# SECTION 3 FEATURES OF STRUCTURE AND ASSEMBLY AND REPAIR

- **1. Engine Body**
- The engine body is composed of cylinder block, crankcase, oil pan, cylinder head, timing gear case and flywheel casing. The cylinder block and the crankcase are made of high-strength gray cast iron and divided horizontally into the upper and lower parts from the centerline of the crankshaft. As shown in Fig. 2-8, WD615 diesel engine adopts an integral crankcase which together with the seven main bearing caps constitutes a highly rigid frame structure, hence increases the rigidity, reduces the noise and prolonges the service life of the engine body.
- As shown in Fig. 2-8, the main bearing bores in the cylinder body and the crankcase are located and paired for machining by three ϕ12mm locating pins, which has guaranteed the axiality and cylindricity of the seven ϕ 108+0.220 main bearing bores (≤0.05mm). Therefore, when a cylinder block is to be replaced during maintenance/repair, the cylinder block and the crankcase must be replaced in pairs at the same time.
- The cylinder block and the crankcase will be secured together by 14 M18 main bearing bolts as well as 24 M8 bolts. There is no gasket between the cylinder block and the crankcase. When assembling, apply some Loctite 510 sealant on their contacting surfaces as per Fig. 2-9. Then, tighten the main bearing bolts in the order as shown in Fig. 2-10 to their specified torque (first tighten them to 30 Nm, then to 80 Nm, and finally to 250+25 Nm). Finally, tighten the 24 crankcase fixing bolts.

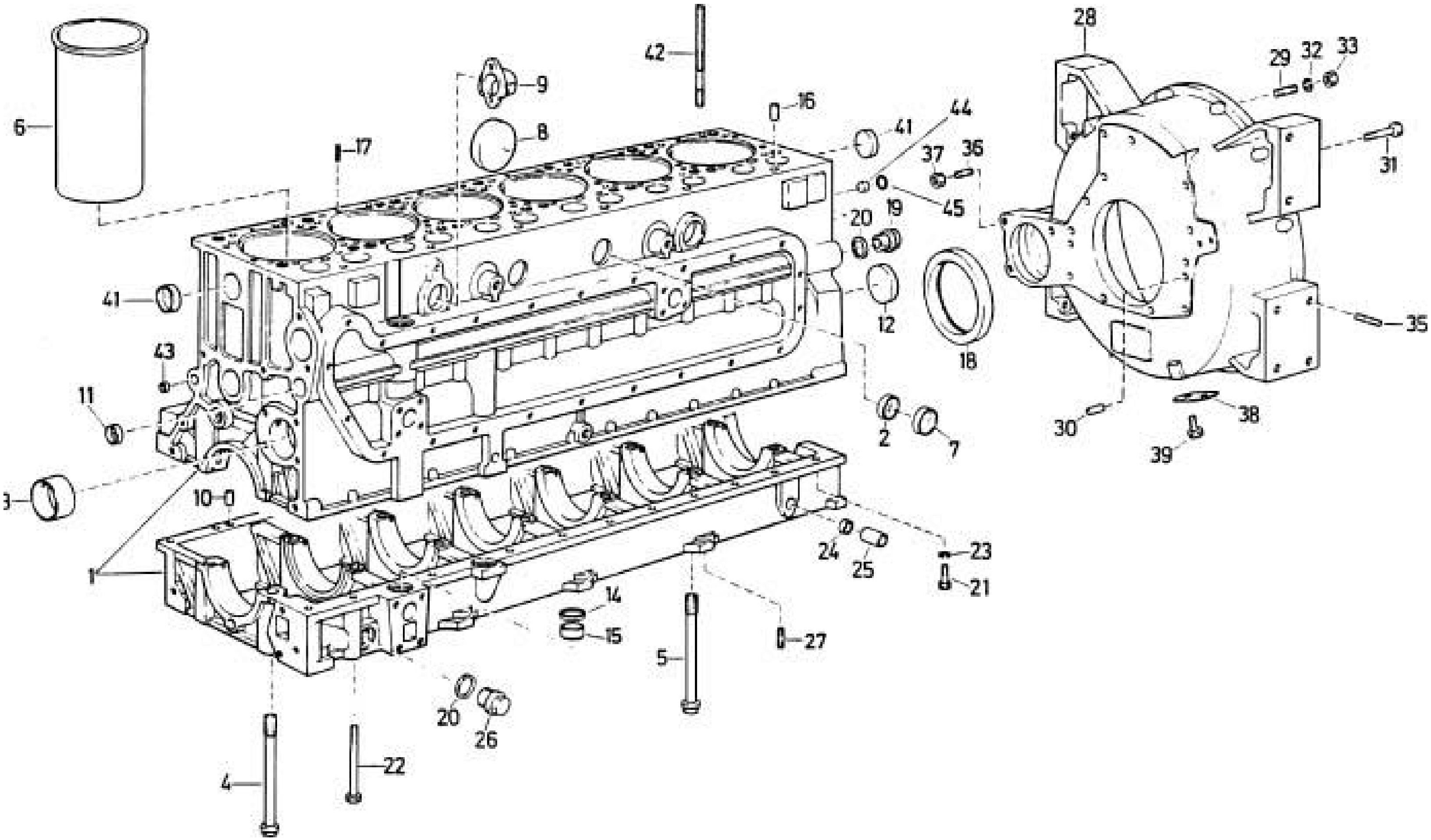
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Fig. 2-8 Cylinder block, crankcase and flywheel casing

1.Engine body and crankcase 2,7.Bell-shaped plug 3.Camshaft bushing 4,5.Main bearing bolt 6.Cylinder sleeve 8.LH side bowl plug 9.Ventilation elbow 10.Cylindrical pin 11.oil passage bow plug 12.Rear end face bowl plug 14,15 Seal ring, sleeve, 16.Cylindrical pin 17.Elastic cylindrical pin 18.Real oil seal 19,20.Screw plug, washer 21,23.Hexagon socket head cap bolt, washer 24,25.Bowl plug, short oil return tube 26.Screw plug 27.Studbolt 28.Flywheel casing 29,30,32,33.Studbolt, spring washer, hex nut 31.Flywheel casing bolt 35.Studbolt 36,37.Studbolt, nut 38.Sight hole cover 39.Hex bolt 41.Bowl plug 42.Cylinder head, stud bolt

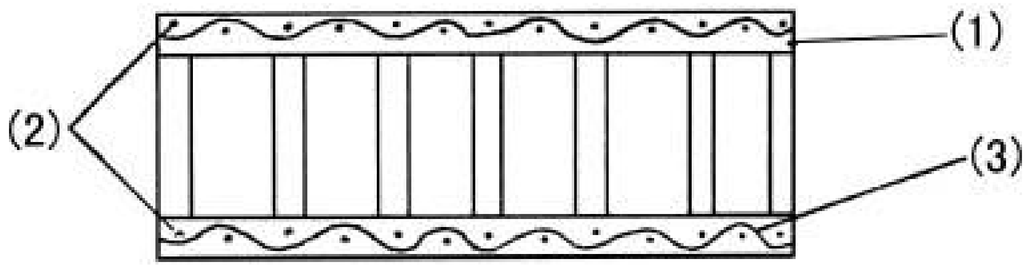



Fig. 2-9 Application of adhesive mating surfaces of cylinder block and crankcase

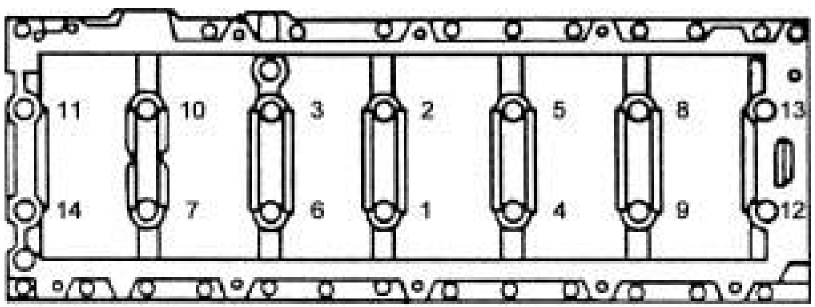



Fig. 2-10 Order of tightening crankcase main bearing bolts

- The nonparallelism of the upper face and the lower face of the cylinder block should be ≤0.1mm, and the unevenness of the surface within 100mm length should be ≤0.03mm (service limit is 0.05mm). The height of the cylinder block is 363.75～363.85mm with a service limit of 363.5mm. The ellipticity of the cylinder block boss should be ≤0.02mm with a service limit of 0.5mm, and the conicity ≤0.02mm.
- Seven main bearings on the cylinder block must be exactly the same, and the thrust bearing should be located on each side of the second main bearing. The cylinder block uses bore holes with the same center distance (150mm). The structure is compact. The cylinder sleeve is thin-wall and dry type made of high phosphorous iron. The thickness of the wall is 2mm. The inner surface of the cylinder sleeve is specially treated into plane reticulate pattern, which may speed up fitting up and improve the efficiency of lubrication so as to increase its wear resistance. The cylinder sleeve and the bore hole are transition fit (bore hole ф130 +0.025/0mm,and cylinder sleeve ф130 +0.01/-0.008mm). During assembly, it is advisable to use clearance fit. Before assembly, use trichloroethylene to remove the grease on the contacting surfaces of the cylinder sleeve and the bore hole, and then apply some molybdenum powder. This might allow you to lightly press the cylinder sleeve into the bore hole by hand or with the help of special tools. After the cylinder sleeve is pressed into the bore hole, the cylinder sleeve should be above the upper face of the cylinder block by 0.05～0.10mm, and the out of roundness of the inner diameter of the cylinder sleeve should be smaller than 0.04mm. When the cylinder and cylinder sleeve are overhauled, the diameters of the bore hole and the cylinder sleeve are permitted to be 0.5mm larger than the standard diameter, i.e. the bore hole is allowed to be reamed to ф130.525mm max.

- The camshaft hole is at the right side of the cylinder block (looking forward), and there are altogether seven bearing journals. The magnitude of interference between the camshaft bushing and the shaft hole is 0.057～0.107mm, and there is a oil orifice in the bushing. When assembling, be careful to align this oil hole with the oil passage hole in the cylinder block.
- There is a ϕ27mm run-through main oil passage at the right side of the mid part of the engine body (looking forward) used for lubricating the main bearing and the camshaft bearing. There is a secondary oil passage (it does not run through) connecting to a oil nozzle in each cylinder for cooling the piston, and lubricate the small end of the connecting rod and the piston pin. Attention should be paid to the locating pin when the oil nozzle is installed.
- There are 12 valve tappet holes in the engine body above the oil holes at the right side of the cylinder block. The fit clearance between the tappet and its hole is 0.025 ～0.089mm, and the wear limit is 0.15mm.

- The tappet hole in the cylinder block meets the main oil passage at 4mm oil passage. It provide lubrication to the valve rocker arm and other mechanism through the hollow lifter.
- There is a chamber at the right side of the cylinder body (looking forward) for mounting oil cooler. In the cooling chamber, oil cooler element is installed to cool the oil. The oil cooler element is of pipe structure.
- Each cylinder of WD615 diesel engine uses one head. The cylinder head is made of nickel-chromium pearlite alloy cast iron and machined into a hexahedron. Each cylinder head is fixed to the cylinder block by means of four M16 main bolts, and the two adjacent cylinder heads at the front and rear ends each will be tightened by three M12 stud bolts together with U-shaped plates, spherical washers and locking nuts. The order of tightening the cylinder head main and secondary bolts is as shown Fig. 2-11 and Fig. 2-12. The tightening method is as follows:

- ● After the cylinder heads are mounted and their exhaust side is made flush, first tighten all main and secondary bolts to 30 Nm in the order given.
- ● Tighten all secondary bolts to 100 Nm in given order.
- ● Tighten all main bolts to 200 Nm in given order.
- ● Turn all secondary bolts by 90° in given order.
- ● Turn all main bolts by 90° in given order.
- ● Turn all secondary bolts by 90° in given order, and check and make sure that the their torque is 120～160 Nm. If unsatisfactory, the bolts must be replaced.
- ● Turn all main bolts by 90° in given order, and check and make sure that the their torque is 260～380 Nm. If unsatisfactory, the bolts must be replaced.
- ● It is allowed to use the cylinder head main bolts repeatedly for three times, and the secondary bolts for two times.

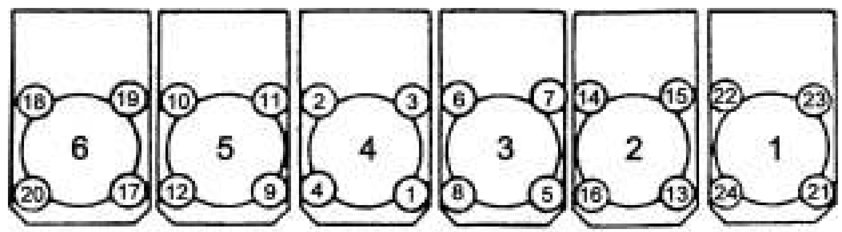



Fig. 2-11 Tightening order of cylinder head main bolts

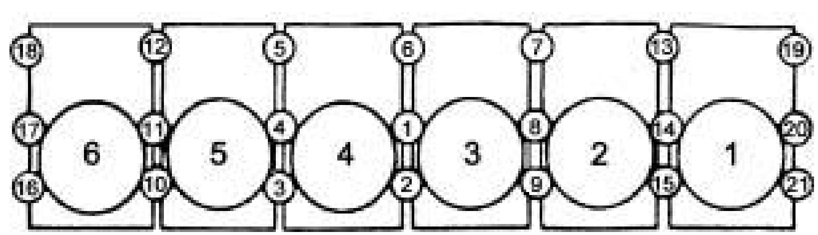



Fig. 2-12 Tightening order of cylinder head secondary bolts

- The height of the cylinder head is 124.8～125.0mm with a service limit of 124mm; and the nonparallelism of the upper and lower faces is 0.1mm and the unevenness of the surface within 100mm length is 0.03mm with a service limit of 0.05mm.
- Each cylinder head has an air intake valve and an exhaust valve. There is a seat made of special cast iron for each valve. The seating angle of the intake valve is 110°, and that of the exhaust valve is 90°. As shown in Fig. 2-13, after assembly, the sinkage X of the intake valve should be 0.95-0.28mm and that Y of the exhaust valve should be 1.25±0.18mm. Its maximum should not exceed 1.8mm. When exceeding 1.8mm, the bottom face of the cylinder head can be milled by 0.5mm. Two millings are allowed for 1mm in total. The valve seat and the cylinder head are fit by interference. They can be assembled by heating the cylinder head to 320℃ or cooling the valve seat in liquid nitrogen.

Valve guide can be replaced. After the valve guide is replaced, ensure that the valve guide is 22mm higher than the cylinder head concave surface, as shown in Fig. 2-14.

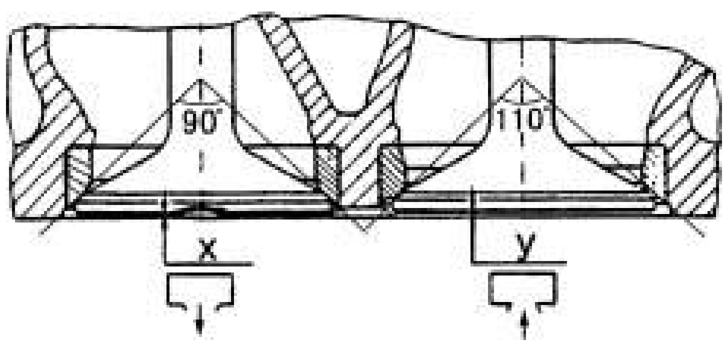



Fig. 2-13 Dimensions of air intake and exhaust valves

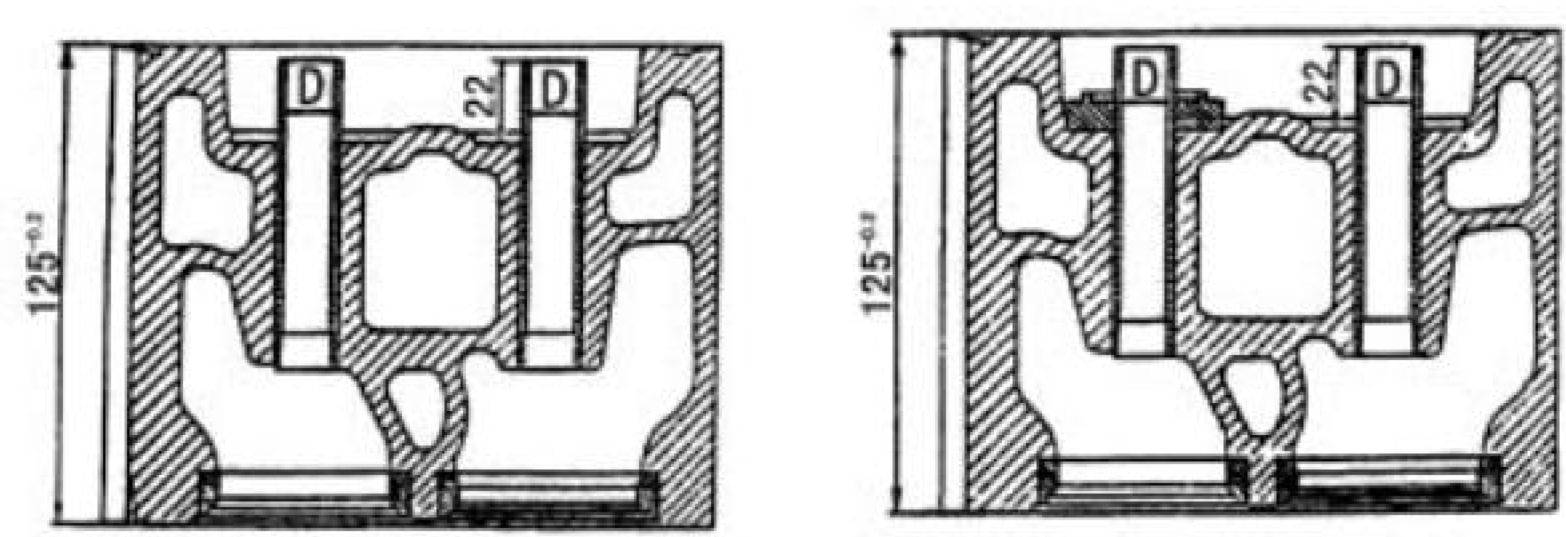



Fig. 2-14 Dimensional requirement on valve guide after fitting

- The cylinder head is inlaid with oil nozzle copper sleeve. The cooling water after entering the cylinder head will pass the nose-bridge hot water jacket, then flows into the water outlet pipe through oil nozzle copper sleeve. It is extremely efficient for cooling the oil nozzle. The oil injector is mounted on the left side of the cylinder head. The included angle between the oil injector and the cylinder head plane is 75°, and the protrusion (C) of the tip of the oil nozzle from the cylinder head plane after assembling is 3.2～4.0mm.
- In case of that the bottom face of the cylinder head has been milled by 0.5mm (or 1mm), in order to guarantee the protrusion of the oil nozzle tip, a 0.5mm (1mm) standard shim D must be used, as shown in Fig. 2-15a.
- Reuse of the cylinder gasket is permitted. However, care must be taken to guarantee the fitting position of the cylinder gasket, cylinder head and the cylinder block by means of locating pins. Apply some sealant within a 2-3mm wide zone around the ϕ8.5 water passage in the cylinder gasket and around the lifter through hole respectively, so as to prevent the penetration of the cooling water and the oil.

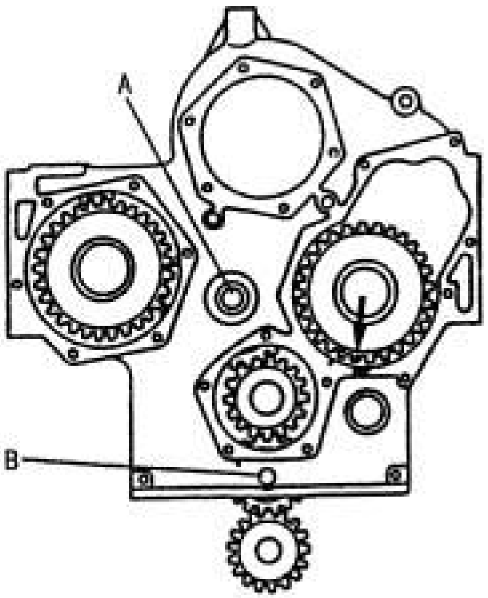
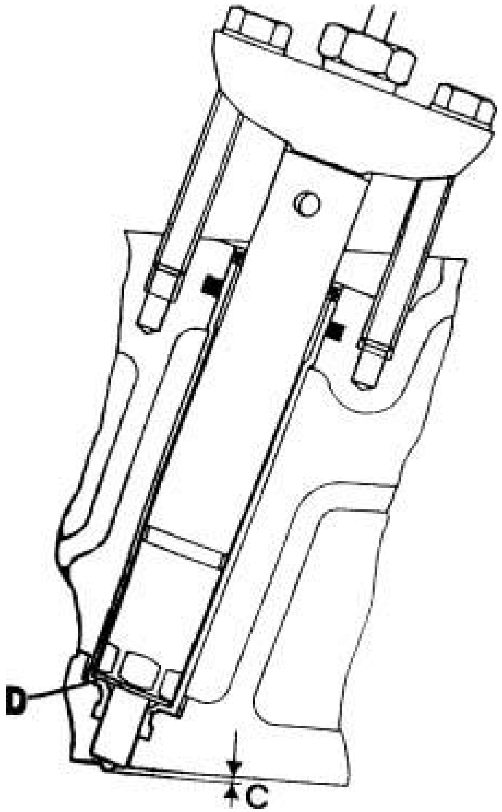



Fig. 2-15 Timing gear case Fig.




2-15a Protrusion of oil injector head

- As shown in Fig. 2-15, the timing gear case is made of high-strength gray cast iron. There is no locating pins between the timing gear case and the cylinder block. They are aligned with each other by the timing intermediate gear shaft "A" and the oil pump intermediate gear shaft "B". Therefore, when assembling the timing gear case, the timing intermediate gear shaft "A" and the oil pump intermediate gear shaft "B" should be tightened first (65 Nm), and the timing gear case fixing bolts. The air compressor, the steering boost pump and the water pump are all mounted on the timing gear case. Tighten symmetrically the flywheel casing fixing bolts first to the torque of 40 Nm, and then turn the bolts by 120°±5° and make sure the final torque of 110～140 Nm is reached.
- There are no gaskets between the timing gear case and the flywheel casing/cylinder block. In assembly, Lotite 510 sealant should be applied on their contacting surfaces.
- V-shaped rubber seal is used between the oil pan and the engine body. It not only has good sealing effect but also acts as a shock damper.

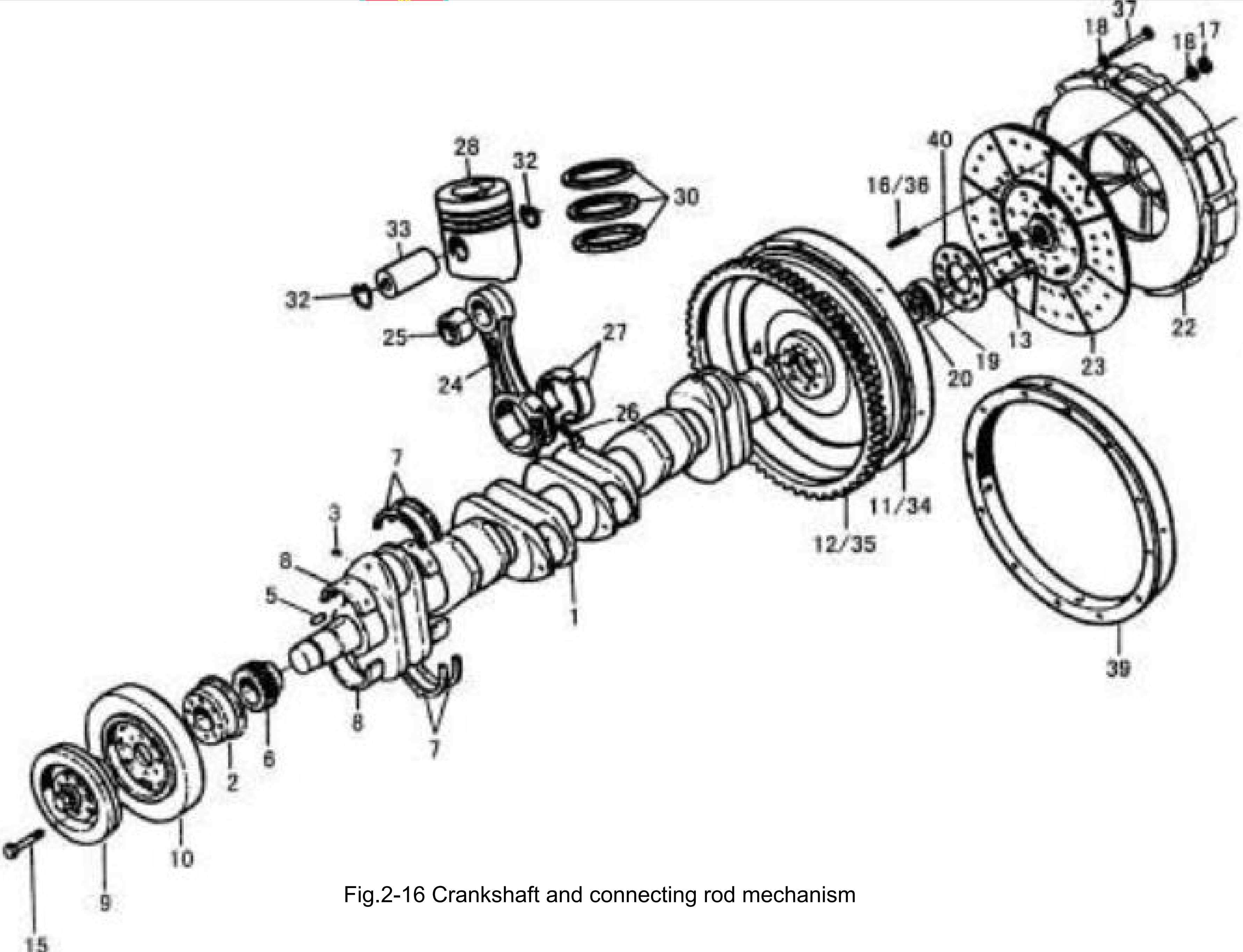


Fig.2-16 Crankshaft and connecting rod mechanism

- **2. Crankshaft, Piston and Connecting Rod**

- WD615 series diesel engines adopt conventional crankshaft and connecting rod mechanism, as shown in Fig. 2-16.

- 1.Crankshaft 2.Flange 3,4.Cylindrical pin 5.Flat key 6.Crankshaft gear 7.Thrust plate 8.Main bearing shell 9.Belt wheel 10.Shock absorber 11,34.Flywheel 12,35.Gear ring 13.Flywheel bolt 15.Hex bolt 16.Studbolt 19.Rolling bearing 20.Elastic collar for hole use 24.Connecting rod 25.connecting rod bushing 26.Connecting rod bolt 27.Connecting rod bearing shell 28.Piston 30.Piston ring 32. Retainer 33.Piston ring 39.Spacer flange

- WD615 engine uses die forging crankshaft. It has undergone special surface and soft-nitriding treatment. Hence, it has a very good wear resistance and a very good antifatigue layer.
- The ellipticity of the crankshaft journal and the connecting rod journal should be ≤0.01mm with a service limit of 0.015mm,and the conicity ≤0.01mm with a service limit of 0.015mm The eccentricity of the crankshaft intermediate journal relative to the two end journals (crankshaft bending) is 0.3mm.
- 266 hp engine can use Φ260 dia. silicon oil damper, and other high horse-power diesel engines can use Φ280 dia. silicon oil dampers. At the front end of the crankshaft, a shock absorber fixing flange and crankshaft gear are mounted by thermal fit. For thermal fit, heat the crankshaft gear to 180℃, heat the fixing flange to 290℃, and then insert them into the crankshaft. The seven crankshaft bearing shells are made of steel-backed low-tin aluminum alloy of the same thickness. They are exchangeable. The thrust shoes are installed on both sides of the second main bearing. In assembly, the bearing shell bore and the journal dimensions must be measured. Choose proper main bearing shells to make the radial clearance of the main bearing 0.095～0.163mm with a service limit of 0.18mm. The max. unbalance of the dynamic balance is 60g·cm. The axial clearance of the crankshaft is 0.052～0.255mm with a service limit of 0.35mm. The bearing shell of the connecting rod is made of steel-backed low-tin aluminum alloy of the same thickness. The crankshaft and the flywheel are secured together by means of reinforced bolts. When installing the flywheel, first tighten the its bolts symmetrically to 60 Nm, then turn all the bolts by 90°±5°, and tighten them to a final torque of 230～280 Nm. Replace those bolts that failed to reach the final torque. The flywheel bolts can be used twice.

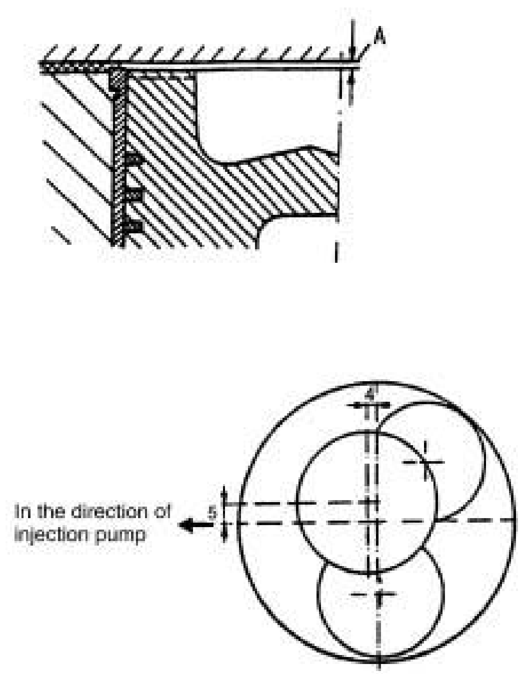
- The piston is made of aluminum alloy, as shown in Fig. 2-17. There is a ω-shaped combustion chamber and intake and exhaust valve avoiding recesses. The combustion chamber volume is usually 87±0.75ml, and its position is offset to the center of the piston. The compression clearance of the piston after installation is A=1mm.
- 


Fig. 2-17 Combustion chamber position and compression clearance

- As shown in 2Fig. 2-18, installed on the piston are two air rings and one oil ring. The air ring is inside a cast iron ring groove. There is cut groove in its inner surface. Its working surface is aluminum sprayed. Its ring gap is 0.40～0.
60mm with a wear limit of 1mm. The second air ring is a chrome plated tapered ring. Its height is 3mm, the annular gap is 0.07～0.102mm with a wear limit of 0.28mm, the opening gap is 0.25～0.40mm with a wear limit of 1.0mm. The cone angle of its single side outer ring face is 90'±5'. There is a "TOP" assembly marking on the upper surface of each air ring. When assembling, the side with "TOP" marking must face up. The third ring is a oil ring with a spring cast iron bushing ring. The ring is 4mm high. Its both edge surfaces are chrome plated. Its annular ring gap is 0.05～0.075mm with a wear limit of 0.26mm. Its opening gap is 0.35～0.55mm with a wear limit of 1.0mm.
- When assembling the piston, care should be taken to check the side play between rings. The openings of the three rings must be staggered by 120°, and within 30° of the piston pin hole.
- The diameter of the piston pin hole is Φ50mm. The pin hole and the piston center should offset 1mm to the turning direction of the crankshaft. The piston pin and the piston hole/connecting rod bushing are clearance fit. When assembling, the piston should be heated to over 80℃. The piston skirt is coated with 0.01mm thick graphite coating for the purpose of reducing friction.
- There is a cut in the piston at the location corresponding to the oil nozzle in the secondary oil passage in the cylinder block. Its purpose is to avoid interference of the piston with the oil nozzle. The piston is cooled by oil

- The connecting rod with H-shaped cross-section is forged with No. 35 chrome molybdenum steel. The center distance of the big and small ends is 219mm. The big end is 46mm wide, and the small end is 41mm wide. The big end of the connecting rod is 45° domatic partition. The parting plane is 60° sawtooth located. The big end is secured by means of bolts made of No.42 chrome molybdenum alloy steel. The connecting rod bolts are tightened by torque/rotation method (i.e. torque them to 120 Nm first, then turn them by 90°±5° confirm if the final torque reaches 170～250 Nm, and replace those with unsatisfactory torque). The connecting rod bolts can only be used once. Remember that the H-shaped cross-sectional connecting rod is solid and there is no center oil passage inside the connecting rod. The piston pin and the small end bushing are lubricated by oil flown through the oil hole in the small end of connecting rod in the end surface of the piston when the piston falls. The small end bushing is made of steel-backed pot metal. Its thickness is 2.5mm and has a T-shaped oil groove. The connecting rod bearing shell is made of steel-backed low-tin aluminum alloy of different thickness. Its surface has a coating of lead-tin-aluminum alloy in 0.015mm thickness and a coating of anticorrosion material in 0.002mm thickness. Scraping is not allowed for the main bearing shell and the connecting rod bearing shell. As shown in Fig. 2-19, the connecting rods are divided into 9 groups (C, D, E, F, G, H, J, K, L) by weight differing from one another by 29g. The connecting rod body and its bearing shell match marking and the weight group code will be impressed on the connecting rod and the side of the bearing shell respectively. The axial location of the connecting rod is realized by means of the half-round face of its big end. The width of the bearing shell is 2mm smaller that that of the big end. It not only reduced weight, but also decreased the machining accuracy of the

- When assembling the piston and the connecting rod, pay attention to the direction of the connection of the piston and the connecting rod. The valve avoiding recess on the top of the piston should be at the right side of the cylinder block (looking forward). The 45° porting place must correspond to the right side of the cylinder block (looking forward), as shown in Fig. 2-19a. Match markings on the connecting rod body and its bearing shell seat must be checked. One engine must use connecting rods in the same weight group, or the operation of the engine might be unstable and the cylinder knocking may happen. The weight of pistons used by the same engine must not differ by more than 10g.
- When assembling the crankshaft, the piston and the connecting rod, the clearance between the connecting rod bearing shell and the connecting rod journal must be kept within the specified range.
- a. The hole diameter wear limit of the big end of the connecting rod is Φ 88.035mm,and that of the small end is Φ55.05mm. b. The clearance between the connecting rod shaft and the connecting rod bearing shell is 0.028～0.08mm with a service limit of 0.1mm. c. The clearance between the piston pin and the bushing is 0.04～0.06mm with a service limit of 0.1mm. d. The clearance between the piston pin and the piston pin hole is 0.002～0.015mm with a service limit 0.03mm. e. the magnitude of interference between the connecting rod bushing and the small end of the connecting rod is 0.065～0.145mm with a service limit 0.083～0.118mm.

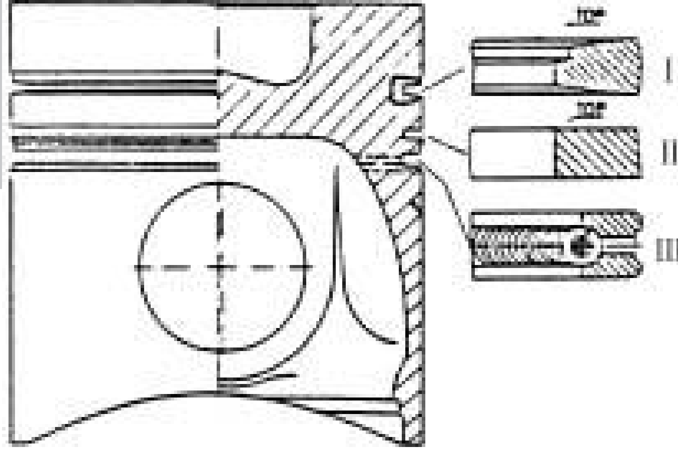



Fig.2-18

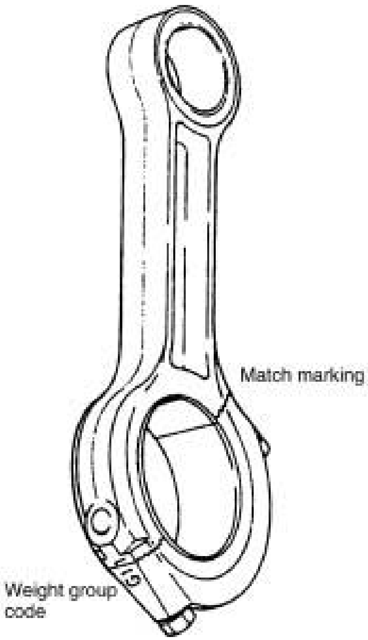



Fig. 2-19 Connecting rod marking

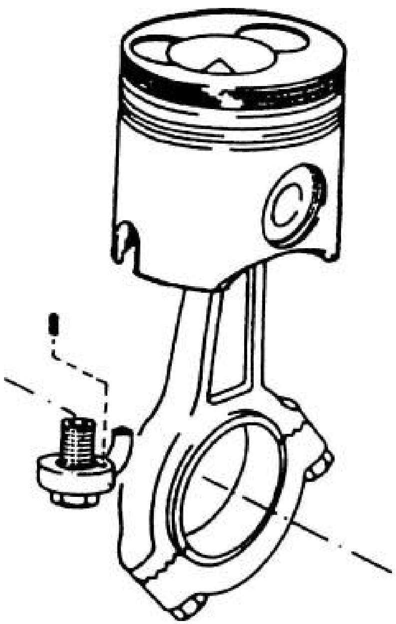


Fig. 2-19a Mounting position of the piston connecting rod

- **3. Valve mechanism**
- The valve mechanism is composed of camshaft, tappet, lifter and rocker arm, intake valve, exhaust valve, valve rotating mechanism, etc.
- The cam form and the dimension of the camshaft of WD615 series diesel engines are as shown in Fig. 2-20. The camshaft has seven bearings and there are seven camshaft bearing bores in the cylinder block. The camshaft has seven bearings, which are pressed into camshaft bearing bushings with a magnitude of interference of 0.057～0.107. There is a oil orifice in the crankshaft bushing corresponding to the slant oil passage in the main oil passage. When installing bushing, use a special tool to align the bushing oil orifice with the oil passage in the cylinder block. The inner diameter of the installed bushing is ϕ60.01～60.06mm, and the clearance between the bearing bushing and the camshaft journal is 0.04～0.12mm. There is a 6mm wide locating groove between the first bearing of the camshaft and the shaft head. The locating retainer fixed to the engine body by two screws is inserted into the groove for axial location of the camshaft. The axial clearance of the camshaft is kept within 0.1～0.4mm. The camshaft gear is coupled to the camshaft head by means of locating pin and four fixing screws. There is a timing mark line on one tooth of the camshaft gear for ensuring proper valve timing.

- The rocker arm shaft and the rocker seat are an integral part. The intake rocker ratio is 1.64 and the exhaust rocker ratio is 1.36. The rocker arm shaft has no axial locating spring. The axial location of the rocker arm is realized by the side end surfaces of the high-precision cast iron valve housing cover. The fit clearance between the rocker arm shaft hole and the rocker arm shaft is 0.012～0.066mm with a service limit of 0.1mm

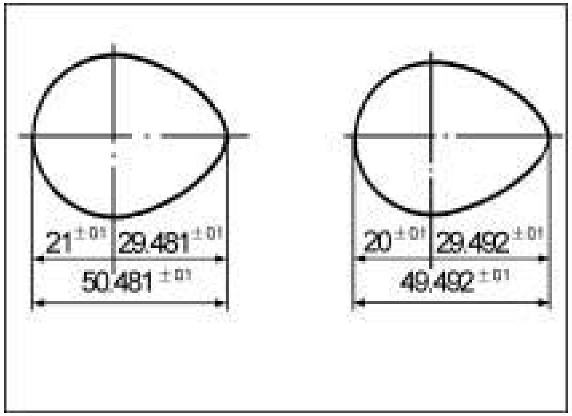



Fig.2-20 Cam form and dimensions

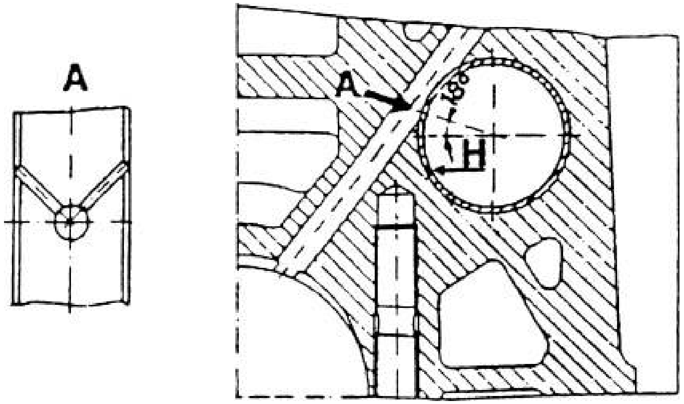



Fig.2-20a Camshaft bushing installation dimensions

- There are two ring grooves in the valve tappet. A ϕ3mm slant hole in the upper ring groove is communicated with the main oil passage. Oil is supplied through the slant hole and the oil passage in the hollow lifter to the valve rocker arm, the rocker arm and the valve intermittently for lubrication. There is ϕ5mm oil return hole in the lower ring groove.
- The intake valve is made of Nickel-Silicon copper steel. The exhaust valve is made of two materials by friction welding. The valve seat face is bead welded, and the valve stem is chrome plated.
- The valve rotating mechanism generates rotating motion between the valve and two valve seat surfaces on the cylinder head, so as to prolong the service life of the valve. The valve rotating mechanism is composed of a fixed spring seat (1) and a rotating spring seat (2). Between (1) and (2) are the steel ball (4) and the disk spring (3). When the valve opens, the disk spring is pressed flat, and the steel ball rolls along the slang track towards the center and moves the spring seat (2), making the valve turn slightly. For its structure, refer to Fig. 2-20c.

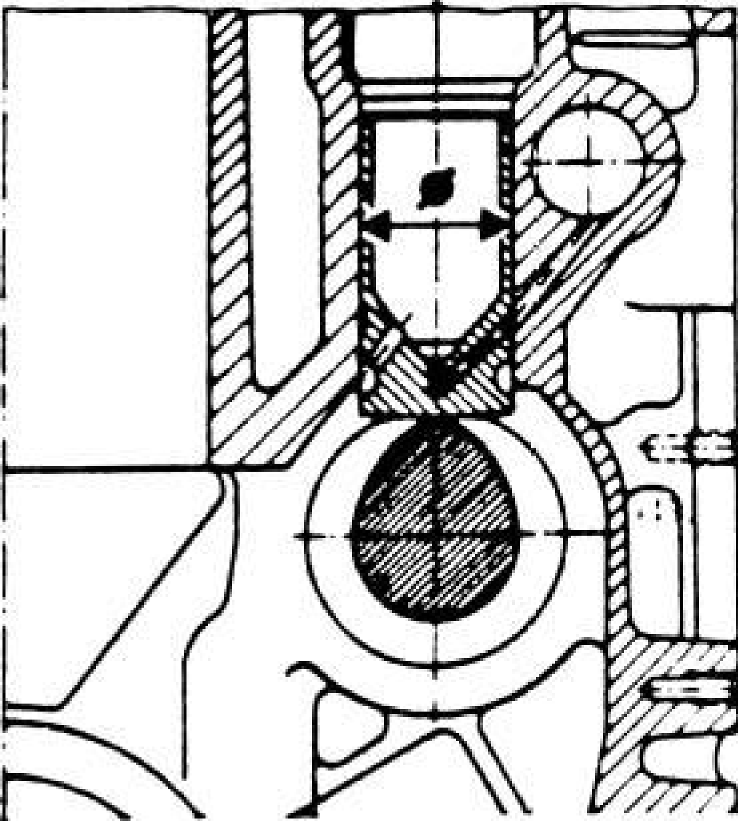


Fig. 2-20b Installation of tappet

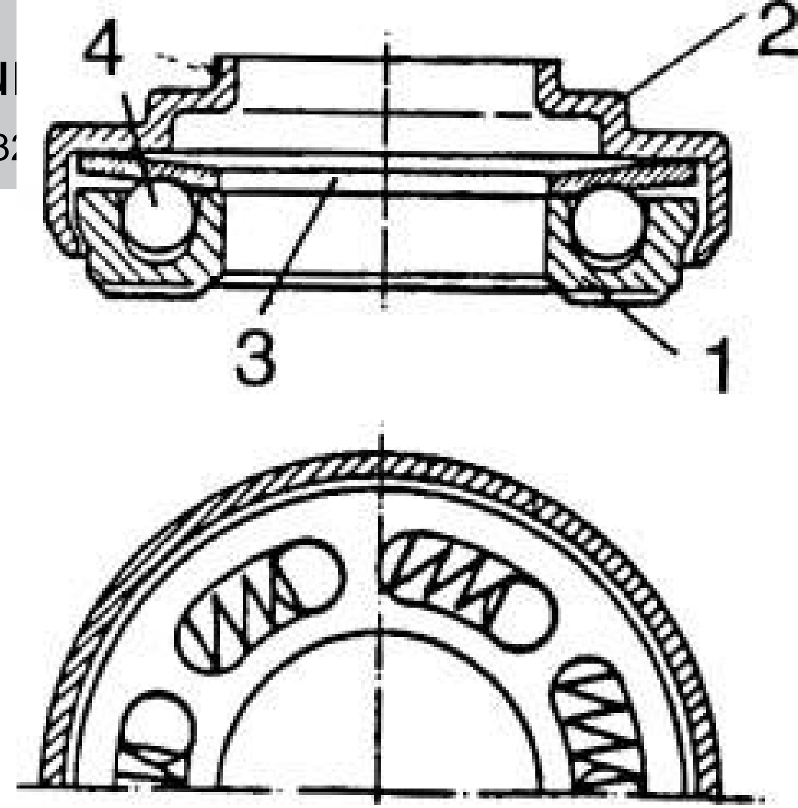
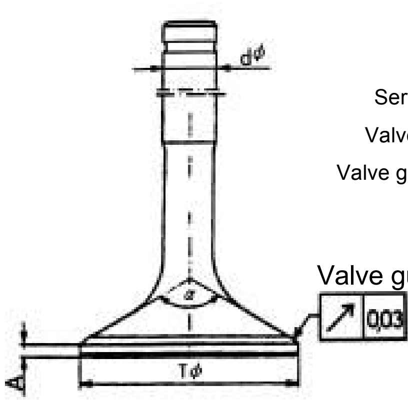



Fig. 2-20c Valve rotating mechanism
1. Valve spring seat 2.Spring seat 3. Disk spring 4.Steel ball

valve dimension

110° 90°




| | intake valve | exhaust valve |
|---|---|---|
| Service limit A | 110° | 90° |
| Valve stem dia. | 1.6 mm | 1.6mm |
| Valve guide pipe ID | 10.97-10.98 | 10.965-10.975 |
| | $11^{+0.018}_{0}$ | $11^{+0.018}_{0}$ |
| Valve guide pipe oD | $16r6\left(^{+0.034}_{+0.023}\right)$ | $16r6\left(^{+0.034}_{+0.023}\right)$ |

Fig.2-21 Dimensions of intake and exhaust valves

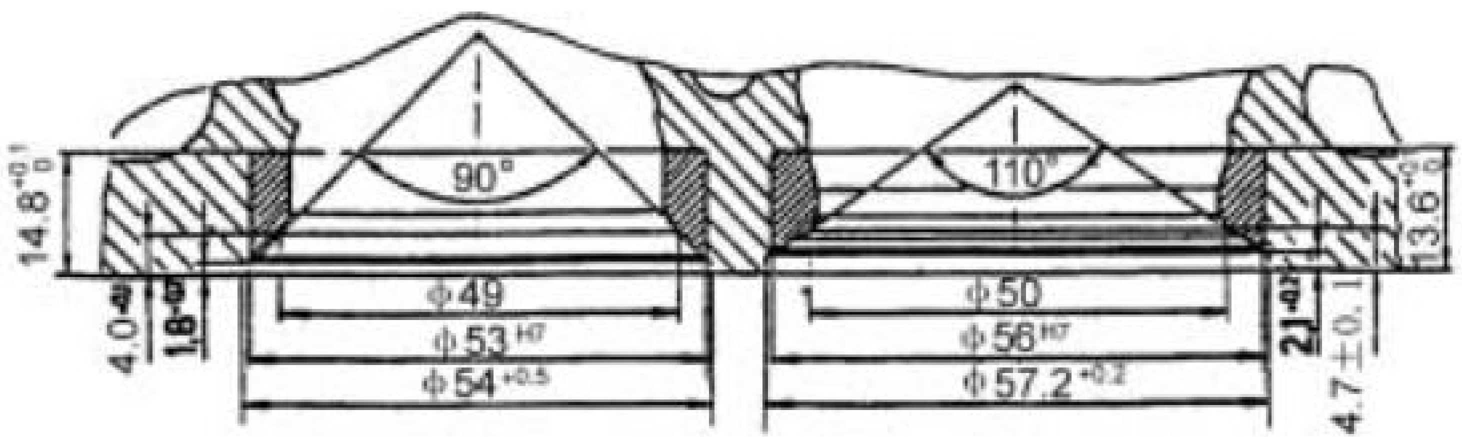
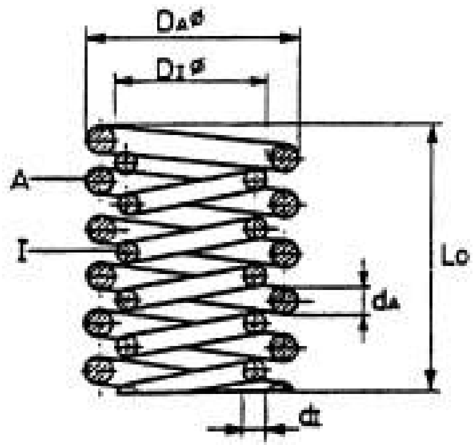



Fig. 2-22 Dimensions of intake and exhaust valve seats




| Intake valve | exhaust valve |
|---|---|
| A L。 = 65 | A L。 = 69 |
| ϕ DA = 39.8 | ϕ DA = 40 |
| dA = 4.4 | dA = 4.5 |
| I L。 = 59 | I L。 = 59 |
| ϕ DI = 26.8 | ϕ DI = 26.8 |
| dI = 2.9 | dI = 2.9 |

Fig. 2-23 Valve spring dimensions

- In order to guarantee that the oil does not enter the cylinder through valve stem and the valve guide pipe, seals are placed on the guide pipes of the intake and exhaust valves, as shown in Fig. 2-23a.
- The fitting clearance between the valve guide pipe and the valve stem is 0.02～0.048 for intake valve, and 0.025～0.053mm for exhaust valve Their wear limit is 0.1mm. When exceeding the service limit, the valve guide pipe should be replaced timely.
- Fig. 2-23a Valve sealing

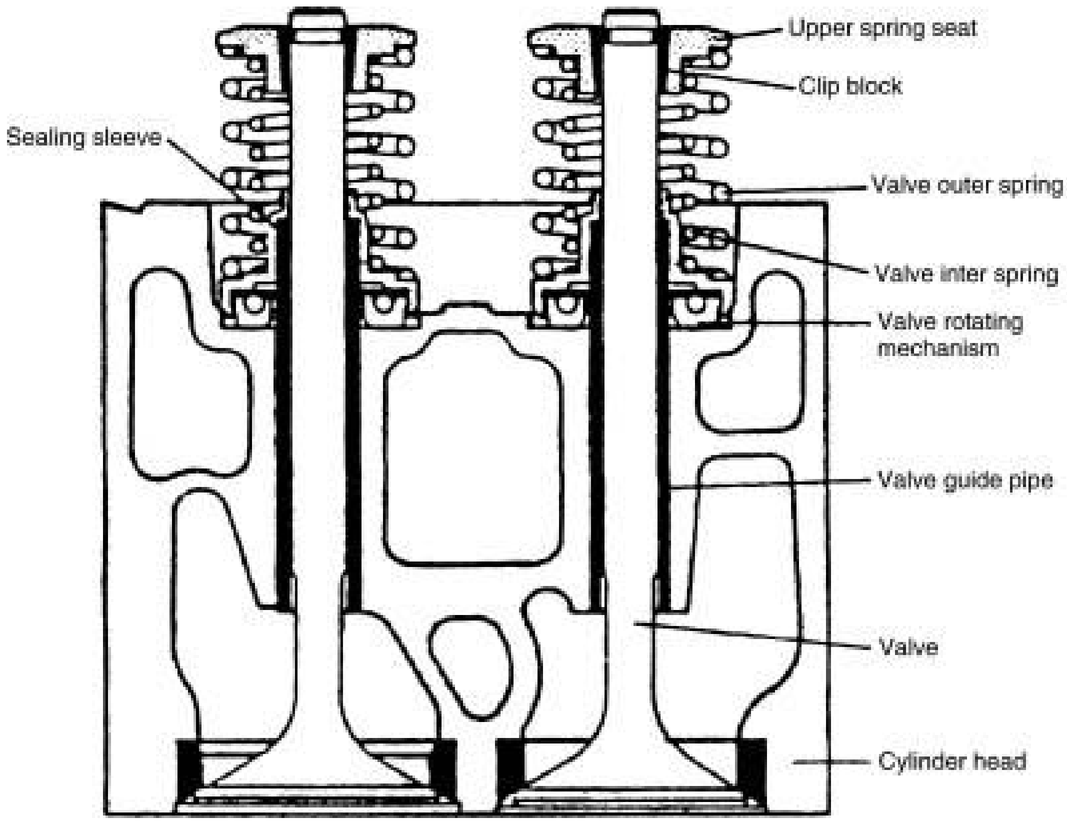



Fig. 2-23a Valve sealing

## 4. Timing Gear Drive

The timing gear drive is composed of 8 gears. The configuration of gears and the number of teeth of each gear are as shown in Fig. 2-24.

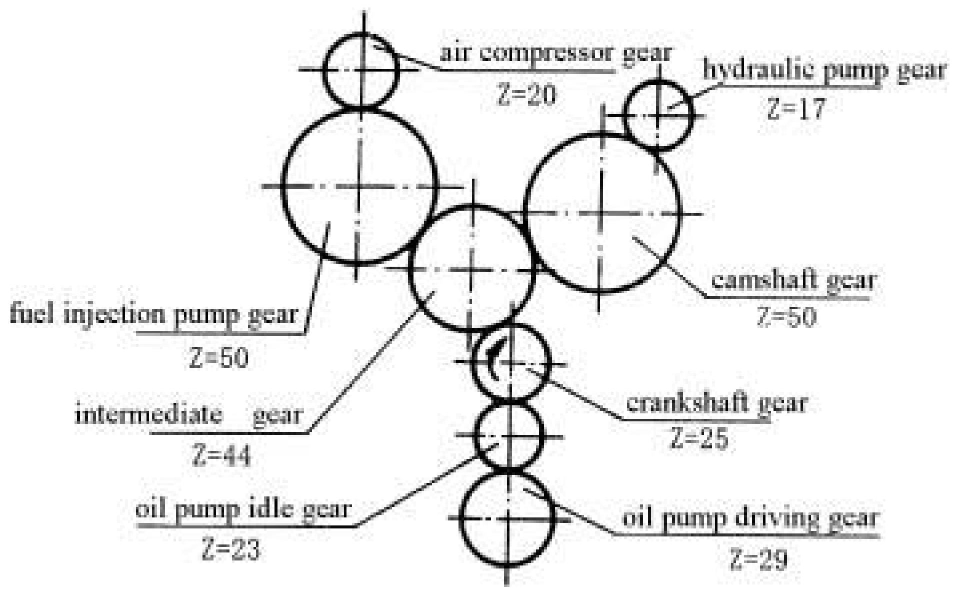
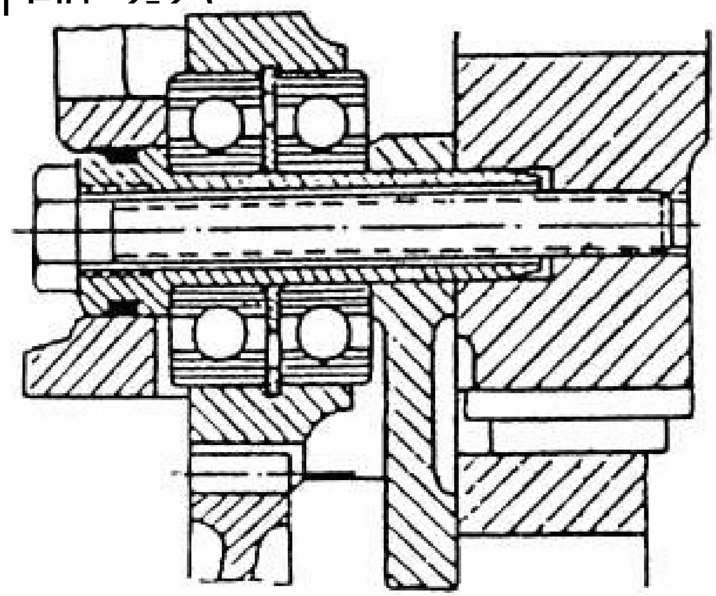



Fig.2-24 The timing gear drive

- The crankshaft gear is heated to 180℃ and then installed and keyed to the crankshaft. There is a fixing flange in the front of the crankshaft gear, used to fix the crankshaft belt pulley and the shock absorber. This flange is heated to 290℃ and installed on the crankshaft. The crankshaft gear transmits its power to the oil pump gear through the intermediate gear. The oil pump intermediate gear is supported between the timing gear case and the cylinder block by means of the intermediate gear and two 303 bearings, as shown in Fig. 2-25



Fig, 2-25 Structure of oil pump intermediate gear

- The oil pump gear is heated to 240℃, and fit on the oil pump shaft with no key used.
- The crankshaft gear is coupled with the fuel injection pump gear via the timing intermediate gear and the camshaft gear. The timing intermediate gear is support in the timing gear case by means of the intermediate gear shaft sleeve (the shaft sleeve is fixed inside the timing gear case with support bolts) and the bearing. The camshaft gear is located by a Φ8mm locating pin, and coupled to the camshaft head by means of four MSx20 bolts.
- When adjusting timing, set the first cylinder to its top dead center and make sure that the OT marking is aligned with the marking on the flywheel casing. It then indicates that the valve timing of the engine (i.e. the time when the intake and exhaust valves open and close) is guaranteed. When installing camshaft timing gear during the adjustment, make sure that the timing mark line on the camshaft timing gear is aligned with the timing mark line on the timing gear case, as shown at position E in Fig. 2-26

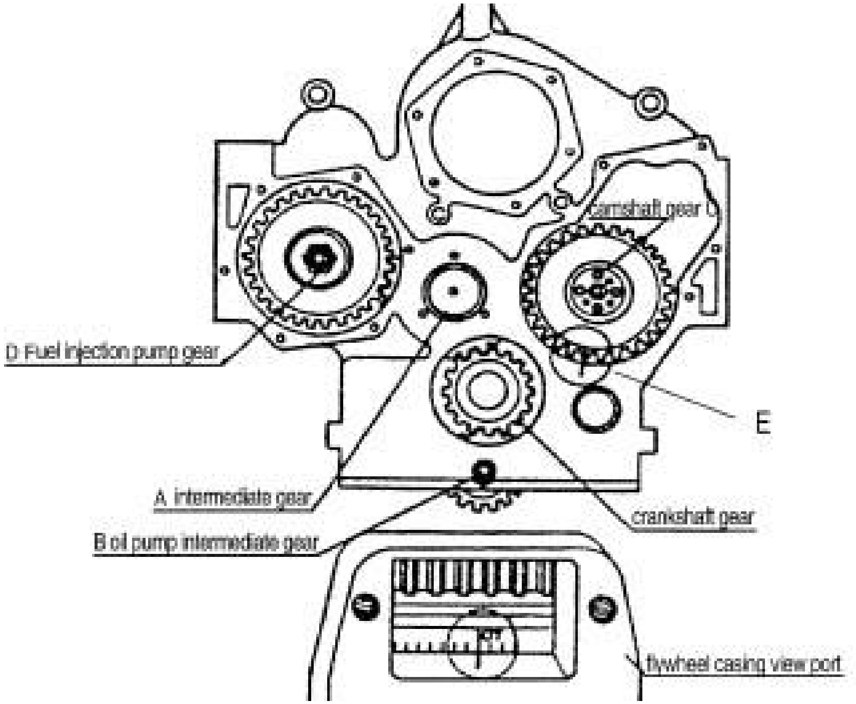



Fig. 2-26 Timing mark line

- In Fig. 2-26, apply Lotite 242 sealant on fastening bolts at positions A, B, C and D. The tightening torques of the fastening bolts of the intermediate gear A, the oil pump intermediate gear B, the camshaft C and the high-pressure oil pump driving gear D are 60Nm, 32Nm, 300Nm and 350Nm respectively.
- The air compressor oil pump driving gear is coupled to the drive shaft through a tapered hole and conical face at high torque with self-locking and without key, and secured by a M18X1.5 nut, as shown in Fig. 2-27. It is characterized by simple assembly, proper injection timing and stepless adjustment. The Fuel injection pump driving shaft is supported by a cylindrical roller bearing at the side of the gearbox and by the biserial radial thrust bearing at the side of the air compressor crankcase. The cylindrical roller bearing is fixed in the gearbox by a cap. At the upper surface, a lubricating groove is milled (facing up). The inner race of the biserial radial thrust bearing is fixed on the shaft by a nut and the outer race is secured in the air compressor crankcase by a cover plate. When assembling, apply Lotite 242 sealant on bolts A, B, D and E, and tighten these bolts to 350Nm, 23Nm, 23Nm and 200Nm respectively. Apply Lotite 638 sealant on bolt C and tighten it to 150Nm. Apply Lotite 270 on the outer races of the bearing G. Apply Lotite 641 on the outer races of the bearing F. The two bearings are heated to 110°C and then installed.

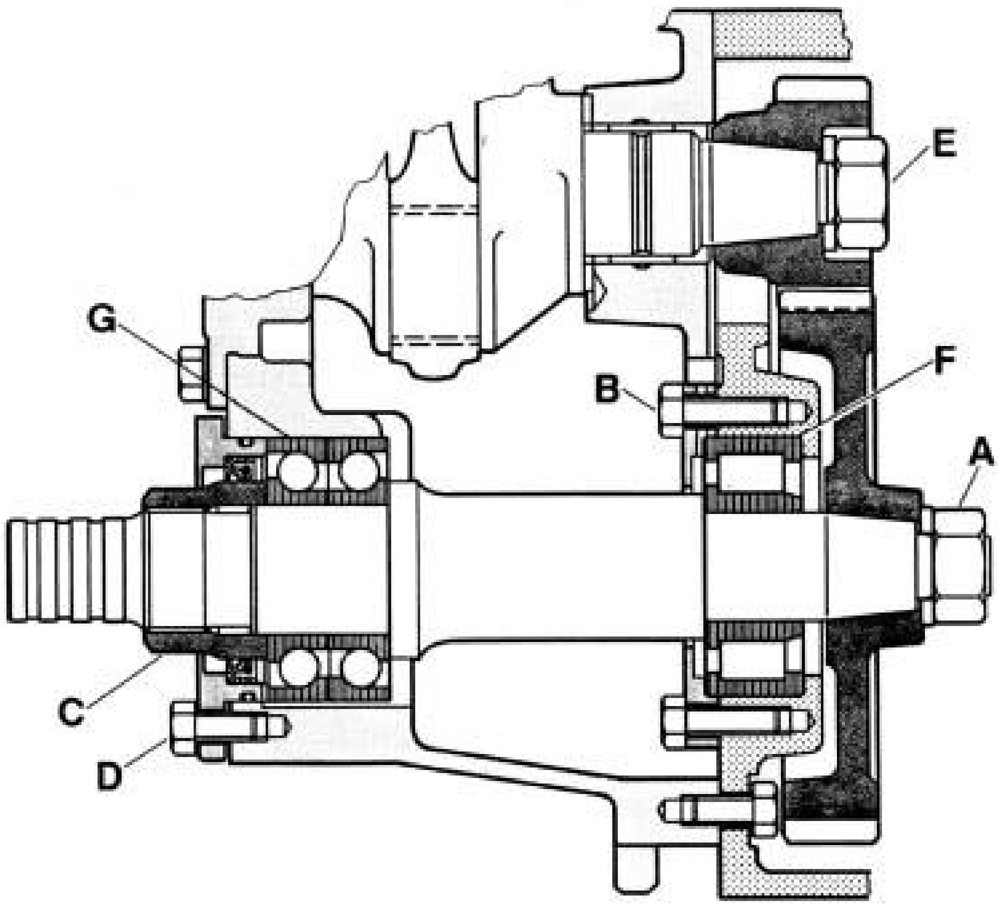



Fig. 2-27 Assembly of fuel injection pump drive shaft

- The air compressor gear is also coupled to the crankshaft at high torque through a tapered hole and conical face with self-locking and without key. It is secured in the timing gear case by means of a suspension arm.
- The steering boost pump drive gear is keyed to the pump shaft, and secured in the timing gear case by means of a suspension arm.
- There are openings in the timing gear case at the location of the camshaft gear and the fuel injection pump drive gear. The camshaft gear and the fuel injection pump drive gear can be removed and installed through these openings with their covers removed. To replace the timing intermediate gear, you must first remove the camshaft gear, the camshaft axial locating plate, and all valve chamber cover and valve lifters, use special tools to lift all valve tappets to the top of the cylinder block (separating the valve tappets from the camshaft), push in the camshaft to the rearward direction of the diesel engine, withdraw the timing intermediate gear shaft, and finally take out the timing intermediate gear together with the bearing through the camshaft gear opening. Install the new timing intermediate gear in the opposite order as removal

- When replacing the camshaft gear and the fuel injection pump drive gear, if the operation of the engine was normal, the relationship of motion among various gears were not disturbed, and the engine crankshaft has not been rotated during the entire process of removal and installation of the gears, then there is no need to align the timing mark lines during installation of the gears. If the original timing gear driving relationship is disturbed because of the damage of gears, or the engine crankshaft was rotated during the process of removal of the two gears mentioned above, then the timing mark lines must be realigned when installing the camshaft gear. The timing of the fuel injection should be rechecked and readjusted after the fuel injection pump drive gear is installed. When replacing the intermediate gear, the camshaft gear should also be installed with the timing mark lines aligned.
- To remove the crankshaft gear, the timing gear case must be removed. The crankshaft gear and the crankshaft flange must be removed or installed under heated conditions. When reassembling the timing gear case, you should first tighten the fixing bolts of the timing intermediate gear and the oil pump intermediate gear to their specified torque, and then tighten the fixing bolts around the timing gear case.
- In order to guarantee the support rigidity of the timing intermediate gear and realize effective and reliable lubrication, the timing intermediate gear adopts a sliding bearing structure, as shown in Fig. 2-28.

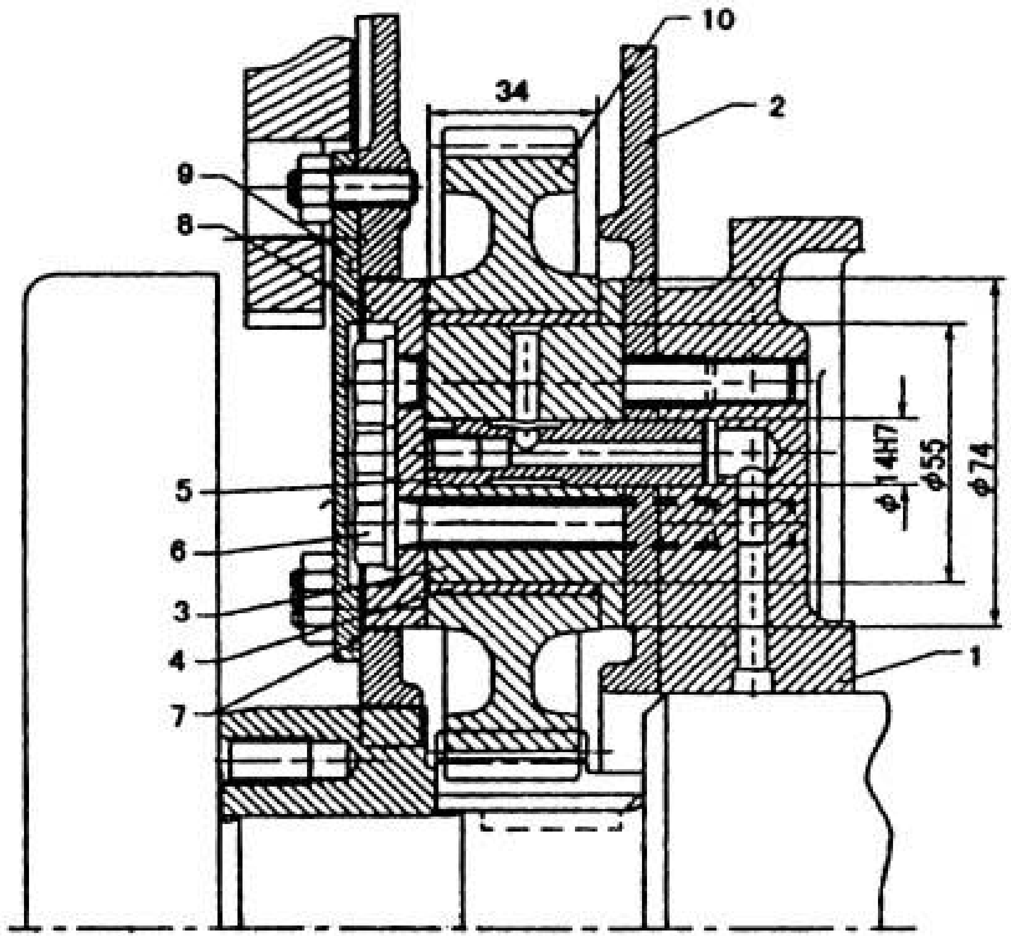



Fig. 2-28 Timing intermediate gear drive

1.Cylinder block 2.Timing gear case 3.Bearing seat 4.Bearing bush
5.Spindle 6.Bearing seat fixing bolt 7.O-ring 8． Bearing cap
9． Hold-down plate 10.Timing intermediate gear

- The sliding bearing is composed of bearing seat (3), bearing bush (4) and spindle (5). The spindle does not only plays the action of a lubricating passage, but also and more importantly a locating action for the bearing seat (3). The bearing seat (3) is fixed to the timing gear case (2) and the cylinder block (1) by means of 4 fastening bolts (6) via the hold-down plate (8). As the bearing seat is comparatively large in diameter and secured by means of 4 blots, it greatly increased the support rigidity of the intermediate gear, which together with the use of the sliding bearing has kept the radial clearance of the timing intermediate gear within a very small range. Thus it can guarantee the engaging accuracy of the gears, decrease the possibility of occurrence of tooth knocking., and prolonge the service life of the intermediate gear.
- The timing gear case is sealed at the location of the intermediate gear by means of a end cover (9) and an O-ring (7).
- In order to ensure reliable lubrication of the bearing, the timing intermediate gear shaft sleeve is lubricated under pressure. Therefore, as shown in Fig. 2-28, an oil passage leading to the timing intermediate gear bearing is opened in the first main bearing seat bore of the cylinder block. And at the same time, four blot holes and a spindle locating hole are drilled in the end surface of the cylinder block at the corresponding positions for fixing the intermediate gear bearing, as shown in Fig. 2-29.
- The radial clearance of the intermediate gear is 0.04～0.089mm, and the axial clearance is 0.15～0.25mm.

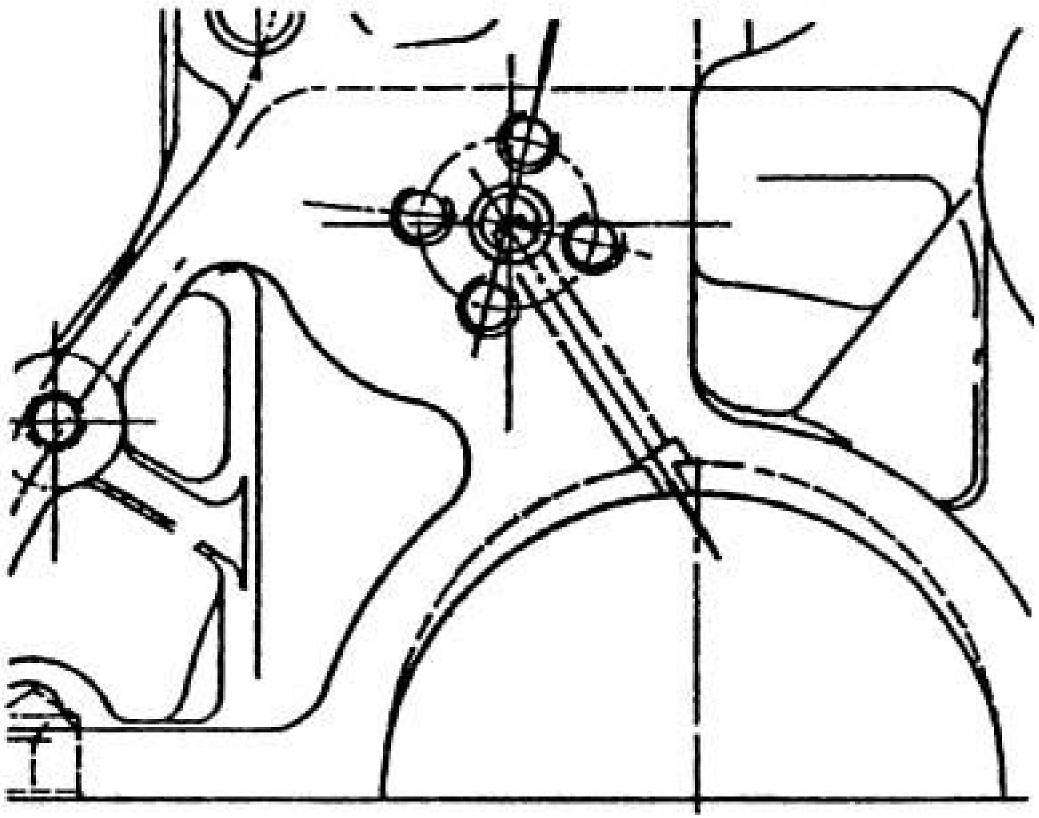


Fig. 2-29 Local structure of the cylinder block intermediate gear portion

- **5. Intake and Exhaust Systems and Supercharger**
- The intake and exhaust systems differ as the form of intake is different. The intake manifold is made of aluminum alloy. The intake manifold faces rearward for natural aspirated and supercharged engines and forward for inter-cooling engines. There are also two kinds of exhaust manifolds: the natural aspirated engine uses simple straight-way type exhaust manifold, and the supercharged engine uses two exhaust manifolds (one for the first three cylinders and another for the last three cylinders). The exhaust manifold used for the last three cylinders is a kind of pipe with laminated wall and having two exhaust ports. The front and the rear exhaust manifolds are sealed from each other by means of steel sheet seal ring.
- The air filter is of a double-element spiral-flow type. Air is sucked into the housing of the air filter. Under the centrifugal force generated by the spiral flow inside the cowl, large particles and impurities and dust in the air are thrown to the filter housing and fall into a dust collector. The collected particles and impurities and dust will be disposed manually. Fine dusts will pass together with the air and be filtrated by the paper filter element and the felt safety element. Pure air after filtration will enter the engine. When the filter element and the safety element are too dirty and the vacuum inside the filter increases to a certain level, the switch of the air filter closes, illuminating the air filter indicator lamp on the instrument panel, and signaling the operator to clean the filter elements. As the filter element is dry outward-blow type, it is forbidden to soak clean the filter element and the safety element in solutions (such as gasoline). Before cleaning the filter with compressed air, check if the filter is damaged. Replace it if it is damaged. During operation, attention must be paid to the following two points:

- 1. The suction pipe in the front of the air filter is composed of two parts, and its upper half is a integral part of the driving cab, and its lower half is fixed on the chassis. There is open-type joint between the two halves. In operation, try to keep the joint out of the air filter, as this may increase the load of the air filter, and increase the opportunities of dust getting into the cylinder, speeding up the wear of the cylinder sleeve. 2. Although there is a sensor on the air filter and a filter blockage indicator lamp on the instrument panel, the operators should not rely on them absolutely due to the problem of their reliability, but check and clean the filter periodically, especially when operating in construction site or in a highly dusty environment.
- The supercharger is made up of two parts: the turbine assembly and the pump impeller assembly. The exhaust from the engine blows the turbine together with the pump impeller to rotate at high speed, which in turn blows air into the intake manifold and increases the intake air pressure (air input). The boost pressure increases as the rotating speed rises. When the engine is at its rated speed (about 2,200 rpm), the speed of the rotor of the supercharger is as high as 70,000～100,000 rpm. The rotor shaft of the supercharger adopts full-floating bearing, i.e. there is a certain radial clearance between the shaft and the shaft sleeve, and the rotor shaft is floated by the lubrication oil under a given pressure. The pressure lubrication oil supplied by the main oil passage of the engine directly flows into the rotor shaft chamber of the supercharger and then back to the oil pan. There are seal rings on the turbine casing and the pump impeller casing respectively used to stop the lubricating oil of the rotor shaft from coming out, as shown in Fig. 2-30. Therefore, when replacing the supercharger, remember to add lubricating oil.
- As the supercharger has the above-mentioned features, the following three

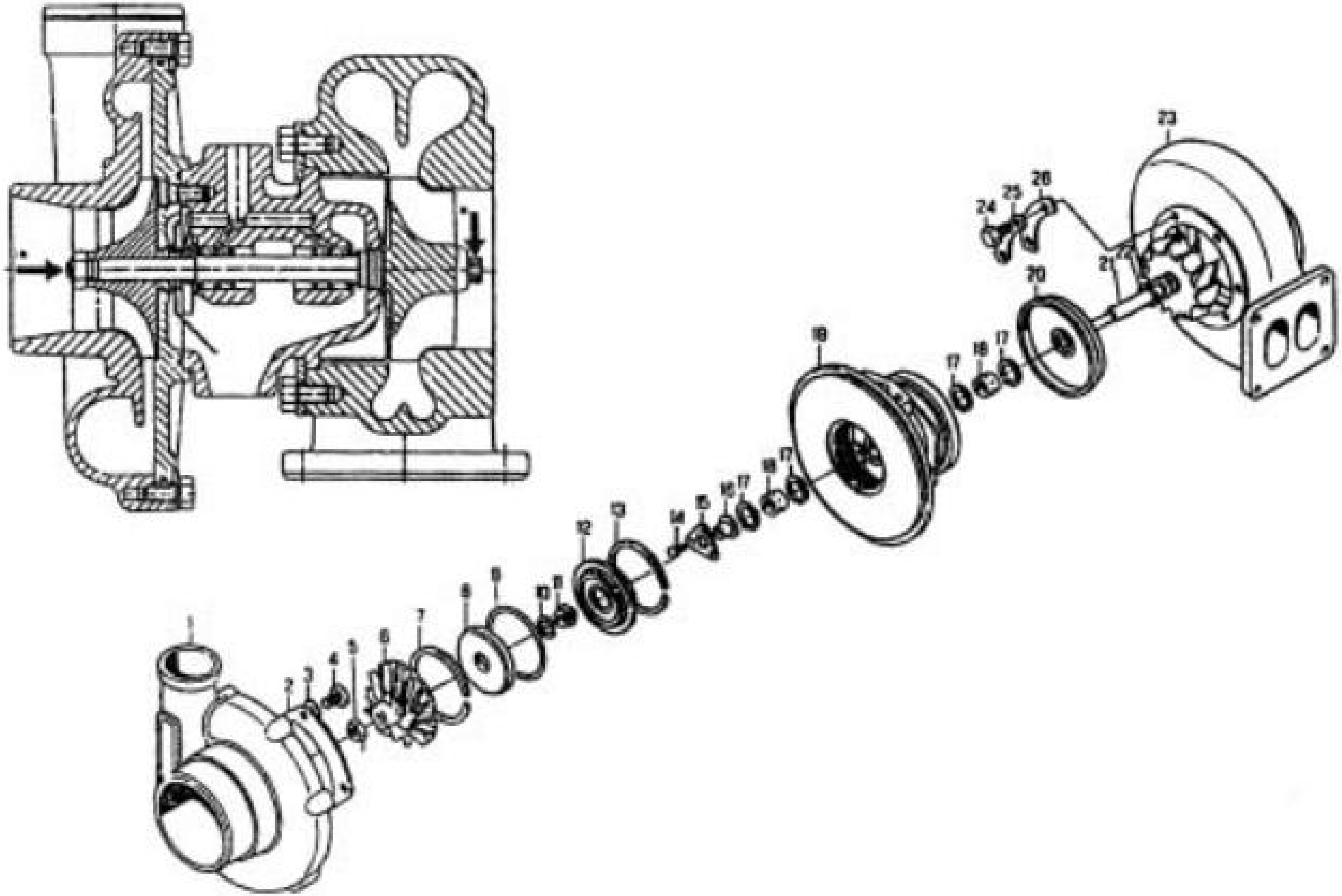


Fig. 2-30 Exhaust turbocharger

1．Air compressor casing 2．Air compressor hold-down plate 3．Locking washer 4．Hex bolt 5．Locking nut 6．Air compressor impeller 7．Airclip 8．Air seal plate 9.O-ring 10．Air compressor end seal 11.Shaft seal 12．Oil deflector 13．Airclip 14．Flat head screw 15．Thrust bearing 16．Distance fixing thrust sleeve 17．Bearing retainer 18．Floating bearing 19．Mid casing 20．Thermal baffle 21．Turbine parts 22．Turbin end seal ring 23．Turbine casing 24．Hex bolt 25．Turbine casing lock piece 26．Turbine casing hold-down plate

- First, when the engine is started, apply load only after the oil pressure and the oil temperature become normal, especially in cold days, or the supercharger bearing and the seal rings might be pre-worn due to lack of lubricating oil.
- Second, when shutdown the engine, first let the engine run at idle speed for 3-5 minutes to allow the rotating speed of the supercharger to decrease. Never advance the throttle abruptly before shutdown, as sudden increase of engine speed may accelerate the speed of the supercharger too much (70,000～100,000 rpm). If the engine is shutdown at this time, the oil pump stops running, and the oil circulation stops too. However, the supercharger rotor would continue to rotate at high speed under inertia force, and the rotor shaft, the bearing and the seal rings would be burnt due to lack of lubricating oil. The habit of advance the throttle abruptly during operation is fatal to the service life of the supercharger.
- Third, when starting a engine parking for a long time, the supercharger must be pre-lubricated. This can be realized by removing the oil inlet pipe of the supercharger and fill a proper amount of clean oil into the oil inlet port. otherwise, the engine would suffer from pre-wear due to lack of lubricating oil during initial starting. The phenomenon of pre-wear of the supercharger is oil leakage. During operation, if large amount of oil leakage is found from the intake or exhaust manifolds or the radial or axial clearance of supercharger rotor shaft is found exceeding their service limit, it indicates that the supercharger needs repair or replacement. The pre-wear of the supercharger normally results in decrease of engine power

- The primary inspection index for the exhaust turbocharger is the axial clearance and the radial play. Take T45 supercharger as an example, the radial play is 0.075～0.18mm and the axial clearance is 0.025～0.1mm. Superchargers used for engines of different powers are also different. When submitting a request to the spare supplier for a new supercharger, the model of the engine must also be clearly pointed out.
- A disk valve and a control cylinder are mounted on the exhaust pipe of WD615 series diesel engines. They are used for engine shutdown and exhaust braking.
- Engines with 266 hp or above are of inter-cooling type. The inter cooler is located in the front of the engine radiator, as shown in Fig. 2-31. As the supercharged air is cooled in the inter-cooler, the air entering the cylinder is low in temperature and high in density. As a result, the power is increased and fuel consumption lowered. As the temperature of inlet air is low, the thermal load of the engine is decreased, the temperature of the exhaust air is lowered and the amount of NO x emission is reduced.

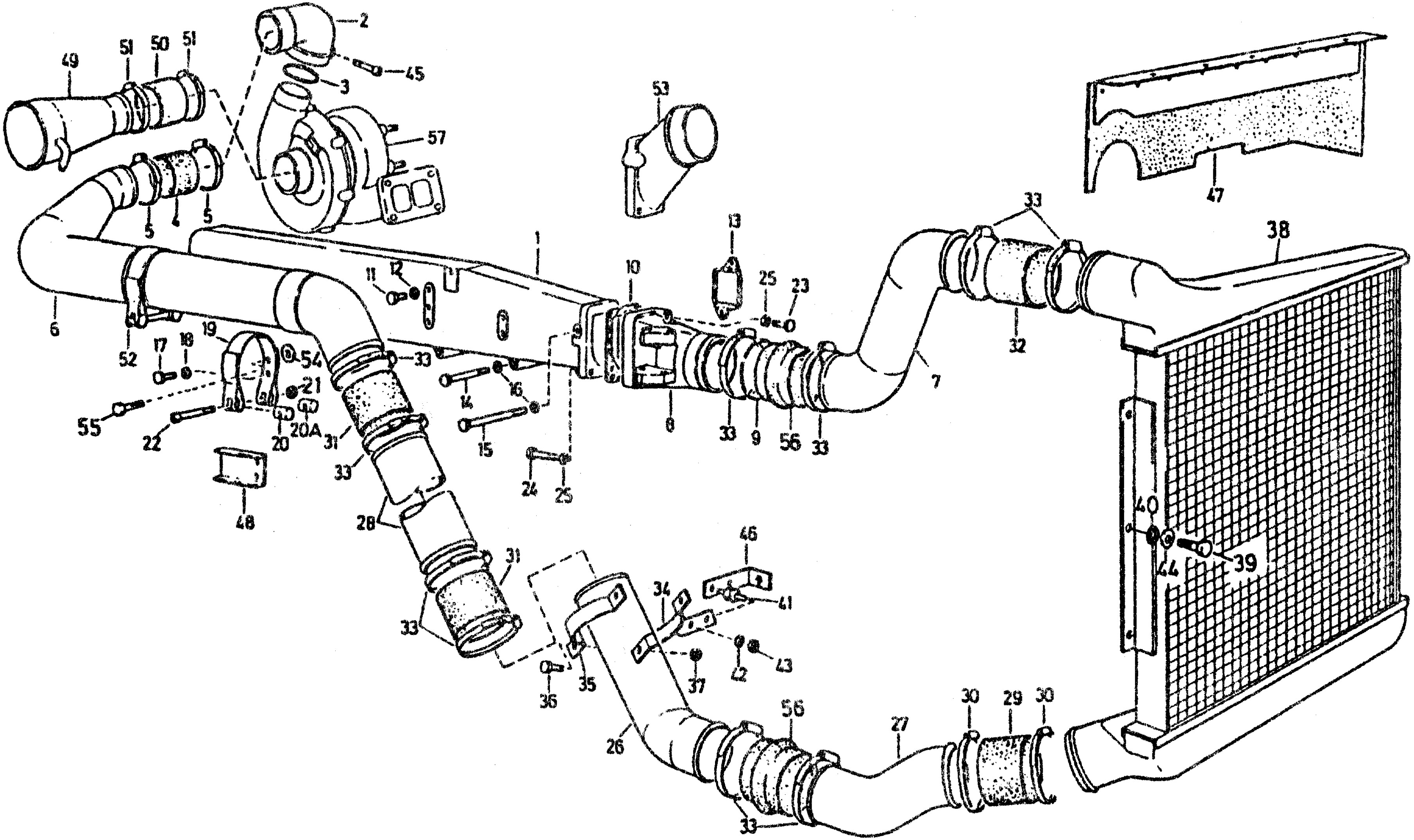



Fig. 2-31 Component location of supercharging and inter-cooling system

1.Air intake pipe 2.Elbow 6,7,26,27,28 Pipe 8.Air intake union 9.Inter-cooler 49.Diffuser pipe 57.Turbocharger

- **6．Lubricating System**
- WD615 series diesel engines use conventional lubricating system. Fig. 2-32 is a diagram of lubricating system and Fig. 2-33 a diagram of oil circulation in the lubricating system.

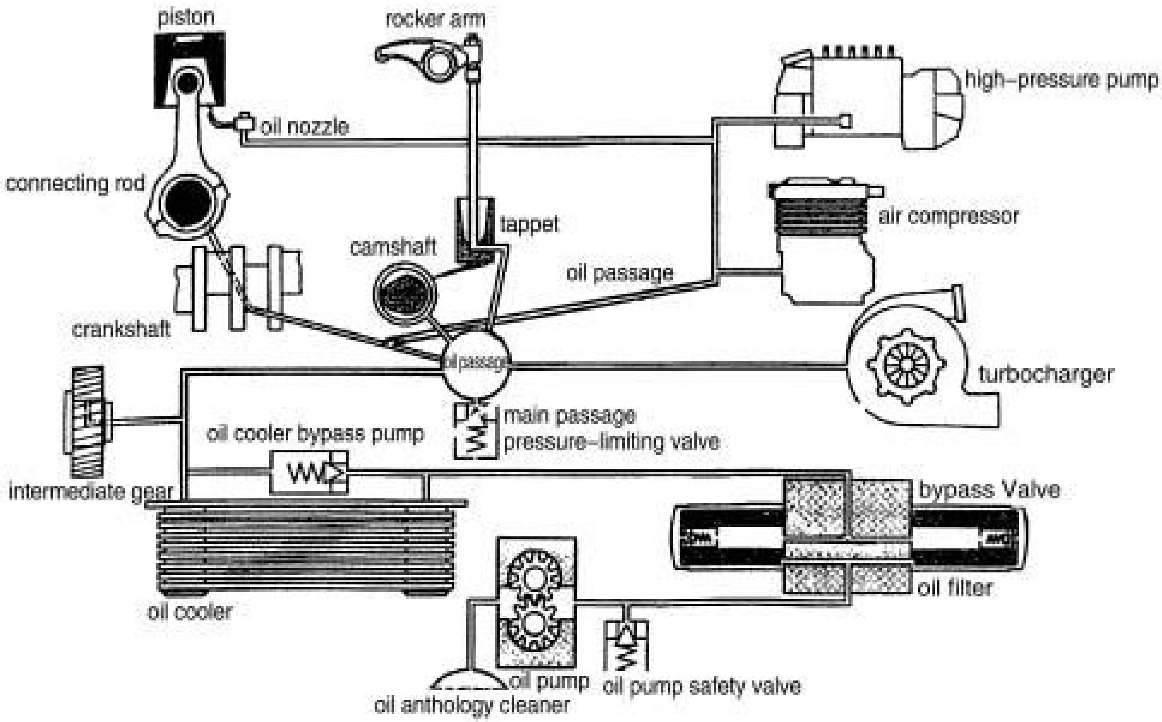



Fig. 2-32 Lubricating system

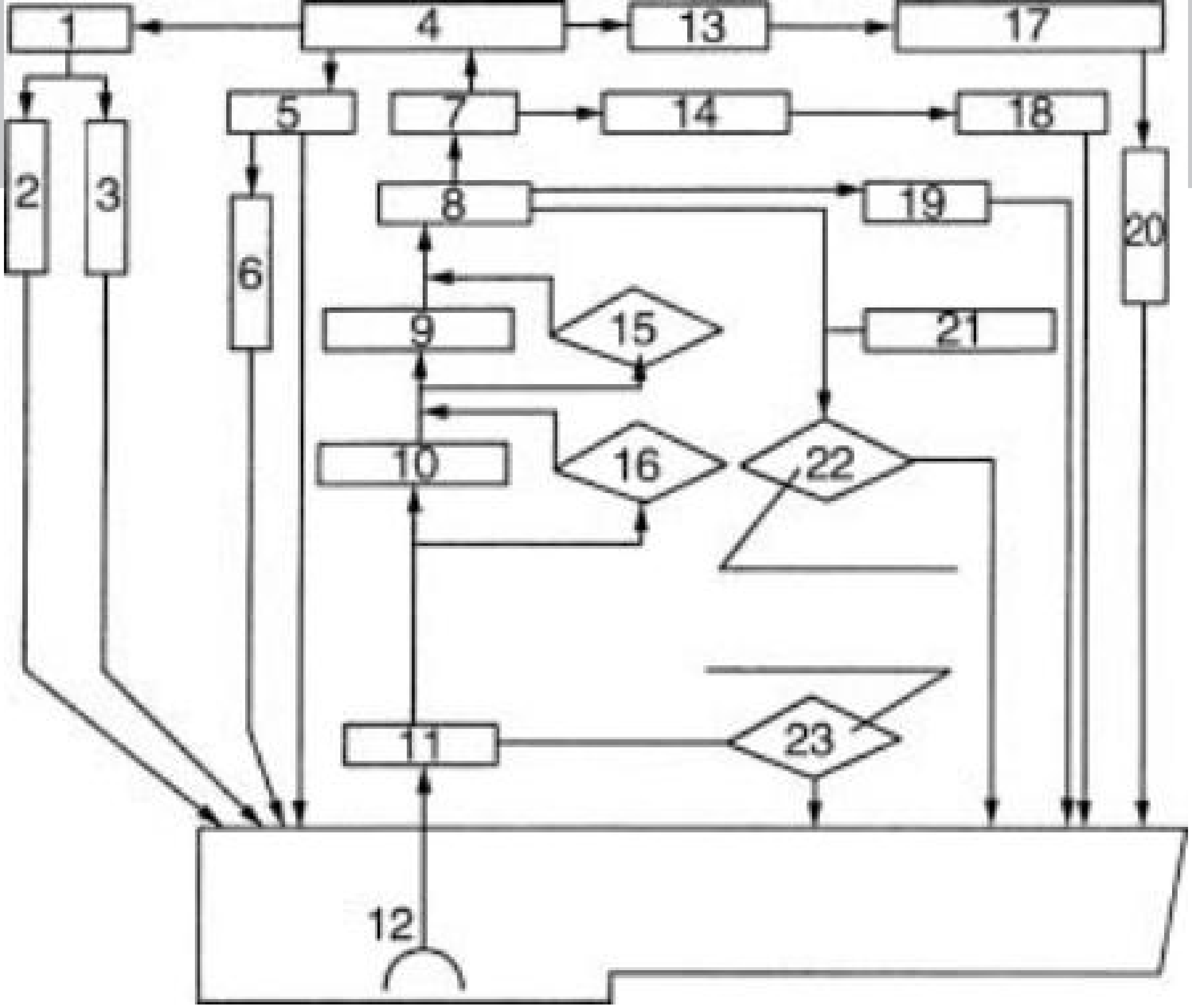



Fig. 2-33 oil circulation in lubricating system
1.secondary oil passage 2.fuel injection pump 3.air compressor 4.crankshaft main bearing oil passage 5.main bearing 6.connecting rod bearing 7.slant oil passage 8.main oil passage 9.oil cooler 10.oil filter 11.oil pump 12.oil pan 13.secondary oil passage 14.camshaft bearing 15.bypass valve 16.bypass valve 17.piston cooling oil nozzle 18.valve mechanism 19.supercharger 20.piston inner chamber 21.oil pressure sensor 22. main oil passage pressure-limiting valve 23. oil pump pressure-limiting valve

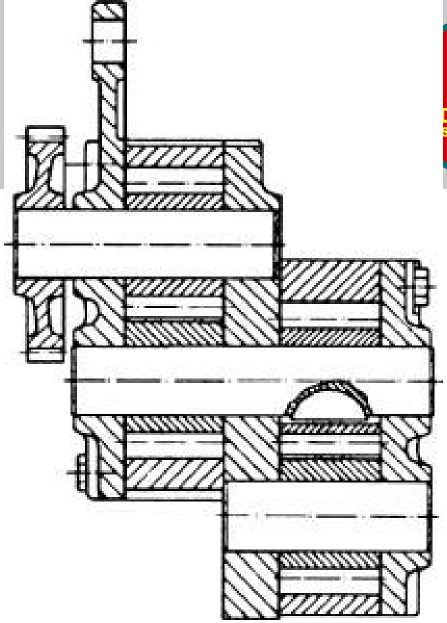


Fig. 2-33a Structure of gear pump

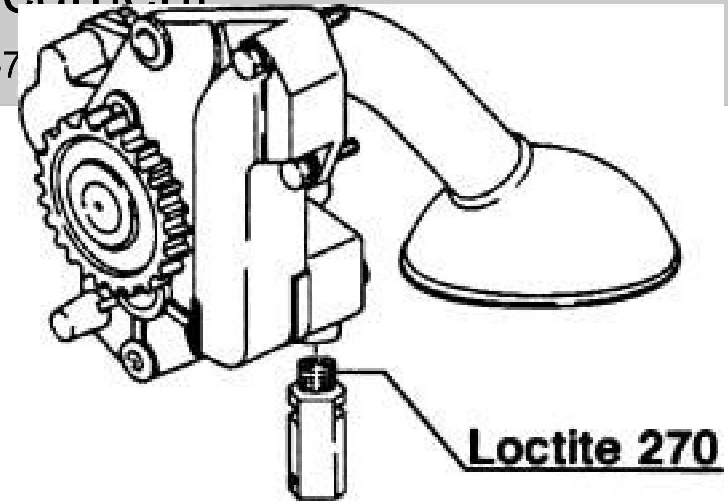



Fig. 2-33b Mounting valve of oil pump

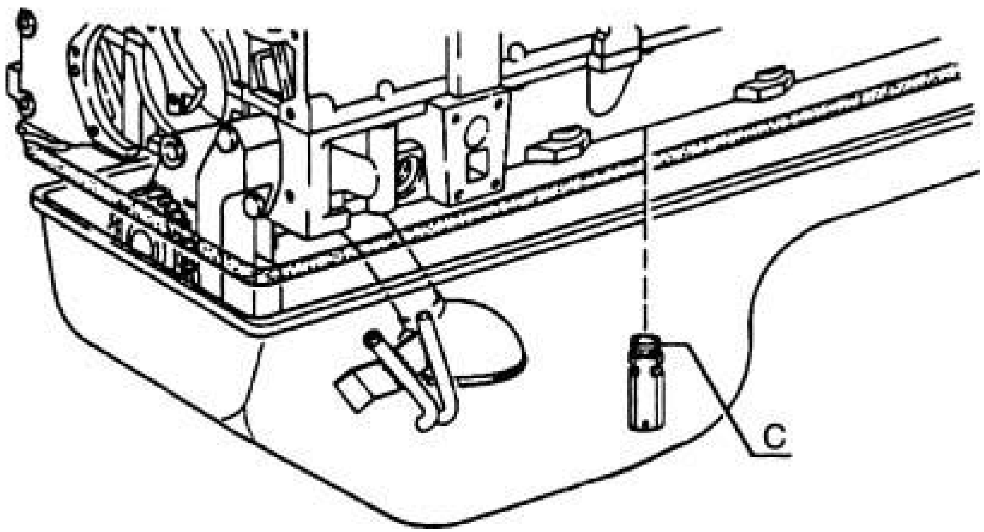



Fig. 2-33c Mounting position of oil overflow valve

- The oil pump sucks oil through the oil anthology cleaner in the oil pan and directly supplies it to a screw-in type oil filter through oil passage in the crankcase. The filtrated oil is fed to the oil radiator element at the right side of the cylinder block (looking forward) and cooled by cooling water. The cooled oil flows into the main oil passage in the cylinder block, and then further to the crankshaft journal and the connecting rod shaft journal for lubrication of the main shaft shell and the connecting rod shaft shell. The oil also flows from the main oil passage to the camshaft bushing for lubrication of camshaft bearing. With the intermittent opening between the oil passage orifice and the valve tappet, oil flows to the valve rocker arm shaft through the oil orifice in the valve tappet and the hollow valve lifter to lubricate the rocker arm shaft and the valve. The main oil passage is connected to the secondary oil passage on the left side of the cylinder block through an oil passage. oil is sprayed by an oil nozzle in each cylinder onto the top of the piston to cool the piston. When the piston falls, oil then flows into the piston pin bushing through V-shaped orifice in the small end of the connecting rod to lubricate the piston pin. The fuel injection pump, the air compressor and the supercharger are lubricated by oil coming from special supply pipes connected to the main oil passage. The timing gear is lubricated as follows:

- The oil pump is a gear pump with 45mm face width of tooth. See Fig. 2-33a. The fitting clearance between the gear shaft of the oil pump and the gear shaft seat bore is 0.04-0.08mm with a wear limit of 0.10mm, and the end clearance of the pump gear is 0.098-0.16mm with a wear limit of 0.20mm.
- The area of heat dissipation of the tube-type oil radiator is 2,765 cm2. The oil filter is of an integral screw-in structure. Replace it during service.
- There is a safety valve on the oil pump. Its opening pressure is 15.5±1.5 bars. See Fig. 2-33b. There is a pressure-limiting valve on the main oil passage in the cylinder block. Its opening pressure is 5.0±0.5 bars. In order to prevent the oil filter from being blocked, a bypass valve with a opening pressure of 2.5±0.175 bars is installed on the filter. There is also a bypass valve on the oil radiator whose opening pressure is 6±0.36 bars. There is an overflow valve in the main oil passage of the cylinder block. Its opening pressure is 5±0.5 bars, as shown in Fig. 2-33c. In order to guarantee safety, there is an oil pressure-sensing plug in the main oil passage. When oil pressure is below 0.25±0.15 bars, an alarm indicator lamp will be illuminated.
- Under normal operating temperature of the engine, the minimum oil pressure is 1 bar at idle speed and 3 bars at the rated rotating speed.
- As for the double-stage oil pump assembly used on a cross-country vehicle, one of its pump will pump oil from the rear of the oil pan to the front of the oil pan. Another pump will pump oil from the front of the oil pan into the main oil passage.

- **7. Cooling System**
- WD615 series engines adopt an enclosed cooling system of conventional structure of modern strengthened diesel engine and with an expansion water tank, as shown in Fig. 2-34. Fig. 2-35 is a flow diagram of the cooling system. The water pump is as shown in Fig. 2-35a.
- On WD615 series engines, the water pump is mounted at the fore end of the engine. The volute casing of the water pump is above the timing gear case. The volute casing and the timing gear case are cast into one integral part. The water from the volute casing directly enters the water chamber at the right side of the engine body. The cold water flows across the oil cooler and flows into the interlayer of the cylinder sleeve through a passage hole at the lower right side of the engine body to cool the cylinder sleeve, and then enters the water chamber in the cylinder head through a water inlet hole to cool the cylinder head, and is finally discharged into the water exit pipe through a water exit hole in the cylinder head. There is a thermostat at the end of the exit pipe. The thermostat has two exits: one is communicated with the water tank and another connected to the water inlet of the water pump for minor circulation. When the temperature of the cooling water is 80℃, the thermostat begins to open. It comes to full open at the temperature of 95℃. And now, all cooling water will be cooled by the radiator and then pump into the engine body. When the cooling water temperature is low, the

- water pump directly, making the engine temperature rise quickly to the warm state of operation, and thus avoided cold scuffing and prolonged the service life of the engine. For engines operating on highlands and in hot regions, thermostats with an opening temperature of 71℃ and full-open temperature of 85℃ can be used so as to prevent the engine from overheat.
- The oil chamber in the water pump is filled with approx. 120ml general vehicle-use lithium base grease. Periodical replenishment of the grease is required.
- The function of the expansion tank is to replenish cooling water and to eliminate low-pressure vapor in the cooling system so as to suppress the generation of the phenomenon of vapor lock. The pressure inside the expansion tank should be maintained at 50 kPa. It must be higher than the engine and the radiator by 400mm.
- Caps of various water tanks must be kept intact and in good condition. Never leave them open. To maintain a 50kPa pressure inside the cooling system may increase the efficiency of cooling and make water unlikely to boil.

- The plastic fan is die-cast from fiberglass strengthened PA6.
- Fans can be driven by either positive driving or silicone oil clutch driving (i.e. viscous driving).
- The operation of the silicone oil clutch fan is controlled by a bimetal temperature-sensing element. Its is good in energy saving, and more importantly, it can ensure diesel engine at a good hot state and is good to its operation and may prolong its service life. The primary principle of this fan is that, the engine drives the driving wheel in the clutch hub, the fan blades and the wheel hub are an integral part and there is a clearance between the driving wheel and the wheel hub. When this clearance is filled with silicone oil, the driving wheel can drive the hub to rotate; and when there is no oil in the clearance, the driving wheel would run idle (practically it can drive the fan to rotate at low speed). The bimetal probe is a valve to control the entry of the silicone oil into the working space, therefore, the operation of the fan is controlled by temperature. When the temperature of the air before the fan is below 40℃, the bimetal probe closes the silicone oil chamber valve. The driving wheel basically does not transmit power, and the fan rotates at a speed of 45% of the driving wheel speed. When the temperature is higher than 40℃, the silicone chamber valve opens, and silicone oil fill up the working space. The fan speed now is 95% of the driving wheel speed.
- When the silicone oil clutch fan is removed, do not lay it horizontally, otherwise, silicone oil would leak out through the fit clearance of the sensor

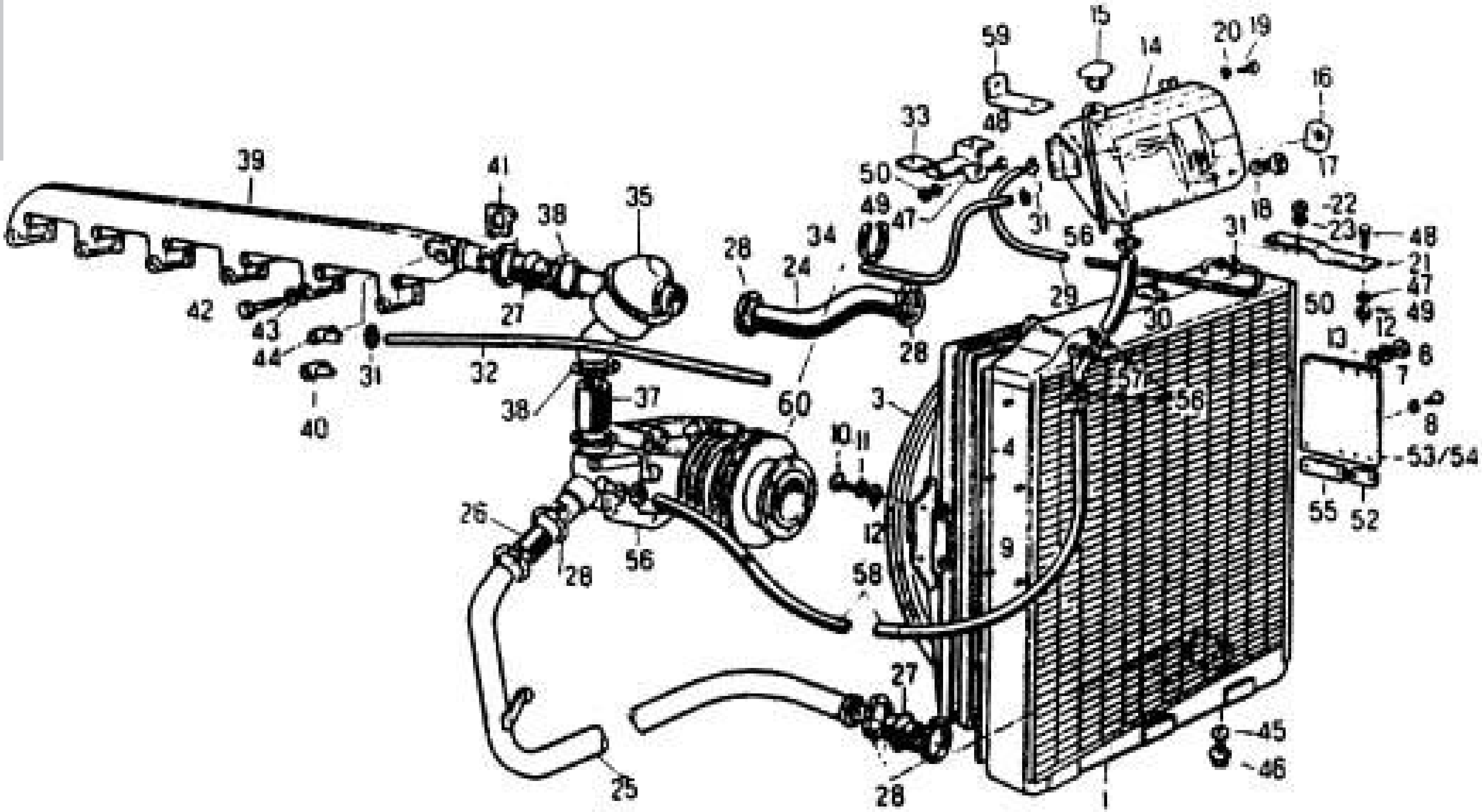


Fig. 2-34 Structure of cooling system

1.Radiator 3.Cow 4.Rubber seal 5.Bracket 6,7,8,10,11,12,13.Bolt, washer, etc. 14.Expansion water tank 15,16.Water tank cap 17.Water level indicator 18.Washer 19,20.Fixing bolt 25.Water inlet pipe 26.Rubber union 35.Thermostat 39.Water exit pipe 60.Water pump

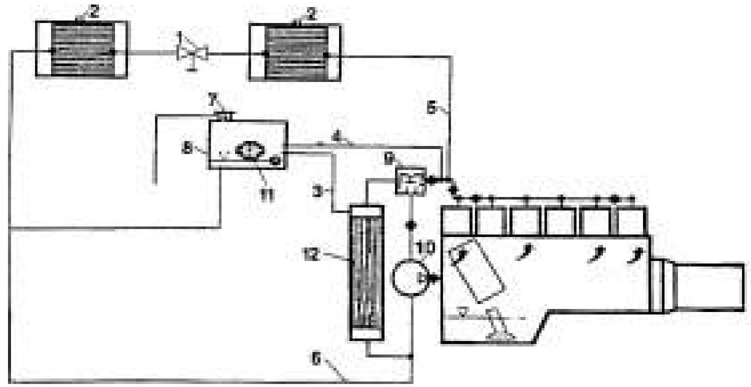



Fig. 2-35 Water circulation in cooling system

The water pump is of backward curved vane centrifugal type. The liquid flows into the pump, and is driven by the rotating impeller and accelerated so that the cooling liquid has some energy. The water pump shaft is water sealed. A spring in the water seal makes the sliding ring stay against the sealing face.
Apply Loctite 641 sealant on bearing D.
The tightening torque for the fastening nut of the belt pulley is 130+ 2oNm.
Apply Loctite 572 to the location of water seal A.
Water seal dimension B is reduced to 10.4mm. After the water pump impeller is pressed in, the dimension C is 1mm.

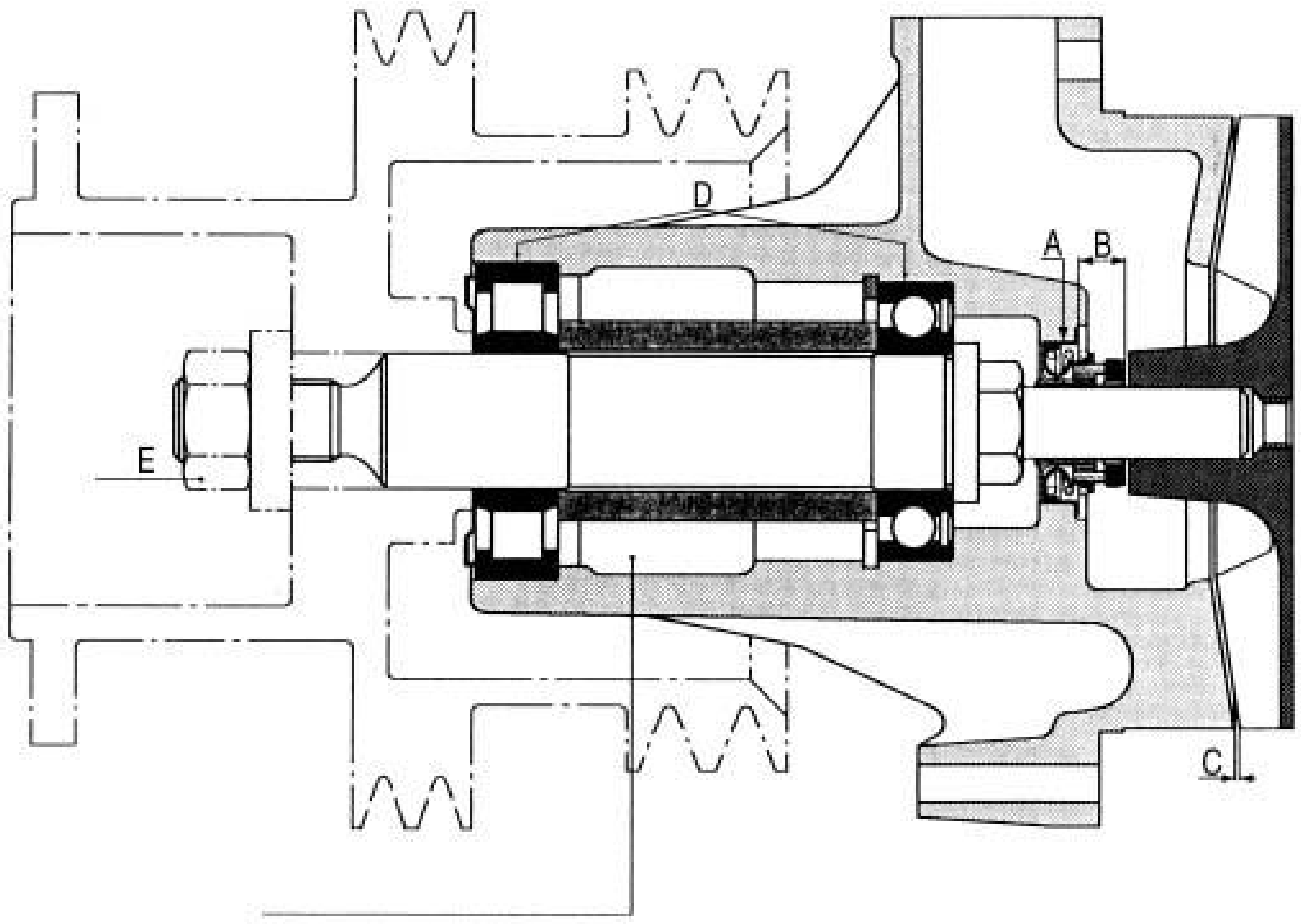



Fig. 2-35a Water pump

- **8. Air compressor**
- WD615 series engines use single cylinder air compressors. For its structure, refer to Fig. 2-36. The air compressor cylinder bore X stroke is 90 x 46mm, displacement 293ml, working pressure 8.33 bars and max. pressure 10 bars. The speed ratio of the air compressor to the crankshaft j=1.25, and the volumetric efficiency of the compressor i=0.568. The axial clearance of the crankshaft is 0.08～0.18mm.
- The intake and exhaust valves of the compressor are in reed structure. Apply Loctite sealant on the fixing nut of the drive gear, and tighten it to a torque of 200Nm. The compressor is force lubricated by oil supplied through a special pipe connected to the engine body. The lubricating oil comes from the main oil passage through oil pipe fixed on the cylinder block into the compressor to lubricate its bearings. After lubrication, oil then goes back to the scavenge oil pan from the timing gear case.
- Air entering the compressor has been filtrated by an air filter through a branch pipe at the front of the supercharger.
- The compressor is cooled by water coming through a pipe from the engine cylinder block to the compressor cylinder head. Water from the cylinder head then goes to the inlet of the engine water pump.
- Tighten cylinder head bolts to 50 Nm, Tighten connecting rod bolts to 14 Nm(box bead) and 25 Nm. The axial clear ance of the cronkshaft is kept within 0.08~0.18mm.

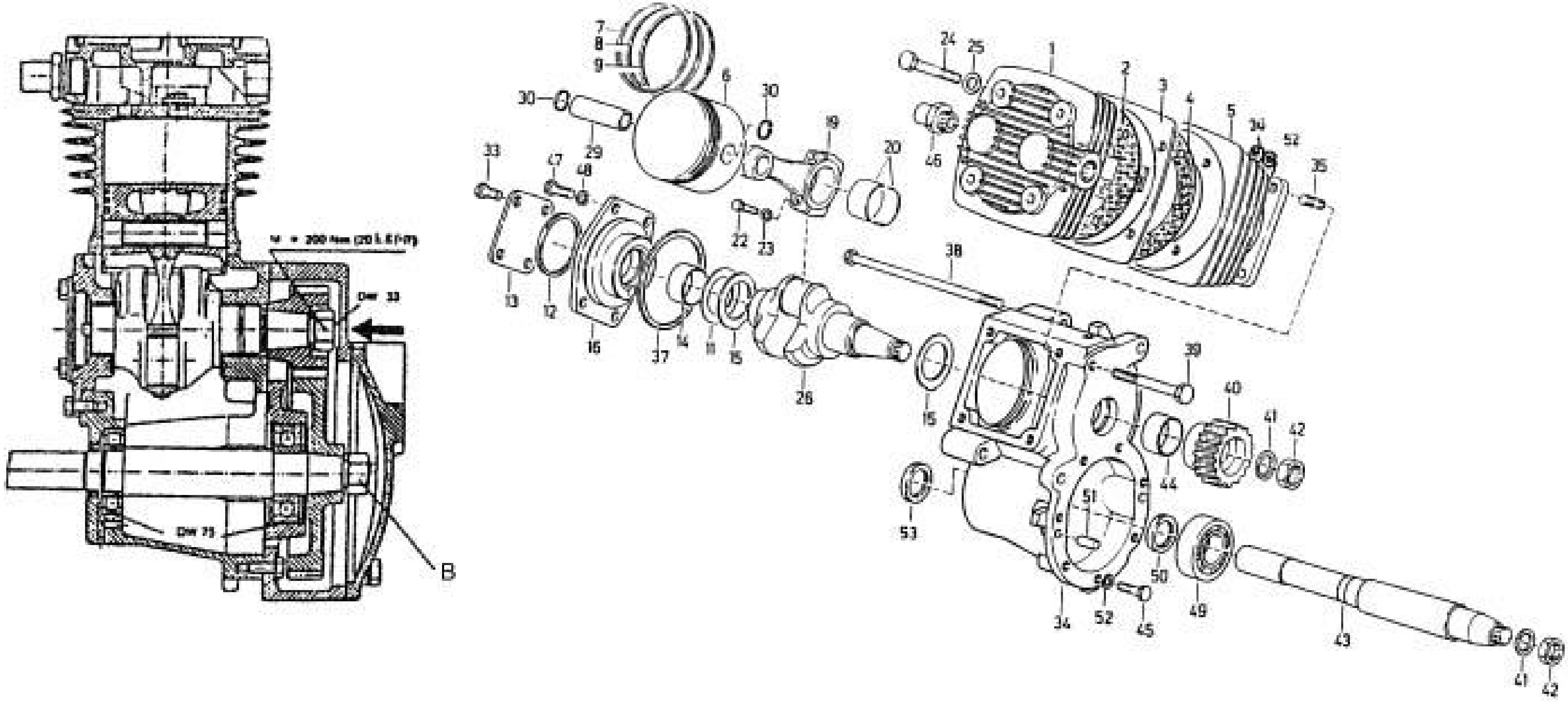


Fig. 2-36 Structure of air compressor

1.Compressor cylinder head 2、4.Shim 3、Top cover 5.Cylinder sleeve 6.Piston 7、8、9.Piston ring 14、44. Main bearing shaft sleeve 16.Rear bear seat 19.Connecting rod 20. Connecting rod shaft shell 22、23.Connecting rod bolt washer 26.Crankshaft 29.Piston ring 30.Retiner 34.Crankcase 35.Fastening studbolt 36.Nut 38、39.Fastening bolt 40.Air compressor gear 41、42.Washer, nut 43.Drive shaft 49.Rolling bearing 53.Oil seal

- **9. Fuel injection system**
- Fig. 2-37 and Fig. 2-37a are diagrams of fuel circulation in WD615 series diesel engines fuel supply system. WD615 series engines use typical plunger, in-line pump type fuel injection system. The key component of such system is the P-type strengthened fuel injection pump with a timing device and a full-range governor.
- The Bosch P-type pump is a typical strengthened pump characterized mainly in compact structure and wide range of application. It adopts a fully-sealed pump body, plunger matching parts and suspension structure. Fuel injection timing is realized by means of adding or reducing the number of shims at the suspension sleeve. The amount of fuel supply is adjusted by rotating the suspension sleeve. The adjustment is easy and reliable. The amount of fuel supply of the P-type pump is adjusted by means of a pull rod slot and a ball engaging mechanism on the fuel supply control sleeve. The adjustment of fuel supply is flexible and reliable. In order to meet the requirement of high speed and high pressure of fuel injection, the plunger matching parts and the lifter are both forced lubricated. As for the structure of Bosch P-type pump, see Fig. 2-38.

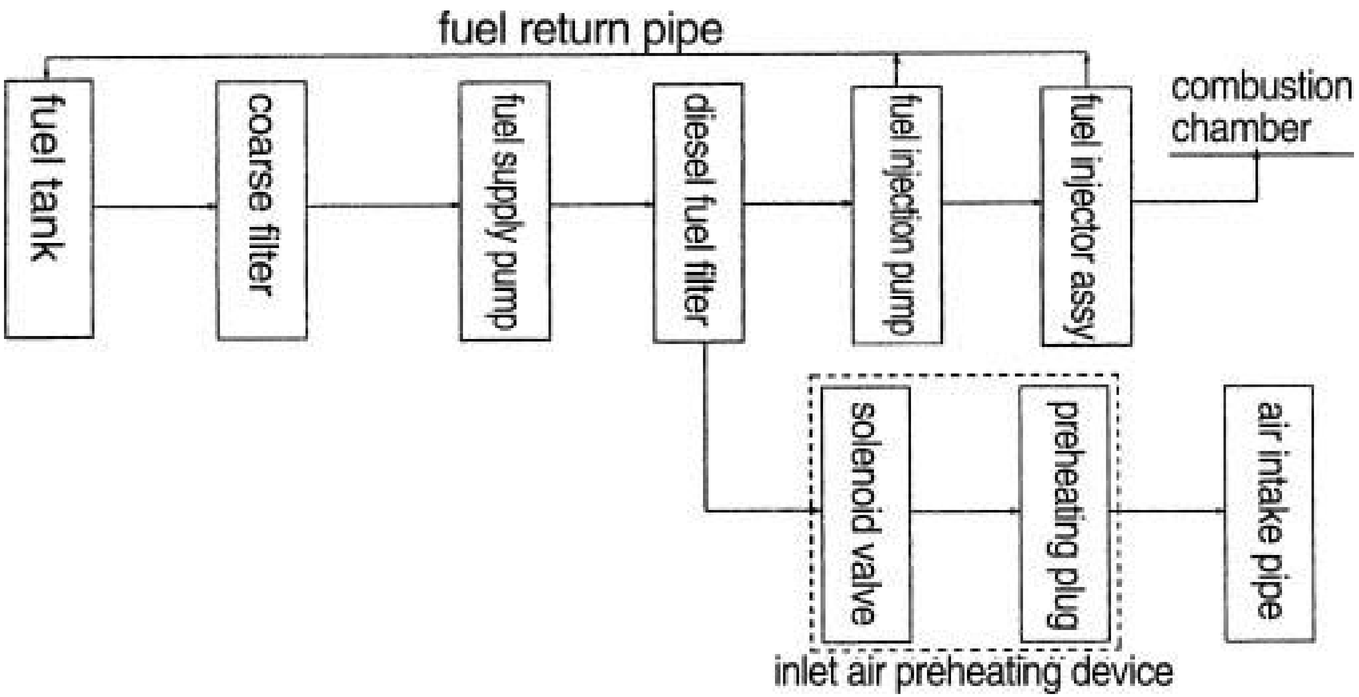



Fig. 2-37 Fuel circulation of fuel supply system

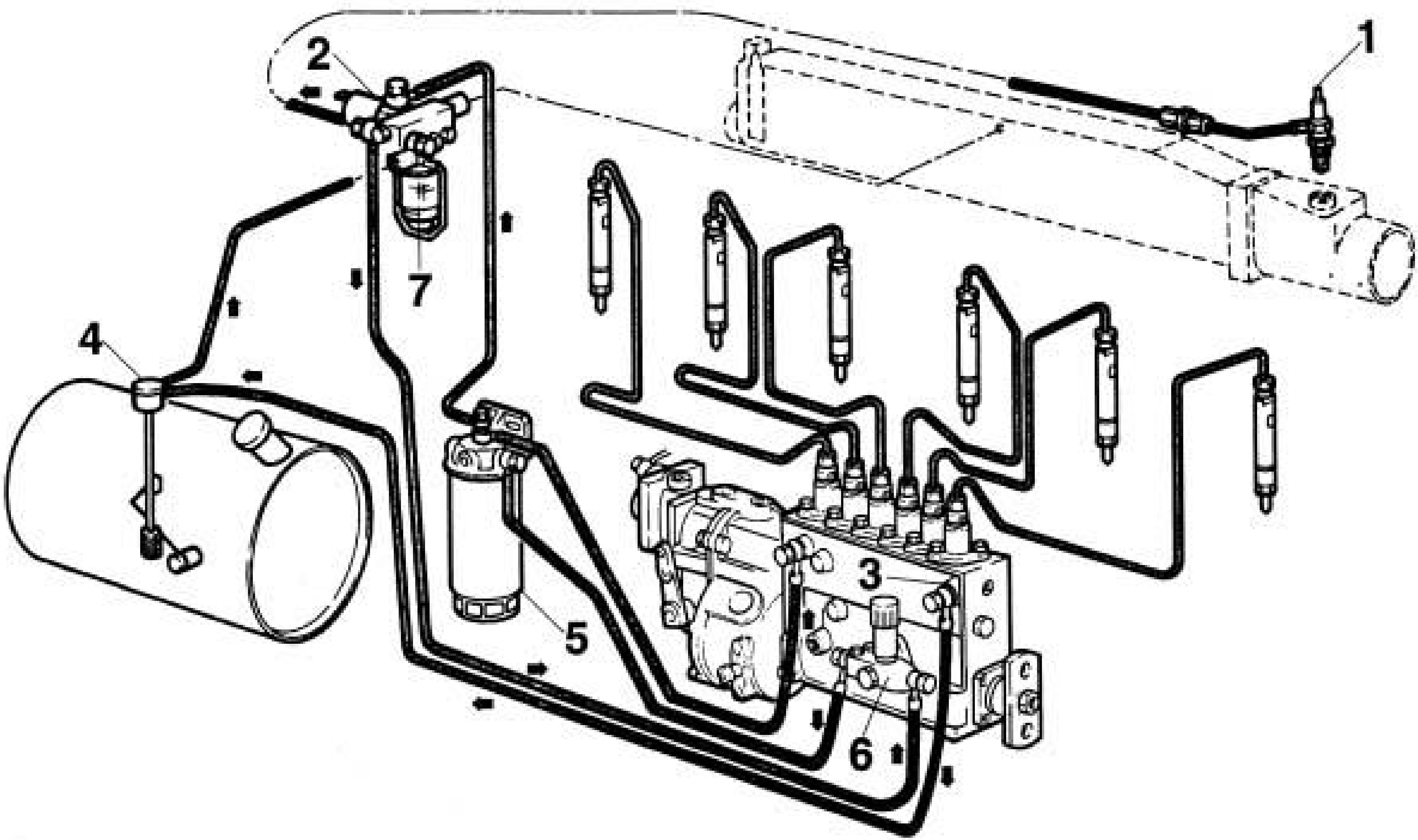



Fig. 2-37a Fuel supply system

1.Preheating plug 2.Solenoid valve 3.Overflow valve 4.Fuel tank 5.Fuel filter 6.Fuel supply pump 7.Fuel course filter

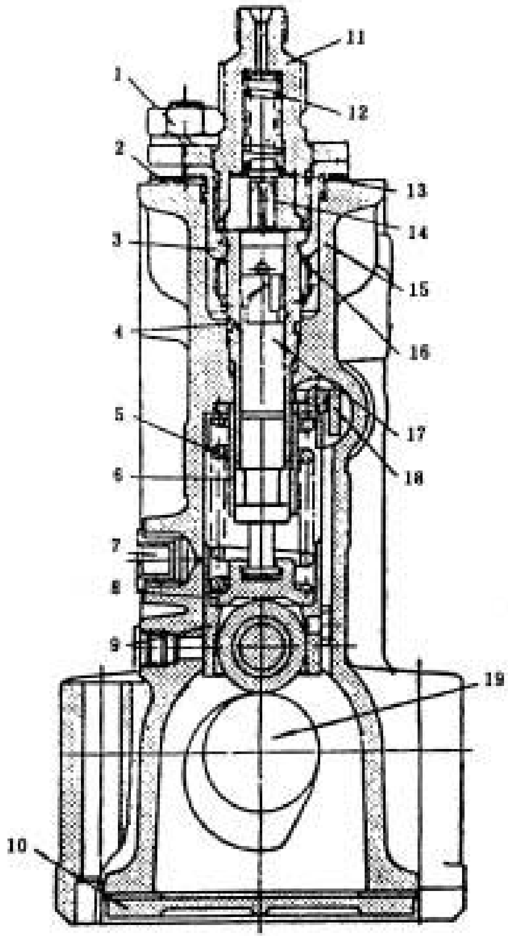
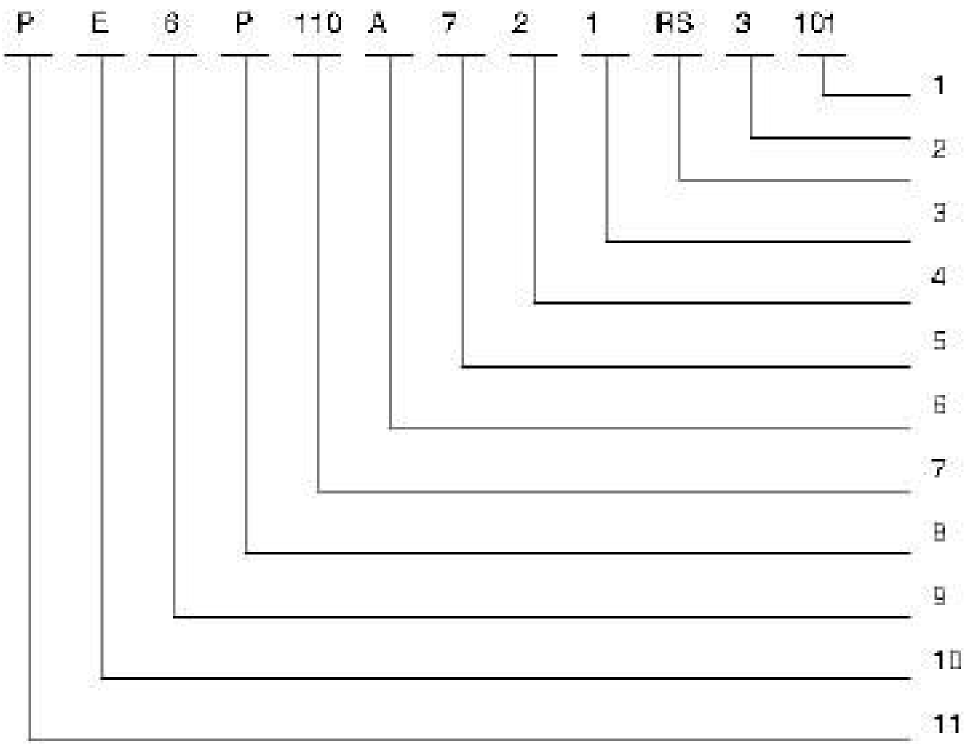



Fig. 2-38 Structure of German Bosch P-type pump

1.Nut 2.Adjusting shim of commencement of fuel supply 3.Steel sleeve flange 4.Leakage fuel return orifice 5.Plunger spring 6.Control sleeve 7.Lubricating oil injection port 8.Spring bottom seat 9.Roller body 10.Bottom cover 11.Oil delivery valve tightening cap 12.Oil delivery valve spring 13.Oil delivery valve gasket 14.Oil delivery valve 15.Pump body 16.Oil deflector bushing 17.Plunger 18.Pull rod 19.Camshaft

- Definition of the type of Bosch pump:




1. Design code 2.With fuel feed pump mounting port 3.Fuel injection pump rotating direction code 4. Timing device mounting position code 5.Governor mounting position code 6.Fuel feed pump mounting form code 7.Design code 8.Plunger diameter X10 (mm) 9.Fuel injection pump type (p) 10.Number of cylinders 11.E indicates camshaft

- WD615 diesel engine uses two-speed governor or full-range governor (Euro II type) Bosch pump uses RQ two-speed governor, as shown in Fig. 2-39. Its load control lever and floating lever are jointed by means of a sliding sleeve. Their lever ratio is variable.

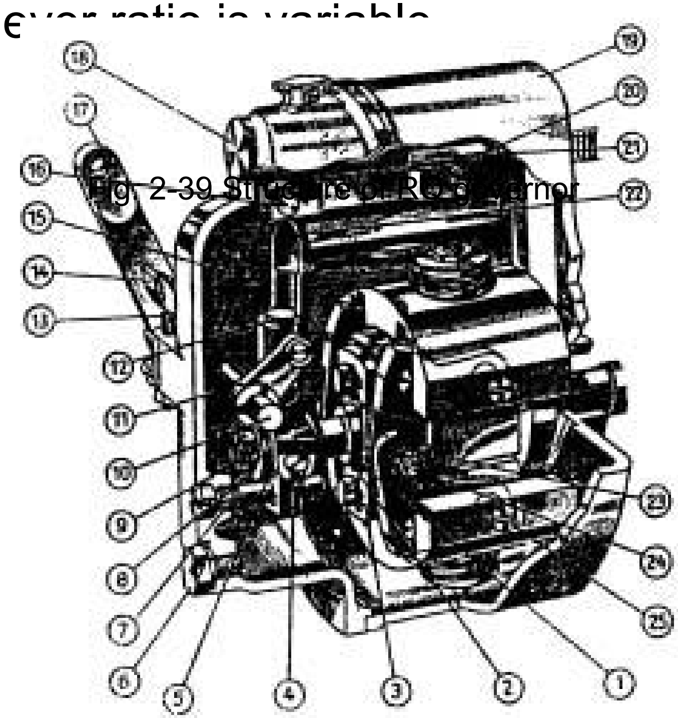


Fig. 2-39 Structure of RQ governor

1.Slide 2.Locking steel cable 3.Angle lever bracket 4.Slide 5.Adjusting shim 6.Oil drain pipe plug 7.Support lever 8.Sliding sleeve nut 9.Lock pin 10.Control shaft 11.Control lever 12.Floating lever pin 13.Idle speed limiting bolt 14.Limiting stopper 15.Full-load limiting bolt 16.Coupling pin 17.Load control lever 18.Governor rear casing 19.Governor casing 20.Fuel supply coupling rod 21.Fuel supply gear rack 22.Floating lever 23.Angle lever 24.Lever shaft 25.Flyweight pin

- At idle speed, the joint pivot of the load control lever and the floating lever is close to the the mid position of the loating lever, and the upper and lower lever ratio of floating lever is 1.4:1. When the load control lever is at the full-load position, the joint pivot is close to the lower end of the floating lever, and the upper and lower lever ratio of floating lever is 2:1. The advantage of the variable lever ratio is: when operating at idle speed, as the rotating speed is comparatively low and the travel range of the idle speed adjusting gear rack is small. Small lever ratio can not only guarantee sufficient adjustment force, but also meet the requirement of the change of the idle speed gear rack. When operting at full-load and high-speed, as the flyweight has sufficient adjusting force, big lever ratio can not only ensure that the gear rack has sufficient travel, but also increase the speed governing rate with full load and at high speed and improve the sensitivity of the speed adjustment. The idle-speed, high-speed and correction springs of RQ governor are all fit in the flyweight.
- As shown in Fig. 2-39a, the structure of the RQV governor is similar to that of RQ governor with some differences. In RQV, the speed adjsutment spring is inside the flyweight. Within the specified range of speed adjustment, when the rotating speed increases, the flyweight will move outward continuously.
- The controlled starting speed is related to various postions of the control handle. The movement of the control handle is transmitted to the floating lever via an elbow rocker arm and a guide, and then to the adjusting pull rod. The pivot of the floating lever can move in the sliding groove. The pivot is guided by a flat-face cam fixed on the rear casing of the governor, making the drive ratio vary between 1:1.7 and 1:5.9

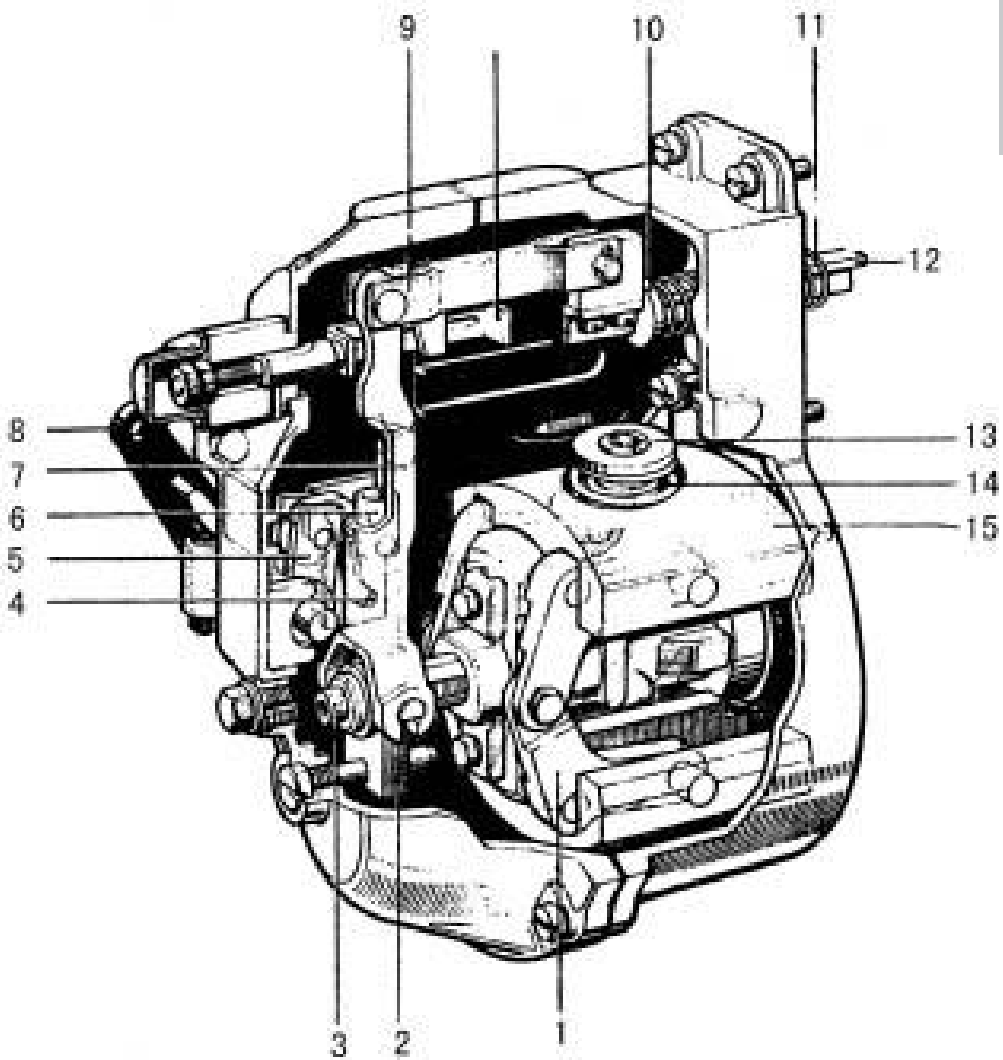



Fig. 2-39a

1. Angle lever 2.Slider 3.Spring supported telescopic shaft 4.Flat-face cam 5.Rocker 6.Guide 7.Floating lever 8.Control handle 9.Connecting fork full-load limiter 10.Spring holder 11.Balancing spring (clearance) 12.Fuel injection pump adjustment pull rod 13.Adjusting nut 14.Adjusting spring 15.Flyweight

- In order to meet the matching requirement of the amount of the fuel supply and the amount of pressurized air of WD615 supercharger, a smoke limiter is installed on the governor used Bosch pump. The smoke limiter is actually a variable-travel gear rack limiter used to control the maximum fuel supply under various supercharging operating conditions. Fig. 2-40 shows a Bosch pump smoke limiter

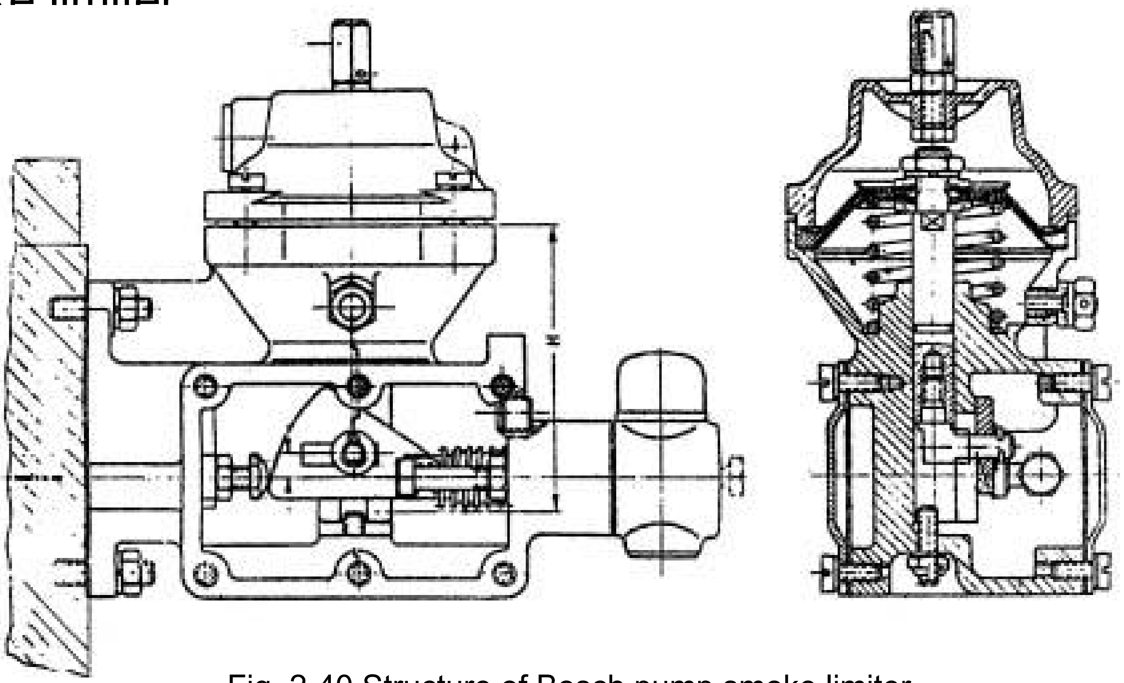
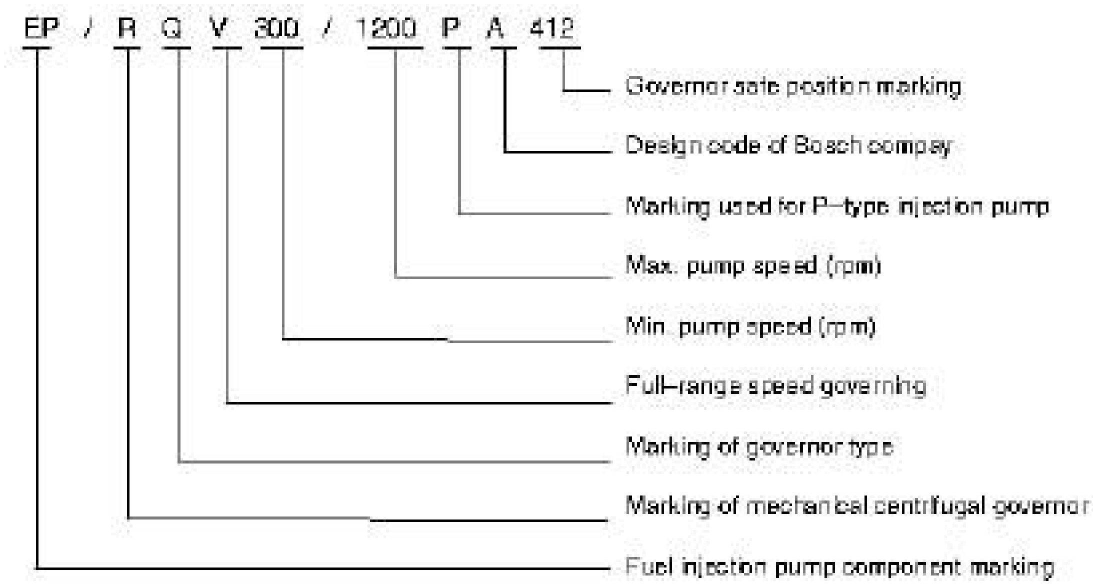
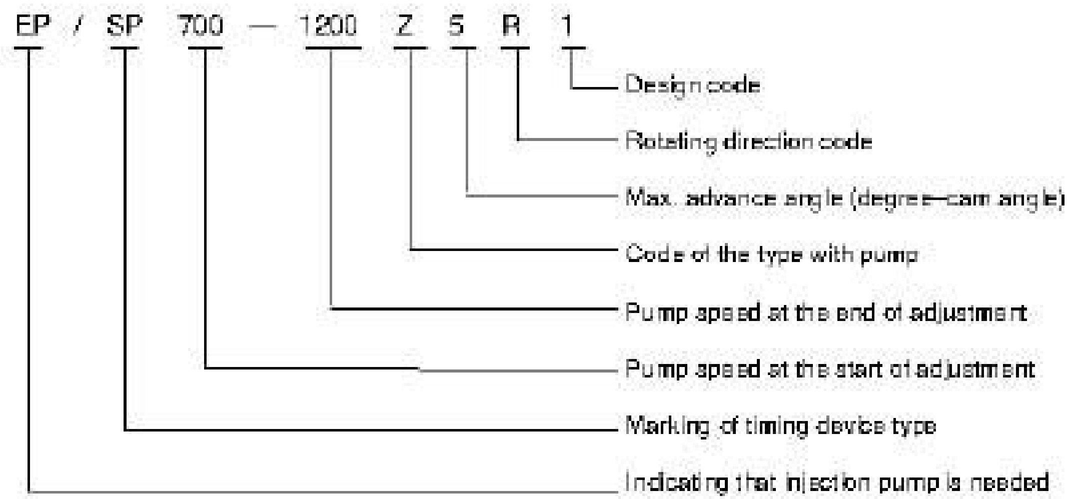


Fig. 2-40 Structure of Bosch pump smoke limiter

- On Bosch injection pump, a starting enrichment device can be mounted. The enrichment device is actually a variable-travel gear rack limiter. When starting, pulling this limiter may obtain an amount of fuel supply for starting more than the amount of maximum full-load fuel supply.
- The codification of type of Bosch governor is defined as follows:



- The fuel injection advance angle automatic adjusting device (timing device ) used on WD615 series engines is of mechanical centrifugal type.
- The codification of type of the timing device used on Bosch pump is defined as follows:



- The Bosch pump uses a plunger fuel supply pump. All fuel injectors are of multi-orifice direct injection type. The injection pressure is 30,000+800/0 kPa.
- The structure of the fuel injector is as shown in Fig. 2-41.

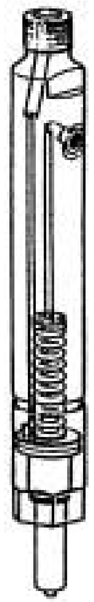
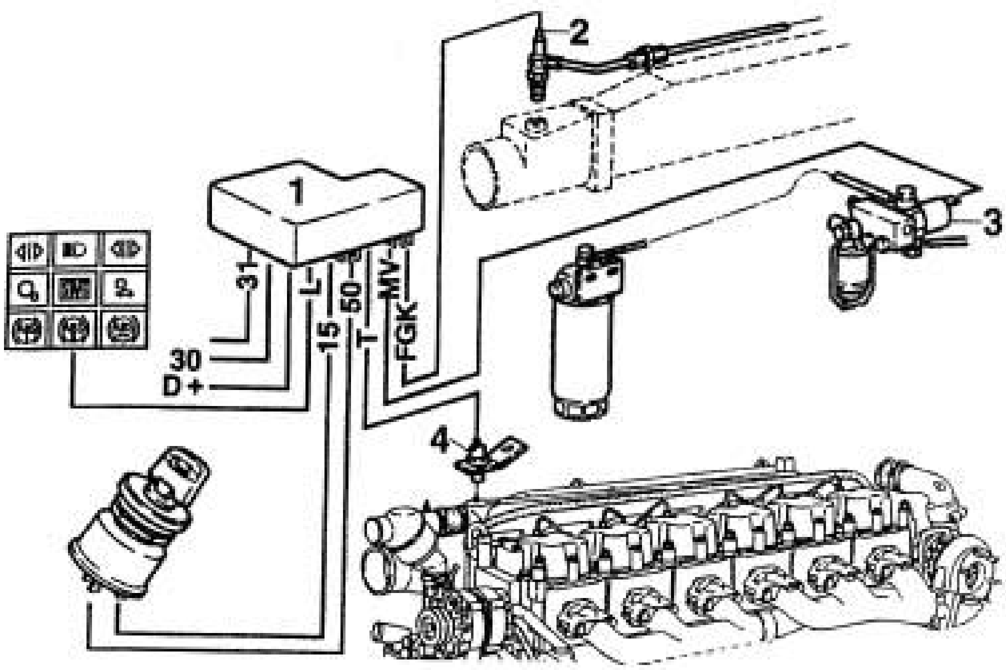


Fig. 2-41 Structure of Bosch injection pump

## 10. Cold starting system

- When starting the engine in winter seasons in cold areas, cold starting system must be used. There are two type of cold starting systems. One uses an intake manifold preheating system. The circuit of the system is shown in Fig. 2-42. The preheating system is composed of preheating relay (1), solenoid valve (3), preheating plug (2), temperature sensor (4) and preheating indicator lamp.
- When the engine water temperature is below 23℃, turn the key switch to "Preheating" position. The relay (1) switches on the preheating plug (2) on the intake manifold, and the "START" preheating indicator lamp comes on. The lamp will flash after 50s, and now the operator may start the engine. Depress the start button, solenoid valve (3) is switched on, fuel is injected onto the burnt preheating plug and ignited, the start motor begins to run and drives the engine to rotate to preheat the coming air, and the engine is started rapidly. After the engine is started, the incoming preheating will last 1-2 minutes and stops itself. If the ambient temperature is above23℃, turn the key switch to normal operation position, the indicator lamp comes on and goes off after 3s. The preheating plug now does not function, and the engine can be started directly. When the indicator lamp fails, the preheating device stops. If one or two preheating plugs is broken-circuited, the indicator lamp will flash for 15s and goes off, and the preheating device stops operating. Another method is to use a starting device with cold-start liquid. The cold-start liquid is a kind of explosive blended fuel mainly composed of ether. Spray a small amount of cold-start liquid into cylinder before starting to support low temperature combustion. It must be noted that the combustion of cold-start liquid is violent, when using it, the amount of spray must be kept under well control and never increase the speed and the load of the engine at once, otherwise, the life of the engine would be seriously shortened.
- The cold starting system is an optional device, which will be mounted only on request.
- Another method is to use a starting device with cold-start liquid. The cold-start liquid is a kind of explosive blended fuel mainly composed of ether. Spray a small amount of cold-start liquid into cylinder before starting to support low temperature combustion. It must be noted that the combustion of cold-start liquid is violent, therefore, when using it, the amount of spray must be kept under well control and never increase the speed and the load of the engine at once, otherwise,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