SL2100

OPERATIONS

MANUAL

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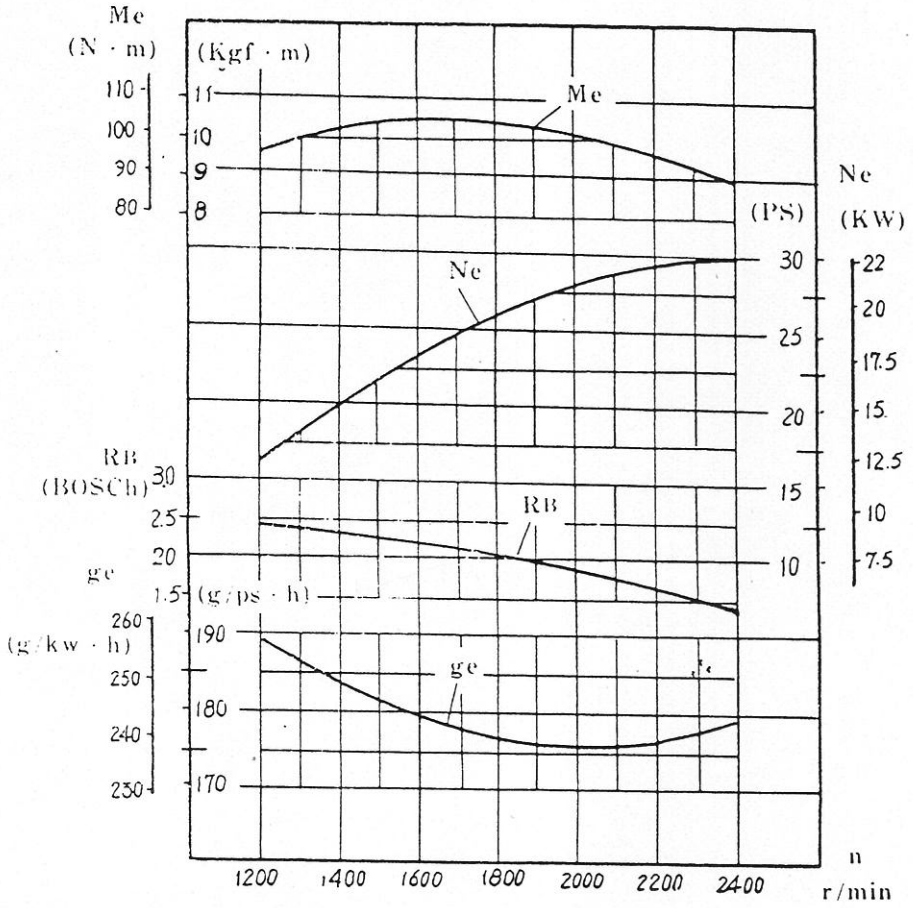
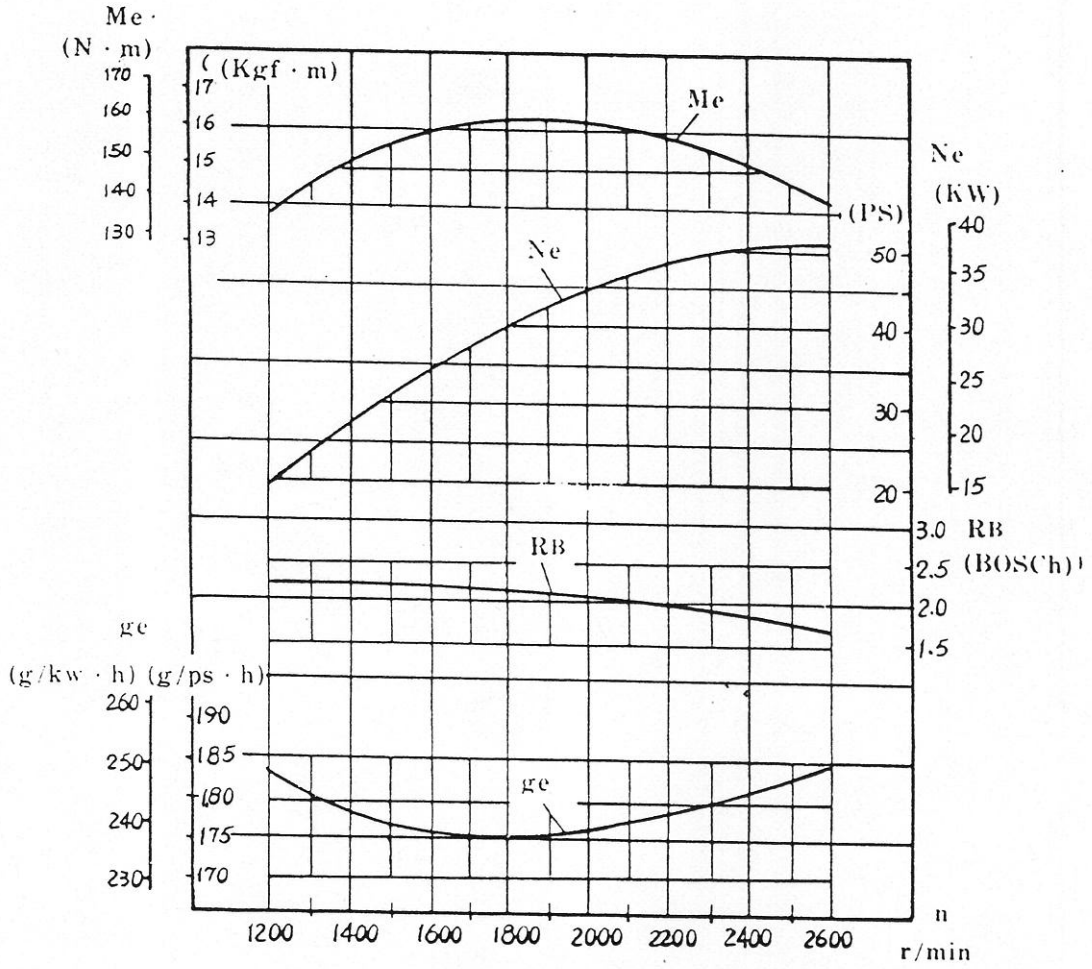
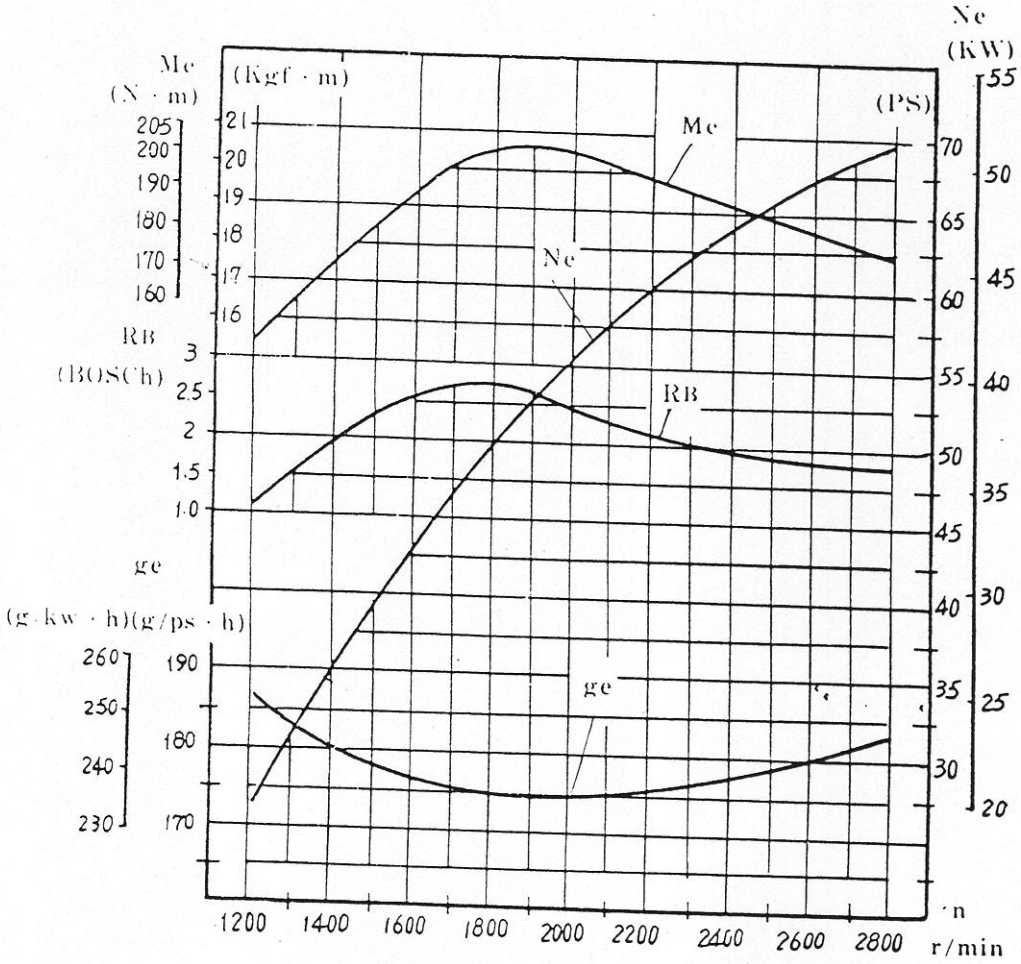


The Speed Characteristic Curve of Model SL2100 Diesel Engine



The Speed characteristic Curve of Model SL3100 Diesel Engine



The Speed characteristic Curve of Model SL4100 Diesel Engine

SL100 Series Diesel Engine Technical Data

Type	№. of Cylinder —Bore×Stroke (mm)	Rated output kW(PS)	Rated Speed (r/min)	Max Torque (N. m)	Application
SL2100K	2—100×110	22(30)	2400	101	1. 5T Dumpers
SL2100N		20. 6(28)	2200	102. 8	1. 0T Truck
SL2100T		19. 1(26)	2000	102. 8	Tractor
SL2100T		20. 6(28)	2200	102. 8	Tractor
SL2100G		20(27. 2)	2200		Station Type
SL2100C		18(24. 5)	2200		Marine
SL2100D		14. 7(20)	1500		12kW Generating Set
SL3100T	3—100×110	30. 9(42)	2200	154. 4	Tractor
SL3100G		30(40. 2)	2200		Station Type
SL3100C		27(36. 7)	2200		Marine
SL3100D		22(30)	1500		16kW Generating Set
SL4100Q	4—100×110	54(73. 4)	2800	203	3T Truck
SL4100K		44(60)	2400	203	3T Dumpers
SL4100T		41. 2(56)	2200	205. 7	Tractor
SL4100G		40(54. 4)	2200		Station Type
SL4100C		36(49)	2200		Marine
SL4100D		29. 4(40)	1500		24kW Generating Set

* 15 min output

Chapter I principal Technical Specifications and Main Data of Diesel Engines

A. Main Technical Specifications

Model			SL2100	SL3100	SL4100
Type			Vertical, in-line. Water-cooled , four stroke.		
Number of Cylinders			2	3	4
Cylinder bore/Piston Stroke		(mm)	100/110		
Total Piston Displacement		(liter)	1.728	2.592	3.456
Combustion Chamber			Swirl Combustion Chamber		
Compression Ratio			19.5		
Firing Order			1－2	1－3－2	1－3－4－2
Rated output /Rating Speed kW(PS) / r/min	15-min rating output				55.1(75) /2800
	1-hr. rating output		24.2(33)/2400	38.2(52) /2600	51.5(70) /2600
	12-hr. rating output		22 (30) /2400	35.3(48) /2600	47.8(65) /2600
Mean effective Pressure (at Max. torque)		Kpa(kgf/cm²)	734.5 (7.49)	761 (7.76)	738.4 (7.53)
Mean Piston Speed		(m/sec)	8.8	9.53	10.27/9.53
Max. torque		N・M(kg・m)	101 (10.3)	156.9 (16)	203 (20.7)
Speed at Max. torque		(r/min)	1750	1950	1950
Min. Specific fuel Consumption (at full load)		g/kW・h	255.7 (188)		251.6 (185)
Lubricating Oil Consumption (12-hr. rating output		(g/ps・h)	2.04 (1.5)		
Crankshaft rotating direction			counter-clockwise (view from flywheel end)		
Lubrication Method			Combination of Pressure and Splash Lubrating		
Cooling Method			Pressure force feed circulation		
Overall Dimension (Length × Width × Height)		(mm)	510×510×695	664×510×702	795×510×702
Engine Net Weight		(kg)	210	260	310

Note (1) The rating output in the above table denote that the engine is running at a standard environment condition-100 kpa(750mmHg) atmospheric pressure, 25°C temperature, 30% relative humidity-and doesn't carry air cleaner and exhaust silencer.

(2) The rating output in the above table is only concerned in the application to fork-lifter and truck: so far as for used in tractor, marine, generating set, agriculture machine etc, the rating output value should be refered to the table of the pricipal specifications for various application of model SL100 series engine.

B. Main Technical Data

1.	Valve Timing (Crank Angle)	Inlet Valve Opens	12° before T.D.C.
		Inlet Valve closes	44° after B.D.C.
		Exhaust Valve Opens	52° before B.D.C.
		Exhaust Valve closes	12° after T.D.C.
2.	Valve Clearance (cold)	Inlet Valve	0.30-0.35 mm
		Exhaust Valve	0.35-0.40 mm
3.	Advance angle of Injection timing	before T. D. C. (Crank Angle)	17° – 21°
4.	The Opening pressure of the injector	12753-13244 (130-135) Kpa (kgf/cm²)	
5.	Lubricating Oil Pressure	196.1-441.3 (2-4.5) kpa (kgf/cm²)	
6.	Exhaust temperature	12 hr. Rated Output	753 (480) K (°C)
7.	Lubricating Oil temperature	12 hr. Rated Output	368 (95) K (°C)
8.	Outlet Water temperature	12 hr. Rated Output	353-363 (80-90) K (°C)
9.	Tightening torque of Main Bolts and Nuts	Cylinder head nuts	107.9 – 137.3 (11 – 14) N·M (kgf·M)
10.		Main bearing bolts	137.3 – 166.8 (14 – 17) N·M (kgf·M)
11.		Connecting-rod bolts	98.1 – 117.7 (10 – 12) N·M (kgf·M)
12.		Flywheel Nuts	98.1 – 117.7 (10 – 12) N·M (kgf·M)
13.	Lubricating oil Capacity of Oil Sump	4.5 liter (SL2100 Engine), 6.0 liter (SL3100 Engine) 7.5 liter (SL4100 Engine).	

Chapter II Operation of the Engine

A. Precausion for Operation of the Engine

1. The user of this engine should understand the operating principle and construction of diesel engine well, operate the engine correctly and keep the regular service and maintenance.

2. Use the specified fuel and lubricating oil. They must be clean and purified by setlling and filtering before being put into use.

3. The new or overhauled engine should carry on run-in before being put into the regular operation

4. Remain the water temperature and oil pressure in the normal range. The water temperature should be in 80—90℃, the oil pressure in 2.0-4.5 kgf/cm^2.

5. Avoid working of the engine under overload or too low speed conditions for a long period.

6. It is not allowed to operate the engine with trouble. The engine should be immediately stopped and inspected, if any abnormal phenomenon happens.

B. Preparation for the operation

1. Fuel, lubricating oil and cooling water

(1) Fuel:

The grade No.0 light diesel fuel (according to Chinese standard) should be used in summer. Grade No. -10 or No.-20 (Chinese standard: GB252-81) should be used in winter. The proper fuel should be determind according to the local ambient temperature. For example, grade No.-35 light diesel fuel should be used in winter in frigid zones such as Northern east China and Inner Mongolia of China.

(2) Lubricating oil:

The grade HC-11 lubricating oil made in China can be used in summer and the grade HC-8 (Chinese ministry standard: SY 1152-79) oil can be used in winter. The grade HC-14 oil can also be used in tropic zones, such as Southern China. The proper lubricating oil should be determined according to the ambient temperature.

Check the oil level of the sump before each starting of the engine. The oil level should be between the upper and lower mark lines of the dipstick.

(3) Cooling water:

The clean soft water should be used. In the frigid seasons the antifreeze must be added to the cooling water. The cooling water level should be below the lower edge of the water inlet in the radiator. Check the water level before starting. It is not allowed to fill cold water into the running engine. In the frigid season it is also not allowed to fill boiling water into the engine directly in order to protect the engine against cracking.

2. Inspection before starting

Before starting, the engine should be inspected thoroughly. Be sure that the foundation bolts and other connections have been really tightened and all the transmitting parts and control mechanism can freely moved. Besides these, following jobs have to be done.

(1) Check the lubricating oil quantity in injection pump. Fill oil into it, if necessary.

(2) Open shut-off valve of the fuel tank. Check for leakage of fuel pipes and all connections.

(3) Check for the charging ability of the battery and make sure the connections in the electrical system are correct and reliable.

(4) Make sure of the reliable connection for all accesories, such as injection pump, filters, fan-water pump, electrical starter, alternator and radiator etc.

(5) Turn the crankshaft for a few rotations by means of the handcrank, so that the lubricating oil feed to frictional surfaces. Observe the movement of the relevant parts and inspect the adjustment of the decompression mechanism.

C Starting the Engine

After checking, seperate the gear box or the part taking off power from the engine, i.e. put the operating lever to the neutral position. Then start the engine according to following steps.

1. Set the lever for speed adjustment to the medium-speed position.

2. Press the decompression handle to reduce the pressure in the cylinder (in summer or for the hot engine it is not necessary).

3.Turn the ignition key clockwise to switch the electric circuit on. Turn pre-heating switch to"Starting" position for starting the engine. (In frigid season turn to "Pre-heating" position first, in 10-20 sec. turn to "Starting" after pre-heating). When the speed raise up. reset the decompression handle. When the starting of the engine is completed, the starting switch should be reset to "O" position immediately, and set the speed adjusting lever to "Idling Speed" position.

At the normal technical condition of the engine it can be successfully started within 3-5 sec., when the ambient temperature is not lower than 0°C. Should the starting fail within 15 sec., the next starting should be carried out after 1-2 minutes to protect the startor from damage and the battery from excess discharge. Should the starting continually fail for three times, the causes must be found out. Only by remedying the trouble can re-starting be done.

4. After starting, make sure that the readings for all the instruments are within the normal extent. If the oil pressure is too low or other abnormal phenomena happen, the engine should be stopped, then remedy the trouble.

D Running of the Engine

1. After starting, do not immediately run the engine at the full load. The engine should be run at the low and medium speed in turn, so that it gets warm. Then increase the load gradually. When the cooling water temperature reaches 50°C and the oil temperature is above 40°C only the engine can be operated under load. When the engine, however, works at the nominal power, the cooling water Temperature at the outlet should reach 80-90°

2. The speed and load of the engine should be increased or decreased smoothly and slowly. In general, it is not allowed to increase or decrease the load suddenly.

3. The engine should be run within the power and speed range indicated in the name-plate. Too high speed will affect the service life of the engine and it will impel the wear of the components to run the engine at the idling speed for a long period.

4. Attention should be paid to the readings of oil temperature, oil pressure, cooling water temperature, charging ammetre and other gauges during the engine running. Observe the exhaust smoke colour and listen to the sound in the engine. Should the abnormal Phenomena be found, the engine must be stopped for checking.

E. Stopping the Engine

1. Before stopping the engine unload it and slow down its speed first . Remain the engine to run at the idling speed for a few minutes. Move the stopping lever rearward to the position "stop". Then the engine will be stopped.

2. After the engine is stopped, turn off the fuel tank cock and turn the ignition key to the position "Neutral" to prevent the battery from discharging.

3. In order to prevent the valves from damaging and the air from going into the fuel line it is not usually recommended to stop the engine with decompressing or turning off the fuel tank. In order to protect the cylinder head, insert in the swirl chamber and needle valve couple from damaging it is also not allowed to stop the engine suddenly at the high cooling water temperature.

4. When stopping the engine in winter, the cooling water in the radiator and block must be drained out completely in time and crank the crankshaft for a few rotations to avoid freezing inside water pump. If the cooling water contains antifreeze, it is not necessary to drain out the water.

Chapter III Construction of the Engine

A. Cylinder Block

The cylinder block is a box-like casting made of cast iron HT 25-47. The side walls with the criss-cross reinforced ribs extends below the crankshaft centre, giving high rigidity of the engine (Fig. 1).

Wet cylinder liners are used. On its lower section surface there are two seal rings for water and a water collection groove, which is connected to a hole for leaking on the right side of the block to prevent the leaking water going into the sump and spoiling the lubricating oil. In order to ensure sealing of the cylinder head, the top surface of the cylinder liner should protrude the top surface of the block by 0.07-0.186mm when the liner is located into the block.

The main bearings are fully supported and they are underslung. The thin-wall bearing shells are made of high tin-aluminium alloy. The bearing cap is positioned in the block by a milled slot and bolted to the block by the high strength bolts. The crankshaft thrust washers are located at the rear main bearing on each side of the bearing for controlling the axial clearance of the crankshaft.

The bearing caps are bored together with the block under assembly condition Pay attention to the fitting marks when reassemble them. It is not allowed to exchange the caps each other or install the cap in the direction of the wrong face. He upper half of the main bearing shells is grooved for lubrication. Pay attention to it when install or repair it. The thrust washers undergo the thrust along the axile direction from the crankshaft. On the working face only the oil grooves were machined. There are no grooves on the back face. Be sure always to keep the right face in the correct direction when install them. The bolts for main bearing should be tightened smoothly and in steps. Before tightening the rear main bearing cap, tap on the crankshaft to and fro to remain the upper and lower thrust washer on the same plane. Then tighten them to the specified torque in steps. If the installation has been completed properly, the crankshaft will rotate freely when turn it on the flywheel end by hand.

A steel plate with 7.5mm thick is installed to the front end of the block. Together with the cover it forms the gear case, on the lower section of which a connecting strip made of square steel is bolted and forms the front seal surface together with the oil sump. A magnetic plug, which can concentrate the iron particles in lubricating oil, is screwed on the lower section of the right side wall of the sump.

B. Cylinder Head

The cylinder head is the casting made of HT20-40 cast iron. At the front end a thermostat is located, which is used for adjusting the cooling water outlet temperature. The intake and exhaust manifolds are arranged at two sides of the cylinder head respectively. The swirl chamber is in the lower part of the cylinder head. For the sake of easy starting a electric-heating plug is arranged in the swirl chamber for each cylinder, as shown in Fig. 2.

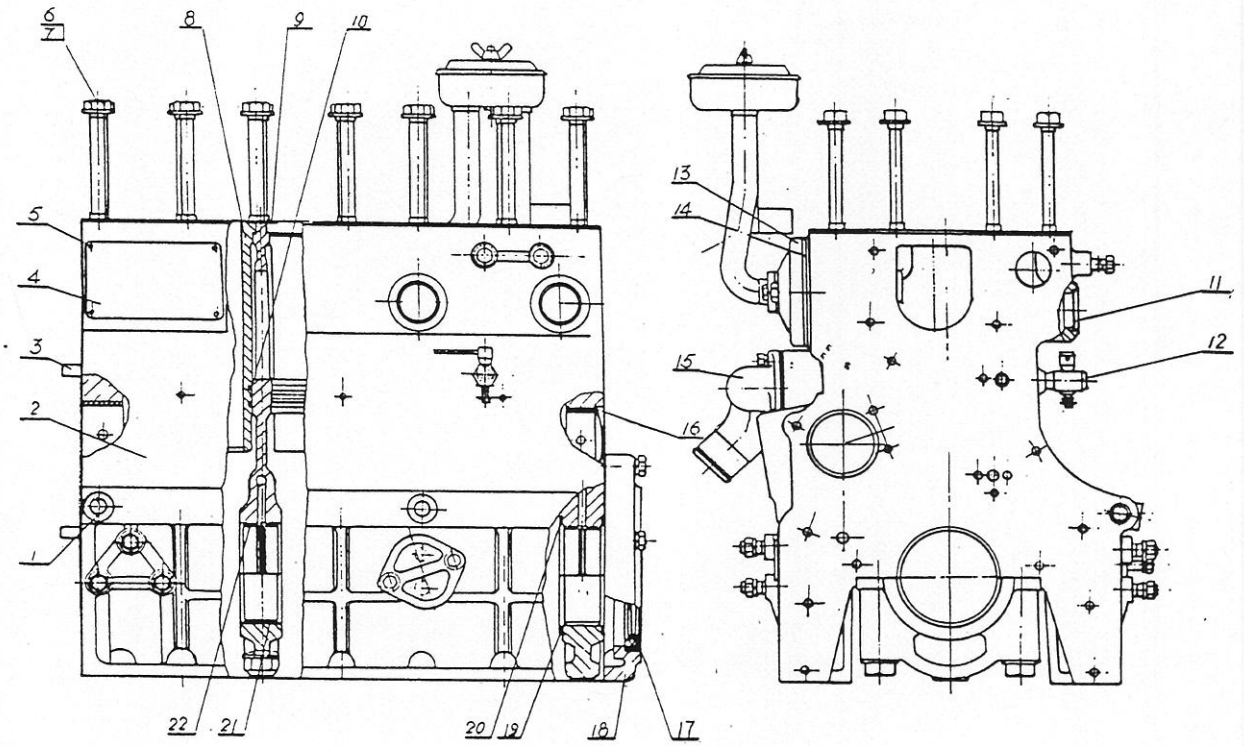


Fig. 1. Block Assembly

1. plug 2. block 3. pin 4. name-plate 5. rivet 6. cylinder head stud 7. washer 8. cylinder liner 9. cylinder head gasket 10. water seal ring 11. plug 12. cooling water drain cock 13. breather 14. side cover 15. water inlet tube 16. cap 17. oil sealer 18. cover of oil sealer 19. lower thrust washer 20. upper thrust washer 21. lower main bearing shell 22. upper main bearing shell

The intake and exhaust valves are made of alloy steel.The one-piece rocker shaft is a kind of hollow design. The lubricating oil from the cylinder head feed to the frictional surface of the rocker shaft through the rocker shaft bracket and the rocker shaft hollow.

The valve seats are made of alloy cast iron. A couple of seat and valve should be lapped together to ensure good sealing. When dissembling or assembling, it is not allowed to exchange one for the other. The normal width of the contact line of the valve and seat is 1.2—1.5mm. When the valve seat is burnt out, oblong or the contact line width is too large, which causes gas leakage, lap the seat or ream it prior to lapping. If reaming is needed, first ream the valve seat using the 15° and 75° reamer with ø 9mm stem guide, then ream the contact line of the valve seat with a 45° reamer. The line width should be in 1.2—1.5 mm, as shown in Fig. 3.

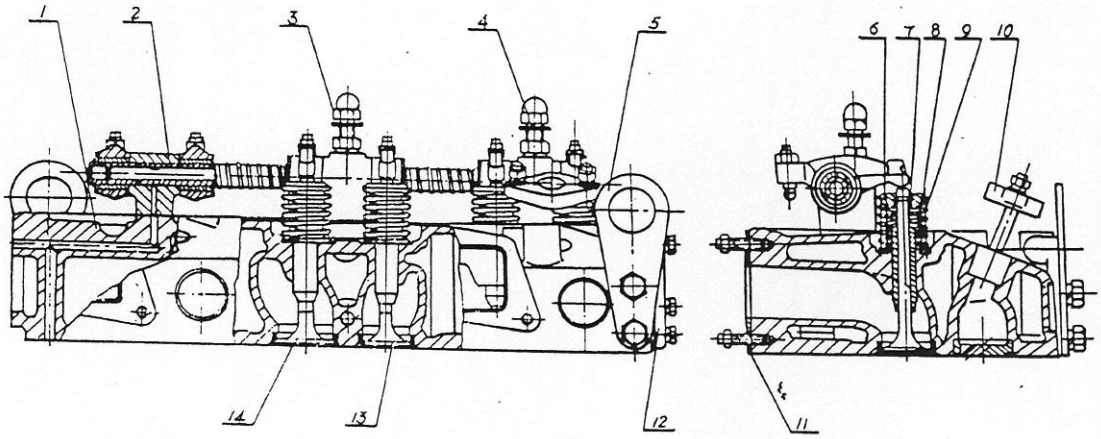


Fig. 2 Cylinder Head Assembly

1. cylinder head 2. rocker shaft bracket 3. ball-head nut 4. bolt of bracket 5. lifting eye 6. upper seat of valve spring 7. split collar 8.9. valve springs 10. press plate of injector 11. gasket of exhaust manifold 12. rear end plate 13. exhaust valve 14. intake valve.

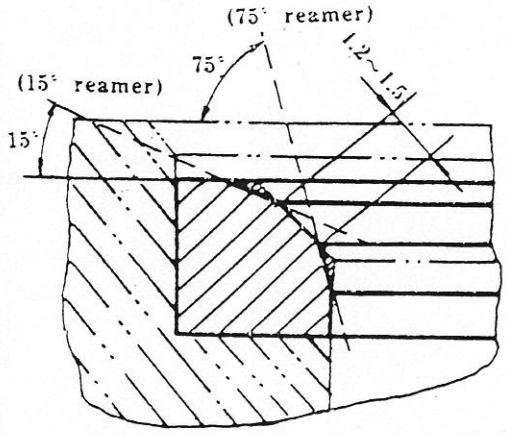
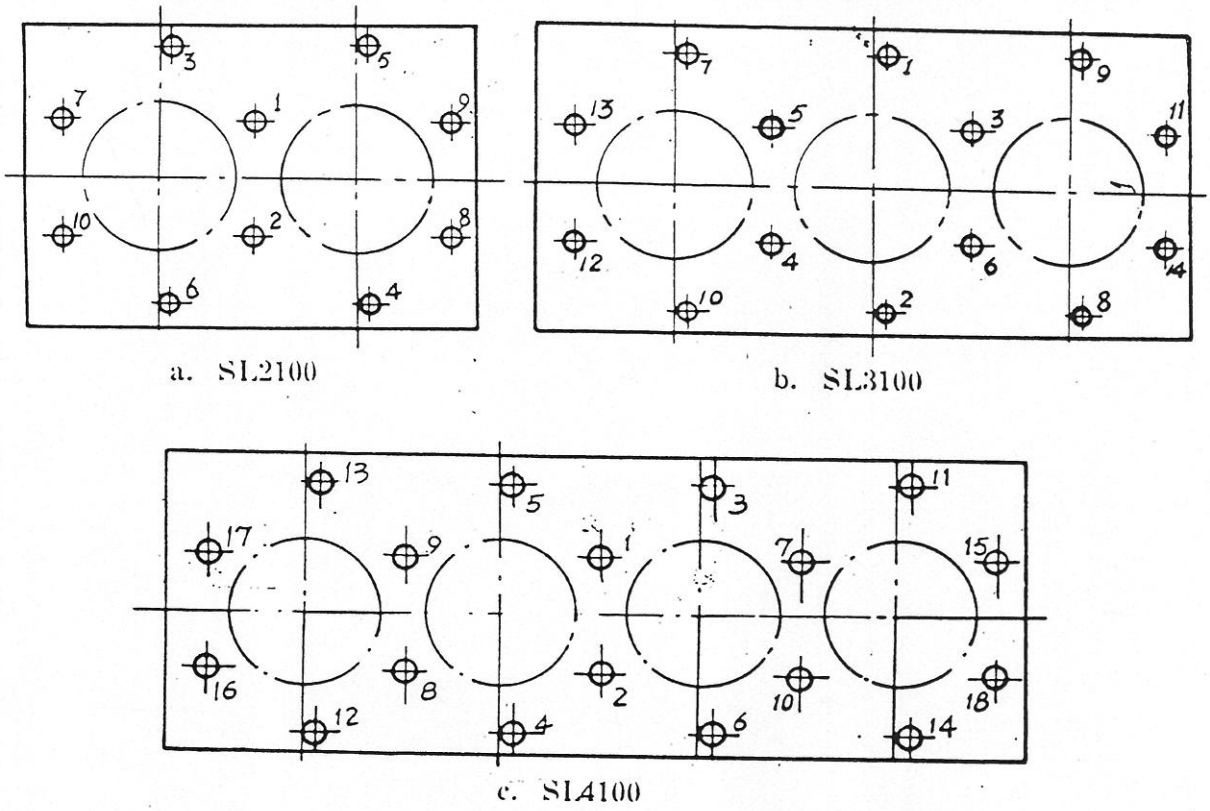


Fig.3. The Scheme of Reaming Valve Seat

When the valve sinks in the cylinder head too much, it is needed to replace the valve seat first, then to ream and lap it. If the burning out and oblong of the valve and seat are not serious and the width of the contact line does not exceed 2.5mm, reaming is only needed. The grinding paste can be used for lapping. First the coarse should be used, then use the fine paste. Take care to prevent the grinding paste going into the valve guide. The contact line of the lapped valve and seat should be the grey-white continuous one without the pits. After that, clean carefully the valve and seat with kerosene or diesel fuel, then install the valve spring. Putting the cylinder head on its side surface, fill the duct with kerosene or diesel fuel. If the leakage between the valve and seat can not be seen, the good sealing condition is proven.

The insert of the swirl chamber is made of heat-resistant alloy steel. The installation for it should ensure the correct relative position to the cylinder head. The cone jet passage for starting should be located at the side near to the cylinder centre. When the insert of the swirl chamber and valve seat are being installed into the cylinder head, the 100℃ temperature difference between them should be kept to ensure they will not be slackened or drop.

In order to be easy to start the engine a special decompression mechanism is equipped. There are three decompression screws on its shaft. When turn the decompreession shaft by hand, the intake valve is opened and the air in the cylinder will not be compressed. As the results, the resistance for turning the crankshaft will be reduced and the engine will be speed up rapidly, and started easily. In the particular case, it is allowed to pull the decompression mechanism for engine shutdown.



a. SL2100 b. SL3100

c. SL4100

Fig.4. The Tightening Order of Cylinder Head Studs

Between the cylinder head and block the cylinder head gasket made of the copper-asbestos plate is installed for the sealing of oil, water and gas. The cylinder head gasket should be glossy and smooth. Be sure the contact surfaces of the cylinder head and block are clean and perfect before tightened to the specified torque with the torque wrench in the specified order to prevent the parts against deformation and obtain the favourable seal. The specified order for the tightening is shown in Fig.4.

The tightening should be carried out in 3 steps. The first tightening torque is 5 ± 1 kgm, then 9 ± 1 kgm, finally 13 kgm. After each checking of the torque of the cylinder head studs, the valve clearance should be re-checked and adjusted. When the cylinder head gasket is replaced, the contact surface of the block and cylinder head should be carefully cleaned up. It is not allowed to coat them with oil, sealing gum or other packing.

C. Camshaft

The camshaft is made of nodular iron QT60-2 or steel No.45. There is a drive gear for oil pump in the middle part of the camshaft. A thrust plate is between the timing gear of the camshaft and the shaft shoulder for controlling the axial clearance of the camshaft. All the journals of the camshaft are lubricated with the forced lubricating oil, which is from the main oil passage. On the rear end of the camshaft there is an oil hole, which connects to the oil hole of the oil pump drive gear by a passage. When installing the camshaft bushing, the oil holes of bushing and block should coinside, as shown in Fig.5.

The tappet center line is offset from the cam center line by 2mm. At working the tappets can be rotated, so that the wear of their bottom and the cylinder surface of the tappets can be uniform.

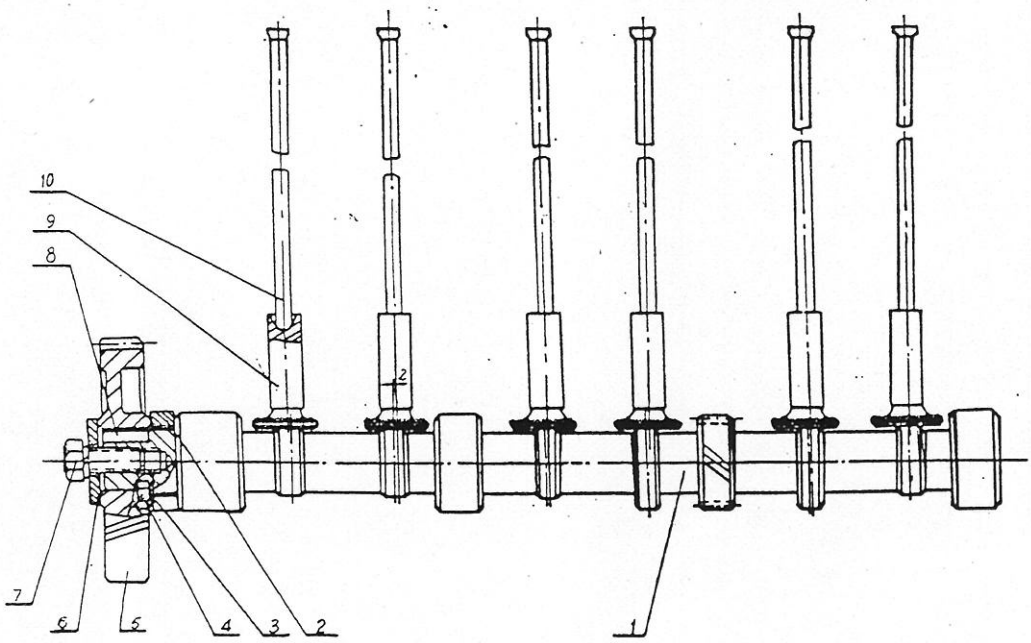


Fig.5. Camshaft Assembly

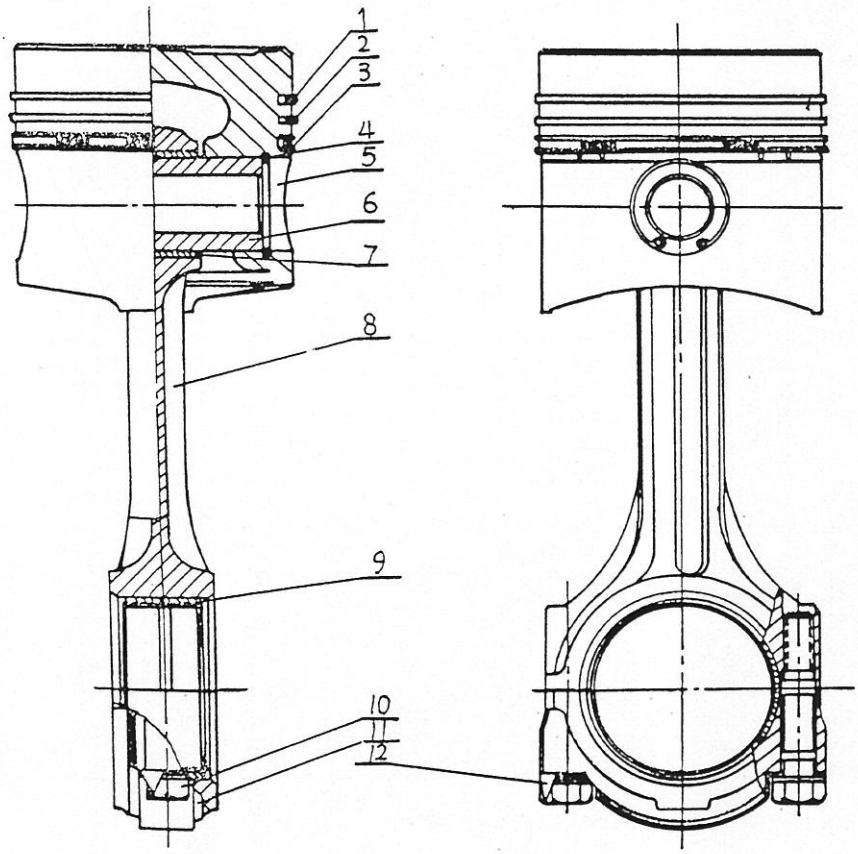
1. camshaft 2. thrust plate 3. spring washer 4. screw 5. camshaft gear 6. retainer 7. screw 8. key 9. tappet 10. push rod

The piston-connecting rod assembly is shown in Fig.6.

The piston is made of aluminium alloy. Tow compression rings and one oil ring are installed on the piston. The first compression ring is the chrome-plated barrel-faced ring. The second ring is the taper-faced ring. When install the piston rings to the piston, the face, on which there is the mark, should be upward. The oil ring is the chrome-plated cast iron ring with a spring expander. The piston pin is of the fully floating type. Therefore the piston must be pre-heated, when it is assembled or dissembled.

The connecting rod is made of drop-forged 40Cralloy steel.The split plane is perpendicular to the rod body, i.e. the flat seam design is used. The cap is fitted on the connecting rod body with two studs. The connecting rod is bored together with the cap. Therefore the assembling should be carried out according to the marks and specified direction. It is not allowed to exchange one for the other.

A bushing is pressed into the small end bore. When installing, it should be ensured that the hole in the bushing coincides with the upper hole of the small end, so that the piston pin and bushing can be lubricated. The clearance between the connecting rod bearing shell and journal is not adjustable. When the clearance exceeds the allowable value,renew the bearing shell.



1.2.3. piston ring
4. snap ring
5. piston
6. piston pin
7. bushing
8. connecting rod
9. bearing shell
10. bolt
11. connecting rod cap
12. lock washer

Fig.6. Piston-Connecting Rod Assembly

E. Crankshaft and Flywheel

The crankshaft and flywheel assembly is shown in Fig.7.

The crankshaft is made of nodular cast iron QT70-2. After normalized, it undergoes the soft-nitrizing on the surface. Therefore it obtains high fatique strength and resistance to wear. The main journals and connecting rod journals of the crankshaft are a kind of hollow design. The rubber, oil seals and oil slingers are installed on both front and rear ends to ensure the reliable seal. The flywheel is made of high strength cast iron HT25-47. On the outside flange of the flywheel a starting gear ring is mounted and the mark for T. D. C is cut for adjusting the time of fuel delivery.

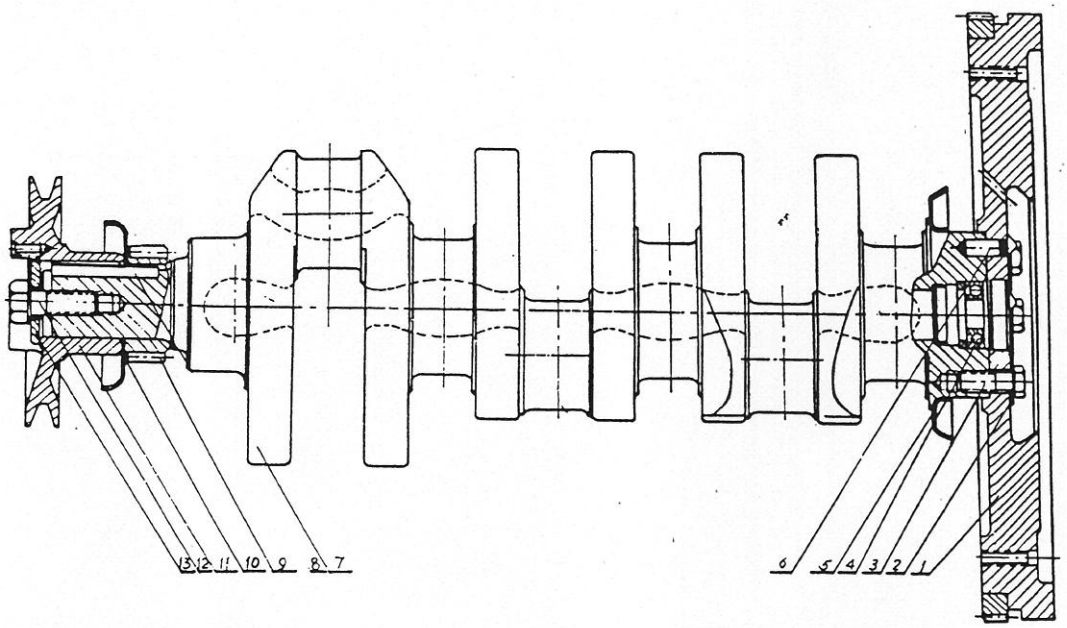


Fig. 7. Crankshaft and Flywheel Assembly

1. flywheel 2. lock washer 3 flywheel-removing bolt 4. bearing 5. rear oil slinger 6. dowel pin 7. crankshaft 8. key 9. crankshaft gear 10. front oil slinger 11. pulley 12. screw 13. press plate

F Gear Train System

The gear train system consists of 4 gears, as shown in Fig. 8.

The crankshaft gear is made of carbon steel No. 45. The others are made of nodular cast iron QT 60-2. In the idler gear shaft a ø4 oil hole is drilled, which connects to the branch oil passage in the front end of the cylinder block for lubricating the idler gear bore and the gear system. When installing the idler gear shaft, make its oil hole coincide with the relevant oil passage in the cylinder block. On each gear the timing marks are stamped. In order to ensure the correct timing for valves and beginning of delivery of the injection pump and the correct kinematic ralation of all motion parts, the matching marks on all gears should be aligned each other when installing.

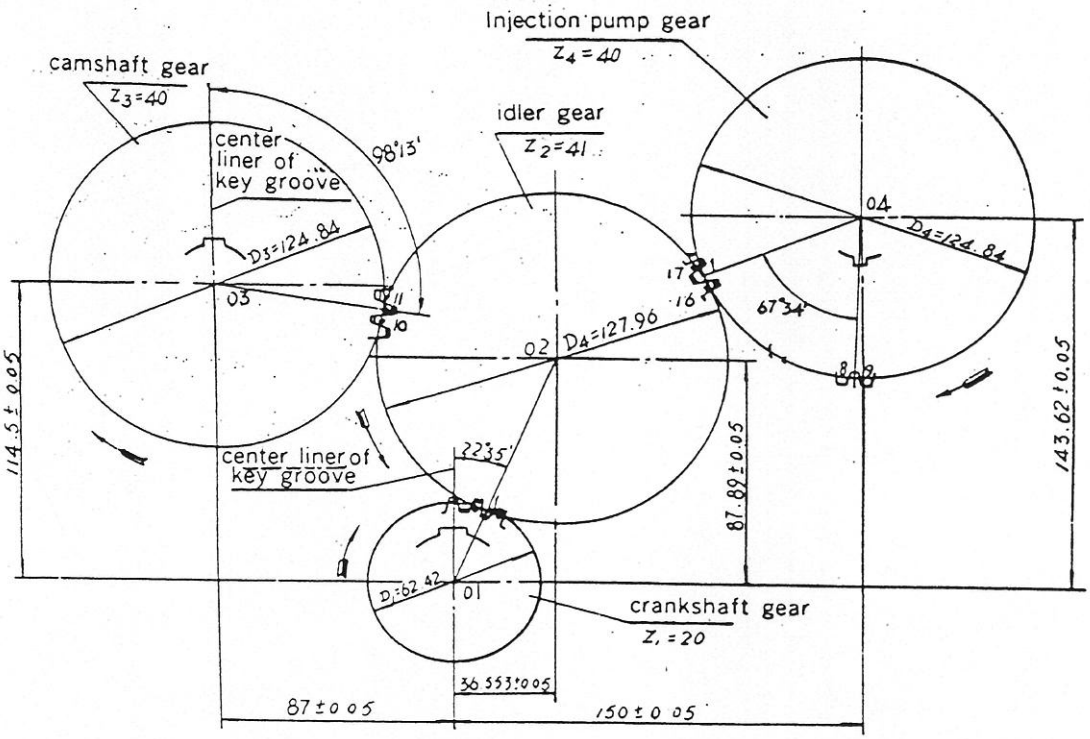


Fig. 8. Timing Gear Matching Marks

G. Fuel Injection System

The Fuel Injection is shown in Fig. 9.

Fuel transfer pump delivers fuel from fuel tank to fuel filter, after filtering, the pressured fuel enters to the fuel injection pump. Then, the high pressured fuel flows through the high pressure pipe from the injection pump to the fuel injector. The fuel is atomized and injected into the swirl combustion chamber, where it mixed with air and then burns. The leakage off from the injector flows back to the fuel filter via flow-back pipe.

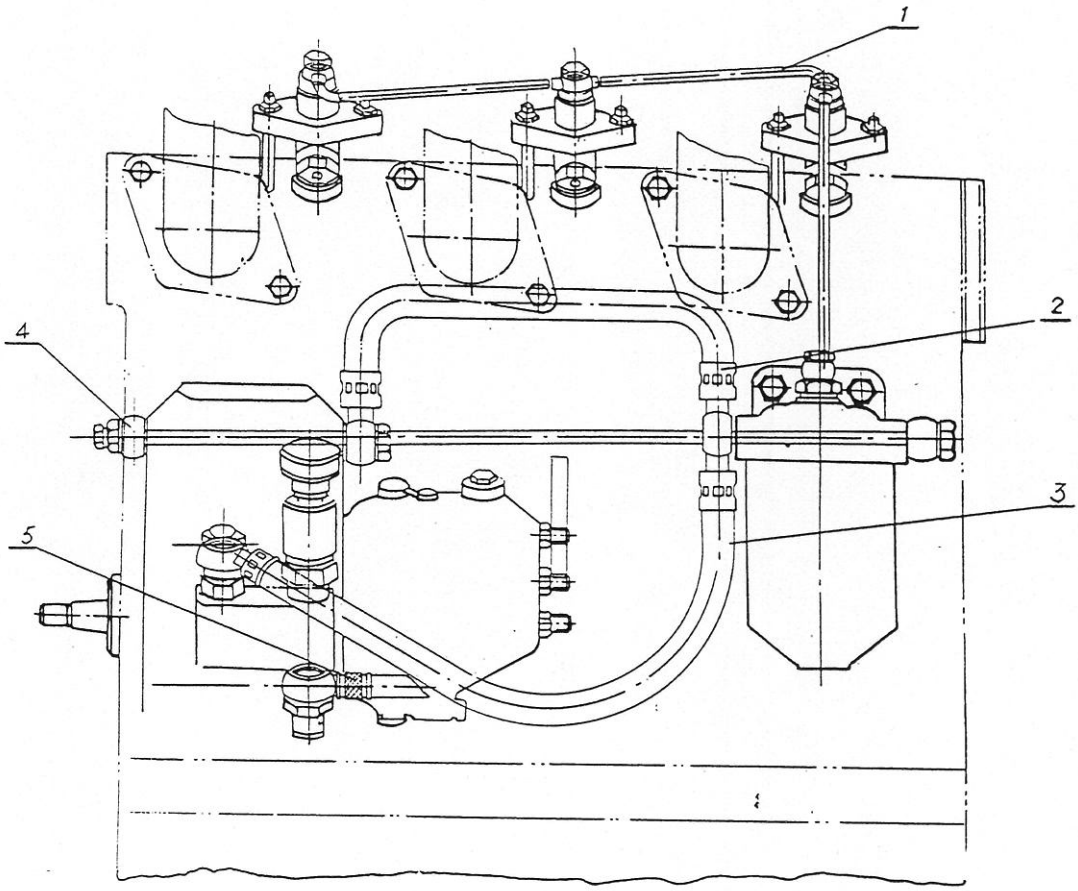


Fig.9. Fuel System

1. fuel leak-off pipe of injector. 2. fuel inlet pipe of fuel injection pump. 3. delivery pipe of fuel transfer pump. 4. flow-back pipe of injection pump. 5. inlet pipe of fuel transfer pump.

1. Fuel Transfer Pump

The single action piston type fuel transfer pump is mounted on the injection pump case, which is driven by an essentric on the camshaft of the injection pump as shown in Fig.10. It overcomes the resistance of the fuel filter and the fuel pipes keeping the fulfil of the fuel in the low pressure fuel pipes with certain low pressure.

A screen is provided at the inlet connecting of the transfer pump for preventing from dirt. If it is plugged or break down, then, it should be cleaned or be replaced by a new one immediately, else, it will cause rapid wearing of the precesion parts of the fuel system or fuel supply shortage. A hand primer is used before starting engine for filling up fuel in the fuel system and also bleeding air from the fuel pipes. Its piston should be pushed down and be tightened with the handle screw for avoiding air to be sucked into the fuel lines.

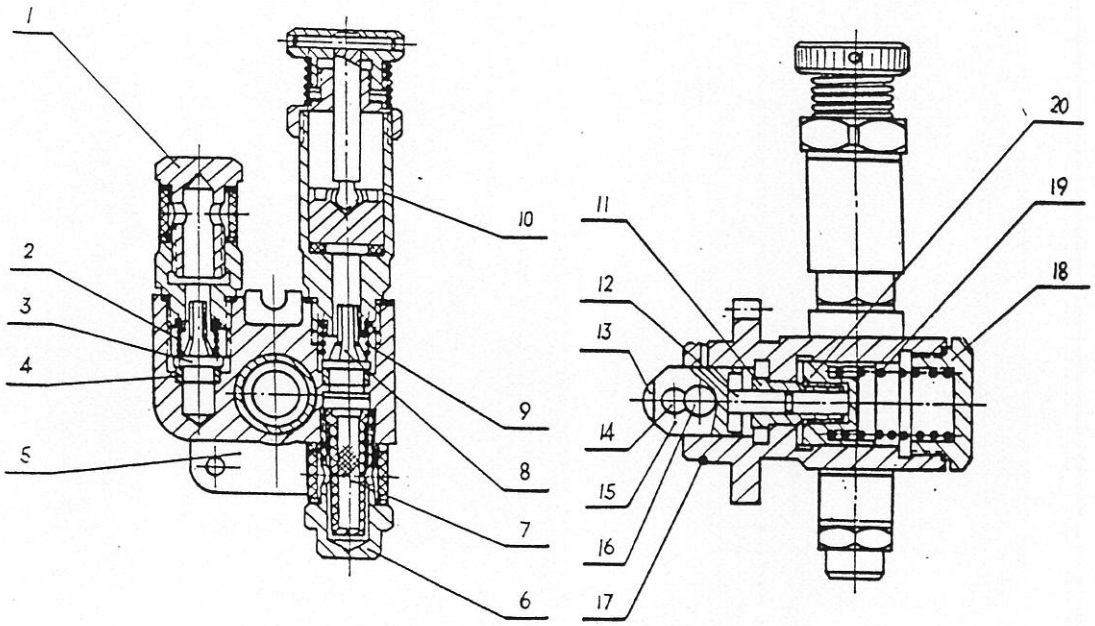


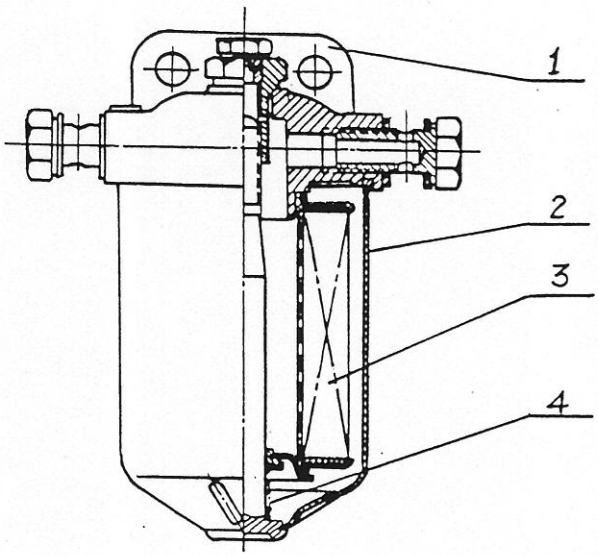
Fig.10. Fuel Transfer Pump

1. fuel outlet pipe connecting screw. 2. one-way valve spring (outlet). 3. one-way valve (outlet) 4.one-way valve seat. 5. fuel transfer pump body. 6. fuel inlet pipe connecting screw. 7. filtering screen. 8.one-way valve (inlet). 9. one-way valve spring (inlet). 10. hand primer. 11. spindle sleeve. 12. spindle. 13. roler. 14. roler pin. 15. roler shell. 16.slide. 17. circlip. 18.screw plug. 19. piston spring. 20. piston.

2. Fuel filter

The fuel filter is a C 0708 paper element type, dust and small particulates can be removed from it, abnormal wear of the precisely lapped pairs can be prevented. A fuel inlet connection and a vent screw are provided on the filter head, as shown in Fig.11.

The filter element is made of a kind of specially treated micronic cellulose paper, it should be checked and cleaned or replaced priodically.



1. filter head
2. shell
3. paper type filter element
4. spring

Fig.11. Fuel Filter Assembly

3. Fuel injection pump

The injection pump is a strengthened, single unit, plunger type in series I right board engine. The plunger diameter is 8mm., it injects required quantity of high pressure fuel at the specified time and time interval, the injected fuel quantity can be changed according to the variation of the engine load. The construction of the fuel injection pump is shown in Fig.12.

The injected fuel quantity is controlled by the relative position of the plunger and its barrel. Rotating the plunger and then changing the position relating to its barrel, the injection fuel quantity can be varied with different engine load. The plunger is rotated by a control fork on the control rod controlled by the governor.

The plunger-barrel and delivery valve pairs are highly precise and highly polished components, which are carefully lapped individually, they should be kept clean when they are being assembled. All these parts can only be used with their own partners. If a replacedment of these parts have to be conducted, only new pairs can be replaced.

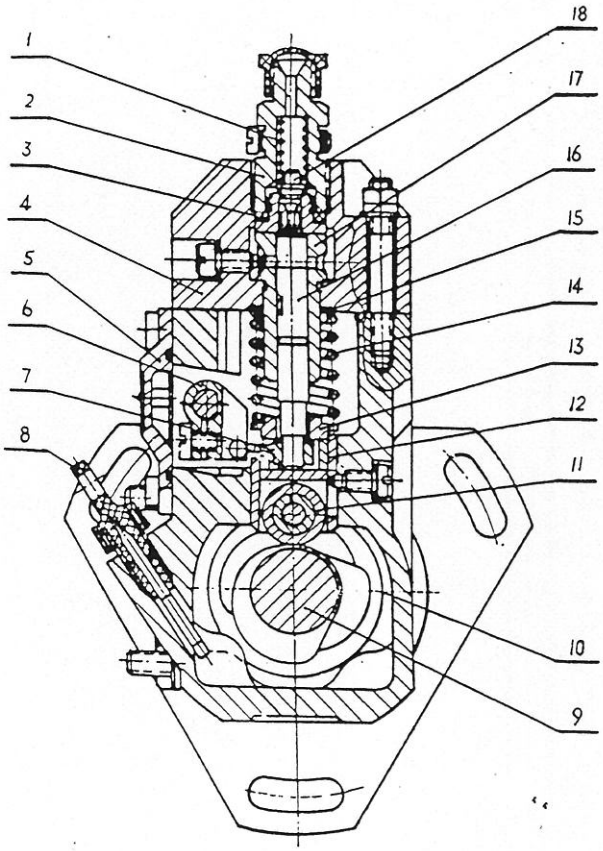


Fig.12. Fuel Injection Pump

1.delivery valve spring 2. delivery valve connection 3. delivery valve washer 4. upper body 5. injection pump inspection window cover 6. control fork 7. regulation arm (plunger arm) 8. oil scale 9. fuel eam-shaft 10. lower body 11. roller 12. tappet shell 13. spring lower seat 14. plunger spring 15. spring upper seat 16. plunger 17. barrel 18. delivery valve

4. Governor

A mechanical centrifugal whole range governor is mounted at the rear end of the pump . when the control handle is fixed at a position, the governor can change the injection fuel quantity with the variation of the engine load and keeps the engine running at a constant speed. The maximum and minimum engine speed are also limited by the governor. The construction of the governor is shown in Fig.13.

A control handle is used for engine speed control. When it is fixed at a position between the maximum speed and the idling speed stopping screws, the centrifugal force of the steel balls is balanced with the forces of the governor spring and the auxiliary spring and the friction of the mechanism, then, the diesel could run at a constant speed, changing the position of the control handle, then, the engine will run at a new constant speed, since the preset force of the governor has been reset, a new force balance has been established.

A stop handle is mounted at the governor case. Moving the handle toward the rear direction end, the engine can be stopped when it is in emer; nc·· Usually, before stopping the engine, the engine load should be released gradually until the coolant temperature down below to 60°C.

The maximum speed and the idling speed stopping screw are located at the governor case for limiting the engine maximum and idling speed. The full load stopping screw is used for setting maximum injection fuel quantity of the fuel injection pump. On the upper side of the governor an oiling and air release screw nut are located, and also a drain plug is on the lower side. The lubrication oil is contained in the governor case and the injection pump body, which are communicated each other. A normal oil leval height should be kept for proper operation.The fuel injection pump and the governor assembly is accurately set by the maker, then, be lead sealed. Disassembling is not allowed for users. Any trouble or break down apperas. it should be checked and reset by experimental technician on special fuel pump test stand.

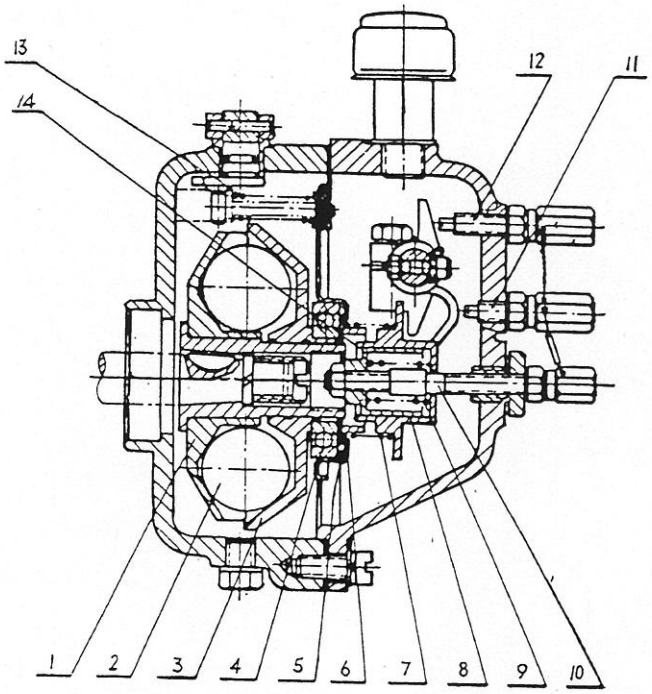


Fig. 13. Governor

1. driving assembly 2.steel ball 3. sliding disc 4.single-row deep-groove ball bearing 5. spring seat 6. control rod rotating plate 7.starting spring 8.sleeve 9. torque control spring 10. full load stopping screw 11. idling speed stopping screw 12. maximum speed stopping screw 13.stop spring 14. supporting sleeve

5. Fuel Injector

The high pressure fuel pump transfers fuel to the fuel injector, where, the fuel is injected and atomized into the swirl combustion chamber at suitable time and mixed with air. The injector has a Model P662 single hole pintle type nozzle, the nozzle needle pair is Model ZS4SI. The construction of the injector is shown in Fig. 14.

From the fuel injection pump the high pressure fuel passes through the inlet passage and three holes on the upper side of the nozzle body into the annlar pressure chamber of the body. When the fuel pressure is over 130 kg/cm^2, the force on the lift area of the needle overcomes the set spring force, the needle valve lifts off its seat and directs the metered fuel into the combustion chamber.

Ensuring the tightness of the injector, under the nozzle nut a copper washer is provided. The valve needle and its seat are precisely lapped in pairs which can not be interchanged individually, great care should be taken when it is disassembled.

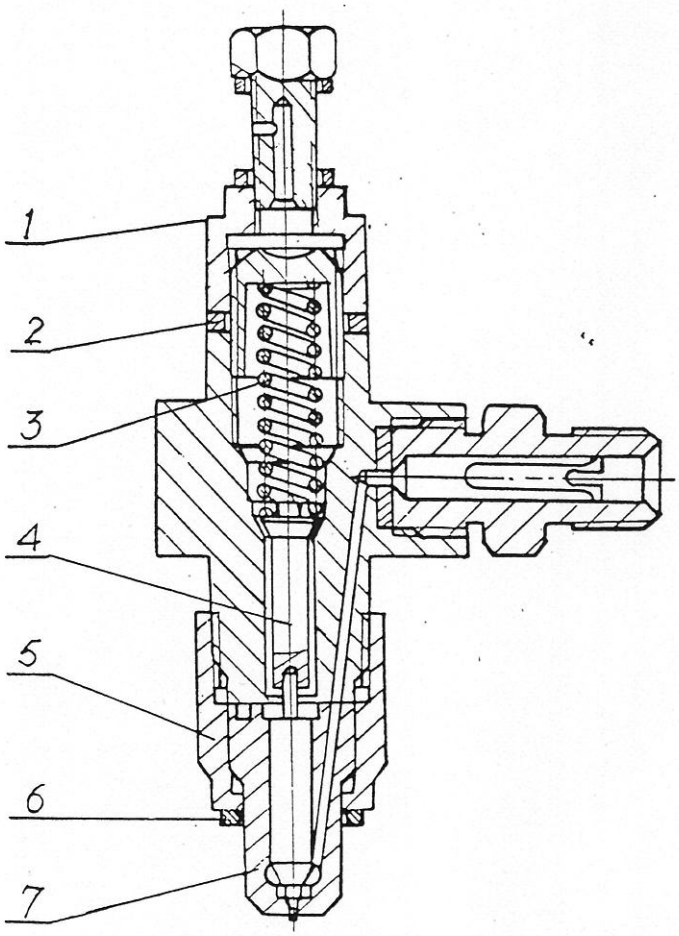


Fig. 14. Fuel Injector

1. holdle nut 2. washer 3.pressure regulating spring 4.spindle 5.nozzle nut 6.washer 7. needle valve pair

H. Lubrication System

The engine is lubricated by pressured and splashed oil. The main bearings, connecting rod bearings,

camshaft bushes and rocker arm bushes are lubricated by pressured oil. The cylinder liners, pistons, cams and their tappets, valves and their guides are lubricated by spalshed oil. Other parts, such as water pump bearings and generator bushes are lubricated using grease injected in periodically. The lubrication system is shown in Fig. 15. Via a screen, the oil pump draws oil from the oil pan, then the pressured oil is delivered to oil filter. After filtering, the oil flows to the oil gallery where the oil is distributed in three ways: first, part of the oil flows to the main bearings through longitudial and inclined passages, then, through inclined passages in the crankshaft to the connecting-rod bearings.The second, part of the oil passes through the inclined passages to the camshaft bushes, and then, it passes through the

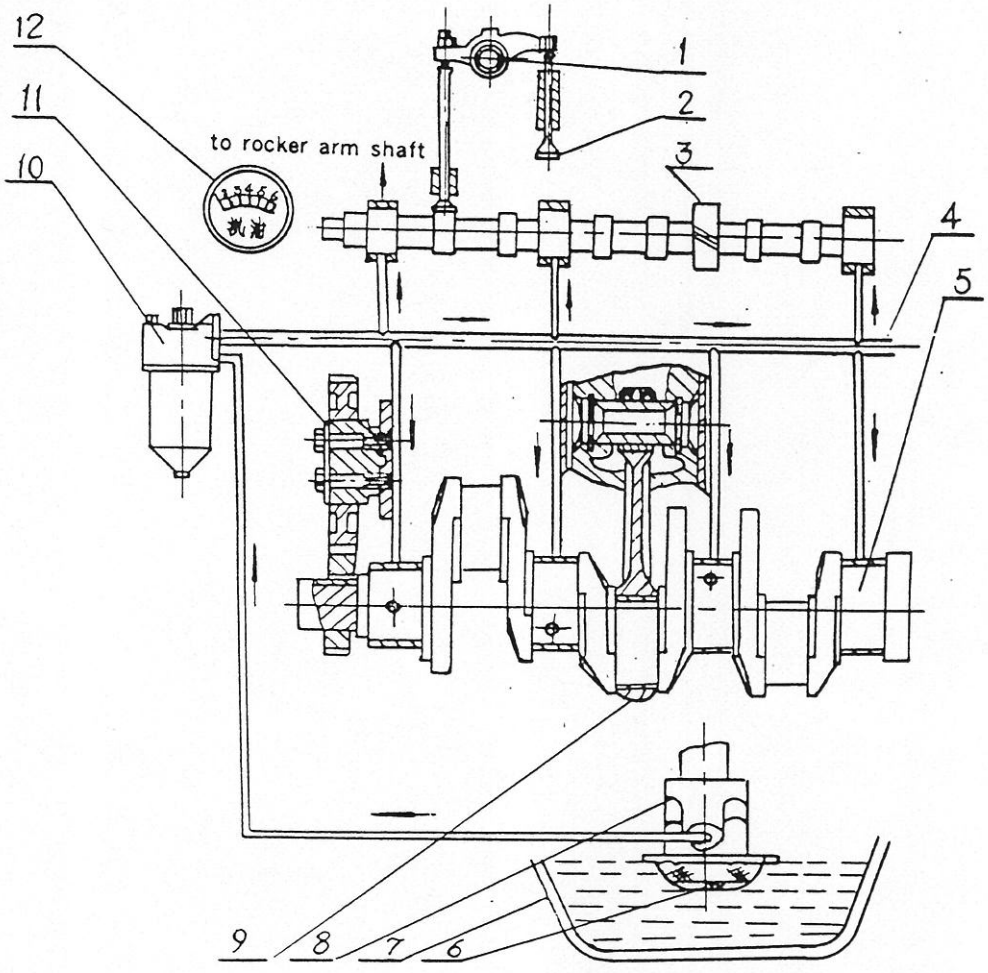


Fig. 15. Lubrication System Diagram

1. rocker arm shaft 2.valves and valve guides 3.camshaft and bushes 4. oil passages in cylinder block 5. crankshaft and bearings 6. oil screen 7.oil pan 8. lubrication oil pump 9. piston-connecting rod assembly and cylinder liner 10. lubrication oil filter 11. gear system 12. lubrication oil pressure gauge

essentric groove on the camshaft journal in the front end of the camshaft to the rocker arms periodically. A part of the oil used at the camshaft journals at the rear end passes through the passage in the shaft to the oil pump driving gears for lubrication. Finally, part of the oil passes through the passage in the front plate of the cylinder block to the idling gear shaft for the lubrication of the gear system.

1. Lubrication pump

A geroto type lubrication pump is inserted inclinedly in the cylinder block, which is driven by a helical gear in the middle of the camshaft. Under the lubrication pump, a suction pipe is connected with a suction screen and the pump itself. Fig. 16 shows the construction of the pump. Addition to the inlet and outlet passages casted in the pump cover, a relief valve is provided for controlling oil pressure and flow rate. The sealing at the suction pipe connection should be carefully kept, else, the pump could not work properly. The clearance between the outer gear and the pump body upper face should be kept within 0.05-0.12mm , if the end face of the gear is worn out, the gasket should be replaced in time for keeping a normal clearance, else, normal oil pressure and the oil flow rate of the lubrication pump would be disturbed.

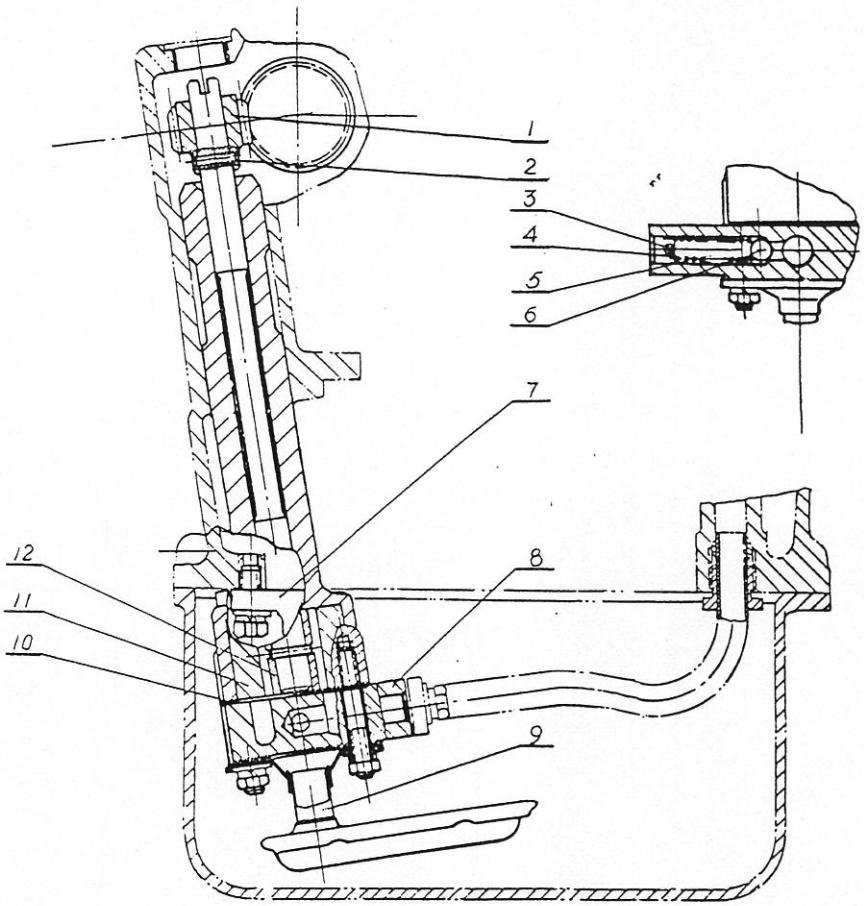


Fig. 16. Lubrication Pump Assembly

1. driving gear 2.3. pins 4.washer 5. pressure relief spring 6.steel ball 7. lubrication pump body 8. pump cover 9. inlet screen 10. pump gasket 11. outer gear 12.inner gear.

2. Oil filter

A whole flow paper-cartridge oil filter is used in the engine. The construction is shown in Fig. 17.

On the filter seat, a pressure regulation valve is provided for regulating the pressure of the main gallery. When the cartidge surface is heavy sludged or the oil viscosity is too high while the engine started in very cold weather, the oil flows into the oil gallery would be heavy insufficient, then, the relief valve would be lift up, by passing the filter, the oil flows into the oil gallery ensuring the engine operation without damaging the components. The release pressure of the bypass valve was set using special instruments by the maker. Usually, there is no need to disassemble or regulate it in operation.

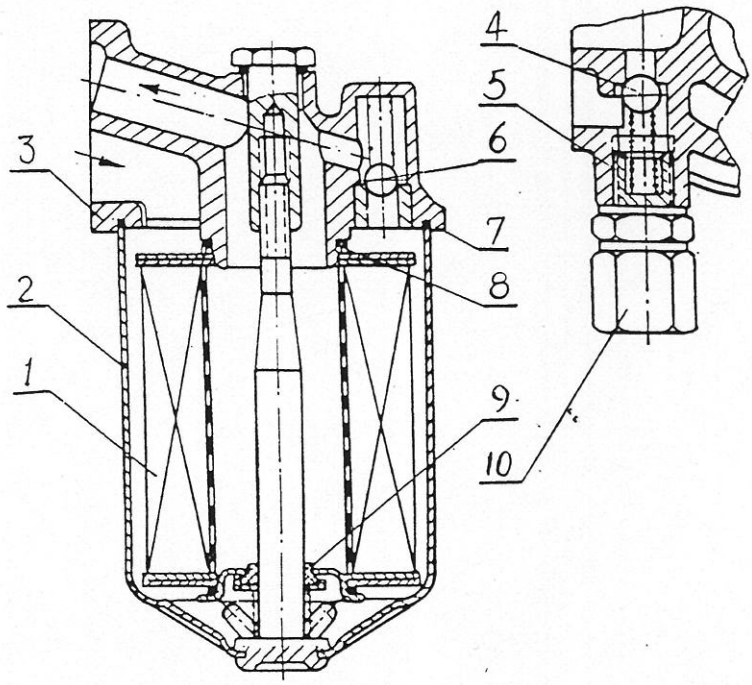


Fig.17. Model 0810 Oil Filter

1. 0810 paper cartridge 2. filter body assembly 3. filter seat 4. pressure regulation valve 5. regulation screw 6. relief valve 7.8. sealing rings 9. sealing washer 10. sealing screw

I. Cooling System

A forced circulation water cooling system is used in the engine, as shown in Fig.18:

Water pump delivers coolent from the radiator into the main passage within the engine cylinder block, part of the coolent passing through the three tangential holes flows to the outer space of each cylinder liner for liner cooling, then, the water flows through the holes on the both inlet and exhaust manifold sides up into the cylinder heads. Ensuring the cylinder head well cooling, there is another part of the coolant flowing to the cylinder head directly from the main water passage. In the cylinder head a few of ⌀ 10 drillings are provided. The coolant is directed to the "Thermal Triangle" regions forms by the inlet valves, exhaust valves and the swirl combustion chambers, where the thermal load is maximum, then, the operation reliability can be ensured. When the engine is in operation, the heated coolant passing through a thermostat and an outlet pipe into the upper part of the cylinder head flows into the radiator, where the high temperature coolant is cooled by a fan, then, flows back into the cylinder block for circulating again, this is called large coolant circulation.

There is an optimum operation temperature range for the coolant, if the temperature is too high, it would cause insufficient cooling and overheat of the components, insufficient charging to the cylinders, reduce the visicosity of the lubricating oil or cause carbon deposit and oil deterioration, cause engine power loss, rapid wear out, even damage components. On the contrary, if the coolant temperature is too low, it would cause more heat loss and worsen combustion process of the engine. Therefore, low temperature is also disadvantage to the engine operation. For the coolant temperature control, on the front cover plate of the cylinder head, a thermostat is provided, the temperature, of which, the valve lifts its seat is about 70°C, the full lift-off temperature is 85°C. When the coolant temperature is too low, the thermostat valve closes, the coolant can not get into the radiator but flows back to the water pump through a thin water pipe under the thermostat, that is called coolant circulation.

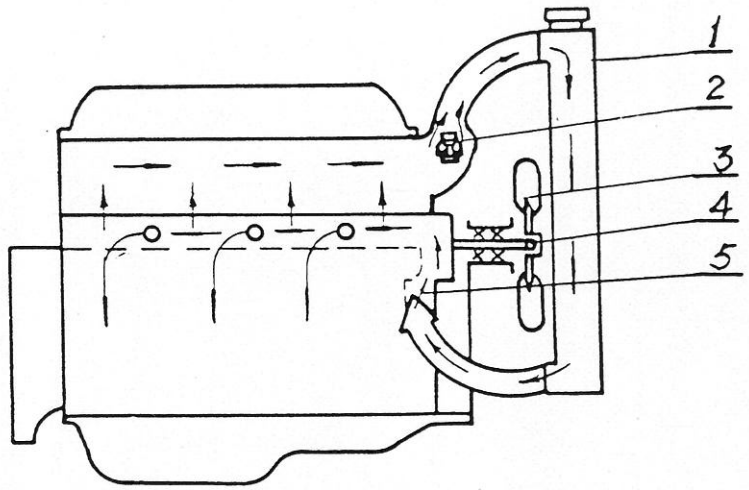


Fig.18. Scheme of the Cooling System

1.radiator 2. thermostat 3. fan 4. water pump 5. inlet pipe

1. Cooland Pump (water pump)

A single side, centrifugal impeller type coolant pump is used as shown in Fig.19:

The coolant pump is driving througn a V-belt and a crankshaft pulley, the pump is fixed o on the body plate, and then, onto the upper part of the cylinder block. The inlet port of the coolant pump is casted on the front of the cylinder block, the coolant small circulation holes are located in the coolant inlet ports of the cylinder heads and the cylinder block, then, the small coolant circulating pipe can be omitted. A F17 ceramic-carbon water seal is mounted in between of the pump impeller and the bearing, the water sealing spring presses the ring onto the ceramic O-ring which rotates synchronized with the coolant pump shaft for sealing, water leakage drains out from the drain hole on the lower part of the pump body. If the seal is worn out in operation, a large mount of water leakage will appear from the drain hole, it shows that a new water seal should be replaced, the drain hole should not be plugged when water leakage ocurs, else, the coolant would pass into bearing, and damage it, then, it would cause abnormal noise. On the upper part of the pump body, a grease fitting is provided, calcium grease should be injected in periodically. Not too much grease should be injected in, only 1/2-1/3 of the bearing space can be filled, else, it will cause insufficient heat dissipation and bearing overheat.

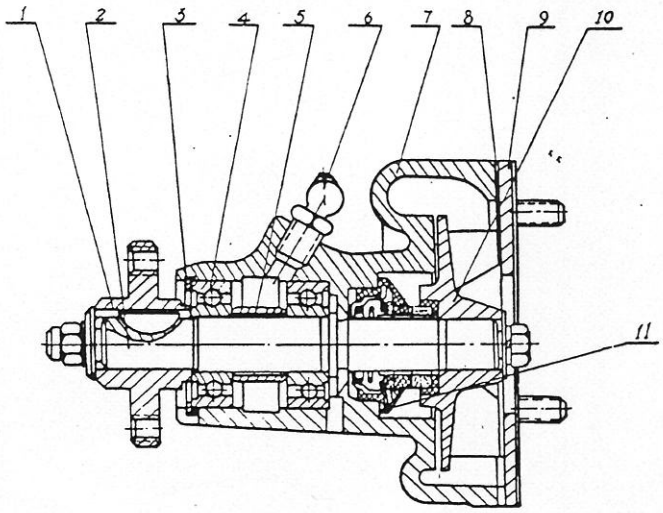


Fig. 19. Coolant Pump

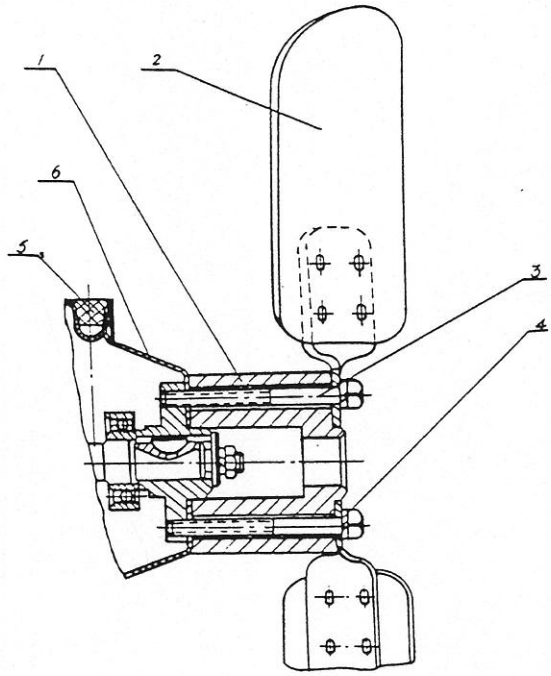
1. fan pulley hob 2. coolant pump shaft 3. spacer ring 4. bearing 5. spacer 6. oil ring 7. coolant pump body 8. plate washer 9. coolant spacer plate 10. pump impeller 11. water sealing

2. Fan

Fan assembly is connected on the coolant pulley hob using bolts and pulley. There are 4 blades or 6 blades fans driven by the crankshaft through V-belt which can be chosen for different applications, as shown in Fig. 20.

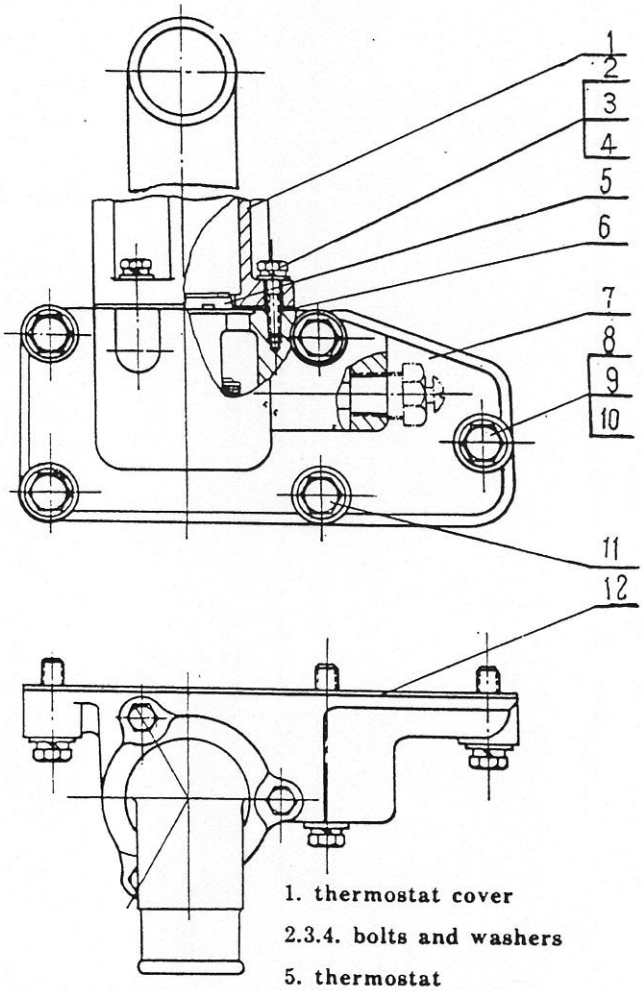
3. Thermostat

In the cylinder head front cover, a thermostat is mounted for the coolant temperature control. The construction of the thermostat is shown in Fig. 21. The thermostat is a bellows single valve type, temperature-sensing liquid is filled in, the lift-off or close-down of the valve varies with the coolant temperature variation. The valve starts to lift at 70°C, full lifts off at 85°C. After the engine starting at cold condition, if the coolant flows out from the coolant outlet pipe when the coolant temperature is below 70°C or no coolant flows out from the pipe when the coolant temperature is higher than 70°C after the engine has been warmed up, those indicate that there is failure of the thermostat, then, the thermostat should be removed and be checked, else, it will cause engine failure.



1. fan spacer
2. fan
3. bolts
4. wacher
5. V—belt
6. fan pulley

Fig. 20. Fan Assembly



1. thermostat cover
2.3.4. bolts and washers
5. thermostat
6.washer
7. thermostat case
8.9.10.11. bolts and washers
12. washer

Fig.21. Thermostat Assembly

J. Electrical System

The electrical system mainly consists of battery, starting motor, generator, regulator, instruments and switches etc. The system is a single wire system of electric generating, supply and consume. The diagram of the electrical system is shown in Fig.22.

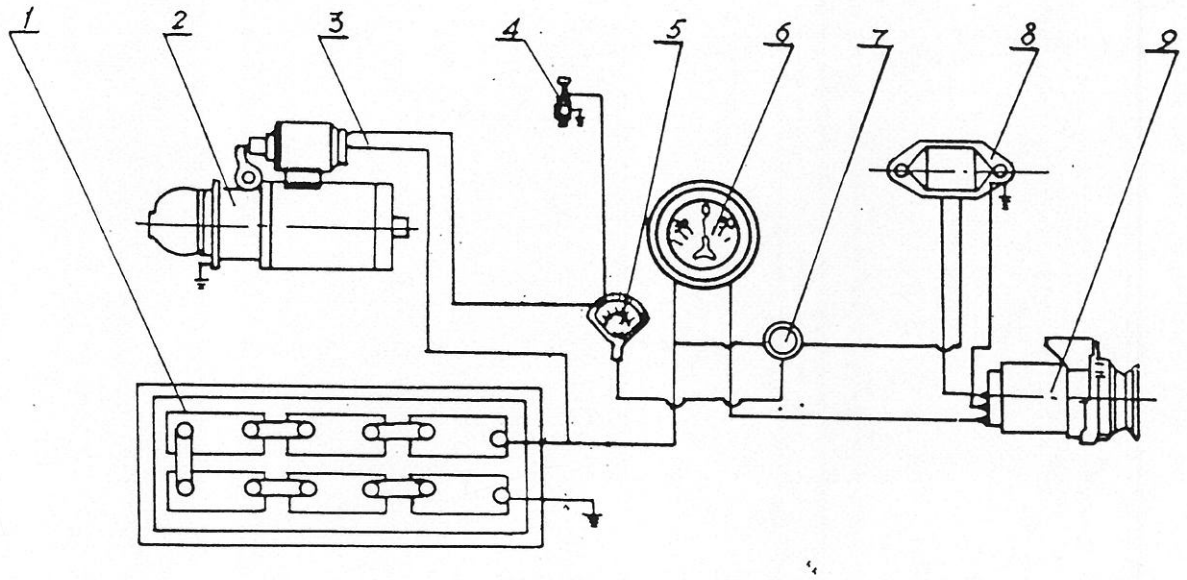


Fig.22. Electrical System Diagram

1. battery 2.starting motor 3. wire 4. electrical heater plug (glow plug) 5. preheat starting switch 6. ammeter 7. ignition switch 8. regulater 9. silicon rectification generator

1. Battery

6-Q-135 type battery can be chosen for the engine. Users should better charge the battery when they get a new or uncharged one. Battery is the electricity supply of diesel engine, the performance of the battery affects the starting of diesel engine directly.

The charging current value should be checked frequently when diesel engine is running, if the current value approaches "0", that indicates the battery has been fully charged, the charging circuit can be shut off.

The battery cover opening should be tightly closed in operation, the vent on the cover opening should be kept in good condition. It is important of keeping the battery surface clean and dry.

After discharging, the battery can not be storaged in very long period, for preventing sulphidization of the polar plates. Usually, the battery should be recharged within 24 hours. The battery should be fully charged before the battery to be storaged for a period of time without operation. Never pour electroiyte out when the battery is being storaged.

2. Generator

A JF11AS type whole water resistant generator is used in the engine, The generator set consists of a AC generator and silicon diode rectifier. Its negative terminal should be carefully grounded (being connected to metal parts), else, the generator might be burnt.

The operation and maintenance can be seen from the reference "Operation and Maintenance Manual of Silicon Rectification Generator Series JF".

3. Regulator

A FT70 voltage regulator is matched with JF11AS silicon rectification generator in application. it stabilizes the generator output voltage within 13.8-14.5 volts automatically, limits load current, connects on or shut off the circuit connecting the battery and generator automatically.

The regulator should be located in perpendicular direction, connection wires should be directed downward, all the connection terminal should be carefully fixed and should not be disassembled unnecessarily.

4. Starting Motor

The starting motor is a 2Q2CA series excitation type, its operation voltage is 12 volts, its maximum output is 2.5 horse power, module of the starting gear is 3, number of the teeth is 11.

The engagement of the starting motor pinion with the flywheel ring gear is electromagnetical controlled, after connecting the starting switch, the solenoid switch engages the pinion with the ring gear, meanwhile ,the starting motor circuit being switched on, the flywheel is then driven. After the engine being started, the starting switch should be shut off soon, the spring forces the iron corn and then, the pinion back to the original position.

5. Electrical Heater (glow plug)

For the purpose of improving the starting performance of the engine in cold weather, an electrical heater plug (glow plug) is provided in each cylinder head combustion chamber. Before starting the engine, switch on the current circuit for 40-60 seconds, heating the resistance wire up to about 1000°C, then, the injecte fuel spray in the vicinity of the plug ignites.

6. Key Switch of the Circuit

It is also named ignition switch. It had three operation: When the switch is turned on the middle position, it cuts off the whole circuit; Turn on the switch in clockwise direction, it connects the preheat starting switch on and the regulator voltage at the same time, then, you can start the engine. As soon as the engine has been started, you should turn the key switch in the counter clockwise direction to the end, then, only the regulator circuit is connected on, when the battery can be switched on and be charged by the generator, but the starting motor can not be switched on, therefore, the accident can be avoided.

7. Preheat Starting Switch

The preheat switch had four positions: Turn on the switch on the "Preheat" position, only the glow plug circuit is closed; when the switch is turned on the "Starting" position, only the motor circuit is connected: if the switch is turned on the "Prehear Starting" position, both the preheat and starting circuits are connected to the battery: turn on the switch to the "O" position, the whole circuit is cut off.

Chapter Ⅳ. Adjustment of the Engine

A. Valve Clearance Adiustment

During operation or maintenance of the engine the valave clearance should be checked as follows. (Fig.23)

1. Remove the cylinder head cover, check and tighten the rocker bracket nuts.

2. Turn the crankshaft to move the piston of the first cylinder to its T. D. C. on the compression stroke. At that time the mark on the observation window of the flywheel housing just aligns the "O" cut line of the flywheel and the "O" line on the pulley just aligns the pointer on the gear case cover.

3. Using 0.35 and 0.40mm feeler gauges, set the clearances between the vlave stem top and rocker head for each cylinder in turn.

4. After the adjustment is completed, recheck the clearance again. Should the clearance be corrected, the adjustment can be put to the end.

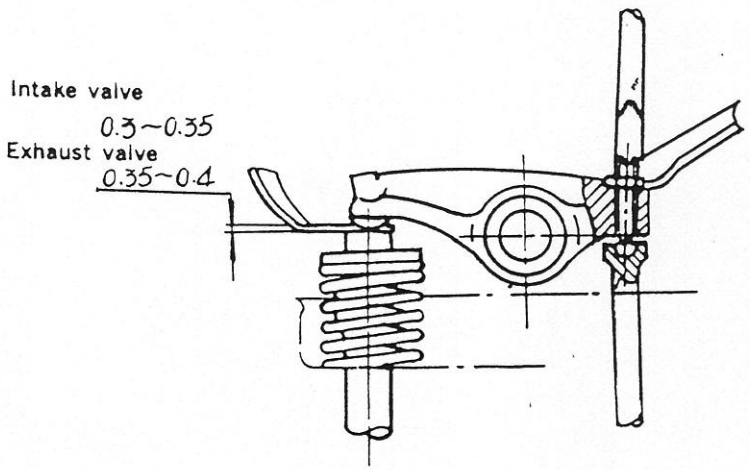


Fig. 23. Valve Clearance Adjustment

B. Decompression Device Adjustment

Turn the flywheel to close the intake valve of the cylinder, which is to be adjusted, i. e. move the piston to T. D. C. on the compression stroke. Turn the decompression shaft to set it to the decompression position. Loosen the lock nut of the decompression screw and turn the decompression screw by means of a screw-driver. When its head contacts the rocker head, turn it again by 1-1.5 rotations to open the valve by 0.8-1.2mm. Then lock it by the nut (Fig. 24). After the adjustment is completed one cylinder by one. the inspection for it should be carried out. If the decompression shaft is set to the decompression position, the flywheel can be Lightly turned without any interference between the valve and piston or other parts: or if the decompression shaft is set to the other position, the decompression screw will be seperated from the valve rocker thoroughly, those show the adjustment is correct.

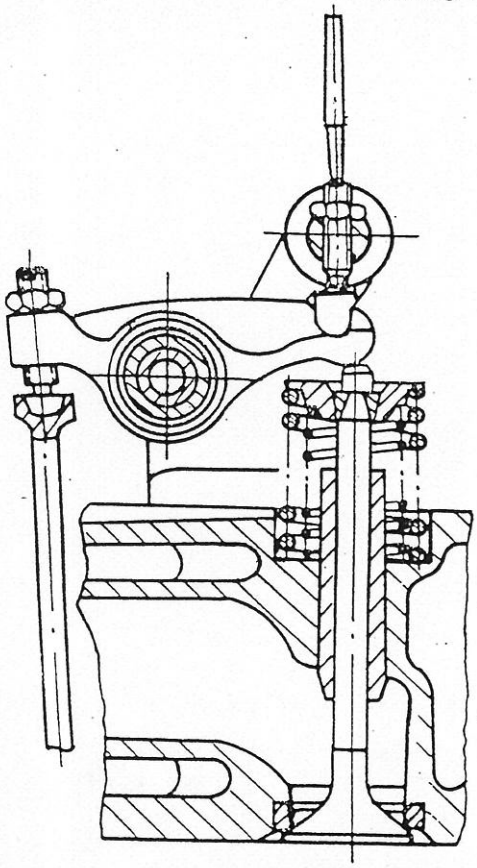


Fig. 24. Decompression Device Adjustment

C. Adjustment of the Delivery advance Beginning

The delivery advance angle affects directly the performance on power and economy and the starting ability of the engine. After operating the engine for a period of time and after maintaining or dissembling and assembling of the engine, the delivery time of the fuel should be inspected and adjusted according to the following method.

1. Set the contact lever of fuel to the "Full Fuel" position. Operate the hand-pump to eliminate the air in the fuel system.

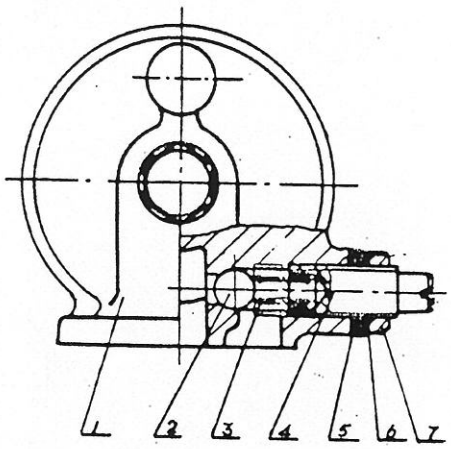
2. Dismounted the injection pipe of the first cylinder, blow off the fuel in the connection of the delivery valve holder. Then turn the crankshaft slowly in the working direction and pay close attention to the fuel level inside the connection. As soon as the fluctuation of the fuel level is seen, stop the crankshaft.

E. Injector Adjustment

For the injectors, the spray pattern and injection pressure should be basically inspected. The injectors should be washed in kerosene or diesel fuel. If the seal between the needle valve body and seat is poor, use No.500 Green fine chrome oxide grinding paste to lap them. Then, wash them carefully. After reassembling, check the injection pressure and spray pattern on the iniector testing apparatus. If the injector is in good condition, the injecting sound is clear and melodious the atomization of the fuel should be fine, no obvious fuel drip can be seen and the injector can stop injecting snappily. The injection pressure should be 130+5kg/cm^2 Should the pressure not be correct, remove the nut on the injector top and turn the adjusting screw with a screw driver. When turn it clockwise, the injection pressure will be increased. When turn it in the opposite direction, the injection pressure will be decreased. After adjusting, lock the adjusting screw and recheck it again.

F. Oil Pressure Adjustment

The oil pressure adjustment usually should be carried out after the engine warming-up, so that the correct adjusted data can be obtained. At the nominal speed of the engine remove the regulating valve cap of the oil filter, loosen the lock nut of the regulating screw, and turn the screw with a screw-driver. When turning it into, the pressure will be increased; when turning it out, the pressure will be decreased. The proper adjusted pressure is 2-4kg/cm^2 Then, lock the regulating screw with the lock-nut and tighten the regulating valve cap. (Fig.26)



1. filter housing
2. steel ball
3. regulating spring
4. regulating screw
5. seal washer
6. washer
7. lock nut

Fig.26 Oil Pressure Adjustment

G. Fan Belt Adjustment

Although the belt deflection adjustment is very simple, it has a great influence on the speeds and operation of the water pump and generator, and it is directly relative to the reliability of the engine operation.

The method for checking is following. Depress the belt at its midway with 3-4 kg pressure (it is equivalent to the force in which a medium-strength people depresses it with a hand), and the normal deflection is 10-15mm. Otherwise change the position of the adjusting bracket of the alternator for adjusting.

Chapter V. Technical Maintenance of the Engine

The technical conditions of the diesel engine are changing with the operating period and conditions. And the performance of the engine is also to be deteriorated gradually. Therefore the schedule technical maintenance system should be taken, so that the engine can be raliably operated. The schedule maintenance includes the shift maintenance and No. 1,2,3 and 4 teahnical maintenance.

A. Daily Maintenance (8—10 hour shift maintenance)

1. Check the fixation of the engine and the conditions of other attachments.

2. Eliminate the oil and gas leakage in the fuel system, lubricating system, cooling water and etc. Clean off the dust, water and oil stains on the engine starting equipment and instruments. Keep them clean in any time.

3. Check regularly and tighten the engine fastening bolts (including the fundation bolts) and other nuts and bolts, which can probably be slackened.

4. Check the fuel, lubricating oil and cooling water. Replenish them if necessary.

5. Check the deflection of the drive belt. Adjust it if necessary.

6. Check the battery. Its electrolyte level should be at the height of 10-15mm above the electrode plates. If the electrolyte level is lower, add the distilled water.

7. Observe regularly the readings of all instruments. If abnormal, cneck and eliminate them immediately.

8. Remedy other troubles and abnormal phenomenon.

B. No.1 Technical Maintenance (Every 50 Hours)

Besides all the items included in above daily maintenance, following jobs should be carried out.

1. Clean the inside of the air cleaner. Brush down the dust on the paper filtering element.

2. Clean the inside of the oil filter. Brush and wash the paper filtering element with diesel fuel.

3. Check the electrolyte level of the battery and make sure that the vent-hole in the battery cover is unblocked. Add distilled water, if necessary. Then wipe the battery clean with cloth.

4. Cheak the deflection of the fan belt.

5. Fill grease into the cooling water pump bearing.

C. No.2 Technical Maintenance (Every 250 Hours)

Besides all the items included in No.1 Technical Maintenance, following jobs should be carried out.

1. Change the lubricating oil in sump. Wash the sump, oil sump strainer and the screen of the oil filler.

2. Wash the lubricating oil filter or replace the paper filtering element.

3. Wash the air cleaner or replace the element.

4. Wash the fuel filter and the outside surface of the cartridge or replace the cartridge.

5. Check and adjust the valve clearance and decompression stroke.

D. No.3 Technical Maintenance (Every 500 Hours)

Besides all the items included in No. 2 Technical Maintenance, following jobs should be carried out.

1. Check the injector pressure and atomazation quality. If necessary, wash the needle valve couple and readjust the injection pressure. If above work is still invalid, replace the needle valve couple.

2. Check and adjust the beginning of delivery of the injection pump. Change the lubricating oil in the fuel pump.

3. Wash the fuel tank and pipes.

4. Check for the fastening and anti-loosening of the connecting rod bolts, main bearing bolts and cylinder head studs.

5. Flush the surface of the battery with hot water. Measure the specific gravity of the electrolyte. When the ambient temperature is 15°C, the specific gravity of electrolyte should be 1.24-1.27. If it is lower than 1.24, add electrolyte and charge the battery.

E. No.4 Technical Maintenance (Every 1000 Hours)

Besides all the items included in No. 3 Technical Maintenance, following jobs should be carried out.

1. Deterge the incrustation in cooling system and wash the cooling system.

2. Check for the water leakage of the water pump. If necessary, replace the water seal or other parts. Change the grease in the water pump bearing.

3. Remove the cylinder head. Check the valve seal. Clean down the carbon deposits. It depends whether lapping of valves or reamingof valve seals will be needed or not.

4. Clean down the carbon deposits on the upper parts of the liner and piston. Remove the piston-connecting rod assembly and check for the wear on the surface of the cylinder liner, piston and piston ring. If necessary, replace the piston ring.

5. Remove the sump. Check the crankshaft, main bearing, thrust washer and connecting rod bearing for the wear.

6. If necessary, remove the oil pump and adjust the end clearance of the rotor.

7. Check and repair the alternator and electrical starter. Change the grease of bearings.

8. Check, adjust and test the injection pump and governor (if necessary.)

F. Schedule Technical Maintenance of the Systems and Parts of the Engine

According to the requirements of the systems and parts of the engine the items and periods for the maintenance are summed up as follows.

Item	Jobs	Period
1. Cooling water	1. Check the cooling water level. Add water in time, if it is not enough.	Frequently
	2. Wash the radiator and water passage	1500 hours
2. Lubricating oil in sump, injection pump and governor	1. Check the oil levels in sump, injection pump and governor. Keep them between the upper and lower mark lines.	Frequently
	2. Drain oil after the first 50 hour running for a new overhauled engine. Wash the inside of the sump with diesel fuel, then fill new oil in to it. After this, wash and change oil every 500 hours.	50 hours or 500 hours
3. Lubricating oil filter	1. Wash or change the filtering element after the first 50 hour runing for a new or overhauled engine.	50 hours
	2. For the paper filtering element, it is not recommended to wash it. Replace it after every 200 hour running.	200 hours
4. Oil suction tube (pre-filter)	Remove it from the sump and wash it with the clean diesel fuel. For a new or overhauled engine after the first 50 hour running. After that, for every 100 hours.	50 hours 100 hours
5. Fuel filter	For the paper filtering element, don't wash it. Replace it after every 200 hours	200 hours
6. Fuel tank	Wash the inside of the tank with the clean diesel fuel.	1500 hours

7. Air cleaner	Brush the paper element with a thick and soft brush. In general, brush it in every 50 hours. If operate the engine at dust condition, brush it in every 8 hours and replace it according to judgement.	50 hours. (or 8 hours)
8. Injector couple	Remove the couple and wash it with clean diesel fuel. If necessary. lap it with the fine grinding paste. When reassembling, pay close attention to keeping it clean.	When the trouble happens. check and maintain it.
9. Cylinder head, intake and exhaust valves	Clean down the carbon deposits. After washing lap the valve and seat to get the correct contact line. (if the power and smoke colour are normal, this job can be cancelled).	Under normal condition check and maintain them in every 500 hours.
10. Piston and piston rings	Clean down the carbon deposit: and wash them with clean diesel fuel. Inspect the ring gap and elasticity. Replace them, if the specified value is exceeded.	Under normal conditions check and maintain them in every 500 hours.
11. Check the connecting rod bolts and main bearing bolts.	If loosened, retighten and lock them.	Every 500 hours.
12. Check the specific gravity of the electrolyte and voltage	The specific gravity of the electrolyte should be 1.27-1.28. The voltage for each cell is not lower than 2.1V	Every 500 hours.

• The sodium hydroxide or the soda solution for washing clothing (100-150 gram soda/1 liter water) can be used for deterging the diposition. It is better to add some filtered kerosene (25kg/1 liter) into the cooling water pump. The engine works for a shift, then drain out the solution. Use great amount of water to clean the inside when remain the draining cock to open (can be also used the washing solution: 40 gram soda and 10 gram sodium silicate in one liter water).

This job can be deferred or moved up, depending on the deposition.

Chapter Ⅵ. Defects and Elimination of Engine

Cause of Trouble	Remedy Method
A. Engine Failing to Start	
Ⅰ. Starting speed too low	
1. Battery not fully charged or joint loosen.	1. Recharge battery; tightening the joint.
2. Bad contact between the carbon brush and rotor of starting electric motor.	2. Repair or renew the carbon brush.
3. Starting motor pinion can not engage with the gearring of flywheel.	3. Turn flywheel another position. Inspect or remount the starting motor and keep its Axis in parallel with the flywheel.
Ⅱ. Faults in the fuel system	
1. Fuel tank empty or its cock is off.	1. Supply with sufficient quantity of fuel to tank, turn on the cock.
2. Air within the fuel system, fuel leakage from joint.	2. Vent air from fuel system, fill tank with clean fuel, tightening the joint.
3. Fuel piping or filter clogged.	3. Clean the fuel piping system, replace fuel filter cartridge, clean intake pipe of transfer pump.
4. The fuel transfer pump out of order.	4. Check if there is any air in the fuel intake piping. Inspect fuel transfer pump.
5. Injector fails to deliver fuel, insufficient injection pressure, poor atomization; pressure adjusting spring broken; nozzle hole chocked.	5. Check injector and adjusting if on the injector testing bench.
6. The fuel injection pump plunger or barrel worn, delivery valve leaks, spring broke.	6. Lap the valve, repair or replace components.

Ⅲ. Insufficient compression pressure	
1. Valve clearance too small.	1. Readjust valve clearance according to the specification.
2. Valve leakage.	2. Lap valves.
3. Air leakage through cylinder head gasket.	3. Replace cylinder head gasket, tightening cylinder head nuts according to the specification.
4. Piston ring excessively worn, seize, the opening gap possition of the piston ring coincide in a line.	4. Replace with new ring, clean, readjusting.
Ⅳ. Other causes	
1. The ambient weather too cold, oil viscosity too high.	1. Pour cooling system with hot water, using starting heating acessory, using oil according to recommended grade.
2. Water within combustion chamber or cylinder.	2. Inspect, repair, replace.
B. Insufficient Output	
1. The intake piping joint of fuel filter or fuel transfer pump clogged.	1. Clean or replace.
2. The injection pressure not correct or poor atomization.	2. Check injector or replace nozzle.
3. Pumping elements (plunger & barrel) excessively worn out.	3. Readjust the fuel delivery quantity or check the plunger, barrel and fuel delivery valve.
4. The governor spring deformation and loosen, rating speed doesn't reach.	4. Adjust high speed stopping screw, replace governing spring.
5. Air within the fuel system.	5. Bleed air from fuel system.
6. Incorrect advance angle of fuel injection.	6. Adjustment according to the specification.
7. Uneven distribution of fuel quantity to cylinders.	7. Readjusting distribution of fuel quantity to each cylinder.
8. Insufficient air supply due to air cleaner.	8. Clean or replace the cartridge of air cleaner
9. Valve leakage.	9. Check valve clearance, valve spring, valve guide and the seating of the valve. Relap and renew if necessary.
10. Insufficient compression pressure.	10. Ref. A. 3. on this chapter.
11. Incorrect valve timing.	11. Inlet or exhaust valve camprofile excessively worn, replace camshaft if necessary.
12. Hole seating of injector on the cylinder head leakage.	12. Replace copper washer, even tightening injector holder.
13. Cylinder head nuts loosen.	13. Tightening the force moment according to the specification.

C. Smoky Exhaust	
I. Black smoke	
1. The nozzle orifice clogged, needle valve seized.	1. Check, repair or replace.
2. Engine overload.	2. Reduce the engine load.
3. Injection timing too late, partial fuel burns during exhaust process.	3. Adjusting the advance angle of injecting pump.
4. Incorrect valve clearance, leaky valve.	4. Check over the valve clearance and lap it.
5. Uneven distribution of fuel quantity by the fuel injection pump.	5. Readjusting the delivery quantity of fuel for each cylinder.
6. Intake pipe or air cleaner clogged.	6. Clean air cleaner.
II. Whits smoke	
1. Injection pressure too low poor atomization, appear fuel drip phenomenu m.	1. Inspect, adjust, repair or replace nozzle if necessary.
2. Cooling water temperature too low.	2. Raise cooling water temperature.
3. Water leakage within the cylinder.	3. Inspect cylinder head, gasket.
III. Blue smoke	
1. The piston ring excessively worn or seized, oil getting into the cylinder.	1. Clean or replace piston ring.
2. Excessively high oil level in the oil sump.	2. Drain out the excess oil.
3. The compression ring mounted reversely, then disturb its scrapping effect.	3. Keep the mark "Upper" of the ring on upper way.
D. Unordinary Noise	
1. Advance angle of injection too early, cylinder emit rhythmically metallic knocking noise.	1. Adjusting injection advance angle.
2. Valve clearance too large, causes valve mechanism emit clear and rhythemical knocking noise.	2. Adjusting valve clearance.
3. Valve bumps against the top of piston, heavy but even rhythmical knocking noise occurred.	3. Slightly enlarge the valve clearance, readjust connecting rod clearance or replace connecting rod bushes.
4. Piston bumps against the bottom part of cylinder head, sounded heavy and forced knocking noise.	4. Replace cylinder head gasket.
5. Valve mechanism emit metallic clicking noise, as a result of valve spring broken, valve push rod bending and valve tappet worn out.	5. Replace valve spring, push rod or tappet etc. Adjust valve clearance.

6. Noise occurred due to the clearance between the piston and cylinder liner too large, but it will gradually become lighter as soon as the engine run "Warm up".	6. Replace piston and cylinder liner if necessary.
7. When the engine suddenly decreases its speed, a heavy pounding noise occurred due to connecting rod clearance too large.	7. Replace connecting rod shell.
8. Engine emits sharp clicking noise, during idling, as a result of excessive clearance between the piston pin and the connecting rod small end bush.	8. Replace connecting rod small end bush.
9. Excessive axial clearance due to the thrust ring of the crankshaft severly worn out, then an axial pounding noise will be heard.	9. Replace thrust ring.
E. Severe Vibration	
1. Uneven distribution of fuel quantity to cylinders; some few cylinder nozzle poor atomization; indivitial cylinder seriously leakage, unequal compression ratio.	1. Check and adjust fuel quantity of injection pump; repair nozzle; eliminate leakage, check and adjust cylinder compression pressure.
2. Water or air within fuel.	2. Bleed air, thoroughly precipitated fuel.
3. Incorrect engine alignment, bedplate bolts loosen.	3. Check over engine alignment, uniformly tighten bolts.
4. Engine knocking, running roughly.	4. Check the injection advance angle, loading after engine "Warm up".
F. Engine Overheating	
1. Fuel drop enter crankcase, or water within oil, oil become diluted, oil quantity not enough or too much; unsufficient oil flow quantity; low oil pressure; bearing fitting clearance too small.	1. Inspect and replace piston ring, change oil, check oil level; inspect the wearing valve of the external and internal gears of gear pump check and adjust the fitting clearance of bearing.
2. The impeller of water pump broken; sliding occurred between the fan-wheel and V-belt, the location of air fan and water tank (radiator) not well-matched, thermostat faulty, cooling water system chocking, the thickness of water filth on jacket too thick, unenough water pump flow, unenough water quantity, cylinder head gasket worn, hot (combustion) gas entered water channel.	2. Inspect & repair the impeller of water pump; check tesile of far driving belt, or replace belt; inspect water tank mounting location, inspect thermostat performent; clean cooling water system and water jacket; check water pump impeller clearance pouring water tank with enough quantity water, change the cylinder head gasket.

G. Abnormal Oil Pressure	
I. Oil pressure can't build up	
1. Lubricating oil level in oil sump too low, oil dilution.	1. Fill with enough oil; Change the oil.
2. Oil piping broken, piping joint untightening and oil leakage; oil pressure gauge damage.	2. Welding, tightening; replace.
3. Oil pump adjusting spring distorted or broken.	3. Replace.
4. Oil pump clearance too large.	4. Repair or replace.
5. Oil pump packing shim broken.	5. Replace.
6. The fitting clearance of bearings too large.	6. Inspect, adjust or replace.
7. Oil channel plug loosen and leak.	7. Inspect and seal.
II. Oil pressure too high	
1. Abnormal operating of pressure regulating valve of oil pump, oil backflow unstable.	1. Inspect and adjust.
2. Ambient temperature too low, oil viscosity too high.	2. Employ oil with recommended grade.
III. Oil can't be pressed to the rocker arm shaft	
1. The oil channel of the upper cylinder lid and the oil hole at the bottom of the rocker arm shaft clogged.	1. Clean & dredge.
H. Excessive consumption of lubricating oil	
1. The employing oil viscosity too low, incorrect oil grade.	1. Change with recommended grade oil.
2. Piston and cylinder liner excessively worn; oil returned holes on the piston ring grove blocked by carbon deposted.	2. Replace; clean oil returned holes on the piston.
3. Piston ring stuck, compression ring assembly turn reverse and excessively worn.	3. Clean and replace.
4. Oil leakage from the front and wear end oil seals of crankshaft, oil sump and sidecover seal shims.	4. Check and replace.
5. Oil vaporization and splash due to the oil temperature and pressure are too high.	5. Lowering temperature, check and readjust the pressure regulation valve of oil pump.
I. Overspeeding	
1. Governer out of order, the pull rod of injection pump stuck in high fuel deliverating position.	1. Dismental and repair governer and its rod.
2. The driving sleeve of governer stucked.	2. Inspect and repair.
3. Adjust arm gets off from the fork.	3. Inspect and repair.
4. Oil scurry up too much.	4. Ref. this chapter No. H.

J. Engine Stalls	
1. Air within oil system, fuel feed pump out of order; fuel filter clogged.	1. Bleed air, check and repair fuel feed pump, clean fuel filter.
2. Piston seized in the cylinder; crank journal seized with bearing shell.	2. Incorrect fitting clearance, repair or replace.
3. Fuel delivery valve of injection pump seized, plunger spring damage, the sliding sleeve of governer seized.	3. Repaire and replace.
K. Engine Hunting	
1. Uneven fuel distribution to cylinders, fuel drips from the nozzle, pull rod fork screw loosen.	1. Readjust the fuel distribution, repair or re replace injector needle valve, fixing fork screw.
2. The clearance between fork and adjusting arm too large. Steel balls and sliding disc worn out and cave occurred.	2. Replace component.
3. The axial clearance of injection pump cramshaft too large.	3. Adjust with cupper washer.
1. The sleeve of sliding disc stuck	1. Clean, inspect and replace.
L. Rising of oil level in oil sump	
1. The water sealing ring of liner damaged.	1. Replace water sealing ring.
2. Cylinder head gasket damaged.	2. Replace cylinder head gasket.
3. Crank occurred at cylinder head and engine block.	3. Check, repair and replace.

Appendix I Fitting Clearance and Wear Limits of the Main Moving Parts

Item №.	Designation	Standard Dimensions	Standard Clearance	Wear Limits
1.	Main bearing bore and main journal	$\varnothing 80^{+0.122}_{+0.070}$ / $\varnothing 80^{-0.010}_{-0.029}$	0.080—0.151	0.25
2.	Connecting rod bearing bore and crankpin diameter	$\varnothing 65^{+0.085}_{+0.060}$ / $\varnothing 65^{0}_{-0.019}$	0.060—0.104	0.25
3.	Width of main journal and width of thrust main bearing		Axial 0.165—0.306	0.40
4.	Width of crank pin and width of connect rod big end bearing		Axial 0.180—0.342	0.40
5.	Cylinder liner bore and piston skirt diameter	$\varnothing 100^{+0.035}_{0}$ / $\varnothing 100^{-0.14}_{-0.17}$	0.14—0.205	0.30
6.	Connect rod small end bush bore and piston pin diameter	$\varnothing 35^{+0.045}_{+0.020}$ / $\varnothing 35^{0}_{-0.011}$	0.020—0.056	0.12
7.	1st. piston ring groove and 1st. piston ring		Axial 0.050—0.062	0.20
8.	2nd. piston ring groove and 2nd. piston ring		Axial 0.030—0.062	0.15
9.	Oil ring groove and oil ring		Axial 0.030—0.062	0.20
10.	1st. piston ring gap in bore	Gauge $\varnothing 100^{+0.04}_{+0.03}$	0.3—0.5	2.0

Item No.	Designation	Standard Dimensions	Standard Clearance	Wear Limits
11.	2nd. piston ring gap bore	Gauge ϕ 100 $^{+0.04}_{+0.03}$	0.25－0.40	2.0
12.	Oil scraper ring gap in bore	Gauge ϕ 100 $^{+0.04}_{+0.03}$	0.25－0.40	2.0
13.	Camshaft bushing bore and camshaft journal	ϕ 52 $^{+0.030}_{0}$ / ϕ 52 $^{-0.06}_{-0.09}$	0.06－0.12	2.0
14.	Camshaft thrust surface and camshaft thrust plate surface	12 $^{+0.20}_{+0.10}$ / 12 $^{-0.06}_{-0.12}$	Axial 0.16－0.32	0.45
15.	Depth of cylinder block spigot and height of cylinder liner collar	8 $^{-0.07}_{-0.15}$ / 8 $^{+0.036}_{0}$	Protude 0.070－0.186	
16.	Valve tappet guide hole and valve tappet diameter	ϕ 16 $^{+0.027}_{0}$ / ϕ 16 $^{-0.025}_{-0.040}$	0.025－0.067	2.0
17.	Idle gear bush hole and idle gear journal	ϕ 45 $^{+0.025}_{0}$ / ϕ 45 $^{-0.025}_{-0.05}$	0.025－0.075	0.25
18.	Idle gear journal thrust surface and width of idle gear	28.5 $^{+0.10}_{0}$ / 28.5 $^{-0.15}_{-0.25}$	Axial 0.15－0.35	0.45
19.	Valve guide hole and valve stem diameter	ϕ 9 $^{+0.036}_{0}$ / ϕ 9 $^{-0.040}_{-0.055}$	0.040－0.091	0.15
20.	Rocker arm bushing and rocker arm shaft diameter	ϕ 16 $^{+0.043}_{+0.016}$ / ϕ 16 $^{0}_{+0.018}$	0.016－0.061	0.20
21.	End clearance of rotors of oil pump		Adjust 0.05－0.12	
22.	Radial clearance of rotor of oil pump		0.07－0.18	
23.	Backlash of gears		0.13－0.20	0.40

Appendix Ⅱ Specifications of Main Accessory Parts

Item No.	Diesel Engine Model		SL2100	SL3100	SL4100
1.	Injection pump	Model	No. 1 series pump		
			2114—left 1400	3114—left 1400	4114—left 1400
		Plunger diameter	8 mm		
		Governor type	T7B whole range mechanical centrifugal type		
2.	Injector	Model	P662		
		Nozzle type	ZS4S1A or ZS4 S1		
		Injection pressure	12753+491 (130+5) Kpa (kgf/cm²)		
3.	Lubricating oil pump	Model and type	JZX 1435 Internal & External Rotor Type		
		Speed	1400 r/min	1500 r/min	1600 r/min
		Displacement	14 liter/min	22 liter/min	24 liter/min
		Pressure	196.1—441.3 (2—4.5) Kpa (kgf/cm²)		
4.	Cooling water pump	Model	Centrifugal type		
		Speed	2800 r/min	3000 r/min	3200 r/min
		Displacement	75 liter/min	110 liter/min	117 liter/min
5.	Air cleaner	Model	K1712		
6.	Lubricating Oil filter	Model	J0708		J0810
7.	Fuel filter	Model	Diesel 0708 Paper Cartridge		C0708A

Item No.	Diesel Engine Model		SL2100	SL3100	SL4100
8.	Starting motor	Model	2Q2CA	QD1302A	3Q5
		Power	1.84 (2.5) KW(ps)	2.5 (3.4) KW(ps)	3.68 (5) KW(ps)
		Voltage	12V		24V
9.	Generator	Model	JF11AS		JF12A
		Power	350W		350W
		Voltage	14.4V		28V
10.	Voltage regulator	Model	FT111 (or FT-70)		FT-70A
		Reted voltage	14V		24V
11.	Heating plug	Model and type	M10X65 Mini closed heating plug		
			12V		24V

ENGINE

PARTS

LIST

SECTION