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beml

NEW FRONTIERS. NEW DREAMS

SHOP MANUAL

# B(S)(C)4D105 SERIES DIESEL ENGINE

## BEML LIMITED

### MYSORE, INDIA.

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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 and decribed in this manual are both effective and safe methods of operation. Some of these operations require the use of tools specially designed by 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 REAIR 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 oi1 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.

# *FOREWORD*

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 adjust ments 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 **beml** Regional Office for the latest information.

# HOW TO READ THE SHOP MANUAL

## VOLUMES

Shop manuals are issued as a guide to carrying out repairs. They are divided as follows:

**Chassis volume :** Issued for every machine model
**Engine volume :** Issued for each engine series.
**Electrical volume :** Each issued as one volume to
**Attachments volume :** cover all models

These various volumes are designed to avoid duplicating the same information. Therefore to deal with all repairs for any model, it is necessary that chassis, engine, electrical and attachment volumes are ready.

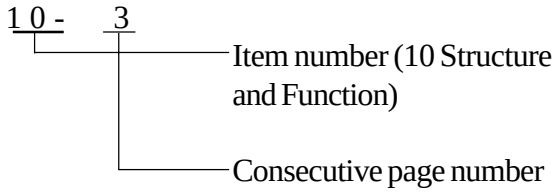
## DISTRIBUTION AND UPDATING

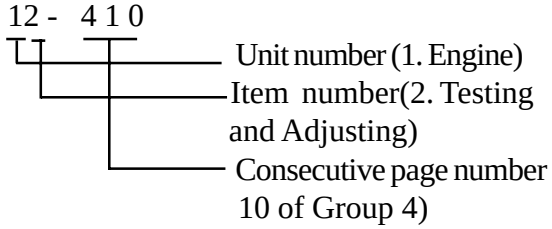
Any additions, amendments or other changes will be sent to **beml** Regional office. Get the most upto-date information before you start any work.

## FILING METHOD

1. See the page number on the bottom of the page. File the pages in correct order.
2. Following examples shows how to read the page number.

Example.




## REVISED EDITION MARK ( ① ② ③ ...)

When a manual is revised, an edition mark is recorded on the bottom outside corner of the pages.

## REVISIONS

Revised pages are shown at the LIST OF REVISED PAGES on the between the title page and SAFETY page.

## SYMBOLES

So that the shop manual can be of ample practical use, important places for safety and quality are marked with the following symbols.

| Symbol | Item | Remarks |
|---|---|---|
|  | Safety | Special safety precautions are necessary when performing the work. |
|  | | Extra special safety precautions are necessary when performing the work because it is under internal pressure. |
|  | Caution | Special technical precautions or other precautions for preserv ing standards are necessary when performing the work. |
|  | Weight | Weight of parts or systems. Caution necessary when selecting hoisting wire, or when working posture is important, etc. |
|  | Tighten- ing torque | Places that require special attention for the tightening torque during assembly. |
|  | Coat | Places to be coated with adhesives and lubricants etc. |
|  | Oil, water | Places where oil, water or fuel must be added, and the capacity. |
|  | Drain | Places where oil or water must be drained, and quantity to be drained. |

# 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 


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

**2. Wire ropes**

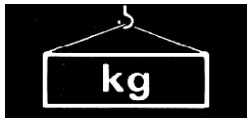
1) Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

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

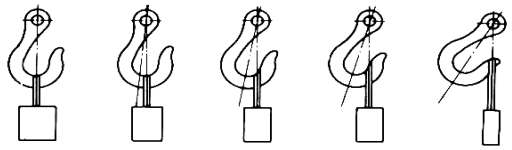
| Rope diameter (mm) | Allowable load (tons) |
|---|---|
| 10 | 1.0 |
| 11.2 | 1.4 |
| 12.5 | 1.6 |
| 14 | 2.2 |
| 16 | 2.8 |
| 18 | 3.6 |
| 20 | 4.4 |
| 22.4 | 5.6 |
| 30 | 10.0 |
| 40 | 18.0 |
| 50 | 28.0 |
| 60 | 40.0 |

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

2) Sling wire ropes from the middle portion of the hook.
Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result.




Hooks have maximum strength at the middle portion.

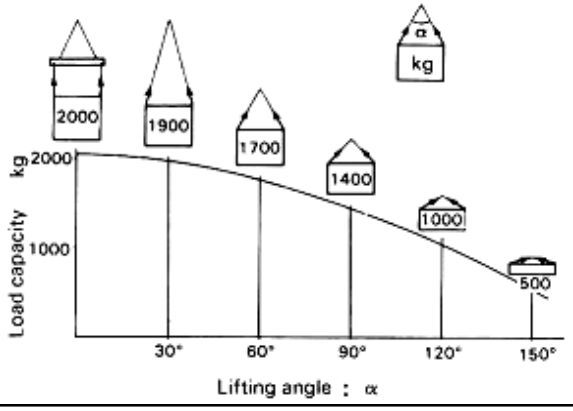


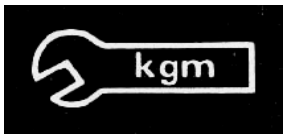
100% 88% 79% 71% 41%

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

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

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






# 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 section 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±1.9 |
| 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 |

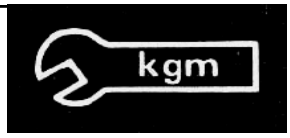
This torque table does not apply to the bolts with which nylon packings or other non-ferrous metals washers are to be used, or which require tightening to otherwise specified torque.

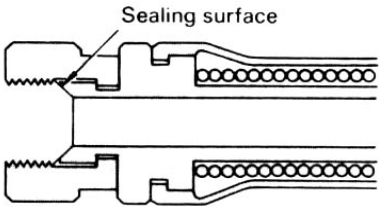
★ **Nm (newton meter): 1 Nm = 0.1 kgm**

## 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 |

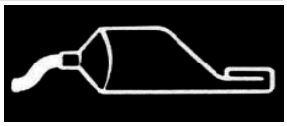



## 3. TIGHTENING TORQUE FOR NUTS OF FLARED

Use these torques for nut part of flared.

| 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 **beml** Shop Manuals are listed below.

| Nomenclature | BEML 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. |
| | LT-4 | Used to coat plugs (plate shaped, bowl shaped) and holes, and mating portion of shaft. |
| Sealant 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. |
| | LG-6 | Silicon base type used in combination with LG-1 and LG-4. |
| | LG-7 | Has a shorter curing time than LG-6, and is easier to peel off. |
| Antifriction compound (Lubricant including molybdenum disulfide) | LM-P | Applied to bearings and taper shafts to facilitate press-fittings and to prevent sticking, burning or rusting. |
| Grease ( Lithium grease) | G2-L1 - | 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

# 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: 5WB indicates a cable having a nominal number 5 and white coating with black stripe.

## CLASSIFICATION BY THICKNESS

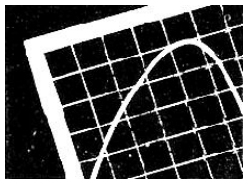
| Nominal number strands | Copper Wire | | | Cable O.D (A) | Current rating | Applicable circuit |
|---|---|---|---|---|---|---|
| | Number (mm) | Dia.of strands ($mm^2$) | Cross section (mm) | | | |
| 0.85 | 11 | 0.32 | 0.88 | 2.4 | 12 | Starting,lighting,signal etc. |
| 2 | 26 | 0.32 | 2.09 | 3.1 | 20 | Lighting,signal etc. |
| 5 | 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 | Classification \ Circuits | | Charging | Ground | Starting | Lighting | Instrument | Signal | Other |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Primary | Code | W | B | B | R | Y | G | L |
| | | Color | White | Black | Black | Red | Yellow | Green | Blue |
| 2 | Auxiliary | Code | WR | - | BW | RW | YR | GW | LW |
| | | Color | White & red | - | Black & White | Red & White | Yellow &Red | Green & White | Blue & White |
| 3 | | Code | WB | - | BY | RB | YB | GR | LR |
| | | Color | White & Black | - | Black & Yellow | Red & Black | Yellow & Black | Green & Red | Blue & Red |
| 4 | | Code | WL | - | BR | RY | YG | GY | LY |
| | | Color | White & Blue | - | Black & Red | Red & Yellow | Yellow & Green | Green & Yellow | Blue & Yellow |
| 5 | | Code | WG | - | - | RG | YL | (GB) | (LB) |
| | | Color | White & Green | - | - | Red & Green | Yellow & Blue | (Green & Black) | (Blue & Black) |
| 6 | | Code | - | - | - | RL | YW | (GL) | - |
| | | Color | - | - | - | Red & Blue | Yellow & White | (Green & Blue) | - |

# ENGINE

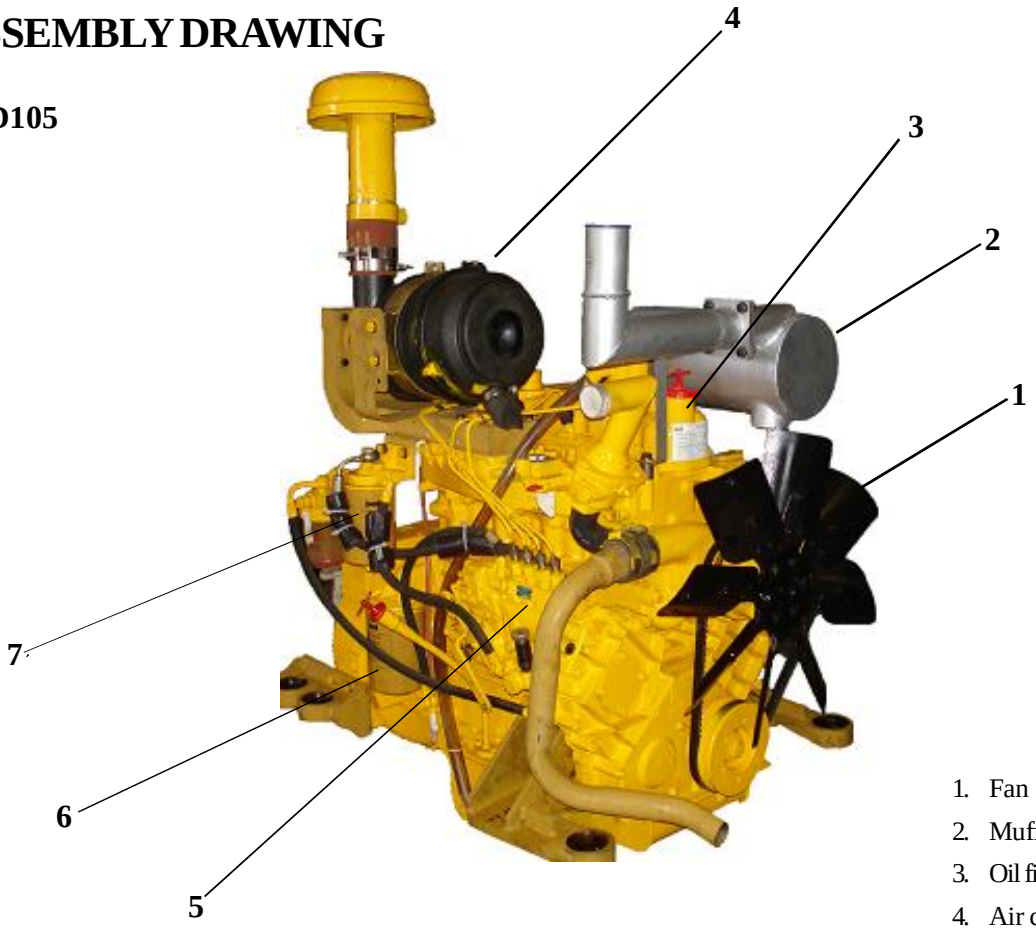
## 11 GENERAL



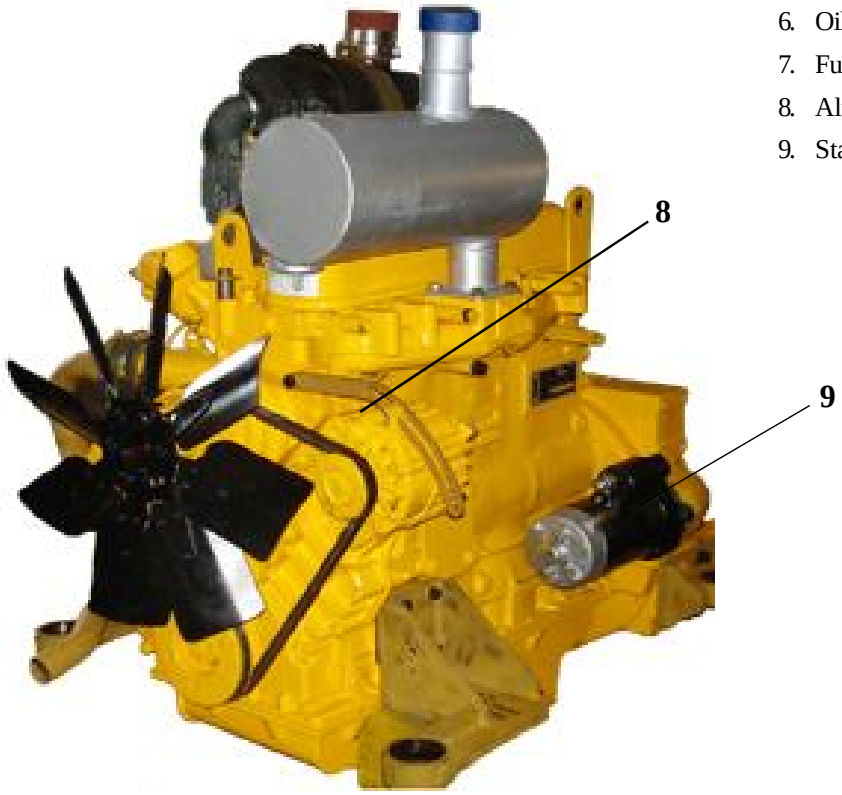

General view ..... 11-002
Specifications ..... 11-004
General assembly drawing ..... 11-006
Performance curve ..... 11-010
Weight table ..... 11-014

# ASSEMBLY DRAWING

**B4D105**

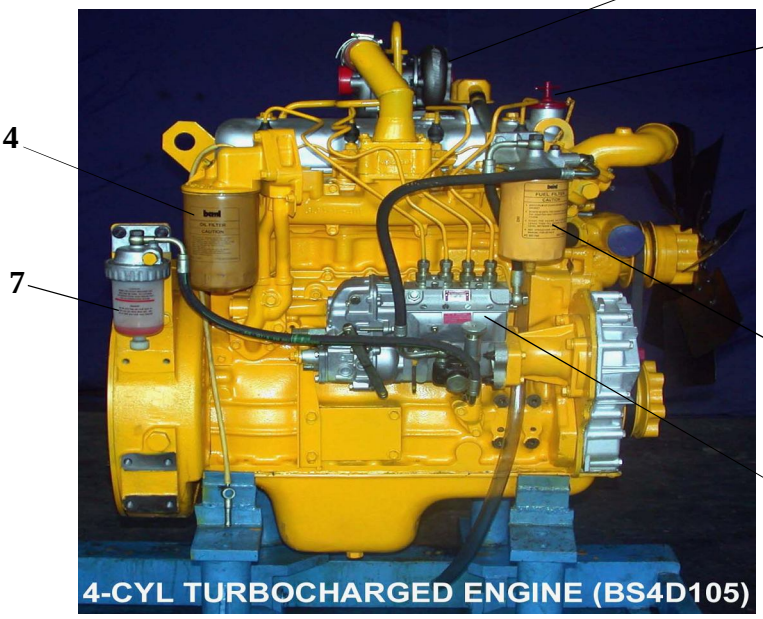


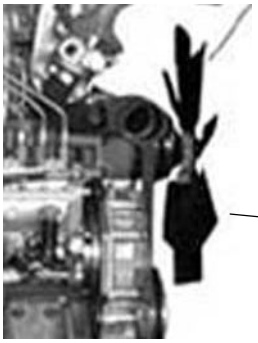

1. Fan
2. Muffler
3. Oil filler
4. Air cleaner
5. Fuel injection pump
6. Oil filter
7. Fuel filter
8. Alternator
9. Starting motor



## BS4D105

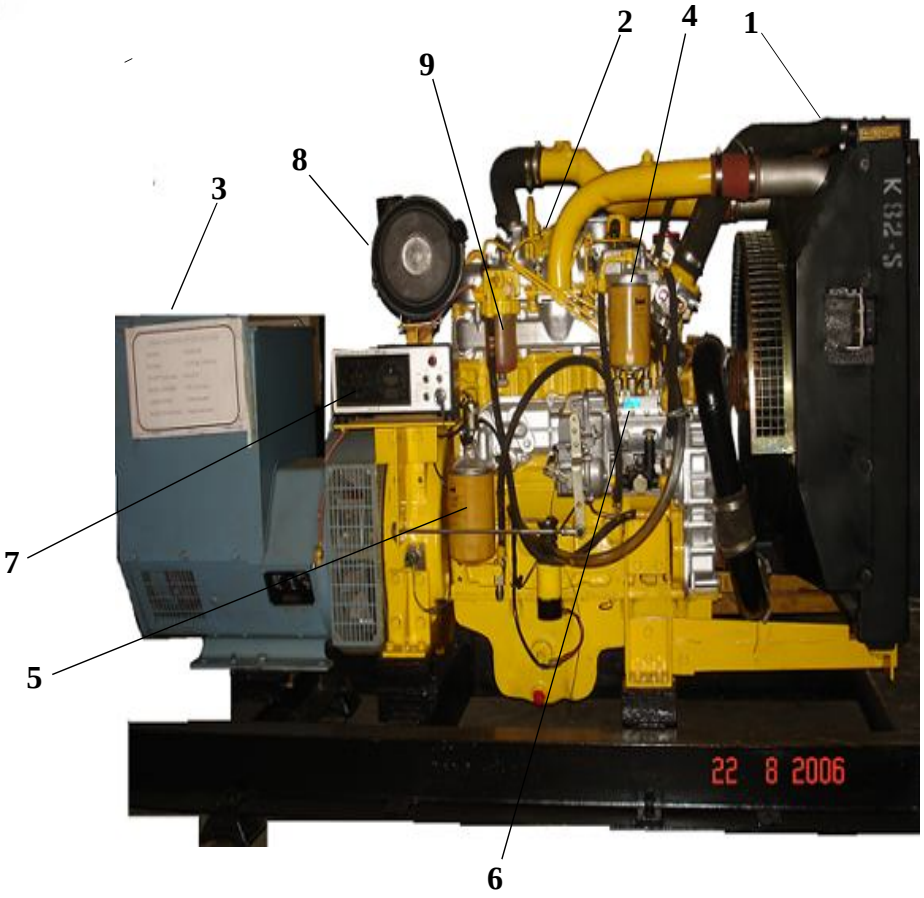
1. Fan
2. Turbocharger
3. Oil filler
4. Oil Filter
5. Fuel Filter
6. Fuel injection pump
7. Water Separator




## BSC4D105

1. Radiator
2. Turbocharger
3. Transmission
4. Fuel Filter
5. Oil Filter
6. Fuel injection pump
7. Engine Safety System
8. Air Cleaner
9. Water separator



# SPECIFICATIONS

| | | | | | |
|---|---|---|---|---|---|
| | Engine model | | B4D105 | B4D105 | |
| | Applicable machine | | BL9H | | |
| | No. of cylinders - Bore x Stroke | mm | 4 - 105 x 125 | | |
| | Total piston displacement | cc | 6,490 | | |
| | Firing order | | 1 - 3 -4 - 2 | | |
| Dimensions | Overall length (Fan to flywheel housing) | mm | 1018 | | |
| | Overall width | mm | 740 | | |
| | Overall height (Muffler to oil pan) | mm | 1115 | | |
| Performance | Flywheel horsepower | (kW) | 54@2200 | | |
| | | (bhp @ r/min) | 73@2200 | | |
| | Torque | (N.m/min) | 278 @1400 | | |
| | | kgm/rpm | @1400 | | |
| | High idling speed | r/min | 2380~2400 | | |
| | Low idling speed | r/min | 700 - 800 | | |
| | Min. fuel consumption | g/kWh | 225 | | |
| | Dry weight | kg | xxx | | |
| | Fuel pump | | MICO | | |
| | Governor | | Bosch type All-speed type mechanical | | |
| | Lubricating oil amount (Refil capacity) | (l) | 15 (14) | | |
| | Coolant amount (Engine Only) | (l) | 24 | | |
| | Aternator | | 12V, 90A | | |
| | Starting motor | | 12V, 3kW | | |
| | Battery | | 12V, 200Ah x 1 | | |
| | Air compressor | | -- | | |
| | Others | | --- | | |

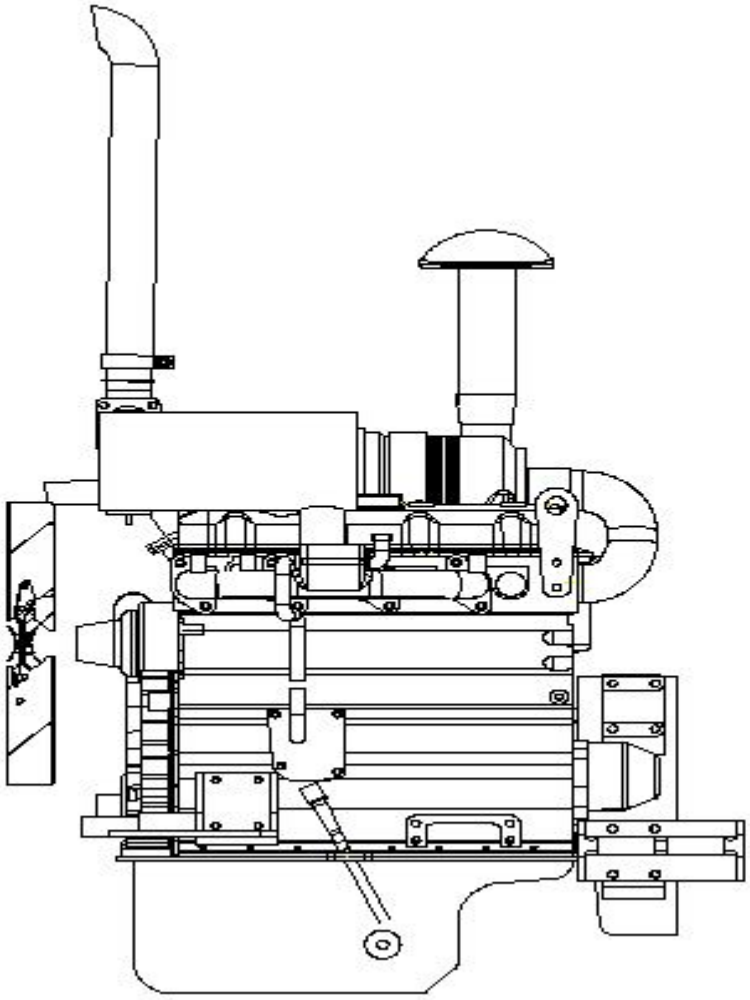
# SPECIFICATIONS

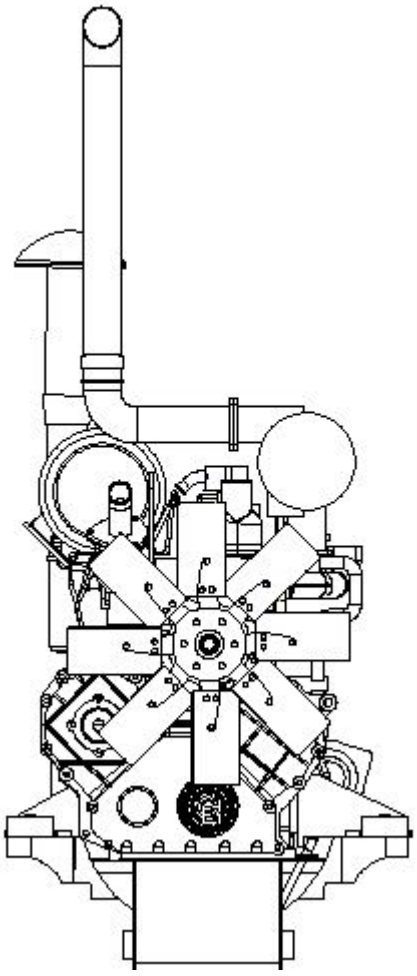
| | | | | | |
|---|---|---|---|---|---|
| | Engine model | | BS4D105 | BSC4D105 | |
| | Applicable machine | | 62.5 kVA | 82.5 kVA | |
| | No. of cylinders - Bore x Stroke | mm | 4 - 105 x 125 | | |
| | Total piston displacement | cc | 6,490 | | |
| | Firing order | | 1 - 3 -4 - 2 | | |
| Dimensions | Overall length (Fan to flywheel housing) | mm | 960 | 965 | |
| | Overall width | mm | 740 | 740 | |
| | Overall height (Muffler to oil pan) | mm | 1100 | 1100 | |
| Performance | Flywheel horsepower | (kW) | 58@1500 | 78@1500 | |
| | | (bhp @ r/min) | 80@1500 | 102@1500 | |
| | Torque | (N.m/min) | ---- | ---- | |
| | | kgm/rpm | ---- | ---- | |
| | High idling speed | r/min | 1560max. | 1560 max. | |
| | Low idling speed | r/min | 1000~1050 | 1000~1050 | |
| | Min. fuel consumption | g/kWh | | | |
| | Dry weight | kg | | | |
| | Fuel pump | | MICO Bosch type | MICO Bosch type | |
| | Governor | | All-speed type mechanical | All speed type Mechanical | |
| | Lubricating oil amount (Refil capacity) | (l) | 15 (14) | 15 (14) | |
| | Coolant amount Engine Only) | (l) | 24 | 24 | |
| | Aternator | | 12V, 40A | 12V, 40A | |
| | Starting motor | | 12V, 3 kW | 12V, 3kW | |
| | Battery | | 12V, 200Ah x 1 | 12V,200Ah x l | |
| | Air compressor | | -- | -- | |
| | Others | | -- | – | |

# GENERAL ASSEMBLY DRAWING

## B4D105

**LEFT SIDE VIEW**

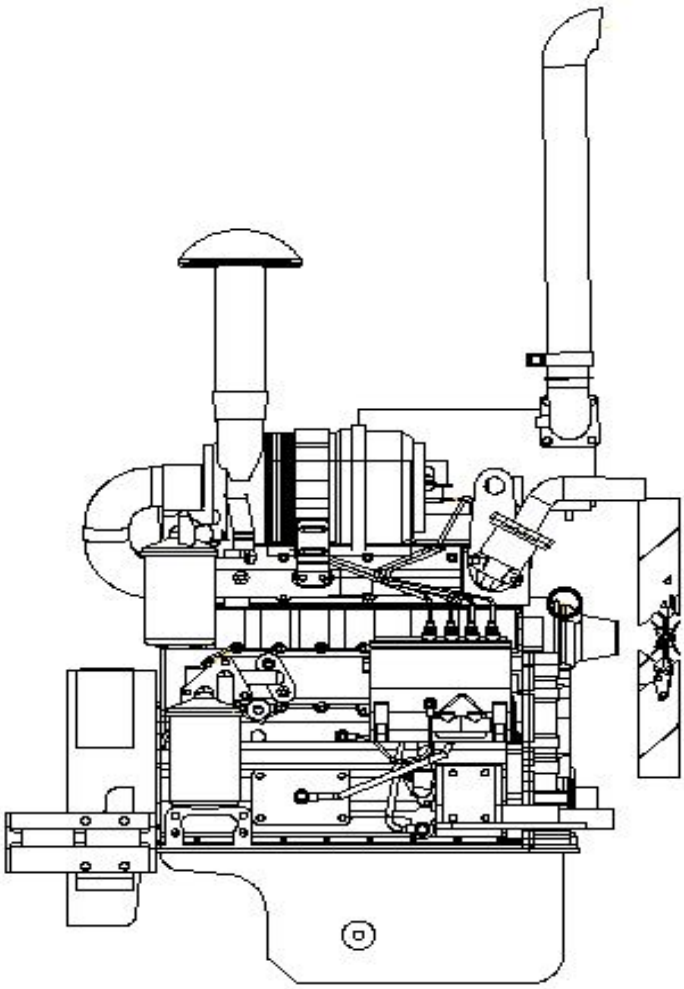


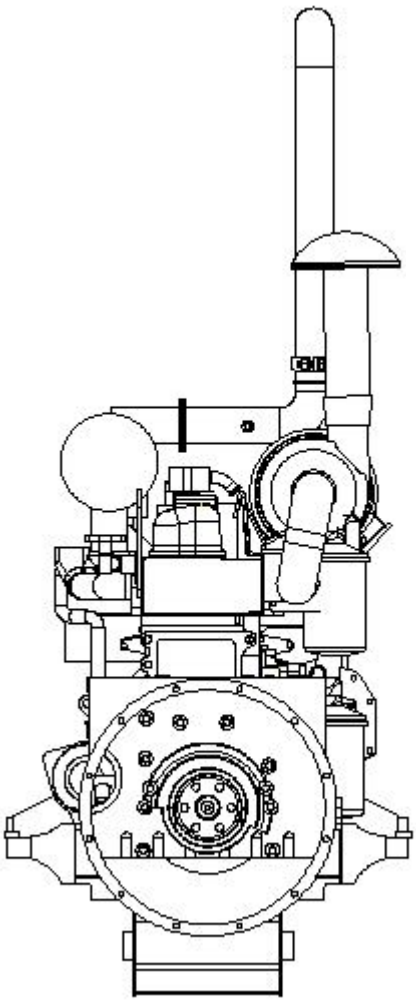


**FRONT VIEW**

# GENERAL ASSEMBLY DRAWING
# B4D105

## RIGHT SIDE VIEW

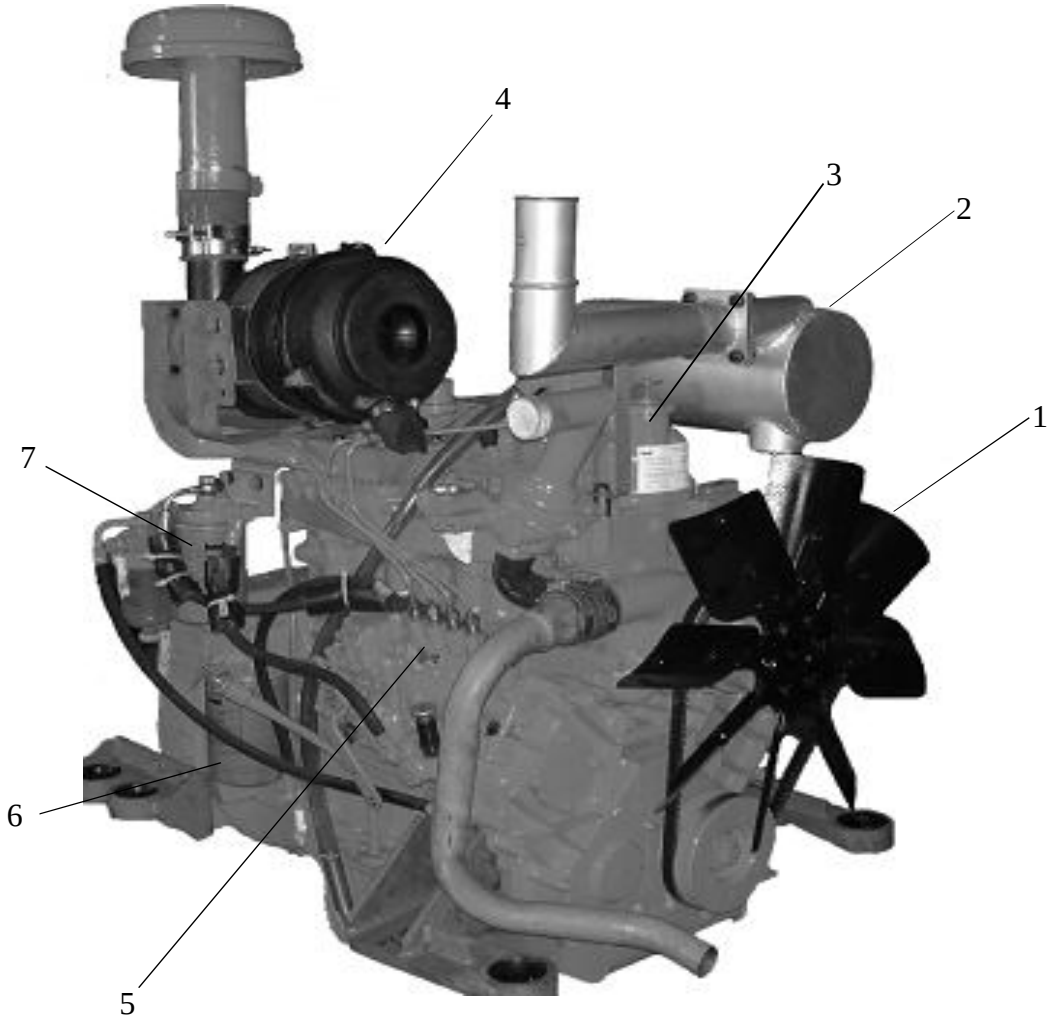


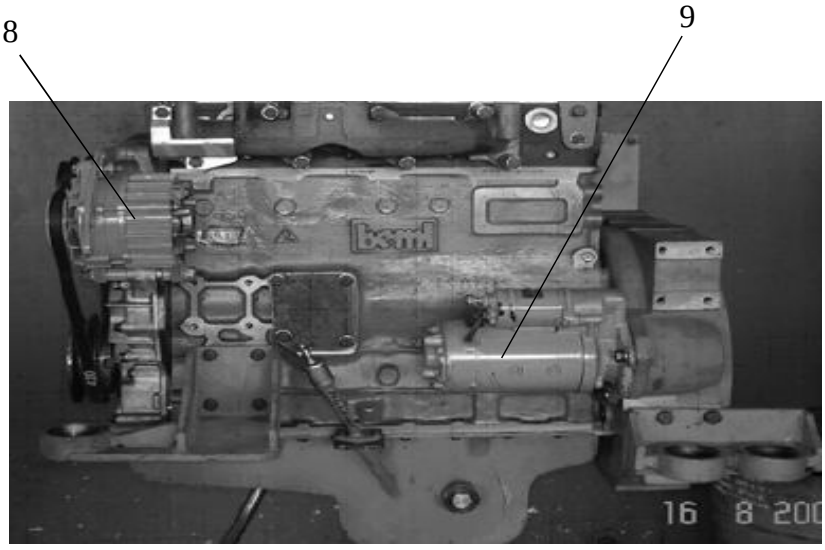


## REAR VIEW

# GENERAL ASSEMBLY DRAWING

## B4D105

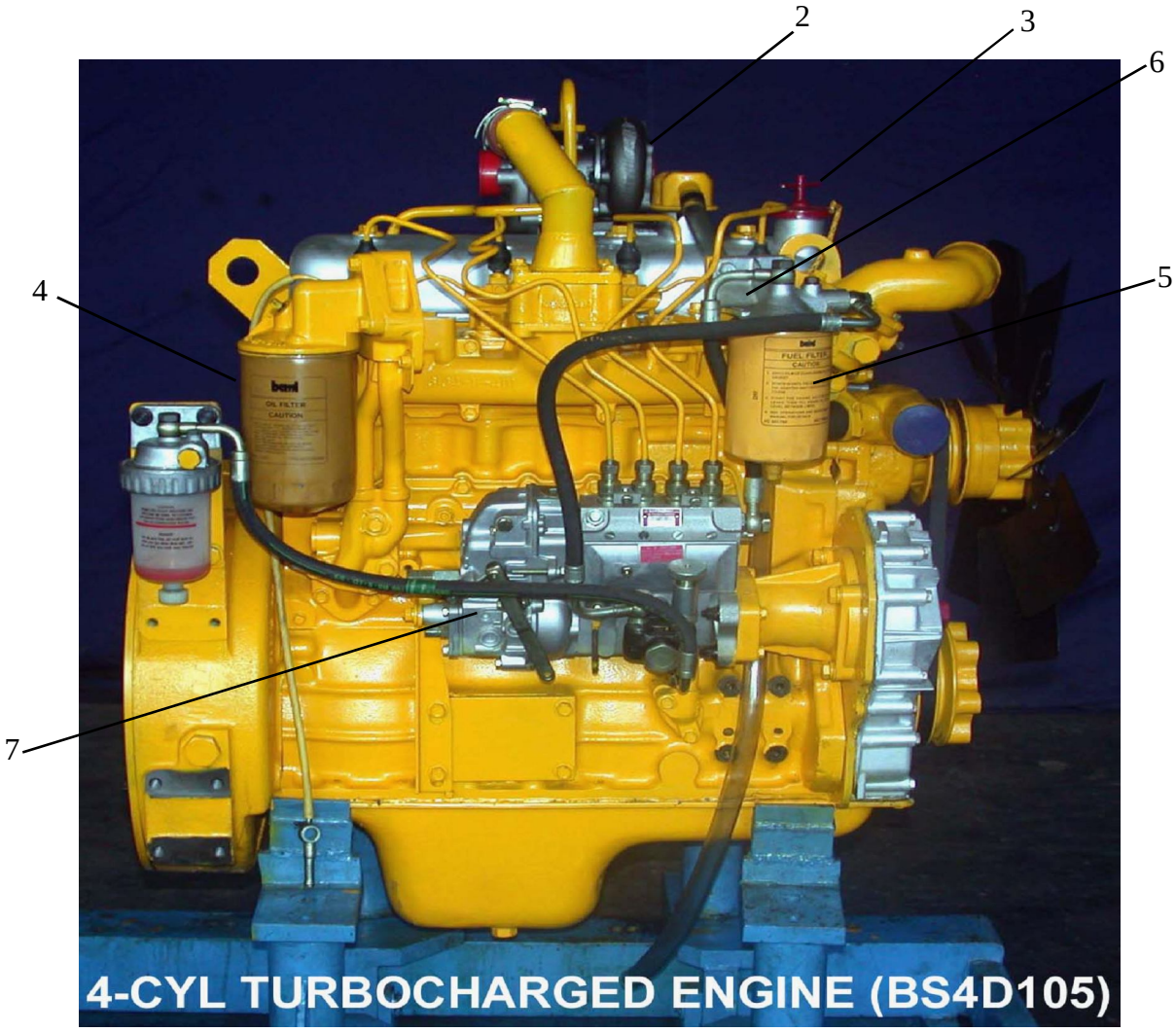


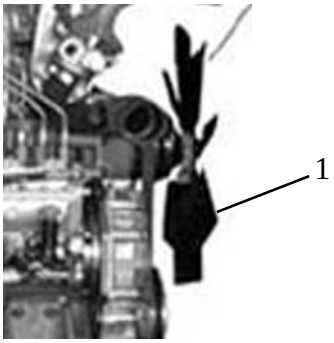

1. Fan
2. Muffler
3. Oil filler
4. Air cleaner
5. Fuel injection pump
6. Oil filter
7. Fuel filter
8. Alternator
9. Starting motor

# GENERAL ASSEMBLY DRAWING

## BS4D105

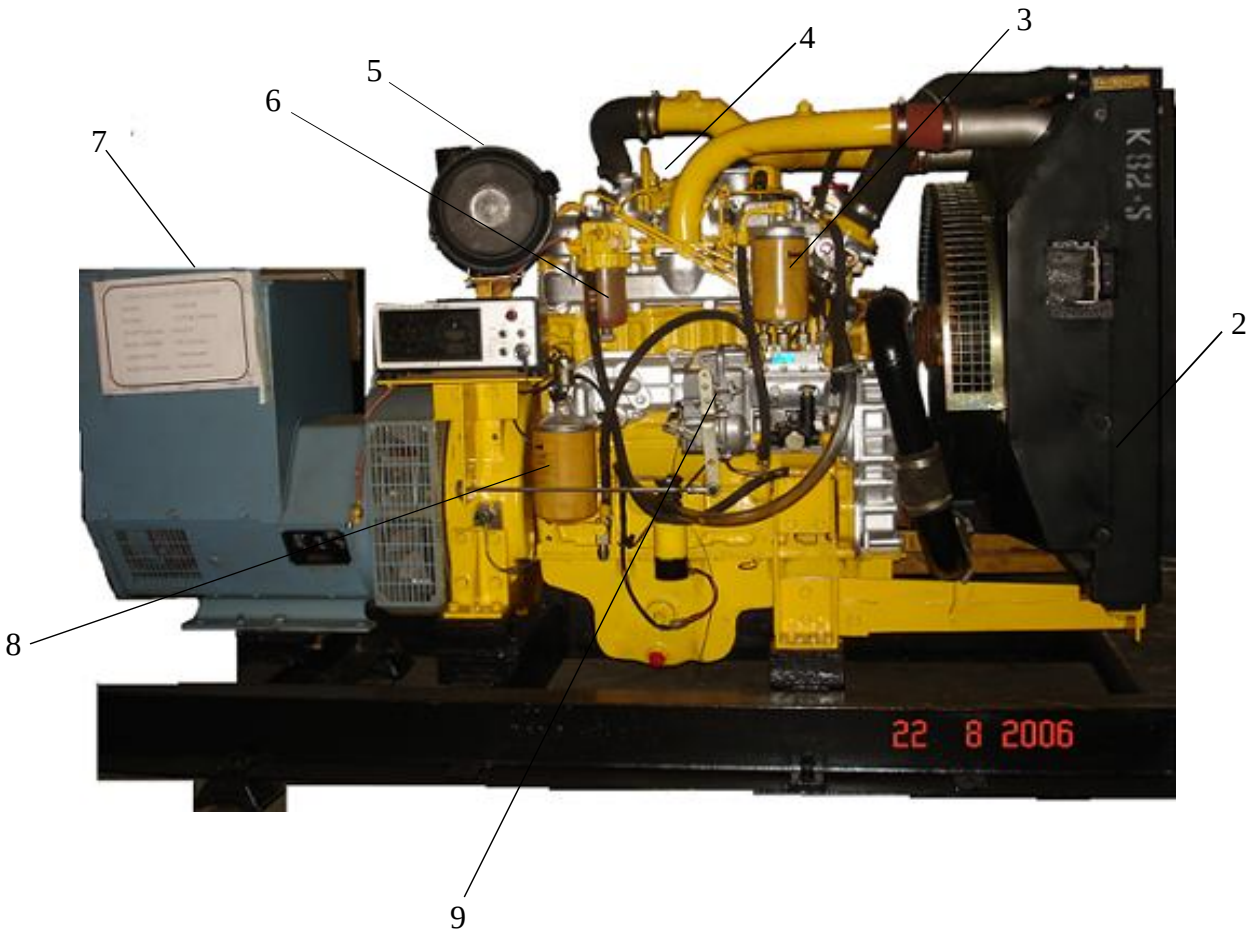



1. Fan
2. Turbocharger
3. Oil filler
4. Oil filter
5. Fuel Filter
6. Thermostat case
7. Fuel injection pump

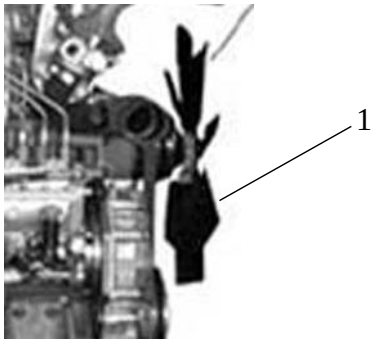


# GENERAL ASSEMBLY DRAWING

## BSC4D105 (82.5 kVA)



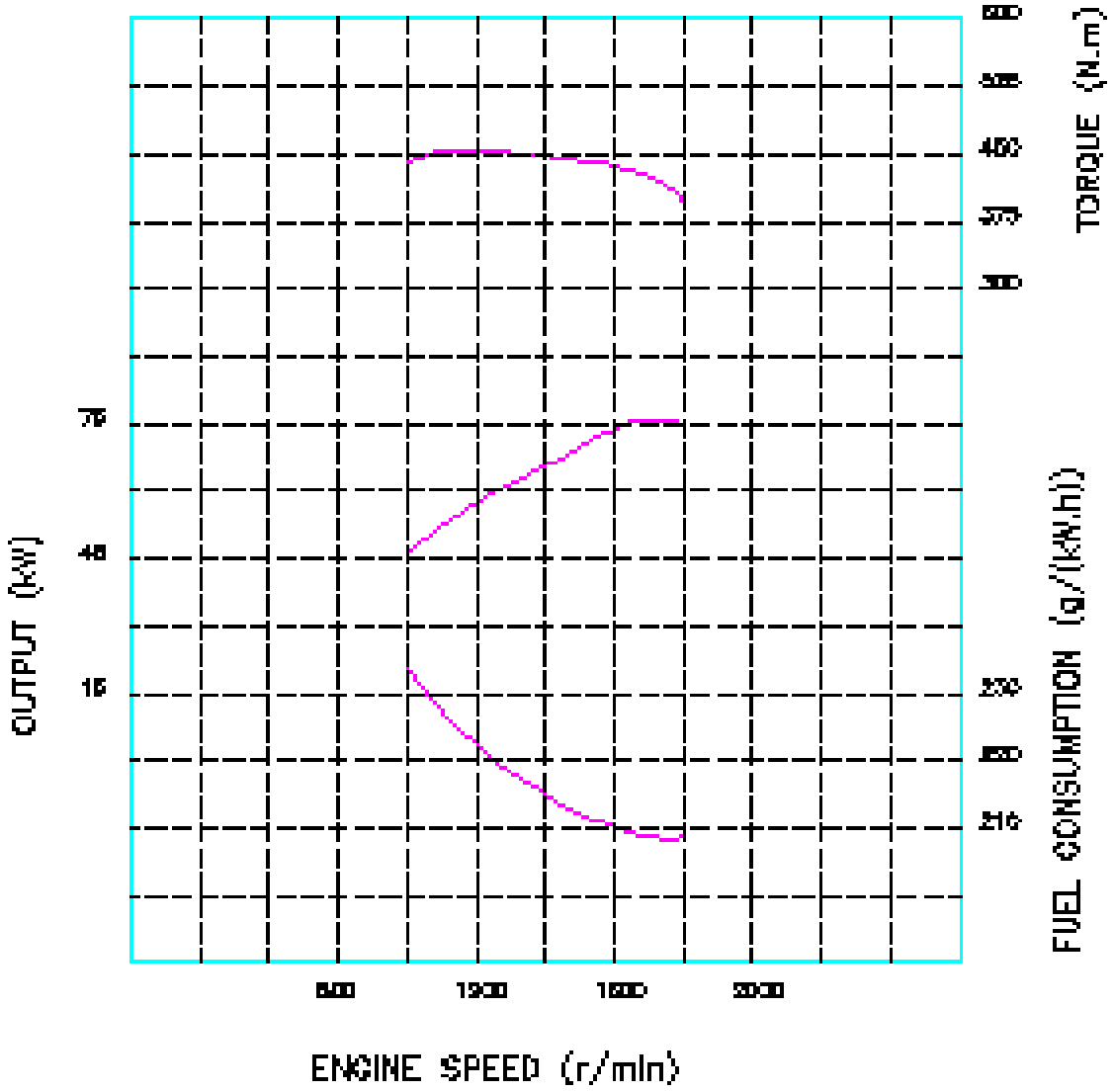

1. Fan
2. Radiator
3. Fuel Filter
4. Turbocharger
5. Air cleaner
6. Water Separator
7. Transmission
8. Oil FIlter
9. Fuel Injection Pump



# PERFORMANCE CURVE

## B4D105 (BL9H) ENGINE

| | |
|---|---|
| Flywheel Horse Power | : 54 kW @ 2200 r/min. |
| Maximum torque | : 275 N.m @ 1400 r/min. |
| Minimum fuel consumption ratio | : 215 g/(kW.h) |



# PERFORMANCE CURVE

## BS4D105 ( 62.5 kVA)

| | |
|---|---|
| Flywheel horsepower | : 66 hp/2.350 rpm |
| Max. Torque | : 25.58 kgm/1,400 rpm |
| Min. fuel consumption ratio | : 165 g/HP.h |

# PERFORMANCE CURVE

## BSC4D105 ( 82.5 kVA)

| | |
|---|---|
| Flywheel horsepower | : 66 hp/2.350 rpm |
| Max. Torque | : 25.58 kgm/1,400 rpm |
| Min. fuel consumption ratio | : 165 g/HP.h |

# WEIGHT TABLE

## B(S)(C)4D105 ENGINE

⚠ This weight table is a guide for use when transporting or handling component.

Unit:Kg

| No. | Item | Components | B4D105 BL9H | | BS(C)4D105 62.5 kVA, 82.5 kVA | |
|---|---|---|---|---|---|---|
| 1 | Turbocharger | NIPPON GARRETT T04B | – | | 7.5 | |
| 2 | Cylinder head assembly | Cylinder head, valve valve spring | 40 | | 40 | |
| 3 | Cylinder block assembly | Cylinder block, cylinder liner, main bearing cap | 105 | | 105 | |
| 4 | Flywheel assembly | Flywheel, ring gear | BL9H | 20 | 62.5 kVA 82.5 kVA | 38 |
| 5 | Flywheel housing assembly | Flywheel housing | BL9H | 30 | 62.5 kVA 82.5 kVA | 30 |
| 6 | Timing gear assembly | | | | | |
| 7 | Oil pan | | BL9H | | | |
| 8 | Crankshaft assembly | Crankshaft, crankshaft gear | 42 | | 42 | |
| 9 | Camshaft assembly | Camshaft, camshaft gear | 8 | | 8 | |
| 10 | Piston connecting rod assembly (for one engine) | Piston, piston ring, piston pin, connecting rod, connecting rod cap bolt | 17 | | 17 | |
| 11 | Fuel injection pump | | 13 | | 13 | |
| 12 | Water pump | | 15 | | 15 | |
| 13 | Starting motor | | 16 | | 16 | |
| 14 | Alternator | | 8 | | 8 | |

# ENGINE

## 12 STUCTURE AND FUNCTION


**GENERAL STRUCTURE** ..... 12-002

**INTAKE AND EXHAUST SYSTEM**
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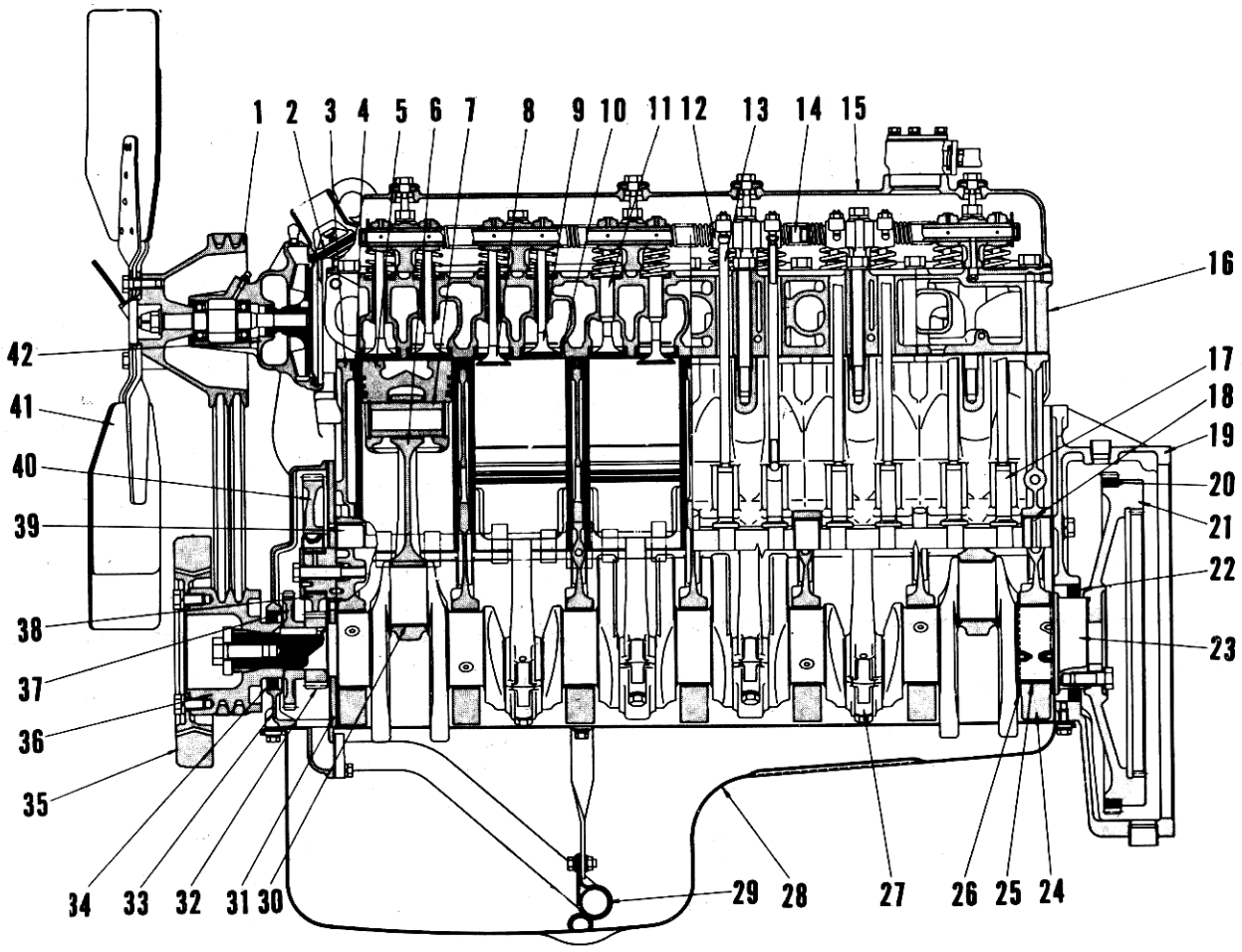
- Starting aid ..... 12-049
- Sensor ..... 12-050

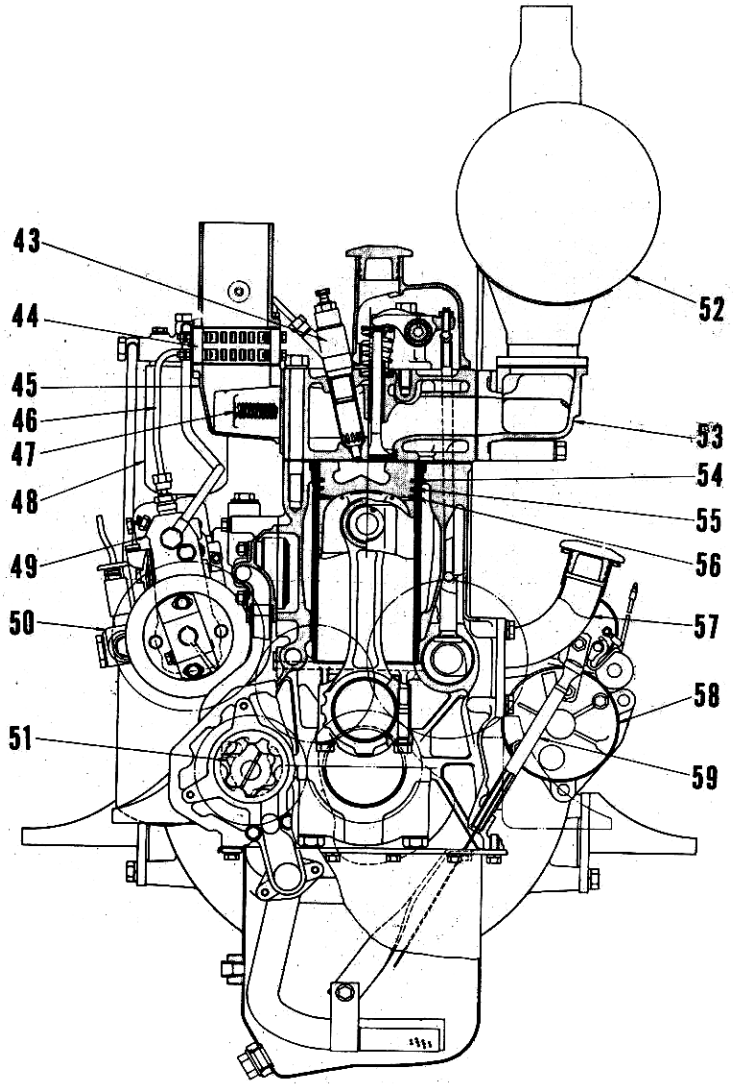
**ACCESSORY**
- Air compressor ..... 12-054

# GENERAL STRUCTURE

**B6D105-1**




1. Fan pulley
2. Thermostat
3. Cylinder block
4. Cylinder liner
5. Piston
6. Connecting rod
7. Piston pin
8. Exhaust valve
9. Intake valve
10. Valve seat
11. Valve guide
12. Rocker arm
13. Push rod
14. Rocker arm shaft
15. Cylinder head cover
16. Cylinder head
17. Tappet
18. Camshaft bushing
19. Flywheel housing
20. Ring gear
21. Flywheel
22. Rear seal
23. Crankshaf
24. Main bearing cap
25. Main bearing
26. Thrust bearing
27. Connecting rod cap
28. Oil pan
29. Oil strainer
30. Connecting rod bearing

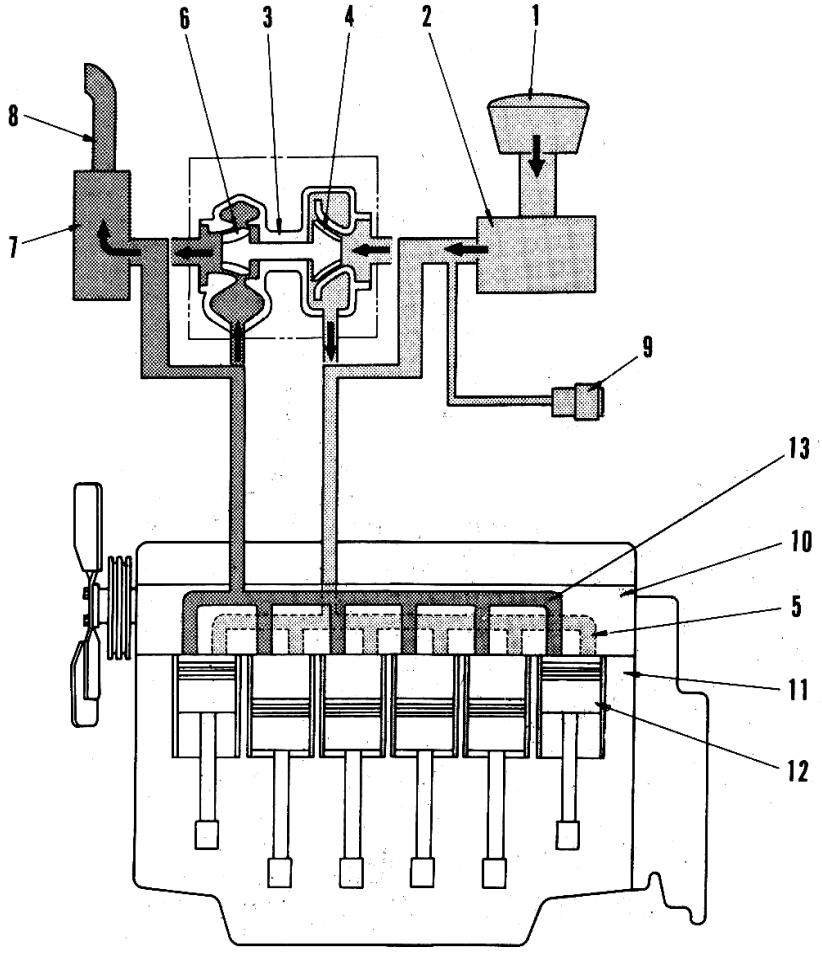



31. Front plate
32. Crankshaft gear
33. Front cover
34. Front seal
35. Vibration damper
36. Crankshaft pulley
37. Oil pump drive crank gear
38. Idler gear
39. Camshaft
40. Camshaft gear
41. Fan
42. Water pump
43. Nozzle holder
44. Ribbon heater
45. Intake manifold
46. Fuel injection pipe
47. Coil heater
48. Fuel filter
49. Fuel injection pump
50. Feed pump
51. Oil pump
52. Muffler
53. Exhaust manifold
54. Piston top ring
55. Piston second ring
56. Piston oil ring
57. Oil filter
58. Starting motor
59. Dipstick

# INTAKE AND EXHAUST SYSTEM

## INTAKE AND EXHAUST SYSTEM CHART

**BS6D105-1**




1. Precleaner
2. Air cleaner
3. Turbocharger (BS6D105)
4. Blower impeller (BS6D105)
5. Intake manifold
6. Turbine impeller (BS6D105)
7. Muffler
8. Exhaust pipe
9. Dust indicator
10. Cylinder head
11. Cylinder block
12. Piston
13. Exhaust manifold

### General description

**1. Structure of intake and exhaust system**

- The intake and exhaust system consists of the precleaner, air cleaner, exhaust manifold, muffler and exhaust pipe. The intake manifold is built-in as a part of the cylinder head.
- BS6D105-1 ENGINE have turbocharger.

**2. Circulation of intake**

- The air intake is first filtered through the precleaner to remove large dust particles after which it is cleaned of fine dirt and dust by the air cleaner. The air is then charged into the engine.
- In case of turbocharger type engine, afte filter through the air cleaners, th air intake is charged into the cylinders under pressure by the blower impellers in the turbocharger.

**3. Functions of dust indicator**

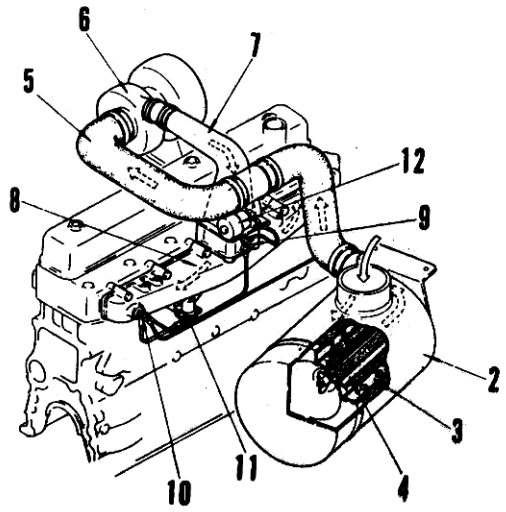
- After filtered through the air cleaner, the negative intake air pressure is transmitted to the dust indicator on the operator's instrument panel. Thereby, the clogged condition of the air cleaer can be sensed by the operator in his seat.
- **Dust indicator** is actuated (gives a red warning mark) when the negative air pressure reaches 635 mm (water column).

**4. Circulation of exhaust**

- Gases produced by the combusions in the cylinders pass through the exhaust manifold, silenced by muffler, and expelled from the exhaust pipe.
- In case of turbocharger type engine, gases passed through the exhaust manifold are charged into muffler after driving the turbine impellers (the blower impellers).

## BS6D105-1 INTAKE SYSTEM

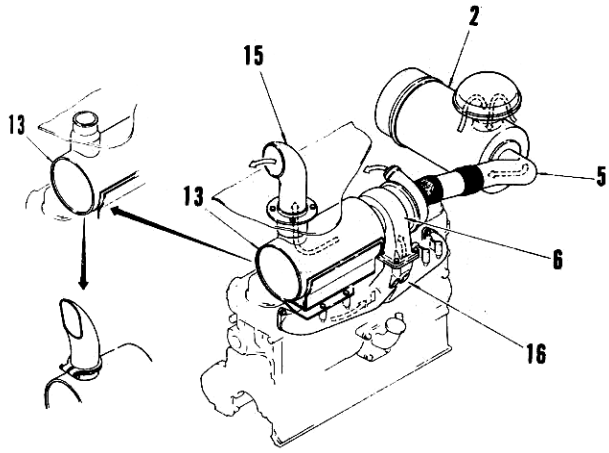
**For BE220-1, BE220LC-2**



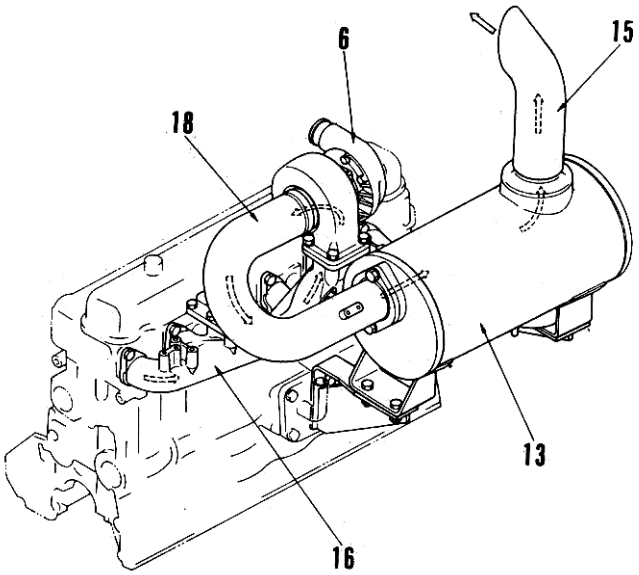

2. Air cleaner body
3. Outer element
4. Inner element
5. Intake pipe
6. Turbocharger
7. Intake pipe
8. Intake manifold
9. Electrical intake air heater
10. Coil heater
11. Relay switch
12. Dust indicator

## BS6D105-1 EXHAUST SYSTEM

**For BE220-1, BE220-2, BE220LC-2 BE100-2, BE125-1**

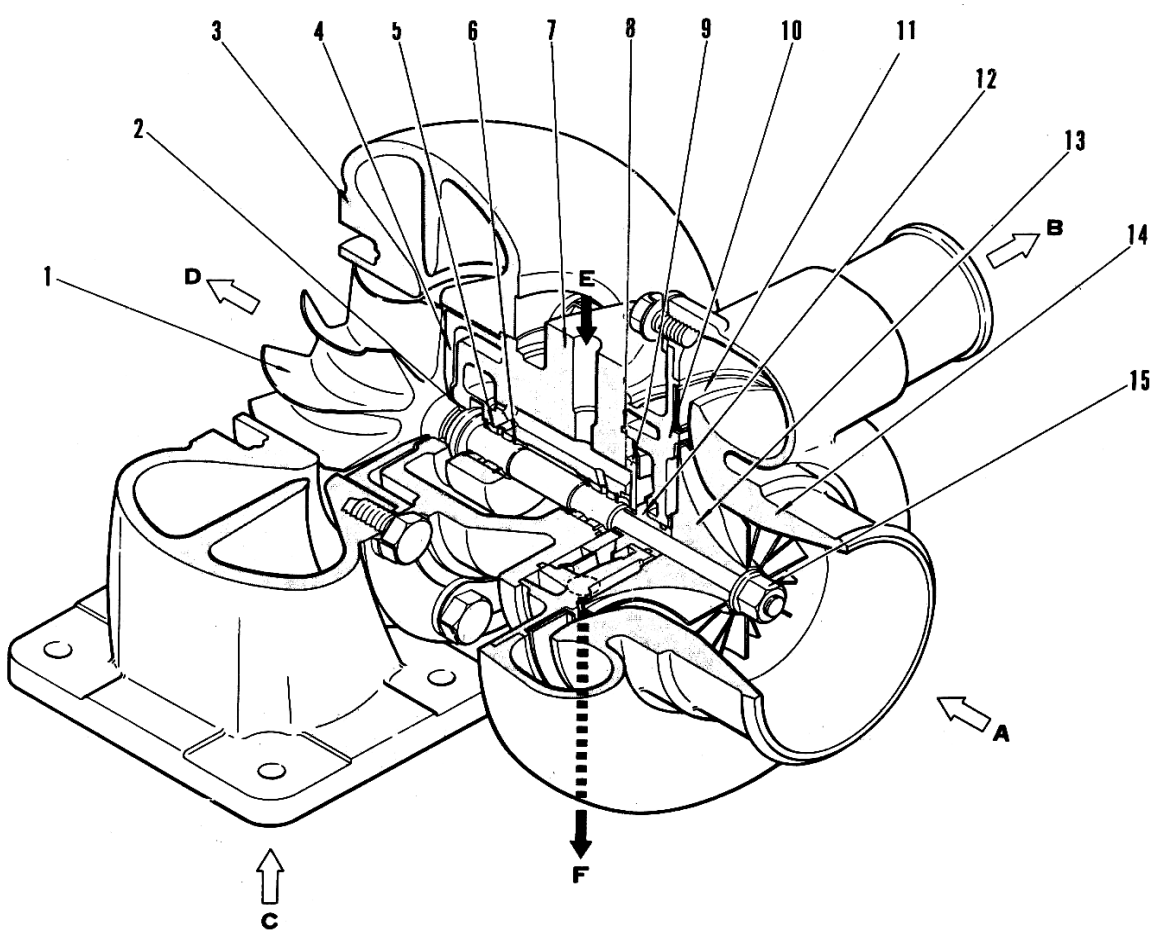



**For BE200-3, BE200LC-3, BE220-3, BE220LC-3**




2. Air cleaner body
5. Intake pipe
6. Turbocharger
13. Muffler
15. Exhaust pipe
16. Exhaust manifold
18. Exhaust connector pipe

# TURBOCHARGER




1. Turbine impeller (Wheel shaft)
2. Piston ring
3. Turbine housing
4. Shroud
5. Journal bearing
6. Retaining ring
7. Center housing
8. Seal ring
9. Thrust bearing
10. Back plate
11. Spring
12. Thrust collar
13. Blower impeller
14. Blower housing
15. Lock nut

A. Air inlet port
B. Air outlet port
C. Exhaust inlet port
D. Exhaust outlet port
E. Oil inlet port
F. Oil outlet port

**Structure :**

- The turbocharger for BS6D105 type engine is the type T04B.
- The turbocharger consists mainly of the blower housing, blower impeller, turbine housing, wheel shaft and the center housing provided with bearings and seals and forming the lubrication and support section.
- As the rotating components of a turbocharger, a wheel shaft consists of turbine impellers and a shaft integrated together, and blower impellers are forcefitted on the shaft portion opposite to the turbine impellers and fixed positively with lock nuts.
- The blower housing and the center housing and inter connected with ring type V-clamps, while the center housing and the turbine housing are mutually secured with 6 bolts.

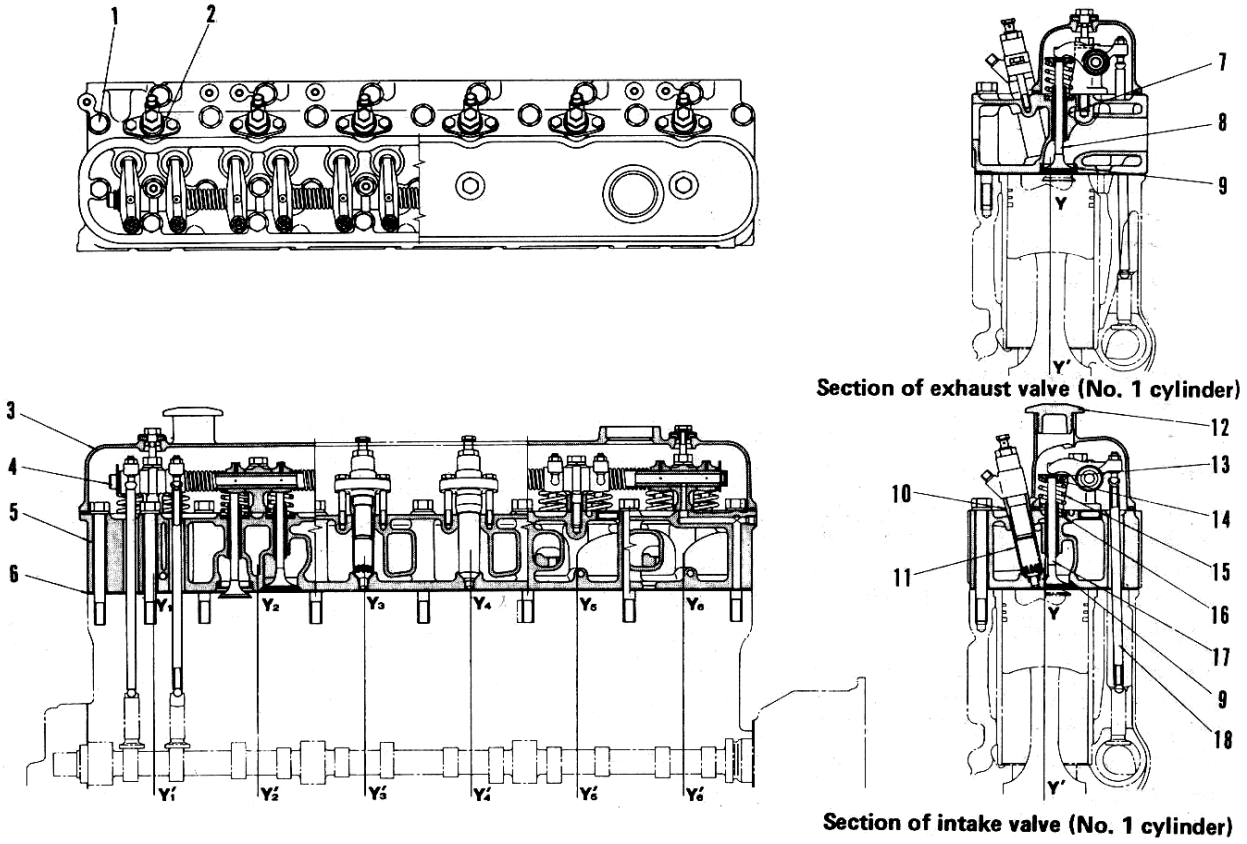
**Function :**

- In the turbocharger, the turbine impeller is rotated by the energy of the flowing gases poduced by combustion in the cylinders, and the blower impeller on the same shaft in turn charges the intake air into the cylindes under pressure.
- For lubrication, the engine oil is supplied through a hole in the top of the center housing. The oil flows back into the engine oil pan through a hole in the bottom of the center housing after lubricating the bearing.
  Oil in the turbocharger is prevented from leaking out by means of the seals on both sides of the center housing.

**Specification :**

| Item | | Specification |
|---|---|---|
| Type | | NIPPON GARRETT T04B |
| Overall length | (mm) | 225 |
| Overall width | (mm) | 195 |
| Overall height | (mm) | 150 |
| Weight | (kg) | 7.5 |
| Continuous rotating speed | (rmp) | 125,000 (max.) |
| Maximum charge | (kg/min.) | 22 |
| Compression ratio | | 3 (max.) |
| Appropriate ( °C ) exhaust temp. | | 675 max. (at inlet port) |
| Direction of rotation | | Clockwise as viewed from the blower side |

# ENGINE BODY
## CYLINDER HEAD




1. Cylinder head mounting bolt
2. Nozzle holder
3. Head cover
4. Rocker arm shaft
5. Cylinder head
6. Cylinder head gasket
7. Valve guide
8. Exhast valve
9. Valve seat
10. Nozzle holder packing
11. Nozzle holder sleeve
12. Oil filler cap
13. Valve spring guide
14. Valve cotter
15. Valve spring
16. Valve spring seat
17. Intake valve
18. Push rod

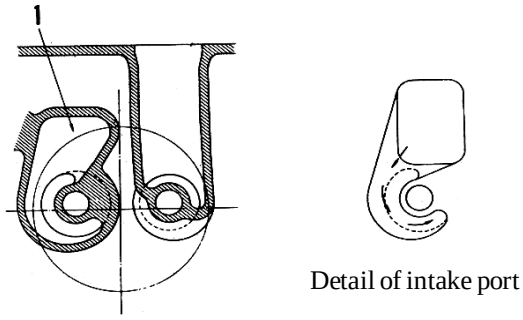
Y - Y' : Center of cylinder

## Structure :

**1. Cylinder head**

- The cylinder head is provided with the following. features, for the smooth flow of the intake air and exhaust, as well as, for the satisfactory mixing of fuel and air;by imparting a swirling motion.

1) One intake air port and one exhaust port are provided separately for each cylinder with a large space between the valves.
2) The intake air port (1) is shaped as a spiral as shown below.




Section of intake and exhaust ports



Detail of intake port

- Furthermore, the cylinder head is designed to prevent the concentration of thermal and mechanical stresses.

1) Edges are eliminated from the machine parts.
2) The intake and exhaust valves are positioned alternately for the uniform distribution of heat on the heads underside surfacc.
3) The flow of cooling water surrounding the injection nozzles, exhaust ports, where the temperature is liable to rise a marked degree, is forced to flow fast by means of guide tubes (directors).

**2. Intake and exhaust valve**

- Valve inserts with high heat and wear resistant qualities are force fitted into the seats for the intake and exhaust valve.

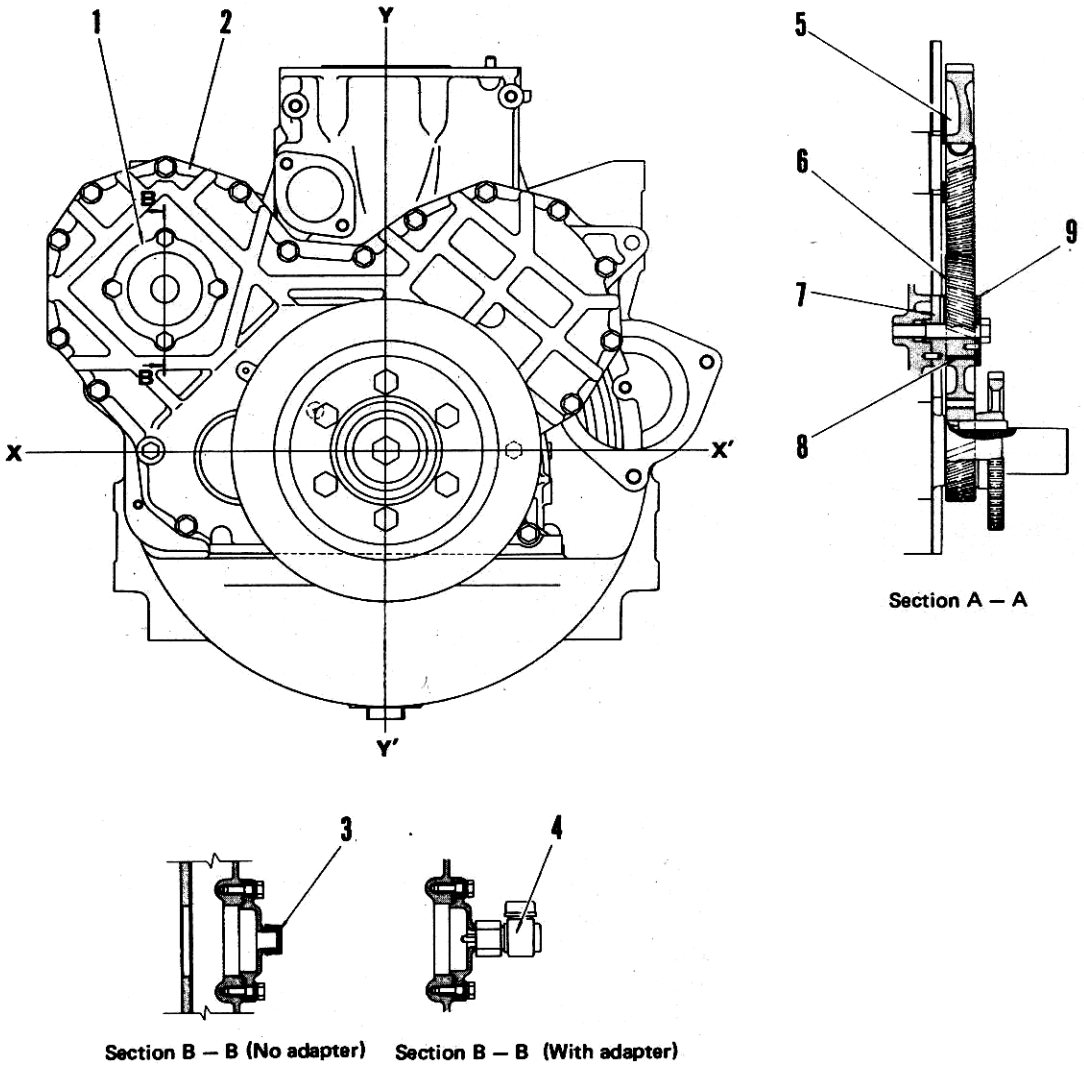
**3. Valve seat insert**

- When the valve seats have worn out excessively, only the inserts need to be replaced, eliminating the necessity of replacing the heads.

**4. Cylinder head gasket**

- The cylinder head gasket comprises top the bottom sheets of steel with interlocking claws, and containing a sheet of asbestos rubber adhered to the inside face of the sheets, to withstand the high pressure and heat.
- The areas surrounding water oil and tappet holes are treated with a special coating to increase their sealing effect.
- Steel wires are inserted around the holes in the cylinders to catch hold of the stainless steel grommets;thereby preventing gas leakage.

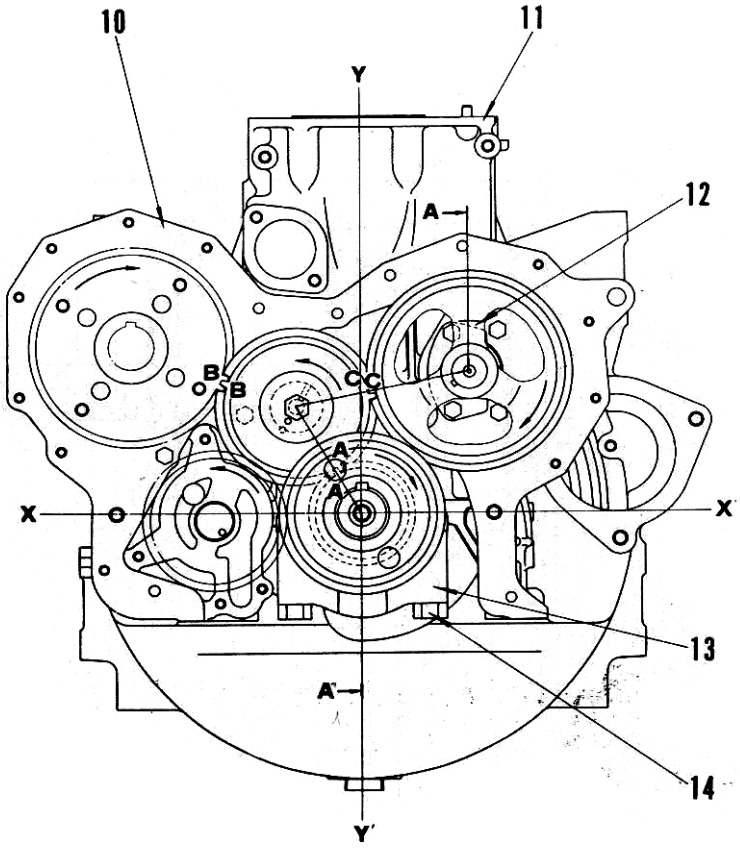
# MAIN CIRCULATION PART (1/3)




1. Bearing cover
2. Front cover
3. Cap (for engine speed take out)
4. Adapter (For engine speed take out)
5. Camshaft gear (52 teeth)
6. Idler gear (40 teeth)
7. Idler gear shaft
8. Bushing
9. Thrust plate (for idler gear)
10. Front plate
11. Cylinder block
12. Thrust plate (for camshaft gear)
13. Main bearing cap
14. Main bearing cap bolt

X - X': Center of crankshaft

Y - Y': Center of cylinder



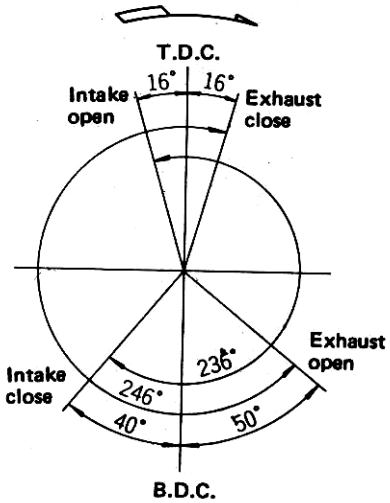

**Cylinder block**

Crankshaft : 7 bearings
Camshaft : 4 bearings

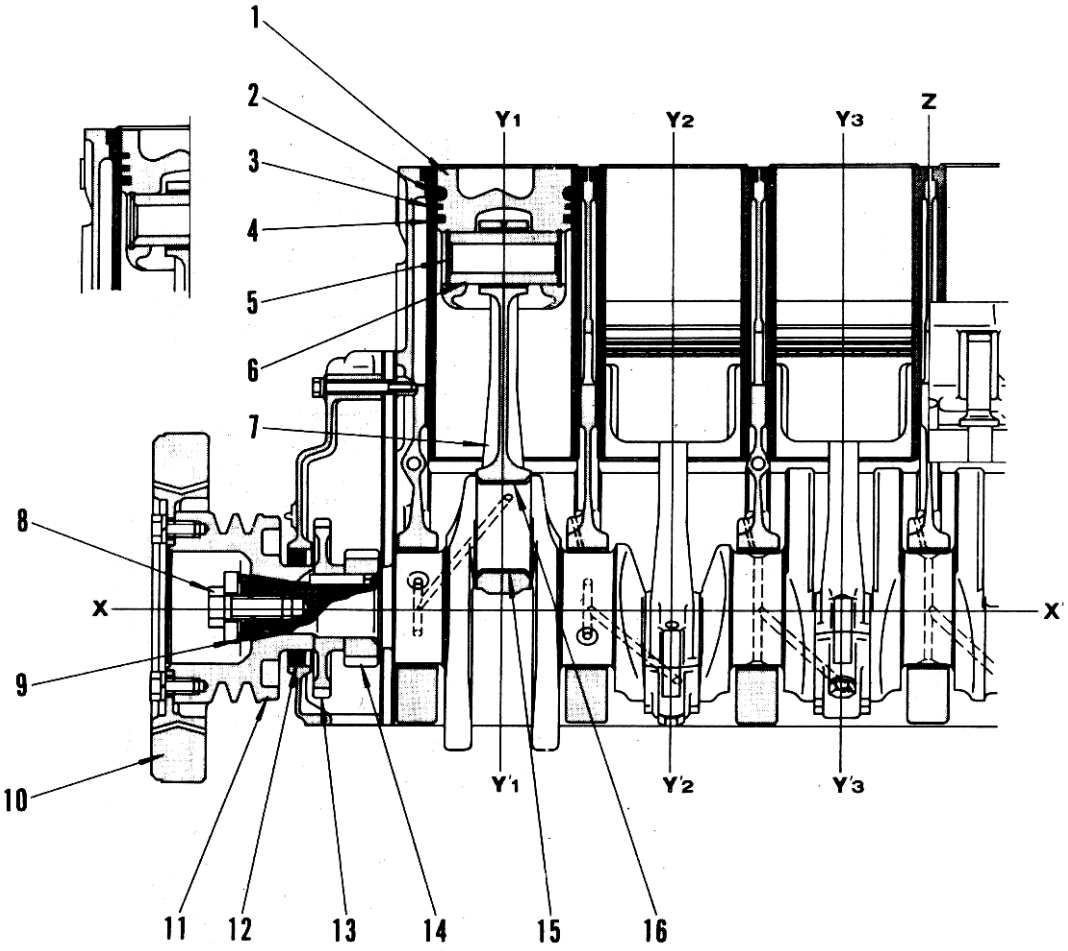
**Crankshaft :** Stamp forging
High frequency hardening
on journal face

**Camshaft :** Stamp forging
High frequency hardening
on journal face and cam face

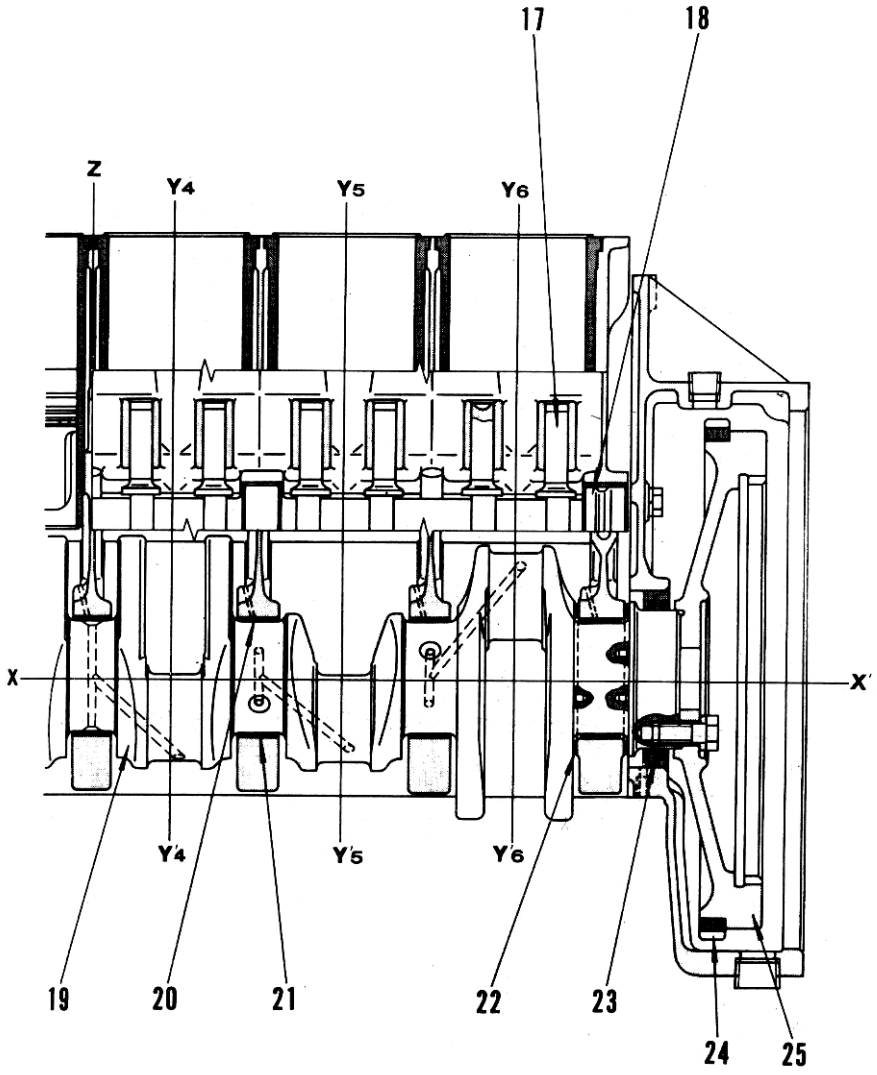
**Valve timing**



# MAIN CIRCULATION PART (2/3)

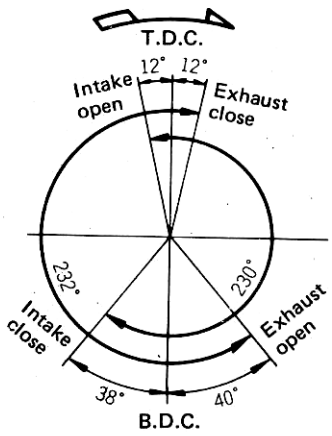



1. Piston
2. Top ring
3. Second ring
4. Oil ring
5. Snap ring
6. Piston pin
7. Connecting rod
8. Crankshaft pulley mounting bolt
9. Tapered collar
10. Vibration damper
11. Crankshaft pulley
12. Front seal
13. Oil pump drive gear (44 teeth)
14. Crankshaft gear (26 teeth)
15. Connecting rod bearing (Lower)
16. Connecting rod bearing (Upper)
17. Tappet
18. Cam shaft
19. Crankshaft
20. Main bearing (Upper)
21. Main bearig (Lower)
22. Thrust metal
23. Rear seal
24. Ring gear
25. Flywheel



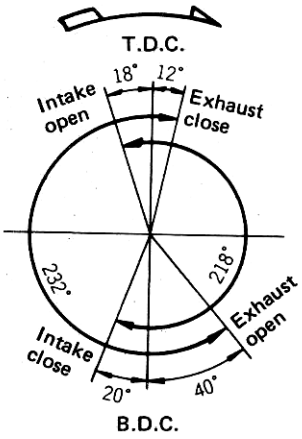

**Valve timing**

**B6D105-1**




**Valve timing**

**BS6D105-1**




**Piston**

. Type: Oval taper profile, thermal flow type.

Combustion chamber :
MTCC (Micro Turbulence combustion Chamber) Maelstrom-combustion chamber.

Front seal :
Single lip with dust seal.

Rear seal :
Double lip (for construction equipment)
Single lip (for generator)

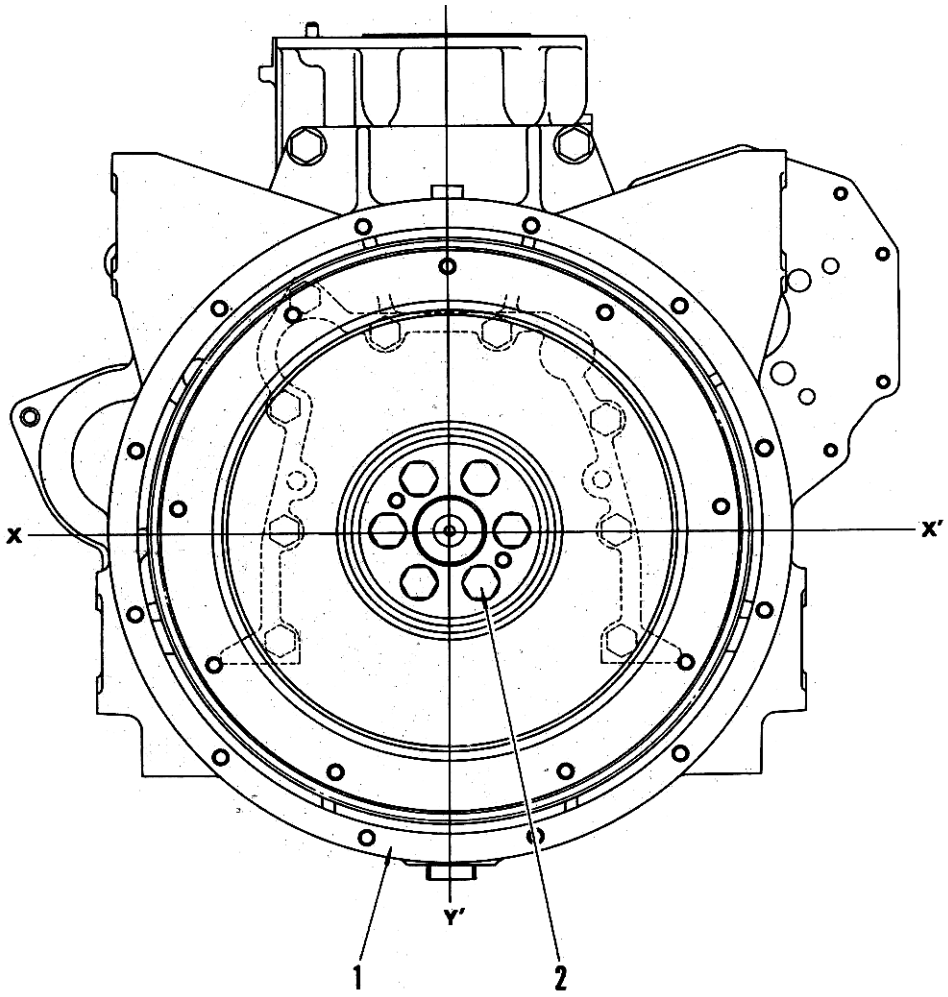
Piston cooling :
Holes on cylinder block for cooling

**Piston ring**

| Engine | Top ring | Second ring | Oil ring |
|---|---|---|---|
| B6D105-1 | Flat barrel. Hard chrome plated. | Tapered face. Inner cut. | With coil expander. Hard chrome plated. |
| BS6D105-1 (Engine No. — ★) | Keystone barrel. Hard chrome plated. | Single keystone tapered face. | With coil expander. Hard chrome plated. |
| BS6D105-1 (Engine No. ★ —) | Keystone barrel. Hard chrome plated. | Single keystone tapered face. | Coil steel type  With coil expander. Hard chrome plated. |

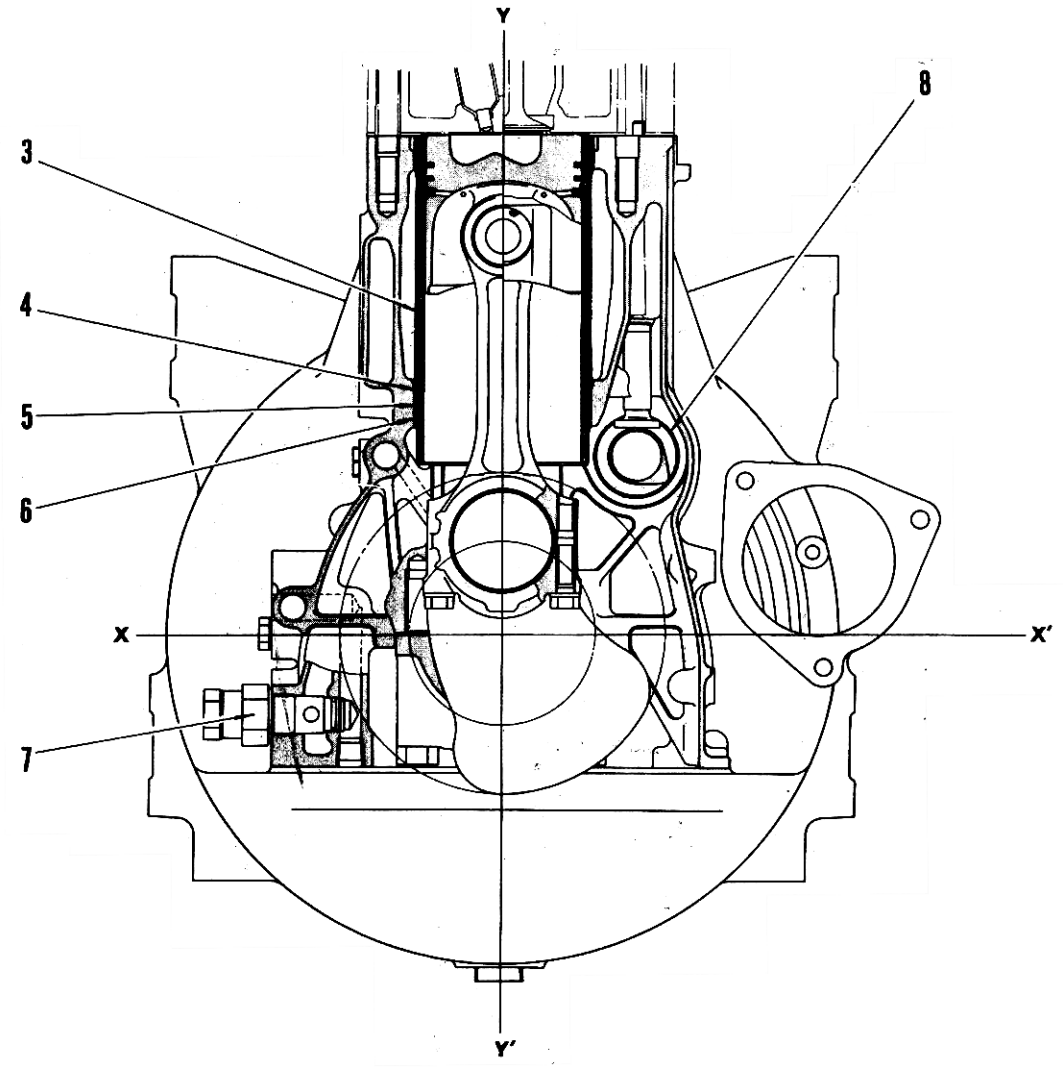
★: Refer to Parts Book for applicable Engine No.

# MAIN CIRCULATION PART (3/3)




1. Flywheel housing
2. Flywheel mounting bolt
3. Cylinder liner
4. Crevice seal
5. Liner O-ring (Black)
6. Liner O-ring (Orange)
7. Oil pump regulator valve
8. Camshaft bushing

X - X' : Center of crankshaft
Y - Y' : Center of cylinder




**Cylinder liner**

Wet type. Inside horning

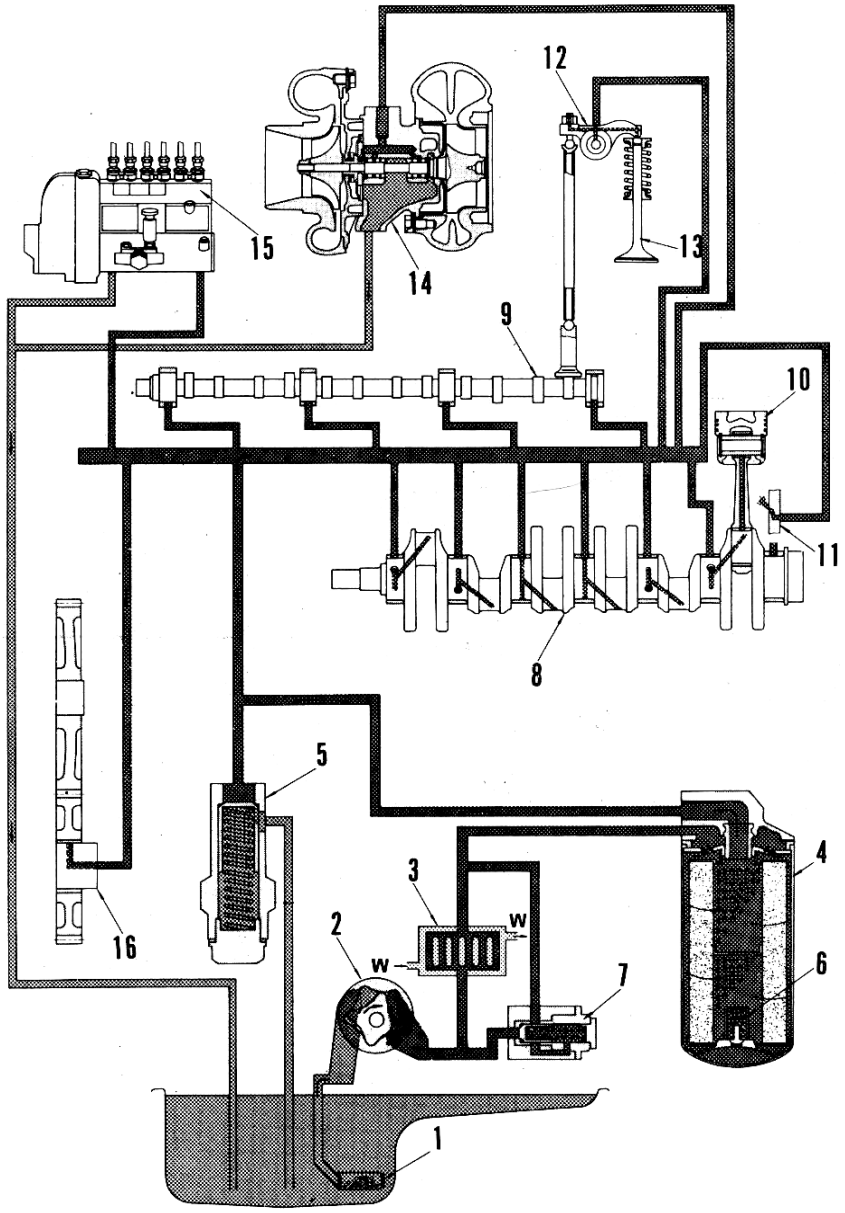
Liner ring

Top : Crevice seal
Center : O-ring (Nitrile rubber)
Lower : O-ring (Silicon rubber)

# LUBRICATING SYSTEM

## LUBRICATING SYSTEM CHART

**B(S)6D105-1**




1. Oil strainer
2. Oil pump
3. Oil cooler
4. Oil filter
5. Regulator valve
6. Oil filter safety valve
7. Oil cooler relief valve

7'. Oil cooler thermo valve

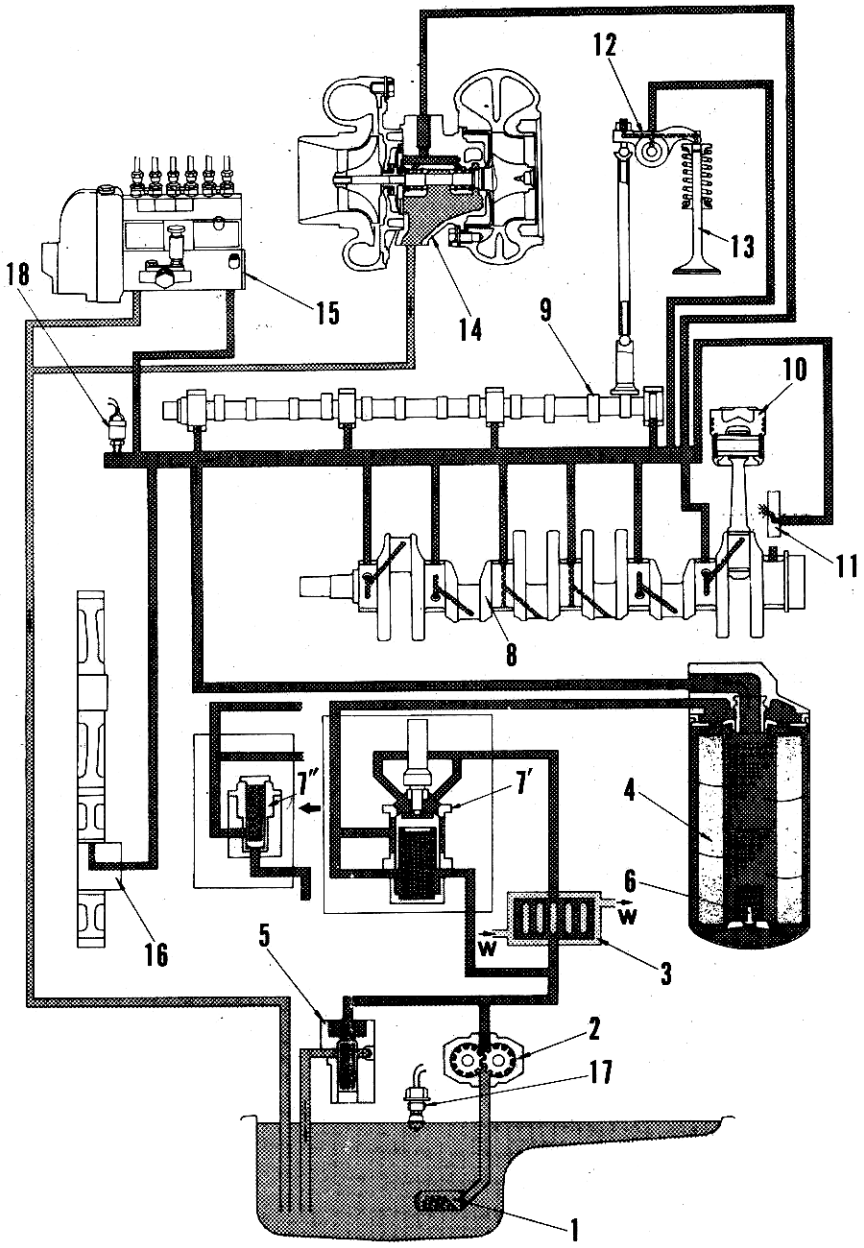
7". Oil cooler relief valve

8. Crankshaft
9. Camshaft
10. Piston
11. Piston cooling
12. Rocker arm
13. Intake or exhaust vavle
14. Turbocharger (BS6D105-1)
15. Fuel injection pump
16. Timing gear

17. Oil level sensor
(For BE200-3,CE220-C
BE200LC-3, BE220LC-3)

17. Oil Pressure sensor
(For BE200-3,CE220-C
BE200LC-3, BE220LC-3)

W. Cooling water




**1. Structure of lubricating system**

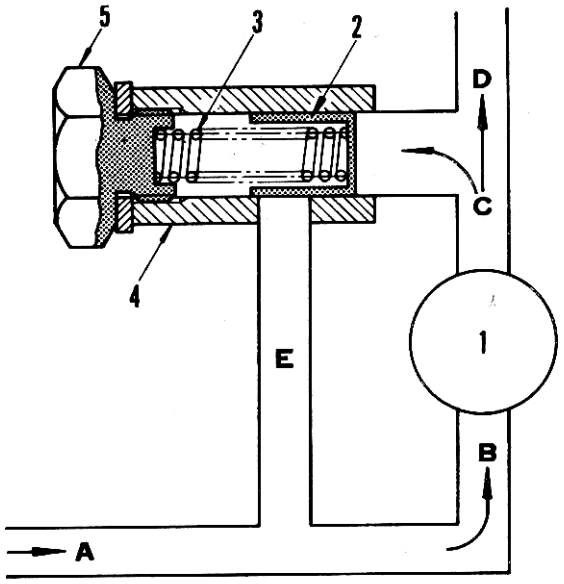
- The lubricating system consists mainly of the oil strainer, oil pump, oil pump regulato, oil coller, oil filter and safety valve to lubricate various engine parts.

**2. Circulation of lubricating oil**

- The lube oil flows from the oil pan to the oil pump through the oil strainer where relatively large particles of dust, dirt or foreign matter is removed from the oil. The oil pump is driven by the gear in the crankshaft cluster to such in and charge out the oil under pressure.
- The oil discharged from the pump is cleaned fully through the oil filter (**full-flow** type.)
  Thus, the oil is distributed to various lubrication points in the engine.
- The oil is cooled, through heat exchanger with the engine cooling water in the oil cooler.

## FUNCTION OF THE OIL PUMP REGULATOR

- The oil pump regulator is provided in the discharge circuit of the main oil pump. To prevent excessive increase in the oil pressure in the lubrication system.
- If the oil pressure rises excessively, the oil pressure on the discharge side (C) will depress the regulator valve (2), opening the return circuit (E), which will, in turn, cause the oil to flow back the the suction side of the pump.

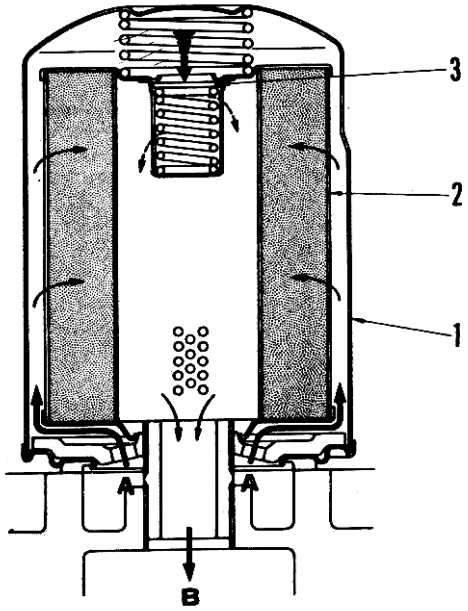



1. Oil pump
2. Regulator valve
3. Valve spring
4. Regulator case
5. Plug

A. From oil pump
B. Oil pump suction side
C. Oil pump discharge side
D. To oil filter
E. Oil return circuit

## FUNCTION OF THE SAFETY VALVE

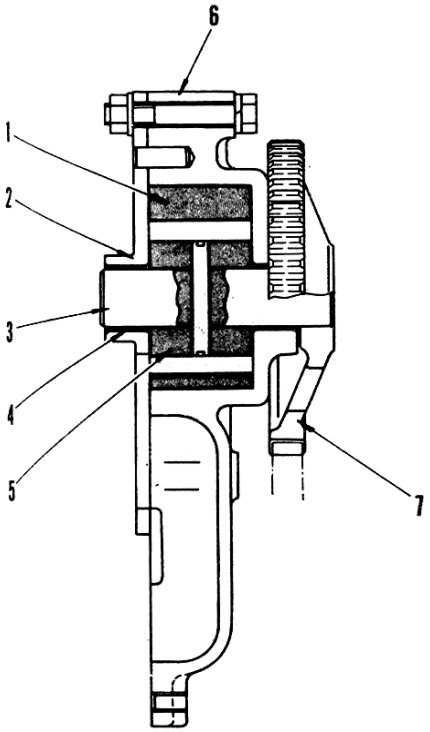
- In the lubrication circuit, a safety valve is provided in the filter in addition to the oil pump regulator to prevent the interruption of oil flow to the lubricating points due to the clogged oil filter.
- The safety valve is actuated by the pressure difference at the in and out side of the oil filter.
- In the element (2) of the oil filter (1) is clogged, the pressure deference between outside and inside of the filter element will be larger, pushing in the valve (3), which will in turn, casue the oil discharged from the oil pump (A) to flow directly to various engine parts (B), not by-passing the filter element.

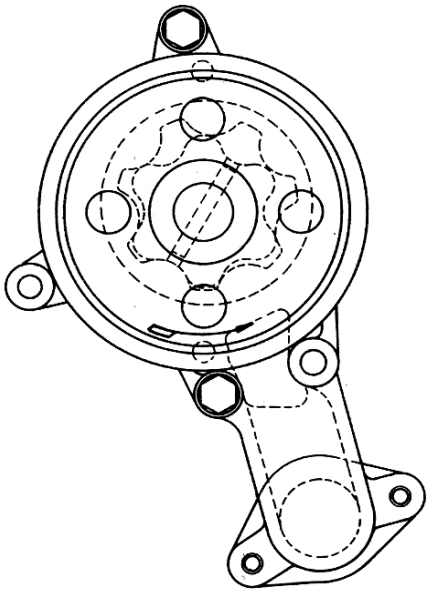



1. Oil filter
2. Filter element
3. Safety valve

A. From oil pump
B. To various engine parts

# OIL PUMP



1. Outer rotor
2. Pump cover
3. Pump shaft
4. Bushing
5. Inner rotor
6. Pump body
7. Drive gear (38 teeth)

**Oil pump**

Type: Trochoid Pump
Pump speed: Engine speed x 1.158

**Front oil seal**

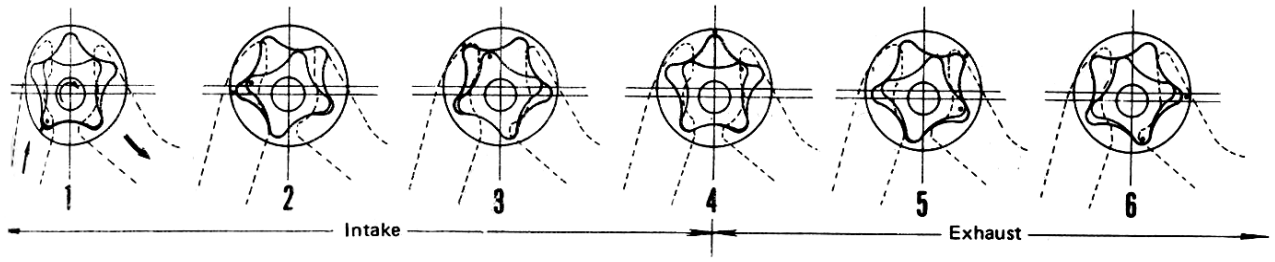
Single lip with dust seal

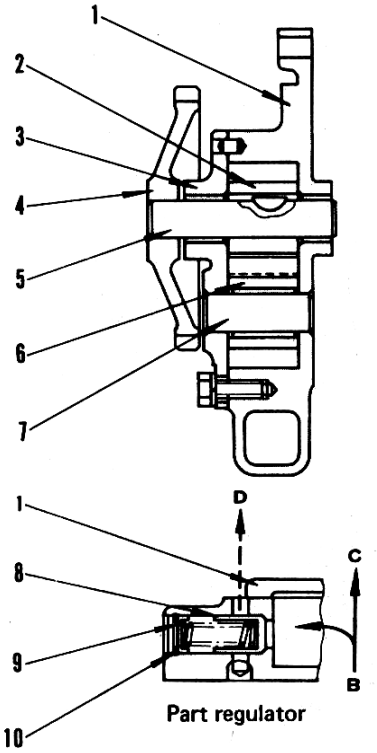
**Structure**

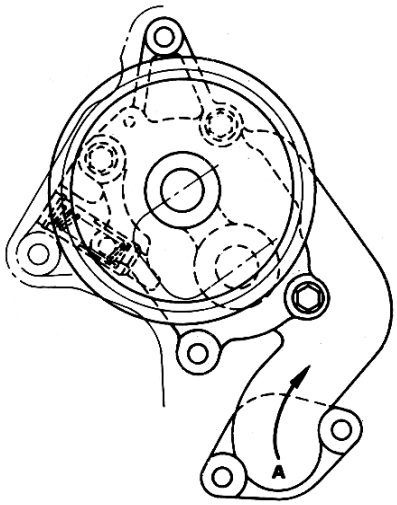
- Oil pump is installed in the engine front cover.
- The drive gear is attached at the rear end of the rotor shaft of the oil pump and is in gear with the drive gear at the front side of the crankshaft.

**Function**

- The inner rotor (1) of a trochoid pump is rotated together with the rotor shaft (3). The number of teeth in the inner rotor is one less than the outer rotor (2). Both rotors rotates in the same direction with their respective centers set off.
- The oil is sucked into the pump when the tooth clearance between the inner and outer rotors is extended. The oil is discharged when the tooth clearance becomes smaller.






1. Oil pump body
2. Drive gear
3. Pump cover
4. Pump drive gear (38 teeth)
5. Drive shaft
6. Driven gear
7. Driven shaft
8. Regulator valve
9. Valve spring
10. Valve retainer

A. From oil strainer
B. From oil pump
C. To engine each section
D. To oil pan

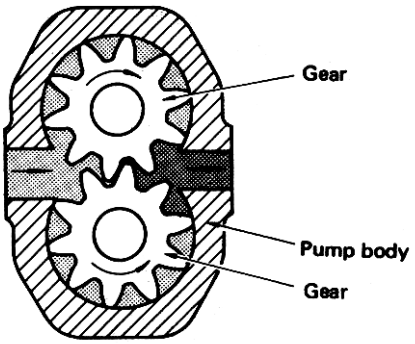
**Oil pump**

Type: Gear Pump
Pump speed: Engine speed x 1.158

**Regulator valve**

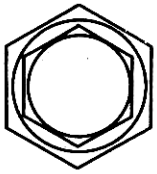
Cracking pressure : 6.5± 0.5 kg/cm²

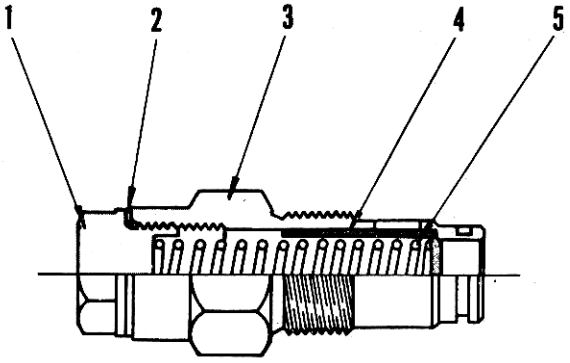
**Function**




- The gears rotate in the direction shown by arrow so that the vacancy enclosed with each gear and pump body is filled with oil.
- The enclosed oil is moved along the pump body wall toward the pump outlet with rotation of the gear.
- On the oil outlet side, two gear are meshed with each other to eliminate clearance, thus forcing the oil to go out of the outlet port.

# REGULATOR VALVE

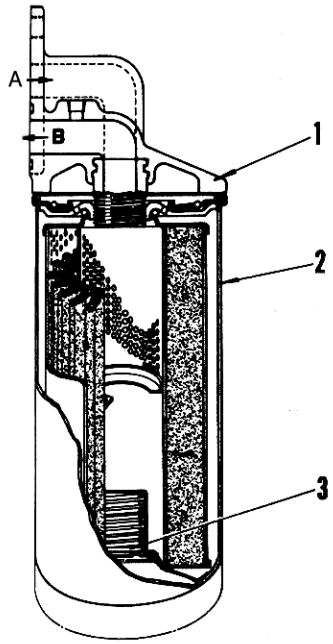


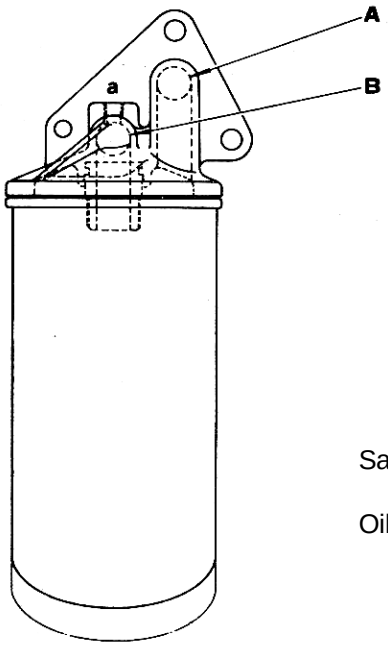



1. Nut
2. Shim
3. Valve body
4. Valve
5. Valve spring

**Regulator valve**
Cracking pressure: 8.25 to 8.75 kg/cm²

# OIL FILTER (with safety valve)



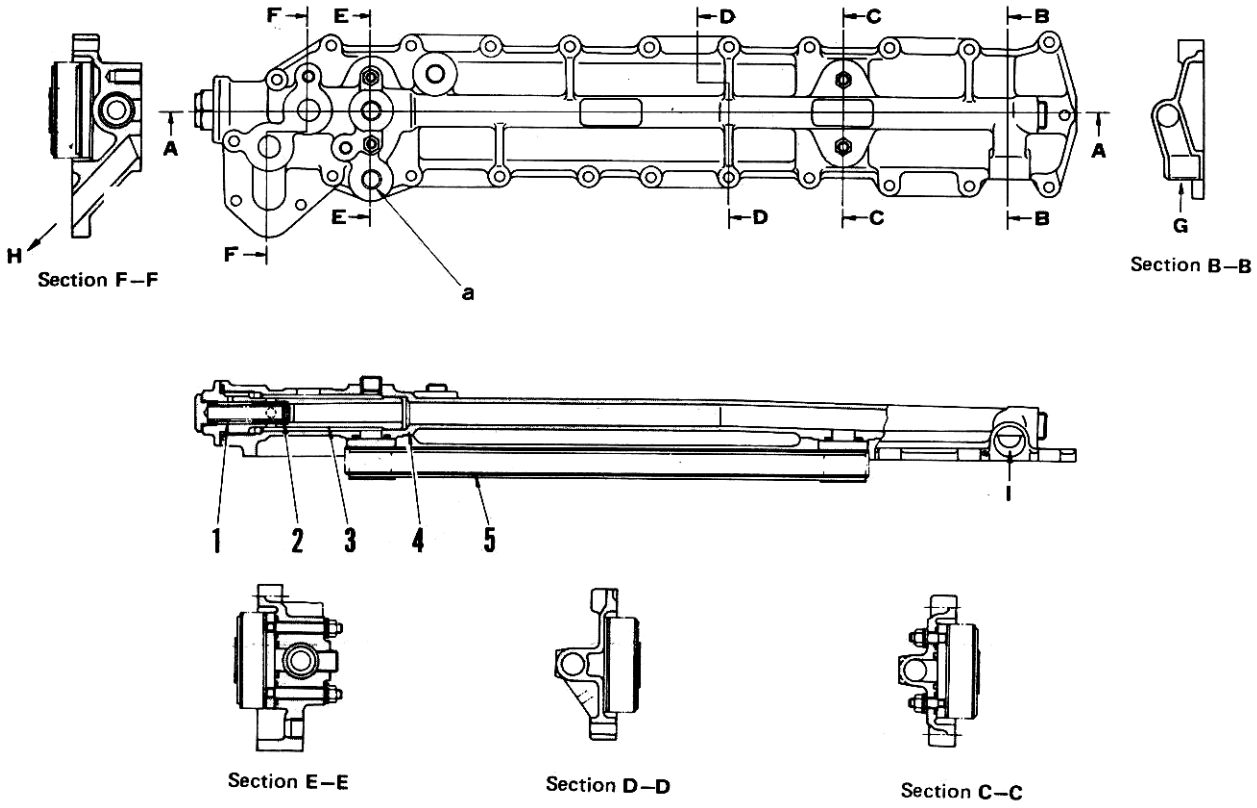




1. Filter bracket
2. Cartridge

A. From oil pump
B. To engine each section
a. Oil pressure tap

Safety valve cracking pressure
: 1± 0.2 kg/cm²
Oil filter effective area : 0.5 m²

# OIL COOLER




1. Valve spring
2. By-pass valve
3. Valve case
4. Cooler cover
5. Cooler element

G. From oil pump (oil)

H. To engine each section (oil)

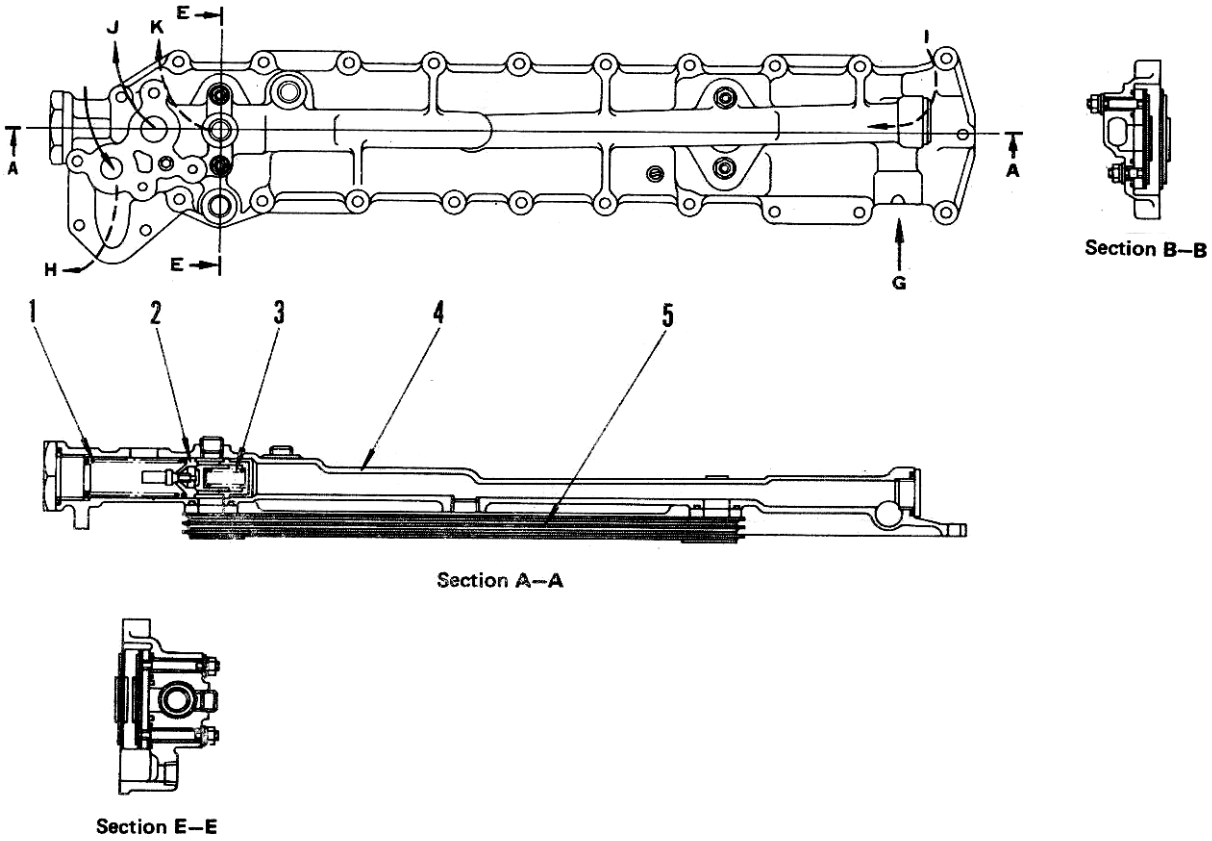
I. From water pump (Water)

a. Water drain port

Oil cooler by-pass valve
Cracking pressure : 4± 0.2 kg/cm²

**Structure and function**

- The oil cooler consists of element and cover. The oil flowing through the cooler element with the cooling fin is cooled properly by the engine cooling water flowing outside the element.



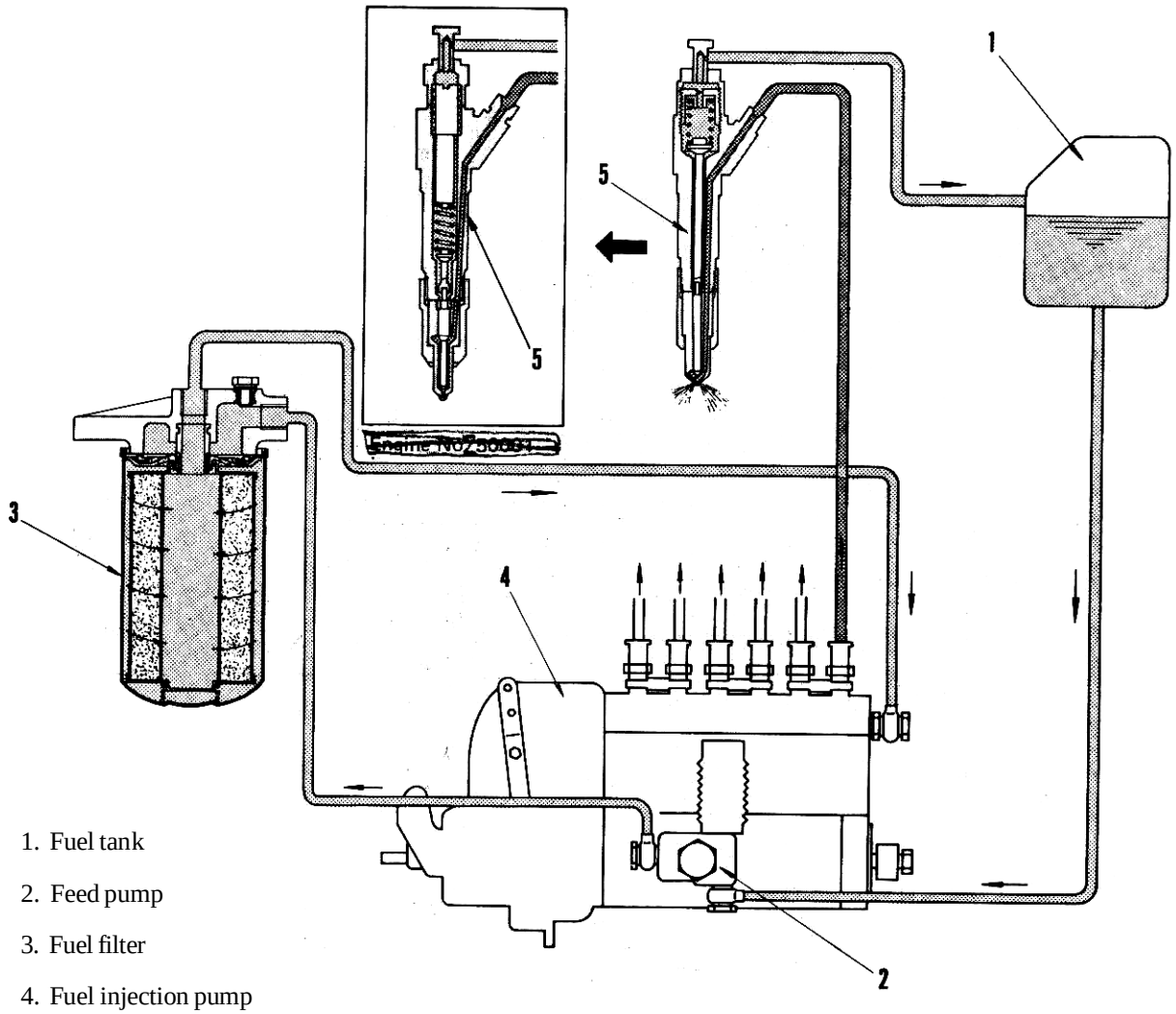

1. Spring
2. Thermo valve
3. Valve spring
4. Cooler cover
5. Cooler element

G. From oil pump (oil)
H. To engine each section (oil)
I. From water pump (Water)
J. To oil filter (Oil)
K. To engine each section (Water)

**Oil cooler thermo valve**

- Valve opening temperature : 104° C
- Temperature when fully open : 110° C
- Lift when fully open : 5mm min.

# FUEL SYSTEM
## FUEL SYSTEM CHART




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

**GENERAL DESCRIPTION**

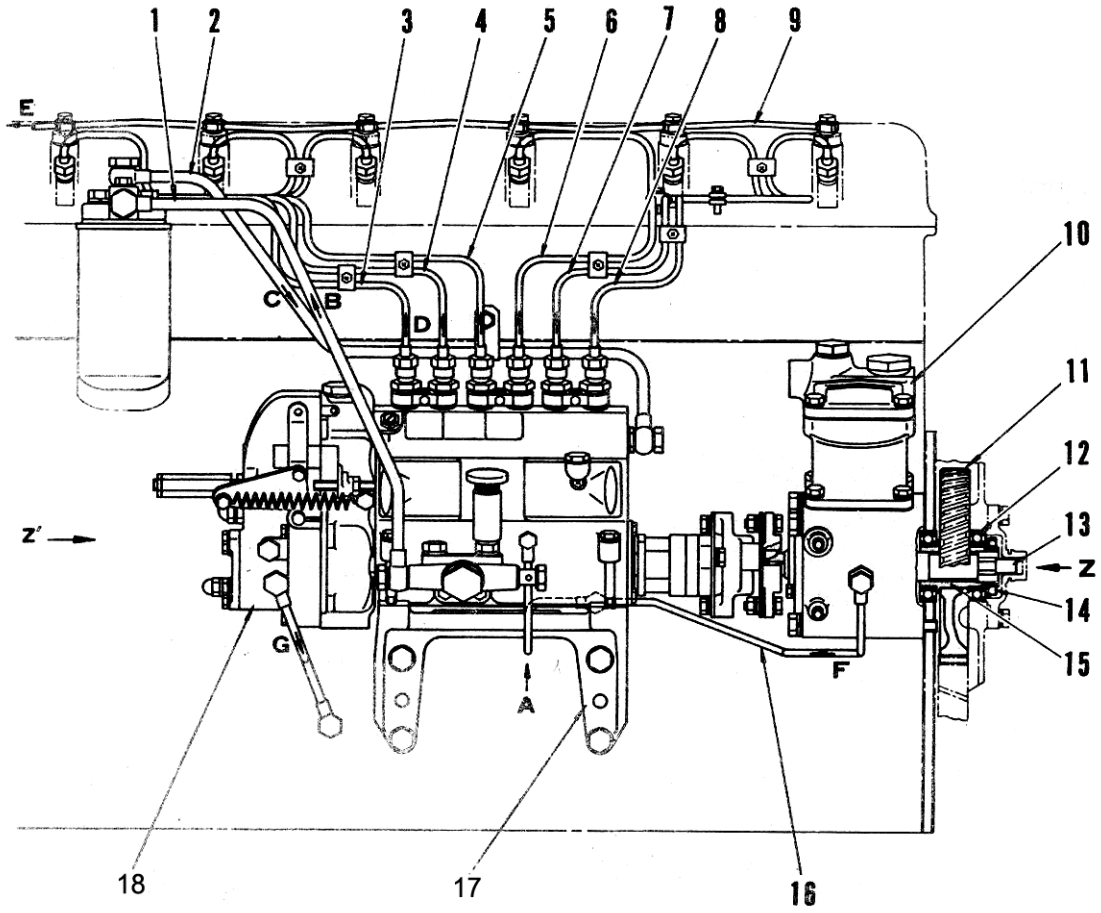
**1. Structure and function**

. The Fuel system consists mainly of the fuel tank, feed pump, fuel filter, fuel injection pump, fuel injection nozzles and governor (built as one unit with the fuel injection pump).

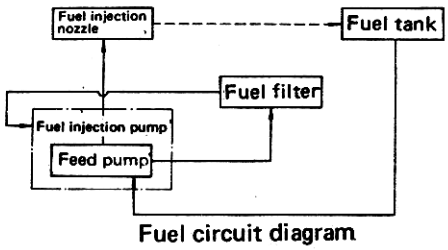
**2. Circulation of fuel**

1) Fuel isdelivered from the fuel tank to the injection pump though the fuel filter by the feed pump driven by the fuel injection pump cam. During the course from the tank to the injection pump, the fuel is cleaned of rough dirt through the gauge filter at the inlet to the feed pump. Then, complete dust removal and water sepa ration from the oil are accomplished through the filter.
2) Fuel entering the injection pump is pressurized by the pump plunger to that required for injection and injected into each cylinder through the injection nozzle timing for the cylinder.

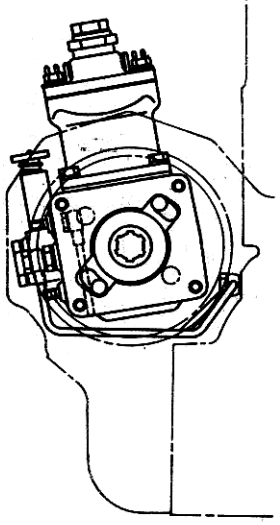
# FOR CONSTRUCTION EQUIPMENT

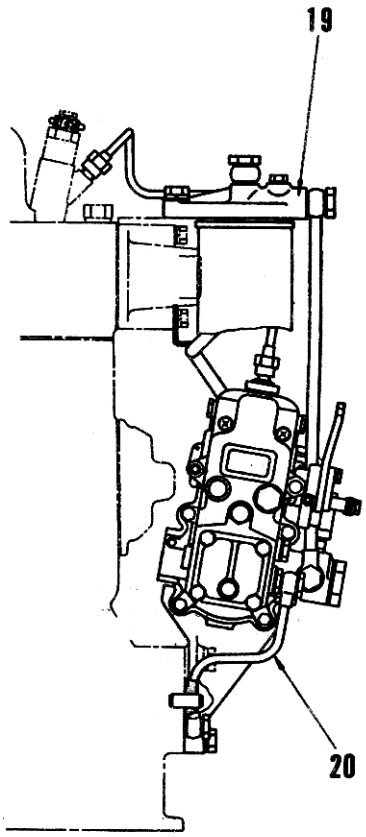



1. Fuel hose (Filter inlet)
2. Fuel hose (Filter outlet)
3. Fuel injection pipe (No. 6)
4. Fuel injection pipe (No. 5)
5. Fuel injection pipe (No. 4)
6. Fuel injection pipe (No. 3)
7. Fuel injection pipe (No. 2)
8. Fuel injection pipe (No. 1)
9. Spill tube
10. Air compressor
11. Fuel injection pump drive gear (52 teeth)
12. Ball bearing
13. Engine speed takeout shaft
14. Lock nut
15. Drive shaft
16. Oil tube (Supply)
17. Pump bracket
18. Fuel injection pump
19. Fuel filter
20. Oil tube (return)



Fuel circuit diagram


Z view



Z' view

A: Form fuel tank (Fuel)

B: From feed pump (Fuel)

C: From fuel filter (Fuel)

D: From injection pump (Fuel)

E: To fuel tank (Fuel)

F: From oil pump (Oil)

G: To oil pan (Oil)

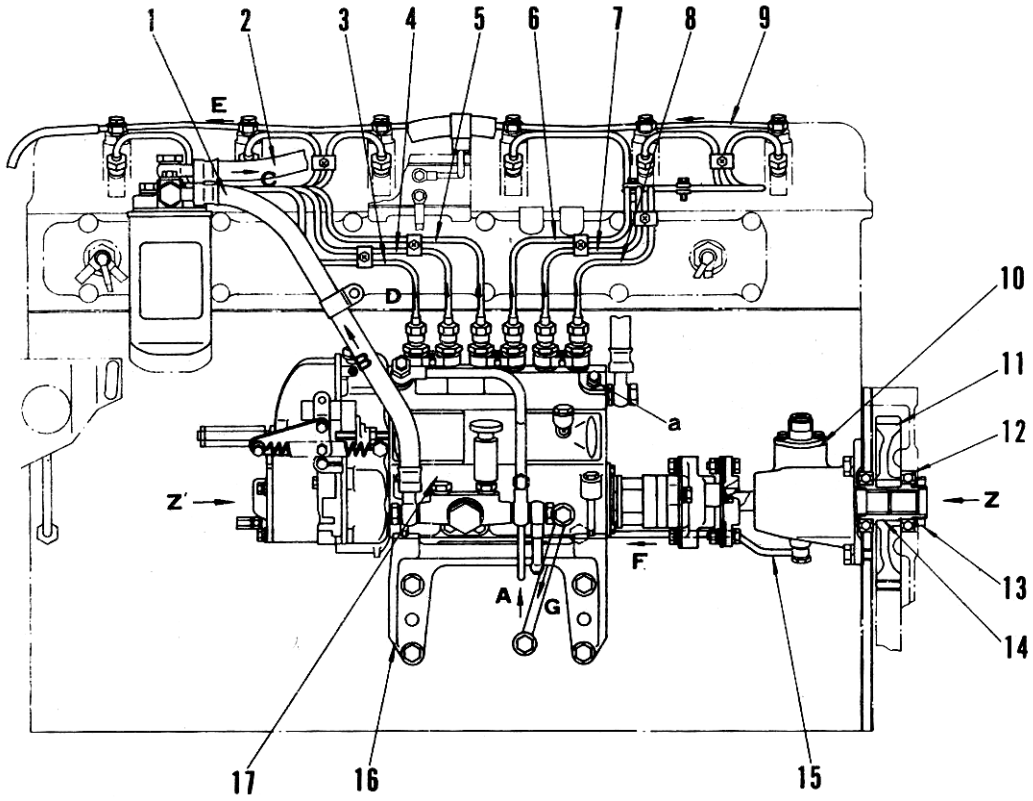
Fuel injection pump
Type : Bosch type PE-A
Lubrication : Forced lubrication

Governor
Type : Bosch RSV, centrifugal, all speed

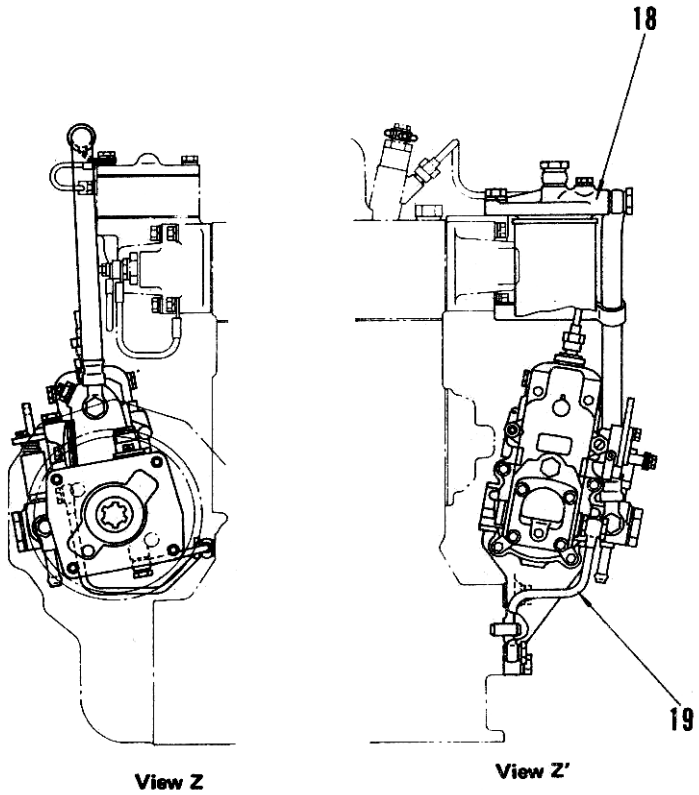
Fuel injection nozzle
Type : Multiple hole
Injection pressure : 225 kg/cm$^2$

Fuel injection timing
See TESTING AND ADJUSTING DATA.

# FOR GENERATOR




1. Fuel hose (Filter inlet)
2. Fuel hose (Filter outlet)
3. Fuel injection pipe (No. 6)
4. Fuel injection pipe (No. 5)
5. Fuel injection pipe (No. 4)
6. Fuel injection pipe (No. 3)
7. Fuel injection pipe (No. 2)
8. Fuel injection pipe (No. 1)
9. Spill tube
10. Injection pump drive gear
11. Fuel injection pump drive gear (52 teeth)
12. Ball bearing
13. Lock nut
14. Drive shaft
15. Oil tube (Supply)
16. Pump bracket
17. Fuel injection pump
18. Fuel filter
19. Oil tube (return)




A: Form fuel tank (Fuel)

B: From feed pump (Fuel)

C: From fuel filter (Fuel)

D: From injection pump (Fuel)

E: To fuel tank (Fuel)

F: From oil pump (Oil)

G: To oil pan (Oil)

a. Air bleeding bolt

Fuel injection pump

Type : Bosch type PE-A

Lubrication : Forced lubrication

Governor

Type : Bosch RSV, centrifugal, all speed

Fuel injection nozzle

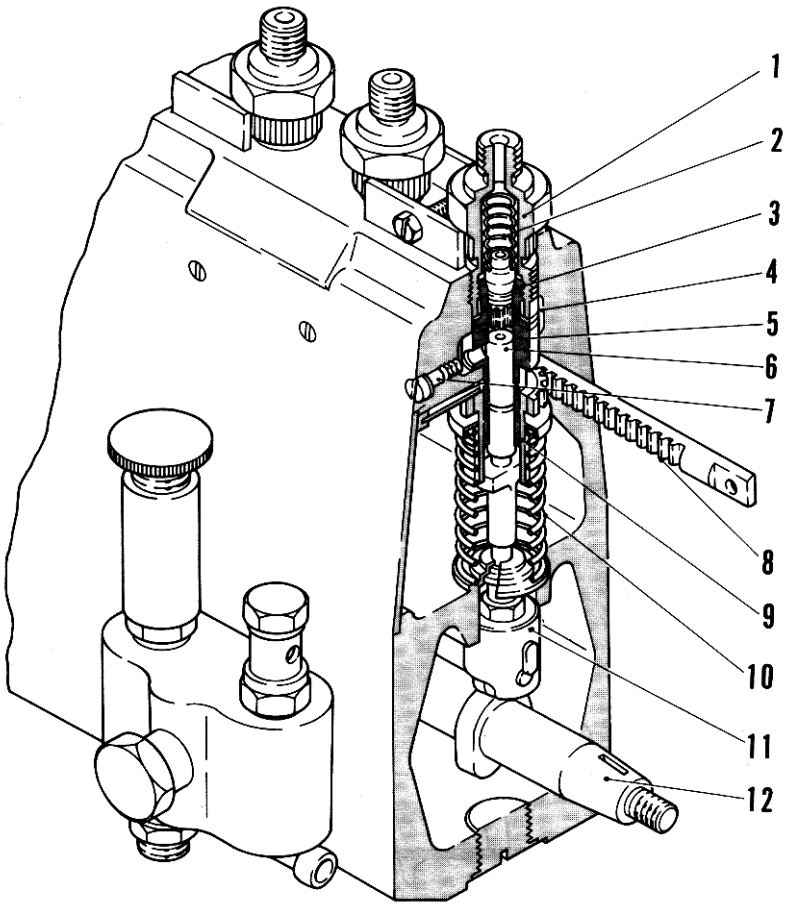
Type : Multiple hole

Injection pressure : 225 kg/cm$^2$

Fuel injection timing

See TESTING AND ADJUSTING DATA.

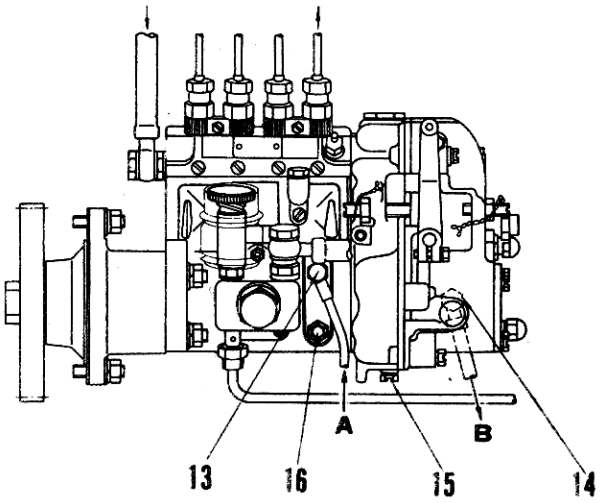
# FUEL INJECTION PUMP




1. Delivery valve holder
2. Delivery valve spring
3. Delivery valve
4. Oil reservoi
5. Plunger barrel
6. Plunger
7. Deflector
8. Control rack
9. Control sleeve
10. Plunger spring
11. Tappet
12. Camshaft

**GENERAL DESCRIPTION**

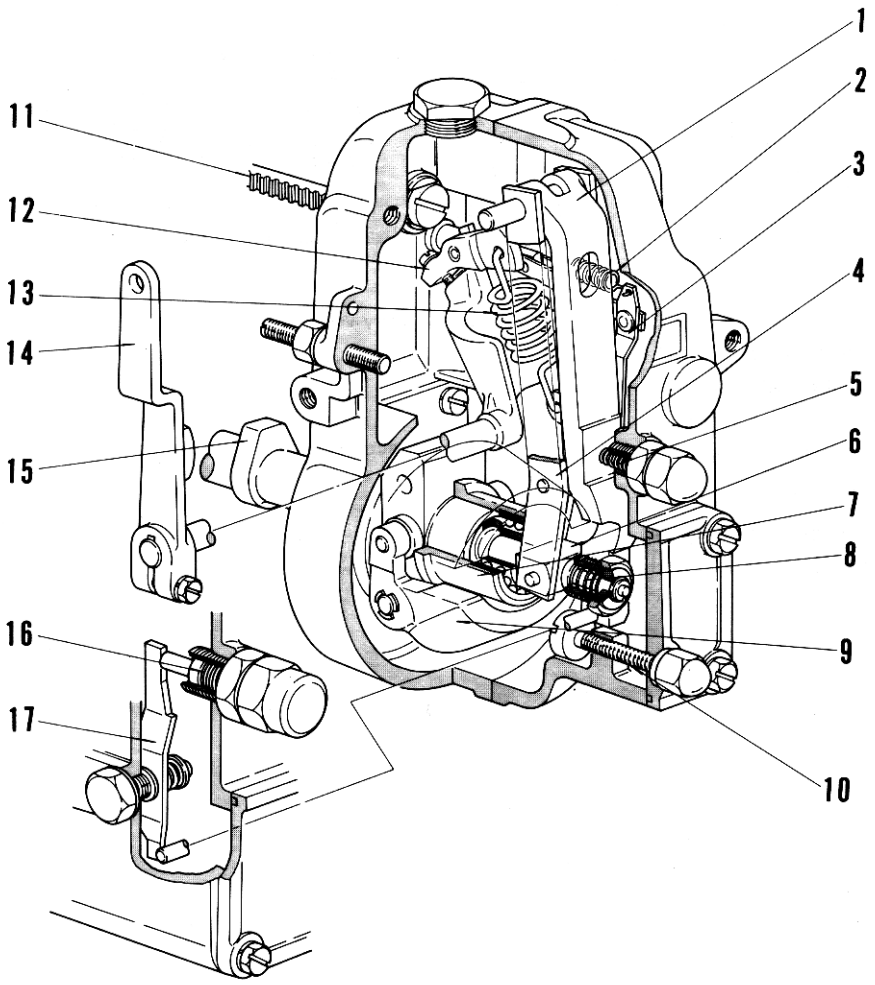
- The fuel injection pump is a Bosh type PES-A. Its pump housing, governor housing are forced lubricated with the engine oil.
- The fuel injection pmp is driven by the pump drive gear in the timing gear cluster and the direction of its rotation is clockwise as viewed from the driving (fly-wheel) side.




13. Oil inlet port
14. Oil outlet port
15. Drain plug
16. Drain plug

A. From main gallery
B. To oil pan

# GOVERNOR



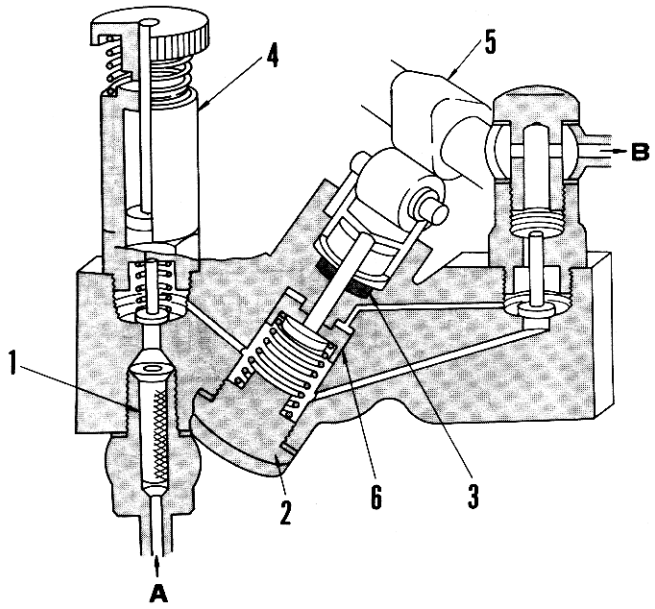

1. Tension lever
2. Start spring
3. Floating lever
4. Guide lever
5. Idling sub-spring
6. Shifter
7. Sleeve
8. Angleich spring
9. Flyweight
10. Full-load stopper
11. Control rack
12. Swivel lever
13. Governor spring
14. Control lever
15. Camshaft
16. Torque spring
17. Lever

**GENERAL DESCRIPTION**

**1. Functions of governor**

- The governor is a Bosch RSV mechanical all-speed type and serves to control the engine output power by changing the position of the control rack in the fuel injection pump (by adjusting the quantity of fuel injected).
- A flyweight actuated by the centrifugal force in the governor serves to move the sleeve depending on change in the rotational speed and adjust the move ment of control rack through the guide lever.
  On the other hand, the fuel control lever adjusts the movement of the contol rack though the tension lever for the governor spring.
- In addition to the above, the angleich unit adjusting the maximum fuel injection quantity at various rotational speeds, the torque spring unit to obtain an injection quantity corresponding to a sharp change in load during engine operation, an idling such-spring to maintain an idling speed, a start spring to as the engine starting, etc. are installed in the governor.

# FEED PUMP




1. Gauze filter
2. Nut
3. Oil seal
4. Priming pump
5. Camshaft
6. Piston

A. Suction port

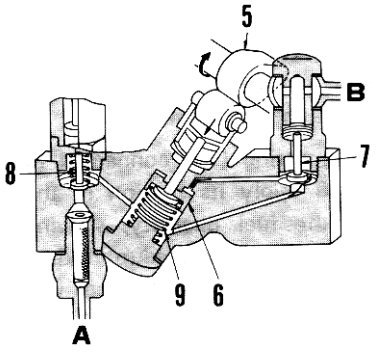
B. Discharge port

- The fuel pump is driven by the cam on the fuel injection pump camshaft and delivers fuel under pressure of approx. 1.5 kg/cm$^2$ . When removing the air, you can feed the fuel by pushing the priming pump by hands.

**Function**

1. Preparation for fuel delivery

- The piston (6) in the pump is pushed in by the cam on the camshaft (5) causing the fuel in the lower section below the piston to open the check valve (7) on the discharge side and flow into the upper section of the piston.
- At this time, the check valve (8) on the suction side is closed under the pressure of fuel pushed in by the piston, thereby preventing the reverse flow of fuel.



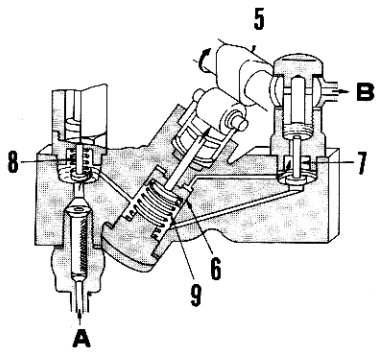

5. Camshaft
6. Piston
7. Check valve
8. Check valve
9. Piston spring

A. Suction port

B. Discharge port

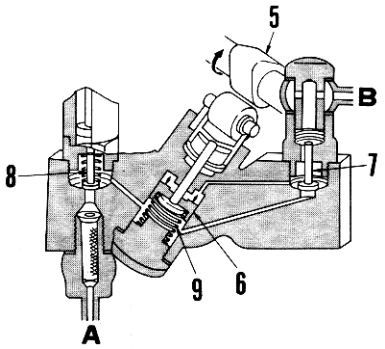
2. Suction and discharge

- If the camshaft (5) is rotated, bringing the cam out of the piston, the piston (6) will be pushed upward by the piston spring (9). The resultant fuel pressure will close the check vavle (7) on the discharge side, while fuel is delivered to the discharge port (B).
- In the section below th piston will be generated the negative prssure, causing the check vavle (A) on the suction side to open so as to draw in fuel.



3. Control fuel supply

- Fuel in the section above the piston is through directly to the passage on the discharge side. If the fuel pressure on the discharge side increases, it will becom impossible to push the piston (6) upward by the piston spring (9). Tus, the suction and discharge of fuel will be stopped until the fuel pressure on the discharge side drops by controlling the fuel quantity to be delivered.

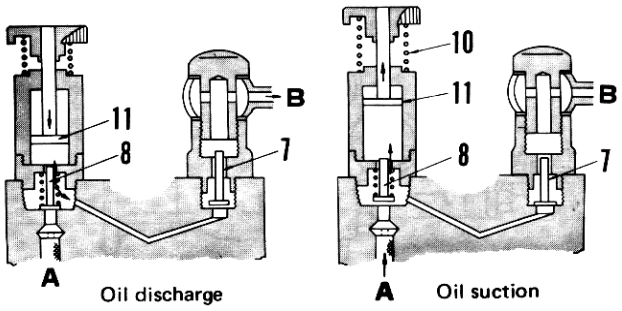



6. Piston
7. Check valve
8. Check valve
9. Piston spring

A. Suction port
B. Discharge port

4. Function of the priming pump

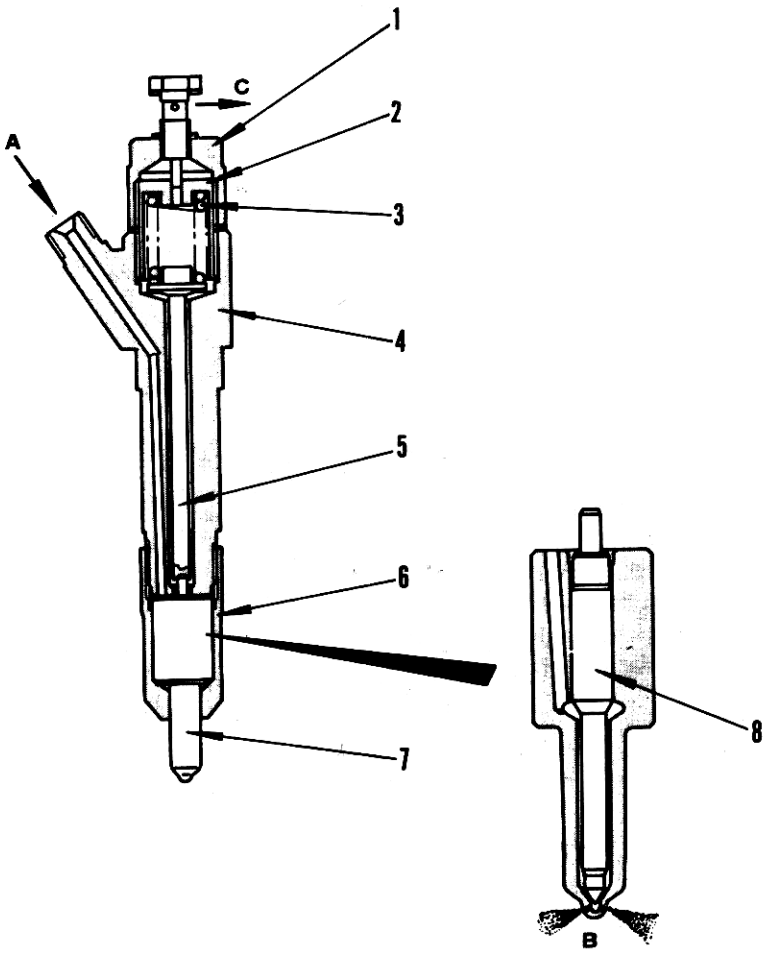
- The priming pump discharges fuel in the section below the piston when the piston (11) is pushed in by hand, and sucks in fuel when the piston is drawn up by spring (10).
- The check valves on the suction and the discharge sides (7) and (8) are used i common with those in the feed pump body. When delivery fuel, the valves on the suction side are closed and those on the discharge side are opened. When sucking in fuel, the valves on the suction sides are opened and those on th dicharge side are closed.




7. Check valve
8. Check valve
10. Spring
11. Piston

A. Suction port
B. Discharge port

# FUEL INJECTION NOZZLE




1. Nozzle holder cap
2. Adjust screw
3. Nozzle spring
4. Nozzle holder body
5. Push rod
6. Nozzle cap
7. Nozzle body
8. Nozzle

A. From fuel pump
B. Fuel chamber
C. To fuel tank

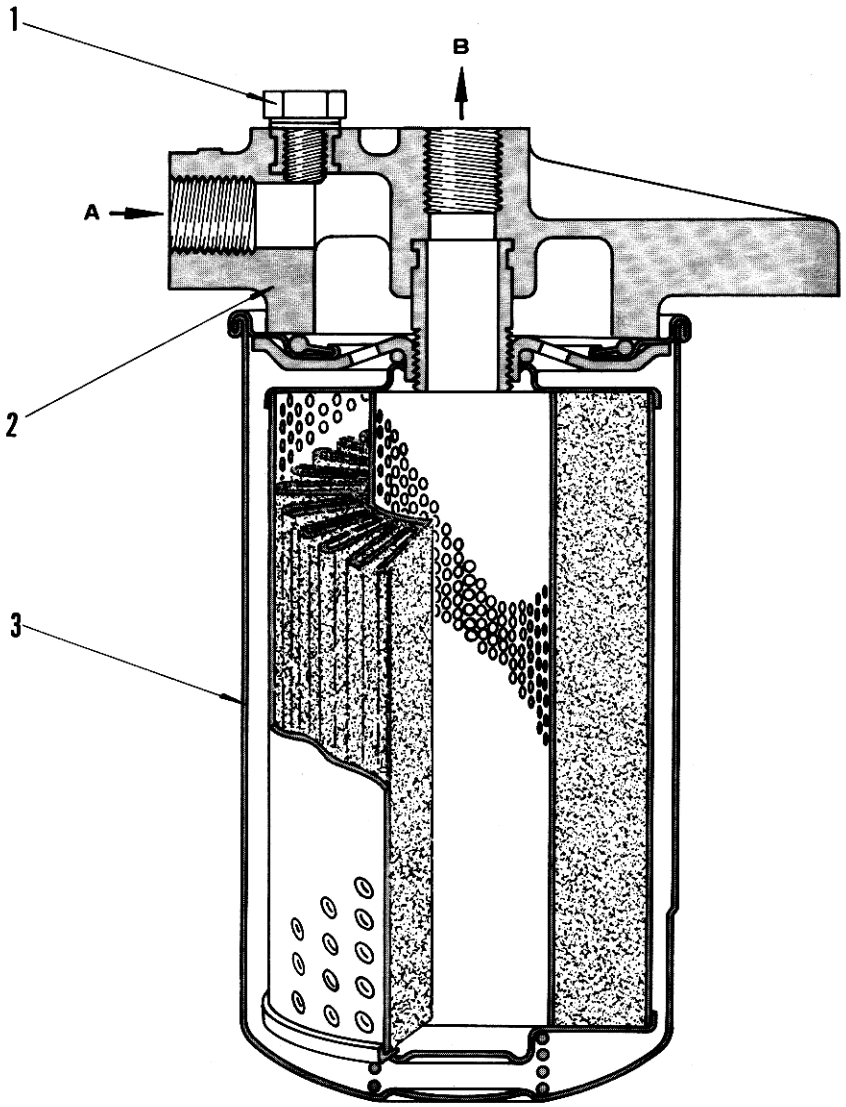
**Structure and function**

- The fuel injection nozzle is of a MULTIPLE HOLE type
- Fuel injection pressure: 225 kg/cm$^2$
- The high-pressure fuel delivered from the fuel injection pump is accumulated in the space at the tip of the nozzle. When the fuel pressure built up in the space overcome the tension of the nozzle spring compressing plunger (5), the plunger is lifted. Thus, fuel is injected into the combustion chamber through the four holes .

**Specification**

- Type : DIESEL KIKI
- Fuel injection presure : 225 kg/cm$^2$

# FUEL FILTER




1. Air bleeding plug
2. Filter bracket
3. Cartridge

A. From feed pump

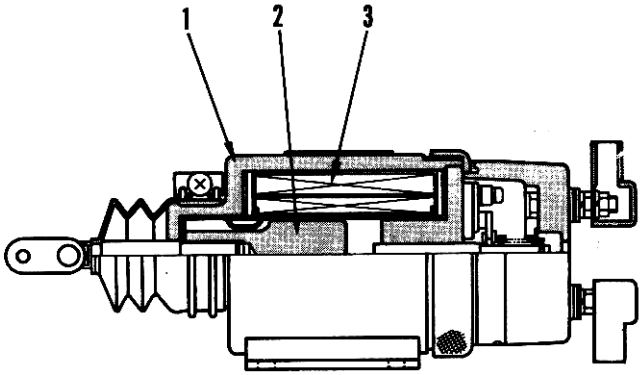
B. To fuel injection pump

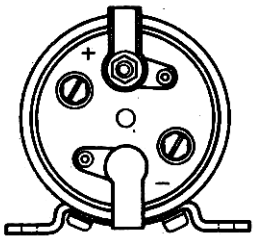
**Fuel filter**
Fuel filter effective area : 0.3 $m^3$

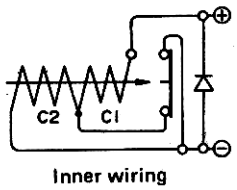
**Function**

- The fuel filter is a cartridge type and serves to remove dust, foreign substances of the fuel through filter paper from the feed pump.
- When fuel is contaminated with water, the wate will be separated from the fuel while flowing through the filter, resulting in accumulated water in the lower part of filter.

# FUEL CUT SOLENOID



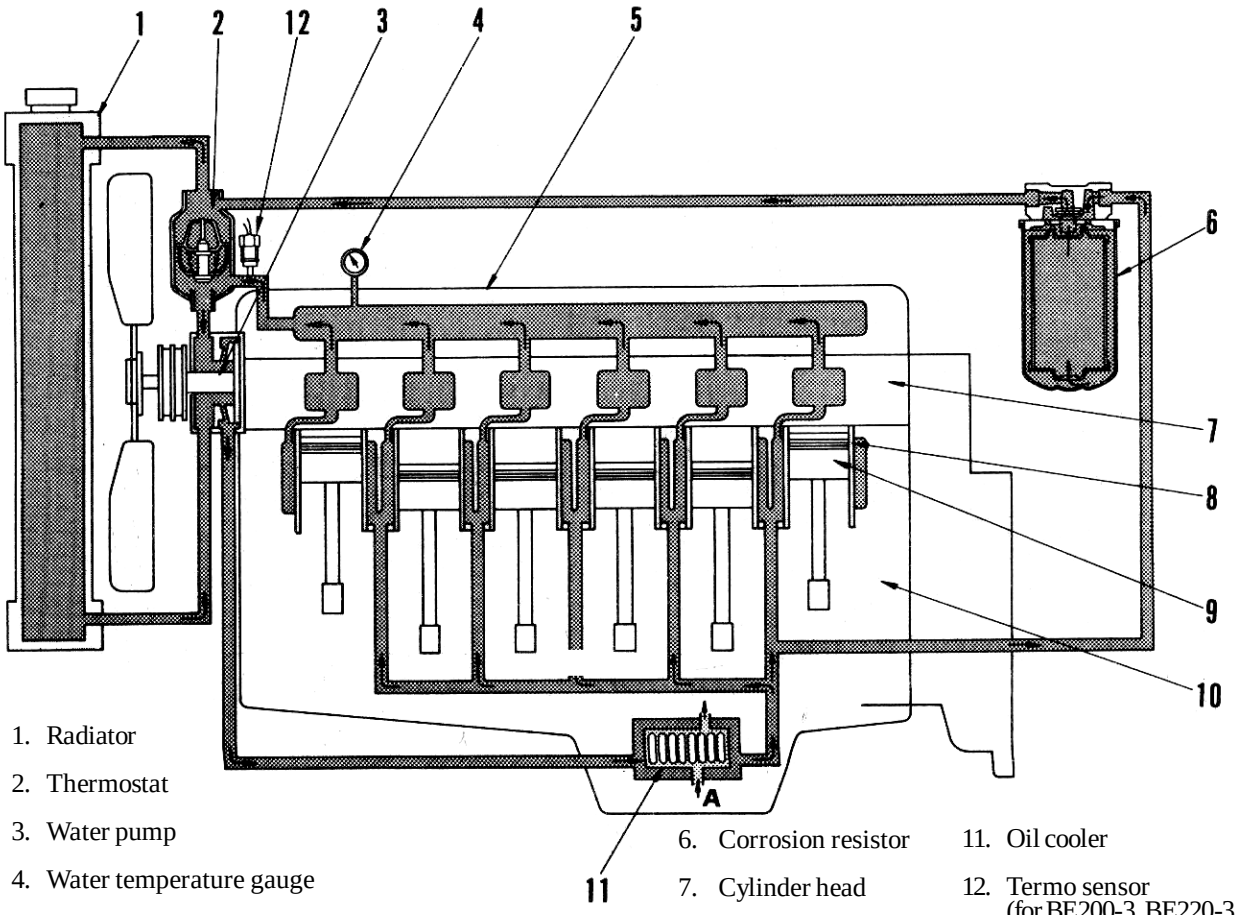

1. Case
2. Piston
3. Coil

**MAGNETIC SWITCH**

- Maker: NIKKO DENKI
- Type: Sealed
- Rated voltage: DC 24V
- Operating current
  - Maximum: 35A max.
  - Continuity: 0.5A max.
- Stroke: 12 ± 0.1 mm
- Weight: 2.7 kg

# COOLING SYSTEM

## COOLING SYSTEM CHART




1. Radiator
2. Thermostat
3. Water pump
4. Water temperature gauge
5. Water manifold (integrated with the cylinder head)
6. Corrosion resistor
7. Cylinder head
8. Cylider liner
9. Piston
10. Cylinder block
11. Oil cooler
12. Termo sensor (for BE200-3, BE220-3, (BE200LC-3,BE220LC-3
A. From oil pump (Oil)

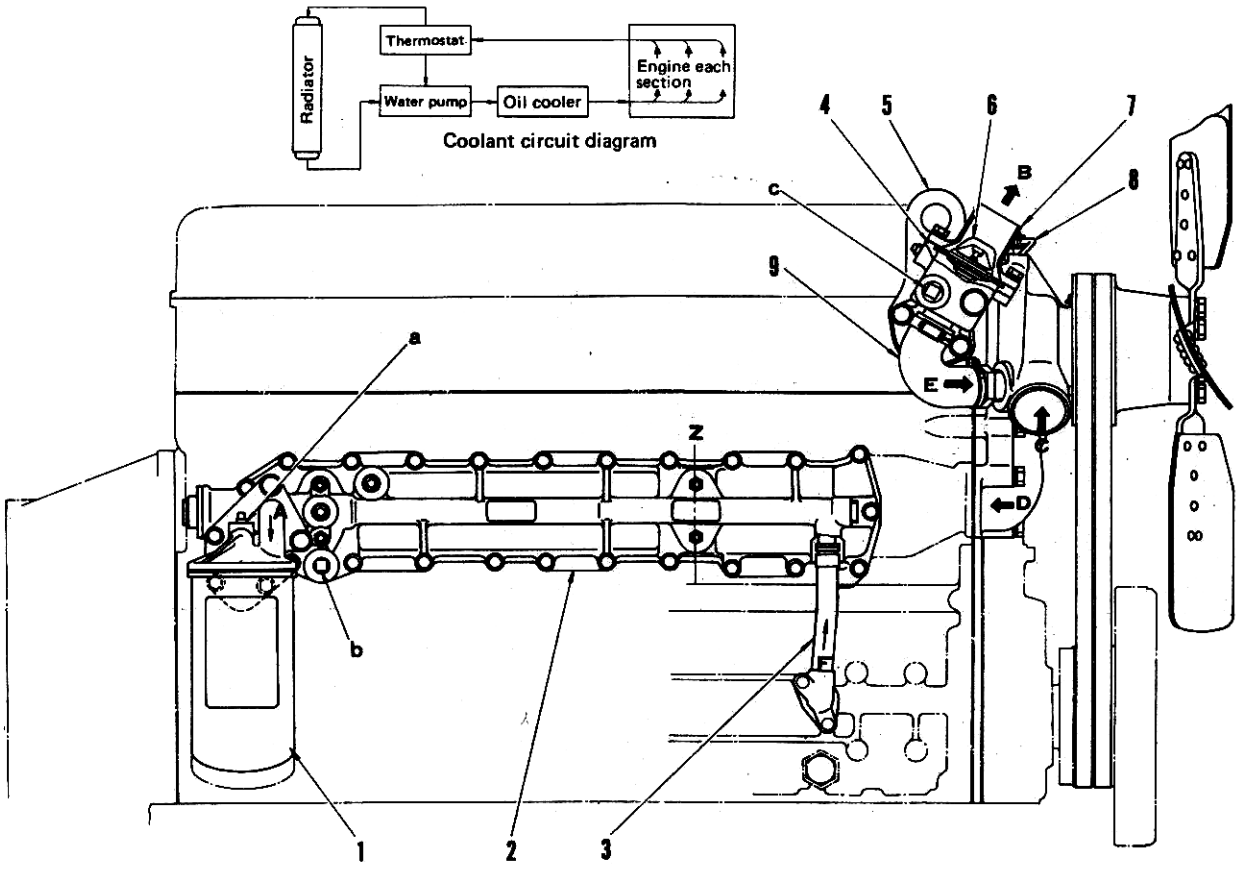
**GENERAL DESCRIPTION**

**1. Structure of cooling system**

- The cooling system consists of the water pump, thermostat, radiator, fan and water piping. It serves to cool the cylinder liners, and the areas surrounding the combustion parts in the cylinder heads.
- In addition, oil piping or oil cooler is equipped for cooling oil by the engine cooling water.

**2. Circulation of cooling water**

1) The cooling water is distributed under pressure from the water pump driven together with the fan through the fan belt from the crank pulley.
2) The cooling water distributed under pressure from the water pump passes through the oil cooer, cools various parts in the engine, collects in the cylinder heads, and from there flows into the thermostat.
3) The cooling water in Thermostat will flow back to the water pump, when the water temperature is below appox. 76 °C (generator: 80 to 84°C). If the water temperature is over approx. 90°C (generator: 95°C) OR SO, the thermostat will be opened fully, causing the water to flow into the radator for cooling.
4) While the water temperature ranges from 76° (generator: 80 to 84°C) to approx. 90°C (generator: 95°C), some of the water flows back to the water pump and the other to the radiator. The ratio of water flowing to the pump and the radiator depends on the degree of opening (varyling with the temperatre) of the thermostat.




1. Oil filter
2. Oil cooler
3. Oil pipe
4. Thermostat housing
5. Singer
6. Thermostat
7. Water connector
8. Water tube
9. Water hose

A. From oil cooler (oil)
B. To radiator (water)
C. From radiator (water)
D. To oil cooler (water)
E. To engine (water)
F. From oil pump (oil)

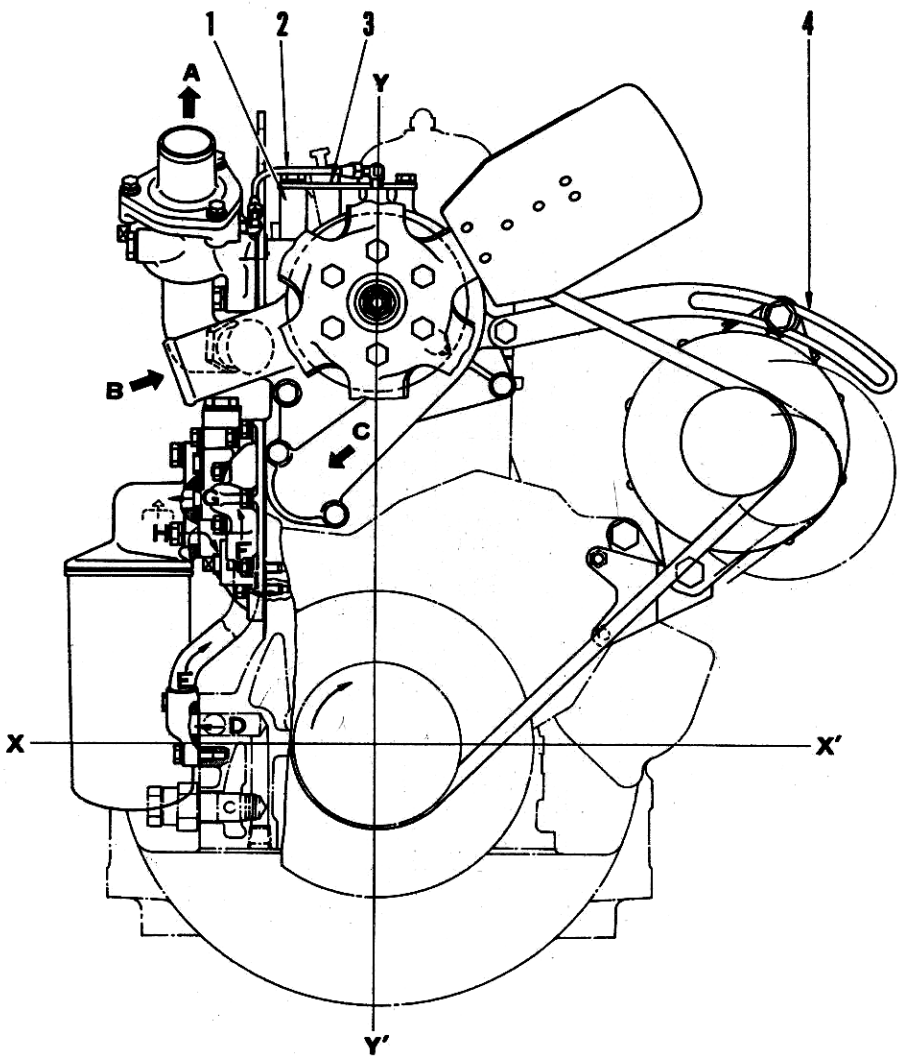
a. Oil pressure takeout port
b. Water drain plug
c. Car heater takeout port

**Thermostat**

Temperature when start to open : 76.5° C

Temperature when full open : 90° C

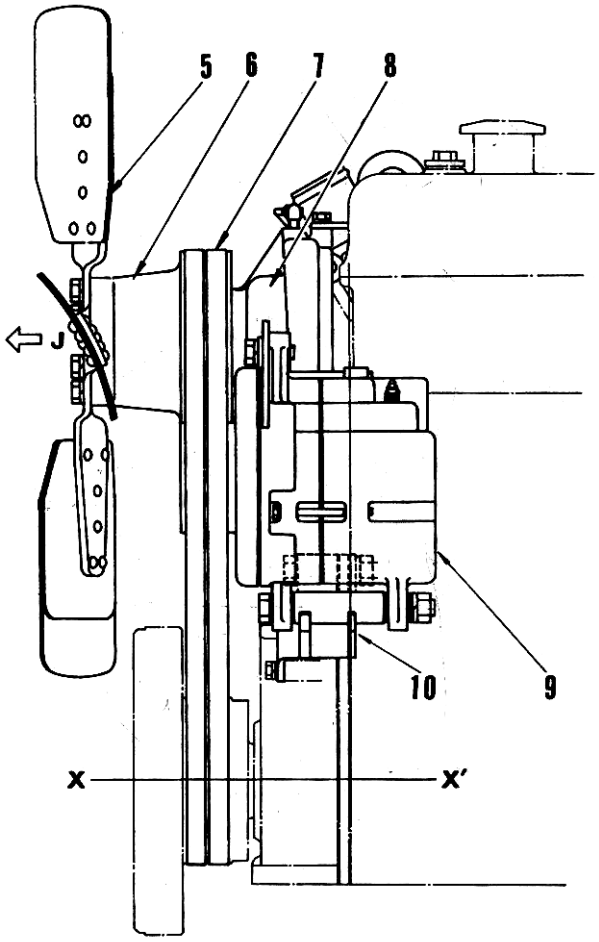
Full opening life : 10mm




1. Spacer
2. Water tube
3. Bracket
4. Adjust plate
5. Fan
6. Fan pulley
7. Fan belt
8. Water pump
9. Alternator
10. Alternator bracket

A. To radiator (water)
B. From radiator (water)
C. To engine each section (water)
D. From oil pump (oil)
E. To oil cooler (oil)
F. From oil cooling (oil)
G. To oil filter (oil)
H. From oil filter (oil)
I. To engine each section (oil)
J. To radiator

X - X': Center of crankshaft
Y - Y': Center of cylinder




**Pulley diameter**

Crankshaft pulley : 144mm

Fan pulley : 156mm

Alternator : 95 mm

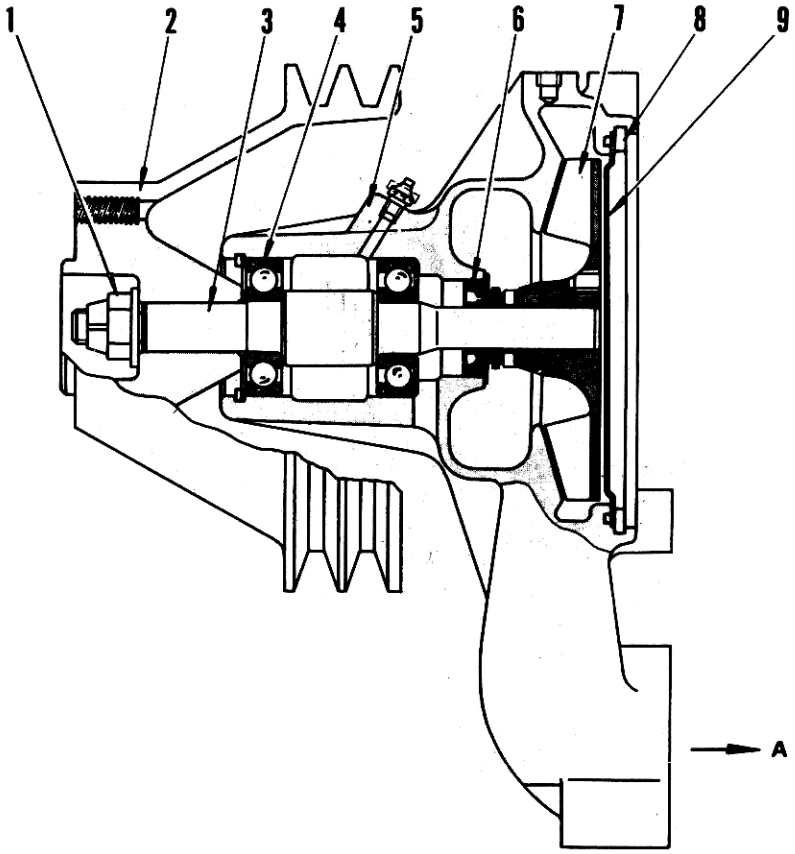
**Alternator**

24V, 2A

Closed with regulator type

# WATER PUMP

## B6D105-1, BS6D105-1 For BDG75, BDG100, BE200, BE220



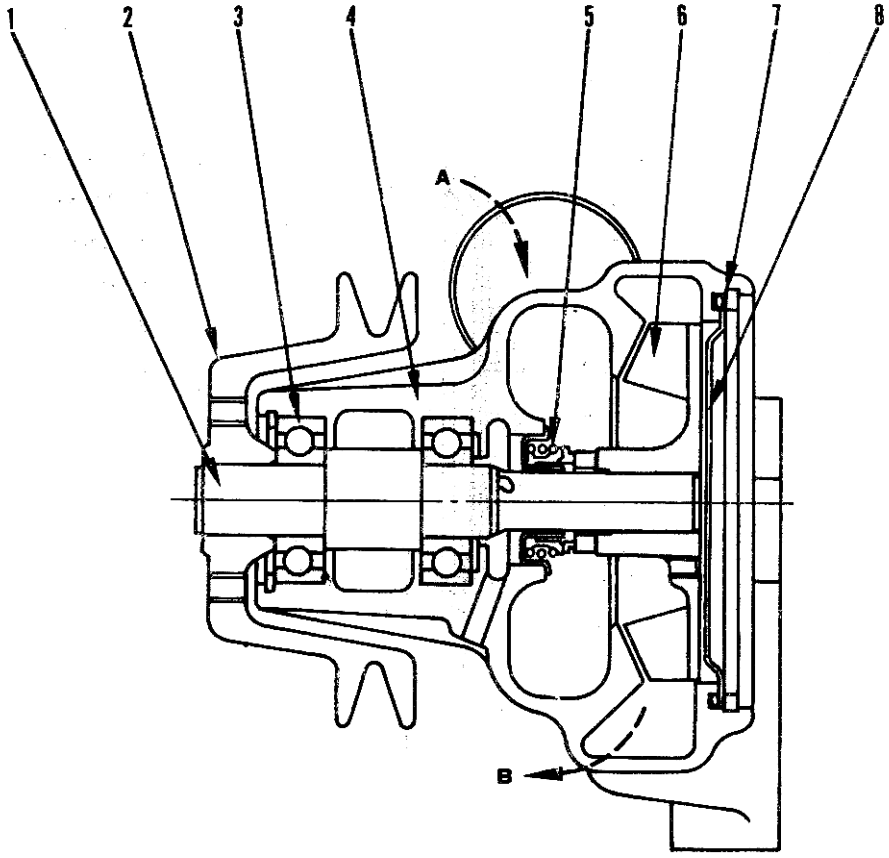

1. Lock nut
2. Pulley
3. Shaft
4. Ball bering
5. Pump body
6. Water seal
7. Impeller
8. Snap ring
9. Pump cover

A. To engine each part (water)

### Fan pulley

| Engine | Applicable machines | Pulley O.D. (mm) |
|---|---|---|
| B6D105-1 | BDG75 | 156 |
| | BE200-1, BE200-2, BE200LC-2 | 200 |
| BS6D105-1 | BDG100 | 156 |
| | BE220-1,BE220-2,BE220LC-2 | 175 |
| | BLW200-1 | 256 |

**BS6D105-1, for BE200-3, BE200LC-3, BE220-3 AND BE220LC-3**




1. Pump shaft
2. Pump pulley
3. Ball bering
4. Pump body
5. Water seal
6. Impeller
7. Snap ring
8. Pump cover

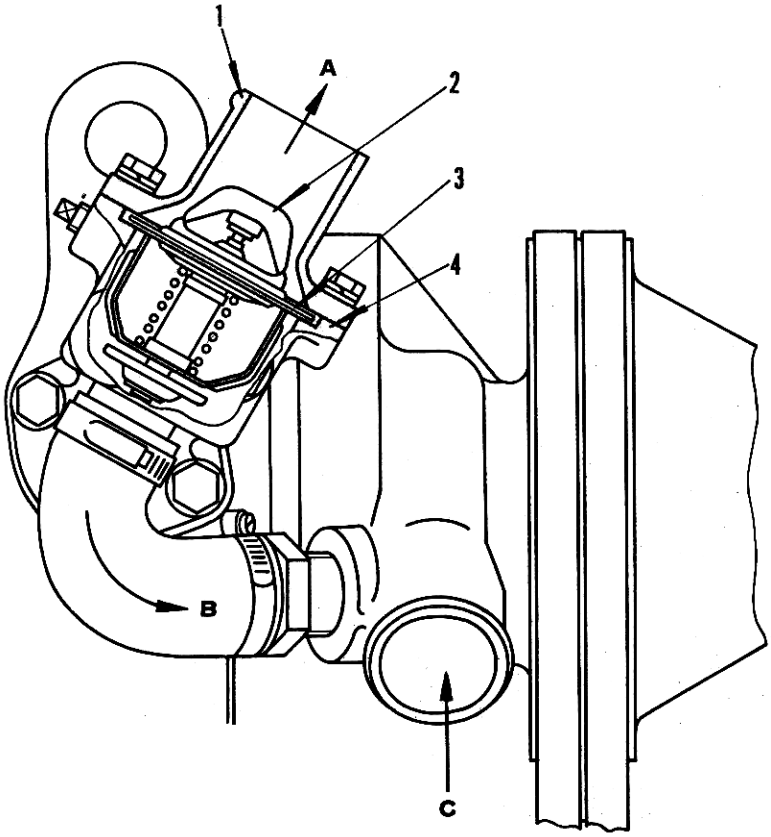
A. From radiator

B. To engine each part

**Pump Pulley**

| Engine | Applicable machin models | O.D. Pulley (mm) |
|---|---|---|
| BS6D105-1 | BE200-3, BE200LC-3<br>BE220-3, BE220lc-3 | 125 |

# THERMOSTAT




1. Connector
2. Thermostat
3. Gasket
4. Thermostat case

A. To radiator
B. To water pump
C. From radiator

**Thermostat operation**

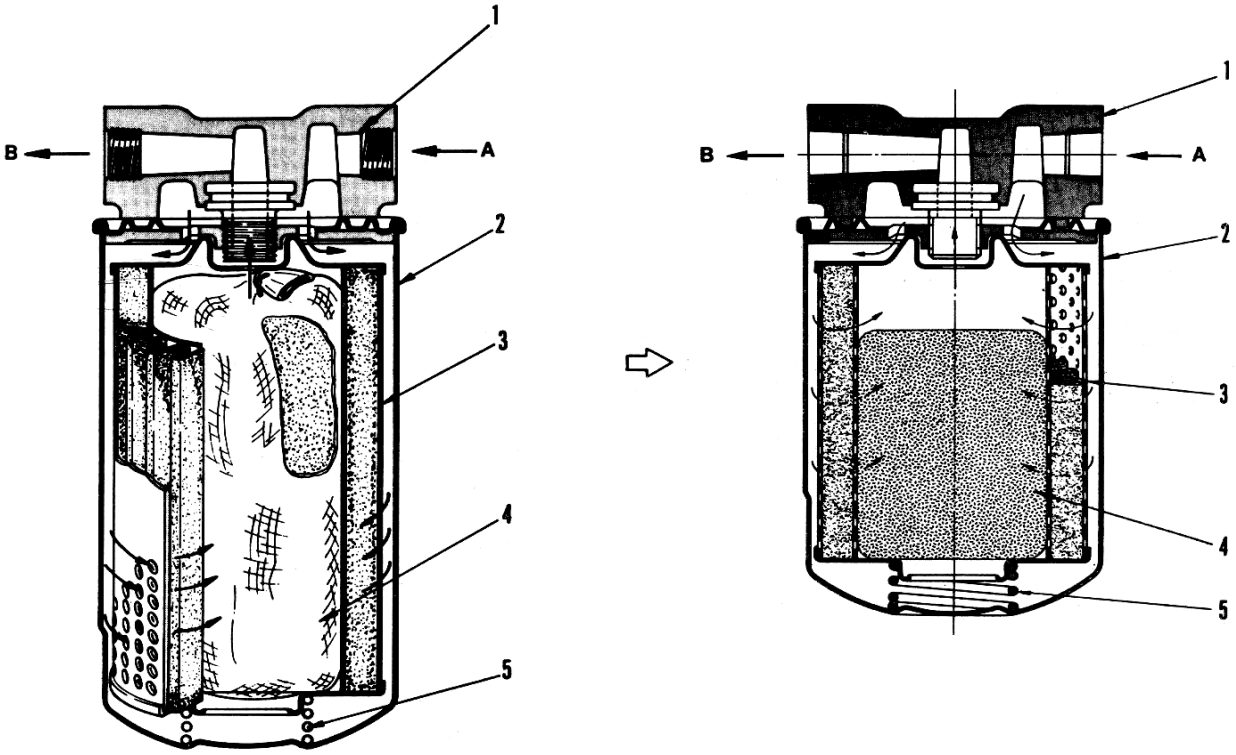
| | |
|---|---|
| Valve cracking temperature | : 74.5 - 78.5°C |
| Valve full opening temperature | : 90°C |
| Full opening lift | : 8mm |

**Structure and function**

- The thermostat opens or closes depending on the water temperature and serves to keep the cooling water temperature withi the optimum range by automatically adjusting the flow rate of the engine cooling water into the radiator.
- Within the thermostat is a cylinder containing was; with a high expansion coefficient, movement of the case opens and closes the thermostat valve.
- The optimum temperature of the engine cooling water ranges from 75° to 90° C. If the water temperature is too low, the engine will not be warmed up, resulting in poor engin performance due to improper clearances between pistons and liners. Eventually, excessive oil lubrication, oil contamination, and excessive BLOW-BY will be encountered, during engine operatio
- ★ where a thermostat is used for a generator, its operat ing temperature is set at a high degree, because a continuous operation under light load is relatively frequent and the engine is difficult to warm up.
- If the enigne cooling water temperature is too high, oil deterioration, premature deterioration of seals, O-rings, etc. and overheating will be caused.
- Function of the thermostat

| Application | For construction machine | Fog generator set |
|---|---|---|
| Valve cracking temperature (°C) | 75 - 78 | 80 - 84 |
| Valve full opening temperature (°C) | 90 | 95 |

# CORROSION RESISTOR




1. Head
2. Cartridge
3. Element (paper)
4. Element (drug)
5. Spring

A. Inlet cooling water

B. Outlet cooling water

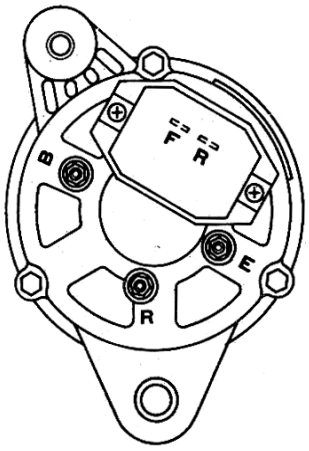
**Corrosion resistor**

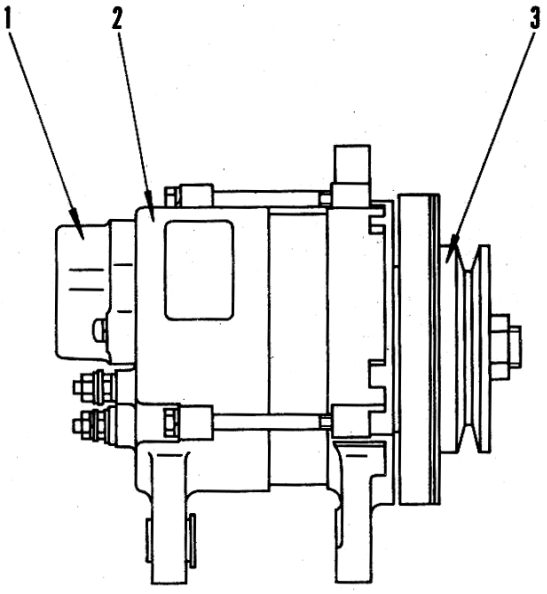
Filter area : 0.19 $m^2$

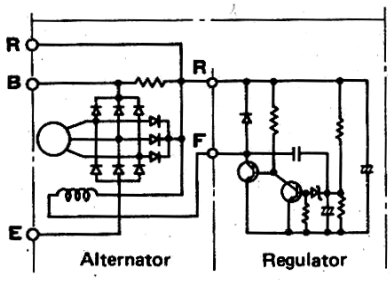
# ELECTRICAL SYSTEM

## ALTERNATOR

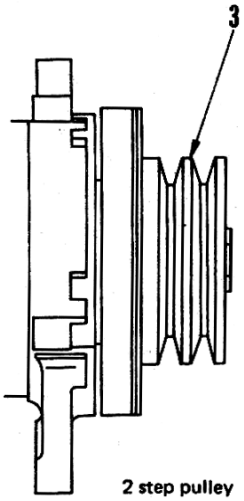
**Built in regulator, open type (1)**




Inner connecting diagram

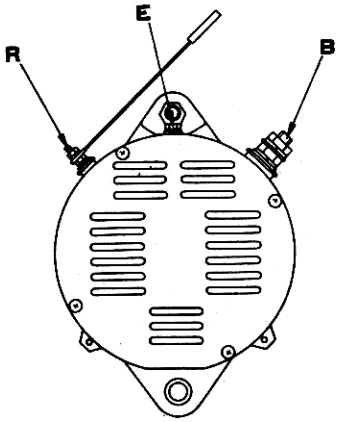


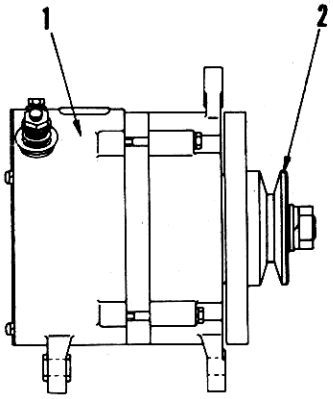

1. Regulator
2. Alternetor
3. Alternator

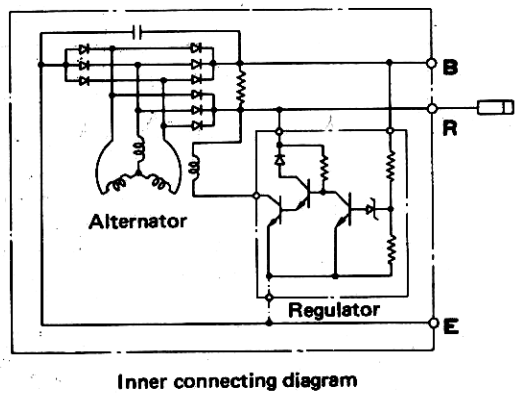
B, E, F, R : Each terminal

| Engine | Applicable machine | Model | Specification | Weight (kg) | Outside diameter of pulley (mm) |
|---|---|---|---|---|---|
| BS6D105-1 | BE200 | Nikko Denki Open type | 24V, 25A | 7.3 | 95 |
| BS6D105-B-1 | BE220LC-3 | Nikko Denki Open type | 24V, 25A | 7.0 | 95 |
| BS6D105-1 | BE200 BE220LC BE220LC-2 | | | 7.3 | 95 |
| | BLW200L-1 | | | 7.0 | 77 |

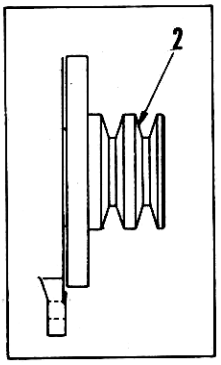
**Built in regulator, open type (2)**




Inner connecting diagram



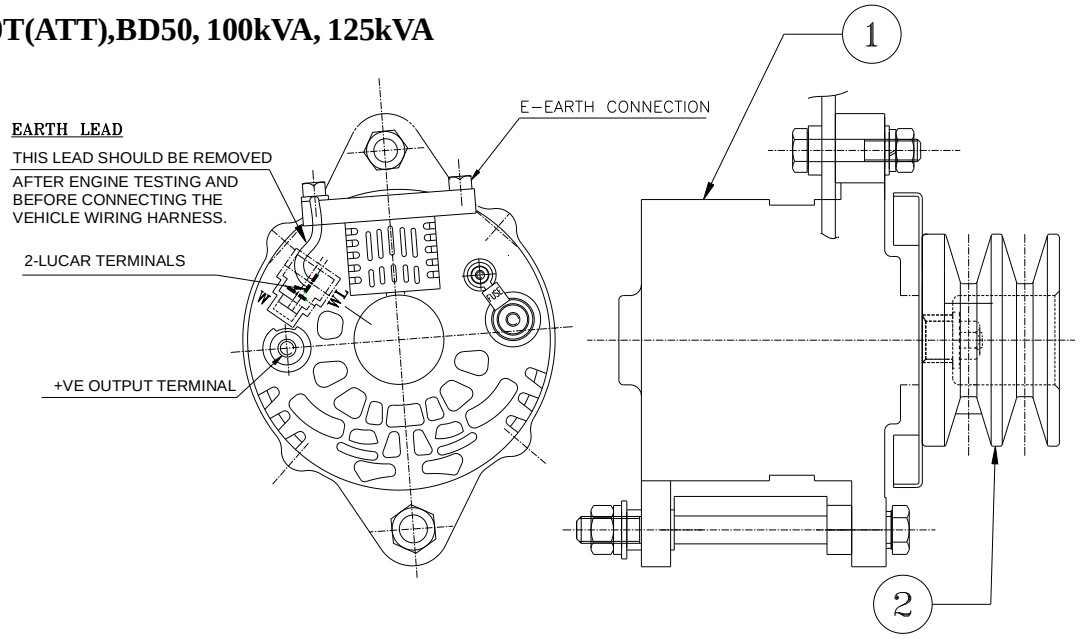

2 step pulley

1. Alternetor
2. Alternator pulley

B, E, R : Each terminal

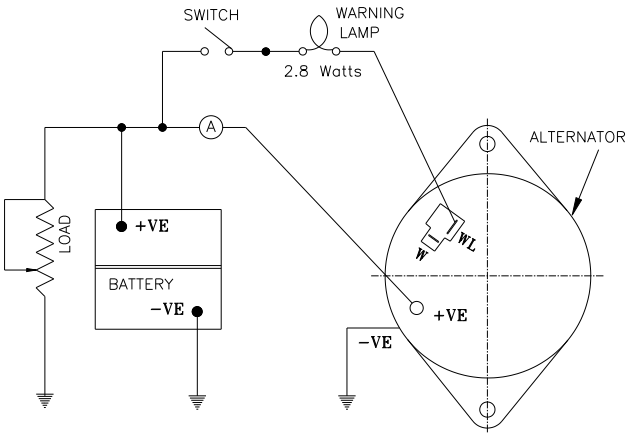
| Engine | Applicable machine | Model | Specification | Weight (kg) | Outside diameter of pulley (mm) |
|---|---|---|---|---|---|
| B6D105-1 | BLW200-1 | Sawafuji Denki Open type | 24V, 50A | 12.5 | 85 |
| BS6D105-1 | | | | | |

## BL200, G10T(ATT),BD50, 100kVA, 125kVA




1. Alternetor
2. Alternator Pulley

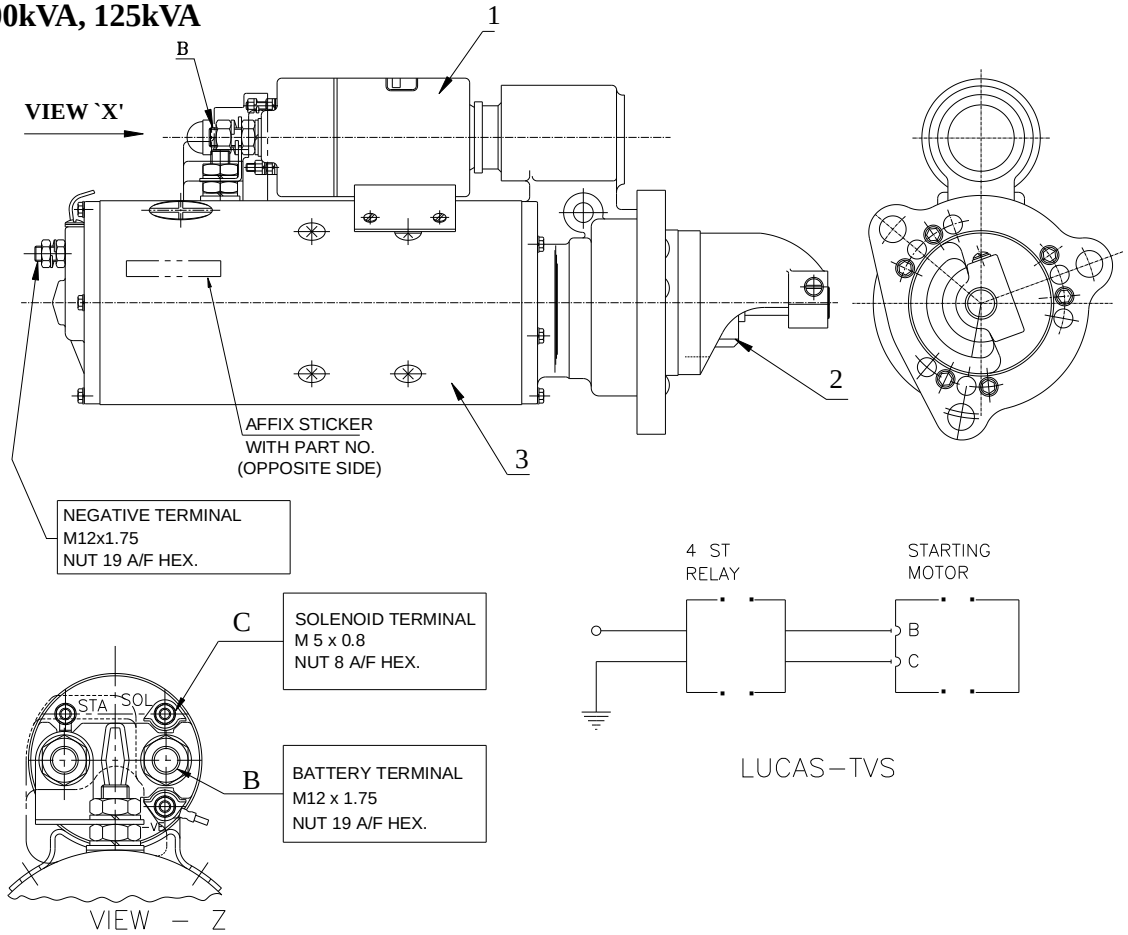
| TERMINAL | SIZE | TIGHTENING TORQUE |
|---|---|---|
| +VE | M8 x 1.25 | 45kg.cm - 55kg.cm |
| -VE | M6 x 1 | 25kg.cm - 30 kg.cm |
| WL | LUCAR 6.35 x 0.8t | - |
| W | - "- | - |
| W = A.C PHASE TAP TERMINAL (UNREGULATED VOLTAGE TERMINAL) | | |




| Engine Model | Applicable machine model | Type | Specification | Weight (kg) | Outside diameter of pulley (mm) |
|---|---|---|---|---|---|
| B6D105-1 | BL200 | LUCAS TVS | 24V, 30A | 10 | 95 |
| | G10T (ATT) | | | | |
| BS6D105-1 | BD50 | LUCAS TVS | 24V, 45A | 10 | 95 |
| BS6D105-1 | BG605BX / G12T(ATT) | LUCAS TVS | 24V, 45A | 10 | 95 |
| BS6D105G | 100 kVA ENGINE | LUCAS TVS | 24V, 30A | 10 | 95 |
| BSA6D105G | 125 kVA ENGINE | LUCAS TVS | 24V, 30A | 10 | 95 |

# STARTING MOTOR

**BD50, 100kVA, 125kVA**



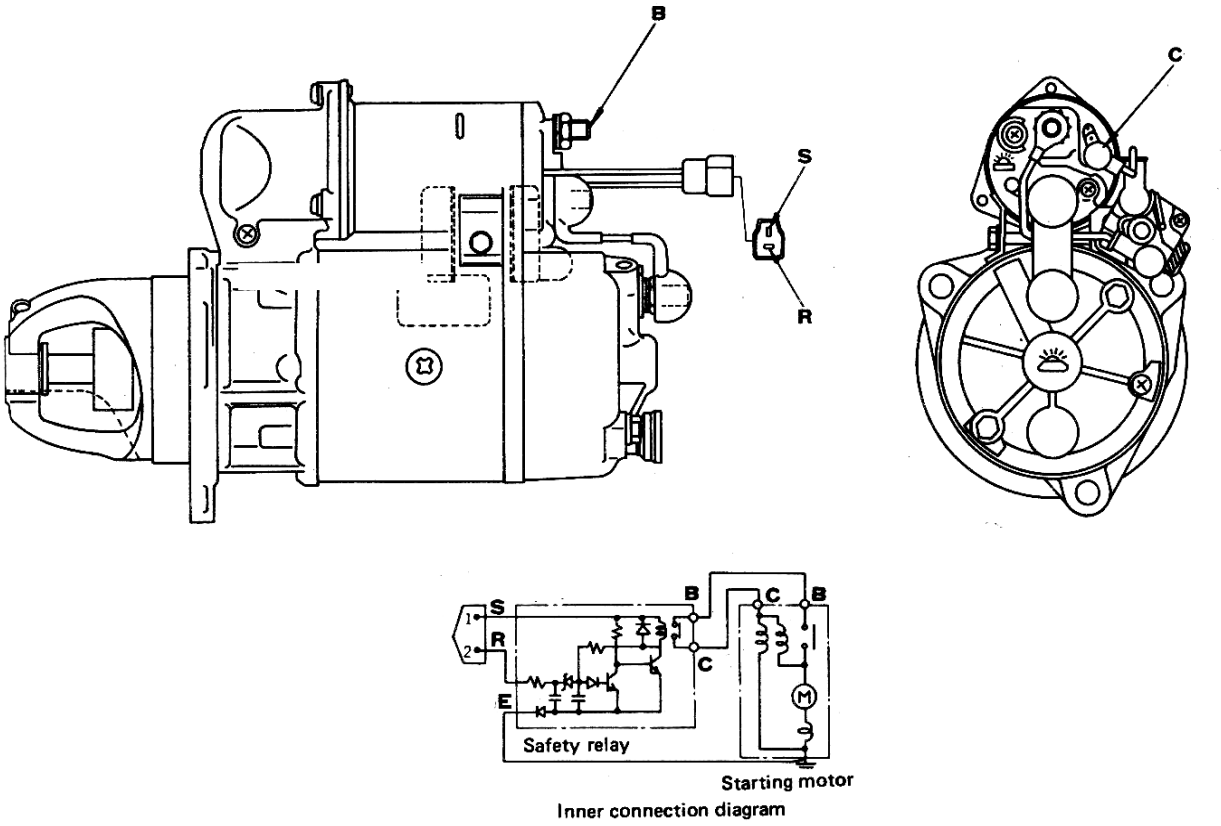

1. Magnetic Switch
2. Pinion
3. Starting Motor

B,C,E : TERMINALS

STARTING MOTOR

| Engine Model | Applicable machine model | Type | Specification | Weight (kg) | No. of teeth for pinion |
|---|---|---|---|---|---|
| BS6D105-1 | BD50 | LUCAS TVS (SM 130 PE) | 24V, 7.5 kW | 32 | 12 |
| BS6D105-1 | BG605BX / G12T (ATT) | LUCAS TVS | 24V, 4.5 kW | 32 | 11 |
| BS6D105G | 100 kVA | LUCAS TVS | 24V, 4.5 kW | 32 | 11 |
| BSA6D105G | 125 kVA | LUCAS TVS | 24V, 4.5 kW | 32 | 11 |
| B6D105-1 | BL200 | LUCAS TVS | 24V, 4.5 kW | 32 | 11 |
| | G10T (ATT) | | | | |

**Buit in safety relay**




Inner connection diagram

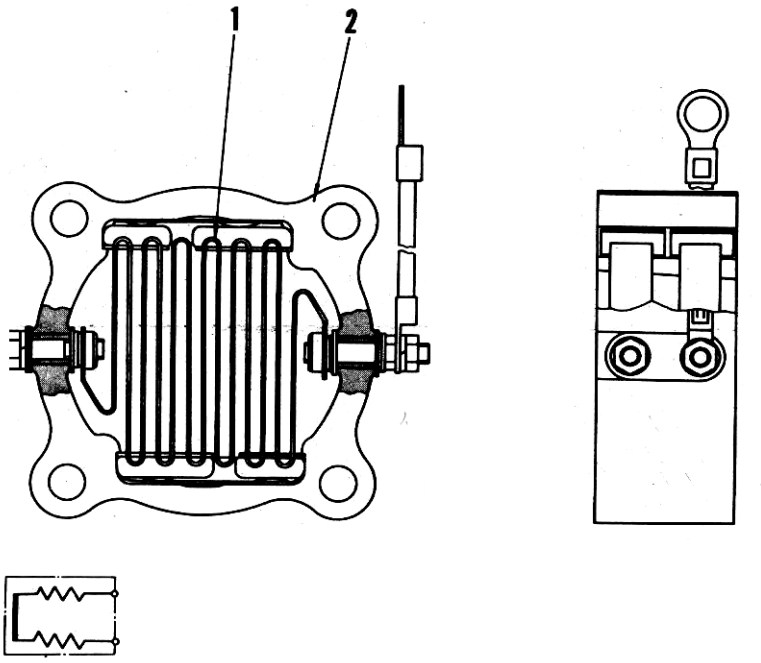
B, C, SW : Each terminal

| Engine | Applicable machine | Model | Specification | Weight (kg) | No. of teeth for pinion |
|---|---|---|---|---|---|
| | | Nikko Denki Sealed type | 24V, 5.5 KW | 16 | 13 |
| B6D105-1 | BE200-1, BE200-2, BE200LC-2 | Nikko Denki Sealed type | 24V, 7.5 KW | 24 | 13 |
| | BE200-1, BE200-2, BE200LC-2 | Nikko Denki Sealed type | 24V, 7.5 KW | 18 | 13 |
| BS6D105-B-1 | BE200-3, BE200LC-3 | Nikko Denki Sealed type | 24V, 7.5 KW | 18 | 13 |
| | | Nikko Denki Sealed type | 24V, 5.5 KW | 16 | 13 |
| BS6D105-1 | BE220-1, BE220-2, BE220LC-2 | Nikko Denki Sealed type | 24V, 7.5 KW | 24 | 13 |
| | BE220-3, BE220LC-3 | Nikko Denki Sealed type | 24V, 7.5 KW | 18 | 13 |

# STARTING AID

For easy starting in cold weather, a electrical intake air heater is attached to inlet of intake manifold and a coil heater is attached to both ends of intake manifold respectively. Pull heater switch to ON, Heater is red while starting switch is HEAT or START position to heat intake air.

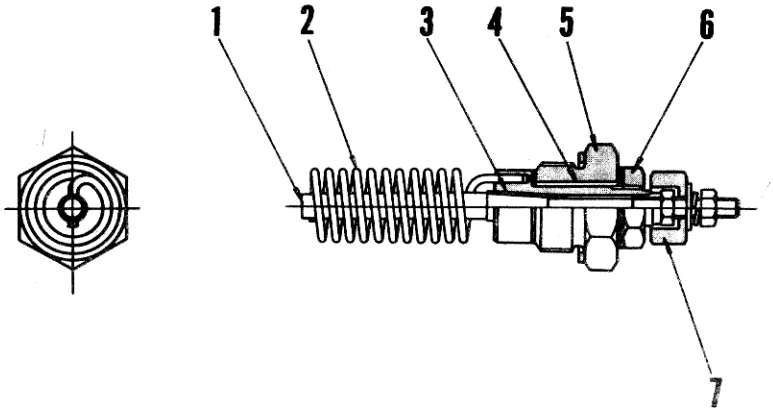
1. Electrical intake air heater




1. Heater coil
2. Housing

Rated current : 110A at 22V

2. Coil heater



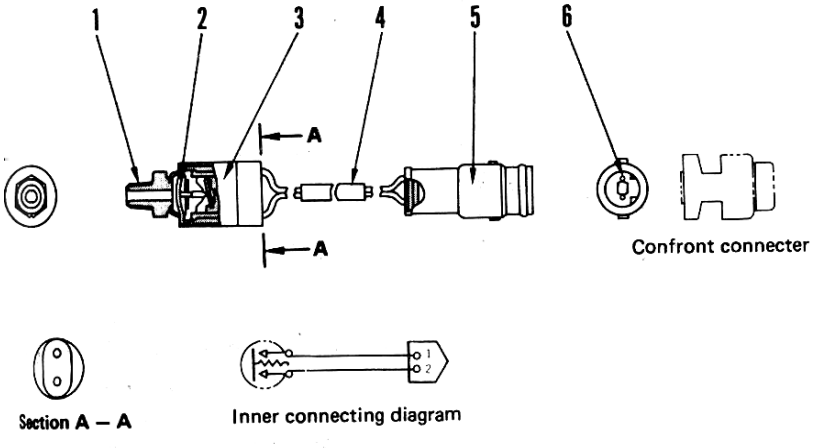

1. Inner pole
2. Heater coil
3. Outer pole
4. Insulator
5. Body
6. Nut
7. Insulator

Rated Voltage : 11.25V

Rated current : 33A

# SENSOR

## OIL PRESSURE SENSOR



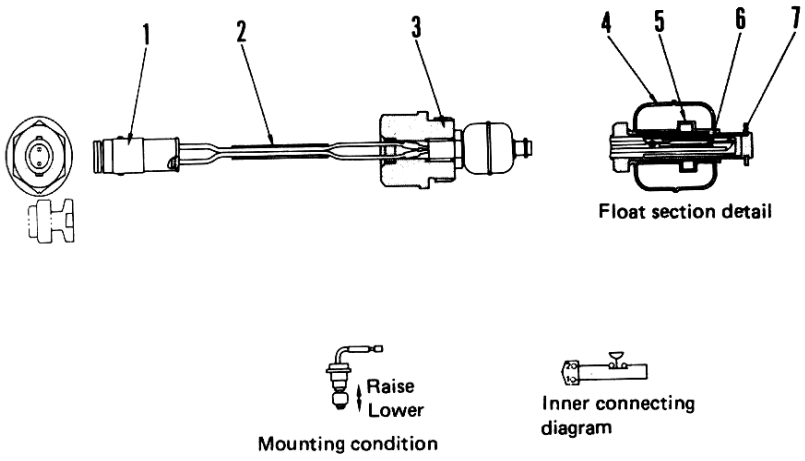

1. Port
2. Diaphragm
3. Sensor
4. Tube
5. Connector
6. Terminal

**Oil pressure sensor**

- Type : Daaphragm type, normally opened type (NO type)
- Operating points
  ON : $1.3 \pm 0.3$ kg/cm$^2$

  Off : $0.5 \; {}^{+0.3}_{0.2}$ kg/cm$^2$
- When the oil pressure increses, the tip of the diaphragm comes into con tact with the terminal, turning the switch ON. When the oil pressure decreases, the switch turns OFF. Thus, you can tell wheather the oil pressure is normal or not by seeing if the switch is ON or OFF.

## OIL LEVEL SENSOR

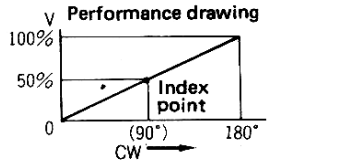


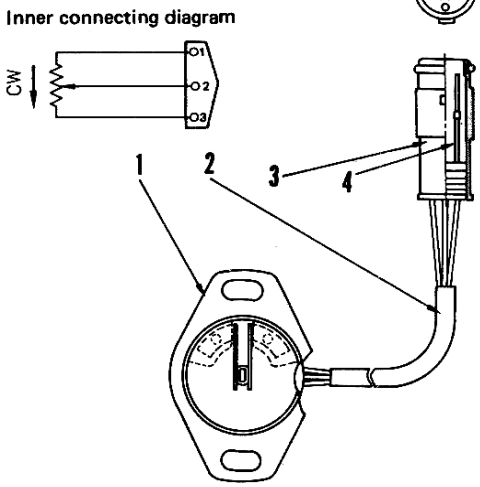

1. Connector
2. Tube
3. Plug
4. Float
5. Magnet
6. Switch
7. Case

**Oil level sensor**

- Type : Float type reed switch
- The float moves up and down according to the chage in the oil level, and also causes the magnet in the float to move up and down. This movement of the magnet in turn causes the switch to turn ON or OFF. Thus, you can find out the oil level by seeing if the switch is ON or OFF.

## THROTTLE SENSOR



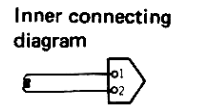

1. Throttle sensor body
2. Tube
3. Connector housing
4. Pin

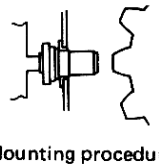
CW : Variable angle

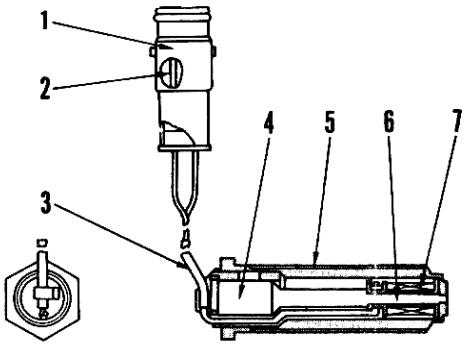
**Throttle sensor**

- Resistance value : 5 kΩ ± 20%
- This meter is a variable resistor. Its electric resistance varies according to the change in the lever angle and when the current flows, the voltage varies.
  This change in the voltage is detected as an electric signal.

## SPEED SENSOR



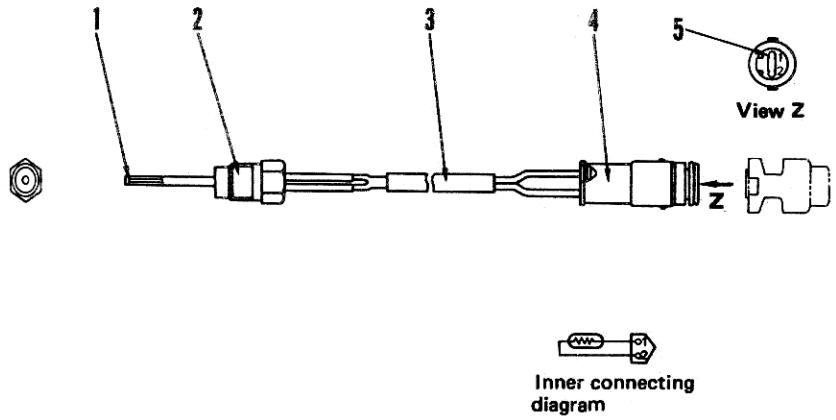




1. Connector hosing
2. Pine
3. Tube
4. Magnet
5. Case
6. Pole
7. Bobbin (coil)

**Speed sensor**

- This sensor is called the electromagnetic pickup. It has a built-in magnet and coil to form a magnetic field. When a piece of iron rapidly passes across the magnetic filed, the voltage builds up.
  This voltage is detected as an electric signal.

## THERMO - SENSOR



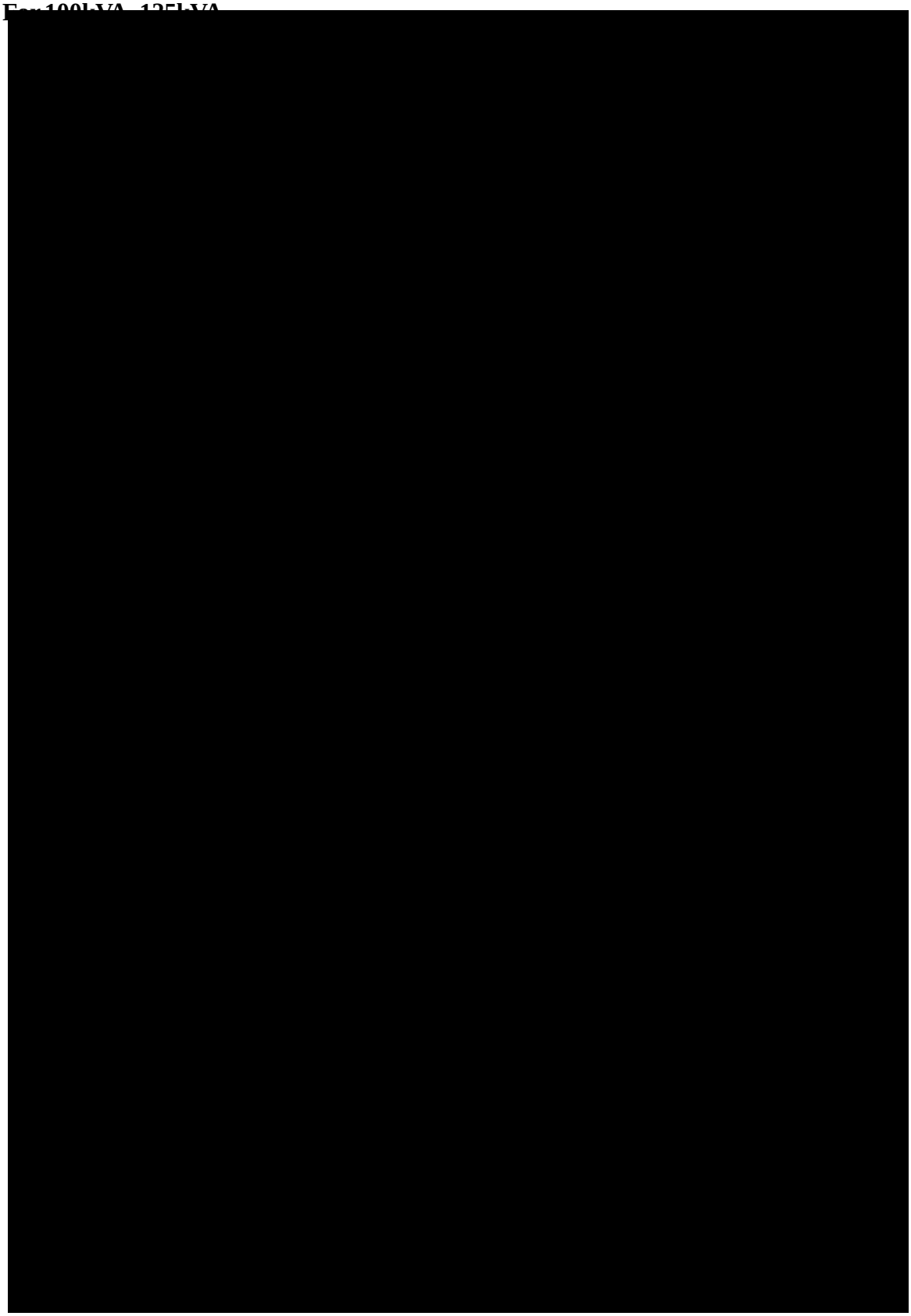

**Thermo - sensor**

- Applicable temperature range : - 50°C to 150°C
- When the current flows to the thermistor (which change the electric resistance depending on the temperature), the magnitude of the current can be detected. In this way, you can tell whether or not the cooling water temperature is normal. The thermistor temperature gauge indicates the magnitude of the current on the teperature scael.

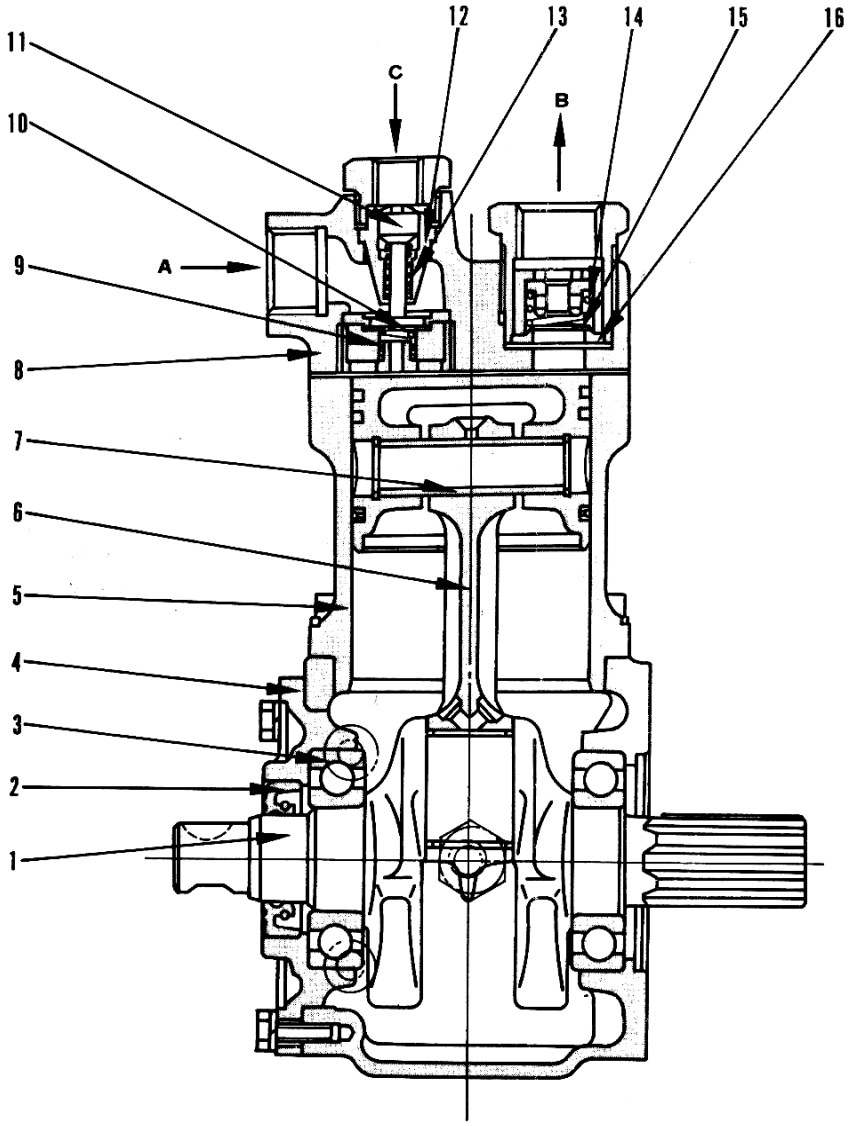
1. Thermistor
2. Sensor body
3. Tube
4. Connector
5. Terminal

## WIRING DIAGRAM FOR PRICOL ENGINE SAFETY SYSTEM

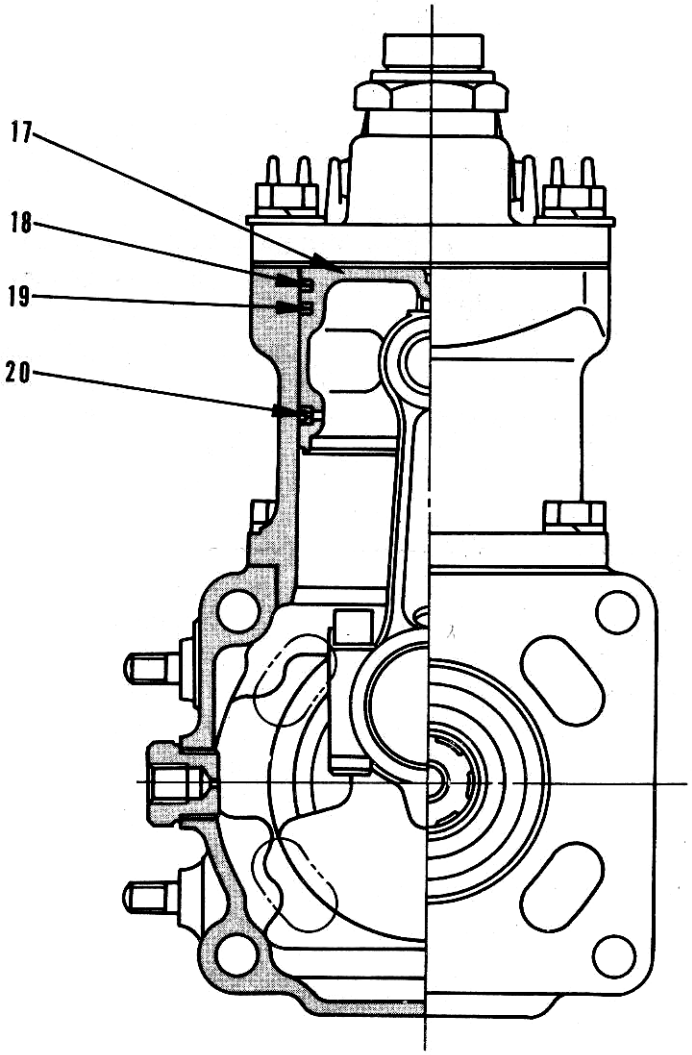
For 100kVA, 125kVA



# ACCESSORY
## AIR COMPRESSOR




1. Crankshaft
2. Oil seal
3. Ball bearing
4. Crankcase
5. Cylinder block
6. Connecting rod
7. Piston pin
8. Cylinder head
9. Inlet valve spring
10. Inlet valve
11. Unloader valve
12. Unloader valve guide
13. Unloader valve spring
14. Outlet valve spring
15. Outlet valve
16. Outlet valve seat
17. Piston
18. Top ring
19. Second ring
20. Oil ring




A. Air intake (inlet)
B. Air exhaust (outlet)
C. Unload

**Air compressor**

- Type : DIESEL KIKI
  single cylinder, double acting
- Cylinder : 70 x 40mm (Dia x stroke)
- Discharge volume : 385 l/min. (2500 rpm)
- Air pressure : 10 kg/cm$^2$
- Wieght : 6.5 kg

**Unloader valve**

- Valve opening pressure : 7.0 to 8.0 kg/cm$^2$
- Valve shutting pressure : 6.2 to 7.3 kg/cm$^2$

# ENGINE
## 13 TESTING AND ADJUSTING

**FUEL SYSTEM**
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# FUEL SYSTEM

## ADJUSTING OF FUEL INJECTION TIMING

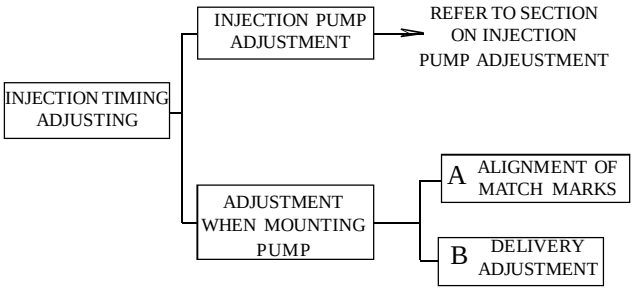
- Adjustment of fuel injection timing consists of adjutment of the injection pump itself and also adjustment when fitting the pump onto the engine.

- Adjustment when fitting the pump onto the engine consists of the following:

  A. Alignment of the match marks when re-fitting the injection pump onto the engine without actually repairing it.

  B. Delivery adjustment when either re-fitting a repaired pump or fitting a new pump.

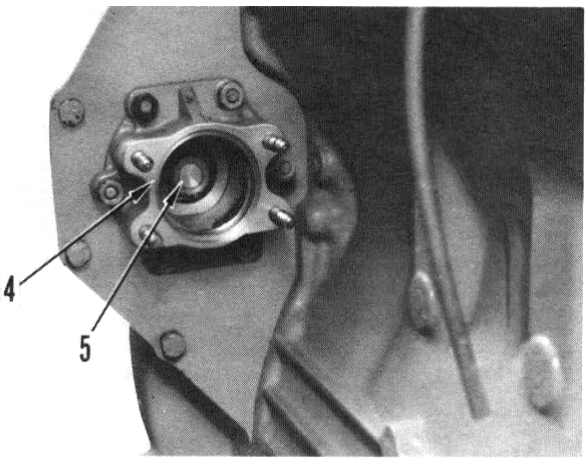
  ★ Carry out adjustment with cylinder 1 set to the compression TDC position.



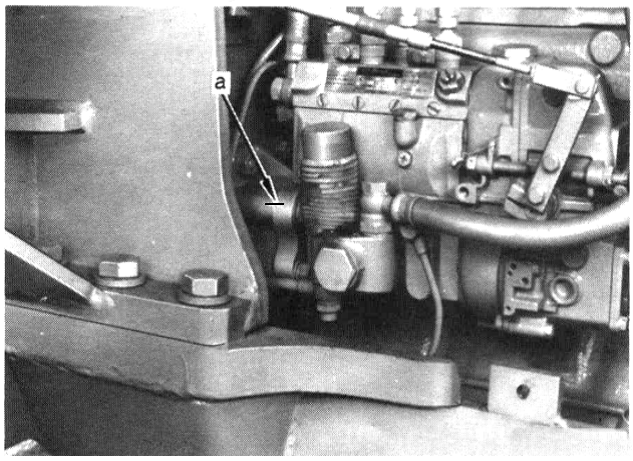

### 1. ADJUSTMENT OF MATCH MARKS

1) Fit a new O-ring onto the seal cover part of the injection pump, and lightily smear it with grease.

2) Align the thick tooth of coupling (5) in drive case (4) with the thick tooth of injection pump drive shaft spline, and then mount the injection pump.

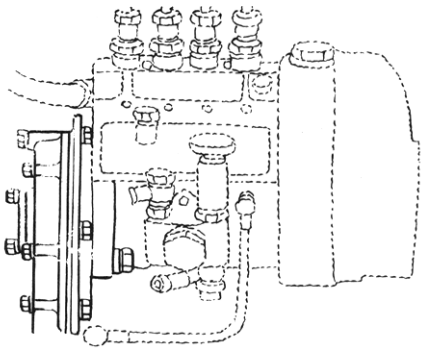



3) Align the spline part of the injection pump with the mark (a) on the drive case, and tighten up the mounting stud bolt and nut.



## 2. DELIVERY ADJUSTMENT

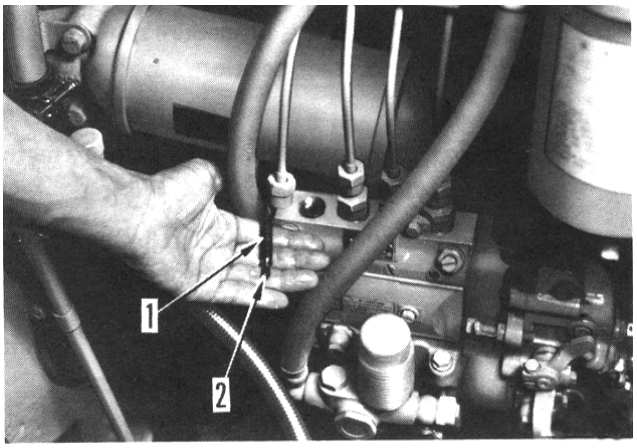
- Delivery adjustment is the same as the match mark alignment method of adjustment up to the time when the pump is mounted ( except for some slight differences in sequence).
- The adjustment method differs from the point where the pump mounting bolts are tighten up.
  Here, a description will be given of the procedure after the mounting bolts are tightened up.
- Adjustment of a flange type injection pump is performed by adjusting the position of the flange mounting bolts and nuts in the slotted holes.



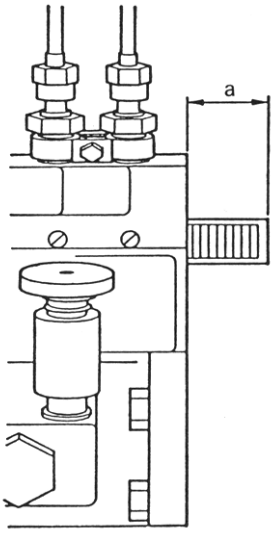
Flange type

## 1. Checking injection timing by delivery method

1) Set cylinder 1 at the compression T.D.C. position. (refer to the section on valve clearance adjustment.)
2) Rotate the crankshaft 30 to 45° in the reverse direction from the compression T.D.C. position.
   - Because the crankshaft is adhead of the T.D.C. position, it is necessary to rotate it slightly counter clockwise.




3) Remove the delivery vavle holder from cylinde 1 of the injection pump, then remove delivery valve spring (1) and delivery valve (2) from inside the holder and reassemble the holder.
   - Unless the delivery valve is fitted, fuel will pass through the intake and outlet ports of the plunger barrel and flow out from the delivery holder if the priming pump is operated when the pump plunger is not in the injection position.
   - Check the injection timing at the position where fuel ceases to flow (the position at which the plunger closes the intake and outlet valves).
4) Remove rack cover and adjust rack position by pushing in as follows.

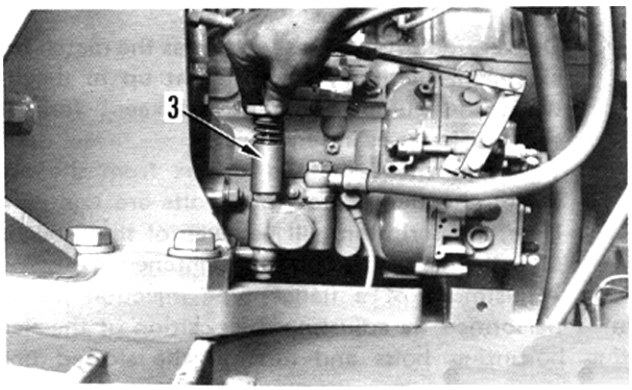



★ Rack position (Dimension a)

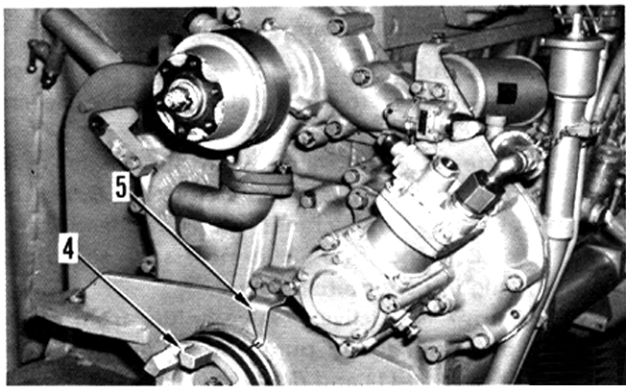
| Engine model | Engine No. | Machine model | Dimension a (mm) |
|---|---|---|---|
| B4D105-1 | | - | 5 |
| BS4D105-5 | | All model | 14 |

5) Check the position at which fuel ceases to flow out of the delivery valve holder by gradually turning the crankshaft clockwise while lightly operating priming pump (3).

⚠ Do not operate the priming pump vigorously otherwise fuel will spurt out and get and the face and hands.



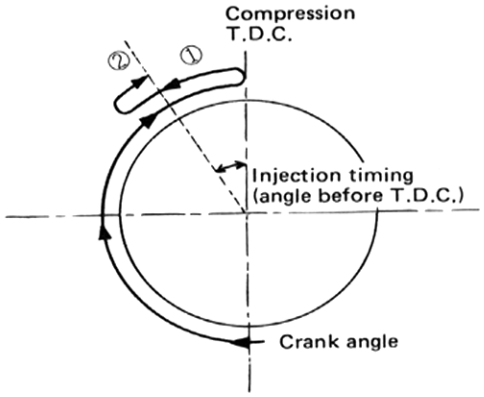

★ If the "OO° I.J" injection timing mark on either crank pulley (4) or the vibration damper is in line with pointer (5) at the point where fuel ceases to flow out, the injection timing is satisfactory.
★ If BEYOND line: Injection timing is RETARDED.
★ If BEFORE line: Injection timing is ADVANCED.
★ Rotate the crankshaft in the clockwise direction. If it is turned too far, turn it back in the opposite direction. Repeat this procedure until the crankshaft is in the correct position.

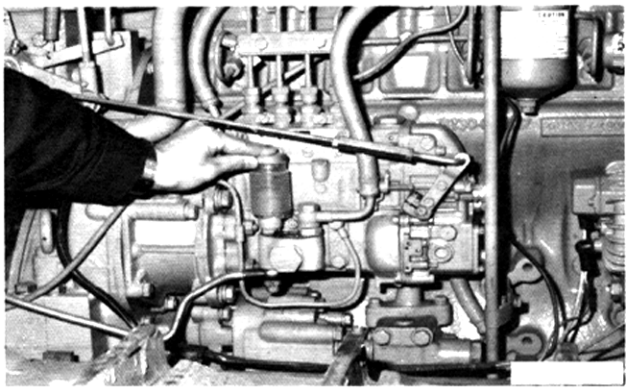



**2. Adjustment of injection timing by delivery method (additional checking work)**

. If the injection timing is found to be incorrect as a result of the above inspection, adjust it according to the following procedure:

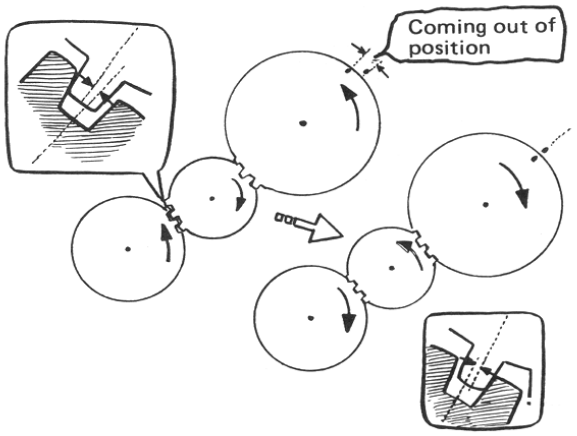
1) Rotate the crankshaft 30 to 45° counterclockwise from the T.D.C. position.
2) Rotate the crankshaft clockwise and align the pointer with the "OO° I.J" injection timing mark on either the crankshaft pulley or vibration damper.
   ★ Carry out alignment accurately.
3) Loosen the nut and bolt at the slotted hole in the mounting flange of the injection pump.
4) Loosen the four mounting bolts of the injection pump.
5) Push the injection pump 5 to 10° outwards.
6) Shift the injection pump very gradually to the inside (cylinder block side) while lightly operating the priming pump until the fuel ceases to come out of the valve holder (check by injecting fuel).
   ★ If the pump is shifted too far, bring it back again and read just.

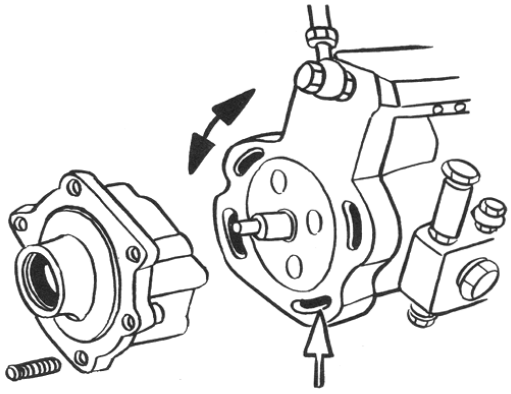


★ Carry out adjustment in such a way that the pump moves to inner side.
- Because the crankshaft and the injection pump drive shaft rotate in the same direction, moving the pump to the inner side (by turning it down in the opposite direction to the shaft) will cause the shaft to rotate relatively clockwise.
- Unless adjustment is made by rotating the shaft clockwise the resultant setting will be inaccurate by the amount of gear backlash.

7) Tighten up the injection pump mounting bolt.
8) After tightening up the mounting bolt of the injection pump, recheck the injection timing and confirm that it meets the specifications.

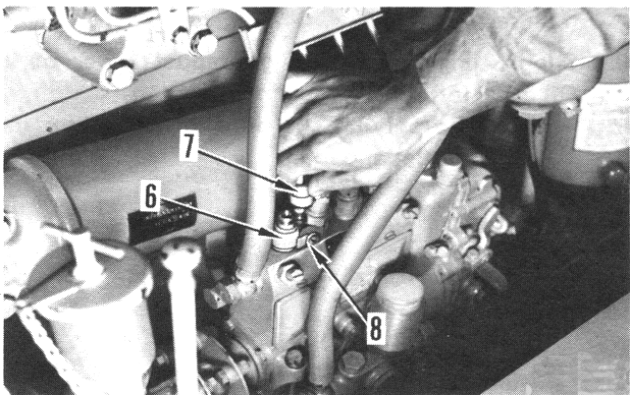


9) Remove delivery valve holder (6), then fit the delivery valve and delivery valve spring which were previously removed and tighten up the delivery holder to the specified torque.
★ Take care that dirt does not get into the pump.

10) Connect up the injection pipe and tighten up injecton pipe lock nut (7) to the specified torque.

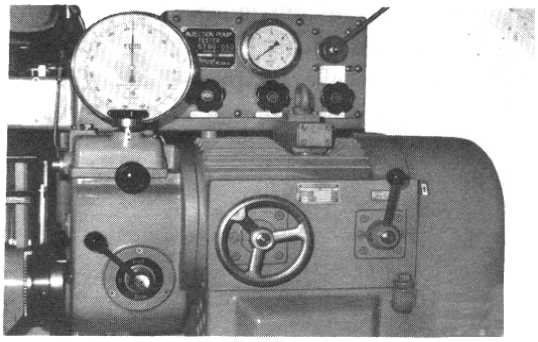
11) Fit holder lock (8).



# ADJUSTMENT OF FUEL INJECTION PUMP

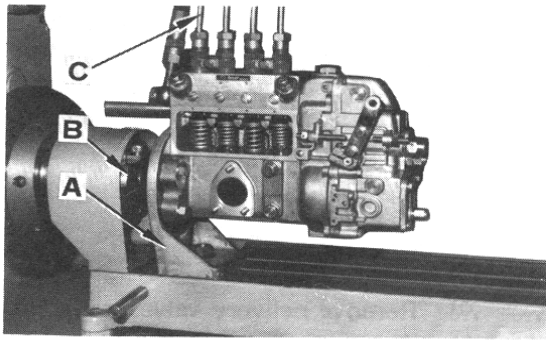
| Necessary tools | A | B | C | Necessary tools | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| Fixing stand | 1 | | | Measuring device (Rack) | 1 | | | | |
| Coupling | | 1 | | Adjusting device | | 1 | | | |
| Nozzle holder | | | 1 | Measuring device (plunger) | | | 1 | | |
| Nozzle | | | 1 | Special wrench | | | | 1 | |
| Injection pipe | | | 1 | Special wrench | | | | | 1 |

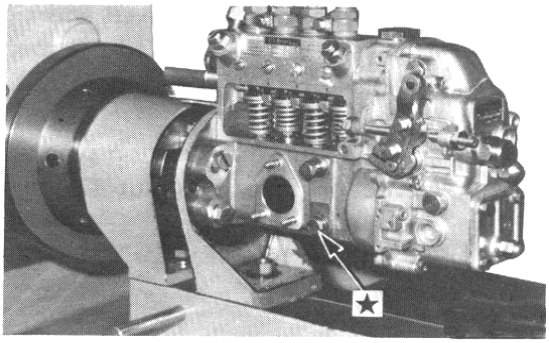
★ For adjusment procedure described here, the test stand of diesel unit type 5760-050 (10PS) is used. When other type of test stand is applied, proceed to the following adjustment procedure after having been familiar with the instruction manual for corresponding test stand.



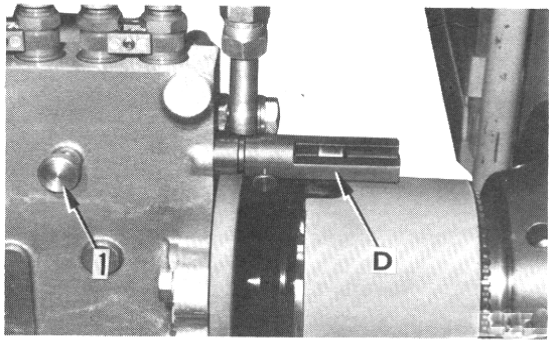
**Preparatory work**

1. Remove tappet cover, feed pump and coupling.
2. Fit rubber cap or plate to installation part of feed pump to plug part.
3. By means of fixing stand A, mount injection pump on test stand.
4. Connect pump to test stand with coupling B.
5. Connect nozzle, nozzle holder, injection tube C and fuel inlet hose respectively.
6. Supply engine oil through tappet cover of injection pump. Oil capacity: 200cc.
   ★ Before supplying, be sure to put plugs in both lubricating oil outlet and inlet.



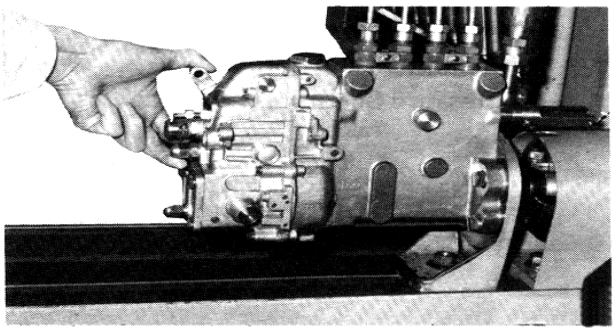




7. Install measuring device D to control rack.
   Loosen control rack stopper (1).
   ★ The control rack cap nut should be removed in advance.

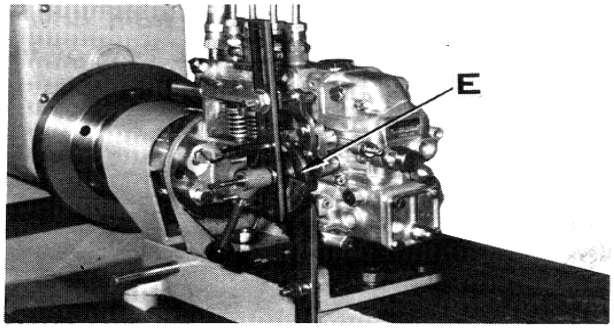


8. Pull fully control lever (control pinion) in non-injection direction, and set the measuring device after aligning zero point of vernia with zero point of scale.
   ★ After setting device, make sure rack moves smoothly by pushing fully control lever.

   Displacement of rack: About 14 mm

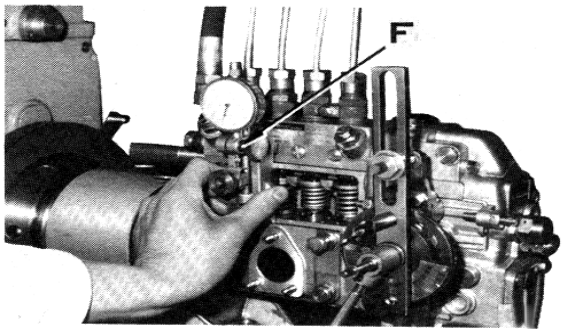


9. Install adjusting device E to test stand and set the device to control lever.




**Adjustment of fuel injection timing**

1. Place control lever in its full load position and fix lever in that position with adjusting device. (Fix control rack to full load position.)
2. Manually rotate pump until the 2nd cylinder tappet comes to its lower dead point.
3. Set measuring device F to pump cover plate. Allow measring edge of dial gauge to contact tappet guide of 2nd cylinder, and fix gauge.
4. Match pointer of dial gauge to zero, and make sure pointer does not move when turning gently the pump to right and left ( in other words, tappet lies in its lower dead point.)



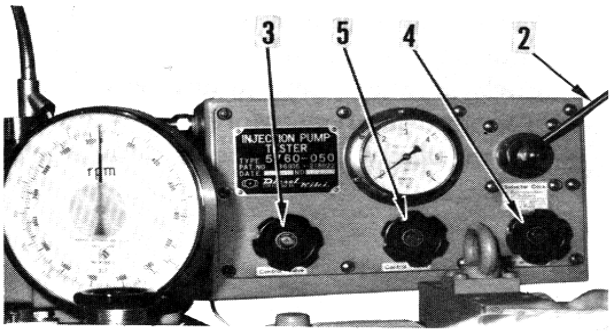

5. Place each levers and control valves on test stand to their starting position.
   1) Place selector cock lever (2) to vertical position.

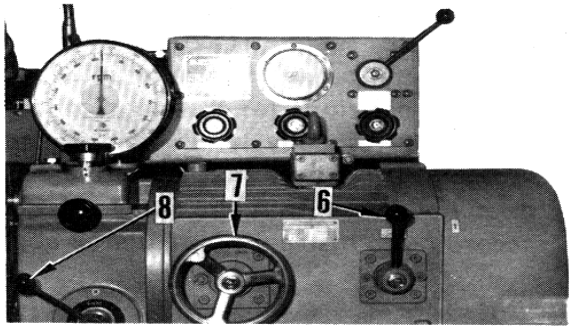
   2) Turn fully both high pressure valve (3) and cut-off valve (4) in clockwise direction for closing.

   3) Operate liquid pump adjustment lever (6) to vertical position.

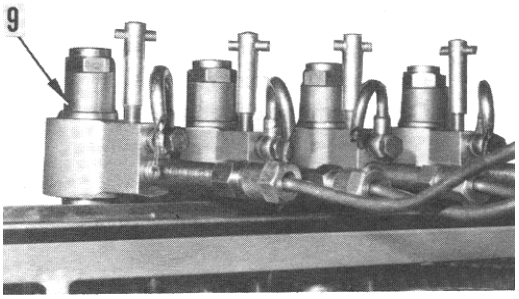
   4) Turn liquid motor adjustment handle (7) to the full counter clockwise to open it.

   5) Place charge lever (8) to zero position.

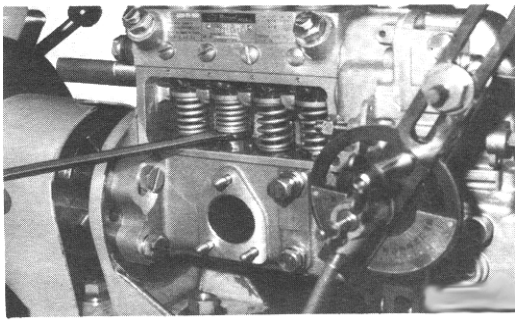


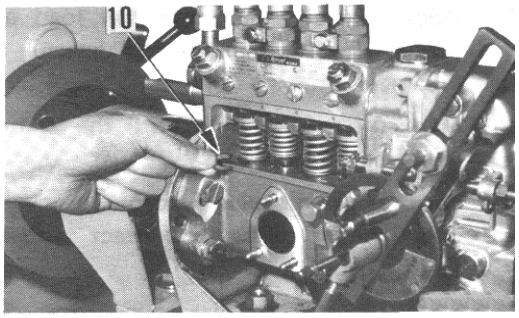
6. Turn on switch of fuel supply pump to open ball valve of nozzle holder (9). Fuel will flow.
7. Adjust the oil supply pressure adjustment valve so that the oil pressure becomes 1.6 kg/cm$^2$.



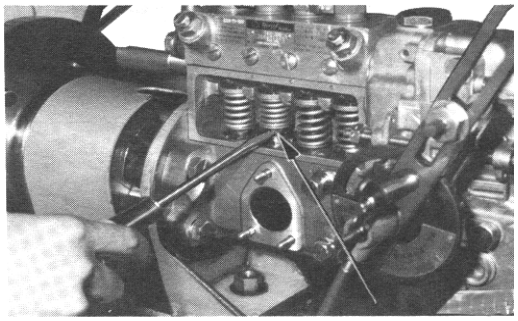

8. Manually rotate fuel injection pump in the regular direction ( clockwise when viewed from drive side), and make adjustment on cylinder so that flow of fuel stops just when value of dial gauge of measuring device (stroke of tappet) becomes 2.7 ± 0.05 mm.



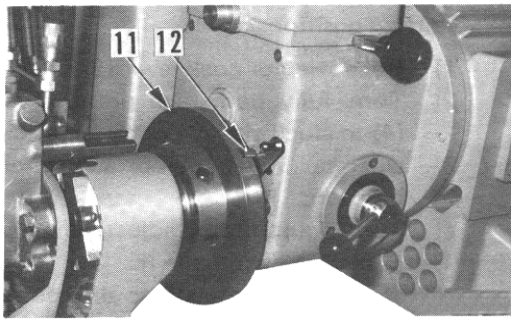
. To adjust fuel injection timing, loosen tappet lock nut and change the thickness of shims (10) inserted between tappet and plunger.
**Thickness of shim → allows the injection timing to quicken.**
**Thinning of shim → allows the injection timing to retard.**




9. With tappet positioned to upper dead point, inspect clearance (tappet clearance) between tappet and plunger when lifting both plunger spring by means of a screw driver.
Tappet clearance: More than 0.3 mm
When tappet clearance is smaller, re-adjust the injection timing.

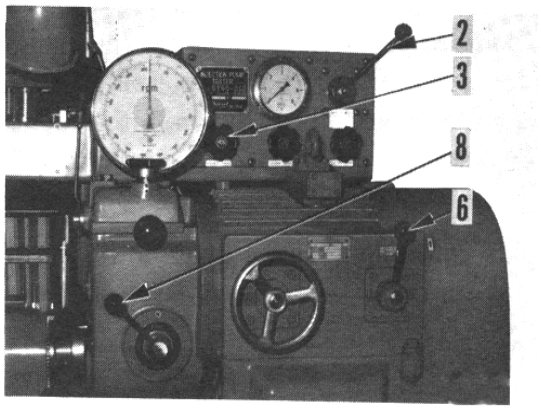


10. Taking cylinder whose injection timing has been adjusted as standard, set dial (12) of flywheel (11) to a round degree. Then, by rotating manually injection pump clockwise, make sure the positions for stoppage of fuel flow have an interval of 90° ± 30' A respectively in the injection order of 1-2-4-3, looking at flywheel that is graduated in degree. If such interval does not fall within the range of 90° ± 30', make adjustment according to instruction of Item 8 above.

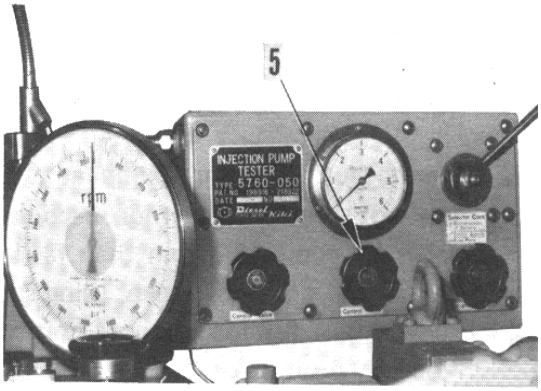


**Adjustment of fuel injection quantity**

1. Throw selector valve lever (2) down to right. (Position of Delivery Quantity).
2. Turn to open high pressure adjustment valve (3) counter clockwise to the full.
3. Throw change lever (8) down to left (Slow).
4. Turn liquid pump adjustment lever (6) down to right (Clockwise).
5. Close ball valve of nozzle holder and turn on switch of drive motor for both fuel feeding pump and injection pump.

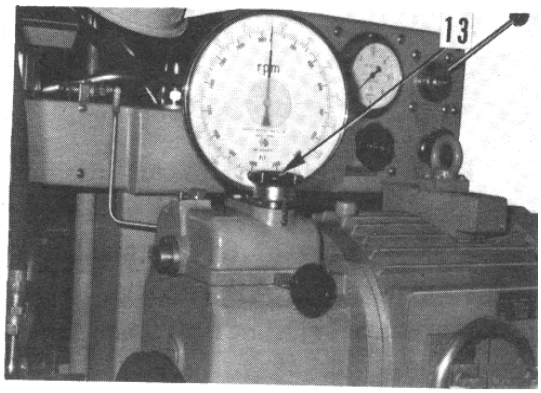



6. When oil feeding pressure adjustment valve (5), adjust pressure to 1.6 kg/cm$^2$.




7. Match control rack to position as shown in adjustment specification, and fix it by rack stopper.
8. By means of liquid motor adjustment handle, operate injection pump at a rotating speed by which injection quantity is measured.

   ★ When rotating speed exceeds 1000rpm, throw down change lever to right (High).

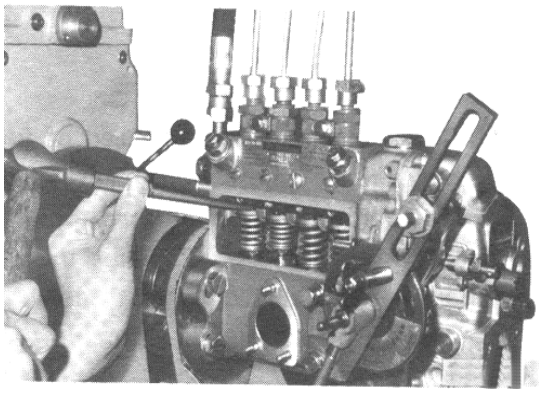



9. To measure injection quantity, set stroke setting device dial (13) to the specified stroke.

- To adjust fuel injection amount, loosen clamp of control pinion and turn control sleeve both to right and left.

  **Clockwise of control sleeve makes injection to increase the capacity.**

  **Counter clockwise of control sleeve makes injection to decrease the capacity.**



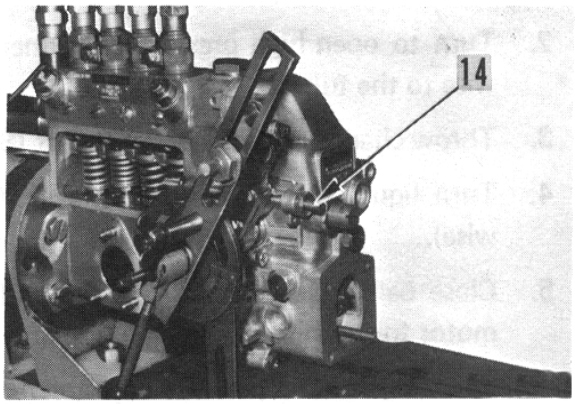
**Adjustment of governor**

Number of rotating of pump shown in the following procedure for governor adjustment as well as symbols for positions of rack are the same as those shown in the characteristic curve of governor.

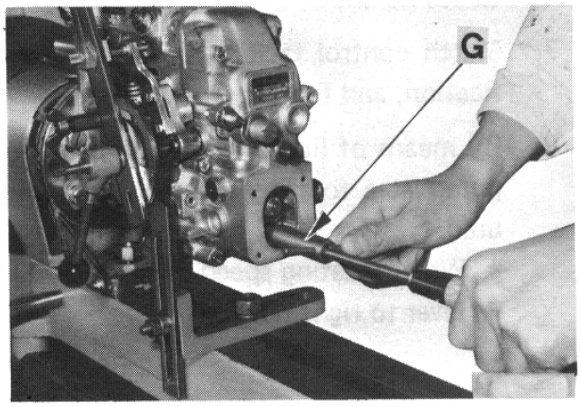
★ Prior to proceeding with adjustment, loosen idling subspring, angleich spring and torque spring so that they do not actuate.

1. Pull fully control lever in STOP direction, **and set stopper bolt (14) of control lever** so that position of control rack becomes 0.5 to 1.0 mm.

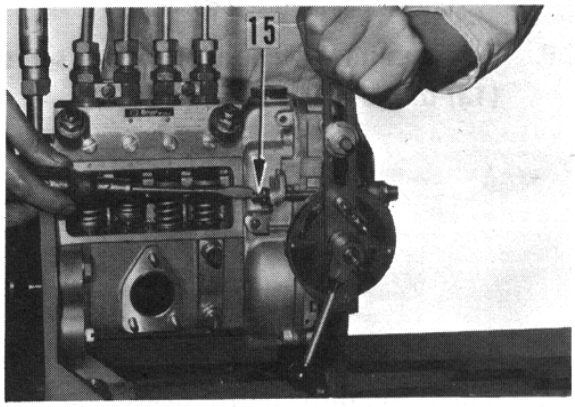
   ★ By this measure, when pulling control lever fully in top direction, excessive force does not apply to link mechanism inside the governor.




2. Operate fuel injection pump at a speed by which governor does not actuate (governor becomes non operative at lower speeds by about 200 rpm than rated rpm), and place control lever to full position. Then, using special wrench G and screw driver, adjust full load stopper bolt so that control rack comes to occupy position of (a).




3. Place control lever to full position, and gradually increase rotating speed of fuel injection pump. when rotating speed reaches speed of B', set maximum speed stopper bolt (15) so that control rack becomes to occupy a position of (b) for purpose of adjusting high speed control point.



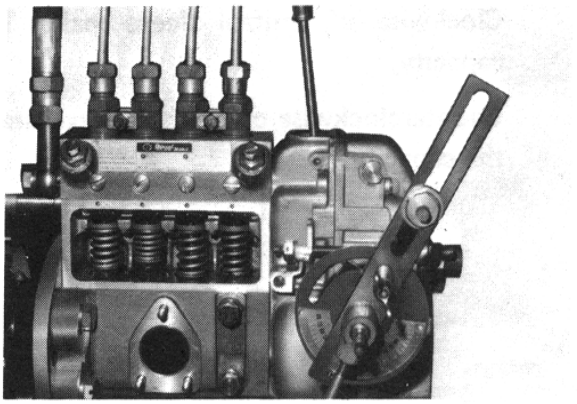

4. Further increase rotating speed of fuel injection pump. With screw driver, adjust adjustment screw of swivel lever so that when control rack is returned to position C, its rotating speed falls within 1340 to C'. Like this, set speed deviation ratio. Before adjusting adjustment screw, control lever should be fully returned to stop direction.

   **Tightening of screw makes the speed deviation ratio better.**

   **Loosening of screw makes the speed deviation ratio worse.**

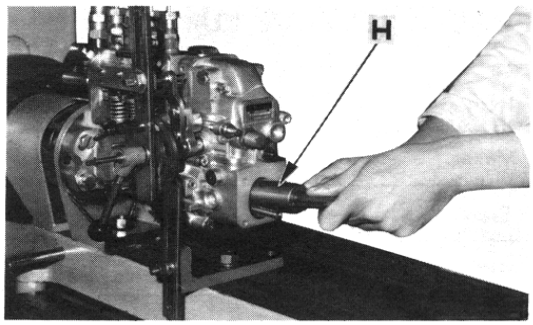
   ★ Never loosen screw by more than 20 notches (5 turns) from fully tightened position. Otherwise, it may fall free.

   ★ By adjusting adjustment screw, tension of governor spring varies o cause high speed control point to be displaced. Read just control point.

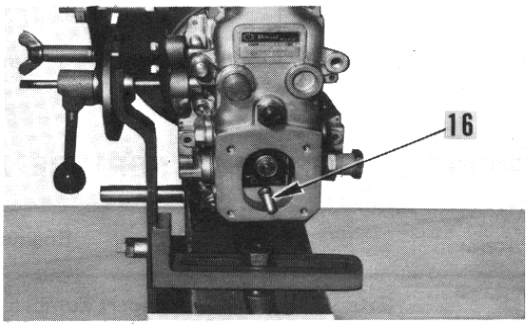


5. Operate injection pump at speed a little slower than D' and place control lever to full position. With special wrench H, tighten angleich spring so that control rack comes to position d for pupose of adjusting angleich.

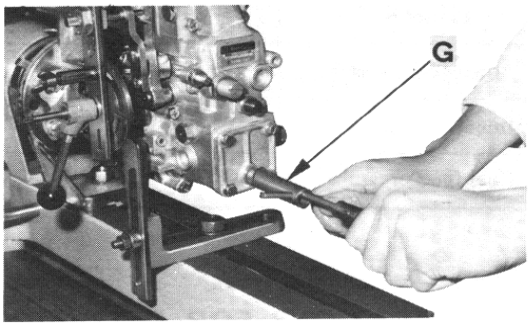
   Gradually increase rotating speed, and make sure when speed reaches D', control rack starts to move, and when speed reaches A', control rack comes to postion (a). If above relationship can not be obtained, adjust tightening amount of angleich for positions of control rack, and adjust thickness of shim of angleich spring for rotaing speeds.



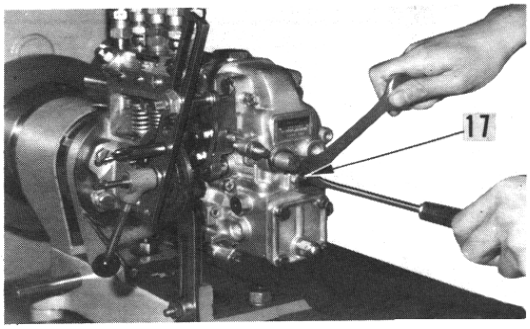

6. Removes lock nuts of full load stopper bolts (16) situ ated at boss of governor cover, taking care not to allow stopper bolts to turn. Instead, install closing cover.



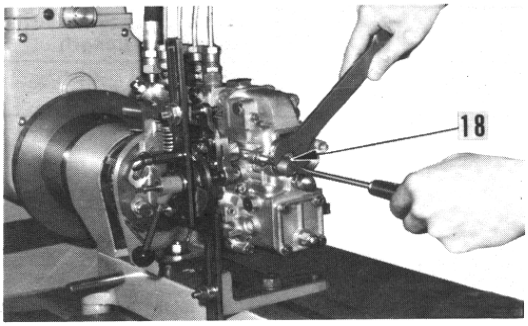

7. Operate injection pump at speed a little slower than D', and with special wrench G and screw driver, make adjustment on full load stopper bolt finally so that control rack comes to position D'. Then, secure bolt with lock nut (that has been removed in Item 6). After securing bolt, install cap nut.




8. Once stopping fuel injection, set control lever so that control rack occupies postion (f). Then, operate pump at speed of G', and adjust tightening amount of idling subspring (17) so that control rack becomes to occupy position (g). After that, set idling. After adjusting, secure spring with lock nut and install cap nut.




9. Operate injection pump at speed of E', and adjust tightening amount of torque spring (18) so that control rack becomes to occupy position (e). Set torque spring. After adjusting, secure spring with lock nut and install cap nut.



# ADJUSTING FUEL INJECTION QUANTITY

## FUEL INJECTION PUMP

| Item \ Engine | B4D105-1 | BS4D105-1 |
|---|---|---|
| Maker | MICO | MICO |
| Type | Bosch PES-A | Bosch PES-A |
| Direction of rotation | Clockwise as viewing from drive side | Clockwise as viewng from drive side |
| Injection order | 1 - 3 - 4 - 2 | 1 - 3 - 4 - 2 |
| Cam lift | | |

**DATA WILL BE GIVEN LATER**

## SPECIFICATIONS FOR SERVICE ADJSTMENT

| Item \ Engine | | B4D105-1 | BS4D105-1 |
|---|---|---|---|
| Injection nozzle | Maker part number | | |
| Nozzle holder | Maker part number | | |
| ★ Injection pressure | kg/cm² | | |
| Injection pipe | Inside diameter x Outside diameter x Length mm | | |
| Fuel feed pressure | kg/cm² | | |

## SPECIFICATIONS FOR DELIVERY ADJSTMENT

| Item \ Engine | | B4D105-1 | BS4D105-1 |
|---|---|---|---|
| Injection nozzle | Maker part number | | Nozzle holder |
| Maker part number | | | |
| ★ Injection pressure | kg/cm² | | |
| Injection pipe | Inside diameter x Outside diameter x Length mm | | |
| Fuel feed pressure | kg/cm² | | 1.6 |

## SPECIFICATIONS FOR ENGINE IS ON MACHINE

| Item \ Engine | | B4D105-1 | BS4D105-1 |
|---|---|---|---|
| Injection nozzle | Maker part number | | |
| Nozzle holder | Maker part number | | |
| ★ Injection pressure | kg/cm² | | |
| Injection pipe | Inside diameter x Outside diameter x Length mm | | |
| Fuel feed pressure | kg/cm² | | |

★ The value of injection pressure is under the bench test. This value differs from conditions

## Pump Assembly Number

6134-71-1110 (190000-6910)
( ): Manufacturer's part No.

| Injection Pump Type | Pump Manufacturer |
|---|---|
| | |

| Applicable Machine | | Applicable Engine | |
|---|---|---|---|
| Model | Serial No. | Model | Serial No. |
| BL9H | | B4D105-1 | |
| | | | |
| | | | |

## Injection Timing

| | Unit | Basis | Allowance |
|---|---|---|---|
| Rotating direction | | Clockwise viewed from drive end | |
| Injection order | | 1 - 3 - 4 - 2 | |
| Injection interval | | | |
| Plunger pre-stroke | mm | | |
| Delivery valve retraction volume | $mm^3$ | | |

## Engine specification

| | | |
|---|---|---|
| Rated horsepower | HP/r/min | |
| Maximum torque | kgm/rpm | |
| High idling | r/min | |
| Low idling | rpm | |

## Calibration Standard

**Conditions**

- **Manufacture standard** is data for factory test.
- **Service standard** indicates data using calibration test parts

| | Manufacture standard | Service standard |
|---|---|---|
| Nozzle part no. | | |
| Nozzle holder part no. | | |
| Injection pipe (O/D × I/D × length) mm | | |
| Test oil | | |
| Oil temperature ℃ | | |
| Nozzle opening pressure $kg/cm^2$ | | |
| Transfer pump pressure $kg/cm^2$ | | |

**Injection volume**

- Rack positions B to E are the reference volume when adjusting the injection volume.
- Marks ★ are average volumes.

| | | Rack Position (mm) | Pump Speed (rpm) | **Service standard** (cc/100 st) Basis | Allowance | Maximum variance between cylinder | **Manufactur standard** (cc/100st) Basis | Allowance | Maximum variance between cylinder |
|---|---|---|---|---|---|---|---|---|---|
| Calibration Basic point | | | | | Each cylinder | max. | Each cyl. | | max. |
| B | | | | | | | | | |
| C | | | | | | | | | |
| D | | | | | | | | | |
| E | | | | | | | | | |

**Governor performance**

**DATA WILL BE GIVEN LATER**

# CALIBRATION DATA

| Machine Model | Engine Model | Pump Assembly No. | Applicable Engine Serial Number | Ref. Page |
|---|---|---|---|---|
| BL9H | B4D105 | 05Z 710 0289 (30G 401 3618) | Z057840002- | |
| 62.5 kVA | BS4D105-1 | 06Z 710 0018 | Z06A060001- | |
| 82.5 kVA | BSC4D105-1 | | | |
| | | | | |
| | | | | |

# PERFORMANCE TEST
## TESTING METHOD OF PERFORMANCE

★ When the engine was overhauled or was given an extensive repair, this test is done to check the engine for performance and presence of abnormalities after assembly.

**1. OIL SUPPLY**

- Supply the engine oil, class-CD SAE30 (class-CD, SAE10W if temperature is 0° C within) until it goes as far as to the marking **H** of the oil level gauge.
- When the injection pump was removed and repaired, supply about **200 cc** of the same oil to the governor room of the pump and about **60 cc** to the cam room.

**2. INSTALLATION TO THE DYNAMOMETER**

- Mount the engine on the stand of the dynamometer. After installing the saucer to the flywheel with the bolts of more than 6 ($\phi$10, P = 1.5), adjust levelling of the engine on the stand against the dynamometer in regard to all directions, up, down, right, left, forward and backward. Then, tighten all set bolts to secure the engine to the stand.
- Eccentricity of the flanges located at the engine side and the dynamometer side, should be, if the flexible joint is used, within **0.13** mm of full deflection of the dial indicator.
- Check the dynamometer for levelling and functions.

**3. WIRING AND PIPING**

- Make all connections to the cooling system using the pipes.
- Make all connections to the system, and pour the fuel to the filter.
- Install the start up switch, set-motor, and thermostat to the **24V 120 Ah 2** battery, and distribute all wires between them.
- Install the exhaust pipes in a manner that they do not affect the intake air temperature as much as possible.
- Install the fuel control lever.

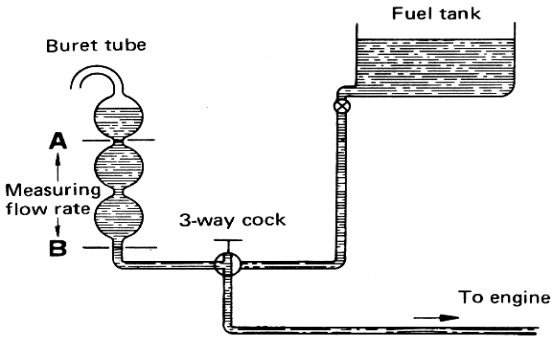
**4. INSTALLATION OF MEASURE DEVICES**

- **Engine tachometer**

  The tachometer equipped with a dynamometer gives, in general, relatively large error in measurements because of its wide speed range. Therefore, it is advisable to take measurement by placing the clock type tachometer (Hussler tachometer, minimum graduation: 5 rpm) on the edge of the dynamometer, or by installing to the shaft of the dynamometer the electromagnetic pickup which is connected to the counter.

- **Measurement apparatus for fuel consumption**

  Connect the 3-way cock and buret tube between engine and the fuel tank as follows. (Measuring accuracy: 1%)




- **Thermometer for intake air**

  Install the bar thermometer or thermistor thermometer at the inlet of the air cleaner. (Minimum graduation: 1°C)

- **Thermometer for exhaust air**

  Install the thermocouple on the exhaust pipe approximately 50 mm from the flange of the exhasut mani fold outlet. If cold junction is not provided for the thermocouple, measurement are subject to the effect of room temperature.

  As thermometer, alumel-chromel thermocouple is recommended. (Minimum graduation: 1°C)

- **Thermometer for coolant**

  Install the bar thermometer (adapter is necessary) or the thermistor thermometer to the outlet for water temperature gauge provided on the top of the cylin der head. (minimum graduation: 10°C)

**5. RUN-IN**

- After the engine has been repaired, perform the Run-In according to the standard procedure so that the piston and piston ring can get good familiarity with sliding areas such as cylinder liner and bearings for smooth running of the engine.

**1) Before starting engine, make sure the followings.**

- Each part of the engine, and tightness of the engine set bolts.
- Tension of the fan-belt.
- Replenishment of the engine oil and coolant.
- Oil supply to each part of the dynamometer.
- Injection timing.
- ★ The fan must be removed.
- When starting up the engine, place the lever in NO INJECTION position, and idle with the starting motor for 15 to 20 seconds during which make sure the followings.
  1. The dial of the oil pressure gauge deflects.
  2. The engine runs smoothly without any abnormal sound.

     Do not idle the starting motor for more than 20 seconds.

**2) During running of the engine, make sure the followings.**

- **Lube oil**
  1. Oil level is between H and L of the dipstick.
  2. Oil pressure is between 1.0 and 6.0 kg/cm².
  3. Coolant is not entered in the oil.

- **Coolant**
  1. After start up of the engine, replenish the coolant as necessary so as to fill the cooling system with coolant.
  2. Temperature of the coolant is maintained at 70 to 80°C.

- **Exhaust color**
- **Presence of leakage of coolant, oil and compressed gases**
- **Abnormal sound on each part**
- **Tightness of each part installed**

**3) After Run-In, make sure the followings.**

- Check the oil. If badly dirted, replace with new oil.
- Adjust the valve clearance.

**6. POWER ADJUSTMENT AND PERFORMANCE TEST**

**1) Standard performance test**

The flywheel horsepower is the value of the measured power multiplied by (JIS) modification factor. This value should exceed 96% of the lower limit specified in the Standard Performance Test.

- Make sure the engine performance transfers smoothly, referring to the performance curve at ship ment from the factory (See Page 01-12 to 17).
- According to the degree of overhaul or adjustment, the engine performance may be below the standard values.
- The values shown in the standard performance test differrs from those in the specifications, because the standard test is done without the fan.

**2) Conditions for performance test.**

- Alternator : No load
- Air cleaner : Installed
- Fuel Injection timing:

  B4D 105-1 18° before the top dead center

  BS4D 105-1 19° before the top dead center
- Fuel used : ASTM D975 No.2 diesel
- Lube oil used : DS-class series NO.3 DAE NO.30 engine oil (Komatsu recommended).

# RUN-IN STANDARD

| Engine model | Applicable machine | Test item | Order | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| B4D105-1 | BL9H | Running time min. | 5 | 10 | 15 | 20 | 10 | 5 |
| | | Engine speed rpm | 700 - 750 | 1,150 | 1,450 | 1,850 | 2,150 | 2,350 |
| | | Load kg | 0 | 8 | 12.5 | 19.5 | 25 | 31 |
| | | Output Hp | 0 | 9 | 17 | 35 | 52 | 71 |
| BS4D105-1 | 62.5 kVA | Running time min. | 5 | 10 | 10 | 15 | 15 | 5 |
| | | Engine speed rpm | 775 - 825 | 1,050 | 1,300 | 1,650 | 1,900 | 2,100 |
| | | Load kg | 0 | 10 | 17 | 26 | 34 | 41.5 |
| | | Output Hp | 0 | 9.5 | 21 | 42 | 62.5 | 85 |

# PERFORMANCE TEST CRITERIA

| Engine model | Applicable machine | Test item | Specified value (fully equipped) | Engine speed (rpm) | Dynamometer (kg) |
|---|---|---|---|---|---|
| B4D105-1 | BL9H | Flywheel horsepower | 70 HP/ 2,350 rpm | 2,345 - 2,355 | 30.9 - 32.6 |
| | | Max. torque | 24 kgm/ 1,400 rpm | 1,300 - 1,500 | 33.8 - 37.4 |
| | | High idling speed | 2,650 - 2,750 | 2,650 - 2,750 | 0 |
| | | Low idling speed | 700 - 750 rpm | 700 - 750 | 0 |
| BS4D105-1 | 62.5 kVA | Flywheel horsepower<br>Max. torque<br>High idling speed<br>Low idling speed | | | |
| BSC4D105-1 | 82.5 kVA | Flywheel horsepower<br>Max. torque<br>High idling speed<br>Low idling speed | | | |
| | | | | | |

- ★ The values given for the output and torque are with the fan removed, so they differ from those of the specification.
- ★ Values are standardized under the following conditions: Air cleaner installed; alternator idling; and air compressor (if installed) open.
- ★ Dynamometer are given for the case of the arm length is 716 mm.
- ★ Fuel used: ASTM D975 No. 1 or No. 2 diesel fuel.
- ★ Lubrication oil used: CLASS - CD SAE30.

| Output (HP) | Torque (kgm) | Fuel consumtion (sec /500 cc) | Coolant temperature (℃) | Lubrication oil temperature (℃) | Lubrication oil pressure (kg/cm² ) | Exhaust temperature (℃) t = Intake temp. - 20°C |
|---|---|---|---|---|---|---|
| 68.0- 72.0 | - | Min. 23.6 | 70 - 95 | 80 - 115 | 3.0 - 5.5 | 650 + 3t max. |
| - | 25.2 - 26.8 | Min. 34.4 | 70 - 95 | 80 - 115 | - | 650 + 3t max. |
| 0 | 0 | - | 70 - 95 | 80 - 115 | - | - |
| 0 | 0 | - | 70 - 95 | 80 min. | 1.0 min. | - |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Table 1. Relationship between dry/wet bulb temperature and partial water vapor pressure PW**

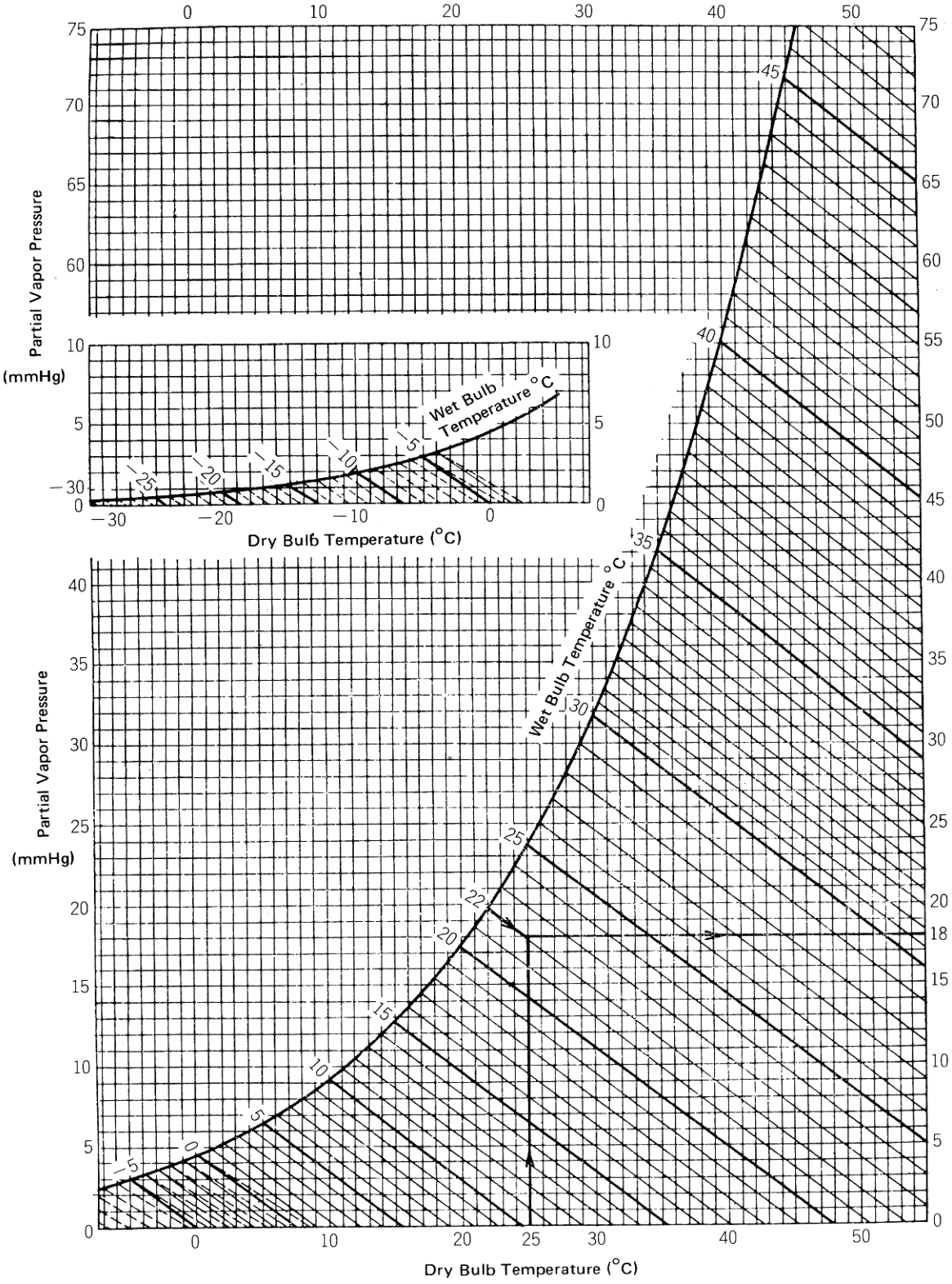
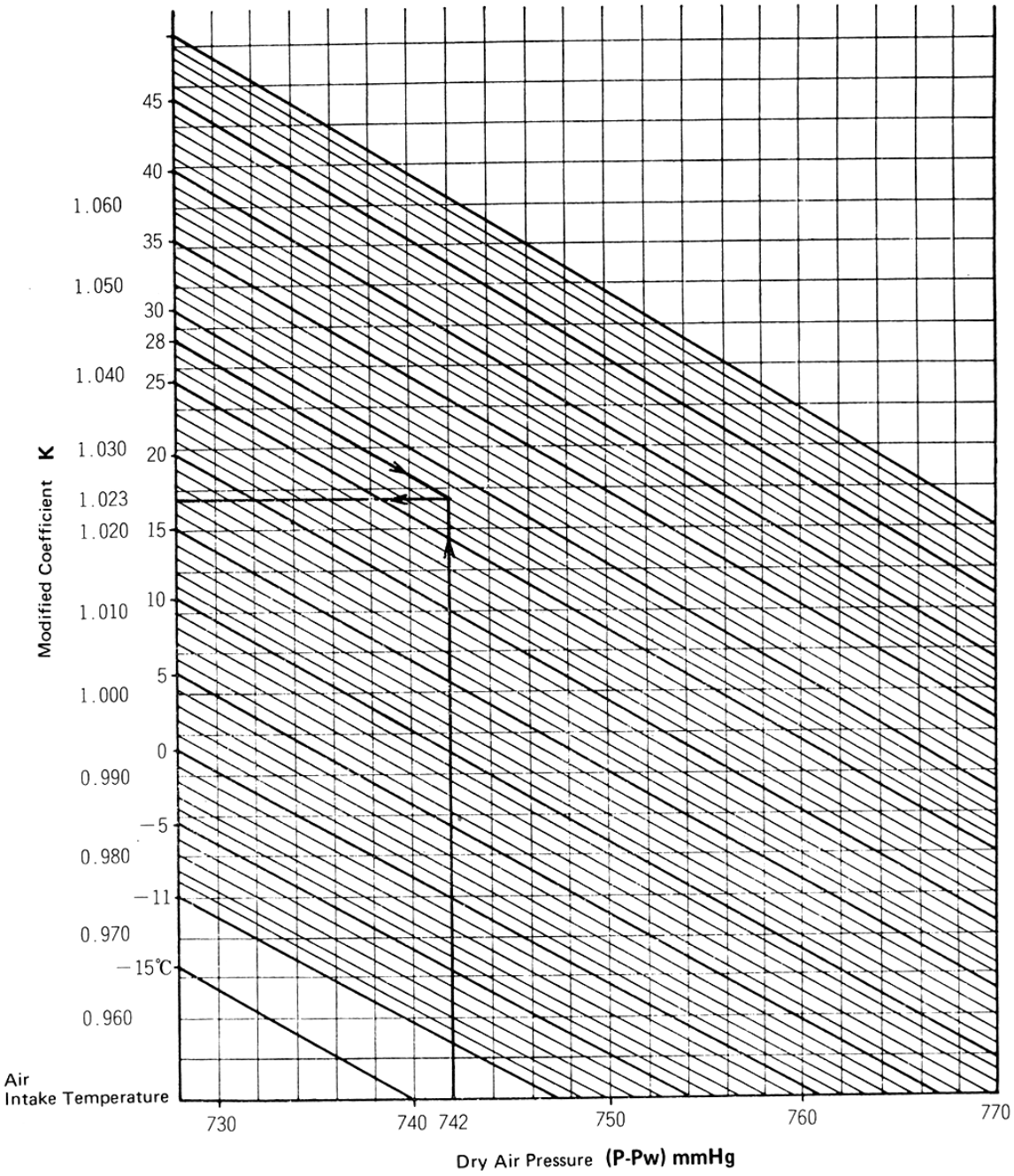


**Table 2. Chart for modification factor K**



## 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<br>60 ~ 2,000 rpm |
| 2 | Battery S.G | Battery, coolant tester | 795-500-1000 | 1,100 ~ 1,300 |
| 3 | Freezing temperature of cooling water | | | -5° C ~50° C |
| 4 | Water temperature, oil temperature, air intake temperature | Thermistor temperature gauge | 790-500-1300 | 0° C ~200° C |
| 5 | Exhaust temperature | Engine pressure measuring kit | 799-203-2002 | 0~1,000° C |
| 6 | Lubrication oil pressure | | | 0~ 10 kg/cm² |
| 7 | Fuel pressure | | | 0 ~ 20 kg/cm² |
| 8 | Intake pressure, exhaust pressure | | | 0 ~ 1,500 mmHg |
| 9 | Blow-by pressure | | | 0 ~ 1,000 mm$H_2O$ |
| 10 | Air intake resistance | | | - 1,000 ~ 0 mm$H_2O$ |
| 11 | Compression pressure | Compression gauge | 795-502-1204 | 0~ 70 kg/cm² |
| 12 | Blow-by pressure | Blow-by checker | 799-201-1503 | 0~ 500 mm$H_2O$ |
| 13 | Valve clearance | Feeler gauge | 795-125-1330 | 0.25, 0.45 mm |
| 14 | Exhaust gas color | Handy smoke checker | 795-116-1330<br>799-201-9000 | 0.35, 0.65 mm<br>Dirtiness 0 ~ 70% with standard color |
| 15 | Water and fuel content in oil | Engine oil checker | 799-201-6000 | (Dirtiness % × 1/10= Bosch scale)<br>Provided with 0.1and 0.2 water content standard samples. |
| 16 | Fuel injection pressure<br>Fuel injection nozzle spray condition | Nozzle tester | Commercially available | 0 ~ 300 kg/cm² |
| 17 | Coolant quality | Water quality tester | 799-202-7001 | PH, nitrite ion concentration |
| 18 | Pressure valve performance<br>Leakage in cooling water system | Radiator cap tester | 799-202-9001 | 0 ~ 2 kg/cm² |
| 19 | Radiator blockage (wind speed) | Anemometer (Air speed gauge) | 799-202-2001 | 1 ~ 40 m/s |
| 20 | Engine cranking | Cranking kit | 799-610-1000 | DC24V with starting engine |
| | | Barring device | 795-215-1600 | |
| 21 | Electrical circuits | Tester | Commercially available | Current, voltage, resistance |

## TESTING AND ADJUSTNG DATA

| Engine Model | | | | B4D105-1 | | BS(C)4D105-1 | |
|---|---|---|---|---|---|---|---|
| Applicable machine model | | | | BL9H | | 62.5 & 82.5 kVA | |
| Classification | Item | Condition,etc | Unit | Standard | Tolerance | Standard | Tolerance |
| Performance | Engine speed | High idling speed | r/min | 2,650 - 2,750 | | | |
| | | Low idling speed | r/min | 700-750 | | | |
| | Necessary | 0° C | r/min | Min. 200 | | | |
| | Starting speed | - 20° C (with starting aid) | r/min | Min. 100 | | | |
| Intake and exhaust system | Intake resistance | At rated output | $mmH_2O$ | Max. 300 | | | |
| | Intake pressure | At rated output | mmHg | - | | | |
| | Exhaust pressure | At rated output | mmHg | - | | | |
| | Exhaust temperature | All speed (20° C) | ° C | Max. 650 | | | |
| | Exhaust gas color | Quick acceleration | Bosch | Max. 6.0 | | | |
| | | At high idling | Scale | - | | | |
| | Valve clearance | Intake valve | mm | 0.25 | | | |
| | (at cold.) | Exhaust valve | mm | 0.45 | | | |
| Engine body | Compression | Oil temperature: | | | | | |
| | Pressure | 40° C ~ 60° C | $Kg/cm^2$ | Min. 32 | | | |
| | | (Engine speed) | (rpm) | (270 - 350) | | | |
| | Blow-by pressure | At high idling | | | | | |
| | | (Oil temperature: | $mmH_2O$ | Max. 50 | | | |
| | | Min. 60° C min) | | | | | |
| Lubrication system | Oil Pressure | At high idling | $Kg/cm^2$ | 3.0 - 6.0 | | | |
| | (SAE30 Oil | | | | | | |
| | temperature: | At low idling | $Kg/cm^2$ | Min. 1.0 | | | |
| | Min. 80° C min.) | | | | | | |
| | Oil temperature | All speed (Oil in oil pan) | ° C | 80 - 115 | | | |
| | Oil consumption | At continuous rated output | % | Max. 0.6 | | | |
| | ratio | (Ratio of fuel consumption) | | | | | |
| Fuel system | Fuel injection | Nozzle tester | $Kg/cm^2$ | 225 | | | |
| | pressure | | | | | | |
| | Fuel injection | B.T.D.C | degree | 20 | | | |
| | timing | | | | | | |
| Cooling system | Coolant temperature | All speed | ° C | 70 ~95 | | | |
| | | (at engine outlet) | | | | | |
| | | Valve cracking temp. | ° C | 74.5~ 78.5 | | | |
| | Thermostat function | Full open temperature | ° C | 90 | | | |
| | | Full open lift | mm | 10 ± 0.5 | | | |
| | Radiator pressure | Opening pressure | $Kg/cm^2$ | 0.75 ± 0.1 | | | |
| | valve | (Differential pressure) | | | | | |
| | Fan speed | At rated engine speed | r/min | | | | |
| | Fan belt tension | | mm | 10 | | | |

★ The values given in the Testing and Adjusting data are NOT for adjustment of the output.
Do not use these values as a guide to change the setting of the fuel injection pump.

# Trouble Shooting

# TROUBLESHOOTING

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# POINTS TO REMEMBER WHEN TROUBLESHOOTING

Troubleshooting means locating the basic cause of the failure, and carrying out swift repairs, and ensuring that the failure does not occur again.
When carrying out troubleshooting, it is of course important to understand the structure and function. But to carry out the troubleshooting effectively, a quick method is to carry out troubleshooting using the problems mentioned by the operator as a guide in locating the cause.

**1. Do not disassemble the machine simply because there is a failure.**

If the machine is disassembled immediately just because there is a failure:

- Unrelated or unnecessary places are also disas sembled
- It becomes difficult to locate the cause of the failure

This means that there is not only a waste of time and money on replacement parts, oil, and grease, but this action will also lose the confidence of the user and operator.
For this reason also, it is important to carry out troubleshooting based on full investigation before starting and troubleshooting following the correct order.

**2. Questions to ask the user and operator**

1) Are there any problems other than those already reported ?
2) Did anything unusual happen before the failure occurred ?
3) Did the failure occur suddenly, or had the condition of the machine been poor before the failure occurred ?
4) What were the conditions when the failure occurred?
5) Had any repairs been carried out before the failure occurred ?
6) Had any similar failure occurred before ?

**3. Checks before troubleshooting**

1) Check the oil level
2) Check for any external leakage of oil from the piping and hydraulic equipment.
3) Check the travel of the control levers.
4) Other maintenance items can also be carried out visually, so carry out any check that is considered necessary.

**4. Confirming failure**

Check the degree of the problem to judge for yourself if it is really a failure, or if there is some problem in the handling or operation of the machine.

★ When driving the machine and re-enacting the failure, be sure that the investigation or measurement does not make the failure worse.

**5. Trouble shooting**

Narrow down the causes of the failure from the results of the questions and checks in the above Items 2 - 4, then follow the troubleshooting flow chart to locate the failure.

★ Basic procedure for troubleshooting

1) Start from the simple places.
2) Start from the most probable places.
3) Investigate related parts also.

**6. Basic action to remedy cause of failure**

Even if the failure is repaired, if the root cause of the failure is not repaired, the same failure will occur again.
To prevent this, it is necessary to investigate why the failure occurred, and to remove the root cause of the failure.

# 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 TROUBLE-SHOOTING TABLE

- The symbol ○ in the table is inserted only for causes which can be diagnosed. If a casuse can not 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. 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.

| Problems \ Causes | a | b | c | d | e |
|---|---|---|---|---|---|
| Remedy | X | C | Δ X | A | X |
| 1 | ○ | ○ | ○ | ○ | |
| 2 | | | ○ | | ○ |
| 3 | | ○ | | ○ | |
| 4 | ○ | | | ○ | |
| 5 | | ○ | | | ○ |

Example 1:

Problems 1→ Abnormal
Problems 2→ Normal
Problems 3→ Abnormal
Problems 4→ Normal

} From the table of example 1, the cause of the fault is b.

Example 1

| Problems \ Causes | a | b | c | d | e |
|---|---|---|---|---|---|
| Remedy | X | C | Δ X | A | X |
| 1 | ● | ● | ● | ● | |
| 2 | | | Ⓛ | | Ⓛ |
| 3 | | ● | | ● | |
| 4 | Ⓛ | | | Ⓛ | |
| 5 | | ○ | | | ○ |

Not necessary problems → 5

Example 2 :

Problems 1→ Normal
Problems 2→ Abnormal

} From the table of example 2, the cause of the fault is e.

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

Example 2

| Problems \ Causes | a | b | c | d | e |
|---|---|---|---|---|---|
| Remedy | X | C | Δ X | A | X |
| 1 | Ⓛ | Ⓛ | Ⓛ | Ⓛ | |
| 2 | | | ● | | ● |
| 3 | | ○ | | ○ | |
| 4 | ○ | | | ○ | |
| 5 | | ○ | | | ○ |

Not necessary problems → 3

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

| Problems \ Causes / Remedy | a | b | c | d | e |
|---|---|---|---|---|---|
| | X | C | Δ X | A | X |
| 1 | ● | ● | ● | ● | |
| 2 | | | ● | | ● |
| 3 | | Ⓛ | | Ⓛ | |
| 4 | ○ | | | ○ | |
| 5 | | ○ | | | ○ |

Example 3-1

| Problems \ Causes / Remedy | a | b | c | d | e |
|---|---|---|---|---|---|
| | X | C | Δ X | 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

| Problems \ Causes / Remedy | a | b | c | d | e |
|---|---|---|---|---|---|
| | X | C | Δ X | A | X |
| 1 | ● | ● | ● | ● | |
| 2 | | | Ⓛ | | Ⓛ |
| 3 | | ○ | | ○ | |
| 4 | ○ | | | ○ | |
| 5 | | ○ | | | ○ |

Example 4-1

| Problems \ Causes / Remedy | a | b | c | d | e |
|---|---|---|---|---|---|
| | X | C | Δ X | 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 trouble-shooting**

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

★ **Cause h:** battery charging rate

| Temperature \ Charging rate | 100% | 90% | 80% | 75% | 70% |
|---|---|---|---|---|---|
| 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.

| No. | Problems \ Remedy / Cause | a Stopping piston from moving by foreign matter in cylinder. | b Damage to connecting rod or crankshaft | c Bushing and metal biting into each other | d Intake and exhaust valves are blocked in cylinder | e Damage to pump or supply system | f Failure in power train | g Seizure of moving parts | h Battery insufficiently charged → See No. 20 | i Damage to pinion or ring gear | j Pinion movement force insufficient, wrong meshing position | k Battery terminal connection defective, wiring defective | l Electrical system defective → See No. 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | X | X | X | X | X | X | X | X | X | X Δ | Δ 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, forein matter appears. | ○ | | | | | | | | | | | |

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

X : Replace ; Δ : Repair
A : Adjusting; 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.)
6. Is compression release lever placed in "RELEASE" position. (For 155-4 series engine)

| No. | Problems / Remedy | Injection pump plunger seized, rack rusted (a) | Feed pump piston seized (b) | Injection pump drive shaft damaged (c) | Fuel filter element clogged (d) | Feed pump strainer clogged (e) | Fuel piping clogged between fuel tank and injecton pump (f) |
|---|---|---|---|---|---|---|---|
| | | XC | X | X | X | XC | C |
| 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. | ○ | ○ | ○ | | | |
| 3 | 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 locked.

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

**3) Exhaust gas in emitted but engine does not start.**

If there is always great difficulty in starting, lack of output power is a possible cause, so perform this troubleshooting.

**Check before troubleshooting**

1. Is dust indicator red ? → Air cleaner element clogged.
2. Is SAE30 oil being used at temperature below 0° C? (Oil viscosity is too high) → At temperature below 0°C,use SAE10W oil.
3. Is ASTM D975 No. 2 diesel fuel being used at temperatures below - 10°C? (Clogging caused by precipitated parafin)→ Use ASTM D975 No. 1 at temperature below - 10°C.
4. Is fuel control lever bent? Is there any play? Is the pin out of place?

| No. | Problems / Remedy | a | b | c | d | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Cause* | *Foreign matter causing block between cylinder head and air cleaner* | *Injection timing defective (rarely sole cause of failure)* | *Valve clearance defective (rarely sole cause of failure)* | *Piston, ring or liner worn* | *Injector nozzle clogged or seized* | *Injection pump plunger sized or worn* | *Injection pump rack function defective* | *Air cleaner elements clogged* | *Battery charge too low → See No. 20* | *Electrical intake air heater wiring broken* | *Electrical intake air heater wiring defective* |
| | | C | A | A | X | CX | X | XΔ | CX | AX | X | XΔ |
| 1 | When turning starting switch to HEAT. (At cold weather operation).<br>1) Heater signal lamp does not light. | | | | | | | | | | | ○ |
| | 2) Heater mount does not become warm. | | | | | | | | | | ○ | |
| 2 | Rotating speed of starting motor is too slow to start engine. | | | | | | | | | ○ | | |
| 3 | When checking battery, electrolyte level or specific gravity is too low. | | | | | | | | | ○ | | |
| 4 | Engine starts if air cleaner element is removed. | | | | | | | | ○ | | | |
| 5 | When removing injection pump tappet cover, control rack and plunger do not move. | | | | | | ○ | | | | | |
| 6 | When checking injector nozzle with nozzle tester, it does not inject. | | | | | ○ | | | | | | |
| 7 | Compression pressure is too low; blow-by is high. | | | | ○ | | | | | | | |
| 8 | Valve clearance is not proper value. | | | ○ | | | | | | | | |
| 9 | Injection timing is not proper position. | | ○ | | | | | | | | | |
| 10 | Air cleaner does not aspirate air.<br>(After maintenance) | ○ | | | | | | | | | | |

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

X : Replace ; Δ : Repair
A : Adjusting; 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 beed hole of fuel tank cap clogged?

| No. | Problems / Remedy | Cause: Injection pump plunger seized (a) | Feed pump piston seized (b) | Injection pump drive shaft damaged (c) | Fuel filter element clogged (d) | Feed pump strainer cloggedd (e) | Fuel piping clogged between fuel tank and injection pump (f) | Part of intake or exhaust valve blocking cylinder (g) | Pump or other auxiliary mechanism seized (h) | Piston or bearing (metal) seized (i) | Failure of machine power train (j) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Remedy | X | X | X | XC | X | C | X | X | X | XΔ |
| 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<br>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;<br>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. | ○ | ○ | ○ | | | | | | | |
| 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 locked.

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

## 3. Engine runs abnormally.

**1) Engine speed is too high.**

| | Cause | Remedy |
|---|---|---|
| a | Governor function defective | XA△ |
| 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. | △ |
| b | Injection pump control rack function defective | X△ |
| c | Injection pump function defective (part other than rack) | XA△ |
| d | Governor function defective | XA△ |

**3) Hunting.**

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

★ Set injection pump and governor on test stand when adjusting.

★ Making up fuel pump by injecting more fuel than standing 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) | X△ |
| b | Excessive fuel injection, poor fuel combustion 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 kerosens) | △ Change oil |

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

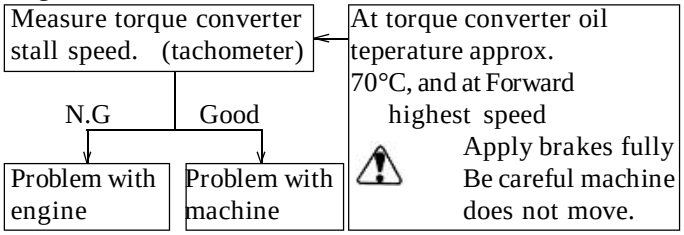
X : Replace ; Δ : Repair

A : Adjusting; 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.)

| No. | Problems / Remedy | Injection pump control rack function defective (a) | injection pump plunger seized (b) | Injection nozzle seized or clogged (c) | Fuel filter element clogged (d) | Feed pump strainer clogged (e) | Fuel piping clogged between fuel tank and injection nozzle (f) | Fuel tube leaking between fuel tank and feed pump (g) | Fuel piping leaking between feed pump and injector nozzle (h) | Fuel control lever linkage bent, loose or out of adjustment (i) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | XΔ | X | XC | X | CX | C | XΔ | XΔ | ΔA |
| 1 | Even with fuel control lever at FULL position, injection pump lever does not contact to the full-stopper. | | | | | | | | | ○ |
| 2 | When operating priming pump;<br>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 pump pipe sleeve nut is loosened. | | ○ | ○ | | | | | | |
| 7 | Some cylinder little or no pulse when injection pipe is held between fingers. | | ○ | | | | | | | |
| 8 | When removing injection pump tappet cover and checking movement of plunger, piston does not move up and down. | | ○ | | | | | | | |
| 9 | 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 locked.

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

## 6. Exhaust gas is black.

**Check before troubleshooting**

1. Is dust indicator red?→Air cleaner element clogged.
2. Is injection pump seal out of position?→Pump out of ad justment (excessive injection).
3. Is air leaking between turbocharger and cylinder head?
4. Is standard spec. machine operating at high altitude?

| No | Problems / Remedy | a Injection pump defective | b Turbocharger seized | c Muffler, exhaust pipe damaged or clogged | d Valve clearance defective | e Defective contact between valve and valve seat | f Piston, ring or liner worn | g Improper injection timing | h Injector nozzle blocked, spray defective | i Air cleaner elements clogged |
|---|---|---|---|---|---|---|---|---|---|---|
| | | XΔ | XΔ | ΔC | A | ΔX | X | A | CX | XC |
| 1 | Exhaust gas color improves when air cleaner element is removed. | | | | | | | | | ○ |
| 2 | When checking with nozzle tester, defective injection spray is defective or injection pressure is low. | | | | | | | | ○ | |
| 3 | Match marks of injection pump plunger and coupling or drive case are not properly aligned. Checking injection timing by delivery method shows timing is out of adjustment. | | | | | | | ○ | | |
| 4 | Blow-by is excessive. | | | | | | ○ | | | |
| 5 | Compression pressure is lack. | | | | | ○ | ○ | | | |
| 6 | Valve clearance is too large or too small. | | | | ○ | | | | | |
| 7 | Exhaust gas color improves when muffler is removed. | | | ○ | | | | | | |
| 8 | Turbocharger is sluggish when turned by hands. (For engines with turbocharger) | | ○ | | | | | | | |
| 9 | Exhaust gas color improves when injection pump is replaced. | ○ | | | | | | | | |

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

X : Replace ; Δ : Repair
A : Adjusting; 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 seal turbocharger seal.

| No. | Problems / Remedy | Cause: Intake valve, valve guide worn (oil coming down into cylinder) (a) | Breather element clogged (b) | Piston, ring or liner worn (oil coming up into cylinder) (c) | Seal worn at turbocharger turbine side (d) | Seal worn at turbocharger blower side (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 locked.

X : Replace ; Δ : Repair

A : Adjusting; C : Clean

## 8. Oil Consumption too high.

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

★ If answer is: “Oil consumption was high and exhaust gas was blue”, follow problems “7. Exhaust gas is blue”.

**Check before troubleshooting**

- Is engine or engine lower part coated with oil. (Remove earth and sand and check.)

| No. | Problems / Remedy | Cause a: Rear seal or seal contact face worn or damaged | b: Oil cooler damaged | c: Oil leaking from oil drain plug | d: Oil leaking from cylinder head, oil pan, gear case, flywheel housing and mounts | e: Oil leaking from oil piping | f: Oil leaking from oil filter or oil cooler | g: Oil leaking from turbocharger |
|---|---|---|---|---|---|---|---|---|
| | Remedy | XΔ | X | Δ | XΔ | ΔX | ΔX | ΔX |
| 1 | Oil leaking out of engine (check around engine). | | | | ○ | | | |
| 2 | Cooling water is mixed with engine oil. | | ○ | | | | | |
| 3 | Oil in main clutch or TORQFLOW transmission or damper increases. | ○ | | | | | | |

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

X : Replace ; Δ : Repair
A : Adjusting; 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: Failure in hydraulic pump for machine | b: Rear seal or seal contact face worn or damaged | c: Oil leaking inside injection pump | d: Fuel leaking from tube inside cylinder head cover | e: Nozzle holder defective | f: Liner O-ring damaged | g: Cylinder block or cylinder liner damaged | h: Cylinder head gasket damaged | i: Oil cooler pipe or O-ring damaged |
|---|---|---|---|---|---|---|---|---|---|---|
| | | XΔ | XΔ | XΔ | XΔ | 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 locked.

X : Replace ; Δ : Repair

A : Adjusting; 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: Leak of exhaust gas through seal on turbocharger turbine side (a) | Cause: Piston, ring or liner worn (b) | Cause: Valve or valve guide worn (c) |
|---|---|---|---|---|
| | | XΔ | X | XΔ |
| 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 locked.
X : Replace ; Δ : Repair
A : Adjusting; C : Clean

## 11. Engine oil pressure gauge indicator fluctuates abnormally.

| No. | Problems / Remedy | Regulator valve defective (a) | Instrument panel loose (b) | Engine oil pressure gauge defective (c) | Lack of oil in oil pan (fluctuation occurs particularly when operating on slopes) (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 catched, 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 locked.

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

## 12. Lack of oil pressure.

(At enigne 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 temperature above 0°C?

| No. | Problems / Remedy | Δ X | Δ XA | C | X C | X | X ΔA | C XΔ | C XΔ | X | A | – | X Δ | X Δ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cause | a Oil pump defective | b Regulator valve function defective | c Oil strainer in oil pan clogged | d Oil pipe in oil pan damaged or clogged | e Bearing or journal worn | f Oil filter element clogged and bypass valve function defective | g Oil hose, tube clogged or damaged | h Engine oil pressure gauge damaged | i Gauge defective | j Lack of oil in oil pan (particularly with operating on slopes) | k Water or fuel mixed with oil → see No. 9 | l Oil leaking from connection of oil hose and tube | m Oil leaking from tube or connections of engine oil pressure gauge |
| 1 | Oil is leak from hose or tube. (Check for signs of external oil leakage). | | | | | | | | | | | | ○ | |
| 2 | Water or fuel mixed with fuel. | | | | | | | | | | | ○ | | |
| 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 bypass 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 locked.

X : Replace ; Δ : Repair

A : Adjusting; 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: Thermostat defective (stays open) (a) | Cause: Water temperature gauge defective (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 locked.

X : Replace ; Δ : Repair

A : Adjusting; 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 temperatre 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 maintenace 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 ?

| No. | Problems \ Cause / Remedy | a | b | c | d | e | f | g | h | i | j | k | l | m | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Excessive use of machine with torque converter stalled | Torque converter damaged | Water temperature gauge defective | Thermostat seal defective (dose not open) | Thermostat defective (does not open) | Water pump defective | Radiator core fins clogged or damaged | Fan belt tension incorrect | Cylinder block or head cracked, sleeve damaged | Head gasket, precombustion chamber gasket damaged | Cylinder liner or piston ring damaged, oil cooler pipe damaged | Water leaking from water tube or hose | Water leaking from radiator | Water leaking from water pump or oil cooler |
| | | A | ΔX | X | X | X | XΔ | CX | A | X | X | X | XΔ | XΔ | XΔ |
| 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 is extreme. | | | | | ○ | | | | | | | | | |
| 6 | Radiator is only slightly warm. | | | ○ | ○ | | | | | | | | | | |
| 7 | Valve opens when testing thermostat only. | | | ○ | | | | | | | | | | | |
| 8 | If water temperature gauge is replaced, it returns to normal. | | ○ | | | | | | | | | | | | |
| 9 | Torque converter oil temperature is too high. (with TORQFLOW transmission) | ○ | | | | | | | | | | | | | |

★ 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 locked.

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

## 16. Too much vibration.

| No. | Problems / Remedy | a ΔX | b X | c X | d X | e X | f XΔ | g X | h A | i CX | j X | k Δ AX | l ΔX | m X | n Δ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cause | Wear of front support pilot | Tappet stuck | Intake or exhaust valve stuck | Intake or exhaust valve broken | Bushings or bearings (main bearing, connecting rod bearing, balancer bushing, cam bushing, etc.) worn | Injection pump plunger seized; function defective | Injector nozzle seized | Injection pump out of adjustment (excessive injection) | Injector nozzle clogged, spray defective | Thermostat defective (stays open) | Governor defective | Air in fuel piping between fuel tank and feed pump | Vibration damper defective | Engine mounting bolts loose |
| 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 injector 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 pliers) | | | | | | | ○ | | | | | | | |
| 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 is large. | ○ | | | | | | | | | | | | | |

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

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

## 17. Abnormal noises emitted.

★ When noises indicating internal damage are being emitted continuing to operate machine may make the damage worse.

★ As far as possible, classify the abnormal noise to make location of the cause easie

Type of noise;

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

| No. | Problems \ Remedy | a | b | c | d | e | f | g | h | i | j | k | l | m | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cause | Valve or piston broken | Valve stem or tappet 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 cap | Camshaft bushing or balancer bushing out of place | Injector nozzle clogged | Injector 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 |
| | | 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 | Seal is broken. (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 injector 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 occured. | | ○ | | | | | | | | | | | | |
| 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 locked.

X : Replace ; Δ : Repair
A : Adjusting; 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 Manul"?
4. Is the fuel filter element cleaned and replaced according to the "Operation and Maintenance Manul"?
5. Are the engine oil and oil filter element replaced according to the "Operation and Maintenance Manul"?
6. Has there been repeated rapid acceleration, or rapid gear shifting?
7. Is the machine warmed up before operation, and left idlig before stopping engine according to the "Operation and Maintenance Manul"?

| No. | Problems / Remedy | 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 between precleaner and cylinder head | h Air cleaner element damaged | i Precleaner damaged or improperly cleaned |
|---|---|---|---|---|---|---|---|---|---|---|
| | | X | C | – | – | – | ΔX | X | XC | |
| 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 locked.

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

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

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

**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", use this problems.

| No. | Problems / Remedy | Cause a: Starting motor defective | b: Internal wiring or performance of safety relay defective | c: Internal wiring or performance of safety switch defective | d: Internal wiring or performance of battery relay switch defective | e: Internal wiring or performance of starting switch defective |
|---|---|---|---|---|---|---|
| | | XΔ | ΔX | ΔX | ΔX | ΔX |
| 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 locked.

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

## 20. Battery does not charge. (Chek starting circuit)

When checking, take care not to be caught in fan or other rotating parts if engine starts. Take care also to cause short circuits. Before starting the troubleshooting, ask the operator if the battery is old (in se for 2 or more years).

**Check before troubleshooting**

1. Is alternator drive belt loose?
2. Check starting circuit for broken or disconnected wires, loose terminals or short circuits. (Visual check, continuity check)
   Battery ↔ Safety switch ↔ Ammeter ↔ Regulator ↔ Starting motor↔ 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 cir cuit.

4. Following repairs, mistaken wiring connec tion is possible cause.

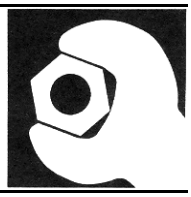
| No. | Problems / Remedy | Cause: Alternator defective (a) | Internal wiring or performance of regulator defective (b) | Internal wiring or performance of ammeter or charging lamp defective (c) | Internal wiring or performance of starting switch defective (d) | Battery defective (e) |
|---|---|---|---|---|---|---|
| | | XΔ | ΔX | ΔX | ΔX | X |
| 1 | During operation, deflection of ammeter and charging lamp are normal. | | | | | ○ |
| 2 | Continuity test using tester shows;<br>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.<br>1) Tester does not show charging voltage (26 – 30V) between terminal (E) of alternator and terminal (N) of regulator. | ○ | ○ | | | |
| | 2) Tester shows charging voltage between terminals (B) and (E) of alternator, but does not shown with above. | | ○ | | | |
| | 3) Tester shows charging voltage with 2) only. | ○ | | | | |

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

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

# ENGINE

## 14 DISASSEMBLY AND ASSEMBLY




**GENERAL**

Disassembly ..... 14-002
Assembly ..... 14-016
Assembly Tools ..... 14-017

**TURBOCHARGER**

Disassembly ..... 14-042
Assembly ..... 14-045

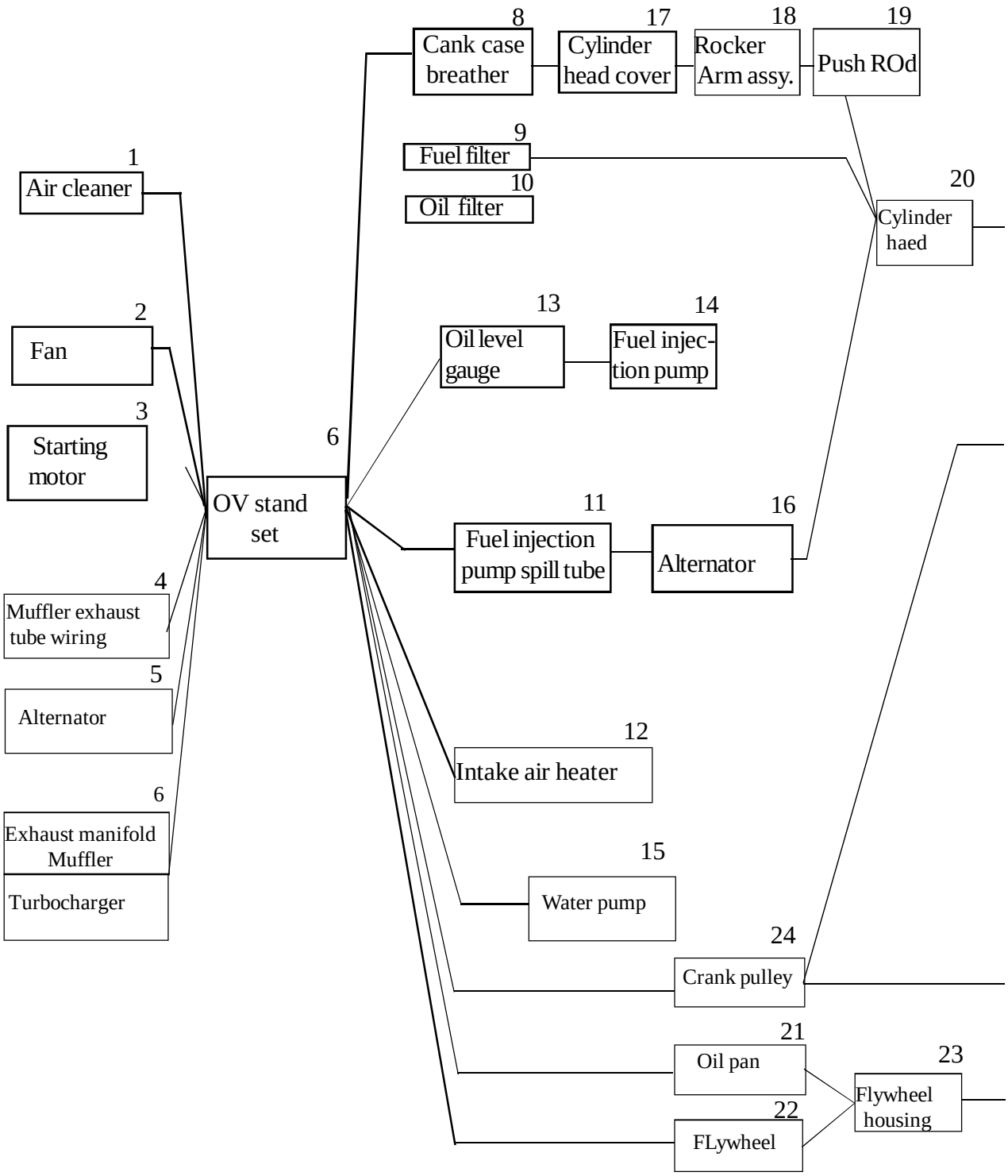
**OIL PUMP**

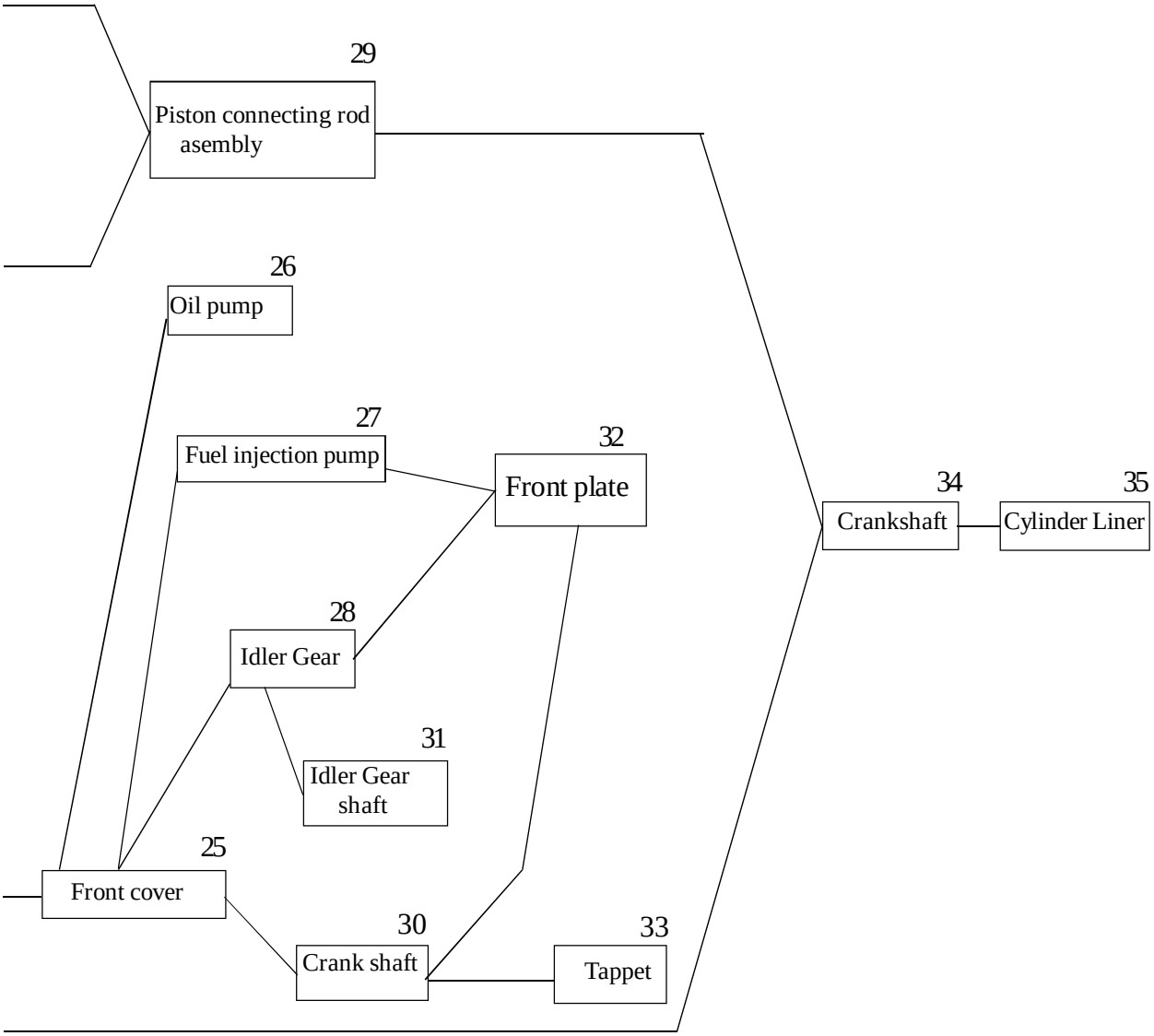
Disassembly ..... 14-050
Assembly ..... 14-051

**WATER PUMP**

Disassembly ..... 14-052

# GENERAL DISASSEMBLY




29
Piston connecting rod asembly
26
Oil pump
27
Fuel injection pump
32
Front plate
34
35
Crankshaft
Cylinder Liner
28
Idler Gear
31
Idler Gear shaft
25
Front cover
30
33
Crank shaft
Tappet

## Special tool required

| Part No. | Part Name | A | B | C | D | E |
|---|---|---|---|---|---|---|
| - | Engine stand | 1 | | | | |
| - | Engine stand | | 1 | | | |
| - | • Adapter plate | | 1 | | | |
| - | Remover | | | 1 | | |
| - | Piston ring tool | | | | 1 | |
| - | Spring pusher | | | | | 1 |

**Preparatory work**

- Clean the outside thoroughly, removing all mud and dirt.
- Drain the coolant and engine oil.

Engine oil : approx. 15l

- Prepare engine stand A to secure the engine for prevention of turnover.


Engine assembly: approx. 425 kg

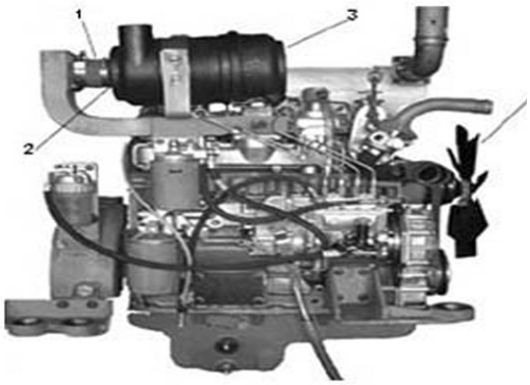
★ These values depend on installation vehicles.

**B4D105 ENGINE ASSEMBLY TOOLS**

| Sl. No. | Part Number BEML TOOL DESIGN | Description |
|---|---|---|
| 1 | 008003600215 | REAR SEAL DRIVER |
| 2 | 008003600355 | CYL. BLOCK LINER REMOVAL TOOL |
| 3 | 008003600365 | CON. ROD PULLER |
| 4 | 008003600105 | PISTON HOLDER |
| 5 | 008003600165 | FRONT SEAL PRESS TOOL |
| 6 | 008003600345 | CYL. BOLCK LINER PRESSING TOOL |
| 7 | 008003600655 | CAMBUSH PRESS TOOL |
| 8 | 008005600135 | CYL. HEAD COTTER SPRING PUSHER |
| 9 | 008003600875 | CRANK GEAR DRIVE TOOL |
| 10 | 00803600155 | MAIN BEARING CAP REMOVAL TOOL |
| 11 | 00803600055 | FIP SHAFT SEAL DRIVE TOOL |
| 12 | 008000801525 | FUP GUIDING / ALIGNMENT MANDREL |
| 13 | 008003600895 | FIP SHAFT DRIVING TOOL (B4D105-BL9H) |

**1. Air cleaner**

. Disconnect the connection tube (1) at the hose connection part (2), and remove the air cleaner (3).

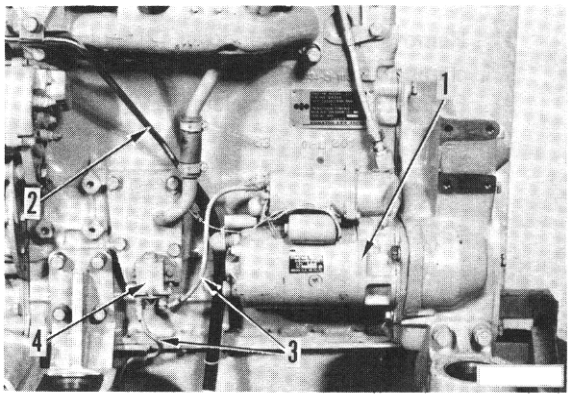



**2. Fan**

. Remove tha fan (4).

**3. Starter**

. Remove the starter (1).

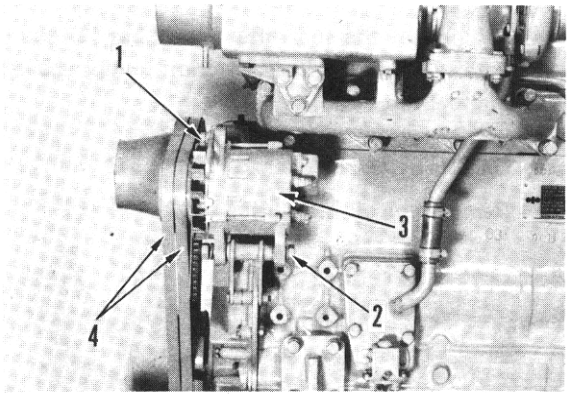



**4. Muffler drain tube and wiring**

1) Remove the muffler drain tube (2).
2) Disconnect the wire (3), and remove the relay (4).

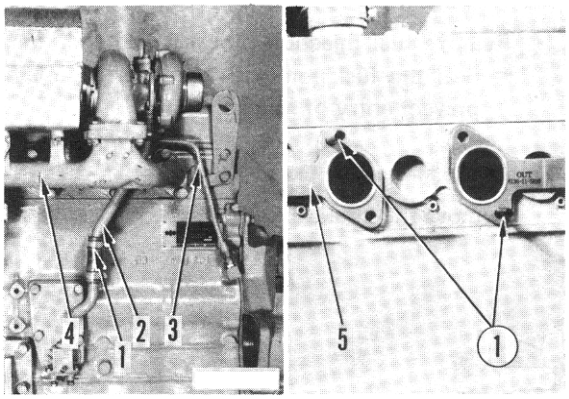
**5. Alternator**

1) Remove the fan belt tension adjustment bolt (1), loosen the alternator mounting bolt (2), push the alternator (3) to the engine side, and remove the V-belt (4).
2) Remove the alternator (3).




**6. Exhaust manifold, turbocharger**

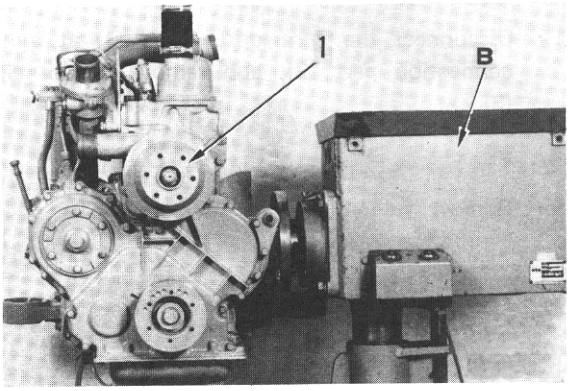
1) Loosen the hose clamp (1), and remove the turbocharger outlet pipe (2).
2) Remove the turbocharger inlet pipe (3).
3) Mount the guide bolt (10 mm, pitch = 1.5, length = 200mm) on the exhaust manifold (4), and remove the exhaust manifold, turbocharger and muffler as a unit.
4) Remove the gasket (5).



**7. Engine overhaul stand set**

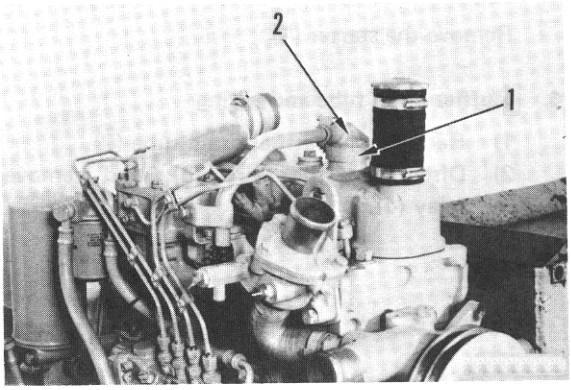
1) Mount the adapter plate supplied with the engine overhaul stand **B** to the engine.
2) Lift the engine assembly (1), and install the engine overhaul stand **B** to the adapter plate attached.

kg Engine assembly: 425 kg




**8. Crankcase breather**

1) Remove the breather cover (2) by loosening the clamp (1).
2) Extract the breather element.

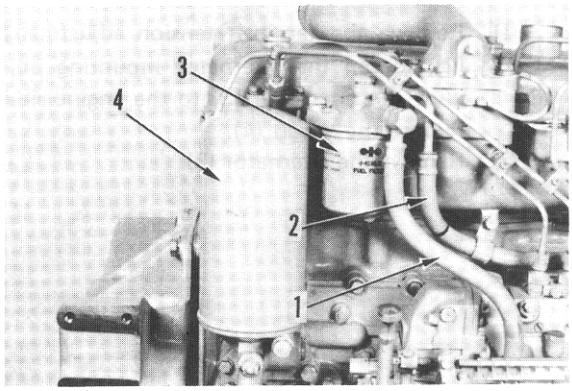



**9. Fuel filter**

. Disconnect the fuel filter inlet hose (1) and outlet hose (2) from the fuel injection pump, and remove the fuel filter (3).

**10. Oil filter**

. Remove the oil filter (4).

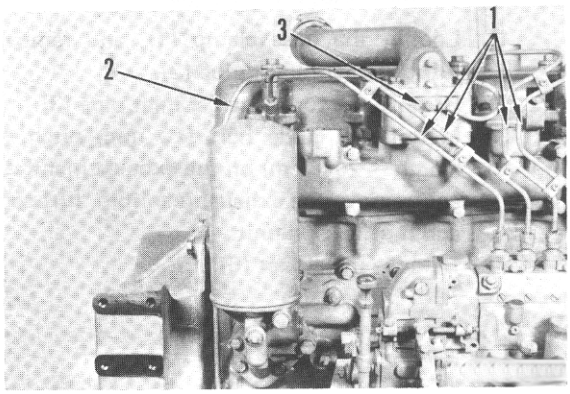



**11. Fuel injection pipe and spill tube**

. Remove fuel injection pipe (1) and spill tube (2).
  ★ Seal the fuel port with a rubber cap or tape to prevent entry of foreign matter

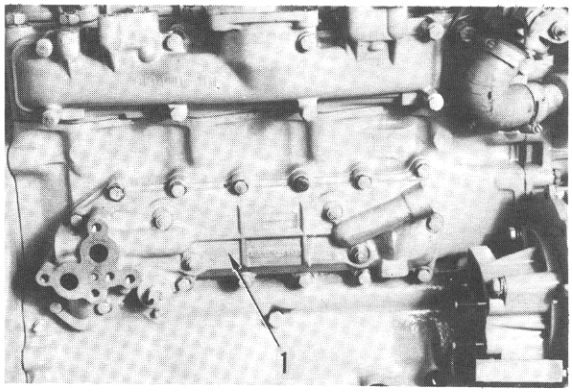
**12. Intake air heater**

. Remove the intake air heater (3).



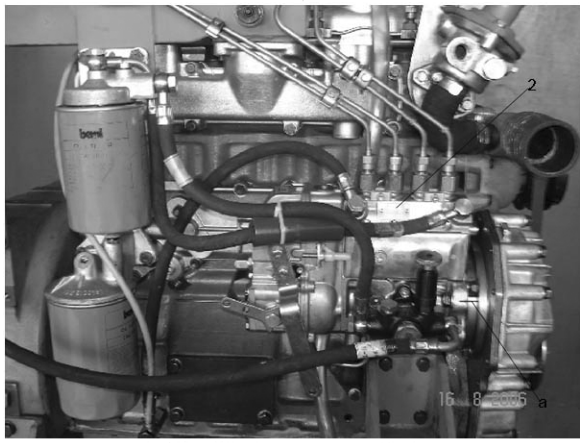
**13. Oil level gauge and oil cooler**

1) Remove the bracket, and remove the oil level gauge guide.
2) Remove the oil cooler (1).



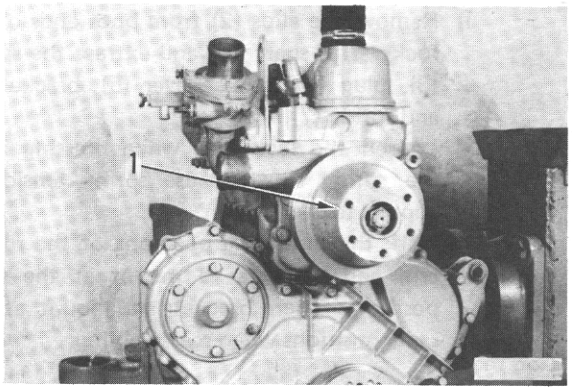

**14. Fuel injection pump**

1) Disconnect the feed pipe from the fuel injection pump.
2) Check the matching mark (a) of the injection pump and Spacer.
   - ★ If no mark is provided, punch the matching mark before removal.
3) Remove the fuel injection pump (2).
   - ★ Seal the fuel and oil ports with tape to prevent entry of foreign matter.



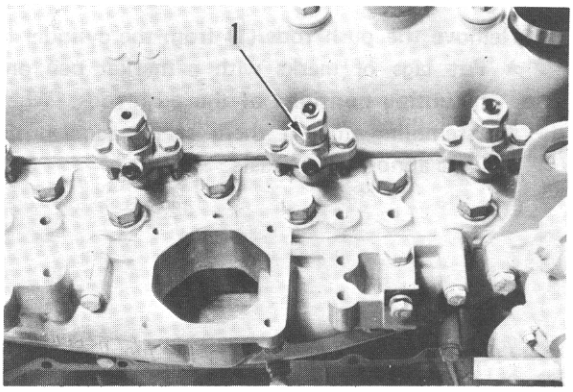

**15. Water pump**

- Remove the water pump (1).



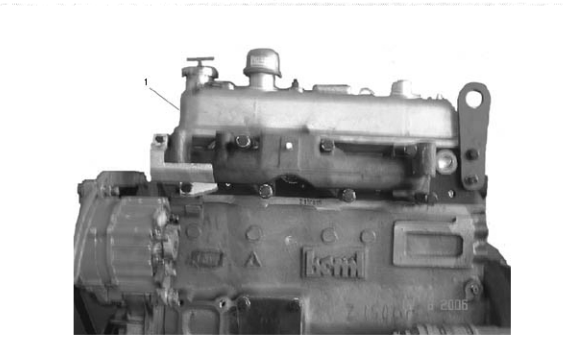

**16. Nozzle holder**

- Remove the nozzle holder (1).
  - ★ Carefully handle the nozzle holder so as not to strike the tip against anything.
  - ★ Put a tag on the nozzle holder monting position. When reassembling, mount it at the same position if no abnormality exists.



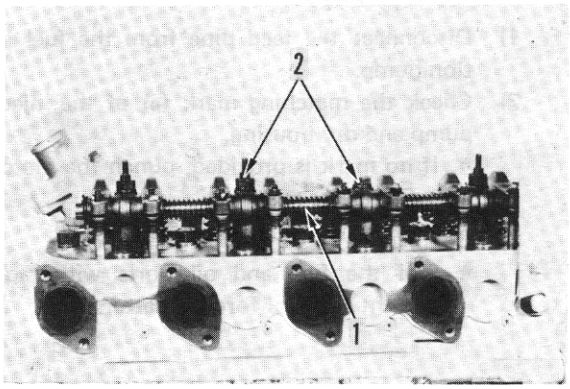
**17. Cylinder head cover**

- Remove the cylinder head cover (1).



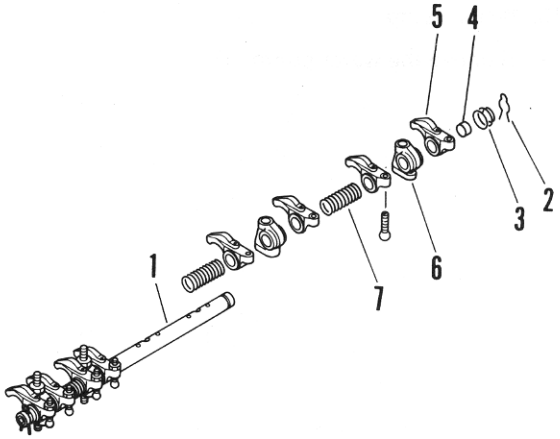
**18. Rocker arm assembly.**

1) Loosen the adjusting screw lock nuts, and loosen each adjusting screw a few turns.
   - ★ The adjusting screws are loosened at this stage so as not to apply excessive pressure on the push rod when installing the rocker arm assembly.
2) Remove the mounting bolts (2), and remove the rocker arm assembly (1).



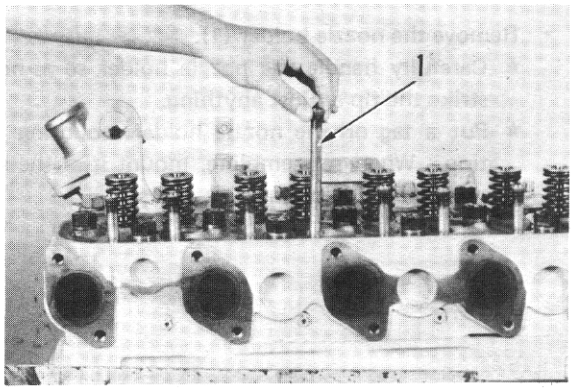

★ Disassembly of rocker arm assembly

i) Remove the clips (2) from both ends of the rocker arm shaft (1), and extract the spring (3), plug (4), rocker lever (5), bracket (6) and spring (7).
   - ★ Loosen the lock bolt while pressing it to the spring side because spring tension is applied to the bracket.
   - ★ Mark the mounting positions of the rocker arm and brackets to mount at the same positions when brackets to mount at the same positions when reassembling.




**19. Push rod**

- Remove the push rods (1) from the cylinder head.
  - ★ Put tags or marks with a marker pen on the mounting positions of the push rods. When reassembling, mount them at the same positions if no abnormality exists.

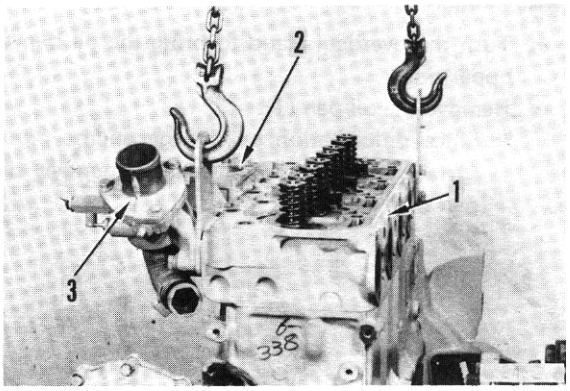


**20. Cylinder head**

1) Remove the cylinder head mounting bolts.
2) Remove the cylinder head assembly (1) assembled with the intake manifold (2) and ther mostat (3).

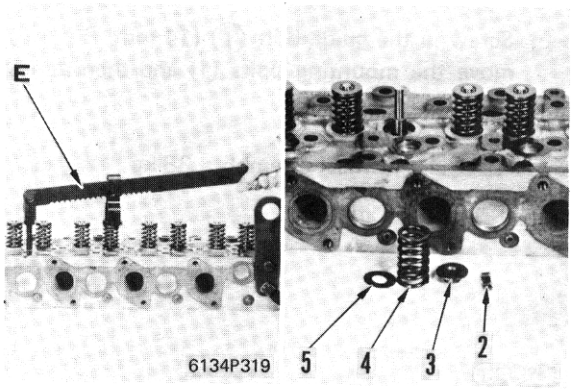
kg Cylinder head assembly: 40 kg

3) Remove the cylinder head gasket.

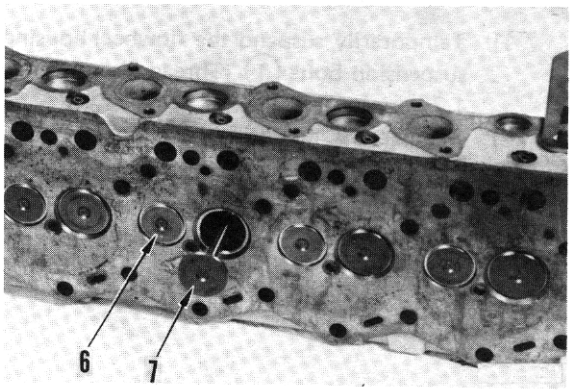



★ Disassembly of cylinder head

i) Press the valve spring with the valve spring pusher (E) to remove the valve cotter (2).
ii) Slowly decrease the spring pressure, and remove the spring guide (3), spring (4) and seat (5).

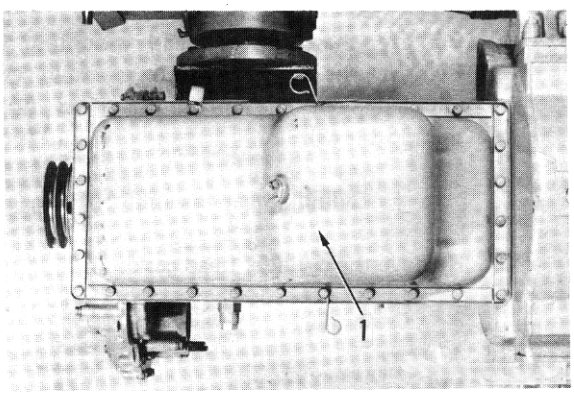



iii) Raise the cylinder head, and remove the intake valve (7) and exhaust valve (6).
★ Arrange valves in order after marking respective mounitng positions.



**21. Oil pan**

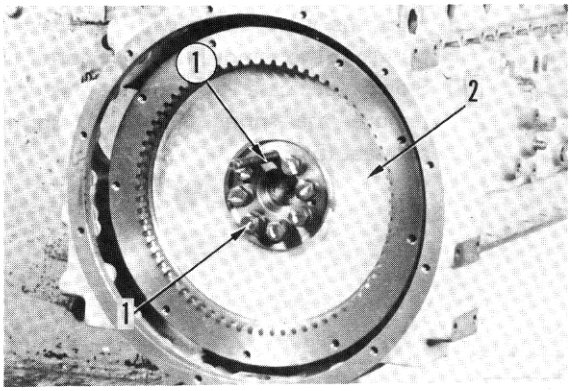
- Turn the overhaul stand to bring the oil pan to the upper side.
- Remove the oil pan (1).
  - ★ Since deformation or damage on the mounting surface may cause oil leakage, remove the oil pan with care.




**22. Flywheel**

- Screw in the guide bolt ① (14 mm, P = 1.5). Remove the mounting bolts (1) and then remove the flywheel assembly (2).

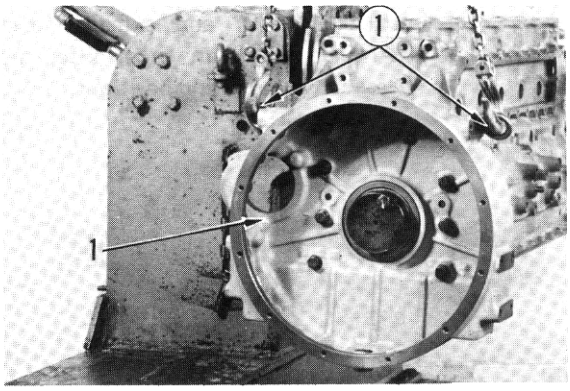
kg Flywheel assembly : 38 kg




**23. Flywheel housing**

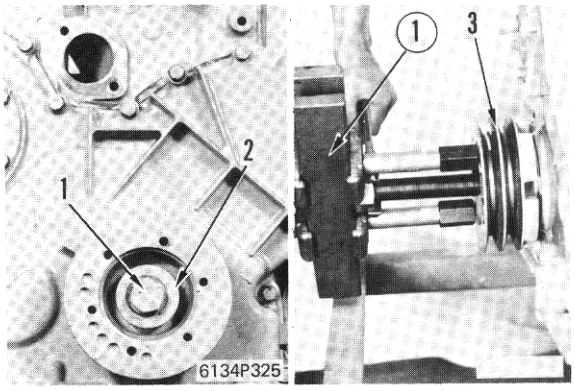
1) Temporarily suspend the flywheel housing (1) using suspension bolts ① (Thread dia.= 12mm, Pitch 1.75 mm).
2) Remove the mounting bolts and flywheel housing.

kg Flywheel housing: 30 kg



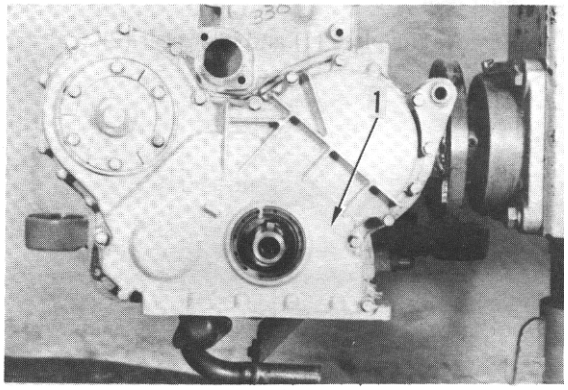

**24. Crank pulley**

1) Remove the bolt (1), and remove the plate (2).
2) Extract the crank pulley (3) with the puller ①, and remove the taper collar.



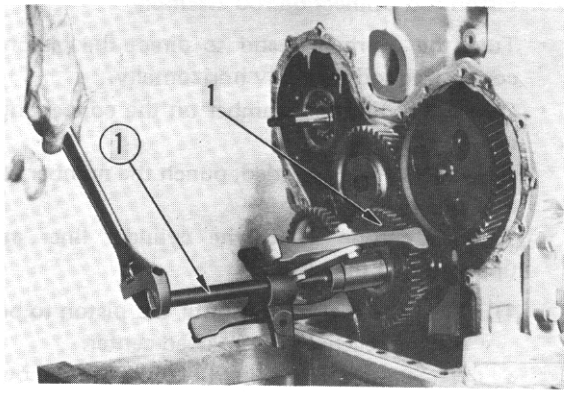
**25. Front cover**

- Remove the front cover (1).

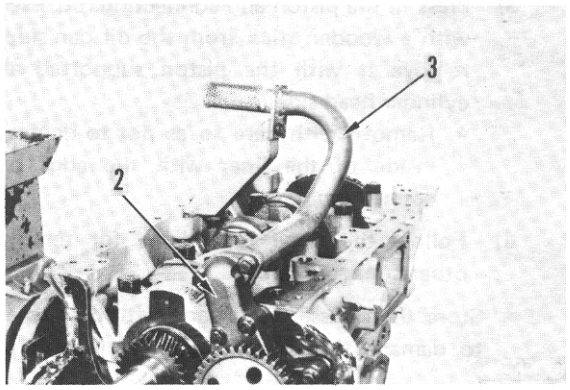



**26. Oil pump**

1) Extract the oil pump drive gear (1) with the puller ①.

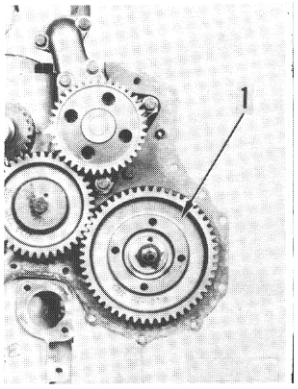



2) Remove the oil pump (2) and suction tube (3).



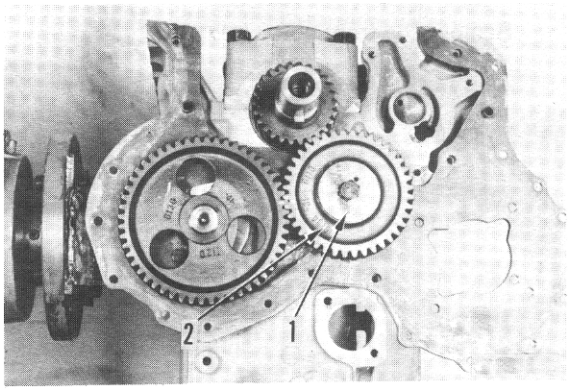

**27. Fuel injection pump drive case.**

1) Remove the fuel injection pump drive gear (1).



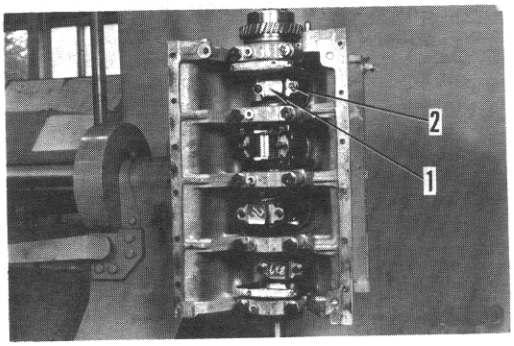
**28. Idler gear**

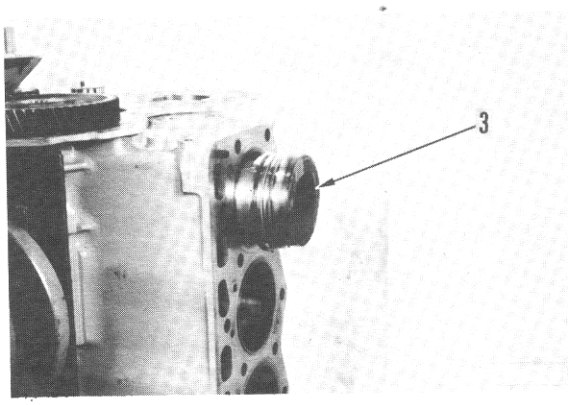
- Remove the plate (1) and idler gear (2).



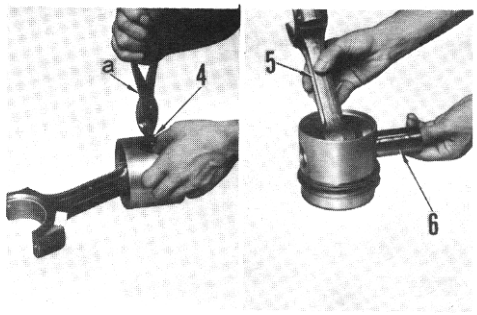

**29. Piston and connection rod assembly**

- Turn the overhaul stand to direct the piston and connecting rod assembly horizontally.
- Check the punched number on the connecting rod cap.
  If no marking is provided, punch the number on the cam side before removal.
- Remove carbon inside the cylinder liner at the upper side of the piston.
  1) Turn the crank shaft until the piston to be extracted reaches bottom dead center.
  2) Remove the mounting bolt (2), and remove the connecting rod cap (1).
  3) Press in the piston and connecting rod assembly with a wooden stick from the oil pan side, and remove it with the piston supported at the cylinder head side.
  ★ Remove with care so as not to damage the inside of the line with the edge of the connecting rod.
  4) Follow the same procedures for removal of other connecting rods.
  ★ Store the disassembled parts with care so as not to damage the piston sliding surface or metal.

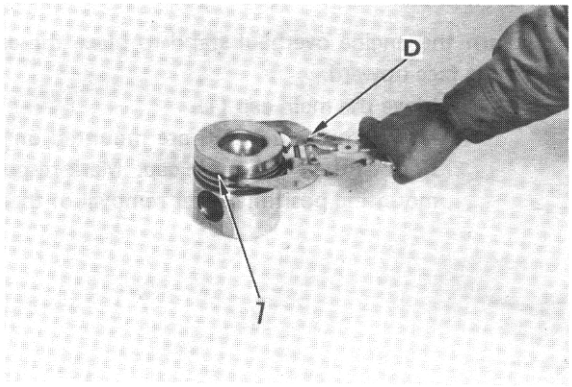


★ Disassembly of piston and connecting rod assembly
  i) Remove the snap ring (4) on one side with pliers (a).
  ii) Hold the connecting rod (5) by hand, gently extract the piston pin (6), and disconnect the connecting rod from the piston.
  iii) Remove the other snap ring.

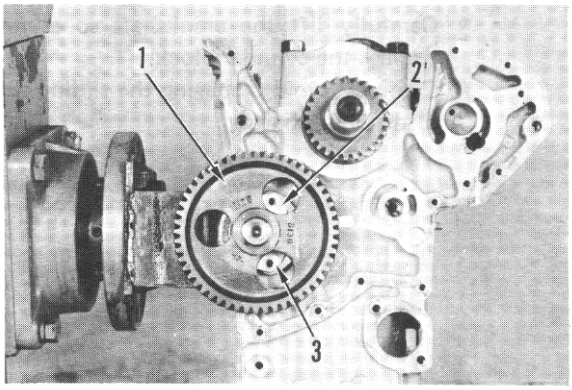



  iv) Remove the piston ring (7) with a piston ring tool **(D)**.
★ Arrange piston pins, connecting rods, bearings, piston rings and piston pins in the order of cylinder numbers.




**30. Camshaft**

. Remove the thrust plate (2) mounting bolt (3), and then remove the camshaft assembly assembled with the gear (1).

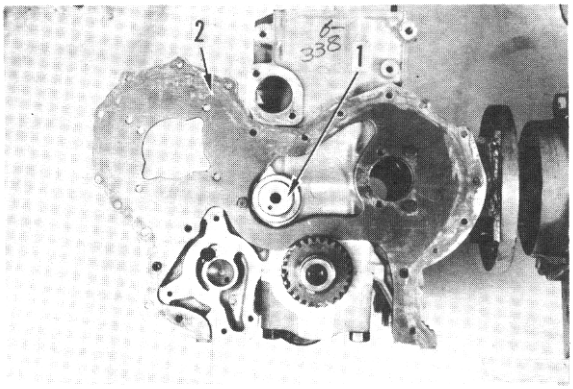



**31. Idler gear shaft**

. Remove the idler gear shaft (1).

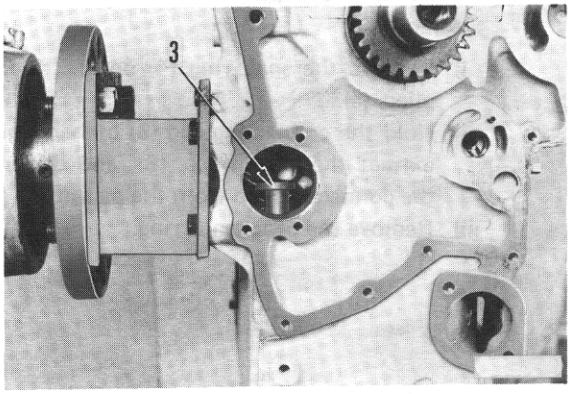
**32. Front plate**

. Remove the front plate (2).



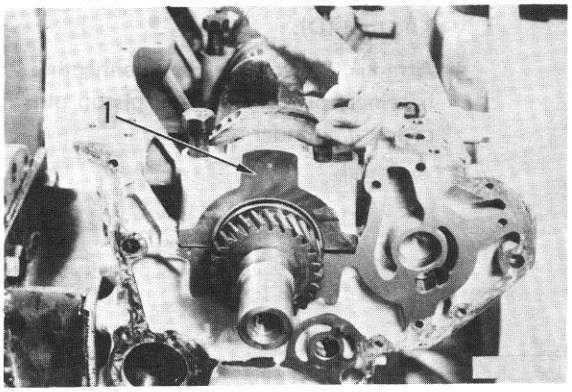
**33. Tappet**

- Remove the tappet (3).

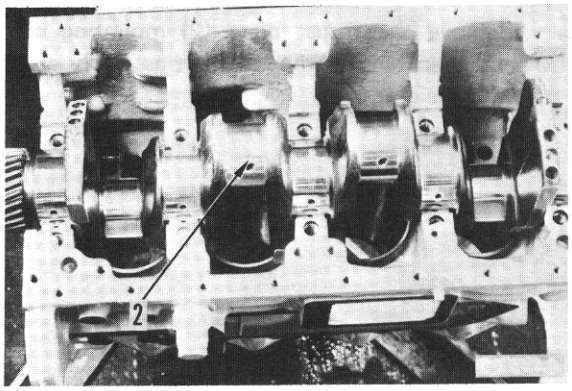



**34. Crankshaft.**

- Turn the engine overhaul stand to place the crankshaft face upward.
  1) Remove the main cap (1).
     - ★ Lower thrust bearings are mounted on both sides of the No. 5 main cap. Mark respective mounting positions after removal of these.

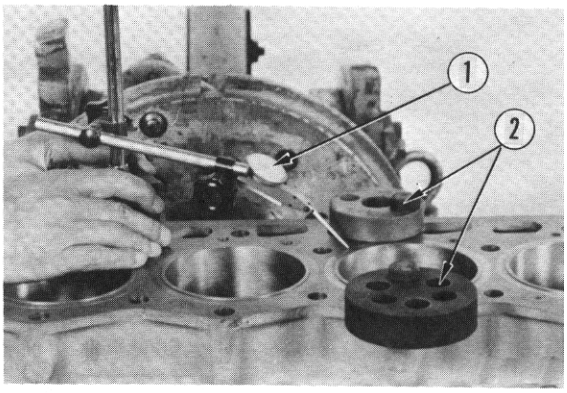


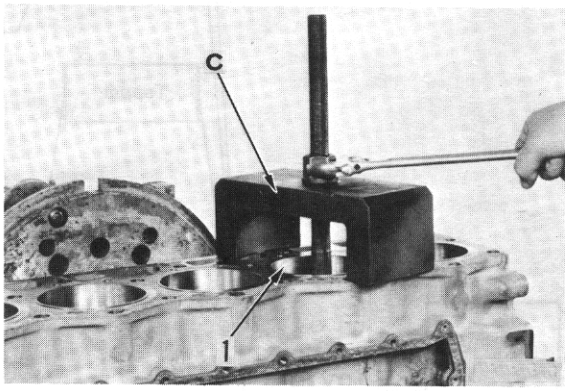

  2) Remove the crankshaft (2) with a nylon sling.
     - ★ Carefully lift the crankshaft so as not to damage the cylinder block.
     - ★ Carefully avoid damaging the sliding surface of the crankshaft.



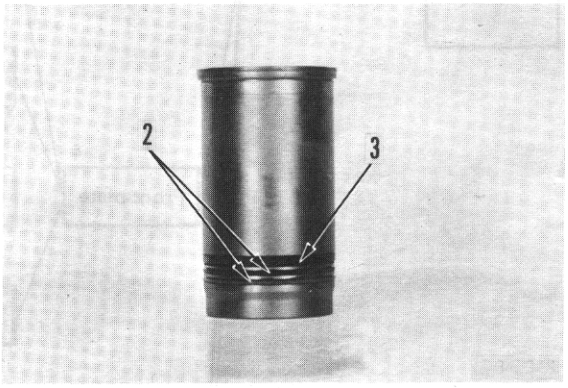
**35. Cylinder liner**

- Turn the engine overhaul stand to make the cylinder head face upward.
- Before removal of the cylinder liner, measure the protrusion of the liner with dial gauge ① .
  - ★ When measuring the protrusion, press down the liner with the plate ② to eliminate any lift caused by the O-ring.
  - ★ Always measure the liner protrusion if oil leakage from the cylinder head mounting gasket or entry of water into the oil pan is detected.
- Measure the liner bore before removal of the liner for judgement on wear. The standard cylinder bore is specified after it is installed in the cylinder block.
  1) Set the remover **C**, and remove the cylinder liner (1).

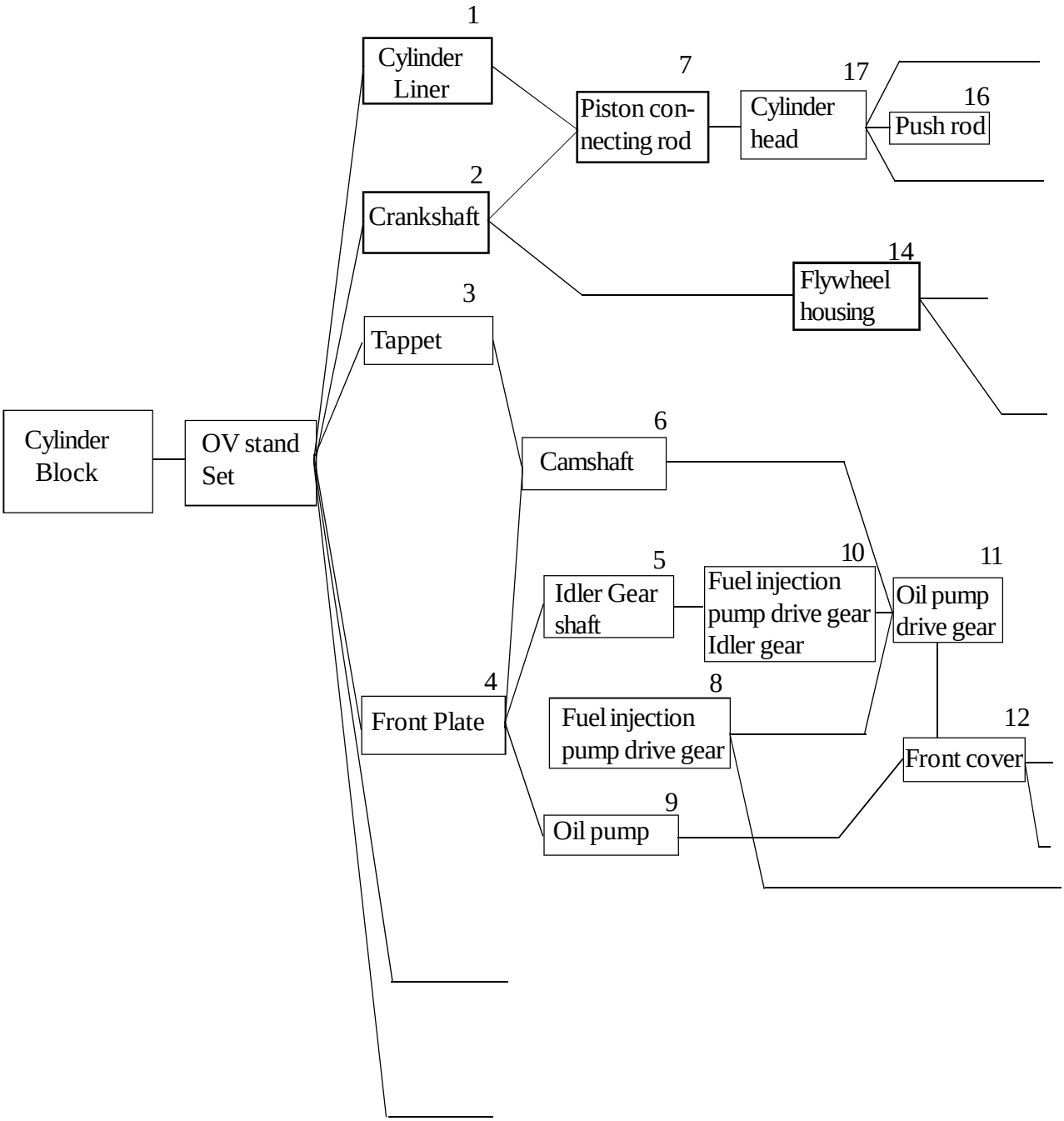


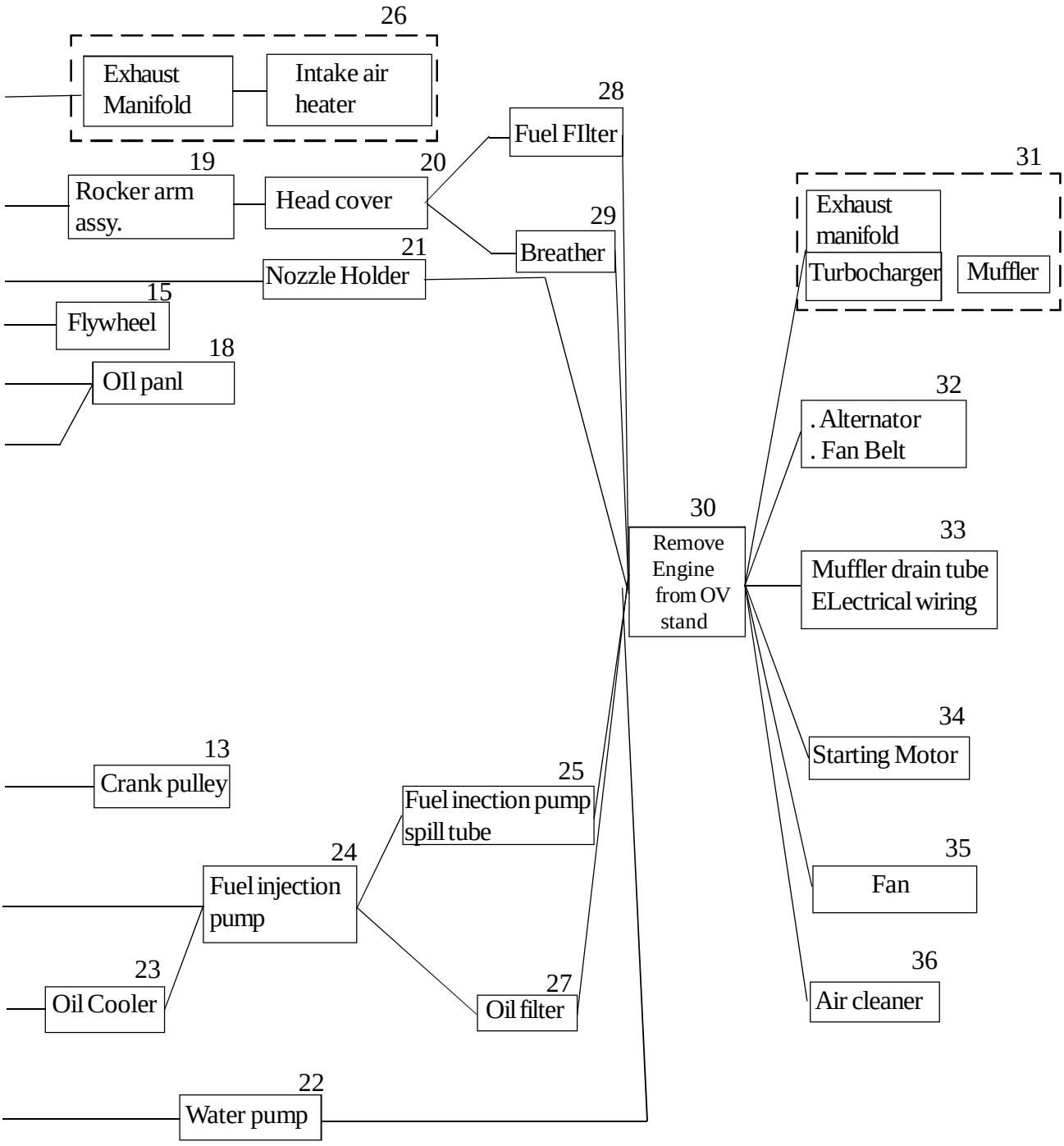




  2) Remove the O-ring (2) and clevis seal (3) of the cylinder liner.



# GENERAL ASSEMBLY




26
Exhaust Manifold
Intake air heater
28
Fuel FIlter
19
Rocker arm assy.
20
Head cover
29
Breather
21
Nozzle Holder
15
Flywheel
18
OIl panl
31
Exhaust manifold
Turbocharger
Muffler
32
. Alternator
. Fan Belt
30
Remove Engine from OV stand
33
Muffler drain tube
ELectrical wiring
34
Starting Motor
13
Crank pulley
25
Fuel inection pump spill tube
24
Fuel injection pump
35
Fan
23
Oil Cooler
27
Oil filter
36
Air cleaner
22
Water pump

## Special tool required

| Part No. | Part Name | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| - | Engine stand | 1 | | | | | | | |
| - | Engine OV-stand | | 1 | | | | | | |
| - | • Adapter plate | | 1 | | | | | | |
| - | Liner drive | | | 1 | | | | | |
| - | Piston ring tool | | | | 1 | | | | |
| - | Spring pusher | | | | | 1 | | | |
| - | Piston holder | | | | | | 1 | | |
| - | Seal guide | | | | | | | 1 | |
| - | Filler guage | | | | | | | | 1 |

**Preparatory works**

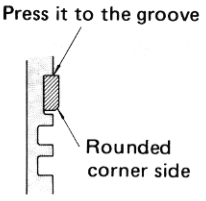
- Clean all parts, and check for rust, sharp edges and breakage.
- Mount the adapter plate on the cylinder block, and set it on the engine overhaul stand **B**.

**1. Cylinder liner**

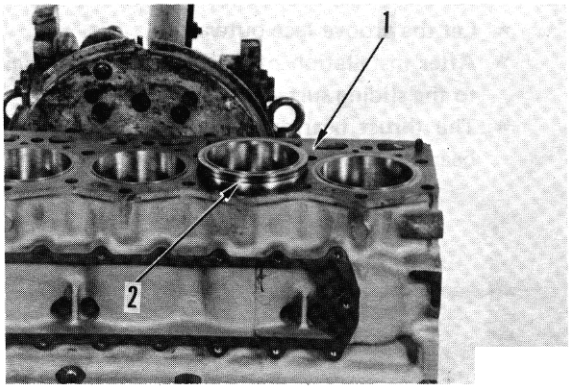
★ Check the cylinder block liner mounting part, contact surface with the O-ring and O-ring groove for rust or pitting defects.
If rusted or pitted, remove the rust with No. 100 sand paper and smooth pitting with Three Roy.

1. Mount the cylinder liner.
   1) Apply engine oil (CLASS-CD-SAE30) to the O-ring groove of the liner and the contact surface with the O-ring of the cylinder block.
   2) Appl engine oil (CLASS-CD-SAE30) to the O-ring, and perfectly fit it in the O-ring groove of the liner with fingers.
   3) Put in a smooth stick (approx. ϕ10) as shown in the figure, and make one or two turns around the liner to eliminate any twist caused during installation.

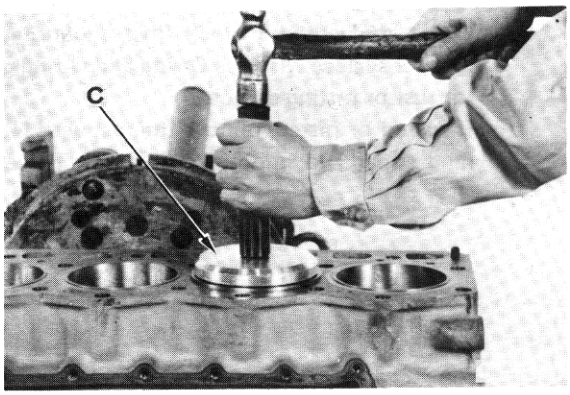
2. Mount the liner clevis seal.
   1) Apply engine oil (CLASS-CD-SAE30) to the clevis seal groove of the liner.
   2) Apply engine oil (CLASS-CD-SAE30) to the clevis seal, and fit it in the groove of the liner with fingers.
   3) Mount the seal as shown in the figure.



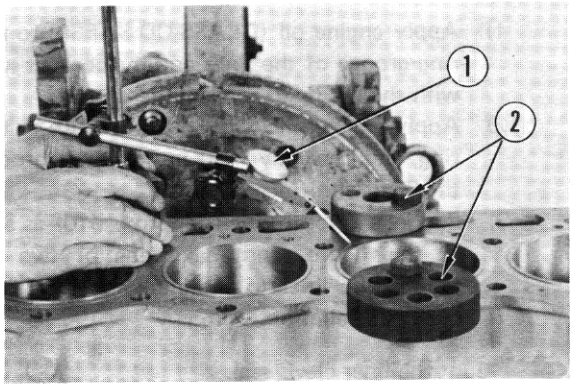

3. Install the cylinder liner.
   1) push the cylinder liner (2) with fingers until the O-ring is brought into contact with the block (1).



2) Install the liner (2) perfectly with a liner driver (C).

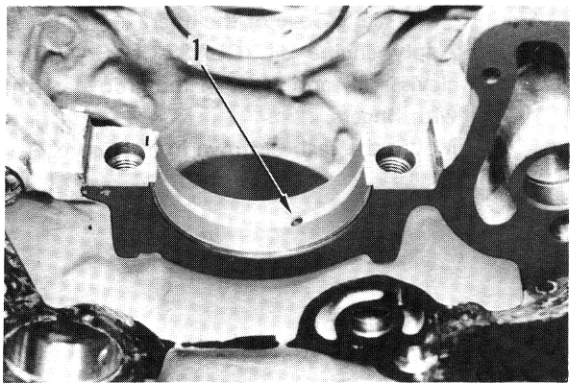



4 After press fit of the liner, measure the protrusion with a dial gauge ① .
- ★ When measuring the protrusion, press down the liner with the plate ② to eliminate any lift caused by the O-ring.
- ★ Cylinder liner protrusion: 0.05 to 0.13 mm.

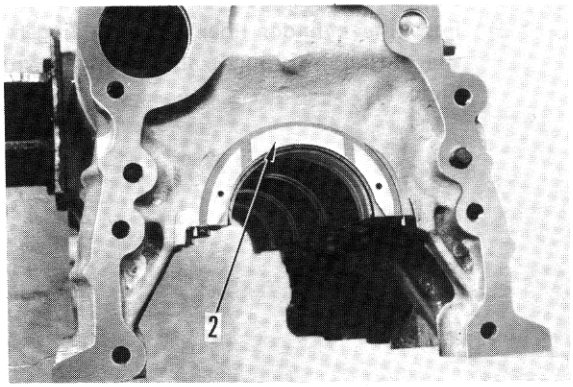



**2. Crankshaft**

1. Mount the upper bearing (1) with the bearing protrusion adjusted to the cylinder block notch.
- ★ Check the oil port alignment.
- ★ Apply engine oil (CLASS-CD SAE30) to the bearing surface.

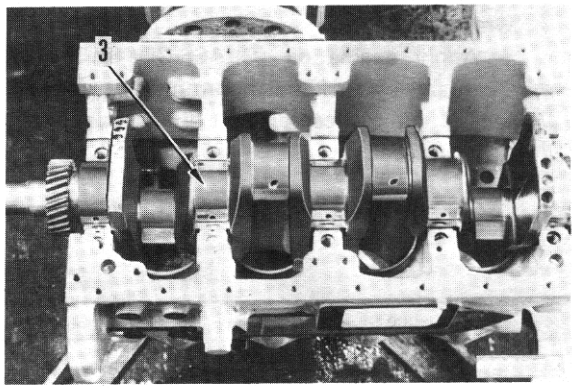



2. Install the thrust bearing (2).
- ★ Let the groove face outwad.
- ★ After installation of the bearing, apply engine oil to the sliding surface.
- ★ The trust bearing are composed of two upper bearing and two lower bearings.

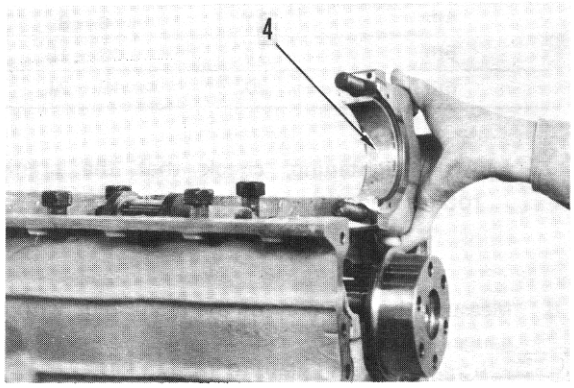


3 Lift the crankshaft (3) with a nylon sling, and adjust the positioning with the cylinder block.
- ★ Carefully prevent the crankshaft from striking the cylinder block.
- ★ Apply engine oil (CLASS-CD-SAE30) to the crankshaft journal.

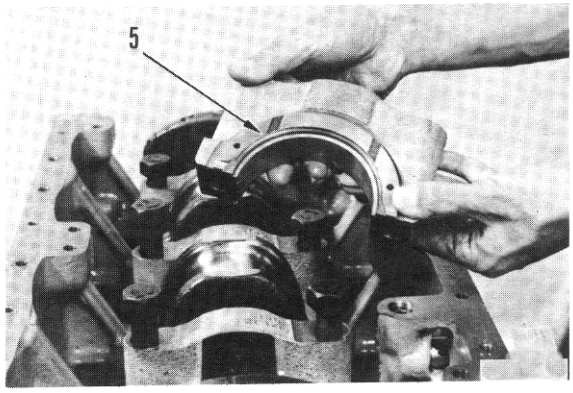
kg Crankshaft (including crank gear): 42kg



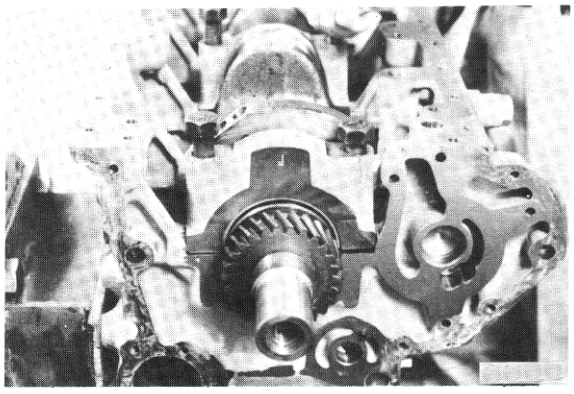

4. Mount the lower bearing (4) with the bearing projection adjusted to the main cap notch.
- ★ Mount the lower bearing with the "**F**" mark facing the engine.




5. Mount lower thrust bearing (5) on both sides of No. 5 main cap.
- ★ Mount thrust bearing with the groove facing outward.
- ★ Check that the roll pin protrusion is in the range from 1.5 to 1.9 mm.




6. Install the main cap.
- ★ Check that number marked on the main cap agrees with the cylinder number and install it with the "**F**" mark facing forward.



7. Tighten bolts of the main cap (6) with a torque wrench ④.
   - ★ Apply engine oil (CLASS-CD SAE30) to the thread part of the mounting bolt and the seat.
   - ★ Tighten the center bolt first, then outer bolts sequentially.

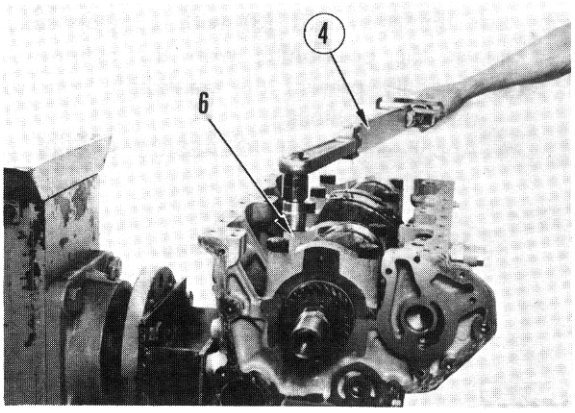
   kgm Main cap tightening torque

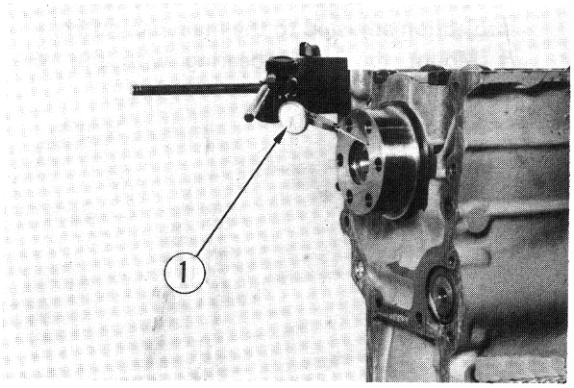
kgm

| Sequence | Target | Range |
|---|---|---|
| 1st | 7 | 6 ~ 8 |
| 2nd | 20 | 19 ~ 21 |
| 3rd | 0 | Loosen completely |
| 4th | 7 | 6 ~ 8 |
| 5th | 14 | 13 ~ 15 |
| 6th | 20 | 19 ~ 21 |

   - ★ After tightening, check that the crankshaft rotates smoothly.

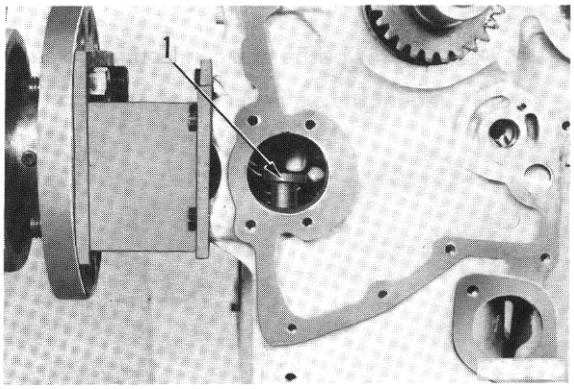
8. Measure the end play of the crankshaft with a dial gauge ① .
   - ★ Crankshaft end ply: 0.14 to 0.315 mm



**3. Tappet**

- Apply engine oil (EO30-CD) to the periphery of the tappet, and install the tappet (1).
  - ★ Check that the tappet moves up and down without resistance.

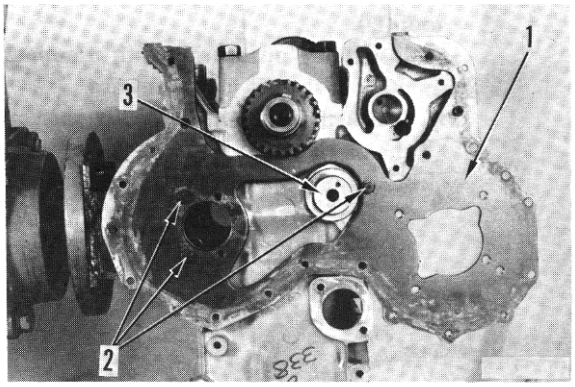



**4. Front plate**

- Install the front plate (1) with the gasket attached.
  - ★ Apply adhesive agent (LG-1) to the gasket for installation so that bolt holes will not be displaced during front cover installation.
  - ★ Be sure to tighten all three mounting bolts (2).

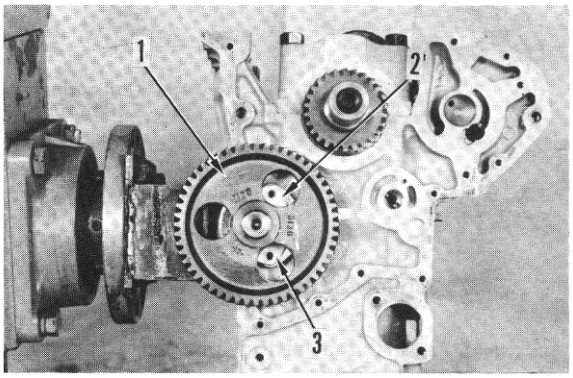
**5. Idler gear shaft**

- Install the camshaft (3).




**6. Camshaft**

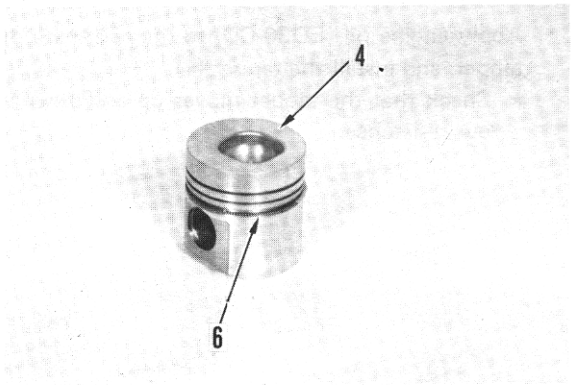
1) Install the camshaft (1).
   - ★ Gently install so as not to damage the camshaft.
2) Install thrust plates (2), and tighten the mount ing bolts (3).



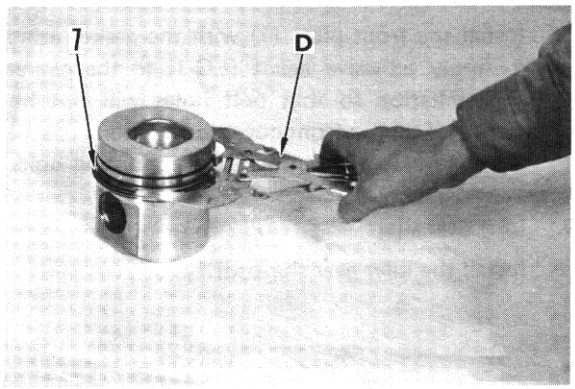
**7. Piston connecting rod assembly**

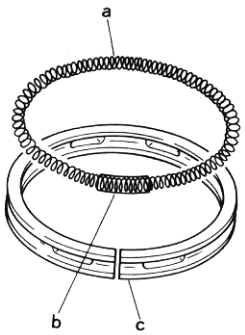
★ Assembly of piston and connecting rod assembly

1) Mount the expander (6) on the piston (4).

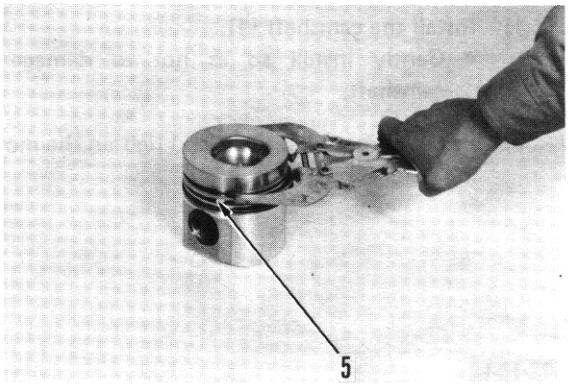



2) Mount the oil ring (7) with the piston ring tool **(D)**.
   - ★ Install the piston ring with the matching mark at the slit facing upward.
   - ★ Check that the expander fits perfectly to the oil ring.
     - ★ Adjust the relative positioning of the expander and ring as shown in the figure below.



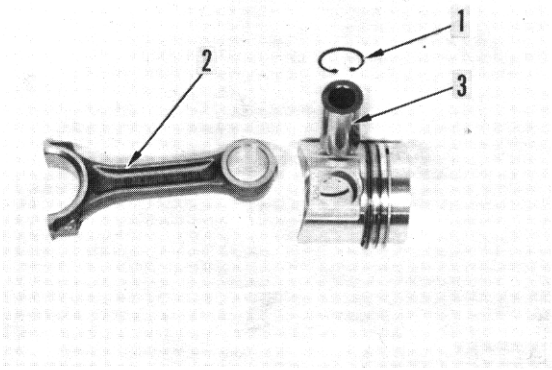




a: Coil connection port
b: Teflon tube
c: Slit



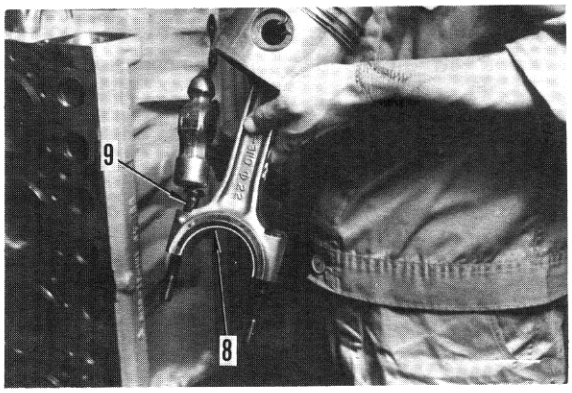

3) Mount the compression ring (5).

4) Insert the piston pin (3) with the mark "FRONT" on the piston head set on the same side as the embossed item number of the connecting rod, and assemble the connecting rod (2) and the piston.
   - ★ If it is hard to insert the piston pin, warm the piston in hot water before installation.
   - ★ Check the cylinder number of the piston and connecting rod.
   - ★ The cylinder number should be marked on the connecting rod with an electric pen.




5) Mount snap rings (1) on both sides of the piston.

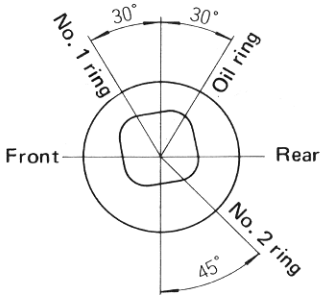
6) Assemble upper bearing (8) of the connecting protrusion.
7) Install the connecting rod bolt (9) to the connecting rod.
   ★ Direct the notch of the head to the connecting rod center and prevent the head from protruding.




- Turn the overhaul stand to direct the cylinder block horizontally.
- Bring the crank pin of the cylinder, to which the piston connecting rod assembly is installed, to bottom dead center.

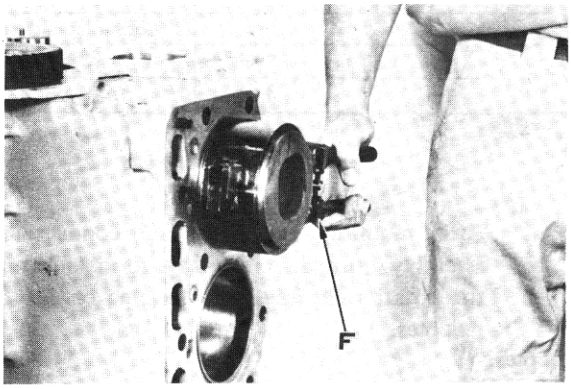
★ Apply engine oil to inside of the cylinder, piston ring and connecting rod metal.

1 Direct the slit of the piston ring as shown in the figure.



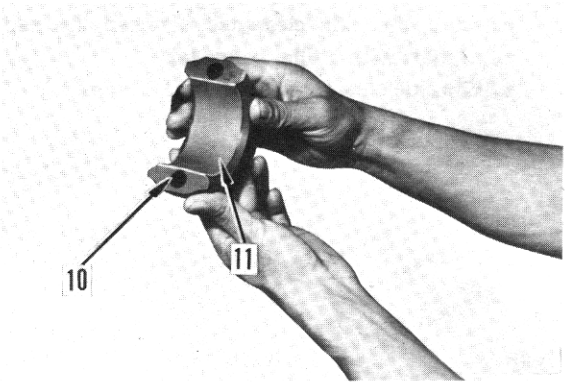

2 Insert the piston and connecting rod assembly (4) from the cylinder head side to the piston ring position.

   ★ Install the piston with the embossed mark "FRONT" facing forward.
   ★ Check that the cylinder number of the piston and connecting rod assembly faces the cam side.

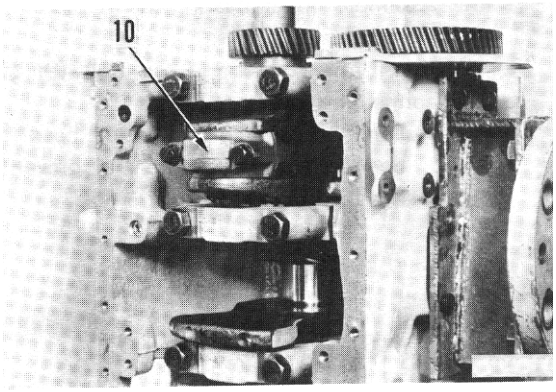



3 Depress the piston ring with the piston holder **F**, push the piston head with a wooden stick, then draw in the large end of the connecting rod until it is fitted to the crank pin.

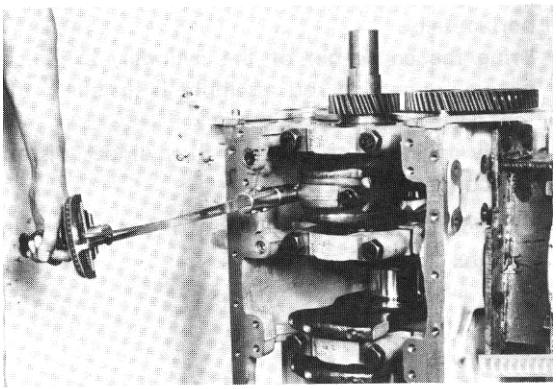
4. Install the bearing with the notch of the connecting rod cap (10) adjusted to the protrusion of the lower bearing (11).



5. Install the connecting rod cap (10) having the same cylinder number as the one on the connecting rod, and with the number facing the cam side.




6. Install the connecing rod cap according to the following procedure:
   - ★ Apply engine oil to the threaded part of the connecting rod bolt and the seat.
   - ★ Mount the bolts alternately according to the following steps.



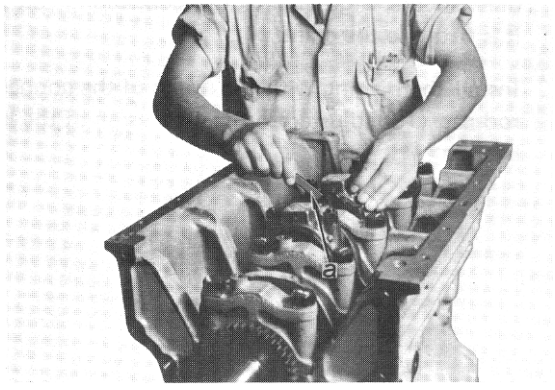
kgm Connecting rod cap tightening torque

kgm

| Tightening sequence | Target | Range |
|---|---|---|
| 1st | 6 | 5 ~ 7 |
| 2nd | 11 | 10 ~ 12 |
| 3rd | 0 | Loosen completly |
| 4th | 6 | 5 ~ 7 |
| 5th | 11.2 | 10.6 ~ 11.7 |

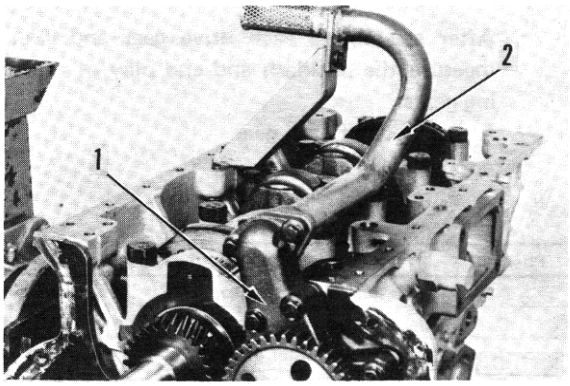
   - ★ After mounting the piston and connecting rod assembly, turn the crankshaft to make sure that the rotation is free from binding or any other troubles.

7. Move the connecting rod cap to one side, and measure the side clearance between the cap and crankshaft with a feeler gauge (a).
   - ★ Cap side clearance: 0.16 to 0.33 mm



**8. Oil pump**

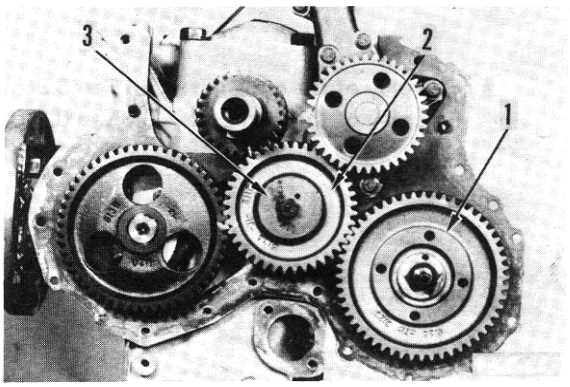
1. Install the oil pump (1).
2. Install the suction pipe (2) with the O-ring.
   - ★ Tighten the clamp so that no execessive pressure is applied to the suction pipe during installation.



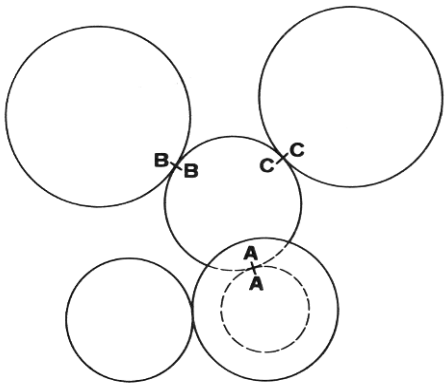

**9. Fuel injection pump drive gear and idler gear**

1. Install the fuel injection pump drive gear (1).
2. Assemble the idler gear (2), and then install the thrust plate (3) with correct positioning of the roll pin.

Bolt tightening torque: 11 ± 1.5 kgm (kgm)

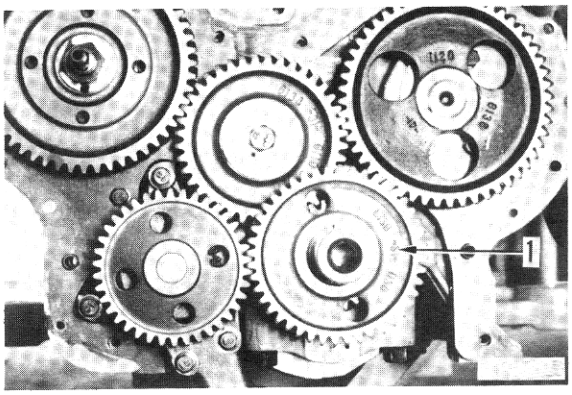



★ Check the matching marks on drive gears and the idler gear.



**10. Oil Pump drive gear**

· Install the oil pump drive gear (1).

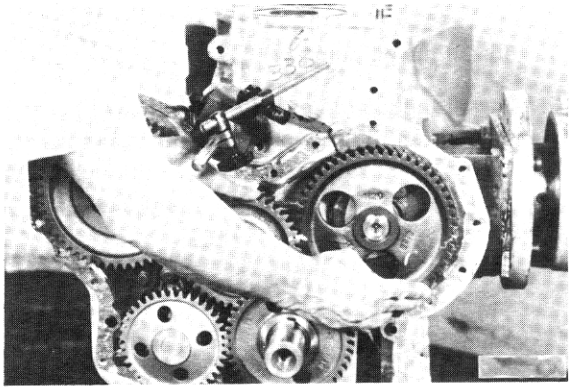


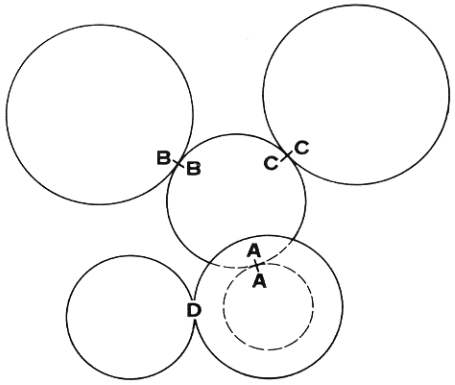

★ Measurement of gear backlash and end play

· After assembling each drive gear and idler gear, measure the backlash and end play of the following gears:

★ Backlash of each gear

| | | mm |
|---|---|---|
| Position | Point to be measured | Range |
| A | Crank gear idler gear | 0.11 ~ 0.37 |
| B | Fuel injection drive gear and idler gear | 0.09~ 0.43 |
| C | Cam gear and idler gear | 0.11 ~ 0.41 |
| D | Oil pump gear and idler gear | 0.12 ~ 0.37 |

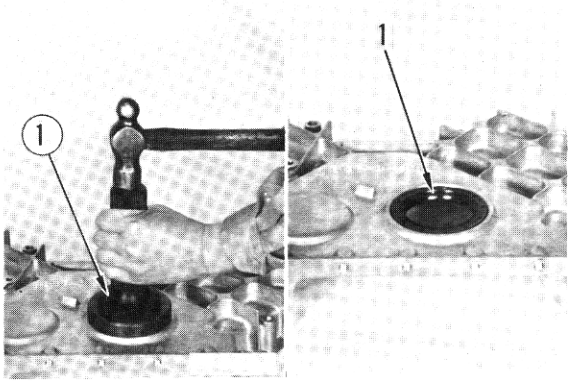





★ End play of the camshaft: 0.15 to 0.35 mm
End play of the idler gear: 0.05 to 0.21 mm

**11. Front cover**

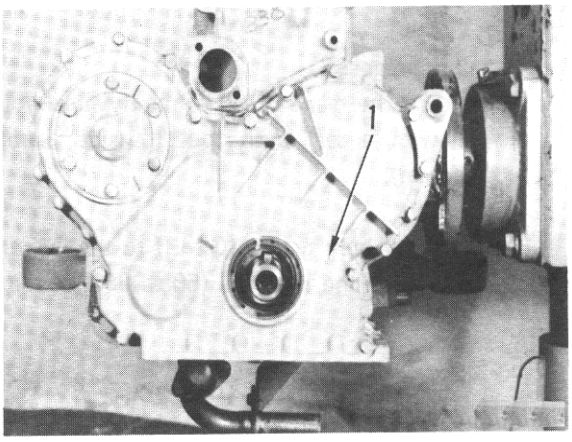
1. Press fit the oil seal (1) to the case with a push tool ① (Outside diameter: 90 mm).



2. Install the front cover (1) on the gasket.

Apply grease (G2-LI) to the lip surface of the front seal (50 to 80% of the lip).

★ Since gasket recess from the mounting surface may cause oil leakage, check that the gasket is protruding from the surface. Cut the gasket is protruding from the bottom of the cylinder block so as to be flush with the cylinder block surface.

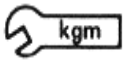



**12. Crank pulley**

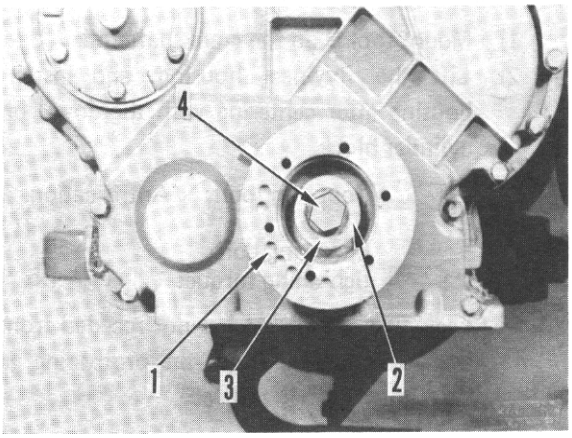
1. Assemble the crank pulley (1) to the crankshaft after aligning the key.

2. Assemble the taper collar (2).

3. Install the plate (3), and tighten the bolt (4).
   ★ Apply engine oil EO30 - CD) to the screw and seat of bolt.



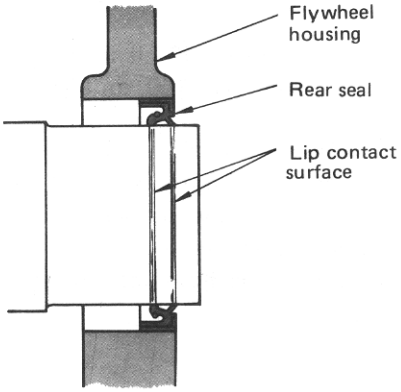

Mounting bolt: 38 ± 3 kgm



**13. Flywheel housing**

1. Install the rear seal.
   - Press fit the rear seal (2) to the flywheel housing (1) with a seal push tool (outside diameter: 135 mm).

Apply grease (G2-LI) to the lip surface of the front seal (50 to 80% of the lip).



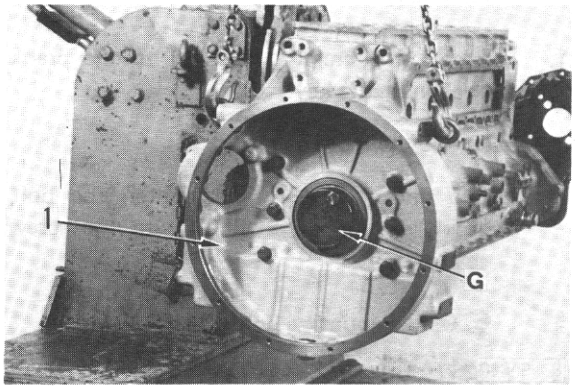

2. Install the flywheel housing (1).
   1) Mount tool **G** on the crankshaft end.
   2) Lift the flywheel housing, and install the housing after centering with the dowel on the cylinder block.

Mounting blot:Antifriction agent (LM-P)

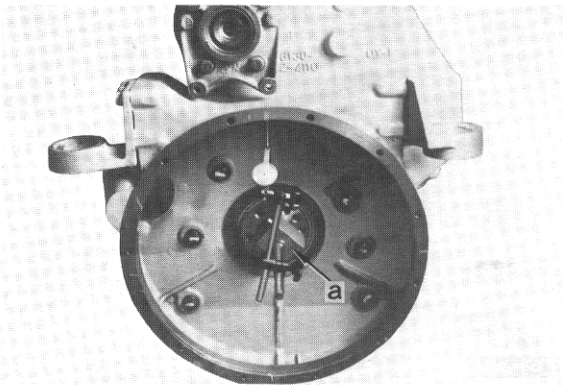
Mounting bolt


tightening torque: 11±1.5 kgm

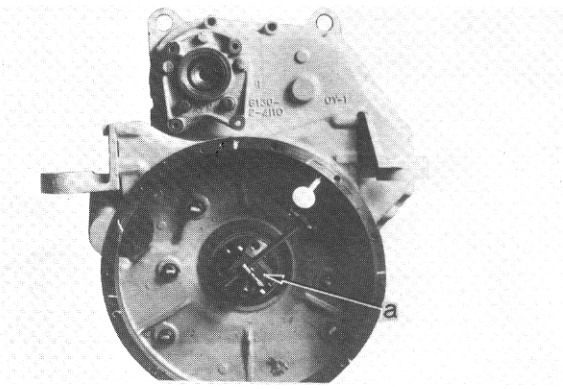
★ Check that the gasket has not receded from the installed surface, and cut the protruding gasket so it is flush with the surface.




3. Measure radial runout and face runout.
   1) To measure the radial runout, set magnet stand (**a**) on the crankshaft end surface, Contact the spindle of the dial gauge with the flywheel housing end. Rotate the crankshaft one complete turn and read the difference between the maximum and minimum indications.
      ★ Move the crankshaft to one side to eliminate the error caused by the end plate. Check that the dial gauge indicates the starting value after the crankshaft has made a complete turn.
      ★ Flywheel housing radial runout limit 0.35 mm : (indicator deflection)

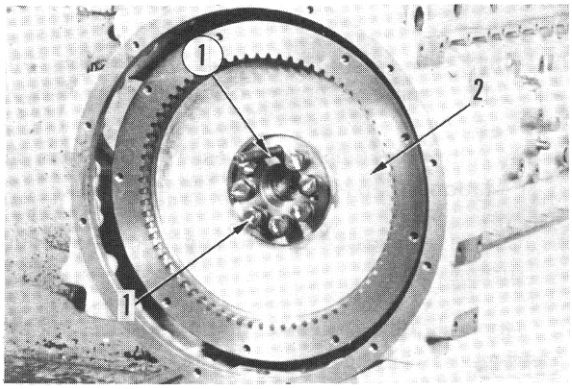



   2) To measure the face runout, bring the spindle into contact with the socket joint portion of the flywheel housing. Rotate the crankshaft one complete turn and record the maximum reading.
      ★ Flywheel housing face runout limit 0.30 mm : (indicator deflection)

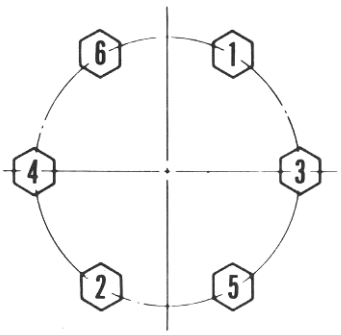


**14. Flywheel**

1. Screw in the guide bolt ① (14 mm, P = 1.5) to the flywheel mounting surface.
2. Set the flywheel (2) on the crankshaft.




3. Tighten the flywheel mounting bolt (1) as follow:
   - ★ Apply engine oil (EO30-CD) to the threaded part of the bolt, seat and washer.
   - · Tighten the bolts in the order given in the figure.

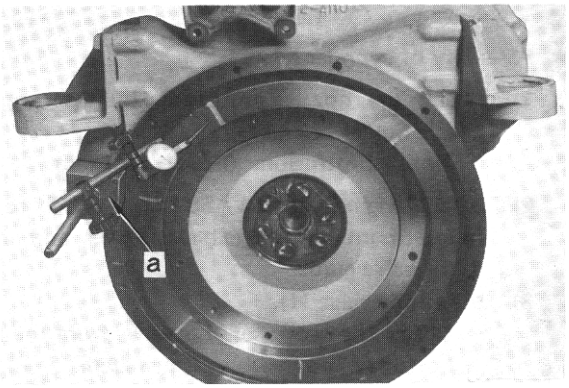



kgm Flywheel tightening torque

kg.m

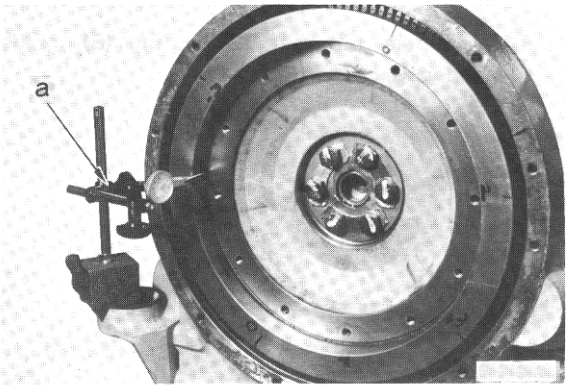
| Procedure | Target | Range |
|---|---|---|
| 1st time | 9 | 3 ~ 12 |
| 2nd time | 18 | 16 ~ 20 |

4. Measure the flywheel radial and face runouts.
   1) Place a magnet stand (a) on the damper cover mounting surface of the flywheel housing. Bring the spindle of the dial gauge into contact with the flywheel end. Rotate the crankshaft one complete turn and the read the difference between the maximum indications.
      - ★ The radial runout is me asured with the crankshaft moved to one side to eliminate the error caused by the end plate. Check that the dial gauge indicates the same value as the starting indication after the crank shaft has made a complete turn.




      - ★ Flywheel radial runout limit: 0.15 mm

   2) The face runout is measured with the spindle head in contact with the socket joint portion of the flywheel. Rotate the crankshaft one complte turn, and read the difference between the maximum indications.




      - ★ Face runout limit: 0.15 mm (indicator deflection)

**15. Oil pan**

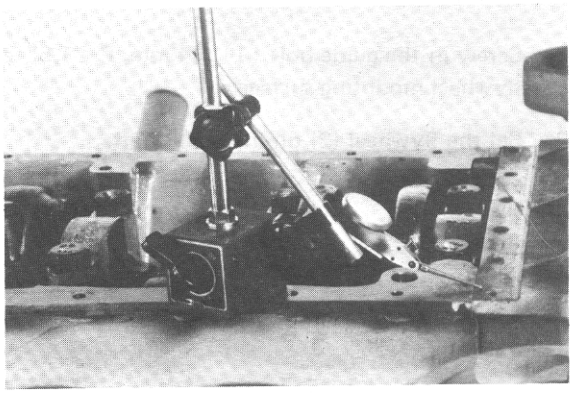
1. Check the height difference between the cylinder block, gear case cover, front plate, and flywheel housing.
   ★ Allowable height difference for oil pan installation: 0.25 mm max.
2. Cut off the gasket protruding from the mounting surface.
3. Apply liquid gasket to mating surfaces of the oil pan, gear case cover, the front plate and flywheel housing.

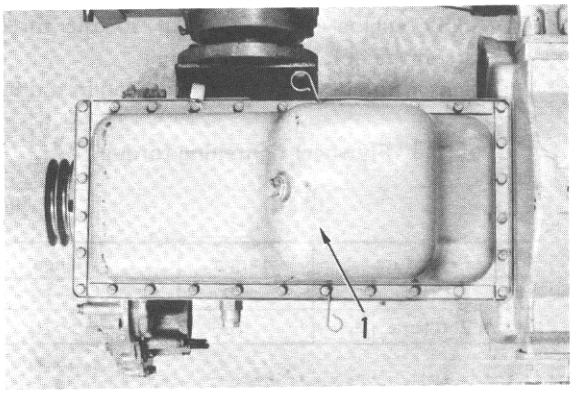
   Oil pan mounting surface: (LG-1)

4. Install the oil pan (1) with gasket.
   ★ Set the gasket with the hot rolled surface (with luster) facing the block side.

   Gasket: Liquid gasket (LG-1)

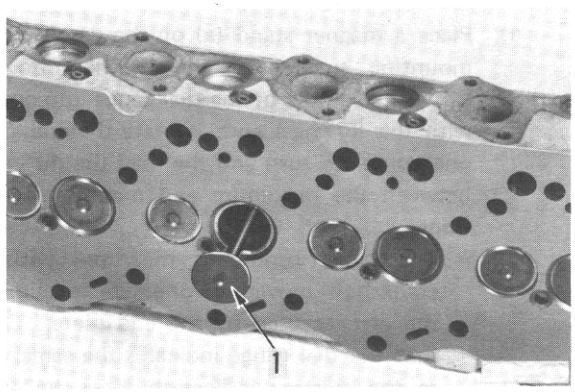
   kgm Oil pan moounting bolt tightening torque: 2.5 ± 1 kgm

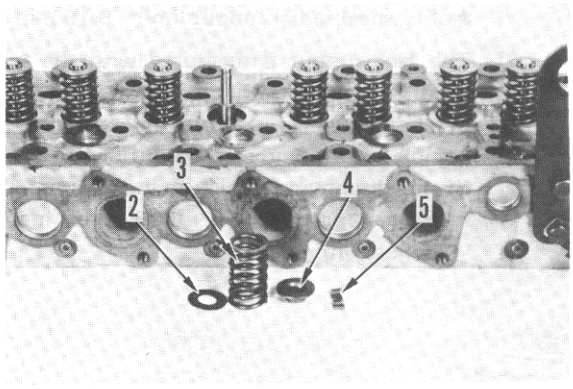




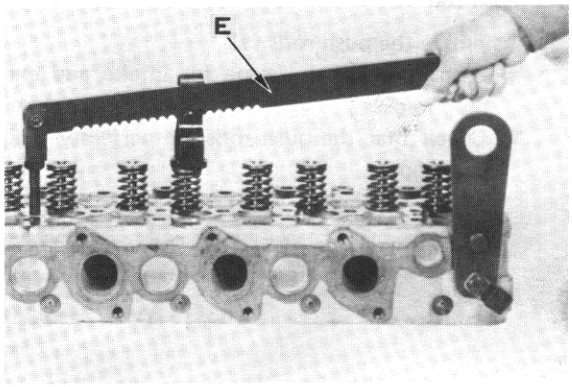

**16. Cylinder head**

★ Assembly of cylinder head
   1) Check the nozzle protrusion by inserting the nozzle holder assembly.
      ★ Nozzle protrusion: 0.79 to 1.71 mm
   2) Apply engine oil (CLASS-CD SAE30) to the stems of intake and exhaust valves and inside of the valve guide.
   3) Install the valve (1).
      · Check the recess of the valve from the head bottom when the valve is installed.
      ★ Valve recess: Intake valve: 1.5 ± 0.24 mm
         Exhaust valve: 1.5 ± 0.28 mm
   4) Assemble the seat (2), spring (3), guide (4) and valve cotter (5).

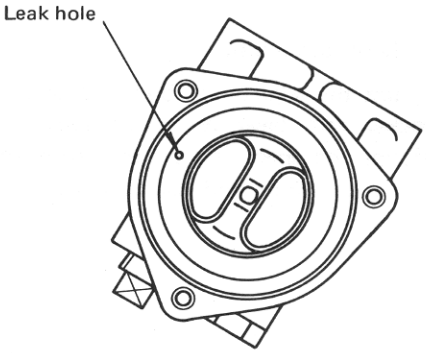


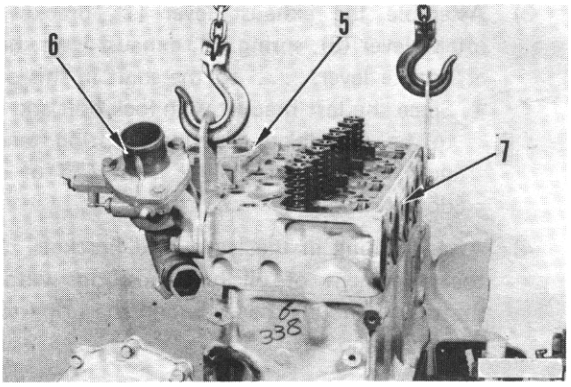
5). Push the vlave spring with a valve spring pusher (**E**) to fit the valve cotter to the valve stem.
   ★ Lightly strike the valve stem with a plastic hammer to check that the cotter is perfectly fitted.




1. Install the intake manifold (5) and thermostat assembly (6) on the cylinder head.
   ★ If the thermostat has been removed, assemble it with the leak hole at the position shown in the figure.




2. Install the cylinder head assemlby
   ★ Different materials are used for cylinder heads with and without turbocharger (not inter-changeable. Care must be excercised at the time of repair.
   · Check the cylinder head and cylinder block mounting surfaces for dirt, and inside of the cylinder for dirt and other foreign matter.




3. Mount the gasket on the cylinder head.

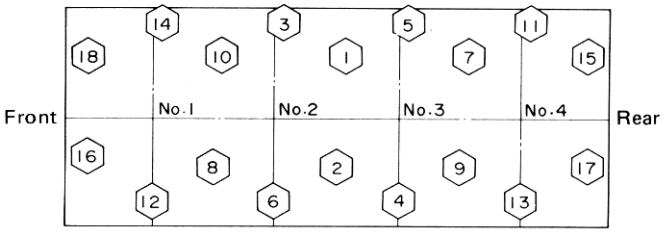
4. Lift the cylinder head assembly (7), and install it with four mounting bolts as the guide.

5. Tighten the cylinder head in the following order:
   ★ Apply molybdenum disulfide (LM-P) or engine oil (CLASS-CD SAE30) to the threaded part of the cylinder head mounting bolts and both sides of washers.
   ★ Tighten mounting bolts in the order given in the figure.

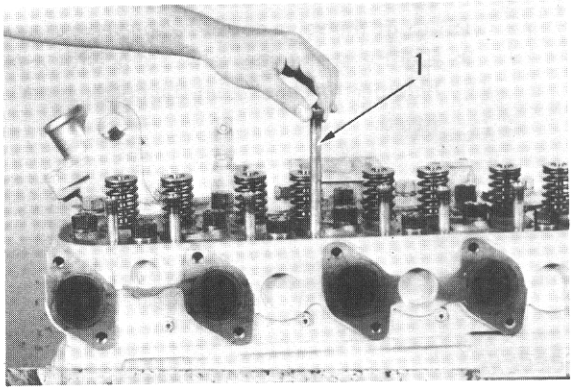
kgm Cylinder head mounting bolt tightening torque:

kgm

| Sequence | When coat with $MoS_2$ | | Coated engine oil | |
|---|---|---|---|---|
| | Target | Range | Target | Range |
| 1st | 9 | 8 ~ 10 | 9 | 8 ~ 10 |
| 2nd | 13 | 12 ~ 14 | 13 | 12 ~ 14 |
| 3rd | 18 | 17.5 ~ 18.5 | 20 | 19.5 ~ 20.5 |



**17. Push rod**

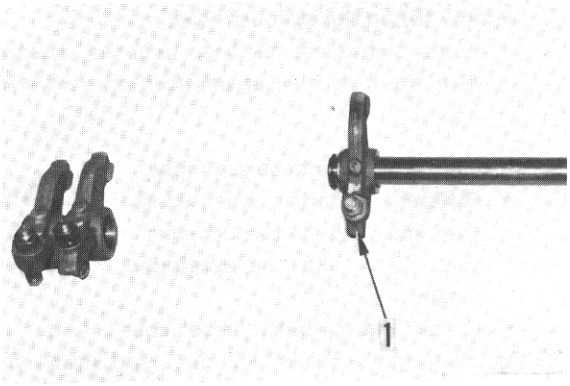



- Assemble the push rods (1).
- ★ Push rods are the same for intake and exhaust manifolds.
- ★ Check that the push rods are perfectly fitted to the tappets.

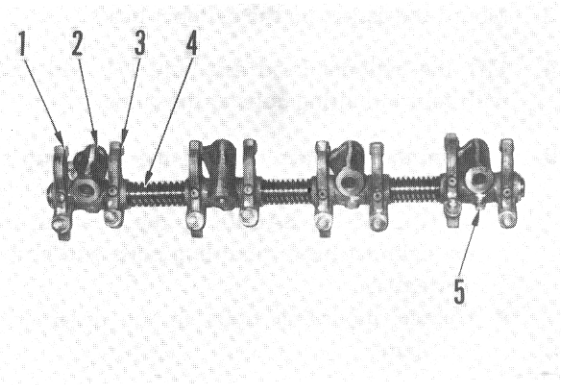
**18. Rocker arm assembly**

★ Assembly of rocker arm

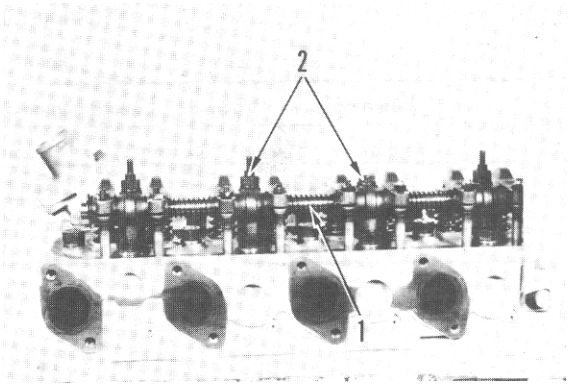
1) Mount the adjustment bolt and lock nut to the rocker arm lever (When previously removed).
2) Mount the snap ring on the front end of the rocker arm shaft, and insert the plate.




3) Assemble the exhaust lever (1), bracket (2), intake lever (3), spring (4), exhaust lever, bracket, intake lever.... to the shaft in this order.
   - ★ Since the last bracket with lock bolt and lever to be assembled are under spring tension, push these in with the front end of shaft downward.
4) After pushing in the levers and brackets, check the agreement of oil hole positions with the shaft, and mount the plate and snap ring to the shaft rear end.



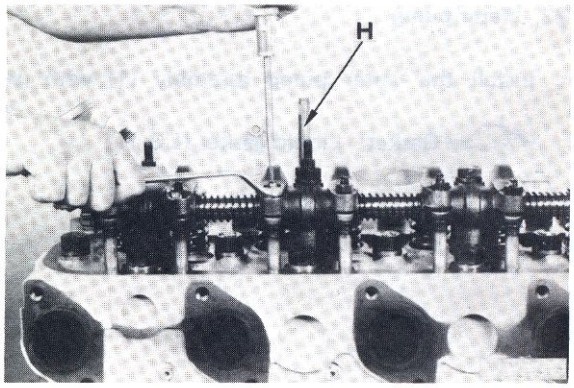

1. Correctly position the rocker arm assembly (1).
   - ★ Check that adjustment screw balls are fitted to the sockets of the push rod.
   - ★ Release the valve spring tension on the rocker arm, if any with the adjusting screw, so that no excessive pressure is applied to the push rod.
2. Tighten the mounting bolts (2).



3. Adjust the valve clearance as follows:
   - ★ Adjust the clearances between the valves and the rocker arm to the values below.
     Intake valve : 0.35 mm
     Exhaust valve: 0.6 mm
   - ★ Engine ignition order: 1 - 3 - 4 - 2

   1) Turn the crankshaft forward, and align the "1.4 TOP" line of the crank pulley with the pointer, while observing the valve movement.
      - ★ When No. 1 cylinder reaches top dead center, adjust the valves marked with ● in the table.
      - ★ When No. 4 cylinder reaches the top dead center, adjust the valves marked with ○ in the figure.

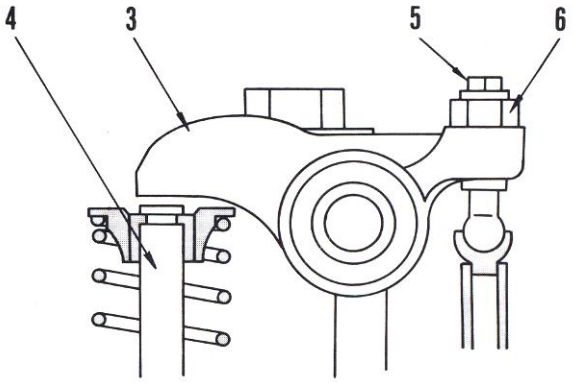
| Cylinder No. | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| Intake valve | | ● | | ○ | | ● | | ○ |
| Exhaust valve | ● | | ● | | ○ | | ○ | |




   2) Put the filler gauge (H) between the rocker arm (3) and valve stem (4), and turn the adjustment screw (5) to allow smooth movement.
   3) Tighten the lock nut (6) at this position to fix the adjustment screw.

      kgm Lock nut: 3.15 ± 0.35 kgm

   - ★ After tightening the lock nut, check the valve clearance again.




**19. Cylinder head cover**

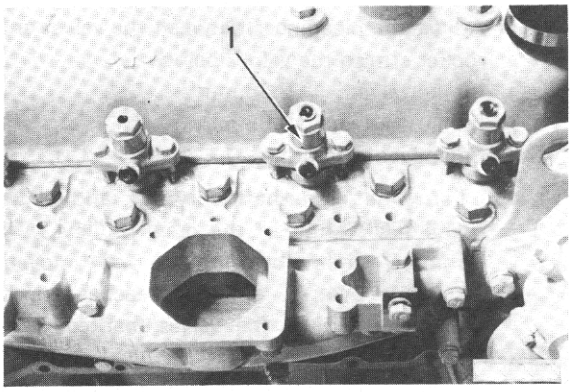
- Install the O-ring on the cylinder head cover (1).
  ★ The O-ring should be mounted to the head cover with adhesive to avoid twisting.

  kgm Head cover mounting nut: 01 to 0.9 kgm

**20. Nozzle holder**

★ Check the inside of the holder sleeve and contact surface of the nozzle holder for dirt and defects.
★ Apply engine oil (EO30-CD) to the threaded part of the nozzle holder mounting bolt.
• Install the nozzle holder (1) on the cylinder head.
  ★ Evenly tighten the nozzle holder mounting bolts.

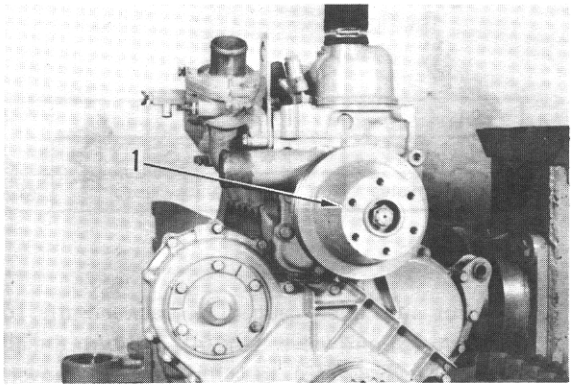
kgm Nozzle holder: 1.75 ± 0.25 kgm




**21. Water pump**

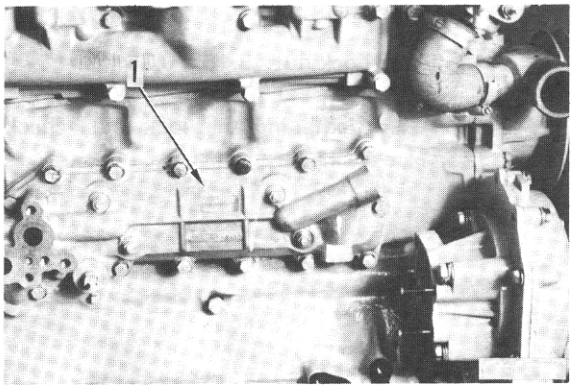
· Install the water pump assembly (1) with gasket.

Gasket: Liquid gasket (LG-1)




**22. Oil cooler**

· Install the oil cooler (1) with gasket.



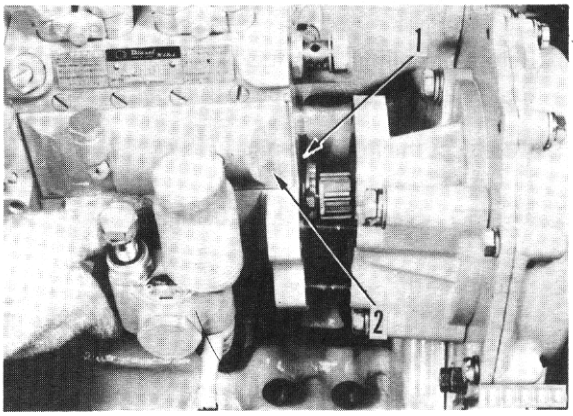
**23. Fuel injection pump**

1. Mount the O-ring (1) to the fuel injection pump (2).

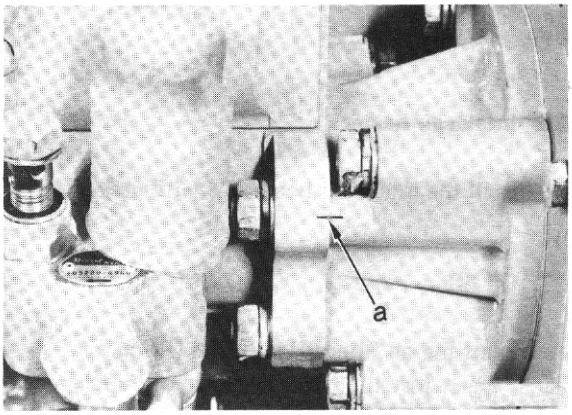

O-ring: Grease (G2-LI)

2. Align the coupling wide tooth center in the coupling with the drive shaft spline wide tooth center of the fuel injection pump.

3. Put the injection pump gently in the case, and combine the coupling and spline.

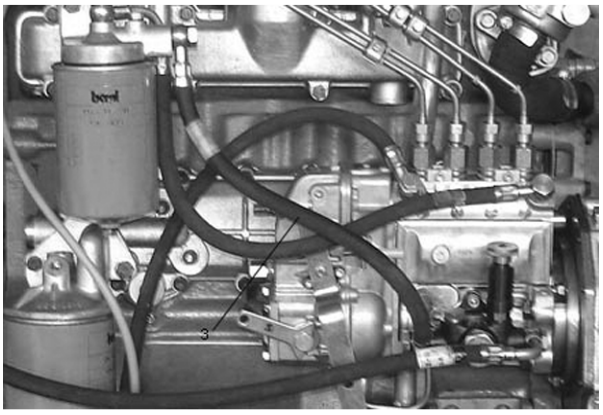



4. Install the fuel injection pump by aligning the marked line on the flange with the matching mark (a) of the coupling case.



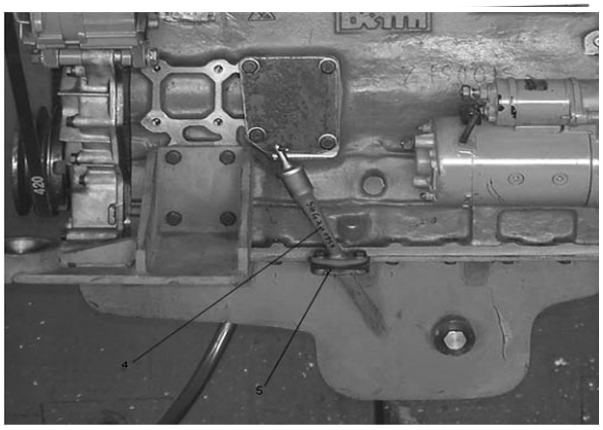

5. Connect the feed pipe (3).

★ Fill 60cc of engine oil to the pump cam case and 200cc to the governor case.




★ Oil level gauge guide

· Mount the oil level gauge guide (4) and bracket (5).



**24. Fuel injection pipe and spill tube**

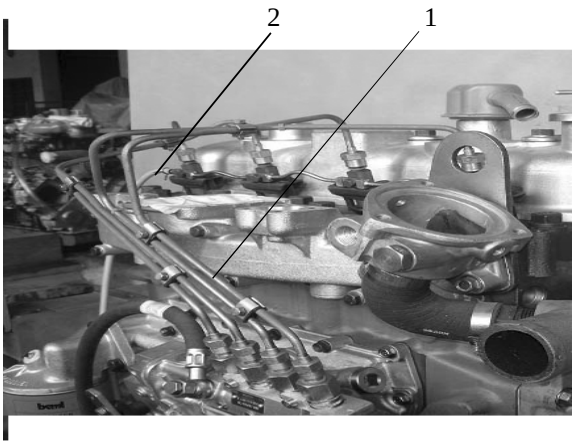
★ Before installing the fuel injection pipe and spill tube, clean inside the pipe with an air cleaner.

1. Connect the injection pipes (1).

kgm Sleeve nut: 2.2 ± 0.1 kgm

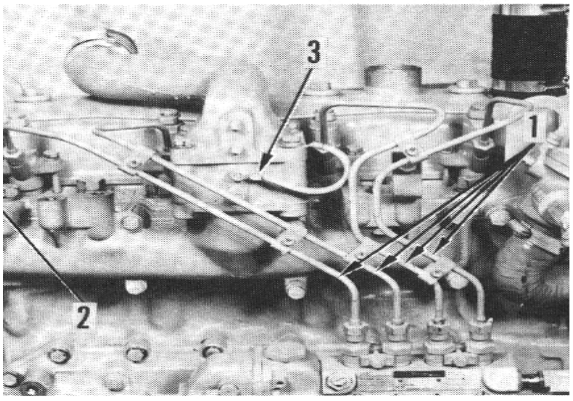
2. Connect the spill tube (2).
   ★ Since it is hard to take out a joint bolt gasket that has fallen inside the cylinder head, be careful during mounting.

kgm Joint bolt: 1.8 ± 0.2 kgm




**25. Intake air heater**

· Install the intake air heater (3) gasket.

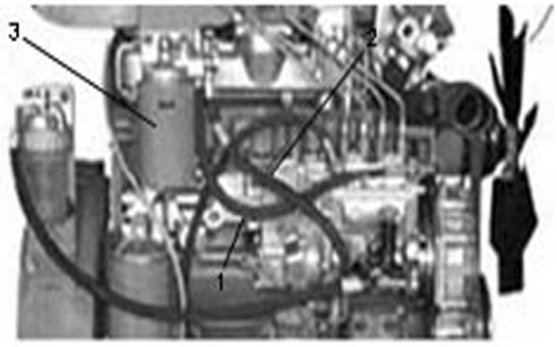



**26. Oil filter**

· Mount the oil filter (4) with the O-ring.
   ★ When installing the filter, lightly apply engine oil (CLASS-CD SA30) to the O-ring at the connection surface of th filter. Tighten another 2/3 turns after the packing surface is brought into contact with the seal surface of the filter stand.

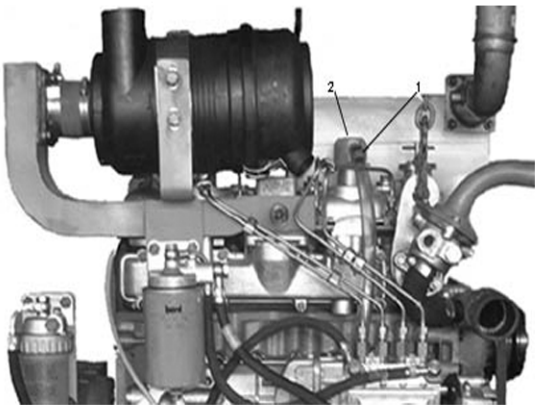
**27. Fuel filter**

· Install the fuel filter (3), and connect the outlet hose (2), and inlet hose (1).




**28. Crankcase breather**

· Install the breather element, and mount the breather cover (2) using the clamp (1).

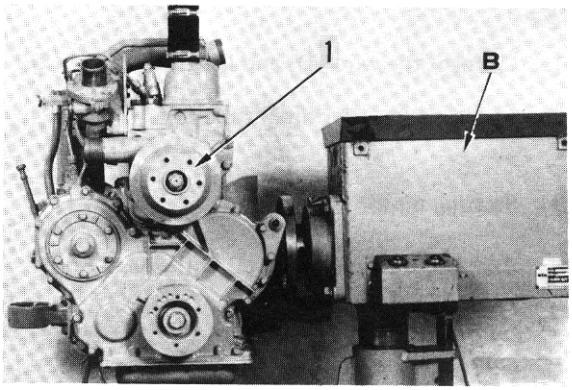


**29. Removal from engine stand**

1. Temporarily suspend the engine assembly, remove the connecting bolts of the adapter plate and overhaul stand (B), and remove the engine assembly.

2. Set the engine assembly (1) on engine stand A.

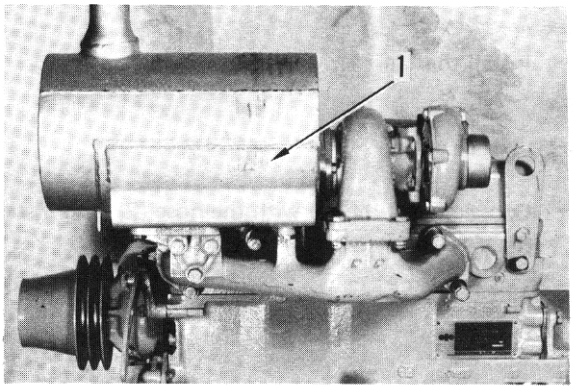
3. Remove the adapter plate.




**30. Exhaust manifold, turbocharger and muffler.**

1. Mount the gasket, and install the exhaust manifold, turbocharger and muffler (1) in assembled state.

2. Connect the turbocharger outlet and inlet pipes.
   ★ Connect each connection pipe carefully so that no excessive twisting pressure is applied.




**32. Alternator and fan belt.**

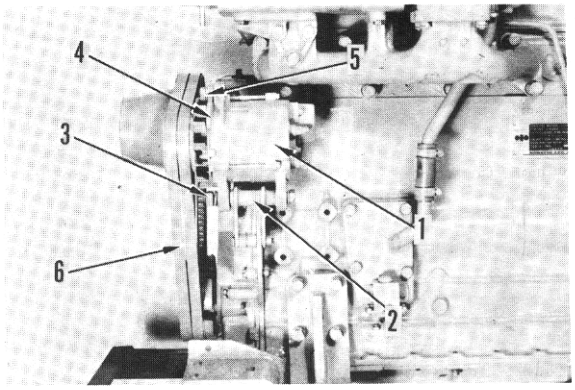
1. Install the alternator (1) on the mounting bracket (2).

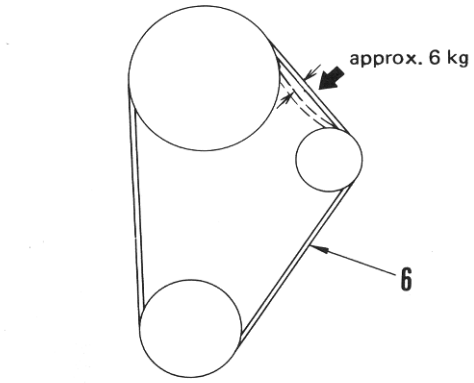
2. Set the alternator mounting bolt (3) from the fan side, and temporarily tighten nuts (with spring washer inserted).

3. Set the adjustment plate (4) to the water pump and mount the adjustment lock bolt (5).

4. Set the fan belt (6) on the pulley groove.

5. Put the bar between the alternator and cylinder bolck to adjust the belt tension, and tighten the adjusting bolt and mounting bolts.
   ★ The tension of the fan belt should be adjusted to give 10 mm of flexure when depressed with finger (approx. 6 kg) at the middle part of the water pump pulley and the alternator pulley.



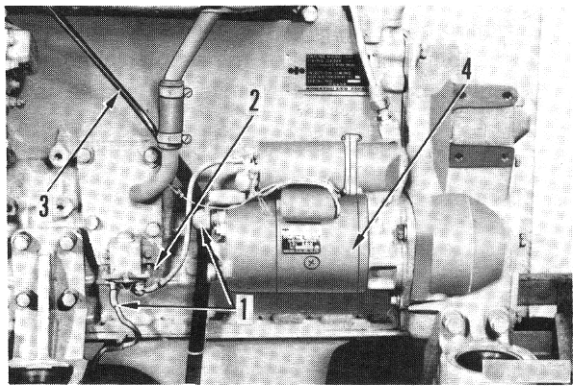



**32. Muffler drain tube**

1. Connect the wire (1), and install the relay (2).
2. Install the muffler drain tube (3).

**33. Starting motor**

- Install the staring motor (4) with the plug.

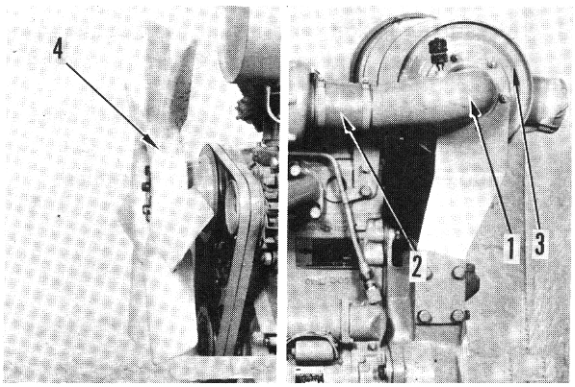



**34. Fan**

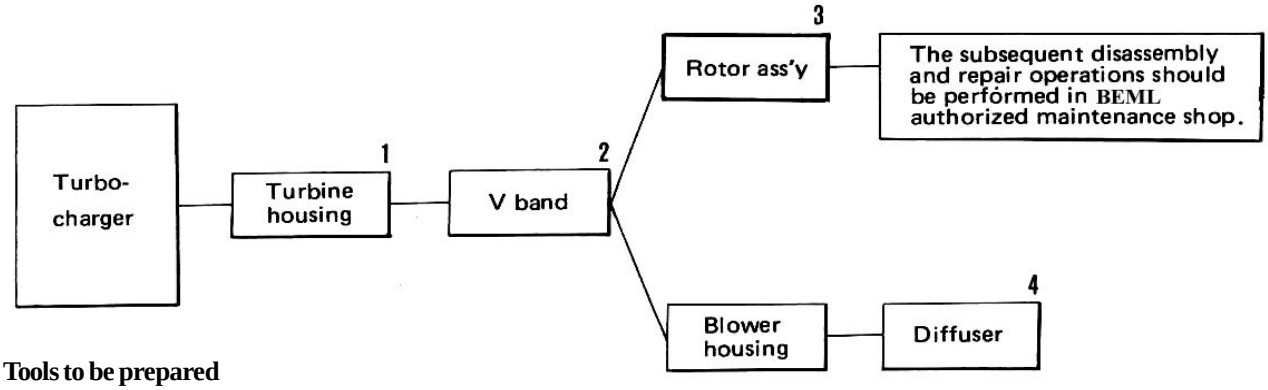
- Install the fan (4).

**35. Air cleaner**

- Connect the tube (1) with the hose (2), and install the air cleaner (3).



# DISASSEMBLY OF TURBOCHARGER

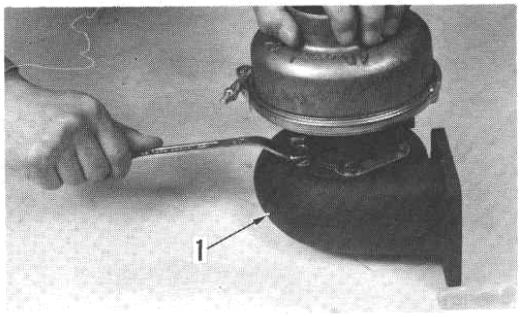


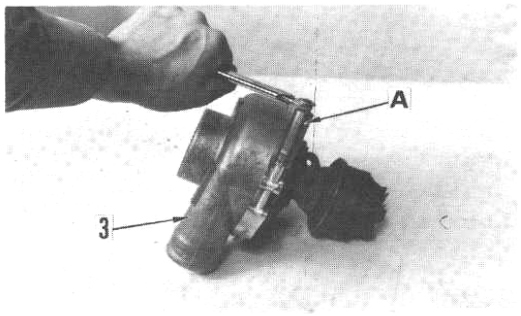

**Tools to be prepared**

| beml Gallet P/N | Part Name | A | B | C | D |
|---|---|---|---|---|---|
| - | Penetrating oil | | | | |
| - | Deep socket | 1 | | | |
| - | Cartridge holder | | 1 | | |
| - | T-wrench | | | 1 | |
| - | Retaining ring remover | | | | 1 |

**1. Turbine housing**

1) Spray penetrating oil on the turbine housing mounting bolts and leave the housing as sprayed for about 15 minutes.
   - ★ Since the mounting bolts are often found in burnt or seized state by high heat, be sure the oil penetrates to their thread areas.
2) Give matching marks to the turbine housing mating or contacting parts.
   - ★ These matching marks are given to prevent erroneous locations of parts in reassembling the turbine housing.
3) Straighten lock plates and loosen bolts.
4) Remove the turbine housing.
   - ★ At this time, be careful not to damage the turbine housing. If the housing is stuck in position, remove the housing gently, giving light blows to the outer circumference with a plastic face hammer.



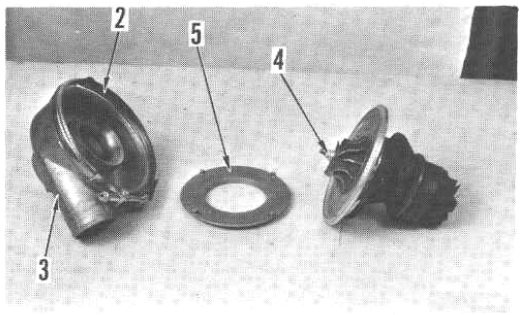




**2. V band**

- Remove V band (2), using a deep socket A.

**3. Rotary assembly**

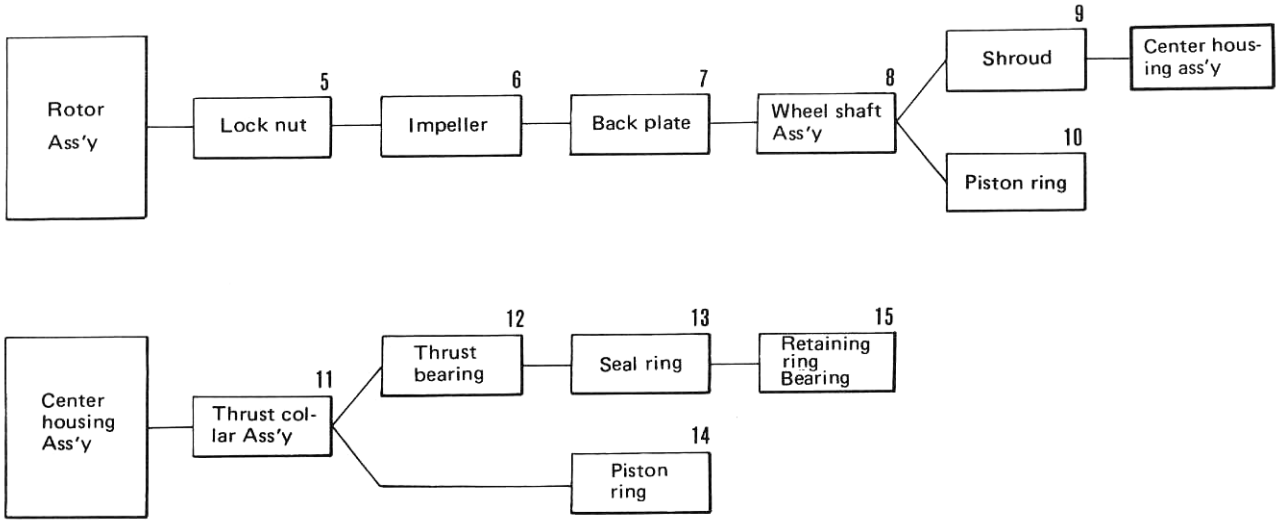
- Remove rotor assembly from compressor housing (3).
- ★ Impeller and turbine wheel are in the state of high-precision, dynamic balance, requiring extreme care in their handling. If damaged or deformed, they cannot be reconditioned.




**4 Diffuser**

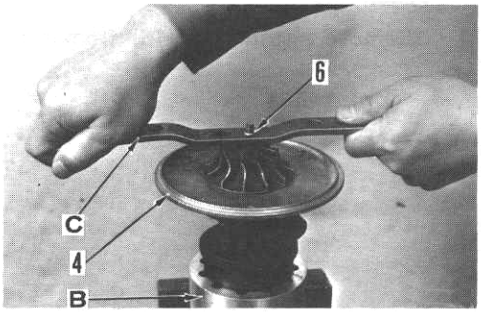
Remove diffuser (5) from the compressor housing.

★ The subsequent disassembly and reassembly operations should be performed in a BEML authorized maintenance shop.




**5. Lock nut**

1) Secure cartridge holder with a vice. Put rotor assembly (4) in the holder and keep it so that the end of wheel shaft is set in socket.
2) Remove locknut (6), using T wrench C.
   ★ If the lock nut is removed, the wheel shaft assembly will fall out of the rotor assembly. Therefore, when carrying the rotor assembly, be sure to support the wheel and center housing sections by two hands.




**6. Impeller**

1) Remove rotor assembly (4) from the cartridge holder and rest it on blower housing (3).
2) Remove back plate (7) mounting bolts.
3) Remove impeller (8) out of place.


**7. Back plate**

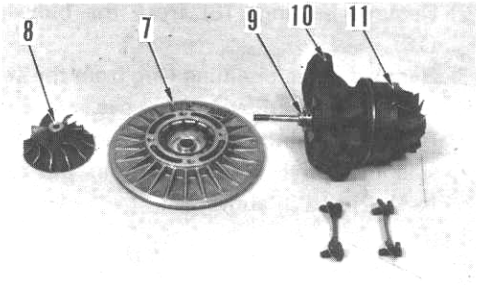
· Remove back plate (7) out of place.

**8. Wheel shaft assembly**

· Remove wheel shaft assembly (9) from center housing (10).

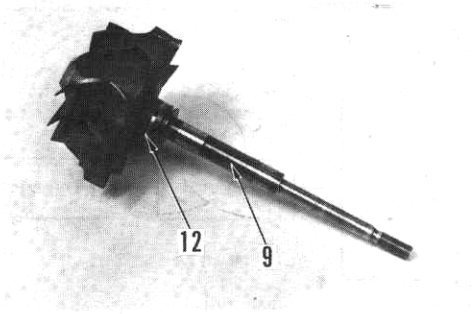
**9. Shroud**

· Remove shroud ( 11) from the center housing.



**10. Piston ring**

- Remove piston ring ( 12) from wheel shaft assembly by separating the mating parts wide by fingers.




**11. Thrust collar assembly**

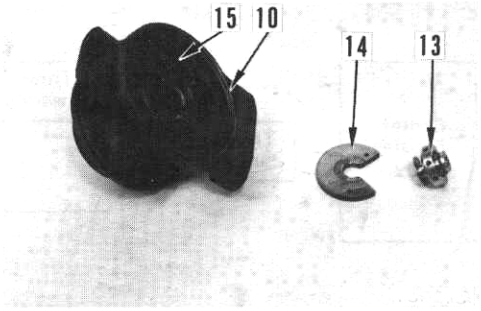
- Remove thrust collar assembly ( 13) from center housing (10).

**12. Thrust bearing**

- Remove thrust bearing (14) from center housing (10).

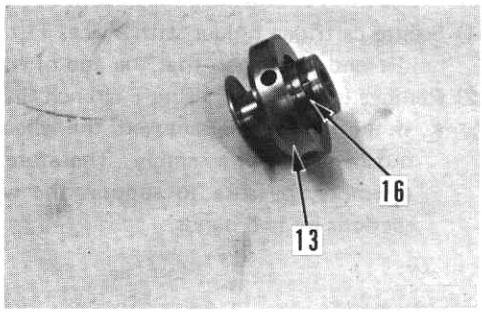
**13. Seal ring**

- Remove seal ring (15) from center housing (10).



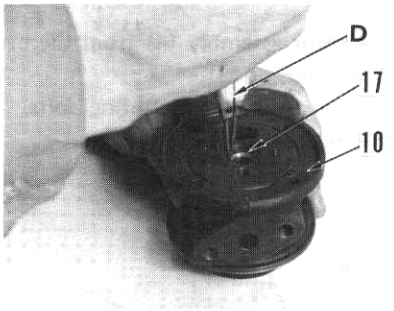

**14. Piston ring**

- Remove piston ring (16) from thrust collar assembly (13),

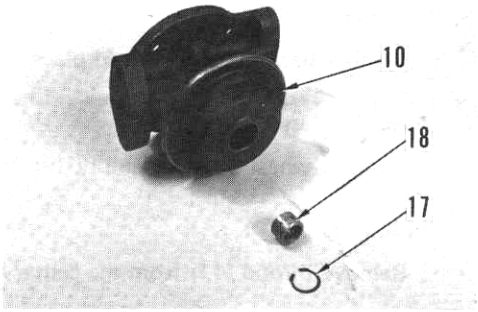



**15. Retaining ring and bearing**

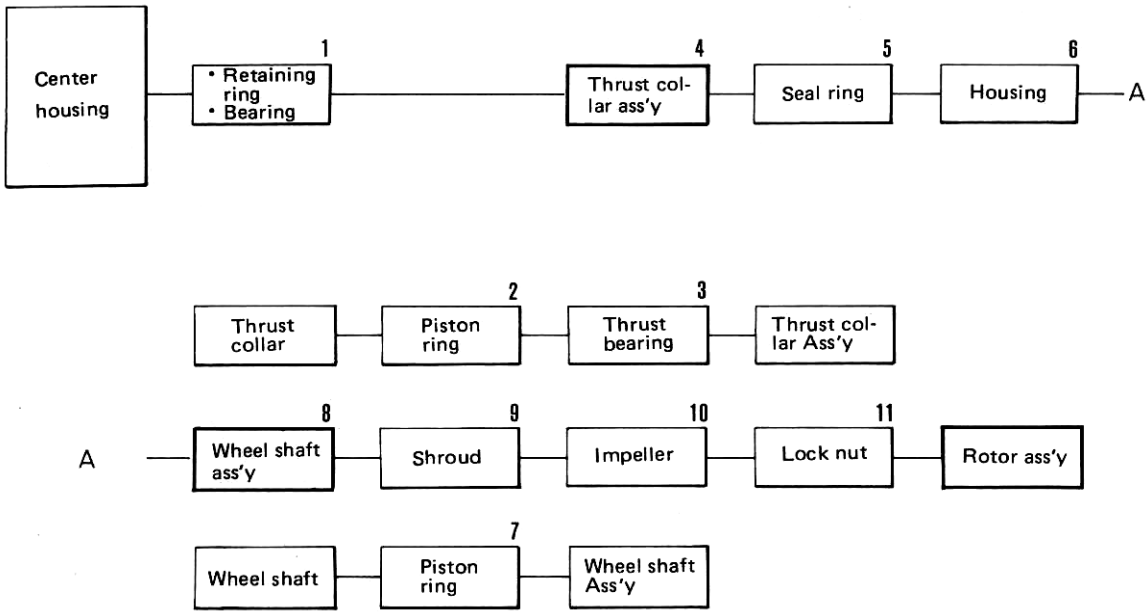
1) Remove outer retaining ring ( 17) from the blower side of center housing (10), using a retaining ring remover D.




2) Remove bearing ( 18) from the blower side of center housing (10).
3) Remove inner retaining ring from the center housing in the same manner as described in 1) above.
4) Remove retaining ring ( 17) and bearing ( 18) from the turbine side of center housing (19) in the same manner as described in 1), 2) and 3) above.



# ASSEMBLY OF TURBOCHARGER

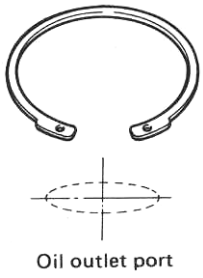


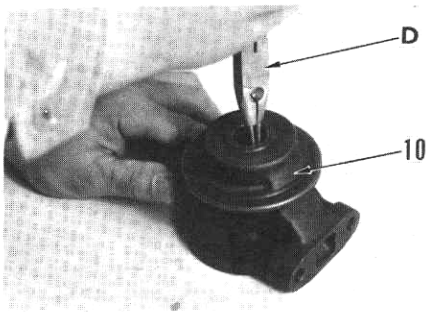

**Tools to be prepared**

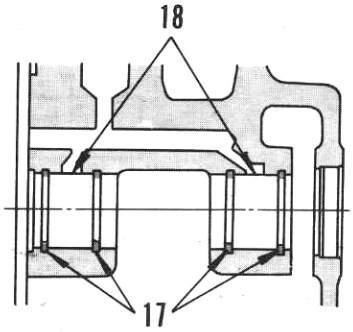
| beml Gallet P/N | Part Name | - | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| - | Lubriplate | 1 | | | | | | | | |
| - | Deep socket | | 1 | | | | | | | |
| - | Cartridge holder | | | 1 | | | | | | |
| - | T-wrench | | | | 1 | | | | | |
| - | Retaining ring remover | | | | | 1 | | | | |
| - | Piston ring guide | | | | | | 1 | | | |
| - | Pig | | | | | | | 1 | | |
| - | Radial play measuring Intrument | | | | | | | | 1 | |
| - | Radial play measuring Instrument | | | | | | | | 1 | |
| - | End play measuring instrument | | | | | | | | | 1 |
| - | End play measuring instrument | | | | | | | | | 1 |

**1. Retaining ring and bearing**

1) Insert retaining ring (17) into center housing (10). using retaining ring remover D.
   ★ Make sure that the mating ends of ring are in a correct contact with each other with the oil outlet side up.
2) Coat the inner and outer surfaces of bearing with engine oil
3) Set bearing ( 18) in the center housing.
4) Insert the outer retaining ring in the same manner as described in 1 ).

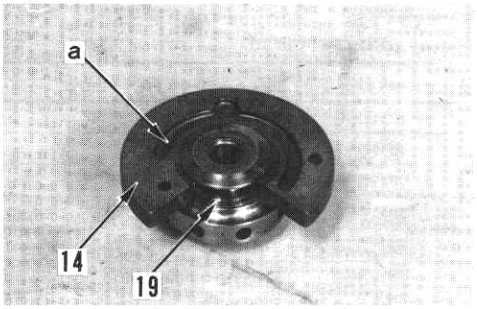



**2. Piston ring**

· Install piston ring (16) on thrust collar (19)

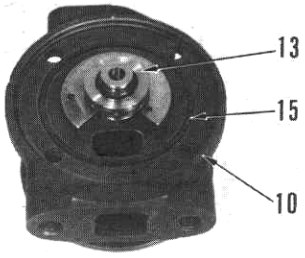



**3. Thrust collar assembly**

1) Coat thrust bearing ( 14) with engine oil.
2) Install the thrust bearing in groove in thrust collar (19).
   ★ At this time, oil groove (a) in the thrust collar should~face outside. .

**4. Thrust collar assembly**

· Install thrust collar assembly in center housing (10).

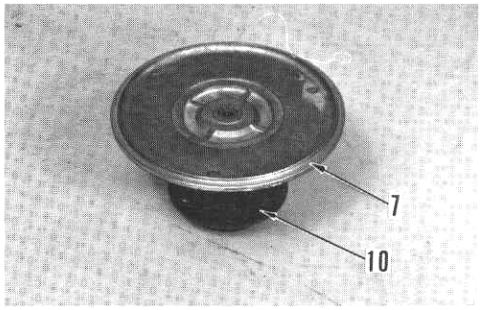



**5. Seal ring**

· Install seal ring ( 15) in the groove on the circumference of center housing (19).

**6. Back plate**

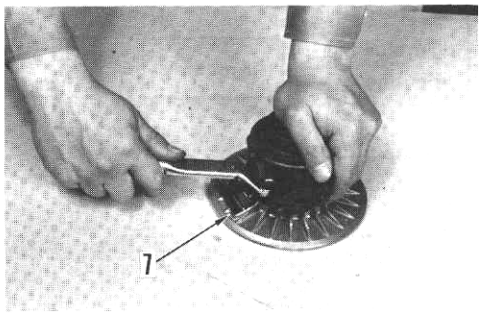
1) Coat the inside hole of back plate with engine oil.
2) Install back plate (7) with threaded hole plate and drilled hole in center housing ( 10) aligned with each other .
   ★ Provide a space for name plate away from oil hole in the housing.



3) Hold the center housing and back plate by hands, taking care not to allow the set parts t o get out of place, and turn them with the back plate down.

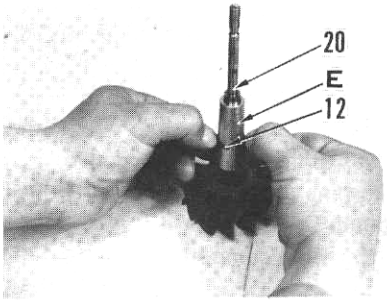
4) Tighten the back plate (7) mounting bolts.

kgm Tightening torque of the back plate mounting bolts: 0.95 ± 1 kgm



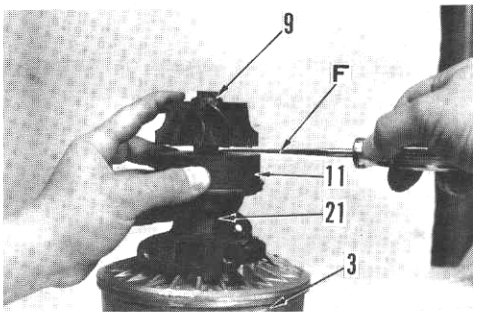

**7. Piston ring**

· Install piston ring (12) on wheel shaft (20), using piston ring Guide E.



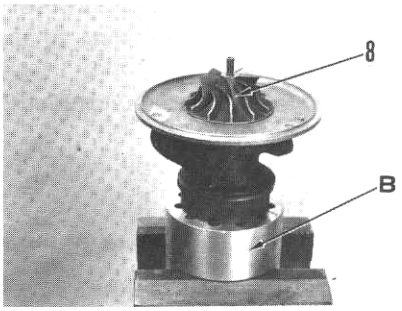

**8. Wheel shaft assembly**

1) Rest center housing assembly (21) on blower housing (3) used as support.
2) Coat a bearing section in wheel shaft assembly (9) with oil.
3) Correct piston ring in the wheel shaft assembly, using pig F and insert wheel into the center housing, rotating the wheel gently.




**9. Shroud**

· Install shroud (11) in center housing assembly (21)




**10. Impeller**

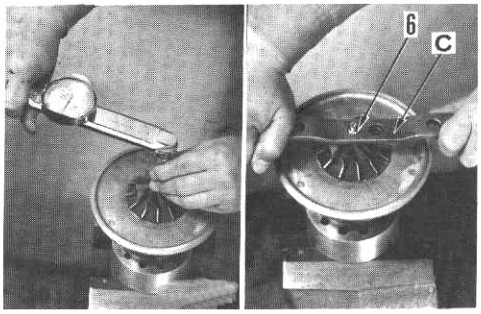
1) Remove the center housing wheel shaft assembly from the blower housing and set it in cartridge holder B.
   ★ Take care of no pulling out the wheel shaft assembly.
2) Coat the impeller mounting shaft and the lock nut installing thread area with lubriplate (to prevent-seizure).
3) Install impeller (8).

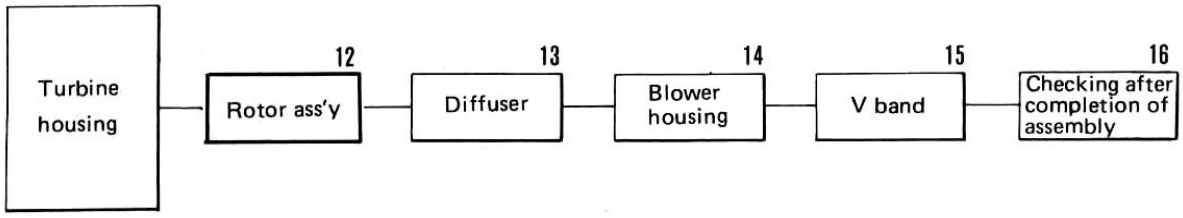
**11. Lock nut**

1) Tighte lock nut (6).

kgm Lock nut tightening torque: Q.22 ± 0.01 kgm

2) Retighten the lock nut further by 90°, using T -wrench C.



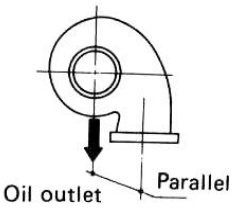



**12. Rotary assembly**

1) Install rotor assembly (4) in turbine housing (1).
   - ★ Install the rotor assembly gently, taking care not to impair parts.
   - ★ Install the turbine housing in place as shown in schematic drawing.
   - ★ Locate drilled hole in shroud so as to face an oil inlet side.
2) Coat turbine housing mounting bolt holes with antifrication compound.
   - ★ Antifrication compounds: NICHIMOLI PG Paste or MOLICOAT AST Compound
3) Tighten the turbine housing mounting bolts.

   kgm Tightening torque of turbine housing mounting bolts: $1.7 \pm 0.1$ kgm

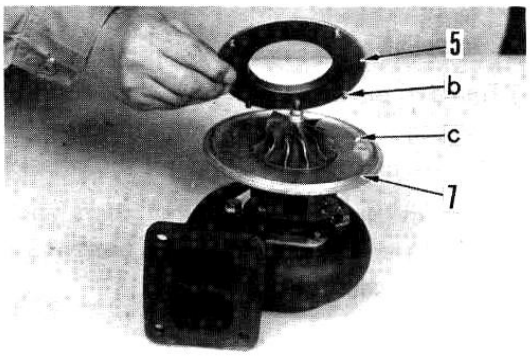
4) Bend lock plates.


View from turbine side

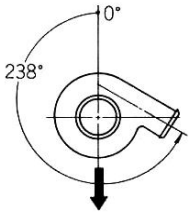
**13. Diffuser**

- Install diffuser (5) on back plate (7).
- ★ Bring protrusion (b) of the diffuser to the right side of protrusion (c) of the back plate to prevent the diffuser from turning clockwise.
- ★ If the diffuser has three protrusions, bring these protrusions in holes in the back plate.




**14. Blower housing**

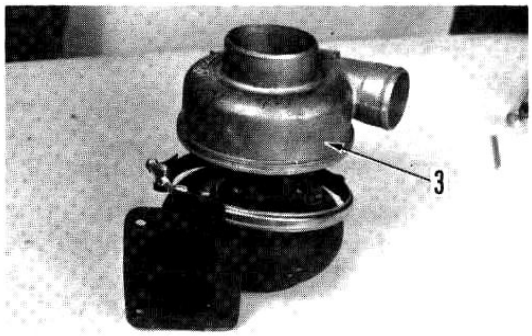
1) Install blower housing in place as shown in schematic drawing below.




View from blower side

2) Tighten the tightening bolt of blower housing.

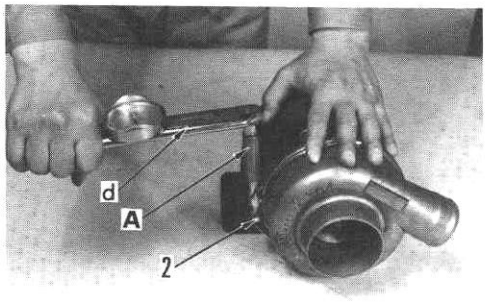
   kgm Housing of tighten bolt: $1.35 \pm 0.15$ kgm



**15. V band**

· Attach and tighten V band (2), using deep socket A and torque wrench (d).

kgm V band tightening torque: 0.8 ± 0.1 kgm




**16. Checks after completion assembling**

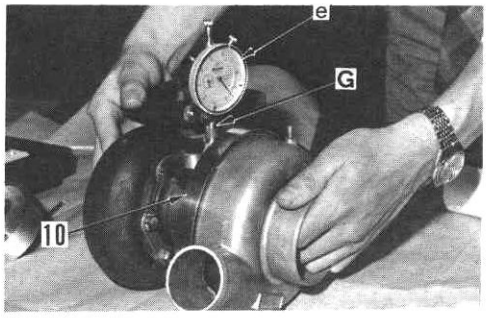
1) Make sure that the rotor assembly rotates smoothly by giving light push there to.

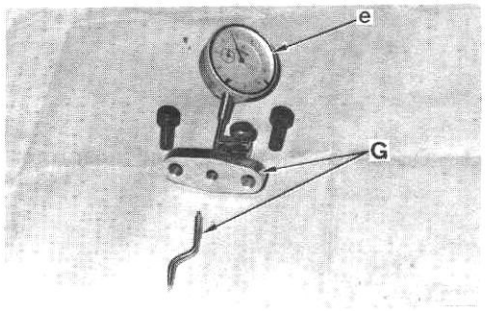
2) Check play of rotor in the radial direction (radial play).

i) Attach a measuring instrument G to oil outlet of center housing (10) and set a dial gauge so that its probe comes into contact with shaft.

ii) Hold the rotor by hands on both ends and move it in parallel in the radial direction to measure play.

★ Rotor radial play allowable range: 0.975 to 0.150 mm




3) Check play of rotor in the axial direction. (End play)

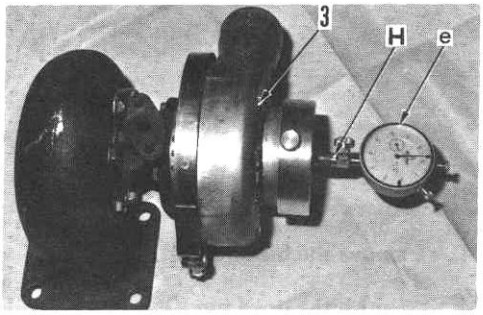
i) Set dial gauge in end play measuring instrument H and replace the gauge probe with an exclusive one for this measurement.

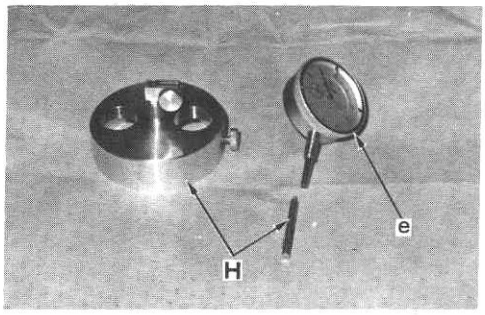
ii) Attach the measuing instrument to inlet port in blower housing (3) and set the dial gauge so that a probe comes into contact with the shaft end.

iii) Measure end play by moving the rotor in its axial dirction.

★ Play of rotor in axial direction (End play)

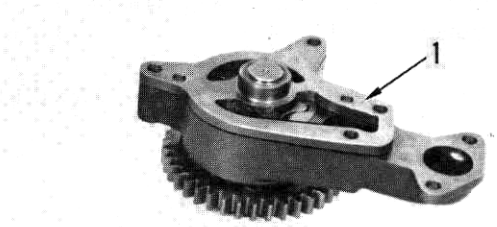
Allowable range: 0.025 to 0.075 mm



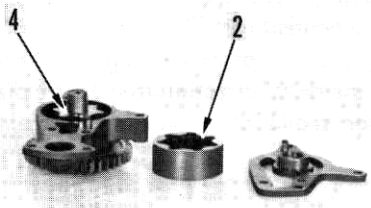



# DISASSEMBLY OF OIL PUMP

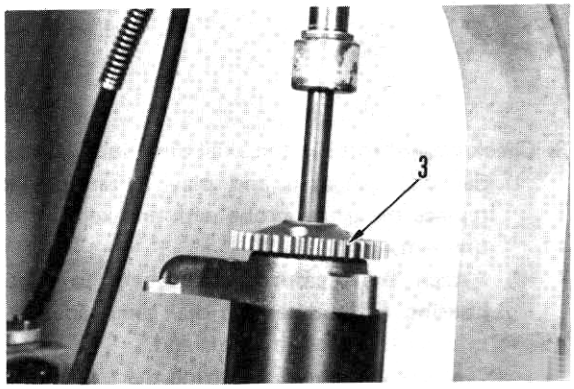
1. Remove the cover (1).



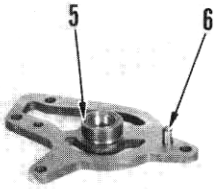

2. Remove the outer rotor.




3. Disconnect the gear (3) and inner rotor (4).

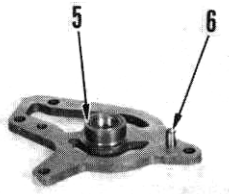



4. Remove the bushing (5).
5. Remove the dowel pin (6).

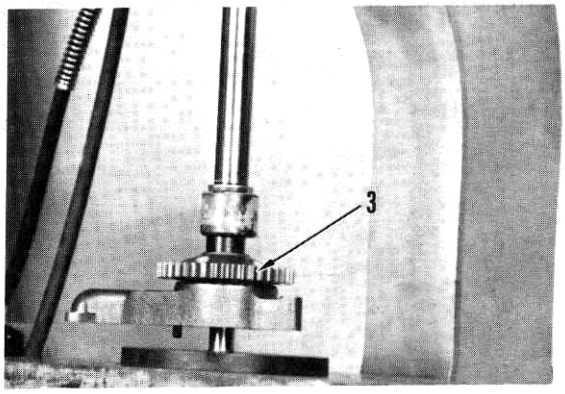


# ASSEMBLY OF OIL PUMP

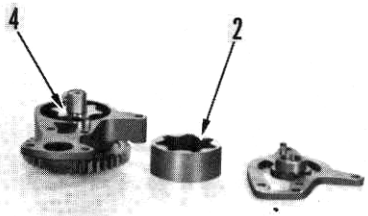
1. Install the cushing (5).
2. Drive in the dowel pin (6).



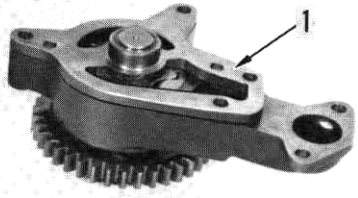

3. Press fit the gear (3) to the inner rotor (4).




4. Istall the outer rotor (2).

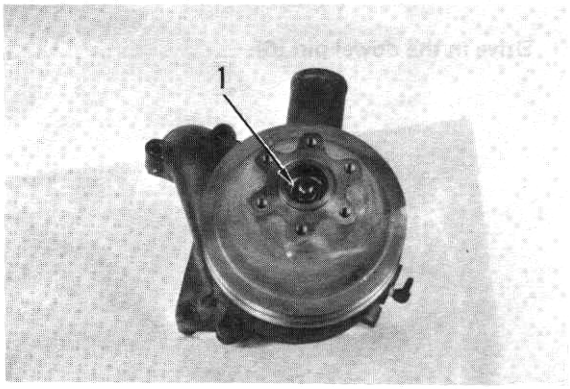



5. Install the cover (1) with the dowl pin position correctly adjusted.

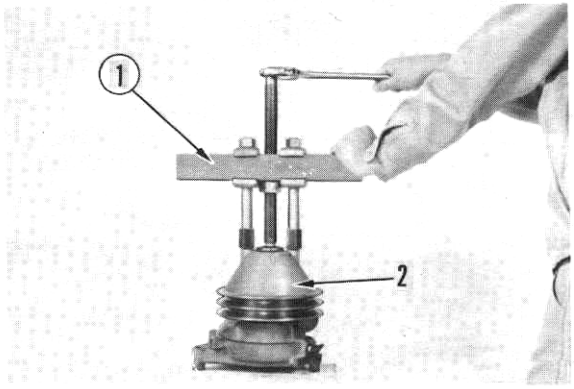


# DISASSEMBLY OF WATER PUMP

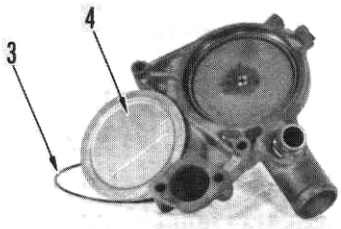
1. Remove the nut (1).



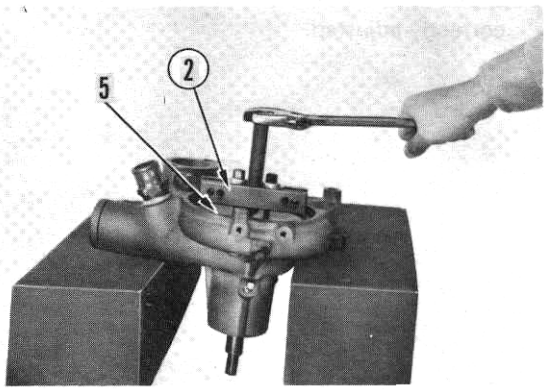

2. Remove the fan pulley (2) with the puller ①.



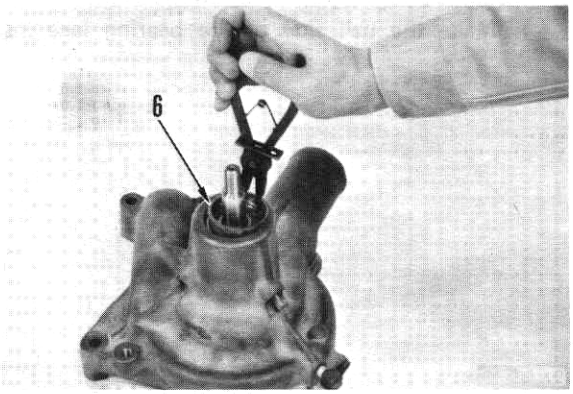

3. Take off the snap ring (3) to remove the cover.



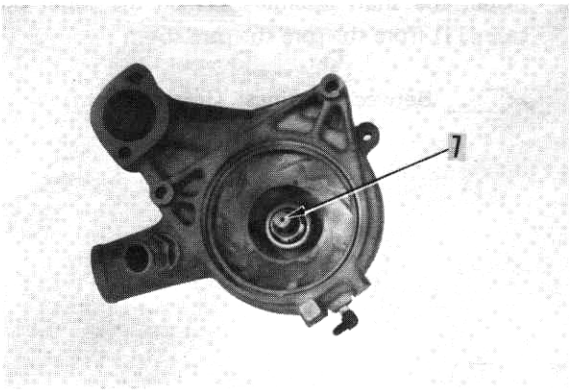

4. Remove the impeller (5) with the puller ②.



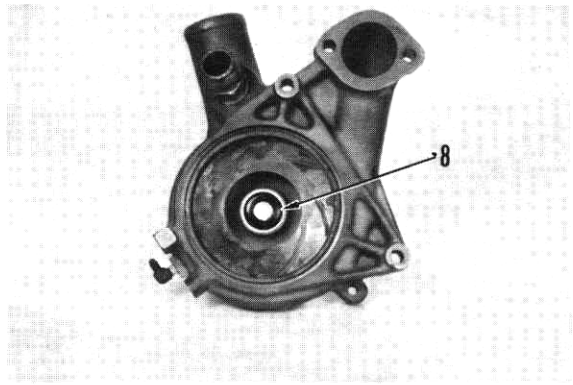
5. Remove the snap ring (6).



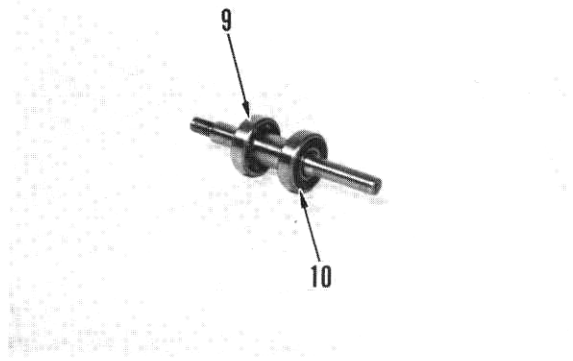

6. Extract the shaft (7) from the impeller side.
   ★ Remove the shaft and bearing as a unit.




7. Remove the water seal (8).

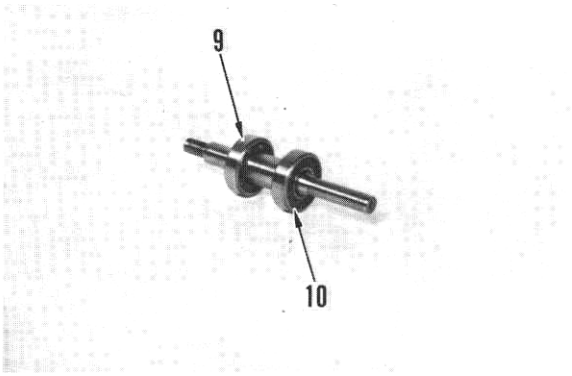



8. Remove bearing (9) and (10) from the shaft.



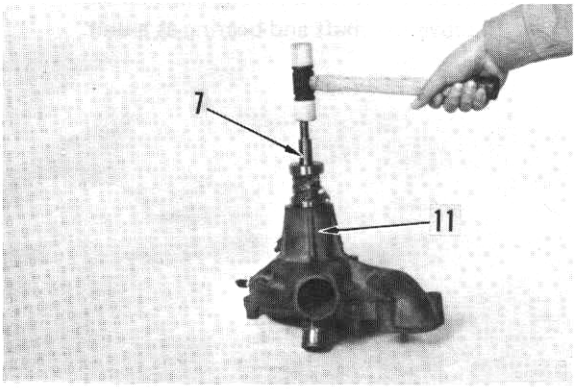
# ASSEMBLY OF WATER PUMP

1. Install bearing (9) and (10) on the shaft.
   ★ Make the ball side of the bearing face inside.

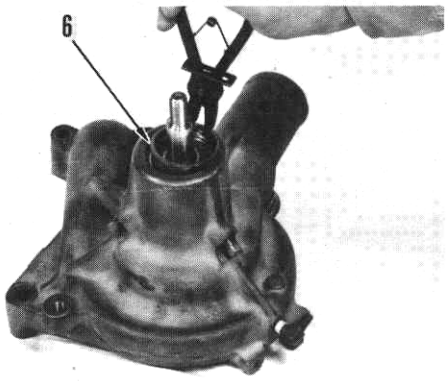



2. Install the shaft assembly (7) on the water pump case (11) from the pulley side.

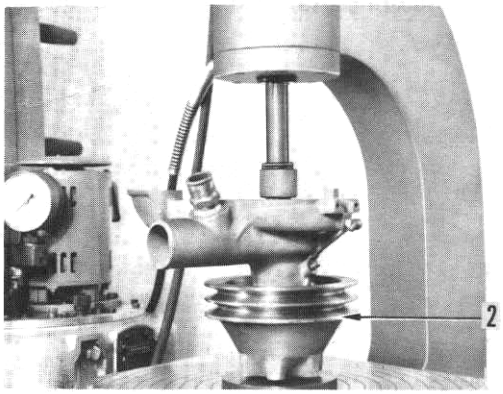
   Between bearing: Grease (G2-LI)



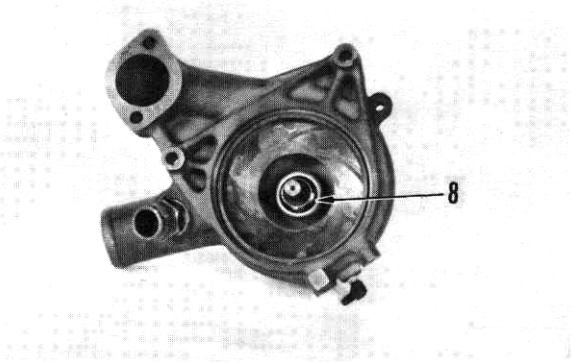

3. Fix the shaft assembly with the snap ring (6).



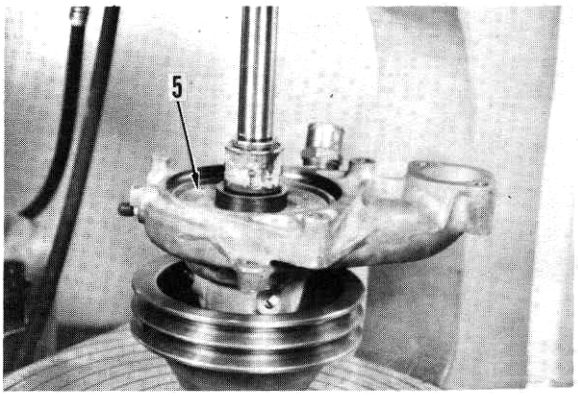

4. Press fit the fan pulley (2).
5. Fix it with nuts.



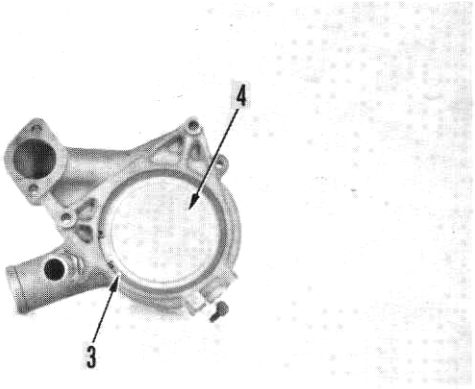
6. Install the water seal (8).




7. Press fit the impeller (5).

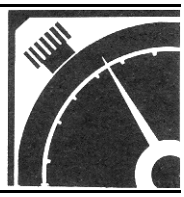



8. Mount the cover (4) with the O-ring.
9. Fix it with the snap ring (3).



# ENGINE

## 15 MAINTENANCE STANDARD




**INTAKE AND EXHAUST SYSTEM**

Turbocharger ..... 15-002

**ENGINE BODY**

Cylinder head ..... 15-004
Rocker arm shaft, push rod and tappet ..... 15-005
Valves and valve guide ..... 15-006
Cylinder block ..... 15-008
Cylinder liner ..... 15-010
Crankshaft ..... 15-011
Camshaft ..... 15-012
Timing gear ..... 15-013
Piston, piston ring and piston pin ..... 15-014
Connecting rod ..... 15-016
Flywheel and flywheel housing ..... 15-017

**LUBRICATION SYSTEM**

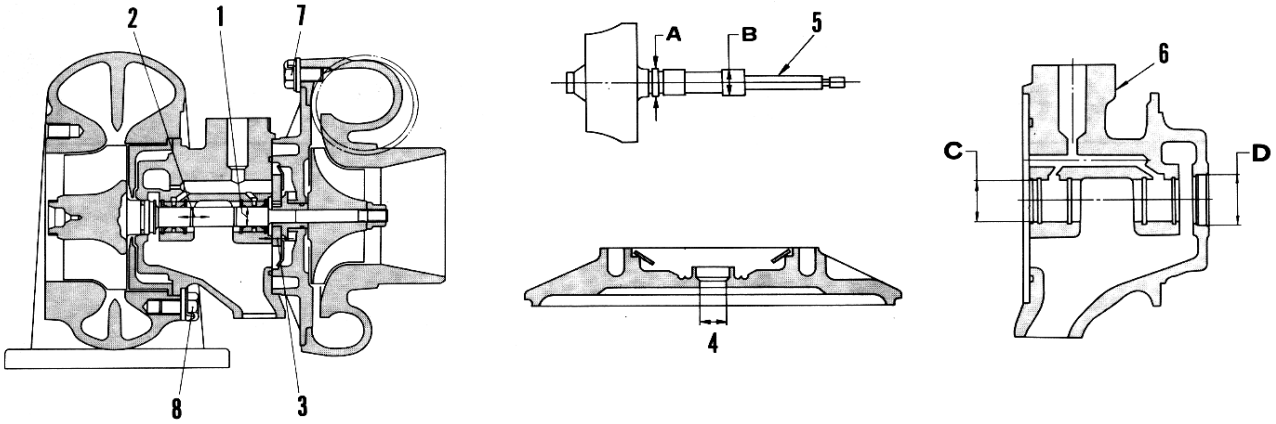
Oil pmp ..... 15-018

**COOLING SYSTEM**

Water pump and thermostat ..... 15-019

# TURBOCHARGER

**(BS4D105)**




Unit: mm

| No. | Check item | Criteria | | | Remedy |
|---|---|---|---|---|---|
| 1 | Axial play of rotor | Standard | | Repair limit | Repair or replace |
| | | 0.075 - 0.150 | | 0.18 | |
| 2 | Radial play of rotor | 0.025 -0.075 | | 0.10 | |
| 3 | Thickness of thrust bearing | 4.36 | | 4.35 | |
| 4 | Inside diameter of back plate | 12.70 | | 12.73 | |
| 5 | Outer diameter of wheel shaft | Measuring point | Standard | Repair limit | Replace |
| | | A | 10.155 | 10.13 | |
| | | B | 17.340 | 17.29 | |
| | Bend of wheel shaft | Repair limit: 0.010 (Total indicator reading) | | | |
| 6 | Inside diameter of center housing | Measuring point | Standard | Repair limit | |
| | | C | 15.80 | 15.81 | |
| | | D | 18.03 | 18.08 | |
| 7 | Tightening torque of blower housing mounting bolts | 1.3 ± 0.2 kgm | | | |
| 8 | Tightening torque of turbine housing mounting bolts | 1.7 ± 0.1 kgm | | | |

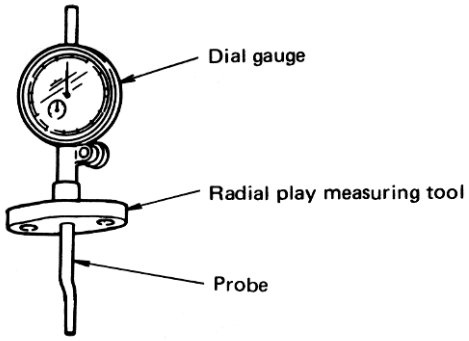
## CHECKING AND INSPECTION

**A. Rotating**

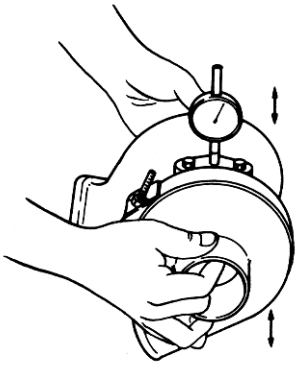
- Disconnect the pipe from the blower and rotate the blower impeller while pushing it toward the turbine to see if the blower is in contact with the housing or it interferes with something.
- Rotate the rotary by hand to see if it rotates smoothly.

**B. Radial play of the rotor**

- Set a dial gauge to the redial play measuring instrument, and replace the measuring indicator of the guage with that of exclusive use.

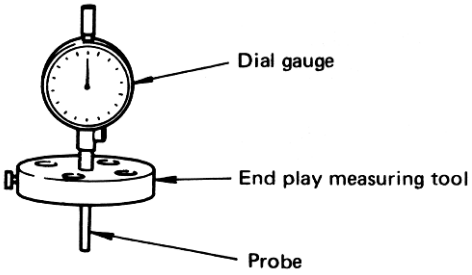



- Put the gauge to the oil outlet of the center housing and set the indicator so that it touch the shaft.
- Measure the radial play, by moving the rotor up and down with hands at both ends.

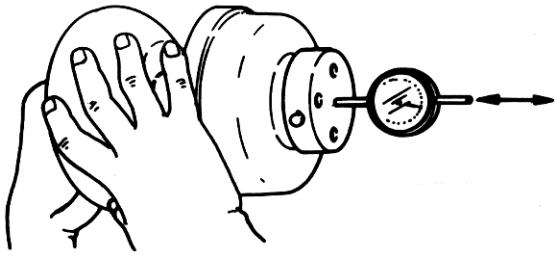


**C. Rotating**

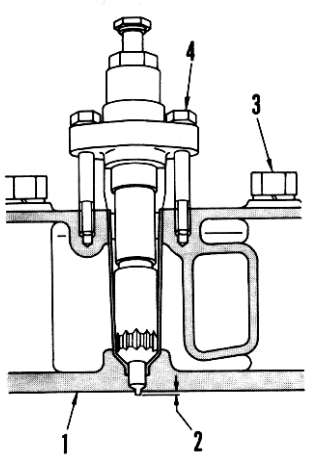
- Set a dial gauge to the redial play measuring instrument, and replace the measuring indicator of the guage with that of exclusive use.

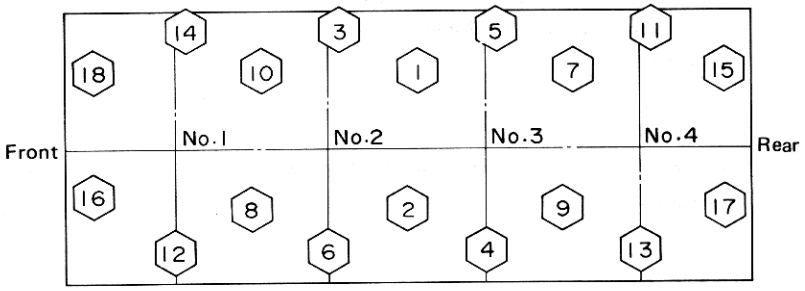



- Put the gauge to the air inlet the blower housing and set the indicator so that it touch the end face of the shaft.
- Measure the end play, by moving the rotor in an axial direction.



# CYLINDER HEAD

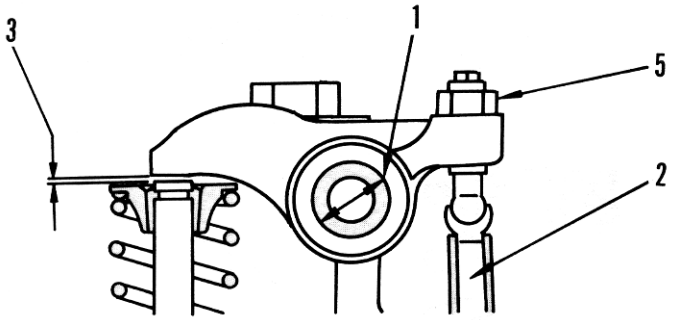


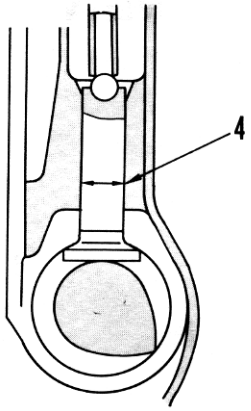




Unit: mm

| No. | Check item | Criteria | | | | | Remedy |
|---|---|---|---|---|---|---|---|
| 1 | Distortion of cylinder head mounting surface | Tolerance | | | Repair limit | | Repir by grinding or replace |
| | | 0 - 0.09 | | | 0.12 | | |
| 2 | Protrusions of nozzles | Engine No. | | | Standard | | Replace nozzle sleeve |
| | | | | | 1.29~2.21 | | |
| 3 | Tightening torque of cylinder head mounting bolts (Coat the thread with molybdenum disulfide or engine oil) | Order | When coat with $MoS_2$ | | When coat with engine oil | | Tighten in sequence as indicated above |
| | | | Target (kgm) | Range (kgm) | Target (kgm) | Range (kgm) | |
| | | 1st | 9 | 8 - 10 | 9 | 8 - 10 | |
| | | 2nd | 13 | 12 - 14 | 13 | 12 - 14 | |
| | | 3rd | 18 | 17.5 - 18.5 | 20 | 19.5 - 20.5 | |
| 4 | Tightening torque of nozzle holder mounting bolt | 1.75 ± 0.25kgm | | | | | |
| 5 | Tightening torque of cylinder head cover | 0.9 ± 0.1 kgm | | | | | |

# ROCKER ARM SHAFT, PUSH ROD AND TAPPET

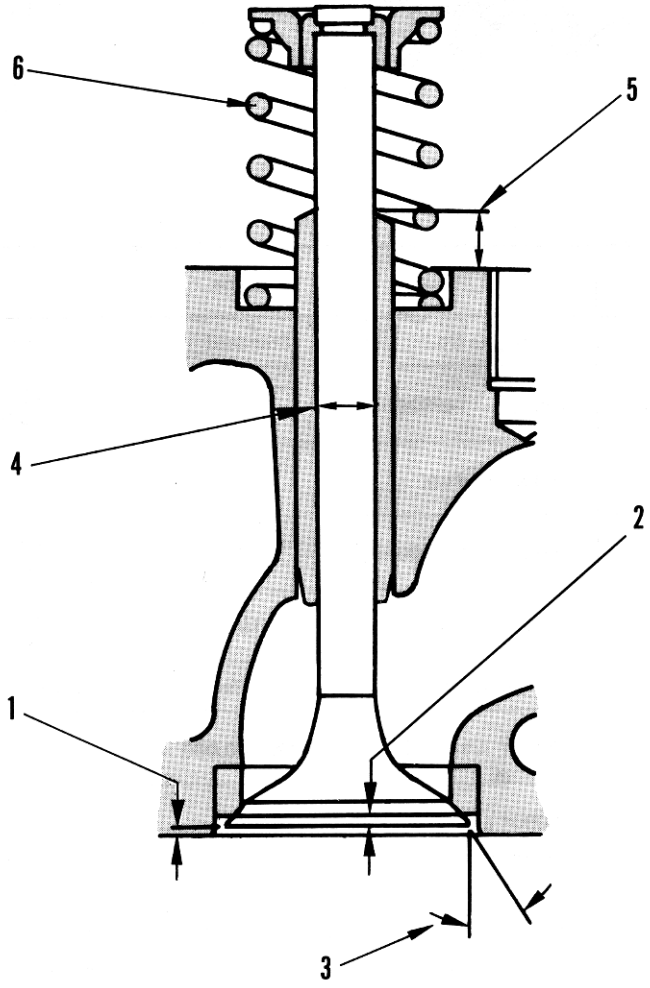



unit: mm

| No. | Check item | Criteria | | | | Remedy |
|---|---|---|---|---|---|---|
| 1 | Outside diameter of rocker arm shaft | Engine No. | | Standard | Tolerance | Replace rocker arm shaft |
| | | | | 19 | -0.010<br>-0.030 | |
| | Inside diameter of rocker arm shaft hole | | | 19 | +0.020<br>+0 | Replace rocker arm |
| | Clearance between rocker arm shaft and rocker arm | Engine No. | | Standard clearance | Clearance limit | Replace rocker arm shaft or rocker arm |
| | | | | 0.020 - 0.060 | 0.13 | |
| | Bend of rocker arm shaft | Repair limit : 0.20 (Total indicator reading) | | | | Replace rocker arm shaft |
| 2 | Bend of push rod | Repair limit : 0.30 (Total indicator reading) | | | | Replace push rod |
| 3 | Valve clearance (at cold) | Engine No. | Valve | Standard | Tolerance | Adjust |
| | | | Intake | 0.25 | ± 0.02 | |
| | | | Exhaust | 0.45 | ± 0.02 | |
| 4 | Outside diameter of tappet | Standard | | Tolerance | | Replace tappet |
| | | 18 | | -0.015<br>-0.035 | | |
| | Inside diameter of tappet hole | 18 | | +0.020<br>0 | | Replace cylinder head |
| | Clearance between tappet and tappet hole | Standard clearance<br>0.015 - 0.055 | | Clearance limit<br>0.20 | | Replace tappet or cylinder head |
| 5 | Tightening torque of rocker arm adjustment screw locknut | 3.15 ± 0.35 kgm | | | | |

# VALVES AND VALVE GUIDE



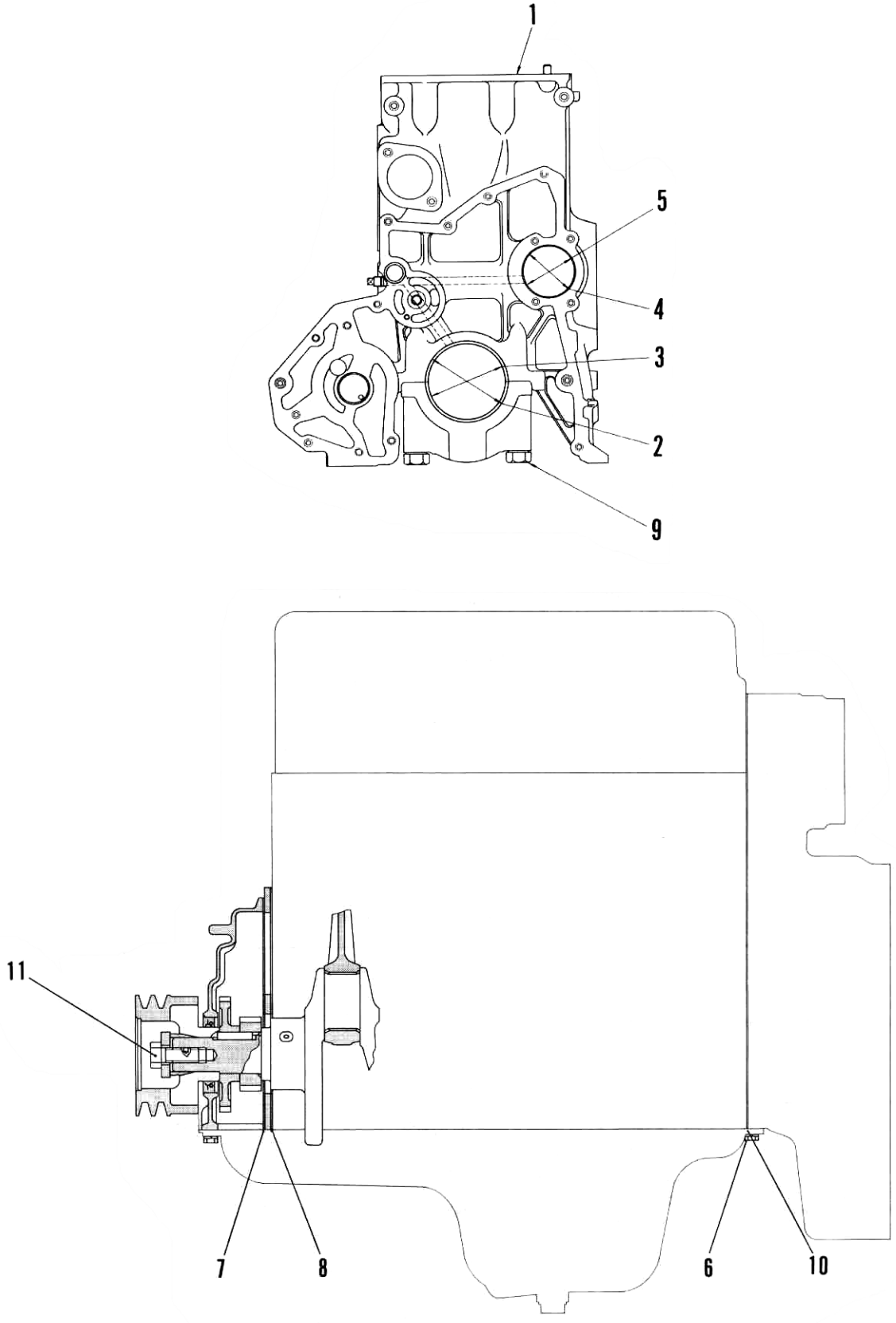

unit: mm

| No. | Check item | Criteria | | | | | Remedy |
|---|---|---|---|---|---|---|---|
| | | Engine No. | Valve | Standard | Tolerance | Repair limit | |
| 1 | Amount of valve sinking | | Intake | 0 | ±0.1 | 1.1 | Replace valve or valve seat |
| | | | Exhaust | 0 | ±0.1 | 1.1 | |

Unit: mm

| No. | Check item | Criteria | | | | | Remedy |
|---|---|---|---|---|---|---|---|
| 2 | Thickness of valve lip | Valve | Standard | Repair limit | | | Replace valve |
| | | intake | 2.10 | 1.7 | | | |
| | | Exhaust | 1.50 | 1.7 | | | |
| 3 | Valve seat angle | Intake | 30° | – | | | Replace valve and valve seat or replace |
| | | Exhaust | 45° | – | | | |
| 4 | Outside diameter of valve stem | Engine No. | Valve | Standard | Tolerance | | Replace valve |
| | | | Intake | 9 | -0.030 | | |
| | | | Exhaust | - | -0.045 | | |
| | Inside diameter of valve guide | | Intake | 9 | +0.030 | | Replace valve guide |
| | | | Exhaust | | +0.010 | | |
| | Clearance between valve guide and stem | Engine No. | Valve | Std.Clearance | Clearance limit | | Replace valve or valve guide |
| | | | Intake | 0.040 - 0.075 | 0.20 | | |
| | | | Exhaust | | | | |
| | Bend of valve stem | Repair limit: 0.02 (Total indicator reading for 100 mm) | | | | | Replace |
| 5 | Protrusion of valve guide | Engine No. | Valve | Standard | Tolerance | | Repair |
| | | | Intake | 25.9 | ±0.25 | | |
| | | | Exhaust | | | | |
| 6 | Valve spring (Intake and Exhaust) | Engine No. | Standard size | | | Repair limit | | Replace |
| | | | Free length | Installed length | Installed load(kg) | Free length | Installed load | |
| | | | 63.6 | 50.1 | 29.0 ± 1.3 | 62.4 | 26.0 kg | |
| | Squareness of valve spring | Repair limit: 2° (for both end) | | | | | |

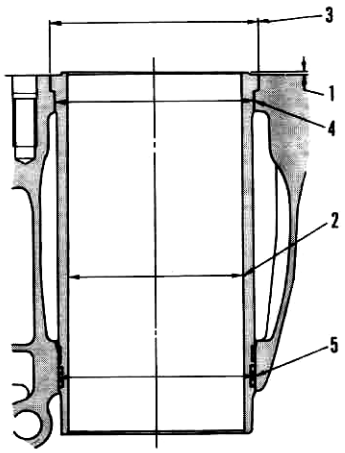
# CYLINDER BLOCK



Unit: mm

| No. | Check item | Criteria | | | Remedy |
|---|---|---|---|---|---|
| 1 | Distortion of cylinder head mounting surface | Tolerance | Repair limit | | Repair by grinding or replace |
| | | 0 – 0.080 | 0.12 | | |
| 2 | Inside diameter of main bearing mounting hole | Standard | Tolerance | | Replace main bearing cap |
| | | 91 | +0.020<br>0 | | |
| | Straightness of mounting hole | Repair limit: 0.010 | | | |
| | Roundness of mounting hole | Repair limit: 0.005 | | | |
| 3 | Inside diameter of main bearing | Standard | Tolerance | Repair limit | Replace main bearing |
| | | 81 | +0.130<br>+0.060 | 85.16 | |
| 4 | Inside diameter of cam bushing mounting hole | Standard | Tolerance | | Repair or replace cylinder block |
| | | 57.5 | +0.030<br>0 | | |
| 5 | Inside diameter of cam bushing | Standard | Tolerance | Repair limit | Replace cam bushing |
| | | 54.5 | +0.075<br>0 | 54.78 | |
| 6 | Uneven mounting surfaces between cylinder block and flywheel housing | Repair limit: 0.16 | | | Repair by reassembling |
| 7 | Uneven mounting surfaces between cylinder block and front cover | Repair limit: 0.13 | | | |
| 8 | Uneven mounting surfaces between cylinder block and front plate | Repair limit Protrusion of plate: 0.04<br>Retreat of plate: 0.22 | | | |
| 9 | Tightening torque of main bearing cap bolts<br>(Coat thread area with engine oil) | Order | Target (kgm) | Range (kgm) | |
| | | 1st | 7 | 6 – 8 | |
| | | 2nd | 20 | 19 – 21 | |
| | | 3rd | 0 | Loosen completely | |
| | | 4th | 7 | 6 – 8 | |
| | | 5th | 14 | 13 – 15 | |
| | | 6th | 20 | 19 – 21 | |
| 10 | Tightening torque of oil pan mounting bolts | 2.5 ± 1.0 kgm | | | |
| 11 | Tightening torque of crankshaft pulley mounting bolt | 38 ± 3 kgm | | | |

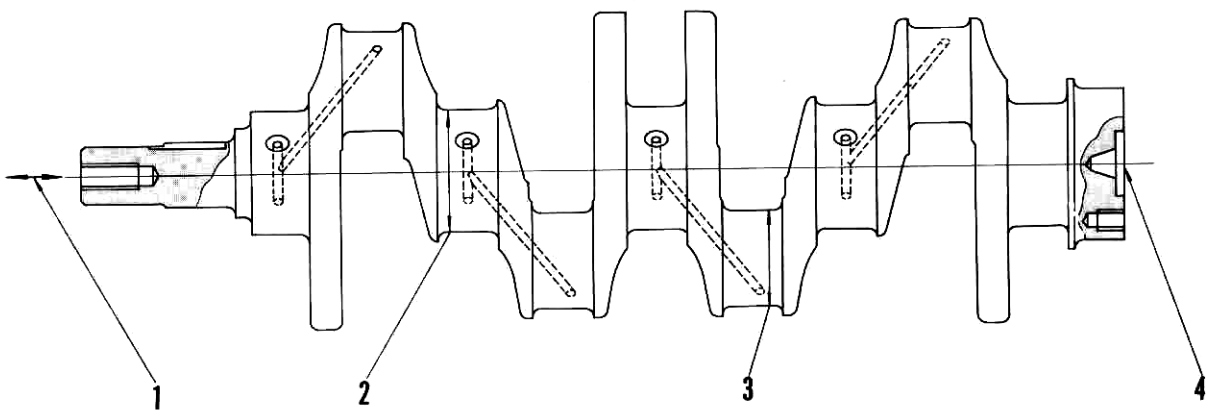
# CYLINDER LINER




Unit: mm

| No. | Check item | Criteria | | | Remedy |
|---|---|---|---|---|---|
| 1 | Protrusion of cylinder liner | Permissible range: 0.05 ~ 0.13 | | | Replace liner or cylinder block |
| 2 | Inside diameter of cylinder liner | Standard size | Tolerance | Repair limit | Replace cylinder liner |
| | | 105 | +0.035<br>0 | 105.20 | |
| | Roundness of bore | Repair limit: 0.08 | | | |
| | Cylindricity of bore | Repair limit: 0.08 | | | |
| 3 | Outside diameter of cylinder liner (counterbore) | Standard size | Tolerance | | |
| | | 127 | +0.115<br>+0.075 | | |
| | Interference between cylinder liner and block (counterbore) | Standard inferference | Interference limit | | Replace cylinder liner or block |
| | | 0.015 – 0.115 | 0.01 | | |
| 4 | Outside diameter cylinder liner (counterbore bottom) | Standard size | Tolerance | | Replace cylinder line |
| | | 121 | –0.120<br>–0.170 | | |
| | Cleance between cylinder liner and block (counterbore bottom) | Standard clearance: 0.165 – 0.280 | | | Replace cylinder liner or block |
| 5 | Outside diameter of cylinder liner (O-ring) | Standard size | Tolerance | | Replace cylinder liner |
| | | 118.7 | –0.010<br>–0.035 | | |
| | Clearance between cylinder liner and block (O-ring) | Standard clearance: 0.010 – 0.070 | | | Replace cylinder liner or block |

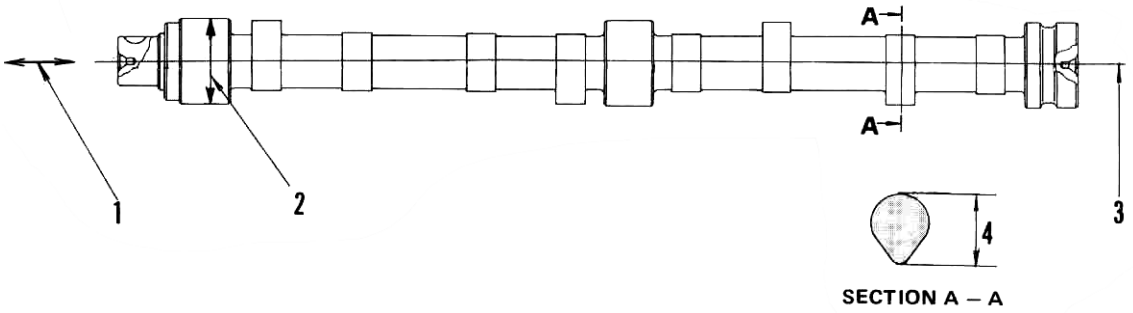
# CRANKSHAFT




Unit: mm

| No. | Check item | Criteria | | | | Remedy |
|---|---|---|---|---|---|---|
| 1 | End play | Standard | | Repair limit | | Replace thrust bearing or correct oversize |
| | | 0.140 – 0.315 | | 0.40 | | |
| 2 | Outside diameter of main journal | | Standard | Tolerance | Repair limit | Current undersize or replace |
| | | S.T.D. | 85.00 | −0.050 −0.070 | 84.86 | |
| | | 0.25 U.S. | 84.75 | | 84.61 | |
| | | 0.50 U.S. | 84.50 | | 84.36 | |
| | | 0.75 U.S. | 84.25 | | 84.11 | |
| | | 1.00 U.S. | 84.00 | | 83.86 | |
| | Roundness of main journal | Repair limit: 0.020 | | | | |
| | Clearance of main journal | Standard clearance | | Clearance limit | | Replace main bearing |
| | | 0.060 – 0.130 | | 0.30 | | |
| 3 | Outside diameter of crank pin journal | | Standard | Tolerance | Repair limit | Current undersize or replace |
| | | S.T.D. | 66.00 | −0.050 −0.070 | 65.91 | |
| | | 0.25 U.S. | 65.75 | | 65.66 | |
| | | 0.50 U.S. | 65.50 | | 65.41 | |
| | | 0.75 U.S. | 65.25 | | 65.16 | |
| | | 1.00 U.S. | 65.00 | | 64.91 | |
| | Roundness of crank pin journal | Repair limit: 0.020 | | | | |
| | Clearance of crank pin journal | Standard clearance | | Clearance limit | | Replace connecting rod bearing |
| | | 0.040 – 0.110 | | 0.30 | | |
| 4 | Bend of crankshaft | Repair limit: 0.090 (Total indicator reading) | | | | Current undersize or replace |

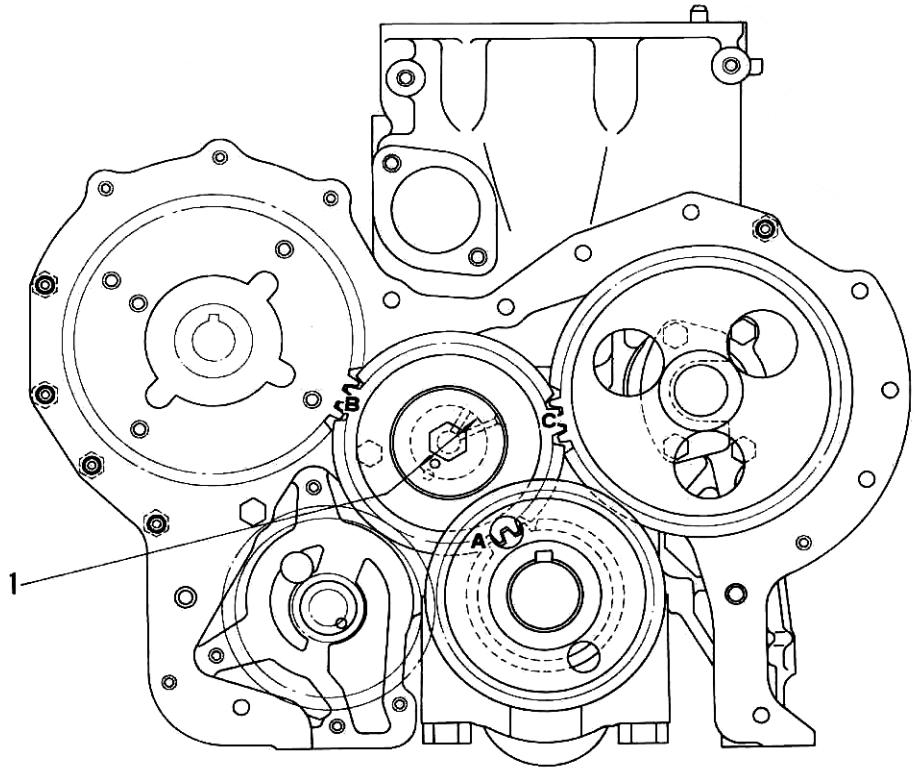
# CAMSHAFT




Unit: mm

| No. | Check item | Criteria | | | | | | Remidy |
|---|---|---|---|---|---|---|---|---|
| 1 | End play | Standard | | | Repair limit | | | Replace thrust plate |
| | | 0.15~0.35 | | | 0.50 | | | |
| | Outside diameter of camshaft journal | Standard | | | Tolerance | | | |
| | | 54.5 | | | -0.080<br>-0.110 | | | Replace camshaft |
| 2 | Clearance of Camshaft journal | Standard clearance | | | Clearance limit | | | |
| | | 0.080~0.180 | | | 0.280 | | | Replace cam bushing |
| 3 | Bend of camshaft | Repair limit : 0.03 (Total indicator reading) | | | | | | |
| 4 | Cam height | Engine model | Engine No. | Cam | Standard | Tolerance | Repair limit | |
| | | B4D105 | | Intake<br>Exhaust | 45.74 | ± 0.10 | 45.24 | |
| | | | | | | | | |
| | | BS4D105 | | Intake<br>Exhaust | 46.24 | ± 0.10 | 45.74 | |
| | | | | | | | | |

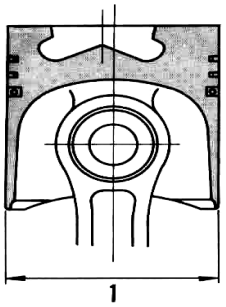
# TIMING GEAR

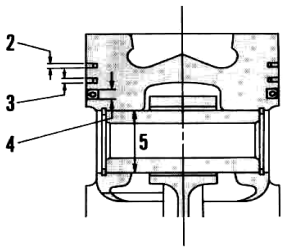



Unit: mm

| No. | Check item | Criteria | | | | Remidy |
|---|---|---|---|---|---|---|
| -- | Gear backlash | Measuring point | Gears | Standards | Repair limit | Replace bushing of gear. |
| | | A | Crakshaft gear and idler gear | 0.11~0.37 | 0.6 | |
| | | B | Idler gear and injection pump gear | 0.09~0.43 | | |
| | | C | Idler gear and cam shaft gear | 0.11~0.41 | | |
| 1 | Outside diameter of idler gear shaft | Standard | | Tolerance | | Replace bushing. |
| | | 44 | | -0.025<br>-0.050 | | |
| | Inside diameter of idler gear shaft | 44 | | +0.075<br>+0.010 | | |
| | Clearance between idler gear bushing & shaft | Standard clearance | | Tolerance limit | | |
| | | 0.035~0.125 | | 0.20 | | |
| | End play of idler | Standard | | Repair limit | | Replace thrust plate. |
| | | 0.05~0.21 | | 0.4 | | |

# PISTON, PISTON RING AND PISTON PIN

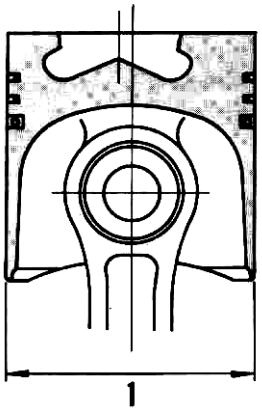


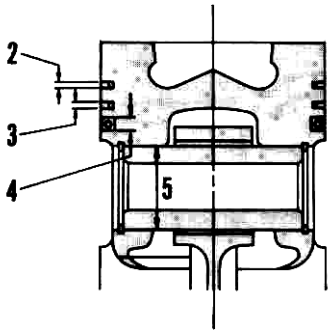




Unit: mm

| No. | Item | Criteria | | | | Remedy |
|---|---|---|---|---|---|---|
| 1 | Outside diameter of piston | Standard size | | Tolerance | Repair limit | Replace piston |
| | | 105 | | -0.125<br>-0.150 | 104.80 | |
| 2 | Thickness of piston ring | No. | Measuring point | Standard | Tolerance | Replace piston ring |
| | | 2 | No. 1 ring | 3.0 | -0.01<br>-0.03 | |
| | | 3 | No. 2 ring | 2.5 | | |
| | | 4 | Oil ring | 5.0 | | |
| 3 | Width of piston ring groove | 2 | Top ring | Clearance is 1.5 mm or less when raplace with new ring | | Replace piston |
| | | 3 | Second ring | | | |
| | | 4 | Oil ring | 5 | + 0.04<br>+ 0.2 | |
| 4 | Clearance between piston ring and ring groove | No. | Measuring point | Standard | Clearance limit | Replace piston or piston ring |
| | | 2 | Top ring | Clearance is 1.5 mm or less when installed ring | | |
| | | 3 | Second ring | | | |
| | | 4 | Oil ring | 0.03 - 0.07 | 0.15 | |
| | Piston ring gap | 2 | Top ring | 0.3-0.5 | 2.0 | Replace piston ring or cylinder liner. |
| | | 3 | Second ring | 0.3-0.45 | 1.5 | |
| | | 4 | Oil ring | 0.3-0.45 | 1.0 | |
| 5 | Outside diameter of piston pin hole | Standard clearance | | Tolerance | | Replace piston |
| | | 40 | | 0<br>-0.005 | | |
| | Inside diameter of piston pin hole | 40 | | -0.015<br>0 | | Replace piston or piston pin |
| | Clearance between piston and piston pin | Standard clearance | | Clearance limit | | |
| | | 0-0.020 | | -0.005 | | |
| _ | Weight of Piston | 1,150±15g | | | | Replace piston |

**BS4D105-1**

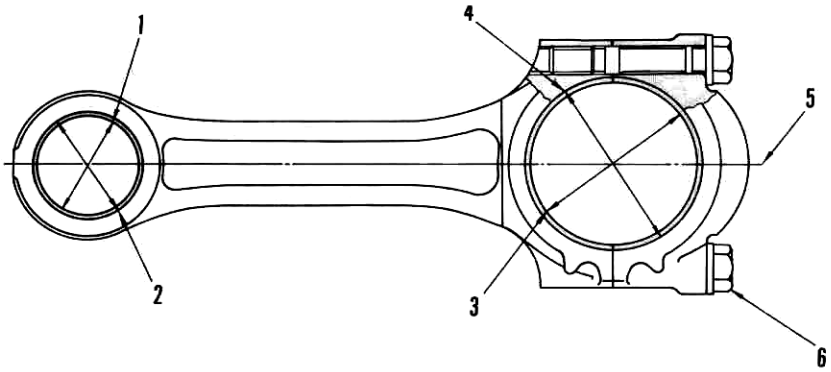


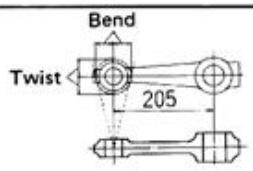

**Unit: mm**

| No. | Item | Criteria | | | | Remedy |
|---|---|---|---|---|---|---|
| 1 | Outside diameter of piston (20°C) | Standard size | | Tolerance | Repair limit | Replace piston |
| | | 105 | | -0.125<br>-0.155 | 104.80 | |
| 2 | Thickness of piston ring | No. | Measuring point | Standard | Tolerance | Replace piston ring |
| | | 2 | No. 1 ring | 3.0 | -0.01<br>-0.03 | |
| | | 3 | No. 2 ring | 2.5 | | |
| | | 4 | Oil ring | 5.0 | | |
| 3 | Width of piston ring groove | 2 | Top ring | Clearance is 1.5 mm or less when raplace with new ring | | Replace piston |
| | | 3 | Second ring | | | |
| | | 4 | Oil ring | 5 | + 0.04<br>+ 0.2 | |
| 4 | Clearance between piston ring and ring groove | No. | Measuring point | Standard | Clearance limit | Replace piston or piston ring |
| | | 2 | Top ring | Clearance is 1.5 mm or less when installed ring | | |
| | | 3 | Second ring | | | |
| | | 4 | Oil ring | 0.03 - 0.07 | 0.15 | |
| | Piston ring gap | 2 | Top ring | 0.3-0.5 | 2.0 | Replace piston ring or cylinder liner. |
| | | 3 | Second ring | 0.3-0.45 | 1.5 | |
| | | 4 | Oil ring | 0.3-0.45 | 1.0 | |
| 5 | Outside diameter of piston pin hole | Standard clearance | | Tolerance | | Replace piston |
| | | 40 | | 0<br>-0.005 | | |
| | Inside diameter of piston pin hole | 40 | | -0.015<br>0 | | Replace piston or piston pin |
| | Clearance between piston and piston pin | Standard clearance | | Clearance limit | | |
| | | 0-0.020 | | -0.005 | | |
| _ | Weight of Piston | 1,200±50g | | | | Replace piston |

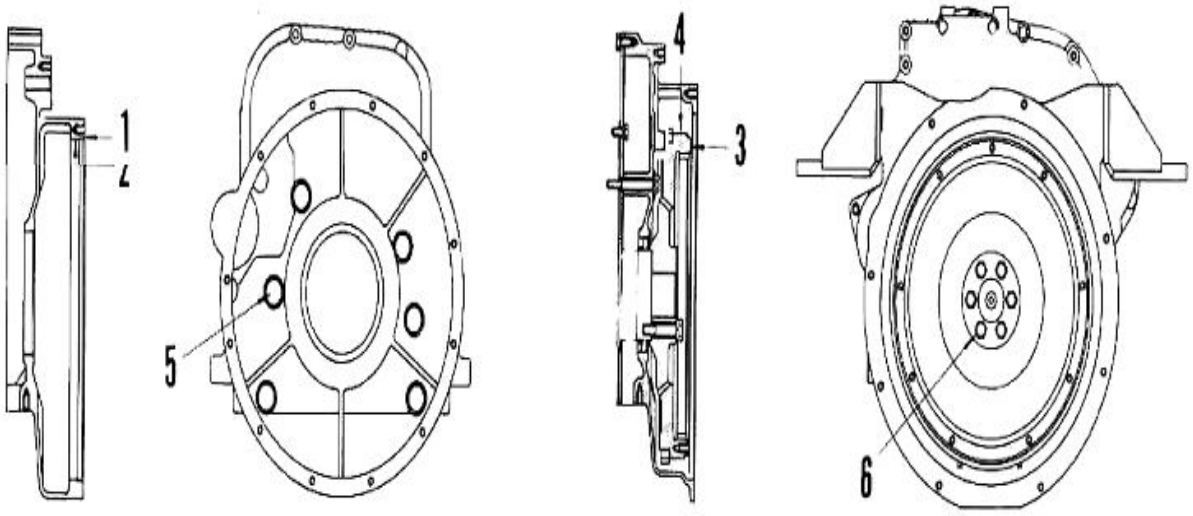
# CONNECTING ROD



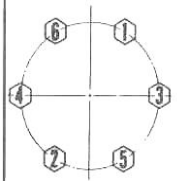

Unit: mm

| No. | Check item | Criteria | | | Remedy |
|---|---|---|---|---|---|
| 1 | Inside diameter of bushing at connecting rod small end | Standard: 40 | Tolerance: +0.040 +0.025 | | Replace bushing |
| | Clearance between bushing at connecting rod small end and piston pin | Standard clearance: 0.025 – 0.050 | Clearance limit: 0.10 | | Replace bushing or piston pin |
| 2 | Inside diameter of bushing hole at connecting rod big end | Standard: 43 | Tolerance: +0.035 +0.010 | | Replace connecting rod |
| 3 | Inside diameter of bearing at connecting rod big end (crank pin journal) | Standard: 66 | Tolerance: +0.030 –0.010 | Repair limit: 66.15 | |
| 4 | Inside diameter of bearing hole at connecting rod big end | 70 | +0.025 0 | 70.04 | |
| | | Measure after tightening connecting rod cap with specified torque. | | | |
| 5 | Bend and twist of connecting rod |   | | Repair limit: Bend 0.08; Twist 0.30 | Replace connecting rod |
| 6 | Tightening torque of connecting rod cap mounting bolts (Coat the bolt threads and nut seats with engine oil.) | Order: 1st | Target (kgm): 6 | Rang (kgm): 5 – 7 | |
| | | 2nd | 11 | 10 – 12 | |
| | | 3rd | 0 | Loosen completely | |
| | | 4th | 6 | 5 – 7 | |
| | | 5th | 11.2 | 10.6 – 11.7 | |
| 7 | Weight of connecting rod | 2,087 ± 70 g | | | Replace connecting rod |

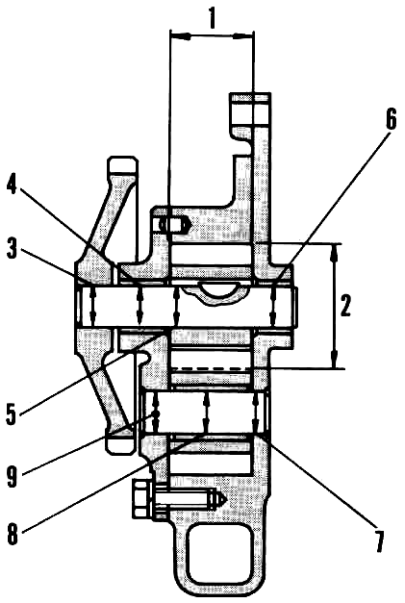
# FLYWHEEL AND FLYWHEEL HOUSING




Unit: mm

| No. | Check item | Criteria | | | Remedy |
|---|---|---|---|---|---|
| 1 | Face runout of flywheel housing | Repair limit: 0.35 | | | Repair by reassembling |
| 2 | Radial runout of flywheel housing | Repair limit: 0.30 | | | |
| 3 | Face runout of flywheel | Repair limit: 0.20 | | | |
| 4 | Radial runout of flywheel | Repair limit: 0.15 | | | |
| 5 | Tightening torque of flywheel housing mounting bolts | 11 ± 1.5 kgm | | | |
| 6 | Tightening torque of the flywheel mounting bolts (Coat the bolt threads with engine oil.) |  | Order | Target (kgm) | Range (kgm) |
| | | | 1st | 9 | 6 – 12 |
| | | | 2nd | 18 | 16 – 20 |

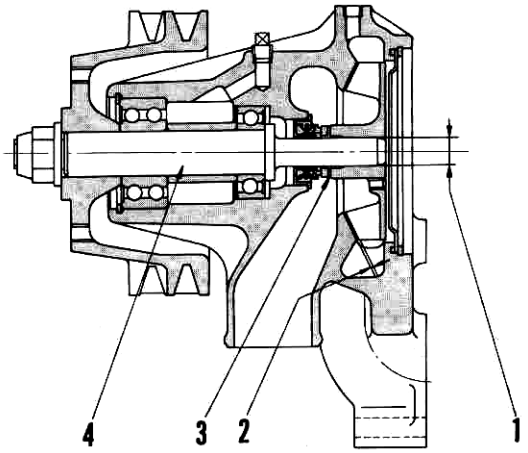
# OIL PUMP

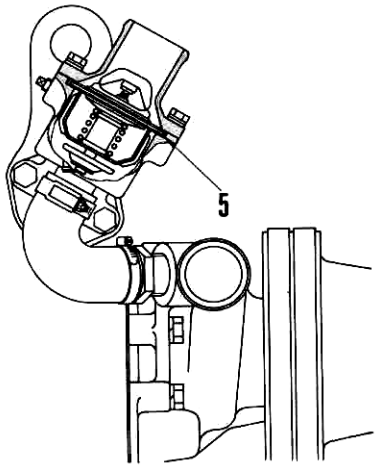



Unit: mm

| No. | Check item | Criteria | | | | | Remedy |
|---|---|---|---|---|---|---|---|
| 1 | Axial clearance of rotor | Standard size | Tolerance: Thickness of rotor | Tolerance: Depth of rotor room | Standard clearance | Clearance limit | Replace |
| | | 25 | 0 −0.020 | +0.075 +0.040 | 0.040 – 0.095 | 0.15 | |
| 2 | Radial clearance of rotor | Standard size | Tolerance: Rotor O.D. | Tolerance: Rotor room I.D. | Standard clearance | Clearance limit | |
| | | 78 | −0.10 −0.13 | +0.055 +0.010 | 0.110 – 0.180 | 0.25 | |
| 3 | Clearance between shaft and bushing | Standard size | Tolerance: Shaft | Tolerance: Hole | Standard clearance | Clearance limit | Replace bushing |
| | | 22 | 0 −0.015 | +0.060 +0.030 | 0.030 – 0.075 | 0.10 | |
| 4 | Clearance between oil pump and block | 33 | −0.010 −0.035 | +0.025 0 | 0.010 – 0.060 | 0.10 | Replace |
| 5 | Interference between oil pump gear and shaft | Standard size | Tolerance: Shaft O.D. | Tolerance: Gear I.D. | Standard interference | Interference limit | Replace |
| | | 22 | 0 −0.015 | −0.040 −0.060 | 0.025 – 0.060 | 0.02 | |
| 6 | Backlash between oil pump gear and oil pump drive gear | Standard | | Repair limit | | | Repair or replace |
| | | 0.12 – 0.37 | | 0.60 | | | |

# WATER PUMP AND THERMOSTAT




Unit: mm

| No. | Check item | Criteria | | | | | Remedy |
|---|---|---|---|---|---|---|---|
| 1 | Interference between impeller and shaft | Standard size | Tolerance | | Standard interference | Interference limit | Replace impeller |
| | | | Shaft | Hole | | | |
| | | 15.9 | +0.020 +0.005 | −0.020 −0.050 | 0.025 – 0.070 | | |
| 2 | Clearance between impeller and body | Standard clearance: 0.1 – 0.63 (include end play) | | | | | Replace |
| 3 | Abrasion of seal ring in water seal |  Repair limit A: 0 | | | | | |
| 4 | Bend of shaft | Repair limit: 0.1 (Total indicator reading: Specified as face runout at 40 mm radius of pulley) | | | | | |
| 5 | Thermostat function | Construction machine | Valve cracking temperature (°C) | 74.5 – 78.5 | | | Replace |
| | | | Full opening temperature (°C) | 90 | | | |
| | | | Full opening lift (mm) | 10 min. | | | |
| | | Generator | Valve cracking temperature (°C) | 80 – 84 | | | |
| | | | Full opening temperature (°C) | 95 | | | |
| | | | Full opening lift (mm) | 10 min. | | | |