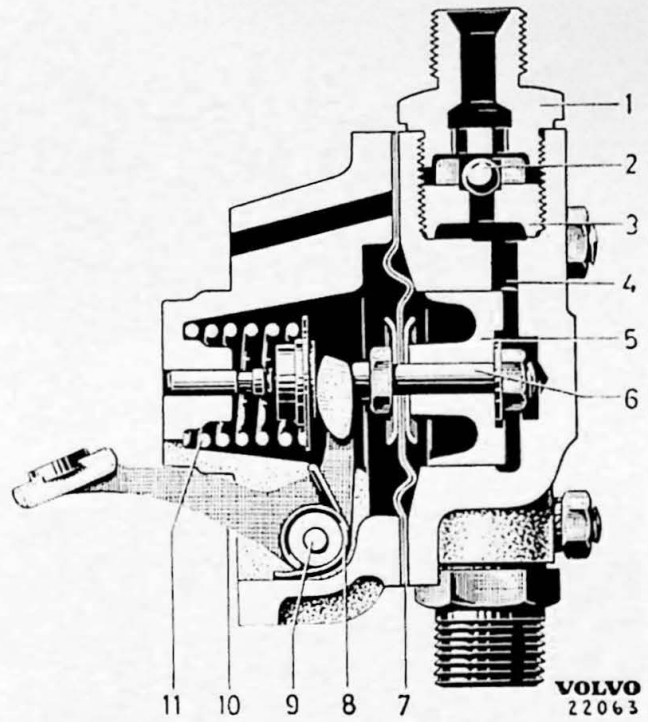


Fig. 1—107. Fuel feed pump.

1. Valve housing
2. Valve ball
3. Valve seat
4. Pressure channel
5. Plunger
6. Push rod
7. Diaphragm
8. Rocker arm shaft
10. Rocker arm
11. Push rod spring

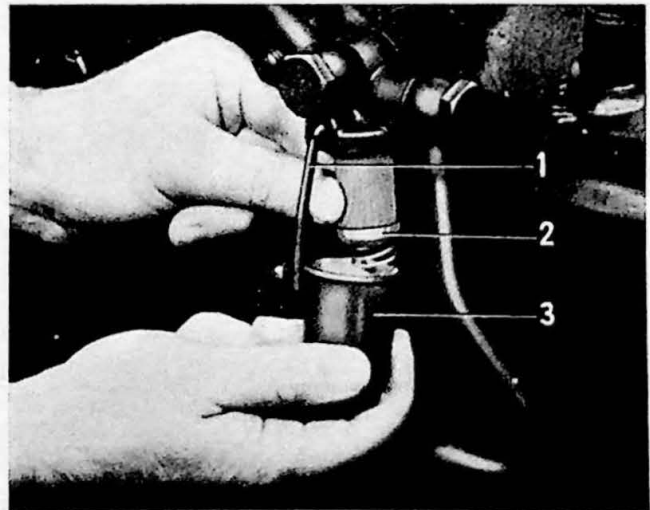
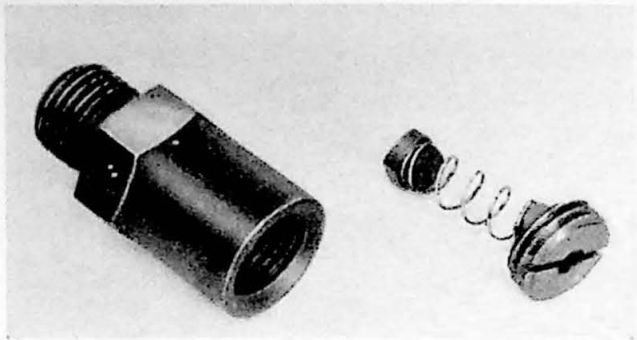


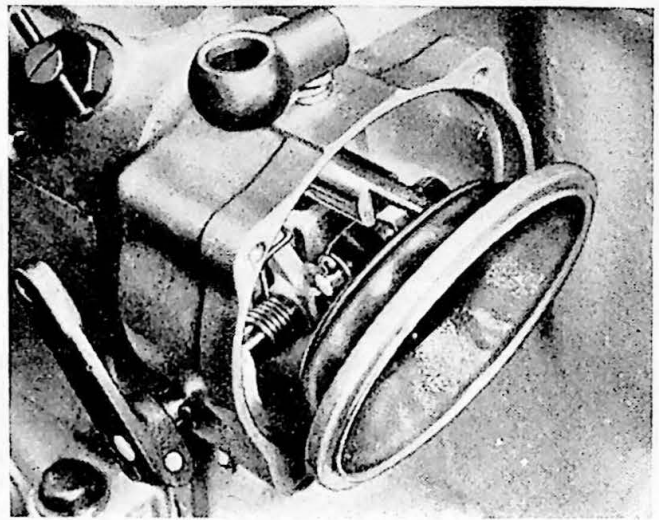
Fig. 1—108. Removing pre-filter.

1. Bail
2. Filter element
3. Container



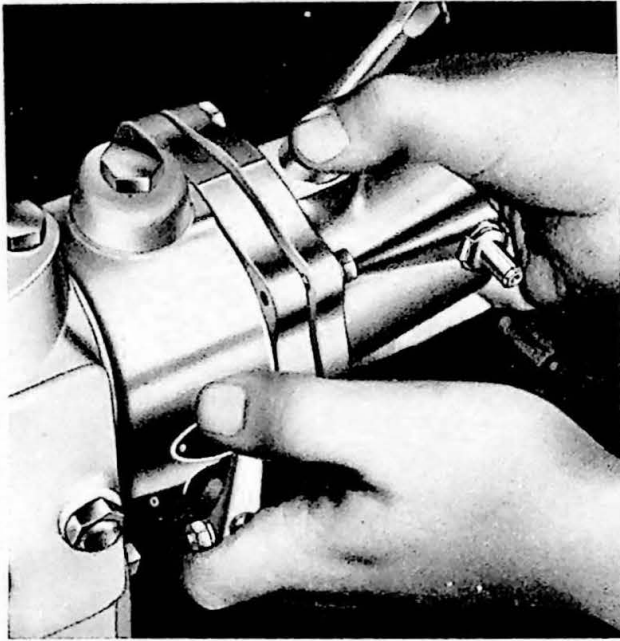
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Fig. 1—109. Relief valve.



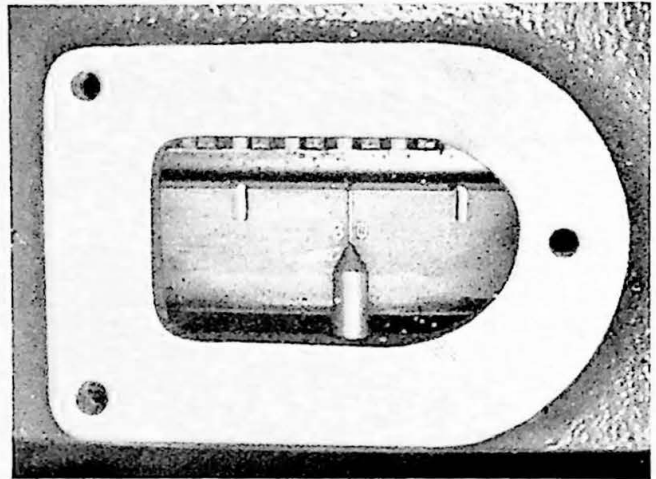
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Fig. 1—112. Removing diaphragm.



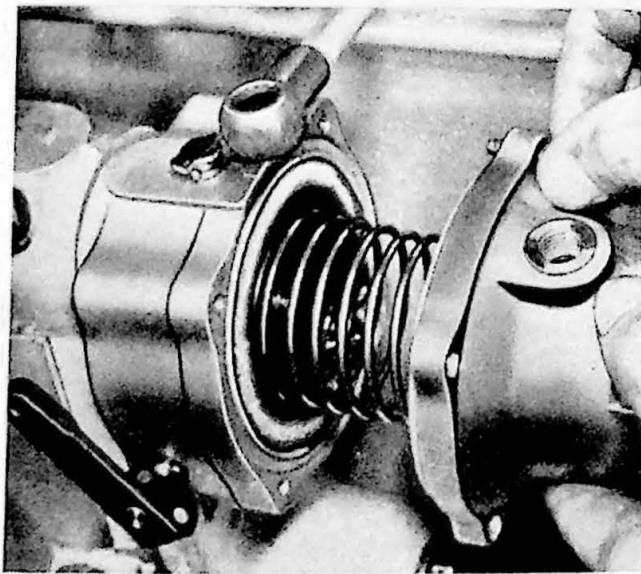
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Fig. 1—110. Testing diaphragm for leaks.



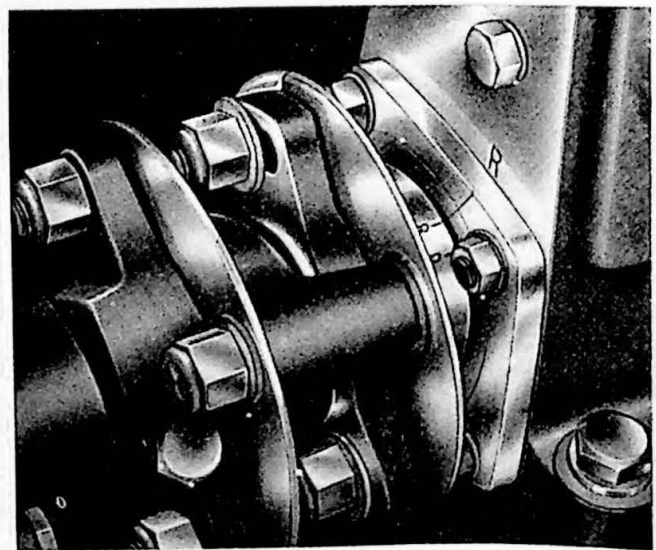
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Fig. 1—113. Injection mark on flywheel.



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Fig. 1—111. Removing diaphragm.



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Fig. 1—114. Pump setting marks.

6. Open the air-venting screws and operate the hand primer pump to feed fuel to the filters. Continue with this until about 2 liters (4 U.S. pints) of fuel has passed out through the air-venting screws and then tighten these.
7. Air-vent the fuel system in accordance with the instructions given on page 1-75 "Air-venting of the Fuel System".

Relief valve

Testing
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If the fuel feed pump has been tested and found to be in good condition and, in spite of this, feed pressure is low the relief valve should be examined. It can be checked in the following way:

1. Give the hand priming pump a few strokes and open the air-venting screw. Fuel should then spurt out.
2. Operate the hand priming pump a few strokes then wait for 1/2-1 minute before opening the air-venting screw. If the fuel does not spurt out so strongly this time then it is probable that the valve is leaking and the spring and valve body should be replaced. If the seat is damaged the complete valve should be replaced.

If a test apparatus is available, the relief valve should be removed and tested. The opening pressure should be 0.6-1.0 kg/cm² (8.5-14 p.s.i.).

Fuel injection pump

Work that can be carried out without Removing the Fuel Injection Pump
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Testing the vacuum governor:

Leakage in the governor can be investigated by disconnecting the vacuum line and then placing a finger over the hole after the control rod has been pushed over to the position for zero feed. When the control rod is then released it should remain in the stop position or move over very slowly to the full feed position. If the spring moves the control rod over to the full feed position rapidly, then there is a leak.

If there is a leak it is possible that it may be partly in the diaphragm itself and partly in the attachment between the governor housing and the governor casing. Leaks of this type are quite normal and can cause excessively high idling speed and maximum speed. It is therefore important to ensure that this test is carried out.

Replacement of diaphragm:

1. Clean the fuel injection pump, the pipe lines and the parts of the engine around the

pump very thoroughly.

2. Disconnect the vacuum line from the governor.
3. Disconnect the idling control connection.
4. Remove the four nuts retaining the governor casing on the governor housing and then lift off the casing and the governor spring (Fig. 1-111).
5. Pull out the diaphragm and remove the cotter pin and the washer. Remove the diaphragm from the control rod (Fig. 1-112).
6. Fit the new diaphragm. Fit the washer and secure it with the cotter pin. Move the diaphragm into its correct position in the governor housing and then fit the governor spring and casing.
7. Connect the vacuum line and fit the idling damper control.
8. Check the idling speed and the maximum speed of the engine if necessary and adjust these according to instructions given on page 1-65 "Adjustment of Idling Speed and Maximum Engine Speed".

Removing the fuel injection pump

1. Clean the fuel injection pump, pipe lines, pump coupling and the parts of the engine around the pump very thoroughly.
2. Loosen the delivery pipes, the vacuum line, the pipes between the feed pump and the fuel filter and the injection pump as well as the pipe between the pre-filter and the feed pump. Fit protector caps on all connections to prevent dirt from coming into the pump.
3. Loosen the stop arm control and the damper device.
4. Remove the four bolts retaining the pump on the bracket.
Lift off the pump.
5. Send the pump to a diesel repair shop or the diesel repair section of the workshop if there is such a section.

NOTE. Repair work which requires disassembly of the internal parts of the fuel injection pump and can alter its setting may only be carried out by a mechanic specially trained to work with fuel injection pumps and with the required tools and test devices at his disposal.

Fitting and Adjusting

1. Open the inspection cover over the flywheel marking.
2. Remove the front rocker arm cover.

3. Turn over the engine in its correct direction of rotation until both the valves of number 1 cylinder are closed.
4. When both valves are closed, carry on turning the engine over until the injection mark 30° before T.D.C. is opposite the pointer in the flywheel housing. Be careful to hold your head exactly over the pointer when reading off. An error of several degrees can result from reading the mark from the side.
5. Turn the pump shaft in the correct direction of rotation until the marking on the coupling is opposite the marking on the pump housing. The markings are shown in Fig. 1-114.
- 6a. Place the pump on its bracket and slide the coupling into the cross plate until the pump comes into its correct position. The coupling should then go in without it being necessary to twist. If twisting is found to be necessary when adjusting, the bolts on the adjuster device are loosened, after which the graduated plate is turned in a desired direction. After adjustment has been carried out, the bolts should be tightened thoroughly.

The above-mentioned procedure concerns CAV pump couplings.

- 6b. On late production couplings (steel disk couplings) the pump is placed on its bracket and the coupling is slid in in such a way that both the attaching bolts pass through the holes in the flange (2, Fig. 1-116), the domed washers (4, Fig. 1-116) being between the steel disks and the flange. The nuts (5, Fig. 1-116) for the adjuster device should be loosened so that the center part of the coupling (2, Fig. 1-116) can be turned so that the coupling slides easily into the holes in the flange. The nuts for the adjuster device are then tightened (5, Fig. 1-116). The attaching nuts (1, Fig. 1-116) are then also tightened. These hold together the "Pump part" of the coupling (3, Fig. 1-116) with the flange part (2, Fig. 1-116). Make sure that the washers are in position between the flange and the steel disks. These washers are domed. Be careful to ensure that they are fitted with the domed side towards the steel disk (see Fig. 1-116). Since the nuts are self-locking, make sure that they are in good condition and that they lock correctly and do not become loose in any way.

NOTE. The nuts should be tightened again after the vehicle has run for 2,500 km (1,500 miles).

7. Insert the four attaching bolts for the fuel injection pump and tighten them slightly. If the pump coupling is to function in a satisfactory manner it is important to ensure that the pump is aligned both vertically and horizontally. No stresses in either of these directions are permissible. When this check has been carried out, the four

attaching bolts are thoroughly tightened.

8. Attach and tighten the delivery pipes. Make sure that they are fitted properly and that the nuts are carefully tightened. Use a fixed wrench to avoid damage to the hexes on the nuts. See the instructions for "Replacement of Delivery Pipes" on page 1-74.
9. Fit the fuel lines between the fuel injection pump and the fuel filters, between the feed pump and the fuel filters and between the pre-filter and the feed pump.
10. Connect the vacuum line and tighten the controls for the damper device and the stop lever in position.
11. Check the settings. This can easily be done by turning over the motor half a revolution backwards and then in the normal direction of rotation until the injection mark on the flywheel is opposite the indicator on the flywheel housing, care being taken to ensure that your head is exactly over the pointer when you read it off otherwise faulty settings will be obtained.

When the settings are correct, the marks on the coupling and the pump housing should be opposite one another (Fig. 1-114 and 1-115). If this should not be the case, loosen the nuts on the adjusting device and turn the coupling halves until the setting marks are opposite one another.

12. Air-vent the fuel system according to the instructions given on page 1-75 "Air-venting the Fuel System".

Replacing a CAV Coupling with a Steel Disk Coupling

A CAV coupling can be replaced by the stronger, Volvo-designed steel disk coupling so that in cases where the old coupling has become worn, we recommend that the new disk coupling is fitted as follows:

1. Turn over the engine until it is in a position for injection on cylinder number 1 (see "Fitting and Adjusting" on page 1-62 and then remove the fuel injection pump and coupling.
2. Loosen the nuts marked 1 on Fig. 1-116 and separate the pump part (3, Fig. 1-116 from the center part 2 and the flange 7 (2 and 3 on Fig. 1-116 remain attached together through the bolts 9). Take care to ensure that the steel disks are not damaged.
3. Fit the coupling "Pump half" (3, Fig. 1-116) on the pump. Check that the Woodruff key in the pump shaft is undamaged and that the shaft cone is free from scoring and dirt. Do not finally tighten the nut on the pump shaft. Remove the plate with the setting mark. If the threads on the bolts are not sufficient in certain cases, flat washers can be fitted instead of this plate. Check that the coupling rotates freely without

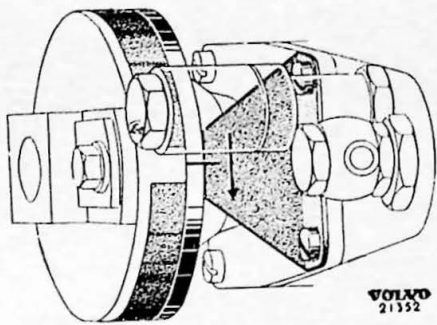


Fig. 1—115. "CAV" pump coupling.

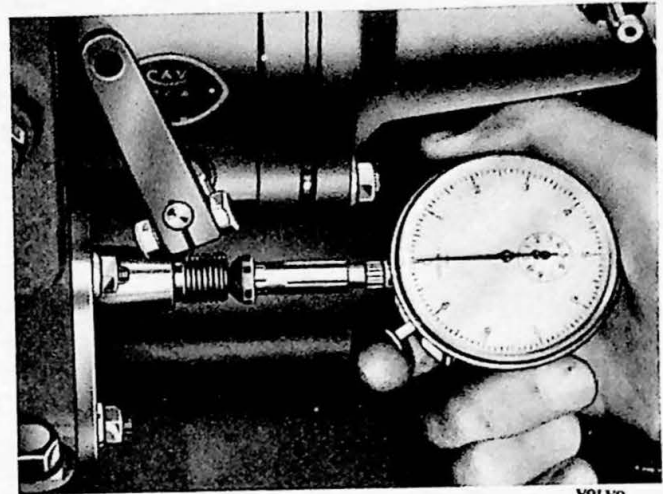


Fig. 1—118. Checking pump speed.

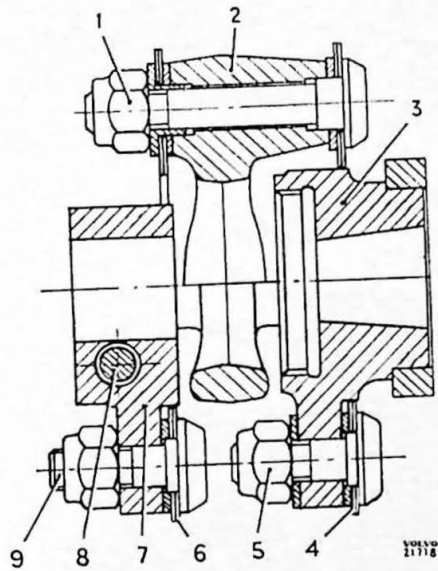


Fig. 1—116. "Volvo" steel disk pump coupling.

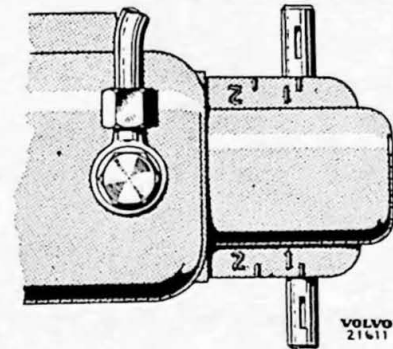


Fig. 1—119. Adjusting idling speed.

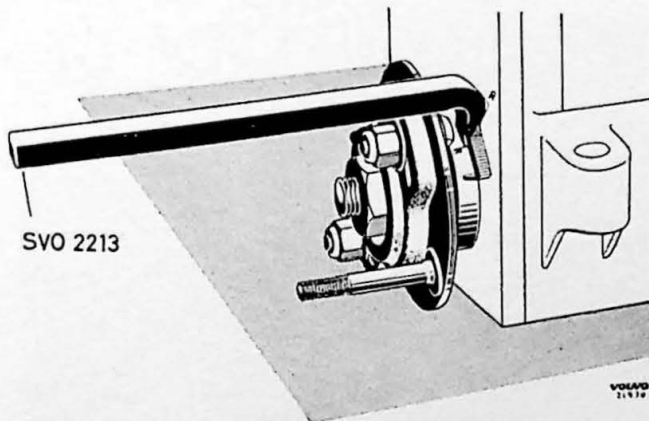


Fig. 1—117. Transferring marking to pump housing.

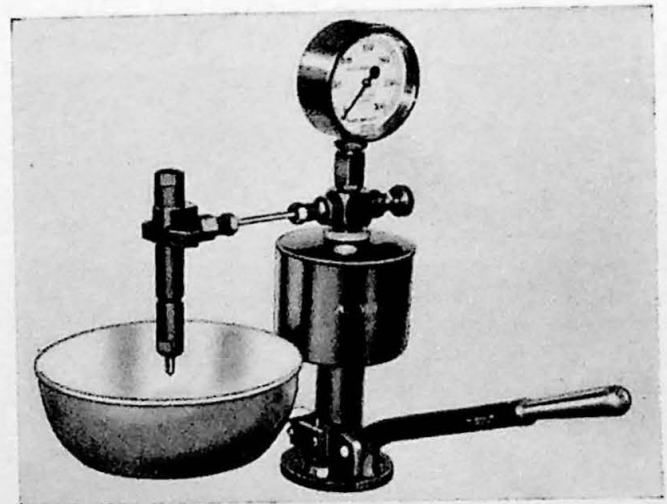
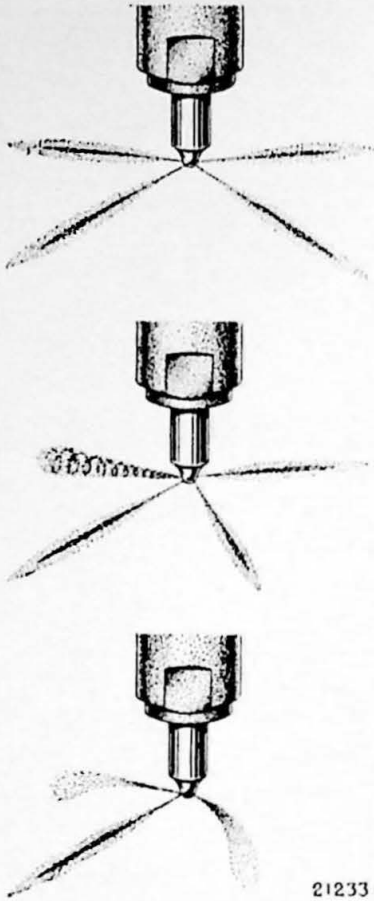


Fig. 1—120. Injector tester.



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Fig. 1—121. Checking spray form and direction.

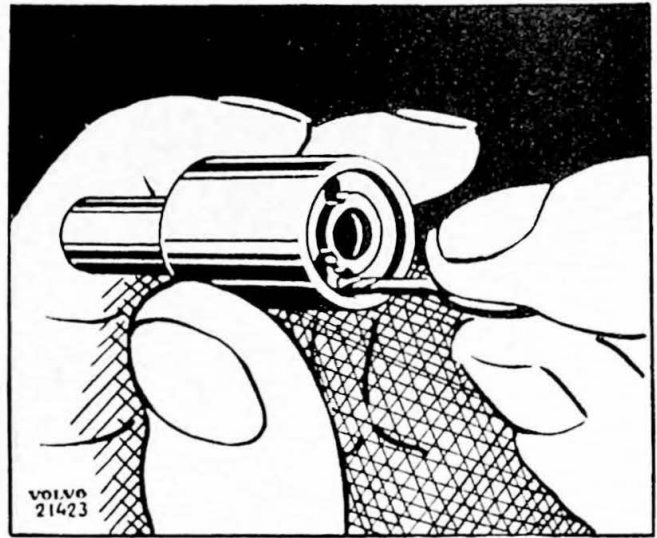
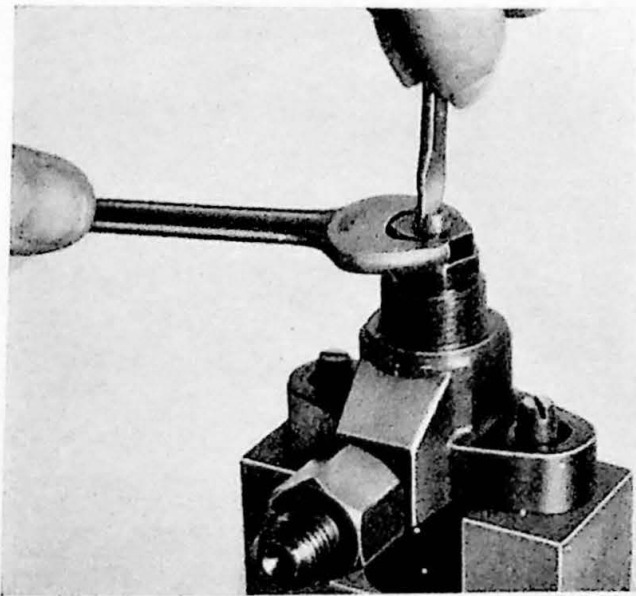


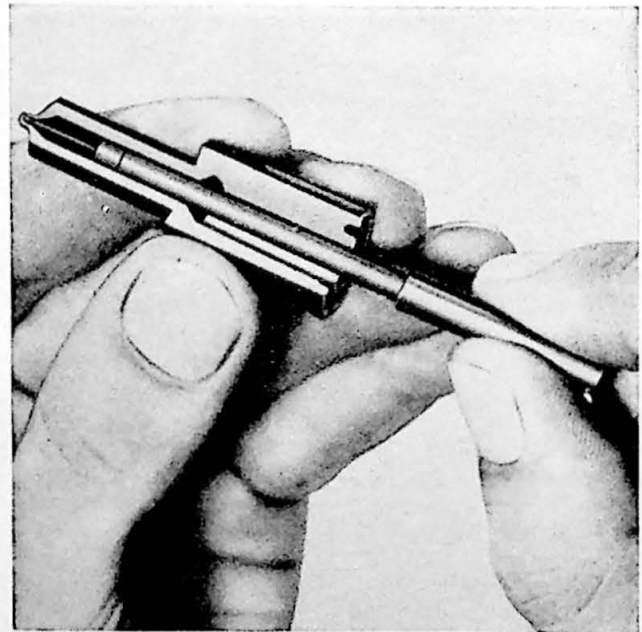
Fig. 1—123. Cleaning pressure chamber.



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Fig. 1—124. Cleaning walls of pressure chamber.



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Fig. 1—122. Releasing spring pressure before removing.



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Fig. 1—125. Cleaning nozzle chamber.

coming into contact with the bolts on the end of the pump.

Since the outer circumference of the steel disks reaches a point below the bottom level of the pump, the disks can be damaged if the pump is laid directly on a bench. For this reason, the pump should always be placed in a fixture.

4. Adjust the pump camshaft for the commencement of injection on cylinder number 1 either by the overflow method or by level control. Note the direction of rotation so that this setting is carried out on the correct side of the cam.
5. Transfer the mark on the coupling to the end of the pump (Fig. 1-117) with the greatest possible degree of accuracy. A deviation of 0.4 mm (1/64") = 2 crankshaft degrees. Use the marking tool SVO 2213 and the mark with the designation R. This mark is to facilitate the reading which has been moved 20° in the direction of rotation relative to the earlier marking position.

Remove the coupling, stamp in the letter R over the mark in the pump housing and make the mark easier to read by using a suitable chisel.

6. Fit the coupling "Pump half" and tighten the nut finally.
7. Assemble the coupling and fit the pump with the coupling on the engine. Loosen the lock screw (8, Fig. 1-116) and if necessary carefully open up the slit in the flange by using a screwdriver so that the coupling slides on to the pump drive shaft. Do not exert so much force on the coupling that the steel disks are deformed.
8. Tighten the pump into position and tighten the nut on the lock screw taking care to ensure that the coupling is completely free from stresses in an axial direction. Such stresses can shorten the lifetime of the coupling considerably.
9. Check the pump settings in accordance with instruction 11 under the heading "Fitting and Adjusting" on page 1-62. Check the idling and maximum speeds and adjust speed if necessary in accordance with the instructions "Adjusting Maximum Speed" and "Adjusting Idling Speed" below.
10. Start the engine and check that the steel disks are free from distortion due to axial stresses. If this should not be the case, loosen the lock screw and slide the flange on the drive shaft until the deformation disappears.
11. Check that all nuts have been tightened properly and that the domed washers are fitted in the correct positions.

Adjusting Maximum Speed

1. Run the engine at an average speed until the operating temperature has been obtained.
2. Clean the air cleaner and fill with oil to the correct level.

3. Determine the speed (Fig. 1-118) by means of a revolution counter which is placed against the free end of the pump shaft under the vacuum governor. Then depress the accelerator pedal fully and maintain it depressed until the engine speed has stabilized itself. At this point the revolution counter should show 1250 r.p.m. The pump rotates at a speed which is equal to half the engine speed.
4. If the right speed has not been obtained, adjustment is carried out by means of the adjuster screw furthest away from the rocker arm covers. The lock nut must be released first. After adjustment has been carried out, relock the adjuster screw by means of the lock nut.
5. Check the idling speed.

NOTE. While the maximum speed is being adjusted, the idling damper device should be complete disconnected. This is to ensure that the opening angle of the throttle is as favorable as possible.

Adjusting Idling Speed

1. Run the engine at average speed until normal operating temperature has been reached.
2. Clean the air cleaner and fill with oil to the correct level.
3. Loosen the lock nut on the idling adjuster screw on the throttle housing, the screw which is nearest the rocker arm covers. The governor cover should also be removed so that the idling adjuster screw is accessible.
4. Loosen the clamp screw on the lever which is fitted on the control arm at the rear end of the engine block on the fuel injection pump side so that this arm can be turned on its shaft.
5. Turn the idler damper shaft to the right as far as it will go with the keyway on the shaft facing upwards (Fig. 1-119).
6. With the control in the above-mentioned position let the engine idle while the correct idling speed is adjusted by means of the adjuster screw on the throttle housing (400-450 r.p.m.).
7. Lock the lever on the control arm on the rear end of the engine block and release the ball joint from the lever and screw in the ball joint one turn on the control rod. Then resecure the ball joint.
8. If it is difficult to obtain a stable setting, a certain adjustment can be carried out by using the idling adjuster screw which supports the idler pin by increasing the spring tension. Never screw in the screw so far that the speed is too high. This adjustment should be carried out a little at a time and should always be followed by a check

of the idling and maximum speeds.

9. Check the maximum engine speed.

NOTE. If the engine should show a tendency to surge or hunt in spite of the above-mentioned idling adjustment, the cause of this hunting must be determined by checking the following possible causes:

- a. Blocked fuel filter.
- b. Uneven fuel feed (fault in feed pump).
- c. Air in fuel system.
- d. Chafing or leaking nozzle needles.
- e. Chafing pump plunger.
- f. Chafing pump plunger lifter device.
- g. Unevenly worn lifter roller.
- h. Broken plunger spring.
- i. Broken pressure valve spring.
- j. Worn and leaking pressure valve.
- k. Variations in injector opening pressures.
- l. Broken pressure spring in injector.
- m. Chafing control rod.
- n. Chafing governor.
- o. Chafing idling control.
- p. Worn governor and controls.
- q. Water in the fuel oil.

Adjusting Maximum Pump Stroke
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An exact adjustment of the fuel pump must be carried out in an engine test bed where the engine can be braked under full control.

When the engine is run in a test bench everything carried out during adjustment work can be checked. Speed and loading can be varied as required for a universal test.

But since many workshops do not have a test bed, the engine must be adjusted by other methods, that is to say with the engine fitted in the vehicle running in top gear with full loading. The procedure is as follows:

1. Drive the vehicle on a level road with the accelerator pedal fully depressed. Check to ensure that the throttle is fully open.
2. With the accelerator pedal still fully depressed apply the brakes and reduce the speed of the vehicle to about 30 km/hour (20 m.p.h.) and watch the exhaust tail pipe.
3. If the exhaust gases are in the form of a transparent smoke then the settings are correct.

If the exhaust gases are thick and black, fuel feed is excessive. This fault can be eliminated by loosening the lock nut retaining the control rod set screw in position and screwing in the set screw until the exhaust gases are free from smoke. Then back out the set screw about 1/4 of a turn so that there is a slight smokiness under full loading.

4. If no smoke at all is developed when the above-mentioned test is carried out, this can depend upon the fact that the set screw is already screwed in too far. Back it out and then carry out the above test.
5. Check the test by carrying out braking tests.
6. After adjusting the maximum stroke, the set screw should be locked after which the cover is fitted on the cold starting device and sealed.

NOTE. Make sure that the cold starting device is disconnected while the test is being carried out.

Injectors

Removing

1. Clean the injector, delivery pipe and the parts of the cylinder head around the injector.
2. Unscrew the delivery pipe and the leak-off line from the injector. Fit protector caps.
3. Loosen both the nuts retaining the injector in the cylinder head and lift up the injector.

In order to avoid damage to the copper sleeve when removing the injector, it should be worked backwards and forwards before being pulled out.

If the injector sits tightly in position, use puller SVO 2035. Screw off the cap nut and attach this tool in its place. After removing the injector, screw the cap nut in position again.

Testing

The injectors must be tested with some fuel pressure with which they operate in the engine. For this reason there are special types of test apparatus. A test apparatus consists of a pump unit producing a pressure equal to that produced by the fuel injection pump, a fuel container and filter, a lever operating the pump, a pressure gauge showing the pressure and a valve enabling the pressure gauge to be shut off (Fig. 1-120).

The injector to be tested is fitted to the apparatus by means of a delivery pipe and in most cases there is also a bowl to collect the fuel passing through the injector.

It is important to ensure that the fuel used is filtered properly if the test is to proceed smoothly. Small particles which can come into the injector give the impression of leakiness or faulty spray patterns. For testing purposes, fuel oil is used or Shell Fusus A, Esso Mentor 28 or corresponding types since these are odorless and do not harm the skin.

NOTE. Never use the same oil again until it has been filtered.

An injector is tested in accordance with the following instructions:

1. Attach the injector to the delivery pipe on the test apparatus with the nozzle pointing downwards.
2. Close the pressure gauge valve and give the apparatus several energetic strokes in order to flush out the apparatus and the injector.
3. Leak check:

Open the pressure gauge valve. Increase the injector opening pressure to 160-170 kg/cm² (2270-2410 p.s.i.). Adjustment of the opening pressure is carried out by removing the cap nut and screwing the adjuster screw in or out by which the thrust spring tension against the nozzle needle is altered. With the pressure gauge connected pump up the pressure to 160-165 kg/cm² (2270-2340 p.s.i.). Allow the pressure to go down and use a stop watch to determine how long it takes for the pressure to fall from 150 to 100 kg/cm² (from 2160 to 1410 p.s.i.). This fall in pressure should take at least 6 seconds but should not take longer than 30 seconds maximum. If the pressure fall takes more than 30 seconds, then the clearance between the nozzle needle and the injector body is too small so that there is risk of the needle chafing due to engine heat. If all connections are tight but the pressure falls during a shorter time than 6 seconds, this in all probability depends upon excessive leakage between the injector body and the lapped surfaces of the nozzle needle. During the test it should be ensured that there is no leakage between the lapped surfaces between the nozzle holder and the nozzle. If there is leakage here, oil will seep out between the nozzle nut and the nozzle holder. Leakage can depend upon the fact that the nut has loosened, that there is dirt between the sealing surfaces or that the sealing surfaces themselves are damaged. This is remedied by unscrewing the nozzle nut and cleaning or lapping the sealing surfaces.

NOTE. Never try to improve the sealing properties by tightening the nozzle nut even more.

4. Adjustment of opening pressure:

With the pressure gauge valve open press the pump arm gently downwards and read off the pressure gauge at the moment when the injector opens. The opening pressure should be $130\text{--}140\text{ kg/cm}^2$ ($1850\text{--}1990\text{ p.s.i.}$). If the pressure is too low, the spring in the nozzle holder must be tensioned; if it is too high the tension on the spring should be reduced. This is carried out by means of the adjuster screw which is accessible after the cap nut has been removed.

After the correct opening pressure has been set, close off the pressure gauge and move the test apparatus lever slowly downwards until the injector opens. At this moment the test oil should be sprayed out jerkily and with a clearly audible creaking noise. The shorter these jerks are, the better the condition of the injector.

5. Check the seat for leakage:

Check that the opening pressure is 135 kg/cm^2 (1910 p.s.i.), dry off the injector and then pump the pressure up to 125 kg/cm^2 (1770 p.s.i.). Maintain the pressure of this value for about 5 seconds and examine to make sure that the test oil does not drip out through the spray holes in the nozzle. During and after this test, the injector should be completely dry.

6. Check of spray formation and direction:

For this test, the injector should be fitted with a special cam and valve (for example CAV type BNT 1) or a fuel injection pump with 9 mm plunger units can be used since a normal hand pump is not capable of producing finely divided spray and showing a particularly marked spray pattern. If the fuel injection pump is used for this purpose it should be installed in a test bench so that it delivers 20 cm^3 per 100 strokes.

Connect up the injector and run the pump or the test apparatus at a speed of 100 r.p.m. Check the formation and direction of the fuel spray. The following specifications must be satisfied:

- A. The spray should be formed at the specified pressure ($135\text{ kg/cm}^2 = 1920\text{ p.s.i.}$).
 - B. The spray must consist exclusively of a finely atomized fog.
 - C. The four individual sprays should be evenly divided and have exactly the same shape. The fuel delivered should be equally divided round the spray holes.
 - D. The angle covered by the sprays should be 150° .
7. If the opening pressure of the injector, spray pattern and freedom from leakage are normal, the injector should not be disassembled for cleaning and adjustment. A protector cover and protector cap should be fitted instead. If the injector is not to be immediately

refitted on the engine, it should be smeared with vaseline and should be packed in a dust-tight container.

If there is any fault in the injector, it should be cleaned and adjusted, care being taken to observe the directions given under the heading "Disassembly and Cleaning" below.

Disassembly and Cleaning

Due to the fact that the injectors are extremely sensitive to dirt, the diesel workshop should be separated from the other departments in the workshop.

The best cleaning fluid to use is fuel oil or white spirit. The cleaning fluid used should be changed often and maintained absolutely free from impurities. The tools used should always be kept in the best condition so that the injectors are not damaged when they are disassembled.

Avoid touching ground sealing surfaces on needles or injector parts with the bare hands. Finger prints can be the cause of rust and this can effectively destroy the precision-made qualities possessed by the part in question.

The nozzles and the nozzle needles have been matched so care should be taken to avoid getting them mixed up with corresponding parts from other nozzles.

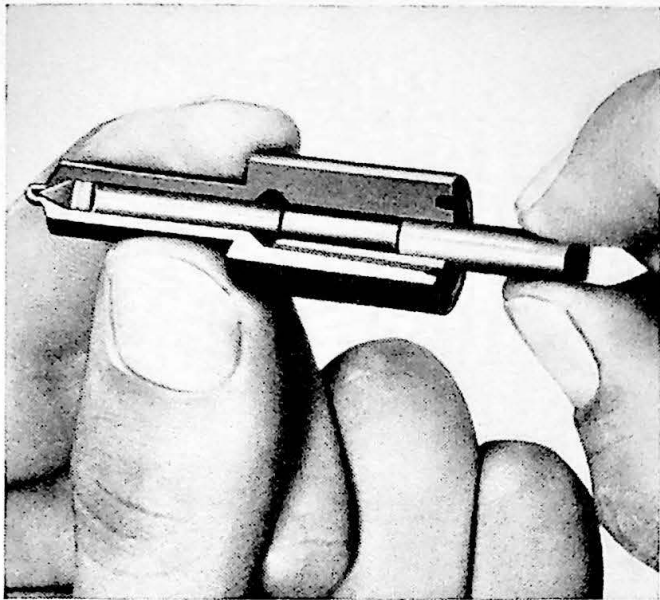
The injectors are disassembled best in the following way:

1. Place the injector in a special fixture. Remove the cap nut (1, Fig. 1-25) and the washer (15). Loosen the adjuster screw (2) to ease off the pressure exerted by the spring (14) on the nozzle needle (8). Turn the injector over. Remove the nozzle nut (9) and then remove the nozzle (10) from the nozzle holder (12).
2. Remove the nozzle needle and remove any external soot by using a metal brush and cleaning fluid. If difficulty is encountered in cleaning the needle and the nozzle they should be immersed in alcohol or similar resin-dissolving fluid for about 1/2 hour. Be careful to ensure that nozzles and needles are not mixed up together.
3. Clean out the canals leading to the nozzle pressure chamber by using a drill or a silver steel wire (Fig. 1-123).
4. Clean the nozzle pressure chamber by using a special scraper which should be carefully introduced through the guide without damaging this. When the scraper has reached the wall of the pressure chamber it should be pressed hard downwards and twisted round (Fig. 1-124).
5. A special reamer (Fig. 1-125) is used to remove soot from the nozzle spray chamber (the space between the seat and the spray holes).

6. The nozzle seat is cleaned from soot by using a seat reamer, which is pressed downwards at the same time as it is twisted round (Fig. 1-126).
7. The spray holes in the nozzle tips should be cleaned if they are wholly or partially blocked with soot by using a small cleaning needle fitted in a holder. When cleaning out the holes use a cleaning needle with a diameter 0.02 mm (0.0008") smaller than the diameter of the spray holes and make sure that the beveled parts of the cleaning needle are used. For the nozzles used in this engine (BDLL 150 S 6 123 with a hole diameter of 0.27 mm = 0.0106") a cleaning needle with a diameter of 0.25 mm (0.0098") should be used.

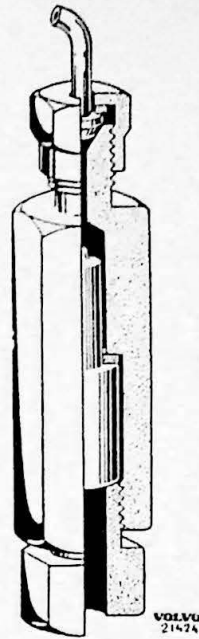
Insert the cleaning needle in the hole, move it backwards and forwards at the same time as it is twisted until the hole is clean. If the holes cannot be cleaned out with a normal cleaning needle, the nozzle should be immersed in fuel oil or white spirit after which a special reamer with tapered steel points is used. When the reamer is used the tapered point is held against the blocked hole and the reamer is pressed inwards at the same time as it is turned. Take care to ensure that the point does not break off and fasten in the hole.

8. Remove any loose particles from the nozzle and its holes by fitting the nozzle in a flushing apparatus (Fig. 1-128) which is connected to the injector tester after which the nozzle is thoroughly flushed out by means of powerful pump strokes. The pressure gauge valve on the apparatus should be closed while this is done.
9. Insert the nozzle needle in the seat cleaner and turn it round at the same time as it is pushed hard inwards. The seat cleaner can otherwise be fitted in a lathe or drill and run at a speed of about 600 r.p.m. while the nozzle needle is pushed inwards towards the cleaning surface. The pressure surface and pin should then be carefully cleaned with a wire brush followed by flushing in cleaning fluid (Fig. 1-129 and 1-130).
10. The nozzle holder should be washed in cleaning fluid, care being taken to protect the sealing surface towards the nozzle. The wire brush is used to clean the nozzle holder outer surface free from soot, dirt and rust.
11. Place the nozzle holder in a fixture. Remove the sleeve (16, Fig. 1-25) above the thrust spring. Take out the thrust plate (4), the thrust spring and the push rod (13). Loosen the screw union (6) and take out the filter (7) and the cone (5).
12. Clean all components and channels. Make sure that the filter in the injector is completely clean.



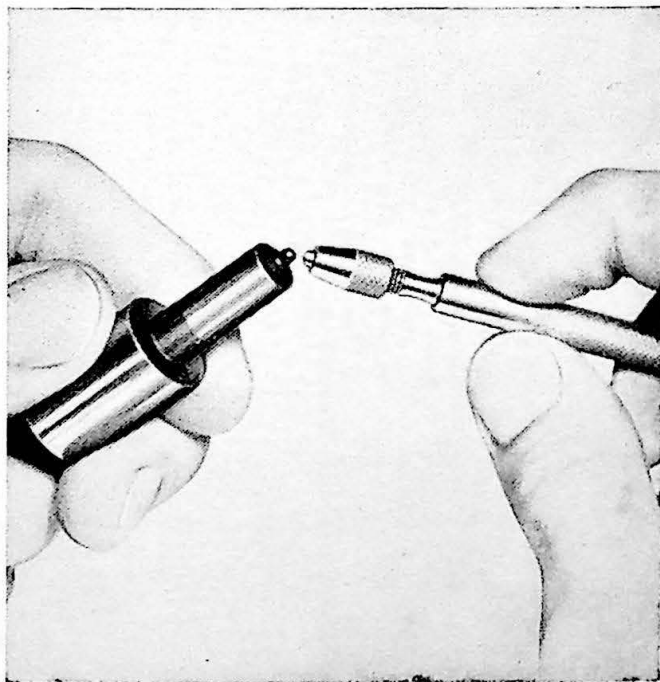
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Fig. 1—126. Cleaning nozzle seat.



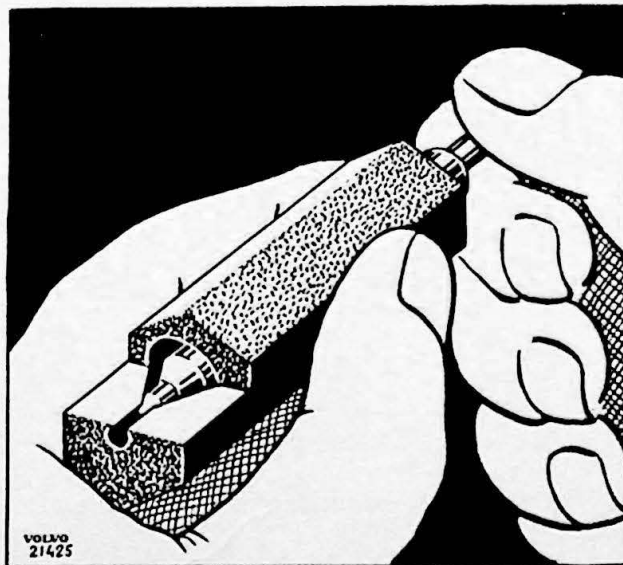
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Fig. 1—128. Flusher.



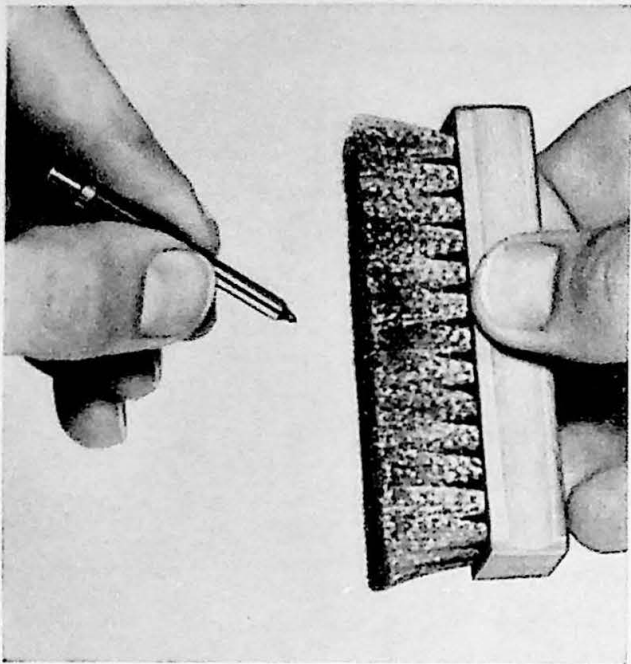
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Fig. 1—127. Cleaning spray holes.



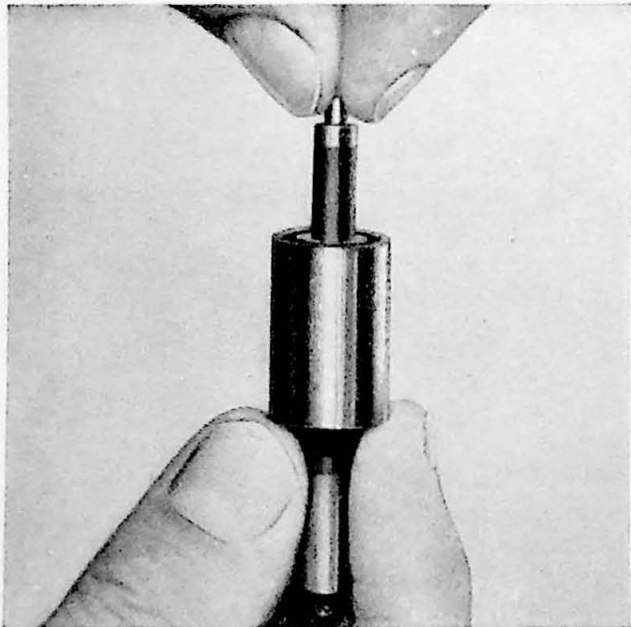
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Fig. 1—129. Seat cleaner.



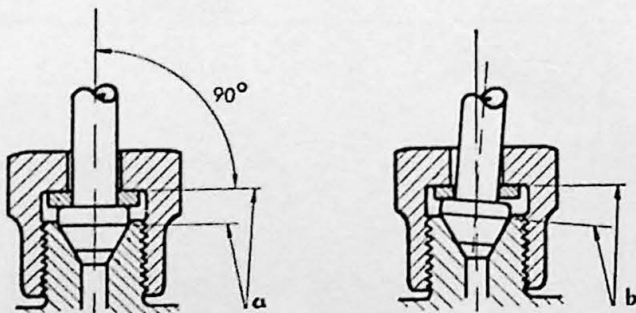
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Fig. 1—130. Cleaning nozzle needle.



21242

Fig. 1—131. Checking nozzle needle.



21246

Fig. 1—132. Delivery pipe screw union.

Correctly fitted
Surfaces (a) parallel

Incorrectly fitted
Surfaces (b) not parallel

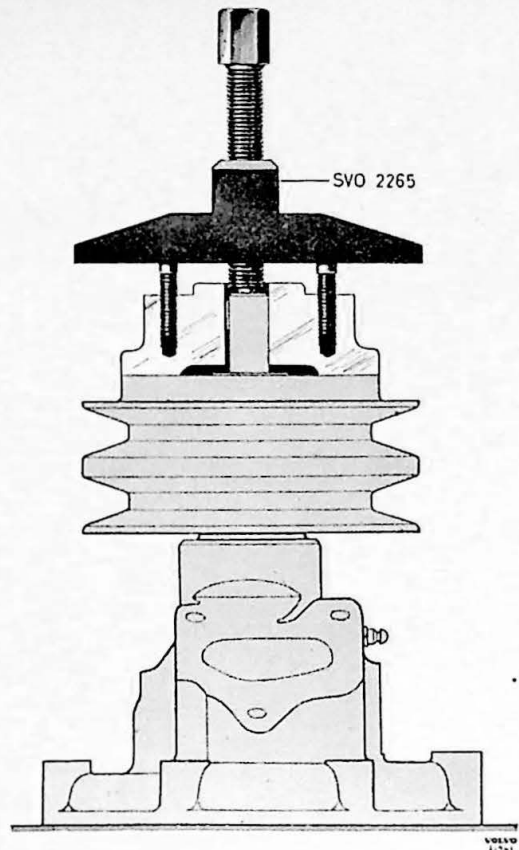


Fig. 1—133. Removing fan hub.

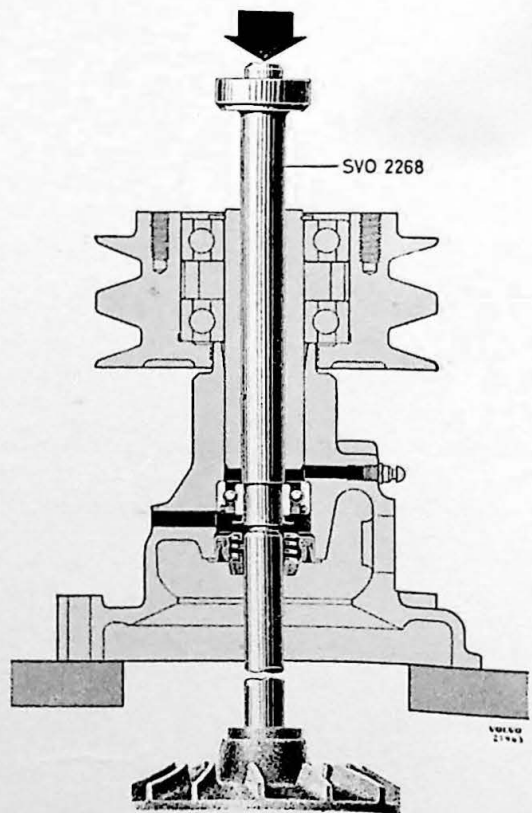


Fig. 1—134. Removing impeller, shaft, seat, slinger ring and bearing.

Inspection and Adjustment

The following points should be checked when inspecting the injectors. These points cover most of the faults which may occur.

1. Check that the needle runs easily in the guide. If the clearance between the needle and the guide is correct the needle should slide in without chafing. Hold the nozzle vertically, lift the needle 10-15 mm (about half an inch) and then release it. The needle should then slide down against the seat under its own weight. Repeat the test several times after turning the needle a little. If the needle shows a tendency to chafe, careful lapping should be carried out with tallow. Both the nozzle and the needle must be carefully cleaned after lapping.
2. The needle may not be loose in the guide. If this is found to be the case, both the needle and the nozzle should be replaced.
3. Examine the tapered sealing surface of the needle. This should not be so worn that there is a depression in it. Make sure that the point of the needle is not deformed.
4. Make sure that the pin on the nozzle needle fits easily in the push rod.
5. Make sure that the nozzle sealing surface for the nozzle is highly polished so that it can seal properly.
6. Check that the nozzle tip with the holes is undamaged.
7. Check the condition of the spring.
8. Check that the hex on the cap nut, the lock nut for the adjuster screw and the delivery pipe nut as well as the threads on these are undamaged.

Assembly

1. Fit the push rod, the spring, the spring washer and the spring nut with the adjuster screw and lock nut in the nozzle holder. Tighten the spring nut with the wrench specially designed for this purpose.
2. Fit the cone, the filter and the delivery pipe screw union.
3. Check that the flat, lapped surfaces on the nozzle and the nozzle holder are clean and free from dirt, metallic particles and dust.

Unscrew the adjuster screw and then flush the nozzle needle and nozzle with fuel oil. Fit the nozzle needle and nozzle and then tighten the nozzle nut but not too hard.

Make sure that the nozzle is in its correct position and then screw in the adjuster screw slightly.

4. Adjust the injector opening pressure in accordance with the instructions on page 1-68 "Testing".

Fitting

1. In order to blow the copper sleeves clean, the engine should be turned over a few times before the injectors are fitted.
2. Slide down the injectors into position and then fit the spring washers and nuts. Tighten the nuts by tightening the nuts alternatively so that there are no stresses which can influence the function of the nozzle needle.

See the specifications for the correct tightening torques.

3. Connect the leak-off line. Replace damaged washers.
4. Tighten the delivery pipe, taking care to ensure that the cones come into their correct positions (Fig. 1-132).

Pipe Lines

Replacement of Fuel Lines

Damaged fuel lines should always be replaced. If an attempt is made to repair them by welding or bracing, slag and scale can form on the inside of the lines. This scale can cause damage in the fuel injection pump, the injector and the feed pump.

Before replacing a pipe, both this and the surrounding parts should be thoroughly cleaned before removing the pipe. The new pipe should be flushed through with clean oil before fitting. Replace all washers and make sure that the pipe fits properly without stresses since these can cause breakages.

Air-vent the system after replacing a pipe.

Replacement of Delivery Pipe

Delivery pipes which are fractured or damaged in any other way should be replaced. No attempt should be made to repair them by welding since the scale formed gradually loosens and is forced into the injector which can be severely damaged.

Before fitting a new delivery pipe, flush it through with clean fuel oil. When fitting make sure that the cones on the end of the pipe are carefully fitted in the connections at the injector and the pump and that the pipe fits correctly without any stresses since these stresses can cause breakage or other forms of damage.

Make sure that the nuts rotate easily and that the wrench used is in good condition. Tighten the screw union on the fuel injection pump first and then the screw union on the injector.

Air-venting the Fuel System

1. If the fuel system has been completely emptied, the fuel lines, the feed pump, the filters and the fuel injection pump must be filled with fuel by operating the hand primer pump.

Since air collects in the highest points in the system, air-venting is commenced by opening the air-venting cock on the upper fuel filter and operating the hand primer pump until the fuel passing out is completely free from air bubbles.

Close the air-venting cock on the upper fuel filter and then open the air-venting cock on the fuel injection pump.

3. Continue to operate the hand primer pump until the fuel passing out is free from air bubbles.
4. A final air-venting which is sometimes necessary concerns the delivery pipes since it is not possible to air-vent the injectors themselves.

Loosen the delivery pipe nuts and remove the inspection cover on the fuel injection pump. Operate the plunger units in the injection pump one at a time by inserting a special tool in the plunger lifter hole to the right of the guide groove at the top and use this tool as a lever. Continue pumping until the fuel passing out is free from air bubbles after which the nut on the delivery pipe is tightened and pumping is continued on the next plunger unit.

NOTE. While this pumping is being carried out, the stop arm should be in such a position that full feed is being obtained. The cold starting device should also be coupled in since this increases the amount of fuel delivered by the pump.

COOLING SYSTEM

Cooling Water Pump

The cooling water pump can be removed without having to take off the radiator. Removal is carried out in the following way:

1. Drain off the cooling system.
2. Remove the fan.
3. Loosen the tensioning device for the drive belts and the generator and then remove the drive belts.
4. Loosen the hose connections between the pump and the thermostat housing and between the pump and the radiator.
5. Loosen the attaching bolts and lift out the pump.