# WSM

## WORKSHOP MANUAL
## DIESEL ENGINE

## EA300-E2-NB1,
## EA300-E2-NB1-APU,
## EL300-E2-AR,
## EL300-E2-AR-KCL

Kubota

# TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the mechanism, service and maintenance of EA / EL 300-E2 series. It is divided into three parts, "General", "Mechanism" and "Servicing".

## ■ General

Information on the engine identification, the general precautions, maintenance check list, check and maintenance and special tools are described.

## ■ Mechanism

Information on the construction and function are included. This part should be understood before proceeding with troubleshooting, disassembling and servicing.

## ■ Servicing

Information on the troubleshooting, servicing specification lists, tightening torque, checking and adjusting, disassembling and assembling, and servicing which cover procedures, precautions, factory specifications and allowable limits.

All information illustrations and specifications contained in this manual are based on the latest product information available at the time of publication.

The right is reserved to make changes in all information at any time without notice.

Due to covering many models of this manual, information or picture being used have not been specified as one model.

**March 2005**



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# ⚠ SAFETY FIRST

This symbol, the industry's "Safety Alert Symbol" is used throughout this manual and on labels on the machine itself to warn of the possibility of personal injury. Read these instructions carefully.It is essential that you read the instructions and safety regulations before you attempt to repair or use this unit.

**⚠ DANGER**
- **Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.**

**⚠ WARNING**
- **Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**

**⚠ CAUTION**
- **Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.**

**■ IMPORTANT**
- **Indicates that equipment or property damage could result if instructions are not followed.**

**■ NOTE**
- **Gives helpful information.**

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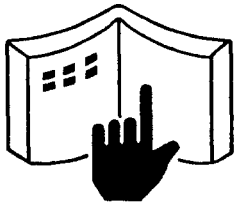

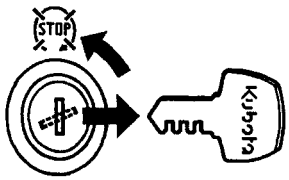


BEFORE SERVICING AND REPAIRING

- Read all instructions and safety instructions in this manual and on your engine safety decals.
- Clean the work area and engine.
- Park the machine on a firm and level ground.
- Allow the engine to cool before proceeding.
- Stop the engine, and remove the key
- Disconnect the battery negative cable

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SAFETY STARTING

- Do not start the engine by shorting across starter terminals or bypassing the safety start switch.
- Unauthorized modifications to the engine may impair the function and / or safety and affect engine life.

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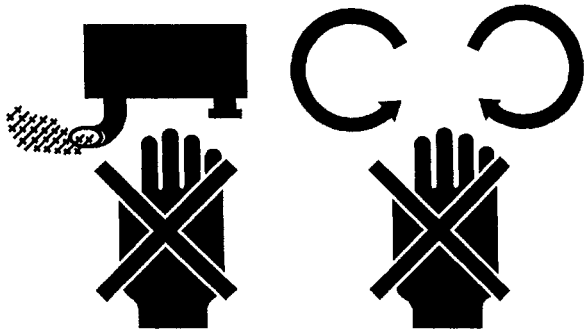

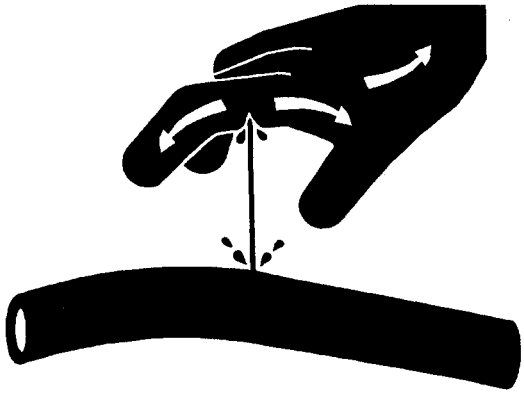

SAFETY WORKING

- Do not work on the machine while under the influence of alcohol, medication, or other substances or while fatigued.
- Wear close fitting clothing and safety equipment appropriate to the job.
- Use tools appropriate to the work. Makeshift tools, parts, and procedures are not recommended.
- When servicing is performed together by two or more persons, take care to perform all work safely.
- Do not touch the rotating or hot parts while the engine is running.
- Never remove the radiator cap while the engine is running, or immediately after stopping. Otherwise, hot water will spout out from radiator. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen the cap to first stop to relieve pressure before removing completely.
- Escaping fluid (fuel or hydraulic oil) under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or fuel lines. Tighten all connections before applying pressure.
- Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

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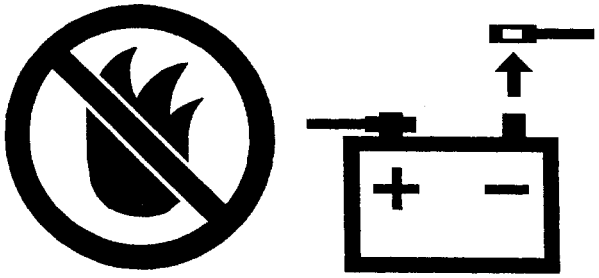

AVOID FIRES

- Fuel is extremely flammable and explosive under certain conditions. Do not smoke or allow flames or sparks in your working area.
- To avoid sparks from an accidental short circuit, always disconnect the battery negative cable first and connect it last.
- Battery gas can explode. Keep sparks and open flame away from the top of battery, especially when charging the battery.
- Make sure that no fuel has been spilled on the engine.

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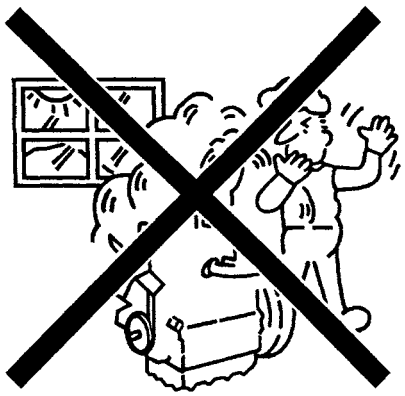

VENTILATE WORK AREA

- If the engine must be running to do some work, make sure the area is well ventilated. Never run the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.

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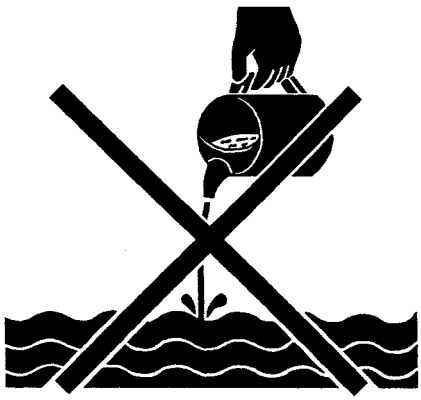

DISPOSE OF FLUIDS PROPERLY

- Do not pour fluids into the ground, down a drain, or into a stream, pond, or lake. Observe relevant environmental protection regulations when disposing of oil, fuel, coolant, electrolyte and other harmful waste.

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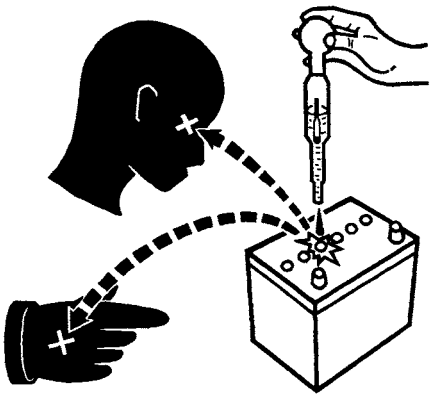

PREVENT ACID BURNS

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, clothing and cause blindness if splashed into eyes. Keep electrolyte away from eyes, hands and clothing. If you spill electrolyte on yourself, flush with water, and get medical attention immediately.

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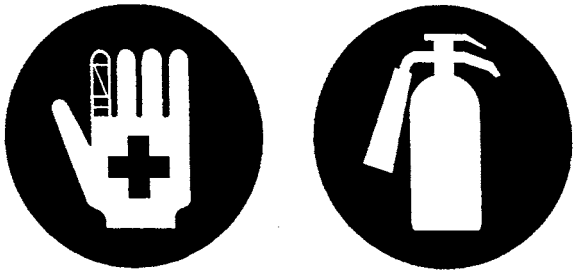

PREPARE FOR EMERGENCIES

- Keep a first aid kit and fire extinguisher handy at all times.
- Keep emergency numbers for doctors, ambulance service, hospital and fire department near your telephone.

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# SPECIFICATIONS

| Model | | EA300-E2-NB1 | EA300-E2-NB1-APU |
|---|---|---|---|
| Type | | Horizontal, water-cooled, 4-cycle diesel engine | |
| Number of Cylinder | | 1 | |
| Bore x Stroke | | 75 mm x 70 mm | |
| | | 2.95 in x 2.76 in | |
| Displacement | | 309 cc | |
| | | 18.86 cu.in. | |
| Brake Horsepower | SAE Intermittent kW (PS) / rpm | 5.1 (7) / 3000 | |
| | SAE Cont. kW (PS) / rpm | 4.4 (6) / 3000 | |
| Cooling System | | Radiator | |
| Combustion System | | Spherical type (TVCS) | |
| Injection Timing | | 0.45 rad (25.5 °) | |
| | | Before T.D.C. | |
| Fuel | | SAE No. 2-D Light Diesel Oil | |
| Lubricating oil | | Class CF lubricating oil as per API classification is recommended.<br>If this class of lubricating oil is not available, preferably use Class CD or CE lubricating oil.<br>For details on recommended lubricating oils. (see page G-5) | |
| Lubricating System | | Forced Lubrication with Trochoid Pump | |
| Starting System | | Electric Start | |
| Direction of Revolution | | Counterclockwise Facing Flywheel | |
| Cooling Water Capacity | | 1.2 L (1.3 U.S.qts, 1.06 Imp.qts) | |
| Fuel Tank Capacity | | 4.8 L (1.27 U.S.qts, 1.06 Imp.qts) | |
| Engine Oil Capacity | | 1.3 L (1.4 U.S.qts, 1.14 Imp.qts) | |
| Dry Weight | | 54.0 kg (119.1 lbs) | 46.0 kg (101.2 lbs) |

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| Model | | EL300-E2-AR | EL300-E2-AR-KCL |
|---|---|---|---|
| Type | | Horizontal, water-cooled, 4-cycle diesel engine | |
| Number of Cylinder | | 1 | |
| Bore x Stroke | | 75 mm x 70 mm | |
| | | 2.95 in x 2.76 in | |
| Displacement | | 309 cc | |
| | | 18.86 cu.in. | |
| Brake Horsepower | SAE Intermittent kW (PS) / rpm | 3.3 (4.5) / 2000 | |
| | SAE Cont. kW (PS) / rpm | 2.9 (4.0) / 2000 | |
| Cooling System | | Radiator | |
| Combustion System | | Spherical type (TVCS) | |
| Injection Timing | | 0.38 rad (22 °) | |
| | | Before T.D.C. | |
| Fuel | | SAE No. 2-D Light Diesel Oil | |
| Lubricating oil | | Class CF lubricating oil as per API classification is recommended.<br>If this class of lubricating oil is not available, preferably use Class CD or CE lubricating oil.<br>For details on recommended lubricating oils. (see page G-5) | |
| Lubricating System | | Forced Lubrication with Trochoid Pump | |
| Starting System | | Electric Start | |
| Direction of Revolution | | Counterclockwise Facing Flywheel | |
| Cooling Water Capacity | | 1.2 L (1.3 U.S.qts, 1.06 Imp.qts) | |
| Fuel Tank Capacity | | — | |
| Engine Oil Capacity | | 1.9 L (2.0 U.S.qts, 1.14 Imp.qts) | |
| Dry Weight | | 46.0 kg (101 lbs) | |

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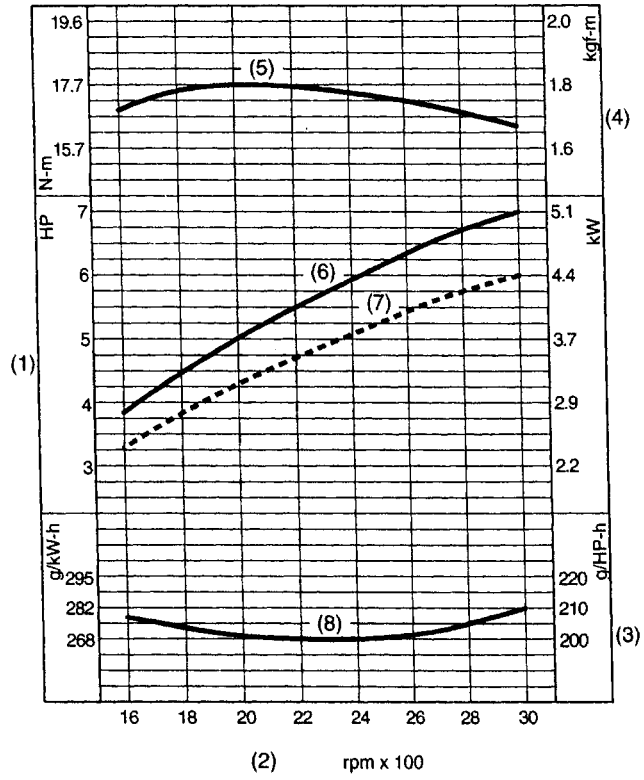
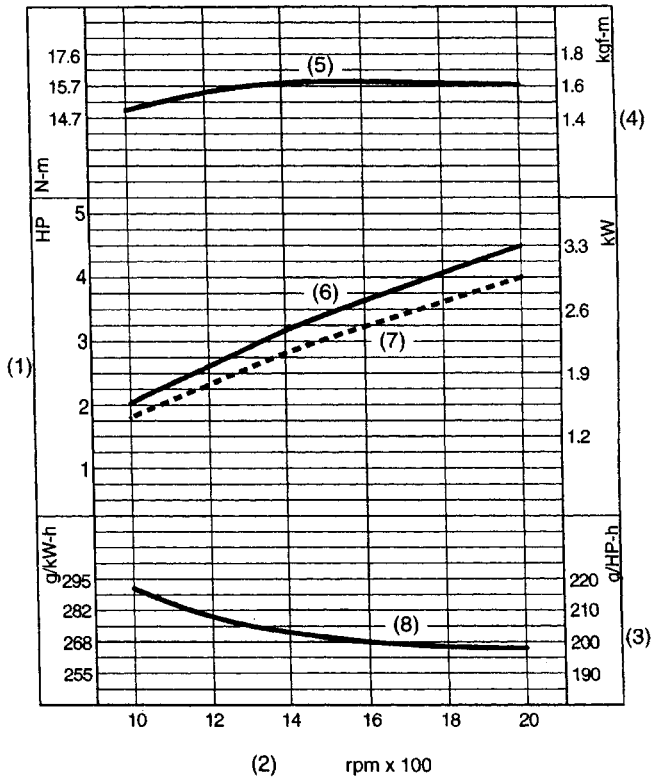
# PERFORMANCE CURVES

**EA300-E2-NB1**
**EA300-E2-NB1-APU**




**EL300-E2-AR**
**EL300-E2-AR-KCL**

——— Intermittent
----- Continuous

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(1) Brake Horsepower
(2) Engine Speed
(3) Fuel Consumption
(4) Torque
(5) Intermittent Torque
(6) Intermittent B.H.P.
(7) Cont. B.H.P.
(8) Fuel (Intermittent)

**■ NOTE**

- Each performance curves obtained in accordance with SAE J816b are corrected to 760 mm Hg (29.92 in. Hg), 20 ℃ (68 ℉) 60 % humidity.

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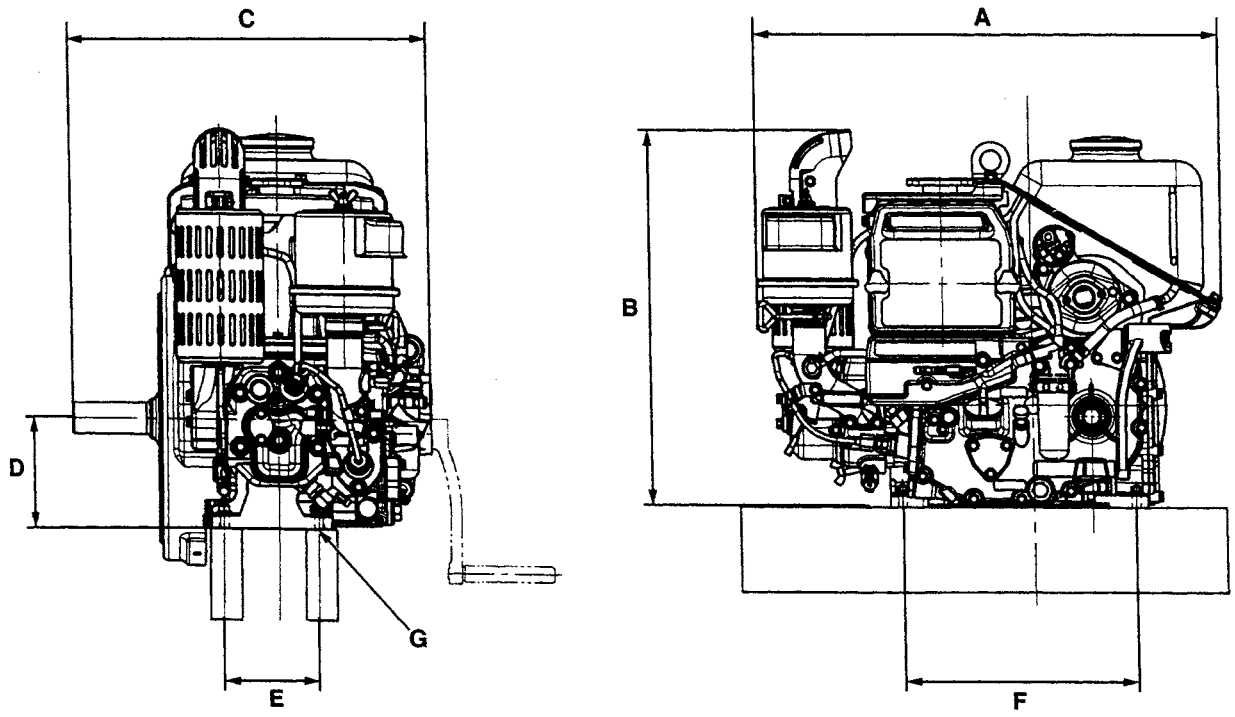
# DIMENSIONS

## ■ EA300-E2-NB1

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| | |
|---|---|
| A | 565.5 mm (22.64 in.) |
| B | 457 mm (17.99 in.) |
| C | 410.4 mm (16.16 in.) |
| D | 125 mm (4.92 in.) |
| E | 110 mm (4.33 in.) |
| F | 285 mm (11.22 in.) |
| G | $\phi$ 11 mm (0.43 in.) x 4 |

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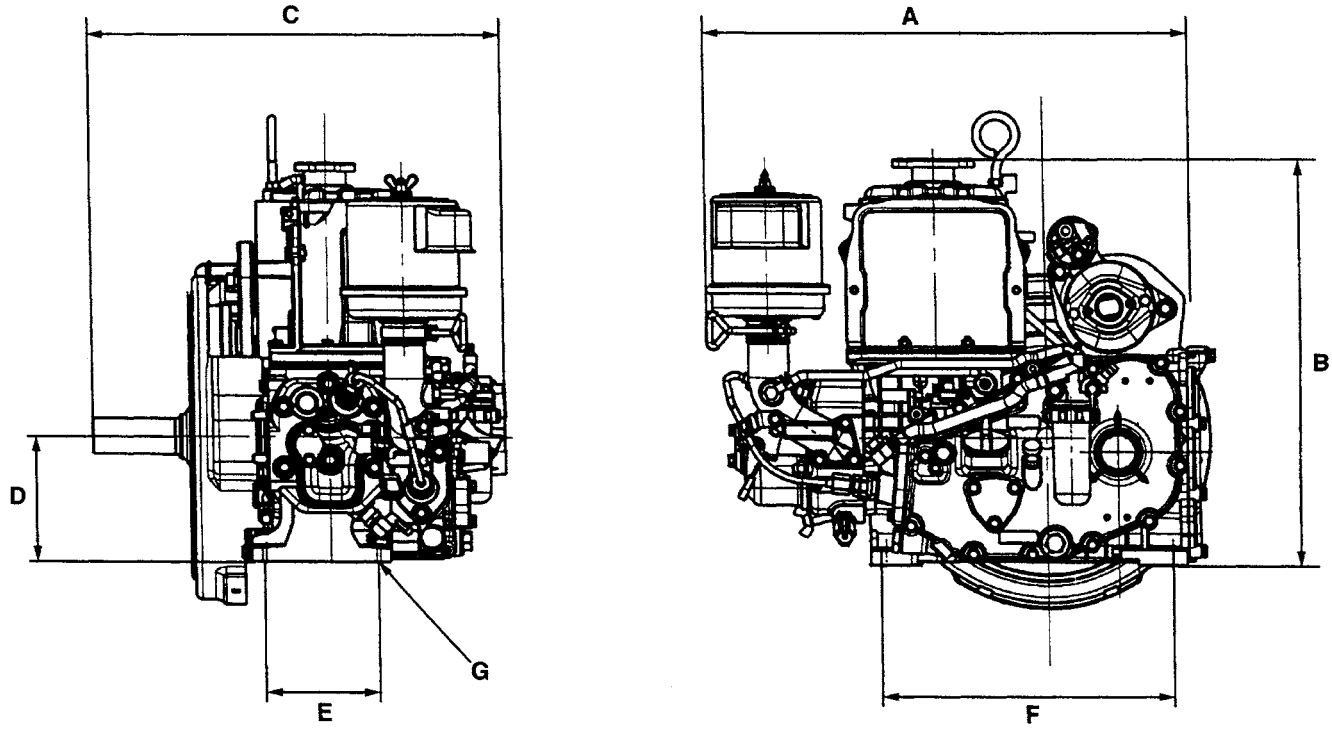
## ■ EA300-E2-NB1-APU

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| | |
|---|---|
| A | 503 mm (19.80 in.) |
| B | 400 mm (15.75 in.) |
| C | 410.4 mm (16.16 in.) |
| D | 125 mm (4.92 in.) |
| E | 110 mm (4.33 in.) |
| F | 285 mm (11.22 in.) |
| G | $\phi$ 11 mm (0.43 in.) x 4 |

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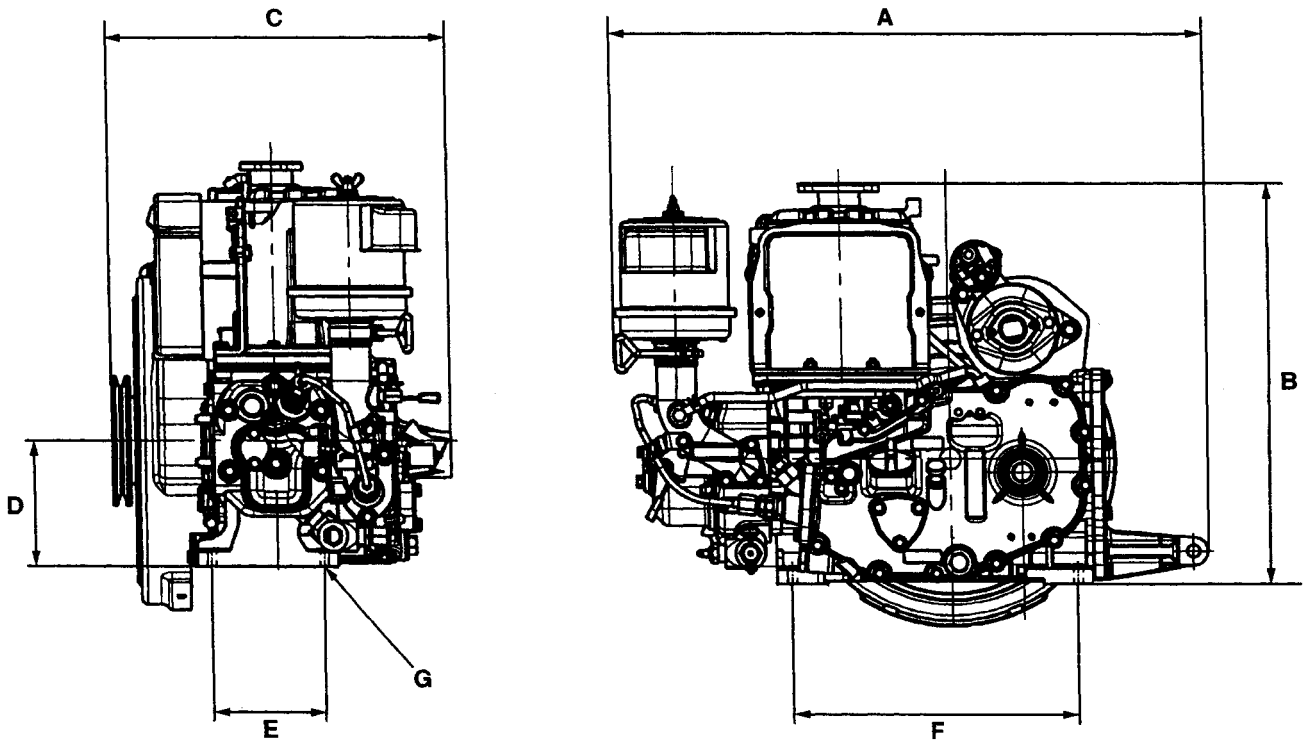
## ■ EL300-E2-AR

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| | |
|---|---|
| A | 588.6 mm (23.17 in.) |
| B | 400.5 mm (15.77 in.) |
| C | 334.5 mm (13.17 in.) |
| D | 125 mm (4.92 in.) |
| E | 110 mm (4.33 in.) |
| F | 285 mm (11.22 in.) |
| G | $\phi$ 9 mm (0.35 in.) x 4 |

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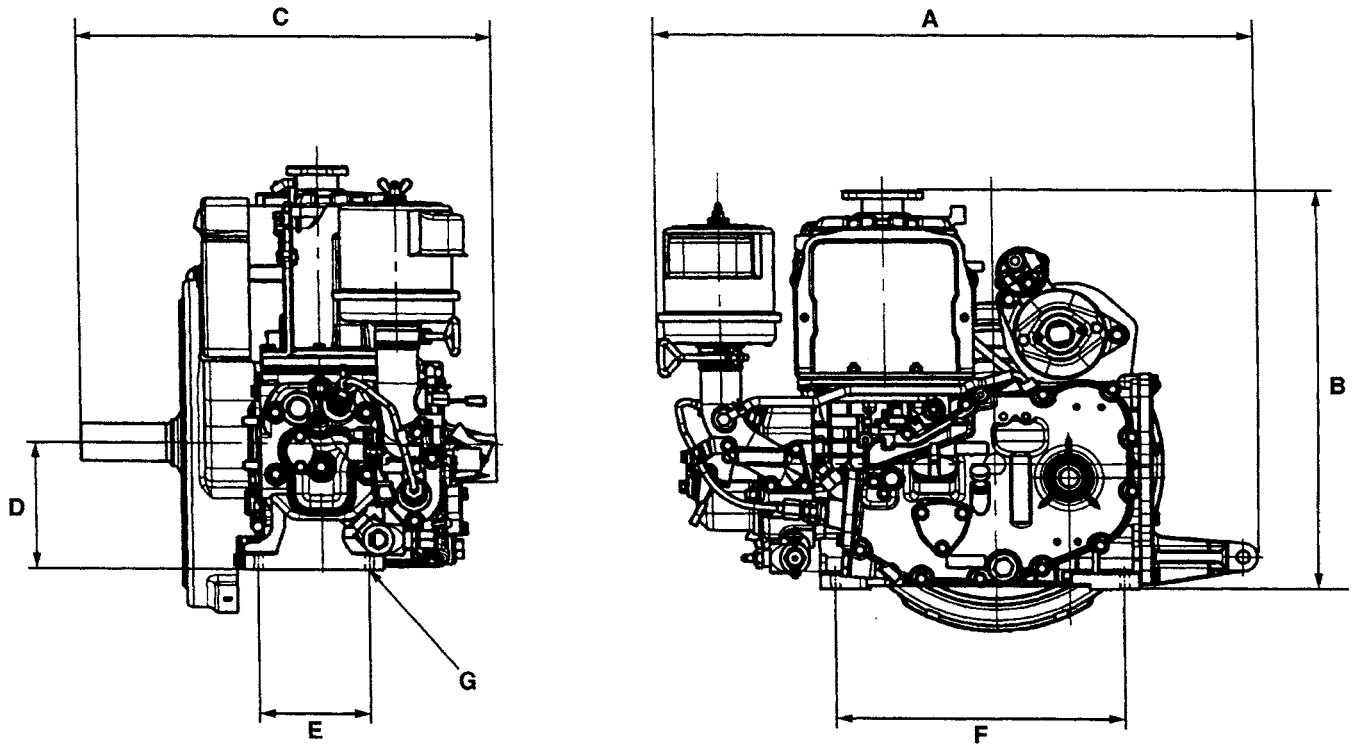
## ■ EL300-E2-KCL




3EDAAABFP004A

| | |
|---|---|
| A | 565.5 mm (22.64 in.) |
| B | 457 mm (17.99 in.) |
| C | 410.4 mm (16.16 in.) |
| D | 125 mm (4.92 in.) |
| E | 110 mm (4.33 in.) |
| F | 285 mm (11.22 in.) |
| G | $\phi$ 11 mm (0.43 in.) x 4 |

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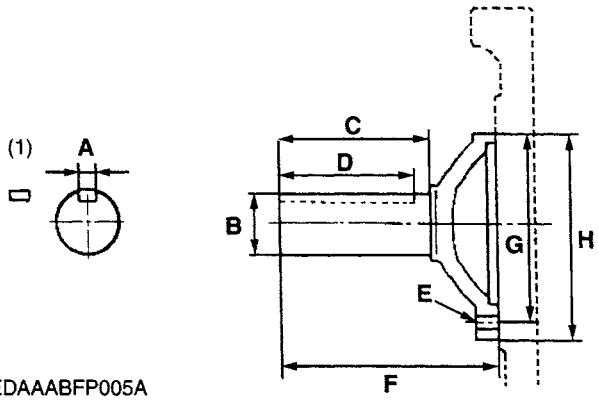
## ■ Pulley Shaft (EA300-E2-NB1, EA300-E2-NB1-APU, EL300-E2-AR-KCL)

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| No. | 19501-8451-0 |
|---|---|
| A | 9.525 to 9.575 mm (0.37500 to 0.37697 in.) |
| B | 36.487 to 36.512 mm dia. (1.43650 to 1.43748 in.) |
| C | 88.9 mm (3.500 in.) |
| D | 66.6 to 66.9 mm (2.622 to 2.634 in.) |
| E | 3 Through holes-9 mm dia. (0.35 in. dia.) |
| F | 128.9 mm (5.075 in.) |
| G | 116 mm dia. (4.57 in. dia.) |
| H | 138 mm dia. (5.43 in. dia.) |

(1) Key

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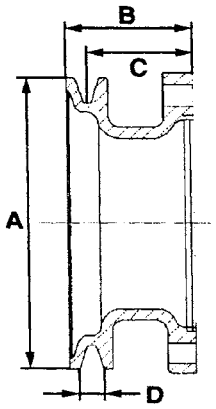
## ■ V-Pulley (EL300-E2-AR)

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| No. | 19704-8401-0 |
|---|---|
| A | 130 mm dia. (5.12 in. dia.) |
| B | 53 mm (2.08 in.) |
| C | 44 mm (1.73 in.) |
| D | 10 mm (0.39 in.) |

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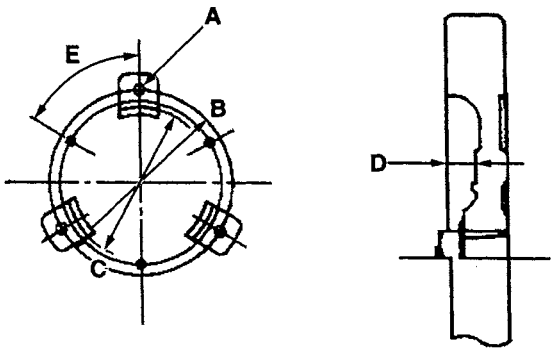
## ■ Flywheel

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| A | 3 Screw holes - Screw dia. size 8 mm (0.31 in.) |
|---|---|
| B | 116 mm dia. (4.57 in. dia.) |
| C | 97.000 to 97.035 mm dia. (3.81890 to 3.82028 in. dia.) |
| D | 16.8 to 17.2 mm (0.66 to 0.67 in.) |

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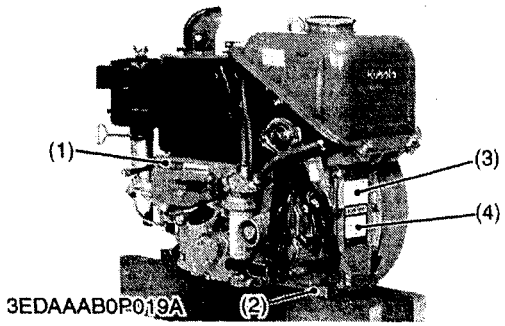
# CONTENTS

# 1. ENGINE IDENTIFICATION

## [1] MODEL NAME AND ENGINE SERIAL NUMBER




When contacting the manufacture, always specify your engine model name and serial number.

The engine model and its serial number need to be identified before the engine can be serviced or parts replaced.

### ■ Engine Serial Number

The engine serial number is an identified number for the engine. It is marked after the engine model number.

It indicates month and year of manufacture as follows.

### ● Year of manufacture

| Alphabet or Number | Year | Alphabet or Number | Year |
|---|---|---|---|
| 1 | 2001 | F | 2015 |
| 2 | 2002 | G | 2016 |
| 3 | 2003 | H | 2017 |
| 4 | 2004 | J | 2018 |
| 5 | 2005 | K | 2019 |
| 6 | 2006 | L | 2020 |
| 7 | 2007 | M | 2021 |
| 8 | 2008 | N | 2022 |
| 9 | 2009 | P | 2023 |
| A | 2010 | R | 2024 |
| B | 2011 | S | 2025 |
| C | 2012 | T | 2026 |
| D | 2013 | V | 2027 |
| E | 2014 | | |

(1) Engine Model
(2) Serial Number
(3) Emission Label
(4) Engine Label

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● **Month of manufacture**

| Month | Engine Serial Number | |
|---|---|---|
| | 0001 ~ 9999 | 10000 ~ |
| January | A0001 ~ A9999 | B0001 ~ |
| February | C0001 ~ C9999 | D0001 ~ |
| March | E0001 ~ E9999 | F0001 ~ |
| April | G0001 ~ G9999 | H0001 ~ |
| May | J0001 ~ J9999 | K0001 ~ |
| June | L0001 ~ L9999 | M0001 ~ |
| July | N0001 ~ N9999 | P0001 ~ |
| August | Q0001 ~ Q9999 | R0001 ~ |
| September | S0001 ~ S9999 | T0001 ~ |
| October | U0001 ~ U9999 | V0001 ~ |
| November | W0001 ~ W9999 | X0001 ~ |
| December | Y0001 ~ Y9999 | Z0001 ~ |

EA300-5A0001

"5" indicates 2005 and "A" indicates January.

So, 5A indicates that the engine was manufactured on January, 2005.

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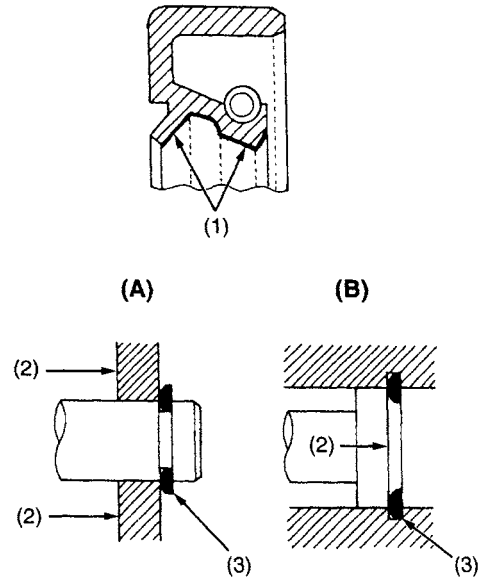
# 2. GENERAL PRECAUTIONS

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- During disassembly, carefully arrange removed parts in a clean area to prevent confusion later. Screws, bolts and nuts should be replaced in their original position to prevent reassembly errors.
- When special tools are required, use KUBOTA genuine special tools. Special tools which are not frequently used should be made according to the drawings provided.
- Before disassembling or servicing live wires, make sure to always disconnect the grounding cable from the battery first.
- Remove oil and dirt from parts before measuring.
- Use only KUBOTA genuine parts for parts replacement to maintain engine performance and to ensure safety.
- Gaskets and O-rings must be replaced during reassembly. Apply grease to new O-rings or oil seals before assembling.
- When reassembling external or internal snap rings, position them so that the sharp edge faces against the direction from which force is applied.
- Be sure to perform run-in the serviced or reassembled engine. Do not attempt to give heavy load at once, or serious damage may result to the engine.

(1) Grease
(2) Force
(3) Place the Sharp Edge against the Direction of Force

**(A) External Snap Ring**
**(B) Internal Snap Ring**

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# 3. E2 ENGINE

[ex.: Model Name EA300-E2-NB1]

The emission controls that have been put into effect in various countries to prevent air pollution will be stepped up. The time to enforce the regulations differs depending on the engine output classifications.

Kubota has been supplying the diesel engines conforming to the emission regulations in respective countries. Exhaust emissions regulations shift to the second stage. Kubota executed the improvement of the engine according to this regulation.

In order to discriminate the engines conforming to Tier 1 / Phase 1 requirements and those conforming to Tier 2 / Phase 2 requirements, we have adopted E2 as a new model name for the engines conforming Tier 2 / Phase 2 regulations.

In the after-sale services for EA/EL300-E2 series engines, only use the dedicated parts for E2 models and carry out the maintenance services accordingly.

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# 4. MAINTENANCE CHECK LIST

To maintain long-lasting and safe engine performance, make it a rule to carry out regular inspections by following the table below.

| Location \ Interval | | Service Interval | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Daily | Initial 50 h | Every 50 h | Every 100 h | Every 300 h | Every 500 h | Every 800h | Every 1500 h | Every 3000 h | Every 1 year | Every 2 years | |
| Radiator coolant | Check | ☆ | | | | | | | | | | | |
| | Change | | | | | | | | | | | ☆ | |
| Crankcase oil | Check | ☆ | | | | | | | | | | | |
| | Change | | ☆ | | ☆ | | | | | | | | |
| Fuel feed piping | Check | | | ☆ | | | | | | | | | |
| | Change | | | | | | | | | | | ☆ | |
| Air cleaner element | Check | | | ☆ | | | | | | | | | @ |
| | Clean | | | | ☆ | | | | | | | | |
| | Change | | | | | | | | | | ☆ | | |
| Fuel filter | Clean | | | | ☆ | | | | | | | | |
| | Change | | | | | | ☆ | | | | | | |
| Fuel tank | Check | ☆ | | | | | | | | | | | |
| | Clean | | | | | ☆ | | | | | | | |
| Valve clearance | Check | | | | | | | ☆ | | | | | |
| Nozzle | Check | | | | | | | | ☆ | | | | @ |
| Fan belt | Change | | | | | | ☆ | | | | | | |
| Battery | Check | | | | ☆ | | | | | | | | |

- When the battery is used for less than 100 hours in a year, check its electrolyte yearly. (for refillable battery's only.)
- The items listed above (@ marked) are registered as emission related critical parts by KUBOTA in the U.S.EPA nonroad emission regulation. As the engine owner, you are responsible for the performance of the required maintenance on the engine according to the above instruction. Please see the Warranty Statement in detail.

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**■ NOTE**

- **Lubricating Oil**

With the emission control now in effect, the CF-4 and CG-4 lubricating oils have been developed for use of a low-sulfur fuel on-road vehicle engines. When an off-road vehicle engine runs on a high-sulfur fuel, it is advisable to employ the CF, CD or CE lubricating oil with a high total base number. If the CF-4 or CG-4 lubricating oil is used with a high-sulfur fuel, change the lubricating oil at shorter intervals.

- **Lubricating oil recommended when a low-sulfur or high-sulfur fuel is employed.**

| Lubricating oil class \ Fuel | Low sulfur (0.5 % ≥) | High sulfur | Remarks |
|---|---|---|---|
| CF | O | O | TBN ≥ 10 |
| CF-4 | O | X | |
| CG-4 | O | X | |

O : Recommendable X : Not recommendable

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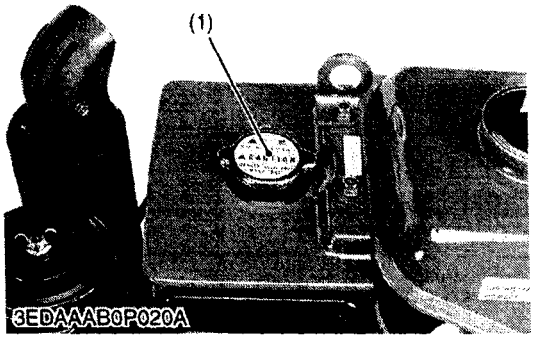
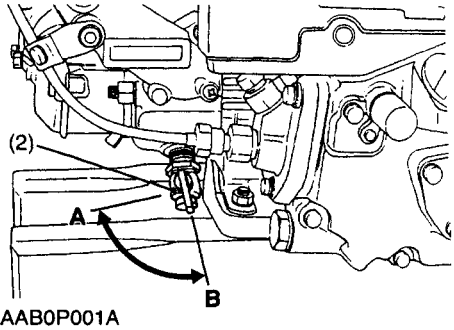
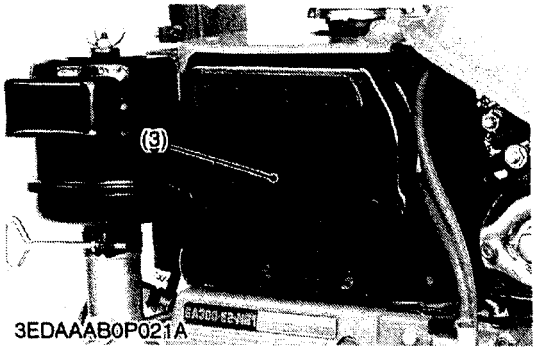
# 5. CHECK AND MAINTENANCE

## [1] DAILY CHECK LIST




Checking Cooling Water Level (Daily)

**⚠ CAUTION**

- **During operation or immediately after operation, cooling water in the radiator is extremely hot. If the radiator cap is removed, hot water may gush out, causing scalding. Open the radiator cap after the engine has cooled.**

1. Fill the radiator with tap or fresh water

**■ NOTE**

- **Dirt or dust in the water will hinder water flow, impairing cooling efficiency.**

2. When draining cooling water, open both the drain cock (2) and the radiator cap (1). Water will drain even more completely if the engine is shaken several times.
3. When there is a chance of freezing and no antifreeze is added to cooling water, drain it after every use.
4. Periodically remove the radiator net (3) and check to see if the radiator fin may greatly lower cooling or pressurized water, do not use anything hard like a screwdriver or a spatula which may scratch the fin.

(1) Radiator Cap
(2) Drain Cock
(3) Radiator Net

**[A] OPEN**
**[B] CLOSE**

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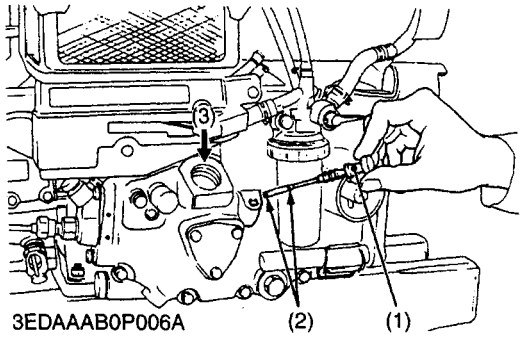


Checking Engine Oil Level (Daily)

**■ NOTE**

- **Engine should be on a level surface when oil level is checked.**
- **Use the specified oil to replenish.**

1. Pull out dipstick (1) and check oil level.
2. If necessary, add engine oil to bring oil level between the oil level mark (2) on dipstick.

(1) Dipstick
(2) Oil Level Mark
(3) Oil Inlet

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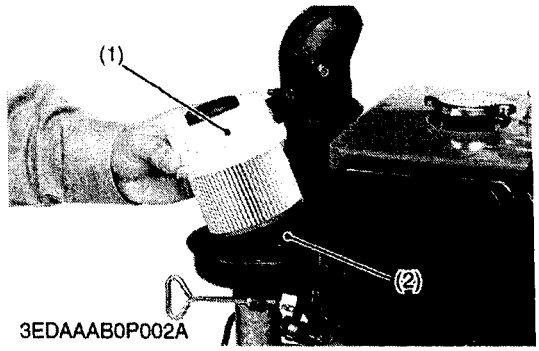
# [2] CHECK POINT OF EVERY 50 HOURS




Checking Air Cleaner Element

**■ IMPORTANT**

- **When used in a dustily place, check the cleaner every day, and clean.**

1. Ensure that the element (1) or the dust cup (2) is not clogged by dirt or dust.
2. If necessary, clean them according to the procedure in the following section **"Cleaning Air Cleaner Element"**.

**■ NOTE**

- **Do not let dust build up to move than half way up the dust cap.**

(1) Air Cleaner Element (2) Dust Cap

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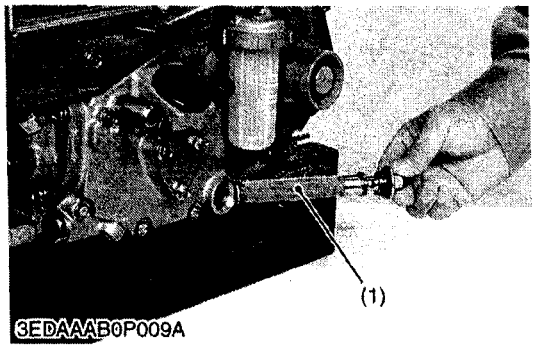
# [3] CHECK POINTS OF EVERY 100 HOURS




Changing Engine Oil and Cleaning Oil Strainer (First 50 Hours and Every 100 Hours)

1. After warming up the engine, remove the drain plug (1) and drain the oil completely.
2. Clean the inside of the oil strainer and the cylinder block withe gas oil.
3. Supply the specified quantity of the specified oil through the oil inlet.

| | | |
|---|---|---|
| Engine oil quantity | EA300-E2-NB1<br>EA300-E2-NB1-APU | 1.3 L<br>1.4 U.S.qts<br>1.14 Imp.qts |
| | EL300-E2-AR<br>EL300-E2-AR-KCL | 1.9 L<br>2.0 U.S.qts<br>1.76 Imp.qts |

**■ IMPORTANT**

- **Engine oil should be Supplement 1/MIL-L-46152 or have properties of API classification CC.**
- **Change the type of engine oil according to the ambient temperature.**

| | |
|---|---|
| Above 20 °C (68 °F) | SAE30 |
| 5 °C to 20 °C (41 °F to 68 °F) | SAE20 |
| Below 5 °C (41 °F) | SAE10W or SAE10W-30 |

(1) Drain Plug (Oil Strainer)

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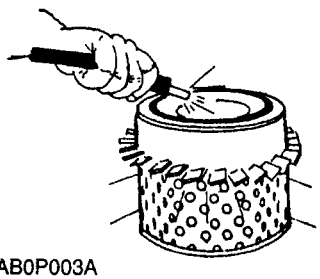


Cleaning Air Cleaner Element

**(Removing dry dust or dirt)**

1. Blow compressed air from inside the element to clean.

**■ IMPORTANT**

- **Maintain reasonable distance between the nozzle and the filter.**

| | | |
|---|---|---|
| Air pressure | Factory spec. | 205 kPa or less<br>2.1 kgf/cm$^2$<br>30 psi |

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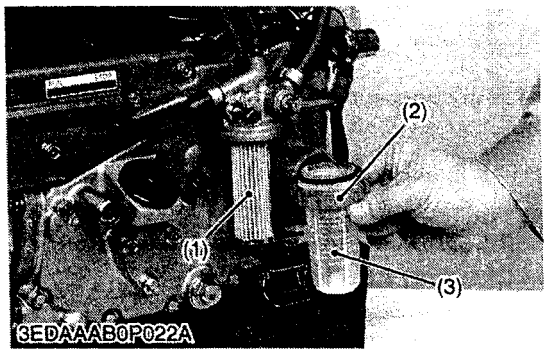


Cleaning Fuel Element

**⚠ CAUTION**

- **If the element is damaged, replace it. Otherwise, dust may enter the injection pump and the nozzle, shortening their service life.**

1. Close the fuel cock.
2. Loosen the retainer ring (2) on the cap (3) and the bolt mounting element holder, take out the cap, and clean out any dust or water collected in the bottom of it.
3. The element (1) can be detached by pulling downward gently. Immerse it in new fuel and swish gently to wash.
4. Apply a thin film of fuel to the O-ring and then fully tighten it by hand.

**■ IMPORTANT**

- **The retainer ring must be tightened by hand at all times.**

(1) Filter Element
(2) Retainer Ring
(3) Filter Cap

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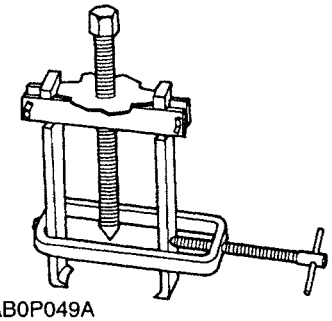
# 6. SPECIAL TOOLS



3TMABAB0P049A

Special Use Puller Set

Code No : 07916-09032

Application : Use exclusively for pulling out bearing, gears and other parts with ease.

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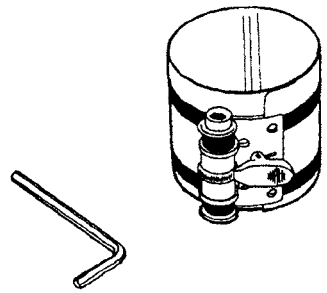


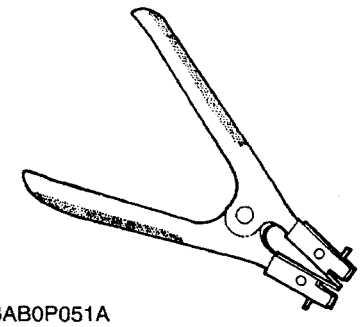
3TMABAB0P050A

Piston Ring Compressor

Code No : 07909-32111

Application : Use exclusively for pushing in the piston with piston rings into the cylinder.

0000000678E



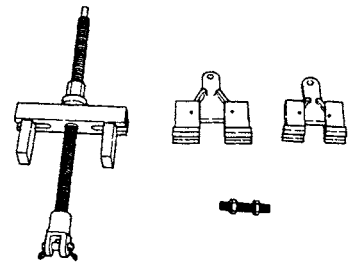
3TMABAB0P051A

Piston Ring Tool

Code No : 07909-32121

Application : Use exclusively for removing or installing the piston ring with ease.

0000000679E



3EDAAAB0P005A

Wet Liner Puller

Code No : 07916-30012

Application : A puller for pulling out the wet liner.
It combines with a presser for pushing in the wet liner.

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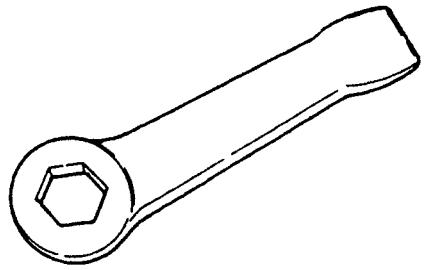


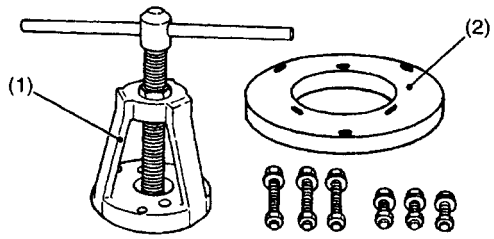
3EDAAAB0P004A

Socket Wrench 29

Code No : 07916-31820

Application : Use exclusively for loosing the flywheel nut with easy (for EA300 Series)..

0000009690E



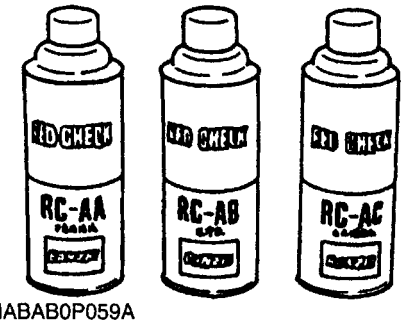

3EDAAAB0P007A

Flywheel Puller

Code No : (1) 07916-04052
(2) 07916-32491

Application : Use to remove the flywheel.

0000009692E




3TMABAB0P059A

Red Check

Code No : 07909-31371

Application : Use to check cracks on cylinder head, cylinder block, etc..

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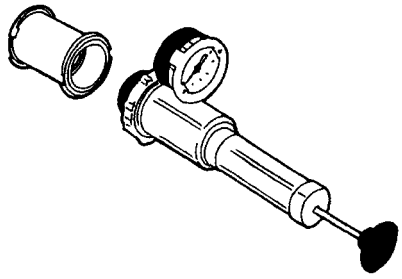


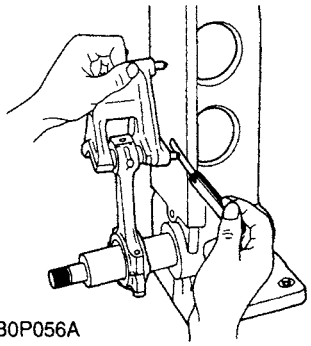
3TMABAB0P055A

Radiator Tester

Code No : 07909-31551

Application : Use to check of radiator cap pressure, and leaks from cooling system.

0000003103E

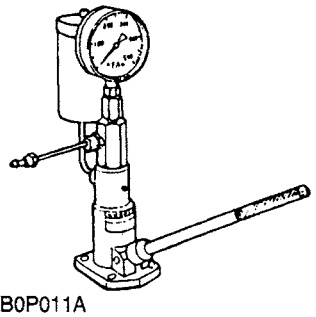


3TMABAB0P056A

Connecting Rod Alignment Tool

Code No : 07909-31661
Application : Use to check the connecting rod alignment.
Applicable : Connecting rod big end I.D.
range 30 to 75 mm (1.18 to 2.95 in.) dia.
Connecting rod length
65 to 300 mm (2.56 to 12.99 in.)

0000009694E

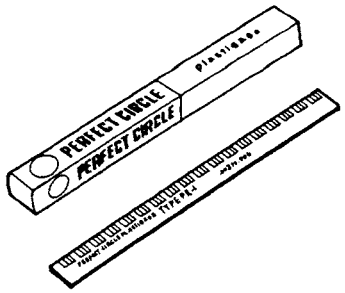


3ECAAAB0P011A

Nozzle Tester

Code No : 07909-31361
Application : Use to check the fuel injection pressure and spray pattern of nozzle.
Measuring : 0 to 50 MPa
range (0 to 500 kgf/cm$^2$, 0 to 7000 psi)

0000000685E

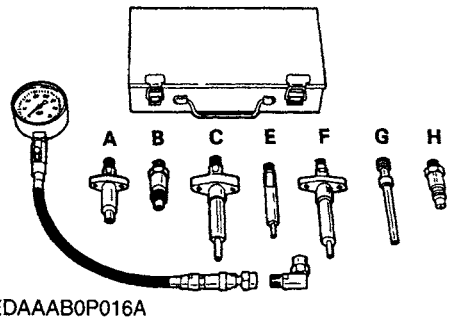



3TMABAB0P058A

Plastigage

Code No : 07909-30241
Application : Use to check the oil clearance between crankshaft and bearing, etc..
Measuring : Green.....0.025 to 0.076 mm (0.001 to 0.003 in.)
range Red.....0.051 to 0.152 mm (0.002 to 0.006 in.)
Blue.....0.102 to 0.229 mm (0.004 to 0.009 in.)

0000000686E

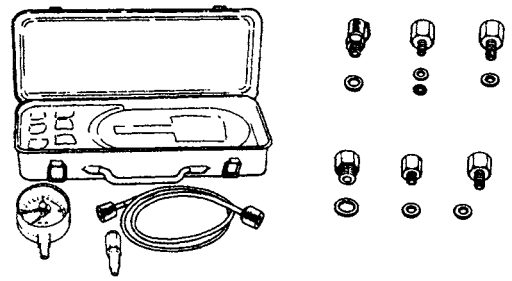



3EDAAAB0P016A

Diesel Engine Compression Tester

Code No : 07909-30204 (Assembly) 07909-30933 (**A** to **H**)
07909-31211 (**G**) 07909-31231 (**H**)
EA300 Series : Adapter **B** / **H**
Application : Use to measure diesel engine compression and diagnostics of need for major overhaul.

0000009695E



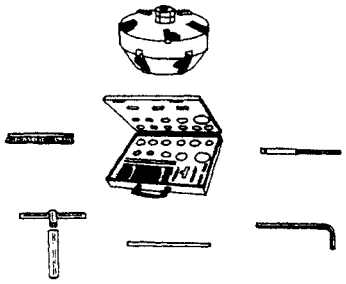
3EDAAAB0P023A

Oil Pressure Tester

Code No : 07916-32031

Application : A teter to measure lubricating oil pressure for all kinds of diesel engines.

0000009696E



3TMABAB0P054A

Valve Seat Cutter

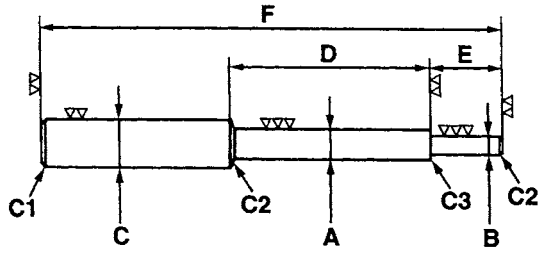
Code No : 07909-33102

Application : Use to reseat valves.

Angle : 0.785 rad (45°)
0.262 rad (15°)

Diameter : 28.6 mm (1.126 in.) 38.0 mm (1.496 in.)
31.6 mm (1.244 in.) 41.3 mm (1.626 in.)
35.0 mm (1.378 in.) 50.8 mm (2.000 in.)

0000000682E



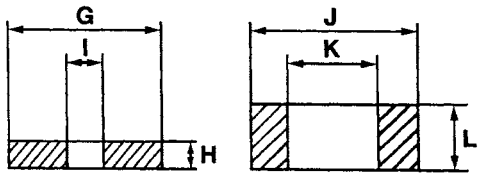

3EDAAAB0P017A

Valve Guide Replacing Tool

Application : Use to press out and to press fit the valve guide.

Material : S43C

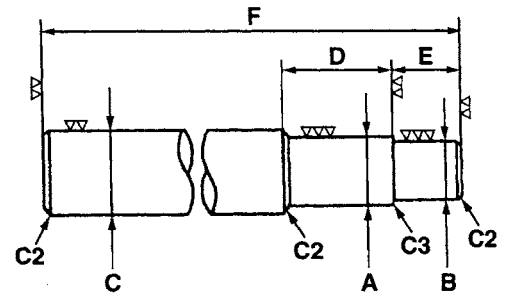
Heat Treatment : Hardening, Anneal




3TMABAB0P064A

| | |
|---|---|
| A | 11.90 to 11.95 mm dia. (0.4685 to 0.4705 in. dia.) |
| B | 6.85 to 6.95 mm dia. (0.270 to 0.274 in. dia.) |
| C | 18 dia. (0.71 dia.) |
| D | 40 mm (1.57 in.) |
| E | 40 mm (1.57 in.) |
| F | 100 mm (3.94 in.) |
| G | 23 mm ( 0.906 in.) |
| H | 5 mm (0.197 in.) |
| I | 6.9 to 7.0 mm dia. (0.272 to 0.276 in. dia.) |
| J | 18 mm dia. (0.701 in. dia.) |
| K | 12.2 to 12.5 mm dia. (0.481 to 0.492 in. dia.) |
| L | 6.3 to 6.7 mm (0.248 to 0.264 in.) |
| C1 | Chamfer 2.0 mm (0.079 in.) |
| C2 | Chamfer 1.0 mm (0.039 in.) |
| C3 | Chamfer 0.3 mm (0.012 in.) |

0000009698E




3EDAAAB0P011A

Rocker Arm Bushing Replacing Tool

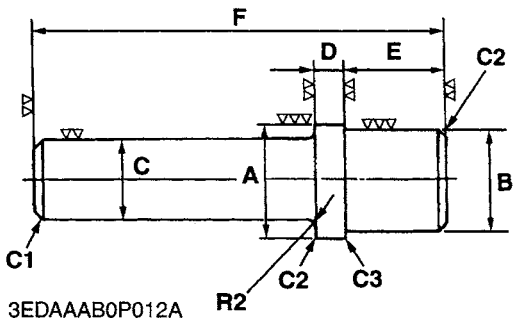
Application : Use to press out and to press fit the rocker arm bushing.

Material : S43C

Heat Treatment : Hardening, Anneal

| | |
|---|---|
| A | 12.90 to 12.95 mm dia. (0.5079 to 0.5098 in. dia.) |
| B | 10.90 to 10.95 mm dia. (0.4291 to 0.4311 in. dia.) |
| C | 20 dia. (0.79 dia.) |
| D | 25 mm (0.98 in.) |
| E | 15 mm (0.95 in.) |
| F | 140 mm (5.51 in.) |
| C1 | Chamfer 2.0 mm (0.079 in.) |
| C2 | Chamfer 1.0 mm (0.039 in.) |
| C3 | Chamfer 0.3 mm (0.012 in.) |

0000009699E




3EDAAAB0P012A

Idle Gear Bushing Replacing Tool

Application : Use to press out and to press fit the idle gear bushing.

Material : S43C

Heat Treatment : Hardening, Anneal

| | |
|---|---|
| A | 19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.) |
| B | 17.90 to 17.95 mm dia. (0.7047 to 0.7067 in. dia.) |
| C | 15 dia. (0.59 dia.) |
| D | 8 mm (0.31 in.) |
| E | 25 mm (0.98 in.) |
| F | 100 mm (3.94 in.) |
| C1 | Chamfer 2.0 mm (0.079 in.) |
| C2 | Chamfer 1.0 mm (0.039 in.) |
| C3 | Chamfer 0.3 mm (0.012 in.) |

0000009700E

Piston Pin Bushing Replacing Tool

Application : Use to press out and to press fit the piston pin bushing.

Material : S43C

Heat Treatment : Hardening, Anneal

| | |
|---|---|
| A | 22.90 to 22.95 mm dia. (0.9016 to 0.9035in. dia.) |
| B | 19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.) |

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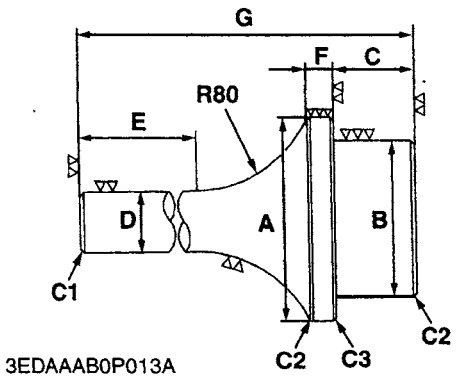

3EDAAAB0P013A

Crankshaft Main Bearing 1 Inserting Tool

Application : Use to tap in the outer ring of the main bearing 1.

Material : SS41

| | |
|---|---|
| A | 72 mm dia. (2.83 in. dia.) |
| B | 57 mm dia. (2.24 in. dia.) |
| C | 22.95 to 23.05 mm dia. (0.9035 to 0.9075 in. dia.) |
| D | 25 dia. (0.98 dia.) |
| E | 70 mm (2.76 in.) |
| F | 10 mm (0.39 in.) |
| G | 150 mm (5.91 in.) |
| C1 | Chamfer 2.0 mm (0.079 in.) |
| C2 | Chamfer 1.0 mm (0.039 in.) |
| C3 | Chamfer 0.3 mm (0.012 in.) |
| R80 | R80 mm (R3.15 in.) |

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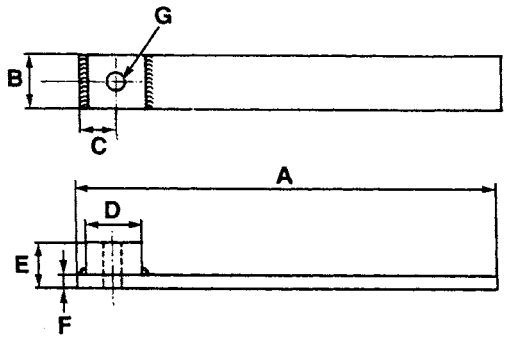


3EDAAAB0P014A

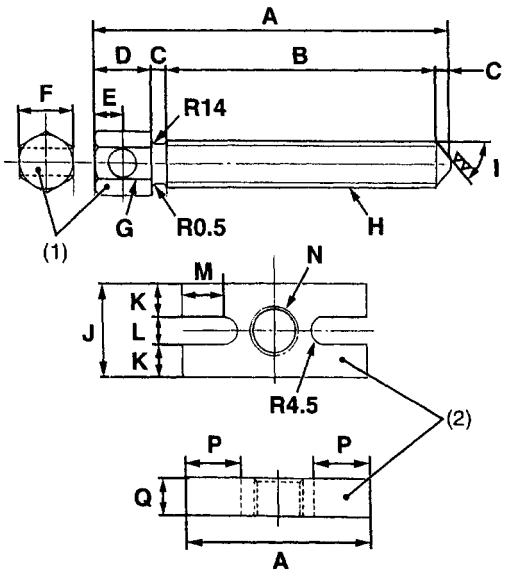
Flywheel Stopper

Application : Use to loosen and tighten the flywheel nut.

Material : SS41

| | |
|---|---|
| A | 235 mm dia. (9.25 in. dia.) |
| B | 30 mm (1.18 in.) |
| C | 20 mm dia. (0.79 in. dia.) |
| D | 30 mm (1.18 in.) |
| E | 26 mm (1.02 in.) |
| F | 8 mm dia. (0.31 in. dia.) |
| G | 10 mm dia. (0.39 in. dia.) |

0000009703E




3EDAAAB0P015A

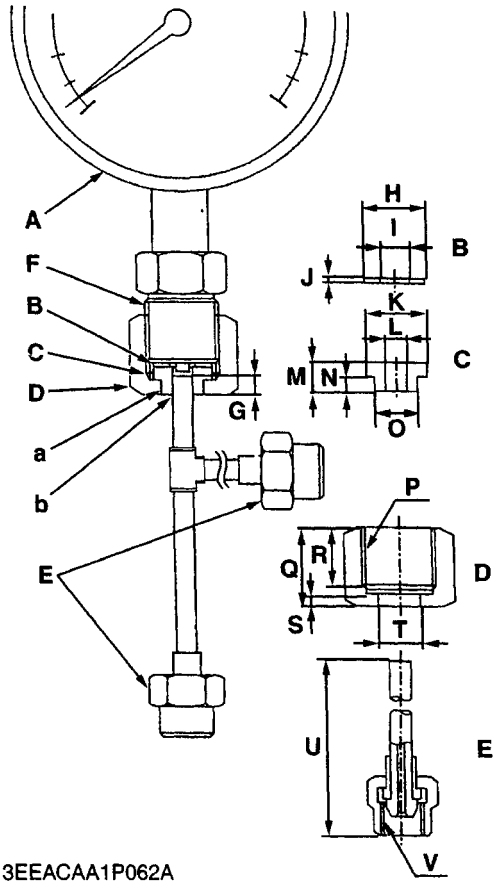
Crank Gear Puller

Application : Use exclusively to pull out easily the crank gear.

Material : (1) Hexagonal Bar Steel
(2) SS41

| | |
|---|---|
| A | 125 mm dia. (4.92 in. dia.) |
| B | 95 mm dia. (3.74 in. dia.) |
| C | 5 mm dia. (0.20 in. dia.) |
| D | 20 mm dia. (0.79 in. dia.) |
| E | 10 mm dia. (0.39 in. dia.) |
| F | 19 mm dia. (0.75 in. dia.) |
| G | 10 mm dia. (0.39 in. dia.) |
| H | M16 x P1.5 |
| I | 0.87 rad. (50 °) |
| J | 30 mm dia. (1.18 in. dia.) |
| K | 10.5 mm dia. (0.41 in. dia.) |
| L | 9 mm dia. (0.35 in. dia.) |
| M | 13.5 mm dia. (0.53 in. dia.) |
| N | M16 x P1.5 |
| O | 60 mm dia. (2.36 in. dia.) |
| P | 18 mm dia. (0.71 in. dia.) |
| Q | 12 mm dia. (0.47 in. dia.) |
| C2 | Chamfer 2 mm (0.08 in.) |
| R0.5 | R0.5 mm (0.020 in.) |
| R4.5 | R4.5 mm (0.177 in.) |
| R14 | R14 mm (0.55 in.) |

0000009704E




3EEACAA1P062A

## Injection Pump Pressure Tester

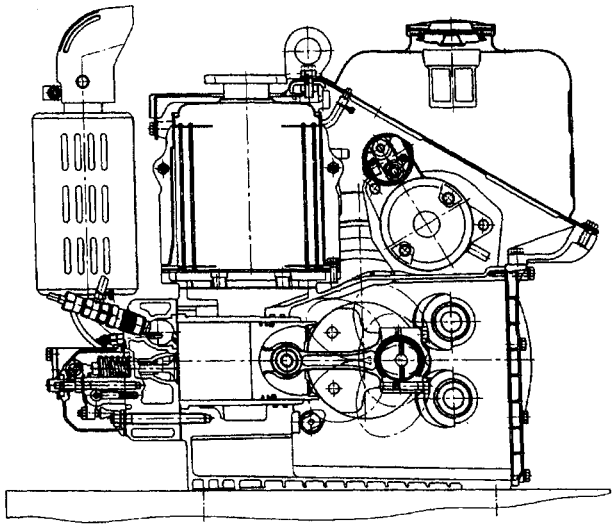
Application : Use to check fuel tightness of injection pumps.

| | |
|---|---|
| A | Pressure gauge full scale : More than 29.4 MPa (300 kgf/cm$^2$, 4267 psi) |
| B | Copper gasket |
| C | Flange (Material : Steel) |
| D | Hex. nut 27 mm (1.06 in.) across the plat |
| E | Retaining nut |
| F | PF 1/2 |
| G | 5 mm (0.20 in.) |
| H | 17 mm dia. (0.67 in.dia.) |
| I | 8 mm dia. (0.31 in.dia.) |
| J | 1.0 mm (0.039 in.) |
| K | 17 mm dia. (0.67 in.dia.) |
| L | 6.10 to 6.20 mm dia. (0.2402 to 0.2441 in.dia.) |
| M | 8 mm (0.31 in.) |
| N | 4 mm (0.16 in.) |
| O | 11.97 to11.99 mm dia. (0.4713 to 0.4721 in.dia.) |
| P | PF 1/2 |
| Q | 23 mm (0.91 in.) |
| R | 17 mm (0.67 in.) |
| S | 4 mm (0.16 in.) |
| T | 12.00 to 12.02 mm dia. (0.4724 to 0.4732 in.dia.) |
| U | 100 mm (3.94 in.) |
| V | M12 x P1.5 |
| a | Adhesive application |
| b | Fillet welding on the enter circumference |

0000001341E

# CONTENTS

# 1. FEATURE



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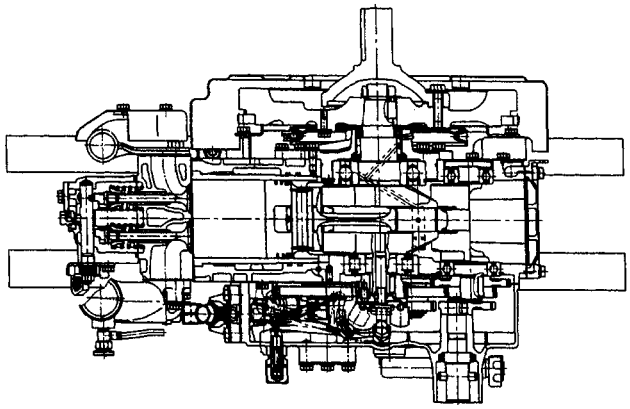

3EDAAAB1P002A

■ **NOTE**

● **Figure shows EA300 engine.**

The EA / EL300-E2 series engines are horizontal, water-cooled 4-cycle diesel engine.

They are incorporated KUBOTA's foremost technologies.

With KUBOTA's exclusive E-TVCS (Three Vortex Combustion System) combustion chamber and 2-shaft dynamic balances (EA /EL 300-E2), well-known Bosch M type injection pump, they give greater power, low fuel consumption, little vibration and quiet operation.

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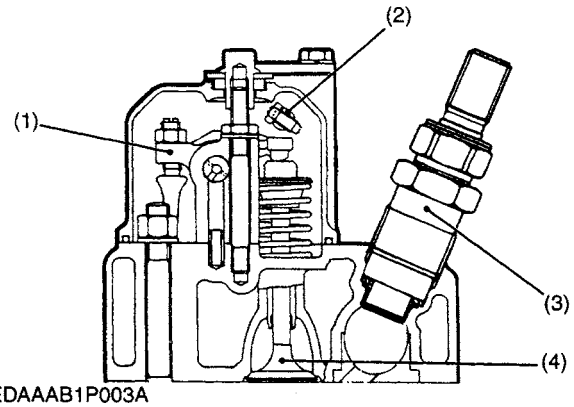
# 2. ENGINE BODY

## [1] CYLINDER HEAD




3EDAAAB1P003A

As the cylinder head is subjected to high temperature and high pressure, it is made of special alloy iron.

The cylinder head is installed on top of the cylinder block, it houses the intake and exhaust valves (4), rocker arm (1), injection nozzle (3), and others.

It is also equipped with a decompressor to reduce compression in the cylinder so the crankshaft rotates with less force for staring.

The area of the cylinder head that faces the piston head and forms the combustion chamber has the intake and exhaust holes and nozzle hole. In the other area, a lubricating oil gallery, cooling water gallery, screw hole, and others are machined symmetrically with the cylinder block.

The NB1 engine is equipped with the glow plug for easy starting even in cold weather.

(1) Rocker Arm
(2) Decompression Shaft
(3) Injection Nozzle
(4) Valve

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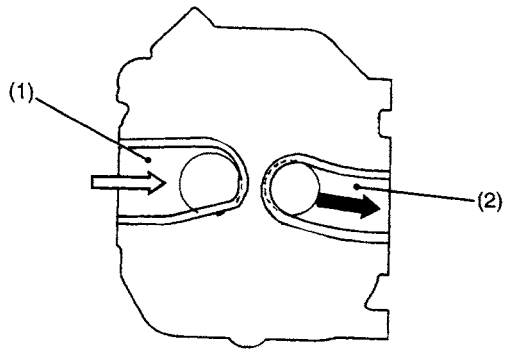


3EDAAAB1P004A

The intake port (1) and exhaust port (2) are cross flow type which open respectively at both sides of the cylinder head. In this cylinder head, less exhaust heat is hardly conducted to the intake port, so that high density air is always inhaled into the cylinder for stable combustion.

(1) Intake Port
(3) Exhaust Port

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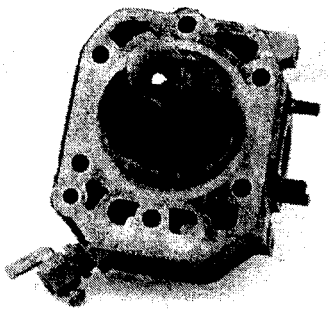

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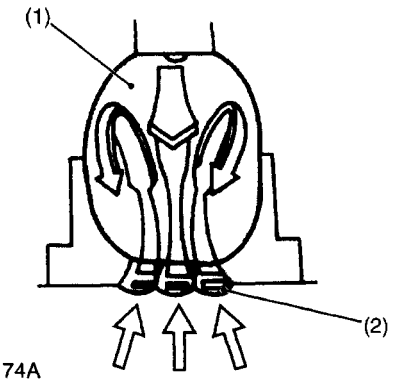


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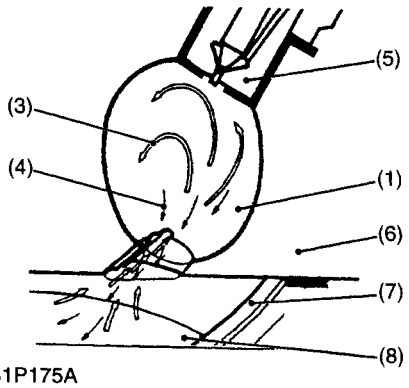


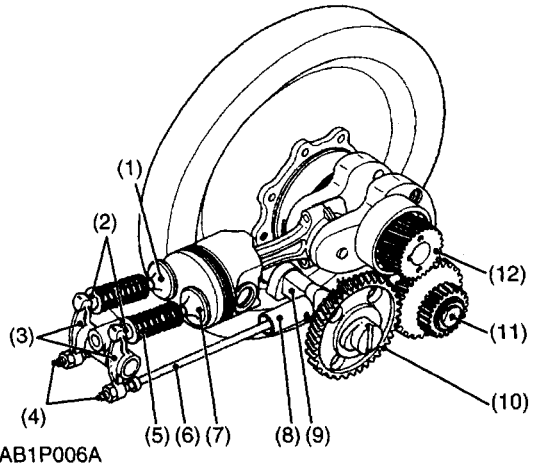

3EDAAAB1P175A

This engine employs Kubota's exclusive (Three Vortex Combustion System) system. This system provides three swirls inside a spherical vortex chamber during the combustion stroke for effective combustion. Specific fuel consumption is improved by approx. 10 % over our conventional engines. This combustion system also features good starting performance and reduced noise.

(1) Combustion Chamber
(2) Intake Air Port
(3) Atomized Fuel (During Compression)
(4) Atomized Fuel (During Explosion)
(5) Injection Nozzle
(6) Cylinder Head
(7) Cylinder Liner
(8) Piston

0000009680E

# [2] VALVE MECHANISM




3TAAAB1P006A

This engine adopts the overhead valve (OHV) mechanism. The intake and exhaust valves (7), (1) open and close as follows:

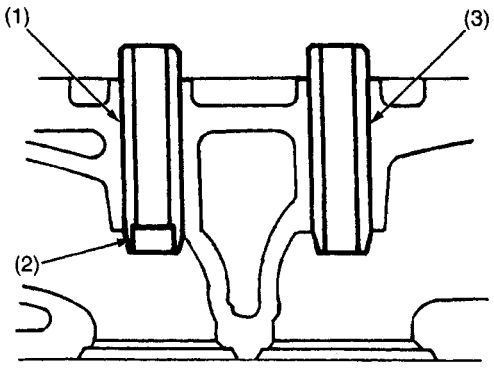
1. The crankshaft rotation is transmitted to the camshaft via the timing gears (crank gear (12), cam gear (10) and idle gear (11)).
2. The cam actuated by the rotation of the camshaft push up the tappet (8) and push rad (6), and the rocker arm (3) rocks with the rocker arm shaft as an axis like a seesaw and overcomes the tension or the valve spring (5), allowing the valve to open.
3. When the convex portion of the cam passes its top, the valve closes by the spring tension.

Since the intake / exhaust valves expand due to heat during engine running, a small clearance (valve clearance) is provided between the end of rocker arm (3) and the valve cap (2) in cold condition to prevent compression leak caused by the valve pushing-up. This clearance is adjusted with an adjusting screw (4) mounted on the rocker arm.

The intake / exhaust valves are made of heat resisting steel, and induction hardened at the valve stem ends for improved wear resistance. The valve cap is forged and carburized, and induction hardened at the contact section with the valve cap of the rocker arm for improved wear resistance. The valve springs (5) are made of piano wires and its surfaces is performed shot-peening for greater fatigue strength.

| | | | |
|---|---|---|---|
| (1) | Exhaust Valve | (7) | Intake Valve |
| (2) | Valve Caps | (8) | Tappet |
| (3) | Rocker Arms | (9) | Camshaft |
| (4) | Adjusting Screw | (10) | Cam Gear |
| (5) | Valve Spring | (11) | Idle Gear |
| (6) | Push Rod | (12) | Crank Gear |

0000009706E




3TAAAB1P007A

### 1) Valve Guide

The valve guides are cast iron and reamer-finished after being pressed into the cylinder head. The lower area of the exhaust valve guide has a carbon cutter which prevents carbon adhesion to the valve.

| | | | |
|---|---|---|---|
| (1) | Exhaust Valve Guide | (3) | Intake Valve Guide |
| (2) | Carbon Cutter | | |

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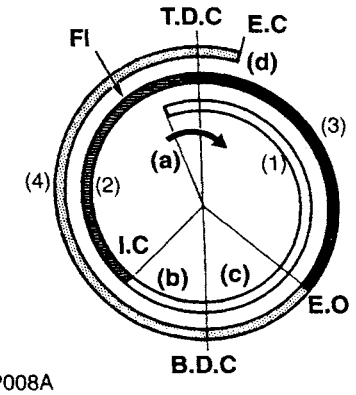



3EDAAAB1P008A

### 2) Valve Timing

The valve opening and closing timing is extremely important for effectively taking air into the cylinder and sufficiently discharging unnecessary exhaust gas.

An appropriate timing can be obtained by aligning the alignment line on the crank gear, idle gear and cam gear.

| | |
|---|---|
| Intake valve open (I.D.) | 0.35 rad. before T.D.C. (20° before T.D.C.) |
| Intake valve close (I.C.) | 0.79 rad. after B.D.C. (45° after B.D.C.) |
| Exhaust valve open (E.O.) | 0.87 rad. before B.D.C. (50° before B.D.C.) |
| Exhaust valve close (E.C.) | 0.26 rad. after T.D.C. (15° after T.D.C.) |

| | | |
|---|---|---|
| **FI** Fuel Injection Timing | EA300-E2-NB1 EA300-E2-NB1-APU | 0.45 rad. (25.5°) before T.D.C. |
| | EL300-E2-AR EL300-E2-AR-KCL | 0.38 rad. (22°) before T.D.C. |

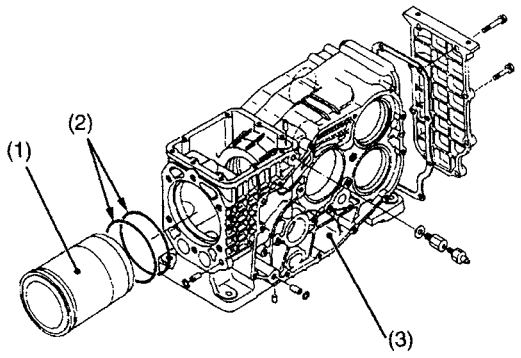
(1) Intake
(2) Compression
(3) Combustion (Power)
(4) Exhaust

**FI: Fuel Injection**
**T.D.C.: Top Dead Center**
**B.D.C.: Bottom Dead Center**

**(a) 0.35 rad. before T.D.C. (20 ° before T.D.C.)**
**(b) 0.79 rad. after B.D.C. (45 ° after B.D.C.)**
**(c) 0.87 rad. before B.D.C. (50 ° before B.D.C.)**
**(d) 0.26 rad. after T.D.C. (15 ° after T.D.C.)**

0000010112E

# [3] CYLINDER BLOCK AND CYLINDER LINER




3TAAAB1P009A

The cylinder block is made of aluminium die-cast.

The cylinder block is provided with oil galleries to lubricate the crankshaft, main bearing case and rocker arm bracket. The cylinder liner (1) made of special cast iron having excellent wear resistance, is pressfitted into the cylinder block.

These engines adopt a wet type cylinder liner which periphery comes into direct contact with cooling water. To prevent water leakage, O-rings (2) are installed at the lower part of cylinder liner periphery. To prevent gas leakage, the upper part of the liner slightly protrudes from the cylinder block. This is because the gasket at this part is tightened strongly between the cylinder head and the liner.

**■ NOTE**

- **Similarly as the aluminum alloy gear case, etc. cylinder blocks that are made of aluminum alloy are prone to scratches and greater thermal expansion. Therefore, following advises need to be followed during repair.**
- Parts must be tightened when they are cold.
- Follow specified tightening torques accurately.
- Protect processed surfaces, especially, from scratches.

(1) Cylinder Liner
(2) O-ring
(3) Cylinder Block

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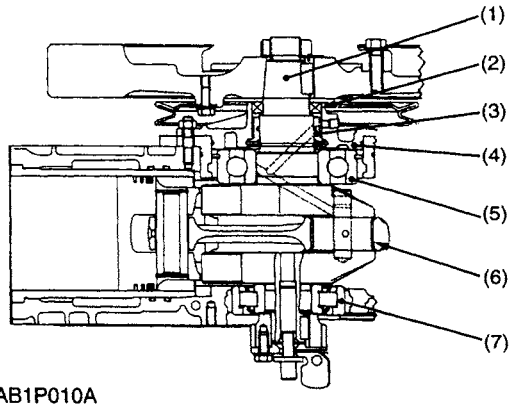
# [4] CRANKSHAFT AND CRANKSHAFT JOURANAL BEARING




3EDAAAB1P010A

The crankshaft (1) is made of tough special alloy steel, and the pin and oil seal slinging portions are induction hardened to increase the hardness for higher wear resistance.

The journal portions are supported by main bearing 1 (7) and 2 (5).

The crankshaft is provided with an oil gallery which feeds engine oil to the pin portion and lubricate it.

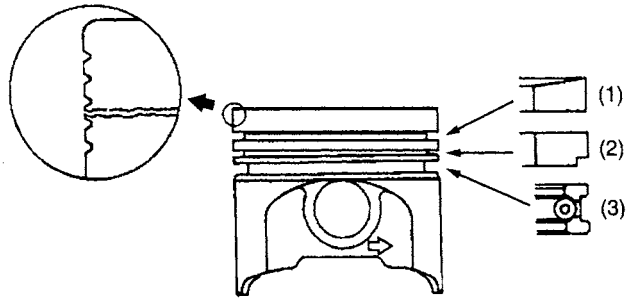
The oil fed from the oil pump travels along the groove on the oil filler rings (3), passes through the oil gallery in the crankshaft and lubricates the crank pin part. The filler ring is made of aluminum alloy casting.

The oil seal (2) is provided to prevent oil leakage.

(1) Crankshaft
(2) Oil Seal
(3) Oil Filler Ring
(4) Main Bearing Case
(5) Main Bearing 2
(6) Crank Pin Bearing
(7) Main Bearing 1

0000009710E

## [5] PISTON AND PISTON RING




3EDAAAB1P068A

Since the piston is always subjected to high temperature and high pressure and reciprocates within the cylinder, it must be lightweight, tough, heat resistant, wear resistant, and of little thermal expansion. For this reason, the piston is made of High-silicone (aluminium alloy).

The piston crown is flat-formed. Grooves are formed around the piston crown and these aid heat dissipation and prevent scuffing of the piston and cylinder liner.

The piston has three piston rings.

The top ring (1) is of a Keystone type to prevent gas leakage, and it designed for a better initial fit and to prevent abnormal wear and sizure. The ring surface is hard-chromium plated for improved wear resistance.

The second ring (2) is an under-cut type which effectively prevents the rise of oil.

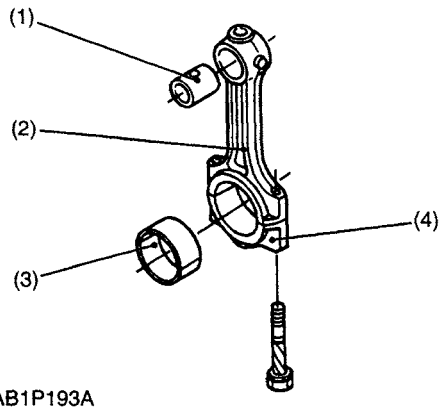
The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

A portion of the scraped oil is forced inside the piston as it passes through escape holes in rings and piston. These oil rings are plated with hard chrome to give increased wear resistance.

(1) Top Ring
(2) Second Ring
(3) Oil Ring

0000009711E

## [6] CONNECTING ROD AND CONNECTING ROD BEARING




3EDAAAB1P193A

The connecting rod (2) is made of I-shape forging of carbon steel so that it can withstand large repetitive impacts.

The big end of the connecting rod is of a horizontal split type and tightened with special screws. Since the connecting rod body (2) and cap (4) are I.D. machined after matching, matching must not be changed.

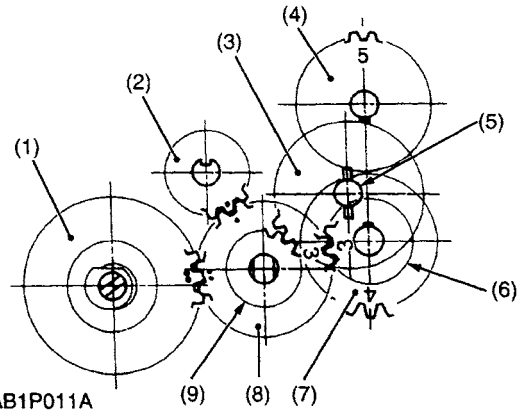
The crank pin bearing (3) is a split type, and made of copper-lead alloy (called Kelmet) (with a mild steel back metal). The surface is tin plated to obtain a better initial fit.

The piston pin bushing (1) is made of lead bronze (with a mild steel back metal) which has the most excellent shock resistance, load resistance and heat resistance. The surface is tin plated.

(1) Piston Pin Bushing
(2) Connecting Rod
(3) Crank Pin Bearing
(4) Connecting Rod Cap

0000009712E

## [7] TIMING GEAR




3EDAAAB1P011A

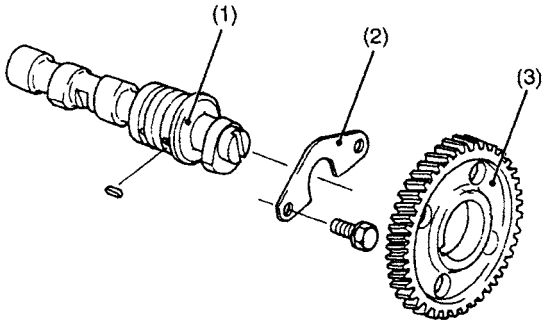
The timing gears consisting of the crank gear (2), cam gear (1), starting gears (3) idle gear (8), (9) and balancer gears (6), (7) serve to correctly control the intake and exhaust valves opening, closing timing, fuel injection timing and balance movement, etc.

Respective gears are marked with alignment marks to assure correct relative positioning of gears when assembling. For these timing gears, herical gears are used. They smoothly convey rotations with less noise.

(1) Cam Gear
(2) Crank Gear
(3) Starting Gear
(4) Balancer Gear 1
(5) Starting Shaft Pin
(6) Balancer Gear 1
(7) Balancer Gear 3
(8) Idle Gear (45T)
(9) Idle Gear (21T)

0000009713E

## [8] CAMSHAFT




3EDAAAB1P012A

The camshaft is made of carbon steel forging and its cam and journal faces are induction hardened.

The oval-shaped cam improves intake efficiency and at the same time reduces noise.

On the camshaft, the cam gear (3) is installed.

The camshaft is provided with an intake and exhaust cam to actuate the intake and exhaust valves. In addition, a groove is machined at the tip of the camshaft to drive the trochoid pump for lubrication.

(1) Camshaft
(2) Camshaft Stopper
(3) Cam Gear

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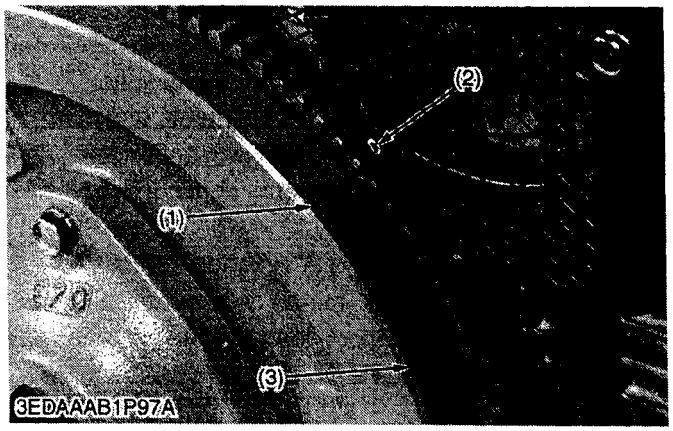
## [9] FLYWHEEL




The flywheel stores the rotating force in the combustion stroke as inertial energy, reduces crankshaft rotating speed fluctuation and maintains the smooth rotating conditions.

On the circumference of the flywheel are stamped the top dead center "**T**" mark and four lines indicating every 0.035 rad. (2 °) of crank angle from 0.35 rad. (20 °) to 0.42 rad. (28 °) before mark "**T**".

On the NB type, ring gears are press-fitted into the periphery inside the flywheel to allow the engine to be started withe a starter.

(1) Fuel Injection Timing Line
(2) Fan Cover Mark
(3) T.D.C. Mark (**T**)

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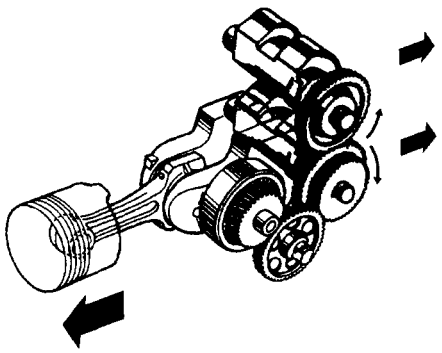
# [10]DYNAMIC BALANCER



3EDAAAB1P013A

The engine has a dynamic balancer (biaxial balancer) to offset primary force caused by the reciprocating motion of the piston. This significantly reduces engine vibration and resultant vibrating noises.

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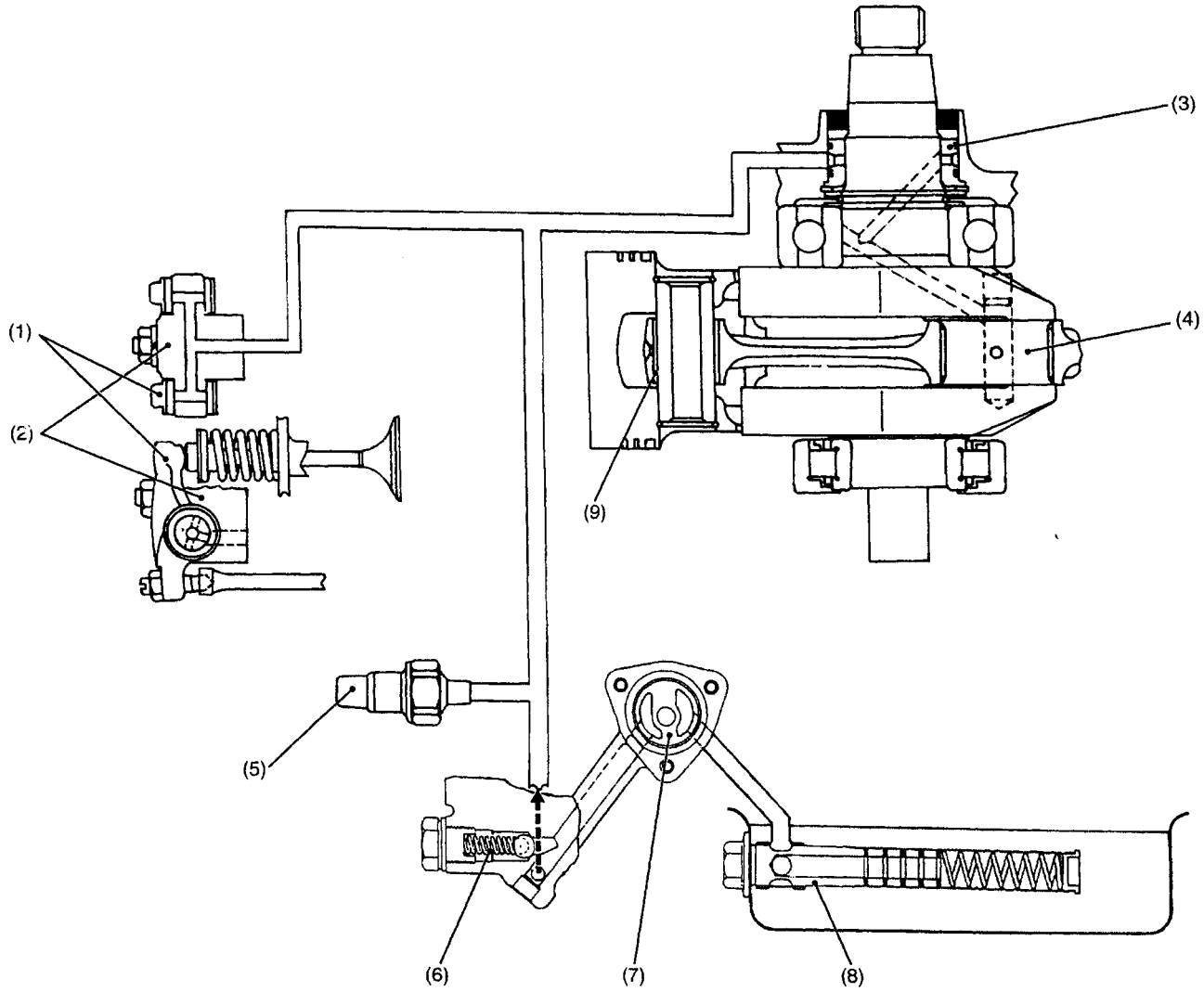
# 3. LUBRICATING SYSTEM

## [1] GENERAL




3EDAAAB1P014A

(1) Rocker Arm
(2) Rocker Arm Bracket
(3) Oil Filler Ring
(4) Crank Pin Portion
(5) Oil Signal
(6) Relief Valve
(7) Trochoid Pump
(8) Oil Strainer
(9) Piston Pin Bushing

Lubrication is forced on with a trochoid pump.

Lubrication oil is sucked in by the trochoid pump (7) via an oil strainer (8) mounted on the side of the gear case. The pressure of lubricating oil discharged from the trochoid pump is regulated by a relief valve (6) to 196 to 392 kPa (2.0 to 4.0 kgf/cm$^2$, 28 to 57 psi) (at the rated revolution speed of the engine), and the pressure-regulated oil is then fed to various portions through the oil gallery in the cylinder block.

Lubricating oil sent to the oil gallery in the crankshaft lubricates the crank pin portion (4).

Oil sent to the cylinder head via the oil gallery in the cylinder block lubricates rocker arms (1) via a rocker arm bracket (2).

Other items such as the piston, piston pin bushing (9), cam shaft journal portion, tappet, timing gear and bearings are lubricated by splash of the crankshaft, etc.

An oil signal (5) is provided to enable the judgement whether the oil pressure is 49 kPa (0.5 kgf/cm$^2$, 7 psi) or more.

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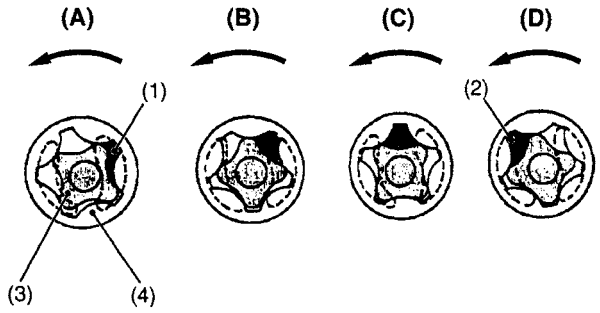
## [2] OIL PUMP




3ECAAAB1P111B

The oil pump is of trochoid pump type, whose rotors have trochoid lobes. The inner rotor (3) has 4 lobes and the outer rotor (4) has 5 lobes, and they are eccentically engaged with each other. The inner rotor, which is driven by the crankshaft through the gears, rotates the outer rotor in the same direction, varying the spaces between the lobes.

While the rotors rotate from **A** to **B**, the space leading to the inlet port increases, which causes the oil to flow through the inlet port.

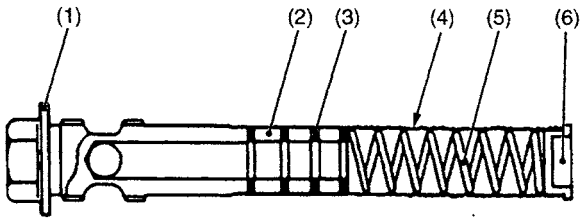
When the rotors rotate to **C**, the port to which the space leads is changed from inlet to outlet.

At **D**, the space decreases and sucked oil is discharged from the outlet port.

(1) Inlet
(2) Outlet
(3) Inner Rotor
(4) Outer Rotor

0000009718E

## [3] OIL STRAINER




3ECAAAB1P008B

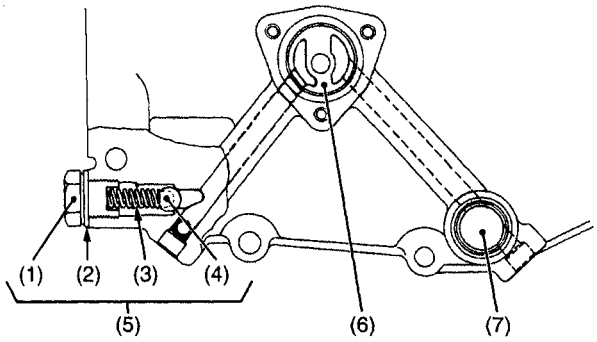
Entry of foreign material such as iron chips, dirt, etc. into the lubricating system may damage the lubricated parts. To prevent this, an oil strainer is equipped prior to the oil pump. This strainer has a double wound stainless steel net (50 meshes) at the outside, and four magnets (2) are mounted inside.

This stainless steel net (screen (4)) removes small dirt in the lubricating oil. Further, fine iron chips passing through this net are attracted by these magnets to prevent them from entering the lubricating system.

(1) Plug
(2) Magnet
(3) Spacer
(4) Stainless Steel Net
(5) Spring
(6) End Plate

0000009719E

## [4] RELIEF VALVE




3EDAAAB1P015A

The relief valve consists of ball (4), spring (3), and plug (1), which holds them, and is built into the lower part of the gear case.

The relief valve (5) is used to adjust the lubricating oil pressure to a proper level (196 to 392 kPa, 2.0 to 4.0 kgf/cm$^2$, 28 to 57 psi).

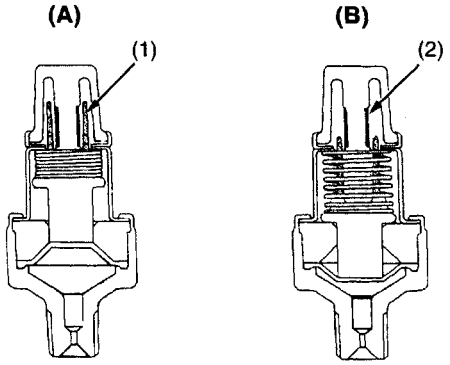
The oil which has passed through the relief valve falls to the cylinder block.

If this regulated pressure is too low, the delivery of lubricating oil to various portions will become deficient and may cause seizure. Too high oil pressure may cause oil leakage.

(1) Plug
(2) Gasket
(3) Spring
(4) Ball
(5) Relief Valve
(6) Trochoid Pump
(7) Oil Strainer

0000009720E

## [5] OIL SIGNAL




3EDAAAB1P016A

The oil signal is mounted to the cylinder block to warn the operator that the lubricating oil pressure is poor.

At engine stop and at unusually low pressure (Less than 49 kPa, 0.5 kgf/cm$^2$, 7 psi), the red indication (2) is displayed.

When the oil pressure is normal (49 kPa, 0.5 kgf/cm$^2$, 7.0 psi or more), the blue signal (1) is pushed out by means of the oil pressure.

(1) Blue Signal
(2) Red Indication
**(A) At Proper Oil Pressure**
**(B) At Low Oil Pressure**

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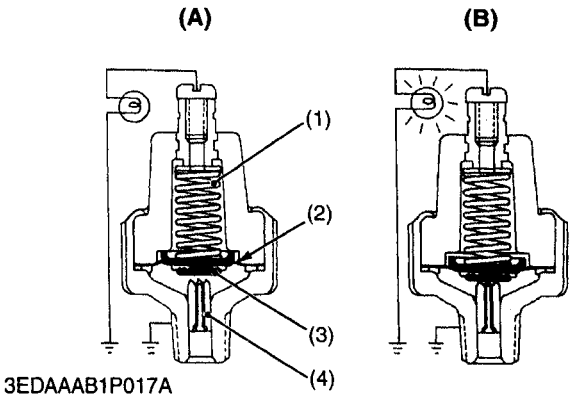
## [6] OIL PRESSURE SWITCH




3EDAAAB1P017A

While oil pressure is high and the force applied to the diaphragm (2) is larger than the spring tension, the terminal contact (3) is separated from the body contact (4).

If the pressure drops below 49 kPa (0.5 kgf/cm$^2$, 7.1 psi), the contact closes.

(1) Spring
(2) Diaphragm
(3) Terminal Contact
(4) Body Contact
**(A) At Proper Oil Pressure**
**(B) At Low Oil Pressure**

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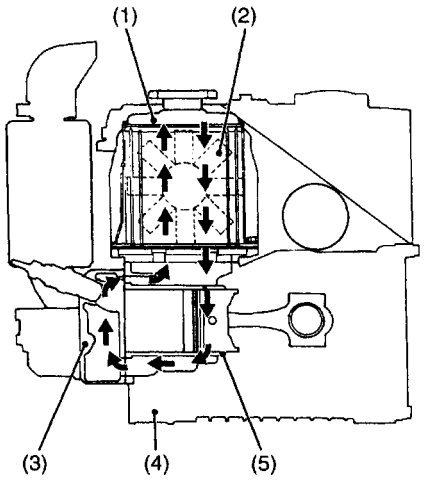
# 4. COOLING SYSTEM

## [1] GENERAL




3EDAAAB1P018A

This engine employ a pressurized radiator natural convection cooling system.

Cooling by the radiator (1) and radiator fan (2) increases in specific gravity. And it absorbs combustion heat of the cylinder liner (5) and cylinder head (3) and friction heat generated from moving parts to cool them.

Then, cooling water moves upward, as the water absorbs heat and decreases in specific gravity.

The heated water is cooled again by the radiator. Thus, the cooling water circulates naturally to cool the engine.

(1) Radiator
(2) Radiator Fan
(3) Cylinder Head
(4) Cylinder Block
(5) Cylinder Liner

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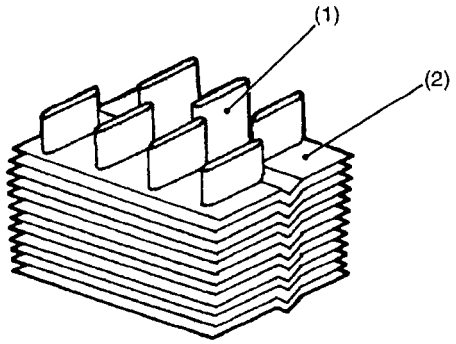
## [2] RADIATOR




3EDAAAB1P177A

The radiator adopted is of a plate fin type which is durable and resistant to pressure, and has good heat transfer proper ties. As it passes through the radiator core, cooling water is cooled by air from outside, and is again circulated to the engine body.

The radiator core is composed of a tube (1), through which water flow, and cooling fins (2). Both of the components are formed of thin copper plate, etc. which gives good heat transfer. Cooling air passing between the fins helps cooling water in the tube to give off heat.

(1) Tube
(2) Cooling Fin (Waved Plate Fin)

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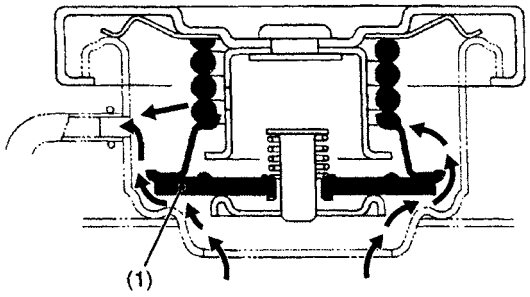
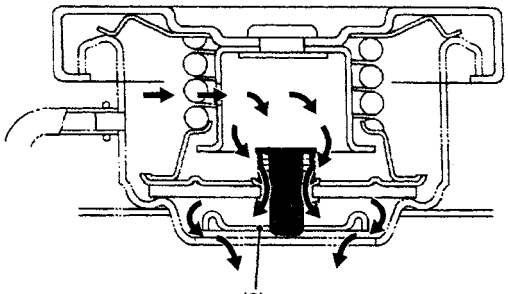
# [3] RADIATOR CAP

[A]




3EDAAAB1P019A

[B]




3EDAAAB1P020A

Radiator Cap Function

**■ When Radiator Pressure is High**

When temperature increases inside the radiator, there is expansion of water followed by conversion of water to steam as the temperature continues to increase.

The pressure valve is designed to prevent internal pressure rising above specified opening pressure (108 kPa, 1.1 kgf/cm$^2$, 16 psi) in order to protect the radiator, therefore, the pressure valve opens allowing steam to escape, as shown in the figure.

An additional function of the radiator cap is to prevent foam forming inside the engine and to restrict the loss of cooling water resulting from temperature increase.

**■ When Radiator Pressure is Negative**

When the temperature of the cooling water decreases, internal pressure becomes negative as a result of water contraction. In this situation, the vacuum valve opens allowing the entry of air and a return to atmospheric pressure, thereby preventing distortion of the radiator.

(1) Pressure Valve
(2) Vacuum Valve
**[A] At High Pressure**
**[B] At Negative Pressure**

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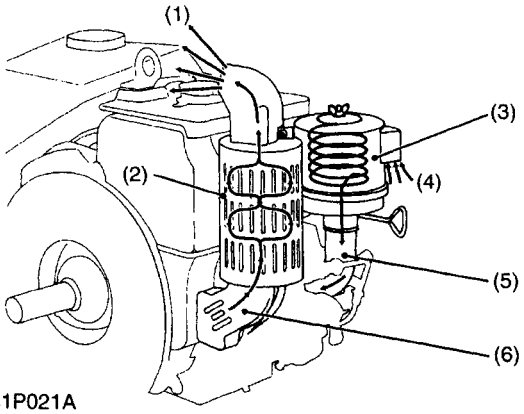
# 5. INTAKE / EXHAUST SYSTEM

## [1] GENERAL




3EDAAAB1P021A

The intake / exhaust system consists of an intake system to supply clean air into the cylinder and an exhaust system to reduce exhaust noise.

The intake system consists of an air cleaner (3) and an inlet pipe (5). The air cleaner prevents dust and dirt in the air (4), or raindrops from entering into the cylinder and the inlet pipe directs clean, filtered air into the cylinder. The exhaust system consists of a muffler flange (6) that directs exhaust gas (1) from the cylinder collectively into the muffler (2), and muffler to reduce exhaust noise.

(1) Exhaust Gas
(2) Muffler
(3) Air Cleaner
(4) Intake Air
(5) Inlet Pipe
(6) Muffler Flange

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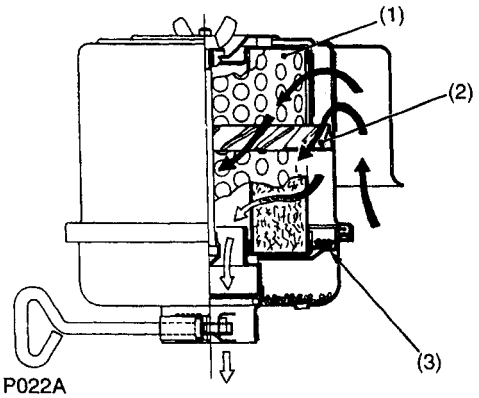
## [2] AIR CLEANER




3EDAAAB1P022A

The air cleaner is a dry type. The air enters it from the periphery of the element (1), and the air is turned into a cyclone swirl by the impeller (2) to separate coarse dust particles centrifugally from the air. As the air passes the element, remaining dust is removed from the air, and the clean air is sucked into the cylinder from the center.

(1) Element
(2) Impeller
(3) Dust Guide

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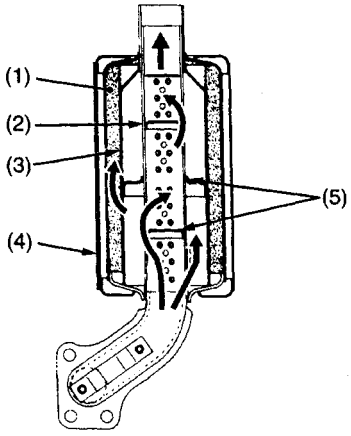
## [3] MUFFLER




3EDAAAB1P023A

The muffler consists of the perforated inner tube (2) and outer tube (3), glass wool (1), main body (4), etc. The inner and outer tube baffle plates (5) effectively dampen exhaust noises. The glass wool placed between the outer tube and main body, absorb higher frequency of exhaust noises.

(1) Glass Wool
(2) Inner Tube
(3) Outer Tube
(4) Main Body
(5) Baffle Plate

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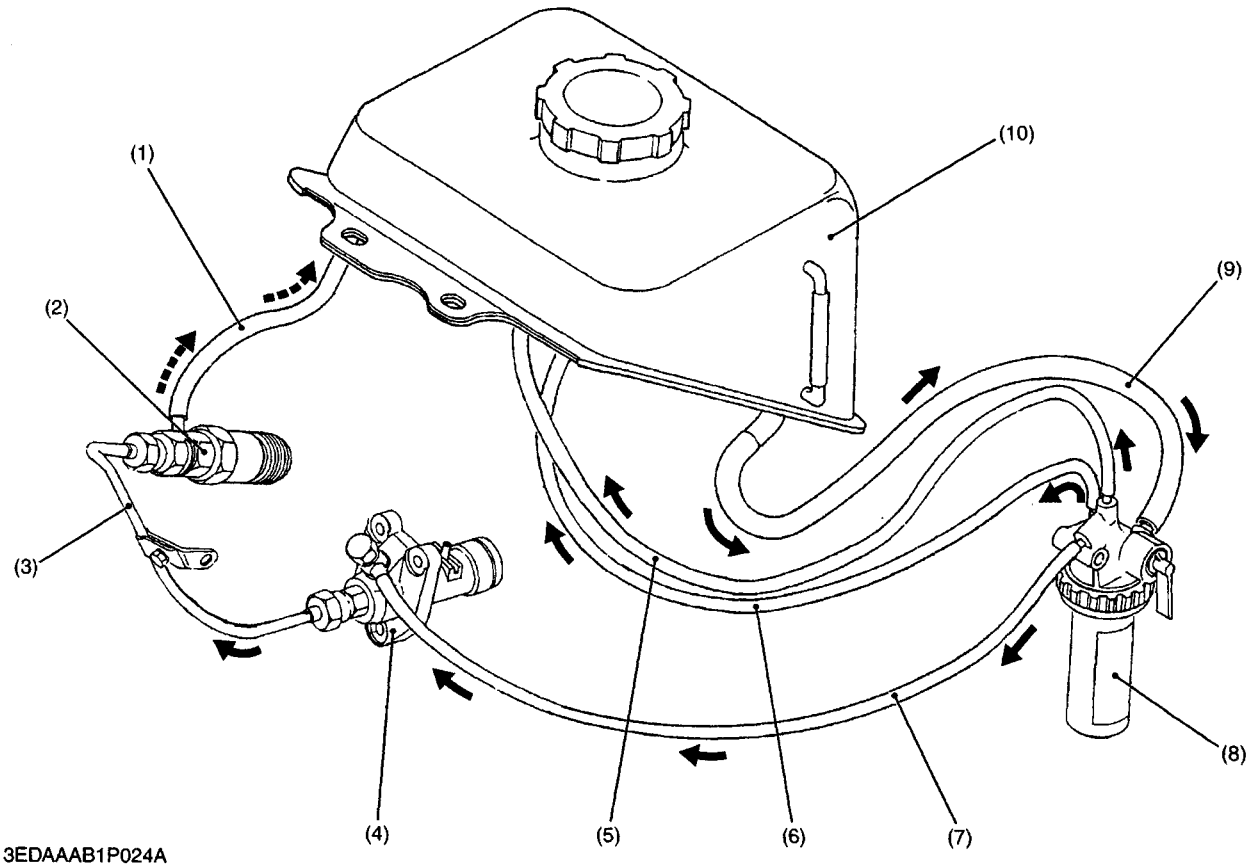
# 6. FUEL SYSTEM

## [1] GENERAL




3EDAAAB1P024A

| | | | |
|---|---|---|---|
| (1) Fuel Overflow Pipe | (4) Injection Pump | (7) Fuel Pipe 2 | (9) Fuel Pipe 1 |
| (2) Injection Nozzle | (5) Air Vent Pipe 1 | (8) Fuel Filter | (10) Fuel Tank |
| (3) Injection Pipe | (6) Air Vent Pipe 2 | | |

Fuel from the fuel tank (10) passes through the fuel filter (8), and then enters the injection pump (4) after impurities such as dirt, water, etc. are removed.

The fuel pressurized by the injection pump to the opening pressure (13.73 to 14.22 MPa, 140 to 150 kgf/cm$^2$, 1991 to 2062 psi), of the injection nozzle (2) is injected into the combustion chamber.

Part of the fuel fed to the injection nozzle (2) lubricates the moving parts of the plunger inside the nozzle, then returns to the fuel tank through the fuel overflow pipe (1) from the upper part of the nozzle holder.

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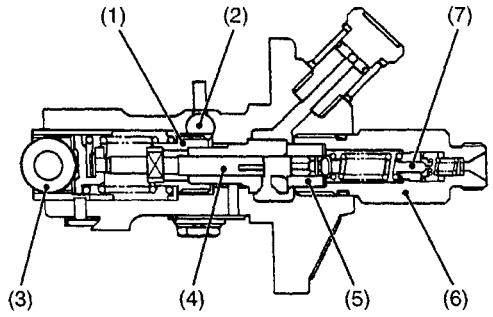
# [2] INJECTION PUMP




3EDAAAB1P025A

A Bosch M type mini pump is used for the injection pump. It is small, lightweight and easy to handle.

The plunger (4) with a left-hand lead reciprocates via the tappet roller (3) by means of the camshaft fuel cam, causing the fuel to be delivered into the injection nozzle.

The fuel in the fuel chamber is drawn into the delivery chamber when the plunger lowers. When the plunger rises, delivery valve (5) is pushed open to force into the injection nozzle.

The control rack (2) is actuated by the governor, and the control rack movement is transmitted to the control sleeve (1). As a result, the plunger rotates to vary the amount of fuel fed into the injection nozzle.

When the speed control lever is set to the stop position, the fuel is not pressurized, and is not injected since the feed hole meets with the control groove.

(1) Control Sleeve
(2) Control Rack
(3) Tappet Roller
(4) Plunger
(5) Delivery Valve
(6) Delivery Valve Holder
(7) Dumping Valve

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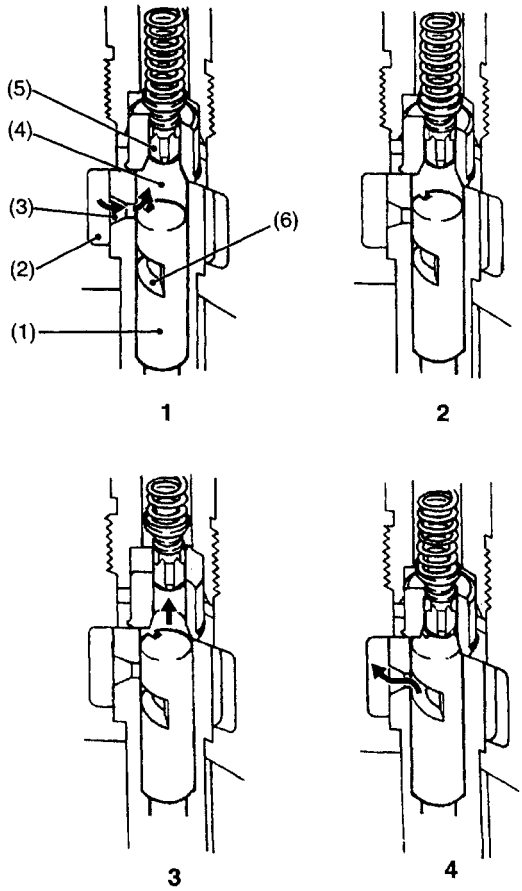


3EDAAAB1P178A

## ■ Fuel Pressure-feed Stroke to Injection Nozzle

### 1. Fuel Suction

The fuel fed into fuel chamber (2) by the action of the fuel feed pump when plunger (1) is down is drawn into delivery chamber (4) after passing through feed hole (3).

### 2. Fuel Pressure-feeding Commencement

When plunger (1) rises, the surface of the plunger head blocks feed hole (3) and the pressure inside delivery chamber (4) increases thereby raising delivery valve (5) and fuel commences to be pressure-feed into the nozzle.

### 3. During Fuel Pressure-feeding

The plunger continues to rise and pressure-feeding of fuel continues.

### 4. Conclusion of Fuel Pressure-feeding

The plunger continues to rise even further and control groove (6) on the outer periphery of the plunger reaches the feed hole, fuel then passes from delivery chamber (4) through the control groove and returns to fuel chamber (2) after passing once again through feed hole (3).

(1) Plunger
(2) Fuel Chamber
(3) Feed Hole
(4) Delivery Chamber
(5) Delivery Valve
(6) Control Groove

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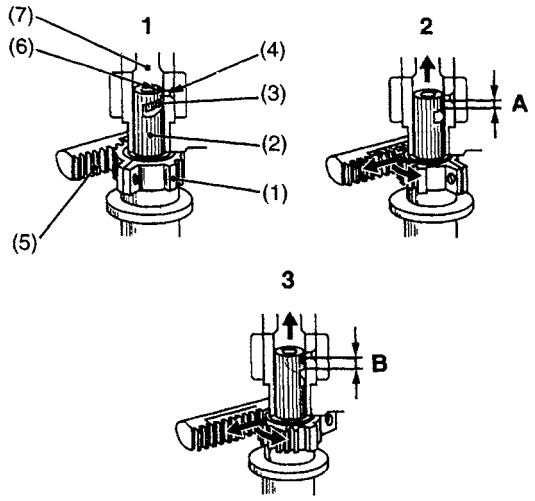


3EEAAAA1P058B

## ■ Regulating Fuel Injection

### 1. No Fuel Delivery....Engine Stopped

When the control rack (5) is set at the engine stop position, the plunger (2) is rotated to a position where the vertical slot (6) in the plunger (2 aligns with the feed hole (4). Since the vertical slot prevents the feed hole from being covered, pressure in the delivery chamber (7) cannot build up. Therefore, no fuel can be forced to the injection nozzle.

### 2. Fuel Injection....Small to Medium

When the plunger rotates in the direction of the arrow by the action of the control rack (as shown in the figure) and after the head-section of plunger (2) closes off feed hole (4), the quantity of fuel in the effective stroke **A** (the section of strode up until control groove (3) reaches the feed hole) is fed to the nozzle and injected.

### 3. Fuel Injection....Maximum

When the control rack has moved maximum distance in the direction of the arrow, effective stroke **B** of the plunger is at its maximum, consequently, fuel injection is also at maximum.

| | | | |
|---|---|---|---|
| (1) | Control Sleeve | (6) | Vertical Rack |
| (2) | Plunger | (7) | Delivery Chamber |
| (3) | Control Groove | | |
| (4) | Feed Hole | **A:** | **Effective Stroke (Small)** |
| (5) | Control Rack | **B:** | **Effective Stroke (Large)** |

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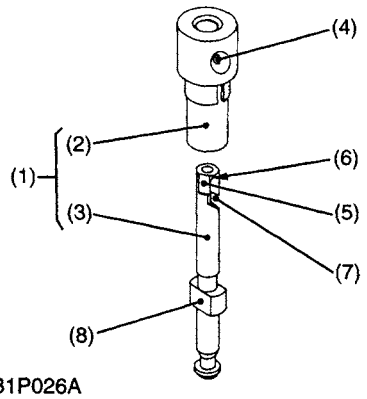


3EDAAAB1P026A

#### 1) Pump Element

The pump element (1) consists of the plunger (3) and the cylinder (2). Their sliding surfaces are super-precision finished to maintain a sufficient injection pressure at low speeds.

The driving face (8) goes inside the control sleeve, and moves the control rack. As a result, the plunger (3) is turned and increases or decreases the fuel injection rate accordingly.

As explained earlier, the plunger is provided with a control groove (7), a notch (5) for stopping and a speed advance lead (6). The control groove is a left-hand lead.

| | | | |
|---|---|---|---|
| (1) | Pump Element | (5) | Notch for Stopping |
| (2) | Cylinder | (6) | Speed Advance Lead |
| (3) | Plunger | (7) | Control Groove |
| (4) | Feed Hole | (8) | Driving Face |

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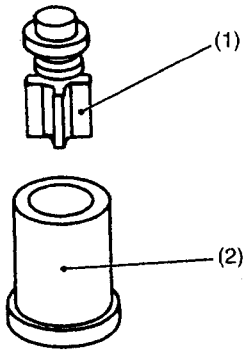


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### 2) Delivery Valve

The delivery valve consists of the relief valve (1) and delivery valve seat (2).

(1) Relief Valve (2) Delivery Valve Seat

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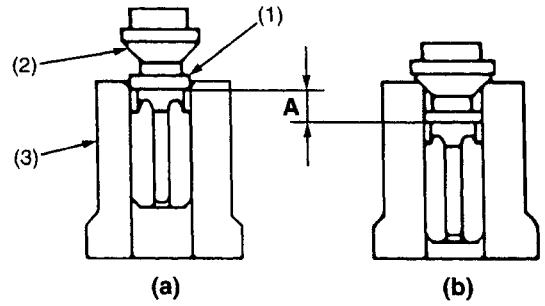


3ECAAAB1P014B

## ■ Delivery Valve Operation

### Non-return Function

Time delay from the beginning of pressure-feeding of the pump element to the beginning of nozzle feed-injection becomes large when the delivery chamber of the pump and the injection nozzle are in alignment and the cut-off of fuel is also delayed. Then, simultaneously with the completion of the pressure-feeding of fuel, the delivery valve descends as a result of the action of the delivery valve spring thereby forming a cut-off between the delivery chamber and the injection pipe preventing any reverse flow of fuel.

### Reverse Suction Function (Dripping Prevention)

1. When the pressure-feeding of fuel ends, the delivery valve lowers and relief valve (1) section comes into contact with the valve seat.
2. Furthermore, the valve descends until seat surface (2) is in contact with delivery valve seat (3) but as the amount of fuel during interval **A** is sucked back from inside the injection pipe, pressure within the pipe is reduced giving improved cut-off of fuel injection by the nozzle, thereby preventing subsequent dripping of the injectors.

(1) Relief Valve
(2) Seat Surface
(3) Delivery Valve Seat
(3) Delivery Valve Seat
**(a) Non-return Function**
**(b) Reverse Section Function (Dripping Prevention)**

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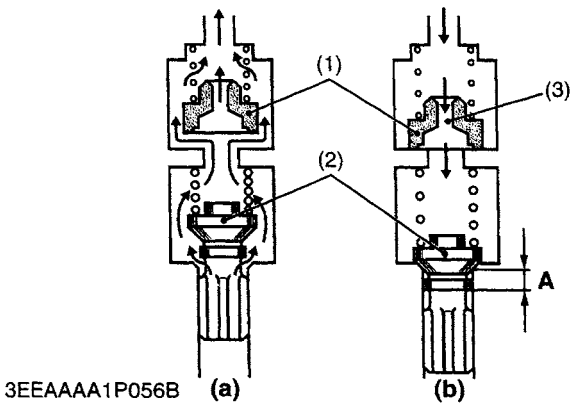

3EEAAAA1P056B

■ **Dumping Valve**

**At Fuel Injection**

Since dumping valve is pushed up to press the spring, fuel is pressure-fed to injection nozzle the same as without dumping valve.

**At Suck-Back**

At suck-back by delivery valve after fuel injection, fuel returns through dumping valve orifice. Generally second injection is apt to occur by reflex pressure due to reaction of sudden pressure drop when changing into suck-back by delivery valve from high injection pressure. As a result of preventing this second injection perfectly by dumping valve and dissolving nozzle clogging, durability of injection nozzle is improved.

(1) Dumping Valve
(2) Delivery Valve
(3) Orifice

**(a) At Fuel Injection**
**(b) At Suck-Back**

**A: Suck-back Stroke**

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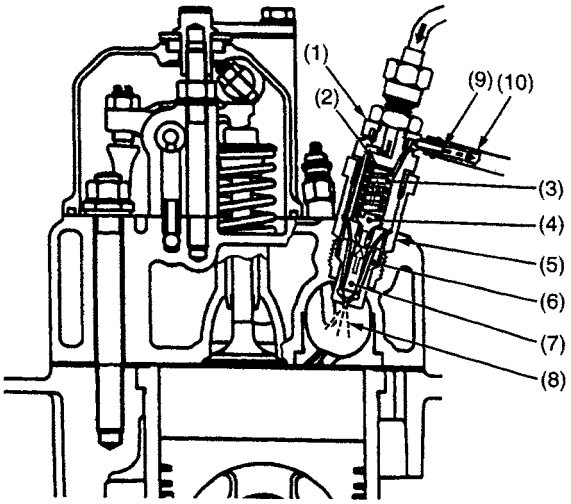
# [3] INJECTION NOZZLE



3EDAAAB1P122A

Since the nozzle is a throttle type, only a small amount of fuel is injected at the initial stage of injection, and the amount increases gradually until a full amount is injected. As a result, combustion starts up more smoothly with less noise. Fuel pressurized by the injection pump pushes up needle valve (7), and as a result, fuel is injected into the combustion chamber.

The injection pressure is adjusted to opening pressure values in the table below.

If the pressure drops and adjustment is necessary, a shim must be inserted between nozzle holder body (1) and adjustment washer (2). Increases of approximately 981 kPa (10 kgf/cm$^2$, 142 psi) will occur with shim thicknesses of 0.1 mm (0.004 in.).

As these components are precision-machined like the nozzle and pump, adequate care must be taken to prevent entry of water or foreign matter.

(1) Nozzle Holder Body
(2) Adjustment Washer
(3) Nozzle Spring
(4) Push Rod
(5) Retaining Nut
(6) Nozzle Body
(7) Needle Valve
(8) Combustion Chamber
(9) Eye-tube Joint
(10) Overflow Pipe

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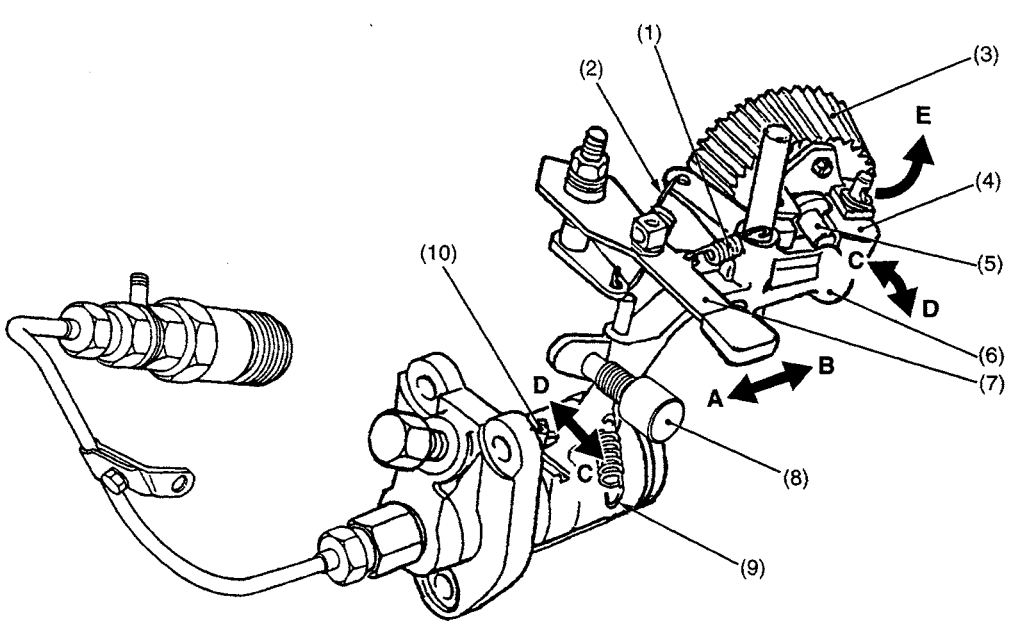
# [4] GOVERNOR MECHANISM




(1) Governor Spring
(2) Stop Spring
(3) Crank Gear
(4) Governor Weight
(5) Governor Shaft
(6) Governor Lever
(7) Speed Control Lever
(8) Fuel Limiter
(9) Idling Spring
(10) Control Rack

3EDAAAB1P027A

The governor maintains the constant engine speed and at the same time controls the output. The centrifugal mechanical governor used in this engine is an all-speed type which controls engine speed at any point between idling and maximum speed positions.

### ■ At Starting

When the speed control lever (7) is moved in the direction **A**, the governor lever (6) is pulled in the direction **C** by the force the governor spring (1). At this time, the governor weight (4) has no active centrifugal force, since the engine is not rotating. Thus, the control rack (10) moves to the maximum fuel injection position to facilitate starting of the engine.

### ■ At Idling

When the speed control lever (7) is set in the idling position, the governor spring (1) is almost relaxed and the idling spring (9) of small tension alone is at work. This idling spring works in the direction **C** (to increase fuel supply). To the contrary, the governor weight (4) extends by the centrifugal force in the direction of **E** to push the governor shaft (5) and in turn move the governor lever (6) in the direction of **D** (to decrease the fuel supply). The engine will idle in a condition in which the two forces are balanced with each other.

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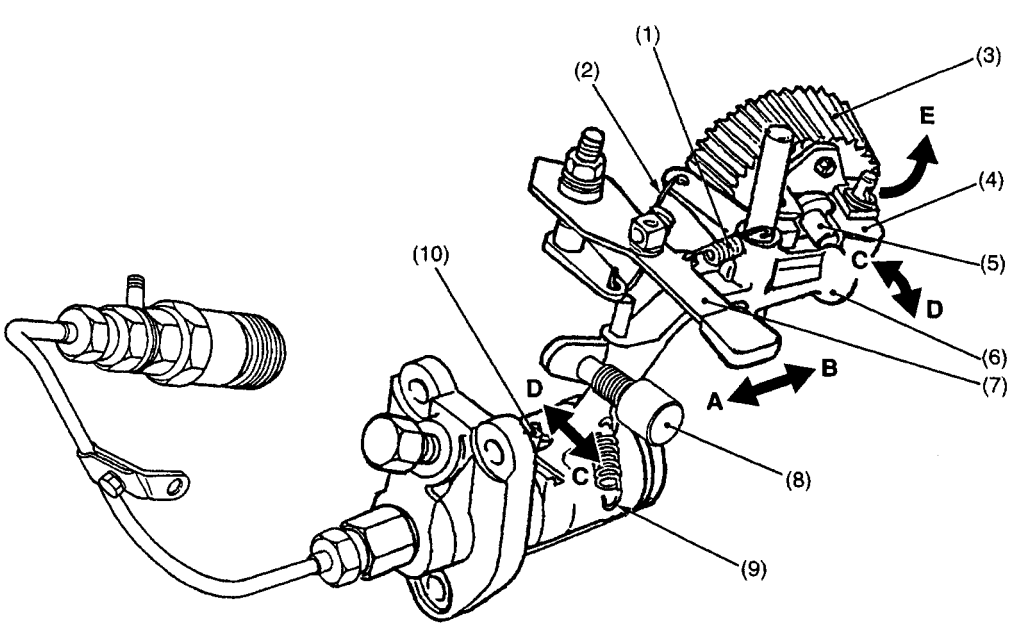


(1) Governor Spring
(2) Stop Spring
(3) Crank Gear
(4) Governor Weight
(5) Governor Shaft
(6) Governor Lever
(7) Speed Control Lever
(8) Fuel Limiter
(9) Idling Spring
(10) Control Rack

3EDAAAB1P027A

### ■ At Idling to Maximum Speeds

When the engine rotates at idling to maximum speeds, engine rotates at a constant speed at the point where the governor spring tension and the governor weight's centrifugal force are well balanced. If the load is increased, the engine speeds down and the centrifugal force of the governor weight (4) becomes smaller, so that the control rack (10) is moved in the direction C in which fuel is increased to restore the original speed. In this way, the engine speed is automatically controlled for a constant revolution.

### ■ At Maximum Engine Speed

When the speed control lever (7) is moved in the direction **A**, the governor weight (4) is at the maximum centrifugal force, with the governor lever (6) contacting the fuel limiter (8). As the load becomes large, the speed is reduced, decreasing the governor lever pushes the fuel limiter (the limiter contains a spring) and moves in the direction **C**. Thus, the control rack (10) is placed at the maximum fuel injection position, producing the maximum engine output power.

### ■ At Engine Stop

When the speed control lever (7) is moved fully in the direction **B** to the stop position, arm pushes the governor lever pin to move the governor lever (6) in direction **D**, thus the control rack (10) is set to the stop position (No fuel injection) and the engine stops.

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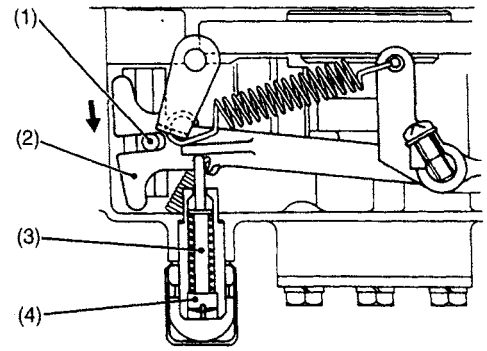


3EDAAAB1P029A

Fuel Limiter Apparatus Construction

At starting and maximum power point, the governor lever (2) of the fuel limiter pushes the pin (3), which touches the lock screw (4) and stops. As a result, the control rack (1) moves to the position at which point the largest amount of fuel is injected.

(1) Control Rack
(2) Governor Lever
(3) Pin
(4) Lock Screw

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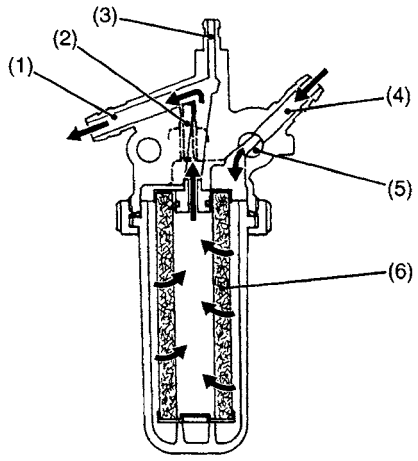
## [5] FUEL FILTER




3EDAAAB1P028A

Each moving part of the injection pump and nozzle is extremely precision machined, and clearances of their sliding parts are extremely small. Fuel itself serves as lubricating oil. For this reason, it is extremely important to completely remove water and dirt contained in fuel.

This fuel filter, which uses very fine filter paper, serves to separate and filter dirt in fuel and water accumulated in the tank.

After passing through the filter element (6) from outside to the center of the filter, the fuel flows to the injection pump from the fuel outlet port (1).

When the filter element (6) is replaced, or the pipe is removed, or air enters together with fuel, air is automatically bled from the air vent port (2), (3).

(1) Fuel Outlet Port
(2) Air Vent Port
(3) Air Vent Port
(4) Fuel Inlet
(5) Fuel Cock
(6) Fuel Element

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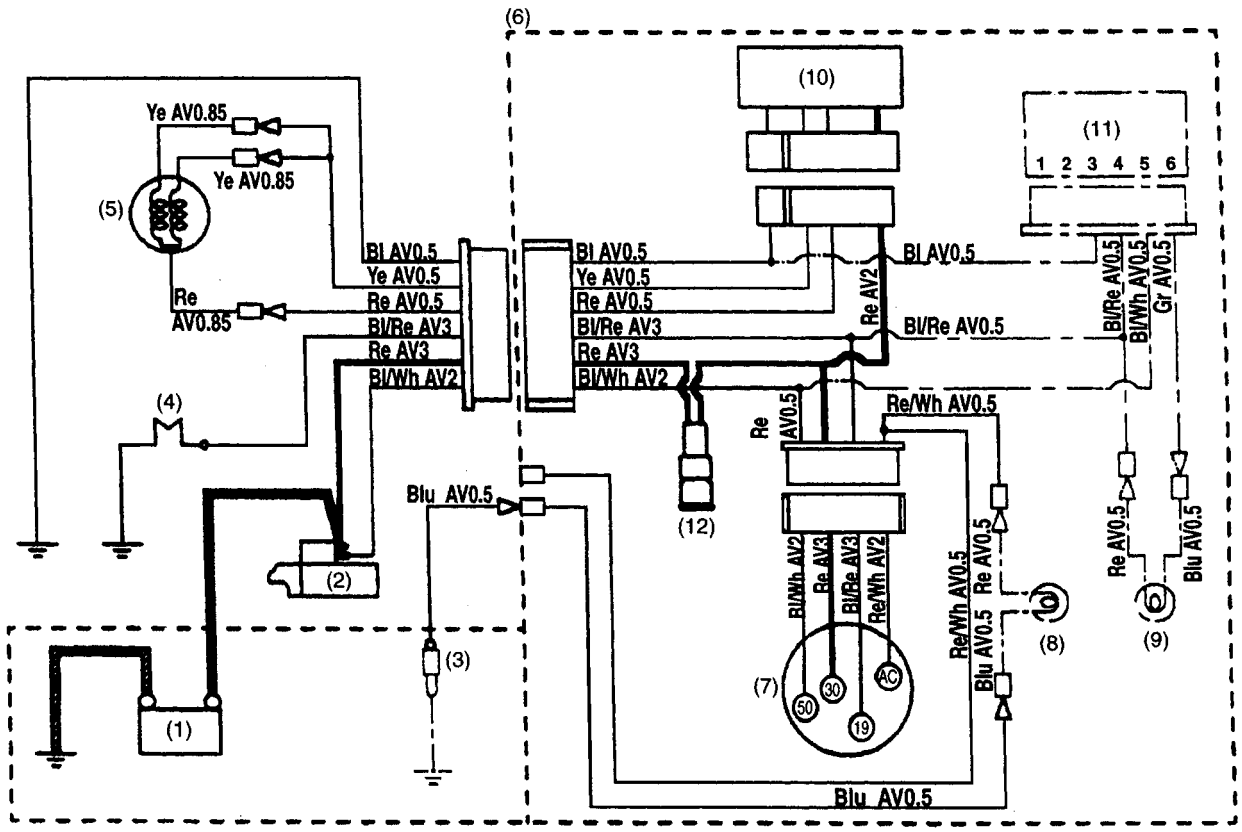
# 7. ELECTRICAL SYSTEM

## [1] GENERAL

### ■ EA300-E2-NB1




3EDAAAB1P030A

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | Battery (option) | (5) | Fan Dynamo | (8) | Oil Lamp | (11) | Glow Lamp Timer |
| (2) | Starter | (6) | Switch Box | (9) | Glow Lamp | (12) | Fuse |
| (3) | Oil Switch (option) | (7) | Starter Switch | (10) | Regulator | | |
| (4) | Glow Plug | | | | | | |

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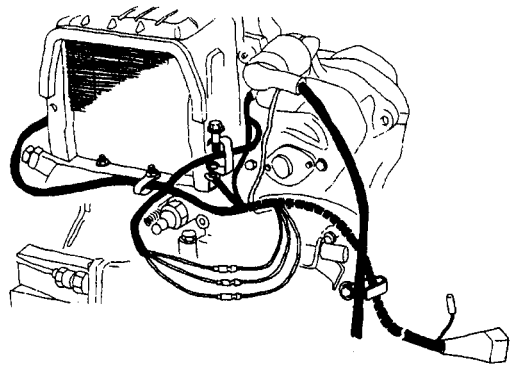

3EDAAAB1P031A

The electrical system of this engine comes equipped with the starter, glow plug, fan dynamo and switch box as standard.

The fan dynamo is a single-phase alternating current generator built in the radiator fan. The rectifier rectifies the single-phase alternating current. When the rectified current voltage is higher than the battery voltage, the battery is charged. When the battery is charged and its voltage exceeds approximately 14V, the zener diode of the current limiter conduct, causing the thyristor to conduct. Thus, current generated at the dynamo is grounded directly through the thyristor, preventing overcharge.

| | |
|---|---|
| Recommendation battery changing capability | 28 to 32 Ah |

■ **NOTE**

- **The thick line — indicates a circuit normally live with 12V.**

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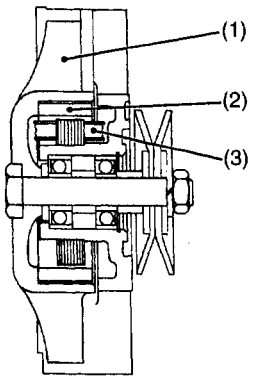
## [2] FAN DYNAMO

**[A]**

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The fan dynamo generates a single-phase alternating current as the permanent magnet (2) which is an integral part of the fan (1) rotates outside the dynamo coil (3) which is fixed.

**Power Generating Performance**

| | |
|---|---|
| EA300-E2-NB1 | 13V 1.6 to 2.6 A<br>(Fan speed: 6950 $min^{-1}$ (r.p.m)) |

(1) Fan
(2) Permanent Magnet
(3) Fan Dynamo

**[A] EA300-E2-NB1**
**EA300-E2-NB1-APU**

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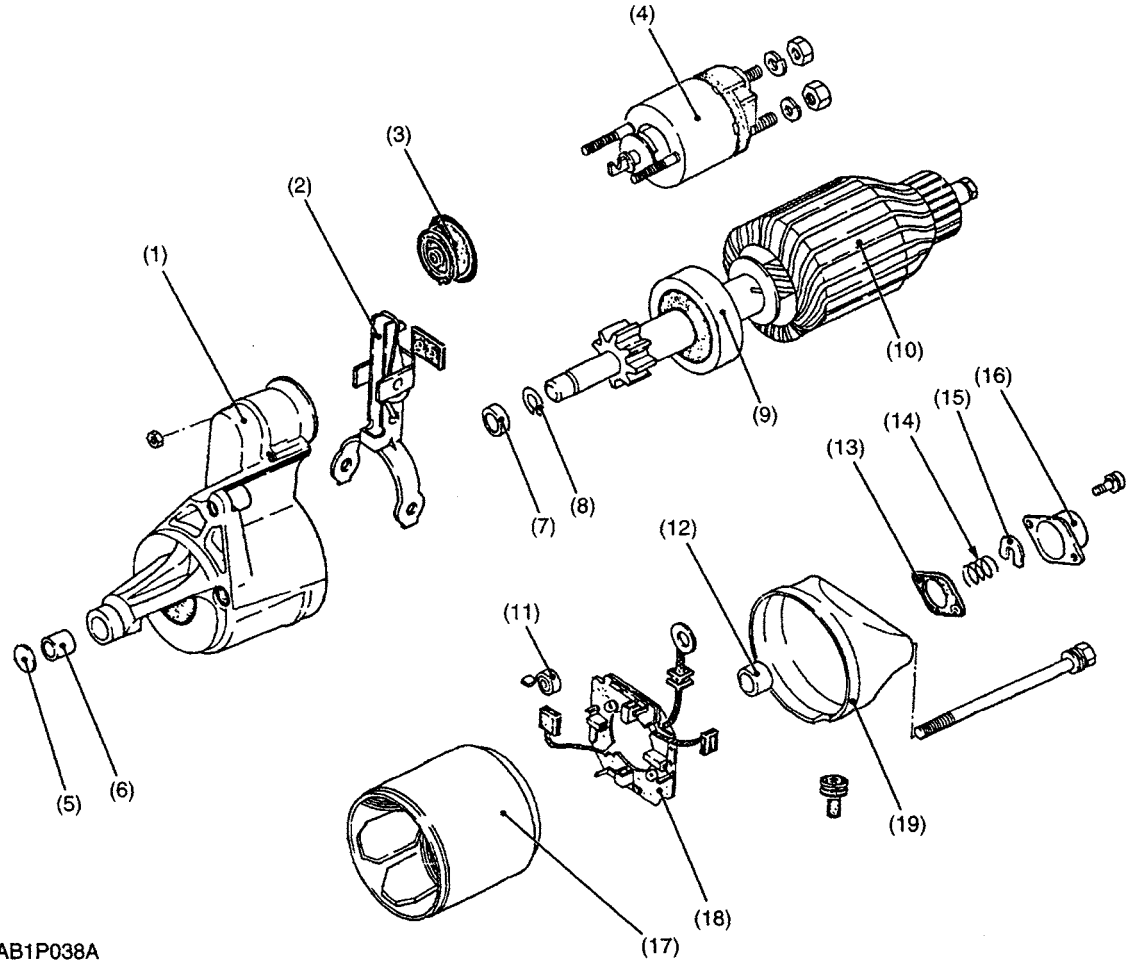
# [3] STARTER

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| | | | |
|---|---|---|---|
| (1) Drive End Frame | (6) Bushing | (11) Brush Spring | (16) End Frame Cap |
| (2) Drive Lever | (7) Collar | (12) Bushing | (17) Yoke |
| (3) Cover | (8) Snap Pin | (13) Gasket | (18) Brush Holder |
| (4) Magnet Switch | (9) Overrunning Clutch | (14) Brake Spring | (19) End Frame |
| (5) Plug | (10) Armature | (15) Brake Shoe | |

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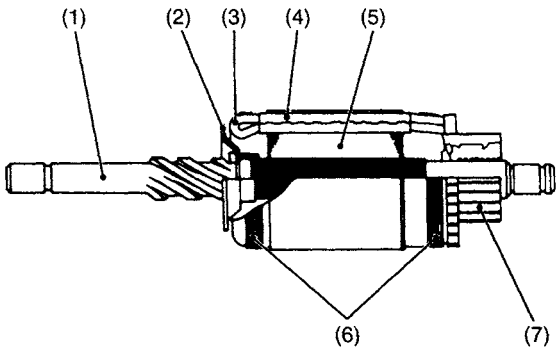
[A]

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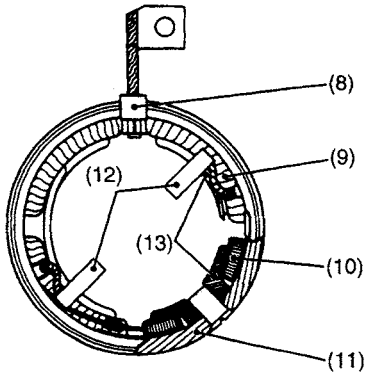
[B]

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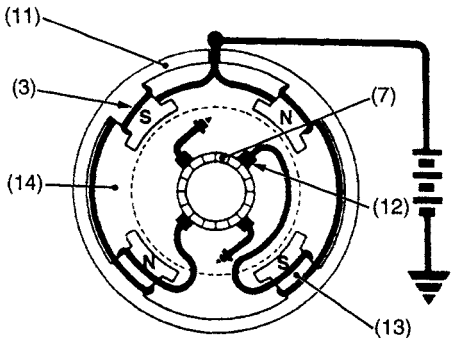
[C]

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### 1) Starting Motor

The starting motor converts the electrical energy into rotary mechanical energy to crank the engine, and is composed of an armature, commutator, field coil, brushes and others.

(1) Armature Shaft
(2) Stopper
(3) Coil
(4) Slot Insulator
(5) Armature Core
(6) Hemp String
(7) Commutator
(8) Rubber Bushing
(9) Cotton Tape
(10) Flat Wire
(11) Yoke
(12) Brush
(13) Pole Core
(14) Armature

**[A] Armature Construction**
**[B] Field Coil and Brush Constructions**
**[C] Motor Circuit**

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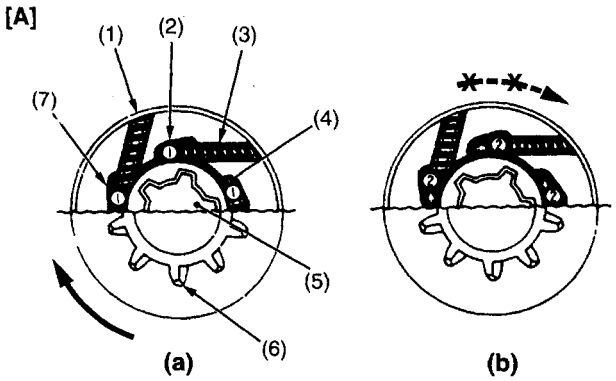


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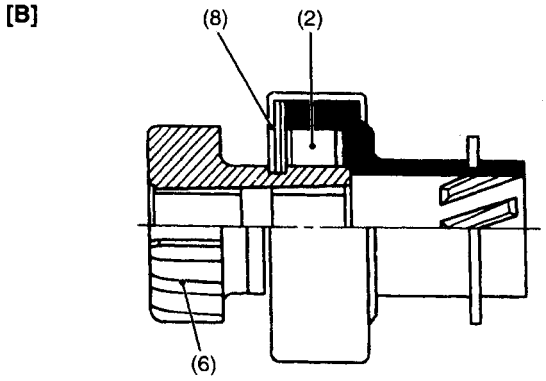


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### 2) Overrunning Clutch

The overrunning clutch prevents the armature from being driven by the rotational force of the engine when the pinion and the engine flywheel ring gear are in mesh.

1. When power is transmitted, the rotational force of the outer clutch gear (1) drives the pinion gear (6) through the roller (2).
2. Even when the pinion gear is driven by the engine flywheel ring gear and its speed exceeds that of the outer clutch gear, the rotation force of the ring gear is not transmitted to the outer clutch gear.

(1) Outer Clutch Gear
(2) Roller
(3) Roller Spring
(4) Inner Spline Tube
(5) Pinion Shaft, Solid with Pinion Gear
(6) Pinion Gear
(7) Locked Position
(8) Clutch Cover

**[A] Overrunning Clutch Operation**
**[B] Overrunning Clutch Construction**

**(a) When Power Is Transmitted**
**(b) Idling Rotation with Shaft Speed Exceeding That of Outer Clutch**

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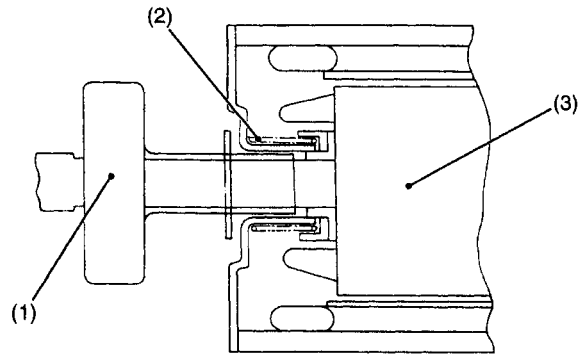


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### 3) Armature Brake

The armature brake stops armature rotation immediately after the starter switch is turned off.

(1) Overrunning Clutch
(2) Brake Spring
(3) Armature
(4) Yoke
(5) Brush Spring
(6) Brush Holder
(7) Brush
(8) Washer
(9) Brake Spring
(10) End Frame
(11) Field Coil

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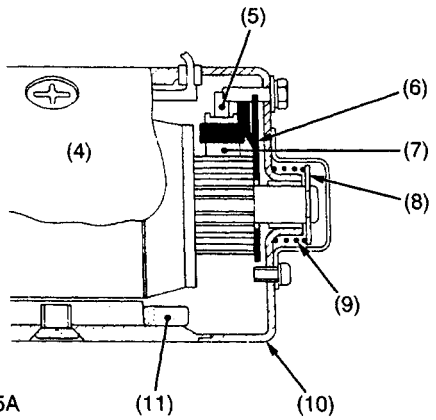


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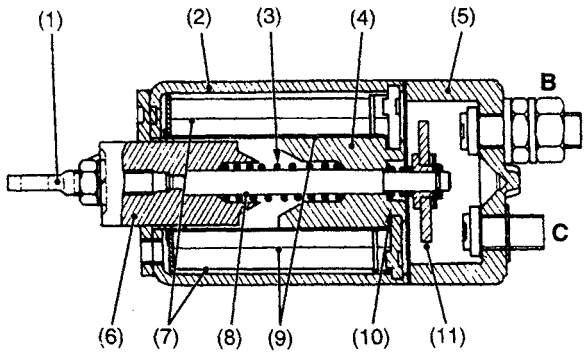
[A]

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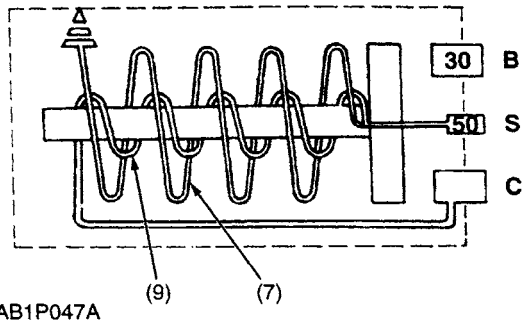
[B]

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**4) Magnet Switch**

The magnet switch serves as a relay to drive the armature. It consists of a pull-in coil, a holding coil and a plunger. It works as follows.

1. When the starter switch is set to **START** position, the armature is rotated at a small amperage as the pull-in coil (9) and the holding coil (7) attract the plunger (6) to the left.
2. When the main circuit from the contact plate (11) to armature is closed by the plunger (6), the armature starts rotating at a strong torque.
   At the same time, a current stops flowing into the pull-in coil and the plunger is kept attracted by the holding coil alone.
3. When the starter switch is released after starting the engine, the flow of a current to the holding coil also stops. Thus, the armature stops rotating.

(1) Joint
(2) Switch Housing
(3) Return Spring
(4) Magnetic Cover
(5) Switch Cover
(6) Plunger
(7) Holding Coil
(8) Plunger Shaft
(9) Pull-in Coil
(10) Spring
(11) Contact Plate

**[A] Magnet Switch Construction**
**[B] Pull-in and Holding Coil**

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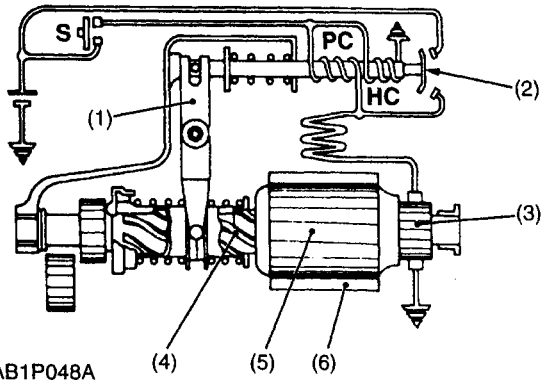


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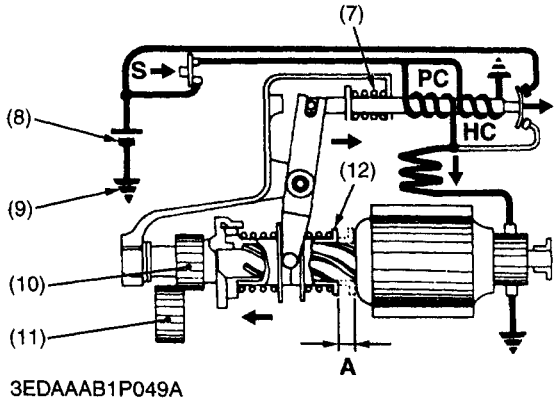


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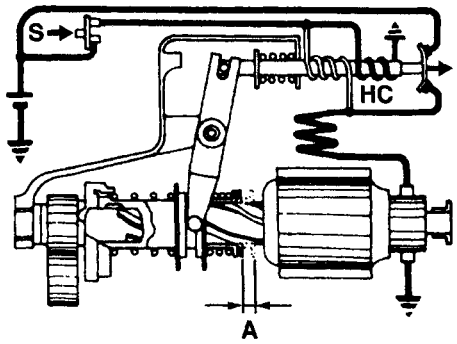


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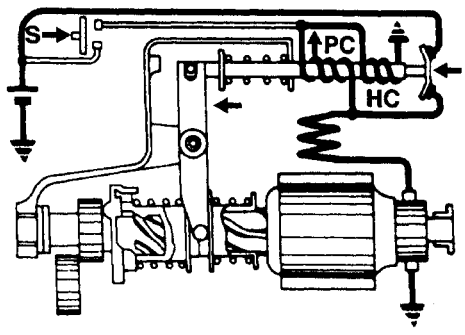


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### 5) Operation of Starter

#### ■ When Starter Switch is Turned to START Position

Current from the battery flows through the pull-in coil and holding coil, producing the magnetism in the windings to pull the plunger in.

At this time, the drive lever moves the pinion to engage with the ring gear.

| | | | |
|---|---|---|---|
| (1) | Drive Lever | **A:** | **Operated by Lever** |
| (2) | Contact Plate | **PC:** | **Pull-in Coil** |
| (3) | Commutator | **HC:** | **Holding Coil** |
| (4) | Screw | **S:** | **Switch** |
| (5) | Armature | | |
| (6) | Pole Core | | |
| (7) | Return Spring | | |
| (8) | Battery | | |
| (9) | Ground | | |
| (10) | Pinion | | |
| (11) | Ring Gear | | |
| (12) | Spline Tube | | |

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#### ■ When Contact Plate is Closed

Large current flows through the motor section to operate the motor.

At this time, the pinion is moved forward by the screw for more contact.

Since the pull-in coil ends are short-circuit by the contact plate, the plunger is held only by the magnetism of the holding coil.

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#### ■ When Starter Switch is Released

Current flows instantaneously through the pull-in coil the opposite direction as shown in figure. Therefore, the magnetic field is collapsed immediately.

As a result, the plunger is returned by the return spring. Simultaneously, the pinion is disengaged from the ring gear, the contact plate is disconnected, and the starter is immediately stopped by the armature brake.

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# CONTENTS

# 1. TROUBLESHOOTING

| Symptom | Probable Cause | Solution | Reference Page |
|---|---|---|---|
| **Engine Does Not Start** | ● No fuel | Replenish fuel | — |
| | ● Air in the fuel system | Vent air | — |
| | ● Water in the fuel system | Replace fuel and repair or replace fuel system | G-8, M-16 |
| | ● Fuel hose clogged | Clean | — |
| | ● Fuel filter clogged | Clean | G-8 |
| | ● Excessively high viscosity of fuel or engine oil at low temperature | Use specified fuel or engine oil | 4, 5 |
| | ● Fuel with low cetane number | Use specified fuel | — |
| | ● Fuel leak due to loose injection pipe retaining nut | Tighten nut | M-16 |
| | ● Incorrect injection timing | Adjust | S-19 |
| | ● Fuel camshaft worn | Replace | S-59 |
| | ● Injection nozzle clogged | Clean | S-21 |
| | ● Injection pump malfunctioning | Repair or replace | M-16 |
| | ● Seizure of crankshaft, camshaft, piston, cylinder liner or bearing | Repair or replace | — |
| | ● Compression leak | Replace head gasket, tighten cylinder head screw, glow plug, nozzle holder and correct valve seat | S-12, 28 |
| | ● Deficient compression | Check top clearance and correct valve recessing | S-12, 14, 15 |
| | ● Improper valve seat alignment, valve spring broken, valve seized | Repair or replace | S-47, 48, 50 |
| | ● Improper valve timing | Correct or replace timing gear | M-5, S-36 |
| | ● Piston ring and liner worn | Replace | S-53, 60 |
| | ● Excessive valve clearance | Adjust | S-14 |
| **Starter Does Not Run (NB type)** | ● Battery discharged | Charge | — |
| | ● Starter malfunctioning | Repair or replace | S-63 |
| | ● Starter switch malfunctioning | Replace | — |
| | ● Wiring disconnected | Connect | M-24 |

| Symptom | Probable Cause | Solution | Reference Page |
|---|---|---|---|
| **Engine Revolution is Not Smoothly** | ● Fuel filter clogged or dirt | Clean or replace | G-8 |
| | ● Air cleaner clogged | Clean or replace | G-7 |
| | ● Fuel leak due to loose injection pipe retaining nut | Tighten nut | M-18 |
| | ● Injection pump malfunctioning | Replace | M-16 |
| | ● Incorrect nozzle opening pressure | Adjust | S-21 |
| | ● Injection nozzle stuck or clogged | Repair or replace | S-21 |
| | ● Fuel over flow pipe clogged | Clean | — |
| | ● Governor malfunctioning | Repair | M-21 |
| **Either White or Blue Exhaust Gas is Observed** | ● Excessive engine oil | Reduce to the specified level | G-6 |
| | ● Piston ring and liner worn or stuck | Repair or replace | S-53, 60 |
| | ● Incorrect injection timing | Adjust | S-19 |
| | ● Deficient compression | Check top clearance and correct valve recessing | S-12, 14, 15 |
| **Either Black or Dark Gray Exhaust Gas is Observed** | ● Overload | Lessen the load | — |
| | ● Low grade fuel used | Use specified fuel | — |
| | ● Fuel filter clogged | Replace | G-8 |
| | ● Air cleaner clogged | Clean or replace | G-7 |
| **Deficient Output** | ● Incorrect injection timing | Adjust | S-19 |
| | ● Engine's moving parts seem to be seizing | Repair or replace | — |
| | ● Uneven fuel injection | Repair or replace the injection pump | S-21 |
| | ● Deficient nozzle injection | Repair or replace the nozzle | S-21 |
| | ● Compression leak | Replace head gasket, tighten cylinder head screw, glow plug, nozzle holder and correct valve seat | S-12, 14, 15 |
| **Excessive Lubricant Oil Consumption** | ● Piston ring's gap facing the same direction | Shift ring gap direction | S-31 |
| | ● Oil ring worn or stuck | Replace | S-53 |
| | ● Piston ring groove worn | Replace the piston | S-53 |
| | ● Valve stem and guide worn | Replace | S-48 |
| | ● Crank pin bearing worn | Replace | S-54, 55 |
| | ● Oil leak | Repair | — |
| **Fuel Mixed into Lubricant Oil** | ● Injection pump's plunger worn | Replace injection pump | S-19, 20 |
| | ● Injection pump broken | Replace | S-19, 20 |

| Symptom | Probable Cause | Solution | Reference Page |
|---|---|---|---|
| **Water Mixed into Lubricant Oil** | ● Head gasket defective | Replace | S-28 |
| | ● Cylinder block or cylinder head flawed | Replace | S-45 |
| **Low Oil Pressure (Engine oil pressure)** | ● Engine oil insufficient | Replenish | G-6 |
| | ● Oil strainer clogged | Clean | G-8 |
| | ● Relief valve stuck with dirt | Clean | M-10, 12 |
| | ● Relief valve spring weaken or broken | Replace | M-10 |
| | ● Excessive oil clearance of oil filler ring | Replace | S-39 |
| | ● Excessive oil clearance of crank pin bearing | Replace | S-54 |
| | ● Excessive oil clearance of rocker arm bushing | Replace | S-50 |
| | ● Oil passage clogged | Clean | M-12 |
| | ● Different type of oil | Use the specified type of oil | 4, 5 |
| | ● Oil pump defective | Repair or replace | S-61 |
| **High Oil Pressure (Engine oil pressure)** | ● Different type of oil | Use specified type of oil | 4, 5 |
| | ● Relief valve defective | Replace | M-12 |
| **Engine Overheated** | ● Engine oil insufficient | Replenish | G-6 |
| | ● Fan belt broken or tensioned improperly | Replace or adjust | S-17 |
| | ● Cooling water insufficient | Replenish | G-6 |
| | ● Radiator net and radiator fin clogged with dust | Clean | — |
| | ● Inside of radiator corroded | Clean or replace | G-6 |
| | ● Cooling water flow route corroded | Clean or replace | M-13 |
| | ● Radiator cap defective | Replace | G-6 |
| | ● Overload running | Loosen the load | — |
| | ● Head gasket defective | Replace | S-28 |
| | ● Incorrect injection timing | Adjust | S-19 |
| | ● Unsuitable fuel used | Use specified fuel | 4, 5 |
| **Battery Quickly Discharge (NB type)** | ● Battery fluid insufficient | Replenish distilled water and charge | — |
| | ● Fan belt slips | Adjust belt tension or replace | S-17 |
| | ● Wiring defective | Correct | M-24 |
| | ● Fan dynamo defective | Replace | M-25 |
| | ● Battery defective | Replace | — |
| **Glow Plug Indicator Heats too Slowly or Does Not Heat (EA300-NB1)** | ● Glow plug defective | Replace | S-22 |
| | ● Wiring improper | Check and correctly connect | M-24 |
| | ● Glow plug indicator defective | Replace | — |
| | ● Battery discharged or defective | Charge or replace | — |

| Symptom | Probable Cause | Solution | Reference Page |
|---|---|---|---|
| **Glow Plug Indicator Heats too Quickly (EA300-NB1)** | ● Glow plug or glow plug indicator short-circuited or wiring between them short-circuit | Repair or replace | M-24 |
| **Lamp Does Not Light (EA300-NB1)** | ● Lamp bulb brunt | Replace | M-24 |
| | ● Wiring broken | Repair | M-24 |
| | ● Connector disconnected | Check and connect | M-24 |
| | ● Wiring short-circuit | Correct | M-24 |
| | ● Fan dynamo defective | Replace | M-25 |

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# 2. SERVICING SPECIFICATIONS

**ENGINE BODY**

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Cylinder head surface Flatness | | — | 0.05 mm / 100 mm<br>0.0020 in. / 3.94 in. |
| Top Clearance | | 0.6 to 0.8 mm<br>0.024 to 0.031 in. | — |
| Cylinder Head Gasket Thickness (Grommet Section) | Free | 1.05 to 1.20 mm<br>0.0413 to 0.0472 in. | — |
| | Tightened | 0.95 to 1.05 mm<br>0.0374 to 0.0413 in. | — |
| Compression Pressure | | 3.481 MPa<br>35.5 kgf/cm$^2$<br>505 psi | 2.559 MPa<br>26.5 kgf/cm$^2$<br>377 psi |
| Compression Device | | 0.94 to 1.31 mm<br>0.037 to 0.0516 in. | — |
| Valve Clearance (Cold) | | 0.16 to 0.20 mm<br>0.0063 to 0.0079 in. | — |
| Valve Face Angle | | 0.785 to 0.794 rad<br>45.0 to 45.5 ° | — |
| Valve Seat Angle | | 0.785 rad<br>45.0 ° | — |
| Valve Seat Width | | 2.1 mm<br>0.083 in. | — |
| Valve Head Thickness | | 0.9 to 1.1 mm<br>0.035 to 0.043 in. | 0.85 mm<br>0.0335 in. |
| Valve Recessing | | 0.8 to 0.9 mm<br>0.031 to 0.035 in. | 1.5 mm<br>0.059 in. |
| Valve Stem and Valve Guide | Oil Clearance | 0.035 to 0.065 mm<br>0.00138 to 0.00256 in. | 0.1 mm<br>0.004 in. |
| | Valve Stem (O.D.) | 6.960 to 6.975 mm<br>0.27402 to 0.27461 in. | — |
| | Valve Guide Bore (I.D.) | 7.010 to 7.025 mm<br>0.27598 to 0.27657 in. | — |
| Intake Valve | Open | 0.35 rad<br>20 ° before T.D.C. | — |
| | Close | 0.79 rad<br>45 ° after B.D.C. | — |
| Exhaust Valve | Open | 0.87 rad<br>50 ° before B.D.C. | — |
| | Close | 0.26 rad<br>15 ° after T.D.C. | — |
| Free Length | | 34.5 mm<br>1.358 in. | 33.8 mm<br>1.331 in. |

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Setting Load / Setting Length | | 58.8 N / 31 mm<br>6.0 kgf / 31 mm<br>13.2 lbs / 1.22 in. | 49.0 N / 31 mm<br>5.0 kgf / 31 mm<br>11.0 lbs / 1.22 in. |
| Tilt | | — | 1.2 mm<br>0.047 in. |
| Rocker Arm shaft and Rocker Arm I.D. | Oil Clearance | 0.016 to 0.045 mm<br>0.0006 to 0.0018 in. | — |
| | Rocker Arm Shaft (O.D.) | 10.973 to 10.984 mm<br>0.4320 to 0.4324 in. | — |
| | Rocker Arm (I.D.) | 11.000 to 11.018 mm<br>0.4331 to 0.4338 in. | — |
| Tappet and Guide | Oil Clearance | 0.020 to 0.062 mm<br>0.00079 to 0.00244 in. | 0.15 mm<br>0.0059 in. |
| | Tappet (O.D) | 19.959 to 19.980 mm<br>0.78579 to 0.78661 in. | — |
| | Tappet Guide Bore (I.D.) | 20.000 to 20.021 mm<br>0.78740 to 0.78823 in. | — |
| Push Rod Alignment | | — | 0.125 mm<br>0.00492 in. |
| Piston Skirt O.D. | | 74.925 to 74.945 mm<br>2.94980 to 2.95059 in. | Liner I.D. -<br>0.25 mm<br>0.0098 in. |
| Piston Pin Bore I.D. | | 20.000 to 20.013 mm<br>0.78740 to 0.78791 in. | 20.04 mm<br>0.7890 in. |
| Fitting between Piston Pin Bore and PIn | | -0.010 to + 0.011 mm<br>-0.00039 to + 0.00043 in. | — |
| Clearance between Ring Groove and Ring | Top Ring | — | — |
| | Second Ring | 0.085 to 0.112 mm<br>0.00335 ti 0.00441 in. | 0.2 mm<br>0.008 in. |
| | Oil Ring | 0.020 to 0.055 mm<br>0.00079 to 0.00217 in. | 0.15 mm<br>0.0059 in. |
| Piston Ring Width | Top Ring | — | — |
| | Second Ring | 1.458 to 1.470 mm<br>0.05740 to 0.05787 in. | — |
| | Oil Ring | 3.975 to 3.990 mm<br>0.15650 to 0.15709 in. | — |
| Piston Ring Groove Width | Top Ring | — | — |
| | Second Ring | 1.555 to 1.570 mm<br>0.06122 to 0.06181 in. | — |
| | Oil Ring | 4.01 to 4.03 mm<br>0.1579 to 0.1587 in. | — |

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Ring Gap | Top Ring | 0.30 to 0.45 mm<br>0.0118 to 0.0177 in. | 1.2 mm<br>0.047 in. |
| | Second Ring | 0.30 to 0.45 mm<br>0.0118 to 0.0177 in. | 1.2 mm<br>0.047 in. |
| | Oil Ring | 0.25 to 0.40 mm<br>0.0098 to 0.0157 in. | 1.2 mm<br>0.047 in. |
| Connecting Rod Alignment | | — | 0.05 mm / 100 mm<br>0.0020 in. / 3.94 in. |
| Piston Pin and Bushing | Oil Clearance | 0.014 to 0.038 mm<br>0.00055 to 0.00150 in. | 0.15 mm<br>0.0059 in. |
| | Piston Pin (O.D.) | 20.002 to 20.011 mm<br>0.78748 to 0.7874 in. | — |
| | Piston Pin Bushing (I.D.) | 20.025 to 20.040 mm<br>0.78839 to 0.78898 in. | — |
| Connecting Rod End Play | | 2.9 to 3.3 mm<br>0.114 to 0.130 in. | — |
| Crankshaft Alignment | | — | 0.04 mm<br>0.0016 in. |
| Crankshaft and Oil Filler Ring | Oil Clearance | 0.025 to 0.066 mm<br>0.00098 to 0.00260 in. | 0.2 mm<br>0.008 in. |
| | Crankshaft (O.D.) | 34.959 to 34.975 mm<br>1.37634 to 1.37697 in. | — |
| | Oil Filler Ring (I.D.) | 35.000 to 35.025 mm<br>1.37795 to 1.37894 in. | — |
| Crank Pin and Bearing | Oil Clearance | 0.019 to 0.077 mm<br>0.00075 to 0.00303 in. | 0.2 mm<br>0.008 in. |
| | Crank Pin (O.D.) | 36.959 to 36.975 mm<br>1.45508 to 1.45571 in. | — |
| | Crank Pin Bearing (I.D.) | 36.994 to 37.036 mm<br>1.45646 to 1.45811 in. | — |
| Crankshaft End Play | | 0.05 to 0.46 mm<br>0.0020 to 0.0181 in. | 0.56 mm<br>0.0220 in. |
| Timing Gear Backlash | Barancer Gear 1 x Barancer Gear 2 | 0.049 to 0.135 mm<br>0.00193 to 0.00531 in. | 0.3 mm<br>0.012 in. |
| | Other Gears | 0.043 to 0.130 mm<br>0.00169 to 0.00512 in. | 0.3 mm<br>0.012 in. |
| Idle Gear Side Clearance | | 0.20 to 0.51 mm<br>0.0079 to 0.0201 in. | 0.9 mm<br>0.035 in. |
| Idle Gear Shaft and Idle Gear Bushing | Oil Clearance | 0.016 to 0.045 mm<br>0.00063 to 0.00177 in. | 0.1 mm<br>0.004 in. |
| | Idle Gear Shaft (O.D.) | 17.973 to 17.984 mm<br>0.70760 to 0.70803 in. | — |
| | Idle Gear Bushing (I.D.) | 18.000 to 18.018 mm<br>0.70866 to 0.70937 in. | — |
| Camshaft Alignment | | — | 0.08 mm<br>0.0031 in. |

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Cam Height (IN, EX) | | 27.0 mm<br>1.063 in. | 26.5 mm<br>1.043 in. |
| Camshaft (Flywheel Side) | Oil Clearance | 0.020 to 0.054 mm<br>0.00079 to 0.00213 in. | 0.25 mm<br>0.0098 in. |
| | Camshaft Journal (O.D.) | 21.967 to 21.980 mm<br>0.86484 to 0.86535 in. | — |
| | Camshaft Bore (I.D.) | 22.000 to 22.021 mm<br>0.86614 to 0.86697 in. | — |
| Camshaft (Gear Side) | Oil Clearance | 0.025 to 0.066 mm<br>0.00098 to 0.00260 in. | 0.1 mm<br>0.004 in. |
| | Camshaft Journal (O.D.) | 32.959 to 32.975 mm<br>1.29760 to 1.29823 in. | — |
| | Camshaft Bore (I.D.) | 33.000 to 33.025 mm<br>1.29921 to 1.30020 in. | — |
| Cam Gear Side Clearance | | 0.070 to 0.220 mm<br>0.00276 to 0.00866 in. | 0.3 mm<br>0.012 in. |
| Cylinder Liner I.D. | | 75.000 to 75.019 in.<br>2.95276 to 2.95351 in. | +0.25 mm<br>+0.0098 in. |
| Projection of Cylinder Block | | 0.03 to 0.13 mm<br>0.0012 to 0.0051 in. | — |

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**LUBRICATING SYSTEM**

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Engine Oil Pressure | At Idle Speed | 49 kPa<br>0.5 kgf/cm$^2$<br>7 psi or more | — |
| | At Rated Speed (Engine Speed) | 245 kPa<br>2.5 kgf/cm$^2$<br>36 psi or more<br>(3000 r.p.m) | 196 kPa<br>2.0 kgf/cm$^2$<br>28 psi<br>(3000 r.p.m) |
| Inner Rotor to Outer Rotor | Clearance | 0.15 mm or less<br>0.0059 in. or less | 0.20 mm<br>0.0079 in. |
| Outer Rotor to Pump Body | Clearance | 0.090 to 0.171 mm<br>0.00354 to 0.00673 in. | 0.24 mm<br>0.0094 in. |
| Inner Rotor to Cover | Clearance | 0.02 to 0.06 mm<br>0.0008 to 0.0024 in. | 0.25 mm<br>0.0098 in. |
| Relief Pressure | | 196 to 392 kPa<br>2.0 to 4.0 kgf/cm$^2$<br>28 to 57 psi | — |

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## COOLING SYSTEM

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Fan Belt | Tension | 9.0 to11.0 mm / 98 N<br>0.35 to 0.43 in.<br>(10 kgf, 22 lbs) | — |
| Radiator Water Tightness | | No leak at<br>186 kPa<br>1.9 kgf/cm$^2$<br>27 psi | — |
| Radiator Cap Air Leakage | | 10 seconds or more<br>108 → 78 kPa<br>1.1 → 0.8 kgf/cm$^2$<br>16 → 11 psi | — |

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## FUEL SYSTEM

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Injection Timing (Static) | EL300-E2-AR<br>EL300-E2-AR-KCL | 0.38 rad<br>(22 °)<br>before T.D.C. | — |
| | EA300-E2-NB1<br>EA300-E2-NB1-APU | 0.45 rad<br>(25.5 °)<br>before T.D.C. | — |
| Fuel Tightness of Pump Element | | — | — |
| Fuel Tightness of Delivery Valve | | 10 seconds or more<br>14.22 → 13.73 MPa<br>150 → 140 kgf/cm$^2$<br>2062 → 1991 psi | — |
| Fuel Injection Pressure | | 13.73 to 14.22 MPa<br>140 to 150 kgf/cm$^2$<br>1991 to 2062 psi | — |
| Fuel Tightness of Nozzle Valve Seat | | 12.75 to 13.73 MPa<br>130 to 140 kgf/cm$^2$<br>1849 to 1991 psi) | — |

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## ELECTRICAL SYSTEM

### [Fan Dynamo (EA300-E2-NB1)]

| Item | | Factory Specification | Allowable Limit |
|---|---|---|---|
| Power Generation Performance | Fan Speed | 6900 min$^{-1}$ (r.p.m) | — |
| | Voltage | Approx. 13 V | — |
| | Current | 1.6 to 2.6 A | — |

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# 3. TIGHTENING TORQUES

## [1] TIGHTNING TORQUES FOR SPECIAL USE SCREWS, BOLTS AND NUT

Screw, bolts and nuts must be tightened to the specified torque using a torque wrench.
Several bolts and nuts such as ones used on the cylinder head must be tightened in proper sequence and to the proper torque.

| Item | Size x Pitch | N·m | kgf·m | ft-lbs |
|---|---|---|---|---|
| Cylinder head Stud | M9 x 1.25 | 24.5 to 29.4 | 2.5 to 3.0 | 18.1 to 21.7 |
| *Cylinder head Nut | M9 x 1.25 | 56.9 to 61.8 | 5.8 to 6.3 | 43.4 to 47.0 |
| **Connecting rod screw | M7 x 0.75 | 26.5 to 30.4 | 2.7 to 3.1 | 19.5 to 22.4 |
| **Flywheel nut | M20 x 1.5 | 137 to 157 | 14 to 16 | 101 to 116 |
| **Main bearing case / screw mounting screw | M6 x 1.0 | 9.81 to 11.23 | 1.00 to 1.15 | 7.23 to 8.32 |
| Crankcase cover mounting screw | M6 x 1.0 | 7.85 to 9.32 | 0.80 to 0.95 | 5.79 to 6.87 |
| Gear case mounting screw | M6 x 1.0 | 9.81 to 11.28 | 1.00 to 1.15 | 7.23 to 8.32 |
| Idle gear shaft screw | M6 x 1.0 | 9.81 to 11.28 | 1.00 to 1.15 | 7.23 to 8.32 |
| Head cover mounting nut | M7 x 1.0 | 9.8 to 10.8 | 1.0 to 1.1 | 7.2 to 8.0 |
| *Rocker arm bracket mounting nut | M7 x 1.0 | 16.7 to 20.6 | 1.7 to 2.1 | 12.3 to 15.2 |
| Oil signal holder | PT 1/8 | 14.7 to 19.6 | 1.85 to 2.0 | 10.8 to 14.5 |
| Oil signal | PT 1/8 | 6.9 to 9.8 | 0.7 to 1.0 | 5.1 to 7.2 |
| Injection pump mounting screw | M6 x 1.0 | 9.81 to 11.28 | 1.00 to 1.15 | 7.23 to 8.32 |
| Injection pump delivery valve holder | M8 x 1.5 | 39 to 49 | 4 to 5 | 29 to 36 |
| Nozzle holder | M20 x 1.5 | 49 to 69 | 5 to 7 | 36 to 51 |
| Muffler mounting bolt | M8 x 1.25 | 23.5 to 27.5 | 2.4 to 2.8 | 17.4 to 20.3 |
| Tension pulley remer screw | M8 x 1.25 | 19.6 to 23.5 | 2.0 to 2.4 | 14.5 to 17.4 |
| Air cleaner mounting bolt | M6 x 1.0 | 2.9 to 4.9 | 0.3 to 0.5 | 2.2 to 3.6 |
| Injection pipe nut | M12 x 1.5 | 24.5 to 34.3 | 2.5 to 3.5 | 18.1 to 25.3 |
| Injection pump eye joint bolt | M12 x 1.5 | 24.5 to 29.4 | 2.5 to 3.0 | 18.1 to 21.7 |
| Glow plug EA300-E2 | M8 x 1.0 | 7.85 to 14.7 | 0.8 to 1.5 | 14.5 to 18.1 |

**■ NOTE**

- For "*" marked the bolts and nuts of cylinder head, never apply engine oil to their threads and seats before tightening.
- For "**" marked screws and nuts on the table, apply engine oil to their threads and seats before tightening.

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# [2] TIGHTNING TORQUES FOR GENERAL USE SCREWS, BOLTS AND NUT

When the tightening torques are not specified in each section, tighten the screws, bolts and nuts according to the table below.

| Grade / Nominal Diameter / Unit | Standard Screw and Bolt ④ | | | Special Screw and Bolt ⑦ | | |
|---|---|---|---|---|---|---|
| | N·m | kgf·m | ft-lbs | N·m | kgf·m | ft-lbs |
| M6 | 7.85 to 9.32 | 0.80 to 0.95 | 5.79 to 6.87 | 9.81 to 11.2 | 1.00 to 1.15 | 7.24 to 8.32 |
| M8 | 17.7 to 20.6 | 1.8 to 2.1 | 13.0 to 15.2 | 23.6 to 27.5 | 2.4 to 2.8 | 17.4 to 20.3 |
| M10 | 39.2 to 45.1 | 4.0 to 4.6 | 28.9 to 33.3 | 48.1 to 55.9 | 4.9 to 5.7 | 35.4 to 41.2 |

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below.

| Punched number | Screw and bolt material grade |
|---|---|
| None | Standard screw and bolt SS41, S20C |
| 7 | Special screw and bolt SS43, S48C (Refined) |
| 9 | Special screw and bolt SCr435, SCM435 (Refined) |

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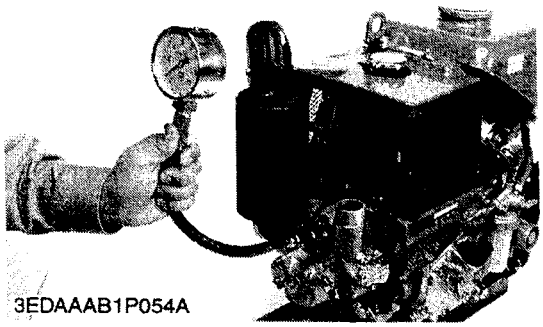
# 4. CHECKING, DISASSEMBLING AND SERVICING

## [1] CHECKING AND ADJUSTING

### (1) Engine Body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Compression Pressure

1. Run the engine until warm up.
2. Stop the engine and remove the air cleaner and nozzle holder.
3. Attach a compression tester (Code No. 07909-30204) to the adapter **B** or **H**.
4. After making sure that the speed control lever (1) is set at the stop position (Non-injection), run the flywheel at 320 to 440 $min^{-1}$ (r.p.m) with the starting handle (or the starter for **NB** type) and read constant maximum on the tester. Execute the test at least twice. (Run the engine the for 5 to 10 seconds for each test.)

**■ NOTE**

- **For the NB type batteries, measure specific gravity of the electrolyte and ensure that the battery is fully charged.**
- **Compression occurs every second approximately when the engine speed is 320 to 440 $min^{-1}$ (r.p.m). Try to learn this "feeling" and ensure that the engine is running at this speed range when measuring compression.**

5. If the pressure does not reach the allowable limit, apply a small amount of oil to the cylinder wall through the nozzle holder hole and measure the pressure again.
6. If the pressure raises after applying oil, check the cylinder wall and piston rings.
7. If the pressure is still low, check the top clearance, valve clearance, cylinder head and piston rings.

**■ NOTE**

- **Check the compression pressure with the specified valve clearance for proper air in taking.**

| | | |
|---|---|---|
| Compression Pressure | Factory spec. | 3.481 MPa<br>35.5 kgf/cm$^2$<br>505 psi |
| | Allowable limit | 2.599 MPa<br>26.5 kgf/cm$^2$<br>377 psi |

(1) Speed Control Lever

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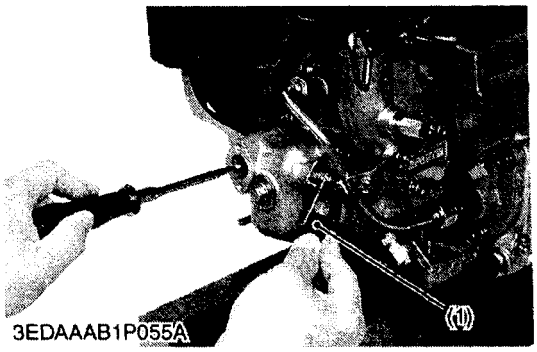

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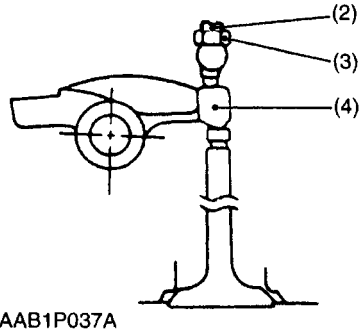

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Decompression Device

1. Align the **T** mark on the flywheel to the mark on the fan cover at the top dead center in the compression stroke.
2. Remove the decompression cover from the cylinder head cover.
3. Pull the decompression lever (1) to the operating position.
4. Loosen the lock nut (3) and screw (2) until it contacts the rocker arm (4).
5. From the position where the adjusting screw contacts the rocker arm, further screw in the adjusting screw by one and a half turns (9.42 ± 1.57 rad., 540 ± 90°).
6. Tighten the lock nut.
7. After adjustment, make sure that the piston does not push up the valve when slightly turning the flywheel with the decompression lever.

| | | |
|---|---|---|
| Decompression device | Factory spec. | 0.94 to 1.31 mm<br>0.0370 to 0.0516 in. |

(Adjusting screw pitch: 0.75 mm (0.0295 in.))

(1) Decompression Lever
(2) Decompression Adjusting Screw
(3) Lock Nut
(4) Rocker Arm

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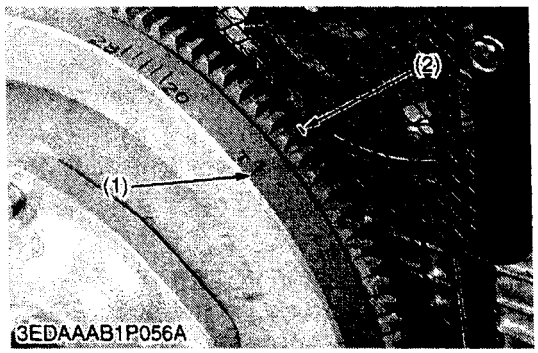


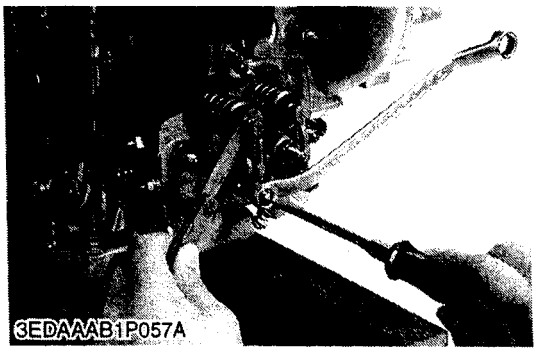


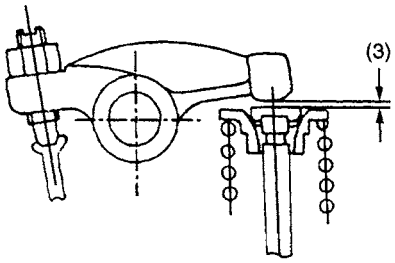


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Valve Clearance

**■ IMPORTANT**

- **The valve clearance must be inspected and adjusted as needed when the engine is cold (equal to the atmospheric air temperature).**

1. Remove the cylinder head cover.
2. Align the **T** mark (1) on the flywheel with the fan cover mark (2) at the top dead center in the compression stroke.
3. Measure the valve clearance using a thickness gauge
4. If the clearance is not within the factory specifications, adjust with the adjusting screw.
5. After tightening the lock nut and turning the flywheel twice or three times counterclockwise, recheck the valve clearance.

| | | |
|---|---|---|
| Valve clearance (Cold) | Factory spec. | 0.16 to 0.20 mm<br>0.0063 to 0.0079 in. |

(1) **T** Mark
(2) Fan Cover Mark
(3) Valve Clearance

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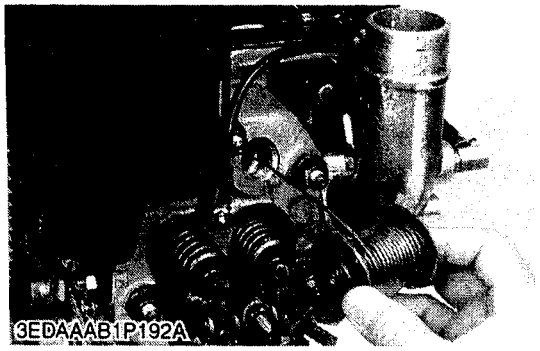


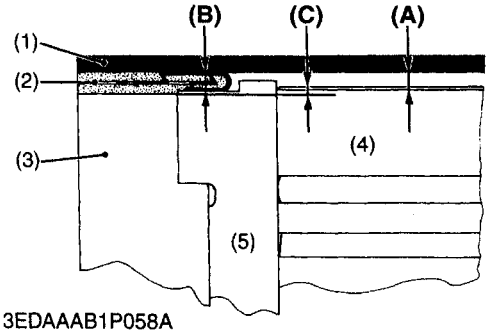

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Top Clearance

1. Tighten the cylinder head to the specified torque (56.9 to 61.8 N·m, 5.8 to 6.3 kgf·m, 42 to 45.6 ft-lbs).
2. Remove the nozzle holder.
3. Set the piston to the bottom dead center and insert a high-quality fuse through the nozzle holder hole. (Use care so that the fuse does not contact the valve head.)
4. Turn the piston slowly with the flywheel until it passes the top dead center.
5. Pull out the fuse slowly without letting it drop.
6. Measure the top clearance three times, each with a new fuse positioned in different directions.
7. Measure the thickness of the crushed fuse with a vernier calipers.

**(Reference)**

- The top clearance **(A)** can be determined also from the amount of projection **(C)** above the liner.

**[Top clearance (A) = (B) - (C)]**

| | | |
|---|---|---|
| Head gasket thickness **(B)** | Tightened | 0.95 to 1.05 mm<br>0.0374 to 0.0413 in. |

8. If the clearance is not within the factory specifications, check and correct the oil clearance at the crank pin, oil filler ring and piston pin.

| | | |
|---|---|---|
| Top clearance | Factory spec. | 0.6 to 0.8 mm<br>0.024 to 0.031 in. |

(1) Cylinder Head
(2) Head Gasket
(3) Cylinder Block
(4) Cylinder Liner
(5) Piston

**(A) Top Clearance**
**(B) Head Gasket Thickness**
**(C) Amount of Projection**

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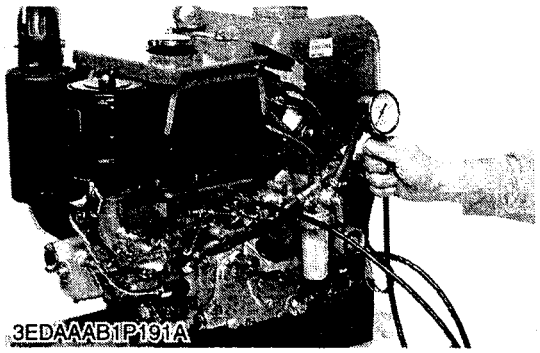
## (2) Lubricating System




Engine Oil Pressure

1. Remove the oil signal and install an oil pressure tester (Code No. 07916-32031) (Adaptor screw size : PS 1/8).
2. Start the engine. After warming up, measure the oil pressure of both idling and rated speeds.
3. If the oil pressure is less than the allowable limit, check the following.

- Engine oil insufficient
- Oil pump defective
- Oil strainer clogged
- Excessive oil clearance of bearing
- Foreign matter in the relief valve
- Oil gallery clogged

| | | | |
|---|---|---|---|
| Engine oil pressure | At idle speed | Factory spec. | More than 49 kPa<br>0.5 kgf/cm$^2$<br>7 psi |
| | At rated speed | EA300<br>3000 rpm | 245 kPa<br>2.5 kgf/cm$^2$<br>36 psi |
| | | EL300<br>2000 rpm | 196 kPa<br>2.0 kgf/cm$^2$<br>28 psi |

* When engine oil is 100 to 120 ℃ (212 to 248 ℉)

**(When installing)**

| | | |
|---|---|---|
| Tightening torque | Oil signal | 6.9 to 9.8 N·m<br>0.7 to 1.0 kgf·m<br>5.1 to 7.2 ft-lbs |
| | Oil signal holder | 14.7 to 19.6 N·m<br>1.5 to 2.0 kgf·m<br>10.8 to 14.5 ft-lbs |

**■ NOTE**

- Check for oil leakge after installing the oil signal.

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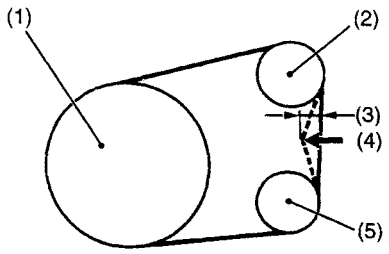
## (3) Cooling System

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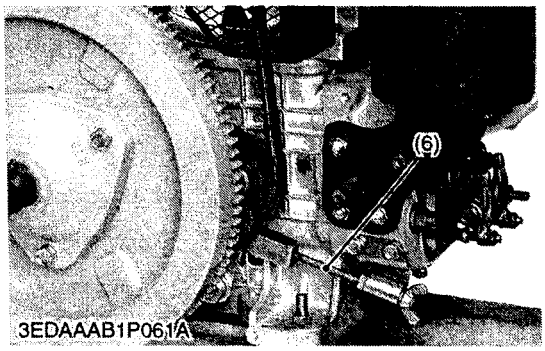


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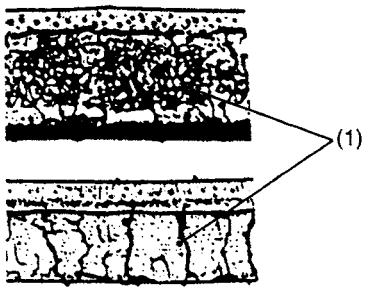


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Fan Belt Tension

1. Check to see the belt tension allows a depression of the specified amount when the belt is pressed down by a finger midway between the cooling fan pulley (2) and tension pulley (5).
2. Adjust the tension by the tension bolt (6).

| | | |
|---|---|---|
| Fan belt tension | Factory spec. | 9 to 11 mm<br>0.35 to 0.43 in. |

| | | |
|---|---|---|
| Size of fan belt | EA300 Series | FM 32.5 |

* The FM type refers to a low edge plain type, which is a van rope for general fans having a upper canvas width of 11.0 mm (0.433 in.) and a height of 8.0 mm (0.315 in.).

■ **NOTE**

- **Whenever a new fan belt is installed, provide a tension somewhat higher than specified, and adjust it as specified after running the fan for some time.**

(1) Fan Drive Pulley
(2) Fan Pulley
(3) Tension
(4) Force of 98 N (10 kgf, 22 lbs)
(5) Tension Pulley
(6) Tension Bolt

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Fan Belt Damage and Wear

1. Check the fan belt for wear.
2. Check if the fan belt is worn and sunk in the pulley groove.
3. Replace the fan belt if the belt is nearly worn out or deeply sunk in the pulley groove.

(1) Defective Belt

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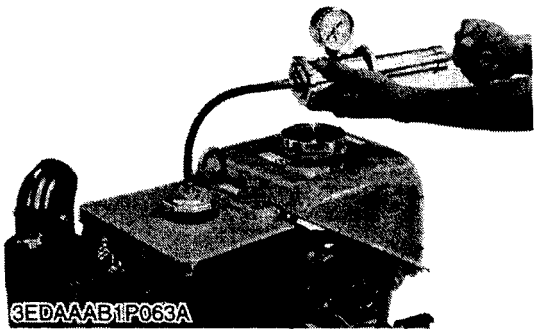


Radiator Water Tightness

1. Fill the radiator with water to the specified amount and warm up the engine.
2. Set a radiator tester (Code No. 07909-31551) and raise the water pressure to the specified pressure.
3. Check the radiator for water leaks.
4. For water leak from the pin hole, repair with the radiator cement, and for other leaks, replace the radiator.

**⚠ CAUTION**

- **During operation or immediately after operation, cooling water in the radiator is extremely hot.**
  **If the radiator cap is removed, hot water may gush out, causing scalding. Open the radiator cap after the engine has cooled.**

| | | |
|---|---|---|
| Radiator water tightness | Factory spec. | No leak at 186 kPa<br>1.9 kgf/cm$^2$<br>27 psi |

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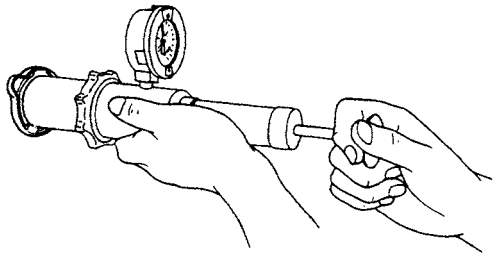

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Radiator Cap Air Leakage

1. Set a radiator tester (Code No. 07909-31551) on the radiator cap.
2. Apply specified pressure and measure the time for the pressure to fall.
3. If the measurement is less than the factory specification, replace the radiator cap.

| | | |
|---|---|---|
| Radiator cap air leakage | Factory spec. | 10 seconds or more<br>108 kPa (1.1 kgf/cm$^2$, 16 psi)<br>→ 78 kPa<br>(0.8 kgf/cm$^2$, 11 psi) |

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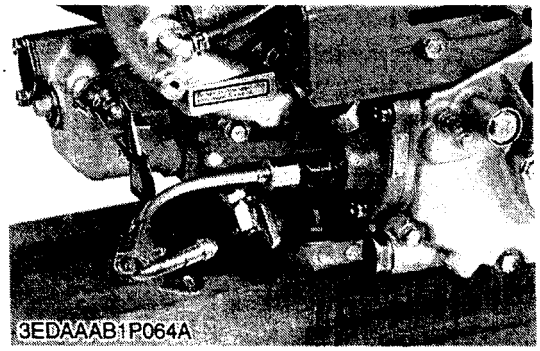
## (4) Fuel System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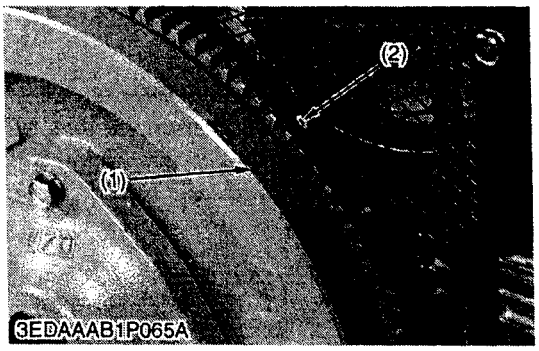

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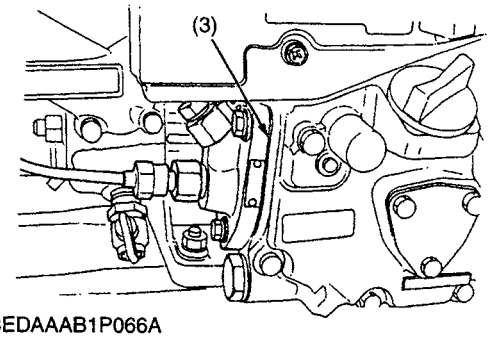

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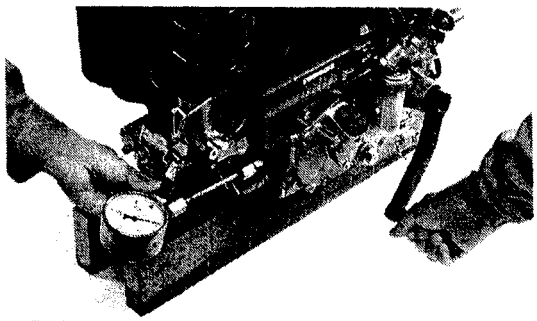
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Adjusting Injection Timing

1. Connect the injection pipe to the injection pump as shown in the photograph.
2. Set the speed control lever to the maximum speed position.
3. Turn the flywheel counterclockwise to check that fuel comes out from the tip of the injection pipe.
4. Turn the flywheel so that the timing angle lines (1) on the flywheel circumference reaches near below the mark (2) on the fan cover slowly turn the flywheel counterclockwise from that position, and stop it immediately when the fuel level at the tip of the injection pipe begins rising. At this time, check if the injection timing line on the flywheel circumference aligns with the fan cover mark.
5. If the timing is in incorrect, adjust it with shims (3).
6. After adjustment, apply liquid gasket to the both sides of shim thinly before reassembling.

| | | | |
|---|---|---|---|
| Injection timing (static) | Factory spec. | EA300 | 0.42 rad<br>25.5 ° before T.D.C. |
| | | EL300 | 0.38 rad<br>22 ° before T.D.C. |

**(Reference)**

- Adding or removing one shim (0.1 mm, 0.0039 in.) varies the crank angle by approx. 0.017 rad (1°).

(1) Timing Angle lines
(2) Fan Cover Mark
(3) Injection Timing Adjusting Shim

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Pump Element Fuel Tightness

1. Remove the injection pipe.
2. Install an injection pump pressure tester to the injection pump.
3. Set the speed control lever to the maximum speed position.
4. Turn the engine ten times or more with the start handle to increase the pressure.
5. If the pressure can not reach the allowable limit, replace the pump element.

| | | |
|---|---|---|
| Pump element fuel tightness | Allowable limit | 14.22 MPa<br>150 kgf/cm$^2$<br>2062 psi |

**■ IMPORTANT**

- **After replacing only pump element, the amount of injection should be adjusted on a specified test bench.**

**(Reference)**

- The pump should discharge no fuel from stop position to 3 mm (0.12 in.) of control rack at 1500 min$^{-1}$ (r.p.m) of camshaft speed.

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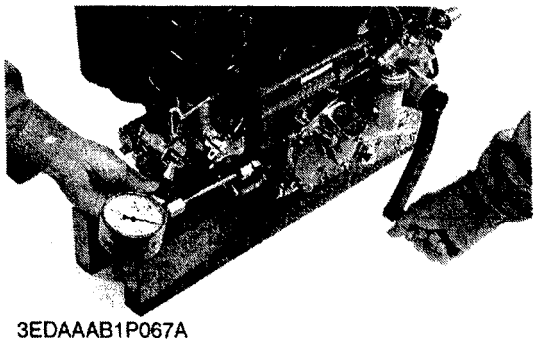

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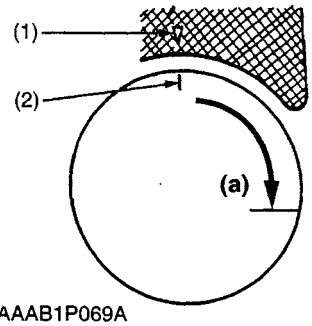


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Delivery Valve Fuel Tightness

1. Remove the injection pipe.
2. Set an injection pump pressure tester to the injection pump.
3. In the same way as to check the pump element fuel tightness, turn the engine ten times or more with the start handle so that the pressure is increased to specified pressure (Refer to the table).
4. Set the plunger at the bottom dead center to reduce the delivery chamber pressure to zero.
5. Measure the fall time for the pressure to drop to the reference pressure from the specified initial pressure.
6. If the measurement is less than the allowable limit, replace the delivery valve or injection pump.

**(Reference)**

- How to set the plunger to the bottom dead center.

Turn the flywheel to clockwise 1.57 rad (90°) from the injection timing position. (Align the injection timing line (2) on the flywheel with the fan cover mark (1).)

| | | | |
|---|---|---|---|
| Delivery valve fuel tightness | Factory spec. | 10 seconds or more | 14.71 MPa → 13.73 MPa<br>150 kgf/cm² → 140 kgf/cm²<br>2133 psi → 1991 psi |
| | Allowable limit | 5 seconds | |

(1) Fan Cover Mark
(2) Timing Line
**(a) 1.57 rad (90 °)**

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**⚠ CAUTION**

- **Be careful not to come into direct contact with the injected spray destroys any cells it touches. It may also cause blood poisoning, etc, Check the injection nozzle after confirming that nobody is standing in the direction of the spray.**

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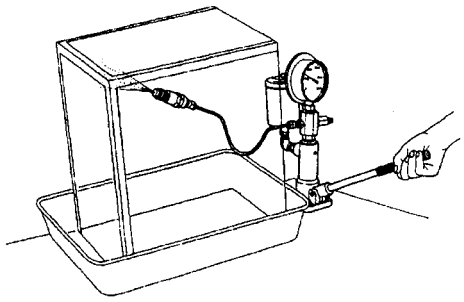

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Fuel Injection Pressure

1. Set the injection nozzle to a nozzle tester (Code No. 7909-32361).
2. Measure the injection pressure.
3. If the measurement is not within the factory specifications, adjust with the adjusting washer inside the nozzle holder.

| | | |
|---|---|---|
| Fuel injection pressure | Factory spec. | 13.73 to 14.71 MPa<br>140 to 150 kgf/cm$^2$<br>1991 to 2133 psi |

**(Reference)**

- Pressure change per 0.1 mm (0.039 in.) adjusting washer:
  Approx. 235 kPa
  10 kgf/cm$^2$
  142 psi

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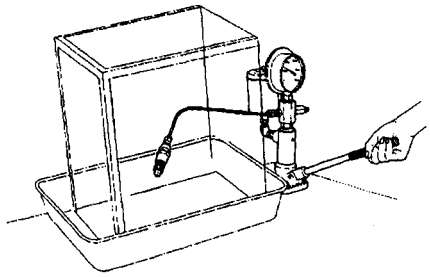

3TLABAB1P041A

Fuel Tightness of Nozzle Valve Seat

1. Apply a pressure 981 kPa (10 kgf/cm$^2$, 142 psi) lower than the fuel injection pressure.
2. After keeping the nozzle under this pressure for 10 seconds, check to see if fuel leaks from the nozzle.
3. If fuel should leak, replace the nozzle piece.

| | | |
|---|---|---|
| Fuel tightness of nozzle valve seat | Factory spec. | 12.75 to 13.73 MPa<br>130 to 140 kgf/cm$^2$<br>1849 to 1991 psi |

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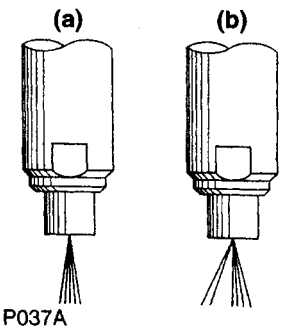


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Nozzle Spraying Condition

1. Set the nozzle to a nozzle tester (Code No. 07909-313612) and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the nozzle piece.

**(a) Good** **(b) Bad**

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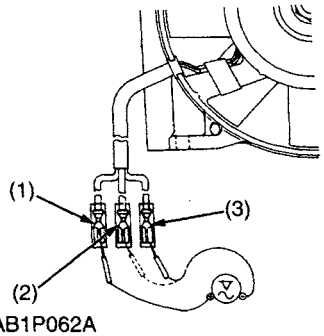
## (5) Electrical System

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Fan Dynamo

**Power Generation Performance**

1. Disconnect the lead from the dynamo.
2. Run the engine at the rated speed, and measure AC voltage between the two leads (yellow) (2), (3) and lead (red) (1) from the dynamo.
3. If the voltage is less than the factory specification, replace the cooling fan assembly.

| | | | | |
|---|---|---|---|---|
| Power generation performance | Factory spec. | Fan speed | 6950 $min^{-1}$ (r.p.m) | Approx. 13 V |

(1) Lead (Red) (3) Lead (Yellow)
(2) Lead (Yellow)

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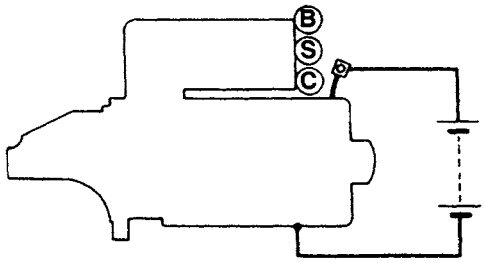


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Starter

**Motor Test**

1. Disconnect the ground cable clamp from the battery negative terminal post.
2. Disconnect the battery positive cable and leads from the starter.
3. Remove the starter from the engine.
4. Disconnect the connecting lead from the starter **C** terminal.

**CAUTION**

- **Secure the starter in a vise to prevent it from jumping up and down while testing the motor.**

5. Connect a jumper lead from the connecting lead to the battery positive terminal post.
6. Connect a jumper lead momentarily between the starter housing and battery negative terminal post.
7. If the motor does not run, check the motor.

(1) Body Earth (2) Connecting Lead

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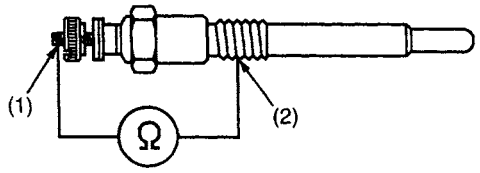


3TMABAB9P012B

Glow Plug (EA300-NB1)

**Glow Plug Disconnection / Short-circuit Test**

1. Remove the glow plug cord.
2. Measure the resistance between the thread (1) at the glow plug end and engine body or the resistance between the thread and housing (2) with an ohmmeter.
3. If the resistance is 0 ohm or infinity, replace the glow plug.

| | | |
|---|---|---|
| Glow plug resistance | Factory spec. | 0.9 Ω (Normal temperature) |

(1) Thread (2) Housing

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# [2] DISASSEMBLING AND ADJUSTING

## (1) Draining Water and Oil

Draining Coolant and Engine Oil

**CAUTION**

- **Never remove radiator cap until coolant temperature is below its boiling point. Then loosen cap slightly to the stop to relieve any excess pressure before removing cap completely.**

1. Prepare a bucket. Open the drain cock to drain coolant.
2. Prepare an oil pan. Remove the drain plug to drain engine oil in the pan.

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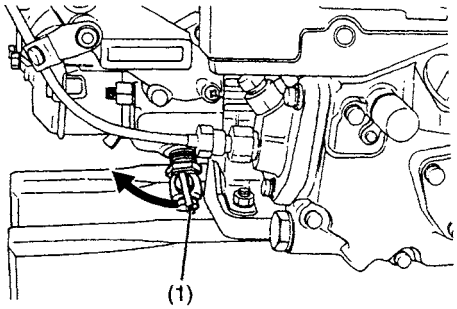
## (2) Extermal Components

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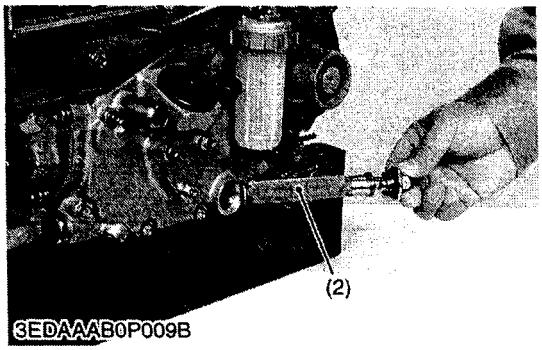


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Draining Cooling Water and Engine Oil

**CAUTION**

- **During operation or immediately after operation, cooling water in the radiator is extremely hot.**
  **If the radiator cap is removed, hot water may gush out, causing scalding. Open the radiator cap after the engine has cooled.**

1. Open the cock (1) to drain cooling water.
2. Remove the oil strainer (2) (drain plug) to drain engine oil.

| | | | |
|---|---|---|---|
| Specified quantity | Cooling water | EA300-E2-NB1<br>EA300-E2-NB1-APU | 1.3 L<br>1.4 U.S.qts.<br>1.14 Imp.qts. |
| | Engine oil | EL300-E2-AR<br>EL300-E2-AR-KCL | 1.9 L<br>2.0 U.S.qts.<br>1.6 Imp.qts. |

(1) Drain Cock (2) Oil Strainer

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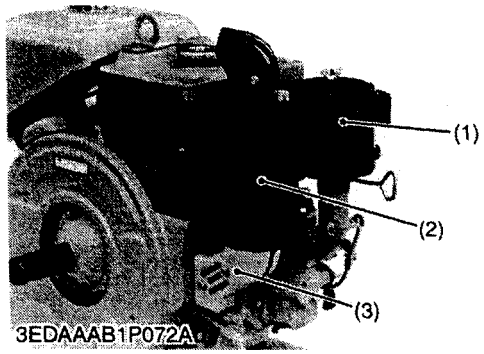


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Air Cleaner and Muffler

1. Loosen the band to remove the air cleaner (1).
2. Remove the muffler flange cover (3).
3. Remove the muffler (2).

**(When reassembling)**

- When installing the muffler gasket, face the steel to the muffler flange.
- When installing the air cleaner, face an air inlet as shown in the figure.

| | | |
|---|---|---|
| Tightening torque | Muffler mounting nut | 23.5 to 27.5 N·m<br>2.4 to 2.8 kgf·m<br>17.4 to 20.3 ft-lbs |

(1) Air Cleaner (3) Muffler Flange Cover
(2) Muffler

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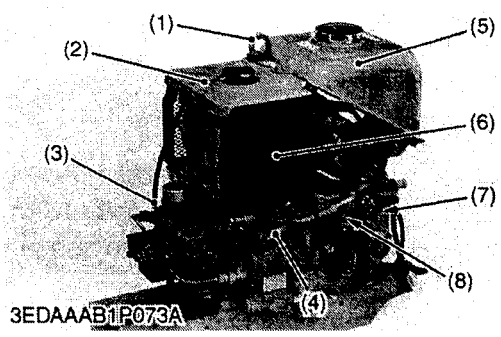

3EDAAAB1P073A

Fuel Tank and Filter

1. Close the fuel cock (7) as shown in the photograph.
2. Remove the engine hook (1) and radiator cover (2).
3. Disconnect the overflow pipe (4).
4. Remove the eye joint bolt of the injection pump to detach the fuel pipe 2 (4).
5. Remove the fuel filter mounting screw (9).
6. Remove the fuel tank (6), fuel filter and pipe as an unit.
7. Remove the radiator net (7).

**(When reassembling)**

- Lap the overflow pipe (4) below the radiator cover (2) as shown in the photograph.
- Set the pipe clamps securely.

| | | |
|---|---|---|
| Tightening torque | Injection pump eye joint bolt | 24.5 to 29.4 N·m<br>2.5 to 3.0 kgf·m<br>18.1 to 21.7 ft-lbs |

(1) Engine Hook
(2) Radiator Cover
(3) Overflow Pipe
(4) Fuel Pipe 2
(5) Fuel Tank
(6) Radiator Net
(7) Fuel Cock
(8) Fuel Filter Mounting Screw

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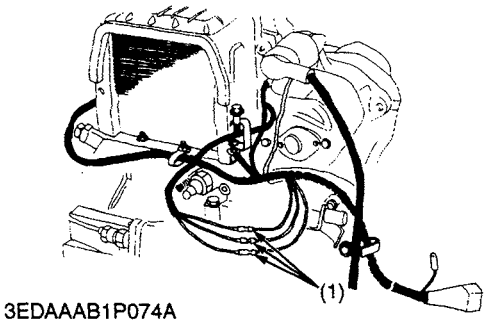

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Wire Harness

1. Disconnect the fan leads (1).

**(When reassembling)**

- The lead wire must be grounded at particular locations as illustrated.

(1) Fan Lead

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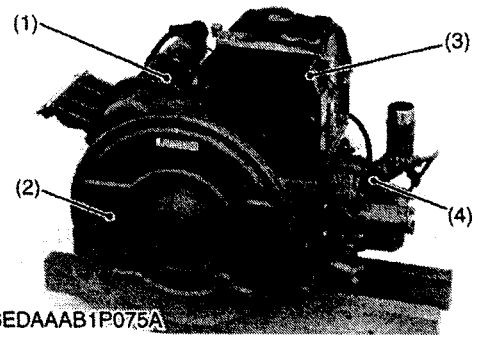

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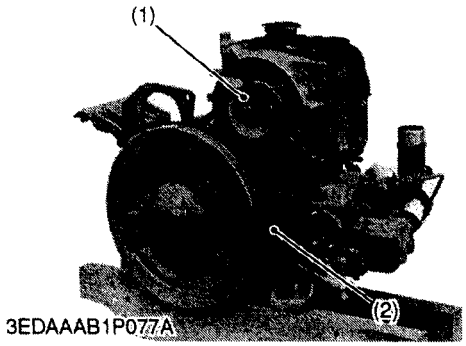
Fan Cover and Starter

1. Disconnect the glow plug cord (4).
2. Remove the flywheel cover (2).
3. Remove the fan cover (3).
4. Remove the starter (1), wire harness and battery cable as an unit.

(1) Starter
(2) Flywheel Cover
(3) Fan Cover
(4) Glow Plug Cord

0000009791E



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Cooling Fan

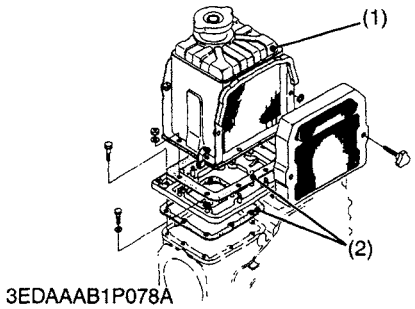
1. Remove the tension pulley (2).
2. Remove the cooling fan assembly (1).

**(When reassembling)**

- Adjust the fan belt tension to the factory specifications.

(1) Cooling Fan Assembly (2) Tension Pulley

0000009792E



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Radiator

**(When reassembling)**

- Apply liquid gasket (Three Bond 1102 or equivalent) to the both sides of radiator gasket (2).

(1) Radiator Assembly (3) Fuel Tank Support
(2) Radiator Gasket

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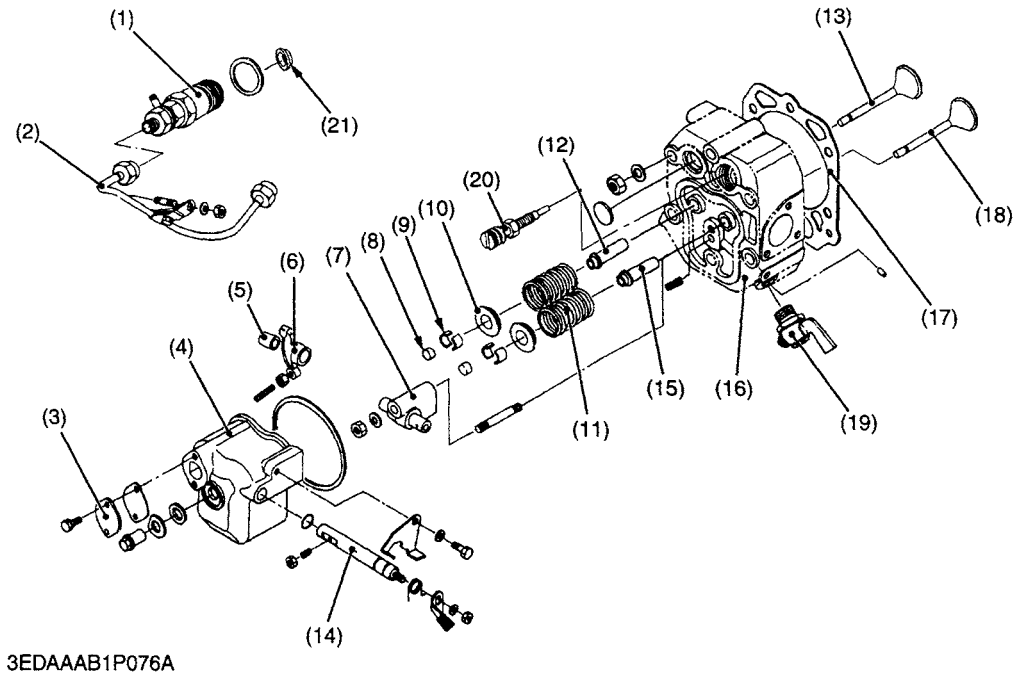
## (3) Cylinder Head



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(1) Nozzle Holder
(2) Injection Pipe
(3) Decompress Hole Cover
(4) Cylinder Head Cover
(5) Rocker Arm Bushing
(6) Rocker Arm
(7) Rocker Arm Bracket
(8) Valve Cap
(9) Valve Spring Collet
(10) Valve Spring Retainer
(11) Valve Spring
(12) Exhaust Valve Guide
(13) Exhaust Valve
(14) Decompress Shaft
(15) Intake Valve Guide
(16) Cylinder Head
(17) Cylinder Head Gasket
(18) Intake Valve
(19) Drain Cock
(20) Glow Plug
(21) Heat Seal

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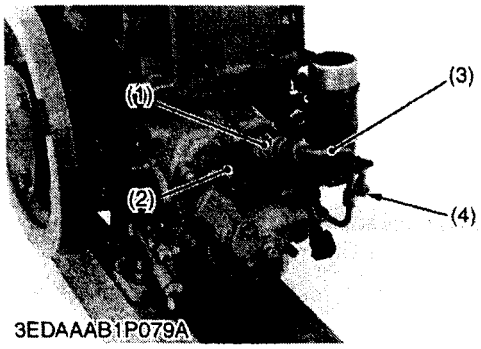

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Injection Pipe and Nozzle Holder

1. Close the fuel cock.
2. Remove the injection pipe (3).
3. Remove the nozzle holder (1) with a socket wrench and heat seal and remove the copper gasket.
4. Remove the glow plug (2).

**(When reassembling)**

- When reassembling the nozzle holder, take care that no carbon or dirt gets in.
- Replace the copper gasket with a new one.

| | | | |
|---|---|---|---|
| Tightening torque | Nozzle holder | M20 x 1.5 | 49 to 69 N·m<br>5 to 7 kgf·m<br>36 to 51 ft-lbs |
| | Glow plug | | 7.84 to 14.7 N·m<br>0.8 to 1.5 kgf·m<br>5.8 to 10.87 ft-lbs |

(1) Nozzle Holder
(2) Glow Plug
(3) Injection Pipe
(4) Pipe Clamp Mounting Screw

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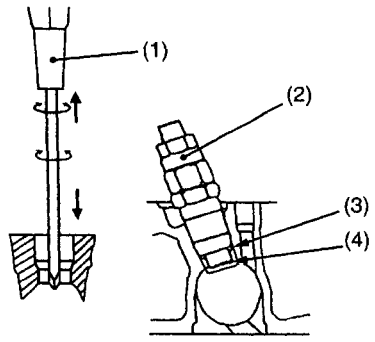

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Nozzle Heat Seal Service Removal Procedure

**■ IMPORTANT**

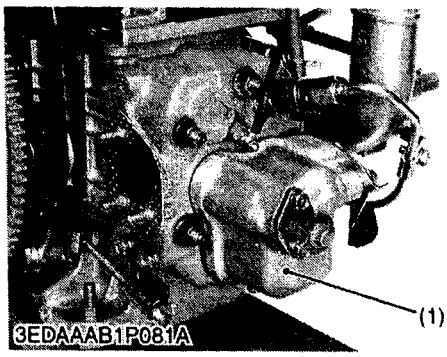
- **Use a plus (phillips head) screw driver that has a Dia. which is bigger than the heat seal hole (Approx. 6 mm (1/4 in.))**

1. Drive screw driver lightly into the heat seal hole.
2. Turn screw driver three or four times each way.
3. While turning the screw driver, slowly pull the heat seal out together with the injection nozzle gasket.

If the heat seal drops, repeat the above procedure. Heat seal and injection nozzle gasket must be changed when the injection nozzle is removed for cleaning or for service.

(1) Plus Screw Driver
(2) Injection Nozzle
(3) Injection Nozzle Packin
(4) Heat Seal

0000004949E



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Cylinder Head Cover

1. Remove the cylinder head cover (1).

**(When reassembling)**

- After reassembling the head cover, adjust decompress device.

| | | |
|---|---|---|
| Tightening torque | Head cover mounting nut | 9.8 to 10.8 N·m<br>1.0 to 1.1 kgf·m<br>7.2 to 8.0 ft-lbs |

(1) Cylinder Head Cover

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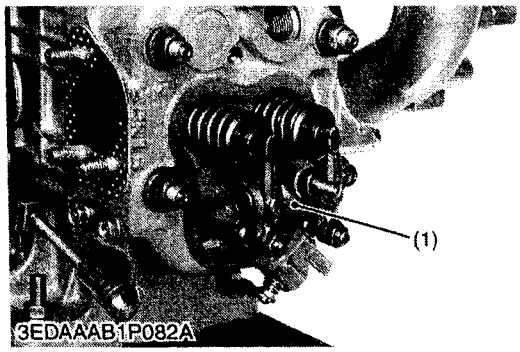


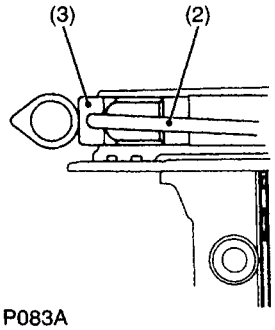


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Rocker Arm Bracket and Push Rod

1. Remove the rocker arm bracket (1) and rocker arms together.
2. Pull out the push rods (2).

**(When reassembling)**

- Apply engine oil to the rocker arm bushing bore and nut thread.
- Insert the push rod into groove of tappet securely as shown in the figure.
- After tightening bracket mounting nut to the specified torque, check that the rocker arm smoothly.

**■ NOTE**

- **Do not keep the push rods apart from the rocker arms while tightening the nut.**

**■ IMPORTANT**

- **The valve clearance must be adjusted after the rocker arm is installed.**

| | | |
|---|---|---|
| Tightening torque | Bracket mounting nut | 16.7 to 20.6 N·m<br>1.7 to 2.1 kgf·m<br>12.3 to 15.2 ft-lbs |

(1) Rocker Arm Bracket
(2) Push Rod
(3) Tappet

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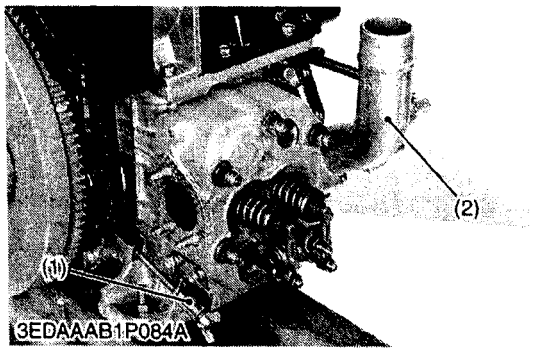



Cylinder Head

1. Remove the screws of tension bolt guide (1).
2. Remove the air cleaner flange (2).
3. Remove the cylinder head with a plastic hammer by tapping it.

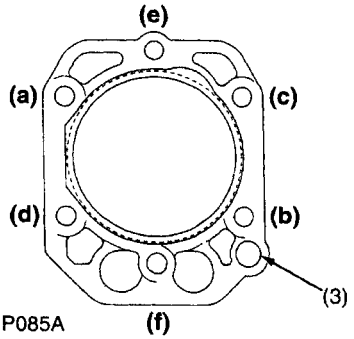
**(When reassembling)**

- Replace on the O-ring (3) between cylinder block and cylinder head with a new one.
- Replace the head gasket with a new one.
- When installing the new head gasket, be careful of the installation direction.

**■ IMPORTANT**

- **Gradually tighten the nuts in three passes in the order of (a) to (f) as shown in the figure. After tuning the engine for more than 30 minutes, be sure to retighten the head nut.**
- **The valve clearance must be adjusted after the cylinder head is installs even when it was removed without first removing the rocker arm.**

| | | |
|---|---|---|
| Tightening torque | Cylinder head mounting nut | 56.9 to 61.8 N·m<br>5.8 to 6.3 kgf·m<br>41.9 to 45.5 ft-lbs |

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(1) Tension Bolt Guide
(2) Air Cleaner Flange
(3) O-ring

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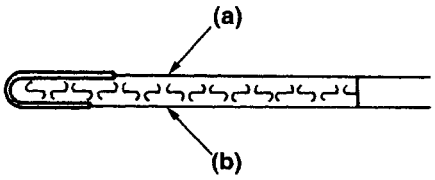


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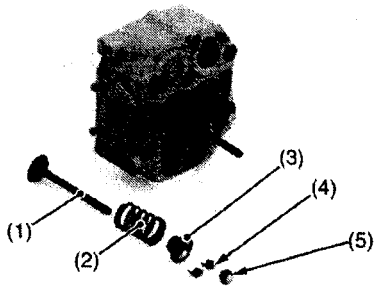
Valve

1. Remove the valve caps (5).
2. Remove the valve spring collets (4) with a valve lifter (6).
3. Remove the valve spring retainers (3), valve springs (2) and valves (1).

**(When reassembling)**

- Wash the valve stem and valve guide hole, and apply engine oil sufficiently.
- After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.

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(1) Valve
(2) Valve Spring
(3) Valve Spring Retainer
(4) Valve Spring Collet
(5) Valve Cap
(6) Valve Lifter

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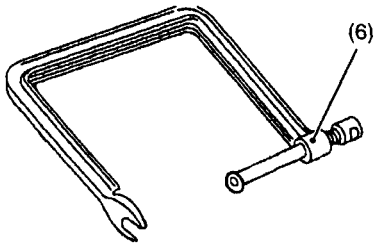


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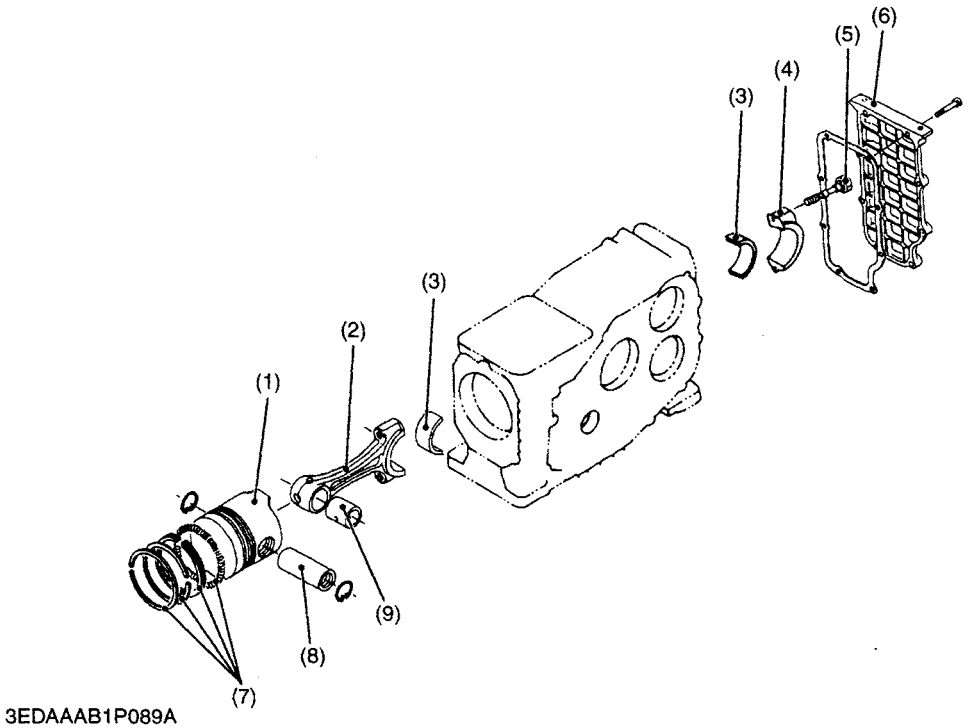
## (4) Piston and Connecting Rod

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(1) Piston
(2) Connecting Rod
(3) Crank Pin Bearing
(4) Connecting Rod Cap
(5) Connecting Rod Screw
(6) Crankcase Cover
(7) Piston Ring Assembly
(8) Piston Pin
(9) Piston Pin Bushing

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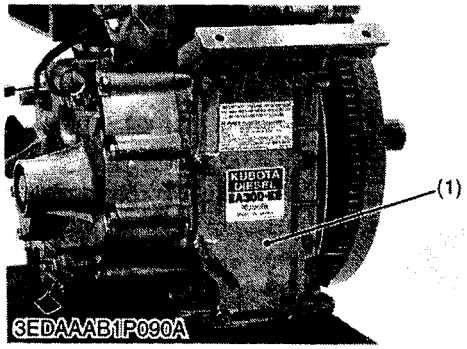


Crankcase Cover

1. Remove the crankcase cover (1).

**(When reassembling)**

- Tighten the crankcase cover mounting screws gradually in the order of **(a)** to **(h)** as shown in the figure.

| | | |
|---|---|---|
| Tightening torque | Crankcase cover mounting screw | 7.85 to 9.32 N·m<br>0.80 to 0.95 kgf·m<br>5.79 to 6.87 ft-lbs |

(1) Crankcase Cover

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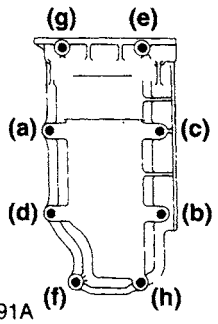


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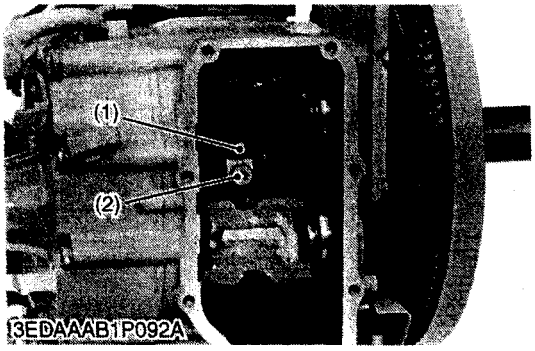


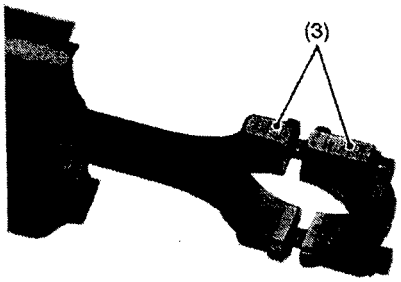


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Connecting Rod Cap

1. Set the piston in the bottom dead center.
2. Remove the connecting rod screws (2) to remove the connecting rod cap (1).

■ **NOTE**

- **Untighten rod screws slowly and equally.**

**(When reassembling)**

- Apply engine oil to the crank pin bearings and connecting rod screws.
- The connecting rod cap must be installed with the stamped mark facing the radiator so the mark (3) of the connecting rod and that of the connecting rod cap are aligned.

■ **IMPORTANT**

- **Screw the rod screws light by hand and fully insert it. If it cannot be screwed in lightly by hand, clean the thread. If it is still hard to screw, replace the screw.**

| | | |
|---|---|---|
| Tightening torque | Connecting rod screw | 26.5 to 30.4 N·m<br>2.7 to 3.1 kgf·m<br>19.5 to 22.4 ft-lbs |

(1) Connecting Rod Cap
(2) Connecting Rod Screw
(3) Mark

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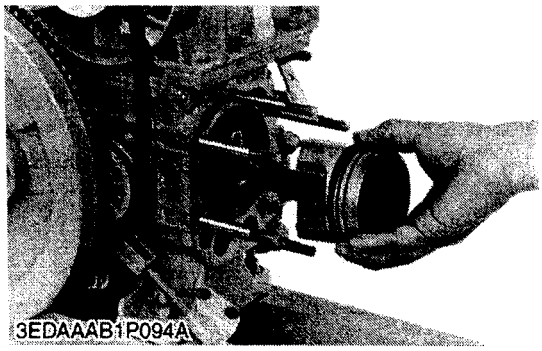
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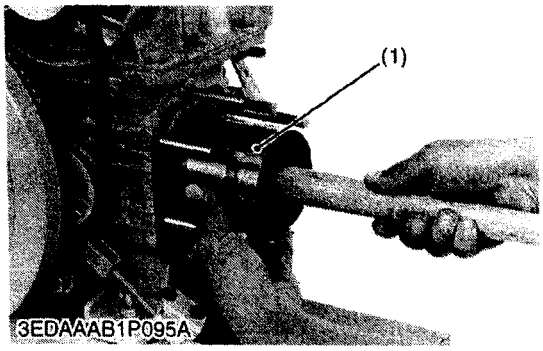

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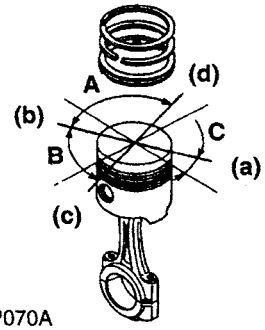

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Piston and Connecting Rod

1. Turn the flywheel and bring the piston to the top dead center.
2. Pull out the piston upward by tapping it from the bottom of the cylinder block with the grip of a hammer.

**(When reassembling)**

- Before installing the piston into the cylinder, apply enough engine oil to the cylinder liner wall.
- When inserting the piston into the cylinder, face the mark on the connecting rod to the radiator side.
- When inserting the piston into the cylinder, place the top ring gap **(b)** on the opposite side of the combustion chamber **(a)**, and stagger the second ring gap **(c)** and oil ring gap **(d)** marking a right angle from the top ring gap.

(1) Piston Ring Compressor

**(a) Combustion Chamber**
**(b) Top Ring Gap**
**(c) Second Ring Gap**
**(d) Oil Ring Gap**

**A: 1.57 rad (90 °)**
**B: 1.57 rad (90 °)**
**C: 0.31 rad (18 °)**

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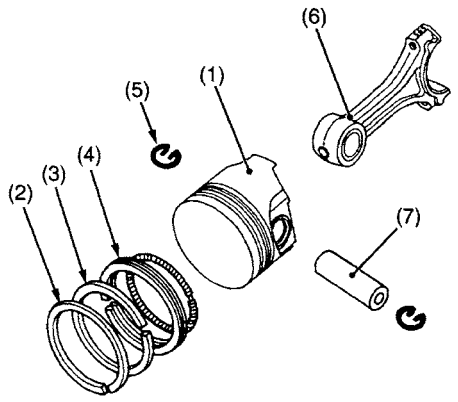


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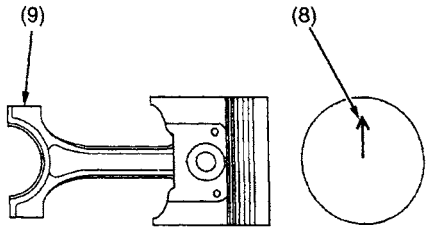


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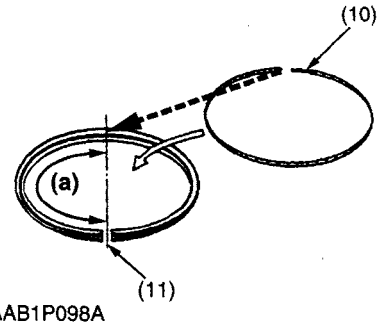


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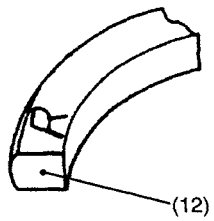


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Piston Ring and Connecting Rod

1. Remove the piston rings with a piston ring tool (Code No. 07909-32121).
2. Put the parting mark (8) on the piston head as shown in the photograph.
3. Remove the piston pin (7), and separate the connecting rod (6) from the piston (1).

**(When reassembling)**

- Clean all the parts before assembling.
- When installing the ring, assemble the rings so that the manufacturer's mark **R** near the gap faces the top of piston.
- When installing the oil ring onto the piston, place the expander joint (10) on the opposite side of the oil ring gap (11).
- Apply engine oil to the piston pin, and insert it to the piston.
- When installing the connecting rod to the piston, align the stamped mark (9) on the connecting rod to the parting mark (8).

(1) Piston
(2) Top Ring
(3) Second Ring
(4) Oil Ring
(5) Piston Pin Snap Ring
(6) Connecting Rod
(7) Piston Pin
(8) Parting Mark
(9) Mark
(10) Expander Joint
(11) Oil Ring Gap
(12) Manufacturer's Mark

**(a) 3.14 rad. (180 °)**

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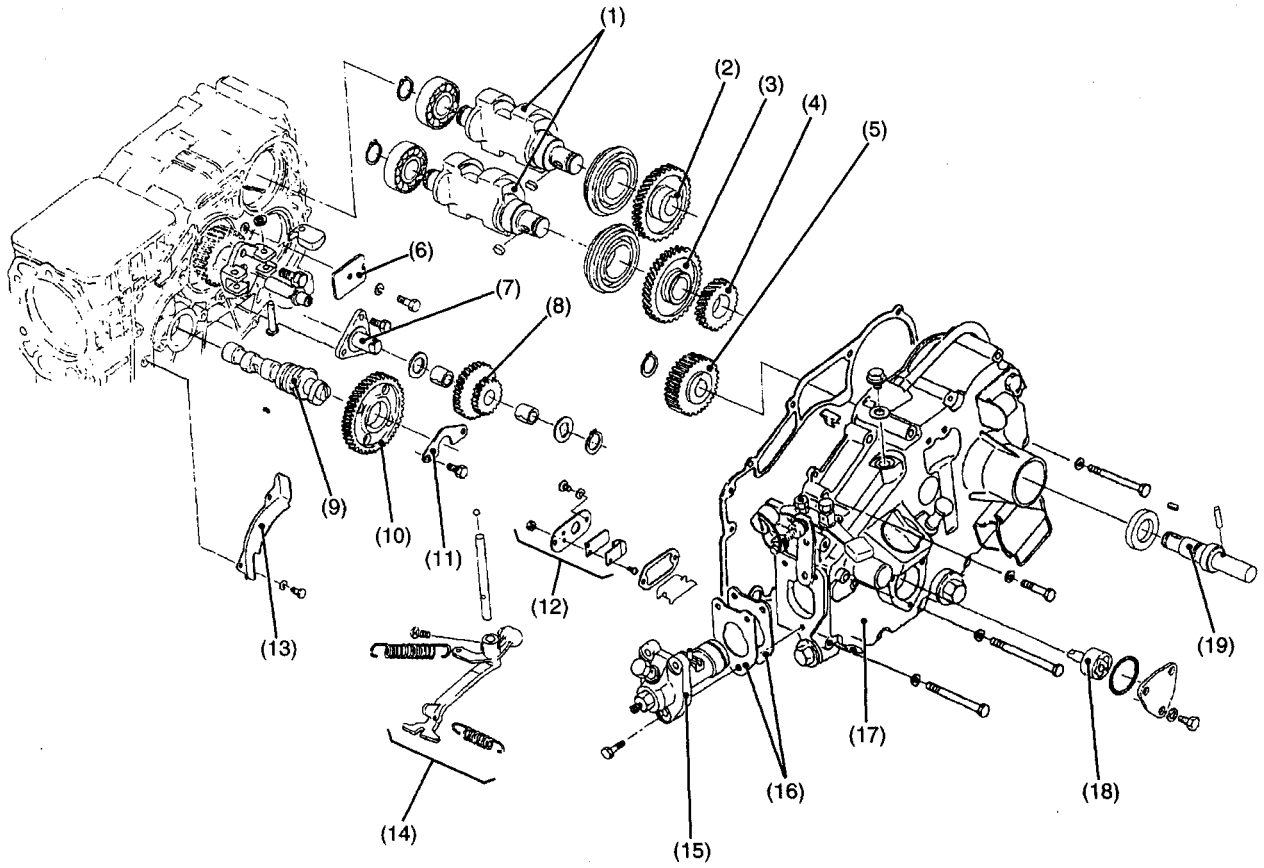
## (5) Gear Case

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| | | | |
|---|---|---|---|
| (1) Balancer | (6) Balancer Bearing Retainer | (11) Camshaft Stopper | (16) Pump Adjusting Shim |
| (2) Balancer Gear 2 | (7) Idle Gear Shaft | (12) Breather Assembly | (17) Gear Case |
| (3) Balancer Gear 1 | (8) Idle Gear | (13) Breather Oil Guard | (18) Oil Pump Rotor Assembly |
| (4) Balancer Gear 3 | (9) Camshaft | (14) Governor | (19) Starter Shaft |
| (5) Starting Gear | (10) Camshaft Gear | (15) Injection Pump Assembly | |

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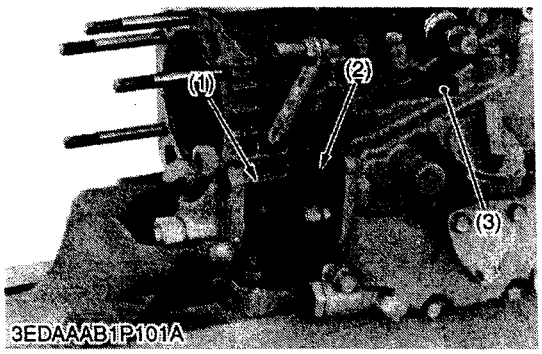


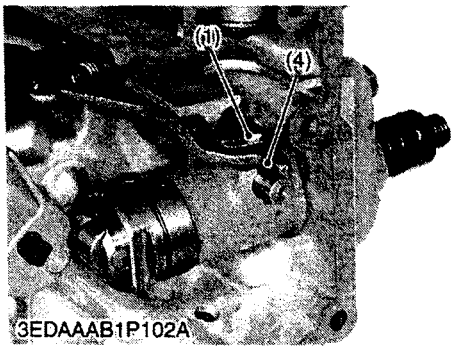


Injection Pump

1. Remove the injection pump mounting screws.
2. Move the speed control lever (3) and align the control rack pin (1) and notch (2) on the gear case to remove the injection pump.

■ **NOTE**

- **Record the number of injection timing adjusting shims used to adjust the injection timing.**

**(When reassembling)**

- Apply a thin coat of liquid gasket (Three bond 1215 or equivalent) to the shim.

■ **IMPORTANT**

- **Insert the same number of shims as used before, install the pump and then check the injection timing.**
- **Correctly fit the control rack pin (1) into the groove of the governor lever (4).**

| | | |
|---|---|---|
| Tightening torque | Injection pump mounting screw | 9.81 to 11.28 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.32 ft-lbs |

(1) Control Rack Pin
(2) Notch
(3) Speed Control Lever
(4) Governor Lever

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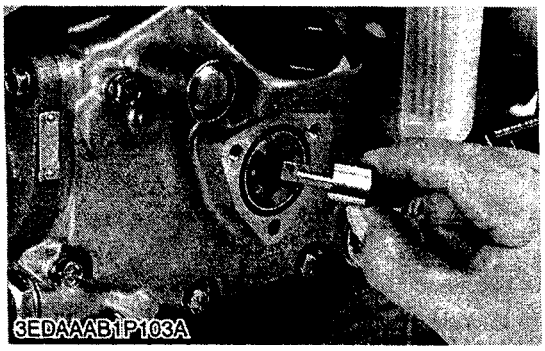


Oil Pump Cover and Oil Pump

1. Remove the oil pump cover.
2. Remove the gear case.
3. Push out the inner rotor shaft from inside of the gear case.

**(When reassembling)**

- Apply engine oil in each section (gear case oil pump body, inner rotor shaft, inner rotor, outer rotor.)

■ **NOTE**

- **After installing the gear case to the cylinder block, be sure to fit the inner rotor shaft into the camshaft end groove.**

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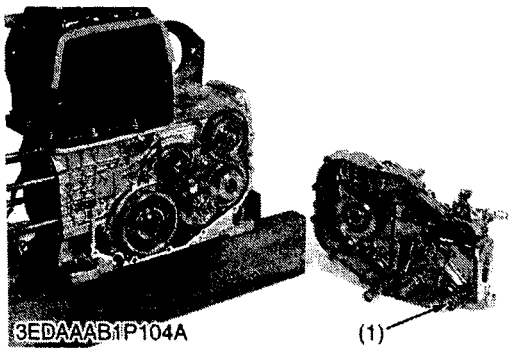


Gear Case

1. Remove the gear case.

**(When reassembling)**

- Dismount the inner rotor shaft of oil pump beforehand.
- Replace the O-ring (1) of the oil gallery connection with a new one.
- Coat the gear case gasket with grease, and take case to avoid any misalignment of the new O-ring or screw holes.

| | | |
|---|---|---|
| Tightening torque | Gear case mounting screw | 9.81 to 10.30 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 7.59 ft-lbs |

(1) O-ring

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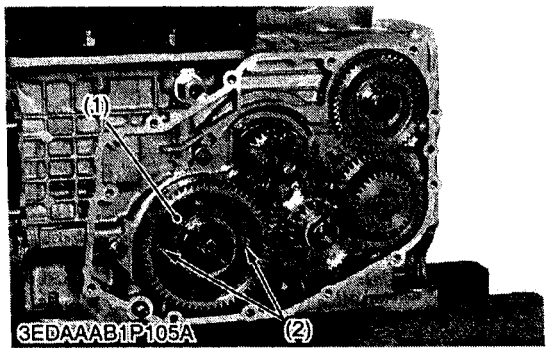


Cam Gear and Camshaft

■ **NOTE**

- **Before disassembling, check the backlash of each gears. Also check them during reassembly.**

1. Remove the lock plate mounting screw (2).
2. Remove the cam gear (1) and camshaft together.

**(When reassembling)**

■ **IMPORTANT**

- **Align the alignment marks of each gears.**

(1) Cam Gear (2) Lock Plate Mounting Screw

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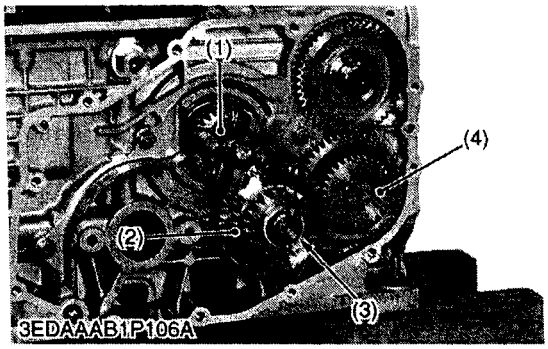



Idle Gear

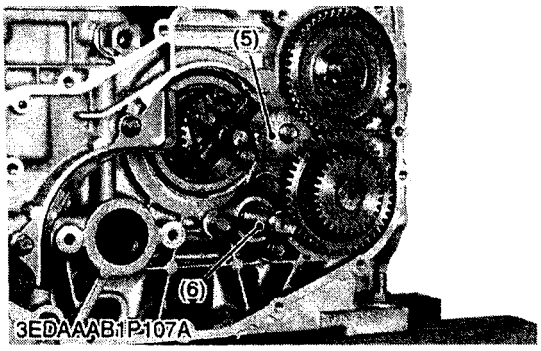
1. Draw out the external snap ring (3) on the idle gear shaft (6) and take out the idle gear (2).
2. Alternatively, remove the idle gear shaft screw, and the take out the idle gear and gear shaft together.
3. Remove the balancer bearing retainer (5).

**(When reassembling)**

■ **NOTE**

- **Align the alignment marks of the idle gear, balancer gear (4) and crank gear (1).**

| | | |
|---|---|---|
| Tightening torque | Idle gear shaft screw | 9.81 to 11.28 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.32 ft-lbs |




(1) Crank Gear (4) Balancer Gear
(2) Idle Gear (5) Balancer Bearing Retainer
(3) External Snap Ring (6) Idle Gear Shaft

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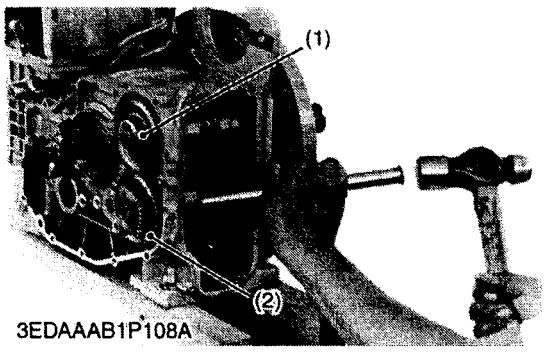


Balancer Gear and Balancer

■ **NOTE**

- **Before disassembling, check the backlash of the balancer gears 1 (2) and 2 (1). Also check it during reassembly.**

1. From the inside of the cylinder block place a brass rod against the end of the balancer and tap it off to the gear case side with a hammer.

**(When reassembling)**

- If the piston and the connecting rod have been removed, it is easier to reassemble the connecting rod cap first, and then proceed to the balancer gear reassembly.

■ **IMPORTANT**

- **Align the alignment marks of the balancer gears 1 (2) and 2 (1).**

(1) Balancer Gear 2 (2) Balancer Gear 1

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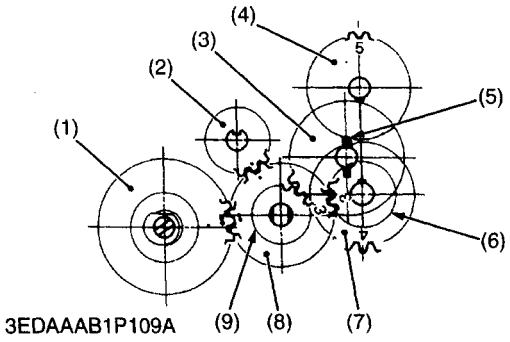

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Reassembling Procedure of Gears

1. Set the crankshaft so the crank pin comes directly to the left side as viewed from the gear.
2. Align the alignment marks of balancer gear 2 (4) and balancer gear 1 (6).
3. Turn the balancer gear by 3.14 rad (180°) to the position as shown in the figure.
4. Align the alignment marks of the crank gear (2), cam gear (1) and balancer gear 3 (7), and reassemble the idle gear (8), (9).

(1) Cam Gear
(2) Crank Gear
(3) Starting Gear
(4) Balancer Gear 2
(5) Starting Shaft Pin
(6) Balancer Gear 1
(7) Balancer Gear 3
(8) Idle Gear (45T)
(9) Idle Gear (21T)

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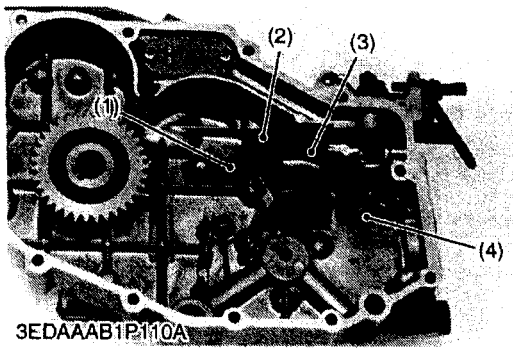

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Governor Lever

1. Detach the governor spring (3) and spring (4) from the governor lever (1).
2. Remove the screw (2) and pull out the governor lever shaft toward the breather side.
3. Remove the governor lever.

■ **NOTE**

- **Do not lose the ball onto the governor shaft in the process.**

(1) Governor Lever
(2) Screw
(3) Governor Spring
(4) Idling Spring

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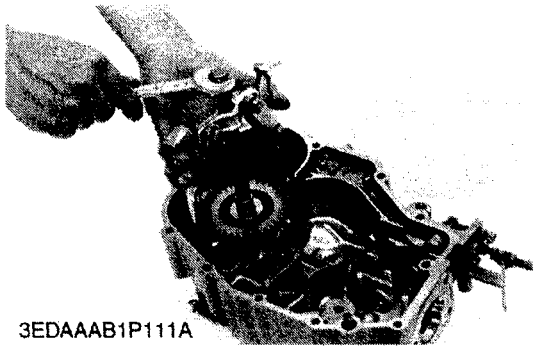

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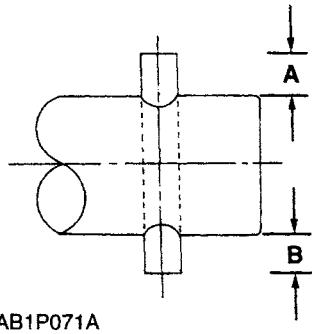


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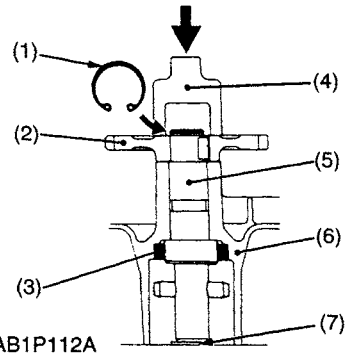


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Starting Shaft

1. Draw out the external snap ring to remove the staring gear 2.
2. Remove the key to remove the starting shaft.
3. Tap out the starting shaft pin.

**(When reassembling)**

- When driving the starting shaft pin, a difference of its protrusion must be below 1 mm (0.04 in.) (Difference between **A** and **B**).
- Apply engine oil to the oil seal (3) of the starting shaft (5).
- Apply oil over the driven position of the gear, tap it until it reaches the starting shaft step, and install the external snap ring (1) accurately in the groove.
- After parts are assembled, turn the gear and the shaft by hand and ensure they turn smoothly.

(1) External Snap Ring
(2) Start Gear
(3) Oil Seal
(4) Socket
(5) Starting Shaft
(6) Gear Case
(7) Plane Washer

**A, B : Shaft Pin Protrusion**

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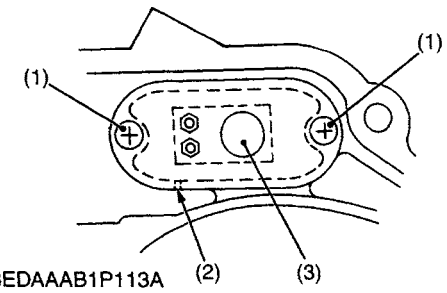


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Breather

1. Remove the breather mounting screw (1) to remove the breather assembly.

**(When reassembling)**

- Install the breather assembly with the valve hole (3) in the opposite side of the oil escape groove (2).

(1) Mounting Screw
(2) Oil Escape Groove
(3) Valve Hole

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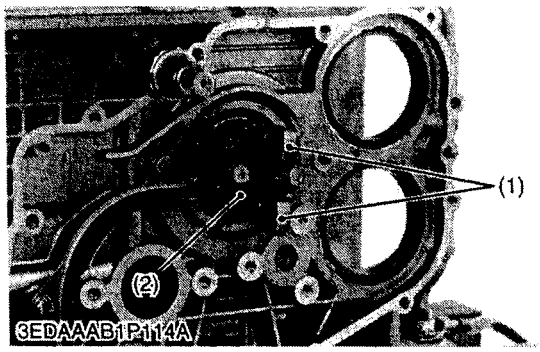


Governor Weight

1. Remove the governor weight (1) and governor weight holder (2) together.

(1) Governor Weight (2) Governor Weight Holder

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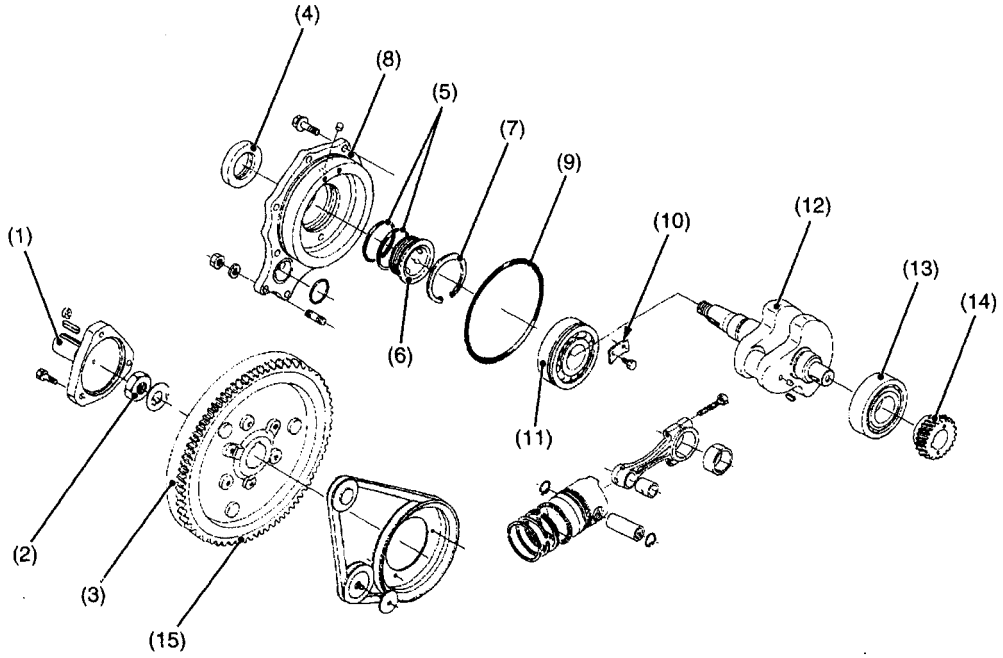
## (6) Flywheel and Crankshaft




(1) Pulley Shaft
(2) Flywheel Nut
(3) Flywheel
(4) Oil Seal
(5) O-ring
(6) Oil Filler Ring
(7) Internal Snap Ring
(8) Main Bearing Case
(9) O-ring
(10) Main Bearing Retainer
(11) Main Bearing 2
(12) Crankshaft
(13) Main Bearing 1
(14) Crankshaft Gear
(15) Ring Gear

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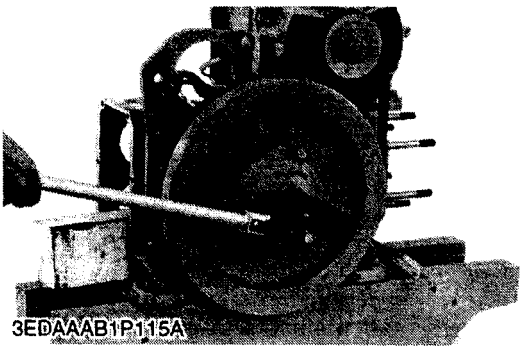

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Pulley Shaft

1. Place a wood block, etc. to prevent the crankshaft from turning, and remove the pulley shaft (or the pulley).

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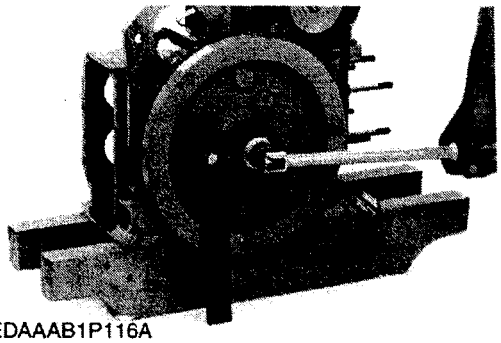

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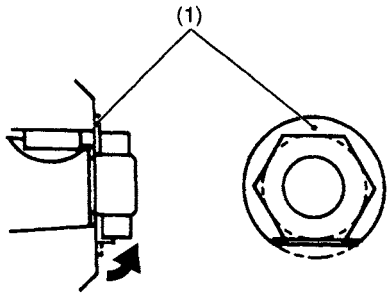
Flywheel Nut

1. Stretch the lock washer.
2. Lock the flywheel nut to turn with a flywheel stopper.
3. Remove the flywheel nut with a socket wrench 29 (Code No. 07916-31820).

**(When reassembling)**

- Apply molybdenum disulfide oil to the flywheel nut seat and thread, and tighten the flywheel nut to the specified torque.
- Be sure to bend up the lock washer (1) to prevent loosening as shown in the figure.

| | | |
|---|---|---|
| Tightening torque | Flywheel nut | 137 to 157 N·m<br>14 to 16 kgf·m<br>101 to 116 ft-lbs |

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(1) Lock Washer

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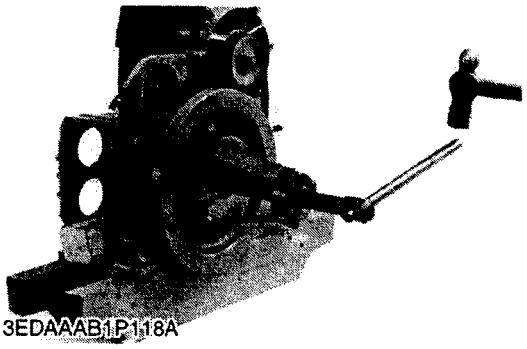

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Flywheel

1. Set a flywheel puller (Code No. 17916-04052) and remove it with the flywheel.

**■ IMPORTANT**

- **Clean the flywheel and crankshaft tapered section to be free from any dirt or chips. Also take care so that oil does not stick to the crankshaft tapered section.**

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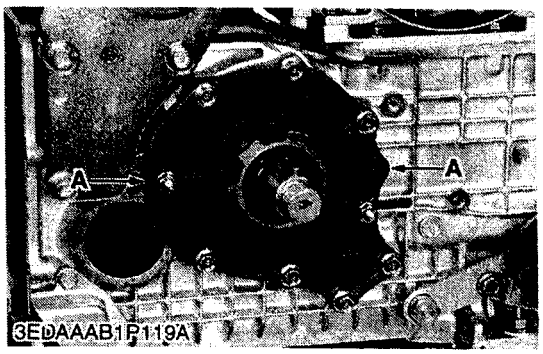



3EDAAAB1P119A

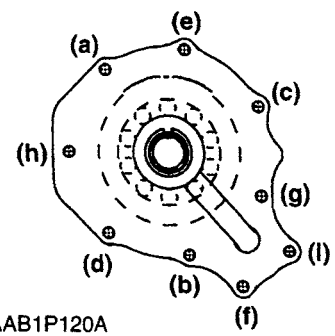
Crankshaft and Main Bearing Case

1. Remove the flywheel key.
2. Remove the bolts of main bearing case.
3. Insert the tip of a screwdriver in the gap **A** between the bearing case and the cylinder block (as shown with in the photo). Then, by prying the screwdriver to left and right evenly, pull out the bearing and the crank shaft together.

**(When reassembling)**

- Check that the O-ring is not damaged and apply a light coating of oil to the ring.
- Tighten the main bearing case retaining bolts gradually in the order of **(a)** to **(i)** as shown in the figure.

**A : Gap**

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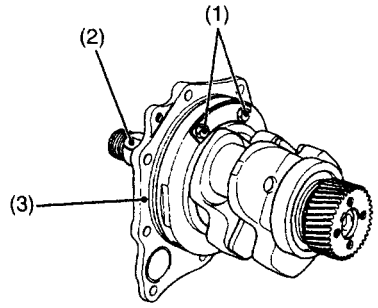


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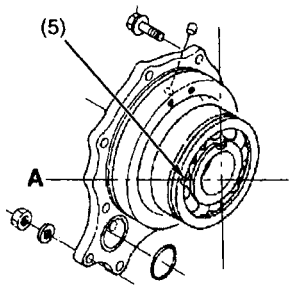


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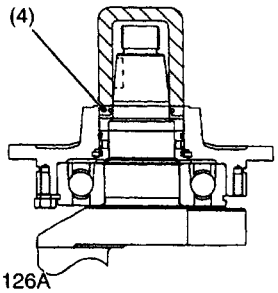



3EDAAAB1P126A

Main Bearing Case and Crankshaft

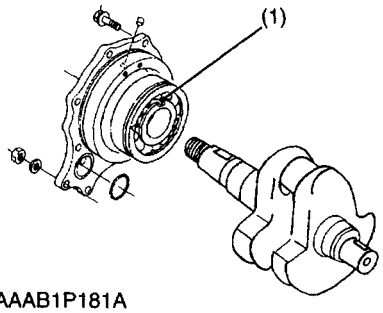
1. Remove the bolts retaining (1) the bearing retainer.
2. Remove the flywheel key (2) from the crankshaft.
3. Tap the main bearing case (3) with a plastic hammer to separate it from crankshaft.

**(When reassembling)**

- Fit the outer lace notch (5) of the bearing into the **A** position shown in the figure.
- Press the oil seal (4) until outside surface of the oil seal becomes lush with boss of the main bearing case.

(1) Retaining Bolt
(2) Flywheel Key
(3) Main Bearing Case
(4) Oil Seal
(5) Notch

0000009821E




3EDAAAB1P181A

Main Bearing and Crank Shaft

1. Pull the main bearing off using press.

**(When reassembling)**

- The crank shaft, the main bearing and fitting part of the bearing must be thoroughly cleaned before oiling and pressing in.
- Place the notch (1) in the inner ring to the orientation of flywheel key of the crank shaft, and then press in the bearing so that the gap between the inner ring and the crank shaft is eliminated.

(1) Notch

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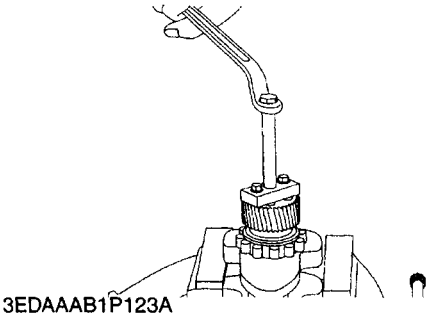
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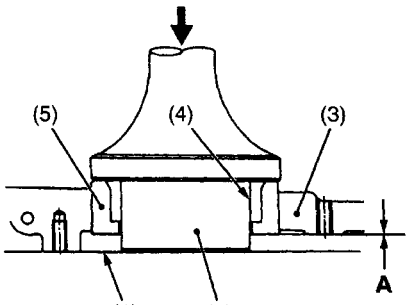

3EDAAAB1P124A

Crank Gear and Main Bearing 1

1. Secure the crankshaft with a vise and installing a crank gear puller.
2. Pull out the crank gear.

**(When reassembling)**

- Tap the outer ring (5) of the main bearing 1 (roller bearing near the gear case) into the cylinder block (3) until the end surface of the outer ring (5) is flush with that of the cylinder block (3).

**■ IMPORTANT**

- **Tap the outer ring of the bearing carefully without damaging the roller raceway surface (4).**
- **Confirm that main bearing is press-fitted so that the gap between the crankshaft end surface and main bearing side surface is 0 mm (0 in.).**
- **Press-fit the crank gear (6) so that the gap between the bearing side and bearing inner side is 0 mm (0 in.).**

(1) Gear Case Surface
(2) Inserting Tool
(3) Cylinder Block
(4) Roller Raceway Surface
(5) Roller Bearing Outer Ring
(6) Crank Gear
**A : 0 mm (0 in.)**

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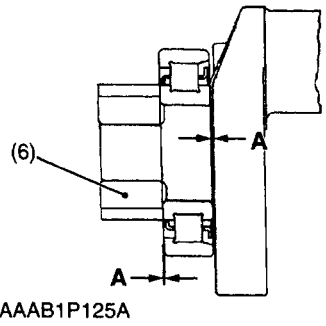

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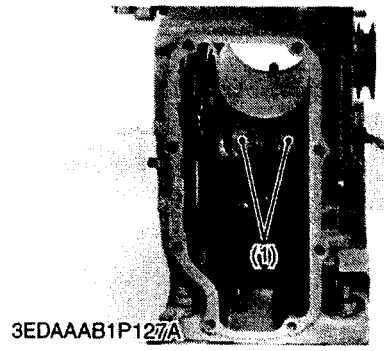
3EDAAAB1P127A

Tappet

1. Pull out the tappet (1).

**(When reassembling)**

- Before installing the tappet, apply engine oil around it.

(1) Tappet

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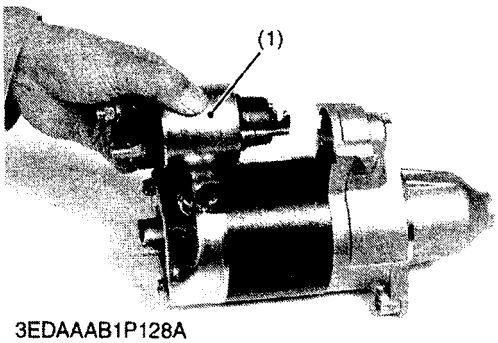
## (7) Starter




3EDAAAB1P128A

Magnet Switch

1. Disconnect the connecting lead.
2. Remove the mounting nut.
3. Remove the magnet switch (1) by sliding it up so that it is disconnected from the drive lever.

(1) Magnet Switch

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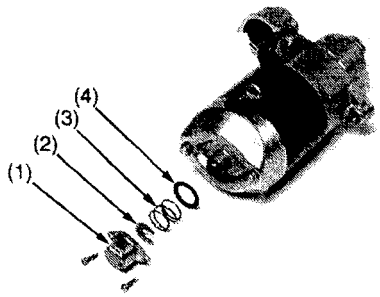


3EDAAAB1P129A

Armature Brake

1. Remove the end frame cap (1).
2. Remove the brake shoe (2).
3. Remove the brake spring (3).
4. Remove the gasket (4).

**(When reassembling)**

- After reassembling the brake shoe (2), adjust the shaft thrust gap.

(1) End Frame Cap
(2) Brake Shoe
(3) Brake Spring
(4) Gasket

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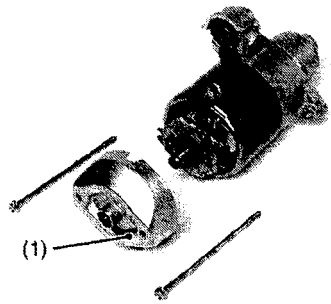


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End Frame

1. Remove the two through bolts.
2. Remove the end frame (1).

(1) End Frame

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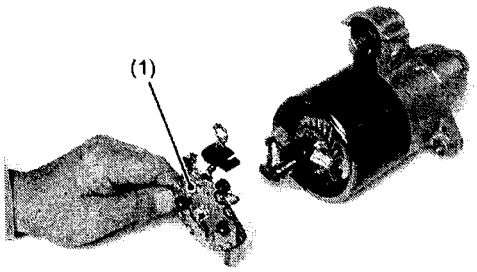


3EDAAAB1P131A

Brush Holder

1. Draw out the brush from the holder while holding the spring up.
2. Remove the brush holder (1).

**(When reassembling)**

- When replacing the spring, install it by referring to the figure.
- Do not contact the brush's positive lead with the body.

(1) Brush Holder
(2) Spring Hanger
(3) Attach the brush spring in this method
(4) Brush

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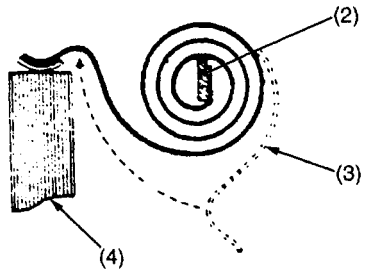


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Yoke

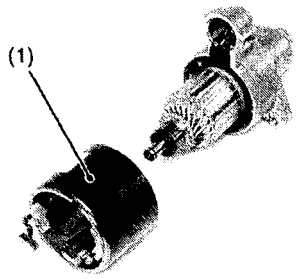
1. Draw out the yoke (1) from the drive end frame.

**(When reassembling)**

- Install the yoke, nothing the location of dowel pin.

(1) Yoke

0000009897E

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Armature

1. Draw out the armature (2) with the drive lever (1).

**(When reassembling)**

- Install the drive lever, nothing its direction.

(1) Drive Lever
(2) Armature
(3) Drive End Frame

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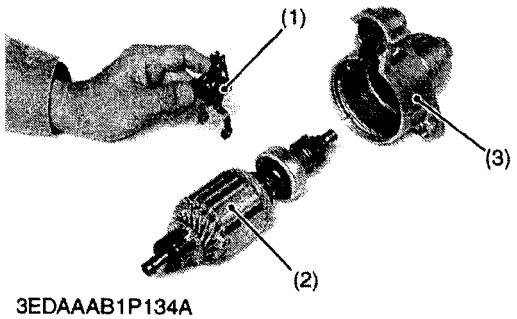


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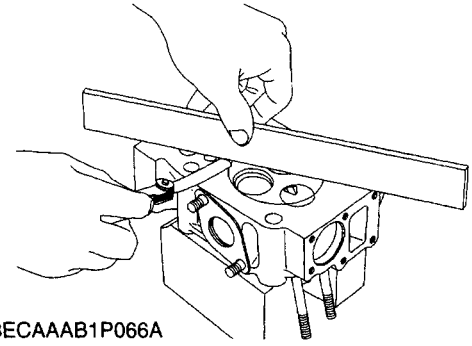
# [3] SERVICING

## (1) Cylinder Head and Valves



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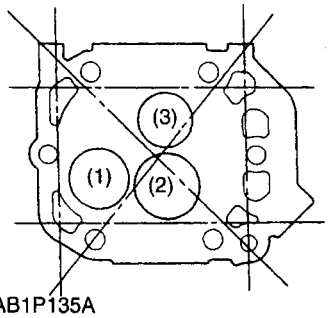


3EDAAAB1P135A

Cylinder Head Surface Flatness

1. Clean the surface of the cylinder head.
2. Place a straight edge on each of the cylinder head's four sides and two diagonal as shown at the right to check the straightness of the surface.
3. Insert a feeler gauge between the straight edge and the cylinder head surface.
4. The maximum thickness that can be inserted is the amount of distortion.

■ **NOTE**

- **Do not place the straight edge on the combustion chamber (1).**

5. If the measurement exceeds the allowable limit, correct it with a surface grinder. Inspect the amount of the valve recession after correction.

| | | |
|---|---|---|
| Cylinder head surface flatness | Allowable limit | 0.05 mm / 100 mm<br>0.0020 in. / 3.94 in.<br>of cylinder head surface length |

| | |
|---|---|
| Finshing | 8 μRmax ▽▽ |

(1) Combustion Chamber
(2) Intake Valve
(3) Exhaust Valve

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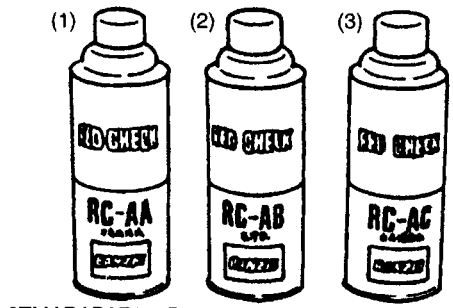


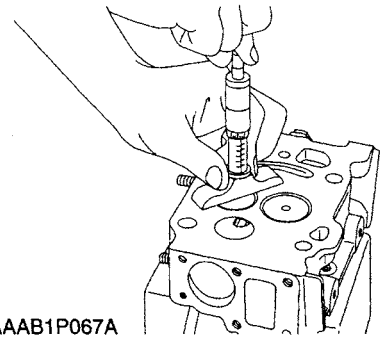

3TMABAB0P059B

Cylinder Head Flaw

1. Prepare an air spray red check (Code No. 07909-31371).
2. Clean the surface of the cylinder head with the detergent (2).
3. Spray the cylinder head surface with the red permeative liquid (1). Leave it five to ten minutes after spraying.
4. Wash away the red permeative liquid on the cylinder head surface with the detergent (2).
5. Spray the cylinder head surface with the white developer (3).
6. If flawed, it can be identified as red marks.

(1) Red Permetive Liquid
(2) Detergent
(3) White Developer

0000000875E



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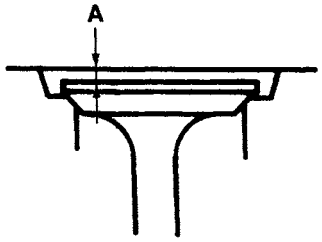


3EDAAAB1P136A

## Valve Recessing

1. Clean the cylinder head, the valve face and seat.
2. Insert the valve into the guide.
3. Measure the valve recessing **A** with a depth gauge.
4. If the recession exceeds the allowable limit, replace the valve. In addition, repair the cylinder head seat surface with a valve seat cutter (Code No. 07909-33102) or valve seat grinder, and then repair the head surface with a surface grinder. Or, replace the cylinder head.

| | | |
|---|---|---|
| Valve recessing (IN and EX) | Factory spec. | 0.8 to 0.9 mm<br>0.031 to 0.035 in. |
| | Allowable limit | 1.5 mm<br>0.059 in. |

**A: Valve recessing**

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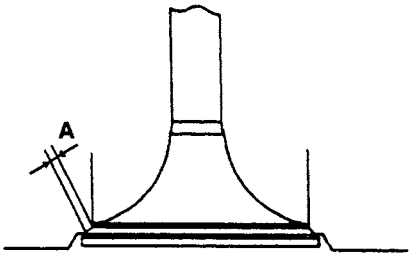


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## Width of Contact between Valve and Valve Seat

1. Check the contact between the valve face and valve seat.
2. When parts are not contacting evenly, or the contact width **A** (See figure) is extremely wide, repair or replace the valve and cylinder head seat, rub and refit parts to each other applying an appropriate amount of compound.

| | | |
|---|---|---|
| Valve seat width | Factory spec. | 2.12 mm<br>0.083 in. |

**A: Contact Width**

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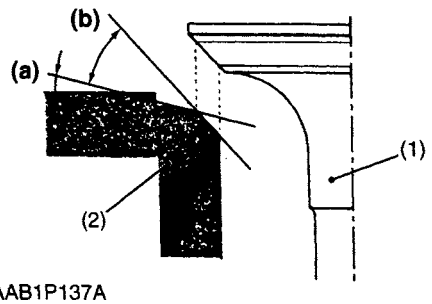


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## Cylinder Wear

1. Correct the valve seat to the factory specification with a valve seat cutter (Code No. 07909-33102) or a valve seat grinder.
2. Correct the valve using a valve refacer.

| | | |
|---|---|---|
| Valve seat angle | Factory spec. | 0.785 rad<br>45.0 ° |
| Valve face angle | Factory spec. | 0.785 to 0.794 rad<br>45.0 to 45.5 ° |

(1) Valve
(2) Corrected Valve Seat
(3) Valve Refacer

**(a) 0.262 rad (15°)**
**(b) 0.785 rad (45°)**

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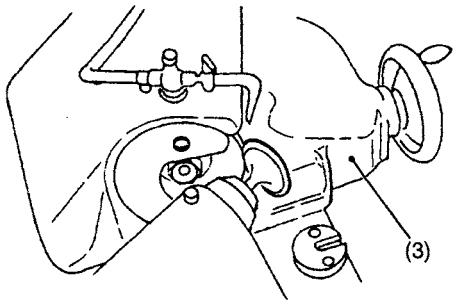


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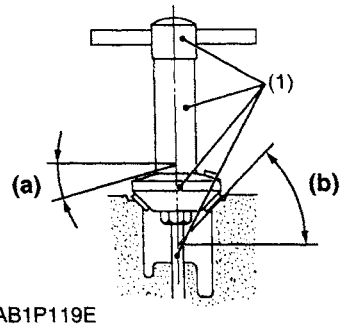


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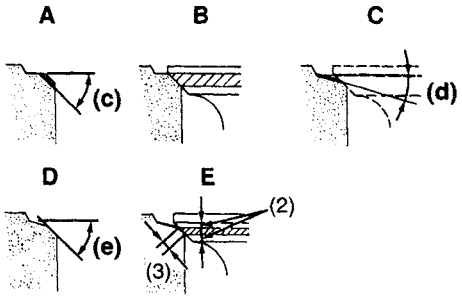


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Correcting Procedure for Valve Seat

■ **NOTE**

- **Always try to minimize the valve seat recession.**

1. Correct the valve seat surface with a 0.785 rad (45°) valve seat cutter (Valve seat cutter set : Code No. 07909-33102).
2. Place the valve and visually check the contact position between the valve face and valve seat with red lead. (If the valve has been used for a long period of time, the seat tends to come into contact with the upper side of the valve face.)
3. Cut the seat with a 0.262 rad (15°) valve seat cutter so that the valve seat width makes contact in the same dimensions to the valve face width.
4. Cut the seat with a 0.785 rad (45°) valve seat cutter again, and visually recheck the contact between the valve and seat.
5. Repeat steps **B** and **C** until the correct contact is achieved.
6. Continue lapping until the seated rate is more than 70% of the total contact area.

(1) Valve Seat Cutter
(2) Identical Dimensions
(3) Seat Surface Width

**(a) 0.262 rad (15°)**
**(b) 0.785 rad (45°)**
**(c) 0.785 rad (45°)**
**(d) 0.262 rad (15°)**
**(e) 0.785 rad (45°)**

**A : 0.785 rad. (45°) Cutter**
**B : Contact Check**
**C : 0.262 rad. (15°) Cutter**
**D : 0.785 rad. (45°) Cutter**
**E : Contact Check**

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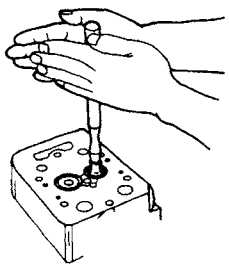

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Correcting Valve Seating (Valve Lapping)

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70 %, repeat valve lapping again.

■ **IMPORTANT**

- **When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.**

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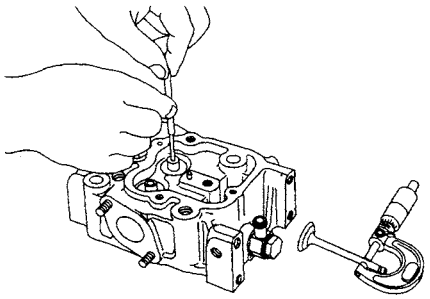

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Oil Clearance between Valve Stem and Valve Guide

1. Remove carbon from the valve guide bore.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure I.D. of the cylinder head valve guide at the most worn part with a small hole gauge, and find the oil clearance. (Normally, a greater wear results in parallel to the rocker arm.)
4. If the clearance exceeds the allowable limit, replace the valve guide and valve.

| | | |
|---|---|---|
| Oil clearance between valve stem and valve guide | Factory spec. | 0.035 to 0.065 mm<br>0.00138 to 0.00256 in. |
| | Allowable limit | 0.1 mm<br>0.004 in. |

| | | |
|---|---|---|
| Valve stem O.D. | Factory spec. | 6.960 to 6.975 mm<br>0.27402 to 0.27461 in. |
| Valve guide bore I.D. | Factory spec. | 7.010 to 7.025 mm<br>0.27598 to 0.27657 in. |

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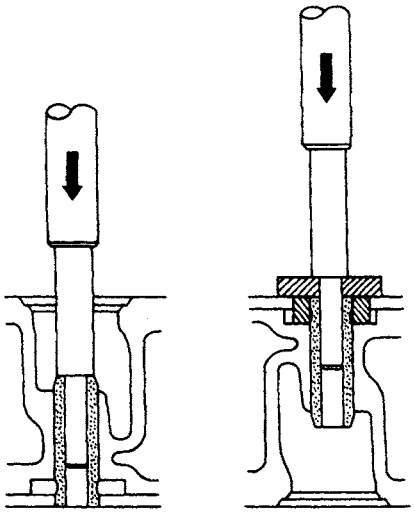

3EEABAB1P117B

Replacing Valve Guide

**(When removing)**

1. Press out valve guide with a valve guide replacing tool.

**(When installing)**

1. Clean the valve guide bore, and apply engine oil to it.
2. Press in the valve guide until its flange contacts the cylinder head.
3. Provide an oil return hole in the exhaust valve with a drill.
4. Ream precisely the bore of the valve guide to the specified dimension in the table below.

**■ IMPORTANT**

- **Do not hit the valve guide with a hammer during replacement.**

| | | |
|---|---|---|
| Valve guide bore I.D. | Factory spec. | 7.010 to 7.025 mm<br>0.27598 to 0.27657 in. |

| | |
|---|---|
| Finshing | 6.3 S ▽▽▽ |

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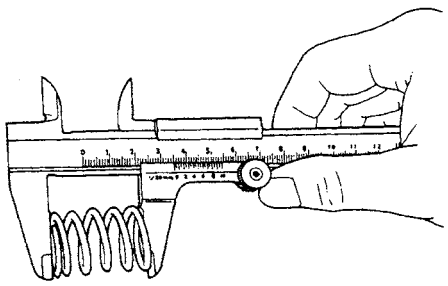

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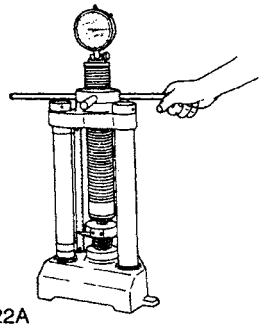

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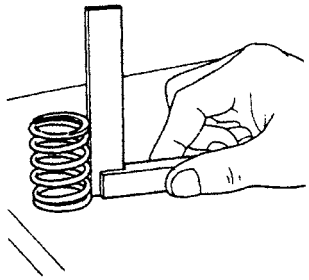

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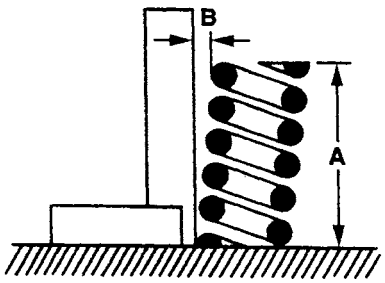


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Valve Spring Free Length and Tension

1. Measure the free length of the spring with vernier calipers.
2. Place the spring on a spring compression tester and compress to the specified length, and get the tension.
3. If the measurement is less than the allowable limit, replace the valve spring.

| | | |
|---|---|---|
| Free length | Factory spec. | 34.5 mm<br>1.358 in. |
| | Allowable limit | 33.8 mm<br>1.331 in. |

| | | |
|---|---|---|
| Setting load / Setting length | Factory spec. | 58.8 N / 31 mm<br>6.0 kgf / 31 mm<br>13.2 lbs / 1.22 in. |
| | Allowable limit | 49.0 N / 31 mm<br>5.0 kgf / 31 mm<br>11.0 lbs / 1.22 in. |

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Valve Spring Squareness

1. Place the spring on the surface plate and a square at its side.
2. Measure the free length **A** (See figure) by rotating spring.
3. If the measurement exceeds the allowable limit, replace the valve spring.

| | | |
|---|---|---|
| Tilt **B** | Allowable limit | 1.2 mm<br>0.047 in. |

**A : Free Length** **B : Tilt**

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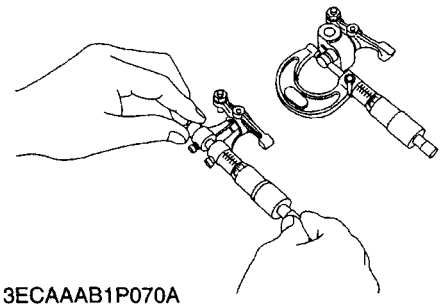

3ECAAAB1P070A

Oil Clearance between Rocker Arm Shaft and Bushing

1. Measure the rocker arm shaft O.D. with an outside micrometer.
2. Measure the rocker arm I.D. with an inside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the rocker arm.

| | | |
|---|---|---|
| Oil clearance between rocker arm and shaft | Factory spec. | 0.016 to 0.045 mm<br>0.0006 to 0.0018 in. |
| | Allowable limit | 0.15 mm<br>0.0059 in. |

| | | |
|---|---|---|
| Rocker arm I.D. | Factory spec. | 11.000 to 11.018 mm<br>0.4331 to 0.4338 in. |

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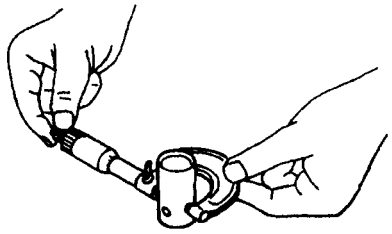

3EDAAAB1P144A

Oil Clearance between Tappet and Guide

1. Measure the tappet O.D. with a outside micrometer.
2. Measure the tappet guide bore I.D. of the cylinder block with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit or the sliding surface is scored, replace the tappet.

| | | |
|---|---|---|
| Oil clearance between tappet and guide | Factory spec. | 0.020 to 0.062 mm<br>0.00079 to 0.00244 in. |
| | Allowable limit | 0.15 mm<br>0.0059 in. |

| | | |
|---|---|---|
| Tappet O.D. | Factory spec. | 19.959 to 19.980 mm<br>0.78579 to 0.78661 in. |
| Guide bore I.D. | Factory spec. | 20.000 to 20.021 mm<br>0.78740 to 0.78823 in. |

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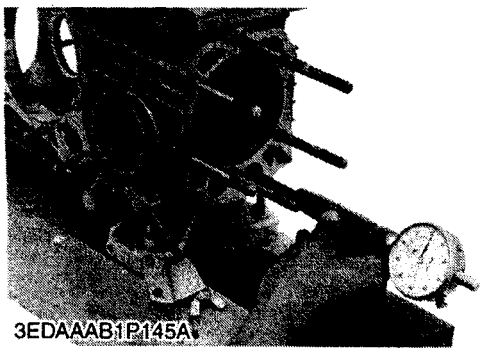

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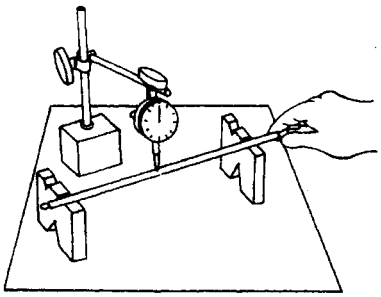

3EDAAAB1P146A

Push Rod Alignment

1. Check the both end of the push rod for cracks, damage and unusual wear.
2. Measure the bending of the push rod with a dial indicator.
3. If the measurement exceeds the allowable limit, replace the push rod.

| | | |
|---|---|---|
| Bending | Allowable limit | 0.125 mm<br>0.00492 in. |

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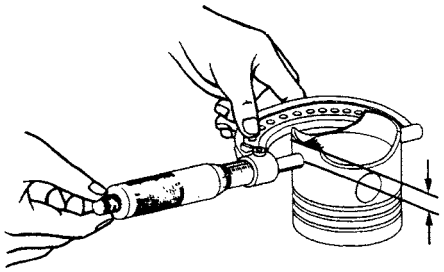
## (2) Piston and Connecting Rod



3EDAAAB1P147A

Piston Skirt O.D.

1. Measure the piston skirt O.D. with an outside micrometer. (Measuring points are shown in the figure.)
2. If the measurement is less than the allowable limit, replace the piston.

| | | |
|---|---|---|
| Piston skirt O.D. | Factory spec. | 74.925 to 74.945 mm<br>2.94980 to 2.95059 in. |
| | Allowable limit | Cylinder liner I.D.<br>- 0.25 mm<br>-0.0098 in. |

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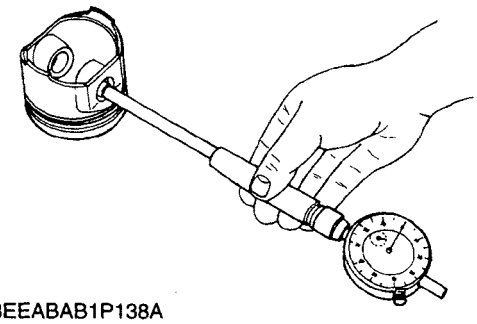

3EEABAB1P138A

Piston Pin Bore

1. Measure the I.D.'sof piston pin bore (lengthwise and widthwise of the piston) with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

| | | |
|---|---|---|
| Piston pin bore I.D. | Factory spec. | 20.000 to 20.013 mm<br>0.78740 to 0.78791 in. |
| | Allowable limit | 20.04 mm<br>0.7890 in. |

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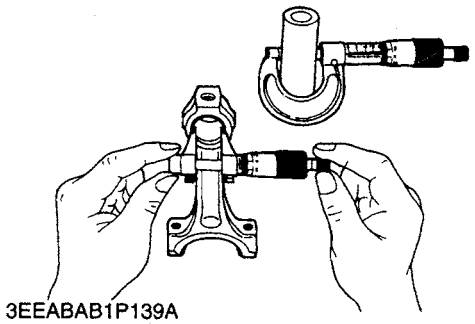

3EEABAB1P139A

Oil Clearance between Piston Pin and Bushing

1. Measure the piston pin O.D. with an outside micrometer.
2. Measure the piston pin bushing I.D. with an inside micrometer and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the bushing.
4. If the clearance still exceeds the allowable limit with new bushing, replace the piston pin.

| | | |
|---|---|---|
| Oil clearance between piston pin and bushing | Factory spec. | 0.014 to 0.038 mm<br>0.00055 to 0.00150 in. |
| | Allowable limit | 0.15 mm<br>0.0059 in. |

| | | |
|---|---|---|
| Piston pin O.D. | Factory spec. | 20.002 to 20.011 mm<br>0.78748 to 0.78784 in. |
| Small end bushing I.D. | Factory spec. | 20.025 to 20.040 mm<br>0.78839 to 0.78921 in. |

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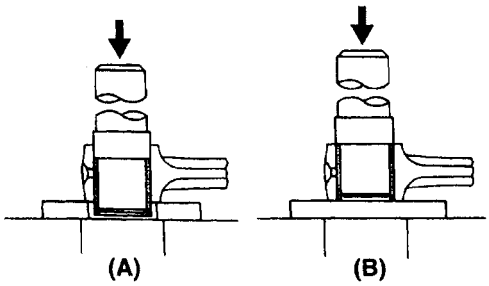

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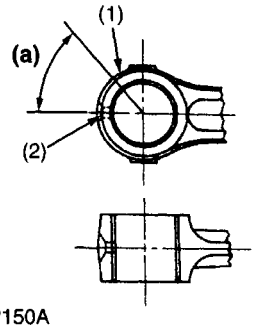

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Replacing Piston Pin Bushing

**(When removing)**

1. Press out piston pin bushing with a piston pin bushing replacing tool.

**(When installing)**

1. Clean the new bushing and bore, and apply engine oil to them.
2. Insert a new bushing onto the tool and press-fit it with the press so that the oil holes (2) are aligned as shown in the figure, until it is flush with the connecting rod.
3. Drill a hole to the bushing with aligning the oil hole (2) of connecting rod using 4.0 mm dia. (0.157 in. dia.) drill.

**■ NOTE**

- **Be sure to chamfer the oil hole circumference with an oil stone.**
- **Check that the seam (1) of the bushing positions as shown in the figure.**

**(Reference)**

- Service parts dimension:

| | | |
|---|---|---|
| Oil clearance between piston pin and bushing | Factory spec. | 0.015 to 0.075 mm<br>0.00059 to 0.00295 in. |
| | Allowable limit | 0.15 mm<br>0.0059 in. |

| | | |
|---|---|---|
| Piston pin O.D. | Factory spec. | 20.002 to 20.011 mm<br>0.78748 to 0.78784 in. |
| Piston pin bushing I.D. | | 20.026 to 20.077 mm<br>0.78843 to 0.79043 in. |

(1) Seam
(2) Oil Hole
**(A) When Removing**
**(B) When Installing**
**(a) 45°**

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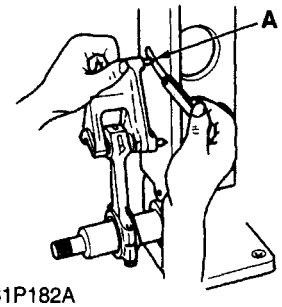
Connecting Rod Alignment

**■ NOTE**

- **Since the piston pin bushing I.D. is the basis of this check, check bushing for wear beforehand.**

1. Remove the connecting rod bearing and install the bearing cap.
2. Install the piston pin into the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool (Code No. 07909-31661).
4. Put a gauge over the piston pin and move it against the face plate.
5. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.



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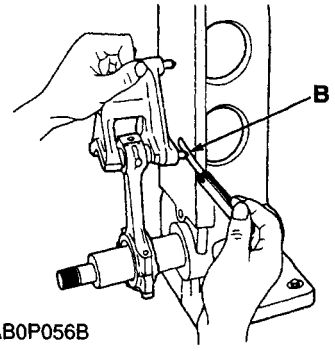

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| | | |
|---|---|---|
| Bent **A** | Allowable limit | 0.05 mm / 100 mm<br>0.0020 in. / 3.94 in. |
| Twist **B** | | 0.05 mm /100 mm<br>0.0020 in. / 3.94 in. |

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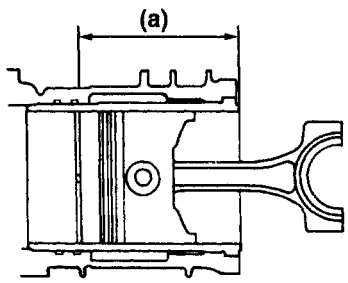


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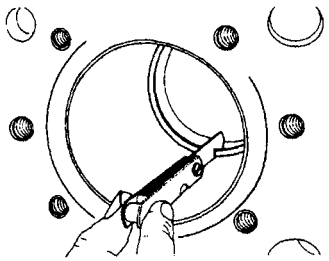

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Piston Ring Gap

1. Insert the piston ring into the lower part of the liner (Measuring points are shown in the figure) with a piston ring compressor and the piston.
2. Measure the ring gap with a feeler gauge.
3. If the gap exceeds the allowable limit, replace the piston ring.

| | | | |
|---|---|---|---|
| Ring gap | Factory spec. | Top ring Second ring | 0.30 to 0.45 mm<br>0.0118 to 0.0177 in. |
| | | Oil ring | 0.25 to 0.40 mm<br>0.0098 to 0.0157 in. |
| | Allowable limit | | 1.2 mm<br>0.047 in. |

**(a) Approx. 90 mm (3.54 in.)**

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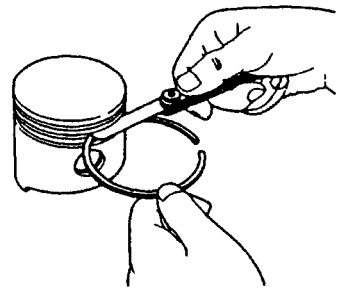

3ECAAAB1P076B

Clearance between Piston Ring and Ring Groove

1. Clean the rings and the ring grooves, and install each ring into its groove.
2. Measure the clearance between the ring and the groove with a feeler gauge.
3. If the clearance exceeds the allowable limit, replace the piston ring.
4. If the clearance still exceeds the allowable limit with new ring, replace the piston.

| | | | |
|---|---|---|---|
| Valve face angle | Factory spec. | Top ring | Keystone ring |
| | | Second ring | 0.085 to 0.112 mm<br>0.00335 to 0.00441 in. |
| | | Oil ring | 0.020 to 0.055 mm<br>0.00079 to 0.00217 in. |
| | Allowable limit | Second ring | 0.2 mm<br>0.008 in. |
| | | Oil ring | 0.15 mm<br>0.0059 in. |

**■NOTE**

- **As the top ring is a Keystone type, it cannot be measured by this method.**

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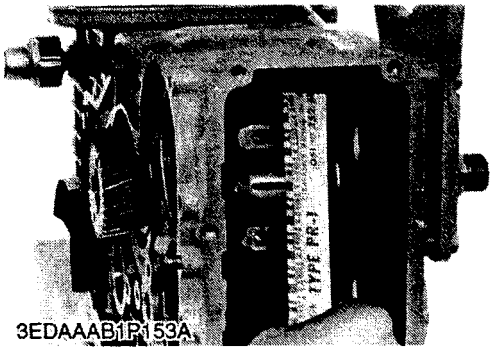
## (3) Crankshaft



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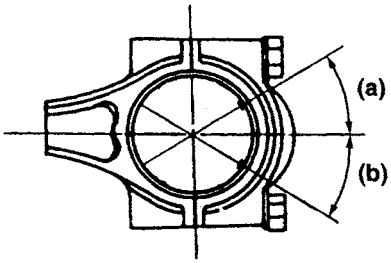

3EDAAAB1P154A

Oil Clearance between Crank Pin and Bearing

1. Put a strip of press gauge (Code No. 17909-30241) lengthwise on the center of the crank pin in each direction as shown in the figure.
2. Install the connecting rod cap and tighten the screws to the specified torque (26.5 to 3.04 N·m, 2.7 to 3.1 kgf·m, 19.5 to 22.4 ft-lbs) once, and remove the cap again.
3. Measure the amount of the flattening with the scale and get the oil clearance.
4. If the clearance exceeds the allowable limit, replace the bearing.

**■ NOTE**

- **Do not insert the press gauge into the crank pin oil hole.**
- **Fasten the crankshaft so that it does not turn.**

**(Reference)**

- When the crank pin wears further over a long period of use and oil clearance exceeds the allowable limit after replacing the standard bearing, use a undersize bearing. Machine the crank pin according to the following precautions.

| | | |
|---|---|---|
| Oil clearance between crank pin and bearing | Factory spec. | 0.019 to 0.077 mm<br>0.00075 to 0.00303 in. |
| | Allowable limit | 0.2 mm<br>0.008 in. |

| | | |
|---|---|---|
| Crank pin O.D. | Factory spec. | 36.959 to 36.975 mm<br>1.45508 to 1.45571 in. |
| Crank pin bearing I.D. (When tightening) | Factory spec. | 36.994 to 37.036 mm<br>1.45646 to 1.45811 in. |

**(a) 0.52 rad (30°)** **(b) 0.52 rad (30°)**

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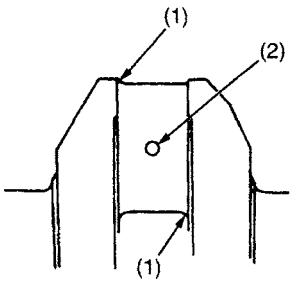


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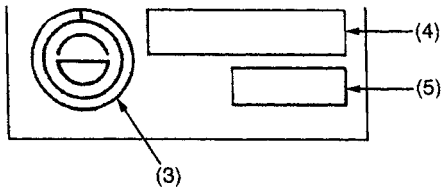
**[A]**

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Use of Under size Bearing and Crank Pin Correction

1. Be sure to correctly grind the corner radius of the crank pin.
2. Be sure to chamfer the entire circumference of each oil hole, using an oil stone.
3. Be sure to precision finish the crank pin section to higher than 0.4S ▽▽▽.

**Under size bearing and crankshaft dimension**

| | 0.2 mm (0.008 in.) | 0.4 mm (0.016 in.) |
|---|---|---|
| Bearing Code No. | 15531-2297-1 | 15531-2298-1 |
| Bearing Name | Crank pin bearing (0.2) | Crank pin bearing (0.4) |
| Bearing Mark | 0.2 US | 0.4 US |
| Crankshaft machined Dimension D (See figure) | 36.759 to 36.775 mm 1.44721 to 1.44784 in. | 36.559 to 36.575 mm 1.43933 to 1.43995 in. |

(1) Corner Radius 2.8 to 3.2 mm R (0.110 to 0.126 in. R)
(2) The End of the Oil Hole Should be Chamfered to 1.0 to 1.5 mm R (0.039 to 0.059 in. R)
(3) Marker Mark
(4) Manufactur's No.
(5) Size

**[A] Marking and Numbering on Under size Bearing**

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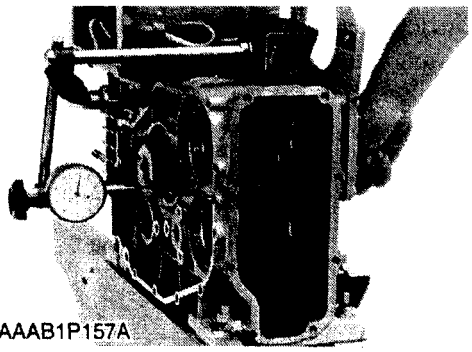
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End Play of Crankshaft

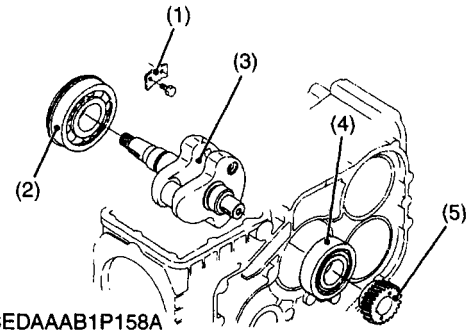
1. Move the crankshaft to the flywheel side.
2. Attach a dial gauge to the crankshaft (3).
3. Measure the end play by pushing the crankshaft toward the crank gear (5).
4. If the measurement exceeds the allowable limit, replace the main bearing retainer (1).
5. If the new end play still exceeds the allowable limit, check main bearings 2 (2) and 1 (4). If worn abnormally, replace main bearings.

**■ NOTE**

- **When the end play is below the factory specifications, it may be heavy turning or difficult starting, and when it is over, it may be vibration of the flywheel or knocking.**

| | | |
|---|---|---|
| End play of crankshaft | Factory spec. | 0.05 to 0.46 mm<br>0.0020 to 0.0181 in. |
| | Allowable limit | 0.56 mm<br>0.0220 in. |

| | | |
|---|---|---|
| Thickness of main bearing retainer | Factory spec. | 1.9 to 2.0 mm<br>0.075 to 0.079in. |



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(1) Main Bearing Retainer
(2) Main Bearing 2
(3) Crankshaft
(5) Main Bearing 1
(6) Crank Gear

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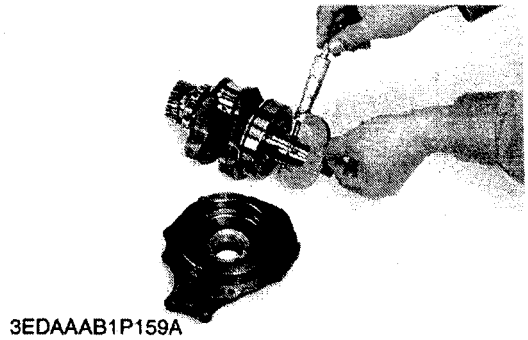
Oil Clearance between Crankshaft and Oil Filler Ring

1. Measure the crankshaft O.D. with an outside micrometer.
2. Measure the oil filler ring I.D. with an inside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the oil filler ring.

| | | |
|---|---|---|
| Oil clearance between crankshaft and oil filler ring | Factory spec. | 0.025 to 0.066 mm<br>0.00098 to 0.00260 in. |
| | Allowable limit | 0.2 mm<br>0.008 in. |

| | | |
|---|---|---|
| Crankshaft O.D. | Factory spec. | 34.959 to 34.975 mm<br>1.37634 to 1.37697 in. |
| Oil filler ring I.D. | Factory spec. | 35.000 to 35.025 mm<br>1.37795 to 1.37894 in. |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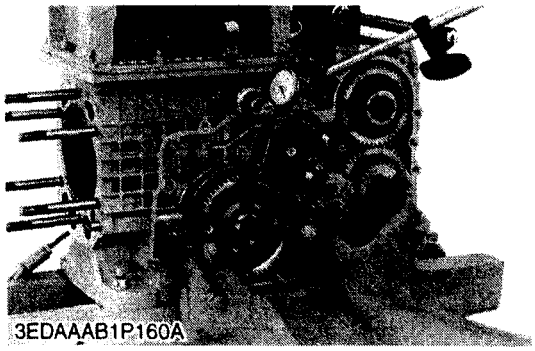
## (4) Timing Gear and Camshaft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Timing Gear Backlash

1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and gear.
4. If the oil clearance is proper, replace the gear.

| | | | |
|---|---|---|---|
| Valve face angle | Factory spec. | Barancer gear 1 x gear 2 | 0.049 ti 0.135 mm<br>0.00193 to 0.00531 in. |
| | | Other gears | 0.043 to 0.130 mm<br>0.00169 to 0.0512 in. |
| | Allowable limit | All gears | 0.3 mm<br>0.012 in. |

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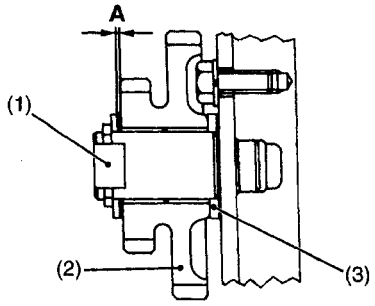

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Side Clearance of Idle Gear

1. Pull the idle gear collar 2 (1) and push the idle gear (2) to each end.
2. Measure the clearance **A** between the idle gear and idle gear collar 2 with a feeler gauge.
3. If the clearance exceeds the allowable limit, replace the idle gear collar 1 (3).

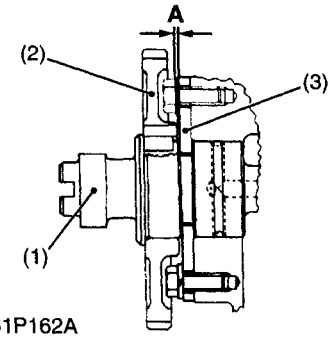
| | | |
|---|---|---|
| Idle gear side clearance | Factory spec. | 0.20 to 0.51 mm<br>0.0079 to 0.0201 in. |
| | Allowable limit | 0.9 mm<br>0.035 in. |

| | | |
|---|---|---|
| Thickness of idle gear collar 1 | Factory spec. | 2.45 to 2.50 mm<br>0.0965 to 0.0984 in. |

(1) Idle Gear Collar 2
(2) Idle Gear
(3) Idle Gear Collar 1

**A : Clearance**

0000009875E



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Side Clearance of Cam Gear

1. Pull the cam gear (2) with the camshaft (1) to its end.
2. Measure the clearance **A** between the cam gear (2) and camshaft stopper (3).
3. If the clearance exceeds the allowable limit, replace the camshaft stopper.

| | | |
|---|---|---|
| Cam gear side clearance | Factory spec. | 0.070 to 0.220 mm<br>0.0076 to 0.0866 in. |
| | Allowable limit | 0.3 mm<br>0.0012 in. |

| | | |
|---|---|---|
| Thickness of camshaft stopper | Factory spec. | 3.780 to 3.855 mm<br>0.14882 to 0.15177 in. |

(1) Camshaft
(2) Cam Gear
(3) Stopper

**A : Clearance**

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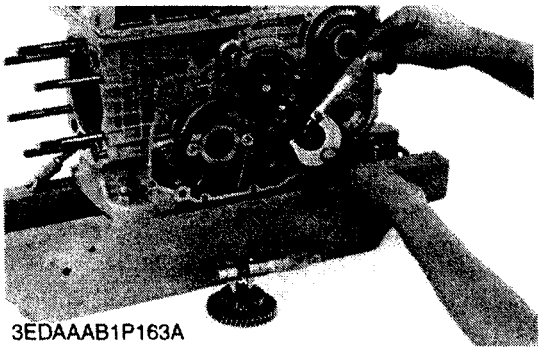

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Oil Clearance between Idle Gear Shaft and Bushing

1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear bushings I.D. with an inside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the bushing.
4. If the clearance still exceeds the allowable limit with new bushing, replace the idle gear shaft.

| | | |
|---|---|---|
| Oil clearance between idle gear shaft and bushing | Factory spec. | 0.016 to 0.045 mm<br>0.00063 to 0.00177 in. |
| | Allowable limit | 0.1 mm<br>0.004 in. |

| | | |
|---|---|---|
| Idle gear shaft O.D. | Factory spec. | 17.973 to 17.984 mm<br>0.707060 to 0.70803 in. |
| Idle gear bushing I.D. | Factory spec. | 18.000 to 18.018 mm<br>0.70866 to 0.70937 in. |

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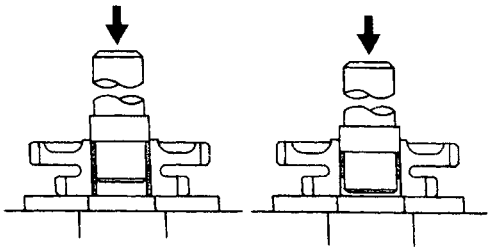

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Replacing Idle Gear Bushing

**(When removing)**

1. Press out the bushings with an idle gear bushing replacing tool.

**(When installing)**

1. Clean the new bushings and bore, and apply engine oil to them.
2. Press in the bushing with an idle gear bushing replacing tool.

**(Reference)**

- Service parts dimension:

| | | |
|---|---|---|
| Oil clearance between idle gear shaft and bushing | Factory spec. | 0.016 to 0.078 mm<br>0.00063 to 0.00307 in. |
| | Allowable limit | 0.1 mm<br>0.004 in. |

| | | |
|---|---|---|
| Idle gear shaft O.D. | Factory spec. | 17.973 to 17.984 mm<br>0.707060 to 0.70803 in. |
| Idle gear bushing I.D. | Factory spec. | 18.000 to 18.048 mm<br>0.70866 to 0.71055 in. |

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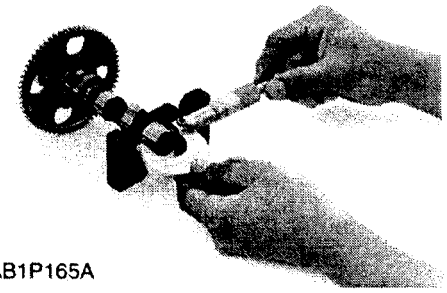

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Oil Clearance of Camshaft

1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the camshaft bore I.D. withe an inside micrometer and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the camshaft.
4. If the clearance still exceeds the allowable limit with new camshaft, replace the cylinder block.

| | | |
|---|---|---|
| Oil clearance of camshaft [Flywheel side] | Factory spec. | 0.020 to 0.054 mm<br>0.00079 to 0.00213 in. |
| | Allowable limit | 0.25 mm<br>0.0098 in. |

| | | |
|---|---|---|
| Camshaft journal O.D. | Factory spec. | 21.967 to 21.980 mm<br>0.86484 to 0.86535 in. |
| Camshaft bore I.D. | Factory spec. | 22.000 to 22.021 mm<br>0.86614 to 0.86697 in. |

| | | |
|---|---|---|
| Oil clearance of camshaft [Gear side] | Factory spec. | 0.025 to 0.066 mm<br>0.00098 to 0.00260 in. |
| | Allowable limit | 0.1 mm<br>0.004 in. |

| | | |
|---|---|---|
| Camshaft journal O.D. | Factory spec. | 32.959 to 32.975 mm<br>1.29760 to 1.29823 in. |
| Camshaft bore I.D. | Factory spec. | 33.000 to 33.025 mm<br>1.29921 to 1.30020 in. |

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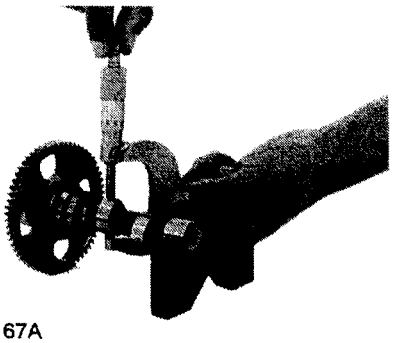

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Intake and Exhaust Cam Height

1. Measure the height of the camshaft lobes at their largest O.D. with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft and tappet.

| | | |
|---|---|---|
| Cam height (IN, EX) | Factory spec. | 27.0 mm<br>1.063 in. |
| | Allowable limit | 26.5 mm<br>1.043 in. |

(1) Cam Height

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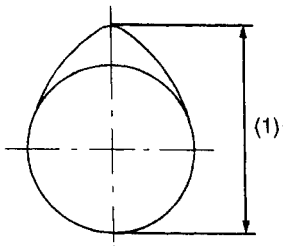


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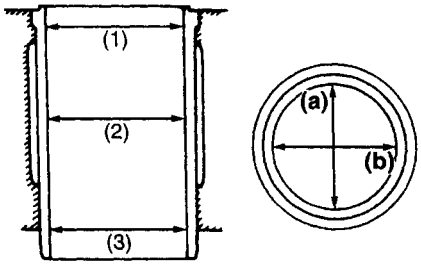
## (5) Cylinder Liner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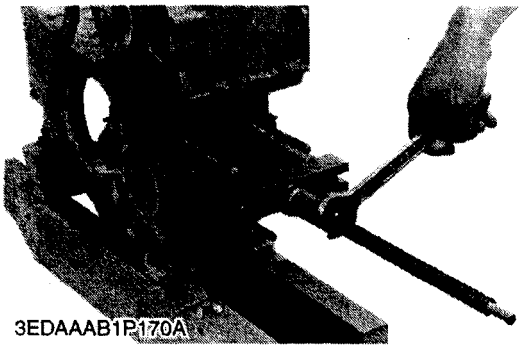


Cylinder Liner I.D.

1. Visually check the cylinder liner I.D. for vertical scratches.
2. Measure the six points as shown in the figure with a cylinder gauge to find out the maximum wear. Generally, position (1) in the **(a)** direction (at approx. 10 mm (0.39 in.) from the top) shows the maximum wear. Since position (3) at the lower part of the liner shown the minimum wear, find this difference.
3. If the measurement exceeds the allowable limit, replace the cylinder liner.

| | | |
|---|---|---|
| Cylinder liner I.D. | Factory spec. | 75.000 to 75.019 mm<br>2.95276 ti 2.95351 in. |
| | Allowable limit | +0.25 mm<br>+0.0098 in. |

(1) Top
(2) Middle
(3) Bottom (Skirt)

**(a) Right-angle to the Piston Pin**
**(b) Parallel to the Piston Pin**

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Replacing Cylinder Liner

**(When removing)**

1. Pull out the liner with a wet liner puller (Code No. 07916-30012).

**(When installing)**

2. Clean the fitting surface of liner and cylinder block and apply engine oil to the wall of cylinder liner bore, and apply grease to the O-ring.
3. Press-fit the cylinder liner into the cylinder block.
4. After press-fitting the liner, check the projection of cylinder liner.

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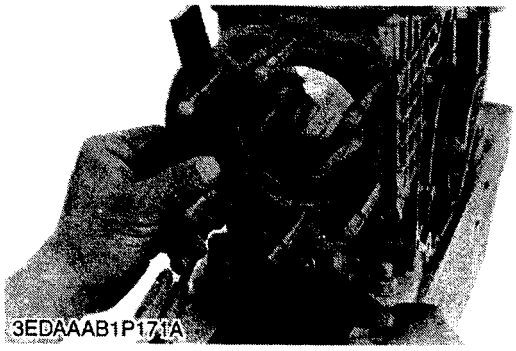


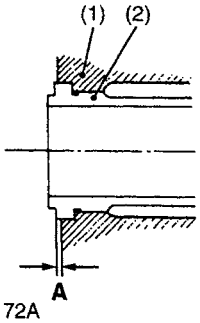


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Projection of Cylinder Liner

1. Apply straight edge to the flange portion of cylinder liner, and measure the gap **A** between the cylinder block and the straight edge with a feeler gauge.
2. If the measurement is not within the factory specifications, check the press-fit condition.

| | | |
|---|---|---|
| Projection of cylinder liner | Factory spec. | 0.03 to 0.13 mm<br>0.0012 to 0.0051 in. |

(1) Cylinder Block
(2) Cylinder Liner

**A: Gap**

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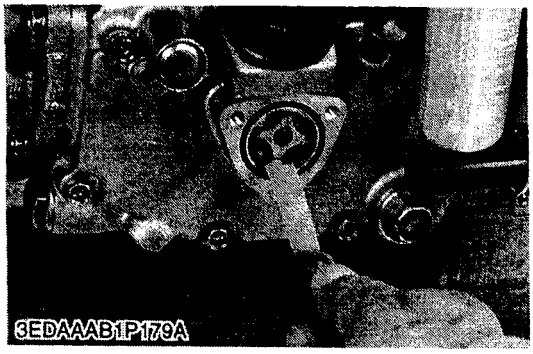
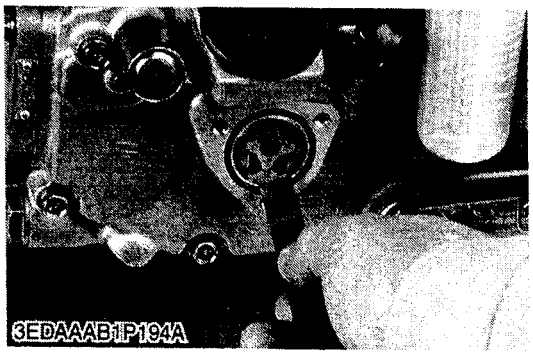
## (6) Oil Pump




Clearance between Inner Rotor and Outer Rotor

1. Measure the clearance between a high point on the inner rotor and high point on the outer rotor with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

| | | |
|---|---|---|
| Clearance between inner rotor and outer rotor | Factory spec. | 0.15 mm or less<br>0.0059 in. or less |
| | Allowable limit | 0.20 mm<br>0.0079 in. |

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Clearance between Outer Rotor and Pump Body

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

| | | |
|---|---|---|
| Clearance between outer rotor and pump body | Factory spec. | 0.090 to 0.171 mm<br>0.00354 to 0.00673 in. |
| | Allowable limit | 0.24 mm<br>0.0094 in. |

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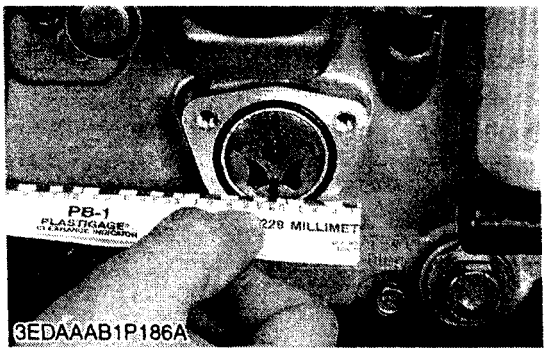


Clearance between Rotor and Cover

1. Put a strip of press gauge (Code No. 07909-30241) onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the depression of press gauge with a sheet of gauge.
4. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

| | | |
|---|---|---|
| Clearance between rotor and cover | Factory spec. | 0.02 to 0.06 mm<br>0.0008 to 0.0024 in. |
| | Allowable limit | 0.25 mm<br>0.0098 in. |

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## (7) Starter


Magnet Switch

■ **NOTE**

- **Each test should be carried out for a short time (3 to 5 seconds), and at half of the rated voltage (6V).**

**1) Pull - in Coil (Attraction Test)**

1. Connect jumper lead from the battery negative terminal post to the **C** terminal.
2. The plunger should be attracted strongly when a jumper lead is connected from the battery positive terminal to the **S** terminal.

**2) Holding Coil (Retention Test)**

1. Connect jumper leads from the battery negative terminal post to the body and the battery positive terminal post to the **S** terminal.
2. Push the plunger in by hand and release it.
   Then, the plunger should remain being attracted.

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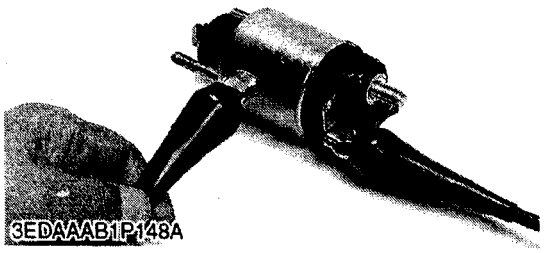


Continuity Across Terminal

1. Check the resistance with an ohmmeter across the **C** terminal and the **B** terminal, pushing in the plunger.
2. If 0 ohm is not indicated, replace the magnet switch.

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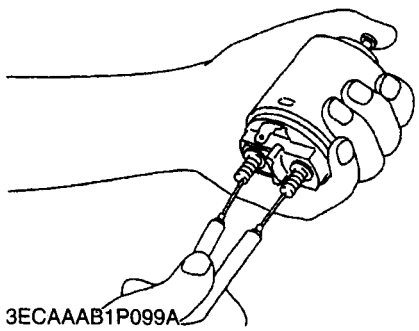

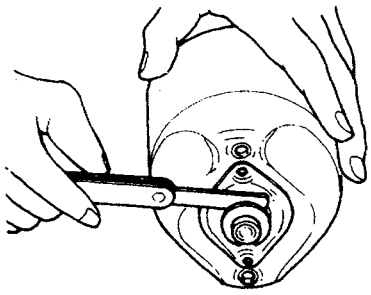

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Shaft Thrust Gap

1. Measure the thrust gap of armature shaft with a feeler gauge.
2. If the gap is not within factory specifications, adjust by the brake shoe.

| | | |
|---|---|---|
| Shaft thrust gap | Factory spec. | 0.05 to 1.00 mm<br>0.0020 to 0.0394 in. |

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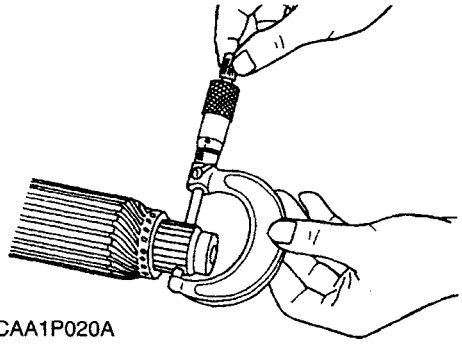

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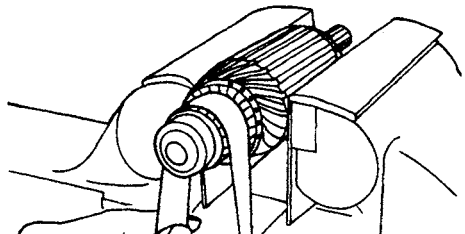
Commutator and Mica

1. Check the contact face of the commutator for wear, and grind the commutator with sand paper if it is slightly worn.
2. Measure the commutator O.D. at several points.
3. If the difference of the O.D.'s exceeds the allowable limit, correct the commutator on a lathe to the factory specification.
4. If the minimum O.D. is less than the allowable limit, replace the armature.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct with a saw blade and chamfer the segment edges.

| | | |
|---|---|---|
| Commutator O.D. | Factory spec. | 28.0 mm<br>1.102 in. |
| | Allowable limit | 27.0 mm<br>1.063in. |

| | | |
|---|---|---|
| Difference of O.D.'s | Factory spec. | Less than 0.1 mm<br>0.004 in. |
| | Allowable limit | 0.4 mm<br>0.008 in. |

| | | |
|---|---|---|
| Mica undercut | Factory spec. | 0.5 to 0.8 mm<br>0.020 to 0.031 in. |
| | Allowable limit | 0.2 mm<br>0.008 in. |



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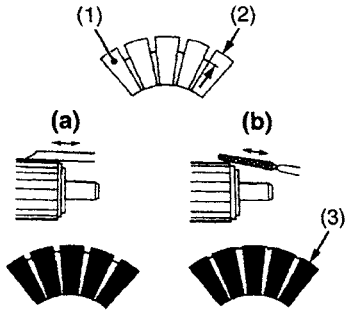


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(1) Segment
(2) Undercut
(3) Mica

**(a) Correct**
**(b) incorrect**

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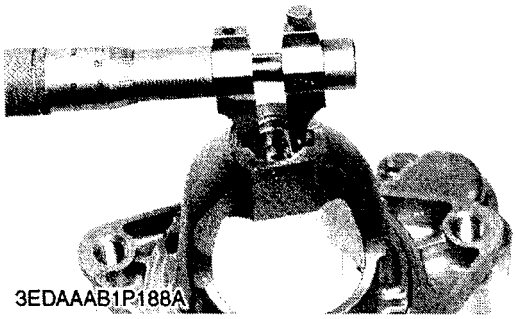
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Clearance between Shaft and Bushing

1. Measure the bushing I.D. on the drive side and commutator side.
2. Measure the shaft O.D. on the drive side and commutator side.
3. If the clearance exceeds the allowable limit, replace the bushing.

| | | | |
|---|---|---|---|
| Clearance between shaft and bushing | Factory spec. | Commutator side | 0.03 to 0.10 mm<br>0.0012 to 0.0039 in. |
| | | Drive side | 0.05 to 0.10 mm<br>0.0020 to 0.0039 in. |
| | Allowable limit | | 0.20 mm<br>0.0079 in. |

| | | |
|---|---|---|
| Shaft O.D. | Factory spec. | 12.50 mm<br>0.4921 in. |
| Commutator bushing I.D. | | 12.53 to 12.60 mm<br>0.4933 to 0.4961 in. |
| Drive bushing I.D. | | 12.55 to 12.60 mm<br>0.4941 to 0.4961 in. |

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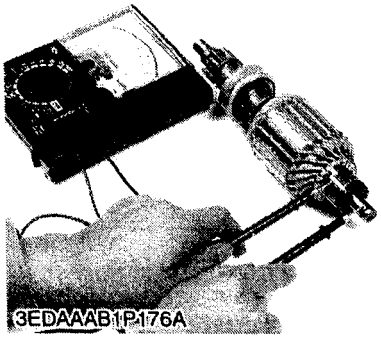
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Armature Coil

1. Check the continuity across the commutator and armature shaft with an ohmmeter.
2. If it conducts, replace the armature.

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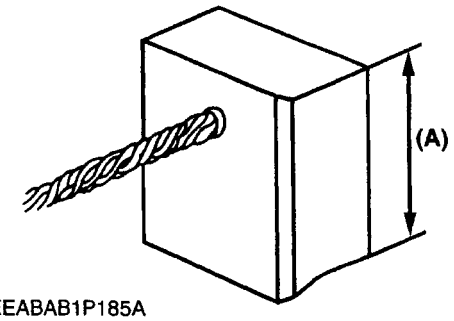

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Brush Wear

1. Measure the brush length **(A)**.
2. If the length is less than the allowable limit, replace the brush holder.

| | | |
|---|---|---|
| Brush length **(A)** | Factory spec. | 16.0 mm<br>0.630 in. |
| | Allowable limit | 10.5 mm<br>0.413 in. |

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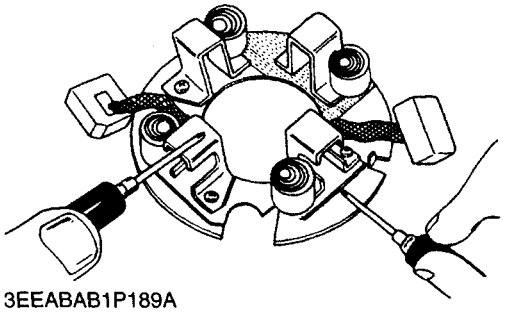

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Brush Holder

1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.

| | | |
|---|---|---|
| Resistance | Brush holder - Holder support | Infinity |

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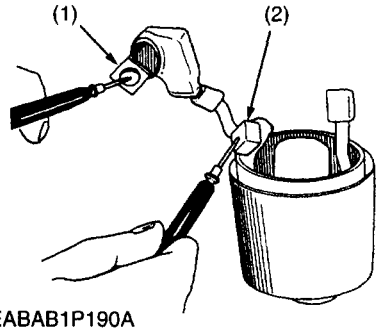


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Field Coil

1. Check the continuity across the lead (1) and brush (2) with an ohmmeter.
2. If it does not conduct, replace the yoke assembly.
3. Check the continuity across the brush (2) and yoke (3) with an ohmmeter.
4. If it conducts, replace the yoke assembly.

(1) Lead
(2) Brush
(3) Yoke

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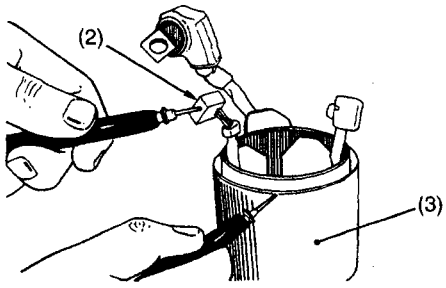


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Bearing and Clutch

1. Check the bearing and clutch for smooth rotation.
2. The clutch should engage and rotate with the pinion shaft in driving direction and disengage in reverse.

**(a) Free**
**(b) Lock**

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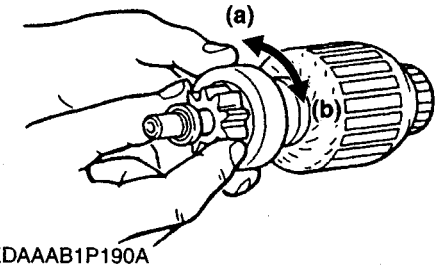


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