

GENERAC[®]
POWER SYSTEMS, INC.

3.9 LITER

***MITSUBISHI
DIESEL
ENGINE***

***SERVICE
MANUAL***

FOREWORD

This manual has been published by GENERAC[®] POWER SYSTEMS, INC. to aid our dealers' mechanics, company service personnel and general consumers when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products, manufactured and marketed by GENERAC[®] POWER SYSTEMS, INC. It is also assumed that they have been trained in the recommended servicing procedures for these products, which includes the use of mechanics hand tools and any special tools that might be required.

Proper service and repair is important to the safe, economical and reliable operation of the products described herein. The troubleshooting, testing, service and repair procedures recommended by GENERAC[®] POWER SYSTEMS, INC. and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

We could not possibly know of and advise the service trade of all conceivable procedures or methods by which a service might be performed, nor of any possible hazards and/or results of each procedure or method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or method not recommended by the manufacturer must first satisfy himself that neither his safety, nor the product's safety, will be endangered by the service or operating procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. However, GENERAC[®] POWER SYSTEMS, INC. reserves the right to change, alter or otherwise improve the product at any time without prior notice.

Some components or assemblies of the product described in this manual may not be considered repairable. Disassembly, repair and reassembly of such components may not be included in this manual.

The engines described herein may be used to power a wide variety of products. Service and repair instructions relating to any such products are not covered in this manual. For information pertaining to use of these engines with other products, refer to any owner's or service manuals pertaining to said products.

SERVICE RECOMMENDATIONS A_2
mitsubishi Foreword and Contents

The 3.9 Liter Gas Engine has been engineered for use in Generac Power Systems products. The contents of this manual have been reprinted from the original manufacturer's service and repair manual.

3.9 Liter Diesel Engine Service Recommendations

◆ ENGINE OIL RECOMMENDATIONS

The unit has been filled with “break in” engine oil at the factory. Use a high-quality detergent oil classified “For Service CC, SD, SE or SF.” Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE viscosity rating, based on the ambient temperature range anticipated before the next oil change:

Engine Lubrication System:

Type of Oil PumpGear
 Oil FilterFull Flow, Cartridge
 Crankcase Oil Capacity18 L (19 U.S. qts.)

| Temperature | Oil Grade (Recommended) |
|----------------------------|-------------------------|
| Above 86° F (30° C) | SAE 40 or 15W-40 |
| 32° to 86° F (0° to 30° C) | SAE 30 or 15W-40 |
| Below 32° F (0° C) | SAE 20W or 15W-40 |
| All Seasons | SAE 15W-40 |

◆ COOLANT

Use a mixture of half low silicate, ethylene glycol base antifreeze and half soft water. Use only soft water and only low silicate antifreeze. If desired, you may add a high quality rust inhibitor to the recommended coolant mixture. When adding coolant, always add the recommended 50-50 mixture.

Cooling System:

Type.....Pressurized, Closed Recovery
 Coolant Capacity
 System.....15.9 L (4.2 U.S. qts.)
 Engine6.4 L (1.7 U.S. qts.)

—▲ DANGER ▲—

- ▲ Do not remove the radiator pressure cap while the engine is hot or serious burns from boiling liquid or steam could result.
- ▲ Ethylene glycol base antifreeze is poisonous. Do not use your mouth to siphon coolant from the radiator, recovery bottle or any container. Wash your hands thoroughly after handling. Never store used antifreeze in an open container because animals are attracted to the smell and taste of antifreeze even though it is poisonous to them.

—▲ CAUTION ▲—

- ▲ Do not use any chromate base rust inhibitor with ethylene glycol base antifreeze, or chromium hydroxide (“green slime”) will form and cause overheating. Engines that have been operated with a chromate base rust inhibitor must be chemically cleaned before adding ethylene glycol base antifreeze. Using any high silicate antifreeze boosters or additives also will cause overheating. We also recommend that you DO NOT use any soluble oil inhibitor for this equipment.

PERIODIC MAINTENANCE SCHEDULE:

SERVICE SCHEDULE

◆ AUTHORIZED OPERATOR MAINTENANCE FUNCTIONS

Every Month or 100 Hours

(whichever comes first)

- Test standby generator system.
- Inspect battery and cables.
- Check engine oil level.
- Check gearbox oil level (if so equipped).
- Check engine coolant level.
- Check generator ground connections.
- Test/inspect starting aids.

Every Three Months or Every 120 Hours

(whichever comes first)

- Inspect and test fuel system and connections.
- Inspect exhaust system.
- Inspect/test fuel supply system.

◆ AUTHORIZED SERVICE TECHNICIAN MAINTENANCE FUNCTIONS

After First 30 Hours of Operation

- Inspect wiring.
- Change engine crankcase oil and oil filter.
- Inspect engine fan belts.
- Inspect battery and cables.

Every Six Months or Every 100 Hours

(whichever comes first)

- Change engine oil and filter.
- Lubricate engine controls.
- Service engine air cleaner.
- Service engine fuel filter.
- Inspect AC generator.
- Test engine safety controls.
- Inspect fan belts.
- Check engine coolant level.
- Inspect engine cooling system hoses.
- Check optional starting aids.
- Check battery.
- Check engine compression.
- Check electrical connections.
- Check/test annunciator panel.
- Perform operational test.

Annually or Every 600 Hours

(whichever comes first)

- Check engine valve clearance.
- Test fuel injection nozzles.
- Test injection timing.
- Inspect all wiring.
- Test engine starter operation.
- Drain water from fuel tank.
- Retorque fan bolts.
- Drain and refill gearbox (if so equipped)

Every Two Years

- Replace all rubber hoses.
- Replace engine fan belts.
- Inspect the Standby Generator System.
- Drain, flush, refill cooling system.

Every 1,000 Operating Hours

- Inspect engine DC alternator.
- Inspect engine starter.
- Retorque engine mounting brackets.
- Remove/test fuel injection pump.
- Remove/test cooling system thermostat.

As Required

- Bleed engine fuel system.



Shop Manual

diesel engine (for industrial use)

3.9L

4D3 '95

4D3 '95

diesel engine

(for industrial use)

Shop Manual

FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of Mitsubishi 4D3 series diesel engine, and includes procedures for adjustment and maintenance services.

We earnestly look forward to seeing that this manual is made full use of in order to perform correct service with no wastage.

For more details, please consult your nearest authorized Mitsubishi dealer or distributor.

Kindly note that the specifications and maintenance service figures are subject to change without prior notice in line with improvement which will be effected from time to time in the future.

Applicable models

4D31
4D31-T
4D32
4D33
4D34-T

GROUP INDEX

HOW TO READ THIS MANUAL




| | |
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HOW TO READ THIS MANUAL

How This Manual Is Compiled

- This manual is compiled by classifying various systems into certain groups.
- Each group contains specifications; troubleshooting; maintenance service standards;  tightening torque;  lubricant, fluid and sealant;  special tools; and service procedure.
- Page enumeration is independent by every group where first page is always 1.

| Group No. | Group denomination | Contents |
|-----------|--------------------|---|
| 00 | General | General specifications, engine No. and name plate, precautions for maintenance operations, table of standard tightening torques |
| 11 | Engine | Engine body |
| 12 | Lubrication | Lubrication system |
| 13 | Fuel | Fuel system |
| 14 | Cooling | Cooling system |
| 15 | Intake and exhaust | Intake and exhaust system, air cleaner, turbocharger |
| 21 | Clutch | Clutch proper, clutch control |
| 54 | Electrical system | Starter, alternator, preheating system, engine start system |

MEMO

HOW TO READ THIS MANUAL

How This Manual is Structured

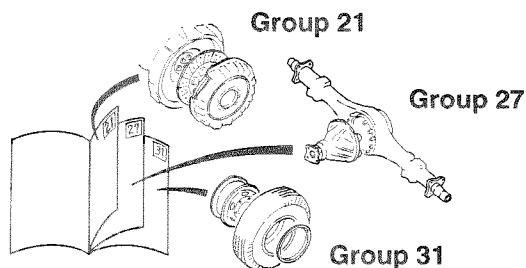
I'm here to explain how to use this manual. To get the most out of your manual, follow along carefully and read all the notes given by my assistant.



We're here to help you.



This manual is divided into groups, with one group for each main area of the vehicle. (An index of groups is given on page ii.)
By way of example, let's look at Group 21, which covers the clutch.



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23915

Each group is divided into five parts, as shown below.



Specifications

Specifications, oil quantities, and other information pertaining to system components.

Structure and Operation

Information on the structure and operation of the overall system and its components.

Troubleshooting

An item-by-item guide to fault symptoms and their probable causes.

On-Vehicle Inspection and Adjustment

Instructions for on-vehicle inspection and adjustment operations.

Service Instructions

(See the next and subsequent pages.)

GROUP 21 CLUTCH

- SPECIFICATIONS
- STRUCTURE AND OPERATION
- TROUBLESHOOTING
- ON-VEHICLE INSPECTION AND ADJUSTMENT .
 - Clutch Fluid Replacement and Air Bleeding
 - Inspection of Clutch Booster Functionality
 - Clutch Pedal Play
- CLUTCH PEDAL
- CLUTCH MASTER CYLINDER
- CLUTCH BOOSTER AND CLUTCH MASTER CYLINDER
- CLUTCH POWER CYLINDER
- CLUTCH-PROPER
- CLUTCH HOUSING
- CLUTCH DISC WEAR INDICATOR SWITCH

The service instructions are the most important parts of this manual. Starting on the next page, you'll learn more about them.



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Service procedures

1

Now, let's take a detailed look at the service instructions. Please follow along carefully.



GROUP 21 CLUTCH

SPECIFICATIONS

ON-VEHICLE INSPECTION AND ADJUSTMENT

- Clutch Fluid Replacement and Air Bleeding
- Inspection of Clutch Booster Functionality
- Clutch Pedal Play

CLUTCH PEDAL

CLUTCH MASTER CYLINDER

CLUTCH BOOSTER AND CLUTCH MASTER CYLINDER

CLUTCH POWER CYLINDER

CLUTCH-PROPER

CLUTCH HOUSING

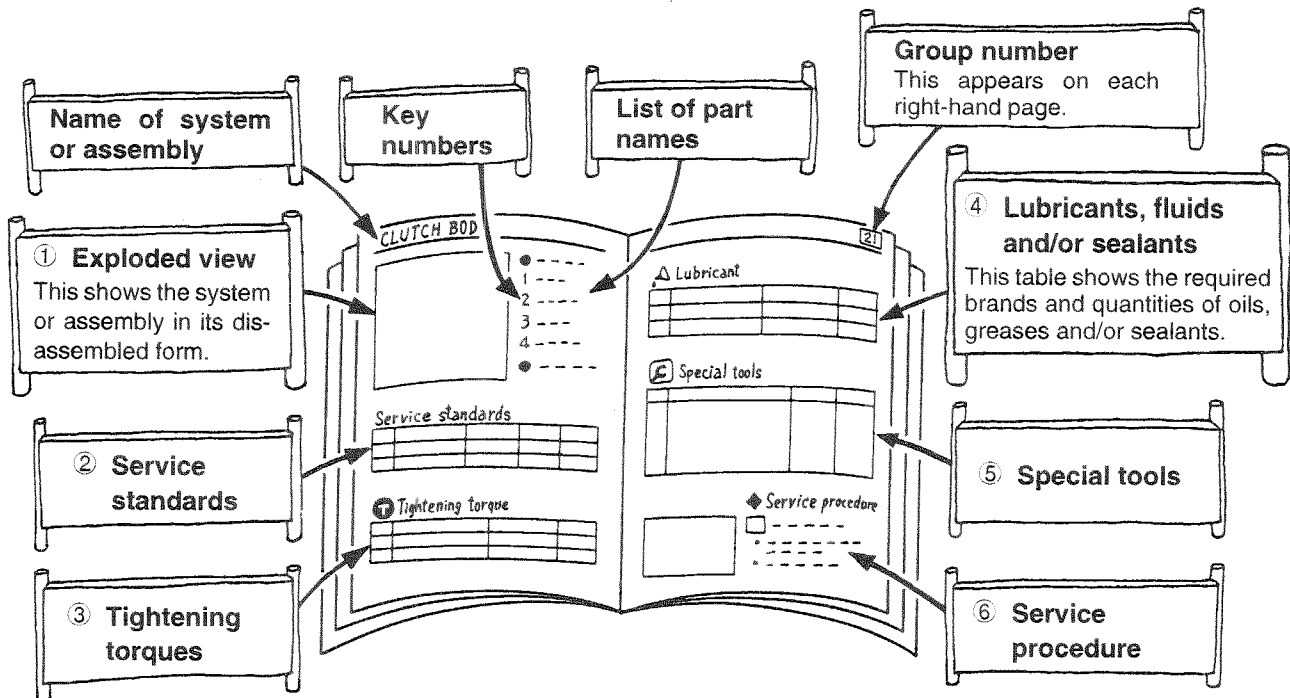
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2



The service instructions consist of the parts shown below. Starting on page vii, these parts are described in detail in order of the circled numbers.

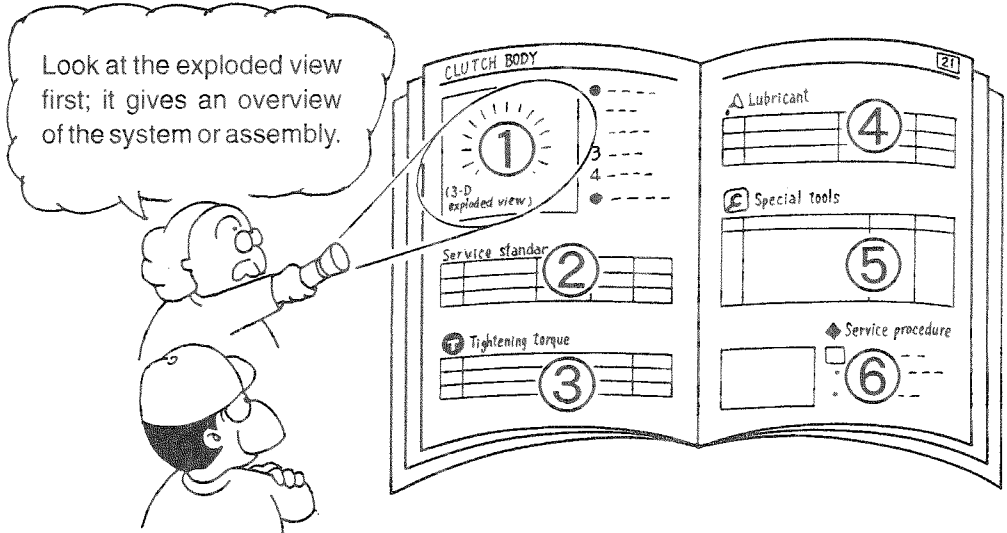
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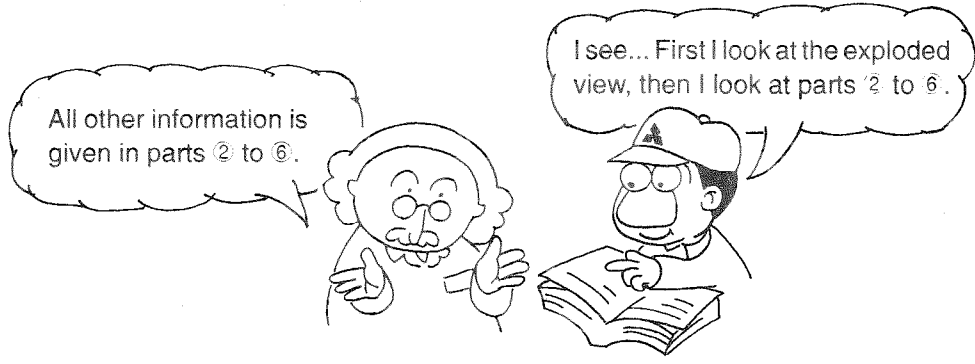
HOW TO READ THIS MANUAL

3



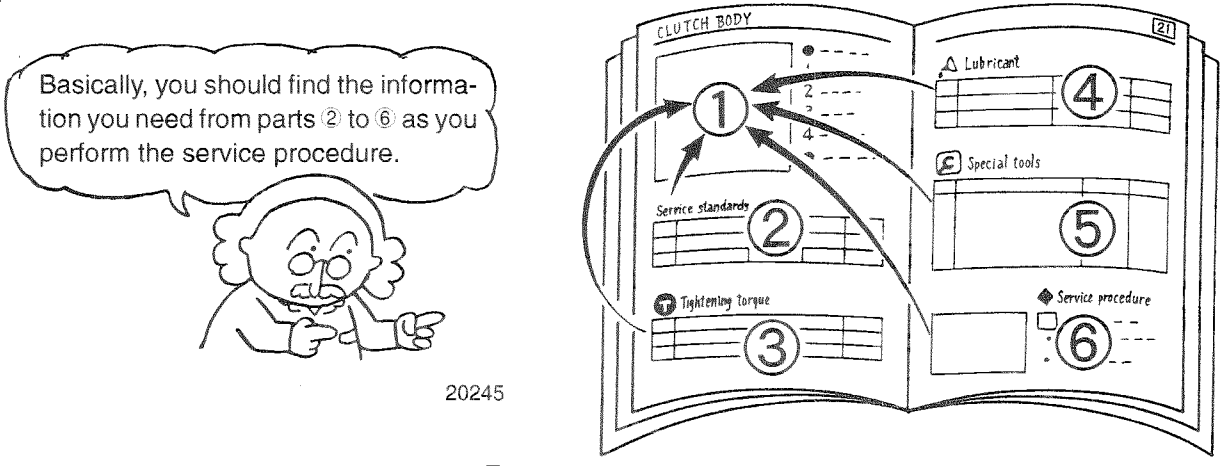
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4



23921

5



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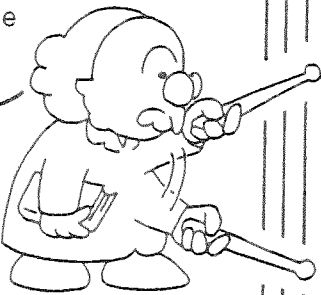
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23922

Find the information you need using the key numbers.
For example, let's assume you're assembling the clutch and need the tightening torque for the bolt ①.

To find the tightening torque, just look up key number 1 in the "Tightening torques" table.



CLUTCH BODY

1 ---
2 ---
3 ---
4 ---

Service standards

| | | | |
|--|--|--|--|
| | | | |
| | | | |

① Tightening torque

| | |
|--------|-----------|
| 1 Bolt | 5.9 (0.6) |
|--------|-----------|

I see... The key numbers for the exploded view match the key numbers on other parts of the page.



26313

NOTE

20252

To help you find information quickly:
Tightening torques are marked with ①. Lubricants, fluids and sealants are marked with Δ. And every key number that appears in the service procedure is enclosed with a square.

CLUTCH BODY

Δ Lubricant

| | | | |
|---|--|--|--|
| 3 | | | |
|---|--|--|--|

Ⓛ Special tools

| | | | |
|--|--|--|--|
| | | | |
|--|--|--|--|

◆ Service procedure

②

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HOW TO READ THIS MANUAL

1 Exploded view

1

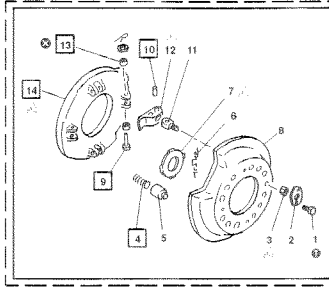
Explanatory notes for the exploded view are given below. Explanatory notes for the parts list are given on the facing page.



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CLUTCH-PROPER <C5>

Pressure Plate-and-Lever Assembly



● Pre-disassembly operations

P21-44

● Disassembly sequence

- 1 Bolt
- 2 Lock plate
- 3 Support nut
- 4 Pressure spring
- 5 Pressure spring cap
- 6 Return spring
- 7 Release lever plate
- 8 Clutch cover
- 9 Release lever pin
- 10 Support lever pin
- 11 Support lever
- 12 Release lever
- 13 Bushing
- 14 Pressure plate

⊗: Non-reusable part

NOTE

Do not remove the bushing 13 unless it is defective.

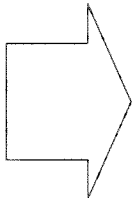
● Assembly sequence

Follow the disassembly sequence in reverse.

Repair kit: Clutch Release Lever Kit

● Post-assembly inspection and adjustment

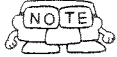
P21-44



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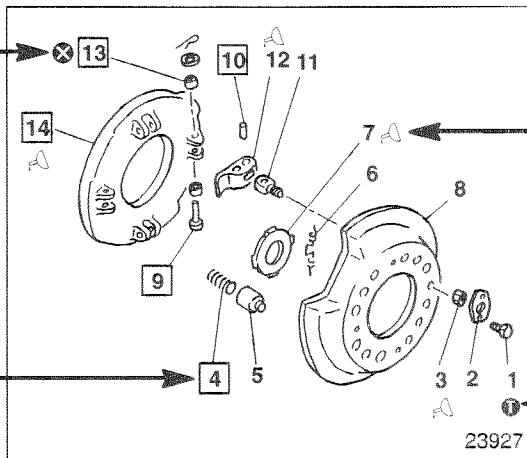


This mark indicates a part that cannot be reused.

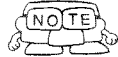


The key number enclosed with a square indicates that the part is mentioned in the service procedure.

Pressure Plate-and-Lever Assembly



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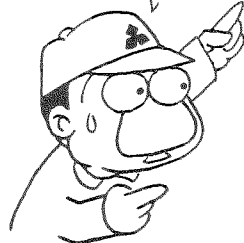


This mark indicates that lubricant or sealant must be applied to the part.

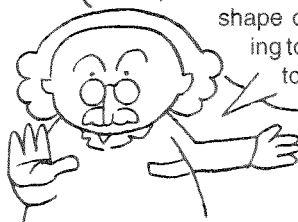


This mark indicates that a tightening torque is specified for the part.

So parts without T marks don't have specified tightening torques?



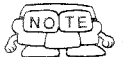
No, they don't. But every bolt and nut must be tightened to a standard torque. A T mark shows either that the part must be tightened to a torque other than the standard torque or that the standard torque cannot be determined from the part's shape or markings. Standard tightening torques are explained at the bottom of the next page.



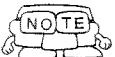
23928



The key numbers are given here.



The key numbers show the disassembly sequence.



The assembly sequence is given here. Assembly is usually performed in the opposite order to disassembly. If the assembly sequence is otherwise specified, it is given in terms of key numbers like this:

- **Assembly sequence**
14 → 12 → 10 → 13 → 11

● **Pre-disassembly operations**

📖 P21-44

● **Disassembly sequence**

- 1 Bolt
- 2 Lock plate
- 3 Support nut
- 4 Pressure spring
- 5 Pressure spring cap
- 6 Return spring
- 7 Release lever plate
- 8 Clutch cover
- 9 Release lever pin
- 10 Support lever pin
- 11 Support lever
- 12 Release lever
- 13 Bushing
- 14 Pressure plate

⊗ : Non-reusable part

NOTE

Do not remove the bushing 13 unless it is defective.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Repair kit: Clutch Release Lever Kit

● **Post-assembly inspection and adjustment**

📖 P21-44

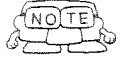


This shows that certain operations must be performed before disassembly.



Links to reference information are given as follows:

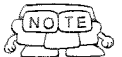
- 📖 P21-44
Refer to the indicated page of the same group.
- 📖 Gr22
Refer to the indicated group in this manual.



The names of parts are given here.



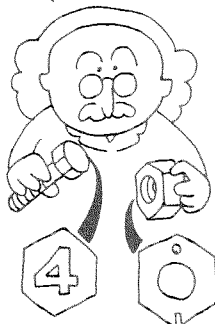
The name of the specified repair kit (if any) is given here.



This shows that certain operations must be performed after assembly.

Now let's look at standard tightening torques. Normally, bolts and nuts have numbers or markings to show their material strength.

Tightening torques for bolts and nuts with such numbers and markings are shown in the Table of Standard Tightening Torques that appears in group 00.



GROUP 00 GENERAL

ENGINE NUMBER AND NUMBER PLATE

PRECAUTIONS FOR MAINTENANCE OPERATIONS

TABLE OF STANDARD TIGHTENING TORQUES

HOW TO READ THIS MANUAL

② Service standards

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|--|---|------------------------------------|--------------------|
| 4 | Pressure spring | Installed load (installed length 49.1) | 885 N (90.2 kgf) | 750 N (76.7 kgf) | Replace |
| | | Squareness | 2.9 or less | 5.0 | Replace |
| 7 | Release lever plate height | | 53.8 ± 0.7 | Relative difference 0.5 maximum | Adjust |
| 10, 13 | Clearance between release lever pin and bushing | | [10] 0.02 to 0.11 | 0.4 | Replace |
| 14 | Pressure plate | Thickness | 23.6 ± 0.1 | 21 | Replace |
| | | Flatness | 0.05 or less | 0.2 | Correct or replace |
| | | Strap bolt hole I. D. | 10.2 to 10.25 | 10.5 | Replace |



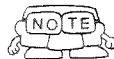
Number(s) in this column match the key number(s) on the exploded view ①.

③ Tightening torques

① Tightening torque

Unit: N · m (kgf · m)

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|----------------------------|-------------------------|---------|
| 1 | Bolt (lock plate mounting) | 5.9 to 7.8 {0.6 to 0.8} | - |



Number(s) in this column match the key number(s) on the exploded view ①.



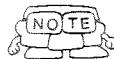
If oil or grease must be applied to the threads before tightening, the word "Wet" appears in this column.

| Remarks |
|---------|
| Wet |

④ Lubricant, fluid and/or sealant

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|---|---|-------------|
| 3 | Threads and spherical surface of support nut | Anti-seizure compound | As required |
| 7, 12 | Sliding surfaces of release lever plate and release lever | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |
| 11, 12 | Sliding surfaces of support lever and release lever | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |
| 11, 14 | Sliding surfaces of support lever and pressure plate | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |



Number(s) in this column match the key number(s) on the exploded view ①.

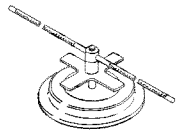


The specified types/brands are shown here.

⑤ Special tools

☐ Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|--|
| 8 | Clutch Installer  | MH061051 | Removal and installation of clutch cover |

01984



Number(s) in this column match the key number(s) on the exploded view ①.

For any special tool that is not a Mitsubishi genuine part, no illustration is shown; only the part number is given, as shown below.

☐ Special tools

| Location | Tool name and shape | Part No. | Application |
|----------|---------------------|------------|-----------------------------|
| 21 | Insertion Tool | *910-24461 | Installation of O-ring |
| 32 | Retainer | *910-24590 | Retention of primary piston |

* JIDOSHA KIKI part No.

⑥ Service procedure

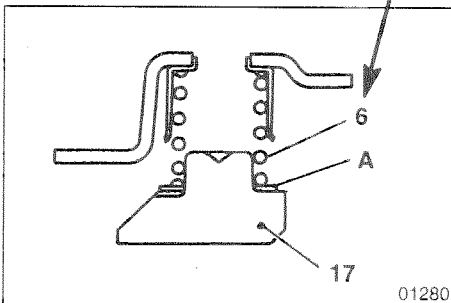
1



Number(s) in this column match the key number(s) on the exploded view ①.



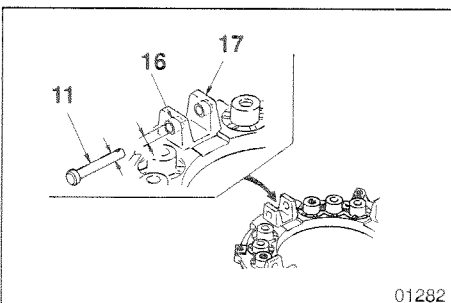
The service procedure gives instructions in order of key numbers.



⑥ Installation of pressure spring

If the pressure plate 17 has been reground, insert between the pressure plate and pressure spring 6 an adjusting washer A whose thickness matches that of the ground off material.

| Regrind amount | Thickness and number of washer(s) |
|----------------------------------|-----------------------------------|
| Less than 1 mm | Not required |
| 1 mm (or more) to less than 2 mm | 1.2 mm × 1 |
| 2 mm (or more) to less than 3 mm | 1.2 mm × 2 or 2.3 mm × 1 |



⑪ ⑫ Clearance between release lever pin and bushing

If the measurement exceeds the specified limit, replace the defective part(s).

NOTE

Perform this check with the bushing 16 press-fitted into the pressure plate 17.

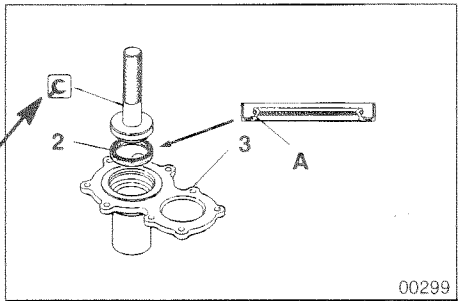
2

Service procedures contain a variety of symbols and other indications. Let's look at some examples.



Key number

[Example 1: Special tools]



2 Installation of oil seal

- Apply grease to the lip **A** of the oil seal **2**.
- Using the **C** **Oil Seal Installer**, fit the oil seal **2** into the front bearing retainer **1**. Make sure the oil seal is aligned as illustrated.

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Name of special tool

Every special tool is indicated by a **C** symbol. The text of the service procedure also includes the special tool's name. To see the part number and shape of a special tool, find the tool's key number and name in the "Special tools" table **5**.

| Symbol | Tool Name | Key Number | Service Procedure |
|--------|-------------------|------------|-------------------|
| △ | Lubricant | | |
| □ | Special tools | 5 | |
| ◆ | Service procedure | | |

23932

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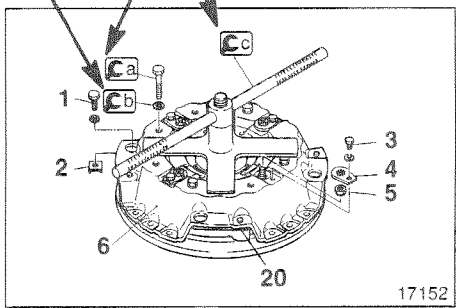
If more than one special tool is used, the symbols are supplemented by letters (for example, **Ca**, **Cb**, **Cc**) to enable cross-referencing between the exploded view and service procedure.

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6 Removal and installation of clutch cover

[Removal]

- Compress the pressure spring **8** using the **Cc** Clutch Installer, then remove the **Ca** Stopper Bolt, **Cb** Washer, strap bolt **1**, washer **2**, bolt **3**, lock plate **4**, and support nut **5**.
- Gradually loosen the **Cc** Clutch Installer until the pressure spring **8** is ineffective, then remove the clutch cover **6**.



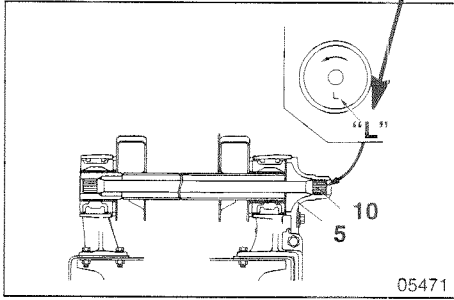
17152

3

[Example 2: Identification or mating marks]



Any mark on an actual part is given in quotation marks " " in the service procedure.



10 Installation of torsion bar

Fit the torsion bar 10 such that the "L" identification mark is on the side of the anchor lever 5.

CAUTION ⚠

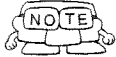
Make sure the torsion bar 10 aligned as specified. If the torsion bar is installed the wrong way around, the torsion direction will be reversed, resulting in damage.



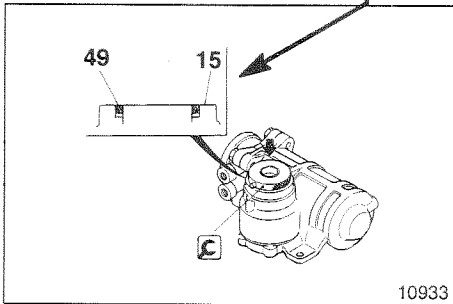
26304

4

[Example 3: Alignment of parts]



All illustrations show the correct alignment/direction of parts relative to each other. Provided the alignment/direction is shown clearly in the exploded view 1, no further explanation is given in the text of the service procedure.



15 Installation of oil seal

Fit the oil seal 15 into the body 49, making sure it is aligned as illustrated.

That's all from us. We hope these notes will help you get the most of this manual.

Bye!




23934


HOW TO READ THIS MANUAL


Terms and Units

The terms and units in this manual are defined as follows.

- This service manual contains important cautionary instructions and supplementary information under the following four headings which identify the nature of the instructions and information:

DANGER  ————— Precautions that should be taken in handling potentially dangerous substances such as battery fluid and coolant additives.

WARNING  ————— Precautionary instructions, which, if not observed, could result in serious injury or death.

CAUTION  ————— Precautionary instructions, which, if not observed, could result in damage to or destruction of equipment or parts.

NOTE ————— Suggestions or supplementary information for more efficient use of equipment or a better understanding.

- **Front and rear**

The terms “front” is the fan side and “rear” the flywheels side of the engine.

- **Left and right**

The terms “right” and “left” shall be used to indicate the side as viewed from the flywheel side of the engine.

- **Terms of service standards**

(1) Standard value

Standard value dimensions in designs indicating: the design dimensions of individual parts, the standard clearance between two parts when assembled, and the standard value for an assembly part, as the case may be.

The figure in [] is the basic diameter.

(2) Limit

When the value of a part exceeds this, it is no longer serviceable in respect of performance and strength and must be replaced or repaired.

- **Tightening torque**

Appropriate tightening torque has particular importance in respect of performance. Accordingly, tightening torque is specified in locations that are to be tightened.

Where there is no specified figure for tightening torque, follow the table covering standard tightening torques.

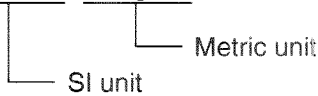
When the item is to be tightened in a “wet” state, wet is indicated. Where there is no indication, read it as dry, and tighten at specified torque.

● Units

Tightening torques and other parameters are given in SI* units with metric units added in brackets { }.

*SI: Le Système International d'Unités

Example: 390 N · m {40 kgf · m}



| Unit | SI unit {metric unit} | Conversion factor |
|------------------|-----------------------|----------------------------|
| Force | N {kgf} | 9.80665 N {1 kgf} |
| Moment of force | N · m {kgf · m} | 9.80665 N · m {1 kgf · m} |
| Pressure | Positive pressure | kPa {kgf/cm ² } |
| | Vacuum pressure | kPa {mmHg} |
| | | Pa {mmH ₂ O} |
| Volume | dm ³ {L} | 1 dm ³ {1 L} |
| Power | kW {PS} | 0.7355kW {1 PS} |
| Heat quantity | J {kcal} | 4186.8 J {1 kcal} |
| Heat flow | W {kcal/h} | 1.16279 W {1 kcal/h} |
| Angle | ° | – |
| Temperature | °C | – |
| Electric current | A | – |
| Voltage | V | – |
| Resistance | Ω | – |
| Electric power | W | – |

| Unit | SI unit | Foot-pound unit | Conversion rate |
|-------------------------|-------------------|----------------------|--|
| Force | N (Newton) | lbf | 1 N = 0.2248 lbf |
| Moment of force | N · m | lbf.ft | 1 N · m = 0.7375 lbf.ft |
| Pressure | kPa (kilopascal) | lbf/in. ² | 1 kPa = 0.145 lbf/in. ² 1 kPa = 0.2953 in. Hg |
| Volume | L | gal. | 1 L = 0.2642 gal. (U.S.) 1 L = 0.220 gal. (Imp.) |
| | cm ³ | oz | 1 cm ³ = 0.033814 oz (U.S.) 1 cm ³ = 0.035195 oz (Imp.) |
| | cm ³ | cu.in. | 1 cm ³ = 0.061023 cu.in. |
| Power | kW (kilowatt) | HP | 1 kW = 1.34 HP |
| Temperature | °C | °F | t°C = (1.8t°C + 32)°F |
| Mass quantity of matter | kg | lb | 1 kg = 2.2046 lb |
| | g | oz | 1 g = 0.035274 oz |
| Dimension | m | ft. | 1 m = 3.2808 ft. |
| | mm | in. | 1 mm = 0.03937 in. |
| Stress | N/cm ² | lbf/in. ² | 1 N/cm ² = 1.45 lbf/in. ² |

GROUP 00 GENERAL

GENERAL SPECIFICATIONS 00-2

ENGINE NUMBER, NAME PLATE AND CAUTION PLATE ... 00-3

PRECAUTIONS FOR MAINTENANCE OPERATION 00-4

TABLE OF STANDARD TIGHTENING TORQUES 00-11



GENERAL SPECIFICATIONS

Major Specifications

| Item | | Engine model | | 4D31 | 4D31-T | 4D32 | 4D33 | 4D34-T |
|---|--|-----------------------------|-----------|-------|-----------|-----------|-----------|--------|
| | | Water-cooled 4-cycle diesel | | | | | | |
| Type | | Direct injection type | | | | | | |
| Combustion chamber type | | 4-cylinder in-line | | | | | | |
| No. of cylinders – arrangement | | 4-cylinder in-line | | | | | | |
| Bore × Stroke | | mm | 100 × 105 | | 104 × 105 | 108 × 115 | 104 × 115 | |
| Total displacement | | cc | 3298 | | 3567 | 4214 | 3907 | |
| Engine dimensions (With cooling fan, without air cleaner) | | Overall length | mm | 841.5 | | 845 | 843 | 922 |
| | | Overall width | mm | 680 | | 631 | 636 | |
| | | Overall height | mm | 767 | 858 | 755 | 772 | 774 |
| Empty mass | | kg* | 315 | 330 | 320 | 325 | 335 | |

* Empty mass as measured according to Mitsubishi Motors Corporation standard.

Engine Outputs Classified by Application

| Item | | Engine model | | 4D31-T | | 4D32 | 4D33 | 4D34-T | |
|---|--|--------------|----|----------------------------|--------------------------|------|------|----------------------------|--------------------------|
| | | 4D31 | | For middle speed operation | For high speed operation | | | For middle speed operation | For high speed operation |
| Rated output PS JIS D1005-1986 (With cooling fan and air cleaner, without muffler) | | 1500 rpm | 41 | 62 | 53 | 46 | 56 | 77 | 68 |
| | | 1800 rpm | 49 | 75 | 67 | 55 | 68 | 91 | 83 |
| | | 2000 rpm | 54 | 82 | 75 | 60 | 73 | 96 | 92 |
| | | 2200 rpm | 60 | 89 | 83 | 65 | 77 | 103 | 100 |
| | | 2500 rpm | 66 | 94 | 91 | 70 | 85 | — | 107 |
| | | 2800 rpm | 72 | — | 96 | — | 90 | — | 115 |
| | | 3000 rpm | 76 | — | 98 | — | — | — | — |
| Continuous rated output PS (10 hours) JIS B8002-1986 (With cooling fan and air cleaner, without muffler) | | 1500 rpm | 37 | 56 | 48 | 42 | 51 | 70 | 62 |
| | | 1800 rpm | 44 | 68 | 61 | 50 | 62 | 82 | 76 |
| | | 2000 rpm | 49 | 74 | 68 | 54 | 67 | 88 | 84 |
| | | 2200 rpm | 54 | 81 | 75 | 59 | 70 | 94 | 91 |
| | | 2500 rpm | 60 | 85 | 83 | 63 | 77 | — | 97 |
| | | 2800 rpm | 65 | — | 87 | — | 82 | — | 104 |
| | | 3000 rpm | 69 | — | 89 | — | — | — | — |

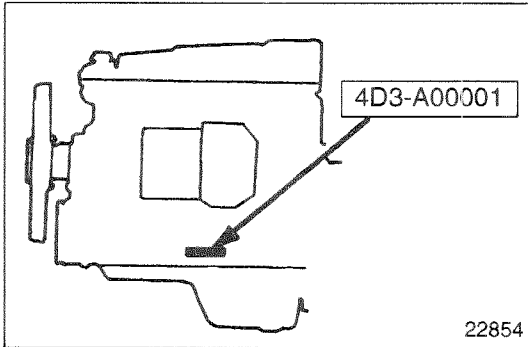
NOTE:

- The output (SAE, gross) is corrected to standard ambient conditions based on SAE J1349.
- The continuous rated output allows 10% (one hour) overload operation.

ENGINE NUMBER, NAME PLATE AND CAUTION PLATE 00

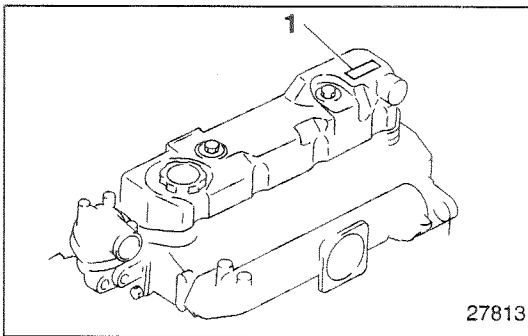
The serial number for engine is assigned to the respective engine in manufacturing sequence: every engine has its own number. This number is required for incidental inspection of the engine. Please do not fail to mention this number to the dealers when ordering spare parts.

Engine Number



The engine number is punch-marked on the shown location.

Name Plate and Caution Plate



1: Name plate or caution plate

<Name plate>
<4D31, 31-T>

| | | |
|--|--|----------|
| | | A |
| TOTAL CYL. VOL. 3298cc(201cu. in) | | B |
| OUT PUT PS / rpm | | C |
| MITSUBISHI MOTORS CORPORATION TOKYO JAPAN | | |
| VALVE CLEARANCE (COLD) | | D |
| INLET & EXHAUST 0.4mm(0.016in) | | D |
| FIRING ORDER 1-3-4-2 | | E |
| FUEL INJECTION TIMING | | F |

27814

<4D33, 34-T>

| | | |
|--|------|----------|
| | 4D33 | A |
| TOTAL CYL. VOL. 4214cc(257cu. in) | | B |
| OUT PUT PS / rpm | | C |
| MITSUBISHI MOTORS CORPORATION TOKYO JAPAN | | |

27815

<Caution plate>

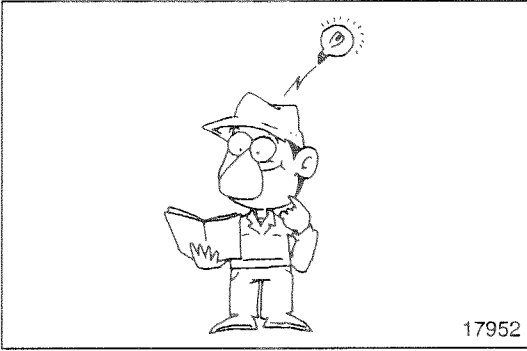
| | | |
|------------------------------|--|----------|
| VALVE CLEARANCE (COLD) | | D |
| INLET&EXHAUST 0.4mm(0.016in) | | D |
| FIRING ORDER 1-3-4-2 | | E |
| FUEL INJECTION TIMING | | F |

27816

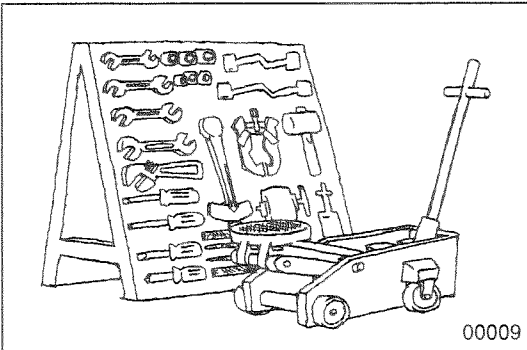
- A** Engine model
- B** Total displacement
- C** Maximum output
- D** Valve clearance
- E** Firing order
- F** Fuel injection timing

PRECAUTIONS FOR MAINTENANCE OPERATION

In order to determine the condition of the vehicle adequately, attend the vehicle beforehand to find and keep record of the accumulated mileage, operating condition, what the customer's demand is, and other information that may be necessary. Prepare the steps to be taken and perform efficient and wasteless maintenance procedure.



- Determine where the fault exists and check for the cause to see whether removal or disassembly of the part is necessary. Then follow the procedure specified by this manual.
- Perform maintenance work at a level area.



- Prepare general and special tools necessary for the maintenance work.

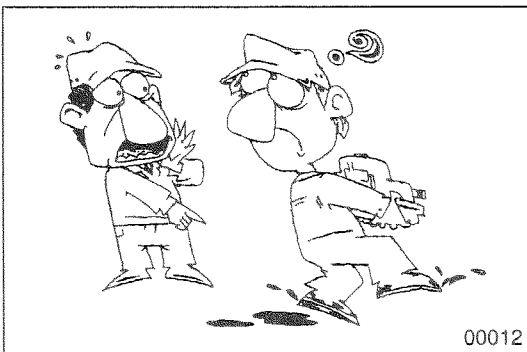
WARNING

Do not attempt to use tools other than special tools where use of special tools is specified in this manual. This will avoid injury or damage.

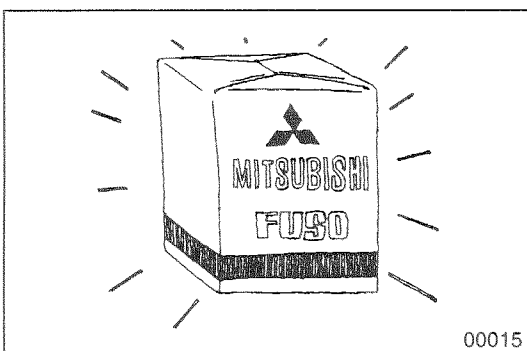
- When removing or installing the engine, attach the lifting wire rope hooks to the engine's lifting eyes and hoist the engine slowly such that it does not touch other components.

WARNING

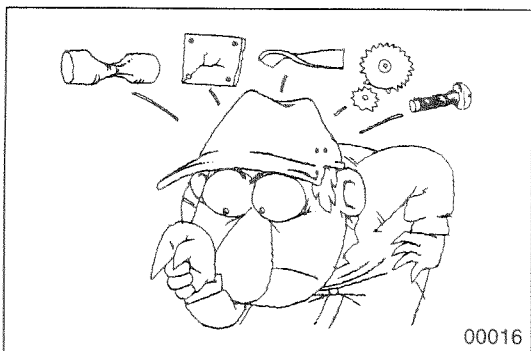
Check that the wire rope and crane are sufficiently strong.



- Be particularly careful not to work in shoes that have oily soles and are slippery. When working as a team of two or more, arrange signals in advance and keep confirming safety. Be careful not to accidentally bump switches or levers.
- Check for oil leakage before cleaning the area having the fault otherwise you might miss detecting the leakage.
- Prepare replacement part(s) beforehand.

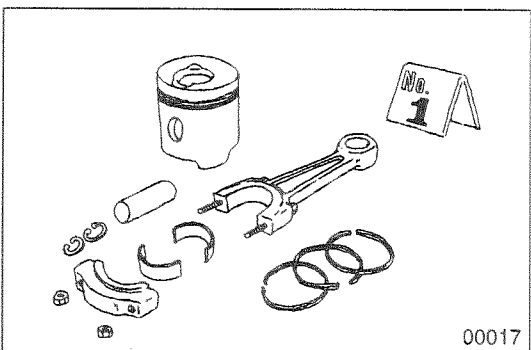


- Replace oil seals, packing, O-rings and other rubber parts; gaskets and split pins with new parts whenever any of them has been removed. Use only genuine MITSUBISHI replacement parts.



00016

On disassembly, visually inspect all parts for wear and tear, cracks, damage, deformation, degradation, rust, corrosion, smoothness in rotation, fatigue, clogging and any other possible defect.



00017

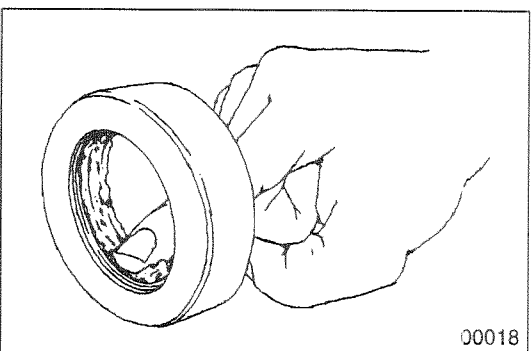
Put alignment marks on part combinations before disassembly and arrange the disassembled parts neatly. This will help avoid mismatching of the parts later.

Put the alignment marks, punch marks, etc. where performance and appearance will not be affected.

Cover the area left open after removal of parts to keep it free from dust.

CAUTION ⚠

- Take care to avoid mixing up numerous parts, similar parts, left and right, etc.
- Keep new parts for replacement and original (removed) parts separate.

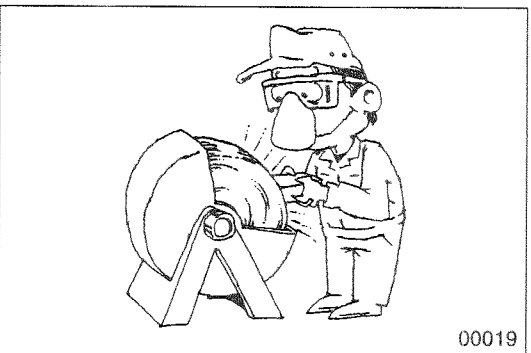


00018

Apply the specified oil or grease to U-packings, oil seals, dust seals and bearings during assembly.

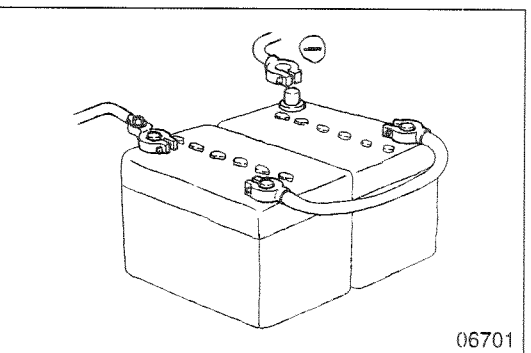
CAUTION ⚠

Use only the specified oil, grease, etc. for lubricant. Remove the excess immediately after application with a piece of rag.



00019

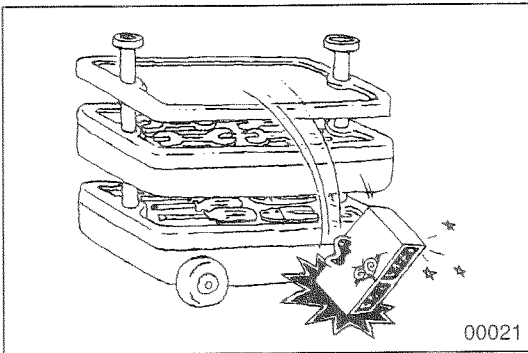
Wear goggles when using a grinder or welder. Pay full attention to safety by wearing gloves when necessary. Watch out for sharp edges, etc. that might injure your hands or fingers.



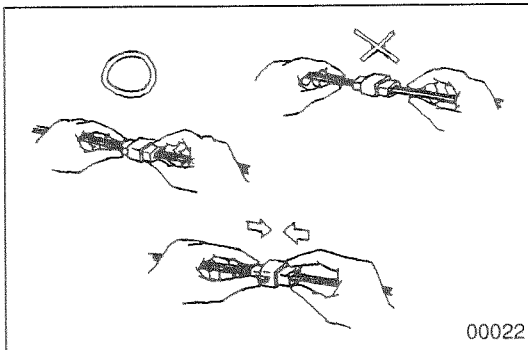
06701

Before carrying out maintenance work on the electric system, disconnect the negative terminals of the batteries.

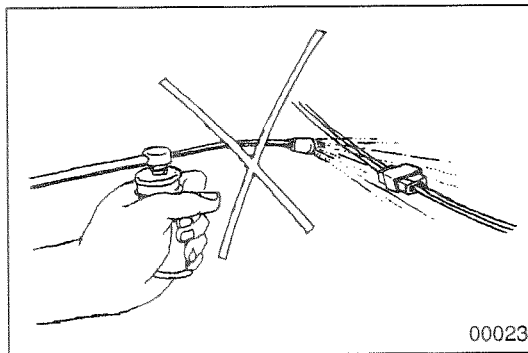
PRECAUTIONS FOR MAINTENANCE OPERATION



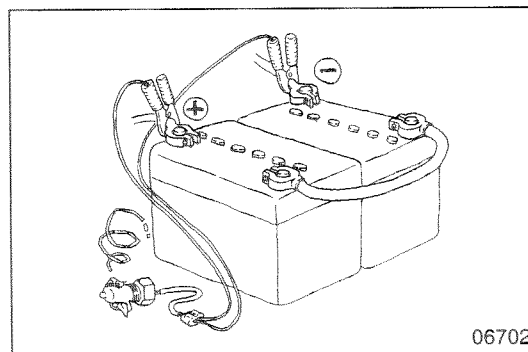
- Take care when handling sensors, relays, etc. which are vulnerable to shock and heat.



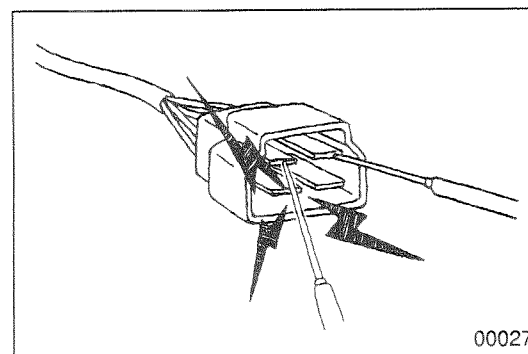
- Pull the connector, and not the harness lead, to separate connectors. To separate a lock-type connector, first push toward arrow mark. To re-connect a lock-type connector, press the separated parts until they click together.



- When washing the vehicle, cover the electric system parts and instruments with waterproof material beforehand (Cover with vinyl sheet or the like). Keep water away from harness wire connectors and sensors. If any of them should get wet, wipe them off immediately.

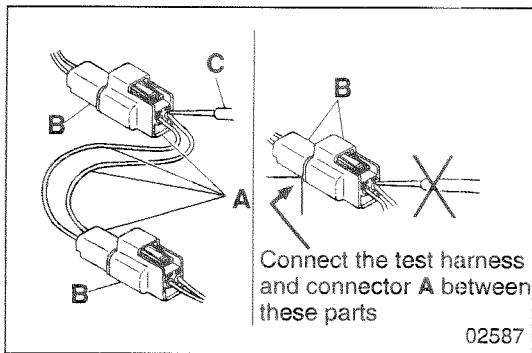


- To apply voltage for testing, check that the positive and negative cables are connected properly, then increase voltage gradually from 0 volt. Do not apply voltage higher than the specified value. In particular, pay close attention to the electronic control unit and sensors, since they are not always supplied with 24V.



- When using testers or the like for continuity tests, be careful not to allow test probes to touch the wrong terminals.

Measurement Procedures Using Connectors

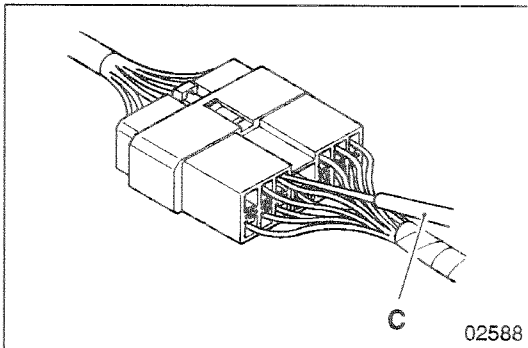


Test with connectors engaged (continuity through circuit obtained)

<Waterproof connector>

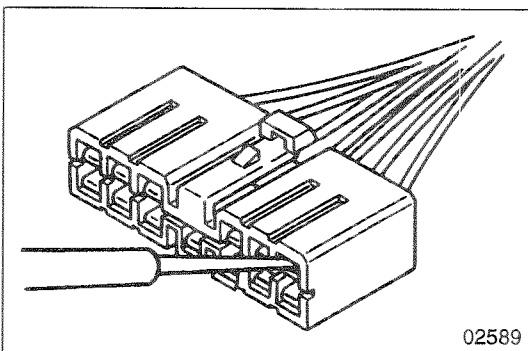
Prepare a test harness and connectors **A**, then connect it between the two parts of harness **B** that is to be tested. Check the circuit by touching test probe **C** to the test connector.

Never insert the test probe from the harness side of the waterproof connection, or waterproof performance might be diminished causing corrosion of the connector.



<Non-waterproof connector>

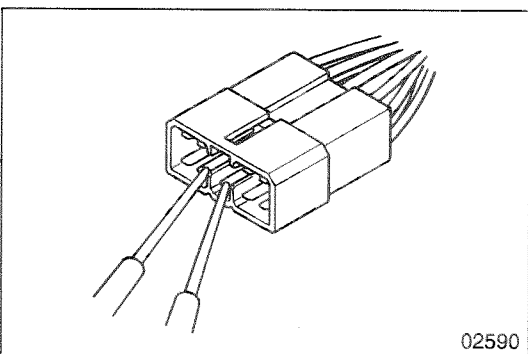
Insert test probe **C** from the harness side of the connector. Where control units, etc. have connectors that are too small to accept the test probe, do not force the test probe into them.



Test with connectors disengaged

Using female pins

Insert a test probe into a terminal. However, do not force the probe into the terminal, or it will cause a poor contact.



Using male pins

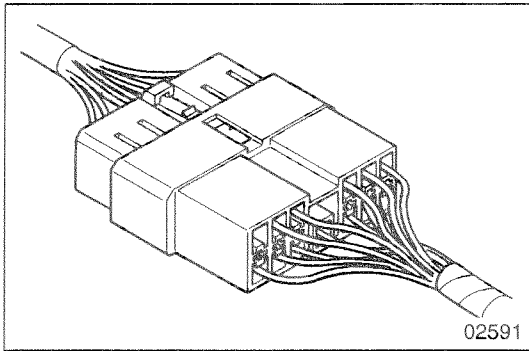
Touch the pins directly using test probes.

CAUTION ⚠

Be sure that you do not short circuit the connector pins when you use the test probe because this could damage the internal circuit of the electronic control unit.

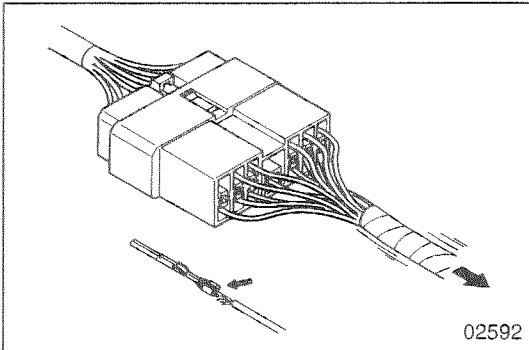
PRECAUTIONS FOR MAINTENANCE OPERATION

Connector Inspection Procedures

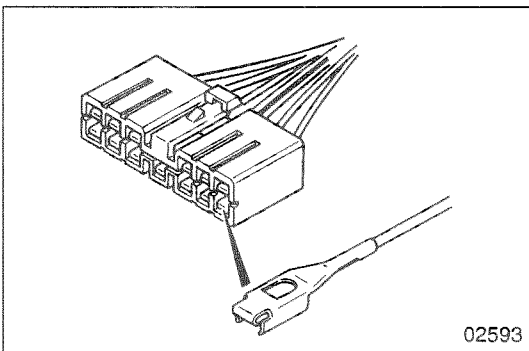


Visual inspection

Check for loose connection and poor engagement.

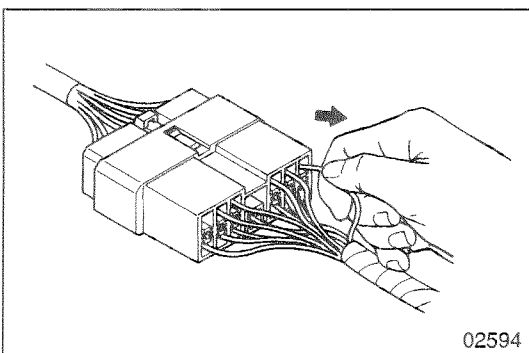


Check if harnesses are broken by pulling gently around the terminals.



Check for a decrease in contact pressure between the male and female terminals.

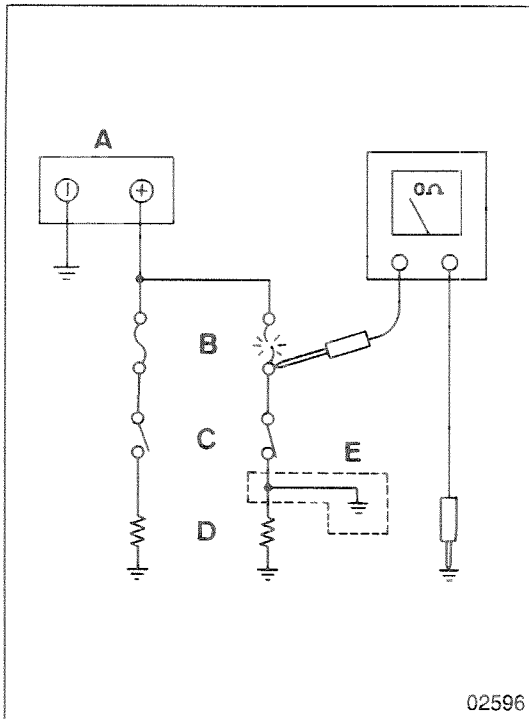
Check for poor contact caused by connector pins having fallen out, rusted terminals or foreign particles.



Connector pin fall out inspection

Damaged connector pin stoppers can cause poor engagement of the terminals (male and female pins) even if the connector body is secured, and might cause some pins to fall out. Check if the pins have fallen out from the connector by pulling each harness gently.

Inspection Procedures for Blown Fuses



Remove fuse **B** and measure resistance between the loaded side of the fuse and ground.

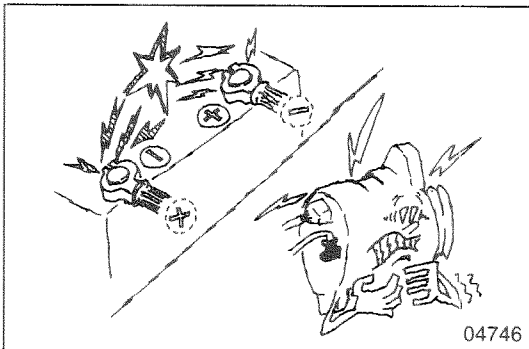
Turn on all circuit switches (connected to the fuse). If the resistance value reading is approximately 0, a short has occurred between the switch and the loaded point. A value of other than zero may indicate that the fuse was blown by a temporary short but the short is no longer present.

The major causes of a short circuit are as follows:

- Harness stuck onto the vehicle body.
- Harness sheath damaged by friction or heat.
- Water in connectors or circuits.
- Mistakes (accidental short circuits)

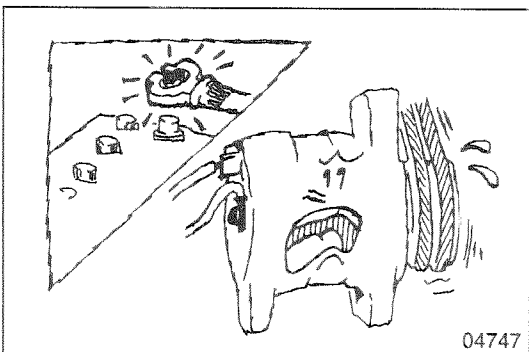
- A: Battery
 B: Fuse
 C: Loaded switch
 D: Load
 E: Short circuit

Precautions for Handling Alternator



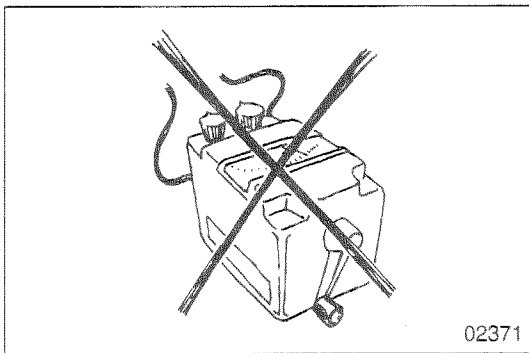
When servicing the alternator, pay attention to the following:

- Do not connect the alternator with battery polarities reversed. If the alternator is connected with reversed polarities, a large current flow from the battery to the alternator occurs, and the diode or regulator might be damaged.

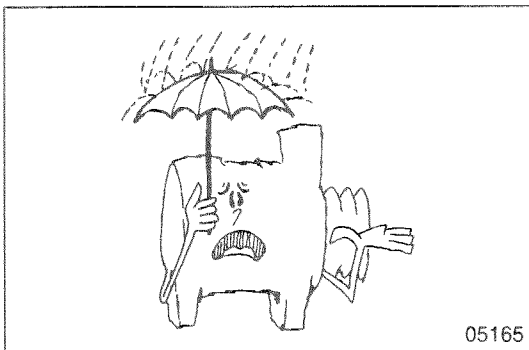


- While the engine is running, do not remove the battery terminals. If the battery terminals are removed at that time, a surge voltage is generated and the diode or regulator might be weakened.

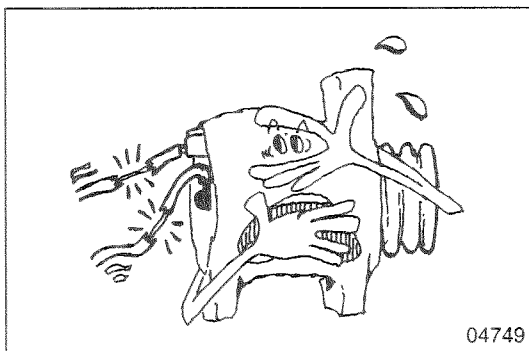
PRECAUTIONS FOR MAINTENANCE OPERATION



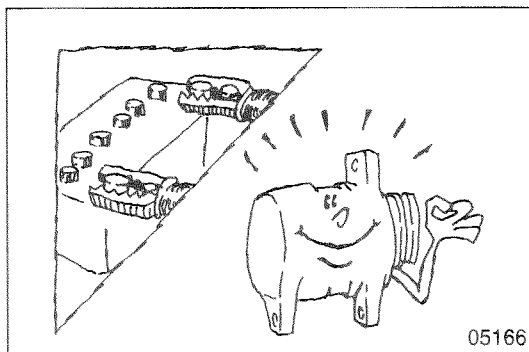
- Do not use a high-voltage tester such as a megger for inspection. If a high-voltage tester is used, the diode or regulator might be destroyed.



- Do not splash water over the alternator. If water is directly splashed over the alternator, individual components will be short-circuited and might be destroyed.



- Do not short-circuit terminal B and terminal L while running the alternator. If the terminals are short-circuited while the alternator is running, the diode trio might be destroyed.












- Disconnect the battery terminals before quick-charging the battery. Quick-charging without disconnecting the battery terminals might damage the diode or regulator.

- Use specified bolts and nuts and tighten them at specified torques according to the following table, unless otherwise specified.
- Threads and contact seats shall be dry.
- Where there is a difference in strength classification between the nut and bolt (or stud bolt), the torque specified for the bolt shall apply.

Hex-head Bolt and Stud Bolt

Unit: N · m {kgf · m}

| Strength classification | 4T | | 7T | | 8T | |
|-----------------------------------|---|---|---|--|---|--|
| Representation Diameter symbol |   (Stud) |  |   (Stud) |  |   (Stud) |  02154 |
| M5 | 2 to 3 {0.2 to 0.3} | – | 4 to 6 {0.4 to 0.6} | – | 5 to 7 {0.5 to 0.7} | – |
| M6 | 4 to 6 {0.4 to 0.6} | – | 7 to 11 {0.7 to 1.1} | – | 8 to 12 {0.8 to 1.2} | – |
| M8 | 9 to 14 {0.9 to 1.4} | – | 17 to 26 {1.7 to 2.6} | – | 20 to 29 {2.0 to 3.0} | – |
| M10 | 19 to 28 {1.9 to 2.8} | 18 to 26 {1.8 to 2.7} | 36 to 52 {3.5 to 5.5} | 33 to 49 {3.3 to 5.0} | 45 to 60 {4.5 to 6.0} | 41 to 59 {4.3 to 6.0} |
| M12 | 35 to 50 {3.4 to 5.0} | 31 to 46 {3.1 to 4.7} | 70 to 95 {7.0 to 9.5} | 65 to 85 {6.5 to 8.5} | 85 to 110 {8.5 to 11} | 75 to 100 {7.5 to 10} |
| M14 | 60 to 85 {6.0 to 8.5} | 55 to 75 {5.5 to 7.5} | 120 to 160 {12 to 16} | 110 to 140 {11 to 14} | 130 to 180 {13 to 18} | 120 to 160 {12 to 17} |
| M16 | 90 to 130 {9.5 to 13} | 90 to 120 {9.0 to 12} | 180 to 240 {18 to 24} | 160 to 220 {16 to 22} | 200 to 270 {20 to 27} | 190 to 260 {19 to 26} |
| M18 | 140 to 190 {14 to 19} | 120 to 160 {12 to 16} | 260 to 340 {26 to 35} | 220 to 290 {22 to 30} | 290 to 390 {30 to 40} | 260 to 340 {26 to 35} |
| M20 | 190 to 260 {19 to 26} | 170 to 230 {17 to 23} | 350 to 470 {36 to 48} | 320 to 420 {32 to 43} | 410 to 550 {41 to 56} | 370 to 490 {37 to 50} |
| M22 | 260 to 340 {26 to 35} | 230 to 300 {23 to 31} | 470 to 640 {48 to 65} | 430 to 570 {43 to 58} | 550 to 740 {56 to 75} | 490 to 670 {50 to 68} |
| M24 | 340 to 450 {34 to 46} | 290 to 390 {29 to 40} | 630 to 840 {63 to 86} | 540 to 730 {55 to 74} | 730 to 980 {74 to 100} | 630 to 840 {64 to 86} |

Hex-head Flange Bolt

Unit: N · m {kgf · m}












| Strength classification | 4T | | 7T | | 8T | |
|-----------------------------------|---|---|---|--|---|--|
| Representation Diameter symbol |  |  |  |  |  |  02154 |
| M6 | 4 to 6 {0.4 to 0.6} | – | 8 to 12 {0.8 to 1.2} | – | 9 to 14 {0.9 to 1.4} | – |
| M8 | 10 to 15 {1.0 to 1.5} | – | 19 to 28 {1.9 to 2.8} | – | 22 to 32 {2.2 to 3.3} | – |
| M10 | 21 to 30 {2.1 to 3.1} | 20 to 28 {1.9 to 2.9} | 39 to 58 {3.9 to 6.0} | 37 to 53 {3.6 to 5.4} | 50 to 65 {5.0 to 6.5} | 45 to 65 {4.5 to 6.5} |
| M12 | 38 to 54 {3.8 to 5.5} | 35 to 51 {3.4 to 5.2} | 80 to 110 {8.0 to 11} | 70 to 95 {7.0 to 9.5} | 90 to 120 {9.0 to 12} | 85 to 110 {8.5 to 11} |


TABLE OF STANDARD TIGHTENING TORQUES

Hex-head Nut

Unit: N · m {kgf · m}

| Strength classification | 4T | | 6T | | | |
|-------------------------|---|--------------------------|---|---|---|---|
| Representation |  | |  |  |  |  |
| Diameter symbol | Standard screw | Coarse screw | Standard screw | Coarse screw | 02155 | |
| M5 | 2 to 3 {0.2 to 0.3} | — | 4 to 6 {0.4 to 0.6} | — | | |
| M6 | 4 to 6 {0.4 to 0.6} | — | 7 to 11 {0.7 to 1.1} | — | | |
| M8 | 9 to 14 {0.9 to 1.4} | — | 17 to 26 {1.7 to 2.6} | — | | |
| M10 | 19 to 28 {1.9 to 2.8} | 18 to 26 {1.8 to 2.7} | 36 to 52 {3.5 to 5.5} | 33 to 49 {3.3 to 5.0} | | |
| M12 | 35 to 50 {3.4 to 5.0} | 31 to 46 {3.1 to 4.7} | 70 to 95 {7.0 to 9.5} | 65 to 85 {6.5 to 8.5} | | |
| M14 | 60 to 85 {6.0 to 8.5} | 55 to 75 {5.5 to 7.5} | 120 to 160 {12 to 16} | 110 to 140 {11 to 14} | | |
| M16 | 90 to 130 {9.5 to 13} | 90 to 120 {9.0 to 12} | 180 to 240 {18 to 24} | 160 to 220 {16 to 22} | | |
| M18 | 140 to 190 {14 to 19} | 120 to 160 {12 to 16} | 260 to 340 {26 to 35} | 220 to 290 {22 to 30} | | |
| M20 | 190 to 260 {19 to 26} | 170 to 230 {17 to 23} | 350 to 470 {36 to 48} | 320 to 420 {32 to 43} | | |
| M22 | 260 to 340 {26 to 35} | 230 to 300 {23 to 31} | 470 to 640 {48 to 65} | 430 to 570 {43 to 58} | | |
| M24 | 340 to 450 {34 to 46} | 290 to 390 {29 to 40} | 630 to 840 {63 to 86} | 540 to 730 {55 to 74} | | |

Hex-head Flange Nut Unit: N · m {kgf · m}

| Strength classification | 4T | |
|-------------------------|---|--------------------------|
| Representation |  | |
| Diameter symbol | Standard screw | Coarse screw |
| M6 | 4 to 6 {0.4 to 0.6} | — |
| M8 | 10 to 15 {1.0 to 1.5} | — |
| M10 | 21 to 30 {2.1 to 3.1} | 20 to 28 {1.9 to 2.9} |
| M12 | 38 to 54 {3.8 to 5.5} | 35 to 51 {3.4 to 5.2} |

Tightening torque for flare nut for general purpose

Unit: N · m {kgf · m}

| | | | | | | |
|-------------------|----------|----------|----------|----------|----------|-----------|
| Pipe diameter | φ4.76 mm | φ6.35 mm | φ8 mm | φ10 mm | φ12 mm | φ15 mm |
| Tightening torque | 17 {1.7} | 25 {2.6} | 39 {4.0} | 59 {6.0} | 88 {9.0} | 98 {10.0} |

Tightening torque for air piping nylon tube for general purpose {DIN type}

Unit: N · m {kgf · m}

| | | | | |
|-------------------|---|--|--|---|
| Standard diameter | 6 × 1 mm | 10 × 1.25 mm | 12 × 1.5 mm | 15 × 1.5 mm |
| Tightening torque | $20^{+6}_0 \left\{ \begin{array}{l} 2.0^{+0.6} \\ 0 \end{array} \right\}$ | $34^{+10}_0 \left\{ \begin{array}{l} 3.5^{+1.0} \\ 0 \end{array} \right\}$ | $49^{+10}_0 \left\{ \begin{array}{l} 5.0^{+1.0} \\ 0 \end{array} \right\}$ | $54^{+5}_0 \left\{ \begin{array}{l} 5.5^{+0.5} \\ 0 \end{array} \right\}$ |

Tightening torque for air piping nylon tube for general purpose {SAE type}

Unit: N · m {kgf · m}

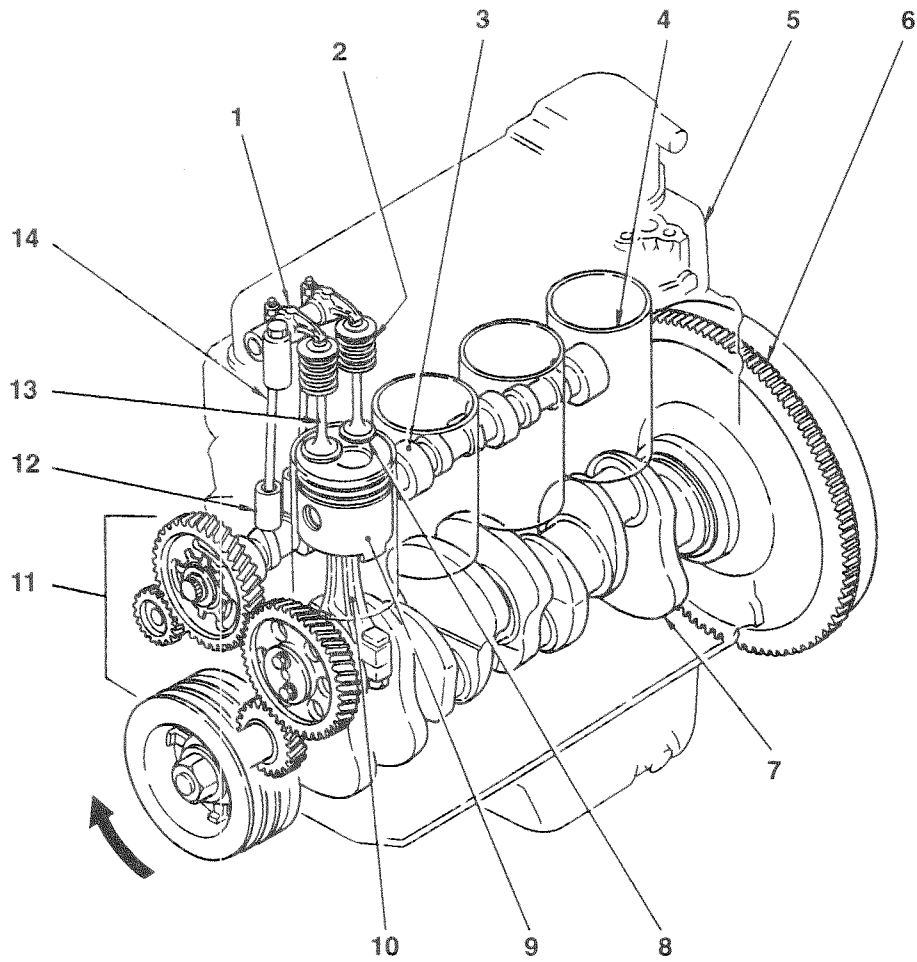
| | | | | |
|-------------------|---|---|---|---|
| Standard diameter | 1/4 in. | 3/8 in. | 1/2 in. | 5/8 in. |
| Tightening torque | $13^{+4}_0 \left\{ \begin{array}{l} 1.3^{+0.4} \\ 0 \end{array} \right\}$ | $29^{+5}_0 \left\{ \begin{array}{l} 3.0^{+0.5} \\ 0 \end{array} \right\}$ | $49^{+5}_0 \left\{ \begin{array}{l} 5.0^{+0.5} \\ 0 \end{array} \right\}$ | $64^{+5}_0 \left\{ \begin{array}{l} 6.5^{+0.5} \\ 0 \end{array} \right\}$ |

GROUP 11 ENGINE

| | |
|---|-------|
| SPECIFICATIONS | 11-2 |
| STRUCTURE AND OPERATION | 11-3 |
| TROUBLESHOOTING | 11-7 |
| ON-VEHICLE INSPECTION AND ADJUSTMENT | |
| • Measuring Compression Pressure | 11-8 |
| • Inspecting and Adjusting Valve Clearances | 11-9 |
| CYLINDER HEAD AND VALVE MECHANISM | 11-12 |
| TIMING GEAR | 11-30 |
| CAMSHAFT | 11-34 |
| PISTON, CONNECTING ROD AND CYLINDER SLEEVE | 11-42 |
| FLYWHEEL | 11-58 |
| CRANKSHAFT AND CRANKCASE | 11-62 |

SPECIFICATIONS

| Item | Engine model | 4D31 | 4D31-T | 4D32 | 4D33 | 4D34-T |
|-----------------------------------|--------------|------------------------------|--------|-----------|-----------|-----------|
| Type | | 4-cycle diesel, water-cooled | | | | |
| Combustion chamber type | | Direct injection type | | | | |
| Number of cylinders – arrangement | | 4-cylinder in-line | | | | |
| Bore × stroke | mm | 100 × 105 | | 104 × 105 | 108 × 115 | 104 × 115 |
| Total displacement | cc | 3298 | | 3567 | 4214 | 3907 |
| Compression ratio | | 17.5 | 16 | 17.5 | 18 | 16.5 |



27817

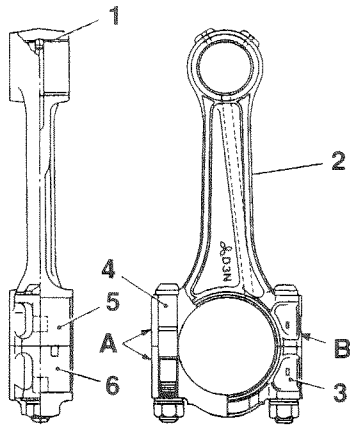
- | | |
|--|-------------------|
| 1 Rocker arm | 8 Exhaust valve |
| 2 Valve spring | 9 Piston |
| 3 Camshaft | 10 Connecting rod |
| 4 Cylinder sleeve <4D31, 31-T, 32, 34-T> | 11 Timing gear |
| 5 Cylinder head | 12 Tappet |
| 6 Flywheel | 13 Inlet valve |
| 7 Crankshaft | 14 Push rod |

On 4D31, 31-T, 32 and 34-T engines, the pistons reciprocate in the cylinder sleeves inserted in the crankcase, while on 4D33 engine they do in the cylinders bored directly in the crankcase.

STRUCTURE AND OPERATION

Connecting Rods

<4D31, 32>

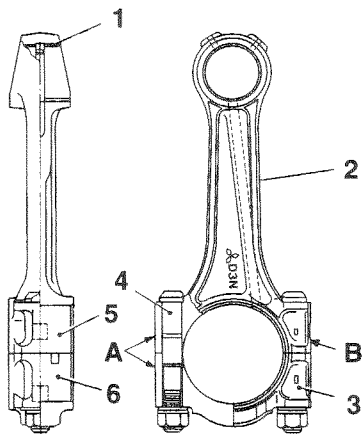


27818

- 1 Connecting rod bushing
- 2 Connecting rod
- 3 Connecting rod cap
- 4 Connecting rod bolt
- 5 Upper connecting rod bearing
- 6 Lower connecting rod bearing

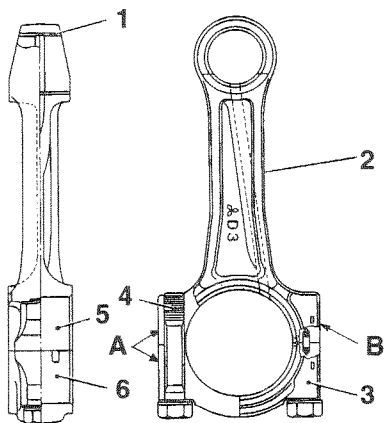
A : Alignment mark
B : Mass mark

<4D31-T, 33>



03140

<4D34-T>

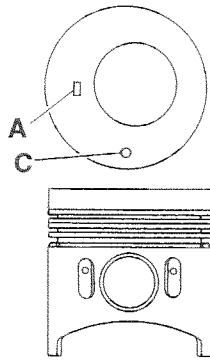


03141

Pistons

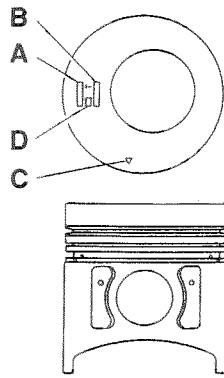
- A:** Mass mark (STD), mass mark (oversize)
- B:** Part number
- C:** Front mark
- D:** Oversize symbol (0.50)

<4D31>



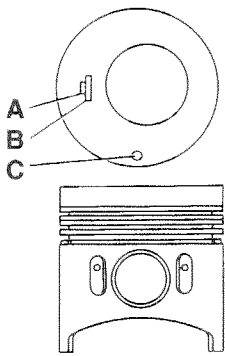
27820

<4D31-T, 34-T>



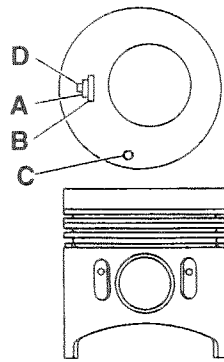
27819

<4D32>



09923

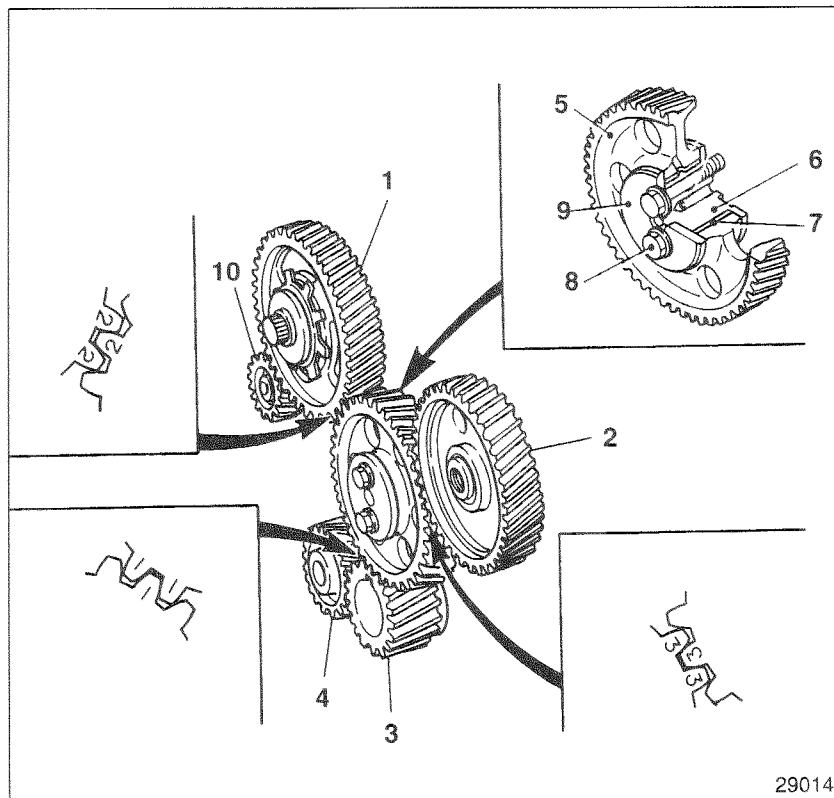
<4D33>



27822

STRUCTURE AND OPERATION

Timing Gear



- 1 Camshaft gear
- 2 Injection pump gear
- 3 Crankshaft gear
- 4 Oil pump gear
- 5 Idler gear
- 6 Idler shaft
- 7 Idler bushing
- 8 Bolt
- 9 Thrust plate
- 10 Power steering oil pump gear

Alignment mark "1", "2", "3" are stamped on each timing gear to ensure proper engagement of the gears at installation.

| Symptoms | Possible causes | | Remarks |
|---|--------------------------|--------------------------|-----------------|
| | Decrease of power | Engine noise abnormal | |
| | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 12 |
| Oil viscosity unsuitable | <input type="checkbox"/> | <input type="checkbox"/> | |
| Fuel incorrect or unsuitable | <input type="checkbox"/> | <input type="checkbox"/> | |
| Valve clearance faulty | <input type="checkbox"/> | <input type="checkbox"/> | |
| Cylinder head gasket faulty | <input type="checkbox"/> | <input type="checkbox"/> | |
| Valve and valve seat worn, and carbon deposits | <input type="checkbox"/> | <input type="checkbox"/> | |
| Valve spring fatigued | <input type="checkbox"/> | <input type="checkbox"/> | |
| Piston ring worn or damaged | <input type="checkbox"/> | <input type="checkbox"/> | |
| Piston ring grooves worn or damaged | <input type="checkbox"/> | <input type="checkbox"/> | |
| Injection timing faulty | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 13 |
| Injection pump malfunctioning | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 13 |
| Cooling system malfunctioning | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 14 |
| Injection nozzle malfunctioning | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 13 |
| Air trapped in fuel system | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 13 |
| Air cleaner clogged | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 15 |
| Muffler clogged | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 15 |
| Turbo-charger malfunctioning <4D31-T, 34-T> | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 15 |
| Pipes and hoses installed incorrectly | <input type="checkbox"/> | <input type="checkbox"/> | |
| Injection pump, alternator or other auxiliary device(s) faulty or incorrectly installed | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 13, Gr 54 |
| V-belt loose or damaged | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 14 |
| Crankshaft pulley mounted incorrectly | <input type="checkbox"/> | <input type="checkbox"/> | |
| Air cleaner or muffler malfunctioning | <input type="checkbox"/> | <input type="checkbox"/> | [[Gr 15 |
| Rocker shaft and bracket faulty | <input type="checkbox"/> | <input type="checkbox"/> | |
| Rocker shaft bracket lubrication faulty | <input type="checkbox"/> | <input type="checkbox"/> | |
| Timing gear backlash faulty | <input type="checkbox"/> | <input type="checkbox"/> | |
| Timing gear and idler shaft area lubricated poorly | <input type="checkbox"/> | <input type="checkbox"/> | |
| Connecting rod small end bushing worn and piston pin worn | <input type="checkbox"/> | <input type="checkbox"/> | |
| Crankshaft pin and big end bearing of connecting rod worn or damaged | <input type="checkbox"/> | <input type="checkbox"/> | |
| Crankshaft journal and main bearing worn or damaged | <input type="checkbox"/> | <input type="checkbox"/> | |
| Crankshaft and camshaft end play excessive | <input type="checkbox"/> | <input type="checkbox"/> | |
| Tappet and camshaft worn | <input type="checkbox"/> | <input type="checkbox"/> | |

ON-VEHICLE INSPECTION AND ADJUSTMENT

Measuring Compression Pressure

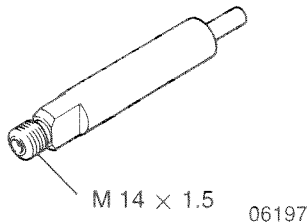
Service standards

Unit: kPa {kgf/cm²}

| Location | Maintenance item | Standard value | Limit | Remedy | |
|----------|----------------------|---------------------------------------|-----------|----------------|---------|
| — | Compression pressure | Each cylinder (200 rpm) | 2550 {26} | 1960 {20} | Inspect |
| | | Pressure difference between cylinders | — | Within 390 {4} | Inspect |

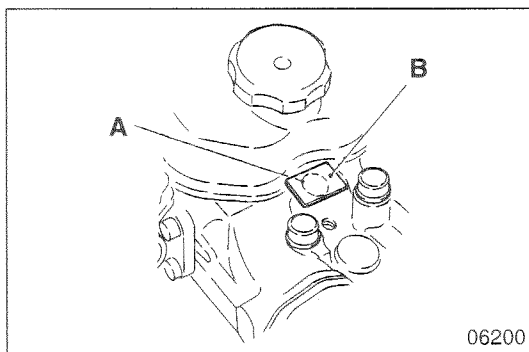
Special tools


Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|-----------------------------------|
| — |  <p>Compression Gauge Adapter</p> | MH061460 | Measuring of compression pressure |

Reductions in compression pressure should be used as a guide in determining the timing of engine overhauls. Take measurements regularly and keep track of changes; an overview of pressure variations can be useful in fault diagnosis. During the engine's run-in period and after parts have been replaced, the compression pressure will increase slightly as piston rings, valve seats, and other parts fit snugly in position. The pressure will then normalize as parts wear.

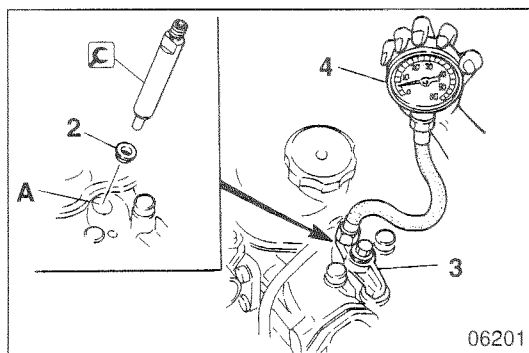
- Before inspection make sure that engine oil, starter and battery are in normal condition.
- Before inspecting the vehicle, do the following.
 - Run the engine to bring the temperature of the coolant up to approximately 75 to 85°C.
 - Turn all the lights and accessory equipment OFF.




- Remove the injection nozzle.  Gr 13
- Cover injection nozzle mounting hole **A** with a cloth **B**. Then, turn the engine over with the starter and check that no foreign matter adheres to the cloth.

WARNING

If any cylinder is cracked, coolant, engine oil, and fuel will enter the cylinder through the crack. When the engine is turned over, these substances will spray out of nozzle mounting hole **A** at a high temperature. For safety, move away from the nozzle mounting hole before turning over the engine.



- Fit the  Compression Gauge Adapter onto injection nozzle mounting hole **A** together with a gasket **2**. Lock these items in position with nozzle bridge **3**, then connect compression gauge **4**.
- Turn the engine over and measure the compression pressure.
 - Standard value: 2550 kPa {26 kgf/cm²} (at 200 rpm)
 - Limit: 1960 kPa {20 kgf/cm²}
- Measure the compression pressure in every cylinder and determine the pressure differences between cylinders.
 - Limit: within 390 kPa {4 kgf/cm²}

- If any compression pressure or cylinder-to-cylinder pressure difference exceeds the specified limit, pour a little engine oil into the cylinder via the injection nozzle mounting hole then take the measurement again.
- If the compression pressure increases:
There may be wear or damage on piston rings and inner surfaces of cylinders.
- If the compression pressure does not increase:
Valves may be seized or incorrectly seated, or the cylinder head gasket may be defective.

Inspecting and Adjusting Valve Clearances

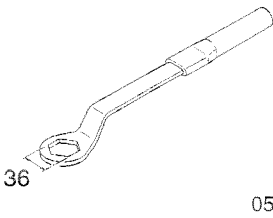
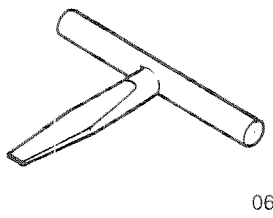
Service standards

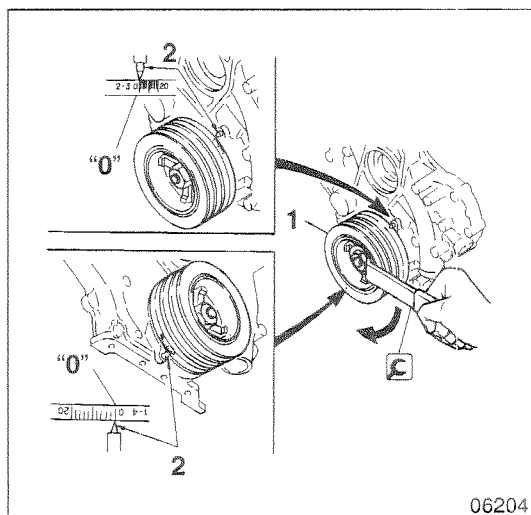
Unit: mm

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---------------------------------------|----------------|-------|--------|
| — | Valve clearance (when engine is cold) | 0.4 | — | Adjust |

☒ Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|--|
| — |  <p>Cranking Handle</p> | MH061289 | Cranking of engine |
| — |  <p>Flat-blade Screwdriver</p> | MH060008 | Valve clearance adjustment (Used for an installed engine) |



Inspect and adjust the valve clearance in the following way while the engine is cold.

[Inspection]

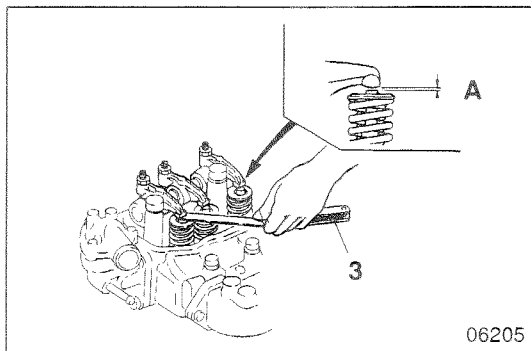
- Bring No.1 piston or No.4 piston to the top dead center of the compression stroke. To do this, turn crankshaft pulley 1 clockwise using the ☒ Cranking Handle to align punched mark "0" on the crankshaft pulley with pointer 2.

NOTE

Pistons whose push rods are not pushing up their rockers are at the top-dead-center (TDC) positions of their compression strokes.

Pointer 2 is provided in two places. Either pointer can be used. However, note that must be aligned with the respective punched marks on crankshaft pulley 1 as illustrated.

ON-VEHICLE INSPECTION AND ADJUSTMENT



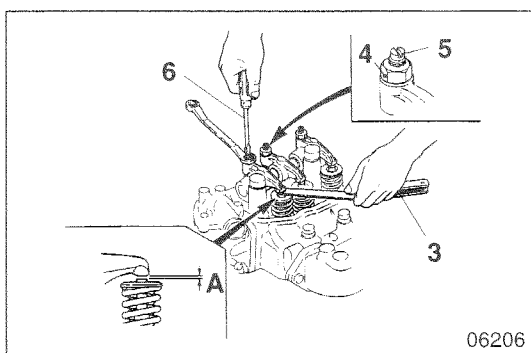
- Measure the valve clearance **A** of every valve marked "○" in the following table when either No.1 or No.4 piston is at top dead center of the compression stroke.

| Cylinder No. | 1 | | 2 | | 3 | | 4 | |
|--|--------|---------|--------|---------|--------|---------|--------|---------|
| Valve arrangement | Intake | Exhaust | Intake | Exhaust | Intake | Exhaust | Intake | Exhaust |
| No.1 piston at top dead center of the compression stroke | ○ | ○ | ○ | - | - | ○ | - | - |
| No.4 piston at top dead center of the compression stroke | - | - | - | ○ | ○ | - | ○ | ○ |

NOTE

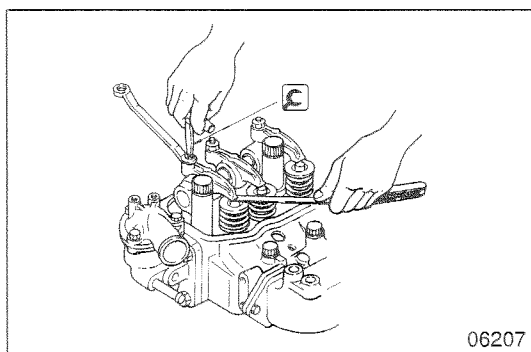
To measure the clearance, insert a feeler gauge **3**. The gauge should be able to move in the gap, albeit not loosely. Accurate measurements cannot be taken if the gauge moves loosely in the gap.

- If the measured value deviates from the limit, adjust as follows:



[Adjustment]

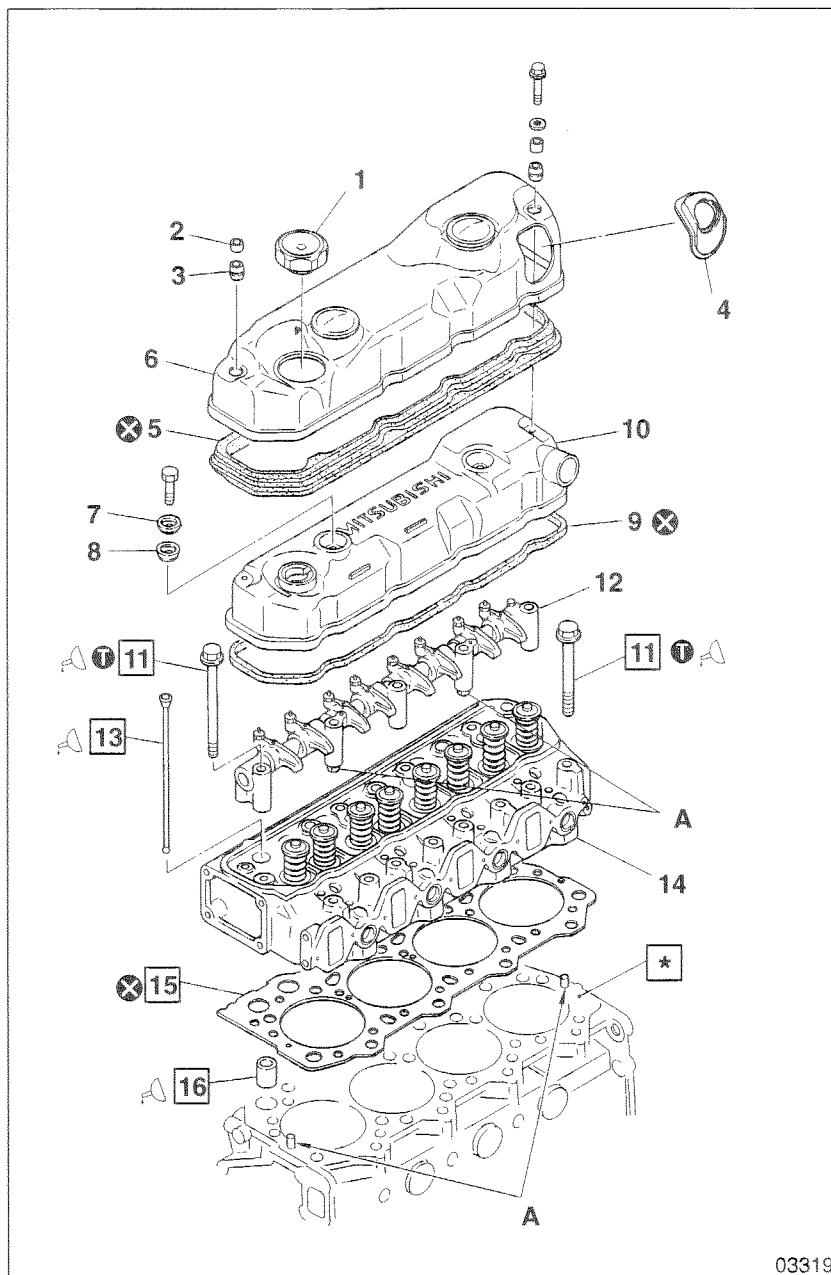
- To adjust valve clearance **A**, loosen lock nut **4** and turn adjusting screw **5** until feeler gauge **3** moves more stiffly in the gap.
- After adjusting the clearance, tighten lock nut **4**. At this time, use a screwdriver **6** to stop adjusting screw **5** from turning. Next, insert feeler gauge **3** once more to confirm that clearance **A** is correct.



- When turning adjusting screw **5** with the engine installed, use the **C** Flat-blade Screwdriver to make the work easier.

MEMO

CYLINDER HEAD AND VALVE MECHANISM



● Disassembly sequence

- 1 Oil filler cap
- 2 Spacer
- 3 Insulator
- 4 Breather cap
- 5 Rocker cover gasket
- 6 Outer rocker cover <4D33, 34-T>
- 7 Washer
- 8 Insulator
- 9 Inner rocker cover gasket
- 10 Inner rocker cover
- 11 Cylinder head bolt
- 12 Rocker and bracket assembly P11-17
- 13 Push rod
- 14 Cylinder head assembly P11-20
- 15 Cylinder head gasket
- 16 Tappet

*: Crankcase P11-62

A: Positioning pin

⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|--|---|-------|---------|
| 13 | Push rod deflection | — | 0.4 | Replace |
| 16, * | Clearance between tappet and crankcase tappet hole | [28] 0.05 to 0.09 | 0.2 | Replace |

① Tightening torque

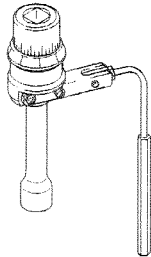
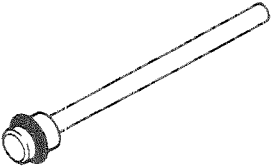
Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-------------------|-----------------------------------|
| 11 | Cylinder head bolt | 145 {15} -- 90° | Wet (Can be reused up to 3 times) |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-------------------------------|---------------------|-------------|
| 11 | Threads of cylinder head bolt | Engine oil | As required |
| 13 | Both ends of push rod | Engine oil | As required |
| 16 | External periphery of tappet | Engine oil | As required |

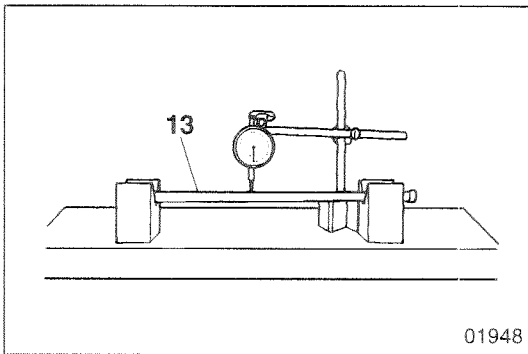
Special tools

| Location | Tool name and shape | Part No. | Application |
|----------|---|------------------------------|-------------------------------|
| 14 | Socket Wrench  | MH061560 | Installation of cylinder head |
| 16 | Tappet Extractor  | MH061288 <4D31, 31-T, 32> | Removal of tappet |
| | | MH063329 <4D33, 34-T> | |

Service procedure

13 Push rod deflection

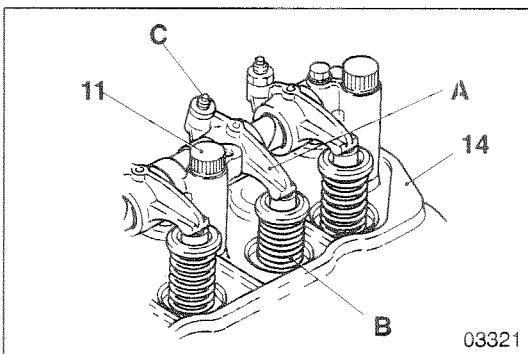
If the measured value is higher than the limit, replace push rod 13.



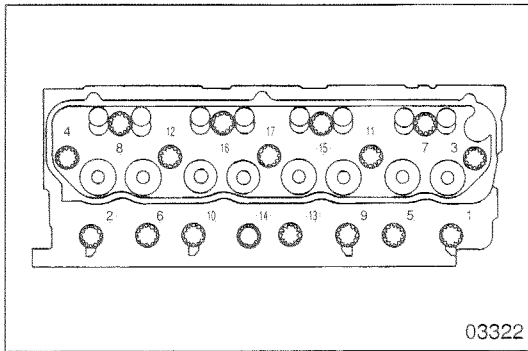
14 Cylinder head assembly

[Removal]

- Before undoing cylinder head bolts 11, first loosen adjusting screw C of every rocker A that is pushing down valve spring B.

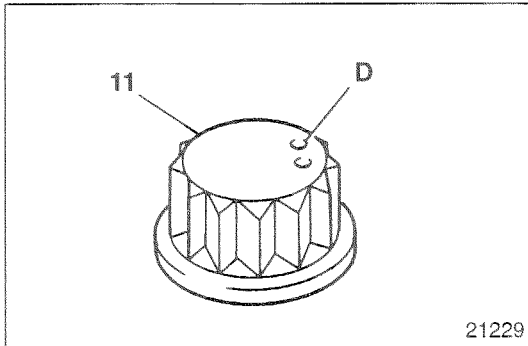


CYLINDER HEAD AND VALVE MECHANISM



03322

- Loosen cylinder head bolts **11** step by step in the order of the encircled numbers given in the illustration, then remove them.

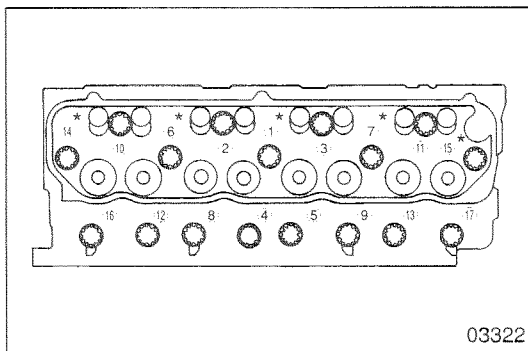


21229

[Installation]

CAUTION

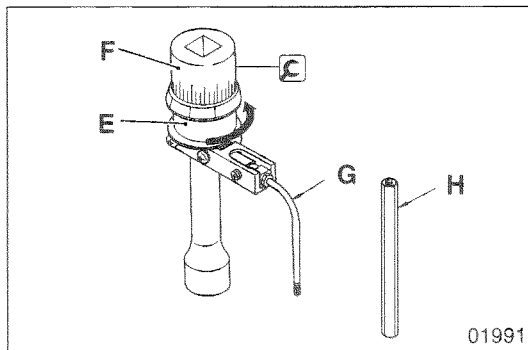
- Before fitting any cylinder head bolt **11**, check the punch marks **D** on its head. Do not use the bolt if there are more than two punch marks.
- The punch marks indicate the number of times each bolt has been tightened using the plastic area tightening method. Any bolt that already has three punch marks must be replaced.




03322

- Tighten cylinder head bolts **11** step by step to the specified torque [145 N·m (15 kgf·m)] in the sequence shown. Then, turn the bolts further in accordance with the following procedure.

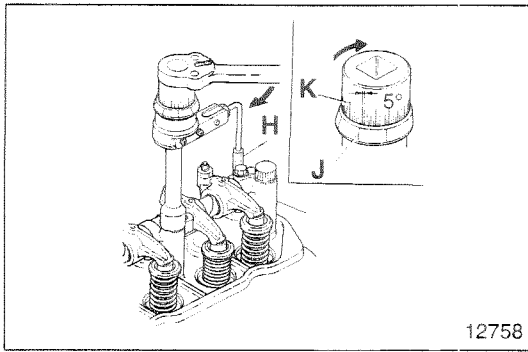
*: Tighten together with rocker and bracket assembly



01991

- Before fitting the  Socket Wrench over a cylinder head bolt, turn holder **E** counter-clockwise to tension the built-in spring.

F: Socket
G: Rod
H: Rod (extension)

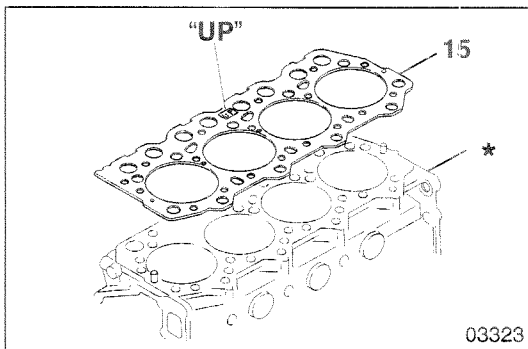


12758

- Set the socket such that the built-in spring force forces rod **H** against the rocker shaft bracket, an injection pipe, or another nearby part.
- On holder **E**, select inscribed line **J** that is easiest to see.
- Using the selected line as a reference, turn socket **F** 90° clockwise. (One gradation on scale **K** represents 5°.)
- After tightening the cylinder head bolts **11** using the plastic region tightening method, make a punch mark on the head of each one to indicate the times of use.

CAUTION ⚠

Since cylinder head bolts **4** utilize the plastic region tightening method, they must not be tightened further after this procedure.



03323

15 Cylinder head gasket

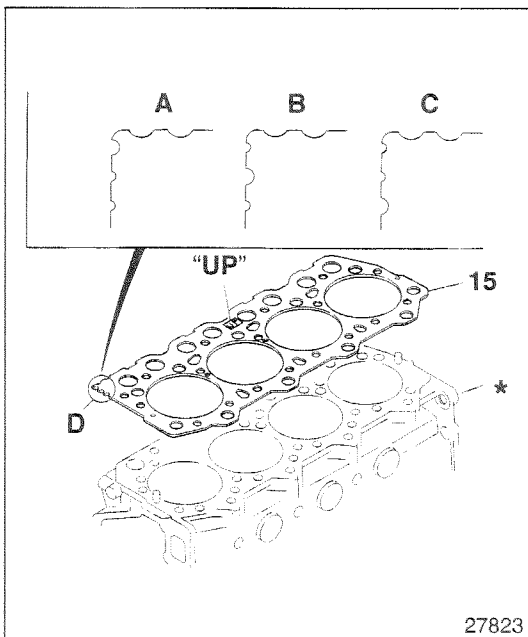
[Removal]

CAUTION ⚠

Be careful not to scratch cylinder head assembly **14** or the crankcase ***** when removing cylinder head gasket **15**.

[Installation]

Install cylinder head gasket **15** in the direction as illustrated.



27823

- Cylinder head gasket **15** installed must be the one which can accommodate the piston projection. To obtain such a gasket, measure the piston projection at each cylinder and take an average. Select a cylinder head gasket appropriate for the average value from the following table.
- If any of the piston projection measurements is more than 0.05 mm larger than the average value, then use the gasket one rank higher than that rank (**A** → **B**, **B** → **C**).

Unit: mm

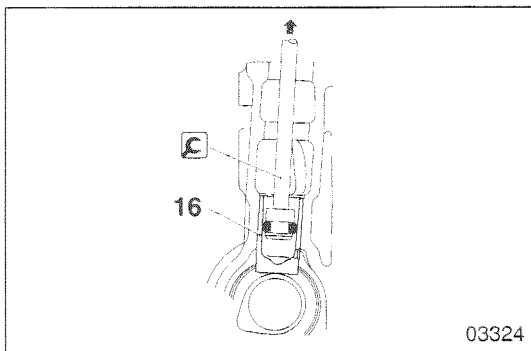
| Average value of piston projection | Cylinder head gasket | |
|------------------------------------|----------------------|---------------------------|
| | Size classification | Thickness when tightening |
| 0.546 to 0.610 | A | 1.35 ± 0.03 |
| 0.610 to 0.674 | B | 1.40 ± 0.03 |
| 0.674 to 0.738 | C | 1.45 ± 0.03 |

- The classification (size) and the application (engine model) of cylinder head gasket **15** can be known from the shape of the notches **D** cut in the gasket edge.

CAUTION ⚠

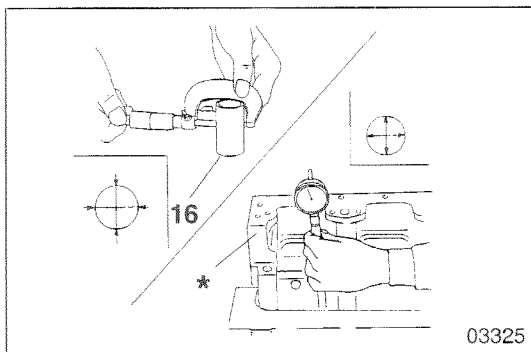
Changing a piston or a connecting rod can cause the piston projection to change. Measure the piston projection whenever a piston or connecting rod is replaced.

CYLINDER HEAD AND VALVE MECHANISM



16 Tappet removal

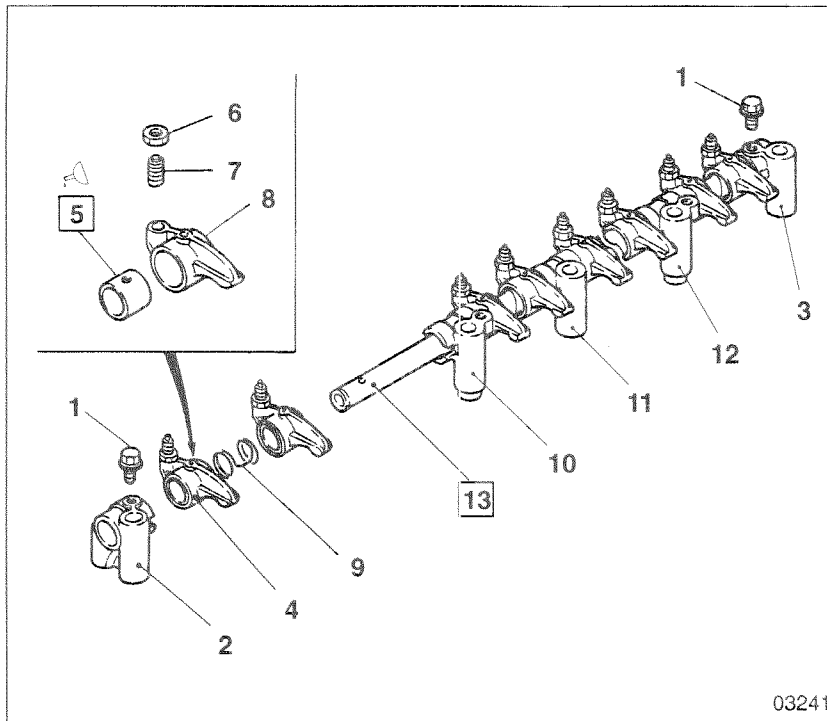
C : Tappet Extractor



16 * Tappet-to-crankcase clearance

If the measured value is higher than the limit, replace the faulty parts.

Rocker and Bracket Assembly



● Disassembly sequence

- 1 Set bolt
- 2 Front rocker shaft bracket
- 3 Rear rocker shaft bracket
- 4 Rocker assembly
- 5 Rocker bushing
- 6 Lock nut
- 7 Adjusting screw
- 8 Rocker
- 9 Rocker shaft spring
- 10 No.2 rocker shaft bracket
- 11 No.3 rocker shaft bracket
- 12 No.4 rocker shaft bracket
- 13 Rocker shaft

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

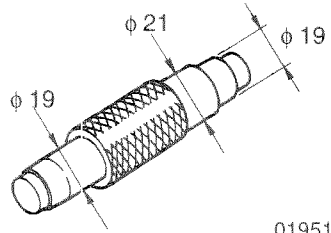
| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|---|-------|---------|
| 5, 13 | Clearance between rocker bushing and rocker shaft | [19] 0.06 to 0.11 | 0.2 | Replace |

🔧 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|---------------------------------|---------------------|-------------|
| 5 | Inner surface of rocker bushing | Engine oil | As required |

🛠️ Special tools

Unit: mm

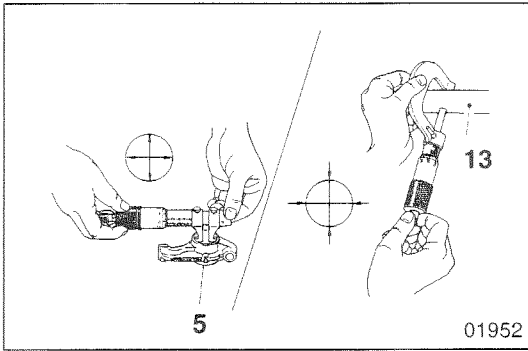
| Location | Tool name and shape | Part No. | Application |
|----------|--|-------------------|--|
| 5 | Rocker Bushing Puller  | MH061378 01951 | Removal and installation of rocker bushing |

CYLINDER HEAD AND VALVE MECHANISM

◆ Service procedure

5 13 Inspection of rocker bushing and rocker shaft

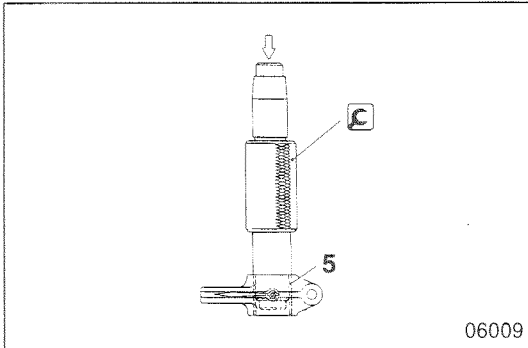
If the clearance is higher than the limit, replace the faulty parts.



Rocker bushing

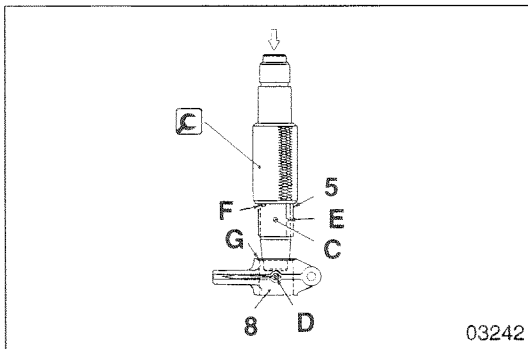
[Removal]

Ⓢ : Rocker Bushing Puller



[Press-fitting]

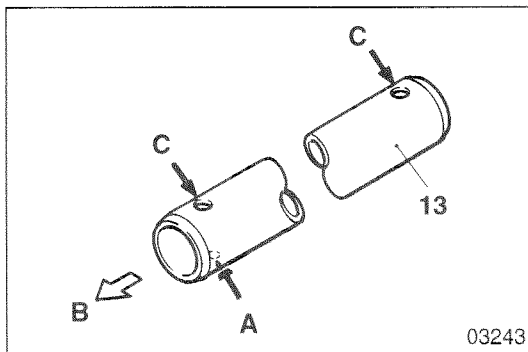
- Align oil hole **C** in rocker bushing **5** with oil hole **D** in rocker **8**.
- Position notch **F** and seam **E** on rocker bushing **5** as shown.
- Install rocker bushing **5** into rocker **8** from chamfered side **G**.



13 Installing rocker shaft

Install rocker shaft **13** with engine oil supply hole **A** (this is provided for lubrication) toward the front of engine **B**.

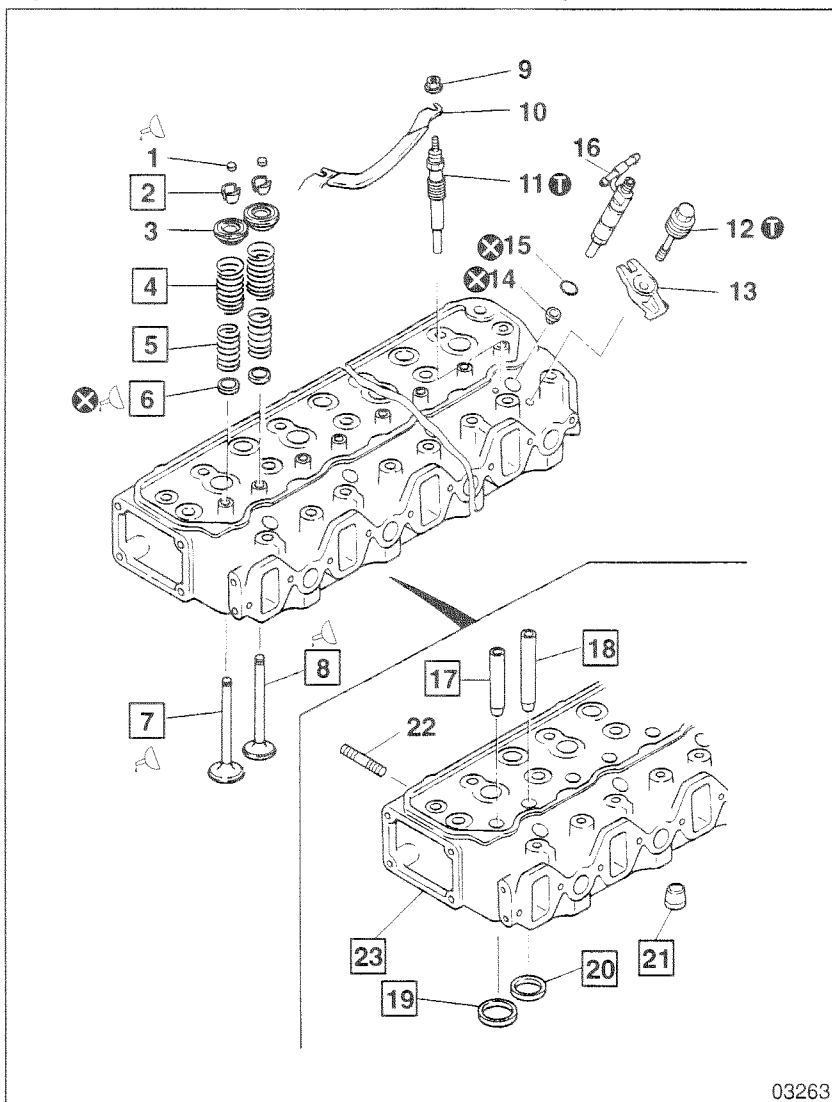
C : Hole for set bolt **1**





MEMO

CYLINDER HEAD AND VALVE MECHANISM

Cylinder Head and Valve Assembly



● Disassembly sequence

- 1 Valve cap
- 2 Valve cotter
- 3 Upper retainer
- 4 Outer valve spring
- 5 Inner valve spring
- 6 Valve stem seal
- 7 Inlet valve
- 8 Exhaust valve
- 9 Nut
- 10 Connecting plate
- 11 Glow plug  Gr 54
- 12 Bolt
- 13 Nozzle bridge
- 14 Nozzle tip gasket
- 15 O-ring
- 16 Injection nozzle  Gr 13
- 17 Inlet valve guide
- 18 Exhaust valve guide
- 19 Inlet valve seat
- 20 Exhaust valve seat
- 21 Water director
- 22 Stud
- 23 Cylinder head

⊗: Non-reusable part

CAUTION

Injection nozzles 16 and glow plugs 11 project from the bottom surface of cylinder head 23. Take care not to damage them.

● Assembly sequence

Follow the disassembly sequence in reverse.

NOTE

Any valve stem seal 6 removed from an exhaust valve 8 or inlet valve 7 must be replaced.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|--|---|---|---------------------|------------------------|
| 4 | Outer valve spring | Free length | 60.84 | 57.8 | Replace |
| | | Installed load (Installed length 47.25) | 240 ± 12 N {24.5 ± 1.2 kgf} | 204 N {20.8 kgf} | |
| | | Squareness | — | 2.5 | |
| 5 | Inner valve spring | Free length | 55.07 | 52.1 | Replace |
| | | Installed load (Installed length 40.3) | 93 ± 4 N {9.5 ± 0.45 kgf} | 80 N {8.1 kgf} | |
| | | Squareness | — | 2 | |
| 7 | Inlet valve | Stem diameter | φ 8.96 to 8.97 | φ 8.85 | Replace |
| | | Sinkage from cylinder head bottom surface | 0.75 to 1.25 | 1.5 | Inspect every location |
| | | Valve margin | 1.5 | 1.2 | Reface or replace |
| | | Valve seat angle | 45° ± 1.5' | — | Correct or replace |
| 7, 17 | Clearance between stem of inlet valve and inlet valve guide | | [9] 0.04 to 0.06 | 0.15 | Replace |
| 8 | Exhaust valve | Outside diameter of stem | φ 8.93 to 8.94 | φ 8.85 | Replace |
| | | Sinkage from cylinder head bottom surface | 0.95 to 1.45 | 1.7 | Inspect every location |
| | | Valve margin | 1.5 | 1.2 | Reface or replace |
| | | Valve seat angle | 45° ± 15' | — | Correct or replace |
| 8, 18 | Clearance between exhaust valve stem and exhaust valve guide | | [9] 0.07 to 0.1 | 0.2 | Replace |
| 19 | Seat width of inlet valve seat | 4D33 | 2 ± 0.2 | 2.8 | Correct or replace |
| | | 4D31, 31-T, 32, 34-T | 2.8 ± 0.2 | 3.6 | |
| 20 | Seat width of exhaust valve seat | | 2 ± 0.2 | 2.8 | Correct or replace |
| 23 | Cylinder head | Distortion of bottom surface | 0.05 or less | 0.2 | Correct or replace |
| | | Height from top to bottom surface | 95 ± 0.1 | 94.6 | Replace |

① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-------------------------------|-----------------------|---------|
| 11 | Glow plug | 15 to 20 {1.5 to 2.0} | — |
| 12 | Bolt (Nozzle bridge mounting) | 25 {2.5} | — |

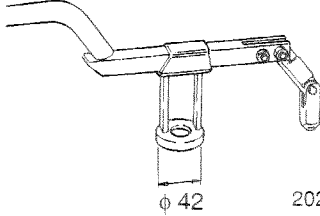
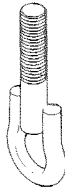
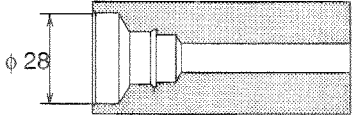
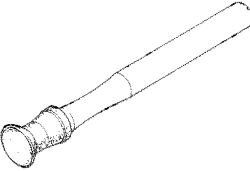
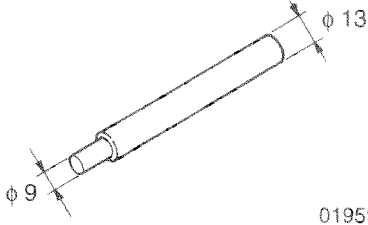
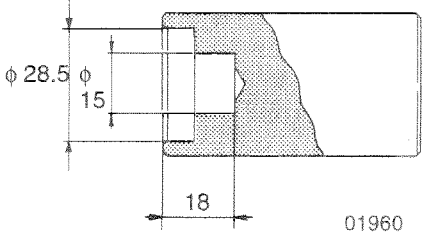
② Lubricant

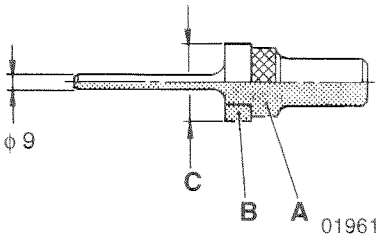
| Location | Points of application | Specified lubricant | Quantity |
|----------|---|---------------------|-------------|
| 1 | Slide-contact areas of valve cap and rocker | Engine oil | As required |
| 6 | Lip of valve stem seal | Engine oil | As required |
| 7, 8 | Valve stem | Engine oil | As required |

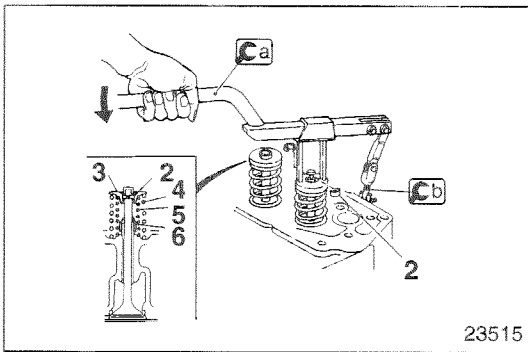
CYLINDER HEAD AND VALVE MECHANISM

Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|-------------|--|
| 2 | Valve Lifter  $\phi 42$ 20239 | MH061668 | Removal and installation of valve cotter |
| | Valve Lifter Hook  20240 | MH061679 | |
| 6 | Valve Stem Seal Installer  $\phi 28$ $\phi 9$ 01957 | MH061293 | Installation of valve stem seal |
| 7, 8 | Valve Lapper  01958 | 30091-07500 | Lapping of valve and valve guide |
| 17, 18 | Valve Guide Remover  $\phi 9$ $\phi 13$ 01959 | MH061066 | Removal of valve guide |
| | Valve Guide Installer  $\phi 28.5$ $\phi 15$ 18 01960 | MH061998 | Press-fitting of valve guide |

| Location | Tool name and shape | Part No. | Application | | | | | | |
|---|---|--|-----------------------------|-------------|-------------|----------|--------|----------|--------|
| 19, 20 | A: Caulking Tool Body B: Caulking Ring <Inlet> | A: MH061067 B: MH061695 <4D33> MH061275 <4D31, 31-T, 32, 34-T> MH061696 <4D33> MH061069 <4D31, 31-T, 32, 34-T> | Press-fitting of valve seat | | | | | | |
| | <table border="1"> <tr> <td></td> <td>C dimension</td> </tr> <tr> <td>MH061695</td> <td>φ 49</td> </tr> <tr> <td>MH061275</td> <td>φ 47.6</td> </tr> </table> | | | | C dimension | MH061695 | φ 49 | MH061275 | φ 47.6 |
| | | | | C dimension | | | | | |
| | MH061695 | | | φ 49 | | | | | |
| MH061275 | φ 47.6 | | | | | | | | |
|  | | | | | | | | | |
| <Exhaust> | | | | | | | | | |
| | <table border="1"> <tr> <td></td> <td>C dimension</td> </tr> <tr> <td>MH061696</td> <td>φ 42</td> </tr> <tr> <td>MH061069</td> <td>φ 40.6</td> </tr> </table> | | C dimension | MH061696 | φ 42 | MH061069 | φ 40.6 | | |
| | C dimension | | | | | | | | |
| MH061696 | φ 42 | | | | | | | | |
| MH061069 | φ 40.6 | | | | | | | | |



◆ Service procedure

2 Valve cotter

[Removal]

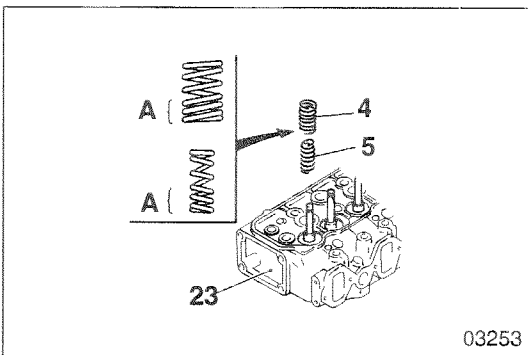
To remove valve cotter 2, use the **Ca** Valve Lifter and **Cb** Valve Lifter Hook to evenly compress valve springs 4, 5.

[Installation]

To install valve cottes, follow the removal instructions in reverse.

CAUTION ⚠

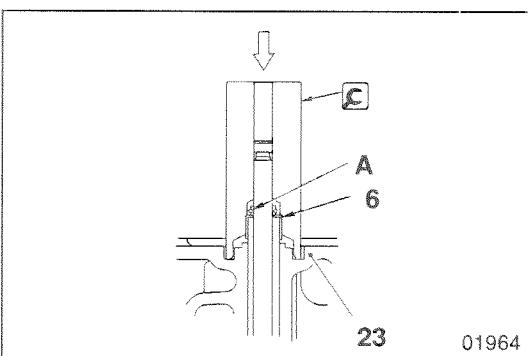
Do not compress valve springs 4, 5 more than is necessary. If the valve springs are compressed excessively, upper retainer 3 can touch valve stem seal 6 and be damaged.



4 5 Installation of outer and inner valve springs

Fit the outer and inner valve springs 4, 5 onto cylinder head 23 as shown.

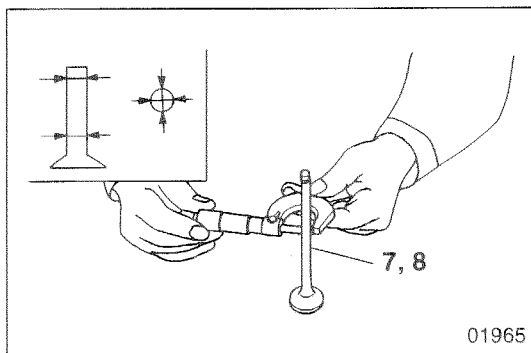
A: Tightly wound portion



6 Installation of valve stem seal

- Apply engine oil to lip A of valve stem seal 6.
- Install valve stem seal 6 using the **C** Valve Stem Seal Installer. Strike the Valve Stem Installer until it sits snugly on the cylinder head 23.

CYLINDER HEAD AND VALVE MECHANISM



01965

7 8 Inlet and exhaust valves

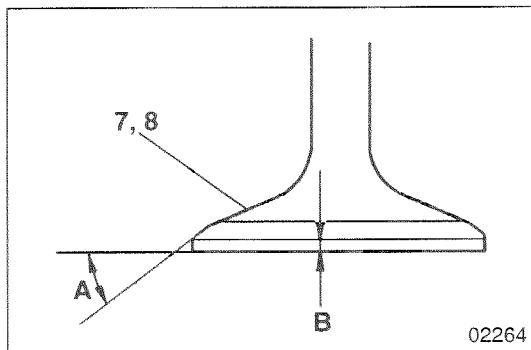
[Inspection]

(1) Valve stem outside diameter

Replace valve 7, 8 if its stem's outside diameter is below specification or severely worn.

CAUTION

Whenever valve 7, 8 is replaced, be sure to lap valve and valve seat 19, 20. P11-25



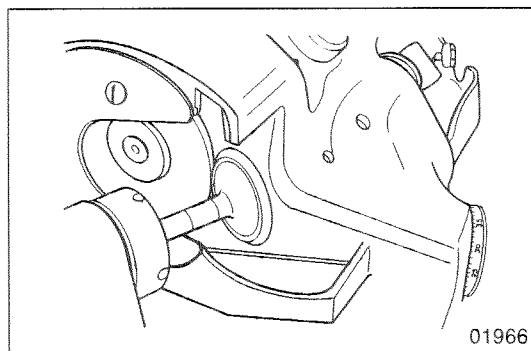
02264

(2) Valve seat angle and valve margin

Reface or replace valve 7, 8 if the valve seat angle or valve margin exceeds the specified limits.

A: Valve seat angle

B: Valve margin

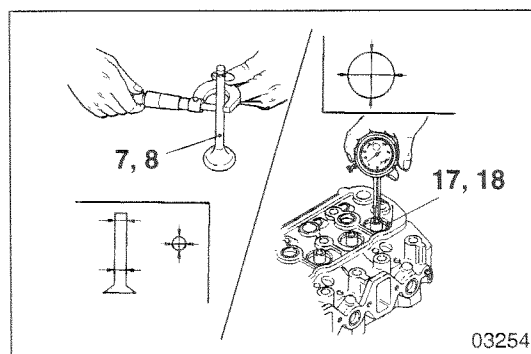


01966

[Rectification]

NOTE

- Keep grinding to a minimum.
- If the valve margin is below specification after grinding, replace valve 7, 8.
- After grinding, be sure to lap valve 7, 8 and valve seat 19, 20. P11-25

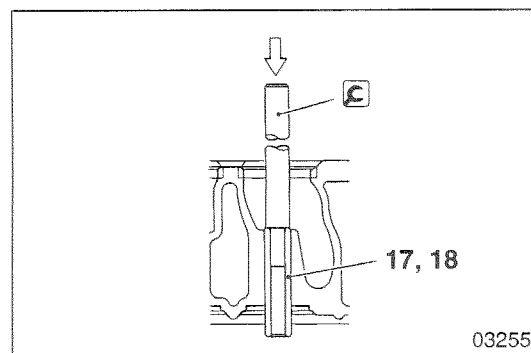


03254

7 8 17 18 Valves and valve guides

[Inspection]

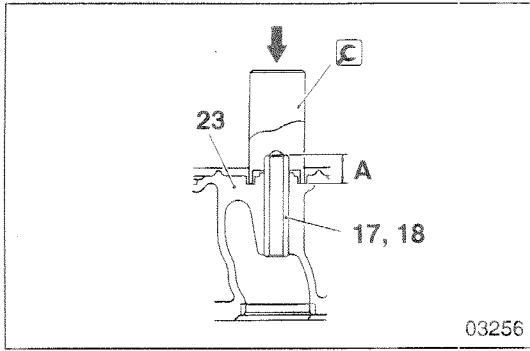
If any clearance exceeds the specified limit, replace the defective part(s).



03255

[Removal]

: Valve Guide Remover

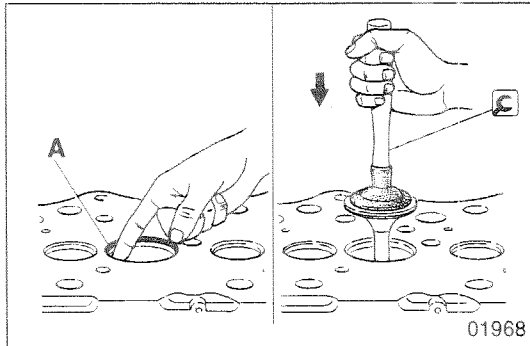


[Installation]

Install valve guide 17, 18 using the (C) Valve Guide Installer. Strike the Valve Guide Installer until it sits snugly on cylinder head 23.

CAUTION ⚠

- Valve guides 17, 18 must be pressed in to the specified depth A. Be sure to use the (C) Valve Guide Installer for this operation.
A: 10mm
- Exhaust valve guides 18 are longer than inlet valve guides 17. Be sure to install the correct type of guide in each location.



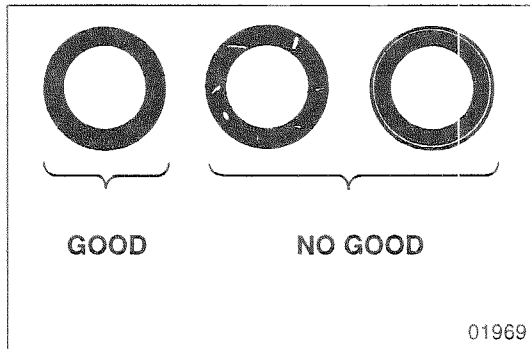
7 8 19 20 Valves and valve seats

[Inspection]

- Apply an even coat of minium to valve seat 19, 20 surface A that makes contact with valve 7, 8.
- Using the (C) Valve Lapper, strike valve 7, 8 against valve seat 19, 20 once. Do not rotate the valve during this operation.

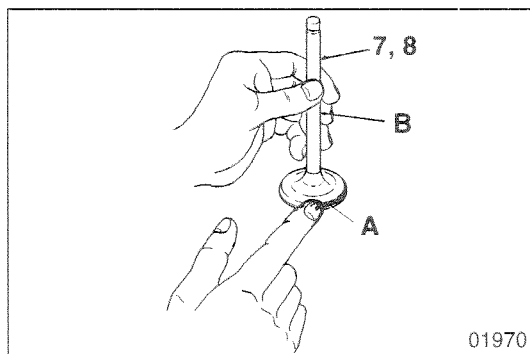
NOTE

Carry out these inspections after inspecting valves 7, 8 and valve guides 17, 18.



- If the minium deposited on valve 7, 8 indicates a poor contact pattern, rectify the contact pattern as follows:

| Contact | Corrective action |
|----------------|--|
| Minor defect | Lapping |
| Serious defect | Reface or replace valve and valve seat |



[Correction]

Lap the valve in accordance with the following procedure:

- Apply a thin, even coat of lapping compound to surface A of valve 7, 8 that makes contact with valve seat 19, 20.

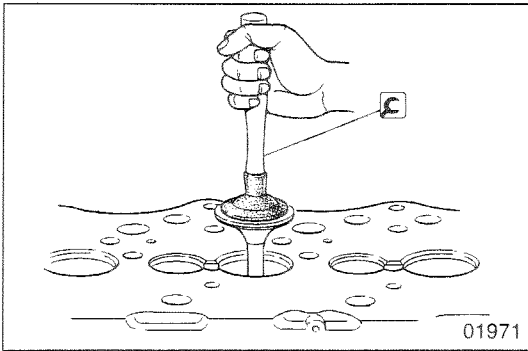
CAUTION ⚠


Ensure that no compound adheres to stem B of valve 7, 8.

NOTE

- Start with intermediate-mesh compound (120 to 150 mesh) and finish with fine-mesh compound (200 mesh or more).
- The addition of a small amount of engine oil makes lapping compound easier to apply.

CYLINDER HEAD AND VALVE MECHANISM



- Using the  Valve Lapper, lightly strike valve 7, 8 against valve seat 19, 20 while turning it little by little.
- Wash away compound with gas oil or a similar fluid.
- Apply engine oil to contact surfaces **A** of valve seat 19, 20 and rub it in so that the contact surfaces are lubricated and mate together snugly.
- Inspect the contact pattern of valve 7, 8 and valve seat 19, 20 once more.
- If the contact pattern is still defective, replace valve seat 19, 20.

Valve seats

[Inspection]

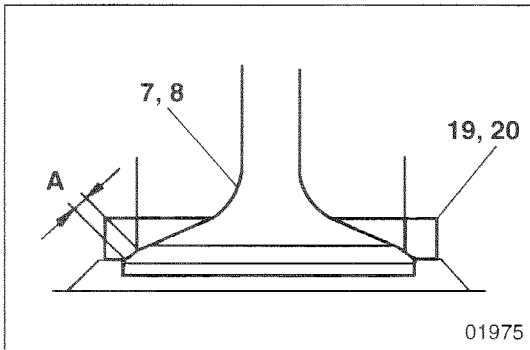
(1) Valve seat width

If the measurement exceeds the specified limit, rectify or replace the valve seat.

A: Valve seat width

NOTE

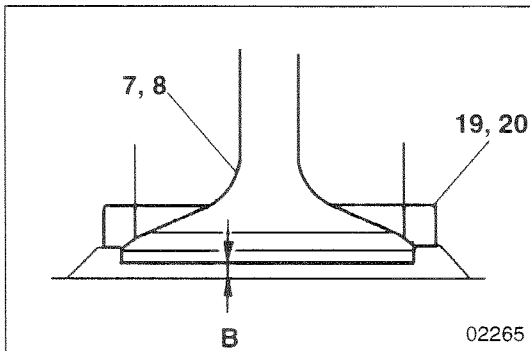
Whenever valve seat 19, 20 is rectified or replaced, be sure to lap valve seat 19, 20 and valve 7, 8.



(2) Valve sinkage from cylinder head bottom surface

If any measurement exceeds the specified limit, rectify or replace the defective part(s).

B: Valve sinkage



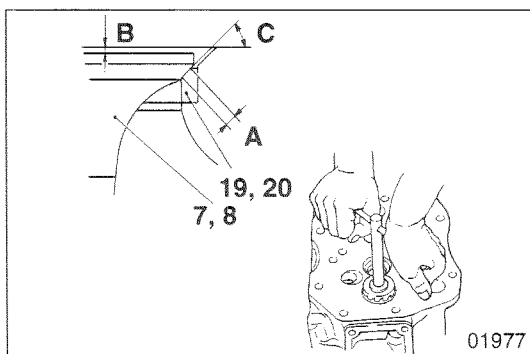
[Correction]

- Grind valve seat 19, 20 using a valve seat cutter or valve seat grinder.
- After grinding, put some sandpaper of around #400 grade between the cutter and valve seat and grind the valve seat lightly.
- Use a 15° or 75° cutter to achieve specified valve seat width **A**.

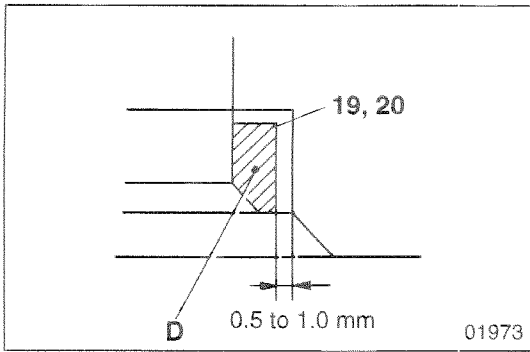
C: Valve seat angle

CAUTION

Ensure that grinding does not cause valve sinkage **B** to exceed the specified limit.



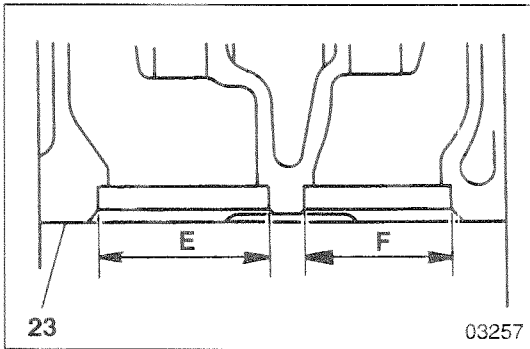
- After rectification, lap valve 7, 8 and valve seat 19, 20.



[Removal]

Valve seats **19, 20** are installed by expansion fitting. To remove a valve seat, grind the inside surface to reduce its thickness, then remove the valve seat at room temperature.

D: Material to remove

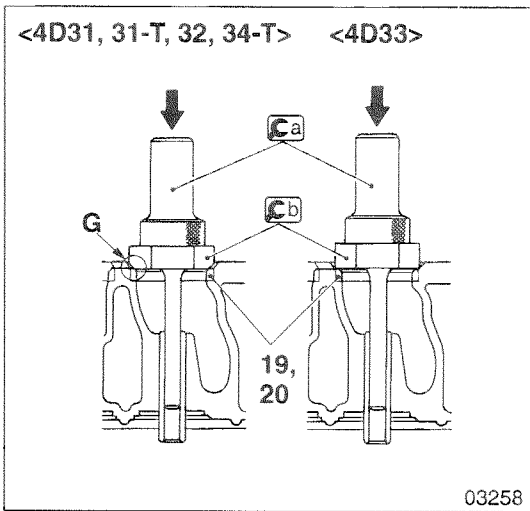


[Installation]

- Check that the valve seat hole diameters in the cylinder head **23** conform with the values shown below.

Unit: mm

| | 4D33 | 4D31, 31-T, 32, 34-T |
|------------------------------------|---|---|
| E : Inlet valve seat hole | $\phi 49 \begin{smallmatrix} +0.03 \\ 0 \end{smallmatrix}$ | $\phi 46 \begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ |
| F : Exhaust valve seat hole | $\phi 42 \begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ | $\phi 39 \begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$ |



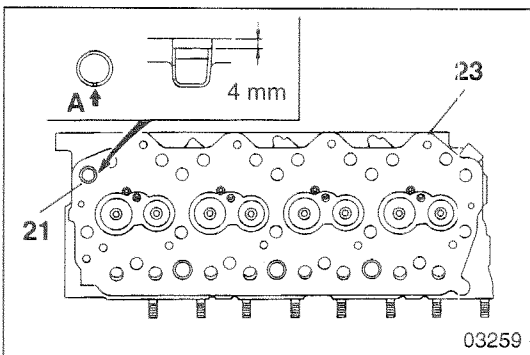
- Cool valve seat **19, 20** by immersing it in liquid nitrogen.

Install the valve seat in the cylinder head using the **Ca** CaULKING Tool Body and **Cb** CaULKING Ring.

CAUTION ⚠

On **4D31, 31-T or 32** engine, place CaULKING Ring's chamfered side **G** on inlet and exhaust valve seats **19, 20** when installing them.

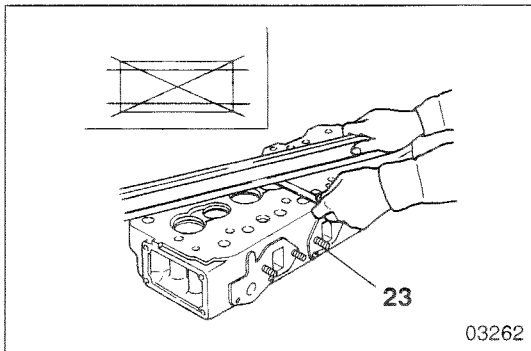
- After installing valve seat **19, 20**, lap the valve seat and valve **7, 8**.



21 Installing water directors

With notch **A** aligned as shown, strike water directors **21** into cylinder head **23** to the specified depth.

CYLINDER HEAD AND VALVE MECHANISM



23 Inspecting cylinder head

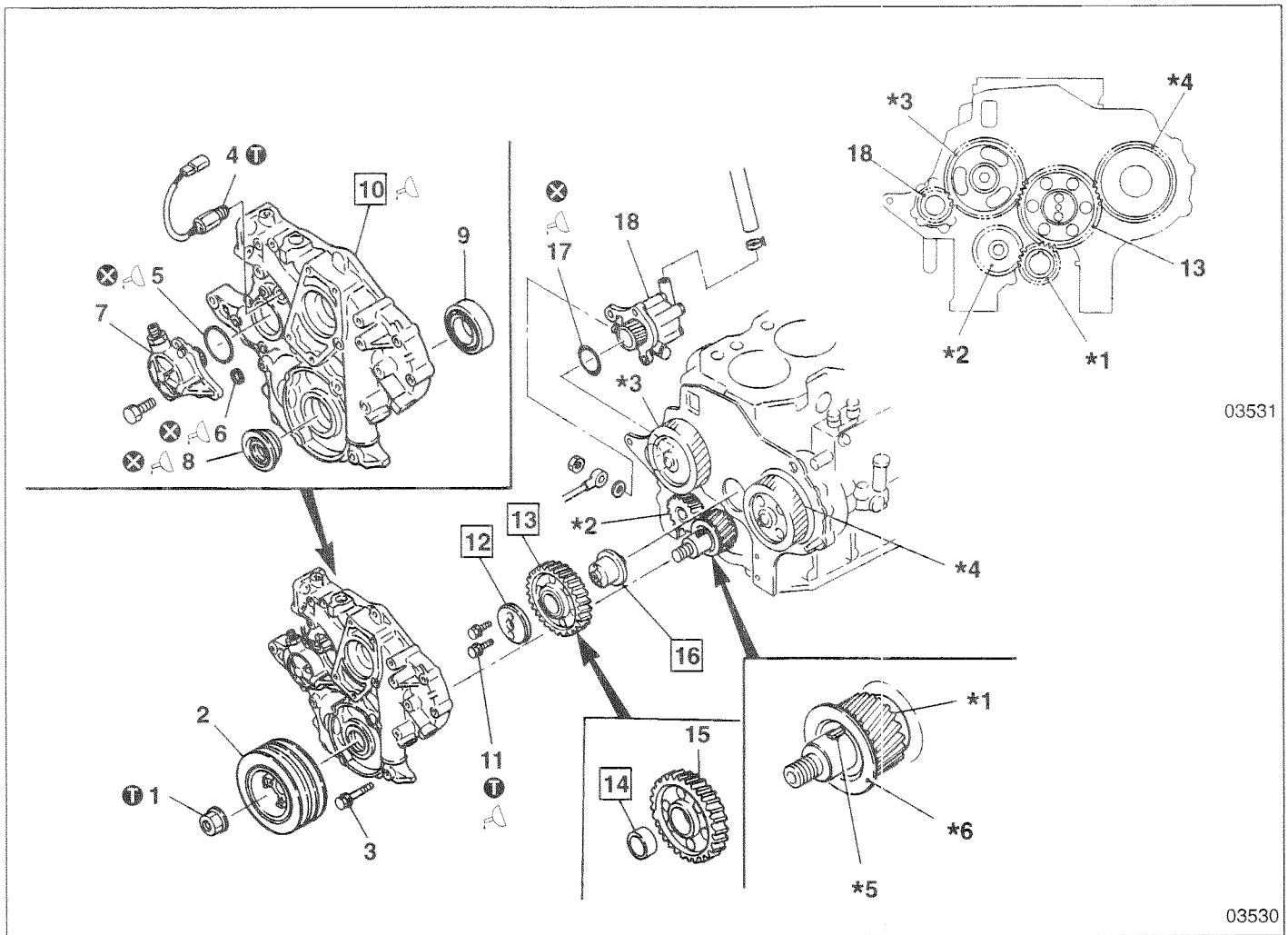
- Measure the extent of distortion in the cylinder head's 23 bottom surface.
If the degree of distortion exceeds the specified limit, rectify the distortion with a surface grinder.

CAUTION

Ensure that grinding does not cause the cylinder head's top surface-to-bottom surface distance to fall below the specified limit.

MEMO

TIMING GEAR



● Disassembly sequence

- | | |
|----------------------------|----------------------------|
| 1 Nut | 10 Timing gear case |
| 2 Crankshaft pulley | 11 Bolt |
| 3 Bolt | 12 Thrust plate |
| 4 Engine revolution sensor | 13 Idler gear assembly |
| 5 O-ring | 14 Idler gear bushing |
| 6 O-ring | 15 Idler gear |
| 7 Vacuum pump assembly | 16 Idler shaft |
| 8 Front oil seal | 17 O-ring |
| 9 Bearing | 18 Power steering oil pump |

- *1: Crankshaft gear P11-62
- *2: Oil pump gear Gr 12
- *3: Camshaft gear P11-34
- *4: Injection pump gear Gr 13
- *5: Key P11-62
- *6: Front oil seal slinger P11-62

⊗: Non-reusable part

NOTE

Do not remove front oil seal 8 and bearing 9 unless they are faulty.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Be sure to install key *5 when installing crankshaft pulley 2.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|--|--|---|-------|---------|
| — | Gear backlash | Idler gear assembly and crankshaft gear | 0.07 to 0.15 | 0.3 | Replace |
| | | Idler gear assembly and camshaft gear | 0.07 to 0.17 | 0.3 | |
| | | Idler gear assembly and injection pump gear | 0.07 to 0.17 | 0.3 | |
| | | Crankshaft gear and oil pump gear | 0.07 to 0.15 | 0.3 | |
| | | Camshaft gear and power steering oil pump gear | 0.08 to 0.16 | 0.3 | |
| — | Idler gear end play | | 0.05 to 0.15 | 0.3 | Inspect |
| 14, 16 | Clearance between idler gear bushing and idler shaft | | [45] 0.03 to 0.06 | 0.1 | Replace |

① Tightening torque

Unit: N·m (kgf·m)

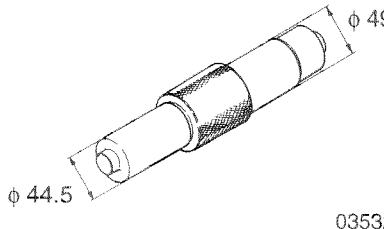
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|----------------------------------|-------------------|---------|
| 1 | Nut (crankshaft pulley mounting) | 590 {60} | — |
| 4 | Engine revolution sensor | 29 {3} | — |
| 11 | Bolt (thrust plate mounting) | 24 {2.4} | — |

🔧 Lubricant and/or sealant

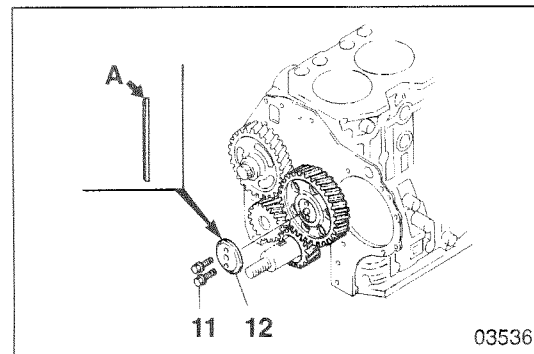
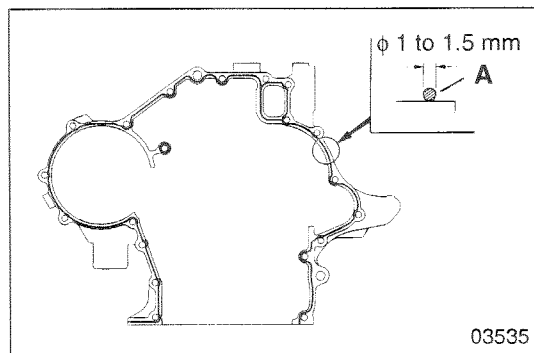
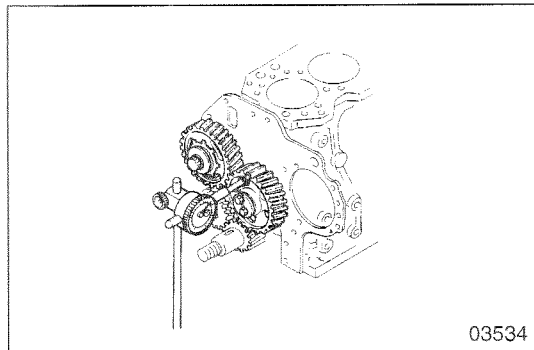
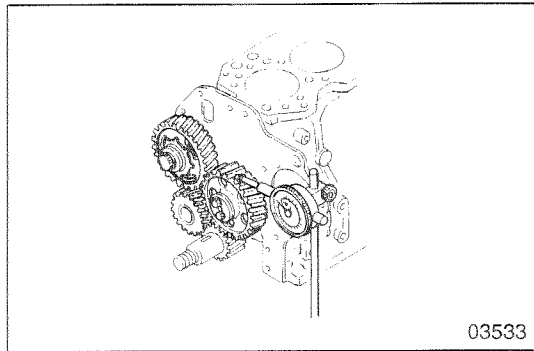
| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|--|------------------------------------|-------------|
| 4 | Mounting surface of engine revolution sensor | THREEBOND 1104J | As required |
| 5, 6, 17 | O-ring | Engine oil | As required |
| 8 | Front oil seal lip | Engine oil | As required |
| 10 | Mounting surface of timing gear case | THREEBOND 1207C | As required |
| 11 | Thread area of bolt | Engine oil | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|---|
| 14 | Idler Gear Bushing Puller  | MH062224 | Removal and installation of idler gear bushings |

TIMING GEAR



◆ Service procedure

● Inspection before disassembly

(1) Gear backlash

For each gear pair, measure backlash at three or more points. If any measurement exceeds the specified limit, replace the defective part(s).

(2) Idler gear end play

If the measurement exceeds the specified value, replace the defective part(s).

10 Installation of timing gear case

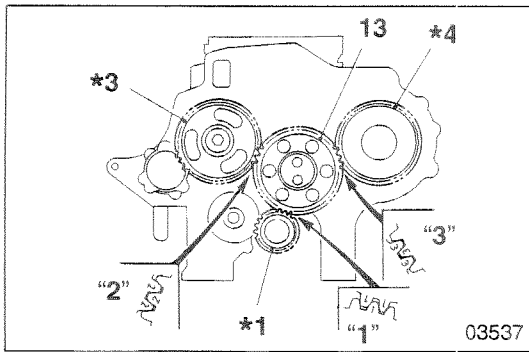
Apply an even, unbroken bead of sealant **A** to the mounting surface of timing gear case **10**. Fit the timing gear case onto the front plate within three minutes of applying the sealant.

CAUTION

- When fitting the timing gear case, hold it firmly in position to prevent spreading the sealant.
- Before applying the sealant, make sure the application surface is free of oil and other contamination.
- Apply a new bead of sealant whenever bolts **3** have been loosened.
- After fitting the timing gear case, wait at least an hour before starting the engine.

12 Installation of thrust plate

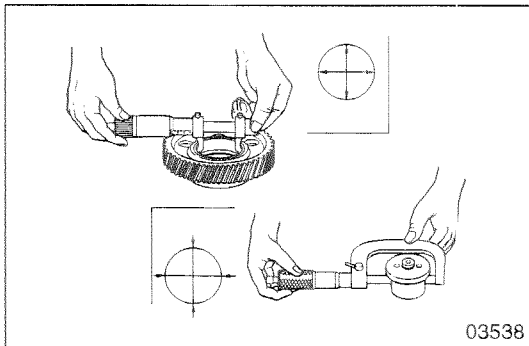
A: Chamfered end



13 Installation of idler gear assembly

- Fit idler gear assembly **13** such that the alignment marks ("1", "2", and "3") on the idler gear are aligned with those on the gears with which it mates.

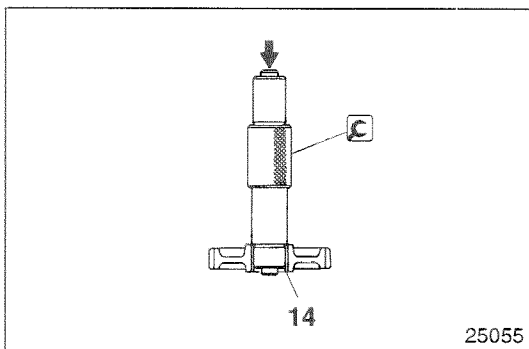
- *1 : Crankshaft gear
- *3 : Camshaft gear
- *4 : Injection pump gear



14 16 Idler gear bushing and idler shaft

[Inspection]

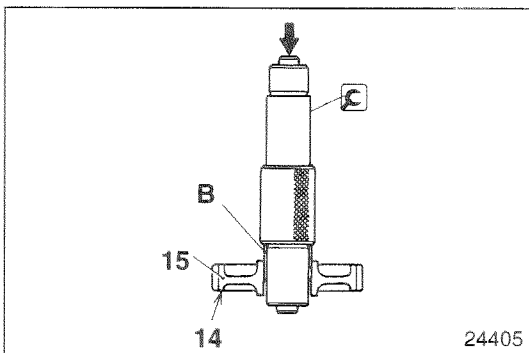
If the clearance exceeds the specified limit, replace the defective part(s).



Idler gear bushing

[Removal]

- C** : Idler Gear Bushing Puller

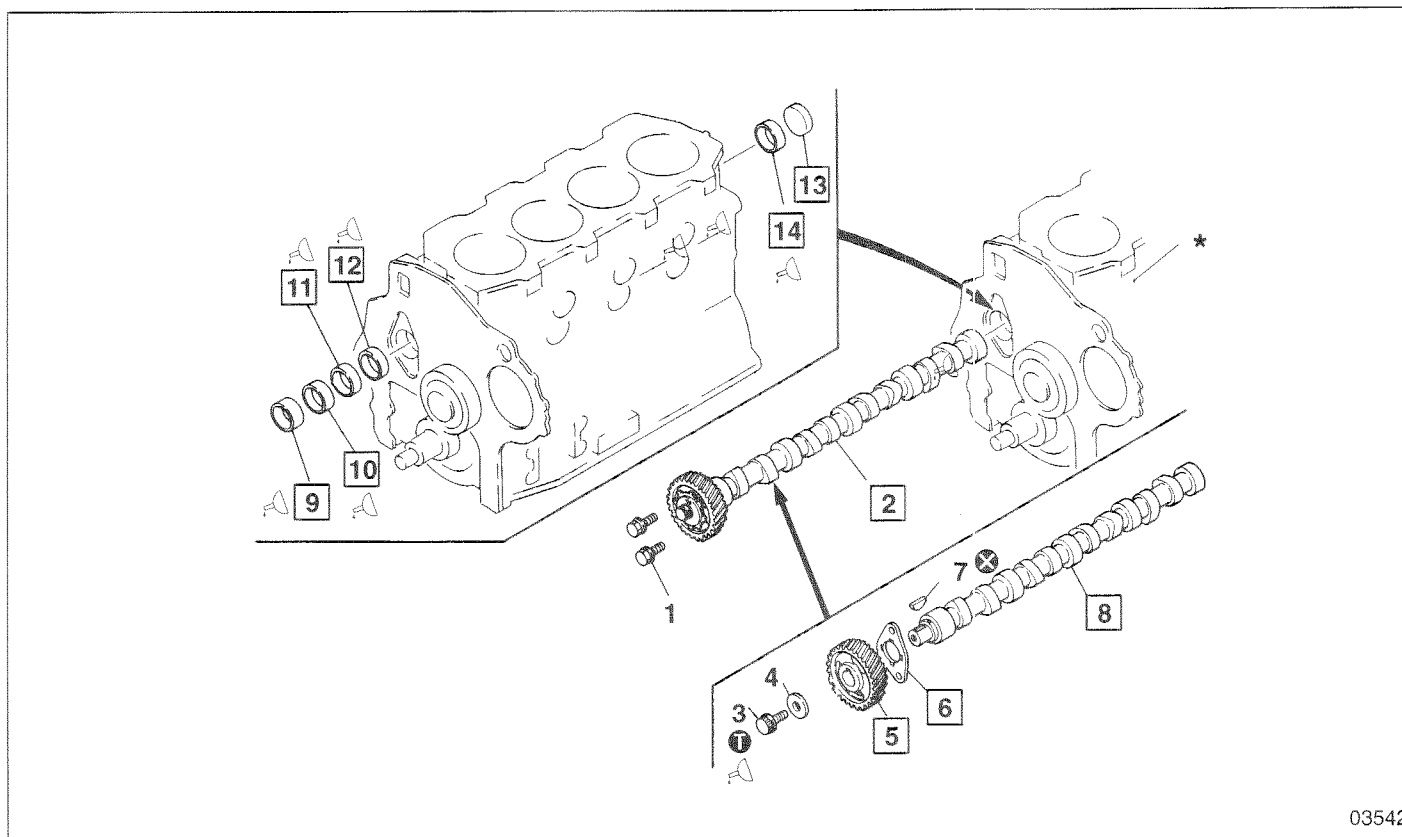


[Installation]

- Press idler gear bushing **14** into idler gear **15** from the side of the gear on which alignment mark "1", "2" or "3" is stamped. Make sure the oil holes **B** in the idler gear and bushing are aligned.
- After installation, ream the idler gear bushing **14** to achieve the specified clearance between the bushing and idler shaft **16**.

- C** : Idler Gear Bushing Puller

CAMSHAFT



03542

● Disassembly sequence

- | | | |
|---------------------|--------------------------|--------------------------|
| 1 Bolt | 7 Key | 13 Sealing cap |
| 2 Camshaft assembly | 8 Camshaft | 14 No.5 camshaft bushing |
| 3 Bolt | 9 No.1 camshaft bushing | |
| 4 Washer | 10 No.2 camshaft bushing | *: Crankcase P11-62 |
| 5 Camshaft gear | 11 No.3 camshaft bushing | ⊗: Non-reusable part |
| 6 Thrust plate | 12 No.4 camshaft bushing | |

NOTE

Do not remove the camshaft gear 5 unless it is faulty.

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | | | Standard value (Basic diameter in []) | Limit | Remedy |
|-------------------|---|----------|------------------------------|---|-------|---|
| – | Camshaft assembly end play | | | 0.05 to 0.22 | 0.3 | Replace |
| 8 | Camshaft | Cam lift | Inlet | 7.195 ± 0.05 | 6.70 | Replace. Lobe height: 47.105 Base circle diameter: 39.910 |
| | | | Exhaust | 7.321 ± 0.05 | 6.82 | Replace. Lobe height: 46.979 Base circle diameter: 39.658 |
| | | Bend | | 0.02 or less | 0.05 | Replace |
| 8, 9 to 12, 14 | Camshaft journal-to-camshaft bushing clearance | | No.1 through No.4 journal | [54.5] 0.04 to 0.09 | 0.15 | Correct or Replace |
| | | | No.5 journal | [53] 0.04 to 0.09 | | |

 Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-------------------------------|-------------------|---------|
| 3 | Bolt (camshaft gear mounting) | 175 {18} | Wet |

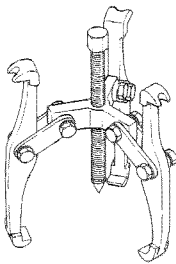

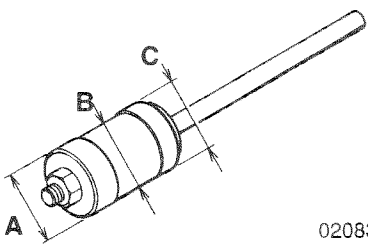
 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------------|--------------------------------------|---------------------|-------------|
| 3 | Bolt threads | Engine oil | As required |
| 9 to 12, 14 | Inside surfaces of camshaft bushings | Engine oil | As required |

CAMSHAFT

Special tools

Unit: mm

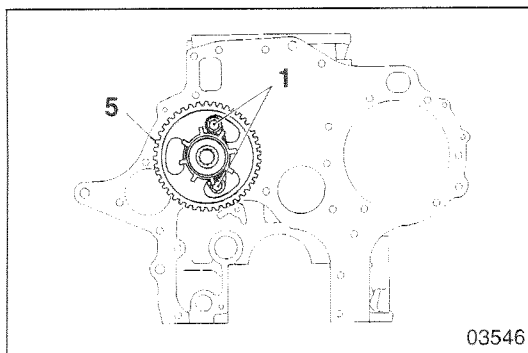
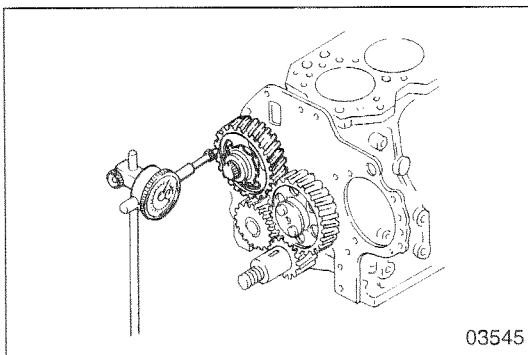
| Location | Tool name and shape | Part No. | Application | | | | | | | | | | | | | | | | |
|-------------|---|-------------|---|-------------|------|--------|--------|------|------|--------|------|------|--------|------|------|------|------|----------|---|
| 5 | Gear Puller  02065 | MH061326 | Removal of camshaft gear | | | | | | | | | | | | | | | | |
| | Plug  M14 × 1.5 03543 | MF665004 | Blanking plug for use when removing camshaft gear | | | | | | | | | | | | | | | | |
| 9 to 12, 14 | Camshaft Bushing Installer and Extractor <table border="1"> <thead> <tr> <th></th> <th>A, C dimension</th> <th>B dimension</th> </tr> </thead> <tbody> <tr> <td>No.1</td> <td>φ 58.5</td> <td>φ 54.5</td> </tr> <tr> <td>No.2</td> <td rowspan="2">φ 58</td> <td rowspan="2">φ 54.5</td> </tr> <tr> <td>No.3</td> </tr> <tr> <td>No.4</td> <td>φ 57.5</td> <td>φ 54</td> </tr> <tr> <td>No.5</td> <td>φ 57</td> <td>φ 53</td> </tr> </tbody> </table>  02083 | | A, C dimension | B dimension | No.1 | φ 58.5 | φ 54.5 | No.2 | φ 58 | φ 54.5 | No.3 | No.4 | φ 57.5 | φ 54 | No.5 | φ 57 | φ 53 | MH061276 | Removal and installation of camshaft bushings |
| | A, C dimension | B dimension | | | | | | | | | | | | | | | | | |
| No.1 | φ 58.5 | φ 54.5 | | | | | | | | | | | | | | | | | |
| No.2 | φ 58 | φ 54.5 | | | | | | | | | | | | | | | | | |
| No.3 | | | | | | | | | | | | | | | | | | | |
| No.4 | φ 57.5 | φ 54 | | | | | | | | | | | | | | | | | |
| No.5 | φ 57 | φ 53 | | | | | | | | | | | | | | | | | |

◆ Service procedure

● Inspection before disassembly

Camshaft end play

If the end play measurement exceeds the specified limit, replace the defective part(s).



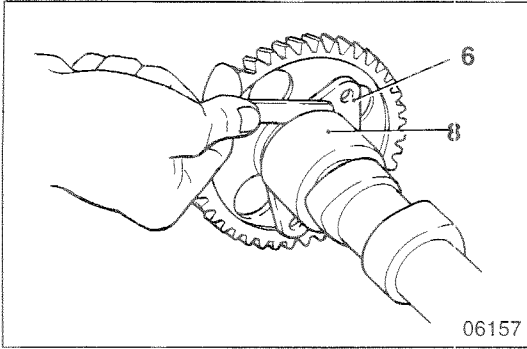
2 Camshaft assembly

[Removal]

Loosen and remove bolts 1 through the holes in camshaft gear 5, then remove camshaft assembly 2.

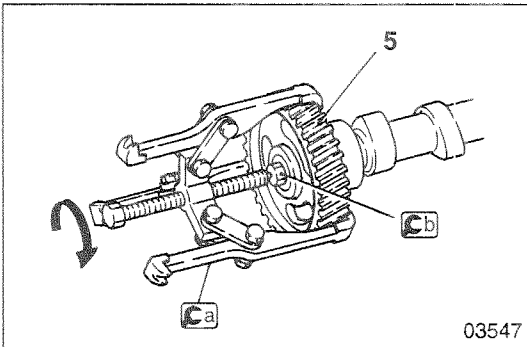
NOTE

Take care not to damage camshaft bushings 9 to 12 and 14 when removing camshaft assembly 2.



[Installation]

- Before installing camshaft assembly 2, measure the end play between thrust plate 6 and camshaft 8.
- If the measurement exceeds the specified limit, replace the thrust plate.
- With the alignment marks lined up on camshaft gear 5 and the idler gear, fit the camshaft assembly. P11-34

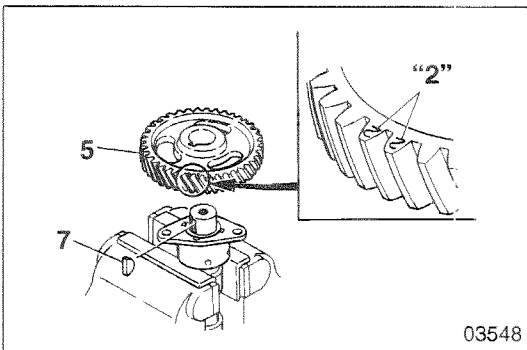
**5** Camshaft gear

[Removal]

- Do not tap off camshaft gear 5 since this could damage it.

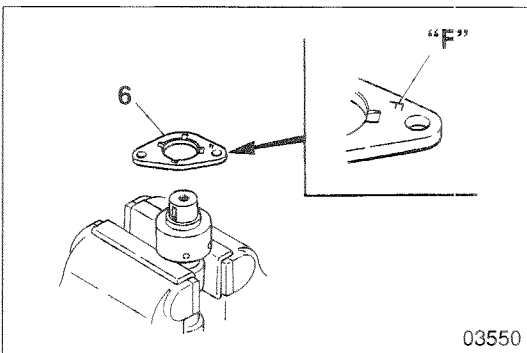
Ca: Gear Puller

Cb: Plug



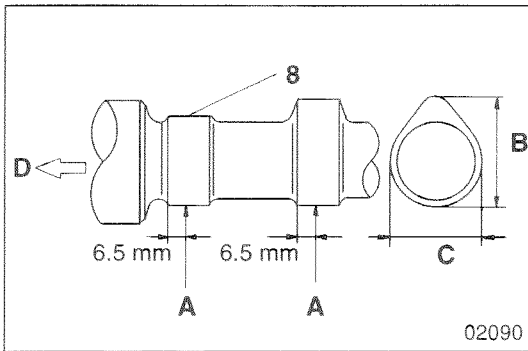
[Installation]

- Fit camshaft gear 5 onto camshaft 8 with "2" alignment marks positioned as shown.
- Do not forget to fit key 7.

**6** Installation of thrust plate

Fit thrust plate 6 with "F" mark positioned as shown.

CAMSHAFT



8 Inspection of camshaft

(1) Cam lift

If any base circle-to-lobe height difference is less than the required value, replace camshaft 8.

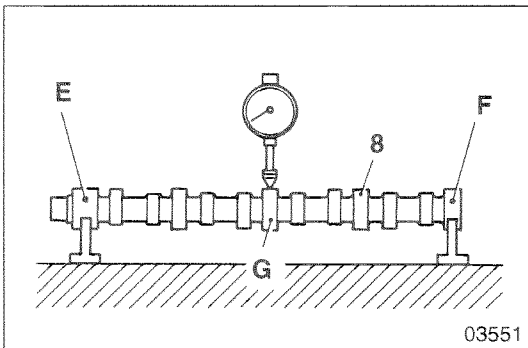
NOTE

Since the cams are tapered, they must be measured at the position A shown in the diagram.

B : Lobe height

C : Base circle diameter

D : Front of engine

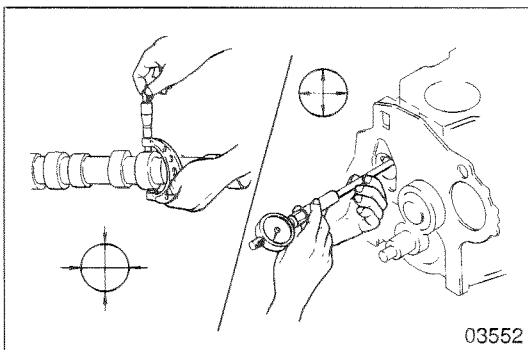


(2) Camshaft bend

Support camshaft 8 at its No.1 journal E and No.5 journal F, then take measurements at No.3 journal G. If the measurement exceeds the specified limit, replace the camshaft.

NOTE

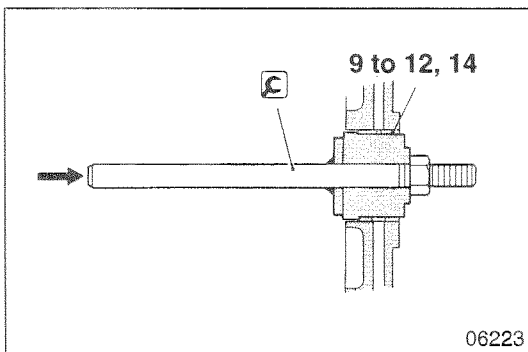
Turn camshaft 9 through one revolution. One-half of the dial indicator reading represents the camshaft's bend.



8 9 to 12 14 Camshaft and camshaft bushings

[Inspection]

If any clearance exceeds the specified limit, replace the defective part(s).

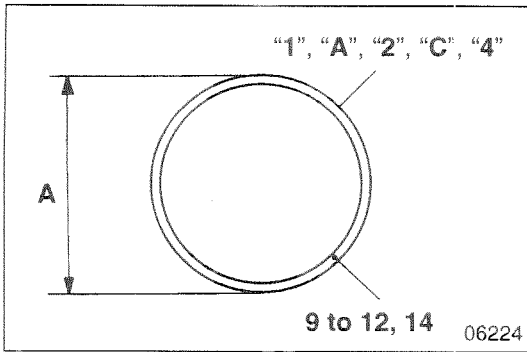


9 to 12 14 Camshaft bushings

[Removal]

Remove the No.5 camshaft bushing 12 from the rear end of the crankcase.

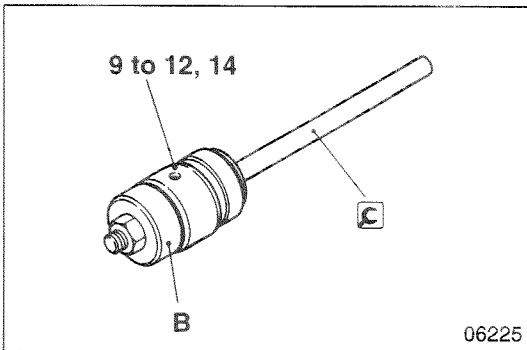
C : Camshaft Bushing Installer and Extractor




[Installation]

Identify the No. 1 to 5 camshaft bushings (9 to 12 and 14) from their identification marks ("1", "A", "2", "C", and "4") in accordance with the table below. If any bushing's identification mark is unclear, identify the bushing from its outside diameter **A**.

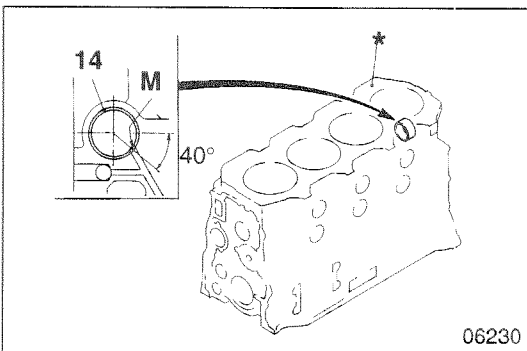
| Bushing No. (from front of engine) | Identification mark | Outer diameter A (mm) |
|---------------------------------------|---------------------|--------------------------|
| No.1 | 1 | φ 58.50 |
| No.2 | A | φ 58.25 |
| No.3 | 2 | φ 58.06 |
| No.4 | C | φ 57.75 |
| No.5 | 4 | φ 57.06 |



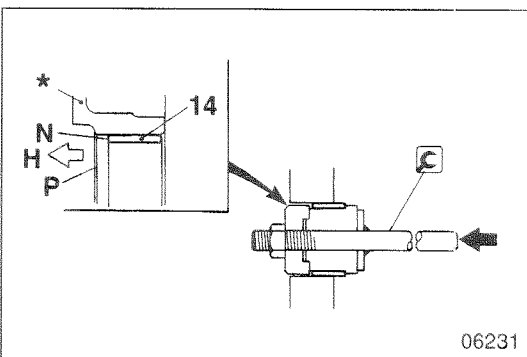
- Install the bushings using the  Camshaft Bushing Installer and Extractor with appropriate guide **B** fitted.
- Install the camshaft bushings in the following order: No.5, No.4, No.3, No.2, No.1.

NOTE

Fit the No.5 camshaft bushing from the rear of the engine. Fit the No.4, No.3, No.2, and No.1 camshaft bushings from the front of the engine.




- Make sure oil hole **M** in the No.5 camshaft bushing **14** is aligned as shown.

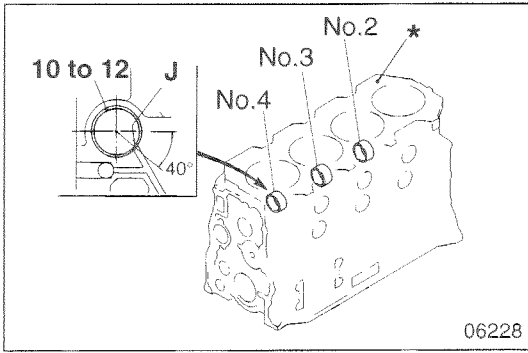


- Press in No.5 camshaft bushing **14** until its end surface **N** is flush with chamfer **P** on the crankcase *****.

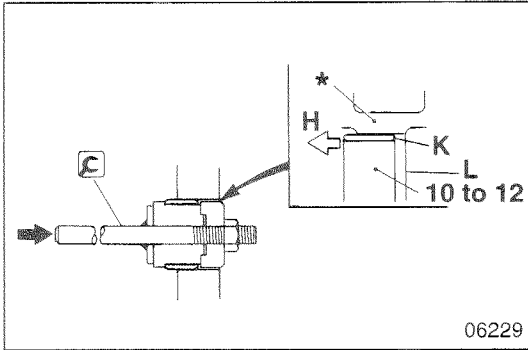
H: Front of engine

: Camshaft Bushing Installer and Extractor

CAMSHAFT



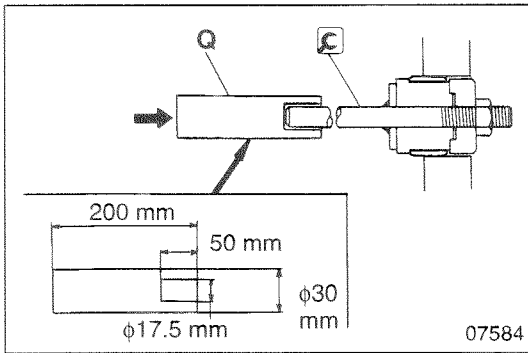
- Make sure oil holes **J** in No.2 to No.4 camshaft bushings **10 to 12** are aligned as shown.



- Press in No.2 to No.4 camshaft bushings **10 to 12** until their end surfaces **K** are flush with end surface **L** of the crankcase *****.

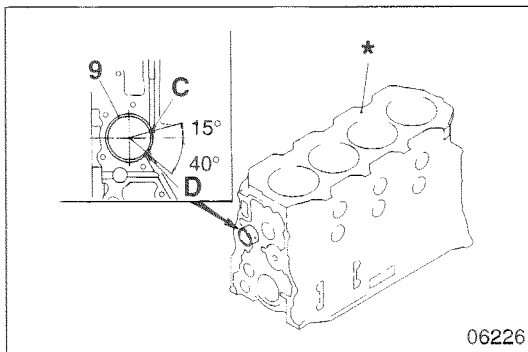
H: Front of engine

C: Camshaft Bushing Installer and Extractor



- Press in the No.4 camshaft bushing using the type of jig **Q** shown in the drawing.

C: Camshaft Bushing Installer and Extractor

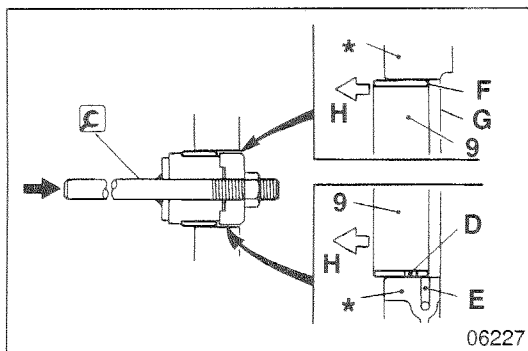


- Make sure oil holes **C**, **D** in No.1 camshaft bushing **9** are aligned as shown.

C: $\phi 3$ mm

D: $\phi 8$ mm

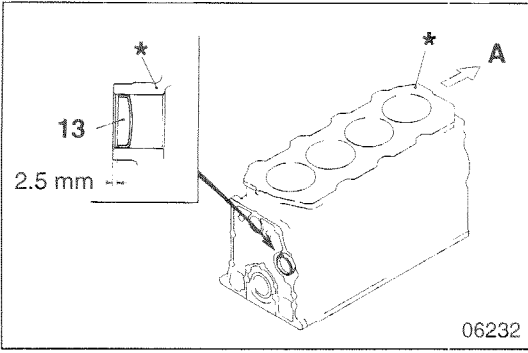
*****: Crankcase



- Make sure oil hole **D** in No.1 camshaft bushing **9** is aligned with oil hole **E** in the crankcase *****. Press in the camshaft bushing until its end surface **F** is flush with crankcase end surface **G**.

H: Front of engine

C: Camshaft Bushing Installer and Extractor

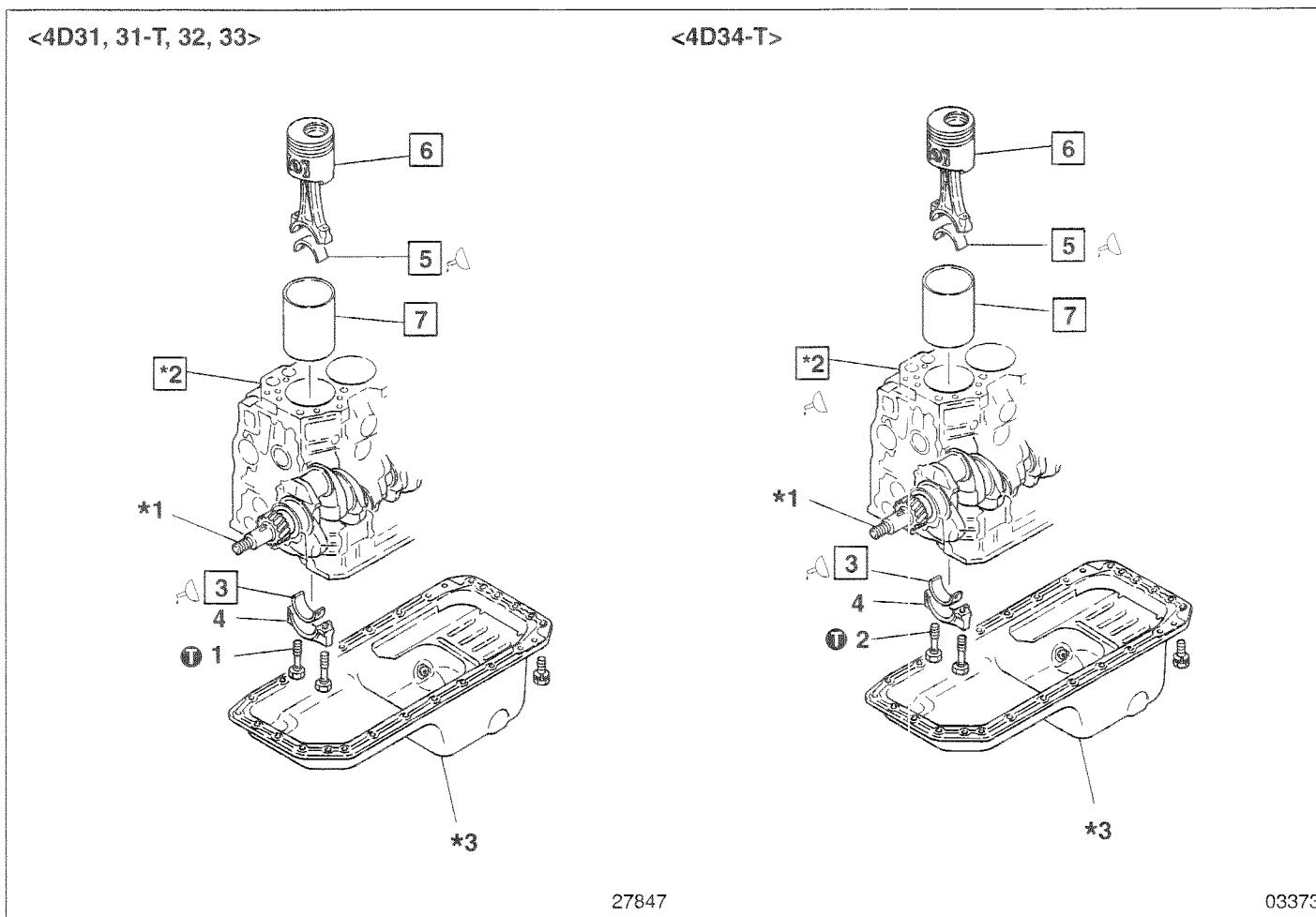


13 Installing sealing cap

Tap sealing cap 13 into the crankcase * to the specified depth.

A: Front of engine

PISTON, CONNECTING ROD AND CYLINDER SLEEVE



● Disassembly sequence

- | | |
|--------------------------------|--|
| 1 Nut <4D31, 31-T, 32, 33> | 6 Piston and connecting rod assembly P11-52 |
| 2 Bolt <4D34-T> | 7 Cylinder Sleeve |
| 3 Lower connecting rod bearing | <4D31, 31-T, 32, 34-T> |
| 4 Connecting rod cap | |
| 5 Upper connecting rod bearing | |

- | |
|------------------------|
| *1: Crankshaft P11-62 |
| *2: Crankcase P11-62 |
| *3: Oil pan Gr 12 |

● Installation sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy | |
|----------|--|----------------------|---|--------------------|---|-------------------------------|
| — | Piston projection | | 4D31, 33 | 0.48 to 0.74 | — | Inspect each loca- tion |
| | | | 4D31-T, 34-T | 0.43 to 0.69 | | |
| | | | 4D32 | 0.6 to 0.8 | | |
| | Connecting rod end play | | | 0.15 to 0.45 | 0.6 | Inspect |
| 3, 5 | Connecting rod bearing | Oil clearance | 4D31, 31-T, 32, 33 | [60] 0.04 to 0.09 | 0.2 | Replace |
| | | | 4D34-T | [65] 0.04 to 0.09 | 0.2 | |
| | | Span when free | 4D31, 31-T, 32, 33 | — | Upper: Less than 64.5 Lower: Less than 64.27 | Replace |
| | | | 4D34-T | — | Less than 69.5 | |
| 6, *2 | Piston and connecting rod assembly-to-crankcase cylinder clearance | | 4D33 | [108] 0.07 to 0.12 | — | Bore to oversize or replace |
| 6, 7 | Piston and connecting rod assembly-to-cylinder sleeve clearance | | 4D31 | [100] 0.05 to 0.09 | — | Bore to oversize or replace |
| | | | 4D31-T | [100] 0.11 to 0.15 | — | |
| | | | 4D32 | [104] 0.04 to 0.09 | — | |
| | | | 4D34-T | [104] 0.07 to 0.11 | — | |
| 7 | Cylinder sleeve | 4D31, 31-T | Inside diameter | 100 to 100.03 | 104.25 | Bore to oversize or replace |
| | | | Roundness | 0.01 or less | — | |
| | | | Cylindricity | 0.03 or less | — | |
| | | 4D32, 34-T | Inside diameter | 104 to 104.03 | 104.25 | Bore to oversize or replace |
| | | | Roundness | 0.01 or less | — | |
| | | | Cylindricity | 0.03 or less | — | |
| 7, *2 | Cylinder sleeve-to-crankcase interference | 4D31, 31-T, 32, 34-T | Standard | 0.17 to 0.23 | — | Replace with oversize |
| | | | Oversize | 0.19 to 0.21 | — | Replace |
| *2 | Crankcase cylinder | Inside diameter | 4D33 | 108 to 108.03 | 108.25 | Bore to oversize or replace |
| | | Roundness | | 0.01 or less | — | |
| | | Cylindricity | | 0.03 or less | — | |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|-----------------------|--------------------|-------------------|---------|
| 1 | Nut | 4D31, 31-T, 32, 33 | 100 {10.5} | Wet |
| 2 | Bolt | 4D34-T | 29 {3} + 90° ± 5° | Wet |

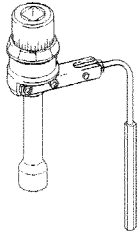
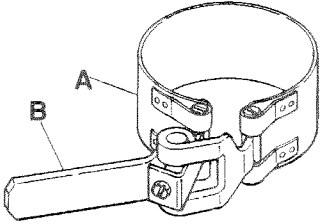
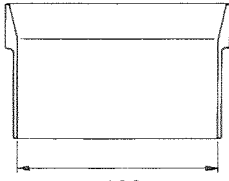
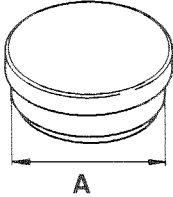
🔧 Lubricant

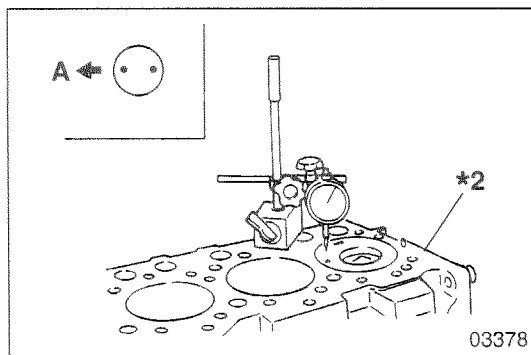
| Location | Points of application | Specified lubricant | Quantity |
|----------|---------------------------------------|----------------------------------|-------------|
| 3, 5 | Connecting rod bearing inside surface | Engine oil | As required |
| *2 | Sleeve hole in crankcase | 4D34-T Spindle oil [ISO VG32] | As required |

PISTON, CONNECTING ROD AND CYLINDER SLEEVE

Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application | | | | | | |
|----------|--|--|--|----------|------|----------|-------|--|---------------------------------|
| 2 | Socket Wrench  | MH061560 <4D34-T> | Tightening of connecting rod cap mounting bolt | | | | | | |
| 6, *2 | A: Piston Guide Clamp B: Piston Guide Lever  | A: <4D33> MH062041 <4D32, 34-T> MH061890 B: MH061658 | Installation of piston and connecting rod assembly | | | | | | |
| | Piston Guide  | MH061294 <4D31, 31-T> | | | | | | | |
| 7 | Cylinder Sleeve Installer <table border="1"> <thead> <tr> <th></th> <th>Dimension A</th> </tr> </thead> <tbody> <tr> <td>MH061295</td> <td>φ 99</td> </tr> <tr> <td>MH062228</td> <td>φ 103</td> </tr> </tbody> </table>  | | Dimension A | MH061295 | φ 99 | MH062228 | φ 103 | MH061295 <4D31, 31-T> MH062228 <4D32, 34-T> | Installation of cylinder sleeve |
| | Dimension A | | | | | | | | |
| MH061295 | φ 99 | | | | | | | | |
| MH062228 | φ 103 | | | | | | | | |



◆ Service procedure

● Inspection before disassembly

(1) Piston projection from crankcase *2 top surface

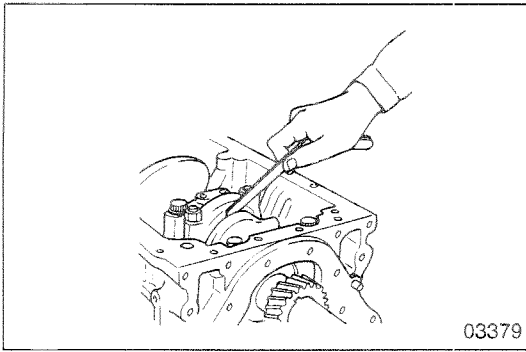
NOTE

The piston projections affect engine performance and must therefore be checked.

- Measure the projection of each piston at two points and calculate the average of the two values.

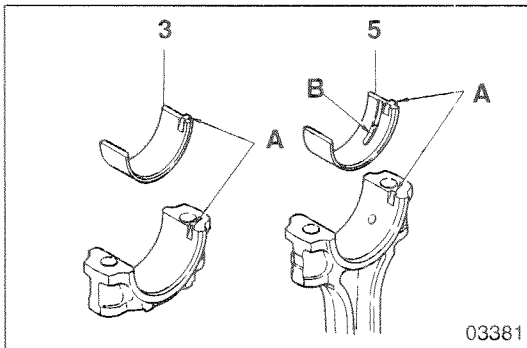
A: Front of engine

- If the average value is out of specification, check the clearances between all relevant parts.



(2) Connecting rod end play

- Measure the end play of every connecting rod.
- If any measurement exceeds the specified limit, replace the defective part(s).



3 5 Connecting rod bearings

[Installation]

Install connecting rod bearings 3, 5 by fitting lugs A into their respective grooves.

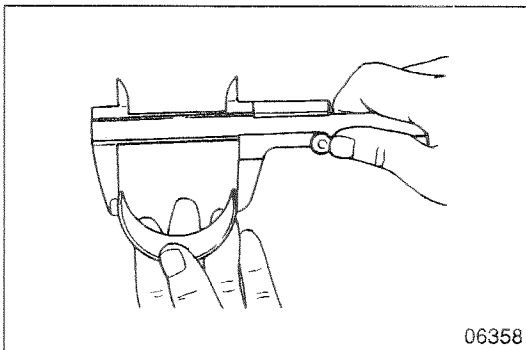
CAUTION

Upper connecting rod bearing 5 has an oil hole B. Lower connecting rod bearing 3 has no oil hole. Take care not to confuse the upper and lower parts.

[Inspection]

CAUTION

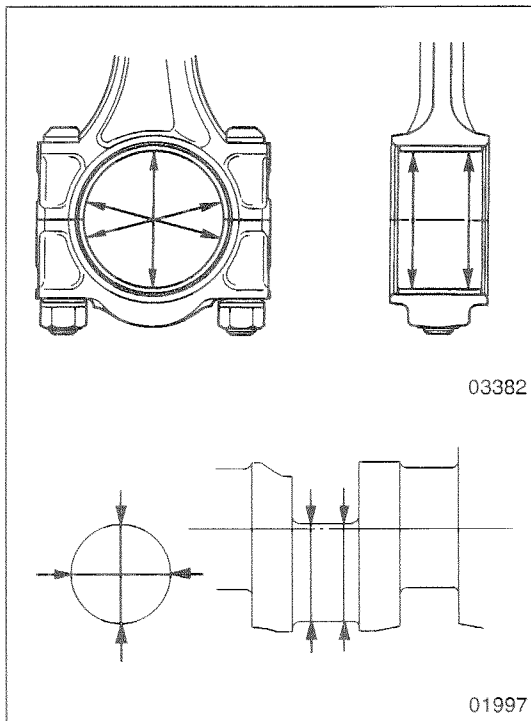
- Do not attempt to manually expand a connecting rod bearing 3, 5 if its span is insufficient.
- Upper and lower connecting rod bearings 3, 5 must be replaced as a set.



(1) Span when free

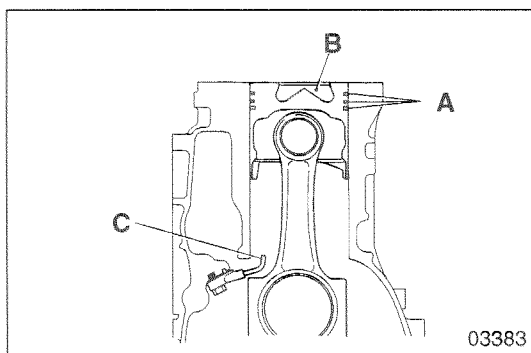
If the span is less than the specified requirement, replace the upper and lower connecting rod bearings 3, 5 as a set.

PISTON, CONNECTING ROD AND CYLINDER SLEEVE




(2) Connecting rod bearing-to-crankshaft pin clearance

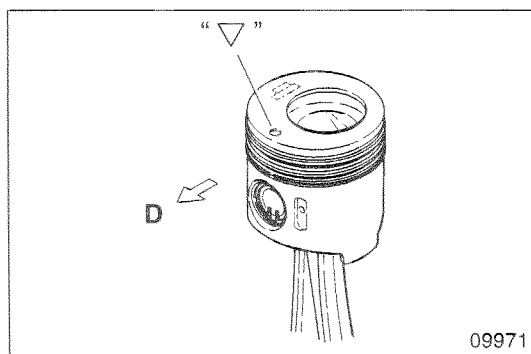
If the connecting rod bearing-to-crankshaft pin clearance exceeds the specified limit, replace the defective part(s).



6 Installation of piston and connecting rod assembly

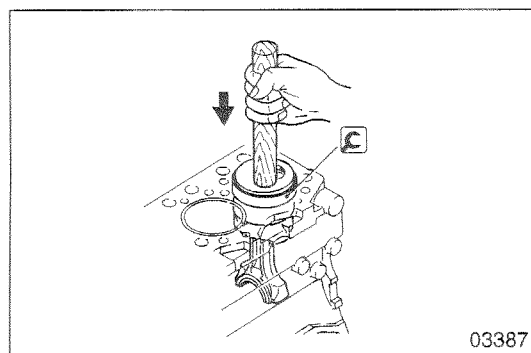
CAUTION

- Ensure that piston ring gaps A remain in their correct positions.
 P11-56
- Take care not to damage piston crown B (the area that forms part of the combustion chamber).
- Ensure that the connecting rod does not touch oil jet C.



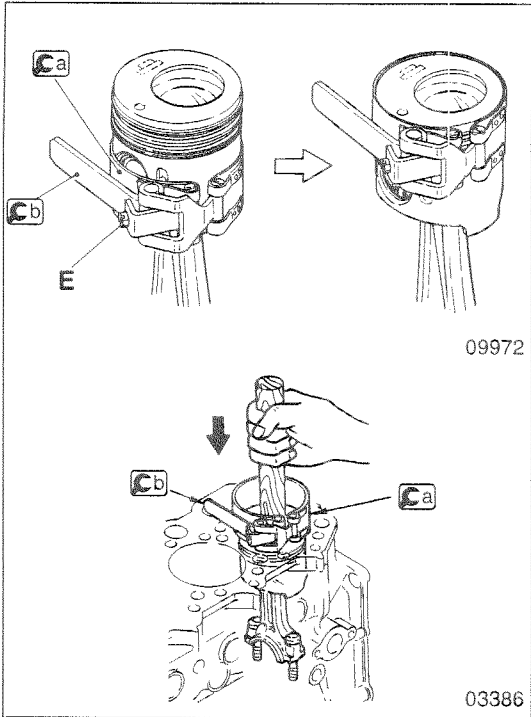
- With the piston's front mark ("○" or "▽") facing the front of the engine, install the piston and connecting rod assembly in accordance with the following procedure.

D: Front of engine



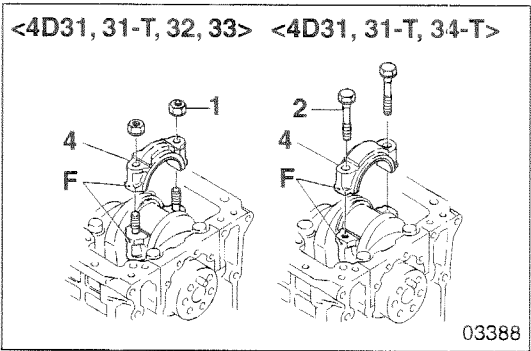
<4D31, 31-T>

 : Piston Guide

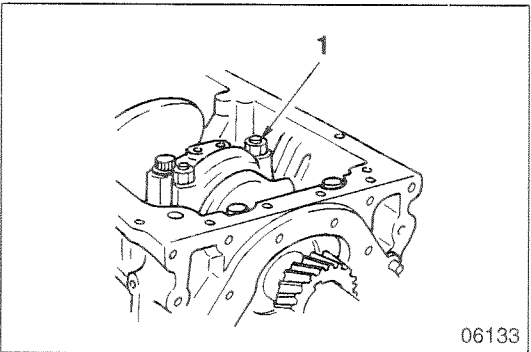


<4D32, 33, 34-T>

- Fit the **Ca** Piston Guide Clamp over the piston skirt. Using bolt **E** of the **Cb** Piston Guide Lever, adjust the clamp's inside diameter such that it matches the piston's outside diameter.
- Move the **Ca** Piston Guide Clamp and **Cb** Piston Guide Lever to the top of the piston.

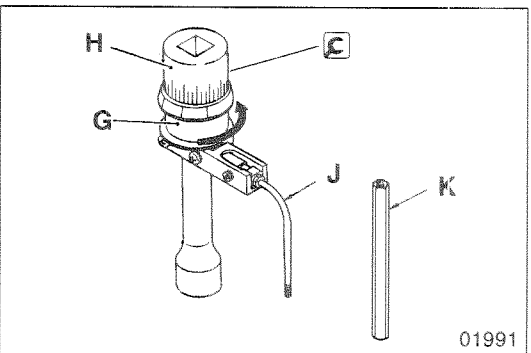


- With the piston installed, align mating marks **F** on the connecting rod and connecting rod cap **4** and install the cap in accordance with the following procedure.



<4D31, 31-T, 32, 33>

Tighten nut **1** to the specified torque.



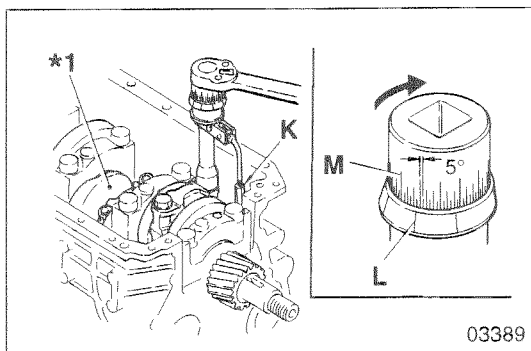
<4D34-T>

Tighten the bolt **2** to the specified torque, then turn the **C** Socket Wrench by an additional $90^\circ \pm 5^\circ$.

- Before fitting the **C** Socket Wrench over a bolt, turn holder **G** counter-clockwise to tension the built-in spring.

- H**: Socket
- J**: Rod
- K**: Rod (extension)

PISTON, CONNECTING ROD AND CYLINDER SLEEVE



- Set the socket wrench such that the built-in spring force forces the rod K against crankshaft *1.
- On holder G, select inscribed line L that is easiest to see.
- Using the selected line as a reference, turn socket H $90^\circ \pm 5^\circ$ clockwise. (One gradation on scale M represents 5° .)

NOTE

After fitting connecting rod caps 4, inspect the following items:

- Connecting rod end play (P11-45)
- Piston projections (P11-44)

6 *2 Piston and connecting rod assembly and crankcase cylinder <4D33>

[Inspection]

- If the inside diameter of the cylinder bore in crankcase *2 exceeds the specified limit, rebore the cylinder to oversize. Also replace the piston and piston rings with ones suitable for the oversized cylinder inside diameter.

CAUTION

Even if only one cylinder requires boring, bore every cylinder to the same oversized inside diameter.

A: Measuring direction of cylinder bore (crankshaft axis direction)

B: Measuring direction of cylinder bore (perpendicular to crankshaft axis)

C: Measuring position of piston diameter (perpendicular to piston pin hole axis)

- Even if the inside diameter of the cylinder bore in crankcase *2 is within the specified limit, the piston and piston rings must be replaced if the piston-to-cylinder clearance is out of specification.

[Use of oversize pistons]

- Oversizes available: 0.50 mm, 1.00 mm (two sizes in total)
- To determine the required oversize, measure the inside diameter of every cylinder and find the cylinder of the largest inside diameter. Select an oversize most suitable for the diameter.
- Measure the outside diameter **C** of the oversize piston to be used.
- Bore all cylinders to achieve the specified nominal piston-to-cylinder clearance.

CAUTION

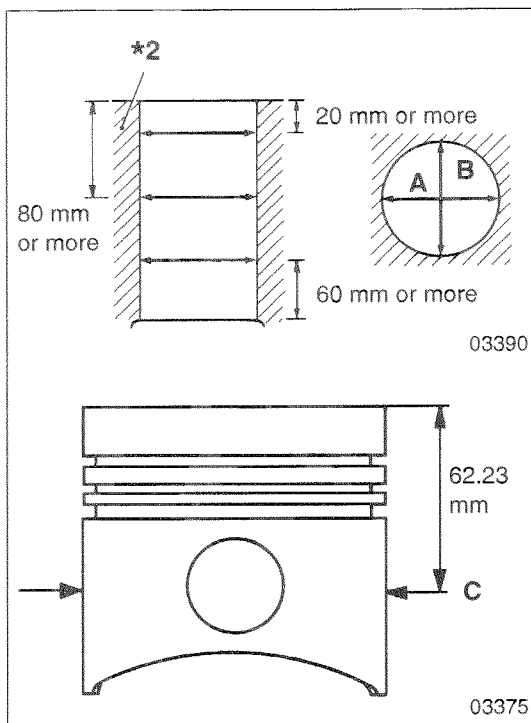
Be sure to bore the cylinders in the following order to prevent distortion due to heat generated during boring.

No.2 → No.4 → No.1 → No.3

Boring finish dimension (tolerances ± 0.005) =

Oversize piston diameter **C** (measurement) – Piston-to-cylinder clearance (nominal range central value) – 0.02 mm (honing margin)

- After boring, hone the cylinders to final diameter (tolerances ± 0.005).



Final diameter (tolerances ± 0.005) =

Oversize piston diameter **C** (measurement) – Piston-to-cylinder clearance (nominal range central value)

NOTE

- Honed surface roughness : 2 to 4 μm
- Cross-hatching angle : 15 to 25° (half angle)
- Squareness of cylinder bore : 0.05 mm

- Check the clearance between piston and cylinder.

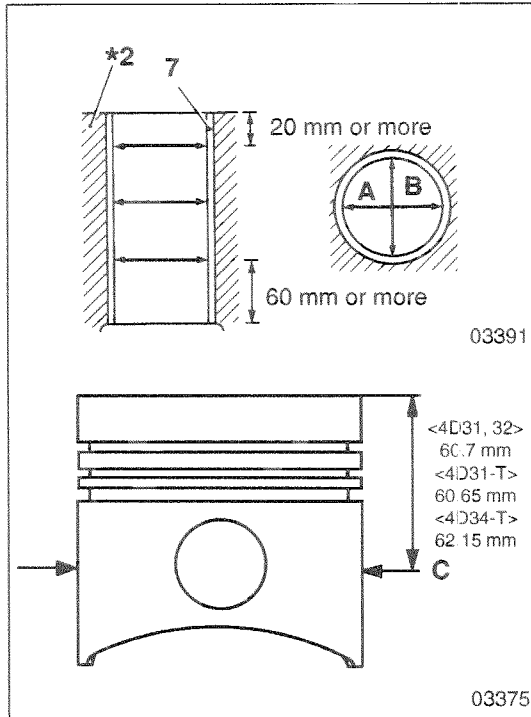
6 7 Piston and connecting rod assembly and cylinder sleeve <4D31, 31-T, 32, 34-T>

[Inspection]

- If the inside diameter of cylinder sleeve 7 exceeds the specified limit, rebore the cylinder sleeve to oversize. Also replace the piston and piston rings with ones suitable for the oversized cylinder sleeve inside diameter.

CAUTION

Even if only one cylinder requires boring, bore every cylinder to the same oversized inside diameter.



A: Measuring direction of cylinder sleeve bore (crankshaft axis direction)

B: Measuring direction of cylinder sleeve bore (perpendicular to crankshaft axis)

C: Measuring position of piston diameter (perpendicular to piston pin hole axis)

- Even if the inside diameter of cylinder sleeve 7 is within the specified limit, the piston and piston rings must be replaced if the piston-to-cylinder sleeve clearance is out of specification.

[Use of oversize pistons]

- Oversizes available: 0.50 mm, 1.00 mm (two sizes in total)
- To determine the required oversize, measure the inside diameter of every cylinder and find the cylinder of the largest inside diameter. Select an oversize most suitable for the diameter.
- Measure the outside diameter **C** of the oversize piston to be used.
- Bore all the cylinder sleeve to achieve the specified nominal piston-to-cylinder clearance.

CAUTION

Be sure to bore the cylinders in the following order to prevent distortion due to heat generated during boring.

No.2 → No.4 → No.1 → No.3

Boring finish dimension (tolerances ± 0.005) =

Oversize piston diameter **C** (measurement) – Piston-to-cylinder clearance (nominal range central value) – 0.02 mm (honing margin)

- After boring, hone the cylinders to final diameter (tolerances ± 0.005).

PISTON, CONNECTING ROD AND CYLINDER SLEEVE

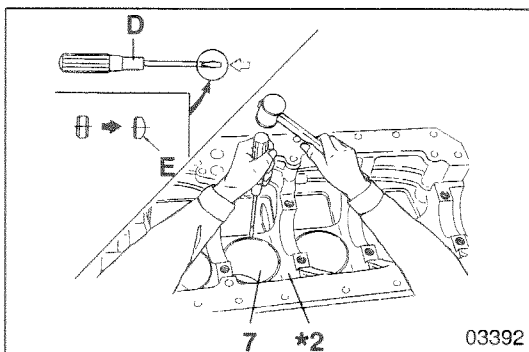
Final diameter (tolerances ± 0.005) =

Oversize piston diameter **C** (measurement) – Piston-to-cylinder clearance (nominal range central value)

NOTE

- Honed surface roughness : 2 to 4 μm
- Cross-hatching angle : 15 to 25° (half angle)
- Squareness of cylinder bore : 0.05 mm

- Check the clearance between piston and cylinder sleeve.



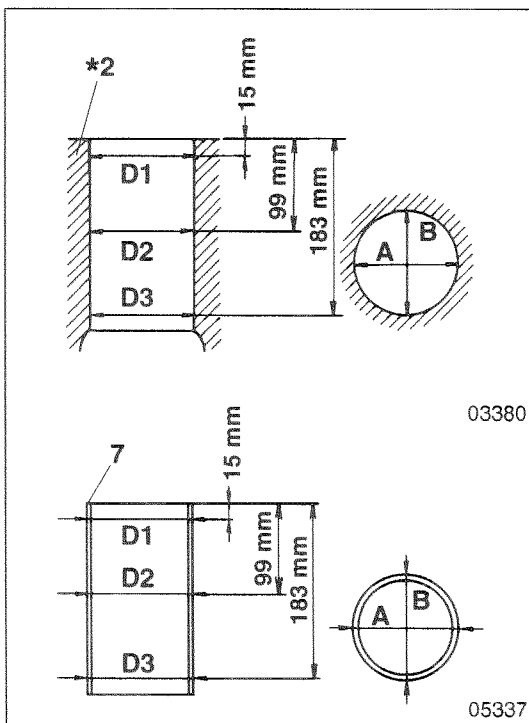
Cylinder sleeve

[Removal]

- Mount a boring machine on crankcase *2 and center it. Center the boring machine in the bottom of cylinder sleeve 7, where there should be little eccentric wear.
- Bore cylinder sleeve 7 to achieve a thickness of approximately 0.5 mm.
- Insert an appropriately shaped tool **D** (for example, a suitably machined screwdriver) between crankcase *2 and cylinder sleeve 7, then lightly tap the tool so that the cylinder sleeve splits and can be removed.

CAUTION

Insert tool **D** with its rounded side **E** against crankcase *2.



[Installation]

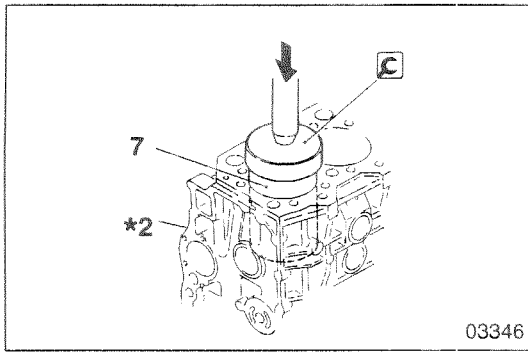
- Before installing a cylinder sleeve 7, inspect the sleeve hole in crankcase *2. If the hole is defective due to damage, insufficient interference, or some other problem, rectify it by boring.

CAUTION

- If any crankcase *2 sleeve hole requires boring, remove cylinder sleeves 7 from all the cylinders and bore each sleeve hole such that is perfectly round.
- Be sure to bore the cylinders in the following order to prevent distortion due to heat generated during boring.
No.2 → No.4 → No.1 → No.3
- Apply spindle oil [ISO VG32] to the crankcase *2 sleeve holes before press-fitting cylinder sleeves 7.

Check for correct interference as follows:

- At the positions shown in the drawing, measure the inside diameter of the crankcase *2 sleeve hole and the outside diameter of cylinder sleeve 7.
- Calculate the average of the vertical dimensions (**D1**, **D2**, and **D3**) and the diametrical dimensions (**A** and **B**). If the degree of interference is not up to specification, bore the crankcase *2 sleeve hole to oversize.



<If interference is sufficient>

- Using the **C** Cylinder Sleeve Installer, press cylinder sleeve **7** into crankcase ***2** such that its chamfered end goes in first.

NOTE

Press in cylinder sleeve 7 until its top edge is flush with the top surface of crankcase *2.

- After press-fitting cylinder sleeve **7**, hone-finish its surface to achieve the specified inside diameter.

<If interference is insufficient>

- Make ready a 0.5 mm oversize cylinder sleeve **7**.
- Hone crankcase ***2** to achieve the specified interference between the cylinder sleeve outside diameter and crankcase sleeve hole.
- Using the **C** Cylinder Sleeve Installer, press cylinder sleeve **7** into crankcase ***2** such that its chamfered end goes in first.

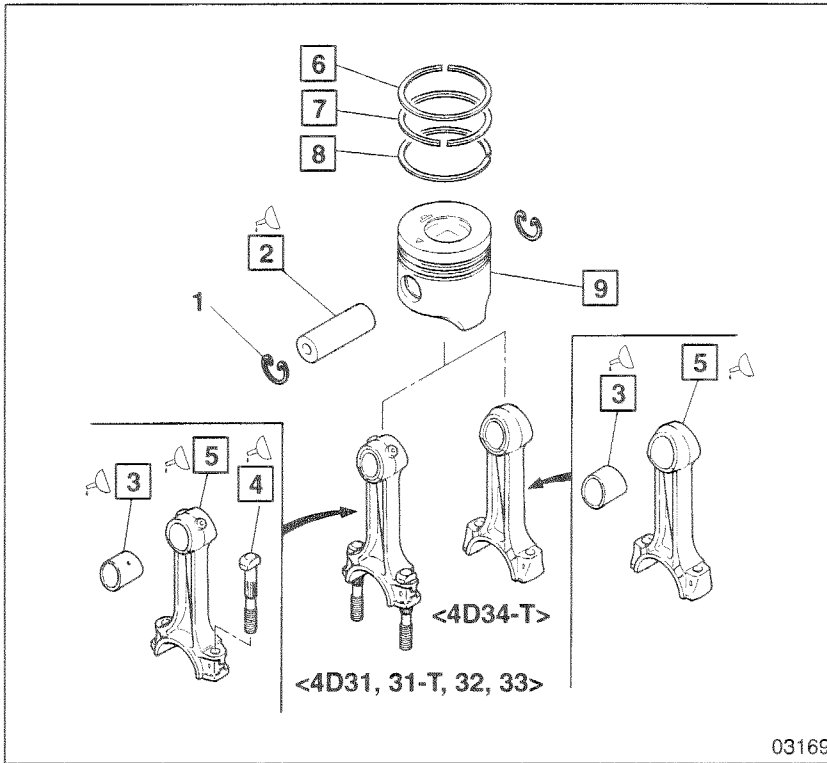
NOTE

Press in the cylinder sleeve 7 until its top edge is flush with the top surface of crankcase *2.

- After press-fitting cylinder sleeve **7**, hone-finish its surface to achieve the specified inside diameter.

PISTON, CONNECTING ROD AND CYLINDER SLEEVE

Piston and Connecting Rod Assembly



● Disassembly sequence

- 1 Snap ring
- 2 Piston pin
- 3 Connecting rod bushing
- 4 Connecting rod bolt <4D31, 31-T, 32, 33>
- 5 Connecting rod
- 6 1st compression ring
- 7 2nd compression ring
- 8 Oil ring
- 9 Piston

● Assembly sequence

Follow the disassembly sequence in reverse.

NOTE

Do not remove connecting rod bolt 4 <4D31, 31-T, 32, 33> unless it is faulty.

Service standards

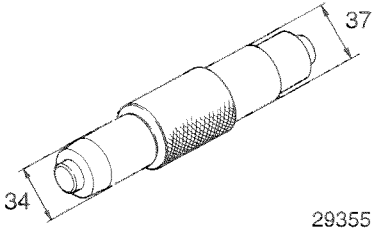
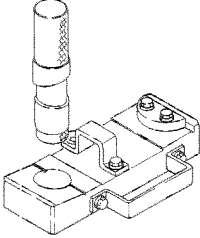
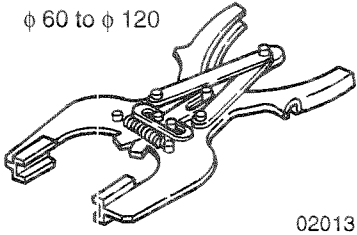
Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy | |
|-----------|--|---------------------------|---|--------------|-----------------------|---------|
| 2, 3 | Piston pin-to-connecting rod small end bushing clear- ance | 4D31, 31-T, 32, 33 | [34] 0.03 to 0.05 | 0.1 | Replace | |
| | | 4D34-T | [36] 0.03 to 0.04 | | | |
| 2, 9 | Piston pin-to-piston clear- ance | 4D31, 31-T, 32, 33 | [34] 0.007 to 0.021 | 0.05 | Replace | |
| | | 4D34-T | [36] 0.007 to 0.021 | | | |
| 5 | Connecting rod bend and torsion | | — | 0.05 | Correct or replace | |
| 6 to 8 | Piston ring end gap | 1st com- pression ring | 4D32, 33, 34-T | 0.3 to 0.45 | 1.5 | Replace |
| | | | 4D31, 31-T | 0.3 to 0.5 | | |
| | | 2nd com- pression ring | 4D33 | 0.3 to 0.45 | | |
| | | | 4D31, 31-T, 32, 34-T | 0.3 to 0.5 | | |
| Oil ring | 4D33 | 0.3 to 0.5 | | | | |
| | 4D31, 31-T, 32, 34-T | 0.25 to 0.45 | | | | |
| 6 to 8, 9 | Piston ring- to-piston ring groove clearance | 1st com- pression ring | 4D31 | 0.04 to 0.10 | 0.2 | Replace |
| | | | 4D31-T | 0.06 to 0.12 | | |
| | | | 4D32, 33 | 0.09 to 0.13 | | |
| | | | 4D34-T | 0.05 to 0.10 | | |
| | 2nd com- pression ring | 4D31, 32, 33 | 0.03 to 0.06 | 0.15 | Replace | |
| | | 4D31-T | 0.07 to 0.10 | | | |
| | | 4D34-T | 0.05 to 0.08 | | | |
| Oil ring | | 0.03 to 0.06 | 0.15 | Replace | | |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---------------------|-------------|
| 2 | Piston pin outer surface | Engine oil | As required |
| 3 | Connecting rod bushing outer surface | Engine oil | As required |
| 4 | Knurled section of connecting rod bolt | Engine oil | As required |
| 5 | Bushing installation surface of connecting rod | Engine oil | As required |

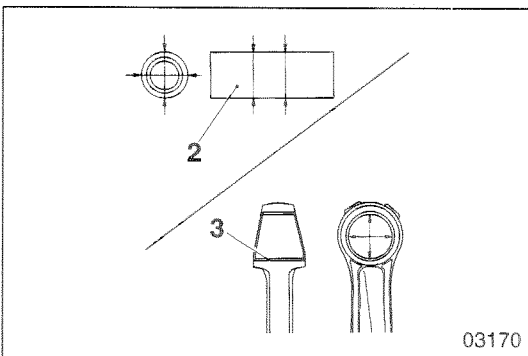
Special tools

| Location | Tool name and shape | Part No. | Application |
|----------|---|--|---|
| 3 | Connecting Rod Bushing Puller Kit  | MH061296 <4D31, 32> | Removal and installation of connecting rod bushings |
| 3 | Connecting Rod Bushing Puller Kit  | MH061891 <4D31-T, 33> MH062225 <4D34-T> | Removal and installation of connecting rod bushings |
| 6 to 8 | Piston Ring Tool  | MH060014 | Removal and installation of piston rings |

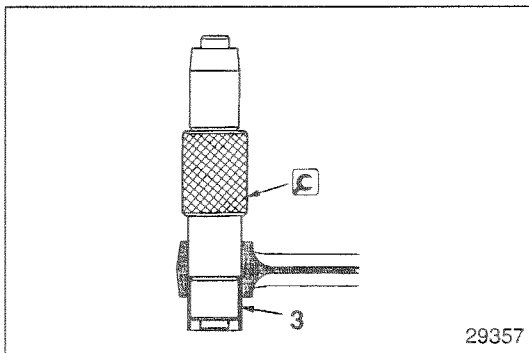
Service procedure

2 3 Piston and connecting rod

If the clearance exceeds the specified limit, replace the defective part(s).



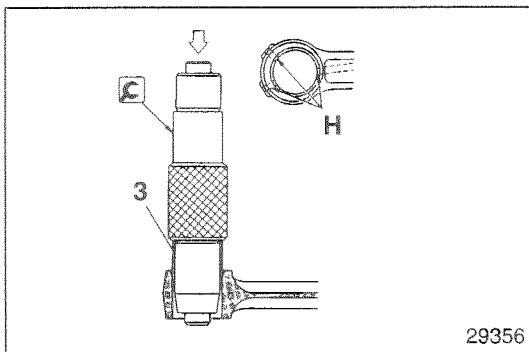
PISTON, CONNECTING ROD AND CYLINDER SLEEVE



3 Connecting rod bushing <4D31, 32>

[Removal]

Replace connecting rod bushing 3 using the **C** Connecting Rod Bushing Puller.

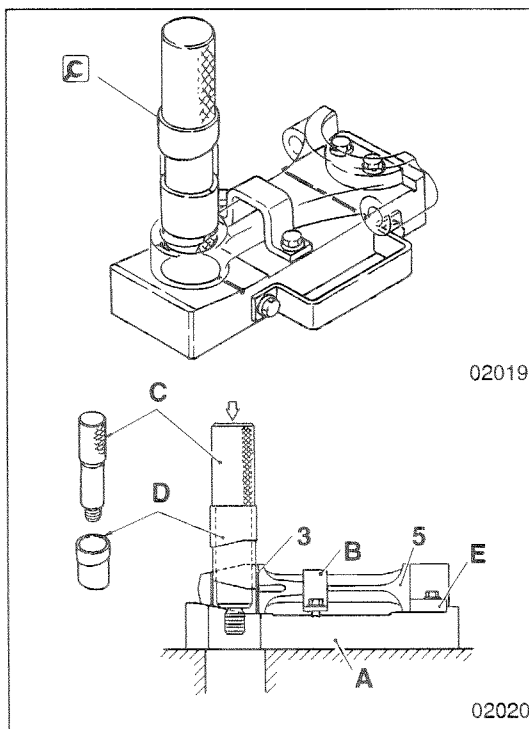


[Installation]

- Apply engine oil to the outer surface of the connecting rod bushing 3 and to the bushing fitting hole surface of the connecting rod 5.
- Align oil holes H in connecting rod bushing 3 and the small end of connecting rod 5. Then, use a press to slowly apply pressure of approximately 49 kN (5,000 kgf) until the bushing is pressed into place.
- After press-fitting connecting rod bushing 3, ream it to achieve the specified nominal clearance between the bushing and piston pin 2.

NOTE

After installing connecting rod bushing 3, insert piston pin 2 and check that it turns smoothly and without play.



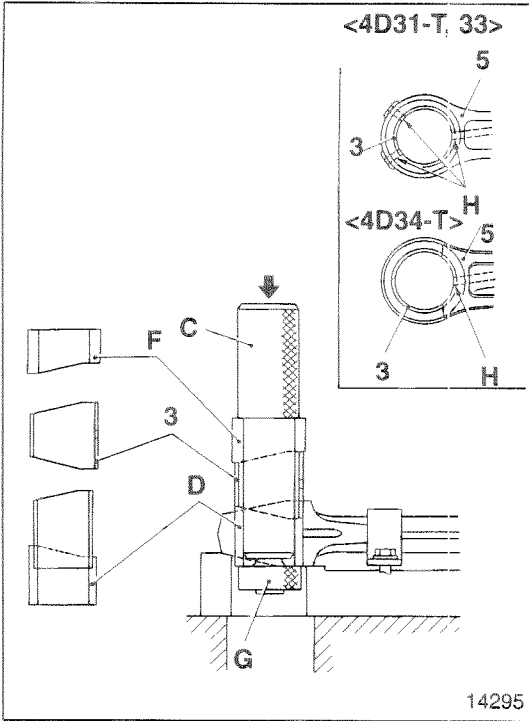
3 Connecting rod bushing <4D31-T, 33, 34-T>

Replace connecting rod bushing 3 using the **C** Connecting Rod Bushing Puller Kit. This consists of the following parts:

- A: Base
- B: Bracket
- C: Puller
- D: Collar
- E: Plate
- F: Collar
- G: Nut

[Removal]

- Remove the bearing (if fitted) from the big end of connecting rod 5.
- Mount the connecting rod 5 on base A and lock it in position with bracket B and plate E.
- Position puller C and collar D as shown in the illustration. Then, slowly apply pressure of approximately 49 kN (5,000 kgf) until connecting rod bushing 3 is pressed out.

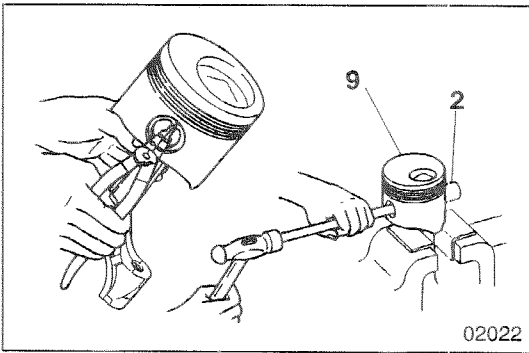


[Installation]

- Apply engine oil to the small end of connecting rod 5 and to the outer surface of connecting rod bushing 3.
- Fit collar F over puller C, position connecting rod bushing 3 and collar D as shown in the illustration, and lock this arrangement together with nut G.
- Align oil holes H in connecting rod bushing 3 and the small end of connecting rod 5. Then, use a press to slowly apply pressure of approximately 49 kN (5,000 kgf) until the bushing is pressed into place.
- After press-fitting connecting rod bushing 3, ream it to achieve the specified nominal clearance between the bushing and piston pin 2.

NOTE

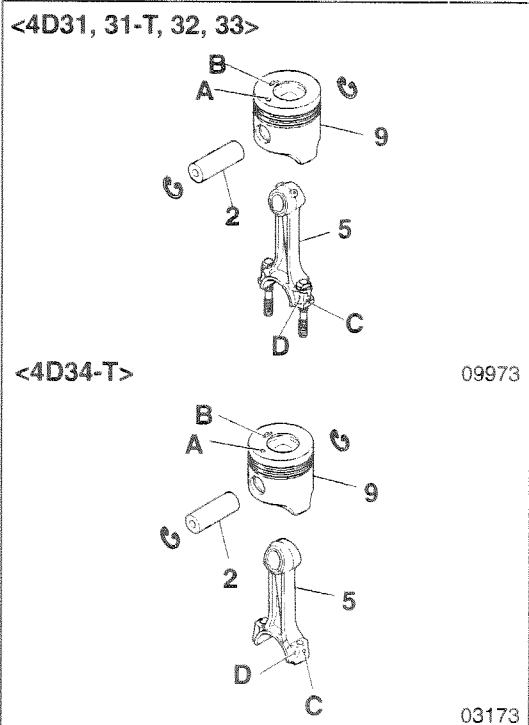
After installing connecting rod bushing 3, insert piston pin 2 and check that it turns smoothly and without play.



2 5 9 Piston pin, connecting rod, and piston

[Removal]

- Tap out piston pin 2 using a rod and hammer.
- If piston pin 2 is difficult to remove, heat piston 9 in hot water or using a piston heater.



[Installation]

- Apply engine oil to piston pin 2. With connecting rod 5 and piston 9 aligned as illustrated, insert the piston pin to hold these components together.

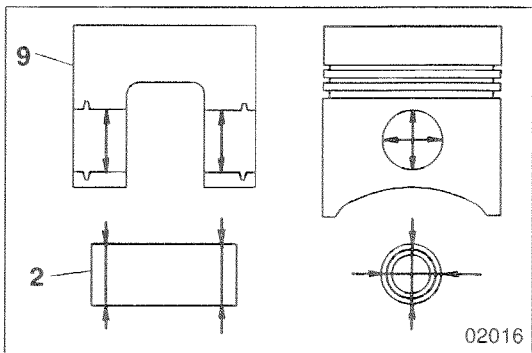
- A: Front mark ("O" or "▽")
- B: Piston mass mark (Alphabet letter)
- C: Connecting rod mass mark (Alphabet letter)
- D: Alignment mark for connecting rod cap

- If piston pin 2 is difficult to insert, heat piston 9 in hot water or using a piston heater.

CAUTION ⚠

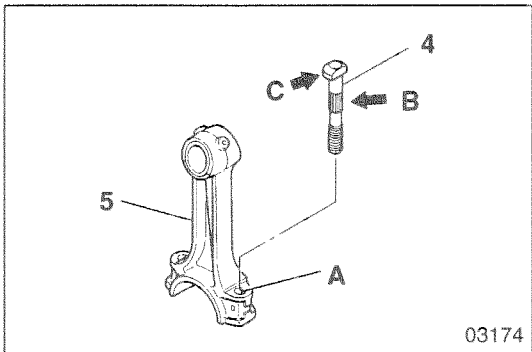
- Pistons 9 must all have the same mass mark.
- Connecting rods 5 must all have the same mass mark.
- After inserting piston pin 2, check that it turns smoothly and without play.

PISTON, CONNECTING ROD AND CYLINDER SLEEVE



2 9 Piston pin-to-piston clearance

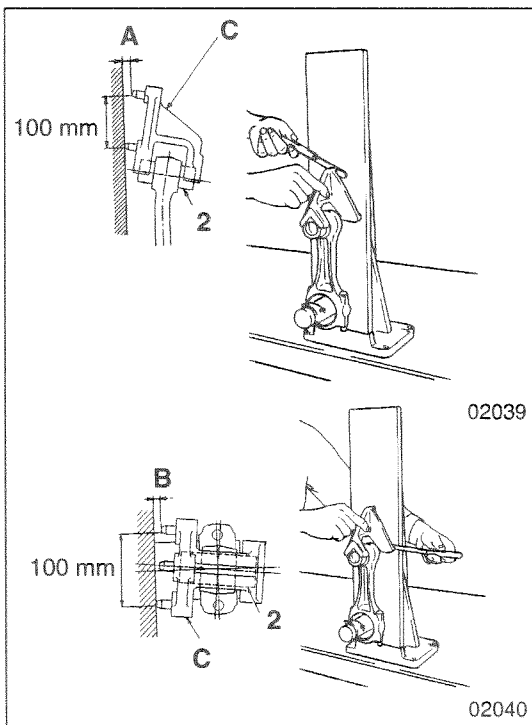
If the clearance exceeds the specified limit, replace the defective part(s).



4 Installation of connecting rod bolt <4D31, 31-T, 32, 33>

- Make sure that there is no score or burr in bolt hole **A** of connecting rod **5**.
- Apply engine oil to knurled area **B** of connecting rod bolt **4** and press it into position, with the bolt head in the direction as illustrated, applying a pressure of 4.9 kN {500 kgf}.

C: One of the bolt head flats should be directed toward the connecting rod.



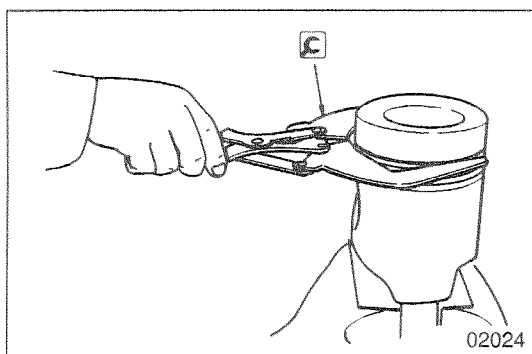
5 Connecting rod bend and twist

- Fit connecting rod bushing **3** and piston pin **2** in their respective positions of connecting rod **4**.
- Measure the extent of bending **A** and twisting **B** in connecting rod **5**. If either measurement exceeds the specified limit, replace connecting rod **5**.

C: Connecting rod aligner (measurement device)

NOTE

- Before mounting connecting rod **5** on connecting rod aligner **C**, install the upper and lower connecting rod bearings in their respective positions.
- Measurements must be made with the connecting rod cap mounting bolts or nuts tightened to their specified torque. P11-47

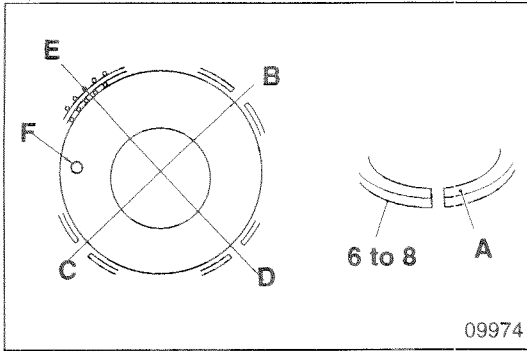


6 to 8 9 Piston rings and piston

Piston rings

[Removal]

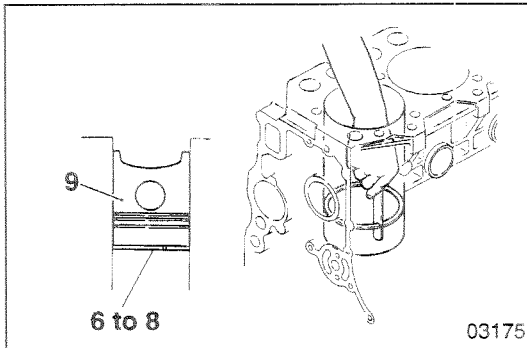
: Piston Ring Tool



[Installation]

Fit piston rings **6 to 8** such that manufacturer's marks **A** near the gaps face upward. Align the ring gaps as shown in the drawing.

- B**: 1st compression ring gap
- C**: 2nd compression ring gap
- D**: Oil ring gap
- E**: Oil ring expander spring location lugs
- F**: Piston front mark



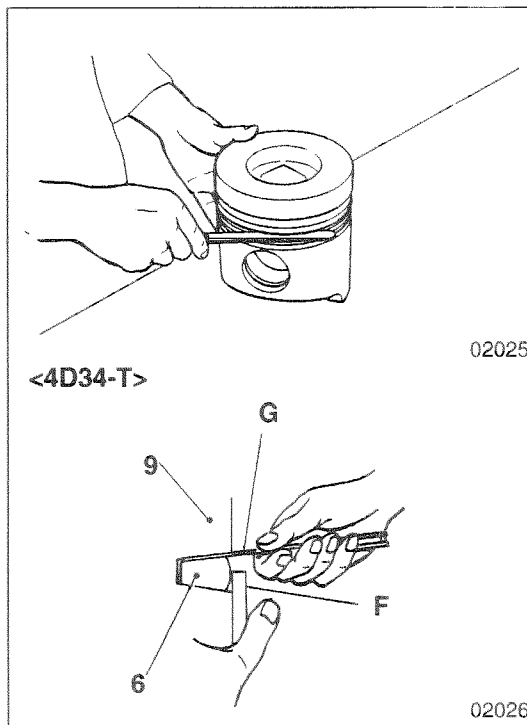
[Inspection]

(1) Piston ring end gap

- Using the crown of piston **9**, push piston ring **6, 7 or 8** horizontally into a cylinder for measurement.
- Taking care not to move the piston ring, measure the end gap. Replace all the rings of a piston if any gap exceeds the specified limit.

NOTE

- To keep piston ring **6, 7 or 8** horizontal, be sure to insert them into the cylinder using a piston **9**.
- Push piston ring **6, 7 or 8** down to the bottom of the cylinder; the bottom should be less worn than the top.
- Piston rings **6, 7 or 8** must be replaced as a set. Never replace piston rings individually.

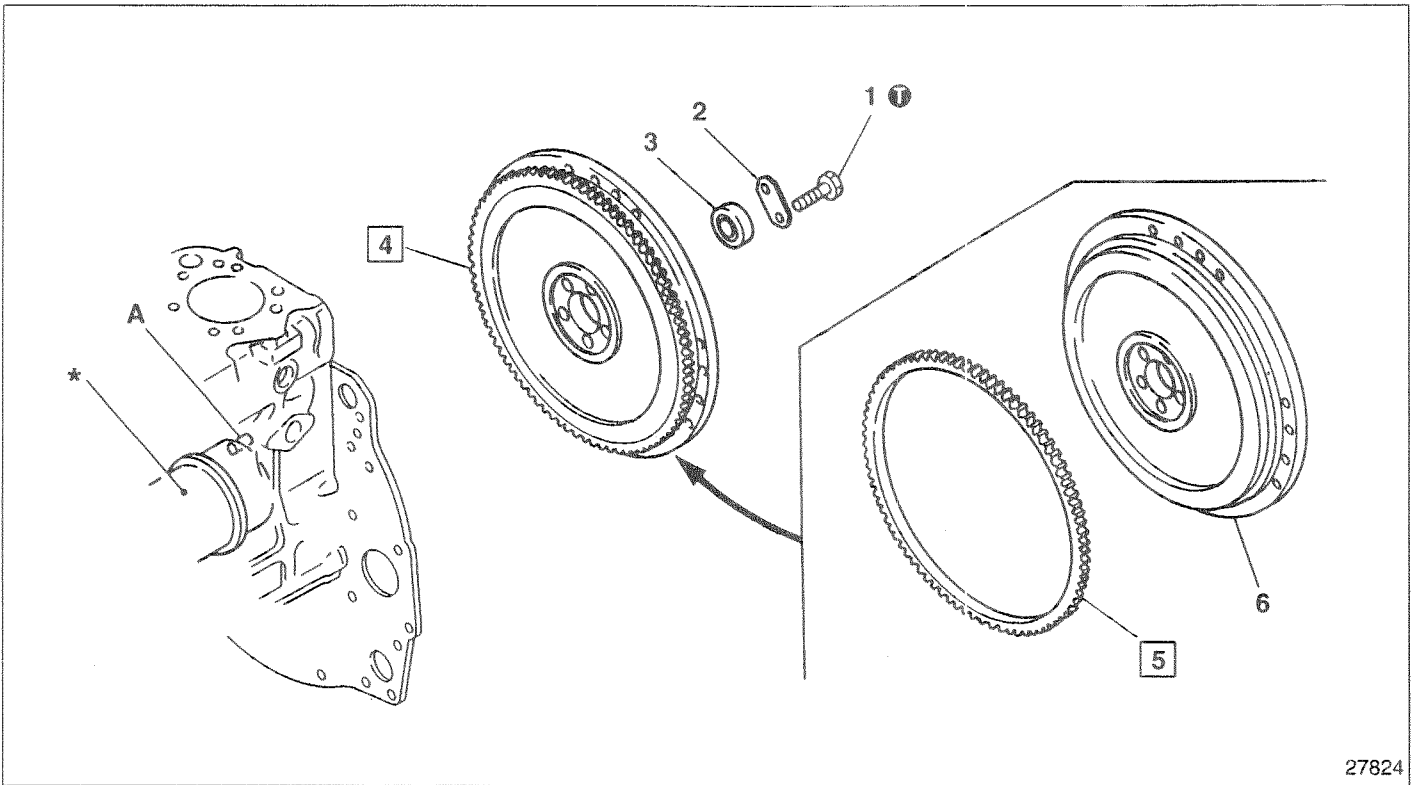
**(2) Piston ring-to-piston ring groove clearance**

- If any measurement exceeds the specified limit, replace the defective part(s).
- In case of 4D34-T, measure the 1st compression ring **6** clearance with a thickness gauge **G** while pressing the ring against piston **9** with a straight edge **F**.

NOTE

- Remove any carbon deposits from the ring groove of piston **9** and measure the clearance around the piston's entire periphery.
- Piston rings **6, 7, 8** must be replaced as a set. Never replace piston rings individually.

FLYWHEEL



● Disassembly sequence

- | | |
|---------------------|------------|
| 1 Bolt | 6 Flywheel |
| 2 Plate | |
| 3 Bearing | |
| 4 Flywheel assembly | |
| 5 Ring gear | |

*: Crankshaft assembly P11-62
A: Positioning pin

● Assembly sequence

Follow the disassembly sequence in reverse.

NOTE

Be sure to check the runout of flywheel 6 after installing flywheel assembly 4. P11-59

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy | | |
|----------|---------------------------------------|-----------------------------|----------------|-------|--------|--------------------|----|
| 4 | Flywheel assembly | Height of friction surface | 4D31 | 22.8 | 21.8 | Correct or replace | |
| | | | 4D31-T, 32 | 16 | | | 15 |
| | | | 4D33, 34-T | 23 | | | 22 |
| | | Friction surface distortion | 0.05 or less | | 0.2 | | |
| | Friction surface runout (when fitted) | — | | 0.2 | | | |

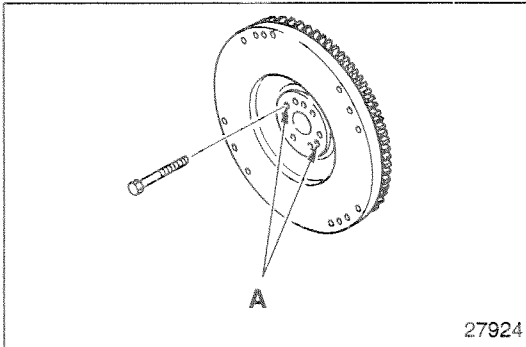
① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|--------------------------|----------|-------------------|---------|
| 1 | Bolt (Flywheel mounting) | M12 bolt | 100 {10.5} | Wet |
| | | M14 bolt | 175 {18} | |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---------------------|-------------|
| 1 | Bolt threads | Engine oil | As required |



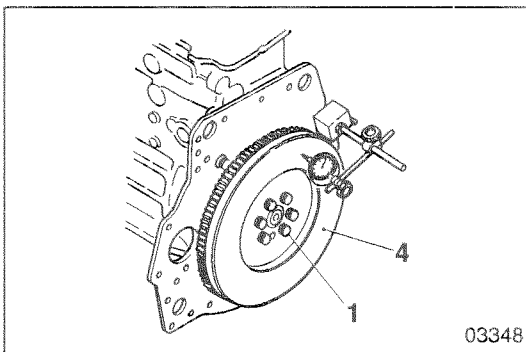
◆ Service procedure

4 Flywheel assembly

[Removal]

To remove flywheel assembly **4**, screw flywheel mounting bolts evenly into the removal holes **A** if there are provided.

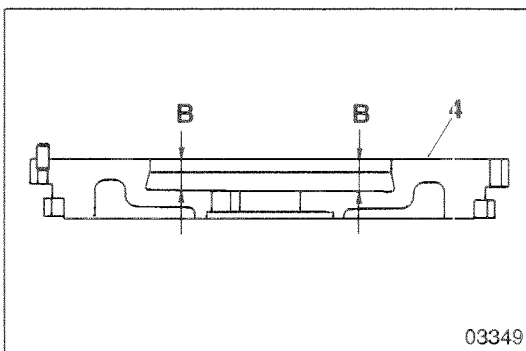
Do not separate the ring gear from the flywheel before removing the flywheel assembly.



[Inspection]

(1) Runout

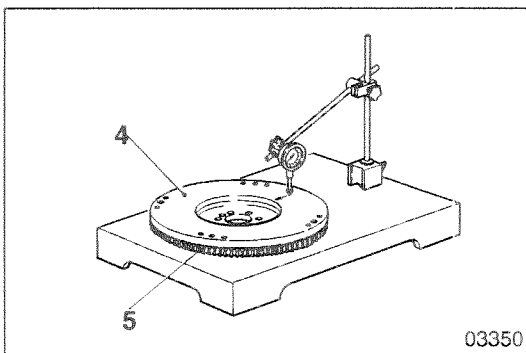
If runout exceeds the specified limit, check that bolts **1** are tightened correctly and inspect the crankshaft * mounting surface. Then, rectify or replace flywheel assembly **4** as required.



(2) Height of friction surface

If the measurement is below the specified value, rectify or replace flywheel assembly **4**.

B: Height of friction surface



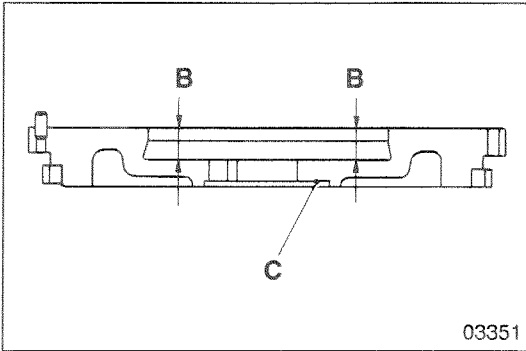
(3) Distortion of friction surface

If distortion exceeds the specified limit, rectify or replace flywheel assembly **4**.

NOTE

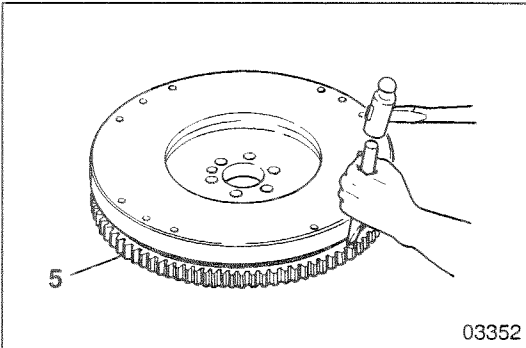
If any abnormality is evident on ring gear **5**, replace the ring gear before making inspections.

FLYWHEEL



[Correction]

Grind the friction surface such that its height **B** remains greater than the specified minimum. The friction surface must remain parallel with surface **C** with a tolerance of 0.1 mm.



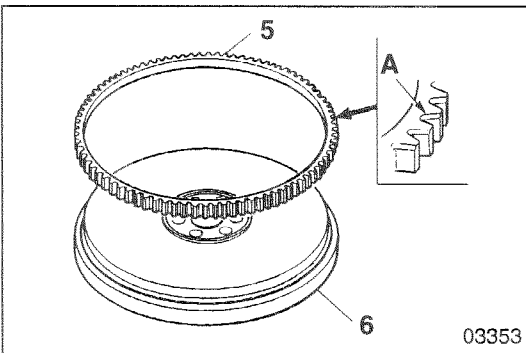
5 Ring gear

[Inspection]

Inspect ring gear **5** for damage and abnormal wear. If any defect is evident, the ring gear must be replaced.

[Removal]

- Heat ring gear **5** evenly with an acetylene torch or the like.
- Remove ring gear **5** from the flywheel by tapping around its entire periphery.



[Installation]

- Using a piston heater or the like, heat ring gear **5** to approximately 100°C for 3 minutes.

WARNING ⚠

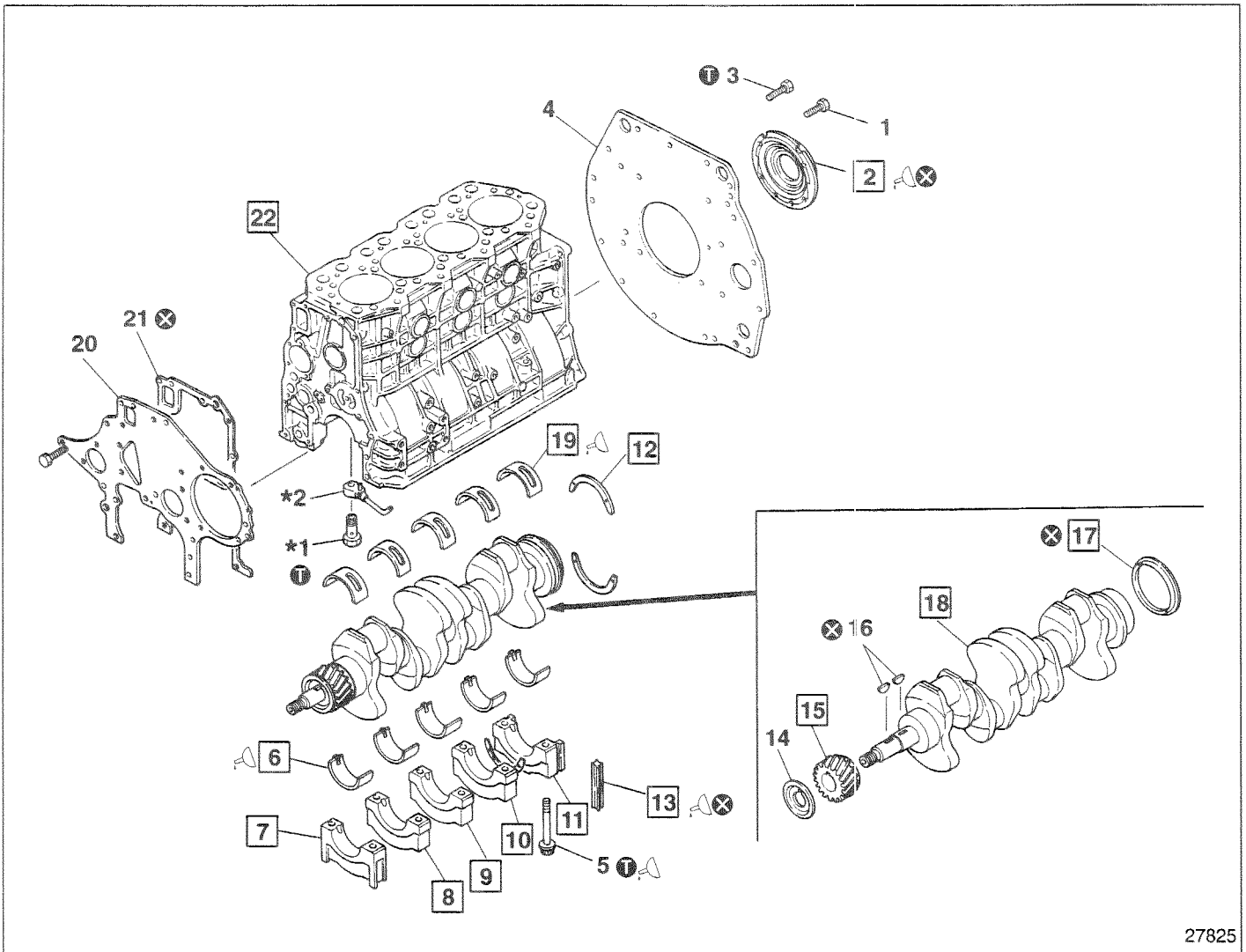
Be careful not to get burned.

- Fit ring gear **5** with the non-chamfered side of its teeth toward the flywheel **6**.

A: Chamfered side of ring gear



MEMO

CRANKSHAFT AND CRANKCASE



27825

● Disassembly sequence

- | | | |
|----------------------------------|---------------------------|---|
| 1 Bolt | 10 No.4 main bearing cap | 19 Upper main bearing |
| 2 Rear oil seal | 11 Rear main bearing cap | 20 Front plate |
| 3 Bolt | 12 Thrust plate | 21 Gasket |
| 4 Rear plate or flywheel housing | 13 Side seal | 22 Crankcase |
| 5 Bolt | 14 Front oil seal slinger | |
| 6 Lower main bearing | 15 Crankshaft gear | *1: Check valve  Gr 12 |
| 7 No.1 main bearing cap | 16 Key | *2: Oil jet  Gr 12 |
| 8 No.2 main bearing cap | 17 Rear oil seal slinger | ⊗: Non-reusable part |
| 9 No.3 main bearing cap | 18 Crankshaft | |

NOTE

Do not remove the crankshaft gear 15 unless it is faulty.

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|-------------------------------------|-----------------|---|-------------------|-----------------------|
| — | Crankshaft end play | | 0.10 to 0.26 | 0.4 | Inspect |
| 6, 19 | Main bearing | Oil clearance | No.1, 2, 4, 5 [78] 0.04 to 0.09 | 0.15 | Replace |
| | | | No.3 [78] 0.06 to 0.12 | | |
| | Span when free | | — | Less than 82.5 | |
| 18 | Crankshaft | Bend | 0.02 or less | 0.05 | Replace |
| | | Pin and journal | Roundness | 0.01 or less | 0.03 |
| | Cylindricity | | 0.006 or less | — | |
| 22 | Distortion of crankcase top surface | | 0.07 or less | 0.2 | Correct or replace |

⑩ Tightening torque

Unit: N · m {kgf · m}

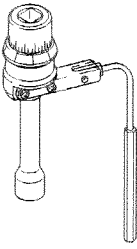
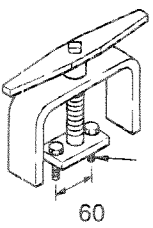
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|----------------------------------|-------------------|-------------------------------|
| *1 | Check valve | 0.31 {3.0} | Wet |
| 3 | Bolt (Rear plate mounting) | 64 {6.5} | — |
| 5 | Bolt (Main bearing cap mounting) | 59 {6} + 90° | Wet Reusable up to 3 times |

🔧 Lubricant and sealant

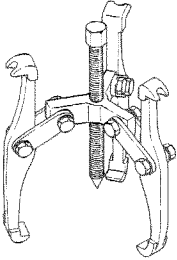
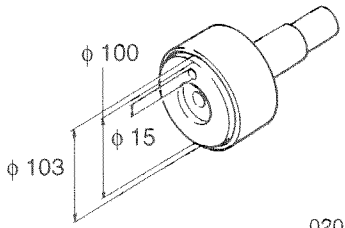
| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|---|------------------------------------|-------------|
| 2 | Rear oil seal lip | Engine oil | As required |
| | Rear oil seal mounting surface of crankcase | Threebond 1207C | As required |
| 6, 19 | Main bearing inside surfaces | Engine oil | As required |
| 13 | Side seal ends and grooves | Threebond 1207C | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|----------------------------------|
| 5 | Socket Wrench  01984 | MH061560 | Installation of main bearing cap |
| 11 | Bearing Cap Extractor  M8 × 1.25 60 03516 | MH061083 | Removal of main bearing caps |


CRANKSHAFT AND CRANKCASE

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|---------------------------------------|
| 15 | Gear Puller  02065 | MH061326 | Removal of crankshaft gear |
| 17 | Rear Oil Seal Slinger Installer  02051 | MH062677 | Installation of rear oil seal slinger |

◆ Service procedure

● Inspection before disassembly

Crankshaft end play

If the measurement exceeds the specified limit, replace thrust plate 12 with an oversize type.  P11-66

<Oversize types>

+0.15, +0.30, +0.45 mm

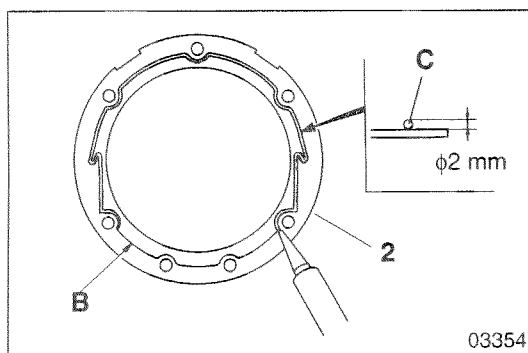
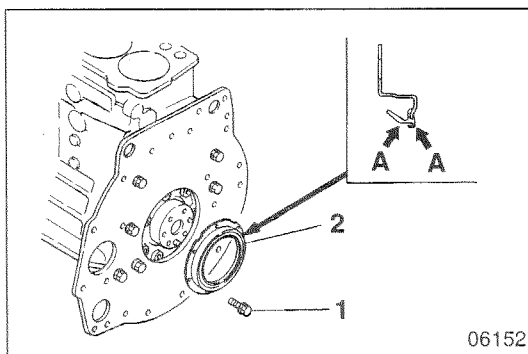
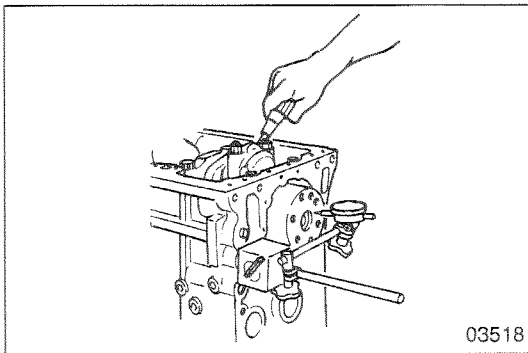
2 Mounting of rear oil seal

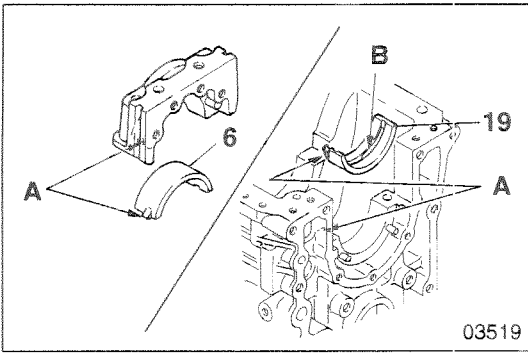
- Apply engine oil to lips **A** of rear oil seal 2.

- Apply sealant **C** along line **B** inscribed on the rear oil seal 2 evenly without break. (φ2 mm)
- After applying sealant **C**, install the rear oil seal 2 within three minutes.

CAUTION

- After fitting rear oil seal 2, wait at least an hour before starting the engine.
- Apply a new bead of sealant **C** whenever mounting bolts 1 of rear oil seal 2 have been loosened.

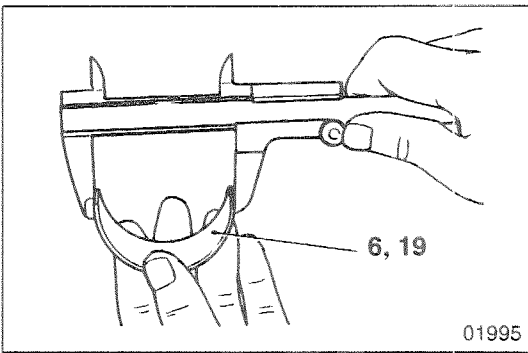




6 19 Main bearings

[Installation]
Install main bearings 6, 19 such that their lugs A fit into the corresponding grooves.

CAUTION ⚠
Upper main bearings 19 have an oil hole B. Lower main bearings 6 have no oil hole. Take care not to confuse the upper and lower parts.

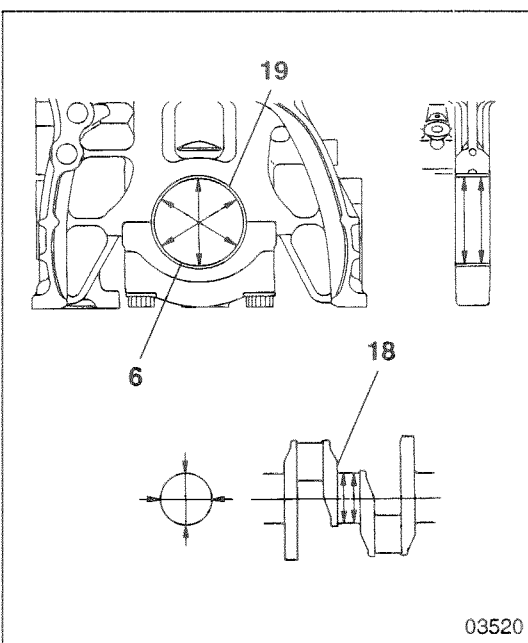


[Inspection]

CAUTION ⚠
• Do not attempt to manually expand either bearing 6, 19 if its span is insufficient.
• Upper and lower bearings 6, 19 must be replaced as a set.

(1) Span when free

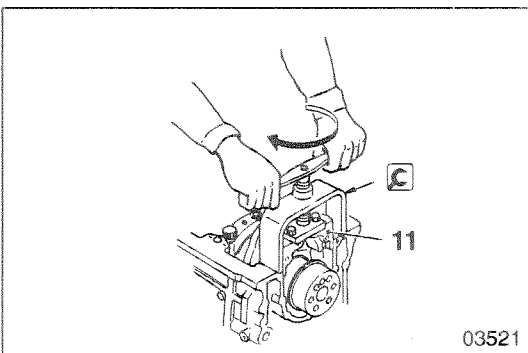
If either bearing's span when free exceeds the specified limit, the bearings 6, 19 must be replaced.



(2) Main bearing-to-crankshaft clearance

If any measurement exceeds the specified limit, replace the defective part(s).

If the main bearings 6, 19 are replaced with undersize types, rectify the outside diameter of the crankshaft 18 journal to the specified undersize dimension. P11-68

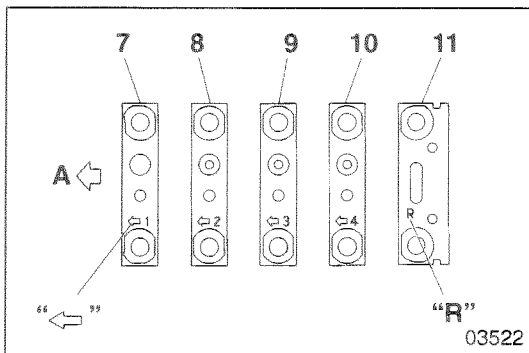


7 to 11 Main bearing caps

[Removal]

Side seals 13 are pressed into rear main bearing cap 11 to achieve a secure fit in crankcase 22. Therefore, the rear bearing cap must be removed with the (C) Bearing Cap Extractor.

CRANKSHAFT AND CRANKCASE

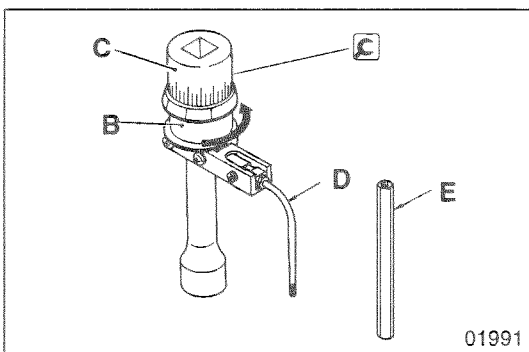


[Installation]

- Fit main bearing caps 7 to 10 with their front marks ("⇔") pointing toward the front of engine A.
- Fit rear main bearing cap 11 with its embossed mark ("R") positioned as shown in the drawing.
- Bolts 5 can be reused only three times. Before fitting the bolts, make a punch mark on the head of each one to indicate how many times it has been reused.

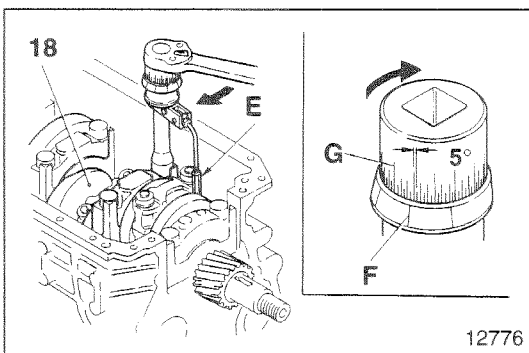
CAUTION ⚠

If any bolt already has three punch marks, it cannot be used again; replace it with a new one.



- Tighten bolts 5 to the specified torque [59 N · m (6 kgf · m)]. Then, turn the bolts further in accordance with the following procedure:
- Turn holder B of the C Socket Wrench counter-clockwise to tension the built-in spring.

C: Socket
D: Rod
E: Rod (extension)



- Set the socket wrench such that the built-in spring force forces rod E against crankshaft 18.
- On holder B, select inscribed line F that is easiest to see.
- Using the selected line as a reference, turn socket C 90° clockwise. (One gradation on scale G represents 5°.)

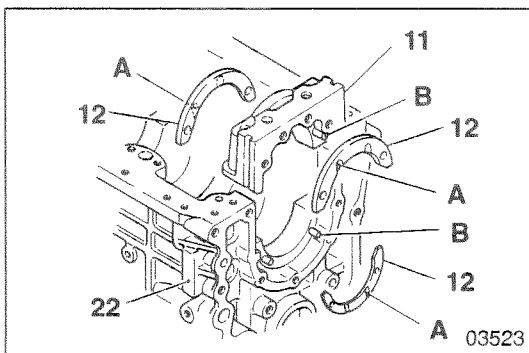
CAUTION ⚠

Since bolts 1 utilize the plastic region tightening method, they must not be tightened further after this procedure.

After installing the main bearing caps:

- Check that crankshaft 18 can be turned easily by hand;
- Check the amount of end play in crankshaft 18.

📖 P11-64



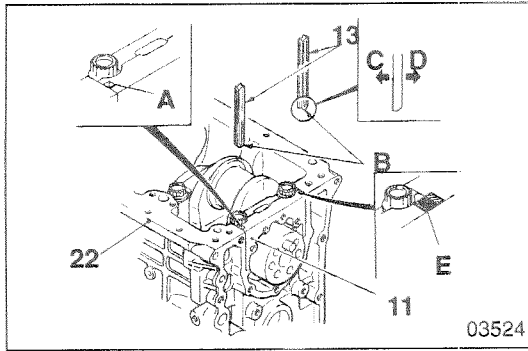
12 Installation of thrust plates

Fit a thrust plate 12 on each side of main bearing caps 11 and at the rear end of crankcase 22 such that the oil grooves A are on the outside.

B: Locating pin

NOTE

If oversize thrust plates 12 are used, they must be fitted on both sides of bearing caps 11. Ensure that the bearing cap rear thrust plates and the rearmost thrust plate in crankcase 22 are the same size. Note, however, that the front and rear thrust plates on each bearing cap may be of different sizes.



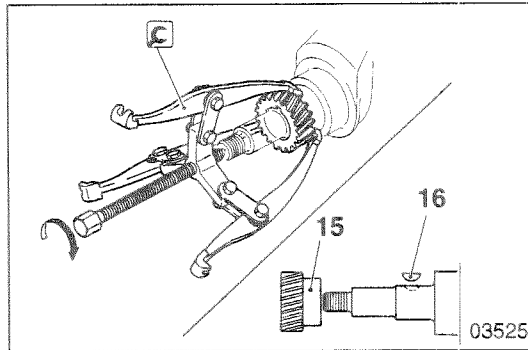
13 Installation of side seals

- Fill sealant into side seal mounting grooves **A** in rear main bearing cap **11**.
- Coat ends **B** of side seals **13** with sealant.
- Drive side seal **13** into the grooves between rear main bearing cap **11** and crankcase **22**.

C: Rear main bearing side

D: Crankcase side

- Apply sealant to main bearing cap **11** at section **E** where the side seal has been installed.



15 Crankshaft gear

[Removal]

Avoid striking crankshaft gear **15** when it is removed.

Gear Puller

[Installation]

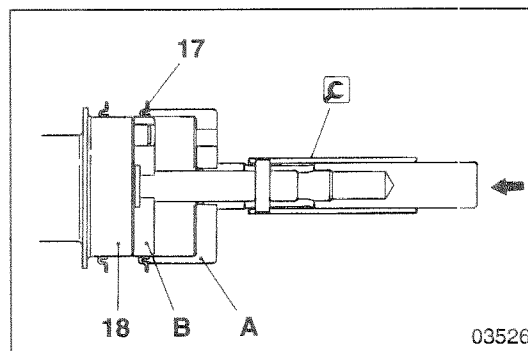
Heat crankshaft gear **15** with a piston heater to approx. 100°C before installation.

NOTE

Be sure to install key **16** which prevents the gear from rotating on the shaft.

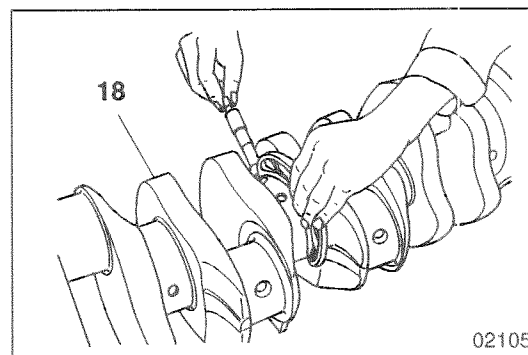
WARNING

Be careful not to get burned.



17 Installation of rear oil seal slinger

Fit rear oil seal slinger **17** by striking the end of the Oil Seal Slinger Installer until the Installer section **A** presses firmly against guide section **B**.



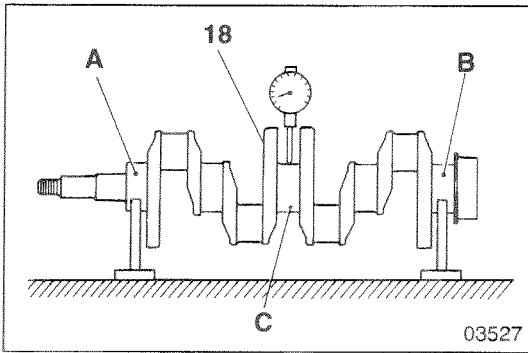
18 Crankshaft

[Inspection]

(1) Roundness and cylindricity of crankshaft journal and pin

If either measurement exceeds the specified limit, replace crankshaft **18** or grind it to undersize.

CRANKSHAFT AND CRANKCASE

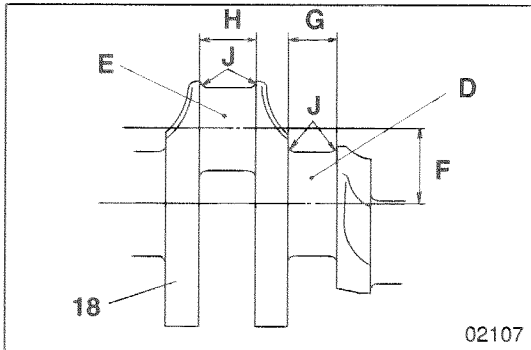


(2) Bend

- Support crankshaft 18 at its No. 1 journal A and No. 5 journal B. Measure the extent of bending in the crankshaft at the centre of No. 3 journal C.
If the measurement exceeds the specified limit, replace the crankshaft.

NOTE

With the dial indicator applied to the centre journal, turn the crankshaft 18 through one revolution. One-half of the dial indicator reading represents the extent of bending.



[Correction]

NOTE

If crankshaft 18 is rectified by grinding, main bearings 6, 19 must be replaced with undersized ones.

- Grind such that centre-to-centre distance F between journal D and pin E does not change.

F: 57.5 ± 0.05 mm <4D33, 34-T>
 52.5 ± 0.05 mm <4D31, 31-T, 32>

- Grind such that journal width G and pin width H do not change.

G: 35 mm (No. 1 journal 32 mm)

H: $41 \begin{smallmatrix} +0.2 \\ 0 \end{smallmatrix}$ mm

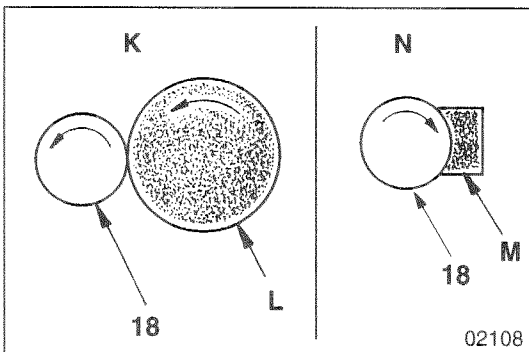
- Finish corner fillets J smoothly and to the specified radius.

J: $R4 \pm 0.2$ mm

- Carry out a magnetic inspection to check for cracks caused by grinding. Also, check that the Shore hardness of the surface has not dropped below Hs 75.

- When grinding K, turn crankshaft 18 counter-clockwise as viewed from its front end. Grinder L should rotate in the same direction.

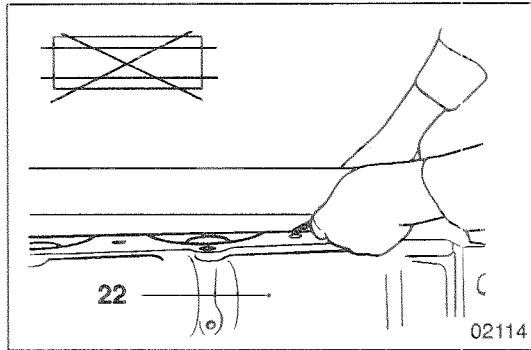
- When finishing N the crankshaft 18 with sandpaper or a whetstone M, rotate the crankshaft clockwise.



Crankshaft undersize dimensions

Unit: mm

| | | Degree of undersize | | | |
|---------------------------|--------------------|---------------------|------------------|------------------|------------------|
| | | 0.25 | 0.50 | 0.75 | 1.00 |
| Finished journal diameter | No.1, 2, 4, 5 | 77.68 to 77.70 | 77.43 to 77.45 | 77.18 to 77.20 | 76.93 to 76.95 |
| | No.3 | 77.66 to 77.68 | 77.41 to 77.43 | 77.16 to 77.18 | 76.91 to 76.93 |
| Finished pin diameter | 4D31, 31-T, 32, 33 | 59.695 to 59.715 | 59.445 to 59.465 | 59.195 to 59.215 | 58.945 to 58.965 |
| | 4D34-T | 64.69 to 64.71 | 64.44 to 64.46 | 64.19 to 64.21 | 63.94 to 63.96 |
| Roundness | | 0.01 or less | | | |
| Cylindricity | | 0.006 or less | | | |



22 Distortion of crankcase top surface

If distortion exceeds the specified limit, correct it with a surface grinder.

CAUTION

When grinding crankcase 22, take care that the piston projections stay within specification.

Piston projection: P11-44

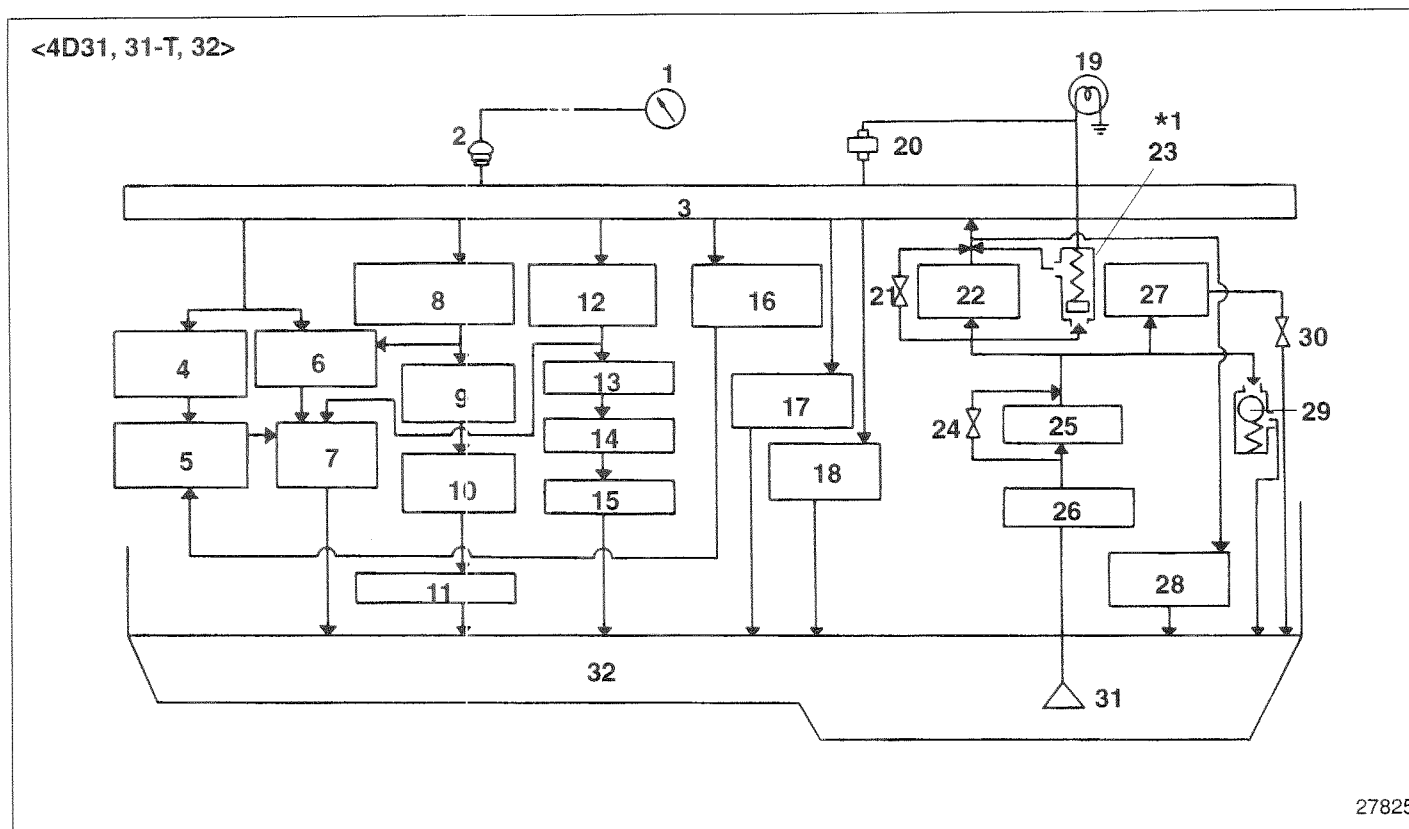
GROUP 12 LUBRICATION

| | |
|--|--------------|
| SPECIFICATIONS | 12-2 |
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| • Engine Oil Replacement | 12-14 |
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| OIL PUMP | |
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| <4D32, 33, 34-T> | 12-20 |
| OIL COOLER AND OIL FILTER | |
| <4D31, 31-T> | 12-24 |
| <4D32, 33, 34-T> | 12-26 |

SPECIFICATIONS

| Item | | | Specifications |
|----------------------|----------------------|--------------|---|
| Mode of lubrication | | | Oil pump type |
| Oil filter type | | | Spin-on paper-element type |
| Regulator valve type | | | Piston valve type |
| Bypass valve type | | | Piston valve type |
| Oil cooler type | | | Shell and plate type (multi-plate type) |
| Engine oil | Grade | 4D31, 32, 33 | API CC or above |
| | | 4D31-T, 34-T | API CD or above |
| | Quantity of oil L | Oil pan | 7 <Option: 10> |
| | | Oil filter | |
| | 4D31, 31-T, 32 | 1.2 | |
| | 4D33, 34-T | 1 | |

Lubrication System (Oil Flow)

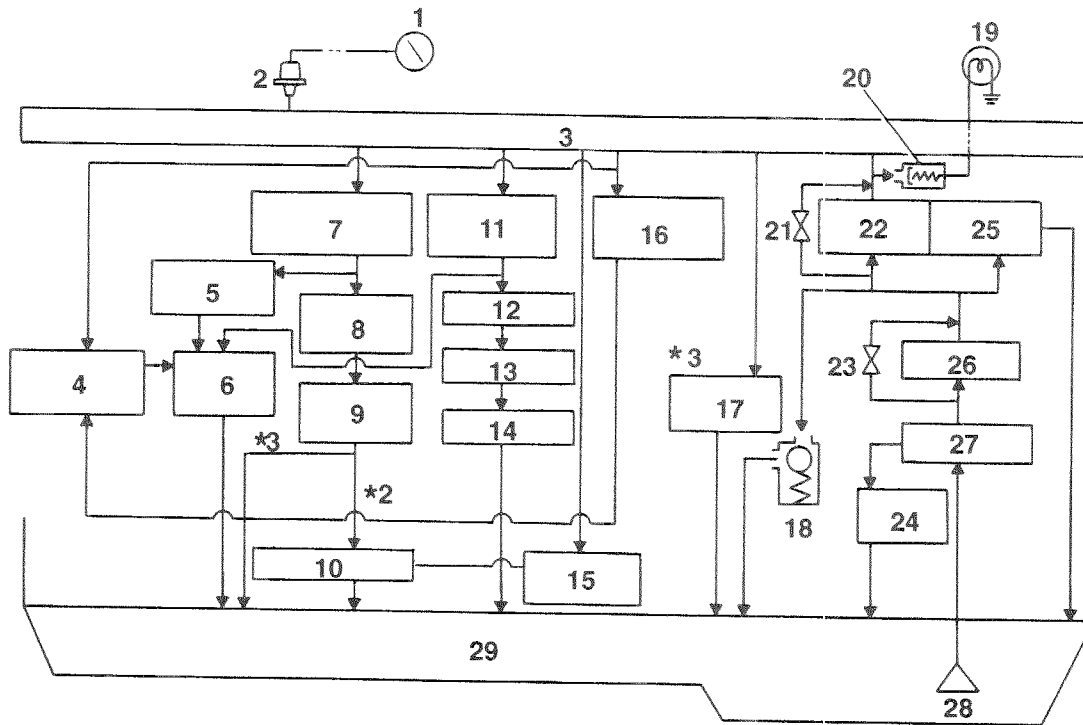


27825

- | | |
|---------------------------|-------------------------|
| 1 Oil pressure gauge | 18 Turbocharger |
| 2 Oil pressure gauge unit | 19 Warning lamp |
| 3 Main oil gallery | 20 Oil pressure switch |
| 4 Oil jet | 21 Bypass valve |
| 5 Automatic timer | 22 Full-flow oil filter |
| 6 Idler gear bushing | 23 Oil bypass alarm |
| 7 Timing gear | 24 Bypass valve |
| 8 Crankshaft main bearing | 25 Oil cooler |
| 9 Connecting rod bearing | 26 Oil pump |
| 10 Connecting rod bushing | 27 Bypass oil filter |
| 11 Piston cooling | 28 Oil pump gear |
| 12 Camshaft bushing | 29 Regulator valve |
| 13 Rocker bushing | 30 Check valve |
| 14 Push rod | 31 Oil strainer |
| 15 Tappet | 32 Oil pan |
| 16 Injection pump | |
| 17 Vacuum pump | |
- *1 : With oil bypass alarm

STRUCTURE AND OPERATION

<4D33, 34-T>



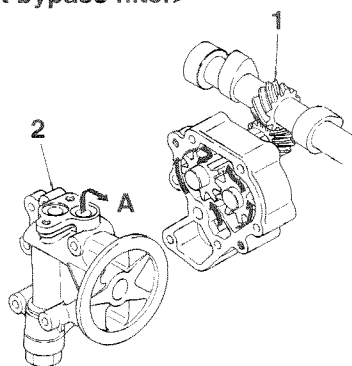
27826

- | | |
|-----------------------------|-------------------------|
| 1 Oil pressure gauge | 17 Turbocharger |
| 2 Oil pressure gauge unit | 18 Regulator valve |
| 3 Main oil gallery | 19 Warning lamp |
| 4 Automatic timer | 20 Oil pressure switch |
| 5 Idler gear bushing | 21 Bypass valve |
| 6 Timing gear bushing | 22 Full-flow oil filter |
| 7 Crankshaft main bearing | 23 Bypass valve |
| 8 Connecting rod bearing | 24 Relief valve |
| 9 Connecting rod bushing | 25 Bypass oil filter |
| 10 Piston cooling | 26 Oil cooler |
| 11 Camshaft bushing | 27 Oil pump |
| 12 Rocker bushing | 28 Oil strainer |
| 13 Push rod | 29 Oil pan |
| 14 Tappet | |
| 15 Oil jet (piston cooling) | *2: 4D33 |
| 16 Injection pump | *3: 4D34-T |

Oil Pump

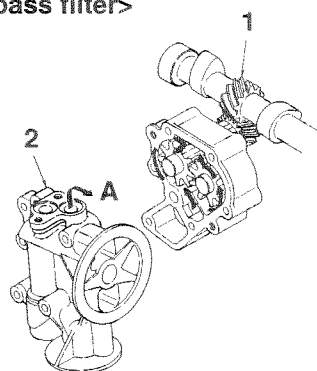
<4D31, 31-T>

<Without bypass filter>



29358

<With bypass filter>



29359

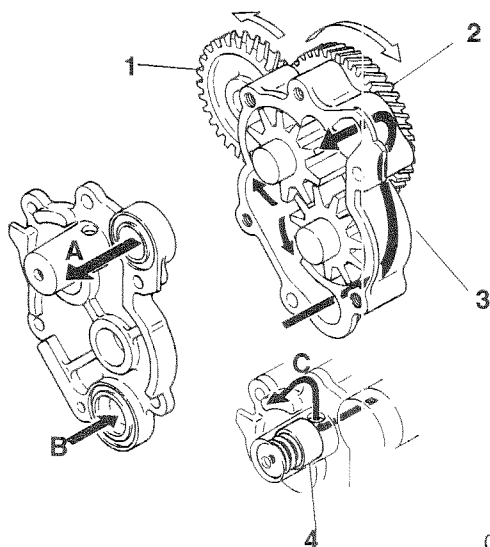
- 1 Skew gear
- 2 Oil pump cover

A: To oil cooler

The oil pump, of a gear type, is driven by the skew gear **1** mounted on the camshaft.

The oil pump cover **2** serves also as the oil filter head, requiring no oil pipe.

<4D32, 33, 34-T>



06429

- 1 Crankshaft gear
- 2 Oil pump gear
- 3 Oil pump
- 4 Relief valve

A: To oil cooler

B: From oil strainer

C: To oil pan

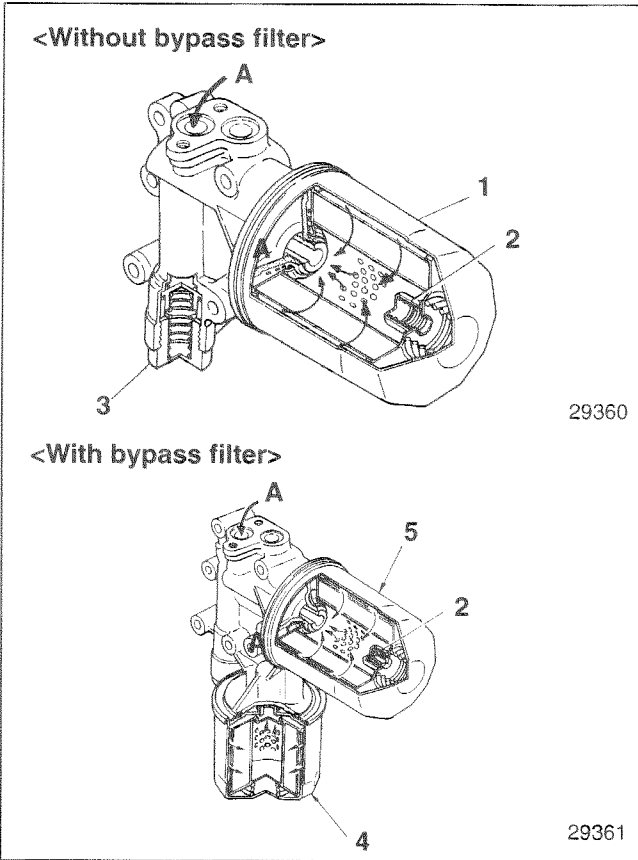
Oil pump **3** is a gear type. It is driven by rotation of the crankshaft via crankshaft gear **1** and oil pump gear **2**.

Relief valve **4** is fitted to the oil pump. When the oil pump discharge pressure exceeds a specified level, the relief valve returns some of the engine oil to the oil pan, thus protecting the lubrication system from excessive oil pressure.

STRUCTURE AND OPERATION

Oil Cooler and Oil Filter

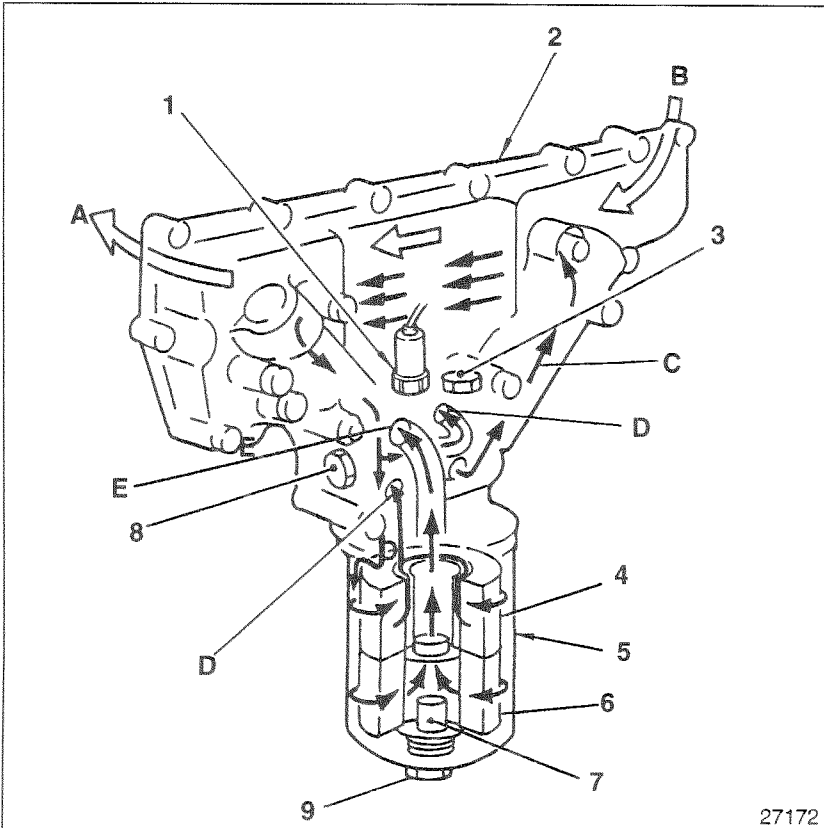
<4D31, 31-T>



- 1 Oil filter
- 2 Bypass valve
- 3 Relief valve
- 4 Bypass oil filter
- 5 Full flow filter

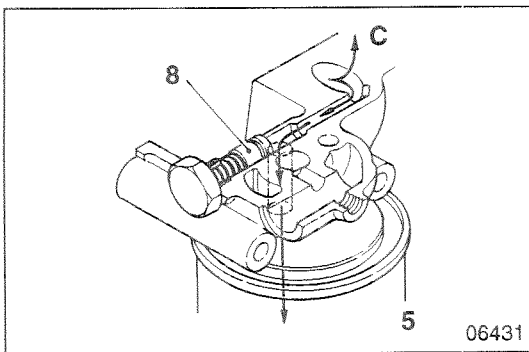
A: From oil cooler

<4D32, 33, 34-T>



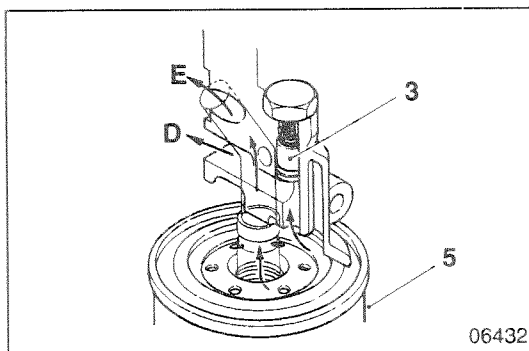
- 1 Oil pressure switch
- 2 Oil cooler
- 3 Regulator valve
- 4 Bypass filter
- 5 Oil filter
- 6 Full-flow filter
- 7 Bypass valve
- 8 Bypass valve
- 9 Drain plug

A: Coolant outlet
 B: Coolant inlet
 C: To oil cooler
 D: To oil pan
 E: To oil main gallery



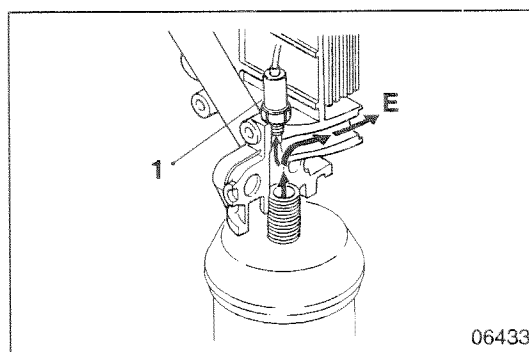
● Bypass valve

When the oil's viscosity is high at low temperatures or when oil cooler 2 element is clogged and resists the oil's flow, bypass valve 8 opens, thus allowing oil to flow to oil filter 5 without passing through the cooler.



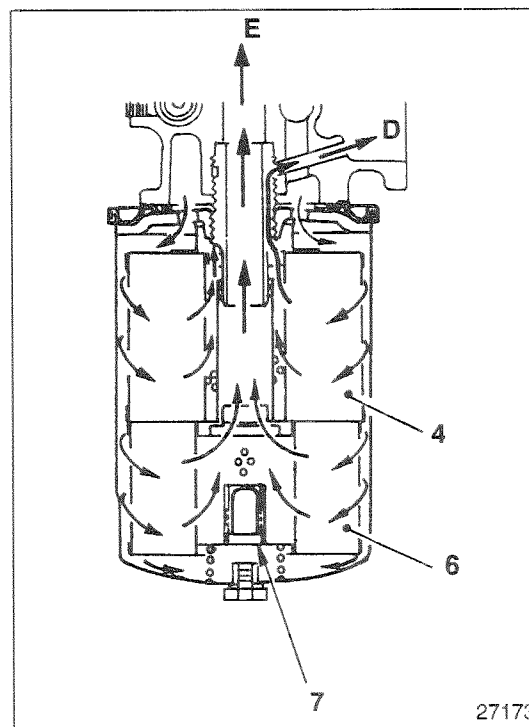
● Regulator valve

When the pressure of oil going to the main oil gallery exceeds a specified level, regulator valve 3 opens, allowing some of the oil to return to the oil pan. The oil pressure is thus constantly regulated.



● Oil pressure switch

If the pressure of oil fed to main oil gallery E drops below the specified level, electric contacts close inside pressure switch 1. As a result, a warning lamp illuminates in the meter cluster to alert the driver.



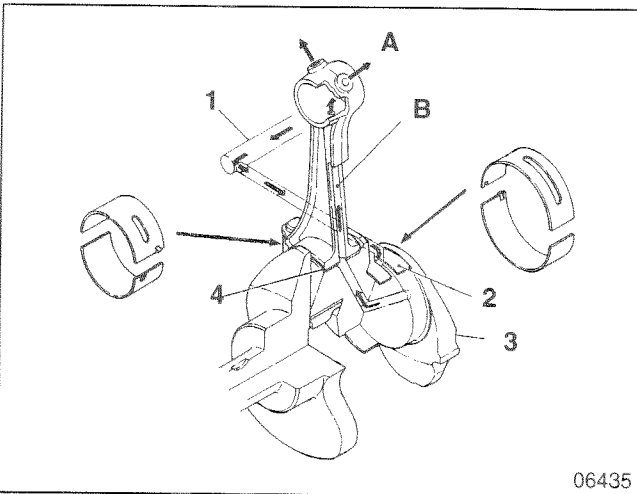
● Oil filter

The oil filter is a spin-on filter-paper type incorporating a full-flow filter 6 and a bypass filter 4.

A bypass valve 7 is fitted at the bottom of the filter assembly. If the elements become clogged, the bypass valve opens and allows oil to flow to main gallery E without passing through the elements. This operation prevents seizure of the engine.

STRUCTURE AND OPERATION

Lubrication of Related Parts



● Main bearing and connecting rod bearing

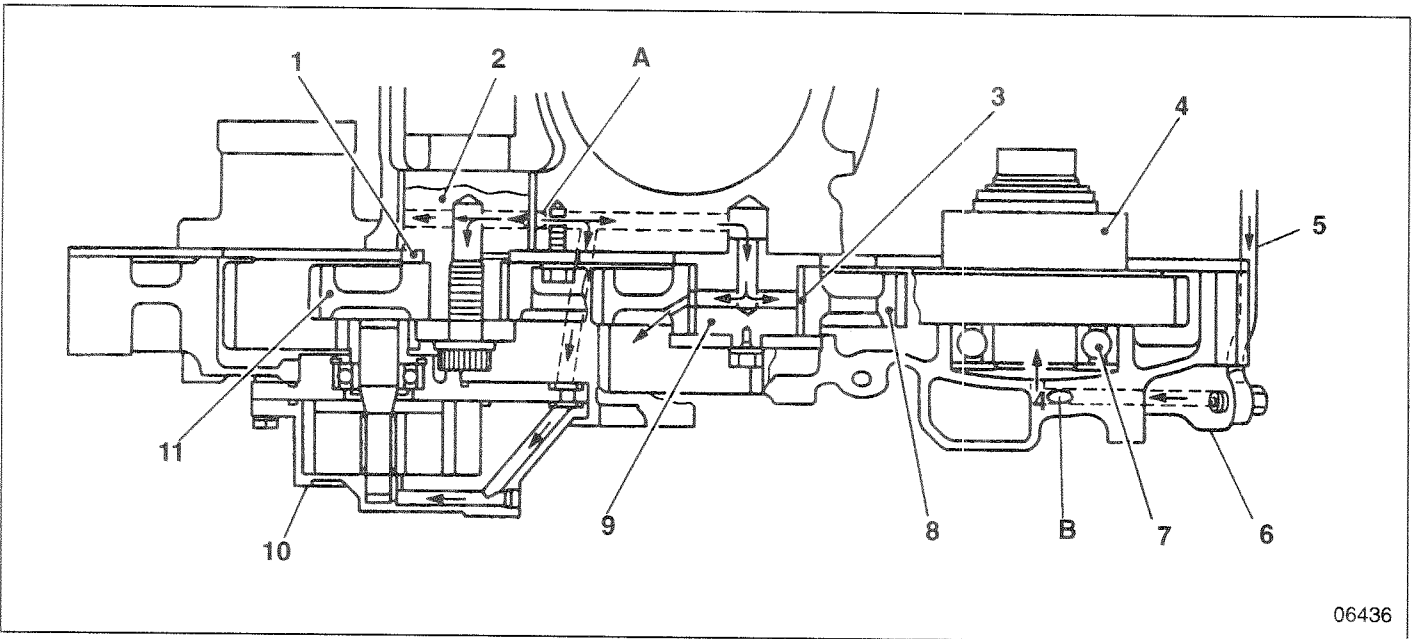
- 1 Oil main gallery
- 2 Main bearing
- 3 Crankshaft
- 4 Connecting rod bearing

A: Oil jet <4D33>
 B: Connecting rod oil passage

Oil supplied via the oil passage in the crankshaft flows through oil passage **B** in the connecting rod to lubricate the connecting rod's small end. On 4D33 engine, the oil then sprays out from oil jet **A** at the top of the connecting rod to cool the piston.

06435

● Timing gear

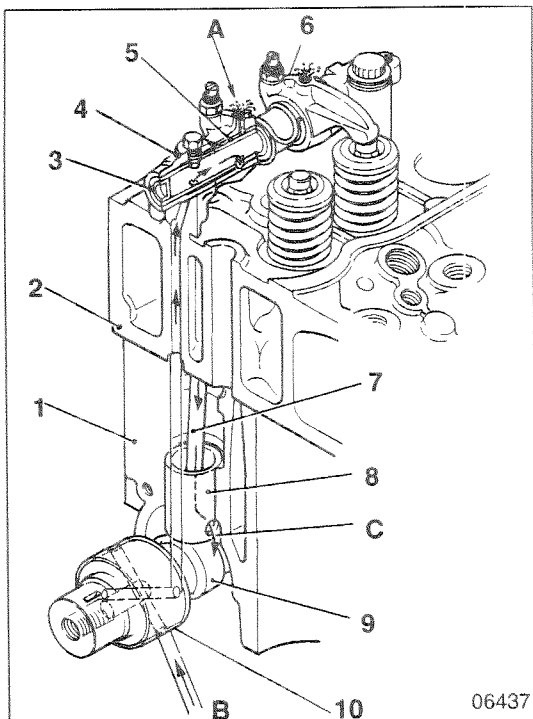


06436

- 1 Thrust plate
- 2 Camshaft
- 3 Idler gear bushing
- 4 Automatic timer
- 5 Oil pipe
- 6 Timing gear case
- 7 Bearing
- 8 Idler gear
- 9 Idler shaft
- 10 Vacuum pump
- 11 Camshaft gear

A: From main oil gallery
 B: Oil jet (for forced lubrication of automatic timer)

Engine oil from main oil gallery **A** passes through camshaft **2** and idler shaft **9** to lubricate the gears and vacuum pump **10**. An oil jet **B** is provided in timing gear case **6** to provide constant, forced lubrication of the automatic timer.



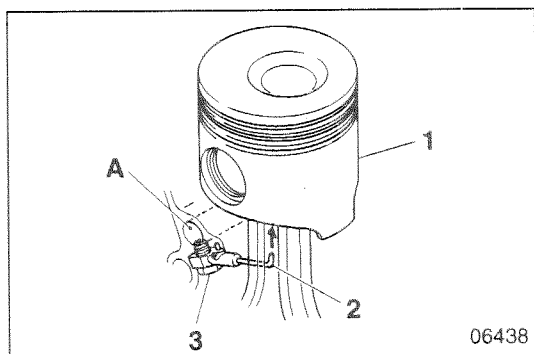
● Valve mechanism

- 1 Crankcase
- 2 Cylinder head
- 3 Rocker shaft
- 4 Rocker shaft bracket
- 5 Rocker bushing
- 6 Rocker
- 7 Push rod
- 8 Tappet
- 9 Camshaft
- 10 Camshaft bushing No. 1

A: Rocker oil hole

B: From main oil gallery

C: To oil pan

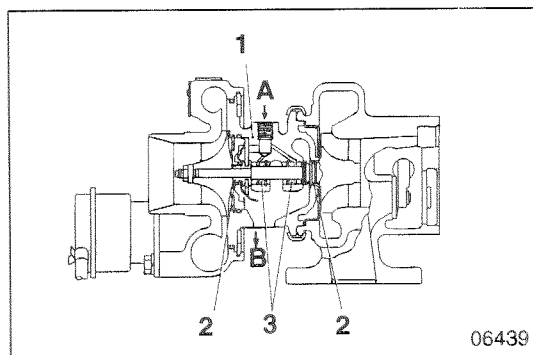


● Oil jet

- 1 Piston
- 2 Oil jet
- 3 Check valve

A: Main oil gallery

An oil jet 2 is fitted in the lower part of main oil gallery A for each piston. These oil jets cool pistons 1 by injecting oil into them. Each oil jet is fitted with a check valve 3 that opens and closes at specified oil pressure levels. At low oil pressures, these check valves close to maintain the required volume of oil in the lubrication system and prevent reductions in oil pressure.



● Turbocharger <4D31-T, 34-T>

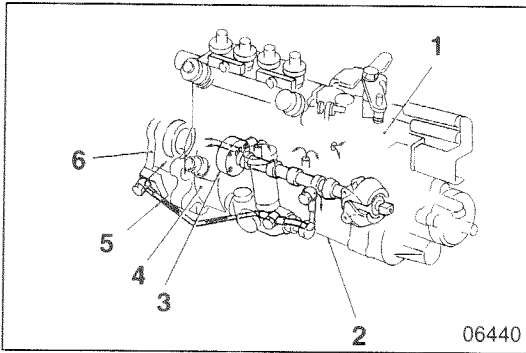
- 1 Bearing housing
- 2 Piston ring
- 3 Bearing

A: From main oil gallery

B: To oil pan

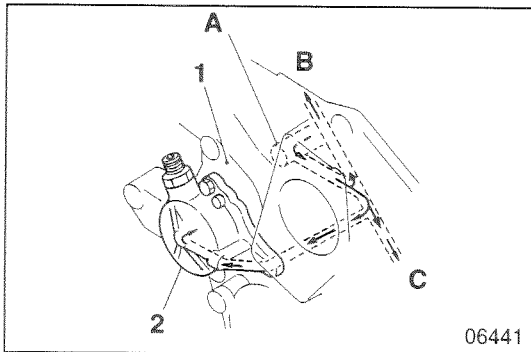
Via an oil pipe, engine oil is delivered from the main oil gallery to bearing housing 1 to lubricate bearing 3. At each end of the turbine wheel shaft, piston ring 2 acts as an oil seal.

STRUCTURE AND OPERATION



- **Injection pump**
 - 1 Governor
 - 2 Injection pump
 - 3 Bearing cover
 - 4 Timer
 - 5 Oil pipe
 - 6 Timing gear case

Engine oil that has lubricated injection pump 2 and governor 1 returns to the oil pan through the oil passage of bearing cover 3.



- **Vacuum pump**
 - 1 Timing gear case
 - 2 Vacuum pump

- A: Main oil gallery
- B: To camshaft
- C: To crankshaft

Engine oil is delivered from main oil gallery A to vacuum pump 2 through the oil passage of timing gear case 1 to lubricate the vanes. Then, the oil is discharged to timing gear case through the air outlet port together with air to be returned to the oil pan.

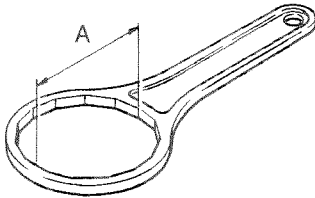
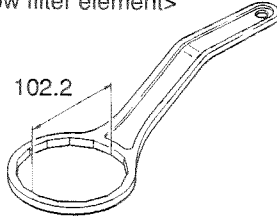
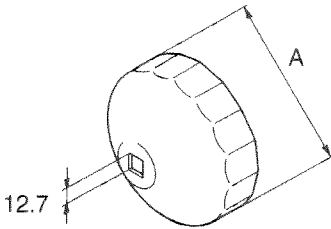
| Possible causes | | Symptoms | | | | Remarks |
|---|---|-----------------------|-----------------------|-----------------------|---|---------|
| | | Engine hard to start | Overheating | Low oil pressure | Excessive oil consumption (oil leakage) | |
| Oil cooler | Oil cooler element installed poorly | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| | Gasket defective | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| | O-ring defective | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| | Oil cooler element clogged | | <input type="radio"/> | <input type="radio"/> | | |
| | Oil cooler element damaged | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| | Fatigue in bypass valve spring | | <input type="radio"/> | | | |
| | Fatigue in regulator valve spring | | | <input type="radio"/> | | |
| Oil pump | Oil pump malfunctioning | | <input type="radio"/> | <input type="radio"/> | | |
| | Interference between oil pump gear and oil pump case or cover | <input type="radio"/> | | <input type="radio"/> | | |
| | Fatigue in relief valve spring | | | <input type="radio"/> | | |
| Oil filter | Oil filter fitted poorly | | | | <input type="radio"/> | |
| | Element clogged | | <input type="radio"/> | <input type="radio"/> | | |
| | Gasket defective | | | <input type="radio"/> | | |
| Oil strainer installed poorly and/or clogged | | | <input type="radio"/> | <input type="radio"/> | | |
| Crankshaft front oil seal defective | | | | | <input type="radio"/> | Gr 11 |
| Crankshaft rear oil seal defective | | | | | <input type="radio"/> | Gr 11 |
| Timing gear case installed poorly | | | | | <input type="radio"/> | Gr 11 |
| Piston cooling oil jet(s) defective | | | <input type="radio"/> | | | |
| Oil working its way up into combustion chamber(s) | | | | | <input type="radio"/> | |
| Oil working its way down into combustion chamber(s) | | | | | <input type="radio"/> | |
| Oil viscosity too high | | <input type="radio"/> | | | | |
| Unsuitable oil quality | | | <input type="radio"/> | | | |
| Deterioration in oil | | | <input type="radio"/> | | | |
| Fuel mixed with oil | | | <input type="radio"/> | | | |

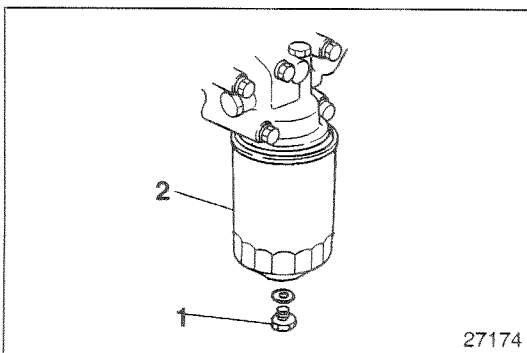
ON-VEHICLE INSPECTION AND ADJUSTMENT

Oil Filter Replacement

☑ Special tools

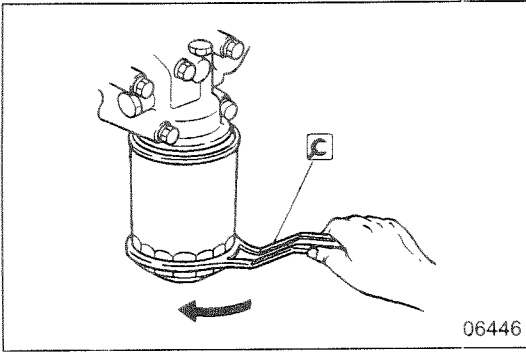
Unit: mm

| Location | Tool name and shape | Part No. | Application | | | | | | | | | |
|---|---|---------------------------------------|---------------------------------------|-------------|----------|--------------------------|--------------------------|----------|---------------------------------------|---------------------------------------|----------------------|--------------------|
| — |  01882 <table border="1"> <thead> <tr> <th>Part No.</th> <th>Dimension A</th> <th>Application</th> </tr> </thead> <tbody> <tr> <td>MH061510</td> <td>102.2</td> <td>Full-flow filter element</td> </tr> <tr> <td>MH061509</td> <td>90.2</td> <td>Bypass filter element <4D31, 31-T></td> </tr> </tbody> </table> | Part No. | Dimension A | Application | MH061510 | 102.2 | Full-flow filter element | MH061509 | 90.2 | Bypass filter element <4D31, 31-T> | MH061509 MH061510 | Oil filter removal |
| | Part No. | Dimension A | Application | | | | | | | | | |
| | MH061510 | 102.2 | Full-flow filter element | | | | | | | | | |
| | MH061509 | 90.2 | Bypass filter element <4D31, 31-T> | | | | | | | | | |
| <For full-flow filter element>  06478 | MH061587 | | | | | | | | | | | |
| Oil Filter Element Socket  27828 | MH061565 | | | | | | | | | | | |
| Bypass Oil Filter Element Socket <table border="1"> <thead> <tr> <th>Part No.</th> <th>Dimension A</th> <th>Application</th> </tr> </thead> <tbody> <tr> <td>MH061565</td> <td>102.2</td> <td>Full-flow filter element</td> </tr> <tr> <td>MH061564</td> <td>89.4</td> <td>Bypass filter element <4D31, 31-T></td> </tr> </tbody> </table> | Part No. | Dimension A | Application | MH061565 | 102.2 | Full-flow filter element | MH061564 | 89.4 | Bypass filter element <4D31, 31-T> | MH061564 | | |
| Part No. | Dimension A | Application | | | | | | | | | | |
| MH061565 | 102.2 | Full-flow filter element | | | | | | | | | | |
| MH061564 | 89.4 | Bypass filter element <4D31, 31-T> | | | | | | | | | | |

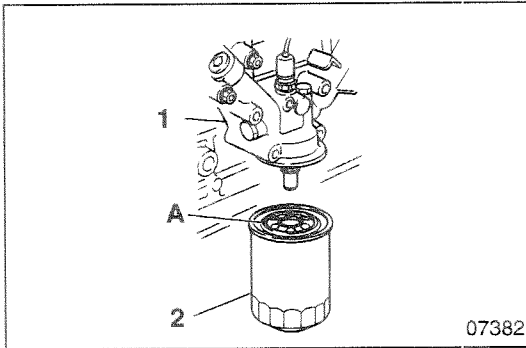


[Removal]

On 4D32, 33, 34-T, remove drain plug 1 of oil filter 2 to drain engine oil inside it before removing the filter.



C: Oil Filter Wrench



[Installation]

- Clean the surface on oil cooler body **1** that makes contact with oil filter **2**.
- Apply a film of engine oil to gasket area **A** of filter **2**.
- Screw on the oil filter until gasket area **A** touches oil cooler body **1**. Then, give the oil filter another three-quarters of a turn to tighten it completely.
- Start the engine and check that no oil leaks from gasket area **A**.
- Check the engine oil level and add oil if necessary.

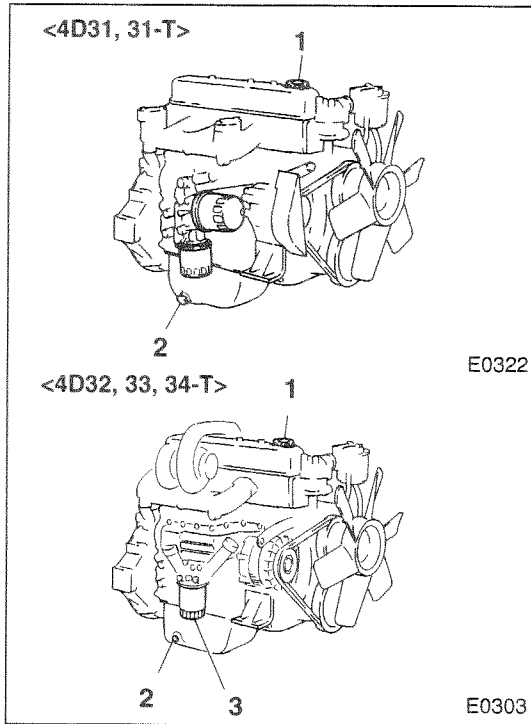
ON-VEHICLE INSPECTION AND ADJUSTMENT

Engine Oil Replacement

① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|--|-----|-----------------------|---------|
| — | Oil pan drain plug | M14 | 34 to 39 {3.5 to 4.0} | — |
| | | M18 | 68 {7.0} | Dry |
| — | Oil filter drain plug <4D32, 33, 34-T> | | 9.8 ± 2 {1 ± 0.2} | — |



[Draining]

Warm up the engine and remove oil filler cap 1. Then, remove oil pan drain plug 2 and allow the engine oil to drain out.

<4D32, 33, 34-T>

Remove the oil filter drain plug 3 to allow the engine oil inside the oil filter to drain out.

[Filling]

Tighten oil pan drain plug 2 to the specified torque. Then, pour the specified amount of new engine oil into the engine.

Tightening torque: 34 to 39 N · m {3.5 to 4.0 kgf · m}

Engine oil used:

Quality: API CC or above <4D31, 32, 33>

API CD or above <4D31-T, 34-T>

Quantity: Oil pan 7 L <Option: 10 L>

Oil filter 1.2 L <4D31, 31-T>

1 L <4D32, 33, 34-T>

Oil Pressure Measurement

Service standards

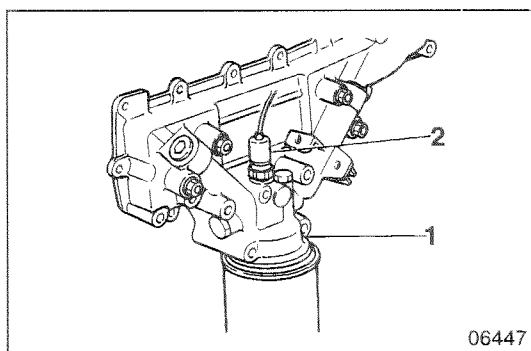
Unit: kPa {kgf/cm²}

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|--|--------------------------|---------------------|---------|
| — | Oil pressure (at oil temperature 70 to 90°C) | At no-load minimum speed | 145 {1.5} | Inspect |
| | | At no-load maximum speed | 295 to 490 {3 to 5} | |

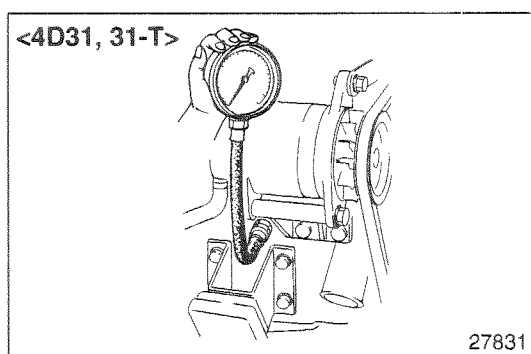
① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|----------------------------|------------------------|-------------|
| 2 | Engine oil pressure switch | 7.8 to 15 {0.8 to 1.5} | Cold engine |



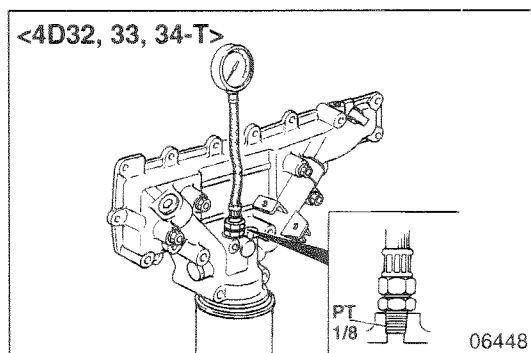
- Remove engine oil pressure switch **2** from oil cooler **1**. Mount an oil pressure gauge in that place, and warm up the engine until the oil temperature reaches 70 to 90°C.
- Measure the oil pressure at the engine's no-load minimum speed and no-load maximum speed. If the measurements are below specification, overhaul the lubrication system.



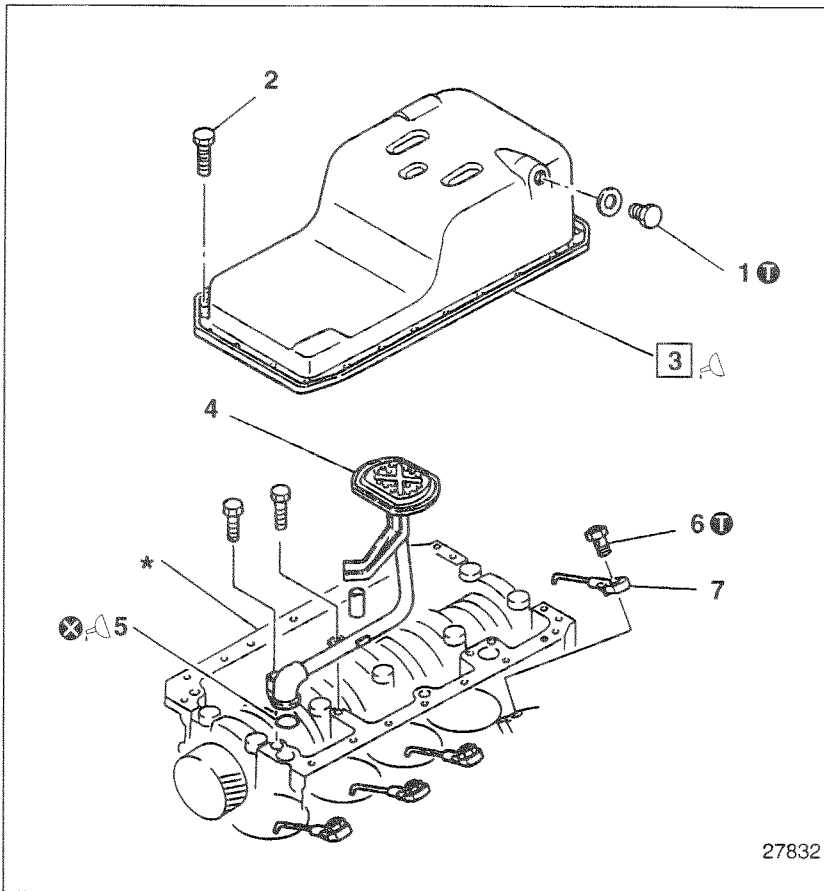
- After taking measurements, refit engine oil pressure switch **2** and tighten it to the specified torque.

Inspection of engine oil pressure switch Gr54

CAUTION _____
 Install oil pressure switch **2** while the engine is cold.



OIL PAN, OIL STRAINER, AND OIL JET



● Disassembly sequence

- 1 Drain plug
- 2 Bolt
- 3 Oil pan
- 4 Oil strainer
- 5 O-ring
- 6 Check valve <4D33, 34-T>
- 7 Oil jet <4D33, 34-T>

*: Crankcase

⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Overtightening of check valve 6 can cause it to malfunction, resulting in engine seizure. Be sure to observe the specified torque.

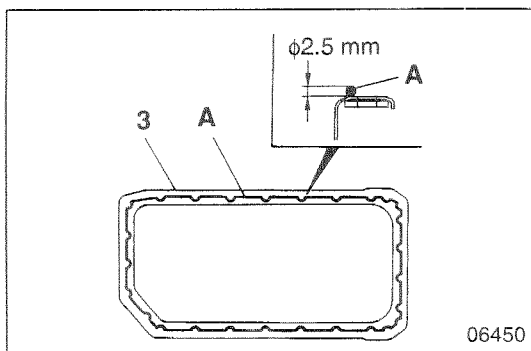
① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------|-----------------------|---------|
| 1 | Drain plug | 34 to 39 {3.5 to 4.0} | — |
| 6 | Check valve <4D33, 34-T> | 29 {3.0} | Wet |

Lubricant and/or sealant

| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|---------------------------------------|------------------------------------|-------------|
| 3 | Crankcase mounting surface of oil pan | Threebond 1207C | As required |
| 5 | Entire circumference of O-ring | Engine oil | As required |



◆ Service procedure

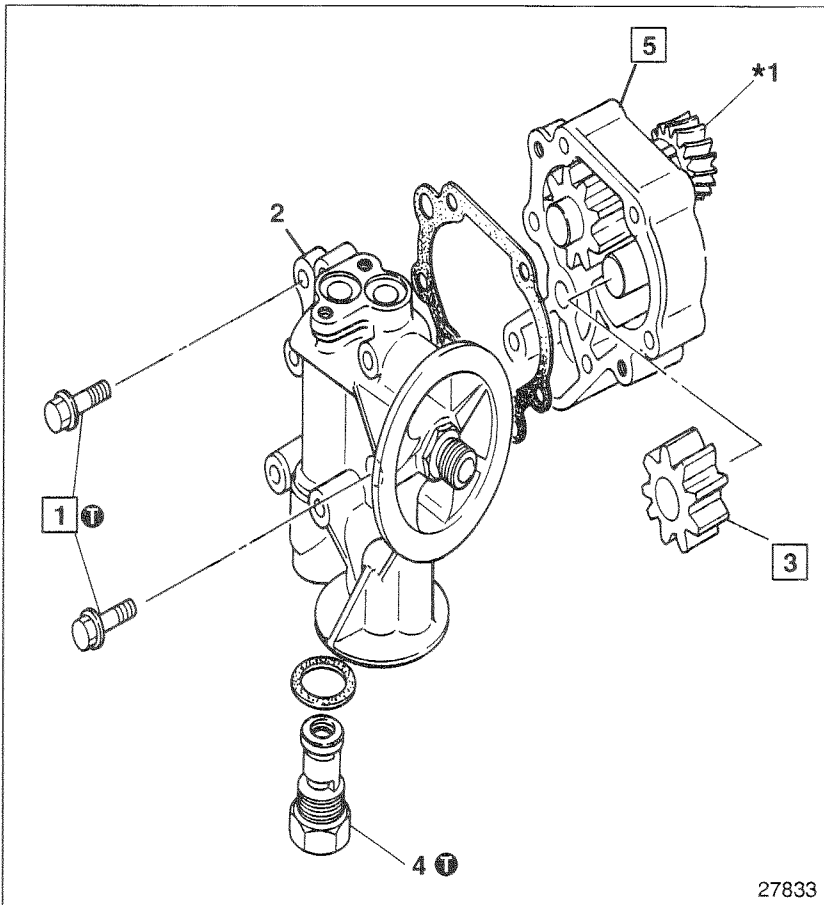
3 Installation of oil pan

- Apply sealant **A** to the mounting surface of oil pan **3** as illustrated. Apply the sealant evenly and without breaks.
- Within three minutes of applying sealant **A**, fit oil pan **3** onto the crank-case*.

CAUTION

- Clean the oil pan mounting surface and ensure it is free of oily substances before applying sealant.
- Carefully mount oil pan **3** exactly in the correct position. Ensure that sealant **A** does not spread to other areas.
- After fitting oil pan **3**, wait at least one hour before starting the engine.
- Apply a new bead of sealant **A** whenever oil pan **3** mounting bolts **2** have been loosened or removed.

OIL PUMP <4D31, 31-T>



● Disassembly sequence

- 1 Bolt
- 2 Oil pump
- 3 Driven gear
- 4 Regulator valve
- 5 Oil pump case assembly

*1: Drive gear

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|--|-------|---------|
| — | Clearance between driven gear shaft and driven gear | [20] 0.04 to 0.07 | 0.15 | Replace |
| 3, 5 | Clearance between oil pump case and tooth tips of each gear | 0.10 to 0.19 | 0.2 | Replace |
| | Difference between height of each gear and depth of oil pump case | 0.01 to 0.07 | 0.18 | Replace |
| 4 | Regulator valve opening pressure | 365 to 420 kPa {3.7 to 4.3 kgf/cm ² } | — | Replace |
| * | Drive gear end play | 0.03 or more | — | — |

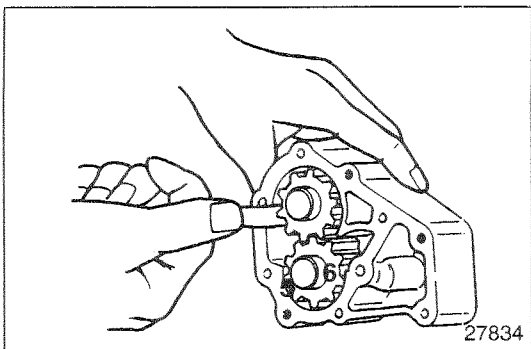
① Tightening torque

Unit: N·m {kgf·m}

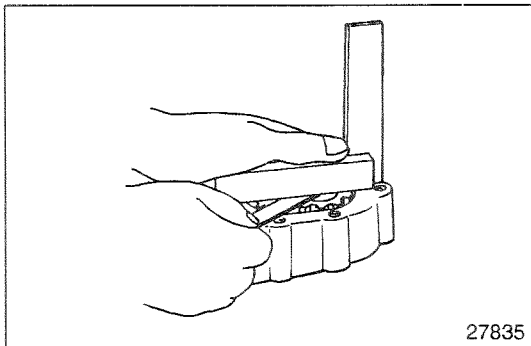
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------------------|-------------------|---------|
| 1 | Oil pump cover to case mounting bolt | 20 {2} | — |
| 4 | Regulator valve | 68 {7} | — |

◆ Service procedure**3 5 Inspection of driven gear and oil pump case assembly****(1) Clearance between oil pump case and tooth tips of each gear**

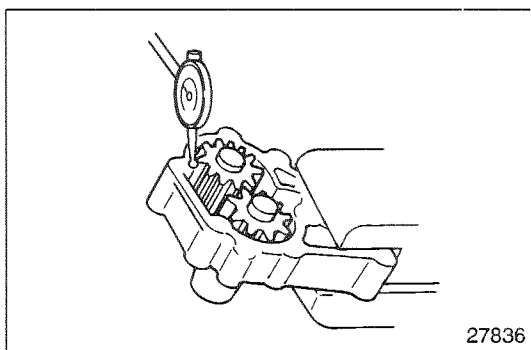
If the measured value exceeds the limit, replace the faulty parts.

**(2) Difference between height of each gear and depth of oil pump case**

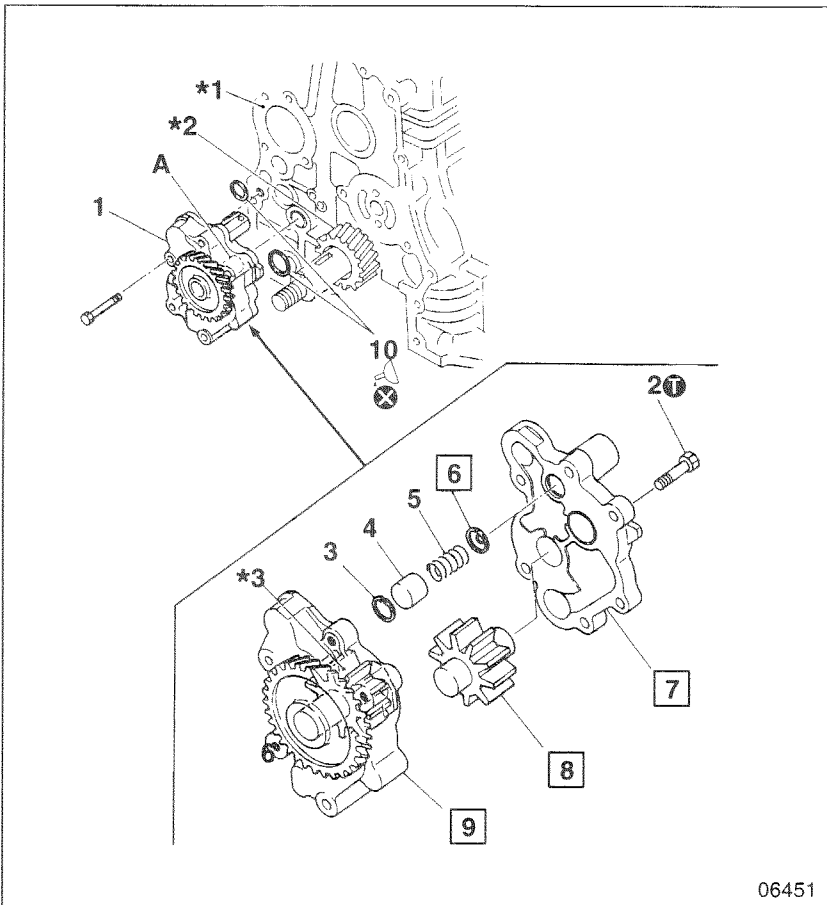
If the measured value exceeds the limit, replace the faulty parts.

**(3) Clearance between driven gear shaft and driven gear**

If the measured value exceeds the limit, replace the faulty parts.



OIL PUMP <4D32, 33, 34-T>



● Disassembly sequence

- 1 Oil pump assembly
- 2 Bolt
- 3 Snap ring
- 4 Relief valve
- 5 Spring
- 6 Seat
- 7 Oil pump cover
- 8 Driven gear assembly
- 9 Oil pump case assembly
- 10 O-ring

*1: Crankcase Gr11

*2: Crankshaft gear

*3: Drive gear

A: Locating pin (bushing)

⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|--|-------|---------|
| — | Backlash between oil pump gear and crankshaft gear Gr11 | 0.10 to 0.18 | 0.3 | Replace |
| 4 | Relief valve opening pressure | 1.1 ± 0.1 MPa { 11 ± 1.0 kgf/cm ² } | — | — |
| 5 | Relief valve spring load (installed length = 33.4) | 217 ± 11 N { 22.1 ± 1.1 kgf ¹ } | — | Replace |
| 7, 8, 9 | Clearance between gear shaft and oil pump case or cover | [20] 0.04 to 0.07 | 0.15 | Replace |
| 7, *3 | Clearance between gear shaft and oil pump cover | [20] 0.04 to 0.07 | 0.15 | Replace |
| 8, 9, *3 | Difference between height of each gear and depth of oil pump case | 0.01 to 0.07 | 0.18 | Replace |
| | Clearance between oil pump case and tooth tips of each gear | 0.10 to 0.19 | 0.2 | Replace |

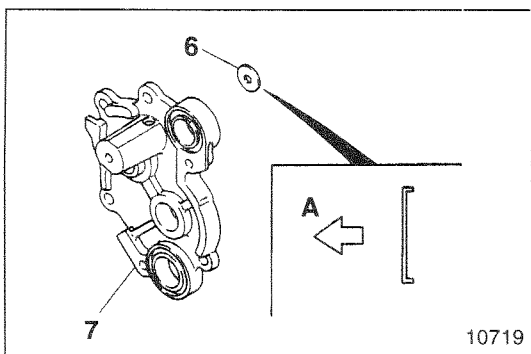
① Tightening torque

Unit: N·m (kgf·m)

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------------|------------------------------|---------|
| 2 | Bolt (oil pump cover mounting) | 10 ± 2 { 1.0 ± 0.2 } | — |

Lubricant

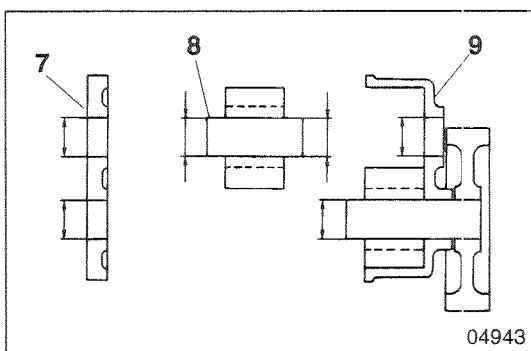
| Location | Points of application | Specified lubricant | Quantity |
|----------|--------------------------------|---------------------|-------------|
| 10 | Entire circumference of O-ring | Engine oil | As required |



◆ Service procedure

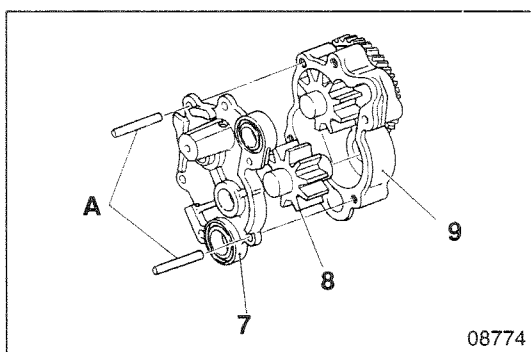
6 Installation of seat

A: Oil pump assembly side



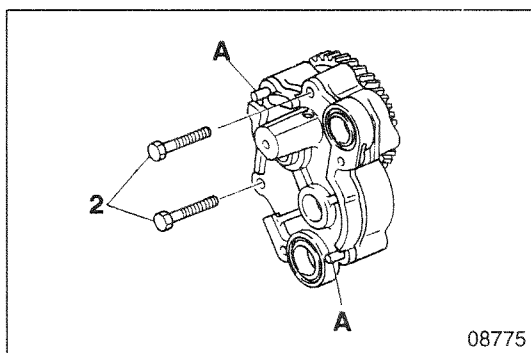
7 to 9 Inspection of oil pump cover, driven gear assembly, and oil pump case assembly

Measure the clearance between each gear shaft and the oil pump case or cover. If the measured value exceeds the limit, replace the faulty parts.

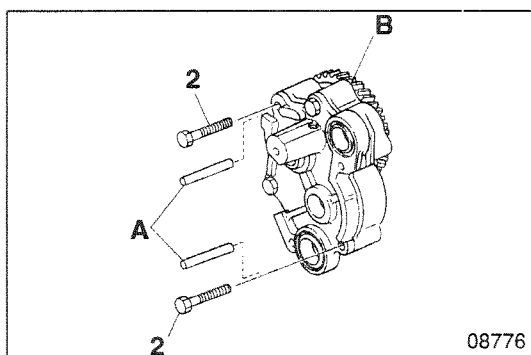


7 9 Installation of oil pump cover and oil pump case assembly

- Position oil pump cover 7 on oil pump case assembly 9 using two $\phi 9$ mm pins A.



- Fit bolts 2 and tighten them to the specified torque.

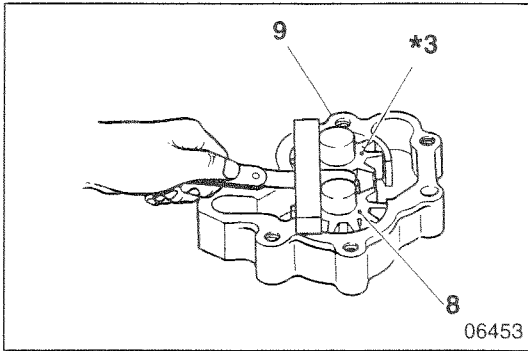


- Remove pins A, then fit other bolts 2 and tighten them to the specified torque.

NOTE

After assembly, turn the oil pump gear B by hand and check that it rotates smoothly. If the gear does not rotate smoothly, disassemble and reassemble the components.

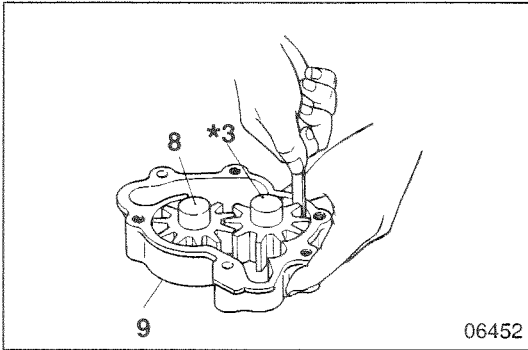
OIL PUMP <4D32, 33, 34-T>



8 9 Inspection of driven gear assembly and oil pump case assembly

(1) Differences between gear heights and case depth

Replace any component whose measurement is out of specification.

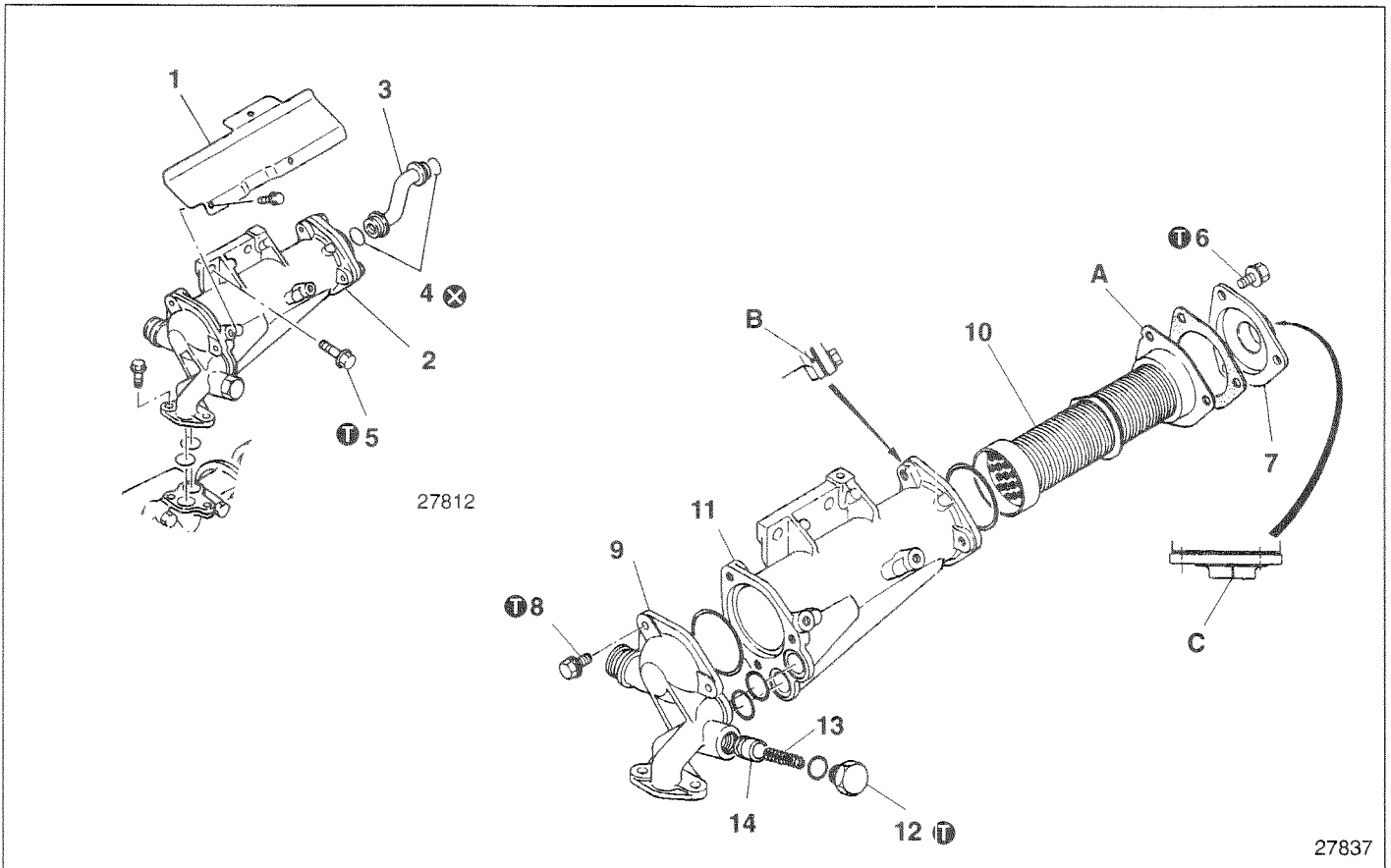


(2) Clearance between gear teeth and oil pump case

Replace any component whose measurement is out of specification.

MEMO

OIL COOLER AND OIL FILTER <4D31, 31-T>



● Disassembly sequence

- | | | |
|------------------|-----------------------|-----------------------|
| 1 Heat insulator | 8 Bolt | A: Notch |
| 2 Oil cooler | 9 Rear cover | B: Matching mark "▽" |
| 3 Water pipe | 10 Oil cooler element | C: Matching mark "—" |
| 4 O-ring | 11 Oil cooler shell | ⊗: Non-reusable parts |
| 5 Bolt | 12 Plug | |
| 6 Bolt | 13 Spring | |
| 7 Front cover | 14 Bypass valve | |

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|--|--|-------|--------|
| 10 | Air leakage from oil cooler element (air pressure 1.5 MPa {15 kgf/cm ² }) | 0 cm ³ | — | — |
| 11 | Air leakage from oil cooler shell (air pressure 295 kPa {3 kgf/cm ² }) | 0 cm ³ | — | — |
| 13 | Bypass valve spring load (installed length = 51) | 26 to 27 N {2.6 to 2.7 kgf} | — | — |
| 14 | Bypass valve opening pressure | 175 to 215 kPa {1.8 to 2.2 kgf/cm ² } | — | — |

① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------------|-----------------------|---------|
| 4 | Bolt (oil cooler mounting) | 44 {4.5} | — |
| 5 | Bolt (front cover mounting) | 13 to 21 {1.3 to 2.1} | — |
| 8 | Bolt (rear cover mounting) | 13 to 21 {1.3 to 2.1} | — |
| 12 | Bypass valve plug | 15 to 20 {1.5 to 2.0} | — |

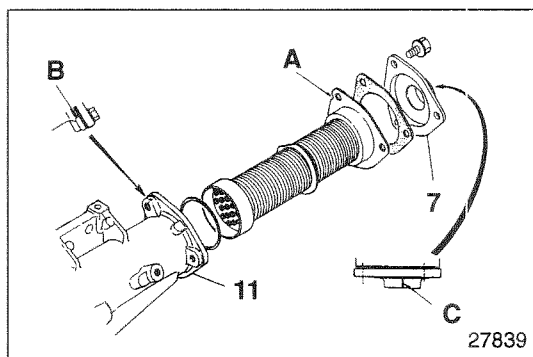
🔊 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---------------------|-------------|
| 4 | O-rings | Engine oil | As required |

◆ Service procedure

[Cleaning]

- Check whether carbon deposits or sludge have accumulated in the oil passages of oil cooler element **10** and the oil cooler's bypass arrangement. Remove any deposits with cleaning sealant.
- Clean out any water scale or fur that has accumulated in oil cooler element **10** or oil cooler shell **11**.



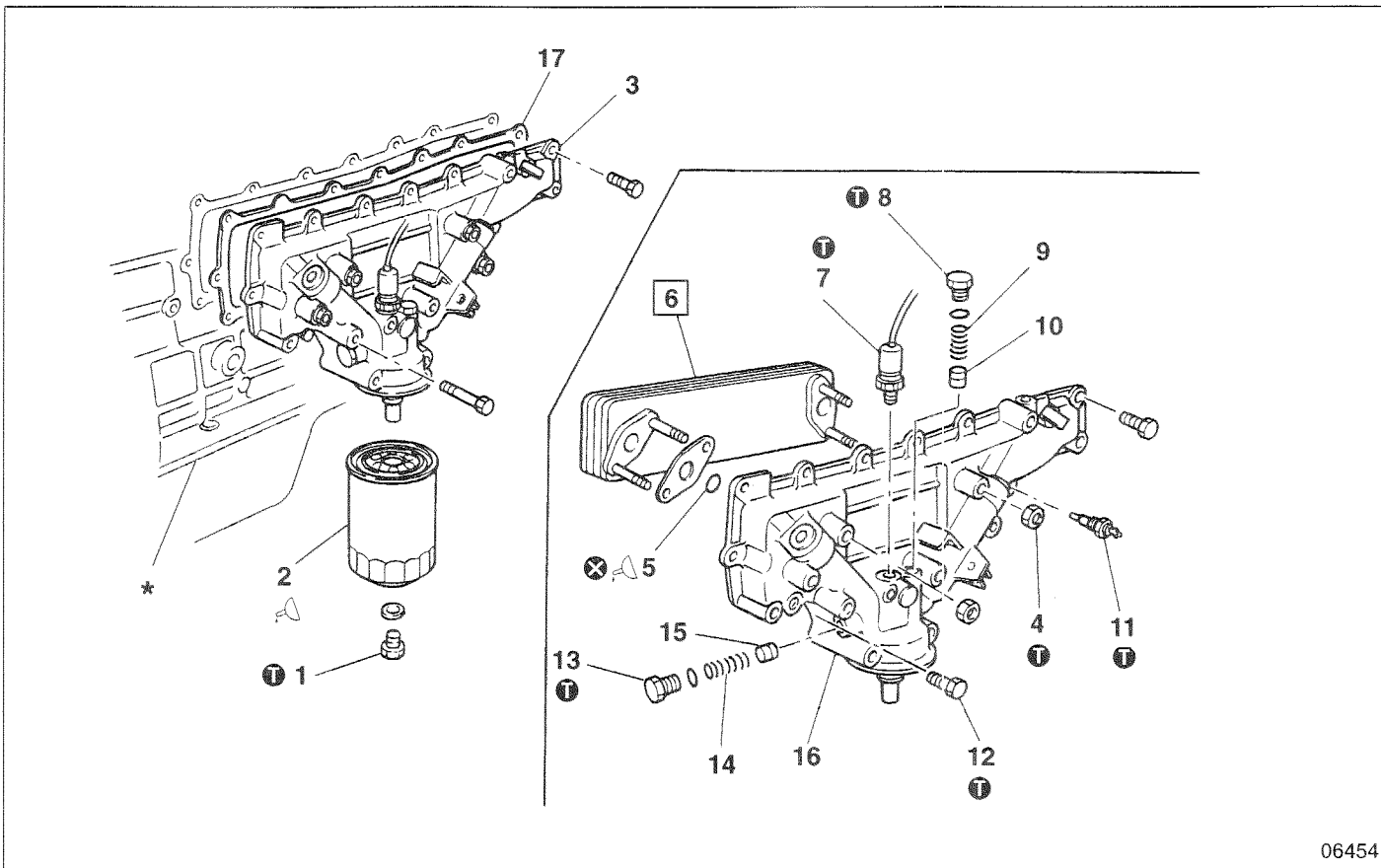
3 Installation of water pipe

Install water pipe **3** with its inscribed line **C** aligned with alignment mark **B** on front cover **7**.

10 Installation of oil cooler element

Install oil cooler element **10** with notch **A** aligned with ∇ mark **B** on oil cooler shell **11**.

OIL COOLER AND OIL FILTER <4D32, 33, 34-T>



06454

● Disassembly sequence

- | | |
|------------------------------------|--------------------------------------|
| 1 Oil filter drain plug | 11 Thermal switch <4D33, 34-T> Gr54 |
| 2 Oil filter P12-12 | 12 Oil cooler drain plug |
| 3 Oil cooler assembly | 13 Plug |
| 4 Nut | 14 Spring |
| 5 O-ring | 15 Bypass valve |
| 6 Oil cooler element | 16 Oil cooler body |
| 7 Engine oil pressure switch Gr54 | 17 Gasket |
| 8 Plug | |
| 9 Spring | |
| 10 Regulator valve | |
- *: Crankcase Gr11
 ⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: kPa {kgf/cm²}


| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---|----------------------|-------|---------|
| 6 | Air leakage from oil cooler element (air pressure 980 kPa {10 kgf/cm ² } for 15 seconds) | 0 cm ³ | — | Replace |
| 10 | Regulator valve opening pressure | 590 ± 29 {6.0 ± 0.3} | — | Replace |
| 15 | Bypass valve opening pressure | 390 ± 29 {4.0 ± 0.3} | — | Replace |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--|--------------------------------|---------|
| 1 | Oil filter drain plug <4D32, 33, 34-T> | 9.8 ± 2 { 1.0 ± 0.2 } | — |
| 4 | Nut (oil cooler element mounting) | 20 ± 4.9 { 2.0 ± 0.5 } | — |
| 7 | Engine oil pressure switch | 7.8 to 15 {0.8 to 1.5} | — |
| 8 | Plug (regulator valve spring mounting) | 20 ± 4.9 { 2.0 ± 0.5 } | — |
| 11 | Thermal switch <4D33, 34-T> | 34 ± 4.9 { 3.5 ± 0.5 } | — |
| 12 | Drain plug (oil cooler) | 25 ± 4.9 { 2.5 ± 0.5 } | — |
| 13 | Plug (bypass valve spring mounting) | 20 ± 4.9 { 2.0 ± 0.5 } | — |

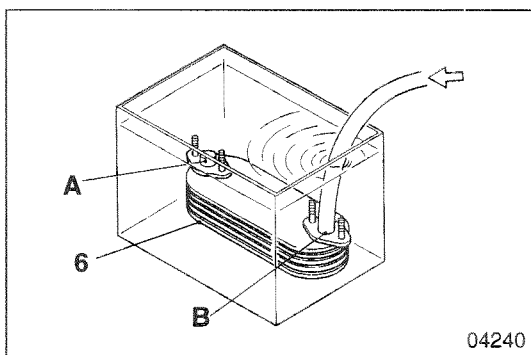
🔊 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---------------------|-------------|
| 2 | Oil filter gasket  P12-12 | Engine oil | As required |
| 5 | O-rings | Engine oil | As required |

◆ Service procedure

[Cleaning]

- Check whether carbon deposits or sludge have accumulated in the oil passages of oil cooler element **6** and the oil cooler's bypass arrangement. Remove any deposits with cleaning sealant.
- Clean out any water scale or fur that has accumulated in oil cooler element **6** or oil cooler body **16**.



⑥ Inspection of oil cooler element

[Inspection]

- Seal outlet **A** of oil cooler element **6** and connect a hose to engine oil inlet **B**. Then, immerse the oil cooler element in a tank of water.
- Apply air pressure of 980 kPa {10 kgf/cm²} for 15 seconds via the hose and check whether air leaks out of oil cooler element **6**.
- If any air leaks, replace the oil cooler element **6**.

GROUP 13 FUEL

| | |
|--|-------|
| SPECIFICATIONS | 13-2 |
| STRUCTURE AND OPERATION | 13-3 |
| TROUBLESHOOTING | 13-13 |
| ON-VEHICLE INSPECTION AND ADJUSTMENT | |
| • Inspection and Adjustment of Injection Timing | 13-16 |
| • Inspection and Adjustment of Minimum and Maximum No-load Speeds | 13-19 |
| • Bleeding Air from Fuel System | 13-20 |
| FUEL FILTER | 13-21 |
| WATER SEPARATOR | 13-23 |
| INJECTION PUMP | 13-24 |
| INJECTION NOZZLE | 13-28 |

SPECIFICATIONS

Injection Pump

| Item | Engine model | 4D31 | 4D31-T | 4D32 | 4D33 | 4D34-T |
|----------------------|--------------|----------|--------|-------|------|--------|
| Manufacturer | | DENSO | Zexel | DENSO | | Zexel |
| Model | | A | | | | |
| Governor type | | FSV-type | | | | |
| Feed pump type | | KS | | | | |
| Automatic timer type | | SCZ | SCDM | SB0 | | SCDM |

Injection Nozzle

| Item | Engine model | 4D31 | 4D31-T | 4D32 | 4D33 | 4D34-T | | | |
|--------------------|--------------|--------------------|--------|-------|-------|--------|-------|-------|------------------------|
| Manufacturer | | DENSO | Zexel | DENSO | | Zexel | | | |
| Model | | Hole-type 1-spring | | | | | | | |
| No. of holes | | 5 | | | | | | | |
| Hole diameter (mm) | | φ0.28 | φ0.3 | φ0.28 | φ0.26 | φ0.26 | φ0.24 | φ0.32 | φ0.29 × 3 φ0.31 × 2 |

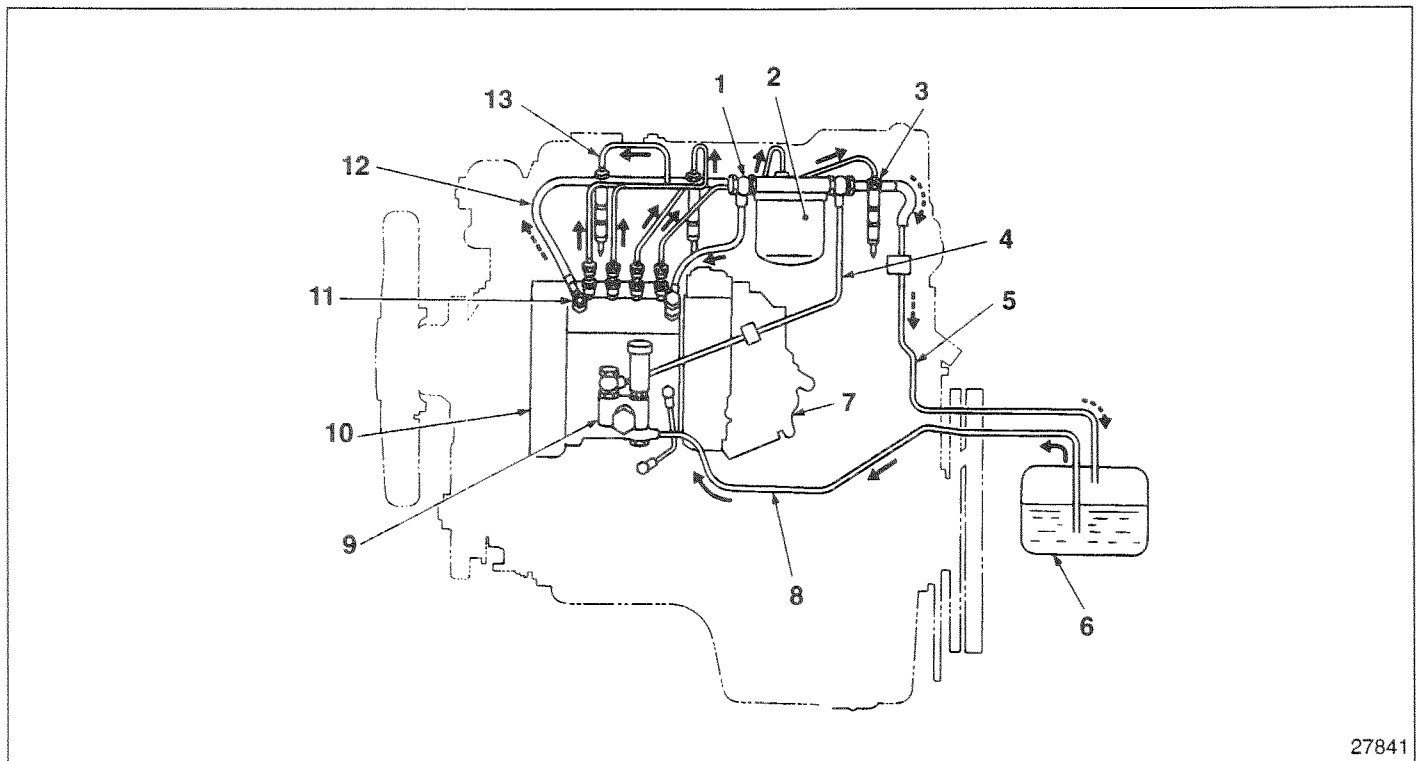
Fuel Filter

| Item | Specifications |
|------------------|-----------------------------|
| Fuel filter type | Spin-on type (paper filter) |

Water Separator

| Item | Specifications |
|----------------------|--------------------|
| Water separator type | Sediment trap type |

Fuel System (Fuel flow)



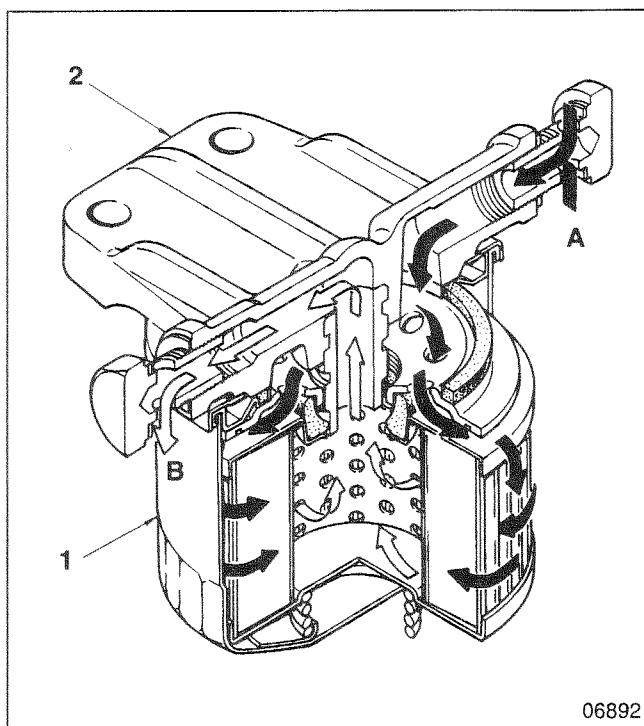
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- | | |
|--------------------|---------------------|
| 1 Fuel feed pipe | 8 Fuel suction pipe |
| 2 Fuel filter | 9 Feed pump |
| 3 Injection nozzle | 10 Injection pump |
| 4 Fuel feed pipe | 11 Overflow valve |
| 5 Fuel return pipe | 12 Leak-off pipe |
| 6 Fuel tank | 13 Injection pipe |
| 7 Governor | |

- Fuel from fuel tank **6** is drawn up by feed pump **9** and strained by fuel filter **2**. The feed pump is driven by a cam in injection pump **10**.
- After filtration, fuel is fed to injection pump **10**. From there, it is fed under high pressure to injection nozzles **3**. The injection nozzles spray the fuel into the combustion chambers.
- Surplus fuel from injection nozzles **3** returns to fuel tank **6** via fuel return pipe **5**.
- If the fuel pressure in injection pump **10** exceeds a preset level, overflow valve **11** opens to allow excess fuel to return to fuel tank **6**.

STRUCTURE AND OPERATION

Fuel Filter

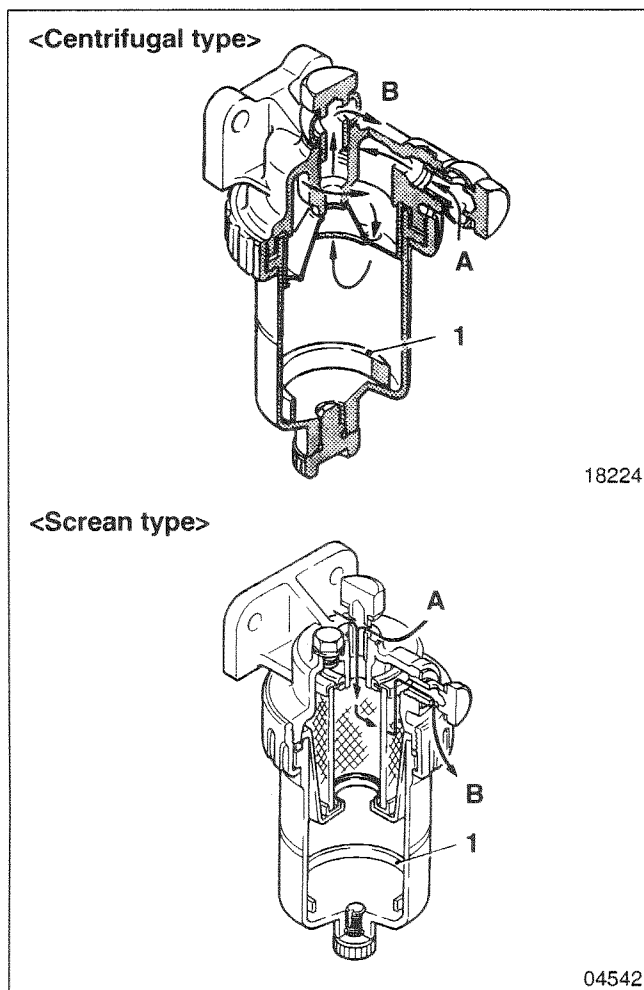


- 1 Fuel filter element
- 2 Fuel filter head

A: From feed pump
B: To injection pump

The fuel filter separates any water content out of fuel fed from the injection pump's feed pump, and fuel filter element 1 removes any impurities.

Water Separator



- 1 Water level ring

A: Fuel inlet (from fuel tank)
B: Fuel outlet (to feed pump)

The water separator is effective in removing not only water but also dirt and other impurities. A red water level ring 1 floats inside the case, enabling the water quantity to be checked at a glance.

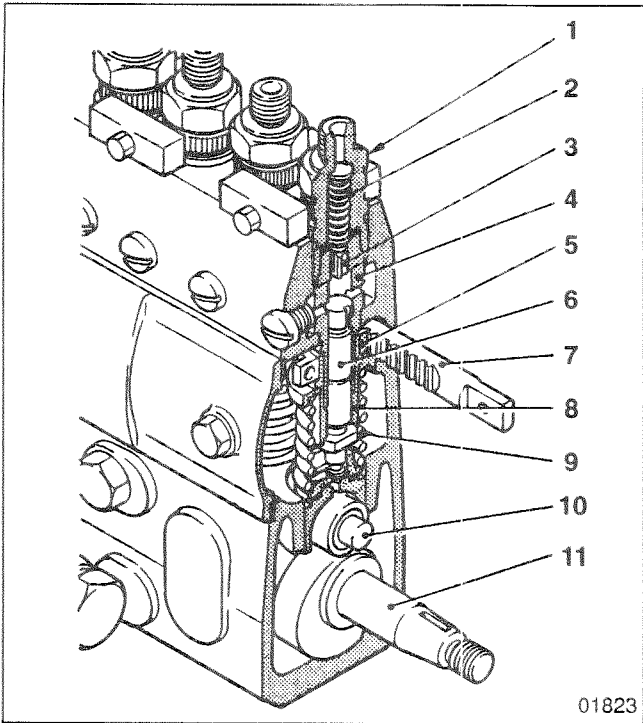
<Centrifugal type>

The sediment trap type water separator splits fuel and water centrifugally utilizing the difference in specific gravity between the two fluids. Fuel entering from the inlet connector is squeezed through a passage in the head, resulting in a faster flow with a more powerful axial twist. Water separated from the fuel settles in the case, and the water-free fuel flows to the feed pump via a passage in the center of the head.

<Screen type>

Any water present in the fuel is separated by the baffle plate and the screen assembly.

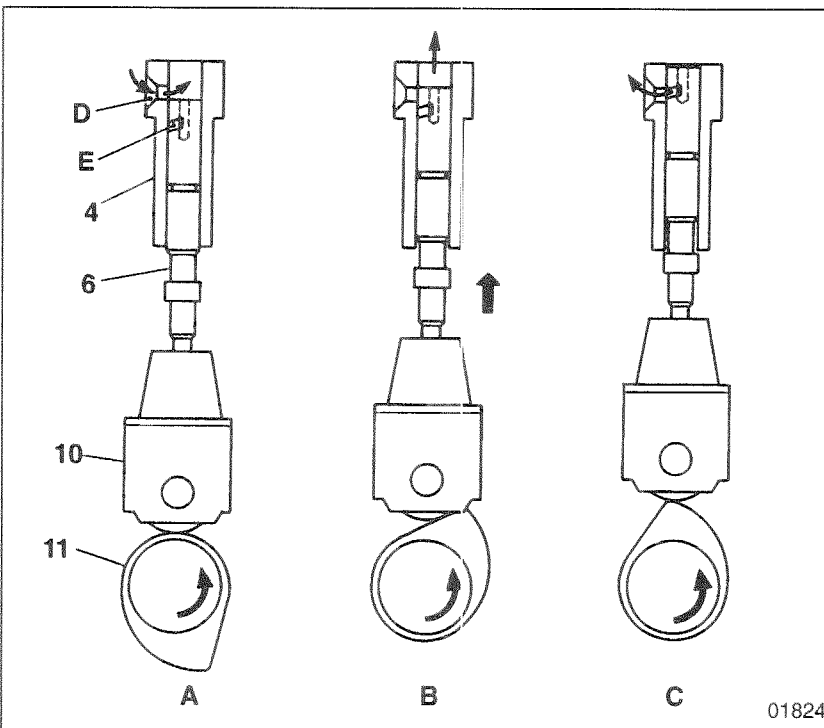
Injection Pump



- 1 Delivery valve holder
- 2 Delivery valve spring
- 3 Delivery valve
- 4 Plunger barrel
- 5 Control pinion
- 6 Plunger
- 7 Control rack
- 8 Control sleeve
- 9 Plunger spring
- 10 Tappet
- 11 Camshaft

The injection pump feeds fuel to the injection nozzles under high pressure and incorporates a mechanism for increasing and decreasing the fuel flow.

01823

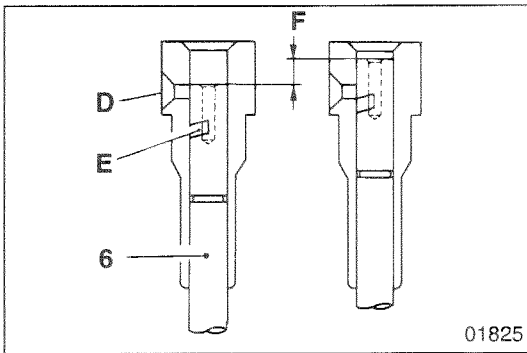


● Fuel feed action

- A: Fuel drawn in
- B: Start of pressure feed
- C: End of pressure feed
- D: Inlet/outlet hole
- E: Lead

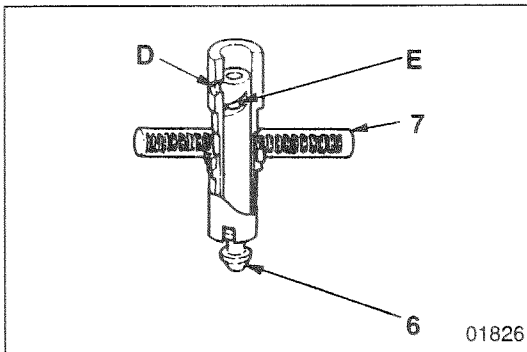
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STRUCTURE AND OPERATION



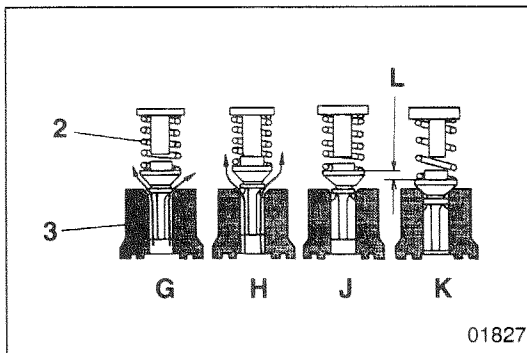
As plunger 6 rises and its lead E meets the fuel inlet/outlet hole D, fuel flows through the center of the plunger and is expelled from the inlet/outlet hole. Regardless of how much further the plunger rises, no fuel feed takes place thereafter.

The stroke length F of the plunger during which pressure feed takes place is known as the "effective stroke."



● Injection volume adjustment mechanism

To match changes in engine loading, an adjustment mechanism controls the amount of fuel injected. This mechanism turns plunger 6 by a given angle, thereby altering the point at which fuel inlet/outlet hole D meets lead E. Simply stated, the effective stroke is made longer or shorter. A single control rack 7 is used to rotate every plunger in the engine, so the plungers rotate simultaneously and by the same angle.



● Delivery valve

G: Pressurization starts

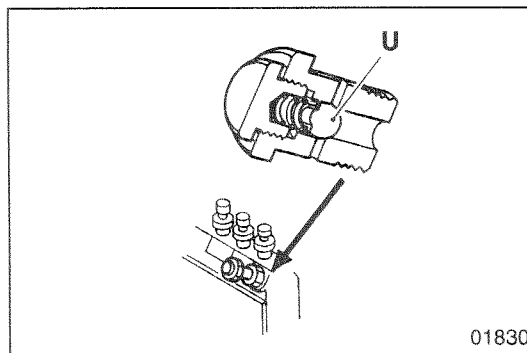
H: Injection

J: Pressurization ends (Starting suction)

K: Suction ends

L: Suction stroke

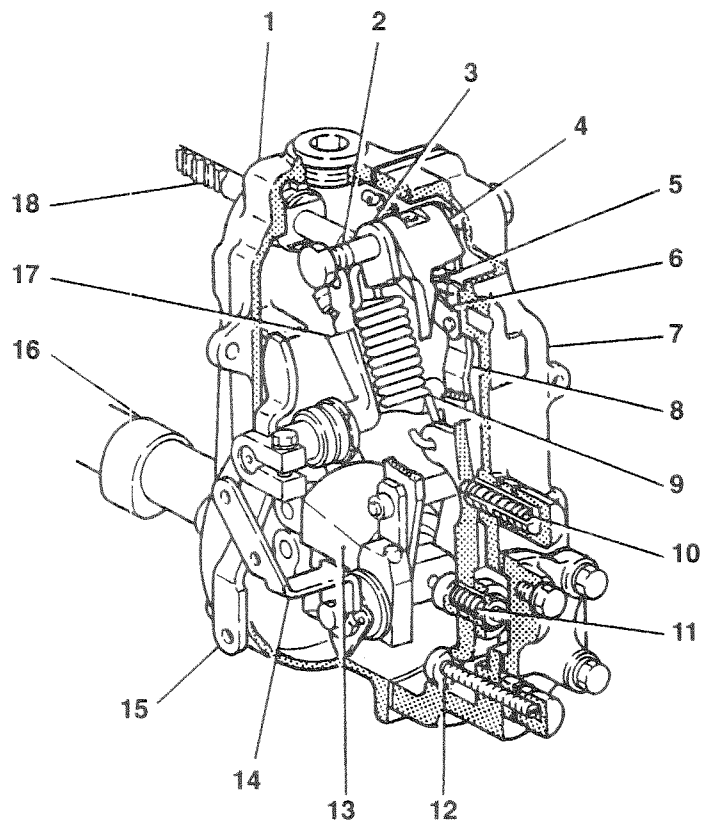
Fuel highly pressurized by plunger pushes up delivery valve 3 for injection, and when delivery of pressurized fuel ends, delivery valve returns by the force of delivery valve spring 2 to close fuel passage, thus avoiding reverse flow of fuel. Delivery valve lowers further to rest at its seat, and for this stroke L, residual pressure between delivery valve and injection nozzle is for an instant lowered. This return suction makes fuel-cutting at nozzles effective and avoids post-injection dripping.



● Overflow valve

When the fuel pressure in the injection pump exceeds a preset level, the steel ball U is pushed up, allowing fuel to flow out from the injection pump and return to the fuel tank. This stabilizes the fuel temperature and temperature distribution in the injection pump and keeps the injection rate constant in each cylinder.

Governor



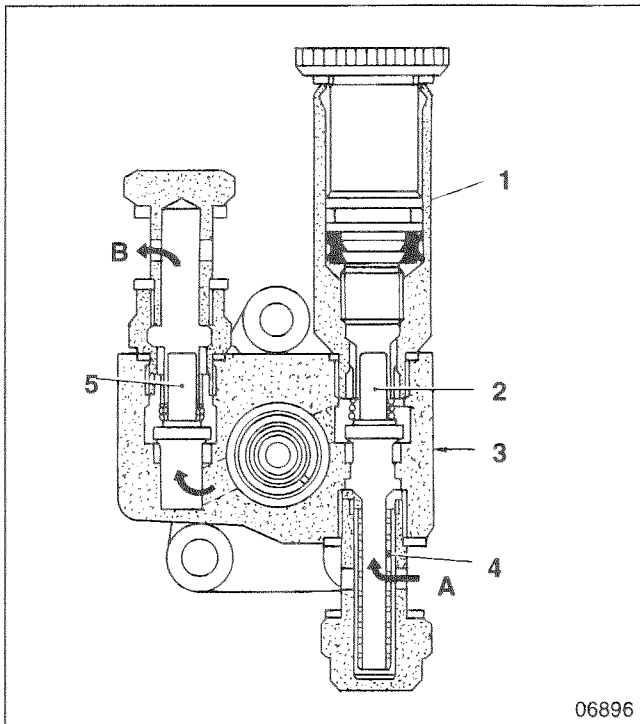
23103

- | | |
|--------------------------|-------------------------------------|
| 1 Governor housing | 10 Idling subspring |
| 2 Supporting lever shaft | 11 Ungleich spring or idling spring |
| 3 Guide lever | 12 Full-load stopper bolt |
| 4 Tension lever | 13 Flyweight |
| 5 Start spring | 14 Stop lever |
| 6 Shackle | 15 Adjusting lever |
| 7 Governor cover | 16 Camshaft |
| 8 Floating lever | 17 Swivel lever |
| 9 Governor spring | 18 Control rack |

The governor is an all-speed type that utilizes the centrifugal force of a flyweight arrangement. In addition to controlling the maximum and minimum speeds, the governor automatically controls the engine speed at any intermediate speed position.

STRUCTURE AND OPERATION

Feed Pump

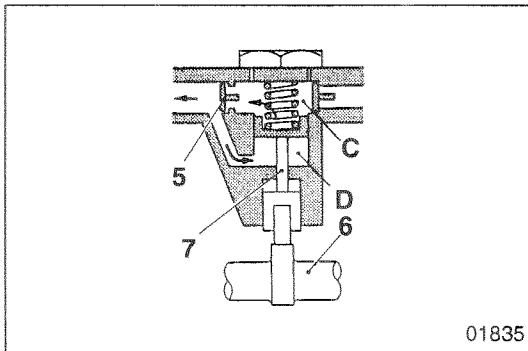


- 1 Priming pump
- 2 Inlet check valve
- 3 Feed pump housing
- 4 Gauze filter
- 5 Outlet check valve

A: From fuel tank
B: To fuel filter

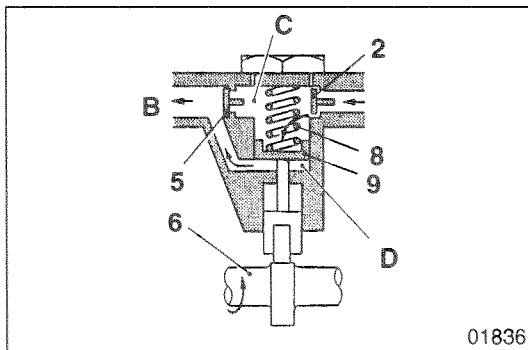
The feed pump is driven by the camshaft in the injection pump. Priming pump 1 enables fuel to be drawn up manually when the injection pump is stationary. It is particularly useful for air bleeding.

Gauze filter 4 removes large impurities from fuel drawn up from the fuel tank and thus prevents clogging of the feed pump. It must be washed regularly in gas oil.



● Suction stroke

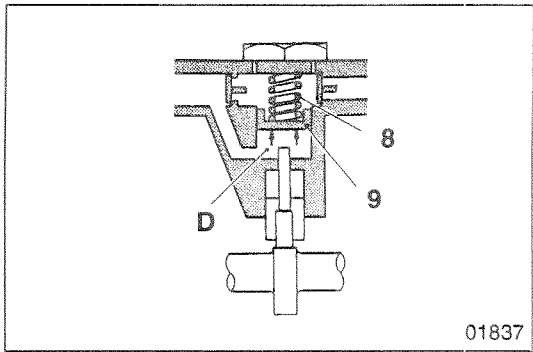
When injection pump camshaft 6 forces up push rod 7, fuel in suction chamber C is compressed and opens outlet check valve 5. Most of the fuel forced out is drawn into pressure chamber D below the piston.



● Pressure feed stroke

As camshaft 6 turns and the cam loses its lift, piston 9 is pushed down by piston spring 8. The fuel in the pressure chamber D is thus forced out and fed toward fuel filter B.

At the same time, outlet check valve 5 closes and inlet check valve 2 opens. As a result, fuel is again drawn into suction chamber C.



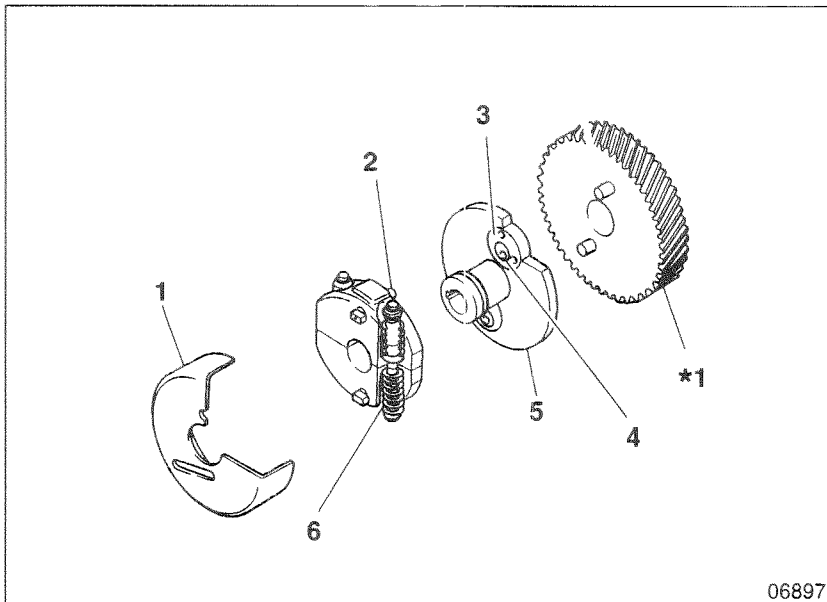
● Stoppage

When pressure in pressure chamber D exceeds a preset level, piston spring 8 cannot push back piston 9. The pump therefore stops operating, preventing pressure in the fuel filter from rising more than necessary.

Automatic Timer

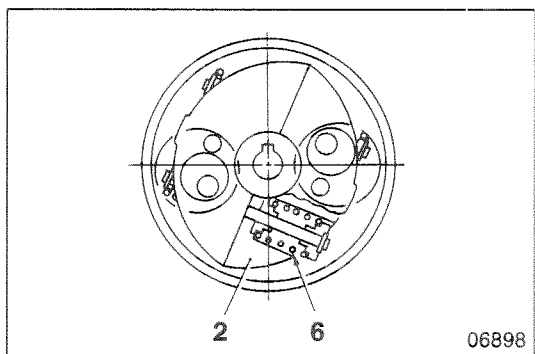
The automatic timer utilizes a mechanical arrangement to adjust the injection timing in accordance with the engine speed. The automatic timer is mounted on the injection pump camshaft using a round nut. It is driven by the idler gear which is in engagement with the injection pump gear.

<SBO type>



- 1 Timer cover
- 2 Flyweight
- 3 Large cam
- 4 Small cam
- 5 Hub
- 6 Timer spring

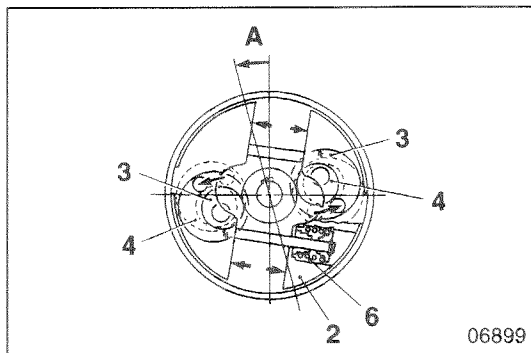
*1: Injection pump gear



● At standstill

Flyweight 2 is forced to close by the tension of timer spring 6.

STRUCTURE AND OPERATION

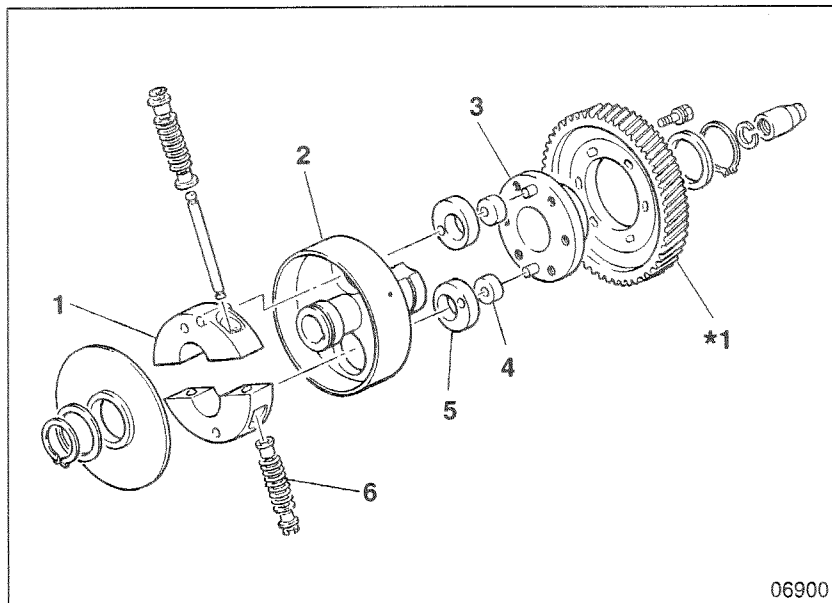


● At operation

As the engine speed rises, the centrifugal force acting on flyweight 2 increases, and when it overcomes the tension of the timer spring 6, the flyweight 2 starts to open. Therefore, the small cam 4 and the large cam 3 move in the direction of rotation. Since the large cam is fitted in the hole of hub 5, the movement of the large cam is transmitted to the hub, thus the injection timing being advanced.

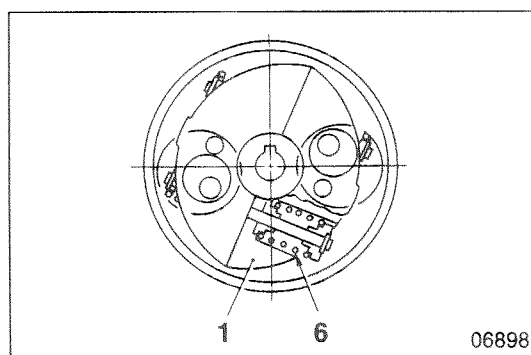
A: Advanced angle

<SCDM type>



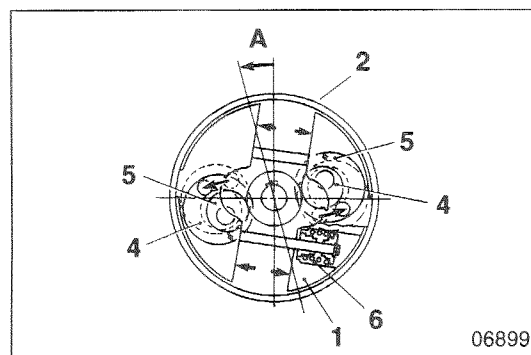
- 1 Flyweight
- 2 Timing flange
- 3 Flange
- 4 Small cam
- 5 Large cam
- 6 Timer spring

*1: Injection pump gear



● At standstill

Flyweight 1 is forced to close by the tension of timer spring 6.

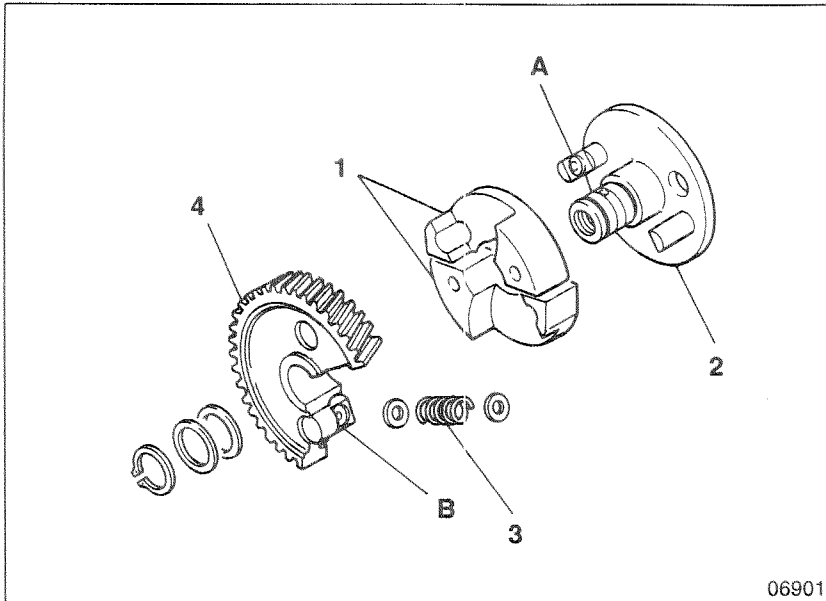


● At operation

As the engine speed rises, the centrifugal force acting on flyweight 1 increased, and when it overcomes the tension of timer spring 6, the flyweight 1 starts to open. Therefore, small cam 4 and large cam 5 move in the direction of rotation. Since the large cam is fitted in the hole of the timing flange 2, the movement of the large cam is transmitted to timing flange, thus the injection timing being advanced.

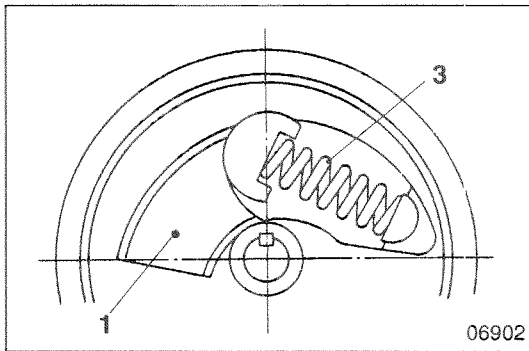
A: Advanced angle

<SCZ type>



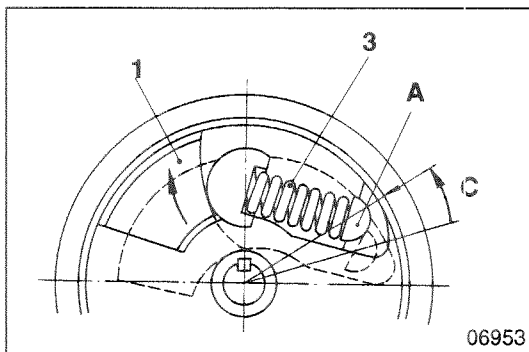
- 1 Flyweight
- 2 Timer hub
- 3 Timer spring
- 4 Injection pump gear

A: Pin
B: Pin



● **At standstill**

Flyweight 1 is forced to close by the tension of timer spring 3.



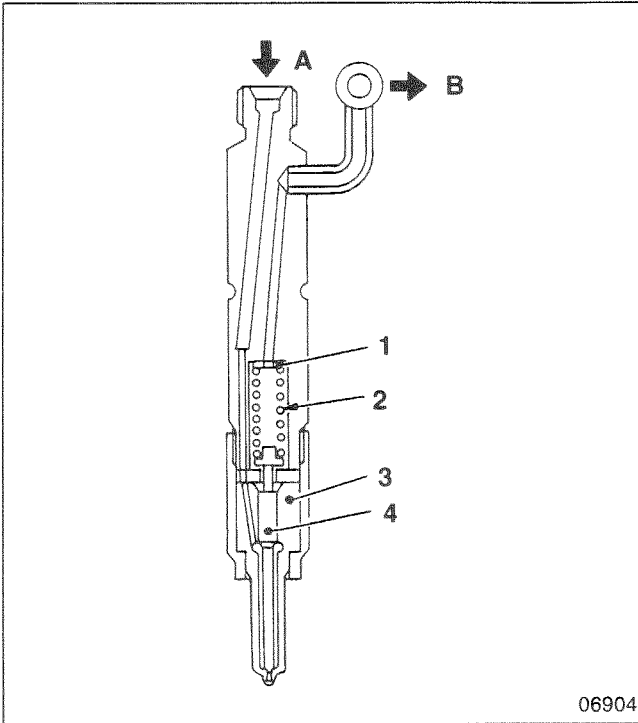
● **At operation**

As the centrifugal force increases in accordance with the increase in engine revolution, flyweight 1 starts opening. At this time, pin A compresses timer spring 3, causing the ignition timing to advance.

C: Advanced angle

STRUCTURE AND OPERATION

Injection Nozzle



- 1 Washer
- 2 Spring
- 3 Nozzle tip
- 4 Needle valve

A: From injection pump

B: To fuel tank

- When pressurized fuel fed from the injection pump overcomes spring 2, it pushes up needle valve 4 and sprays out of the orifice at the end of the nozzle.
- The injection pressure is adjusted by increasing or decreasing the thickness of washer 1.

| Possible causes | | Symptoms | | | | | | | | | | Remarks | | | | |
|--------------------------------------|--|-----------------------|---------------------------|-----------------------|------------------------|----------------------------|-------------------------------|------------------------|----------------------------------|-------------------------------------|----------------------|---------|-----------------------|--|--|--|
| | | Engine will not start | Engine difficult to start | Engine knocks | Unstable engine output | Insufficient engine output | Engine maximum speed too high | Unstable engine idling | Engine stops soon after starting | Engine does not reach maximum speed | Engine will not stop | | Defective fuel supply | | | |
| Injection pump proper | Sticky plunger | <input type="radio"/> | | | | | | | | | | | | | | |
| | Sticky control rack | <input type="radio"/> | | | | | | | | | | | | | | |
| | Sticky delivery valve | <input type="radio"/> | | | | | | | | | | | | | | |
| | Worn tappet | <input type="radio"/> | | | | | | | | | | | | | | |
| | Worn camshaft | <input type="radio"/> | | | | | | | | | | | | | | |
| | Poorly adjusted injection timing | | <input type="radio"/> | | <input type="radio"/> | <input type="radio"/> | | | <input type="radio"/> | | | | | | | |
| | Worn plunger | | | | | <input type="radio"/> | | | <input type="radio"/> | | | | | | | |
| | Defective delivery valve seat | | | | | <input type="radio"/> | | | | | | | | | | |
| | Excessively advanced injection timing | | | <input type="radio"/> | | | | | | | | | | | | |
| | Insufficient plunger slide stroke | | | | <input type="radio"/> | | | | | | | | | | | |
| | Broken plunger spring | | | | <input type="radio"/> | | | | <input type="radio"/> | | | | | | | |
| | Defective sliding action in control rack | | <input type="radio"/> | | <input type="radio"/> | | | <input type="radio"/> | <input type="radio"/> | | | | | | | |
| | Tappet worn or not sliding correctly | | | | <input type="radio"/> | | | | | | | | | | | |
| | Broken delivery valve spring | | | | <input type="radio"/> | <input type="radio"/> | | | | | | | | | | |
| | Poor airtightness due to loose delivery valve holder | | | | <input type="radio"/> | <input type="radio"/> | | | | | | | | | | |
| | Defective delivery valve operation | | | | <input type="radio"/> | | | | | | | | | | | |
| | Loose control pinion | | | | | | | | <input type="radio"/> | | | | | | | |
| | Plunger spring not seating correctly | | | | | | | | <input type="radio"/> | | | | | | | |
| | Delivery valve holder too tight | | | | | | | | <input type="radio"/> | | | | | | | |
| Uneven injection volume to cylinders | | <input type="radio"/> | | | | | | <input type="radio"/> | | | | | | | | |
| Fuel feed pump | Gauze filter clogged | <input type="radio"/> | | | | | | | <input type="radio"/> | <input type="radio"/> | | | | | | |
| | Check valve not operating | <input type="radio"/> | | | | | | | | | | | | | | |
| | Sticky piston | <input type="radio"/> | | | | | | | | | | | | | | |
| | Sticky push rod | <input type="radio"/> | | | | | | | | | | | | | | |
| | Worn tappet | <input type="radio"/> | | | | | | | | | | | | | | |
| | Defective check valve operation | | <input type="radio"/> | | <input type="radio"/> | | | | <input type="radio"/> | | | | | | | |
| | Piston worn | | <input type="radio"/> | | <input type="radio"/> | | | | <input type="radio"/> | | | | | | | |

TROUBLESHOOTING

| Symptoms | | Possible causes | | | | | | | | | | Remarks | | |
|---|--|-----------------------|---------------------------|-----------------------|------------------------|----------------------------|-------------------------------|------------------------|----------------------------------|-------------------------------------|----------------------|---------|-----------------------|-------|
| | | Engine will not start | Engine difficult to start | Engine knocks | Unstable engine output | Insufficient engine output | Engine maximum speed too high | Unstable engine idling | Engine stops soon after starting | Engine does not reach maximum speed | Engine will not stop | | Defective fuel supply | |
| Governor | Insufficient full-load stopper position | | | | | <input type="radio"/> | | | | | | | | |
| | Weak governor spring | | | | | <input type="radio"/> | | | | <input type="radio"/> | | | | |
| | Incorrectly adjusted control lever | | | | <input type="radio"/> | <input type="radio"/> | | | | <input type="radio"/> | | | | |
| | Flyweights not operating effectively | | | | | | <input type="radio"/> | | | | | | | |
| | Weak idling spring | | | | | | | <input type="radio"/> | | | | | | |
| | Bent links | | | | | | | <input type="radio"/> | | | | | | |
| | Excessive friction or play in links | | | | | | | <input type="radio"/> | | | | | | |
| | Loose round nut | | | | | | | <input type="radio"/> | | | | | | |
| | Poorly adjusted idling set bolt | | | | | | | <input type="radio"/> | | | | | | |
| | Stop mechanism damaged | | | | | | | | | <input type="radio"/> | | | | |
| Automatic timer | Defective advancing action | | | | | <input type="radio"/> | | <input type="radio"/> | | | | | | |
| Injection nozzles | Sticky needle valve | <input type="radio"/> | | | | | | | | | | | | |
| | Valve opening pressure too low | <input type="radio"/> | | | | | | | <input type="radio"/> | | | | | |
| | Blocked injection orifice | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | <input type="radio"/> | | | | | |
| | Poor airtightness in nozzle | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | <input type="radio"/> | | | | | |
| | Valve opening pressure too high | | | <input type="radio"/> | | | | | | | | | | |
| | Broken spring | | | | <input type="radio"/> | <input type="radio"/> | | | | | | | | |
| | Defective sliding action in needle valve | | | | <input type="radio"/> | | | | | | | | | |
| | Defective valve opening pressure | | | | <input type="radio"/> | | | | | | | | | |
| Fuel filter | Filter clogged | <input type="radio"/> | | | <input type="radio"/> | | | <input type="radio"/> | <input type="radio"/> | | | | | |
| | Fuel tank empty | <input type="radio"/> | | | | | | | | | | | | |
| Fuel pipes blocked and/or fuel leaking from connections | | <input type="radio"/> | | | | | | | | | | | | |
| Air or water in fuel system | | <input type="radio"/> | | | <input type="radio"/> | | | <input type="radio"/> | <input type="radio"/> | | | | | |
| Low-quality fuel in use | | | <input type="radio"/> | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | | | | | | |
| Cracked fuel pipe | | | | | | | | | | | | | <input type="radio"/> | |
| Leaky fuel tank | | | | | | | | | | | | | <input type="radio"/> | |
| Incorrect oil viscosity | | | <input type="radio"/> | | | | | | | | | | | Gr 12 |
| Incorrect valve clearance | | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | | Gr 11 |
| Defective cylinder head gasket | | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | | Gr 11 |
| Wear and/or carbon deposits on valve and valve seat | | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | | Gr 11 |
| Weakness/deterioration in valve spring | | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | | Gr 11 |
| Worn/damaged piston ring(s) | | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | | Gr 11 |

| Possible causes | Symptoms | | | | | | | | | | Remarks | |
|------------------------------------|-----------------------|---------------------------|---------------|------------------------|----------------------------|-------------------------------|------------------------|----------------------------------|-------------------------------------|----------------------|---------|-----------------------|
| | Engine will not start | Engine difficult to start | Engine knocks | Unstable engine output | Insufficient engine output | Engine maximum speed too high | Unstable engine idling | Engine stops soon after starting | Engine does not reach maximum speed | Engine will not stop | | Defective fuel supply |
| Worn/damaged piston ring groove(s) | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | 📖 Gr 11 |
| Worn piston and cylinder sleeve | | <input type="radio"/> | | | | | | | | | | 📖 Gr 11 |
| Cooling system malfunctioning | | <input type="radio"/> | | | | | <input type="radio"/> | | | | | 📖 Gr 14 |
| Defective starter switch | | <input type="radio"/> | | | | | | | | | | 📖 Gr 54 |
| Defective glow relay | | <input type="radio"/> | | | | | | | | | | 📖 Gr 54 |

ON-VEHICLE INSPECTION AND ADJUSTMENT

Inspection and Adjustment of Injection Timing

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|------------------------------|-------------------------------------|-------|--------|
| — | Fuel injection timing (BTDC) | Depends on the engine specification | — | Adjust |

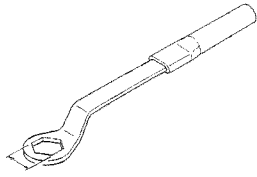
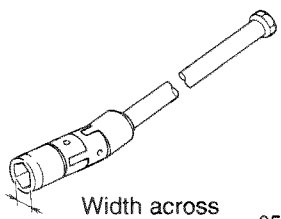
T Tightening torque

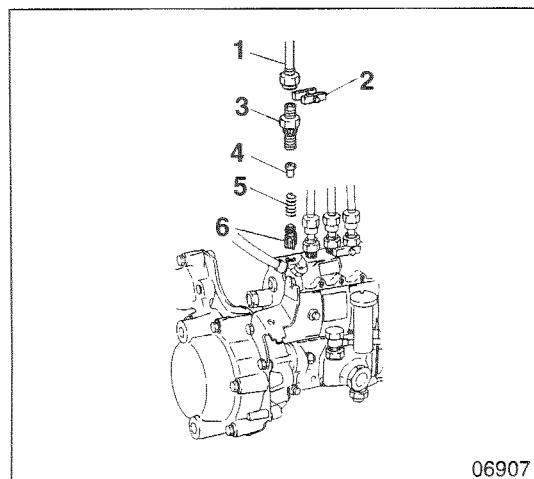
Unit: N·m {kgf·m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|-----------------------------|--------------|--------------------------|---------|
| 1 | Union nut | | 24 {2.5} | — |
| 2 | Lock plate | 4D31, 32, 33 | 7.8 to 10.8 {0.8 to 1.1} | — |
| | | 4D31-T, 34-T | 3.4 to 4.9 {0.35 to 0.5} | |
| 3 | Delivery valve holder | 4D31, 32, 33 | 34 to 39 {3.5 to 4.0} | — |
| | | 4D31-T, 34-T | 39 to 44 {4.0 to 4.5} | |
| 12, 13 | Injection pump mounting nut | | 29 to 39 {3.0 to 4.0} | — |

C Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|---|
| — |  Cranking Handle Width across flat: 36 05999 | MH061289 | For cranking the engine |
| 12, 13 |  Universal Extension Width across flat: 14 05163 | MH061099 | Inspection and adjustment of injection timing |

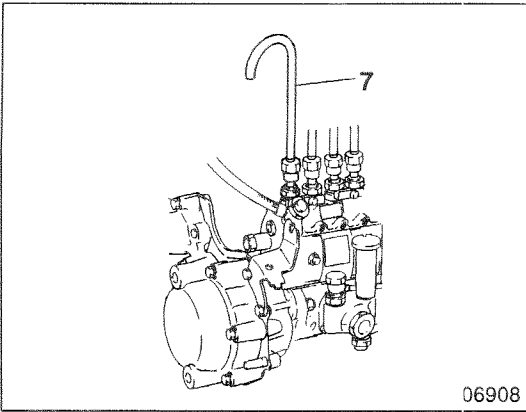


[Inspection]

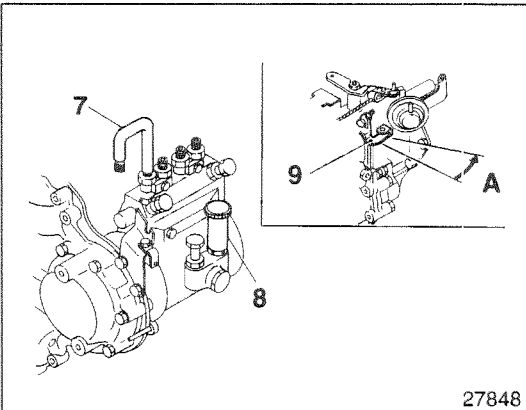
- From the injection pump's No.1 cylinder, remove union nut 1 of injection pipe, lock plate 2, delivery valve holder 3, stopper 4, delivery valve spring 5, and delivery valve 6.
- Fit delivery valve holder 3.

CAUTION 

Place all parts in gas oil after removal to keep them free of dust.



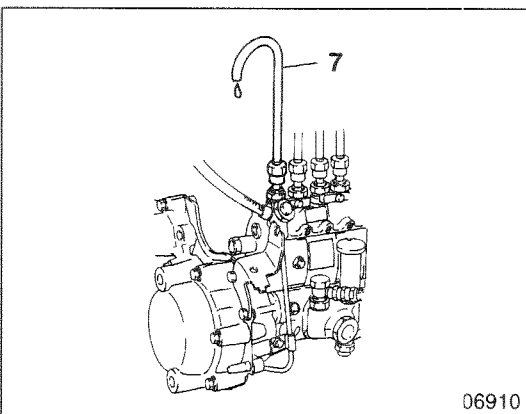
- Fit an injection pipe 7 onto cylinder No.1. Point the pipe's other end downward such that fuel flowing out can be seen clearly.
- Rotate the crankshaft pulley clockwise (as seen from the front of engine) by at least 180° and bring cylinder No. 1 to approximately 30° BTDC on its compression stroke.



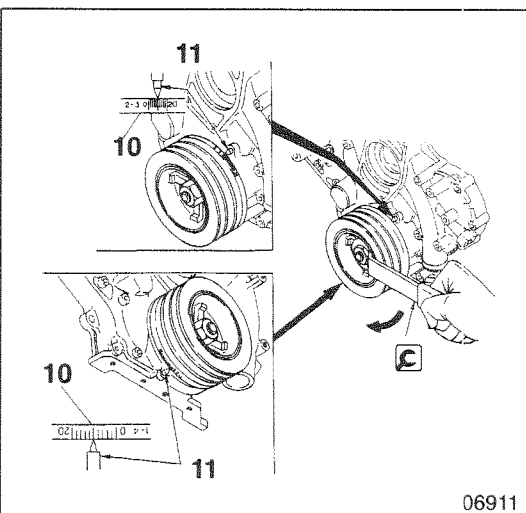
- Feed fuel into the injection pump using priming pump 8. With fuel flowing out of injection pipe 7, crank the engine slowly clockwise (as seen from the front of engine).

NOTE

Make sure the stop lever 9 on top of the governor is in its engine starting position A.



- When the flow of fuel from injection pipe 7 diminishes, crank the engine more slowly. When the flow of fuel stops completely, stop cranking the engine.

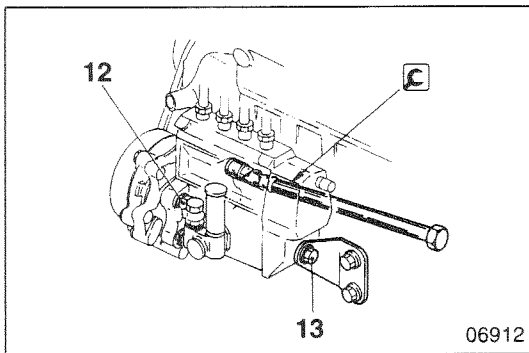


- Check that pointer 11 on the timing gear case is pointing to inscribed line 10 on the crankshaft pulley which corresponds to the specified fuel injection timing.

 Cranking handle

- If the injection timing should be measured in a dusty location, perform as follows:
 - Rotate the crankshaft clockwise (as seen from the front of engine) and bring the No. 1 cylinder to 30° BTDC on its compression stroke.
 - Disconnect injection pipe 7 with a little amount of fuel remained at the top of delivery valve holder 3.
 - Slowly rotate the crankshaft clockwise. When the injection timing is reached, the fuel at the top of delivery valve holder 3 starts to move.

ON-VEHICLE INSPECTION AND ADJUSTMENT



- If the fuel injection timing is out of specification, make adjustments in accordance with the following procedure.

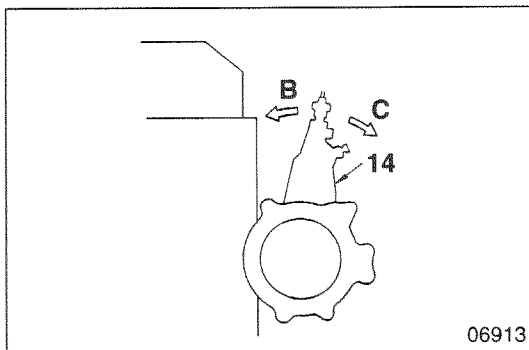
[Adjustment]

- Loosen injection pump mounting nuts 12, 13.

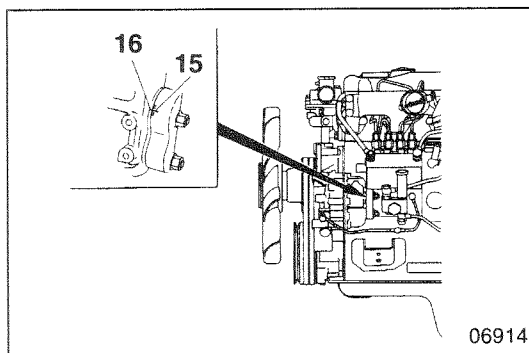
12: Nut (4-off; on flange)

13: Nut (1-off)

C: Universal extension



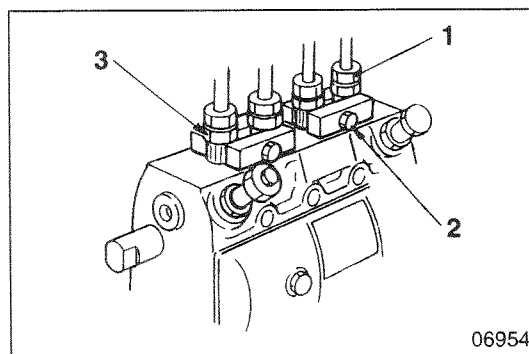
- If the fuel injection timing is overly retarded, incline injection pump 14 toward crankcase B.
- If the fuel injection timing is overly advanced, incline injection pump 14 away from crankcase C.



- Turning the injection pump by one of gradations 15 inscribed on the timer case flange causes a 6° change in the injection timing.

16: Pointer

- Tighten nuts 12, 13 then check the fuel injection timing again.



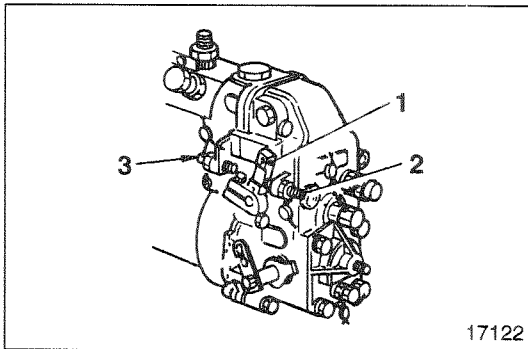
- After checking that the fuel injection timing is up to specification, fit delivery valve 6, delivery valve spring 5, and stopper 4, and then delivery valve holder 3, lock plate 2 and union nut 1.
- Tighten each part to its specified torque.

Inspection and Adjustment of Minimum and Maximum No-load Speeds

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|--------------------------------------|-------------------------------------|-------|--------|
| — | No-load minimum speed (idling speed) | Depends on the engine specification | — | Adjust |
| — | No-load maximum speed | Depends on the engine specification | — | Adjust |

Before making inspections and adjustments, warm up the engine until the coolant reaches 80 to 90°C.



(1) No-load minimum speed

[Inspection]

Confirm that adjust lever **1** is touching idling set bolt **2**. Then check that the minimum speed is up to specification.

[Adjustment]

If the minimum speed is out of specification, adjust it using idling set bolt **2**.

(2) No-load maximum speed

[Inspection]

Confirm that adjusting lever **1** is touching full-speed set bolt **3**. Then, check that the maximum speed is up to specification.

[Adjustment]

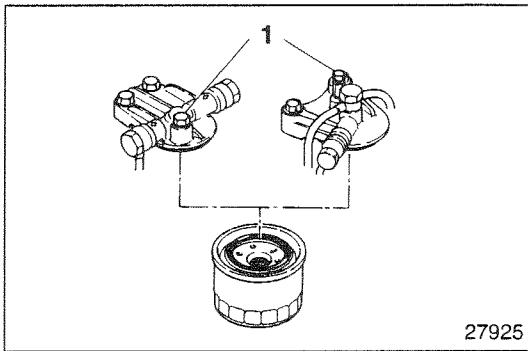
If the maximum speed is out of specification, adjust it using full-speed set bolt **3**.

NOTE

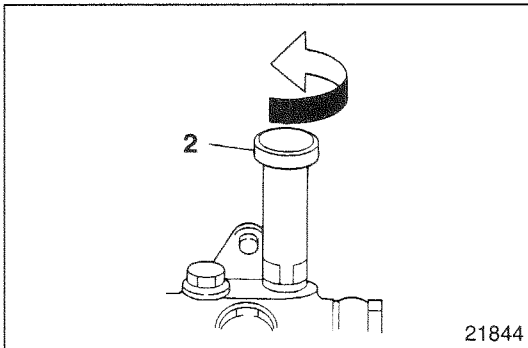
Check that the engine does not stall and that no hunting occurs when adjusting lever 1 is moved quickly from the full-speed position to the idling position. If any abnormality is apparent, make adjustments within the specified range.

ON-VEHICLE INSPECTION AND ADJUSTMENT

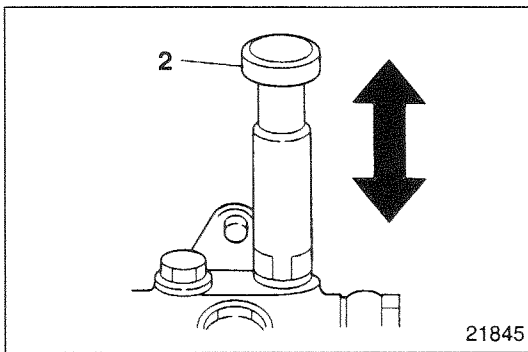
Bleeding Air from Fuel System



- Loosen fuel filter air plug 1.



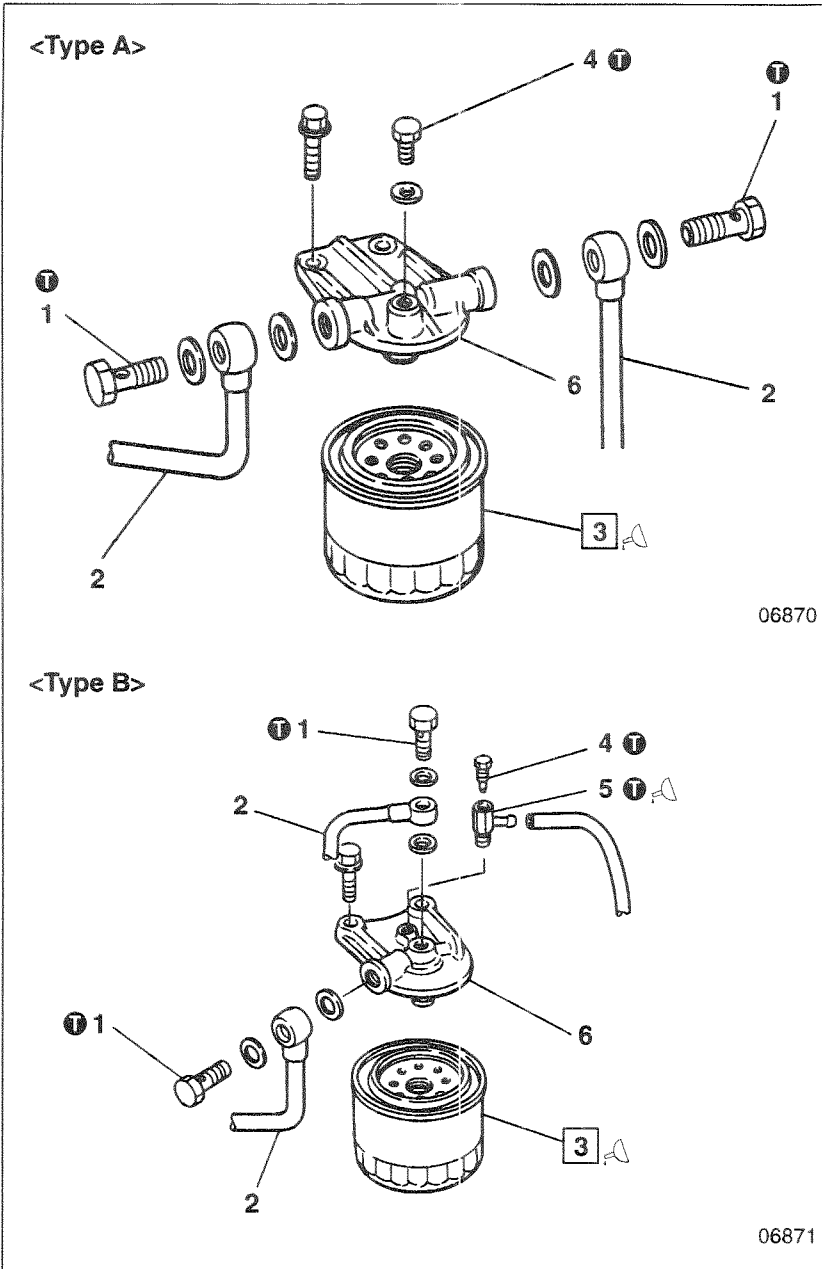
- Turn priming pump knob 2 counterclockwise until it pops up.
- Move priming pump knob 2 up and down to feed fuel through the fuel filter.
- When fuel emerging from fuel filter air plug 1 no longer contains air bubbles, tighten the air plug securely.



- Move priming pump knob 2 up and down five or six more times. Then, press the knob down and screw it clockwise to lock it in position.
- Wipe up all spilled fuel, then start the engine.
- Check that no fuel leakage occurs.

WARNING ⚠

- **Be sure to wipe up all spilled fuel. Unless it is wiped up, it could catch fire.**
- **Fuel is highly flammable. Keep it away from flames and sources of heat.**



● Disassembly sequence

- 1 Eyebolt
- 2 Fuel feed hose
- 3 Fuel filter element
- 4 Air vent plug <Type A>
- 5 Air vent cock <Type B>
- 6 Fuel filter head

● Assembly sequence

Follow the disassembly sequence in reverse.

ⓘ Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-----------------------|---------|
| 1 | Eyebolt | 25 to 35 {2.5 to 3.5} | — |
| 4 | Air vent plug | 8 to 12 {0.8 to 1.2} | — |
| 5 | Air vent cock | 8 to 12 {0.8 to 1.2} | — |

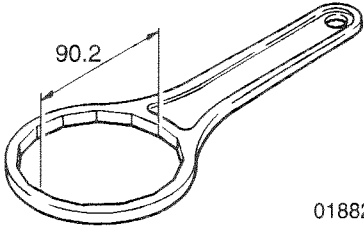
🔧 Lubricant

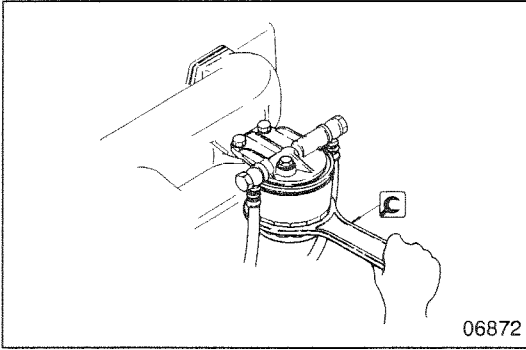
| Location | Points of application | Specified lubricant | Quantity |
|----------|---|-------------------------------------|----------|
| 3 | Gasket between fuel filter element and fuel filter head | Engine oil | — |
| 5 | Threaded section of air vent cock | Threebond Threadlock Super No.1305N | — |

FUEL FILTER

☒ Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|--------------------------------|
| 3 | Filter Wrench  | MH061509 | Removal of fuel filter element |

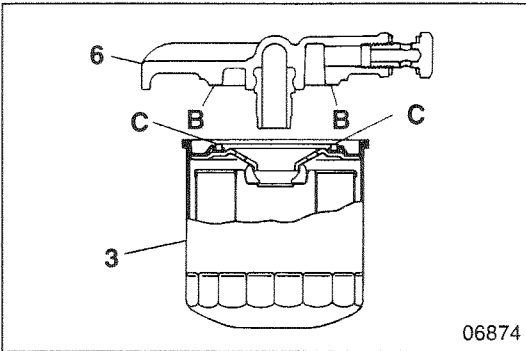


◆ Service procedure

☒ 3 Fuel filter element

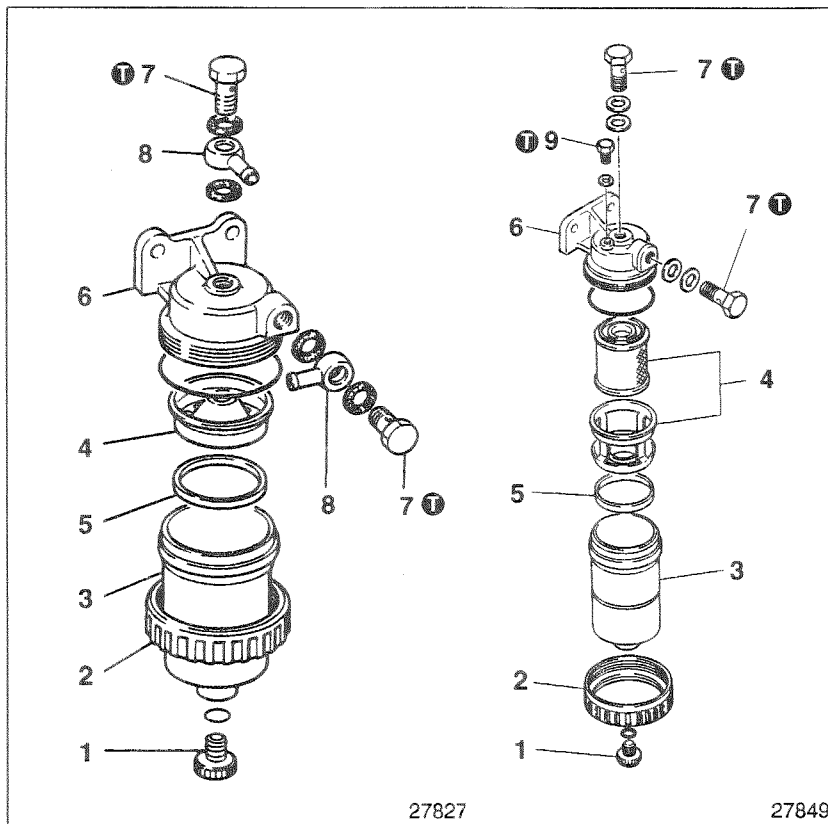
[Removal]

☒ : Filter Wrench



[Installation]

- To fit fuel filter 3, turn it until gasket C touches surface B of fuel filter head 6. Then, tighten the filter by 3/4 to 1 turn. Be sure to turn the filter by hand.
- Start the engine and check for fuel leaks.



● Disassembly sequence

- 1 Drain plug
- 2 Ring nut
- 3 Case
- 4 Baffle plate
- 5 Float
- 6 Head
- 7 Connector bolt
- 8 Joint
- 9 Air plug

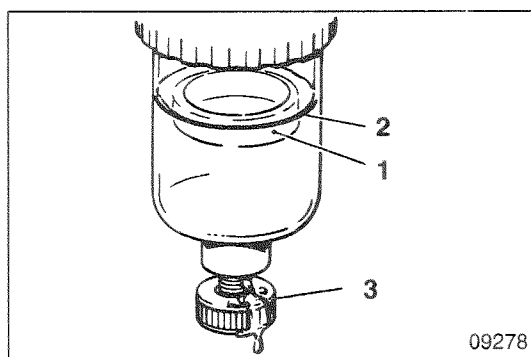
● Assembly sequence

Follow the disassembly sequence in reverse.

① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-------------------------------------|-----------------------|---------|
| 7 | Connector bolt (fuel pipe mounting) | 24 to 33 {2.5 to 3.5} | - |
| 9 | Air plug | 8 to 12 {0.8 to 1.2} | - |



◆ Service procedure

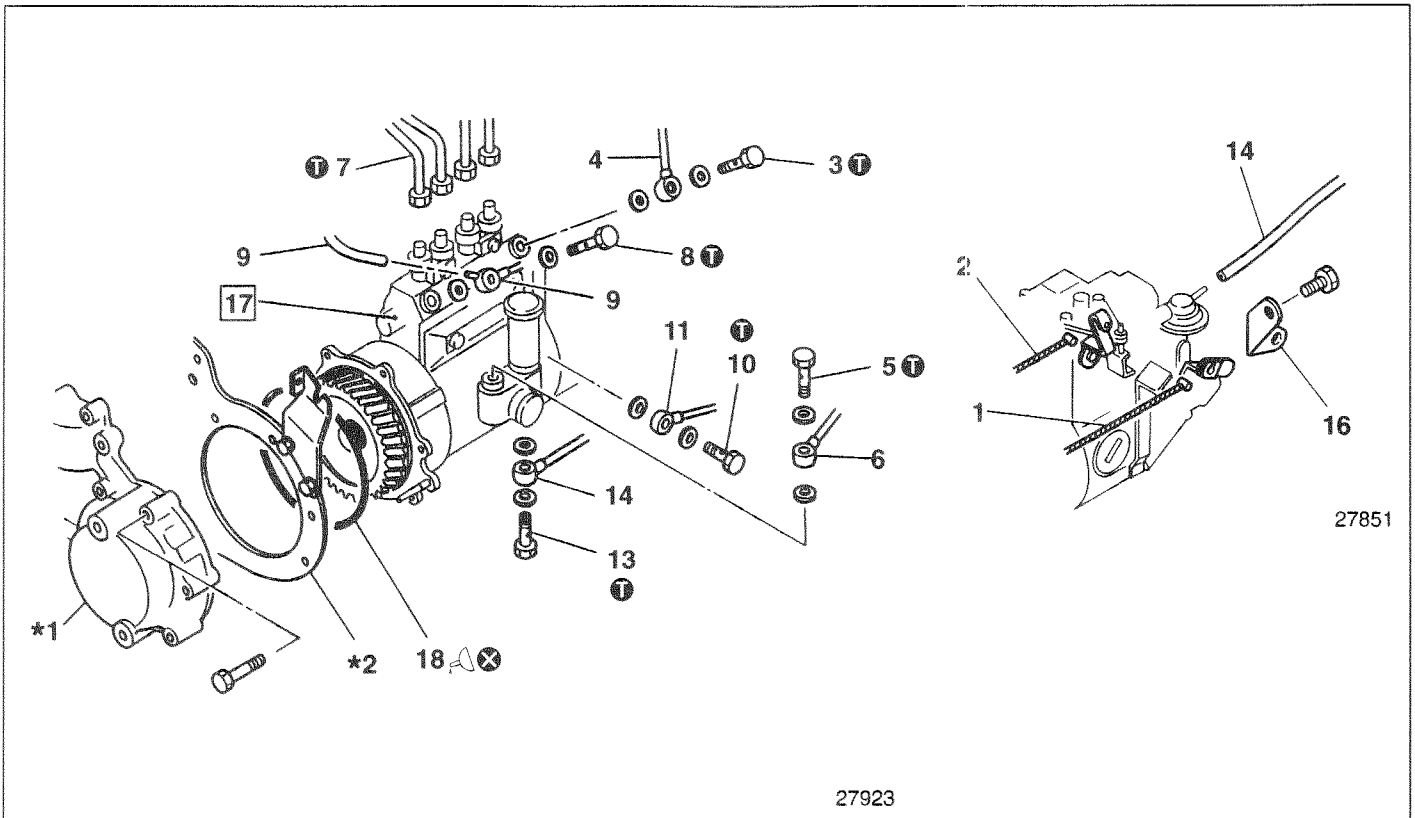
Drain the water separator of accumulated water when the red float 1, visible through the transparent case, is raised up to the red line 2 marked on the periphery of the case.

To remove the water, simply loosen the drain plug 3, and the water will flow out slowly along the groove in the plug. It is not necessary to remove the drain plug.

CAUTION ⚠

Before feeding fuel to the fuel system, check to ensure that the drain plug is securely tightened.

INJECTION PUMP



● Disassembly sequence

- | | |
|-----------------------------|-----------------------------|
| 1 Accelerator control cable | 12 Eyebolt |
| 2 Engine stop cable | 13 Fuel suction pipe |
| 3 Eyebolt | 14 Vacuum hose |
| 4 Fuel feed pipe | 15 Eyebolt |
| 5 Eyebolt | 16 Pump stay |
| 6 Fuel feed pipe | 17 Injection pump assembly |
| 7 Injection pipe | 18 O-ring |
| 8 Eyebolt | |
| 9 Leak-off hose | *1: Timing gear case Gr 11 |
| 10 Eyebolt | *2: Front plate Gr 11 |
| 11 Oil pipe | : Non-reusable part |

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

- Be sure to protect all openings by covering them after removal of hoses and pipes because the engine performance is adversely affected if dirt and foreign particles enter injection pump assembly 17.
- Do not hold the control lever when lifting injection pump assembly 17. Also, do not remove the control lever because removal of the lever might cause poor performance of the pump.

NOTE

For maintenance of injection pump assembly 17, please contact a ZEXEL or DENSO service station.

Tightening torque

Unit: N · m {kgf · m}

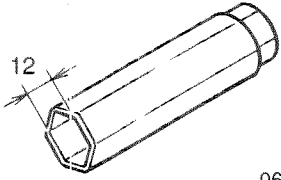
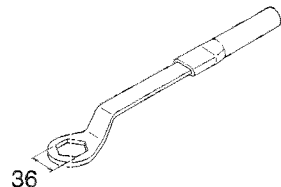
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|---|-----------------------|-----------------------|
| 3 | Eyebolt (fuel feed pipe mounting) | 4D31, 32, 33 | 15 to 20 {1.5 to 2.0} |
| | | 4D31-T, 34-T | 20 to 29 {2 to 3} |
| 5, 8, 12 | Eyebolt (fuel feed pipe, fuel return pipe and fuel suction pipe mounting) | 15 to 20 {1.5 to 2.0} | — |
| 7 | Injection pipe (union nut fastening) | 25 {2.5} | — |
| 10 | Eyebolt (oil pipe mounting) | 8 to 13 {0.8 to 1.3} | — |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---------------------|----------|
| 18 | O-ring | Engine oil | — |

Special tools

Unit: mm

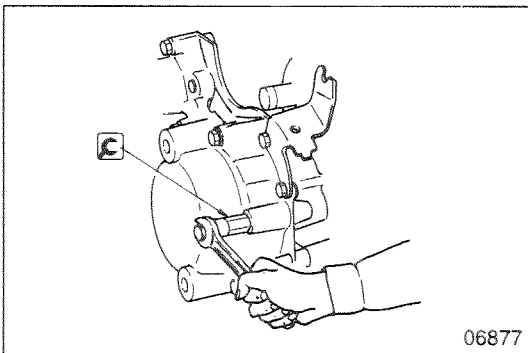
| Location | Tool name and shape | Part No. | Application |
|----------|--|-------------|---|
| 17 |  <p>12</p> <p>06876</p> | 31391-14100 | Removal and installation of injection pump assembly |
| — |  <p>36</p> <p>05999</p> | MH061289 | Cranking of engine |

Service procedure

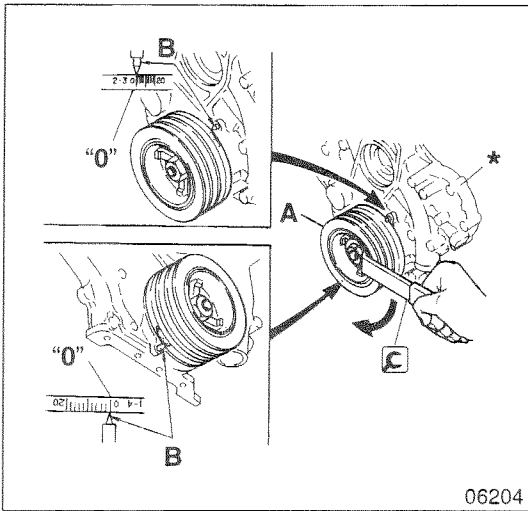
17 Installation of injection pump assembly

[Removal]


 : Socket Wrench

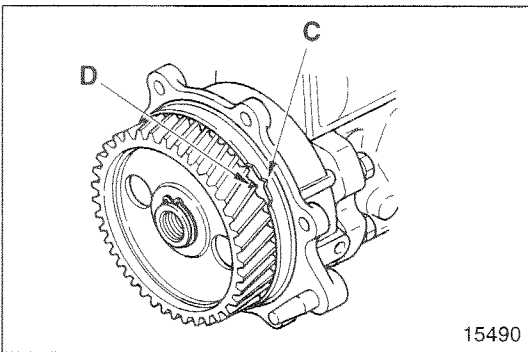


INJECTION PUMP

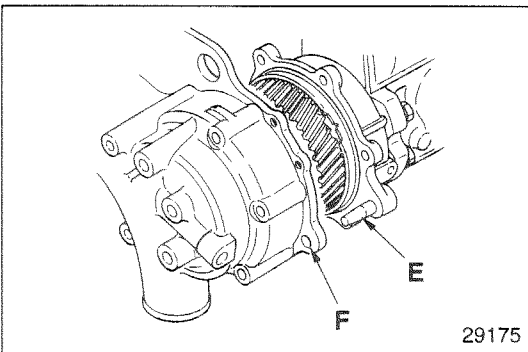


[Installation]

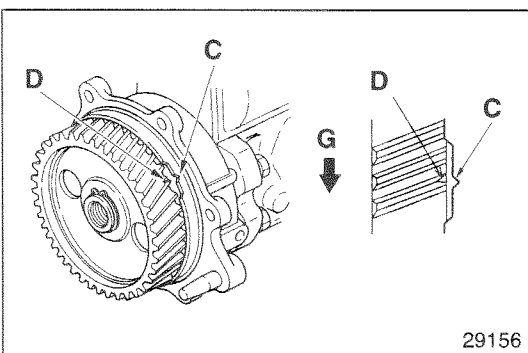
- Turn the engine clockwise using the  Cranking Handle until the "0" mark on the crankshaft pulley **A** is aligned with the pointer **B** on the timing gear case *. With the engine in this condition, piston No. 1 is at the top-dead-center (TDC) position of its compression stroke. If the inlet and exhaust valves of cylinder No. 1 are not pushed up by their push rods with the engine in this condition, piston No. 1 is at the TDC position of its compression stroke. If the inlet and exhaust valves are pushed up, turn the crankshaft by 360°.



- Align notch **C** on the timer case with notch **D** on the injection pump gear.



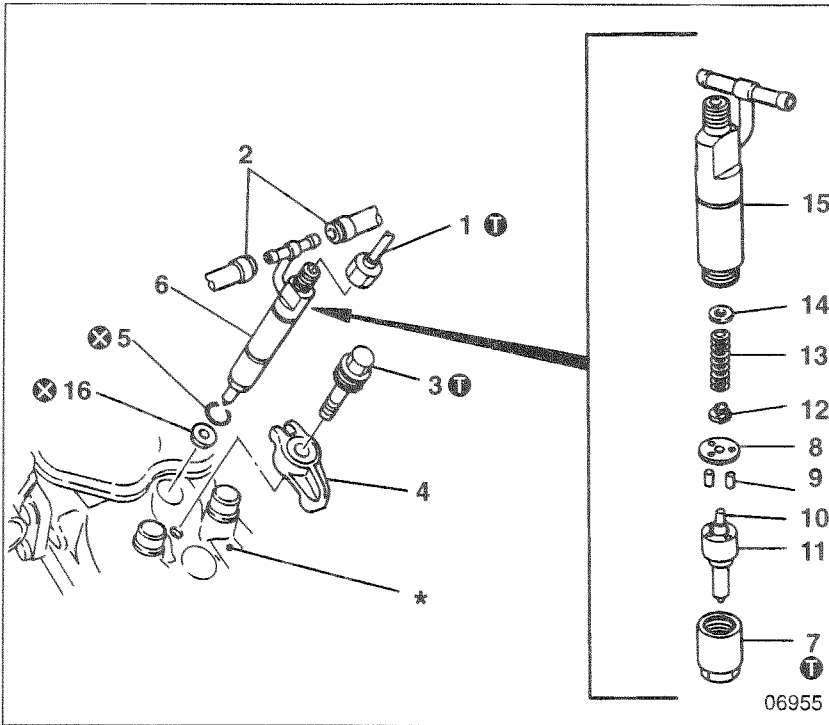
- Insert timer case guide bar **E** into front plate guide hole **F**. Using the bar as a guide, push the injection pump until the injection pump gear almost reaches the idler gear.



- Make sure notch **D** on the injection pump gear is aligned with notch **C** on the timer case, then push the injection pump. As the gears mesh and the injection pump gear turns, gear notch **D** will move in "**G**" direction.

MEMO

INJECTION NOZZLE



● Disassembly sequence

- 1 Injection pipe
- 2 Fuel leak-off pipe
- 3 Bolt
- 4 Bridge
- 5 C-ring
- 6 Injection nozzle assembly
- 7 Retaining nut
- 8 Tip packing
- 9 Straight pin
- 10 Needle valve
- 11 Nozzle
- 12 Pressure pin
- 13 Spring
- 14 Adjusting shim
- 15 Nozzle holder
- 16 Nozzle gasket

*: Cylinder head (Gr 11)

⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

- Do not touch the sliding part of needle valve 10. If the sliding part is touched, it could suffer damage or corrosion, causing nozzle 11 to lose its air-tightness.
- Under no circumstances change needle valve 10 and nozzle 11 combination used on each cylinder.
- Dirt particles in injection nozzle assembly 6 can seriously detract from engine performance. To prevent the ingress of dirt, cover all mounting points after removal.

NOTE

Clean off any carbon deposits before disassembling, reassembling, or adjusting injection nozzle assembly 6. Before disassembly, check the pressure and shape of the spray and inspect the assembly for fuel leaks. If no abnormality is apparent, do not commence disassembly.

Service standards

Unit: MPa (kgf/cm²)

| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|---|---|--|-------|--------|
| 6 | Injection pressure (valve opening pressure) | 4D31, 31-T (φ0.28) 32, 33, 34-T (φ0.32) Orifice diameter in () | $17.7 \begin{smallmatrix} +0.98 \\ 0 \end{smallmatrix} \{180 \begin{smallmatrix} +10 \\ 0 \end{smallmatrix}\}$ | — | Adjust |
| | | 31-T (φ0.3) 34-T (φ0.29 × 3, φ0.31 × 2) Orifice diameter in () | $21.6 \begin{smallmatrix} +0.49 \\ 0 \end{smallmatrix} \{220 \begin{smallmatrix} +5 \\ 0 \end{smallmatrix}\}$ | — | Adjust |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-------------------------------------|-------------------|---------|
| 1 | Union nut (injection pipe mounting) | 24 {2.5} | — |
| 3 | Bolt (bridge mounting) | 24 {2.5} | — |
| 7 | Retaining nut | 29 to 39 {3 to 4} | — |

② Special tools

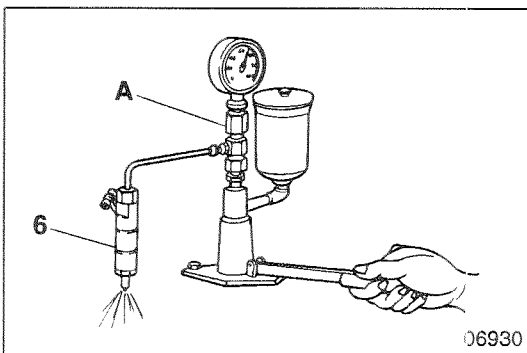
| Location | Tool name and shape | Part No. | Application |
|----------|----------------------|--------------|---------------------------------------|
| — | Nozzle Cleaning Tool | *105789-0010 | Cleaning of injection nozzle assembly |

* ZEXEL part number

◆ Service procedure

● Inspection before disassembly

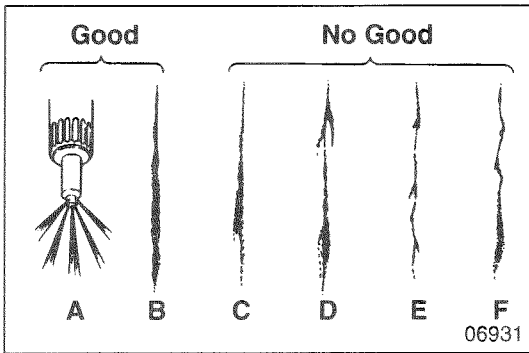
Fit injection nozzle assembly 6 onto nozzle tester A ready for inspection.

WARNING ⚠**Do not touch the spray that comes out of nozzle 11.****NOTE****Before commencing inspection, operate the lever on nozzle tester A two or three times to bleed all air out of the arrangement.**

(1) Checking valve opening pressure

- Push down the lever on nozzle tester A slowly. The pressure gauge reading will gradually rise, then the needle will suddenly deflect. Note the pressure when the needle starts to deflect.
- If the measurement is out of specification, disassemble the nozzle, clean it, and make adjustments using adjusting shim 14.
- Every 0.05 mm change in thickness of shim 14 corresponds to a 735 kPa {7.5 kgf/cm²} change in nozzle opening pressure. (A 9.8 kPa {1 kgf/cm²} change in nozzle opening pressure requires an approx. 0.0067 mm change in shim thickness.)
- If the measurement is still out of specification after adjustment, replace injection nozzle assembly 6.

INJECTION NOZZLE



(2) Inspecting spray condition

- Pump the lever on nozzle tester **A** quickly at a rate of about 4 to 6 strokes per second, and maintain a continuous spray.

A: Even spray from all five injection orifices (Good)

B: Even and symmetrical spray (Good)

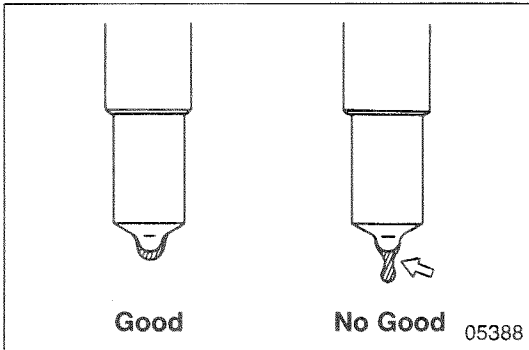
C: Asymmetrical spray (No Good)

D: Branched spray (No Good)

E: Thin spray (No Good)

F: Irregular spray (No Good)

- If the spray is unsatisfactory, disassemble and clean injection nozzle assembly **6**, then inspect the spray again. If the spray is still unsatisfactory, replace the injection nozzle assembly.
- Check that no fuel drips from the nozzle after the spray is complete.



(3) Inspecting for leaks

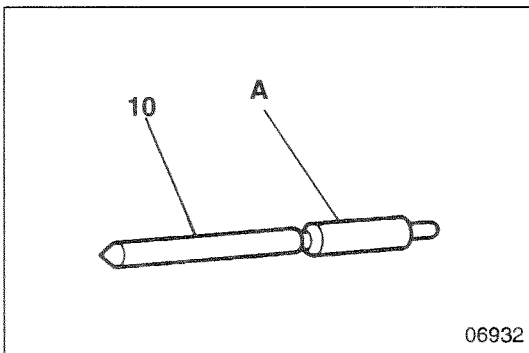
- Slowly increase the nozzle pressure to 1,960 kPa {20 kgf/cm²} below the specified valve opening pressure. Maintain this pressure for 10 seconds and check that no fuel drips from the end of the nozzle.
- If injection nozzle assembly **6** appears defective, disassemble and clean it, then inspect it again. If the injection nozzle assembly still appears defective, it must be replaced.

6 Injection nozzle assembly

[Disassembly]

CAUTION ⚠

- Do not touch sliding parts **A** of needle valve **10**.
- Do not change needle valve **10** and nozzle **11** combination on each cylinder.



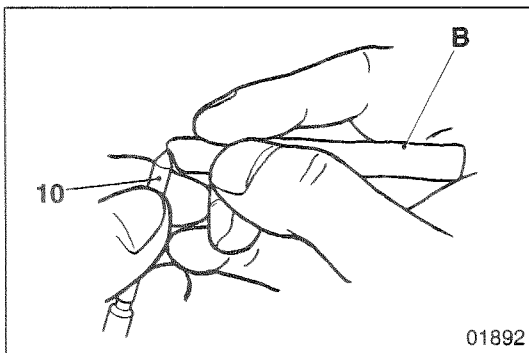
[Cleaning]

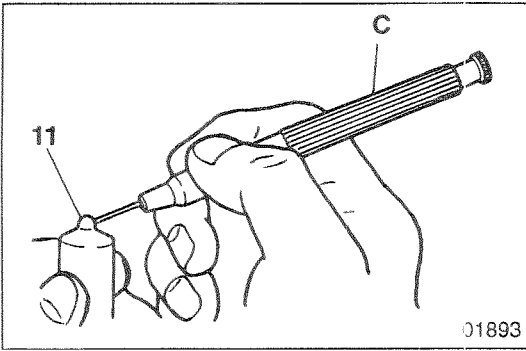
Wash needle valve **10** and nozzle **11** in gas oil, then use the **C** Cleaning Tool Set to remove any carbon deposits in accordance with the following procedure.


- Remove carbon from the end of needle valve **10** using the Cleaning Bar **B** of the **C** Cleaning Tool Set.

CAUTION ⚠

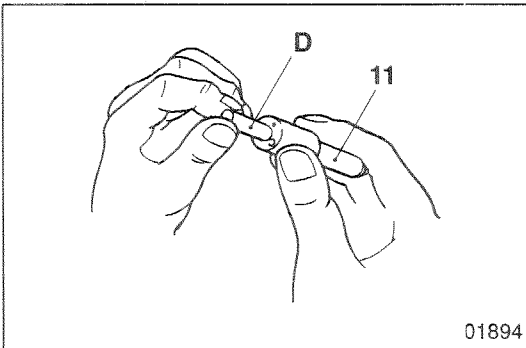
Do not use a wire brush or any hard metallic object for cleaning.




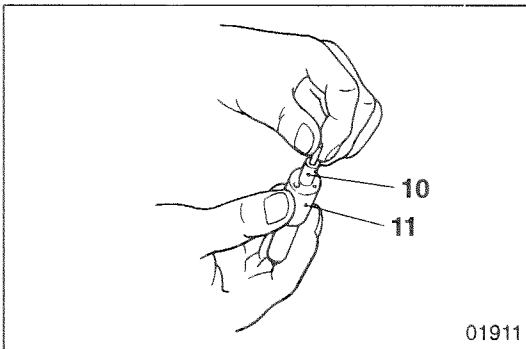


- Remove carbon from the injection orifice of nozzle **11** using the Needle Cleaner **C** of the  Cleaning Tool Set. Insert the Needle Cleaner and rotate it to dislodge the carbon.

Cleaning needle diameter: $\phi 0.25$ mm or less



- Clean the seat of nozzle **11** using the Cleaning Needle **D** of the  Cleaning Tool Set.
- To remove burned and hardened carbon, use FUSO Carbon Remover.



[Inspection]

- Wash needle valve **10** and nozzle **11** in gas oil, then fit them together.
- Pull up needle valve **10** by approximately 1/3 of its entire stroke, then check that it drops under its own weight. Repeat this test several times, turning the needle valve each time.
- If needle valve **10** does not drop as required, wash it in gas oil and carry out this test again. If the needle valve is still defective, replace the needle valve and nozzle **11** as a set.

GROUP 14 COOLING

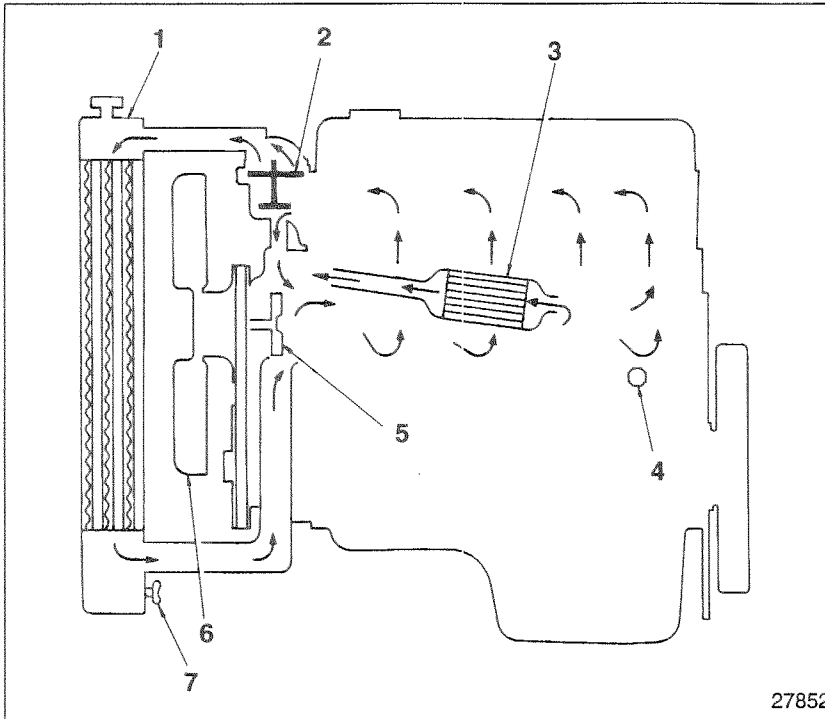
| | |
|---|-------|
| SPECIFICATIONS | 14-2 |
| STRUCTURE AND OPERATION | 14-3 |
| TROUBLESHOOTING | 14-5 |
| ON-VEHICLE INSPECTION AND ADJUSTMENT | |
| • Coolant Replacement and Cooling System Cleaning | 14-6 |
| • Air Bleeding of Cooling System | 14-8 |
| • Gas Leak Testing | 14-8 |
| RADIATOR | 14-9 |
| COOLING FAN, V-BELT AND WATER PUMP | 14-10 |
| THERMOSTAT | 14-17 |

SPECIFICATIONS

| Item | Specifications |
|--------------------------------------|--|
| Cooling system | Forced water circulation type |
| Water pump type | Belt-driven involute type |
| Thermostat type | Wax pellet, bottom bypass type (with jiggle valve) |
| Radiator type | Tube and corrugated fin type |
| Coolant capacity dm ³ {L} | Approx. 8.3 (8.3) |

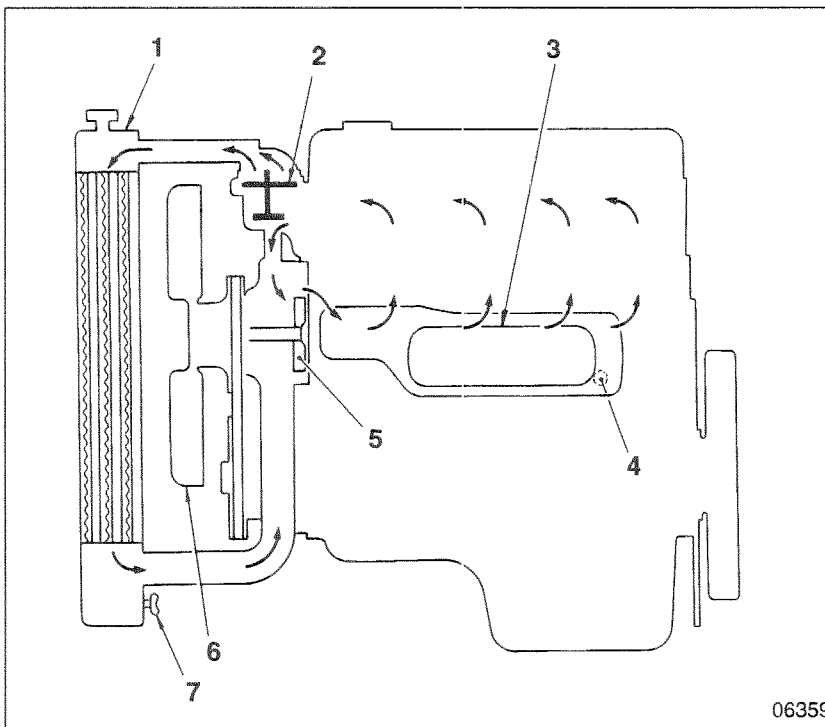
Cooling System (Coolant Flow)

<4D31, 31-T>



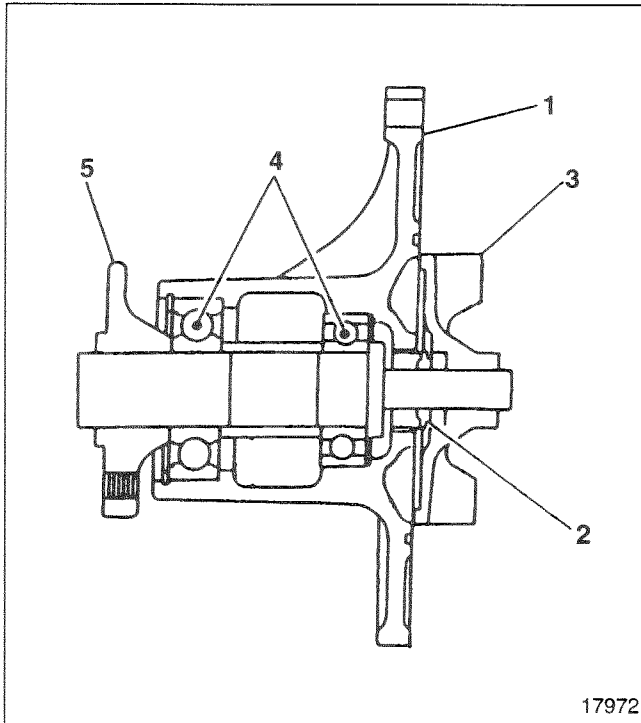
- 1 Radiator
- 2 Thermostat
- 3 Oil cooler
- 4 Crankcase drain cock
- 5 Water pump
- 6 Cooling fan
- 7 Radiator drain cock

<4D32, 33, 34-T>



STRUCTURE AND OPERATION

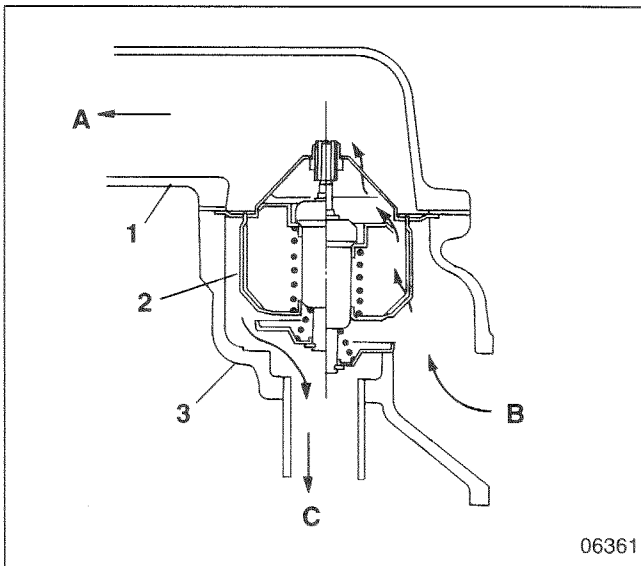
Water Pump



- 1 Case
- 2 Unit seal
- 3 Impeller
- 4 Unit bearing
- 5 Flange

17972

Thermostat



- 1 Thermostat cover
- 2 Thermostat
- 3 Thermostat case

- A: To radiator
- B: From cylinder head
- C: To water pump

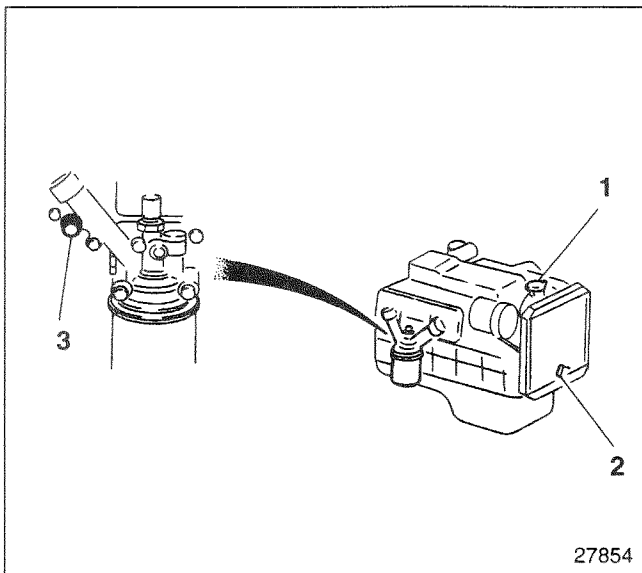
Thermostat **2** is a bottom bypass type that uses wax-charged pellets as its regulating element. As the wax changes from solid to liquid in line with temperature increases, the total wax volume changes. As a result, the position of the valve, changed by the coolant temperature, regulates the flow of coolant to the radiator and water pump (bypass side) and controls the coolant temperature.

06361

| Symptoms | | | | | | Remarks |
|---------------------------------------|---|--------------------------|--------------------------|--------------------------|--------------------------|---------|
| | | | | | | |
| Possible causes | | | | | | |
| V-belt | Loose or damaged | <input type="checkbox"/> | | <input type="checkbox"/> | | |
| | Excessive tension | | | <input type="checkbox"/> | | |
| | Oil on belt | <input type="checkbox"/> | | | | |
| Water pump | Water pump fitted poorly | <input type="checkbox"/> | | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Unit bearing defective | <input type="checkbox"/> | | <input type="checkbox"/> | | |
| | Impeller defective | <input type="checkbox"/> | | <input type="checkbox"/> | | |
| | Unit seal defective | <input type="checkbox"/> | | | <input type="checkbox"/> | |
| | Loose fit between unit bearing and flange and/or shaft and impeller | <input type="checkbox"/> | | <input type="checkbox"/> | | |
| Thermostat | Case fitted poorly | <input type="checkbox"/> | | | <input type="checkbox"/> | |
| | Valve opening temperature too high; valve remains closed | <input type="checkbox"/> | | | | |
| | Valve opening temperature too low; valve remains open | | <input type="checkbox"/> | | | |
| Oil cooler | Oil cooler fitted poorly | <input type="checkbox"/> | | | <input type="checkbox"/> | Gr12 |
| | Gasket defective | <input type="checkbox"/> | | | <input type="checkbox"/> | |
| Cylinder head | Cylinder head fitted poorly | <input type="checkbox"/> | | | <input type="checkbox"/> | Gr11 |
| | Gasket defective | <input type="checkbox"/> | | | <input type="checkbox"/> | |
| Coolant quantity insufficient | | <input type="checkbox"/> | | | | |
| Coolant passages dirty and/or clogged | | <input type="checkbox"/> | | | | |
| Hoses fitted poorly | | <input type="checkbox"/> | | | <input type="checkbox"/> | |
| Ambient temperature extremely low | | | <input type="checkbox"/> | | | |

ON-VEHICLE INSPECTION AND ADJUSTMENT

Coolant Replacement and Cooling System Cleaning



- 1 Pressure cap
- 2 Radiator drain cock
- 3 Crankcase drain plug

27854

ⓘ Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-----------------------|---------|
| 3 | Crankcase drain plug | 33 to 39 {3.5 to 4.0} | — |

Using the radiator for extended periods without cleaning the cooling system will cause overheating since rust and scale deposits will accumulate. The cooling system must be cleaned periodically.

● Draining coolant

Before draining the coolant, loosen pressure cap 1 to reduce the pressure in the cooling system.

WARNING

Allow the coolant to cool down sufficiently before loosening the pressure cap. When the temperature is high, there is a danger that boiled coolant gushes out from the filler port.

● Cleaning procedure

- Run the engine and keep the coolant at a temperature of approximately 90°C so that the thermostat valve remains open and the coolant continues to circulate in the radiator.
- To increase the coolant temperature quickly, cover the front of the radiator with cardboard or a similar material.
- If cleaning is carried out after a large amount of rust has accumulated, the radiator may start to leak. Carefully examine the radiator for leaks after cleaning the cooling system.
- Soft water to be used should have the following properties.

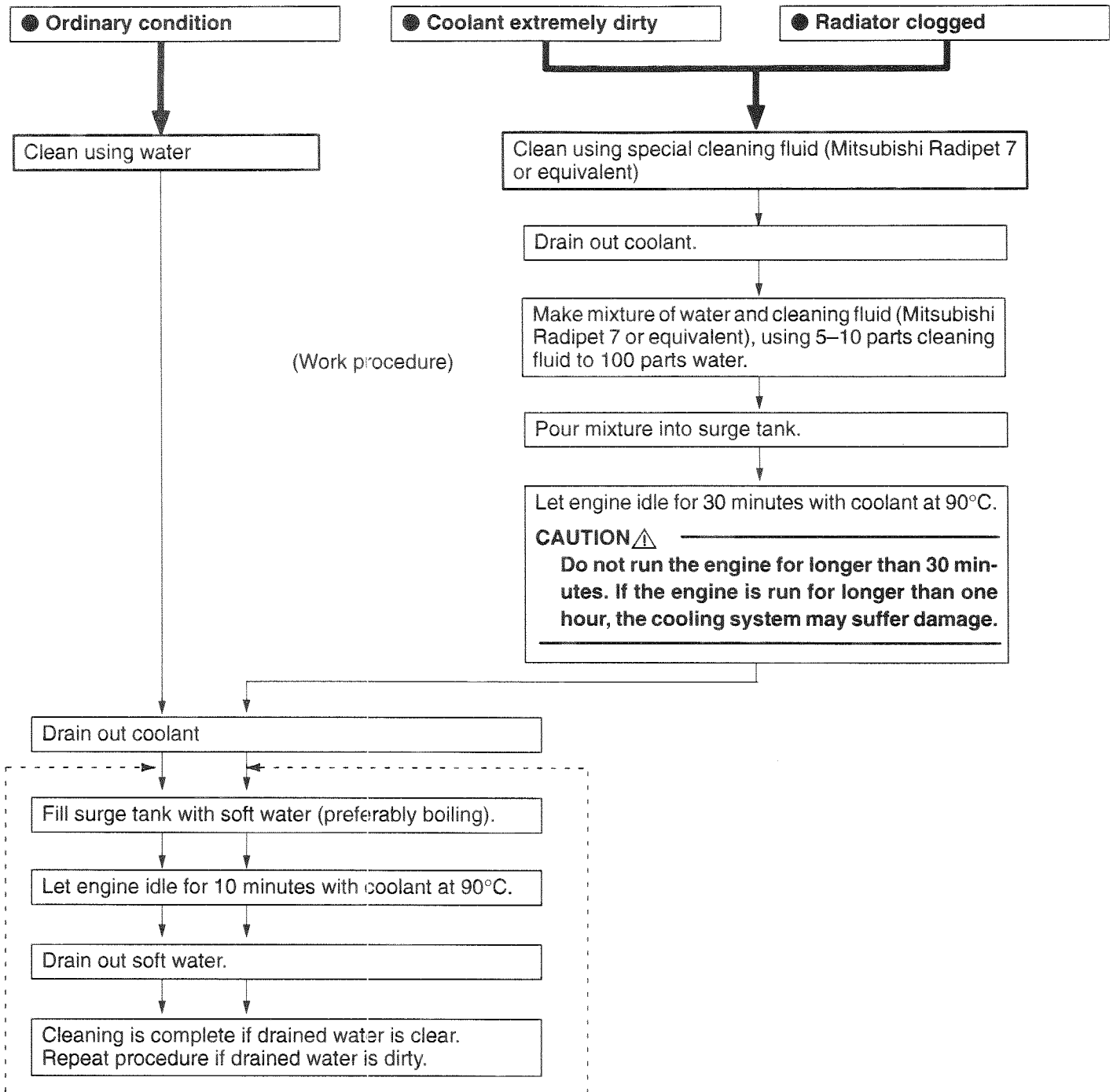
CAUTION

Do not use hard water as it causes scale and rust.

Required properties of soft water

| | | | |
|--------------------------------------|-----------------|------------------------|-----------------|
| Total hardness | 300 ppm or less | Total dissolved solids | 500 ppm or less |
| Sulfate SO ₄ ⁻ | 100 ppm or less | pH | 6 to 8 |
| Chloride Cl ⁻ | 100 ppm or less | — | — |

As shown below, the cleaning method for the cooling system depends on the system's condition.



DANGER

If you accidentally splash FUSO Diesel Long Life Coolant, FUSO Antifreeze, or Radiator Antirust (Radipet 9) in your eyes, wash it out immediately with water and seek medical attention.

WARNING

FUSO Diesel Long Life Coolant, FUSO Antifreeze, and Radiator Antirust (Radipet 9) are flammable. Keep them away from heat and naked flames.

ON-VEHICLE INSPECTION AND ADJUSTMENT

NOTE

- After cleaning the cooling system with cleaning fluid, fill it with coolant as soon as possible .
- To prevent freezing of the coolant and corrosion of the cooling system, add to the coolant the specified proportion of FUSO Diesel Long Life Coolant, FUSO Antifreeze, or Radiator Antirust (Radipet 9). (See the Owner's Handbook for instructions on the use of these products.)

Air Bleeding of Cooling System

- Remove the pressure cap 1. Keeping the coolant temperature at 90°C, let the engine idle until the cooling system is completely bled of air.
- After bleeding the cooling system of air, add coolant to the radiator as required.

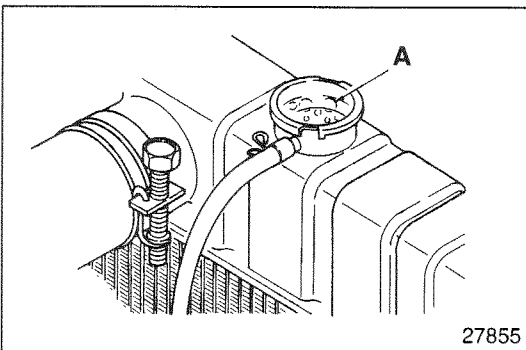
Gas Leak Testing

The presence of air or exhaust gas in the coolant increases corrosion and rust in the cooling system. Check for air or exhaust gas in the coolant using the following procedure:

- Remove pressure cap 1.

WARNING

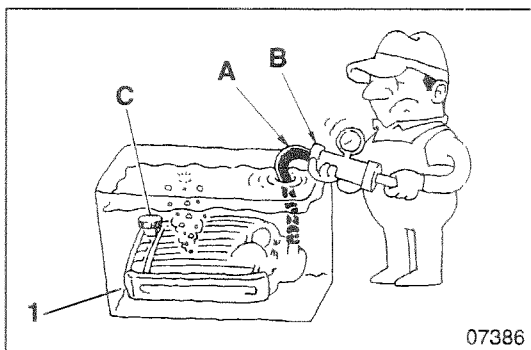
Make sure the coolant is sufficiently cool before loosening the pressure cap. If the coolant is hot, it will gush out.



- Run the engine until the coolant temperature reaches approximately 90°C.
- If bubbles **A** appear continuously, there is air or exhaust gas in the coolant.
- If the coolant contains air, the cylinder head bolts, water pump mounting bolts, or hose connections may be loose. Alternatively, the hoses may be damaged.
- If the coolant contains exhaust gas, it is possible that the cylinder head gasket is damaged or that the cylinder head is cracked.

Service standards

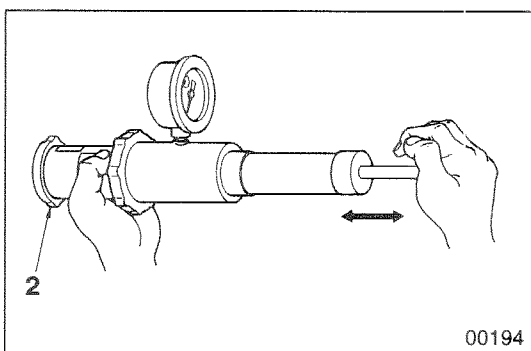
| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|--|-------|-------------------|
| 1 | Air leakage from radiator (Under air pressure of 145 kPa {1.5 kgf/cm ² }) | 0 cc | — | Repair or replace |
| 2 | Pressure cap valve opening pressure | 88 ± 15 kPa {0.9 ± 0.15 kg/cm ² } | — | Replace |



◆ Service procedure

1 Inspection of radiator

- Install radiator cap tester **B** by connecting hose **A** to the radiator inlet port.
- Plug any openings **C** other than inlet port, and immerse the entire body of the radiator in water.
- Apply the specified air pressure (145 kPa {1.5 kgf/cm²}) using cap tester **B** and check for any air leakage.
- If air leakage is found, repair or replace radiator **1**.

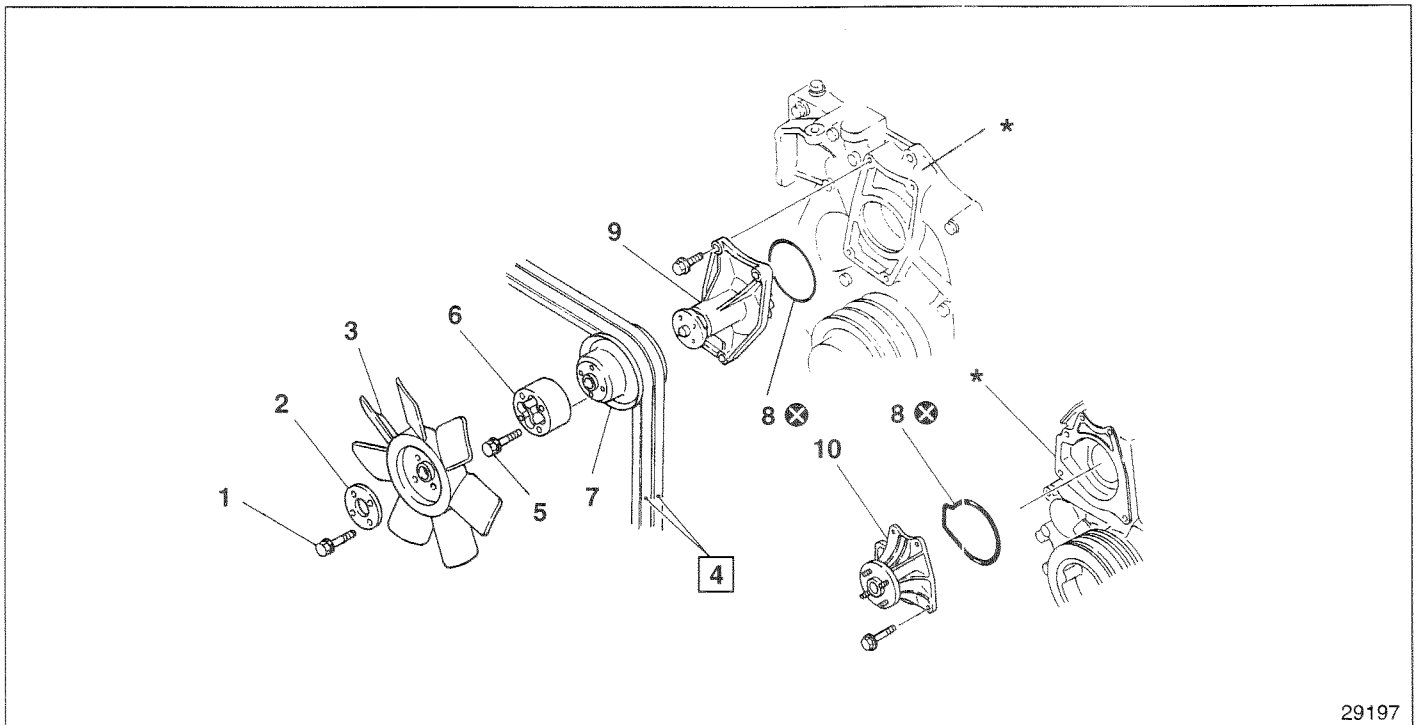


2 Pressure cap inspection

• Pressure valve opening pressure

Measure the pressure valve's opening pressure. If the measurement does not comply with the standard value, replace pressure cap **2**.

COOLING FAN, V-BELT AND WATER PUMP



29197

● Disassembly sequence

- 1 Bolt
- 2 Washer
- 3 Cooling fan
- 4 V-belt
- 5 Bolt
- 6 Spacer

- 7 Water pump pulley
- 8 O-ring
- 9 Water pump assembly <A type> P14-4
- 10 Water pump assembly <B type>

- *: Timing gear case Gr 11
- ⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

- The water pump assembly <B type> 10 cannot be disassembled. Replace the whole assembly if it is malfunctioning.
- V-belts 4 must be replaced together as a set. Never replace either V-belt individually.
- Apply soap suds to O-ring 8 before fitting it. Do not apply engine oil to the O-ring since this would make it swell.

Service standards


Unit: mm

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|------------------|----------------|-------|--------|
| 4 | V-belt tension | 10 to 15 | — | Adjust |

Lubricant

| Location | Points of application | Specified lubricant, | Quantity |
|----------|----------------------------|----------------------|-------------|
| 9 | Entire periphery of O-ring | Soap suds | As required |



Special tools

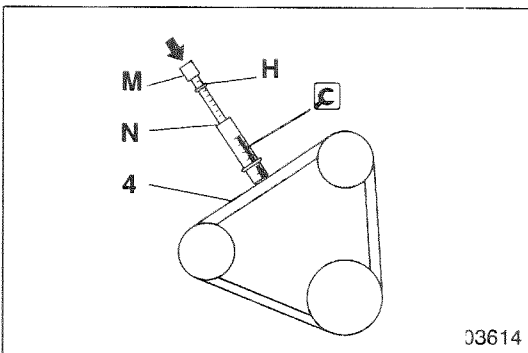
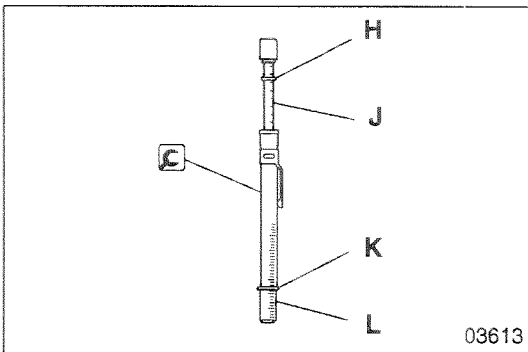
| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|----------------------------|
| 4 | Belt Tension Gauge  | MH062345 | V-belt tension measurement |
| | 03612 | | |


Service procedure

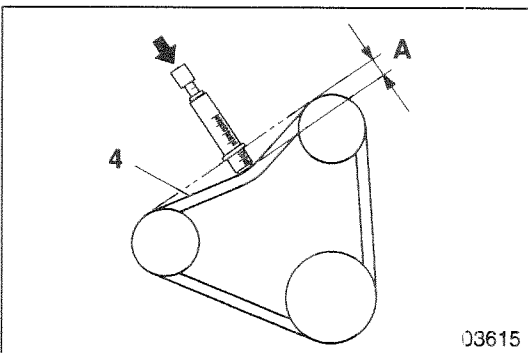
4 V-belt

● Use of Belt Tension Gauge

- Set upper O-ring **H** of the  Belt Tension Gauge to 98 N {10 kgf} (push load) on scale **J**.
- Set lower O-ring **K** of the  Belt Tension Gauge to the V-belt's correct maximum deflection value on scale **L**.

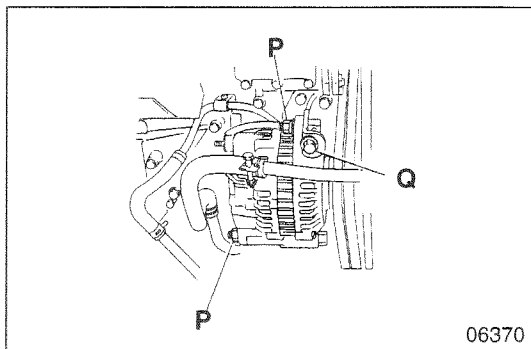


- Apply the  Belt Tension Gauge to the center of V-belt **4** and push the gauge's handle **M** until O-ring **H** reaches flange **N**.



- Measure the extent of V-belt **4** deflection **A**. If the measurement does not conform with the standard value, adjust the V-belt as shown below.

COOLING FAN, V-BELT AND WATER PUMP



[Adjustment]

- Loosen alternator mounting bolts **P** (2 places) and adjust the V-belt **4** tension by turning adjusting bolt **Q**.
- When the adjustment is complete, tighten the bolts and nuts securely.

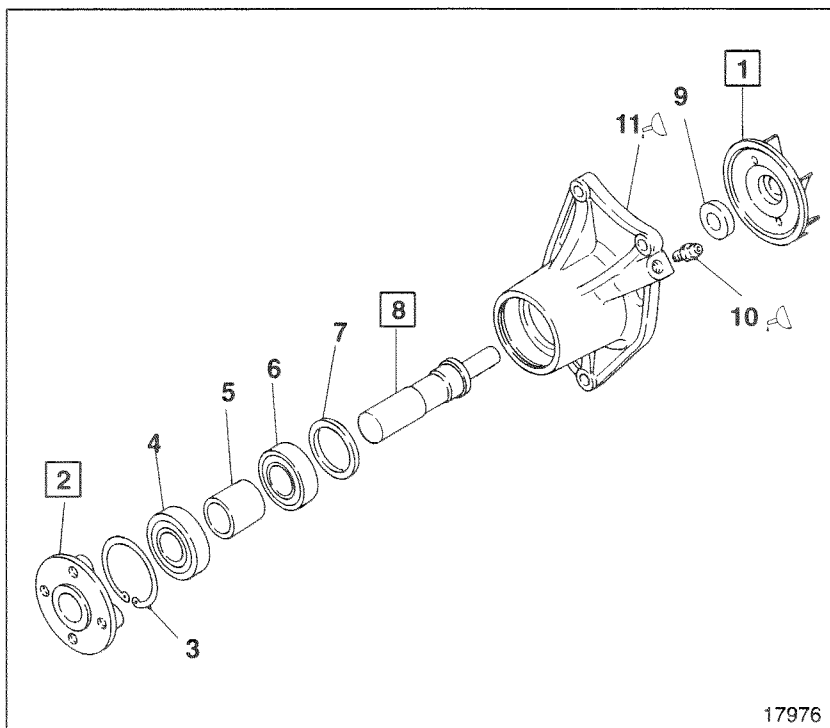
CAUTION

- Excessive tension in V-belt **4** may damage the belt and related bearings.
 - Be sure to replace V-belts **4** as a set to maintain even tension between them.
 - Keep V-belt **4** free of oil. If the belt becomes oily, it will slip, resulting in overheating of the engine and insufficient charging of the battery.
-

MEMO

COOLING FAN, V-BELT AND WATER PUMP

Water Pump Assembly <4D31, 31-T, 32 (A type), 34-T (A type)>



● Disassembly sequence

- 1 Impeller
- 2 Flange
- 3 Snap ring
- 4 Bearing, front
- 5 Spacer
- 6 Bearing, rear
- 7 Washer
- 8 Water pump shaft
- 9 Unit seal
- 10 Grease nipple
<4D32 (A type), 34-T(A type)>
- 11 Water pump case

● Assembly sequence

- 8 → 7 → 6 → 5 → 4 } → 3 → 2 → 9 → 1
 11 → 10

17976

Service standards

Unit: mm

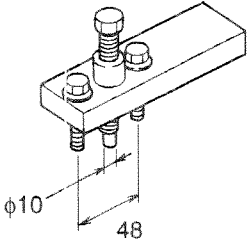
| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy | |
|----------|---|---|-------------------|-------------------------------|-------------------------------|
| 1, 8 | Impeller-to-water pump shaft interference | [13] 0.03 to 0.06 | — | Reassembly allowed only twice | |
| 2, 8 | Flange-to-water pump shaft interference | 4D31, 31-T | [17] 0.02 to 0.05 | — | Reassembly allowed only twice |
| | | 4D32, 34-T | [25] 0.04 to 0.06 | | |

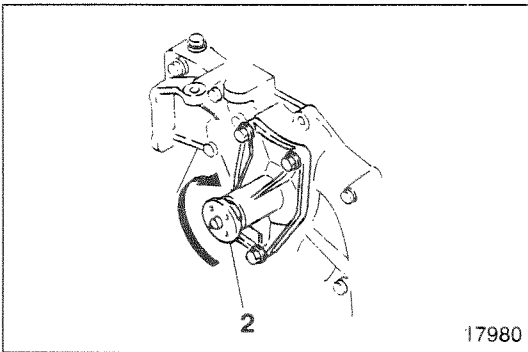
Lubricant and sealant

| Location | Points of application | | Specified lubricant and/or sealant | Quantity |
|----------|--|----------------|--|-------------|
| 4, 6 | Bearings | | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 9 | Unit seal outer periphery | | Threebond 1102 | As required |
| 10 | Grease nipple <4D32 (A type), 34-T (A type)> | | Wheel bearing grease [NLGI No. 2 (Li soap)] | 60 g |
| 11 | Clearance between front and rear bearings <4D31, 31-T> | Shaft diameter | Wheel bearing grease [NLGI No. 2 (Li soap)] | 15 g |
| | | | | 52 g |

☒ Special tools

Unit: mm

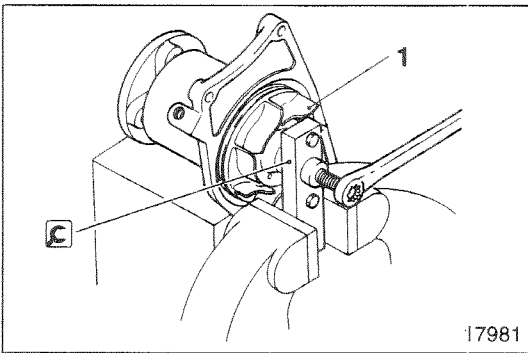
| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|---------------------|
| 1 |  <p>Impeller Puller</p> | MH061417 | Removal of impeller |



◆ **Service procedure**

● **Inspection after assembly**

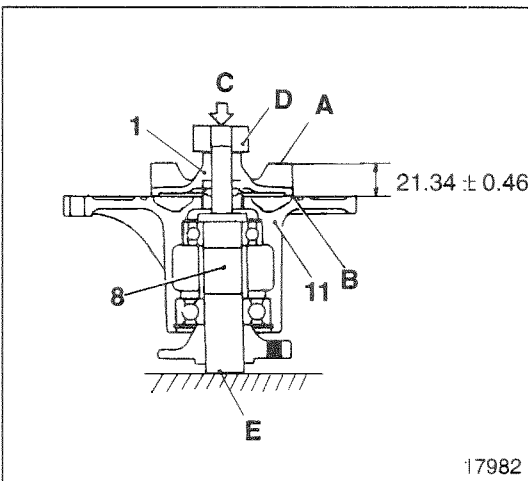
- After assembly, rotate flange 2 by hand and check that it turns smoothly without hindrance.
- If the flange does not turn smoothly, disassemble and inspect the water pump again.



1 Impeller

[Removal]

- Tap threads (M8 × 1.25) into the two holes (φ6 mm) in impeller 1.
- Fit the ☒ Impeller Puller onto the impeller and use it to remove the impeller.



[Installation]

Press-fit the impeller 1 until outer edges A of its blades are the specified distance (see the drawing) from end surface B of water pump case 11.

C: Press

4D31, 31-T: 6.86 to 15.69 kN {700 to 1600 kgf}

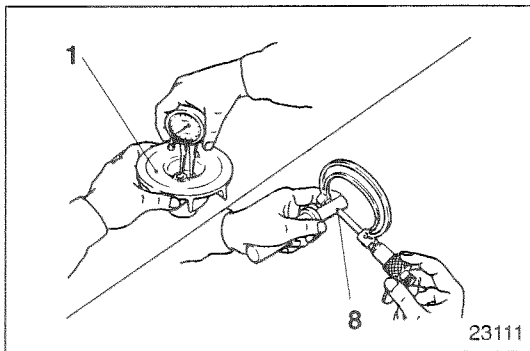
4D32, 34-T: 8830 N {900 kgf} or more

D: Cylindrical jig

CAUTION ⚠

Press-fit the impeller such that flange side E of water pump shaft 8 is the load receiving surface.

COOLING FAN, V-BELT AND WATER PUMP

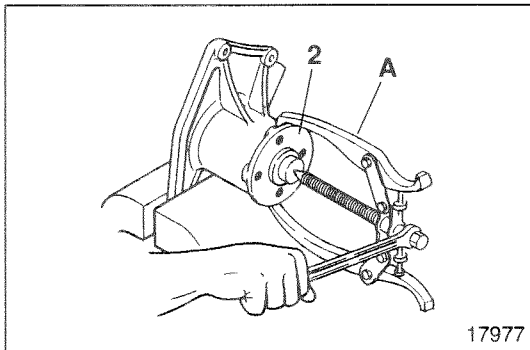


1 8 Impeller-to-water pump shaft interference

If the measurement does not conform with the standard value, replace the defective part(s).

CAUTION

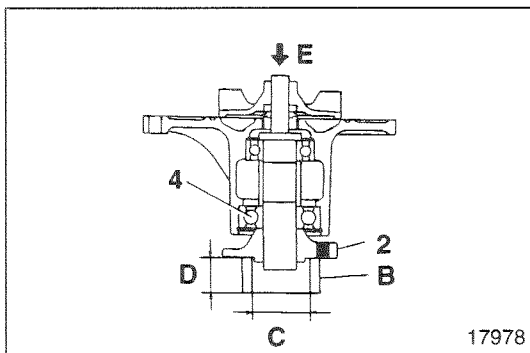
Even if the standard value is satisfied, reassembly must not be carried out more than twice.



2 Flange

[Removal]

A: Gear puller



[Press-fitting]

Press-fit the flange until it touches bearing 4.

B: Cylindrical jig

C: $\phi 40$ mm

D: 20 mm or more

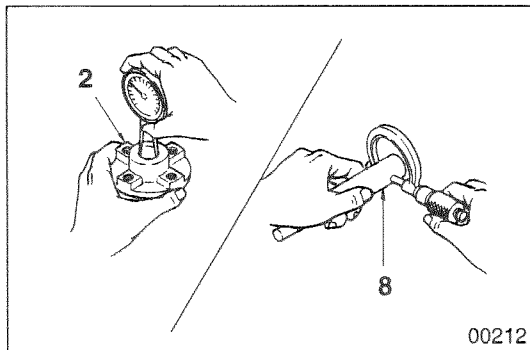
E: Press

4D31, 31-T

Shaft diameter 17: 4.90 to 39.22 kN {500 to 4000 kgf}

Shaft diameter 25: 5.88 to 13.73 kN {600 to 1400 kgf}

4D32, 34-T: 7360 N {750 kgf} or more



2 8 Flange-to-water pump shaft interference

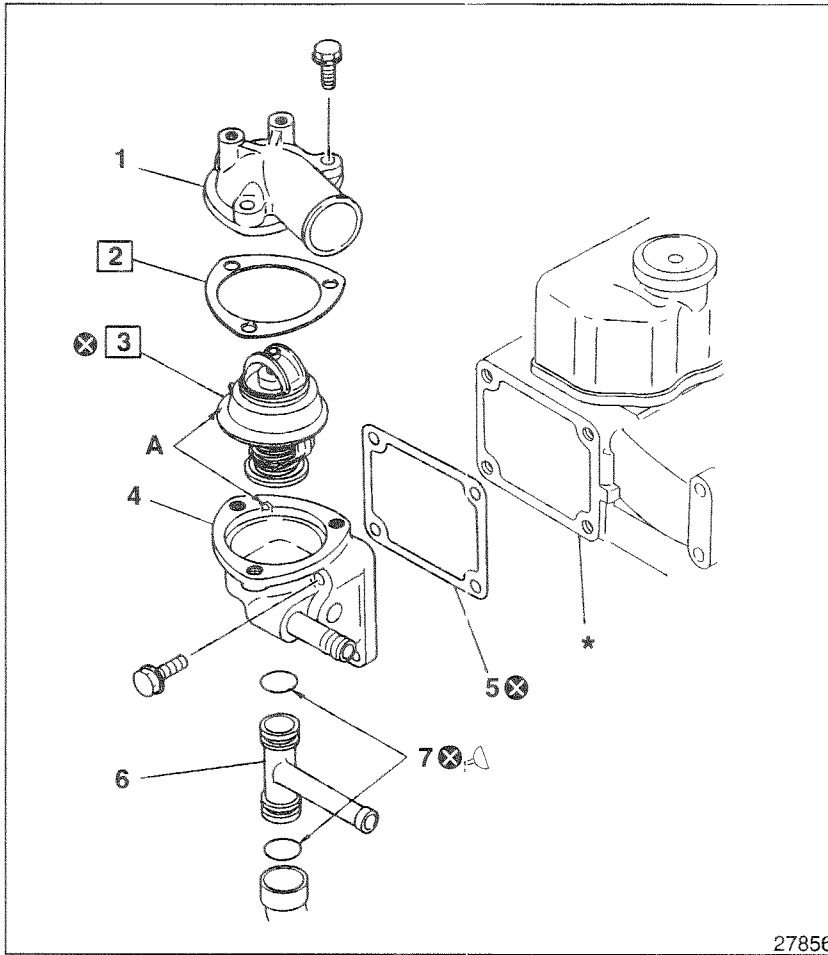
If the measurement does not conform with the standard value, replace the defective part(s).

CAUTION

Even if the standard value is satisfied, reassembly must not be carried out more than twice.


Water Pump Assembly <4D32 (B type), 33, 34-T (B type)>

The water pump is a non-serviceable item. If any fault (faulty bearing, looseness, abnormal noise, water leaks) is found in the water pump, always replace it as an assembly.



● Disassembly sequence

- 1 Thermostat cover
- 2 Thermostat cover gasket
- 3 Thermostat
- 4 Thermostat case
- 5 Thermostat case gasket
- 6 Bypass pipe
- 7 O-ring

* : Cylinder head  Gr 11

A : Locating groove

⊗ : Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Apply soap suds to O-rings 7 before fitting them. Do not apply engine oil to the O-rings since this would make them swell.

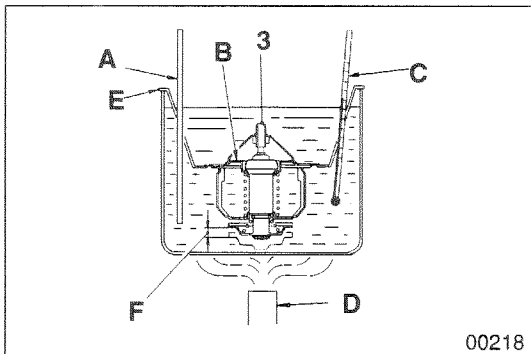
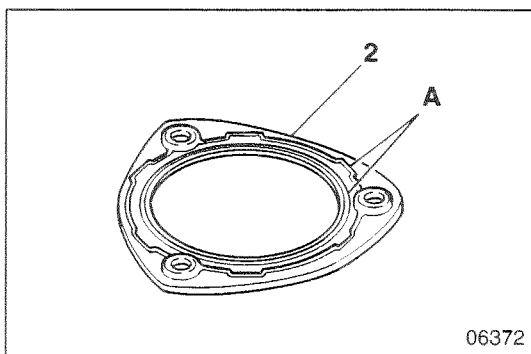
Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|------------------|-------------------------------|---------------|--------|
| 3 | Thermostat | Valve opening temperature | 76.5 ± 2°C | — |
| | | Valve lift/temperature (90°C) | 10 mm or more | — |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---------------------|-------------|
| 7 | Periphery of O-ring | Soap suds | As required |

THERMOSTAT



◆ Service procedure

2 Thermostat cover gasket installation

Install thermostat cover gasket **2** with surface **A** having a sealant application groove toward thermostat case **4**.

3 Thermostat inspection

Place the thermostat in a container of water. While stirring the water with a rod **A** to ensure that it is heated evenly, carry out the following inspection procedure. If the measurements do not conform with the standard values, replace thermostat **3**.

(1) Valve opening temperature:

- Support thermostat **3** with wire **E** to keep it away from heat source **D**.
- Gradually heat the water until it reaches the valve opening temperature.
- Maintain this temperature for 5 minutes and check that valve **B** is open.
- When the water temperature drops below 65°C, check that valve **B** is completely closed.

C: Thermometer

(2) Valve lift

Heat the water to slightly higher than the valve opening temperature. With valve **B** fully open, maintain this water temperature for 5 minutes. Measure the extent of valve lift **F**.

GROUP 15 INTAKE AND EXHAUST

| | |
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| INTAKE MANIFOLD | 15-34 |
| EXHAUST MANIFOLD | 15-35 |

SPECIFICATIONS

Air Cleaner

| Item | Specifications | |
|--------------|---------------------------|-----------------------------|
| Type | Cyclone type paper filter | Cartridge type paper filter |
| Manufacturer | Nihon Donaldson | |

Dust Indicator

| Item | Specifications | |
|------|-----------------|---------------|
| Type | Mechanical type | Electric type |

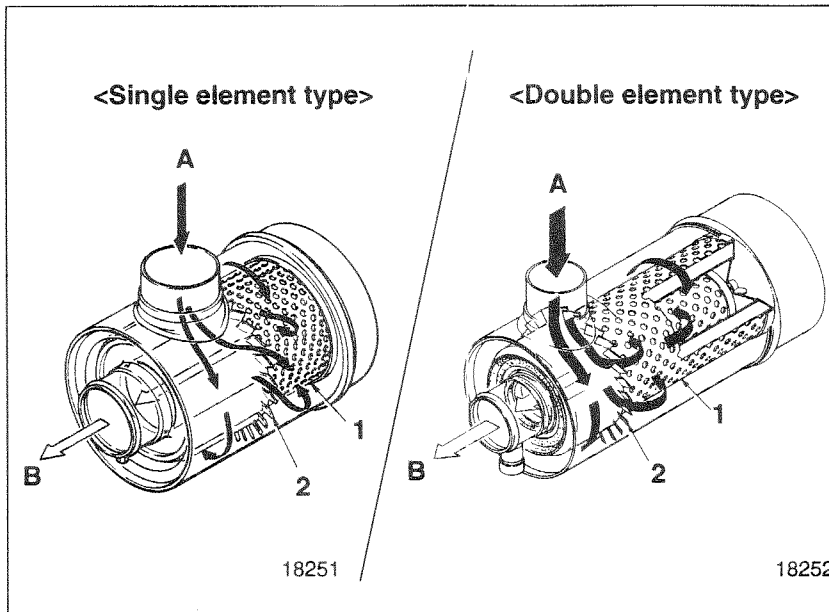
Turbocharger

| Item | Specifications | | |
|--------------|-----------------------------|------|------|
| Type | TD04HL | TD05 | TD06 |
| Manufacturer | Mitsubishi Heavy Industries | | |

Air Cleaner

Cyclone type air cleaner

<FHG, FWG>



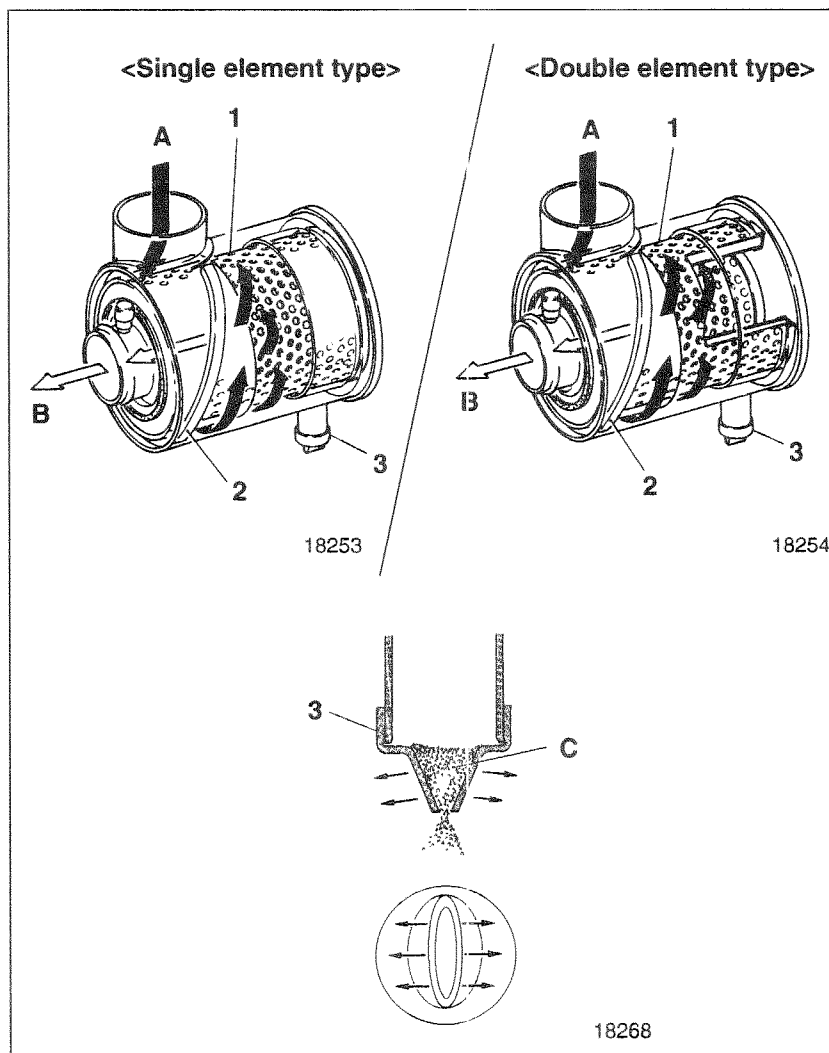
- 1 Element
- 2 Vane

A: Outside air
B: To engine

The element 1, which comes in two types; the single and double element types, is the filter paper type. Coated with plastics and given heat treatment, the element offers outstanding resistance to water and oils.

The air that has been drawn in is made to rotate by vane 2, and large particles of dust are centrifugally separated. Furthermore, small particles of dust are filtered out by the filter paper element, and the air thus made clean is drawn into the engine.

<FTG>



- 1 Element
- 2 Guide vane
- 3 Vacuator valve

A: Outside air
B: To engine

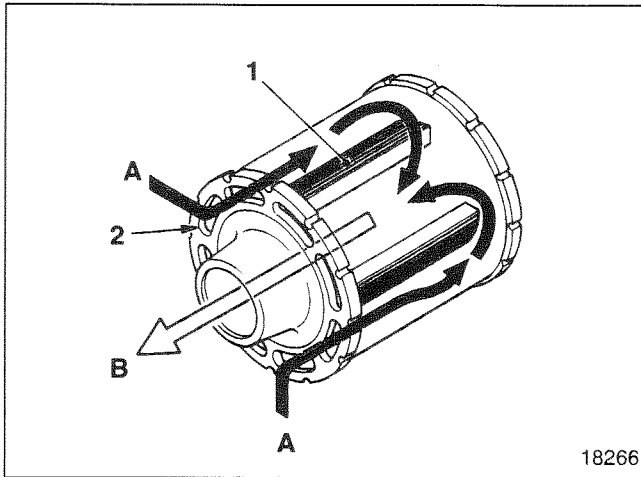
The element 1, which comes in two types; the single and double element types, is the filter paper type. Coated with plastics, is the filter paper type. Coated with plastics and given heat treatment, the element offers outstanding resistance to water and oils.

The air that has been drawn in is made to rotate by guide vane 2, and large particles of dust are centrifugally separated. Furthermore, small particles of dust are filtered out by the filter paper element, and the air thus made clean is drawn into the engine.

Vacuator valve 3 automatically discharges the separated dust and dirt. When the engine speed lowers to a certain speed, the elasticity of the rubber valve overcomes the negative pressure in the air cleaner, thus opens and discharges dust and dirt C.

STRUCTURE AND OPERATION

Cartridge type air cleaner

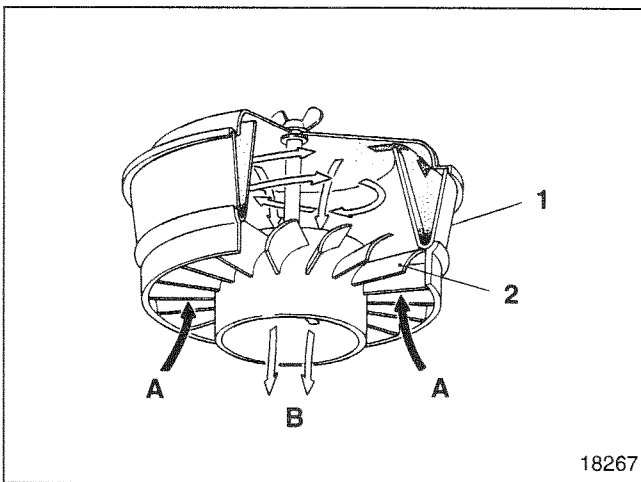


- 1 Element
- 2 Inlet slot

A: Outside air
B: Into engine

Element 1 is the filter paper type. The outside air is directly drawn in from inlet slot 2 of the air cleaner proper.

Pre-cleaner



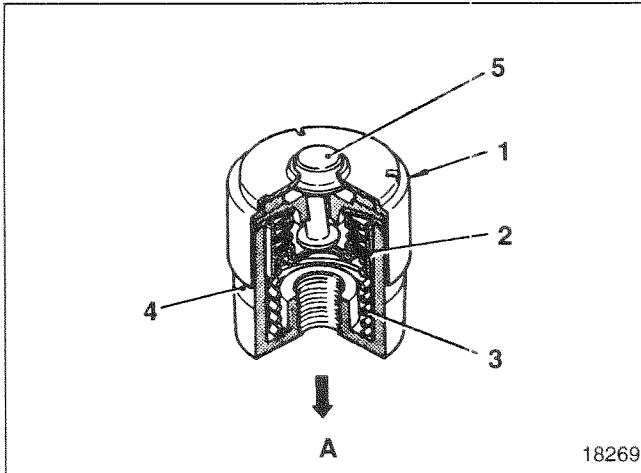
- 1 Pre-cleaner body
- 2 Guide vane

A: Outside air
B: To air cleaner

The pre-cleaner removes relatively large particles of dust contained in the air that has been drawn in. The air that has been drawn in is made to rotate by guide vane 2 in the pre-cleaner, and the centrifugally separated particles of dust are accumulated in pre-cleaner body 1.

Dust Indicator

<Mechanical type>



- 1 Dust indicator
- 2 Signal
- 3 Spring
- 4 Transparent portion
- 5 Reset button

A: Negative pressure

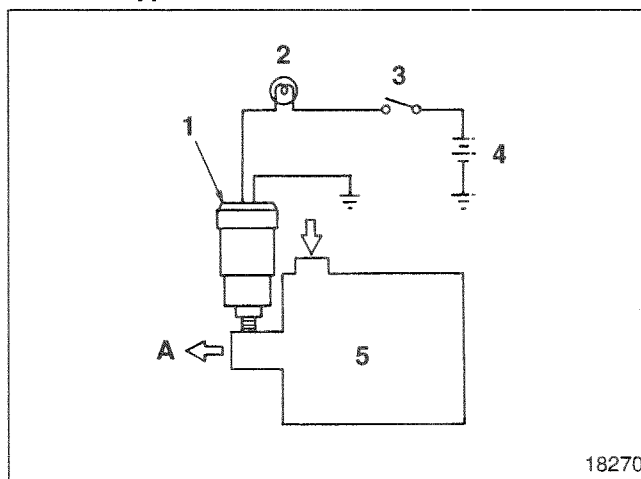
Mechanical type dust indicator 1 is located near the intake air outlet of the air cleaner.

Operated by the negative pressure which is produced when the air is drawn into the engine, the dust indicator indicates that it is high time to clean or replace the element.

In other words, when the element is clogged with dust, the suction resistance increases. When negative pressure **A** reaches 6.23 kPa {635 mmH₂O}, signal **2** (red) is pulled down against the spring pressure of spring **3**. So the signal (red) appears in transparent portion **4** of the body to indicate that it is high time to clean or replace the element.

After cleaning or replacing the element, press the reset button **5**, and the signal will return to its original position.

<Electric type>



- 1 Dust indicator
- 2 Warning lamp
- 3 Starter switch
- 4 Battery
- 5 Air cleaner

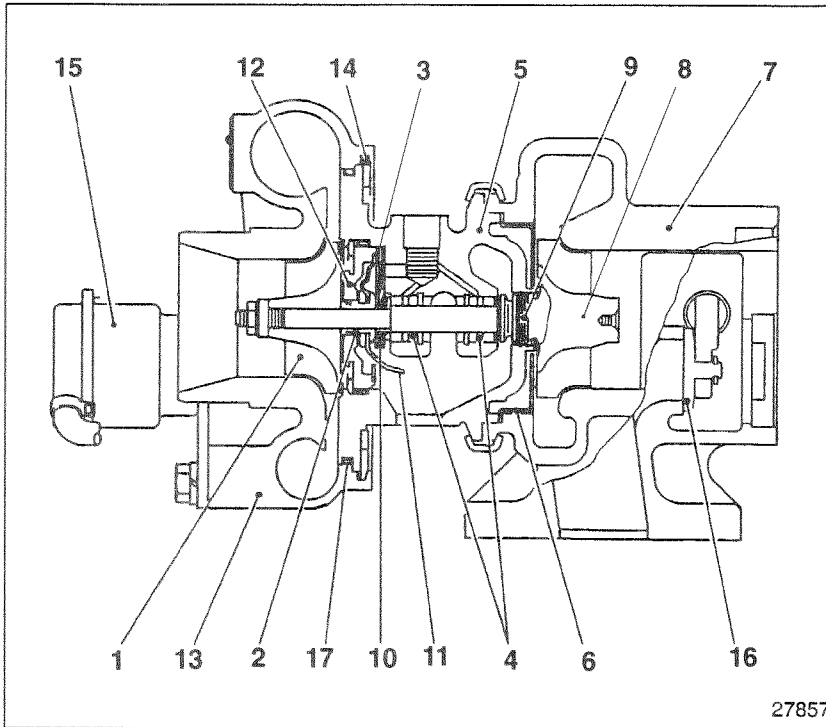
A: Negative pressure

When negative pressure **A** reaches 6.23 kPa {635 mmH₂O}, the electric type dust indicator closes its contact to light warning lamp **2** and alert the driver that it is high time to clean or replace the element.

STRUCTURE AND OPERATION

Turbo Charger Assembly

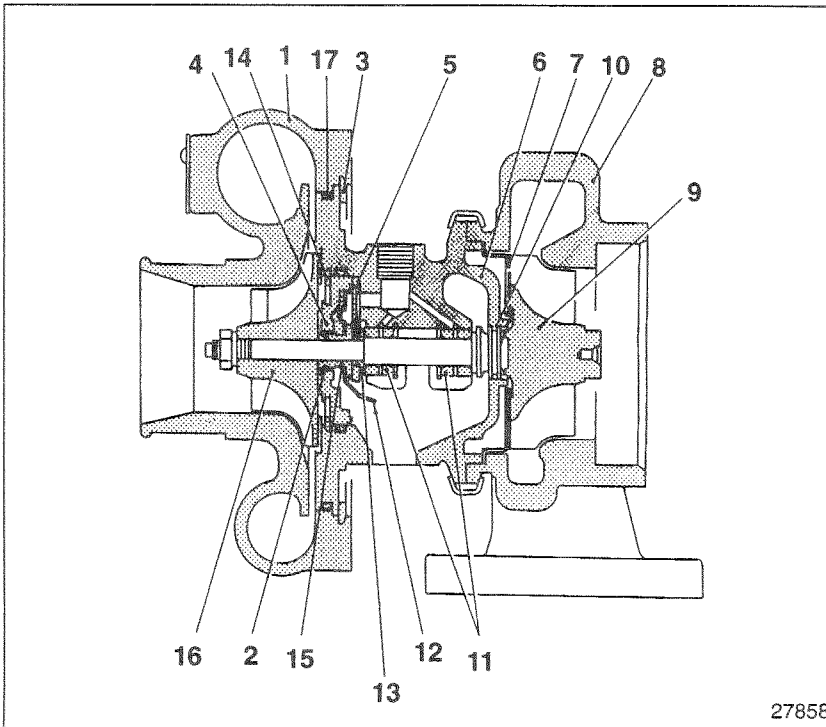
<TD04H, TD05>



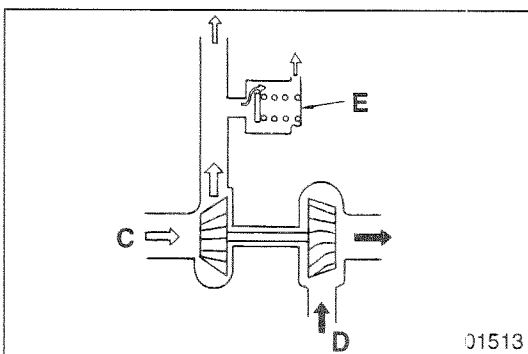
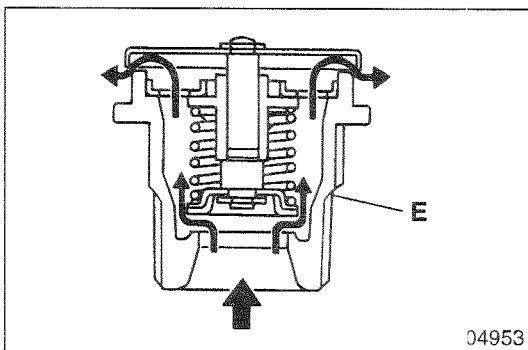
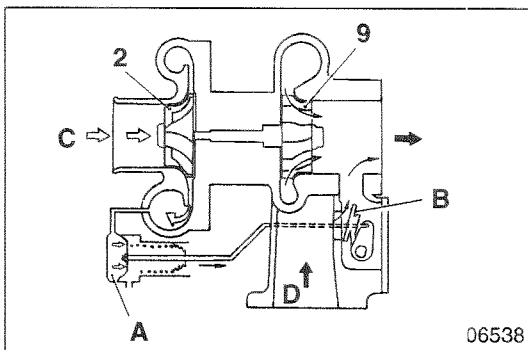
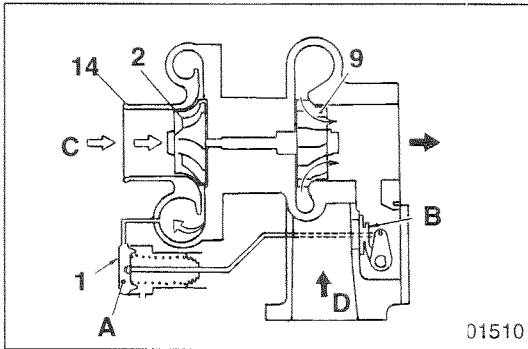
- 1 Compressor wheel
- 2 Thrust sleeve
- 3 Thrust bearing
- 4 Bearing
- 5 Bearing housing
- 6 Turbine back plate
- 7 Turbine housing
- 8 Shaft & turbine wheel
- 9 Piston ring
- 10 Thrust ring
- 11 Oil deflector
- 12 Insert
- 13 Compressor cover
- 14 Snapring
- 15 Actuator
- 16 Waste gate valve
- 17 O-ring

1 to 6, 8 to 12: Cartridge assemblies

<TD06>



- 1 Compressor cover
- 2 Piston ring
- 3 Snap ring
- 4 Insert
- 5 Thrust bearing
- 6 Bearing housing
- 7 Turbine back plate
- 8 Turbine housing
- 9 Shaft & turbine wheel assembly
- 10 Piston ring
- 11 Bearing
- 12 Oil deflector
- 13 Thrust ring
- 14 Snap ring
- 15 Thrust sleeve
- 16 Compressor wheel
- 17 O-ring



● Waste gate mechanism

- The waste gate mechanism has actuator assembly 1 to let extra exhaust gas escape. By so doing, the boost pressure is properly controlled to prevent the turbine wheel from overrunning and prevent an excessive pressure produced in the intake manifold.
- The boost pressure is led from compressor housing 14 through a rubber hose to chamber A of actuator assembly 1. When the boost pressure that acts on chamber A is below the setting, the actuator assembly does not operate, and the waste gate valve remains closed, and exhaust gas D is blown against turbine wheel 9.










- When the boost pressure that acts on chamber A exceeds the setting, the waste gate valve is opened. As a result, the amount of exhaust gas blown against turbine wheel 9 decreases, and the rotating speed of compressor wheel 2 also decreases, and the boost pressure falls.

● Operation of overboost valve

- Overboost valve E operates when the boost pressure becomes abnormally high due to the failure of the waste gate mechanism.

- When the boost pressure of overboost valve E exceeds the setting, the valve releases the boost pressure into the atmosphere to make sure that a boost pressure more than necessary is not applied to the engine. The valve whistles when it is in operation.

TROUBLESHOOTING

| Possible causes | | Symptoms | | | | | | Remarks | |
|---|-----------------------------|--|-----------------------|-----------------------|----------------------------|---------------------------|---|---|--|
| | | Engine hard to start | Black exhaust gas | White exhaust gas | Insufficient engine output | Excessive oil consumption | Strange sound or vibration in intake and exhaust system | | |
| Air cleaner | Clogged air cleaner element | <input type="radio"/> | <input type="radio"/> | | <input type="radio"/> | | | | |
| Turbo-charger | Cartridge assembly | Defective bearing | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | |
| | | Carbon deposited on shaft and turbine wheel | | <input type="radio"/> | | <input type="radio"/> | | | |
| | | Shaft and turbine wheel interfering with turbine back plate | | <input type="radio"/> | | <input type="radio"/> | | | |
| | | Turbine wheel interfering with turbine housing | | <input type="radio"/> | | <input type="radio"/> | | | |
| | | Bent shaft and turbine wheel | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | |
| | | Damaged shaft and turbine wheel | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | |
| | | Compressor wheel interfering with compressor housing | | <input type="radio"/> | | <input type="radio"/> | | | |
| | | Thrust sleeve and thrust bearing seizure | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | |
| | | Damaged compressor wheel | | <input type="radio"/> | | <input type="radio"/> | | <input type="radio"/> | |
| | | Oil leaks due to worn piston ring and insert | | | <input type="radio"/> | | <input type="radio"/> | | |
| | | Improperly mounted piston ring | | | | | <input type="radio"/> | | |
| | | Unsmooth sliding of internal parts due to clogged lubrication oil pipe and eyebolt | | <input type="radio"/> | | <input type="radio"/> | | | |
| | | Damaged oil seals due to clogged oil return pipe | | | <input type="radio"/> | | <input type="radio"/> | | |
| | | Improperly mounted compressor housing | | <input type="radio"/> | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| Improperly mounted turbine housing | | | | <input type="radio"/> | | <input type="radio"/> | | | |
| Deformed front pipe, muffler, tail pipe | | | | | | <input type="radio"/> | | | |
| Improperly mounted front pipe, muffler, tail pipe | | | | | | <input type="radio"/> | | | |
| Incorrect valve clearance | | | <input type="radio"/> | | | | |  Gr 11 | |
| Defective head gasket | | | <input type="radio"/> | | | | |  Gr 11 | |
| Worn valve and valve seat and deposited carbon | | | <input type="radio"/> | | | | |  Gr 11 | |
| Sagging valve spring | | | <input type="radio"/> | | | | |  Gr 11 | |
| Worn or damaged piston ring | | | | <input type="radio"/> | | <input type="radio"/> | |  Gr 11 | |
| Worn or damaged piston ring groove of piston | | | | <input type="radio"/> | | <input type="radio"/> | |  Gr 11 | |
| Malfunctioning cooling equipment | | | <input type="radio"/> | | | | |  Gr 14 | |
| Excessive engine oil | | | | <input type="radio"/> | | | |  Gr 12 | |
| Seizure of major moving parts | | | <input type="radio"/> | | | | |  Gr 11 | |

MEMO

ON-VEHICLE INSPECTION AND ADJUSTMENT

Inspection of Dust Indicator

Service standards

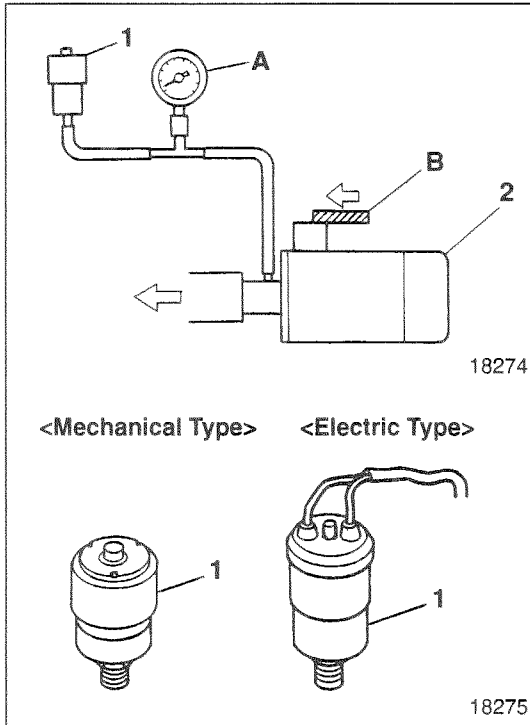
| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---|--|-------|--------|
| — | Negative pressure for operation of dust indicator | 6.23 ± 0.57 kPa { 635 ± 58 mmH ₂ O} | — | — |

◆ Service procedure

- Before checking dust indicator **1**, clean or replace the air cleaner element.
- Start the engine, and cover the inlet of the air cleaner through use of a wooden block **B** in such a way that the negative pressure of the dust indicator **1** will have the nominal value and check that the mechanical type will show the red signal or the electric type will light the warning lamp. If there is anything wrong in operation, replace defective parts.

2 Air cleaner

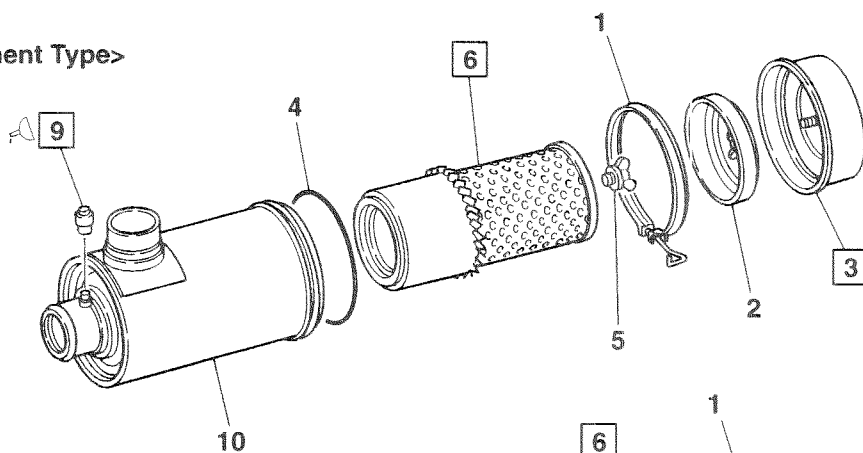
A: Negative pressure gauge



M E M O

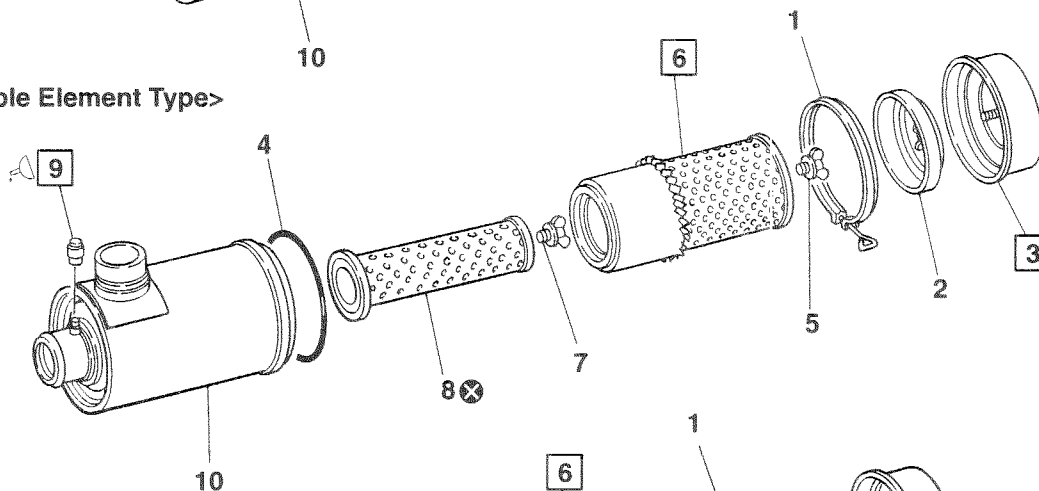
AIR CLEANER <FHG, FWG>

<FHG Single Element Type>



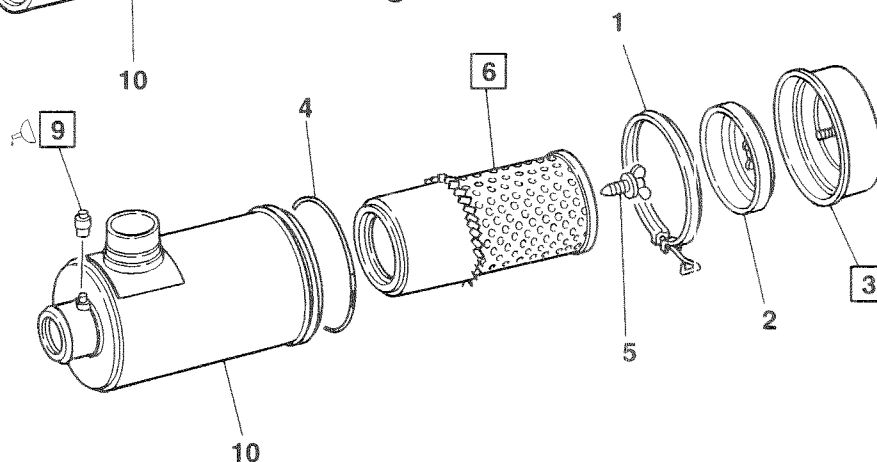
18276

<FHG Double Element Type>



18277

<FWG >



18278

● Disassembly sequence

- | | |
|--------------------|--|
| 1 Clamp | 7 Nut gasket <FHG double element type> |
| 2 Baffle | 8 Safety element <FHG double element type> |
| 3 Dust cup | 9 Dust indicator |
| 4 O-ring | 10 Air cleaner body |
| 5 Nut gasket <FHG> | |
| Bolt gasket <FWG> | |
| 6 Element | |

⊗ : Non-reusable part

NOTE

Do not disassemble safety element 8 except when it need be replaced.

● Reassembly sequence

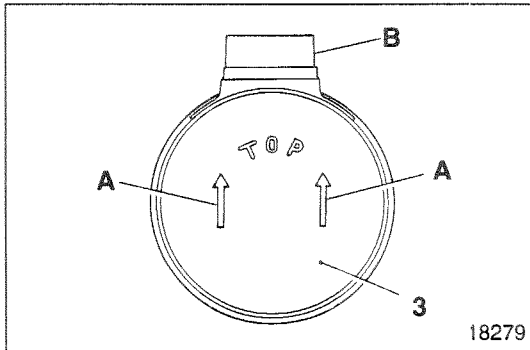
Follow the disassembly sequence in reverse.

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---|--|-------|---------|
| 9 | Negative pressure for operation of dust indicator | 6.23 ± 0.57 kPa (635 ± 58 mmH ₂ O) | — | Replace |

Sealant

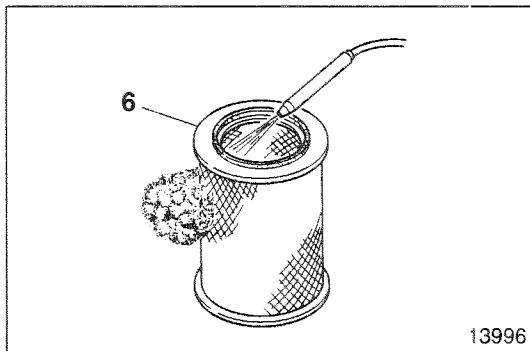
| Location | Points of application | Specified sealant | Quantity |
|----------|---------------------------|-------------------|-------------|
| 9 | Threads of dust indicator | THREE BOND 1401B | As required |



◆ Service procedure

3 Dust cup

Reassemble dust cup 3 with arrow mark **A** toward inlet **B**.



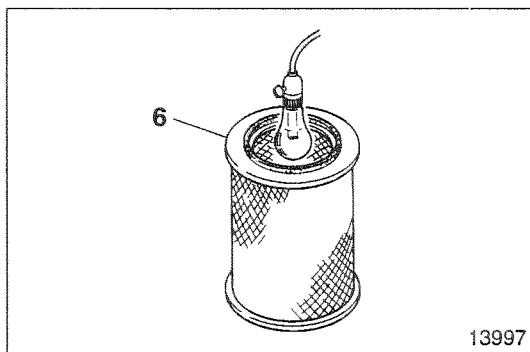
6 Element

[Cleaning]

- Blow compressed air 685 kPa (7 kgf/cm²) or less from inside element 6.
- Blow the compressed air, working along the creases of filter paper of element 6 up and down throughout the element.

CAUTION

- Do not strike element 6 to loosen dust.
- Do not blow the air from outside element 6.



[Inspection]

- Put a light inside element 6.
- If the filter paper is broken or partially thin, or if the packing on the top of element 6 is broken, replace the element.
- If the dust deposited on element 6 is wet with oil smoke or soot, replace the element irrespective of the replacement intervals.

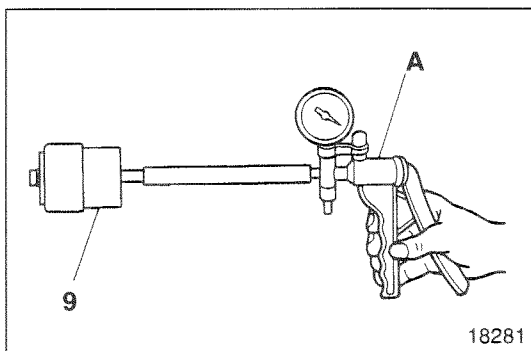
AIR CLEANER <FHG, FWG>

9 Inspection of dust indicator

Perform the following checks. If there is anything wrong, replace dust indicator 9.

<Mechanical type>

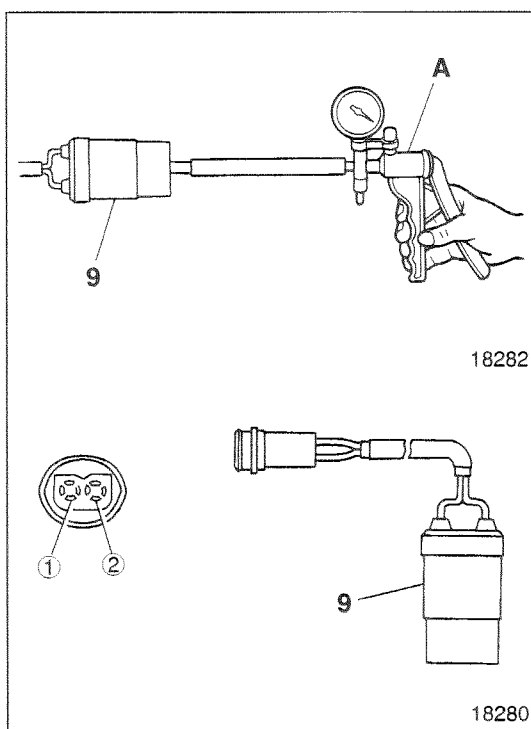
- Mount a hand vacuum pump A on dust indicator 9 and apply the standard operating negative pressure to check whether the red signal appears.



18281

<Electric type>

- Mount a hand vacuum pump A on dust indicator 9 and apply the standard operating negative pressure to check that there is continuity between terminals ① and ②.
- Check that when there is no negative pressure applied to dust indicator 9, there is no continuity between terminals ① and ②.



18282

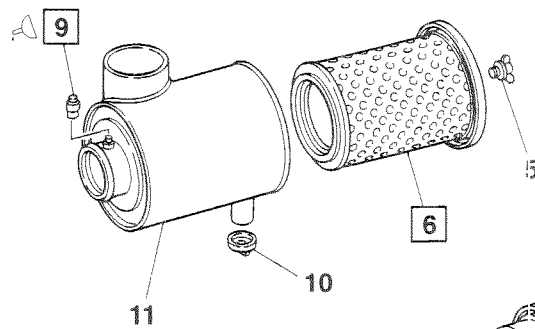
18280

MEMO

AIR CLEANER <FTG>

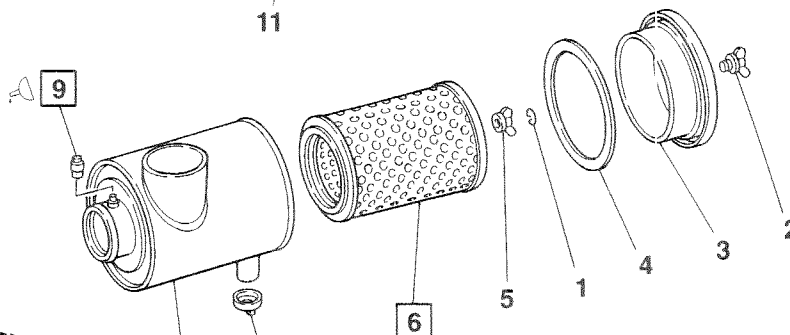
<Single Element Type>

<Type A>



18283

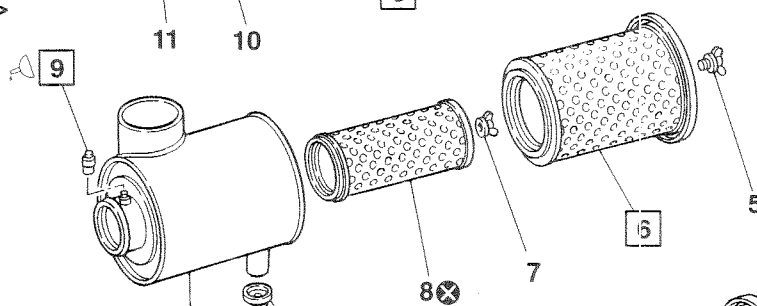
<Type B>



18284

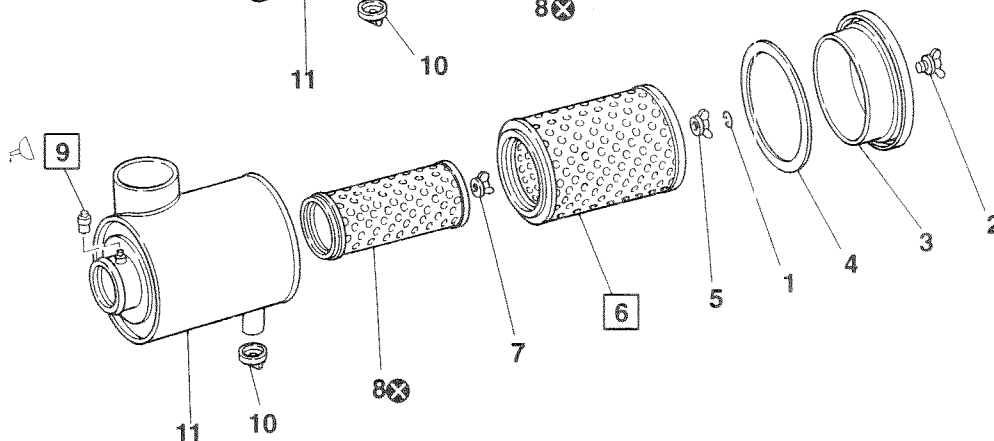
<Double Element Type>

<Type A>



18285

<Type B>



18286

● Disassembly sequence

- | | |
|------------------------------------|--|
| 1 Clip <Type B> | 8 Safety element <Double element type> |
| 2 Wing nut <Type B> | 9 Dust indicator |
| 3 Cover <Type B> | 10 Vacuator valve |
| 4 Gasket <Type B> | 11 Air cleaner body |
| 5 Nut gasket | |
| 6 Element | ⊗ : Non-reusable part |
| 7 Nut gasket <Double element type> | |

NOTE

Do not disassemble safety element 8 except when it need be replaced.

● Reassembly sequence

Follow the disassembly sequence in reverse.

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---|--|-------|---------|
| 9 | Negative pressure for operation of dust indicator | 6.23 ± 0.57 kPa (635 ± 58 mmH ₂ O) | — | Replace |

Sealant

| Location | Points of application | Specified sealant | Quantity |
|----------|---------------------------|-------------------|-------------|
| 9 | Threads of dust indicator | THREEBOND 1401B | As required |

◆ Service procedure

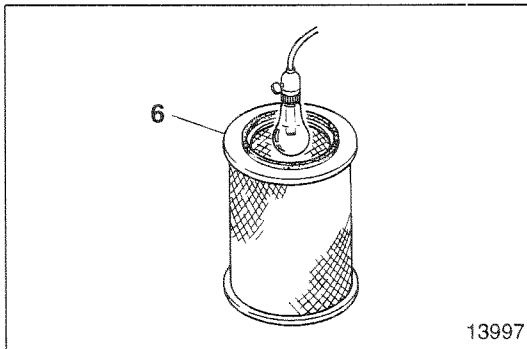
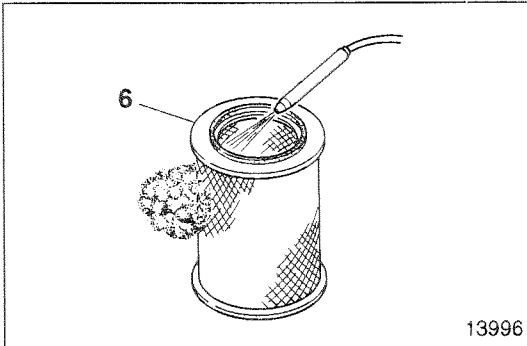
6 Element

[Cleaning]

- Blow compressed air 685 kPa {7 kgf/cm²} or less from inside element 6.
- Blow the compressed air, working along the creases of filter paper of element 6 up and down throughout the element.

CAUTION

- Do not strike element 6 to loosen dust.
- Do not blow the air from outside element 6.



[Inspection]

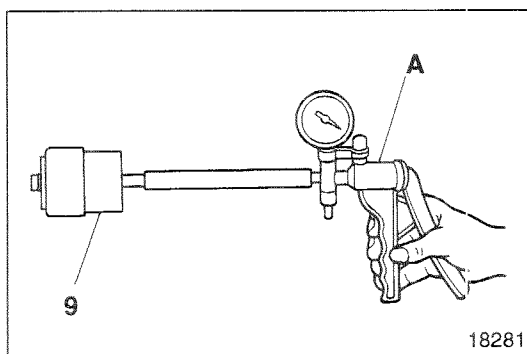
- Put a light inside element 6.
- If the filter paper is broken or partially thin, or if the packing on the top of element 6 is broken, replace the element.
- If the dust deposited on element 6 is wet with oil smoke or soot, replace the element irrespective of the replacement intervals.

9 Inspection of dust indicator

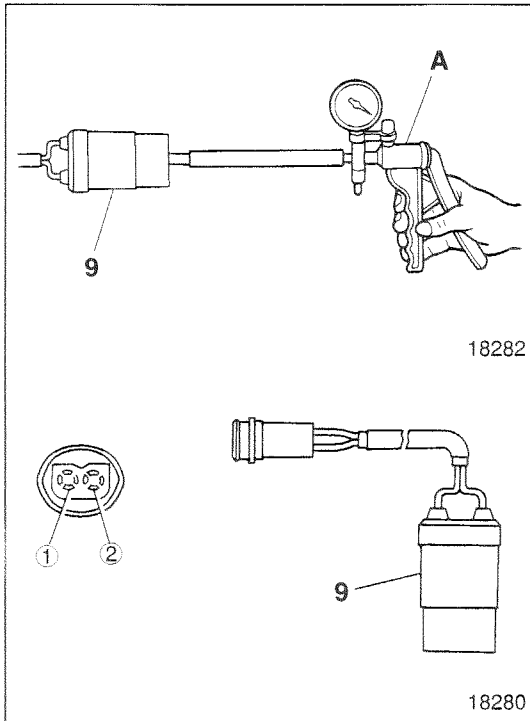
Perform the following checks. If there is anything wrong, replace dust indicator 9.

<Mechanical type>

- Mount a hand vacuum pump A on dust indicator 9 and apply the standard operating negative pressure to check whether the red signal appears.

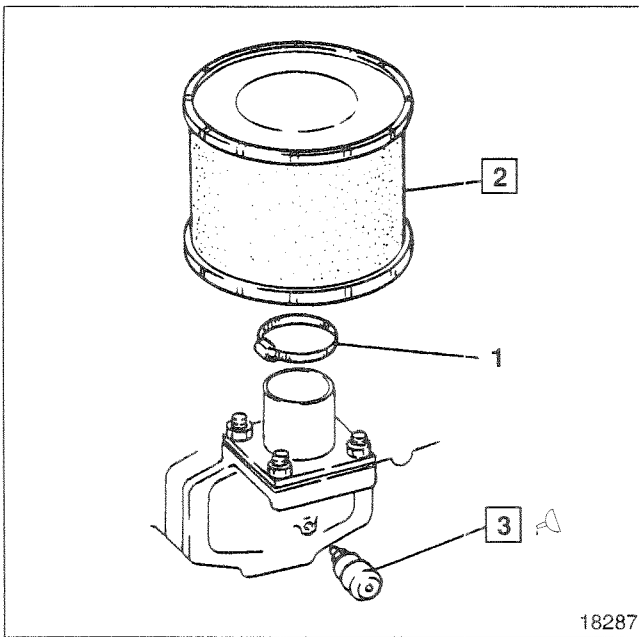


AIR CLEANER <FTG>



<Electric type>

- Mount a hand vacuum pump **A** on dust indicator **9** and apply the standard operating negative pressure to check that there is continuity between terminals ① and ②.
- Check that when there is no negative pressure applied to dust indicator **9**, there is no continuity between terminals ① and ②.



● **Disassembly sequence**

- 1 Clamp
- 2 Air cleaner
- 3 Dust indicator

● **Reassembly sequence**

Follow the disassembly sequence in reverse.

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---|---|-------|---------|
| 3 | Negative pressure for operation of dust indicator | 6.23 ± 0.57 kPa {635 ± 58 mmH ₂ O} | — | Replace |

Sealant

| Location | Points of application | Specified sealant | Quantity |
|----------|---------------------------|-------------------|-------------|
| 3 | Threads of dust indicator | THREE BOND 1401B | As required |

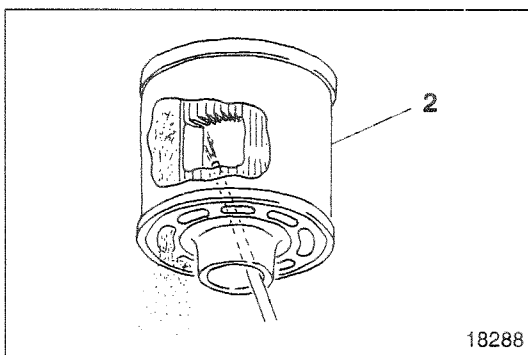
◆ **Service procedure**

2 Cleaning air cleaner

Blow compressed air 685 kPa {7 kgf/cm²} or less from inside air cleaner 2, working along the creases of filter paper up and down to clean the air cleaner.

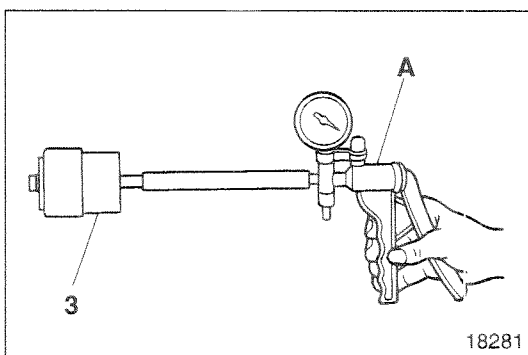
CAUTION ⚠

- Do not strike the element and do not blow the air from the suction portion.
- Make sure that the loosened dust is not blown into the element.

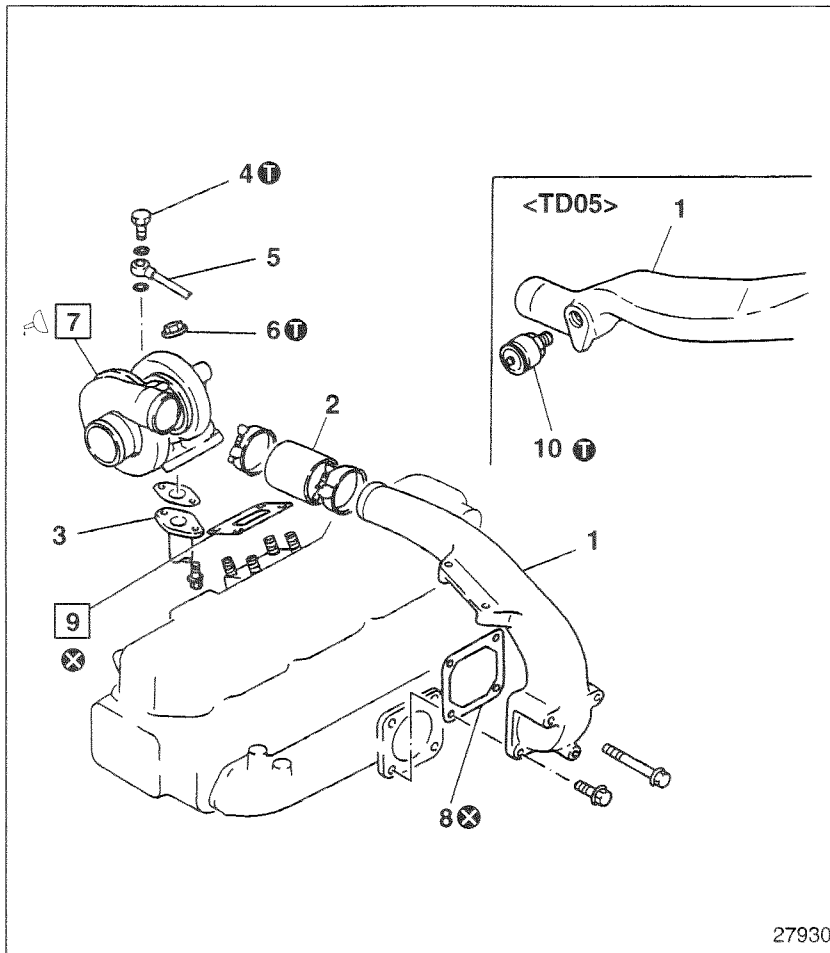


3 Inspection of dust indicator

- Mount a hand vacuum pump A on the dust indicator 3 and apply the standard operating negative pressure to check whether the red signal appears.
- If the red signal does not appear, replace the dust indicator 3 with new one.



TURBOCHARGER



● Removal sequence

- 1 Air inlet pipe
- 2 Rubber hose
- 3 Oil return pipe
- 4 Eyebolt
- 5 Oil pipe
- 6 Nut
- 7 Turbocharger assembly
P15-22, 26
- 8 Gasket
- 9 Gasket
- 10 Overboost valve <TD05>

⊗ : Non-reusable part

● Installation sequence

Follow the installation sequence in reverse.

ⓘ Tightening torque

Unit: N·m {kgf·m}

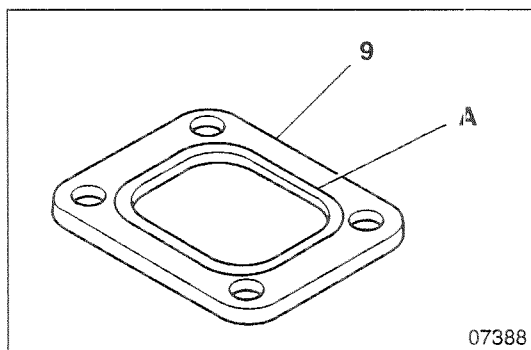
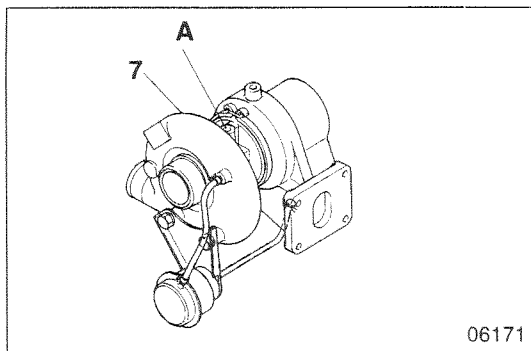
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------------------|-----------------------|---------|
| 4 | Eyebolt (oil inlet pipe mounting) | 17 to 23 {1.7 to 2.3} | — |
| 6 | Nut (turbocharger assembly mounting) | 41 {4.2} | — |
| 10 | Overboost valve | 31 {3.2} | — |

🔧 Lubricant and sealant

| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|---|------------------------------------|-------------|
| 7 | Turbocharger assembly oil hole (supply at time of installation) | Engine oil | As required |
| 10 | Threads of overboost valve | Sealing (Teflon) type | As required |

◆ Service procedure**● Inspection after assembly**

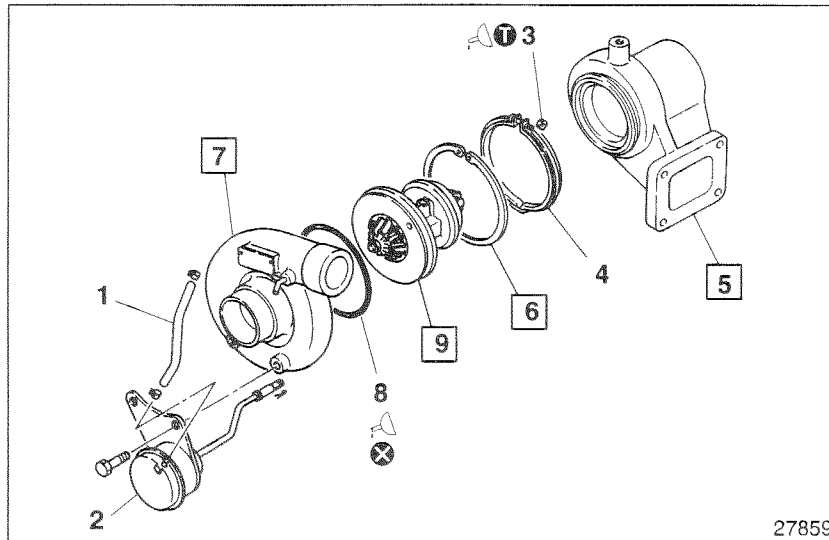
Before installing turbocharger assembly **7**, pour engine oil into oil hole **A** to ensure smooth operation of the internal parts.

**9 Installation of gasket**

Install gasket **9** with grommet fold-back portion **A** toward the exhaust manifold.

TURBOCHARGER <TD04, TD05>

Turbocharger Assembly



● Work before disassembly

📖 P15-23

● Disassembly sequence

- 1 Hose
- 2 Actuator <TD05>
- 3 Bolt
- 4 Coupling
- 5 Turbine housing
- 6 Snap ring
- 7 Compressor cover
- 8 O-ring
- 9 Cartridge assembly

⊗ : Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

● Inspection after assembly

Refer to the preceding section.

NOTE

Cartridge assembly 9 cannot be disassembled. Replace the entire assembly if the turbine wheel or compressor wheel becomes damaged or if the assembly does not rotate smoothly or is otherwise defective.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy | |
|----------|--------------------|--|-----------------------|--------------|---------|---------|
| 9 | Cartridge assembly | Axial play in shaft | 0.05 to 0.09 | 0.1 | Replace | |
| | | Play at right angle to axial direction | Turbine wheel side | 0.40 to 0.53 | 0.58 | Replace |
| | | | Compressor wheel side | 0.55 to 0.66 | 0.72 | |

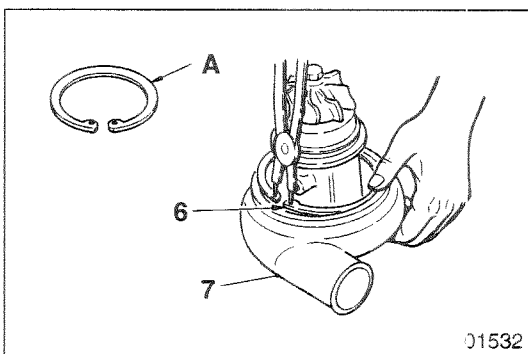
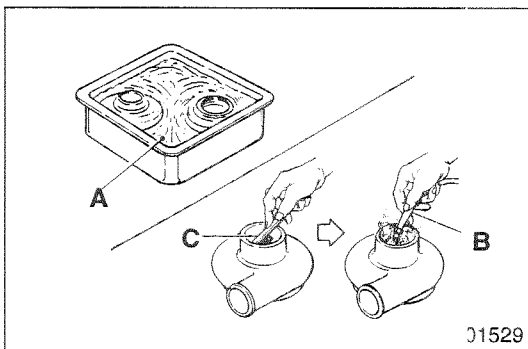
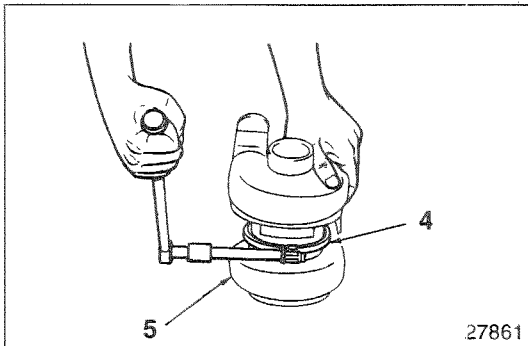
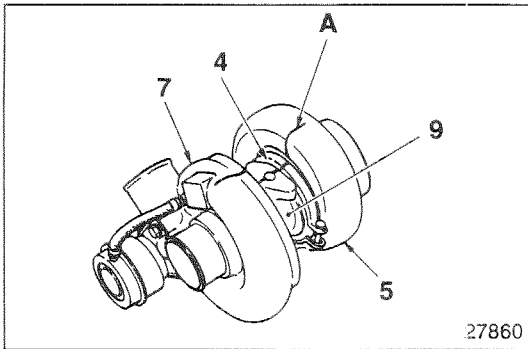
ⓘ Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|--------------------------|--------|---------------------|---------|
| 3 | Bolt (Coupling securing) | <TD04> | 8 to 9 {0.8 to 0.9} | — |
| | | <TD05> | 4 to 5 {0.4 to 0.5} | |

🔧 Lubricant and sealant

| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|-----------------------|------------------------------------|----------|
| 3 | Threads of bolt | MOLYKOTE | — |
| 8 | O-ring | Engine oil | — |



◆ Service procedure

● Work before disassembly

Make alignment marks **A** on coupling **4**, turbine housing **5**, compressor cover **7** and cartridge assembly **9**.

5 Removal of turbine housing

CAUTION ⚠

- While using care to prevent damage to the turbine housing, lightly strike its entire circumference with a rubber hammer or similar tool.
- Since the blades of the turbine wheel are readily bent, use care to make sure that they do not hit turbine housing.

5 7 Cleaning turbine housing and compressor cover

- Before cleaning the components, check them visually for scorching, abrasion, and other defects. (Such problems may be impossible to see after cleaning.) Replace any item that appears defective.
- Remove any hard deposits with a plastic scraper **C** or stiff brush. Then, immerse the disassembled components in non-flammable solvent **A** (DAIDO CHEMICAL INDUSTRY CO., LTD. DAICLEANER T-30). After removing the components from the solvent, blow them clean with compressed air **B**.

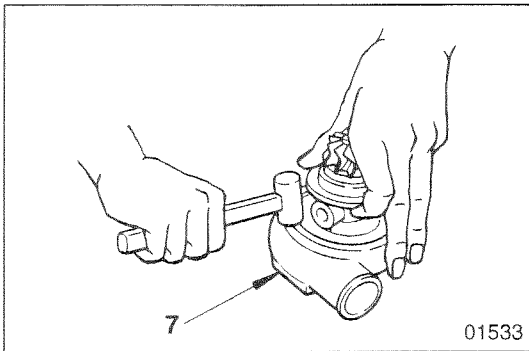
6 Installing snap ring

- Fit snap ring **6** onto compressor cover **7** with its tapered surface **A** facing upward.

WARNING ⚠

When fitting snap ring **6**, hold it down to prevent it from flying off.

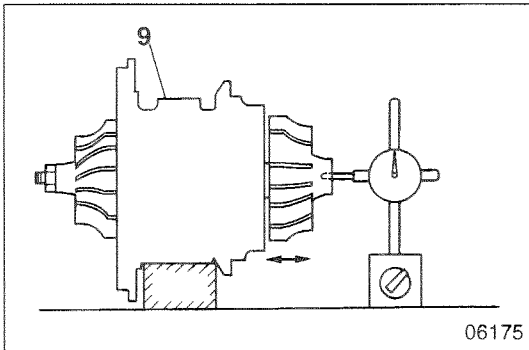
TURBOCHARGER <TD04, TD05>



7 Removal of compressor cover

CAUTION

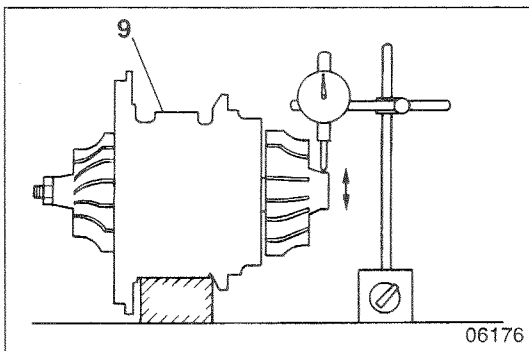
- While using care to prevent damage to compressor cover 7, lightly strike its entire circumference with a rubber hammer or similar tool.
- Since the blades of the compressor wheel are readily bent, use care to make sure that they do not hit the compressor cover.



9 Inspection of cartridge assembly

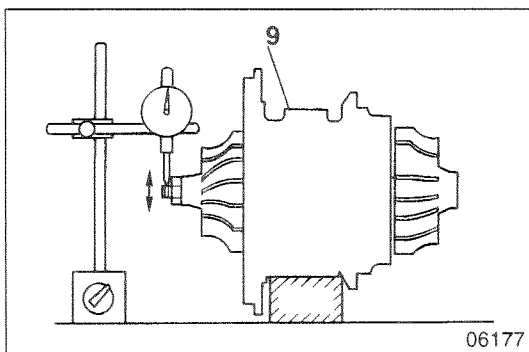
(1) Axial play in shaft and turbine wheel assembly

If the measurement exceeds the specified limit, replace cartridge assembly 9.



(2) Play at right angle to shaft direction in shaft and turbine wheel assembly

- Play on turbine wheel side
If the measurement exceeds the specified limit, replace cartridge assembly 9.

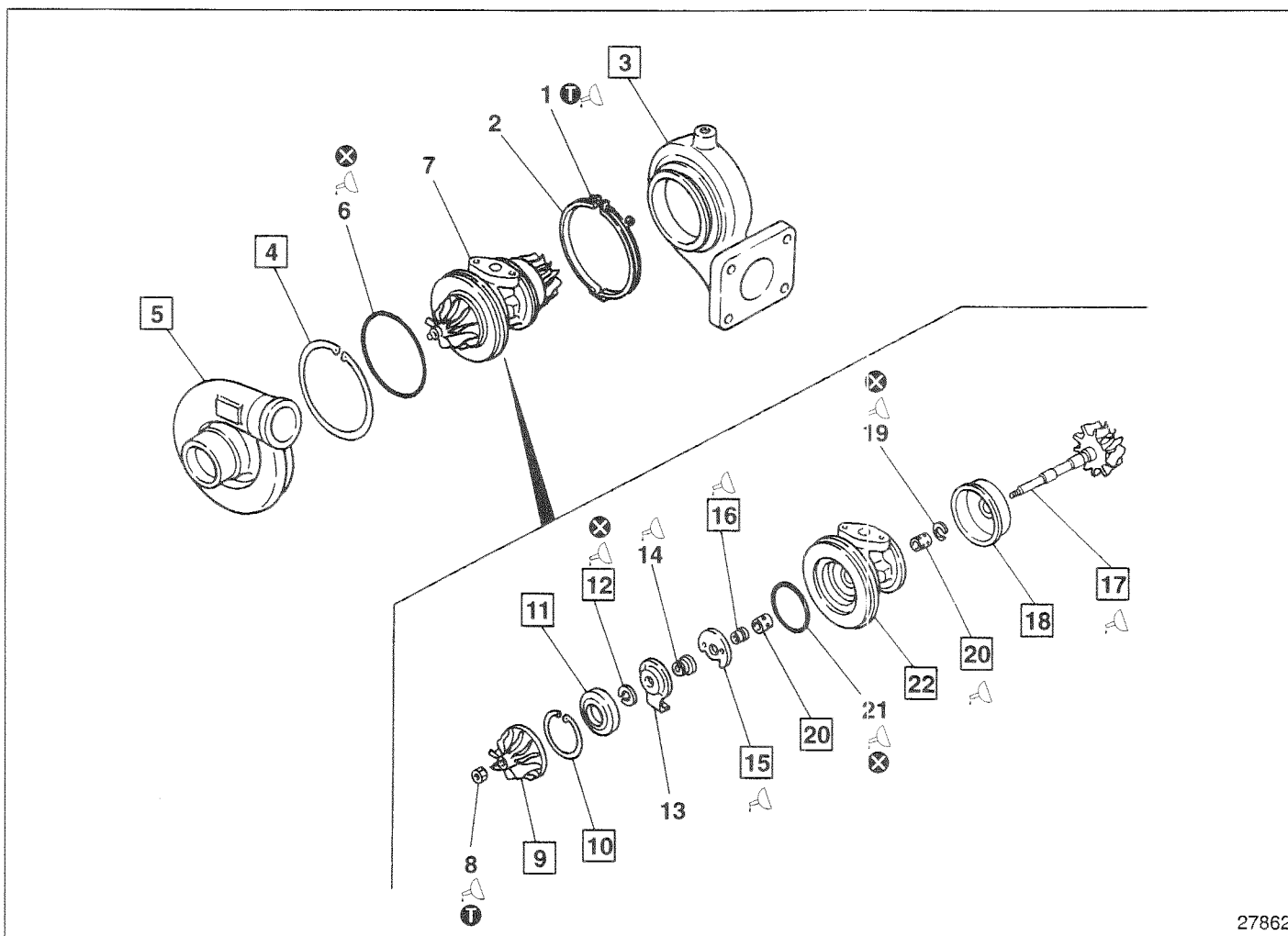


- Play on compressor wheel side
If the measurement exceeds the specified limit, replace cartridge assembly 9.

MEMO

TURBOCHARGER <TD06>

Turbocharger Assembly



27862

● Work before disassembly

📖 P15-28

● Disassembly sequence

- | | | |
|--------------------------------------|--------------------------|-----------------------|
| 1 Bolt | 9 Compressor wheel | 18 Turbine back plate |
| 2 Coupling assembly | 10 Snap ring | 19 Piston ring |
| 3 Turbine housing | 11 Insert | 20 Bearing |
| 4 Snap ring | 12 Piston ring | 21 O-ring |
| 5 Compressor cover | 13 Oil deflector | 22 Bearing housing |
| 6 O-ring | 14 Thrust sleeve | |
| 7 Wheel and bearing housing assembly | 15 Thrust bearing | ⊗ : Non-reusable part |
| 8 Lock nut | 16 Thrust ring | |
| | 17 Shaft & turbine wheel | |

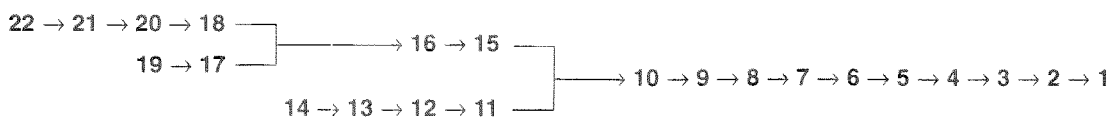
CAUTION ⚠

Carefully remove piston rings 12 and 19, as they are readily broken.

● Cleaning after disassembly

📖 P15-28

● Assembly sequence



● Inspection after assembly

📖 P15-29

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|---|-------------------------------------|----------------|--------|----------------|
| 3, 17 | Clearance between shaft & turbine wheel and turbine housing | | 0.42 to 1.10 | — | Check |
| 12 | Clearance between open ends of piston ring (Measure the clearance of a new piston ring.) | | 0.05 to 0.15 | — | Replace insert |
| 17 | Shaft & turbine wheel | Outside diameter of bearing journal | — | 8.994 | Replace |
| | | Bend of shaft | — | 0.015 | Replace |
| | | End play | 0.057 to 0.103 | — | Check |
| 17, 18 | Clearance between shaft & turbine wheel back surface and turbine back plate | | 0.37 to 0.85 | — | Check |
| 20 | Bearing | Inside diameter | — | 9.04 | Replace |
| | | Outside diameter | — | 15.574 | |
| | | Length | — | 9.34 | |
| 22 | Bearing inserting portion inside diameter of bearing housing | | — | 15.686 | Replace |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------------------|---------------------|---------|
| 1 | Bolt (coupling securing) | 4 to 5 {0.4 to 0.5} | — |
| 8 | Lock nut (compressor wheel mounting) | 8 to 9 {0.8 to 0.9} | — |

🔧 Lubricant and sealant

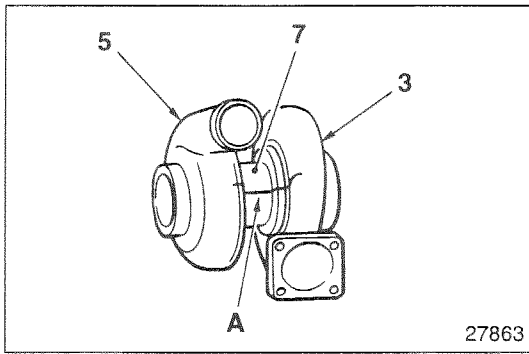
| Location | Points of application | Specified lubricant and sealant | Quantity |
|---------------------------------|-----------------------|---------------------------------|-------------|
| 1 | Threads of bolt | MOLYKOTE | As required |
| 8 | Threads of lock nut | MOLYKOTE | As required |
| 6, 12, 14 to 17, 19 to 21 | Moving parts | Engine oil | As required |

TURBOCHARGER <TD06>

◆ Service procedure

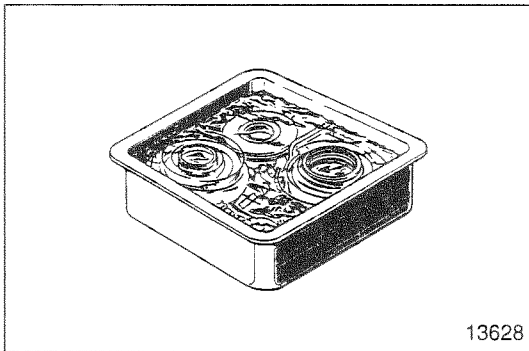
● Work before disassembly

Make alignment marks **A** on turbine housing **3**, compressor cover **5** and wheel & bearing housing assembly **7**.

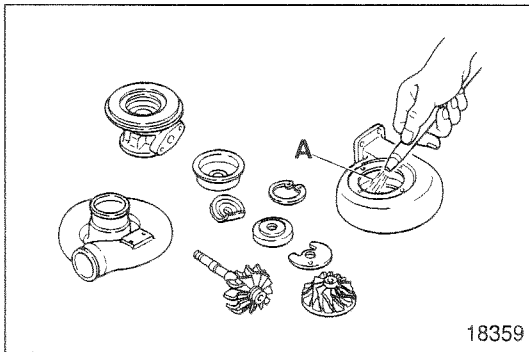


● Cleaning after disassembly

- Before cleaning, visually check the individual parts for burns, rubbed stains, etc. which might disappear after cleaning. If there is anything wrong, replace.
- Immerse the disassembled parts in a non-flammable solvent (DAIDO CHEMICAL INDUSTRY CO., LTD. DAICLEANER T-30).



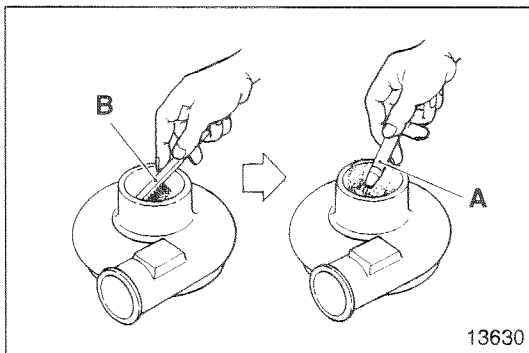
- Take out the parts from the solvent and blow compressed air **A** against them.

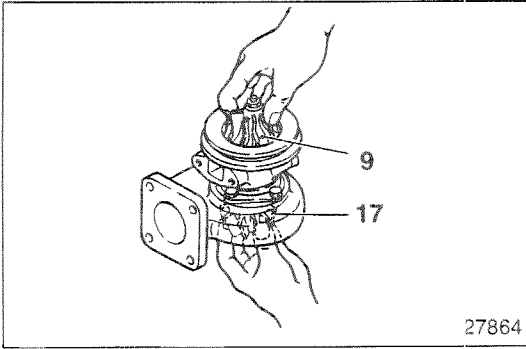


- Scrape off deposits.

B: Plastic scraper or stiff brush

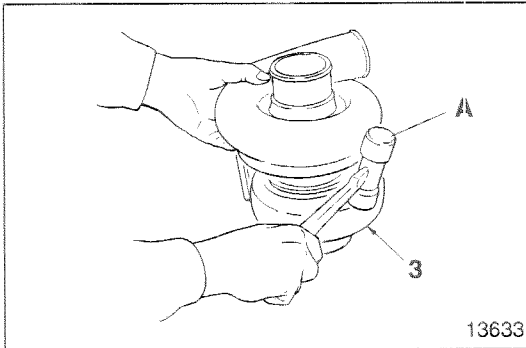
- Re-immerses in the solvent.
- Blow compressed air **A**.





● Inspection after assembly

Manually rotate compressor wheel 9 and turbine wheel 17 to check whether they rotate smoothly.



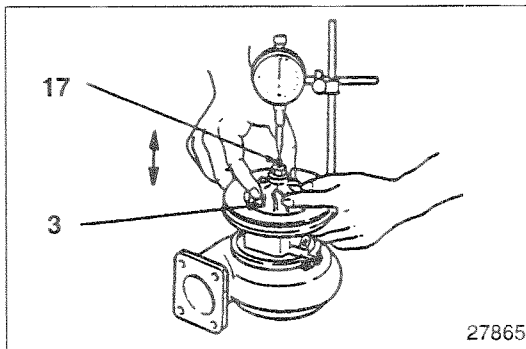
3 Turbine housing

[Removal]

A: Rubber hammer

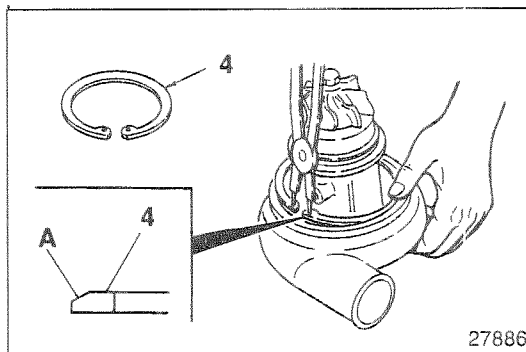
CAUTION ⚠

- While using care to prevent damage to turbine housing 3, lightly strike its entire circumference with a rubber hammer or similar tool.
- Since the blades of shaft & turbine wheel 17 are readily bent, use care to make sure that they do not hit turbine housing 3.



3 17 Measurement of clearance between turbine housing and shaft & turbine wheel

If the reading exceeds the nominal value, disassemble and check to locate the cause.



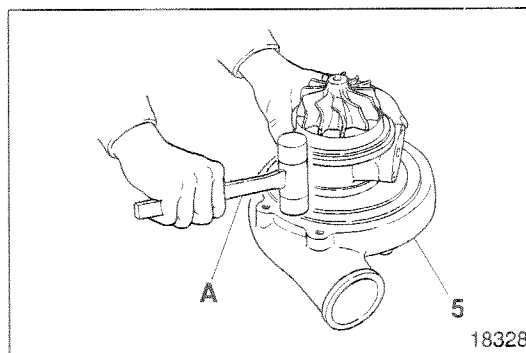
4 Installation of snap ring

Line up the alignment marks made before disassembly and install snap ring 4 as shown.

A: Tapered surface

WARNING ⚠

When snap ring 4 is installed, hold it by hand to make sure that it does not bounce out.



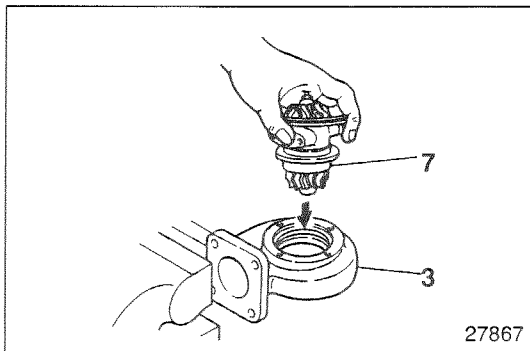
5 Removal of compressor cover

A: Rubber hammer

CAUTION ⚠

- While using care to prevent damage to compressor cover 5, lightly strike its entire circumference with a rubber hammer A or similar tool.
- Since the blades of compressor wheel 9 are readily bent, use care to make sure that they do not hit compressor cover 5.

TURBOCHARGER <TD06>



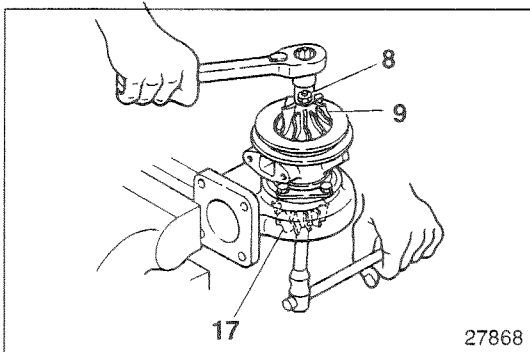
9 Compressor wheel

[Removal]

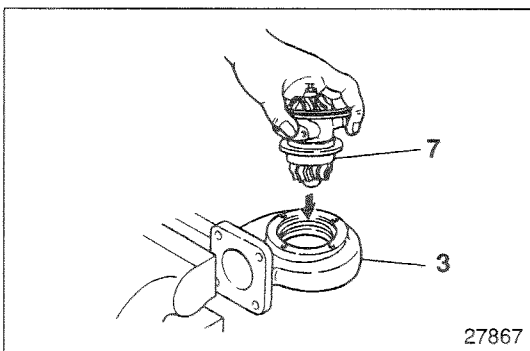
- Hold turbine housing 3 in a vice, and install wheel & bearing housing assembly 7.

CAUTION

Since the blades of shaft & turbine wheel 17 are readily bent, make sure that they do not hit the turbine housing 3.



- While holding down the boss on shaft & turbine wheel 17, remove lock nut 8.

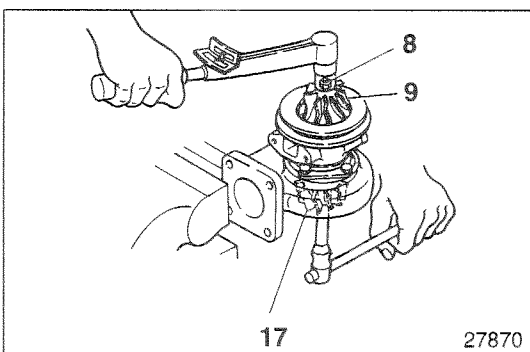


[Installation]

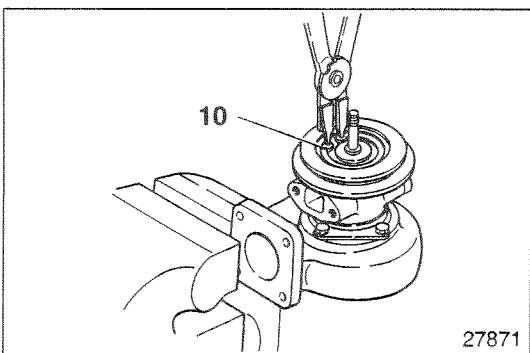
- Hold turbine housing 3 in a vice and install temporarily assembled wheel & bearing housing assembly 7.

CAUTION

Since the blades of shaft & turbine wheel 17 are readily bent, make sure that they do not hit turbine housing 3.



- While holding down the boss on shaft & turbine wheel 17, apply MOLYKOTE to the threaded portion of lock nut 8, and tighten the lock nut to the specified torque.

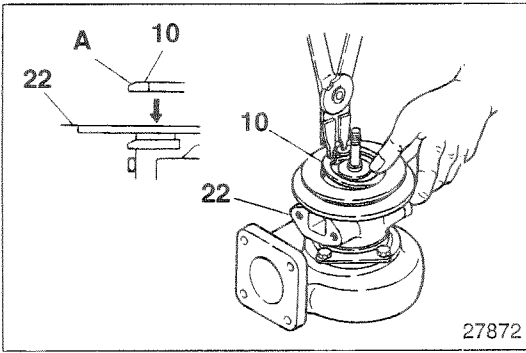


10 Snap ring

[Removal]

WARNING

When snap ring 10 is removed, hold it by hand to make sure that it does not bounce out.



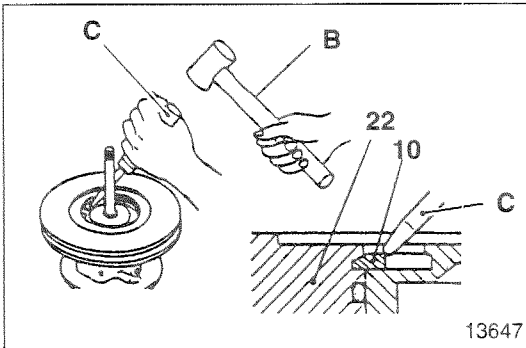
[Installation]

- Install snap ring 10 in the illustrated direction in the bearing housing 22.

A: Tapered surface

WARNING ⚠

When snap ring 10 is installed, hold it by hand to make sure that it does not bounce out.



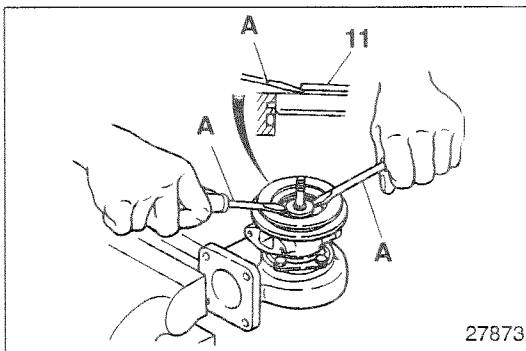
- Install snap ring 10 securely in the groove of bearing housing 22.

B: Hammer

C: Screwdriver

CAUTION ⚠

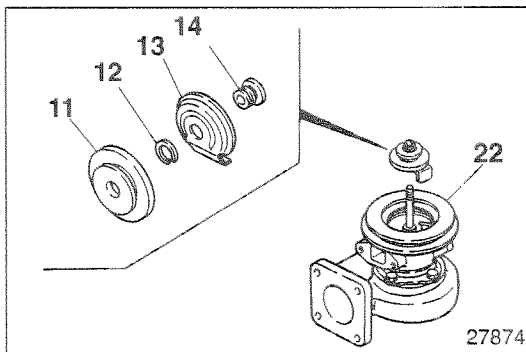
Use care to make sure that plain screwdriver C does not hit bearing housing 22.



11 Insert

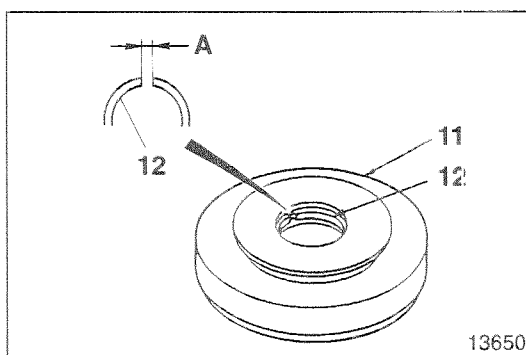
[Removal]

A: Screwdriver



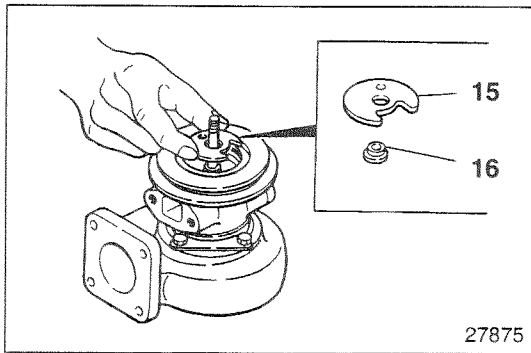
[Installation]

Install oil deflector 13 in the illustrated direction in bearing housing 22.



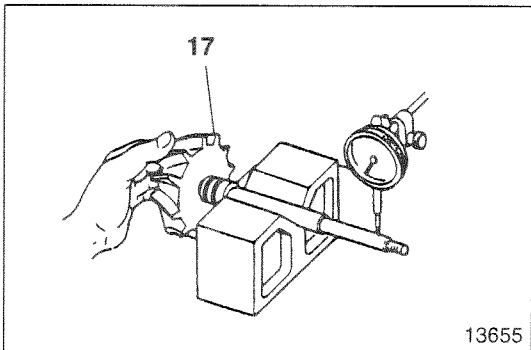
12 Measurement of clearance between open ends of piston ring

- Mount a new piston ring 12 in insert 11.
- Measure clearance A between the open ends of the piston ring.
- If the reading is out of the nominal value, replace insert 11.



15 16 Installation of thrust bearing, thrust ring

Install thrust bearing **15** and thrust ring **16** in such a way that they will be directed as shown.

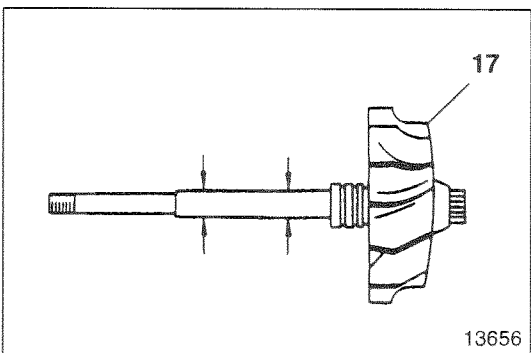


17 Shaft & turbine wheel

[Inspection]

(1) Bend of shaft

- Using a dial indicator, measure at the illustrated position.
- If the reading exceeds the limit, replace shaft & turbine wheel **17**.



(2) Outside diameter of journal

If the reading exceeds the limit, replace shaft & turbine wheel **17**.

(3) Rough journal

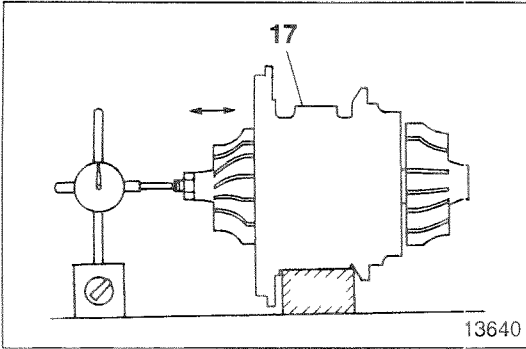
If the journal is rough, repair by the following procedures.

[Repair]

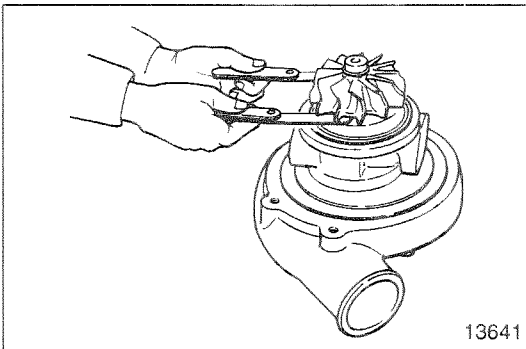
- Install shaft & turbine wheel **17** on a lathe with both centers supported.
- Lightly grind the journal through use of emery paper #400 and engine oil.

CAUTION

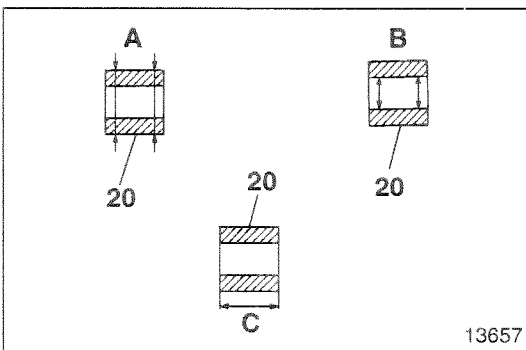
After the journal has been ground, be sure to measure the outside diameter of the journal.

**(4) End play**

If the reading exceeds the nominal value, disassemble and check to locate the cause.

**17 18 Clearance between shaft & turbine wheel back surface and turbine back plate**

- Using two thickness gauges, measure the clearance at the end of blade.
- If any reading exceeds the nominal value, disassemble and check to locate the cause.

**20 Inspection of bearing**

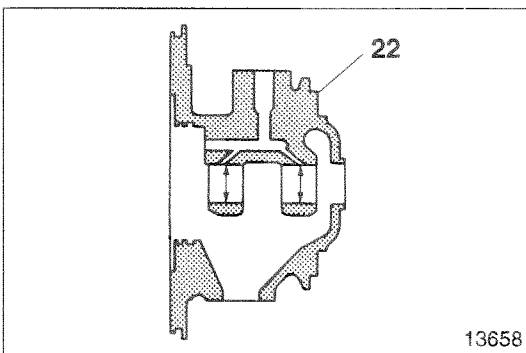
- Measure at the illustrated position

A: Outside diameter

B: Inside diameter

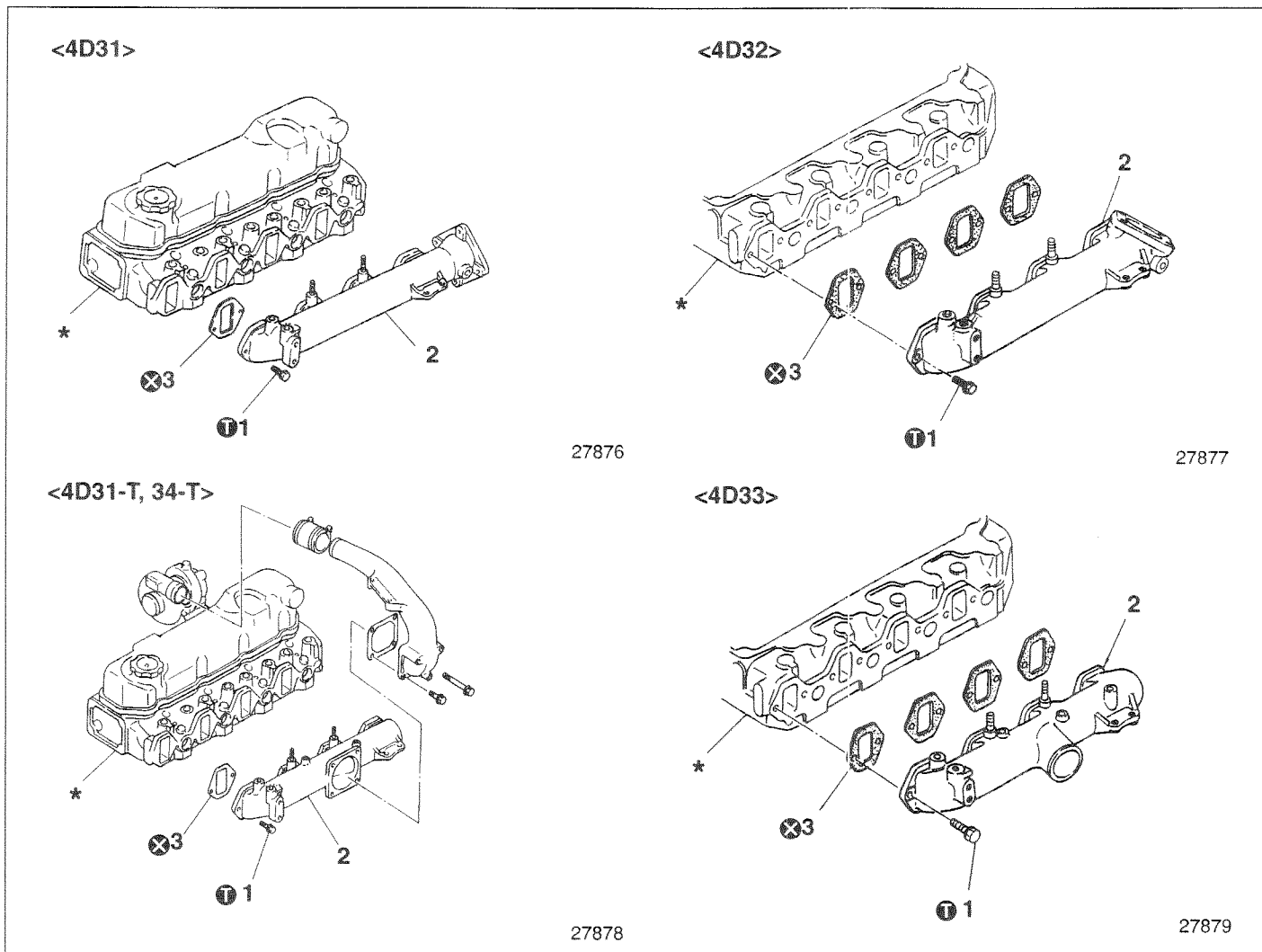
C: Length

- If any reading exceeds the limit, replace bearing 20.

**22 Inspection of bearing housing**


- Measure the inside diameter of the bearing 20 mounting portion.
- If the reading exceeds the limit, replace bearing housing 22.

INTAKE MANIFOLD



● Disassembly sequence

- 1 Bolt
- 2 Intake manifold
- 3 Gasket

*: Cylinder head  Gr11
 ⊗: Non-reusable part

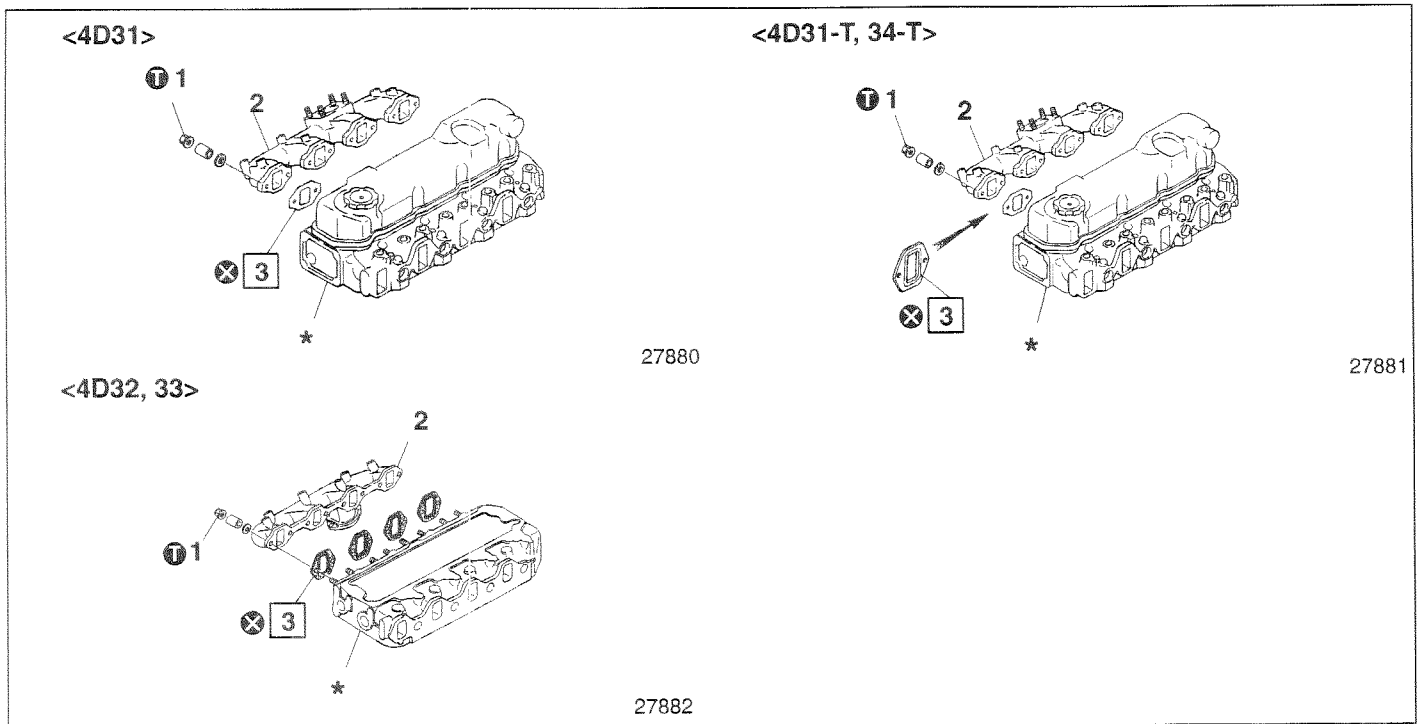
● Assembly sequence

Follow the disassembly sequence in reverse.

ⓘ Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|---------------------------------|-----------------------|---------|
| 1 | Bolt (intake manifold mounting) | 16 to 24 {1.6 to 2.4} | — |



● Disassembly sequence

- 1 Nut
- 2 Exhaust manifold
- 3 Gasket

*: Cylinder head Gr11

⊗: Non-reusable part

● Assembly sequence

Follow the disassembly sequence in reverse.

① Tightening torque

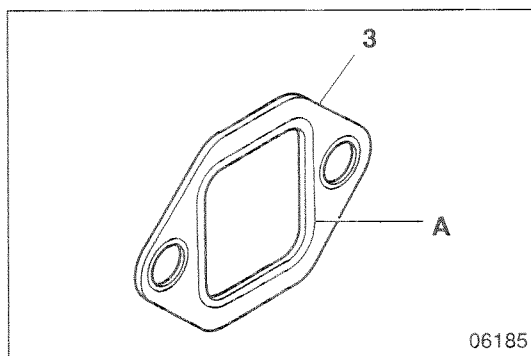
Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|---------------------------------|-----------------------|---------|
| 1 | Nut (exhaust manifold mounting) | 32 to 50 {3.3 to 5.1} | — |

◆ Service procedure

③ Installation of gasket

Install gasket 3 with grommet fold-back portion **A** toward the cylinder head *****.



06185

GROUP 21 CLUTCH

| | |
|--|-------|
| SPECIFICATIONS | 21-2 |
| STRUCTURE AND OPERATION | 21-3 |
| TROUBLESHOOTING | 21-12 |
| CLUTCH MASTER CYLINDER | 21-13 |
| CLUTCH POWER CYLINDER | 21-15 |
| CLUTCH BODY | |
| <C2, C3> | 21-16 |
| <C4> | 21-20 |
| CLUTCH HOUSING | |
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| <C3> | 21-29 |
| BEARING CASE | |
| <PC2: DIRECT COUPLING TYPE> | 21-30 |
| <PC2: LATERAL TRANSMISSION TYPE> | 21-34 |
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| <PC4: LATERAL TRANSMISSION TYPE> | 21-44 |

SPECIFICATIONS

Clutch

| Item | | Specifications | | |
|----------------|-------|-----------------------|-------|------------------|
| Clutch | Model | C2W26 | C3W28 | C4W30 |
| Drive system | | Strap drive | | |
| Clutch disc | Type | Single dry plate | | |
| Pressure plate | Type | Diaphragm spring type | | Coil spring type |

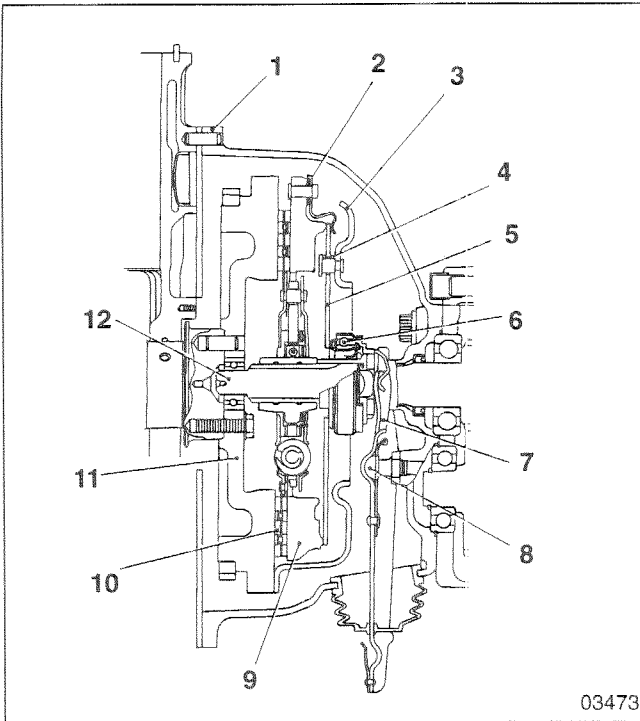
Clutch Control

| Item | | Specifications | |
|------------------------|-------------|---------------------------------------|-----------------|
| Control method | | Hydraulic control with power cylinder | Linkage control |
| Clutch master cylinder | Diameter | 15.87 | — |
| | Max. stroke | 27 | — |
| Clutch power cylinder | Diameter | 15.87 | — |
| | Max. stroke | 26 | — |

Bearing Case

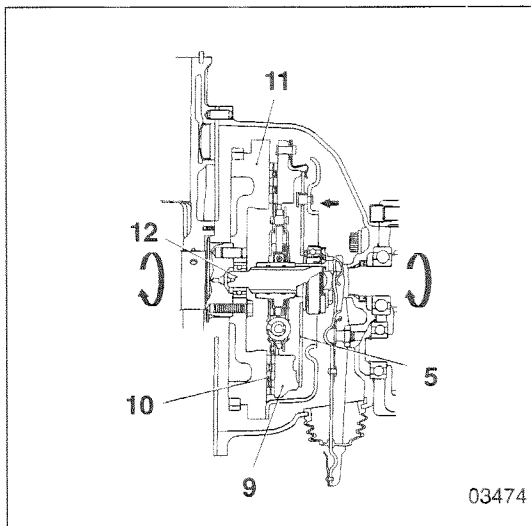
| Item | | Specifications | | | |
|--------------|---------------------|-----------------|----------------------|-----------------|----------------------|
| Model | | PC2 | | PC4 | |
| Type | | Direct coupling | Lateral transmission | Direct coupling | Lateral transmission |
| Oil quantity | dm ³ {L} | — | 0.14 {0.14} | — | 0.4 {0.4} |

Clutch Body <C2, C3>



- 1 Clutch housing
- 2 Strap plate
- 3 Clutch cover
- 4 Pivot ring
- 5 Diaphragm spring
- 6 Clutch release bearing
- 7 Clutch release rocker arm
- 8 Rocker arm pivot
- 9 Pressure plate
- 10 Clutch disc
- 11 Flywheel
- 12 Drive pinion

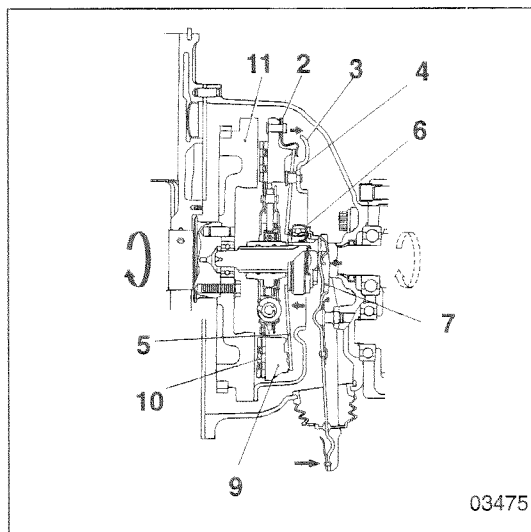
03473



When the clutch pedal is released

- Pressure plate 9, activated by diaphragm spring 5, forces clutch disc 10 against flywheel 11.
- Clutch disc 10 forced against flywheel 11 runs together with the flywheel and transmits power from the engine to transmission drive pinion 12.

03474



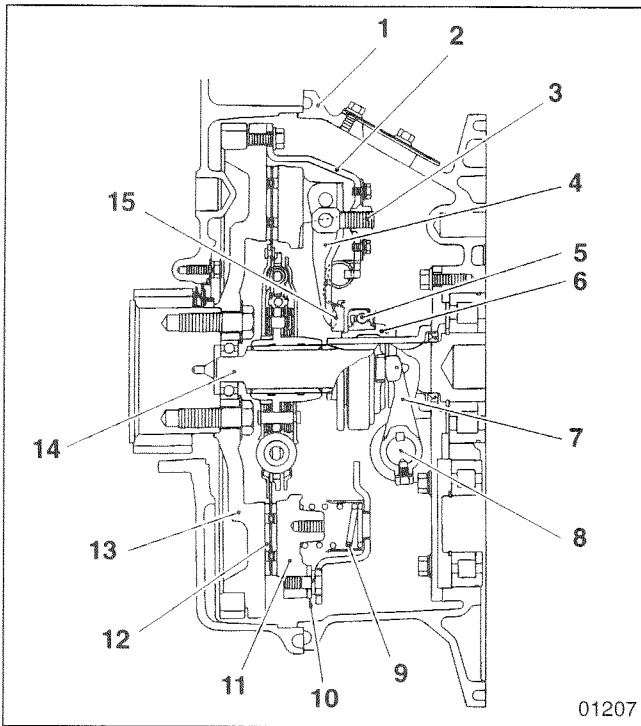
When the clutch pedal is depressed

- Hydraulic pressure generated within the clutch master cylinder activates the power cylinder. This pushes out clutch release bearing 6 via clutch release rocker arm 7 to compress diaphragm spring 5. The diaphragm spring supported by pivot ring 4 retracts pressure plate 9, which is connected to clutch cover 3 via strap plate 2. The resulting clearance between clutch disc 10 and flywheel 11 cuts off the transmission of engine power.

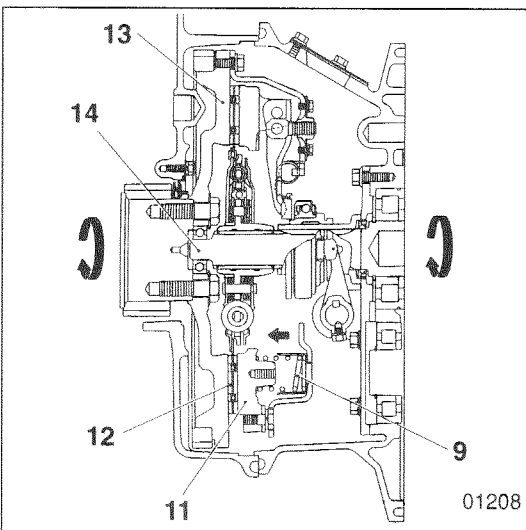
03475

STRUCTURE AND OPERATION

Clutch Body <C4>

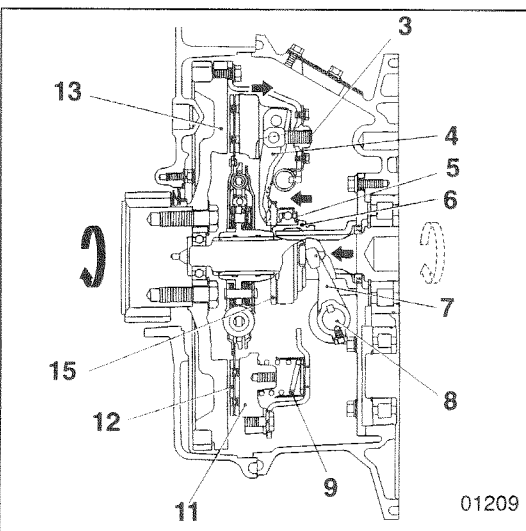


- 1 Clutch housing
- 2 Clutch cover
- 3 Support lever
- 4 Release lever
- 5 Release bearing
- 6 Clutch shifter
- 7 Release fork
- 8 Release fork shaft
- 9 Pressure spring
- 10 Strap plate
- 11 Pressure plate
- 12 Clutch disc
- 13 Flywheel
- 14 Drive pinion
- 15 Release lever plate



When the clutch pedal is released

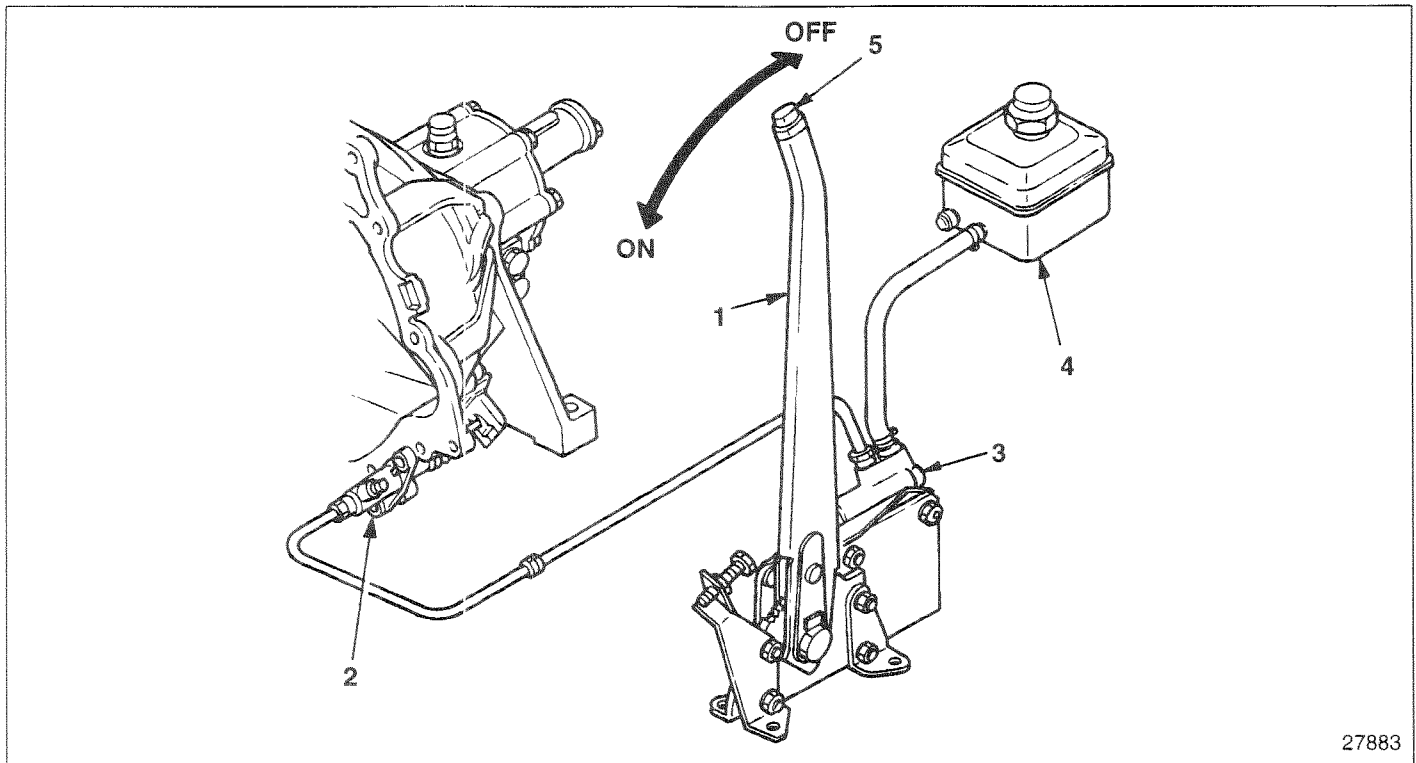
- By the tension of pressure spring 9, pressure plate 11 presses clutch disc 12 up against flywheel 13.
- Being pressed against flywheel 13, clutch disc 12 turns with the flywheel, transmitting power to drive pinion 14 of the transmission.



When the clutch pedal is depressed

- The hydraulic pressure generated by the clutch master cylinder operates the clutch booster. This results in release fork shaft 8 moving release fork 7, pushing out release bearing 5 with clutch shifter 6. This pushes release lever plate 15 and release lever 4.
- Release lever 4 pivots about support lever 3 to compress pressure spring 9, thereby pulling back pressure plate 11. As a result, a clearance is produced between clutch disc 12 and flywheel 13 and therefore no power from the engine is transmitted to the transmission.

Clutch Control



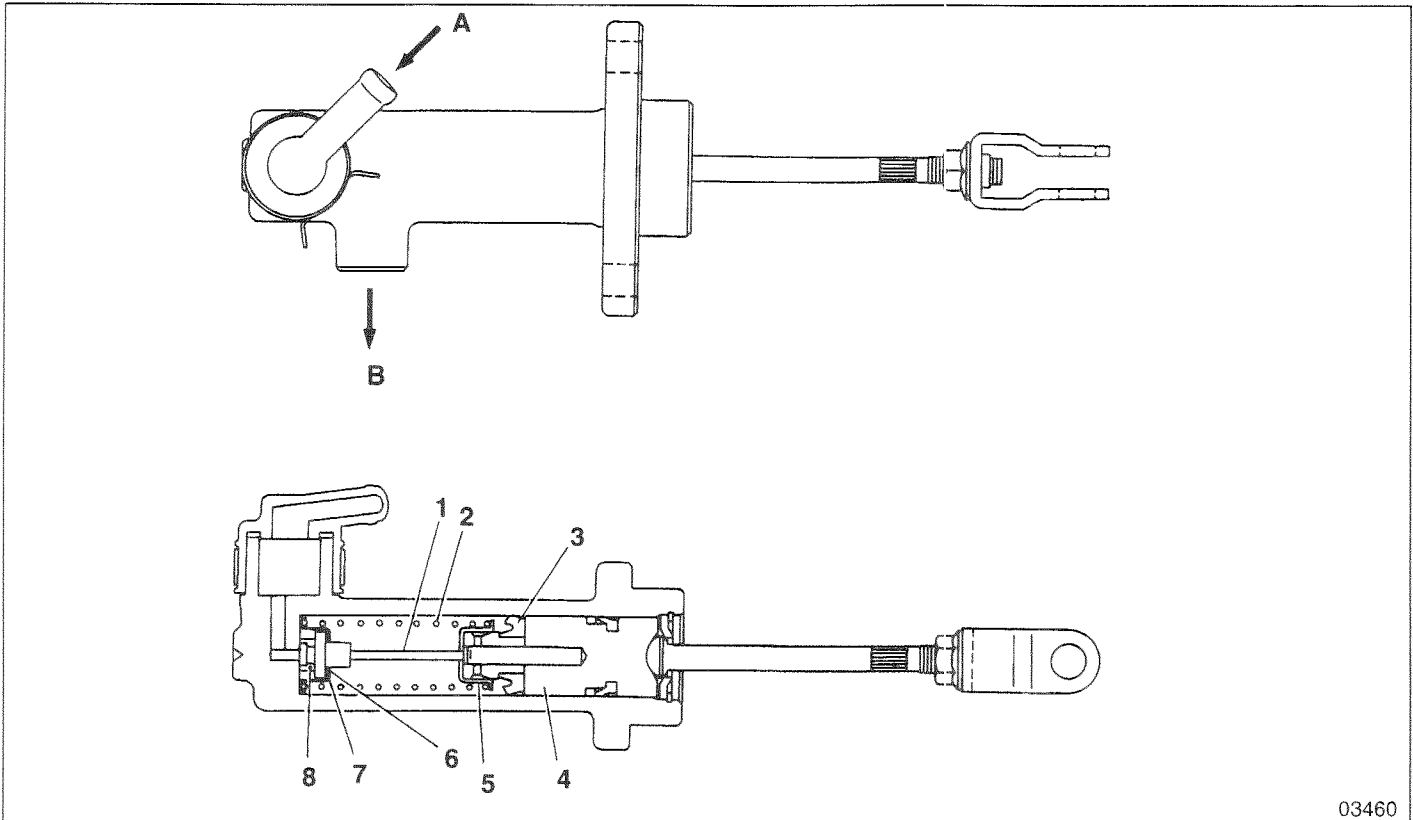
27883

- 1 Clutch lever
- 2 Clutch power cylinder
- 3 Clutch master cylinder
- 4 Reservoir tank
- 5 Release knob

When the clutch lever 1 is pulled, hydraulic pressure is produced in the clutch master cylinder 3, which causes the clutch power cylinder 2 to operate. The action of the power cylinder converts hydraulic pressure into push rod thrust, disengages the clutch and cuts off power transmission. On the other hand, when connected, it provides the clutch with slide and absorbs power transmission impact.

STRUCTURE AND OPERATION

Clutch Master Cylinder

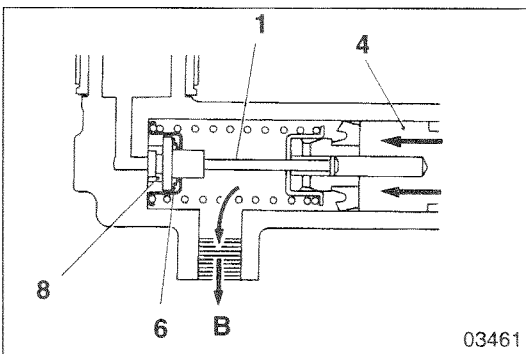


03460

- 1 Valve stem
- 2 Return spring
- 3 Pressure cup
- 4 Piston
- 5 Spring seat
- 6 Valve spring

- 7 Valve case
- 8 Valve seal

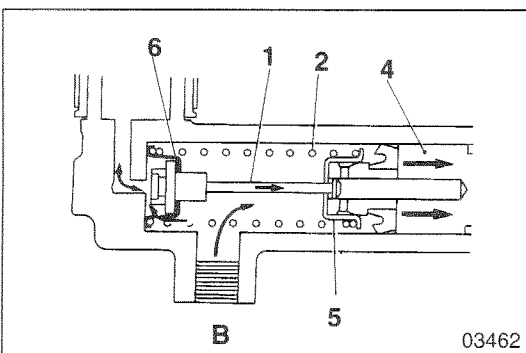
A: From brake fluid reservoir tank
B: To clutch power cylinder (hydraulic pressure)



03461

When the clutch pedal is depressed

- As piston 4 is pressed in the direction as illustrated, valve spring 6 of valve stem 1 forces down valve seal 8 to close the brake fluid tank port.
- Then, the hydraulic pressure in the master cylinder increases to transmit hydraulic pressure B to the power cylinder.

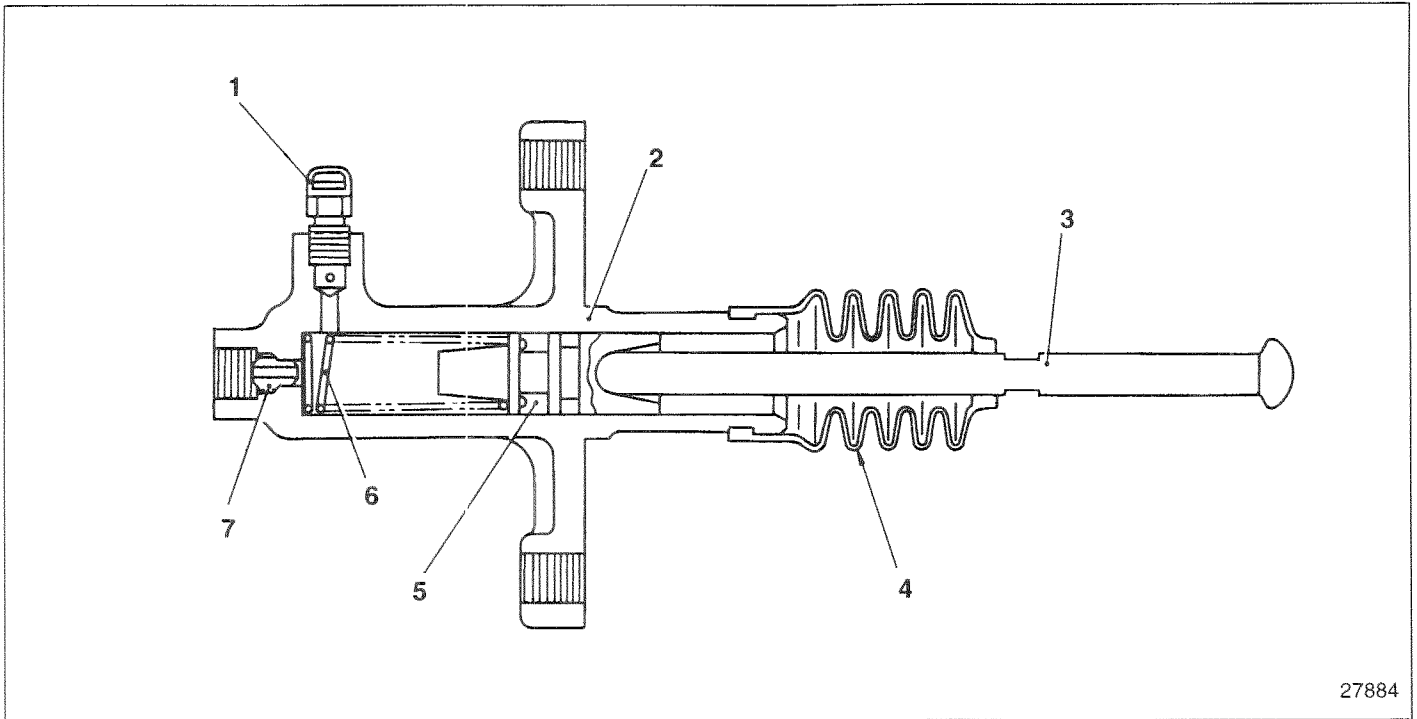


03462

When the clutch pedal is released

- As the clutch pedal is released, hydraulic pressure B from the power cylinder and return spring 2 push back piston 4.
- At the same time, valve stem 1 is retracted by spring seat 5 and compresses valve spring 6 to open the brake fluid tank port.
- Thus released, hydraulic pressure B in the master cylinder returns piston 4 to its original position.

Clutch Power Cylinder



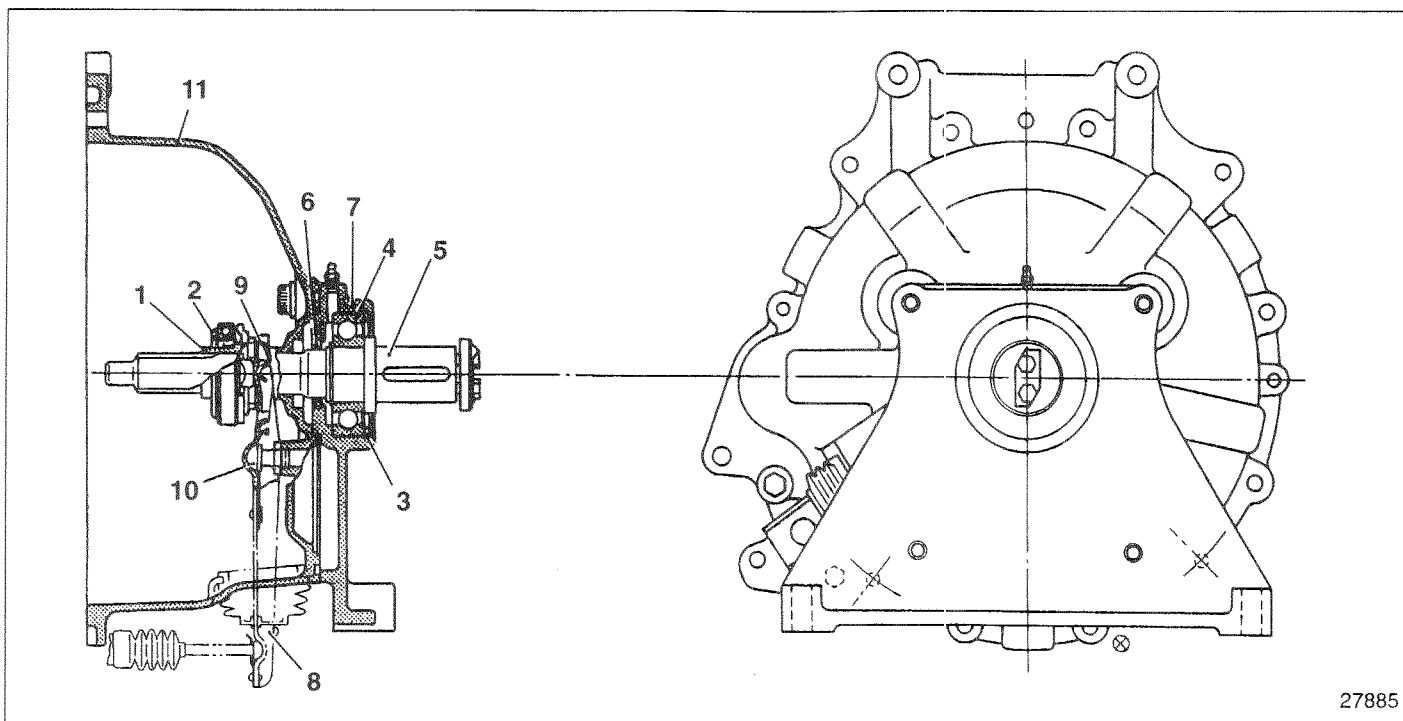
27884

- | | |
|------------------|-----------------|
| 1 Bleeder screw | 5 Piston cup |
| 2 Cylinder body | 6 Return spring |
| 3 Push rod | 7 Seat |
| 4 Cylinder cover | |

The clutch power cylinder connects or disconnects the clutch in converting hydraulic pressure, generated in the master cylinder by operation of the clutch lever or clutch pedal, into push rod thrust.

STRUCTURE AND OPERATION

Bearing Case <PC2: Direct Coupling Type>

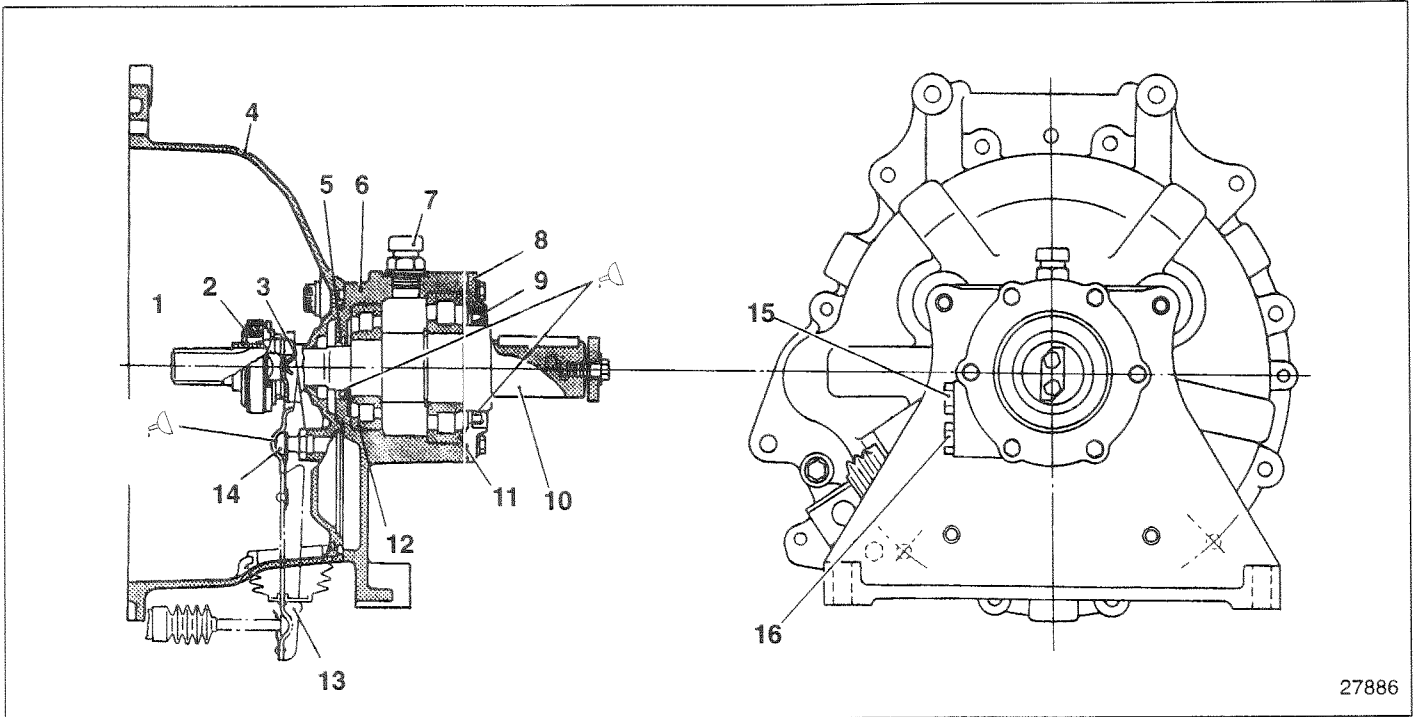


27885

- 1 Clutch shifter
- 2 Clutch release bearing
- 3 Snap ring
- 4 Ball bearing
- 5 Clutch shaft
- 6 Oil seal

- 7 Bearing case
- 8 Clutch release rocker arm
- 9 Return spring
- 10 Rocker arm pivot
- 11 Clutch housing

<PC2: Lateral Transmission Type>

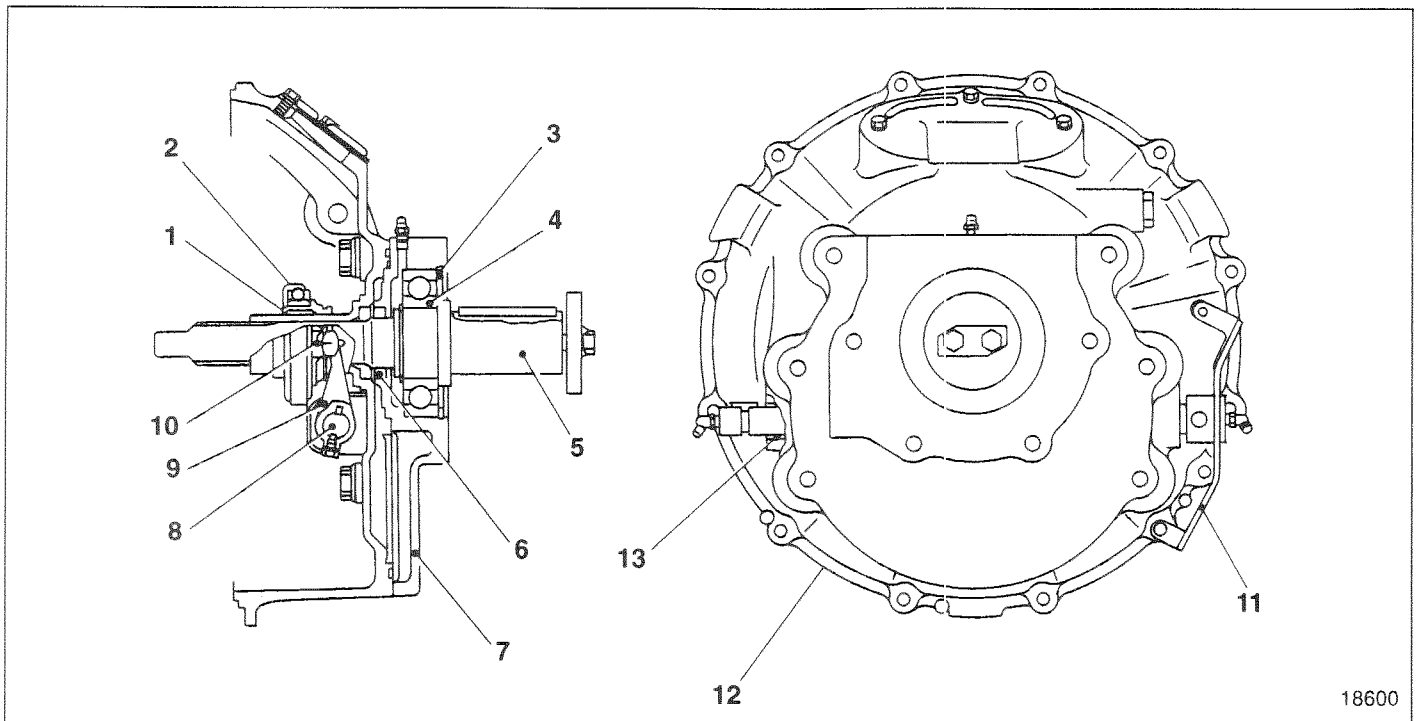


27886

- | | |
|--------------------------|------------------------------|
| 1 Clutch shifter | 9 Oil seal |
| 2 Clutch release bearing | 10 Clutch shaft |
| 3 Return spring | 11 Roller bearing (outer) |
| 4 Clutch housing | 12 Roller bearing (inner) |
| 5 Oil seal | 13 Clutch release rocker arm |
| 6 Bearing case A | 14 Rocker arm pivot |
| 7 Air breather | 15 Inspection plug |
| 8 Oil seal cover | 16 Drain plug |

STRUCTURE AND OPERATION

Bearing Case <PC4: Direct Coupling Type>

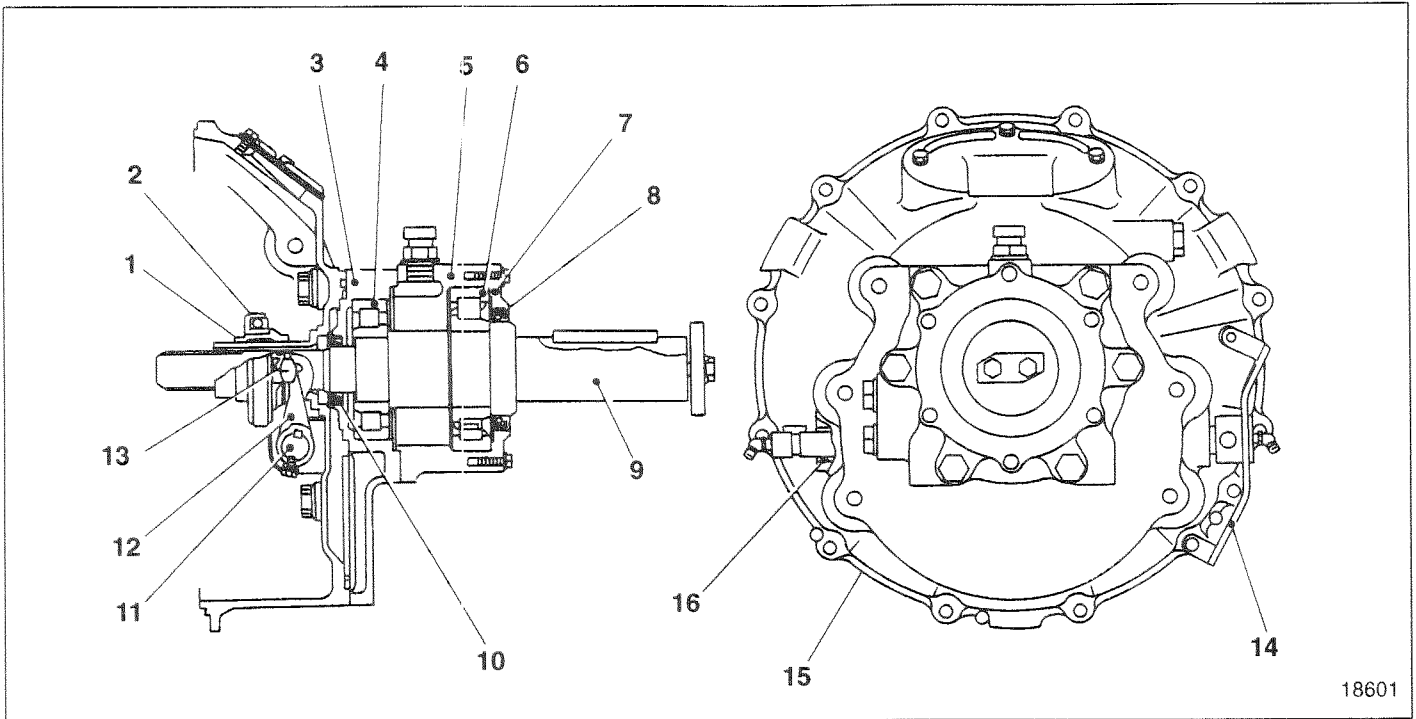


- 1 Clutch shifter
- 2 Clutch release bearing
- 3 Snap ring
- 4 Ball bearing
- 5 Clutch shaft
- 6 Oil seal
- 7 Bearing case

- 8 Clutch release fork shaft
- 9 Clutch release fork
- 10 Return spring
- 11 Stopper
- 12 Clutch housing
- 13 Oil seal

18600

<PC4: Lateral Transmission Type>

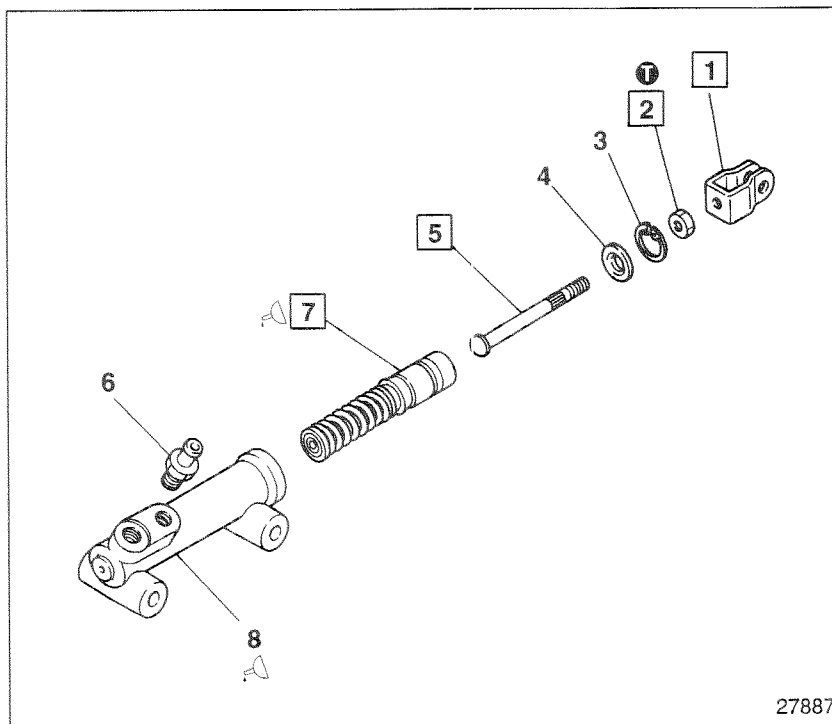


18601

- | | |
|--------------------------|------------------------------|
| 1 Clutch shifter | 9 Clutch shaft |
| 2 Clutch release bearing | 10 Oil seal |
| 3 Bearing case A | 11 Clutch release fork shaft |
| 4 Roller bearing (outer) | 12 Clutch release fork |
| 5 Bearing case B | 13 Return spring |
| 6 Roller bearing (outer) | 14 Stopper |
| 7 Oil seal cover | 15 Clutch housing |
| 8 Oil seal | 16 Needle roller bearing |

TROUBLESHOOTING

| Symptoms | | Dragging | Slipping | Not smooth when engaging | Noise when disengaged | Noise when engaging | Remarks |
|---|---|-----------------------|-----------------------|--------------------------|-----------------------|-----------------------|---------|
| | | | | | | | |
| Clutch cover assembly <C2, C3> | Uneven diaphragm spring height | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Distorted or faulty pressure plate | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Sagging diaphragm spring | | <input type="radio"/> | <input type="radio"/> | | <input type="radio"/> | |
| | Loosened rivets | | | | | | |
| | Bent strap plate | | | | <input type="radio"/> | | |
| Pressure plate & lever assembly <C4> | Defective release bearing | <input type="radio"/> | | | <input type="radio"/> | | |
| | Uneven release lever plate height | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Distorted or faulty pressure plate | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Sagging pressure spring | | <input type="radio"/> | <input type="radio"/> | | <input type="radio"/> | |
| | Bent strap plate | | | | <input type="radio"/> | | |
| Clutch disc | Deformed disc | <input type="radio"/> | | <input type="radio"/> | | | |
| | Loose disc rivet | | | <input type="radio"/> | | | |
| | Sagging or broken disc torsion spring | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| | Worn splines | <input type="radio"/> | | | <input type="radio"/> | <input type="radio"/> | |
| | Rusty splines | <input type="radio"/> | | <input type="radio"/> | | | |
| | Worn facing | | <input type="radio"/> | | | | |
| | Hardened facing | | <input type="radio"/> | <input type="radio"/> | | | |
| | Oil on facing | | <input type="radio"/> | <input type="radio"/> | | | |
| Clutch master cylinder | Piston and piston cup not moving smoothly | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Sagging spring | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Brake fluid port clogged | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| Clutch power cylinder | Piston and piston cup not moving smoothly | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Sagging spring | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| | Brake fluid port clogged | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | |
| Worn clutch shaft splines | | <input type="radio"/> | | | | <input type="radio"/> | |
| Low engine idle speed | | | | | | <input type="radio"/> | Gr13 |
| Distorted, deformed, or shouldered flywheel | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | | | Gr11 |
| Defective flywheel pilot bearing | | <input type="radio"/> | | | <input type="radio"/> | | |
| Leak in clutch fluid circuit | | <input type="radio"/> | | | | | |



27887

● Disassembly sequence

- 1 Clevis
- 2 Lock nut
- 3 Retaining ring
- 4 Stop plate
- 5 Push rod
- 6 Union
- 7 Piston assembly
- 8 Cylinder body

⊗ : Non-reusable part

● Assembly sequence

- 6 → 7 → 5 → 4 → 3 → 2 → 1

Repair kit : Clutch master cylinder kit

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|---|-------|--------|
| 7, 8 | Clearance between piston assembly and cylinder body | [15.87] 0.02 to 0.10 | 0.2 | — |

① Tightening torque

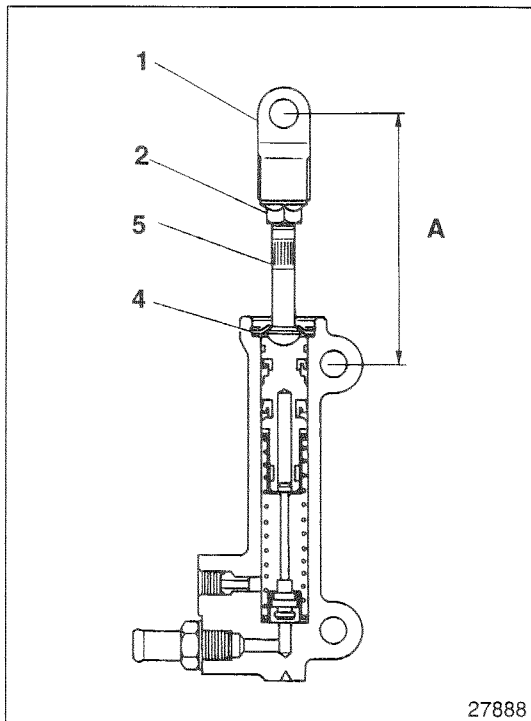
Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|------------------------------|---------------------|---------|
| 2 | Lock nut (push rod mounting) | 3 to 5 {0.3 to 0.5} | — |

🔊 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---------------------|--------------|
| 7, 8 | Friction surfaces of piston assembly and cylinder body | Rubber grease | 0.2 to 0.3 g |

CLUTCH MASTER CYLINDER



◆ Service procedure

1 2 5 Adjustment of push rod length

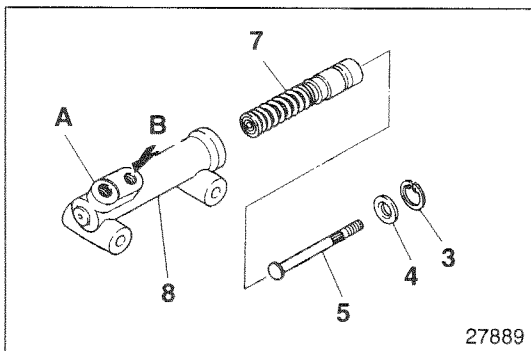
If the length, as illustrated, deviates from the specified value, loosen nut 2, and adjust the length of push rod 5 by turning clevis 1.

A: 85 mm

After adjustment, tighten nut 2 to the specified torque.

NOTE

Measure the length with push rod 5 touching stop plate 4.



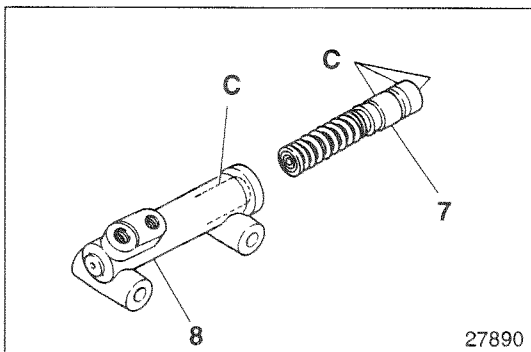
7 Piston assembly

[Removal]

- Remove retaining ring 3, stop plate 4 and push rod 5.
- Block port A of cylinder body 8, and apply compressed air from B as illustrated to remove piston assembly 7.

WARNING ⚠

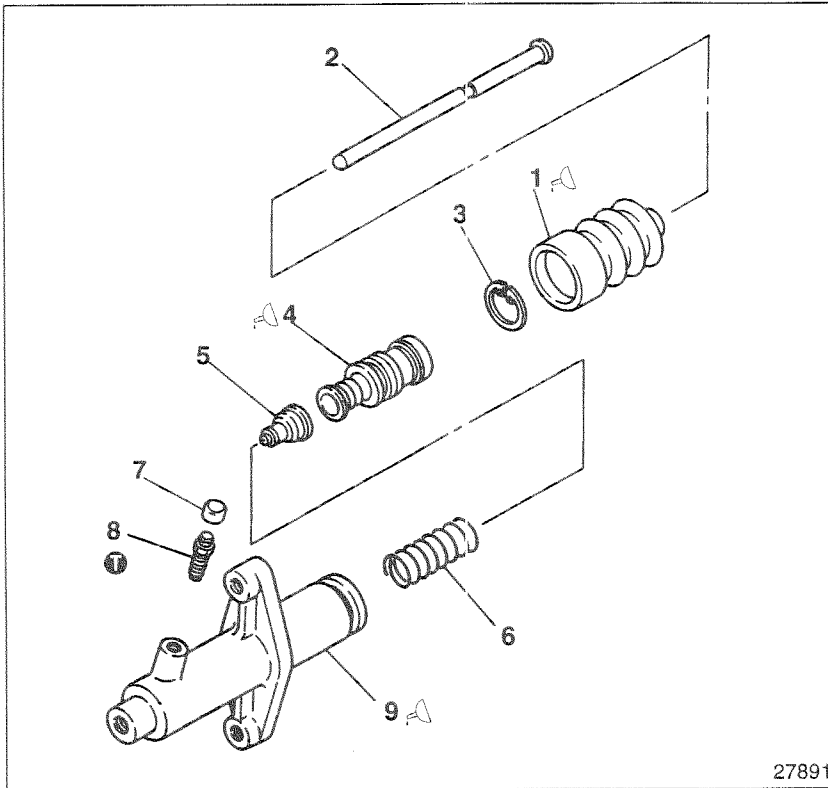
Be careful not to apply air at too high a pressure, or piston assembly 9 might be violently ejected and brake fluid might spray out.



[Installation]

Before installing the assembly, apply grease to friction surface C of piston assembly 7 and cylinder body 8.

Clutch Power Cylinder Assembly



27891

● Disassembly sequence

- 1 Dust cover
- 2 Push rod
- 3 Retaining ring
- 4 Piston assembly
- 5 Wear indicator
- 6 Spring
- 7 Bleeder cap
- 8 Bleeder screw
- 9 Cylinder body

● Assembly sequence

Follow the disassembly sequence in reverse.

Repair kit : Clutch power cylinder kit

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|---|-------|---------|
| 4, 9 | Clearance between piston assembly and cylinder body | [15.87] 0.02 to 0.10 | 0.2 | Replace |

ⓘ Tightening torque

Unit: N · m {kgf · m}

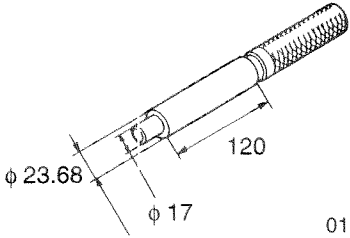
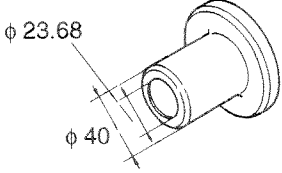
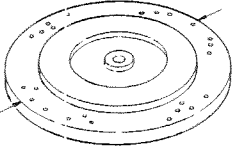
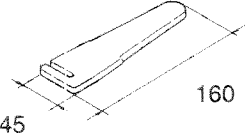
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|---------------------|---------|
| 8 | Bleeder screw | 4 to 7 {0.4 to 0.7} | — |

🔧 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|---|---------------------|-------------|
| 1 | Engagement part of cylinder body | Rubber grease | As required |
| 4, 9 | Lip area of piston cup and area extending approximately 15 mm from end surface of cylinder body | Rubber grease | As required |
| | Piston, piston cup (installation point) and internal surface of cylinder body | Rubber grease | As required |

 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|--|
| 2, 3 | Clutch Alignment Arbor  01270 | MH061386 | Holding of clutch disc |
| | Sleeve  03509 | MH061385 | Inspection of installed height of diaphragm spring |
| | Plate  03510 | MH061384 | Adjustment of diaphragm spring |
| | Adjust Wrench  03508 | MH061314 | Adjustment of diaphragm spring |

CLUTCH BODY <C2, C3>

◆ Service procedure

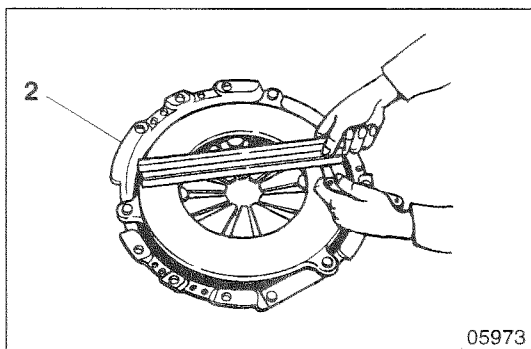
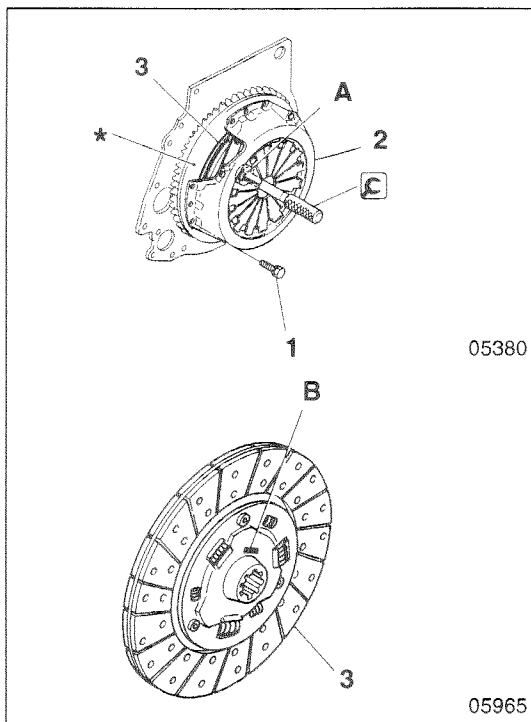
2 Clutch cover assembly

[Removal]

- Insert the **C** Clutch Alignment Arbor into pilot bearing **A** on flywheel ***** to hold clutch disc **3**, and remove clutch cover assembly **2**.
- For installation, follow the removal sequence in reverse.

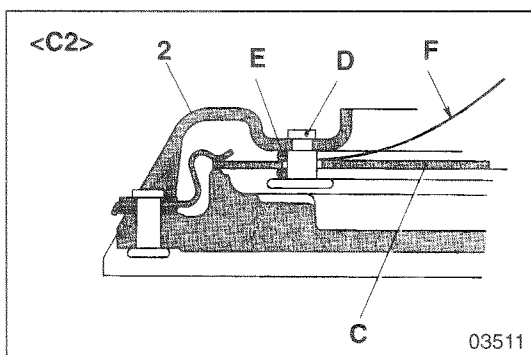
CAUTION

- Clean friction surfaces of clutch disc **3** and flywheel ***** before installation.
- Install clutch disc **3** so that part No. **B** is visible.
- Tighten bolts **1** gradually, in diagonal order, to the specified torque.



[Flatness of pressure plate]

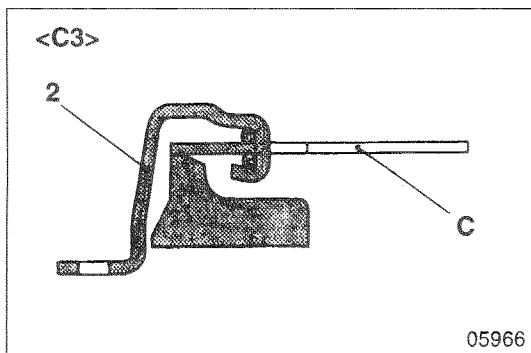
If the measured value is higher than the limit, replace clutch cover assembly **2**.



[Inspection]

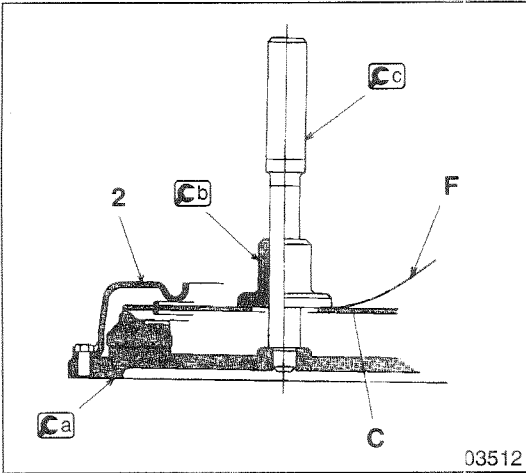
<C2>

Measure the clearance between rivet **D** of diaphragm spring **C** and pivot ring **E** using feeler gauge **F**. If the measured value is higher than the limit, replace clutch cover assembly **2**.



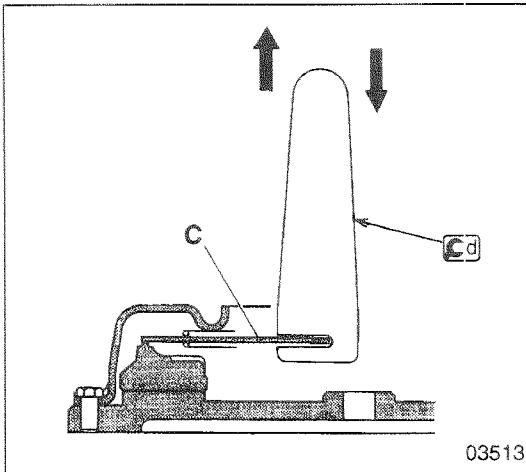
<C3>

- Check for play in diaphragm spring **C**.
- If there is play, replace clutch cover assembly **2**.



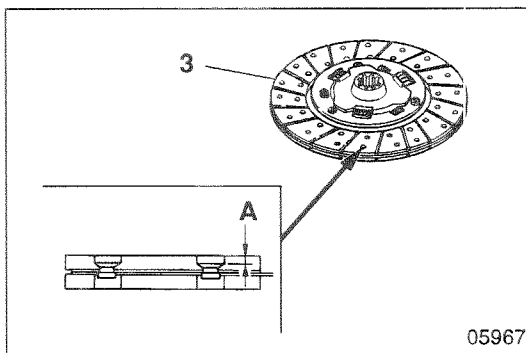
[Inspection of installation height]

- Place the **(a)** Plate on a surface plate and install clutch cover assembly 2.
- Install the **(b)** Sleeve and the **(c)** Clutch Alignment Arbor, measure the finger heights of diaphragm spring **C** to see if they are uneven, using feeler gauge **F**. If the measured value is higher than the limit, correct the heights.



[Correction]

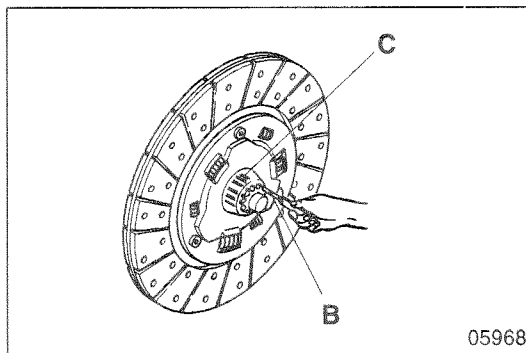
- Correct uneven finger heights of diaphragm spring **C** using the **(d)** Adjust Wrench.



3 Clutch disc

(1) Height of facing

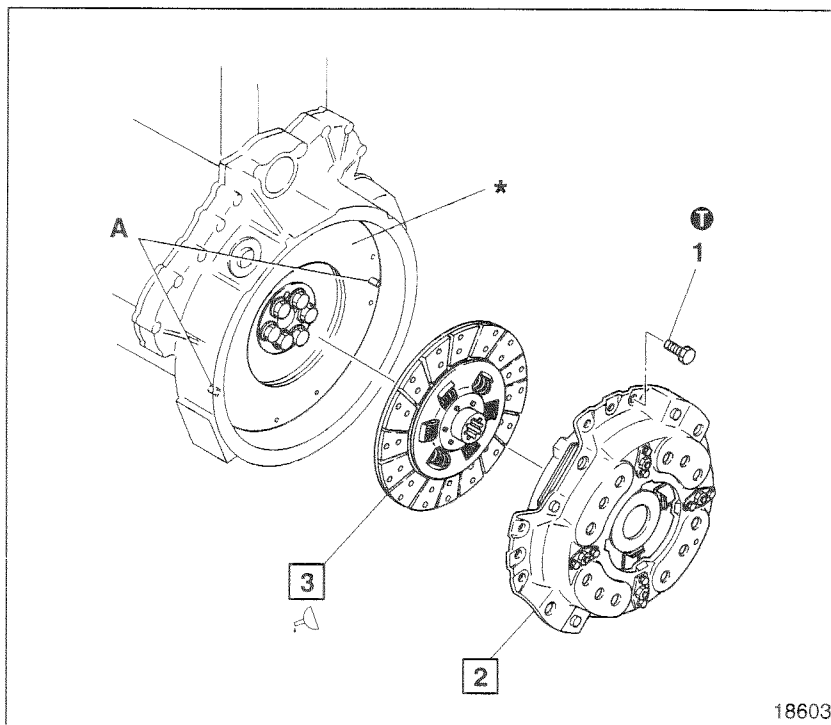
Measure dimension **A** of clutch disc **3**. If the measured value is lower than the limit, replace the clutch disc.



(2) Play in spline turning direction

Machine feeler gauge **B** to a width with which it can be inserted into splines **C** of the drive pinion. Take a measurement with this feeler gauge, and if the measurement exceeds the limit, replace the faulty parts.

CLUTCH BODY <C4>



● Removal sequence

- 1 Bolt
- 2 Pressure plate & lever assembly
- 📖 P21-22
- 3 Clutch disc

*: Flywheel
A: Positioning pin (at 2 places)

CAUTION ⚠

Handle with care pressure plate & lever assembly 2 as it is heavy.

● Installation sequence

Follow the removal sequence in reverse.

CAUTION ⚠

Ensure that no oil or grease is on clutch disc 3, as a slipping clutch results.

Service standards

Unit: mm

| Location | Maintenance item | Standard value | Limit | Remedy | |
|----------|------------------|------------------------------------|--------------|--------|---------|
| 3 | Clutch disc | Horizontal runout | 0.6 or less | — | Replace |
| | | Vertical runout | 1.0 or less | — | Replace |
| | | Play in spline turning direction | 0.05 to 0.23 | 0.5 | Replace |
| | | Depth from facing surface to rivet | 1.9 | 0.2 | Replace |

ⓘ Tightening torque

Unit: N·m {kgf·m}

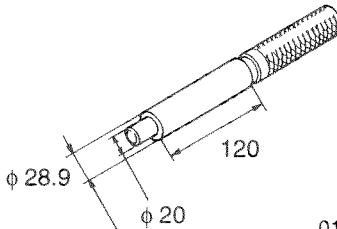
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|---|-------------------|---------|
| 1 | Bolt (securing pressure plate & lever assembly) | 32 {3.3} | — |

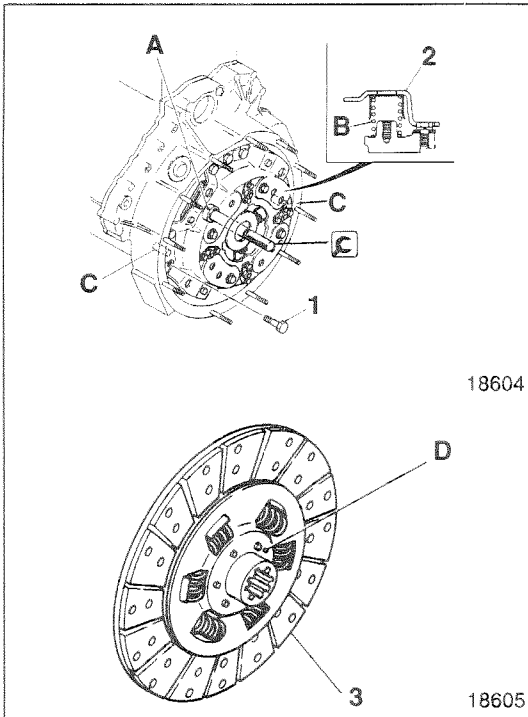
🛢 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|--|--------------|
| 3 | Clutch disc splines | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | 0.7 to 0.8 g |

🛠 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|-------------------|---------------------------------|
| 3 | Clutch Alignment Arbor  | MH061387 01270 | Holding clutch disc in position |



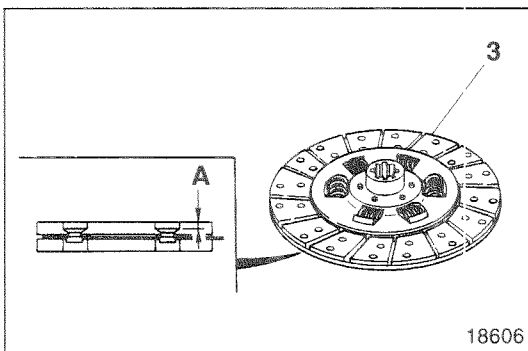
◆ Service procedure

2 Removal and installation of pressure plate & lever assembly

- Insert the **C** Clutch Alignment Arbor in pilot bearing **A** of the flywheel and support clutch disc **3**.
- Remove bolts **1** by gradually loosening them in diagonal order.
- To reinstall, reverse the order of removal.
- Mount clutch disc **3** so that part no. **D** is visible.
- Tighten bolts **1** in diagonal order, gradually up to the specified torque.

CAUTION

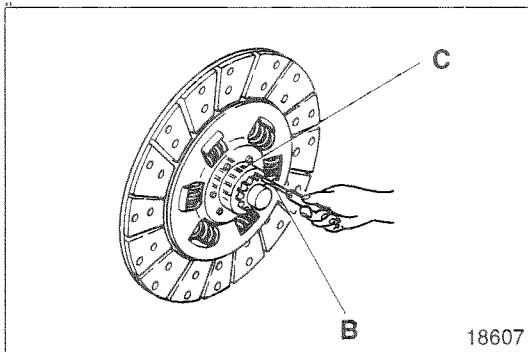
When removing pressure plate & lever assembly **2**, it is raised by the tension of pressure spring **B**. Use care not to allow it to come off positioning pin **C** of the flywheel.



3 Clutch disc

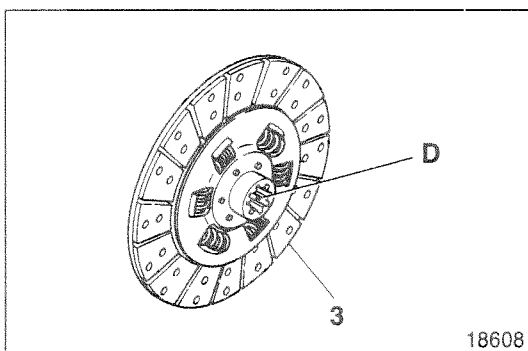
(1) Facing height

Measure dimension **A** of clutch disc **3** and, if the measurement falls short of the limit, replace the clutch disc.



(2) Play in spline turning direction

- Machine feeler gauge **B** to a width with which it can be inserted into splines **C** of the drive pinion. Take a measurement with this feeler gauge and, if the measurement exceeds the limit, replace clutch disc **3** or drive pinion.
- Take the same measurement from new clutch disc **3** and, if the measurement exceeds the limit, replace the drive pinion.



(3) Grease application

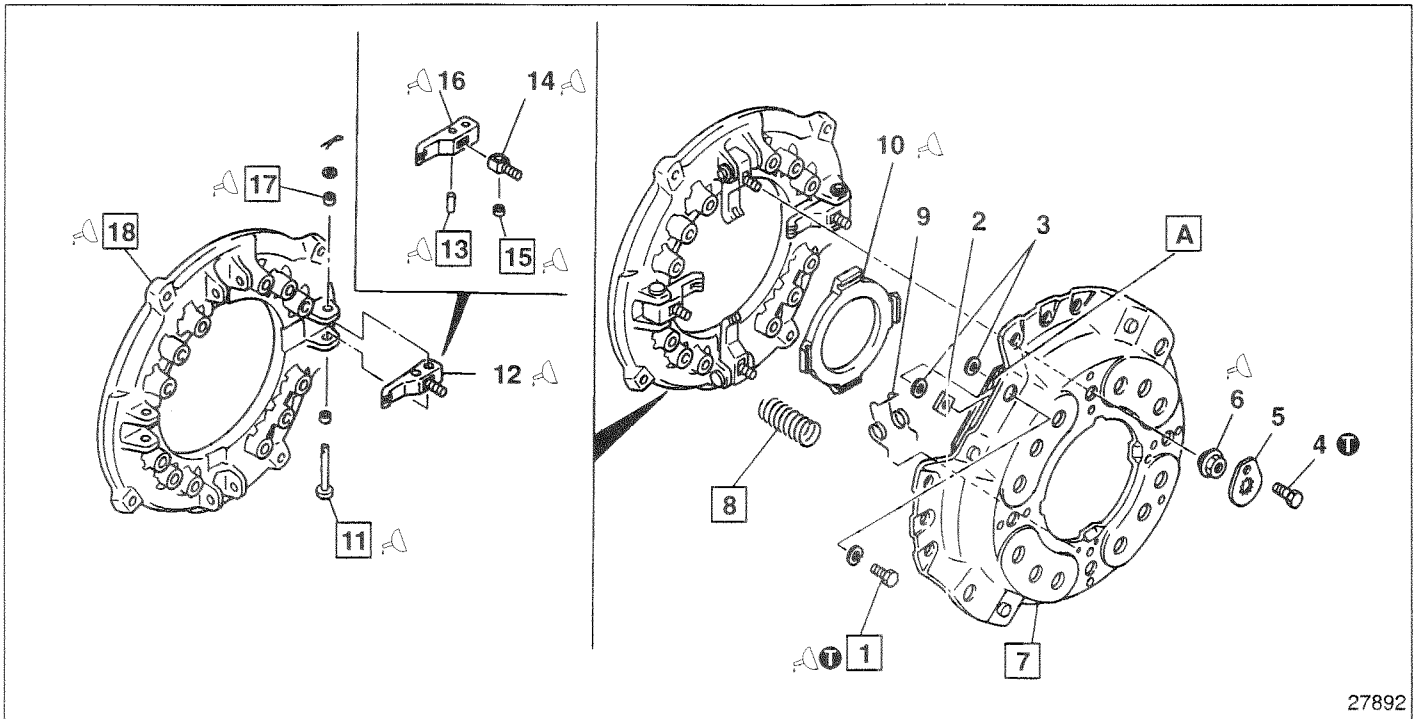
Coat the entire tooth surfaces of splines **D** of clutch disc **3** with grease. Apply the specified amount of grease to the grease groove in the splines up to the larger diameter of the splines.

CAUTION

An excessive amount of grease results in grease leaking from splines **D**, causing the clutch to slip.

CLUTCH BODY <C4>

Pressure Plate & Lever Assembly



27892

● Work before disassembly

📖 P21-24

● Disassembly sequence

- | | |
|------------------------|---------------------------|
| 1 Strap bolt | 11 Release lever pin |
| 2 Washer | 12 Release lever assembly |
| 3 Washer | 13 Support lever pin |
| 4 Bolt | 14 Support lever |
| 5 Lock plate | 15 Bushing |
| 6 Support nut | 16 Release lever |
| 7 Clutch cover | 17 Bushing |
| 8 Pressure spring | 18 Pressure plate |
| 9 Return spring | |
| 10 Release lever plate | |
- A: Strap plate

CAUTION

Remove bushings 15 and 17 only when defects are evident.

● Assembly sequence

Follow the disassembly sequence in reverse.
Repair kit: Clutch Release Lever Kit

● Inspection and adjustment after assembly

📖 P21-24

Service standards

Unit: mm

| Location | Maintenance item | | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|---|--|---|-------------------------------------|------------------------|
| 1, A | Clearance between strap bolt and strap plate | | 0.01 to 0.16 | 0.3 | Replace |
| 8 | Pressure spring | Installed load (installed length 48.5) | 515 to 565 N {52.3 to 57.7 kgf} | 470 N {48 kgf} | Replace |
| | | Squareness | 2.4 or less | 4 | Replace |
| 11, 17 | Clearance between release lever pin and bushing | | [8] 0.019 to 0.123 | 0.4 | Replace |
| 12 | Release lever plate height | | 53.8 ± 0.5 | Mutual difference 0.5 or less | Adjust |
| 13, 15 | Clearance between support lever pin and bushing | | [8] 0.019 to 0.123 | 0.4 | Replace |
| 18 | Pressure plate | Thickness | 28.5 ± 0.1 | 26 | Replace |
| | | Flatness | 0.05 or less | 0.2 | Correct or replace. |
| | | Strap bolt hole I.D. | 10.2 $^{+0.05}_0$ | 10.5 | Replace |

① Tightening torque

Unit: N · m {kgf · m}

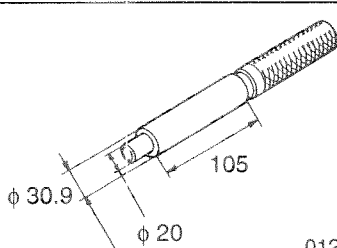
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------------------|-------------------------|---------|
| 1 | Strap bolt (securing strap plate) | 32 {3.3} | — |
| 4 | Bolt (securing lock plate) | 5.9 to 7.8 {0.6 to 0.8} | — |

🔧 Lubricant and/or sealant

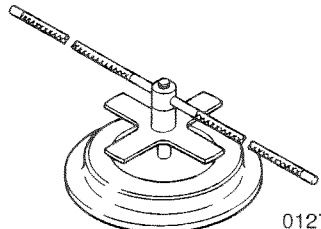
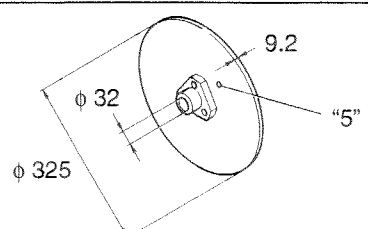
| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|--|---|-------------|
| 1 | Threads of strap bolt | LOCTITE 272 | As required |
| 6 | Threads and spherical surfaces of support nut | Anti-seizure compound | As required |
| 10, 12 | Sliding surfaces of release lever plate and release lever assembly | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |
| 11, 17 | Sliding surfaces of release lever pin and bushing | Molybdenum disulfide grease | As required |
| 13, 15 | Sliding surfaces of support lever pin and bushing | Molybdenum disulfide grease | As required |
| 14, 16 | Sliding surfaces of support lever and release lever | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |
| 16, 18 | Sliding surfaces of release lever and pressure plate | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|---------------------------------------|
| — | Clutch Alignment Arbor  | MH061986 | Release lever plate height adjustment |

CLUTCH BODY <C4>

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|--|
| 7 | Clutch Installer  01277 | MH061051 | Removal and installation of clutch cover |
| 10 | Clutch Master Plate  11065 | MH062291 | Release lever plate height adjustment |

◆ Service procedure

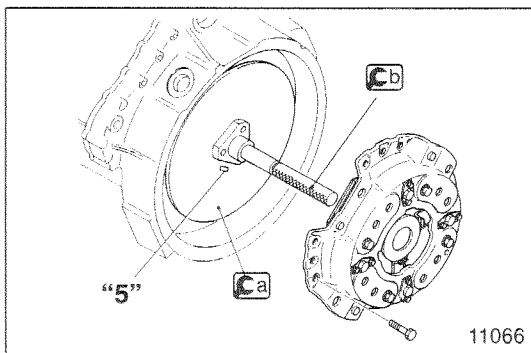
● Work before disassembly

Make alignment marks on parts before disassembly.

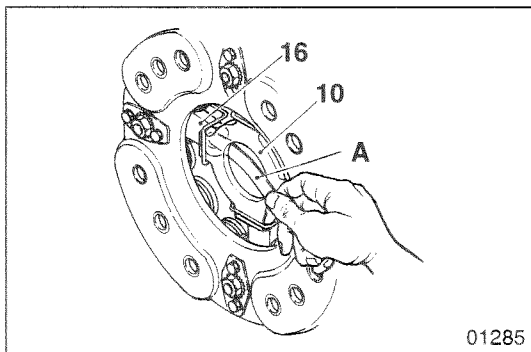
● Inspection and adjustment after assembly

(1) Measurement of release lever plate height

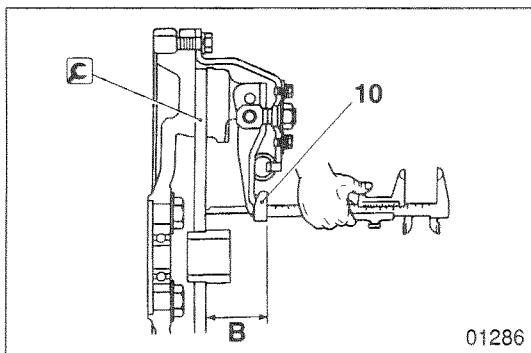
- Using the **C**a Clutch Master Plate and the **C**b Clutch Alignment Arbor instead of the clutch disc, install the pressure plate & lever assembly.
- Mount the **C**a Clutch Master Plate so that the identification mark of "5" is visible.

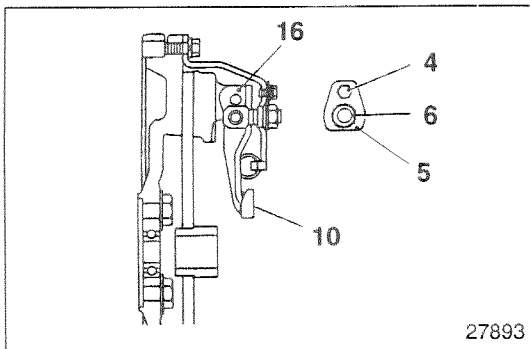


- Check that 0.05-mm feeler gage **A** cannot be inserted into the space between release lever **16** and release lever plate **10**. If there is a clearance, push in the feeler gauge hard, then slowly remove it and eliminate the gap.



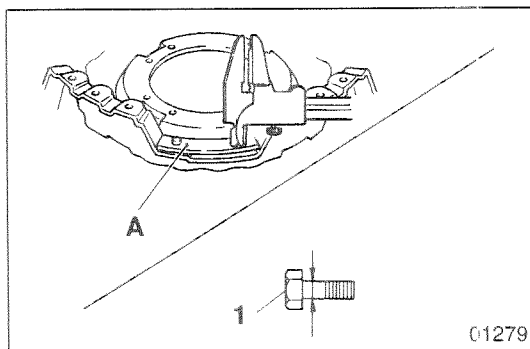
- Measure dimension **B** between the **C** Clutch Master Plate and each release lever plate **10** (at 4 places).
- If the measurements are outside the standard range, adjust by following the steps given below. Make this adjustment if there is a difference of 0.5 mm or more between each of the measurements taken, even if each falls within the standard range.





(2) Adjustment of release lever height

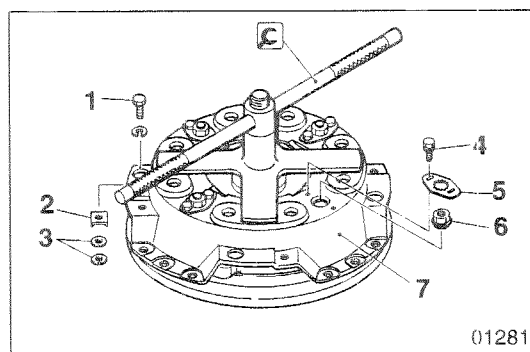
- Remove bolt 4 and lock plate 5 and turn support nut 6 to adjust the height of release lever 16.
- After the adjustment has been made, mount lock plate 5 and secure support nut 6; then, check the height of release lever plate 10.





1 A Clearance between strap bolt and strap plate

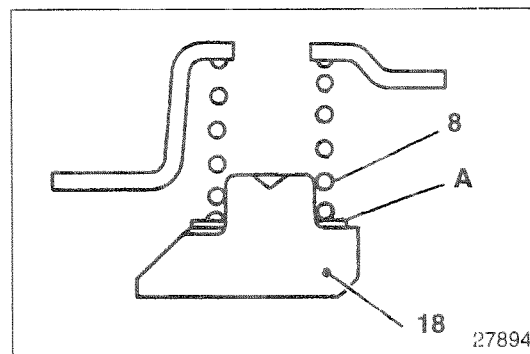
If the measurement exceeds the limit, replace the defective part.

A: Strap plate



7 Removal and installation of clutch cover

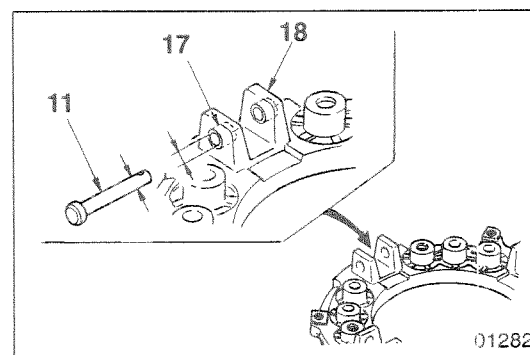
- Using the  Clutch Installer, compress pressure spring 8 and remove strap bolt 1, washer 2, washer 3, bolt 4, lock plate 5, and support nut 6.
- Gradually loosen the  Clutch Installer until pressure spring 8 is inactive and then remove clutch cover 7.
- To install, reverse the order of removal.



8 Installation of pressure spring

If pressure plate 18 has been reground, insert adjusting washer A corresponding to the amount of reground in the space between the pressure plate and pressure spring 8.

| Regrind amount | Type and no. of washers |
|--------------------------------|--------------------------|
| Less than 1 mm | Not required |
| 1 mm or more to less than 2 mm | One 1.2-mm |
| 2 mm or more to less than 3 mm | Two 1.2-mm or one 2.3-mm |



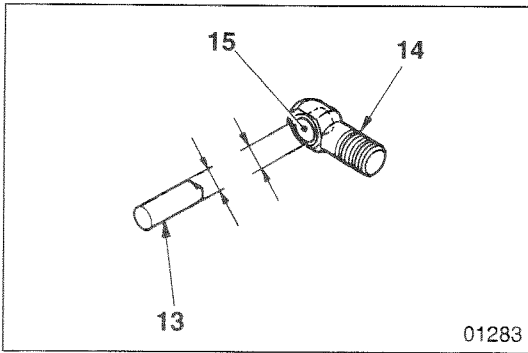
11 17 Clearance between release lever pin and bushing

If the measurement exceeds the limit, replace the defective part.

CAUTION 

Check bushing 17 where it is press-fitted into pressure plate 18.

CLUTCH BODY <C4>

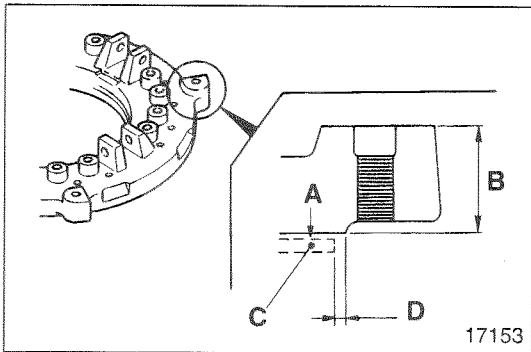


13 15 Clearance between support lever pin and bushing

If the measurement exceeds the limit, replace the defective part.

CAUTION

Check bushing 15 where it is press-fitted into support lever 14.



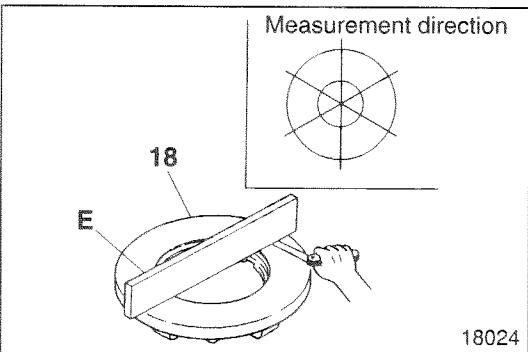
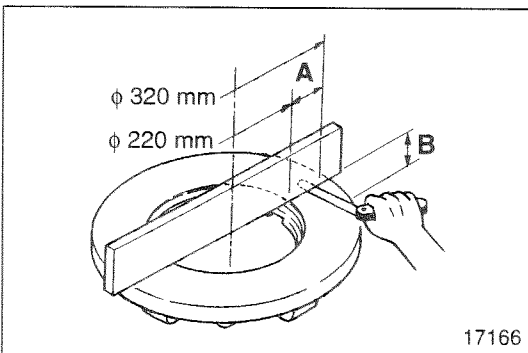
18 Pressure plate

(1) Thickness

For pressure plate 18 thickness, use the following procedure to measure the thickness on friction surface A. If the measurement is below the limit, replace the pressure plate.

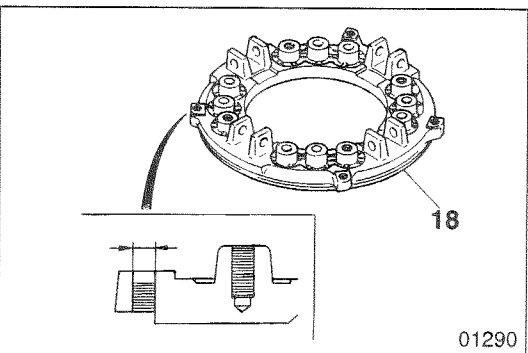
- Measure reference dimension B (part D which is not in contact with clutch disc C) as follows:

- Measure the friction amount of friction surface A (indicated in fig.) and subtract the amount from the reference dimension B. The result is the thickness of pressure plate 18.



(2) Flatness

Measure the clearance between pressure plate 18 and straightedge E over the entire surface (assuming that the pressure plate is flat). If the measurement exceeds the limit, correct or replace the pressure plate.

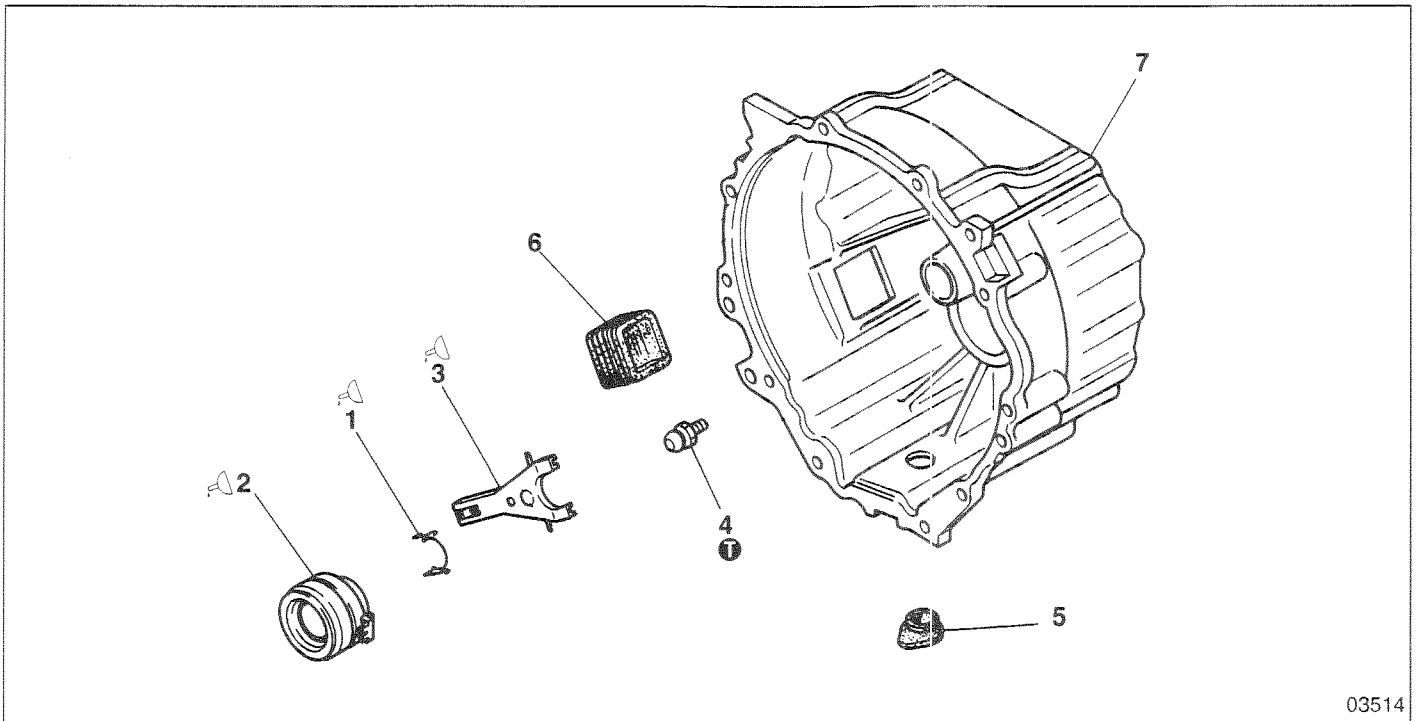


(3) Strap bolt hole I.D.

If the measurement exceeds the limit, replace pressure plate 18.

MEMO

CLUTCH HOUSING <C2>



03514

● Disassembly sequence

- | | |
|-----------------------------|---------------------------|
| 1 Return spring | 5 Dust plug |
| 2 Clutch release bearing | 6 Clutch rocker arm cover |
| 3 Clutch release rocker arm | 7 Clutch housing |
| 4 Rocker arm pivot | |

NOTE

Do not remove rocker arm pivot 4 unless it is faulty.

● Assembly sequence

Follow the disassembly sequence in reverse.

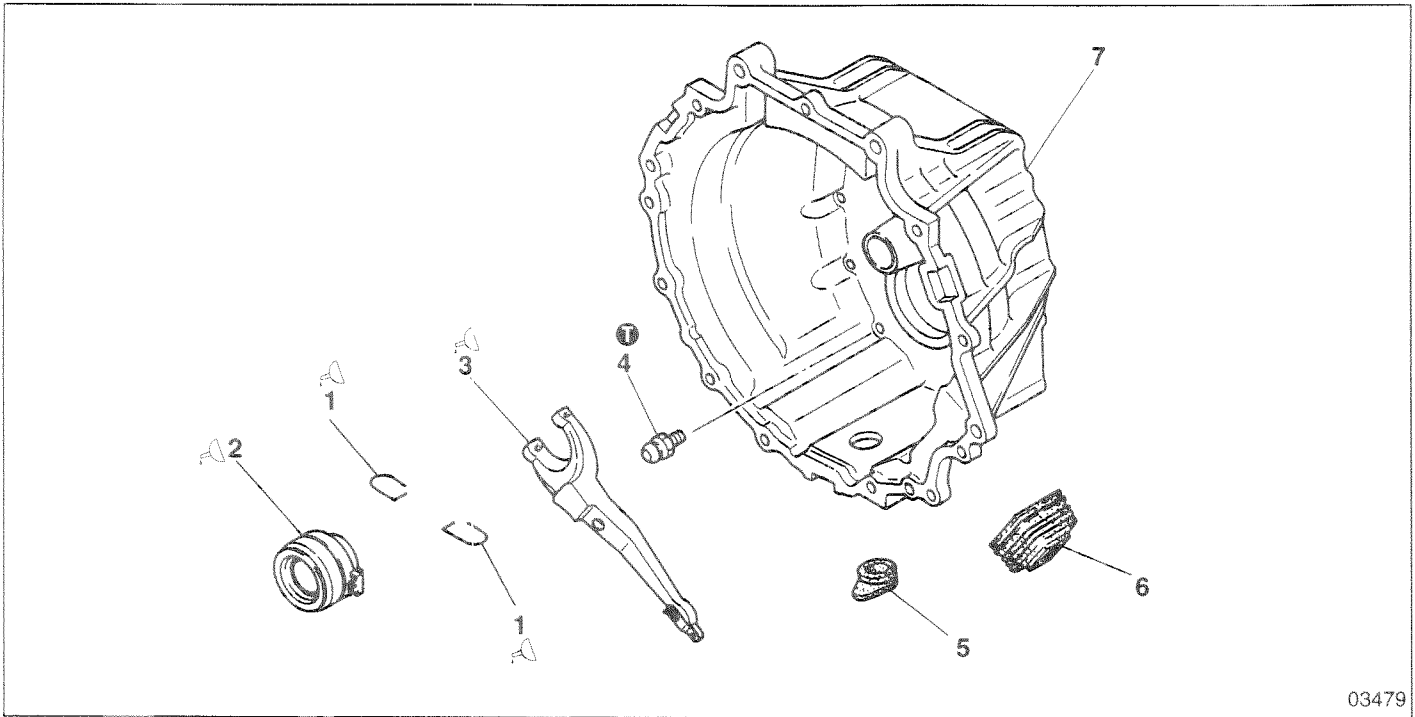
ⓘ Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-------------------|---------|
| 4 | Rocker arm pivot | 57 {5.8} | — |

🔧 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|---|---|-------------|
| 1 to 3 | Friction surfaces of return spring, clutch release bearing, and clutch release rocker arm | Wheel bearing grease [NLGI No.2 (Li soap)] | As required |



03479

● **Disassembly sequence**

- 1 Return spring
- 2 Clutch release bearing
- 3 Clutch release rocker arm
- 4 Rocker arm pivot
- 5 Dust plug
- 6 Clutch rocker arm cover
- 7 Clutch housing

NOTE

Do not remove rocker arm pivot 4 unless it is faulty.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

① **Tightening torque**

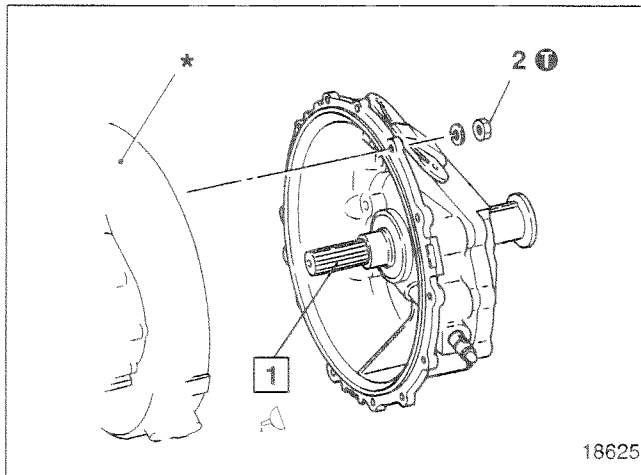
Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-------------------|---------|
| 4 | Rocker arm pivot | 57 (5.8) | — |

🔧 **Lubricant**

| Location | Points of application | Specified lubricant | Quantity |
|----------|---|--|-------------|
| 1 to 3 | Friction surfaces of return spring, clutch release bearing, and clutch release rocker arm | Wheel bearing grease [NLGI No.2 (Li soap)] | As required |

BEARING CASE <PC2: DIRECT COUPLING TYPE>



● Removal sequence

- 1 Bearing case assembly P21-32
- 2 Nut

*: Flywheel housing Gr11

● Installation sequence

Follow the removal sequence in reverse.

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | | Tightening torque | Remarks |
|----------|--------------------------------------|---|-------------------|---------|
| 2 | Nut (mounting bearing case assembly) | A | 82 {8.4} | |
| | | B | 40 {4.1} | |
| | | C | 47 {4.8} | |
| | | D | 47 {4.8} | |

Lubricant

| Location | Points of application | specified lubricant | Quantity |
|----------|-----------------------|---|-------------|
| 1 | Clutch shaft splines | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |

◆ Service procedure

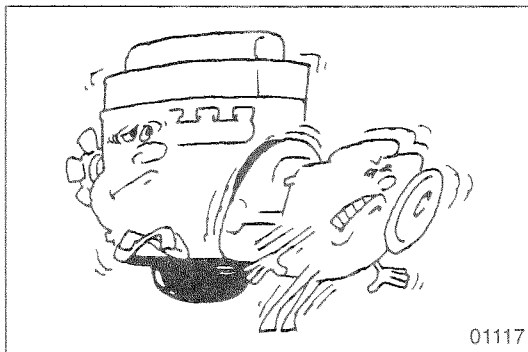
① Bearing case assembly

[Removal]

Move bearing case assembly 1 straight to the rear until the clutch shaft splines come off the clutch.

CAUTION

Be sure to pull bearing case assembly 1 straight out. Rocking it hard could damage the splines between the clutch shaft and clutch.

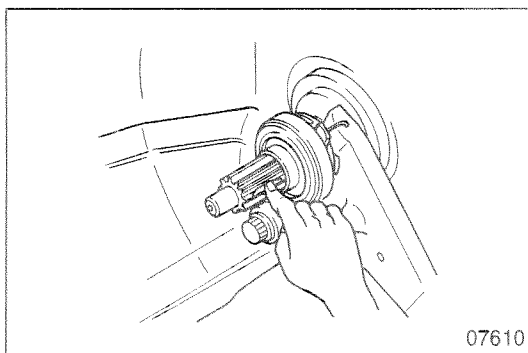


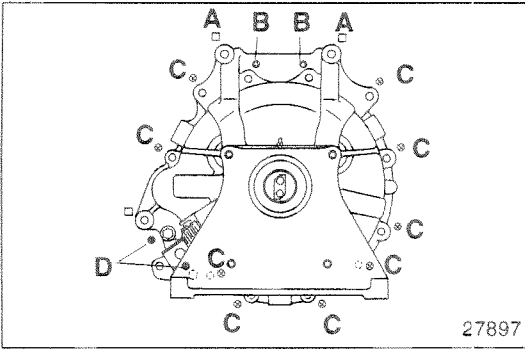
[Installation]

- Check the drive pinion splines for rust.
- If rust gathers on the drive pinion, remove it using a wire brush.
- Rub the surfaces of the drive pinion, over which the clutch disc slides, with grease.

CAUTION

Do not apply an excessive amount of grease, as a grease drop could cause the clutch to slip.





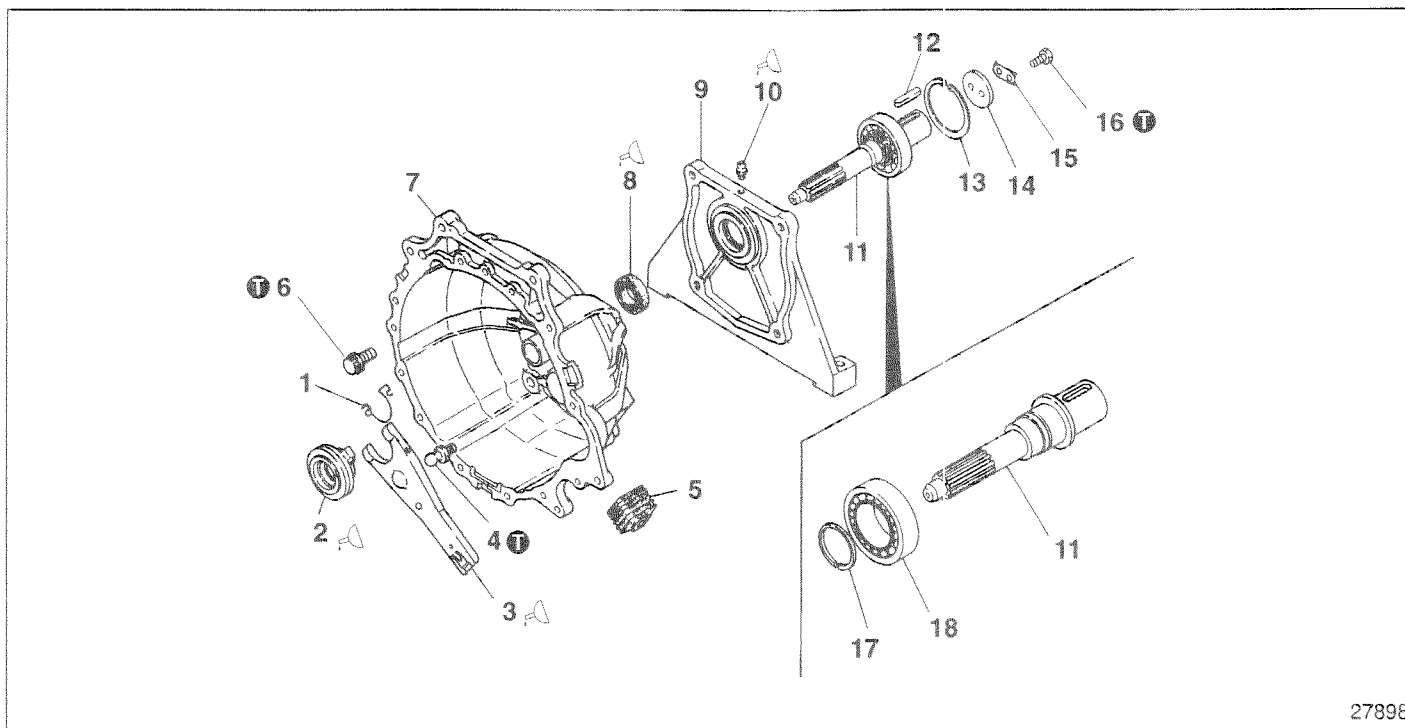
2 Installation of bearing case assembly

Mounting nuts of bearing case assembly 1 differ in tightening torque. Make sure that the nuts are tightened to a correct torque (refer to the figure at left for positions of each nut).

- A (2 places) : 82 N·m {8.4 kgf·m}
- B (2 places) : 40 N·m {4.1 kgf·m}
- C (9 places) : 47 N·m {4.8 kgf·m}
- D (2 places) : 47 N·m {4.8 kgf·m}

BEARING CASE <PC2: DIRECT COUPLING TYPE>

Bearing Case Assembly



27898

● Disassembly sequence

- | | | |
|-----------------------------|------------------|-------------------|
| 1 Return spring | 7 Clutch housing | 13 Snap ring |
| 2 Clutch release bearing | 8 Oil seal | 14 Lock plate |
| 3 Clutch release rocker arm | 9 Bearing case | 15 Lock sheet |
| 4 Rocker arm pivot | 10 Grease nipple | 16 Bolt |
| 5 Rocker arm cover | 11 Clutch shaft | 17 Snap ring |
| 6 Bolt | 12 Key | 18 Roller bearing |

CAUTION

Do not remove rocker arm pivot 4 and oil seal 8 unless defects are evident.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Use care not to apply an excessive amount of grease through grease nipple 10. Excess grease could result in a slipping clutch.

Tightening torque

Unit: N·m {kgf·m}

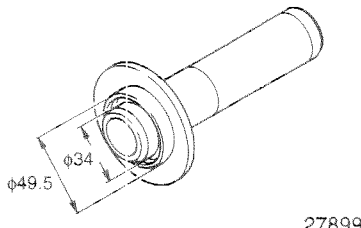
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|------------------------------|-------------------|---------|
| 4 | Rocker arm pivot | 57 {5.8} | — |
| 6 | Bolt (securing bearing case) | 115 {11.9} | — |
| 16 | Bolt (securing lock sheet) | 17{1.7} | — |

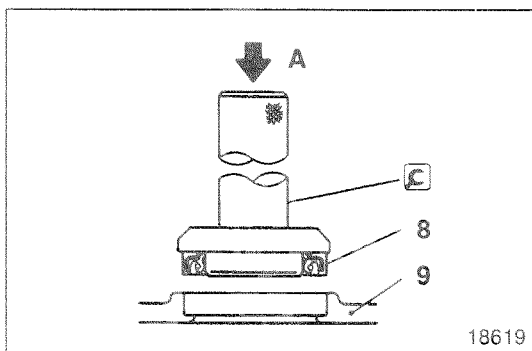
Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|---------------------------|--|-------------|
| 2 | Pack clutch shifter. | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 3 | Clutch release rocker arm | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 8 | Coat oil seal lip | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 10 | Through grease nipple | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |

Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|---|----------|---------------------------------------|
| 8 | Oil Seal Installer  | MH061302 | Driving of oil seal into bearing case |



Service procedure

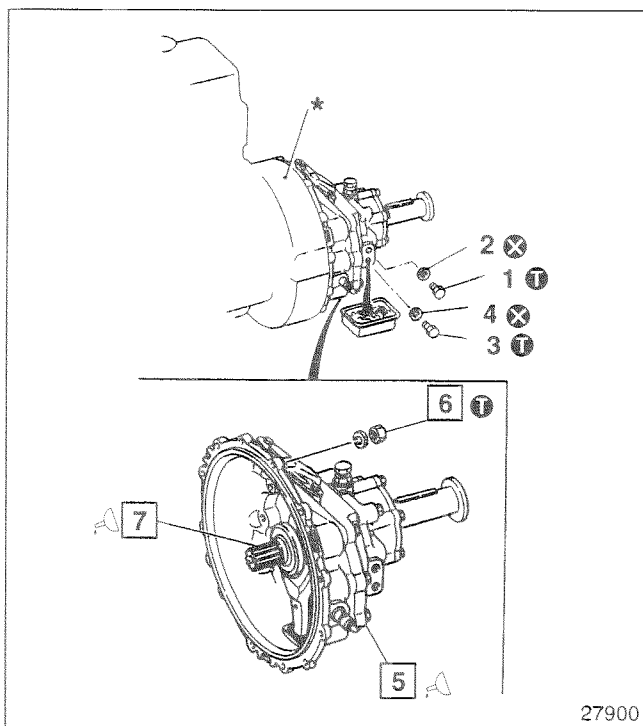
8 Installation of oil seal

Face oil seal 8 as shown and fit it into bearing case 9.

A: Press

C: Oil Seal Installer

BEARING CASE <PC2: LATERAL TRANSMISSION TYPE>



● Removal sequence

- 1 Inspection plug
- 2 Gasket
- 3 Drain plug
- 4 Gasket
- 5 Bearing case assembly
P21-40
- 6 Nut
- 7 Clutch shaft

*: Flywheel housing

⊗: Non-reusable part

● Installation sequence

Follow the removal sequence in reverse.

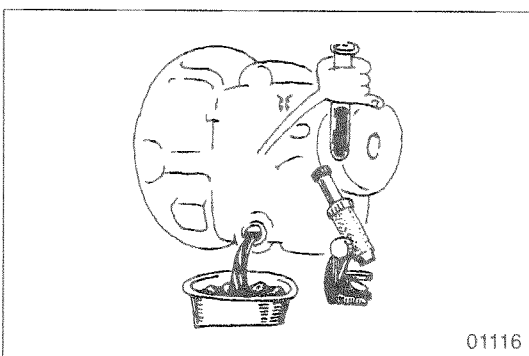
ⓘ Tightening torque

Unit: N·m (kgf·m)

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|--------------------------------------|-------------------|----------|
| 1 | Inspection plug | 97 {9.9} | — |
| 3 | Drain plug | 97 {9.9} | — |
| 6 | Nut (securing bearing case assembly) | A | 82 {8.4} |
| | | B | 40 {4.1} |
| | | C | 47 {4.8} |
| | | D | 47 {4.8} |

🔧 Lubricant

| Location | Points of application | specified lubricant | Quantity |
|----------|-----------------------|---|-------------|
| 7 | Clutch shaft splines | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |



◆ Service procedure

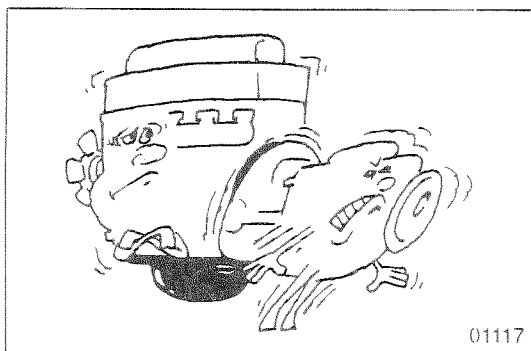
● Oil change

[Discharge]

- When discharging oil, check for quantity and quality of oil, and particularly for metal chips and powders.

[Pouring]

- Check that drain plug 3 has been tightened to specification on the flywheel housing.
- Through the inspection port, pour oil until it overflows. (See specifications for the quantity of oil.)



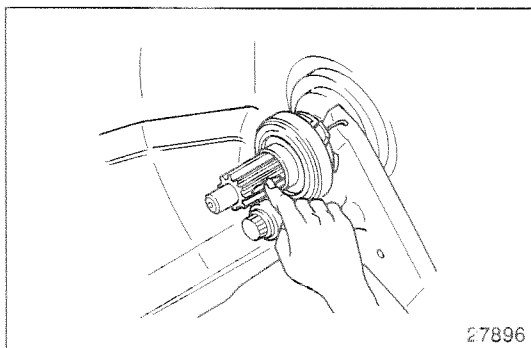
5 Bearing case assembly

[Removal]

Move bearing case assembly 5 straight to the rear until the clutch shaft splines come off the clutch.

CAUTION

Be sure to pull bearing case assembly 5 straight out. Rocking it hard could damage the splines between the clutch shaft and clutch.

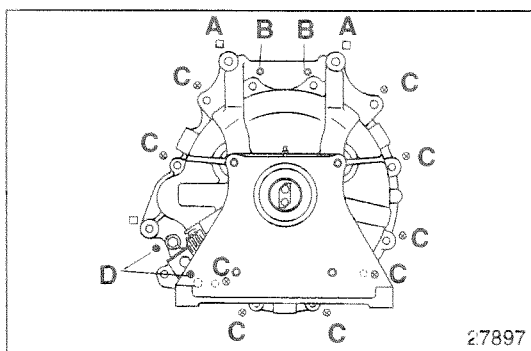


[Installation]

- Check the clutch shaft splines for rust.
- If rust gathers on the clutch shaft, remove it using a wire brush.
- Rub the surfaces of the clutch shaft, over which the clutch disc slides, with grease.

CAUTION

Do not apply an excessive amount of grease, as a grease drop could cause the clutch to slip.



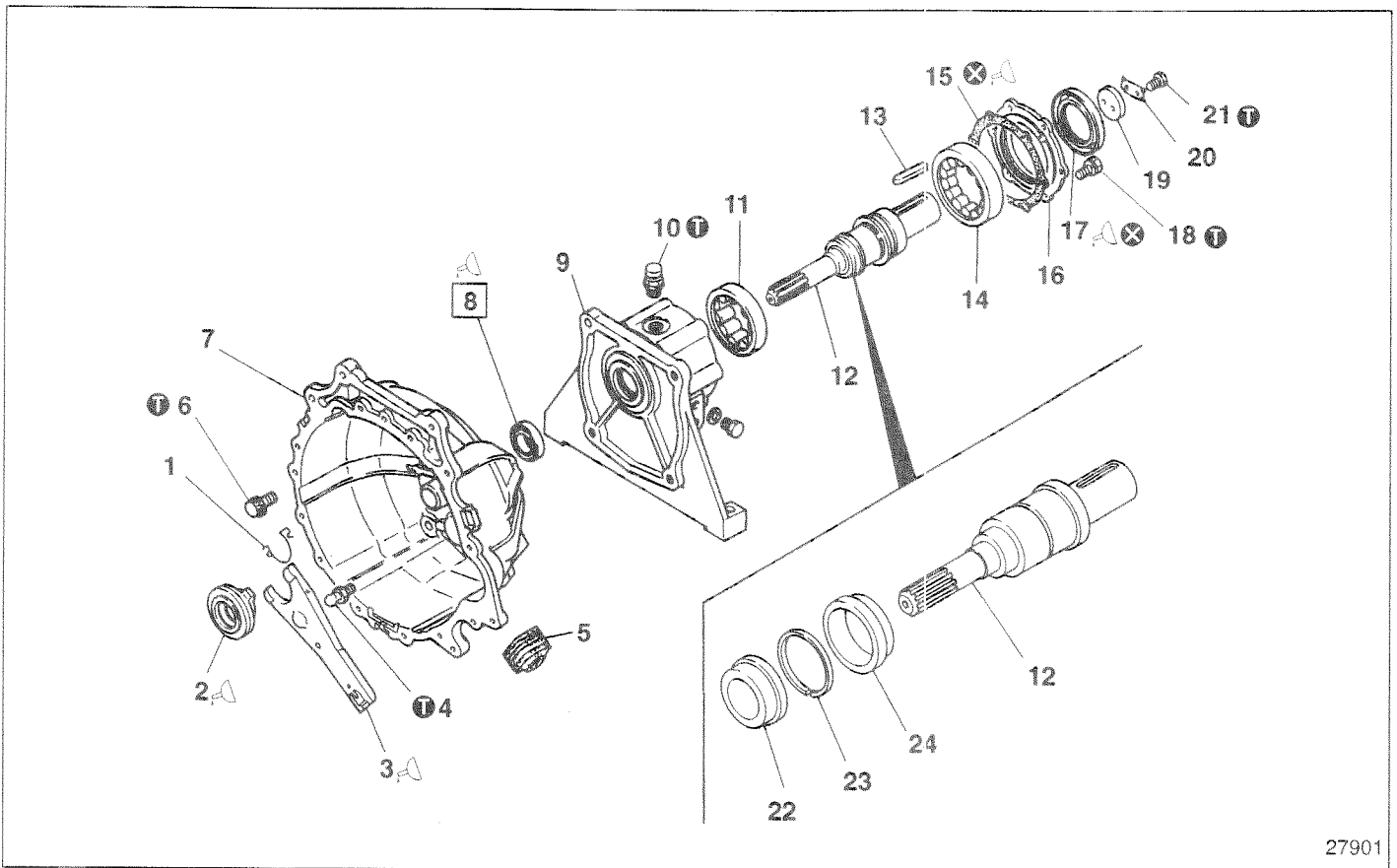
6 Installation of bearing case assembly

Mounting nuts of bearing case assembly 1 differ in tightening torque. Make sure that the nuts are tightened to a correct torque (refer to the figure at left for positions of each nut).

- A (2 places) : 82 N·m {8.4 kgf·m}
- B (2 places) : 40 N·m {4.1 kgf·m}
- C (9 places) : 47 N·m {4.8 kgf·m}
- D (2 places) : 47 N·m {4.8 kgf·m}

BEARING CASE <PC2: LATERAL TRANSMISSION TYPE>

Bearing Case Assembly



27901

● Disassembly sequence

- | | | |
|-----------------------------|---------------------------|---------------------------|
| 1 Return spring | 10 Air bleeder | 19 Lock plate |
| 2 Clutch release bearing | 11 Roller bearing (outer) | 20 Lock sheet |
| 3 Clutch release rocker arm | 12 Clutch shaft | 21 Bolt |
| 4 Rocker arm pivot | 13 Key | 22 Roller bearing (inner) |
| 5 Rocker arm cover | 14 Roller bearing (outer) | 23 Snap ring |
| 6 Bolt | 15 Gasket | 24 Roller bearing (inner) |
| 7 Clutch housing | 16 Rear cover | |
| 8 Oil seal | 17 Oil seal | ⊗: Non-reusable part |
| 9 Bearing case | 18 Bolt | |

CAUTION

Do not remove rocker arm pivot 4 and oil seal 8 unless defects are evident.

● Assembly sequence

Follow the disassembly sequence in reverse.

ⓘ Tightening torque

Unit: N · m {kgf · m}

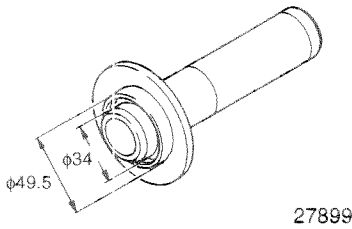
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|------------------------------|-------------------|---------|
| 4 | Rocker arm pivot | 57 {5.8} | — |
| 6 | Bolt (securing bearing case) | 115 {11.9} | — |
| 10 | Air bleeder | 8 {0.8} | — |
| 18 | Bolt (securing rear cover) | 17 {1.7} | — |
| 21 | Bolt (securing lock sheet) | 17 {1.7} | — |

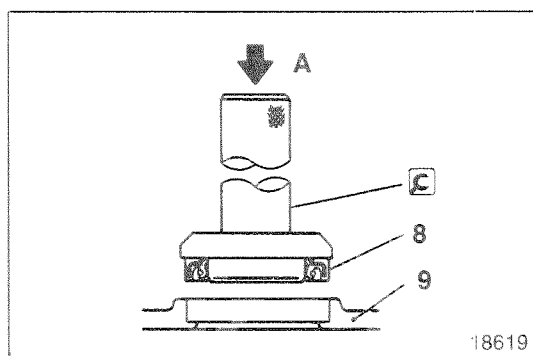
🔧 Lubricant and/or sealant

| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|---------------------------------|--|-------------|
| 2 | Pack clutch shifter | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 3 | Clutch release locker arm | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 8, 17 | Coat oil seal lip inner surface | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 15 | To both sides of gasket | THREE BOND 1104J | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|----------|---------------------------------------|
| 8 | Oil Seal Installer  | MH061302 | Driving of oil seal into bearing case |



◆ Service procedure

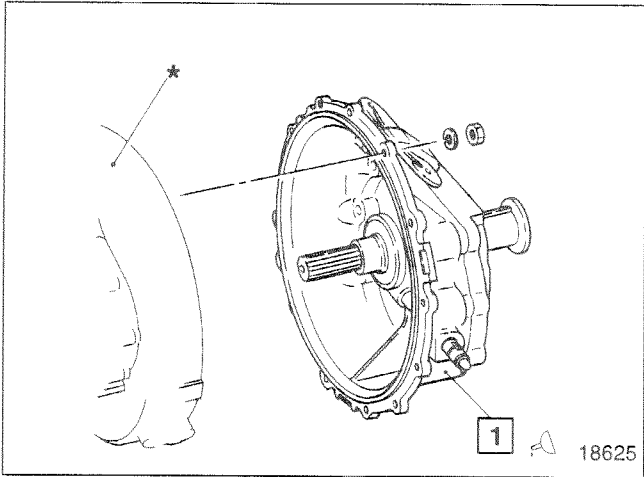
8 Installation of oil seal

Face oil seal 8 as shown and fit it into bearing case 9.

A : Press

C : Oil Seal Installer

BEARING CASE <PC4: DIRECT COUPLING TYPE>



● Removal sequence

1 Bearing case assembly P21-40

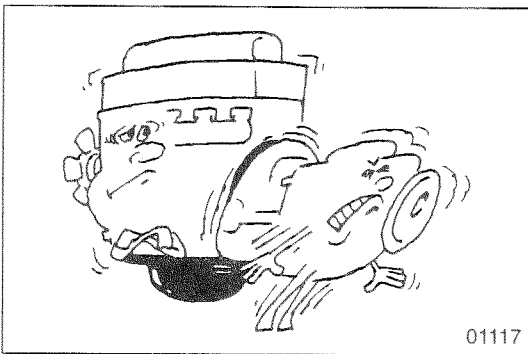
*: Flywheel housing Gr11

● Installation sequence

Follow the removal sequence in reverse.

Lubricants

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---|-------------|
| 1 | Clutch shaft splines | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |



◆ Service procedure

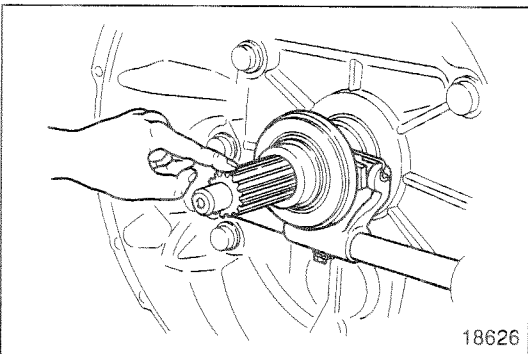
1 Bearing case assembly

[Removal]

Move bearing case assembly 1 straight to the rear until the clutch shaft splines come off the clutch.

CAUTION

Be sure to pull bearing case assembly 1 straight out. Rocking it hard could damage the splines between the clutch shaft and clutch.



[Installation]

- Check the drive pinion splines for rust.
- If rust gathers on the drive pinion, remove it using a wire brush.
- Rub the surfaces of the drive pinion, over which the clutch disc slides, with grease.

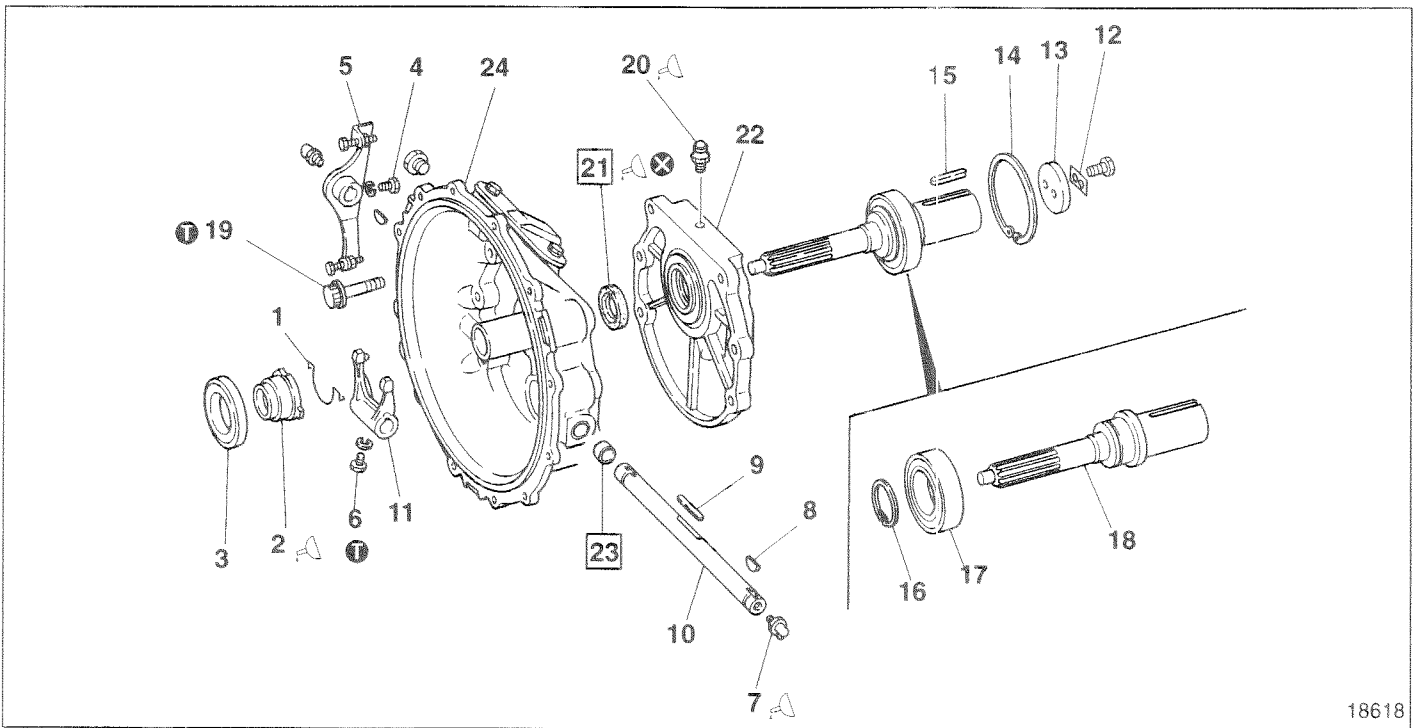
CAUTION

Do not apply an excessive amount of grease, as a grease drop could cause the clutch to slip.

MEMO

BEARING CASE <PC4: DIRECT COUPLING TYPE>

Bearing Case Assembly



18618

● Disassembly sequence

- | | | |
|-------------------|-----------------------|--------------------------|
| 1 Return spring | 10 Release fork shaft | 19 Bolt |
| 2 Clutch shifter | 11 Release fork | 20 Grease nipple |
| 3 Release bearing | 12 Lock sheet | 21 Oil seal |
| 4 Set screw | 13 Lock plate | 22 Bearing case |
| 5 Stopper | 14 Snap ring | 23 Needle roller bearing |
| 6 Set screw | 15 Key | 24 Clutch housing |
| 7 Grease nipple | 16 Snap ring | |
| 8 Key | 17 Roller bearing | ⊗: Non-reusable part |
| 9 Key | 18 Clutch shaft | |

CAUTION

Do not remove release bearing 3 and needle roller bearing 23 unless defects are evident.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Use care not to apply an excessive amount of grease through grease nipple 7. Excess grease could result in a slipping clutch.

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|--|---|-------|---------|
| 10, 23 | Clearance between release fork shaft and needle roller bearing | [23] 0.03 to 0.08 | 0.12 | Replace |

① Tightening torque

Unit: N·m {kgf·m}

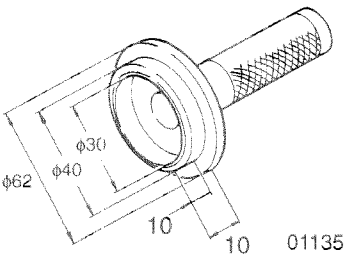
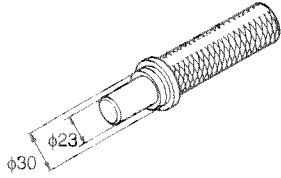
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------------------|-------------------|---------|
| 6 | Set screw (securing release fork) | 17 {1.7} | — |
| 19 | Bolt (securing bearing case) | 140 {14.2} | — |

🔊 Lubricant

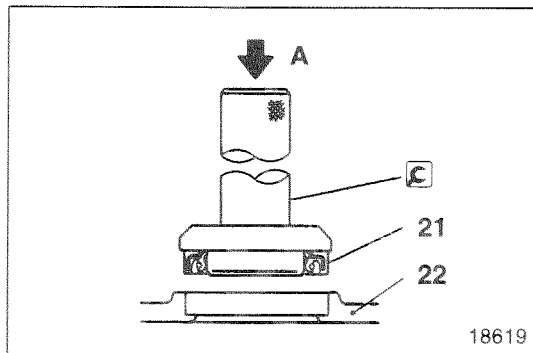
| Location | Points of application | Specified lubricant | Quantity |
|----------|---------------------------------|--|-------------|
| 2 | Pack clutch shifter. | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 7 | Through grease nipple | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 20 | Through grease nipple | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 21 | Coat oil seal lip inner surface | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application |
|----------|--|-------------|--|
| 21 | Oil Seal Installer  | ME624241 | Driving of oil seal into bearing case |
| 23 | Needle Roller Bearing Installer  | 03726-83000 | Press-fitting of needle roller bearing |

BEARING CASE <PC4: DIRECT COUPLING TYPE>



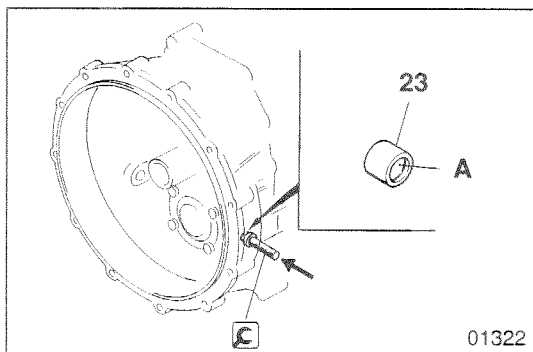
◆ Service procedure

21 Installation of oil seal

Face oil seal 21 as shown and fit it into bearing case 22.

A: Press

C: Oil Seal Installer



23 Installation of needle roller bearing

Mount needle roller bearing 23 with yellow seal end A facing outside.

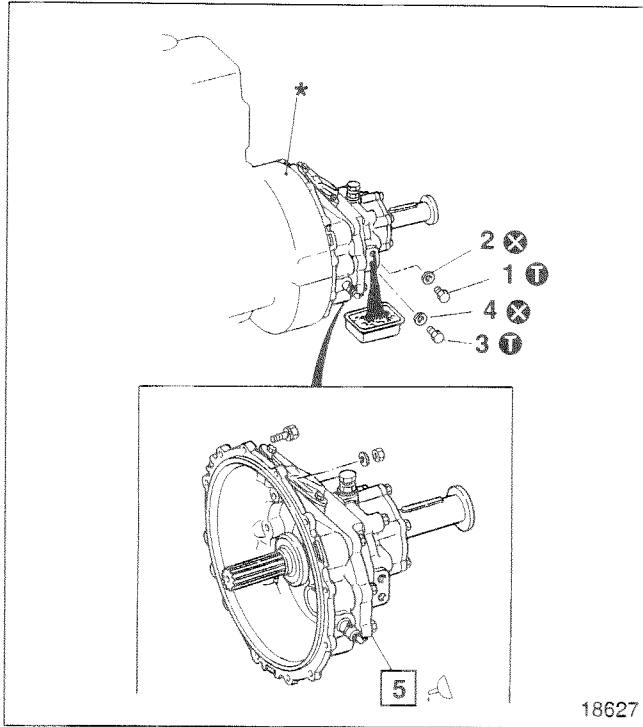
CAUTION ⚠

Do not directly hammer needle roller bearing 23 at installation.

C: Needle Roller Bearing Installer

MEMO

BEARING CASE <PC4: LATERAL TRANSMISSION TYPE>



● Removal sequence

- 1 Inspection plug
 - 2 Gasket
 - 3 Drain plug
 - 4 Gasket
 - 5 Bearing case assembly
- 📖 P21-46

- *: Flywheel housing
 ⊗: Non-reusable part

● Installation sequence

Follow the removal sequence in reverse.

ⓘ Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|-------------------|---------|
| 1 | Inspection plug | 49 {5} | — |
| 3 | Drain plug | 49 {5} | — |

🔊 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|---|-------------|
| 5 | Clutch shaft splines | Molybdenum disulfide grease [NLGI No. 2 (Li soap)] | As required |

◆ Service procedure

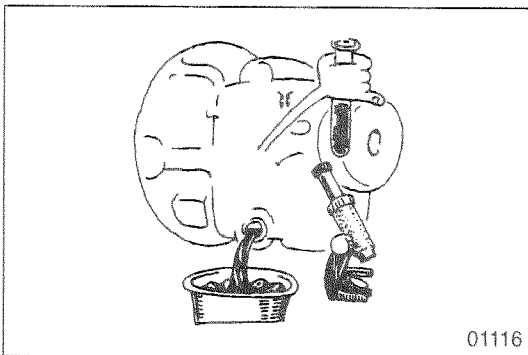
● Oil change

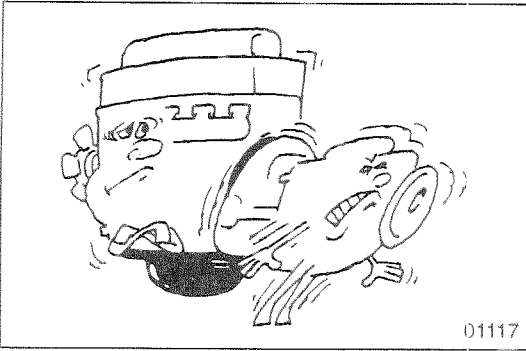
[Discharge]

- When discharging oil, check for quantity and quality of oil, and particularly for metal chips and powders.

[Pouring]

- Check that drain plug 3 has been tightened to specification on the flywheel housing.
- Through the inspection port, pour oil until it overflows. (See specifications for the quantity of oil.)





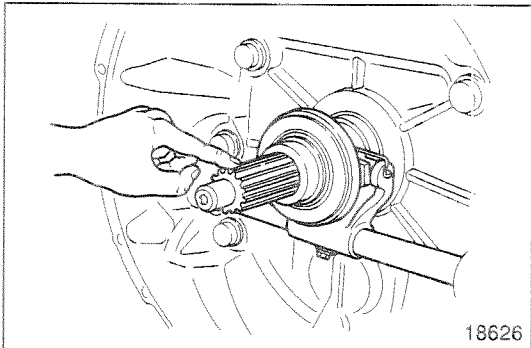
5 Bearing case assembly

[Removal]

Move bearing case assembly 5 straight to the rear until the clutch shaft splines come off the clutch.

CAUTION

Be sure to pull bearing case assembly 5 straight out. Rocking it hard could damage the splines between the clutch shaft and clutch.



[Installation]

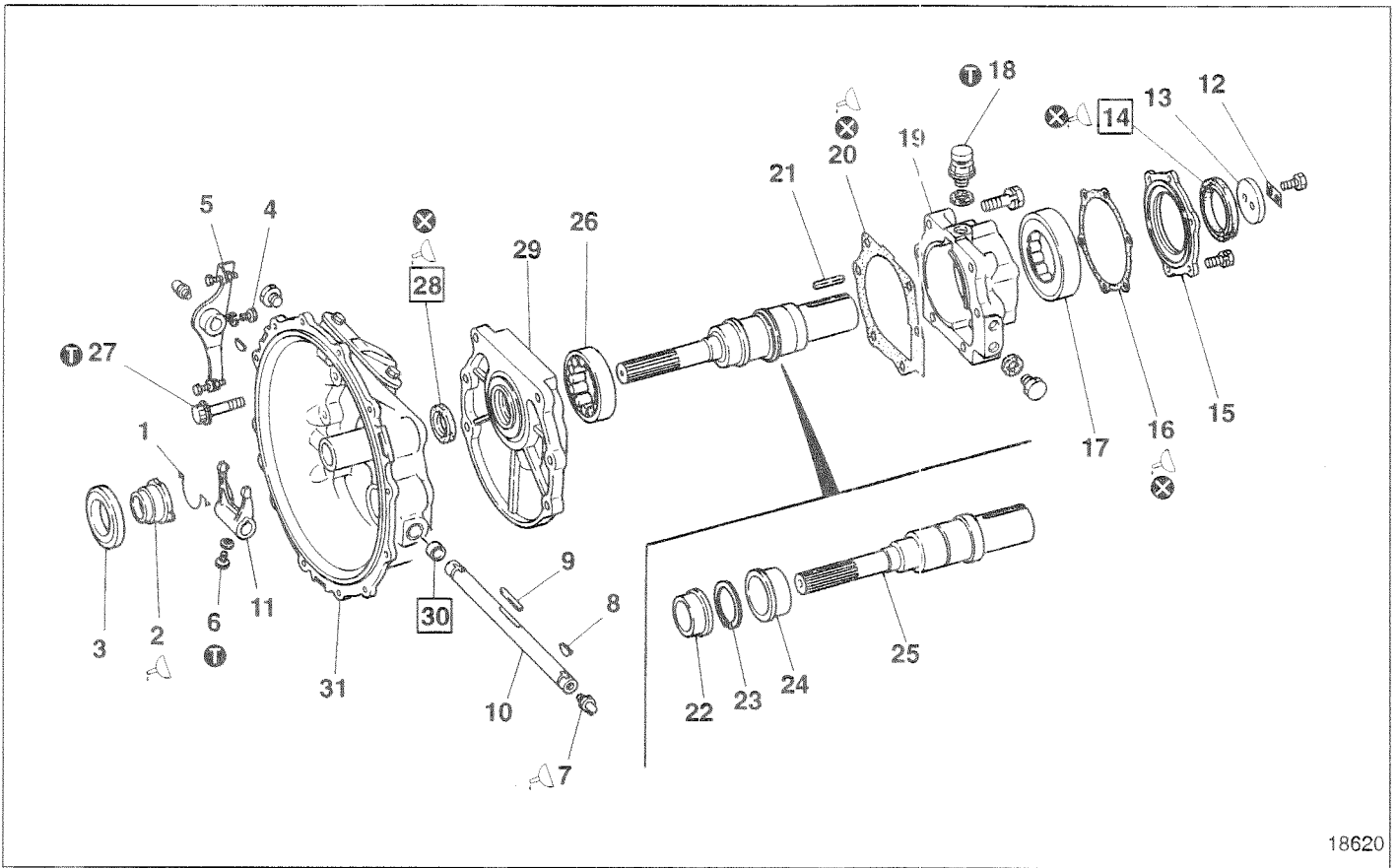
- Check the clutch shaft splines for rust.
- If rust gathers on the clutch shaft, remove it using a wire brush.
- Rub the surfaces of the clutch shaft, over which the clutch disc slides, with grease.

CAUTION

Do not apply an excessive amount of grease, as a grease drop could cause the clutch to slip.

BEARING CASE <PC4: LATERAL TRANSMISSION TYPE>

Bearing Case Assembly



18620

● Disassembly sequence

- | | | |
|-----------------------|---------------------------|---------------------------|
| 1 Return spring | 12 Lock sheet | 23 Snap ring |
| 2 Clutch shifter | 13 Lock plate | 24 Roller bearing (inner) |
| 3 Release bearing | 14 Oil seal | 25 Clutch shaft |
| 4 Set screw | 15 Rear cover | 26 Roller bearing (outer) |
| 5 Stopper | 16 Gasket | 27 Bolt |
| 6 Set screw | 17 Roller bearing (outer) | 28 Oil seal |
| 7 Grease nipple | 18 Oil filler plug | 29 Bearing case A |
| 8 Key | 19 Bearing case B | 30 Needle roller bearing |
| 9 Key | 20 Gasket | 31 Clutch housing |
| 10 Release fork shaft | 21 Key | |
| 11 Release fork | 22 Roller bearing (inner) | |

⊗: Non-reusable part

CAUTION

Do not remove release bearing 3 and needle roller bearing 30 unless defects are evident.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

Use care not to apply an excessive amount of grease through grease nipple 7. Excess grease could result in a slipping clutch.

Service standards

Unit: mm

| Location | Maintenance item | Standard value (Basic diameter in []) | Limit | Remedy |
|----------|--|---|-------|---------|
| 10, 30 | Clearance between release fork shaft and needle roller bearing | [23] 0.03 to 0.08 | 0.12 | Replace |

① Tightening torque

Unit: N·m {kgf·m}

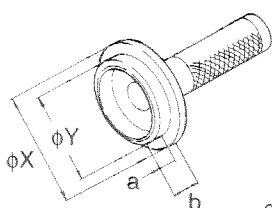
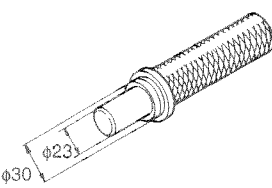
| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------------------|-------------------|---------|
| 6 | Set screw (securing release fork) | 17 (1.7) | — |
| 27 | Bolt (securing bearing case A) | 140 (14.2) | — |

🔧 Lubricant and/or sealant

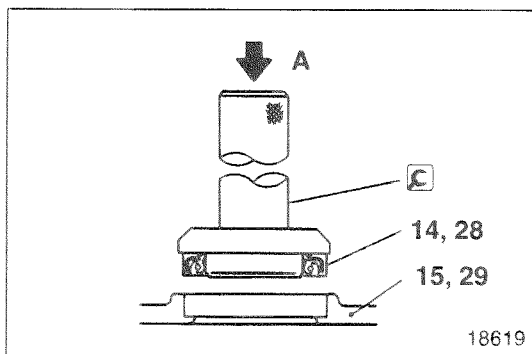
| Location | Points of application | Specified lubricant and/or sealant | Quantity |
|----------|---------------------------------|--|-------------|
| 2 | Pack clutch shifter | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 7 | Through grease nipple | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 14, 28 | Coat oil seal lip inner surface | Wheel bearing grease [NLGI No. 2 (Li soap)] | As required |
| 16, 20 | To both sides of gasket | THREE BOND 1102C | As required |

🔧 Special tools

Unit: mm

| Location | Tool name and shape | Part No. | Application | | | | | | | | | | | | | | | |
|----------|---|-------------|---|----------|---|-----|----|---|----|----|---|----|----|---|----|----|-------------|-------------------------------------|
| 14, 28 | Oil Seal Installer <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td></td> <td>44590-40100</td> <td>ME624241</td> </tr> <tr> <td>X</td> <td>106</td> <td>62</td> </tr> <tr> <td>Y</td> <td>80</td> <td>40</td> </tr> <tr> <td>a</td> <td>14</td> <td>10</td> </tr> <tr> <td>b</td> <td>24</td> <td>20</td> </tr> </table>  | | 44590-40100 | ME624241 | X | 106 | 62 | Y | 80 | 40 | a | 14 | 10 | b | 24 | 20 | 44590-40100 | Driving of oil seal into rear cover |
| | | 44590-40100 | ME624241 | | | | | | | | | | | | | | | |
| X | 106 | 62 | | | | | | | | | | | | | | | | |
| Y | 80 | 40 | | | | | | | | | | | | | | | | |
| a | 14 | 10 | | | | | | | | | | | | | | | | |
| b | 24 | 20 | | | | | | | | | | | | | | | | |
| | | ME624241 | Driving of oil seal into bearing case A | | | | | | | | | | | | | | | |
| 30 | Needle Roller Bearing Installer  | 03726-83000 | Press-fitting of needle roller bearing | | | | | | | | | | | | | | | |

BEARING CASE <PC4: LATERAL TRANSMISSION TYPE>



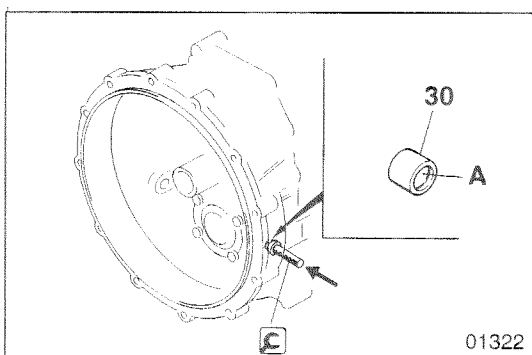
◆ Service procedure

14 28 Installation of oil seal

Face oil seals 14 and 28 as shown and fit them into rear cover 15 and bearing case A 29, respectively.

A: Press

E: Oil Seal Installer



30 Installation of needle roller bearing

Mount needle roller bearing 30 with yellow seal end A facing outside.

CAUTION ⚠

Do not directly hammer needle roller bearing 30 at installation.

E: Needle Roller Bearing Installer

GROUP 54 ELECTRICAL SYSTEM

| | |
|---|-------|
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| ALTERNATOR | |
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| PREHEATER CIRCUIT | 54-93 |
| ENGINE STARTER CIRCUIT | 54-95 |
| AUTOMATIC STOP SYSTEM <SHUTDOWN> | 54-96 |

SPECIFICATIONS

Alternator

| | | | | | | |
|--------------|------------------------------------|----------|----------|---------------------------|----------|----------|
| Manufacturer | MITSUBISHI ELECTRIC CORP. | | | | | |
| Type | Alternator with built-in regulator | | | | | |
| | With brush | | | | | |
| | Fan externally mounted type | | | Fan internal contact type | | |
| Model | A5T70383 | A5T70483 | A2T72999 | A2T72985 | A3TN5399 | A3TN5188 |
| Output | 24V-25A | | 24V-30A | | 24V-35A | |

| | | | | | | | |
|--------------|------------------------------------|-----------------------------|----------|----------|----------|-----------|----------|
| Manufacturer | MITSUBISHI ELECTRIC CORP. | | | | | | |
| Type | Alternator with built-in regulator | | | | | | |
| | With brush | | | | | Brushless | |
| | Fan internal contact type | Fan externally mounted type | | | | | |
| Model | A3TN5288 | A4T57985 | A5T23083 | A4T66083 | A4T66085 | A6T76099 | A4T25699 |
| Output | 24V-40A | | 12V-50A | 24V-50A | | 24V-80A | 12V-80A |

Starter

| | | | | | | | | | |
|---------------------------------|---------------------------|-------------|----------|----------|------------|-------------|----------|----------|----------|
| Manufacturer | MITSUBISHI ELECTRIC CORP. | | | | | | | | |
| Model | M2T54272 | M2T64272 | M2T67881 | M8T80171 | M3T90273 | M2T78381 | M3T57575 | M8T60271 | M8T87171 |
| Output | 12V-2kW | 24V-3.2kW | | | 12V-3.5kW | 24V-5kW | | | |
| Magnet switch operating voltage | 8V or less | 16V or less | | | 8V or less | 16V or less | | | |

Starter Relay

| | | |
|----------------------------|----------|------------|
| Model | U1T35182 | |
| Exciting current | V-A | 24-2.3 |
| Closed magnetic voltage | V | 16 or less |
| Opened magnetic voltage | V | 4 or less |
| Allowable breaking voltage | A | 200 |

Heater Relay

| | | |
|-----------------|---------------------------|----------|
| Manufacturer | MITSUBISHI ELECTRIC CORP. | |
| Model | U1T04290 | U1T06672 |
| Voltage-Current | V-A | 24-2.3 |
| Fuse capacity | A | 127 |

Glow Plug

| | | |
|-----------------|---------------|------|
| Type | Sheathed type | |
| Voltage-Current | V-A | 23-3 |

Safety Relay

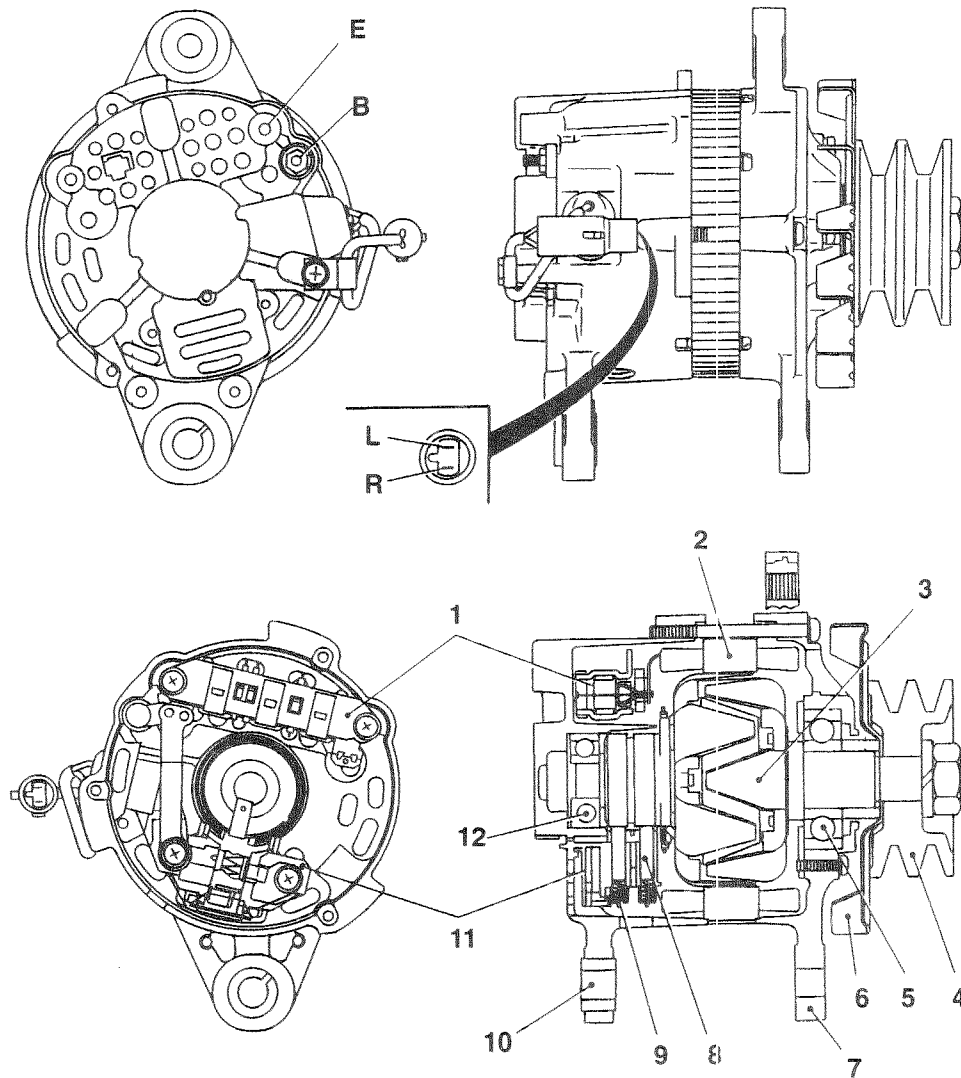
| | |
|-------|----------|
| Model | R8T30171 |
|-------|----------|

Solenoid Relay

| | |
|--------------|----------------|
| Manufacturer | NIKKO DENKI |
| Type | Shut-down type |
| Model | 0-25000-5592 |

STRUCTURE AND OPERATION

<24V-25A, 24V-30A, 24V-40A, 12V-50A> (Fan externally mounted type)



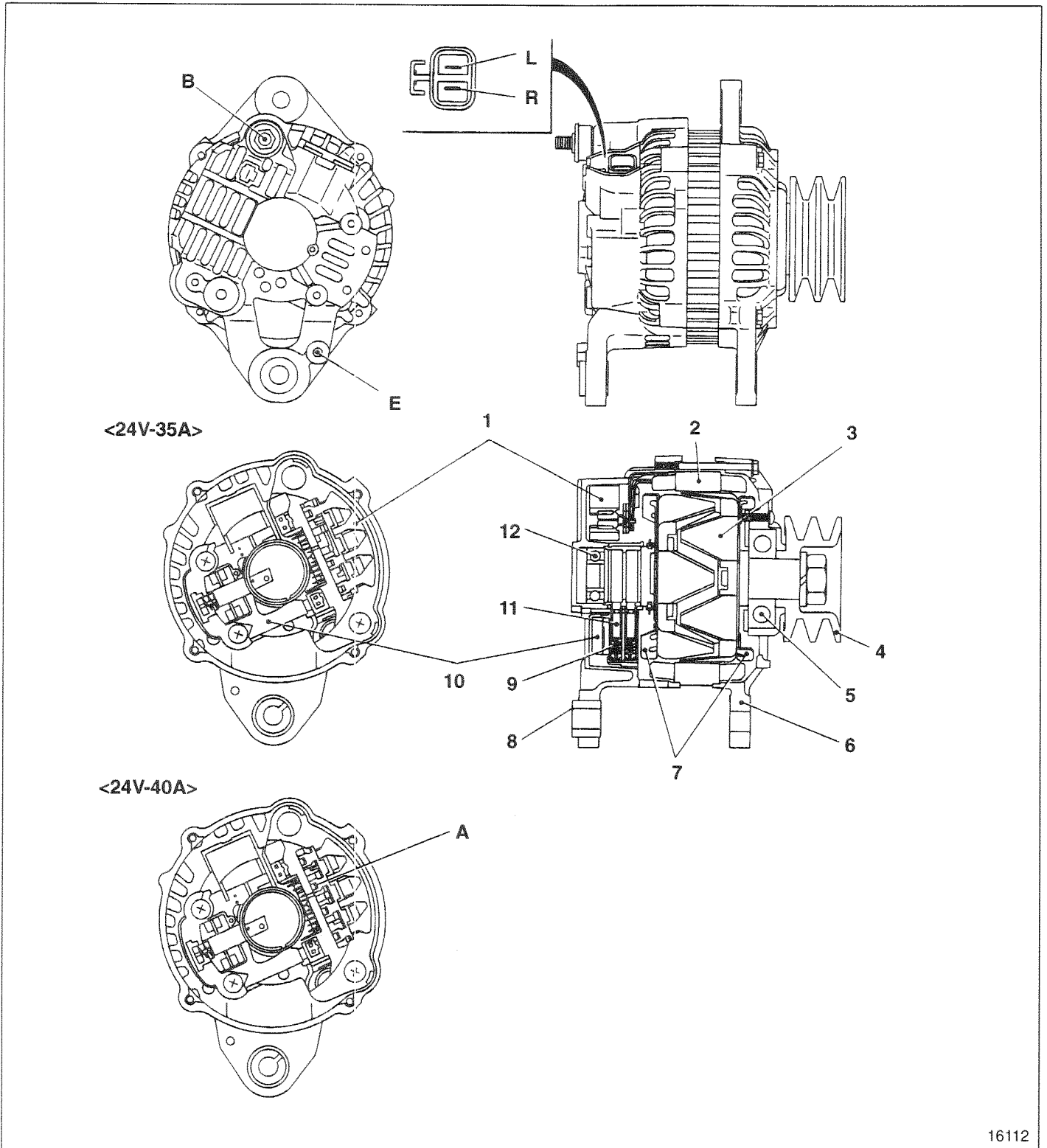
16743

- 1 Rectifier
- 2 Stator assembly
- 3 Rotor assembly
- 4 Pulley
- 5 Front bearing
- 6 Fan

- 7 Front bracket
- 8 Brush
- 9 Brush spring
- 10 Rear bracket
- 11 Regular & brush holder
- 12 Rear bearing

- B: Terminal B
- E: Terminal E
- L: Terminal L
- R: Terminal R

<24V-35A, 24V-40A> (Fan internal contact type)



- 1 Rectifier
- 2 Stator
- 3 Rotor assembly
- 4 Pulley
- 5 Front bearing
- 6 Front bracket

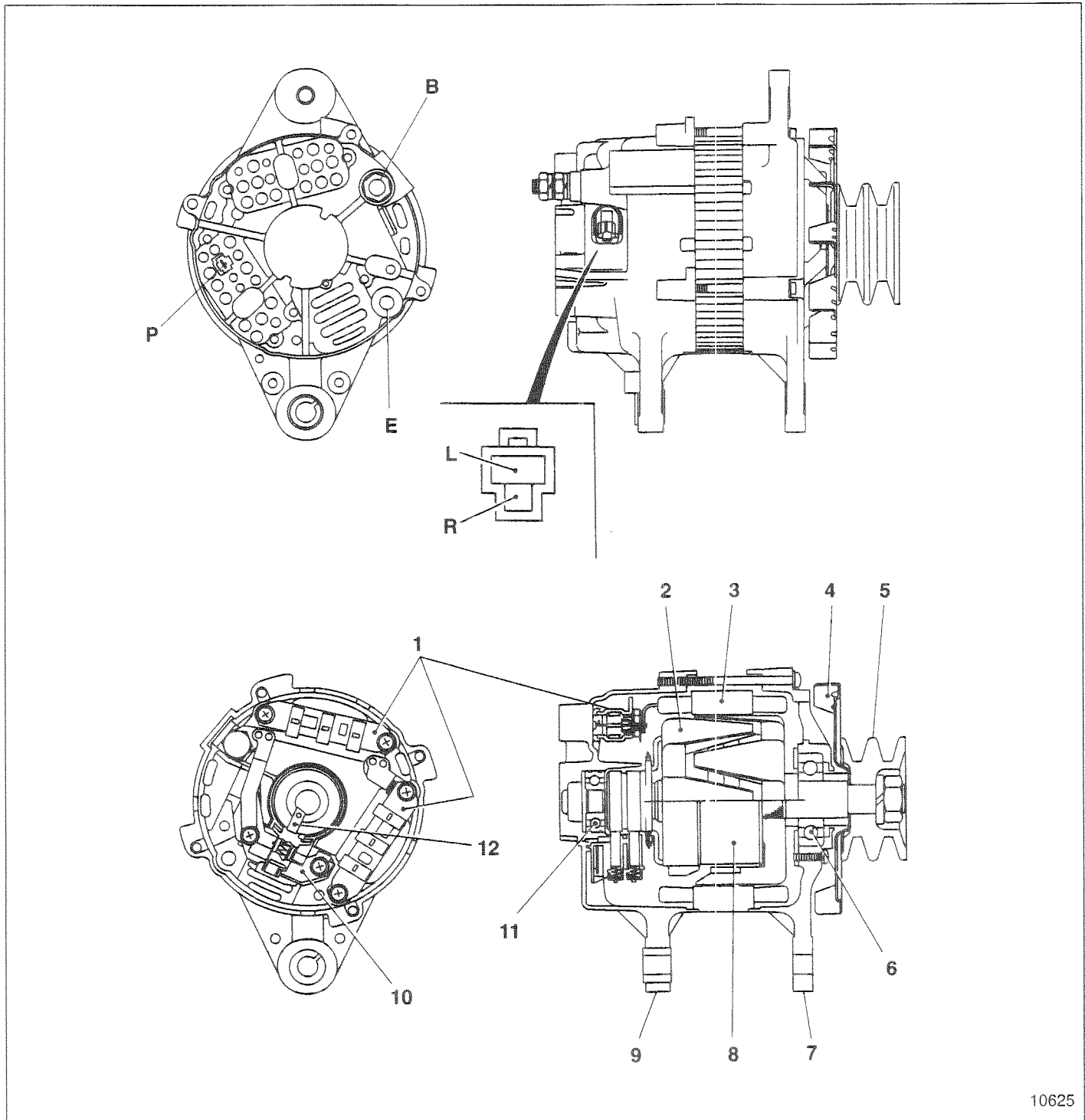
- 7 Fan
- 8 Rear bracket
- 9 Brush spring
- 10 Regulator & brush holder
- 11 Brush
- 12 Rear bearing

- A: Neutral point diode <24V-40A>
- B: Terminal B
- E: Terminal E
- L: Terminal L
- R: Terminal R

16112

STRUCTURE AND OPERATION

<24V-50A, 24V-80A>



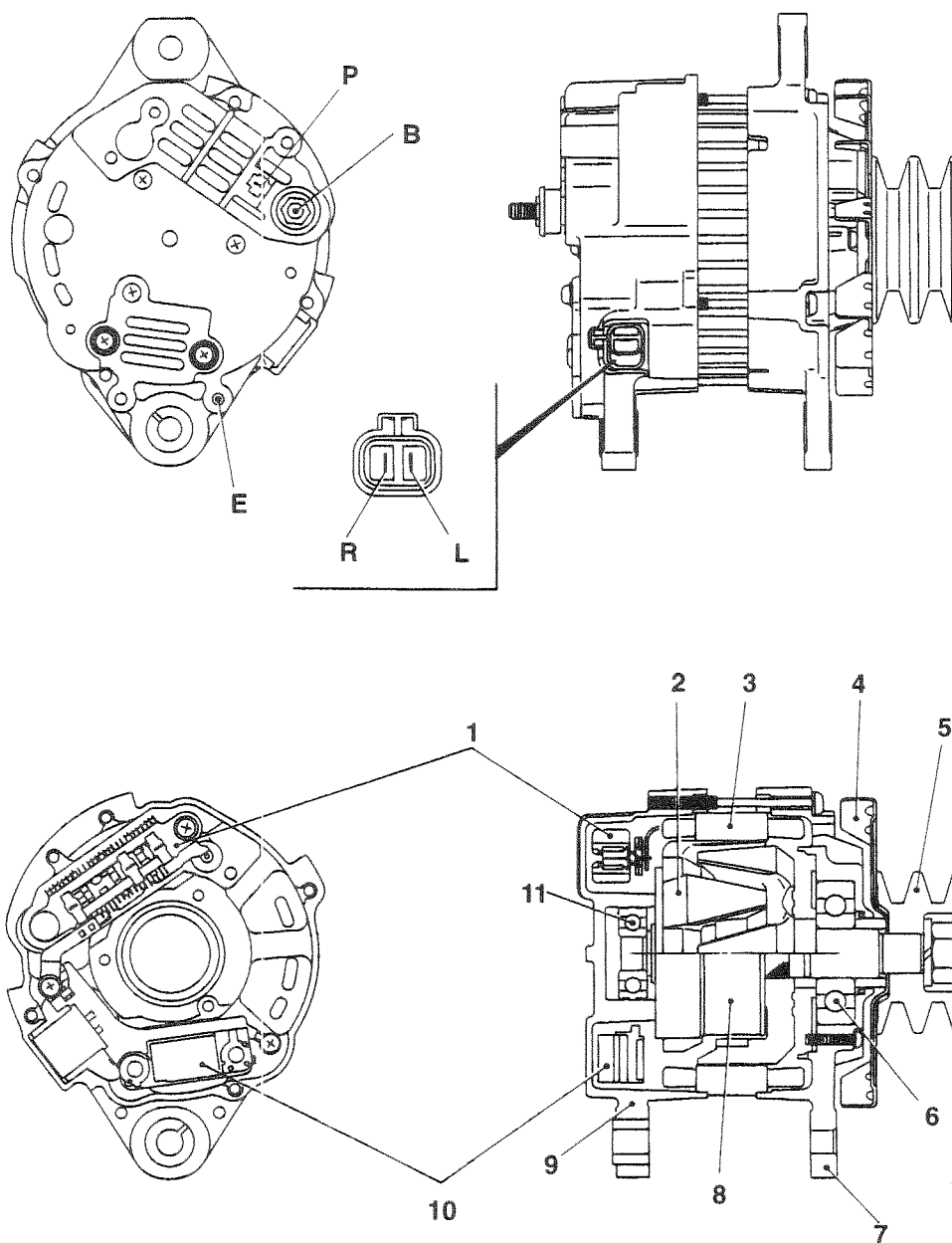
10625

- 1 Rectifier
- 2 Rotor assembly
- 3 Stator assembly
- 4 Fan
- 5 Pulley
- 6 Front bearing

- 7 Front bracket
- 8 Field coil
- 9 Rear bracket
- 10 Regulator
- 11 Rear bearing
- 12 Brush

- B: Terminal B
- E: Terminal E
- L: Terminal L
- P: Terminal P
- R: Terminal R

<12V-80A>



08644

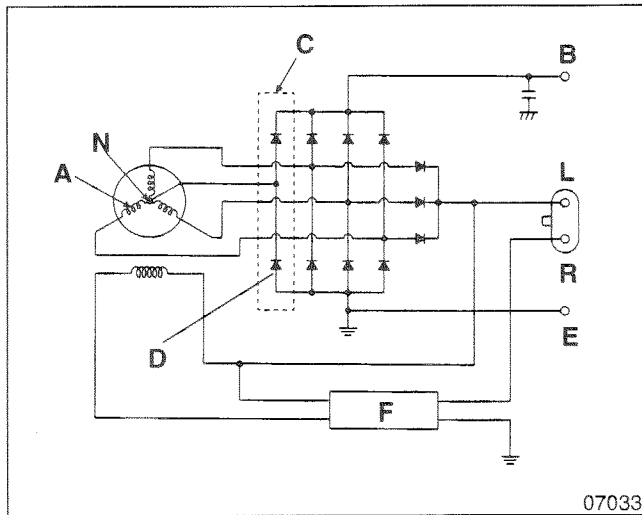
- 1 Rectifier
- 2 Rotor assembly
- 3 Stator assembly
- 4 Fan
- 5 Pulley
- 6 Front bearing

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- 8 Field coil
- 9 Rear bracket
- 10 Regulator
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- B: Terminal B
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STRUCTURE AND OPERATION

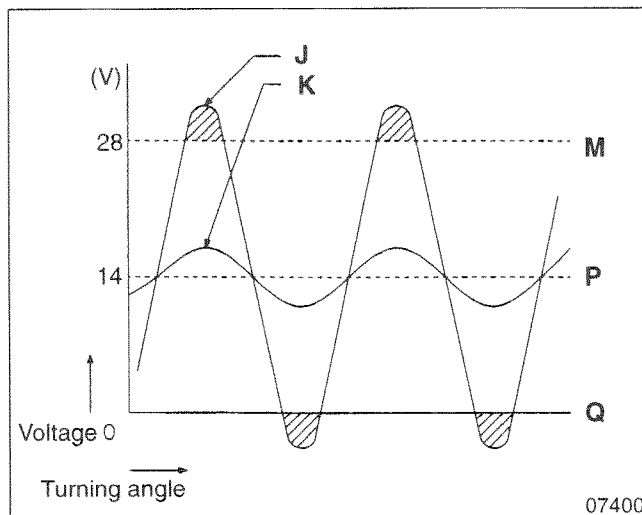
● Alternator with neutral point diode <24V-40A>



Features

- This alternator has neutral point diodes **C** and **D** added to the current alternator.
- Addition of these diodes **C** and **D** makes it possible to provide a higher DC output, when the alternator rotates at a high speed, than an alternator without neutral point diodes.

A: Stator coil
B: Alternator terminal B
E: Alternator terminal E
F: IC regulator
L: Alternator terminal L
N: Neutral point
R: Alternator terminal R



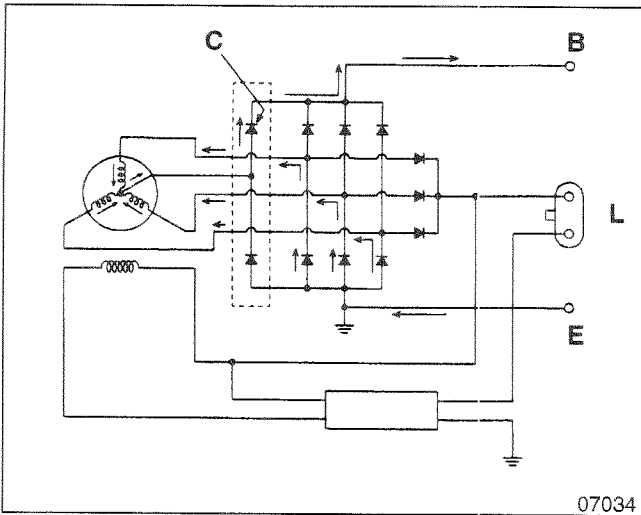
Variations in potential at neutral point, and operation of neutral point diode

- The potential at neutral point **N** varies up and down as shown with the neutral point DC voltage (one half (**P**) of the output voltage) as the center.
- When the alternator rotates at a high speed, the amount (/// portion) by which the voltage at neutral point **N** becomes larger than output voltage **M** (28 V) and the amount (/// portion) by which the voltage at neutral point **N** becomes smaller than ground potential **Q** (0 V), are taken out by neutral point diodes **C** and **D** to add them to the conventional DC output.

J: Neutral point voltage waveform during high-speed rotation
K: Neutral point voltage waveform during low-speed rotation
M: Output voltage
P: Mean voltage at neutral point (one half of output voltage)
Q: Ground potential

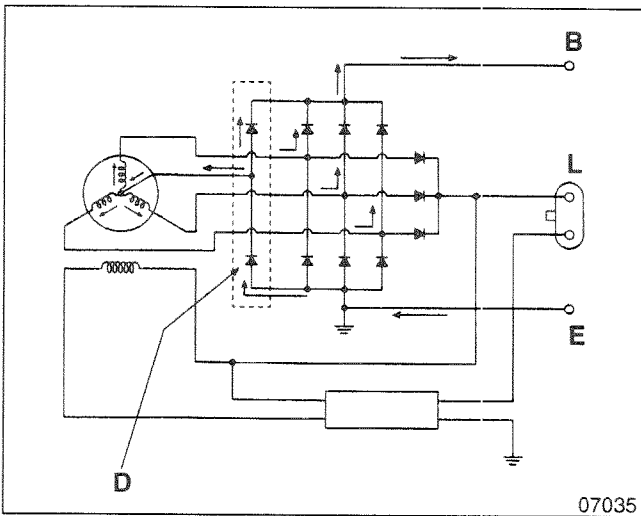
In each of the voltage and potential conditions, neutral point diodes **C** and **D** operate as described below.

- When the neutral point voltage is more than 0V and less than 28V, the six conventional diodes operate.



● When the neutral point voltage is more than 28V

Positive side diode **C** conducts to add to the conventional DC output, so a higher DC voltage is output to each equipment.

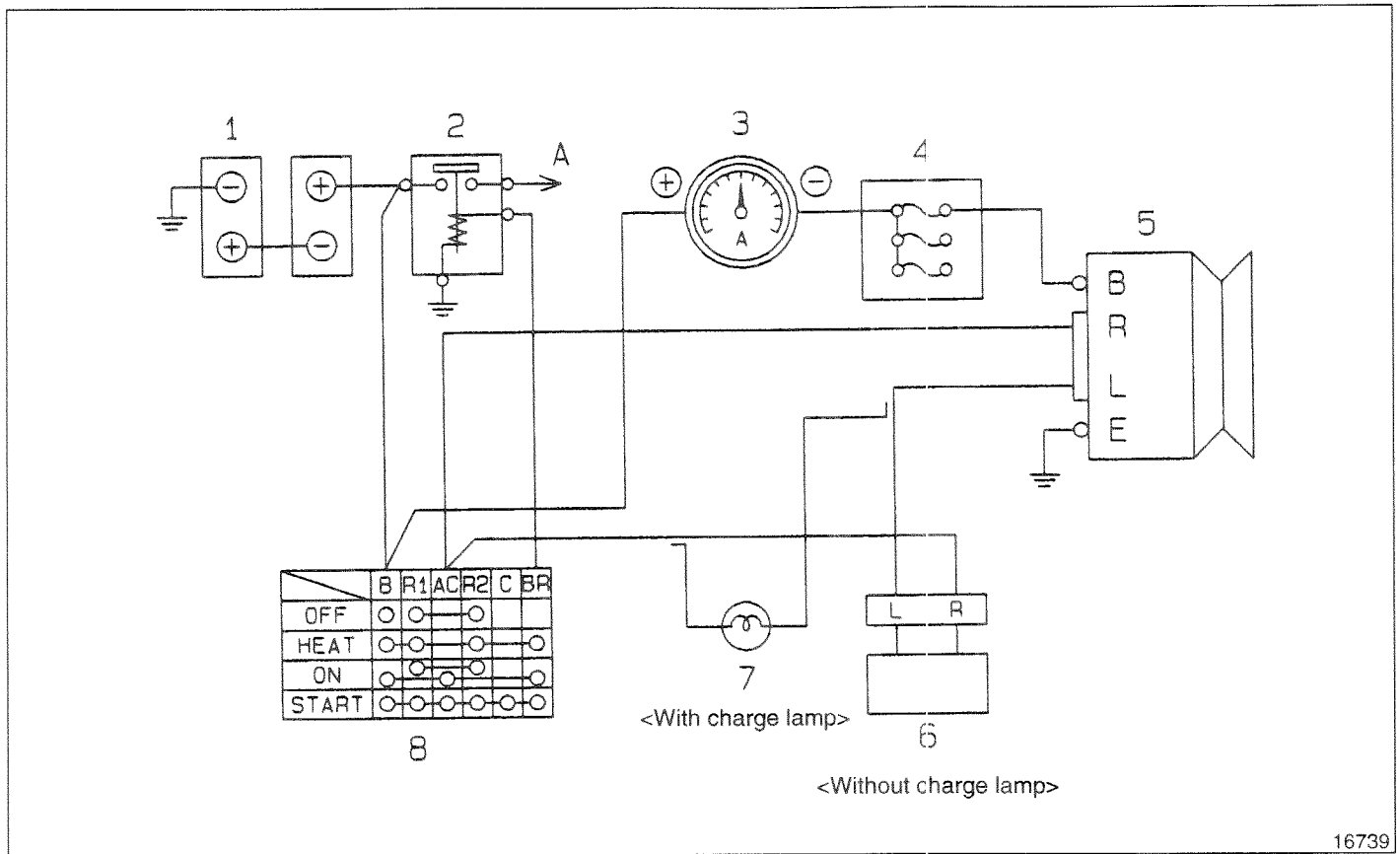


● When the neutral point voltage is less than 0V

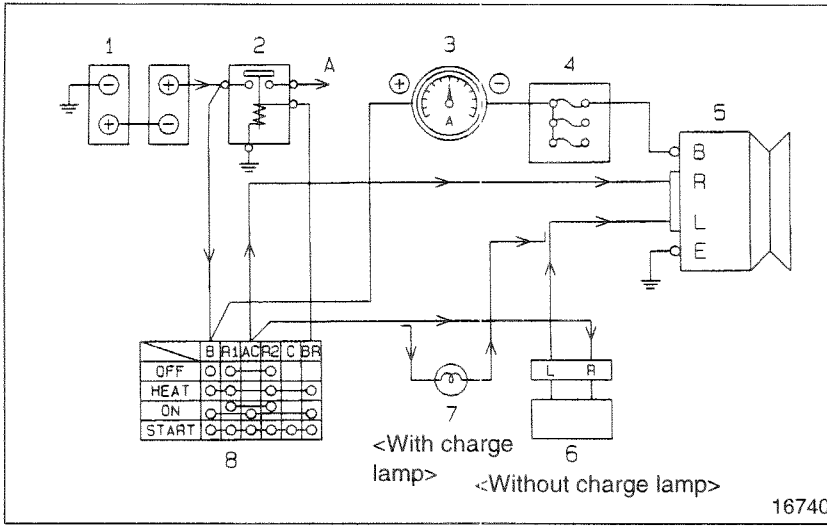
Negative side diode **D** conducts, and the neutral point output is supplied via the three conventional diodes.

STRUCTURE AND OPERATION

Charging Circuit



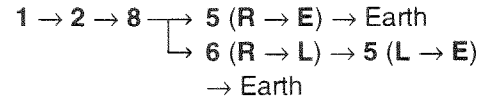
- | | |
|--|--------------------------------|
| 1 Battery | A: To starter relay terminal B |
| 2 Battery relay | B: Terminal B |
| 3 Ammeter | E: Terminal E |
| 4 Fuse box | L: Terminal L |
| 5 Alternator | R: Terminal R |
| 6 Safety relay <Circuit without charge lamp> | |
| 7 Charge lamp <Circuit with charge lamp> | |
| 8 Starter switch | |



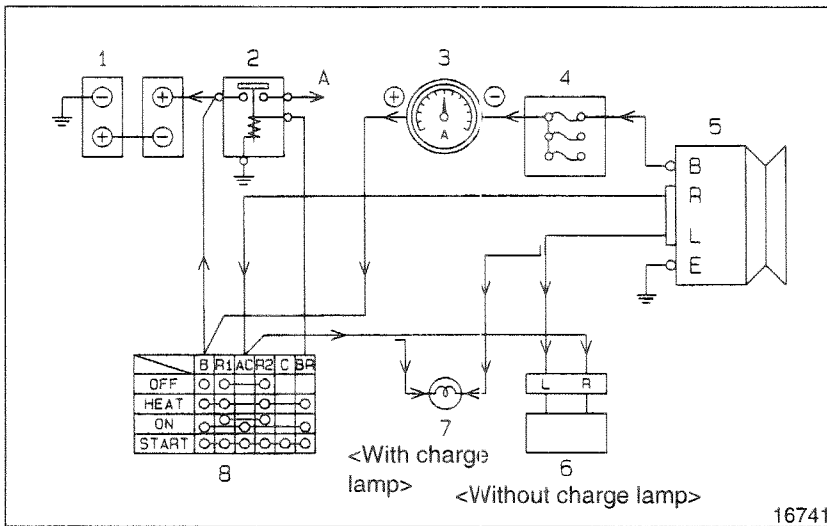
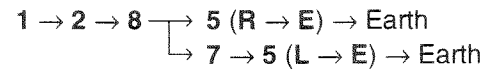
When engine is stationary

Position of starter switch **8**: ON

- To improve the performance of alternator **5** in starting power generation at a low speed immediately after the engine has been started, current is set flowing to terminal R.



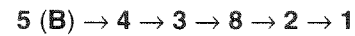
- In the circuit with **A** charge lamp **7**, current flows as shown below.



After engine has been started

Position of starter switch **8**: ON

- Alternator **5** starts generating power.
- The output voltage at terminal B of alternator **5** becomes higher than the voltage of battery **1**.
- Alternator **5** starts charging battery **1**.

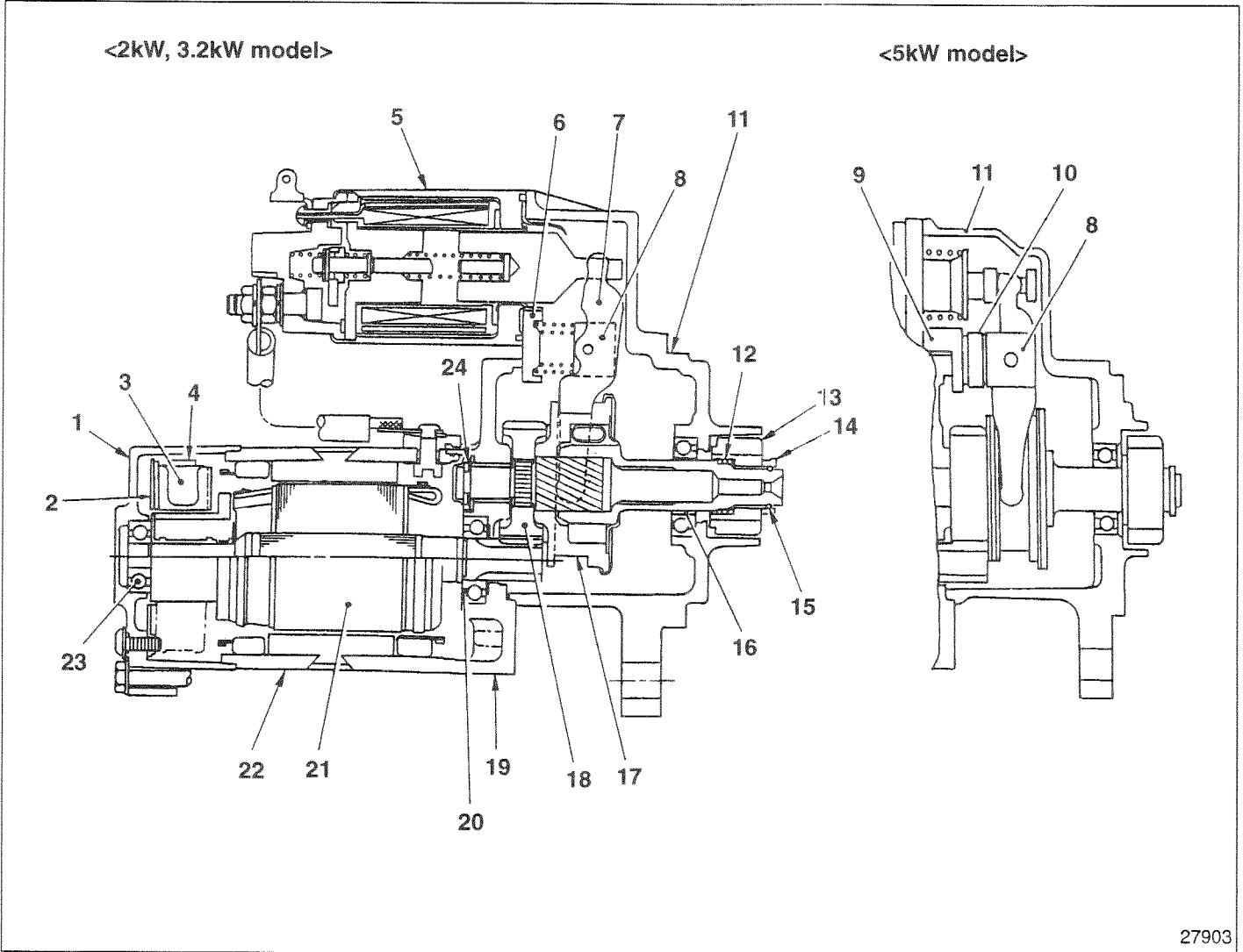


- In the case of the circuit with charge lamp **7**, the charge lamp goes out, as there is no potential difference between the voltage at terminal L of alternator **5** and the battery voltage.

STRUCTURE AND OPERATION

Starter

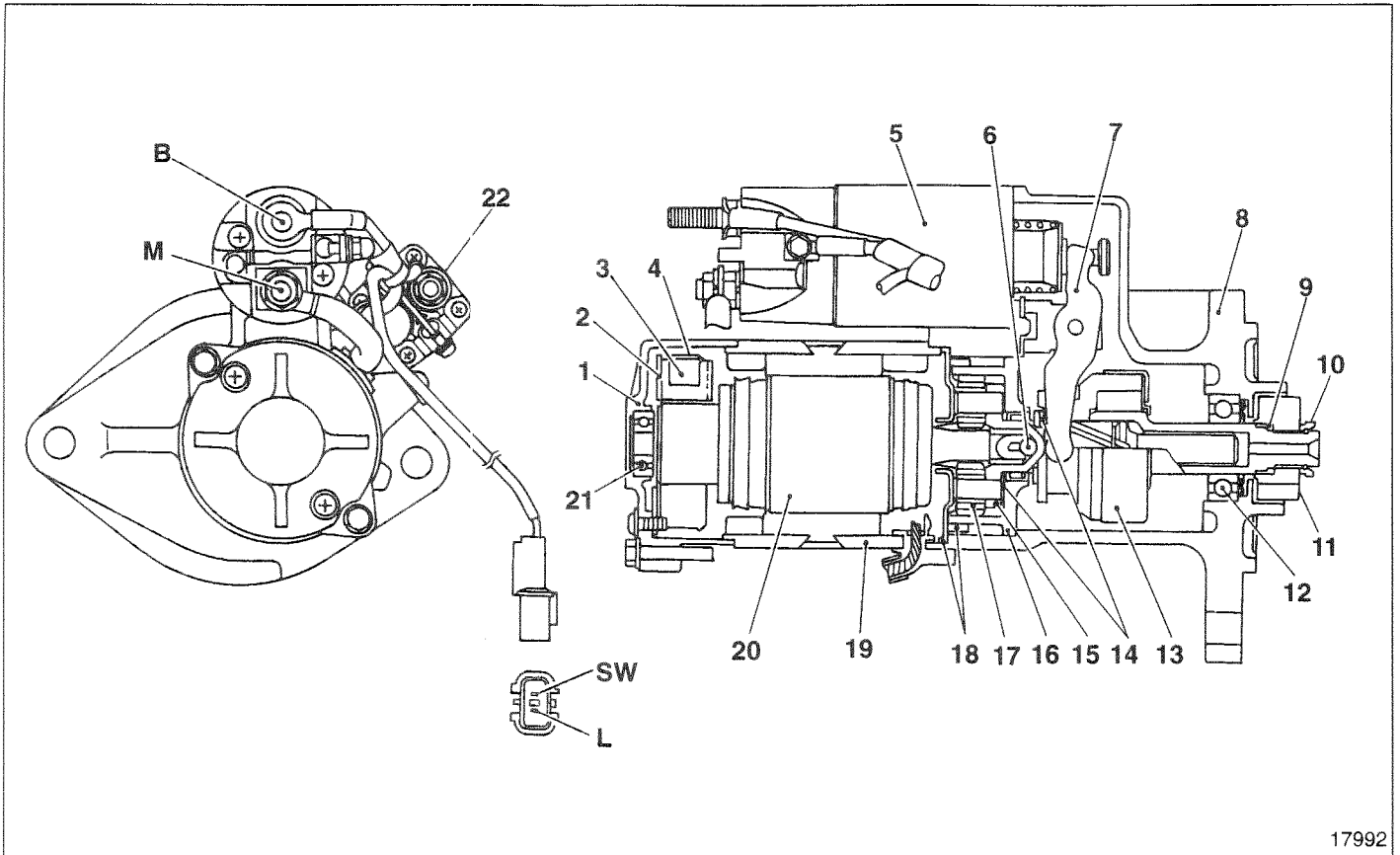
<M2T54272: 12V-2 kW, M2T64272: 24V-3.2 kW, M2T67881: 24V-3.2 kW,
M2T78381: 24V-5 kW, M3T57575: 24V-5 kW>



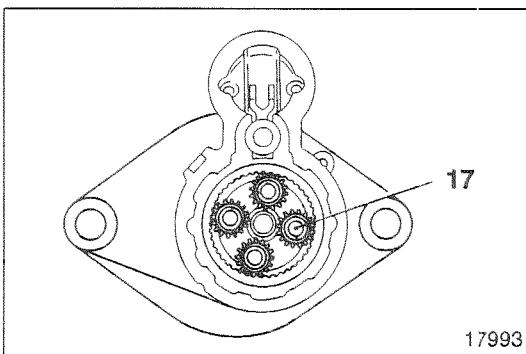
27903

- | | | |
|-------------------------|-------------------|--------------------------|
| 1 Rear bracket | 9 Packing | 17 Pinion shaft assembly |
| 2 Brush | 10 Shim <12V-5kW> | 18 Gear |
| 3 Brush spring | 11 Front bracket | 19 Center bracket |
| 4 Brush holder assembly | 12 Spring | 20 Front bearing |
| 5 Magnet switch | 13 Pinion | 21 Armature assembly |
| 6 Packing | 14 Pinion stopper | 22 Yoke assembly |
| 7 Lever | 15 Stopper ring | 23 Rear bearing |
| 8 Bushing | 16 Front bearing | 24 Cover |

<M8T80171: 24V-3.2 kW, M8T60271: 24V-5 kW, M8T87171: 24V-5 kW>



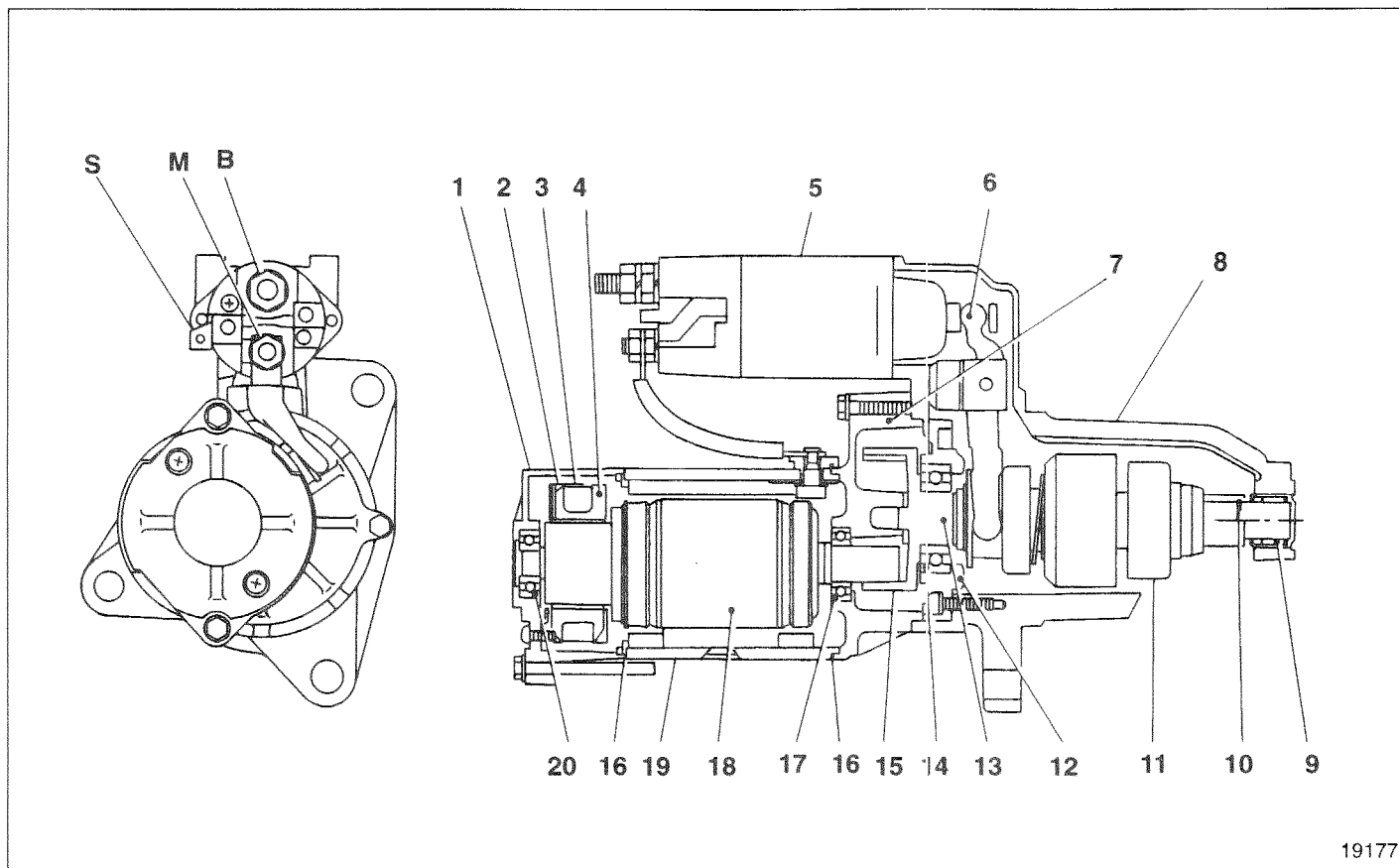
- | | | |
|-----------------|---------------------------|-----------------------|
| 1 Rear bracket | 10 Pinion stopper | 18 Packing |
| 2 Brush holder | 11 Pinion | 19 Yoke assembly |
| 3 Brush | 12 Front bearing | 20 Armature assembly |
| 4 Brush spring | 13 Overrunning clutch | 21 Rear bearing |
| 5 Magnet switch | 14 Washer | 22 Starter relay |
| 6 Ball | 15 Gearshaft assembly | |
| 7 Lever | 16 Internal gear assembly | B : Terminal B |
| 8 Front bracket | 17 Planetary gear | M : Terminal M |
| 9 Spring | | |



This starter uses planetary gear 17 in the reduction gear mechanism.

STRUCTURE AND OPERATION

<M3T90273: 12V-3.5 kW>



19177

1 Rear bracket

2 Brush

3 Brush spring

4 Brush holder assembly

5 Magnet switch

6 Lever

7 Center bracket

8 Front bracket

9 Needle bearing

10 Stopper ring

11 Overrunning clutch

12 Gear bracket

13 Gear shift

14 Gear shift bearing

15 Internal gear

16 Rubber packing

17 Front bearing

18 Armature

19 Yoke assembly

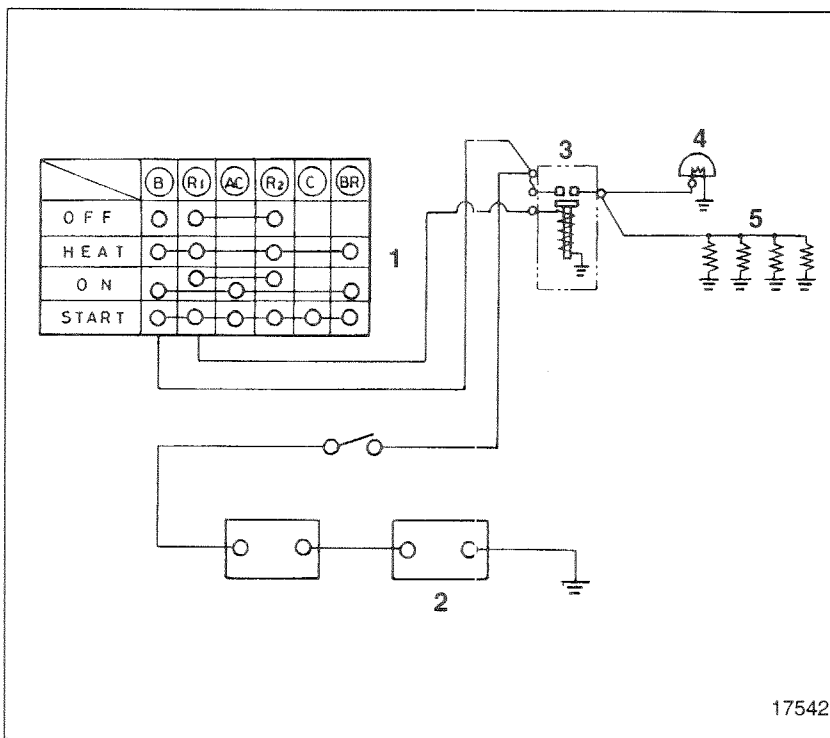
20 Rear bearing

B: Terminal B

M: Terminal M

S: Terminal S

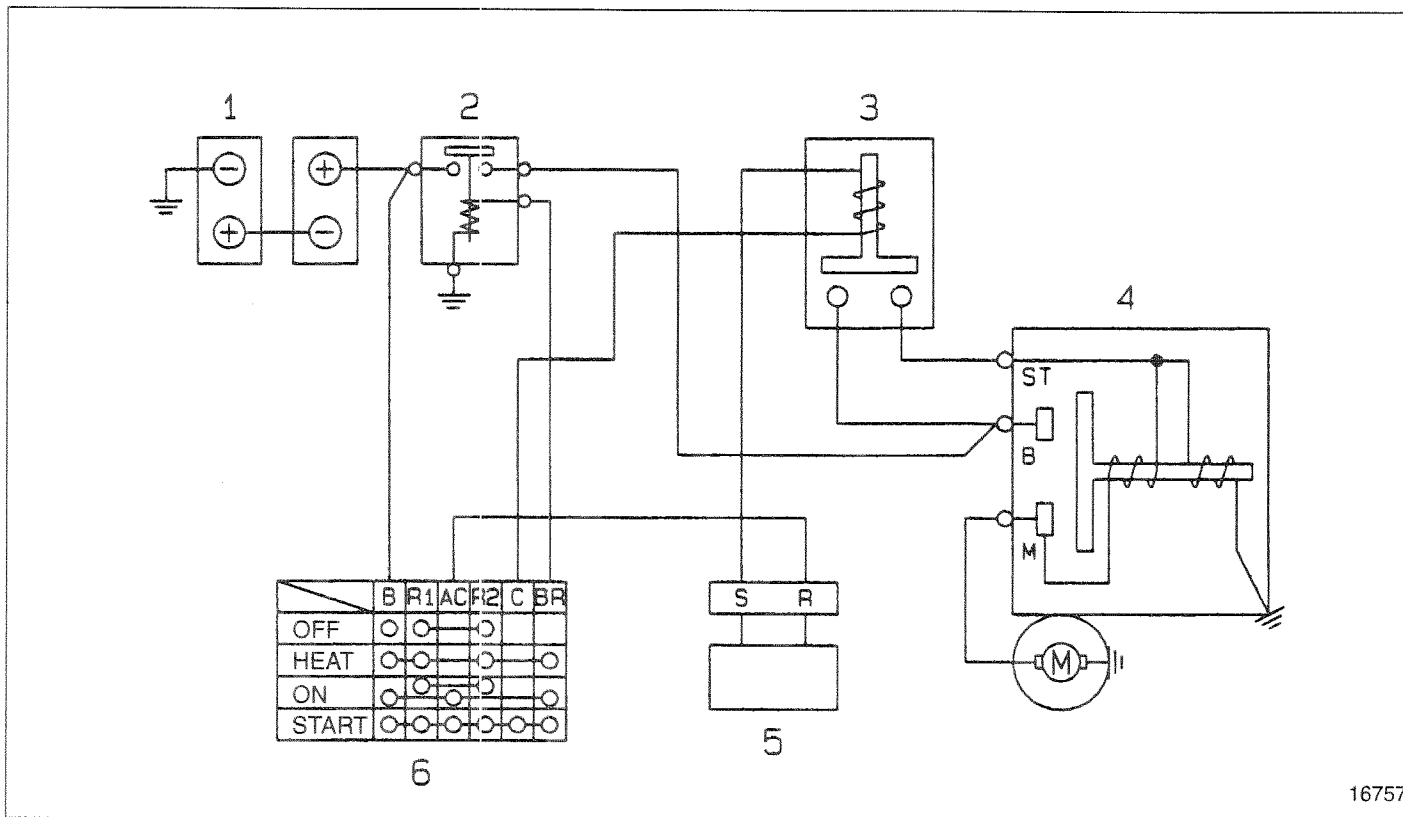
Preheating Circuit



- 1 Starter switch
- 2 Battery
- 3 Heater relay
- 4 Heater indicator
- 5 Glow plug

17542

Engine Starter Circuit

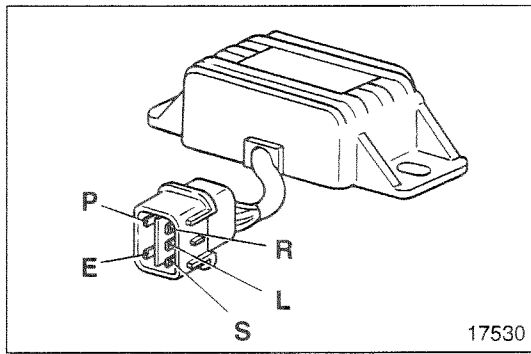


- 1 Battery
- 2 Battery relay
- 3 Starter relay
- 4 Starter
- 5 Safety relay
- 6 Starter switch

16757

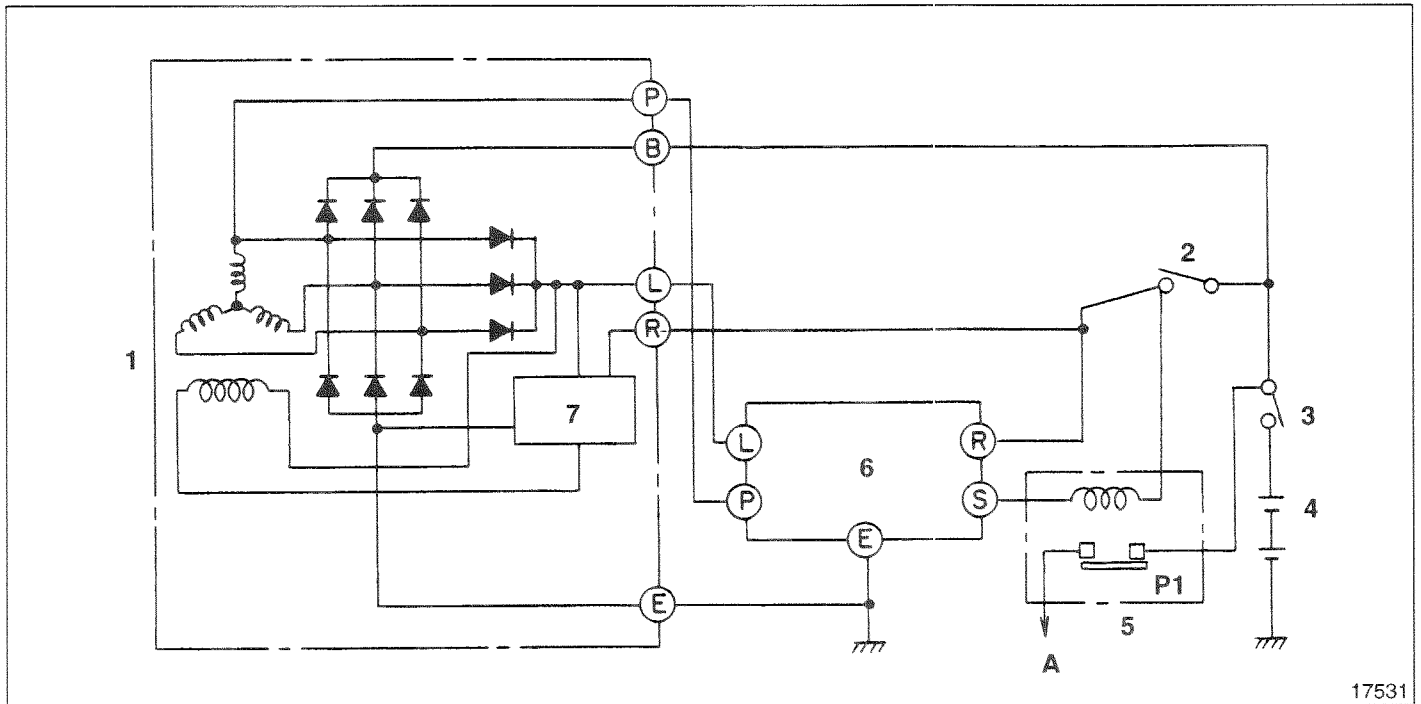
STRUCTURE AND OPERATION

Safety Relay



The safety relay detects the rotating speed of the alternator. When the rotating speed exceeds the reference value, the safety relay keeps the starter inoperative even if the starter switch is accidentally set to ON while the engine is running.

- P: Terminal P
- R: Terminal R
- L: Terminal L
- S: Terminal S
- E: Terminal E



- 1 Alternator
- 2 Starter switch
- 3 Battery switch
- 4 Battery
- 5 Starter relay

- 6 Safety relay
- 7 IC regulator

A: To starter terminal B

- When starter switch 2 is set to ON, current flows from starter relay 5 through terminal S of safety relay 6 to terminal E, and contact P₁ closes.
- When rotation of the starter causes the engine to start running, pulses with a frequency of a tenth of the alternator speed are generated at terminal P of alternator 1.
- When the pulse frequency at terminal P of alternator 1 exceeds the reference value, the continuity between terminals S and E is lost, and the starter remains inoperative even if starter switch 2 is set to ON while the engine is running.

Alternator

| Probable causes | | Defective conditions | | | | Remarks |
|--|---|--|--------------------------|---|---|-------------------------------|
| | | Battery fluid decreases in a short time. | Battery temperature high | Battery is normal but is over-discharged. | Alternator is in order but battery is over-discharged | |
| Connector incorrectly connected, harness open-circuited, defective grounding | | | | <input type="radio"/> | <input type="radio"/> | |
| Blown fuse | | | | <input type="radio"/> | <input type="radio"/> | |
| Weak tension of V belt | | | | <input type="radio"/> | <input type="radio"/> | <input type="checkbox"/> Gr14 |
| Broken V belt | | | | <input type="radio"/> | <input type="radio"/> | <input type="checkbox"/> Gr14 |
| Defective battery | | <input type="radio"/> | | | <input type="radio"/> | |
| Alternator | Stator coil open-circuited | | | <input type="radio"/> | | |
| | Stator coil and core short-circuited | | | <input type="radio"/> | | |
| | Field coil defective | | | <input type="radio"/> | | |
| | Rectifier defective | | | <input type="radio"/> | | |
| | Regulator defective | | <input type="radio"/> | <input type="radio"/> | | |
| | Brush worn (if brush is provided) | | | <input type="radio"/> | | |
| | Sagging brush spring (if brush is provided) | | | <input type="radio"/> | | |
| | Defective wiring | | | <input type="radio"/> | | |

TROUBLESHOOTING

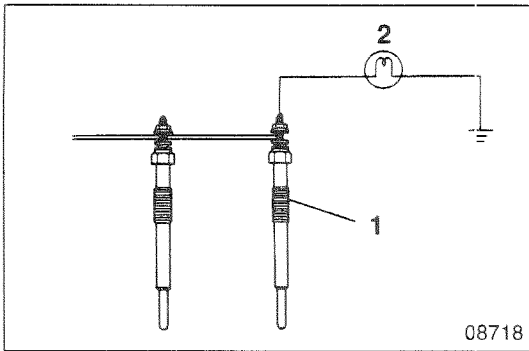
Starter

| Defective condition | | Starter does not start | Starter starts but engine does not start | | | Engine does not stop | Engine cannot be preheated | Engine is hard to start | Remarks |
|--|---|------------------------|---|---|--|-----------------------|----------------------------|-------------------------|---------|
| | | | Pinion does not come in mesh with ring gear | Pinion comes in mesh with ring gear but does not rotate | Flywheel rotates but engine does not start | | | | |
| Possible causes | | | | | | | | | |
| Connector incorrectly connected, harness open-circuited, defective grounding | | <input type="radio"/> | | | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | |
| Blown fuse | | <input type="radio"/> | | | | | | | |
| Insufficient capacity of battery | | <input type="radio"/> | | <input type="radio"/> | | | | | |
| Starter | Contact of magnet switch binding or deposited | <input type="radio"/> | | | | | | | |
| | Coil of magnet switch open-circuited | <input type="radio"/> | | | | | | | |
| | Overrunning clutch in defective operation | | <input type="radio"/> | | | | | | |
| | Worn or damaged pinion | | <input type="radio"/> | | | | | | |
| Defective starter relay | | <input type="radio"/> | | | | | | | |
| Defective starter switch | | <input type="radio"/> | | | | | | | |
| Worn or damaged ring gear of flywheel | | | <input type="radio"/> | | | | | | Gr11 |

Starter, Preheater

| Defective condition | | Engine hard to start | Engine cannot be preheated | Remarks |
|---|--|-----------------------|----------------------------|---------|
| | | | | |
| Defective heater relay wiring | | <input type="radio"/> | <input type="radio"/> | |
| Defective battery wiring | | <input type="radio"/> | <input type="radio"/> | |
| Defective intake air heater or glow plug wiring | | <input type="radio"/> | <input type="radio"/> | |
| Defective intake air heater or glow plug | | <input type="radio"/> | <input type="radio"/> | |
| Defective coolant temperature sensor | | <input type="radio"/> | | Gr14 |
| Defective coolant temperature sensor wiring | | <input type="radio"/> | | |

Inspection of Preheater System



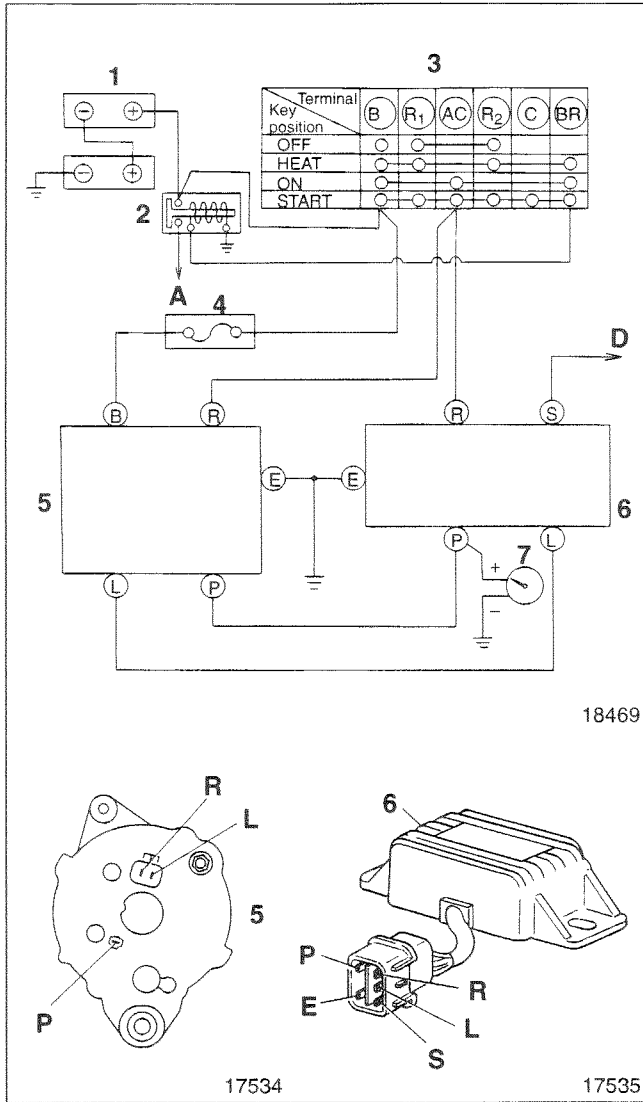
- Set the starter switch to OFF.
- Connect inspection lamp 2 (24V–1.82 W or thereabouts) to glow plug 1.
- If inspection lamp 2 does not come on, check the glow plug or heater relay.

Inspection of Safety Relay

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy | |
|----------|------------------------------|--|-------------------------|--------|--|
| — | Output voltage at terminal P | When engine is stationary | 1V or less | — | Replace alternator or wiring. |
| | | While engine is running (at idle, 600 rpm or more) | 12 – 16V | — | Check and replace wiring. |
| | Output voltage at terminal R | While engine is running | Approx. 24V | — | Check and replace wiring. |
| | Output voltage at terminal S | When engine is started (in cranking state) | 1V or less | — | <ul style="list-style-type: none"> • If the output voltage is close to the battery voltage, replace the safety relay. • If the output voltage is 0V, check and replace parts |
| | Output voltage at terminal L | While engine is running | 5V or less (but not 0V) | — | <ul style="list-style-type: none"> • Replace • If the output voltage is close to the battery voltage, inspect the alternator and harness and replace if necessary. |

ON-VEHICLE INSPECTION AND ADJUSTMENT



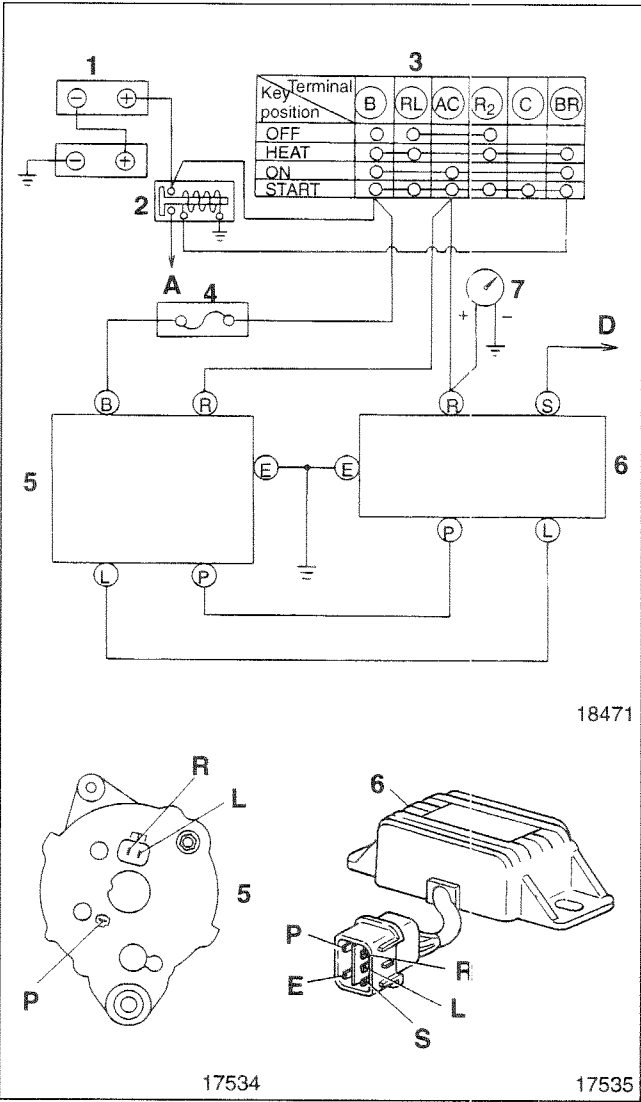
(1) Checking output voltage at terminal P

- Connect the voltmeter (pointer type) 7 as shown.

- 1 Battery
- 2 Battery relay
- 3 Starter switch
- 4 Fuse
- 5 Alternator
- 6 Safety relay
- 7 Voltmeter (pointer type)

- A: To terminal B of starter relay
- D: To terminal L of starter relay
- E: Terminal E
- L: Terminal L
- P: Terminal P
- R: Terminal R
- S: Terminal S

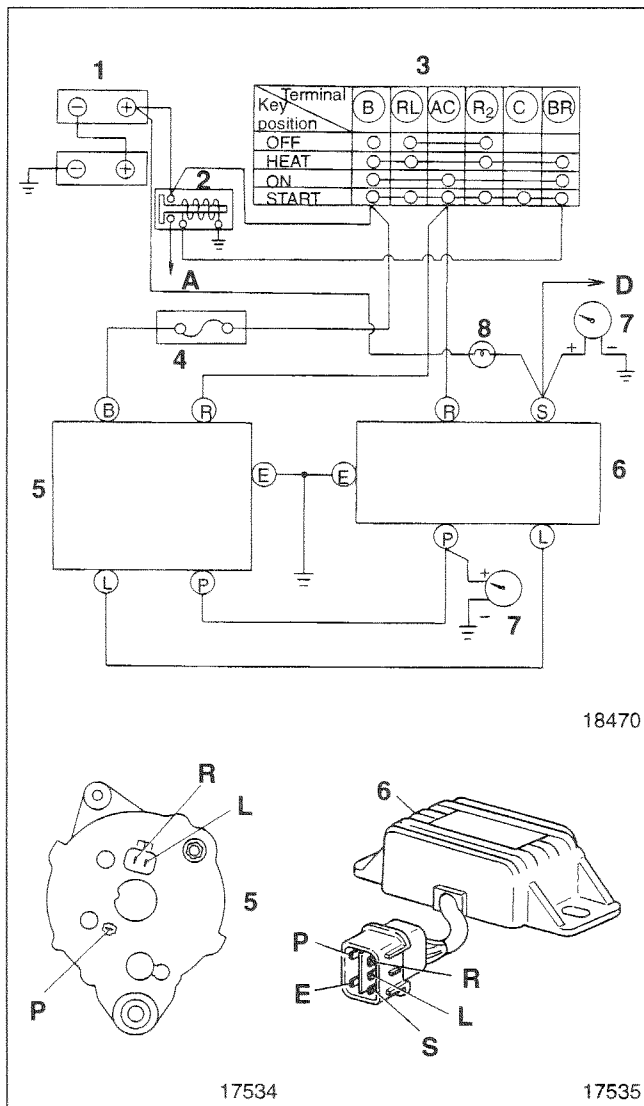
- Measure the voltage between terminal P in the illustration and the ground.
- If the reading is out of the standard value, alternator 5 or wiring is defective. Check all the parts and replace defective ones.
- Start the engine and let it run at idle (600 rpm or more) and measure the voltage.
- If the reading is 0V, the wiring to terminal P is short-circuited. Check the wiring and connector connections. Replace if defective.



(2) Checking output voltage at terminal R

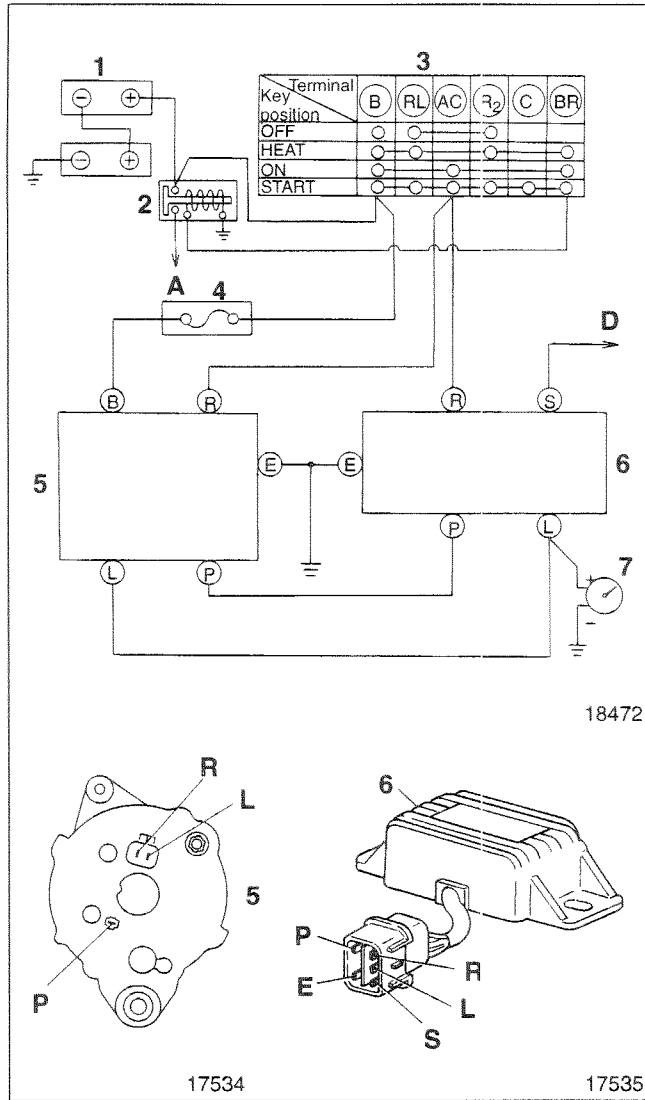
- Connect voltmeter 7 as shown.
- Place starter switch 3 in the ON position and measure the voltage.
- When the reading is out of the standard value, check the wiring. Replace if defective.

ON-VEHICLE INSPECTION AND ADJUSTMENT



(3) Checking output voltage at terminal S

- Connect voltmeter 7 and lamp 8 as shown.
- Set the starter switch 3 to the START position and measure the voltage between safety relay 6 (terminal S) and the earth in the cranking state.
- If the reading is out of the standard value, the following points are likely to be defective. Check all the points and replace if defective.
 - When the reading is close to the battery voltage, safety relay 6 is defective.
 - When the reading is 0V, the following problems are suspected.
 - Defective wiring
 - Incorrectly connected connector
 - Defective starter relay
 - Defective starter switch
- Start the engine and let it run at idle (600 rpm or more).
- Measure the voltage at terminal P.
- If the reading is out of the standard value, replace alternator 5.
- In the idling state, check to ensure that lamp 8 does not come on. When the voltage at terminal P is normal and the lamp comes on, replace safety relay 6.



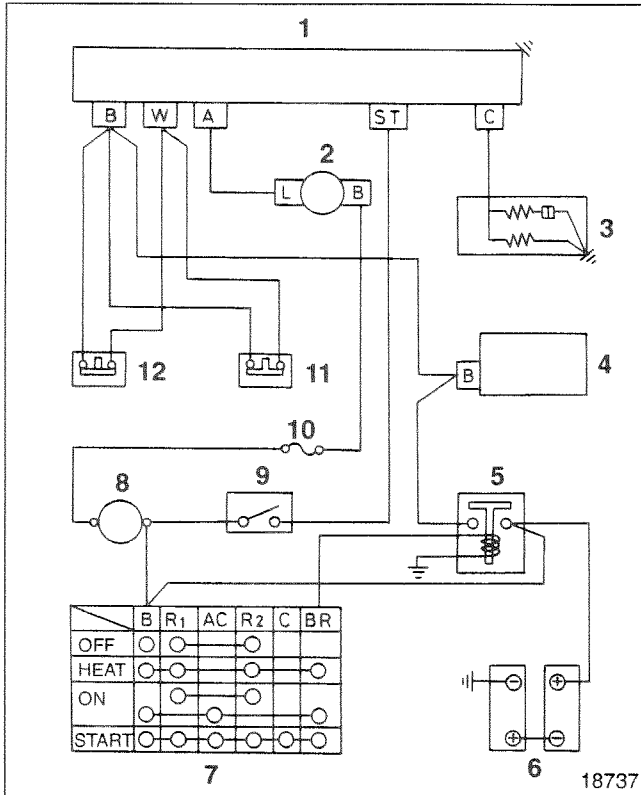
**(4) Checking output voltage at terminal L
(where no charge lamp is provided)**

- Connect voltmeter 7 as shown.
 - Place starter switch 3 at the ON position and measure the voltage.
 - If the reading is out of the standard value, replace safety relay 6.
- If the reading is close to the battery voltage, check alternator 5 and wiring, and replace if defective.

ON-VEHICLE INSPECTION AND ADJUSTMENT

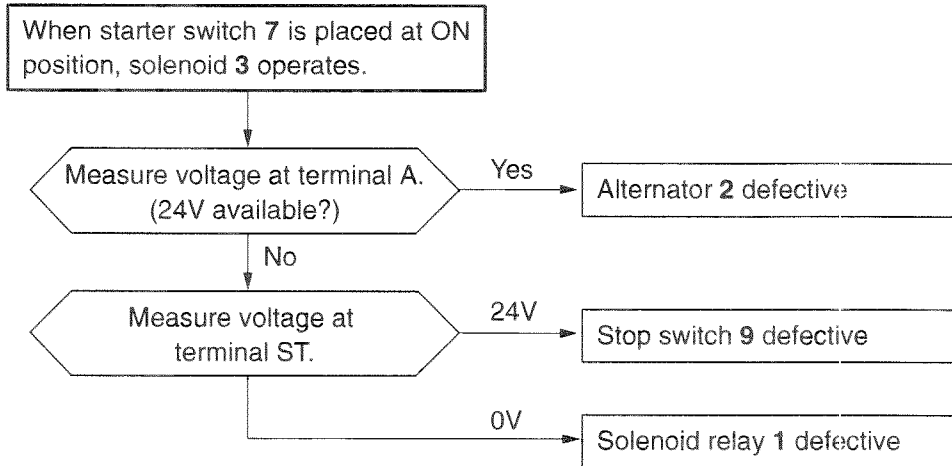
Automatic Stop System

<Shutdown>

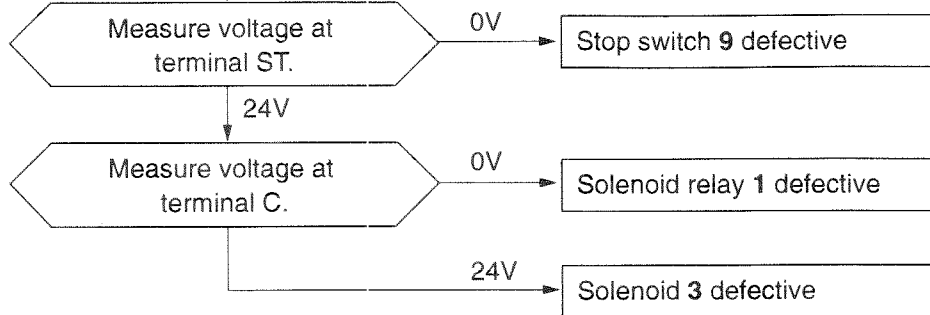


- 1 Solenoid relay
- 2 Alternator
- 3 Solenoid
- 4 Starter
- 5 Battery relay
- 6 Battery
- 7 Starter switch
- 8 Ammeter
- 9 Stop switch
- 10 Fuse box
- 11 Engine oil pressure switch
- 12 Water temperature sensor

Measure the voltages at the terminals of solenoid relay 1. Perform checks as described below and replace defective parts.

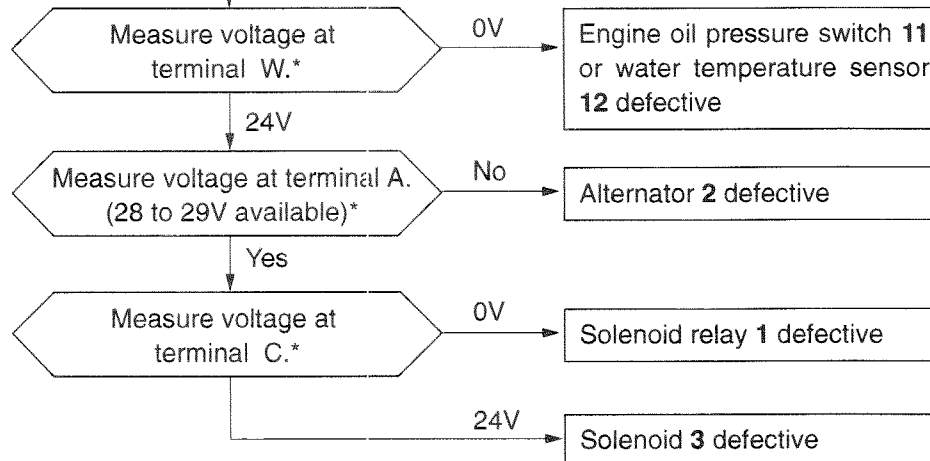


Even when stop switch **9** is set to ON, engine does not stop.

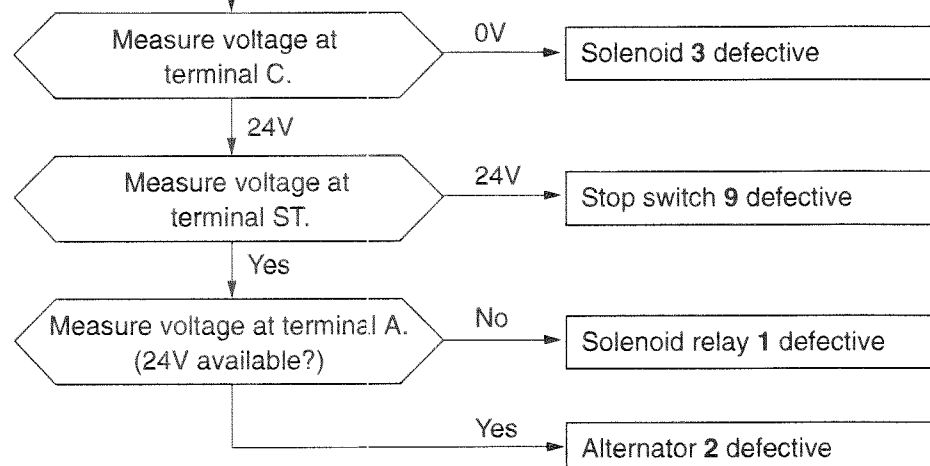


When oil pressure is abnormally low or coolant temperature abnormally high, engine does not stop.

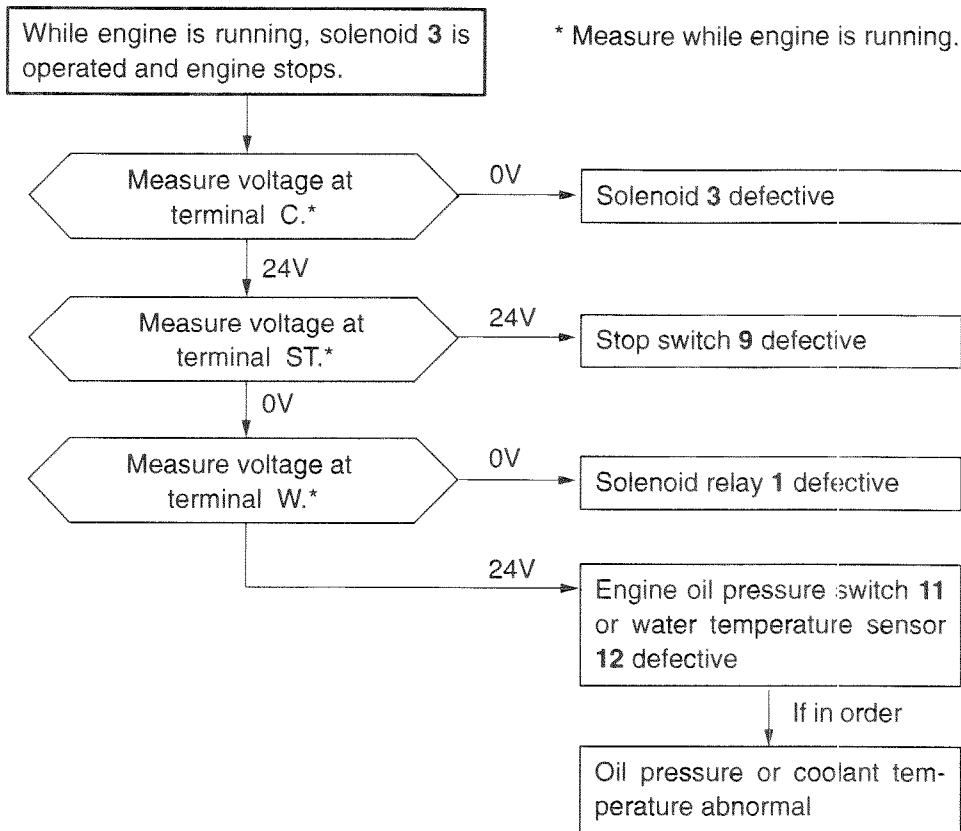
* Measure while engine is running.

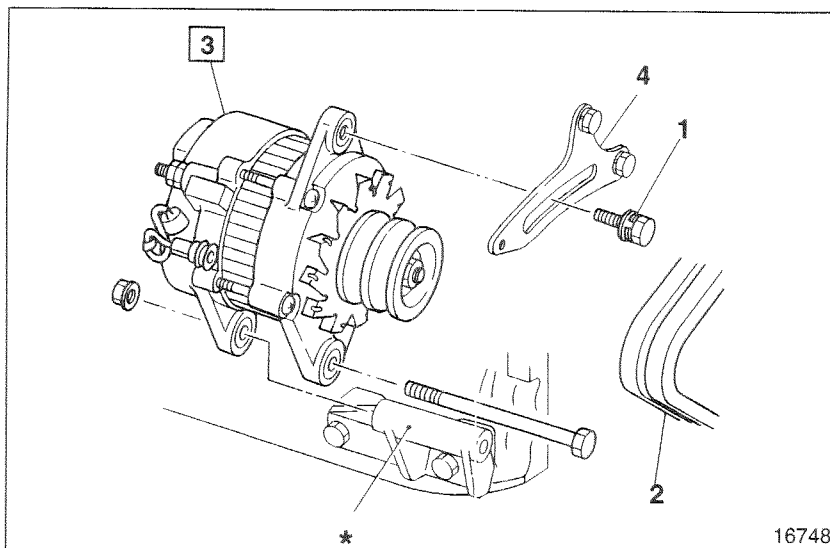


After engine has stopped, solenoid **3** is not caused to be OFF.



ON-VEHICLE INSPECTION AND ADJUSTMENT





● Removal sequence

- 1 Adjust bolt
- 2 V belt
- 3 Alternator assembly P54-30
- 4 Adjust plate

*: Alternator bracket

WARNING

Before removing alternator 3, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● Installation sequence

Follow the removal sequence in reverse.

● Adjustment after installation

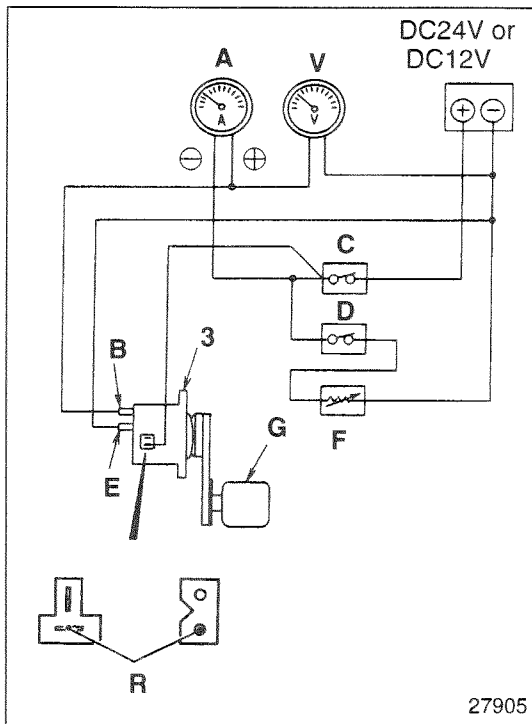
Adjust the tension of V-belt 2. Gr14

Service standards

| Location | Maintenance item | | Standard value | Limit | Remedy | |
|---|--|-----|----------------|-------------|---------|-------|
| 3 | Alternator output current (* When hot, when 27V is generated) | 25A | 1500 rpm | — | — | Check |
| | | | 2500 rpm | — | — | Check |
| | | | 5000 rpm | 25A or more | — | Check |
| | | 30A | 1500 rpm | 13A or more | — | Check |
| | | | 2500 rpm | 22A or more | — | Check |
| | | | 5000 rpm | 30A or more | — | Check |
| | | 40A | 1500 rpm | 22A or more | — | Check |
| | | | 2500 rpm | 33A or more | — | Check |
| | | | 5000 rpm | 40A or more | — | Check |
| | Alternator output current (* When hot, when 13.5V is generated) | 50A | 1500 rpm | — | — | Check |
| | | | 2500 rpm | — | — | Check |
| | | | 5000 rpm | 48A or more | — | Check |
| Regulator regulated voltage (5000 rpm, loads 5A or less) | | 24V | 28.5 ± 0.5V | — | Replace | |
| | | 12V | 14.4 ± 0.3V | — | Replace | |

*: "When hot" refers to the state of the engine after 30 minutes of maximum output operation at 5000 rpm at a normal ambient temperature.

ALTERNATOR <24V-25A, 24V-30A, 24V-40A, 12V-50A> (Fan externally mounted type)



◆ Service procedure

3 Inspection of alternator

(1) Inspection of performance of alternator (Inspection by test bench)

- Wire alternator **3** as shown.

A: Ammeter

B: Alternator terminal B

C: Switch

D: Switch

E: Alternator terminal E

F: Load resistance (variable resistance)

G: Alternator drive motor

R: Alternator terminal R

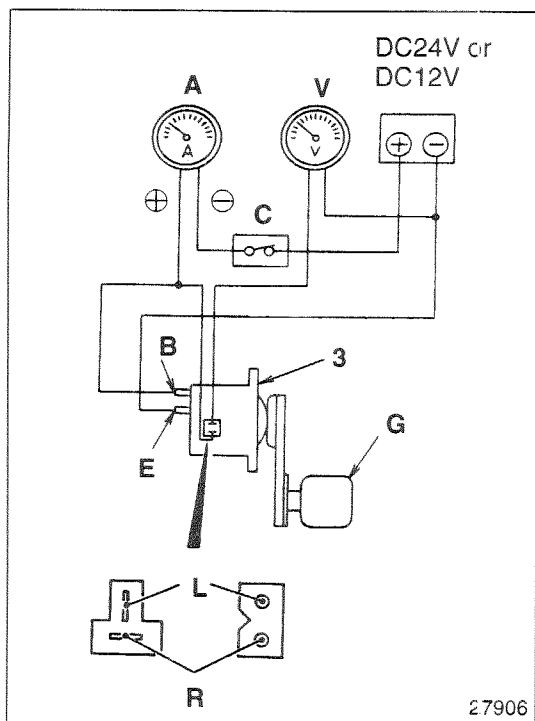
V: Voltmeter

- Increase load resistance **F** to a maximum (where practically no load current flows).
- Set switch **C** and switch **D** to ON.
- Let alternator **3** warm up at 5000 rpm for 30 minutes.
- Adjust load resistance **F** so that the current will have the nominal value.

Nominal value of alternator current

| Model | Output |
|----------|-----------|
| A5T70383 | 24V – 25A |
| A5T70483 | |
| A2T72999 | 24V – 30A |
| A2T72985 | |
| A4T57985 | 24V – 40A |
| A5T23083 | 12V – 50A |

- Measure the current with alternator **3** at each of the specified speeds.
- If the reading is out of the standard value, disassemble and check alternator **3**. P54-30



(2) Inspection of performance of regulator

(Inspection by test bench)

- Wire alternator **3** as shown.

A: Ammeter

B: Alternator terminal B

C: Switch

E: Alternator terminal E

G: Alternator drive motor

L: Alternator terminal L

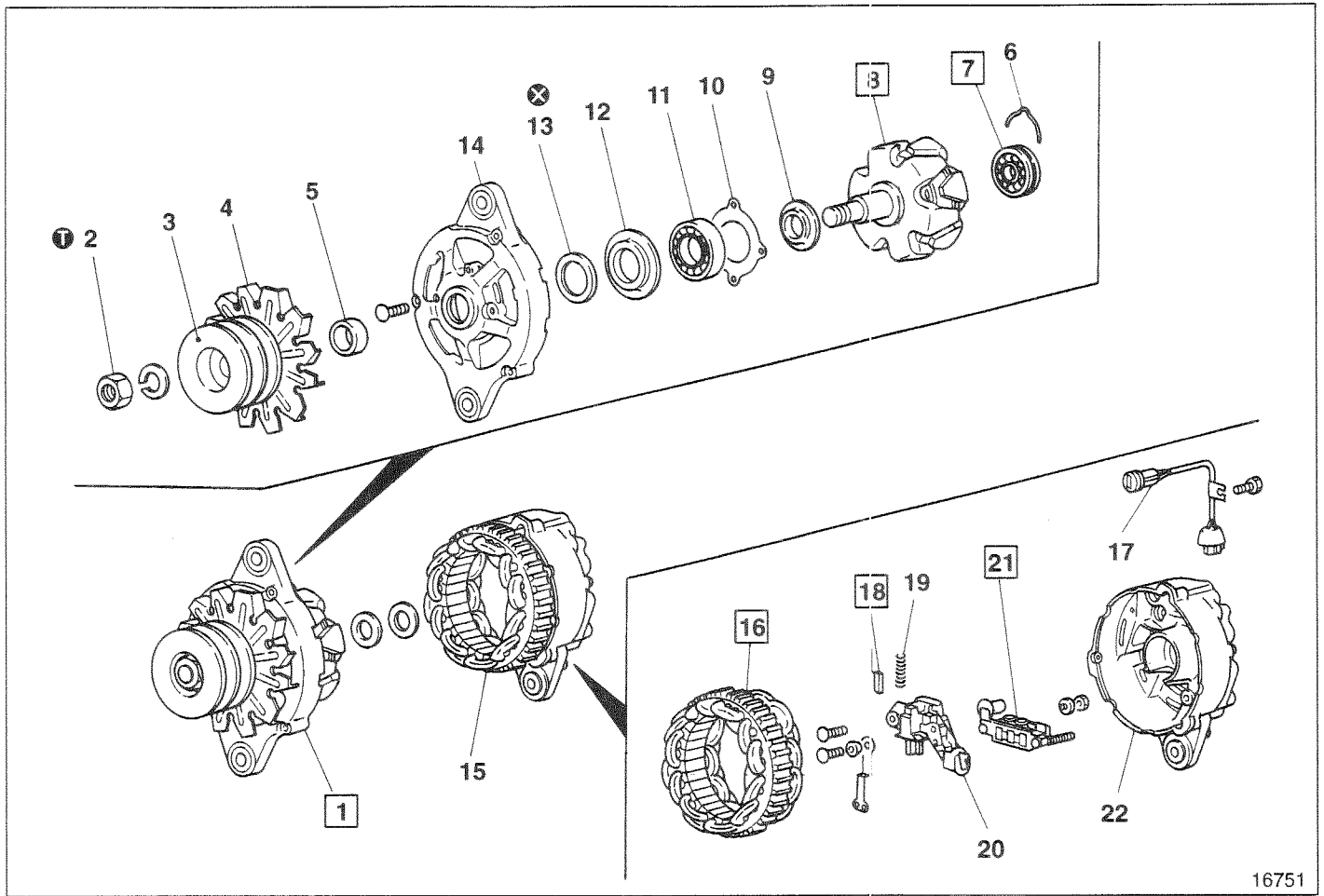
R: Alternator terminal R

V: Voltmeter

- Set switch **C** to ON.
- Let alternator **3** rotate at a low speed.
- Increase the rotating speed of alternator **3** to 5000 rpm and measure the voltage (regulated voltage). At the same time, check to ensure that the current value is 5A or less.
- If the readings are out of the standard values, proceed as described below.
 - If the readings exceed the standard values, replace the regulator (built in alternator **3**).
 - If the readings are below the standard values, check all the parts of the alternator before replacing the regulator.

ALTERNATOR <24V-25A, 24V-30A, 24V-40A, 12V-50A> (Fan externally mounted type)

Alternator Assembly



16751

● Disassembly sequence

- | | | |
|----------------------------------|-----------------------------------|-----------------------------|
| 1 Rotor & front bracket assembly | 9 Cover | 17 Connector |
| 2 Nut | 10 Cover | 18 Brush |
| 3 Pulley | 11 Front bearing | 19 Brush spring |
| 4 Fan | 12 Cover | 20 Regulator & brush holder |
| 5 Spacer | 13 Oil seal | 21 Rectifier |
| 6 Spring | 14 Front bracket | 22 Rear bracket |
| 7 Rear bearing | 15 Stator & rear bracket assembly | |
| 8 Rotor assembly | 16 Stator assembly | ⊗ : Non-reusable part |

NOTE

Do not remove parts 7, 11 and 16 unless they are found to be defective.

● Assembly sequence

15 → 1

15: $\begin{matrix} 20 \rightarrow 19 \rightarrow 18 \\ 21 \rightarrow 16 \end{matrix} \rightarrow 22 \rightarrow 17$

1: $\begin{matrix} 14 \rightarrow 13 \rightarrow 12 \rightarrow 11 \rightarrow 10 \\ 8 \rightarrow 7 \rightarrow 9 \rightarrow 6 \end{matrix} \rightarrow 5 \rightarrow 4 \rightarrow 3 \rightarrow 2$

Service standards

Unit: mm

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---------------------------------|---------------------------------|---------------|---------|
| 8 | Rotor assembly | Field coil resistance (at 20°C) | 2.4 Ω | — |
| | | Slip ring outside diameter | 40.8 to 41.2 | 40.8 |
| 18 | Brush length | 23 | 8 | Replace |
| 19 | Spring pressure of brush spring | 3.1 to 4.3 N (0.32 to 0.44 kgf) | 2 N (0.2 kgf) | Replace |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|---------------------------|---------|
| 2 | Nut (pulley mounting) | 132 to 162 {13.5 to 16.5} | — |

◆ Service procedure

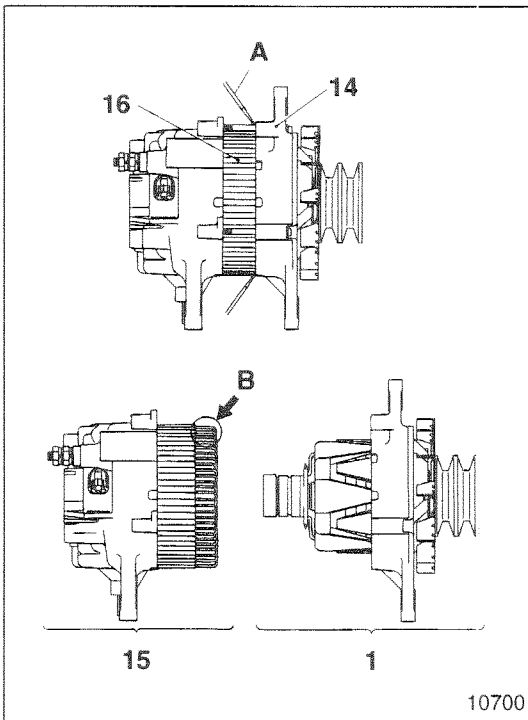
① Rotor & front bracket assembly

[Removal]

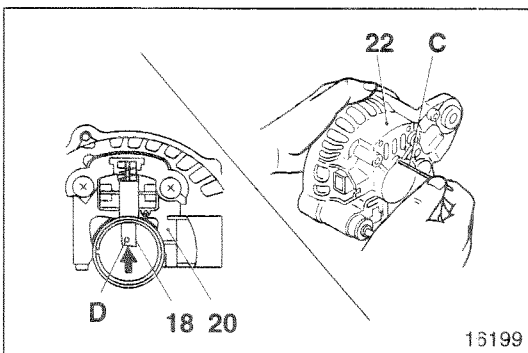
- Insert a plain screwdriver **A** between front bracket **14** and stator assembly **16**.
- While wrenching plain screwdriver **A**, remove rotor & front bracket assembly **1** from stator & rear bracket assembly **15**.

CAUTION ⚠

If plain screwdriver **A** is inserted too far, coil **B** of stator assembly **16** might be damaged and short-circuited.



10700



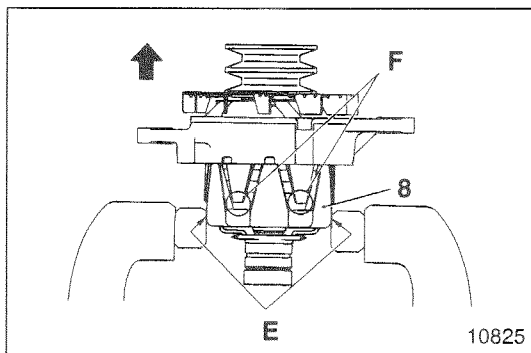
13199

[Installation]

If brush **18** is protruding from regulator & brush holder **20**, rotor assembly **8** cannot be mounted on rear bracket **22**. Therefore, perform the following steps.

- Push brush **18** into regulator & brush holder **20**.
- Insert pin **C** from the rear of rear bracket **22** and press pin **C** against pin hole **D** to hold brush **18**.
If brush **18** is worn and pin hole **D** gone, hold end of brush **18** with pin **C**.
- After installation, slowly remove pin **C**.

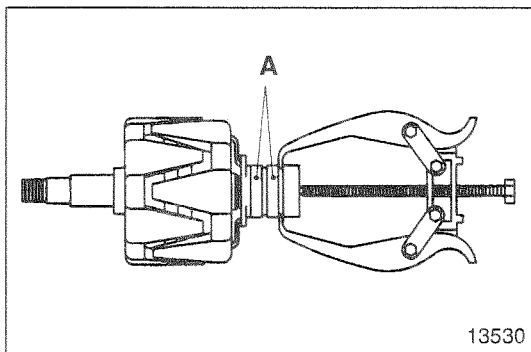
ALTERNATOR <24V-25A, 24V-30A, 24V-40A, 12V-50A> (Fan externally mounted type)



[Disassembly]

CAUTION ⚠

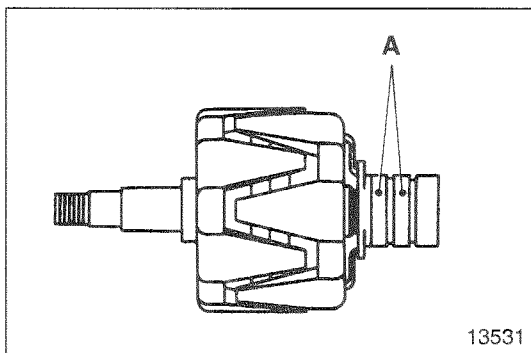
When rotor assembly 8 is held in a vice, make sure that base E of the lugs of the core is held.
If lugs F of the core are held, they will be broken or damaged.



7 Removal of rear bearing

CAUTION ⚠

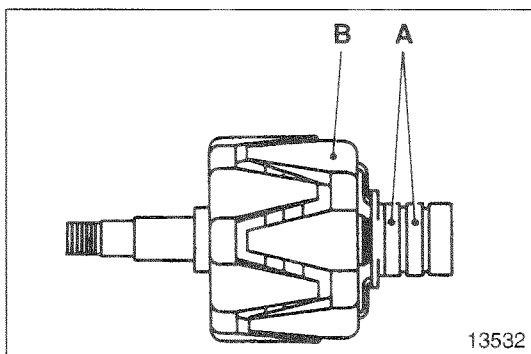
When the bearing puller is installed, use care to prevent damage to slip ring A.
If the slip ring is damaged, the brush will fail to make good contact.



8 Inspection of rotor assembly

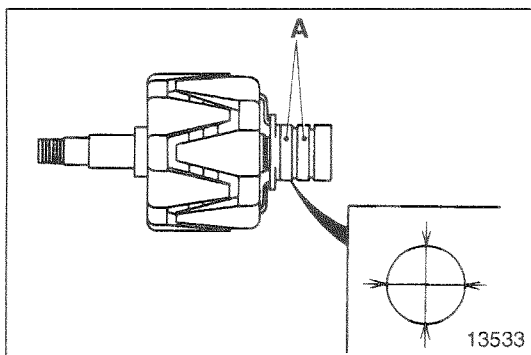
(1) Resistance of field coil

- Measure the resistance across slip ring A.
- If the reading is out of the standard value, replace rotor assembly 8.



(2) Continuity between slip ring and core

- Check to ensure that there is no continuity between slip ring A and core B.
- If there is continuity, it means a short circuit. Therefore, replace rotor assembly 8.

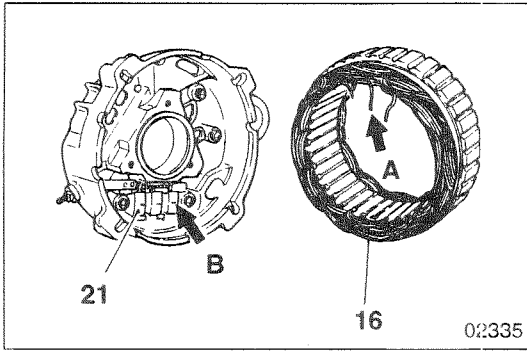


(3) Outside diameter of slip ring

- If outside diameter of slip ring A is below the limit, replace rotor assembly 8.
- If the outside diameter of slip ring A is rough or unevenly worn, correct by grinding with emery paper or a lathe.

CAUTION ⚠

Do corrective grinding within the extent that the outside diameter of slip ring A does not exceed the limit.



16 Stator assembly

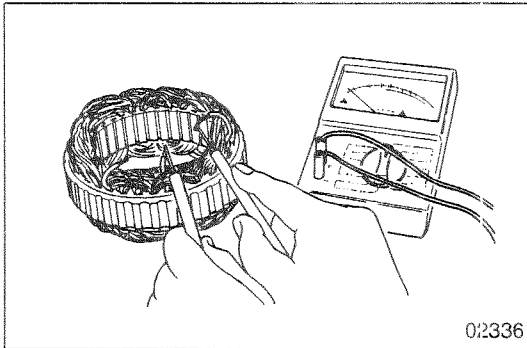
[Removal]

- Disconnect leads **A** and remove stator assembly **16** from rectifier **21**. The leads are soldered to diode leads **B** of the rectifier. (Six places)

CAUTION

De-soldering should be done quickly (in about 5 seconds or less). The diodes will be damaged if heated for a longer time.

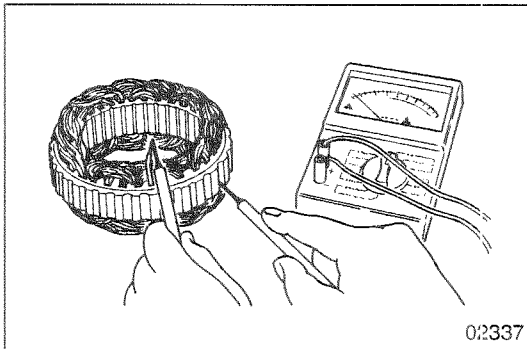
- For installation, reverse the order of removal.



[Inspection]

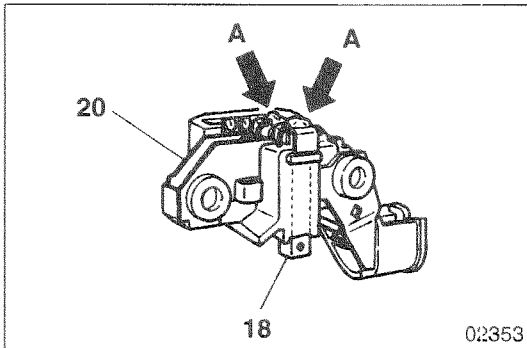
(1) Continuity between leads

- Check to ensure that there is continuity between each lead.
- If there is no continuity, the leads are open-circuited. Replace stator assembly **16**.



(2) Continuity between each lead and core

- Check to ensure that there is no continuity between each lead and the core.
- If there is continuity, it means a short circuit. Replace stator assembly **16**.



18 Brush

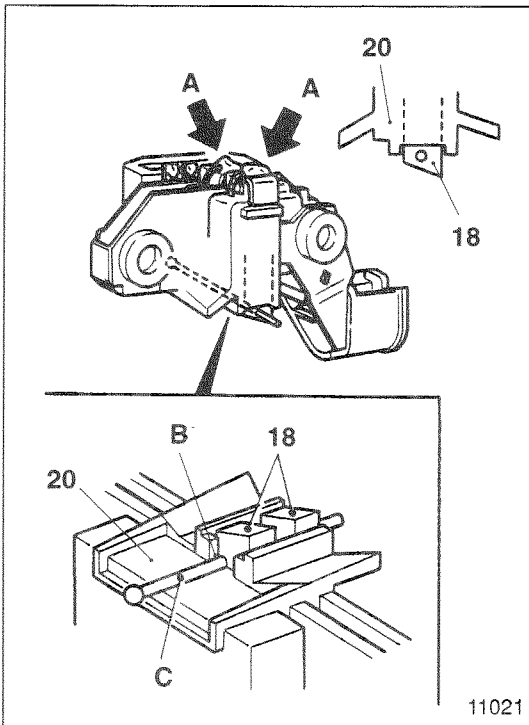
[Removal]

De-solder illustrated points **A** and remove brush **18** from regulator & brush holder **20**.

CAUTION

De-soldering should be done quickly (in about 5 seconds or less). The regulator will be damaged if heated for a longer time.

ALTERNATOR <24V-25A, 24V-30A, 24V-40A, 12V-50A> (Fan externally mounted type)



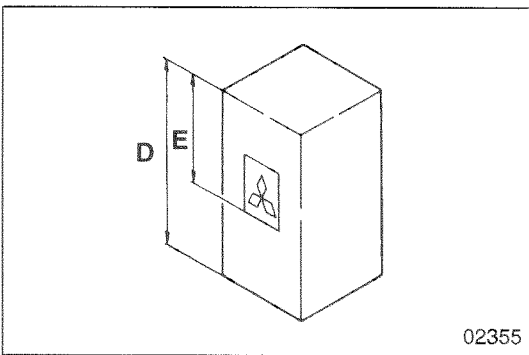
[Installation]

- Install brush 18 in regulator & brush holder 20 in the direction shown.
- Mount pin C in hole B of brush 18 to make sure that the brush does not protrude from regulator & brush holder 20.
- After installation, solder the leads of brush 18 to illustrated points A.

CAUTION

Soldering should be done quickly (in about 5 seconds or less).
The regulator will be damaged if heated for a longer time.

- After soldering, remove pin C.

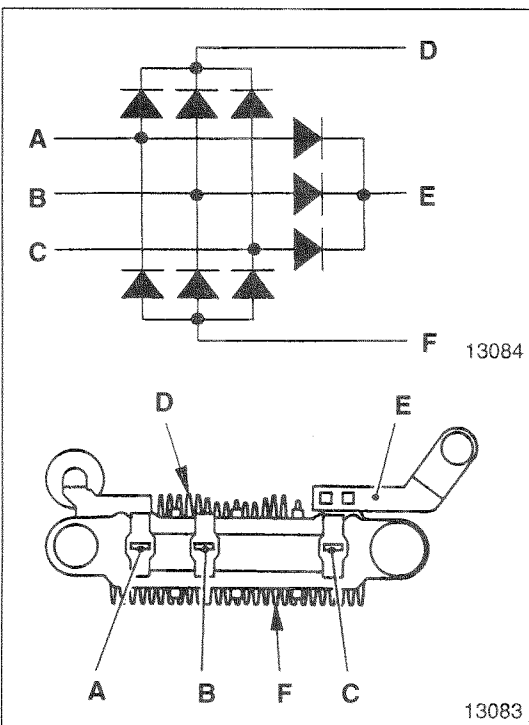


[Inspection]

If the length of brush 18 is less than the limit, replace.

D: Length when new

E: Service limit length



21 Inspection of rectifier

- Check rectifier 21 to see if the internal diodes function properly, and replace if defective.

Resistance infinite in both cases...Open

Resistance close to 0 Ω in both cases...Short

A, B, C: Leads of stator coil connected

D, F: Heat sink portion

E: Regulator connected

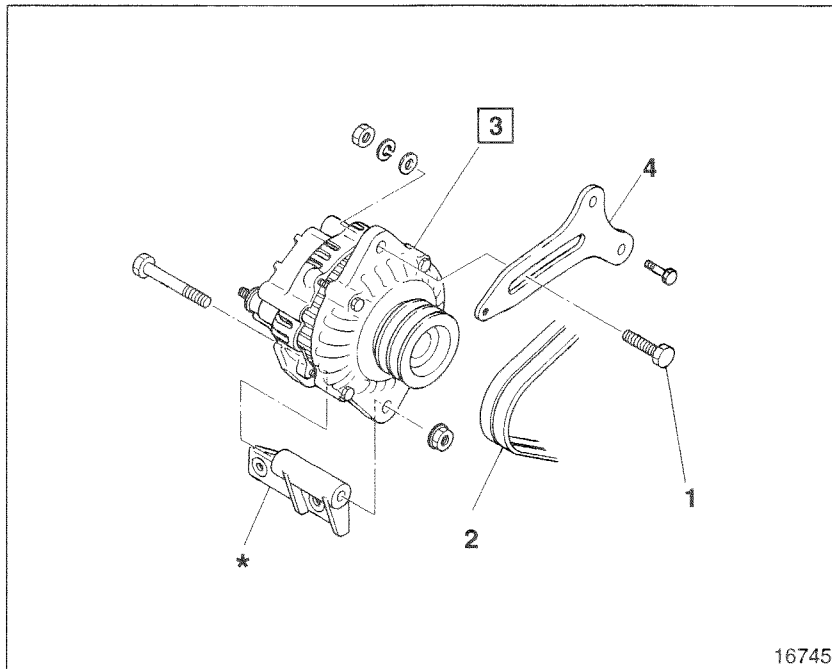
- Exchange the \oplus and \ominus sides of the tester and perform checks in both cases.

CAUTION

When a tester is used for the checks, the current that flows out from the tester is feeble than the current that normally flows through rectifier 21, so the tester may indicate a questionable resistance value. In a low range, this tendency will be stronger. Therefore, it is advisable to use the highest possible range.

MEMO

ALTERNATOR <24V-35A, 24V-40A> (Fan internal contact type)



● Removal sequence

- 1 Adjust bolt
- 2 V-belt
- 3 Alternator assembly P54-38
- 4 Adjust plate

*: Alternator bracket

WARNING

Before removing alternator 3, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● Installation sequence

Follow the removal sequence in reverse.

● Adjustment after installation

Adjust the tension of V-belt 2. Gr 14

Service standards

| Location | Maintenance item | | | Standard value | Limit | Remedy |
|----------|--|-----|----------|----------------|-------|---------|
| 3 | Alternator output current (* When hot, when 27V is generated) | 35A | 1500 rpm | 20A or more | — | Check |
| | | | 2500 rpm | 29A or more | — | |
| | | | 5000 rpm | 33A or more | — | |
| | | 40A | 1500 rpm | 20A or more | — | Check |
| | | | 2500 rpm | 30A or more | — | |
| | | | 5000 rpm | 37A or more | — | |
| | Regulator regulated voltage (5000 rpm, loads 5A or less) | | | 28.5 ± 0.5V | — | Replace |

*: "When hot" refers to the state of the engine after 30 minutes of maximum output operation at 5000 rpm at a normal ambient temperature.

◆ Service procedure

3 Inspection of alternator

(1) Inspection of performance of alternator

(Inspection by test bench)

- Wire alternator **3** as shown.

A: Ammeter
B: Alternator terminal B
C: Switch
D: Switch
E: Alternator terminal E
F: Load resistance (variable resistance)
G: Alternator drive motor
R: Alternator terminal R
V: Voltmeter

- Increase load resistance **F** to a maximum (where practically no load current flows).
- Set switch **C** and switch **D** to ON.
- Let the alternator **3** rotate at 5000 rpm for 30 minutes.
- Adjust load resistance **F** so that the current will have the nominal value.

Nominal value of alternator current

| Model | Output |
|--------------------|-----------|
| A3TN5399, A3TN5188 | 24V – 35A |
| A3TN5288 | 24V – 40A |

- Measure the current with alternator **3** at each of the specified speeds.
- If the reading is out of the standard value, disassemble and check alternator **3**. P54-38

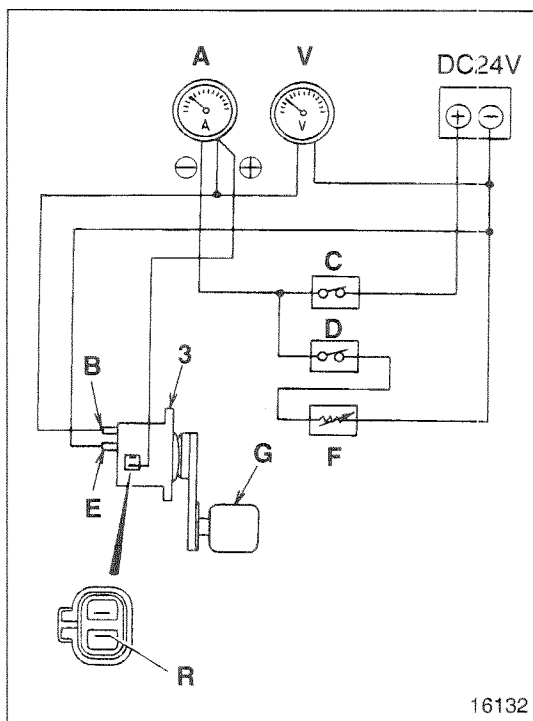
(2) Inspection of performance of regulator

(Inspection by test bench)

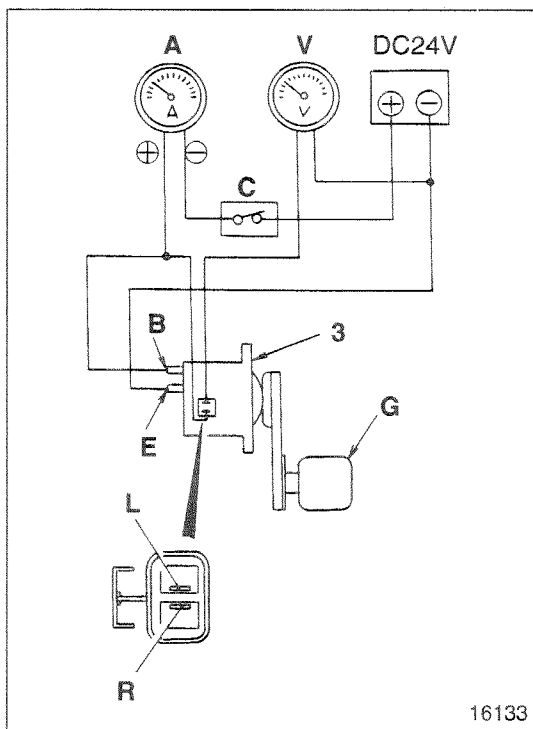
- Wire alternator **3** as shown.

A: Ammeter
B: Alternator terminal B
C: Switch
E: Alternator terminal E
G: Alternator drive motor
L: Alternator terminal L
R: Alternator terminal R
V: Voltmeter

- Set switch **C** to ON.
- Let alternator **3** rotate at a low speed.
- Increase the rotating speed of alternator **3** to 5000 rpm and measure the voltage (regulated voltage). At the same time, check to ensure that the current value is 5A or less.
- If the readings are out of the standard values, proceed as described below.
 - If the readings exceed the standard values, replace the regulator.
 - If the readings are below the standard values, check all the parts of the alternator before replacing the regulator.



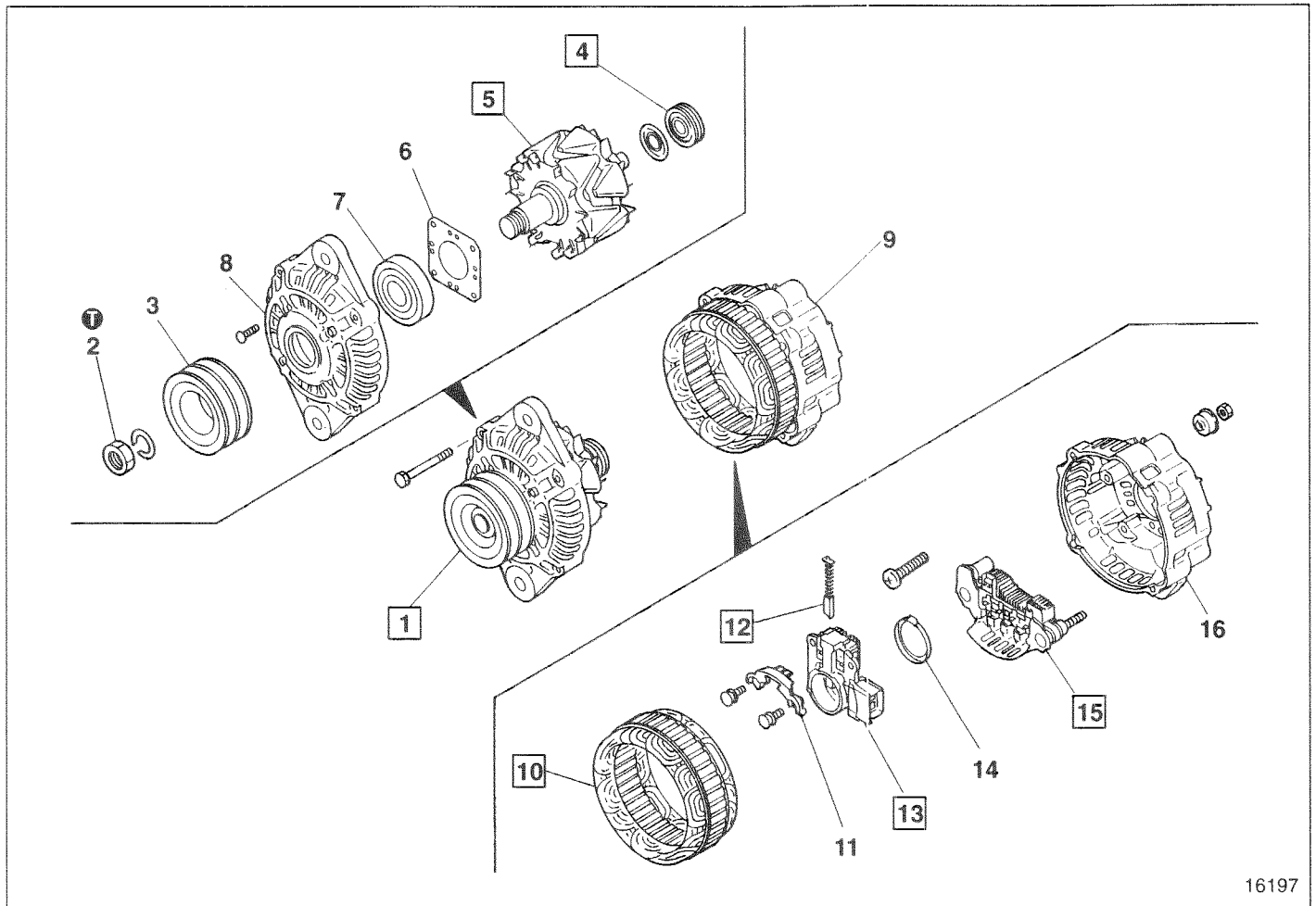
16132



16133

ALTERNATOR <24V-35A, 24V-40A> (Fan internal contact type)

Alternator Assembly



16197

● Disassembly sequence

- | | | |
|------------------------------------|------------------------------------|-------------------------------|
| 1 Rotor and front bracket assembly | 7 Front bearing | 12 Brush |
| 2 Nut | 8 Front bracket | 13 Regulator and brush holder |
| 3 Pulley | 9 Stator and rear bracket assembly | 14 Slinger |
| 4 Rear bearing | 10 Stator assembly | 15 Rectifier |
| 5 Rotor assembly | 11 Cover | 16 Rear bracket |
| 6 Cover | | |

NOTE

Do not remove parts 4, 7, 10 and 12 unless they are found to be defective.

● Assembly sequence

9 → 1

9: 14 → 13 → 12 → 11 → 15 → 16 → 10

1: 8 → 7 → 6 → 5 → 4 → 3 → 2

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|------------------|---------------------------------|--------------------|-------|---------|
| 5 | Rotor assembly | Field coil resistance (at 20°C) | 9 to 10.5 Ω | — | Replace |
| | | Slip ring outside diameter | 33 | 32.4 | |
| 12 | Brush length | | 21.5 | 8 | Replace |

① Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|---------------------------|---------|
| 2 | Nut (pulley mounting) | 132 to 162 {13.5 to 16.5} | — |

◆ Service procedure

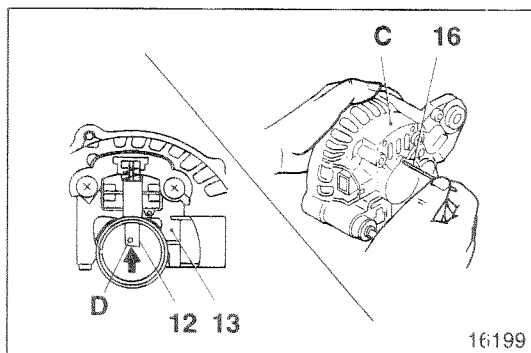
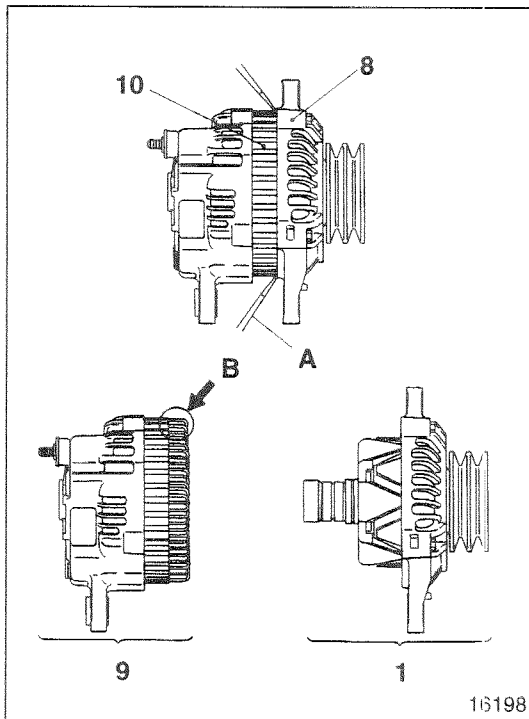
① Rotor & front bracket assembly

[Removal]

- Insert a plain screwdriver **A** between front bracket **8** and stator assembly **10**.
- While wrenching plain screwdriver **A**, remove rotor & front bracket assembly **1** from stator & rear bracket assembly **9**.

CAUTION ⚠

If plain screwdriver **A** is inserted too far, coil **B** of stator assembly **10** might be damaged and short-circuited.

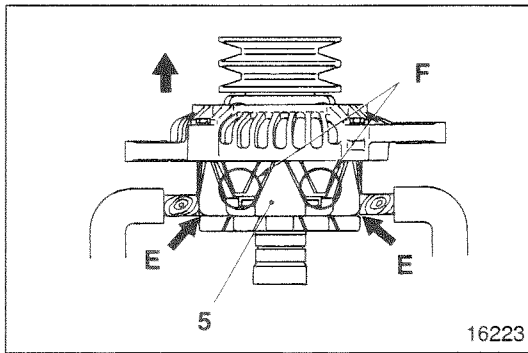


[Installation]

If the brush **12** is protruding from regulator & brush holder **13**, rotor assembly **5** cannot be mounted on rear bracket **16**. Therefore, perform the following steps.

- Push brush **12** into regulator & brush holder **13**.
- Insert pin **C** from the rear of rear bracket **16** and press pin **C** against pin hole **D** to hold brush **12**.
If brush **12** is worn and pin hole **D** gone, hold end of brush **12** with pin **C**.
- After installation, slowly remove pin **C**.

ALTERNATOR <24V-35A, 24V-40A> (Fan internal contact type)

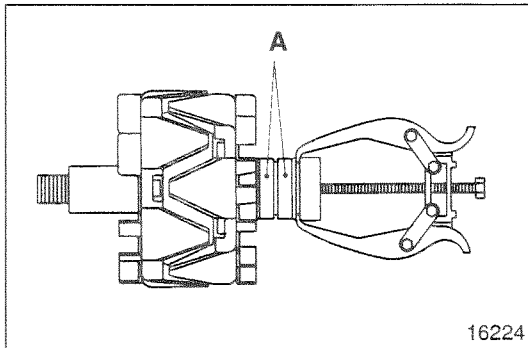


[Disassembly]

CAUTION

When rotor assembly 5 is held in a vice, make sure that base E of the lugs of the core is held.

If lugs F of the core are held, they will be broken or damaged.

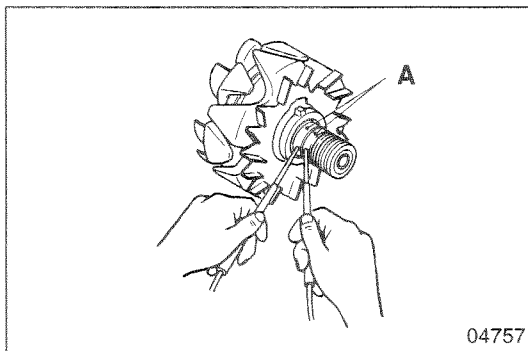


4 Removal of rear bearing

CAUTION

When the bearing puller is installed, use care to prevent damage to slip ring A.

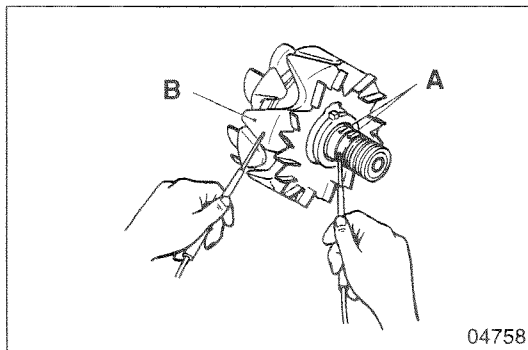
If the slip ring is damaged, the brush will fail to make good contact.



5 Inspection of rotor assembly

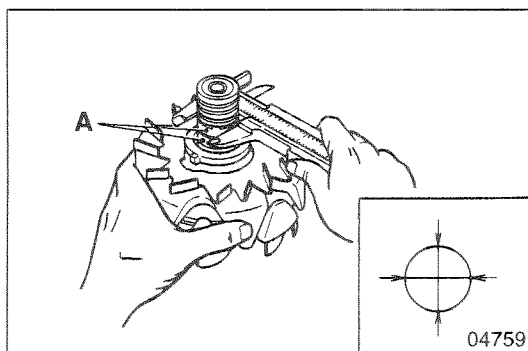
(1) Resistance of field coil

- Measure the resistance across slip ring A.
- If the reading is out of the standard value, replace rotor assembly 5.



(2) Continuity between slip ring and core

- Check to ensure that there is no continuity between slip ring A and core B.
- If there is continuity, it means a short circuit. Therefore, replace rotor assembly 5.

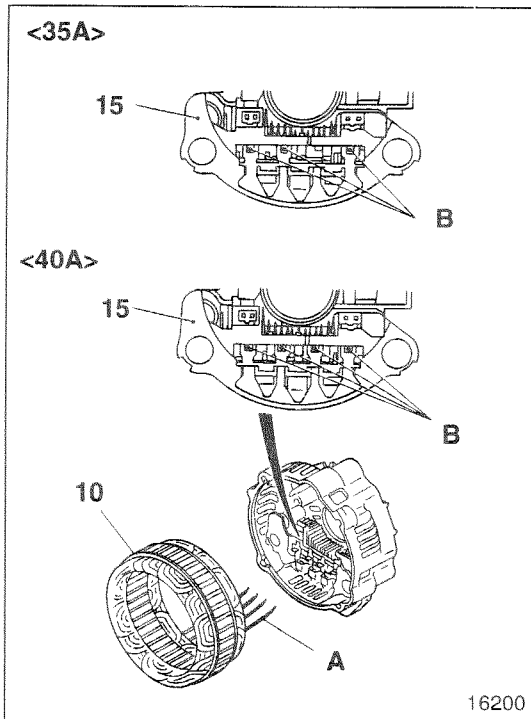


(3) Outside diameter of slip ring

- If the outside diameter of slip ring A is below the limit, replace rotor assembly 5.
- If the outside diameter of slip ring A is rough or unevenly worn, correct by grinding with emery paper or a lathe.

CAUTION

Do corrective grinding within the extent that the outside diameter of slip ring A does not exceed the limit.



10 Stator assembly

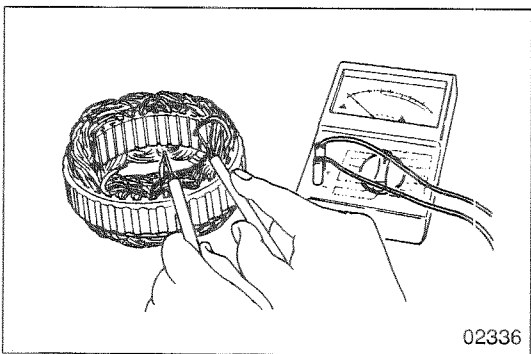
[Removal]

- Disconnect leads **A** and remove stator assembly **10** from rectifier **15**. The leads are soldered to diode leads **B** of the rectifier. (Three places <35A>, four places <40A>)

CAUTION

De-soldering should be done quickly (in about 5 seconds or less). The diodes will be damaged if heated for a longer time.

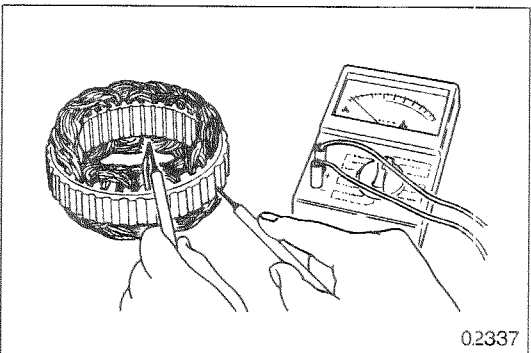
- For installation, reverse the order of removal.



[Inspection]

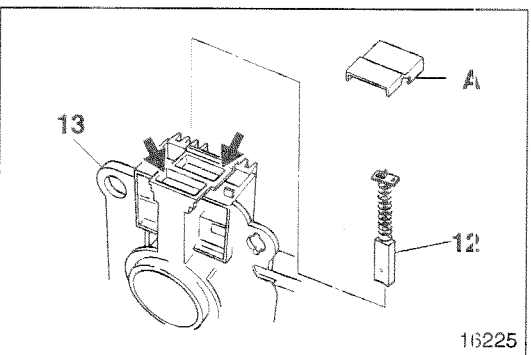
(1) Continuity between leads

- Check to ensure that there is continuity between each lead.
- If there is no continuity, the leads are open-circuited. Replace stator assembly **10**.



(2) Continuity between each lead and core

- Check to ensure that there is no continuity between each lead and the core.
- If there is continuity, it means a short circuit. Replace stator assembly **10**.

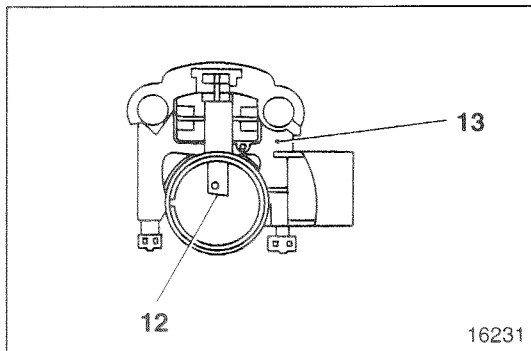


12 Brush

[Removal]

After removing cover **A**, de-solder the leads of brush **12** and remove the brush from regulator & brush holder **13**.

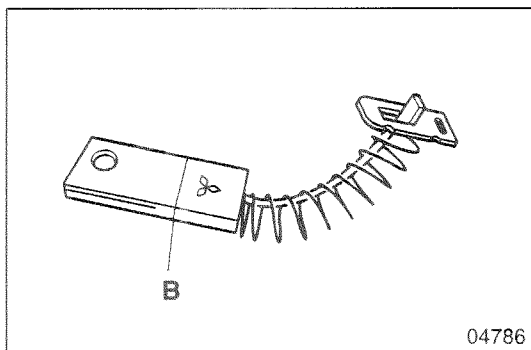
ALTERNATOR <24V-35A, 24V-40A> (Fan internal contact type)



[Installation]

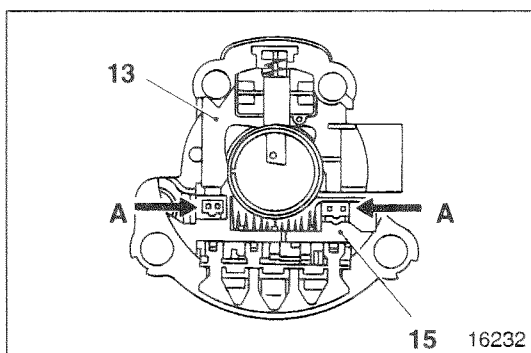
- Install brush 12 in regulator & brush holder 13 in the direction shown.
- After installation, solder the leads of brush 12 to regulator & brush holder 13.

Thereafter, fit cover A as before.



[Inspection]

If the length of brush 12 is near wear limit B, replace.

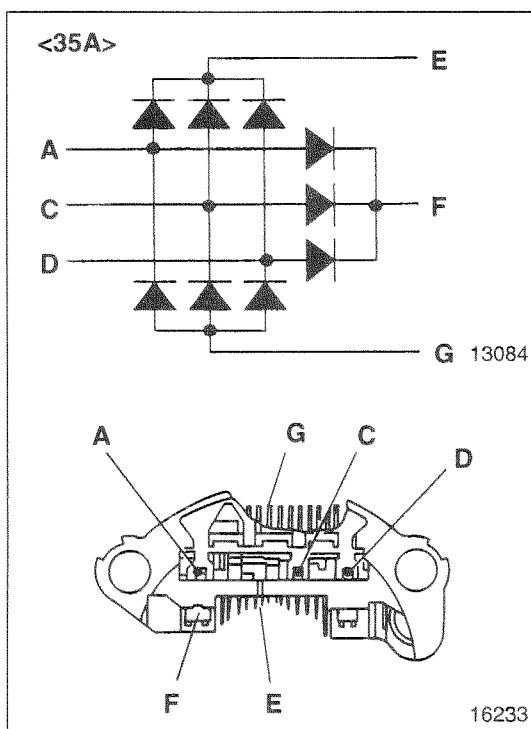


13 Removal of regulator & brush holder

- Remove regulator & brush holder 13 by de-soldering two illustrated points A.
- For installation, reverse the order of removal.

CAUTION

De-soldering should be done quickly (in about 5 seconds or less).
The diodes will be damaged if heated for a longer time.



15 Inspection of rectifier

- Check rectifier 15 to see if the internal diodes function properly. If defective, replace the rectifier.

Resistance infinite in both cases...Open
Resistance close to 0Ω in both cases...Short

A, B, C, D: Leads of stator coil connected

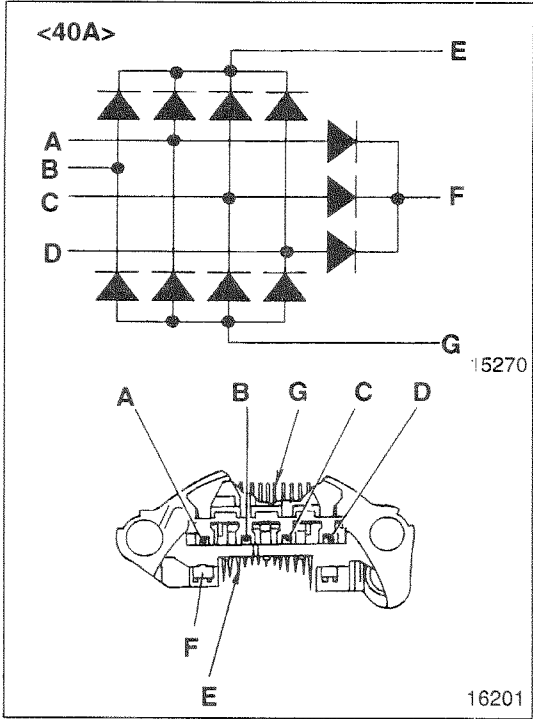
E, G: Heat sink portion

F: Regulator connected

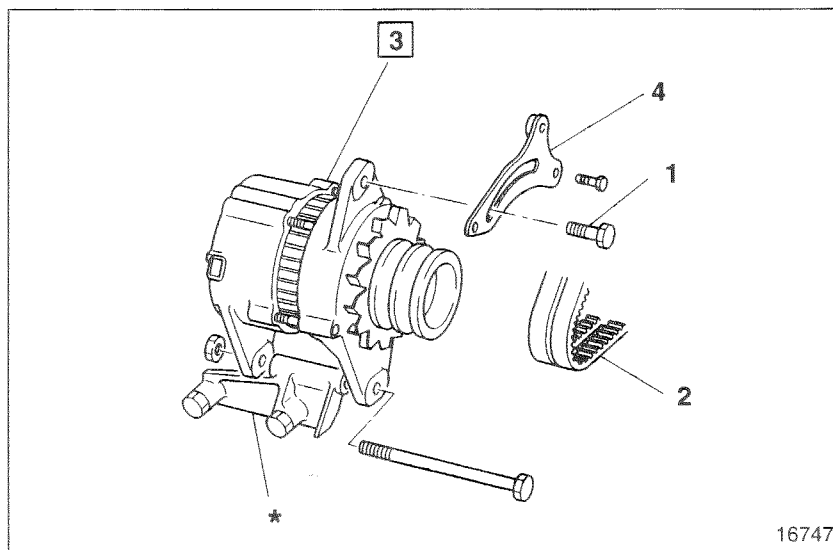
- Exchange the ⊕ and ⊖ sides of the tester and perform checks in both cases.

CAUTION

When a tester is used for the checks, the current that flows out from the tester is feebler than the current that normally flows through rectifier 15, so the tester may indicate a questionable resistance value. In a low range, this tendency will be stronger. Therefore, it is advisable to use the highest possible range.



ALTERNATOR <24V-50A, 24V-80A>



● Removal sequence

- 1 Adjust bolt
- 2 V-belt
- 3 Alternator assembly P54-46
- 4 Adjust plate

*: Alternator bracket

16747

WARNING

Before removing alternator 3, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● Installation sequence

Follow the removal sequence in reverse.

● Adjustment after installation

Adjust the tension of V-belt 2. Gr 14

Service standards

| Location | Maintenance item | | | Standard value | Limit | Remedy |
|----------|--|-----|----------|----------------|-------|---------|
| 3 | Alternator output current (* When hot, when 27V is generated) | 50A | 1500 rpm | 19A or more | — | Check |
| | | | 2500 rpm | 39A or more | — | |
| | | | 5000 rpm | 47A or more | — | |
| | | 80A | 1500 rpm | 32A or more | — | Check |
| | | | 2500 rpm | 69A or more | — | |
| | | | 5000 rpm | 78A or more | — | |
| | Regulator regulated voltage (5000 rpm, loads 5A or less) | | | 28.5 ± 0.5V | — | Replace |

*: "When hot" refers to the state of the engine after 30 minutes of maximum output operation at 5000 rpm at a normal ambient temperature.

◆ Service procedure

3 Inspection of alternator

(1) Inspection of performance of alternator

(Inspection by test bench)

- Wire alternator **3** as shown.

A: Ammeter

B: Alternator terminal B

C: Switch

D: Switch

E: Alternator terminal E

F: Load resistance (variable resistance)

G: Alternator drive motor

R: Alternator terminal R

V: Voltmeter

- Increase load resistance **F** to a maximum (where practically no load current flows).
- Set switch **C** and switch **D** to ON.
- Let alternator **3** rotate at 5000 rpm for 30 minutes.
- Adjust load resistance **F** so that the current will have the nominal value.

Nominal value of alternator current

| Model | Output |
|--------------------|-----------|
| A4T66083, A4T66085 | 24V – 50A |
| A6T76099 | 24V – 80A |

- Measure the current with alternator **3** at each of the specified speeds.
- If the reading is out of the standard value, disassemble and check alternator **3**. P54-46

(2) Inspection of performance of regulator

(Inspection by test bench)

- Wire alternator **3** as shown.

A: Ammeter

B: Alternator terminal B

C: Switch

E: Alternator terminal E

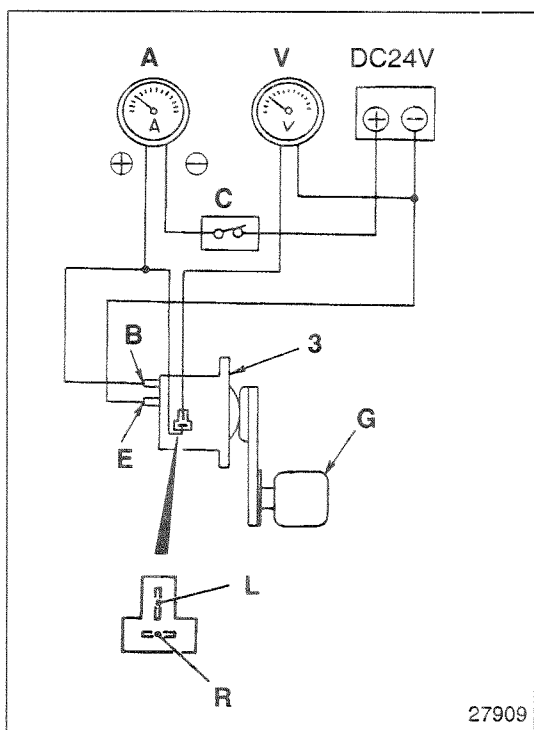
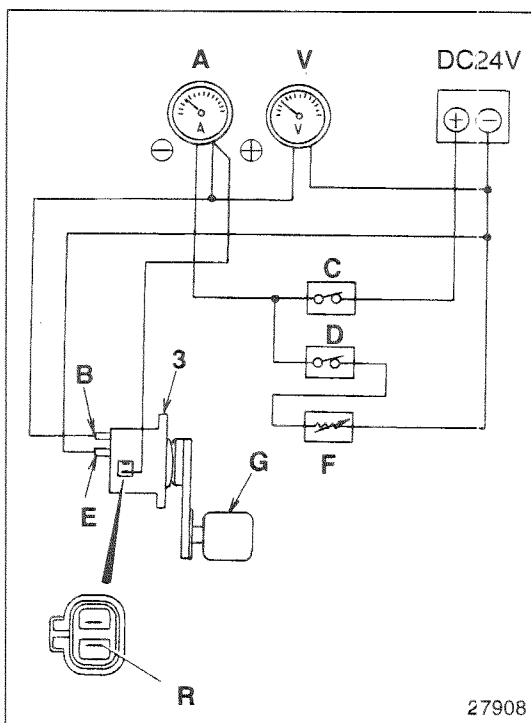
G: Alternator drive motor

L: Alternator terminal L

R: Alternator terminal R

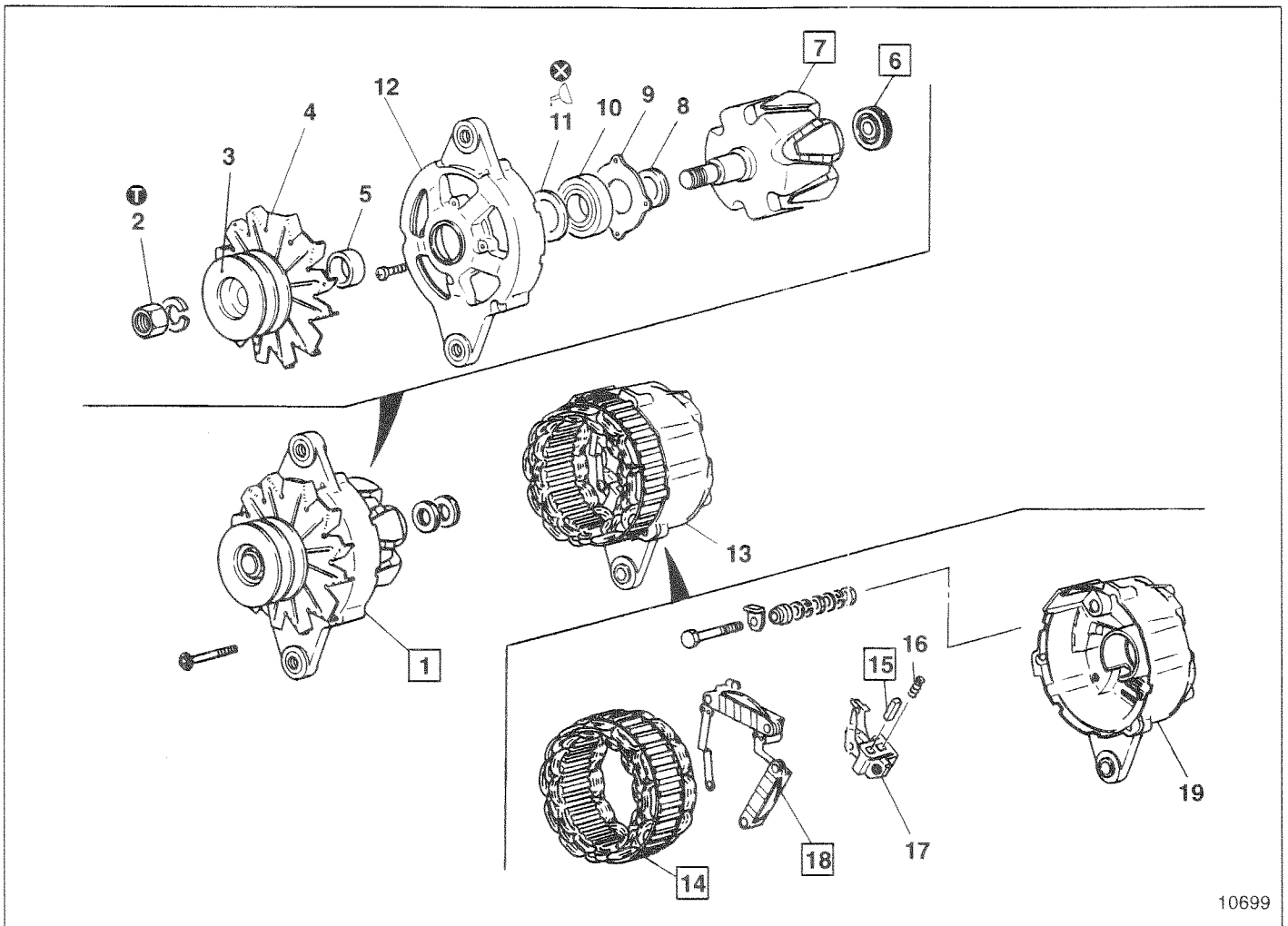
V: Voltmeter

- Set switch **C** to ON.
- Let alternator **3** rotate at a low speed.
- Increase the rotating speed of alternator **3** to 5000 rpm and measure the voltage (regulated voltage). At the same time, check to ensure that the current value is 5A or less.
- If the readings are out of the standard values, proceed as described below.
 - If the readings exceed the standard values, replace the regulator (built in alternator **3**).
 - If the readings are below the standard values, check all the parts of the alternator before replacing the regulator.



ALTERNATOR <24V-50A, 24V-80A>

Alternator Assembly



10699

● Disassembly sequence

- 1 Rotor & front bracket assembly
- 2 Nut
- 3 Pulley
- 4 Fan
- 5 Spacer
- 6 Rear bearing
- 7 Rotor assembly

- 8 Cover
- 9 Cover
- 10 Front bearing
- 11 Oil seal
- 12 Front bracket
- 13 Stator & rear bracket assembly
- 14 Stator assembly

- 15 Brush
- 16 Brush spring
- 17 Regulator & brush holder
- 18 Rectifier
- 19 Rear bracket

⊗: Non-reusable part

NOTE

Do not remove parts 6, 10 and 14 unless they are found to be defective.

● Reassembly sequence

13 → 1

13: 19 → 18 → 17 → 16 → 15 → 14

1: 12 → 11 → 10 → 9 → 7 → 8 → 6 → 5 → 4 → 3 → 2

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|---------------------------------|---------------------------------|---------------------------------|---------------|---------|
| 7 | Rotor assembly | Field coil resistance (at 20°C) | 7.2 Ω | — | Replace |
| | | Slip ring outside diameter | 41 | 40.8 | |
| 15 | Brush length | | 23 | 8 | Replace |
| 16 | Spring pressure of brush spring | | 3.1 to 4.3 N {0.32 to 0.44 kgf} | 2 N {0.2 kgf} | Replace |

① Tightening torque

Unit: N · m {kgf · m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|---------------------------|---------|
| 2 | Nut (to mount pulley) | 132 to 162 {13.5 to 16.5} | — |

◆ Service procedure

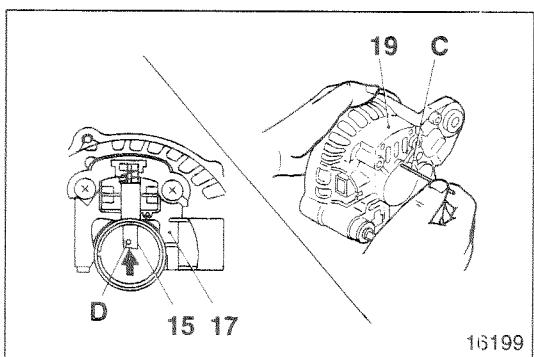
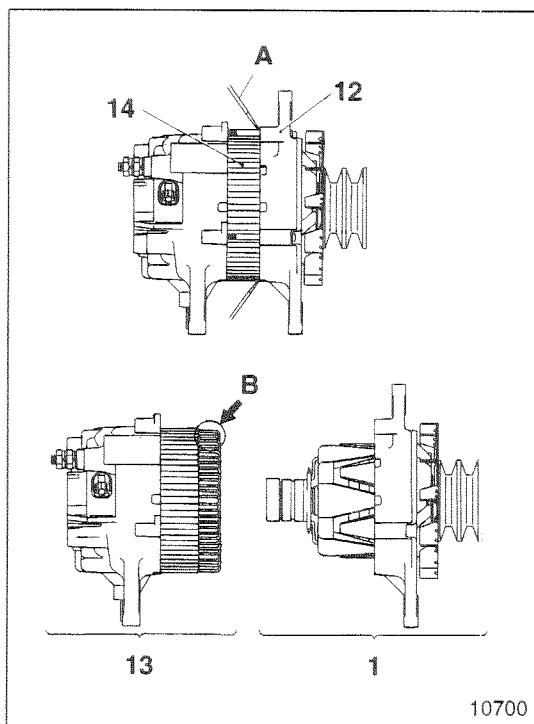
① Rotor & front bracket assembly

[Removal]

- Insert a plain screwdriver **A** between front bracket **12** and stator assembly **14**.
- While wrenching plain screwdriver **A**, remove rotor & front bracket assembly **1** from stator & rear bracket assembly **13**.

CAUTION ⚠

If plain screwdriver **A** is inserted too far, coil **B** of stator assembly **14** might be damaged and short-circuited.

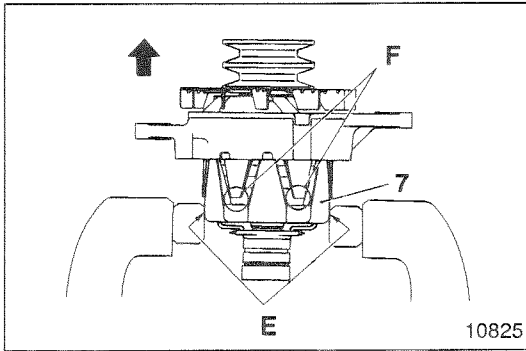


[Installation]

If brush **15** is protruding from regulator & brush holder **17**, rotor assembly **7** cannot be mounted on rear bracket **19**. Therefore, perform the following steps.

- Push brush **15** into regulator & brush holder **17**.
- Insert pin **C** from rear of rear bracket **19** and press pin **C** against pin hole **D** to hold brush **15**.
If brush **15** is worn and pin hole **D** gone, hold the end of brush **15** with pin **C**.
- After installation, slowly remove pin **C**.

ALTERNATOR <24V-50A, 24V-80A>

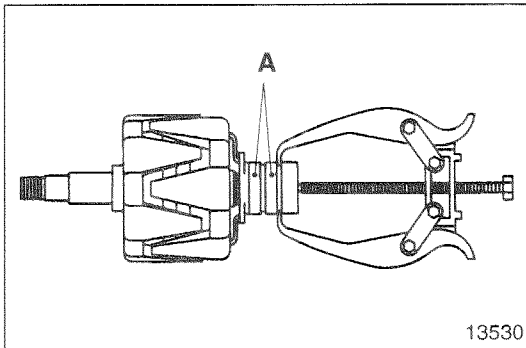


[Disassembly]

CAUTION

When rotor assembly 7 is held in a vice, make sure that base E of the lugs of the core is held.

If lugs F of the core are held, they will be broken or damaged.

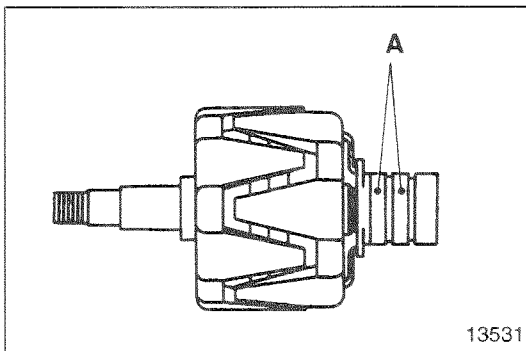


6 Removal of rear bearing

CAUTION

When the bearing puller is installed, use care to prevent damage to slip ring A.

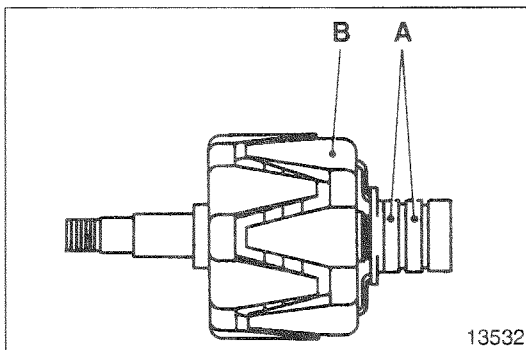
If the slip ring is damaged, the brush will fail to make good contact.



7 Inspection of rotor assembly

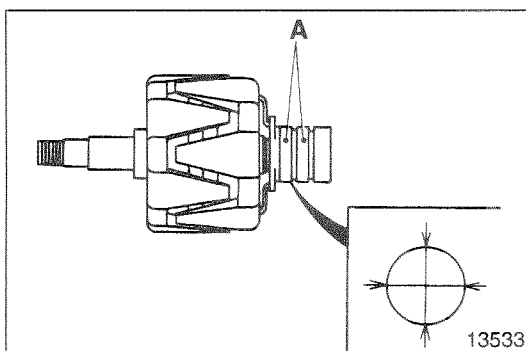
(1) Resistance of field coil

- Measure the resistance across slip ring A.
- If the reading is out of the standard value, replace rotor assembly 7.



(2) Continuity between slip ring and core

- Check to ensure that there is no continuity between slip ring A and core B.
- If there is continuity, it means a short circuit. Therefore, replace rotor assembly 7.

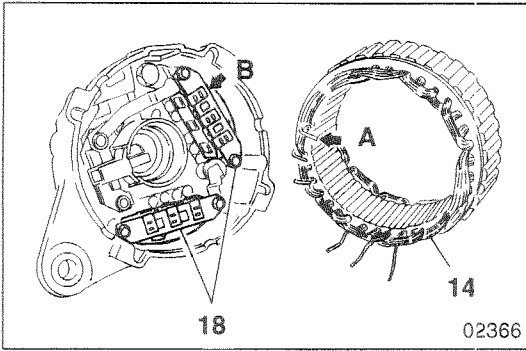


(3) Outside diameter of slip ring

- If the outside diameter of slip ring A is below the limit, replace rotor assembly 7.
- If the outside diameter of slip ring A is rough or unevenly worn, correct by grinding with emery paper or a lathe.

CAUTION

Do corrective grinding within the extent that the outside diameter of slip ring A does not exceed the limit.



14 Stator assembly

[Removal]

- Disconnect leads **A** and remove stator assembly **14** from rectifier **18**. The leads are soldered to diode leads **B** of the rectifier. (Six places)

CAUTION

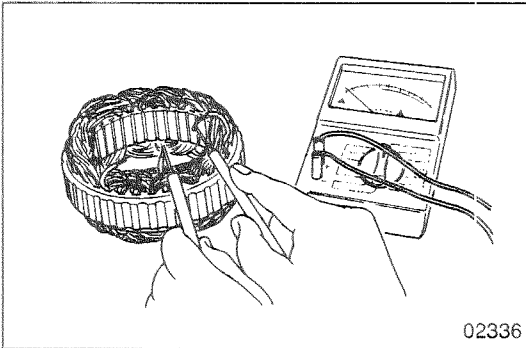
De-soldering should be done quickly (in about 5 seconds or less). The diodes will be damaged if heated for a longer time.

- For installation, reverse the order of removal.

[Inspection]

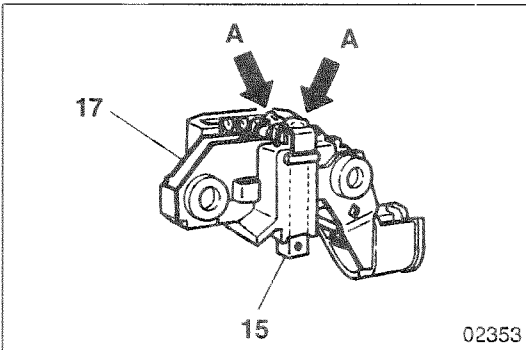
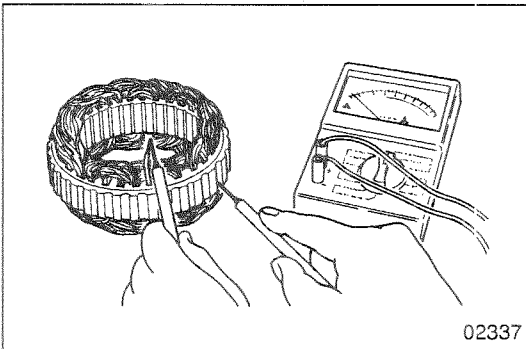
(1) Continuity between leads

- Check to ensure that there is continuity between each lead.
- If there is no continuity, the leads are open-circuited. Replace stator assembly **14**.



(2) Continuity between each lead and core

- Check to ensure that there is no continuity between each lead and the core.
- If there is continuity, it means a short circuit. Replace stator assembly **14**.



15 Brush

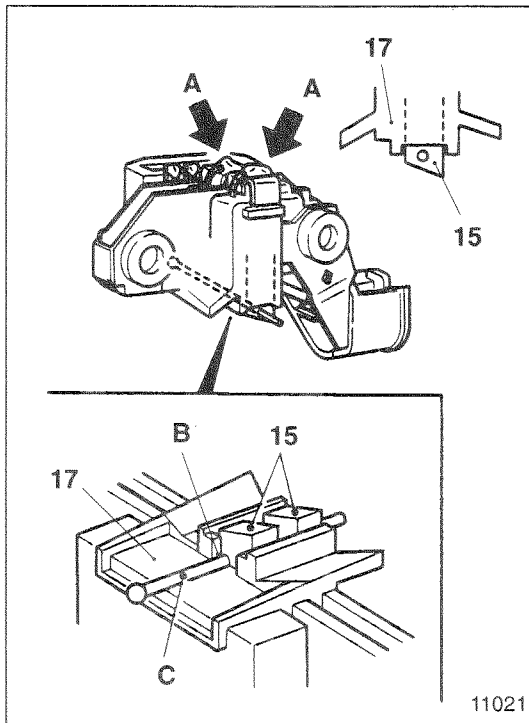
[Removal]

De-solder illustrated points **A** and remove brush **15** from regulator & brush holder **17**.

CAUTION

De-soldering should be done quickly (in about 5 seconds or less). The regulator will be damaged if heated for a longer time.

ALTERNATOR <24V-50A, 24V-80A>



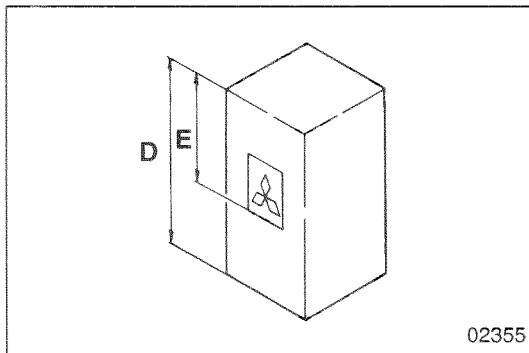
[Installation]

- Install brush 15 in regulator & brush holder 17 in the direction shown.
- Mount pin C in hole B of brush 15 to make sure that the brush does not protrude from regulator & brush holder 17.
- After installation, solder the leads of brush 15 to illustrated points A.

CAUTION

Soldering should be done quickly (in about 5 seconds or less).
The regulator will be damaged if heated for a longer time.

- After soldering, remove pin C.

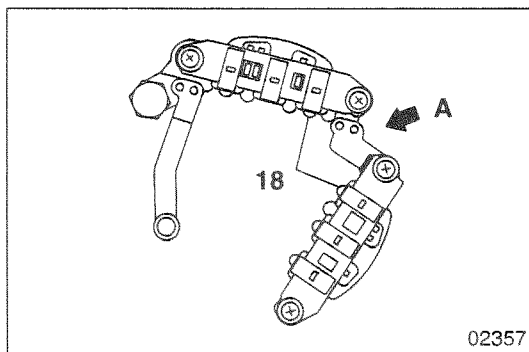


[Inspection]

If the length of brush 15 is less than the limit, replace.

D: Length when new

E: Service limit length



18 Rectifier

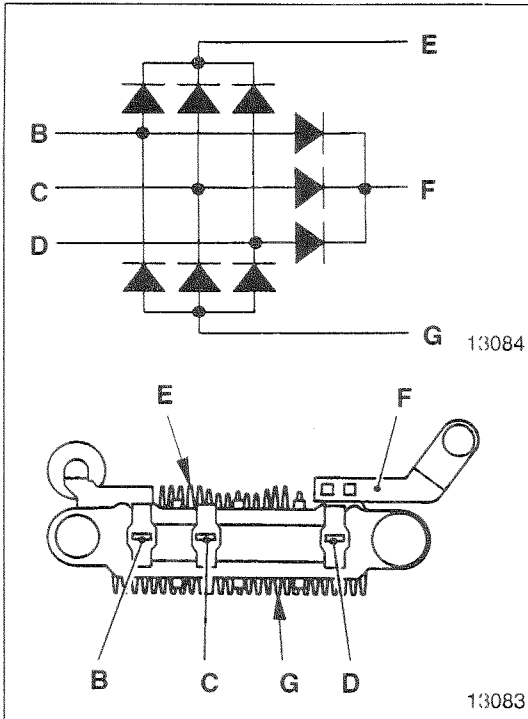
[Removal]

- Remove rectifier 18 by de-soldering illustrated portion A.

CAUTION

De-soldering should be done quickly (in about 5 seconds or less).
The diodes will be damaged if heated for a longer time.

- For installation, reverse the order of removal.



[Inspection]

- Check rectifier 18 to see if the internal diodes function properly, and replace if defective.

Resistance infinite in both cases...Open

Resistance close to 0 Ω in both cases...Short

B, C, D: Leads of stator coil connected

E, G: Heat sink portion

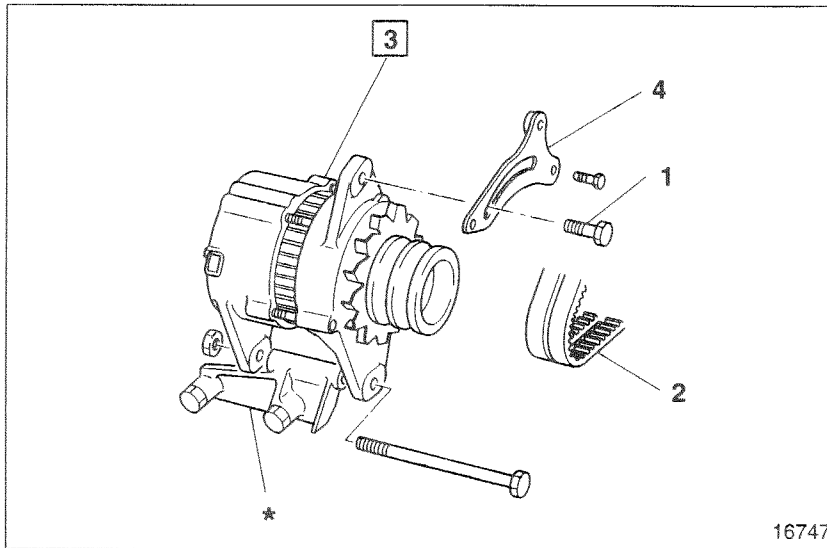
F: Regulator connected

- Exchange the \oplus and \ominus sides of the tester and perform checks in both cases.

CAUTION 

When a tester is used for the checks, the current that flows out from the tester is feeble than the current that normally flows through rectifier 18, so the tester may indicate a questionable resistance value. In a low range, this tendency will be stronger. Therefore, it is advisable to use the highest possible range.

ALTERNATOR <12V-80A>



● Removal sequence

- 1 Adjust bolt
- 2 V-belt
- 3 Alternator assembly P54-54
- 4 Adjust plate

* Alternator bracket

WARNING

Before removing alternator 3, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● Installation sequence

Follow the removal sequence in reverse.

● Adjustment after installation

Adjust the tension of V-belt 2. Gr 14

Service standards

| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|--|----------|----------------|-------|---------|
| 3 | Alternator output current (* When hot, when 13.5V is generated) | 1500 rpm | 38A or more | — | Check |
| | | 2500 rpm | 65A or more | — | |
| | | 5000 rpm | 76A or more | — | |
| | Regulator regulated voltage (5000 rpm, loads 5A or less) | | 14.7 ± 0.3V | — | Replace |

*: "When hot" refers to the state of the engine after 30 minutes of maximum output operation at 5000 rpm at a normal ambient temperature.

◆ Service procedure

3 Inspection of alternator

(1) Inspection of performance of alternator

(Inspection by test bench)

- Wire alternator **3** as shown.

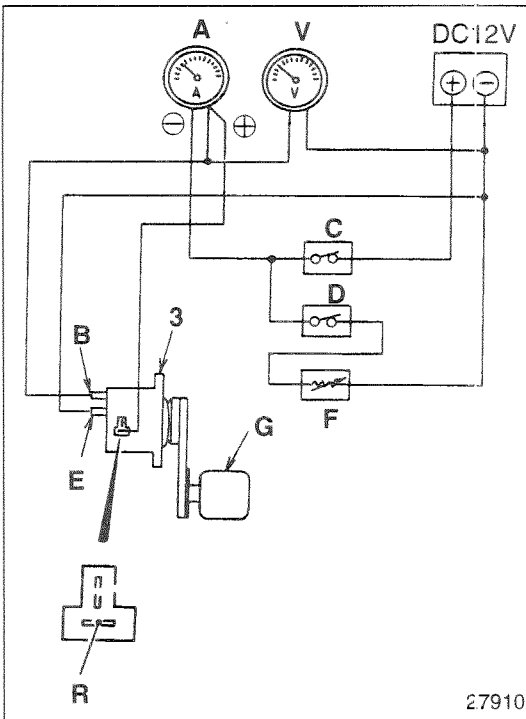
A: Ammeter
B: Alternator terminal B
C: Switch
D: Switch
E: Alternator terminal E
F: Load resistance (variable resistance)
G: Alternator drive motor
R: Alternator terminal R
V: Voltmeter

- Increase load resistance **F** to a maximum (where practically no load current flows).
- Set switch **C** and switch **D** to ON.
- Let alternator **3** warm up at 5000 rpm for 30 minutes.
- Adjust load resistance **F** so that the current will have the nominal value.

Nominal value of alternator current

12V-80A

- Measure the current with alternator **3** at each of the specified speeds.
- If the reading is out of the standard value, disassemble and check alternator **3**. P54-54



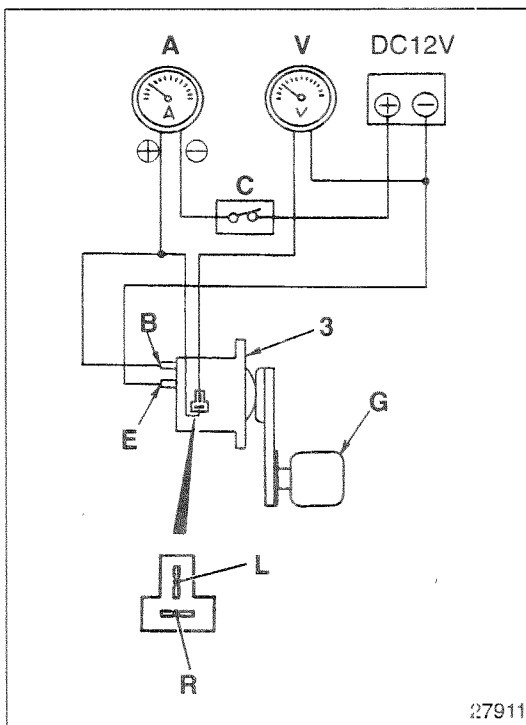
(2) Inspection of performance of regulator

(Inspection by test bench)

- Wire alternator **3** as shown.

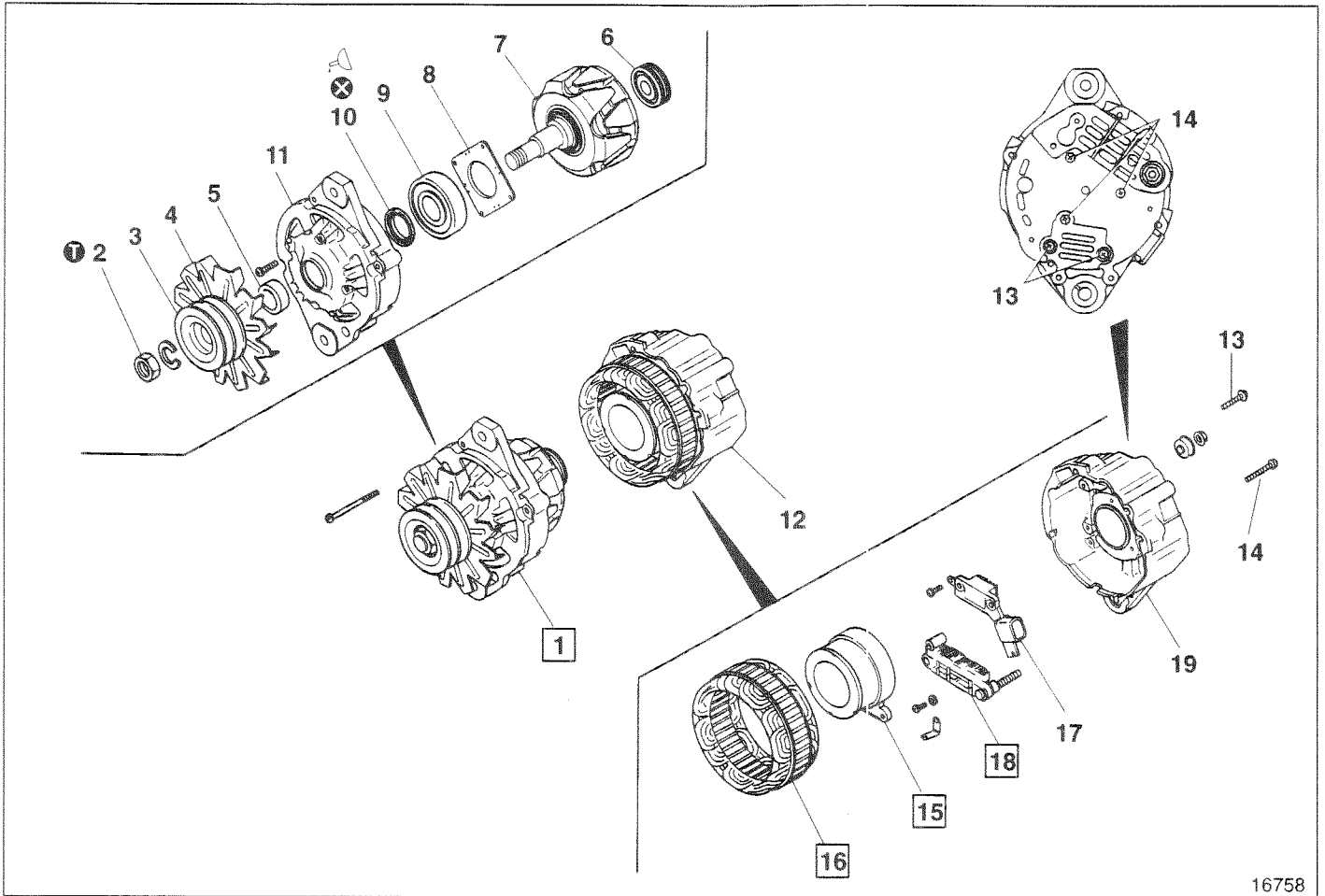
A: Ammeter
B: Alternator terminal B
C: Switch
E: Alternator terminal E
G: Alternator drive motor
L: Alternator terminal L
R: Alternator terminal R
V: Voltmeter

- Set switch **C** to ON.
- Let alternator **3** rotate at a low speed.
- Increase the rotating speed of alternator **3** to 5000 rpm and measure the voltage (regulated voltage). At the same time, check to ensure that the current value is 5A or less.
- If the readings are out of the standard values, proceed as described below.
 - If the readings exceed the standard values, replace the regulator.
 - If the readings are below the standard values, check all the parts of the alternator before replacing the regulator.



ALTERNATOR <12V-80A>

Alternator Assembly



16758

● Disassembly sequence

- | | | |
|----------------------------------|-----------------------------------|-----------------------|
| 1 Rotor & front bracket assembly | 8 Cover | 15 Field coil |
| 2 Nut | 9 Front bearing | 16 Stator assembly |
| 3 Pulley | 10 Oil seal | 17 Regulator |
| 4 Fan | 11 Front bracket | 18 Rectifier |
| 5 Spacer | 12 Stator & rear bracket assembly | 19 Rear bracket |
| 6 Rear bearing | 13 Screw | |
| 7 Rotor assembly | 14 Screw | ⊗ : Non-reusable part |

NOTE

Do not remove parts 6, 9 and 16 unless they are found to be defective.

● Reassembly sequence

12 → 1

12: 19 → 18 → 17 → 16 → 15 → 14 → 13

1: 11 → 10 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|---------------------------------|----------------|-------|---------|
| 15 | Field coil resistance (at 20°C) | 2.6 to 3.4 Ω | — | Replace |

Tightening torque

Unit: N·m {kgf·m}

| Location | Parts to be tightened | Tightening torque | Remarks |
|----------|-----------------------|---------------------------|---------|
| 2 | Nut (to mount pulley) | 132 to 162 {13.5 to 16.5} | — |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|-----------------------|-------------------------------------|-------------|
| 10 | Oil seal lip | Supplied with service part oil seal | As required |

◆ Service procedure

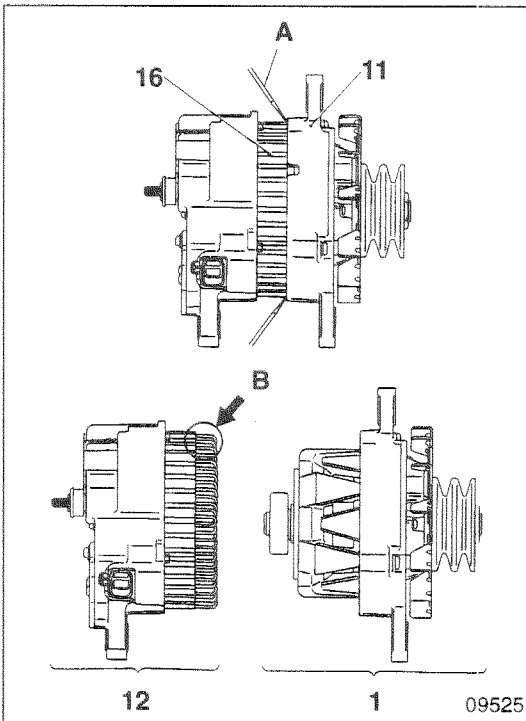
1 Rotor & front bracket assembly

[Removal]

- Insert a plain screwdriver **A** between front bracket **11** and stator assembly **16**.
- While wrenching plain screwdriver **A**, remove rotor & front bracket assembly **1** from stator & rear bracket assembly **12**.

CAUTION

If plain screwdriver **A** is inserted too far, coil **B** of stator assembly **16** might be damaged and short-circuited.

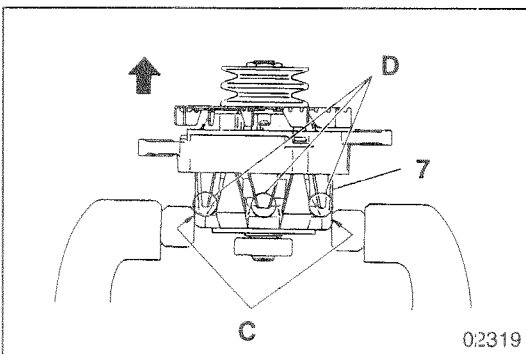


[Disassembly]

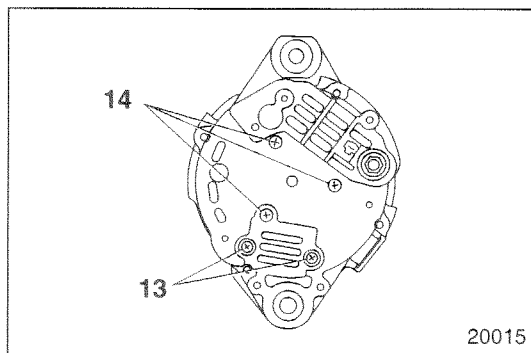
CAUTION

When rotor assembly **7** is held in a vice, make sure that base **C** of the lugs of the core is held.

If lugs **D** of the core are held, they will be broken or damaged.



ALTERNATOR <12V-80A>



15 Field coil

[Removal]

- Remove two screws 13.

CAUTION ⚠

If screws 14 are removed first, the weight of field coil 15 will act on the lead portion secured by screws 13, and damage to the lead portion may result. Therefore, make sure that screws 13 are removed first.

- Remove three screws 14.

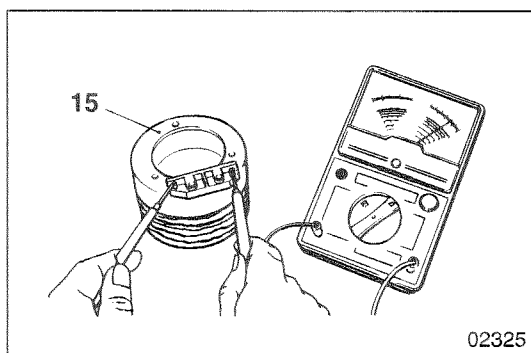
CAUTION ⚠

When screws 14 are removed, field coil 15 will fall under its own weight. Therefore, hold the field coil by hand beforehand.

- Remove field coil 15.

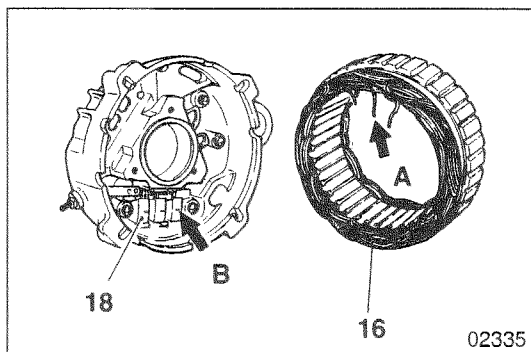
CAUTION ⚠

When field coil 15 is taken out, the coil lead portion may be caught by the stator coil. Don't pull it out with undue force.



[Inspection]

- Measure the resistance between terminals of field coil 15.
- If the reading is out of the standard value, replace field coil 15.



16 Stator assembly

[Removal]

- Disconnect leads A and remove stator assembly 16 from rectifier 18. The leads are soldered to diode leads B of the rectifier. (Three places)

CAUTION ⚠

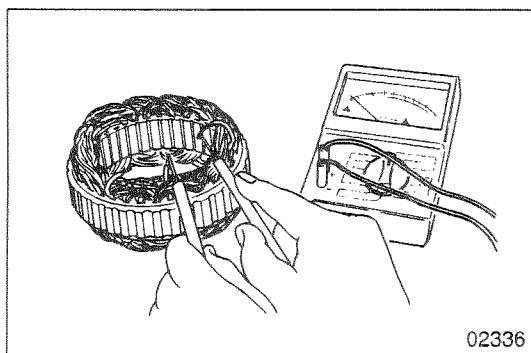
De-soldering should be done quickly (in about 5 seconds or less). The diodes will be damaged if heated for a longer time.

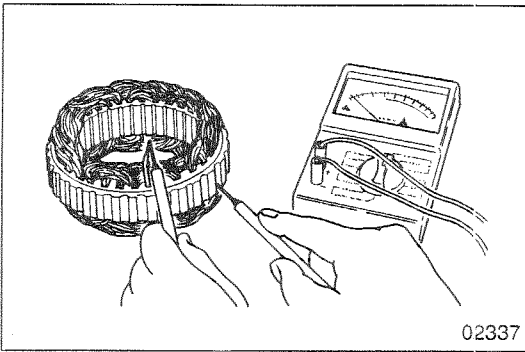
- For installation, reverse the order of removal.

[Inspection]

(1) Continuity between leads

- Check to ensure that there is continuity between each lead.
- If there is no continuity, the leads are open-circuited. Replace stator assembly 16.





(2) Continuity between each lead and core

- Check to ensure that there is no continuity between each lead and the core.
- If there is continuity, it means a short circuit. Replace stator assembly 16.

18 Inspection of rectifier

- Check rectifier 18 to see if the internal diodes function properly, and replace if defective.

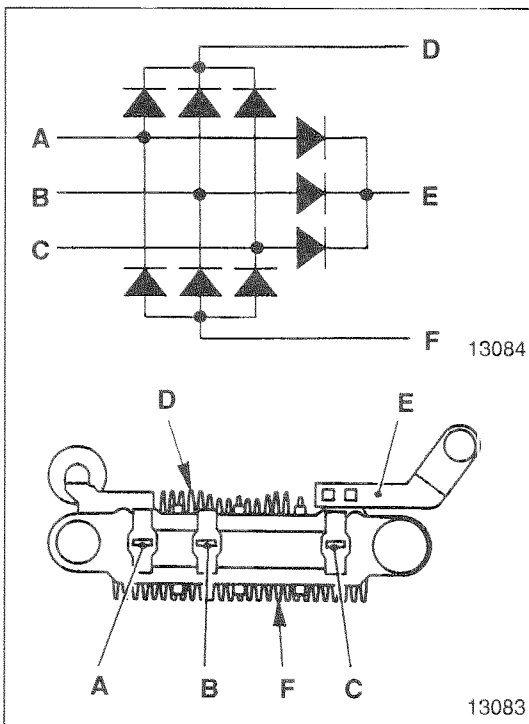
Resistance infinite in both cases...Open
Resistance close to 0 Ω in both cases...Short

A, B, C: Leads of stator coil connected
D, F: Heat sink portion
E: Regulator connected

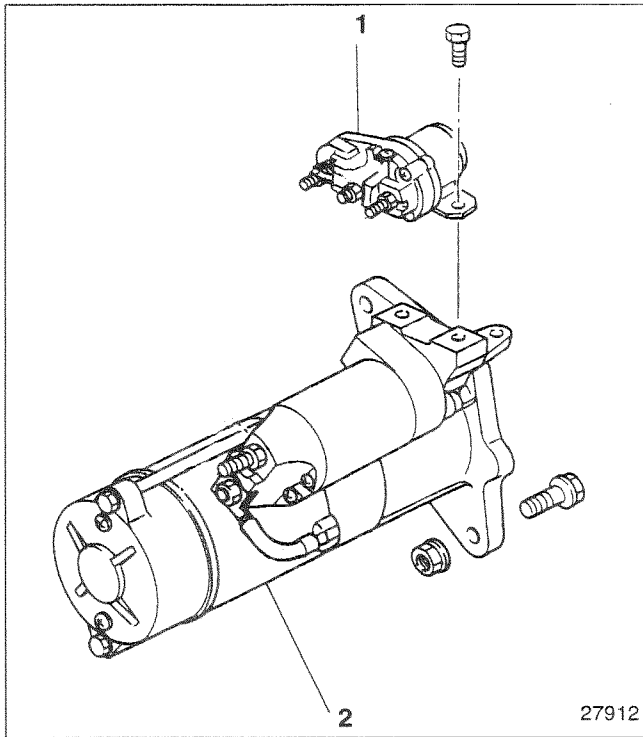
- Exchange the \oplus and \ominus sides of the tester and perform checks in both cases.

CAUTION

When a tester is used for the checks, the current that flows out from the tester is feebler than the current that normally flows through rectifier 18, so the tester may indicate a questionable resistance value. In a low range, this tendency will be stronger. Therefore, it is advisable to use the highest possible range.



STARTER <M8T80171: 24V-3.2kW, M8T60271: 24V-5kW, M8T87171: 24V-5kW>



● Removal sequence

- 1 Glow relay
- 2 Starter assembly P54-60

WARNING

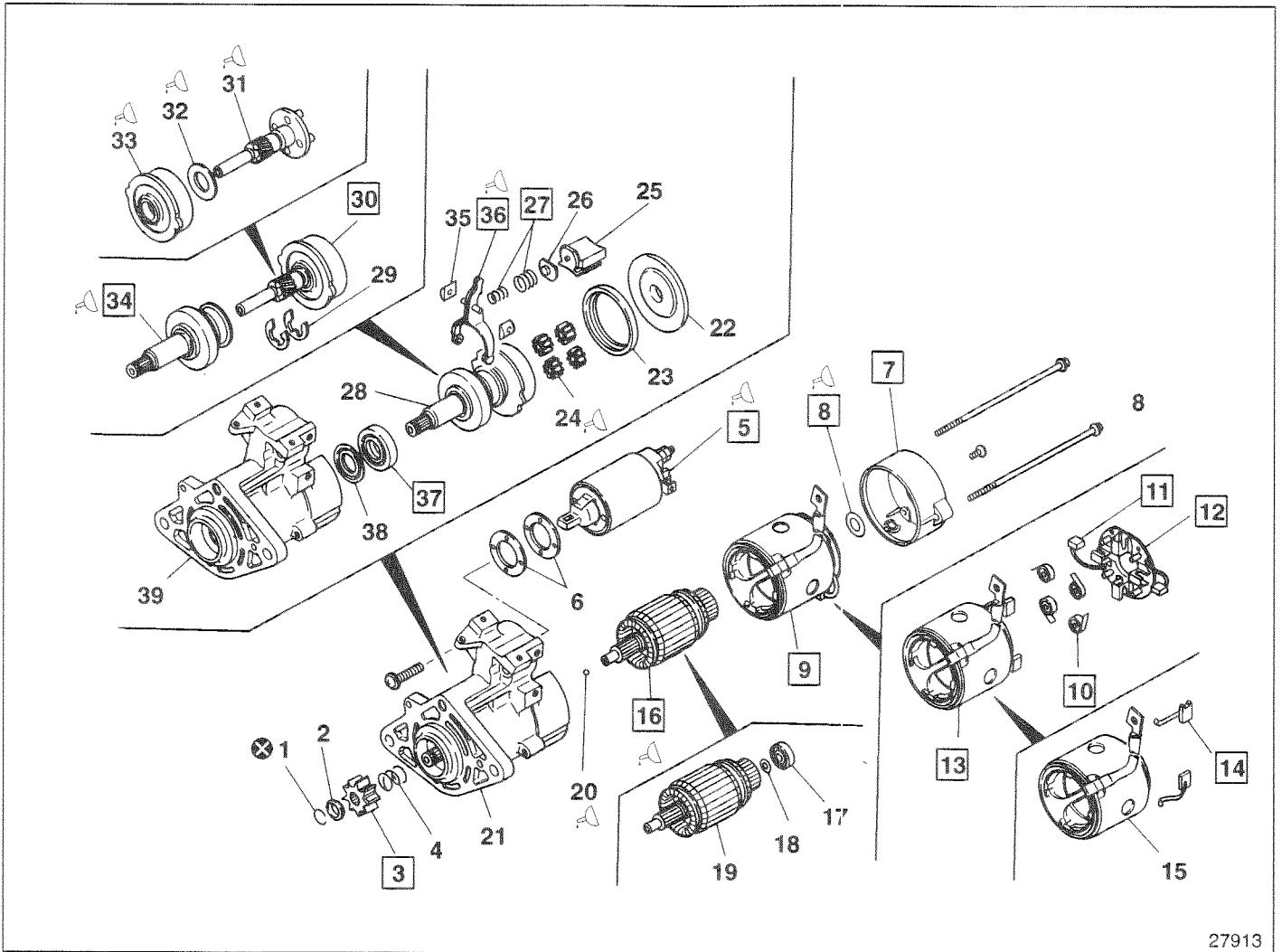
Before removing starter 3, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● Installation sequence

Follow the removal sequence in reverse.

MEMO

Starter Assembly



27913

● **Disassembly sequence**

- | | | |
|--------------------------------|--|---------------------------------------|
| 1 Stopper ring | 16 Armature assembly | 30 Gearshaft & internal gear assembly |
| 2 Pinion stopper | 17 Rear bearing | 31 Gearshaft |
| 3 Pinion | 18 Washer | 32 Washer |
| 4 Spring | 19 Armature | 33 Internal gear |
| 5 Magnet switch | 20 Ball | 34 Overrunning clutch |
| 6 Shim | 21 Front bracket assembly | 35 Holder |
| 7 Rear bracket | 22 Cover | 36 Lever |
| 8 Conical washer <M8T87171> | 23 Rubber packing | 37 Front bearing |
| 9 Yoke & brush holder assembly | 24 Planetary gear | 38 Dust seal <M8T87171> Oil seal |
| 10 Brush spring | 25 Rubber packing | <M8T80171, M8T60271> |
| 11 Brush ⊖ | 26 Plate | 39 Front bracket |
| 12 Brush holder assembly | 27 Spring <M8T80171, M8T60271> | |
| 13 Yoke assembly | 28 Gearshaft & overrunning clutch assembly | |
| 14 Brush ⊕ | 29 E-ring | |
| 15 Yoke | | |

⊗: Non-reusable part

CAUTION 

- Do not remove bearings 17 and 37 unless they are found to be defective.
- When armature assembly 16 is removed, ball 20 may simultaneously come out. Be careful not to lose it.
- When the motor section only is to be disassembled and checked like when the brushes and surrounding areas are to be checked, pinion 3 need not be removed.
Except in the above case, pinion 3 must be removed before disassembly of the individual portions.


● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION 

When magnet switch 5 was replaced, be sure to adjust the pinion gap.

● Inspection after assembly

 P54-62

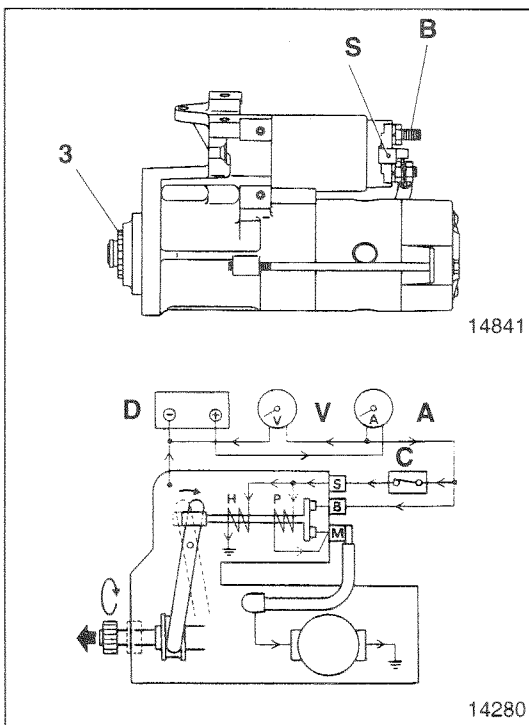
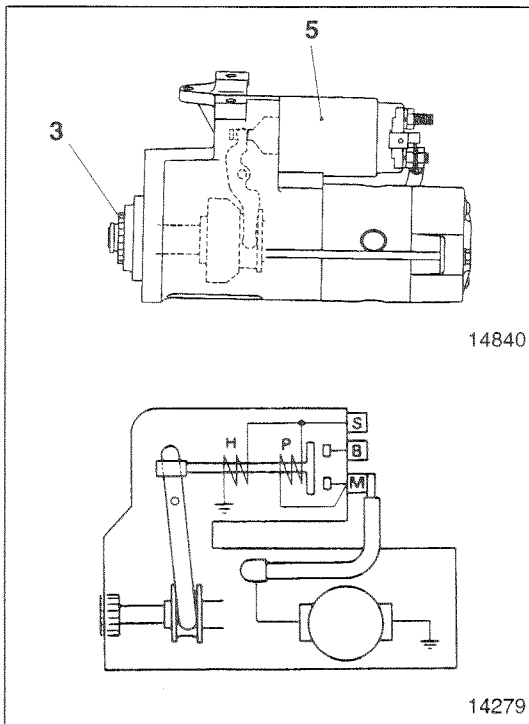
Service standards

Unit: mm

| Location | Maintenance item | | | Standard value | Limit | Remedy | |
|----------|---|-------------------|----------------|-----------------------------|------------------|-------------------|---|
| — | Pinion gap | | | 0.5 to 2.0 | — | Adjust | |
| — | No-load characteristics | During 23V supply | Current | 80A or less | — | Check | |
| | | | Rotating speed | M8T60271 | 3300 rpm or more | | — |
| | | | | M8T80171 | 3000 rpm or more | | — |
| | | | | M8T87171 | 3700 rpm or more | | — |
| 10 | Spring pressure of brush spring | | M8T80171 | 26 to 36 N {2.7 to 3.7 kgf} | 15 N {1.5 kgf} | Replace | |
| | | | M8T60271 | 29 to 39 N {3 to 4 kgf} | 20 N {2 kgf} | | |
| | | | M8T87171 | | | | |
| 11, 14 | Brush length | | | 18 | 11 | Replace | |
| 16 | Outside diameter of commutator | | | 32 | 31.4 | Replace | |
| | Commutator outer circumferential runout | | | — | 0.1 or more | | |
| | Depth of mica between segments | | | — | 0.2 or less | Repair or replace | |

 Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---------------------|-------------|
| 5 | Lever contacting portion of magnet switch. | MULTEMP PS-2 | As required |
| 8 | Conical washer <M8T87171> | MULTEMP PS-2 | As required |
| 16, 24 | Teeth of gears of armature assembly | MOLYCOAT ® AG650 | As required |
| 16, 31 | Sliding surfaces of armature assembly and gearshaft | MOLYCOAT ® AG650 | As required |
| 20 | Apply to ball | MOLYCOAT ® AG650 | As required |
| 24, 33 | Teeth of planetary gear and internal gear | MOLYCOAT ® AG650 | As required |
| 31, 34 | Sliding surfaces of gearshaft and overrunning clutch | MULTEMP PS-2 | As required |
| 32 | Washer | MOLYCOAT ® AG650 | As required |
| 34 | Splined portion of overrunning clutch | MULTEMP PS-2 | As required |
| 36 | Overrunning clutch sliding surfaces of lever | MULTEMP PS-2 | As required |



◆ Service procedure

● Inspection after assembly

After assembly, check the starter by supplying current.

WARNING ⚠

- When current is supplied to the starter, pinion 3 will spring out and rotate. Be careful not to touch it by hand.
- Magnet switch 5 may be very hot after the end of inspection. Be careful when you touch it.

CAUTION ⚠

- The time during which current is supplied to the starter should be limited to 10 seconds or less on the pull-in coil P side and 30 seconds or less on the holding coil H side. If current is supplied to the coils for a longer period, the coils will be overheated and seized.
- When current is supplied to the starter, a large current that exceeds 100A will flow. When the starter is inspected, therefore, use thick cables like booster cables. Check to ensure that all the connections are tight and secure.

(1) Performance test

- Wire the starter as shown.

A: Ammeter

D: DC power supply

B: Starter terminal B

S: Starter terminal S

C: Switch

V: Voltmeter

- Set the voltage at 23V DC.

CAUTION ⚠

The voltage that is applied should be limited to 24V maximum.

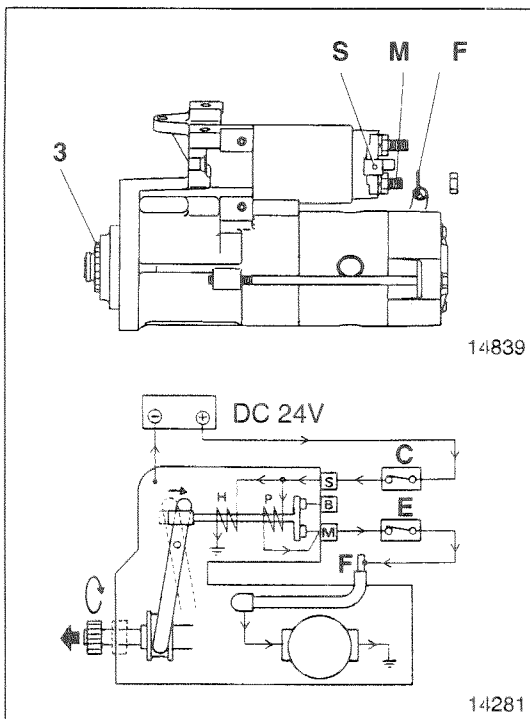
- The following operations are performed by supplying current to the starter. It is therefore necessary that the series of operations ranging from measuring the current that flows through the starter to measuring the rotating speed are completed in less than 30 seconds.
 - Set switch C to ON to supply current to the starter. At the time, pinion 3 will spring out and rotate.

CAUTION ⚠

When switch C is set to ON, current is supplied to both pull-in coil P and holding coil H. When the large current from DC power supply D is supplied from terminal B of the starter to terminal M, the current to the pull-in coil is interrupted, and current flows to the holding coil only.

To prevent seizing the holding coil, therefore, all the operations must be completed in less than 30 seconds.

- Measure the current and rotating speed of the starter. Measure the rotating speed of the starter by illuminating pinion 3 with a stroboscope.
- Set switch C to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, disassemble and check the starter.



(2) Pinion gap

[Inspection]

- Wire the starter as shown.

C: Switch
E: Switch
F: Cable
M: Starter terminal M
S: Starter terminal S

- The following operations are performed by supplying current to the starter. It is therefore necessary that the series of operations up to completion of measurement of the pinion gap are completed in less than 30 seconds.
- Set switch **C** and switch **E** to ON to supply current to the starter. At the time, pinion **3** will spring out and rotate.

- Immediately (in less than 5 seconds) after pinion **3** has started rotation, set switch **E** to OFF stop rotation of the pinion.

CAUTION

When switch **C** and switch **E** are set to ON, current is supplied to both pull-in coil **P** and holding coil **H**. Since wiring is such that no voltage is applied to terminal **B** of the starter, current flows to the pull-in coil during rotation of pinion **3**.

To prevent seizing the pull-in coil, therefore, it is necessary that switch **E** is set to OFF immediately (in less than 5 seconds) after the pinion has started rotating.

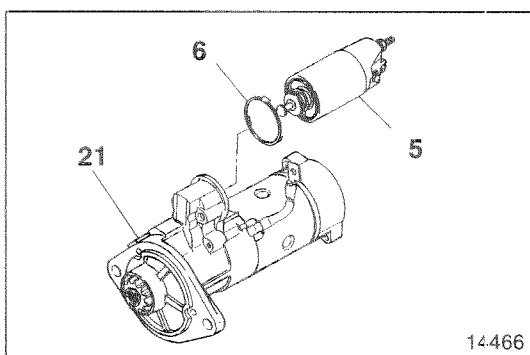
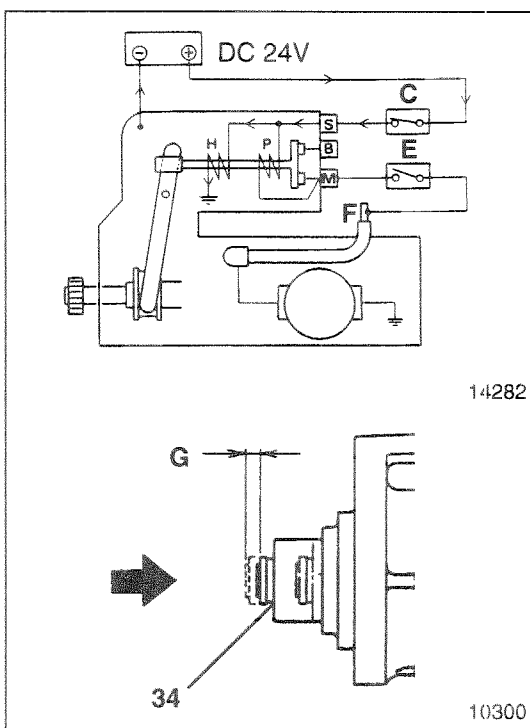
- Lightly push the end of overrunning clutch **34** in and measure amount **G** the clutch moves in the axial direction (pinion gap).
- Set switch **C** to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, adjust by the following procedures.

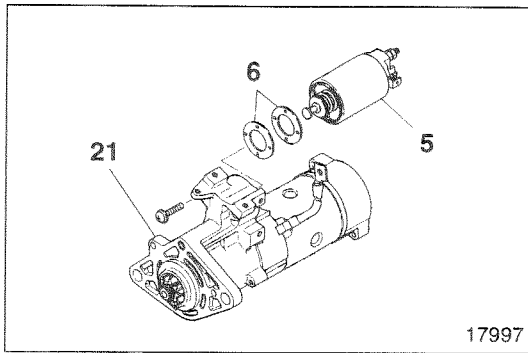
[Adjustment]

<M8T60271, M8T87171>

- Remove magnet switch **5** from front bracket assembly **21**.
- Adjust by changing the thickness of shim **6**.
Increasing the number of shims reduces pinion gap **G**.

Types of shims: 0.25, 0.5 mm

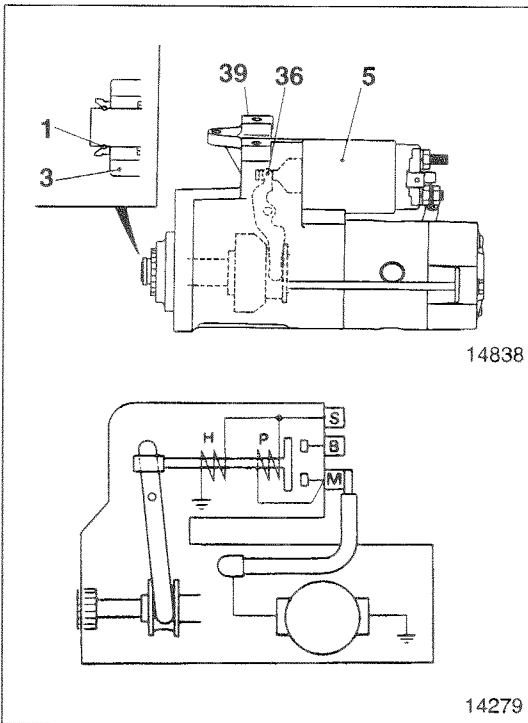




<M8T80171>

- Remove magnet switch 5 from front bracket assembly 21.
- Adjust by changing the thickness of shim 6.
Increasing the number of shims reduces pinion gap G.

Types of shims: 0.25, 0.5 mm



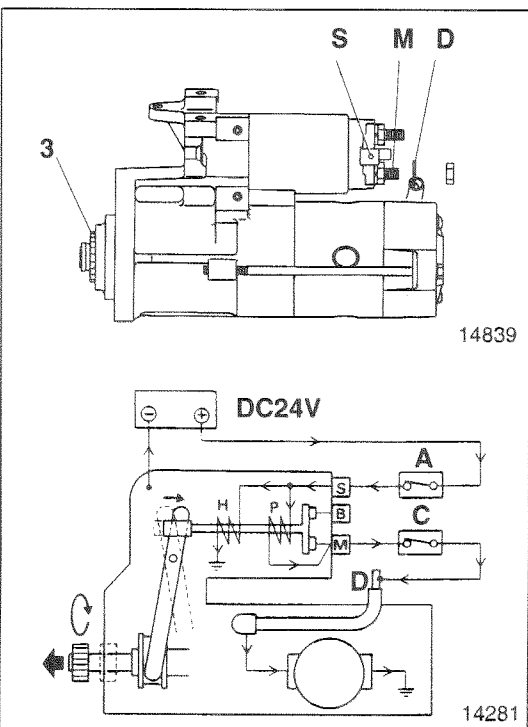
3 Pinion

[Removal]

To remove pinion 3, it is necessary to supply current to the starter and let the pinion spring out.

CAUTION ⚠

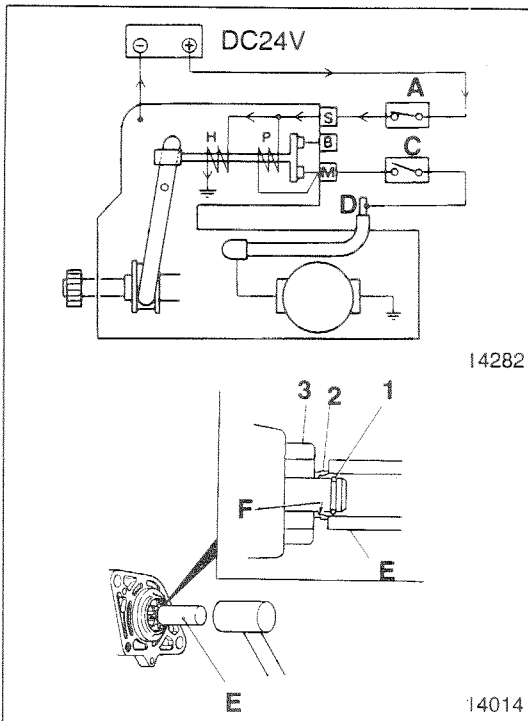
- When current is supplied to the starter, pinion 3 will spring out and rotate. Be careful not to touch it by hand.
- Magnet switch 5 may be very hot after the end of inspection. Be careful when you touch it.
- The time during which current is supplied to the starter should be limited to 10 seconds or less on the pull-in coil P side and 30 seconds or less on the holding coil H side. If current is supplied to the coils for a longer period, the coils will be overheated and seized.
- Make sure that pinion 3 is made to spring out by supplying current to the starter. If the pinion is forced out by pulling lever 36 without supplying current to the starter, front bracket 39 and lever could be damaged by the impact produced when the stopper ring 1 is removed.
- When current is supplied to the starter, a large current that exceeds 100A will flow. When the starter is inspected, therefore, use thick cables like booster cables. Check to ensure that all the connections are tight and secure.



- Wire the starter as shown.

- A: Switch
- C: Switch
- D: Cable
- M: Starter terminal M
- S: Starter terminal S

- The following operations are performed by supplying current to the starter. It is therefore necessary that the series of operations up to removal of the pinion 3 are completed in less than 30 seconds.
 - Set switch A and switch C to ON to supply current to the starter. At the time, pinion 3 will spring out and rotate.



- Immediately (in less than 5 seconds) after pinion 3 has started rotating, set switch C to OFF to stop rotation of the pinion.

CAUTION

When switch A and switch C are set to ON, current is supplied to both pull-in coil P and holding coil H. Since wiring is such that no voltage is applied to terminal B of the starter, current flows to the pull-in coil during rotation of pinion 3.

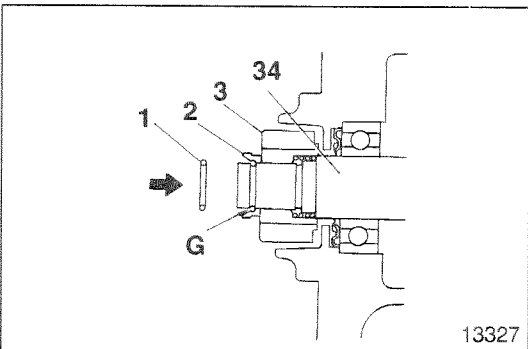
To prevent seizing the pull-in coil, therefore, it is necessary that switch C is set to OFF immediately (in less than 5 seconds) after the pinion has started rotating.

- Set pipe-like tool E on pinion stopper 2.
- Lightly strike tool E with a hammer to remove stopper ring 1 from ring groove F of pinion stopper 2.
- Remove stopper ring 1 and remove pinion 3.
- Set switch A to OFF to stop supplying current to the starter.

CAUTION

When the power supply to the starter is stopped, pinion 3 may move in and stopper ring 1 may fit in ring groove F of pinion stopper 2 again.

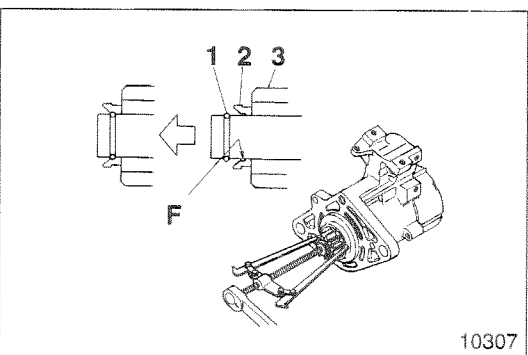
In this case, repeat the operations by supplying current to the starter.



[Installation]

To install pinion 3, it is not necessary to supply current to the starter.

- Install pinion stopper 2 and pinion 3 on overrunning clutch 34 in the direction shown.
- Set stopper ring 1 in ring groove G of overrunning clutch 34.

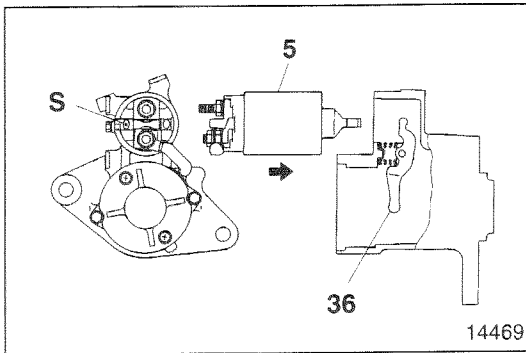


- Pull pinion 3 strongly to make sure that stopper ring 1 securely fits in ring groove F of pinion stopper 2.

5 Magnet switch

[Installation]

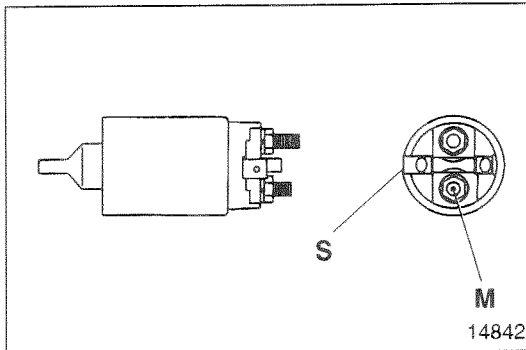
Install magnet switch **5** on lever **36** with terminal **S** in the direction shown.



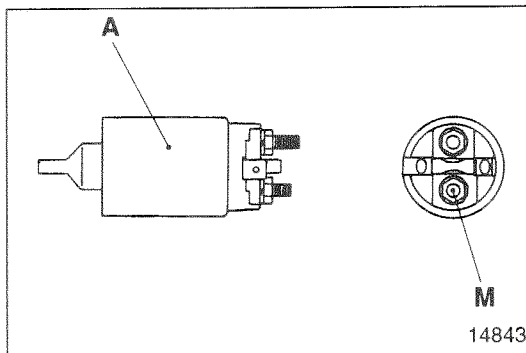
[Inspection]

(1) Open circuit test on coil

- Check to ensure that there is continuity between terminals **S** and **M**.
- If there is no continuity, replace magnet switch **5**.

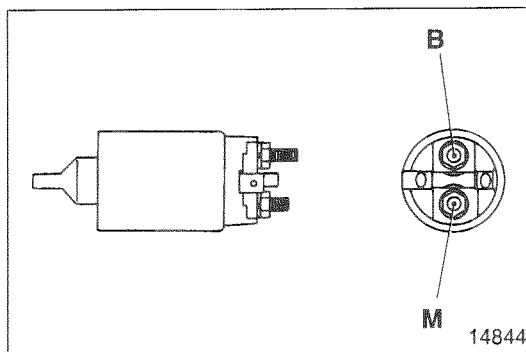


- Check to ensure that there is continuity between terminal **M** and body **A**.
- If there is no continuity, replace magnet switch **5**.



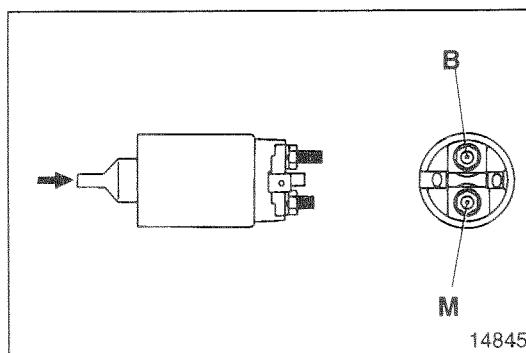
(2) Contact fusion check

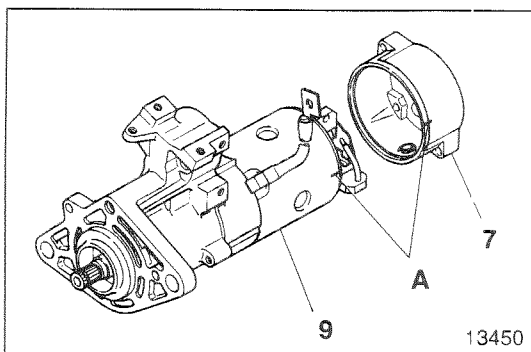
- Check to ensure that there is no continuity between terminals **B** and **M**.
- If there is continuity, replace magnet switch **5**.



(3) Contact contacting check

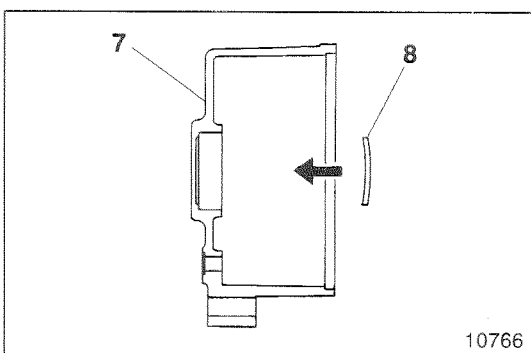
- Push the end of magnet switch **5** in to close the internal contact. In this state, check to ensure that there is continuity between terminals **B** and **M**.
- If there is no continuity, replace magnet switch **5**.





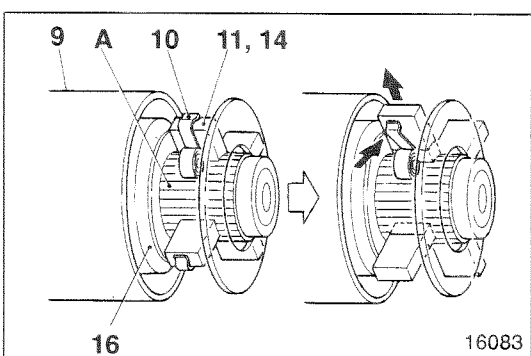
7 Installation of rear bracket

A: Alignment marks



8 Installation of conical washer <M8T87171>

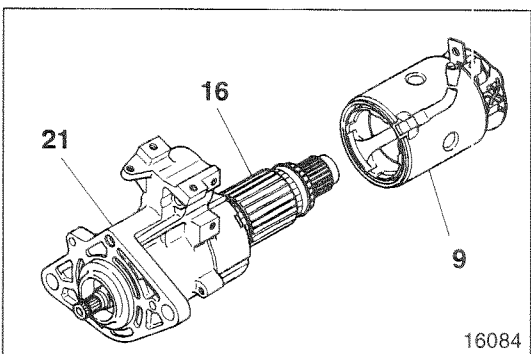
Install conical washer 8 in the illustrated direction in rear bracket 7.



9 Removal of yoke & brush holder assembly

To remove yoke & brush holder assembly 9, proceed as described below, while using care to prevent damage to commutator A of armature assembly 16 by brushes 11 and 14.

- Keep brushes 11 and 14 apart from commutator A and hold brush spring 10 alongside brushes.

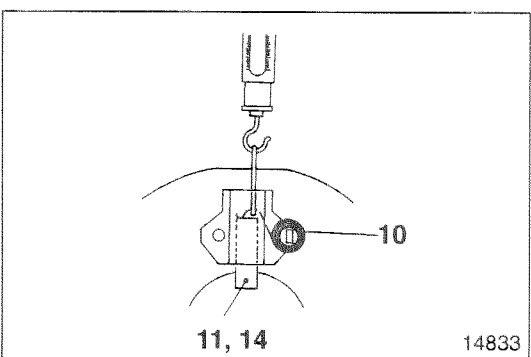


- Remove yoke & brush holder assembly 9 from front bracket assembly 21.

CAUTION

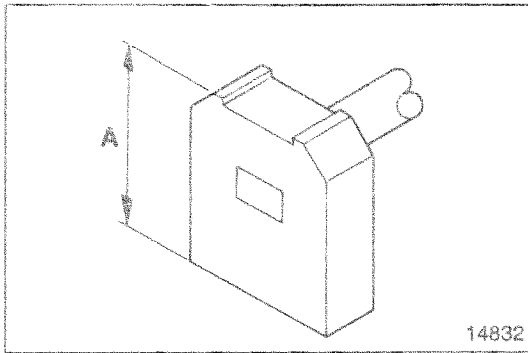
When yoke & brush holder assembly 9 is removed, do not tilt it downward. Otherwise, armature assembly 16 may fall down.

- For installation, reverse the order of removal.



10 Inspection of brush spring

- Use new brushes 11 and 14 and measure the load at the moment the brush spring 10 leaves the brushes as shown.
- If the reading is less than the limit, replace brush spring 10.



14832

11 14 Inspection of brush

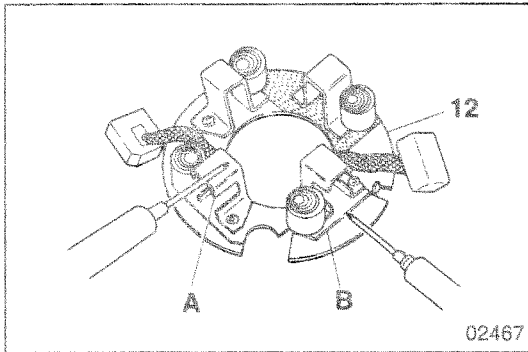
(1) Length of brush

If the reading is less than the limit, replace the brushes 11 and 14.

A: Length of brush

CAUTION

To replace brush \ominus 11, replace brush holder assembly 12.



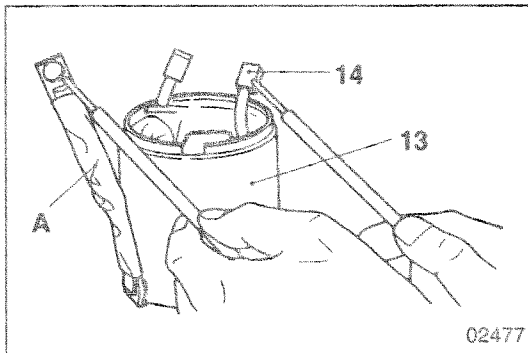
02467

(2) Commutator contacting surfaces

If the contacting surfaces are rough or unevenly worn, repair with emery paper (#300 to 500).

12 Inspection of brush holder assembly

- Check to ensure that there is no continuity between \oplus side brush holder A and \ominus side holder plate B after they have been cleaned.
- If there is continuity, it means a short circuit. Replace brush holder assembly 12.

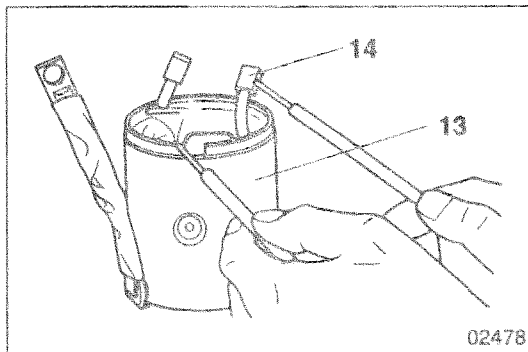


02477

13 Inspection of yoke assembly

(1) Open circuit test on coil

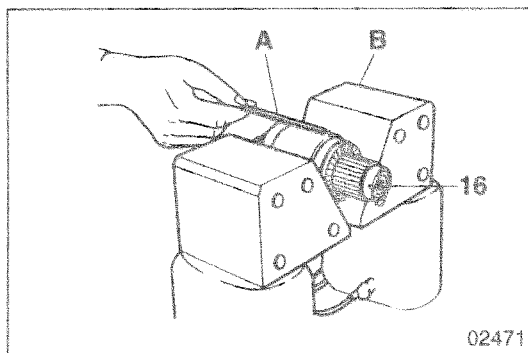
- Check to ensure that there is continuity between cable A and brush \oplus 14.
- If there is no continuity, it means an open circuit. Replace brush \oplus 14 or yoke assembly 13.



02478

(2) Earth test on coil

- Check to ensure that there is no continuity between yoke assembly 13 and brush \oplus 14.
- If there is continuity, it means a short circuit. Check the insulation. If repair is impossible, replace brush \oplus 14 or yoke assembly 13.



02471

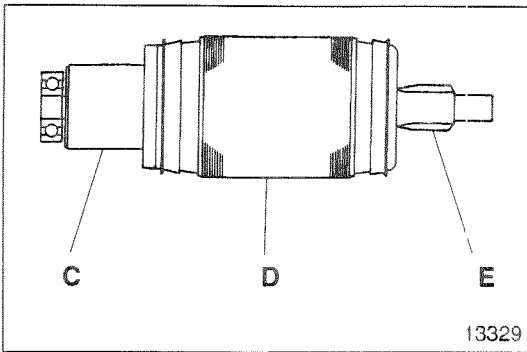
16 Inspection of armature assembly

(1) Short circuit test on coil

- Bring iron piece A close to armature assembly 16, keeping it in parallel.

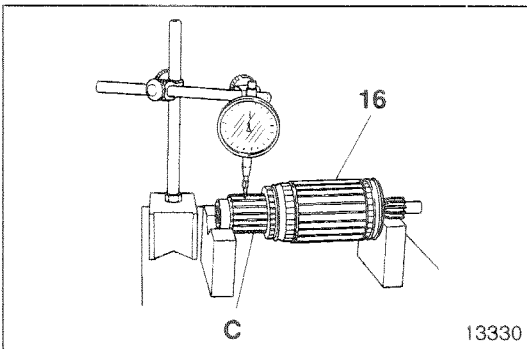
B: Armature tester

- Slowly rotate armature assembly 16 by hand.
- If iron piece A is attracted or vibrates, it means a short circuit. Replace armature assembly 16.



(2) Earth test on coil

- Check to ensure that there is no continuity between commutator **C** and core **D** (or shaft portion **E**).
- If there is continuity, it means a short circuit. Replace armature assembly **16**.

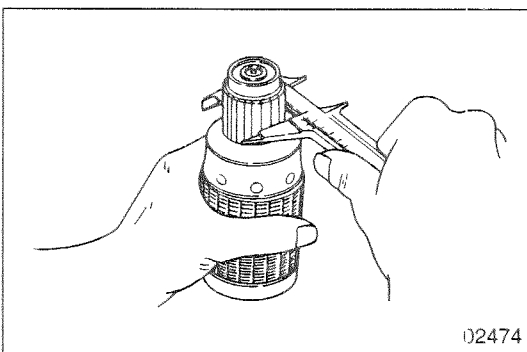


(3) Runout of commutator

If the reading is more than the limit, repair the outside diameter of the commutator portion **C** of armature assembly **16** within the limit.

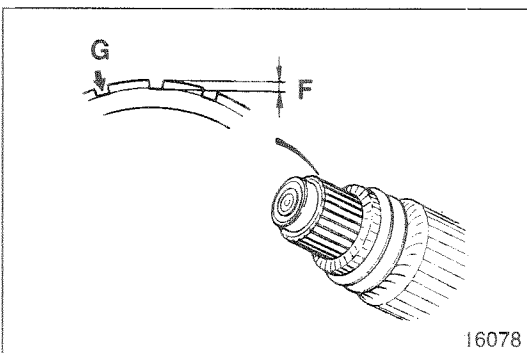
(4) Condition of commutator surface

- If the surface is rough or unevenly worn, repair with emery paper (#300 to 500).
- After the repair, be sure to check the runout of commutator portion **C** of armature assembly **16**.



(5) Outside diameter of commutator

If the reading is less than the limit, replace armature assembly **16**.



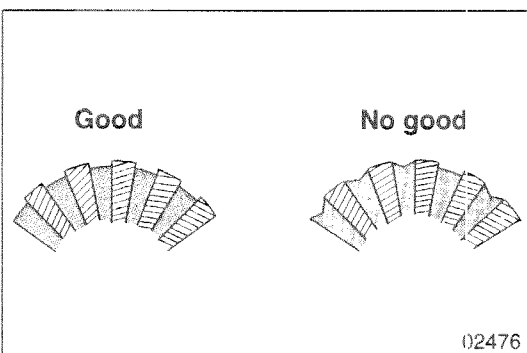
(6) Depth of mold between segments

Before inspection, clean the mold portions.

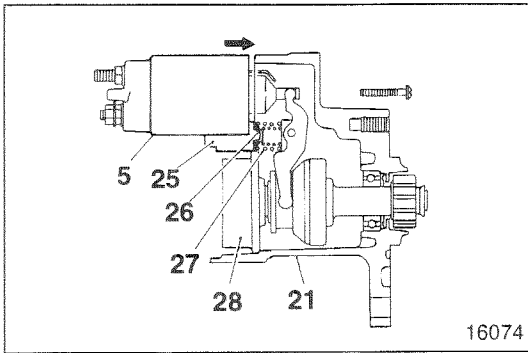
- If the reading is less than the limit, repair or replace armature assembly **16**.

F: Depth of mold

- Make repairs by grinding illustrated portion **G**.

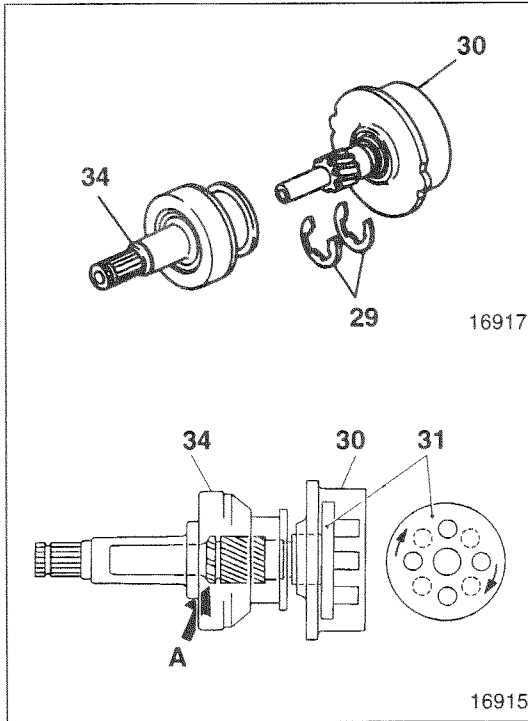


- If the mold portion is as shown, repair or replace armature assembly **16**.



27 Installation of spring

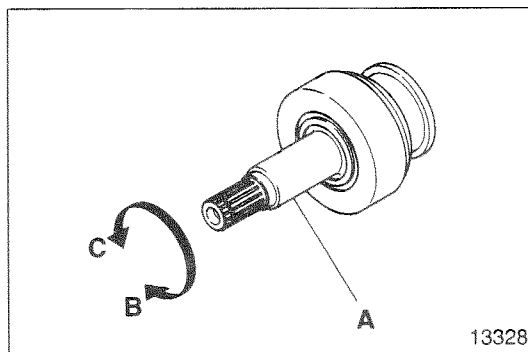
At the same time that magnet switch 5 is installed on the front bracket assembly, install spring 27 while pushing it in.



30 Removal of gearshaft & internal gear assembly

Remove E-ring 29 and remove gearshaft & internal gear assembly 30 from overrunning clutch 34. If splined portion A of gearshaft 31, which is caught inside the overrunning clutch 34, makes it impossible to remove gearshaft 31, proceed as follows:

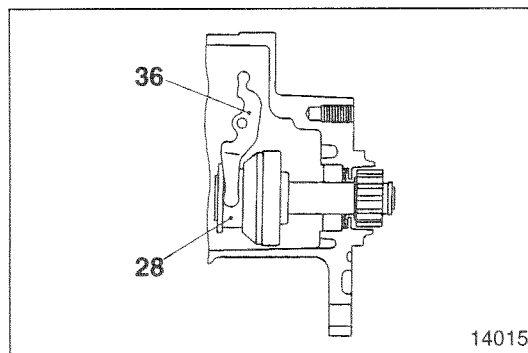
- Press gearshaft 31 against overrunning clutch 34.
- Give gearshaft 31 about 1/8 of a turn to move splined portion A, and remove gearshaft 31.



34 Inspection of overrunning clutch

Perform the following checks. If there is anything wrong, replace overrunning clutch 34.

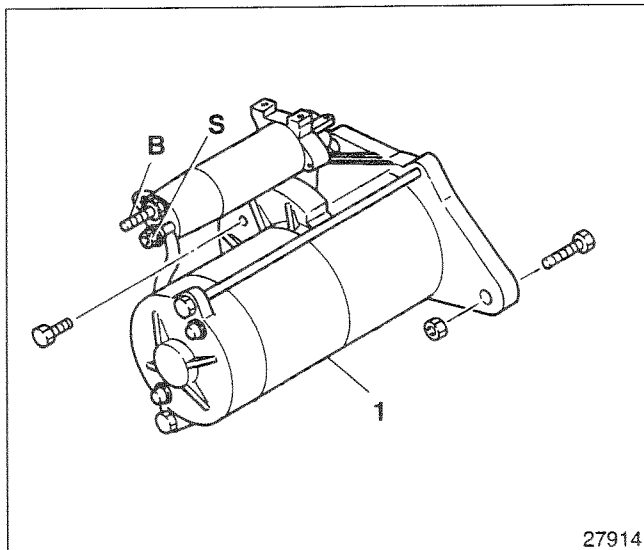
- Check to ensure that when shaft A is made to rotate in the direction B, it rotates smoothly.
- Check to ensure that when shaft A is made to rotate in the direction C, it is locked.



36 Installation of lever

Install lever 36 in the illustrated direction on gearshaft & overrunning clutch assembly 28.

STARTER <M2T54272: 12V-2kW, M2T64272: 24V-3.2kW, M2T67881: 24V-3.2kW, M2T78381: 24V-5kW, M3T57575: 24V-5kW>



● Removal sequence

- 1 Starter assembly P54-74

B: Terminal B

S: Terminal S

WARNING

- The battery voltage is always available at terminal B via starter relay. When the harness is removed from terminal B, if a tool comes into contact with the starter, it causes a short circuit and is dangerous.
- Before removing the harness from terminal B, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else.

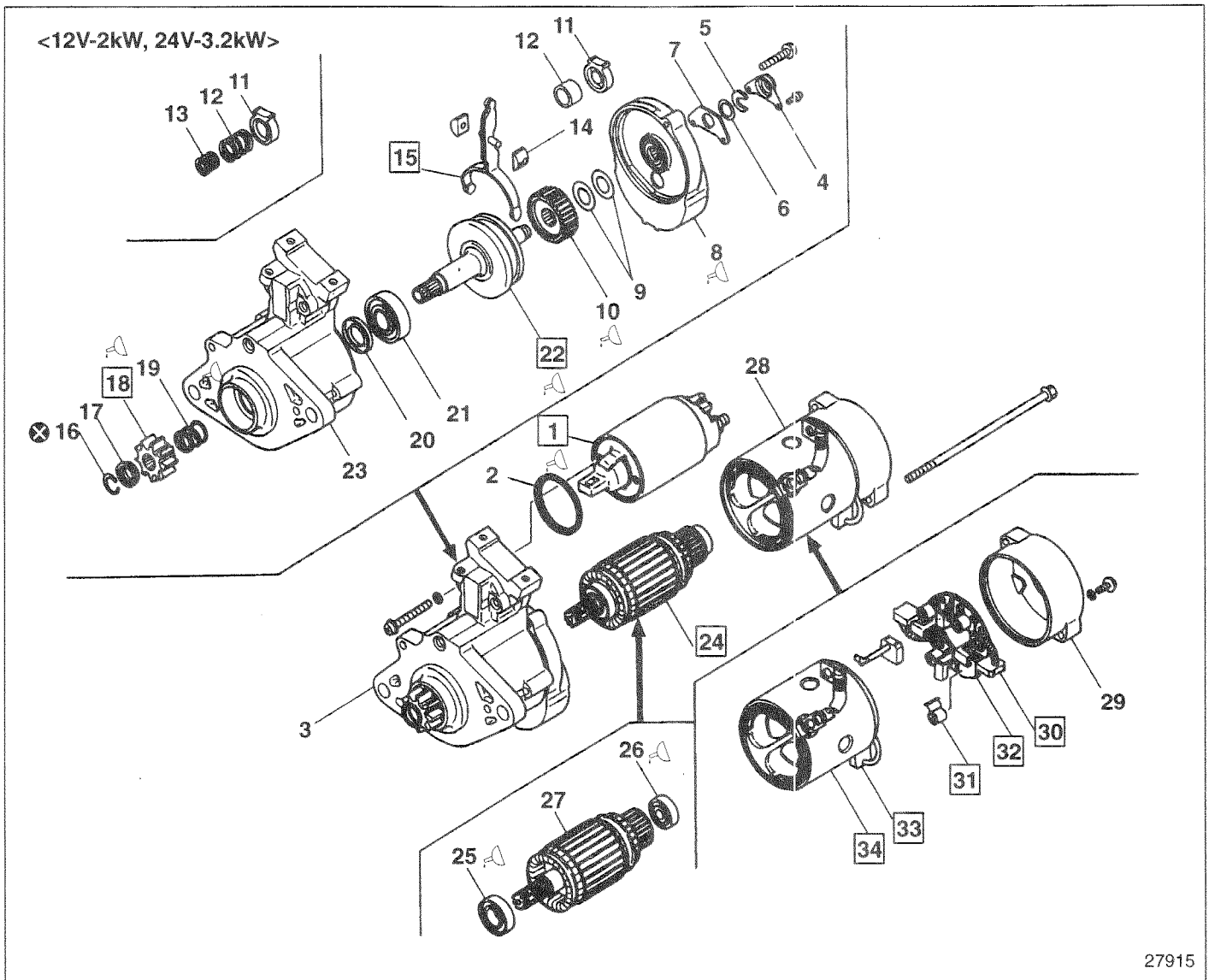
● Installation sequence

Follow the removal sequence in reverse.

MEMO

STARTER <M2T54272: 12V-2kW, M2T64272: 24V-3.2kW, M2T67881: 24V-3.2kW, M2T78381: 24V-5kW, M3T57575: 24V-5kW>

Starter Assembly



27915

● Disassembly sequence

- | | | |
|--------------------------|--------------------------|---------------------------------|
| 1 Magnet switch | 13 Inner spring | 25 Front bearing |
| 2 Shim | <24V-3.2kW, 12V-2.0kW> | 26 Rear bearing |
| 3 Front bracket assembly | 14 Bushing | 27 Armature |
| 4 Cover | 15 Lever | 28 Yoke & rear bracket assembly |
| 5 Stopper | 16 Stopper ring | 29 Rear bracket |
| 6 Washer | 17 Pinion stopper | 30 Brush ⊖ |
| 7 Plate | 18 Pinion | 31 Brush spring |
| 8 Center bracket | 19 Spring | 32 Brush holder assembly |
| 9 Adjust washer | 20 Oil seal | 33 Brush ⊕ |
| 10 Gear | 21 Front bearing | 34 Yoke assembly |
| 11 Packing | 22 Pinion shaft assembly | |
| 12 Shim <24V-5kW> | 23 Front bracket | |
| Outer spring | 24 Armature assembly | |
| <24V-3.2kW, 12V-2.0kW> | | |

⊗: Non-reusable part

CAUTION 

- Do not remove bearings 25 and 26 unless they are found to be defective.
- When yoke & rear bracket assembly 28 is removed from front bracket assembly 3, be careful not to allow armature assembly 24 to fall.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION 

When magnet switch 1 was replaced, be sure to adjust the pinion gap.

Service standards

Unit: mm

| Location | Maintenance item | | Standard value | Limit | Remedy | | |
|----------|---|----------------------|--------------------|-----------------------------|------------------|---------|--------------|
| — | Thrust gap of pinion shaft assembly | | 0.1 to 0.5 | — | Adjust | | |
| — | Pinion gap | | 0.5 to 2.0 | — | Adjust | | |
| — | No-load characteristics | M2T64272 M2T67881 | Driving 23V supply | Current | 80A or less | — | Check |
| | | | | Rotating speed | 3400 rpm or more | | |
| | | M2T78381 | Current | 65A or less | — | Check | |
| | | | Rotating speed | 4250 rpm or more | | | |
| | | M3T57575 | Current | 85A or less | — | Check | |
| | | | Rotating speed | 3300 rpm or more | | | |
| — | M2T54272 | Driving 11V supply | Current | 120A or less | — | Check | |
| | | | Rotating speed | 4000 rpm or more | | | |
| 1 | Operating voltage of magnet switch | | 12V | 8V or less | — | Replace | |
| | | | 24V | 16V or less | | | |
| 24 | Commutator O.D. | Other than below | | 32 | 31.4 | Replace | |
| | | M3T57575 | | 38.7 | | | 38.1 |
| | Runout of outer circumference of commutator | Other than below | | 0.03 or less | 0.1 or less | Replace | |
| | | M2T67881 | | — | | | 0.05 or less |
| | Depth of mica between segments | Other than below | | 0.7 to 0.9 | 0.2 | Replace | |
| | | M2T67881 | | — | | | 0.2 or less |
| 30, 33 | Brush length | | Other than below | 18 | 11 | Replace | |
| | | | M3T57575 | 17 | | | 11 |
| 31 | Spring pressure of brush spring | | Other than below | 30 to 38 N {3.1 to 3.9 kgf} | 20 N {2 kgf} | Replace | |
| | | | M2T78381 | 26 to 32 N {2.7 to 3.3 kgf} | | | 20 N {2 kgf} |
| | | | M2T67881 | 29 to 38 N {3.0 to 3.9 kgf} | | | 20 N {2 kgf} |

 Lubricants

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---------------------|-------------|
| 1 | Lever contacting portion of magnet switch. | Mistick JT-6 grease | As required |
| 8 | Inside surface of needle bearing of center bracket | Multemp MS-2 grease | As required |
| 10, 18 | Pinion and gears | Multemp PS-2 grease | As required |
| 22 | Lever sliding surfaces of pinion shaft assembly | Mistick JT-6 grease | As required |
| | Clutch splined portion of pinion shaft assembly | Multemp MS-2 grease | As required |

◆ **Service procedure**

● **Inspection after assembly**

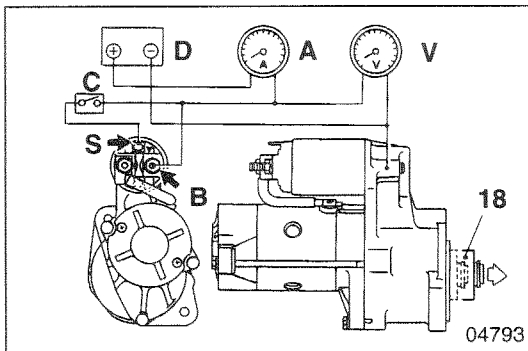
After assembly of the starter, check the starter by supplying current.

WARNING ⚠

- When current is supplied to the starter, pinion 18 will spring out and rotate. Be careful not to touch it by hand.
 - The magnet switch may become very hot during inspection. Be careful when you touch it.
-

CAUTION ⚠

- The time during which current is supplied to the starter should be limited to 10 seconds or less on the pull-in coil P side and 30 seconds or less on the holding coil H side. If current is supplied to the coils for a longer period, the coils will be overheated and seized.
 - When current is supplied to the starter, a large current that exceeds 100A will flow. When the starter is inspected, therefore, use thick cables like booster cables. Check to ensure that all the connections are tight and secure.
-



(1) **Performance test**

- Wire the starter as shown.

A: Ammeter
B: Starter terminal B
C: Switch
D: DC power supply
S: Starter terminal S
V: Voltmeter

- Set the voltage at 11V DC (2 kW) and 23 V DC (3.2 kW and 5 kW).

CAUTION ⚠

The voltage that is applied should be limited to 12V (2 kW) and 24 V (3.2 kW and 5 kW) at maximum.

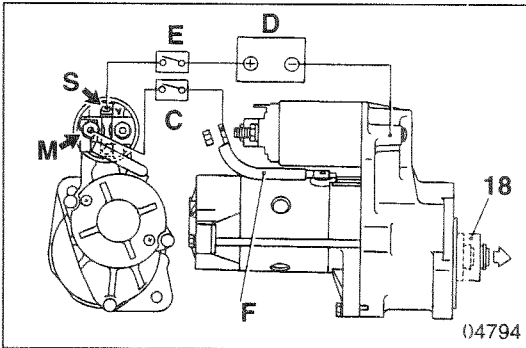
- The following operations are performed by supplying current to the starter. It is therefore necessary that the series of operations ranging from measuring the current that flows through the starter to measuring the rotating speed are completed in less than 30 seconds.
- Set switch C to ON to supply current to the starter. At the time, pinion 18 will spring out and rotate.

CAUTION ⚠

When switch C is set to ON, current is supplied to both pull-in coil P and holding coil H. When the large current from DC power supply D is supplied from terminal B of the starter to terminal M, the current to the pull-in coil is interrupted, and current flows to the holding coil only.

To prevent seizing the holding coil, therefore, all the operations must be completed in less than 30 seconds.

- Measure the current and rotating speed of the starter. Measure the rotating speed of the starter by illuminating pinion **18** with a stroboscope.
- Set switch **C** to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, disassemble and check the starter.



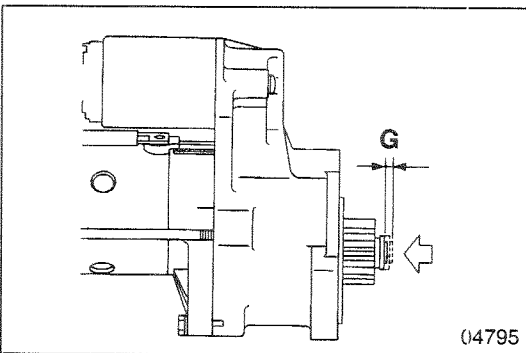
(2) Pinion gap

[Inspection]

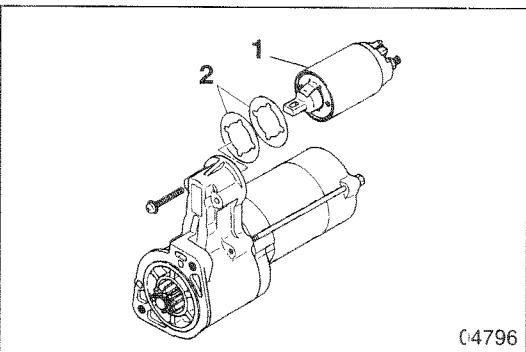
- Wire the starter as shown.

C: Switch
 D: Battery
 E: Switch
 F: Cable
 M: Starter terminal M
 S: Starter terminal S

- Set switch **C** and **E** to ON to let pinion **18** spring out.
- Set switch **C** to OFF to stop pinion **18** from rotating.



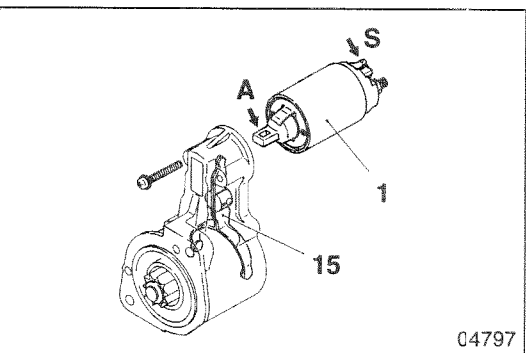
- Lightly push the end of pinion shaft assembly **22** in and measure amount **G** the pinion shaft moves in the axial direction (pinion gap). If the reading is out of the standard value, adjust by the following procedures.



[Adjustment]

- Remove magnet switch **1** from front bracket assembly **3**.
- Adjust by changing the thickness of shim **2**.
 Increasing the number of shims reduces pinion gap **G**.

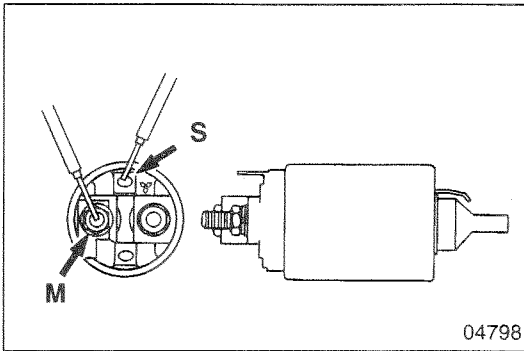
Type of shims: 0.25, 0.5 mm



1 Magnet switch

[Installation]

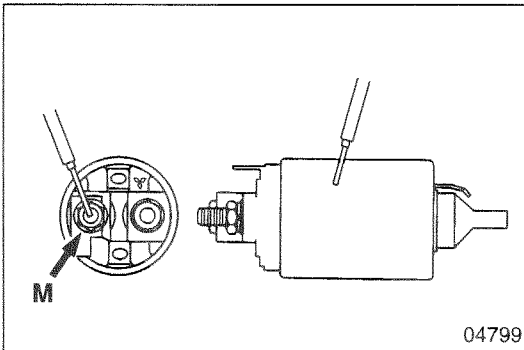
Install magnet switch **1** on lever **15** with illustrated portion **A** coated with grease and terminal **S** directed upward.



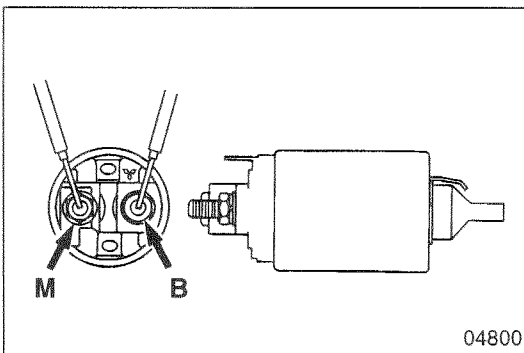
[Inspection]

(1) Open circuit test on coil

- Check to ensure that there is continuity between terminals **S** and **M**. If there is no continuity, replace magnet switch 1.

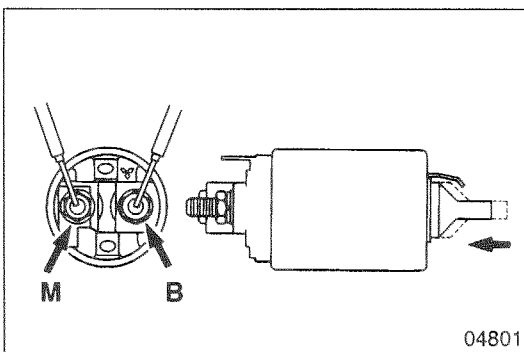


- Check to ensure that there is continuity between terminal **M** and body. If there is no continuity, replace magnet switch 1.



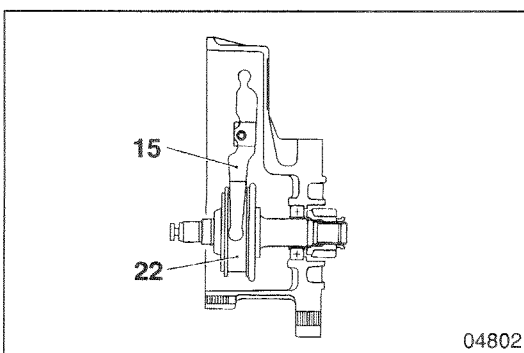
(2) Contact fusion check

- Check to ensure that there is no continuity between terminals **B** and **M**. If there is continuity, replace magnet switch 1.



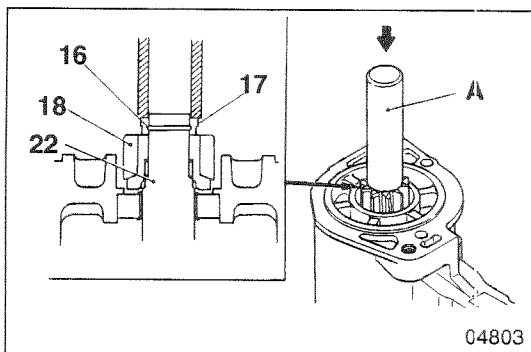
(3) Contact contacting check

- Strongly push the end of magnet switch 1 in to close the internal contact.
- In this state, check to ensure that there is continuity between terminals **B** and **M**. If there is no continuity, replace magnet switch 1.



15 Installation of lever

Install lever 15 in the illustrated direction on pinion shaft assembly 22.



18 Pinion

[Removal]

- Apply pipe-like tool **A** to pinion stopper **17**. While striking it lightly with a hammer, remove stopper ring **16** from the pinion stopper.

NOTE

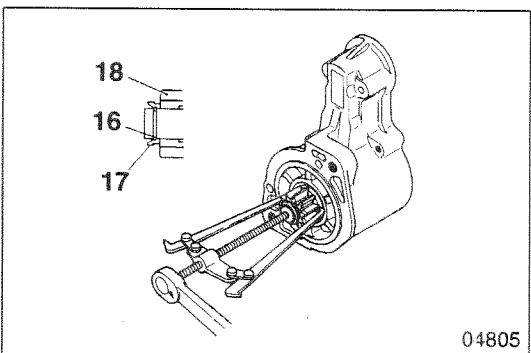
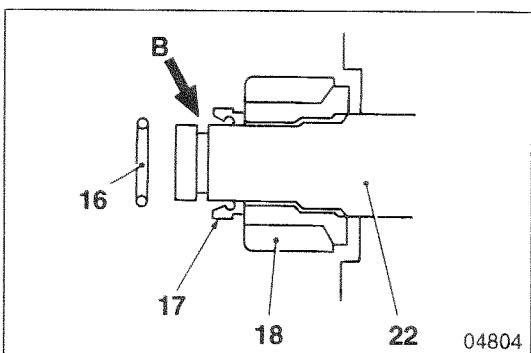
Stopper ring 16 should be removed from pinion stopper 17 with pinion 18 having sprung out.

- Remove stopper ring **16** from pinion shaft assembly **22** to remove pinion **18**.

[Installation]

- Install pinion **18** and pinion stopper **17** in the direction as shown.
- Install stopper ring **16** in ring groove **B** on pinion shaft assembly **22**.

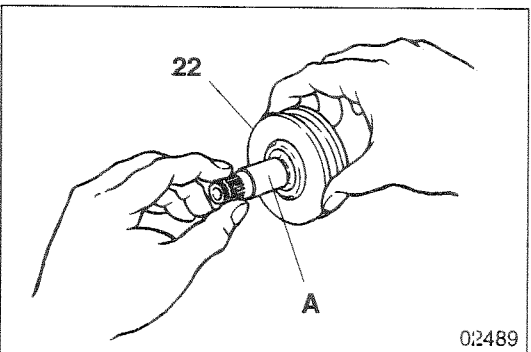
- Strongly pull pinion **18** to securely install pinion stopper **17** in stopper ring **16**.



22 Inspection of pinion shaft assembly

Make sure that when illustrated portion **A** of pinion shaft assembly **22** is turned in the drive direction (clockwise), the pinion shaft turns smoothly, and that when portion **A** is turned in the reverse direction (counterclockwise), the pinion shaft locks in position.

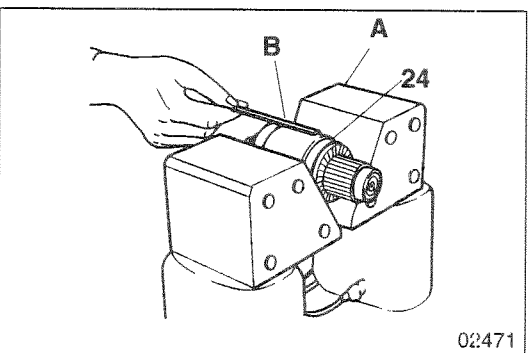
When anything abnormal is found during movement of the pinion shaft, replace the pinion shaft assembly.

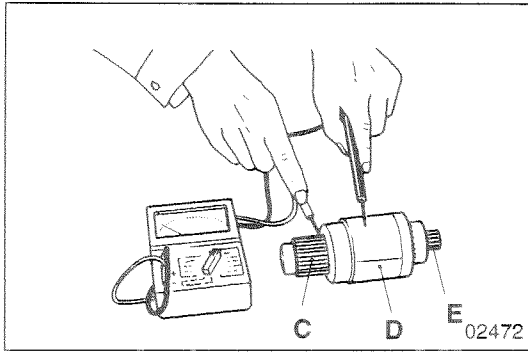


24 Inspection of armature assembly

(1) Short circuit test on coil

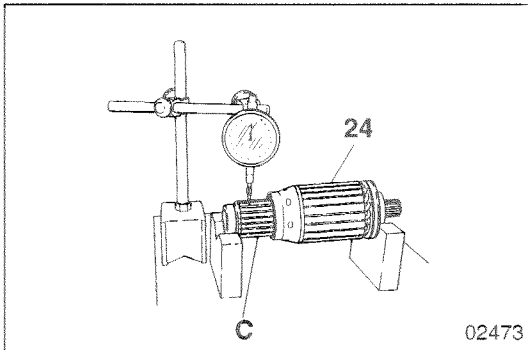
- Place armature assembly **24** on armature tester **A**. Bring iron piece **B** close to armature assembly **24**, keeping it in parallel.
- Slowly rotate the armature assembly **24** by hand.
- If iron piece **B** is attracted or vibrates, it means a short circuit. Replace armature assembly **24**.





(2) Earth test on coil

- Check to ensure that there is no continuity between commutator **C** and core **D** (or shaft portion **E**).
- If there is continuity, it means a short circuit. Replace armature assembly **24**.

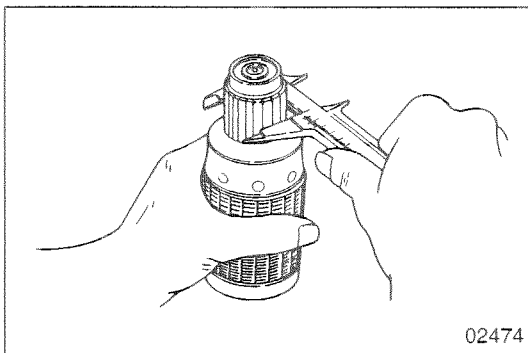


(3) Runout of commutator

Rotate armature assembly **24** by hand to measure the runout of commutator **C**. If the reading is more than the limit, repair the outside diameter of the commutator within the limit.

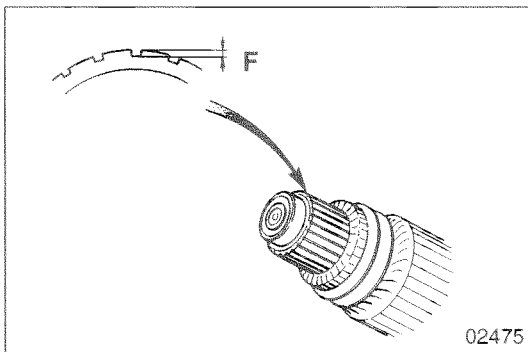
(4) Roughness of commutator surface

- If the surface is rough or unevenly worn, repair with emery paper (#300 to 500).
- After the repair, be sure to check the runout of the commutator portion **C**.



(5) Outside diameter of commutator

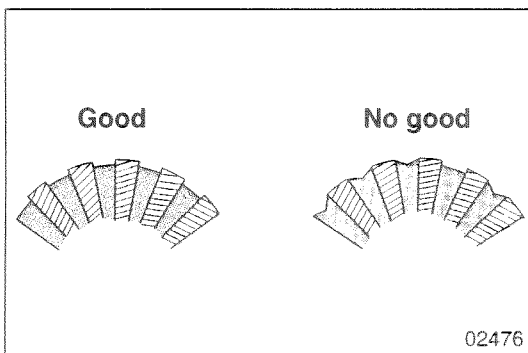
If the reading is more than the limit, replace armature assembly **24**.



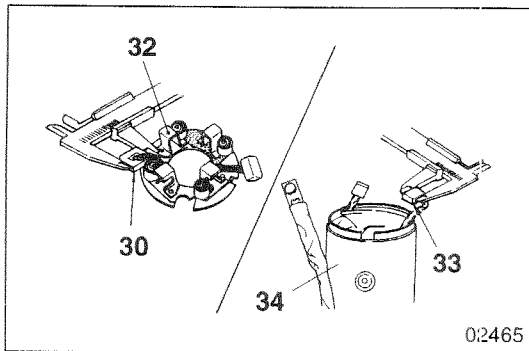
(6) Depth of mica between segments

- If the reading is less than the limit, replace armature assembly **24**.

F: Depth of mica



- If the mica portion is as shown, replace armature assembly **24**.



30 33 Inspection of brush

(1) Length of brush

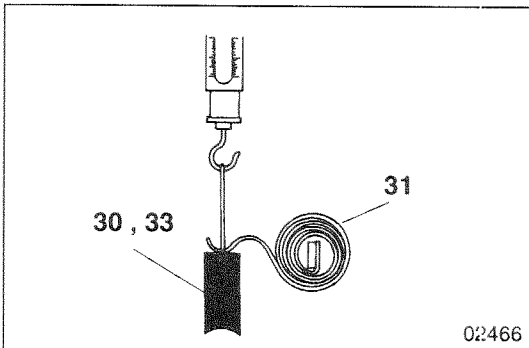
If the reading is less than the limit, replace \oplus brush 33 as yoke assembly 34 and \ominus brush 30 as brush holder assembly 32.

(2) Commutator contacting surfaces

If the contacting surfaces are rough or unevenly worn, repair with emery paper (#300 to 500).

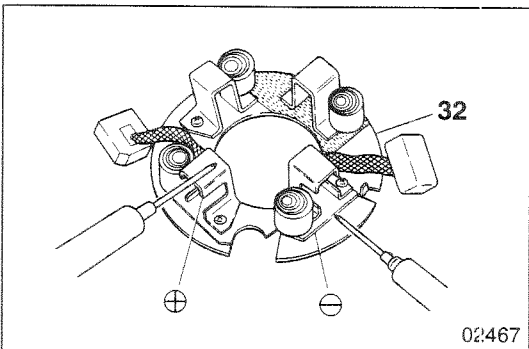
CAUTION

The contacting surfaces should be finished in a curvature similar to that of the commutator.



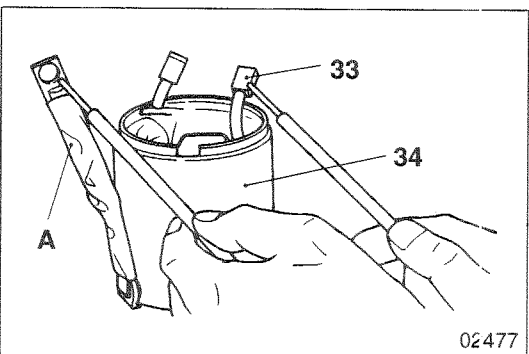
31 Inspection of brush spring

- Use new brushes 30 and 33 and measure the load at the moment the brush spring 31 leaves the brushes as shown.
- If the reading is below the limit, replace brush spring 31.



32 Inspection of brush holder assembly

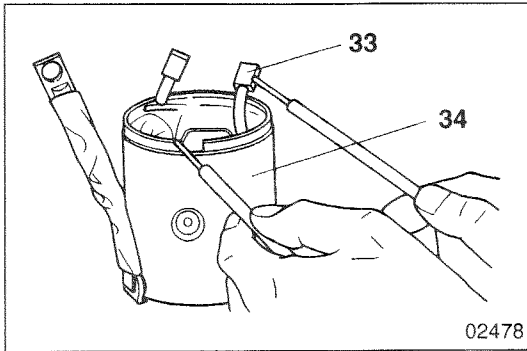
- Check to ensure that there is no continuity between the \oplus side brush holder and \ominus side holder plate.
- If there is continuity, it means a short circuit. Replace brush holder assembly 32.



34 Inspection of yoke assembly

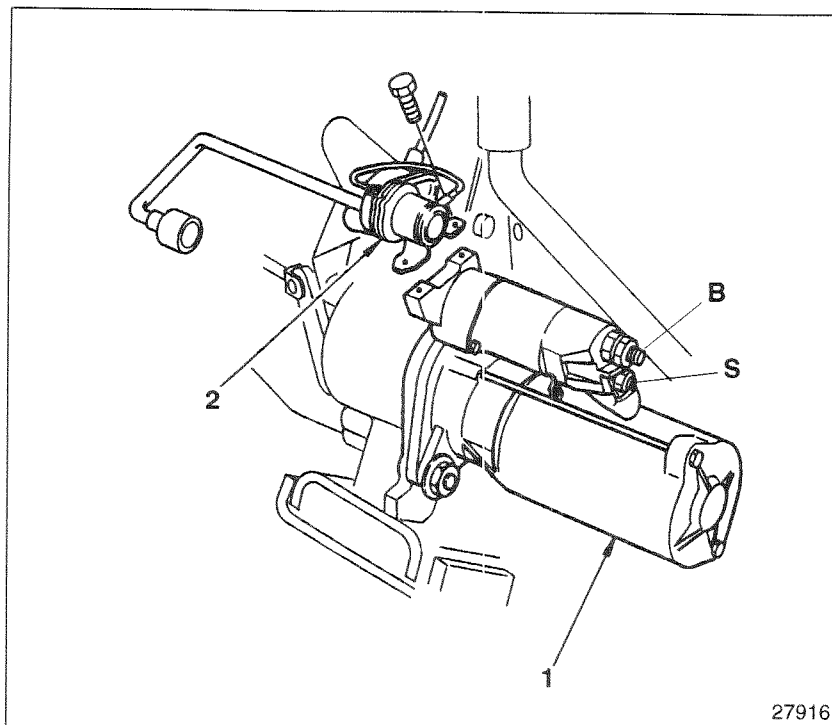
(1) Open circuit test on coil

- Check to ensure that there is continuity between connector A and \oplus brush 33.
- If there is no continuity, it means an open circuit. Replace yoke assembly 34.



(2) Earth test on coil

- Check to ensure that there is no continuity between yoke assembly 34 and ⊕ brush 33.
- If there is continuity, the coil is earthed. Check the insulation. If repair is impossible, replace yoke assembly 34.



● **Removal sequence**

- 1 Starter assembly P54-84
- 2 Air heater relay P54-93

B: Terminal B
S: Terminal S

WARNING

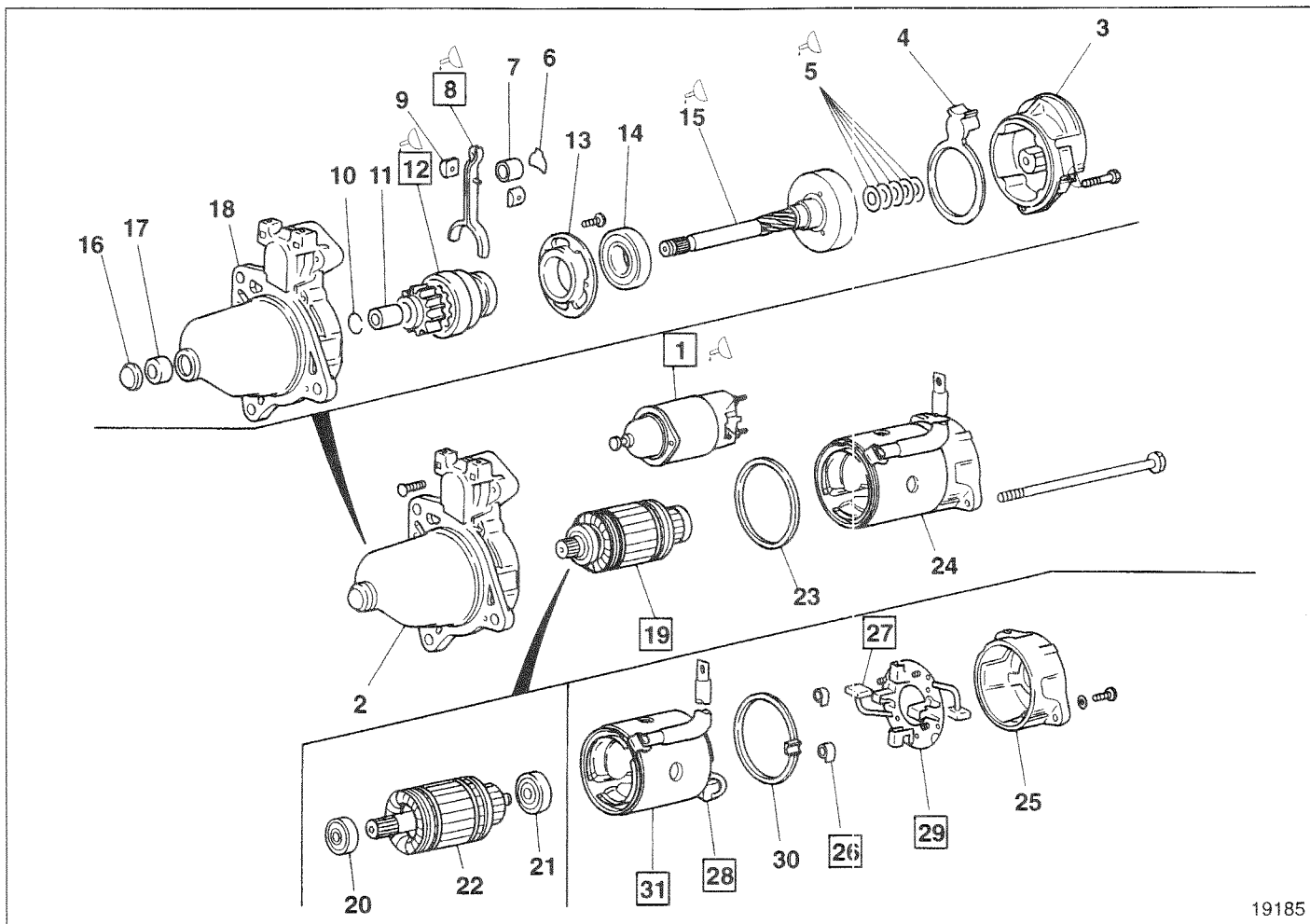
Before removing starter 1 and starter relay, be sure to disconnect the negative \ominus terminal of the battery and insulate it with a tape or something else. If the negative \ominus terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● **Installation sequence**

Follow the removal sequence in reverse.

STARTER <M3T90273: 12V-3.5kW>

Starter Assembly



19185

● Disassembly sequence

- | | | |
|--------------------------|--------------------------------|---------------------------------|
| 1 Magnet switch assembly | 12 Overrunning clutch assembly | 22 Armature |
| 2 Front bracket assembly | 13 Gear bracket | 23 Packing |
| 3 Center bracket | 14 Gearshaft bearing | 24 Yoke & rear bracket assembly |
| 4 Packing | 15 Gearshaft | 25 Rear bracket |
| 5 Adjust washer | 16 Cover | 26 Brush spring |
| 6 Plate | 17 Needle bearing | 27 Brush ⊖ |
| 7 Spacer | 18 Front bracket | 28 Brush ⊕ |
| 8 Lever | 19 Armature assembly | 29 Brush holder assembly |
| 9 Collar | 20 Front bearing | 30 Packing |
| 10 Stopper ring | 21 Rear bearing | 31 Yoke assembly |
| 11 Pinion stopper | | |

CAUTION

- Do not remove bearings 20 and 21 unless they are found to be defective.
- When yoke & rear bracket assembly 24 is removed from front bracket assembly 2, be careful not to allow armature assembly 19 to fall.


● Assembly sequence

Follow the disassembly sequence in reverse.

NOTE

When magnet switch 1 was replaced, be sure to adjust the pinion gap.

● Inspection after assembly

 P54-86

Service standards

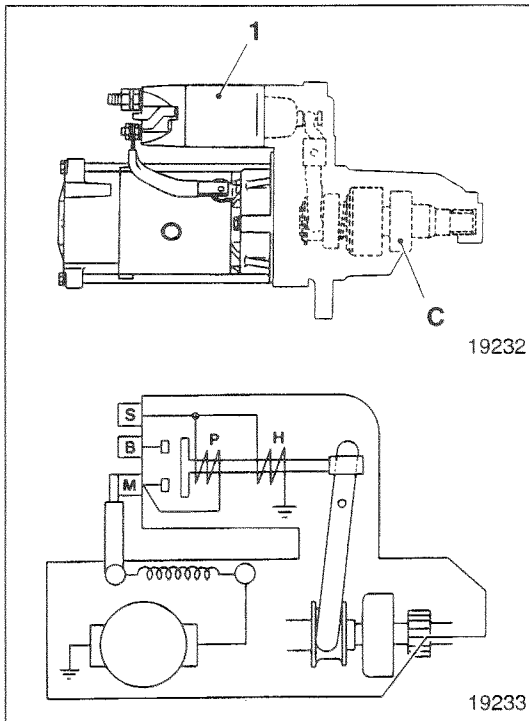
Unit: mm

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|--|-----------------------------|-------------------|-------------------|
| — | Pinion gap | 1 to 3 | — | Adjust |
| — | No-load characteristics (During 11V supply) | Current | 180A or less | Check |
| | | Rotating speed | 3,200 rpm or more | |
| 19 | Outside diameter of commutator | 38.7 | 38.1 | Replace |
| | Runout of outer circumference of commutator | 0 to 0.03 | 0.1 or more | Replace |
| | Depth of mica between segments | 0.7 to 0.9 | 0.3 or less | Repair or replace |
| 26 | Spring pressure of brush spring | 33 to 45 N {3.4 to 4.6 kgf} | 8 N {0.8 kgf} | Replace |
| 27, 28 | Brush length | 17 | 11 | Replace |

Lubricant

| Location | Points of application | Specified lubricant | Quantity |
|----------|--|---|-------------|
| 1 | Lever contacting portion of magnet switch. | Multipurpose grease [NLGI No.2 (Li soap)] | As required |
| 5 | Adjusting washer | Multipurpose grease [NLGI No.2 (Li soap)] | As required |
| 8 | Lever sliding surfaces of overrunning clutch | Multipurpose grease [NLGI No.2 (Li soap)] | As required |
| 12 | Splined portion of overrunning clutch | Multipurpose grease [NLGI No.2 (Li soap)] | As required |
| 15 | Splined portion and internal gear of gearshaft | Multipurpose grease [NLGI No.2 (Li soap)] | As required |

STARTER <M3T90273: 12V-3.5kW>



◆ Service procedure

● Inspection after assembly

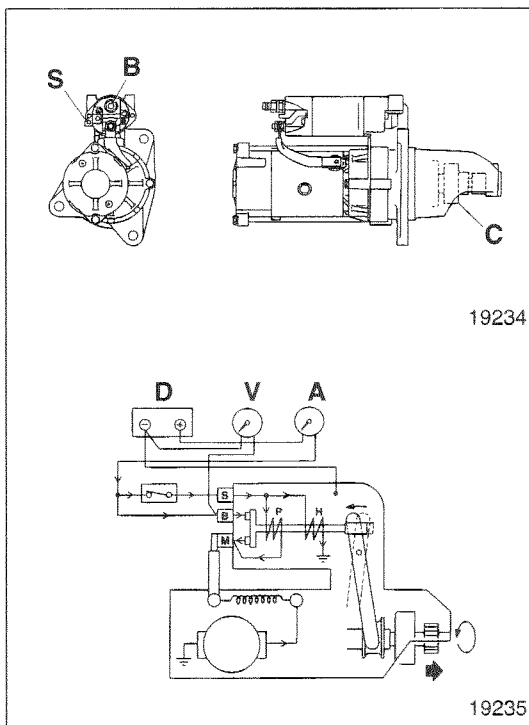
After assembly of the starter, check the starter by supplying current.

WARNING ⚠

- When current is supplied to the starter, pinion C will spring out and rotate. Be careful not to touch it by hand.
- Magnet switch 1 may become very hot during inspection. Be careful when you touch it.

CAUTION ⚠

- The time during which current is supplied to the starter should be limited to 10 seconds or less on the pull-in coil P side and 30 seconds or less on the holding coil H side. If current is supplied to the coils for a longer period, the coils will be overheated and seized.
- When current is supplied to the starter, a large current that exceeds 100A will flow. When the starter is inspected, therefore, use thick cables like booster cables. Check to ensure that all the connections are tight and secure.



(1) Performance test

- Wire the starter as shown.

- A: Ammeter
- B: Starter terminal B
- C: Pinion
- D: DC power supply
- E: Switch
- S: Starter terminal S
- V: Voltmeter

- Set the voltage at 11V DC.

CAUTION ⚠

The voltage that is applied should be limited to 12V maximum.

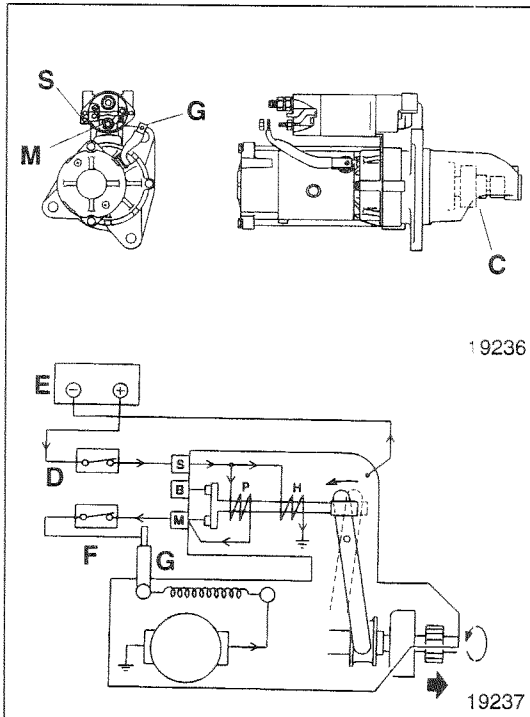
- The following operations are performed with the starter running. It is therefore necessary that the series of operations ranging from measuring the current that flows through the starter to measuring the rotating speed are completed in less than 30 seconds.
- Set switch E to ON to supply current to the starter. At the time, pinion C will shift out and rotate.

CAUTION ⚠

When switch E is set to ON, current is supplied to both pull-in coil P and holding coil H. When the large current from the DC power supply D is supplied from terminal B of the starter to terminal M, the current to the pull-in coil is interrupted, and current flows to the holding coil only.

To prevent seizing the holding coil, therefore, all the operations must be completed in less than 30 seconds.

- Measure the current and rotating speed of the starter. Measure the rotating speed of the starter by illuminating pinion **C** with a stroboscope.
- Set switch **E** to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, disassemble and check the starter.



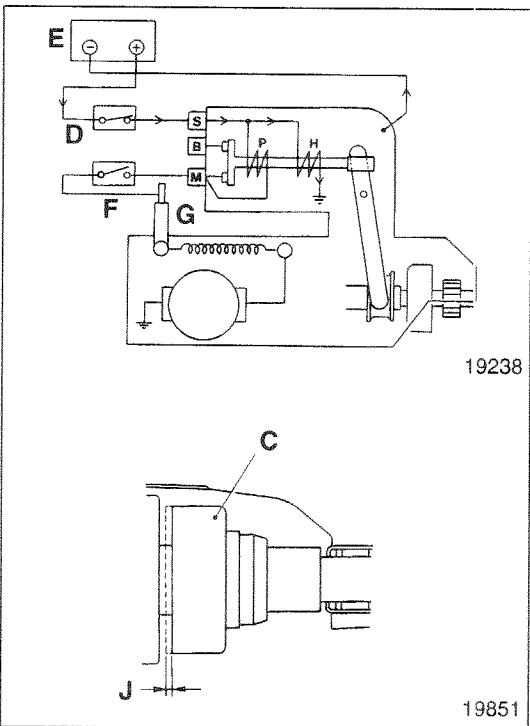
(2) Pinion gap

[Inspection]

- Wire the starter as shown.

C: Pinion
D: Switch
E: 12V DC
F: Switch
G: Connector
M: Starter terminal M
S: Starter terminal S

- The following operations are performed by supplying current to the starter. It is therefore necessary that the series of operations up to completion of measurement of the pinion gap are completed in less than 30 seconds.
- Set switch **D** and switch **F** to ON to supply current to the starter. At the time, pinion **C** will spring out and rotate.



- Immediately (in less than 5 seconds) after the pinion has started rotation, set switch **F** to OFF stop rotation of the pinion.

CAUTION

When switch **D** and switch **F** are set to ON, current is supplied to both pull-in coil **P** and holding coil **H**. Since wiring is such that no voltage is applied to terminal **B** of the starter, current flows to the pull-in coil during rotation of pinion **C**.

To prevent seizing the pull-in coil, therefore, it is necessary that the switch **F** is set to OFF immediately (in less than 5 seconds).

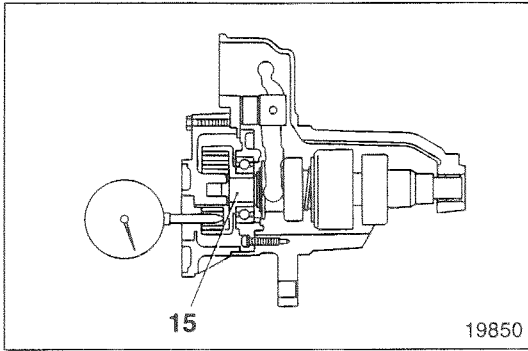
- Lightly push the end of pinion **C** in and measure amount **J** the clutch moves in the axial direction (pinion gap).

NOTE

When the pinion is strongly pushed, the pinion moves back, while compressing the spring.

- Set switch **C** to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, it means that the starter has been incorrectly reassembled. Therefore, repeat disassembly and reassembly.

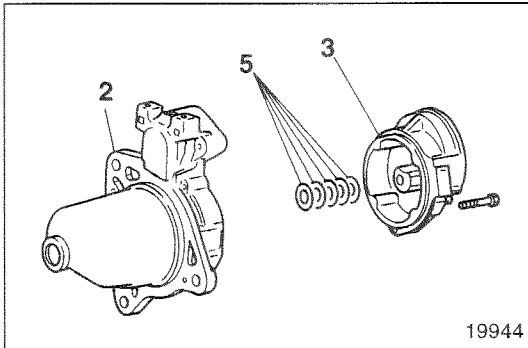
STARTER <M3T90273: 12V-3.5kW>



(3) Thrust gap of gearshaft

[Inspection]

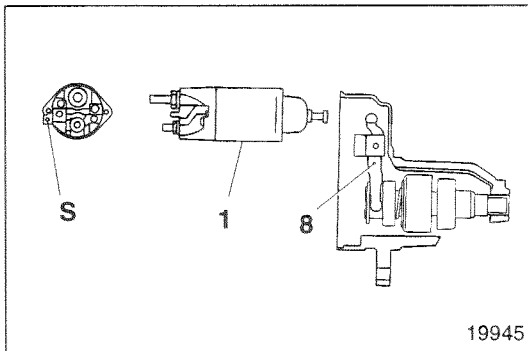
- Measure the play of gearshaft **15** in the axial direction (thrust gap).
- If the measurement is out of the standard value, adjust by the following procedure.



[Adjustment]

- Remove center bracket **3** from front bracket assembly **2**.
- Adjust by changing the thickness of adjust washer **5**.

Types of adjust washer: 0.25 mm, 0.5 mm

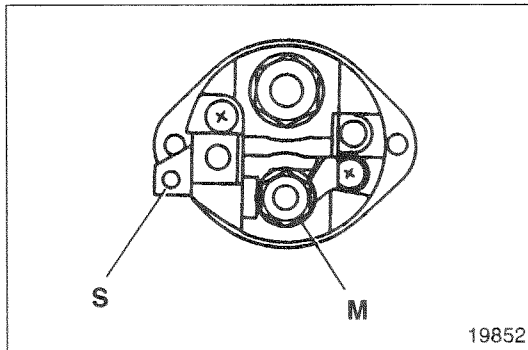


1 Magnet switch

[Installation]

Install magnet switch **1** on lever **8** with terminal **S** directed as shown.

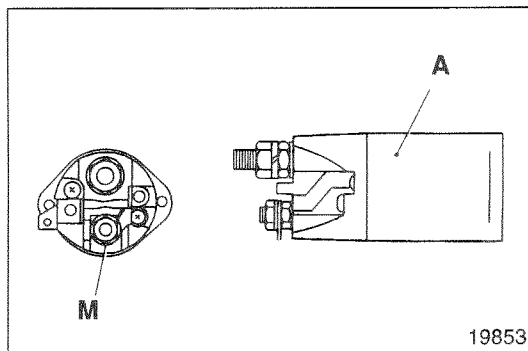
S: Terminal S



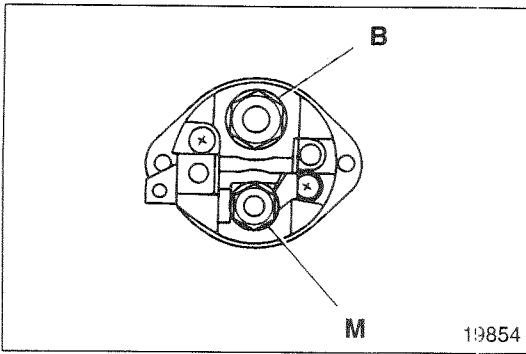
[Inspection]

(1) Open circuit test on coil

- Check to ensure that there is continuity between terminals **S** and **M**.
- If there is no continuity, replace magnet switch **1**.

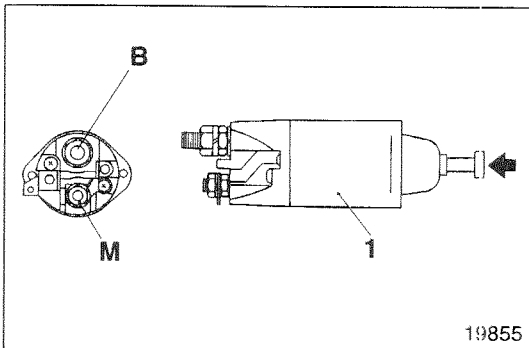


- Check to ensure that there is continuity between terminal **M** and body **A**.
- If there is no continuity, replace magnet switch **1**.



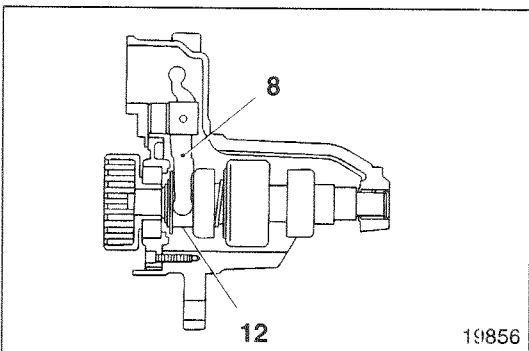
(2) Contact fusion check

- Check to ensure that there is no continuity between terminals **B** and **M**.
- If there is continuity, replace magnet switch **1**.



(3) Contact contacting check

- Strongly push the end of magnet switch **1** in to close the internal contact. In this state, check to ensure that there is continuity between terminals **B** and **M**.
- If there is no continuity, replace the magnet switch **1**.



8 Installation of lever

Install the lever **8** in the illustrated direction on overrunning clutch **12**.

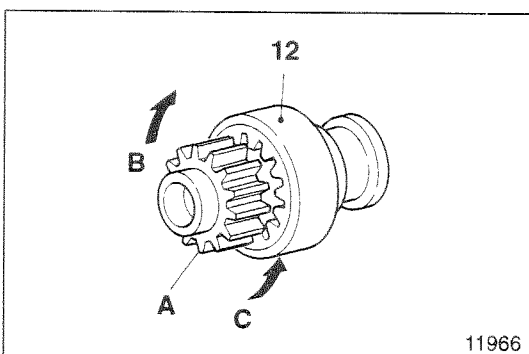
12 Overrunning clutch

[Removal]

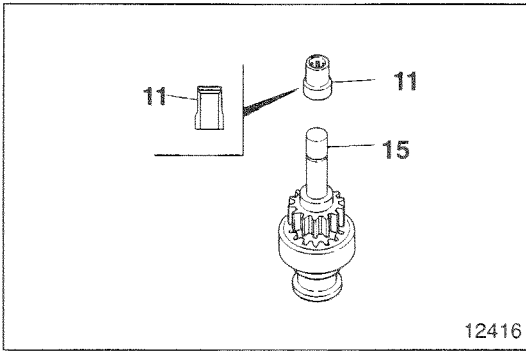
- Set pipe-like tool **A** on pinion stopper **11**.
- Lightly strike tool **A** with a hammer to remove pinion stopper **11** from stopper ring **10**.
- Remove stopper ring **10** from gearshaft **15** and withdraw pinion stopper **11**.

[Inspection]

- Check to ensure that pinion **A** of overrunning clutch **12** rotates in direction **B** and does not rotate in direction **C**.
- If there is anything wrong, replace overrunning clutch **12**.

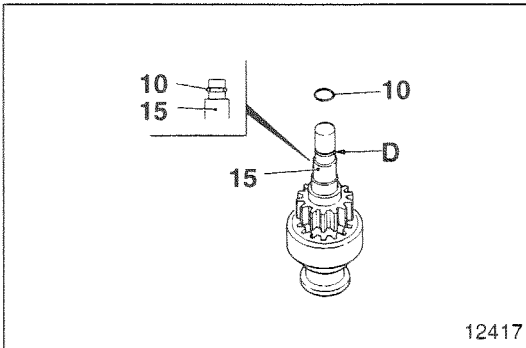


STARTER <M3T90273: 12V-3.5kW>

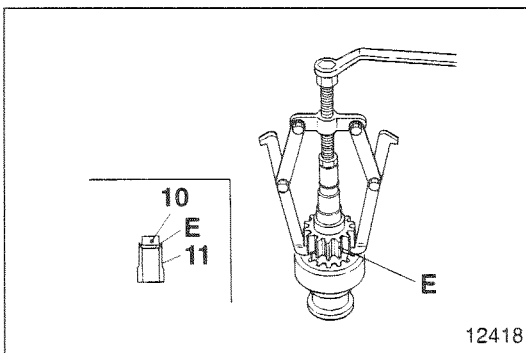


[Installation]

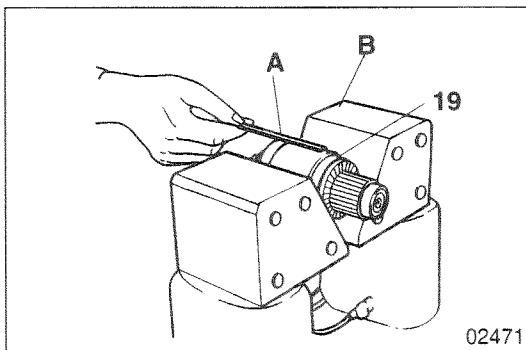
- Install pinion stopper **11** in the illustrated direction on gearshaft **15**.



- Install stopper ring **10** in ring groove **D** of gearshaft **15**.



- Strongly pull pinion gear **E** to securely mount pinion stopper **11** in stopper ring **10**.



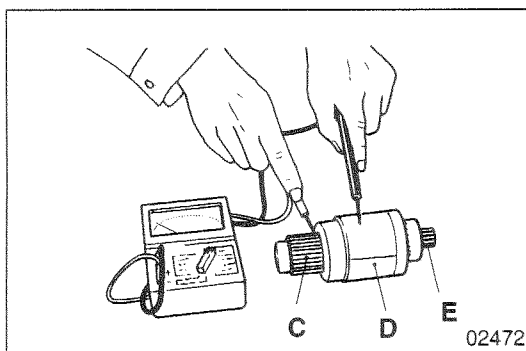
19 Inspection of armature assembly

(1) Short circuit test on coil

- Bring iron piece **A** close to armature assembly **19**, keeping it in parallel.

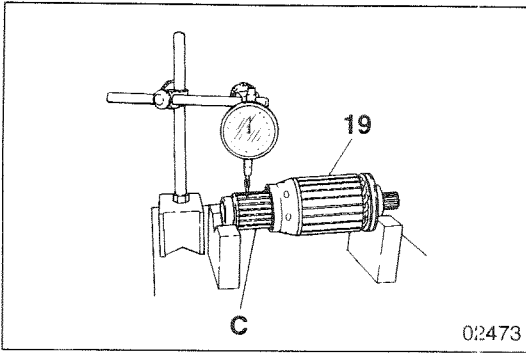
B: Armature tester

- Slowly rotate armature assembly **19** by hand.
- If iron piece **A** is attracted or vibrates, it means a short circuit. Replace armature assembly **19**.



(2) Earth test on coil

- Check to ensure that there is no continuity between commutator **C** and core **D** (or shaft portion **E**).
- If there is continuity, it means a short circuit. Replace armature assembly.

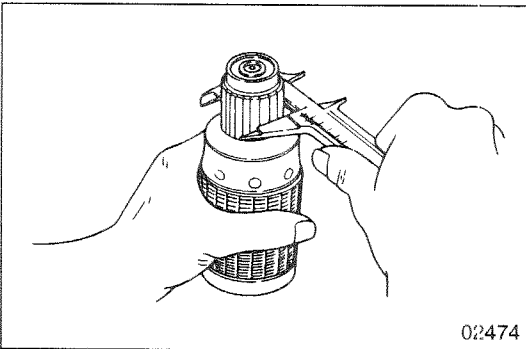


(3) Runout of commutator

If the reading is more than the limit, repair the outside diameter of commutator **C** within the limit.

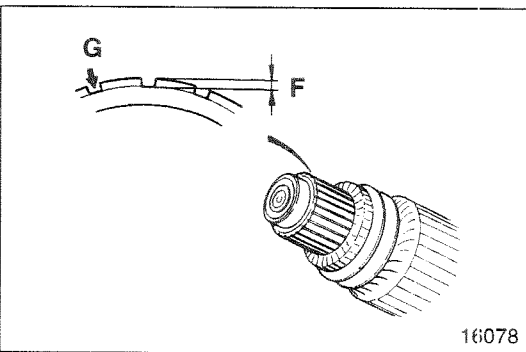
(4) Roughness of commutator surface

- If the surface is rough or unevenly worn, repair with emery paper (#300 to 500).
- After the repair, be sure to check the runout of commutator portion **C**.



(5) Outside diameter of commutator

If the reading is more than the limit, replace armature assembly **19**.

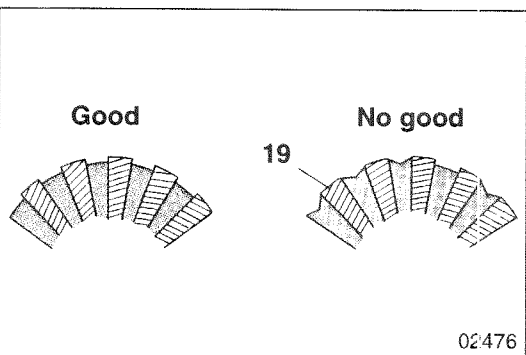


(6) Depth of mold between segments

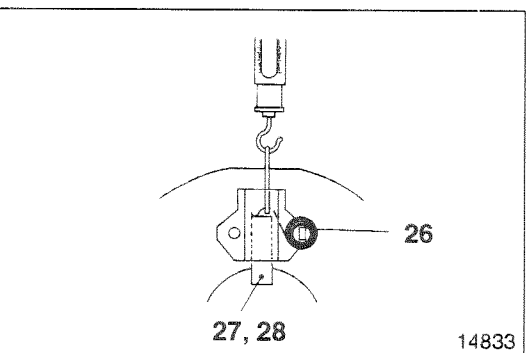
- If the reading is less than the limit, replace armature assembly **19**.

F: Depth of mold

- Make repairs by grinding illustrated portion **G**.



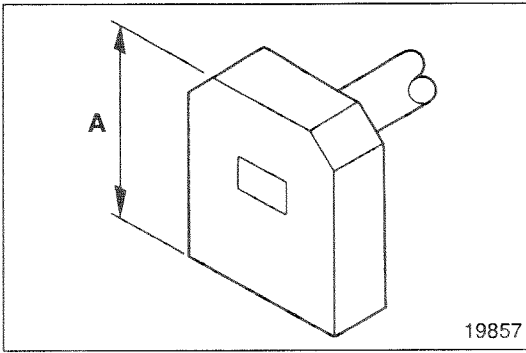
- If the mold portion is as shown, repair or replace armature assembly **19**.



26 Inspection of brush spring

- Use new brushes **27** and **28** and measure the load at the moment brush spring **26** leaves the brushes as shown.
- If the reading is below the limit, replace brush spring **26**.

STARTER <M3T90273: 12V-3.5kW>



27 28 Inspection of brush

(1) Length of brush

If the reading is less than the limit, replace brushes 27 and 28.

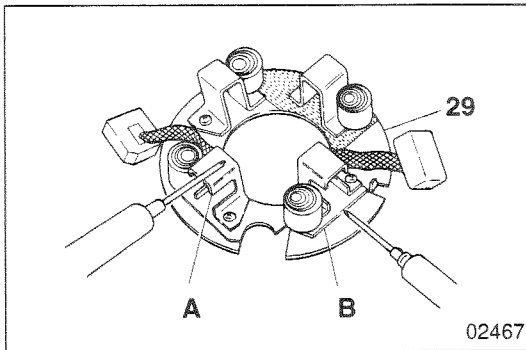
A: Brush length

CAUTION

⊖ brush 27 should be replaced as brush holder assembly 29.

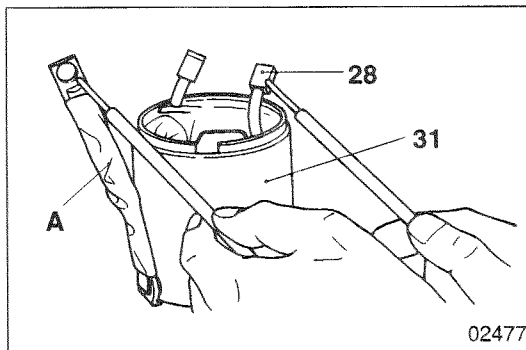
(2) Commutator contacting surfaces

If the contacting surfaces are rough or unevenly worn, repair with emery paper (#300 to 500).



29 Inspection of brush holder assembly

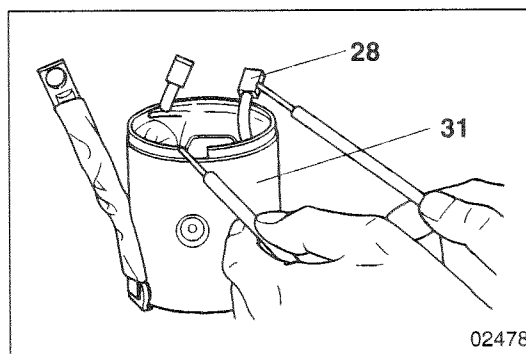
- After thoroughly cleaning the brush holder assembly, check to ensure that there is no continuity between ⊕ side brush holder A and ⊖ side holder plate B.
- If there is continuity, it means a short circuit. Replace brush holder assembly 29.



31 Inspection of yoke assembly

(1) Open circuit test on coil

- Check to ensure that there is continuity between connector A and ⊕ brush 28.
- If there is no continuity, it means an open circuit. Replace yoke assembly 31.

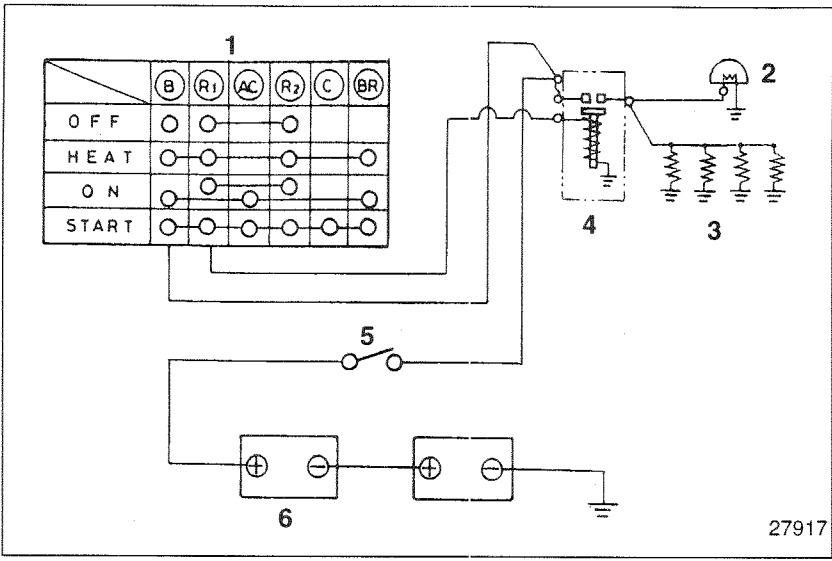


(2) Earth test on coil

- Check to ensure that there is no continuity between yoke assembly 31 and ⊕ brush 28.
- If there is continuity, the coil is earthed. Check the insulation. If repair is impossible, replace yoke assembly 31.

CAUTION

Iron particles (particles produced by worn brush and armature) collected on the coil may establish a ground connection between the coil and yoke assembly 31.



- 1 Starter switch
- 2 Glow plug indicator
- 3 Glow plug
- 4 Glow relay
- 5 Battery switch
- 6 Battery

27917

Service standards

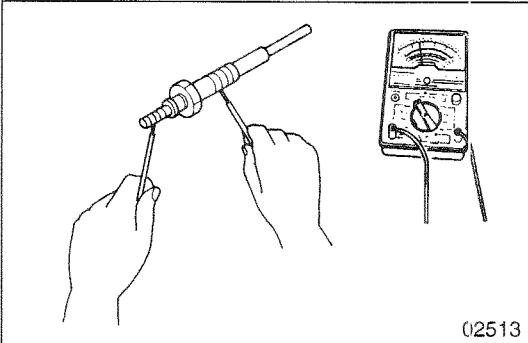
| Location | Maintenance item | | Standard value | Limit | Remedy |
|----------|---|-----|-------------------|-------|---------|
| 3 | Resistance of glow plug at normal temperature | 24V | 3.8 Ω (Reference) | — | Replace |
| | | 12V | 1.0 Ω (Reference) | — | Replace |

◆ Service procedure

3 Inspection of glow plug

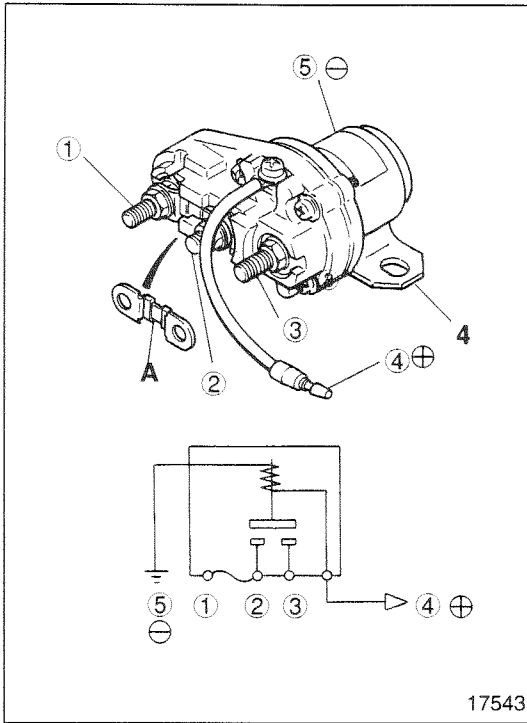
- Measure the resistance of glow plug 3 as shown.
- If the reading is out of the standard value, replace glow plug 3.

📖 Gr 11



02513

PREHEATER CIRCUIT



4 Inspection of glow relay

(1) Inspection of fuse

If fuse **A** is blown, replace it with one having the same amperage stamped on the fuse.

(2) Inspection of main body

- Perform continuity checks according to the following table.

| | ① | ② | ③ | ④ | ⑤ (Body earth) |
|-----------------------------|-------|-------|-------|-------|-------------------|
| When no current is supplied | ○ — ○ | | | ○ — ○ | |
| When current is supplied | ○ — ○ | ○ — ○ | ○ — ○ | ⊕ — ⊖ | ○ — ○ |

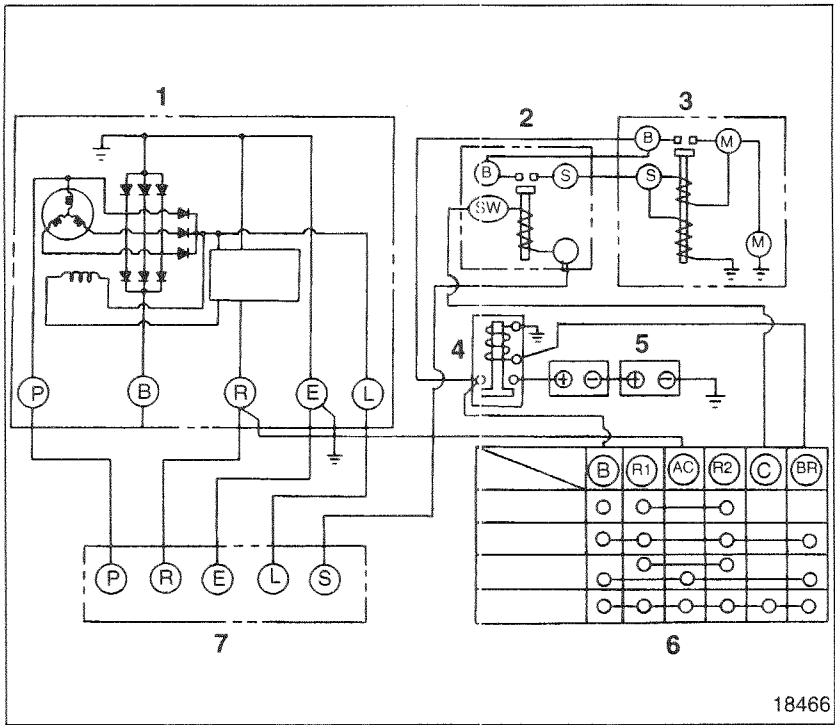
○ — ○ There is continuity between terminals.

⊕ — ⊖ Terminals to which 24V DC is applied

A: Fuse

- If there is anything wrong, replace glow relay **4**.

17543

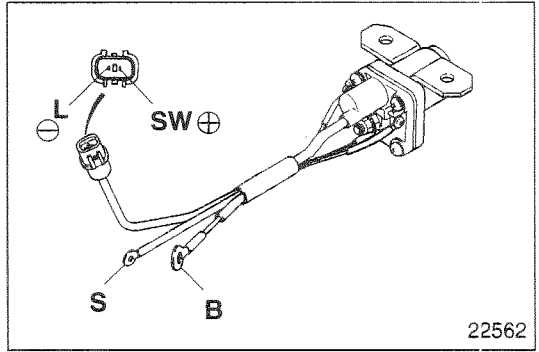


- 1 Alternator
- 2 Starter relay
- 3 Starter
- 4 Battery relay (24V)
Battery switch (12V)
- 5 Battery
- 6 Starter switch
- 7 Safety relay

18466

Service standards

| Location | Maintenance item | Standard value | Limit | Remedy |
|----------|------------------|----------------|-------|---------|
| 7 | Safety relay | Approx. 200Ω | — | Replace |



22562

◆ Service procedure

2 Inspection of starter relay

- Perform continuity checks according to the following table.

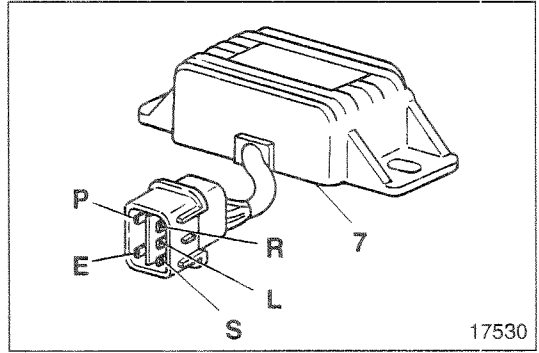
| | B | S | SW | L |
|-----------------------------|-------|-------|-------|-------|
| When no current is supplied | | | ○ — ○ | ○ — ○ |
| When current is supplied | ○ — ○ | ○ — ○ | ⊕ — ⊖ | ⊕ — ⊖ |

- — ○ There is continuity between terminals.
- ⊕ — ⊖ Terminals to which 24V DC is applied

- If there is anything wrong, replace starter relay 2.

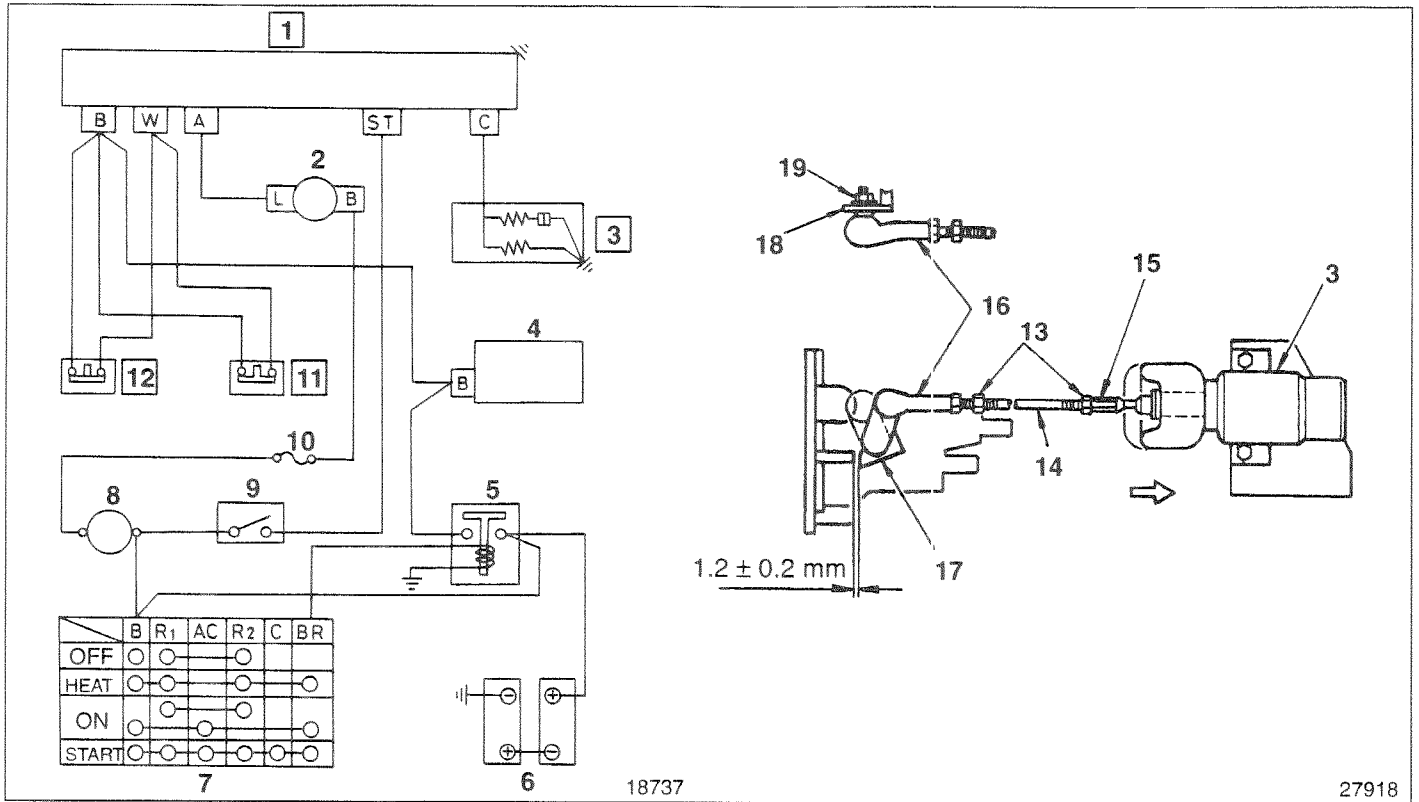
7 Inspection of safety relay

Measure the resistance value between terminals **R-L**. If the reading is out of the standard value, replace safety relay 7.



17530

AUTOMATIC STOP SYSTEM (SHUTDOWN)



- | | | |
|------------------|-------------------------------|-----------------|
| 1 Solenoid relay | 8 Ammeter | 14 Rod |
| 2 Alternator | 9 Stop switch | 15 Swivel joint |
| 3 Solenoid | 10 Fuse box | 16 Ball joint |
| 4 Starter | 11 Engine oil pressure switch | 17 Base lever |
| 5 Battery relay | 12 Coolant temperature sensor | 18 Stop lever |
| 6 Battery | 13 Lock nut | 19 Flange nut |
| 7 Starter switch | | |

Service standards

Unit: mm

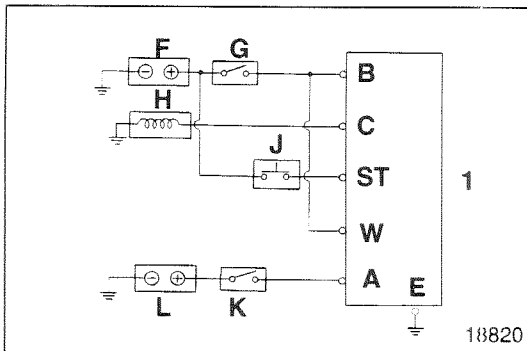
| Location | Maintenance item | Standard value | Limit | Remedy | |
|----------|--|--|--------------|---------|---------|
| 1 | Solenoid relay | Delay time at start (after application of 28.5V to terminal B, and 28.5V to terminal A) | 18 ± 5 secs. | — | Replace |
| | | Delay time at stop (after application of 24V to terminal B and 0V to terminal A) | 30 ± 5 secs. | — | Replace |
| 3 | Solenoid | Clearance between base lever and case stopper | 1.2 ± 0.2 | — | Adjust |
| | | Holding coil current | 0.5A or less | — | Replace |
| 11 | Engine oil pressure switch operating pressure | 78 ± 20 kPa {0.8 ± 0.2 kgf/cm ² } | — | Replace | |
| 12 | Coolant temperature sensor operating temperature | City water cooling | 95 ± 2°C | — | Replace |
| | | Radiator cooling | 101 ± 2°C | — | Replace |

◆ Service procedure

1 Solenoid relay

Wire as shown at left and perform the following inspections.

- F: Power supply
- G: Switch
- H: Solenoid (or coil load: $30 \pm 3A$)
- J: Switch
- K: Switch
- L: Power supply



(1) Inspection of oil pressure timer

- Connect 28.5V DC power supplies to **F** and **L**.
- Set switch **G** to ON.
- Set switch **K** to ON and simultaneously measure the time required before solenoid **H** operates.
- If the reading is out of the standard value, replace defective parts.

NOTE

When the timer is to be re-tested, allow a recovery time of five minutes as the discharge finishing time of the capacitor in solenoid relay 1.

(2) Inspection of stop timer

- Connect 24V DC power supply to **F** and 28.5V DC power supply to **L**.
- Set switches **G** and **K** to ON.
- Set switch **K** to OFF 5 seconds after solenoid **H** has operated. (It takes 5 seconds for the generating voltage of alternator 2 to disappear after the activation of the solenoid.) At the same time, measure the time required before the solenoid returns.
- If the reading is out of the standard value, replace defective parts.

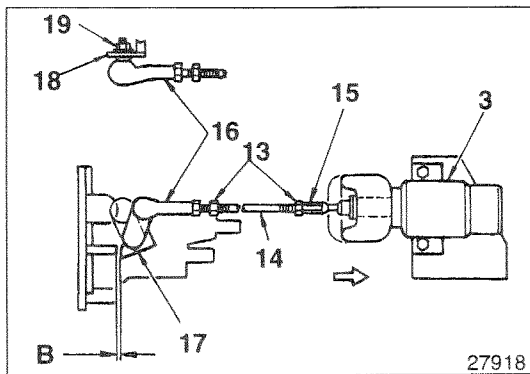
NOTE

When the timer is to be re-tested, allow a recovery time of five minutes as the discharge finishing time of the capacitor in solenoid relay 1.

(3) Manual stop timer

- Connect 24 V DC power supply to **F**.
- Set switch **J** to ON to operate solenoid **H**.
- Measure the time required for solenoid **H** to return after setting switch **J** to OFF.
- If the reading is out of the standard value, replace defective parts.

AUTOMATIC STOP SYSTEM (SHUTDOWN)



3 Solenoid

[Installation]

- Temporarily tighten ball joint **16** to rod **14** and thread the other end six to nine times into swivel joint **15** of solenoid **3** and secure it with lock nuts **13**.
- Check to ensure that the rotating portions of swivel joint **15** and ball joint **16** smoothly rotate.
- Mount solenoid **3** on the engine.
- Rotate ball joint **16** to adjust the length of rod **14**, place stop lever **18** in the normal use position, and install the ball joint with flange nut **19**.

[Adjustment]

- Adjust the length of rod **14** so that clearance **B** between base lever **17** and case stopper **A** will have the standard value with solenoid **3** in operation.

C: Solenoid moving direction

- Firmly tighten lock nuts **13** at both ends of rod **14** and stop operation of the solenoid.

CAUTION

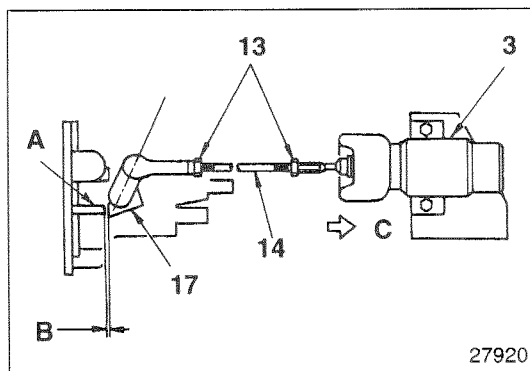
Do not continue to supply current to solenoid **3** for more than 20 seconds. Otherwise the solenoid may be burned.

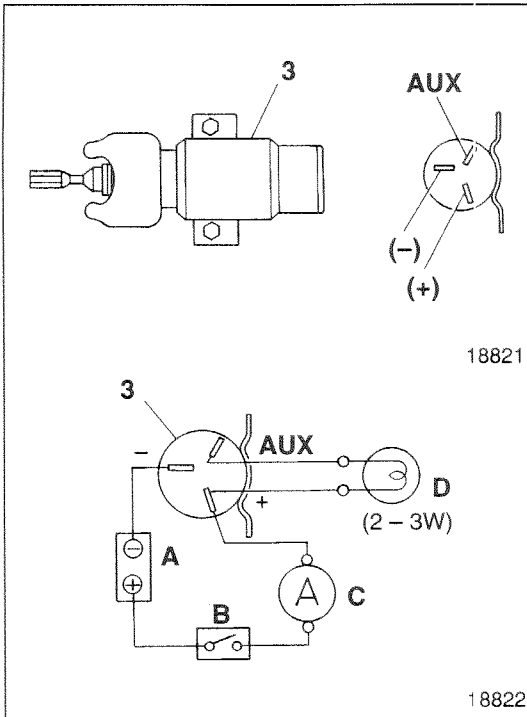
- Switch the switch of the circuit between ON and OFF repeatedly two or three times and check the following items.

CAUTION

Do not switch the switch rapidly between ON and OFF.

- Check to ensure that stop lever **18**, rod **14** and solenoid **3** move smoothly.
- Check to ensure that clearance **B** between base lever **17** and case stopper **A** have the standard value.





[Inspection]

Wire as shown at left and perform the following checks.

NOTE

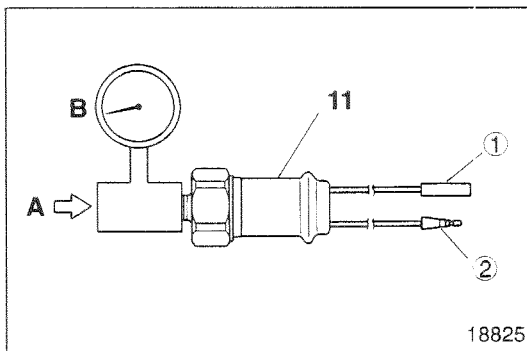
The checks can be performed by use of either ammeter **C** or lamp **D**.

A: Power supply
B: Switch
C: Ammeter
D: Lamp

- Set switch **B** to ON.
- If the reading of ammeter **C** after activation of solenoid **3** is out of the standard value or lamp **D** does not light, replace the solenoid.

CAUTION ⚠

When the check lamp does not light, do not continue to supply current to solenoid **3** for more than 20 seconds. Otherwise the solenoid may be burned.



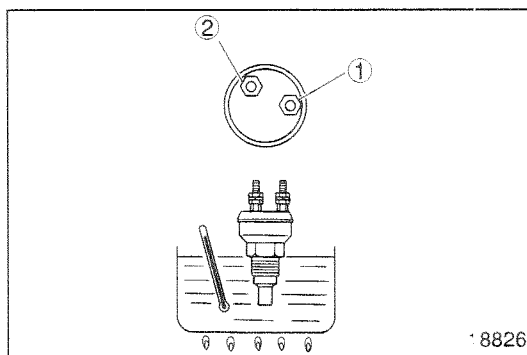
11 Inspection of engine oil pressure switch

Perform the following checks. If defective, replace engine oil pressure switch **11**.

- Under the condition where no air pressure **A** is applied to engine oil pressure switch **11**, check to ensure that there is continuity between terminals ① and ②.
- Slowly apply air pressure **A** to engine oil pressure switch **11**, beginning at 0 kPa (0 kgf/cm²).

When there is no more continuity between terminals ① and ②, measure the air pressure and check to ensure that the air pressure has the standard value.

B: Air pressure gauge



12 Inspection of coolant temperature sensor

- Put coolant temperature sensor **12** in a container filled with engine oil.
- Before raising the oil temperature, check to ensure that there is no continuity between terminals ① and ②.
- Slowly raise the oil temperature and stir the engine oil well.
- Measure the temperature at the time when there is continuity between terminals ① and ②.
- If the reading is out of the standard value, replace defective parts.

NOTE

When the oil temperature is near the operating temperature, slowly heat the oil. (When the operating temperature -5°C is reached, leave it alone for five minutes, and then raise the oil temperature at a rate of 1°C in two or three minutes.)

4D3 '95

diesel engine

Shop Manual

(for industrial use)

 **MITSUBISHI MOTORS CORPORATION**

JUNE 1997

GENERAC[®]
POWER SYSTEMS, INC.

P.O. BOX 310 EAGLE, WI 53119