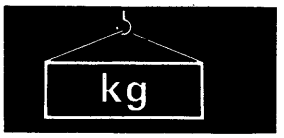
CONTENTS

HOISTING INSTRUCTIONS



⚠ Heavy parts (25 kg or more) must be lifted with a hoist etc. In the **Disassembly and Assembly** section, every part weighing 25 kg or more is indicated clearly with the symbol kg

1. If a part cannot be smoothly removed from the machine by hoisting, the following checks should be made:
   - Check for removal of all bolts fastening the part to the relative parts.
   - Check for existence of another part causing interference with the part to be removed.

2. Wire ropes

1) Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

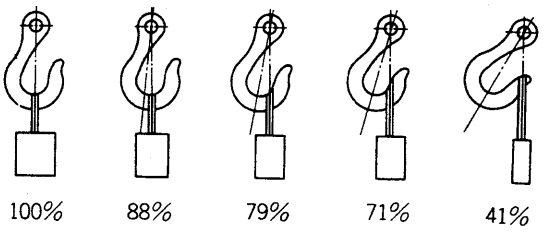
Wire ropes
(Standard "Z" or "S" twist ropes without galvanizing)

Rope diameter (mm)	Allowable load (tons)
10	1.0
11.2	1.4
12.5	1.6
14	2.2
16	2.8
18	3.6
20	4.4
22.4	5.6
30	10.0
40	18.0
50	28.0
60	40.0

The allowable load value is estimated to be one-sixth or one-seventh of the breaking strength of the rope used.

2) Sling wire ropes from the middle portion of the hook.

Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



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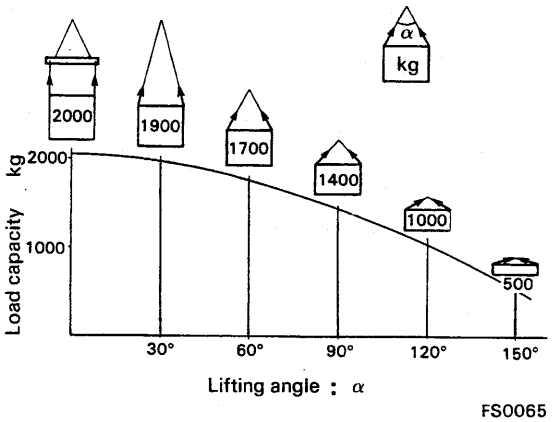
3) Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound on to the load.

⚠ Slinging with one rope may cause turning of the load during hoisting, untwisting of the rope, or slipping of the rope from its original winding position on the load, which can result in a dangerous accident.

4) Do not sling a heavy load with ropes forming a wide hanging angle from the hook.
When hoisting a load with two or more ropes, the force subjected to each rope will increase with the hanging angles. The table below shows the variation of allowable load (kg) when hoisting is made with two ropes, each of which is allowed to sling up to 1000 kg vertically, at various hanging angles.
When two ropes sling a load vertically, up to 2000 kg of total weight can be suspended. This weight becomes 1000 kg when two ropes make a 120° hanging angle. On the other hand, two ropes are subjected to an excessive force as large as 4000 kg if they sling a 2000 kg load at a lifting angle of 150°.



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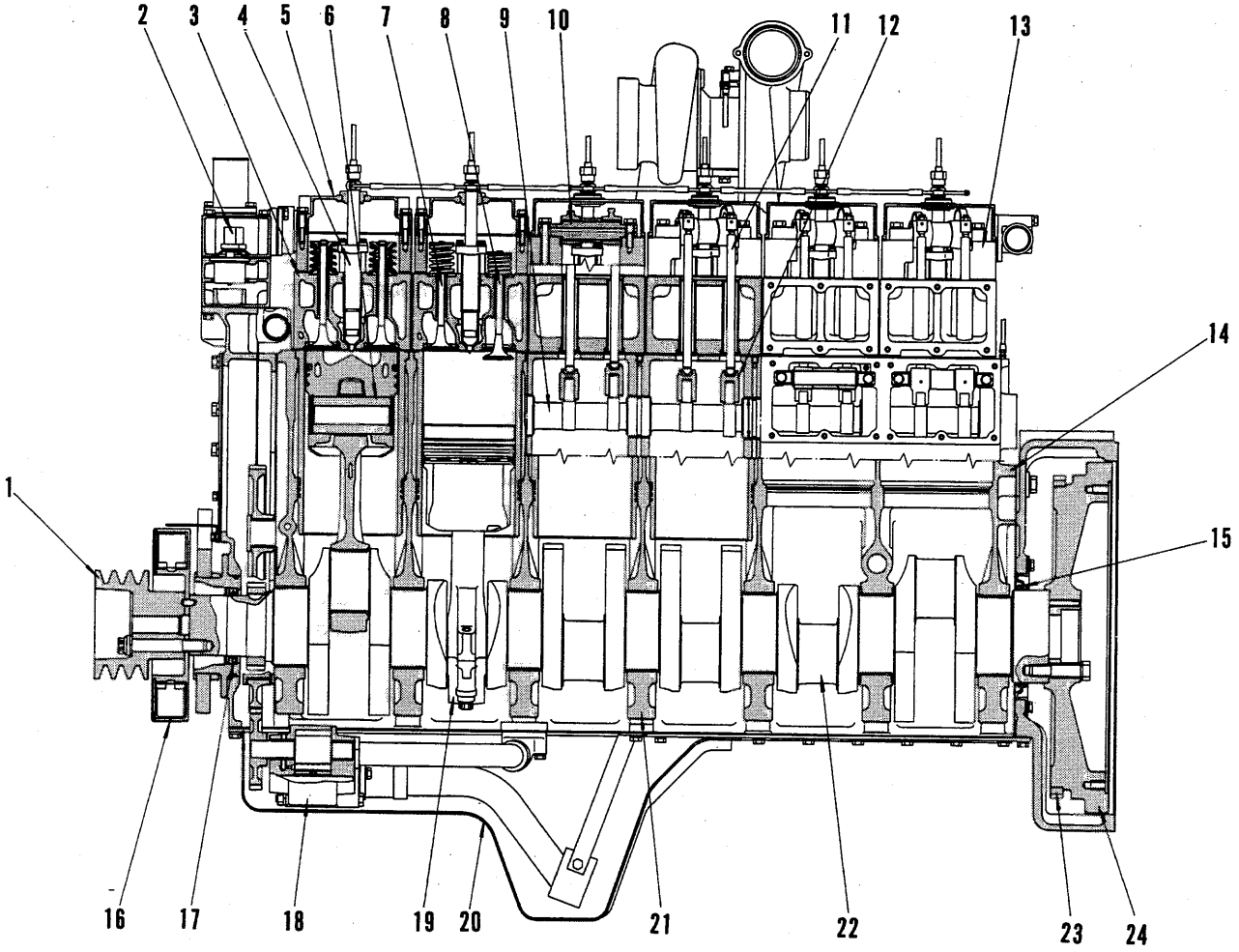
GENERAL STRUCTURE

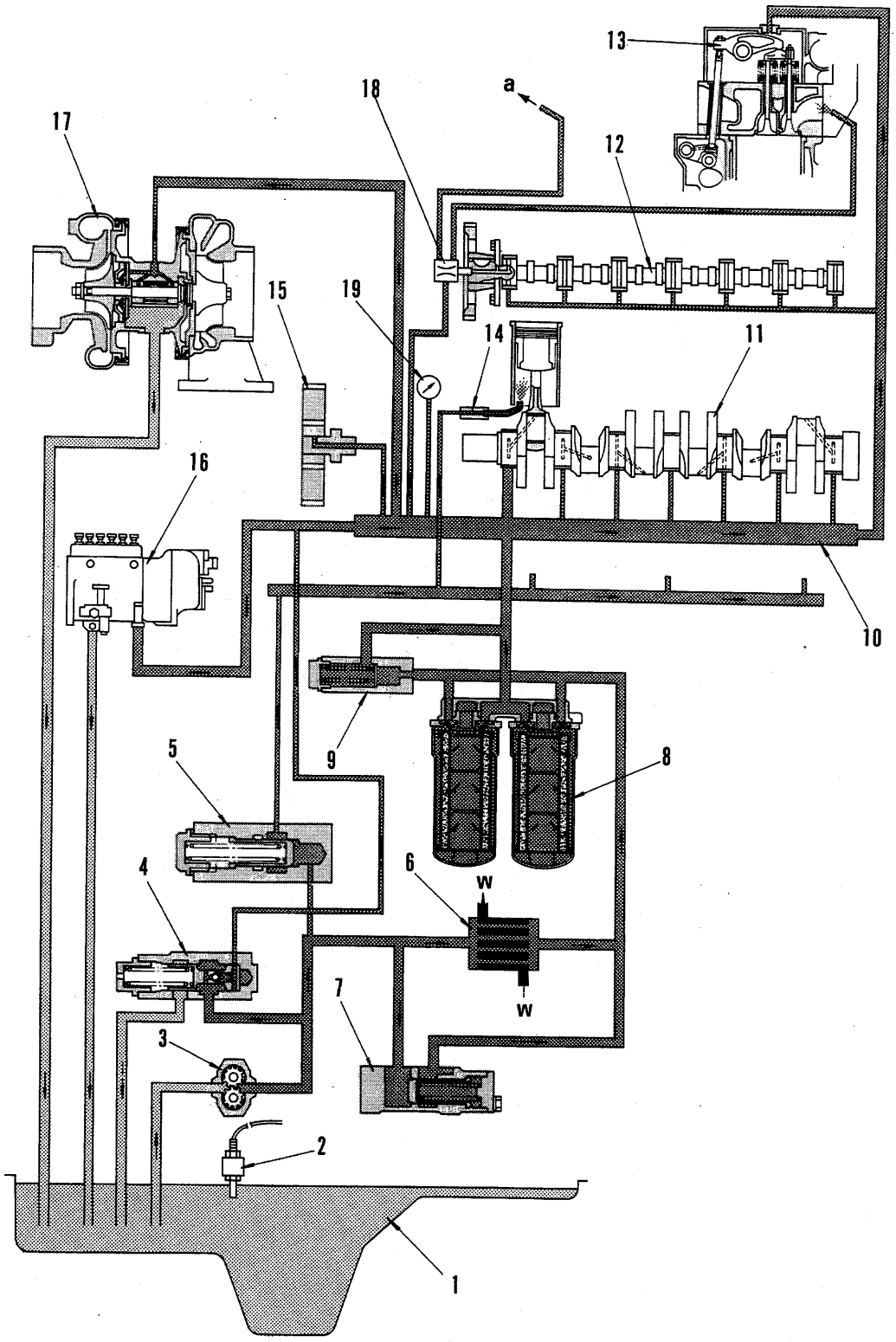


6162F101

1. Crank pulley
2. Thermostat
3. Cylinder head
4. Fuel injection nozzle
5. Rocker arm housing cover
6. Piston pin
7. Intake valve
8. Exhaust valve
9. Camshaft
10. Rocker arm shaft
11. Push rod
12. Tappet
13. Rocker arm housing
14. Cylinder block
15. Rear seal
16. Vibration damper
17. Front seal
18. Oil pump
19. Connecting rod cap
20. Oil pan
21. Main bearing cap
22. Crankshaft
23. Ring gear
24. Flywheel

LUBRICATION SYSTEM

LUBRICATION SYSTEM CHART



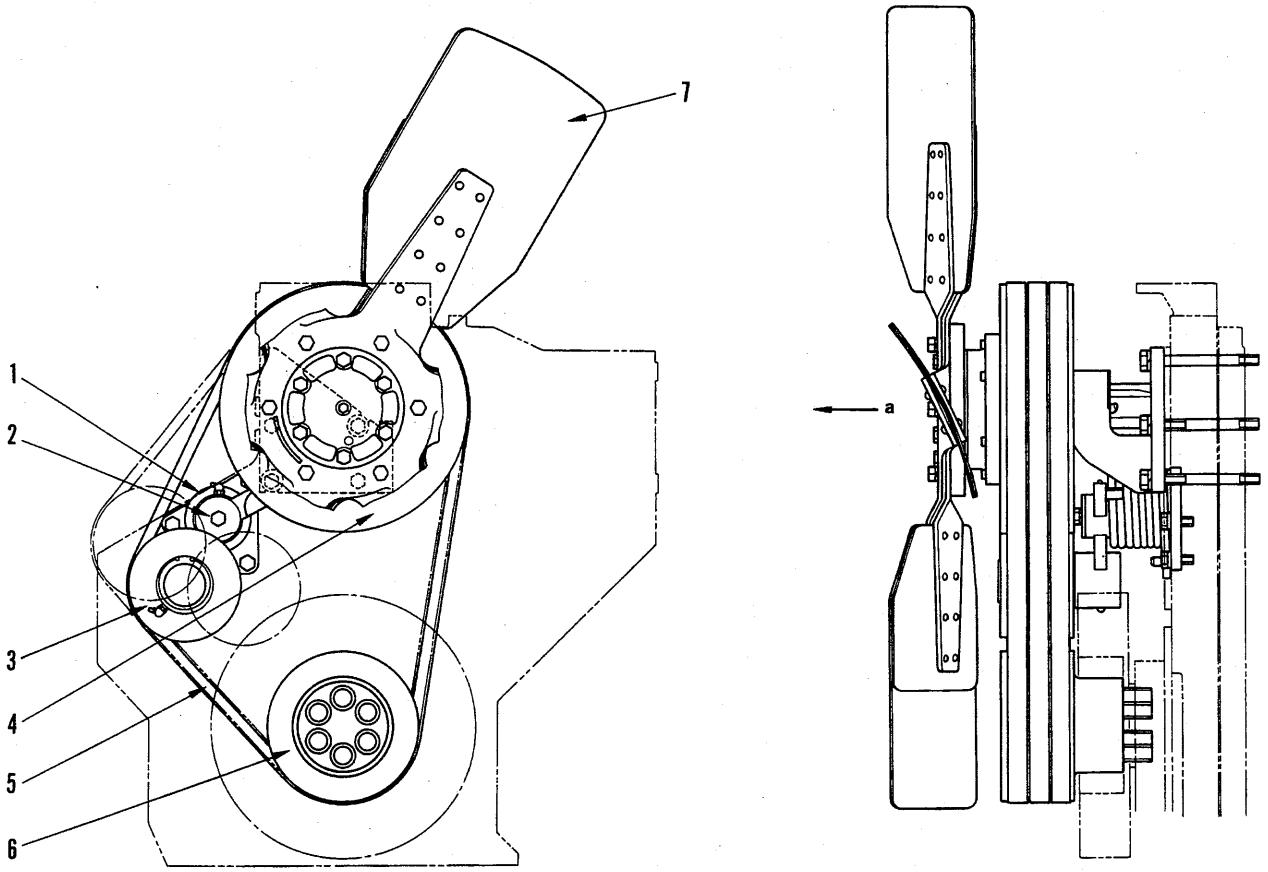
6162F123 A

1. Oil pan
2. Oil level sensor
3. Oil pump
4. Main relief valve
5. Piston cooling valve
6. Oil cooler
7. Oil cooler by-pass valve
8. Oil filter
9. Safety valve
10. Main gallery
11. Crankshaft
12. Camshaft
13. Rocker arm
14. Piston cooling nozzle
15. Timing gear
16. Fuel injection pump
17. Turbocharger
18. Mechanical pump
19. Oil pressure gauge

a. To intake manifold

w. Coolant

(For generators)



1. Tension spring
2. Tension shaft
3. Tension pulley (Outside diameter: 150 mm)
4. Fan pulley (Outside diameter: 332 mm)
5. Fan belt
6. Crankshaft pulley (Outside diameter: 200 mm)
7. Fan

a. Direction of wind

TESTING AND ADJUSTING TOOL LIST

No.	Inspection and measuring item	Fault finding tool	Part No.	Remarks
1	Engine speed	Multi-tachometer	799-203-8000	Digital reading, pressure sensing type 60 to 20,000 rpm
2	Battery S.G.	Battery · coolant tester	795-500-1000	1.100 to 1.300
3	Freezing temperature of cooling water			−5°C to −50°C
4	Water temperature, oil temperature, air intake temperature	Thermistor temperature gauge	790-500-1300	0 to 200°C
5	Exhaust temperature			0 to 1,000°C
6	Lubrication oil pressure	Engine pressure measuring kit	799-203-2002	0 to 10 kg/cm²
7	Fuel pressure			0 to 20 kg/cm²
8	Intake pressure, exhaust pressure			0 to 1,500 mmHg
9	Blow-by pressure			0 to 1,000 mmH_2O
10	Air intake resistance			−1,000 to 0 mmH_2O
11	Compression pressure	Compression gauge kit	795-502-1205	0 to 70 kg/cm²
12	Blow-by pressure	Blow-by checker	799-201-1503	0 to 500 mmH_2O
13	Valve clearance	Feeler gauge	795-125-1340	0.4, 1.0 mm
14	Exhaust gas color	Handy smoke checker	799-201-9000	Dirtiness 0 to 70% with standard color (Dirtiness % x 1/10 ≒ Bosch scale)
15	Water and fuel content in oil	Engine oil checker	799-201-6000	Provided with 0.1 and 0.2% water content standard samples.
16	Fuel injection pressure	Nozzle tester	Commercially available	0 to 300 kg/cm²
17	Fuel injection nozzle spray condition			
18	Coolant quality	Water quality tester	799-202-7001	pH, nitrite ion concentration
19	Pressure valve performance	Radiator cap tester	799-202-9001	0 to 2 kg/cm²
20	Leakage in cooling water system			
21	Radiator blockage (wind speed)	Anemometer (Air speed gauge)	799-202-2001	1 to 40 m/s
22	Engine cranking	Cranking kit	795-610-1000	DC24V with starting engine
		Barring device	6162-23-4820	For 6D170-1 series engine
23	Electrical circuits	Tester	Commercially available	Current, voltage, resistance

13. Oil in cooling system.

	Cause	Remedy
a	Pipe broken in oil cooler, O-ring damaged	X
b	Head gasket damaged	X
c	Cylinder head cracked	X
d	Cylinder block cracked	X

14. Water temperature does not rise.

Water temperature gauge indicator is to left of "green range".

★ In cold weather operation, if reversible fan and radiator shutters are not fitted, the engine may not warm up.

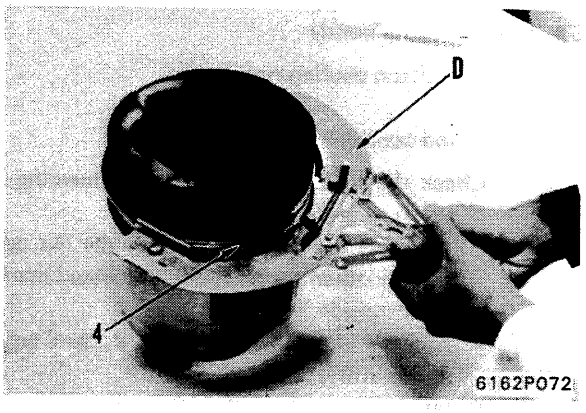
No.	Problems / Remedy	Thermostat defective (stays open) a	Water temperature gauge defective b
1	Water temperature rises if gauge is replaced.		○
2	When thermostat is removed, it is found to stay open; or performance test shown cracking temperature is too low.	○	

The following symbols are used to indicate the action to be taken when a cause of failure is located.

X: Replace Δ: Repair
A: Adjust C: Clean

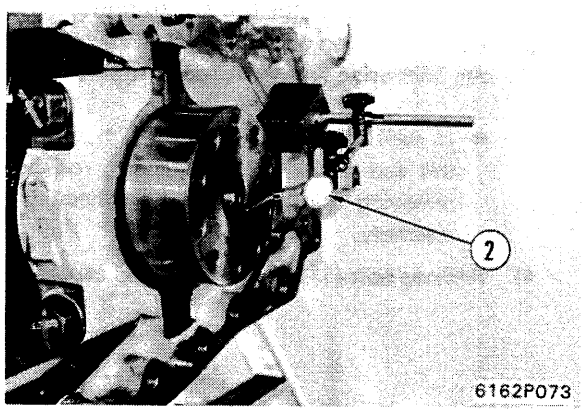
iii) Remove piston ring (4) using tool **D**.

★ Arrange the piston, connecting rod, bearing, piston ring and piston pin of each cylinder No. together.



54. Crankshaft assembly

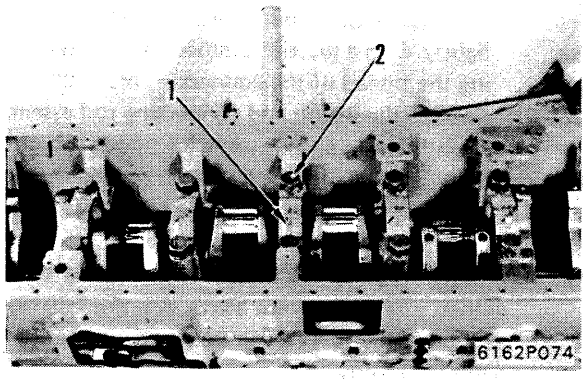
★ If necessary, use dial gauge ② to measure the end play of the crankshaft before removing the crankshaft assembly.



1) Remove mounting bolt (2) of main bearing cap (1).

2) Install bolt into the main bearing cap hole, and remove the cap while moving it.

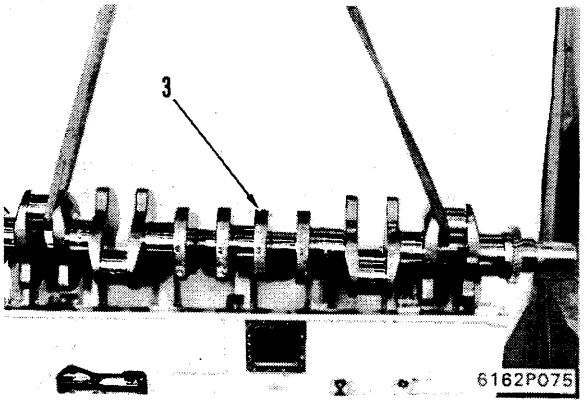
★ Check the position of thrust bearing installed the No. 6 main bearing cap.



3) Lift out crankshaft (3) using nylon sling.

kg Crankshaft assembly: 260 kg

4) Remove upper bearing.

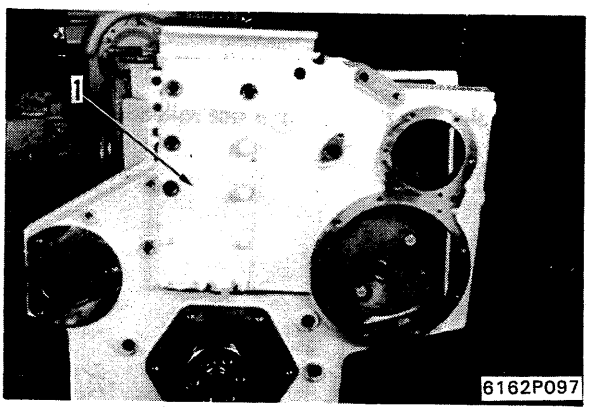


13. Gear cover

1) Stick the gasket to the fitting face of the gear cover.
2) Install gear cover (1).

★ Check the difference in level between the gear case, gear cover, and the bottom face of the cylinder block.

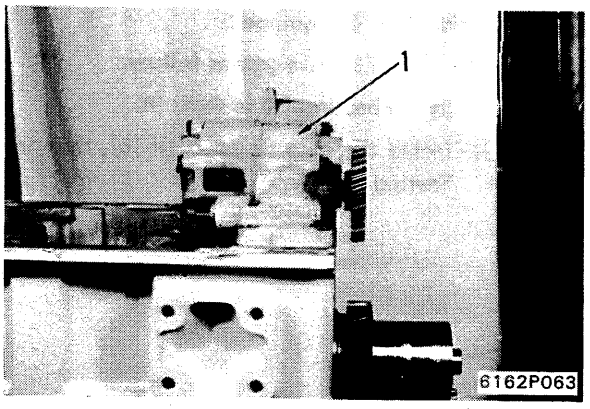
★ Difference in level of bottom face: 0.15 mm or less



14. Oil pump

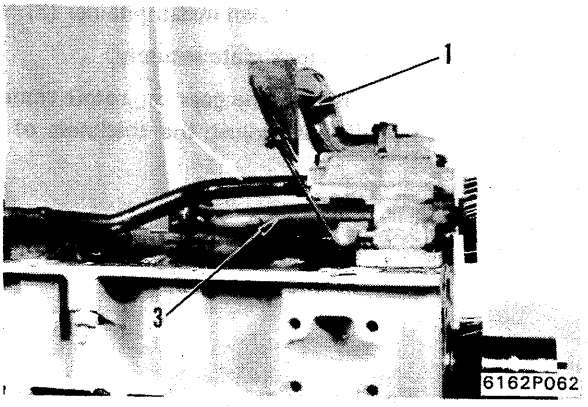
Install oil pump (1).

kgm Oil pump mounting bolt: 11 ± 1.5 kgm



15. Piping for oil pump

Install the gasket and O-ring, then install tube (3).



16. Strainer

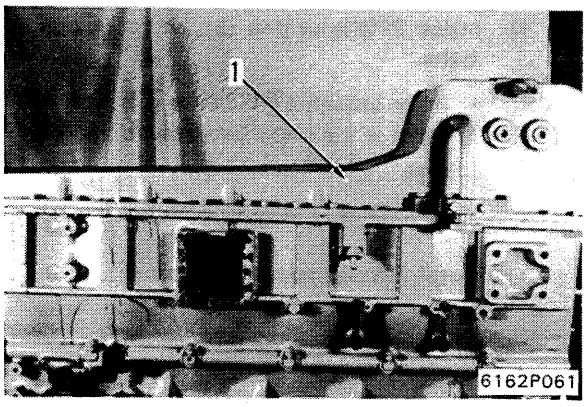
Install the gasket, then install strainer (1) and secure it with the bracket.

17. Oil pan

★ Before installing the oil pan, cut off the gaskets of the flywheel housing, gear case, and gear cover so that they are the same level as the cylinder block.

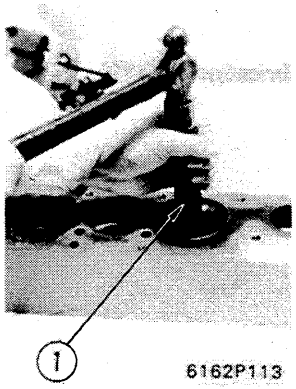
Apply liquid gasket to the face of the oil pan, and install oil pan (1).

Face of oil pan: Liquid gasket (LG-7)



40. Thermostat case

1) Assemble the thermostat case according to the following procedure.
   i) Install thermostat seal (3) with press-fit kit ①.
   ii) Install thermostat and gasket, then install the case cover.
2) Install thermostat case.



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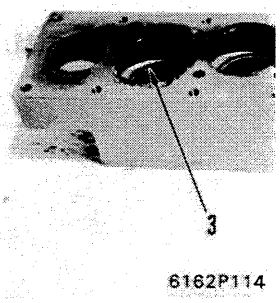
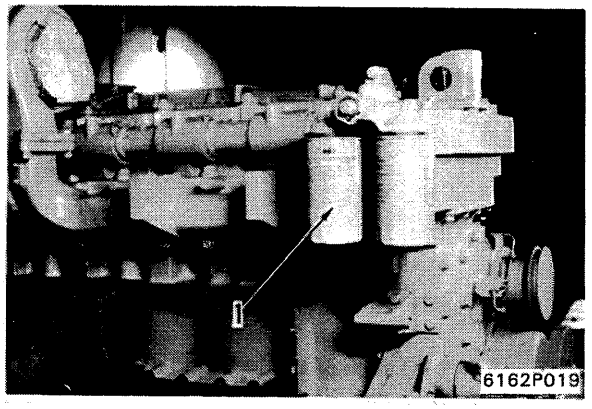


6162P114

41. Corrosion resistor

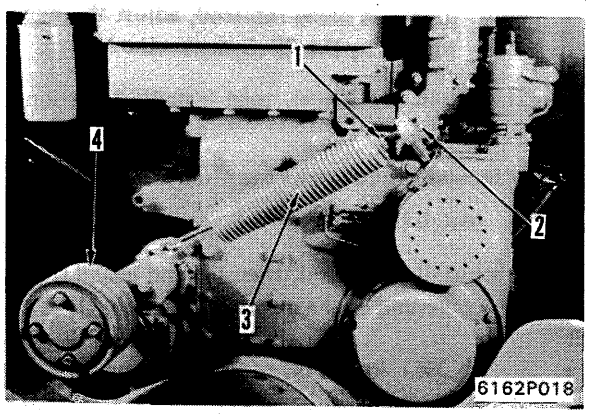
Install corrosion resistor (1).



6162P019

42. Tension pulley and tension spring

1) Install the spacer, then install tension pulley (4).
2) Install tension spring (3) and tighten bolt (2), then secure them with locknut (1).
   ★ The tension spring will be adjusted according to the tension of the fan belt after the engine assembly is mounted.



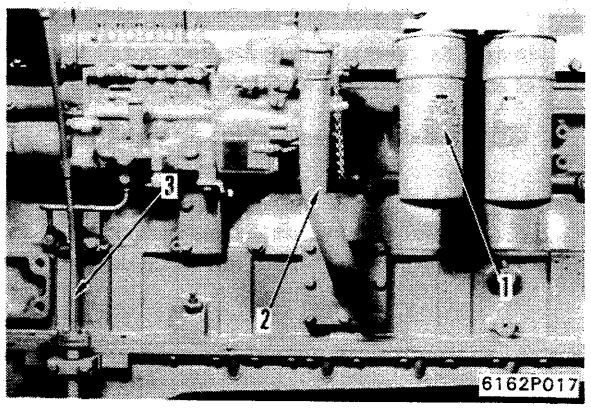
6162P018

43. Oil filler and level gauge guide

1) Install the gasket, and then install level gauge guide (3).
2) Install the gasket, then install oil filler (2).

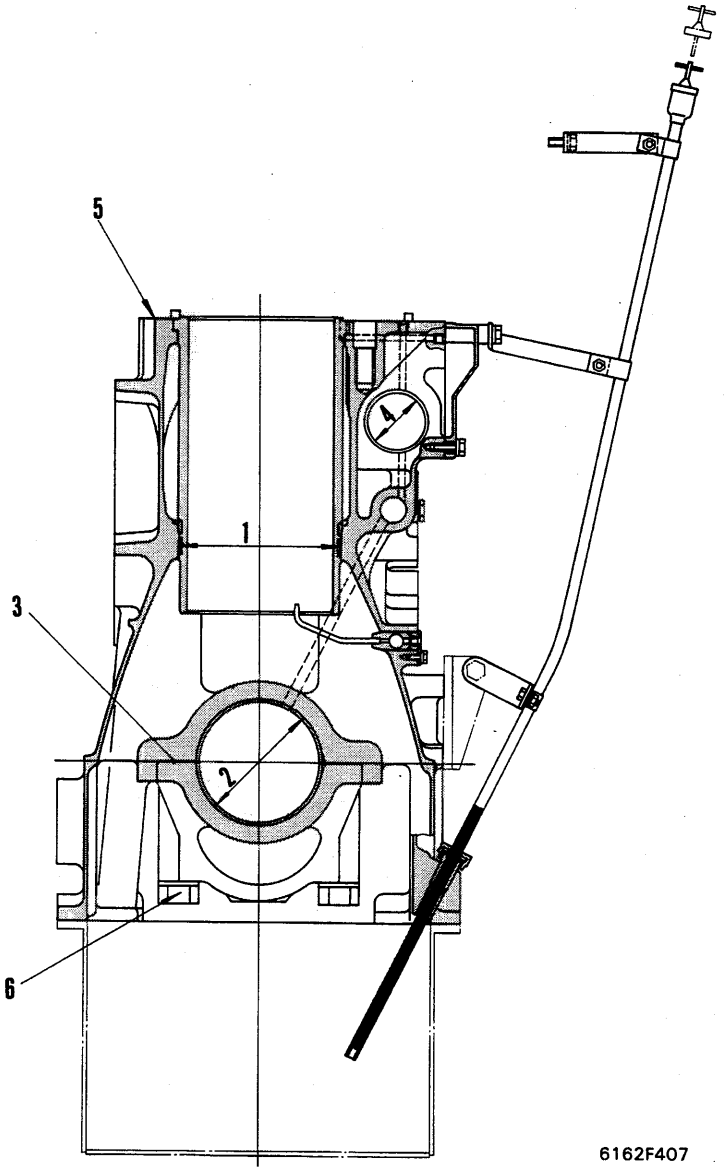
44. Oil filter assembly

Install the O-ring and bracket, then install oil filter assembly (1).



6162P017

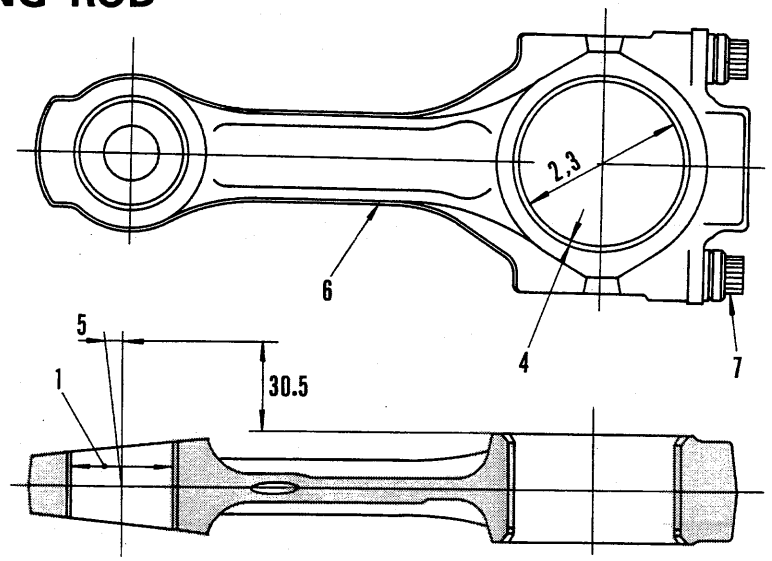
CYLINDER BLOCK



Unit: mm

No.	Check item	Criteria					Remedy
1	Clearance between cylinder block and liner	Standard size	Tolerance		Standard clearance	Clearance limit	Replace cylinder liner or block
			Inside diameter of block	Outside diameter of liner			
		190			0.050 to 0.160		
2	Inside diameter of main bearing hole	Standard size		Tolerance		Repair limit	Repair or replace
		148		+0.025 0		–	
	Thickness of main bearing	4		−0.040 −0.050		3.90	
	Inside diameter of main bearing	140		+0.125 +0.075		140.20	

CONNECTING ROD

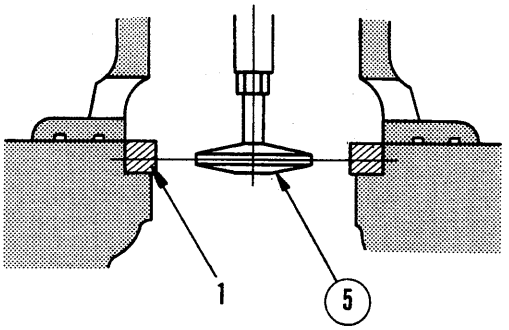


6162F413 Unit: mm

No.	Check item	Criteria				Remedy
1	Clearance between connecting rod bushing and piston pin	Standard size	Tolerance		Standard clearance	Clearance limit	Replace
			Shaft	Hole		
		68	0 −0.060	+0.070 +0.050	0.050 to 0.075	0.11
2	Inside diameter of connecting rod big end	Standard size		Tolerance		
		115		+0.025 0		
3	Clearance between inside diameter of connecting rod big end and crankshaft journal	Standard clearance		Clearance limit		
		0.060 to 0.130		0.30		
4	Connecting rod bearing thickness (Center)	Size	Standard size	Tolerance	Repair limit	
		S. T. D.	3.500	−0.040 −0.030	3.41	
		0.125US	3.625		3.54	
		0.250US	3.750		3.66	
		0.375US	3.875		3.79	
		0.500US	4.000		3.90	
5	Bend or twist of connecting rod	Repair limit of bend: 0.10 Repair limit of twist: 0.25				
6	Connecting rod weight	10.15 ± 0.03 kg				
7	Tightening torque of connecting rod cap (Coat bolt and nut threads with engine oil)	Order	Target (kgm)	Range (kgm)		Tighten
		1st	28	25 to 31		
		2nd	56	53 to 59		
		3rd	Loosen completely			
		4th	14	11 to 17		
		5th	28	25 to 31		
		6th	56	53 to 59		

iii) Adjust the position of the grinder so that the center of grindstone ⑤ will be at the center of seat insert (1), then tighten the set screw to secure the grinder.

iv) Fully open the throttle of the grinder to rotate the grindstone and slowly move it until it contacts insert (1).



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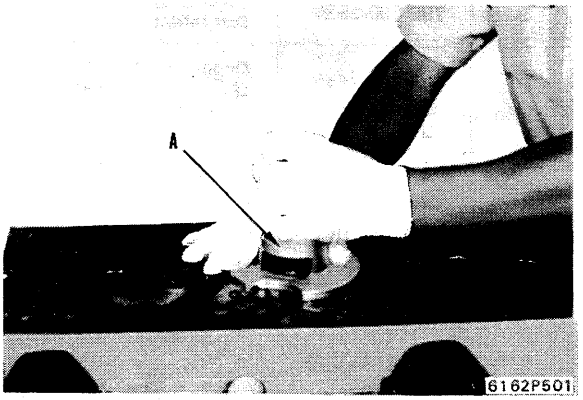
v) Press the grindstone against the inside of the insert, move it in a circular pattern, and make a groove about 1 mm deep.



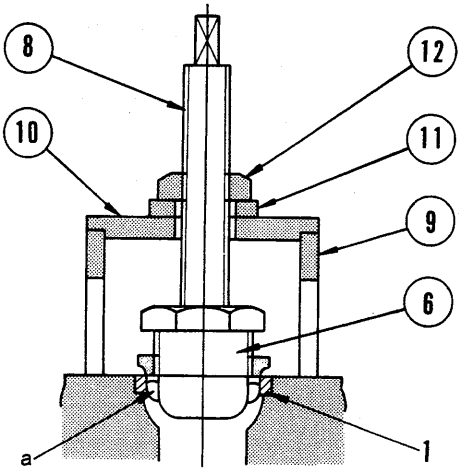
2) Pull out the insert with the puller head of valve seat puller **A** according to the following procedure.

i) Push three claws (a) of puller head ⑥ inward by hand and put them in insert (1).

ii) Tighten screw ⑧ to press the three claws against the groove on the inside surface of the insert.

★ If the screw is tightened too strongly, the insert will break and it will be difficult to pull it out. Therefore, stop tightening the screw when the claws compretely contact the groove.

iii) Place bridge ⑨ over the puller head, then place plates ⑩ and ⑪ on the bridge. Tighten nut ⑫ to pull out the insert.



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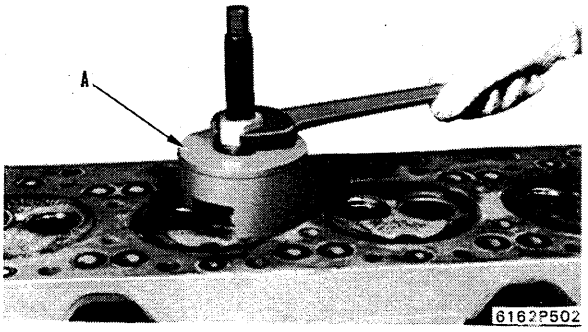
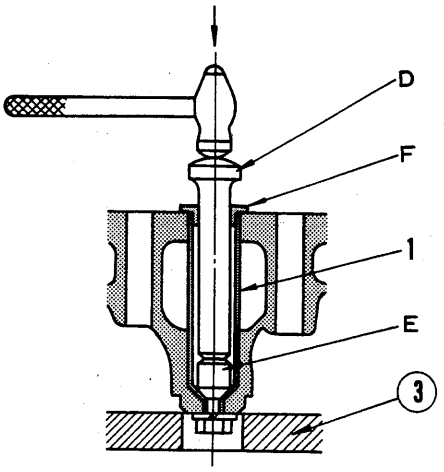


4. Calking the sleeve seat face

1) Fit the sleeve seat with sleeve holder **E**.

kgm Tightening torque for sleeve holder: 2 kgm.

2) Install punch bushing **F** and insert sleeve driver **D**.
3) Place support ③ under the cylinder head to allow the bolt of the sleeve holder to move out.
4) Hit the sleeve driver with a hammer to calk the seat surface.
   ★ Lightly hit with a hammer several times.
5) Remove the sleeve holder and punch bushing.



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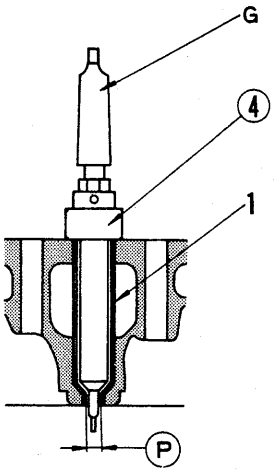
5. Roll-fit the bottom hole of sleeve

- Using sleeve rolling tool **G**, roll-fit bottom hole Ⓟ of sleeve (1).
  ★ Adjust the roll-fitting height with bearing collar ④ so that the shaft of the rolling tool will protrude a little from the bottom hole.
  ★ Install the rolling tool to a radial drilling machine or upright drilling machine to roll-fit with its own weight.
  ★ **Rotating speed: 200 to 300 rpm**



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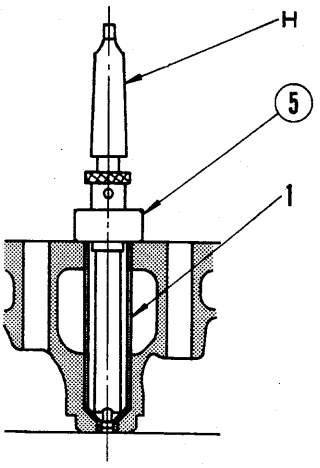
6. Roll-fitting the taper section of sleeve

- Using sleeve expander **H**, roll-fit the taper section of the sleeve.
  ★ Set the roll-fitting amount with stopper ⑤ of the expander.
  ★ Install the expander to a radial drilling machine or upright drilling machine to roll-fit with its own weight.
  ★ **Rotating speed: 200 to 300 rpm**



6162F513

REPLACING MAIN METAL CAP

★ When replacing the main metal cap, machine the semi-finished part according to the following procedure.

1. Machining the bore of main metal cap

1) Remove the cylinder liner.
2) Install the replacement metal cap to the cylinder block and tighten it to specification.

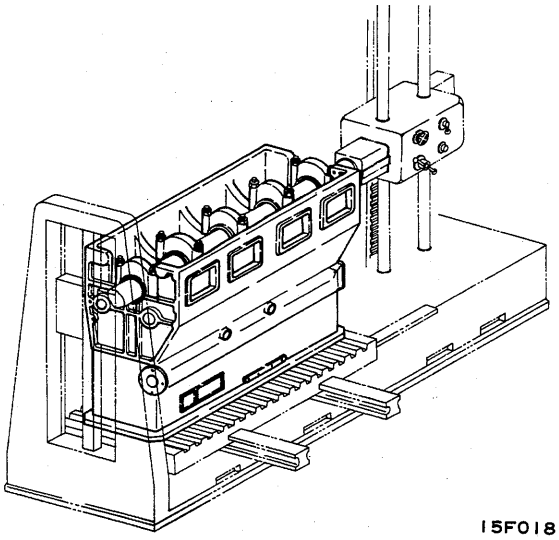
kgm Mounting bolt for main metal cap:

Unit: kgm

Step	Target	Range
1st	56	51 – 61
2nd	113	107 – 118
3rd	0	Completely loosen
4th	38	33 – 43
5th	75	70 – 80
6th	113	107 – 118

★ Align the notches on the cylinder block and cap.

3) Set the jig for mounting the cylinder block to the table of a horizontal boring machine. Install the cylinder block by mounting its hole for the liner to the datum plug of the jig.



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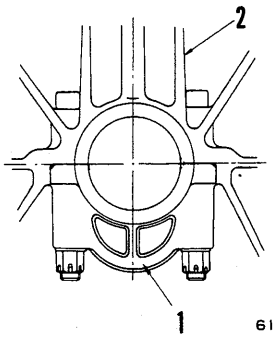
4) Center the arbor of the boring machine by applying a dial gauge to the inside wall of the two metal caps which have the largest pitch in the metal caps to be used again.

5) Cut the inside of metal cap (1) little by little while checking its inside diameter.
★ Cut until the cutting tool contacts the inside wall of cylinder block (2).
★ **Inside diameter of main cap:**
$148^{+0.025}_{0}$ mm
★ **Surface roughness: 3.3S max.**
★ Never cut the inside wall of the cylinder block.



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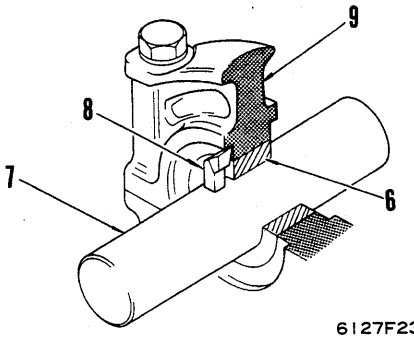
2. Correcting the width of the main metal cap

1) Insert cast iron bushing (6), and pass arbor (7) through.
2) Install facing tool (8) to the arbor.
3) Cut cap (9) until the cutting tool contacts the cylinder block.
4) Cut the opposite side in the same way.
★ **Width of main cap:** $56^{0}_{-0.030}$ mm
★ **Roughness of surface facing thrust metal: 12.5S max.**
★ Never cut the cylinder block.



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