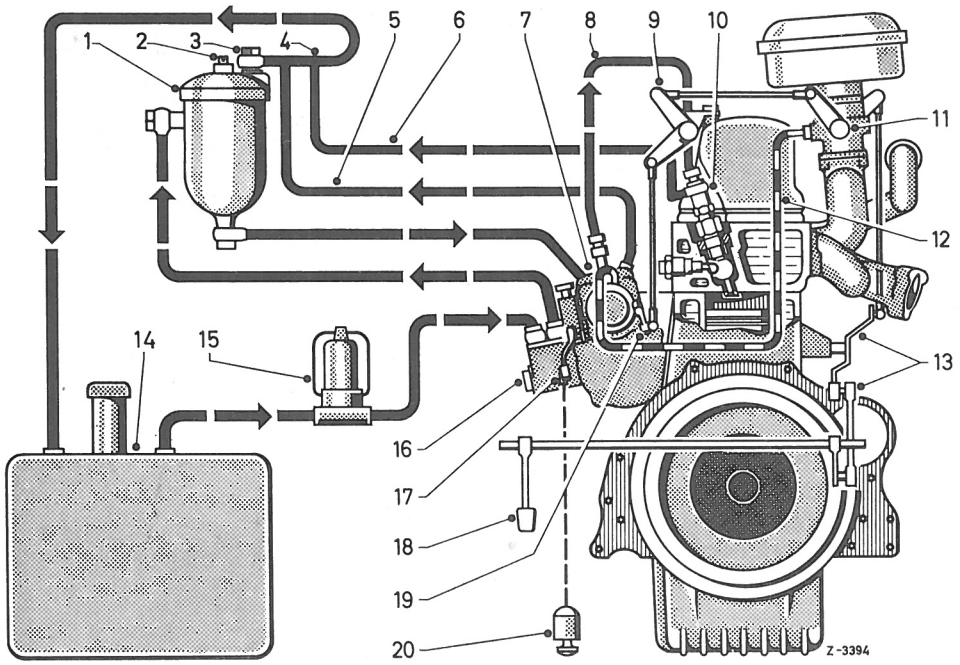


Fig. 07-40/1

1 Main fuel filter
2 Vent screw
3 Hollow screw 615 090 00 69 with throttle screw
4 Fuel return line 615 070 01 32
5 Overflow line
6 Injection nozzle leakage line
7 Injection pump
8 Pressure line from injection pump to injection nozzle
9 Angular lever for auxiliary mechanical control
10 Injection nozzle
11 Venturi control unit
12 Vacuum line with throttle screw
13 Linkage and lever for accelerator pedal control
14 Fuel tank
15 Fuel pre-filter
16 Fuel feed pump with hand pump
17 Adjusting lever
18 Accelerator pedal
19 Lever for auxiliary mechanical control
20 Heater plug starting switch with starting and stopping cable

The above figure illustrates the injection system for a diesel engine in a general way.

The fuel feed pump, which is driven by the injection pump, draws fuel from the fuel tank. After passing through the pre-filter, the fuel is forced through the main filter into the suction chamber of the injection pump. The overflow valve mounted to the end section of the injection pump suction chamber maintains the permanent pressure on the fuel in the suction chamber which is produced by the fuel feed pump. At a minimum pressure of 0.8 atm surplus fuel at the end of the suction chamber flows back into the fuel tank via the overflow valve. In any case, the fuel feed pump will deliver more fuel than is necessary for injection into the engine in order to prevent bubble formation and to ensure that the suction chamber is filled with pressurized fuel. At temperatures below 0° C, the circulation of a larger amount of fuel has the additional advantage of preventing the tank fuel lines from becoming clogged with deposited paraffin.

The plungers of the four injection pump elements force the fuel contained in the suction chamber through the injection pump pressure valves into the injection lines, and from there to the injection nozzles. Through the injection

nozzles, which operate at spray pressure ratings of 110-120 atm, the fuel reaches the pre-chambers and finally the main combustion chamber of the diesel engine.
Fuel leaking from the injection nozzles is returned to the fuel tank via the leakage line and the fuel return line.
Control of the amount of fuel injected is dependent upon the position of the accelerator pedal, and upon engine load and speed, and is effected by the pneumatic governor mounted to the rear of the injection pump.
Trouble free operation of the injection pump and/or the injection nozzles is largely dependent upon the degree of purity of the fuel. Even slight contaminations caused by dirt, dust, hair particles, etc. may lead to injection nozzle malfunctioning (knocking of the engine), and to premature wear of the injection pump. For this reason, it is of paramount importance that the fuel filter elements should be cleaned regularly in accordance with factory specifications.
Heavily soiled filters must be replaced.

The fuel line layout is such that the lines are protected against damage which would impair the fuel system. It is therefore necessary to adhere to the original fuel line layout when replacing parts in the system. Above all, kinks and twists must be carefully avoided.
The injection pump oil level must be checked at regular intervals (see lubrication chart), and must be topped up with engine lubricating oil whenever necessary. Unscrew oil level check screw for checking the oil level. If the injection pump contains too much oil, the excess oil will flow out through the check screw opening. In case oil must be added, the ventilating filter has to be unscrewed and oil poured in slowly through the filter opening until excess oil leaves the check screw bore. Thereafter, screw in check screw and filter. With each pump servicing, the mixture of lubricating oil and leakage fuel must be drained off completely and replaced by new engine oil until the check screw level is reached. The injection pump holds approx. 150 cc of oil.

Removal

1 Screw out all injection lines, the vacuum line and all fuel lines connected to the injection pump. Plug the injection line and fuel hose unions of the injection pump.

2 Detach connecting rod for the auxiliary mechanical control as well as starting and stopping cable at the injection pump adjusting lever. Unscrew screw in the retaining angle (3) and remove coil spring (4) with clamp (Fig. 07-41/1).

3 Screw out hexagon nut at the bell-shaped support and fixing nuts at the front flange; then pull out the injection pump from the crankcase. Remove coupling sleeve from the injection pump drive collar or from the drive shaft (see Fig. 07-41/4).

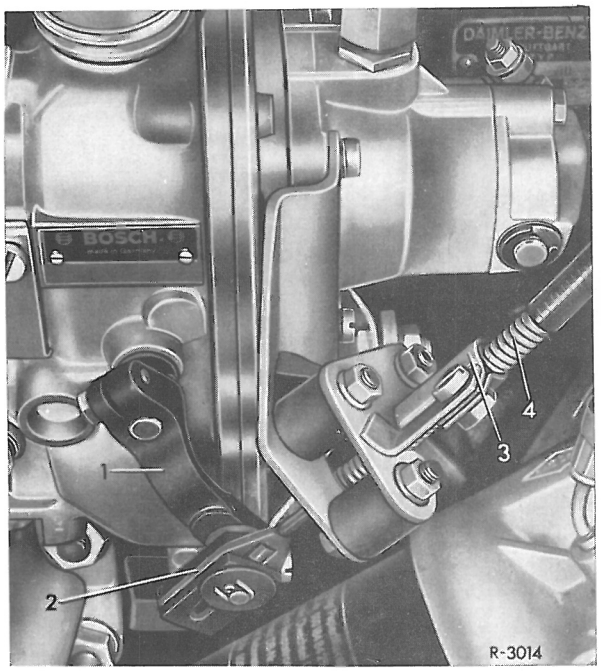


Fig. 07-41/1

1 Adjusting lever (starting and stopping cable lever)
2 Eyelet with rubber molding
3 Retaining angle
4 Coil spring

Note: When replacing a drive collar, hold it steady with Special Wrench 621 589 00 08 00 in order to loosen hexagon nut, then pull off drive collar from the injection pump drive shaft using Puller 636 589 02 23 00. Clean shaft end and drive collar. Both cones must be flawlessly clean and absolutely free from grease.

Observe markings when putting a new drive collar on (see arrows in Fig. 07-41/2).

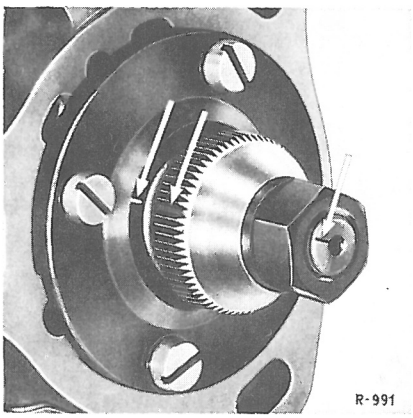


Fig. 07-41/2

Installation

4 Turn crankshaft in the direction of rotation until the **47°** (for Model 200 D/8) or **45°** (for Model 220 D/8) **BTDC Mark** of the graduated rim of the balancing disk (1) coincides with the **alignment indicator** (2). (In Fig. 07-41/3, the crankshaft is shown in the TDC position.) The piston of the first cylinder must be in its compression stroke during this process.

5 Now determine whether the coupling sleeve can be easily slid onto the drive collar of the injection pump. If this is the case, slide coupling sleeve onto the drive shaft in the crankcase (see Fig. 07-41/4).

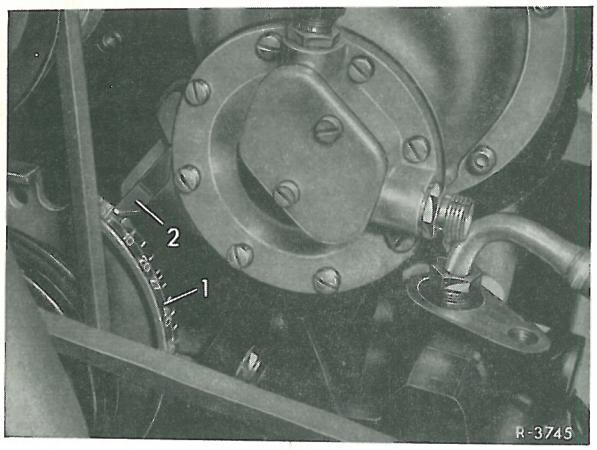


Fig. 07-41/3

(crankshaft is shown at TDC)

1 Balancing disk
2 Alignment indicator

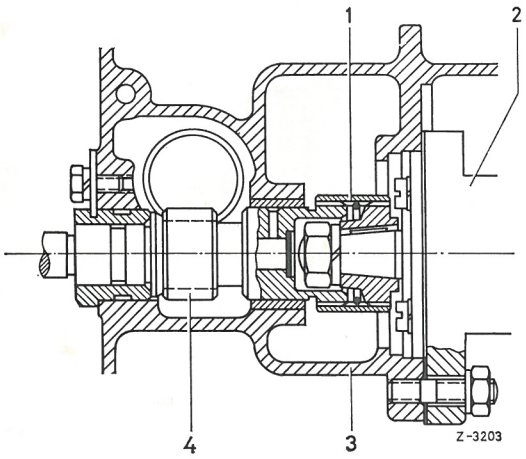


Fig. 07-41/4

1 Coupling sleeve
2 Injection pump
3 Crankcase
4 Idling gear shaft (drive shaft for injection pump and oil pump)

6 Remove plug from oil overflow pipe at rear end of the injection pump.

7 Set injection pump to start delivery position. This is done by turning the pump shaft until the drive collar tooth gap and the injection pump marking coincide (see arrows in Fig. 07-41/2).

8 When applying light leftward oriented pressure to the drive collar (pressure is applied opposite to the direction of rotation), cam pressure action of the camshaft causes the drive collar to jump back by two teeth to the cam base circle. The **second tooth must then coincide with the marking** on the injection pump housing. Before inserting pump, double-check whether the **piston of the first cylinder** is in **compression stroke** position and whether the **crankshaft** is at **47°** (Model 200 D/8) or **45°** (Model 220 D/8) **BTDC,** respectively.

Note: Because the drive collar jumps back by two teeth, crankshaft adjustment to 47° BTDC is necessary.

9 Apply grease to either side of new paper gaskets and place paper gaskets on crankcase.

Installation of Injection Pump

10 Install injection pump in the coupling sleeve in such a way that the stud bolts are centrally positioned within the slotted holes. This way, fine alignment is possible by swiveling to either side.

Note: After swiveling or fine alignment of the injection pump, there must be a clearance of approx. 80 mm between crankcase and center of injection line union in order that the glow plugs can be removed.

11 Place washers in their position and slightly tighten the injection pump with two hexagon nuts.

12 Turn crankshaft further in the direction of rotation until the **26°** (for Model 200 D/8) or **24°** (for Model 220 D/8) **BTDC MARK coincides with the alignment indicator** (2) (Fig. 07-41/3); the piston of the first cylinder must be in the compression stroke position.

Note: As a rule, crank engine only in its proper direction of rotation in order to ensure that the flyweights are not forced from their initial positions and that the chain is kept tensioned.

13 Screw out pipe union (1) of the first pump cylinder, then remove rubber sealing ring (2), coil spring (3), and pressure valve (5) with sealing ring (4) (Fig. 07-41/5).

Screw pipe union without parts (3 to 5) back in and screw overflow pipe (5) back on (Fig. 07-41/6).

14 In order to make sure that the adjusting lever (1) or the control rod, respectively, are positively positioned at full load, actuate adjusting lever (and thus control rod) in stop direction as far as possible then release. Repeat the process several times (Fig. 07-47/1).

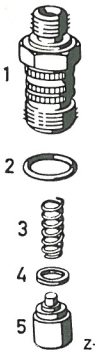


Fig. 07-41/5

1 Pipe union
2 Sealing ring (rubber)
3 Coil spring
4 Sealing ring
5 Pressure valve holder with pressure valve

When checking the beginning of the effective stroke it is imperative that the control rod should be in the full load position since in the case of injection pumps with double control edge the beginning of the effective stroke will be constant only in this position.

In this connection reference must be made again to our instruction to measure **the beginning of the effective stroke according to the overflow method** since the capillary tube method is less reliable.

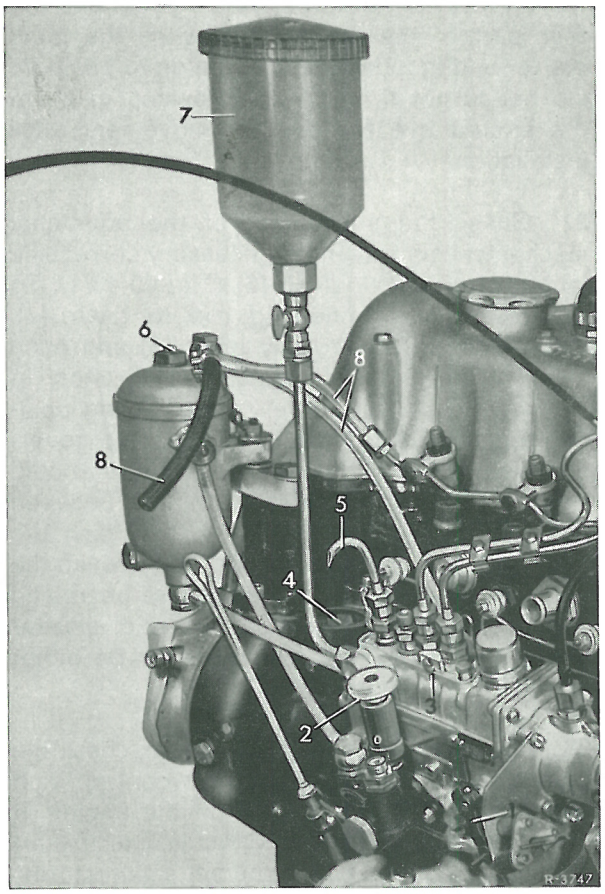


Fig. 07-41/6

1 Adjusting lever of injection pump
2 Hand-operated fuel feed pump
3 Clamping jaws for securing two pipe unions
4 Revolution counter connection
5 Overflow Pipe 636 589 02 23 00
6 Bleed screw on main fuel filter
7 Fuel Tank Part No. 000 589 05 23 00 with stop cock and pipeline
8 Fuel return lines

15 Connect the fuel tank (7) to the injection pump, fill it with clean fuel and open the stop cock of the fuel tank (Fig. 07-41/6).
The fuel will now flow from the overflow pipe (Fig. 07-41/7).

Note: For checking purposes the fuel tank is not necessarily required. It is sufficient to connect the fuel feed line to the injection pump, to bleed the fuel system and then to back out the bleed screw (6) on the main fuel filter as for bleeding. The fuel reserve will be sufficient for one or two checks. Always refill the main fuel filter by means of the hand-operated fuel pump (2).

Adjustment of Beginning of Effective Stroke

16 Correct the beginning of the effective stroke in relation to the crankshaft position by moving the injection pump in the appropriate direction.

Moving the injection pump toward the engine advances the beginning of the effective stroke, moving the pump away from the engine retards it.

The injection pump is at the beginning of the effective stroke in relation to the desired and set crankshaft position when the fuel just begins to stop dripping from the overflow pipe. One more drop may follow after approx. 15-20 sec. (Fig. 07-41/8).

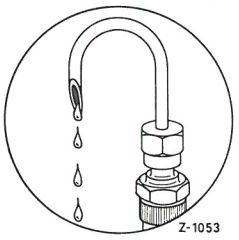


Fig. 07-41/7

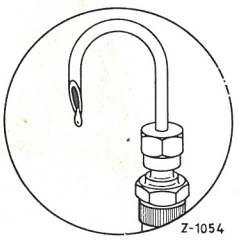


Fig. 07-41/8

17 Tighten the injection pump in this position by means of two hexagon nuts and check the adjustment again.

To repeat the check turn the crankshaft exactly two turns in the direction of rotation. Toward the end of the second turn move the crankshaft **slowly** until **the fuel is on the point of no long-**

er flowing or dripping from the overflow pipe. (One more drop may follow after approx. 15-20 sec.)

In this position the pump plunger just covers the inlet bore in the pump cylinder, i. e. the plunger of the first cylinder of the injection pump is just at the beginning of its effective stroke.

If in addition the pointer **again points to 26° BTDC,** the beginning of the effective stroke of the injection pump has been properly set in relation to the crankshaft position (Fig. 07-41/3).

18 If this check should prove negative, readjust the beginning of the effective stroke (see para 16). Detach the injection pump from the attaching flange just enough for the pump to be moved.

19 When the adjustment is found to be correct firmly tighten all hexagon nuts attaching the pump to the flange.

20 Unscrew the fuel tank and the overflow pipe.

21 Unscrew the pipe union (1) and install the pressure valve (5), a **new** sealing ring (4), the coil spring (3) and an undamaged rubber sealing ring (2) (Fig. 07-41/5). Coat the thread of the pipe union with tallow, screw it in again and tighten with a **torque of 3.0 mkp.** To ensure a **proper** fit of the sealing ring **loosen** the pipe union and retighten it **with a torque of 3.0 mkp, loosen it again and finally tighten it with a torque of 3.0 + 0.5 mkp.**

Malfunction and faults may occur with both the pump and the engine if the tightening torque for the pipe union is either too high or too low.

Absolute cleanliness is of paramount importance when the pressure valve is installed since dirt particles may produce engine trouble.

22 Install the clamping jaws (3) between the pipe unions **taking care to ensure that the tightening torque for the fixing screws does not exceed 0.9 mkp;** excessive tightening may distort the injection pump housing and produce leakage of the elements on the low and high pressure side (Fig. 07-41/6).

23 Connect injection pipes, vacuum pipes and all fuel hoses. Use new sealing rings for all connections. Place the hoses in such a way that they are not under any tension and cannot rub against any part.

Tighten the injection pipes with a torque **of no more than 2.5 mkp.**

24 Bleed the fuel system.

25 Attach wire coil (4) together with clip to the retaining angle (3) and attach the starting and stopping cable to adjusting lever of the injection pump (Fig. 07-41/1).

26 Check the adjustment of the cable (see Job No. 00-42).

Note: When attaching the starting and stopping cable remember that there must be a clearance of approx. 2.0 mm between the adjusting lever pin of the injection pump and the rear part of the slotted eye when the glow starter and stop switch is in the drive position. Do not forget to check the bowden cable in the slotted eye for ease of movement after installation.

27 Check the adjustment of the additional mechanical control and if necessary correct the length of connecting rod (6) (Fig. 00-43/1). To do this attach connecting rod to lever (7), detach it from angle relay lever (3) and push it down until it rests against the idle stop. In this position, i. e. throttle valve in idling position and lever (7) of the injection pump governor resting against the idle stop, there should now be a clearance of appr. 1 mm between ball socket and ball head, i. e. to attach the connecting rod (6) to the ball socket of the angle relay lever (3) the rod must be raised appr. 1 mm. If the distance is larger or smaller than 1 mm the connecting rod must be either lengthened or shortened.

28 Run the engine for a short time, check the unions for leakage, turn the idle control knob over to the right and switch off the engine. If adjustment should prove difficult, i. e. if start and stop positions cannot be set satisfactorily, it is permissible slightly to reduce the starting delivery in favor of an accurate stop position.

29 Check and if necessary correct idling speed, maximum speed under no load and maximum speed under full load (see Job No. 00-43).

Seals for the Diesel Injection Pump

Replacement of seals between the pressure valve holders of the injection pump and the pipe unions

General Instructions

In the event of complaints of severe combustion knock when the car is overrunning the engine or when the engine is shaking whilst idling or running in the lower speed range it is advisable to replace the seals (42) between the pipe unions (3) and the pressure valve holders (6). Such symptoms of uneven operation may be the result of the injection pump clamping jaw (15) being tightened up too hard and the pipe unions (3) being under such stress that the seals (42) can no longer seal properly. The resultant leakage may well cause diesel fuel to fill the pump housing, emerge from the overflow and even get into the regulator vacuum chamber, thus making it impossible for the control rod to move right over to the idle position when the car is overrunning the engine.

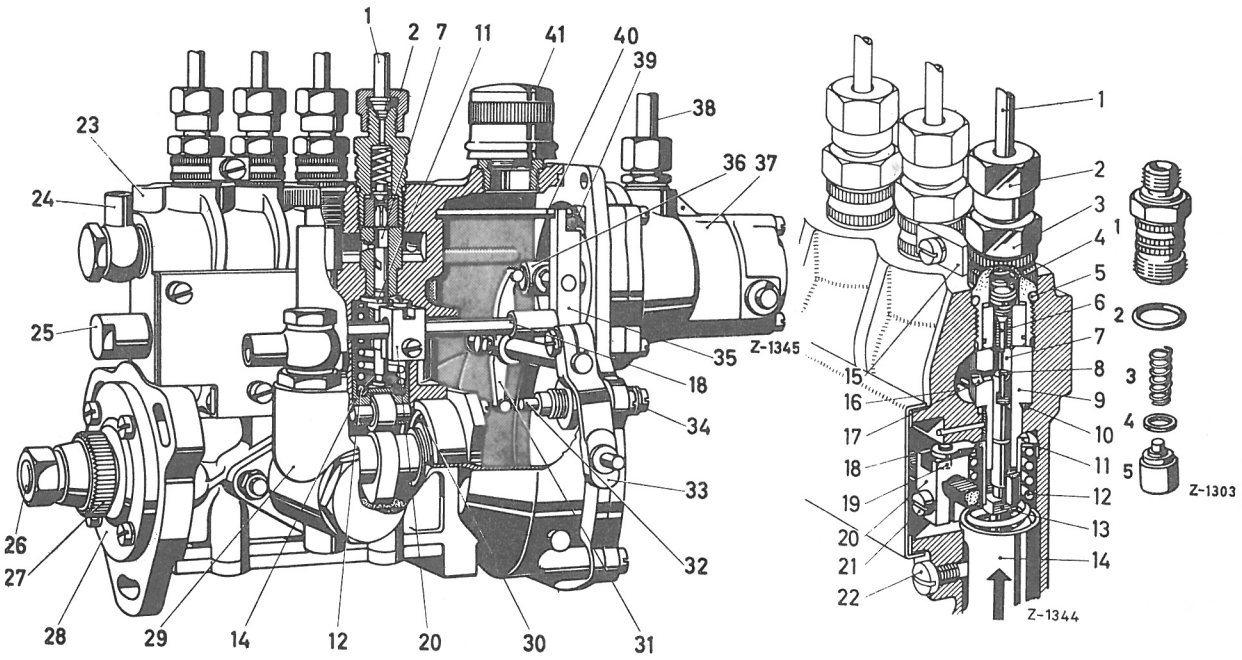


Fig. 07-43/1

1 Pressure pipe (injection pipe)
2 Cap nut
3 Pipe union
4 Valve spring
5 Seal between pipe union and injection pump housing
6 Pressure valve with pressure valve holder
7 Pressure chamber
8 Plunger } = forming pump
9 Cylinder } element
10 Seal
11 Governor sleeve with steering arm
12 Tappet spring
13 Plunger vane
14 Roller tappet
15 Clamping jaws (to grip the pipe unions)
16 Suction chamber
17 Control bore (feed and return bore)
18 Control rod
19 Pin on control sleeve rotating lever
20 Adjustable clamping piece with guide groove
21 Clamp screw
22 Tappet guide screw
23 Injection pump housing
24 Fuel feed union
25 Control rod guide bearing and start-metering stop
26 Camshaft (drive side)
27 Link stud
28 Bearing base-plate with gasket and centering adjustment
29 Fuel feed pump
30 Journal bearing
31 Rocker arm
32 Stop pin for full load stop
33 Setting lever
34 Setting lever stop, also adjustment screw with full load stop
35 Guide lever
36 Diaphragm pin with pressure pin and compensator spring
37 Diaphragm assembly
38 Vacuum line
39 Diaphragm
40 Guide pin
41 Air cleaner and oil filler bore
42 Seal between pipe union and pressure valve holder

Replacement of Seals

1 Take out fixing screws of clamping jaws (15), take off the clamping jaws and thoroughly clean the injection pump around the pipe unions with gasoline.

3 Pull out pressure valve holder with pressure valve (6) and copper seal (42).

4 Flush out suction chamber of pump by operating the manual lever on the fuel feed pump for a few strokes. Use Cleaner 000 589 23 68 00 to remove any foreign bodies which may have collected on the face of the cylinder, which is at the same time the seating surface of the pressure valve holder. (Bosch Number of Cleaner is EFEB 426).

5 Clean seating surface of pressure valve holder. Put a new copper seal 001 997 34 40 (42) on the pressure valve holder and put it back in the injection pump together with the pressure valve.

6 Put valve spring (4) on pressure valve (6). Slide a new rubber seal 001 997 50 40 (5) on to the pipe union (3). Apply tallow to the external thread of the pipe union and screw it home.

In order to be absolutely certain that the seal (42) is properly seated, **use a torque wrench and tighten up the pipe union (3) in accordance with the following tightening scheme:**

Tighten up to 3.0 mkp and slacken off; tighten up again to 3.0 mkp and again slacken off; finally, tighten up to 3.0 mkp + 0.5 mkp.

7 Repeat procedures 2 to 6 in the proper order for the other pipe unions.

8 Install clamping jaws (15) and tighten up the cheese-head screw to a torque of 80-90 cmkp.

9 Slacken the fixing screws of the diaphragm housing (37). Raise the diaphragm housing a little and allow the diesel fuel that has entered the regulator vacuum chamber to drain off; then retighten the diaphragm housing.

10 Bleed the fuel system and run the engine.

A. Testing and Evaluation of Injection Nozzles Installed in Pump

General Instructions

When a complaint is made of so-called "diesel knock" the very first thing to ascertain is the particular operating condition in which this combustion noise appears — i. e. whether it is with the engine warmed up or cold, when starting up, when the idle speed is higher, under partial load or full load conditions, in what engine speed range or road speed range, as the case may be, and finally in what gear.

For evaluation and possible remedies for diesel knock under idling, starting and partial load conditions see Job No. 00-46.

When the engine shakes or runs unevenly or when suddenly a loud and persistent combustion noise ("diesel knock") is heard, or when there is an appreciable loss of power, these symptoms may be due to fouled and sticking metering needles or inadequate nozzle injection pressure, faulty prechamber ball-pin or a leaky vacuum system or leaky diaphragm. If the malfunction is due to one of these things the following checks and/or jobs should be carried out:

Observation of Exhaust Gases

With the vehicle standing, accelerate the engine, for a moment or two, to full or partial revolution speed, keeping the exhaust gas pulsation under observation and noting the noise produced, the "motor-boat effect".

If the exhaust gives off intermittent clouds of black smoke this often means that one or more of the nozzles are not operating evenly. In the same way an increase in the injection rate may be due to a marked fall-off in the nozzle pressure or it may also be due to normal wear or a leaky vacuum system or pump diaphragm. The injection nozzles should be removed and tested and a leak test carried out on the vacuum system and regulator of the injection pump (see Job No. 07-46).

If uneven noise ("motor-boat effect") should be heard at the exhaust, this means that one cylinder is either partly or completely out of action (see following point: Running and Sound Test).

Running and Sound Test

There are two separate tests involved: The first is with the engine idling and the second with the engine running at increased idle speed; slacken the cap nuts of the individual injection pipes on the injection pump half a turn, one after the other, and retighten, at the same time paying attention to the running and the sound of the engine.
If when a cap nut is slackened there is no change at all in the running and the sound of the engine this means that part of the trouble at least is a **defect in the corresponding nozzle** or inadequate sealing between the pipe union and the pressure valve holder (see Job No. 07-43).

If when a cap nut is slackened the engine starts to run unevenly this means that the corresponding injection nozzle is in order.

B. Removal and Installation of Nozzle Holder/Injection Nozzle Assembly

Removal

1 Take off cap nut (7) retaining injection pipe (Fig. 07-44/1).

2 Unscrew hexagon nut (6) holding the through-way jointing piece (5) and the hollow bolt (3) that forms part of the union of the leak-off oil pipe (4) and anchors it in position.

After the four valve holders have been removed, disconnect and remove leak-off oil pipe at the T-piece (junction connecting leak-off oil pipe, overflow pipe and return pipe).

Note: Before unscrewing the hollow bolt (3) and taking off the leak-off oil pipe **the hexagon** nut (6) must be backed out; this will prevent the cap nut (2) or the nozzle holder (1) from coming loose in the event of a jammed nut. If it does come loose however, the nozzle holder should be steadied with an SW 24 wrench.

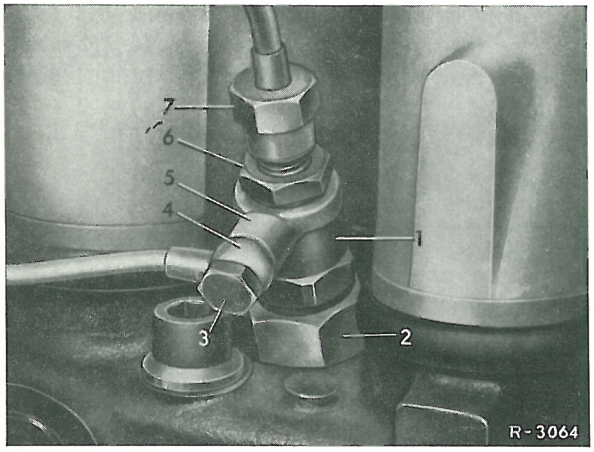


Fig. 07-44/1

1 Nozzle holder
2 Cap nut of nozzle holder assembly
3 Hollow bolt
4 Union head of leak-off oil pipe
5 Through-way jointing piece
6 Hexagon nut anchoring the through-way jointing piece
7 Cap nut anchoring the injection pipe

3 Use Socket-Wrench Head 000 589 61 09 00 to remove assembly consisting of cap nut (2), nozzle holder (1) and injection nozzle. Take out seal (6) (Fig. 07-44/2).
Carry out visual inspection of prechamber. If all is in order tighten up threaded ring (4) to the specified tightening torque (see Fig. 01-25/1 and Job No. 00-0). To prevent dust or foreign bodies from entering the bore it should be kept covered until the assembly is reinstalled.

Note: Checking or adjustment of the nozzle aperture or injection pressure and examination of jet contour are described in Section C. Disassembly, cleaning and reassembly of the nozzle holder and/or the injection nozzle is described in Section D.

Installation

4 Turn the engine over with the starter in order to expel any deposits there may be from

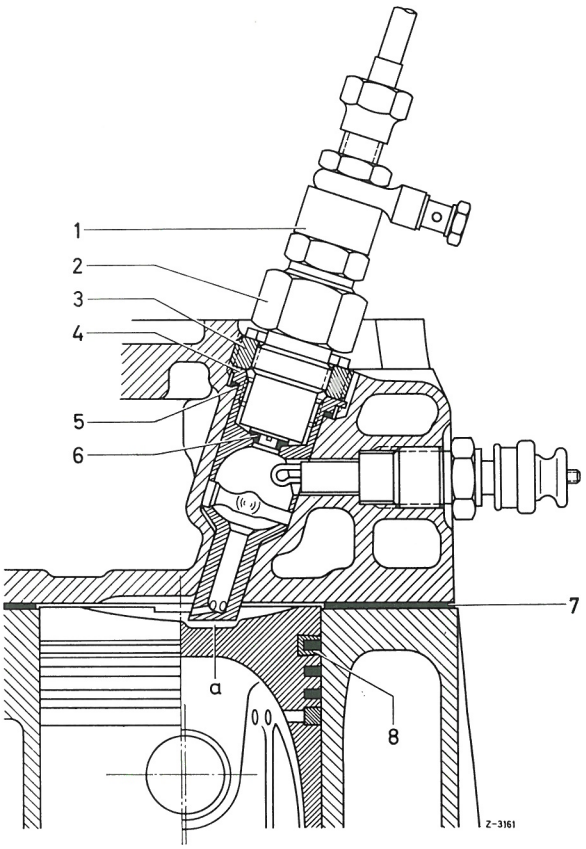


Fig. 07-44/2

1 Nozzle holder
2 Cap nut of nozzle holder
3 Threaded ring
4 Prechamber
5 Sealing ring
6 Seal
7 Cylinder head gasket
8 Piston ring liner
a Piston base recess

the combustion chamber. A new seal (6) between nozzle and prechamber should always be fitted (Fig. 07—44/2). When this seal is fitted care must be taken to ensure that the cylindrical part fits perfectly into the bore of the prechamber and that the threaded ring (3) stands no more than 11 mm high.

5 Install assembly consisting of cap nut (2), nozzle holder (1) and injection nozzle in the prechamber and use Socket-Wrench Head 000 589 61 09 00 to tighten to 7-8 mkp (Fig. 07-44/1).

6 Install the through-way jointing piece (5) on the nozzle holder (1).

Note: The contact surfaces of the nozzle holder and the through-way jointing piece must be absolutely clean and plane-ground in order to ensure that the union seals perfectly. If necessary the sealing surfaces should be polished to final fit or the through-way jointing piece replaced.

7 Install hexagon nut (6), but **do not tighten it as yet.**

8 Tighten up the leak-off fuel pipe with the hollow bolt on the through-way jointing piece after having installed new seals on both sides.

9 Now tighten up the hexagon nut (6) to the specified tightening torque. Under no circumstances must an attempt be made to cure a faulty union by excessive tightening. Tightening to excess stretches the threaded union and renders the nozzle holder useless. If leakage develops it is always due to unsatisfactory sealing surfaces on the through-way jointing piece and the nozzle holder.

10 Connect up injection pipe by installing the cap nut (7) on the nozzle holder (for specified tightening torque see Job No. 00-0).

11 Run engine and check whether all unions are leak-proof.

C. Testing and Evaluation of Uncleaned, Cleaned, Reconditioned and New Injection Nozzles

Bosch Throttle Jets DNO SD 1510

General Instructions

The design features of throttle jets are such that **evaluation of jet and nozzle chatter is conducted in virtue of "second-by-second" operation of the pump lever (speed of lever movement).** If the specified number of down-strokes of the lever per second is not adhered to false evaluations can easily be made and nozzles are rejected when in actual fact they are still quite serviceable.

It is for this reason that the following testing instructions are given in some detail.

Nozzle Testing under Working Conditions

1 With the injection nozzle fitted in the nozzle holder connect up to the Bosch Nozzle Tester for Diesel Pumps, Order No. EFEP 60 F or EFEP 340 (Fig. 07-44/3).

Only clean test oil or filtered diesel oil may be used for the test. **Under no circumstances allow the bare hand to get in the way of the jet.** The jetted fuel penetrates deeply into the flesh and destroys the tissue. Fuel that works its way into the blood may cause blood poisoning.

2 Jet test. When a test is made with short rapid partial strokes **(approx. 2 strokes per second)** the jet must be quite concentrated and cut off smartly between strokes. At the same time, however, a certain amount of common sense must be exercised in making an assessment. A few individual discrete drops or out-of-line, oblique-deltoid, spreading jets or slightly swollen jets have no effect on the combustion process within the engine.

The jet and chatter test must be carried out with the pressure gage turned off.

3 Chatter test. Every nozzle accumulates carbon deposits along the floor of its canal, in the injection orifice and on the injection pin. In order to test wether a used nozzle is fit for further service the manual operation lever must be **slowly** pressed down to its full extent

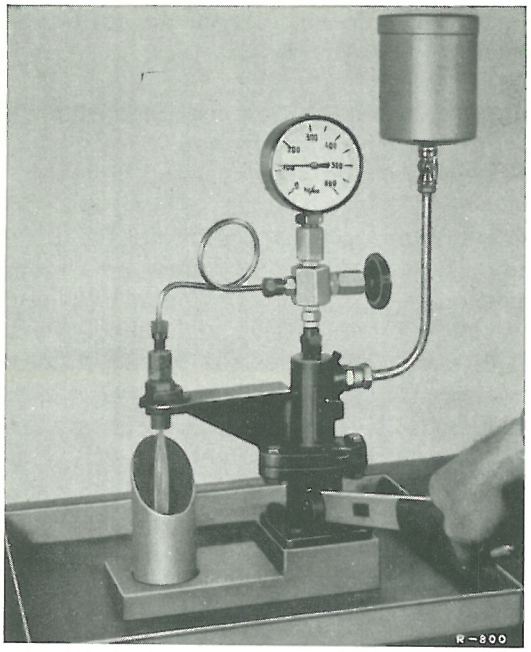


Fig. 07-44/3

(approx. 1 stroke per second) when the nozzle should chatter at low sound-level but quite audibly. If there is only slight chatter or none at all, the procedure laid down in Paragraph 6 should be the next step. The same evaluation standards should be used for the chatter test as for the jet test.

If the test procedures of Paras. 2 and 3 reveal no defect the opening pressure and injection pressure should be tested and a leakage test carried out.

4 Testing of opening pressure and spray pressure of injection nozzle.

Switch on the pressure gage, slowly depress the pump lever (1 stroke per second) and take the pressure at the moment of opening — i. e., at the beginning of injection; during this test the nozzle must be clearly heard to chatter (Fig. 07-44/3).

Caution: With the pressure gage on, advance the pressure very gently — and, above all, release it very gently so as to avoid possible damage to the gage.

New nozzles have an opening pressure of 115 atm. and used ones must have at least 100 atm. to remain serviceable. The difference in opening pressures with a given set of nozzles in an engine must not be more than 5 atm. The opening pressure is a function of the bearing tension of the compression spring and is adjusted by adding washers (15) (actually, machined steel disks) which are fitted at the top between the compression spring and the nozzle holder (Fig. 07-44/6).

These disks are available in a range of gages extending from 1.0 to 1.8 mm in 0.05 mm steps. Increasing the spring tension by 0.05 mm increases the opening pressure by approx. 3.0 atm. (See also Section D, para. 10, Installing Injection Nozzle in Nozzle Holder).

5 Testing injection nozzle for leaks

Slowly depress the pump lever to the point at which the pressure gage pointer shows 20 atm. below the opening pressure set on the gage. If no drops form at the mouth of the nozzle, the nozzle is fluid-tight.

If there is a leakage that cannot be cured by careful cleaning of the seating surfaces of the nozzle casting and of the needle the nozzle must be replaced (see also Section D, Cleaning of Injection Nozzle, Para. 7, Note).

If the nozzle leaks at the screw fitting of the cap nut no attempt must be made to effect a seal by excessive tightening. If the nozzle element (3) does not seal perfectly it can be lapped on both sides with lapping paste on a finishing plate (see Fig. 07-44/6) and the same applies to the end face of the nozzle holder (7). In fact it is often quite sufficient just to turn the nozzle element and retighten the cap nut — but then as laid down in the appropriate procedure.

6 If the test procedures given in Paras. 2 or 3 yield no results the nozzle should be flushed through for 10 seconds, the process consisting of short, rapid full-length strokes of the manual lever at a rate of 2 to 3 strokes per second. **The resultant jet should be concentrated and should emerge with a clearly audible high-pitched whine.** If it does not, the nozzle may be strained, fouled up, damaged or excessively worn. It should then be cleaned (see Section D). If after cleaning, its performance does not come up to standard it must be replaced.

When the conditions of Para. 6 have been fulfilled all the procedures of Paras. 2 to 5 must be repeated. Flushing out rapidly with full-stroke movements may be enough to clean out gummed or slightly fouled nozzles and to improve the chatter and the jet contours.

If the performance fulfils the requirements of all the preceding tests the nozzle is serviceable and can be put back again.

Note: In cases of complaint and where claims are lodged in respect of either a warranty or negotiated replacement the guarantee certificate or tag should always show any nozzle defects that have been discovered; these might include: unsatisfactory jet contour, nozzle fails to chatter even when cleaned, nozzle is not fluid-tight and drips, carbon deposit on needle, needle strained, binding and fouled points on needle guide shaft etc.

In order to avoid damage in transit when a number of nozzles are being sent back to the makers, they must be individually packed in paper and on no account simply bundled together in a single package.

D. Disassembly of Nozzle Holder, Cleaning of Injection Nozzle and Reassembly of Nozzle Holder

Disassembly of Nozzle Holder

When the nozzle holder is disassembled strict attention must be given to the matter of cleanliness, both of the shop and of the tools.

1 The nozzle holder must never be gripped in the vise without using the Special Jaws 636 589 01 31 00 to avoid the nozzle holder being damaged by the contact pressure (Fig. 07-44/4).

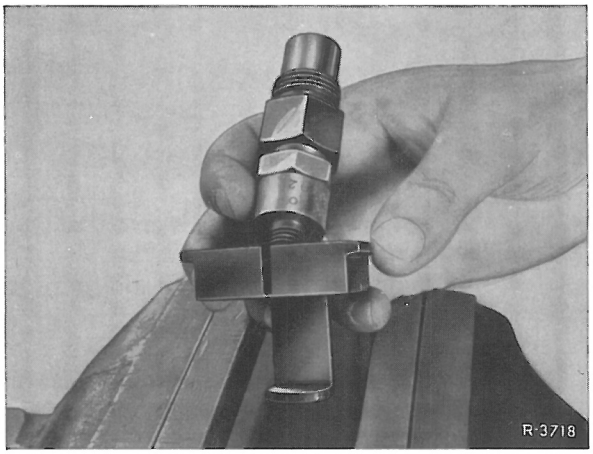


Fig. 07-44/4

If no special jaw attachment is available set up a suitable SW 24 mm socket wrench in the vise and nest the nozzle holder in it.

2 Use an SW 27 mm box spanner to remove cap nut (5) (Fig. 07-44/6). Take nozzle assembly (2) plus jet needle (1) out of the cap nut. Take nozzle element (3), thrust pin (4) and compression spring (6) out of the nozzle holder (7).

In disassembling care must be taken to ensure that the nozzle assembly, the needle and the separate parts of the individual nozzle assembly units are not interchanged. The special washer (15) may remain in the nozzle holder while it is being cleaned.

Do not touch the lapped surfaces of the jet needle since this is liable to cause corrosion; **grasp it only at its thrust pin end** (see Fig. 07-44/11).

Cleaning of Injection Nozzles

Fig. 07-44/5

The Bosch Cleaner EF 8486 B, Part No. 000 589 00 68 00, is used for cleaning already-used injection nozzles (Fig. 07-44/5). Under no circumstances may abrasive paper or scrapers or the like be used. The work of cleaning should only be carried out by specially trained personnel.

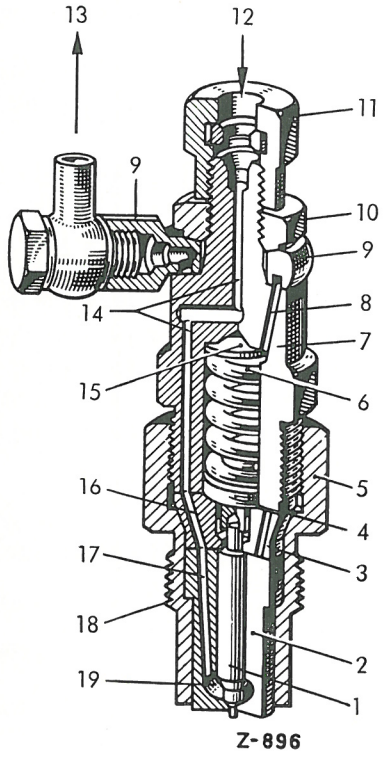


Fig. 07-44/6

Nozzle holder/injection nozzle assembly

1 Jet needle
2 Nozzle assembly
3 Nozzle element
4 Thrust pin
5 Cap nut for fixing injection nozzle
6 Compression spring
7 Nozzle holder
8 Drain hole in the nozzle holder
9 Through-way jointing piece with annular canal for leak-off oil union
10 Hexagon nut for fixing the through-way jointing piece
11 Cap nut for fixing the injection pipe
12 Fuel feed
13 Leak-off oil drain back to fuel tank
14 Pressure canal in the nozzle holder
15 Special washers belonging to compression spring (machined steel disks)
16 Annular groove and feed bores in nozzle element
17 Annular groove and pressure canal in nozzle assembly
18 Mounting thread
19 Pressure chamber in nozzle assembly

3 Brush away combustion deposits on the outside of the face side of the nozzle assembly (2), (Fig. 07-44/6), mainly around the mouth of the nozzle (7), (Fig. 07-44/11), using a brass brush or, if no brass brush is available, clean the end face of the nozzle assembly on a flat piece of diesel-soaked hardwood with a groove in it, along which the protruding injection pin can move. Under no circumstances must a hard object be brought into contact with the mouth of the nozzle.

4 Clean the interior of the nozzle assembly with a suitably-shaped piece of stick and gasoline or diesel fuel.

If a Bosch Nozzle Cleaner is available, the following is the procedure:

Clean **pressure chamber** (19) of nozzle assembly with the annular groove scraper (Figs. 07-44/6 and 07-44/7

Clean the **seat of the jet needle** in the nozzle assembly with the cleaning tool (Fig. 07—44/8). This job should be done with particular care because the serviceability of the nozzle is to a large extent dependent upon the seating of thc jet needle making a proper fit.

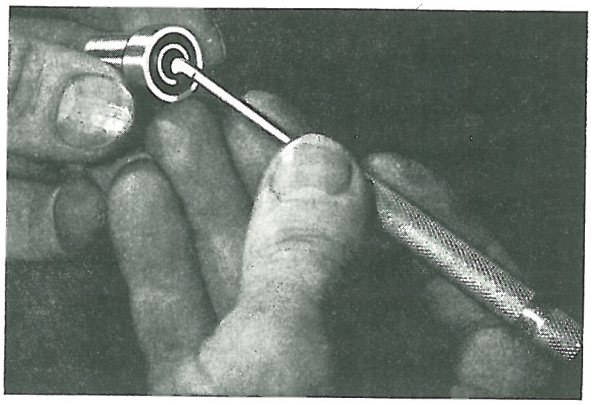


Fig. 07-44/7

Undue pressure must always be avoided when the cleaning tool is being turned.
Clean the **injection orifice** in the mouth of the nozzle with the injection orifice cleaner. As can be seen from Fig. 07-44/9 not inward, but **from the inside outward;** this is so that the injection orifice cleaner can be properly guided without tilting.

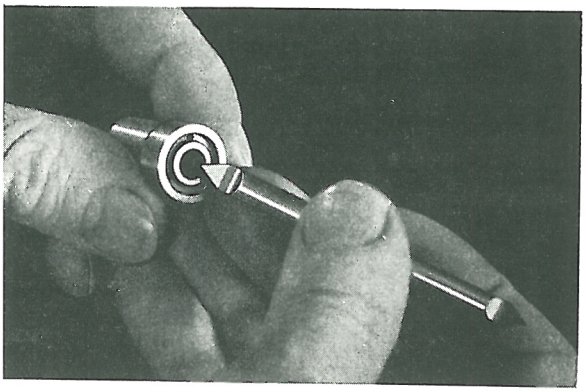


Fig. 07-44/8

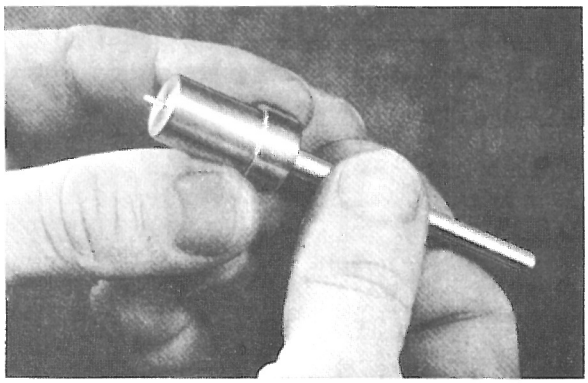


Fig. 07-44/9

5 Use an edged, diesel-soaked hardwood stick to clean the jet needle. If the profile of the jet needle is thickly covered with carbon deposit it can be fitted (by its thrust pin (13) end) in a suitable lathe-chuck or drill-chuck; the injection pin (8), throttle pin (9) and needle seating (10) should then be cleaned with an edged hardwood stick dipped in oil (Figs. 07-44/10 and 07-44/11).

6 Visual inspection. After cleaning, all nozzles that have been used should be visual-inspected.

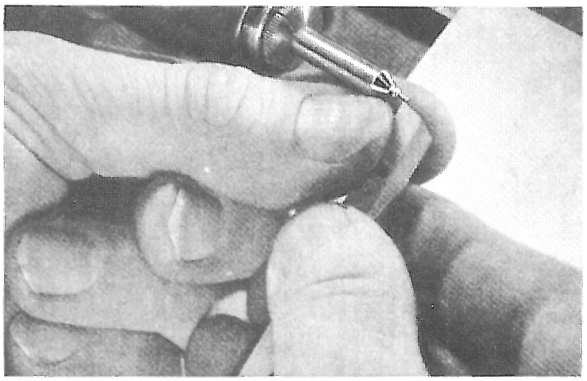


Fig. 07-44/10

Watch out four damaged or rough needle seating surfaces and worn or damaged injection pins.

Examine the nozzle assembly for scarring or carbon deposits on the seating surface (use Illuminating Magnifier EFAW 25 B) and make sure that the injection hole is not out-of-round.

Defective nozzles should be replaced or obtained on a exchange basis from the supplier firm of Bosch.

7 Free-sliding test. For both used and new nozzles inspection should be followed by the free-sliding test.

Check that the jet needle moves easily in the nozzle assembly. Then immerse jet needle and nozzle assembly individually in filtered diesel fuel and install jet needle and nozzle assembly. Now pull the jet needle for approximately a third of its length out of the nozzle assembly and hold the latter vertical; the jet needle must now slide down by gravity until it settles on its seating surface (this is known as the falling test).

Turn the jet needle over and repeat the process. If despite careful cleaning it fails to fall down replace the nozzle.

Note: Temporary repairs may be effected in emergency when it is not possible to lay hands on a replacement nozzle, but this should only be done under exceptional circumstances; use may be made of Bosch Lapping Paste **FT 26 V 2** to free up a jamming jet needle by lapping the shaft of the needle or to seal a leaky nozzle by lapping the seating surface of the jet needle and the nozzle assembly. The relapping process must be confined to the absolute minimum consistent with proper functioning of the nozzle. After lapping, the two parts must be thoroughly cleaned and rinsed.

Nozzles with damaged seating surfaces or too much needle play, as a result of being kept in operation for too long, should be replaced. (Excessive needle play causes abnormal leak-off oil losses and results in impaired engine performance.)

Nozzle needle and nozzle assembly are always a matched pair; they should always be replaced as pairs, and no jet needle should ever be mated to a nozzle assembly to which it is not already matched.

Installation of Injection Nozzle in Nozzle Holder

8 Before assembly give all the parts concerned a further rinsing in pure diesel fuel. Particular attention should be paid to the ground sealing surfaces of the jet holder, the nozzle element and the nozzle assembly, which must be scrupulously clean and undamaged.

New and reconditioned injection nozzles are treated with anti-corrosive grease at the supplier's factory. These nozzles must therefore be washed in clean gasoline and tested for ease of movement as described in Para. 7 above.

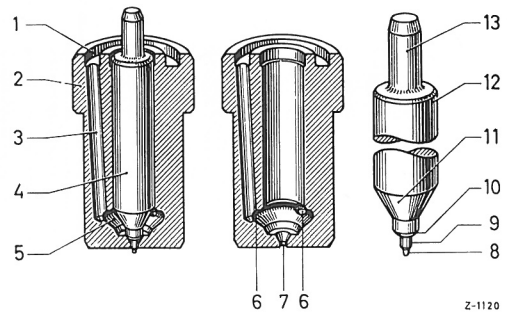


Fig. 07-44/11

1 Annular groove
2 Nozzle assembly
3 Intake bore
4 Jet needle
5 Pressure chamber
6 Mouth of intake bore in pressure chamber
7 Mouth of nozzle
8 Injection pin
9 Throttle pin
10 Needle seating surface
11 Thrust shoulder
12 Needle shaft
13 Thrust shank

9 Then insert nozzle holder in Special Jaws 636 589 01 31 00 or in an SW 24 mm socket wrench (Fig. 07-44/4).

10 Fit special washer (15) in nozzle holder if it had been previously removed; fit compression spring (6) and put thrust pin (4) on the compression spring with the shorter pin pointing toward the spring. Place nozzle element (3) with annular groove downward over the thrust pin (4) (Fig. 07-44/6).

11 Place nozzle assembly (2) plus jet needle (1) on nozzle element (3). Then install cap nut (5) on nozzle holder (7), by hand for the time being.

12 Now tighten up the cap nut with a torque of 7-8 mkp. (Excessive tightening of the cap nut may strain the nozzle assembly and cause binding or jamming of the jet needle.

13 Check and adjust nozzle aperture or injection pressure (see Section C).

14 Check injection nozzle for leakage (see Section C).

15 Carry out jet and chatter test (see Section C).

with pump fitted engine

General Instructions

It is not possible to carry out accurate checking and adjustment of the governor unless the injection pump can be set up on a test stand. The following is a selection of jobs that can be carried out without a test stand and with the pump installed in the vehicle:

The conditions under which it becomes necessary to examine the governor are: impaired car performance, engine producing thick smoke, uneven running, hunting and bursts of acceleration while engine is idling, exceeding of the full-load maximum engine speed — in other words exceeding of the maximum speed allowed in the various gears on the level and of the maximum engine speed allowed under noload conditions.

Testing Diaphragm, Governor Housing and Vacuum-Line Union for Leakage

1 With the engine running, brush soapy water over the intake manifold, vacuum line, fixing flange of Venturi control unit and governor housing; this will reveal leaky spots which should then be made leak-proof.

2 Detach starter and stop cable from control lever (2) of injection pump. Take off protector sleeve (3) above control rod. Unscrew vacuum line from vacuum union (1). Press control rod with control lever (2) hard over to STOP and close vacuum union (1) with one finger. Then release control lever and watch control rod (see Fig. 07-46/1).

If both the diaphragm and the vacuum housing are in order the control rod is simply pushed forward a little by the control spring and is then held fast by the vacuum produced in the vacuum housing. If after moving a short distance the control rod does not stop, either the diaphragm or the vacuum housing is leaking. If the control rod stops, a certain amount of backlash can be felt when the control lever is actuated.

If there is leakage the vacuum housing must be dismantled by taking out the four fixing screws, detaching the diaphragm stud from the control rod and taking out and examining the diaphragm for damage.

If the diaphragm is brittle it must be replaced as a matter of course.

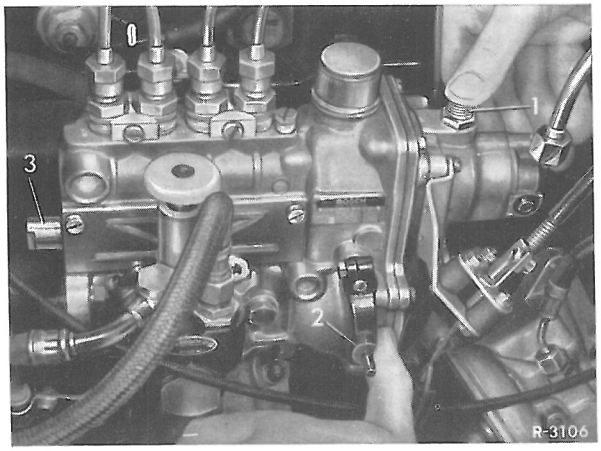


Fig. 07-46/1

1 Vacuum union
2 Control lever
3 Protector sleeve above the control rod

Replacement of Diaphragm in Governor Housing

Remove injection pump, replace diaphragm, set up injection pump on an injection pump test stand, check and/or rectify inserts of compensator system and compensator travel.

It is also possible, however, to replace a diaphragm with the injection pump fitted to the engine, provided that the following instructions are observed:

1 When the diaphragm is being removed care must be taken to ensure that the parts 1 to 4 (compensator mechanism) inserted in the sleeve (5) do not fall out. If they should happen to fall out they must all be put back again in the proper order as shown in Fig. 07-46/2.

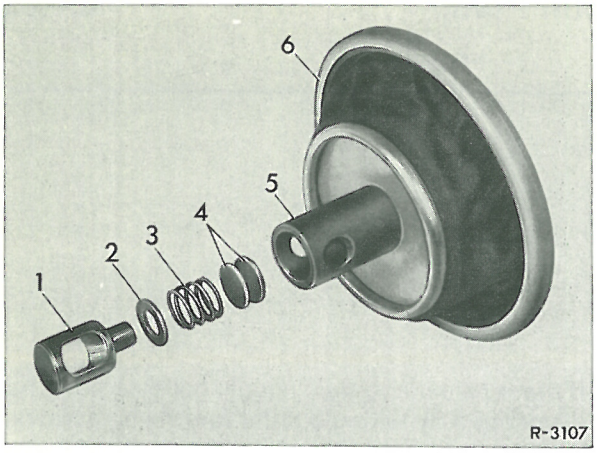


Fig. 07-46/2

1 Compensator pin
2 Shim for compensator spring
3 Compensator spring
4 Shims for compensator spring
5 Sleeve
6 Diaphragm

2 Use dial gage to measure the maximum compensator travel — i. e. the travel of the compensator pin on the old diaphragm (see Figs. 07-46/3 and 4).

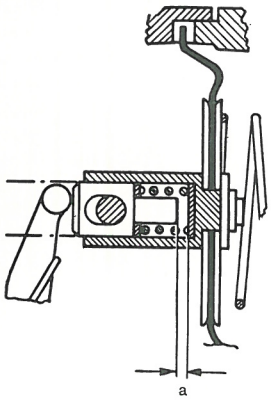


Fig. 07-46/3

a = max. compensator travel

The measurement is taken by putting a 6 mm pin (4) through the sleeve (2) of the diaphragm and through the compensator pin (5) and putting the diaphragm on the piece of tubing (3) which should have an external diameter of no more than 35 mm and an internal diameter of at least 22 mm and must be at least 10 mm long. Then set the stand of the dial gage in such a position that the prod (1) of the gage is placed in the middle of the compensator pin (5). Set dial gage to zero.

Now press down the prod (1) of the dial gage and read off the travel from the dial. The maximum compensator travel will vary according to the type of governor and may be anything from 1.1 to 2.7 mm.

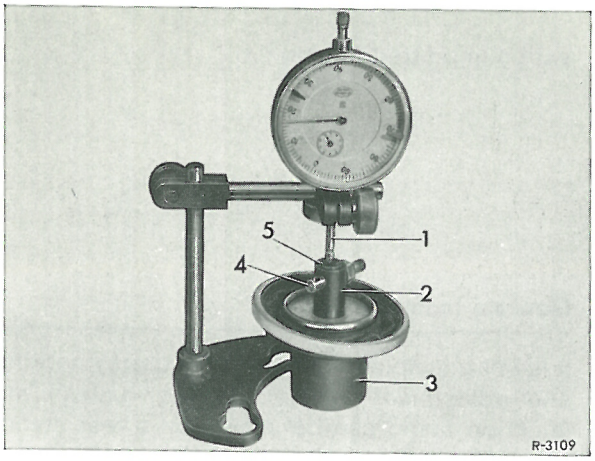


Fig. 07-46/4

1 Prod of dial gage
2 Sleeve of diaphragm
3 Piece of tubing
4 Pin, 6 mm ϕ
5 Compensator pin

Caution: If the prod is not placed in the middle of the compensator pin the latter may tilt; 2 or 3 separate measurements should therefore be taken.

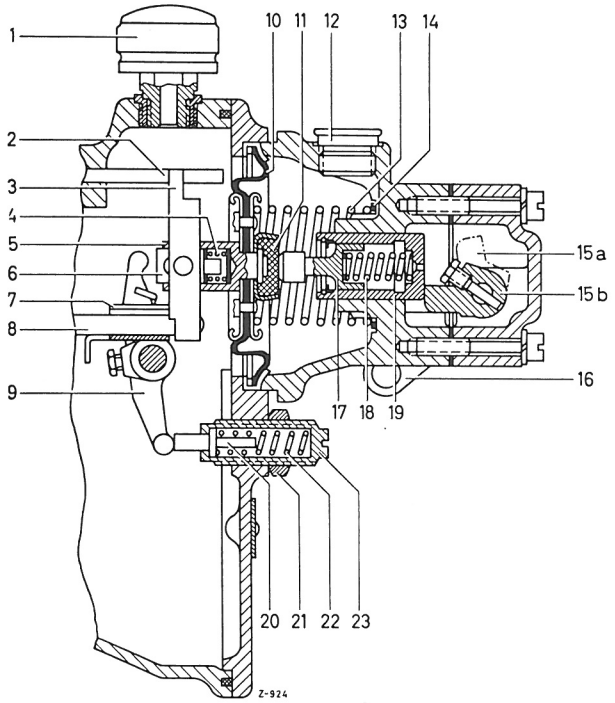
3 Take the compensator pin, the shim, the compensator spring and the compensator shims out of the old diaphragm and insert them in the new diaphragm.

4 Measure the maximum compensator travel of the new diaphragm with the dial gage (see Para. 2). If the difference between this and the old diaphragm is not greater than 0.06 mm the new diaphragm should be installed, together with the old control spring (13), that was matched to the compensator spring, and the backing ring (14) if one was fitted (Fig. 07-46/5).

If the difference in maximum compensator travel is greater, is should be offset by means of the shims (4), which are supplied by Bosch in the gages 0.2 mm, 0.3 mm, 0.5 mm and 1.0 mm (Fig. 0-46/2).

Note: It is only on the injection pump test stand that a proper test can be made to ascertain whether the compensator parts have been properly fitted and in consequence the shim, which determines the initial tension of the compensator spring and thus the fitting of the compensator, must under all circumstances be taken out of the old diaphragm for use in the new one. The same applies to the control

spring (13) and the backing rings (14) which, in turn, are made to match the compensator spring (4) (see Fig. 07-46/5). Arbitrary alteration of the initial tension of either the compensator or the control spring results in incorrect adjustment values.



5 Measure maximum rotation speed under no-load conditions (at the end of the governing process) (see Job No. 00-43).

6 Run road tests to detect carbon monoxide in exhaust gases or to adjust smoke threshold (see Job No. 00-43, Sections E and F).

Fig. 07-46/5

System in idle position

1 Air cleaner
2 Guide rod
3 Guide lever
4 Compensator spring
5 Diaphragm sleeve
6 Compensator pin
7 Start-metering stop
8 Control rod
9 Double-link rocker
10 Diaphragm
11 Rubber buffer
12 Vacuum union to vacuum chamber
13 Control spring
14 Backing ring
15a Switch cam, full-load position
15b Switch cam, idle position
16 Lever for automatic auxiliary governor system
17 Stop stud (butt bolt)
18 Auxiliary spring
19 Butt bolt housing or spring housing, sliding
20 Stop stud for full-load stop
21 Setting nut
22 Spring
23 Full-load stop screw

Models 200 D/8 and 220 D/8

A. General

The function of the injection timer is to govern the injection process in relation to the engine speed, thus ensuring satisfactory torque and performance together with low fuel consumption and improved smoke characteristics.
The drive flange features a cam profile (4) which operates the pump; the flange is fitted to the sprocket (1), the so-called primary element, with 2 stretch screws (5) (Fig. 07-47/1).

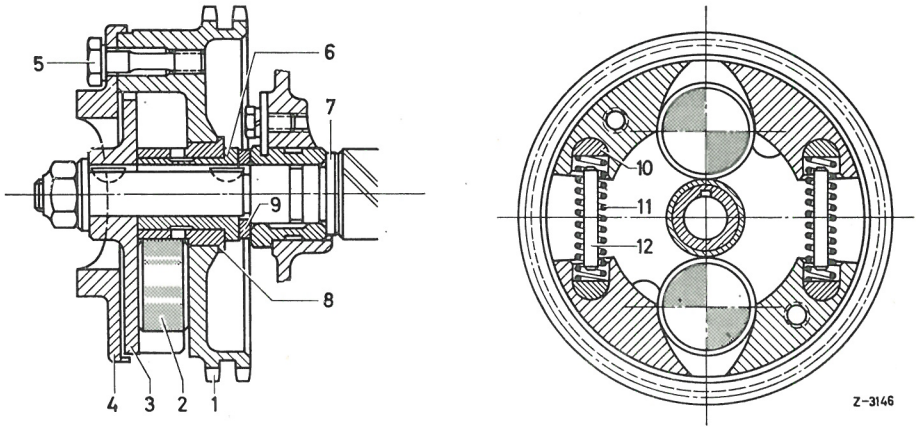


Fig. 07-47/1

Injection timer

1 Sprocket with segmental plate (primary element)
2 Governor weights
3 Segmented flange (secondary element)
4 Drive flange with cam profile
5 Stretch screw
6 Bushing
7 Thrust washer
8 Bushing
9 Stop ring
10 Pin (spring seating)
11 Compression spring
12 Pin (timing adjustment limit)

B. Removal and Installation of Injection Timer

Removal

1 Remove radiator.

2 Detach suction and pressure lines from vacuum pump and take vacuum pump off crankcase.

3 Remove polystop nut together with washer from idling gear shaft.

4 Remove cylinder head cover.

5 Remove fixing screw for camshaft sprocket (1) together with washer (Fig. 07-47/3).

6 Turn the crankshaft by its fixing screw **in the direction of engine rotation** until the **TDC** mark on the balancing disk and the adjustment pointer (Fig. 07-47/2, and the mark on the shim and the 1st camshaft bearing coincide (Fig. 07-47/4).

Caution: The engine must not be turned by the hexagon screw on the camshaft sprocket or the imposed load will distort the tensioning rail (3) (Fig. 07-47/3).

7 Punch-mark the position of the chain on the injection timer or idling gear and the position of the injection timer in relation to the crankcase.

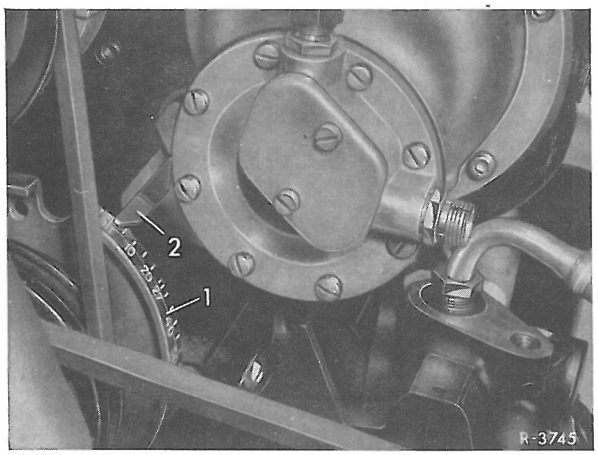


Fig. 07-47/2

1 Balancing disk 2 Pointer

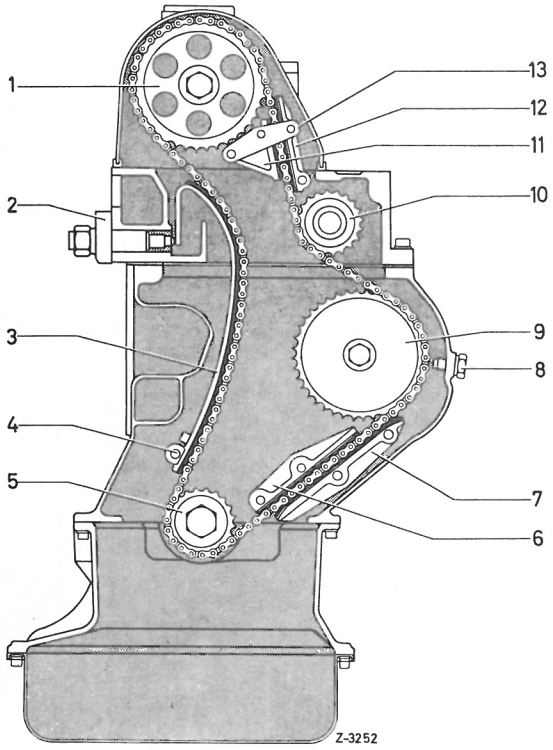


Fig. 07-47/3

Chain drive of models 200 D/8 and 220 D/8

1 Camshaft sprocket
2 Chain tensioner
3 Tensioning rail
4 Pivot pin for tensioning rail
5 Crankshaft sprocket
6 Inner chain guide
7 Outer chain guide
8 Safety screw
9 Idling gear (drive for injection timer, injection pump and oil pump)
10 Diverter sprocket
11 Inner sliding rail
12 Outer sliding rail
13 Inner sliding rail retainer

In addition punch-mark the position of the chain on the camshaft sprocket.

8 Remove chain tensioner.

9 Unscrew hexagon screw at retainer (13) and remove, together with the inner sliding rail (11), from the outer sliding rail (12) and from the cylinder head (Fig. 07-47/3).

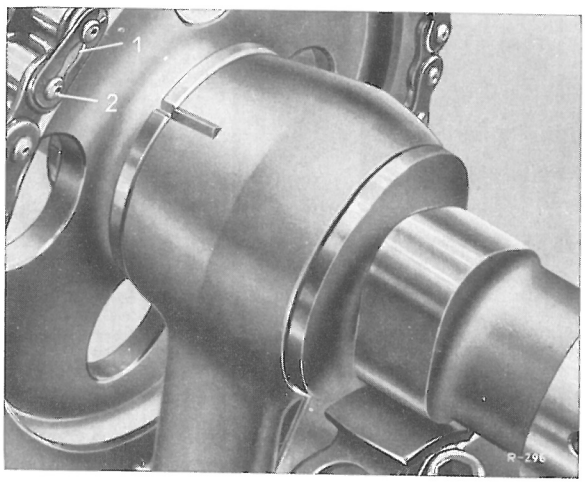


Fig. 07-47/4

1 Spring lock 2 Jointing link (chain lock)

10 Pull off camshaft sprocket, leaving the chain on the sprocket, and put the two parts together in the chain case. (When pulling off camshaft sprocket pay attention to shim between camshaft and camshaft sprocket).

11 Unscrew safety screw (8) for chain drive and pull out upper pivot pin of sliding rail (7) with the aid of Puller 187 589 07 33 00 (see Fig. 07-47/3).

12 Slip a strip of metal or cardboard, of approx. 200 x 70 mm and shaped to match the contour of the idling gear, from left to right between the idling gear (9) and the chain; this will lift the chain clear of the teeth of the idling gear.

13 Pull or pry off injection timer and remove strip of metal or cardboard used.

Caution: Do not turn the engine by turning the crankshaft or the camshaft once the injection timer has been removed.

14 Remove bushing (6) of injection timer and stop ring (9) from idling gear shaft (Fig. 07-47/1).

15 Check sliding rails (6 and 7) (visual inspection) and replace if necessary (Fig. 07-47/3).

Installation

16 Lubricate stop ring (9) and bushing (6) and slide over idling gear shaft. Make sure that the two woodruff keys are properly seated on the idling gear shaft (Fig. 07-47/1).

Note: If the timer has to be exchanged the used timer should be placed on the new timer with the splines lined up. Then the punch-mark on the used timer or idling gear should be transferred onto the new timer.

17 Lift chain, using metal or cardboard strip (see Para. 12). Now slide the cleaned and lubricated timer onto the idling gear shaft.

18 Pull chain upward or raise camshaft sprocket together with chain and make sure that the punch-mark on the injection timer coincides with that on the crankcase; if necessary turn the timer until the two marks coincide. Then remove metal or cardboard strip. If the two marks are offset the strip should be inserted once more and the chain position on the sprocket changed.

19 Slide the camshaft sprocket with fitted chain onto the camshaft and make sure that the mark on the chain corresponds to that on the sprocket. In addition, the timing mark on the balancing disk of the camshaft should coincide with the notch on the first camshaft bearing (Fig. 07-47/4).

Check once more whether all marks are in the same position as before removal and whether the TDC position on the balancing disk is correct (see Paras. 6 and 7).

20 Install the chain tensioner and bleed the system.

21 Insert the upper pivot pin of the sliding rail (7) in the crankcase (Fig. 07-47/3) and coat the end of the pivot pin with sealing compound. When driving the pin in make sure that the locking wire of the sliding rail engages in the pivot pin notch.

22 Insert the inner sliding rail (11) together with the retainer (13) in the bore of the outer sliding rail (12) and fix it to the cylinder head by means of the hexagon screw.

23 Install safety screw (8) for chain drive and tighten.

24 Install washer on idling gear shaft, install polystop nut and tighten with the prescribed tightening torque. Check end play (0.05 to 0.12 mm) of idling gear shaft.

25 Tighten camshaft sprocket fixing screw, together with washer (Fig. 07-47/3).

26 Check performance of injection timer:
Use a fork wrench to turn the polystop nut in the direction of rotation (see Fig. 07-47/1). If the idling gear shaft returns to its previous position after releasing the polystop nut the timer is functioning properly. If not, the cause of the trouble must be established and eliminated.

27 Test the start of delivery (see Job No. 00-41).

28 Fit a new gasket and screw the vacuum pump to the crankcase (Fig. 07-47/2).

29 Put on and screw down the cylinder head cover. Make sure the rubber seals are in place. Also check whether the control cable can move freely in the slot of the stop bracket on the angle relay lever when accelerating the engine.

30 Install the radiator.

31 Run the engine and check the unions for leakage.