

SEBES6161000

**OEM USE**

# SHOP MANUAL

**KOMATSU**

# 6D170-1 SERIES

## DIESEL ENGINE

APPLICABLE  
ENGINE MODELS

**S6D170-1**

**SA6D170-B-1**

**SA6D170-A-1**

 **KOMATSU**



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## IMPORTANT SAFETY NOTICE

Proper service and repair is extremely important for the safe operation of your machine. The service and repair techniques recommended by Komatsu and described in this manual are both effective and safe methods of operation. Some of these operations require the use of tools specially designed by Komatsu for the purpose.

To prevent injury to workers, the symbols  and  are used to mark safety precautions in this manual. The cautions accompanying these symbols should always be followed carefully. If any dangerous situation arises or may possibly arise, first consider safety, and take the necessary actions to deal with the situation.

## SAFETY

### GENERAL PRECAUTIONS

Mistakes in operation are extremely dangerous. Read the Operation and Maintenance Manual carefully BEFORE operating the machine.

1. Before carrying out any greasing or repairs, read all the precautions given on the decals which are fixed to the machine.
2. When carrying out any operation, always wear safety shoes and helmet. Do not wear loose work clothes, or clothes with buttons missing.
  - Always wear safety glasses when hitting parts with a hammer.
  - Always wear safety glasses when grinding parts with a grinder, etc.
3. If welding repairs are needed, always have a trained, experienced welder carry out the work. When carrying out welding work, always wear welding gloves, apron, glasses, cap and other clothes suited for welding work.
4. When carrying out any operation with two or more workers, always agree on the operating procedure before starting. Always inform your fellow workers before starting any step of the operation. Before starting work, hang UNDER REPAIR signs on the controls in the operator's compartment.
5. Keep all tools in good condition and learn the correct way to use them.

6. Decide a place in the repair workshop to keep tools and removed parts. Always keep the tools and parts in their correct places. Always keep the work area clean and make sure that there is no dirt or oil on the floor. Smoke only in the areas provided for smoking. Never smoke while working.

### PREPARATIONS FOR WORK

7. Before adding oil or making any repairs, park the machine on hard, level ground, and block the wheels or tracks to prevent the machine from moving.
8. Before starting work, lower blade, ripper, bucket or any other work equipment to the ground. If this is not possible, insert the safety pin or use blocks to prevent the work equipment from falling. In addition, be sure to lock all the control levers and hang warning signs on them.
9. When disassembling or assembling, support the machine with blocks, jacks or stands before starting work.
10. Remove all mud and oil from the steps or other places used to get on and off the machine. Always use the handrails, ladders or steps when getting on or off the machine. Never jump on or off the machine. If it is impossible to use the handrails, ladders or steps, use a stand to provide safe footing.

## PRECAUTIONS DURING WORK

11. When removing the oil filler cap, drain plug or hydraulic pressure measuring plugs, loosen them slowly to prevent the oil from spurting out.  
Before disconnecting or removing components of the oil, water or air circuits, first remove the pressure completely from the circuit.
12. The water and oil in the circuits are hot when the engine is stopped, so be careful not to get burned.  
Wait for the oil and water to cool before carrying out any work on the oil or water circuits.
13. Before starting work, remove the leads from the battery. Always remove the lead from the negative (—) terminal first.
14. When raising heavy components, use a hoist or crane.  
Check that the wire rope, chains and hooks are free from damage.  
Always use lifting equipment which has ample capacity.  
Install the lifting equipment at the correct places. Use a hoist or crane and operate slowly to prevent the component from hitting any other part. Do not work with any part still raised by the hoist or crane.
15. When removing covers which are under internal pressure or under pressure from a spring, always leave two bolts in position on opposite sides. Slowly release the pressure, then slowly loosen the bolts to remove.
16. When removing components, be careful not to break or damage the wiring. Damaged wiring may cause electrical fires.
17. When removing piping, stop the fuel or oil from spilling out. If any fuel or oil drips on to the floor, wipe it up immediately. Fuel or oil on the floor can cause you to slip, or can even start fires.
18. As a general rule, do not use gasoline to wash parts. In particular, use only the minimum of gasoline when washing electrical parts.
19. Be sure to assemble all parts again in their original places.  
Replace any damaged parts with new parts.
  - When installing hoses and wires, be sure that they will not be damaged by contact with other parts when the machine is being operated.
20. When installing high pressure hoses, make sure that they are not twisted. Damaged tubes are dangerous, so be extremely careful when installing tubes for high pressure circuits. Also, check that connecting parts are correctly installed.
21. When assembling or installing parts, always use the specified tightening torques. When installing protective parts such as guards, or parts which vibrate violently or rotate at high speed, be particularly careful to check that they are installed correctly.
22. When aligning two holes, never insert your fingers or hand. Be careful not to get your fingers caught in a hole.
23. When measuring hydraulic pressure, check that the measuring tool is correctly assembled before taking any measurements.
24. Take care when removing or installing the tracks of track-type machines.  
When removing the track, the track separates suddenly, so never let anyone stand at either end of the track.

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## FOREWORD

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This shop manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This shop manual mainly contains the necessary technical information for operations performed in a service workshop.

For ease of understanding, the manual is divided into chapters for each main group of components; these chapters are further divided into the following sections.

### **STRUCTURE AND FUNCTION**

This section explains the structure and function of each component. It serves not only to give an understanding of the structure, but also serves as reference material for troubleshooting.

### **TESTING AND ADJUSTING**

This section explains checks to be made before and after performing repairs, as well as adjustments to be made at completion of the checks and repairs.

Troubleshooting charts correlating "Problems" to "Causes" are also included in this section.

### **DISASSEMBLY AND ASSEMBLY**

This section explains the order to be followed when removing, installing, disassembling or assembling each component, as well as precautions to be taken for these operations.

### **MAINTENANCE STANDARD**

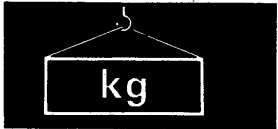
This section gives the judgement standards when inspecting disassembled parts.


### **NOTICE**

**The specifications contained in this shop manual are subject to change at any time and without any advance notice. Contact your KOMATSU distributor for the latest information.**



# 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 

- 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

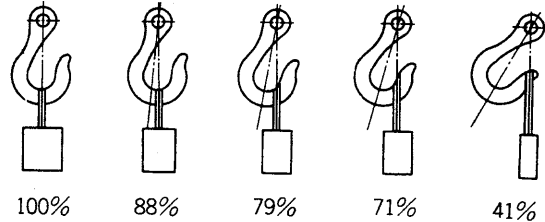
- Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

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.

- Sling wire ropes from the middle portion of the hook.

Slings 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.



FS0064

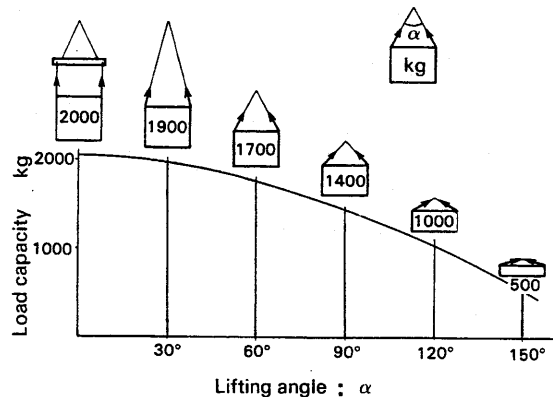
- Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound on to the load.

**!** Slings 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.

- 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°.





FS0065



# STANDARD TIGHTENING TORQUE

## 1. STANDARD TIGHTENING TORQUE OF BOLTS AND NUTS

The following charts give the standard tightening torques of bolts and nuts. Exceptions are given in sections of "Disassembly and Assembly".

Thread diameter of bolt (mm)	Width across flat (mm)		
		kgm	Nm
6	10	1.35±0.15	13.2±1.4
8	13	3.2±0.3	31.4±2.9
10	17	6.7±0.7	65.7±6.8
12	19	11.5±1.0	112±9.8
14	22	18.0±2.0	177±19
16	24	28.5±3	279±29
18	27	39±4	383±39
20	30	56±6	549±58
22	32	76±8	745±78
24	36	94.5±10	927±98
27	41	135±15	1320±140
30	46	175±20	1720±190
33	50	225±25	2210±240
36	55	280±30	2750±290
39	60	335±35	3280±340

This torque table does not apply to the bolts with which nylon packings or other non-ferrous metal washers are to be used, or which require tightening to otherwise specified torque.

★ Nm (newton meter): 1Nm ≅ 0.1 kgm

## 2. TIGHTENING TORQUE OF SPLIT FLANGE BOLTS

Use these torques for split flange bolts.

Thread diameter of bolt (mm)	Width across flats (mm)	Tightening torque	
		kgm	Nm
10	14	6.7±0.7	65.7±6.8
12	17	11.5±1	112±9.8
16	22	28.5±3	279±29

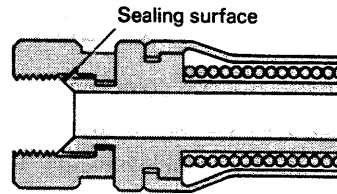


## STANDARD TIGHTENING TORQUE



### 3. TIGHTENING TORQUE FOR NUTS OF FLARED

Use these torques for nut part of flared.



FS0068

Thread diameter of nut part (mm)	Width across flats of nut part (mm)	Tightening torque	
		kgm	Nm
14	19	2.5 ± 0.5	24.5 ± 4.9
18	24	5 ± 2	49 ± 19.6
22	27	8 ± 2	78.5 ± 19.6
24	32	14 ± 3	137.3 ± 29.4
30	36	18 ± 3	176.5 ± 29.4
33	41	20 ± 5	196.1 ± 49
36	46	25 ± 5	245.2 ± 49
42	55	30 ± 5	294.2 ± 49

## COATING MATERIALS



The recommended coating materials prescribed in Komatsu Shop Manuals are listed below.

Nomenclature	Komatsu code	Applications
Adhesives	LT-1A	Used to apply rubber pads, rubber gaskets, and cork plugs.
	LT-1B	Used to apply resin, rubber, metallic and non-metallic parts when a fast, strong seal is needed.
	LT-2*	Preventing bolts, nuts and plugs from loosening and leaking oil.
	LT-3	Provides an airtight, electrically insulating seal. Used for aluminum surfaces.
Liquid gasket	LG-1	Used with gaskets and packings to increase sealing effect.
	LG-3	Heat-resistant gasket for precombustion chambers and exhaust piping.
	LG-4	Used by itself on mounting surfaces on the final drive and transmission cases. (Thickness after tightening: 0.07 – 0.08 mm)
	LG-5	Used by itself to seal grease fittings, tapered screw fittings and tapered screw fittings in hydraulic circuits of less than 50 mm in diameter.
Antifriction compound (Lubricant including molybdenum disulfide)	LM-P	Applied to bearings and taper shafts to facilitate press-fitting and to prevent sticking, burning or rusting.
Grease (Lithium grease)	G2-LI	Applied to bearings, sliding parts and oil seals for lubrication, rust prevention and facilitation of assembling work.
Vaseline	—	Used for protecting battery electrode terminals from corrosion.

\*LT-2 is also called LOCTITE in the shop manuals.



## ELECTRIC WIRE CODE

In the wiring diagrams, various colors and symbols are employed to indicate the thickness of wires.

This wire code table will help you understand WIRING DIAGRAMS.

Example: 05WB indicates a cable having a nominal number 05 and white coating with black stripe.

### CLASSIFICATION BY THICKNESS

Nominal number	Copper wire			Cable O.D. (mm)	Current rating (A)	Applicable circuit
	Number strands	Dia. of strands (mm)	Cross section (mm <sup>2</sup> )			
01	11	0.32	0.88	2.4	12	Starting, lighting, signal etc.
02	26	0.32	2.09	3.1	20	Lighting, signal etc.
05	65	0.32	5.23	4.6	37	Charging and signal
15	84	0.45	13.36	7.0	59	Starting (Glow plug)
40	85	0.80	42.73	11.4	135	Starting
60	127	0.80	63.84	13.6	178	Starting
100	217	0.80	109.1	17.6	230	Starting

### CLASSIFICATION BY COLOR AND CODE

Priority	Circuits		Starting	Charging	Lighting	Signal	Instrument	Other
	Classification							
1	Primary	Code	B	W	R	G	Y	L
		Color	Black	White	Red	Green	Yellow	Blue
2	Auxiliary	Code	BW	WR	RW	GW	YR	LW
		Color	Black & White	White & Red	Red & White	Green & White	Yellow & Red	Blue & White
3	Auxiliary	Code	BY	WB	RB	GR	YB	LR
		Color	Black & Yellow	White & Black	Red & Black	Green & Red	Yellow & Black	Blue & Red
4	Auxiliary	Code	BR	WL	RY	GY	YG	LY
		Color	Black & Red	White & Blue	Red & Yellow	Green & Yellow	Yellow & Green	Blue & Yellow
5	Auxiliary	Code	—	WY	RG	GB	YL	LB
		Color	—	White & Yellow	Red & Green	Green & Black	Yellow & Blue	Blue & Black
6	Auxiliary	Code	—	WG	RL	GL	YW	
		Color	—	White & Green	Red & Blue	Green & Blue	Yellow & White	

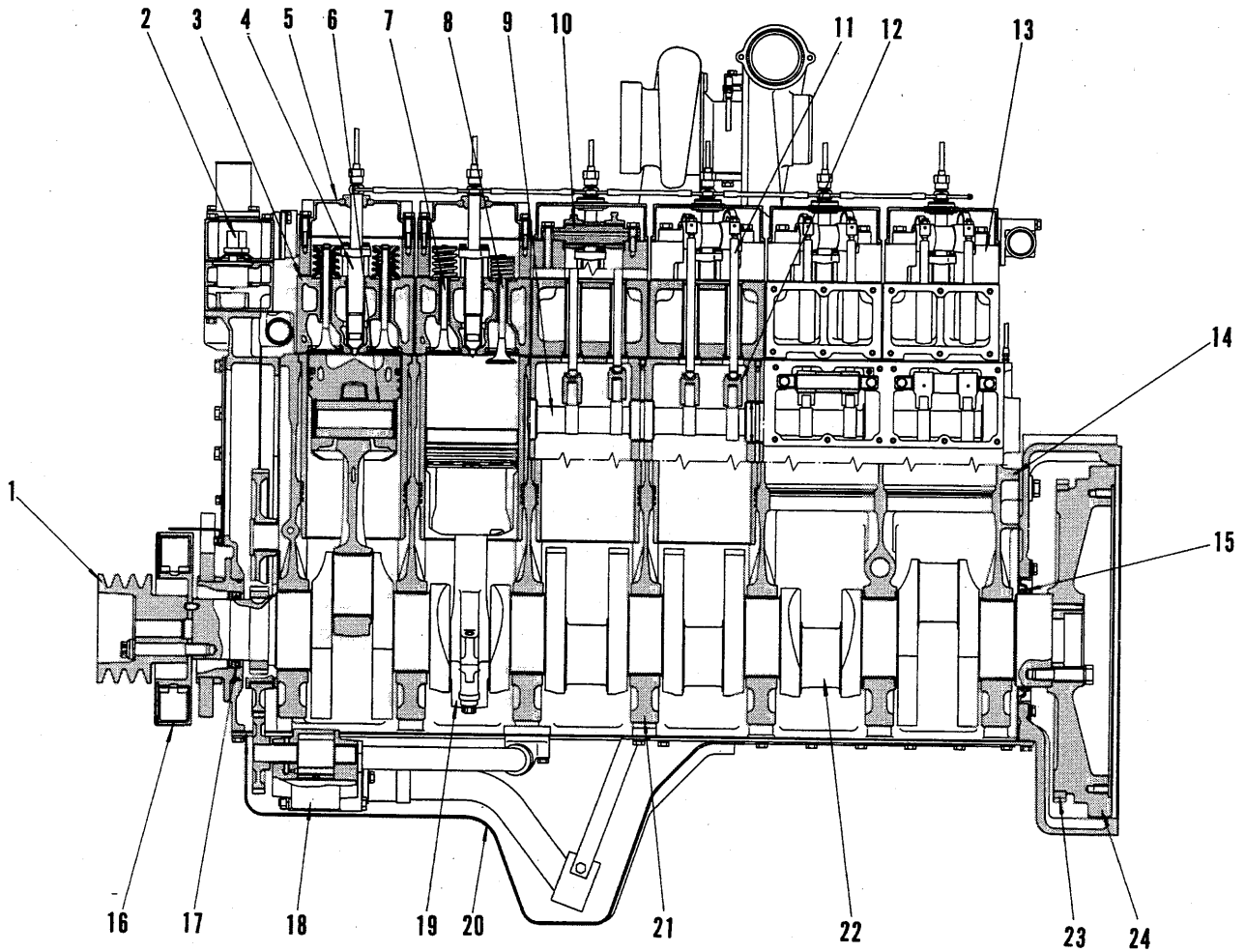
# ENGINE

## 11 STRUCTURE AND FUNCTION



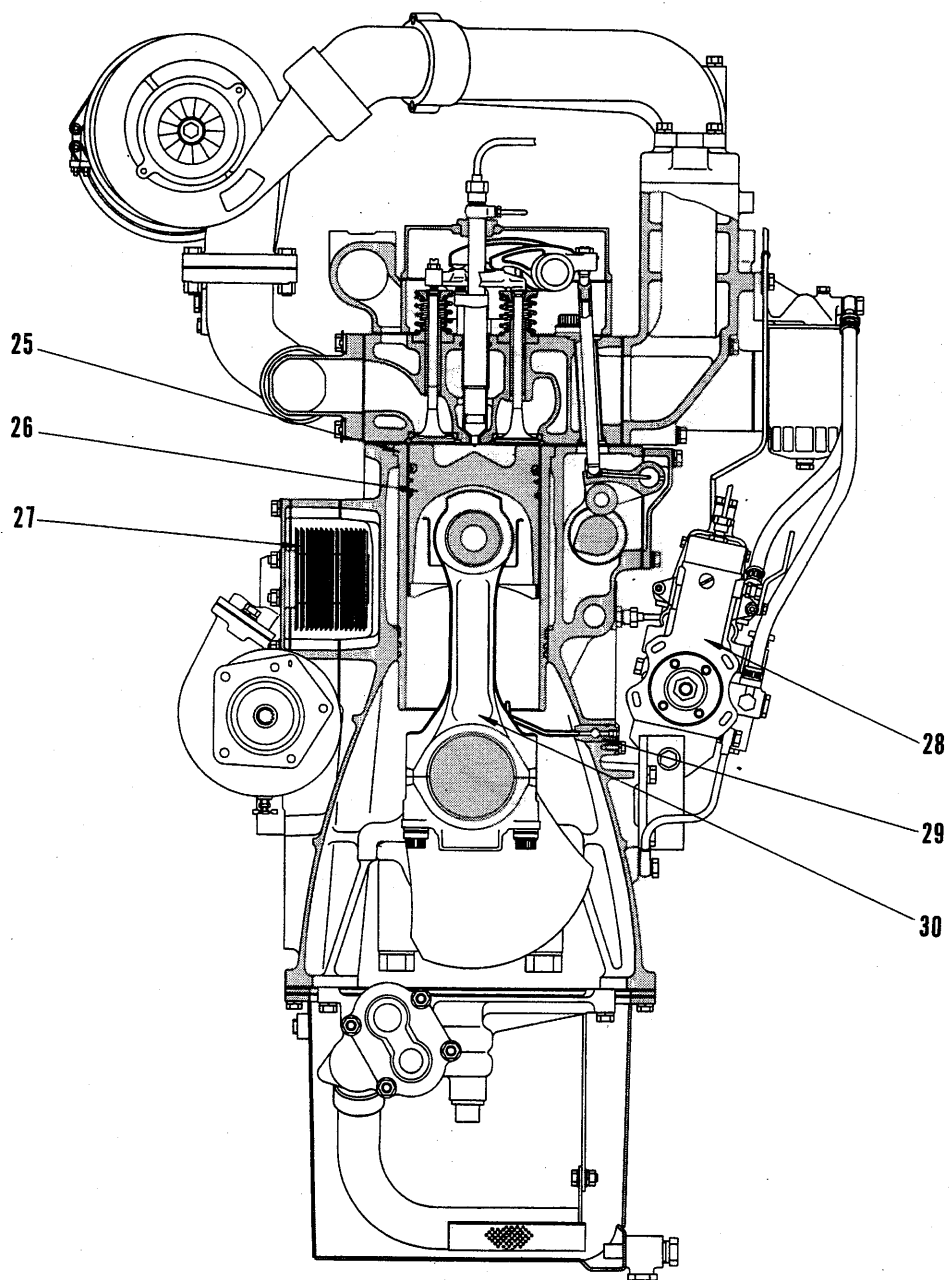
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# GENERAL STRUCTURE



6162F101

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

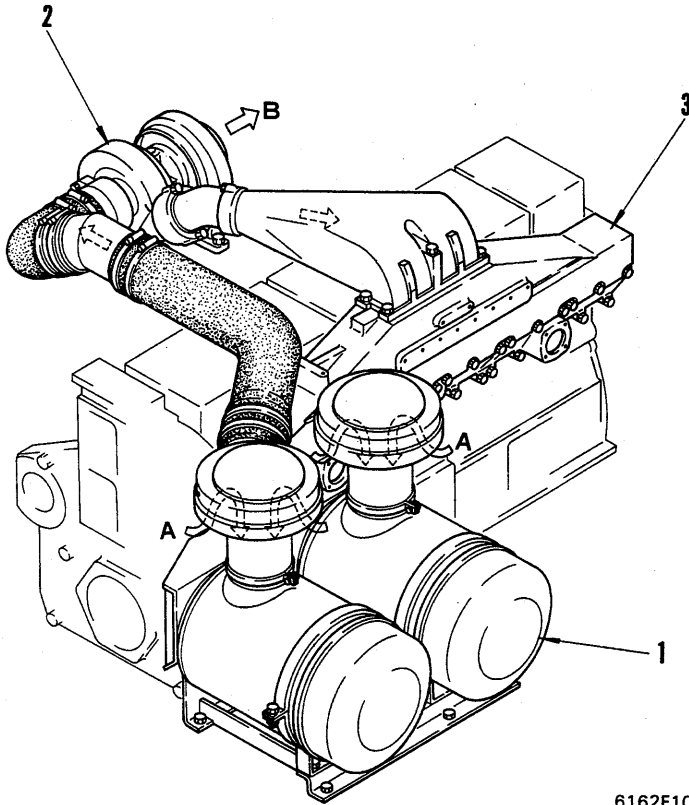


- 25. Cylinder liner
- 26. Piston
- 27. Oil cooler
- 28. Fuel injection pump
- 29. Piston cooling nozzle
- 30. Connecting rod

6162F102

# INTAKE AND EXHAUST SYSTEM

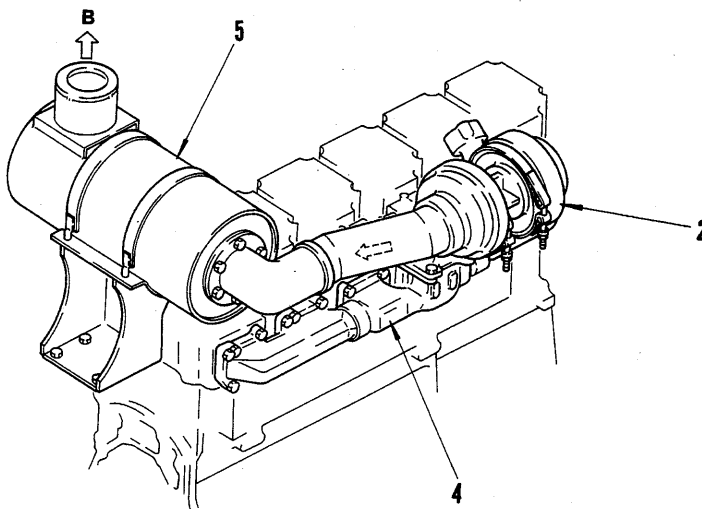
Intake system



6162F106

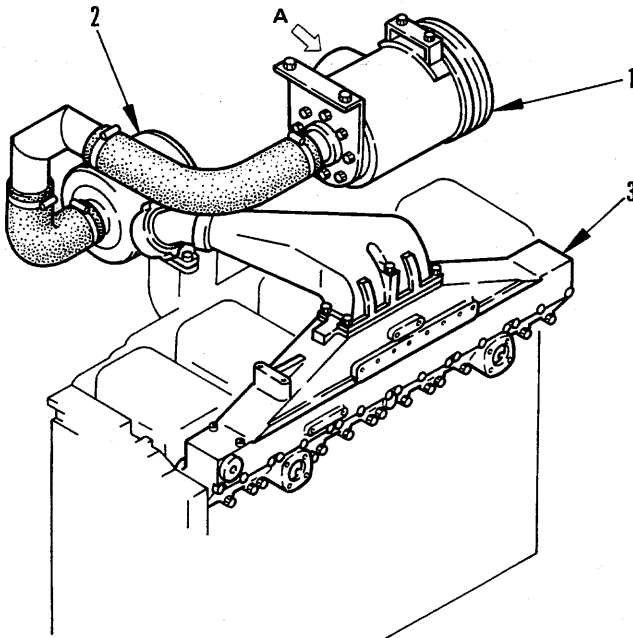
- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler
- A. Intake inlet
- B. Exhaust

Exhaust system



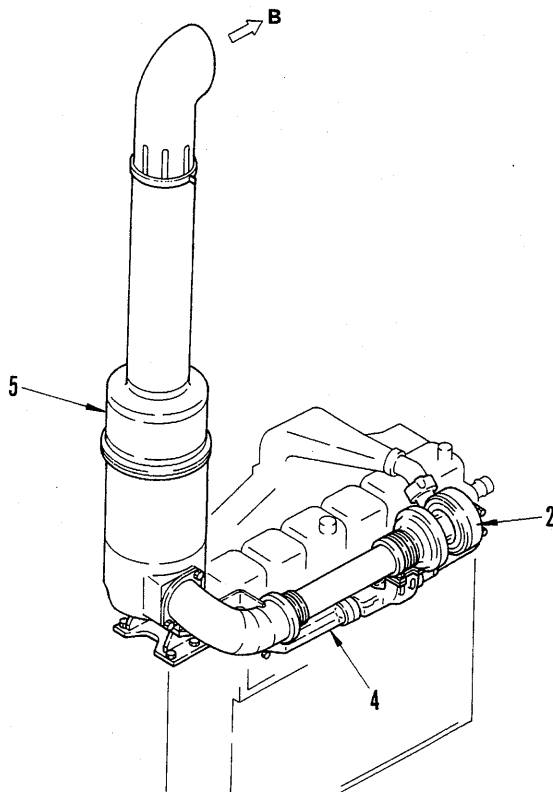
6162F107

Intake system



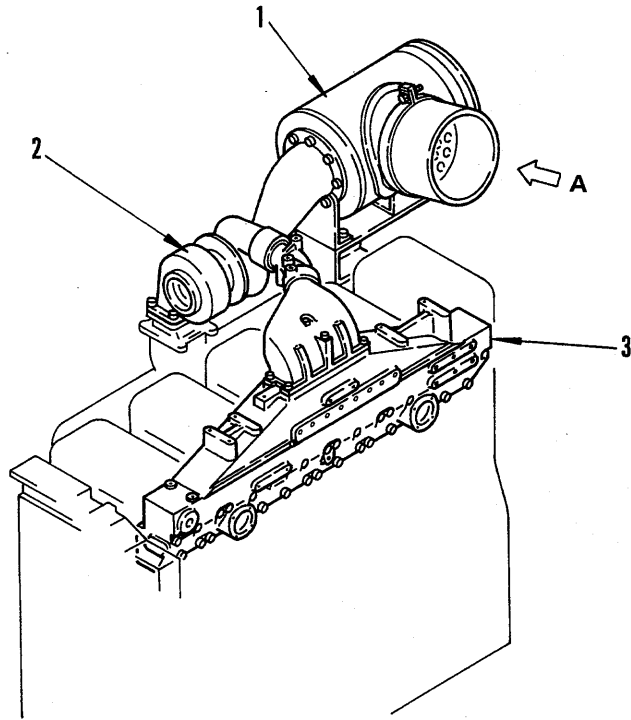
- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler

Exhaust system



- A. Intake inlet
- B. Exhaust

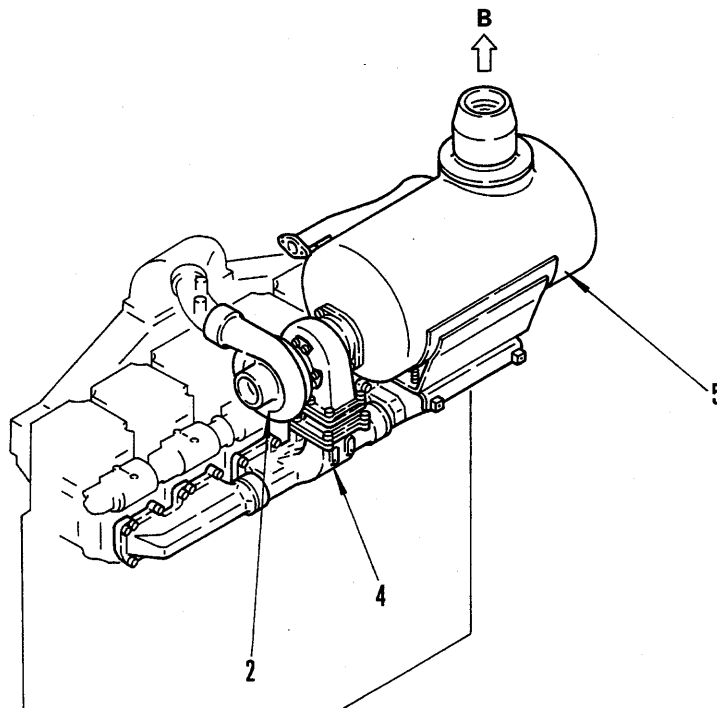
Intake system



- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler

F6161A002

Exhaust system

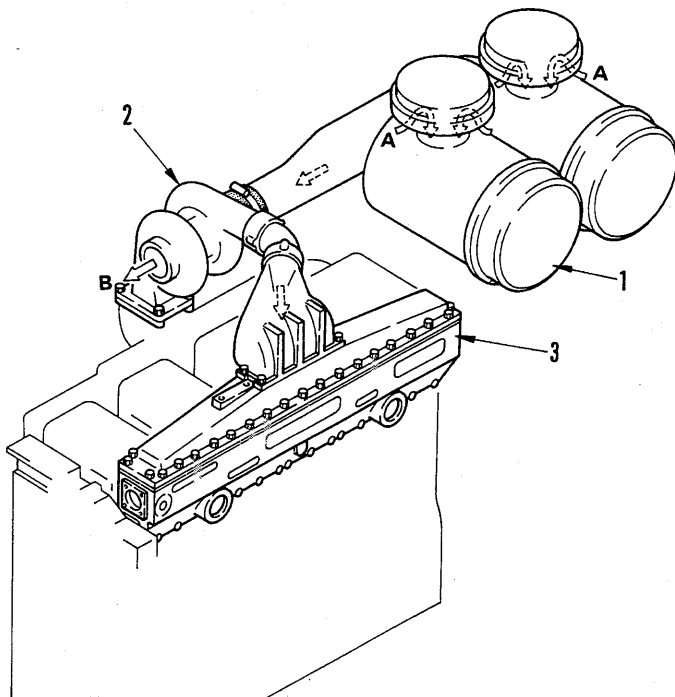


- A. Intake inlet
- B. Exhaust

F6161A003

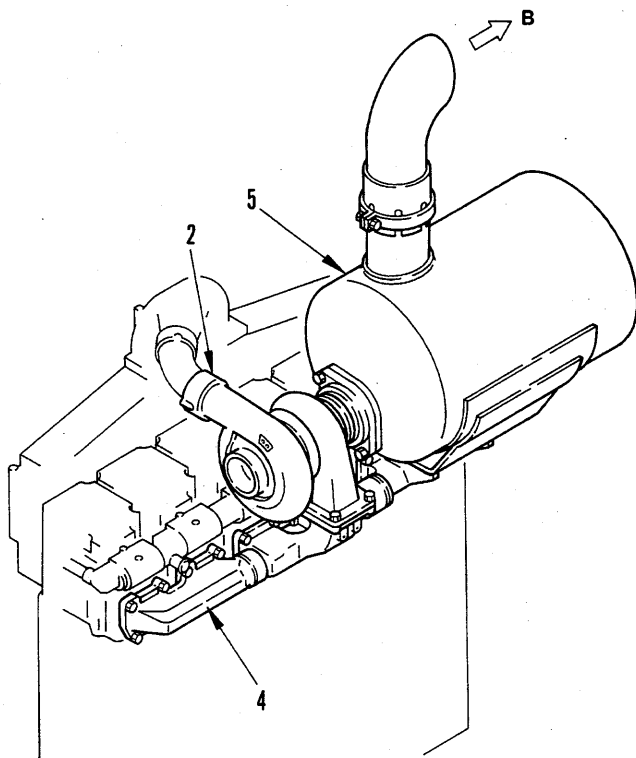


Intake system



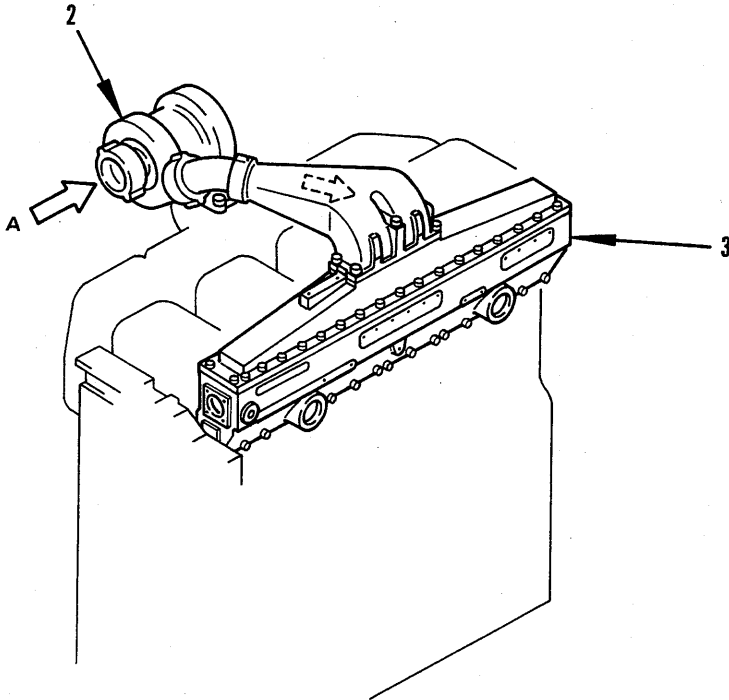
- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler

Exhaust system



- A. Intake inlet
- B. Exhaust

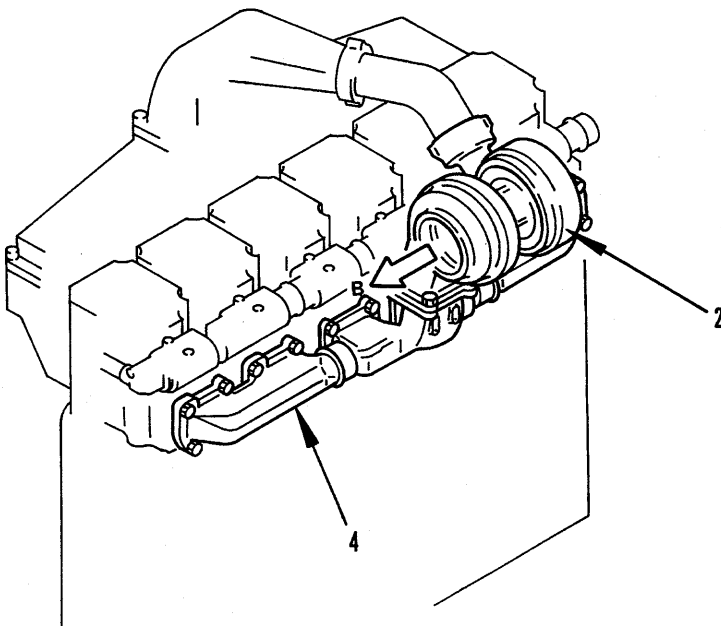
**Intake system**



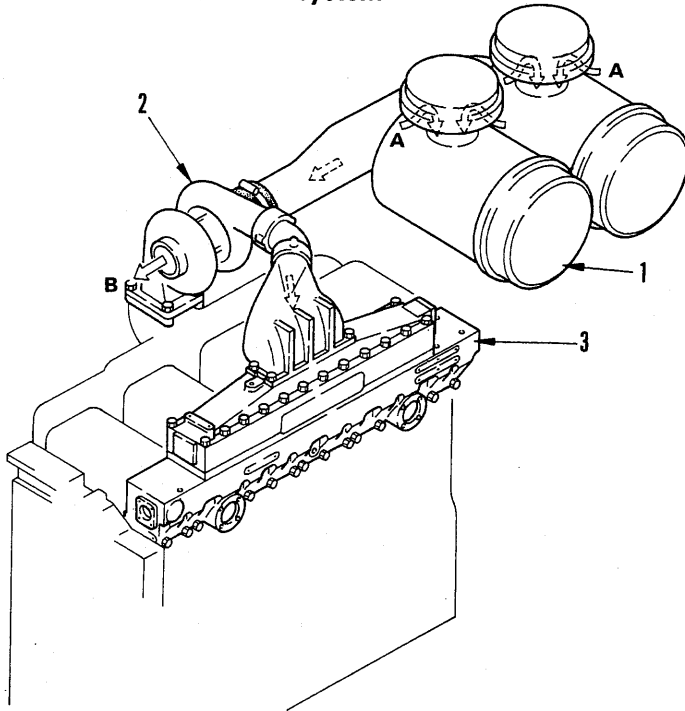
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold

- A. Intake inlet
- B. Exhaust

**Exhaust system**

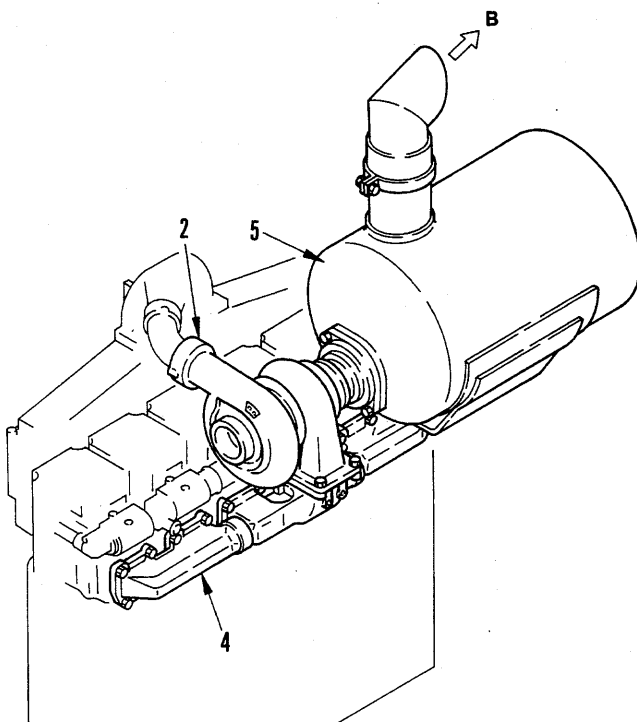


Intake system



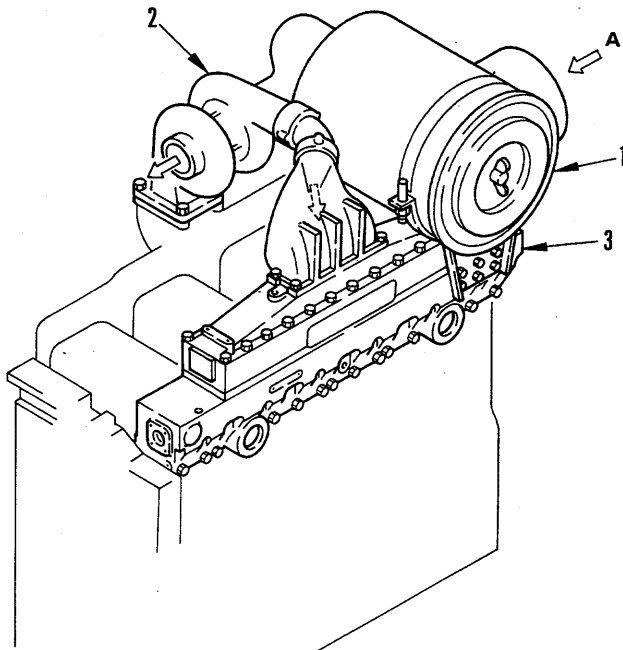
- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler

Exhaust system



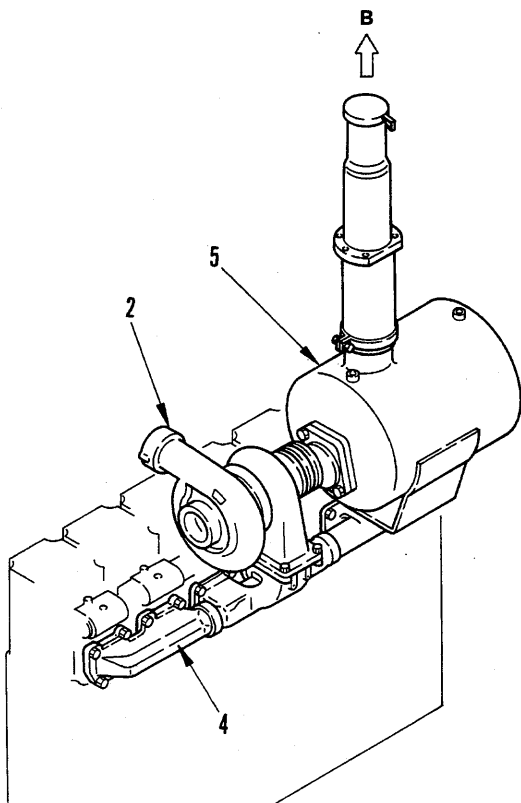
- A. Intake inlet
- B. Exhaust

**Intake system**



- 1. Air cleaner
- 2. Turbocharger
- 3. Intake manifold
- 4. Exhaust manifold
- 5. Muffler

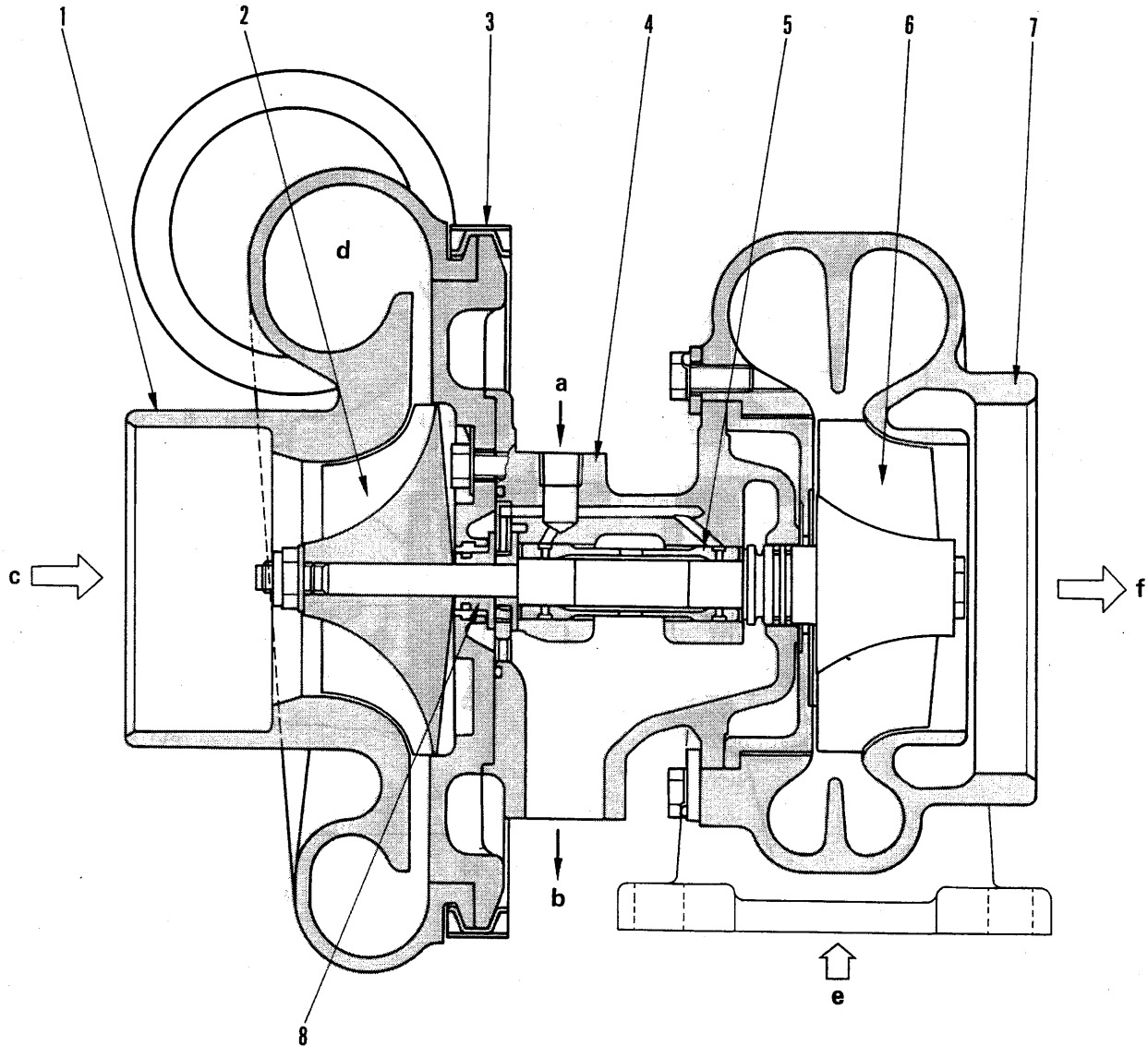
**Exhaust system**



- A. Intake inlet
- B. Exhaust

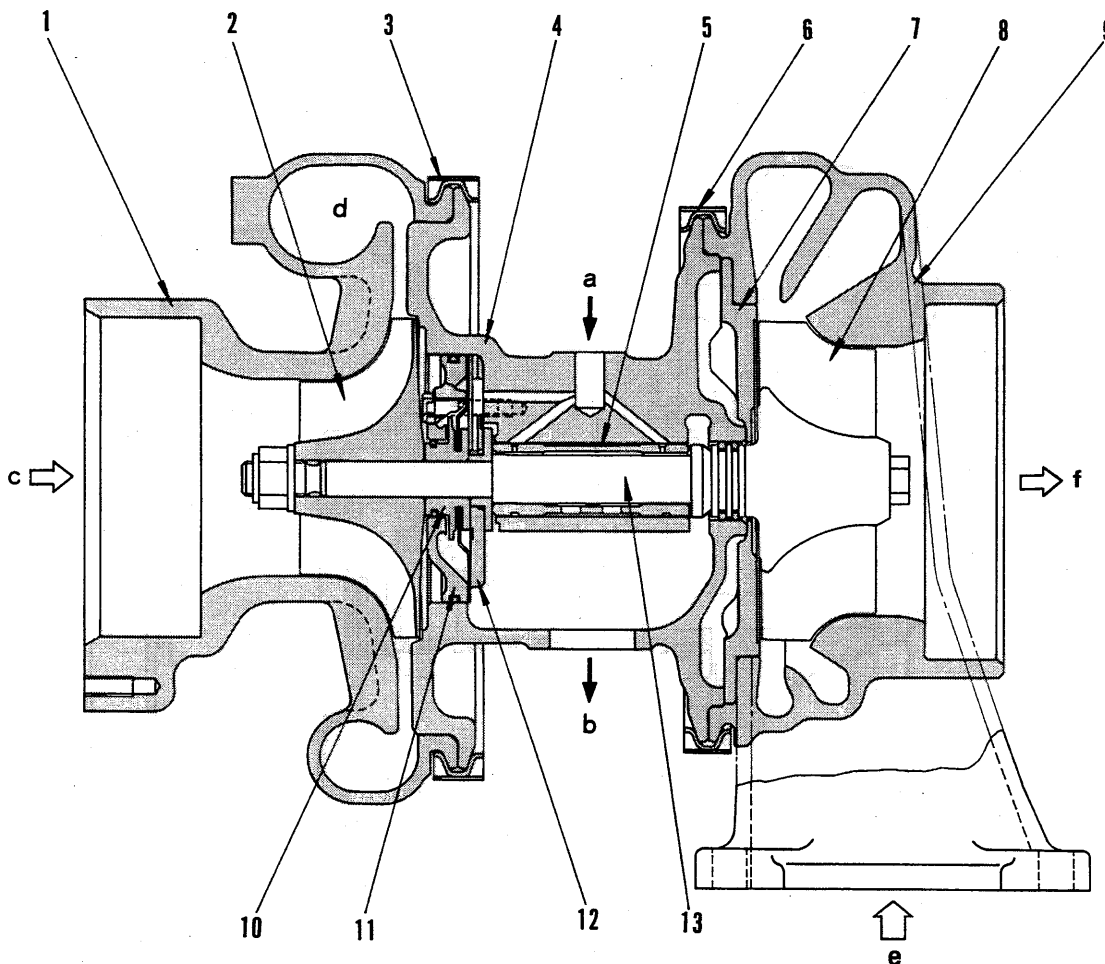
# TURBOCHARGER

(1) KTR110



- |                     |                                |
|---------------------|--------------------------------|
| 1. Blower housing   | a. Oil inlet (from oil filter) |
| 2. Blower impeller  | b. Oil outlet (to oil pan)     |
| 3. Clamp            | c. Air inlet                   |
| 4. Center housing   | d. Air outlet                  |
| 5. Journal bearing  | e. Exhaust inlet               |
| 6. Turbine impeller | f. Exhaust outlet              |
| 7. Turbine housing  |                                |
| 8. Insert           |                                |

(2) KTR130



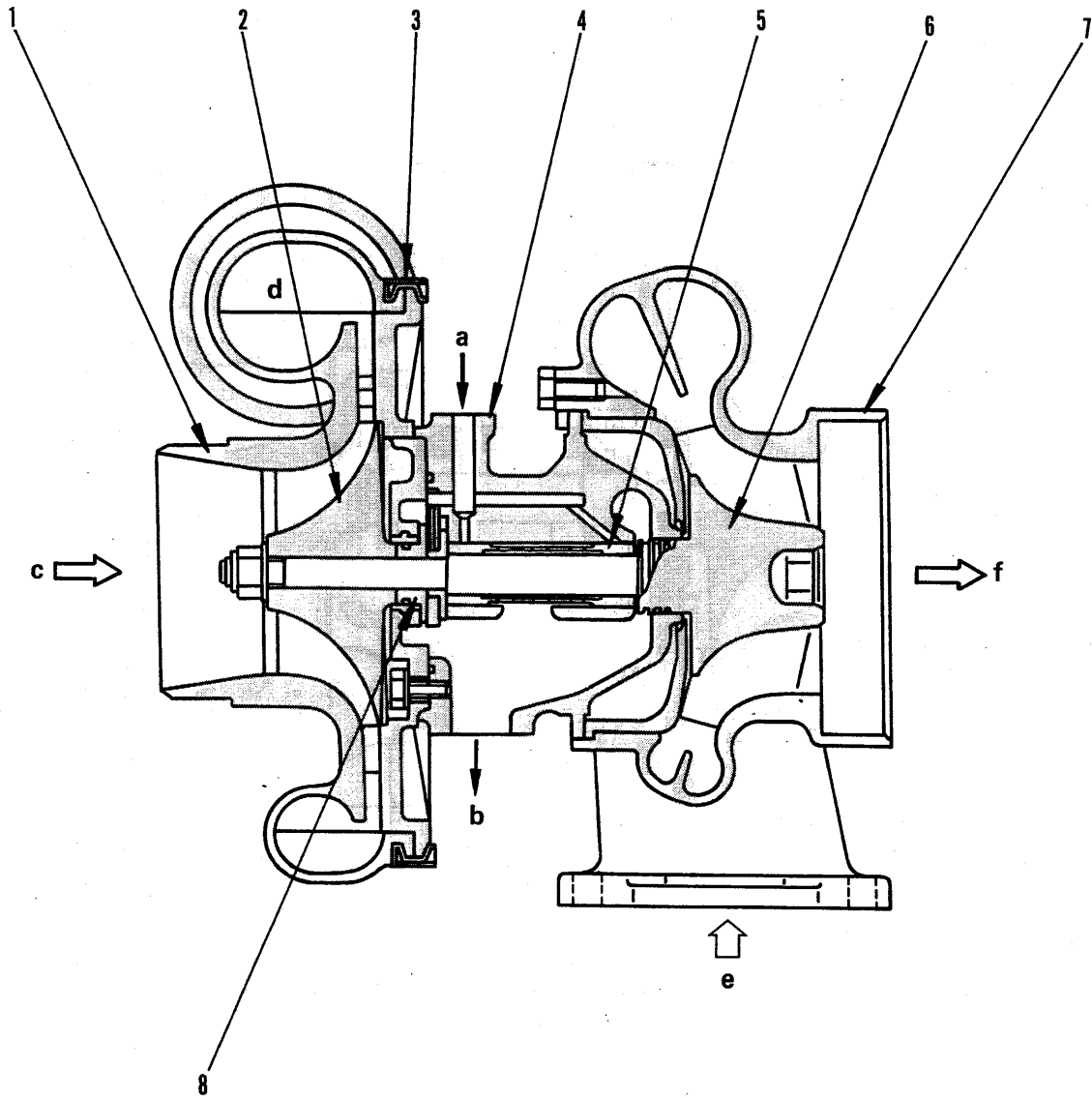
6162F108

- |                     |                                |
|---------------------|--------------------------------|
| 1. Blower housing   | 11. Insert                     |
| 2. Blower impeller  | 12. Thrust bearing             |
| 3. Clamp            | 13. Turbine shaft              |
| 4. Center housing   | a. Oil inlet (from oil filter) |
| 5. Journal bearing  | b. Oil outlet (to oil pan)     |
| 6. Clamp            | c. Air inlet                   |
| 7. Shield           | d. Air outlet                  |
| 8. Turbine impeller | e. Exhaust inlet               |
| 9. Turbine housing  | f. Exhaust outlet              |
| 10. Slinger         |                                |

**Specifications of turbocharger**

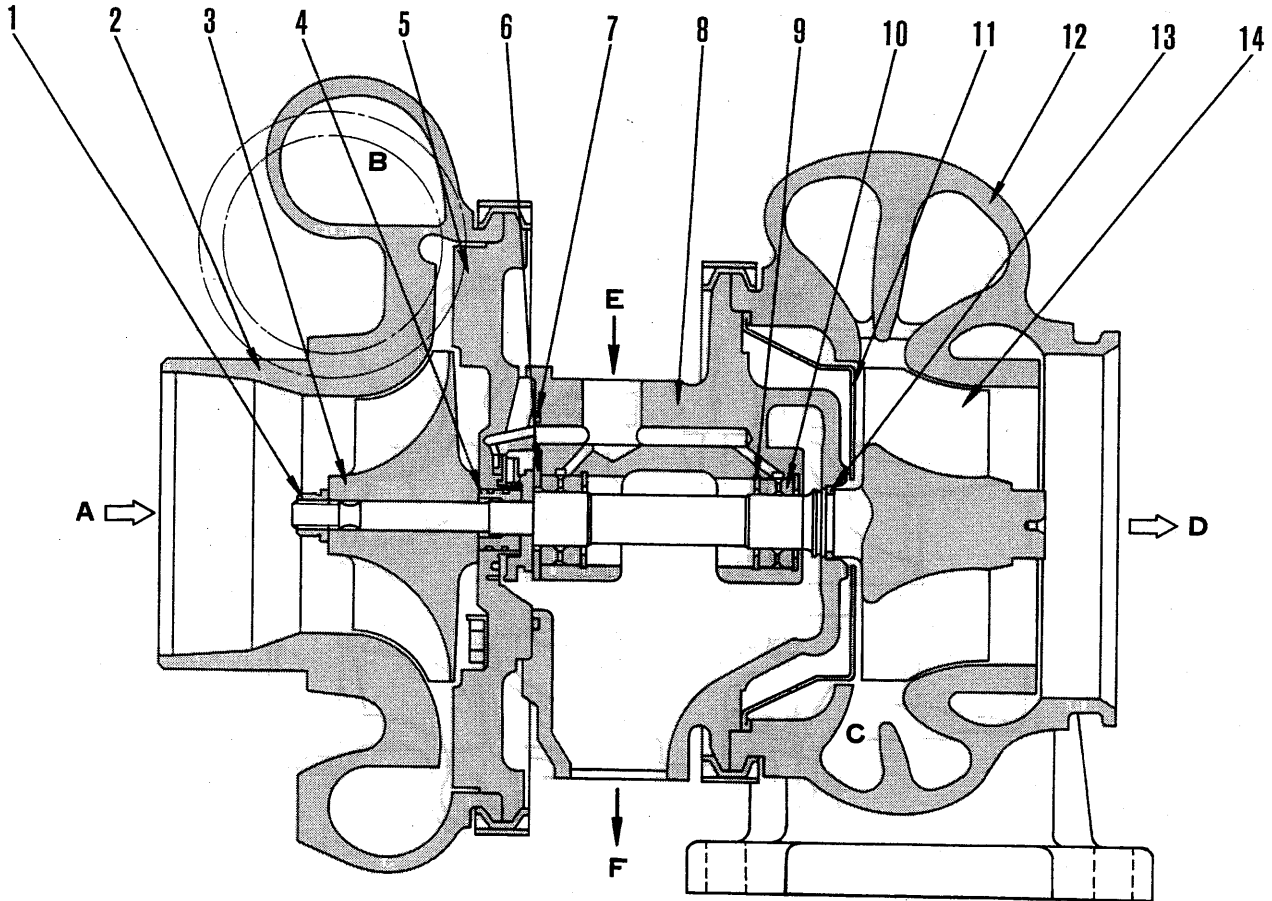
- Type: Komatsu KTR130
- Length x width x height: 366 x 358 x 323 mm
- Weight: 31 kg
- Continuous rotation: 70,000 rpm
- Maximum charging: 32 kg/min.
- Appropriate temperature (inlet, °C): 750°C max.
- Direction of rotation (view from blower side): Right
- Lubrication method: Forced

(3) KTR150



- |                     |                                |
|---------------------|--------------------------------|
| 1. Blower housing   | a. Oil inlet (from oil filter) |
| 2. Blower impeller  | b. Oil outlet (to oil pan)     |
| 3. Clamp            | c. Air inlet                   |
| 4. Center housing   | d. Air outlet                  |
| 5. Journal bearing  | e. Exhaust inlet               |
| 6. Turbine impeller | f. Exhaust outlet              |
| 7. Turbine housing  |                                |
| 8. Insert           |                                |

(4) TV7705

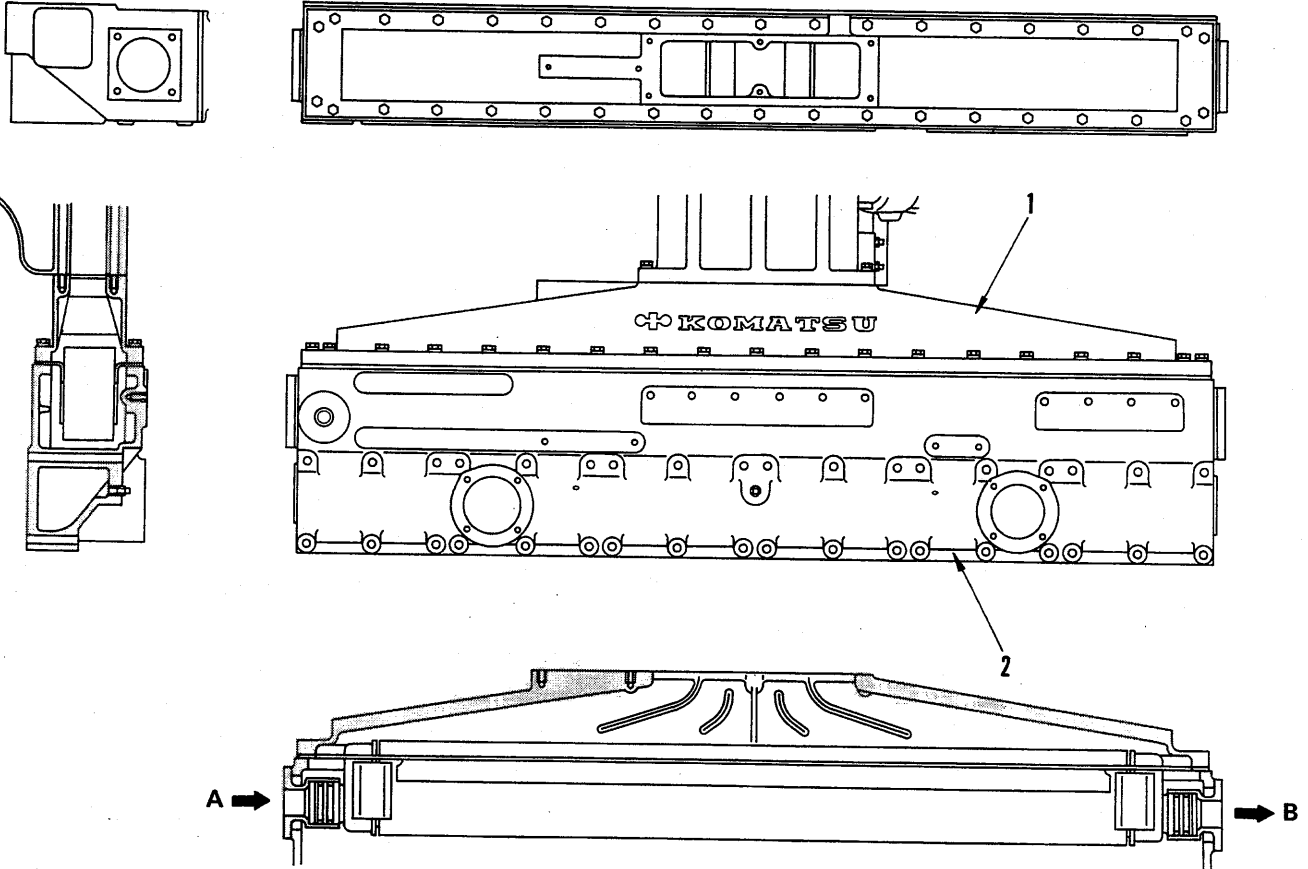


6150F106

- |                     |                      |
|---------------------|----------------------|
| 1. Lock nut         | 12. Turbine housing  |
| 2. Blower housing   | 13. Piston ring      |
| 3. Blower impeller  | 14. Turbine impeller |
| 4. Thrust collar    | A Air inlet          |
| 5. Back plate       | B Air outlet         |
| 6. Thrust bearing   | C Gas inlet          |
| 7. Seal ring        | D Gas outlet         |
| 8. Center housing   | E Oil inlet          |
| 9. Retaining ring   | F Oil outlet         |
| 10. Journal bearing |                      |
| 11. Shroud          |                      |



# AFTER-COOLER



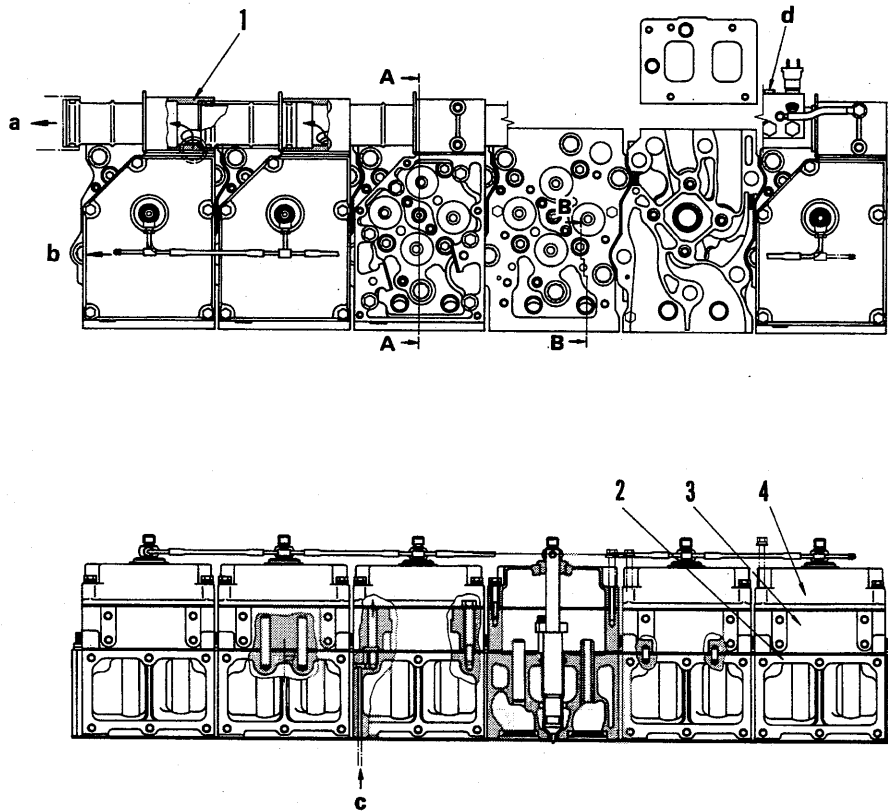
1. Cover

2. After-cooler body

A: From water pump

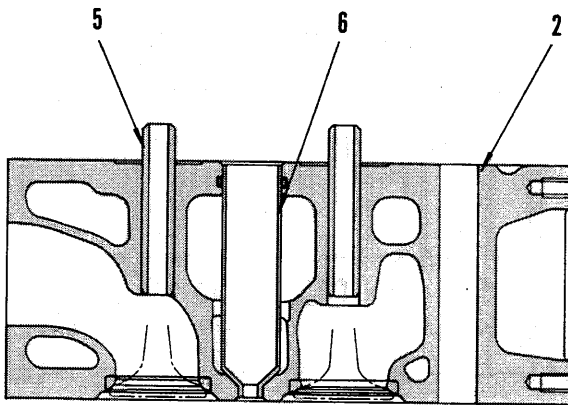
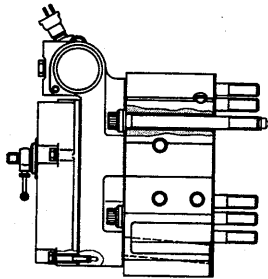
B: To water manifold

# ENGINE BODY CYLINDER HEAD

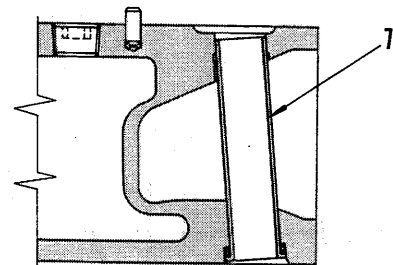


6162F109

- |                             |                                           |
|-----------------------------|-------------------------------------------|
| 1. Water manifold           | a. Coolant (to radiator)                  |
| 2. Cylinder head            | b. Fuel (return)                          |
| 3. Rocker arm housing       | c. Oil (from main gallery)                |
| 4. Rocker arm housing cover | d. Tap for water temperature gauge sensor |
| 5. Valve guide              |                                           |
| 6. Nozzle holder sleeve     |                                           |
| 7. Tube                     |                                           |



Section A - A



Section B - B

6162F110

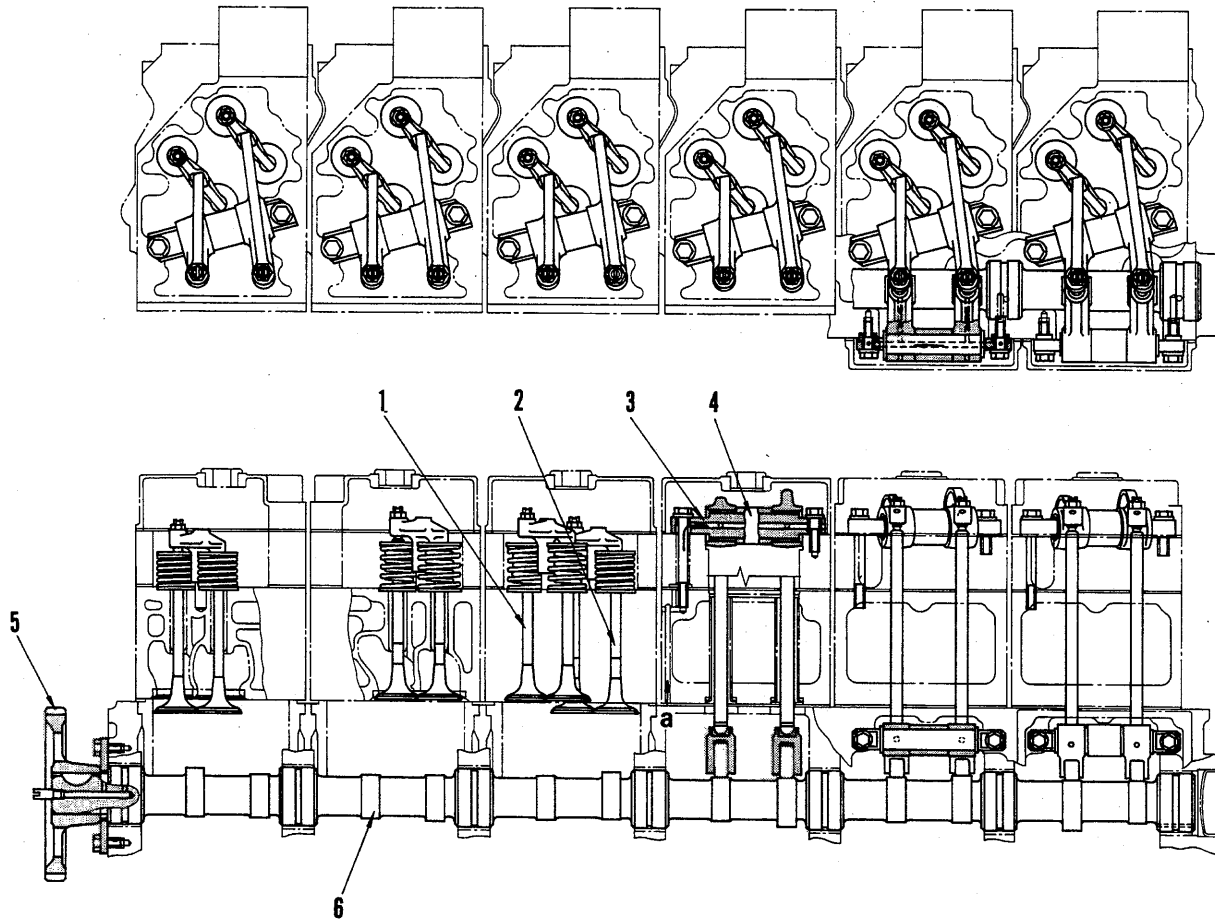
**Cylinder head**

- Direct-injection type, injection nozzle, 4-valve type
- Separate type (1-head for 1-cylinder)

**Valve seat**

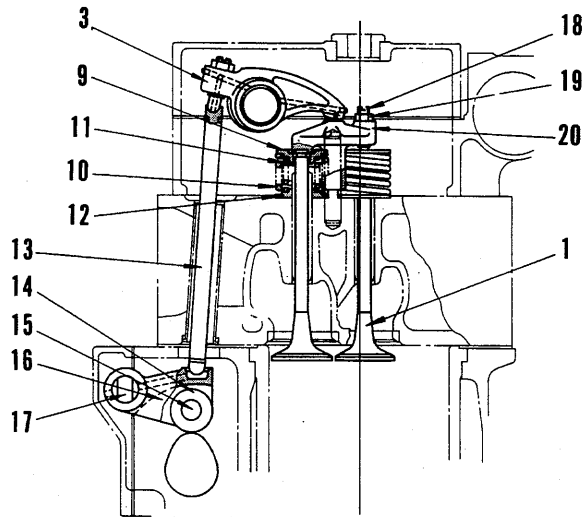
- Press fitted into cylinder head of intake valve and exhaust valves.

VALVE SYSTEM



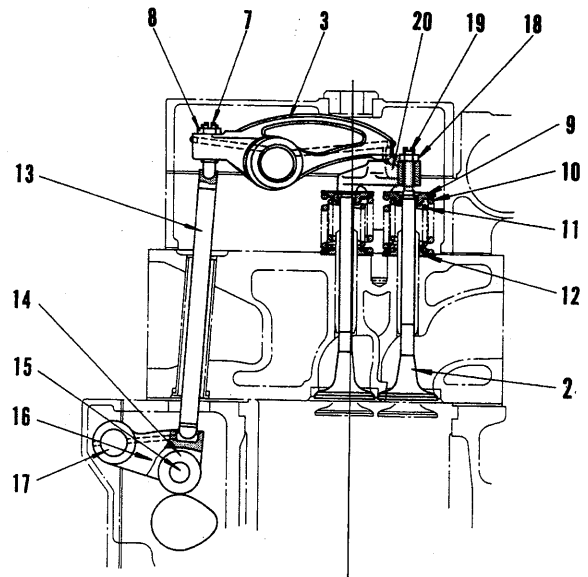
6162F111

- |                                     |                          |                        |
|-------------------------------------|--------------------------|------------------------|
| 1. Intake valve                     | 8. Lock nut              | 15. Cam follower pin   |
| 2. Exhaust valve                    | 9. Upper spring seat     | 16. Cam follower       |
| 3. Rocker arm                       | 10. Valve spring (outer) | 17. Cam follower shaft |
| 4. Collar                           | 11. Valve spring (inner) | 18. Adjustment screw   |
| 5. Camshaft gear (No. of teeth: 48) | 12. Lower spring seat    | 19. Lock nut           |
| 6. Camshaft                         | 13. Push rod             | 20. Cross head         |
| 7. Adjustment screw                 | 14. Cam roller           | a. Oil (from oil pump) |



Intake side of No. 1 cylinder

6162F112



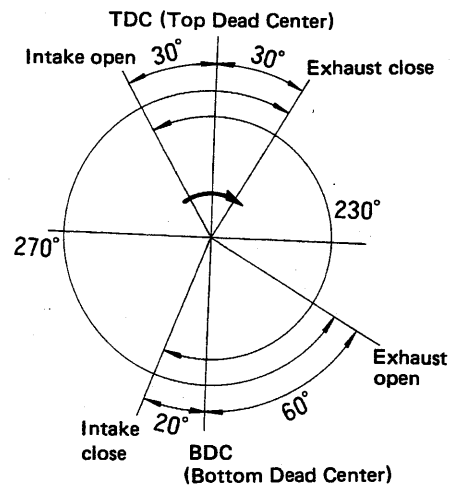
Exhaust side of No. 1 cylinder

6162F113

**Camshaft**

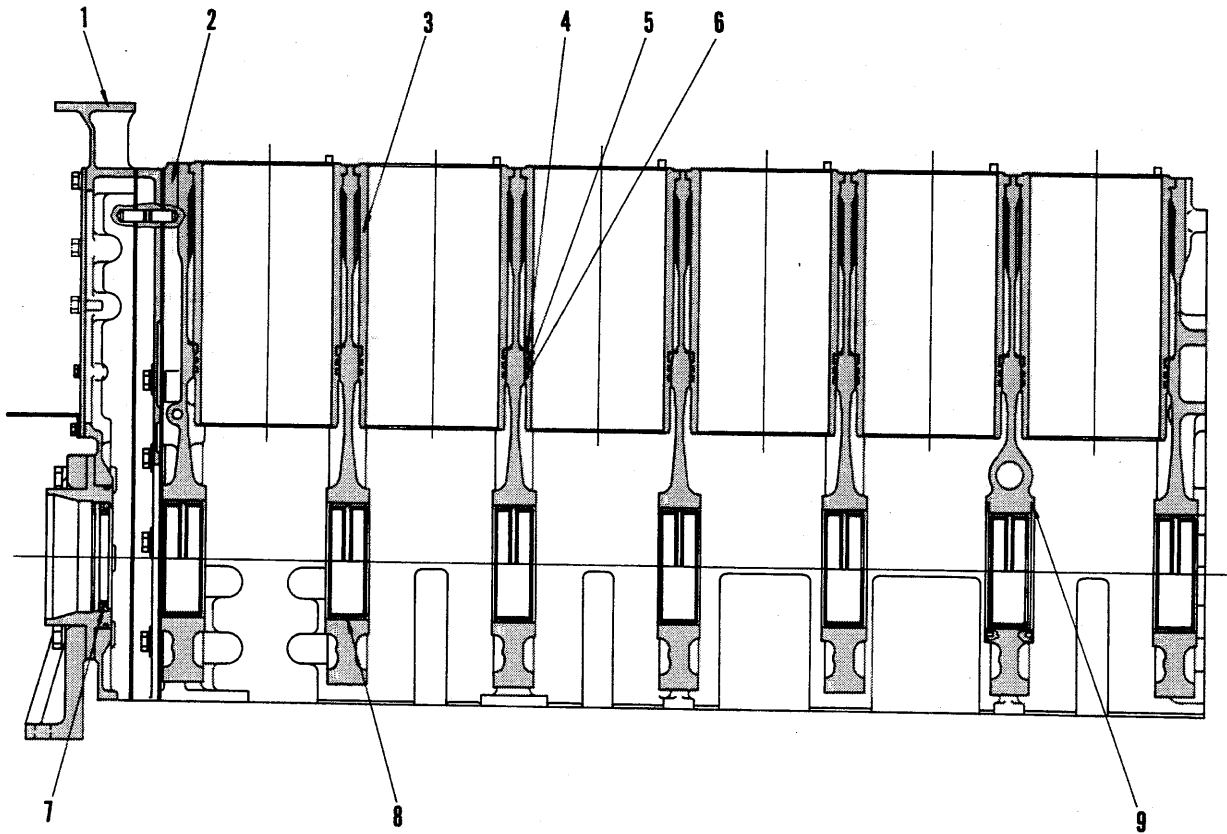
- Special cast/forged alloy, 7 bearings
- Cam face and journal face: High frequency hardening

**Valve timing**



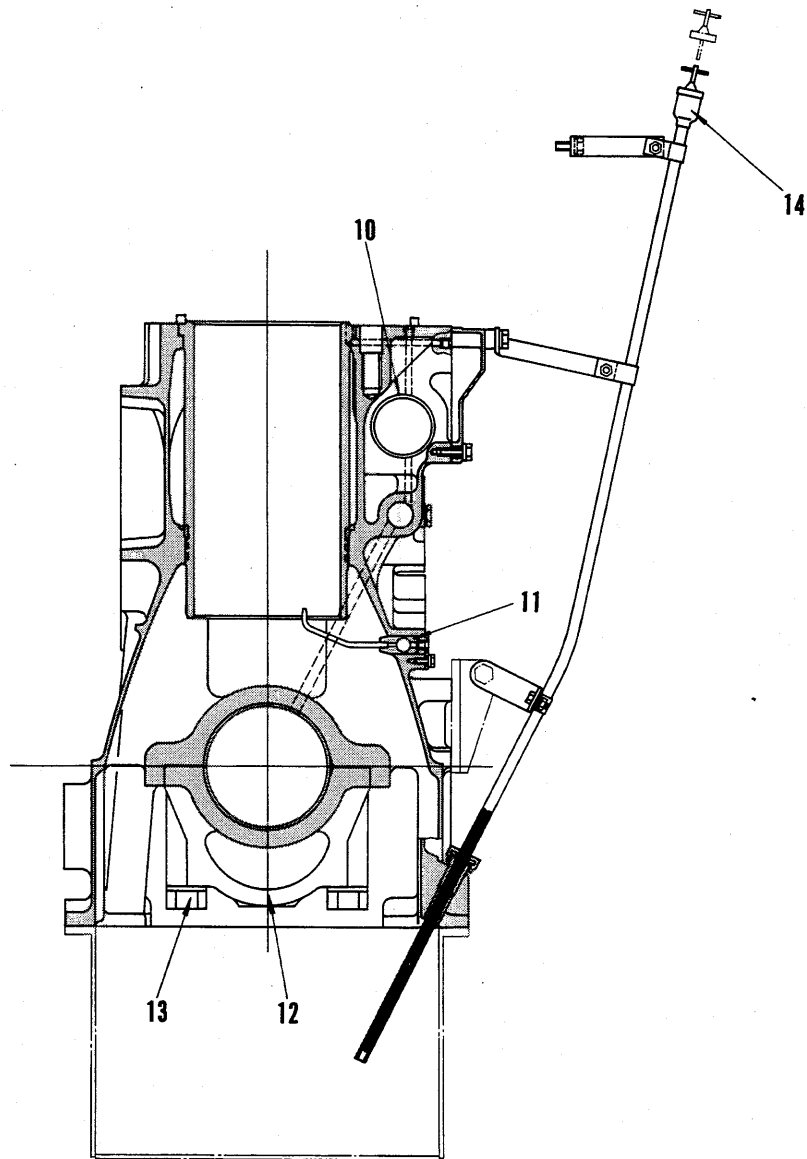
6162F114

CYLINDER BLOCK



6162F115

- |                                   |                           |
|-----------------------------------|---------------------------|
| 1. Front cover                    | 8. Main bearing           |
| 2. Cylinder block                 | 9. Thrust bearing         |
| 3. Cylinder liner                 | 10. Cam bushing           |
| 4. Crevice seal                   | 11. Piston cooling nozzle |
| 5. O-ring (nitrile rubber: black) | 12. Main bearing cap      |
| 6. O-ring (silicone rubber: red)  | 13. Main bearing cap bolt |
| 7. Front seal                     | 14. Oil level gauge       |



6162F116

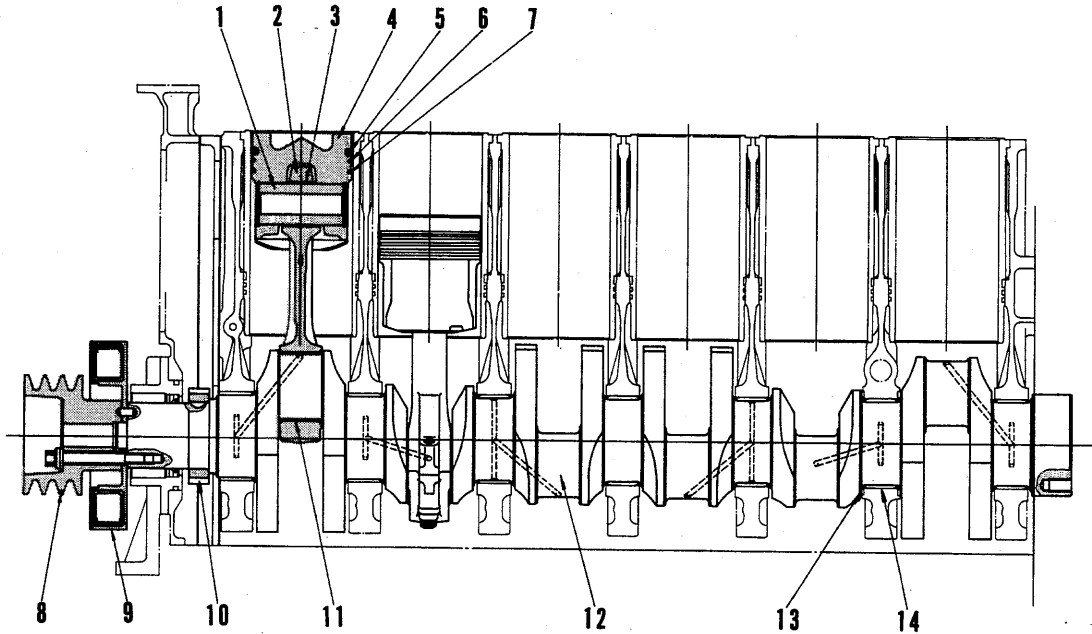
**Cylinder block**

- Crankshaft: Seven bearings
- Camshaft: Seven bearings

**Cylinder liner**

- Wet type liner, tufftride treatment on bore surface
- Crevice seal, two O-rings

MAIN CIRCULATION PART



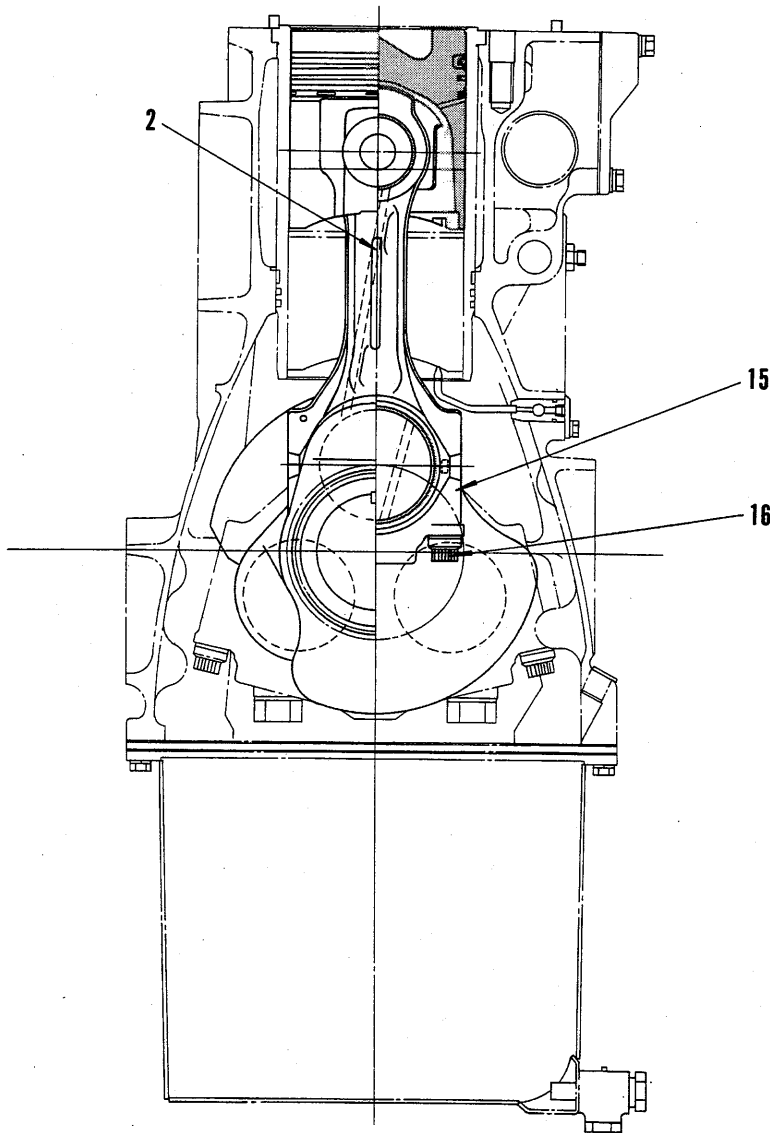
6162F117

- |                                               |                                   |
|-----------------------------------------------|-----------------------------------|
| 1. Piston pin                                 | 9. Vibration damper               |
| 2. Connecting rod                             | 10. Crank gear (No. of teeth: 36) |
| 3. Connecting rod bushing                     | 11. Connecting rod bearing        |
| 4. Piston                                     | 12. Crankshaft                    |
| 5. Top ring                                   | 13. Thrust bearing                |
| 6. 2nd ring                                   | 14. Main bearing                  |
| 7. Oil ring                                   | 15. Connecting rod cap            |
| 8. Crank pulley<br>(Outside diameter: 200 mm) | 16. Connecting rod bolt           |

**Crankshaft**

- Special cast/forged alloy, seven bearings
- Journal face: High frequency hardening





**Main bearing and connecting rod bearing**

- 3-layer Kelmet
- Upper main bearing: with oil groove

**Piston**




- Lo-Ex aluminum alloy
- Groove of top ring: Niresist is cast on top ring.
- Thermal flow solid type (S6D170-1)
- Thermal flow shaker type (SA6D170-A-1) (SA6D170-B-1)
- Forced cooling with piston cooling

**Connecting rod**

- Forged alloy steel

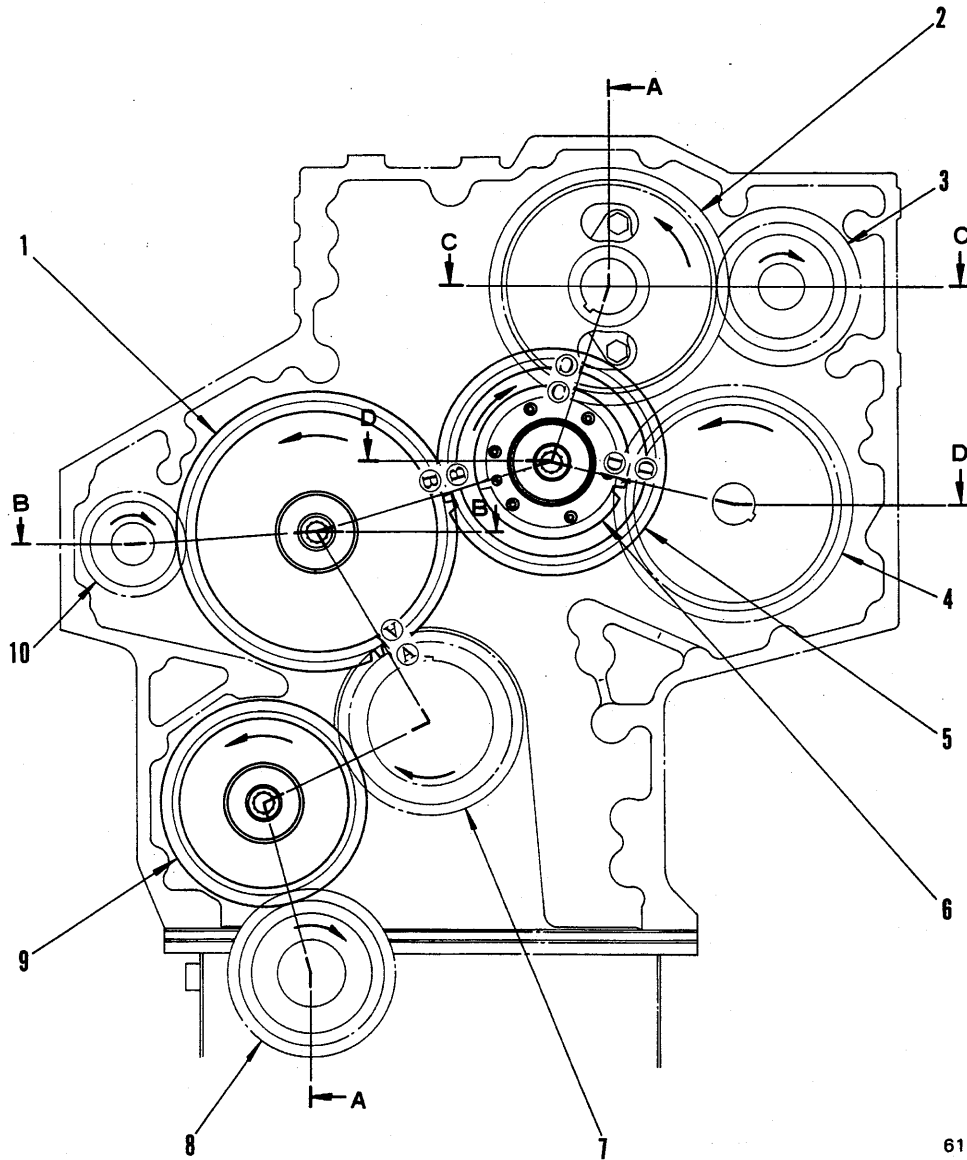
**Piston ring**

6162F118

Engine model	Top ring	2nd ring	Oil ring
S6D170-1 SA6D170-A-1 SA6D170-B-1	Keystone. Barrel face.  Hard chrome plated.	Keystone. Inner cut. Tapered face. Hard chrome plated.	With coil expander. Bevel cut.  Hard chrome plated.
			

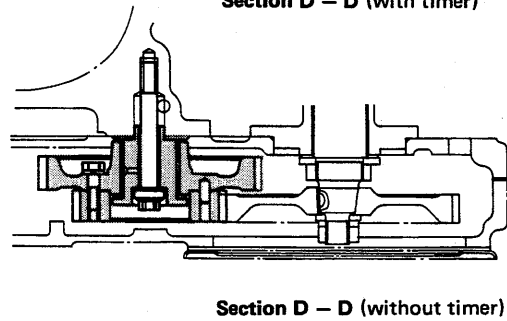
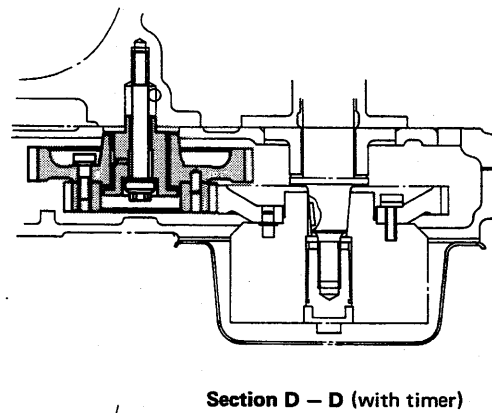
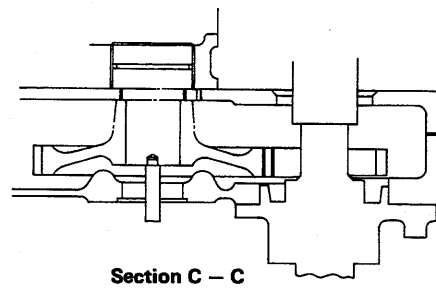
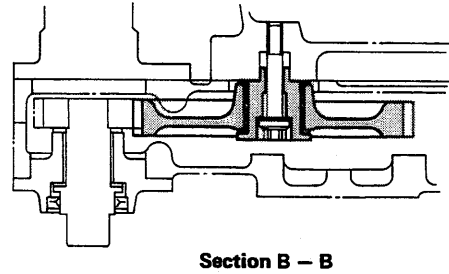
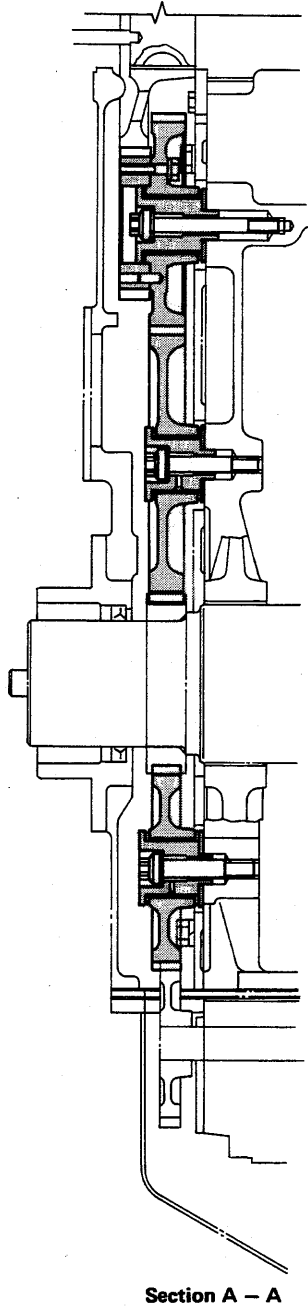
6162F119

# TIMING GEAR



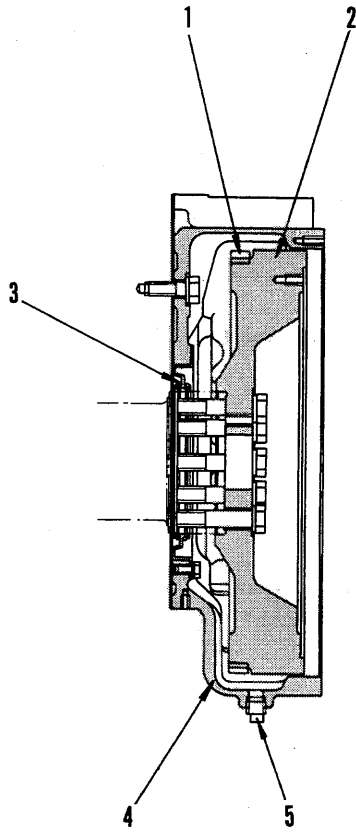
6162F120

- |                                                   |                                                |
|---------------------------------------------------|------------------------------------------------|
| 1. Idler gear (No. of teeth: 57)                  | 6. Idler gear (No. of teeth: 30)               |
| 2. Cam gear (No. of teeth: 48)                    | 7. Crankshaft gear (No. of teeth: 36)          |
| 3. Compressor driving gear (No. of teeth: 24)     | 8. Oil pump driving gear (No. of teeth: 33)    |
| 4. Injection pump driving gear (No. of teeth: 48) | 9. Idler gear (No. of teeth: 41)               |
| 5. Idler gear (No. of teeth: 45)                  | 10. Water pump driving gear (No. of teeth: 20) |



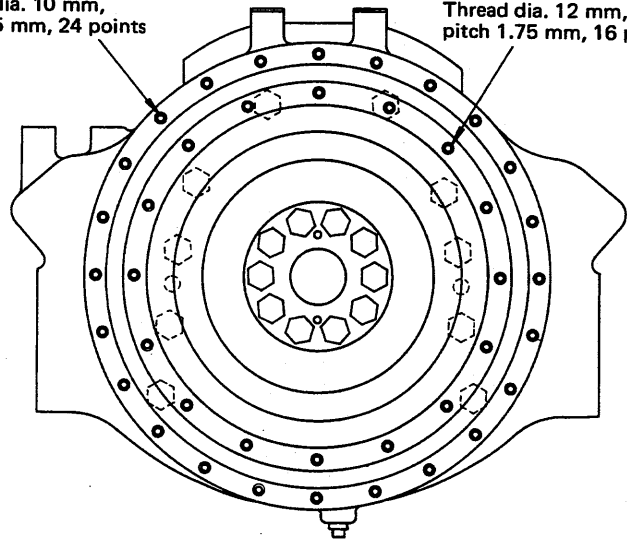
6162F121

# FLYWHEEL AND FLYWHEEL HOUSING



Thread dia. 10 mm,  
pitch 1.5 mm, 24 points

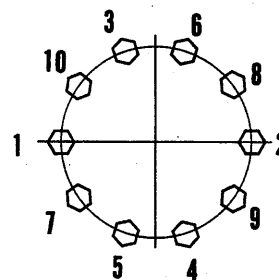
Thread dia. 12 mm,  
pitch 1.75 mm, 16 points



- 1. Ring gear (No. of teeth: 118)
- 2. Flywheel
- 3. Rear seal
- 4. Flywheel housing
- 5. Drain plug

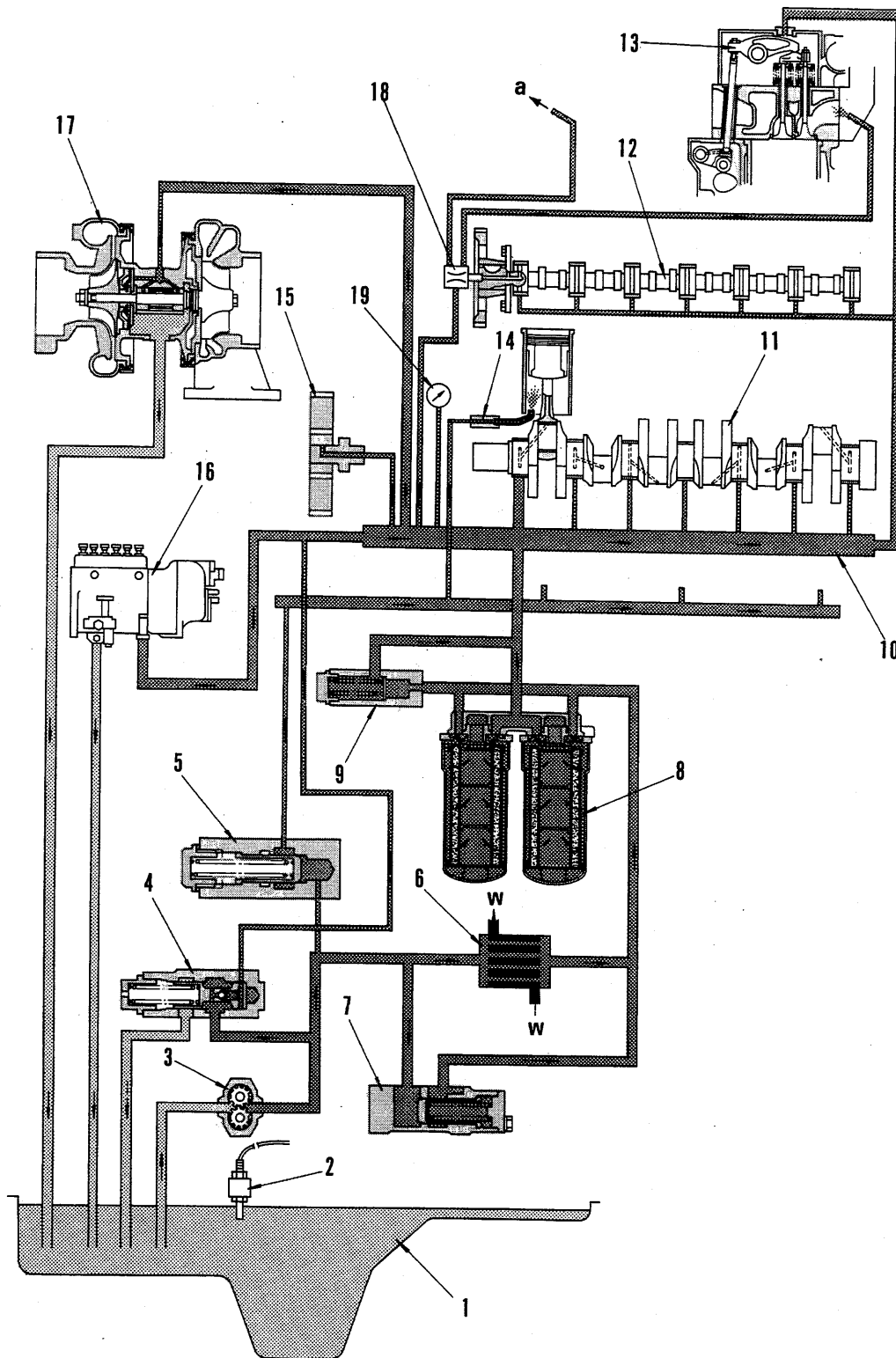
6162F122

Tightening order of flywheel mounting bolt



# LUBRICATION SYSTEM

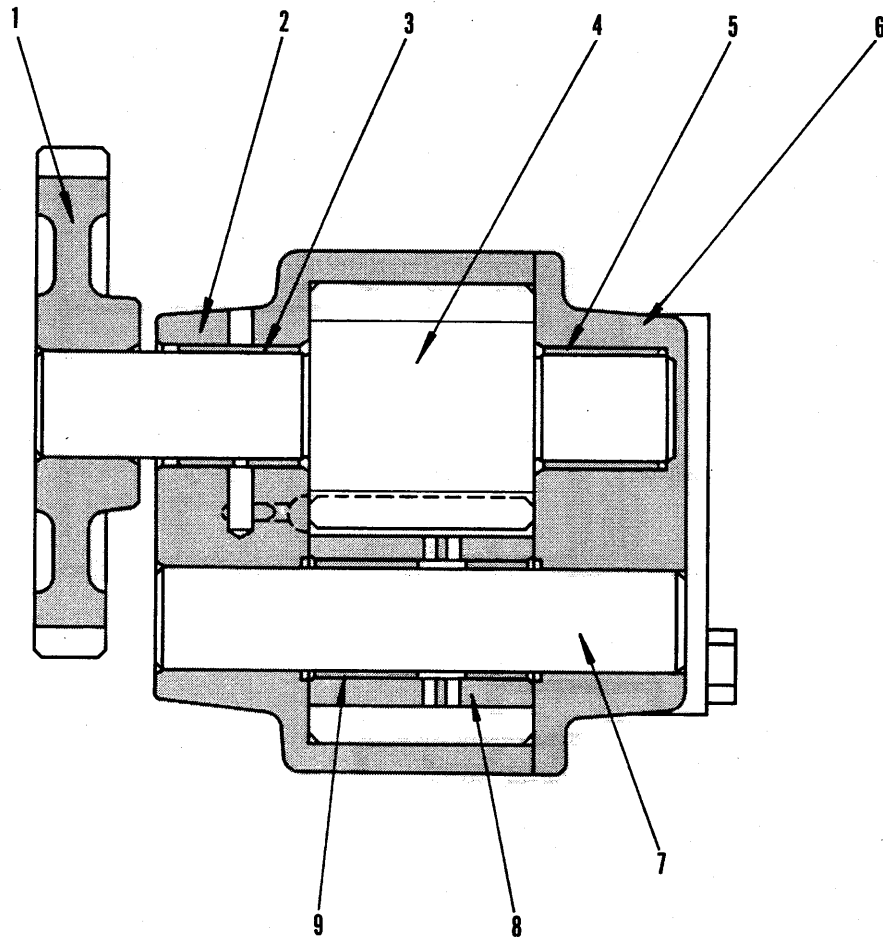
## LUBRICATION SYSTEM CHART



- 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

6162F123 A

OIL PUMP



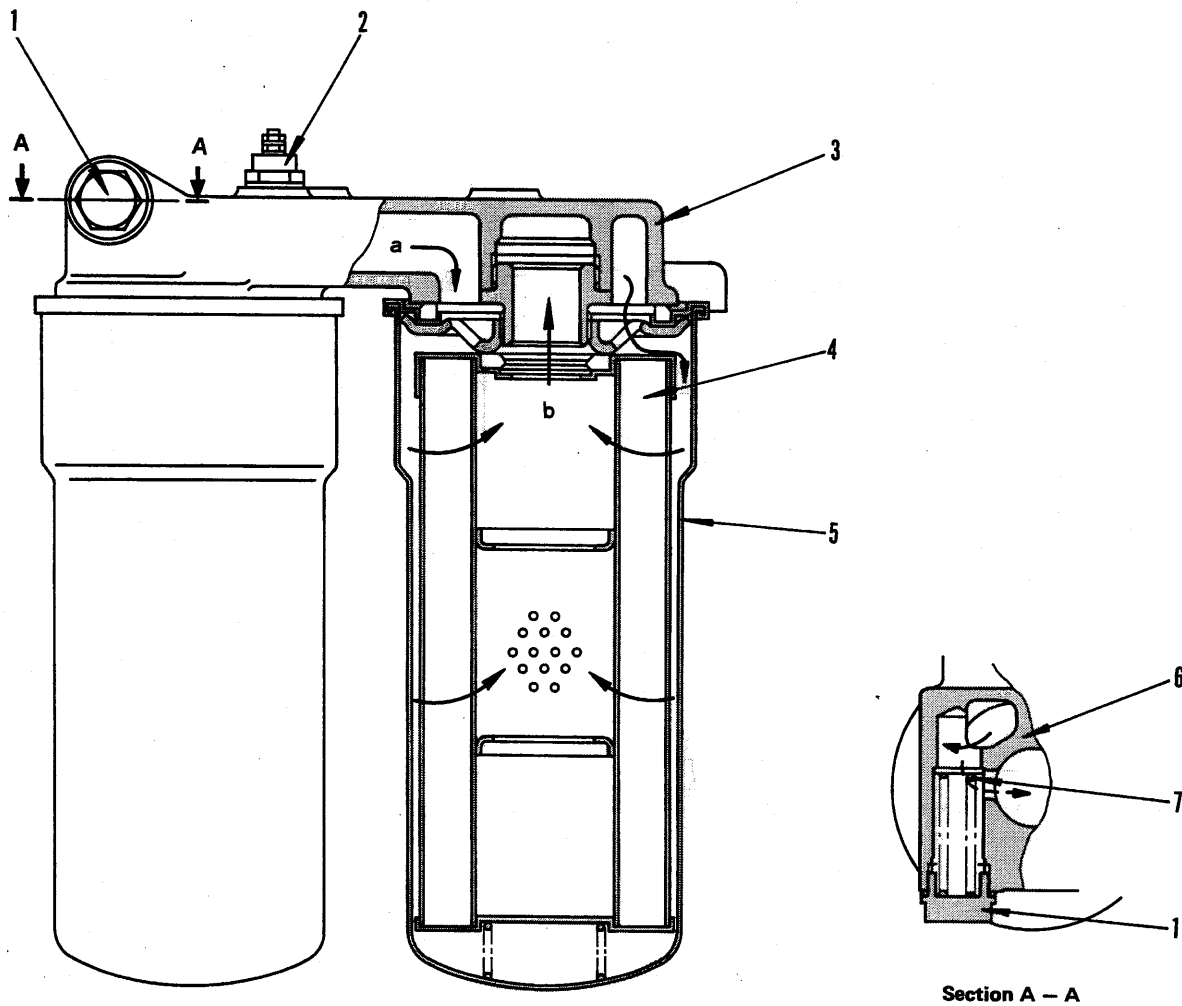
6162F124

- 1. Oil pump driving gear (No. of teeth: 33)
- 2. Oil pump body
- 3. Bushing
- 4. Drive shaft
- 5. Bushing
- 6. Pump cover
- 7. Driven shaft
- 8. Driven gear (No. of teeth: 12)
- 9. Bushing

**Oil pump**

- Gear pump type
- Oil pump speed: Engine speed x 1.091

# OIL FILTER AND SAFETY VALVE



- 1. Safety valve cap
  - 2. Oil pressure sensor
  - 3. Filter bracket
  - 4. Filter element
  - 5. Filter case
  - 6. Safety valve
  - 7. Valve spring
  - a. From oil pump
  - b. To engine each component
- } Cartridge

**Oil filter**

- Filtration area: 0.82 m<sup>2</sup> x 2

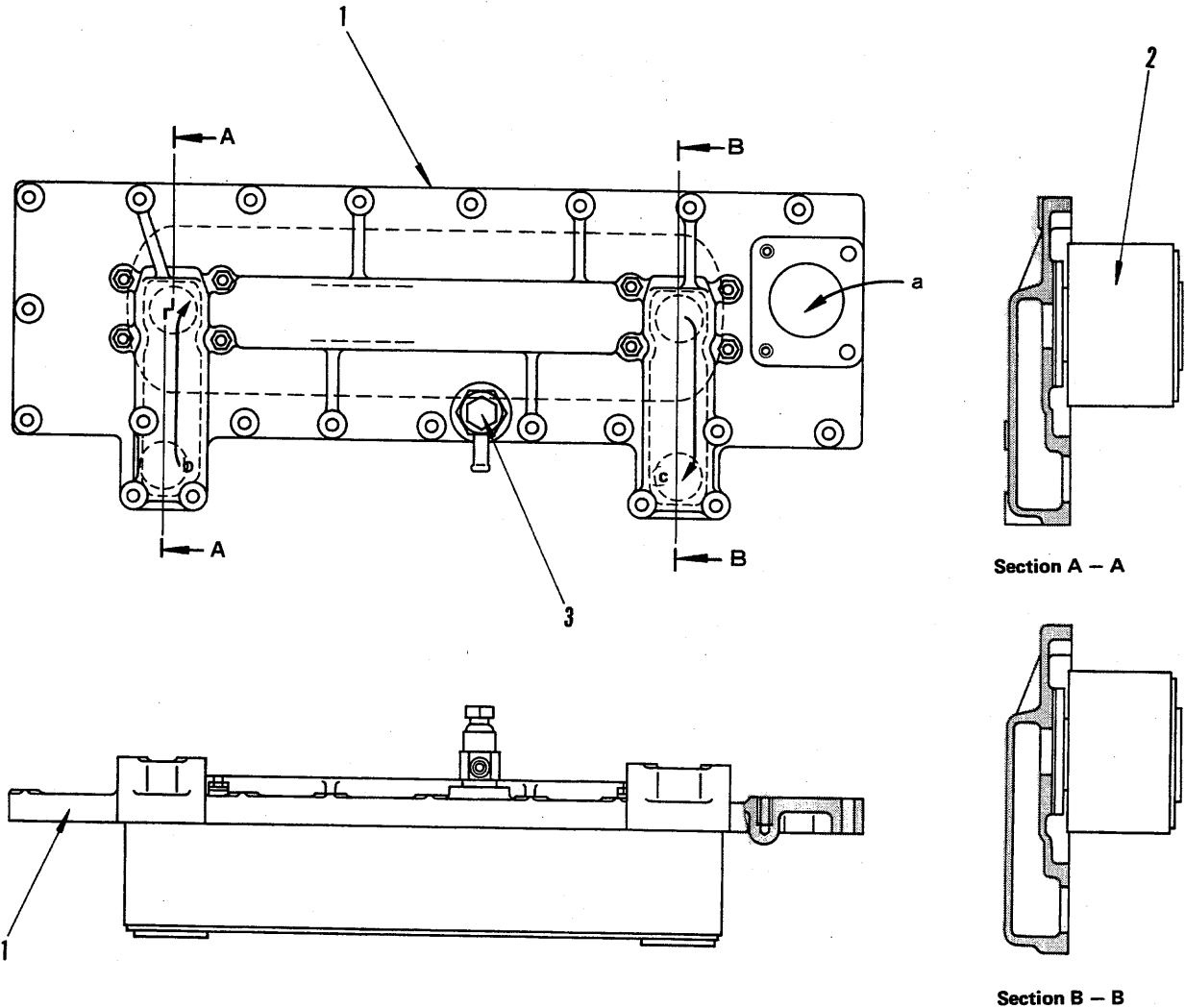
**Safety valve**

- Cracking pressure (difference pressure):  
2.0 ± 0.2 kg/cm<sup>2</sup>

6162F125

# OIL COOLER

S6D170-1  
SA6D170-B-1



- 1. Cooler cover
- 2. Cooler element
- 3. Drain cock
- a. Coolant (from water pump)
- b. Oil (from oil pump)
- c. Oil (to engine each component)

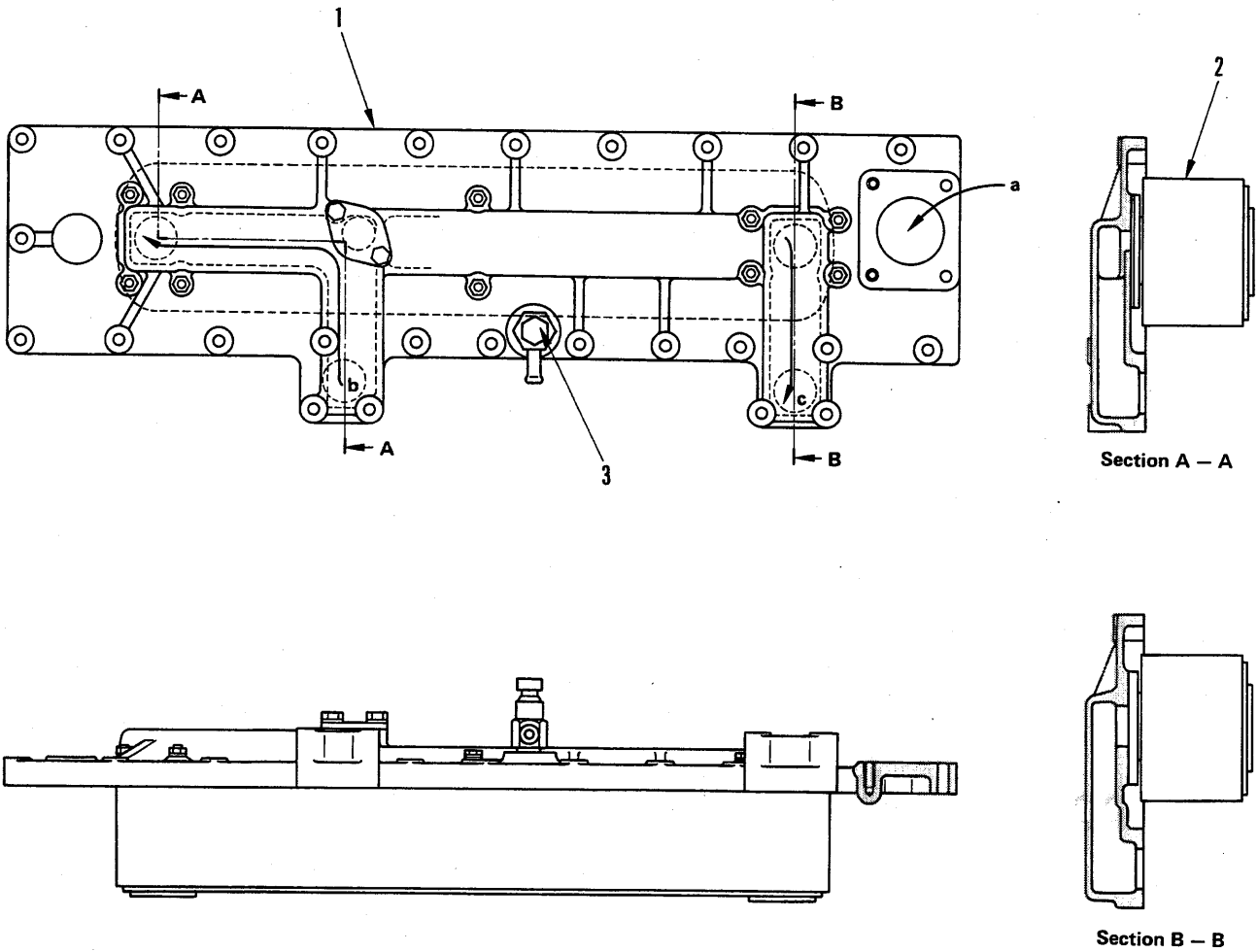
### Oil cooler

- Heat exchanged: Min. 45000 Kcal/hr.
- Heat-transmitting area: 2.94 m<sup>2</sup>
- Oil flow capacity: 180 ℓ/min.
- Water flow capacity: 890 ℓ/min.

6162F126



SA6D170-A-1

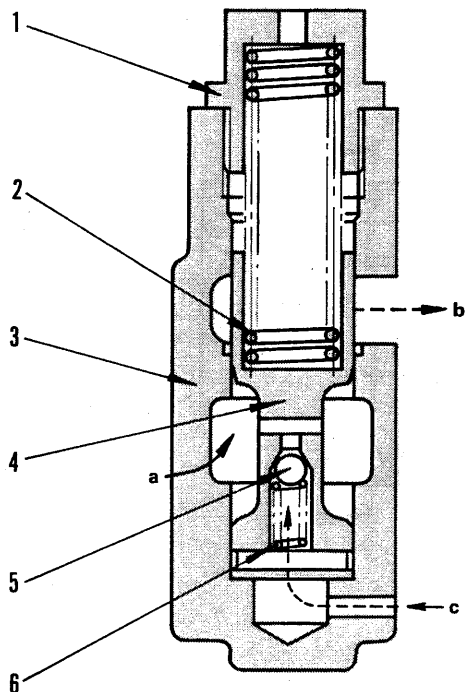


- 1. Cooler cover
- 2. Cooler element
- 3. Drain cock
- a. Coolant (from water pump)
- b. Oil (from oil pump)
- c. Oil (to engine each component)

**Oil cooler**

- Heat exchanged: Min. 55000 Kcal/hr.
- Heat-transmitting area: 4.146 m<sup>2</sup>
- Oil flow capacity: 180 ℓ/min.
- Water flow capacity: 890 ℓ/min.

### MAIN RELIEF VALVE



- 1. Plug
- 2. Valve spring
- 3. Valve body
- 4. Relief valve
- 5. Ball type valve (Main relief valve)
- 6. Main relief valve spring
- a. From oil pump
- b. To oil pan
- c. From main gallery

**Main relief valve**

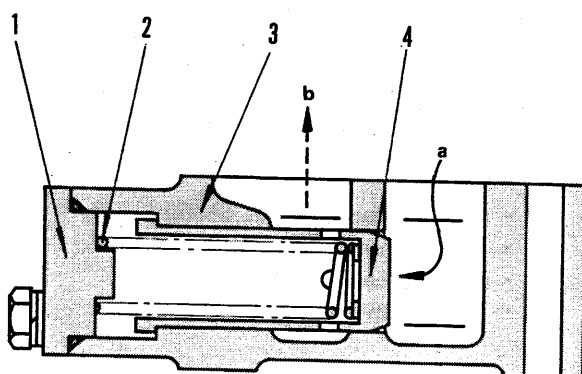
• Cracking pressure (difference pressure):  $8 \pm 1 \text{ kg/cm}^2$

**Oil-line check valve**

• Cracking pressure:  $3.3 \pm 0.3 \text{ kg/cm}^2$

6162F127

### OIL COOLER BY-PASS VALVE



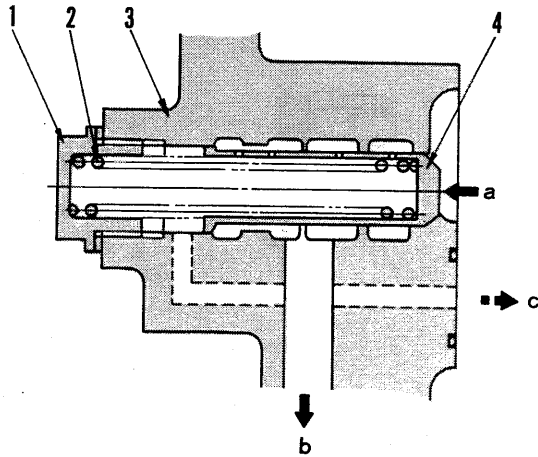
- 1. Cap
- 2. Valve spring
- 3. Valve body
- 4. By-pass valve
- a. From oil pump
- b. To oil filter

**Oil cooler by-pass valve**

• Cracking pressure:  $4.5 \pm 0.5 \text{ kg/cm}^2$

6162F128

# PISTON COOLING VALVE



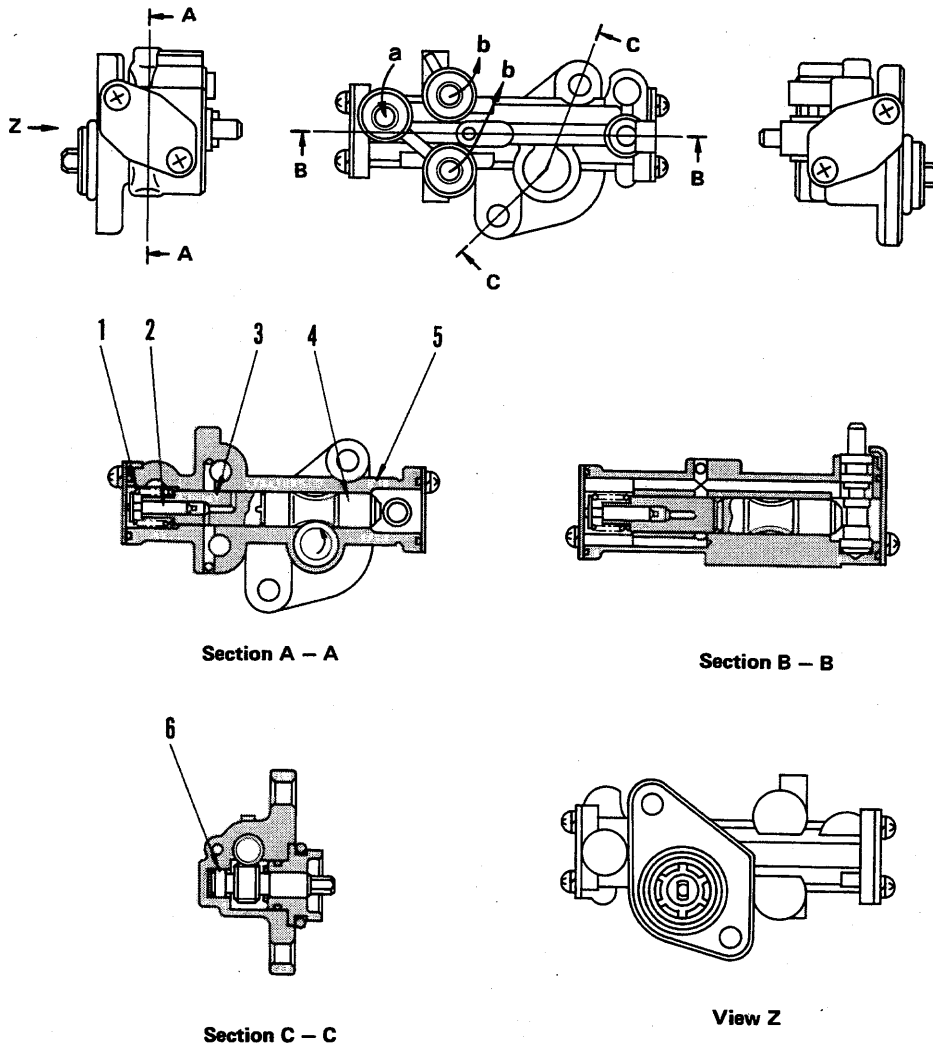
- 1. Cap
- 2. Valve spring
- 3. Oil filter adapter
- 4. Piston cooling valve
- a. From oil pump
- b. To piston cooling nozzle
- c. To cylinder block

**Piston cooling valve**

• Cracking pressure:  $1.3 \begin{matrix} +0.3 \\ -0.1 \end{matrix} \text{ kg/cm}^2$

6162F129

# MECHANICAL PUMP



- 1. Spring
- 2. Plunger
- 3. Plunger
- 4. Plunger
- 5. Pump body
- 6. Worm
- a. Oil inlet (from main gallery)
- b. Oil outlet (to intake manifold)

6162F130

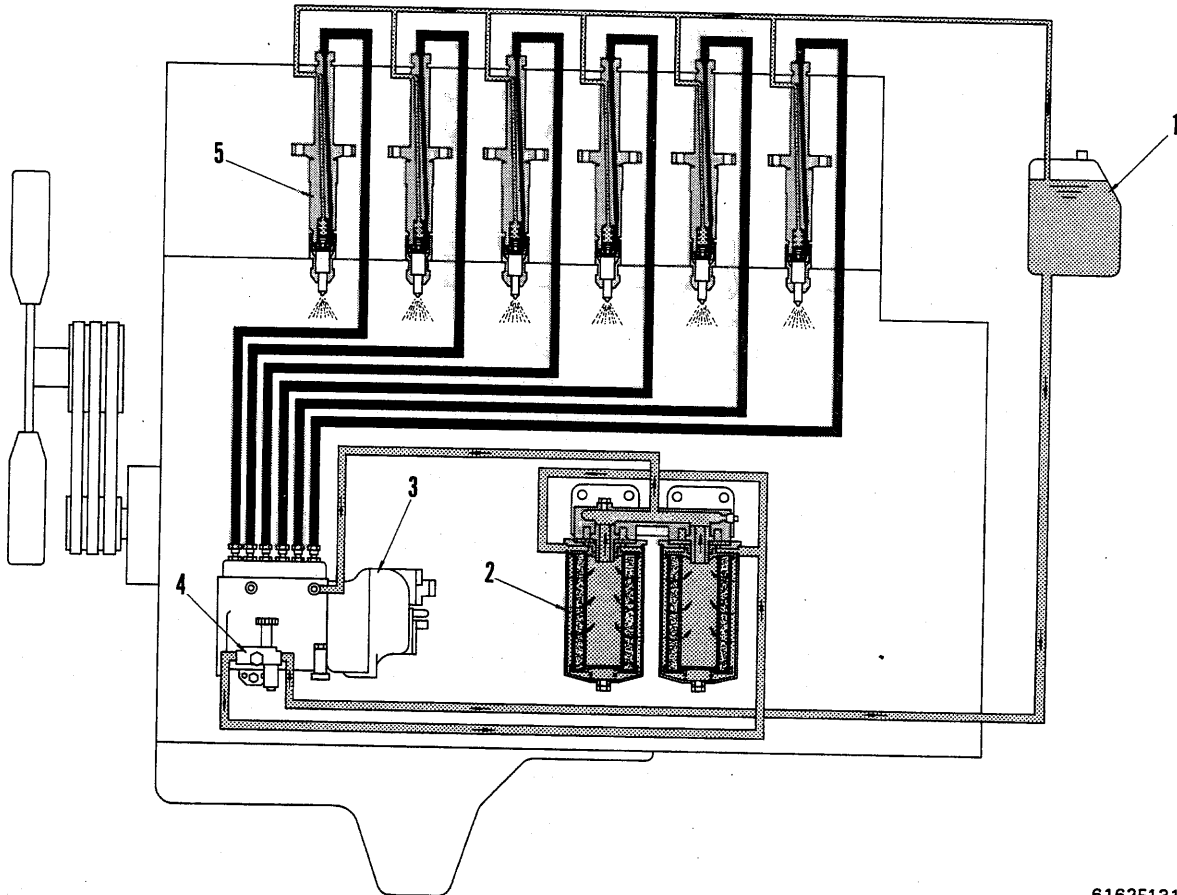
### Mechanical pump

- Capacity:  $10 \pm 1 \text{ cc/h} \times 2$
- The mechanical pump is a worm pump used to increase the wear resistance of the intake valve seat.
- The pump is driven by the slit shaft connected to the camshaft.

- The oil is sent from the main gallery into the pump, and sent out from the two outlets of the pump to the two intake manifolds through the oil tubes. The oil is sprayed in the intake manifolds by the intake air onto the seats of the valves to reduce the wear of the seats.

# FUEL SYSTEM

## FUEL SYSTEM CHART

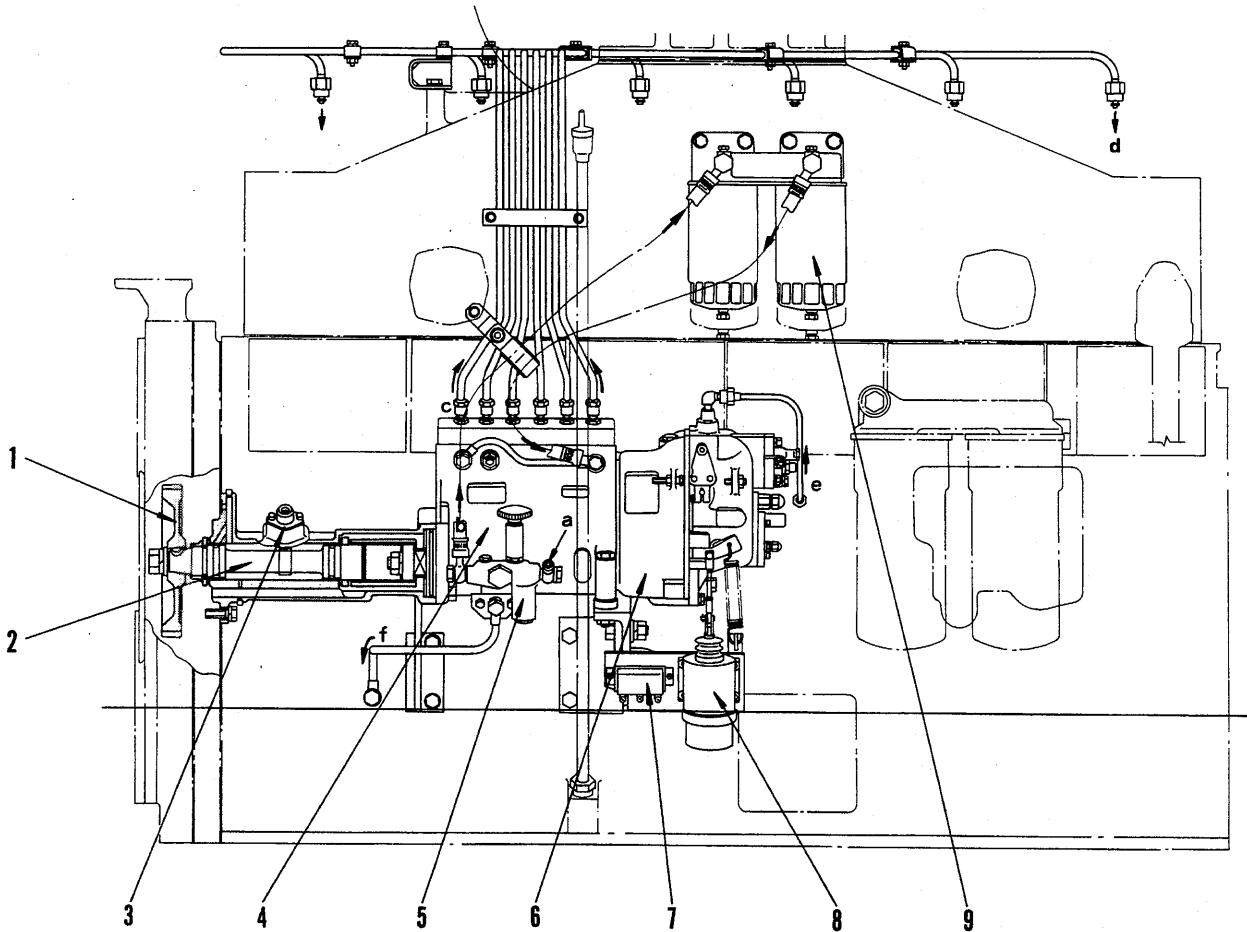


6162F131

- 1. Fuel tank
- 2. Fuel filter
- 3. Fuel injection pump
- 4. Feed pump
- 5. Fuel injection nozzle

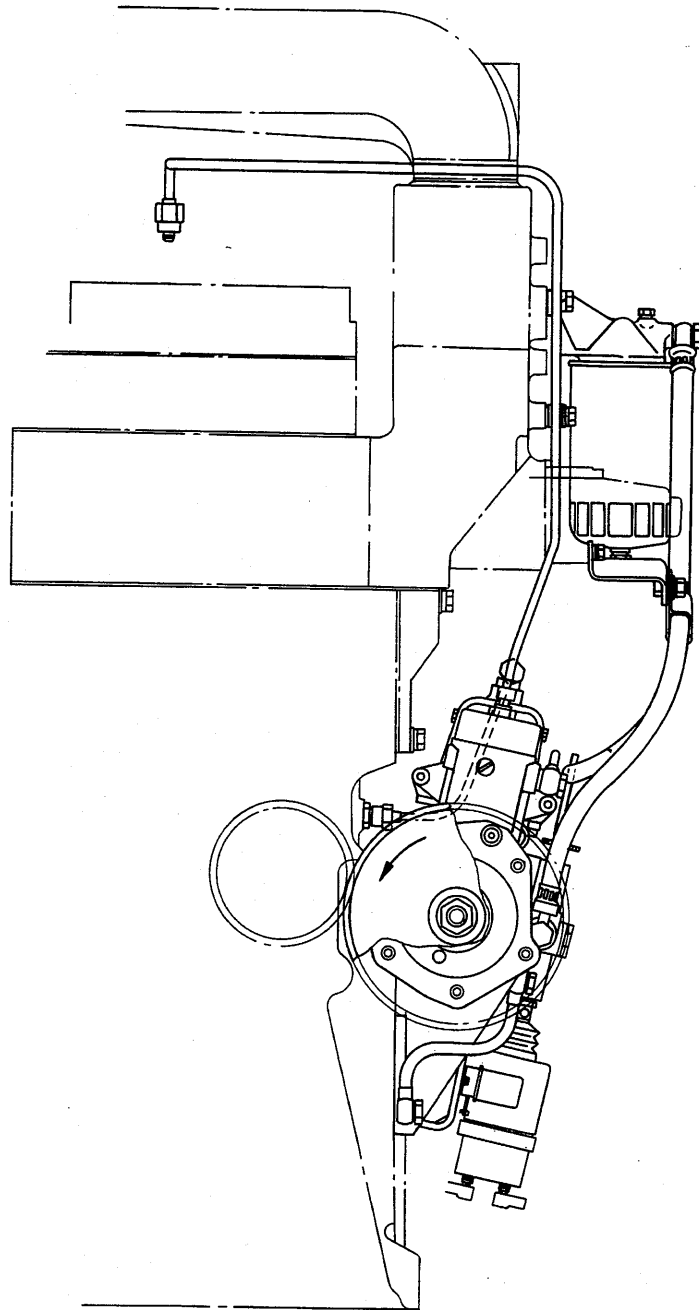
# FUEL INJECTION PUMP

S6D170-1, SA6D170-B-1



6162F132

- |                                                   |                               |
|---------------------------------------------------|-------------------------------|
| 1. Injection pump driving gear (No. of teeth: 48) | a. Fuel (from fuel tank)      |
| 2. Injection pump drive shaft                     | b. Fuel (to fuel filter)      |
| 3. Service meter output                           | c. Fuel (from injection pump) |
| 4. Fuel injection pump                            | d. Fuel (to nozzle holder)    |
| 5. Feed pump                                      | e. Oil (from main gallery)    |
| 6. Governor                                       | f. Oil (to oil pan)           |
| 7. Relay                                          |                               |
| 8. Solenoid                                       |                               |
| 9. Fuel filter                                    |                               |

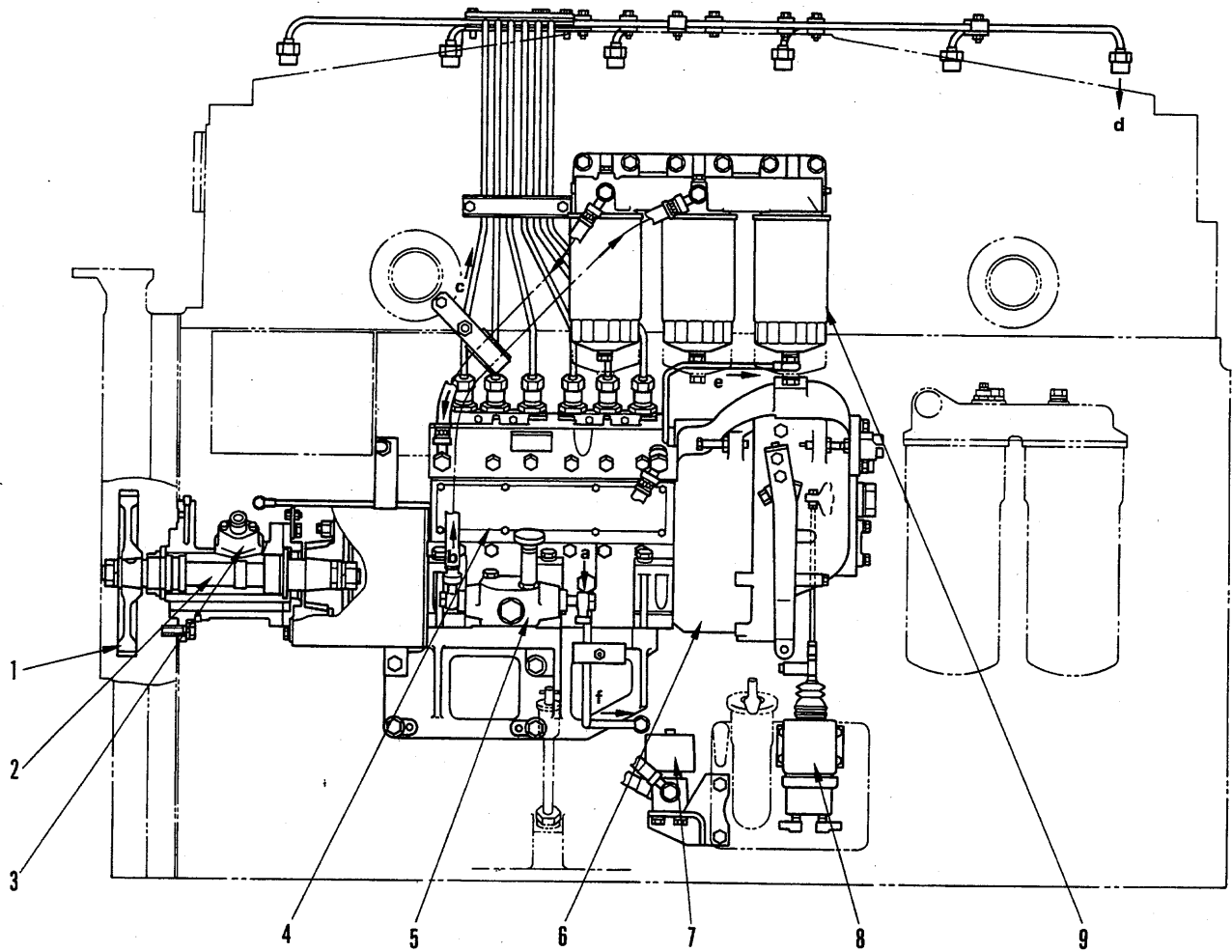


6162F133

**Fuel injection pump**

- Maker: Diesel Kiki
- Type: PES-PD type
- Governor: RSUV, centrifugal type, all-speed type
- Lubrication method: Forced lubrication with engine oil

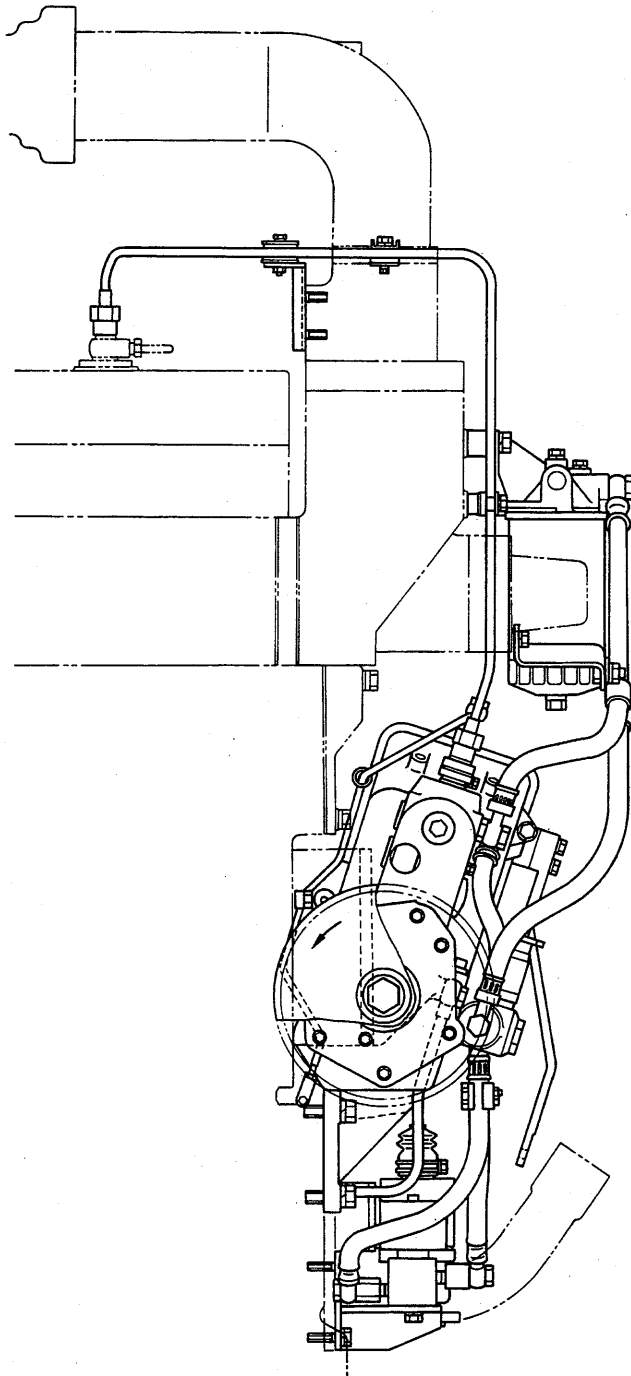
SA6D170-A-1



- 1. Injection pump driving gear (No. of teeth: 48)
- 2. Injection pump drive shaft
- 3. Service meter output
- 4. Fuel injection pump
- 5. Feed pump
- 6. Governor
- 7. Relay
- 8. Solenoid
- 9. Fuel filter

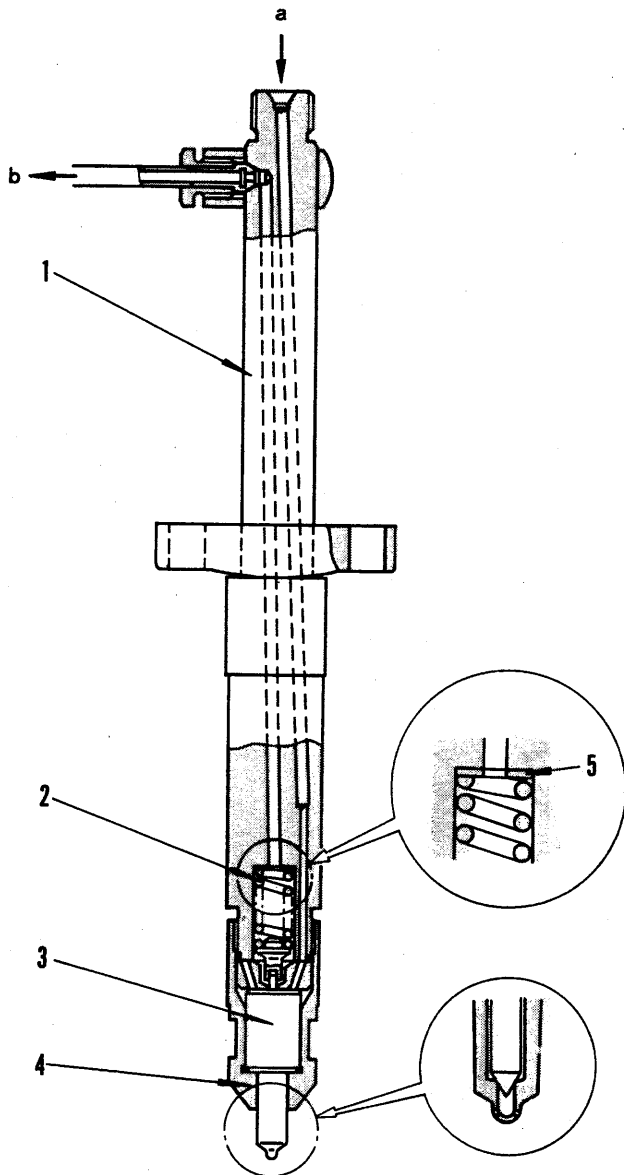
- a. Fuel (from fuel tank)
- b. Fuel (to fuel filter)
- c. Fuel (from injection pump)
- d. Fuel (to nozzle holder)
- e. Oil (from main gallery)
- f. Oil (to oil pan)



**Fuel injection pump**

- Maker: Diesel Kiki
- Type: PE-ZWX type
- Governor: RSUV, centrifugal type, all-speed type
- Lubrication method: Forced lubrication with engine oil

# FUEL INJECTION NOZZLE



- 1. Nozzle holder
- 2. Nozzle spring
- 3. Nozzle
- 4. Retaining cap
- 5. Adjustment shim
- a. Fuel inlet
- b. Fuel return (To fuel tank)

6162F134 A

### Fuel injection nozzle

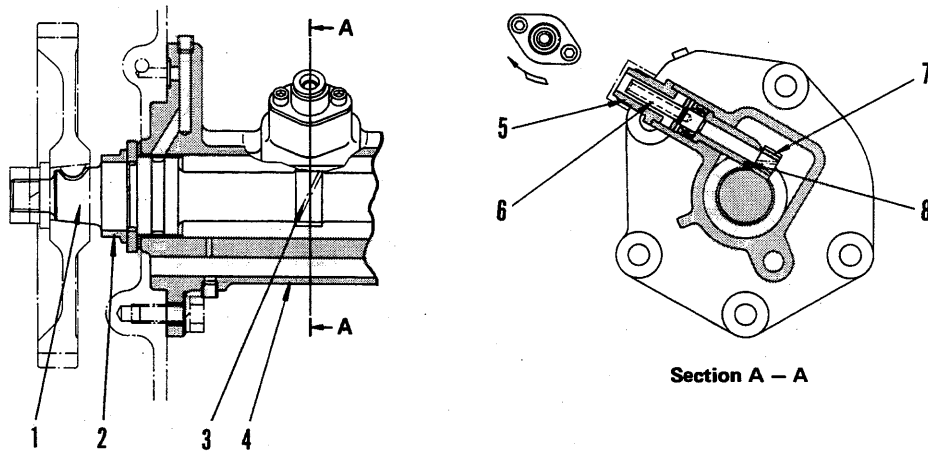
- Maker: Diesel Kiki
- Type: Bosch DLL-S type, multiple hole type

### Fuel injection pressure

Engine	Pressure
S6D170-1	255 kg/cm <sup>2</sup>
SA6D170-A-1	300 kg/cm <sup>2</sup>
SA6D170-B-1	255 kg/cm <sup>2</sup>

- Adjustment of injection pressure is adjusted by upper side shim (5) on nozzle spring (2) after removing nozzle nut (4).

## FUEL INJECTION PUMP DRIVE



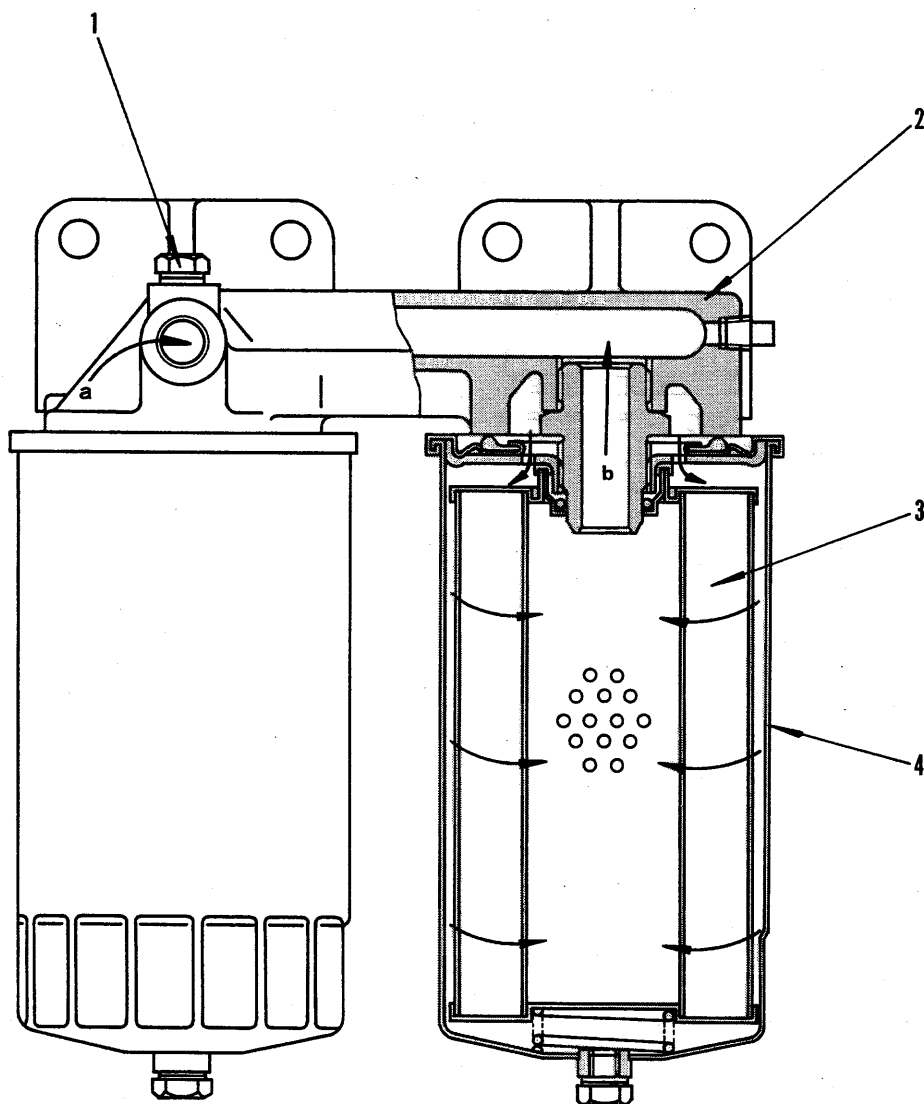
6162F135

1. Fuel injection pump drive shaft
2. Nut
3. Tachometer drive gear (No. of teeth: 14)
4. Drive housing
5. Pinion gear housing
6. Tachometer drive shaft
7. Pinion gear (No. of teeth: 14)
8. Bushing

### Tachometer drive

- Tachometer drive shaft speed = Engine speed x 1/2

# FUEL FILTER



6162F136

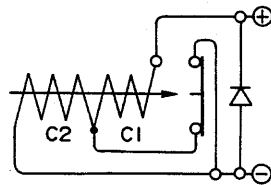
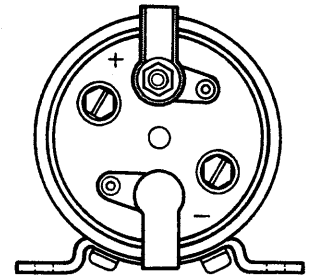
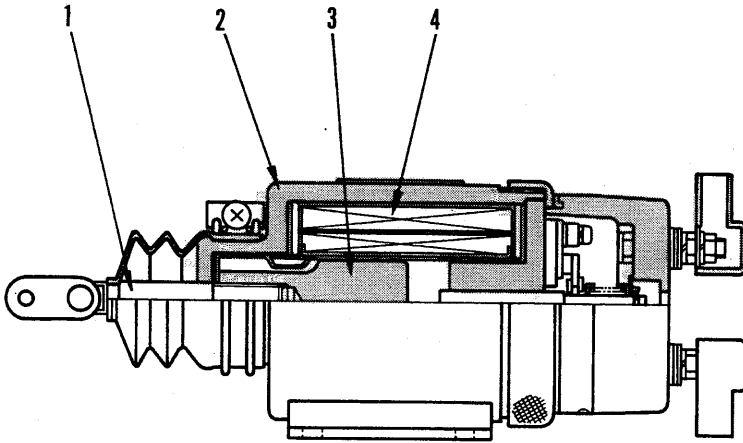
- 1. Air bleeding plug
  - 2. Filter bracket
  - 3. Filter element
  - 4. Filter case
- } Cartridge
- a. From feed pump
  - b. To fuel injection pump

**Fuel filter**

• Filtration area: 0.5 m<sup>2</sup> x 2

# FUEL SOLENOID

B contact (electricity flows in ordinary operations) method



Inner wiring

## FUEL SOLENOID

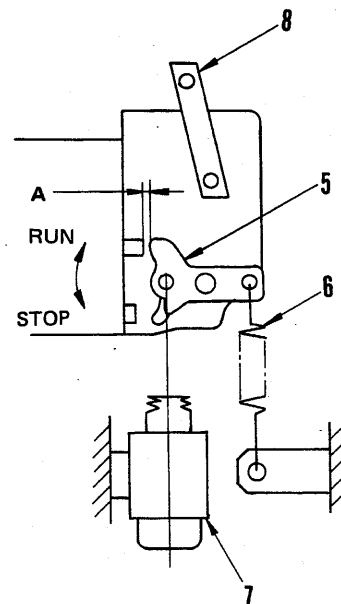
F621201037

- Maker: NIKKO DENKI
- Type: Sealed
- Rated voltage: DC24V
- Operating current: Maximum: 35A max.  
Continuity: 0.5A max.
- Stroke:  $12 \pm 0.1$  mm
- Weight: 2.7 kg

- |           |                       |
|-----------|-----------------------|
| 1. Shaft  | 5. Stop lever         |
| 2. Case   | 6. Return spring      |
| 3. Piston | 7. Solenoid           |
| 4. Coil   | 8. Fuel control lever |

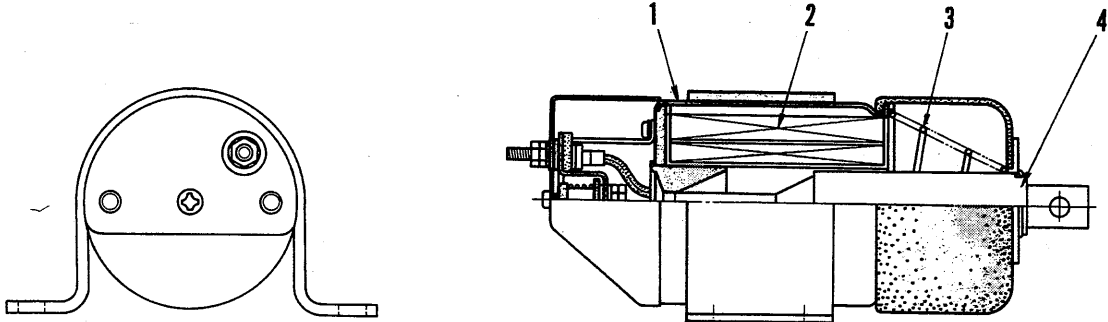
## FUNCTION

- Starting engine  
When the starting key is turned on, the solenoid is energized.  
Solenoid shaft (1) is electrically attracted, pulling injection pump stop lever (5) and fixing it in the RUN position.
- Stopping engine  
When the starting key is turned off, the solenoid is de-energized.  
Injection pump stop lever (5) is returned to STOP position (non-injection position) by return spring (6).
- During operation, the amount of fuel injection is controlled by fuel control lever (8).
- When installing the fuel solenoid, adjust clearance A referring to TESTING AND ADJUSTING.

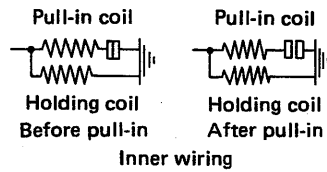


6162F151

A contact (electricity flows when stopped) method



02F082-K



1. Case
2. Coil
3. Return spring
4. Plunger

6134F188A

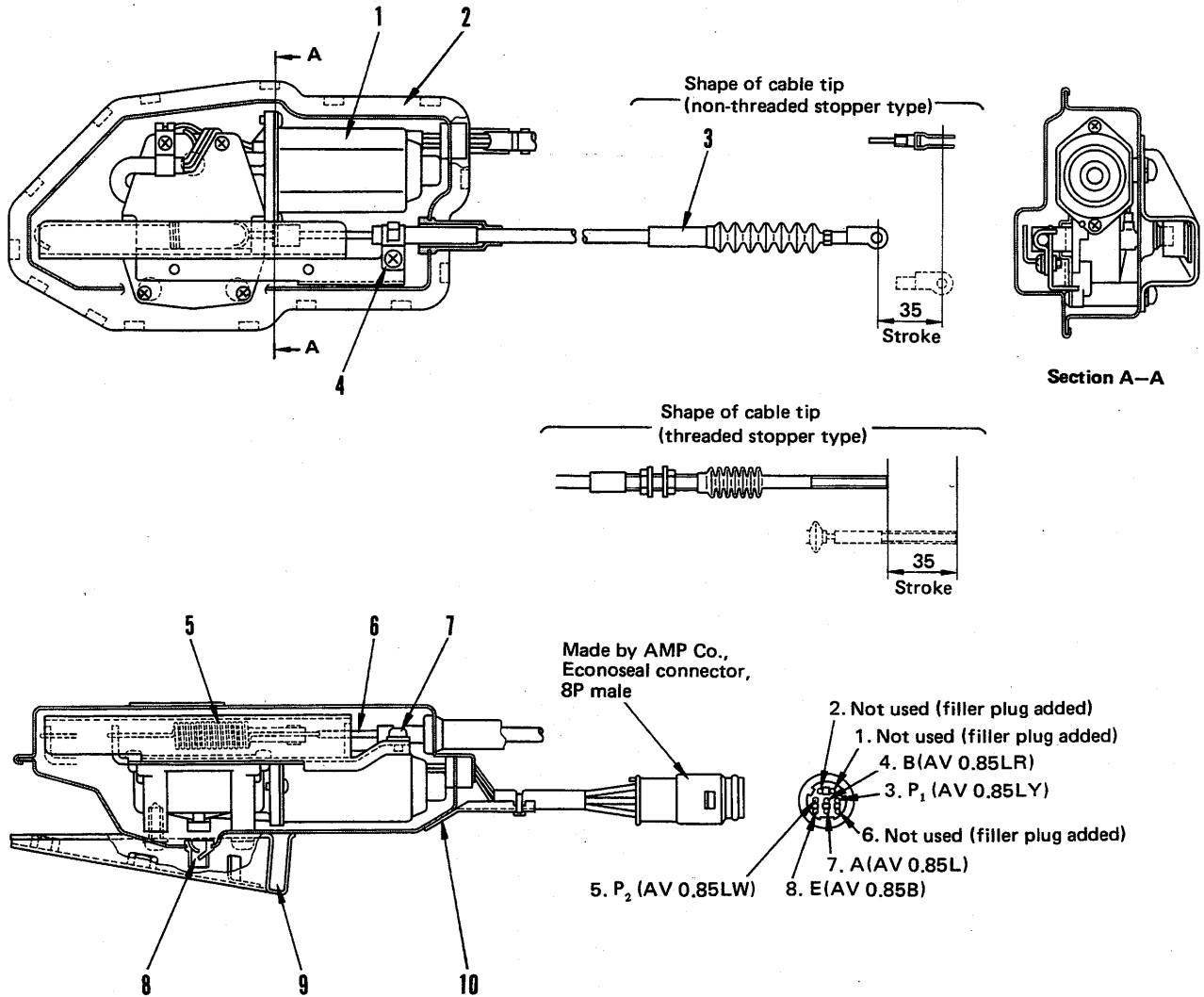
**FUNCTION**

When stopping the engine, the solenoid is energized, the solenoid plunger is electrically attracted, and the stop lever of the injection pump is moved by a rod to the stop (non-injection) position. As a result, the fuel is cut off and the engine is brought to a stop. Accordingly, this solenoid is used only when the engine is being stopped; it is in free condition during ordinary operations.

**FUEL SOLENOID**

- Maker: NIPPON DENSO
- Type: Sealed
- Rated voltage: DC24V
- Operating current
  - Pull-in coil: 20A max.
  - Holding coil: 5A max.
- Stroke: 27 mm

# ENGINE STOP MOTOR

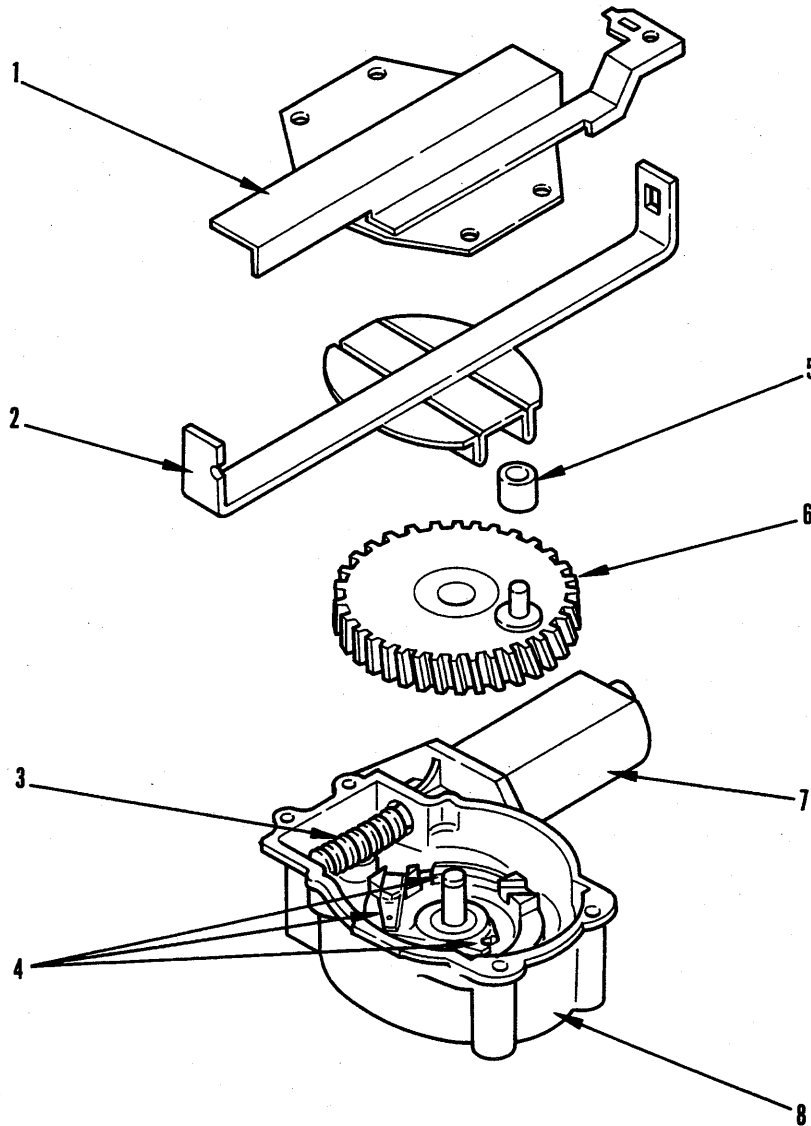


- 1. Motor assembly
- 2. Cover
- 3. Cable assembly
- 4. Cable clamp
- 5. Coil spring
- 6. Cable
- 7. Screw
- 8. Breather
- 9. Bracket assembly
- 10. Cover assembly

**Engine stop motor**

- Maker: Jidosha Denki Kogyo Co., Ltd.
- Rated voltage: DC24V
- Operating force: 15 kg min.
- Stroke: 35<sup>+1.0</sup><sub>-0.4</sub> mm
- Weight: 1.2 kg

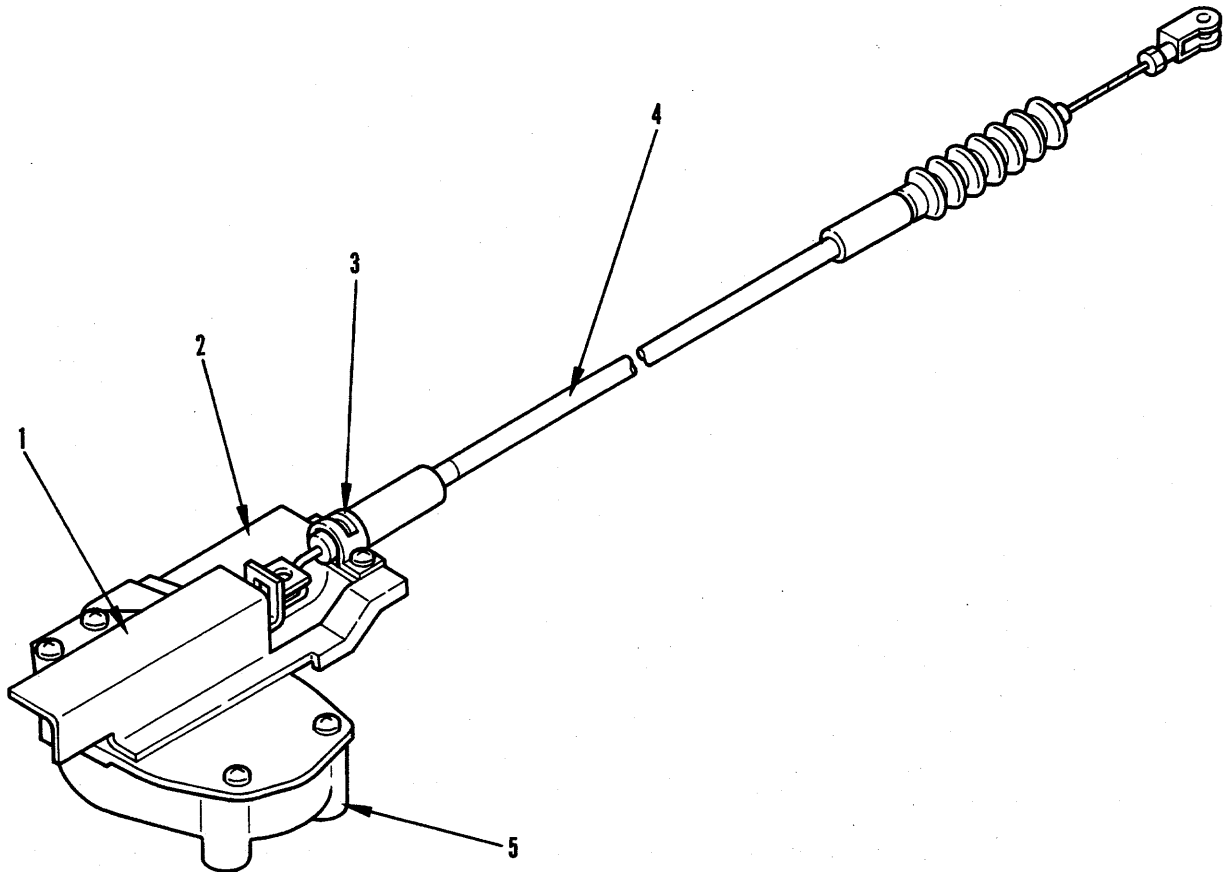
STRUCTURAL DRAWING (1)



- 1. Gear cover assembly
- 2. Slider assembly
- 3. Armature shaft
- 4. Contactor assembly
- 5. Roller
- 6. Worm wheel assembly
- 7. Motor assembly
- 8. Gear case assembly



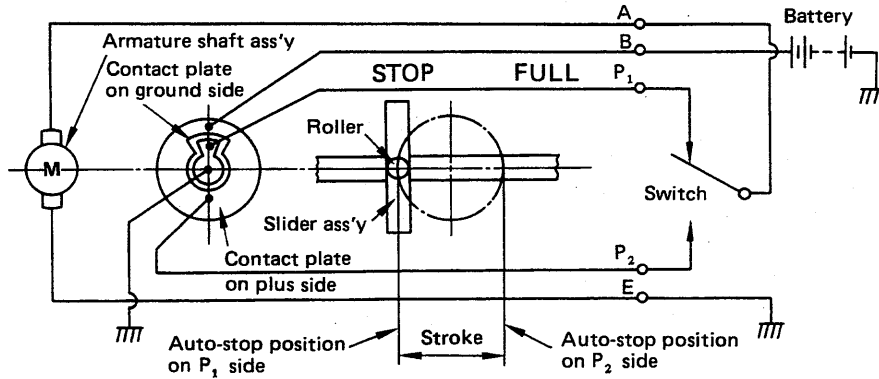
**STRUCTURAL DRAWING (2)**



- 1. Gear cover assembly
- 2. Motor assembly
- 3. Cable clamp
- 4. Cable assembly
- 5. Gear case assembly

DESCRIPTION OF OPERATION AND CIRCUITS

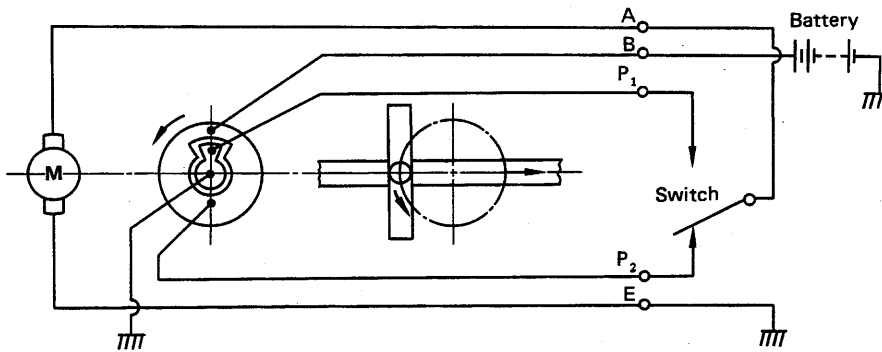
1. Stop condition (0° or 360°)



The above drawing shows the stopped condition when a closed circuit has been formed. The slider

assembly is stopped at the auto-stop position on the P<sub>1</sub> side.

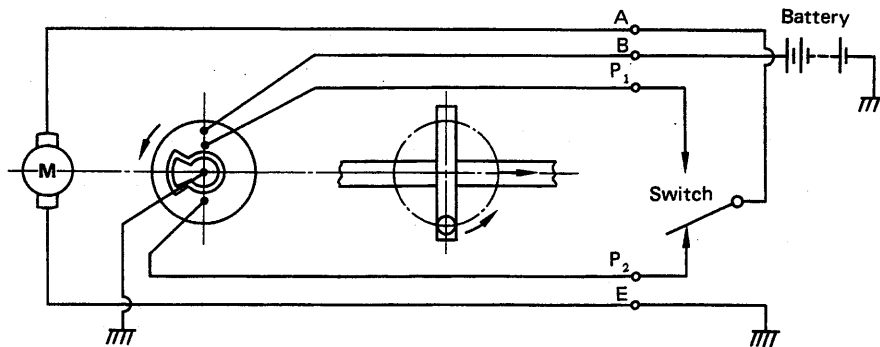
2. When switch is turned (when starting the motor)



When the switch is moved to the P<sub>2</sub> side (starting switch ON), an electric current flows from the plus side contactor plate through the P<sub>2</sub> auto-stop terminal and switch and into the armature shaft assem-

bly, thereby starting the motor. The slider assembly starts to move in the direction of the arrow at the same time as the roller starts to move.

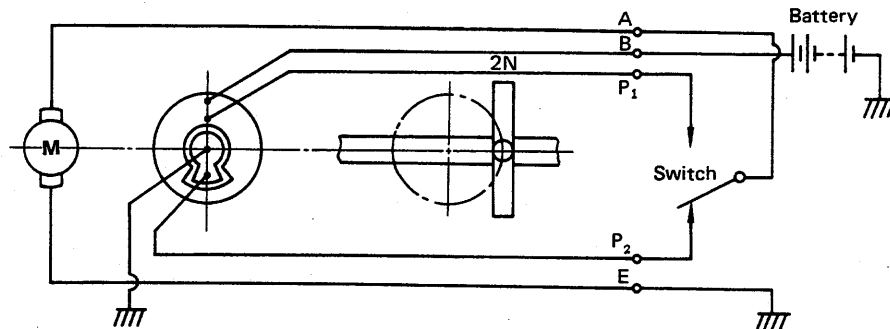
3. Turning condition (90° in the drawing)



Electric current continues to pass through the armature shaft assembly and the motor continues to turn. Because of the rotation of the roller, the

slider assembly also continues to move in the direction of the arrow.

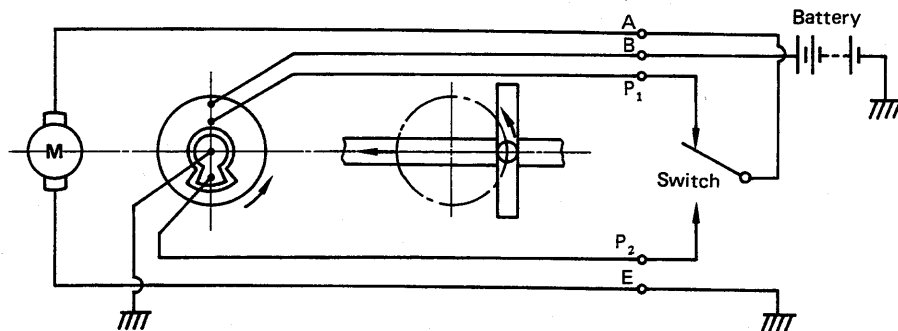
4. When stopped (180°)



A closed circuit is formed when the P<sub>2</sub> auto-stop terminal rides on the minus-side contactor plate,

and the motor comes to a sudden stop. The slider assembly also stops.

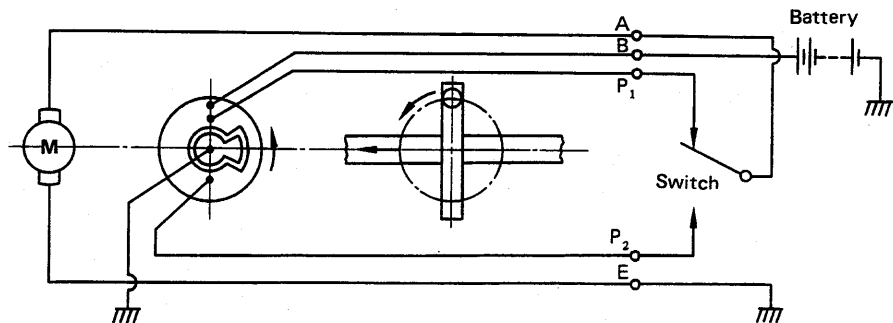
5. When switch is turned (when starting the motor)



When the switch is moved to the P<sub>1</sub> side (starting switch OFF), an electric current flows from the plus contactor plate through the P<sub>1</sub> auto-stop terminal and switch and into the armature shaft assembly,

thereby starting the motor. The slider assembly starts to move in the direction of the arrow at the same time as the roller starts to move.

6. Turning condition (270° in the drawing)

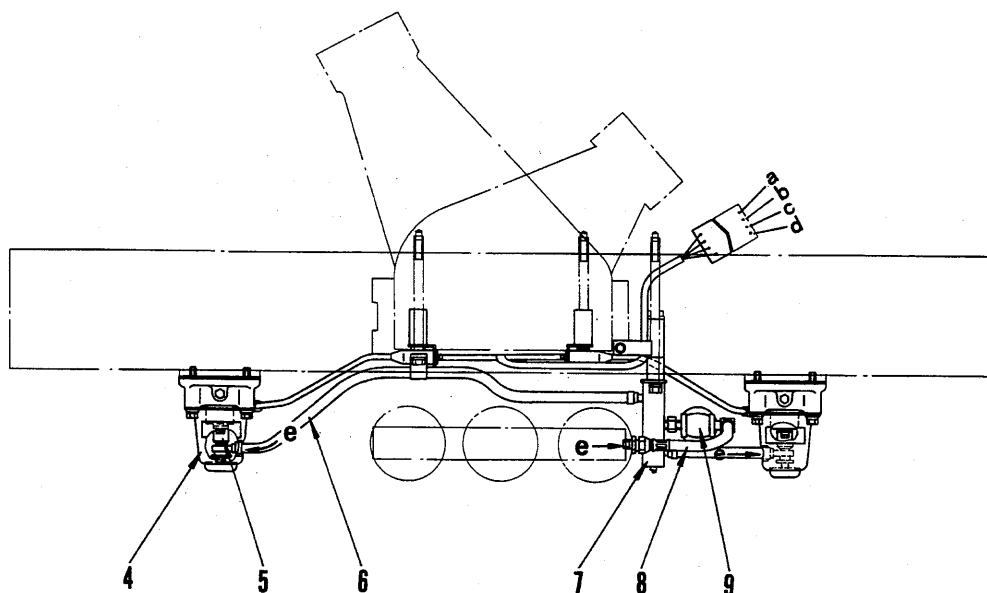
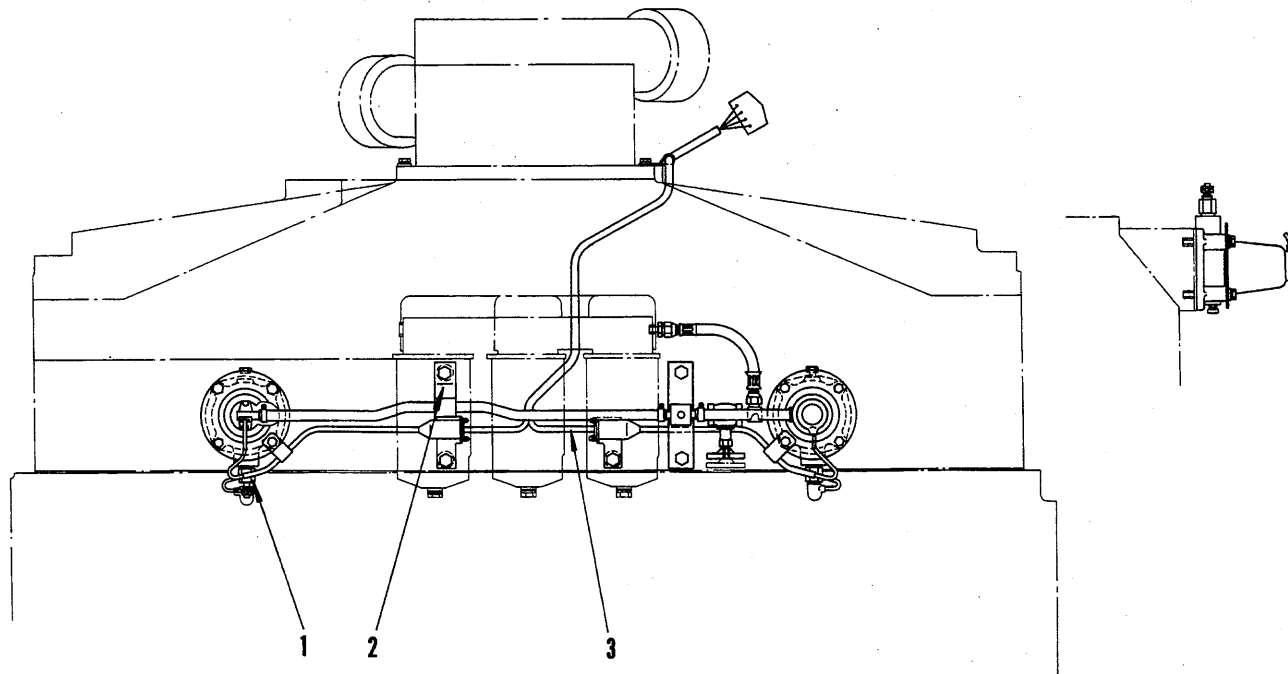


Electric current continues to pass through the armature shaft assembly and the motor continues to turn. The slider assembly also continues to move in

the direction of the arrow. Then the circuit returns to stop condition 1.

# STARTING AID

## Auto priming system (APS)



- 1. Glow plug
- 2. Clamp
- 3. Wiring harness
- 4. Cover
- 5. Nozzle

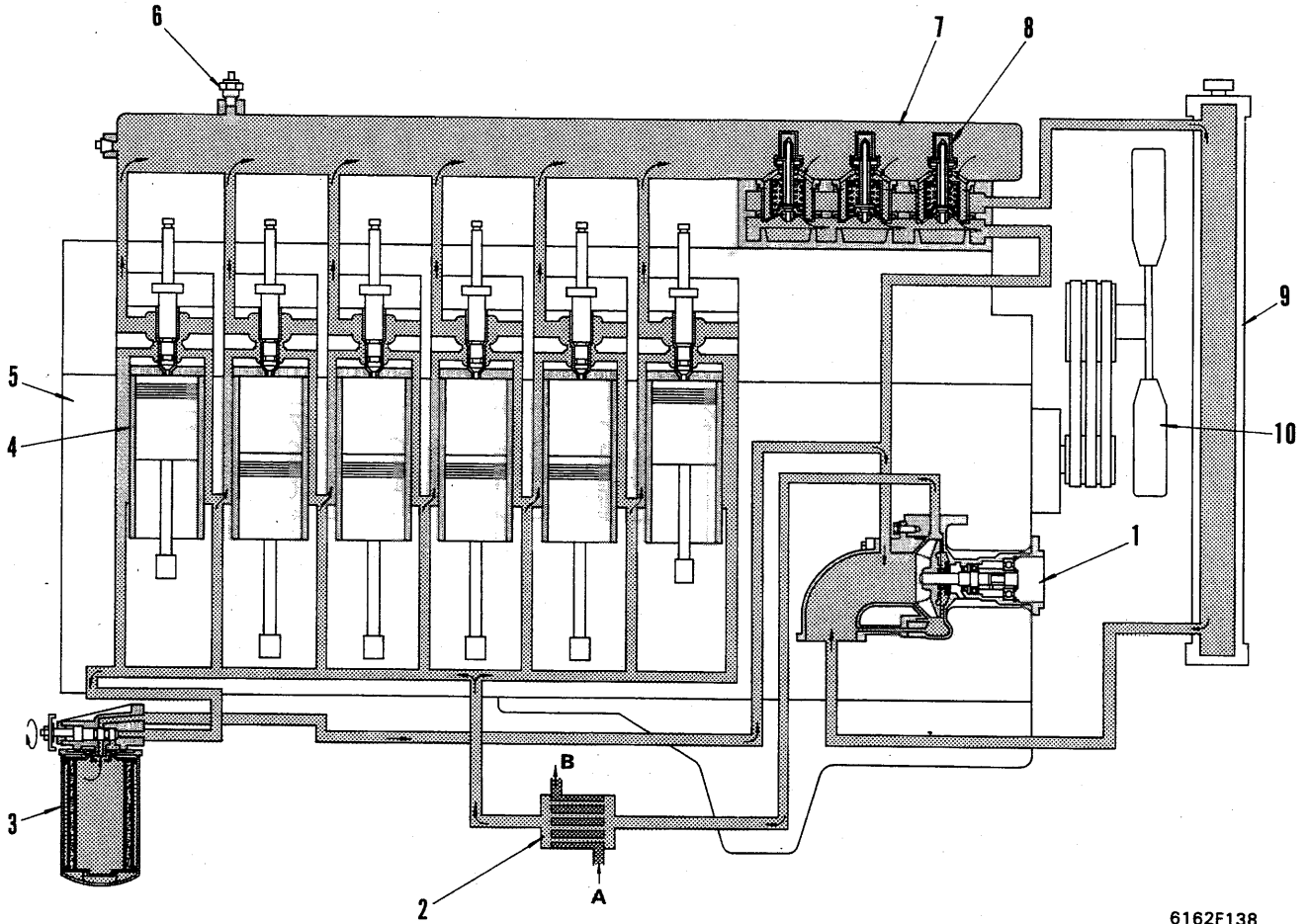
- 6. Hose
- 7. Bracket
- 8. Hose
- 9. Valve

- a. To heater switch
- b. To APS controller
- c. To APS controller
- d. To heater switch
- e. From fuel filter (Fuel)

6162F137

# COOLING SYSTEM

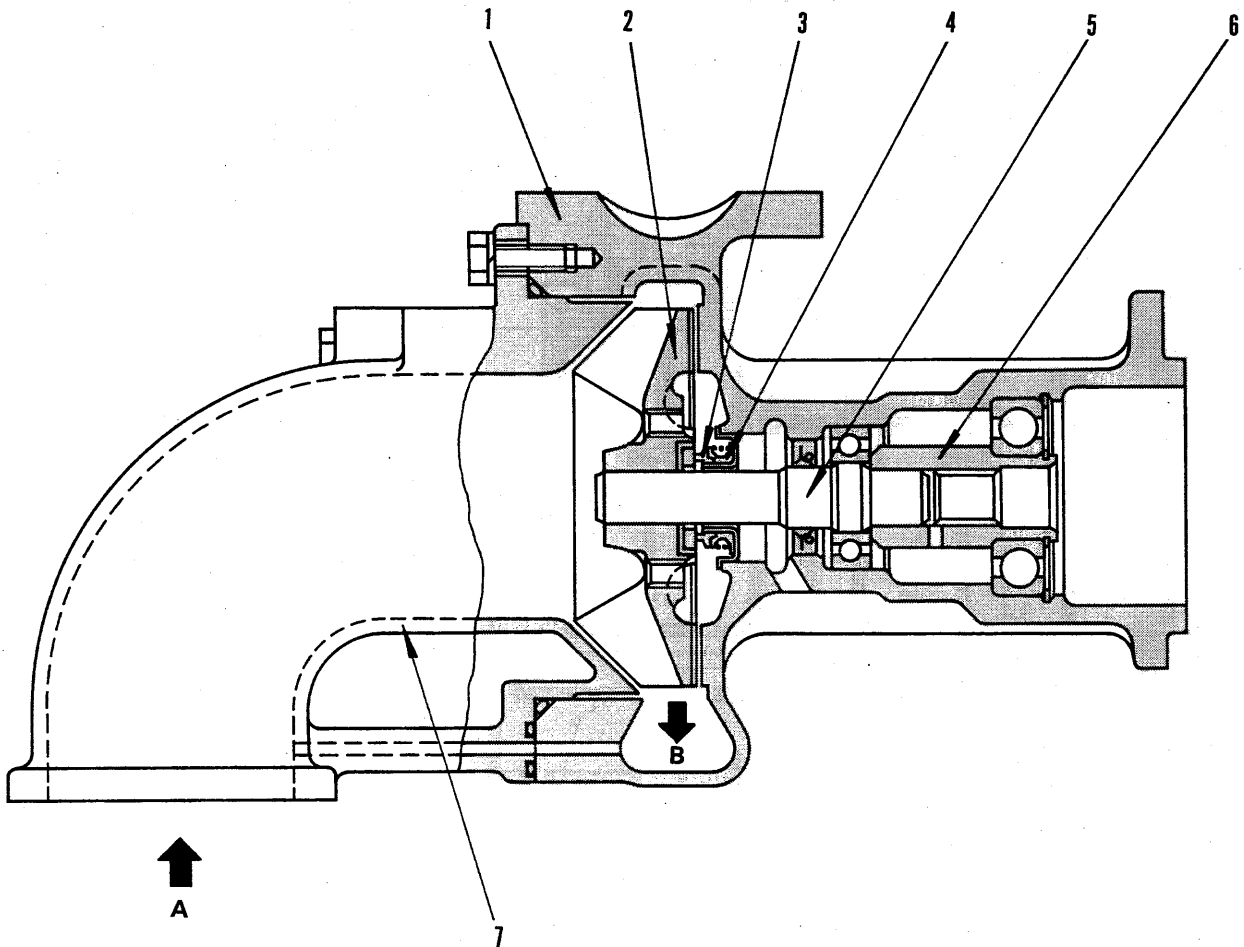
## COOLING SYSTEM CHART



6162F138

- |                       |                                   |
|-----------------------|-----------------------------------|
| 1. Water pump         | 7. Water manifold                 |
| 2. Oil cooler         | 8. Thermostat                     |
| 3. Corrosion resistor | 9. Radiator                       |
| 4. Cylinder liner     | 10. Fan                           |
| 5. Cylinder block     | A. From oil pump (oil)            |
| 6. Thermostat switch  | B. To engine each component (oil) |

# WATER PUMP



6162F139

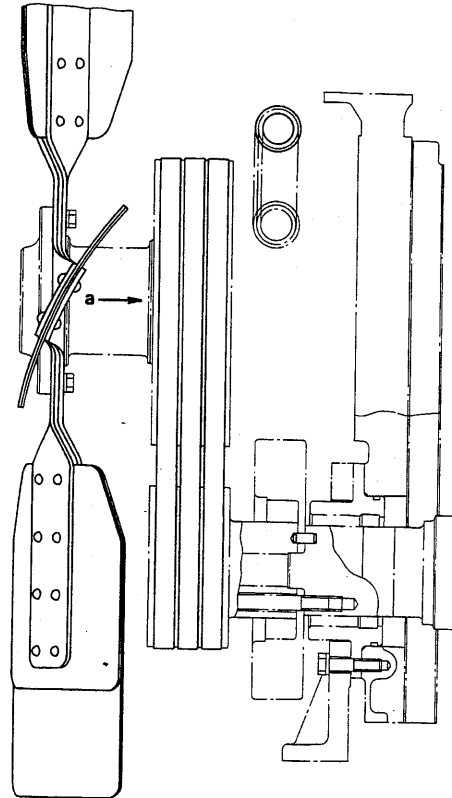
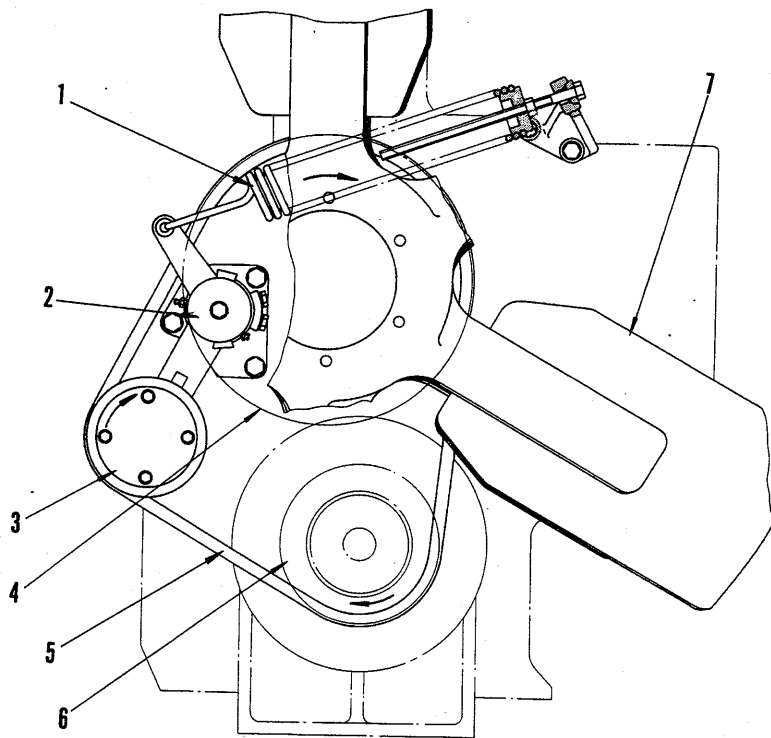
- 1. Pump body
- 2. Impeller
- 3. Floating seal
- 4. Water seal
- 5. Pump shaft (rear)
- 6. Pump shaft (front)
- 7. Inlet housing

- A. From radiator
- B. To oil cooler

**Water pump**

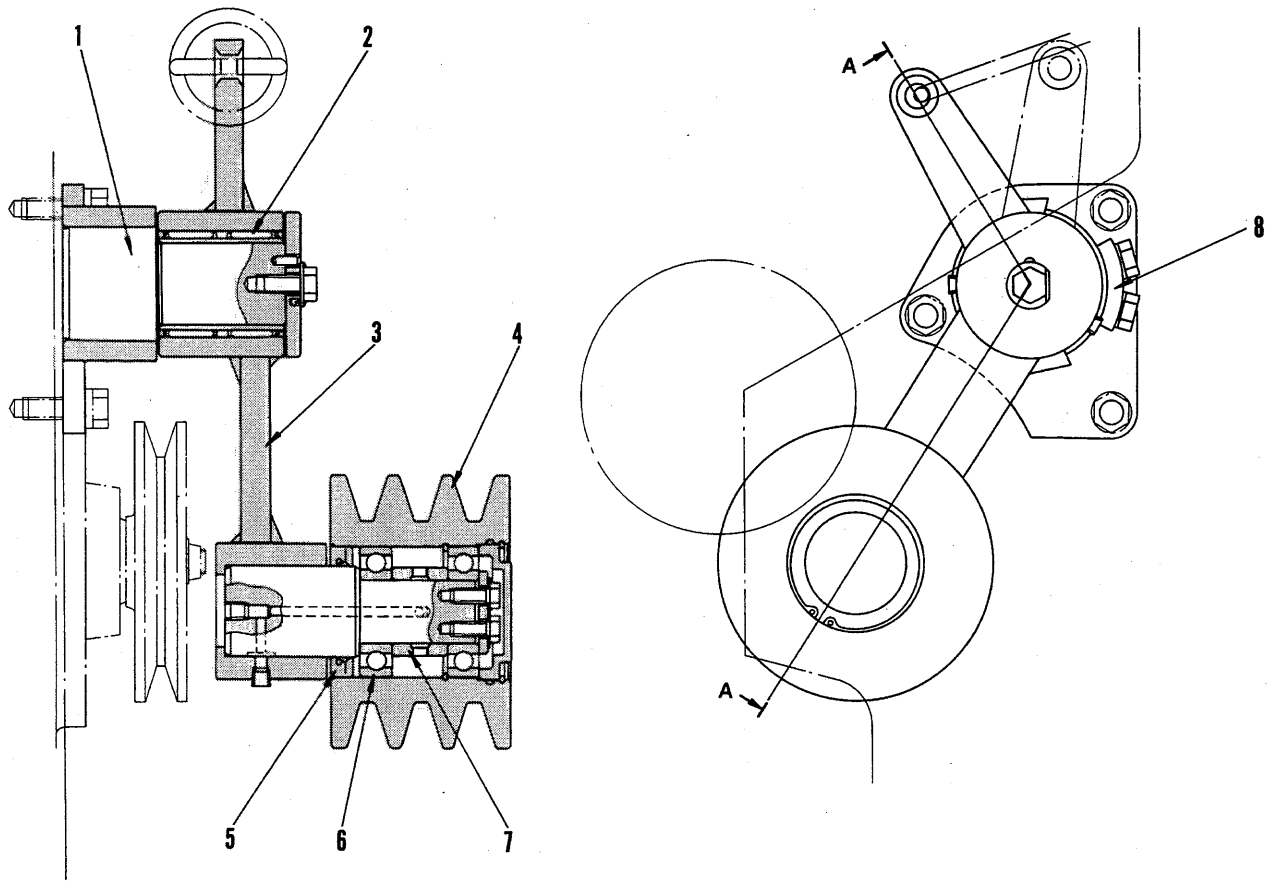
- Water pump speed =  
Engine speed x 1.8
- Flow capacity: 1050 l/min.  
(3,600 rpm)

# FAN DRIVE AND TENSION PULLEY (For construction machines)



6162F140

- 1. Tension spring
- 2. Tension shaft
- 3. Tension pulley (Outside diameter: 150 mm)
- 4. Fan pulley (Outside diameter: 290 mm)
- 5. Fan belt
- 6. Crankshaft pulley (Outside diameter: 200 mm)
- 7. Fan
- a. Direction of wind



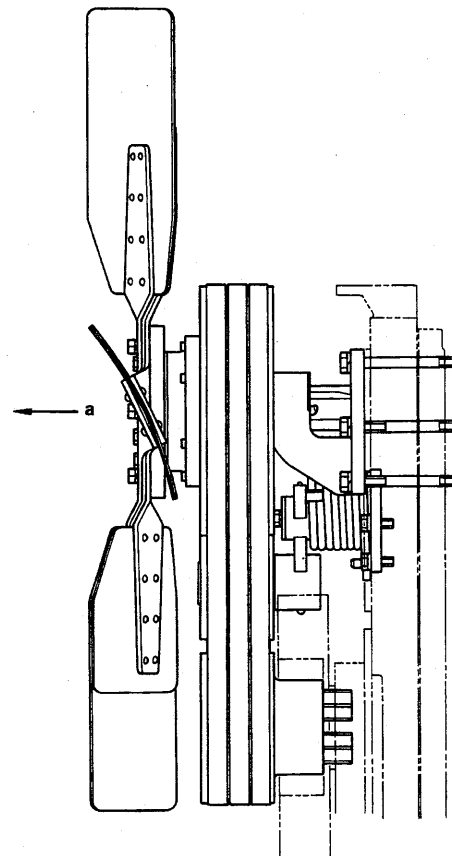
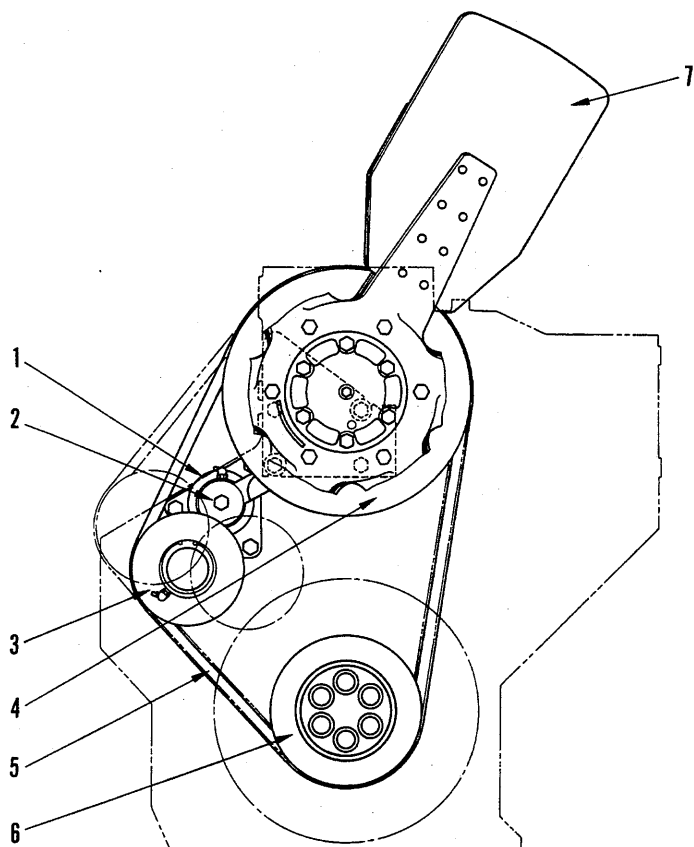
**Section A - A**

6162F141

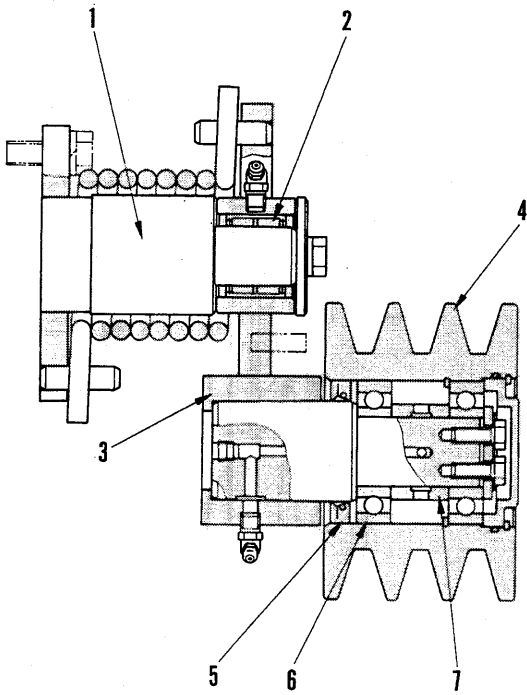
- 1. Tension pulley shaft
- 2. Roller bearing
- 3. Tension pulley bracket
- 4. Tension pulley (Outside diameter: 148 mm)
- 5. Oil seal
- 6. Ball bearing
- 7. Spacer
- 8. Stopper



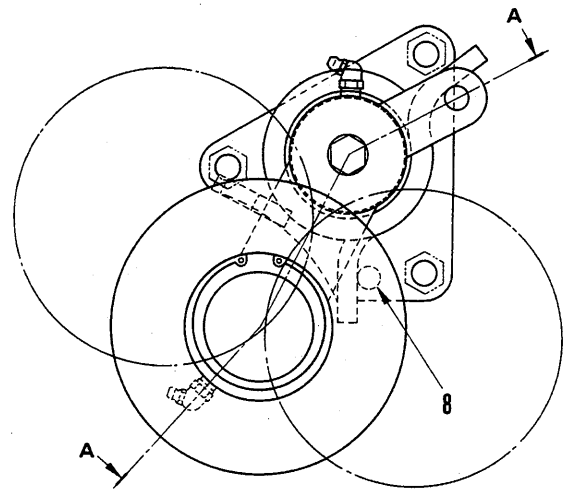
(For generators)



- 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

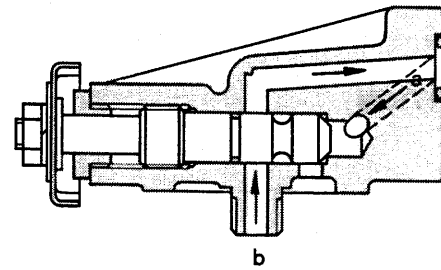
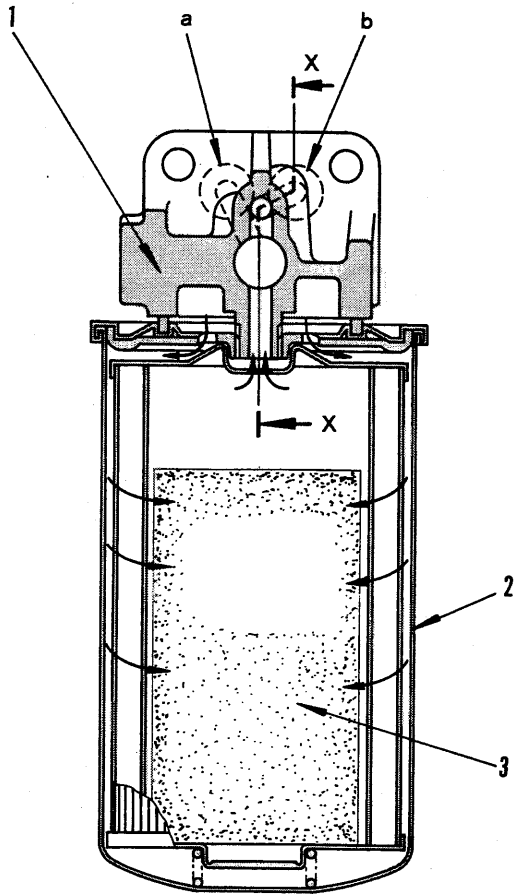


Section A - A



1. Tension pulley shaft
2. Roller bearing
3. Tension pulley bracket
4. Tension pulley (Outside diameter: 148 mm)
5. Oil seal
6. Ball bearing
7. Spacer
8. Stopper

# CORROSION RESISTOR



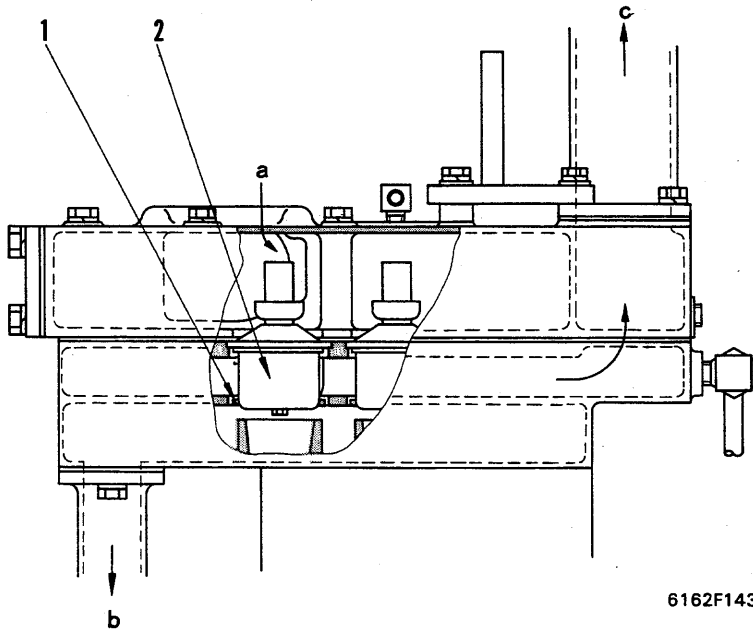
Section X - X (Detail valve)

6162F142

- 1. Head
  - 2. Element case
  - 3. Solid drug (included 1,000 g)
- } Cartridge
- a. Coolant inlet
  - b. Coolant outlet

**Corrosion resistor**  
• Filtration area: 0.13 m<sup>2</sup>

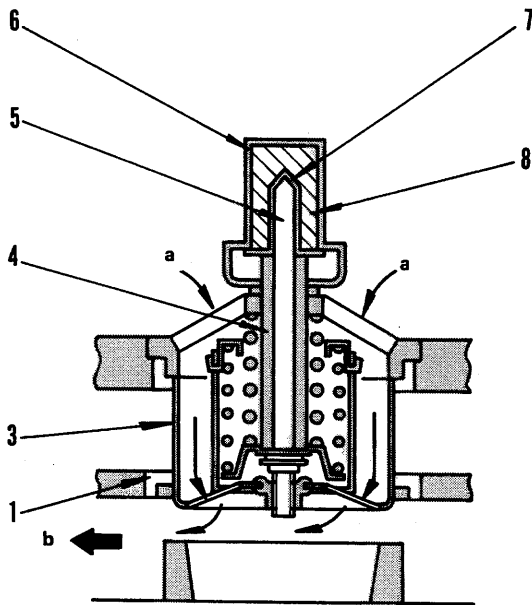
THERMOSTAT



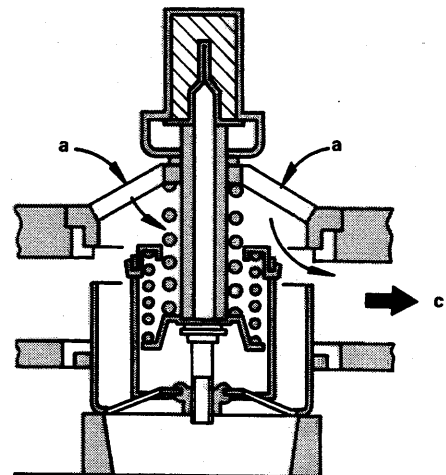
- 1. Seal
- 2. Thermostat
- 3. Valve
- 4. Body
- 5. Piston
- 6. Sensor
- 7. Sleeve
- 8. Wax
- a. From engine each component
- b. To water pump
- c. To radiator

6162F143

OPERATION



At cold (close)



At warm (full open)

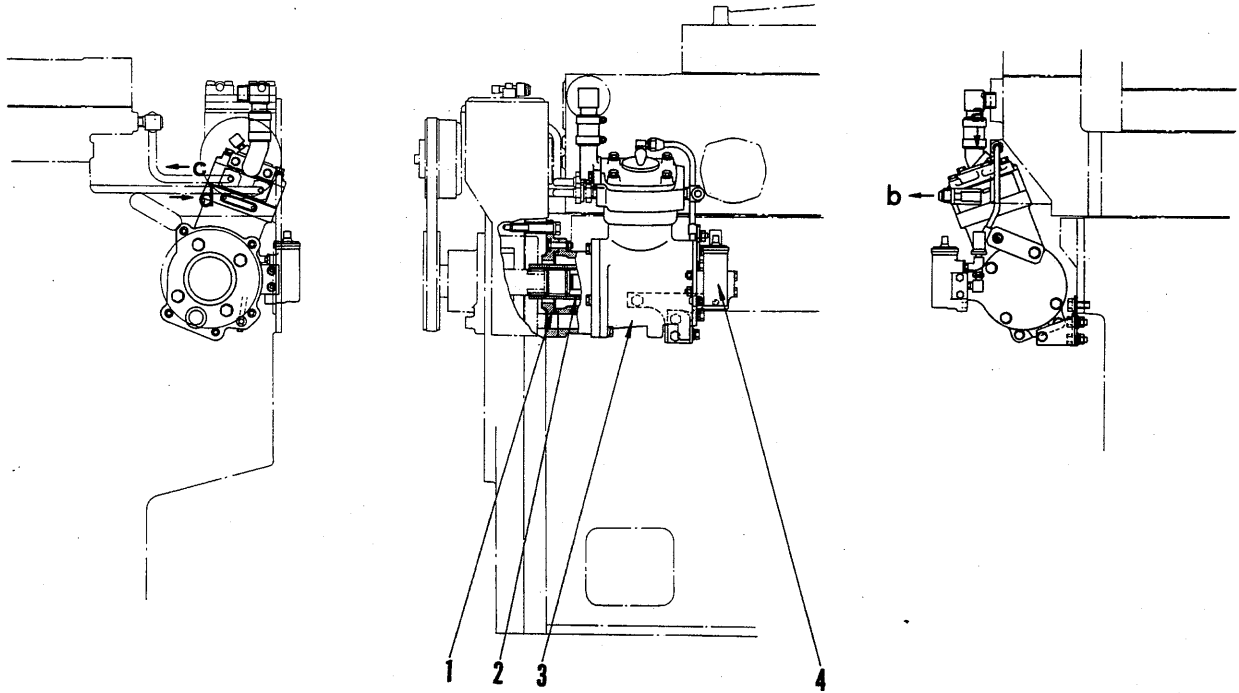
6162F144

Function

- Opening temperature:  $76.5 \pm 2^\circ\text{C}$
- Full opening temperature:  $90^\circ\text{C}$
- Valve lift: Minimum 10 mm

# ACCESSORY

## AIR COMPRESSOR MOUNTING

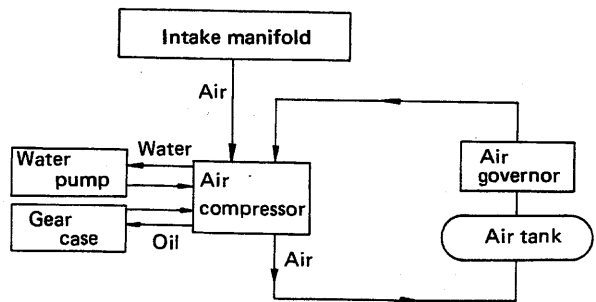


6162F145

- 1. Flange
- 2. Coupling
- 3. Air compressor
- 4. Air governor
- a. Air (from intake manifold)
- b. Air (to air tank)
- c. Coolant (to water pump)
- d. Coolant (from water pump)

**Air governor operating pressure**

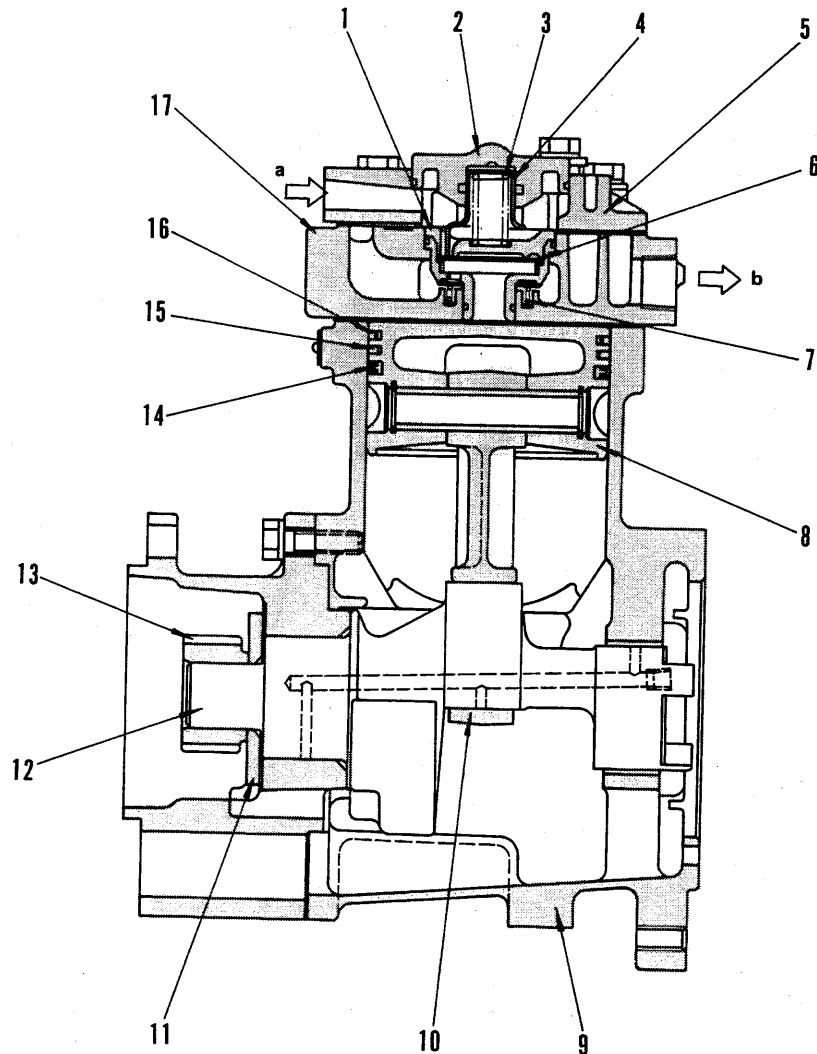
- Unload pressure:  $8.4 \begin{matrix} +0.4 \\ -0.1 \end{matrix} \text{ kg/cm}^2$
- Onload pressure:  $7.0 \begin{matrix} +0.3 \\ -0.1 \end{matrix} \text{ kg/cm}^2$



6162F146

**Air circuit diagram**

# AIR COMPRESSOR



6162F147

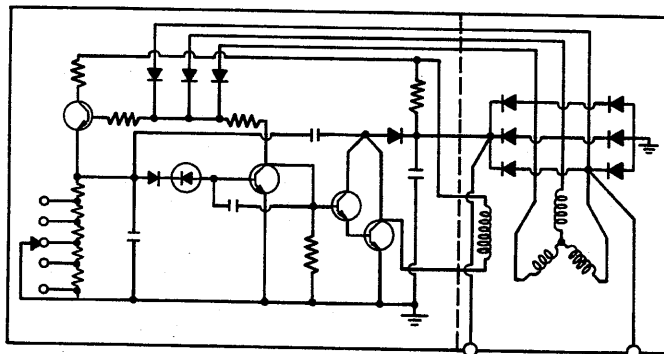
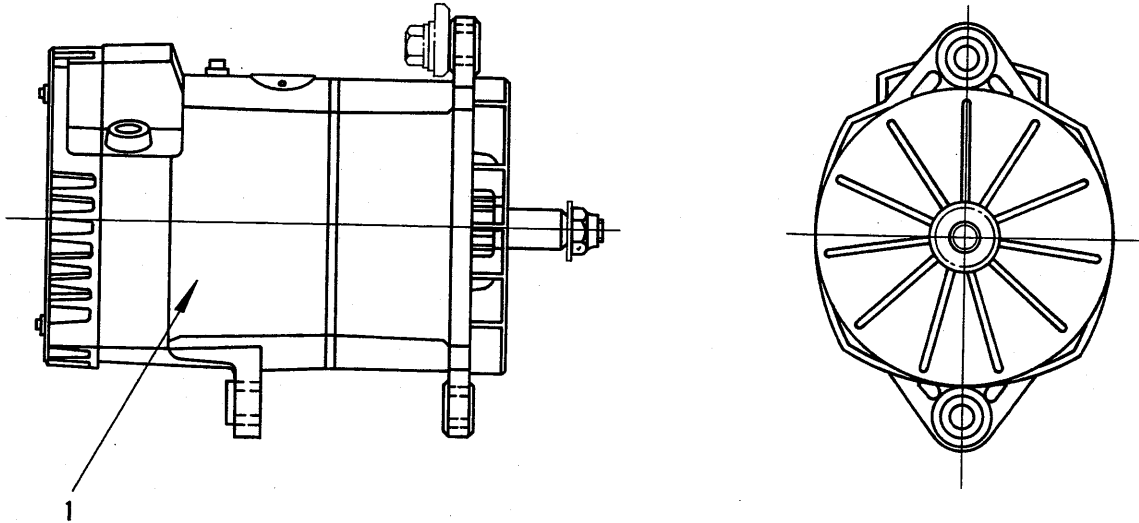
- |                          |                                   |
|--------------------------|-----------------------------------|
| 1. Inlet valve seat      | 11. Thrust washer                 |
| 2. Unloader valve body   | 12. Crankshaft                    |
| 3. Unloader valve spring | 13. Drive gear (No. of teeth: 24) |
| 4. Unloader valve cap    | 14. Oil ring                      |
| 5. Head cap              | 15. 2nd ring                      |
| 6. Inlet valve           | 16. Top ring                      |
| 7. Inlet valve spring    | 17. Cylinder head                 |
| 8. Piston                |                                   |
| 9. Crank case            | a. Air inlet                      |
| 10. Connecting rod       | b. Air outlet                     |

### Air compressor

- Maker: Cummins
- Rated speed: 1,600 rpm  
(at engine rated speed)
- Discharge capacity: 245 ℓ/min.  
(at rated speed)
- No. of cylinder — Bore x Stroke:  
1 — 92.1 x 44.5

# ELECTRICAL SYSTEM

## ALTERNATOR



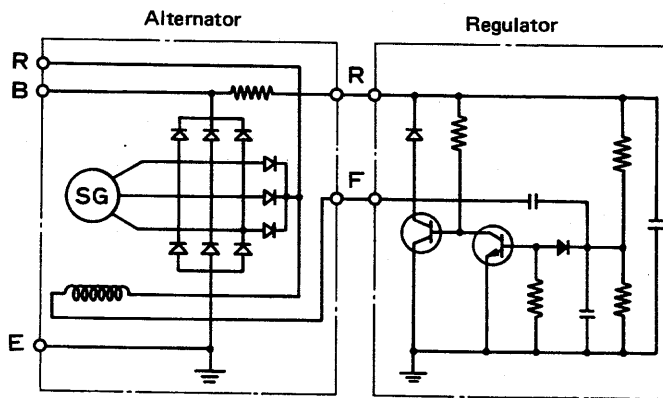
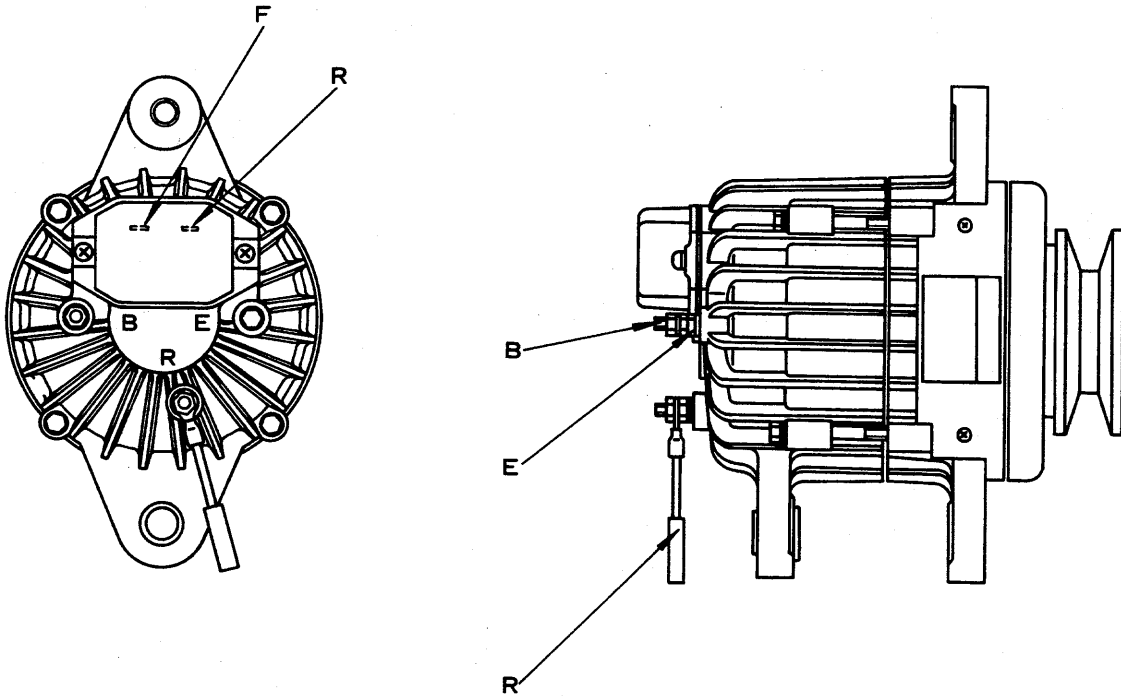
Inner connecting diagram

1. Alternator assembly

6162F148

Engine	Type	Specifications	Pulley outside diameter	Weight
S6D170-1	Delco-Remy, 25SI-450, Open type	24V, 50A	95	15 kg
	Sawafuji, Open type	24V, 50A	95	12 kg
SA6D170-A-1	Nikko Denki, Open type	24V, 50A	95	15 kg
SA6D170-B-1	Nikko Denki, Open type	24V, 35A	95	10 kg

ALTERNATOR WITH REGULATOR



B.E.F.R: Terminal

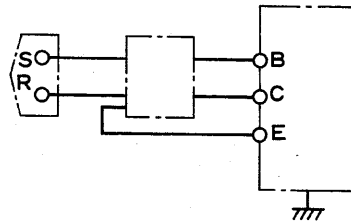
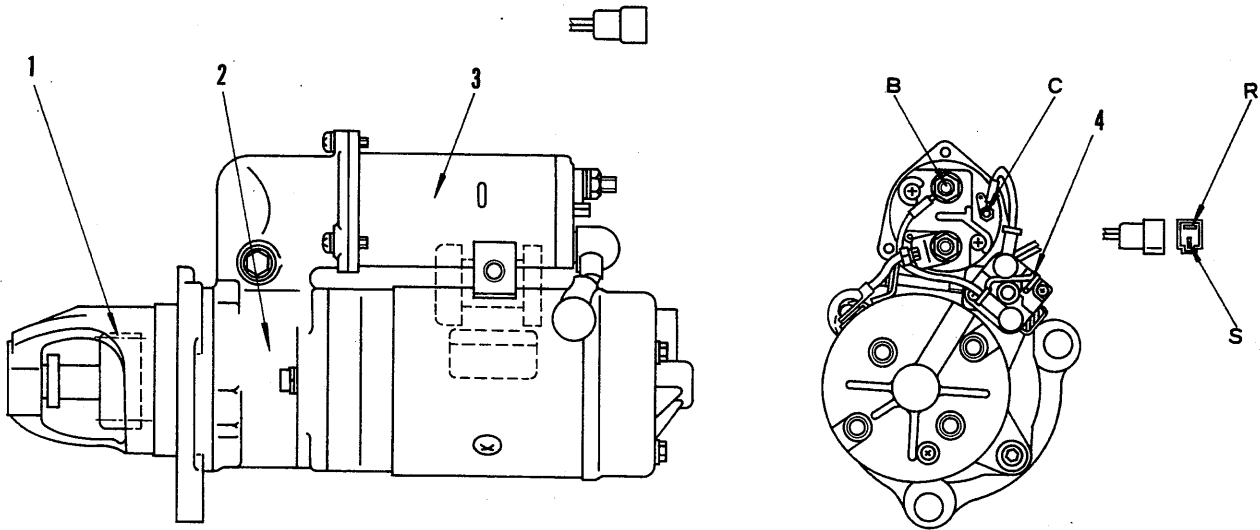
Wiring diagram

6114F151

Engine	Type	Specifications	Pulley outside diameter	Weight
SA6D170-A-1	Nikko Denki, Open type	24V, 50A	95	15 kg
SA6D170-B-1	Nikko Denki, Open type	24V, 13A	95	7.8 kg



# STARTING MOTOR



6162F149

- 1. Pinion gear
  - 2. Starting motor assembly
  - 3. Magnetic switch
  - 4. Safety relay
- B, C, E, R, S: Terminal

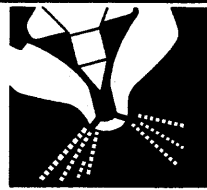
Engine	Type	Specifications	No. of pinion teeth	Weight
S6D170-1	Nikko Denki, Sealed type	24V, 7.5KW	11	18 kg
SA6D170-A-1	Nikko Denki, Sealed type	24V, 7.5KW	11	18 kg
SA6D170-B-1	Nikko Denki, Sealed type	24V, 7.5KW	11	18 kg

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# ENGINE

## 12 TESTING AND ADJUSTING

---



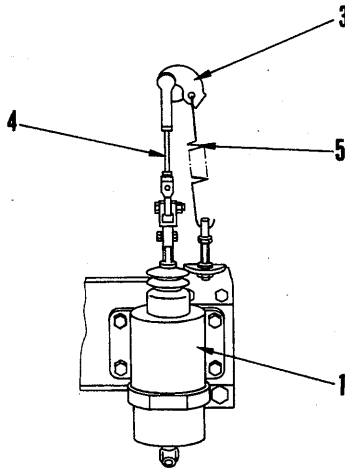
### FUEL SYSTEM

Adjusting fuel solenoid .....	12-2
Adjusting engine stop motor .....	12-3
Adjusting fuel injection pressure .....	12-4
Testing and adjusting tool list .....	12-7
<b>TROUBLESHOOTING .....</b>	<b>12-9</b>

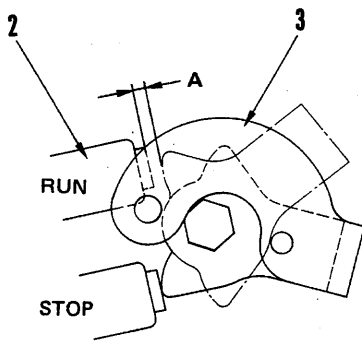
# FUEL SYSTEM

## ADJUSTING FUEL SOLENOID

B contact (electricity flows in ordinary operation) type



1. Solenoid
2. Stopper
3. Stop lever
4. Rod
5. Return spring
6. Rod



6162F201

### Adjusting method

1. Stop the engine and loosen the nuts of rod (4).
2. Adjust rod (4), so that the solenoid has a maximum stroke of 12 mm.  
Then, adjust rod (4) so that there is clearance A of  $0.4 \pm 0.1$  mm between injection pump stopper (2) and stop lever (3), while pulling the rod to the RUN position with hand.
3. Turn on the engine starting key and confirm that solenoid has a stroke of 12 mm and there is clearance A of  $0.4 \pm 0.1$  mm.
4. After turning on and off the key several times, reconfirm the amount of the stroke of the solenoid and clearance A.
5. Tighten up the nuts of the rod.

### A contact (electricity flows when stopped) type

1. A rod forms a link between the solenoid and injection pump. At this time, when the stop lever returns  $1 \pm 0.5$  mm from the stop pin on the RUN side and the solenoid shaft is pushed by hand, the stop lever of the pump will be set in a position in which it has returned  $1 \pm 0.5$  mm from the stop pin.
2. Next, energize the solenoid and see if its movement is smooth. Turn the starting switch ON and OFF two to three times and confirm that the operation condition does not change. If the operation is not smooth, adjust the linkage and carefully observe the movement.

### 3. Confirmation of Functions

After confirming that the operation is smooth, start the engine and confirm that the rated output can be obtained. Next, energize the solenoid and confirm that the engine stops. (The engine should stop within 10 sec.)

### ★ Failures caused by faulty adjustment of solenoid

<ul style="list-style-type: none"> <li>• If the clearance between the stop bolt and lever is 0 when the solenoid is energized.</li> </ul>	<ul style="list-style-type: none"> <li>• Burning of the solenoid core (when solenoid is only partially pulled).</li> <li>• Breakage or scuffing of the injection pump governor (an undue force will be applied to the lever).</li> </ul>
<ul style="list-style-type: none"> <li>• When there is a large clearance between the stop lever and RUN side bolt when the lever is free (faulty linkage).</li> </ul>	<ul style="list-style-type: none"> <li>• Engine power will not be generated because of a decline in amount of fuel injection.</li> </ul>

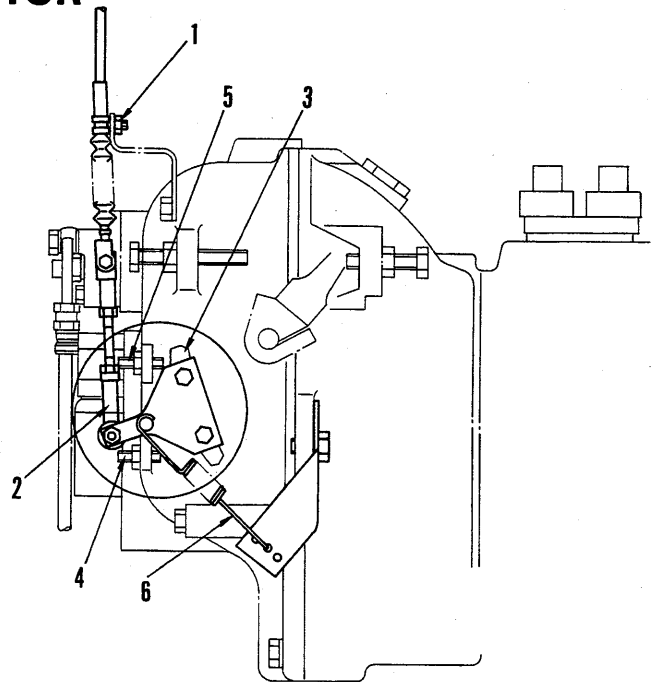
## ADJUSTING ENGINE STOP MOTOR

### Procedure for adjusting engine stop motor

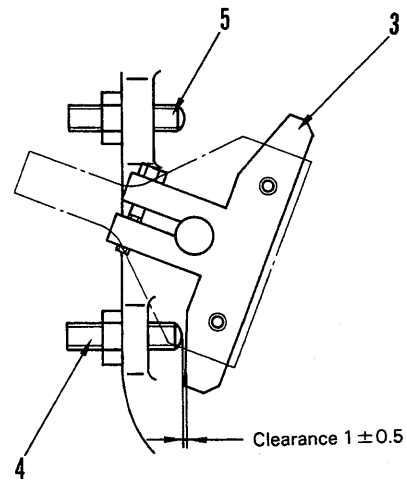
1. Temporarily assemble nut and bolt (1), then with stop motor actuated, assemble ball joint (2).
2. With stop motor actuated, adjust nut and bolt (1) and ball joint (2) so that clearance of stop lever (3) and stopper bolt (4) at STOP end is  $1 \pm 0.5$  mm, then assemble fully.
3. Switch the stop motor on and off ten times, and check the condition of the adjustment. If necessary, adjust ball joint (2).
4. Check that the engine stops.

### [Precautions]

- 1) When the stop motor is actuated, the stop lever (3) and stopper bolt (4) and (5) should not hit.
- 2) Check that there is no clearance between the stop lever (3) and the stopper bolt (5) at the RUN end when the stop motor is OFF. If there is any clearance, adjust the hole position of the return spring (6). (If there is any clearance, the output power may drop.)



F6166104



Detail of stop lever

F6166105

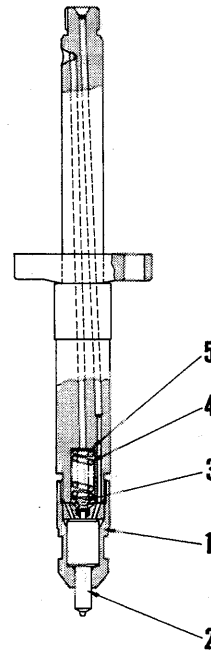
## ADJUSTING FUEL INJECTION PRESSURE (VALVE CRACKING PRESSURE)

### ADJUSTING FUEL INJECTION PRESSURE (VALVE CRACKING PRESSURE)

1. Remove retaining cap (1).
2. Remove nozzle (2), spring seat (3), and nozzle spring (4).
3. Adjust the injection pressure (valve cracking pressure) by adjusting shim thickness (5).
  - ★ Injection pressure adjusted per 0.1 mm shim thickness: Approx. 15 kg/cm<sup>2</sup>

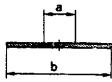
 Retaining cap: 9 ± 1 kgm

4. After adjusting the thickness of shims, check the fuel injection pressure using nozzle tester.



6162F202

DATA FOR INJECTION PRESSURE ADJUSTMENT SHIMS

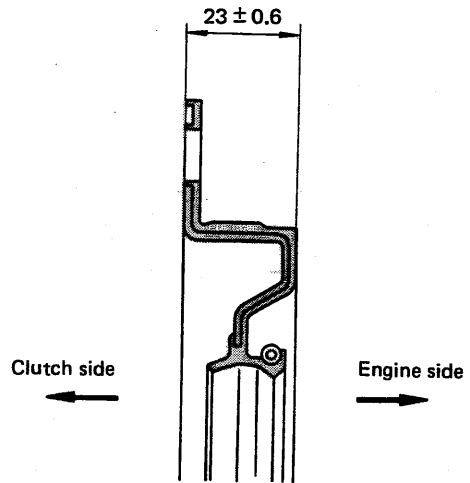
Engine model	Shim contour	Shim thickness (Range)	Shim thickness (Interval)
S6D170-1 SA6D170-A-1 SA6D170-B-1	 a = 4.5 mm b = 11.5 mm	0.50 – 1.54 mm	0.02 mm

Part No.	Thickness (mm)	Part No.	Thickness (mm)
DK150523-5000	0.50	DK150523-7800	1.06
DK150523-5100	0.52	DK150523-7900	1.08
DK150523-5200	0.54	DK150523-8000	1.10
DK150523-5300	0.56	DK150523-8100	1.12
DK150523-5400	0.58	DK150523-8200	1.14
DK150523-5500	0.60	DK150523-8300	1.16
DK150523-5600	0.62	DK150523-8400	1.18
DK150523-5700	0.64	DK150523-8500	1.20
DK150523-5800	0.66	DK150523-8600	1.22
DK150523-5900	0.68	DK150523-8700	1.24
DK150523-6000	0.70	DK150523-8800	1.26
DK150523-6100	0.72	DK150523-8900	1.28
DK150523-6200	0.74	DK150523-9000	1.30
DK150523-6300	0.76	DK150523-9100	1.32
DK150523-6400	0.78	DK150523-9200	1.34
DK150523-6500	0.80	DK150523-9300	1.36
DK150523-6600	0.82	DK150523-9400	1.38
DK150523-6700	0.84	DK150523-9500	1.40
DK150523-6800	0.86	DK150523-9600	1.42
DK150523-6900	0.88	DK150523-9700	1.44
DK150523-7000	0.90	DK150523-9800	1.46
DK150523-7100	0.92	DK150523-9900	1.48
DK150523-7200	0.94	DK150530-0000	1.50
DK150523-7300	0.96	DK150530-0100	1.52
DK150523-7400	0.98	DK150530-0200	1.54
DK150523-7500	1.00		
DK150523-7600	1.02		
DK150523-7700	1.04		

**PRECAUTIONS WHEN OPERATING THE ENGINE INDEPENDENTLY**

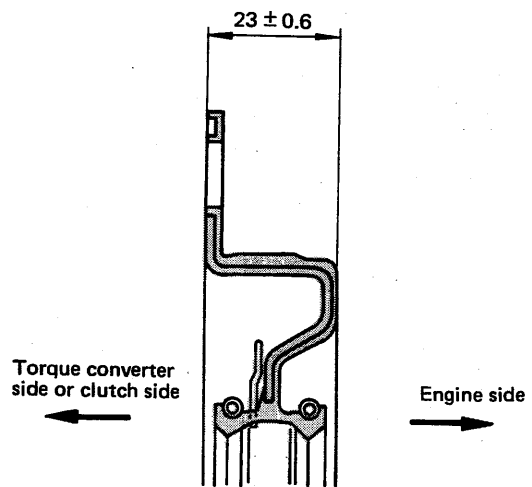
★ If the engine is operated independently on a bench with a double lip seal fitted, the lubricating conditions will differ from actual running conditions, resulting in possible damage to the seal lip.

1. When running-in the engine or subjecting it to a bench test, use the rear seal shown in the diagram at right on all models for the duration of testing.



6162F202

2. After completing running-in or bench testing, fit the correct rear seal.



6162F203

★ Precautions when fitting rear seal

- 1) A new rear seal is coated with grease. In the event that it becomes soiled, however, wipe it clean with a cloth and coat it with about 1.2 to 1.6 cc of G2-L1 (lithium grease).
- 2) Be careful not to damage the rear seal when fitting it.

## 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/cm <sup>2</sup>
7	Fuel pressure			0 to 20 kg/cm <sup>2</sup>
8	Intake pressure, exhaust pressure			0 to 1,500 mmHg
9	Blow-by pressure			0 to 1,000 mmH <sub>2</sub> O
10	Air intake resistance			-1,000 to 0 mmH <sub>2</sub> O
11	Compression pressure	Compression gauge kit	795-502-1205	0 to 70 kg/cm <sup>2</sup>
12	Blow-by pressure	Blow-by checker	799-201-1503	0 to 500 mmH <sub>2</sub> O
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/cm <sup>2</sup>
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/cm <sup>2</sup>
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



# TROUBLESHOOTING

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# METHOD OF READING TROUBLESHOOTING TABLE

## DESCRIPTION OF SYMBOLS USED IN TROUBLESHOOTING TABLE

The following symbols are used in the "Remedy" column to indicate the method of eliminating the cause of a fault.

- X: Replace;           Δ: Repair;
- A: Adjusting;       C: Clean

## METHOD OF READING TROUBLESHOOTING TABLE

- The symbol ○ in the table is inserted only for causes which can be diagnosed. If a cause cannot be diagnosed, the corresponding box is left blank.
- If the result of problems 1 using the troubleshooting table shown at right is abnormal, the cause of the trouble can be assumed to lie between a and d. Because it is not possible to make a problems regarding e, it is necessary to perform the next problems (owing to the possibility of a multiple fault).  
If the result of problems 1 is normal, the cause of the fault does not lie between a and d. In such a case, before diagnosing the cause as e, however, carry out a check by means of problems 2 or 5.
- If now the result of problems 1 is abnormal and the result of problems 2 normal, the cause is one of a, b or d. In addition, if the result of problems 3 is abnormal, the cause will be narrowed down to one of b or d. To determine which of b or d is the actual cause, perform problems 4.
- If the result of problems is abnormal, blacken out the corresponding ○ in the table and then perform the next problems on these causes in order to narrow the likely causes.

**Example 1:**

Problems 1 → Abnormal	}	From the table of example 1, the cause of the fault is b.
Problems 2 → Normal		
Problems 3 → Abnormal		
Problems 4 → Normal		

**Example 2:**

Problems 1 → Normal	}	From the table of example 2, the cause of the fault is e.
Problems 2 → Abnormal		

★ In example 2, it is evident that the cause is e without carrying out problems 2, however problems 2 is performed by way of an additional check.

		Cause				
		a	b	c	d	e
Remedy		X	C	Δ	A	X
Problems						
1		○	○	○	○	
2				○		○
3			○		○	
4		○			○	
5			○			○

**Example 1**

		Cause				
		a	b	c	d	e
Remedy		X	C	Δ	A	X
Problems						
1		●	●	●	●	
2			⊖		⊖	
3			●		●	
4		⊖			⊖	
5	Not necessary problems →		○			○

**Example 2**

		Cause				
		a	b	c	d	e
Remedy		X	C	Δ	A	X
Problems						
1		⊖	⊖	⊖	⊖	
2				●	●	
3	Not necessary problems →		○		○	
4		○			○	
5			○			○

Example 3:

Problems 1 → Abnormal  
 Problems 2 → Normal  
 Problems 3 → Normal

From the table of example 3, the cause is one of a, c and e.

Continue problems

Problems 4 → Normal  
 Problems 5 → Normal

From the table of example 3-1, the cause is c.

Example 3

		Cause				
		a	b	c	d	e
Problems	Remedy	x	c	Δ	A	x
	1	●	●	●	●	
2				●		●
3			⊗		⊗	
4		○			○	
5			○			○

Example 3-1

		Cause				
		a	b	c	d	e
Problems	Remedy	x	c	Δ	A	x
	1	●	●	●	●	
2				●		●
3			⊗		⊗	
4		⊗			⊗	
5			⊗			⊗

Example 4:

Problems 1 → Abnormal  
 Problems 2 → Normal

From the table of example 4, the cause is one of a, b or d.

Continue problems

Problems 3 → Abnormal  
 Problems 4 → Abnormal  
 Problems 5 → Normal

From the table of example 4-1, the cause is a or d.

Example 4

		Cause				
		a	b	c	d	e
Problems	Remedy	x	c	Δ	A	x
	1	●	●	●	●	
2				⊗		⊗
3			○		○	
4		○			○	
5			○			○

Example 4-1

		Cause				
		a	b	c	d	e
Problems	Remedy	x	c	Δ	A	x
	1	●	●	●	●	
2				⊗		⊗
3			●		●	
4		●			●	
5			⊗			⊗

As can be seen from the above examples, it is not necessary to perform all of the problems.

Also, looking at a particular cause, no matter how many ● marks there are in the column corresponding to that cause, it will cease to be an actual cause if there is even one ⊗ mark in the same column.

# TROUBLESHOOTING TABLE

## 1. Starting defective or badness.

### 1) Engine does not turn.

Questions to ask operator before starting troubleshooting

1. Did machine stop suddenly during operation? → Damage or seizure of internal parts.
2. Did machine make abnormal noise during operation? → Damaged parts.

★ Cause h: battery charging rate

Charging rate	100%	90%	80%	75%	70%
Temperature					
20°C	1.28	1.26	1.24	1.23	1.22
0°C	1.29	1.27	1.25	1.24	1.23
-10°C	1.30	1.28	1.26	1.25	1.24

- Specific gravity should be at least figure for 70% charging rate.
- In cold weather, specific gravity must be at least figure for 75% charging rate.

Cause	a	b	c	d	e	f	g	h	i	j	k	l
Stopping piston from moving by foreign matter in cylinder.												
Damage to connecting rod or crankshaft												
Bushing and metal biting into each other												
Intake and exhaust valves are blocked in cylinder												
Damage to pump or other auxiliary mechanism												
Failure of machine power train												
Seizure of moving parts												
Battery insufficiently charged → See No. 20												
Pinion movement force insufficient, wrong meshing position												
Battery terminal connection defective, wiring defective												
Electrical system defective → see No. 19												

No.	Problems	Remedy	a	b	c	d	e	f	g	h	i	j	k	l
			X	X	X	X	X	X	X	X	X	X	△	-
1	When setting the starting switch to START; 1) No sound of pinion moving out.													○
	2) Pinion grates.											○		
	3) Pinion engages but does not turn.		○	○	○	○	○	○						
2	When checking battery, electrolyte level or specific gravity is low.								○					
3	When cranking engine with barring tool; 1) Does not move.							○						
	2) Moves backlash only.					○								
	3) Can be turned in reverse direction.		○	○	○									
4	Remove head cover. When checking valve cotter, it is out of place.				○									
5	Remove oil pan. When checking internal parts, they are abnormal.			○										
6	Remove cylinder head. When checking internal parts, foreign matter appears.		○											

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

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

2) Engine turns but no exhaust gas is emitted.

Check before troubleshooting

1. Is there any fuel in fuel tank?
2. Is fuel feed valve open?
3. Is fuel piping leaking or damaged between fuel tank and injection pump?
4. Is there any leak from fuel filter?
5. Is there any water, rust or sludge mixed with fuel drained from fuel tank or fuel filter?  
(Injection pump or nozzle are frequent causes of failure.)

Cause	
a	Injection pump plunger seized, rack rusted
b	Feed pump piston seized
c	Injection pump drive shaft damaged
d	Fuel filter element clogged
e	Fuel piping clogged between fuel tank and injection pump
f	Feed pump strainer clogged

No.	Problems	Remedy						
			XC	X	X	X	C	XC
1	No fuel comes out even if injection pump bleed plug is loosened and priming pump operated.							○
2	When cranking engine with starting motor; 1) Injection pump (coupling) does not rotate.				○			
	2) No fuel comes out even if injection pump bleed plug is loosened.		○	○				
	3) No fuel spurts out even if injection pump pipe sleeve nut is loosened.	○	○	○				

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



**2. Engine stopped during operation.**

**Questions to ask operator before troubleshooting.**

1. Did engine stop slowly? → Fuel supply cut.
2. Did engine stop suddenly? → Internal parts damaged or seized.
3. Did engine make abnormal noise? → Parts damaged.

**Check before troubleshooting**

1. Is there any fuel in fuel tank?
2. Is fuel control lever bent? Is there any play? Is the pin out of place?
3. Is fuel piping leaking or damaged between fuel tank and injection pump.
4. Is bead hole of fuel tank cap clogged?

Cause	a	b	c	d	e	f	g	h	i
Injection pump plunger seized									
Feed pump piston seized									
Injection pump piston seized									
Fuel pump drive shaft damaged									
Fuel filter element clogged									
Fuel piping clogged between fuel tank and injection pump									
Part of intake or exhaust valve blocking cylinder									
Pump or other auxiliary mechanism seized									
Piston or bearing (metal) seized									
Failure of machine power train									

No.	Problems	Remedy	X	X	X	XC	C	X	X	X	X	Δ
1	Starting motor cranks engine, but engine stops if gear shift lever is moved to any speed position.											○
2	Starting motor does not crank engine. 1) Engine does not turn when cranking engine with barring tool.											○
	2) Engine turns backlash distance only.								○			
	3) Engine can be turned in reverse direction.							○				
3	No fuel comes out even if injection pump bleed plug is loosened and priming pump operated.					○						
4	When cranking engine with starting motor; 1) Injection pump (coupling) does not rotate.						○					
	2) No fuel comes out even if injection pump bleed plug is loosened.			○	○							
	3) No fuel spurts out even if injection pipe sleeve nut is loosened.	○	○	○								
5	When removing injection pump tappet cover, control rack does not move.	○										

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

3. Engine runs abnormally.

1) Engine speed is too high.

Cause		Remedy
a	Governor function defective	XΔ
b	Governor adjustment defective	

2) Engine does not stop.

Cause		Remedy
a	Fuel control lever linkage is bent; there is too much play; pin is out of position; something is catching.	Δ
b	Injection pump control rack function defective	XΔ
c	Injection pump function defective (part other than control rack)	XΔ
d	Governor function defective	XΔ

3) Hunting.

Cause		Remedy
a	Air sucking into system between fuel tank and feed pump	XΔ
b	Governor function defective	XΔ
c	Governor adjustment defective	A
d	Injection pump control rack function defective	XΔ

- ★ Set injection pump and governor on test stand when adjusting.
- ★ Making up fuel pump by injecting more fuel than standard may damaged engine.

4. Fuel consumption too high.

- Before starting the troubleshooting, ask the operator why he noticed the fuel consumption was too high.

Cause		Remedy
a	External leakage of fuel; Fuel tank, injection pump, fuel filter and piping. (Common cause when fuel consumption increases suddenly)	XΔ
b	Excessive fuel injection, poor fuel consumption ratio (in this case exhaust gas is black).	Follow "6. Exhaust gas is black".
c	Internal leakage of fuel; Leakage from fuel tube inside cylinder head cover (In this case, oil level rises and oil smells of kerosene)	Δ Change oil

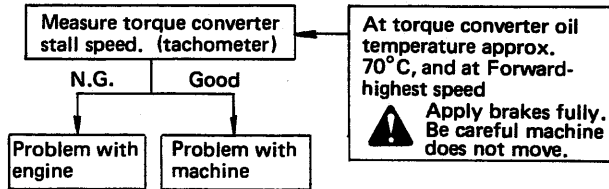
The following symbols are used to indicate the action to be taken when a cause of failure is located.

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



5. Lack of power.

- ★ If lack of power is accompanied by black exhaust gas, follow problems "6. Black exhaust smoke."
- ★ First troubleshoot whether the cause is in the engine or in the chassis as follows.



- Judge mainly checking for track tension, brake function, acceleration and engine high idling speed when mounting DIRECT transmission.

Check before troubleshooting

1. Is fuel piping damaged or fuel leaking between fuel tank and injection pump?
2. Is bleed hole of fuel tank cap clogged?
3. Is tube damaged or leaking between injection pump and nozzle holder?
4. Is incorrect fuel being used?
5. Is there any water, rust or sludge mixed with fuel drained from fuel tank?  
(Injection pump or nozzle are frequent causes of failure.)  
(Check strainer clogged when no fuel comes out.)

Cause	a	b	c	d	e	f	g	h	i
Injection pump control rack function defective									
Injection pump plunger seized									
Injection nozzle seized or clogged									
Fuel filter element clogged									
Feed pump strainer clogged									
Fuel piping clogged between fuel tank and injection nozzle									
Fuel tube leaking between fuel tank and injection nozzle									
Fuel piping leaking between feed pump and feed pump									
Fuel control lever linkage bent, loose or out of adjustment									

No.	Problems	Remedy	X	Δ	X	X	C	X	Δ	X	Δ	Δ	A
1	Even with fuel control lever at FULL position, injection pump lever does not contact to the full-stopper.												
2	When operating priming pump; 1) No reaction or slight reaction and quick return.												
	2) No reaction or slight reaction with normal return.												
3	No fuel comes out even if injection pump bleed plug is loosened and priming pump operated.												
4	Improper engine-running happens by hunting.												
5	When checking with nozzle tester, injection spray is defective or injection pressure is low.												
6	No fuel spurts out even if injection pipe sleeve nut is loosened.												
7	Some cylinders little or no pulse when injection pipe is held between fingers.												
8	When removing injection pump tappet cover and checking movement of control rack, does not move smoothly.												

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



7. Exhaust gas is blue. (Combustion of engine oil)

Check before troubleshooting

1. Has engine continued to run for over 20 mins at low idling? → Oil coming up into cylinder, oil leak from seal at turbocharger turbine side.
2. Has engine continued to run for over 20 mins at high idling? → Oil coming up or down into cylinder, oil leak from seal at turbocharger blower side.
3. Is turbocharger oil return pipe damaged? → oil leak from turbocharger seal.

Cause				
a	b	c	d	e
Intake valve, valve guide worn (oil coming down into cylinder)				
Breather element clogged				
Piston, ring or liner worn (oil coming up into cylinder)				
Seal worn at turbocharger turbine side				
Seal worn at turbocharger blower side				

No.	Problems	Remedy	Cause				
			a	b	c	d	e
			X	C	X	X	X
1	Inside of turbocharger intake pipe is coated with oil.						○
2	Turbocharger shaft play is excessive.					○	○
3	Compression pressure is lack.			○			
4	Blow-by is excessive.			○			
5	When checking breather element, it is clogged with oil.		○				
6	Remove cylinder head. When checking intake valve and valve guide, the clearance of them is big.		○				

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



9. Oil level rises. (Mixed water or fuel)

Check before troubleshooting

- Is the cooler of engine oil dirt – white? → Mixed water.

No.	Problems	Remedy	Cause											
			a	b	c	d	e	f	g	h	i	j		
			XΔ	XΔ	XΔ	XΔ	X	X	X	X	X	X	X	X
1	Water mixed with engine oil.													○
2	Fuel mixed with engine oil.				○									
3	Oil in main clutch or TORQFLOW transmission or damper decreases.			○										
4	Seal or seal contact face of hydraulic pump drive shaft is worn or damaged.		○											

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

10. Oil quickly becomes dirty.

Before starting the troubleshooting, ask the operator the following questions.

1. Were oil and oil filter changed in accordance with the "Operation and Maintenance Manual"?
2. Was improper oil used?

No.	Problems	Remedy	Cause		
			a	b	c
			Leak of exhaust gas through seal on turbocharger turbine side	Piston, ring or liner worn	Valve or valve guide worn
		X△	X	X△	
1	Exhaust gas is blue when engine is run at high speed with light load.			○	○
2	Compression pressure is lack.			○	○
3	Blow-by is excessive.			○	
4	After running at high idling for approx. 10 mins., oil can be seen leaking from turbocharger turbine outlet.	○			
5	Turbocharger shaft play is excessive.	○			

★ If the above problems does not reveal the cause, a common secondary cause of dirty oil is carbon from incomplete combustion mixing with the oil. In this case follow problems in "6. Exhaust gas is black".

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

11. Engine oil pressure gauge indicator fluctuates abnormally.

No.	Problems	Remedy	Cause			
			a	b	c	d
			A ΔX	Δ	X	A
1	Oil level in oil pan is too low. (Check whether oil consumption is excessive.)					○
2	Fluctuation stops when gauge is replaced.				○	
3	Mounts in instrument panel are loose. (Check directly)		○			
4	Regulator valve is caught, spring is fatigued, valve or valve guide is damaged. (Check directly)	○				

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

12. Lack of oil pressure.

(At engine speed of over 700 rpm, indicator of engine oil pressure gauge is to left of "green range".)

Question to be asked before starting troubleshooting.

Is 10W oil being used at temperatures above 0°C?

No.	Problems	Remedy	Cause												
			a	b	c	d	e	f	g	h	i	j	k	l	m
			Δ	Δ	C	X	X	X	C	C	X	A	-	X	X
			X	XA	C	C	X	Δ	X	Δ	X	X	Δ	X	Δ
1	Oil is leak from hose or tube. (Check for signs of external oil leakage).														○
2	Water or fuel mixed with oil.												○		
3	Oil in oil pan is lack (no sign of external oil leakage).											○			
4	Engine oil pressure is normal if gauge is replaced.										○				
5	Oil hose, tube are clogged or damaged. (Check directly)								○						
6	Oil filter is clogged and safety valve function is defective. (Check directly)						○								
7	Metal particles are caught in oil filter element. K.O.W.A (oil analysis) shows abnormality.					○									
8	Remove oil pan. When checking oil, strainer is clogged or oil pipe is damaged.			○											
9	Regulator valve is catching, spring is fatigued, valve or valve guide is damaged. (Check directly)		○												
10	Oil pump does not rotate smoothly and oil pump shaft play is excessive.	○													

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



13. Oil in cooling system.

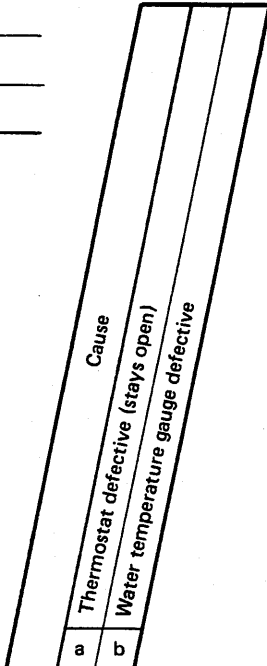
	Cause	Remedy
a	Pipe broken in oil cooler, O-ring damaged	X
b	Head gasket damaged	X
c	Cylinder head cracked	X
d	Cylinder block cracked	X

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	Cause	
			a	b
		X	X	
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
- A: Adjust
- Δ: Repair
- C: Clean

**15. Water temperature rises excessively.**

(Water temperature gauge indicator goes to right of "green range"; engine overheats)

**!** Never remove the radiator cap when the temperature is still high. Boiling water may spurt out and cause serious burns.

**\*** When the engine overheats, stopping the engine immediately means water is no longer sent out by the water pump. As a result the temperature of the parts being cooled rises sharply and this may cause cracking or other damage to the engine.

Before starting the troubleshooting, ask the operator the following questions.

1. Is anti-freeze being used in summer?
2. Is water being supplied according to the "Operation and Maintenance Manual"?

**Check before troubleshooting**

1. Is machine being operated under excessive load?
2. Is fan damaged or deformed?
3. Is belt groove of fan pulley or crank pulley worn?
4. Are radiator shutter and reversible fan being used properly?

Cause	a	b	c	d	e	f	g	h	i	j	k	l
Water temperature gauge damaged												
Thermostat seal defective (does not open)												
Thermostat defective (does not open)												
Water pump damaged												
Radiator core fins clogged or damaged												
Fan belt tension incorrect												
Cylinder block or head cracked												
Head gasket damaged												
Cylinder liner O-ring damaged, sleeve damaged												
Water leaking from water tube or hose												
Water leaking from radiator												
Water leaking from water pump or oil cooler												

No.	Problems	Remedy	Cause															
			a	b	c	d	e	f	g	h	i	j	k	l				
			A	X	X	X	CX	A	X	X	X	X	X	X	X	X	X	X
1	Coolant level is too low.																	
2	Cooling water mixed with oil.																	
3	Fan belt loosens.																	
4	Radiator core is damaged or clogged with mud or dust.																	
5	Difference in temperature between upper and lower tanks of radiator is extreme.																	
6	Radiator is only slightly warm.																	
7	Remove thermostat and check it, it is normal (open).																	
8	If water temperature gauge is replaced, it returns to normal.																	

**\*** If exhaust smoke is black, follow problems "6. Exhaust gas is black".

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

16. Too much vibration.

No.	Problems	Remedy	Cause																
			a	b	c	d	e	f	g	h	i	j	k	l	m	n			
			X	X	X	X	X	X	X	Δ	X	A	CX	X	Δ	AX	ΔX	X	Δ
1	Engine mounting bolts are loose. (Check directly)																		○
2	Vibration damper is not warm to touch after operation, during operation, gear noise is also excessive.																	○	
3	Air is mixed in fuel system.																○		
4	Engine runs abnormally at low idling. (No air in fuel line; exhaust gas color normal)								○							○			
5	Exhaust gas is black.										○	○	○						
6	Water temperature does not rise or rises slowly.												○						
7	When checking injection nozzle with nozzle tester, injection spray is defective or injection pressure is low.									○		○							
8	Injection pump seal is out of position, injection pump is out of adjustment. (Check directly with test stand)											○							
9	When loosening injection pipe sleeve nuts in order at low idling, speed of some cylinders does not change.								○	○									
10	Oil pressure is low at low idling.					○													
11	Remove cylinder head when checking it, the tappet or intake and exhaust valves are abnormal.		○	○	○														
12	The wear and clearance of front support pilot are large.	○																	

17. Abnormal noise emitted.

- ★ When noises indicating internal damaged are being emitted continuing to operate the machine may make the damage worse.
- ★ As far as possible, classify the abnormal noise to make location of the cause easier.

Type of noise;

- Interface
- Abnormal combustion
- Gears
- Internal, external
- Engine, power train

Cause	
a	b
Valve or piston broken	Valve stem or cam follower stuck or worn
Timing gear or oil pump gear or P.T.O. gear broken or worn	Bolt missing from connecting rod cap or main bearing cap
Camshaft bushing out of place	Injection nozzle clogged
Injection nozzle seized	Piston, ring or liner worn
Valve clearance defective	Injection pump plunger defective
Vibration damper defective	Thermostat defective
Injection pump out of adjustment (excessive injection)	Interference of fan or fan belt; fan deformed

No.	Problems	Remedy	Cause													
			a	b	c	d	e	f	g	h	i	j	k	l	m	n
			X	X	X	ΔX	XΔ	CX	X	X	A	X	X	X	A	ΔX
1	External or interference engine noise occurs.															○
2	Exhaust gas is black.					○			○	○				○	○	
3	Combustion noise is abnormal.					○	○		○	○				○	○	
4	Injection pump seal out of position. (Check injection volume on test stand.)														○	
5	Water temperature does not rise.													○		
6	Vibration damper is not warm to touch after operation; during operation, gear noise is also excessive.												○			
7	When loosening injection pipe sleeve nut and setting engine to low idling, engine speed does not change.											○				
8	Valve clearance is too large or too small.									○						
9	Compression pressure is lack; blow-by is excessive.								○							
10	When checking injection nozzle with nozzle tester, injection spray is defective or injection pressure is low.					○	○									
11	Remove oil pan. When checking it, internal engine noise is excessive.				○											
12	Remove gear cover. Gear noise is occurred.		○													
13	When removing cylinder head, Internal engine noise is excessive.	○														

Other causes of abnormal noise (direct check)

	Cause	Remedy
o	PTO gear damaged or worn	X
p	Air compressor damaged	X
q	Turbocharger damaged	X

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

18. Excessive wear of engine parts.

Before starting the troubleshooting, ask the operator the following questions.

1. Is the specified oil being used?
2. Is the specified fuel being used?
3. Is the air cleaner element cleaned and replaced according to the "Operation and Maintenance Manual"?
4. Is the fuel filter element cleaned and replaced according to the "Operation and Maintenance Manual"?
5. Are the engine oil and oil filter element replaced according to the "Operation and Maintenance Manual"?
6. Has there been repeated rapid acceleration, or rapid gear shifting?
7. Is the machine warmed up before operation, and left idling before stopping engine according to the "Operation and Maintenance Manual"?

Cause	
a	Fuel filter element damaged or clogged
b	Dirt or water mixed with fuel
c	Dirty oil
d	Water mixed with oil
e	Fuel mixed with oil
f	Abnormal combustion
g	Air leaking into system
h	Air cleaner element damaged

No.	Problems	Remedy							
		X	C	-	-	-	-	Δ	X
1	Dirt gets into engine. (Check directly)								○
2	Exhaust gas is black. (See problems "6. Exhaust gas is black")							○	
3	Fuel is mixed with oil. (See problems "9. Oil level rise")					○			
4	Water is mixed with oil. (See problems "9. Oil level rise")			○					
5	Oil is dirty. (See problems "10. Oil quickly becomes dirty")		○						
6	Dirt or water drains out when fuel tank drain plug is removed.		○						
7	Fuel filter is dirty or damaged.	○							

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

19. Engine does not start because of fault in electrical system. (Check starting circuit)

**⚠** When checking, take care not to be caught in fan or other rotating parts if engine starts.

**Check before troubleshooting**

1. Is battery electrolyte level or specific gravity too low?
2. Check starting circuit for broken or disconnected wires, loose terminals or short circuits (Visual check)  
 Battery ↔ Safety relay ↔ Starting switch  
 ↔ Battery relay switch ↔ Battery
3. Immediately after repair, mistaken wiring connection is possible cause.
4. When problems 1-1) "Engine does not turn" gives cause i "Electrical system defective", use this problems.

Cause				
a	b	c	d	e
Starting motor defective				
Internal wiring or performance of safety relay defective				
Internal wiring or performance of safety switch defective				
Internal wiring or performance of battery relay switch defective				
Internal wiring or performance of starting switch defective				

No.	Problems	Remedy	Cause				
			a	b	c	d	e
1	If terminals (B) and (C) of starting motor are connected, pinion moves out. * Sparks are produced by this test. ⚠ When pinion movement is confirmed, disconnect-terminals immediately.		○	○	○	○	
2	If terminals (B) and (C) of starting switch are connected, engine will start.					○	
3	If terminals (b) and (E) of battery relay switch are connected, engine will start.				○		
4	If plug terminal of safety switch is connected to terminal (B) or (+) of starting motor, engine will start.			○			
5	If terminals (B) and (C) of safety relay are connected, engine will start.		○				
6	Starting motor does not turn even if No. 1 starting motor terminals (B) and (C) are connected.	○					

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

20. Battery does not charge. (Check charging circuit)

**!** When checking, take care not to be caught in fan or other rotating parts if engine starts. Take care also not to cause short circuits.

Before starting the troubleshooting, ask the operator if the battery is old (in use for 2 or more years).

**Check before troubleshooting**

1. Is alternator drive belt loose?
2. Check charging circuit for broken or disconnected wires, loose terminals or short circuits. (Visual check, continuity check)  
 Battery ↔ Starting switch ↔ Ammeter ↔ Alternator ↔ Battery relay switch ↔ Battery.
3. Do lamps or heater exceed specified limit? Are they left on?  
 ★ When engine is stopped and charged lamp stays on, or ammeter indicator deflects to one side, lamps are still on, or there is a short circuit.
4. Following repairs, mistaken wiring connection is possible cause.

	Cause
a	Alternator defective
b	Internal wiring or performance of regulator defective
c	Internal wiring or performance of regulator defective
d	Internal wiring or performance of ammeter or charging lamp
e	Battery defective

No.	Problems	Remedy	Cause				
			X△	△X	△X	△X	X
1	During operation, deflection of ammeter and charging lamp are normal.						○
2	Continuity test using tester shows; 1) Little or no continuity when terminals (AC) and (B) of starting switch are connected. (with switch ON)						○
	2) When the starting switch is ON, continuity between them above 1) is proper, but when being OFF, no continuity.						○
	3) Little or no continuity between (+) terminal and (-) terminal of ammeter or charging lamp.					○	
3	Run engine at medium speed (1,000 – 1,500 rpm) and measure charging voltage with tester. Tester does not show charging voltage (26 – 30V) between terminal (E) and (R) of alternator.		○	○	○		

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

# ENGINE

## 13 DISASSEMBLY AND ASSEMBLY



### GENERAL

Disassembly .....	13- 3
Assembly .....	13-21

- ★ The description of overall engine disassembly and assembly given in this section is based on the SA6D170-1 engine, assuming the use of an overhaul stand.
- ★ The work procedure may differ slightly from that given here depending upon the machine in which the engine is mounted and also the particular stand used, however it is fundamentally the same.
- ★ Use the correct service tools when performing disassembly and assembly.



## GENERAL DISASSEMBLY CONTENTS

No.	Item	Page	No.	Item	Page
1	Starting motor	13 - 4	30	Front support	13-11
2	Alternator	13 - 4	31	Cover	13-11
3	Water pump	13 - 4	32	Trunnion	13-12
4	Turbocharger oil drain tube	13 - 5	33	Timer assembly	13-12
5	Oil cooler	13 - 5	34	Accessory pulley	13-12
6	Placing engine on the stand	13 - 5	35	Mechanical pump assembly	13-12
7	Air cleaner	13 - 5	36	Injection pump drive case	13-12
8	Intake connector	13 - 6	37	Cam follower assembly	13-13
9	Connector pipe	13 - 6	38	Gear case cover	13-13
10	Fuel filter	13 - 6	39	Camshaft assembly	13-14
11	After-cooler tube and lubrication tube	13 - 6	40	Main idler gear	13-14
12	Fuel injection tube	13 - 6	41	Idler gear for water pump gear	13-14
13	Oil filter	13 - 7	42	Idler gear for oil pump gear	13-14
14	Oil filler and oil level gauge	13 - 7	43	Flywheel	13-14
15	Tension spring and tension pulley	13 - 7	44	PTO drive gear	13-15
16	Corrosion resistor	13 - 7	45	Rear seal cover	13-15
17	Thermostat case	13 - 7	46	Oil pan	13-15
18	Turbocharger and exhaust manifold assembly	13 - 8	47	Strainer	13-16
19	After-cooler and intake manifold assembly	13 - 8	48	Oil pump piping	13-16
20	Fuel injection pump	13 - 8	49	Oil pump	13-16
21	Spill tube, head cover	13 - 9	50	Gear case	13-16
22	Rocker arm assembly	13 - 9	51	Flywheel housing	13-16
23	Crosshead	13 - 9	52	Piston cooling nozzle	13-17
24	Push rod	13 - 9	53	Piston and connecting rod assembly	13-17
25	Nozzle holder	13 - 9	54	Crankshaft assembly	13-18
26	Rocker arm housing	13-10	55	Cylinder liner	13-19
27	Cylinder head	13-10			
28	Crankshaft pulley	13-11			
29	Vibration damper	13-11			

## GENERAL DISASSEMBLY

### Prepared special tool

Mark	Part No.	Part Name	Q'ty
A	790-501-2000	Engine repair stand	1
A <sub>1</sub>	790-901-1170	• Repair stand bracket	1
B	795-102-4210	Spring compressor	1
C	795-100-1181	Timer remover	1
D	795-100-1191	Piston ring tool	1
E	795-102-1300	Liner puller	1

### • Preparation work

#### 1. Cleaning

Remove sand and soil from the engine, before disassembling it.

#### 2. Engine stand

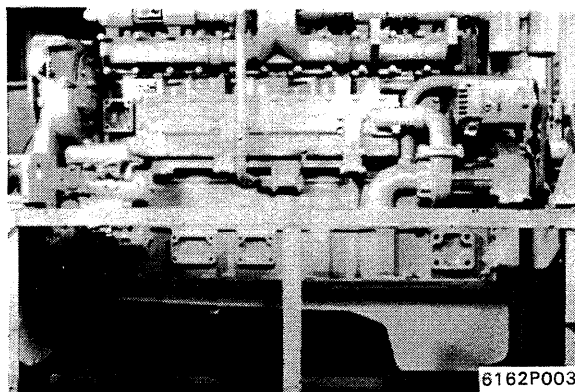
Prepare the stable stand on which the engine can be placed securely.

#### 3. Drain oil

Drain the engine oil.



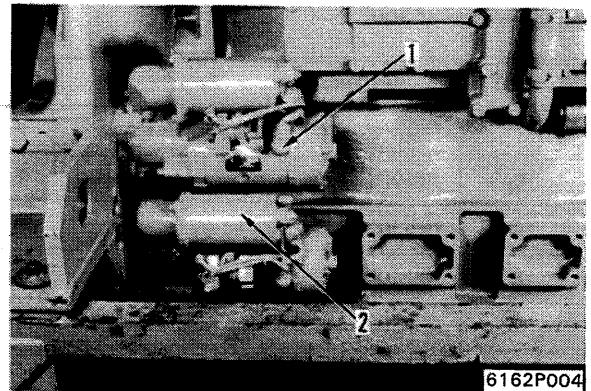
Engine oil pan: Approx. 41 ℓ



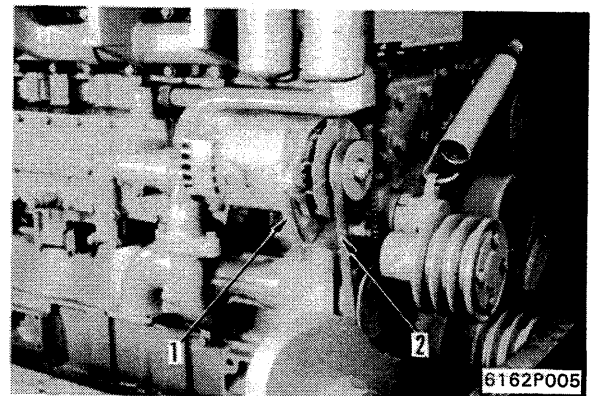
6162P003

**1. Starting motor**

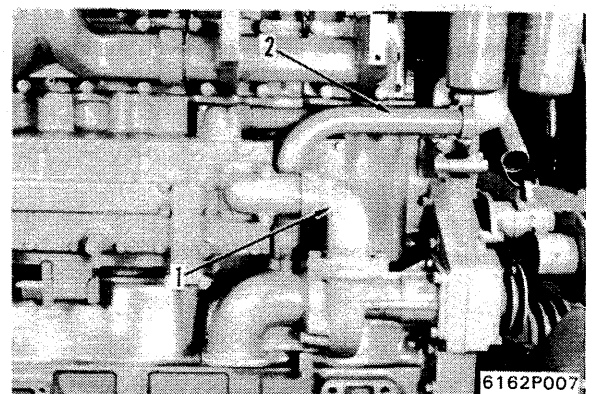
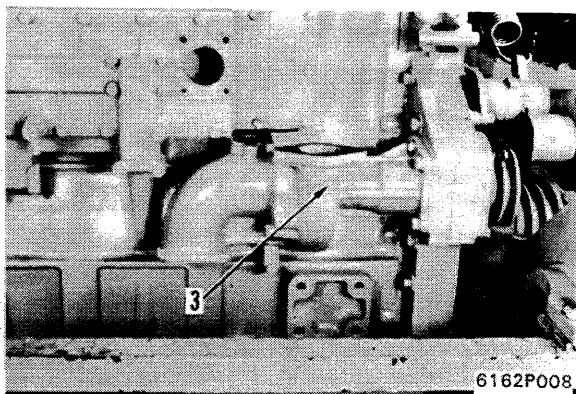
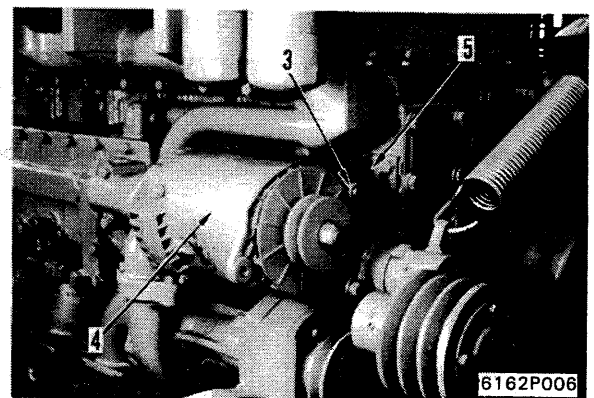
- 1) Remove starting motor (1).
- 2) Remove starting motor (2).

**2. Alternator**

- 1) Remove adjustment plate (1), then loosen the mounting bolt and nut, and remove belt (2).
- 2) Remove mounting bolt and nut (3), and remove alternator (4).
- 3) Remove bracket (5).

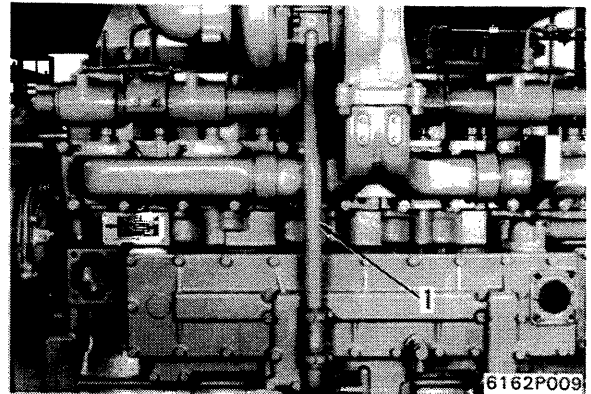
**3. Water pump (See photo No. 6162P007, 6162P008)**

- 1) Disconnect water pipe (1).
- 2) Remove the plate, then disconnect water pipe (2).
- 3) Remove water pump (3).
- 4) Remove the drive shaft.

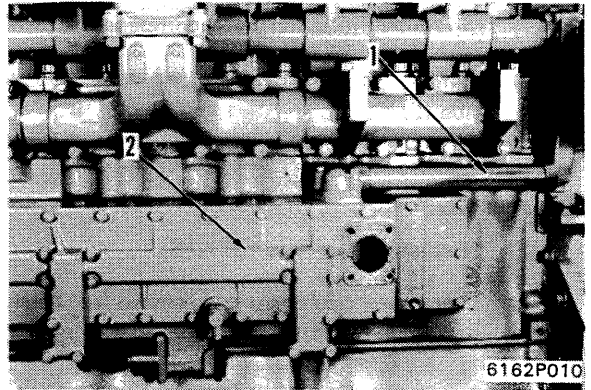


**4. Turbocharger oil drain tube**

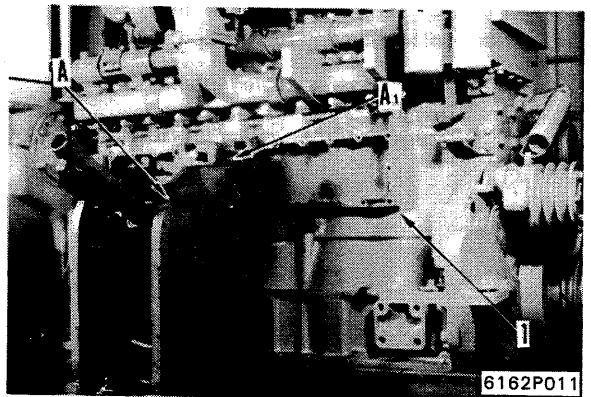
Remove turbocharger oil drain tube (1).

**5. Oil cooler**

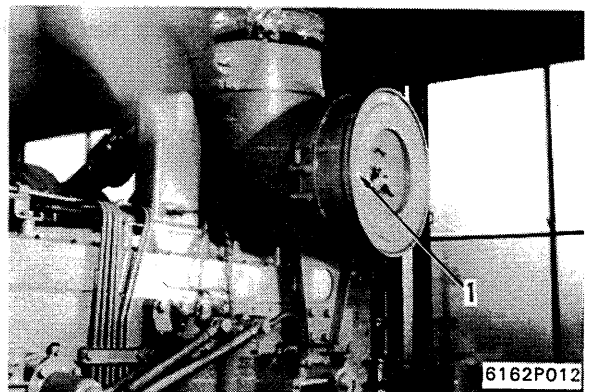
- 1) Remove water tube (1).
- 2) Remove oil cooler (2).

**6. Placing engine on the stand**

- 1) Install bracket  $A_1$  for the engine repair stand A using the threads for the oil cooler.
- 2) Hang engine assembly (1) and set it to the engine repair stand A.
  - ★ Tighten the bolts on the engine repair stand securely.

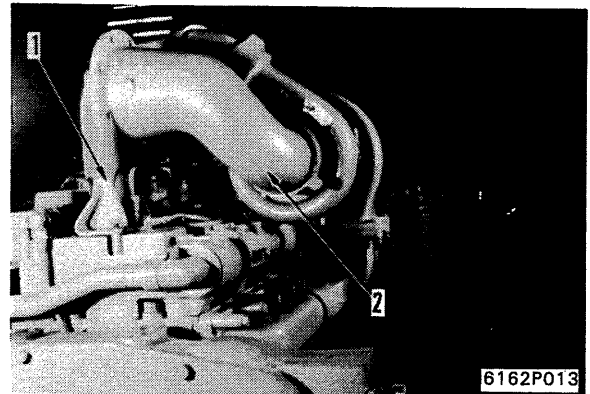
**7. Air cleaner**

Remove air cleaner (1).

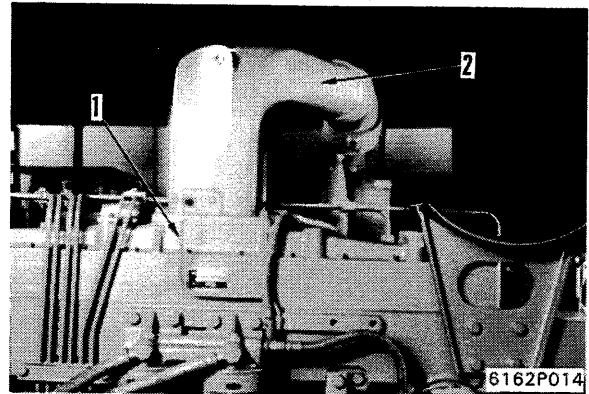


**8. Intake connector**

- 1) Remove bracket (1).
- 2) Disconnect intake connector (2).

**9. Connector pipe**

- 1) Disconnect tube for boost compensator (1).
- 2) Remove the plate, and disconnect connector pipe (2).

**10. Fuel filter**

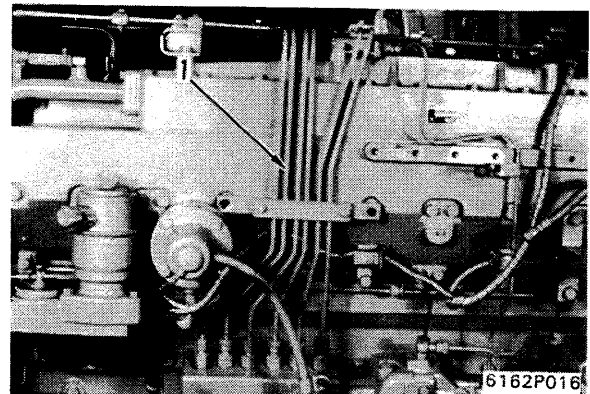
- 1) Disconnect fuel hose for APS.
- 2) Disconnect fuel hoses and remove fuel filter.

**11. After-cooler tube and lubrication tube**

- 1) Disconnect after-cooler tube.
- 2) Disconnect turbocharger lubrication tube.

**12. Fuel injection tube**

Remove the clamp, and disconnect fuel injection tube (1).

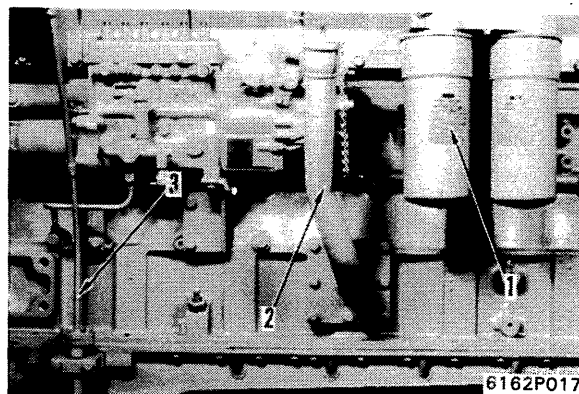


**13. Oil filter**

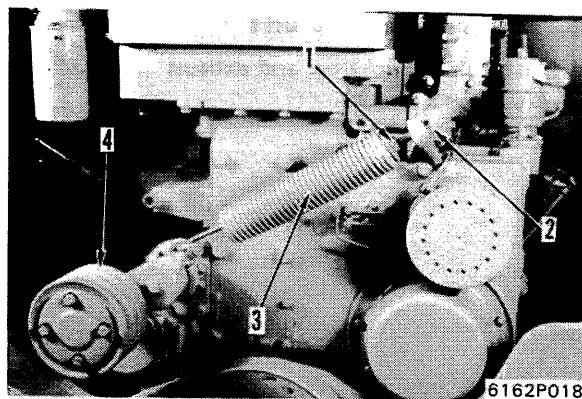
Remove oil filters (1) and the bracket.

**14. Oil filler and oil level gauge**

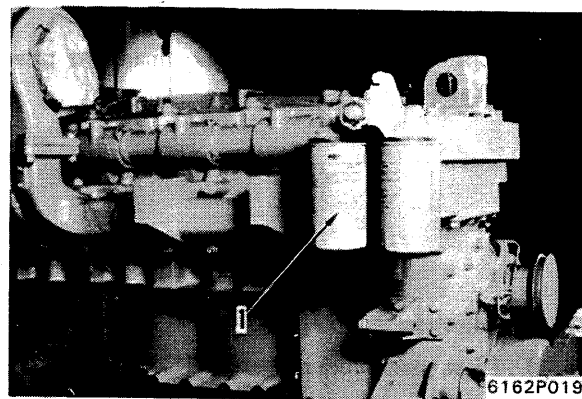
- 1) Remove oil filler (2).
- 2) Remove oil level gauge (3).

**15. Tension spring and tension pulley**

- 1) Loosen lock nut (1) and bolt (2) and remove tension spring (3) by lengthening it.
- 2) Remove tension pulley (4).

**16. Corrosion resistor**

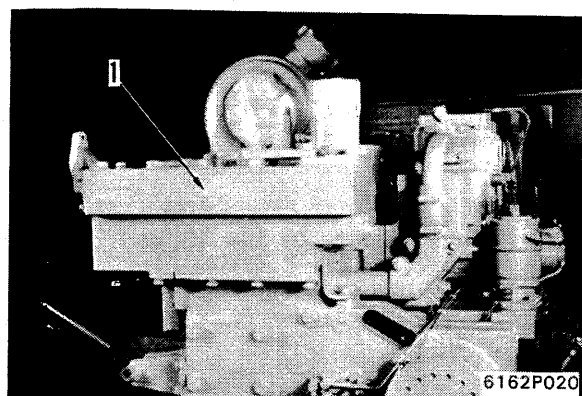
Remove corrosion resistors (1).

**17. Thermostat case**

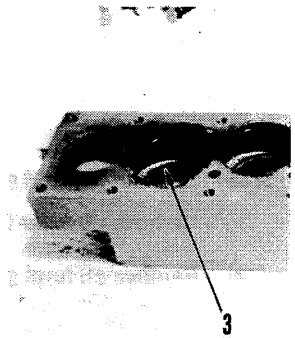
Remove thermostat case (1).

★ Disassemble thermostat case as follows:

- 1) Remove case cover and remove thermostat.



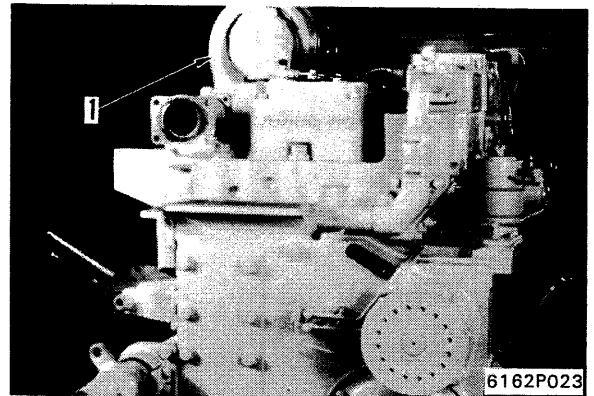
- 2) Remove thermostat seal (3).



6162P114

**18. Turbocharger and exhaust manifold assembly**

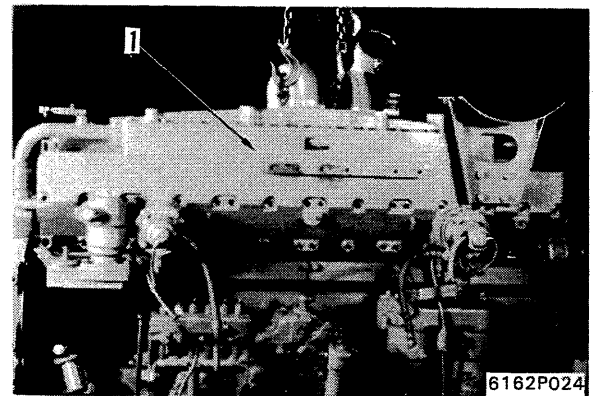
Lift out turbocharger and exhaust manifold assembly (1) as a unit.



6162P023

**19. After-cooler and intake manifold assembly**

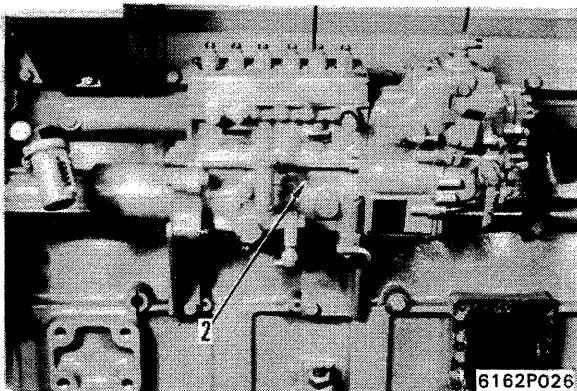
Lift out after-cooler and intake manifold assembly (1) as a unit.



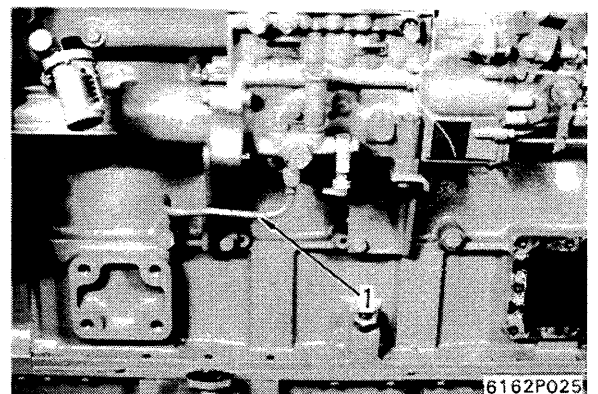
6162P024

**20. Fuel injection pump**

- 1) Disconnect lubrication tube (1).
- 2) Remove fuel injection pump (2).



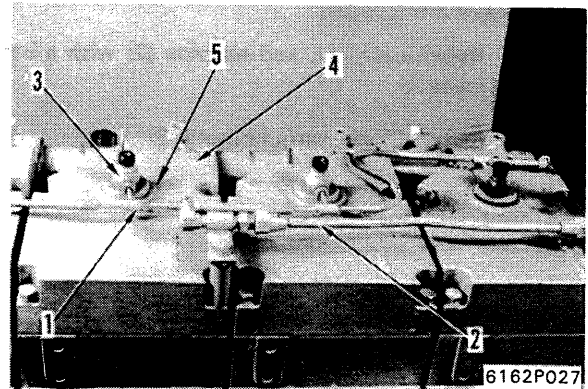
6162P026



6162P025

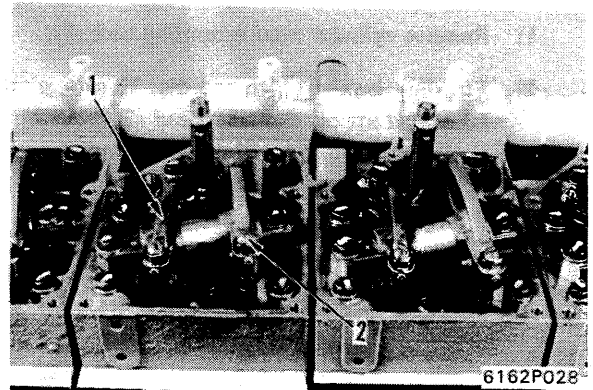
**21. Spill tube, head cover**

- 1) Disconnect spill tube (1).
- 2) Disconnect turbocharger lubrication tube (2).
- 3) Disconnect connection (3) and remove head cover (4).
- 4) Remove rubber packing (5) from head cover (4).

**22. Rocker arm assembly**

Remove rocker arm assembly (1).

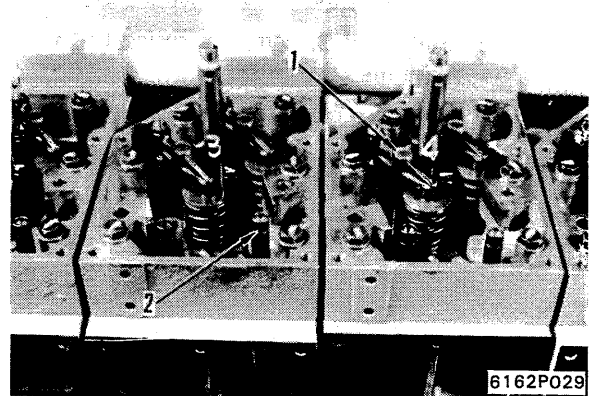
- ★ When installing the rocker arm, loosen the lock nut and loosen adjustment screw (2) 2 to 3 turns to prevent the push rod from pushing up.

**23. Crosshead**

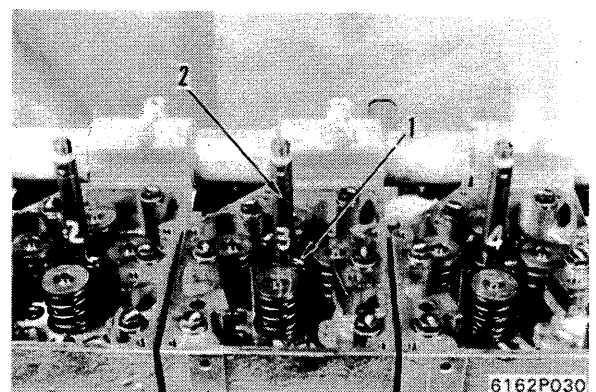
Remove crosshead (1).

**24. Push rod**

Remove push rod (2).

**25. Nozzle holder**

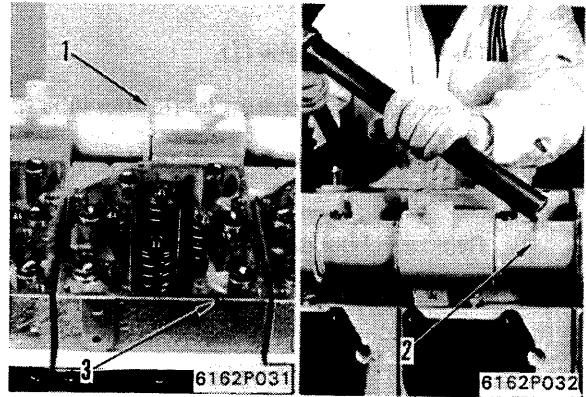
Remove mounting bolt (1), and remove nozzle holder (2).





**26. Rocker arm housing**

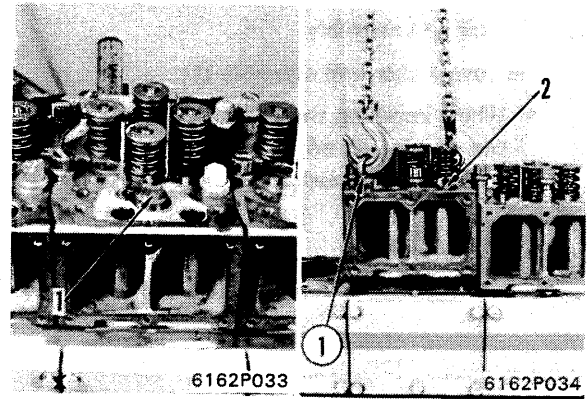
- 1) Remove pin (1), and hit pipe (2) with a bar to move it.
- 2) Remove rocker arm housing (3).



**27. Cylinder head**

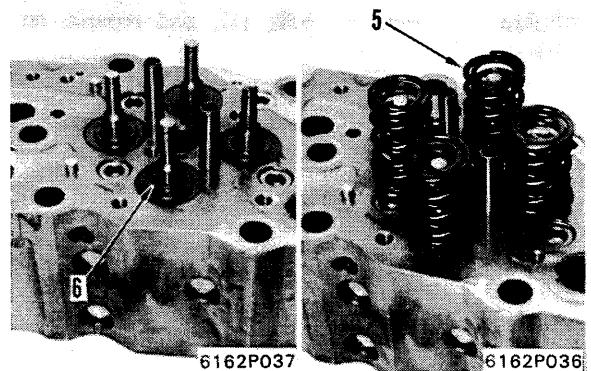
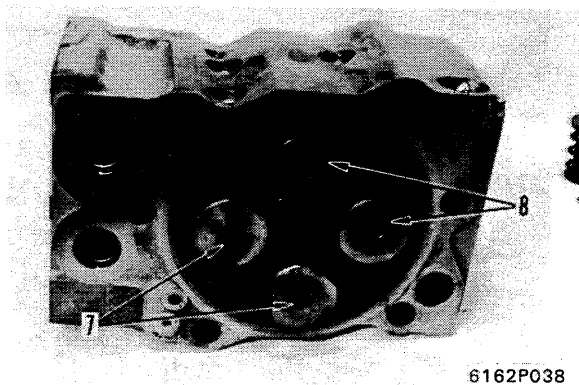
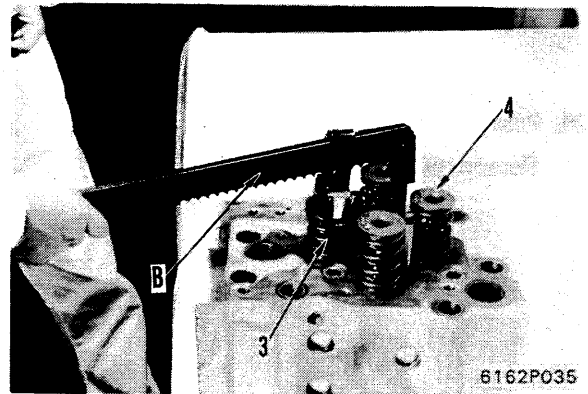
- 1) Remove cylinder head mounting bolt (1).
- 2) Fit sling bolt (1) (thread dia. 12 mm, pitch = 1.75) and lift out cylinder head (2).

 Cylinder head: 40 kg



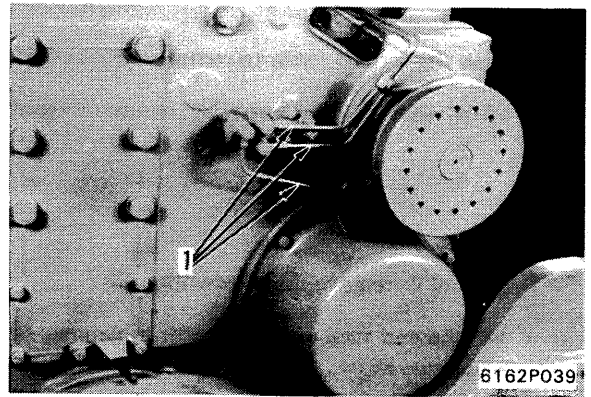
★ Disassemble cylinder head assembly as follows:

- i) Using tool B, compress spring (3), then remove the valve cotter.
- ii) Remove retainer (4) and valve spring (5).
- iii) Remove lower seat (6), then remove intake valve (7) and exhaust valve (8).

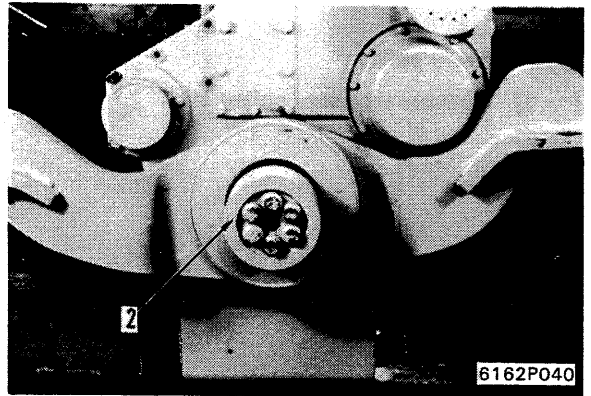


**28. Crankshaft pulley**

- 1) Disconnect lubrication pipe (1).

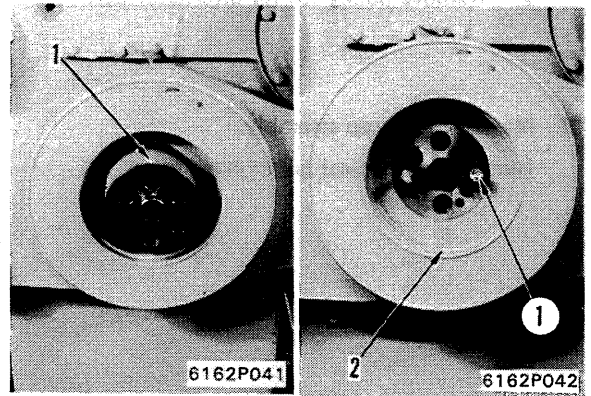


- 2) Remove crankshaft pulley (2).



**29. Vibration damper**

- 1) Remove spacer (1).
  - 2) Tighten forcing screw ① to remove damper (2).
- ★ While tightening the forcing screw, take care not to drop the vibration damper.



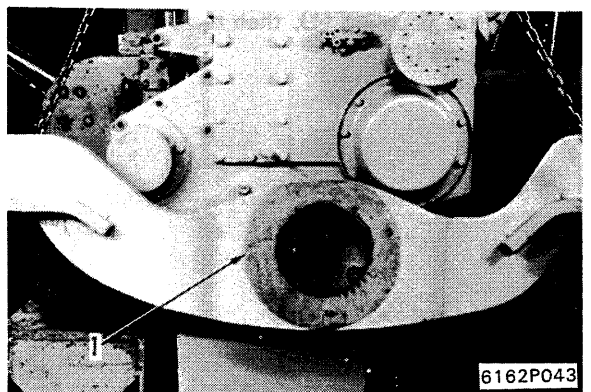
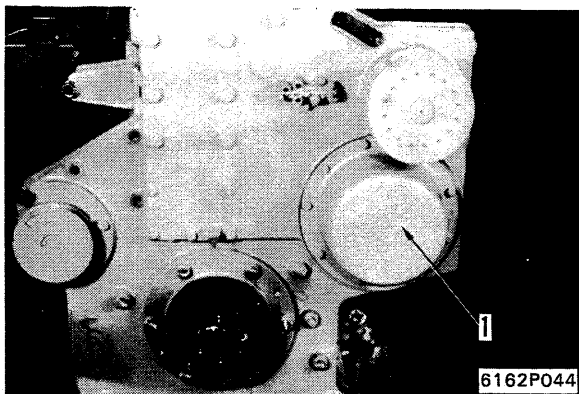
**30. Front support**

Lift out front support (1).

 Front support:

**31. Cover**

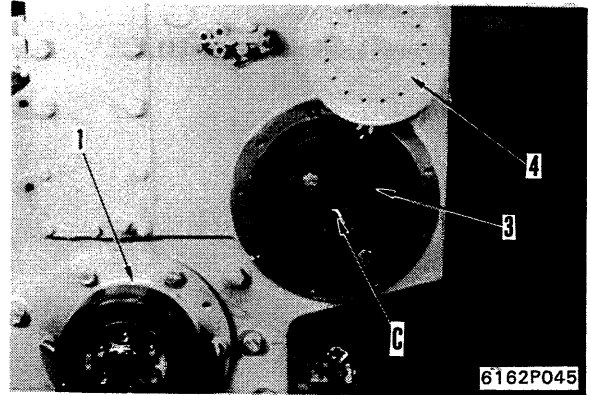
Remove cover (1).



**32. Trunnion**

Tighten the forcing screw to remove trunnion (1).

★ When replacing the front seal, remove oil seal (2).



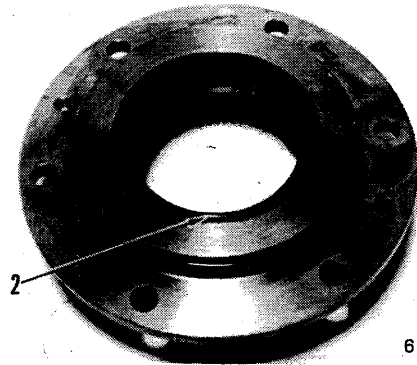
**33. Timer assembly**

Using tool C, remove timer assembly (3).

★ Hit the end face of tool C with a hammer to remove timer assembly which is force-fitted.

**34. Accessory pulley**

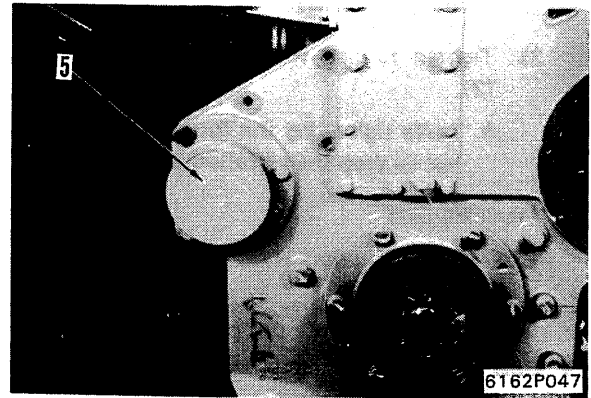
1) Remove accessory pulley (4).



2) Remove pulley (5) for alternator belt.

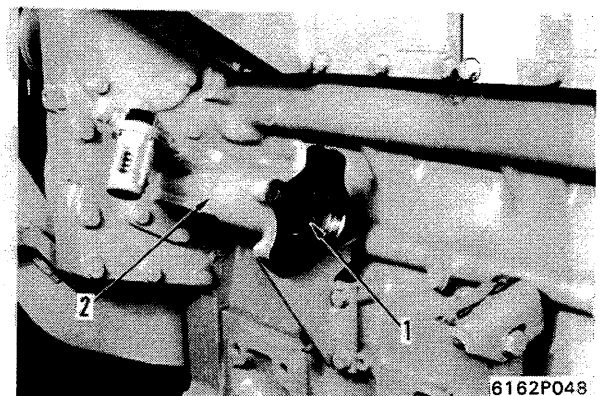
**35. Mechanical pump assembly**

Remove mechanical pump assembly.



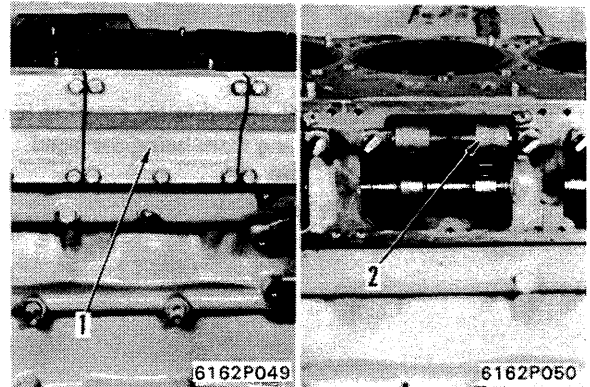
**36. Injection pump drive case**

Remove coupling (1), then remove injection pump drive case (2).



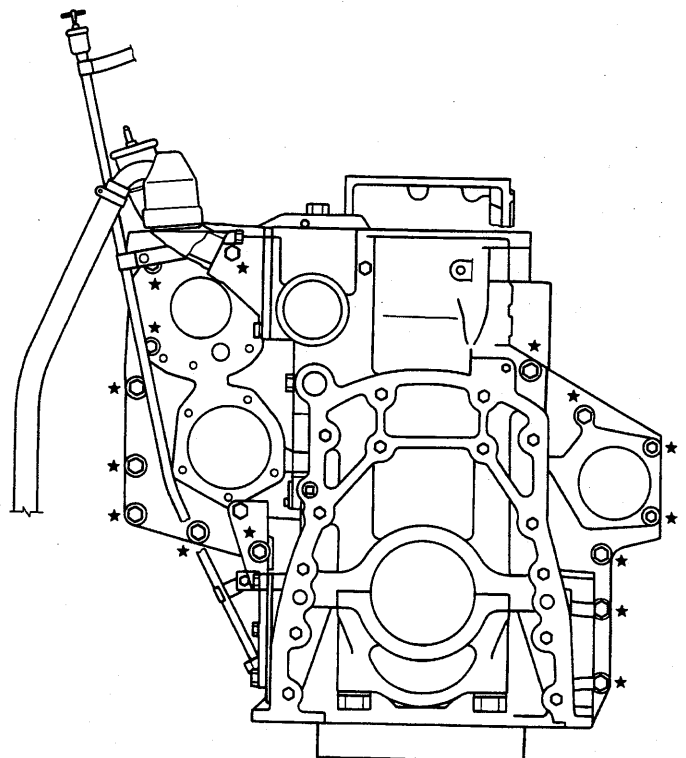
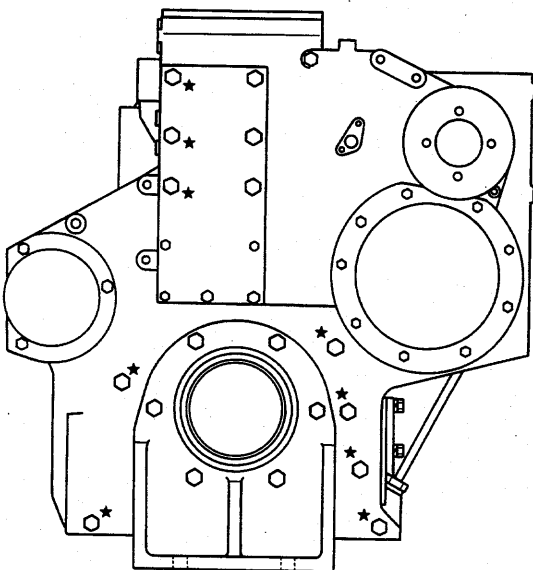
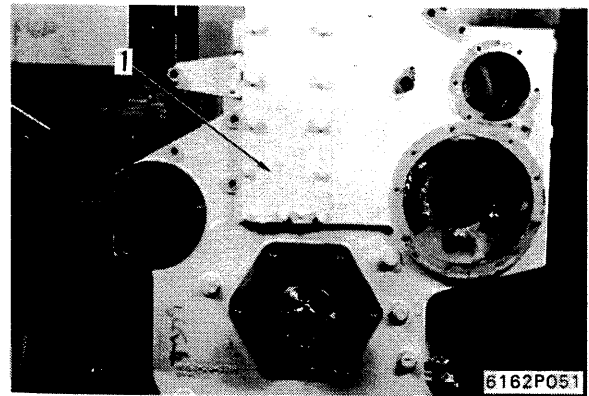
**37. Cam follower assembly**

- 1) Remove cover (1).
- 2) Remove cam follower assembly (2).



**38. Gear case cover**

Remove 24 bolts (★), then remove gear case cover (1).



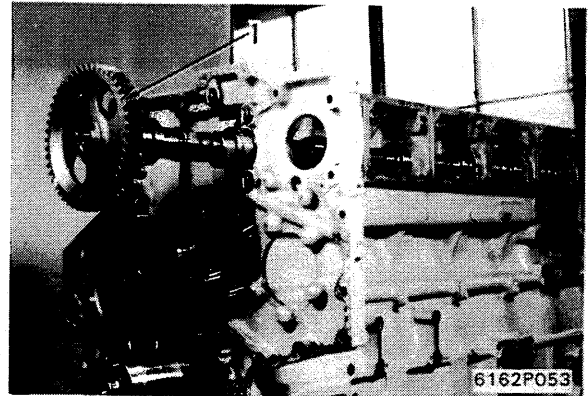
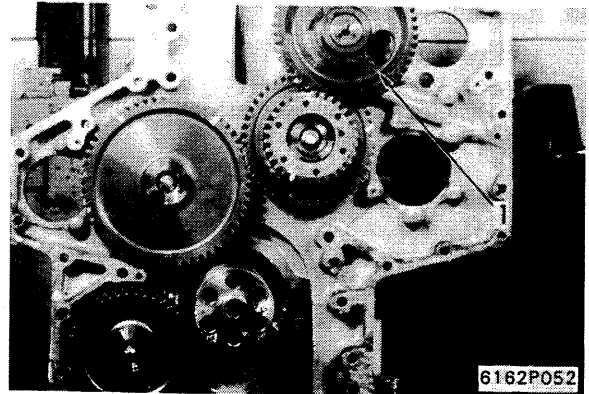
**39. Camshaft assembly**

Remove camshaft assembly (1).

- ★ Remove the camshaft assembly by rotating it to protect the cam bushing from being damaged.



Camshaft assembly: 32 kg

**40. Main idler gear**

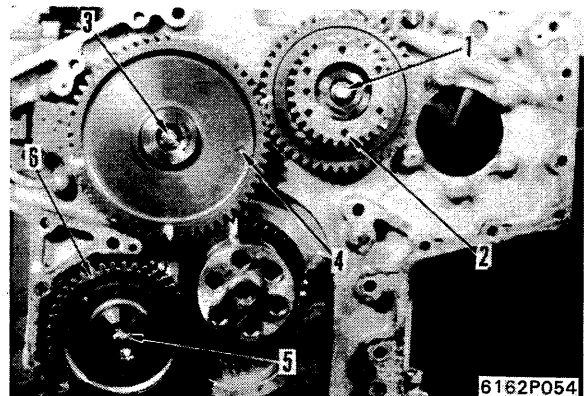
Remove mounting bolt (1), then remove main idler gear (2).

**41. Idler gear for water pump gear**

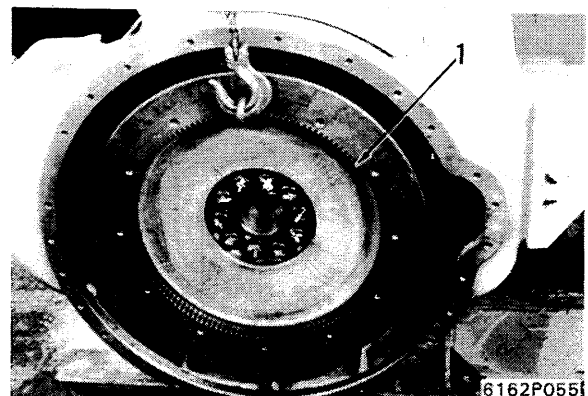
Remove mounting bolt (3), then remove idler gear assembly (4) for water pump gear.

**42. Idler gear for oil pump gear**

Remove mounting bolt (5), then remove idler gear (6) for oil pump gear.

**43. Flywheel**

Using the sling bolts (thread dia. 12 mm, pitch = 1.75), lift out flywheel (1).

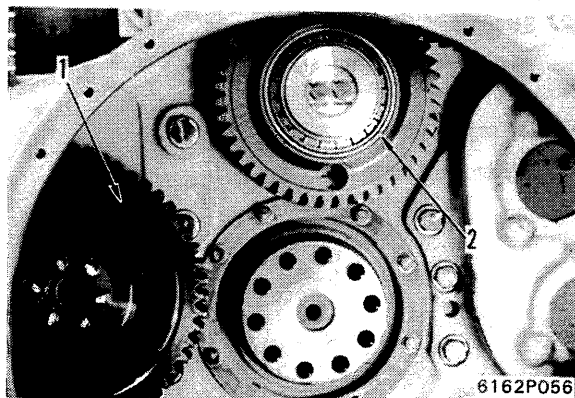


**44. PTO drive gear (If equipped)**

- 1) Remove steering pump drive gear (1) from the case hole.
- 2) Remove the six set bolts, and remove PTO drive gear (2).



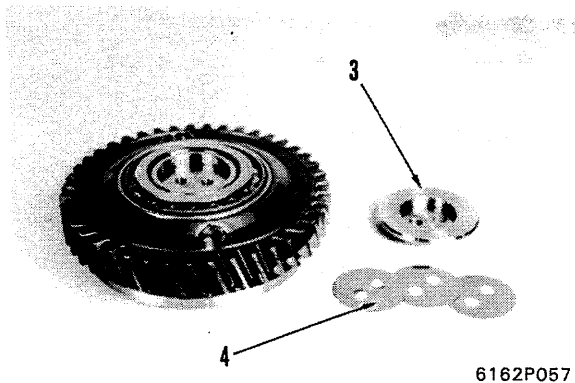
Remove 6 mounting bolts while supporting the PTO drive gear by hand. If the PTO drive gear is not supported, it may fall when the bolts are removed.



6162P056

★ Disassemble PTO driving gear as follows:

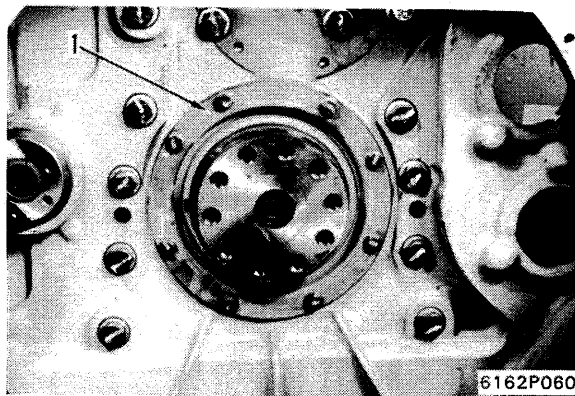
- i) Remove bearing retainer (3) and shim (4).



6162P057

**45. Rear seal cover**

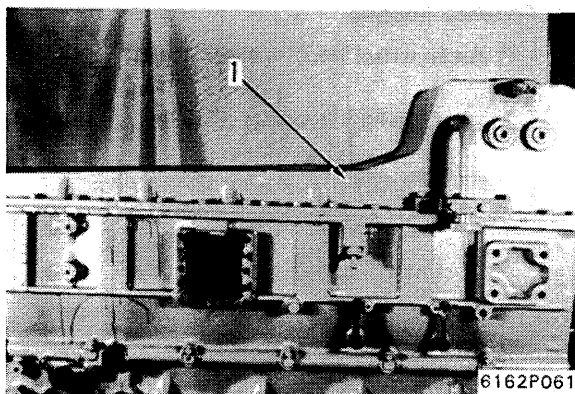
Remove rear seal cover (1).



6162P060

**46. Oil pan**

Remove oil pan (1).



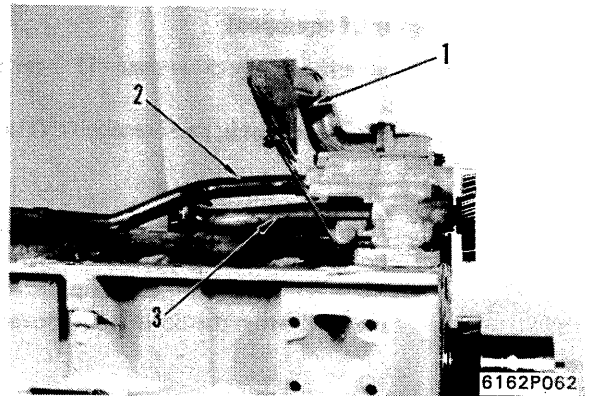
6162P061

47. Strainer

Remove oil strainer (1).

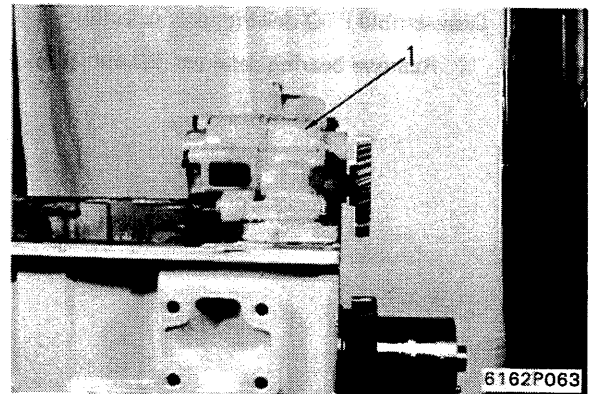
48. Oil pump piping

Disconnect tube (3).



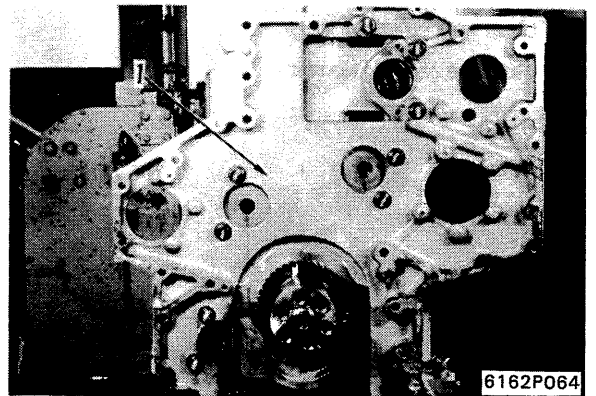
49. Oil pump

Remove oil pump (1).



50. Gear case

Remove gear case (1).

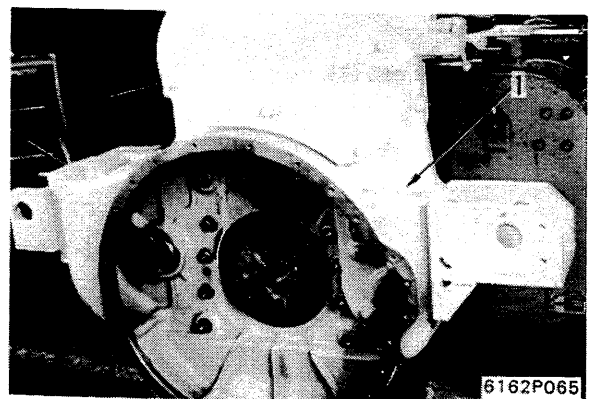


51. Flywheel housing

Lift out flywheel housing assembly (1).

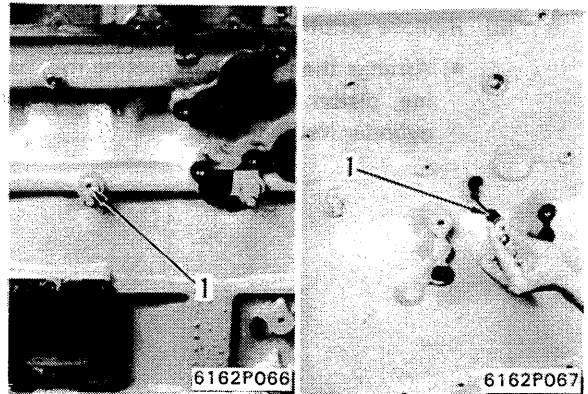


Flywheel housing: 290 kg



**52. Piston cooling nozzle**

Remove piston cooling nozzle (1).

**53. Piston and connecting rod assembly**

- 1) Check the No. embossed on the connecting rod cap.

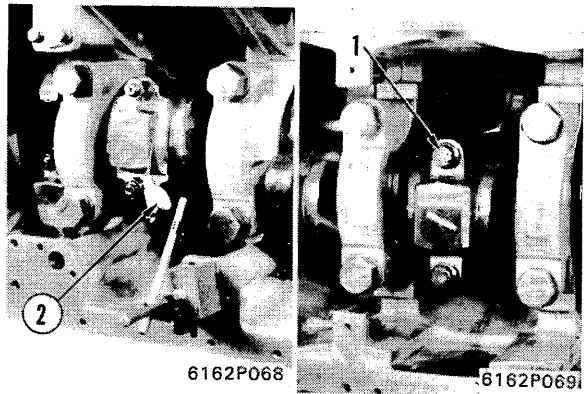
(Check that the cap No. and cylinder No. agree with each other and that the embossed mark is on the cam side.)

★ If there is no mark, emboss a mark before dismounting the cap.

- 2) Rotate crankshaft so that the piston to be removed locates to the B.D.C. position.
- 3) Remove carbon deposits from the upper wall of the liner using fine sandpaper.

★ If necessary, use dial gauge (2) to measure the end play of the connecting rod before removing the piston and connecting rod assembly.

- 4) Remove bolt (1) of connecting rod cap.



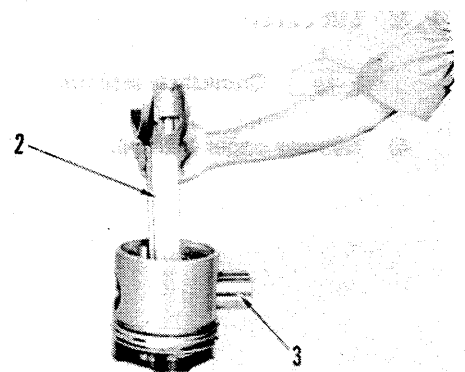
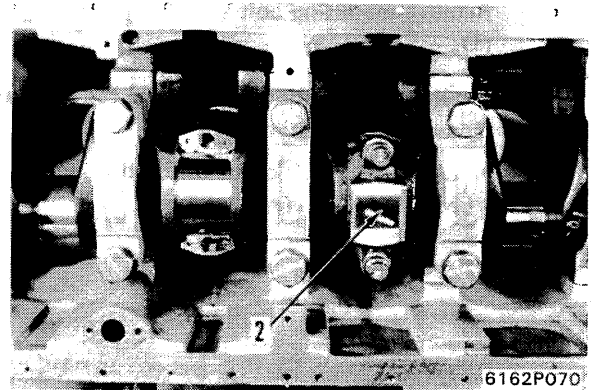
- 5) Remove connecting rod cap (2) together with the connecting rod bearing while tapping it lightly with a plastic hammer to prevent damaging the thread of the connecting rod bolt.

- 6) Extract the piston and connecting rod assembly from the oil pan side using a wooden rod or the like. During this operation, support the position at the cylinder head side to prevent damaging the inside of the cylinder liner.

★ Temporarily fit the connecting rod and cap together, and place them along side the bearing so as to ensure that these part are assembled together correctly.

★ Disassemble piston and connecting rod assembly as follows:

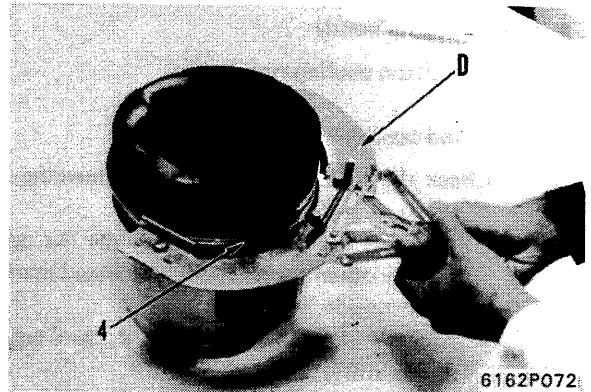
- i) Remove the snap ring.
- ii) Hold connecting rod (2), in the hand, then extract piston pin (3) and disconnect the piston and connecting rod each other.





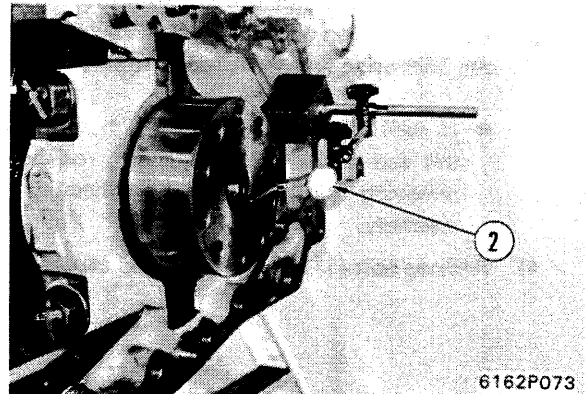
iii) Remove piston ring (4) using tool D.

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



54. Crankshaft assembly

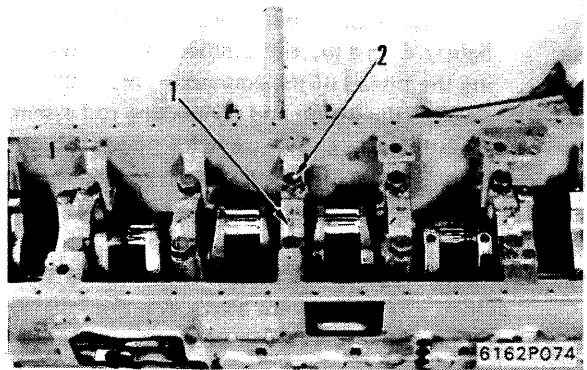
★ If necessary, use dial gauge (2) to measure the end play of the crankshaft before removing the crankshaft assembly.



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.

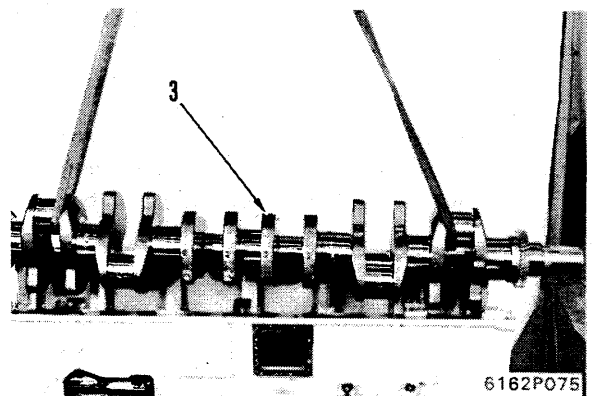
★ Check the position of thrust bearing installed the No. 6 main bearing cap.



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

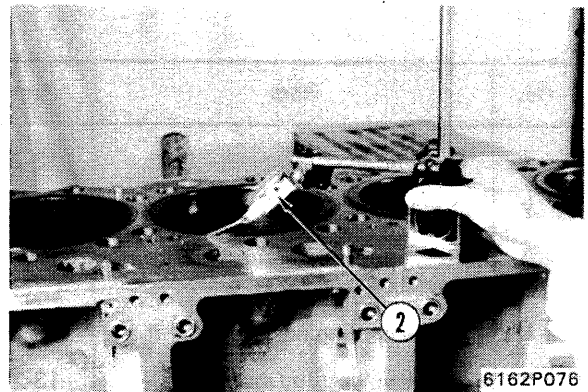
 Crankshaft assembly: 260 kg

4) Remove upper bearing.

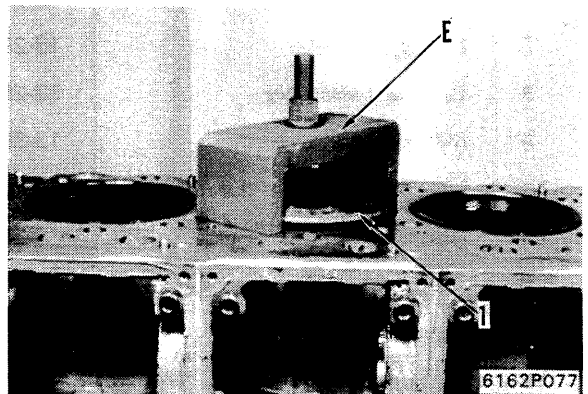


55. Cylinder liner

- ★ If necessary, measure the liner protrusion using dial gauge ②.



Remove cylinder liner (1) using tool E.



## GENERAL ASSEMBLY CONTENTS

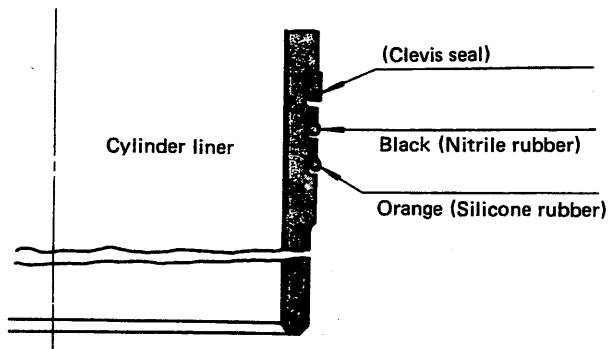
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4	Piston cooling nozzle	13-28	35	Adjustment of valve clearance	13-38
5	Flywheel housing assembly	13-28	36	Head cover and spill tube	13-38
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31	Crosshead assembly	13-37			

**GENERAL ASSEMBLY****Prepared special tool**

Mark	Part No.	Part Name	Q'ty
A	790-501-2000	Engine repair stand	1
A <sub>1</sub>	790-901-1170	Repair stand bracket	1
B	795-102-2102	Spring compressor	1
D	795-100-1191	Piston ring tool	1
F	795-225-1511	Liner driver	1
	790-101-5221	Grip	1
G	795-225-1700	Piston holder	1
H	795-125-1340	Filler gauge	1

### 1. Cylinder liner

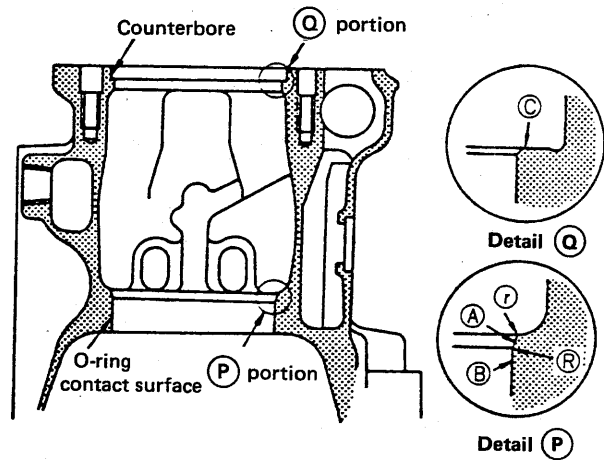
- ★ Be sure to use the new liner O-rings whenever the liner is removed.
- ★ Method of installing the liner O-ring and clevis seals:
  - 1) Confirm that the grooves for the liner O-rings and the liner are not made coarse by pitting, rusting, etc.
    - If coarse, replace the liner to prevent water leakage.
  - 2) Apply engine oil CLASS CD SAE30 to the grooves of the liner, O-rings and clevis seal.
  - 3) Install the clevis seal to the upper section of the liner groove while pressing the all round of clevis seal to prevent twist of clevis seal when inserting the liner.
  - 4) Install the liner O-ring and clevis seal as shown below.



6162F305

★ Before inserting the cylinder liner, prepare the cylinder block according to the following procedure.

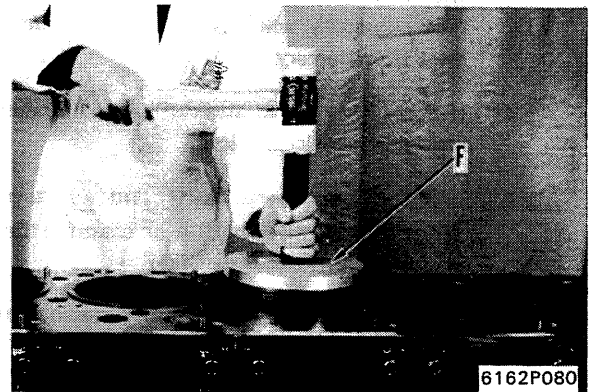
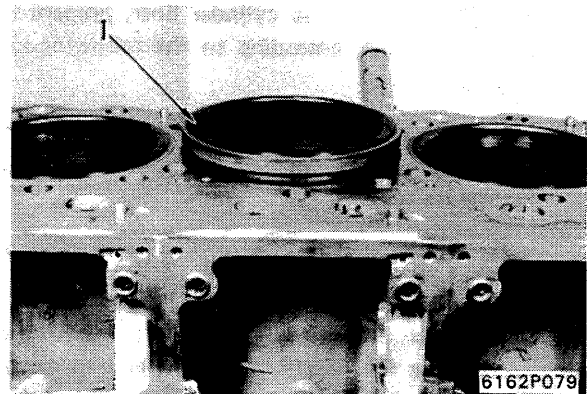
- 1) Remove the scale and rust from face (A) and (B) with sandpaper until the machine surface appears.
  - 2) Polish portions (R) and (r) with sandpaper No. 60 or so to achieve a smooth curve.
  - 3) Polish portions (B), (R) and (r) with sandpaper No. 60 or so. If there are sharp edges or burrs on the curved surface, remove them with a scraper or sandpaper. Finish this surface especially smoothly to protect the O-rings from damage.
  - 4) If face (B) is pitted and can not be repaired, replace the cylinder block.
  - 5) If face (A) and portions (R) and (r) are pitted, finish them smoothly or chamfer them as shown in the figure at right.
  - 6) Inspect the counterbore and remove burrs and fins, if any. If there are metal tips or dust on face (C), the liner will not perfectly and will not have the correct amount of projection, so water will leak.
- ★ If the counterbore is worn or pitted, repair it.



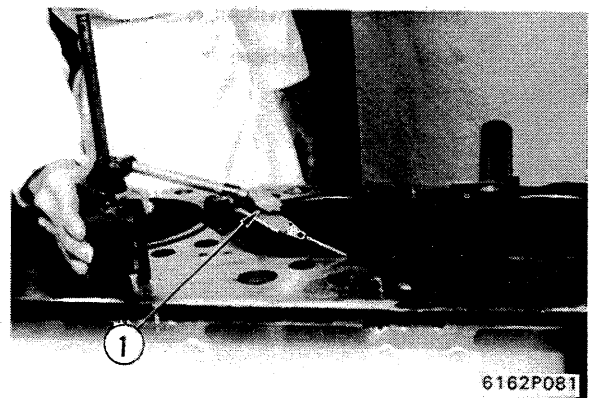
6162F306

★ Method of inserting the cylinder liner:

- 1) Apply engine oil CLASS CD SAE30 to the O-ring grooves of cylinder block and O-ring.
- 2) With the "T" stamped on the upper surface of the liner facing forward, insert the liner into the cylinder block, taking care not to damage the O-ring.
- 3) Push in the liner with your weight.
  - ★ If the liner cannot be inserted smoothly when pushed hard, the O-ring may be damaged. Check the cylinder block for burrs and fins.
- 4) Force-fit cylinder liner (1) into the cylinder block using liner drive F.

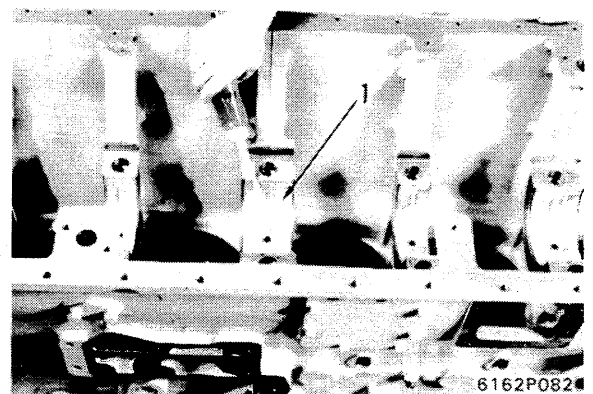


- 5) After force-fitting the cylinder liner, measure the amount of projection of the cylinder liner with dial gauge ①.
  - ★ When measuring the amount of projection of the cylinder liner, press the liner firmly with the plate to protect it from being floated by the O-ring.
  - ★ Amount of projection of cylinder liner:  
0.07 to 0.15 mm

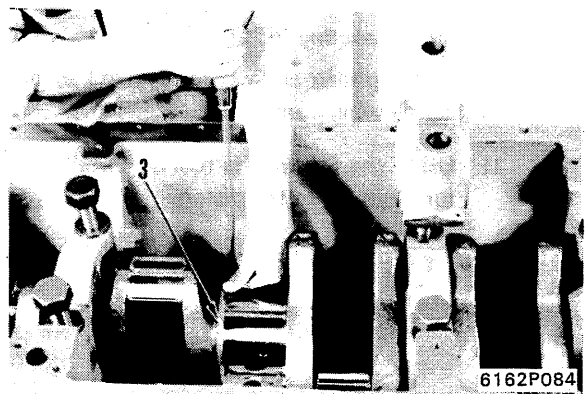
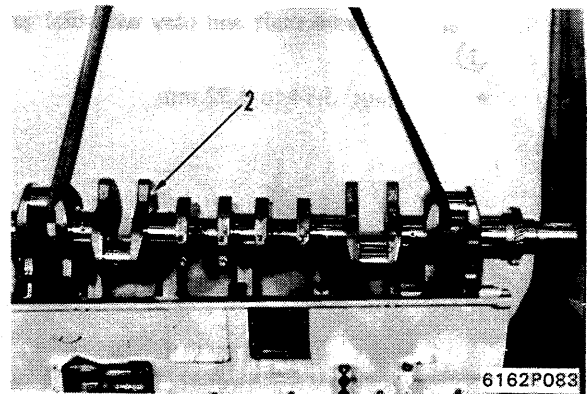



## 2. Crankshaft

- 1) Align the projection of upper bearing (1) with the notch on the cylinder block, and assemble them.
  - ★ Check the reverse side of the bearing for foreign matter and apply engine oil CLASS CD SAE30 to the inside face of the bearing.
  - ★ When replacing the crank gear, put the gear in an electric furnace or similar device and heat it at 200°C for about 30 minutes for shrink fitting.

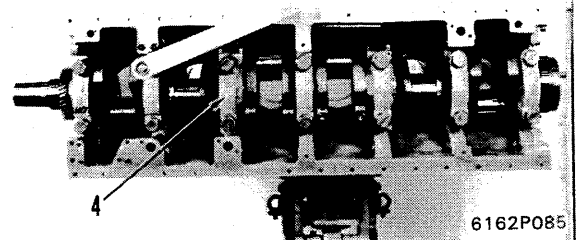


- 2) Hang crankshaft (2) and install it in place, taking care not to let it hit the cylinder block.
- 3) Install upper thrust bearing (3) with its oil groove outside to No. 6 cylinder journal.
- 4) Install the lower bearing, aligning its projection with the notch on the main bearing cap.
- 5) Apply engine oil CLASS CD SAE30 to the journal surface of the crankshaft, and install main bearing cap (4), confirming that the stamped No. on the main bearing cap is the same as the No. on the cylinder block.
- 6) Apply engine oil CLASS CD SAE30 to the threads of the mounting bolts and the washers, and tighten the bolts to secure the main bearing cap.
  - ★ Install the lower thrust bearing to No.6 main bearing cap with the oil groove outside.
- 7) Tighten the mounting bolts for the main bearing cap in the following order.
  - ★ First tighten the bolt at center, then tighten the bolts on the outside in order to the following torque.



 Main bearing cap mounting bolt  
kgm

Order	Target	Range
1st	56	51 to 61
2nd	113	107 to 118
3rd	0	Loosen completely
4th	38	33 to 43
5th	75	70 to 80
6th	113	107 to 118

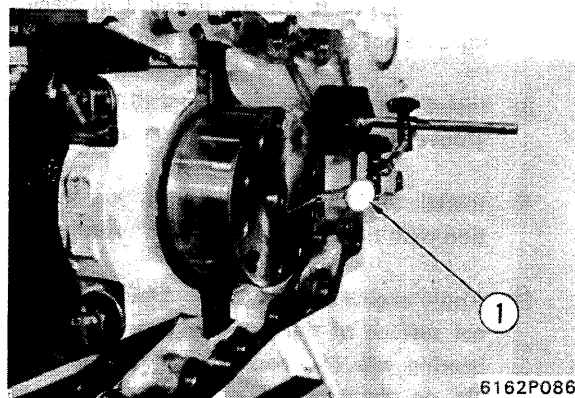


- 8) After tightening the bolts, measure the rotating force of the crankshaft.
  - ★ Standard value: 2.8 kgm or less



- 9) Check the crankshaft end play with dial gauge ①.

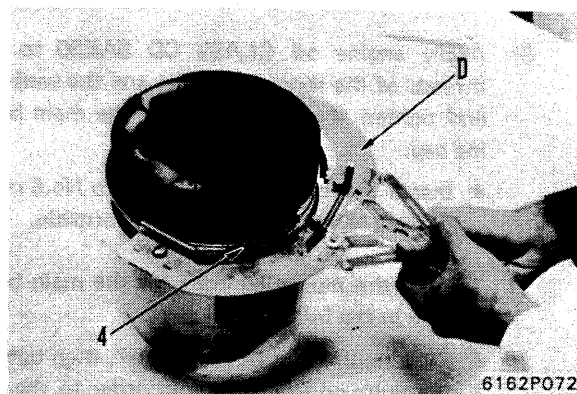
★ End play: 0.14 to 0.32 mm



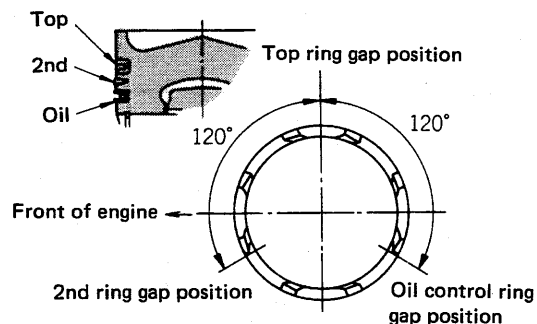
### 3. Piston and connecting rod assembly

- ★ Install the piston and connecting rod according to the following procedure.

- 1) Using the piston ring tool D, install the piston rings (4) to the piston.



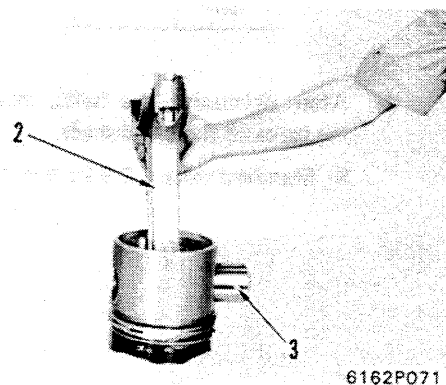
- ★ Install the piston rings as shown right.
- ★ Install each ring with the stamped mark up.
- ★ For the oil ring, take out the expander and install it to the piston, then install the oil ring. Confirm that the expander is properly fitted to the groove.



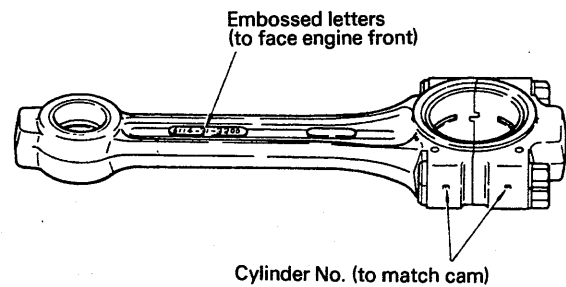
- 2) Set the piston and the connecting rod.

- ★ Match the cylinder No. on the piston head with the stamped No. on the connecting rod (2). With these Nos. in the same direction, insert piston pin (3) to assemble the connecting rod and the piston.

- ★ After assembling the piston and connecting rod, confirm that the snap ring which secures the piston pin is properly fitted to the groove.

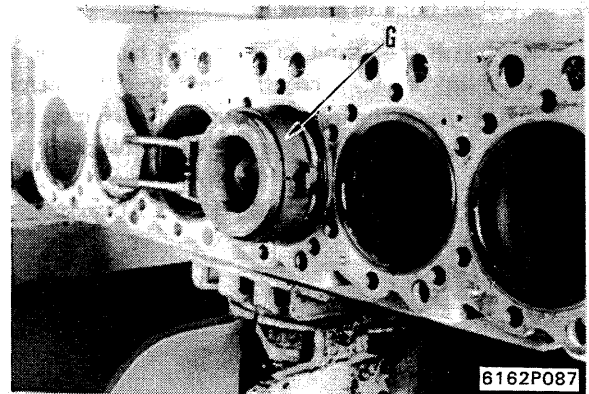


- 3) Install the upper bearing to the connecting rod after the projection of the upper bearing align with the notch on the connecting rod.
- 4) Set the crankshaft of the cylinder to be assembled to the bottom dead center, and apply engine oil CLASS CD SAE30 to the inside face of the connecting rod bearing and the cylinder.
- 5) With the embossed letters forward (with the stamped No. to the camshaft side), insert the piston and connecting rod into the cylinder from the head side.



6162F309

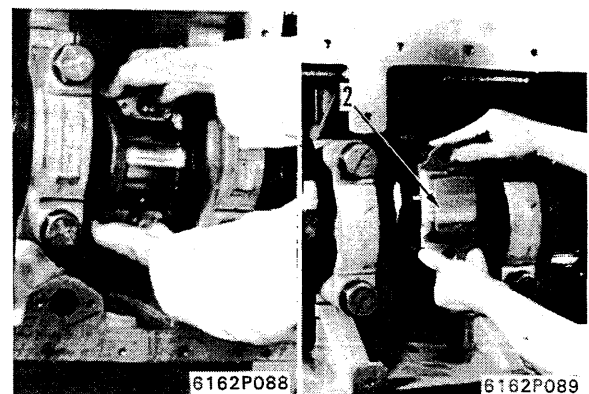
- 6) Using tool **G**, tighten the piston rings, and push it in the piston head with a wood bar.
- 7) Install the lower bearing onto the connecting rod cap with aligning the projection of bearing with the notch on the cap, and then install connecting rod cap (2) while matching the stamped letters on the connecting rod.
- 8) Apply engine oil CLASS CD SAE30 to the threads of the bolts and their seats and tighten them in the following order.



 Connecting rod bolt

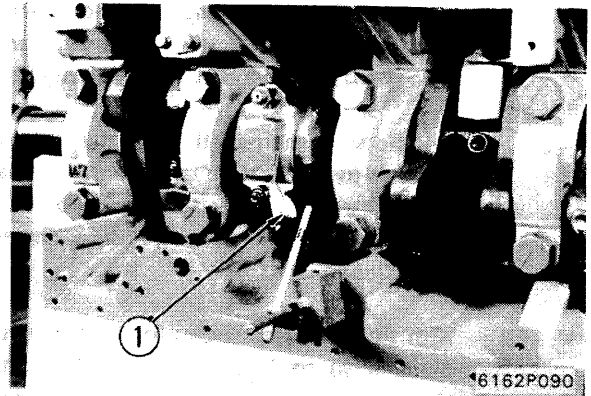
kgm

Order	Target	Range
1st	28	25 to 31
2nd	56	53 to 59
3rd	0	Loosen completely
4th	14	11 to 17
5th	28	25 to 31
6th	56	53 to 59



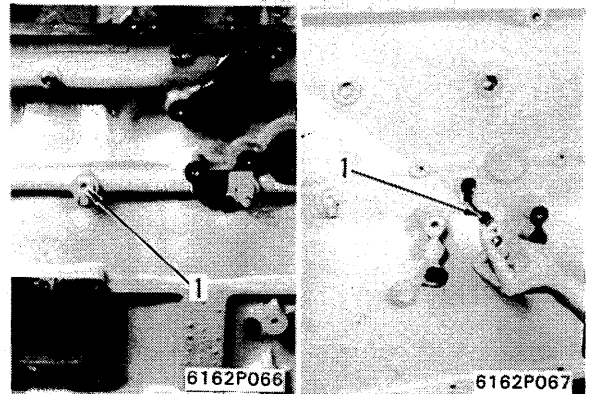
9) Measure the side clearance of the connecting rod with dial gauge ①.

- ★ Standard side clearance:  
0.200 to 0.375 mm
- ★ If the connecting rod cannot be moved, remove the connecting rod cap, and check for mismatching, caught burrs, and foreign matter, etc.



4. Piston cooling nozzle

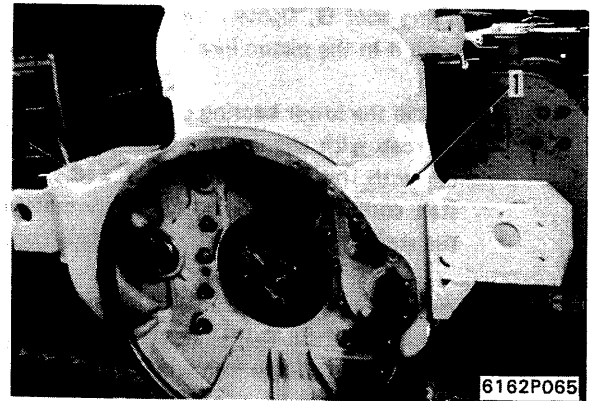
Install the O-rings, then install piston cooling nozzle (1).



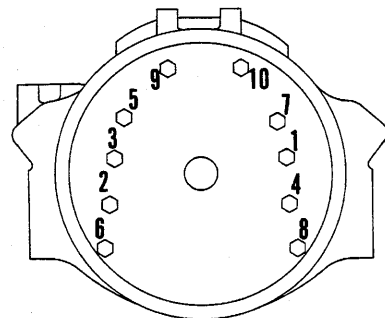
5. Flywheel housing assembly

1) Install the gasket to the fitting face of the cylinder block. Hang flywheel housing assembly (1) using the eyebolt (thread dia. 16 mm, pitch 2.0), and install it to the cylinder block.

 Mounting bolt: 42.0 ± 2.0 kgm



- ★ Tighten the mounting bolts for the flywheel housing in the following order. (See right fig.)
- ★ Note that the lengths of the bolts are different.



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- 2) Measure the face runout and radial runout of the flywheel housing.

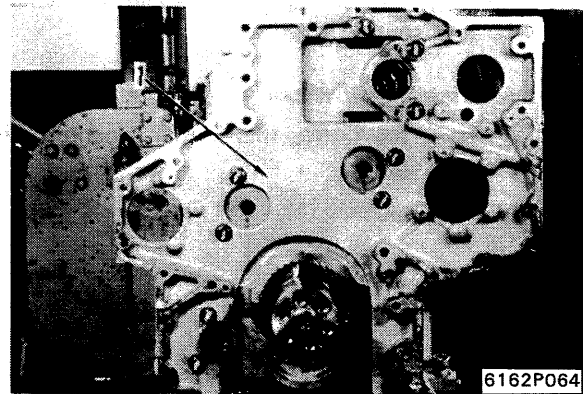
★ Face runout: 0.35 mm or less  
 Radial runout: 0.35 mm or less

- 3) Check the difference in level between the cylinder block and the flywheel housing.

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

#### 6. Gear case

- 1) Install the gasket to the fitting face of the gear case.
- 2) Install gear case (1).



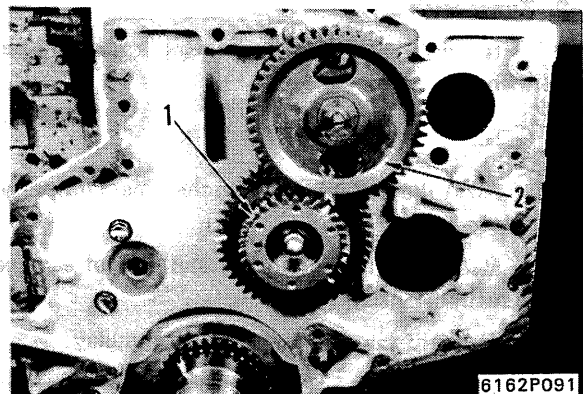
#### 7. Idler gear

- 1) Install idler gear (1).

 Idler gear mounting bolt:  $32.5 \pm 2.5$  kgm

★ Insert the thrust bearing with the oil groove to the gear side.

- 2) Press-fit the thrust plate to the idler shaft.

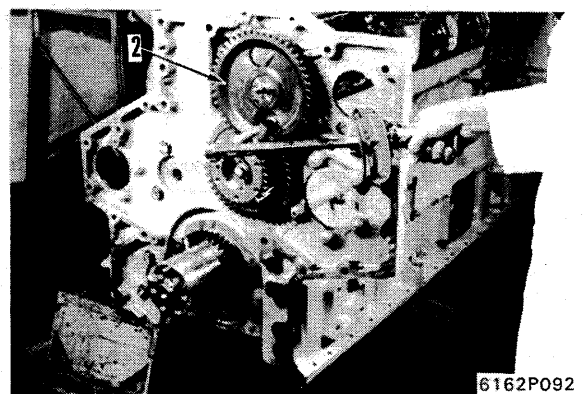


#### 8. Camshaft assembly

Apply engine oil CLASS CD SAE30 to the camshaft journal, and install camshaft assembly (2).

 Camshaft plate:  $3.5 \pm 0.5$  kgm

- ★ When installing the camshaft assembly, rotate it to protect the cam bushing from damage.
- ★ Match the match marks on the camshaft and the gear.
- ★ When replacing the cam gear, put it into an electric furnace or similar device and heat it at  $300^{\circ}\text{C}$  for 30 minutes for shrink fitting.

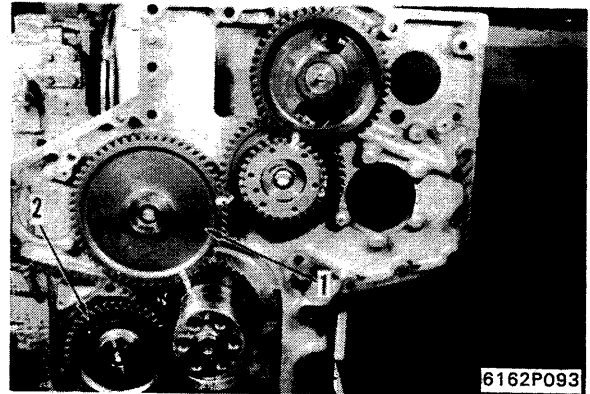


**9. Idler gear for oil pump**

Install idler gear (2) for oil pump.

 Idler gear mounting bolt:  $32.5 \pm 2.5$  kgm

★ Align the match marks on the idler gear and the gear surely.

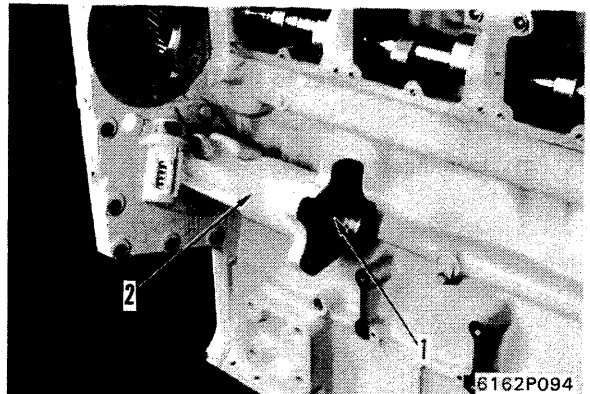


**10. Idler gear for water pump**

Install idler gear (1) for water pump.

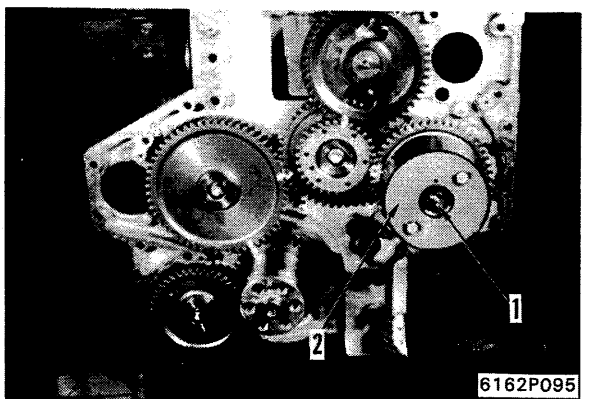
 Idler gear mounting bolt:  $32.5 \pm 2.5$  kgm

★ Align the match marks on the idler gear and the gear surely.




**11. Injection pump drive case**

- 1) Install the O-ring, then install injection pump drive case (2).
- 2) Install coupling (1).



**12. Timer assembly**

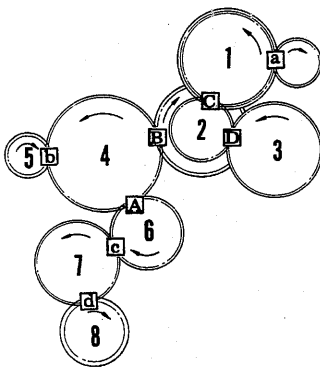
Install timer assembly (2) aligning it with the gear, then tighten nut (1).

 Timer nut:  $17.5 \pm 2.5$  kgm

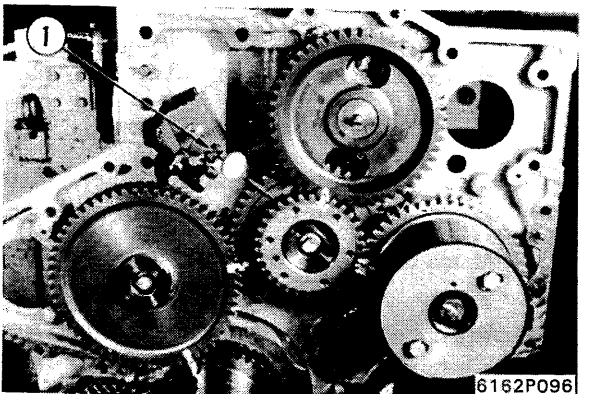
★ Align the match marks on the timer and the gear surely.

★ Measure the backlash and end play of each gear with dial gauge ①.

★ Standard value of backlash and end play:



	Backlash		End play
A	0.140 to 0.460	1	0.075 to 0.21
B	0.130 to 0.470	2	0.100 to 0.32
C	0.130 to 0.470	3	0.090 to 0.44
D	0.100 to 0.500	4	0.100 to 0.32
a		5	
b	0.095 to 0.460	6	0.140 to 0.32
c	0.120 to 0.425	7	0.100 to 0.32
d	0.100 to 0.445	8	0.070 to 0.125



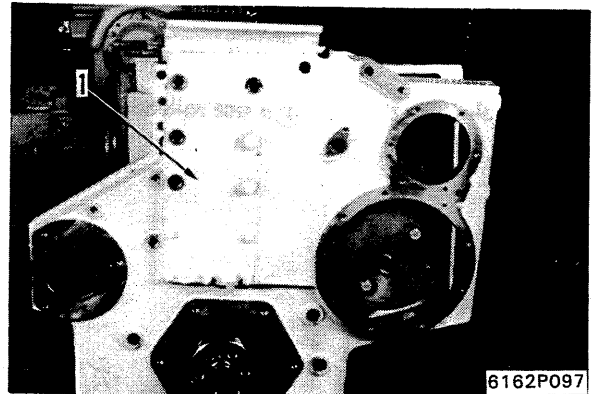
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6162P095

6162P096

**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

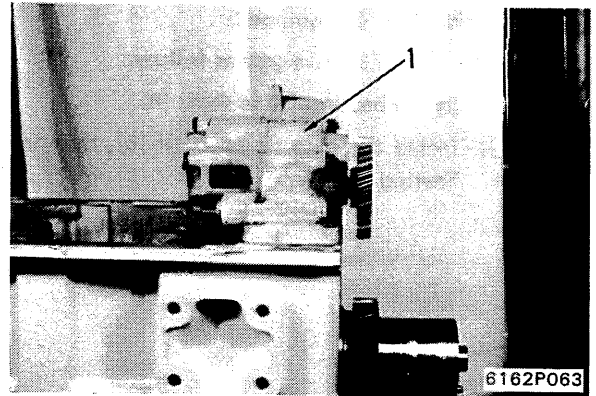


6162P097

**14. Oil pump**

Install oil pump (1).

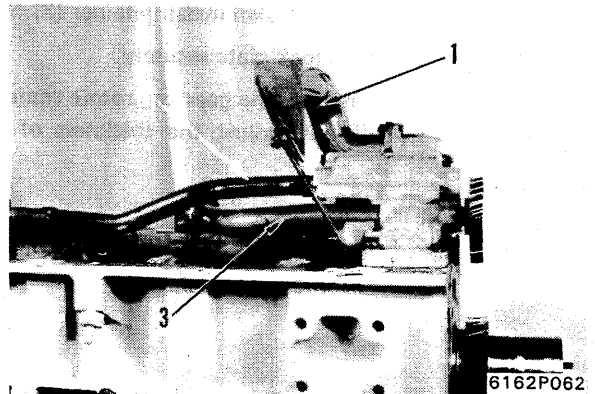
 Oil pump mounting bolt:  $11 \pm 1.5$  kgm



6162P063

**15. Piping for oil pump**

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



6162P062

**16. Strainer**

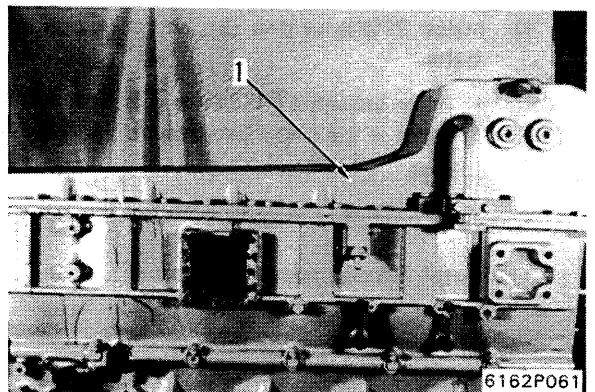
Install the gasket, then install strainer (1) and secure it with the bracket.

**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)

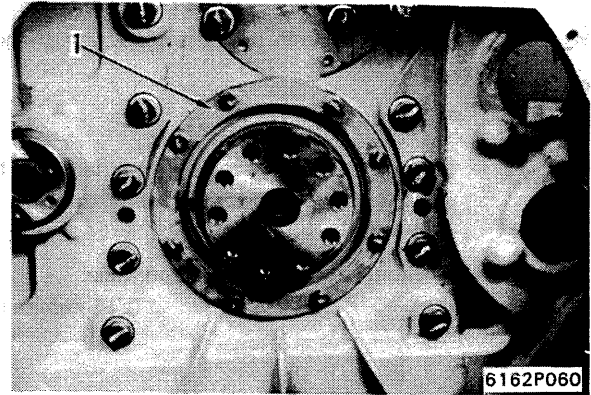


6162P061

**18. Rear seal cover**

Install the O-ring, then install rear seal cover (1).

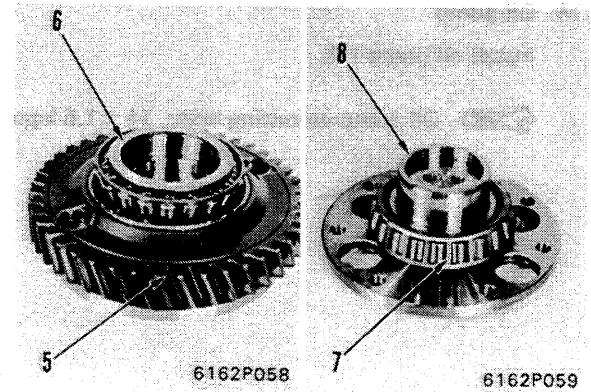
★ Take care that the lip is not rolled up.



**19. PTO drive gear (If equipped)**

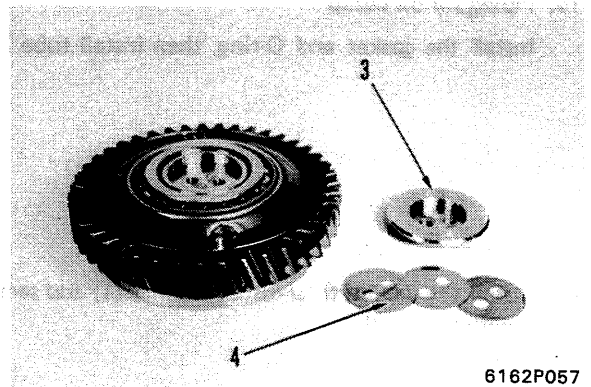
★ Assemble PTO drive gear as follows:

- i) Install bearing (7) to shaft (8).
- ii) Install the snap ring to gear (5), then install bearing (6).



- iii) Install shim (4), then install retainer (3).

- ★ Bend the lock plate securely.
- ★ Confirm that the gear can rotate smoothly. If not, adjust the thickness of the shim.



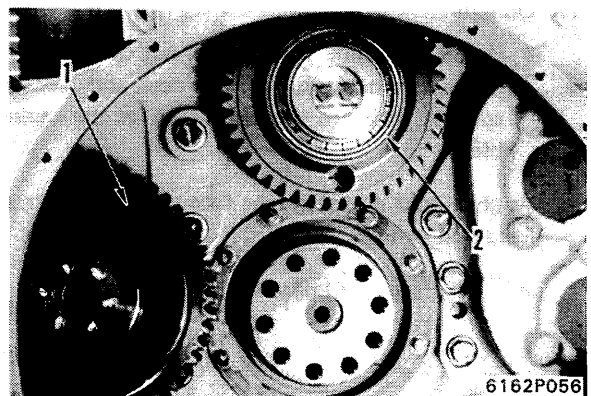
- 1) Install PTO drive gear (2), and then tighten six bolts.

★ After installing PTO drive gear, confirm that there is backlash between it and the PTO gear.

★ Backlash: 0.15 to 0.52 mm

- 2) Install steering pump drive gear (1).

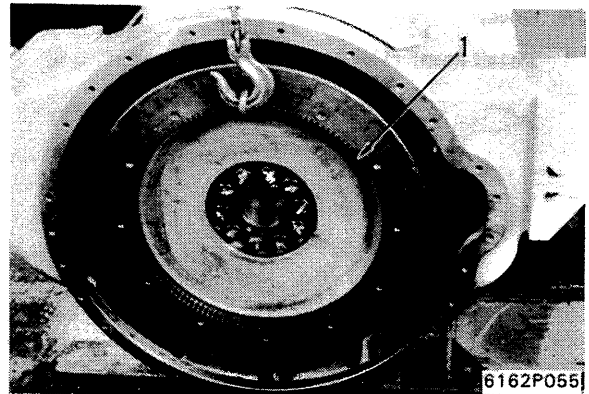
★ Bend the lock plate securely.



**20. Flywheel**


Using the eyebolt (Thread dia. = 12 mm, Pitch = 1.75 mm), hang flywheel (1) and install it.

 Flywheel mounting bolt:  $55 \pm 2$  kgm




**21. Cam follower assembly**

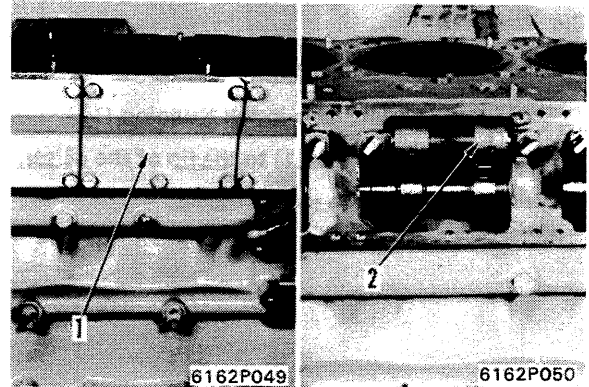
1) Install cam follower assembly (2), aligning it with the pin.

 Cam follower mounting bolt:  $10.0 \pm 0.5$  kgm

★ Before installing the cam follower assembly, wash the oil hole of the mounting bolt.

2) Install cover (1).

 Face of cover: Liquid gasket (LG-7)

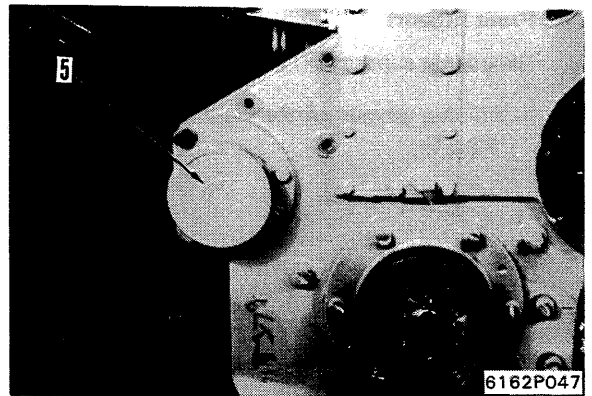


**22. Mechanical pump assembly**

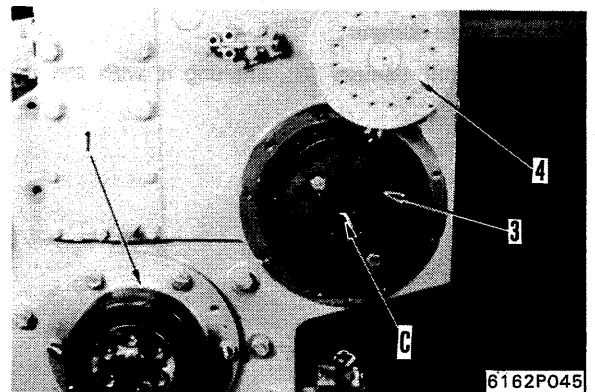
Install the O-ring to the mechanical pump assembly, and install them in alignment with the slit at the end of the camshaft.

**23. Accessory pulley**

1) Install the O-ring, then install pulley (5) for the alternator.




2) Install the O-ring, then install accessory pulley (4).

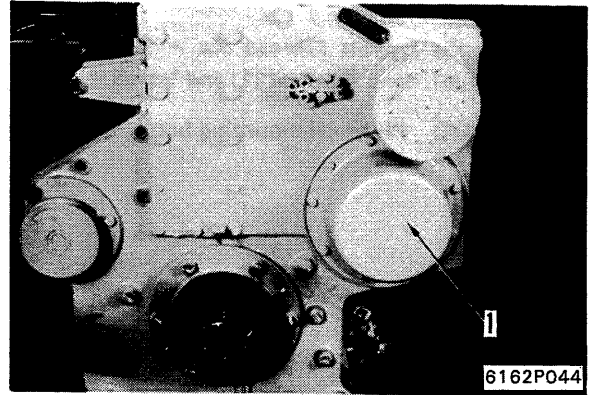




**24. Cover**

Install cover (1).

 Face of cover: Liquid gasket (LG-7)



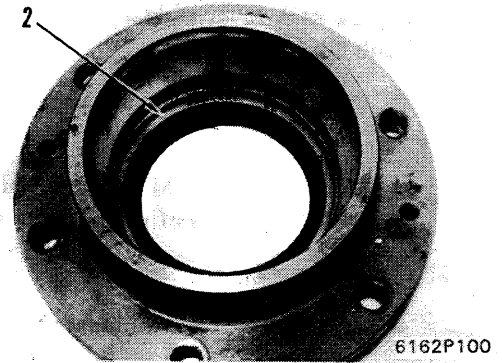
**25. Trunnion**

★ Using the press-fit kit, install oil seal (2).

Install the O-ring, then install trunnion (1).

★ Apply grease (G2-L1) to the lip of the oil seal.

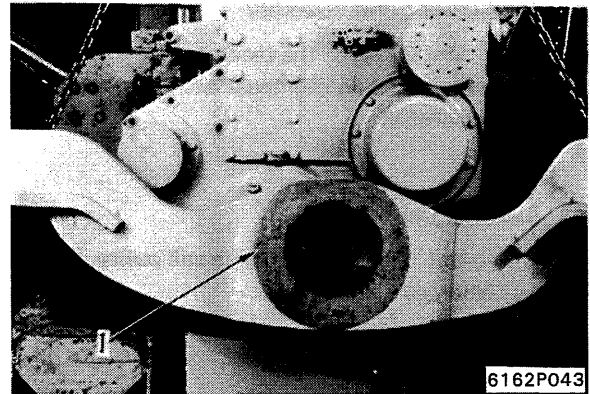
★ Take care not to roll up the lip.



**26. Front support**

Hang front support (1) and install it.

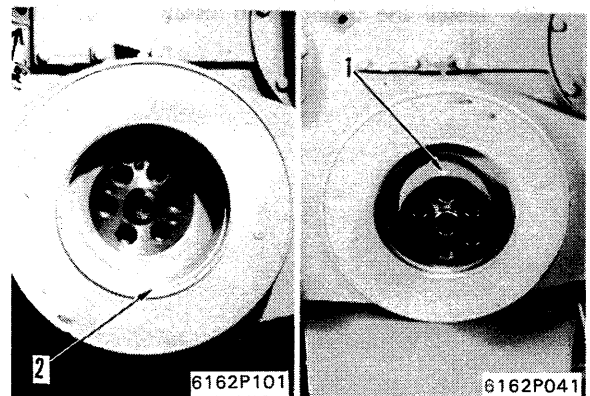
★ Fill the groove of the front support with grease (G2-L1).



**27. Vibration damper**


1) Install damper (2), aligning it with the dowel pin.

2) Install spacer (1).

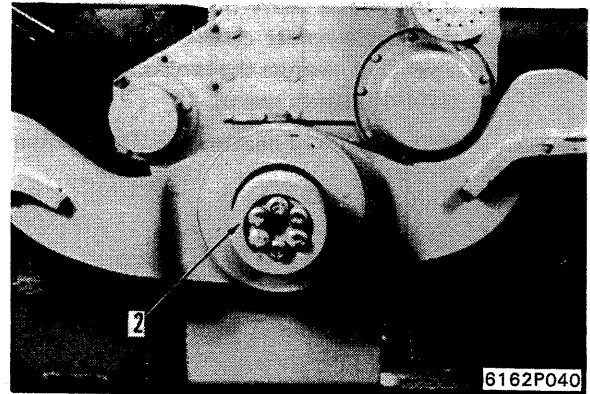


**28. Crank pulley**

- 1) Install crank pulley (2).

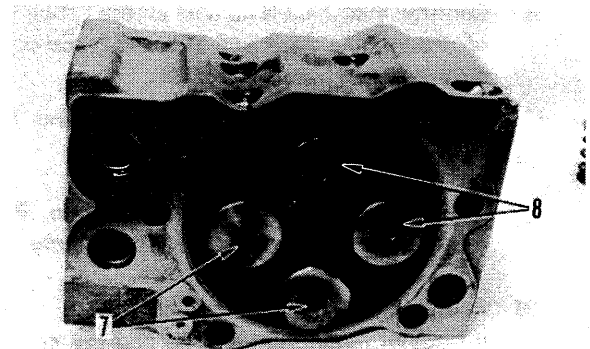
 Crank pulley mounting bolt:  
38 ± 2 kgm

- 2) Install the gasket, and then install lubrication pipe.

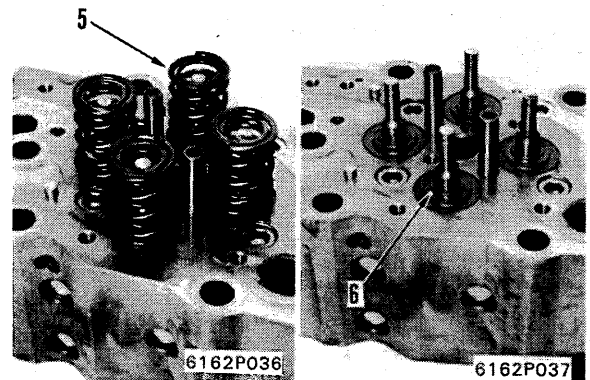
**29. Cylinder head assembly**

- ★ Assemble the cylinder head according to the following procedure.

- i) Apply engine oil CLASS CD SAE30 to the stems of the intake and exhaust valves and the inside face of the valve guides. Then install intake valve (7) and exhaust valve (8).

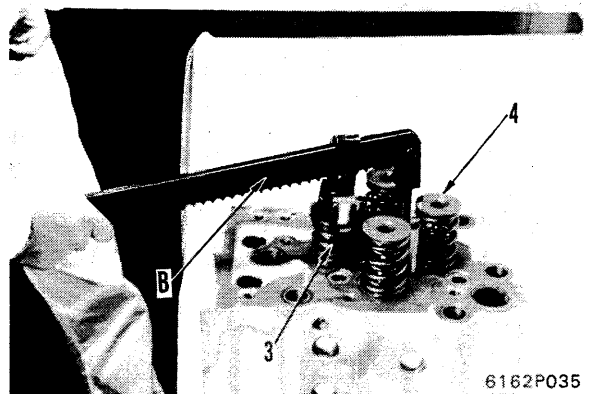


- ii) Set the cylinder head upright, and install lower seat (6).
- iii) Install valve spring (5) and retainer (4).



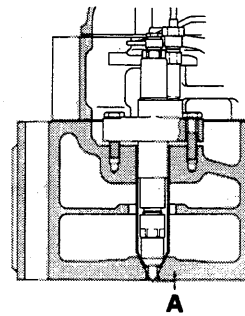
- iv) Shorten spring (3) with spring compressor B, and fit cotters to the grooves of the valve stems.

- ★ Confirm that the cotters are properly fitted to the grooves of the valve stems by hitting the valve stems lightly with a plastic hammer.



- v) If the nozzle sleeve is being replaced, install the nozzle holder assembly to the cylinder head, and measure the projection of the nozzle with a depth gauge.

★ Projection of nozzle A: 4.9 to 5.7 mm



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- 1) Confirm that there is no dust on the fitting face of the cylinder head and the inside face of the cylinder, then install gasket (9).

★ When installing the gasket, confirm that grommet (10) is installed securely.

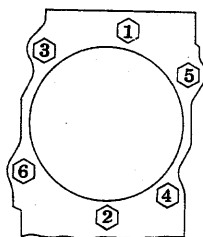
- 2) Using eyebolt ① (Thread dia. = 12 mm, Pitch = 1.75 mm), install cylinder head assembly.

- 3) Apply anti-friction compound (LM-P) to the threads of mounting bolts (1) and the washers, and tighten them.

★ Tighten the mounting bolts 2 to 3 turns with your fingers, then tighten them to the following torque in the order shown.

kgm Cylinder head bolt: kgm

Order	Target	Range
1st	8	6.5 to 9.5
2nd	23.5	22 to 25
3rd	39	37.5 to 40.5
4th	50.5	49 to 52



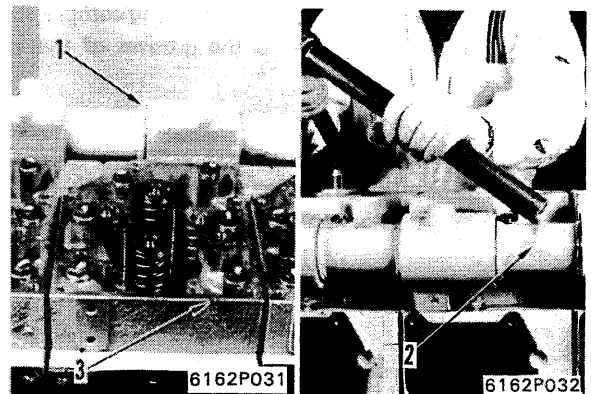
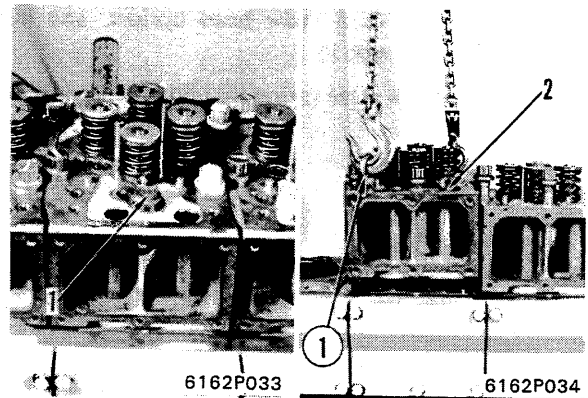
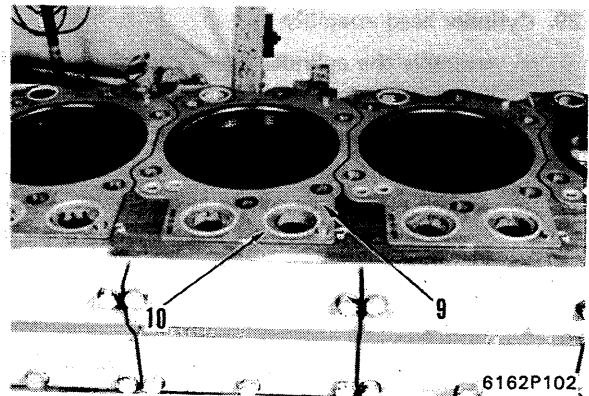
6162F311

30. Rocker arm housing

- 1) Install the gasket, then install rocker housing (3).

kgm Set bolt: 10.0 ± 0.5 kgm

- 2) Install O-ring to the pipe, and hit pipe (2) with a bar to slide it. Then secure it with pin (1).




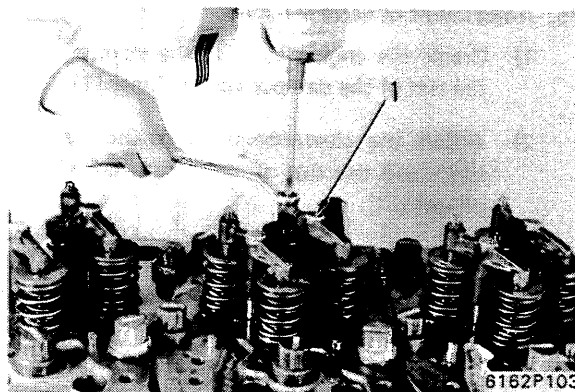
**31. Crosshead assembly**

Install crosshead.

★ Adjust the crosshead (1) according to the following procedure.

- i) Loosen the locknut, and return the adjustment screw.
- ii) Press the top of the crosshead lightly with your fingers, and tighten the adjustment screw.
- iii) Tighten 20 degrees further after the adjustment screw contacts the valve stem.
- iv) Tighten the locknut at this point.

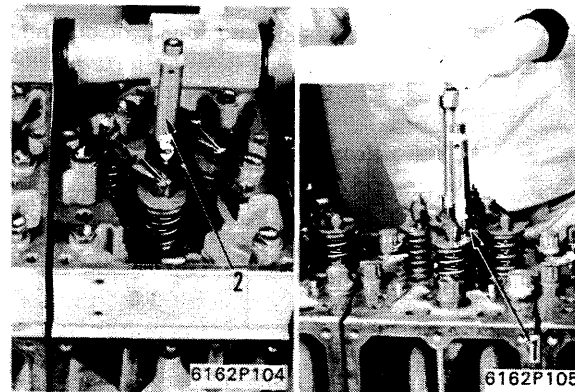
 kgm Locknut:  $4.0 \pm 0.5$  kgm

**32. Nozzle holder**

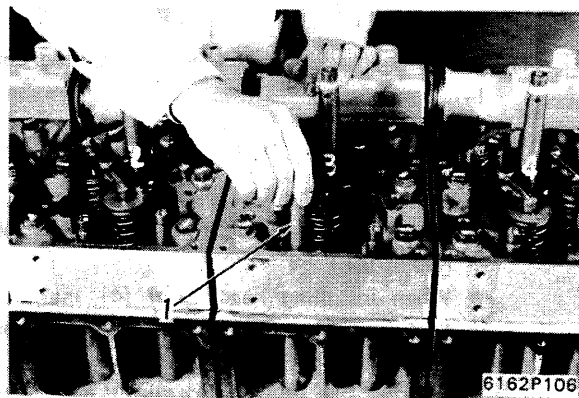
★ Confirm that there is no dust in the nozzle holder sleeve. Install nozzle holder (2), and tighten bolts (1).

★ Tighten the bolts alternately and evenly.

 kgm Mounting bolt:  $2.75 \pm 0.25$  kgm

**33. Push rod**


Install push rod (1).

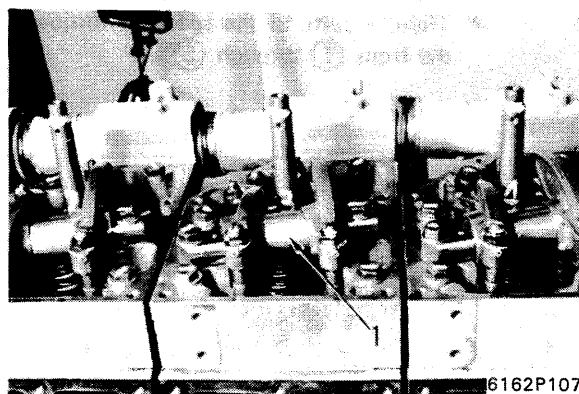
**34. Rocker arm assembly**

Install the gasket, then install rocker arm assembly (1).

★ Confirm that the ball of the adjustment screw is fitted to the socket of the push rod, and tighten the bolt.

★ Before installing the bolt, wash its oil hole of bolt.

 kgm Mounting bolt:  $10.0 \pm 0.5$  kgm




**35. Adjustment of valve clearance**

- 1) Crank the engine to align the stamped line on the rim of the damper with pointer (1).
- 2) Adjust the clearance between the rocker arm lever and the top of the crosshead with filler gauge H.

★ Procedure for adjusting of valve clearance:

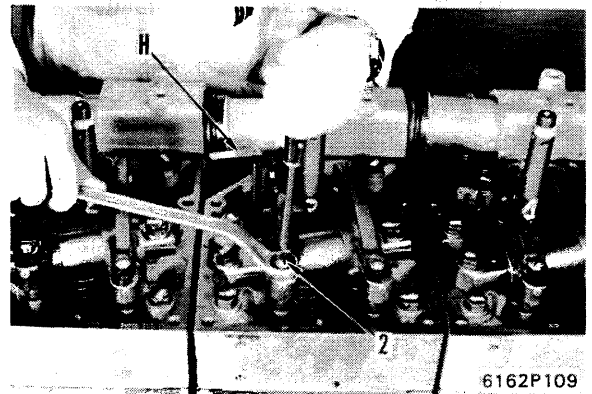
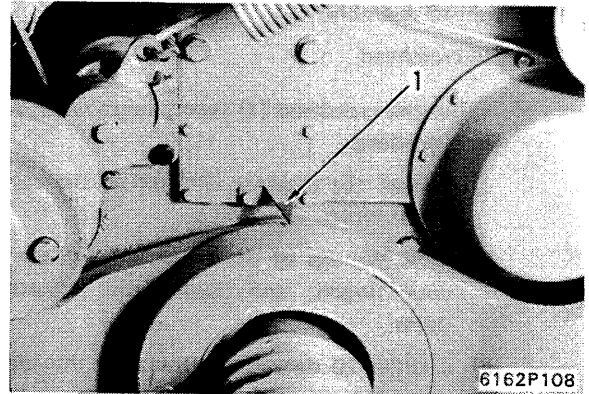
- i) Tighten adjustment screw (2) until filler gauge H barely moves.
- ii) Tighten the locknut at this point.

 Locknut:  $6.0 \pm 1.0$  kgm

★ Crank the engine and adjust the clearance of the valves in each cylinder in fire order 1-5-3-6-2-4.

★ Valve clearance standard value (at hot or cold)

mm	
Intake valve	Exhaust valve
0.4	1.0

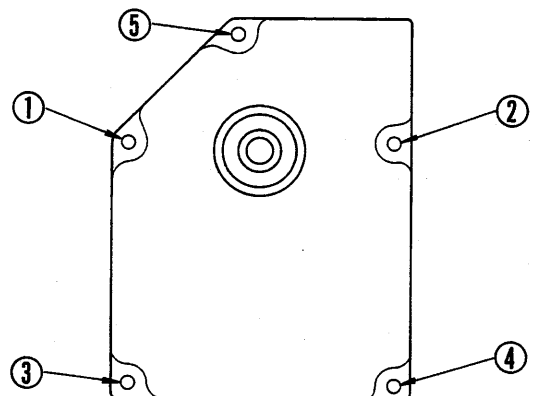
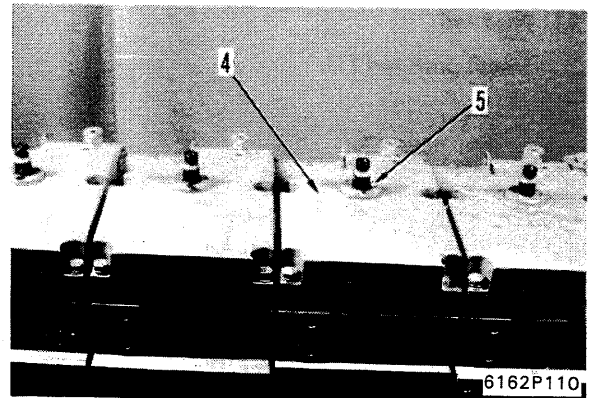


**36. Head cover and spill tube**

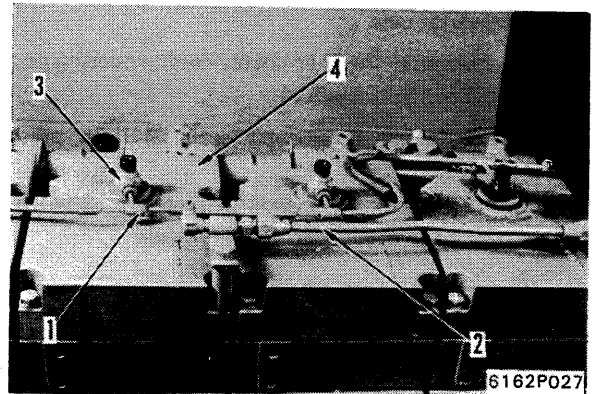
- 1) Install the gasket, and then install head cover (4).

 Mounting bolt:  $3.25 \pm 0.25$  kgm

- ★ Install new rubber gasket (5) to the head cover in advance. (Do not reuse old rubber gasket (5).)
- ★ When installing head cover (4), make sure that no excessive eccentric load is imposed and that all bolt holes are aligned.
- ★ Tighten five bolts uniformly in a criss-cross fashion by using a box and extension.
- ★ Tighten bolts to the specified torque in order from ① through ⑤.



- 2) Install connection (3).
- 3) Install turbocharger lubrication tube (2).
- 4) Install spill tube (1).

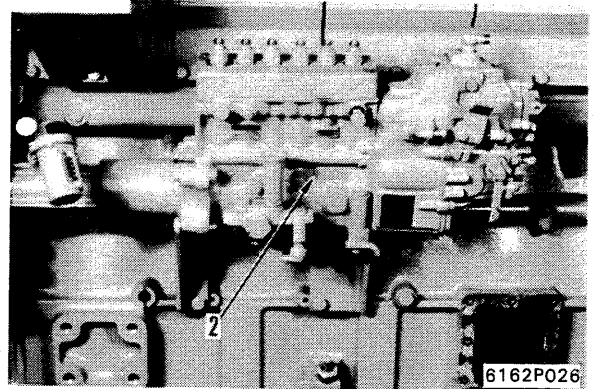


**37. Fuel injection pump**

- 1) Install fuel injection pump (2) aligning it with the spline of the coupling.


- ★ When installing the injection pump, align stamped line 'a' on the flange and line 'b' on the flange of the injection pump.
- ★ If the lines are not stamped or the injection pump is being replaced, adjust the injection timing by the "Delivery method."

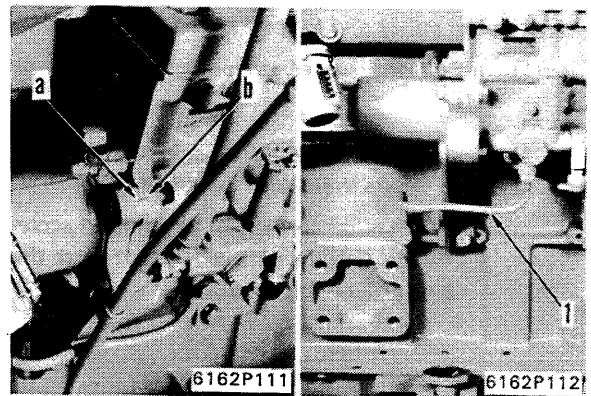
- 2) Install the gasket, then install lubrication tube (1).



**38. After-cooler and intake manifold assembly**


- 1) Install the gasket.
- 2) Install the gasket, then lift and install the after-cooler and intake manifold assembly (1) as a unit.


 Intake manifold mounting bolt:  
6.5 ± 1.0 kgm

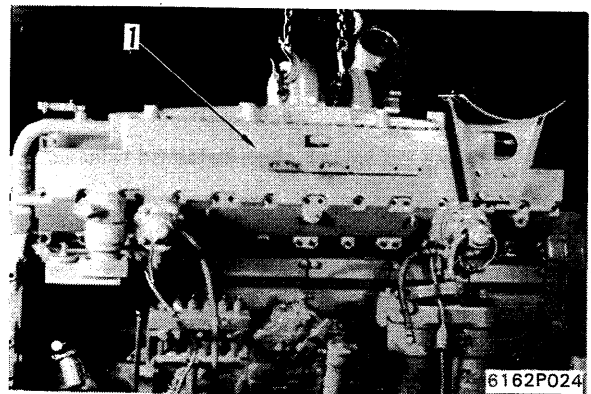


**39. Turbocharger and exhaust manifold assembly**

Install the gasket, then lift and install the turbocharger and exhaust manifold assembly as a unit.

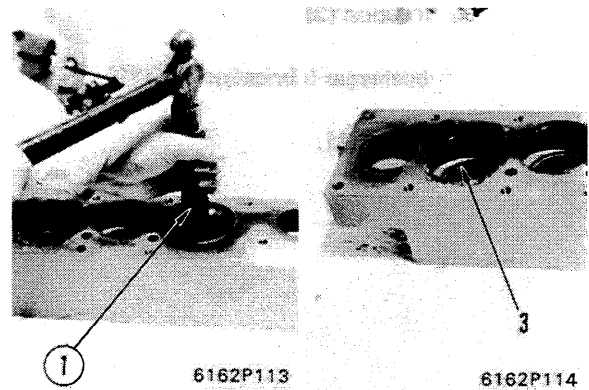
 Exhaust manifold mounting bolt:  
10.5 ± 1.0 kgm

 Exhaust manifold mounting bolt:  
Anti-seizing compound (EP-5)

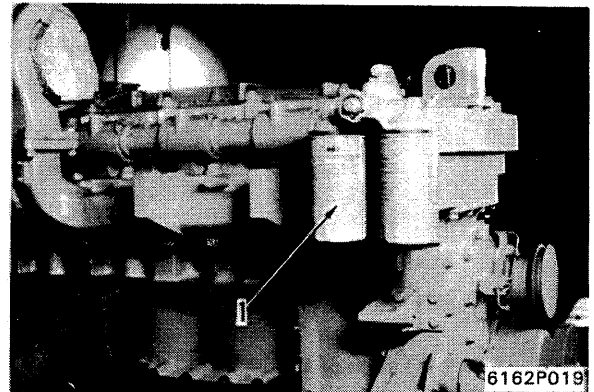


**40. Thermostat case**

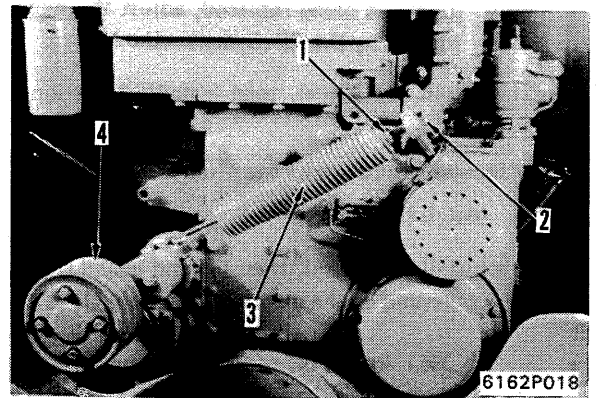
- 1) Assemble the thermostat case according to the following procedure.
  - i) Install thermostat seal (3) with press-fit kit (1).
  - ii) Install thermostat and gasket, then install the case cover.
- 2) Install thermostat case.

**41. Corrosion resistor**

Install corrosion resistor (1).

**42. Tension pulley and tension spring**

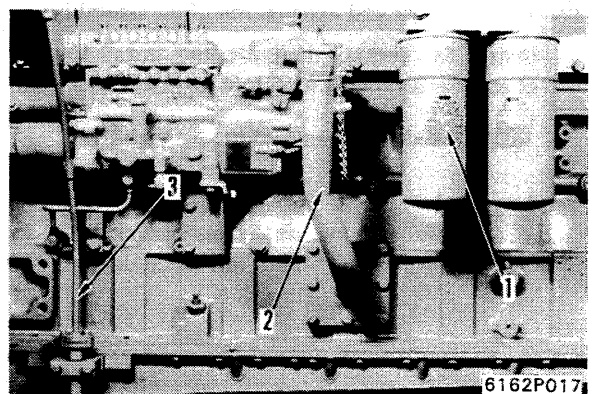
- 1) Install the spacer, then install tension pulley (4).
  - 2) Install tension spring (3) and tighten bolt (2), then secure them with locknut (1).
- ★ The tension spring will be adjusted according to the tension of the fan belt after the engine assembly is mounted.

**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).

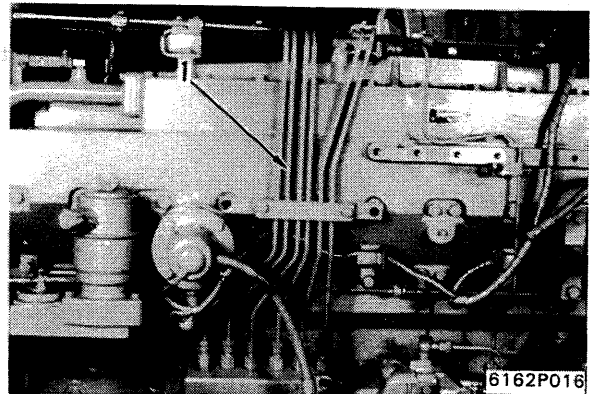


**45. Fuel injection tube**

Install fuel injection tube (1) and secure it with the clamp.

 Sleeve nut:

	Pump side	Nozzle side
PD type pump	2.25 ± 0.25	5.5 ± 0.5
ZW type pump	5.5 ± 0.5	5.5 ± 0.5



**46. After-cooler tube and oil filler tube**


- 1) Install lubrication tube for the turbocharger.
- 2) Install the O-ring and after-cooler tube, then secure them with the lockbolt.

**47. Fuel filter assembly**

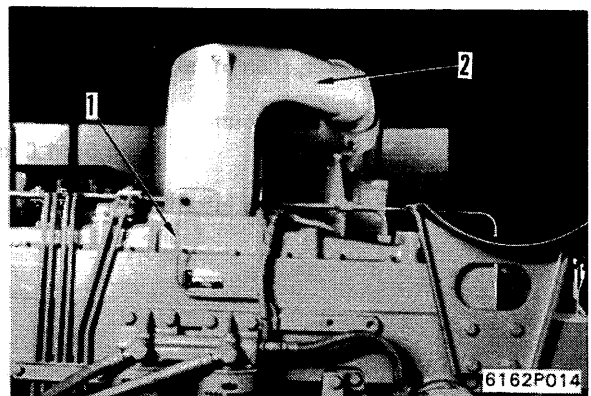
- 1) Install fuel filter assembly.
- 2) Install the gasket, and then connect fuel hoses.
- 3) Connect fuel hose for APS.

**48. Connector pipe**

- 1) Install the O-ring and gasket, install connector pipe (2), then secure it with the plate.


 O-ring: Grease (G2-L1)

- 2) Install the gasket, then install tube (1) for boost compensator.

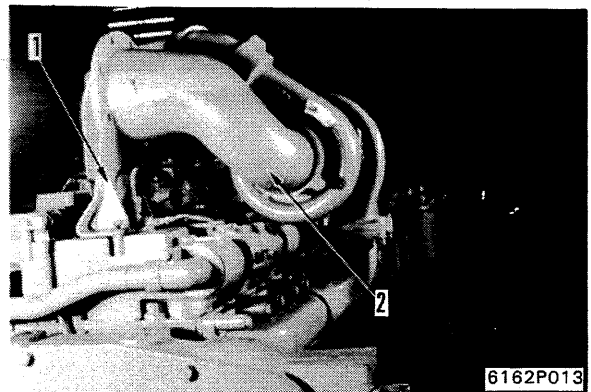


**49. Intake connector**

Install the O-ring, then install intake connector (2). Align the hole on it with the one on bracket (1).

 O-ring: Grease (G2-L1)

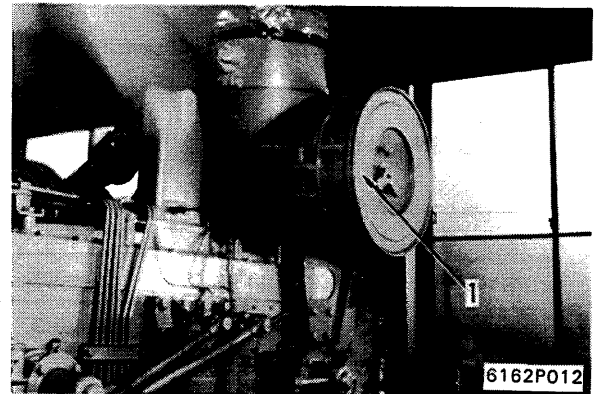
- ★ Insert a plain washer between the connector and the bracket.



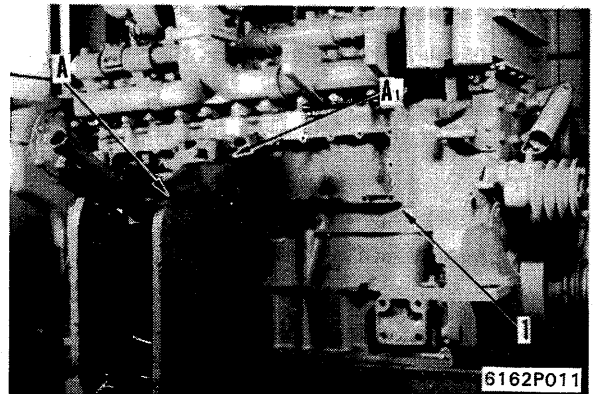


**50. Air cleaner assembly**

Install the gasket, then install air cleaner assembly (1) and secure it with the band.

**51. Setting off engine from engine stand**

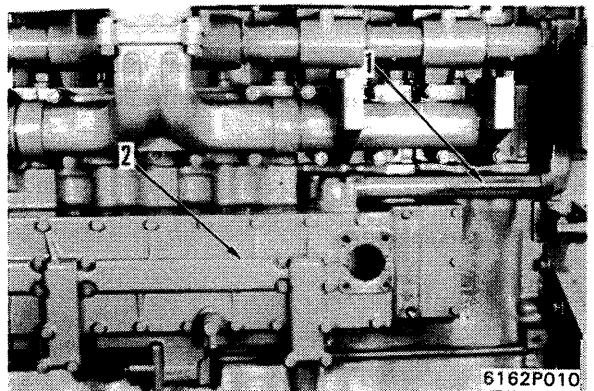
- 1) Lift the engine assembly and remove the mounting bolts to separate the engine assembly from engine repair stand A.
- 2) Remove the bracket for the engine repair stand.

**52. Oil cooler**

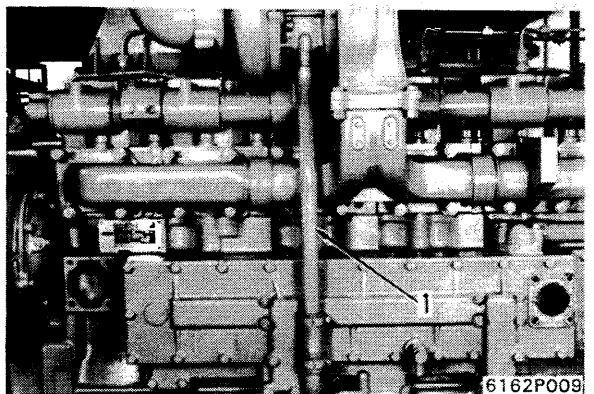
- 1) Install the gasket, then install oil cooler (2).

 Oil cooler mounting bolt:  
6.5 ± 1.0 kgm

- 2) Install the gasket, then install water pipe (1).

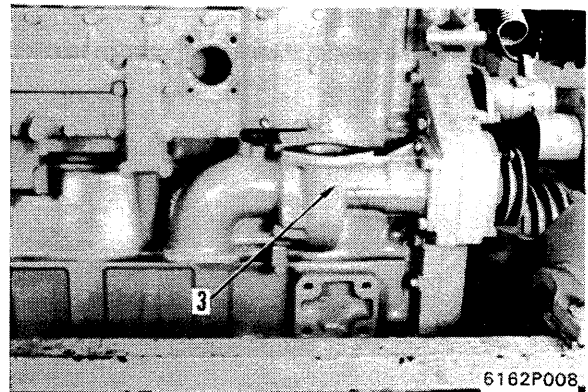
**53. Drain tube of turbocharger**

Install the gaskets to both end faces, then install drain tube (1) for the turbocharger.

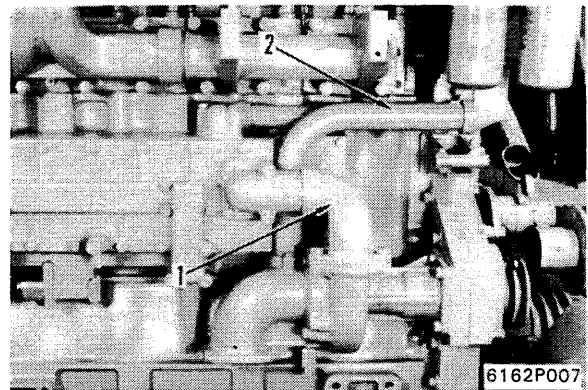


**54. Water pump assembly**

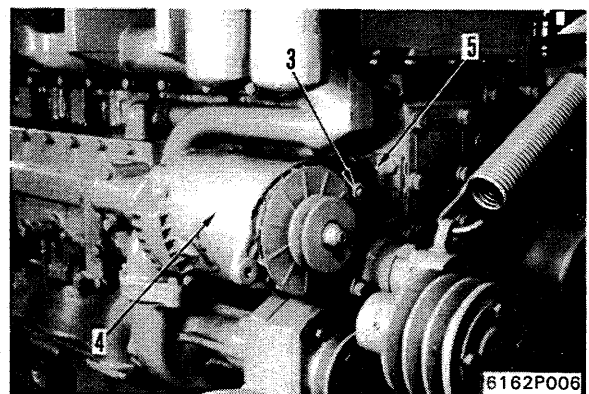
- 1) Install the drive shaft.
- 2) Install the gasket, then install water pump assembly (3), aligning it with the drive shaft.



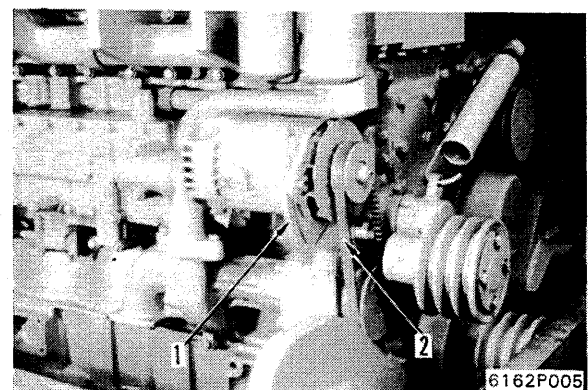
- 3) Install O-rings to both end faces. Install water pipe (2) and secure it with the plate.
- 4) Install O-rings and gaskets to both end surfaces, then install water pipe (1).

**55. Alternator**

- 1) Install bracket (5).
- 2) Install alternator (4) and temporarily tighten nut (3).

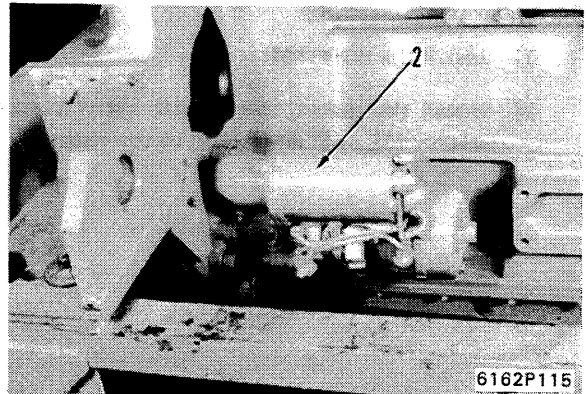


- 3) Fit belt (2) to the pulley, and tighten the mounting bolts for adjustment plate (1).
- 4) Raise the alternator assembly with a bar, and adjust so that the deflection of the belt is approx. 15 mm when pressing its center with 6 kg of force. Then tighten the bolt securely.

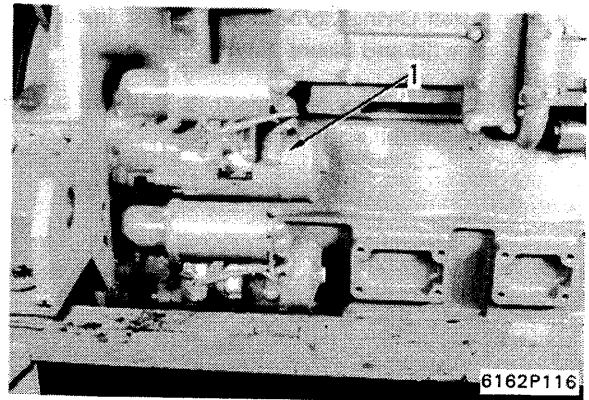


**56. Starting motor**

1) Install the gasket, then install starting motor (2).

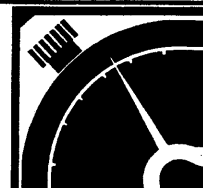


2) Install the gasket, then install starting motor assembly (1).



# ENGINE

## 14 MAINTENANCE STANDARD



### INTAKE AND EXHAUST SYSTEM

Turbocharger ..... 14- 2

### ENGINE BODY

Cylinder head ..... 14- 6

Valves and valve guide ..... 14- 7

Crosshead and crosshead guide ..... 14- 8

Push rod and cam follower ..... 14- 9

Cylinder block ..... 14-10

Cylinder liner ..... 14-12

Crankshaft ..... 14-13

Camshaft ..... 14-14

Timing gear ..... 14-15

Piston, piston ring and piston pin ..... 14-16

Connecting rod ..... 14-17

### LUBRICATION SYSTEM

Oil pump ..... 14-18

Oil pump relief valve, piston cooling  
valve and oil cooler by-pass valve ..... 14-19

### ACCESSORY

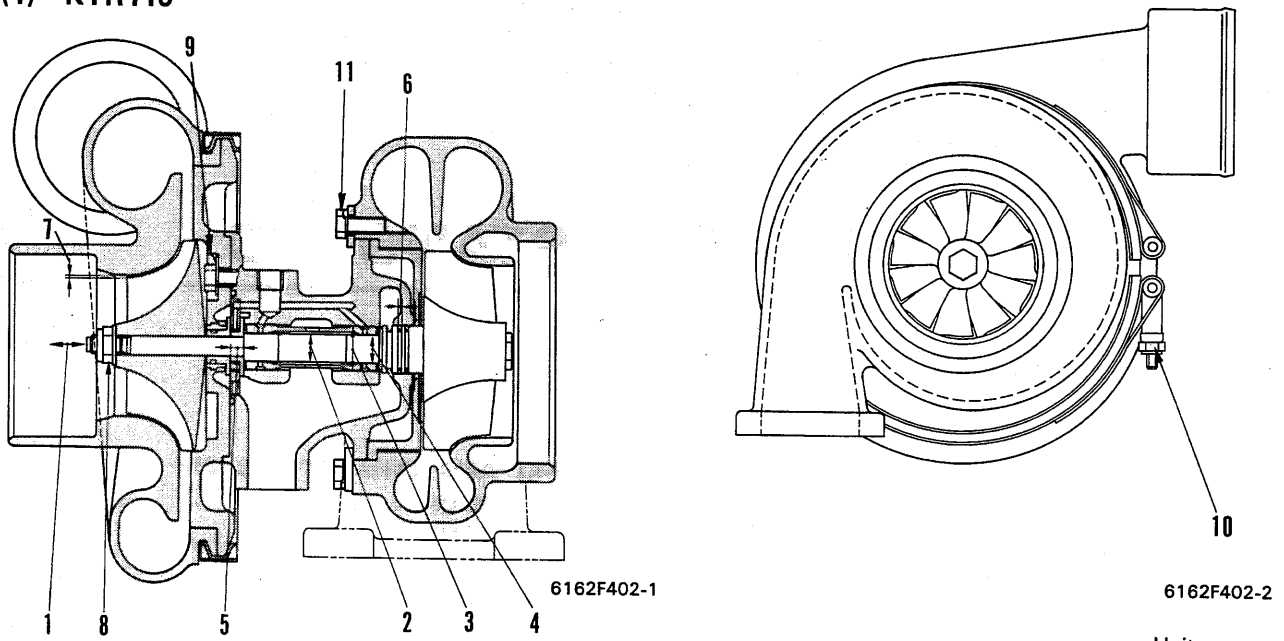
Air compressor ..... 14-20

### COOLING SYSTEM

Water pump ..... 14-22

# TURBOCHARGER

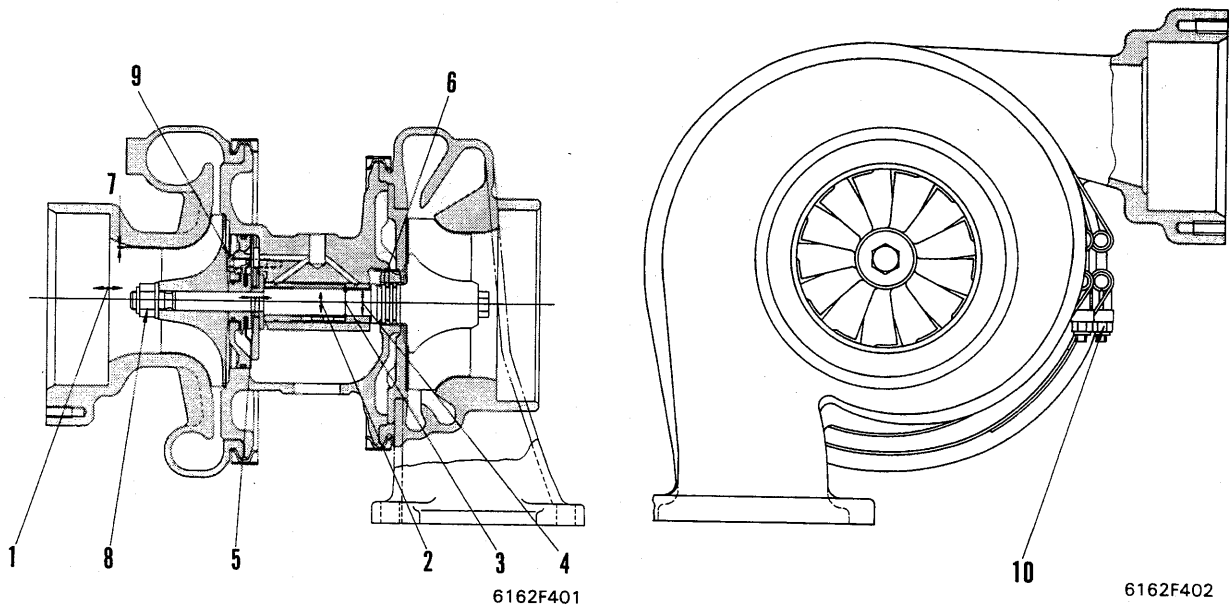
(1) KTR110



Unit: mm

No.	Check item	Criteria				Remedy	
		Standard		Repair limit			
1	End play	0.08 to 0.13		0.18		Replace parts	
		Standard		Repair limit			
2	Radial play	0.25 to 0.44		0.60		Replace parts	
3	Outside diameter of journal bearing. Inner diameter of center housing.	Standard size	Tolerance		Repair limit		Replace
			Shaft	Hole	Shaft	Hole	
4	Inner diameter of journal bearing. Outside diameter of wheel shaft.	23	-0.040	+0.021	22.92	23.03	
			-0.057	0			
4	Bend of wheel shaft	15	-0.032	+0.009	14.95	15.04	
			-0.043	-0.003			
		Repair limit: 0.010 (Total indicated runout)					
5	Thickness of thrust bearing	Standard size	Tolerance		Repair limit		
			Width	Groove	Width	Groove	
6	Thickness of seal ring	2	-0.08	-0.03	1.85	2.05	
			-0.10	-0.04			
6	Blower side	1.6	-0.08	-0.03	1.45	1.65	
			-0.10	-0.04			
7	Clearance between blower housing and impeller	Tolerance: (Min.) 0.20				Replace parts	
8	Tightening torque of blower impeller locknut	2.9 ± 0.3 kgm				Tighten	
9	Tightening torque of diffuser plate mounting bolt	3.15 ± 0.35 kgm					
10	Tightening torque of V band locknut	0.9 ± 0.1 kgm					
11	Tightening torque of turbine housing mounting bolt	6.75 ± 0.75 kgm					

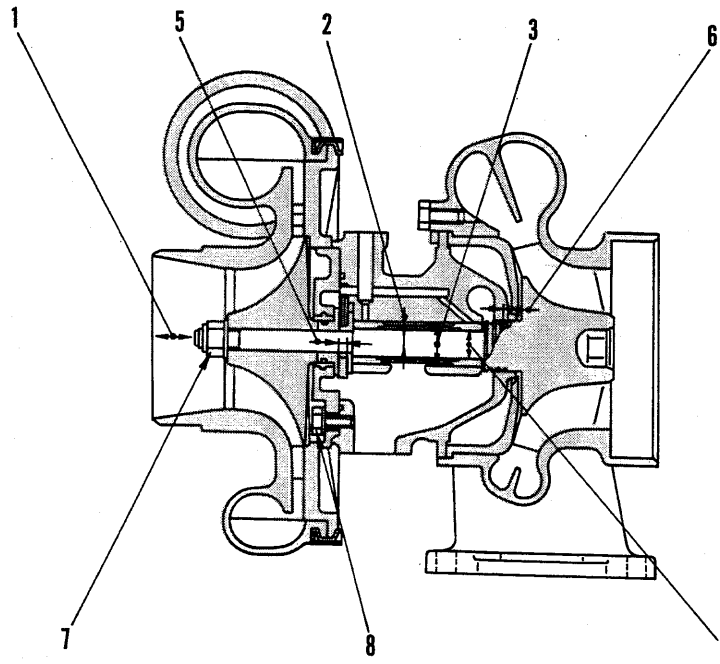
(2) KTR130



6162F402  
Unit: mm

No.	Check item	Criteria				Remedy	
		Standard		Repair limit			
1	End play	0.08 to 0.13		0.18		Replace parts	
		Standard		Repair limit			
2	Radial play	0.25 to 0.43		0.60		Replace parts	
3	Outside diameter of journal bearing. Inner diameter of center housing.	Standard size	Tolerance		Repair limit		Replace
			Shaft	Hole	Shaft	Hole	
4	Inner diameter of journal bearing. Outside diameter of wheel shaft.	20	-0.030	+0.015	19.95	20.05	
			-0.045	0			
	Bend of wheel shaft	Repair limit: 0.010 (Total indicated runout)					
5	Thickness of thrust bearing	Standard size	Tolerance		Repair limit		
			Width	Groove	Width	Groove	
6	Thickness of seal ring	3	-0.08	-0.03	2.85	3.05	
			-0.11	-0.04			
7	Clearance between blower housing and impeller	Tolerance: (min.) 0.20				Replace parts	
8	Tightening torque of blower impeller locknut	8.5 ± 0.5 kgm				Tighten	
9	Tightening torque of insert bolt	1.35 ± 0.15 kgm					
10	Tightening torque of V band locknut	0.9 ± 0.1 kgm					

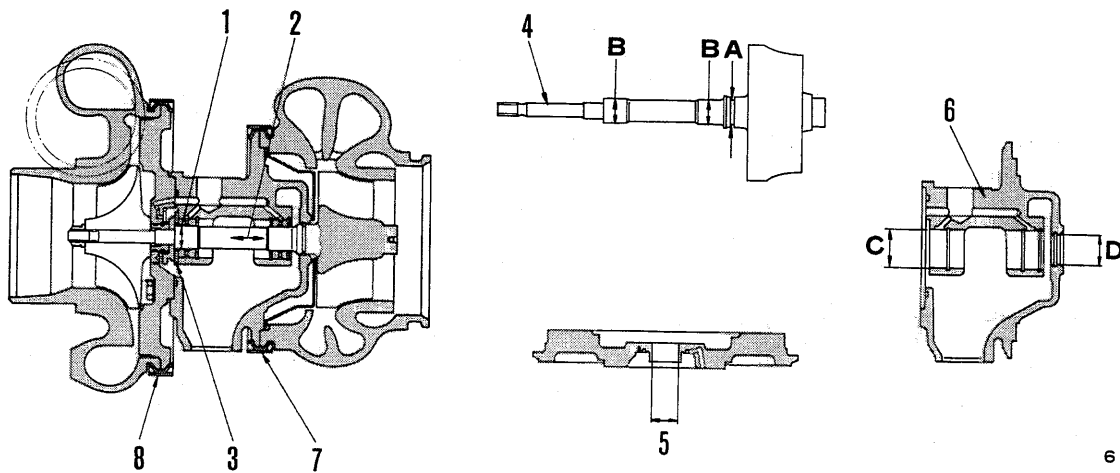
(3) KTR150



Unit: mm

No.	Check item	Criteria				Remedy	
		Standard		Repair limit			
1	End play	0.08 to 0.13		0.18		Replace parts	
		Standard		Repair limit			
2	Radial play	0.25 to 0.43		0.60		Replace parts	
3	Outside diameter of journal bearing. Inner diameter of center housing.	Standard size	Tolerance		Repair limit		Replace
			Shaft	Hole	Shaft	Hole	
4	Inner diameter of journal bearing. Outside diameter of wheel shaft.	20	-0.030	+0.015	19.95	20.05	
			-0.045	0			
Bend of wheel shaft		Repair limit: 0.010 (Total indicated runout)					
5	Thickness of thrust bearing	Standard size	Tolerance		Repair limit		
			Width	Groove	Width	Groove	
6	Thickness of seal ring	3	-0.08	-0.03	2.85	3.05	
			-0.11	-0.04			
7	Tightening torque of blower impeller locknut	9.5 ± 0.5 kgm				Tighten	
8	Tightening torque of insert bolt	6.75 ± 0.75 kgm					
9	Tightening torque of V band locknut	0.9 ± 0.1 kgm					

(4) TV7705



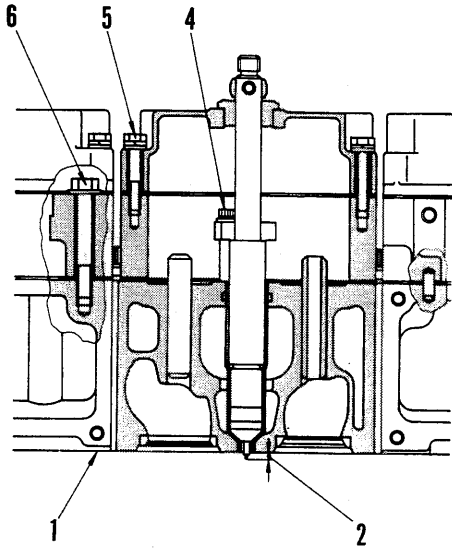
6150F401

Unit: mm

No.	Item	Criteria			Remedy
		Standard	Repair limit		
1	Radial play of rotor	0.080 – 0.150	0.180		Replace
		0.080 – 0.200	0.250		
2	End play of rotor	0.080 – 0.200	0.250		
3	Thickness of thrust bearing	2.315	2.290		
4	Outside diameter of wheel shaft	Measuring point	Standard	Repair limit	
		A	15.880	15.875	
	B	17.530	17.480		
	Bend of wheel shaft	Repair limit: 0.010 (Total indicated runout)			
5	Inside diameter of back plate	Standard	Repair limit		
		17.475	17.490		
6	Inside diameter of center housing	Measuring point	Standard	Repair limit	
		C	20.905	20.930	
		D	24.965	24.970	
7	Tightening torque of turbine housing bolt	Order	Target (kgm)	Range (kgm)	Retighten
		1st step	1.8	1.6 – 2.0	
		2nd step	0	Loosen completely	
		3rd step	1.4	1.27 – 1.50	
8	Tightening torque of blower housing bolt	Target (kgm)	Range (kgm)		
		14	1.27 – 1.50		

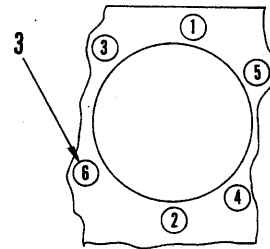


# CYLINDER HEAD

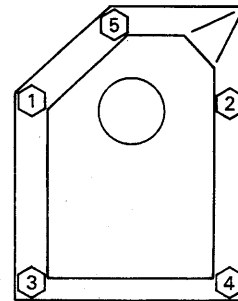


6162F403A

Tightening order of head mounting bolt



Tightening order of head cover mounting bolt

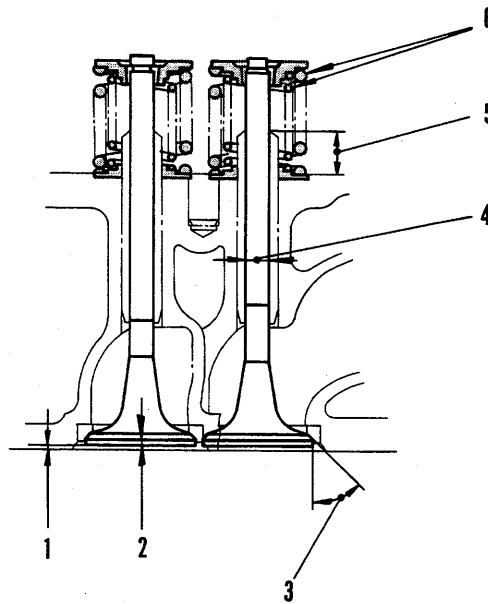


F617001057B

Unit: mm

No.	Check item	Criteria		Remedy	
		Tolerance	Repair limit		
1	Distortion of cylinder head mounting surface	Max. 0.05	0.1	Repair by grinding or replace	
2	Protrusions of nozzles	Standard: 4.9 to 5.7		Replace nozzle sleeves	
3	Tightening torque of cylinder head mounting bolts (Coat bolt threads and washer with anti-friction compound (LM-P))	Order	Target value (kgm)	Range (kgm)	Tighten in sequence as indicated above.
		1st	8.0	6.5 to 9.5	
		2nd	23.5	22.0 to 25.0	
		3rd	39.0	37.5 to 40.5	
4	Tightening torque of nozzle holder mounting bolt	Target value (kgm)	Range (kgm)		Retighten
		2.75	2.5 to 3.0		
5	Tightening torque of cylinder head cover	3.25	3.0 to 3.5		Retighten
6	Tightening torque of rocker arm housing mounting bolt	10	9.5 - 10.5		

VALVES AND VALVE GUIDE

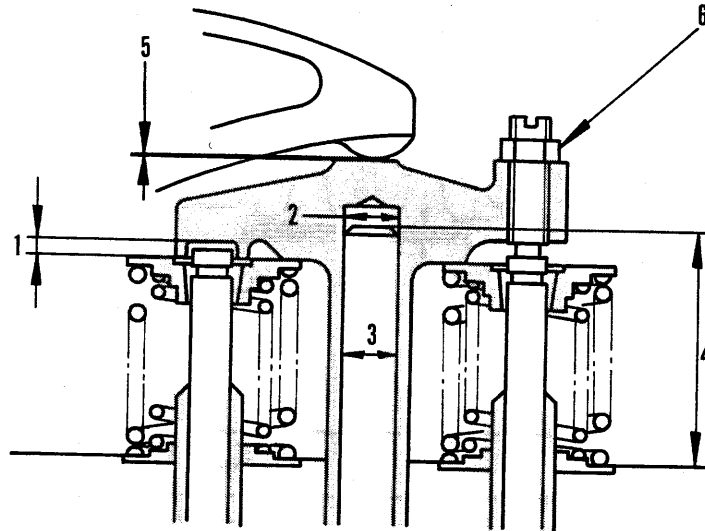


6162F404

Unit: mm

No.	Check item	Criteria				Remedy		
			Standard	Repair limit				
1	Amount of valve sinking	Intake valve	1.10 to 1.30	0.8		Replace valve or seat		
		Exhaust valve						
2	Valve head thickness		Standard size	Tolerance	Repair limit	Replace valve		
		Intake valve	3.4					
		Exhaust valve	3.5					
3	Valve seat angle		Standard	Tolerance				
		Intake valve	60°	±0°10'				
		Exhaust valve	45°	±0°10'				
4	Outside diameter of valve stem	Standard size	Tolerance	Repair limit		Replace		
	12	-0.060 -0.080	11.90					
	Inside diameter of valve guide	12	-0.005 -0.015	12.06				
5	Protrusion of valve guide	23.7	+0.2 -0.3	-				
6	Valve spring	• Valve	Free length	Installed length	Installed load	Load limit	Replace	
		Close	Inner	59.3	47.0	19.07 ± 1 kg		17.4 kg
			Outer	64.8	52.0	43.78 ± 2 kg		39.9 kg
		Open	Inner	59.3	32.5	41.55 ± 2 kg		37.8 kg
			Outer	64.8	37.5	93.23 ± 4.7 kg		84.8 kg
	Squareness of valve spring	Inner spring	Repair limit: 2°					
Outer spring								

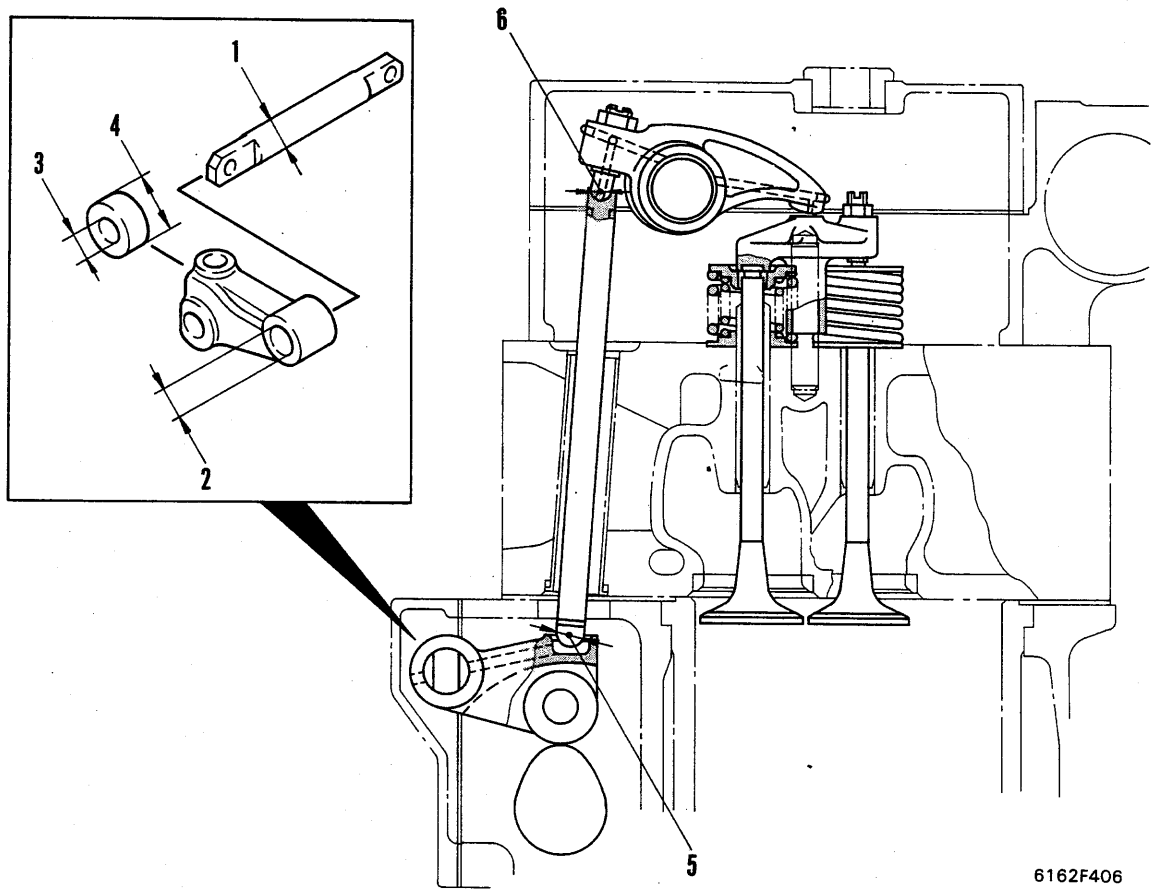
# CROSSHEAD AND CROSSHEAD GUIDE



6162F405

Unit: mm					
No.	check item	Criteria			Remedy
1	Depth of crosshead stem	Standard size	Tolerance	Repair limit	
		2.5	±0.1	—	
2	Inside diameter of crosshead	15	+0.10 +0.05	15.21	Replace
3	Outside diameter of crosshead guide	15	+0.040 +0.030	15.00	
	Clearance between crosshead guide and crosshead	Standard clearance		Clearance limit	Adjust
		0.010 to 0.070		0.02	
4	Protrusion of crosshead guide	Standard size	Tolerance	Repair limit	
		54	0 -0.3	—	
5	Valve clearance (at cold)	Intake valve		Exhaust valve	Replace
		0.4		1.0	
6	Tightening torque of crosshead locknut	4.0 ± 0.6 kgm			Tighten

PUSH ROD AND CAM FOLLOWER

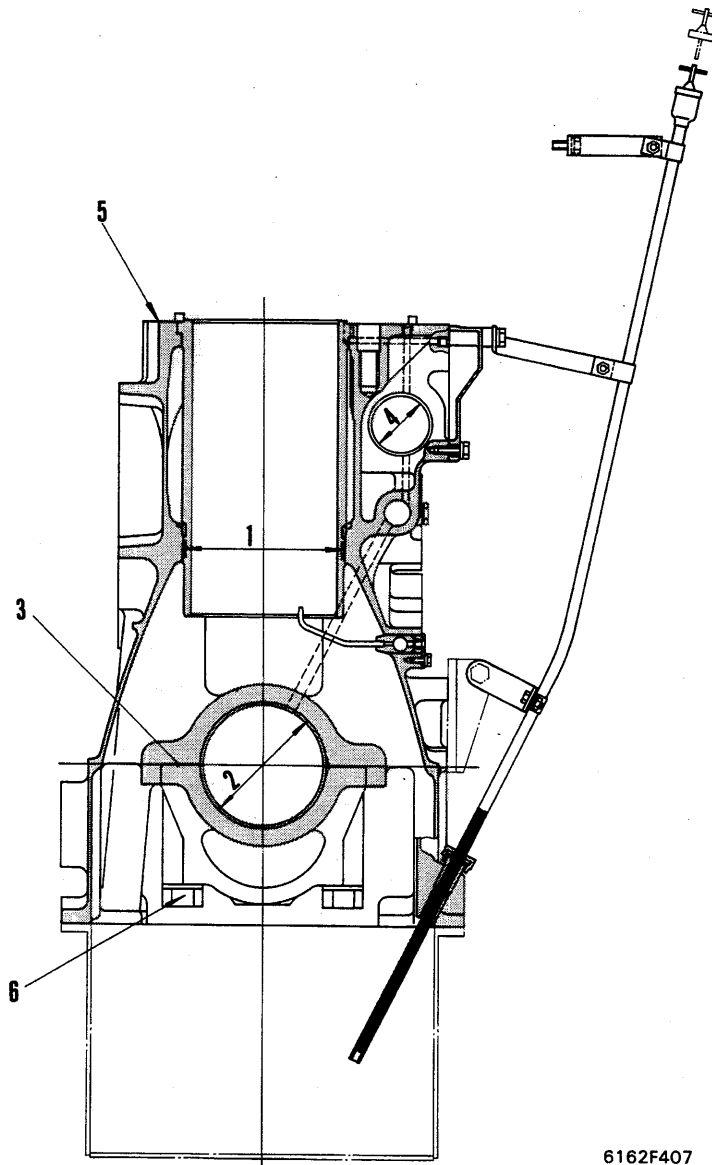


6162F406

Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Tolerance	Repair limit	
1	Outside diameter of cam follower shaft	25.0	-0.040 -0.055	24.9	Replace
2	Inside diameter of cam follower lever	25.0	-0.020 0	25.0	
3	Inside diameter of cam follower roller	19.0	+0.175 +0.150	19.2	
	Outside diameter of cam follower roller pin	19.0	+0.075 +0.065	19.0	
4	Outside diameter of cam follower roller	41.0	+0.050 +0.025	41.0	
5	Diameter of push rod tip ball	15.85	±0.03	-	
6	Inside diameter of push rod socket	12.7	±0.20	-	

CYLINDER BLOCK



6162F407

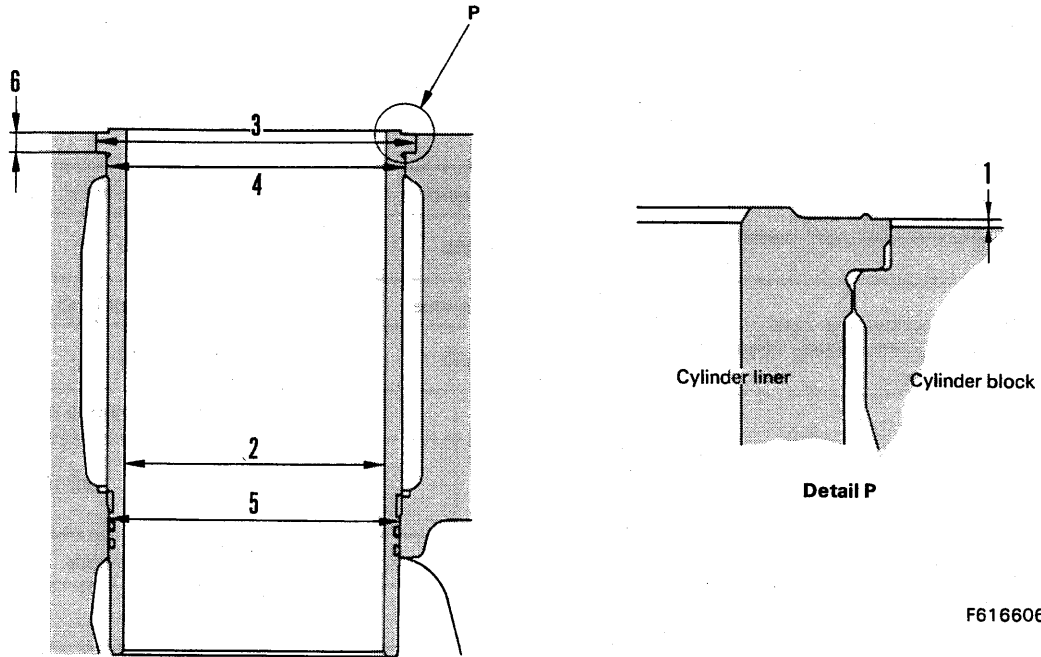
Unit: mm

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

Unit: mm

No.	Check item	Criteria			Remedy
2	Clearance between main bearing and crankshaft journal	Standard clearance		Clearance limit	Repair or replace
		0.075 to 0.150		0.32	
3	Interference between main bearing cap and cylinder block	Standard interference		Interference limit	
		0.080 to 0.160		0.05	
4	Inside diameter of camshaft bushing	Standard size	Tolerance	Repair limit	
		72	+0.070 0	72.10	
	Clearance between camshaft and journal	Standard clearance		Clearance limit	
		0.080 to 0.180		0.24	
5	Distortion of cylinder head face	Tolerance		Repair limit	
		0.09		0.15	
6	Tightening torque of main bearing cap bolt (Coat bolt threads with engine oil)	Order	Target value (kgm)	Range (kgm)	Tighten
		1st	56	51 to 61	
		2nd	113	107 to 118	
		3rd	Loosen completely		
		4th	38	33 to 43	
		5th	75	70 to 80	
		6th	113	107 to 118	

CYLINDER LINER

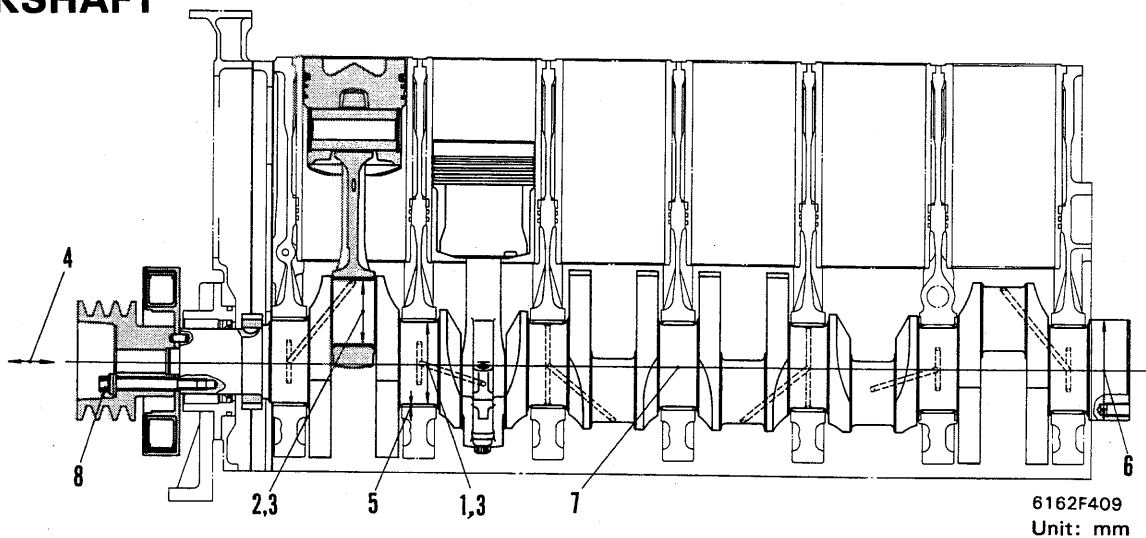


F6166062

Unit: mm

No.	Check item	Criteria			Remedy
1	Protrusion of cylinder liner	Permissible range: 0.07 to 0.15 Difference among cylinders: 0.05 max.			Replace cylinder liner or block
2	Inside diameter of cylinder liner	Standard size	Tolerance	Repair limit	Replace cylinder liner
		170	+0.04 0	170.24	
	Roundness	Repair limit: 0.020			
Cylindricity	Repair limit: 0.015				
3	Outside diameter of cylinder liner (Counter bore part)	Standard size	Tolerance		
	205.99				
	Interference of cylinder liner and block (Counter bore part)	Standard interference: 0.025 to 0.135			
4	Outside diameter of cylinder liner (Counter bore lower part)	Standard size	Tolerance		
	194.59				
	Clearance between cylinder liner and block (Counter bore lower part)	Interference: 0.085 to Clearance: 0.025			
5	Outside diameter of cylinder liner (O-ring part)	Standard size	Tolerance		
	190.24				
	Clearance between cylinder liner and block (O-ring part)	Standard clearance: 0.050 to 0.160			
6	Unevenness of counter bore depth	Tolerance	Repair limit		
		0.05 max.	0.03		

CRANKSHAFT

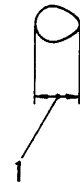
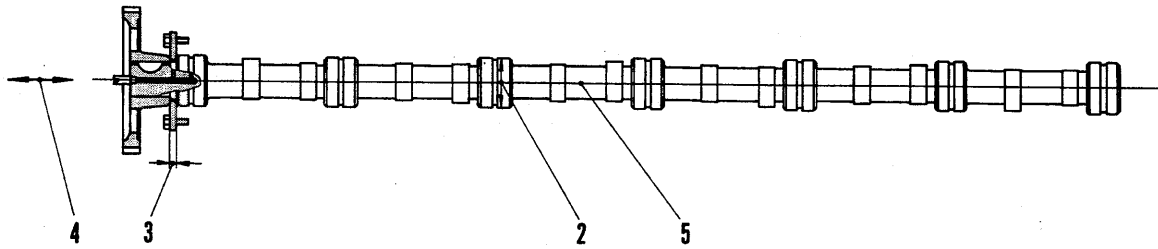


6162F409  
Unit: mm

No.	Check item	Criteria				Remedy
		Size	Standard size	Tolerance	Repair limit	
1	Outside diameter of main journal	S.T.D.	140.00	0 -0.025	139.91	Repair or replace
		0.25US	139.75		139.66	
		0.50US	139.50		139.41	
		0.75US	139.25		139.16	
		1.00US	139.00		138.91	
		S.T.D.	108.00		0 -0.020	
0.25US	107.75	107.66				
0.50US	107.50	107.41				
0.75US	107.25	107.16				
1.00US	107.00	106.91				
3	Journal roundness		Standard	Repair limit		
		Main journal	max. 0.010	0.085		
		Pin journal	max. 0.010	0.065		
4	End play	Tolerance		Repair limit		
		0.140 to 0.320		0.69		
5	Main bearing thickness (Center)	Standard size	Tolerance	Standard interference		
		4	-0.040 -0.050	3.90		
6	Outside diameter of rear flange	170	±0.020	-		
7	Bend of crankshaft (by indicator)	Tolerance		Repair limit		
		0.09		0.20		
8	Tightening torque of crank pulley mounting bolt	38 ± 2 kgm				Tighten



# CAMSHAFT

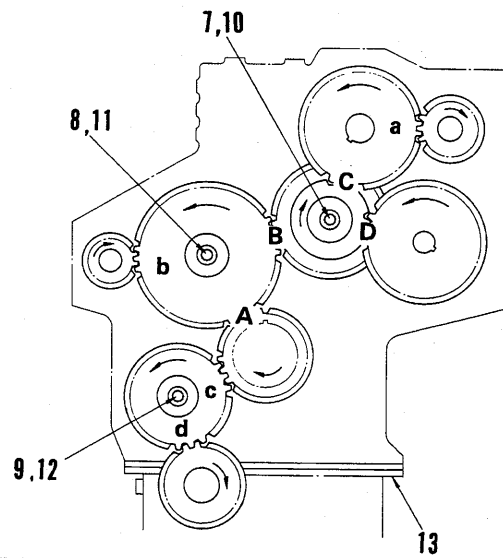


6162F410

Unit: mm

No.	Check item	Criteria			Remedy	
		Standard size	Tolerance	Repair limit		
1	Cam height	Intake side	62	+0.440 +0.240	61.37	Repair or replace
		Exhaust side	61	-0.310 -0.510	59.64	
2	Outside diameter of journal	72.00	-0.080 -0.110	71.86	Replace	
3	Thrust plate thickness	10.00	-0.025 -0.060	6.85		
4	Camshaft end play	Standard clearance		Clearance limit		Replace thrust plate
		0.075 to 0.240		0.40		
5	Bend of camshaft	Repair limit: 0.20 (by indicator)			Replace	

TIMING GEAR

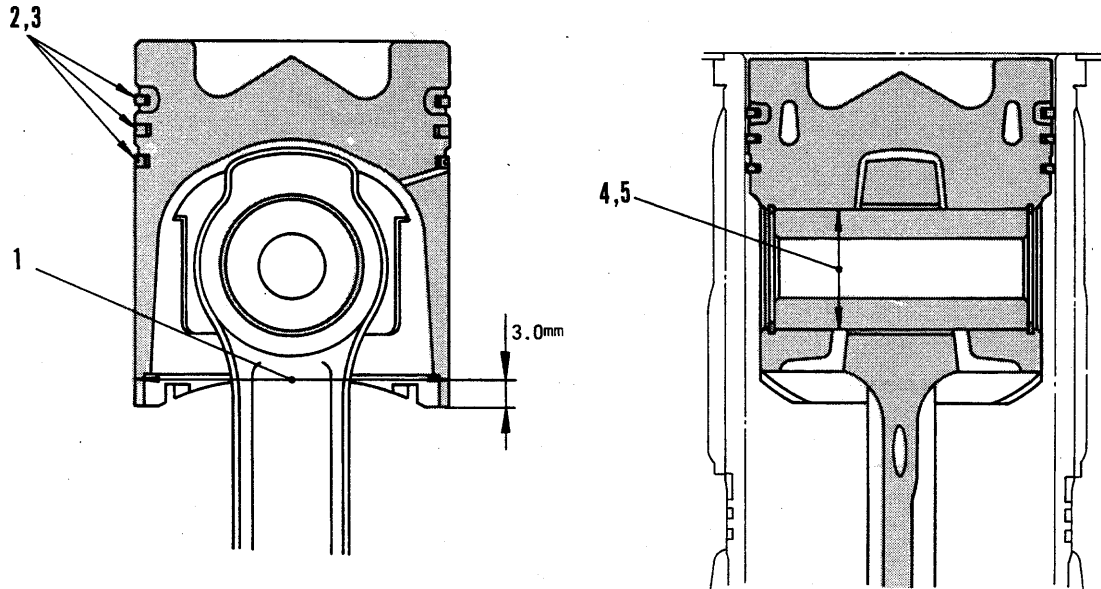


6162F411

Unit: mm

No.	Check item	Criteria				Remedy	
		Position	Measuring point	Standard	Repair limit		
-	Gear backlash	A	Crank gear and idler gear	0.14 to 0.46		Replace	
		B	Main idler gear (large) and idler gear	0.13 to 0.47			
		C	Main idler gear (small) and cam gear	0.13 to 0.47			
		D	Main idler gear (small) and injection pump gear	0.10 to 0.50			
		a	Cam gear and compressor drive gear				
		b	Water pump idler gear and water pump drive gear	0.095 to 0.46			
		c	Crank gear and oil pump idler gear	0.12 to 0.425			
		d	Oil pump idler gear and oil pump drive gear	0.10 to 0.445			
7	Clearance between main idler gear bushing and shaft	Standard size	Tolerance		Standard clearance	Clearance limit	Replace bushing
		Shaft	Hole				
	47	+0.600 +0.585	+0.695 +0.630	0.045 to 0.095			
8	Clearance between idler gear bushing and shaft	47	+0.600 +0.585	+0.695 +0.630	0.045 to 0.095		
9	Clearance between oil pump idler gear bushing and shaft	47	+0.600 +0.585	+0.695 +0.630	0.045 to 0.095		
10	End play of main idler gear	Standard clearance		Clearance limit		Replace thrust bearing	
		0.10 to 0.32					
11	End play of idler gear	0.10 to 0.32					
12	End play of oil pump idler gear	0.10 to 0.32					
13	Difference of timing gear case and cylinder block lower step	Tolerance: 0.15				Repair or replace	

PISTON, PISTON RING AND PISTON PIN



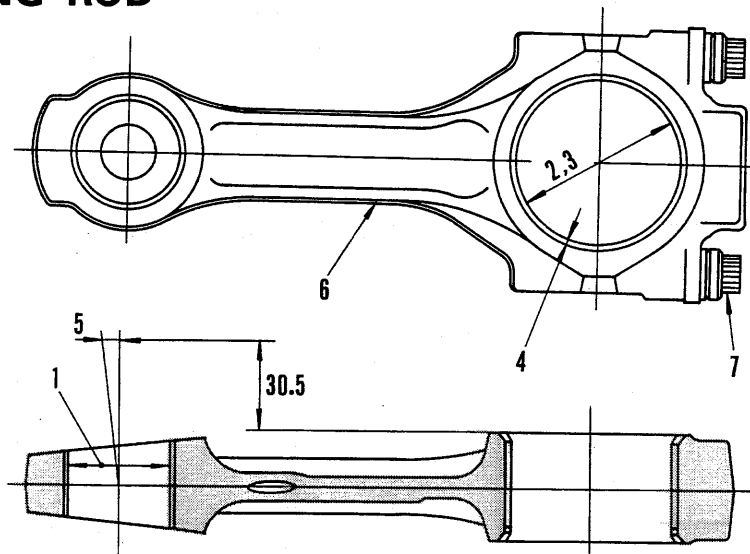
6162F412

Unit: mm

No.	Check item	Criteria			Remedy	
		Standard size	Tolerance	Repair limit		
1	Outside diameter of piston (3.0 mm from bottom and at 20°C)	Standard size	Tolerance	Repair limit		
		170	-0.257 -0.287	169.62		
2	Piston ring groove		Standard size	Tolerance		Clearance limit
				Ring groove	Ring thickness	
		Top ring	Keystone	Check with piston groove wear gauge		0.15
		2nd ring	Keystone			Clearance with new ring
Oil ring	4.80	±0.010	-0.500 -0.075	0.3		
3	Piston ring gap		Standard clearance		Clearance limit	
		Top ring	0.50 to 0.65			
		2nd ring	0.45 to 0.60			
		Oil ring	0.50 to 0.70			
				1.8		
4	Inside diameter of piston pin boss	Standard size	Tolerance	Repair limit		
		68	+0.014 +0.004	68.04		
5	Outside diameter of piston pin	68	0 -0.006	67.98		

Replace

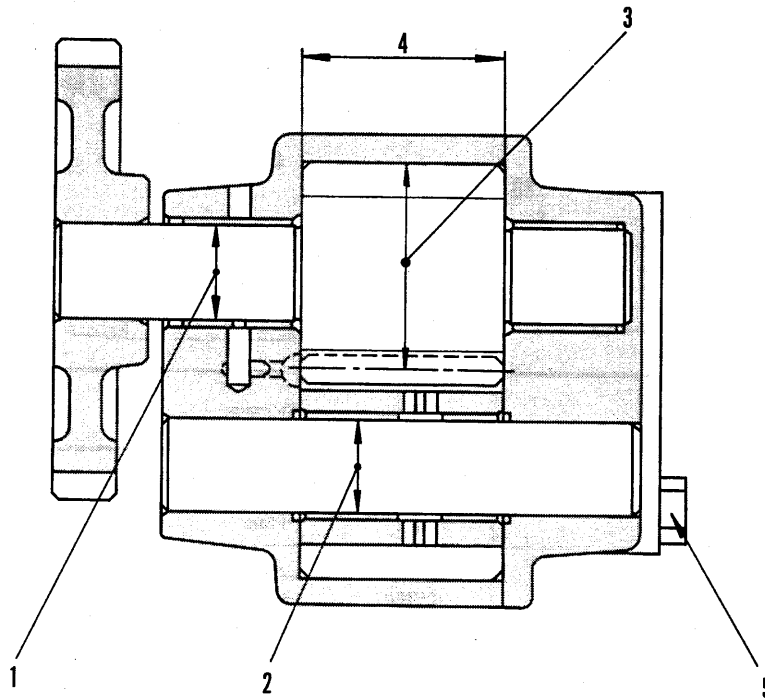
CONNECTING ROD



6162F413 Unit: mm

No.	Check item	Criteria				Remedy
1	Clearance between connecting rod bushing and piston pin	Standard size	Tolerance		Standard clearance 0.050 to 0.075	Clearance limit 0.11
		68	Shaft 0 -0.060	Hole +0.070 +0.050		
2	Inside diameter of connecting rod big end	Standard size		Tolerance		Replace
		115		+0.025 0		
3	Clearance between inside diameter of connecting rod big end and crankshaft journal	Standard clearance		Clearance limit		Replace
		0.060 to 0.130		0.30		
4	Connecting rod bearing thickness (Center)	Size	Standard size	Tolerance	Repair limit	Replace
		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		

OIL PUMP

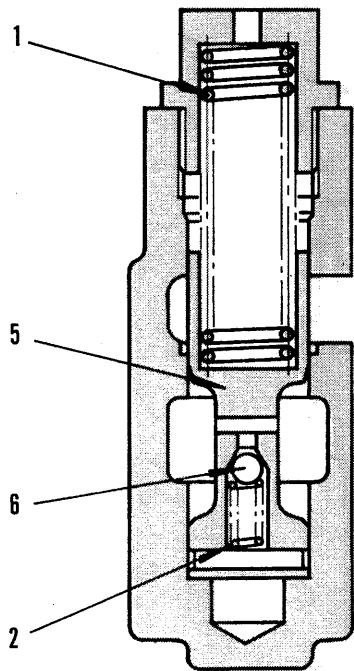


6162F414

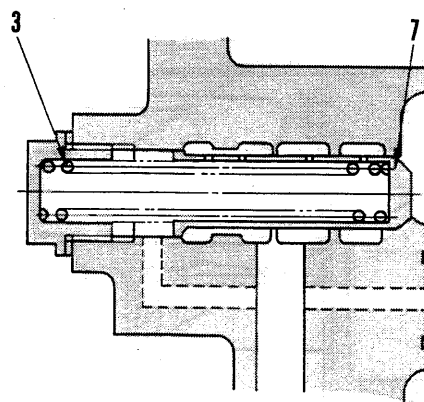
Unit: mm

No.	Check item	Criteria				Remedy
		Standard size	Tolerance		Standard clearance	
Shaft	Hole					
1	Clearance between drive shaft and bushing	32	-0.025 -0.040	+0.035 +0.015	0.040 to 0.075	Replace
2	Clearance between driven shaft and driven gear bushing	30	-0.020 -0.035	+0.030 +0.010	0.030 to 0.070	
3	Clearance between outside diameter of gear and body	71.95	0 -0.030	+0.170 +0.120	0.085 to 0.125	
4	Main pump gear and body end play	66	-0.070 -0.090	+0.035 0	0.070 to 0.125	
5	Tightening torque of mounting bolt	6.9 ± 1.0 kgm				Tighten

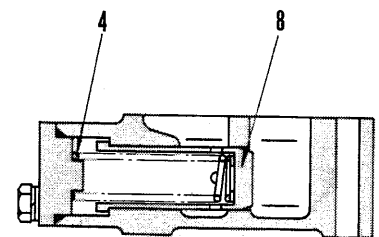
# OIL PUMP RELIEF VALVE, PISTON COOLING VALVE AND OIL COOLER BY-PASS VALVE



6162F415



6162F416

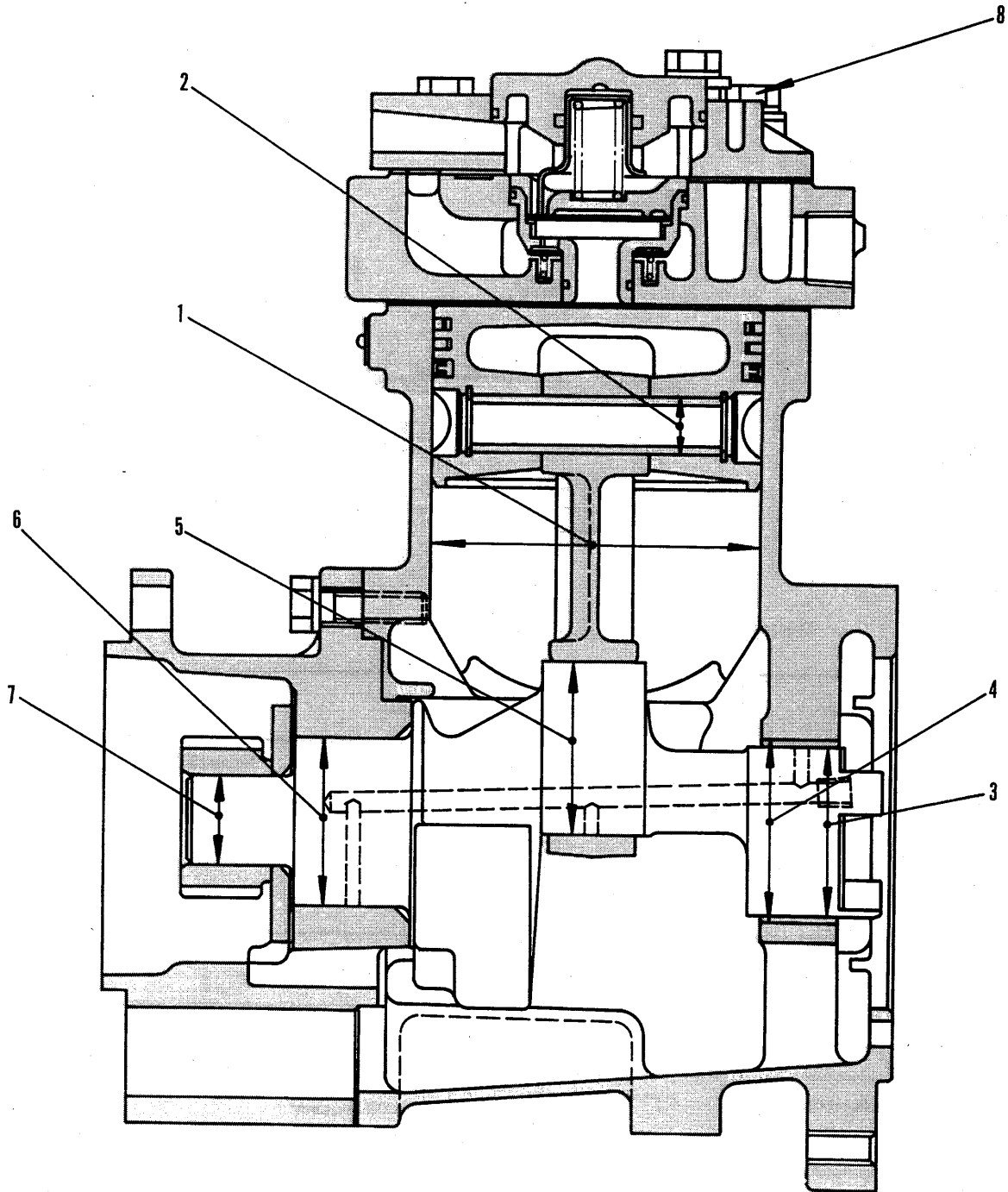


6162F417

Unit: mm

No.	Check item	Criteria				Remedy
		Standard size		Repair limit		
		Free length	Installed length	Installed load	Free length	Installed load
1	Main relief valve spring	73.77	72.0	2.37 kg		
2	Regulator valve spring	21.5	17.6	2.97 kg		
3	Piston cooling valve spring (Check valve)	128.31	102.12	7.1 kg		
4	Oil cooler by-pass valve spring	75.0	72.0	6.0 kg		
5	Main relief valve operating pressure	Standard: $3.3 \pm 0.3 \text{ kg/cm}^2$				Repair or replace spring
6	Regulator valve operating pressure	Standard: $8.0 \pm 0.8 \text{ kg/cm}^2$				
7	Piston cooling valve operating pressure	Standard: $1.3^{+0.3}_{-0.1} \text{ kg/cm}^2$				
8	Oil cooler by-pass valve operating pressure	Standard: $4.5 \pm 0.5 \text{ kg/cm}^2$				

# AIR COMPRESSOR



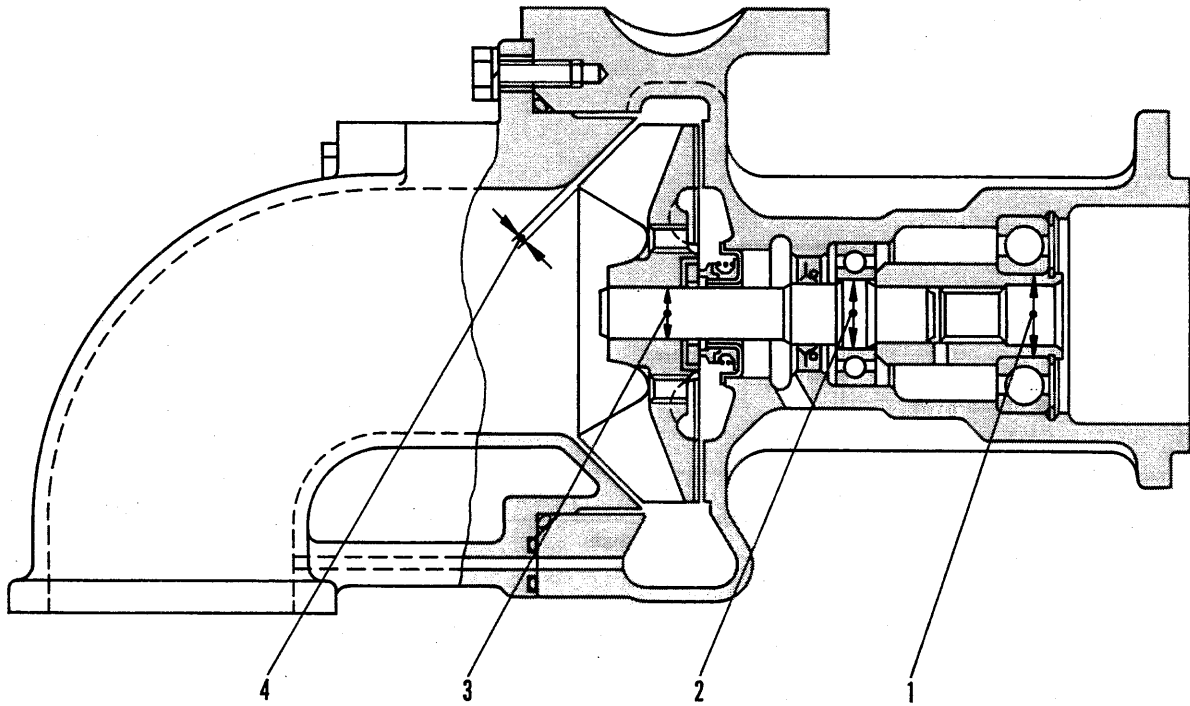
6162F419

Unit: mm

No.	Check item	Criteria				Remedy	
		Standard size	Tolerance		Repair limit		
1	Inside diameter of cylinder	92	+0.08 +0.10			Replace crank case	
2	Clearance between piston and piston pin	Standard size	Tolerance		Standard clearance	Clearance limit	Replace
		17	Shaft	Hole			
			+0.465 +0.460	+0.488 +0.475			
3	Clearance between crankshaft and bushing	47	+0.570 +0.550	+0.662 +0.612	0.042 to 0.113	—	Replace bushing
4	Interference between crank case and bushing	Standard size	Tolerance		Standard interference	Clearance limit	Repair or replace crank case
		51	Shaft	Hole			
			+0.019 -0.006	-0.086 -0.129			
5	Clearance between crankshaft and connecting rod	Standard size	Tolerance		Standard clearance	Clearance limit	Replace
		49	Shaft	Hole			
			+0.162 +0.135	+0.225 +0.213			
6	Clearance between crankshaft and support	47	+0.570 +0.550	+0.638 +0.612	0.042 to 0.089	—	Replace
7	Interference between crankshaft and coupling gear	Standard size	Tolerance		Standard interference	Clearance limit	Replace
		25	Shaft	Hole			
			+0.489 +0.476	+0.425 +0.400			
8	Tightening torque of cylinder head mounting bolt	Standard (kgm)			Limit (kgm)		Tighten
		3			2 to 3.5		



WATER PUMP



6162F418

Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Tolerance		
	Shaft		Hole		
1	Interference between front shaft and bearing	30	+0.015 0	0 -0.010	0 to 0.025
2	Interference between rear shaft and bearing	25	+0.010 0	0 -0.010	0 to 0.020
3	Interference between rear shaft and impeller	19.9	+0.020 +0.005	-0.025 -0.05	0.030 to 0.070
4	Clearance between impeller and connection	Standard clearance		Clearance limit	
		0.23 to 0.66		-	

Replace

# **15 ENGINE REPAIR AND REPLACEMENT OF PARTS**



## **CYLINDER HEAD SECTION**

Repairing mounting face of cylinder head by grinding .....	15- 2
Replacing valve seat inserts .....	15- 3
Replacing nozzle holder sleeve .....	15- 7
Replacing valve guide .....	15-10
Replacing cross head guide .....	15-11
Grinding the valve .....	15-11

## **CYLINDER BLOCK SECTION**

Grinding the top surface of cylinder block .....	15-12
Replacing main metal cap .....	15-13
Repairing the crankshaft .....	15-14
Replacing cam bushing .....	15-18
Replacing crank gear .....	15-19
Replacing cam gear .....	15-19
Replacing flywheel ring gear .....	15-19

## REPAIRING MOUNTING FACE OF CYLINDER HEAD BY GRINDING

### 1. Grinding

- 1) Remove the valve seat inserts. For details, see REPLACING VALVE SEAT INSERTS.
- 2) Remove the nozzle holder sleeves. For details, see REPLACING NOZZLE HOLDER SLEEVES.
- 3) Grind the cylinder head to remove the strained or corroded portions within the limit of the height of the cylinder head (H).

★ Repair limit of cylinder head height (H):

★ Amount to remove per grinding:

0.10 to 0.15 mm

★ Surface roughness of grinding surface:

within 6S

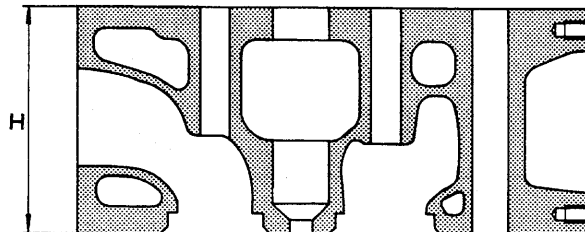
★ Flatness (deformation): 0.05 mm max.

★ Grinding limit: 0.3 mm

★ Difference in head height per unit:

0.15 max.

- 4) Press-fit the one-size-larger inserts. For details, see REPLACING VALVE SEAT INSERTS.
- 5) Press-fit the nozzle holder sleeves. For details, see REPLACING NOZZLE HOLDER SLEEVES.



6162F501

### 2. Check after grinding

- Check the sinking of the valves and the protrusion of the nozzles are within the standard valves.
  - ★ Standard sinking of valves: 1.10 to 1.30 mm
  - ★ Allowable protrusion of nozzle: 4.9 to 5.7 mm

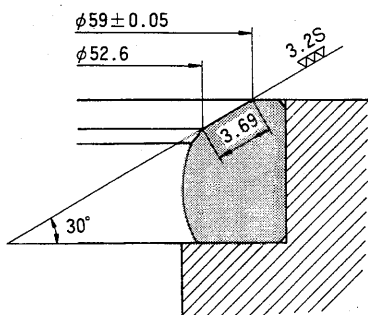
# REPLACING VALVE SEAT INSERTS

## Special tools required

Symbol	Part No.	Part Name	Q'ty
A	795-100-4800	Valve seat puller	1
B	795-100-3002	Valve seat cutter	1
C	795-600-2510	Push tool (for intake valve)	1
C	795-600-2520	Push tool (for exhaust valve)	1
D	795-600-2530	Calking tool (for intake valve)	1
D	795-600-2540	Calking tool (for exhaust valve)	1
D <sub>1</sub>	795-602-2510	Body	1

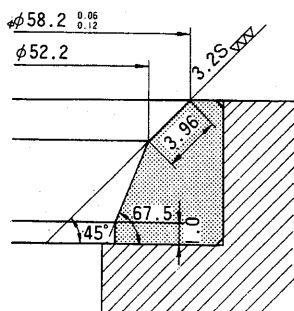
★ When repairing the cylinder head without removing the valve seat inserts, see the following figures.

• Intake valve



6162F502

• Exhaust valve



6162F503

## 1. Pulling out the valve seat insert

1) Using the grinder of valve seat puller A, make grooves on the inserts to pull them out according to the following procedure.

★ Set the air pressure to 5 to 6 kg/cm<sup>2</sup>.

★ When replacing the grindstone of the grinder, shut off the compressed air.

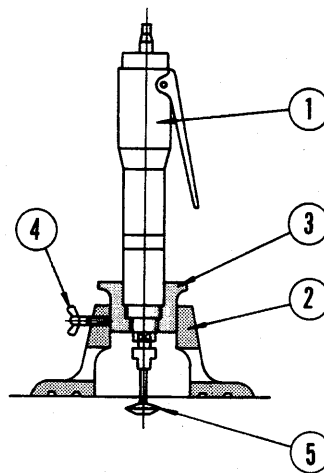
⚠ Before using the grinder, run it for a minute to test it.

• After replacing the grindstone, run the grinder for three minutes to test it.

⚠ Confirm that the grindstone is not damaged, then install it to the shaft of the grinder without applying excessive force. Confirm that there is no play between the grindstone and shaft.

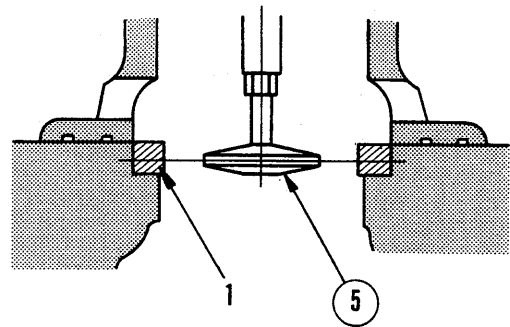
⚠ When using the grinder, wear safety goggles.

- i) Install grindstone ⑤ to grinder ①.
- ii) Install the sleeve and grinder after aligning the groove of sleeve ③ with holder ②. Adjust the position of the grinder with set screw ④.



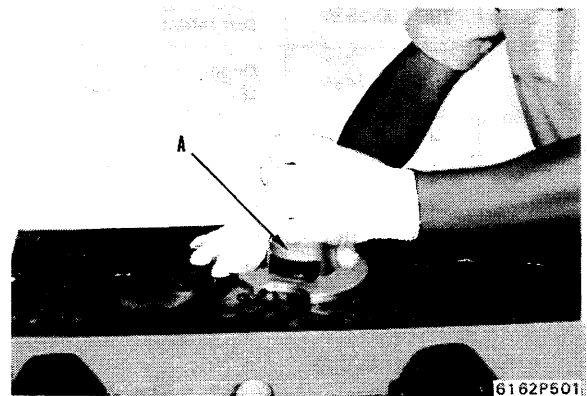
6162F504

- 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).



6162F505

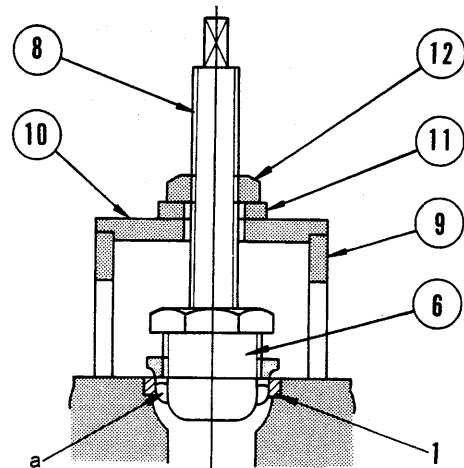
- v) Press the grindstone against the inside of the insert, move it in a circular pattern, and make a groove about 1 mm deep.



6162P501

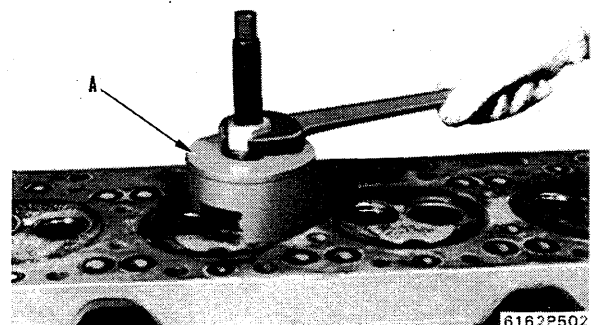
- 2) Pull out the insert with the puller head of valve seat puller A according to the following procedure.

- 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 completely contact the groove.



6162F506

- 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.

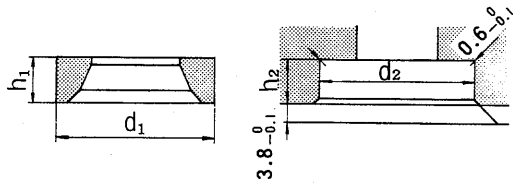


6162P502

2. Machining valve seat insert mounting hole to over-size

1) Using valve seat cutter B, machine the mounting hole to install a one-size-larger insert.

- Dimensions of insert and mounting hole



6162F502-1

- Intake valve side

Unit: mm

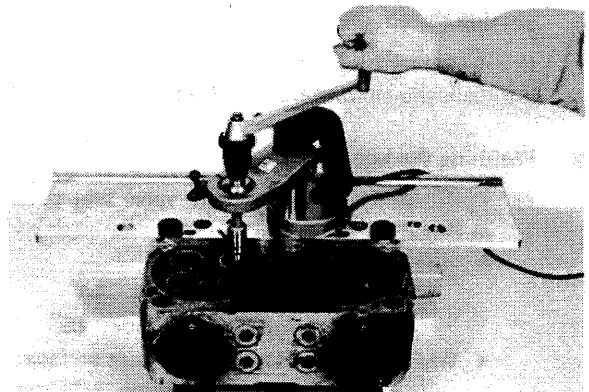
Stamp on insert	Insert		Mounting hole for insert	
	O.D. (d <sub>1</sub> )	Hight (h <sub>1</sub> )	I.D. (d <sub>2</sub> )	Depth (h <sub>2</sub> )
S.T.D.	63.00 <sup>+0.100</sup> / <sub>+0.080</sub>	8.5 <sup>0</sup> / <sub>-0.1</sub>	63.00 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.25 O.S	63.25 <sup>+0.100</sup> / <sub>+0.080</sub>	8.5 <sup>0</sup> / <sub>-0.1</sub>	63.25 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.50 O.S	63.50 <sup>+0.100</sup> / <sub>+0.080</sub>	8.62 <sup>0</sup> / <sub>-0.1</sub>	63.50 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.75 O.S	63.75 <sup>+0.100</sup> / <sub>+0.080</sub>	8.75 <sup>0</sup> / <sub>-0.1</sub>	63.75 <sup>+0.020</sup> / <sub>-0.010</sub>	
1.00 O.S	64.00 <sup>+0.100</sup> / <sub>+0.080</sub>	8.88 <sup>0</sup> / <sub>-0.1</sub>	64.00 <sup>+0.020</sup> / <sub>-0.010</sub>	

- Exhaust valve side

Unit: mm

Stamp on insert	Insert		Mounting hole for insert	
	O.D. (d <sub>1</sub> )	Hight (h <sub>1</sub> )	I.D. (d <sub>2</sub> )	Depth (h <sub>2</sub> )
S.T.D.	61.00 <sup>+0.100</sup> / <sub>+0.080</sub>	8.5 <sup>0</sup> / <sub>-0.1</sub>	61.00 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.25 O.S	61.25 <sup>+0.100</sup> / <sub>+0.080</sub>	8.5 <sup>0</sup> / <sub>-0.1</sub>	61.25 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.50 O.S	61.50 <sup>+0.100</sup> / <sub>+0.080</sub>	8.62 <sup>0</sup> / <sub>-0.1</sub>	61.50 <sup>+0.020</sup> / <sub>-0.010</sub>	
0.75 O.S	61.75 <sup>+0.100</sup> / <sub>+0.080</sub>	8.75 <sup>0</sup> / <sub>-0.1</sub>	61.75 <sup>+0.020</sup> / <sub>-0.010</sub>	
1.00 O.S	62.00 <sup>+0.100</sup> / <sub>+0.080</sub>	8.88 <sup>0</sup> / <sub>-0.1</sub>	62.00 <sup>+0.020</sup> / <sub>-0.010</sub>	

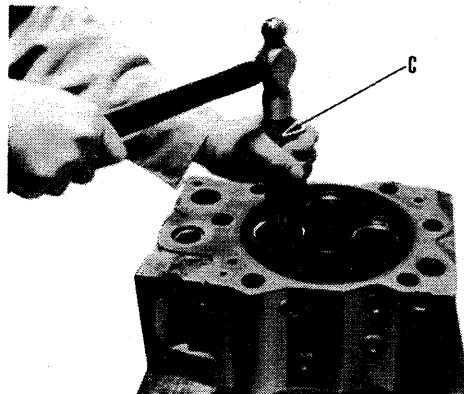
- ★ Inside surface roughness: 6.3S max.
- ★ Mounting hole bottom roughness: 12.5S max.
- ★ Concentricity of valve guide hole and insert: 0.03 mm (T.I.R) max.
- ★ Rectangularity of insert to valve guide bottom: 0.04 mm (T.I.R) max.



2) If the calked portion of the mounting hole is damaged, remove it within the range of 1.00 mm oversize. If the damaged portion cannot be removed within the range of 1.00 mm oversize, replace the cylinder head.

3. Press fitting the insert

1) Using insert push tool C, press-fit the insert.



6162P503

2) Check the sinking distance of the insert from the mounting surface of the cylinder head.

- ★ Standard sinking distance of insert: 1.08 to 1.38 mm

4. Calking the circumference of insert

- Insert calking tool D in the valve guide hole, and hit it to calk the circumference of the insert.

5. Finishing the seat surface

- 1) Finish the seat surface with valve seat cutter B as shown in the figure.

★ Angle of seat surface:

Intake side: 30°  
Exhaust side: 45°

★ Width of contact portion of seat surface:

Intake side: 3.69 mm  
Exhaust side: 3.96 mm

★ Concetricity of valve guide and insert:

0.05 mm (T.I.R) max.

- 2) Fit the seat surface using the compound.

6. Final check

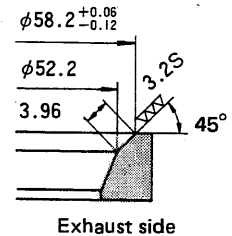
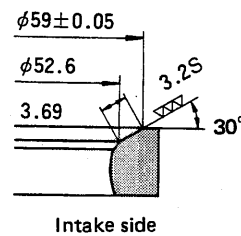
★ Standard sinking distance of valve (new):

1.10 to 1.30 mm

★ Standard width of contact surface against valve:

Intake side: 2.54 ± 0.15 mm

Exhaust side: 2.70 ± 0.15 mm



6162F507

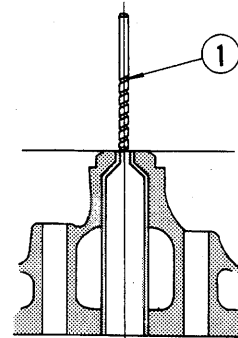
# REPLACING NOZZLE HOLDER SLEEVE

## Special tools required

Symbol	Part No.	Part Name	Q'ty
A	795-600-2110	Push bar	1
B	795-600-1191	Push bar	1
C	795-600-2120	Sleeve driver	1
D	795-600-1130	Sleeve punch	1
E	795-600-2130	Sleeve holder	1
F	795-600-1140	Punch bushing	1
G	795-600-2140	Rolling tool	1
H	795-600-2150	Sleeve expander	1
I	795-600-2160	Sleeve cutter	1
J	795-600-2170	Guide bushing	1

### 1. Cutting a hole at bottom of sleeve

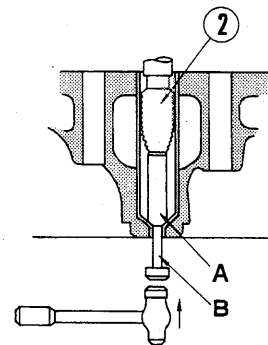
- Insert 12 mm diameter drill ① in the hole at the bottom of the sleeve to make the hole.



6162F508

### 2. Removing the sleeve

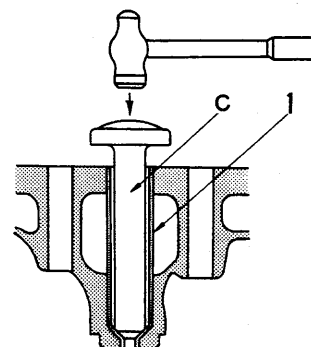
- 1) Insert push bar A inside the sleeve.
- 2) Using sleeve extraction tap ②, cut tap to about 25 mm depth from top face of sleeve. Add oil while cutting.  
★ Sleeve extraction tap: M32, P = 2.0
- 3) Insert push bar B from the bottom of the head and tap with the hammer to remove the sleeve.



6162F509

### 3. Press-fitting the sleeve

- Insert sleeve (1) in the cylinder head, then insert sleeve driver C and lightly tap it until the sleeve contacts the seat surface.
- ★ Before installing the sleeve, clean the sleeve and seat.
- ★ Apply adhesive to the seat around the sleeve.




6162F510

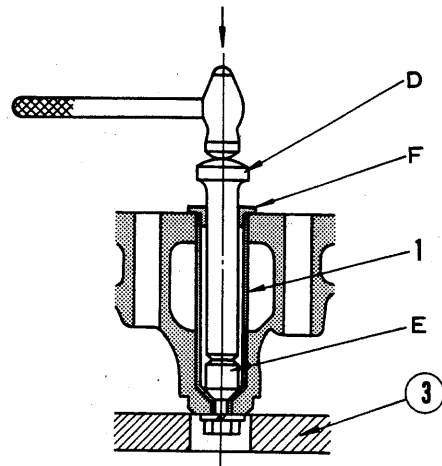


4. Calking the sleeve seat face

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

 Tightening torque for sleeve holder:  
2 kgm.

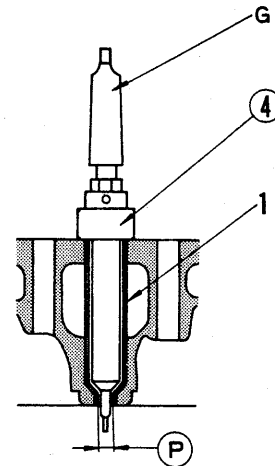
- 2) Install punch bushing F and insert sleeve driver D.
- 3) Place support ③ under the cylinder head to allow the bolt of the sleeve holder to move out.
- 4) Hit the sleeve driver with a hammer to calk the seat surface.  
★ Lightly hit with a hammer several times.
- 5) Remove the sleeve holder and punch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



6162F511

5. Roll-fit the bottom hole of sleeve

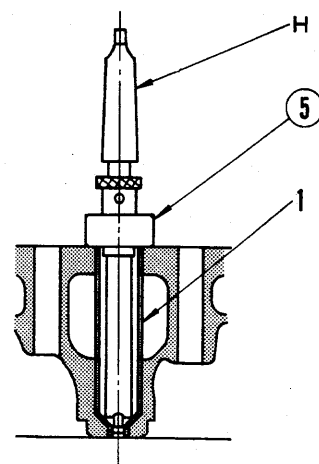
- Using sleeve rolling tool G, roll-fit bottom hole (P) of sleeve (1).
- ★ Adjust the roll-fitting height with bearing collar ④ so that the shaft of the rolling tool will protrude a little from the bottom hole.
- ★ Install the rolling tool to a radial drilling machine or upright drilling machine to roll-fit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



6162F512

6. Roll-fitting the taper section of sleeve

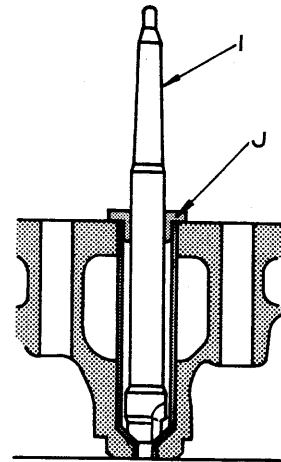
- Using sleeve expander H, roll-fit the taper section of the sleeve.
- ★ Set the roll-fitting amount with stopper ⑤ of the expander.
- ★ Install the expander to a radial drilling machine or upright drilling machine to roll-fit with its own weight.
- ★ Rotating speed: 200 to 300 rpm



6162F513

**7. Spot-facing the inside seat of the sleeve**

- 1) Using guide bushing J as the guide, spot-face the seat with sleeve cutter I.
  - ★ Cut the seat little by little while checking the protrusion of the nozzle with the holder for measuring it and a dial gauge so that the protrusion of the nozzle will be within the specification.
  - ★ Rotating speed: 500 to 600 rpm
  - ★ Protrusion of nozzle: 4.9 to 5.7 mm
- 2) Remove all the metal chips and dust from the machined surface.

**8. Checking the leakage from the seat**

- Confirm that fluid does not leak through the sleeve seat in the water pressure or air pressure test.

6162F514

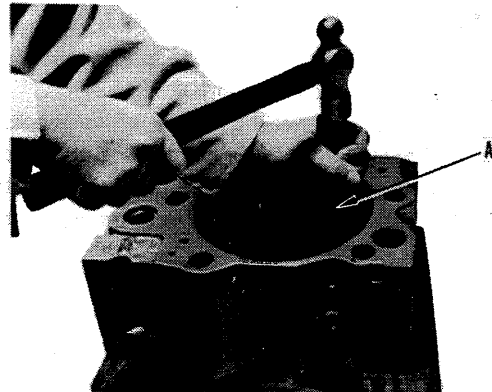
## REPLACING VALVE GUIDE

### Special tools required

Symbol	Part No.	Part Name	Q'ty
A	795-600-2550	Valve guide remover	1
B	795-600-2560	Valve guide driver	1

### 1. Removing the valve guide

- Remove the valve guide with valve guide remover **A**.

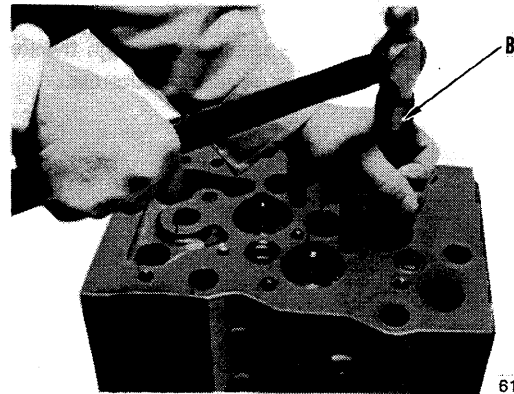


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### 2. Press-fitting the valve guide

- Press-fit the valve guide until the tip of valve guide driver **B** contacts the cylinder head.
- Confirm that the protrusion of the valve guide is within specification.

★ Protrusion of valve guide:  $33.7 \begin{smallmatrix} 0 \\ -0.3 \end{smallmatrix}$  mm



6162P505

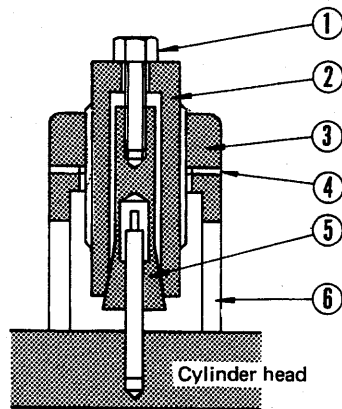
## REPLACING CROSS HEAD GUIDE

### Special tools required

Symbol	Part No.	Part Name	Q'ty
A	795-140-6410	Cross head guide puller	1

### 1. Removing the cross head guide

- Using cross head guide puller A, pull out the cross head guide.
  - 1) As shown in the figure, hold the cross head guide with collet (5) of the puller.
  - 2) Tighten the collet with bolt (1) to lock sleeve (2).
  - 3) Rotate nut (3) and pull out the cross head guide.
  - 4) Remove burrs, fins, etc. from the mounting place of the cross head guide and clean it.



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### 2. Press-fitting the cross head guide

- Insert the cross head guide in the cylinder head, then hit it into the cylinder head with a copper bar or plastic hammer until its protrusion is within specification.
  - ★ Protrusion of cross head guide:  $54_{-0.3}^0$  mm

## GRINDING THE VALVE

### Special tools required

Symbol	Part No.	Part Name	Q'ty
A	— (Purchase)	Valve refacer	1

### 1. Grinding the seat surface

- Grind the seat surface with valve refacer A.
  - ★ Angle of valve seat: Intake valve:  $30^\circ$   
Exhaust valve:  $45^\circ$

### 2. Checking after grinding

- Confirm that the thickness of the valve head, protrusion of the valve, and the contact surface of the valve seat are within specification.
  - ★ Allowable thickness of valve head:
    - Intake valve: 3.4 mm
    - Exhaust valve: 3.5 mm
  - ★ Sinking distance of valve:
    - 1.10 to 1.30 mm
  - ★ Width of contact surface of valve:
    - Intake valve:  $2.54 \pm 0.15$  mm
    - Exhaust valve:  $2.70 \pm 1.15$  mm

## GRINDING THE TOP SURFACE OF CYLINDER BLOCK

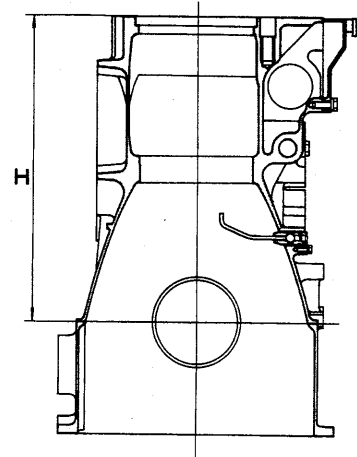
### 1. Grinding

- Grind off the strained and corroded portions of the cylinder block within the allowable height (H) of the cylinder block.

- ★ Allowable height (H) of cylinder block:  
509.84 mm
- ★ Grinding depth/time: 0.03 to 0.08 mm
- ★ Roughness of ground surface:  
6.3S max.
- ★ Flatness (deformation):  
0.09 mm max.

#### If grinding with a grindstone (for reference)

- ★ Speed of grindstone: 1,650 to 1,950 m/min.
- ★ Speed of table: 15 to 30 m/min.
- ★ Grinding depth/time: 0.025 mm
- ★ Cross feed/time: 1 to 2 mm
- ★ Grindstone: A46IV
- ★ Grinding lubricant: Water-soluble grinding lubricant



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### 2. Checking after grinding

- Check the protrusion of the cylinder liner. If it is out of specification, repair the counterbore. For details, see REPAIRING THE COUNTERBORE.
  - ★ Protrusion of cylinder liner
    - Allowable range: 0.07 to 0.15 mm
    - Difference among cylinders: 0.05 mm max.

# 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.

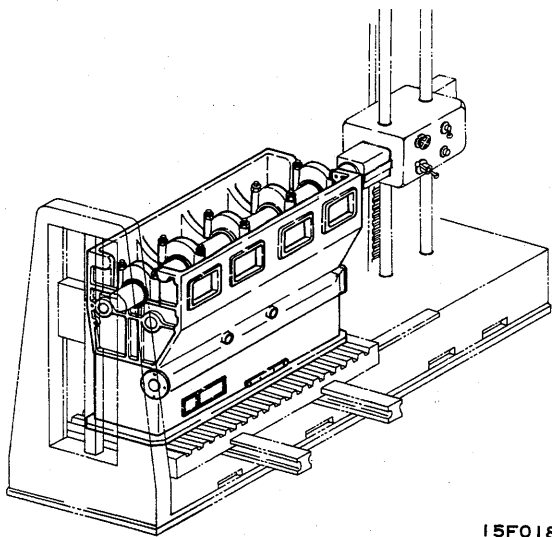
 Mounting bolt for main metal cap:

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.

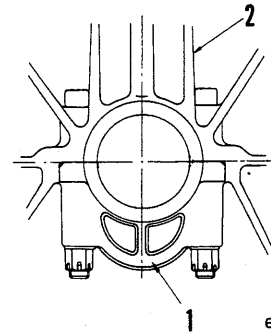
★ Cut until the cutting tool contacts the inside wall of cylinder block (2).

★ Inside diameter of main cap:

$$148^{+0.025}_0 \text{ mm}$$

★ 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.

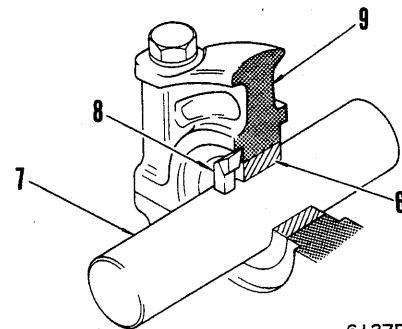
3) Cut cap (9) until the cutting tool contacts the cylinder block.

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.

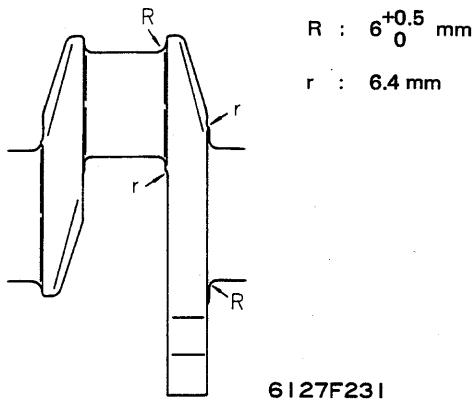
★ Never cut the cylinder block.



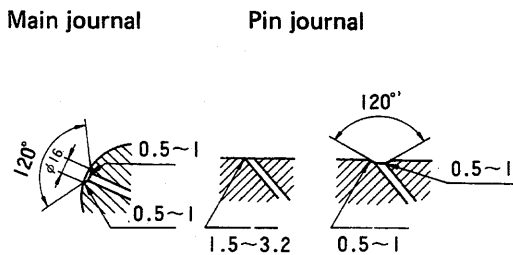
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# REPAIRING THE CRANKSHAFT

- If the crankshaft is worn or slightly seized or damaged, cut it to any one of the following thicknesses.  
**Undersize dimensions: 0.25, 0.50, 0.75, 1.00 mm**
- If the crankshaft is bent or worn unevenly, replace it instead of repairing it. (A lot of skill is required to repair it.)
- Only the following sections can be repaired by plating.
  1. Rear seal journal
  2. Section to which crank gear is installed
- Carefully finish section R of the fillet of the crankshaft, section r on the shoulder, and section R facing the hole.
  - Dimension of fillet



- Dimension of oil hole on journal



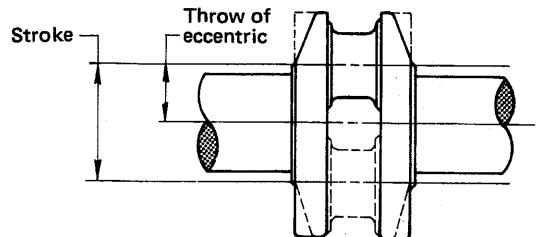
The width of the connecting section of the oil holes must be at least 2.0, and the surface roughness must be 1.6S at maximum. Other surface of the round section must be finished within 6S.

★ **Tolls and jigs required for cutting**

- 1) Magnetic flaw detector
  - 2) Shore hardness tester
  - 3) Etching kit
  - 4) Crankshaft cutting machine
  - 5) Crankshaft grinding machine
  - 6) Roughness gauge
  - 7) Ball gauge for measuring radii of fillets
- For minimum value: 795-500-1140**  
**For maximum value: 795-500-1150**

1. **Check before cutting**

- 1) Visual check  
Check for cracks, damage, seizure, discoloration, wear, etc. to see if it can be repaired.
- 2) Hardness test of journal  
**Hardness of journal (Shore hardness)**  
**Allowable range: 60 to 67 Hs**  
**Limit: 60 Hs**  
If the hardness is below the limit, dispose of the crankshaft.
- 3) Torsion test



**Throw of eccentric:  $85^{0}_{-0.15}$  mm**

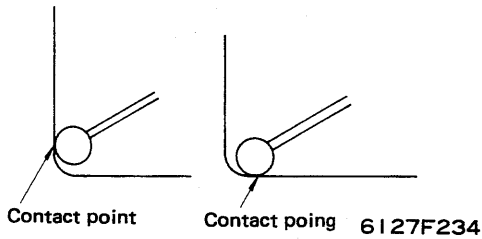
**Limit of horizontal displacement** (Difference in throw of eccentric between No. 1 cylinder and the rearmost cylinder): **0.94 mm**

**Dispersion of throws of eccentric among cylinders: 0.20 max.**

If the above values are out of specification, dispose of the crankshaft.

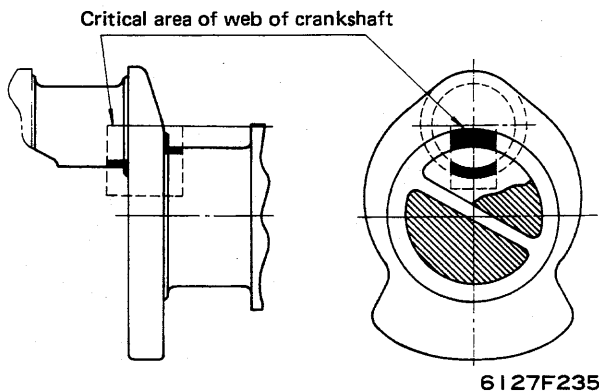
2. Check during and after cutting

- 1) Checking the round sections of fillets
  - i) Confirm that the round sections of fillets are smoothly connected to the shoulders of journals.
  - ii) Using ball gauges for measuring the radii of the fillets, confirm that each radii is between the minimum and maximum limits.



Minimum radius of fillet: 6.00 mm  
 Maximum radius of fillet: 6.50 mm

- 2) Checking the seized surfaces by etching
  - After cutting the journals, confirm that no parts were seized in the cutting procedure by the etching test.
  - If any seized part is found, cut the journal another 0.02 mm to apply the next undersize.
  - After etching the journals, neutralize and wash the checked surface, then apply oil.
- 3) Magnetic flaw detecting
  - Before using the repaired crankshaft, confirm that there are no cracks on it by magnetic flaw detection.
  - Check the fillets of journals which are put in the critical area of each web of the crankshaft especially carefully.



- 4) Measuring the bend (Alignment)
  - Measure the bend of the repaired crankshaft.
  - Measure the bend (alignment) at the following four places.
    - i) Overall length alignment: 0.09 mm max.
    - ii) Adjoining alignment: 0.05 mm max.
    - iii) Forward end alignment: 0.04 mm max.
    - iv) Rear end alignment: 0.03 mm max.

3. Cutting the main journals

- ★ Cut all the main journals to the same undersize.
- ★ When cutting the main journals, count in the finishing allowance for grinding 0.007 to 0.008 mm

• Undersized of main journal

Unit: mm

Size	Basic dimension	Allowable error
S.T.D	140.00	
0.25 US	139.75	
0.50 US	139.50	0 -0.025
0.75 US	139.25	
1.00 US	139.00	

• Out of roundness and cylindricity of main journals (T.I.R)

Allowable error: 0.010 mm max.

Limit: 0.015 mm



4. Grinding the thrust bearing surface

- ★ It is not always required to grind the front and rear thrust bearing surfaces to the same under-size.
- ★ If the thrust bearing surfaces have been ground, confirm that the end play of the crankshaft is within the allowable range (For details, see DISASSEMBLY AND ASSEMBLY).

- Undersizes of thrust bearing surfaces

Unit: mm

		Rear thrust bearing surface		
		S.T.D	0.25 O.S	
Front thrust bearing surface	S.T.D	Basic dimension	64 <sup>+0.050</sup> <sub>0</sub>	64.25 <sup>+0.050</sup> <sub>0</sub>
		Limit	64.060	64.310
	0.25 O.S	Basic dimension	64.25 <sup>+0.050</sup> <sub>0</sub>	64.50 <sup>+0.050</sup> <sub>0</sub>
		Limit	64.310	64.560

- Squareness of thrust bearing surface (T.I.R)

Limit: 0.04 mm

Allowable error: 0.035 mm max.

5. Grinding pin journals

- ★ Grind all the pin journals to the same under-size.
- ★ When grinding, count in finishing allowance for grinding 0.007 to 0.008 mm.

- Undersizes of pin journal

Unit: mm

Size	Basic dimension	Allowable error
S.T.D	108.00	0 -0.020
0.25 US	107.75	
0.50 US	107.50	
0.75 US	107.25	
1.00 US	107.00	

- Out of roundness and cylindricity of pin journal (T.I.R)

Allowable error: 0.010 mm max.

Limit: 0.015 mm

6. Correcting the width of the main journal and pin journal by grinding

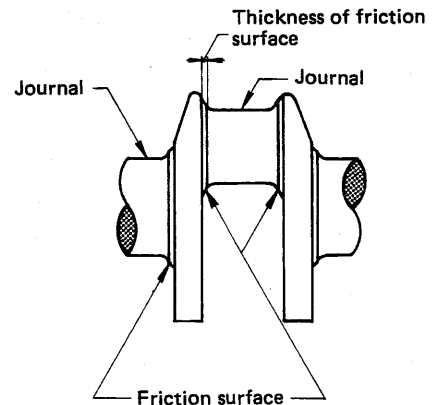
- When correcting the worn surfaces of the main journals and pin journals, limit the grinding thickness to the minimum.
- Width of crank pin journal

If cutting one side only: Standard: 72<sup>+0.075</sup><sub>0</sub> mm

Limit: 74.500 mm

Squareness of thrust bearing surface (T.I.R)

Limit: 0.04 mm

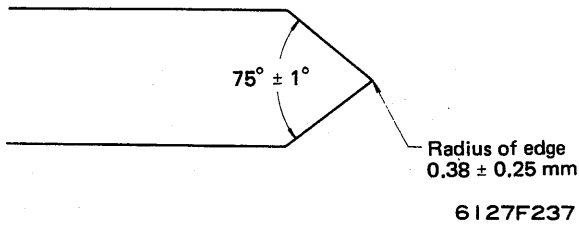


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**7. Correcting the grindstone**

- Dress the grindstone each time one journal is ground.
- Grindstone dresser  
 Tip angle:  $75^\circ \pm 1^\circ$   
 Radius of edge:  $0.38 \pm 0.25$  mm

At the edge of the dresser, a diamond for industrial use must be embedded.



- Adjust the machine for correcting the grindstone, and correct the edge of the grindstone to the radius of the fillet.
- When checking and correcting the grindstone edge, grind a wood bar for trial and use ball gauges.

**8. Preventing seizure caused by grinding**

- 1) Use the plunge grinding method.
- 2) Use the overall width of the grindstone. Do not grind the bosses if possible.
- 3) Apply sufficient cooling oil.
- 4) Set the circumferential speed of the grindstone to 2,000 m/min when the speed of crankshaft is 50 rpm.

**9. Surface finishing**

- Standard surface roughness  
 Journal, thrust bearing, fillet: 1.6S max.  
 Tapered end, bosses of pin and main journal:  
3.2S max.
- Finishing allowance for grinding: 0.007 to 0.008 mm

**10. Treatment after grinding**

- Confirm that each dimension is within specification.
- Carefully wash each section and apply oil to it.
- When storing the crankshaft for a long time, support it at three points or hang it vertically.

**11. Balancing (for reference)**

(Do not perform any repair which will have an adverse effect on the balance of the crank shaft.)

- Limit of unbalance: 110 g.cm
- Limits for reading the balance correctly  
 Bend of crankshaft: 0.05 mm (T.I.R)  
 Speed of crankshaft: 325 rpm max.
- Balance the crankshaft with the crank gear installed or install a weight equivalent to the weight of the gear fixing key to the keyway.
- To balance the crankshaft, make a hole on the counter weight with a drill or cut it.  
 Limit of amount of counterweight to be removed:

56 g

Number of holes: 5 max.

Diameter of hole: 19 mm max.

Depth of hole: .50 mm max.

Distance between hole and side face: 5 mm min.

Distance among holes:  $15^\circ$  of central angle min.

# REPLACING CAM BUSHING

**Special tools required**

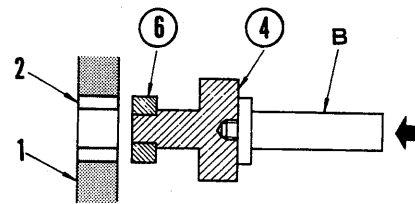
Symbol	Part No.	Part Name	Q'ty
A	795-250-1300	Push tool set	1
B	792-103-0400	Grip	1

★ Before replacing the cam bushing, remove the plug from the rear of the cylinder block.

**1. Removing No. 1 and No. 7 bushings**

• As shown in the figure, assemble push tool ④ and collar ⑥ in push tool set A, and grip B, then pull bushing (2) out of cylinder block (1) by hitting the grip.

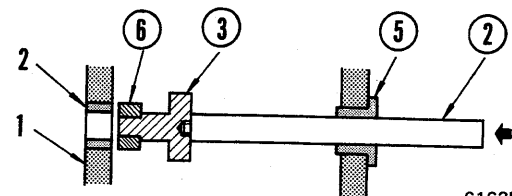
★ **Assembly drawing for cam bushings**



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**2. Removing No. 2 and No. 6 bushings**

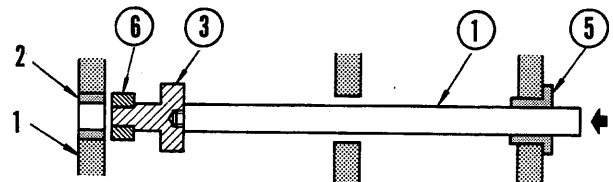
• Assemble push bar ②, push tool ③, guide ⑤, and collar ⑥ in push tool set A, then pull bushing (2) out of cylinder block (1) while hitting the bar.



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**3. Removing No. 3, No. 4, and No. 5 bushings**

• Assemble push bar ①, push tool ③, guide ⑤, and collar ⑥ in push tool set A, then pull bushing (2) out of cylinder block while hitting the bar.

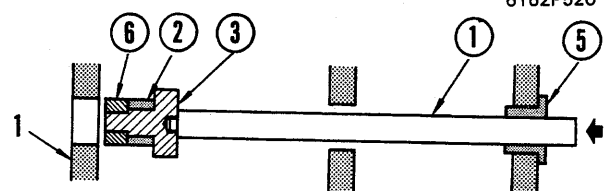


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**4. Press-fitting No. 3, No. 4, and No. 5 bushings**

• Assemble tool set A and bushing (2), then fit the bushing until the end face of push tool ③ contacts cylinder block (1).

★ **Align the oil hole on the bushing.** (This must be cared whenever fitting the bushings.)

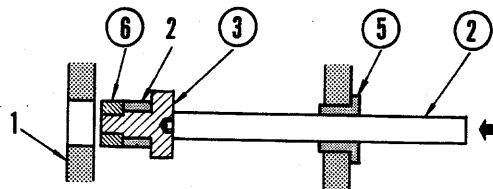


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**5. Press-fitting No. 2 and No. 6 bushings**

• Assemble tool set A and bushing (2), then fit the bushing until the end face of push tool ③ contacts the cylinder block.

★ **Align the oil hole on the bushing.**

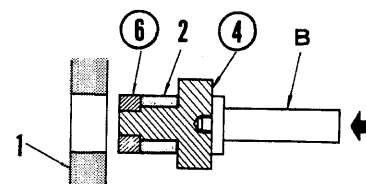


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**6. Press-fitting No. 1 and No. 7 bushings**

• Assemble tool set A, grip B, and bushing (2), then fit the bushing until the end face of push tool ④ contacts the cylinder block.

★ **Align the oil hole on the bushing.**



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★ Press-fit the plug to the rear of the cylinder block.

## REPLACING CRANK GEAR

### 1. Removing the gear

- Make a groove on the tooth bottom surface of the gear with a grinder, then crack the gear with a chisel.

★ Take care not to make flaws on the shaft.

 Take care in handling the grinder and chisel. For details, see the comments on safety in the GENERAL section of this Shop Manual.

### 2. Press-fitting the gear

- 1) Check the gear, keyway, and surface of the flange for flaws. If any flaw is found, repair it with an oilstone.
- 2) Hit a new key into the keyway.
- 3) Heat the gear at the specified temperature for the specified time for shrinkage fitting.


★ Heating temperature for crank gear:  
240 to 260°C

Heating time: 45 minutes

- 4) With the timing mark out, use the fitting tool to press-fit the gear until the gear side contacts the shaft flange.


★ Fit the gear rapidly so that it will not cool.

## REPLACING FLYWHEEL RING GEAR

 Take care not to let the flywheel fall.

### 1. Removing the ring gear

- Make a groove on the tooth bottom surface of the ring gear with a grinder, then crack the gear with a chisel.

 Take care in handling the grinder and chisel. For details, see the discussion on safety in the GENERAL section of this Shop Manual.

### 2. Press-fitting the ring gear

- 1) Check the fitting surface of the ring gear. If any flaw is found, repair it with an oilstone.
- 2) Heat the ring gear at the specified temperature for the specified time for shrinkage fitting.

★ Heating temperature for ring gear:  
295 to 305°C

Heating time: 45 minutes

- 3) With the chamfered side of ring gear facing the flywheel, fit it until its side contacts the flywheel.

## REPLACING CAM GEAR

★ Replace the cam gear in the same way as the crank gear.

★ Heating temperature for cam gear:  
240 to 260°C

Heating time: 45 minutes