6D1

diesel engine

Shop Manual

(for industrial use)

FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of Mitsubishi 6D1 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
6D14 6D14-T
6D15-T 6D16
6D16-E 6D16-T
6D16-TE 6D16-TL
6D16-TLE ·····SK330(N)LC-6E

GROUP INDEX

NOTE ; The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.

HOW TO READ THIS MANUAL

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 firs 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 and engine control	Fuel system
14	Cooling	Cooling system
15	Intake and exhaust	Intake and exhaust system, turbocharger, intercooler
21	Clutch	Clutch proper, bearing case
54	Electrical system	Alternator, starter, preheating system, engine start system, automatic stop system
61	Special equipment	Air compressor, pressure governor

General Explanation of This Manual

● Specifications

Particulars relative to maintenance service are made.

● Structure and operation

(1) Regarding conventional equipment, descriptions are made in brief.
(2) Regarding new equipment, descriptions of system and operating condition are made in detail.

● Troubleshooting

Symptoms of troubles and possible causes are described comparatively.

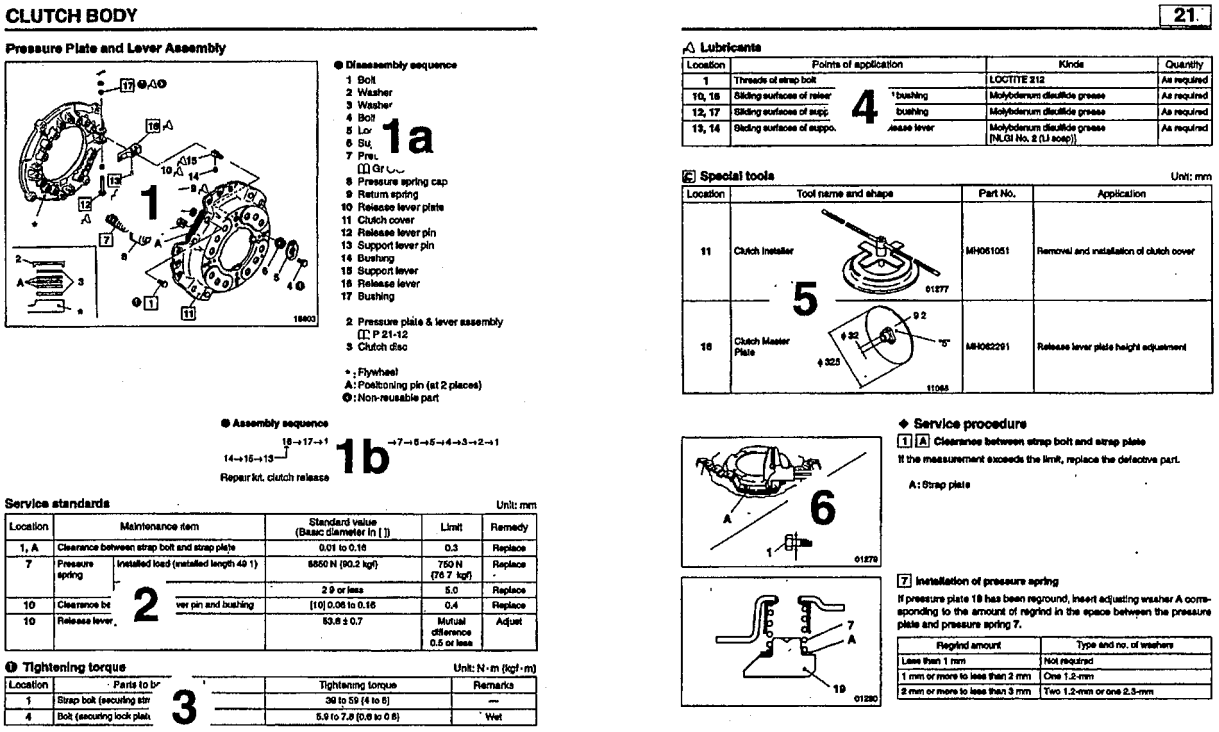
● Inspection and adjustment mounted in vehicle

Descriptions are made regarding inspection and adjustment of units mounted in vehicle.

● Service procedure

In principle, an explanation is given at the spread title page so that the service procedure can be understood. Servicing points are explained as a supplementary explanation.

Regarding the design of this manual



1. ..... Illustration for disassembly and assembly or removal and installation: 3-D exploded view of component parts is displayed.
   1a. ..... Names of parts show an example of the disassembly (removal) sequence.
   1b. ..... When the assembly (installation) sequence differs from the disassembly (removal) sequence, an example of the assembly (installation) sequence is shown.
2. ..... Service standards are shown collectively, classified by location.
3. ..... Tightening torques are shown collectively, classified by location.
4. ..... Points of lubricant, fluid and sealant application are shown collectively, classified by location.
5. ..... Special tools to be used are shown collectively, classified by location.
6. ..... When it is considered hard to understand the service procedure, just by the foregoing description, a supplementary description of the service procedure is given.

HOW TO READ THIS MANUAL

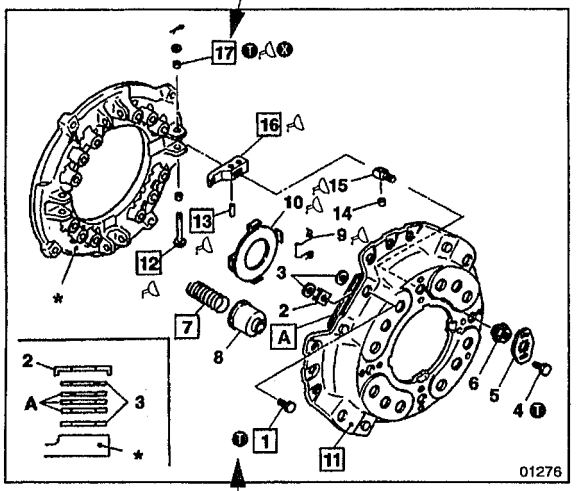
1. Illustration for disassembly and assembly or removal and installation

This shows that the appropriate service procedure is described in the text.

This shows the key No. of the part. In the text, this No. is referred to uniformly throughout.

CLUTCH BODY

Pressure Plate and Lever Assembly



● Disassembly sequence

1 Strap bolt
2 Washer
3 Washer
4 Bolt
5 Lock plate
6 Support nut
7 Pressure spring
🕮 Gr OO
8 Pressure spring cap
9 Return spring
10 Release lever plate
11 Clutch cover
12 Release lever pin
13 Support lever pin
14 Bushing
15 Support lever
16 Release lever
17 Bushing

2 Pressure plate & lever assembly
🕮 P 21-12
3 Clutch disc

*: Flywheel
A: Positioning pin (at 2 places)
⊗: Non-reusable part

● Assembly sequence

16→17→12→10→9→8→7→6→5→4→3→2→1
14→15→13

Repair kit: clutch release lever kit

This shows an example of the disassembly (removal) sequence.

This shows that the service procedure is described in another section.
🕮 POO-OO
: shows reference page within the same group.
🕮 GrOO
: shows reference group within the same book.

No service procedure is referred to in this section, but the item can be an objective of various procedures.

This is shown when the assembly (installation) sequence is not the reverse of the disassembly (removal) sequence.

This shows that a repair kit is available.

Meaning of symbols

- ❶ : shows that the tightening torque is specified.
- 🛆 : shows that application of lubricant, fluid or sealant is required.
- ⊗ : shows that the part should not be reused.

2. Service standards table

Only the relevant service standards are shown.

Service standards

Unit: mm

Location	Maintenance item		Standard value	Limit	Remedy
1, 11	Clearance between strap bolt and strap plate		0.01 to 0.16	0.3	Replace
7	Pressure spring	Installed load (Installed length 49.1)	835 N {85 kgf}	710 N {72.3 kgf}	Replace
		Tilt	2.9 or less	5.0	Replace

This shows the key No. of the relevant part.

3. Tightening torque table

This shows specified tightening torque.

T Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Strap bolts (Strap bolt mounting)	39 to 59 {4 to 6}	–
4	Bolt (Lock plate mounting)	5.9 to 7.8 {0.6 to 0.8}	Wet

This shows the key No. of the relevant part.

This shows that the item is to be tightened wet.

4. Lubricant, fluid and sealant table

Only the relevant lubricant, fluid and sealant are shown.

This shows the application point.

Lubricant, fluid and sealant

Location	Points of application	Kinds	Quantity
1	Thread area of bolt	LOCTITE 272	As required
10, 16	Friction surfaces of release lever plate and release lever	Molybdenum disulfide grease [NLGI No. 2 (Li soap)]	As required

This shows the key No. of the relevant part.

This shows the specified brand.

HOW TO READ THIS MANUAL

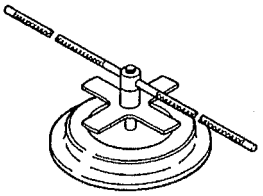
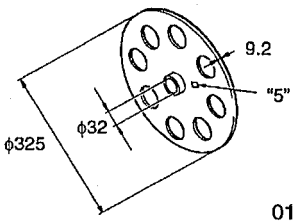
5. Special tools table

Only the relevant special tools are shown.

Purpose of special tools is shown.

Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
11	Clutch installer  01277	MH061051	Removal and installation of clutch cover
16	Master plate  01278	MH062291	Adjust release lever heights

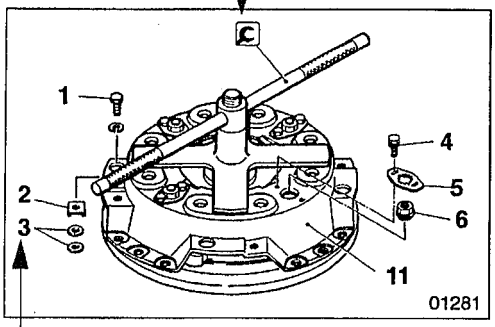
This shows the key No. of the relevant part.

Quote this number when placing an order for the part.

6. Service procedure

This indicates a special service tool.

This shows the key No. of the relevant part.



11 Removal and installation of clutch cover

- Depress pressure spring **7** using clutch installer, then remove the following parts:
  Strap bolt **1**, washer **2**, washer **3**, bolt **4**, lock plate **5**, support nut **6**
- Loosen the clutch installer gradually, then remove clutch cover **11** when the pressure spring is fully released.
- For installation, follow the removal sequence in reverse.

The key No. referred to in the text is always the same as the key No. shown in the illustration.

Servicing procedures of disassembly (removal), assembly (installation), inspection, adjustment, etc. are shown collectively.

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**

Excessive or insufficient 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.

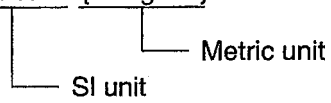
HOW TO READ THIS MANUAL

● Unit

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}	98.0665 kPa {1 kgf/cm^2}
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmH_2O}	9.80665 Pa {1 mmH_2O}
Volume		dm^3 {L}	1 dm^3 {1 L}
Power		kW {PS}	0.7355kW {1 PS}
Heat quantity		J {kcal}	4186.05 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	ft.lbs	1 N·m = 0.7375 ft.lbs
Pressure	kPa (kilopascal)	psi	1 kPa = 0.145 psi 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)	PS	1 kW = 1.3596 PS
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.

GROUP 00 GENERAL

GENERAL SPECIFICATIONS

Item	Specifications								
Engine model	6D14	6D14 -T	6D15 -T	6D16	6D16 -E	6D16 -T	6D16 -TE	6D16 -TL	6D16 -TLE
Type	6-cylinder in-line, water-cooled 4-cycle diesel								
Combustion chamber type	Direct injection type								
Valve mechanism	Overhead valve (OHV) type								
Bore × Stroke mm	110 × 115		113 × 115	118 × 115					
Total displacement cc	6557		6919	7545					
Compression ratio	17.5	16		17.5	19	16			17.5
Empty mass kg*	500	540		500		550		560	

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

Engine Outputs Classified By Application

Application \ Engine model	6D14	6D14-T		6D16	6D16-T	
		Middle-speed specification	High-speed specification		Middle-speed specification	High-speed specification
Intermittent rated output kW (HP)	59 (79)/1500	83 (111)/1500	79 (106)/1500	71 (95)/1500	106 (142)/1500	101 (136)/1500
	70 (94)/1800	98 (132)/1800	95 (127)/1800	85 (114)/1800	123 (165)/1800	121 (163)/1800
	77 (103)/2000	106 (143)/2000	103 (139)/2000	93 (125)/2000	131 (176)/2000	131 (175)/2000
	82 (110)/2200	111 (150)/2200	111 (150)/2200	101 (135)/2200	140 (188)/2200	139 (186)/2200
	87 (117)/2500		120 (161)/2500	111 (149)/2500		147 (197)/2500
	92 (123)/2800		126 (168)/2800	120 (161)/2800		151 (203)/2800
Continuous rated output kW (HP)	53 (72)/1500	75 (101)/1500	72 (96)/1500	65 (87)/1500	96 (129)/1500	92 (123)/1500
	64 (86)/1800	89 (120)/1800	86 (115)/1800	77 (103)/1800	111 (149)/1800	110 (148)/1800
	70 (93)/2000	96 (129)/2000	94 (126)/2000	84 (113)/2000	119 (160)/2000	118 (158)/2000
	74 (99)/2200	101 (136)/2200	101 (136)/2500	93 (125)/2200	127 (170)/2200	125 (168)/2200
	79 (106)/2500		109 (146)/2500	101 (135)/2500		133 (178)/2500
	83 (111)/2800		114 (153)/2800	110 (147)/2800		137 (184)/2800

NOTE

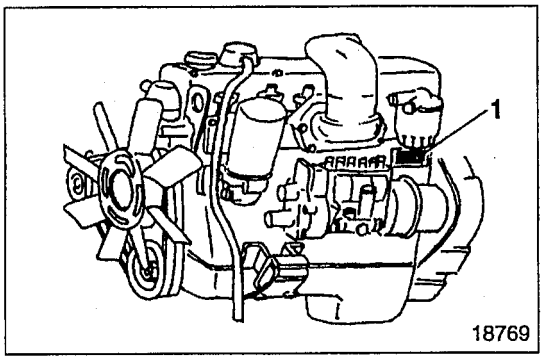
1. The output (SAE, gross) is corrected to standard ambient conditions based on SAE J1349.

2. The continuous rated output allows 10% (one hour) overload operation.

ENGINE NUMBER AND NAME PLATE

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

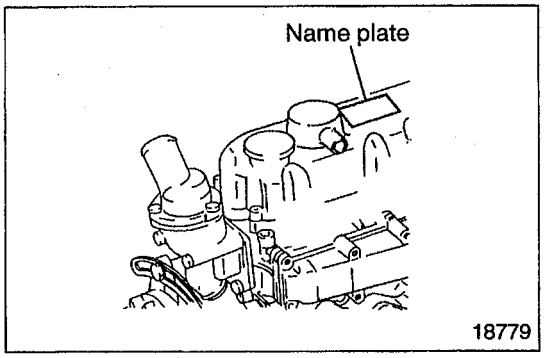


Engine number **1** is punch-marked on the left of the crankcase.

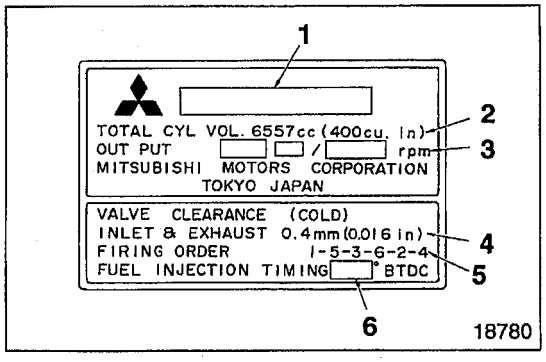
Example: 6D16–□□□□□□

- 6D16 — Engine model
- □□□□□□ — Engine number

Name Plate



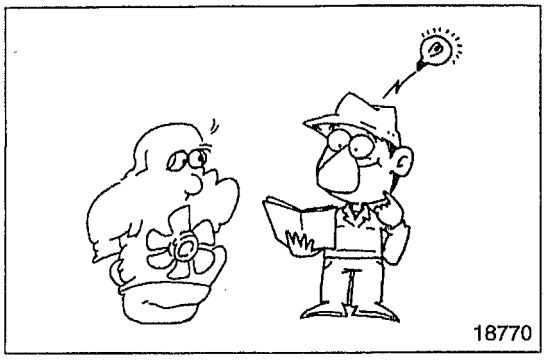
The name plate is attached to the portion shown in the illustration, and indicate the following items.



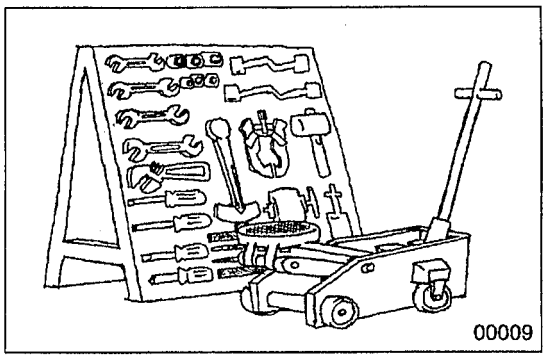
1. Engine model
2. Total displacement
3. Maximum output
4. Valve clearance
5. Firing order
6. Fuel injection timing

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.

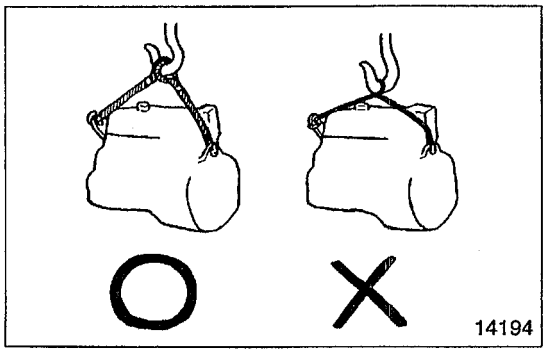


Perform maintenance work at a level area.
Prepare the following.

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

WARNING ⚠

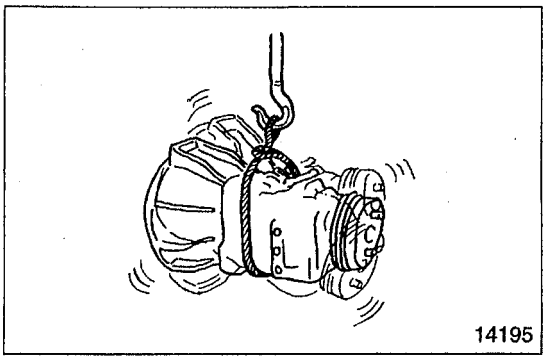
Do not attempt to use tools other than special tools where use of special tools is specified in this manual. This will avoid injury or damage.



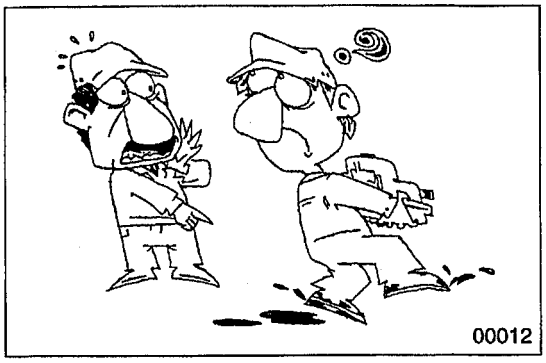
Pay special attention to safety when removing or installing heavy items such as engines, transmissions.

When lifting up heavy items using cables, pay special attention to the following points:

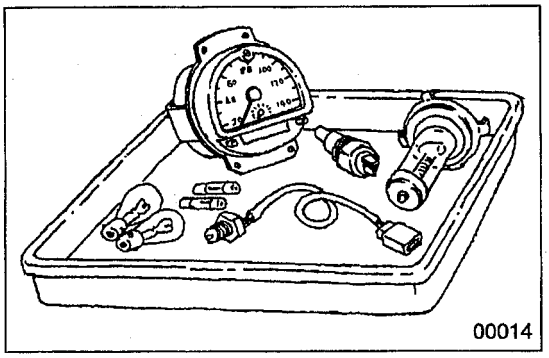
- Check the mass of the item to be lifted and use a cable capable of lifting that mass.



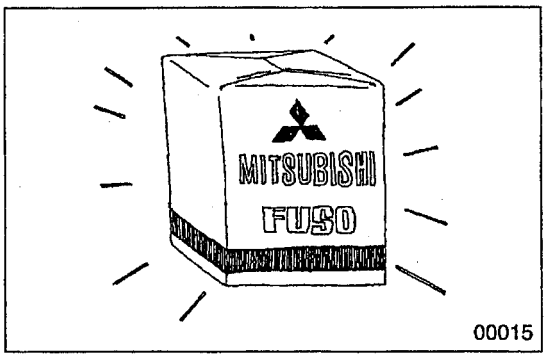
- If you do not have the specified lifting hanger, secure the item using cable taking the point-of-balance of the item into consideration.
- You must work in a position where you will not be injured even if the cable comes undone and the lifted item falls.


00012

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.

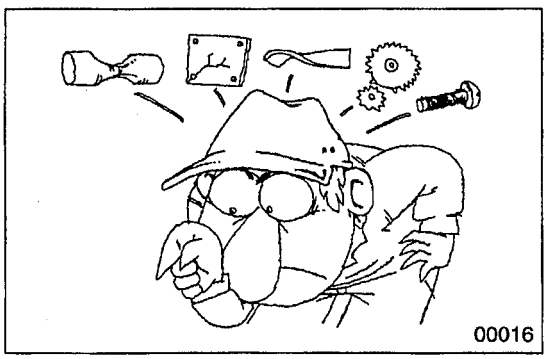

00014

Check for oil leakage before cleaning the area having the fault otherwise you might miss detecting the leakage.
Prepare replacement part(s) beforehand.



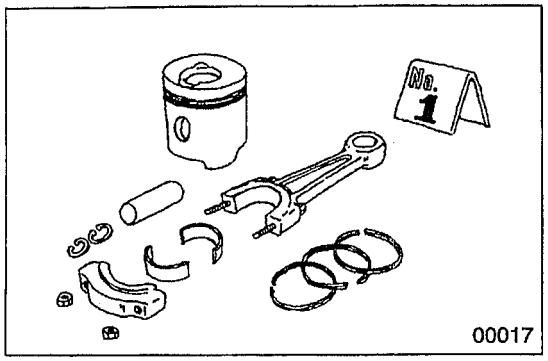
00015

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.

PRECAUTIONS FOR MAINTENANCE OPERATION

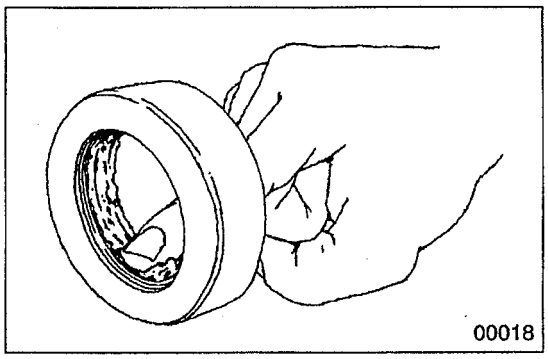


00017

Put alignment marks on part combinations before disassembly and arrange the disassembled parts neatly. This will help avoid mismating 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 ⚠

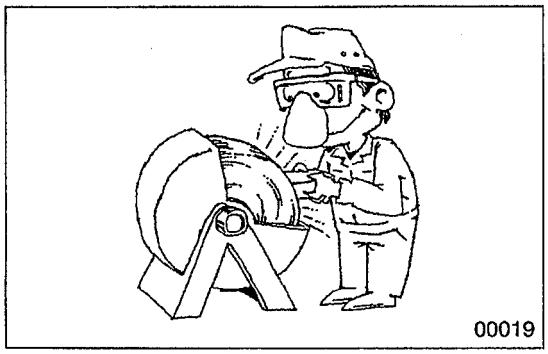
- **Take care to avoid mixing up numerous parts, similar parts, left and right, etc.**
- **Keep new parts for replacement and original (removed) parts separate.**


00018

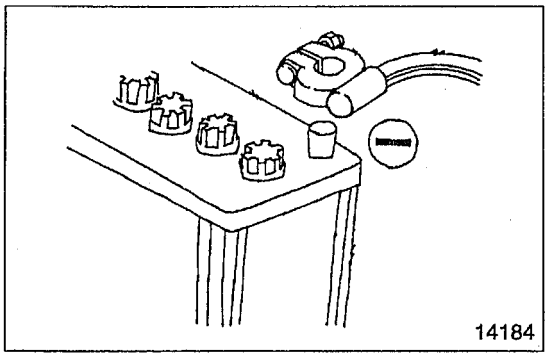
Apply the specified oil or grease to U-packings, oil seals, dust seals and bearings during assembly.
Use only the specified oil, grease, etc. for lubricant, remove the excess immediately after application with a piece of waste, etc.

CAUTION ⚠

When the specified lubricant, fluid and sealant is not available, you may use an equivalent.


00019

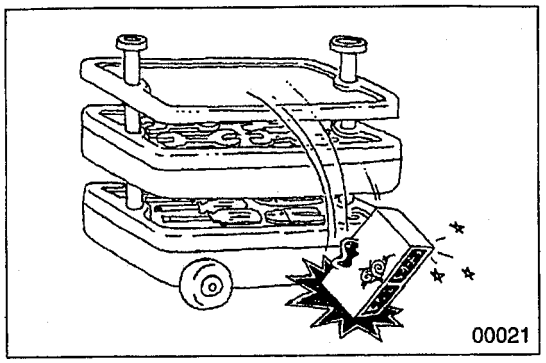
Wear goggles when using a grinder or welder. Pay full attention to safety by wearing gloves when necessary. Watch out for sharp edges, etc. that might injure your hands or fingers.


14184

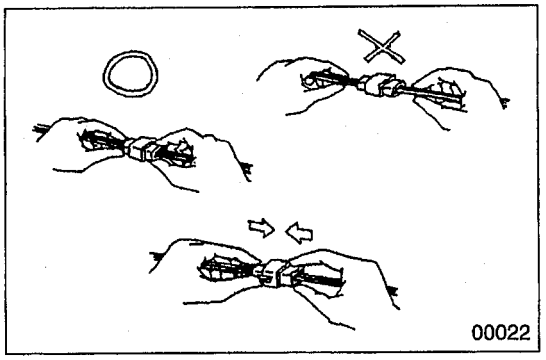
Before carrying out maintenance work on the electric system, disconnect the negative terminals of the batteries to prevent them from short-circuiting and burning-out.

CAUTION ⚠

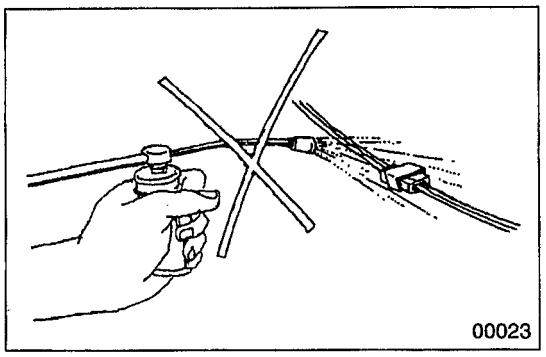
Be sure to turn starter and lighting switches, etc. off before disconnecting or connecting battery terminals, because the semiconductors can be damaged.



Take care when handling sensors, relays, etc. which are vulnerable to shock and heat. Do not attempt to remove the cover from, or apply paint to, the electronic control unit.



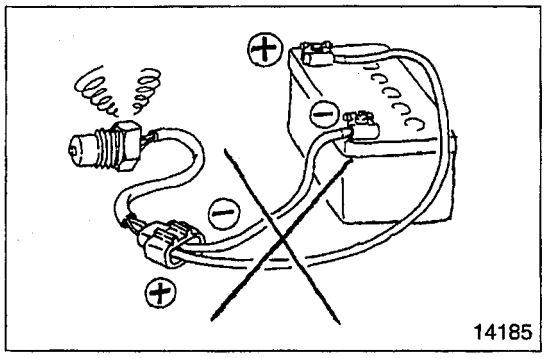
Pull the connector, and not the harness lead, to separate connectors. To separate a lock-type connector, first push toward arrow mark. To reconnect a lock-type connector, press the separated parts until they click together.



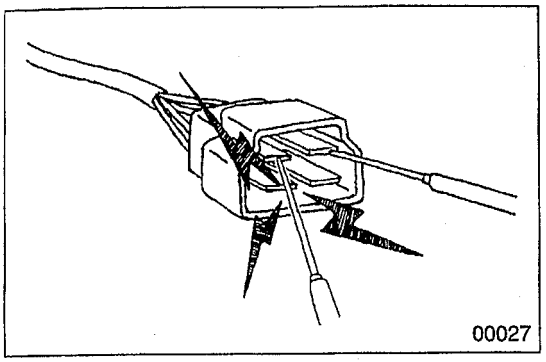
When washing the vehicle, cover the electric system parts and instruments with waterproof material beforehand (Cover with vinyl sheet or the like). Keep water away from harness wire connectors and sensors. If any of them should get wet, wipe them off immediately.

When using an electric welder, such electronic parts that are directly connected to the batteries might be damaged due to the flow of current from the welder that flows through the negative circuit. Parts that have switches might be subject to the same danger if the switches are left on.
Therefore, do not fail to observe the following.

- Connect the negative terminal of the welder as near as possible to the area that is to be welded.
- Disconnect the negative terminals of batteries.

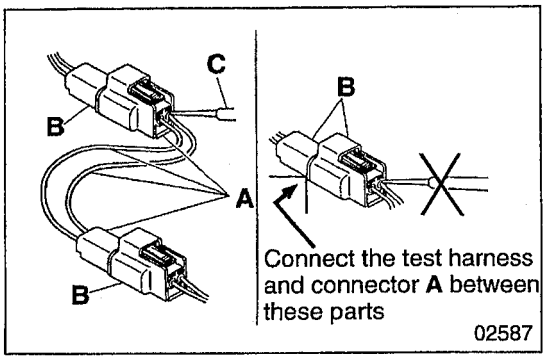


To apply voltage for testing, check that the positive and negative cables are connected properly, then increase voltage gradually from 0 volt. Do not apply voltage higher than the specified value.
In particular, pay close attention to the electronic control unit and sensors, since they are not always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


00027

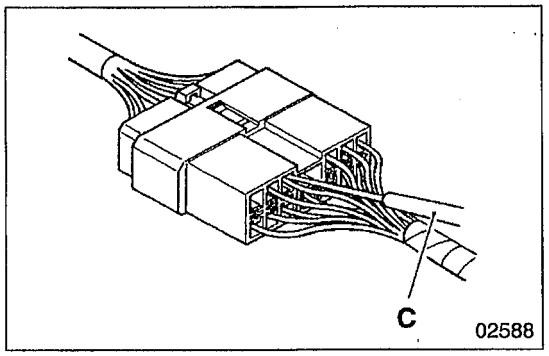
When using testers or the like for continuity tests, be careful not to allow test probes to touch the wrong terminals.

Measurement Procedures Using Connectors



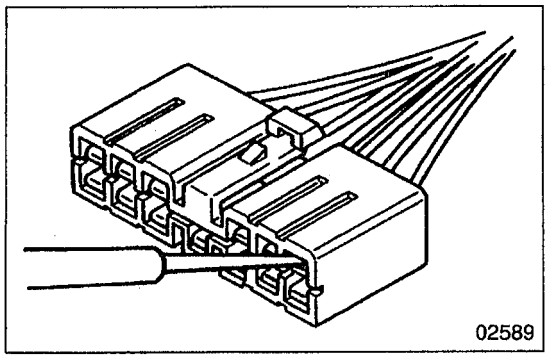
02587

Test with connectors engaged (continuity through circuit obtained)
<Waterproof connector>
Prepare a test harness and connectors **A**, then connect if 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.

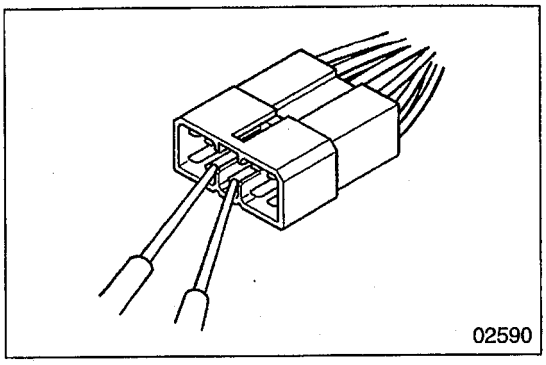


02588

<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.


02589

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.

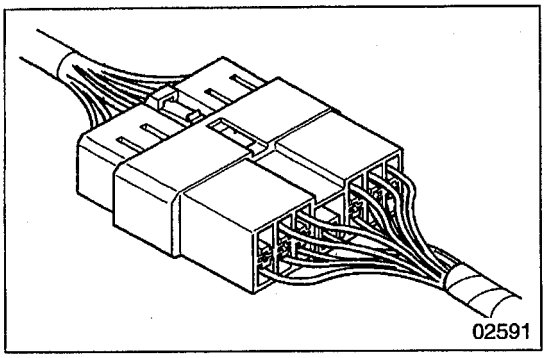


Using male pins
Touch the pins directly using test probes.

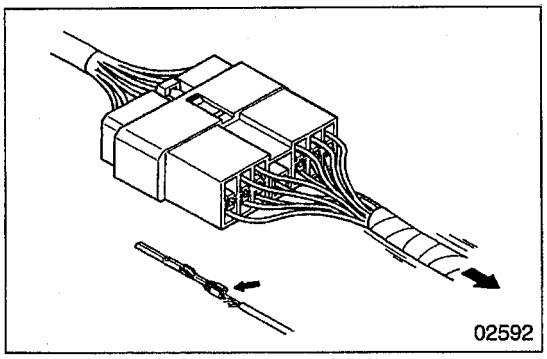
CAUTION ⚠

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.

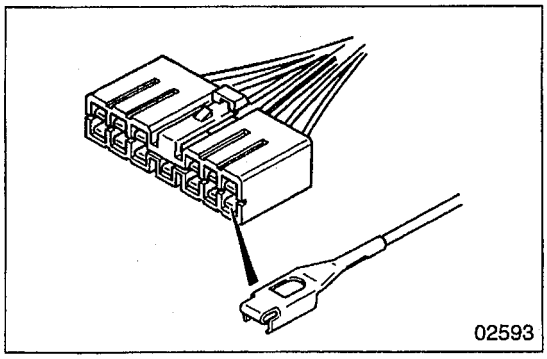
Connector Inspection Procedures



Visual inspection
Check for loose connection and poor engagement.

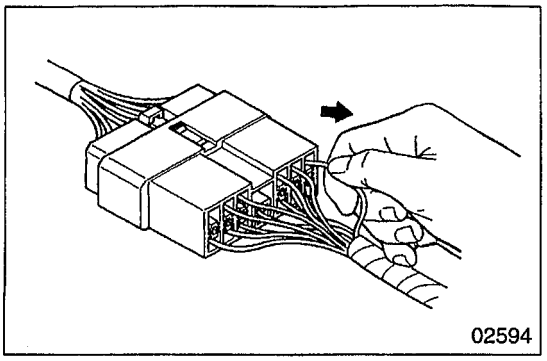


Check if harnesses are broken by pulling gently around the terminals.



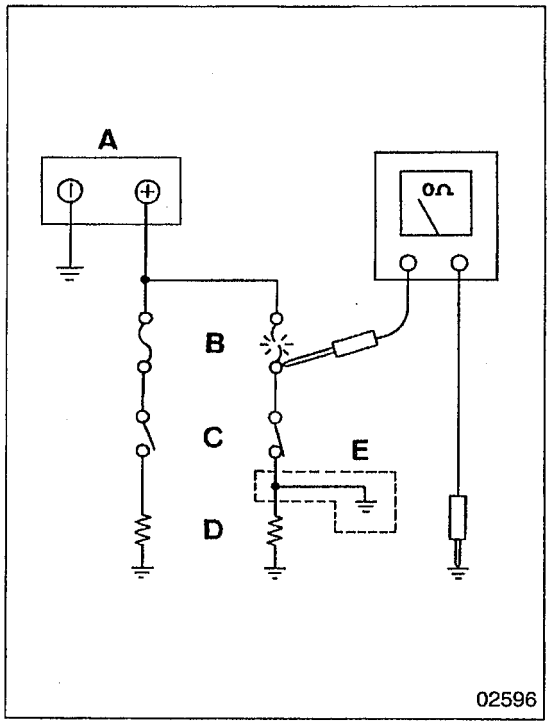
Check for a decrease in contact pressure between the male and female terminals.

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

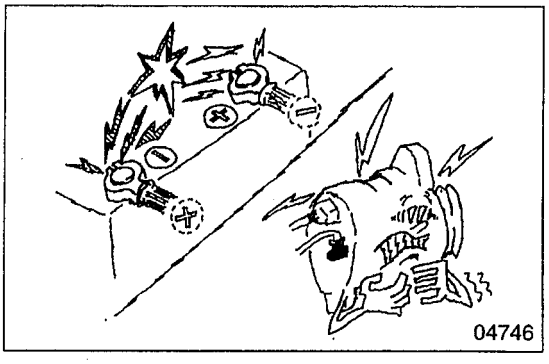


Remove fuse **B** and measure resistance between the loaded side of the fuse and ground.
Turn on all circuit switches (connected to the fuse). If the resistance value reading is approximately 0, a short has occurred between the switch and the loaded point. A value of other than zero may indicate that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

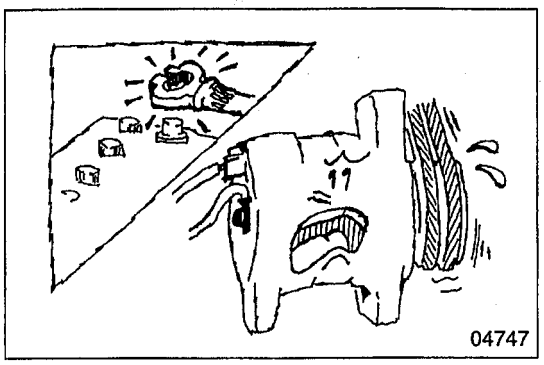
The major causes of a short circuit are as follows:
- Harness stuck onto the vehicle body.
- Harness sheath damaged by friction or heat.
- Water in connectors or circuits.
- Mistakes (accidental short circuits)

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

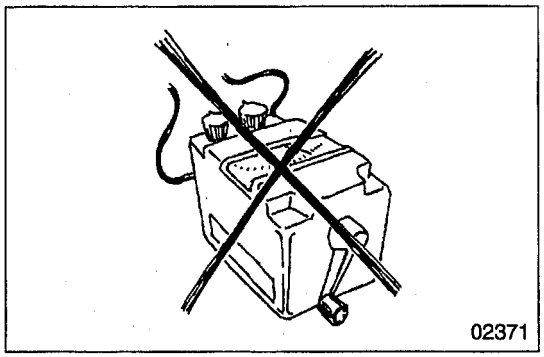
Precautions for Handling Alternator



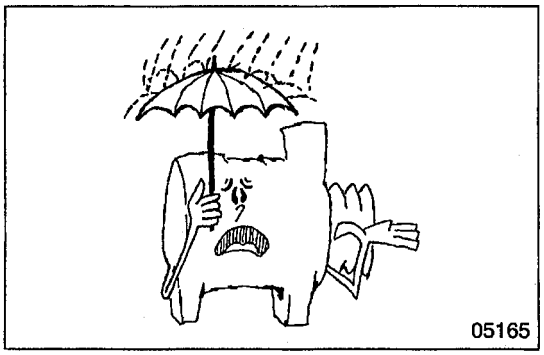
When servicing the alternator, pay attention to the following:
- Do not connect the alternator with battery polarities reversed.
  If the alternator is connected with reversed polarities, a large current flow from the battery to the alternator occurs, and the diode or regulator might be damaged.



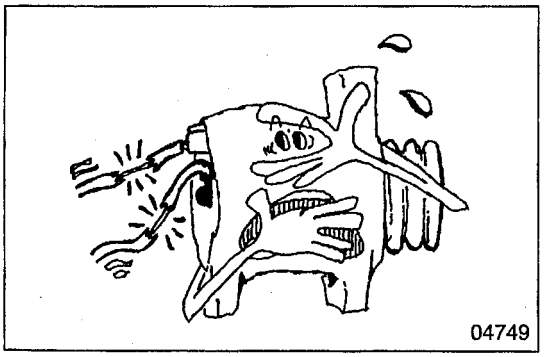
- While the engine is running, do not remove the battery terminals. If the battery terminals are removed at that time, a surge voltage is generated and the diode or regulator might be weakened.



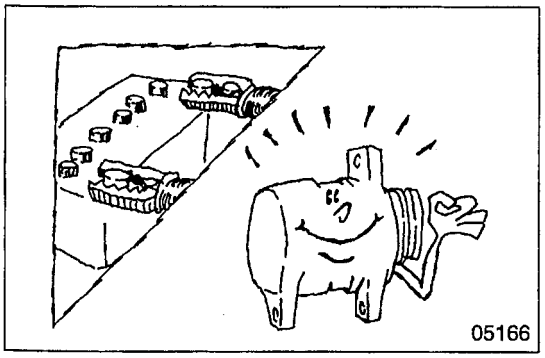
- Do not use a high-voltage tester such as a megger for inspection. If a high-voltage tester is used, the diode or regulator might be destroyed.



- 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.



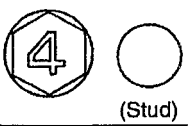
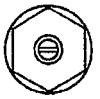
- Disconnect the battery terminals before quick-charging the battery. Quick-charging without disconnecting the battery terminals might damage the diode or regulator.

TABLE OF STANDARD TIGHTENING TORQUES

- 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 6.9}
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 {25 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}

Hex-head Nut

Unit: N·m { kgf·m}

Strength classification	4T		6T	
Repre-sentation / Diameter symbol			    02155	
	Standard screw	Coarse screw	Standard screw	Coarse screw
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 {25 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}

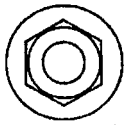
Strength classification	4T	
Repre-sentation / Diameter symbol	 02155	
	Standard screw	Coarse screw
M6	4 to 6 {0.4 to 0.6}	–
M8	10 to 15 {1.0 to 1.5}	–
M10	21 to 30 {2.1 to 3.1}	20 to 28 {1.9 to 2.9}
M12	38 to 54 {3.8 to 5.5}	35 to 51 {3.4 to 5.2}

TABLE OF STANDARD TIGHTENING TORQUES

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} { $2.0^{+0.6}_{-0}$ }	29^{+10}_{-0} { $3.0^{+1.0}_{-0}$ }	49^{+10}_{-0} { $5.0^{+1.0}_{-0}$ }	54^{+5}_{-0} { $5.5^{+1.0}_{-0}$ }

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} { $1.3^{+0.4}_{-0}$ }	29^{+5}_{-0} { $3.0^{+0.5}_{-0}$ }	49^{+5}_{-0} { $5.0^{+0.5}_{-0}$ }	64^{+5}_{-0} { $6.5^{+0.5}_{-0}$ }

GROUP 11 ENGINE

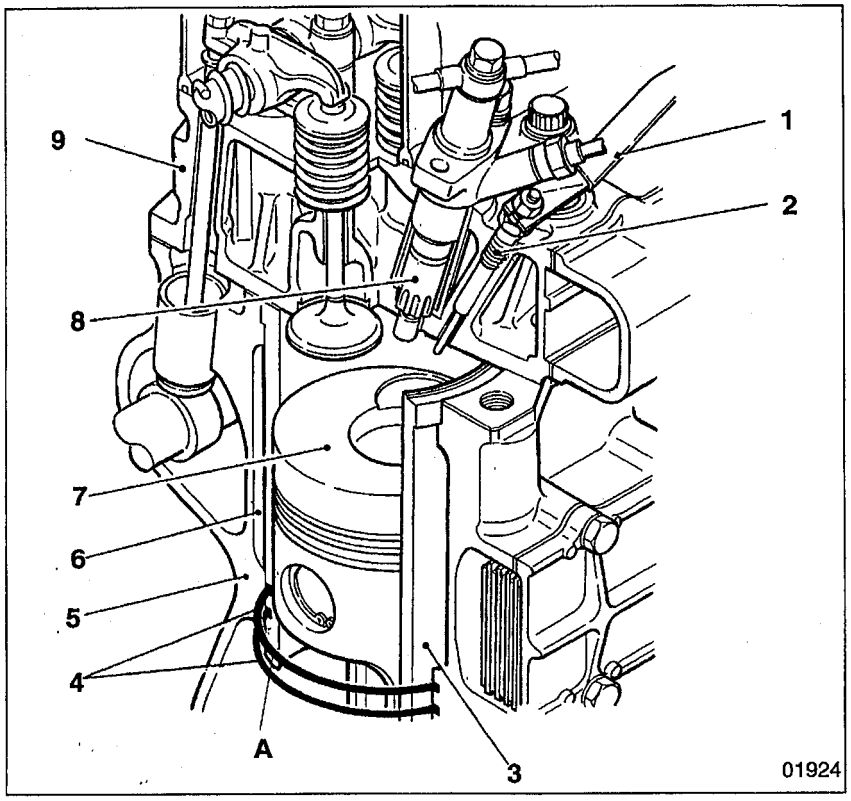
NOTE ; The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.

SPECIFICATIONS

Item	Specifications						
Engine model	6D14	6D14-T	6D15-T	6D16	6D16-E	6D16-T 6D16-TE 6D16-TL	6D16-TLE
Type	6-cylinder, in-line, water-cooled, 4-cycle diesel						
Combustion chamber type	Direct injection						
Valve mechanism	Overhead valve						
Cylinder bore × stroke mm	ϕ110 × 115		ϕ113 × 115	ϕ118 × 115			
Total displacement cc	6557		6919	7545			
Compression ratio	17.5	16.0		17.5	19	16.0	17.5

1. Cylinder Head and Crankcase

<Engines with wet type cylinder liners: 6D14, 14-T, 15-T>

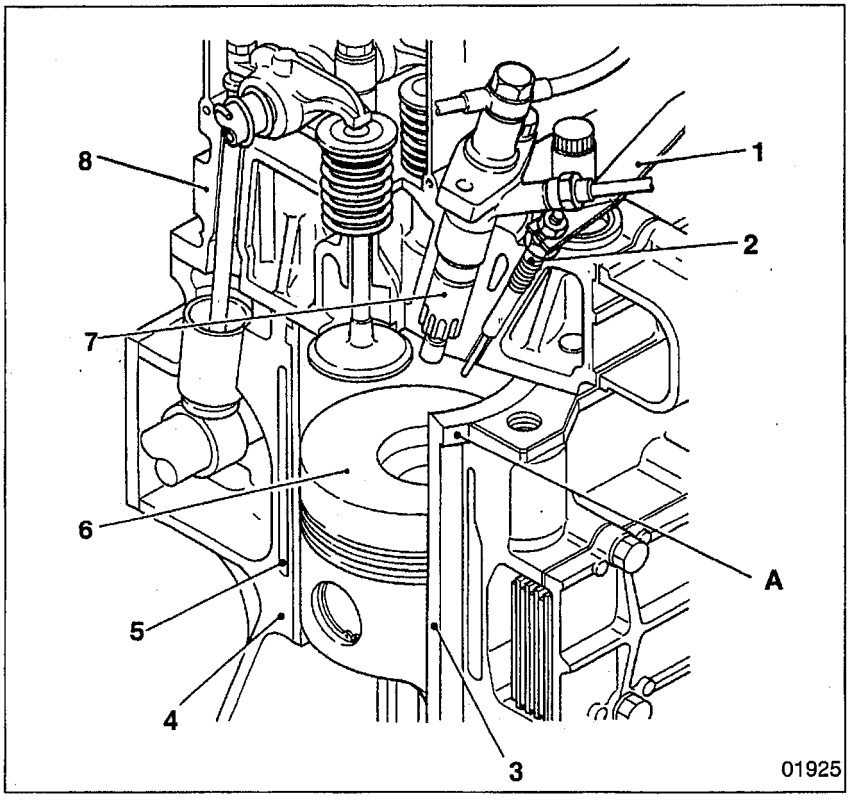


1 Connecting plate
2 Glow plug
3 Cylinder liner
4 O-ring
5 Crankcase
6 Water jacket
7 Piston
8 Injection nozzle
9 Cylinder head

A: Cylinder liner size mark: A, B, C

- The cylinder liners **3** are a removable wet type liners. They are press-fitted into the top of the crankcase **5** and the bottom of the water jacket **6**.
- The O-rings **4** are provided to prevent the ingress of coolant.
- The cylinder liners **3** and pistons **7** have size marks. The liner and piston that are paired should be of the same size mark.

<Engines with dry type cylinder liner: 6D15-T, 16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE>

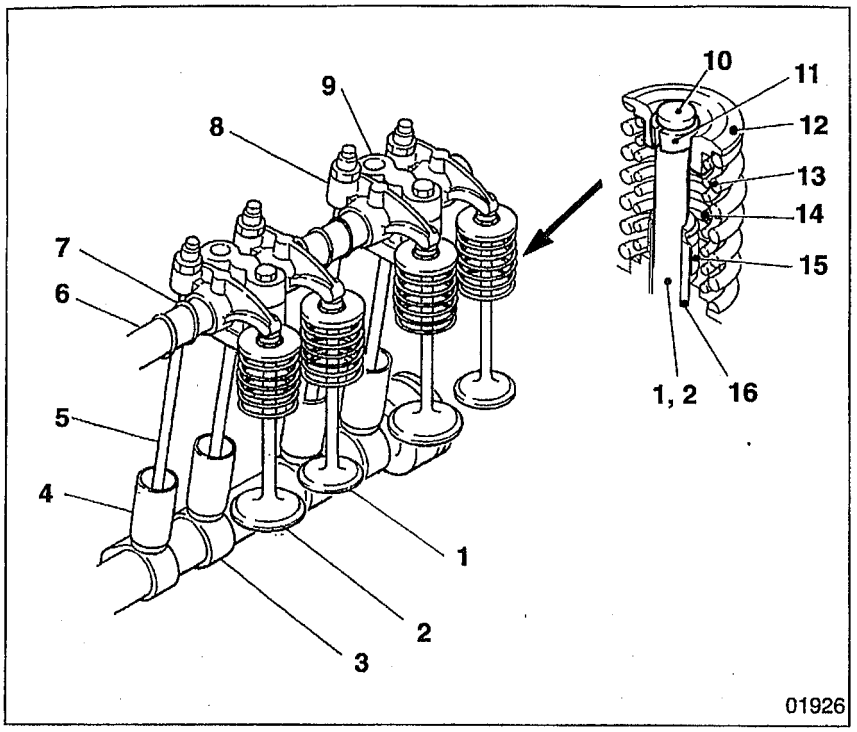


1 Connecting plate
2 Glow plug
3 Cylinder liner
4 Crankcase
5 Water jacket
6 Piston
7 Injection nozzle
8 Cylinder head

A: Cylinder liner size mark
Outer diameter mark: 1, 2, 3
Inner diameter mark: A, B

- The cylinder liners **3** are a dry type liners that are easier to remove than wet liners. Liners are press-fitted into the crankcase **4**.
- The cylinder liners **3**, crankcase **4**, and pistons **6** have size marks. They should be combined as specified according to the size marks. P.11-28

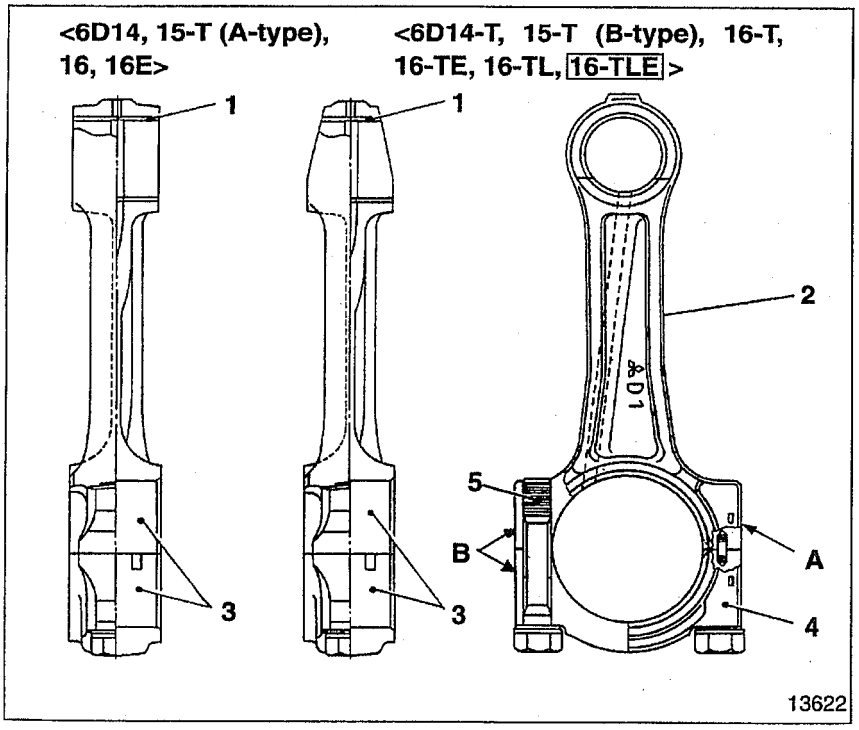
2. Valve Mechanism



1 Exhaust valve
2 Inlet valve
3 Camshaft
4 Tappet
5 Push rod
6 Rocker shaft
7 Rocker shaft spring
8 Rocker
9 Rocker shaft bracket
10 Valve cap
11 Valve cotter
12 Upper retainer
13 Outer valve spring
14 Inner valve spring
15 Valve stem seal
16 Valve guide

- The valve stem seals **15** are fitted onto the valves **1**, **2** to control the amount of lubricant flowing onto the sliding surfaces of the valves **1**, **2** and valve guides **16**.
- The valve springs **13**, **14** are unevenly pitched to prevent abnormal vibration at high speeds. To prevent the inner and outer springs from meshing with each other, the springs are wound in opposite directions.
- To facilitate removal and reinstallation of the camshaft from the rear end of the crankcase, the diameter of each bushing is smaller toward the front of the engine.

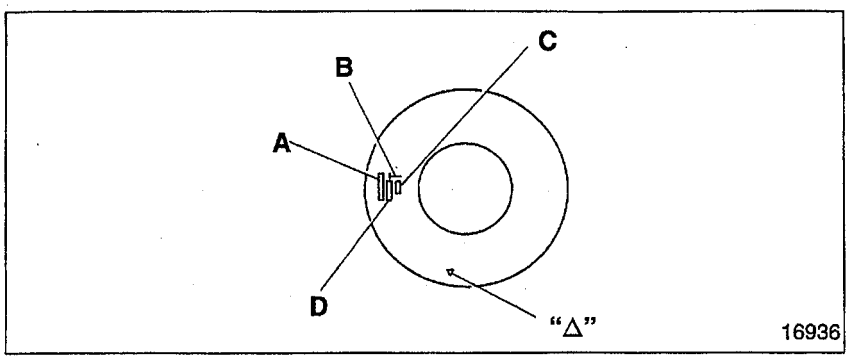
3. Connecting Rods



1 Connecting rod bushing
2 Connecting rod
3 Connecting rod bearing
4 Connecting rod cap
5 Connecting rod bolt

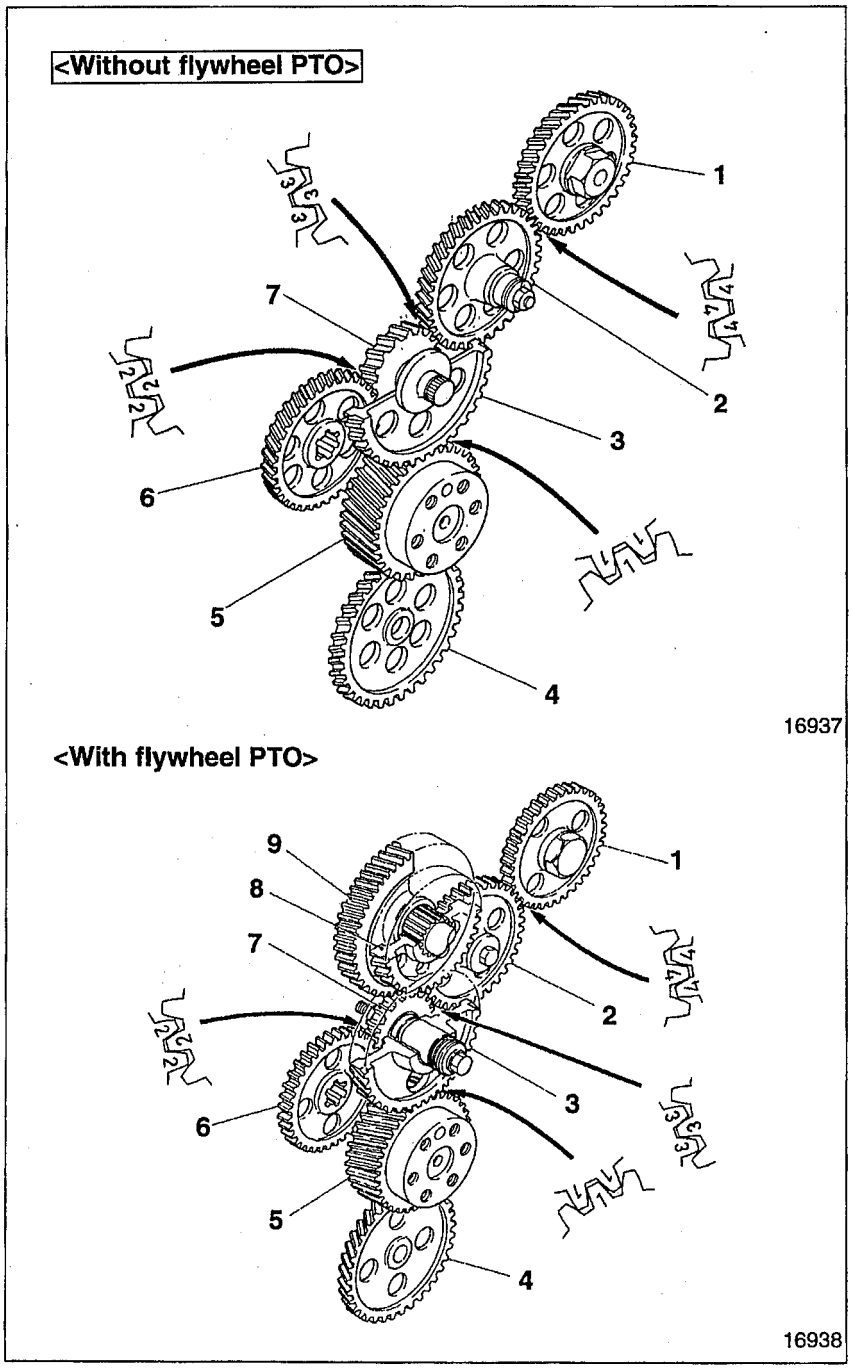
A: Alignment mark
B: Weight mark stamp
(A, B, C, D, E, F, G, H, I, V, W, X, Y, Z: <except 6D16-TLE>)
(A, B, C, D, E, F: <6D16-TLE>)

4. Pistons



A: Part number
B: "T" mark <6D14-T, 15-T, 16-T, 16-TE, 16-TL, 16-TLE>
C: Size mark (A, B, C: <6D14, 14-T, 15-T>)
(A, B: <6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE>)
D: Weight mark
Δ: Front mark

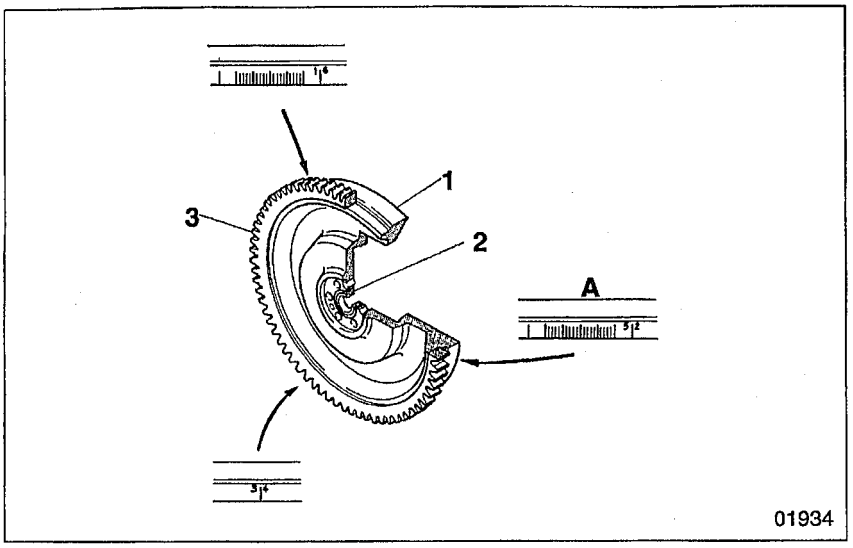
5. Timing Gears



1 Camshaft gear
2 No. 2 idler gear
3 No. 1 idler gear
4 Oil pump gear
5 Crankshaft gear
6 Air compressor drive gear or injection pump drive gear
7 No. 1 idler gear
8 PTO idler gear
<models with flywheel PTO>
9 PTO idler gear
<models with flywheel PTO>

Each gear is stamped with a timing gear alignment mark ("**1**", "**2**", "**3**", or "**4**") to facilitate reassembly.

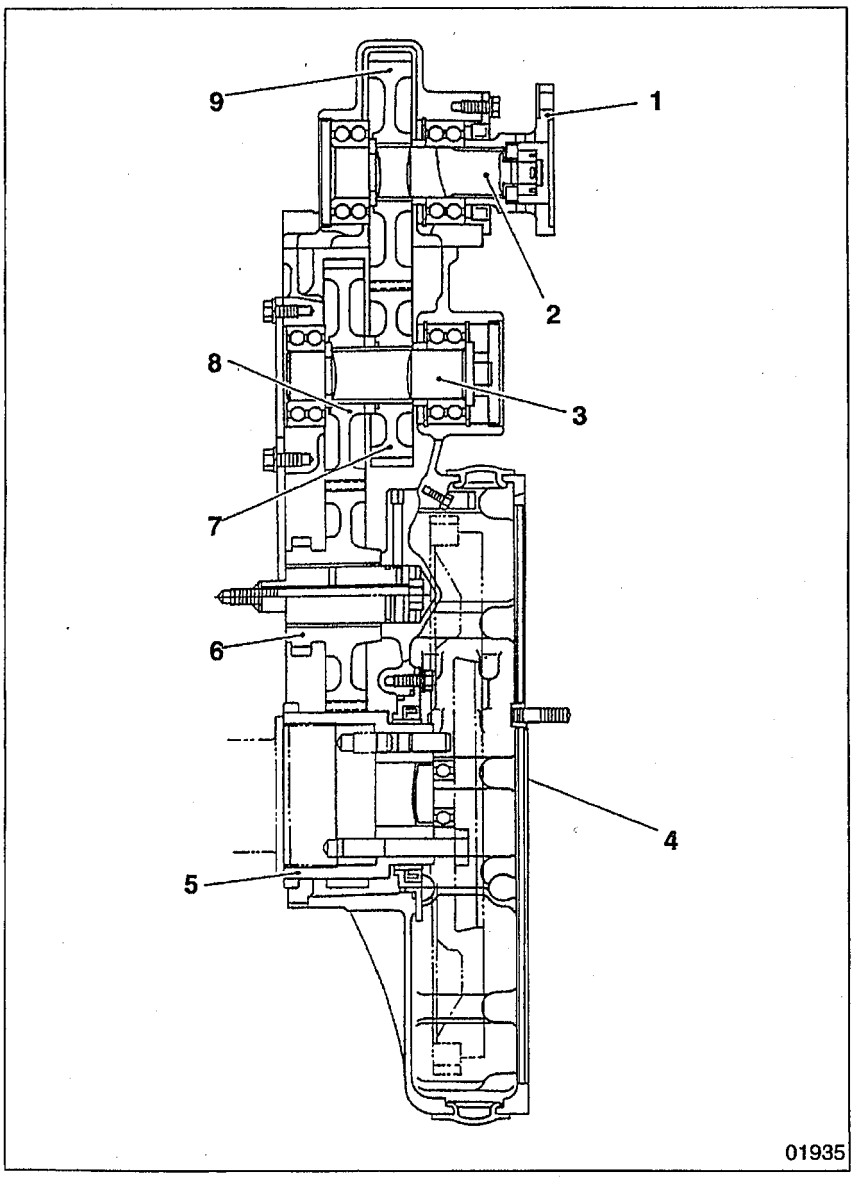
6. Flywheel



1 Flywheel
2 Pilot bearing
3 Ring gear

A: Angle scale, cylinder number

7. Flywheel PTO



1 Flange
2 PTO shaft
3 PTO idler shaft
4 Flywheel housing
5 Crankshaft gear
6 No. 1 idler gear
7 PTO idler gear
8 PTO idler gear
9 PTO gear

The flywheel PTO is fitted onto the top of the flywheel housing **4** and is driven by the crankshaft gear **5**.

Symptoms / Possible causes	Low power output	Abnormal engine noise	Remarks
Incorrect oil viscosity	○		🕮 Gr 12
Incorrect/defective fuel	○		🕮 Gr 13
Incorrect valve clearance	○	○	
Defective cylinder head gasket	○	○	
Worn valve/valve seat, and carbon deposits	○	○	
Weakened valve spring	○	○	
Worn/damaged piston ring(s)	○	○	
Worn/damaged piston ring groove(s)	○	○	
Incorrect injection timing	○	○	🕮 Gr 13
Defective injection pump	○	○	🕮 Gr 13
Defective cooling system	○		🕮 Gr 14
Defective injection nozzle(s)	○	○	🕮 Gr 13
Air trapped in fuel system	○		🕮 Gr 13
Clogged air cleaner	○		🕮 Gr 15
Clogged muffler	○		🕮 Gr 15
Defective turbocharger	○	○	🕮 Gr 15
Incorrectly fitted pipe(s)/hose(s)		○	🕮 Gr 13
Injection pump, alternator, or other auxiliary device(s) defective/incorrectly fitted		○	🕮 Gr 13, 54
Loose/damaged V-belt		○	🕮 Gr 14
Incorrectly fitted crankshaft pulley		○	
Defective air cleaner or muffler		○	🕮 Gr 15
Defective valve spring(s)		○	
Defective rocker shaft and bracket		○	
Incorrect lubrication of rocker shaft bracket		○	
Incorrect backlash in timing gears		○	
Incorrect lubrication of timing gear peripheries and idler shafts		○	
Worn connecting rod small end bushing and piston pin		○	
Worn/damaged crankshaft pin and connecting rod big end bearing		○	
Worn/damaged crankshaft journal and main bearing		○	
Excessive end play in crankshaft and camshaft		○	
Worn tappet(s) and camshaft		○	

ON-VEHICLE INSPECTION AND ADJUSTMENT

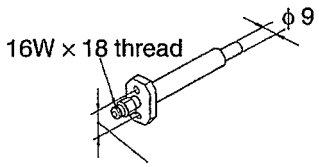
1. Measuring Compression Pressure

Service standards

Location	Maintenance item			Standard value	Limit	Remedy
—	Compression pressure	Each cylinder (at 200 rpm)	Except 6D16-E	2550 kPa {26 kgf/cm^2}	1960 kPa {20 kgf/cm^2}	Inspect
			6D16-E	2940 kPa {30 kgf/cm^2}		
		Cylinder-to-cylinder pressure difference		—	390 kPa {4 kgf/cm^2}	Inspect

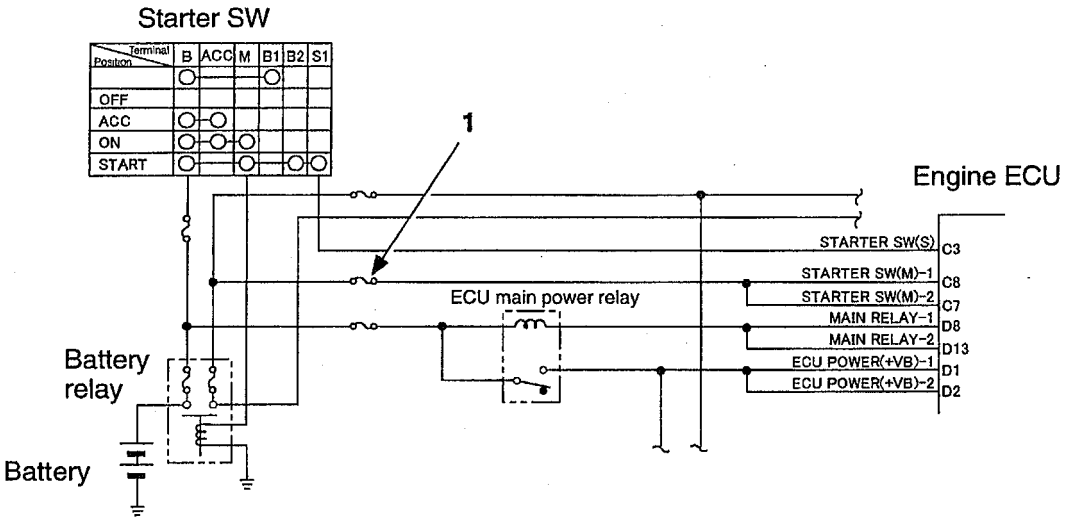
Special tools

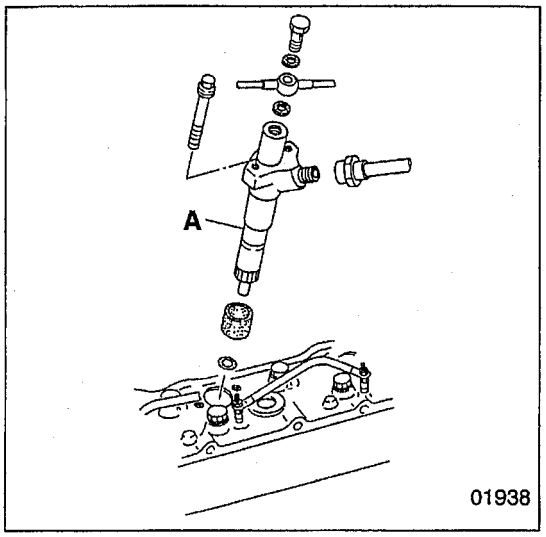
Unit: mm

Location	Tool name and shape	Part No.	Application
—	Compression Gauge Adapter 	MH061461	Measuring 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 inspections, check that the engine oil, starter, and battery are normal.
- Warm up the engine until the coolant temperature reaches 75 to 85°C.
- Turn off all lights and auxiliary devices.
- To prevent injection of fuel while cranking the engine by the starter, perform the following steps.
  - Set the stop lever of the injection pump governor to the stop position. <Mechanical governor>
  - Remove fuse **1** shown in the diagram below. For the terminal arrangement of the engine ECU, refer to Gr. 13E. <Electronic governor>

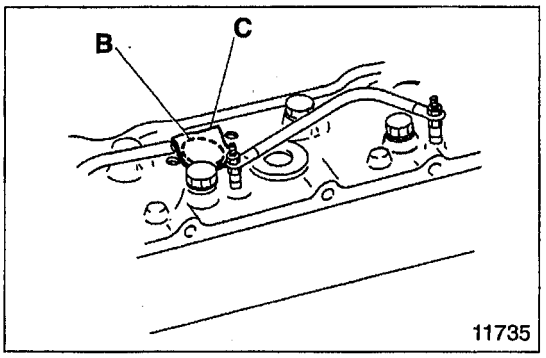




- Remove the injection nozzle **A**.
  Gr 13A

CAUTION ⚠

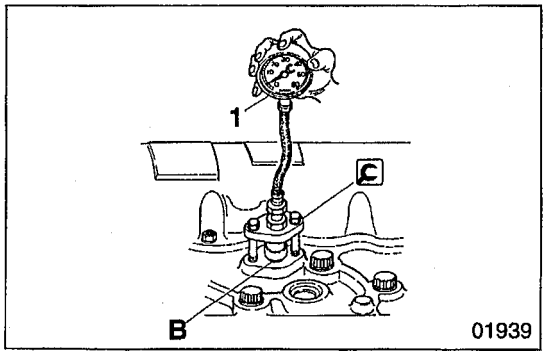
Cover the mounting holes and injection pipes to prevent the entry of dust and dirt.



- Cover the injection nozzle mounting hole **B** with a cloth **C**. 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 the nozzle mounting hole B at a high temperature. For safety, move away from the nozzle mounting hole before turning over the engine.



- Fit the [C] Compression Gauge Adapter onto an injection nozzle mounting hole **B** together with a nozzle gasket. Then, connect the compression gauge **1**.
- Turn the engine over and measure the compression pressure.
- Measure the compression pressure in every cylinder and determine the pressure differences between cylinders.
- 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 **B** 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.

2. Inspecting and Adjusting Valve Clearances

Service standards

Unit: mm

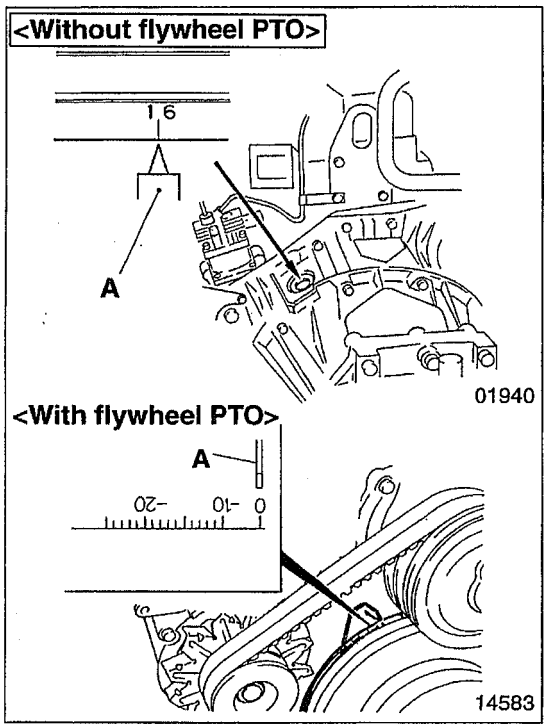
Location	Maintenance item	Standard value	Limit	Remedy
—	Valve clearance (when cold)	0.4	—	Adjust

ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2, 6	Rocker arm adjusting screw lock nut	34 {3.5}	—

Valve clearances should be checked and adjusted when the engine is cold.

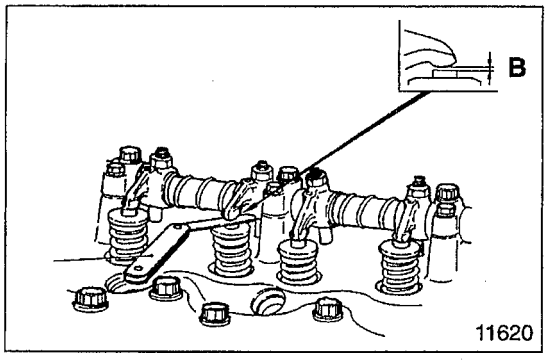


[Inspection]

- Bring piston No. 1 or piston No. 6 to the top-dead-centre (TDC) position of its compression stroke. To do this, crank the engine until the "**1.6**" mark inscribed on the flywheel is aligned with the pointer **A** in the flywheel housing inspection window. (If the engine has a flywheel PTO, align the pointer **A** with the "**0**" mark inscribed on the torsional damper.)

NOTE

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

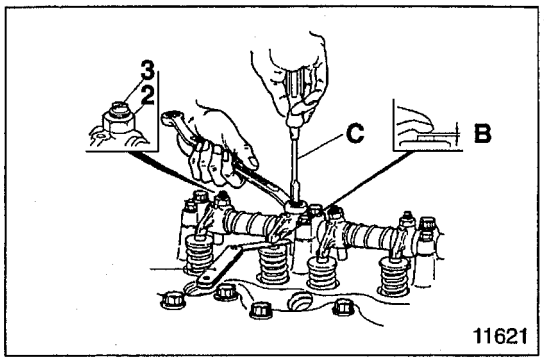


- When piston No. 1 or piston No. 6 is at the TDC position of its compression stroke, measure the clearance **B** of every valve marked "○" in the following table.

Piston No.	1		2		3		4		5		6	
Valve arrangement	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 piston at TDC of compression stroke	○	○	○	×	×	○	○	×	×	○	×	×
No. 6 piston at TDC of compression stroke	×	×	×	○	○	×	×	○	○	×	○	○

NOTE

To measure the clearance, insert a feeler gauge 1. 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.

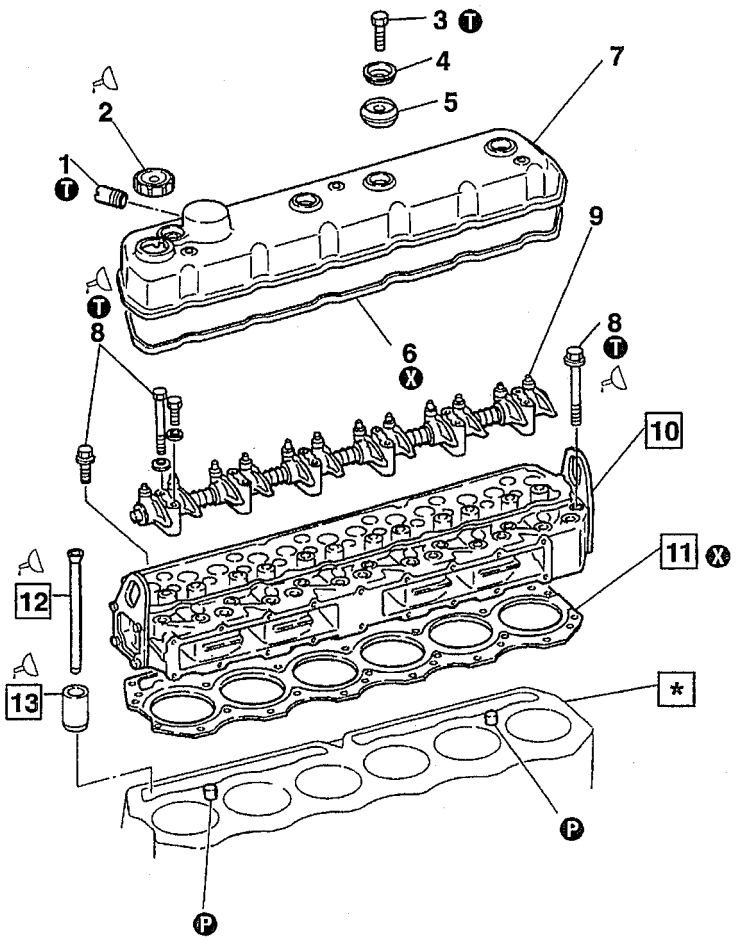


- If any measurement is out of specification, make adjustments as follows:

[Adjustment]

- To adjust the valve clearance **B**, loosen the lock nut **2** and turn the adjusting screw **3** until the feeler gauge **1** moves more stiffly in the gap.
- After adjusting the clearance, tighten the lock nut **2**. At this time, use a screwdriver **C** to stop the adjusting screw **3** from turning. Next, insert the feeler gauge **1** once more to confirm that the clearance **B** is correct.

CYLINDER HEAD AND VALVE MECHANISM



04134

● **Disassembly sequence**

1 Joint
2 Oil filler cap
3 Bolt
4 Plate
5 Rubber
6 Rocker cover gasket
7 Rocker cover
8 Cylinder head bolt
9 Rocker and bracket assembly 📖 P.11-16
10 Cylinder head and valve assembly 📖 P.11-20
11 Cylinder head gasket
12 Push rod
13 Tappet

*: Crankcase 📖 P.11-72
Ⓟ: Locating 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
12	Push rod runout		—	0.4	Replace
13, *	Tappet-to-crankcase clearance	6D14, 14-T,15-T, 16, 16-E	[31] 0.06 to 0.10	0.2	Replace tappet
		6D16-T, 16-TE, 16-TL, 16-TLE	[31] 0.03 to 0.07	0.1	

Tightening torques

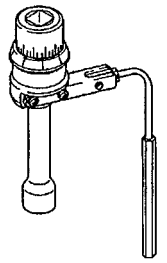
Unit: N·m {kgf·m}

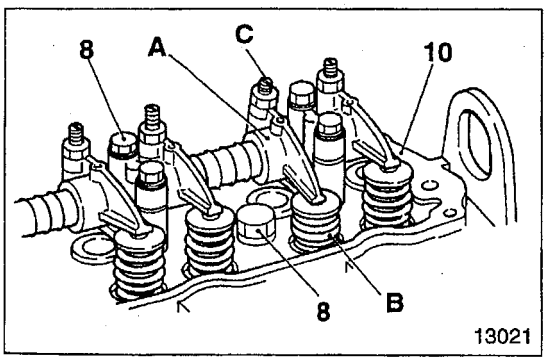
Location	Parts to be tightened		Tightening torque	Remarks
1	Joint		29 {3.0}	—
3	Rocker cover bolt		3.9 {0.4}	—
8	Cylinder head bolt (installation of rocker and bracket assembly and cylinder head and valve assembly)	M14 bolt	78 {8} + 180°	• Wet • Can be reused up to 3 times
		M10 bolt	17 {1.75} + 34 {3.5}	—

Lubricant

Location	Points of application	Specified lubricant	Quantity
2	Rubber seal of oil filler cap	Engine oil	As required
8	Threads of cylinder head bolts	Engine oil	As required
12	Both ends of push rods	Engine oil	As required
13	Outer surfaces of tappets	Engine oil	As required

Special tools

Location	Tool name and shape	Part No.	Application
10	Socket Wrench  01984	MH063388	Tightening cylinder head bolts (M14 bolt only)

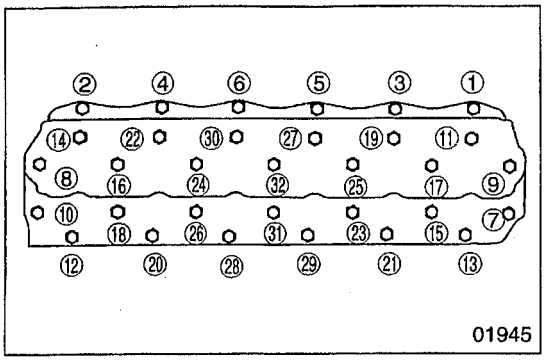


◆ Service procedure

10 Cylinder head and valve assembly

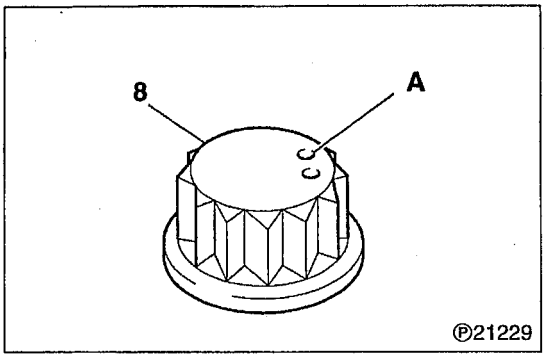
[Removal]

- Before loosening the cylinder head bolts **8**, loosen the adjusting screw **C** on every rocker **A** that is compressing its valve spring **B**.



01945

- Loosen and remove the cylinder head bolts **8** in the sequence shown. Each cylinder head bolt should be loosened a little at a time.

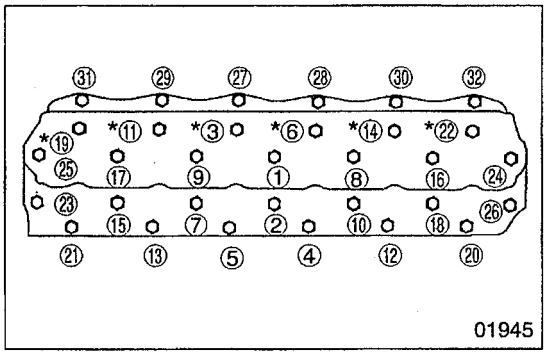


Ⓟ21229

[Installation]

CAUTION ⚠

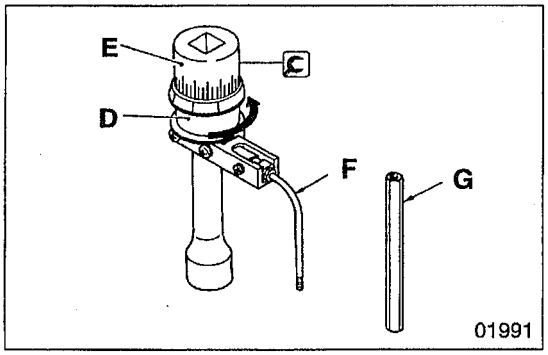
Before fitting any cylinder head bolt 8, check the punch marks A on its head. Do not use the bolt if there are more than two punch marks. The punch marks indicate the number of times each bolt has been tightened using the plastic area tightening method. Any bolt that already has three punch marks must be replaced.



01945

- Tighten the cylinder head bolts **8** to the specified torque (M14 bolts: 78 N·m {8 kgf·m}; M10 bolts: 17 N·m {1.75 kgf·m}) in the sequence shown. Then, turn the bolts further in accordance with the following procedure.

*: Tighten together with rocker and bracket assembly
① to ㉖ : M14 bolt (wet)
㉗ to ㉜ : M10 bolt



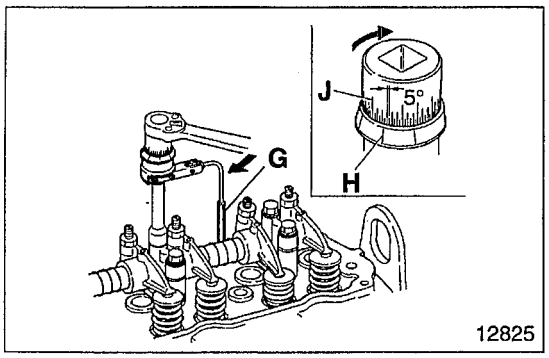
01991

<M14 Bolts>

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

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

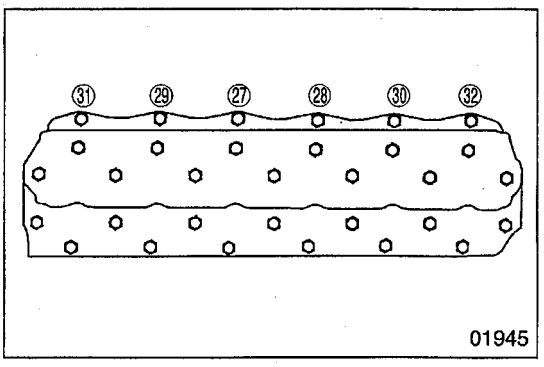
- Set the socket such that the built-in spring force forces the rod **G** against the rocker shaft bracket, an injection pipe, or another nearby part.
- On the holder **D**, select the inscribed line **H** that is easiest to see.
- Using the selected line as a reference, turn the socket E 180° clockwise. (One gradation on the scale **J** represents 5°.)



12825

CAUTION ⚠

Since the M14 cylinder head bolts 8 utilize the plastic region tightening method, they must not be tightened further after this procedure.



<M10 Bolts>

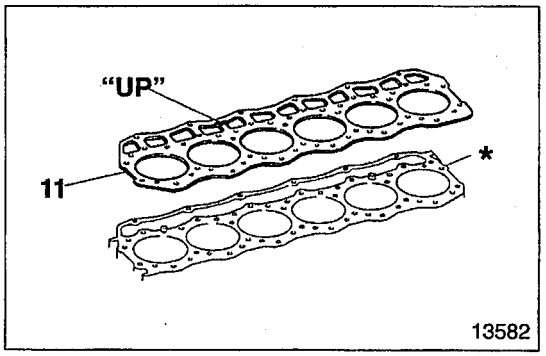
- After fitting the M14 cylinder head bolts **8**, tighten the M10 bolts to the spencified torque (34 N·m {3.5 kgf·m}) in the sequence shown.

11 Cylinder head gasket

[Removal]

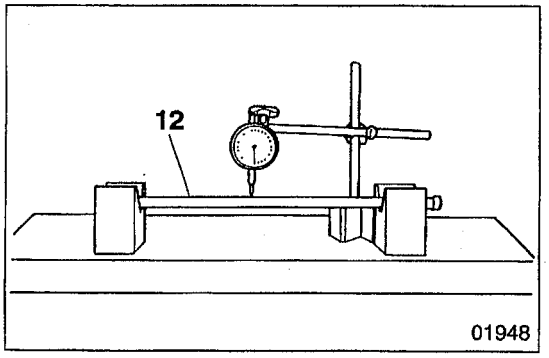
CAUTION

When removing the cylinder head gasket 11, be careful not to scratch the cylinder head and valve assembly 10 and the crankcase *.



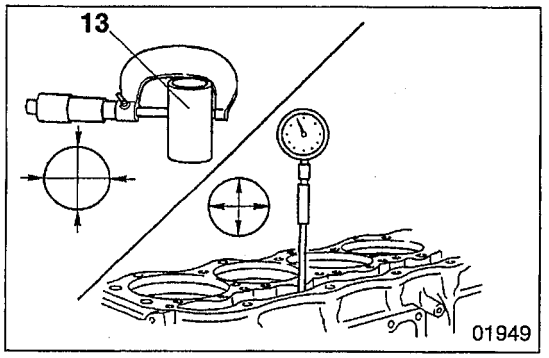
[Fitting]

- Fit the cylinder head gasket **11** onto the crankcase * as shown.



12 Push rod runout

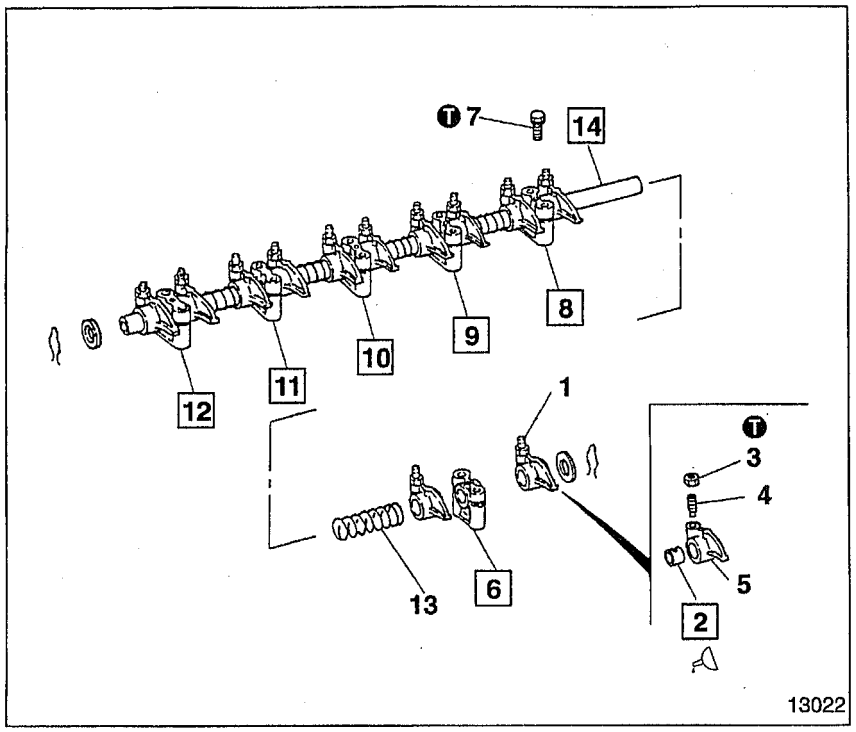
If any measurement exceeds the specified limit, replace the defective part(s).



13 * Tappet-to-crankcase clearance

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

Rocker and Bracket Assembly



● **Disassembly sequence**

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

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
2, 14	Rocker bushing-to-rocker shaft clearance	[24] 0.01 to 0.08	0.12	Replace

T Tightening torques

Unit: N·m {kgf·m}

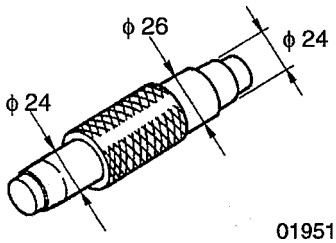
Location	Parts to be tightened	Tightening torque	Remarks
3	Adjusting screw lock nut	34 {3.5}	—
7	Rocker shaft set screw	3.9 {0.4}	—

Lubricant

Location	Points of application	Specified lubricant	Quantity
2	Rocker bushing inner surface	Engine oil	As required

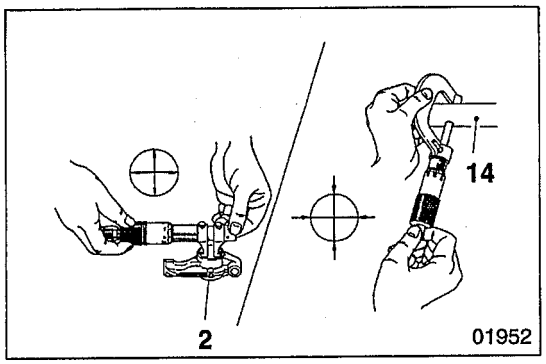
Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
2	Rocker Bushing Puller 	MH061777	Removing and installing rocker bushings

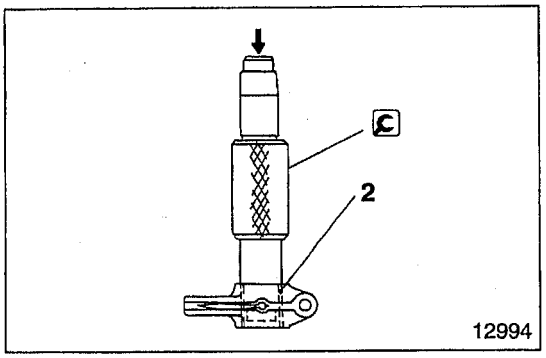
◆ Service procedure

2 14 Rocker bushing and rocker shaft

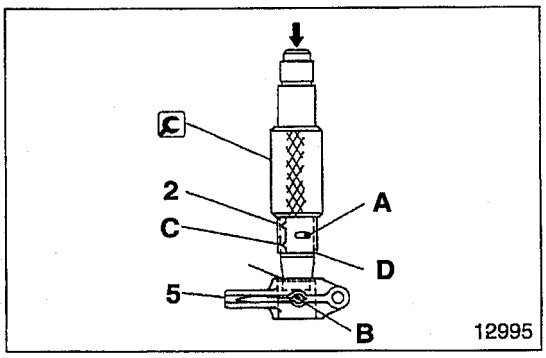


[Inspection]
If any clearance exceeds the specified limit, replace the defective part(s).

Rocker bushing



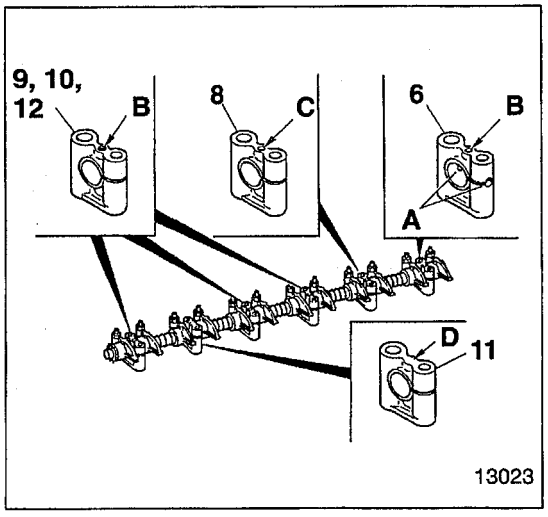
[Removal]



[Installation]

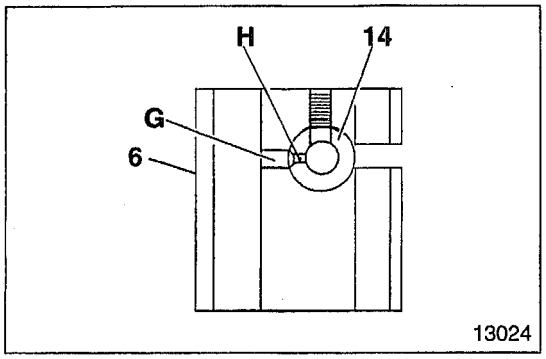
- Align the oil hole **A** in the rocker bushing **2** with the oil hole **B** in the rocker **5**.
- Position the notch **C** and seam **D** on the rocker bushing **2** as shown.
- Install the rocker bushing **2** into the rocker **5** from the chamfered side **F**.

6 8 to 12 14 Installing rocker shaft brackets and rocker shaft



Rocker shaft brackets
Be sure to fit the rocker shaft brackets **6**, **8**, **12** in their correct positions.

A: Oil hole
B: Threaded hole (for M8 rocker cover bolt)
C: Threaded hole (for M6 set screw)
D: No threaded hole



Rocker shaft

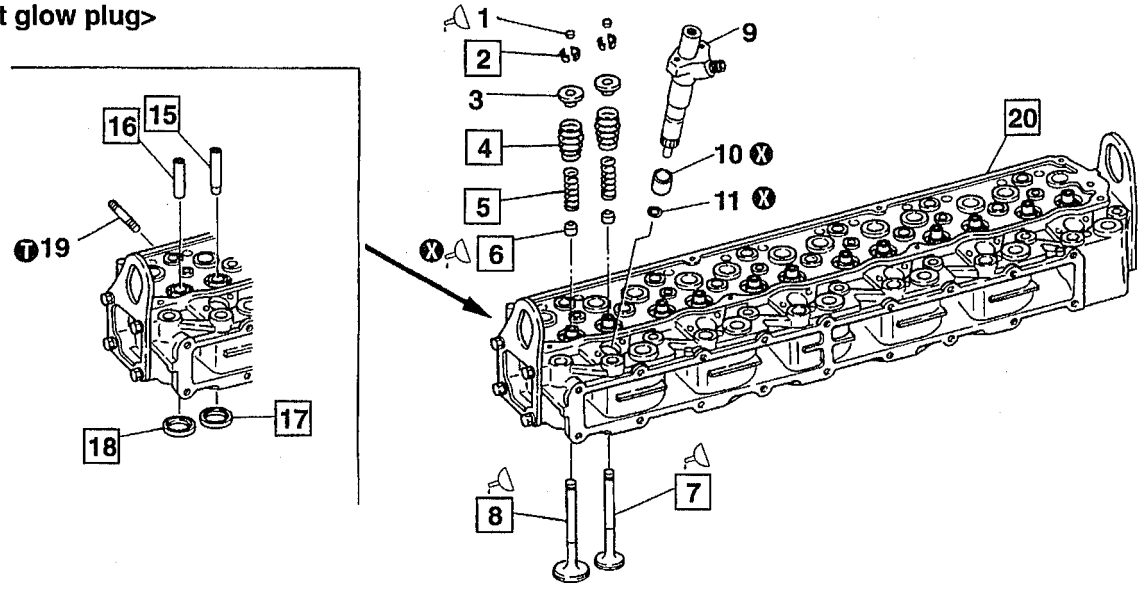
Align the oil hole **G** in the No. 6 rocker shaft bracket **6** with the oil hole **H** in the rocker shaft **14**.

MEMO

CYLINDER HEAD AND VALVE MECHANISM

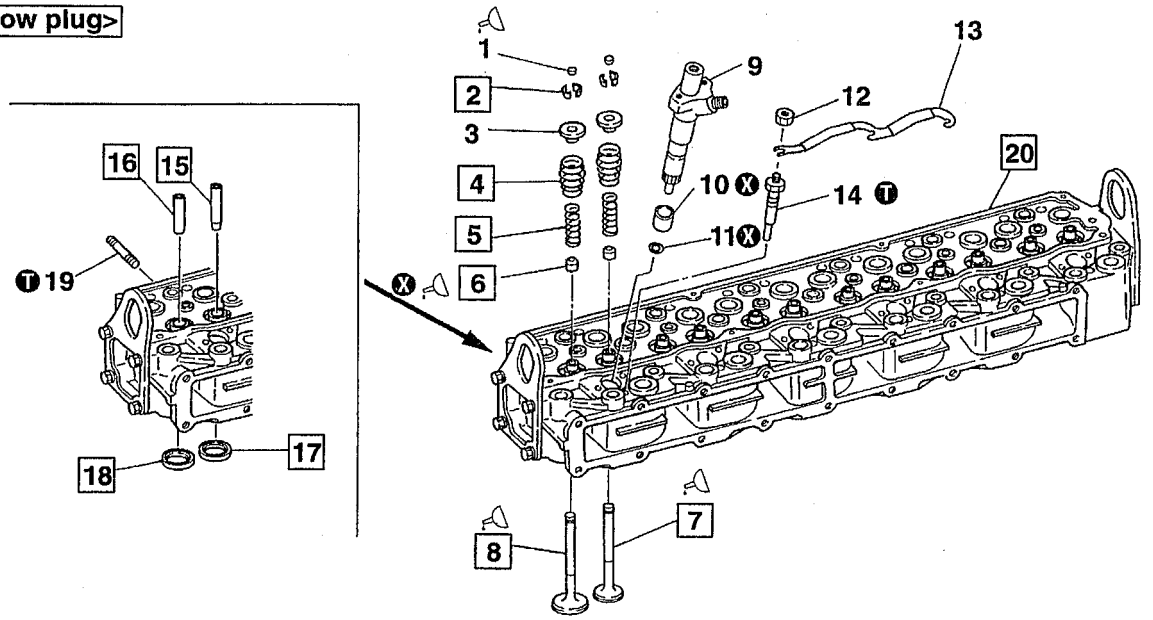
Cylinder Head and Valve Mechanism

<Without glow plug>



20300

<With glow plug>



01955

- **Disassembly sequence**

1 Valve cap
2 Valve cotter
3 Upper retainer
4 Outer valve spring
5 Inner valve spring
6 Valve stem seal
7 Exhaust valve
8 Inlet valve
9 Injection nozzle 🕮 Gr 13
10 Dust seal
11 Nozzle tip gasket
12 Nut <With glow plug>
13 Connecting plate <With glow plug>
14 Glow plug <With glow plug> 🕮 Gr 54
15 Exhaust valve guide
16 Inlet valve guide
17 Exhaust valve seat
18 Inlet valve seat
19 Stud
20 Cylinder head

Ⓧ: Non-reusable part

CAUTION ⚠

The injection nozzles 9 and glow plugs 14 project from the bottom surface of cylinder head 20. 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 7 or inlet valve 8 must be replaced.

Service standards

Unit: mm

Location	Maintenance item			Standard value (Basic diameter in [ ])	Limit	Remedy
4	Outer valve spring	Free length	6D14, 14-T, 15-T, 16, 16-E	67.0	64.0	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE	68.3	65.3	
		Installed load (at 47.8 installed length)	6D14, 14-T, 15-T, 16, 16-E	330 N {33.5 kgf}	290 N {29.7 kgf}	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE	390 N {40.0 kgf}	350 N {35.5 kgf}	
		Squareness		—	2.5	Replace
5	Inner valve spring	Free length	6D14, 14-T, 15-T, 16, 16-E	55.1	52.1	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE	65.1	61.5	
		Installed load (at 40.5 installed length)	6D14, 14-T, 15-T, 16, 16-E	92 N {9.4 kgf}	78 N {8.0 kgf}	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE	155 N {15.8 kgf}	130 N {13.4 kgf}	
		Squareness	6D14, 14-T, 15-T, 16, 16-E	—	2.0	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE	—	2.5	
7	Exhaust valve	Stem outside diameter		ϕ 8.93 to 8.94	ϕ 8.85	Replace
		Sinkage from cylinder head bottom surface		1.3 to 1.7	2.0	Inspect every location
		Valve margin		1.5	1.2	Reface or replace
		Seat angle		45°	—	Correct
8	Inlet valve	Stem outside diameter		ϕ 8.96 to 8.97	ϕ 8.85	Replace
		Sinkage from cylinder head bottom surface	Except 6D16-E	1.1 to 1.5	1.8	Inspect every location
			6D16-E	1.3 to 1.7	2.0	
		Valve margin		1.5	1.2	Reface or replace
		Seat angle		45° ± 15'	—	Correct
7, 15	Exhaust valve stem-to-valve guide clearance			[9] 0.07 to 0.10	0.2	Replace
8, 16	Inlet valve stem-to-valve guide clearance			[9] 0.04 to 0.06	0.15	Replace
17	Exhaust valve seat width			1.8 to 2.2	2.8	Correct or replace
18	Inlet valve seat width			1.8 to 2.2	2.8	Correct or replace
20	Cylinder head	Bottom surface distortion		0.08 or less	0.2	Correct or replace
		Height from top to bottom surface		94.9 to 95.1	94.5	Replace

ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
14	Glow plug <With glow plug>	15 to 20 {1.5 to 2.0}	—
19	Exhaust manifold mounting stud	29 {3}	—

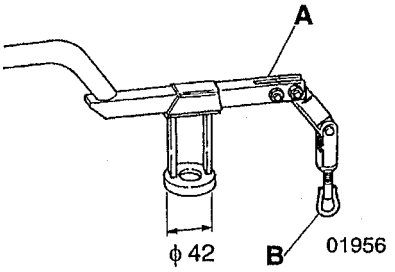
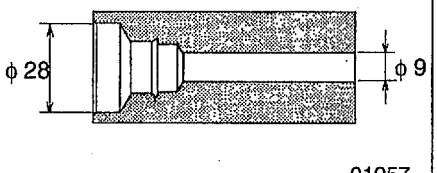
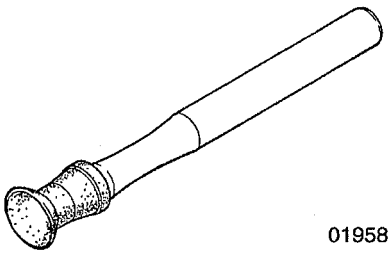
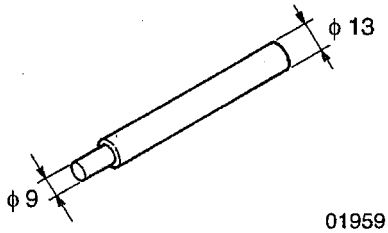
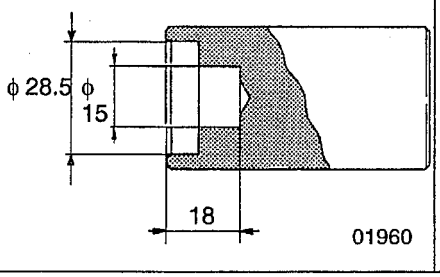
CYLINDER HEAD AND VALVE MECHANISM

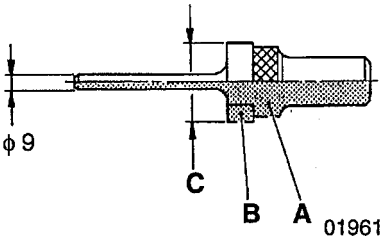
Lubricant

Location	Points of application	Specified lubricant	Quantity
1	Rocker contact surface on valve cap top	Engine oil	As required
6	Lip of valve stem seal	Engine oil	As required
7, 8	Valve stem	Engine oil	As required

Special tools

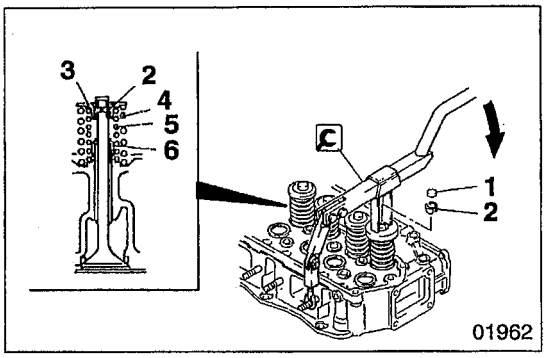
Unit: mm

Location	Tool name and shape	Part No.	Application
2	A: Valve Lifter B: Valve Lifter Hook 	A: MH061668 (with ϕ 42 valve lifter seat) B: MH061679	Removing and installing valve cotters
6	Valve Stem Seal Installer 	MH061293	Installing valve stem seals
7, 8	Valve Lapper 	30091-07500 (inlet, exhaust)	Lapping valves and valve seats
15, 16	Valve Guide Remover 	MH061066 (inlet, exhaust)	Removing valve guides
	Valve Guide Installer 	MH061998	Installing inlet and exhaust valve guides

Location	Tool name and shape	Part No.	Application
17, 18	A: Caulking Tool Body B: Installer Ring C dimension: MH061695 φ 49; MH061696 φ 42; MH061693 φ 51; MH061694 φ 44 	A: MH061067 B: MH061695 <6D14, 14-T, 15-T, 16-T, 16-TE, 16-TL, 16-TLE> (Inlet) MH061696 <6D14, 14-T, 15-T, 16-T, 16-TE, 16-TL, 16-TLE> (Exhasut) MH061693 <6D16, 16-E> (Inlet) MH061694 <6D16, 16-E> (Exhaust)	Installing valve seats

◆ Service procedures

2 Valve cotters

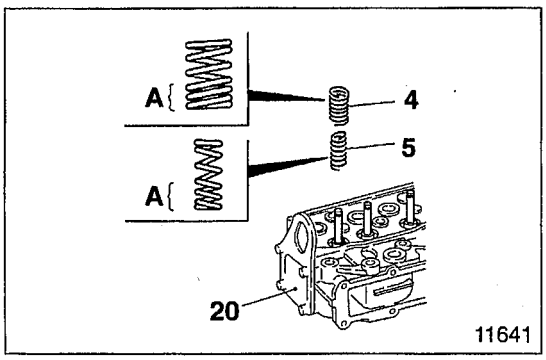


[Removal]
To remove the valve cotter **2**, use the C Valve Lifter to evenly compress the valve springs **4**, **5**.

[Installation]
To install valve cotters, follow the removal instructions in reverse.

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

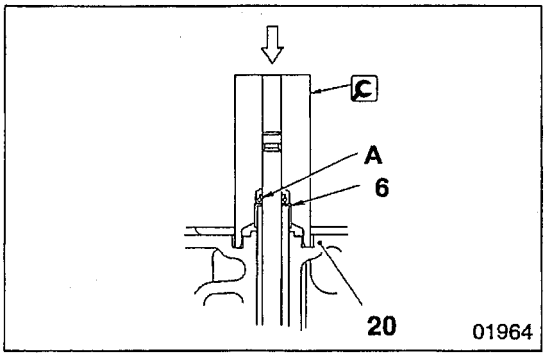
4 5 Installing outer and inner valve springs



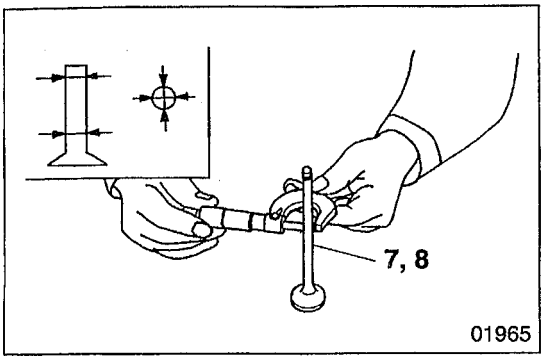
Fit the outer and inner valve springs **4, 5** onto the cylinder head **20** with their painted ends downward.

A: Painted end

6 Installing valve stem seals



- Apply engine oil to the lip **A** of the valve stem seal **6**.
- Install the valve stem seal **6** using the C Valve Stem Seal Installer. Strike the Valve Stem Installer until it sits snugly on the cylinder head **20**.



7 8 Valve

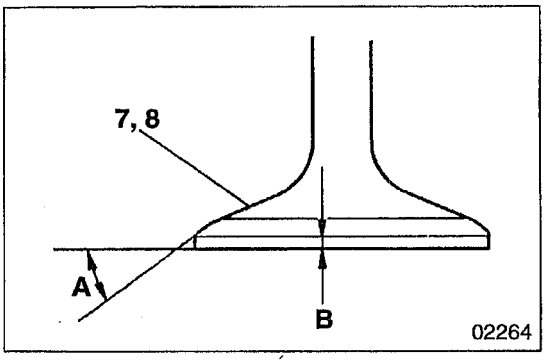
[Inspection]

(1) Valve stem outside diameter

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

CAUTION ⚠

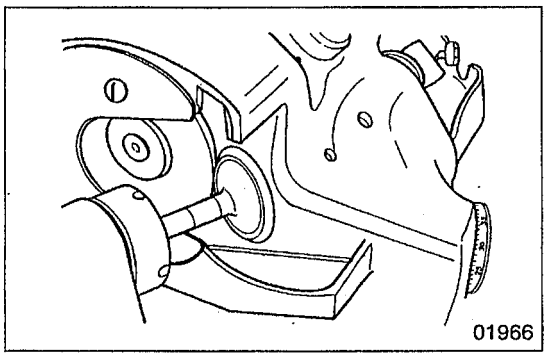
Whenever a valve 7, 8 is replaced, be sure to lap the valve and valve seat 17, 18. 🕮 P.11-25.



(2) Valve seat angle and valve margin

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

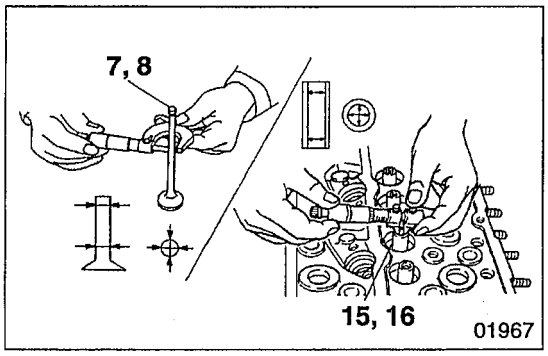
A: Valve seat angle
B: Valve margin



[Rectification]

NOTE

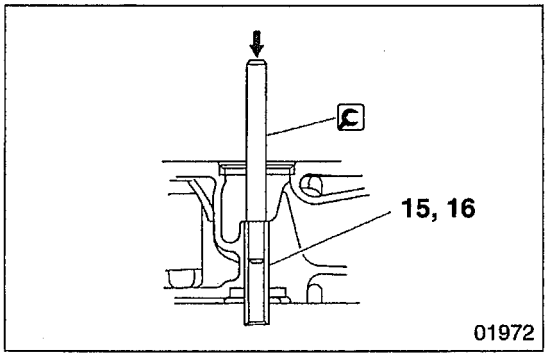
- **Keep grinding to a minimum.**
- **If the valve margin is below specification after grinding, replace the valve 7, 8.**
- **After grinding, be sure to lap the valve and 7,8 valve seat 17, 18. 🕮 P.11-25**



7 8 15 16 Valves and valve guides

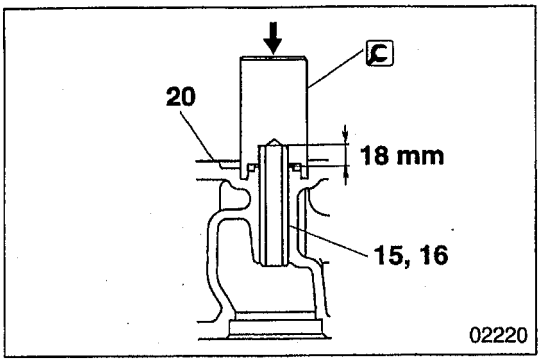
[Inspection]

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



Valve guides

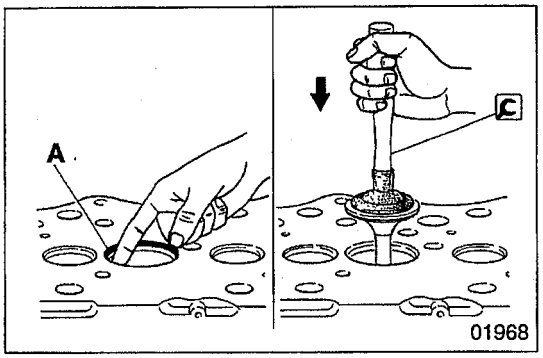
[Removal]



[Installation]
Install the valve guide **15, 16** using the [C] Valve Guide Installer. Strike the Valve Guide Installer until it sits snugly on the cylinder head **20**.

CAUTION

- **The valve guides 15, 16 must be pressed in to the specified depth. Be sure to use the [C] Valve Guide Installer for this operation.**
- **Exhaust valve guides 15 are longer than inlet valve guides 16. Be sure to install the correct type of guide in each location.**



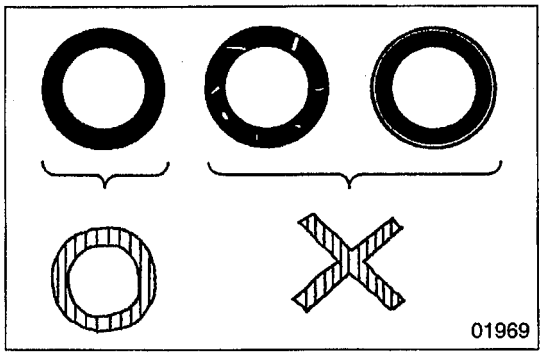
[7] [8] [17] [18] Valves and valve seats

[Inspection]

- Apply an even coat of minium to the valve seat **17, 18** surface **A** that makes contact with the valve **7, 8**.
- Using the [C] Valve Lapper, strike the valve **7, 8** against the valve seat **17, 18** once. Do not rotate the valve during this operation.

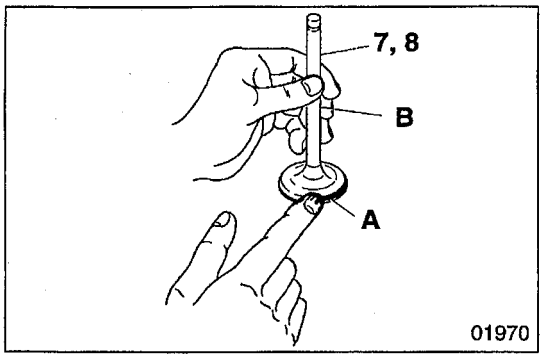
NOTE

Carry out these inspections after inspecting the valves and valve guides.



- If the minium deposited on the 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



[Refacing]
Lap the valve in accordance with the following procedure:

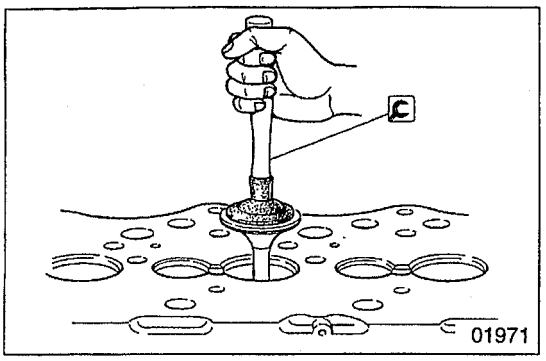
- Apply a thin, even coat of lapping compound to the surface **A** of the valve **7, 8** that makes contact with the valve seat **17, 18**.

CAUTION

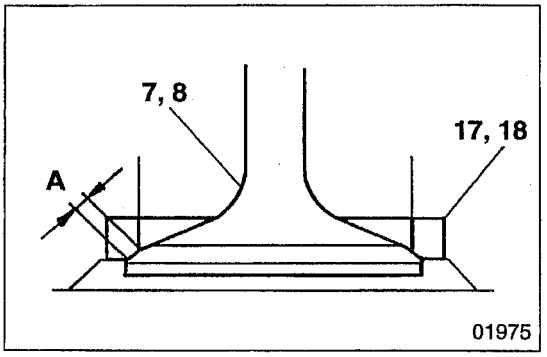
Ensure that no compound adheres to the stem B of the valve 7, 8.

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.**



- Using the C Valve Lapper, lightly strike the valve **7, 8** against the valve seat **17, 18** while turning it little by little.
- Wash away the compound with gas oil or a similar fluid.
- Apply engine oil to the contact surfaces of the valve seat **17, 18** and rub it in so that the contact surfaces are lubricated and mate together snugly.
- Inspect the contact pattern of the valve **7, 8** and valve seat **17, 18** once more.
- If the contact pattern is still defective, replace the valve seat **17, 18.**



17 18 Valve seats

[Inspection]

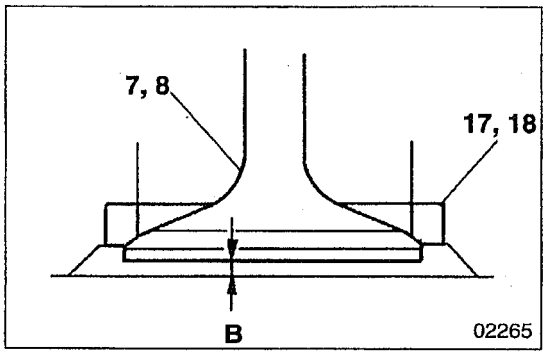
(1) Valve seat width

If the measurement exceeds the specified limit, rectify or replace the valve seat **17, 18.**

A: Valve seat width

NOTE

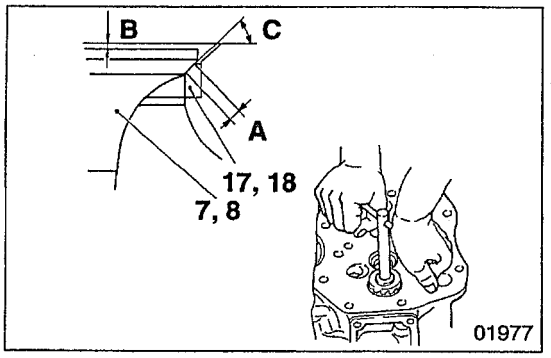
Whenever a valve seat 17, 18 is rectified or replaced, be sure to lap the valve seat and valve 7, 8. P.11-25



(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



[Rectification]

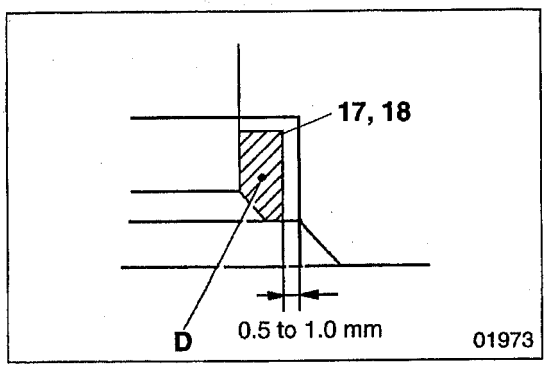
- Grind the valve seat **17, 18** using a valve seat cutter or valve seat grinder.
- After grinding, put some sandpaper of around #400 grade between the cutter and valve seat and grind the valve seat lightly.
- Use a 15° or 17° cutter to achieve the specified valve seat width A.

C: Valve seat angle

CAUTION

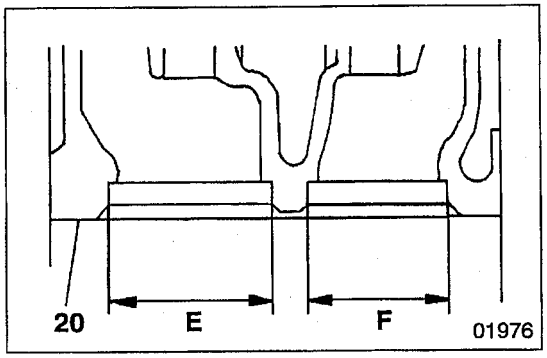
Ensure that grinding does not cause the valve sinkage B to exceed the specified limit.

- After rectification, lap the valve **7, 8** and valve seat **17, 18.**
  P.11-25



[Removal]
Valve seats **17, 18** 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

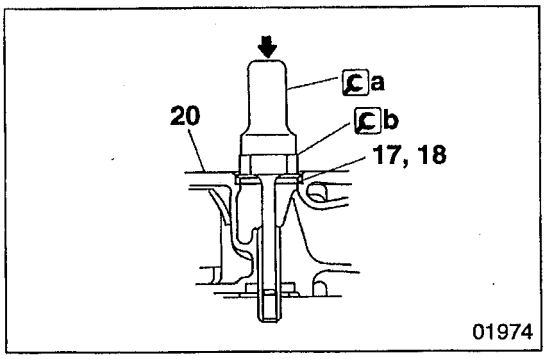


[Installation]

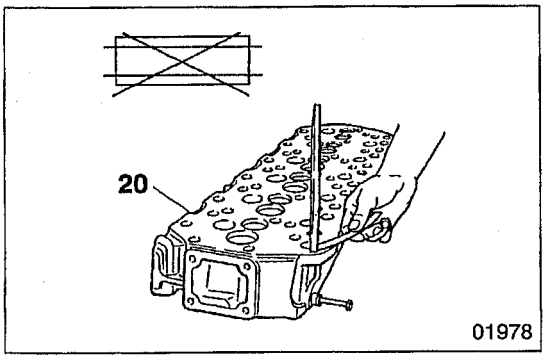
- Check that the valve seat hole diameters **E, F** in the cylinder head **20** conform with the values shown below.

Unit: mm

	6D14, 14-T, 15-T, 16-T, 16-TE, 16-TL, 16-TLE	6D16	6D16-E
Inlet valve seat hole (**E**)	$\phi 49^{+0.025}_{0}$	$\phi 51^{+0.03}_{0}$	$\phi 53^{+0.03}_{0}$
Exhaust valve seat hole (**F**)	$\phi 42^{+0.025}_{0}$	$\phi 44^{+0.025}_{0}$	$\phi 46^{+0.025}_{0}$



- Cool the valve seat **17, 18** by immersing it in liquid nitrogen.
- Install the valve seat **17, 18** in the cylinder head **20** using the a Caulking Tool Body and b Installer Ring.
- After installing the valve seat **17, 18**, lap the valve seat and valve **7, 8**. P.11-25



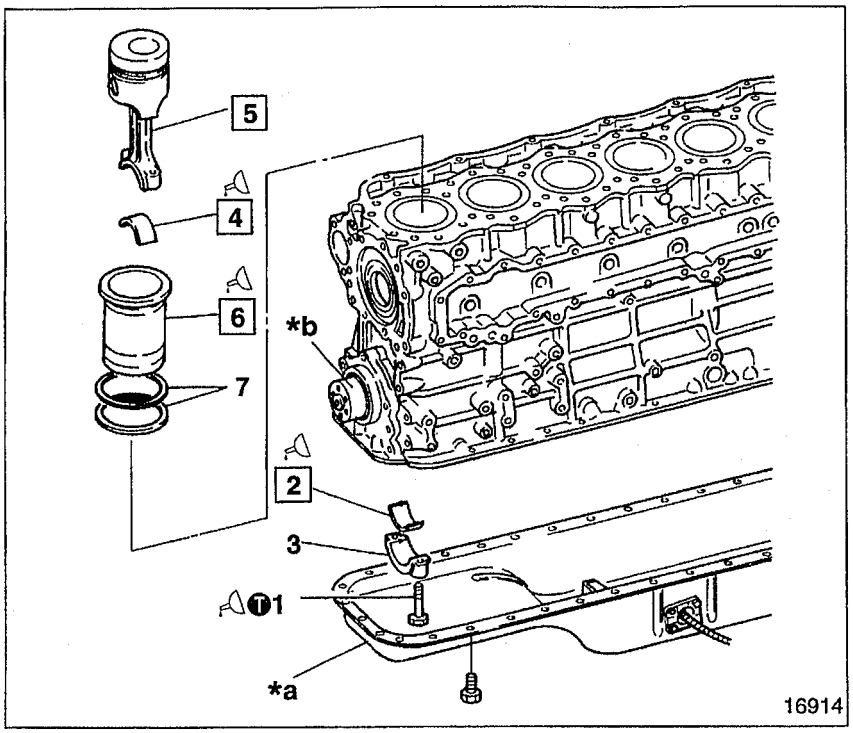
20 Inspecting cylinder head

- Measure the extent of distortion in the cylinder head's 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.

PISTONS, CONNECTING RODS, AND CYLINDER LINERS



● **Pre-disassembly inspection**

P.11-30

● **Removal sequence**

1 Bolt
2 Lower connecting rod bearing
3 Connecting rod cap
4 Upper connecting rod bearing
5 Piston and connecting rod assembly P.11-36
6 Cylinder liner
7 O-ring <6D14, 14-T, 15-T>

*a: Oil pan Gr 12
*b: Crankshaft P.11-72

● **Installation sequence**

Reverse the order of removal.

Service standards

Unit: mm

Location	Maintenance item				Standard value (Basic diameter in [ ])	Limit	Remedy
—	Piston projection				0.85 to 1.06	—	Inspect each location
	Connecting rod end play				0.15 to 0.45	0.6	Replace
2, 4, *b	Connecting rod bearing		Oil clearance	Except 6D16-TLE	[65] 0.04 to 0.09	0.2	Replace
				6D16-TLE	[70] 0.04 to 0.09		
			Span when free	Except 6D16-TLE	—	Less than 69.5	
				6D16-TLE	—	Less than 74.5	
5, 6	Piston and connecting rod assembly-to-cylinder liner clearance		6D14, 14-T		[110] 0.137 to 0.159	—	Replace
			6D15-T		[113] 0.166 to 0.138	—	Replace
			6D16, 16-E		[118] 0.075 to 0.105	—	Replace
			6D16-T, 16-TE, 16-TL, 16-TLE		[118] 0.136 to 0.165	—	Replace
6	Cylinder liner	Flange projection			0.03 to 0.10	—	Replace
		Inside diameter	6D14, 14-T		ϕ 110 to 110.035	ϕ 110.25	Replace or grind to oversize
			6D15-T		ϕ 113 to 113.035	ϕ 113.25	Replace
			6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE		ϕ 118 to 118.03	ϕ 118.25	Replace
		Cylindricity	6D14, 14-T, 15-T		0.02 or less	—	Replace or grind to oversize
			6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE		0.03 or less	—	Replace or grind to oversize

Tightening torques

Unit: N·m {kgf·m}

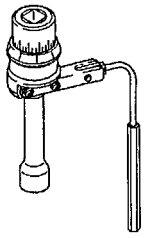
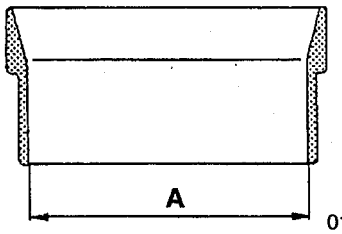
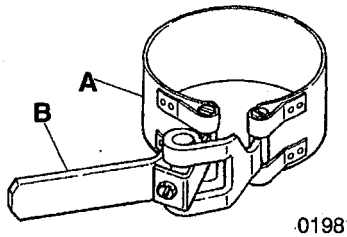
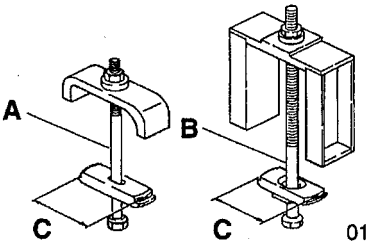
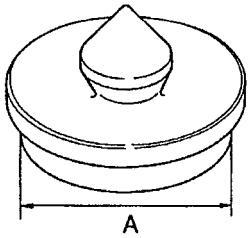
Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (connecting rod installation)	29 {3} + 90° ± 5°	Wet P.11-31

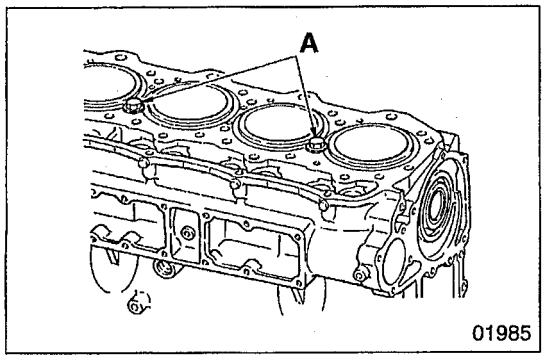
Lubricant

Location	Points of application	Specified lubricant	Quantity
1	Bolt threads	Engine oil	As required
2, 4	Connecting rod bearing inside surface	Engine oil	As required
6	Cylinder liner outside surface	Engine oil	As required

Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
5	Socket Wrench  01984	MH061560	Installing piston and connecting rod assembly
5	Piston Guide A dimension: 6D14, 14-T: ϕ 110; 6D15-T: ϕ 113  01980	<6D14, 14-T> 30091-08200 <6D15-T> MH061327	Installing piston and connecting rod assembly
5	A: Piston Guide Clamp B: Piston Guide Lever  01981	<6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE> A: MH061760 B: MH061658	
6	Cylinder Liner Extractor C dimension: 6D14, 14-T: ϕ 109.5; 6D15-T: ϕ 112.5; 6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE: ϕ 117.5  01982	<6D14, 14-T> A: MH061719 <6D15-T> B: MH062003 <6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE> B: MH061761	Removing cylinder liners
6	Cylinder Liner Installer A dimension: 6D15-T: ϕ 112.5; 6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE: ϕ 117.5  01983	<6D15-T> MH062002 <6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE> MH061771	Installing cylinder liners (dry type)



◆ Service procedure

● Pre-disassembly inspection

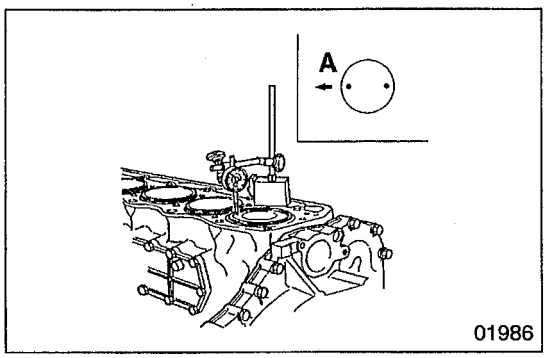
(1) Piston projection from crankcase top surface

NOTE

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

WARNING ⚠

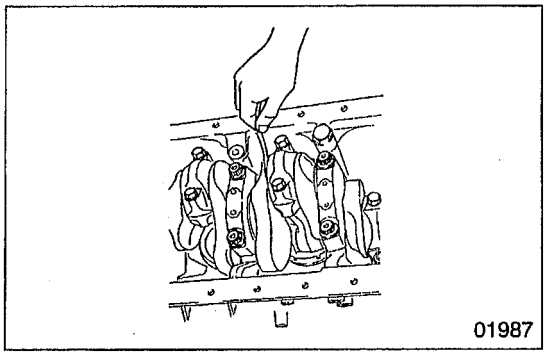
With 6D16, 16-E, 16-T, 16-TE, 16-TL and 16-TLE engines, the cylinder liners may rise out of position when the crankcase is turned over or the crankshaft is turned. Hold their flanges down using bolts and washers A.



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

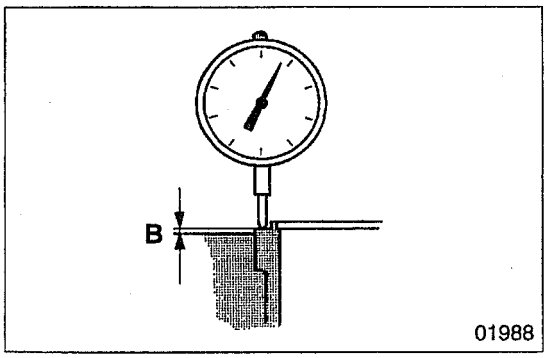
A: Front of engine

- 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).



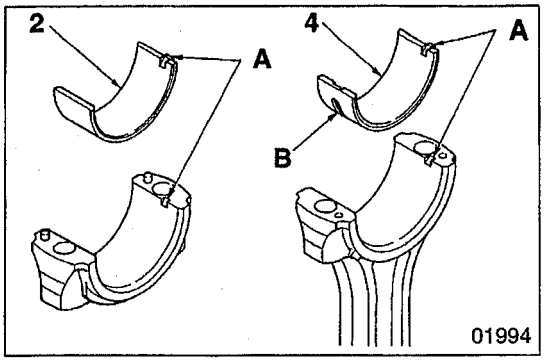
(3) Cylinder liner flange projection

If any measurement is out of specification, replace the defective part(s).

B: Flange projection

CAUTION ⚠

If the cylinder liner 6 flange projection is insufficient, bearing pressure on the cylinder head gasket will be too low in the region of the bore, possibly causing gas to leak.

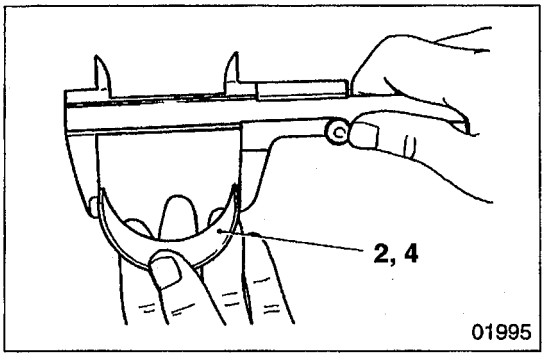


2 4 Connecting rod bearings

[Installation]
Install the connecting rod bearings **2**, **4** by fitting the lugs **A** into their respective grooves.

CAUTION

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



[Inspection]

CAUTION

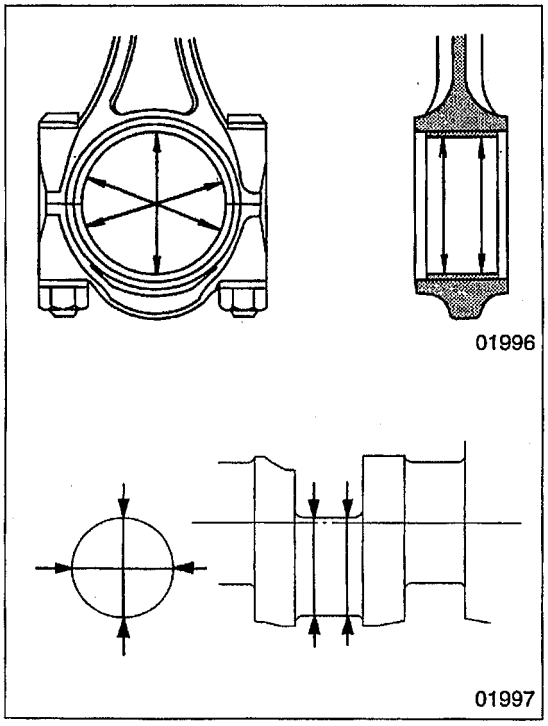
- **Do not attempt to manually expand a connecting rod bearing 2, 4 if its span is insufficient.**
- **Upper and lower connecting rod bearings 2, 4 must be replaced as a set.**

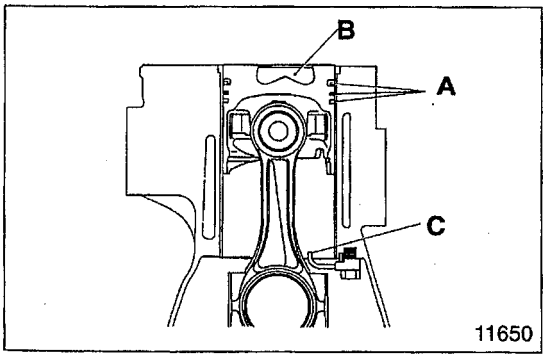
(1) Span when free

If the span is less than the specified requirement, replace the upper and lower connecting rod bearings **2**, **4** as a set.

(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).

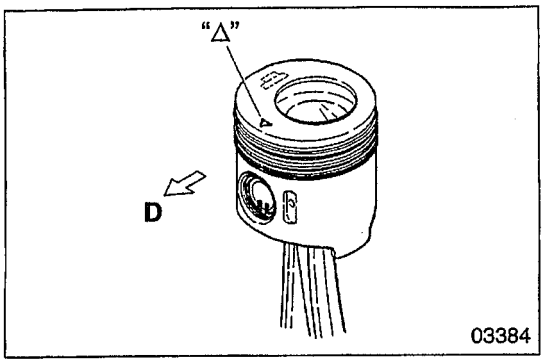




5 Installing piston and connecting rod assembly

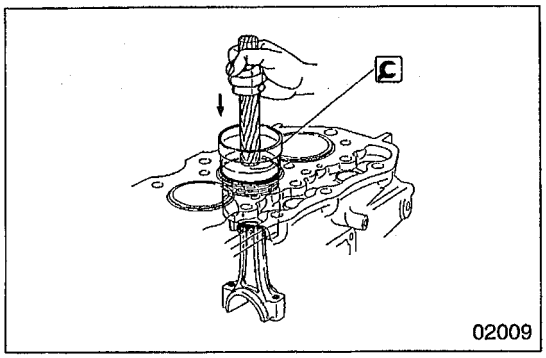
CAUTION

- **Ensure that the piston ring gaps A remain in their correct positions.** **P.11-41**
- **Take care not to damage the piston crown B (the area that forms part of the combustion chamber).**
- **Ensure that the connecting rod does not touch the oil jet C.**

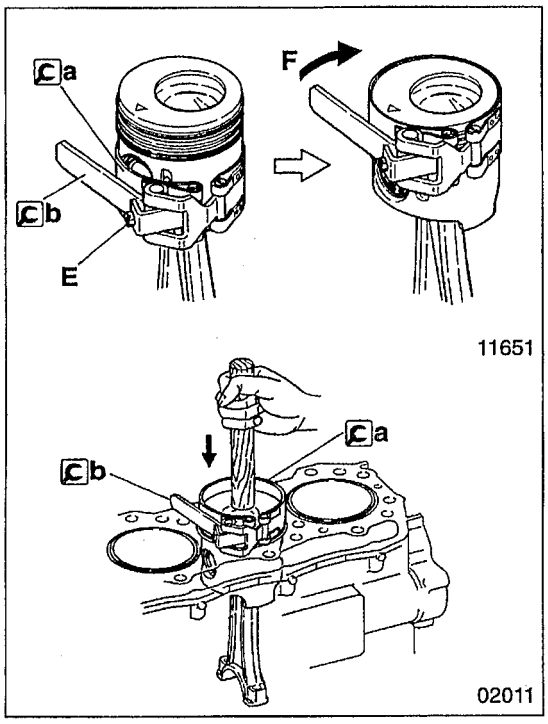


- With the piston's "△" front mark facing the front of the engine, install the piston and connecting rod assembly in accordance with the following procedure.

D: Front of engine



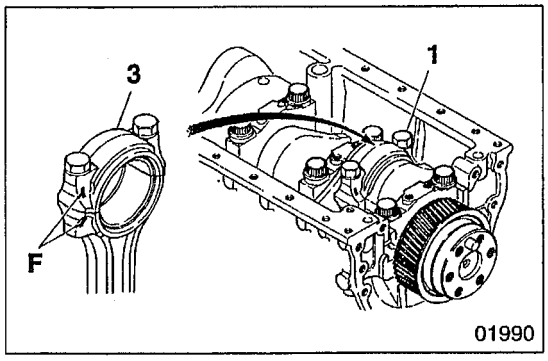
<6D14, 14-T, 15-T>



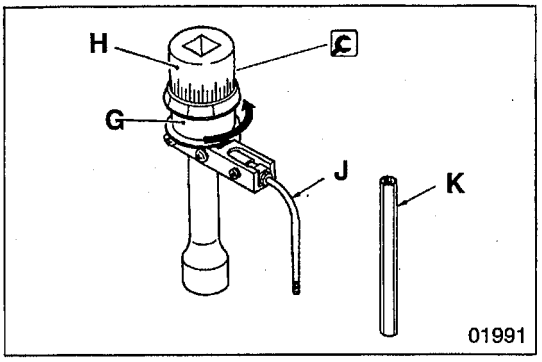
<6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE>

- Fit the a Piston Guide Clamp over the piston skirt. Using the bolt E of the b Piston Guide Lever, adjust the clamp's inside diameter such that it matches the piston's outside diameter.
- Once the a Piston Guide Clamp is adjusted properly, remove it from the piston and smear engine oil over the following items:
  - Outside of piston
  - Inside of the a Piston Guide Clamp
  - Cylinder liner

F: a Piston Guide Clamp tightening direction

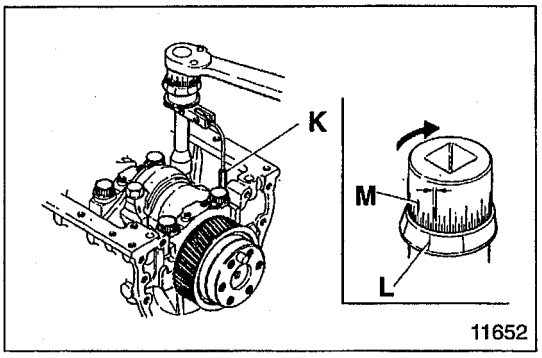


- With the piston installed, align the mating marks **F** on the connecting rod and connecting rod cap **3** and tighten the bolts to the specified torque. Then, tighten the bolts **1** further in accordance with the following procedure.



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

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



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

NOTE

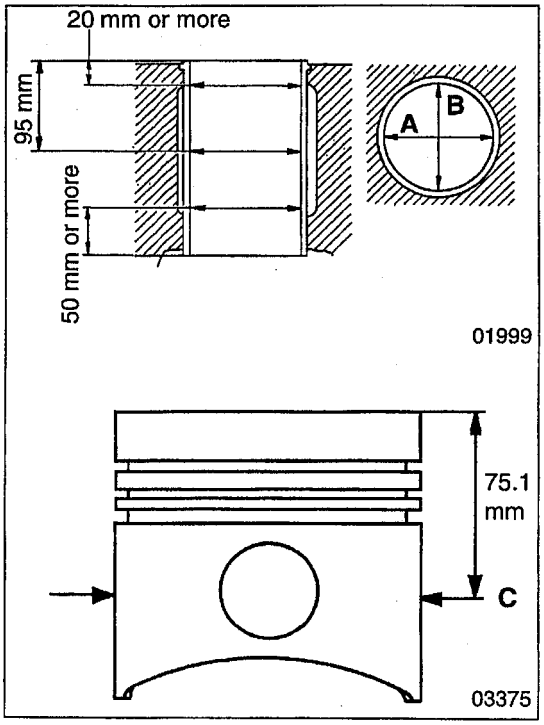
After fitting the connecting rod caps 3, inspect the following items:
- **Connecting rod end play (P.11-30)**
- **Piston projections (P.11-30)**

[5] [6] Piston-and-connecting rod assembly and cylinder liners

[Inspection]

<6D14, 14-T, 15-T>

- If the cylinder section inside diameter of the cylinder liner **6** exceeds the specified limit, remove the cylinder liner from the crankcase and rebore it to oversize. Also replace the piston and piston rings with ones suitable for the oversized cylinder liner inside diameter.



CAUTION

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

A: Measuring direction of cylinder liner bore (crankshaft axis direction)
B: Measuring direction of cylinder liner bore (perpendicular to crankshaft axis)
C: Measuring position of piston diameter (perpendicular to piston pin hole axis)

- Even if the cylinder section inside diameter of the cylinder liner **6** is within the specified limit, the piston and piston rings must be replaced if the piston-to-cylinder liner clearance is out of specification.

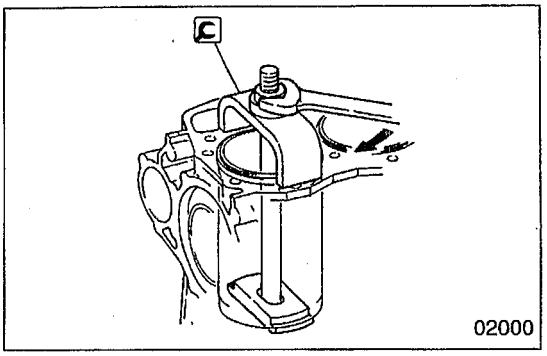
[Use of oversize pistons]
- Oversizes available: 0.50 mm, 0.75 mm, 1.00 mm (three sizes in total)
- To determine the required oversize, measure the inside diameter of every cylinder and find the cylinder of the largest inside diameter. Select an oversize most suitable for the diameter.
- Measure the outside diameter **C** of the oversize piston to be used.
- Bore all the cylinder liners to achieve the specified nominal piston-to-cylinder clearance.
  Diameter after boring (tolerance ± 0.005 mm) = Oversize piston diameter **C** (measurement) + Piston-to-cylinder clearance (nominal range central value) – 0.02 mm (honing margin)

- After boring, hone-finish the cylinder liner to the final diameter (tolerance ± 0.005 mm).
  Final diameter (tolerance ± 0.005 mm) = Oversize piston diameter **C** (measurement) + Piston-to-cylinder clearance (nominal range central value)

CAUTION ⚠

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

- Check the piston-to-cylinder clearance.

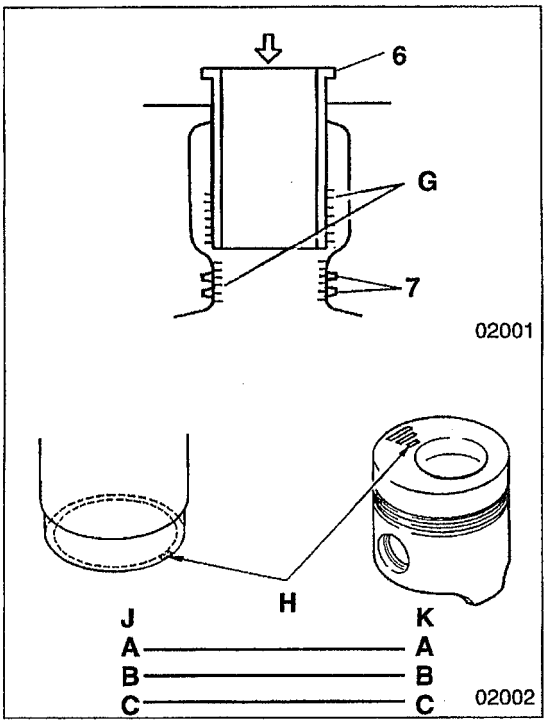


Cylinder liners

[Removal]

NOTE

If any cylinder liner 6 must be reused after removal, make an alignment mark with paint and use this mark to reinstall the cylinder liner in its original position.



[Installation]

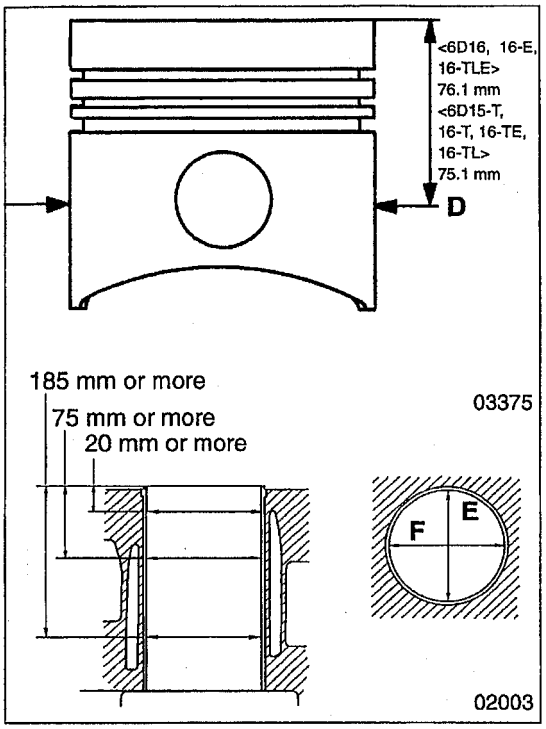
Apply soap suds **G** to the cylinder liner **6**. Taking care not to twist the O-rings **7**, insert the cylinder liner into the crankcase.

CAUTION ⚠

- **Size marks H are provided on the cylinder liner 6 and piston. When the cylinder liner is replaced, the new one must bear the same size mark as the piston.**

  J: Cylinder liner size mark
  K: Piston size mark

- **After installation, check that the O-rings 7 are not twisted.**

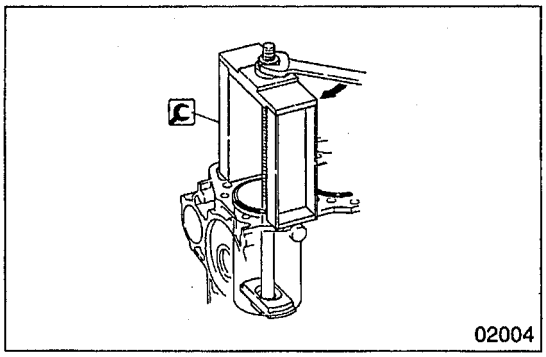


<6D15-T, 16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE>
If any clearance is out of specification, replace the defective part(s).

D: Outside diameter measurement position
E: Direction of crankshaft axis
F: Perpendicular to crankshaft axis

NOTE

The cylinder liners are of a thin design and cannot be bored to oversize dimensions. To prevent deformation of the cylinder liners, do not remove them except for replacement.

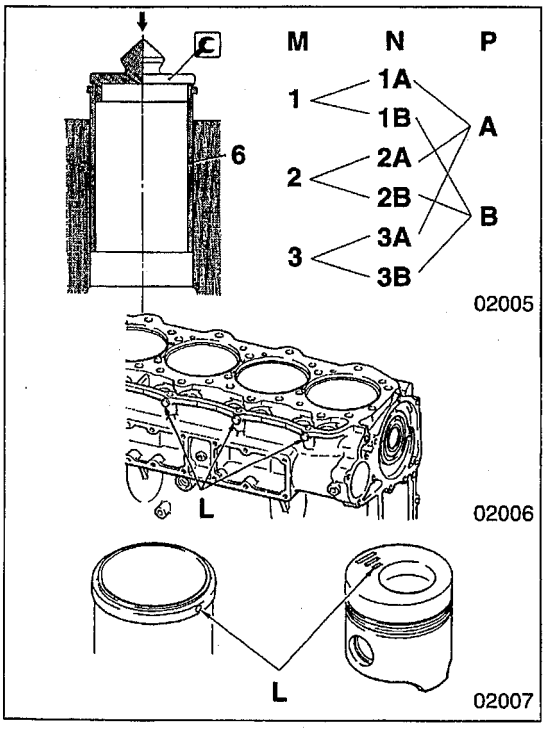


Cylinder liners

[Removal]

NOTE

If any cylinder liner 6 must be reused after removal, make an alignment mark with paint and use this mark to reinstall the cylinder liner in its original position.



- Apply engine oil to the outside surface of the cylinder liner **6**.
- Insert the cylinder liner into the crankcase and press it into position using the Cylinder Liner Installer. Push down evenly on the entire upper surface of the Cylinder Liner Installer.

CAUTION

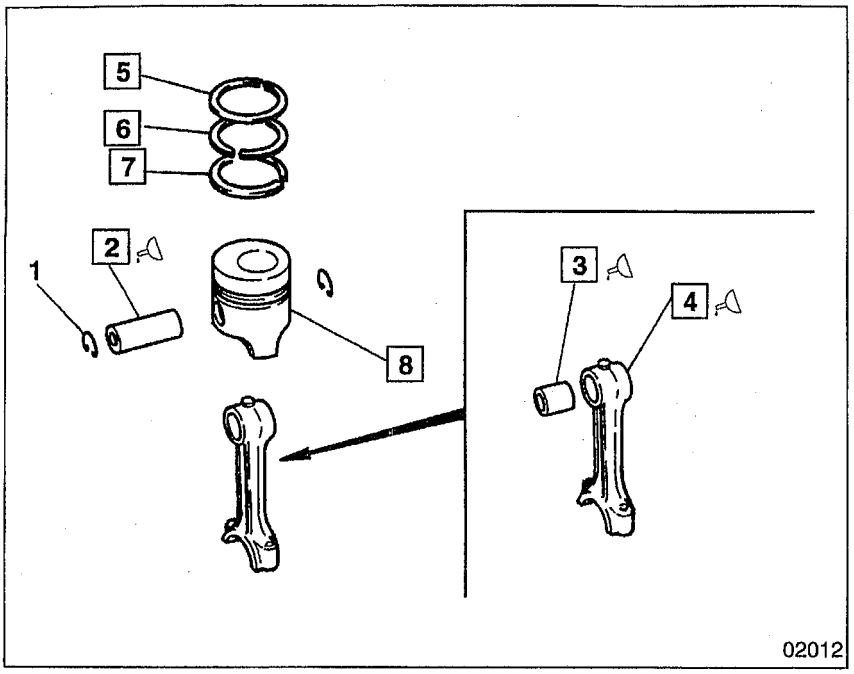
- **Size marks L are provided on the cylinder liner 6, piston, and crankcase (6 places). When the cylinder liner is replaced, select the proper one according to the size marks on the crankcase and the piston, as shown in the illustration.**

  M: Crankcase size mark
  N: Cylinder liner size mark
  P: Piston size mark

- **The cylinder liners are of a thin design. Handle them with care, and do not subject them to hammer blows or other severe shocks.**

PISTONS, CONNECTING RODS, AND CYLINDER LINERS

Piston and Connecting Rod Assembly



● **Disassembly sequence**

1 Snap ring
2 Piston pin
3 Connecting rod bushing
4 Connecting rod
5 1st compression ring
6 2nd compression ring
7 Oil ring
8 Piston

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item			Standard value (Basic diameter in [ ])	Limit	Remedy
2, 3	Piston pin-to-connecting rod small end bushing clearnace		Except 6D16-TLE	[38] 0.02 to 0.05	0.1	Replace
			6D16-TLE	[42] 0.02 to 0.05		
2, 8	Piston pin-to-piston clearance		Except 6D16-TLE	[38] 0.004 to 0.02	0.05	Replace
			6D16-TLE	[42] 0.004 to 0.02		
4	Connecting rod bend and torsion			—	0.05	Correct or replace
5 to 7	Piston ring end gap	1st compression ring	6D14, 14-T, 15-T (B type)	0.3 to 0.45	1.5	Replace
			6D15-T (A type)	0.3 to 0.5	1.5	
			6D16, 16-T, 16-TL	0.35 to 0.55	1.5	
			6D16-E, 16-TE, 16-TLE	0.35 to 0.5	1.5	
		2nd compression ring	6D14	0.3 to 0.5	1.5	Replace
			6D14-T, 15-T	0.3 to 0.45	1.5	
			6D16, 16-T, 16-TL	0.35 to 0.55	1.5	
			6D16-E, 16-TE	0.35 to 0.5	1.5	
			6D16-TLE	0.45 to 0.6	1.5	
		Oil ring	6D14, 14-T, 15-T	0.3 to 0.5	1.5	Replace
			6D16, 16-E, 16-T, 16-TE, 16-TL, 16-TLE	0.35 to 0.55	1.5	

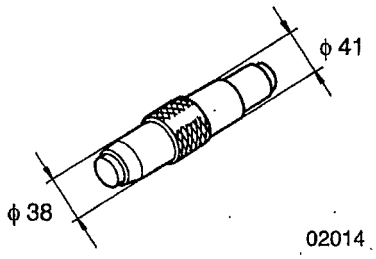
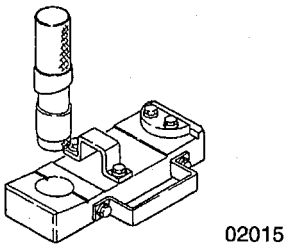
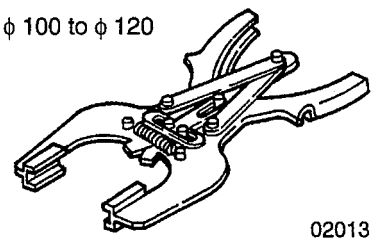
Location	Maintenance item			Standard value (Basic diameter in [ ])	Limit	Remedy
5 to 8	Piston ring-to-piston ring groove clearance	1st compression ring	6D14	0.09 to 0.13	0.2	Replace
			6D14-T, 15-T (B type)	0.05 to 0.10	0.15	Replace
			6D15-T (A type)	0.10 to 0.15	0.2	
			6D16	0.11 to 0.15	0.2	
			6D16-E	0.13 to 0.17	0.2	
			6D16-T, 16-TL, 16-TLE	0.13 to 0.18	0.2	
		2nd compression ring	6D14, 15-T (A type), 16, 16-E	0.05 to 0.08	0.15	Replace
			6D14-T, 15-T (B type), 16-T, 16-TE, 16-TL, 16-TLE	0.07 to 0.10	0.15	
		Oil ring		0.03 to 0.06	0.15	Replace

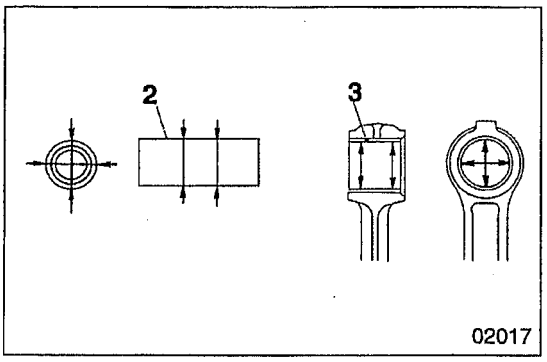
*6D15-T (B type): wedge-shaped connecting rod small end

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	Bushing installation surface of connecting rod	Engine oil	As required

Special tools

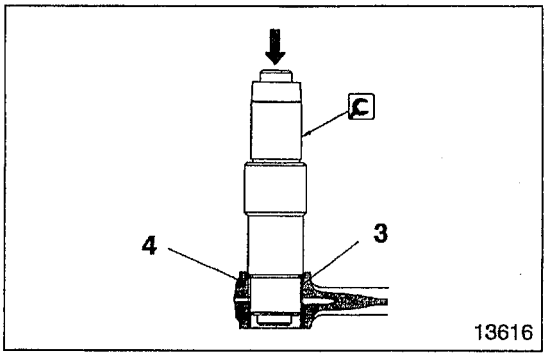
Location	Tool name and shape	Part No.	Application
3	Connecting Rod Bushing Puller 	<6D14, 15-T (A type), 16, 16-E> MH061778	Removing and installing connecting rod bushings
	Connecting Rod Bushing Puller Kit 	<6D14-T, 15-T (B type), 16-T, 16-TE, 16-TL> MH062023 <6D16-TLE> MH062556	
5 to 7	Piston Ring Tool 	30091-07100	Removing and installing piston rings



◆ Service procedure

2 3 Piston and connecting rod

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

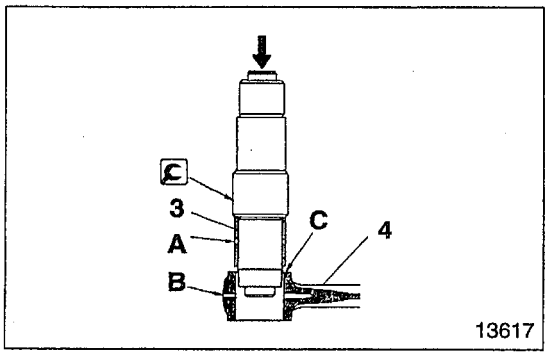


Connecting rod bushing

<6D14, 15-T (A-type), 16, 16-E>

[Removal]

Apply the Connecting Rod Bushing Puller to the connecting rod bushing **3**. Using a press, apply pressure of approximately 49 kN (5,000 kgf) such that the bushing is pressed out of the connecting rod **4**.

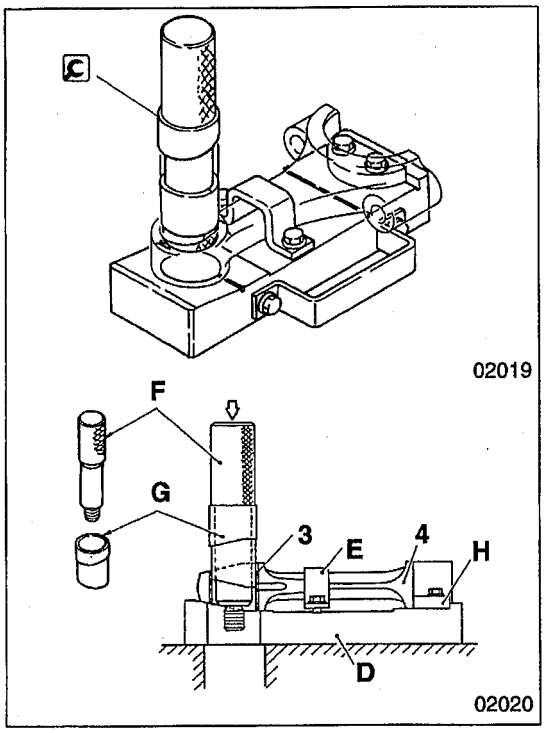


[Installation]

- Align oil hole **A** in the connecting rod bushing **3** with oil hole **B** in the connecting rod **4**.
- Apply the Connecting Rod Bushing Puller to the connecting rod bushing **3**. Using a press, apply pressure of approximately 49 kN (5,000 kgf) such that the bushing is pressed into the connecting rod **4** from the chamfered side **C**.

NOTE

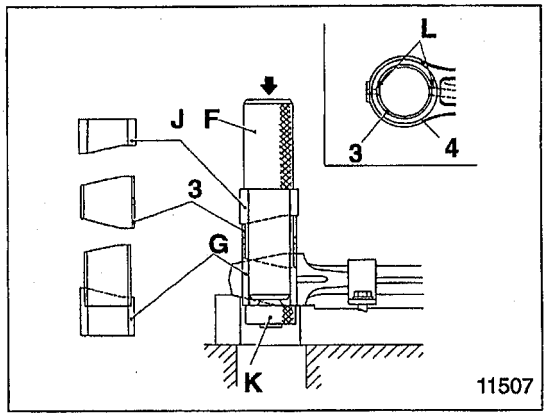
After installing the connecting rod bushing 3, insert the piston pin 2 and check that it turns smoothly and without play.



<6D14-T, 15-T (B-type), 16-T, 16-TE, 16-TL, 16-TLE>
Replace the connecting rod bushing **3** using the C Connecting Rod Bushing Puller Kit. This consists of the following parts:

D: Base
E: Bracket
F: Puller
G: Collar
H: Plate
J: Collar
K: Nut

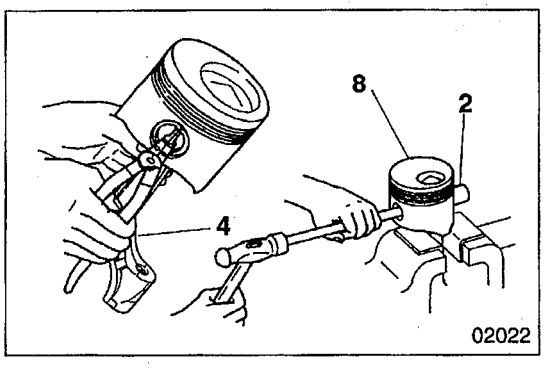
[Removal]
- Remove the bearing (if fitted) from the big end of the connecting rod **4**.
- Mount the connecting rod **4** on the base **D** and lock it in position with the bracket **E** and plate **H**.
- Position the puller **F** and collar **G** as shown in the illustration. Then, slowly apply pressure of approximately 49 kN (5,000 kgf) until the connecting rod bushing **3** is pressed out.



[Installation]
- Apply engine oil to the small end of the connecting rod **4** and to the outer surface of the connecting rod bushing **3**.
- Fit the collar **J** over the puller **F**, position the connecting rod bushing **3** and collar **G** as shown in the illustration, and lock this arrangement together with the nut **K**.
- Align the oil holes **L** in the small end of the connecting rod bushing **3** and connecting rod **4**. 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 the connecting rod bushing **3**, ream it to achieve the specified nominal clearance between the bushing and piston pin **2**.

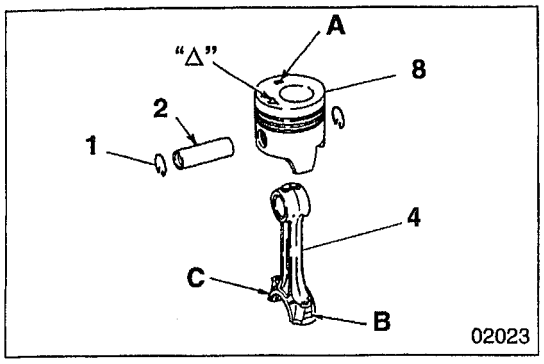
NOTE

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



2 4 8 Piston pin, connecting rod, and piston

[Removal]
- Tap out the piston pin **2** using a rod and hammer.
- If the piston pin **2** is difficult to remove, heat the piston **8** in hot water or using a piston heater.



[Installation]

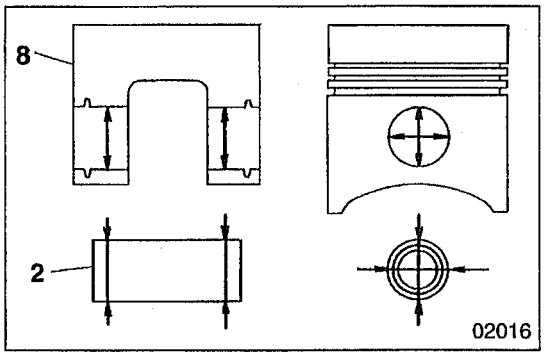
- Apply engine oil to the piston pin **2**. With the connecting rod **4** and piston **8** aligned as illustrated, insert the piston pin to hold these components together.

  A: Weight mark
  B: Weight mark (A, B, C, D, E, F, G, H, I, V, W, X, Y, Z)
  C: Alignment mark for connecting rod cap
  △: Front mark

- If the piston pin **2** is difficult to insert, heat the piston **4** in hot water or using a piston heater.

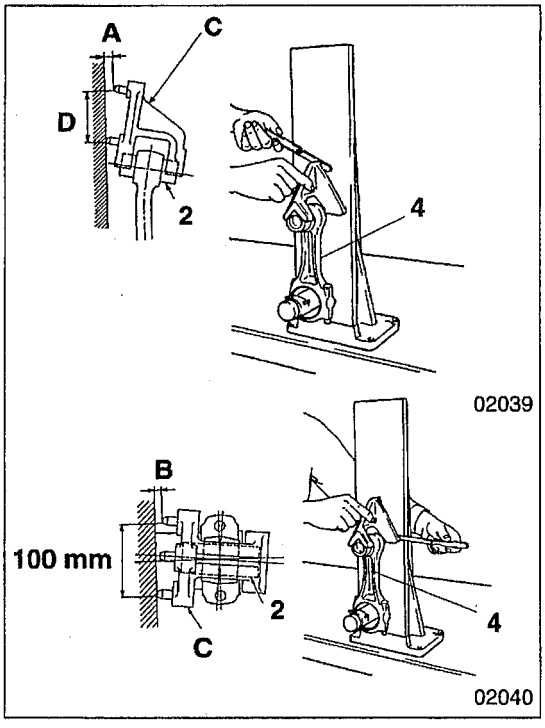
CAUTION ⚠

- **No piston should differ from any other piston by a weight of more than log.**
- **The connecting rods must all have the same weight mark.**
- **After inserting the piston pin 2, check that it turns smoothly and without play.**



[2] [8] Piston pin-to-piston clearance

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



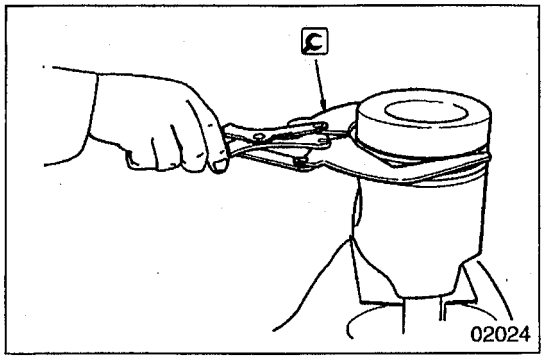
[4] Connecting rod bend and twist

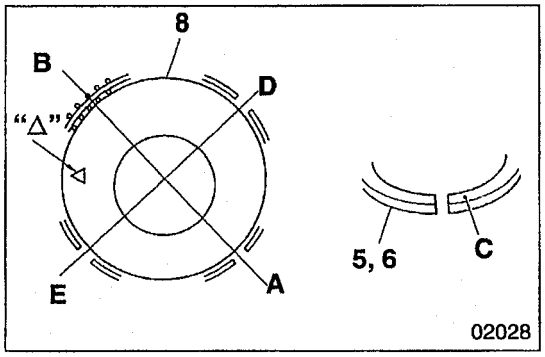
- Fit the connecting rod bushing **3** and piston **2** in their respective positions of the connecting rod **4**.
- Measure the extent of bending **A** and twisting **B** in the connecting rod **4**.
- If either measurement exceeds the specified limit, replace the connecting rod **4** or rectify it.

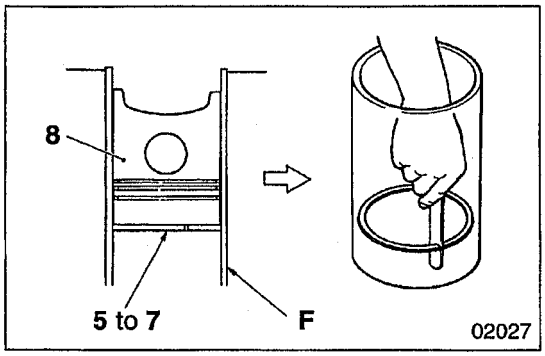
C: Connecting rod **4** aligner (measurement device)

NOTE

- **Before mounting the connecting rod 4 on the 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 nuts tightened to their specified torque.** 🕮 P.11-29







5 to 8 Piston rings and piston

Piston rings

[Removal]

[Installation]

- Fit the oil ring **7** onto the piston **8** with its side rail gaps **A** and the expander spring gap **B** in the positions illustrated.
- Fit the compression rings **5, 6** onto the piston such that the manufacturer's marks **C** near the gaps face upward.
- Align the compression ring gaps **D, E** as illustrated.

D: 1st compression ring gap
E: 2nd compression ring gap
△: Front mark

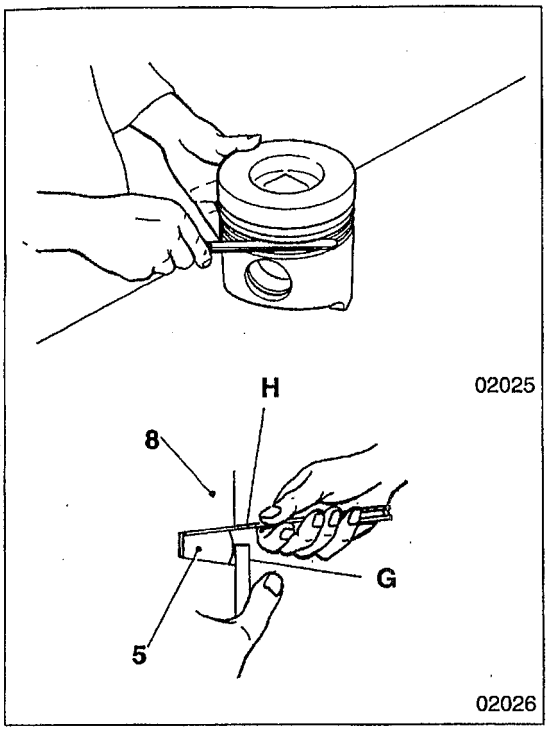
[Inspection]

(1) Piston ring end gap

- Using the crown of a piston **8**, push the piston ring **5, 6 or 7** horizontally into a cylinder liner **F** for measurement.
- Taking care not to move the piston ring **5, 6 or 7**, measure the end gap. Replace all the rings of a piston if any gap exceeds the specified limit.

NOTE

- **To keep the piston ring 5, 6 or 7 horizontal, be sure to insert them into the cylinder liner F using a piston 8.**
- **Push the piston ring 5, 6 or 7 down to the bottom of cylinder liner F; the bottom should be less worn than the top.**
- **Piston rings 5, 6 or 7 must be replaced as a set. Never replace piston rings individually.**



02025

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

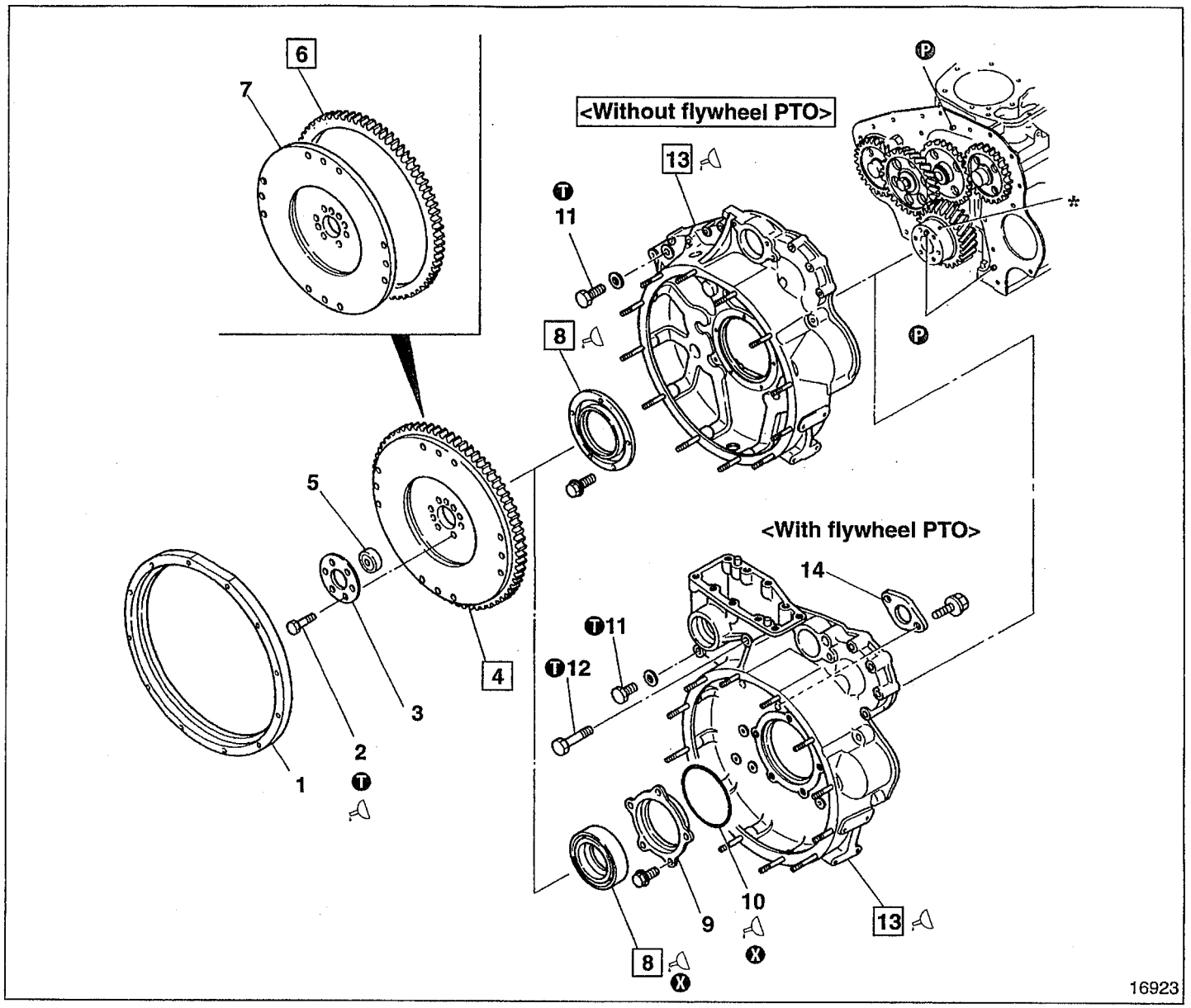
- If any measurement exceeds the specified limit, replace the defective part(s).
- Measure the 1st compression ring **5** clearance with a thickness gauge **H** while pressing the ring against the piston **8** with a straight edge **G**.

NOTE

- **Remove any carbon deposits from the ring groove of the piston 8 and measure the clearance around the piston's entire periphery.**
- **Piston rings 5, 6, 7 must be replaced as a set. Never replace piston rings individually.**

MEMO

FLYWHEEL



● **Disassembly sequence**

1 Spacer
2 Bolt
3 Washer plate
4 Flywheel assembly
5 Pilot bearing
6 Ring gear
7 Flywheel
8 Rear oil seal
9 Rear oil seal retainer <models with flywheel PTO>
10 O-ring <models with flywheel PTO>
11 Plug
12 Bolt <models with flywheel PTO>
13 Flywheel housing
14 Thrust plate <models with flywheel PTO>

*: Crankshaft 🕮 P.11-72
Ⓟ: Locating pin
Ⓧ: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item		Standard value	Limit	Remedy
4	Flywheel assembly	Friction surface distortion	0.05 or less	0.2	Correct or replace
		Height of friction surface	20	19	Replace
		Friction surface runout (when fitted)	—	0.2	Correct or replace
13	Eccentricity of joint		—	0.2	Inspect or replace

Tightening torques

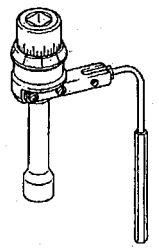
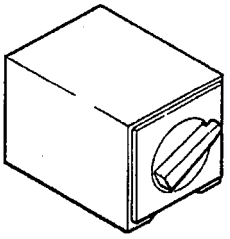
Unit: N·m {kgf·m}

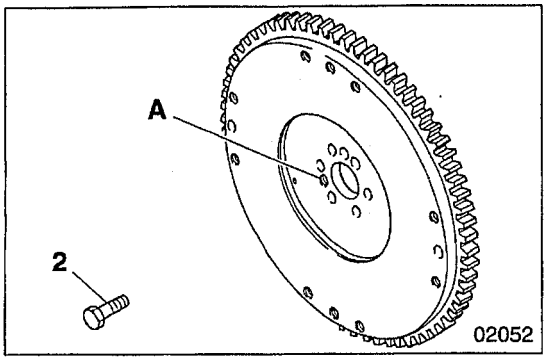
Location	Parts to be tightened	Tightening torque	Remarks
2	Flywheel mounting bolt	98 {10} + 150°	• Wet • Can be reused up to 3 times 📖 P.11-50
11	Plug	88 {9}	—
12	Bolt <models with flywheel PTO>	34 {3.5}	—

Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
2	Bolt threads	Engine oil	As required
8	Rear oil seal lip	Engine oil	As required
	Flywheel mounting surface of rear oil seal <models without flywheel PTO>	Threebond 1207C	As required
10	O-ring	Engine oil	As required
13	Engine mounting surface of flywheel housing	Threebond 1207C	As required

Special tools

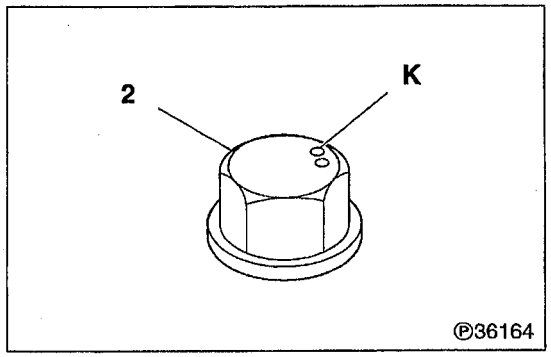
Location	Tool name and shape	Part No.	Application
4	Socket Wrench  01984	MH062354	Fitting flywheel
	Magnetic Base  00471	MH062356	



◆ Service procedure

4 Flywheel assembly

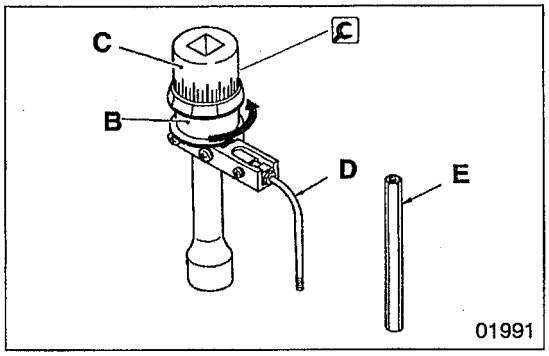
[Removal]
To remove the flywheel assembly **4**, screw the mounting bolts **2** into the removal holes **A**.



[Installation]

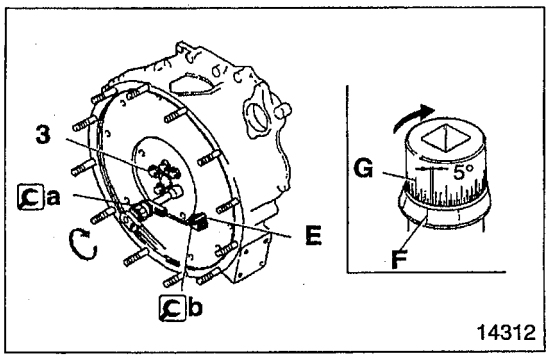
CAUTION

Before installing the bolt 2, check the number of punch marks K on its head. (If there are two or less, the bolt is reusable.) The number of punch marks corresponds with the number of times a bolt has been tightened by the plastic region tightening method. If there are three (which means that the bolt has been tightened 3 times), replace the bolt.



- Tighten the bolts **2** to their specified torque, then tighten them further in accordance with the following procedure:
- Turn the holder **B** of the [C] Socket Wrench counter-clockwise to tension the built-in spring.

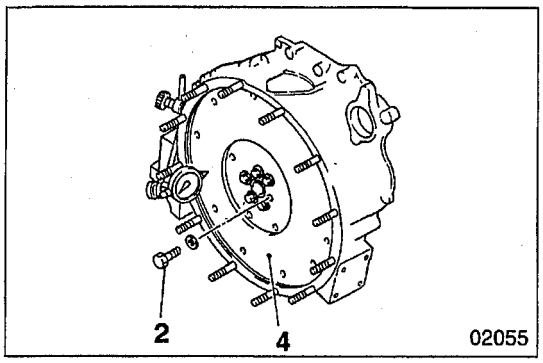
C: Socket
D: Rod
E: Rod (extension)



- Set the socket wrench such that the built-in spring forces the rod **E** against the [C]**b** Magnetic Base.
- On the holder **B**, select the inscribed line **F** that is easiest to see.
- Using the selected line as a reference, turn the socket 150° clockwise. (One gradation on the scale **G** represents 5°.)

CAUTION

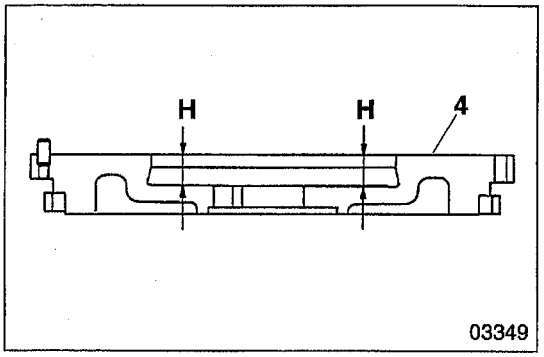
Since the bolts 2 utilize the plastic region tightening method, they must not be tightened further after this procedure.



[Inspection]

(1) Runout

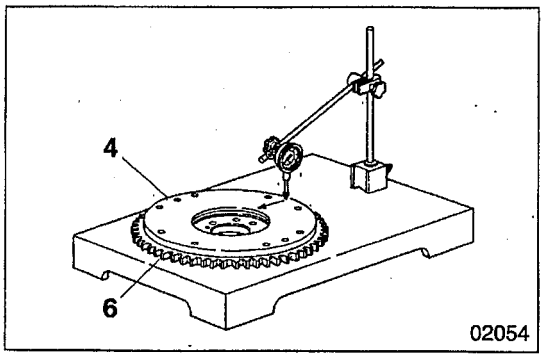
- Tighten the bolts **2** to their specified torque.
- If runout exceeds the specified limit, check that the bolts **2** are tightened correctly and inspect the crankshaft* mounting surface. Then, rectify or replace the flywheel assembly **4** as required.



(2) Height of friction surface

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

H: Height of friction surface

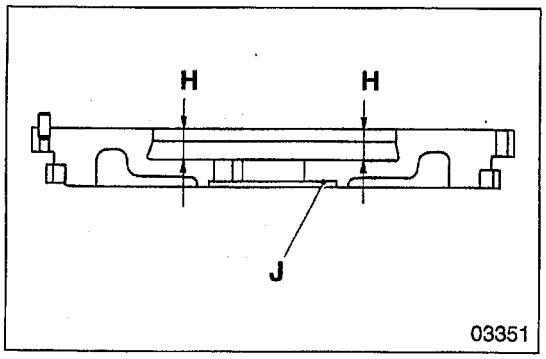


(3) Distortion of friction surface

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

NOTE

If any abnormality is evident on the ring gear 6, replace the ring gear before making inspections.



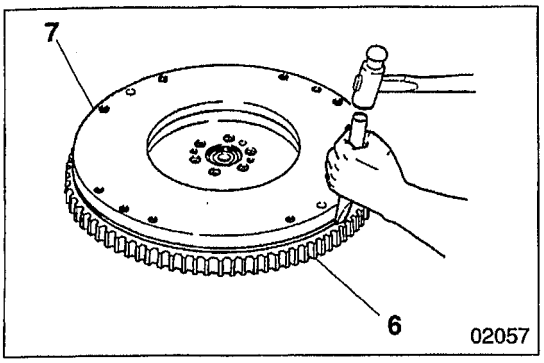
[Rectification]

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

6 Ring gear

[Inspection]

Inspect the ring gear **6** for damage and abnormal wear. If any defect is evident, the ring gear must be replaced.



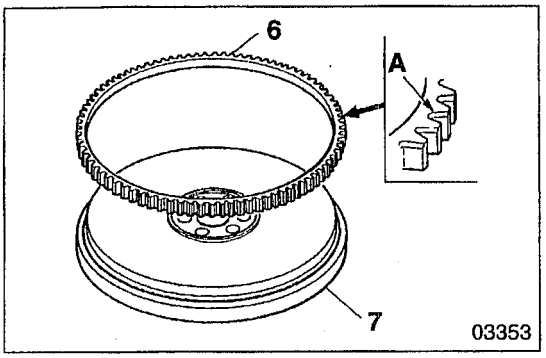
[Removal]

- Heat the ring gear **6** evenly with an acetylene torch or the like.

CAUTION ⚠

Be careful not to get burned.

- Remove the ring gear **6** from the flywheel **7** by tapping around its entire periphery.



[Installation]

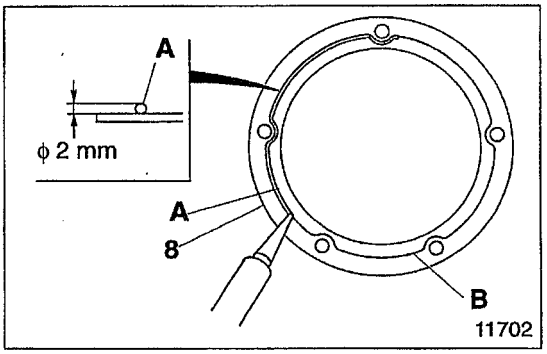
- Using a piston heater or the like, heat the ring gear **6** to approximately 100°C for 3 minutes.

CAUTION ⚠

Be careful not to get burned.

- Fit the ring gear **6** with the non-chamfered side of its teeth toward the flywheel **7**.

A: Chamfered side of ring gear



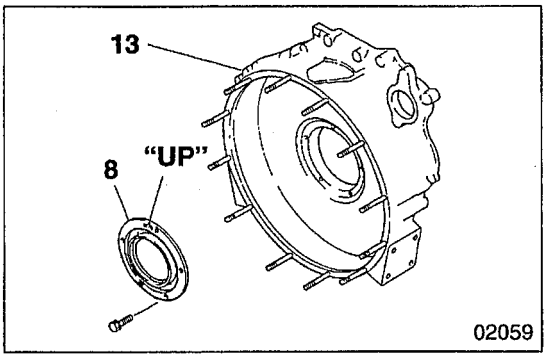
8 Fitting rear oil seal

<Models without flywheel PTO>

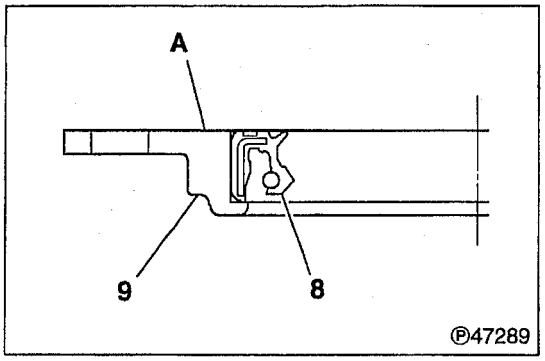
- Apply an even, unbroken bead of sealant **A** to the rear oil seal **8** in the position illustrated **B**.
- Fit the rear oil seal **9** onto the flywheel housing **12** within 3 minutes of applying the sealant **A**.

CAUTION ⚠

- **Ensure that the sealant application position B on the oil seal 8 is clean before applying sealant.**
- **When fitting the rear oil seal 8, hold it firmly in position to prevent spreading the sealant.**
- **After fitting the rear oil seal 8, wait at least 30 minutes before starting the engine.**
- **Apply a new bead of sealant A whenever the mounting bolts of the rear oil seal 8 have been loosened.**

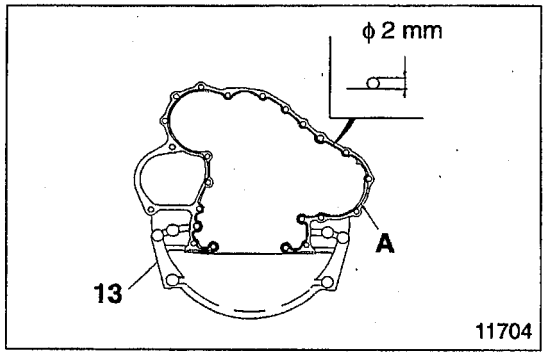


- Apply engine oil to the lip of the rear oil seal **8**.
- Fit the rear oil seal **8** onto the flywheel housing **13** in the direction illustrated.



<Models with flywheel PTO>

- Fit the rear oil seal **8** into the rear oil seal retainer **9** in the direction illustrated by pushing its periphery evenly until the end **A** becomes flush with the end surface of the rear oil seal retainer **9** all around.



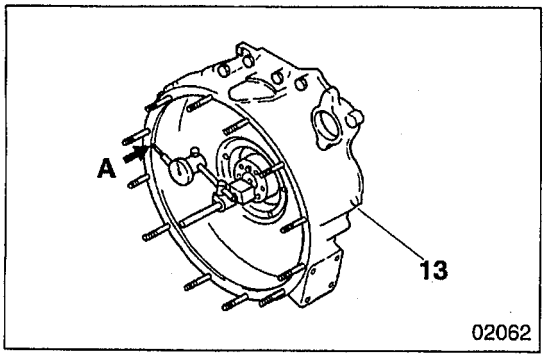
13 Flywheel housing

[Installation]

- Apply an even, unbroken bead of sealant **A** to the crankcase mounting surface of the flywheel housing **13**.
- Fit the flywheel housing **13** onto the crankcase within 3 minutes of applying the sealant **A**.

CAUTION ⚠

- **Ensure that the sealant application position on the flywheel housing 13 is clean before applying sealant.**
- **When fitting the flywheel housing 13, hold it firmly in position to prevent spreading the sealant.**
- **After fitting the flywheel housing 13, wait at least an hour before starting the engine.**
- **Apply a new bead of sealant A whenever the mountiing bolts of the flywheel housing 13 have been loosened.**

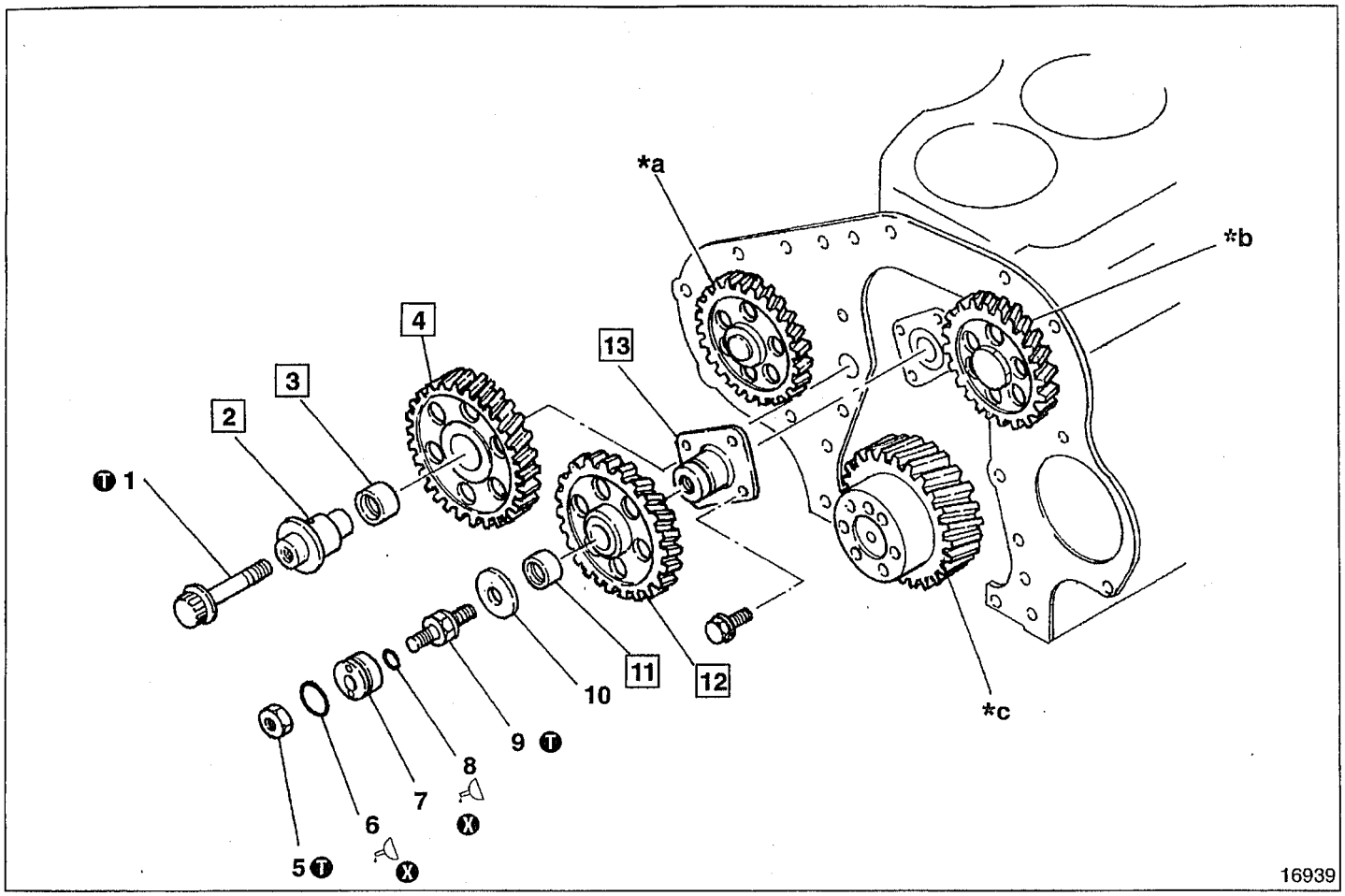


[Inspection]

- Rotate the crankshaft and check the extent of eccentricity at the joint **A** of the flywheel housing **13**.
- If eccentricity exceeds the specified limit, carry out reassembly.
- If eccentricity still exceeds the specified limit after reassembly, replace the defective part(s).

TIMING GEARS

<Without Flywheel PTO>



● **Pre-disassembly inspection**

📖 P.11-56

● **Disassembly sequence**

1 Bolt
2 No. 1 idler shaft
3 No. 1 idler gear bushing
4 No. 1 idler gear
5 Nut
6 O-ring
7 Collar
8 O-ring
9 Bolt
10 Thrust washer
11 No. 2 idler gear bushing
12 No. 2 idler gear
13 No. 2 idler shaft

*a: Drive gear
*b: Camshaft gear 📖 P.11-64
*c: Crankshaft gear 📖 P.11-72

X: Non-reusable part

CAUTION

Since the No. 1 idler gear 4 is supported by the No. 1 idler shaft 2, these parts must be removed as a single unit.

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item		Standard value (Basic diameter in [ ])	Limit	Remedy
—	Gear backlash	Between No. 1 idler gear and crankshaft gear	0.08 to 0.15	0.35	Replace
		Between No. 1 idler gear and No. 2 idler gear	0.07 to 0.15	0.35	Replace
		Between No. 1 idler gear and drive gear	0.07 to 0.15	0.35	Replace
		Between No. 2 idler gear and camshaft gear	0.08 to 0.16	0.35	Replace
2, 3	No. 1 idler shaft-to-gear bushing clearance		[37] 0.01 to 0.05	0.2	Replace
4, 12	Idler gear end play		0.05 to 0.15	0.3	Replace
11, 13	No. 2 idler gear bushing-to-shaft clearance		[32] 0.01 to 0.05	0.2	Replace

❶ Tightening torques

Unit: N·m {kgf·m}

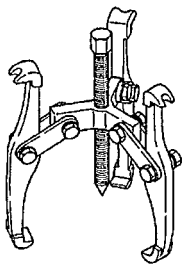
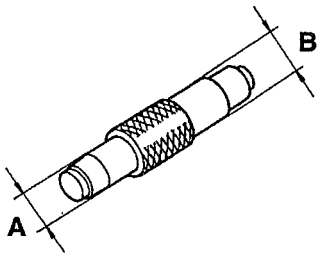
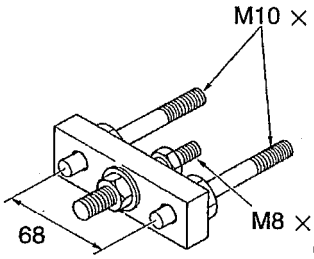
Location	Parts to be tightened	Tightening torque	Remarks
1	No. 1 idler gear mounting bolt	88 {9}	—
5	Collar mounting nut	82 {8.4}	—
9	No. 2 idler gear mounting bolt	95 {9.7}	—

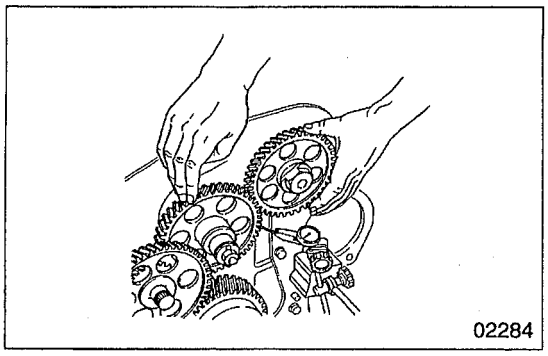
Lubricant

Location	Points of application	Specified lubricant	Quantity
6, 8	O-ring	Engine oil	As required

Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
2, 4	Gear Puller  02065	MH061326	Removing No. 1 idler shaft and gear
3, 11	Idler Gear Bushing Puller A: No. 1 idler gear bushing: φ37; No. 2 idler gear bushing: φ32 B: No. 1 idler gear bushing: φ40; No. 2 idler gear bushing: φ35  02066	<No. 1> MH062601 <No.2> MH061779	Removing and fitting idler gear bushings
13	Idler Shaft Puller  02067	MH062405	Removing No. 2 idler gear shaft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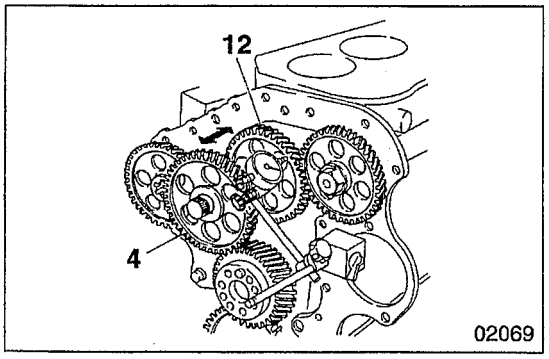


02069

◆ Service procedure

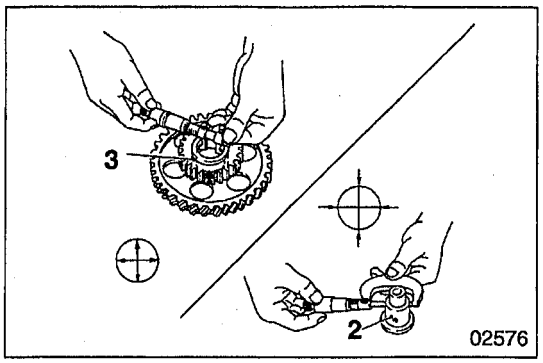
● Pre-disassembly inspection

(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

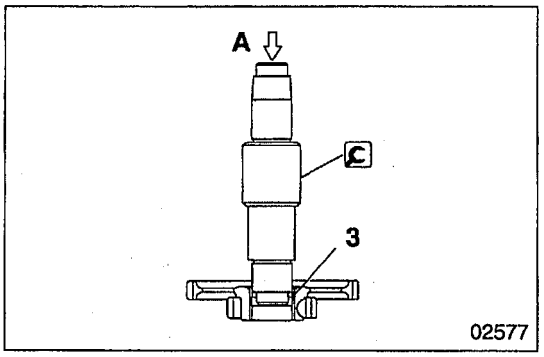
If the measurement exceeds the specified value, replace the defective part(s).



2 3 No. 1 idler shaft and No. 1 idler gear bushing

[Inspection]

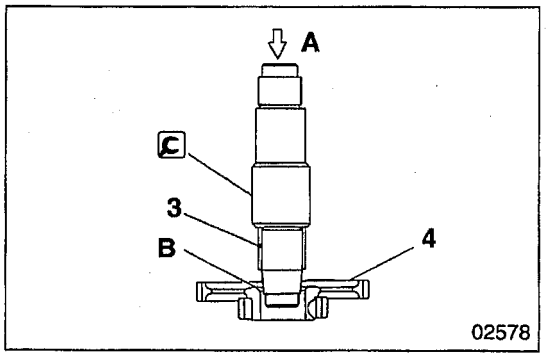
If the clearance exceeds the specified limit, replace the defective part(s).



No. 1 idler gear bushing

[Removal]

A: Press

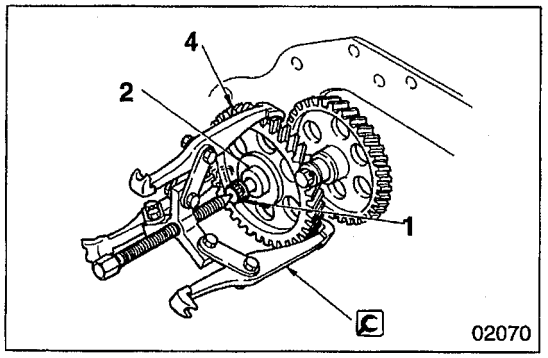


[Installation]

- Using the Idler Gear Bushing Puller, press the No. 1 idler gear bushing **3** into the No. 1 idler gear **4** from the side of the gear whose internal diameter is chamfered **B**.

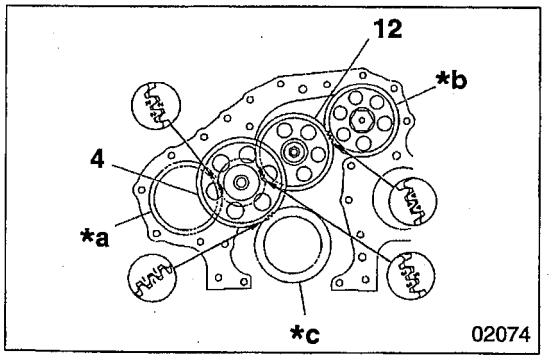
  A: Press

- After installation, measure the clearance again. If the measurement is below the nominal value range, ream the bushing **3**.



2 4 Removing No. 1 idler shaft and No. 1 idler gear

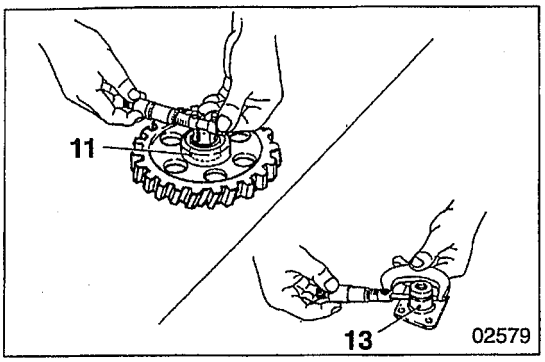
Loosen the bolt **1** by approximately 15 mm, then remove the No. 1 idler shaft **2** and No. 1 idler gear **4** as a single unit.



4 12 Installing No. 1 and No. 2 idler gears

Fit the No. 1 and No. 2 idler gears **4**, **12** such that their alignment marks ("**1**", "**2**", "**3**", "**4**") are aligned with those on the gears with which they mate.

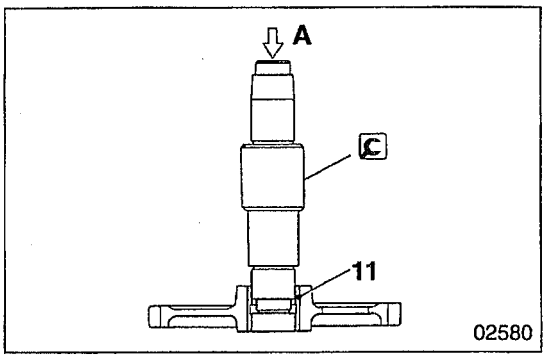
***a**: Drive gear
***b**: Camshaft gear
***c**: Crankshaft gear



11 **13** **No. 2 idler gear bushing and No. 2 idler shaft**

[Inspection]

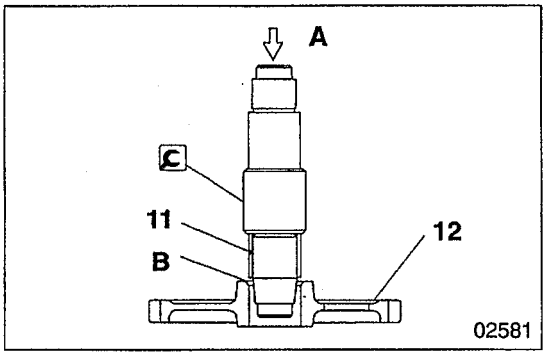
If the clearance exceeds the specified limit, replace the defective part(s).



No. 2 idler gear bushing

[Removal]

A: Press

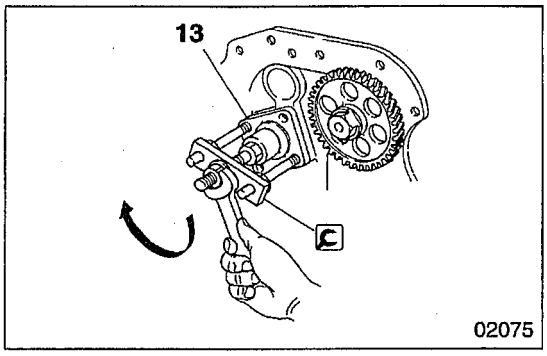


[Installation]

- Using the C Idler Gear Bushing Puller, press the No. 2 idler gear bushing **11** into the No. 2 idler gear **12** from the side of the gear whose internal diameter is chamfered **B**.

  A: Press

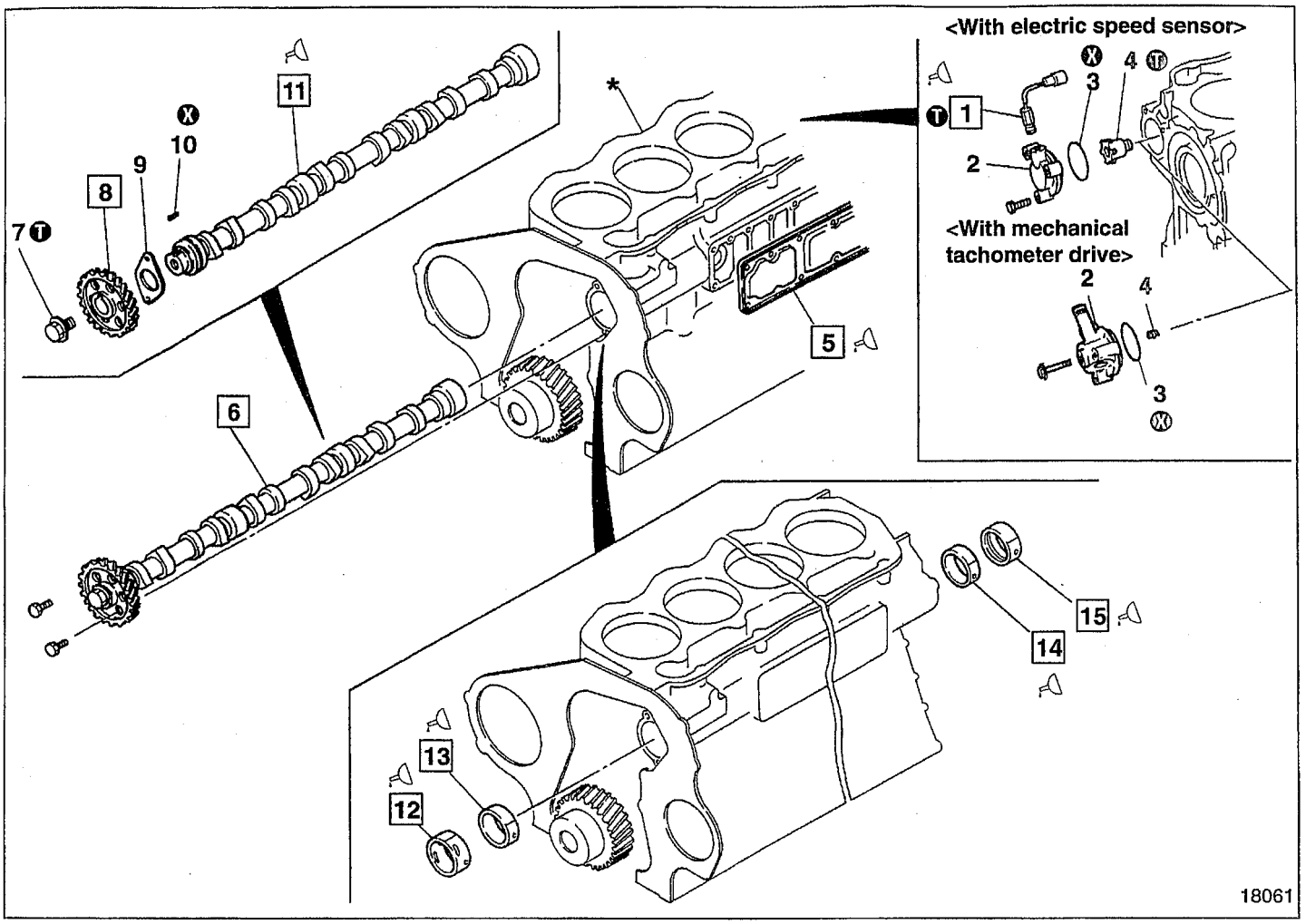
- After installation, measure the clearance again. If the measurement is below the nominal value range, ream the bushing **11**.



13 **Removing No. 2 idler shaft**

MEMO

CAMSHAFT



● **Pre-disassembly inspection**

📖 P.11-66

● **Disassembly sequence**

1 Engine speed sensor <models with electric speed sensor>
2 Adapter <models with electric speed sensor>
Tachometer drive case <models with mechanical tachometer>
3 O-ring
4 Pulse rotor <models with electric speed sensor>
Tachometer drive coupling <models with mechanical tachometer>
5 Side cover
6 Camshaft assembly
7 Bolt
8 Camshaft gear
9 Thrust plate
10 Key
11 Camshaft
12 No. 4 camshaft bushing
13 No. 3 camshaft bushing
14 No. 2 camshaft bushing
15 No. 1 camshaft bushing

*: Crankcase 📖 P.11-72
Ⓧ: Non-reusable part

NOTE

- **Do not remove the engine speed sensor 1 unless defects are evident.**
- **Do not remove the camshaft gear 8 unless defects are evident.**

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item				Standard value (Basic diameter in [ ])	Limit	Remedy
1	Resistance of engine speed sensor (at 25°C)				2.3 ± 0.2 kΩ	—	Replace
6	Camshaft assembly end play				0.05 to 0.22	0.4	Inspect each part
11	Camshaft	Cam lift	Inlet	Except 6D16-E	6.901	6.40	Lobe height: 49.011 Base circle diameter: 42.110
				6D16-E	7.42	6.93	Lobe height: 50.33 Base circle diameter: 42.91
			Exhaust		7.680	7.18	Lobe height: 49.307 Base circle diameter: 41.627
		Bend			0.02 or less	0.04	Replace
11, 12 to 15	Camshaft journal-to-camshaft bushing clearance		No. 1 journal		[57.75] 0.05 to 0.10	0.25	Replace
			No. 2 journal		[58.00] 0.05 to 0.10		
			No. 3 journal		[58.25] 0.13 to 0.18		
			No. 4 journal		[58.50] 0.05 to 0.10		

Tightening torques

Unit: N·m {kgf·m}

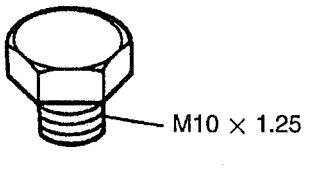
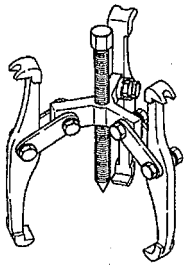
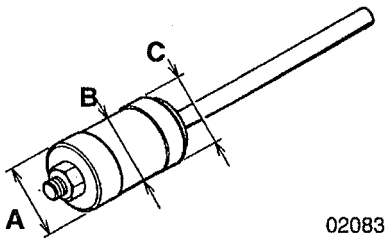
Location	Parts to be tightened	Tightening torque	Remarks
1	Engine speed sensor <models with electric speed sensor>	29 ± 5.9 {3.0 ± 0.6}	—
4	Pulse rotor <models with electric speed sensor>	98 {10}	—
7	Camshaft gear mounting bolt	175 {18}	—

Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
1	Engine speed sensor threads <models with electric speed sensor>	Threebond 1104J	As required
5	Crankcase mounting surface of side cover	Threebond 1207C	As required
11	Camshaft journals	Engine oil	As required
12 to 15	Inside surfaces of camshaft bushings	Engine oil	As required

Special tools

Unit: mm

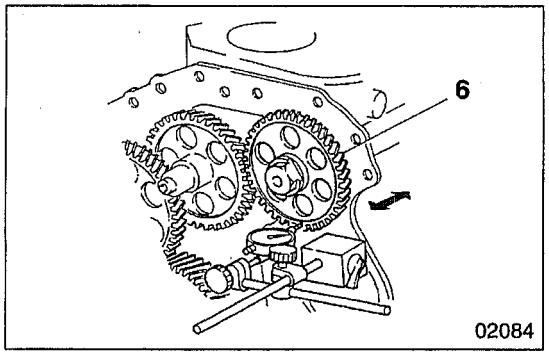
Location	Tool name and shape	Part No.	Application
8	Plug  02082	MF665007	Blanking plug for use when removing camshaft gear
	Gear Puller  02065	MH061326	Removing camshaft gear
12 to 15	Camshaft Bushing Installer and Extractor | | A, C dimension | B dimension | | No. 1 | ϕ 62.00 | ϕ 57.75 | | No. 2 | ϕ 62.25 | ϕ 58.00 | | No. 3 | ϕ 62.50 | ϕ 58.25 | | No. 4 | ϕ 62.75 | ϕ 58.50 |  02083	MH062025	Removing and installing camshaft bushings

◆ Service procedure

● Pre-disassembly inspection

Camshaft end play

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



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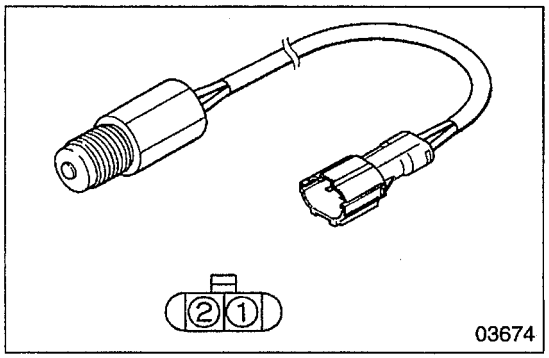


03674

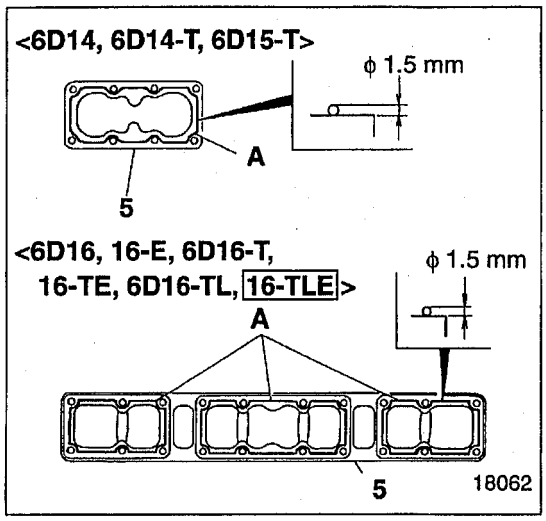
1 Inspecting engine speed sensor

<Models with electric speed sensor>

- Measure the electrical resistance between terminals ① and ②.
- If the measurement is out of specification, replace the speed sensor 1. Gr 11

CAUTION

Check the tightening torque of the engine speed sensor 1. If the sensor is insufficiently tightened, it may not produce signals.

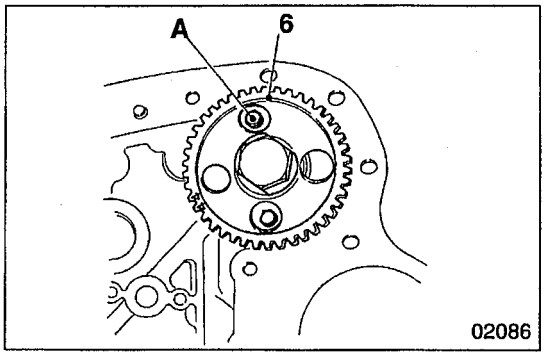


5 Fitting side cover

- Apply an even, unbroken bead of sealant **A** to the side cover **5**.
- Fit the side cover **5** onto the crankcase within **3** minutes of applying the sealant **A**.

CAUTION

- **Ensure that the sealant application surface of the side cover 5 is clean before applying sealant.**
- **When fitting the side cover 5, hold it firmly in position to prevent spreading the sealant.**
- **After fitting the side cover 5, wait at least an hour before starting the engine.**
- **Apply a new bead of sealant A whenever the mounting bolts of the side cover 5 have been loosened.**



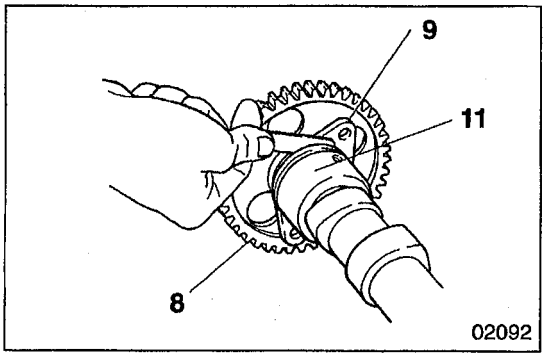
6 Camshaft assembly

[Removal]

- When removing the camshaft assembly **6**, take off the side cover **5** and support the camshaft by hand.
- Remove the bolts **A** from the camshaft gear holes, then slowly remove the camshaft assembly **6**.

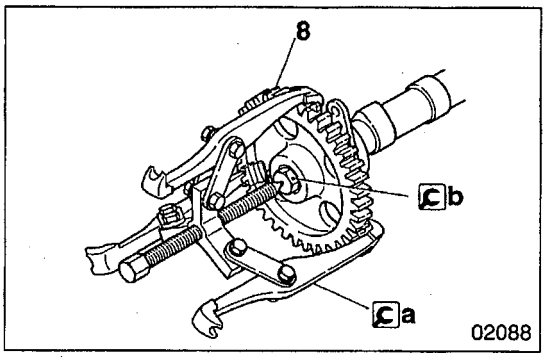
CAUTION

Take care not to damage the camshaft bushings 12 to 15 when removing the camshaft assembly 6.



[Installation]

- Before installing the camshaft assembly **6**, measure the end play between the thrust plate **9** and camshaft **11**.
- If the measurement exceeds the specified limit, replace the defective part(s).
- With the alignment marks lined up on the camshaft gear **8** and No. 2 idler gear, fit the camshaft assembly. P.11-54



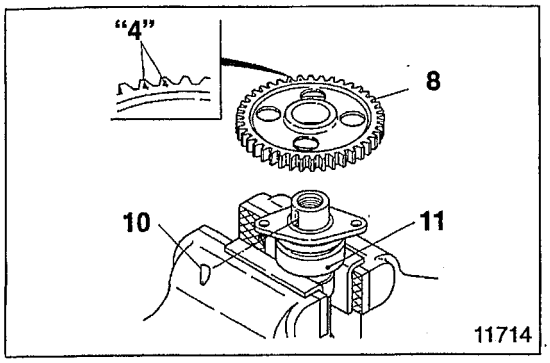
8 Camshaft gear

[Removal]

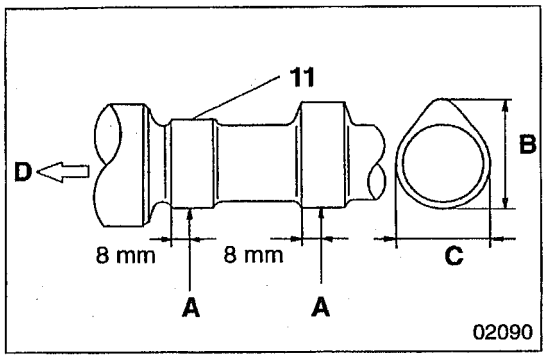
CAUTION

The camshaft gear 8 must be removed with the appropriate special tools. Do not tap off the camshaft gear since this would damage it.

a: Gear Puller
b: Plug



[Installation]
- Fit the camshaft gear 8 onto the camshaft **11** in the direction illustrated.
- Do not forget to fit the key **10**.



11 Inspecting camshaft

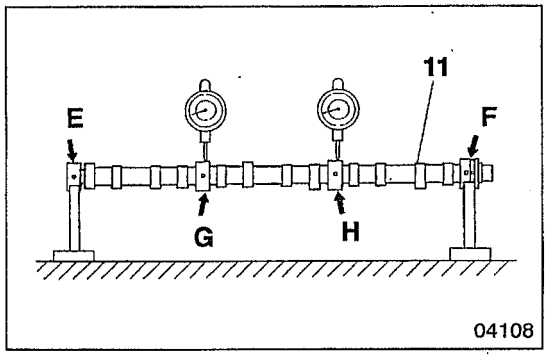
(1) Cam lift

If any base circle-to-lobe height difference is less than the required value, replace the camshaft **11**.

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

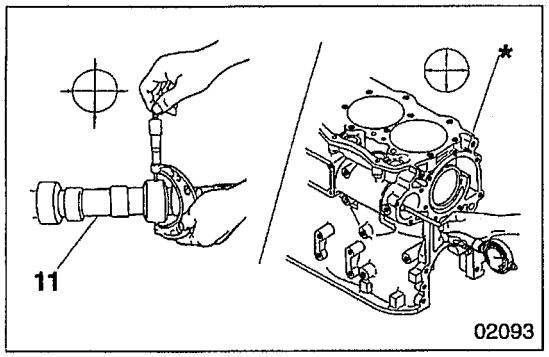


(2) Camshaft bend

Support the camshaft **11** at its No. 1 journal **E** and No. 4 journal **F**, then take measurements at the No. 2 journal **G** and No. 3 journal **H**. If either measurement exceeds the specified limit, replace the camshaft.

NOTE

Turn the camshaft 11 through one revolution. One-half of the dial indicator reading represents the camshaft's bend.

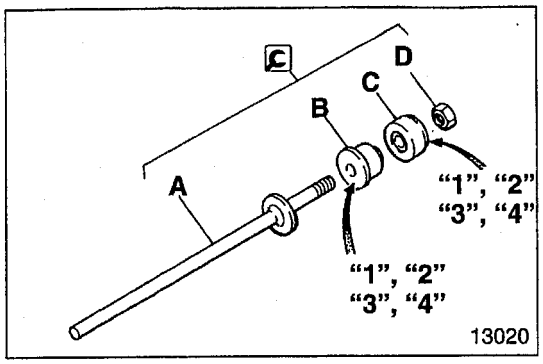


11 to 15 Camshaft and camshaft bushings

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

NOTE

Measure the camshaft bushings 12 to 15 with the camshaft installed in the crankcase*.



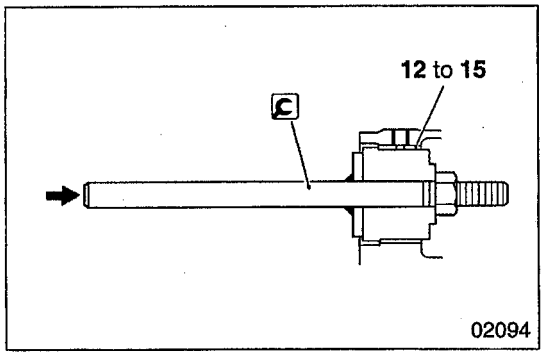
Camshaft bushings

Removal and installation of camshaft bushings should be carried out using the [E] Camshaft Bushing Installer and Extractor. Each guide of the tool is stamped with an identification mark ("1", "2", "3", "4") in the position shown. Use correct adapter and/or guide piece to remove and install a bushing according to the table below.

Bushing No. (from front of engine)	Identification mark
No.1	1
No.2	2
No.3	3
No.4	4

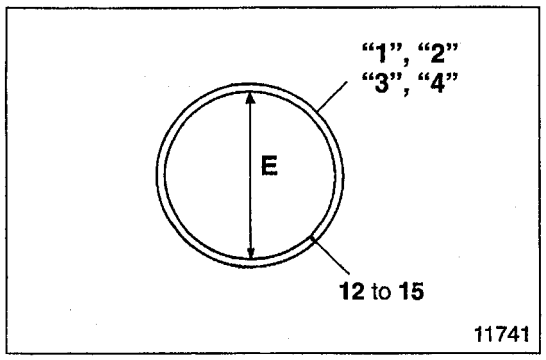
<Components of [E] Camshaft Bushing Installer and Extractor>

A: Rod
B: Camshaft bushing adapter
C: Guide piece
D: Nut



[Removal]
Remove the No. 4 and No. 3 camshaft bushings **12**, **13** from the rear of the engine. Remove the No. 2 and No. 1 camshaft bushings **14**, **15** from the front of the engine.

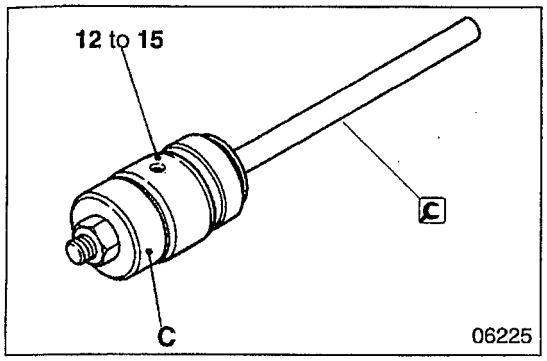
[E]: Camshaft Bushing Installer and Extractor



[Installation]

- Identify the No. 1 to No. 4 camshaft bushings **12** to **15** from their identification marks ("1", "2", "3", "4") in accordance with the table below. If any bushing's identification mark is unclear, identify the bushing from its internal diameter **E**.

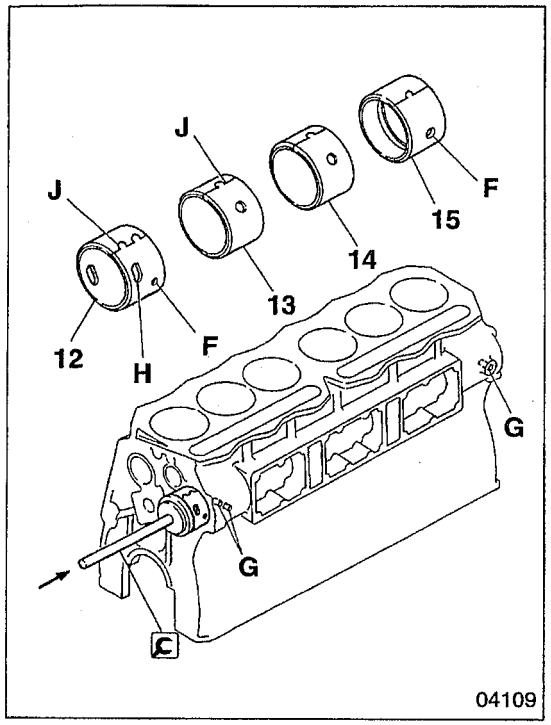
Bushing No. (from front of engine)	Identification mark	Internal diameter (mm)
No.1	1	ϕ 57.75
No.2	2	ϕ 58.00
No.3	3	ϕ 58.25
No.4	4	ϕ 58.50



- Install the bushings **12 to 15** by using all components of the [C] Camshaft Bushing Installer and Extractor (rod **A**, camshaft bushing adapter **B**, guide piece **C** and nut **D**).
- Install the camshaft bushings **12 to 15** in the following order: No. 3, No. 4, No. 2 and No. 1.

NOTE

Install the No. 3 and No. 4 camshaft bushings 12, 13 from the rear of the engine. Install the No. 1 and No. 2 camshaft bushings 14, 15 from the front of the engine.

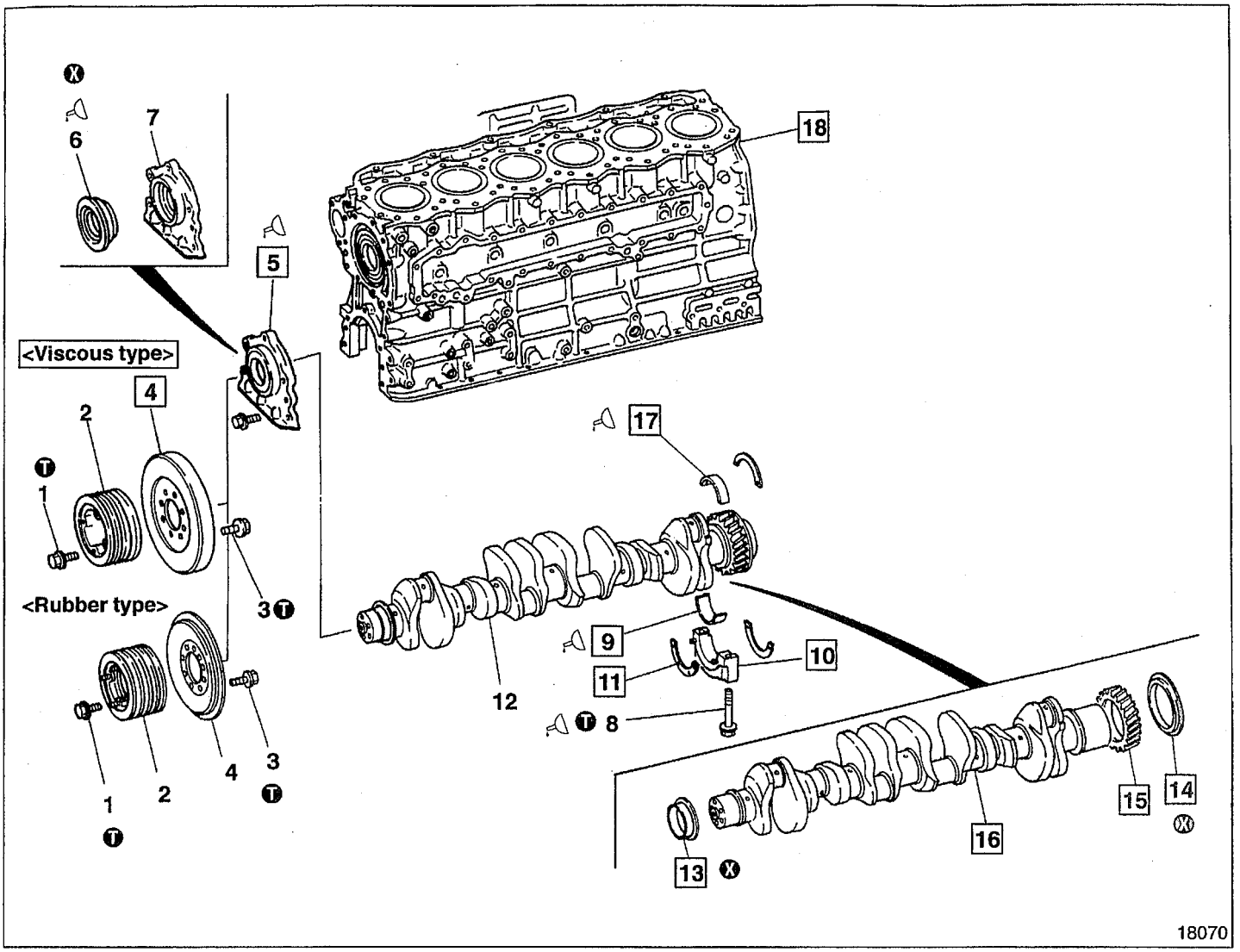


- Ensure that the oil holes **F** in the No. 1 and No. 4 camshaft bushings **15, 12** are aligned with the oil holes **G** in the crankcase. With the No. 4 camshaft bushing, ensure also that the longer oil hole **H** is toward the rear of the engine.

J: Bushing clinch joint
[C]: Camshaft Bushing Installer and Extractor

MEMO

CRANKSHAFT AND CRANKCASE



● **Pre-disassembly inspection**

P.11-75

● **Disassembly sequence**

1 Bolt
2 Crankshaft pulley
3 Bolt
4 Torsional damper
5 Front cover assembly
6 Front oil seal
7 Front cover
8 Bolt
9 Lower main bearing
10 Main bearing cap
11 Thrust plate
12 Crankshaft assembly
13 Front oil seal slinger
14 Rear oil seal slinger
<models without flywheel PTO>
Sleeve
<models with flywheel PTO>
15 Crankshaft gear
16 Crankshaft
17 Upper main bearing
18 Crankcase

: Non-reusable part

NOTE

Do not remove front oil seal slinger 13, rear oil seal slinger (or sleeve) 14 and crankshaft 15 unless faulty.

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item			Standard value (Basic diameter in [ ])	Limit	Remedy
9, 17	Main bearing	Oil clearance	Except 6D15-T (with dry cylinder liners)	[84] 0.05 to 0.10	0.15	Replace
			6D15-T (with dry cylinder liners)	[80] 0.05 to 0.10		
		Span when free		—	Less than 85.5	Replace
16	Crankshaft	End play		0.10 to 0.25	0.4	Replace
		Bend		0.05 or less	0.1	Correct or replace
		Pin and journal	Roundness	0.01 or less	0.03	Correct or replace
			Cylindricity	0.006 or less	—	Correct or replace
18	Distortion of crankcase top surface			0.07 or less	0.2	Replace

ⓣ Tightening torques

Unit: N·m {kgf·m}

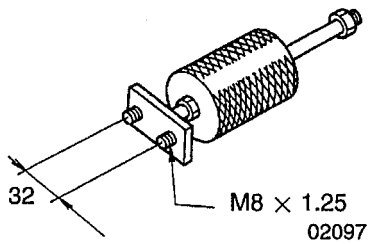
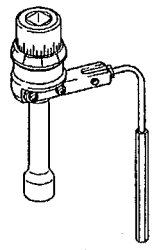
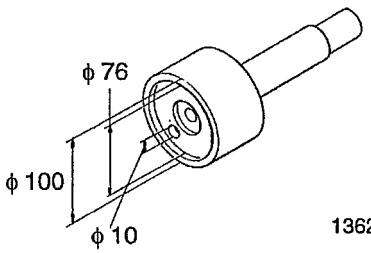
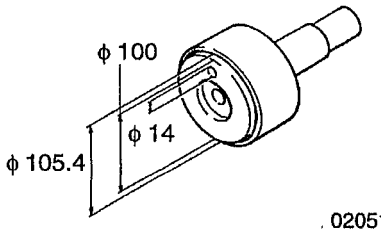
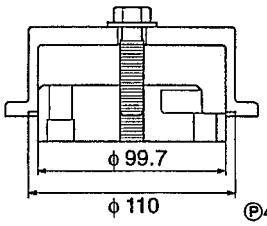
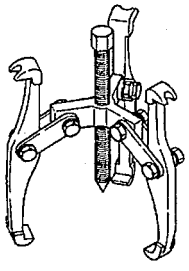
Location	Parts to be tightened	Tightening torque	Remarks
1	Crankshaft pulley mounting bolt	185 {19}	—
3	Torsional damper mounting bolt	67 {8}	—
8	Main bearing cap mounting bolt	67 {8} + 90°	• Wet • Can be reused up to 3 times 📖 P.11-76

Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
5	Crankcase mounting surface of front cover assembly	Threebond 1207C	As required
6	Front oil seal lip	Engine oil	As required
8	Bolt threads	Engine oil	As required
9, 17	Main bearing inside surfaces	Engine oil	As required
14	Apply inner surface of sleeve <with flywheel PTO>	Engine oil	As required

Special tools

Unit: mm

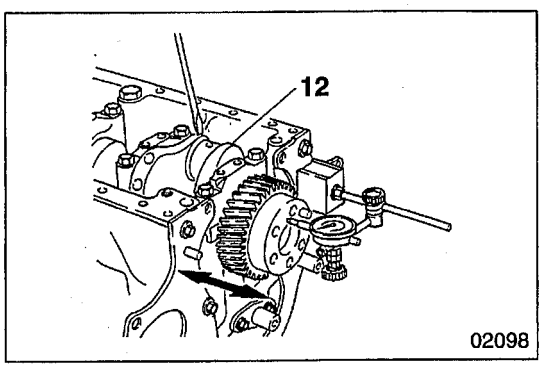
Location	Tool name and shape	Part No.	Application
10	Main Bearing Cap Extractor 	MH061189	Removing main bearing caps
	Socket Wrench 	MH061560	Fitting main bearing caps
13	Front Oil Seal Slinger Installer 	MH062710	Installing front oil seal
14	Rear Oil Seal Slinger Installer 	MH061470	Installing rear oil seal slinger <without flywheel PTO>
	Sleeve Installer 	MH062037	Installing rear oil seal sleeve <with flywheel PTO>
15	Gear Puller 	MH061326	Removing crankshaft gear

◆ Service procedure

● Pre-disassembly inspection

Crankshaft assembly end play

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

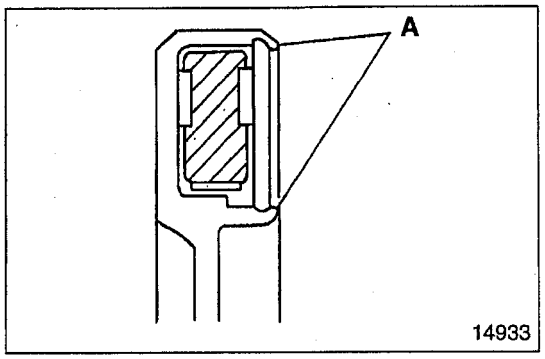


4 Torsional damper <Viscous type>

CAUTION

Leakage of silicon oil from the caulked seam A can cause the viscous-type torsional damper to stop functioning. Note the following points:

- **Check that the caulked seam is free of gouges and other damage.**
- **Do not submit the torsional damper to shock by striking it with a hammer or dropping it.**
- **Do not roll the torsional damper or stack it with other units.**

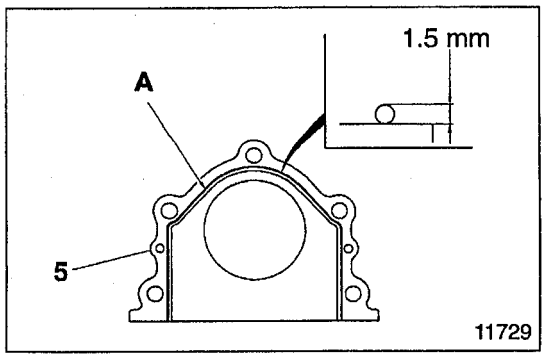


5 Installing front cover assembly

- Apply an even, unbroken bead of sealant **A** to the mating surface of the front cover assembly **5** to be mounted to the crankcase **20**.
- Fit the front cover assembly **5** onto the crankcase **20** within 3 minutes of applying the sealant **A**.

CAUTION

- **Ensure that the sealant application surface of the front cover assembly 5 is clean before applying sealant.**
- **When fitting the front cover assembly 5, hold it firmly in position to prevent spreading the sealant.**
- **After fitting the front cover assembly 5, wait at least an hour before starting the engine.**
- **Apply a new bead of sealant A whenever the mounting bolt of the front cover assembly 5 have been loosened.**



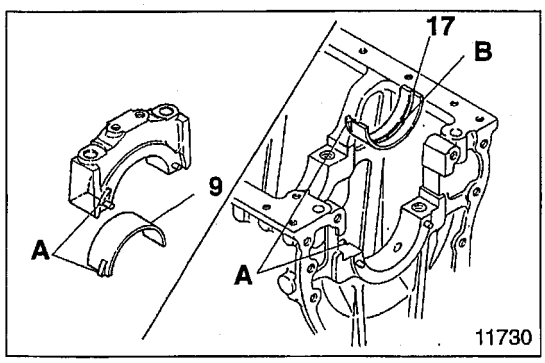
9 17 Main bearings

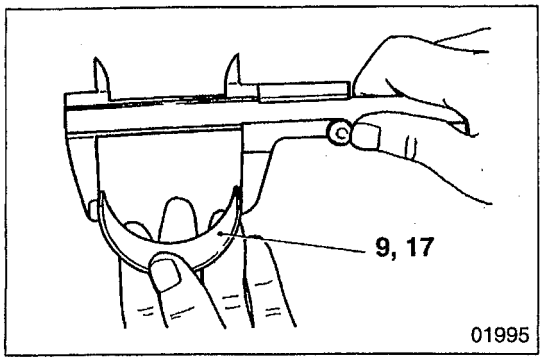
[Installation]

Install the main bearings **9**, **17** such that their lugs **A** fit into the corresponding grooves.

CAUTION

The upper main bearing 17 has an oil hole B. The lower main bearing 9 has no oil hole. Take care not to confuse the upper and lower parts.





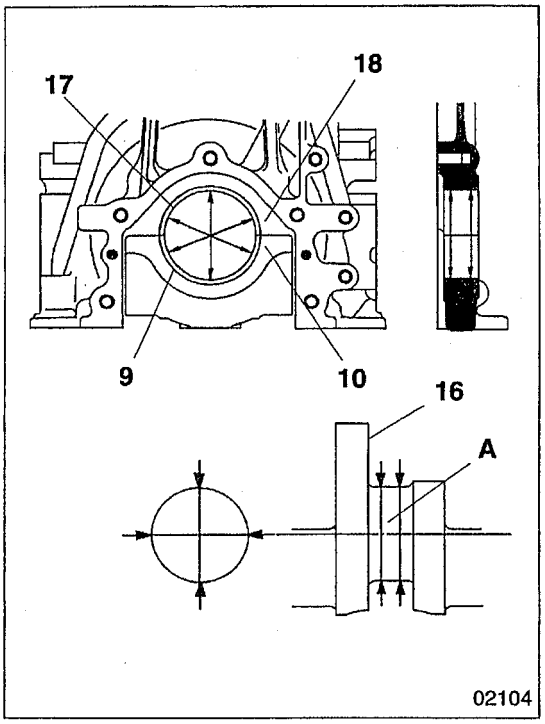
[Inspection]

CAUTION

- **Do not attempt to manually expand either bearing 9, 17 if its span is insufficient.**
- **Upper and lower bearings 9, 17 must be replaced as a set.**

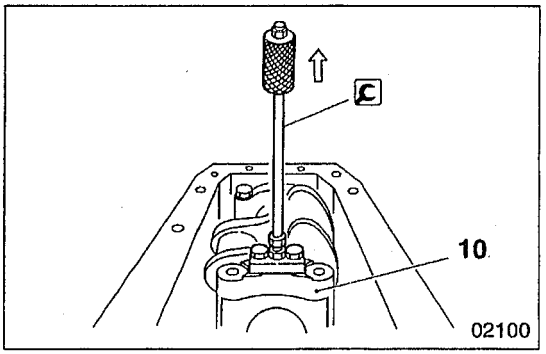
(1) Span when free

If either bearing's span when free exceeds the specified limit, the bearings **9, 17** must be replaced.



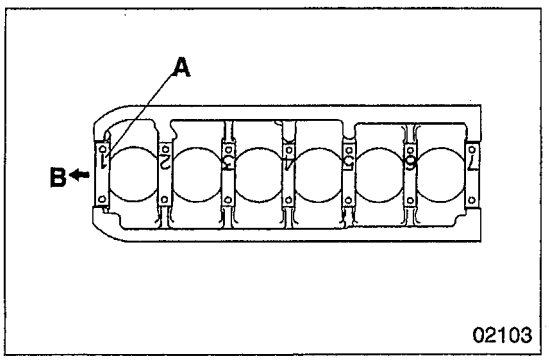
(2) Main bearing-to-crankshaft clearance

- Fit the upper main bearing **17** into the crankcase **18** and the lower main bearing **9** into the main bearing cap **10**. Then, tighten the bolts **8** to their specified torque.
- Measure the internal diameters of the main bearings **9, 17** and the outside diameter **A** of the crankshaft journal. If the clearance exceeds the specified limit, replace the defective part(s).



10 Main bearing caps

[Removal]

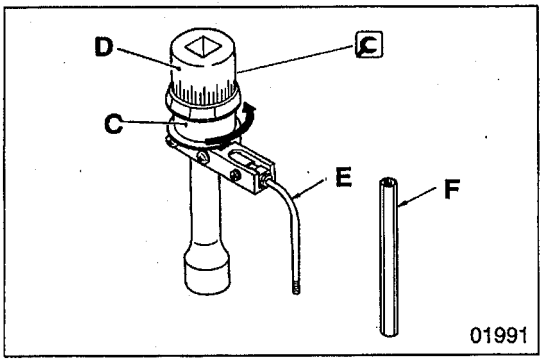


[Installation]

- Starting at the front of the engine **B**, fit the main bearing caps **10** in the order of the numbers **A** embossed on them and such that the numbers are in the positions illustrated.
- The bolts **8** can be reused only three times. Before fitting the bolts, make a punch mark on the head of each bolt to indicate times of reuse.

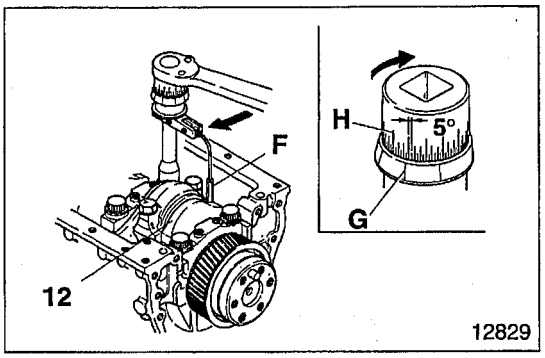
CAUTION

If any bolt already has three punch marks, it must not be reused any more; replace it with a new one.



- Tighten the bolts **8** to the specified torque. Then, turn the bolts further in accordance with the following procedure:
- Turn the holder **C** of the [C] Socket Wrench counter-clockwise to tension the built-in spring.

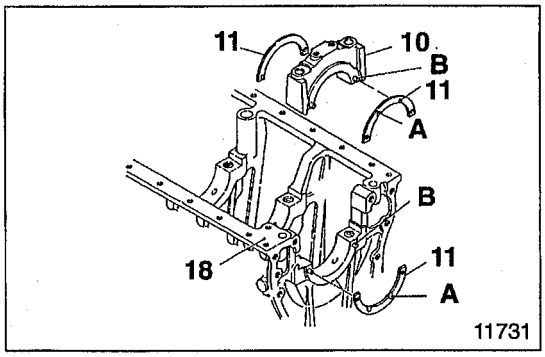
D: Socket
E: Rod
F: Rod (extension)



- Set the socket wrench such that the built-in spring force forces the rod **F** against the crankshaft assembly **12**.
- On the holder **C**, select the inscribed line **G** that is easiest to see.
- Using the selected line as a reference, turn the socket **D** 90° clockwise. (One gradation on the scale **H** represents 5°.)

CAUTION ⚠

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



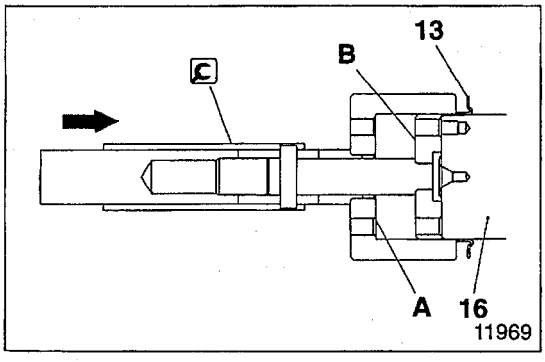
[11] Installing thrust plates

Fit a thrust plate **11** on each side of the main bearing caps **10** and at the rear end of the crankcase **18** such that the oil grooves **A** are on the outside.

B: Locating pin

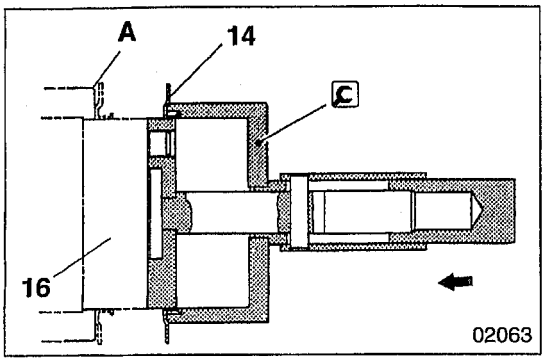
NOTE

If oversize thrust plates 11 are used, they must be fitted on both sides of the bearing caps 10. Ensure that the bearing cap rear thrust plates and the rearmost thrust plate in the crankcase 18 are the same size. Note, however, that the front and rear thrust plates on each bearing cap may be of different sizes.



[13] Installing front oil seal slinger

Using the [C] Front Oil Seal Slinger Installer, drive the front oil seal slinger **13** onto the crankshaft **16** until the tool's end face **A** is pressed firmly against the guide **B**.

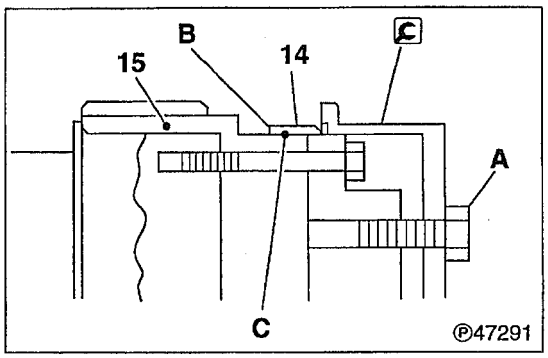


14 Rear oil seal slinger and sleeve

[Installation]

<Models without flywheel PTO>

Using the Rear Oil Seal Slinger Installer, drive the rear oil seal slinger **14** onto the crankshaft **16** until it is pressed firmly against the end face **A** of the crankshaft gear **15**.



<Models with flywheel PTO>

If the outer surface of the sleeve **14** is scratched or grooved, replace the sleeve as follows.

[Removal]

Use a chisel to cut the sleeve **14**, then remove the sleeve from the crankshaft gear **15**.

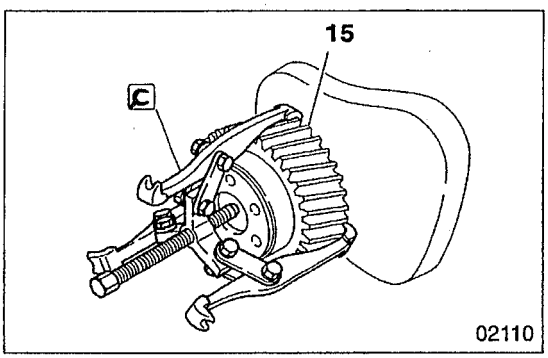
CAUTION

Be careful not to damage the crankshaft gear 15.

[Installation]

With the sleeve **14** set as shown (pay attention to the direction), turn the bolt **A** of the Sleeve Installer as far as it goes. Do not tighten the bolt firmly.

B: White paint
C: Apply engine oil



15 Crankshaft gear

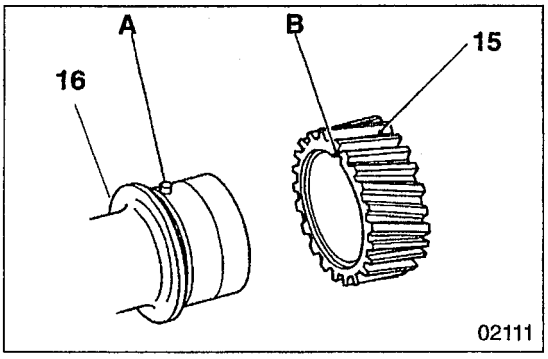
<Models without flywheel PTO>

[Removal]

CAUTION

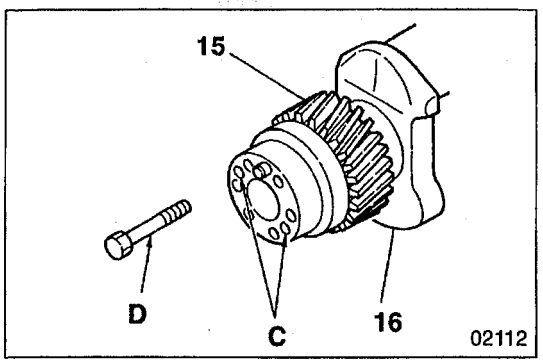
Do not tap off the crankshaft gear 15 since this could damage it.

: Gear Puller



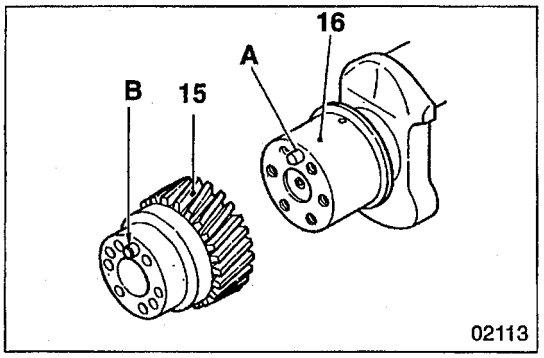
[Installation]

- Using a piston heater or the like, heat the crankshaft gear **15** to a temperature of approximately 100°C.
- Align the locating pin **A** on the crankshaft **16** with the notch **B** in the crankshaft gear **15**. Then, drive the gear into position by striking its end face with a plastic mallet.

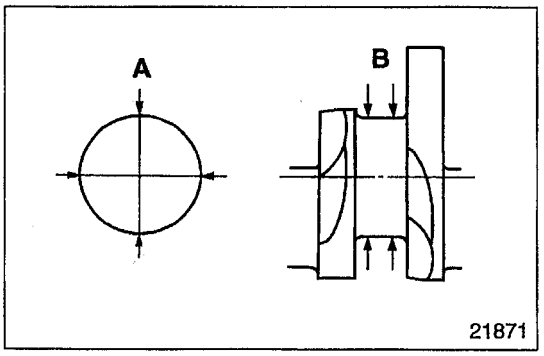


<Models with flywheel PTO>
[Removal]
Screw the flywheel mounting bolts **D** evenly into the threaded removal holes **C** in the crankshaft **16**. Alternatively, remove the crankshaft gear using the [C] Gear Puller.

CAUTION
Do not tap off the crankshaft gear since this could damage it.



[Installation]
- Using a piston heater or the like, heat the crankshaft gear **15** to a temperature of approximately 100°C.
- Align the locating pin **A** on the crankshaft **16** with the dowel pin **B** on the crankshaft gear **15**. Then, drive the gear into position by striking its end face with a plastic mallet.



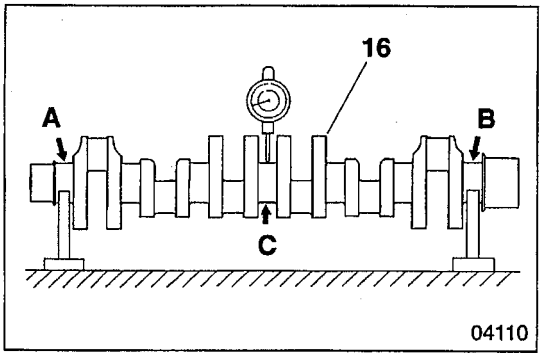
[16] Crankshaft

[Inspection]

(1) Roundness and cylindricity of crankshaft journal and pin

If either measurement exceeds the specified limit, replace the crankshaft **16** or grind it to undersize.

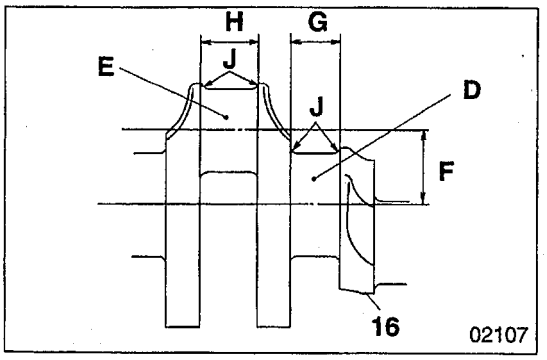
A: Roundness
B: Cylindricity



(2) Bend

- Support the crankshaft **16** at its No. 1 journal **A** and No. 7 journal **B**. Measure the extent of bending in the crankshaft at the centre of the No. 4 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 16 through one revolution. One-half of the dial indicator reading represents the extent of bending.



[Rectification]

NOTE
If the crankshaft 16 is rectified by grinding, the main bearings 9, 17 must be replaced with undersized ones.

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

F: 57.5 $^{+0.025}_{-0.075}$ mm

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

  G: 37 mm
  H: 42 $^{+0.2}_{0}$ mm

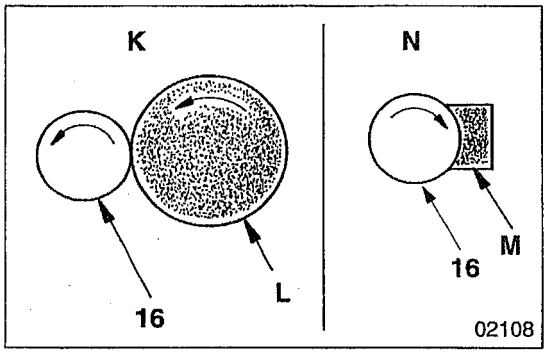
- Finish the corner fillet smoothly and to the specified radius **J**.

  J: R4 ± 0.2 mm

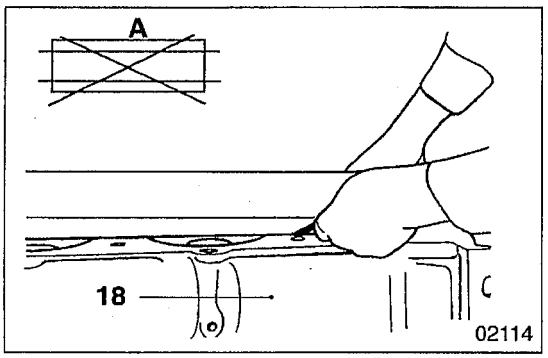
- Carry out a magnetic inspection to check for cracks caused by grinding. Also, check that the Shore hardness of the surface has not dropped below Hs 75.

Crankshaft undersize dimensions — Unit: mm

		Degree of undersize			
		0.25	0.50	0.75	1.00
Finished journal diameter	Except 6D15-T (with dry cylinder liners)	83.685 to 83.705	83.435 to 83.455	83.185 to 83.205	82.935 to 82.955
	6D15-T (with dry cylinder liners)	79.685 to 79.705	79.435 to 79.455	79.185 to 79.205	78.935 to 78.955
Finished pin diameter	Except 6D16-TLE	64.67 to 64.69	64.42 to 64.44	64.17 to 64.19	63.92 to 63.94
	6D16-TLE	69.67 to 69.69	69.42 to 69.44	69.17 to 69.19	68.92 to 68.94
Roundness		0.01 or less			
Cylindricity		0.006 or less			



- When grinding **K**, turn the crankshaft **16** counter-clockwise as viewed from its front end. The grinder **L** should rotate in the same direction.
- When finishing **N** the crankshaft **16** with sandpaper or a whetstone **M**, rotate the crankshaft clockwise.



18 Distortion of crankcase top surface

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

A: Measurement positions

CAUTION ⚠

When grinding the crankcase 18, take care that the piston projections stay within specification.

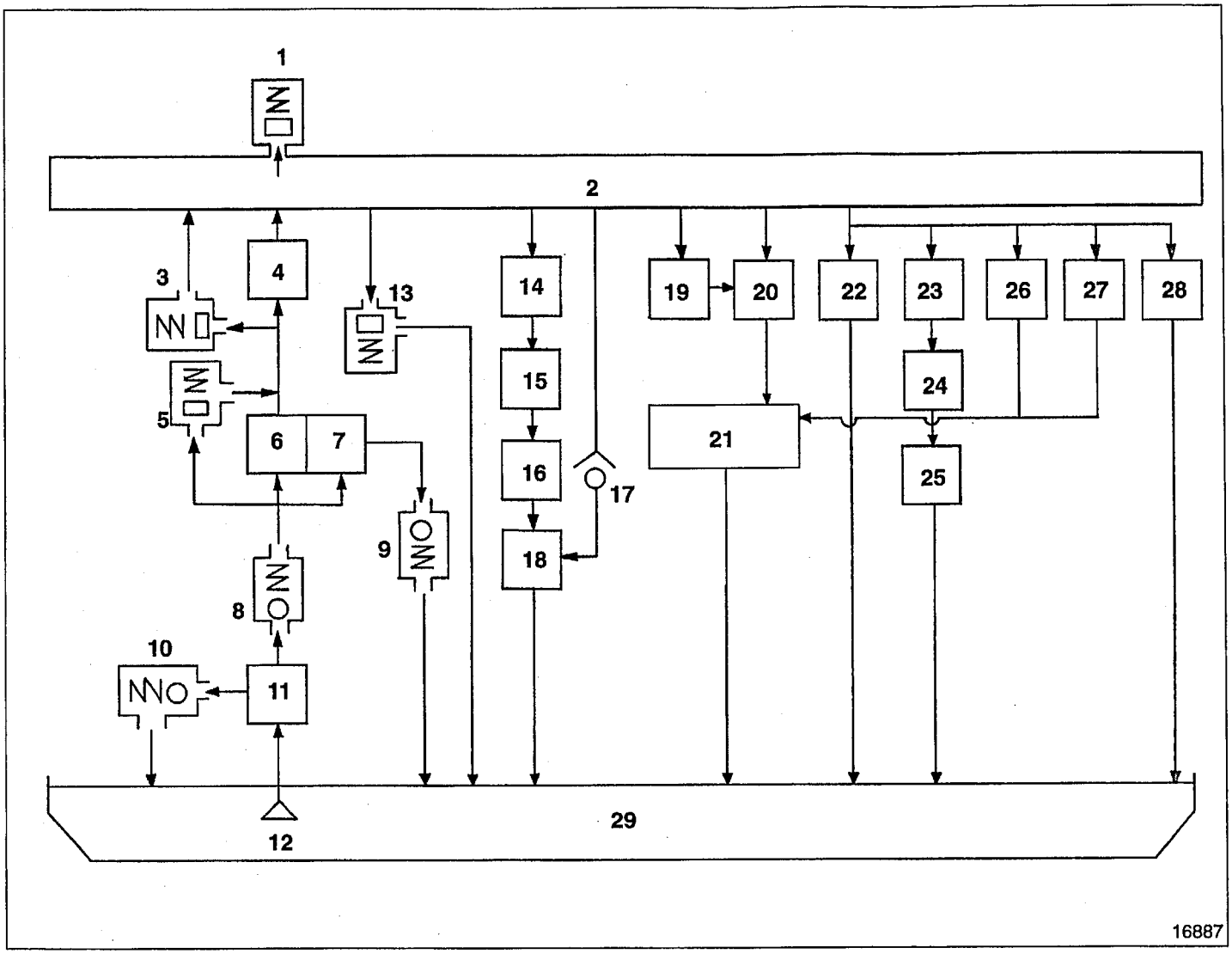
GROUP 12 LUBRICATION

NOTE ; The pages marked "( )" are given,
though they are not applicable to the SK330(N)LC-6E.

SPECIFICATIONS

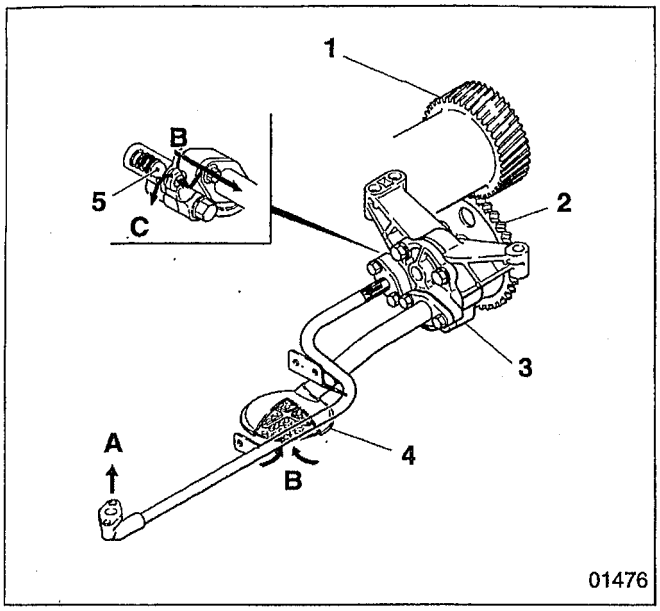
Item			Specifications
Mode of lubrication			Oil pump type
Oil filter type			Spin-on paper-filter type or replaceable-element type
Oil cooler type			Shell and plate type (multi-plate type)
Engine oil			Turbocharged engine: API CD or above
			Non-turbocharged engine: API CC or above
Oil quantity dm^3 {L}	Oil pan	General power applications	Approx. 9.5 {9.5}
		Construction machinery applications	Approx. 16 {16}
	Oil filter	Spin-on type: A, B type	2.1 {2.1}
		Spin-on type: C type, Replaceable-element type	2.3 {2.3}

1. Lubrication System (Oil Flow)



1 Engine oil pressure gauge unit
2 Main oil gallery
3 Bypass valve
4 Oil cooler
5 Engine oil bypass alarm switch
6 Full-flow filter element
7 Bypass filter element
8 Check valve (built into oil filter)
9 Bypass check valve (built into oil filter)
10 Relief valve (built into oil pump)
11 Oil pump
12 Oil strainer
13 Regulator valve
14 Crankshaft main bearing
15 Connecting rod bearing
16 Connecting rod bushing
17 Check valve for oil jet
18 Piston
19 Injection pump
20 Injection pump drive (or air compressor)
21 Timing gears
22 Camshaft bushing
23 Rocker bushing
24 Push rod
25 Tappet
26 Idler gear shaft No. 1
27 Idler gear shaft No. 2
28 Turbocharger <6D14-T, 15-T, 16-T, 16-TL, 16-TLE>
29 Oil pan

2. Oil Pump



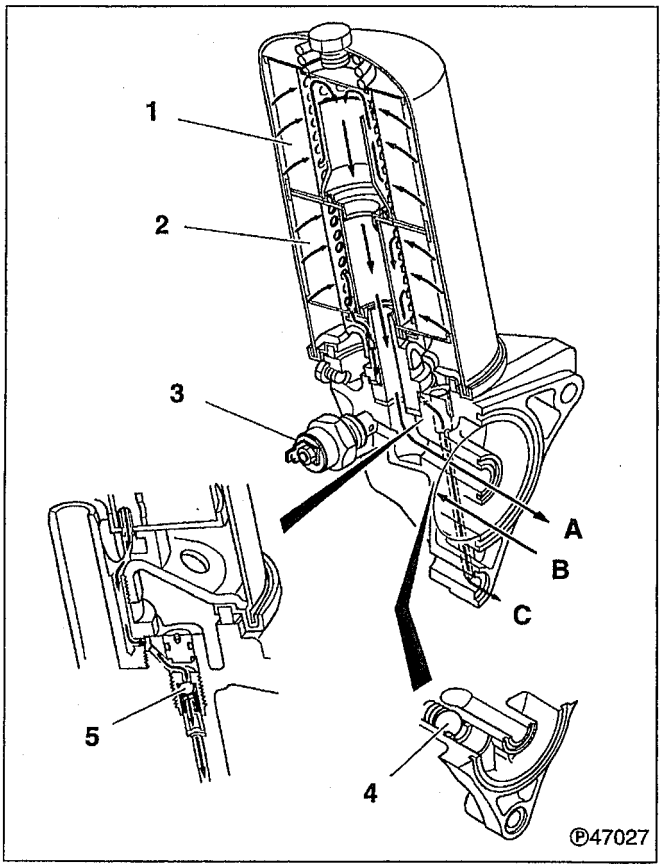
1 Crankshaft gear
2 Oil pump gear
3 Oil pump
4 Oil strainer
5 Relief valve

A: To oil filter
B: From oil pan
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 **5** 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.

3. Oil Filter

<Spin-on type (A, B type)>

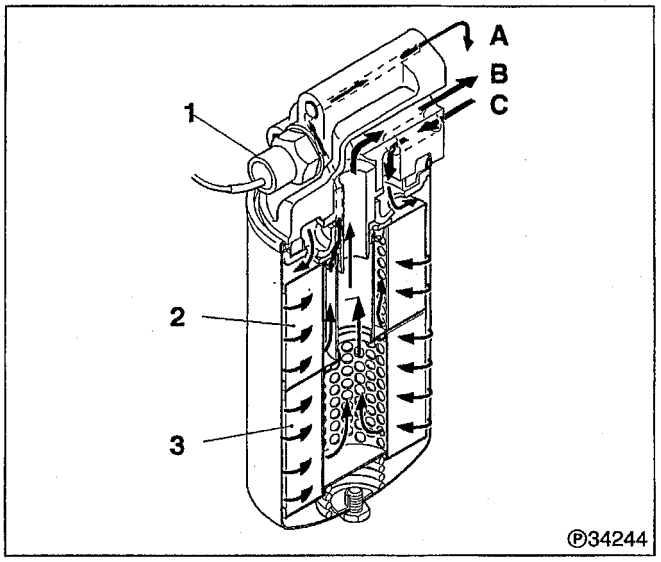


1 Full-flow filter element
2 Bypass filter element
3 Engine oil bypass alarm switch
4 Check valve
5 Bypass check valve

A: To oil cooler
B: From oil pump
C: To oil pan

This oil filter is a spin-on paper-filter type incorporating full-flow filter element **1** and bypass filter element **2**.
Engine oil bypass alarm switch **3** is fitted to the oil filter bracket. If clogging causes the pressure difference before and after the element to exceed a specified level, a valve inside the switch opens to allow oil to flow directly to the oil cooler.
Check valve **4** is fitted to the inlet to prevent a reverse flow of oil out of the filter when the engine is stationary. In conjunction with this, bypass check valve **5** opens only when oil pressure in the bypass arrangement exceeds a specified level. As a result, the oil level in the filter is kept constant and oil reaches all parts of the lubrication system quickly when the engine is started.

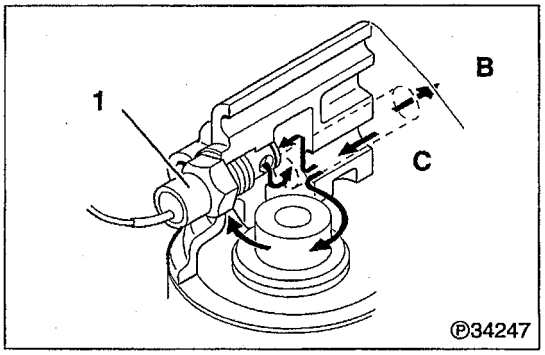
<Spin-on type (C type)>



1 Engine oil bypass alarm switch
2 Bypass filter element
3 Full-flow filter element

A: To oil pan
B: To oil cooler
C: From oil pump

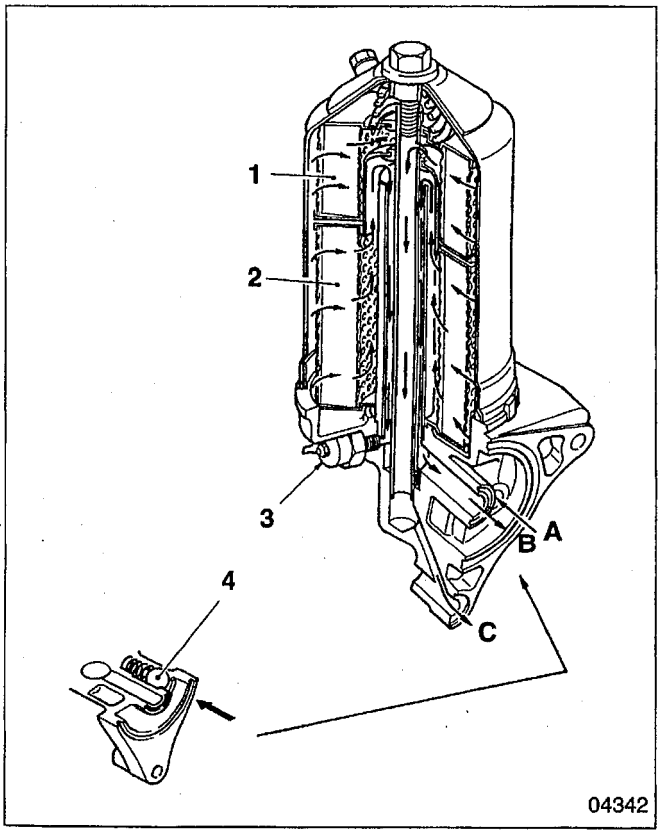
This oil filter is a paper-filter type incorporating full-flow filter element **3** and bypass filter element **2**.



Engine oil bypass alarm switch

- If the oil filter element becomes clogged, the flow of engine oil is restricted, causing engine parts to seize. To prevent this, engine oil bypass alarm switch **1** is fitted to the spin-on filter.
- When the oil filter element becomes clogged, engine oil bypass alarm switch **1** is activated. As a result, engine oil is allowed to flow directly to the oil cooler, bypassing full-flow filter element **3**. When the engine oil bypass alarm switch is activated, a warning lamp illuminates to notify the operator of the clogged oil filter element.

<Replaceable-element type>

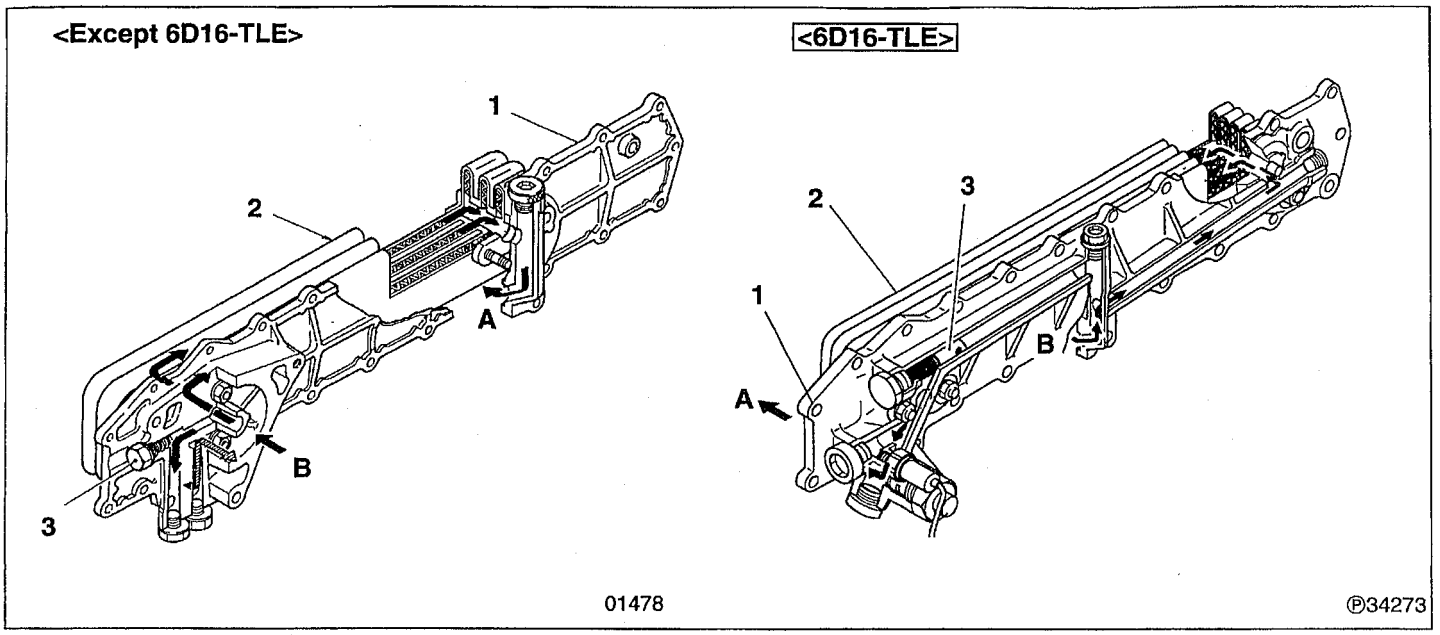


1 Full-flow filter element
2 Bypass filter element
3 Engine oil bypass alarm switch
4 Check valve

A: From oil pump
B: To oil cooler
C: To oil pan

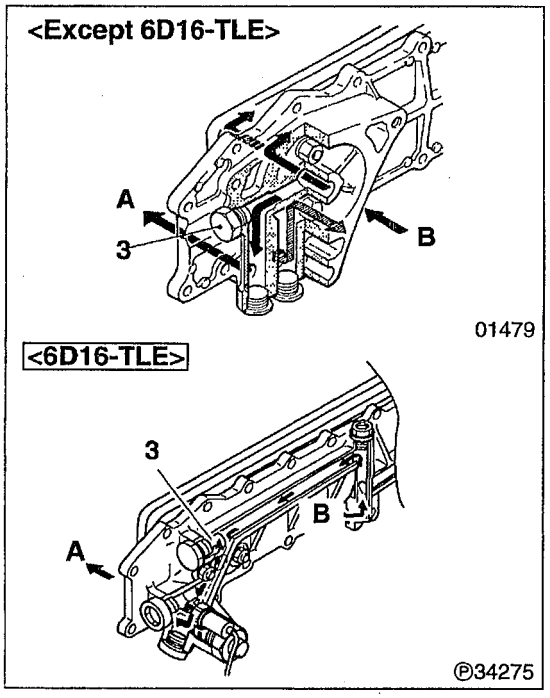
This oil filter is a replaceable-element type incorporating full-flow filter element **1** and bypass filter element **2**.
Engine oil bypass alarm switch **3** is fitted to the oil filter bracket. If clogging causes the pressure difference before and after the element to exceed a specified level, a valve inside the switch opens to allow oil to flow directly to the oil cooler.
Check valve **4** is fitted to the inlet to prevent a reverse flow of oil out of the filter when the engine is stationary. This ensures that the oil level in the filter remains constant such that oil reaches all parts of the lubrication system quickly when the engine is started.

4. Oil Cooler



1 Oil cooler cover
2 Oil cooler element
3 Bypass valve

A: To main oil gallery
B: From oil filter

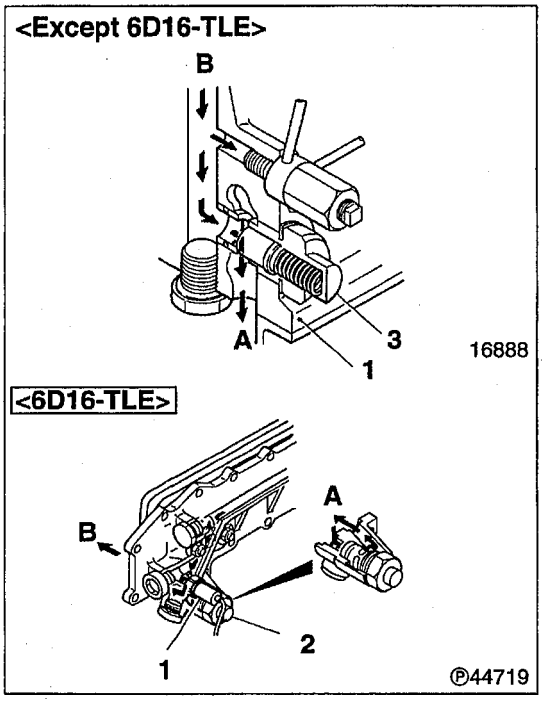


● **Bypass valve**

Bypass valve **3** is fitted to the oil cooler. When engine oil is cool and its viscosity is high, or when the oil cooler element becomes clogged and restricts the flow of engine oil, this valve opens. As a result, engine oil is allowed to flow directly to the main oil gallery, bypassing the oil cooler.

A: To main oil gallery
B: From oil filter

5. Engine Oil Pressure Switch, Regulator Valve



1 Crankcase
2 Engine oil pressure switch
3 Regulator valve

A: To oil pan
B: Main oil gallery

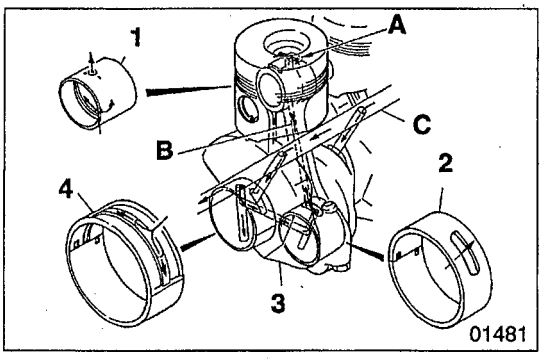
● **Engine oil pressure switch**

If the pressure of engine oil to the main oil gallery drops below a specified level, an electrical contact incorporated in engine oil pressure switch **2** closes. This causes a relevant warning lamp on the meter cluster to illuminate, notifying the operator of the excessive pressure drop.

● **Regulator valve**

If the oil pressure in the main oil gallery exceeds a specified level, regulator valve **3** opens to allow some of the engine oil to return to the oil pan, thereby regulating the oil pressure to specification.

6. Lubrication of Related Parts



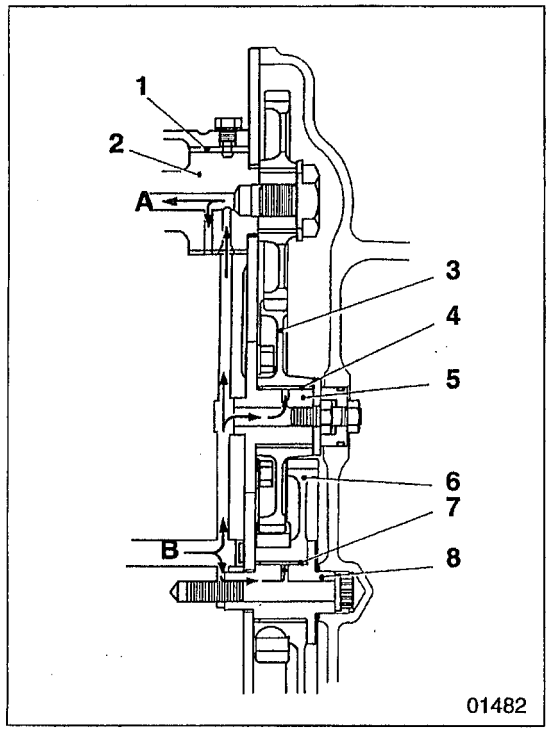
Engine oil fed to the main oil gallery lubricates the following related parts:

● **Main Bearing and Connecting Rod Bearing**

1 Connecting rod bushing
2 Connecting rod bearing
3 Crankshaft
4 Main bearing

A: Oil jet
B: Connecting rod oil passage
C: Main oil gallery

Oil supplied via the oil passage in crankshaft **3** flows through connecting rod oil passage **B** to lubricate the connecting rod's small end. The oil then sprays out of oil jet **A** at the top of the connecting rod to cool the piston.



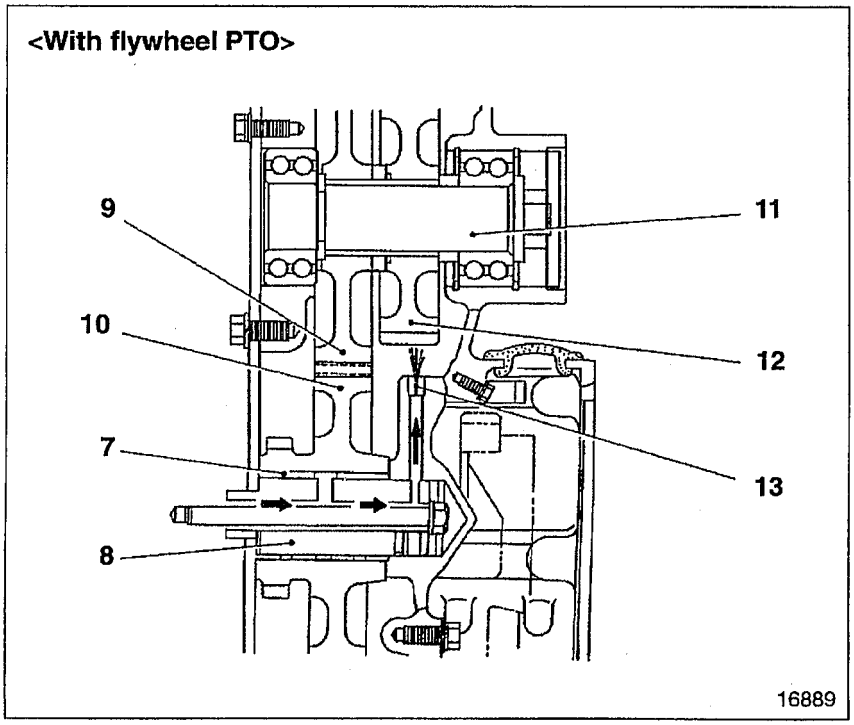
● **Timing gear and camshaft**

1 Camshaft bushing No. 4
2 Camshaft
3 Idler gear No. 2
4 Idler gear bushing
5 Idler shaft No. 2
6 Idler gear No. 1
7 Idler gear bushing
8 Idler gear shaft No. 1

A: To rocker bushing
B: From main oil gallery

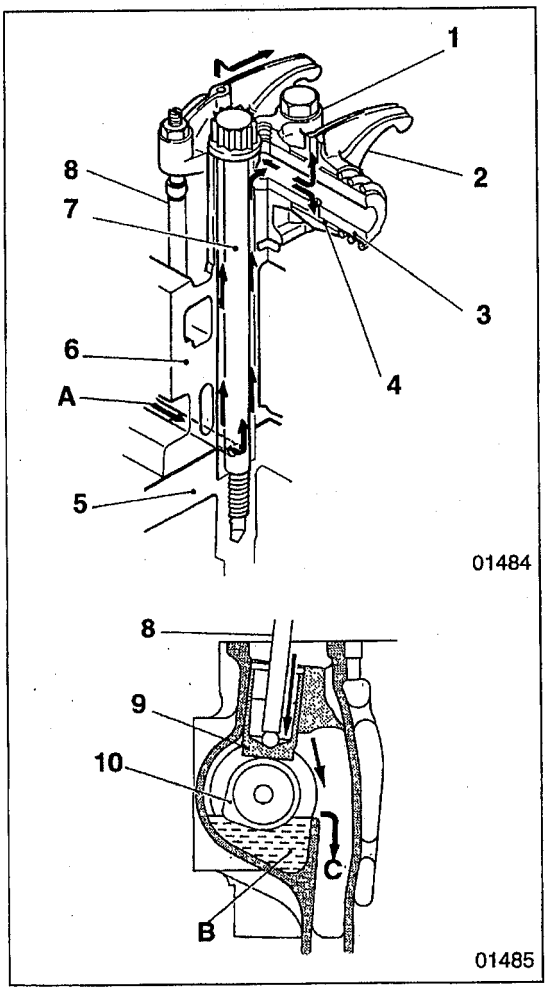
Engine oil flows through the inside of camshaft **2** and lubricates each camshaft bushing.

<With flywheel PTO>



If a flywheel power take-off (PTO) is fitted, oil flows through an oil passage in the flywheel housing and sprays out of the oil jet to lubricate PTO idler gear B **12**.

9 PTO idler gear A
10 Idler No. 1
11 PTO idler shaft
12 PTO idler gear B
13 Oil jet

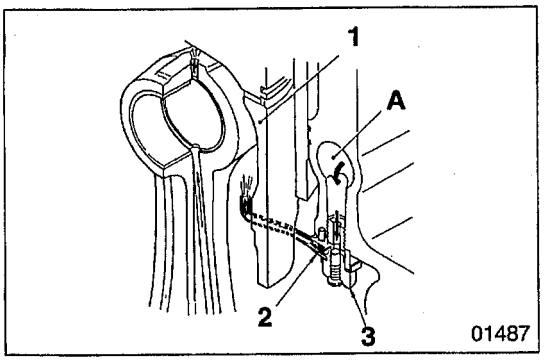


● **Valve mechanism**

1 Rocker shaft bracket
2 Rocker
3 Rocker shaft
4 Rocker bushing
5 Crankcase
6 Cylinder head
7 Cylinder head bolt
8 Push rod
9 Tappet
10 Camshaft

A: From camshaft bushing No. 4
B: Oil reservoir
C: To oil pan

After lubricating rocker **2**, the camshaft bushings, and other components, oil enters oil reservoir **B** to lubricate the cams.

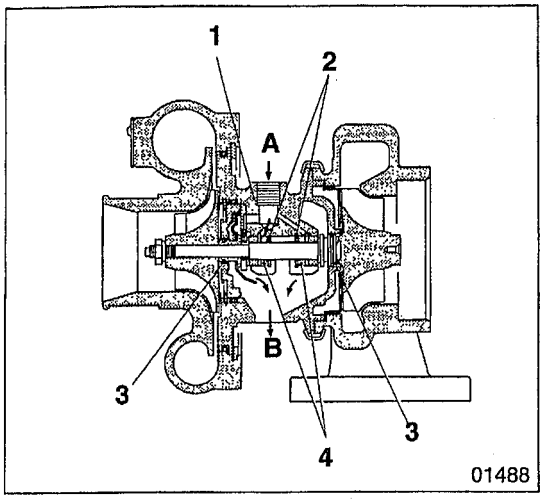


● **Check valve and oil jet**

1 Piston
2 Oil jet
3 Check valve

A: Main oil gallery

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

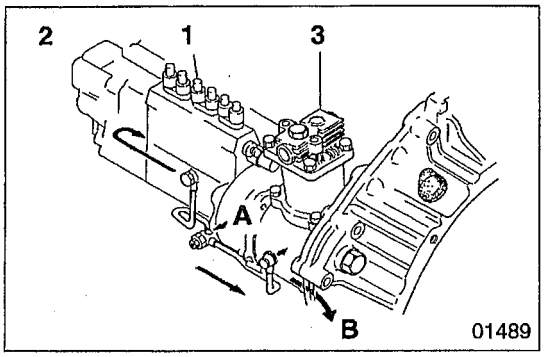


● **Turbocharger <6D14-T, 15-T, 16-T, 16-TE, 16-TL, 16-TLE>**

1 Bearing housing
2 Snap ring
3 Piston ring
4 Bearing

A: From main oil gallery
B: To oil pan

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

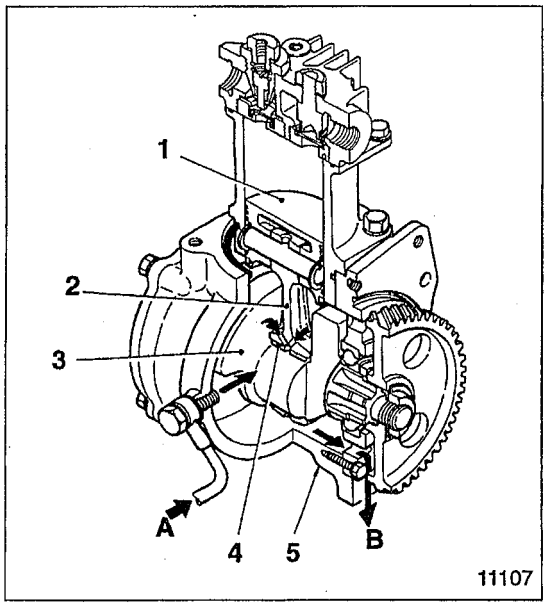


● **Injection pump**

1 Injection pump
2 Governor
3 Air compressor (or injection pump drive)

A: From main oil gallery
B: To oil pan

Engine oil that has lubricated injection pump **1** and governor **2** returns to the oil pan via the timer case, air compressor **3** (or injection pump drive), and timing gear train.

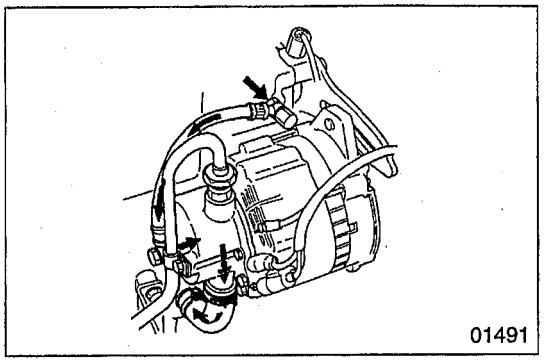


● **Air compressor**

1 Piston
2 Connecting rod
3 Crankshaft
4 Connecting rod bushing
5 Crankcase

A: From main oil gallery
B: To oil pan

Engine oil from the main oil gallery splashes onto connecting rod **2** and lubricates connecting rod bushing **4**. Piston **1** and the connecting rod's small end are lubricated by oil that is splashed onto them by the rotation of the crankshaft **3**.



● **Vacuum pump**

Some of the oil used to lubricate the camshaft bushings is fed to the vacuum pump housing via a flexible hose. After lubricating the vacuum pump vanes, this oil leaves via an outlet at the bottom of the housing and returns to the oil pan.

Possible causes \ Symptoms		Engine hard to start	Overheating	Low oil pressure	Excessive oil consumption (oil leakage)	Remarks
Oil cooler	Oil cooler element installed poorly		○	○	○	
	Gasket defective		○	○	○	
	O-ring defective		○	○	○	
	Oil cooler element clogged		○	○		
	Oil cooler element damaged		○	○	○	
	Fatigue in bypass valve spring		○			
Oil pump	Oil pump malfunctioning		○	○		
	Interference between oil pump gear and oil pump case or cover	○		○		
	Oil pipe poorly fitted		○	○		
	Oil strainer clogged		○	○		
	Fatigue in relief valve spring			○		
Oil filter	Oil filter fitted poorly				○	
	Element clogged		○	○		
	Fatigue in check valve and bypass check valve springs <A, B type>			○		
	O-ring defective			○		
Front cover assembly timing gear case	Front oil seal defective				○	🕮 Gr 11
	Front cover assembly fitted poorly				○	🕮 Gr 11
Flywheel housing	Rear oil seal defective				○	🕮 Gr 11
	Gasket fitted poorly				○	🕮 Gr 11
Fatigue in regulator valve spring				○		
Piston cooling oil jet(s) defective			○			
Oil working its way up into combustion chamber(s)					○	🕮 Gr 11
Oil working its way down into combustion chamber(s)					○	🕮 Gr 11
Oil viscosity too high		○				
Unsuitable oil quality			○			
Deterioration in oil			○			
Fuel mixed with oil			○			

1. Oil Filter Replacement

<Spin-on type>

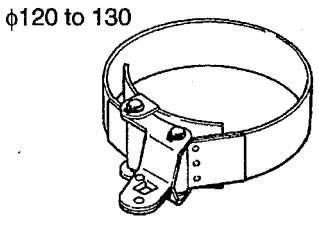
❶ Tightening torques

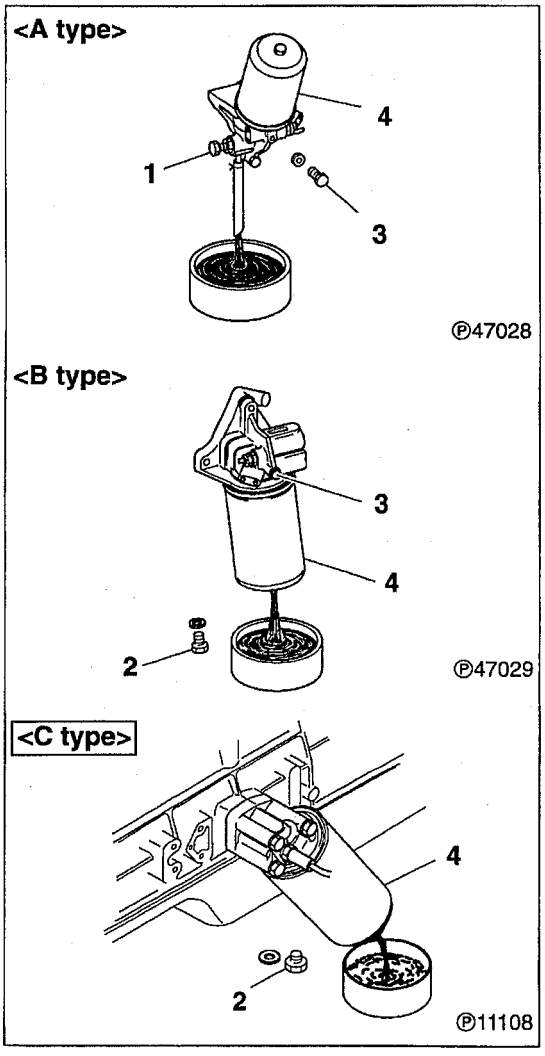
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Oil filter drain valve <A type>	29 ± 4.9 {3 ± 0.5}	—
2	Oil filter drain plug <B, C type>	7.8 ± 2.0 {0.8 ± 0.2}	—

[C] Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
4	Oil Filter Wrench  01503	MH061537	Oil filter removal



WARNING ⚠

- **Wipe up any spilled engine oil since it can cause a fire.**
- **Do not touch oil when the engine is hot since it can inflict severe burns.**

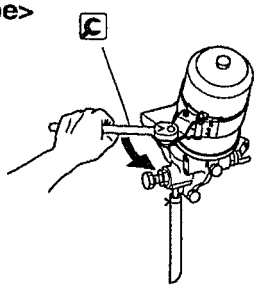
CAUTION ⚠

When pouring oil into the engine, take care not to spill any on the V-belts. Contact with oil could make the V-belts slip, rendering the cooling system less effective.

For type A or type B oil filter, loosen drain plug **1** or oil filter drain plug **2** and air plug **3** in that order, then drain the oil out of filter **4**.

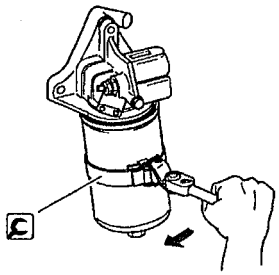
ON-VEHICLE INSPECTION AND ADJUSTMENT

<A type>



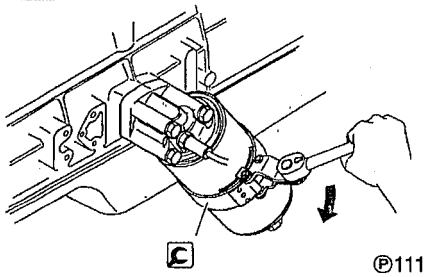
Ⓟ47030

<B type>



Ⓟ47031

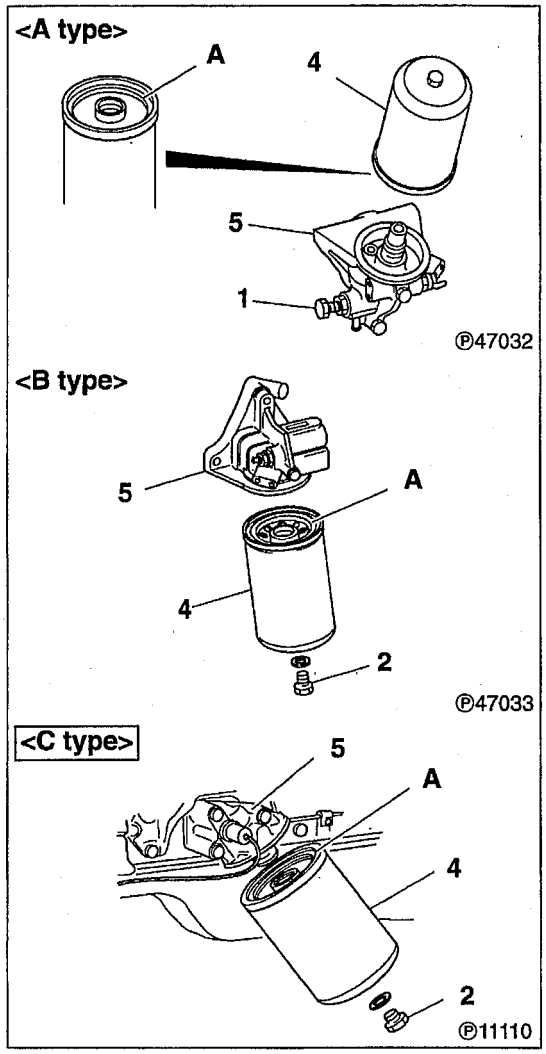
<C type>



Ⓟ11109

[Removal]

: Oil Filter Wrench



[Installation]

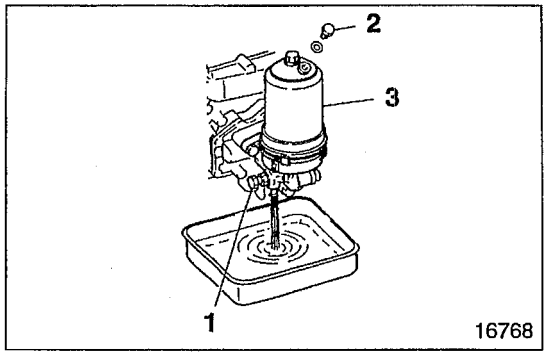
- Clean the surface on oil filter head **5** that makes contact with oil filter **4**.
- Apply a film of engine oil to gasket area **A** of filter **4**.
- Screw oil filter **4** into oil filter head **5** until gasket area **A** touches the oil filter head.
- From this position, tighten filter **3** by a further $1^1/_8$ to $1^3/_8$ of a turn.
- Fit oil filter drain valve **1** or oil filter drain plug **2**.
- Start the engine and check that no oil leaks from gasket area **A**.
- Check the engine oil level and add oil if necessary.

<Replaceable-element type>

ⓜ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Oil filter drain valve	29 ± 4.9 {3.0 ± 0.5}	—
4	Center bolt	54 ± 4.9 {5.5 ± 0.5}	—



WARNING ⚠

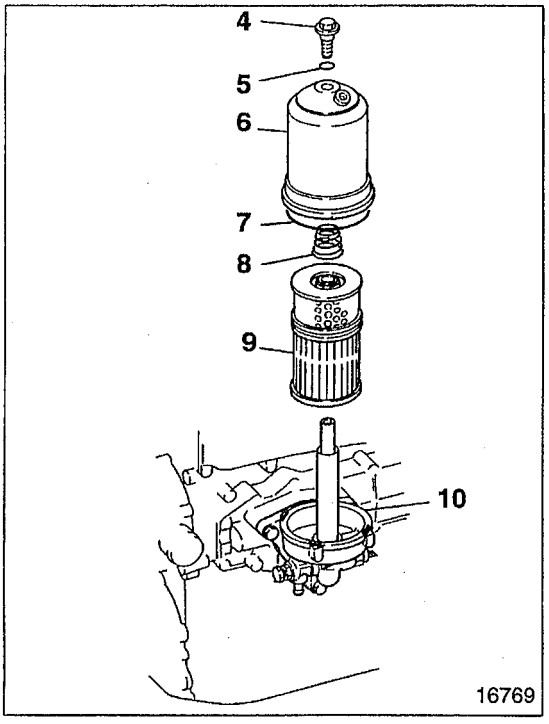
- **Wipe up any spilled engine oil since it can cause a fire.**
- **Do not touch oil when the engine is hot since it can inflict severe burns.**

CAUTION ⚠

When pouring oil into the engine, take care not to spill any on the V-belts. Contact with oil could make the V-belts slip, rendering the cooling system less effective.

With a downward-facing oil filter, loosen drain valve plug 1 and air plug 2 in that order, then drain the oil out of filter 3.

[Removal]



4 Center bolt
5 O-ring
6 Filter case
7 O-ring
8 Set spring
9 Element
10 Filter bracket

[Installation]

Wash all components other than the element in cleaning solvent, then fit the filter in the opposite order from that in which it was removed.

CAUTION ⚠

- **If O-ring 7 is twisted when fitted, it may be severed.**
- **Element 9 cannot be washed and reused.**

2. Engine Oil Replacement

❶ Tightening torques

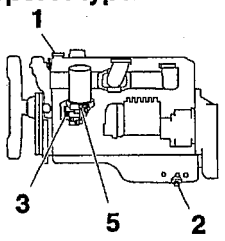
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Oil pan drain plug	69 {7}	—
3	Oil filter drain valve	29 ± 4.9 {3 ± 0.5}	—
4	Oil filter drain plug	7.8 ± 2.0 {0.8 ± 0.2}	—

Lubricants

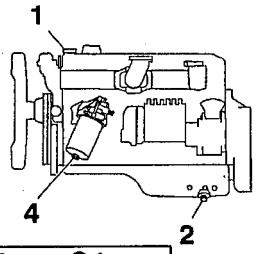
Location	Points of application		Kinds	Quantity
—	Oil pan dm^3 {L}	General power applications	Non-turbocharged engines: API CC or above Turbocharged engines: API CD or above	Approx. 9.5 {9.5}
		Construction machinery applications		Approx. 16 {16}
—	Oil filter dm^3 {L}	Spin-on type: A, B type	Non-turbocharged engines: API CC or above Turbocharged engines: API CD or above	Approx. 2.1 {2.1}
		Spin-on type: C type Replaceable-element type		Approx. 2.3 {2.3}

<Spin-on type: A type>



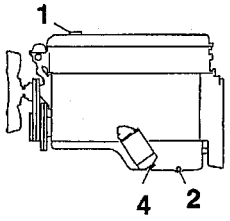
Ⓟ16770

<Spin-on type: B type>



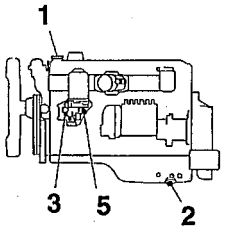
Ⓟ47034

<Spin-on type: C type>



Ⓟ47096

<Replaceable-element type>



Ⓟ16772

WARNING ⚠

- **Wipe up any spilled engine oil since it can cause a fire.**
- **Do not touch oil when the engine is hot since it can inflict severe burns.**

CAUTION ⚠

When pouring oil into the engine, take care not to spill any on the V-belts. Contact with oil could make the V-belts slip, rendering the cooling system less effective.

[Draining]

- Warm up the engine, then remove oil filler cap **1**.
- Remove oil pan drain plug **2**, oil filter drain valve **3** or oil filter drain plug **4**, and air plug **5**. Then, drain the engine oil.

[Filling]

Tighten oil pan drain plug **2** and oil filter drain valve **3** or oil filter drain plug **4** to their specified torques, then pour the specified quantity of engine oil into the engine.

3. Oil Pressure Measurement

<Except 6D16-TLE>

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
—	Oil pressure (at oil temperature 70 to 90°C)	At no-load minimum speed	0.1 MPa {1.0 kgf/cm^2} or higher	Up to 0.1 MPa {1.0 kgf/cm^2}	Adjust
		At no-load maximum speed	0.2 to 0.6 MPa {2.0 to 6.1 kgf/cm^2}	Up to 0.2 MPa {2.0 kgf/cm^2}	

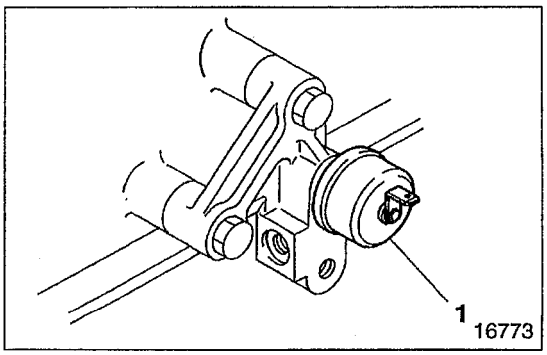
❶ Tightening torque

Unit: N·m {kgf·m}

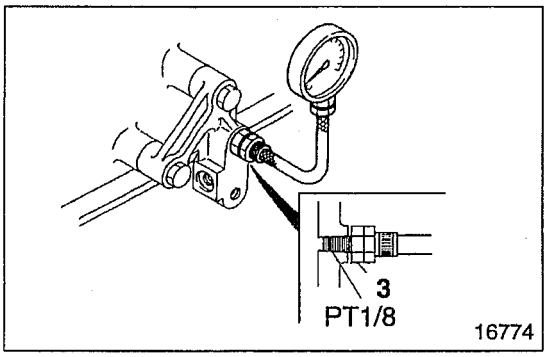
Location	Parts to be tightened	Tightening torque	Remarks
1	Engine oil pressure gauge unit	15 to 22 {1.5 to 2.2}	Check with engine cold

Sealant

Location	Points of application	Specified sealant	Quantity
1	Wrap around thread of engine oil pressure gauge unit	Teflon tape	3 1/2 turns



- Remove engine oil pressure gauge unit **1**.



- Fit adapter **3** onto the engine oil pressure gauge unit mounting, then fit the oil pressure gauge onto the adapter.
- Warm up the engine until the oil temperature reaches 70 to 90°C.
- Measure the oil pressure at no-load minimum speed and at no-load maximum speed. If the measured values are below the specified standard values, overhaul the lubrication system.
- After taking measurements, fit oil pressure gauge unit **1** and tighten it to the specified torque.

NOTE

Oil pressure gauge unit 1 must be fitted with the engine cold.

<6D16-TLE>

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
—	Oil pressure (at oil temperature 70 to 90°C)	At no-load minimum speed	0.1 MPa {1.0 kgf/cm^2} or higher	Up to 0.1 MPa {1.0 kgf/cm^2}	Adjust
		At no-load maximum speed	0.2 to 0.6 MPa {2.0 to 6.1 kgf/cm^2}	Up to 0.2 MPa {2.0 kgf/cm^2}	Adjust

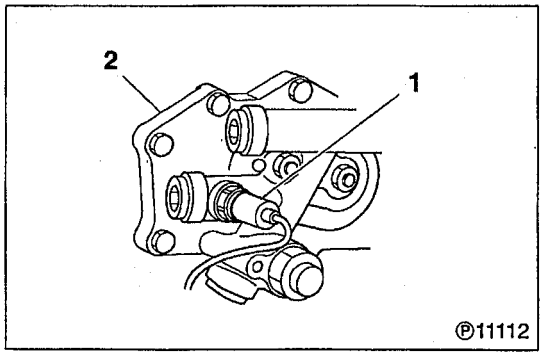
ⓣ Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Engine oil pressure switch	15 to 22 {1.5 to 2.2}	Tighten with engine cold

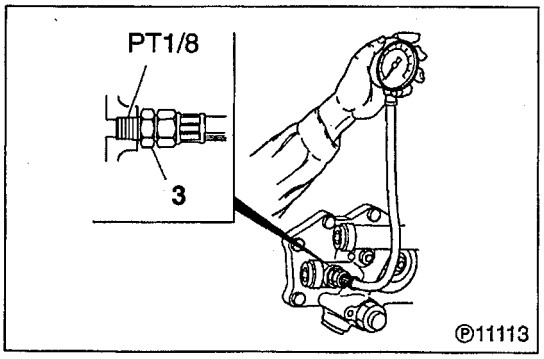
Sealant

Location	Points of application	Specified sealant	Quantity
1	Wrap around thread of engine oil pressure switch	Teflon tape	3 1/2 turns



- Remove engine oil pressure switch **1**.

2: Oil cooler

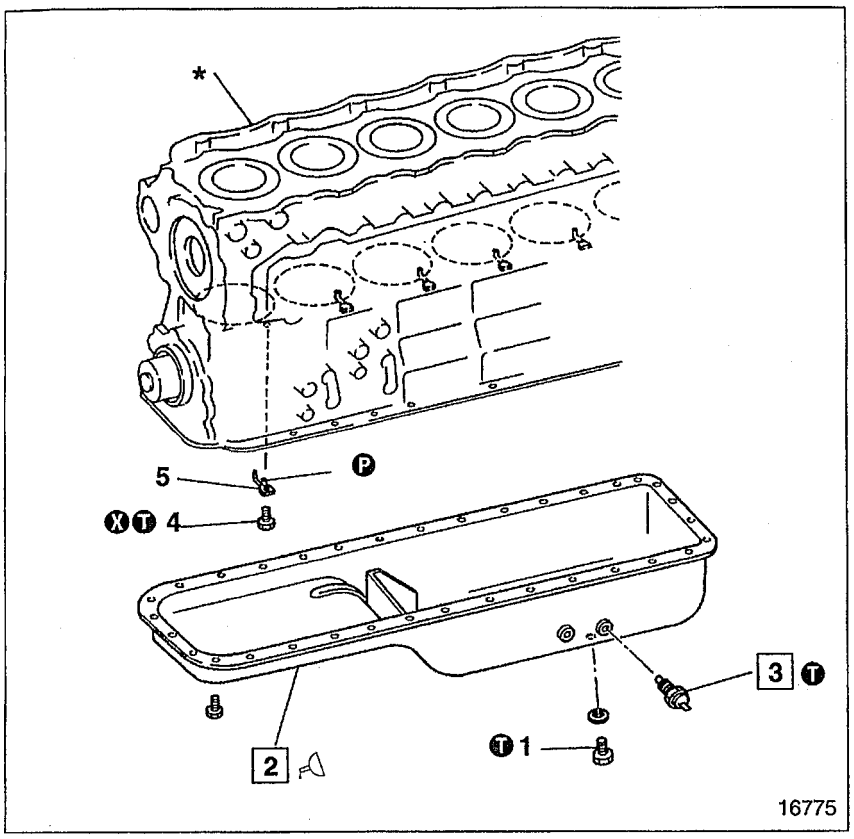


- Fit adapter **3** into the opening from which the engine oil pressure switch has been removed. Install an oil pressure gauge onto the adapter.
- Run the engine until oil temperature reaches 70 – 90°C.
- Measure the oil pressure at both no-load minimum and maximum speeds. If either of the measured values is below the limit pressures, overhaul the lubrication system.
- Fit engine oil pressure switch **1** and tighten it to the specified torque.

NOTE

Installation of engine oil pressure switch 1 must be performed while the engine is cold.

OIL PAN, OIL JET, AND OIL LEVEL SENSOR



● **Disassembly sequence**

1 Drain plug
2 Oil pan
3 Engine oil temperature sensor
4 Check valve
5 Oil jet

*: Crankcase assembly 🕮 Gr 11
P: Locating pin
X: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

CAUTION ⚠

Do not tighten check valve 4 in excess of the specified torque. Excessive tightness can cause defective operation, resulting in scorching of the engine.

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
3	Resistance of engine oil temperature sensor (between ternimal ① and body)	50°C	(136 Ω)	—	Replace
		80°C	48 ± 5 Ω	—	
		100°C	27.2 ± 2 Ω	—	

Figures in parentheses are approximate.

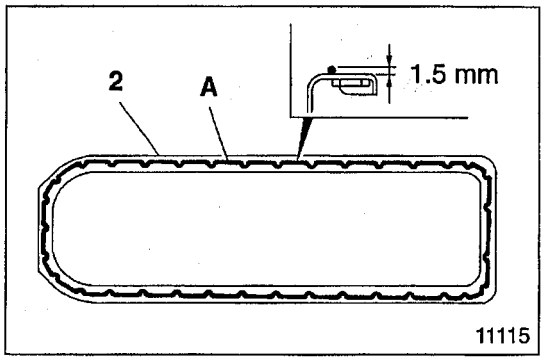
T Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Drain plug	69 {7}	—
3	Engine oil temperature sensor	34 ± 6.9 {3.5 ± 0.7}	—
4	Check valve	34 {3.5}	—

Sealant

Location	Points of application	Specified sealant	Quantity
2	Crankcase mounting surface of oil pan	THREEBOND 1207C	As required



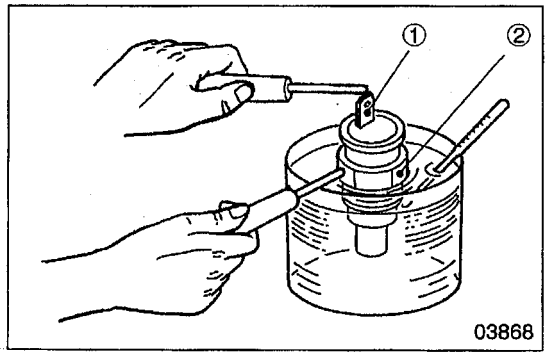
◆ Service procedure

2 Fitting oil pan

- Apply sealant **A** to the mounting surface of oil pan **2** as illustrated. Apply the sealant evenly and without breaks.
- Within three minutes of applying sealant **A**, fit oil pan **2** onto the crankcase*.

CAUTION ⚠

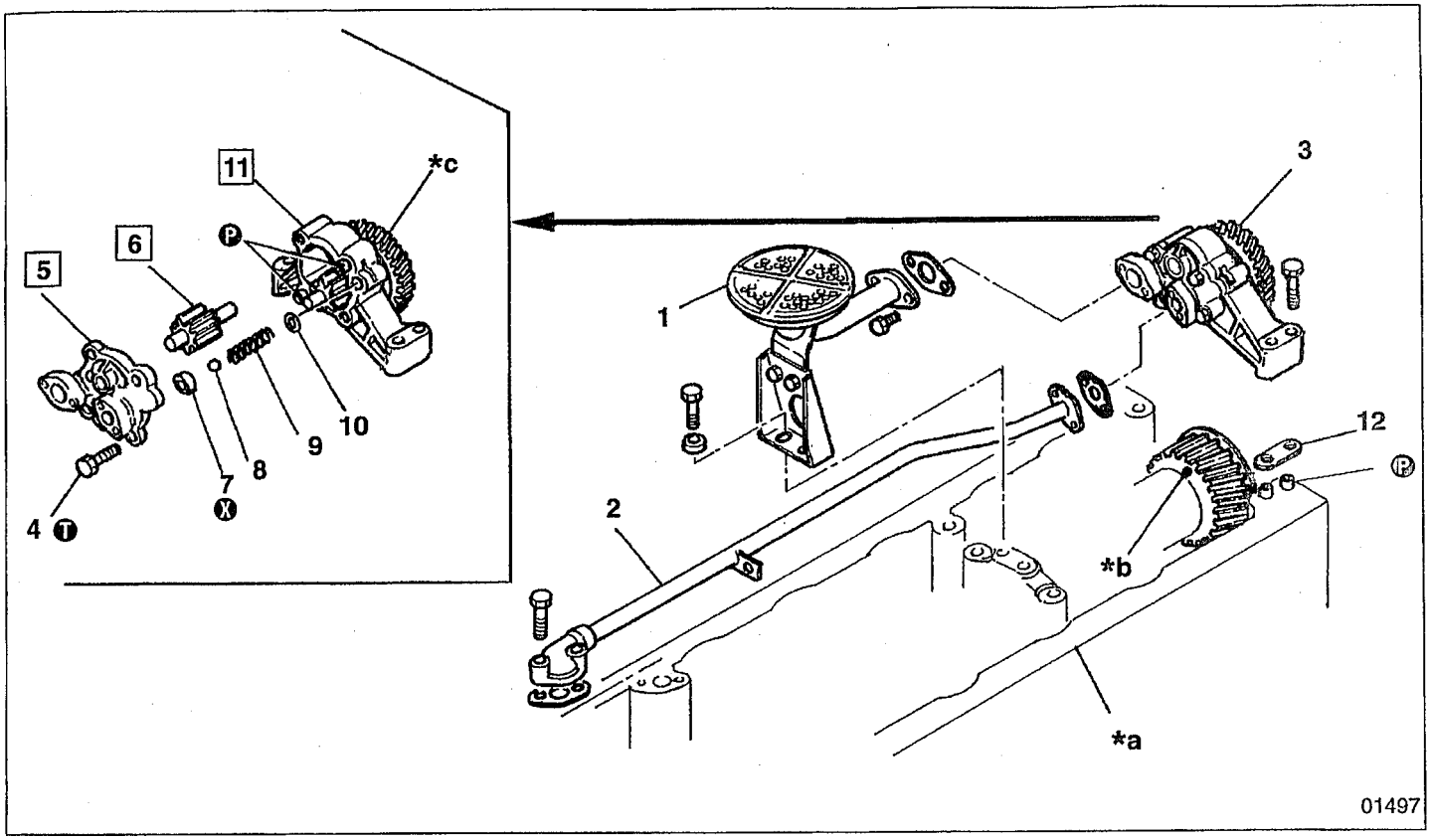
- **Clean the oil pan mounting surface and ensure it is free of oily substances before applying sealant A.**
- **Carefully mount oil pan 2 exactly in the correct position. Ensure that sealant A does not spread to other areas.**
- **After fitting oil pan 2, wait at least one hour before starting the engine.**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



3 Engine oil temperature sensor

- Place engine oil temperature sensor **3** in a container of engine oil.
- Heat the engine oil until it reaches each of the temperatures in the service standards table.
- At each of the given temperatures, measure the electrical resistance between the engine oil temperature sensor's terminal ① and body ②.
- If the resistance values do not match those in the service standards table, replace the engine oil temperature sensor **3**.

OIL PUMP AND OIL STRAINER



● **Inspection before disassembly**

📖 P.12-23

● **Disassembly sequence**

1 Oil strainer
2 Oil pipe
3 Oil pump assembly
4 Bolt
5 Cover
6 Driven gear assembly
7 Ring
8 Relief valve
9 Relief valve spring
10 Washer
11 Gear and case assembly
12 Shim

***a**: Crankcase assembly 📖 Gr 11
***b**: Crankshaft gear 📖 Gr 11
***c**: Oil pump gear

Ⓟ: Locating pin
Ⓧ: Non-reusable part

NOTE

- **Do not remove parts #7 to 10 unless they are defective.**
- **Gear and case assembly 11 is an integrated unit and cannot be disassembled. If any defect is apparent, replace the whole unit.**
- **Do not remove oil strainer 1 and oil pipe 2 from oil pump assembly 3 unless they are defective. Remove those three as a unit.**

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

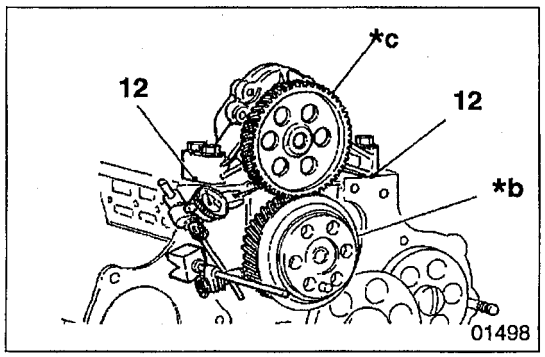
Unit: mm

Location	Maintenance item	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
5, 11	Clearance between drive gear shaft and inner diameter of cover		[20] 0.04 to 0.07	0.15	Replace
5, 6, 11	Clearance between driven gear shaft and inner diameter of case and cover		[20] 0.04 to 0.07	0.15	Replace
6, 11	Clearance between case and tooth tips of each gear		0.10 to 0.19	0.2	Replace
	Difference between height of each gear and depth of case		0.06 to 0.11	0.15	
8	Relief valve opening pressure		980 to 1175 kPa {10 to 12 kgf/cm^2}	—	Replace
9	Relief valve spring load (installed length = 30)		84 N {8.6 kgf}	—	Replace
*b, *c	Backlash between oil pump gear and crankshaft gear	Without PTO	0.08 to 0.18	0.35	Adjust with shims
		With PTO	0.10 to 0.22		

❶ Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
4	Oil pump cover mounting bolt	25 ± 4.9 {2.5 ± 0.5}	—



◆ Service procedure

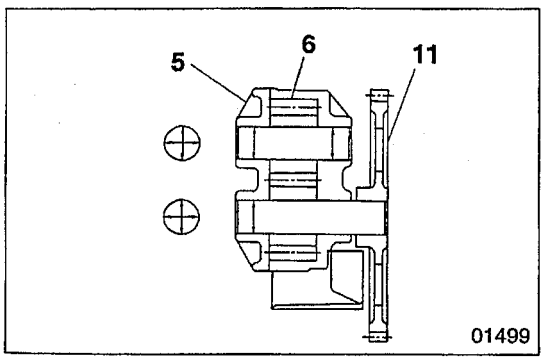
● Inspection before disassembly

Measure the backlash between oil pump gear ***c** and crankshaft gear ***b**. If the amount of backlash exceeds the specified limit, adjust it with shims **12**.

Shim thickness	Change in amount of backlash
0.1 mm	0.073 mm
0.2 mm	0.146 mm

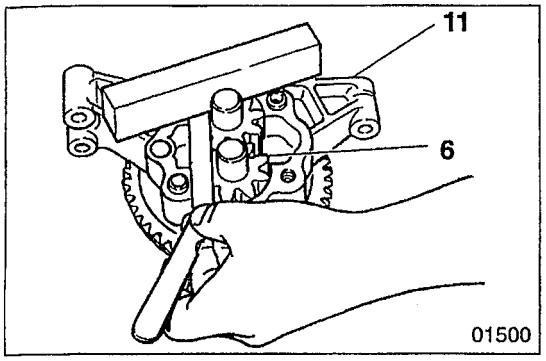
NOTE

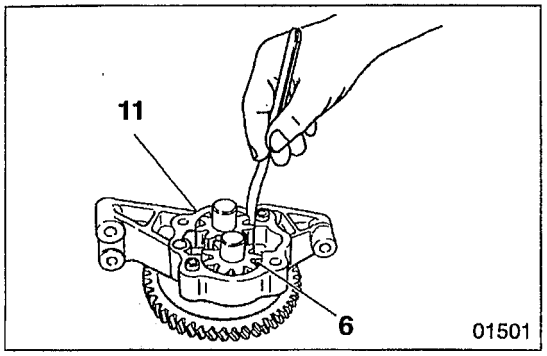
Shim 12 must have the same thickness on the left and right sides.



[5] [6] [11] Inspection of cover, driven gear assembly, and gear and case assembly

Measure the clearance between each gear shaft and the internal diameters of the cover and case.





[6] [11] Inspection of driven gear assembly and of gear and case assembly

(1) Differences between gear heights and case depth

Replace any component whose measurement is out of specification.

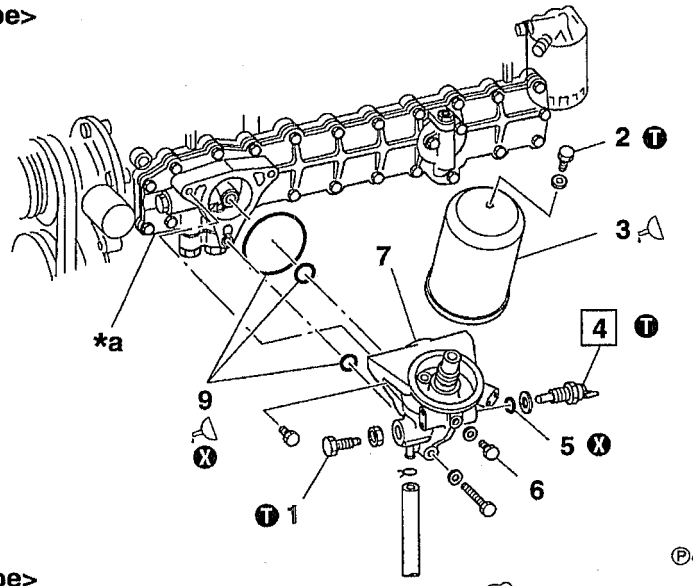
(2) Clearance between gear teeth and case

Replace any component whose measurement is out of specification.

MEMO

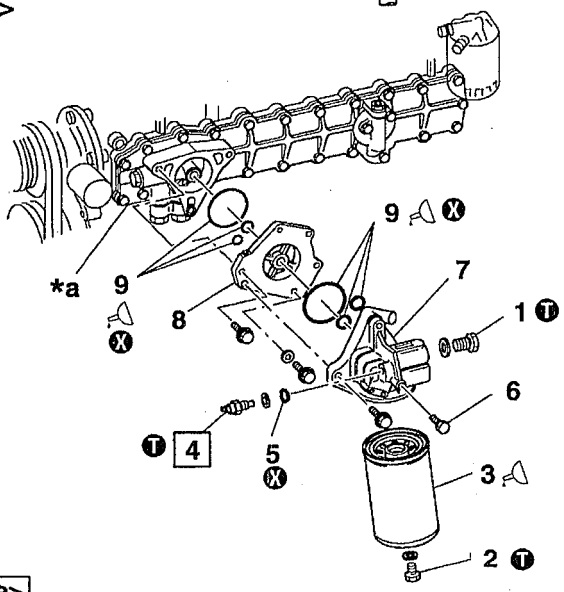
OIL FILTER <Spin-on Type>

<A type>



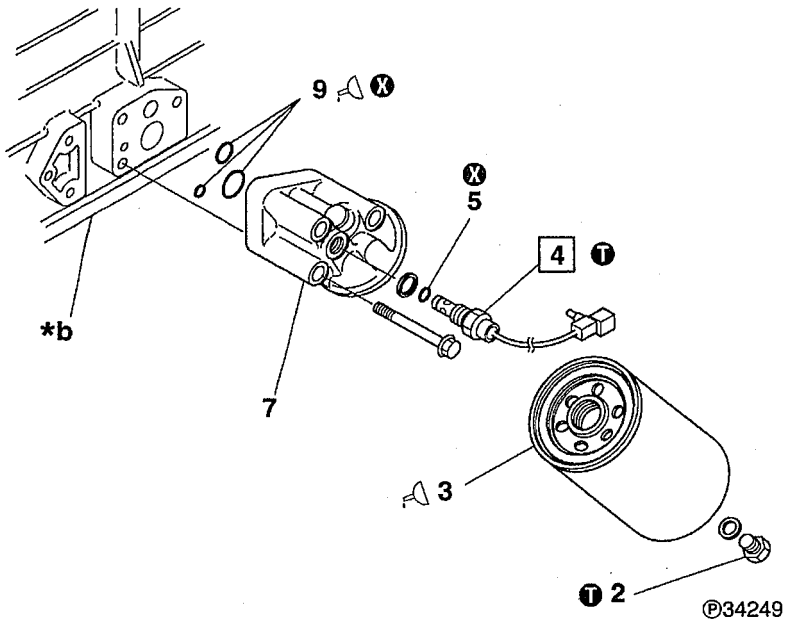
P47035

<B type>



P47036

<C type>



P34249

● **Disassembly sequence**

1 Oil filter drain valve <A, B type>
2 Oil filter drain plug
3 Oil filter P.12-13
4 Engine oil bypass alarm switch
5 O-ring
6 Air plug <A, B type>
7 Oil filter head
8 Spacer <B type>
9 O-ring

*a: Oil cooler P.12-30
*b: Crankcase assembly Gr 11
X: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

WARNING ⚠

- **Wipe up any spilled engine oil since it can cause a fire.**
- **Do not touch oil when the engine is hot since it can inflict severe burns.**

CAUTION ⚠

When pouring oil into the engine, take care not to spill any on the V-belts. Contact with oil could make the V-belts slip, rendering the cooling system less effective.

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
4	Engine oil bypass alarm switch valve opening pressure	$0.19^{+0.05}_{-0}$ MPa {$1.9^{+0.5}_{0}$ kgf/cm^2}	—	Replace

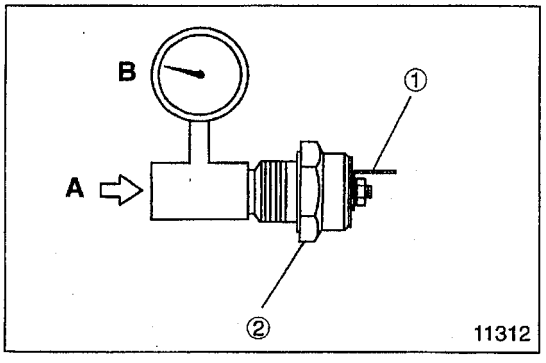
❶ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Oil filter drain valve <A, B type>	29 ± 4.9 {3.0 ± 0.5}	—
2	Oil filter drain plug	7.8 ± 2.0 {0.8 ± 0.2}	—
4	Engine oil bypass alarm switch	49 ± 4.9 {5.0 ± 0.5}	—

Lubricant

Location	Points of application	Specified lubricant	Quantity
3	Apply thin film to oil filter gasket area 📖 P.12-13	Engine oil	As required
9	Apply to O-rings	Engine oil	As required



◆ Service procedure

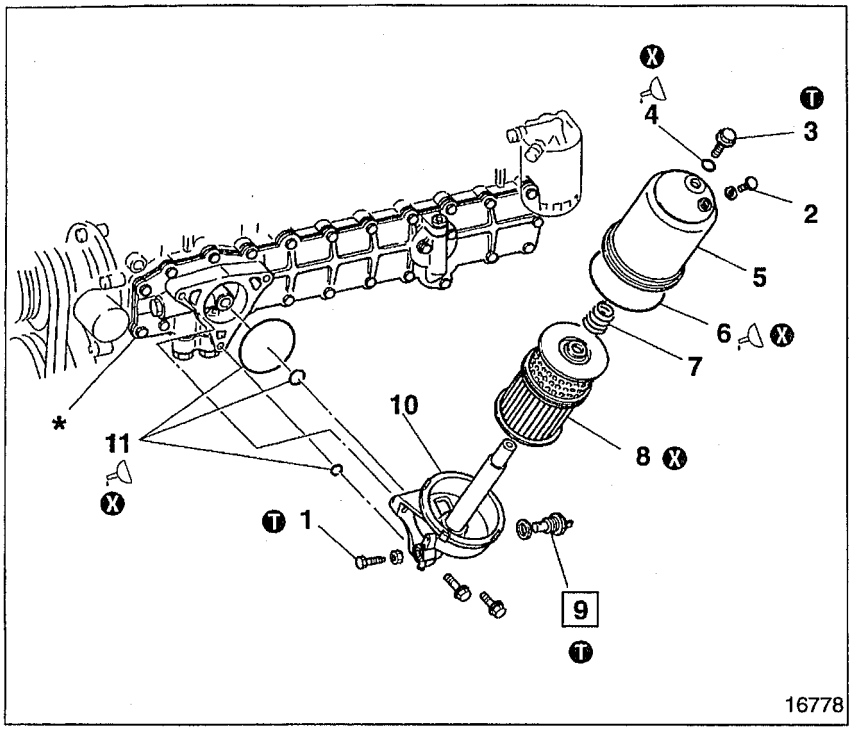
4 Inspection of engine oil bypass alarm switch

Carry out the following inspections and replace the engine oil bypass alarm switch **4** if the results are unsatisfactory:

- With no air pressure **A** applied to engine oil bypass alarm switch **4**, check that there is no electrical continuity between the terminal ① and body ② of the engine oil bypass alarm switch.
- Starting with pressure of 0 kPa {0 kgf/cm^2}, gradually increase the air pressure **A** on engine oil bypass alarm switch **4**. Note the air pressure when electrical continuity appears between the terminal ① and body ②. Verify that this pressure conforms with the specified standard value.

B: Air pressure gauge

OIL FILTER <Replaceable-element Type>



● **Disassembly sequence**

1 Oil filter drain valve
2 Air plug
3 Center bolt
4 O-ring
5 Filter case
6 O-ring
7 Set spring
8 Element
9 Engine oil bypass alarm switch
10 Filter bracket
11 O-ring

*: Oil cooler P.12-30
: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

WARNING

- **Wipe up any spilled engine oil since it can cause a fire.**
- **Do not touch oil when the engine is hot since it can inflict severe burns.**

CAUTION

When pouring oil into the engine, take care not to spill any on the V-belts. Contact with oil could make the V-belts slip, rendering the cooling system less effective.

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
9	Engine oil bypass alarm switch valve opening pressure	145 $^{+50}_{0}$ kPa {1.5 $^{+0.5}_{0}$ kgf/cm^2}	—	Replace

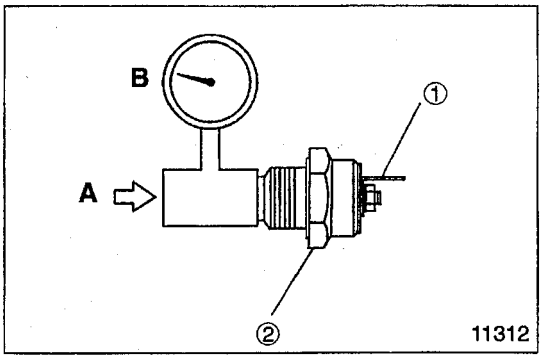
Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Oil filter drain valve	29 ± 4.9 {3.0 ± 0.5}	—
3	Center bolt	54 ± 4.9 {5.5 ± 0.5}	—
9	Engine oil bypass alarm switch	49 ± 4.9 {5.0 ± 0.5}	—

Lubricant

Location	Points of application	Specified lubricant	Quantity
4, 6, 11	Apply to O-rings	Engine oil	As required



◆ Service procedure

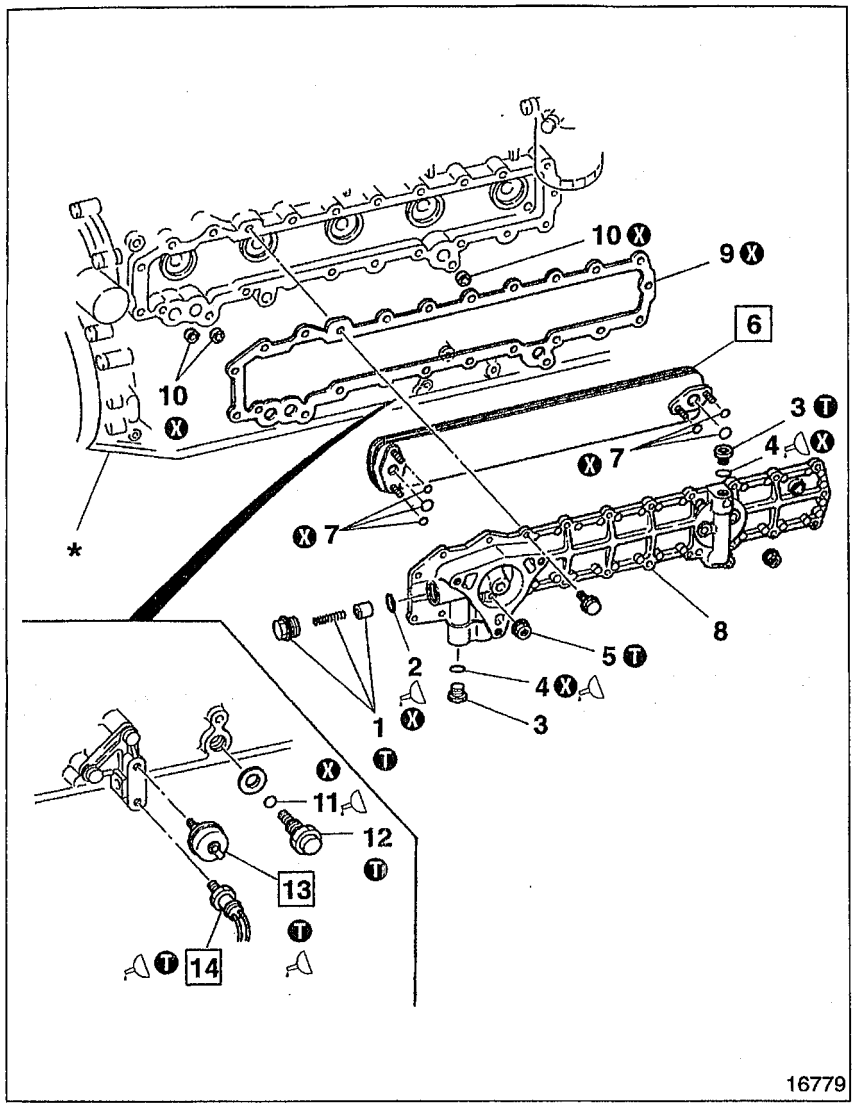
9 Inspection of engine oil bypass alarm switch

Carry out the following inspections and replace the engine oil bypass alarm switch **9** if the results are unsatisfactory:

- With no air pressure **A** applied to engine oil bypass alarm switch **9**, check that there is no electrical continuity between the terminal ① and body ② of the engine oil bypass alarm switch.
- Starting with pressure of 0 kPa {0 kgf/cm^2}, gradually increase the air pressure **A** on engine oil bypass alarm switch **9**. Note the air pressure when electrical continuity appears between the terminal ① and body ②. Verify that this pressure conforms with the specified standard value.

B: Air pressure gauge

OIL COOLER <Except 6D16-TLE>



● **Disassembly sequence**

1 Bypass valve
2 O-ring
3 Oil cooler plug
4 O-ring
5 Nut
6 Oil cooler element
7 O-ring
8 Oil cooler cover
9 Gasket
10 O-ring
11 O-ring
12 Regulator valve 🕮 P.12-34
13 Engine oil pressure gauge unit
14 Engine oil pressure switch

*: Crankcase assembly 🕮 Gr 11
Ⓧ: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
1	Oil cooler bypass valve opening pressure	295 ± 20 kPa {3.0 ± 0.2 kg/cm^2}	—	—
6	Oil cooler element air leakage (air pressure of 980 kPa {10 kgf/cm^2} for 15 seconds)	0 cc	—	Replace
14	Operating pressure of engine oil pressure switch	49 ± 9.8 kPa {0.5 ± 0.1 kgf/cm^2}	—	Replace

Ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Bypass valve	20 ± 4.9 {2.0 ± 0.5}	—
3	Oil cooler plug	25 ± 4.9 {2.5 ± 0.5}	—
5	Nut (oil cooler element mounting)	20 ± 4.9 {2.0 ± 0.5}	—
12	Regulator valve	105 ± 9.8 {11 ± 1}	—
13	Engine oil pressure gauge unit	15 to 22 {1.5 to 2.2}	—
14	Engine oil pressure switch	15 to 22 {1.5 to 2.2}	—

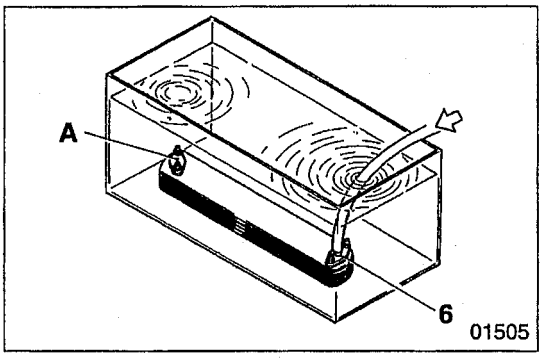
Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
2, 4, 11	Apply to O-rings	Engine oil	As required
13, 14	Wrap around thread of engine oil pressure gauge unit and engine oil pressure switch	Teflon tape	$3^1/_2$ turns

◆ Service procedure

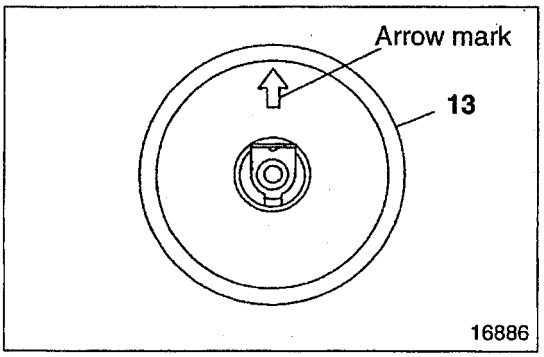
● Cleaning

- Check whether carbon deposits or sludge have accumulated in the oil passages of oil cooler element **6** and oil cooler cover **8** or in the oil cooler's bypass arrangement. Remove any deposits with cleaning sealant.
- Clean out any water scale or fur that has accumulated in the oil cooler element **6** or oil cooler cover **8**. 🕮 Gr 14



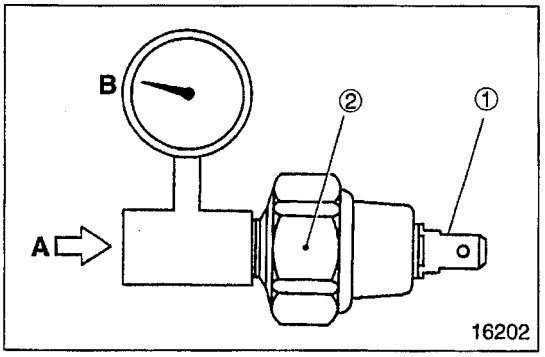
6 Inspection of oil cooler element

Plug outlet **A** of oil cooler element **6** and connect a hose to the oil inlet. Then, immerse the oil cooler element in a tank of water.
Apply the specified air pressure via the hose and check that no air leaks from the oil cooler element.
If any air leaks, replace the oil cooler element.



13 Engine oil pressure gauge unit

If the engine oil pressure gauge unit **13** is installed horizontally, it must be fitted with its arrow pointing upward.



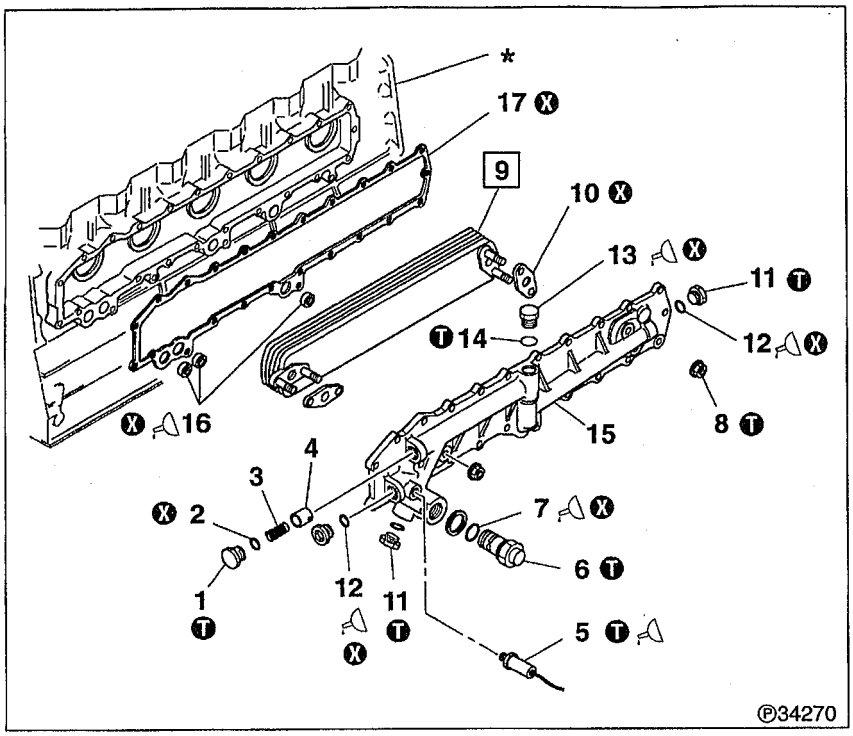
14 Inspection of engine oil pressure switch

Perform the following checks, and if any fault is found, replace the engine oil pressure switch **14**.

- **Inspection by not applying air pressure**
  Make sure that there is continuity between terminals ① and ② (body).
- **Inspection by applying air pressure**
  - Gradually apply air pressure **A** to the switch starting from 0 kPa {0 kgf/cm^2}.
  - Measure the degree of air pressure at the moment when continuity is not detected between terminals ① and ② (body), and make sure to confirm if the value meets the standard.

B: Air pressure gauge

OIL COOLER <6D16-TLE>



● **Disassembly sequence**

1 Bypass valve plug
2 O-ring
3 Bypass valve spring
4 Bypass valve
5 Engine oil pressure switch
6 Regulator valve 🕮 P.12-34
7 O-ring
8 Nut
9 Oil cooler element
10 Gasket
11 Oil cooler plug
12 O-ring
13 Oil cooler plug
14 O-ring
15 Oil cooler cover
16 O-ring
17 Gasket

*: Crankcase assembly 🕮 Gr 11
X: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item		Standard value	Limit	Remedy
3	Bypass valve spring	Free length	104.3 ± 1	—	—
		Spring load (Installed length)	84 ± 3N {8.6 ± 0.3 kgf}	—	Replace
5	Operating pressure of engine oil pressure switch		49 ± 9.8 kPa {0.5 ± 0.1 kgf/cm^2}	—	Replace
9	Oil cooler element air leakage (Apply air pressure of 1000 kPa {10.2 kgf/cm^2} for 15 seconds.)		0 cm^3 {0mL}	—	Replace

T Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Bypass valve plug	34.3 ± 4.9 {3.5 ± 0.5}	—
5	Engine oil pressure switch	15 to 22 {1.5 to 2.2}	—
6	Regulator valve	98 to 118 {10 to 12}	—
8	Nut (for fixing oil cooler element)	20 ± 4.9 {2.0 ± 0.5}	—
11	Oil cooler plug	25 ± 4.9 {2.5 ± 0.5}	—
13	Oil cooler plug	34.5 ± 4.9 {3.5 ± 0.5}	—

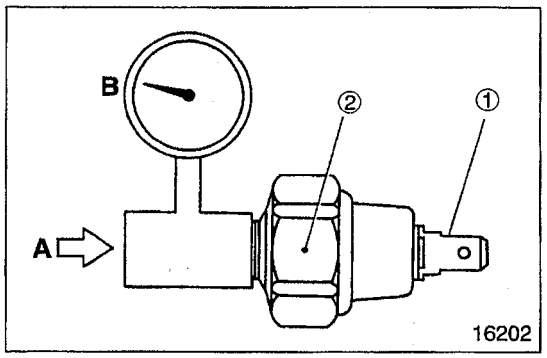
A Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
5	Thread of engine oil pressure switch	Teflon tape	Wrap around 3 1/2 turns
7, 12, 14, 16	O-rings on oil cooler	Engine oil	As required

◆ Service procedure

● Cleaning

- Check whether carbon deposits or sludge have accumulated in the oil passages of oil cooler element **9** and in the oil cooler's bypass arrangement. Remove any deposits with cleaning sealant.
- Clean out any water scale or fur that has accumulated in the oil cooler element **9** or oil cooler cover **15.** 🕮 Gr 14

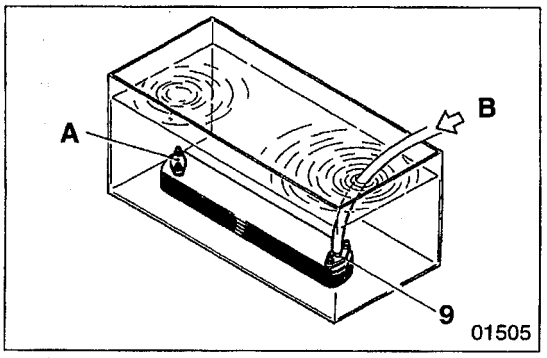


5 Inspection of engine oil pressure switch

Perform the following checks, and if any fault is found, replace the engine oil pressure switch **5.**

- **Inspection by not applying air pressure**
  Make sure that there is continuity between terminals ① and ② (body).
- **Inspection by applying air pressure**
  - Gradually apply air pressure **A** to the switch starting from 0 kPa {0 kgf/cm^2}.
  - Measure the degree of air pressure at the moment when continuity is not detected between terminals ① and ② (body), and make sure to confirm if the value meets the standard.

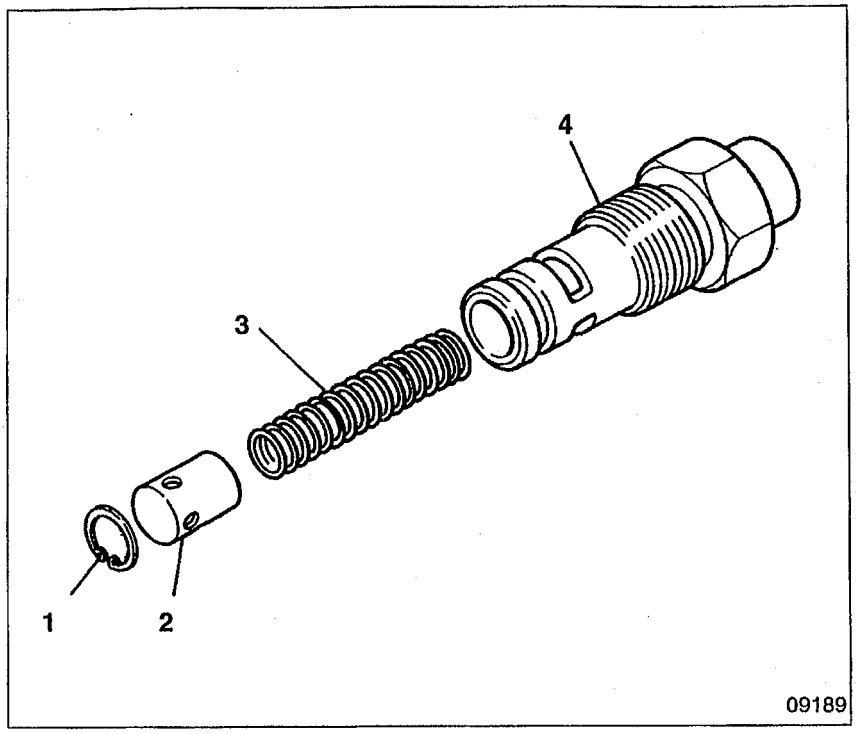
B: Air pressure gauge



9 Inspection of oil cooler element

Plug outlet **A** of oil cooler element **9** and connect a hose to the oil inlet. Then, immerse the oil cooler element in a tank of water.
Apply the specified air pressure **B** via the hose and check that no air leaks from the oil cooler element.
If any air leaks, replace the oil cooler element.

REGULATOR VALVE



● **Disassembly sequence**

1 Snap ring
2 Valve
3 Spring
4 Body

● **Assembly sequence**

Reverse the order of disassembly.

[Installation]
📖 P.12-30, 32

Service standards

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
3	Regulator valve spring load (installed length = 48.3 mm)	76 to 80 N {7.8 to 8.2 kgf}	—	—
—	Regulator valve opening pressure	390 ± 29 kPa {4.0 ± 0.3 kgf/cm^2}	—	—

GROUP 13A FUEL AND ENGINE CONTROL

NOTE ; • The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.
• The pages marked "( )" are given, though they are not applicable to the SK330(N)LC-6E.

SPECIFICATIONS

Injection Pump

Item \ Engine model	6D14	6D14-T		6D15-T	
	STD	STD	OPT	STD	OPT
Model	Bosch A	Bosch A	Bosch A	Bosch A	Bosch A
Governor type	RSV-type all-speed mechanical governor	RSV-type all-speed mechanical governor	RFD-type minimum-maximum mechanical governor	RSV-type all-speed mechanical governor	RFD-type minimum-maximum mechanical governor
Feed pump type	KE	KE	KE	KE	KE
Automatic timer type	SA-type mechanical timer	SA-type mechanical timer	SA-type mechanical timer	—	—
Manufacturer	DENSO	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS

Item \ Engine model	6D16, 16-E			6D16-T, 16-TE	
	STD	OPT	OPT	STD	OPT
Model	Bosch A	Bosch A	Bosch AD	Bosch AD	Bosch AD
Governor type	RSV-type all-speed mechanical governor	RFD-type minimum-maximum mechanical governor	RSV-type all-speed mechanical governor	RSV-type all-speed mechanical governor	RFD-type minimum-maximum mechanical governor
Feed pump type	KE	KE	KE	KE	KE
Automatic timer type	SA-type mechanical timer	SA-type mechanical timer	—	SA-type mechanical timer	SA-type mechanical timer
Manufacturer	DENSO	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS

Item \ Engine model	6D16-TL	6D16-TLE	
	STD	STD	OPT
Model	Bosch AD	Bosch MD	Bosch MD
Governor type	RFD-type minimum-maximum mechanical governor	RSV-type all-speed mechanical governor	RED-IV-type electronic governor
Feed pump type	KE	KE	KE
Automatic timer type	SA-type mechanical timer	SPG mechanical timer	SPG mechanical timer
Manufacturer	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS

Injection Nozzle

Item \ Engine model	6D14	6D14-T		6D15-T		6D16, 16-E	
Model	Hole-type (1-spring)	Hole-type (1-spring)	Hole-type (2-spring)	Hole-type (1-spring)		Hole-type (1-spring)	
No. of holes	5	5		5		5	
Hole diameter (mm)	0.28	0.29	0.315	0.29	0.31	0.31	0.29
Manufacturer	DENSO	BOSCH AUTOMOTIVE SYSTEMS	DENSO	BOSCH AUTOMOTIVE SYSTEMS		BOSCH AUTOMOTIVE SYSTEMS	

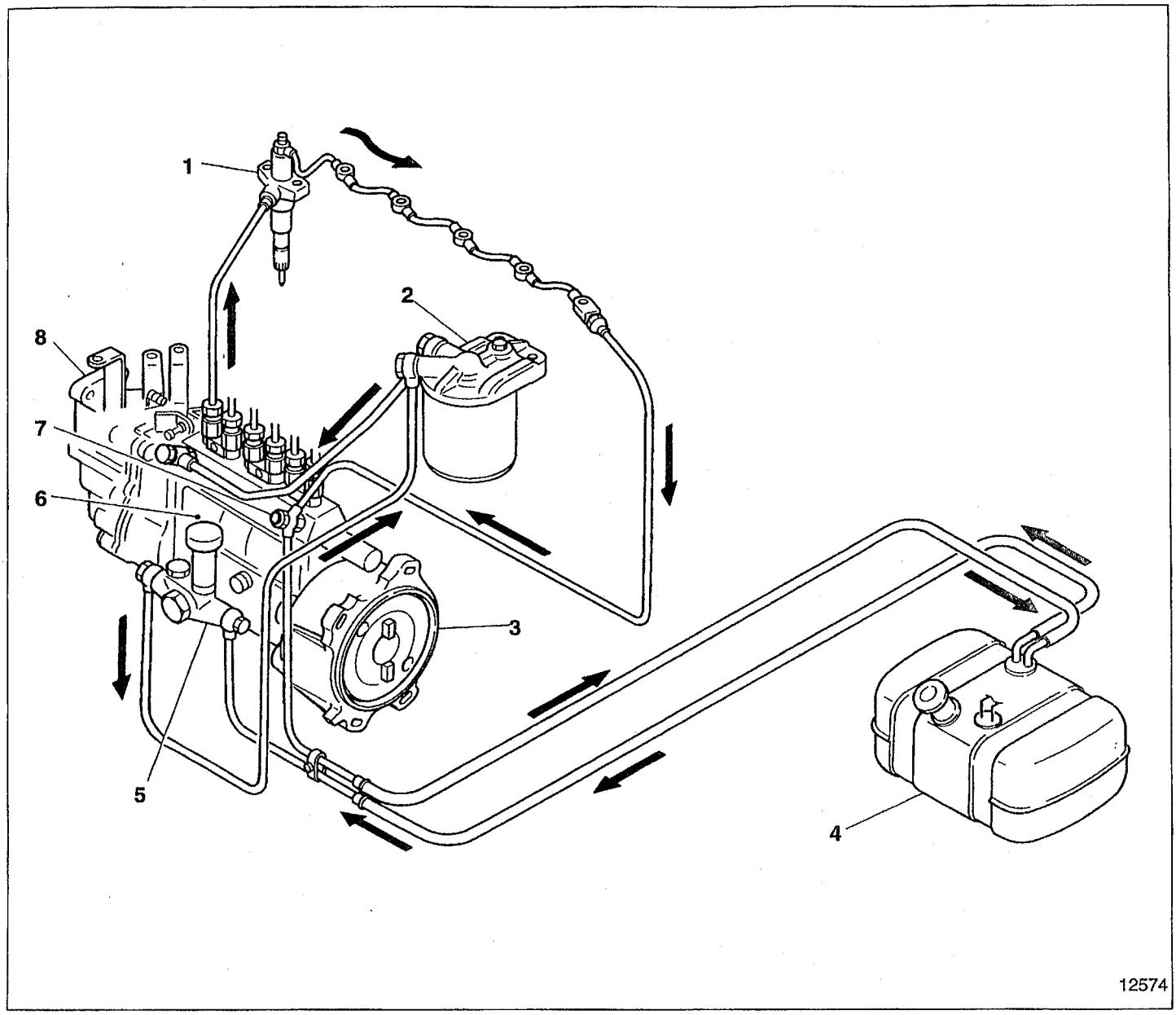
Item \ Engine model	6D16-T, 16-TE		6D16-TL	6D16-TLE	
Model	Hole-type (1-spring)	Hole-type (2-spring)	Hole-type (1-spring)	Hole-type (1-spring)	
No. of holes	5		5	5	
Hole diameter (mm)	0.31		0.31	0.29	0.275
Manufacturer	BOSCH AUTOMOTIVE SYSTEMS		BOSCH AUTOMOTIVE SYSTEMS	BOSCH AUTOMOTIVE SYSTEMS	

Other Items

Item	Specifications
Fuel filter type	Spin-on type (paper filter)
Secondary fuel filter type	Filter paper type
Water separator type	Sediment trap type

1. Fuel System

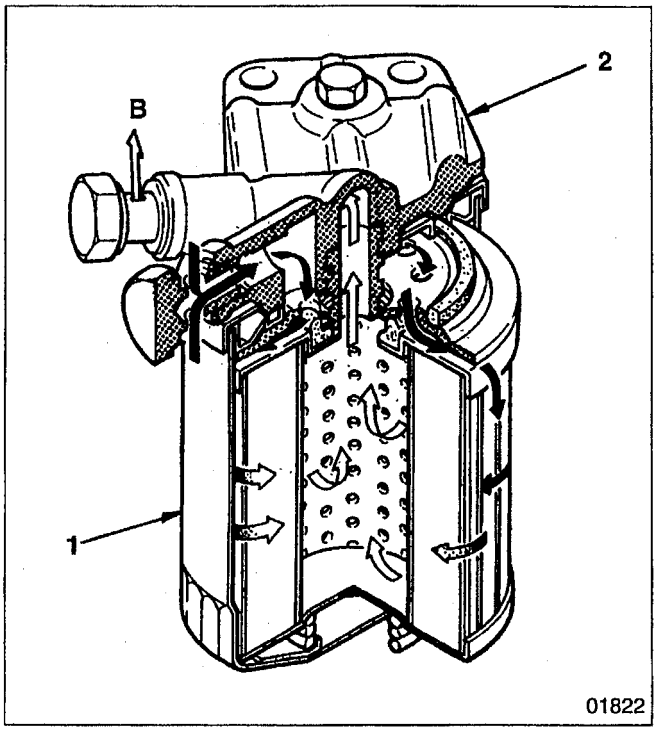
For electronic fuel system, refer to Gr. 13E.



1 Injection nozzle
2 Fuel filter
3 Automatic timer
4 Fuel tank
5 Feed pump
6 Injection pump
7 Overflow valve
8 Governor

- Fuel from the fuel tank **4** is drawn up by the feed pump **5** and strained by the fuel filter **2**. The feed pump is driven by a cam in the injection pump **6**.
- After filtration, fuel is fed to the injection pump **6**. From there, it is fed under high pressure to the injection nozzles **1**. The injection nozzles spray the fuel into the combustion chambers.
- If the fuel pressure in the injection pump **6** exceeds a preset level, the overflow valve **7** opens to allow excess fuel to return to the fuel tank **4**.

2. Fuel Filter

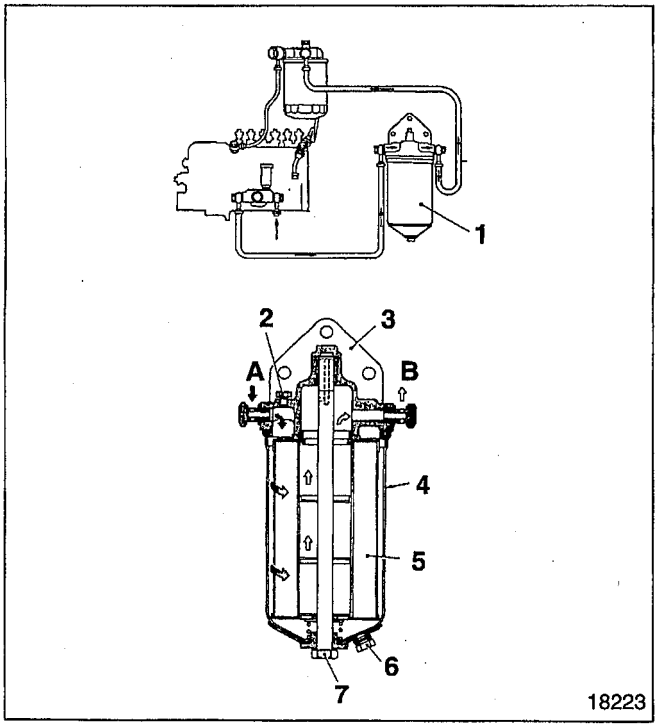


1 Fuel filter
2 Fuel filter head

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 its element removes any impurities.

3. Secondary Fuel Filter

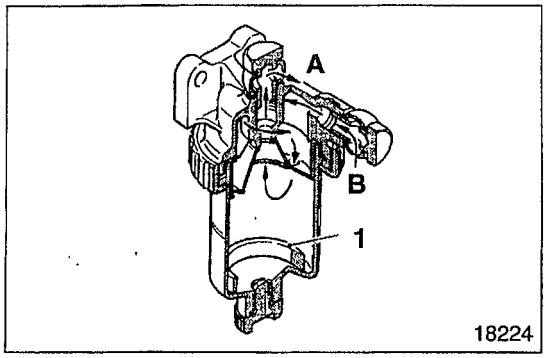


1 Secondary fuel filter
2 Air plug
3 Cover
4 Case
5 Element
6 Drain plug
7 Center bolt

A: From feed pump
B: To fuel filter

When the engine is run on JIS class 1 heavy oil (ASTM No. 4; BS class D, B1 and B2), a secondary fuel filter is fitted in the position illustrated. Like the regular fuel filter, this unit separates any water content out of fuel received from the feed pump. It uses a paper element to remove impurities.

4. Water Separator

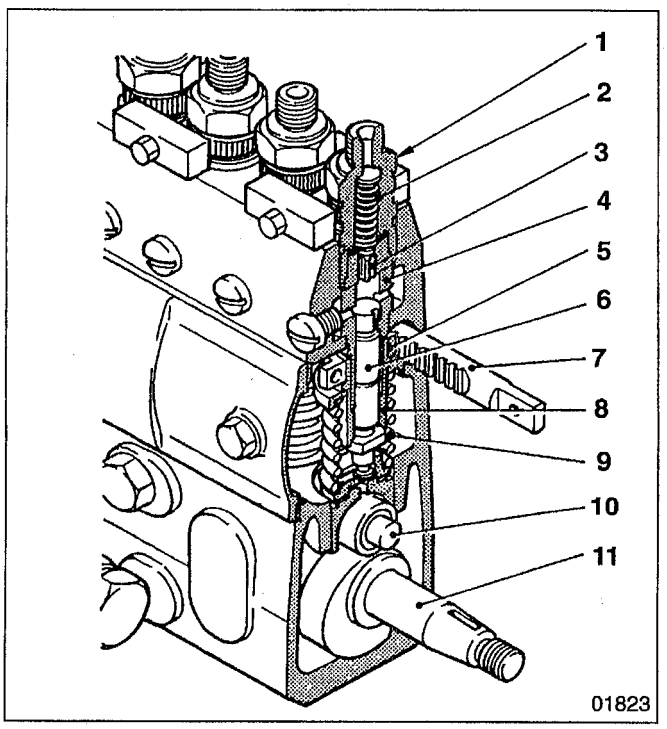


1 Water level ring

A: Fuel outlet (to feed pump)
B: Fuel inlet

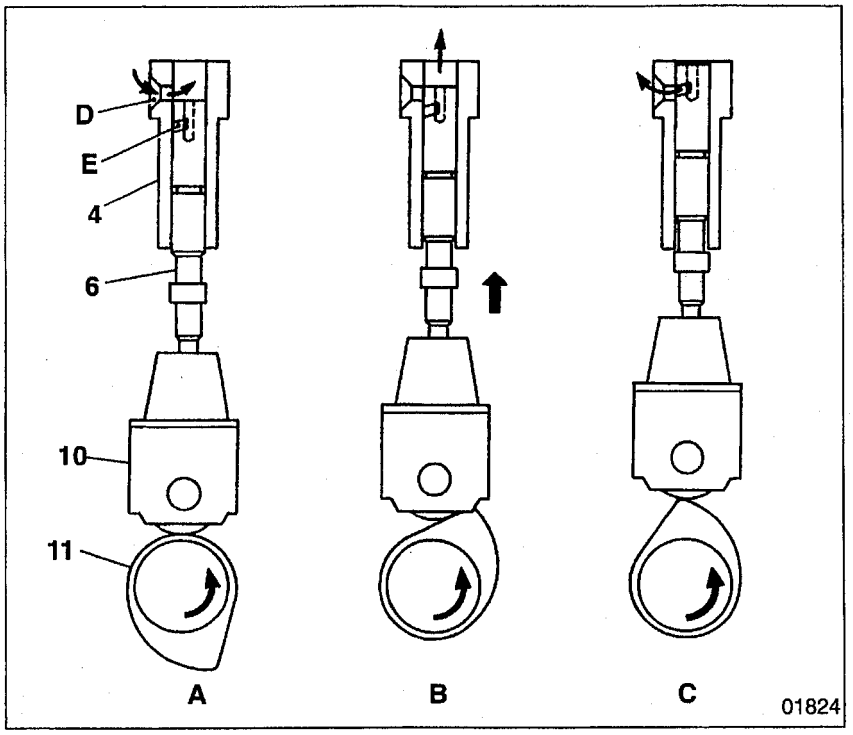
The sediment trap type water separator splits fuel and water centrifugally utilizing the difference in specific gravity between the two fluids. Fuel entering from the inlet connector is squeezed through a passage in the head, resulting in a faster flow with a more powerful axial twist. Water separated 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.
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.

5. Injection Pump



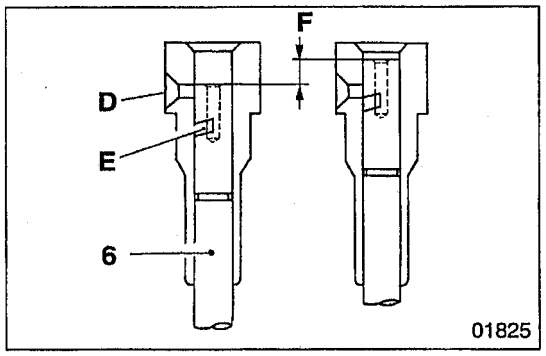
1 Delivery valve holder
2 Delivery valve spring
3 Delivery valve
4 Plunger barrel
5 Control pinion
6 Plunger
7 Control rack
8 Control sleeve
9 Plunger spring
10 Tappet
11 Camshaft

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

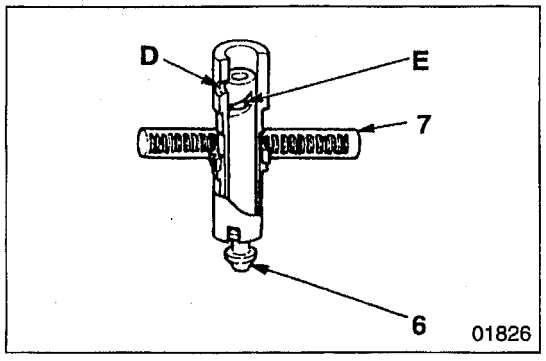


● **Fuel feed action**

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

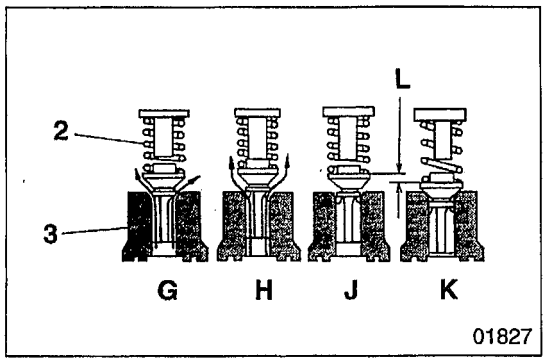


As the plunger **6** rises and its lead **E** meets the fuel inlet/outlet hole **D**, fuel flows through the center of the plunger and is expelled from the inlet/outlet hole. Regardless of how much further the plunger rises, no fuel feed takes place thereafter.
The stroke length **F** of the plunger **6** during which pressure feed takes place is known as the "effective stroke."



● **Injection volume adjustment mechanism**

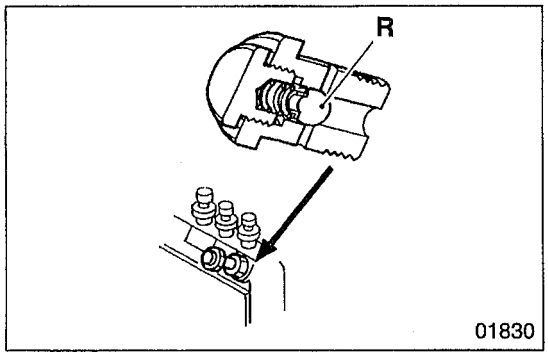
To match changes in engine loading, an adjustment mechanism controls the amount of fuel injected. This mechanism turns the plunger **6** by a given angle, thereby altering the point at which the fuel inlet/outlet hole **D** meets the lead **E**. Simply stated, the effective stroke is made longer or shorter. 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 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.

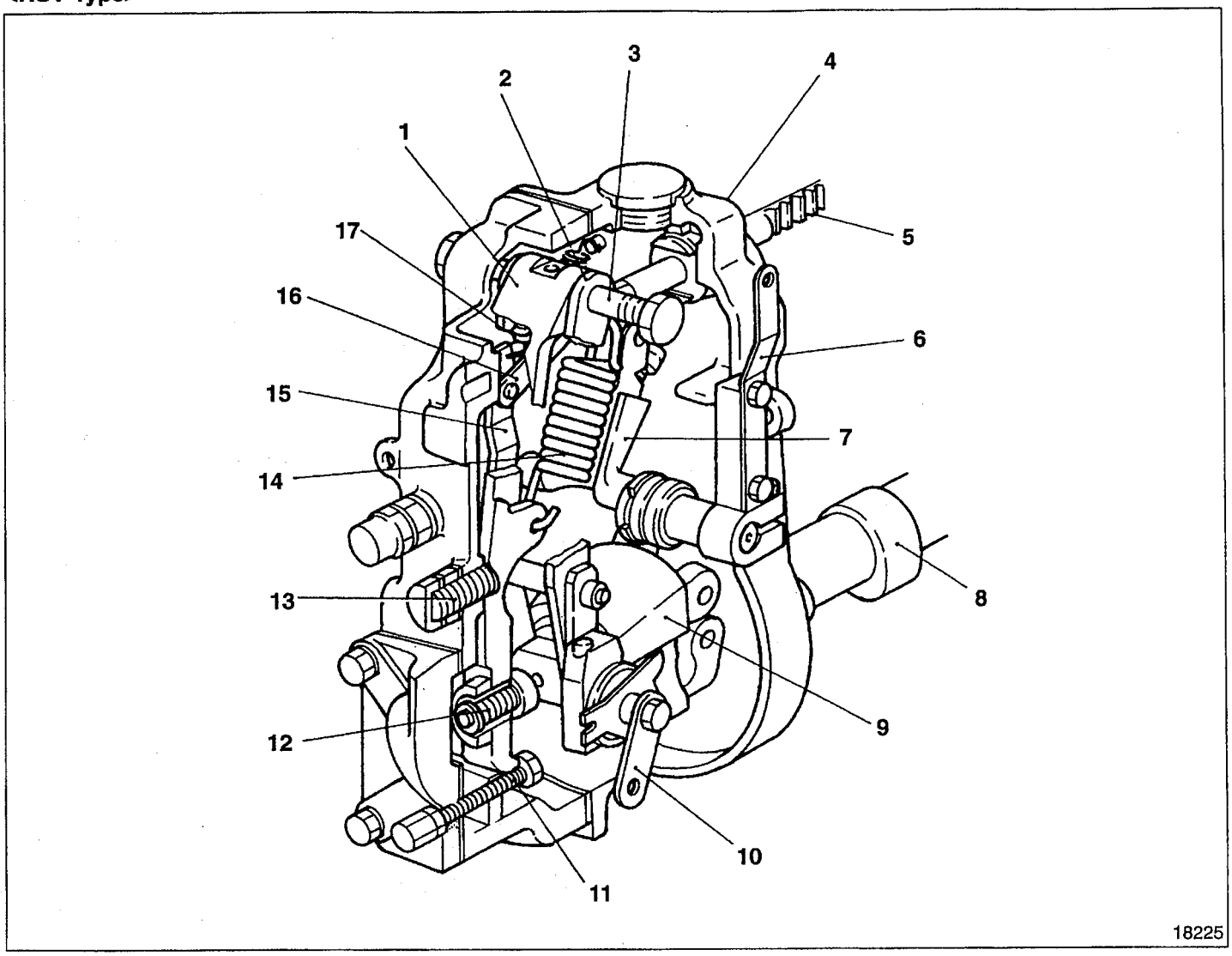


● **Overflow valve**

When the fuel pressure in the injection pump exceeds a preset level, the steel ball **R** 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.

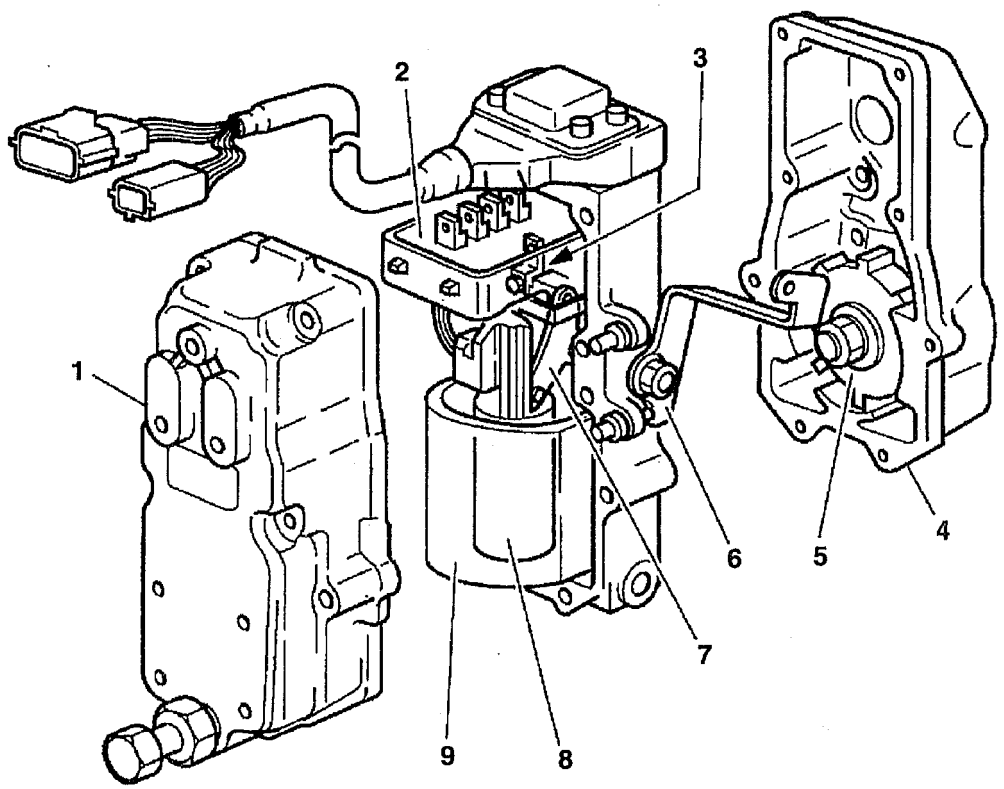
6. Governor

<RSV Type>



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

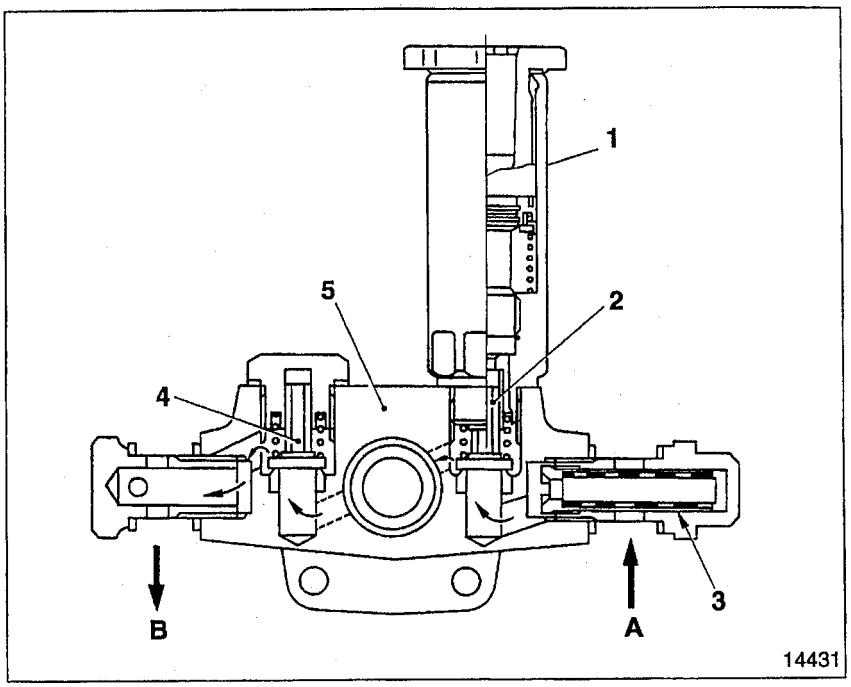
<RED-4 Type>



P35899

1 Cover
2 RED-4 internal circuit
3 Control rack position sensor
4 Housing
5 Sensing gear
6 Emergency engine stop lever
7 Link
8 Coil assembly
9 Linear DC motor

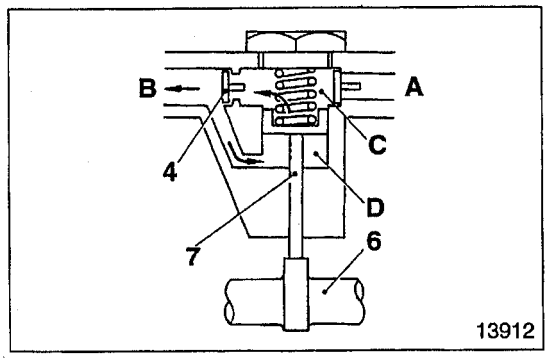
7. Feed Pump



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

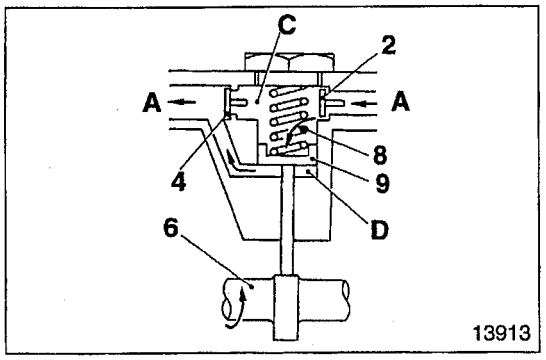
A: From fuel tank
B: To fuel filter

The feed pump is driven by the camshaft in the injection pump. The priming pump **1** enables fuel to be drawn up manually when the injection pump is stationary. It is particularly useful for air bleeding.
The gauze filter **3** 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.



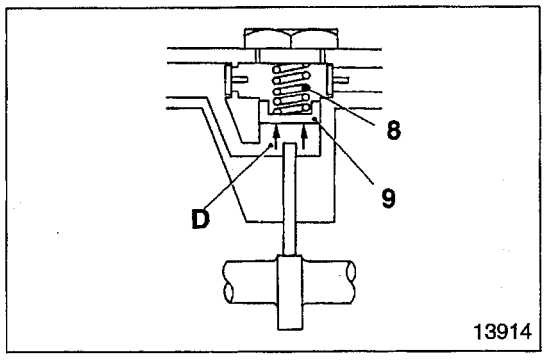
● Suction stroke

When the injection pump camshaft **6** forces up the push rod **7**, fuel in the suction chamber **C** is compressed and opens the outlet check valve **4**. Most of the fuel forced out is drawn into the pressure chamber **D** below the piston.



● Pressure feed stroke

As the camshaft **6** turns and the cam loses its lift, the piston **9** is pushed down by the piston spring **8**. The fuel in the pressure chamber **D** is thus forced out and fed toward the fuel filter.
At the same time, the outlet check valve **4** closes and the inlet check valve **2** opens. As a result, fuel is again drawn into the suction chamber **C**.



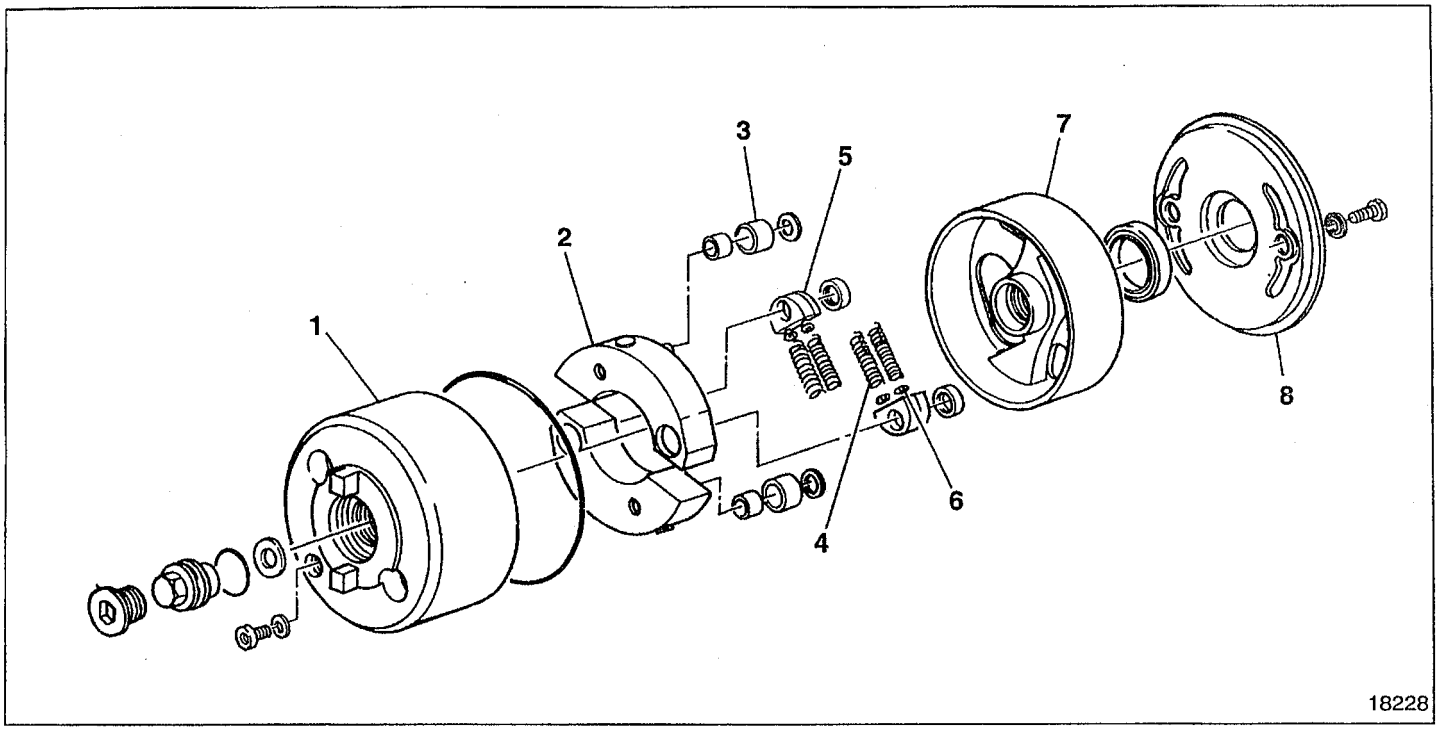
● Stoppage

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

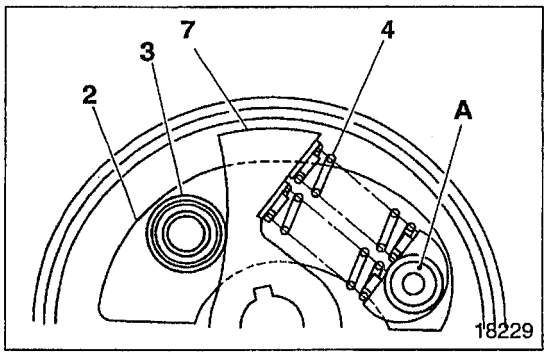
8. Automatic Timer

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. Via a driving disk, it is driven by the air compressor crankshaft or pump drive shaft.

<SA-type automatic timer>

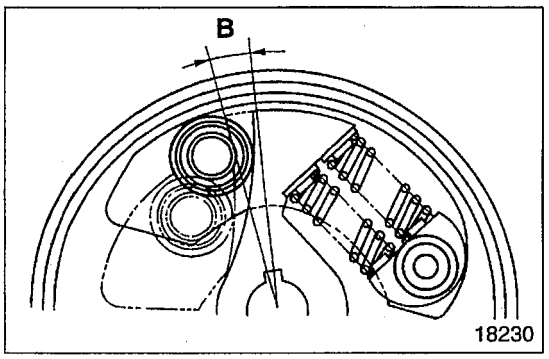


1 Timer housing
2 Flyweight
3 Roller
4 Timer spring
5 Spring seat
6 Shim
7 Flange
8 Cover



● With engine stationary

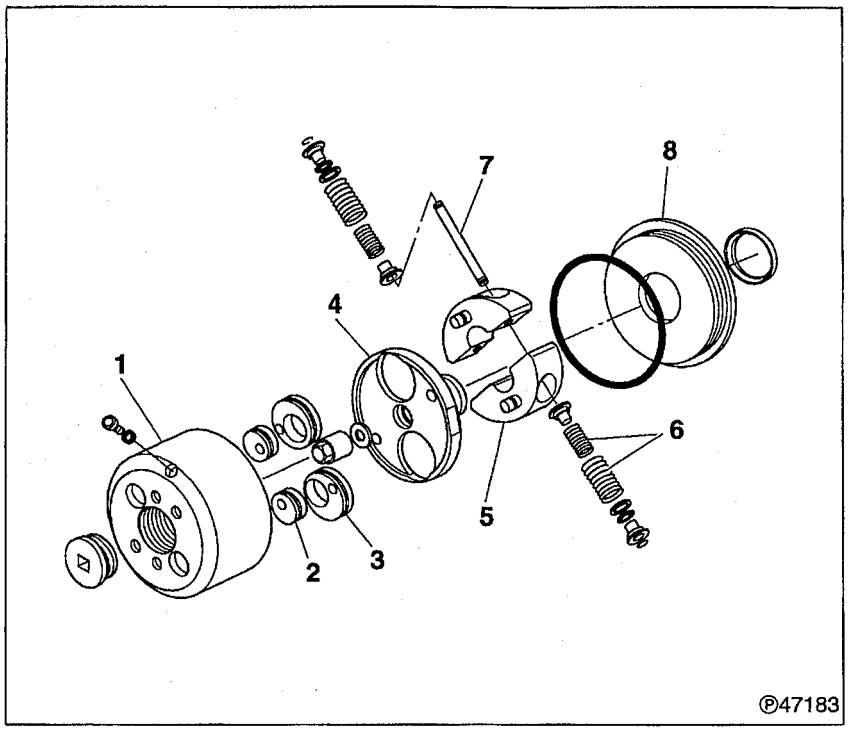
When the engine is stationary, the timer spring **4** overcomes the centrifugal force acting on the flyweight **2**. The flyweight roller is therefore held down by the flange **7**, and the injection timing arrangement is not advanced.



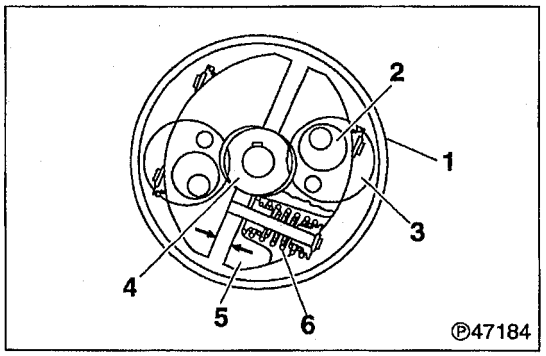
● With engine running

As the engine speed rises, the centrifugal force on the flyweight **2** increases. With the timer housing pin **A** as the fulcrum, the flyweight roller 3 thus moves outward while pushing the curved surface of the flange **7**, causing the flange to compress the timer springs **4**. As a result, the roller **3** of the flyweight **2** moves the flange **7** in the rotating directing and the injection timing is advanced.

<SPG-type automatic timer>

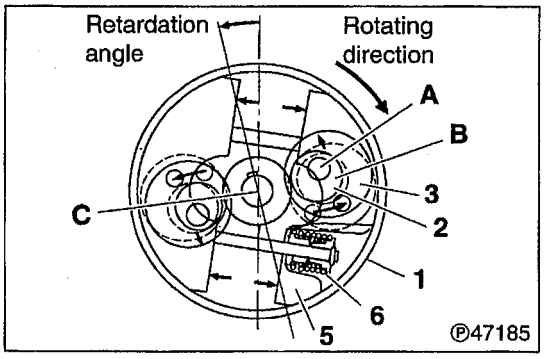


1 Timer housing
2 Eccentric cam (small)
3 Eccentric cam (large)
4 Timer holder
5 Flyweight
6 Timer spring
7 Pilot pin
8 Cover



● With engine stationary

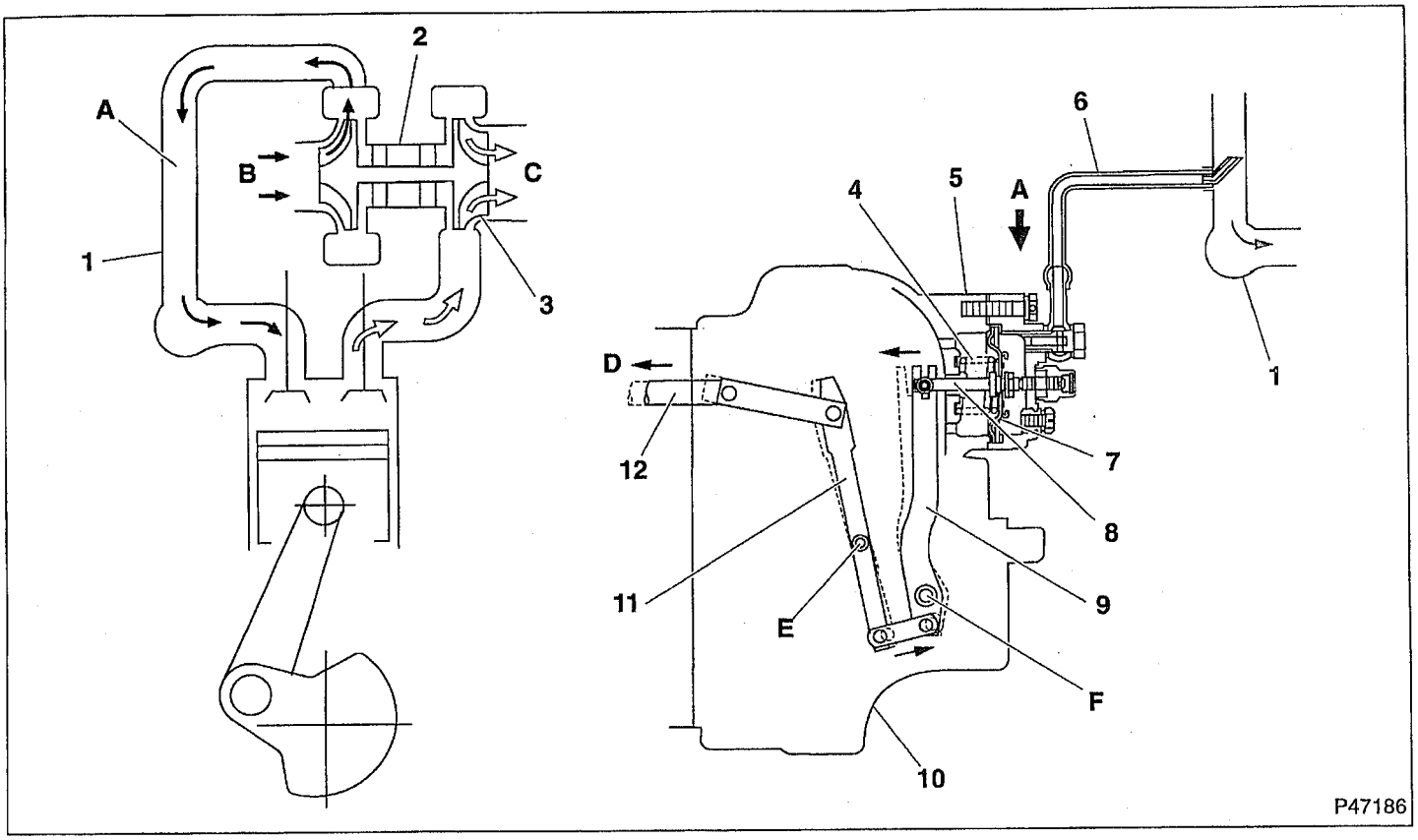
With the engine stationary, flyweight **5** is held against timer holder **4** by the force of timer spring **6**.



● With engine running

As the engine speed increases, the centrifugal force exerted on flyweight **5** matches the force of timer spring **6**. As the engine speed increases further, the centrifugal force overcomes the force of spring, causing the flyweight to move outwards. As the flyweight moves outwards, eccentric cam (small) **2** rotates in the reverse direction of the shaft rotation about pin **A** of the timer housing. Also, center **B** of eccentric cam (large) **3** rotates in the reverse direction of the shaft rotation about center **C** of the timer. The eccentric cam (large) has been fit into timer holder **4**. Therefore, the movement of the eccentric cam (large) is transmitted to the timer holder. The maximum retard is achieved when the back of the flyweight bottoms against the inner surface of timer housing **1**.

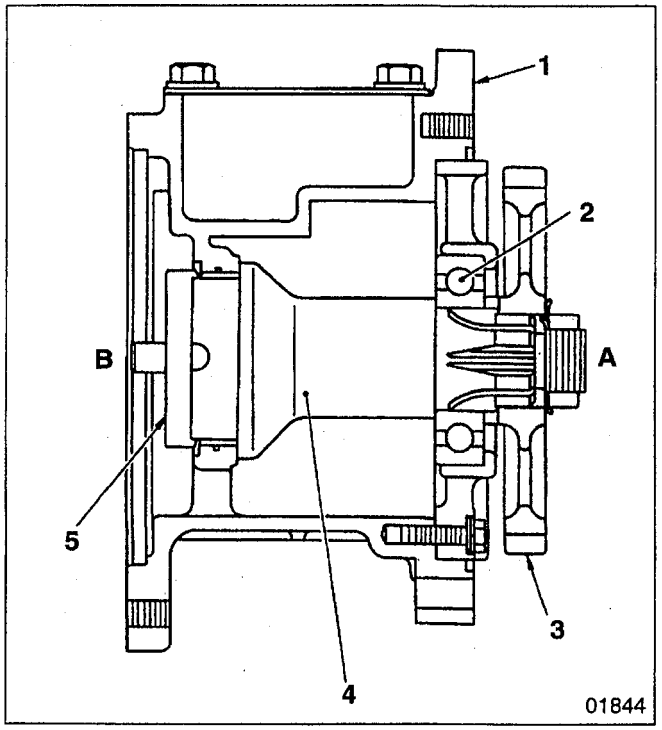
9. Boost Compensator



1 Inlet manifold
2 Turbo charger
3 Turbine
4 Boost compensator spring
5 Boost compensator
6 Hose
7 Diaphragm
8 Push rod
9 Compensator lever
10 Governor
11 Floating lever
12 Control rod
A: Boost pressure
B: Intake air
C: Exhaust
D: More fuel
E, F: Pivot

- The boost compensator is designed to ensure that a greater amount of fuel is injected as the turbo charger feeds more air into the engine so that the engine output increases accordingly.
- As boost pressure **A** in inlet manifold **1** overcomes the force of boost compensator spring **4** of boost compensator **5**, diaphragm **7** and push rod **8** are pushed to the left.
- As push rod **8** is pushed to the left, compensator lever **9** moves counterclockwise about pivot **F** to the position shown by the dotted line. This causes floating lever **11** to move counterclockwise about pivot **E**, which in turn moves control rod **12** in the direction of **D** (more fuel). As a result, a greater amount of fuel is injected irrespective of the operations of governor **10**.

10. Injection Pump Drive



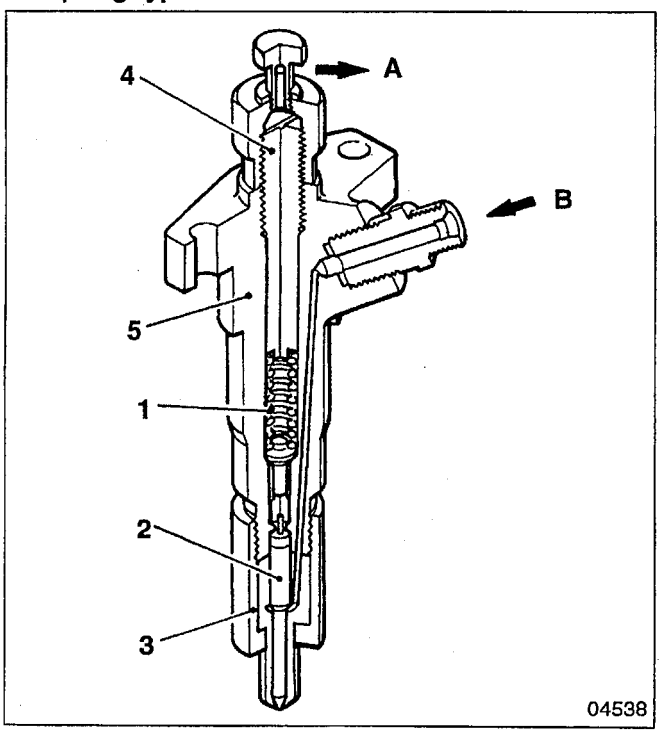
1 Pump drive case
2 Bearing
3 Pump drive gear
4 Pump drive shaft
5 Coupling

A: Timing gear side
B: Timer side

The injection pump drive is fitted onto the flywheel housing on the left of the engine. It is driven by the engine timing gear at half the engine speed.
The pump drive shaft **4** drives the injection pump via the coupling **5** on its timer side.

11. Injection Nozzle

<1-spring type>



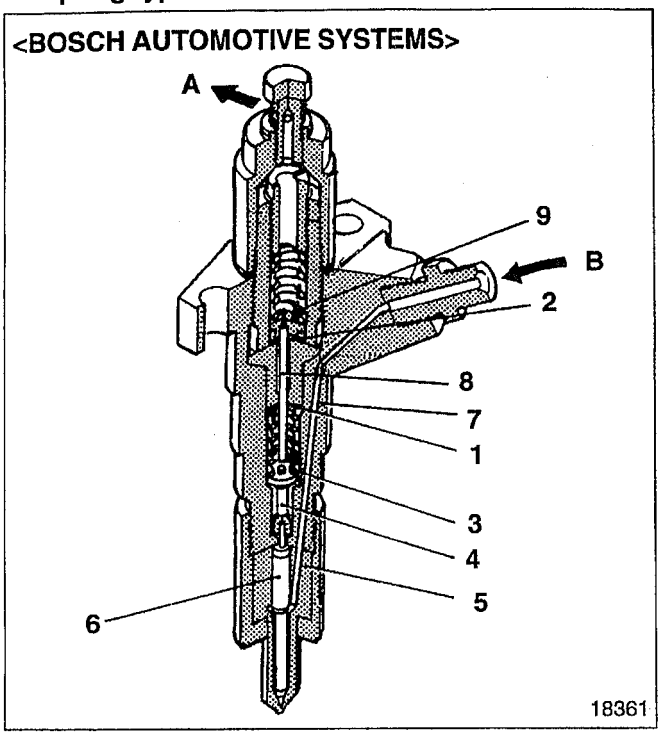
1 Nozzle spring
2 Needle valve
3 Nozzle
4 Adjusting screw
5 Nozzle holder

A: To leak-off pipe
B: From injection pump

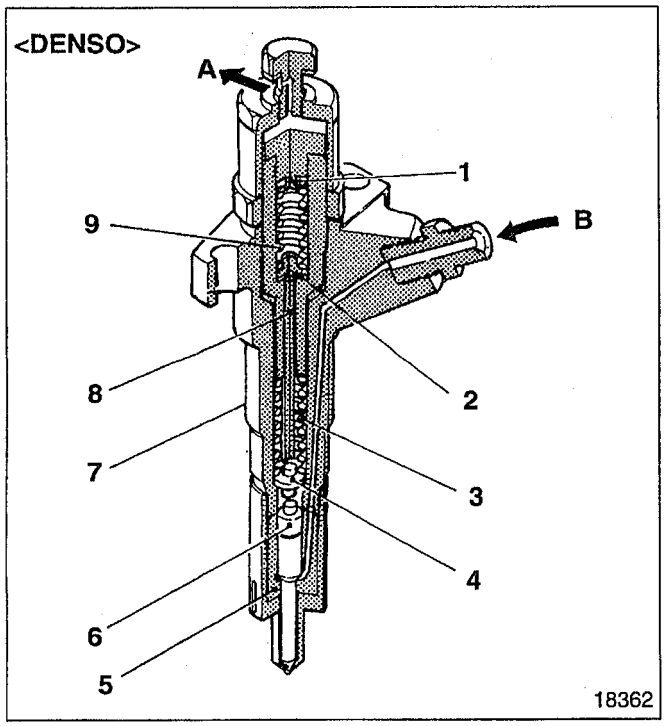
Fuel fed from the injection pump enters the nozzle holder **5**. When the fuel pressure in the nozzle holder exceeds a preset pressure, it overcomes the nozzle spring **1**, pushes up the needle valve **2**, and the fuel is sprayed into the cylinder from the orifice at the end of the nozzle **3**.
Some of the high-pressure fuel lubricates the needle valve **2** and returns to the fuel tank via the leak-off pipe.

<2-spring type>

<BOSCH AUTOMOTIVE SYSTEMS>



<DENSO>



1 Valve opening pressure adjustment shim
2 Prelift adjustment shim
3 1st spring
4 1st push rod
5 Nozzle
6 Needle valve
7 Nozzle holder
8 2nd push rod
9 2nd spring

Inside the nozzle, there are two springs **3**, **9** and two push rods **4**, **8**. A prelift clearance is provided between the two push rods. When high-pressure fuel from the injection pump overcomes the 1st spring **3** (this spring determines the valve opening pressure), the needle valve **6** pushes up the 1st push rod **4**, thereby opening the valve.
When the 1st push rod **4** moves through the prelift clearance and contacts the 2nd push rod **8**, the needle valve **6** momentarily stops lifting. As the fuel pressure increases further and overcomes the combined force of the 1st spring **3** and 2nd spring **9**, the needle valve **6** lifts again for the main injection.

MEMO

TROUBLESHOOTING

Possible causes	Symptoms	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	Accelerator pedal too stiff	Defective fuel supply
Injection pump proper	Sticky plunger	○											
	Sticky control rack	○											
	Sticky delivery valve	○											
	Worn tappet	○											
	Worn camshaft	○											
	Poorly adjusted injection timing		○		○	○		○					
	Worn plunger					○		○					
	Defective delivery valve seat					○							
	Excessively advanced injection timing			○									
	Insufficient plunger slide stroke				○								
	Broken plunger spring				○			○					
	Defective sliding action in control rack		○		○		○	○					
	Tappet worn or not sliding correctly				○								
	Broken delivery valve spring				○	○							
	Poor airtightness due to loose delivery valve holder				○	○							
	Defective delivery valve operation				○								
	Loose control pinion							○					
	Plunger spring not seating correctly							○					
	Delivery valve holder too tight							○					
	Uneven injection volume to cylinders		○					○					
Fuel feed pump	Gauze filter clogged	○						○	○				
	Check valve not operating	○											
	Sticky piston	○											
	Sticky push rod	○											
	Worn tappet	○											
	Defective check valve operation		○		○			○					
	Piston worn		○		○			○					

Possible causes	Symptoms	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	Accelerator pedal too stiff	Defective fuel supply
Governor	Insufficient full-load stopper position					○							
	Weak governor spring					○				○			
	Incorrectly adjusted control lever				○	○				○			
	Flyweights not operating effectively						○						
	Weak idling spring							○					
	Bent links							○					
	Excessive friction or play in links							○					
	Loose round nut							○					
	Poorly adjusted idling set bolt							○					
	Defective sliding action in control lever											○	
	Stop mechanism damaged										○		
Automatic timer	Defective advancing action					○		○					
Injection nozzles	Sticky needle valve	○											
	Valve opening pressure too low	○								○			
	Blocked injection orifice	○		○		○		○		○			
	Poor airtightness in nozzle	○		○		○		○		○			
	Valve opening pressure too high			○									
	Broken spring				○	○							
	Defective sliding action in needle valve				○								
	Defective valve opening pressure				○								
	Weakness/deterioration in spring							○					
Fuel filter	Filter (and/or secondary filter) clogged	○			○			○	○				
Fuel tank empty		○											
Fuel pipes blocked and/or fuel leaking from connections		○											
Air or water in fuel system		○			○			○	○				
Low-quality fuel in use			○	○		○		○					
Cracked fuel pipe													○
Leaky fuel tank													○
Incorrect oil viscosity	🕮 Gr. 12		○										
Incorrect valve clearance	🕮 Gr. 11		○					○					
Defective head gasket	🕮 Gr. 11		○					○					
Wear and/or carbon deposits on valve and valve seat	🕮 Gr. 11		○					○					
Weakness/deterioration in valve spring	🕮 Gr. 11		○					○					

TROUBLESHOOTING

Possible causes \ Symptoms		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	Accelerator pedal too stiff	Defective fuel supply
Worn/damaged piston ring(s)	🕮 Gr. 11		○					○					
Worn/damaged piston ring groove(s)	🕮 Gr. 11		○					○					
Worn piston and cylinder liner	🕮 Gr. 11		○										
Cooling system malfunctioning	🕮 Gr. 14		○					○					
Defective starter switch	🕮 Gr. 54		○										
Defective glow relay	🕮 Gr. 54		○										

MEMO

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Checking and Adjusting Injection Timing

<Except 6D16-TLE>

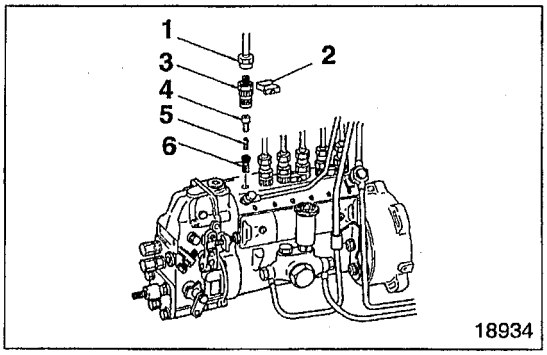
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
—	Fuel injection timing (BTDC)	Depends on specifications	—	Adjust

❶ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened		Tightening torque	Remarks
1	Union nut (injection pipe mounting)		25 {2.5}	—
2	Bolt (delivery valve holder lock plate)	DENSO	7.8 to 11 {0.8 to 1.1}	—
		BOSCH AUTOMOTIVE SYSTEMS <A-type>	4.4 to 6.0 {0.45 to 0.6}	—
		BOSCH AUTOMOTIVE SYSTEMS <AD-type>	3.4 to 4.9 {0.35 to 0.5}	—
3	Delivery valve holder	DENSO	34 to 39 {3.5 to 4}	—
		BOSCH AUTOMOTIVE SYSTEMS <A-type>	39 to 44 {4 to 4.5}	—
		BOSCH AUTOMOTIVE SYSTEMS <AD-type>	49 to 54 {5 to 5.5}	—

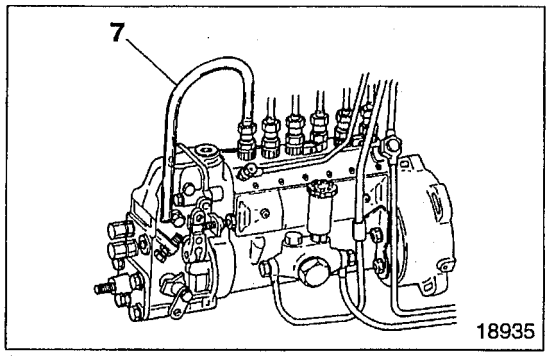


[Inspection]

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

CAUTION ⚠

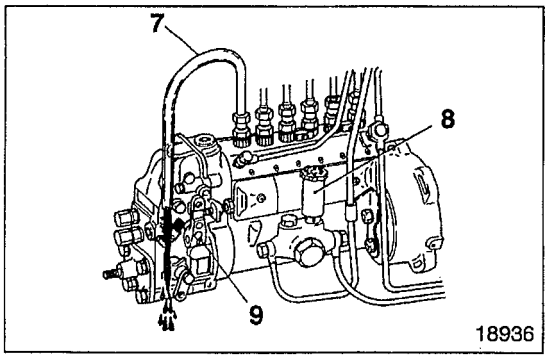
Place all parts in gas oil after removal to keep them free of dust.



- 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.

NOTE

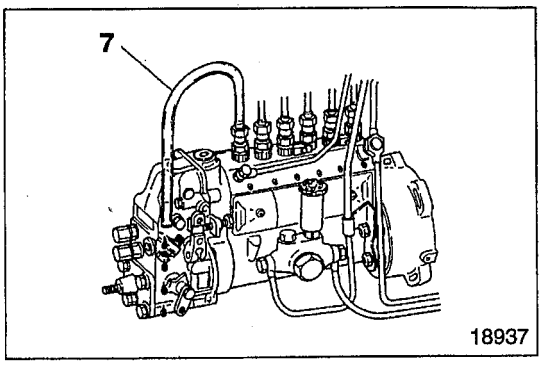
If the engine is turned in its reverse direction (when stopping the engine or by cranking), the automatic timer may stay in an advanced condition. This may not be cancelled by a slight forward rotation of the engine. Be sure to crank the engine forward manually by at least 180°.



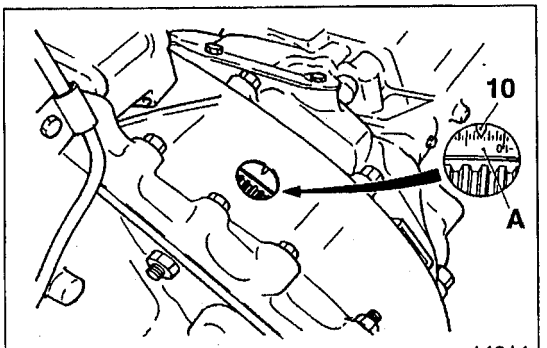
- Feed fuel into the injection pump using the priming pump **8**. With fuel flowing out of the injection pipe **7**, crank the engine slowly clockwise (as seen from the front of engine).

NOTE

Ensure that the stop lever 9 at the side of the governor is not in its STOP position.



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



- Check that the pointer **10** on the flywheel housing or torsional damper **B** indicates the value 1° earlier than the correct fuel injection timing.

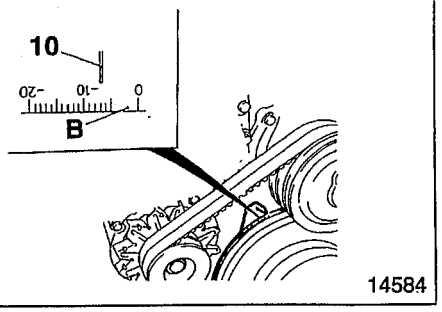
  A: Flywheel

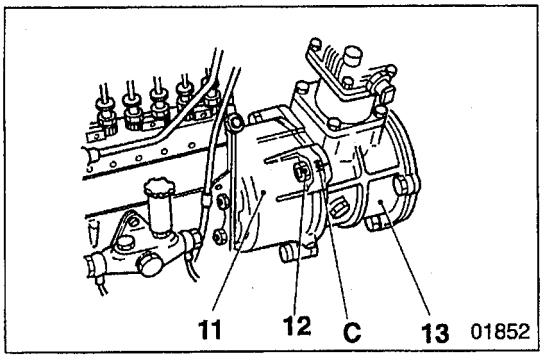
NOTE

- **The injection timing in this measurement becomes 1° earlier than the correct injection timing due to the inactivation of the delivery valve spring.**
- **The correct injection timing is indicated on the plate attached on the rocker cover.**

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

<With flywheel PTO>





[Adjustment]

- Loosen the nuts **12** that hold the timer case **11** onto the pump drive or air compressor **13**.
- If the fuel injection timing is overly retarded, incline the injection pump toward the crankcase.
- If the fuel injection timing is overly advanced, incline the injection pump away from the crankcase.

NOTE

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

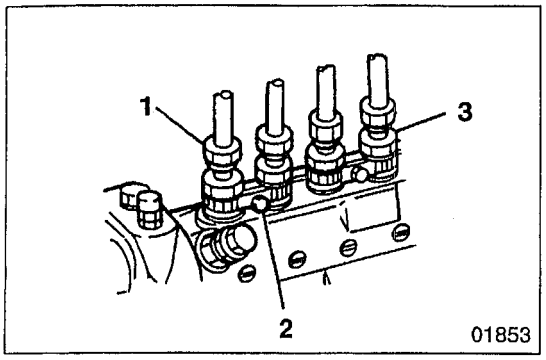
- Tighten the nuts **12**, then check the fuel injection timing again.

NOTE

If the fuel injection timing is so far out of specification that adjustment with the injection pump is not possible, the engine timing gear and injection pump drive gear may not be meshing correctly. If this occurs, remove and refit the air compressor or injection pump drive.

- **Air compressor:** 🕮 Gr. 61
- **Injection pump drive:** 🕮 P.13A-40

- After checking that the fuel injection timing is up to specification, fit the delivery valve **6**, delivery valve spring **5**, and stopper **4**.



- Tighten each part to its specified torque.

<6D16-TLE>

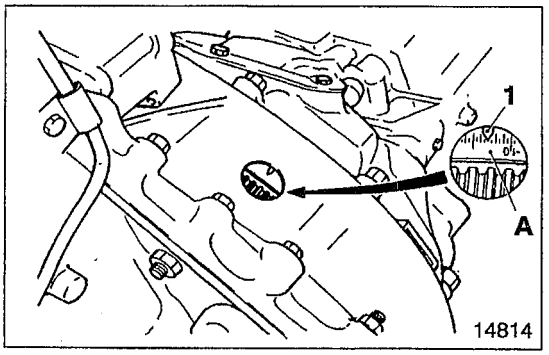
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
—	Fuel injection timing (BTDC)	Depends on specifications	—	Adjust

ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Bolt	59 to 64 {6 to 6.5}	—

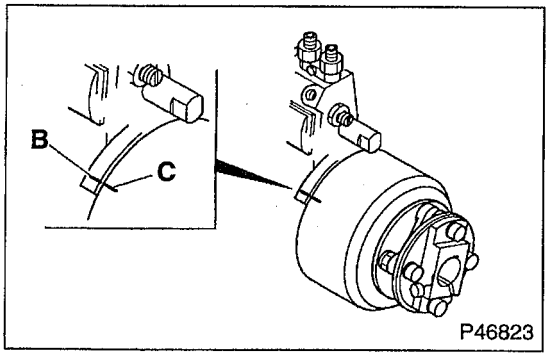


[Inspection]

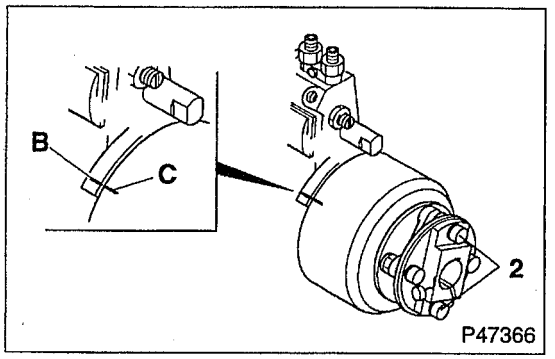
- Turn the crankshaft by 180° or more in the forward direction to bring cylinder No. 1 to TDC on its compression stroke. Set the injection timing by aligning the specified value shown on scale **A** stamped on the periphery of the flywheel with pointer **1** on the flywheel housing.

CAUTION ⚠

If the engine is turned in reverse while the engine is stationary, the automatic timer can move to an advanced position. To return the automatic timer to a normal position, it may be necessary to manually rotate the engine forward by 180° or more.



- The injection timing is correct if line **B** inscribed in the injection pump aligns with line **C** inscribed in the automatic timer.
- If out of alignment, adjust using the following procedures.



[Adjustment]

- Loosen adjusting bolt **2**. Turn the automatic timer to align line **B** with line **C**.
- Tighten adjusting bolt **2** to the specified torque.
- Repeat the injection timing inspection.

CAUTION ⚠

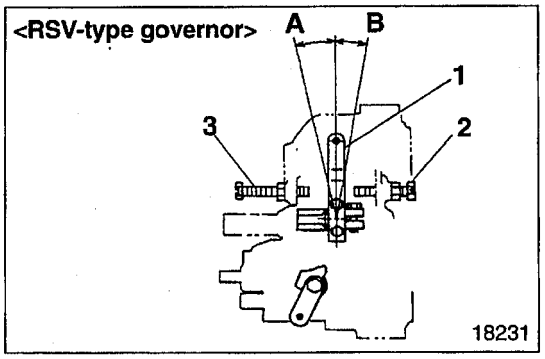
Only adjusting bolt 2 should be loosened.

2. Checking and Adjusting Minimum and Maximum No-load Speeds

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
—	No-load minimum speed	Depends on specifications	—	Adjust
—	No-load maximum speed	Depends on specifications	—	Adjust

Start the engine and allow it to warm up before carrying out the following inspections.

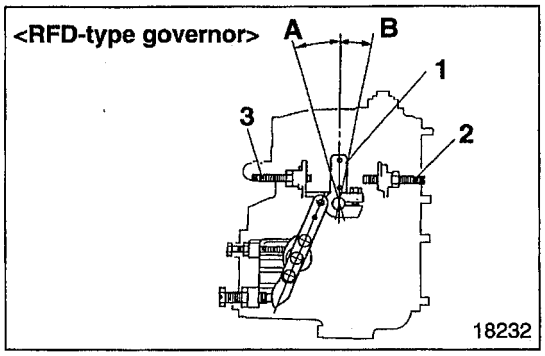


● **No-load minimum speed**

[Inspection]
Confirm that the control lever **1** is touching the idling set bolt **3**. Then check that the minimum speed is up to specification.

A: Idling position

[Adjustment]
If the minimum speed is out of specification, adjust it using the idling set bolt **3**.



● **No-load maximum speed**

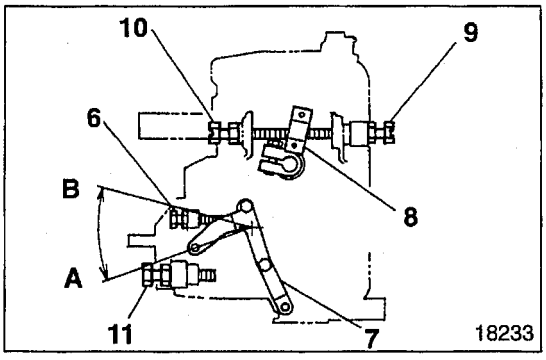
[Inspection]
Confirm that the control lever **1** is touching the full-speed set bolt **2**. Then, check that the maximum speed is up to specification.

B: Full-speed position

[Adjustment]
If the maximum speed is out of specification, adjust it using the full-speed set bolt **2**.

NOTE

Check that the engine does not stall and that no hunting occurs when the control 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.



● **No-load minimum speed**

[Inspection]
Confirm that the load control lever **7** is touching the idling set bolt **6**. Then check that the minimum speed is up to specification.

A: Idling position

[Adjustment]
If the minimum speed is out of specification, adjust it using the idling set bolt **6**.

● **No-load maximum speed**

[Inspection]
Move the load control lever **7** to the full-load position **B**. Then, check that the maximum speed is up to specification.

[Adjustment]
If the maximum speed is out of specification, adjust position of the speed control lever **8** using the maximum speed stopper bolt **9** and stopper bolt **10**.

NOTE

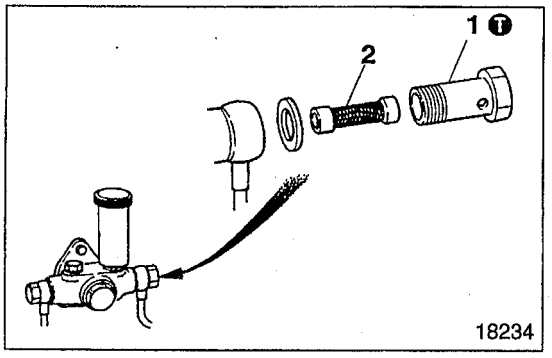
- **Do not alter the position of the full-load stopper bolt 11.**
- **Check that the engine does not stall and that no hunting occurs when the load control lever 7 is moved quickly from the full-load position to the idling position. If any abnormality is apparent, make adjustments within the specified range.**

3. Cleaning Fuel Feed Pump Gauze Filter

❶ Tightening torques

Unit: N·m {kgf·m}

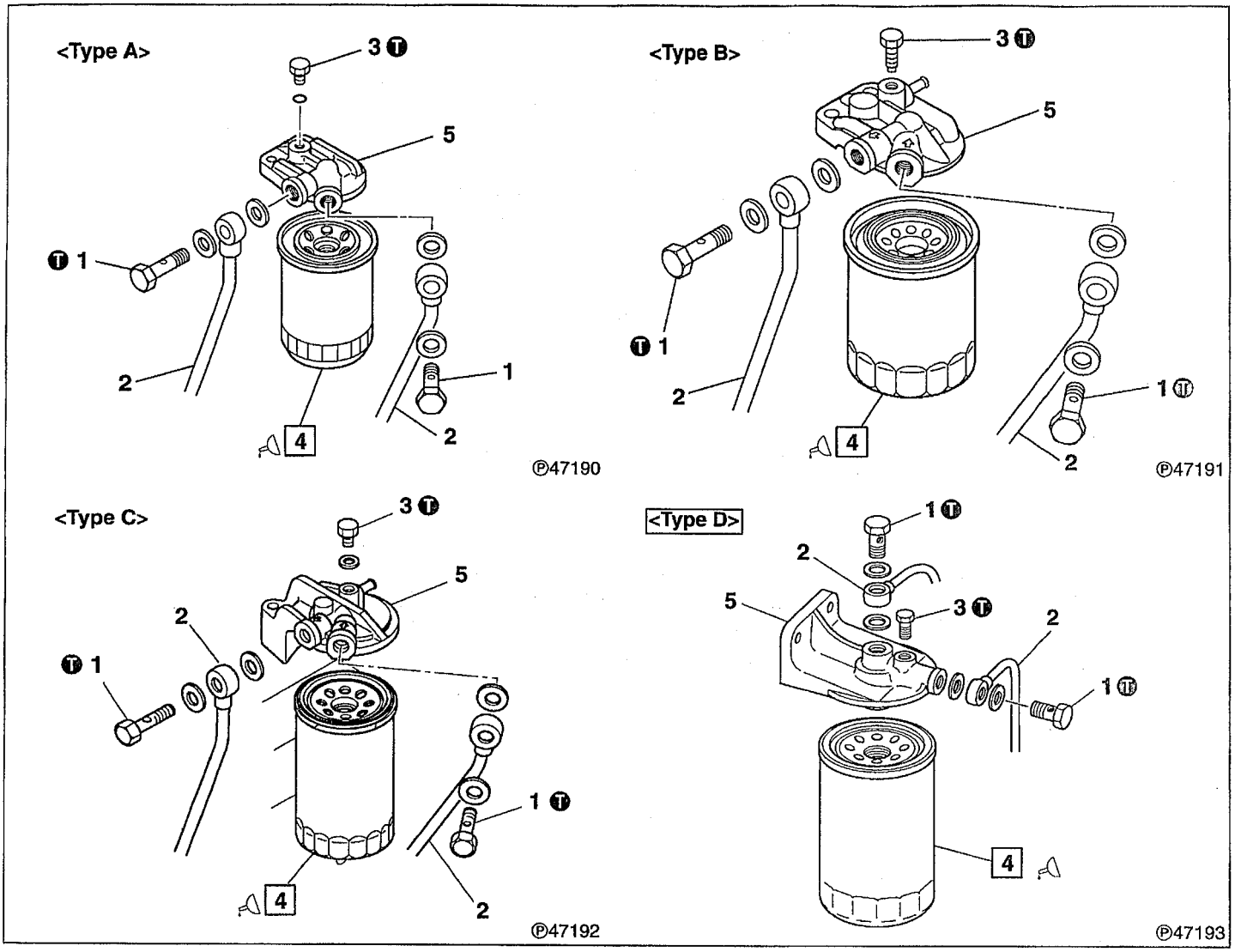
Location	Parts to be tightened		Tightening torque	Remarks
1	Eyebolt	BOSCH AUTOMOTIVE SYSTEMS	20 to 25 {2 to 2.5}	—
		DENSO	15 to 20 {1.5 to 2}	—



- Remove the eyebolt **1** from the suction port side of the fuel feed pump.
- Remove the gauze filter **2** from the eyebolt **1**.
- Clean the gauze filter **2**.
- Refit the gauze filter **2** and eyebolt **1** in the opposite order to their removal.
- Bleed all air out of the fuel system.
- Start the engine and check for fuel leaks.

MEMO

FUEL FILTER



● **Disassembly sequence**

1 Eyebolt
2 Fuel pipe
3 Air vent plug
4 Fuel filter
5 Fuel filter head

● **Assembly sequence**

Reverse the order of disassembly.

T Tightening torques

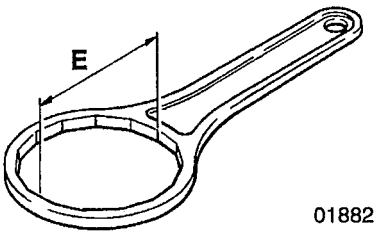
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt	34 {3.5}	—
3	Air vent plug	9.8 ± 2.0 {1 ± 0.2}	—

Lubricant

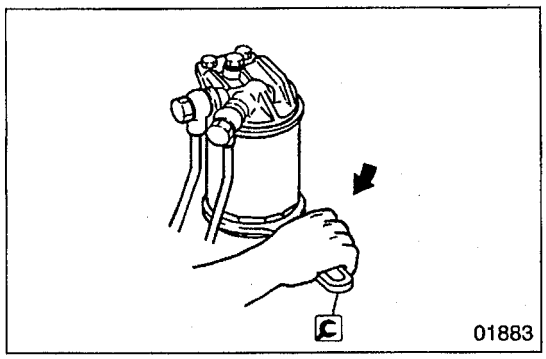
Location	Points of application	Specified lubricant	Quantity
4	Gasket between fuel filter and fuel filter head	Engine oil	As required

Special tools

Location	Tool name and shape	Part No.	Application
4	Filter Wrench Part No. / E / Filter model MH061509 / 90.2 / A, B MH061572 / 94.2 / C, D  01882	MH061509 MH061572	Removing fuel filter

◆ Service procedure

4 Fuel filter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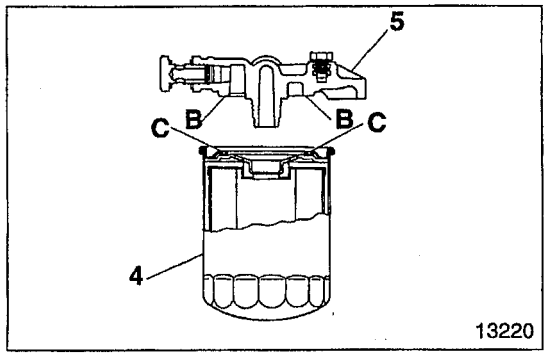
[Removal]

WARNING ⚠

- **Fuel is highly flammable; keep it away from flames and sources of heat.**
- **To minimize the risk of fire, wipe up any spilled fuel.**



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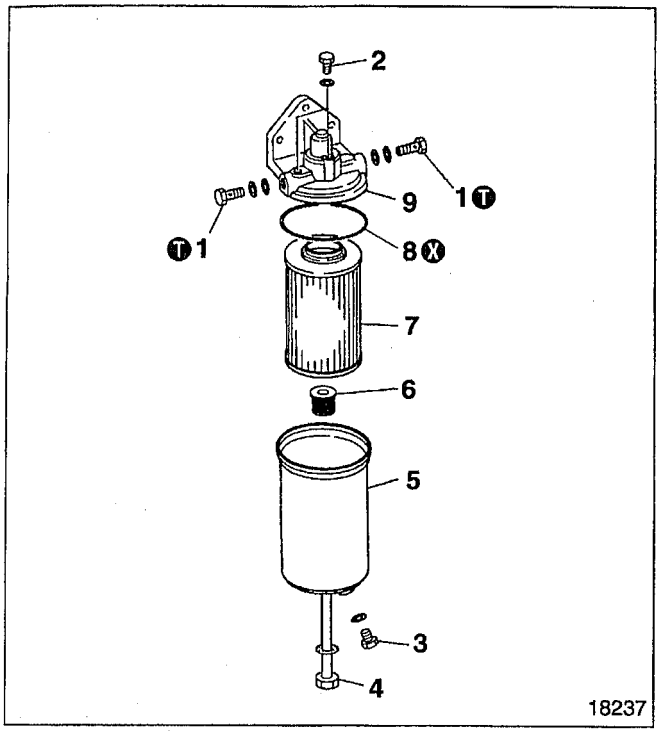
[Installation]

WARNING ⚠

Use of an unsuitable fuel filter 4 can lead to fuel leaks and fires. Be sure to use a genuine Mitsubishi filter.

- To fit the fuel filter **4**, turn it until the gasket **C** touches surface **B** of the fuel filter head **5**. 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.

SECONDARY FUEL FILTER



● **Disassembly sequence**

1 Eyebolt
2 Air vent plug
3 Drain plug
4 Center bolt
5 Case
6 Spring
7 Element
8 O-ring
9 Fuel filter head

Ⓧ: Non-reusable part

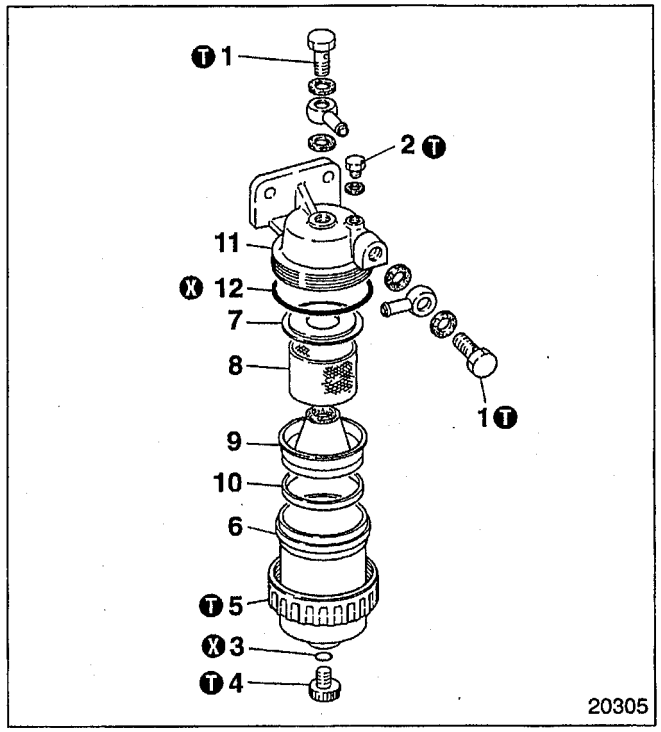
● **Assembly sequence**

Reverse the order of disassembly.

Ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt	34 {3.5}	—



● **Disassembly sequence**

1 Eyebolt
2 Air vent plug
3 O-ring
4 Drain plug
5 Rlng nut
6 Case
7 Isolation plate
8 Screen assembly
9 Baffle plate
10 Water level ring
11 Head
12 O-ring

X : Non-reusable part

WARNING ⚠

- **Fuel ignites easily. Do not get it near flame or heat.**
- **Wipe up any spilled gas oil because it can cause a fire.**

● **Assembly sequence**

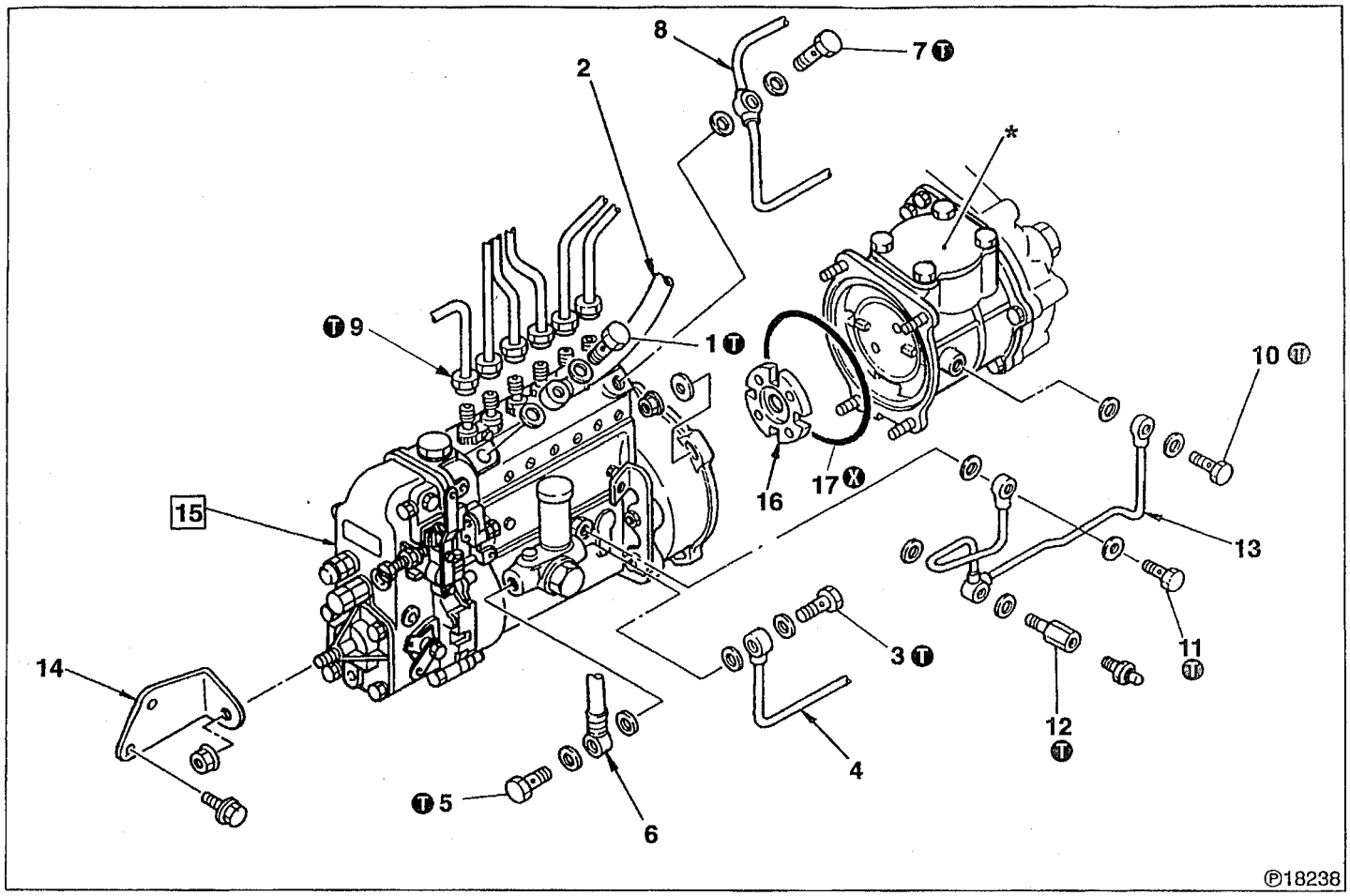
Reverse the order of disassembly.

T Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt	34 {3.5}	—
2	Air vent plug	7.8 to 12 {0.8 to 1.2}	—
4	Drain plug	2.9 to 3.9 {0.3 to 0.4}	—
5	Ring nut	5.9 to 7.8 {0.6 to 0.8}	—

INJECTION PUMP <Oldham's Coupling Type>



● **Disassembly sequence**

1 Eyebolt
2 Fuel feed hose
3 Eyebolt
4 Fuel suction pipe
5 Eyebolt
6 Fuel feed hose
7 Eyebolt
8 Fuel return pipe
9 Injection pipe
10 Eyebolt
11 Eyebolt
12 Connector
13 Oil pipe
14 Injection pump stay
15 Injection pump assembly
16 Driving disk
17 O-ring

*: Injection pump drive
📖 P.13A-40,
or air compressor 📖 Gr. 61
X: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

WARNING ⚠

- **Fuel is highly flammable; keep it away from flames and sources of heat.**
- **To minimize the risk of fire, wipe up any spilled fuel.**

CAUTION ⚠

Dirt particles in the injection pump assembly 15 can seriously detract from engine performance. To prevent the ingress of dirt, cover all pipes, hoses, and other parts after removal.

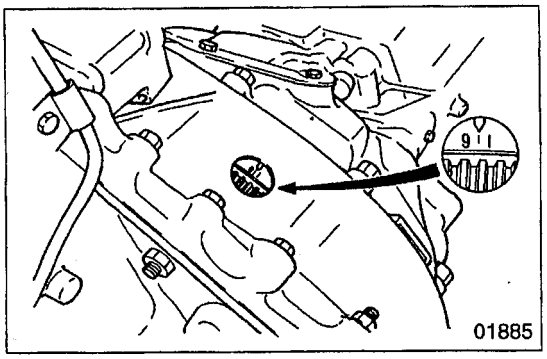
NOTE

For maintenance of the injection pump assembly 15, please contact a BOSCH AUTOMOTIVE SYSTEMS service station or DENSO service station.

❶ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened		Tightening torque	Remarks
1, 7	Eyebolt (fuel feed hose, fuel return pipe)	BOSCH AUTOMOTIVE SYSTEMS	20 to 29 {2 to 3}	—
		DENSO	15 to 20 {1.5 to 2}	—
3, 5	Eyebolt (fuel suction pipe, fuel feed hose)	BOSCH AUTOMOTIVE SYSTEMS	20 to 25 {2 to 2.5}	—
		DENSO	15 to 20 {1.5 to 2}	—
9	Injection pipe union nut		25 {2.5}	—
10	Eyebolt (oil pipe; air compressor or pump drive side)		21 {2.1}	—
11	Eyebolt (oil pipe; injection pump side)	BOSCH AUTOMOTIVE SYSTEMS	10 to 13 {1 to 1.3}	—
		DENSO	7.8 to 13 {0.8 to 1.3}	—
12	Connecter (oil pipe)		21 {2.1}	—



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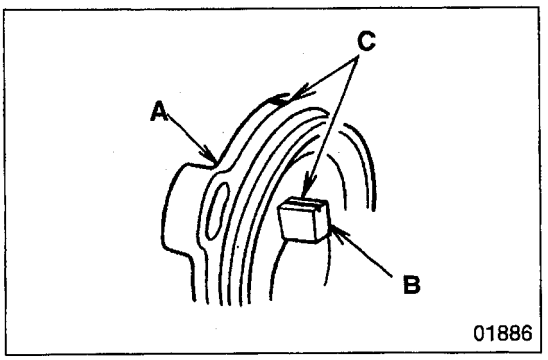

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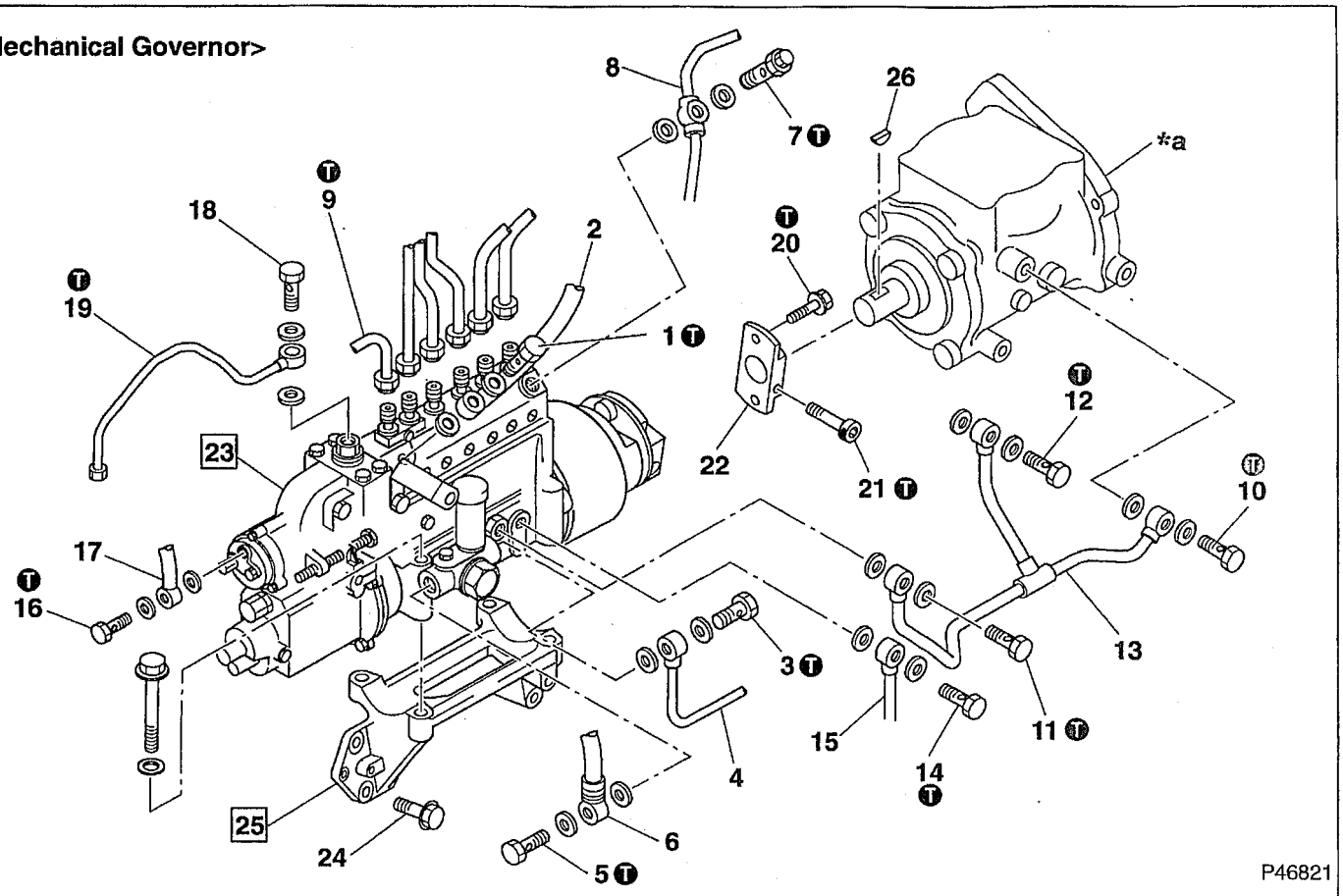
◆ Service procedure

15 Installing injection pump assembly

- Bring cylinder No. 1 of the engine to the TDC position of its compression stroke.
- Align the inscribed lines **C** on the timer case **A** and timer **B**. Then, fit the injection pump assembly **15** onto the air compressor or injection pump drive.

INJECTION PUMP <Laminated Coupling Type>

<Mechanical Governor>



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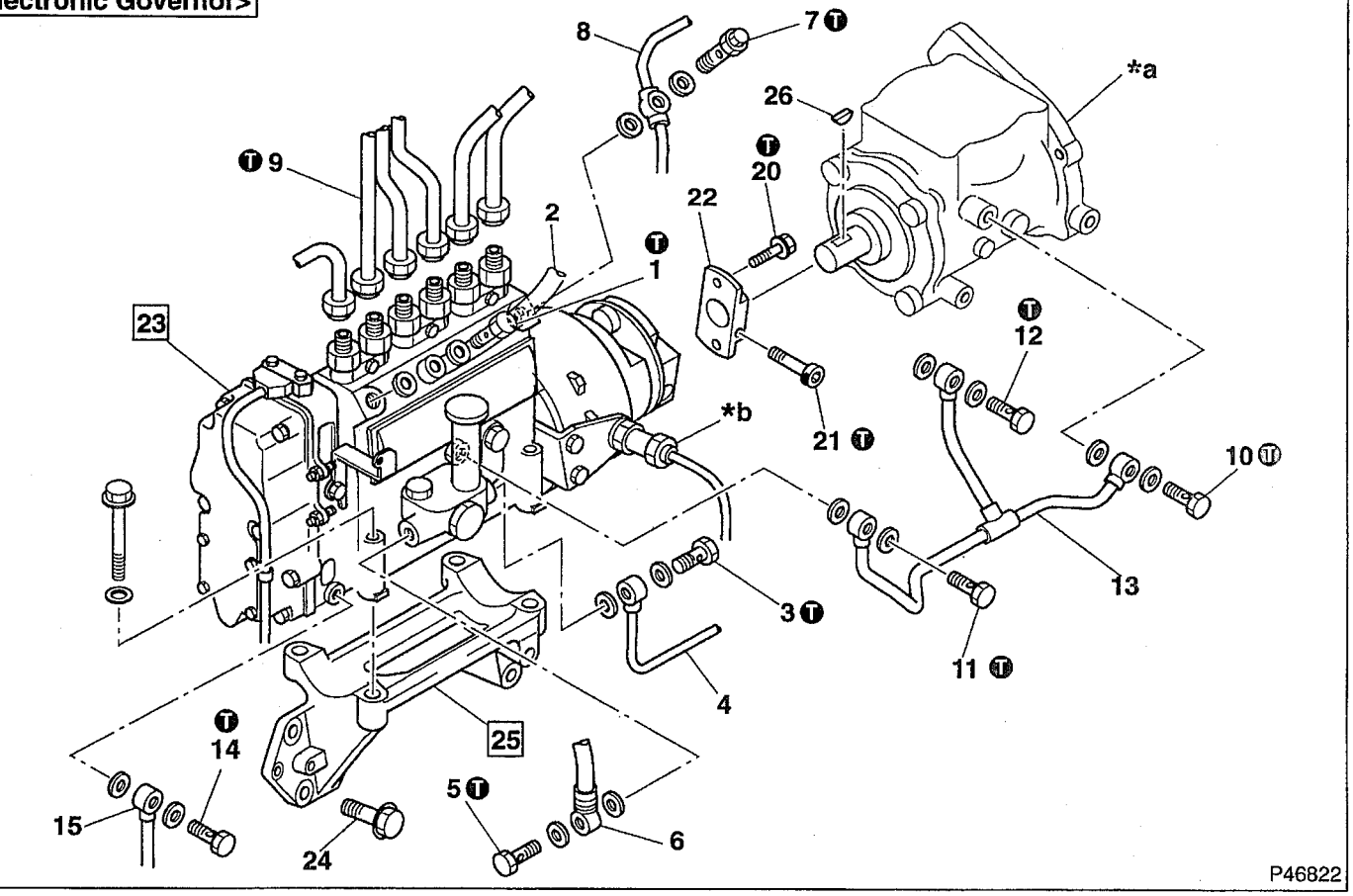
<Electronic Governor>



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● **Disassembly sequence**

1 Eye bolt
2 Fuel feed hose
3 Eye bolt
4 Fuel suction pipe
5 Eye bolt
6 Fuel feed hose
7 Eye bolt
8 Fuel return pipe
9 Injection pipe
10 Eye bolt
11 Eye bolt
12 Eye bolt
13 Oil pipe
14 Eye bolt
15 Oil return pipe
16 Eye bolt (mechanical governor)
17 Boost hose (mechanical governor)
18 Eye bolt (mechanical governor)
19 Oil pipe (mechanical governor)
20 Bolt
21 Cotter bolt
22 Driving coupling
23 Injection pump assembly
24 Bolt
25 Injection pump bracket
26 Key

*a: Injection pump drive 🕮 P.13A-44 or air compressor 🕮 Gr. 61
*b: Engine speed sensor 🕮 Gr. 13E
Ⓧ: Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

CAUTION ⚠

- **Fuel is highly flammable; keep it away from flames and sources of heat.**
- **To minimize the risk of fire, wipe up any spilled fuel.**
- **For maintenance of the injection pump assembly 23, please contact a Bosch Automotive Systems service station or Denso service station.**
- **Dirt particles in the injection pump assembly 23 can seriously detract from engine performance. To prevent the ingress of dirt, cover all pipes, hoses, and other parts after removal.**
- **Never carry around the injection pump assembly 23 by holding it at the lever or the engine speed sensor *b. Removing the lever may result in deteriorated pump performance.**
- **Do not remove the injection pump bracket 25 unless it is faulty.**

INJECTION PUMP <Laminated Coupling Type>

Service standards

Unit: mm

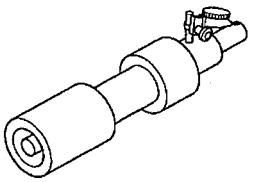
Location	Maintenance item	Standard value	Limit	Remedy
—	Fuel injection timing (BTDC)	Depends on specifications	—	Adjust
25	Injection pump bracket (eccentricity between injection pump centering tool and injection pump drive or air compressor crankshaft)	0.2	—	Adjust

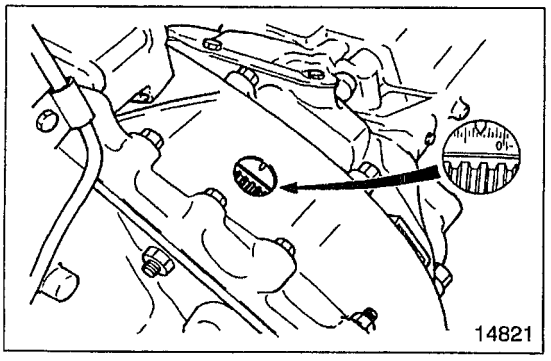
Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened		Tightening torque	Remarks
1, 7	Eye bolt (for fitting fuel feed hose and fuel return pipe)		20 to 29 {2 to 3}	—
3, 5	Eye bolt (for fitting fuel suction pipe and fuel feed hose)		20 to 25 {2 to 2.5}	—
9	Injection pipe (for fitting union nut)		25 {2.5}	—
10	Eye bolt (for fitting oil pipe on either injection pump drive or air compressor side)		20.6 {2.1}	—
11	Eye bolt (for fitting oil pipe on injection pump side)		10 to 13 {1 to 1.3}	—
12	Eye bolt (for fitting oil pipe on crankcase side)		20.6 {2.1}	—
14	Eye bolt (for fitting oil return pipe)	Mechanical governor	20 to 25 {2 to 2.5}	—
		Electronic governor	20 to 29 {2 to 3}	—
16	Eye bolt (for fitting boost hose)		10 to 13 {1 to 1.3}	—
19	Oil pipe		25 {2.6}	—
20	Bolt (for fitting driving coupling)		59 to 64 {6 to 6.5}	—
21	Cotter bolt		83 to 93 {8.5 to 9.5}	—

Special tools

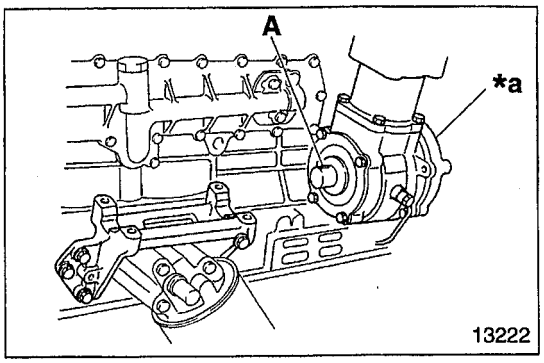
Location	Tool name and shape	Part No.	Application
25	Injection Pump Centering Tool  ⓟ13221	MH063393	Locating injection pump bracket



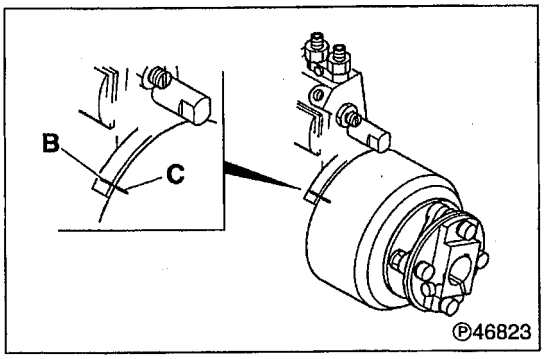
◆ Service procedure

23 Installing injection pump assembly

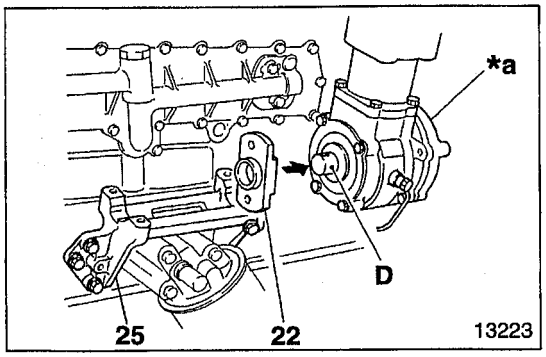
- Crank the engine to set cylinder No. 1 at the specified injection timing position.



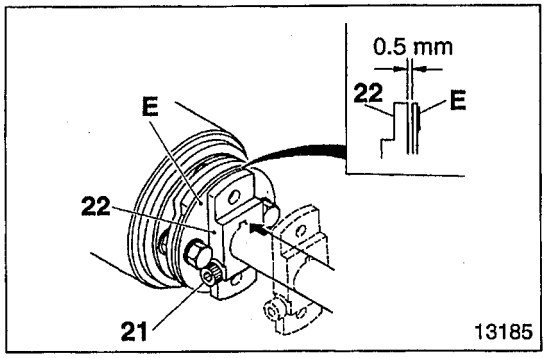
- Ensure that the key way **A** on the injection pump drive or air compressor (***a**) crankshaft is facing upwards.
- If key way **A** is not facing upwards, rotate the engine crankshaft by one turn.



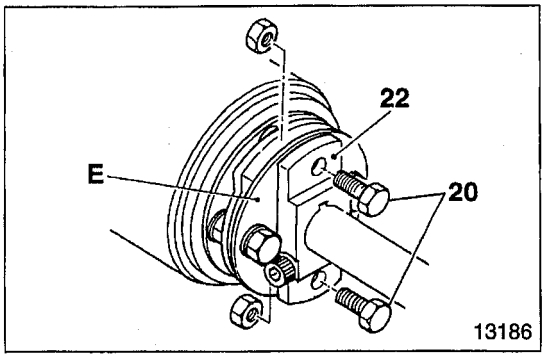
- Align line **B** inscribed on the injection pump and line **C** inscribed on the automatic timer.



- Fit driving coupling **22** to the injection pump drive or air compressor ***a** crankshaft **D**. Push the driving coupling against the injection pump drive or air compressor crankshaft **D**.
- Fit injection pump assembly **23** to injection pump bracket **25**.

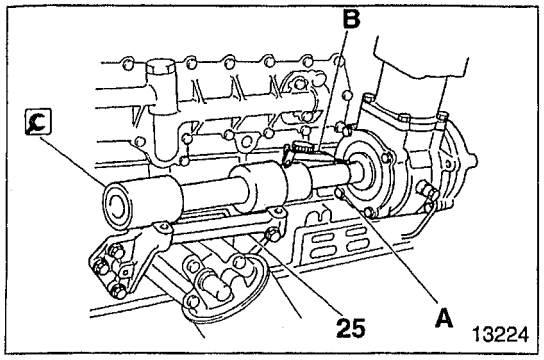


- Set driving coupling **22** apart from coupling plate **E** by 0.5 mm as shown in the illustration. Tighten cotter bolt **21** to the specified torque.



- Using bolts **20**, fit driving coupling **22** and coupling plate **E**.

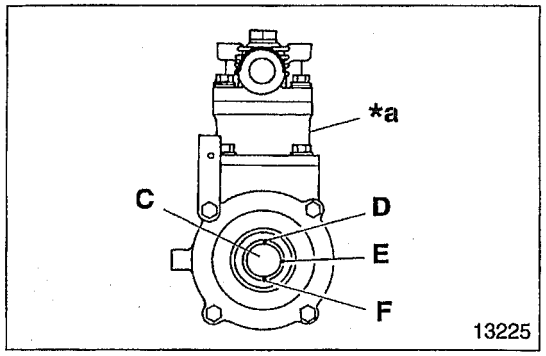
INJECTION PUMP <Laminated Coupling Type>



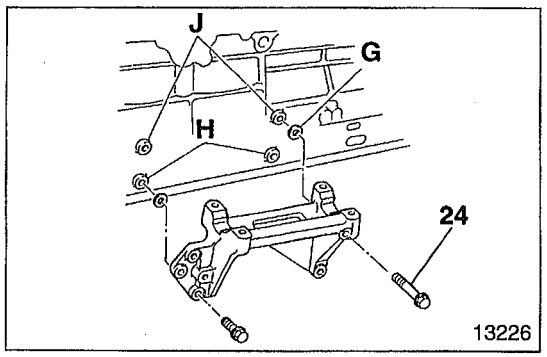
25 Injection pump bracket

[Inspection]

- Set dial gauge **B** at rod **A** of C Injection Pump Centering Tool for zero-point correction.



- Slide dial gauge **B** against the injection pump drive or the air compressor ***a** and measure the eccentricity between rod **A** and the crankshaft **C** of the injection pump drive or the air compressor at **D**, **E** and **F**.
- If one of the measurements exceeds the specified value, adjust as follows.



[Adjustment]

- When the measured value at point **E** is higher than the standard value: Insert shims **G** into four points equally.
- When the measured value at point **D** is higher than the standard value: Insert shims **G** into lower side **H**.
- When the measured value at point **F** is higher than the standard value: Insert shims **G** into upper side **J**.

CAUTION

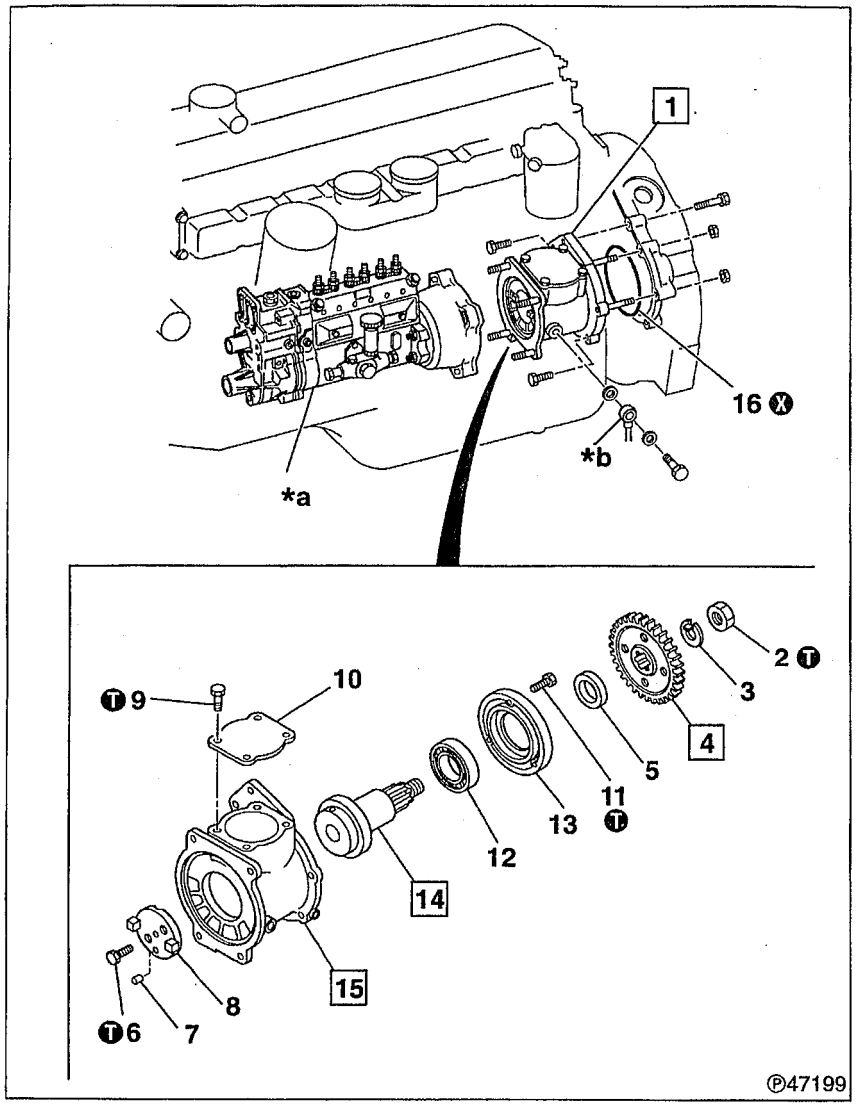
Insert shims G observing the following conditions:

- **Number of shims per point is three or less.**
- **The same number of shims should be used for the front and the rear.**
- **The difference in number of shims used for bottom and top is none or one.**

- Tighten bolts **24** to the specified torque and repeat the inspection.

MEMO

INJECTION PUMP DRIVE <Oldham's Coupling Type>



● **Disassembly sequence**

1 Injection pump drive assembly
2 Nut
3 Lock washer
4 Drive gear
5 Collar
6 Bolt
7 Pin
8 Coupling
9 Bolt
10 Cover
11 Bolt
12 Bearing
13 Bearing holder
14 Shaft
15 Pump drive case
16 O-ring

***a**: Injection pump assembly P.13A-32
***b**: Oil pipe P.13A-32

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item	Standard value	Limit	Remedy
14	Shaft end play	—	0.59	Replace
14, 15	Shaft-to-pump drive case clearance	—	0.12	Replace pump drive case

ⓣ Tightening torques

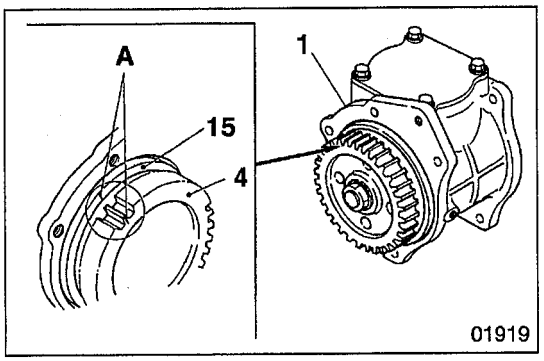
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt	21 {2.1}	—
2	Nut (drive gear mounting)	167 to 211 {17 to 21.5}	—
6	Bolt (coupling mounting)	30 to 36 {3.1 to 3.7}	—
9	Bolt (cover mounting)	25 to 29 {2.5 to 3}	—
11	Bolt (bearing holder mounting)	5.9 to 6.9 {0.6 to 0.75}	—

Lubricant

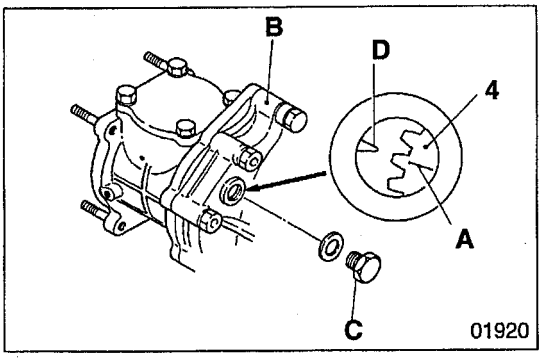
Location	Points of application	Specified lubricant	Quantity
16	O-ring	Engine oil	As required

◆ Service procedure

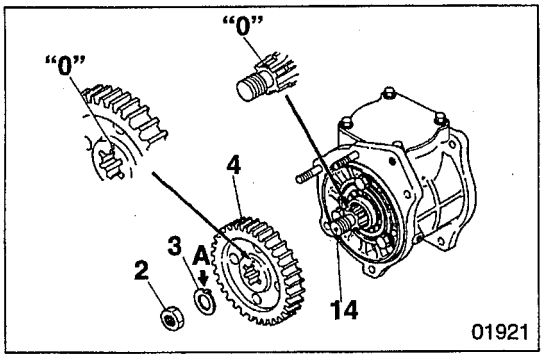


1 Installing injection pump drive assembly

- Bring cylinder No. 1 of the engine to the TDC position of its compression stroke. 🕮 Gr. 11
- Align the inscribed line **A** on the drive gear **4** of the injection pump drive assembly **1** with the inscribed line **A** on the pump drive case **15**.

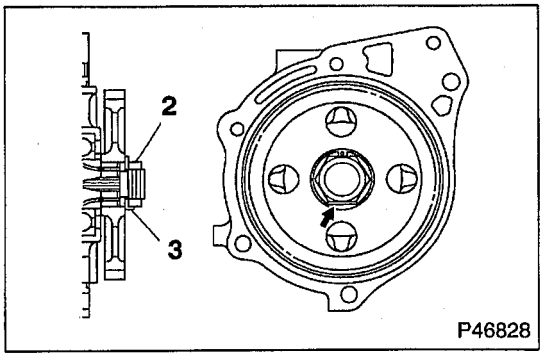


- Remove the plug **C** from the flywheel housing **B**, then check that the inscribed line **A** on the drive gear **4** is aligned with the pointer **D**. If the line and pointer are not aligned, remove and refit the injection pump drive assembly.



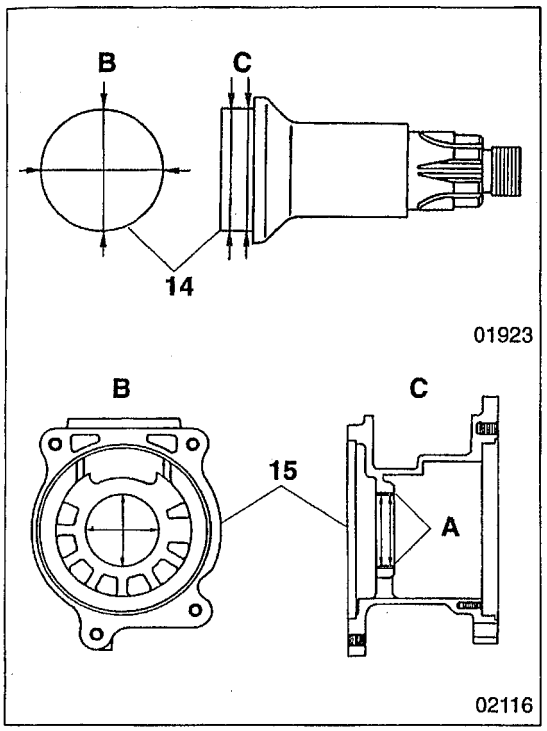
4 Installing drive gear

- Fit the drive gear **4** such that its "0" alignment mark is aligned with the "0" alignment mark on the shaft **14**. Then, fit the lock washer **3** such that its notch **A** is aligned with the drive gear alignment mark, and tighten the nut **2** to the specified torque.



- When the assembly is complete, bend the lock washer **3** down onto the nut **2**.

INJECTION PUMP DRIVE <Oldham's Coupling Type>



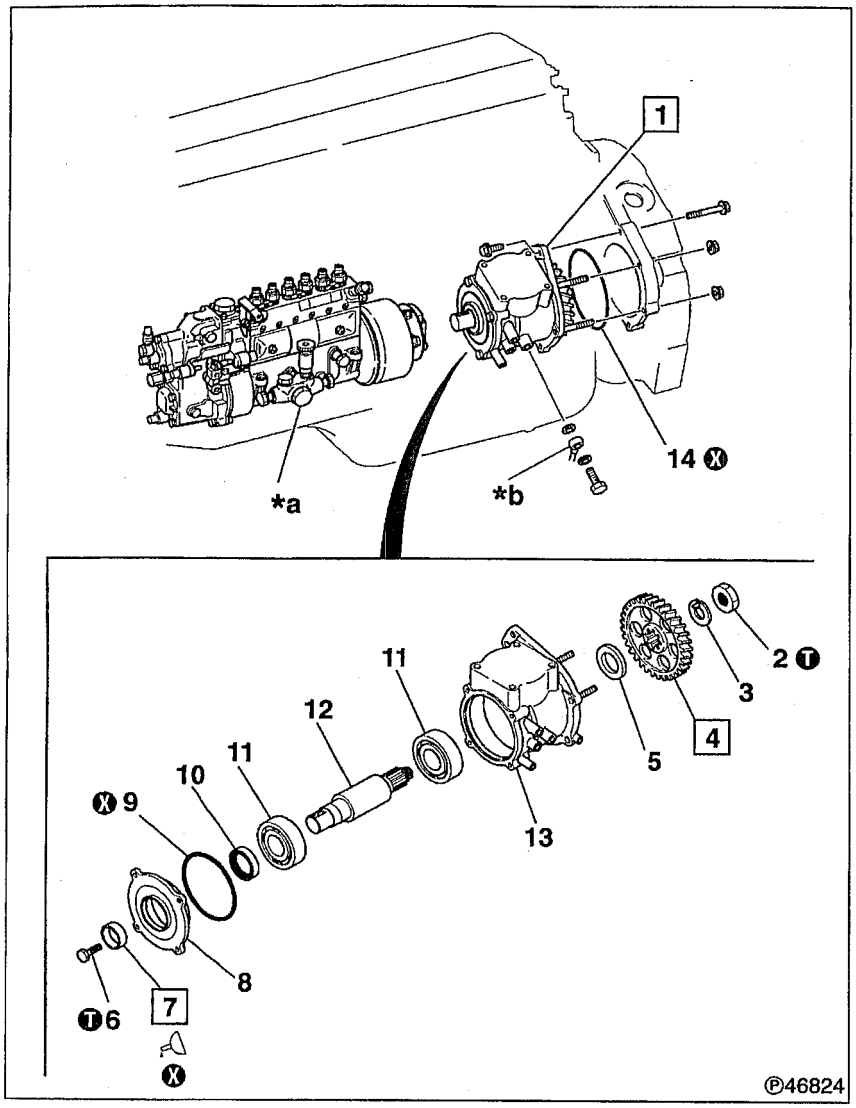
14 15 Shaft-to-pump drive case clearance

If the clearance exceeds the specified limit, replace the pump drive case **15**.

A: Bushing
B: Measurement directions
C: Measurement positions

MEMO

INJECTION PUMP DRIVE <Laminated Coupling Type>



● **Disassembly sequence**

1 Injection pump drive assembly
2 Nut
3 Lock washer
4 Drive gear
5 Collar
6 Bolt
7 Oil seal
8 Bearing holder
9 O-ring
10 Sleeve
11 Bearing
12 Shaft
13 Pump drive case
14 O-ring

***a**: Injection pump assembly P.13A-34
***b**: Oil pipe P.13A-34

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm

Location	Maintenance item	Standard value	Limit	Remedy
12	Shaft end play	—	0.59	Replace

T Tightening torques

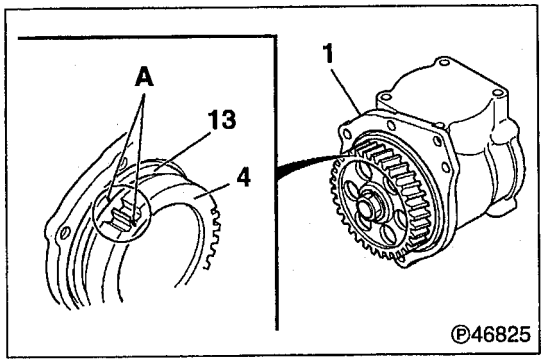
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Nut (drive gear mounting)	167 to 211 {17 to 21.5}	—
6	Bolt (bearing holder mounting)	13.7 to 17.7 {1.4 to 1.8}	—

Lubricant

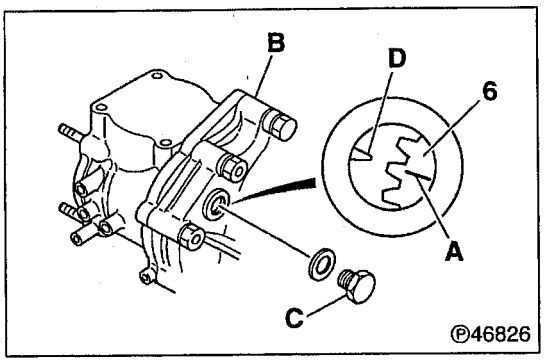
Location	Points of application	Specified lubricant	Quantity
14	O-ring	Engine oil	As required

◆ Service procedure

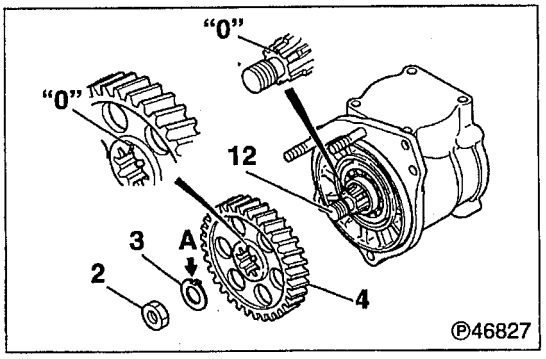


1 Installing injection pump drive assembly

- Set cylinder No. 1 of the engine at TDC on the compression stroke. Gr. 11
- Align line **A** inscribed on drive gear **4** of injection pump drive assembly **1** with line **A** inscribed on pump drive case **13**.

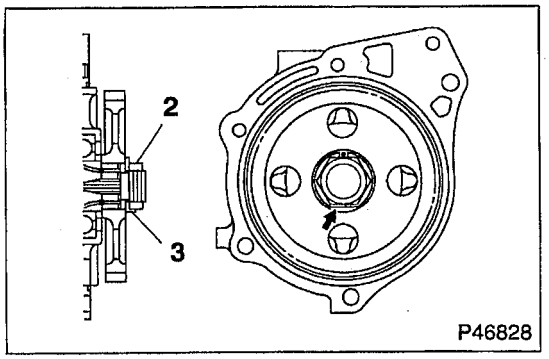


- Remove plug **C** from flywheel housing **B**. Check if line **A** inscribed on drive gear **4** is aligned with pointer **D**. If not, remove and refit injection pump drive assembly **1** to obtain the alignment.

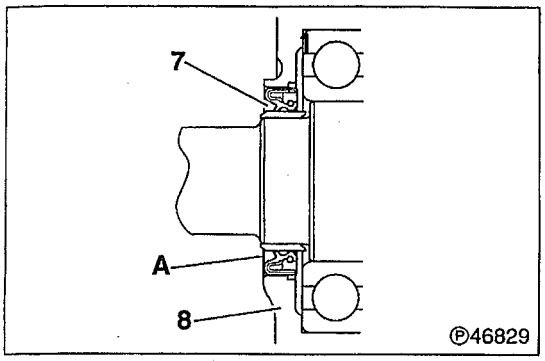


4 Installing drive gear

- Install drive gear **4** such that its "0" alignment mark is aligned with the "0" alignment mark on shaft **12**.
- Fit lock washer **3** such that its notch **A** is aligned with the "0" alignment mark on drive gear **4**. Tighten nut **2** to the specified torque.



- After the drive gear is installed, bend lock washer **3** over nut **2**.

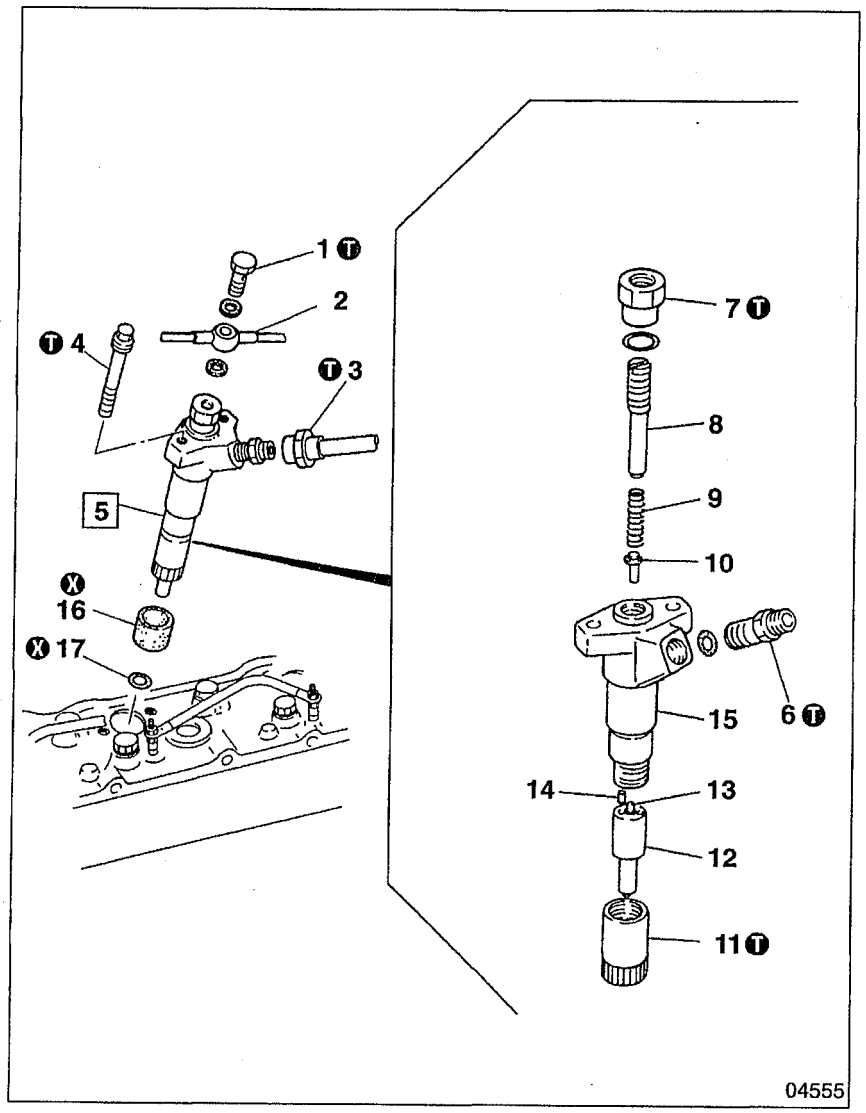


7 Installing oil seal

Face oil seal **7** as shown in the illustration. Then, fit it in bearing holder **8** by pressing evenly until it is flush with the end face **A** of the holder.

MEMO

INJECTION NOZZLE <1-spring Type>



● **Pre-disassembly Inspection**

P.13A-49

● **Disassembly sequence**

1 Eyebolt
2 Fuel leak-off pipe
3 Injection pipe
4 Bolt
5 Injection nozzle assembly
6 Connector
7 Cap nut
8 Adjusting screw
9 Spring
10 Push rod
11 Retaining nut
12 Nozzle
13 Needle valve
14 Pin
15 Nozzle holder
16 Dust seal
17 Gasket

Ⓧ: Non-reusable part
Repair kit : Nozzle Service Kit (for BOSCH AUTOMOTIVE SYSTEMS nozzles only)

● **Assembly sequence**

Reverse the order of disassembly.

WARNING ⚠

To minimize the risk of fire, wipe up any spilled fuel.

CAUTION ⚠

Under no circumstances change the needle valve 13 and nozzle 12 combination used in each injection nozzle assembly 5.

NOTE

- **Clean off any carbon deposits before disassembling, reassembling, or adjusting the injection nozzle assembly 5. 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.**
- **When fitting the injection nozzle assembly 5, tighten each of the two bolts 4 a little at a time.**

Service standards

Unit: mm

Location	Maintenance item	Standard value	Limit	Remedy
5	Injection pressure	17.7 $^{+0.49}_{0}$ MPa {180 $^{+5}_{0}$ kg/cm^2}	—	Adjust

Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened		Tightening torque	Remarks
1	Eyebolt (fuel leak-off pipe mounting)	BOSCH AUTOMOTIVE SYSTEMS	9.8 to 15 {1.0 to 1.5}	—
		DENSO	15 to 20 {1.5 to 2.0}	—
3	Injection pipe union nut		25 {2.5}	—
4	Bolt (injection nozzle mounting)	BOSCH AUTOMOTIVE SYSTEMS	15 {1.5}	—
		DENSO	12 to 14 {1.2 to 1.4}	—
6	Connector	BOSCH AUTOMOTIVE SYSTEMS	69 to 78 {7 to 8}	—
		DENSO	59 to 69 {6 to 7}	—
7	Cap nut		29 to 39 {3 to 4}	—
11	Retaining nut		59 to 78 {6 to 8}	—

Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
—	Nozzle Cleaning Tool	*105789-0010	Cleaning nozzles

* BOSCH AUTOMOTIVE SYSTEMS part number

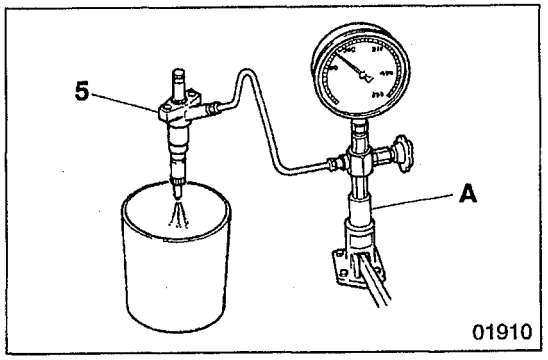
◆ Service procedure

● Pre-disassembly inspection

Fit the injection nozzle assembly **5** onto the nozzle tester **A** ready for inspection.

NOTE

Before commencing inspection, operate the lever on the nozzle tester A two or three times to bleed all air out of the arrangement.

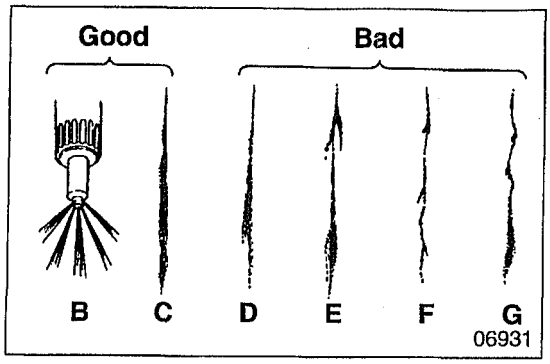


(1) Checking valve opening pressure

- Push down the lever on the nozzle tester **A** at a rate of 1–2 seconds per stroke. 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 the adjusting screw **8**.
- If the measurement is still out of specification after adjustment, replace the injection nozzle assembly **5**.

WARNING ⚠

Do not touch the spray that comes out of the nozzle.



(2) Inspecting spray condition

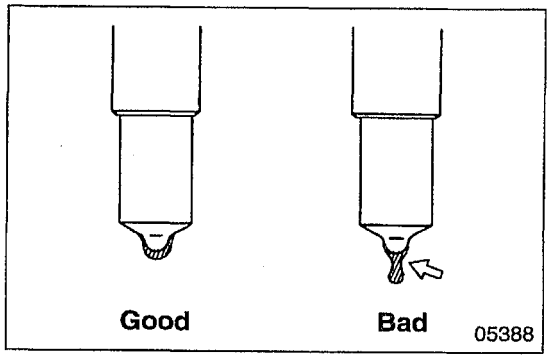
- Pump the lever on the nozzle tester **A** at a rate of about 1–2 seconds per stroke, and maintain a continuous spray.

  B: Even spray from all five injection orifices (Good)
  C: Even and symmetrical spray (Good)
  D: Asymmetrical spray (Bad)
  E: Branched spray (Bad)
  F: Thin spray (Bad)
  G: Irregular spray (Bad)

- If the spray is unsatisfactory, disassemble and clean the injection nozzle assembly **5**, then inspect the spray again. If the spray is still unsatisfactory, replace the injection nozzle assembly **5**.
- Check that no fuel drips from the nozzle after the spray is complete.

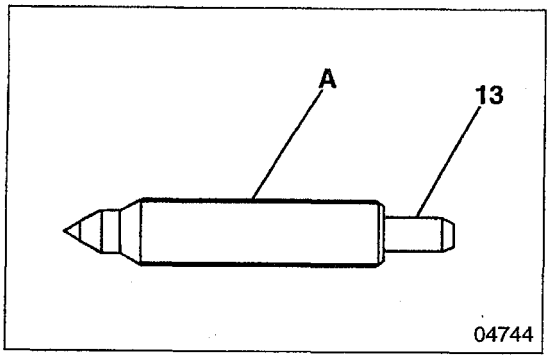
WARNING ⚠

Do not touch the spray that comes out of the nozzle.



(3) Inspecting for leaks

- Slowly increase the nozzle pressure to 1.96 MPa {20 kgf/cm^2} 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 the injection nozzle assembly **5** appears defective, disassemble and clean it, then inspect it again. If the injection nozzle assembly **5** still appears defective, it must be replaced.

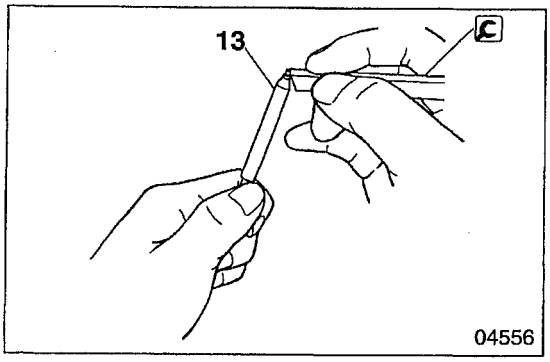


[5] Injection nozzle assembly

[Disassembly]

CAUTION ⚠

- **Do not touch the sliding parts A of the needle valve 7.**
- **Do not change the needle valve 13 and nozzle 12 combination on each cylinder.**



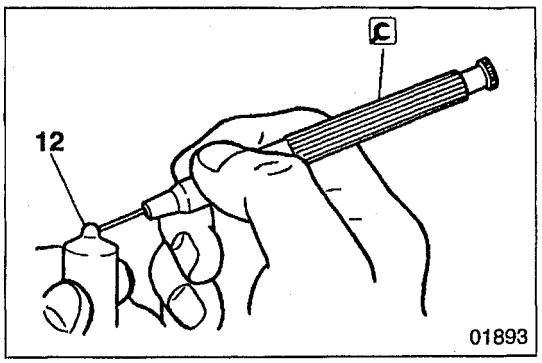
[Cleaning]

Wash the needle valve **13** and nozzle **12** in gas oil, then use the [C] Cleaning Tool Set to remove any carbon deposits in accordance with the following procedure.

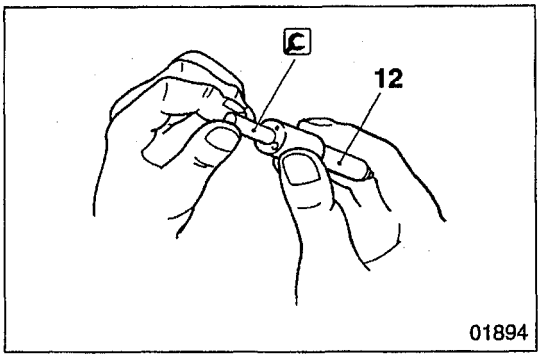
- Remove carbon from the end of the needle valve **13** using the Cleaning Bar of the [C] Cleaning Tool Set.

CAUTION ⚠

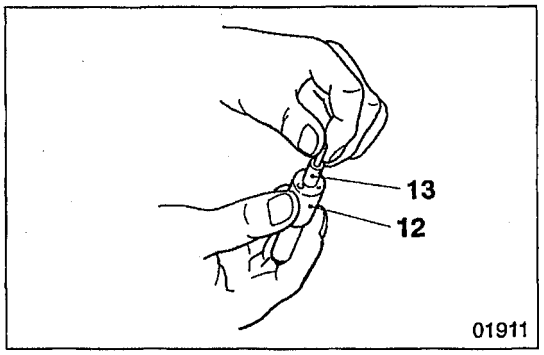
Do not use a wire brush or any hard metallic object for cleaning.



- Remove carbon from the injection orifice of the nozzle **12** using the Needle Cleaner of the [C] Cleaning Tool Set. Insert the Needle Cleaner and rotate it to dislodge the carbon.



- Clean the seat of the nozzle **12** using the Cleaning Scraper of the [C] Cleaning Tool Set.
- To remove burned and hardened carbon, use FUSO Carbon Remover.



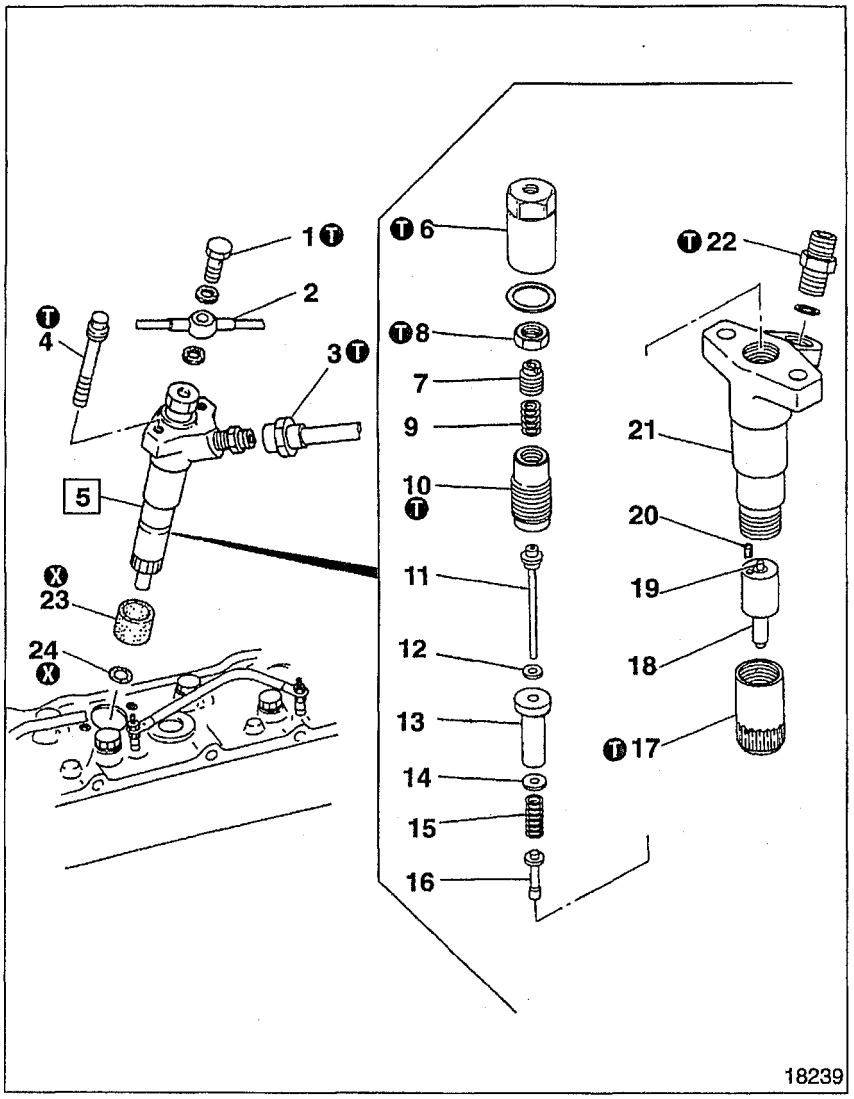
[Inspection]

- Wash the needle valve **13** and nozzle **12** in gas oil, then fit them together.
- Pull up the needle valve **13** 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 the needle valve **13** 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 **12** as a set.

NOTE

Whenever a nozzle 12 is replaced, the nozzle and needle valve 13 must be replaced as a set using Nozzle Service Kit. (This applies to BOSCH AUTOMOTIVE SYSTEMS products only.)

INJECTION NOZZLE <2-spring Type: BOSCH AUTOMOTIVE SYSTEMS>



● **Pre-disassembly inspection**

P.13A-54

● **Disassembly sequence**

1 Eyebolt
2 Fuel leak-off pipe
3 Injection pipe
4 Bolt
5 Injection nozzle assembly
6 Cap nut
7 Adjusting screw
8 Lock nut
9 2nd spring
10 Set screw
11 2nd push rod
12 Shim (for adjusting prelift)
13 Spacer
14 Shim (for adjusting valve opening pressure)
15 1st spring
16 1st push rod
17 Retaining nut
18 Nozzle
19 Needle valve
20 Pin
21 Nozzle holder
22 Nozzle holder joint
23 Dust seal
24 Gasket

X : Non-reusable part

● **Assembly sequence**

Reverse the order of disassembly.

WARNING ⚠

To minimize the risk of fire, wipe up any spilled fuel.

CAUTION ⚠

Under no circumstances change the needle valve 19 and nozzle 18 combination used in each injection nozzle assembly 5.

NOTE

- **Clean off any carbon deposits before disassembling, reassembling, or adjusting the injection nozzle assembly 5. 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.**
- **When fitting the injection nozzle assembly 5, tighten each of the two bolts 4 a little at a time.**

Service standards

Unit: mm

Location	Maintenance item		Standard value	Limit	Remedy
5	Injection pressure	1st valve opening pressure	16.7 $^{+0.49}_{0}$ MPa {170 $^{+5}_{0}$ kgf/cm^2}	—	Adjust
		2nd valve opening pressure (cover pressure)	21.6 $^{+0.49}_{0}$ MPa {220 $^{+5}_{0}$ kgf/cm^2}	—	
	Prelift		0.08	—	Adjust

Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt (fuel leak-off pipe mounting)	9.8 to 15 {1.0 to 1.5}	—
3	Injection pipe union nut	25 {2.5}	—
4	Bolt (injection nozzle mounting)	15 {1.5}	—
6	Cap nut	39 to 49 {4 to 5}	—
8	Lock nut	20 to 25 {2 to 2.5}	—
10	Set screw	49 to 59 {5 to 6}	—
17	Retaining nut	59 to 79 {6 to 8}	—
22	Nozzle holder joint	69 to 79 {7 to 8}	—

Special tools

Unit: mm

Location	Tool name and shape	Part No.	Application
5	Nozzle Cleaning Tool [a]	☆105785-1010	Cleaning injection nozzle assemblies
	Adjusting Device	☆105789-0500	
	*Retaining Nut (for adjustment) [b]	☆157892-1420	
	*Gasket [c]	☆157892-1500	
	*Adjusting Device [d]	☆157892-0220	
	*Dial Gauge [e]	☆157954-3800	
	*Base [f]	☆157892-1800	
	*Pin (ℓ = 60.5 mm) [g]	☆157892-1100	
	*Connector [h]	☆157892-1320	
	*Pin (ℓ = 50 mm) [j]	☆157892-1200	
	*Gasket [k]	☆026508-1140	

☆ BOSCH AUTOMOTIVE SYSTEMS product number

* Component of Adjusting Device (105789-0500)

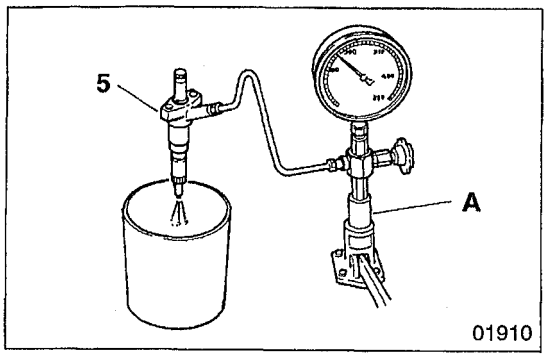
◆ Service procedure

● Pre-disassembly inspection

Fit the injection nozzle assembly **5** onto the nozzle tester **A** ready for inspection.

NOTE

Before commencing inspection, operate the lever on the nozzle tester A two or three times to bleed all air out of the arrangement.

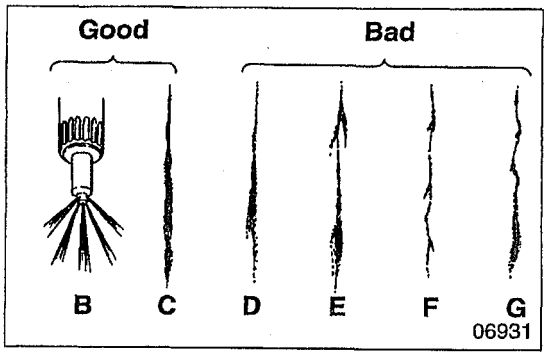


(1) Checking valve opening pressure

- Push down the lever on the nozzle tester **A** at a rate of 1–2 seconds per stroke. 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 the shims **12**, **14**.
- If the measurement is still out of specification after adjustment, replace the injection nozzle assembly **5**.

WARNING ⚠

Do not touch the spray that comes out of the nozzle.



(2) Inspecting spray condition

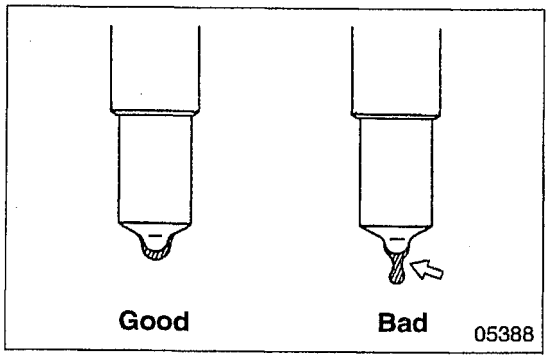
- Pump the lever on the nozzle tester **A** at a rate of about 1–2 seconds per stroke, and maintain a continuous spray.

B: Even spray from all five injection orifices (Good)
C: Even and symmetrical spray (Good)
D: Asymmetrical spray (Bad)
E: Branched spray (Bad)
F: Thin spray (Bad)
G: Irregular spray (Bad)

- If the spray is unsatisfactory, disassemble and clean the injection nozzle assembly **5**, then inspect the spray again. If the spray is still unsatisfactory, replace the injection nozzle assembly **5**.
- Check that no fuel drips from the nozzle after the spray is complete.

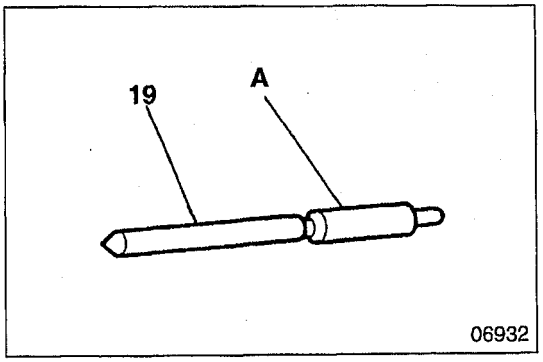
WARNING ⚠

Do not touch the spray that comes out of the nozzle.



(3) Inspecting for leaks

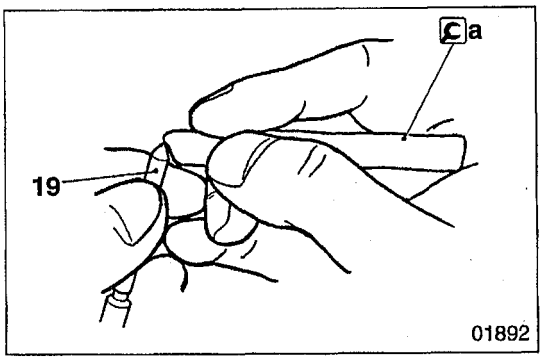
- Slowly increase the nozzle pressure to 1.96 MPa {20 kgf/cm^2} below the specified 1st valve opening pressure. Maintain this pressure for 10 seconds and check that no fuel drips from the end of the nozzle.
- If the injection nozzle assembly **5** appears defective, disassemble and clean it, then inspect it again. If the injection nozzle assembly **5** still appears defective, it must be replaced.



5 Injection nozzle assembly

[Disassembly]

CAUTION
- **Do not touch the sliding parts A of the needle valve 19.**
- **Do not change the needle valve 19 and nozzle 18 combination on each cylinder.**



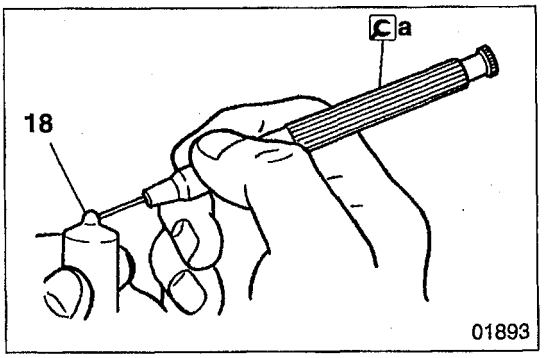
[Cleaning]

Wash the needle valve **19** and nozzle **18** in gas oil, then use the a Cleaning Tool Set to remove any carbon deposits in accordance with the following procedure.

- Remove carbon from the end of the needle valve **19** using the Cleaning Bar of the a Cleaning Tool Set.

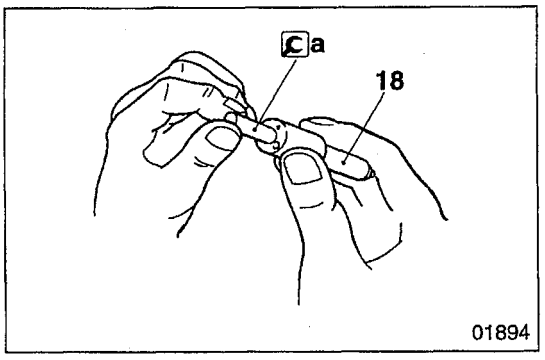
CAUTION

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

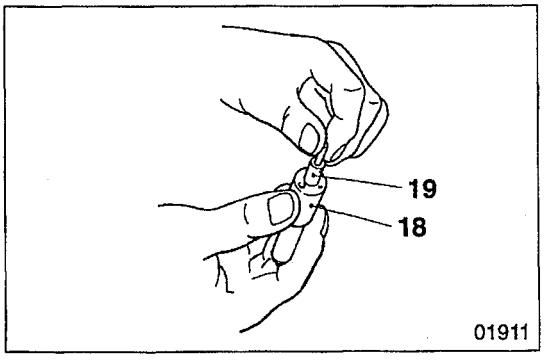


- Remove carbon from the injection orifice of the nozzle **18** using the Needle Cleaner of the a Cleaning Tool Set. Insert the needle cleaner and rotate it to dislodge the carbon.

  Cleaning needle diameter: 0.31 mm or smaller.



- Clean the seat of the nozzle **18** using the Cleaning Scraper of the a Cleaning Tool Set.
- To remove burned and hardened carbon, use FUSO Carbon Remover.



[Inspection]

- Wash the needle valve **19** and nozzle **18** in gas oil, then fit them together.
- Pull up the needle valve **19** 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 the needle valve **19** 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 **18** as a set.

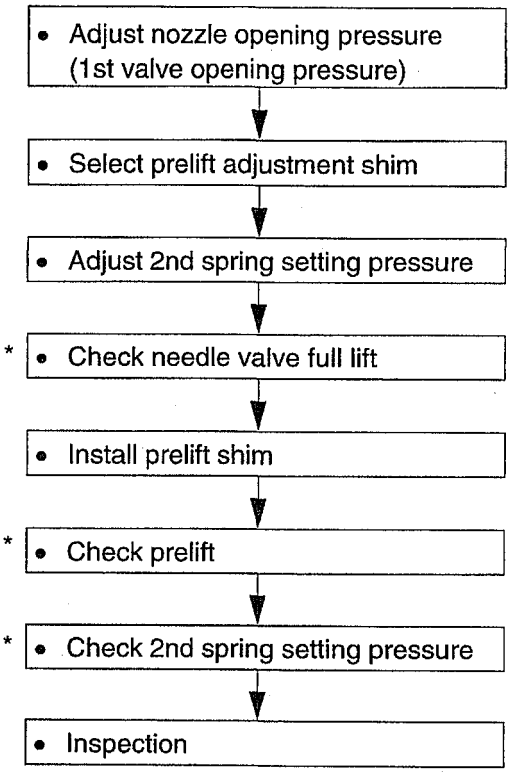
NOTE

After replacing any nozzle 18, be sure to readjust the prelift and ensure that the valve opening pressure is up to specification.

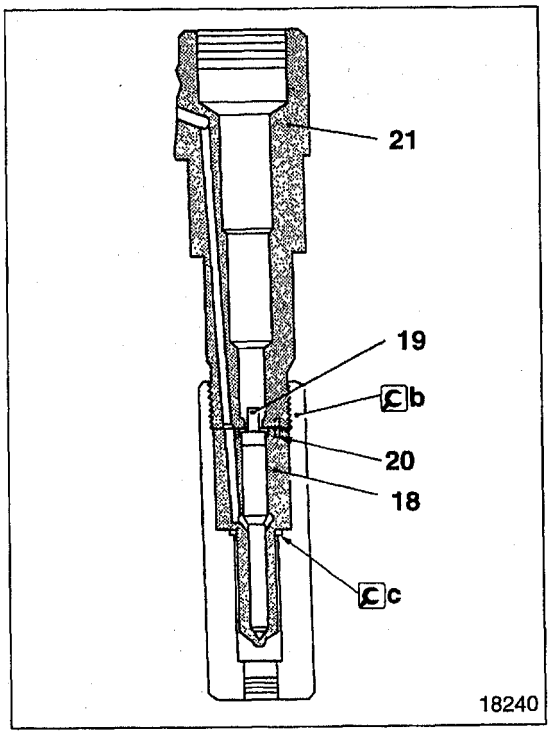
[Adjustment]
During reassembly, make adjustments in the sequence shown below.

CAUTION

- **Before making adjustments, wash all parts in gas oil and ensure that they are free of dirt and other foreign material.**
- **Do not touch the sliding surfaces of the needle valve 19.**



* Carry out if necessary.



● **Adjusting nozzle opening pressure (1st valve opening pressure)**

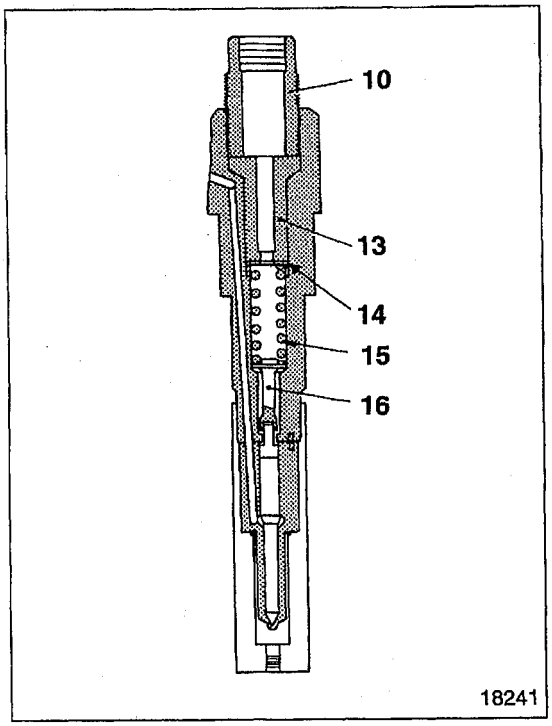
- Fit the nozzle **18** and needle valve **19** into the nozzle holder using the Cb Retaining Nut for Adjustment and Cc Gasket.

NOTE

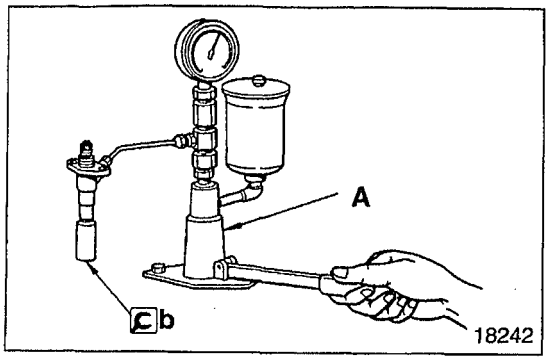
- **Before tightening the Cb Retaining Nut for Adjustment, check that the pin 20 is fully seated in the nozzle 18. Tighten the retaining nut to finger tightness, then tighten it to the specified torque using a torque wrench.**

  Specified torque: 59 to 79 N · m {6 to 8 kgf · m}

- **Remove the bolt from the end of the Cb retaining nut.**



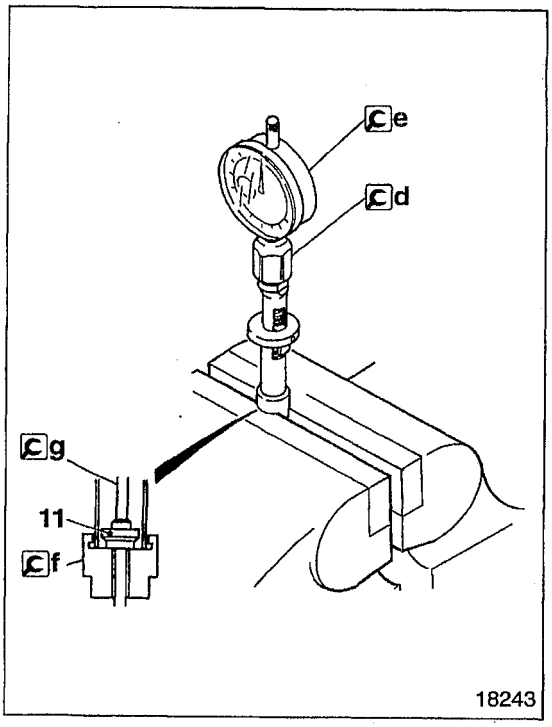
- Insert the 1st push rod **16**, 1st spring **15**, valve opening pressure adjustment shim **4**, and spacer **13** into the nozzle holder. (For the time being, use a shim of approximately 1 mm in thickness.) Then, tighten the set screw **10** to the specified torque.



- Fit the nozzle holder **21** onto the nozzle tester **A** and measure the 1st valve opening pressure.
- If the measurement is out of the specification, adjust by shim **14**. Shims are available in the following thicknesses: 0.50, 0.52, 0.54, 0.56, 0.58, 0.60, 0.70, 0.80, 0.90, 1.00, 0.10, 0.20, 0.30, and 0.40 mm.

NOTE

- **Before using any shim, check its thickness using a micrometer.**
- **These shims are also used for prelift adjustment.**
- **A 0.02 mm change in shim thickness corresponds to a 24 kPa {2.4 kgf/cm^2} change in valve opening pressure.**
- **Leave the bolt off the end of the Retaining b Nut.**

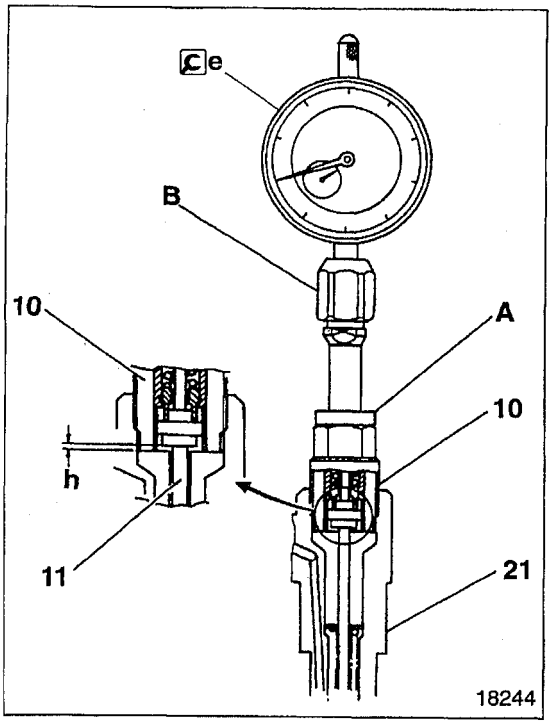


● Selecting prelift adjustment shim

- Fit the e Dial Gauge onto the d Adjusting Device. Then, fit the 2nd push rod **11** into the f Base and mount the assembly in a vise. Next, set the g Pin and Adjusting Device as shown in the illustration, and zero the Dial Gauge.
- Fit the 2nd push rod **11** into the nozzle holder.

NOTE

Do not install the 2nd spring 11 and prelift adjustment shim 12.



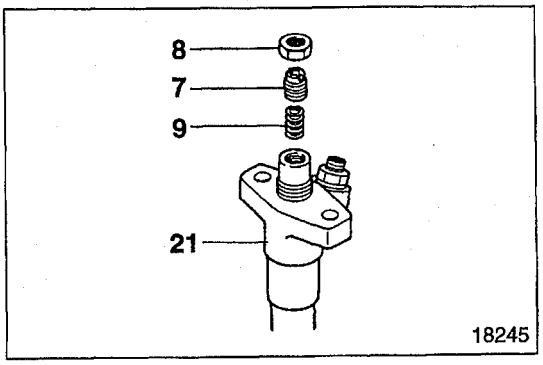
- Using the intermediate screw **A** of the d Adjusting Device, mount the Adjusting Device on the set screw **10**. Then, hold the holder **B** of the e Dial Gauge and move it up and down to check that the gauge operates smoothly.
  Still holding the holder of the dial gauge, push down the gauge and read its lift measurement **h**.

NOTE

Read to a precision of 1/100 mm.

- Select the prelift adjustment shim **12** as follows:
  $t = \ell + h$
  where t: Shim thickness (as measured)
  ℓ: Prelift (nominal value)
  h: Dimension measured in previous step of procedure
  T: = t ± 0.015 mm
  $T = t \pm 0.015$ mm
  where T: Thickness of shim to be used

- Remove the d Adjusting Device from the nozzle holder **21**.

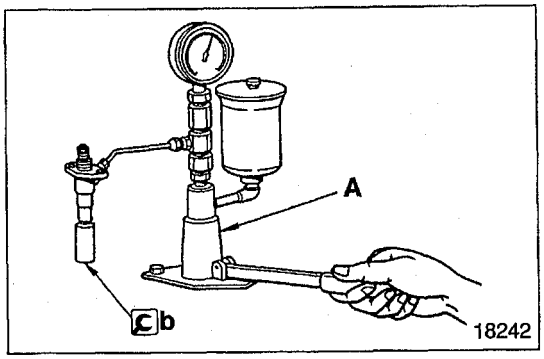


● **Adjusting 2nd spring setting pressure (open pressure)**

- Fit the 2nd spring **9** and adjusting screw **7** into the nozzle holder **21**.
- Tighten the lock nut **8** to the specified torque.

NOTE

Do not install the prelift adjustment shim.



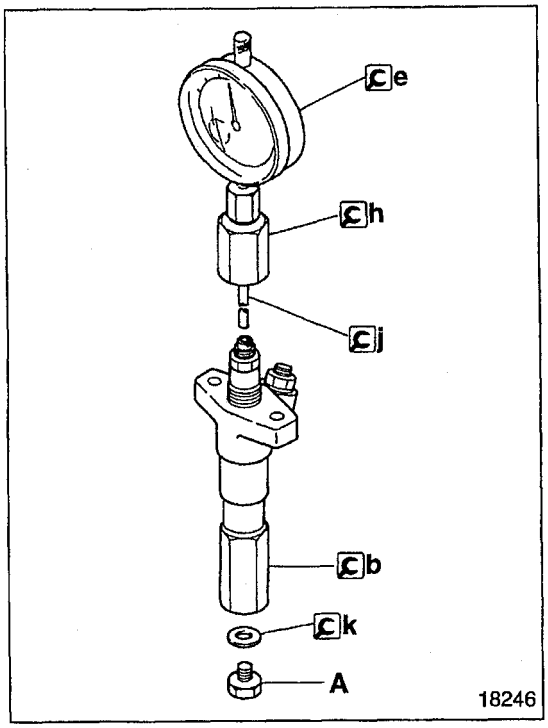
- Measure the 2nd spring setting pressure (open pressure) using the nozzle tester **A**.

NOTE

Leave the bolt off the end of the [b] Retaining Nut.

- If the measurement is out of the specification, adjust by the adjusting screw **7**.

  Nominal value: 24.7 to 25.3 MPa {252 to 258 kgf/cm^2}
- After adjustment, tighten the lock nut **8** to the specified torque.

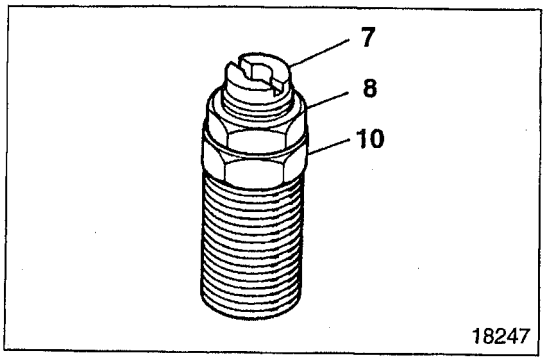


● **Adjusting needle valve full lift**

- Fit the special tools shown in the illustration, then zero the [e] Dial Gauge.

  [h] Connector tightening torque: 39 to 49 N·m {4 to 5 kgf·m}

  A: Bolt
- Fit the nozzle **5** onto the nozzle tester, then operate the nozzle tester lever to bleed all air out of the [b] Retaining Nut (for adjustment). Also, check for fuel leaks.
- Using the nozzle tester lever, increase the pressure to 34.3 to 44.1 MPa {350 to 450 kgf/cm^2} such that the nozzle's needle valve **19** lifts fully. Read the lift dimension shown by the Dial Gauge.
- Remove the [e] Dial Gauge, [h] Connector, and [j] Pin.



● **Installing prelift adjustment shim**

- Remove the set screw **10**, lock nut **8**, and adjusting screw **7** from the nozzle holder **21** as an assembly.

CAUTION ⚠

Do not loosen the lock nut 8. Loosening the lock nut would alter the 2nd spring setting pressure.

- Fit the prelift adjustment shim **12** between the spacer **13** and push rod **11**. Use the shim selected previously in accordance with the "Selecting Prelift Adjustment Shim" procedure.
- Install the 2nd push rod **11** and 2nd spring **9**.
- Fit the set screw **10**, lock nut **8**, and adjusting screw **7** as an assembly, and tighten the set screw to the specified torque.
- Measure the needle valve lift in accordance with the previously described procedure.
  The lift measured this time should be the value of "(full lift) – (prelift)".

● **Checking prelift**

- Check the prelift based on the previously measured "full lift" and "lift" dimensions.

  $L - S = \Delta \ell$

  where $\ell - 0.02 \leqq \Delta \ell \leqq \ell + 0.02$

  $\Delta \ell$: Prelift (as measured)

  ℓ: Prelift (nominal value)

  L: Needle valve full lift dimension (as measured)

  S: Needle valve lift dimension (as measured) with prelift subtracted

  If $\Delta \ell$ is out of the specified range ($\ell \pm 0.02$ mm), replace the prelift adjustment shim **12** in accordance with the previously described procedure, then repeat the last two procedures such that the $\Delta \ell$ dimension falls within $\ell \pm 0.02$ mm.

  Select the thickness of the replacement shim (t') as follows:

  $t' = t + (\ell - \Delta \ell)$

  $T = t' \pm 0.015$ mm

  t: Thickness of shim installed

  t': Shim thickness

  T: Thickness of shim to be used

  ℓ: Prelift (nominal value)

GROUP 13E ELECTRONICALLY CONTROLLED FUEL SYSTEM

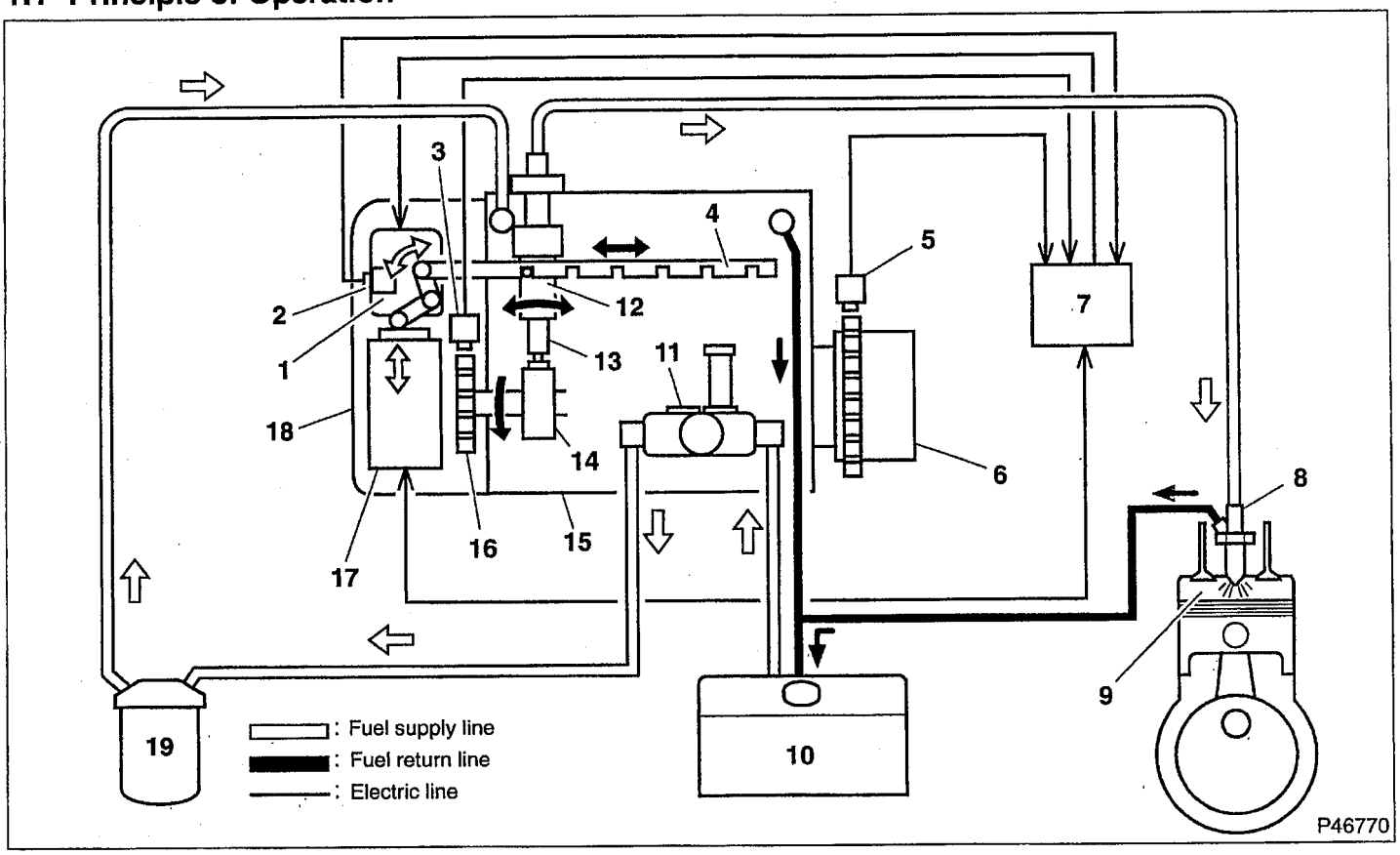
SPECIFICATIONS

Item		Specification
Injection pump assembly	Manufacturer	BOSCH AUTOMOTIVE SYSTEMS
	Model	Electronically controlled in-line pump
	Injection pump model	NP-PE6MD105
	Governor model	RED-4 (RED-4 with internal circuit)
	Timer model	SPG
	Feed pump model	KE
	Manufacturer	BOSCH AUTOMOTIVE SYSTEMS
	Rated voltage V	24

1. GENERAL

- With the electronically controlled injection pump system, electronic control is applied to the governor (the components of the injection pump assembly) to realize the optimum fuel injection rate.
- The electronic governor ECU optimally controls the governor in accordance with data signals from sensors mounted on the engine and other parts of the vehicle.

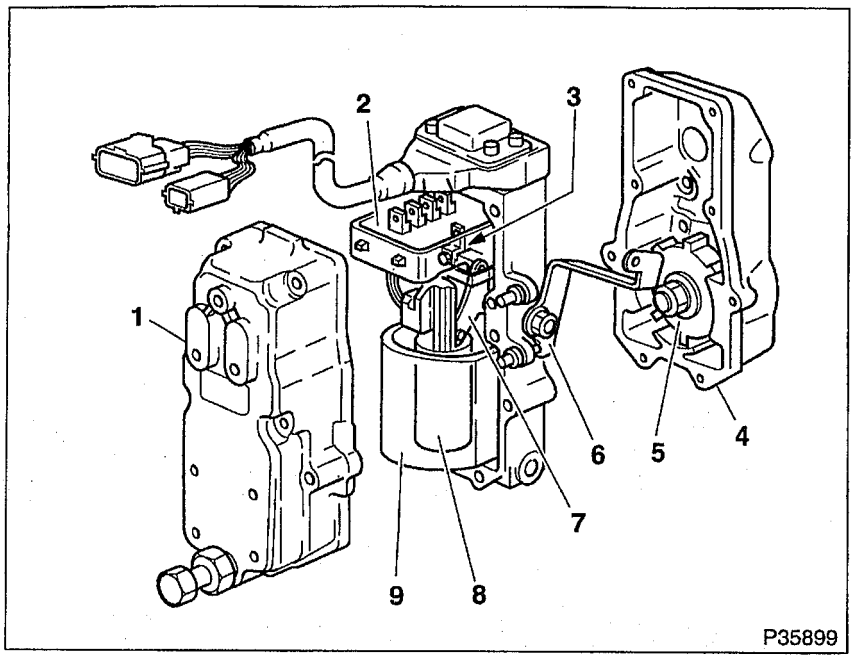
1.1 Principle of Operation



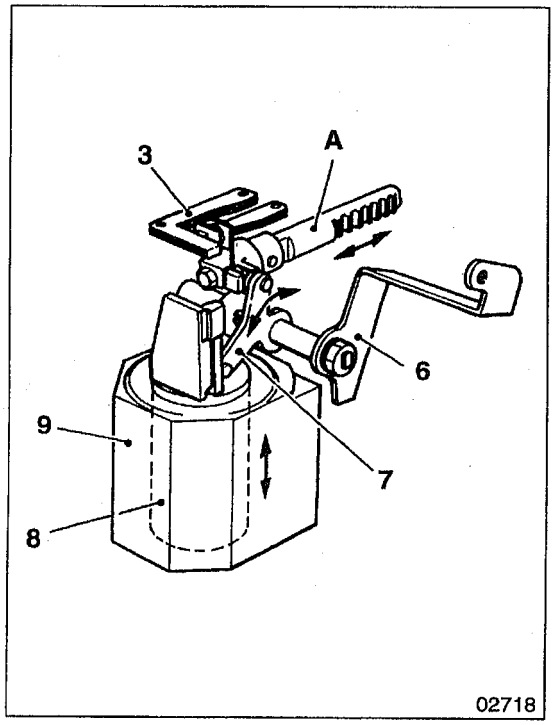
1 RED-4 internal circuit	**8** Injection nozzle	**14** Camshaft
2 Control rack position sensor	**9** Combustion chamber	**15** Injection pump
3 Engine speed sensor 2	**10** Fuel tank	**16** Sensing gear
4 Control rack	**11** Feed pump	**17** Linear DC motor
5 Engine speed sensor 1	**12** Control sleeve	**18** Electronic governor actuator
6 Automatic timer	**13** Plunger	**19** Fuel filter
7 Engine ECU		

- The extent of operation of the linear DC motor **17** are determined by signals from the engine ECU **7**.
- The linear DC motor **17** moves the control rack **4**, thereby changing the fuel injection quantity.
- The RED-4 internal circuit **1** is incorporated into the electronic governor actuator **18.** It contains a control rack position sensor processing circuit and a linear DC motor drive circuit, which are conventionally incorporated into the engine ECU. This arrangement eliminates noise in the harness and thus prevents erroneous ECU operation. More accurate electronic control is possible as a result.
- The engine speed is sensed by engine speed sensor 1 **5** and engine speed sensor 2 **3**. Each of these sensors acts as a backup if the other fails.

1.2 Electronic Governor Actuator



1 Cover
2 RED-4 internal circuit
3 Control rack position sensor
4 Housing
5 Sensing gear
6 Emergency engine stop lever
7 Link
8 Coil assembly
9 Linear DC motor



(1) Linear DC motor

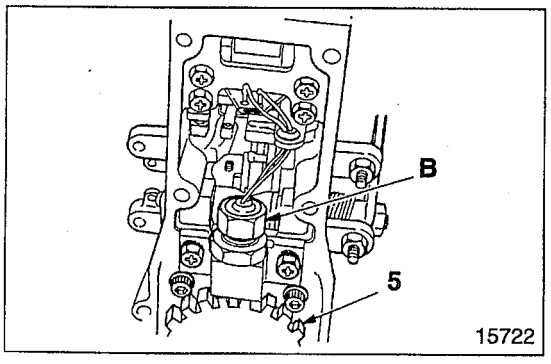
- The linear DC motor **9** moves the coil assembly **8** vertically in accordance with signals from the engine ECU and RED-4 internal circuit.
- Via the link **7**, this movement is transmitted to the control rack **A**, which moves longitudinally to increase and decrease the fuel quantity.

(2) Control rack position sensor

- The control rack position sensor **3** senses whether the control rack **A** is moved to the correct position by the linear DC motor **9**.
- In the event of a discrepancy between the actual control rack position and the target control rack position (this is determined by the engine ECU and RED-4 internal circuit **2**), the engine ECU causes the linear DC motor **9** to perform a corrective movement.

(3) Emergency engine stop lever

- The emergency engine stop lever **6** is connected to the link **7**. Via a wire, it enables the link to be moved from the driver's seat.
- In the event of a system fault that prevents the engine from being stopped normally, operation of the emergency engine stop lever forces the control rack **A** to move to the position at which fuel injection is terminated. This operation takes place irrespective of the position of the linear DC motor **9**.

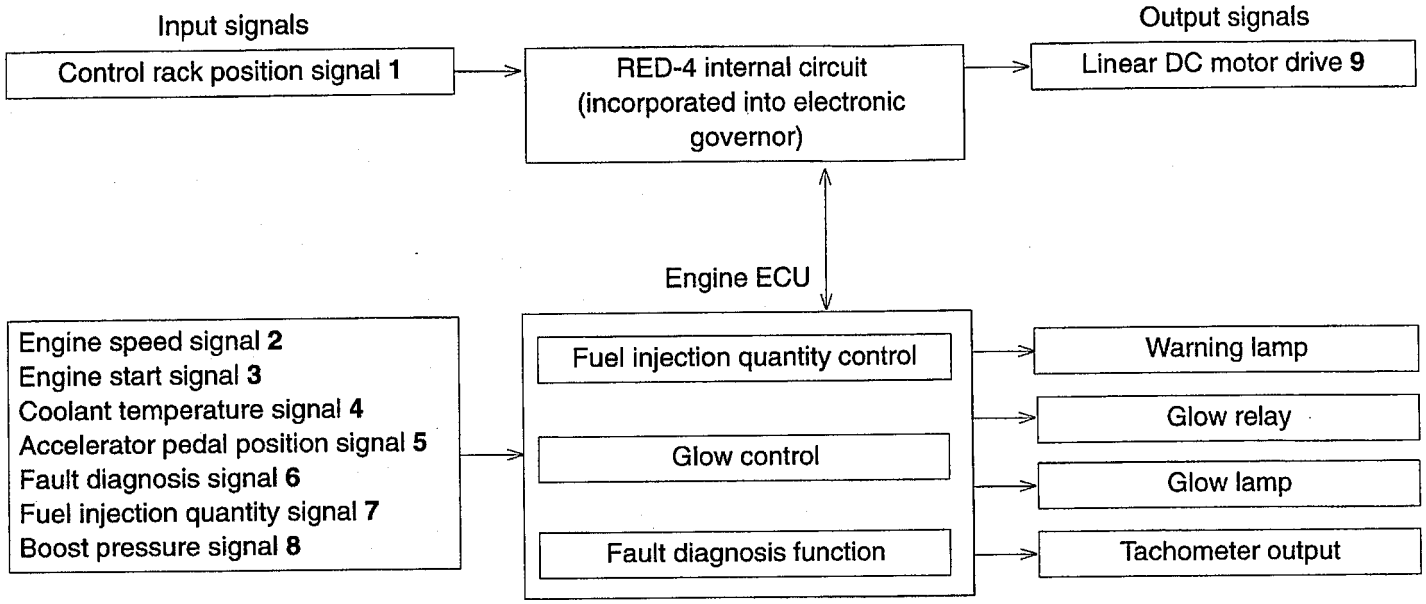


(4) Engine speed sensor 2

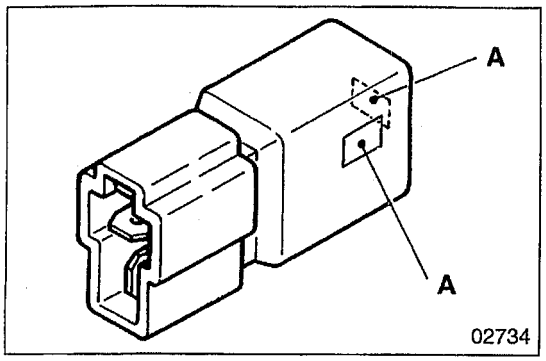
The engine speed sensor 2 **B** is located inside the governor. It converts rotation of the sensing gear **5** into electric signal and outputs the signal to the engine ECU.

2. Electronic Control System

2.1 System Block Diagram



	Signal	Part	Main function/operation
1	Control rack position signal	Control rack position sensor	Sensing of control rack position
2	Engine speed signal	Engine speed sensors 1, 2	Sensing of engine speed Use of two sensors allows for backup if one sensor fails.
3	Engine start signal	Starter switch	Recognition of engine startup with starter switch in START position
4	Coolant temperature signal	Coolant temperature sensor	Sensing of coolant temperature
5	Accelerator pedal position signal	Accelerator pedal position sensor	Sensing of extent of depression of accelerator pedal
		Accelerator pedal switch (ON with pedal released)	Detection of pedal depressed/released condition
6	Fault diagnosis signal	Diagnosis switch	Callup of diagnosis codes
		Memory clear switch	Deletion of diagnosis codes; callup of past diagnosis codes
7	Fuel injection quantity signal	Fuel injection quantity adjusting resistor	Correction of fuel injection quantity
8	Boost pressure signal	Boost pressure sensor	Detection of boost pressure
9	–	Linear DC motor	Moving of control rack



Injection quantity adjusting resistor

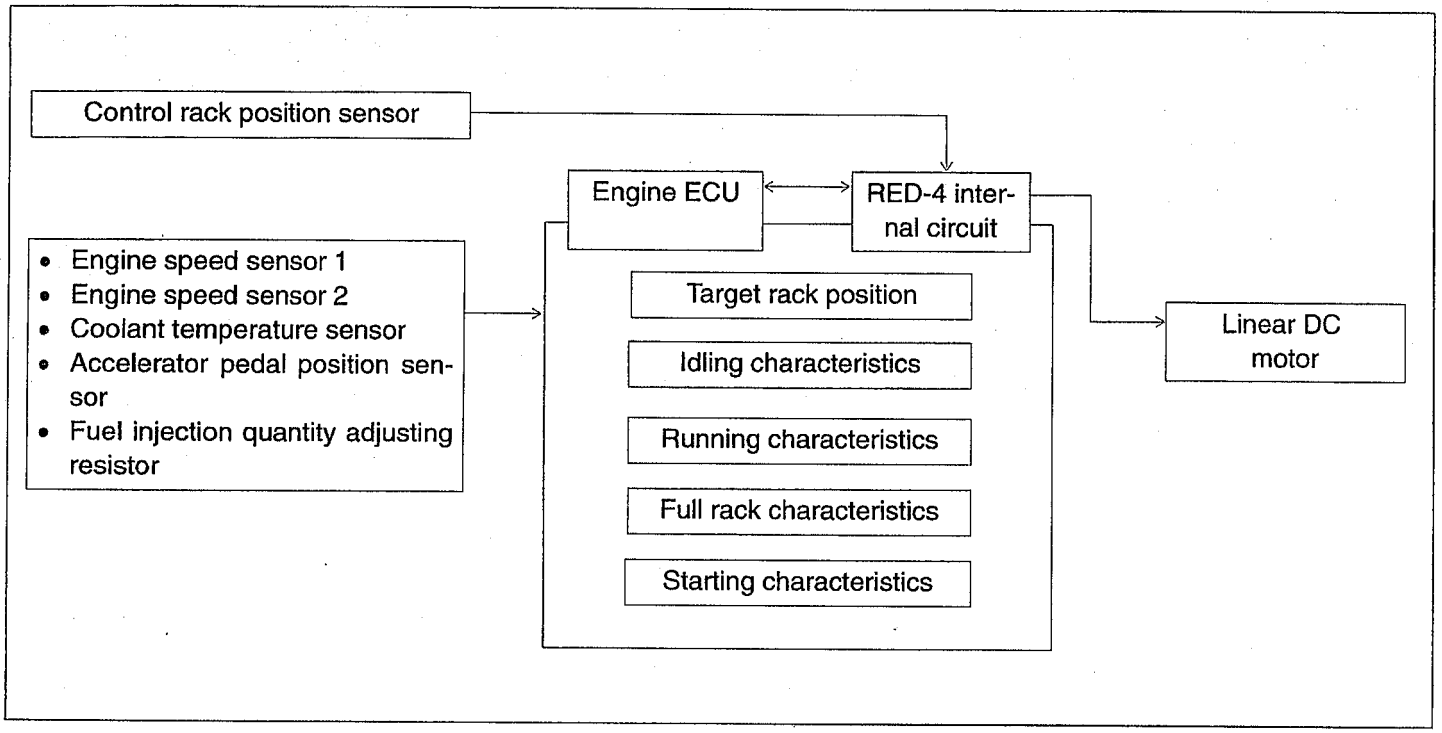
The injection quantity adjusting resistor makes fine adjustments to achieve optimal commensuration of injectied fuel quantity with fuel feed from the common rail.

NOTE

This resistor, selected as the best from among several types, determines the final injection quantity. DO NOT change it for any other type.

A: Resistor No.

2.2 Fuel Injection Quantity Control



(1) Control effected by engine ECU and RED-4 internal circuit

- The RED-4 internal circuit processes control rack position signals and transmits the results to the engine ECU.
- The engine ECU effects control during engine operation using the stored idling characteristics or running characteristics, and it determines the target control rack position appropriate for the amount of fuel injection in accordance with signals issued by the sensors.
- The control rack position signal issued by the engine ECU is sent to the RED-4 internal circuit. It causes activation of the linear DC motor such that the control rack is moved.

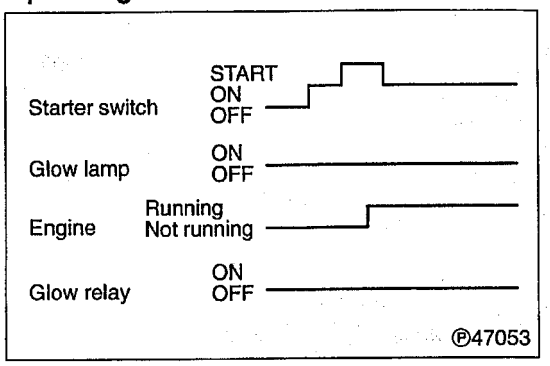
(2) Feedback control effected using control rack position sensor

- The control rack position sensor enables the RED-4 internal circuit to calculate whether the linear DC motor has moved the control rack to the target position. This arrangement enables the RED-4 to ensure that the control rack position always corresponds to the target value.
- The engine ECU receives signals indicating the control rack's actual position from the RED-4 internal circuit and uses them to evaluate control rack position errors.

2.3 Glow Control

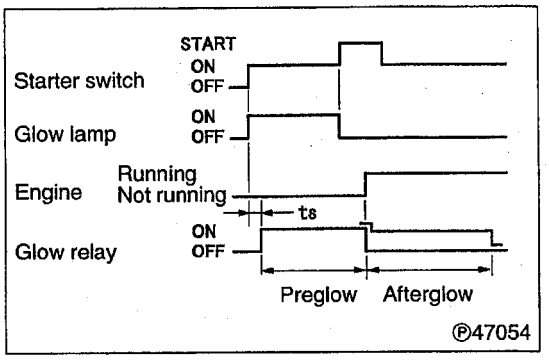
Glow control improves startability when the engine's coolant temperature is low.

Operating modes



(1) Engine coolant temperature higher than 60°C

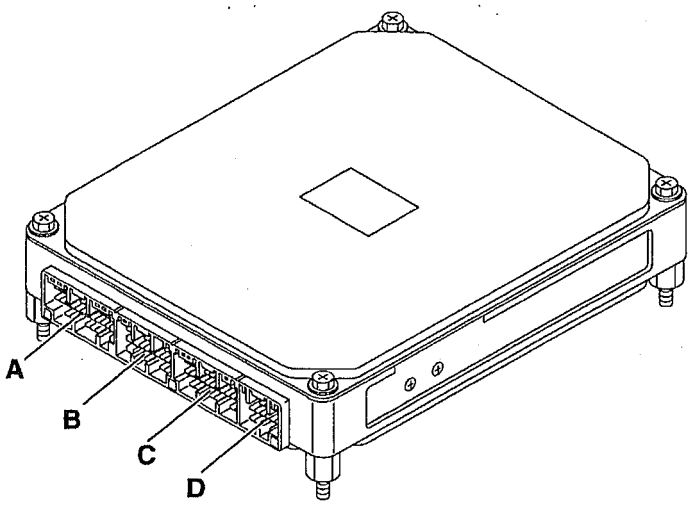
No preheating is necessary at the time of engine startup, so the heater relay is kept OFF.



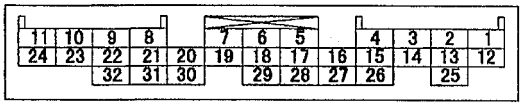
(2) Engine coolant temperature 60°C or lower

- "ts" seconds after the starter switch is turned ON, the glow relay is turned ON, causing preglow to begin. The glow lamp illuminates simultaneously.
- When preheating finishes, the glow lamp goes off to indicate that the engine can be started. The glow relay remains ON until the engine is started.
- When the engine is started, the engine ECU determines whether afterglow is necessary in accordance with the engine coolant temperature. If the engine ECU determines that afterglow is not necessary, preglow control is terminated. If it deems that afterglow is necessary, the glow relay remains ON for a certain period after engine startup to cause afterglow.

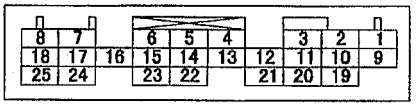
3. Pin Configuration of Electronic Control Unit



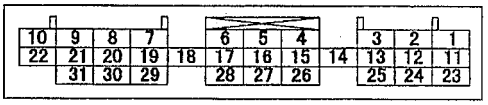
A: CW32A



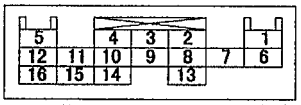
B: CW25A



C: CW31A



D: CW16A



Ⓟ43639

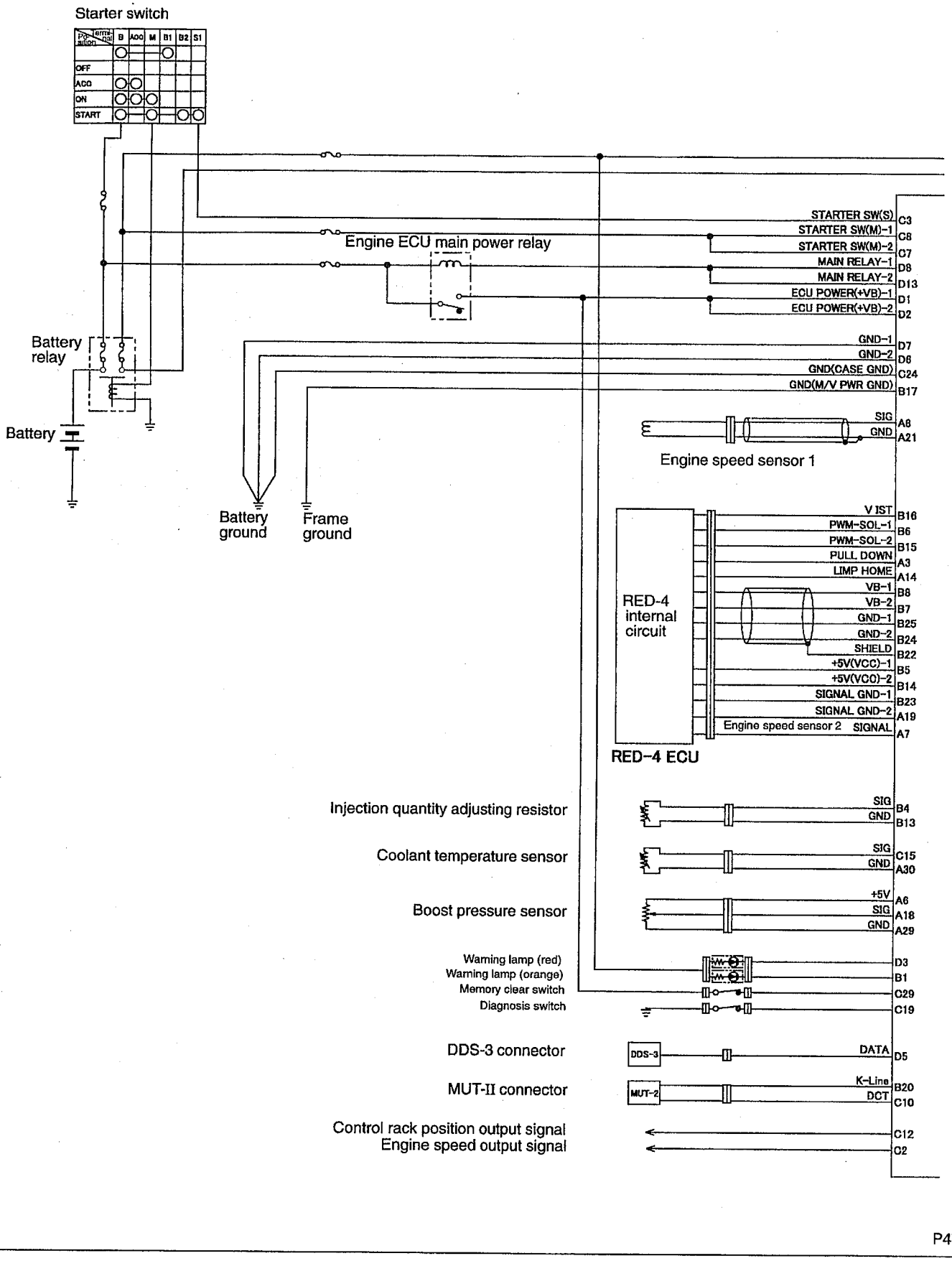
A: CW32A			
Terminal No.	Item(s) to which terminal is connected	Terminal No.	Item(s) to which terminal is connected
1	–	17	–
2	–	18	Boost pressure sensor (SIG)
3	RED-4 ECU (PULL DOWN)	19	Engine speed sensor 2 (GND), RED-4 ECU (SIGNAL GND-2)
4	–	20	–
5	–	21	Engine speed sensor 1 (GND)
6	Boost pressure sensor (+5V)	22	–
7	Engine speed sensor 2 (SIG)	23	–
8	Engine speed sensor 1 (SIG)	24	–
9	–	25	–
10	–	26	–
11	Glow relay	27	–
12	–	28	–
13	–	29	Boost pressure sensor (GND)
14	RED-4 ECU (LIMP HOME)	30	Coolant temperature sensor (GND)
15	–	31	–
16	–	32	–

ECU: Electronic Control Unit

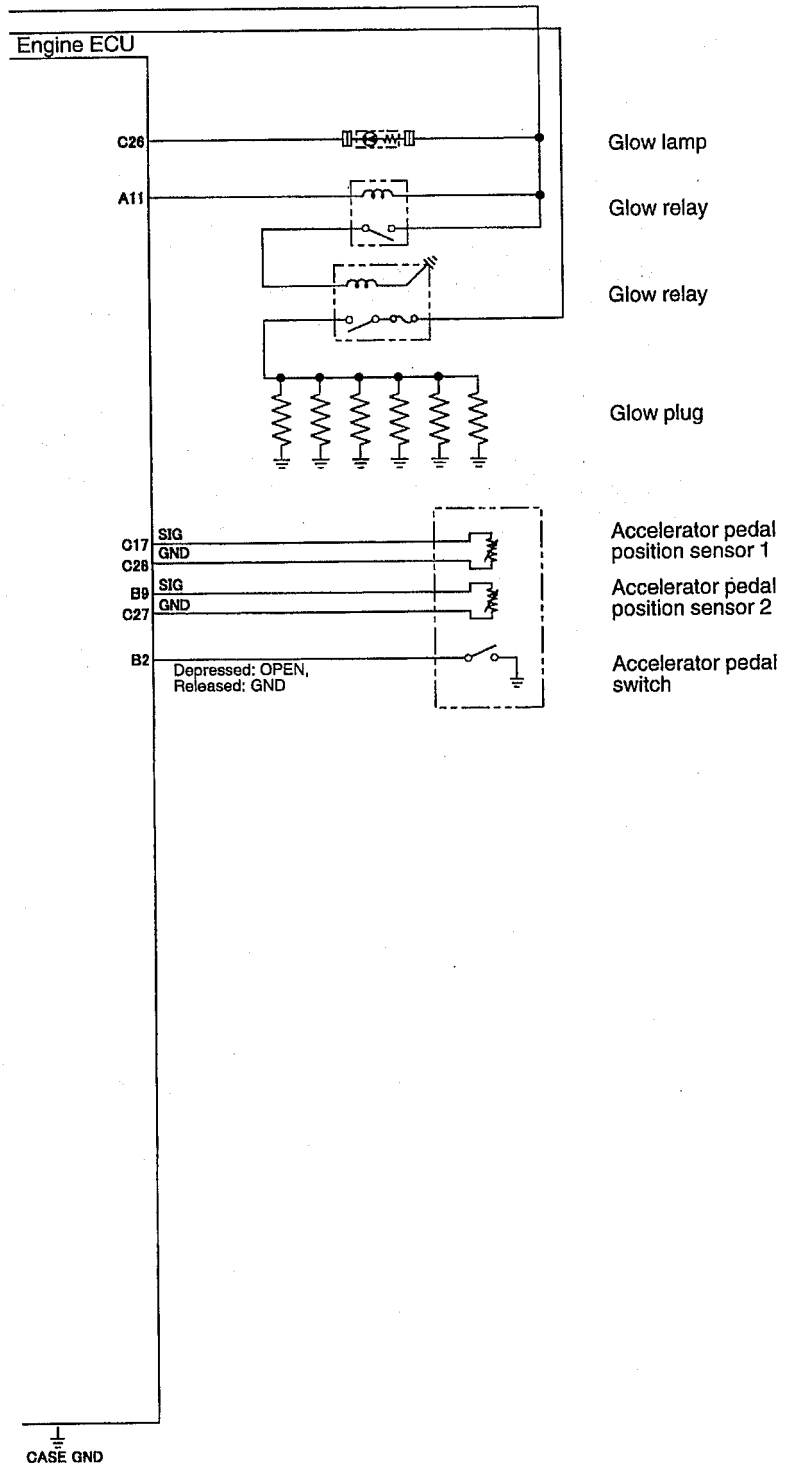
B: CW25A			
Terminal No.	Item(s) to which terminal is connected	Terminal No.	Item(s) to which terminal is connected
1	Warning lamp (orange)	14	RED-4 ECU (+5 VCC-2)
2	Accelerator pedal switch	15	RED-4 ECU (PWM SOL-2)
3	–	16	RED-4 ECU (V-IST)
4	Injection quantity adjusting resistor (SIG)	17	Frame ground (M/V POWER GND)
5	RED-4 ECU (+5 VCC-1)	18	–
6	RED-4 ECU (PWM SOL-1)	19	–
7	RED-4 ECU (VB2)	20	MUT-II connector (K-LINE)
8	RED-4 ECU (VB1)	21	–
9	Accelerator pedal position sensor 2 (SIG)	22	Shield (SHIELD) of VB-1, VB-2, GND-1, and GND-2
10	–	23	RED-4 ECU (SIGNAL GND-1)
11	–	24	RED-4 ECU (GND-2)
12	–	25	RED-4 ECU (GND-1)
13	Injection quantity adjusting resistor (GND)		

C: CW31A			
Terminal No.	Item(s) to which terminal is connected	Terminal No.	Item(s) to which terminal is connected
1	–	17	Accelerator pedal position sensor 1 (SIG)
2	Engine speed output signal (NE OUT SIG)	18	–
3	Starter switch S terminal (STARTER SW S)	19	Diagnosis switch
4	–	20	–
5	–	21	–
6	–	22	–
7	Battery relay (STARTER SW M-2)	23	–
8	Battery relay (STARTER SW M-1)	24	Battery ground (CASE GND)
9	–	25	–
10	MUT-II connector (DCT)	26	Glow lamp (GLOW LAMP)
11	–	27	Accelerator pedal position sensor 2 (GND)
12	Control rack position output signal (RAC OUT SIG)	28	Accelerator pedal position sensor 1 (GND)
13	–	29	Memory clear switch
14	–	30	–
15	Coolant temperature sensor (SIG)	31	–
16	–		

D: CW16A			
Terminal No.	Item(s) to which terminal is connected	Terminal No.	Item(s) to which terminal is connected
1	Engine ECU main power relay (+VB-2)	9	–
2	Engine ECU main power relay (+VB-1)	10	–
3	Warning lamp (red)	11	–
4	–	12	–
5	–	13	Engine ECU main power relay (MAIN RELAY-2)
6	Battery ground (GND-2)	14	–
7	Battery ground (GND-1)	15	–
8	Engine ECU main power relay (MAIN RELAY-1)	16	–


Starter switch
Position
Terminal
B
ACC
M
B1
B2
S1
OFF
ACC
ON
START
Engine ECU main power relay
Battery relay
Battery
Battery ground
Frame ground
STARTER SW(S) C3
STARTER SW(M)-1 C8
STARTER SW(M)-2 C7
MAIN RELAY-1 D8
MAIN RELAY-2 D13
ECU POWER(+VB)-1 D1
ECU POWER(+VB)-2 D2
GND-1 D7
GND-2 D8
GND(CASE GND) C24
GND(M/V PWR GND) B17
SIG A8
GND A21
Engine speed sensor 1
RED-4 internal circuit
V IST B16
PWM-SOL-1 B6
PWM-SOL-2 B15
PULL DOWN A3
LIMP HOME A14
VB-1 B8
VB-2 B7
GND-1 B25
GND-2 B24
SHIELD B22
+5V(VCC)-1 B5
+5V(VCC)-2 B14
SIGNAL GND-1 B23
SIGNAL GND-2 A19
Engine speed sensor 2 SIGNAL A7
RED-4 ECU
Injection quantity adjusting resistor
SIG B4
GND B13
Coolant temperature sensor
SIG C15
GND A30
Boost pressure sensor
+5V A6
SIG A18
GND A29
Warning lamp (red) D3
Warning lamp (orange) B1
Memory clear switch C29
Diagnosis switch C19
DDS-3 connector
DDS-3
DATA D5
MUT-II connector
MUT-2
K-Line B20
DCT C10
Control rack position output signal C12
Engine speed output signal C2

P47052-1


Engine ECU
C26
A11
Glow lamp
Glow relay
Glow relay
Glow plug
C17
SIG
GND
C28
B9
SIG
GND
C27
B2
Depressed: OPEN,
Released: GND
Accelerator pedal position sensor 1
Accelerator pedal position sensor 2
Accelerator pedal switch
CASE GND

P47052-2

TROUBLESHOOTING

1. Inspection Procedures

Diagnostic function

- Whenever the starting switch is placed at ON, the diagnostic function is activated to check all the sensors, etc. If any of them is found faulty, the warning lamp in the meter cluster is lit to alert the driver. At the same time, the fault location is stored in memory, and the system enters the backup mode.
- The stored fault location can be read as a diagnostic trouble code by the Multi-Use Tester-II or the diagnostic switch.
- Warning lamp indications

	Warning lamp
Safety-critical error (Vehicle must not be driven)	Red
Non-safety-critical error (Vehicle can be driven despite poor control feeling)	Orange

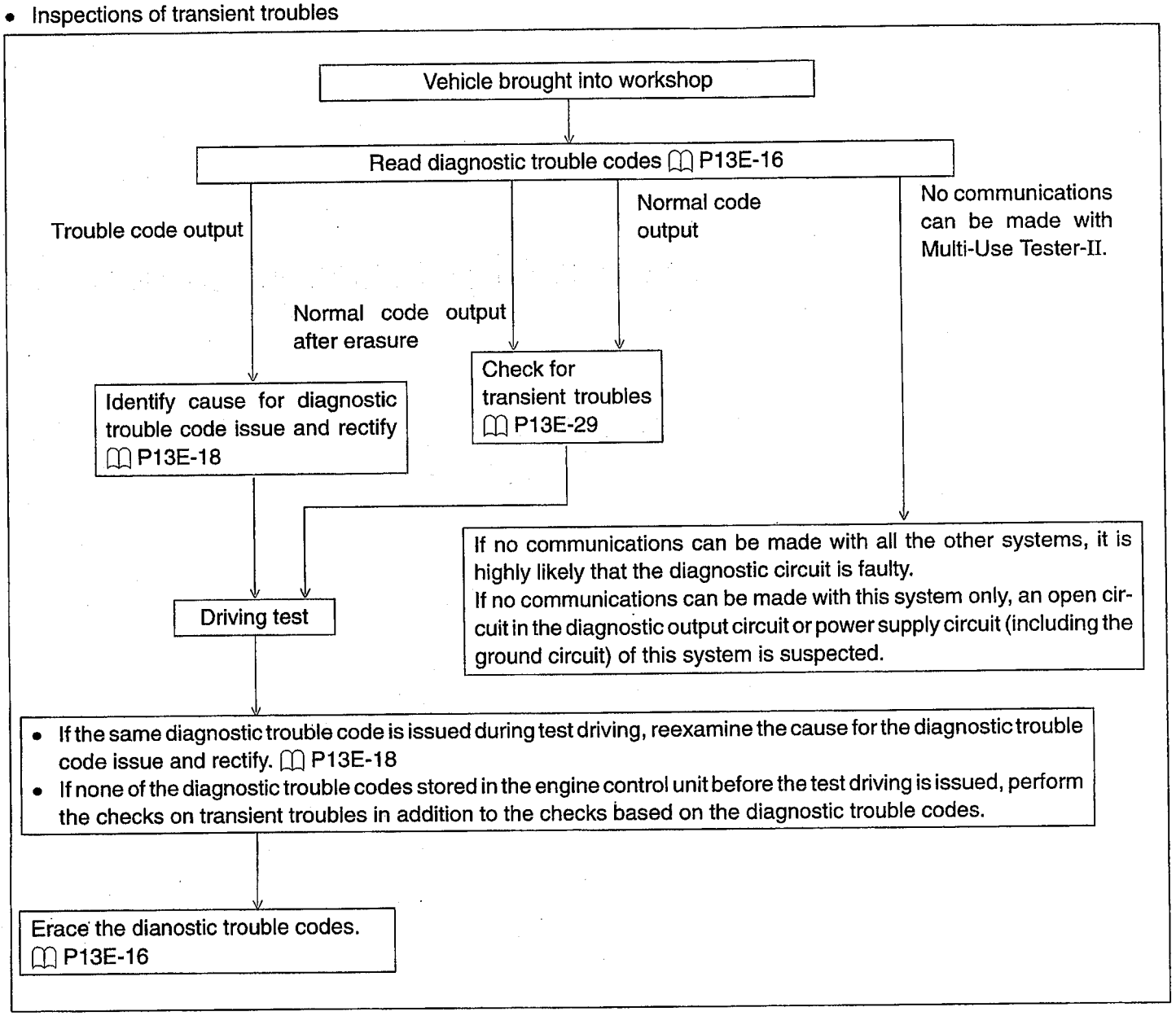
CAUTION ⚠

- **Check to ensure that the battery voltage is within the specified range.**
- **Check all the harness and device connectors for looseness. Always remove a connector at least 20 seconds after placing the starting switch at the LOCK position.**
- **Do not forget to clear the diagnostic trouble code by the Multi-Use Tester-II or memory clear switch after a fault has been rectified.**
- **As a rule, inspection operations should be performed with the starting switch at the LOCK position. Some checks, however, may have to be made with the starting switch at the ON position. In such a case, use care to make sure that no short circuit develops between pins of the connectors or with the body.**
- **The resistance value of each component is affected by the temperature and the accuracy of the tester. The reading, therefore, does not always fall within the standard limits. Note that the check values shown in the text are the values obtained at normal temperature (10 to 35°C).**
- **Whether or not the system automatically returns to normal from the backup mode after a fault has been removed depends on the diagnostic trouble code (fault location).**
- **Even when the fault has been removed and the system has been automatically returned to the normal mode, the diagnostic trouble code of the fault remains stored in the engine control unit.**
- **When a fault occurs at a point where the system is not automatically reset, perform the memory clear procedure to let the system exit from the backup mode. 🕮 P13E-16**

Inspection flowchart

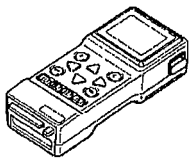
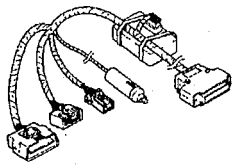
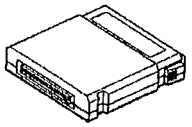
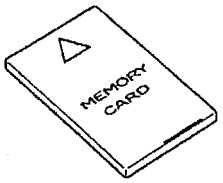
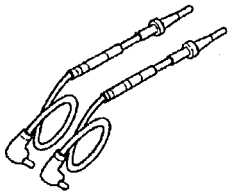
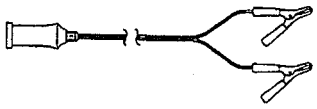
The system inspection can be performed effectively by use of the Multi-Use Tester-II. The types of system inspections may be broadly divided as shown below in accordance with the trouble symptoms and diagnostic trouble code outputs.

- Inspections based on diagnostic trouble codes stored in the engine control unit
- Inspections of transient troubles



2. Connection of Multi-Use Tester-II

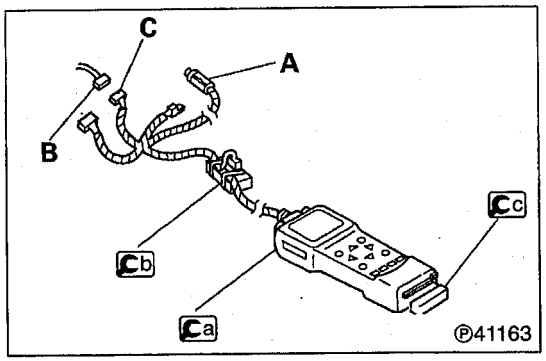
Special Tools

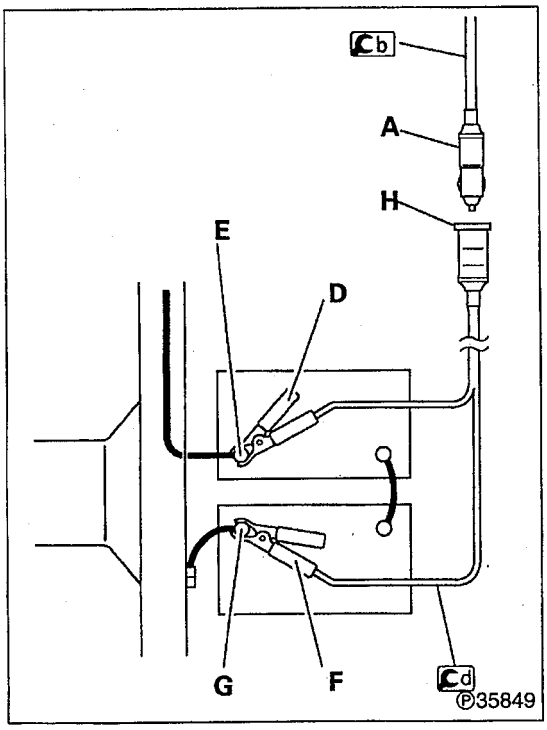
Location	Tool name and shape	Part No.	Application
–	Multi-Use Tester-II  19492	MB991496	Inspection of system
–	Multi-Use Tester-II harness (for communications)  19141	MC887252	To supply power to Multi-Use Tester-II proper and communicate with vehicle side electrical devices
–	Read-only memory pack (MRI-E1)  19493	MK369392	Data for inspection and control of engine control unit
–	Memory card (set in Multi-Use Tester-II proper)  20538	MB991500	To write data
–	Multi-Use Tester-II harness  20536	MB991499	To use Multi-Use Tester-II as a circuit tester
–	Battery clamp harness  20537	MK320193	Power supply to Multi-Use Tester-II in vehicle without cigarette lighter; detection of start signal in vehicle without cigarette lighter

The Multi-Use Tester-II typically draws power from the cigarette lighter. In a vehicle without a cigarette lighter, the power connection of the Multi-Use Tester-II is different depending on the type of the starter switch as follows:

Multi-Use Tester-II power supply connection	With cigarette lighter socket		Without cigarette lighter socket
	Starter switch type A*a	Starter switch type A*b	
Cigarette lighter socket	○	–	–
Battery	–	○	○

*a With starter switch type A, power supply to cigarette lighter continues while engine is being cranked.
*b With starter switch type B, power supply to cigarette lighter is suspended while engine is being cranked.





(1) Power supplied to Multi-Use Tester-II from cigarette lighter

- Place the starting switch at the LOCK position.
- Connect the Ca Multi-Use Tester-II harness to Cb Multi-Use Tester-II and insert the Cc read-only memory in the tester.
- Connect the connector **A** to the cigar lighter socket.
- Connect the Multi-Use Tester-II connector **C** (16 pins) to the data link connector **B** (16 pins).

NOTE

For the operating procedures for the Multi-Use Tester-II, refer to the instruction manual for the Multi-Use Tester-II.

(2) Power supplied to Multi-Use Tester-II from battery

- Place the starter switch in the LOCK position.
- Connect the Cb Multi-Use Tester-II harness (for communication) to the Ca Multi-Use Tester-II, then insert the Cc ROM pack.
- Connect the ⊕ clamp **D** (red) of the Cd battery clamp harness to the ⊕ terminal **E** of the battery and the ⊖ clamp **F** (black) to the ⊖ terminal **G** of the battery.
- Fit the connector **A** into the socket **H** of the Cd battery clamp harness.
- Fit together the Multi-Use Tester-II connector **B** (16 pins) and connector **C** (16 pins).

NOTE

Connect the ⊕ clamp D (red) of the Cd battery clamp harness before connecting the ⊖ clamp F (black).

3. Reading and Erasing Diagnostic Trouble Codes

Two types of methods are available for reading or erasing a diagnostic trouble code; one using the Multi-Use Tester-II and one using the vehicle side diagnostic functions.

(1) Method using Multi-Use Tester-II

● Current diagnostic trouble code

- Check to see that the memory clear switch **1** is connected.
- Set the starting switch to ON.
- Operate the Multi-Use Tester-II to read the current diagnostic trouble code and determine the fault location.

● Past diagnostic trouble code

- Set the starting switch to ON.
- Disconnect the memory clear switch **1**.
- Operate the Multi-Use Tester-II to read the past registered diagnostic trouble codes and determine the fault location.

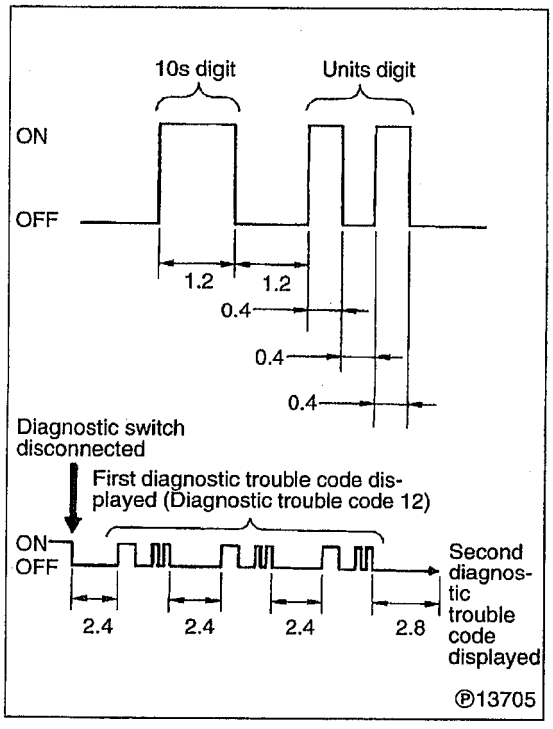
● Erasing diagnostic trouble codes

- Set the starting switch to ON.
- Operate the Multi-Use Tester-II to erase all of the diagnostic trouble codes stored in the engine control unit.

(2) Method Not Using Multi-Use Tester-II (Method Using Diagnostic Switch and Memory Clear Switch)

● Current diagnostic trouble code

- Set the starting switch to ON.
- Disconnect the diagnostic switch **2**.
- The diagnostic trouble code is displayed by flashes of the warning lamp **3**.

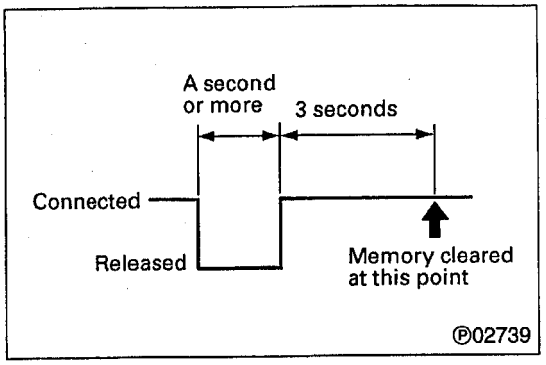


● Reading diagnostic trouble code

- Diagnostic trouble codes are indicated by the number of times the warning lamp **3** flashes and their duration.
  - The flashing intervals also differ between the 10s digit and units digit.
  - 10s digit: 1.2 second interval
  - Units digit: 0.4 second interval
  - Each diagnostic trouble code is displayed from the 10s digit followed by the units digit. As for a code which has no 10s digit, units digit only is displayed.
- Each diagnostic trouble code is displayed three times in succession.
- If there is no more code stored, the sequence is then repeated from the beginning with each code indicated three times.
- When the diagnostic switch **2** is connected, the engine control unit will immediately stop displaying codes.

● Past diagnostic trouble codes

- After reading the current diagnostic trouble codes (with the diagnostic switch **2** disconnected), disconnect the memory clear switch **1**. Then the warning lamp **3** will restart flashing.
- This time, the warning lamp displays the past diagnostic trouble codes. Determine the fault locations based on the indicated codes.



● **Erasing diagnostic trouble codes**

Disconnect the memory clear switch then reconnect it. Then all the diagnostic trouble codes stored in the engine control unit will be cleared.

CAUTION ⚠

- **Remember that the stored codes are cleared only by disconnecting and reconnecting the memory clear switch.**
- **If the contents of memory are not to be cleared after display of the stored codes, set the starting switch to OFF with the memory clear switch disconnected. Thereafter, connect the memory clear switch.**
- **When you change the combination of the injection pump and engine control unit, you must rewrite the pump data stored in the engine control unit. For this purpose, be sure to perform the memory clear operation by disconnecting both the memory clear and diagnostic switches, then reconnecting them.**

4. Diagnostic Trouble Codes and Check Items

4.1 Diagnostic Trouble Code List

Multi-Use Tester-II display		Page of reference
Diagnostic trouble code	Message	
07	OVER REV.	🕮 P13E-18
11	GOV. SERVO	
14	SUB NE SNSR	🕮 P13E-19
15	NE SNSR	
16	ACCEL. SNSR-2	🕮 P13E-20
19	AIR PRES SNSR	
21	WTR TEMP SNSR	
22	RACK SNSR	🕮 P13E-21

Multi-Use Tester-II display		Page of reference
Diagnostic trouble code	Message	
24	ACCEL. SNSR-1	🕮 P13E-21
32	BST PRES SNSR	
33	ECU SYSTEM	
34	Q RESISTOR	🕮 P13E-22
45	ENG. REVERSE	
65	ACCEL SW	
78	HEATER RELAY	🕮 P13E-23

4.2 Diagnostic Trouble Code Issue Conditions and Check Items

Perform service operations with reference to the diagnostic trouble code issue conditions and probable causes shown below.

07 OVER REV.		
Code issue condition [Reset condition]	Diagnostic trouble code **07** indicates that the engine speed is too high. [The code is reset when the engine speed returns to a specified range.]	
Action taken by ECU	Governor operation is stopped.	
Probable cause and check item	Injection pump assembly's control sleeve faulty • Over-revving of engine (for example, on downhill road) • ECU faulty	Inspection of injection pump assembly (Have inspection performed by BOSCH AUTOMOTIVE SYSTEMS service station.)

11 GOV. SERVO		
Code issue condition [Reset condition]	Diagnostic trouble code **11** indicates that the difference between the target control rack position and actual control rack position is too large. [No reset condition]	
Action taken by ECU	Governor operation is stopped.	
Probable cause and check item	• Control rack position sensor faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **09**: Measurement of target rack position No. **0A**: Measurement of actual rack position • Inspection of control rack position sensor (Have inspection performed by BOSCH AUTOMOTIVE SYSTEMS service station.)

14 SUB NE SNSR (electronic governor side)		
Code issue condition [Reset condition]	Diagnostic trouble code **14** indicates that the number of pulses from engine speed sensor 2 (on the electronic governor) is smaller than the number of pulses from engine speed sensor 1 (on the auto-timer). [The code is reset when engine speed sensor 1 is normal and the number of pulses from engine speed sensor 2 returns to normal].	
Action taken by ECU	• Normal control is effected using only engine speed sensor 1. • If engine speed sensor 1 is also faulty, governor operation is stopped.	
Probable cause and check item	• Open circuit or short circuit in harness between ECU and engine speed sensor 2 • Engine speed sensor 2 faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **02**: Measurement of engine speed • Inspection of engine speed sensor 2 (Have inspection performed by BOSCH AUTOMOTIVE SYSTEMS service station.) • Check of circuit between ECU and engine speed sensor 2

14 SUB NE SNSR (electronic governor side) **15 NE SNSR** (auto-timer side)		
Code issue condition [Reset condition]	Diagnostic trouble codes **14** and **15** are both issued if engine speed sensor 1 (on the auto-timer) and engine speed sensor 2 (on the electronic governor) fail at the same time. [The code is reset when pulses are applied from engine speed sensor 1 or engine speed sensor 2 following engine startup.]	
Action taken by ECU	Fuel injection timing control is stopped, and governor operation is stopped.	
Probable cause and check item	• Open circuit or short circuit in harness between ECU and engine speed sensors 1 and 2 • Engine speed sensors 1 and 2 faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **02**: Measurement of engine speed • Inspection using ECU connector 🕮 P13E-27 **01**: Measurement of resistance of engine speed sensor 1 • Inspection of engine speed sensor 1 🕮 P13E-30: Inspection of Electrical Equipment **263** • Inspection of engine speed sensor 2 (Have inspection performed by BOSCH AUTOMOTIVE SYSTEMS service station.) • Check of circuit between ECU and engine speed sensors 1 and 2

15 NE SNSR (auto-timer side)		
Code issue condition [Reset condition]	Diagnostic trouble code **15** indicates that the number of pulses from engine speed sensor 1 (on the auto-timer) is smaller than the number of pulses from engine speed sensor 2 (on the electronic governor). [The code is reset when engine speed sensor 2 is normal and the number of pulses from engine speed sensor 1 returns to normal.]	
Action taken by ECU	• Normal control is effected using only engine speed sensor 2. • If engine speed sensor 2 is also faulty, governor operation is stopped.	
Probable cause and check item	• Open circuit or short circuit in harness between ECU and engine speed sensor 1 • Engine speed sensor 1 faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **02**: Measurement of engine speed • Inspection using ECU connector 🕮 P13E-27 **01**: Measurement of resistance of engine speed sensor 1 • Inspection of engine speed sensor 1 🕮 P13E-30: Inspection of Electrical Equipment **263** • Check of circuit between ECU and engine speed sensor 1

16 ACCEL. SNSR-2		
Code issue condition [Reset condition]	Diagnostic trouble code **16** indicates short or open circuit in accelerator position sensor 2 harness and faulty sensor proper. (If diagnostic trouble code 16 is issued, inspections for diagnostic trouble code **24** must also be performed.) The code is issued when accelerator position sensor 2 voltage is out of specified limits. [When accelerator position sensor 2 voltage is back within specified limits, a reset is made.]	
Action taken by ECU	• Normal control is effected using only non-faulty accelerator pedal position sensor **1**. • If accelerator pedal position 1 is also faulty, control is effected using assumptions of 100% with the pedal depressed and 0% with the pedal released.	
Probable cause and check item	• Open or short circuit in harness between ECU and accelerator position sensor 2 • Accelerator position sensor 2 faulty or poorly adjusted • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **03, 04**: Measurement of throttle opening indicated by accelerator pedal position sensor No. **5**: Measurement of accelerator pedal position sensor's output voltage • Inspection of accelerator pedal position sensor • Check of circuit between ECU and accelerator pedal position sensor 2

19 AIR PRES SNSR		
Code issue condition [Reset condition]	Diagnostic trouble code **19** indicates short or open circuit in air pressure sensor harness and faulty air pressure sensor (built in ECU). The code is issued when air pressure sensor voltage is out of specified limits. [When air pressure sensor voltage falls back within specified limits, a reset is made.]	
Action taken by ECU	Air pressure is defaulted to 100 kPa {760 mmHg}.	
Probable cause and check item	• Air pressure sensor (built in ECU) faulty. • ECU faulty	• Perform checks on the basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **18**: Air pressure measurement

21 WTR TEMP SNSR		
Code issue condition [Reset condition]	Diagnostic trouble code **21** indicates open circuit in water temperature sensor harness and faulty sensor proper. The code is issued when water temperature sensor voltage is out of specified limits. [When water temperature sensor voltage falls back within specified limits, a reset is made.]	
Action taken by ECU	Controls are continued assuming that coolant temperature is –20°C when engine is started and 80°C when engine is running.	
Probable cause and check item	• Open or short circuit in harness between ECU and water temperature sensor • Water temperature sensor faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **16**: Measurement of engine coolant temperature • Inspection using ECU connector 🕮 P13E-27 02 : Measurement of resistance of coolant temperature sensor • Inspection of coolant temperature sensor 🕮 P13E-30: Inspection of Electrical Equipment 262 • Check of circuit between ECU and coolant temperature sensor

22 RACK SNSR		
Code issue condition [Reset condition]	Diagnostic trouble code **22** indicates that the control rack position sensor's output voltage is outside specified limits. [No reset condition]	
Action taken by ECU	Governor is temporarily stopped. (Feedback control is resumed after the engine is restarted.)	
Probable cause and check item	• Control rack position sensor faulty • Control rack not moving smoothly • Governor actuator's link faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **0A**: Measurement of actual rack position • Inspection of control rack position sensor and control rack (Have inspection performed by BOSCH AUTOMOTIVE SYSTEMS service station.)

24 ACCEL. SNSR-1		
Code issue condition [Reset condition]	Diagnostic trouble code **24** indicates short or open circuit in accelerator position sensor 1 harness and faulty sensor proper. (If diagnostic trouble code **24** is issued, inspections for diagnostic trouble code **16** must also be performed.) The code is issued when accelerator position sensor 1 voltage is out of specified limits. [When accelerator position sensor 1 voltage falls back within specified limits, a reset is made.]	
Action taken by ECU	• Normal control is effected using only non-faulty accelerator pedal position sensor 2. • If accelerator pedal position 2 is also faulty, control is effected using assumptions of 100 % with the pedal depressed and 0 % with the pedal released.	
Probable cause and check item	• Open or short circuit in harness between ECU and accelerator position sensor 1 • Accelerator position sensor 1 faulty or poorly adjusted • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **03, 04**: Measurement of throttle opening indicated by accelerator pedal position sensor No. **5**: Measurement of accelerator pedal position sensor's output voltage • Inspection of accelerator pedal position sensor • Check of circuit between ECU and accelerator pedal position sensor 1

32 BST PRES SNSR		
Code issue condition [Reset condition]	Diagnostic trouble code **32** indicates short or open circuit in boost pressure sensor harness and faulty sensor proper. The code is issued when boost pressure sensor voltage is out of specified limits. [When boost pressure sensor voltage falls back within specified limits, a reset is made.]	
Action taken by ECU	Control is effected with the boost pressure assumed to be fixed at 0 kPa {0 mmHg}.	
Probable cause and check item	• Open or short circuit in harness between ECU and boost pressure sensor • Boost pressure sensor faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **2D**: Measurement of boost pressure • Inspection of boost pressure sensor main body 🕮 P13E-31: Inspection of Electrical Equipment 3I8 • Check of circuit between ECU and boost pressure sensor

33 ECU SYSTEM		
Code issue condition [Reset condition]	Diagnostic trouble code **33** indicates a processing error or memory error in the ECU. [No reset condition]	
Action taken by ECU	Governor operation is stopped.	
Probable cause and check item	ECU faulty	–

34 Q RESISTOR		
Code issue condition [Reset condition]	Diagnostic trouble code **34** indicates short or open circuit in injection quantity adjusting resistor harness and faulty adjusting resistor. The code is issued when injection quantity adjusting resistor voltage is out of specified limits. [When injection quantity adjusting resistor voltage falls back within specified limits, a reset is made.]	
Action taken by ECU	Injection quantity correction value is fixed at No. 1 value.	
Probable cause and check item	• Open or short circuit in harness between ECU and injection quantity adjusting resistor • Injection quantity adjusting resistor faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **14**: Check of resistor number of fuel injection quantity adjusting resistor • Inspection using ECU connector 🕮 P13E-27 03 : Measurement of resistance of fuel injection quantity adjusting resistor • Inspection of fuel injection quantity adjusting resistor 🕮 P13E-32: Inspection of Electrical Equipment 328 • Check of circuit between ECU and fuel injection quantity adjusting resistor

45 ENG. REVERSE		
Code issue condition [Reset condition]	Diagnostic trouble code **45** indicates that an extremely low engine speed (a speed lower than that resulting from cranking with the starter) has been detected with the starter switch in the OFF position. [The code is reset when the engine speed is no longer detected with the starter switch in the OFF position or when the starter switch is turned to the ON position.]	
Action taken by ECU	Governor operation is stopped	
Probable cause and check item	• Operating error at time of engine startup • Poor matching of connected devices • ECU faulty	–

65 ACCEL SW		
Code issue condition [Reset condition]	Diagnostic trouble code **65** indicates short or open circuit in accelerator pedal switch harness and faulty accelerator switch. The code is issued when accelerator pedal is released (accelerator switch ON) and accelerator pedal opening signal is input. [When accelerator pedal opening signal returns to normal, a reset is made.]	
Action taken by ECU	Normal control is effected.	
Probable cause and check item	• Open or short circuit in harness between ECU and accelerator pedal switch • Accelerator pedal switch faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **03, 04**: Measurement of throttle opening indicated by accelerator pedal position sensor No. **69**: Check of operation of accelerator pedal switch • Inspection using ECU connector 🕮 P13E-27 04 : Check of continuity of accelerator pedal switch • Inspection of accelerator pedal switch • Check of circuit between ECU and accelerator pedal switch

78 HEATER RELAY		
Code issue condition [Reset condition]	Diagnostic trouble code **78** is issued in the following circumstances: (1) The ECU issues a command to turn the glow relay OFF following a short circuit in the glow relay. [The code is reset when the glow relay returns to normal.] (2) The ECU issues a command to turn the glow relay ON following an open circuit in the glow relay. [No reset condition]	
Action taken by ECU	Preglow control is stopped.	
Probable cause and check item	• Open circuit or short circuit in harness between ECU and glow relay • Glow relay faulty • ECU faulty	• Perform checks on basis of Multi-Use Tester-II service data. 🕮 P13E-24 No. **92**: Check of operation of glow relay • Actuator test using Multi-Use Tester-II 🕮 P13E-26 No. **BC**: Check of operation of glow relay • Inspection of glow relay 🕮 Gr 16 • Check of circuit between ECU and glow relay

5. Service Data of Multi-Use Tester-II

Multi-Use Tester-II display			Condition at time of inspection	Normal condition
No.	Item	Data		
01	BATT VOLTAGE	■■.■■ V	Idling	20 to 30 V
02	ENGINE SPEED	■■■■. rpm	Racing (with engine running)	Same as tachometer indication
03	ACCEL (%)	■■■.■ %	Accelerator pedal released	0 %
			Accelerator pedal gradually depressed	Gradually increases
			Accelerator pedal fully depressed	100 %
04	ACCEL (%) REAL	■■■.■ %	Accelerator pedal released	0 %
			Accelerator pedal gradually depressed	Gradually increases
			Accelerator pedal fully depressed	100 %
05	ACCEL (V)	■.■■■ V	Accelerator pedal gradually depressed from released position	Depends on vehicle specifications
09	TARGET RACK	■■.■■ mm	Starter switch ON	3 mm
0A	REAL RACK	■■.■■ mm	Starter switch ON	3 mm
12	TCV ANG. DIFF.	■■.■■ °CA ■■.■■ deg	Depends on vehicle specifications	
14	Q RESISTOR	■.■■■	–	Same as number marked on fuel injection quantity adjusting resistor
16	WATER TEMP	■■■.■ °C ■■■.■ °F	Engine cold	Approximately same as ambient temperature
			During engine warmup	Gradually increases
			Engine stopped after warmup	Gradually decreases
18	AIR PRESS	■■■■. kPa ■■■■. mmHg	Altitude 0 m	101 kPa
			Altitude 600 m	95 kPa
			Altitude 1,200 m	88 kPa
2D	BOOST PRESS	■■■■. kPa ■■■■. mmHg	Running at high idle speed	Depends on vehicle specifications
4F	DIAGNOSIS SW	ON/OFF	Diagnosis switch ON (connected to connector)	ON
			Diagnosis switch OFF (disconnected from connector)	OFF
51	DIAG LAMP (U)	ON/OFF	Starter switch in ON position (engine not started)	ON
			Starter switch in OFF position	OFF
52	DIAG LAMP (R)	ON/OFF	Starter switch in ON position (engine not started)	ON
			Starter switch in OFF position	OFF
56	KEY SW	ON/OFF	Starter switch in ON position	ON
			Starter switch in any position except ON	OFF
62	DIAG RESET SW	ON/OFF	Memory clear switch ON (connected to connector)	ON
			Memory clear switch OFF (disconnected from connector)	OFF

Multi-Use Tester-II display			Condition at time of inspection		Normal condition
No.	Item	Data			
67	PULL DOWN	ON/OFF	Normal condition		OFF
			Abnormal condition (during pulldown control)		ON
69	ACCEL SW	ON/OFF	Accelerator pedal depressed		ON
			Accelerator pedal released		OFF
73	START SW	ON/OFF	Engine cranked with starter switch in START position		ON
			Starter switch in any position except START		OFF
91	PRE-HEAT LAMP	ON/OFF	Starter switch ON	Coolant temperature low	ON
				Coolant temperature high	OFF
92	HEATER RELAY	ON/OFF	Starter switch ON	Coolant temperature low	ON
				Coolant temperature high	OFF

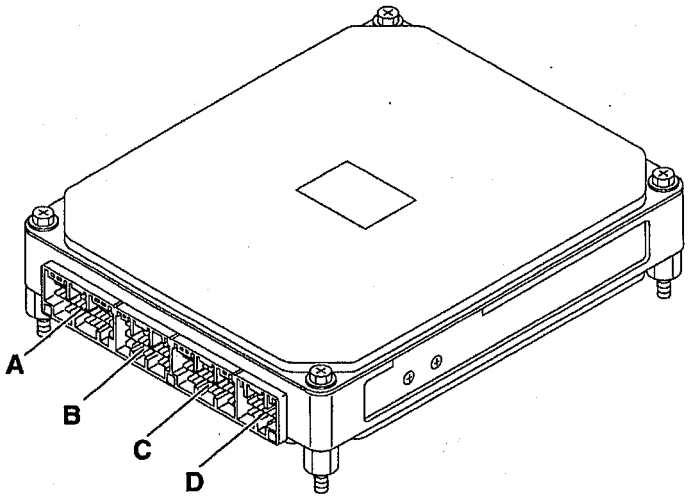
6. Actuator Test by Multi-Use Tester-II

Multi-Use Tester-II display		Method of checking operation
No.	Item	
AC	DIAG LAMP (U)	• Create warning lamp illumination conditions. • Perform test with engine speed of zero and vehicle speed of zero. • Cause warning lamp five times to be on for one second then off for one second.
AD	DIAG LAMP (R)	• Create warning lamp illumination conditions. • Perform test with engine speed of zero and vehicle speed of zero. • Cause warning lamp five times to be on for one second then off for one second.
BB	PRE-HEAT LAMP	• Create indicator lamp illumination conditions. • Perform test with engine speed of zero and vehicle speed of zero. • Cause indicator lamp five times to be on for one second then off for one second.
BC	HEATER RELAY	• Create air glow operating conditions. • Perform test with engine speed of zero and vehicle speed of zero. • Cause air heater five times to be on for one second then off for one second.

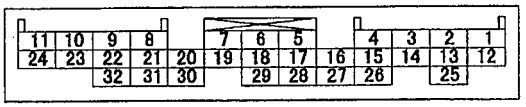
7. Check at Connector of Electronic Control Unit

These checks allow correct transmission of ECU signals via vehicle harnesses and connectors to be verified. They are intended to assist in troubleshooting. The numbers (01 , 02 , etc.) in the tables correspond to reference numbers in section 3.4, "Causes of Diagnostic Trouble Code Issue, and Inspection Items".

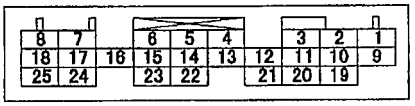
Pin configuration of ECU



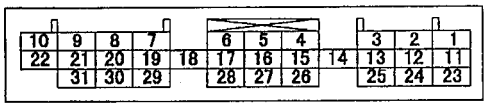
A: CW32A



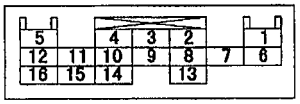
B: CW25A



C: CW31A



D: CW16A



Ⓟ43639

No.	Item	Page of reference
01	Resistance of engine speed sensor 1	🕮 P13E-28
02	Resistance of coolant temperature sensor	
03	Resistance of fuel injection quantity adjusting resistor	
04	Continuity of accelerator pedal switch	

Checking Procedures

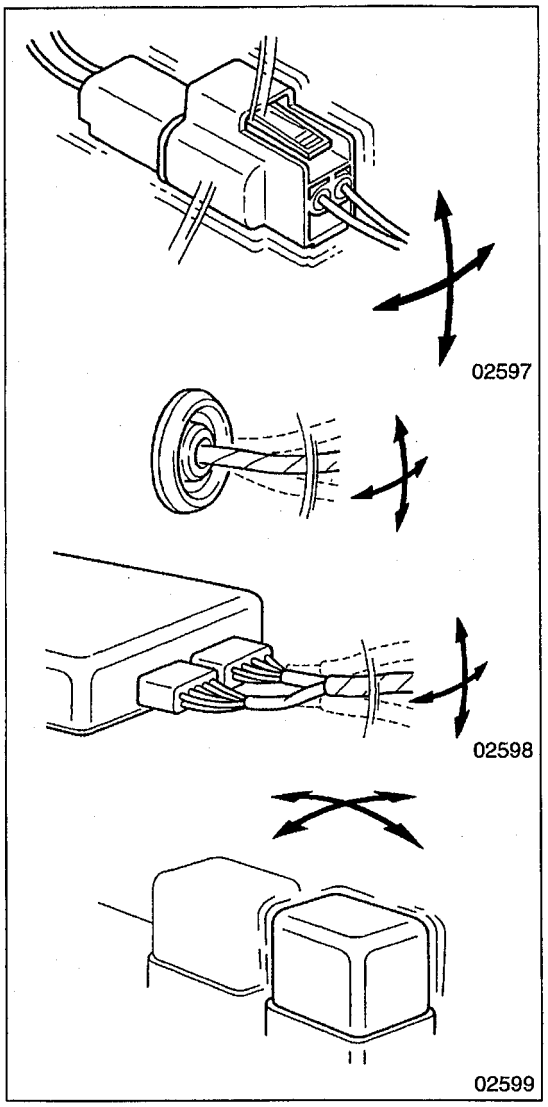
CAUTION ⚠

Some inspections are performed with the connector removed, and others are performed with the connector fitted. Note the following instructions:

- **Do not touch any terminal other than the ones specified for the inspections. Be particularly careful not to cause short circuits between terminals using the tester probes.**
- **Terminal numbers shown in the tables are the numbers of terminals on the ECU. Be careful not to select the wrong terminals for inspections.**

<table>
<tr><th>Check item</th><th>Method</th></tr>
<tr><td>01 Resistance of engine speed sensor 1</td><td>[Check conditions]
• Starter switch OFF
• Connector removed. Check performed on vehicle-side harness.
[Normal condition]
Between terminals A ⑧ and A ㉑: 2.1 to 2.5 kΩ</td></tr>
<tr><td>02 Resistance of coolant temperature sensor</td><td>[Check conditions]
• Starter switch OFF
• Connector removed. Check performed on vehicle-side harness.
[Normal conditions]
Between terminals C ⑮ and A ㉚: 2.3 to 2.6 kΩ (at 20°C)
0.3 to 0.34 kΩ (at 80°C)</td></tr>
<tr><td>03 Resistance of fuel injection quantity adjusting resistor</td><td>[Check conditions]
• Starter switch OFF
• Connector removed. Check performed on vehicle-side harness.
[Normal conditions]
Between terminals B ④ and B ⑬:
<table>
<tr><th>No.</th><th>Resistance</th><th>No.</th><th>Resistance</th><th>No.</th><th>Resistance</th></tr>
<tr><td>1</td><td>270 Ω</td><td>4</td><td>1300 Ω</td><td>7</td><td>5600 Ω</td></tr>
<tr><td>2</td><td>510 Ω</td><td>5</td><td>2000 Ω</td><td>8</td><td>15000 Ω</td></tr>
<tr><td>3</td><td>820 Ω</td><td>6</td><td>3300 Ω</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>04 Continuity of accelerator pedal switch</td><td>[Check conditions]
• Starter switch OFF
• Connector removed. Check performed on vehicle-side harness.
[Normal conditions]
Between terminals (⊕ and ⊖) B ② and D ⑥:
• Accelerator pedal depressed: Continuity does not exist.
• Accelerator pedal released: Continuity exists.</td></tr>
</table>

8. Checks on Transient Troubles

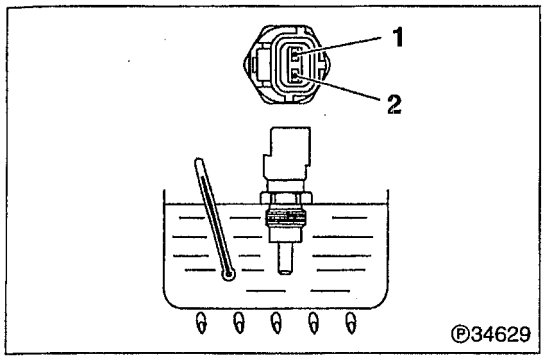


A transient trouble often occurs in a specific condition. Therefore, pinpointing the condition will make it easy to estimate the cause. To pinpoint the condition for a transient trouble, ask the customer in detail about the driving condition when the trouble occures, weather, occurrence frequency and symptoms, and reproduce the symptoms of the trouble.
Depending on the condition where the trouble occurs, determine whether the cause of the trouble is vibration, temperature or any other factor. If the probable cause is vibration, perform the following checks on the relevant connectors harnesses, etc. and check whether the symptoms of the trouble are reproduced.

- Lightly move the connector up and down and to the right and left.
- Lightly move the harness up and down and to the right and left.
- Lightly shake the sensors and other devices by hand.
- Lightly shake the wiring harness located in the moving components such as the suspension.

The connectors and other parts to be checked are identifiable from the descriptions in the Probable Causes or the Checking Procedures for the displayed diagnostic trouble code.

INSPECTION OF ELECTRICAL EQUIPMENT



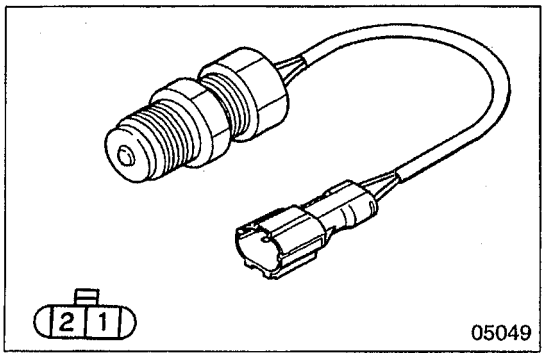
262 Checking Water Temperature Sensor

- Put the water temperature sensor in a container filled with engine oil.
- Heat the engine oil to various specified temperatures while stirring the engine oil.
- Measure the resistance value between pins **1** and **2** (body).

Standard value	20°C	2.3 to 2.6 kΩ
	80°C	0.30 to 0.34 kΩ

Referance value in parentheses

- If the reading is out of the standard value, replace the water temperature sensor. 🕮 Gr 14



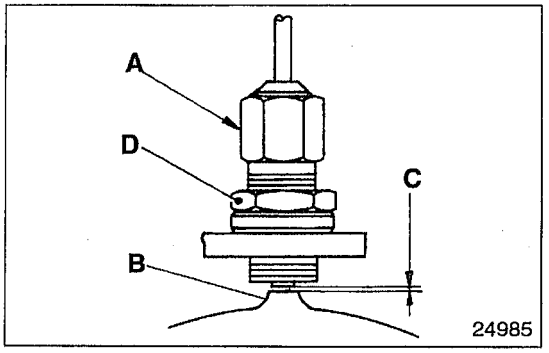
263 Engine Speed Sensor 1

[Inspection]

- Measure the resistance value between pins 1 and 2.

Standard value (at 20°C)	2.1 ± 2.5 kΩ

- If the reading is out of the standard value range, replace the engine speed sensor.



[Installation]

- Adjust the clearance **C** between the engine speed sensor 1 **A** and the timer flange protrusion **B** to the standard value, then lock the sensor by tightening the lock nut **D**.

Standard value	0.8 to 1.0 mm

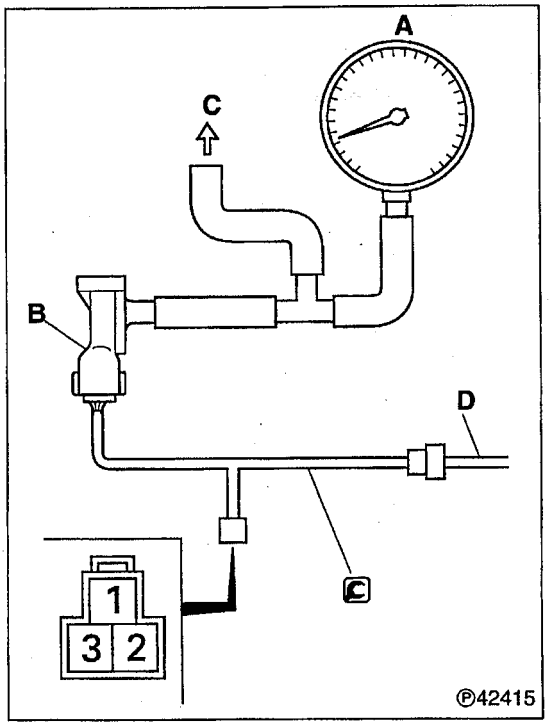
318 Checking Boost Pressure Sensor

NOTE

The boost pressure checking conditions differ between when the boost pressure is checked by use of the Multi-Use Tester-II and when it is checked without use of the Multi-Use Tester-II. So the standard values also differ.

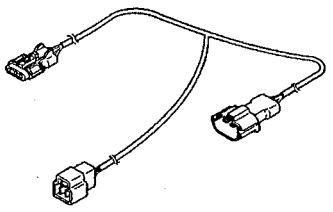
<Checking by use of Multi-Use Tester-II>

P13E-26



<Checking without use of Multi-UseTester II>

- Disconnect the chassis side harness **D** and connect the C inspection harness between them.

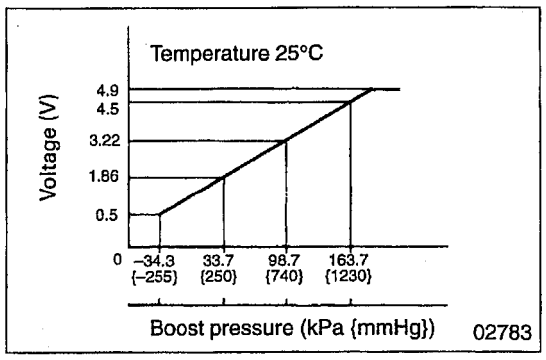
Tool name and shape	Part No.
Inspection Harness  02806	MC854336

- Mount pressure gauge **A** for measurement of the boost pressure.

  C: To inlet manifold
- Set the starting switch to ON.
- Measure the output voltage of the boost pressure sensor **B** according to the following table.

Item	Connector Pin		
	1 Power (+)	2 GND (–)	3 Output (+)
Power voltage	○	○	
*Output voltage (Refer to the output characteristics shown at left.)		○	○

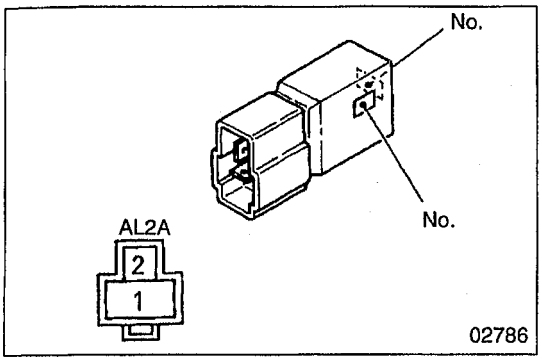
*: Start the engine before measurement.



Output Characteristics

Standard Value	2 – 3	5V
	1 – 2	0.5V/–34.3 kPa {–255 mmHg}
		1.86V/33.7 kPa {250 mmHg}
		3.22V/98.7 kPa {740 mmHg}
		4.5V/163.7 kPa {1230 mmHg}

- If the results of the above mentioned checks show any deviation from the standard values, replace the boost pressure sensor **B**.



828 Checking injection quantity adjusting resistor

- Measure the resistance of the fuel injection quantity adjusting resistor. The standard value corresponds to the resistor number marked on the case.

Standard value (at 20°C)	Resistor No.	1	270 Ω
		2	510 Ω
		3	820 Ω
		4	1300 Ω
		5	2000 Ω
		6	3300 Ω
		7	5600 Ω
		8	15000 Ω

- If the measurement is out of specification, replace the fuel injection quantity adjusting resistor.

NOTE

The fuel injection quantity adjusting resistor is matched to the injection pump. Replace it only with one that has the same resistor number.

GROUP 14 COOLING

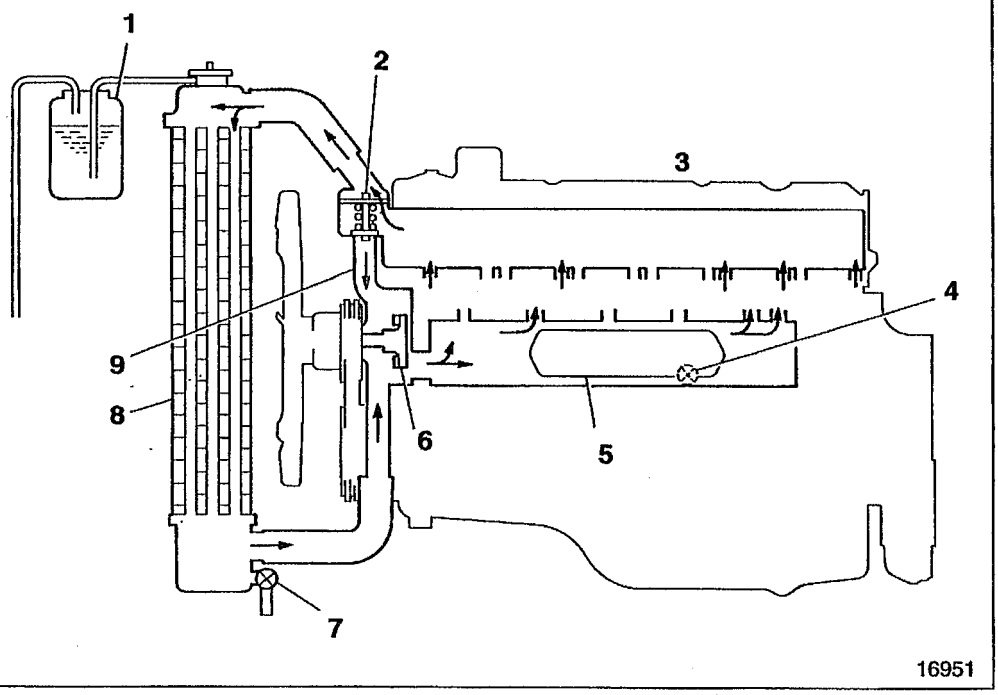
SPECIFICATIONS / STRUCTURE AND OPERATION

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)
Automatic cooling fan coupling type	Constant control type
Radiator type	Tube and corrugated fin type
Coolant capacity dm^3 {L} (engine main body only)	13 {13}

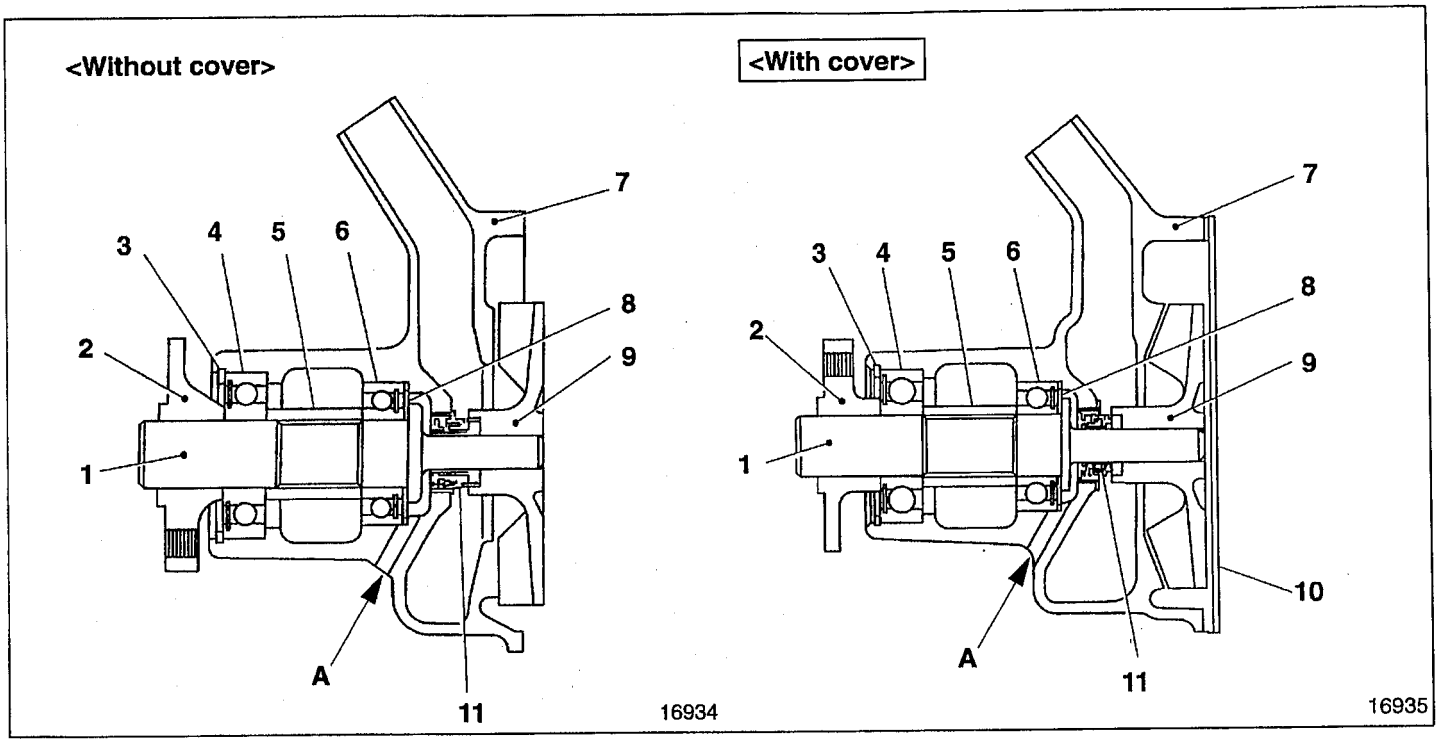
STRUCTURE AND OPERATION

1. Cooling System (Water Flow)



1 Reservoir tank
2 Thermostat
3 Cylinder head
4 Drain plug
5 Oil cooler
6 Water pump
7 Drain cock
8 Radiator
9 Bypass hose

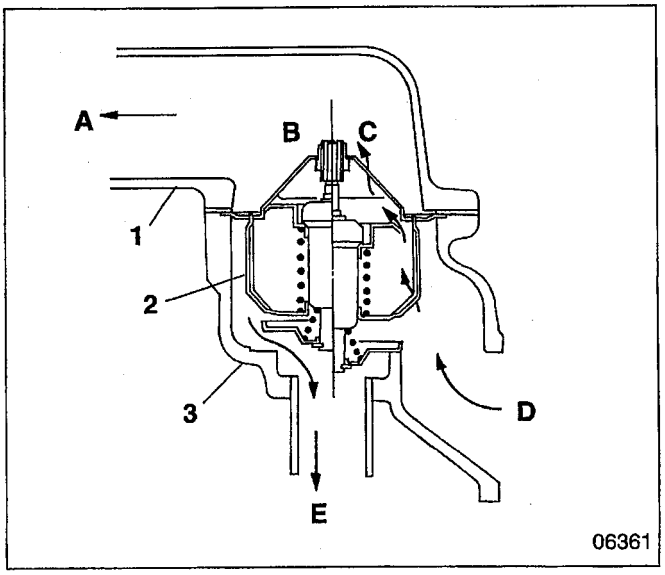
2. Water Pump



1 Water pump shaft
2 Flange
3 Snap ring
4 Bearing
5 Spacer
6 Bearing
7 Water pump case
8 Washer
9 Impeller
10 Cover
11 Unit seal

A: Drain hole

3. Thermostat



1 Thermostat cover
2 Thermostat
3 Thermostat case

A: To radiator
B: With low coolant temperature
C: With high coolant temperature
D: From cylinder head
E: 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.

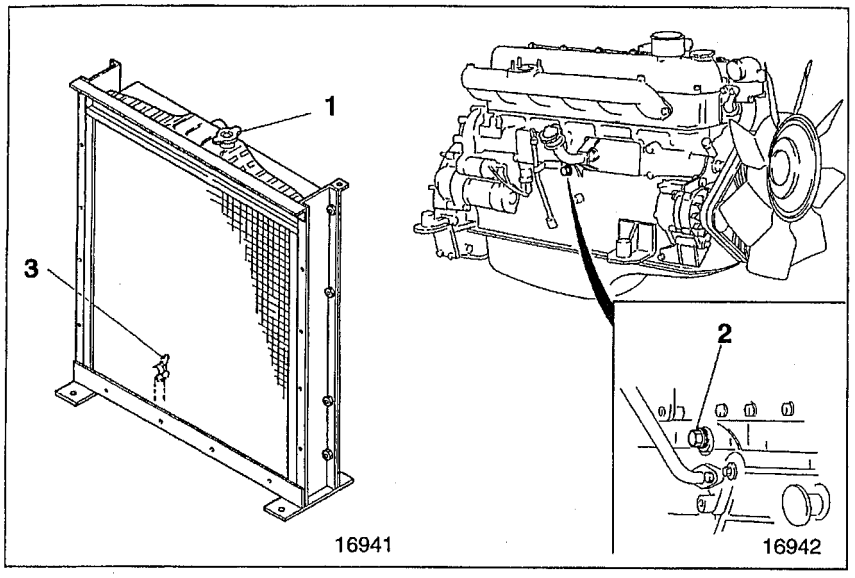
TROUBLESHOOTING

Possible causes / Symptoms		Overheating (insufficient cooling)	Overcooling	Abnormal noise	Excessive coolant loss	Remarks
V-belt	Loose or damaged	○		○		
	Excessive tension			○		
	Oil on belt	○				
Water pump	Water pump fitted poorly	○			○	
	Gasket defective	○			○	
	Bearing defective	○		○		
	Impeller defective	○				
	Unit seal defective	○			○	
	Loose fit between shaft and flange and/or shaft and impeller	○		○		
Thermostat	Case fitted poorly	○			○	
	Gasket defective	○			○	
	Valve opening temperature too high; valve remains closed	○				
	Valve opening temperature too low; valve remains open		○			
	Water leaking from water temperature sensor	○			○	
Radiator	Space between core and fins clogged	○				
	Core cracked and/or separation of soldered joints	○			○	
	Pressure cap not sufficiently airtight	○				
Cooling fan	Fan shroud fitted poorly	○		○		
Automatic cooling fan coupling	Bearing defective	○		○		
	Bimetal damaged	○				
	Bimetal contaminated with foreign particles	○	○			
	Silicon oil leaking	○		○		
Oil cooler	Oil cooler fitted poorly	○			○	🕮 Gr 12
	Gasket defective	○			○	
Cylinder head	Cylinder head fitted poorly	○			○	🕮 Gr 11
	Gasket defective	○			○	
Coolant quantity insufficient and/or coolant dirty		○				
Coolant passages dirty and/or clogged		○				
Hoses fitted poorly		○			○	
Ambient temperature extremely low			○			

MEMO

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Replacing Coolant and Cleaning Coolant System



1 Pressure cap
2 Crankcase drain plug
3 Radiator drain cock

ⓣ Tightening torques

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Crankcase drain plug	115 {12}	—

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 ⚠

- **To avoid being scalded, ensure that the coolant has cooled sufficiently before draining it out.**
- **Unless care is exercised, opening pressure cap 1 when the coolant is hot can cause the coolant to spray out. Cover the pressure cap with a cloth, and loosen the cap slowly to bleed off the pressure before opening it fully.**

● 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.

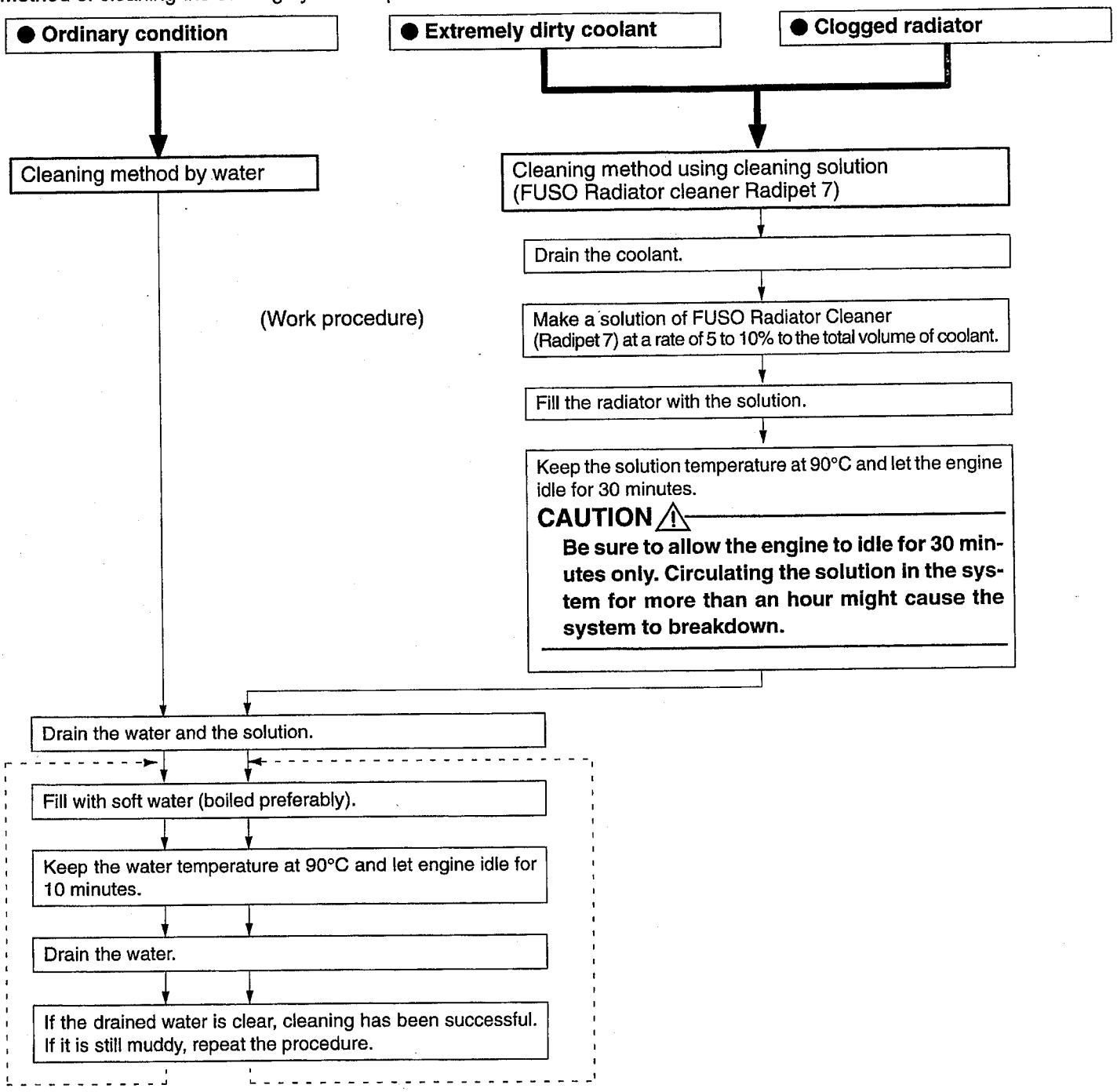
CAUTION ⚠

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

Required propertiies 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	—	—

Method of cleaning the cooling system depends on its 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 is flammable. Keep them away from heat and flames.

NOTE

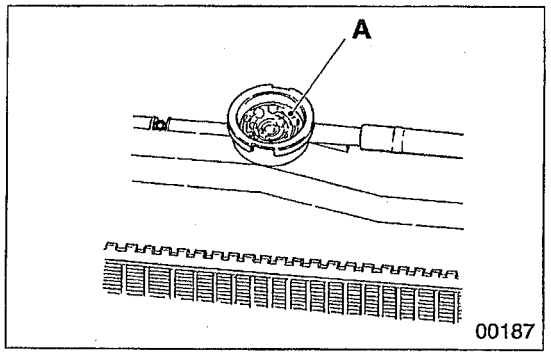
- **After cleaning the cooling system with cleaning fluid, fill it with coolant as son as possible.**
- **To prevent freezing of the coolant and corrosion of the cooling system, add to the coolant the specified proportion of FUSO Diesel Long Life Coolant. (See the Maintenance Manual for instructions on the use of these products).**

2. Air Bleeding of Cooling System

- Remove the pressure cap. Keeping the coolant temperature at 90°C, let the engine idle until the cooling system is completely bled of air. While the engine is idling, keep the heater controller's adjustment lever at its maximum-temperature position so that coolant flows freely in the heater piping.
- After bleeding the cooling system of air, add coolant to the radiator and reservoir tank as required.

3. 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:

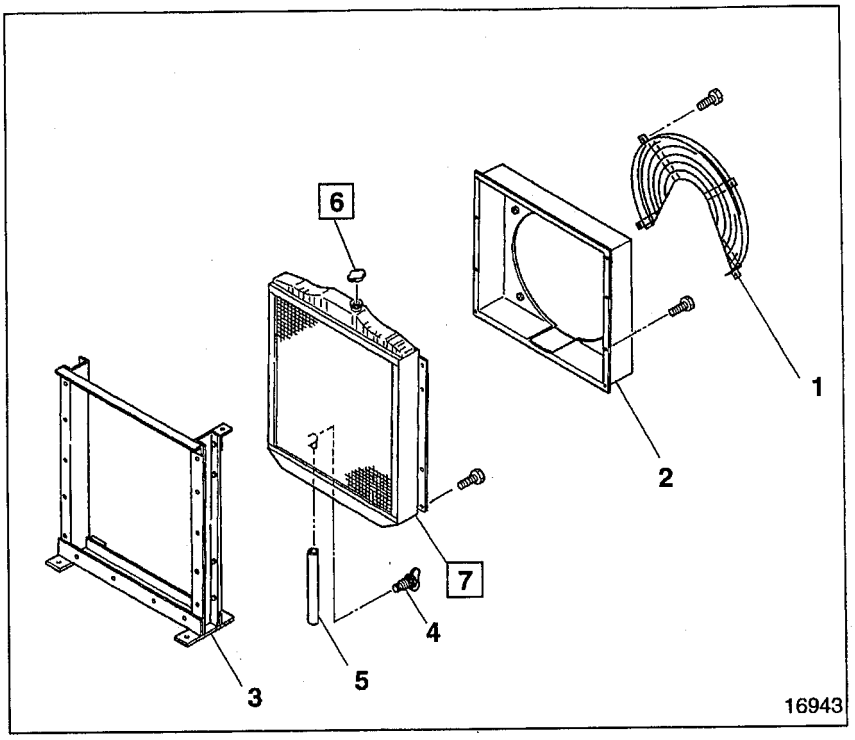


- Remove pressure cap **1**.

WARNING ⚠

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



● **Disassembly sequence**

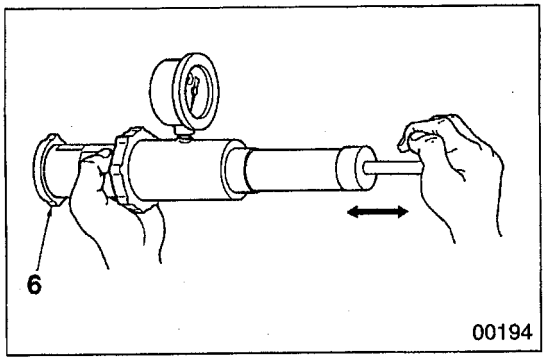
1 Wire net
2 Shroud
3 Frame
4 Drain cock
5 Drain hose
6 Pressure cap
7 Radiator

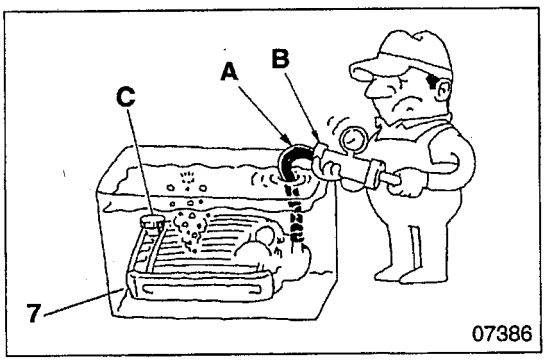
● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
6	Pressure valve opening pressure	69 ± 15 kPa {0.7 ± 0.15 kg/cm^2}	—	Replace
7	Radiator air leakage (with air pressure of 150 kPa {1.5 kgf/cm^2})	0 cc	—	Correct or replace





◆ Service procedure

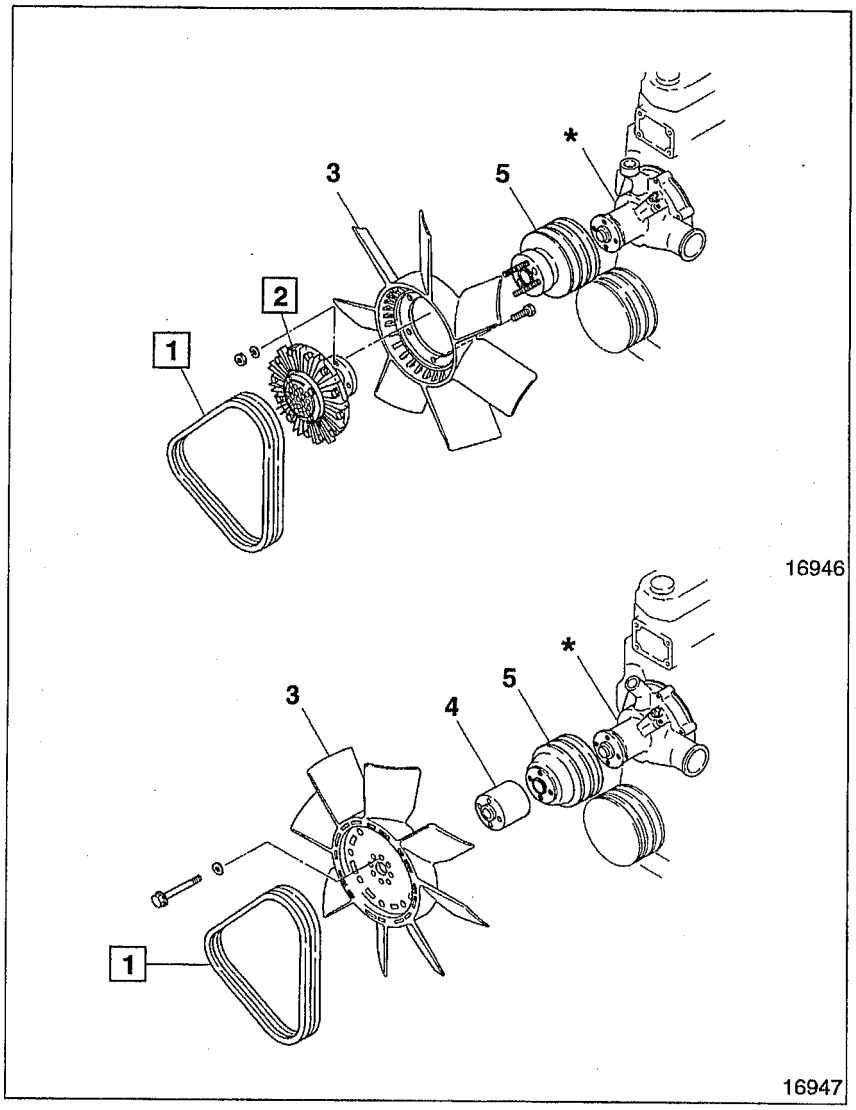
6 Pressure cap inspection

Measure the pressure valve's opening pressure. If the measurement does not conform with the standard value, replace pressure cap **6**.

7 Radiator inspection

- Fit hose **A** and radiator cap tester **B** to the radiator upper tank.
- Fit plug **C** to the lower tank, then immerse the radiator in a tank of water.
- Using radiator cap tester **B**, apply the specified air pressure of 150 kPa {1.5 kgf/cm^2}, and check for air leakage.
- If air leakage is apparent, correct or replace radiator **7**.

COOLING FAN AND V-BELT



● **Disassembly sequence**

1 V-belt
2 Automatic cooling fan coupling
3 Cooling fan
4 Spacer
5 Water pump pulley

*: Water pump assembly
📖 P.14-14

● **Assembly sequence**

Reverse the order of disassembly.

CAUTION ⚠

- **Automatic cooling fan coupling 2 is an integrated unit and cannot be disassembled. If any fault is apparent, replace the whole assembly.**
- **When replacing V-belts 1, be sure to replace them as a set to maintain even tension between them.**

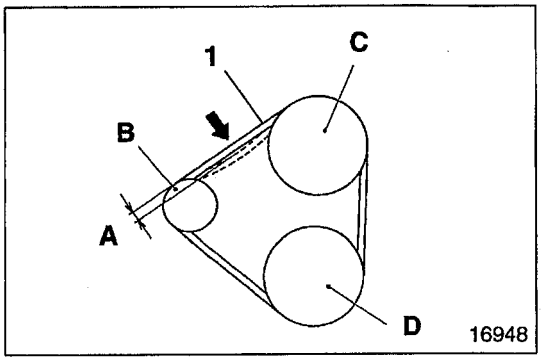
Service standards

Unit: mm

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

Special tools

Location	Tool name and shape	Part No.	Application
1	Belt tension gauge  03612	MH062345	V-belt tension measurement

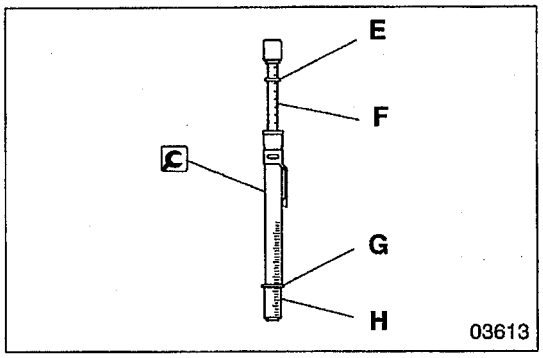


◆ Service procedure

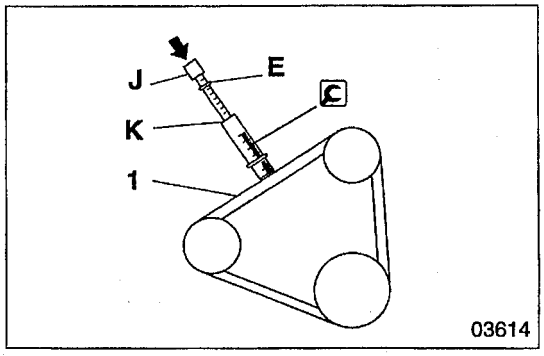
1 V-belt

[Inspection]
Apply force of approximately 98 N {10 kgf} to the center of the V-belt **1** and measure the extent of V-belt deflection **A**.

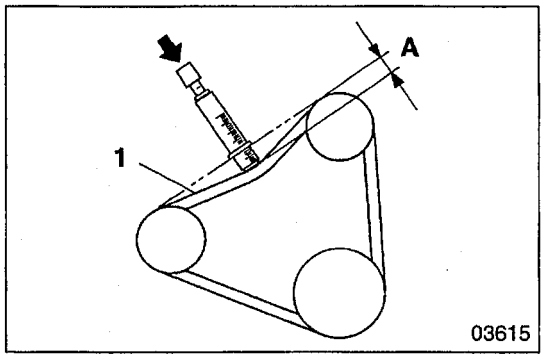
B: Alternator pulley
C: Water pump pulley
D: Crankshaft pulley



- Set upper O-ring **E** of [C] belt tension gauge to 8 N {10 kgf} (push load) on scale **F**.
- Set lower O-ring **G** of [C] belt tension gauge to the V-belt's correct maximum deflection value on scale **H**.

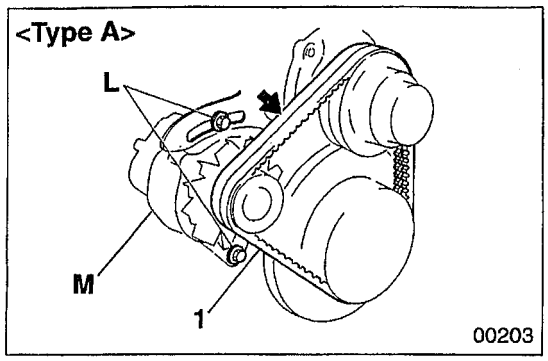


- Apply the [C] belt tension gauge to the center of V-belt **1** and push until O-ring **E** reaches the flange **K**.



- Measure the extent of V-belt **1** deflection **A**. If the measurement does not conform with the standard value, adjust the V-belt as shown below.

COOLING FAN AND V-BELT



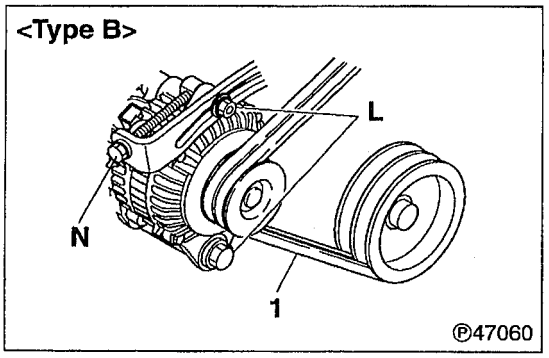
[Adjustment]

CAUTION

- **Excessive tension in V-belt 1 may damage the belt and related bearings.**
- **Be sure to replace the V-belts 1 as a set to maintain even tension between them.**
- **Keep V-belt 1 free of oil. If the belt becomes oily, it will slip, resulting in overheating of the engine and insufficient charging of the battery.**

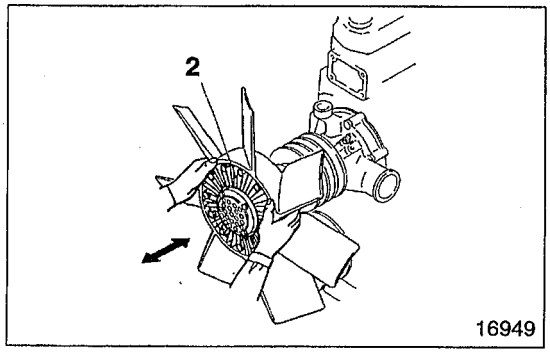
<Type A>

- Loosen alternator mounting bolts **L** (2 places) and adjust the V-belt tension by moving alternator **M** to the left or right.
- When the adjustment is complete, tighten the bolts and nuts securely.



<Type B>

- Loosen alternator retaining bolts **L** (2 places) and adjust the tension of V-belt **1** using adjuster bolt **N**.
- After the belt tension is adjusted, tighten the bolts and nut firmly.

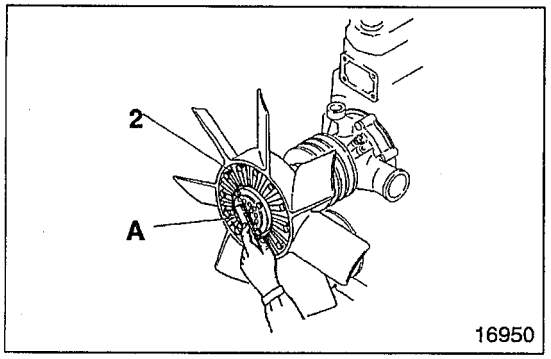


2 Automatic cooling fan coupling

[Inspection]

Inspect automatic cooling fan coupling **2** in accordance with the following procedure. If any defect is evident, replace the unit.

- Check for leakage of oil from the coupling body.
- Rotate automatic cooling fan coupling **2** by hand and check for irregular movement or abnormal noise caused by a defect in the bearing.
- Check for excessive axial play in automatic cooling fan coupling **2** when the engine is cool.

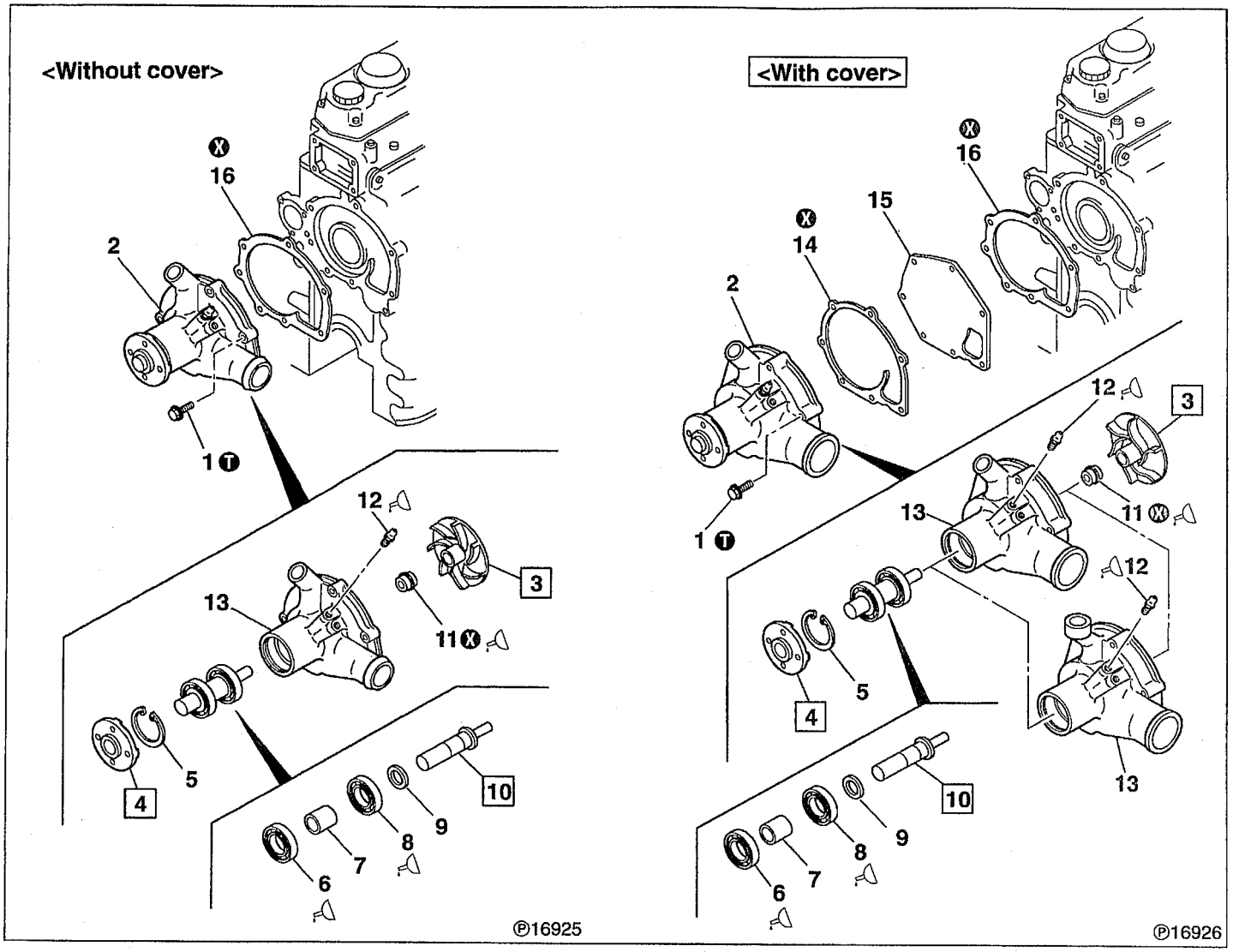


[Cleaning]

If any foreign particles have adhered to bimetal **A**, brush them off gently.

MEMO

WATER PUMP



● **Disassembly sequence**

1 Bolt
2 Water pump assembly
3 Impeller
4 Flange
5 Snap ring
6 Bearing
7 Spacer
8 Bearing
9 Washer
10 Water pump shaft
11 Unit seal
12 Grease nipple
13 Water pump case
14 Gasket (pump with cover)
15 Cover (pump with cover)
16 Gasket

Ⓧ: Non-reusable part

● **Assembly sequence**

16 → 15 → 14 → 2 → 1

2 : 13 → 12 → 5 → 11 → 4 → 3
10 → 9 → 8 → 7 → 6 ↑

● **Inspection after assembly**

📖 P.14-16

Service standards

Unit: mm

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
3, 10	Impeller-to-water pump shaft interference	[13] 0.03 to 0.06	—	Reassembly allowed only twice
4, 10	Flange-to-water pump shaft interference	[26] 0.05 to 0.08	—	Reassembly allowed only twice

❶ Tightening torque

Unit: N·m {kgf·m}

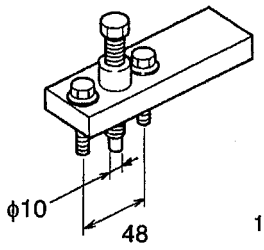
Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (water pump assembly mounting)	9.8 {1.0}	—

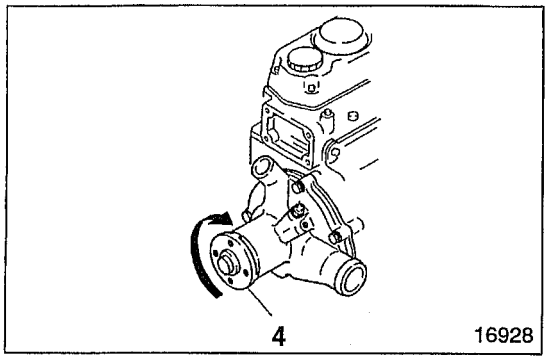
Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
6, 8	Bearings	Wheel bearing grease [NLGI No. 2 (Li soap)]	As required
11	Unit seal outer periphery	THREEBOND 1102	As required
12	Grease nipple	Wheel bearing grease [NLGI No. 2 (Li soap)]	60 g

Special tools

Unit: mm

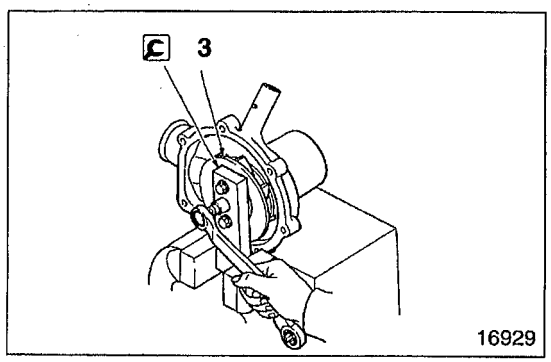
Location	Tool name and shape	Part No.	Application
3	Impeller Puller 	MH061417	Removing impeller



◆ Service procedure

● Inspection after assembly

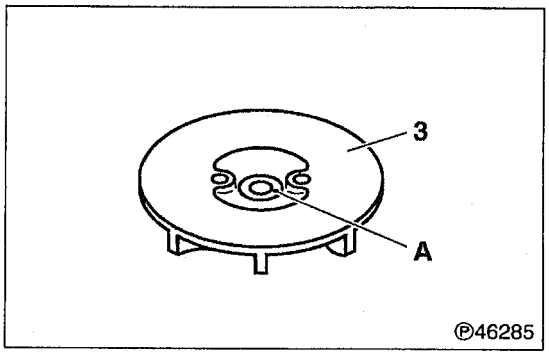
- After assembly, rotate flange **4** by hand and check that it turns smoothly without hindrance.
- If the flange does not turn smoothly, disassemble and inspect the water pump again.



3 Impeller

[Removal]

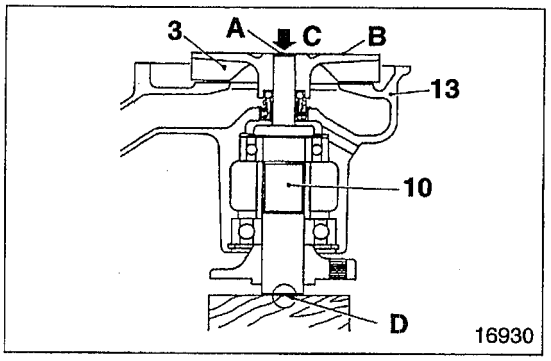
: Impeller Puller



[Installation]

CAUTION

- **Before refitting impeller 3, check the number of punch marks in location A shown in the illustration. If there is no or only one punch mark in location A, the impeller can be refitted. Ensure to punch a mark in location A for future reference before refitting the impeller.**
- **The punch mark is used to show how many times in the past impeller 3 is removed and refit. If there are two punch marks (i.e. removed and refit twice in the past), do not refit the impeller again. Replace it with a new impeller.**

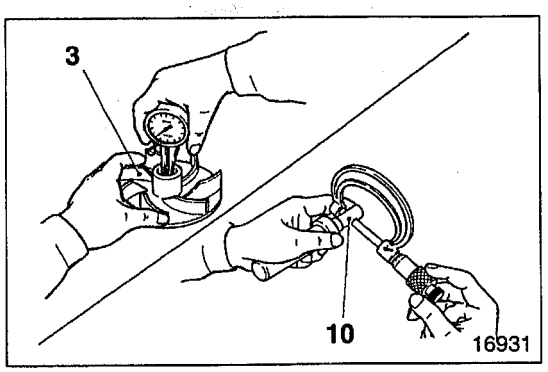


Press-fit impeller **3** until its end face **B** is in line with end face **A** of water pump shaft **10**.

C: Press

NOTE

Press-fit the impeller such that flange side D of water pump shaft 10 is the load receiving surface.

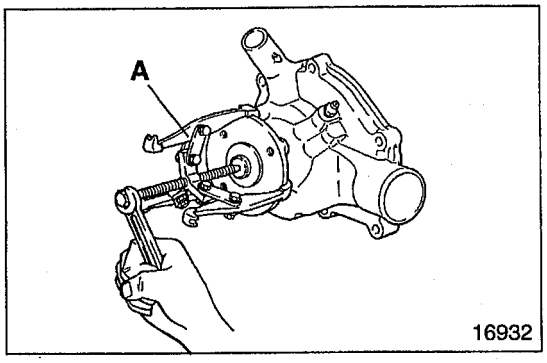


3 **10** **Impeller-to-water pump shaft interference**

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

CAUTION ⚠

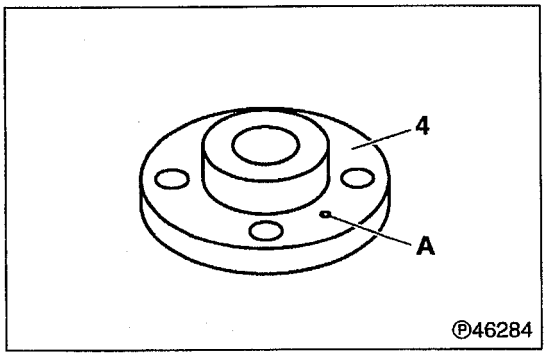
Even if the standard value is satisfied, reassembly must not be carried out more than twice.



4 **Flange**

[Removal]

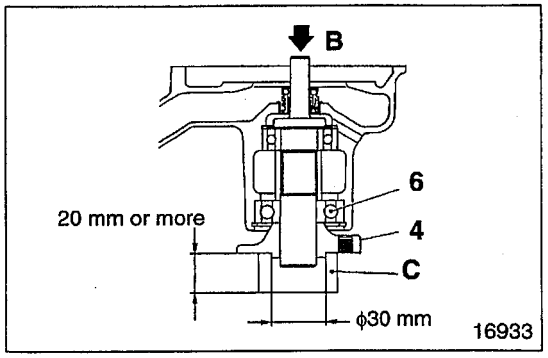
A: Gear puller



[Installation]

CAUTION ⚠

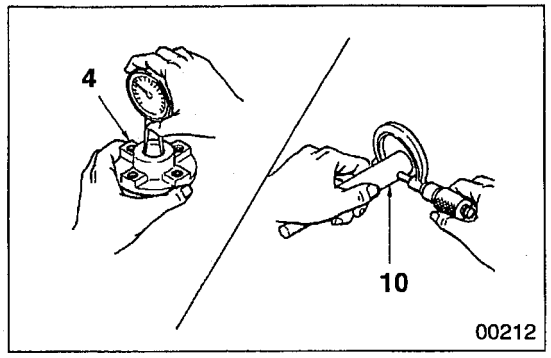
- **Before refitting flange 4, check the number of punch marks in location A shown in the illustration. If there is no or only one punch mark in location A, the flange can be refitted. Ensure to punch a mark in location A for future reference before refitting the flange.**
- **The punch mark is used to show how many times in the past flange 4 is removed and refit. If there are two punch marks (i.e. removed and refit twice in the past), do not refit the flange again. Replace it with a new flange.**



[Press-fitting]

With a load of 9,810 N {4,000 kgf}, press-fit flange **4** until it touches bearing **6**.

B: Press
C: Cylindrical jig



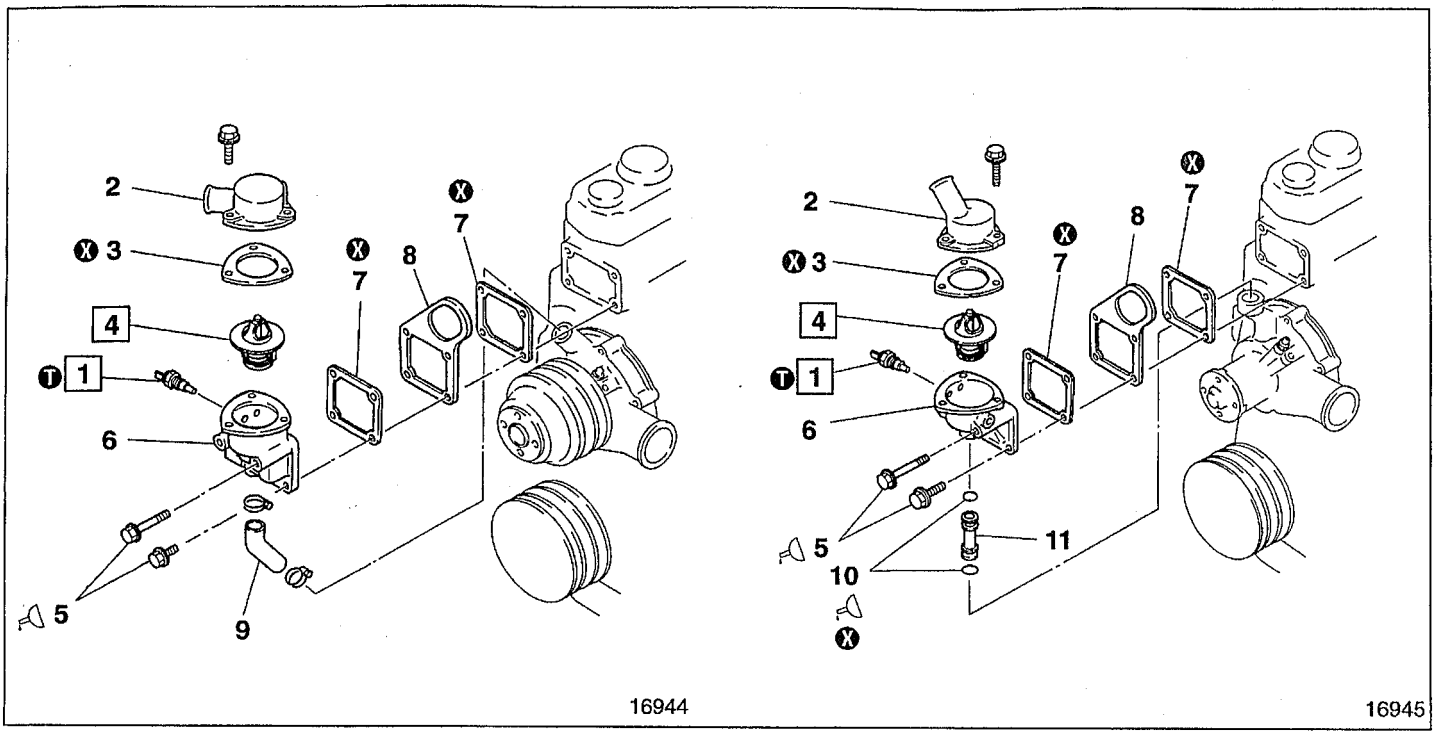
4 **10** **Flange-to-water pump shaft interference**

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.

THERMOSTAT



● **Disassembly sequence**

1 Water temperature sensor
2 Thermostat cover
3 Gasket
4 Thermostat
5 Bolt
6 Thermostat case
7 Gasket
8 Front hanger
9 Bypass hose
10 O-ring
11 Joint

Ⓧ: Non-reusable part

NOTE

Do not remove thermostat case 6 and front hanger 8 unless they are leaking water or otherwise defective.

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
1	Water temperature sensor resistance (Between terminal ① and body)	50°C	(136 Ω)	—	Replace
		80°C	48 ± 5 Ω	—	
		100°C	27.2 ± 2 Ω	—	
4	Thermostat	Valve opening temperature	76.5 ± 2°C	—	Replace
		Valve lift/temperature	10 mm or more at 90°C	—	

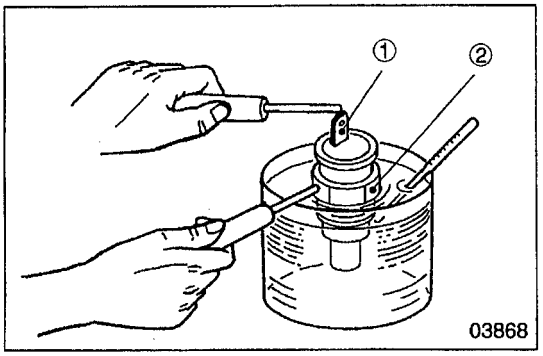
❶ Tightening torque

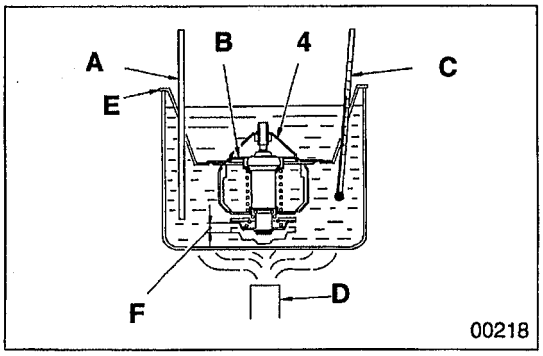
Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Water temperature sensor	34 ± 6.9 {3.5 ± 0.7}	—

Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
5	Threads of bolts (thermostat case mounting)	THREEBOND 2302	As required
10	Periphery of O-ring	Soapy water	As required





◆ Service procedure

1 Water temperature sensor inspection

- Place water temperature sensor **1** in a container of engine oil.
- Heat the oil until it reaches the specified temperatures. Stir the oil to ensure that it heats up evenly..
- Measure the resistance between terminal ① and body ② of the water temperature sensor.
- If the measurements do not conform with the specified values, replace the water temperature sensor **1**.

4 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 the thermostat **4**.

(1) Valve opening temperature

- Support thermostat **4** 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

NOTE ; • The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.
• The pages marked "( )" are given, though they are not applicable to the SK330(N)LC-6E.

SPECIFICATIONS

Air cleaner element

Item	Specifications	
Type	Cyclone type, filter paper type	Cartridge type, filter paper type
Manufacturer	Nihon Donaldson	

Dust indicator

Item	Specifications
Type	Mechanical type
	Electrical type

Turbocharger

Item	Specifications			
Type	T04B	T04E	TBP4	TF07
Manufacturer	Honeywell			Mitsubishi Heavy Industries

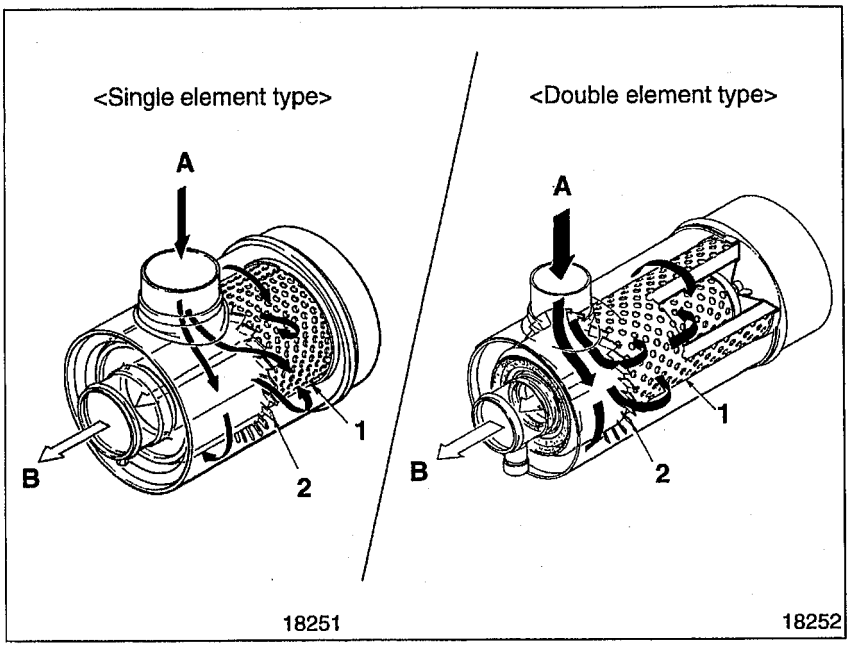
Intercooler

Item	Specifications
Type	Tube & corrugated fin air cooled type

1. Air Cleaner

Cyclone type air cleaner

<FHG, FWG>

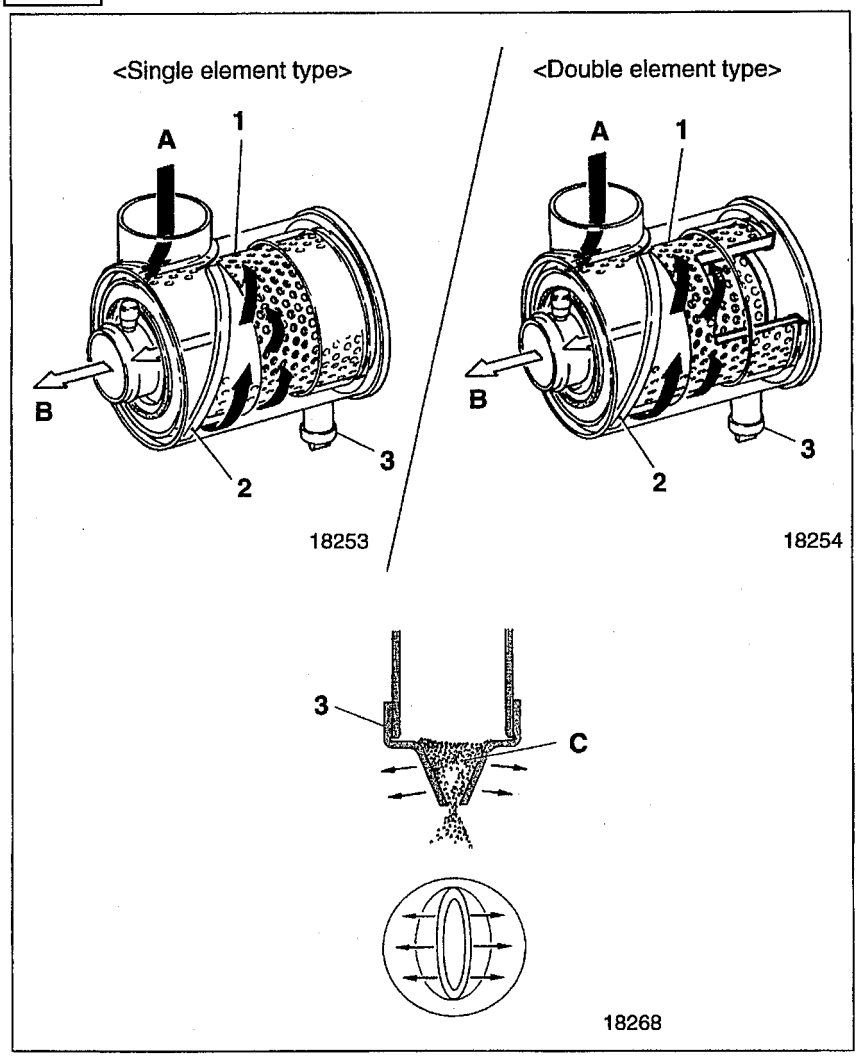


1 Element
2 Vane

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 the 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>

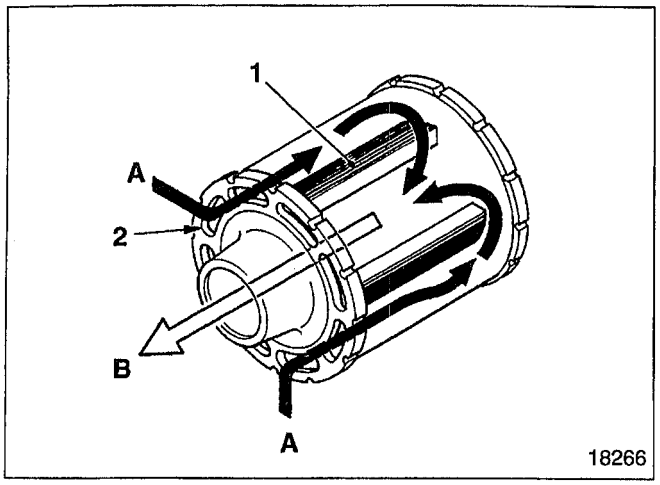


1 Element
2 Guide vane
3 Vacuator valve

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 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 the 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.
The 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 the dust and dirt **C**.

2. Cartridge Type Air Cleaner

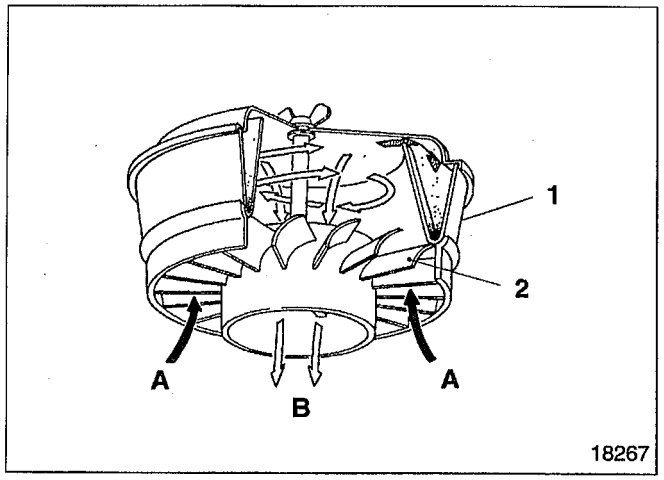


1 Element
2 Inlet slot

A: Outside air
B: Into engine

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

3. Pre-Cleaner



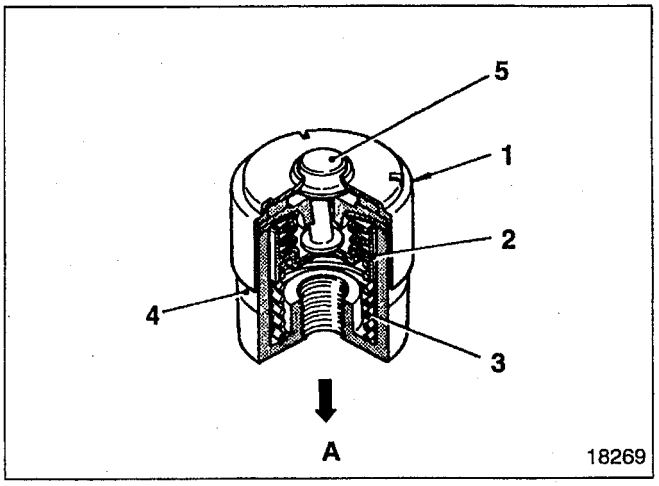
1 Pre-cleaner body
2 Guide vane

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 the guide vane **2** in the pre-cleaner, and the centrifugally separated particles of dust are accumulated in the pre-cleaner body **1**.

4. Dust Indicator

<Mechanical type>

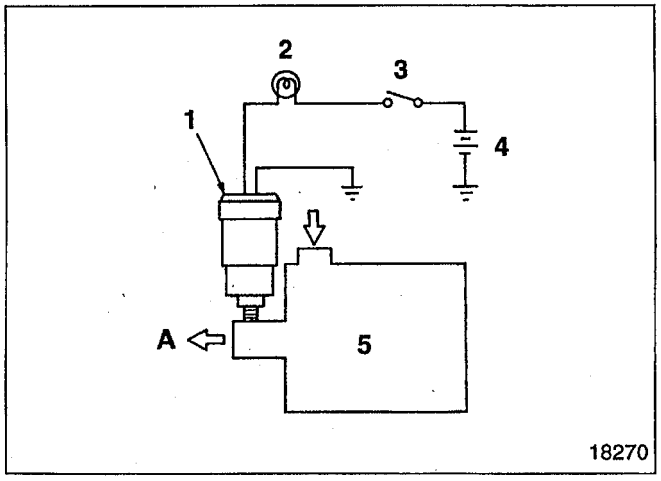


1 Dust indicator
2 Signal
3 Spring
4 Transparent portion
5 Reset button

A: Negative pressure

The 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 the negative pressure **A** reaches 6.23 kPa {635 mmH_2O}, the signal **2** (red) is pulled down against the spring pressure of the spring **3**. So the signal (red) appears in the 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>



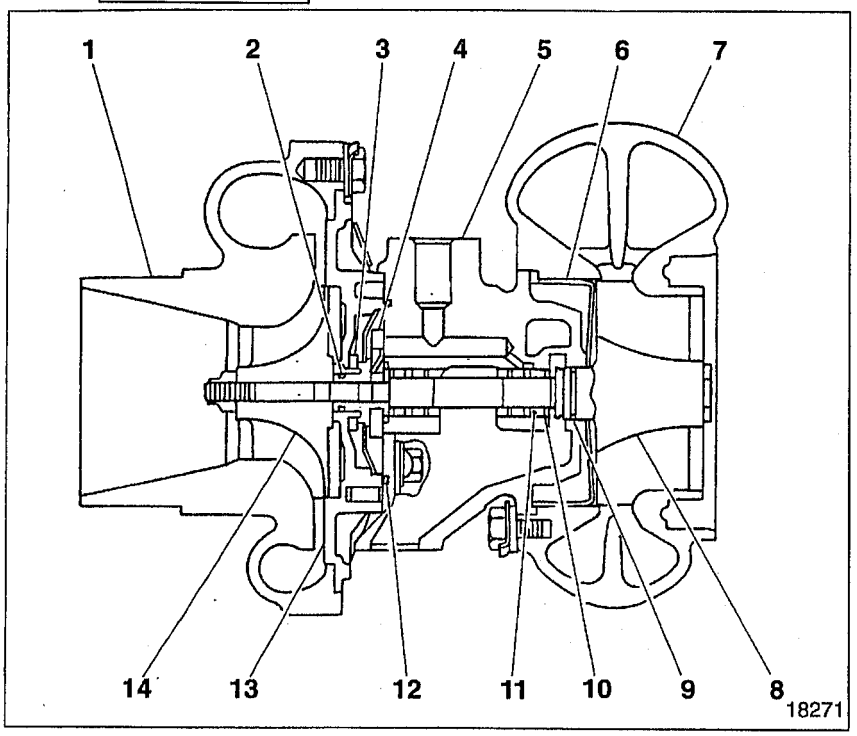
1 Dust indicator
2 Warning lamp
3 Starter switch
4 Battery
5 Air cleaner

A: Negative pressure

When the negative pressure **A** reaches 6.23 kPa {635 mmH_2O}, the electric type dust indicator closes its contact to light the warning lamp **2** and alert the driver that it is high time to clean or replace the element.

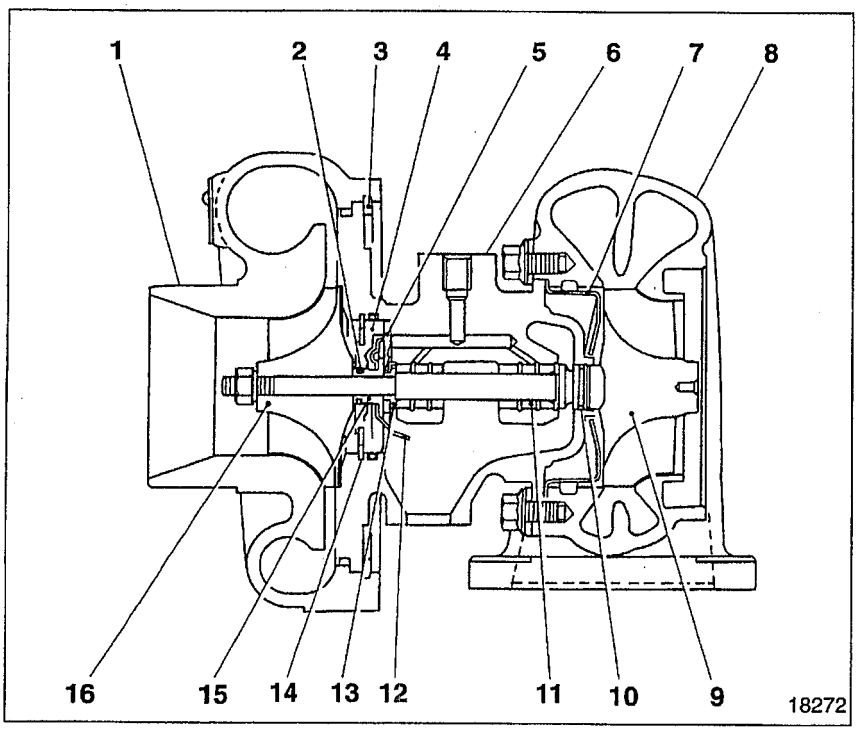
5. Turbo Charger

<T04B, T04E (6D16-TE)>



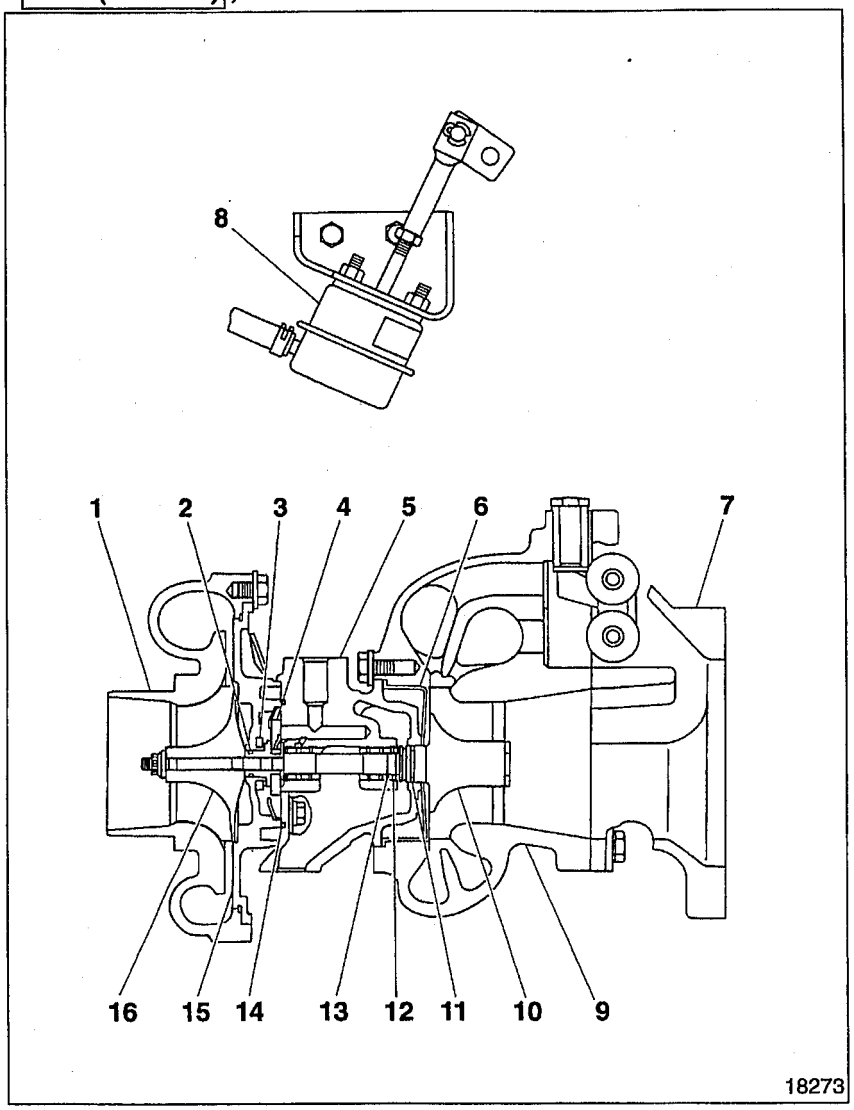
1 Compressor housing
2 Piston ring
3 Thrust collar
4 Thrust bearing
5 Center housing
6 Wheel shroud
7 Turbine housing
8 Turbine wheel
9 Piston ring
10 Retaining ring
11 Bearing
12 Seal ring
13 Back plate
14 Compressor wheel

<TF07>



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

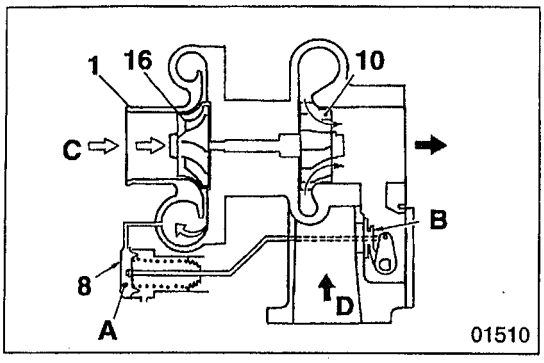
<T04E (6D16-TL), TBP4>

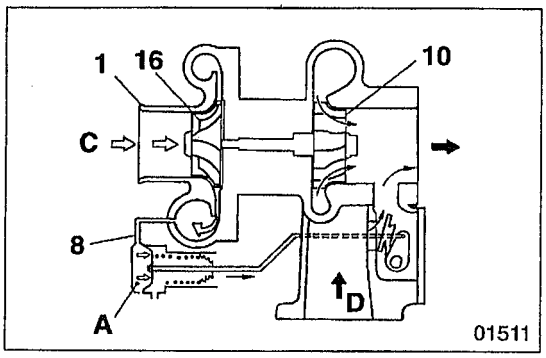


1 Compressor housing
2 Piston ring
3 Thrust collar
4 Thrust bearing
5 Center housing
6 Wheel shroud
7 Exhaust coupler
8 Actuator assembly
9 Turbine housing
10 Turbine wheel
11 Piston ring
12 Retaining ring
13 Bearing
14 Seal ring
15 Back plate
16 Compressor wheel

● **Waste gate mechanism <T04E (6D16-TL), TBP4>**

- The waste gate mechanism has the actuator assembly **8** 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 the compressor housing **1** through a rubber hose to the chamber **A** of the actuator assembly **8**. When the boost pressure that acts on the chamber **A** is below the setting, the actuator assembly does not operate, and the waste gate valve remains closed, and the exhaust gas **D** is blown against the turbine wheel **10**.

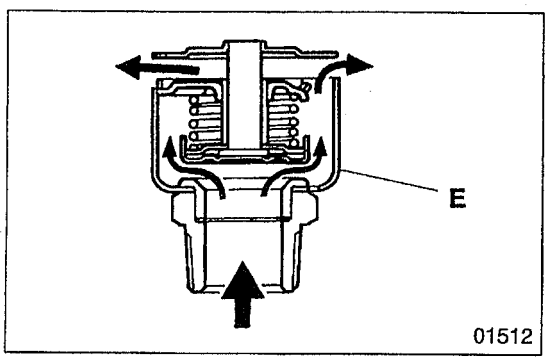


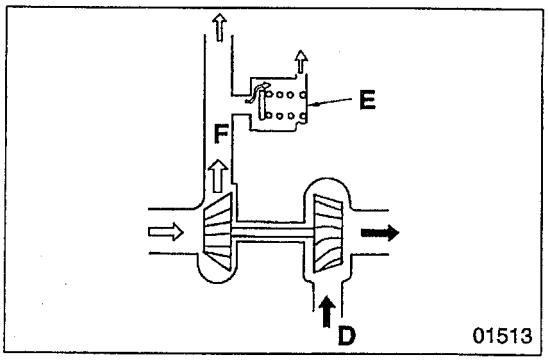


- When the boost pressure that acts on the chamber **A** exceeds the setting, the waste gate valve is opened. As a result, the amount of exhaust gas blown against the turbine wheel **10** decreases, and the rotating speed of the compressor wheel **16** also decreases, and the boost pressure falls.

● **Operation of overboost valve**

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





- When the boost pressure **F** of the 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.

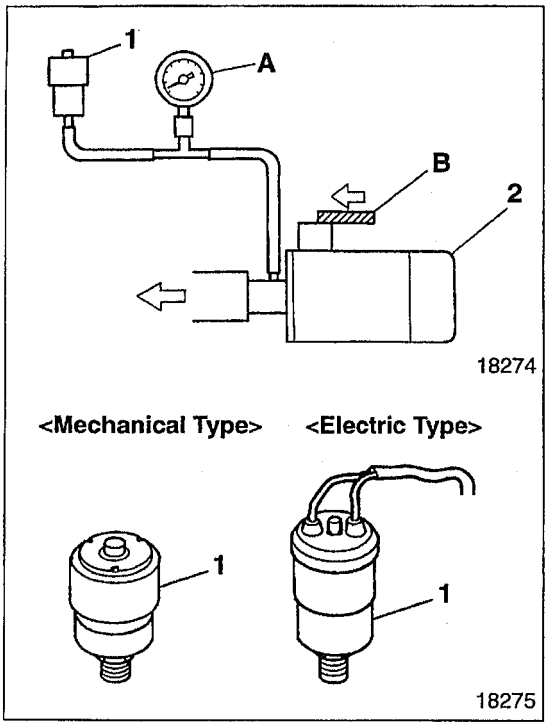
Possible causes / Symptoms		Engine hard to start	Black exhaust gas	White exhaust gas	Insufficient engine output	Excessive oil consumption	Strange sound or vibration in intake and exhaust system	Remarks
Air cleaner	Clogged air cleaner element	○	○		○			
Turbocharger	Defective bearing		○		○		○	
	Carbon deposited on turbine wheel		○		○			
	Turbine wheel interfering with wheel shroud and turbine back plate		○		○		○	
	Turbine wheel interfering with turbine housing		○		○		○	
	Bent turbine wheel		○		○		○	
	Damaged turbine wheel		○		○		○	
	Compressor wheel interfering with compressor housing		○		○		○	
	Thrust sleeve, thrust collar and thrust bearing seizure		○		○		○	
	Damaged compressor wheel		○		○		○	
	Oil leaks due to worn piston ring and insert			○		○		
	Improperly mounted piston ring					○		
	Unsmooth sliding of internal parts due to clogged lubrication oil pipe and eyebolt		○		○			
	Damaged oil seals due to clogged oil return pipe			○		○		
	Improperly mounted compressor housing		○		○	○	○	
	Improperly mounted turbine housing				○		○	
Intercooler	Foreign substances deposited on front core of intercooler				○			
Deformed front pipe, muffler, tail pipe							○	
Improperly mounted front pipe, muffler, tail pipe							○	
Incorrect valve clearance			○					🕮 Gr 11
Defective head gasket			○					🕮 Gr 11
Worn valve and valve seat and deposited carbon			○					🕮 Gr 11
Sagging valve spring			○					🕮 Gr 11
Worn or damaged piston ring				○		○		🕮 Gr 11
Worn or damaged piston ring groove of piston				○		○		🕮 Gr 11
Malfunctioning cooling equipment			○					🕮 Gr 14
Excessive engine oil				○				🕮 Gr 12
Seizure of major moving parts			○					🕮 Gr 11
Uneven or excessive fuel injection			○					🕮 Gr 13

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. 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_2O}	—	—



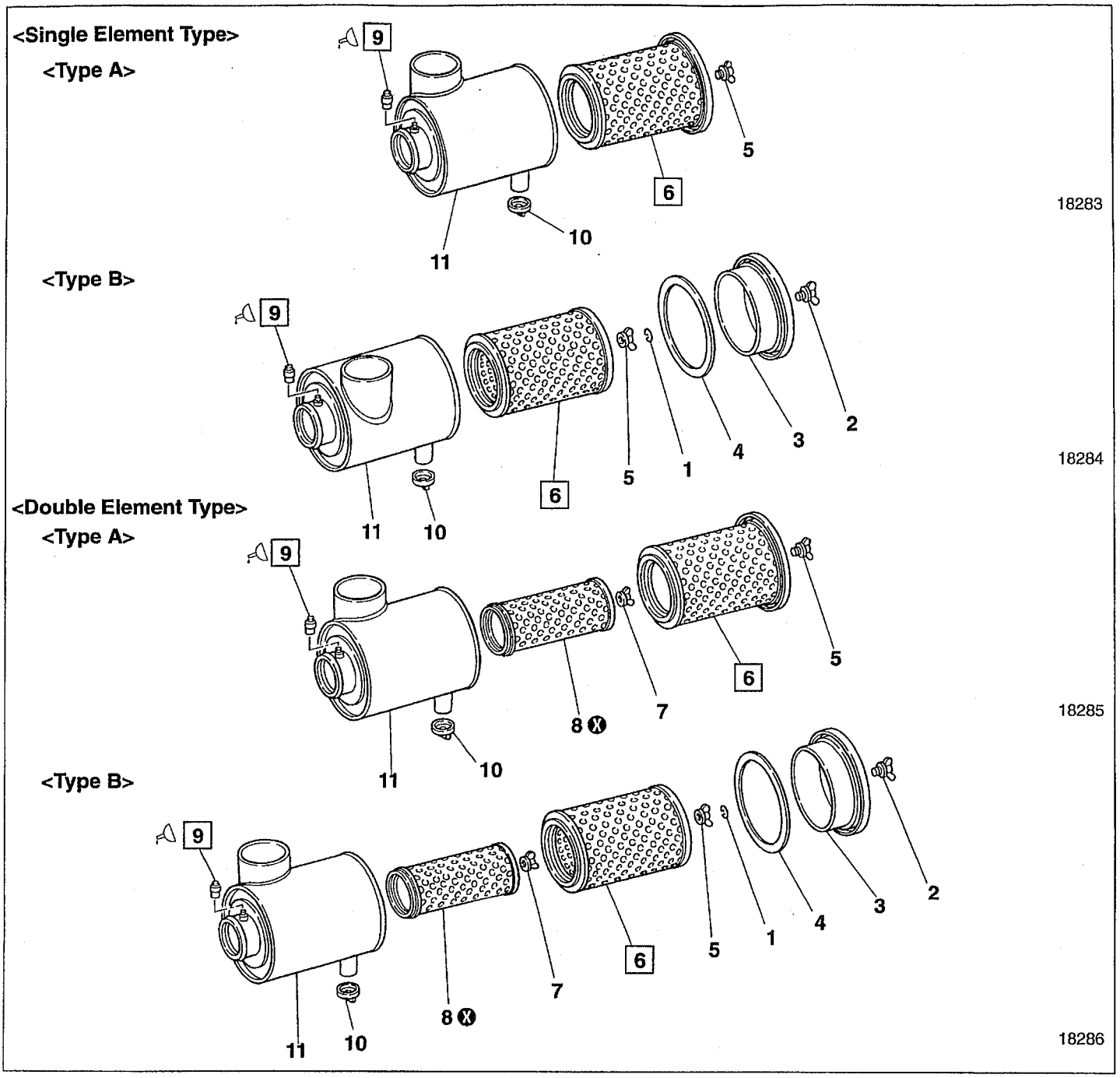
- Before checking the dust indicator **1**, clean or replace the air cleaner element.
- Start the engine, and cover the inlet of the air cleaner through use of a wooden block **B** in such a way that the negative pressure of the dust indicator **1** will have the nominal value and check that the mechanical 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

MEMO

AIR CLEANER <FTG>



● **Disassembly sequence**

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

Ⓧ: Non-reusable part

NOTE

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

● **Reassembly sequence**

Reverse the order of disassembly.

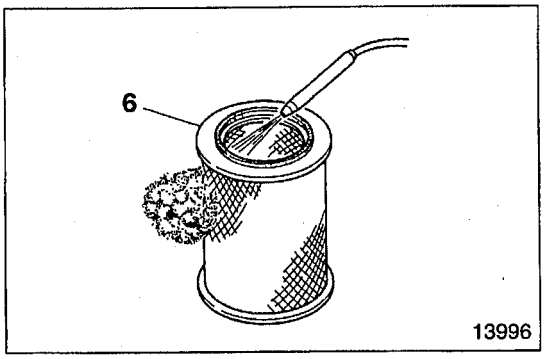
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
9	Negative pressure for operation of dust indicator	6.23 ± 0.57 kPa {635 ± 58 mmH_2O}	—	Replace

Sealant

Location	Points of application	Specified sealant	Quantity
9	Apply to threads of dust indicator	ThreeBond 1401B	As required

◆ Service procedure



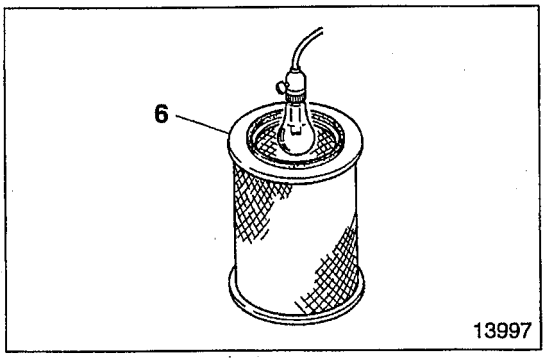
6 Element

[Cleaning]

- Blow compressed air 685 kPa {7 kg/cm^2} or less from inside the element **6**.
- Blow the compressed air, working along the creases of filter paper of the element **6** up and down throughout the element.

CAUTION ⚠

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

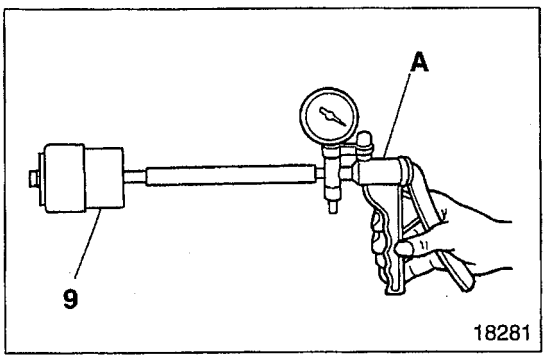


[Inspection]

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

9 Inspection of dust indicator

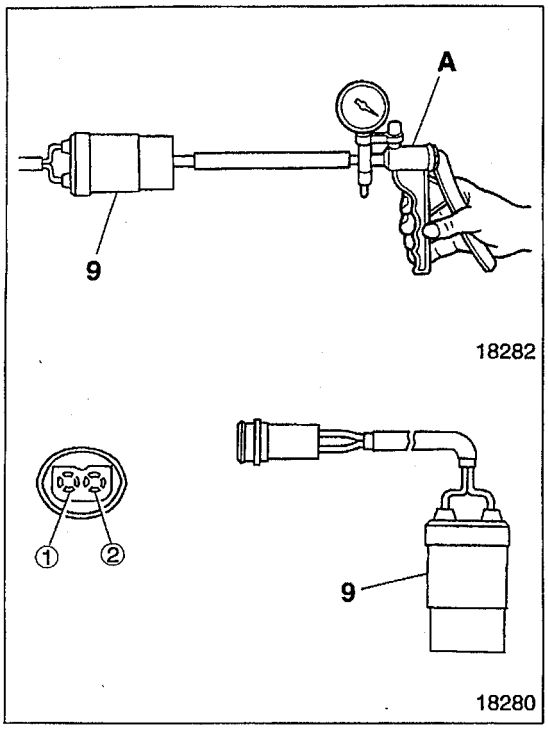
Perform the following checks. If there is anything wrong, replace the dust indicator.



<Mechanical type>

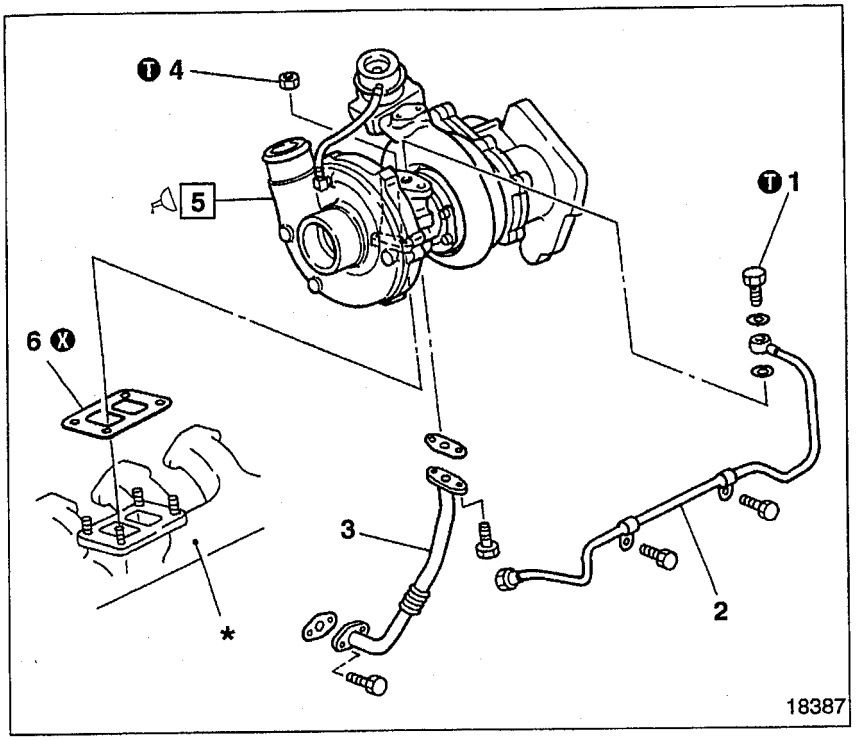
- Mount a hand vacuum pump **A** on the dust indicator **9** and apply the standard operating negative pressure to check whether the red signal appears.

AIR CLEANER <FTG>



<Electric type>

- Mount a hand vacuum pump **A** on the 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 the dust indicator **9**, there is no continuity between the terminals ① and ②.



● **Removal sequence**

1 Eyebolt
2 Oil inlet pipe
3 Oil return pipe
4 Nut
5 Turbocharger assembly P.15-32
6 Gasket

*: Exhaust manifold P.15-63, 64
Ⓧ: Non-reusable part

● **Installation sequence**

Reverse the order of removal.

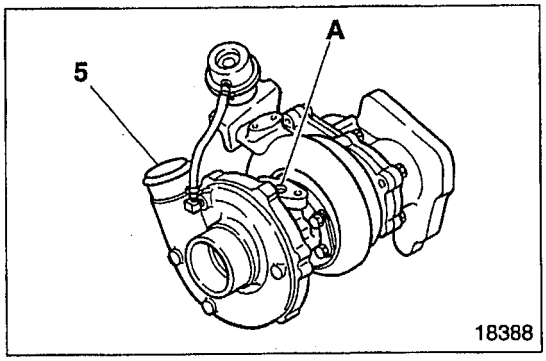
Ⓣ Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Eyebolt (for mounting oil inlet pipe)	21 {2.1}	—
4	Nut (for mounting turbocharger assembly)	41 {4.2}	—

Lubricant

Location	Points of application	Specified lubricant	Quantity
5	Supply when installing turbocharger assembly	Engine oil	As required



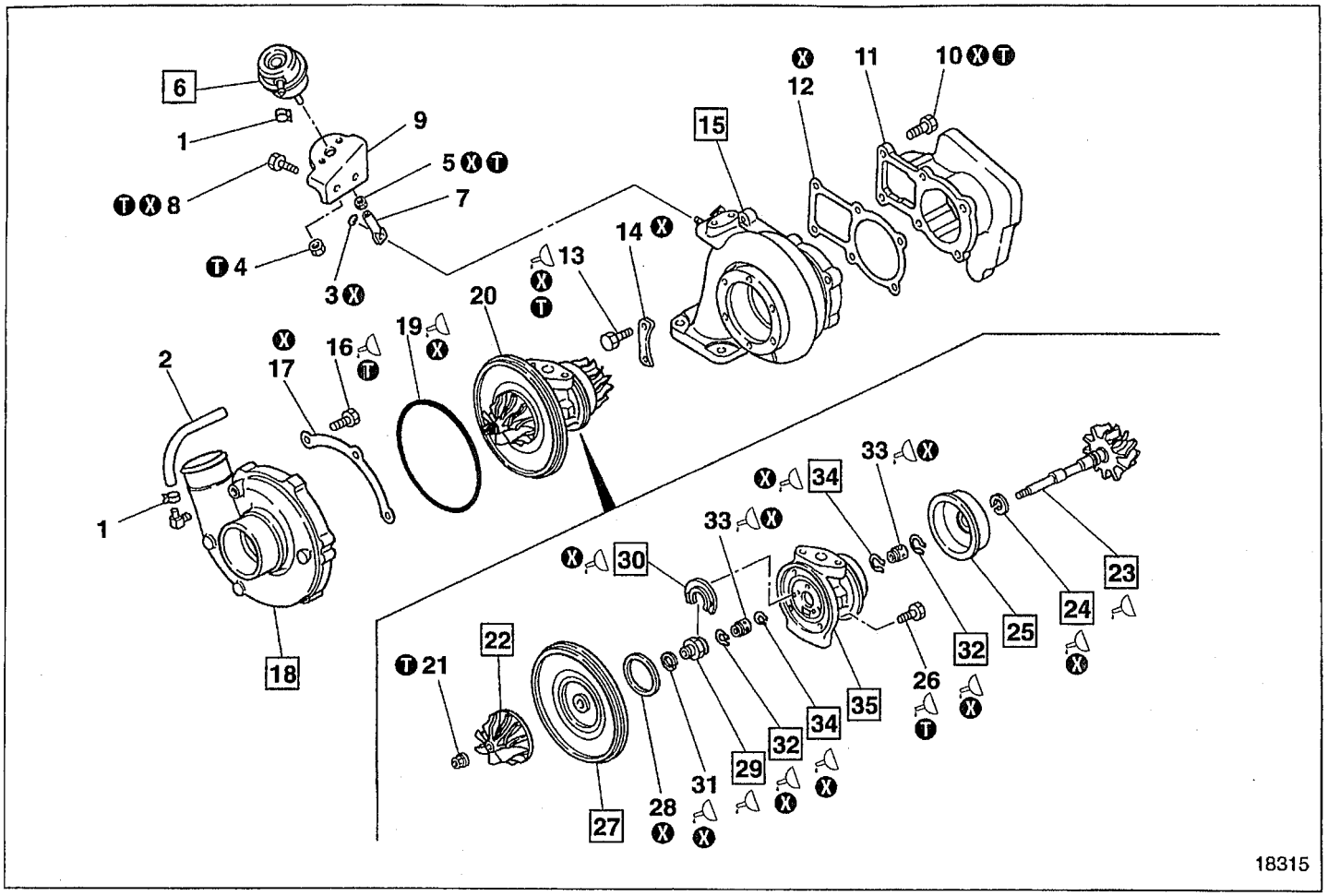
◆ Service procedure

5 Installation of turbocharger assembly

When the turbocharger assembly **5** is installed, supply engine oil from the oil hole **A** to make sure that all the parts operate smoothly.

TURBOCHARGER <T04E (6D16-TL), TBP4>

Turbocharger Assembly



● **Operations before disassembly**

P.15-34

● **Disassembly sequence**

1 Hose clamp
2 Hose
3 Retaining ring
4 Nut
5 Nut
6 Actuator assembly
7 Rod end
8 Bolt
9 Bracket
10 Bolt
11 Exhaust coupler
12 Gasket
13 Bolt
14 Clamp
15 Turbine housing
16 Bolt
17 Clamp
18 Compressor housing
19 O-ring
20 Center housing & rotating assembly
21 Lock nut
22 Compressor wheel
23 Turbine wheel
24 Piston ring
25 Wheel shroud
26 Bolt
27 Back plate
28 Seal ring
29 Thrust collar
30 Thrust bearing
31 Piston ring
32 Retaining ring
33 Bearing
34 Retaining ring
35 Center housing

Ⓧ: Non-reusable part

CAUTION ⚠

Carefully remove the piston rings 24 and 31, as they are readily broken.

● **Cleaning after disassembly**

📖 P.15-35

● **Reassembly sequence**

35 → 34 → 33 → 32 → 29 → 30 → 31 → 28 → 27 → 26 → 24 → 23 → 22 → 21 → 20 → 19 → 18 → 17 → 16 → 15 → 14 → 13 → 12 → 11 → 10 → 9 → 8 → 6 → 4 → 5 → 7 → 3 → 2 → 1

CAUTION ⚠

Do not widen the piston rings 24 and 31 more than necessary, as they are readily broken.

● **Inspection after reassembly**

📖 P.15-35

Service standards

Unit: mm

Location	Maintenance item			Standard value (Basic diameter in [ ])	Limit	Remedy
6	Actuator assembly set pressure			83 to 90 kPa {625 to 675 mmHg}	—	Adjust
23	Turbine wheel	Bearing journal outside diameter		[10.156]	10.152 or more	Replace
		Shaft bend		—	0.01 or less	
		Hub diameter		[17.31]	17.25 or more	
		Piston ring mounting portion	Groove width	1.69	1.74 or less	
			Groove diameter	[14.46]	14.40 or more	
		Play in radial direction		0.076 to 0.150	—	Check
		Play in thrust direction		0.025 to 0.076	—	
27	Back plate	Seal land height		11.672	11.658 or less	Replace
		Seal bore inside diameter		[12.687]	12.712 or less	
29	Thrust collar	Piston ring mounting portion	Groove width	1.640	1.659 or less	Replace
			Groove diameter	[10.35]	10.29 or more	
		Thrust bearing mounting portion	Groove width	4.43	4.44 or less	
			Groove diameter	[9.53]	9.40 or more	
		Inside diameter		[6.358]	6.363 or less	
35	Center housing	Bearing inserting portion inside diameter		[15.800]	15.806 or less	Replace
		Seal bore inside diameter		[18.03]	18.06 or less	

TURBOCHARGER <T04E (6D16-TL), TBP4>

Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
4	Nut (for mounting actuator assembly)	5.6 to 7.8 {0.57 to 0.80}	—
5	Nut (for mounting rod end)	5.6 to 6.8 {0.57 to 0.70}	—
8	Bolt (for mounting bracket)	20 to 22 {2.07 to 2.29}	—
10	Bolt (for mounting exhaust coupler)	20 to 22 {2.07 to 2.29}	—
13	Bolt (for mounting clamp)	20 to 22 {2.07 to 2.29}	—
16	Bolt (for mounting clamp)	16 to 19 {1.67 to 1.89}	—
21	Lock nut (for mounting compressor wheel)	2.1 to 2.3 {0.21 to 0.23}	After tightening, turn down 90°C to 110°C further from that position.
26	Bolt (for mounting back plate)	12 to 14 {1.26 to 1.45}	—

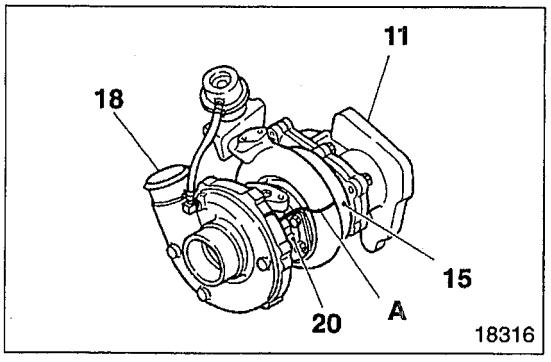
Lubricant

Location	Points of application	Specified lubricant	Quantity
13	Apply to threads and bearing surface of bolt	MOLYKOTE	As required
16, 26	Apply to threaded portion of bolt	LOCTITE	As required
19, 23, 24, 29 to 34	Apply to all of the parts.	Engine oil	As required

Special tools

Location	Tool name and shape	Part No.	Application
22	T-handle	801059-0	Removal and installation of compressor wheel
	Holding fixture	801053-0	
23	Measuring element	801098-0	Inspection of play of turbine wheel in radial direction
24	Piston ring inserter	801050-0	Installation of piston ring
32, 34	Retaining ring remover	801058-0	Removal and installation of retaining ring

Part numbers listed above are Honeywell part numbers.



◆ Service procedure

● Operations before disassembly

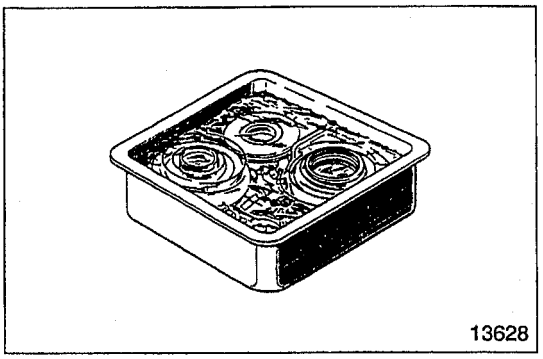
Make alignment mark **A** on the turbine housing **15**, compressor housing **18** and center housing & rotating assembly **20**.

● **Cleaning after disassembly**

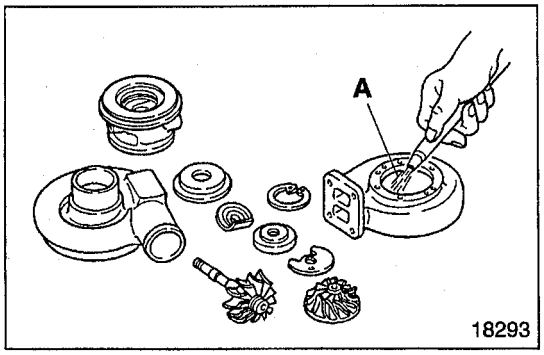
- Before cleaning, visually check the individual parts for burns, rubbed stains, etc. which might disappear after cleaning. If there is anything wrong, replace.

CAUTION ⚠

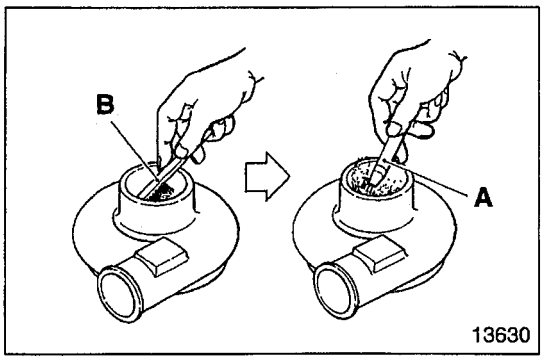
Do not immerse the actuator assembly 6 in the solvent. Clean it with a cloth dipped in kerosene.



- Immerse the disassembled parts in a non-combustible solvent (DAIDO CHEMICAL INDUSTRY CO., LTD. DAI CLEANER T-30).



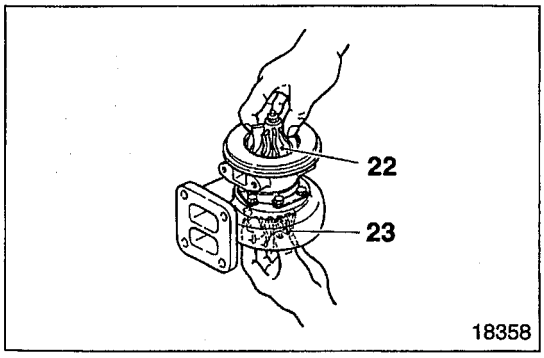
- Take out the parts from the solvent and blow compressed air **A** against them.



- Scrape off deposits.

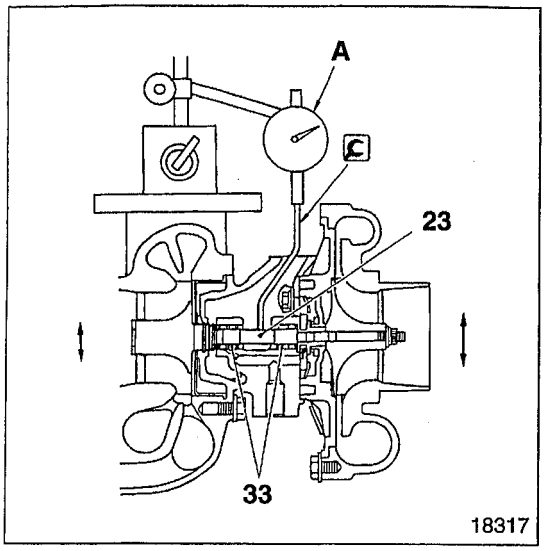
  B: Plastic scraper or stiff brush

- Re-immerse in the solvent.
- Blow compressed air **A**.



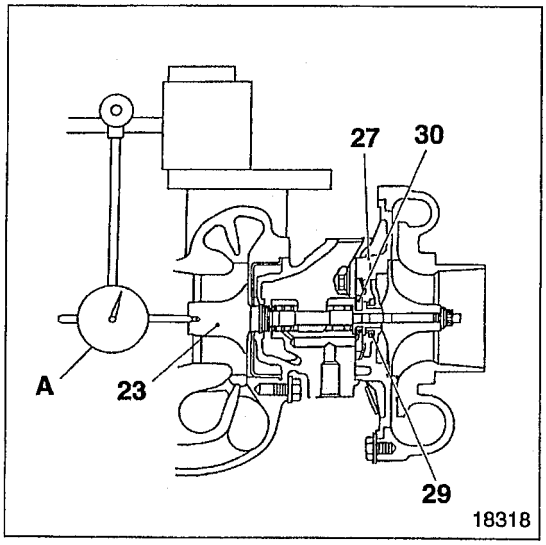
● **Inspection after reassembly**

(1) Manually rotate the compressor wheel **22** and turbine wheel **23** to check whether they rotate smoothly.



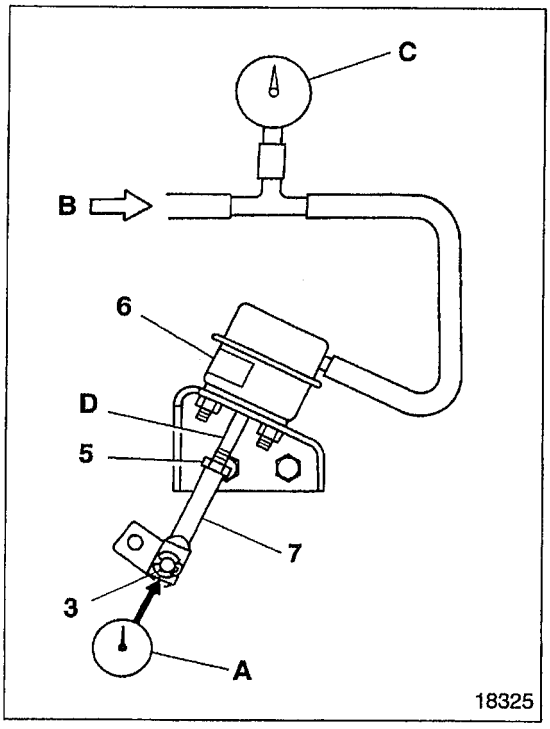
(2) Play of turbine wheel in radial direction

- Mount the C Measuring Element to the dial gauge **A** and insert it from the oil outlet and press it against the shaft of the turbine wheel **23** at right angles.
- Move the shaft of the turbine wheel **23** up and down by both hands to measure the play in the radial direction.
- If the reading exceeds the limit, replace the bearing **33**.



(3) Play of turbine wheel in thrust direction

- Set the dial gauge **A** on the end of the turbine wheel **23** and move the shaft of the turbine wheel in the axial direction to measure the play.
- If the reading exceeds the limit, worn or defective back plate **27**, thrust collar **29** and thrust bearing **30** are suspected. Replace.



(4) Measurement of operating pressure of actuator assembly

- Set the dial indicator **A** on the end of the rod end **7**.
  (In this case, set the scale of the dial indicator to 0.)
- Extend the rod end 0.38 mm by use of the external air **B**.)
  (The scale of the dial indicator **A** is 0.38 mm.)
- With the scale of the dial indicator **A** at 0.38 mm, read the value of the pressure gauge **C**, and check to ensure that the reading is between 83 and 90 kPa {625 to 675 mmHg}.

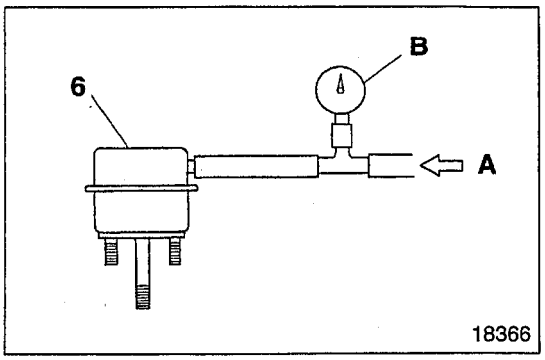
(5) Adjustment of operating pressure of actuator assembly

- If the reading of the pressure gauge **C** is not between 83 and 90 kPa {625 to 675 mmHg}, remove the retaining ring **3**, loosen the nut **5**, and adjust the length of the rod end **7**.

  Rod end length adjusting direction
  Rod end extending direction → Reduces the pressure.
  Rod end retracting direction → Increases the pressure.

CAUTION

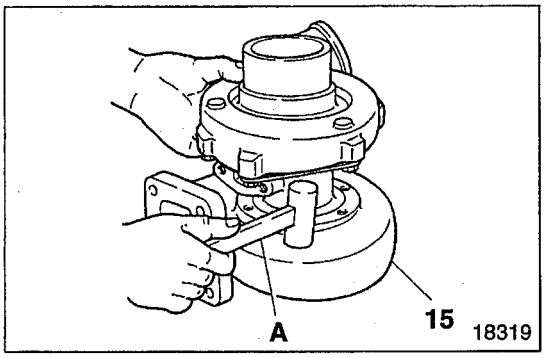
When the rod end length is adjusted, if the piston assembly D is rotated, damage to the diaphragm in the actuator assembly 6 will result. Secure the piston assembly through use of a vice, pliers, etc. to make sure that it is not rotated.



6 Air-tightness check on actuator assembly

Slowly apply the air pressure **A** to the actuator assembly **6** to check that there are no air leaks when the air pressure is 87 kPa {650 mmHg}. If there are air leaks, replace the actuator assembly.

B: Pressure gauge



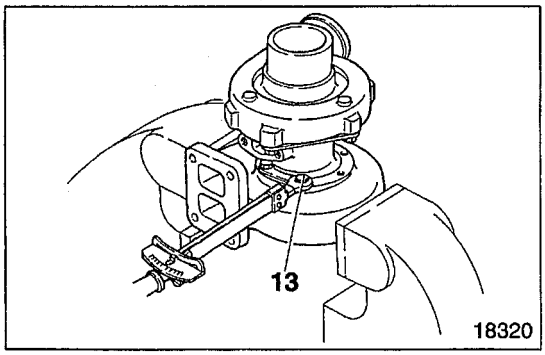
15 Turbine housing

[Removal]

A: Rubber hammer

CAUTION

- **While using care to prevent damage to the turbine housing 15, lightly strike its entire circumference with a rubber hammer or similar tool.**
- **Since the blades of the turbine wheel 23 are readily bent, use care to make sure that they do not hit the turbine housing 15.**

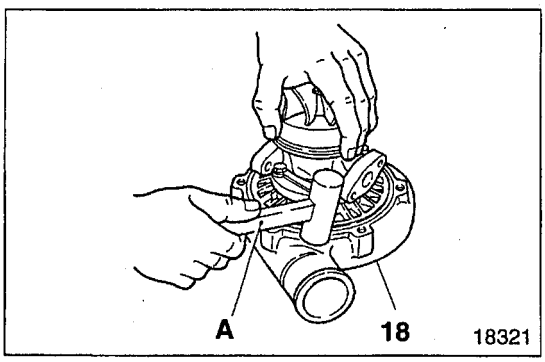


[Installation]

Apply MOLYKOTE to the threads and bearing surface of bolt **13**, partially tighten the bolt, line up the alignment marks made before disassembly, and then tighten the bolt to the specified torque.

CAUTION

Use care to prevent damage to the blades of the turbine wheel 23.



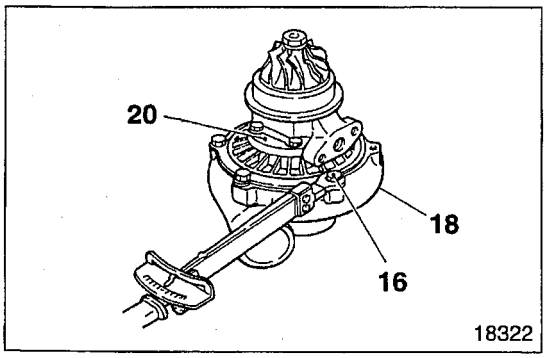
18 Compressor housing

[Removal]

A: Rubber hammer

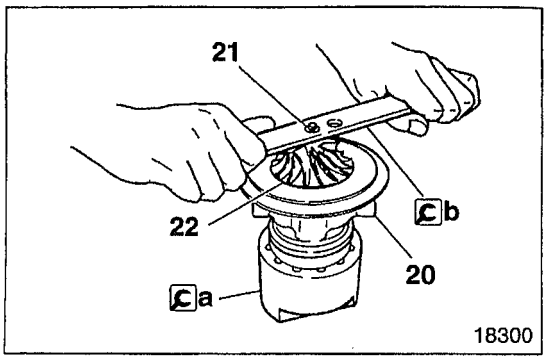
CAUTION

- **While using care to prevent damage to the compressor 18, lightly strike its entire circumference with a rubber hammer A or similar tool.**
- **Since the blades of the compressor wheel 22 are readily bent, use care to make sure that they do not hit the compressor housing 18.**



[Installation]

- Place the center housing & rotating assembly **20** on the compressor housing **18**, line up the alignment marks made before disassembly, and tighten the bolt **16** to the specified torque.



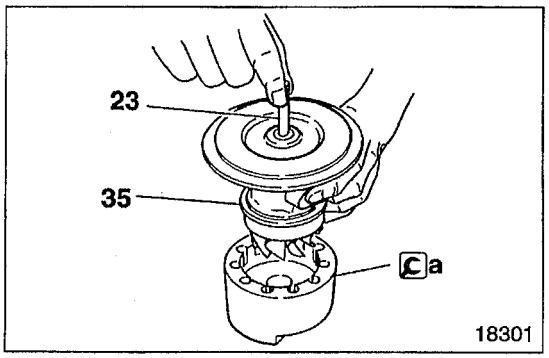
22 Compressor wheel

[Removal]

- Hold the a Holding Fixture in a vice, and slowly insert the center housing & rotating assembly **20**.
- Using the b T-handle, remove the lock nut **21** and slowly withdraw the compressor wheel **22** upward.

CAUTION

Use care to prevent bending the shaft of the turbine wheel 23.

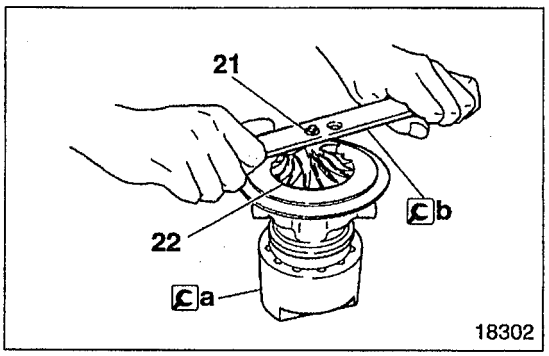


[Installation]

- Hold the shaft of the turbine wheel **23** and center housing **35** by hand, and slowly insert them into the a Holding Fixture.

CAUTION

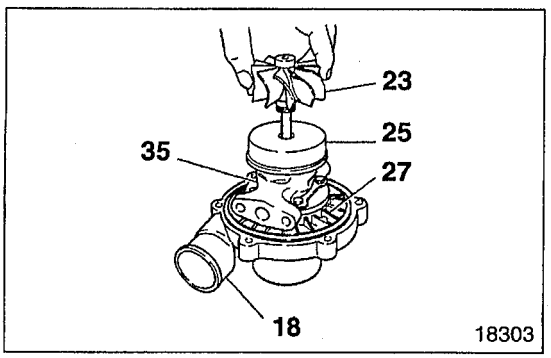
- **When they are inserted, use care to prevent damage to the blades of the turbine wheel 23.**
- **Do not release the shaft before insertion, as the turbine wheel 23 falls down.**



- Hold the a Holding Fixture in a vice and slowly insert the compressor wheel **22**.
- Using the b T-handle, tighten the lock nut **21** to the specified torque, and then turn it down 90°C to 110°C further from that position.

CAUTION

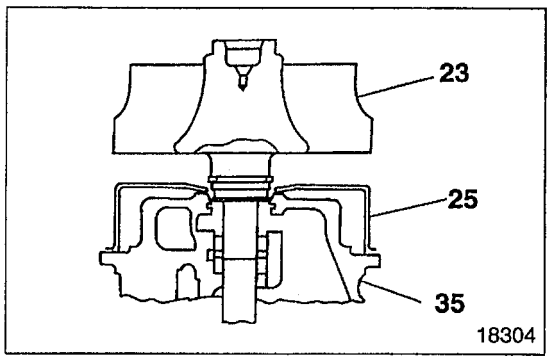
Use care to prevent bending the shaft of the turbine wheel 23.



23 25 Turbine wheel, wheel shroud

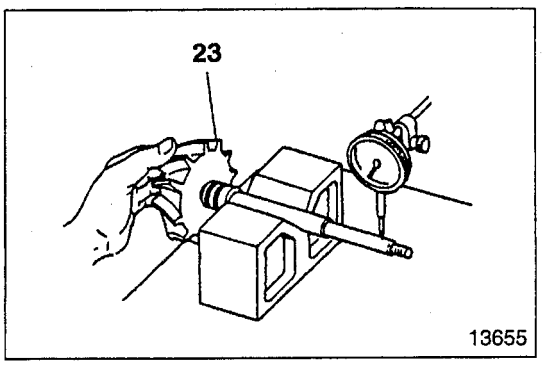
[Removal]

Place the back plate **27** of the center housing **35** on the compressor housing **18** removed beforehand, and remove the turbine wheel **23** and wheel shroud **25**.



[Installation]

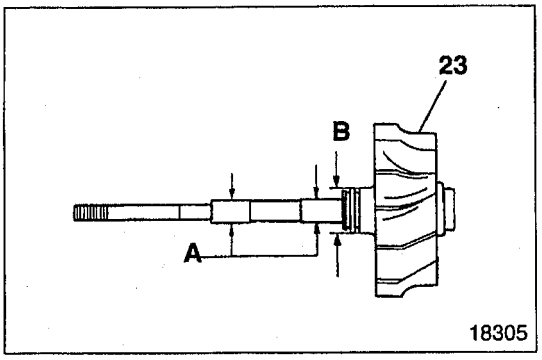
After installation, lightly rotate the turbine wheel **23** by hand to check whether it continues to rotate. If it does not rotate lightly, re-perform the disassembly and reassembly procedures.



[Inspection]

(1) Bend of shaft

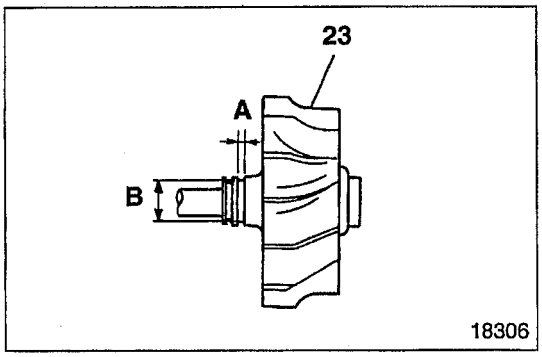
- Using the dial indicator, measure at the illustrated position.
- If the reading exceeds the limit, replace the turbine wheel **23**.



(2) Outside diameters of journal and hub

If any reading exceeds the limit, replace the turbine wheel **23**.

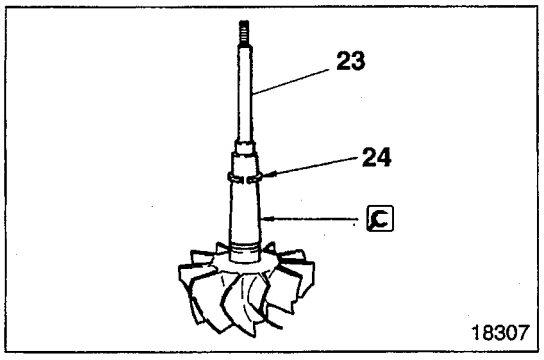
A: Journal
B: Hub



(3) Width and outside diameter of piston ring groove

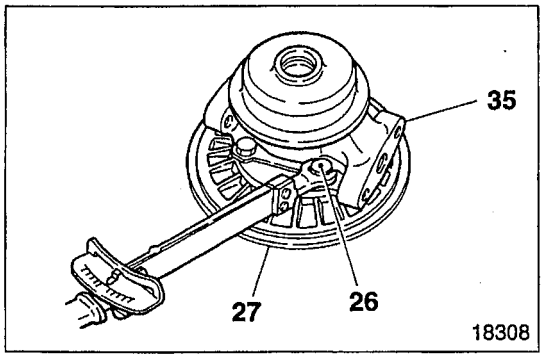
If any reading exceeds the limit, replace the turbine wheel **23**.

A: Width
B: Outside diameter



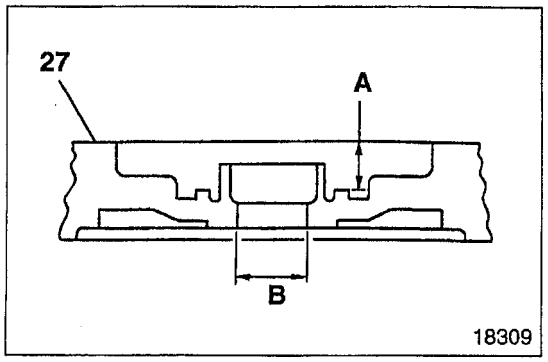
24 Installation of piston ring

Insert the Piston Ring Inserter into the turbine wheel **23** and install the piston ring **24**.

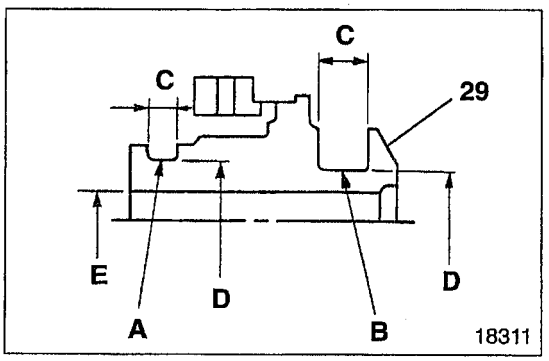


27 Back plate

[Installation]
Slowly install the back plate **27** on the center housing **35**, while lining up the alignment marks made before disassembly, and tighten the bolt **26** to the specified torque.



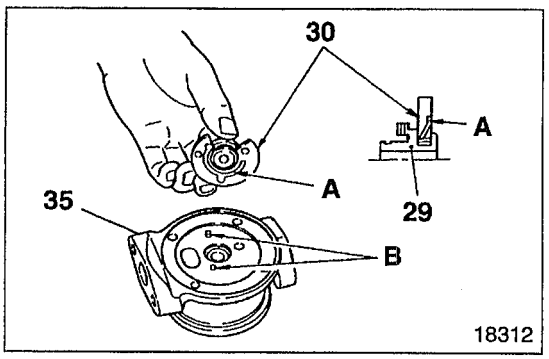
[Inspection]
- Measure the seal land height **A** and seal bore inside diameter **B** of the back plate **27**.
- If any reading exceeds the limit, replace the back plate **27**.



29 Piston ring groove and groove diameter of thrust collar and thrust bearing groove width, groove diameter and bore inside diameter

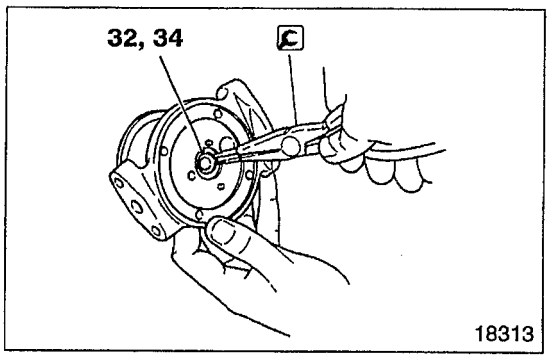
If any reading exceeds the limit, replace the thrust collar **29**.

A: Piston ring groove
B: Thrust bearing groove
C: Groove width
D: Groove diameter
E: Bore inside diameter



30 Installation of thrust bearing

Install the thrust bearing **30** on the thrust collar **29** with the oil groove **A** toward the center housing **35**, and insert it onto the positioning pins **B** of the center housing.



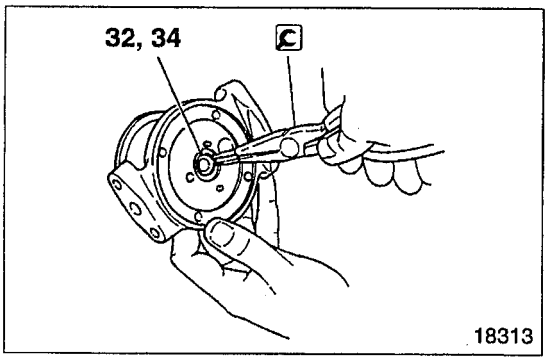
32 34 Retaining ring

[Removal]

: Retaining Ring Remover

CAUTION

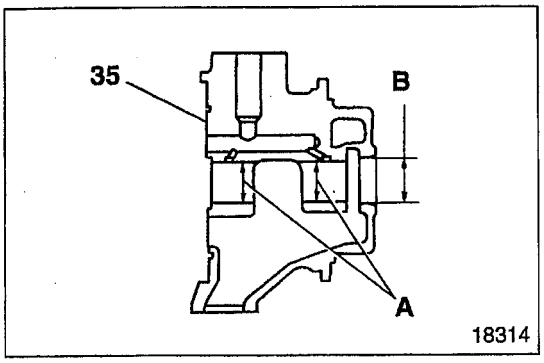
When the retaining rings 32 and 34 are removed, hold your hand over the rings to make sure that they do not bounce out.



[Installation]
Install the retaining rings **32** and **34** securely in the groove of the center housing.

CAUTION

When the retaining rings 32 and 34 are installed, hold your hand over the rings to make sure that they do not bounce out.

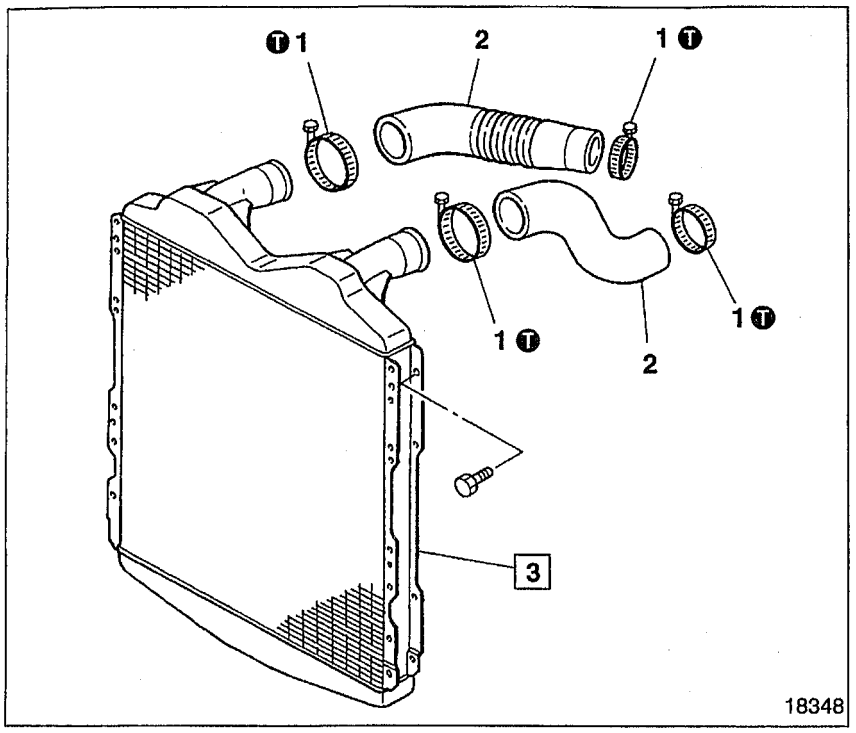


35 Check the bearing inserting portion inside diameter and seal bore diameter of the center housing.

If any reading exceeds the limit, replace the center housing **35**.

A: Bearing inserting portion inside diameter
B: Seal bore diameter

INTERCOOLER <6D16-TL, 16-TLE>



● **Disassembly sequence**

1 Clamp
2 Rubber hose
3 Intercooler

● **Reassembly sequence**

Reverse the order of disassembly.

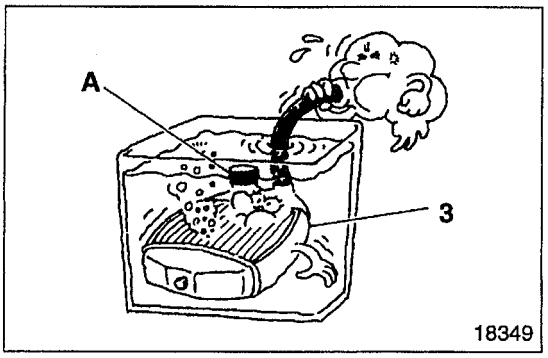
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
3	Intercooler (air leak at the air pressure of 150 kPa {1.5 kgf/cm^2})	0 cm^3 {0 mL}	—	Replace

ⓣ Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Clamp (for mounting rubber hose)	4.9 to 9.8 {0.5 to 1.0}	—



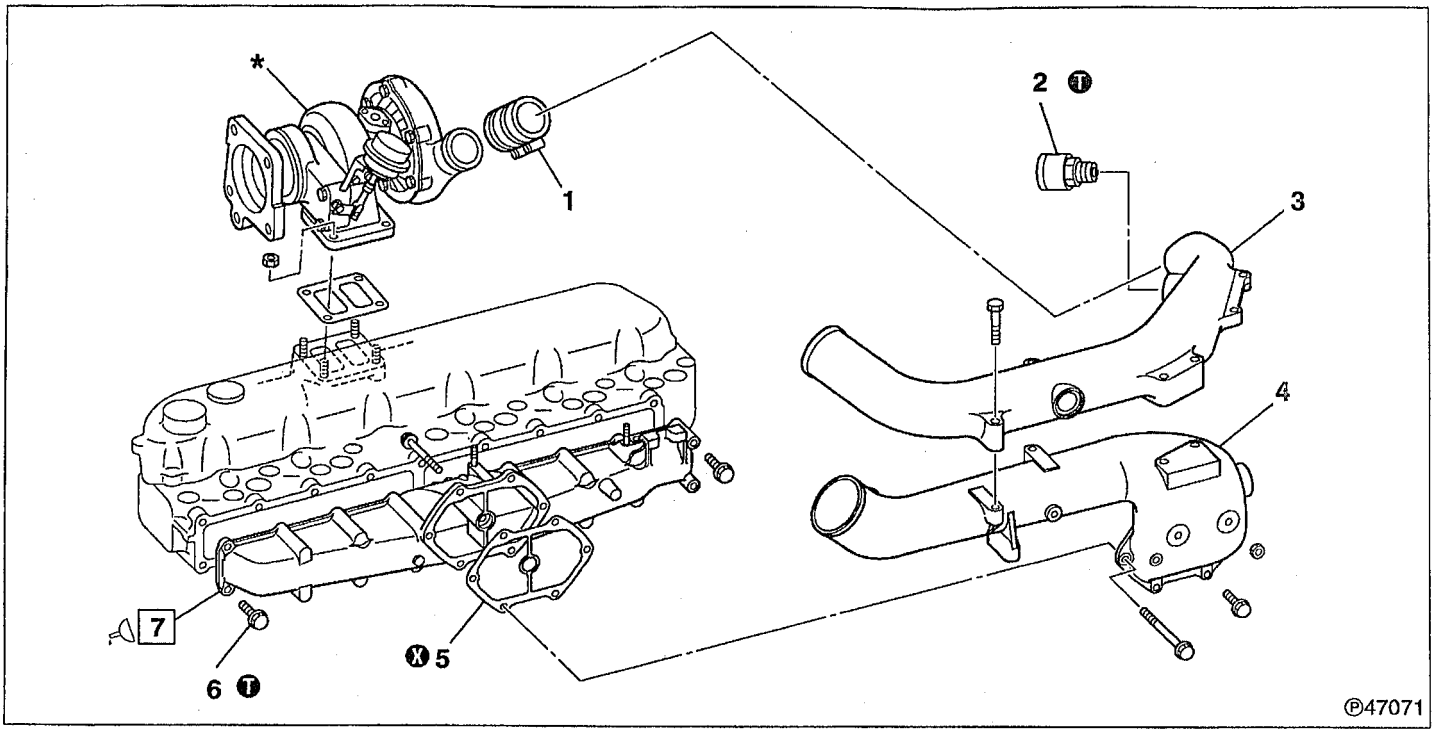
◆ Service procedure

3 Inspection of intercooler

Put a cap **A** on either of the air ports of the intercooler **3** and connect a hose to the other, immerse the intercooler **3** in a water tank, and apply the standard pressure from the hose side to check for air leaks.
If there are air leaks, replace the intercooler.

MEMO

INTAKE MANIFOLD <6D16-TLE>



● **Disassembly sequence**

1 Rubber hose
2 Overboost valve
3 Air inlet pipe
4 Air inlet pipe
5 Gasket
6 Bolt
7 Intake manifold

*: Turbocharger assembly
P.15-30
X: Non-reusable part

● **Reassembly sequence**

Reverse the order of disassembly.

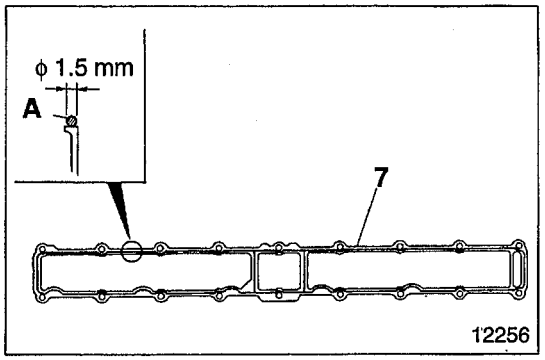
T Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Overboost valve	31 {3.2}	—
6	Bolt (for fitting intake manifold)	23 {2.37}	—

Sealant

Location	Points of application	Specified sealant	Quantity
7	Apply to cylinder head mounting surface of intake manifold	ThreeBond 1207B	As required



◆ Service procedure

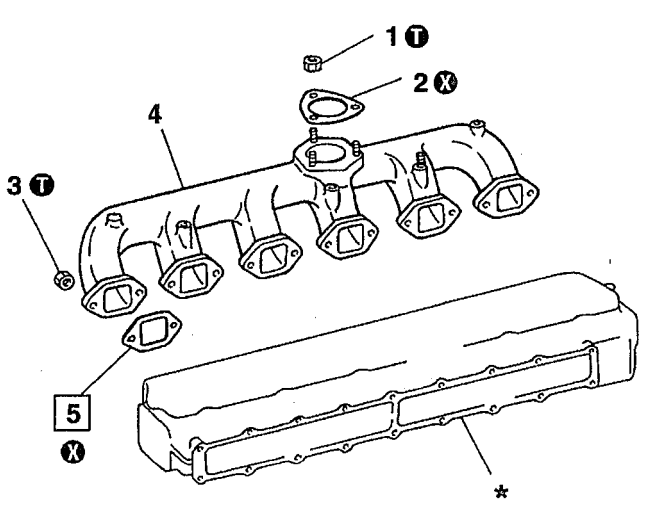
7 Installation of intake manifold

- Apply sealant **A** evenly without a break to the cylinder head mounting surface of the intake manifold **7**.
- Install the intake manifold **7** on the cylinder head in less than three minutes after application of sealant **A**.

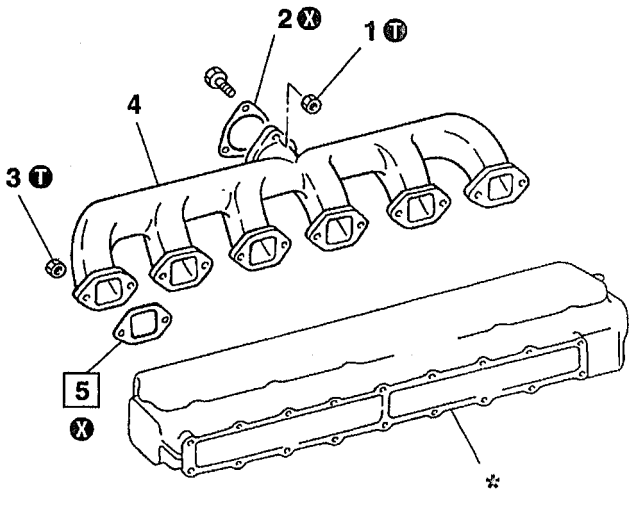
CAUTION ⚠

- **Thoroughly clean the sealant applying surface of the intake manifold 7 beforehand.**
- **When the intake manifold 7 is installed, make sure that it is not out of alignment.**
- **When the manifold mounting bolt 6 was loosened, be sure to reapply sealant A to the intake manifold 7.**
- **Do not start the engine in less than an hour after installation.**

EXHAUST MANIFOLD <6D14, 16, 16-E>



18343



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● **Disassembly sequence**

1 Nut
2 Gasket
3 Nut
4 Exhaust manifold
5 Gasket

*: Cylinder head 📖 Gr.11
X: Non-reusable part

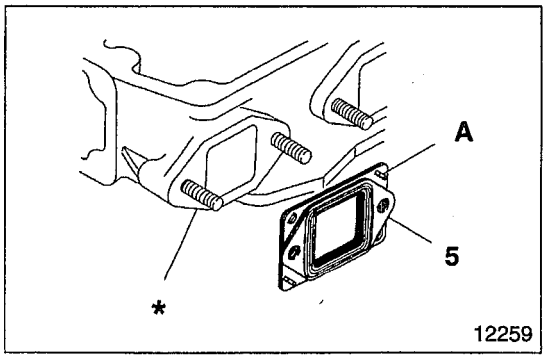
● **Reassembly sequence**

Reverse the order of disassembly.

T Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Nut (for mounting exhaust pipe)	41 {4.2}	—
3	Nut (for mounting exhaust manifold)	58 {5.9}	—



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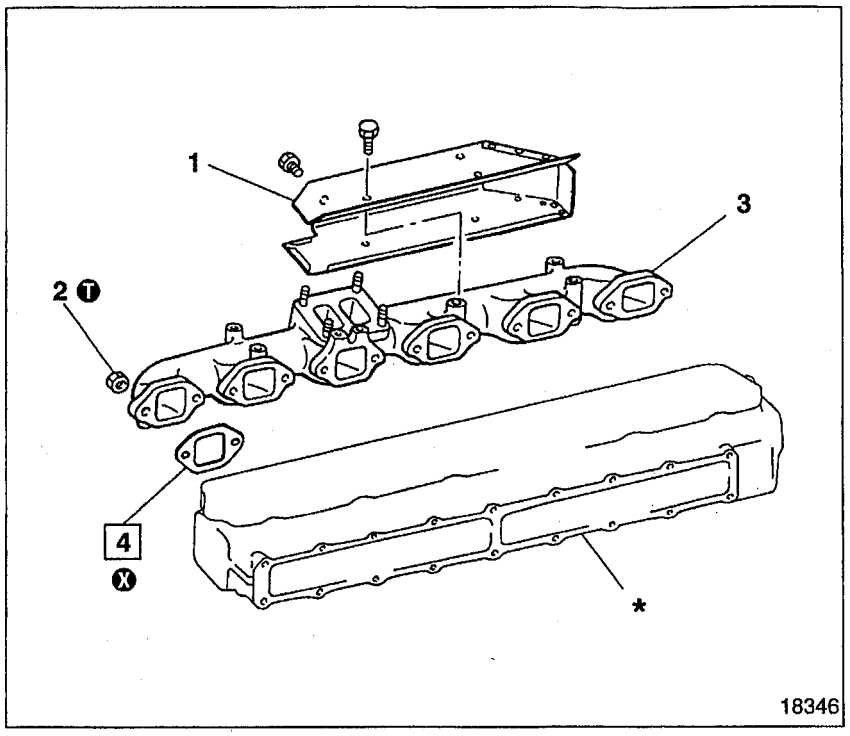
◆ Service procedure

5 Installation of gasket

Install the gasket **5** with the grommet fold-back portion **A** toward the cylinder head.



● **Disassembly sequence**

1 Cover
2 Nut
3 Exhaust manifold
4 Gasket

*: Cylinder head 🕮 Gr.11
X: Non-reusable part

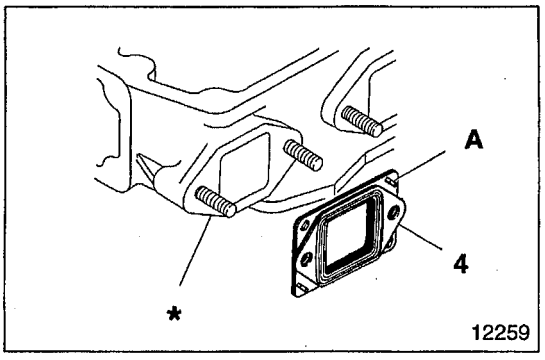
● **Reassembly sequence**

Reverse the order of disassembly.

T Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Nut (for mounting exhaust manifold)	58 {5.9}	—

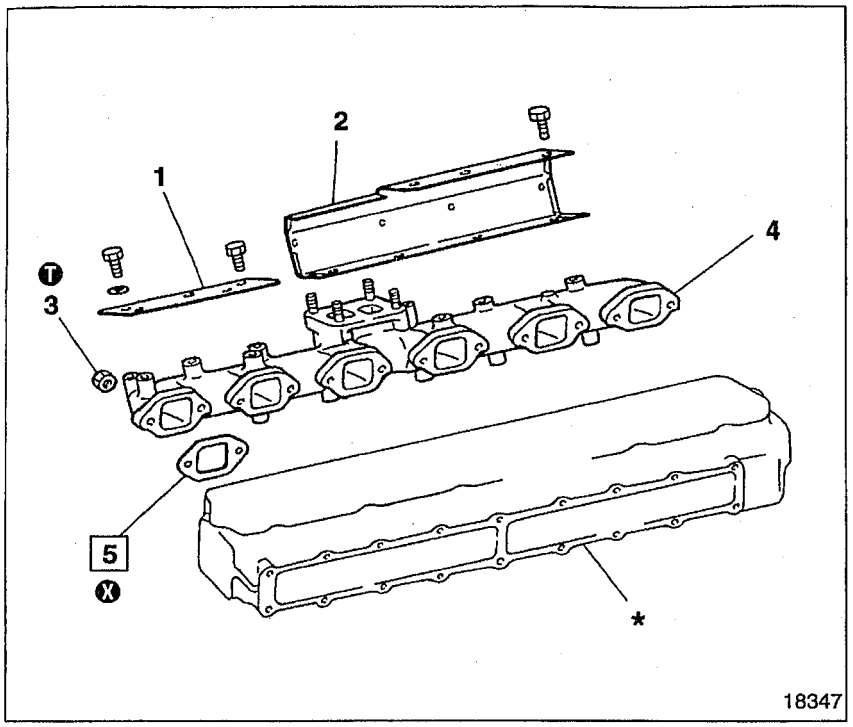


◆ Service procedure

4 Installation of gasket

Install the gasket **4** with the grommet fold-back portion **A** toward the cylinder head.

EXHAUST MANIFOLD <6D14-T, 16-T, 16-TE, 16-TL, 16-TLE>



● **Disassembly sequence**

1 Front insulator
2 Rear insulator
3 Nut
4 Exhaust manifold
5 Gasket

*: Cylinder head 🕮 Gr.11
Ⓧ: Non-reusable part

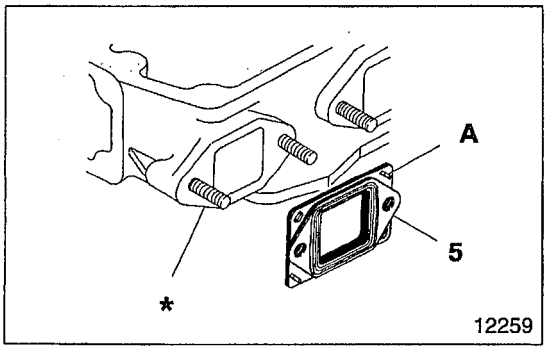
● **Reassembly sequence**

Reverse the order of disassembly.

Ⓣ Tightening torque

Unit: N·m {kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
3	Nut (for mounting exhaust manifold)	58 {5.9}	—



◆ Service procedure

5 Installation of gasket

Install the gasket **5** with the grommet fold-back portion **A** toward the cylinder head.

GROUP 21 CLUTCH

NOTE ; The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.

GROUP 54 ELECTRICAL SYSTEM

NOTE ; The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.

SPECIFICATIONS

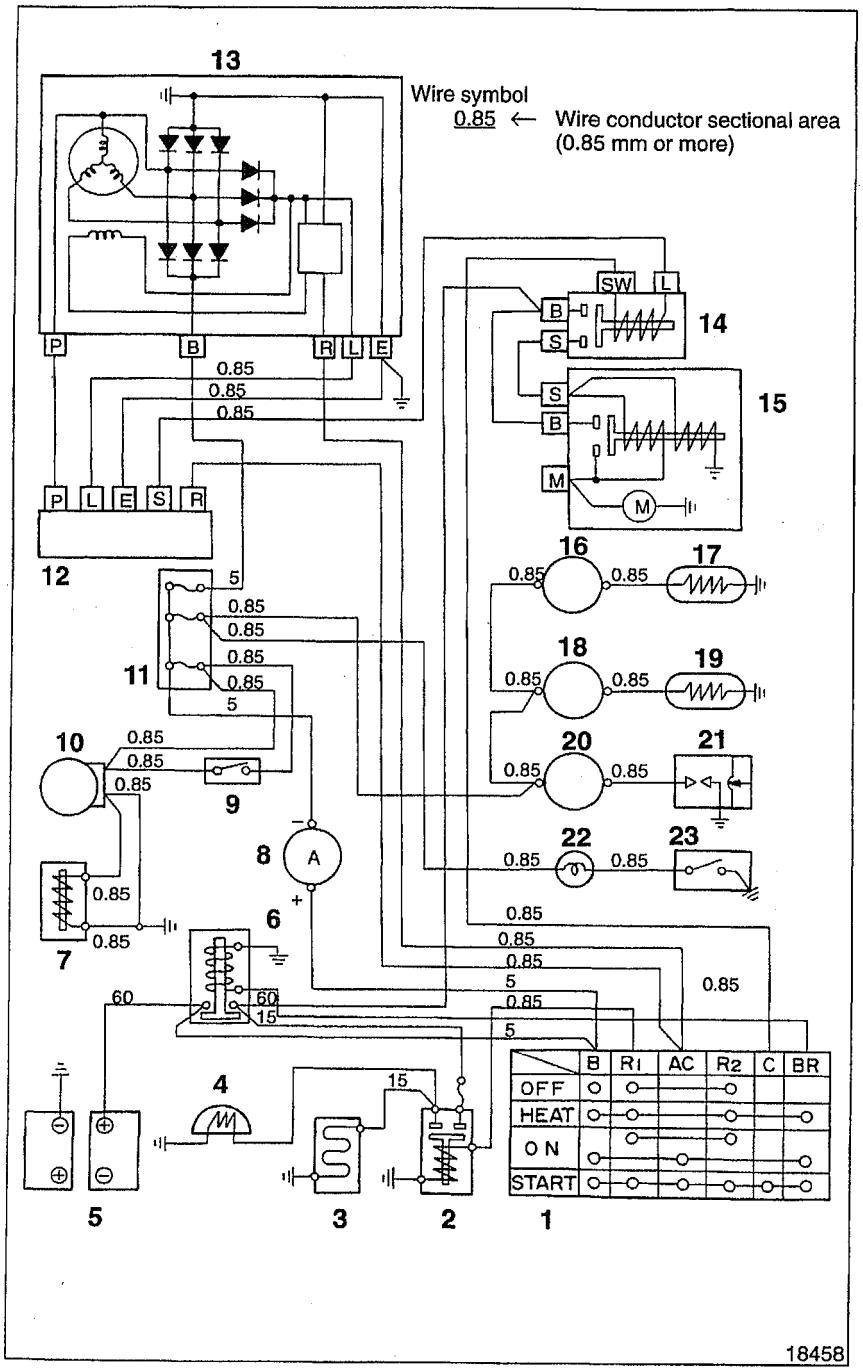
Item		Specifications												
Alternator	Manufacturer	MITSUBISHI ELECTRIC CORP.												
	Type	Alternator with built-in regulator, fan internal contact type	Alternator with built-in regulator, fan externally mounted type											
		With brush				Brushless								
	Vacuum pump	Not provided				Provided	Not provided							
	Model	A3TN 5379	A3TN 5386	A6T7 6086	A2T3 2386	A4TU 3186	A4T4 0286	A4T4 0299	A4T4 0379	A4T4 0386	A4T4 0399	A4T7 0099	A4T7 0199	A4TU 0286
	Output (V–A)	24–35		24–80	12–60	24–40			24–50			24–80	24–90	12–80
Starter	Manufacturer	MITSUBISHI ELECTRIC CORP.												
	Model	M8T60071		M8T60073		M5T50179	M9T50071							
	Output (V–kW)	24–5				24–6	12–5							
	Magnet switch operating voltage (V)	16 or less					8 or less							
Starter relay	Model	U1T35383				U1X15076								
	Exciting current (V–A)	24–2.3				12–4								
	Closed magnetic voltage (V)	16 or less				8 or less								
	Opened magnetic voltage (V)	4 or less				3.5 or less								
	Allowable breaking voltage (V)	200				200								
Intake air heater	Manufacturer	Hiyoshi Denso												
	Voltage – capacity (V–kW)	22–1.83		22–2.9		11–1.83								
	Fuse capacity (A)	–		127		–								
Heater relay	Manufacturer	MITSUBISHI ELECTRIC CORP.												
	Model	U1T31382		[U1T31383]		U1T31384			U1T11373					
	Voltage – current (V–A)	[24–2.3]							12–4					
	Fuse capacity (A)	91		[127]		164			127					

Item			Specifications	
Glow plug	Type		Sheathed type	
	Voltage – current (V–A)		23–3	
Glow relay	Model		U1T06670	
	Voltage – current (V–A)		24–2.3	
	Fuse capacity (A)		127	
Safety relay	Model		R8T30174	R8T30175
Stop solenoid	Manufacturer		Kimura Yoko	DENSO
	Kind		Shut-down type	Run-on type
	Type		Electromagnetic type	
Solenoid relay	Manufacturer		Nikko Denki	
	Kind		Shut-down type	Run-on type
	Model	24V	0-25000-5592	0-25000-6720
		12V	0-25000-6361	0-25000-6990

NOTE)
The engine of this machine is not equipped with stop solenoid and solenoid relay.

1. Circuit Diagram

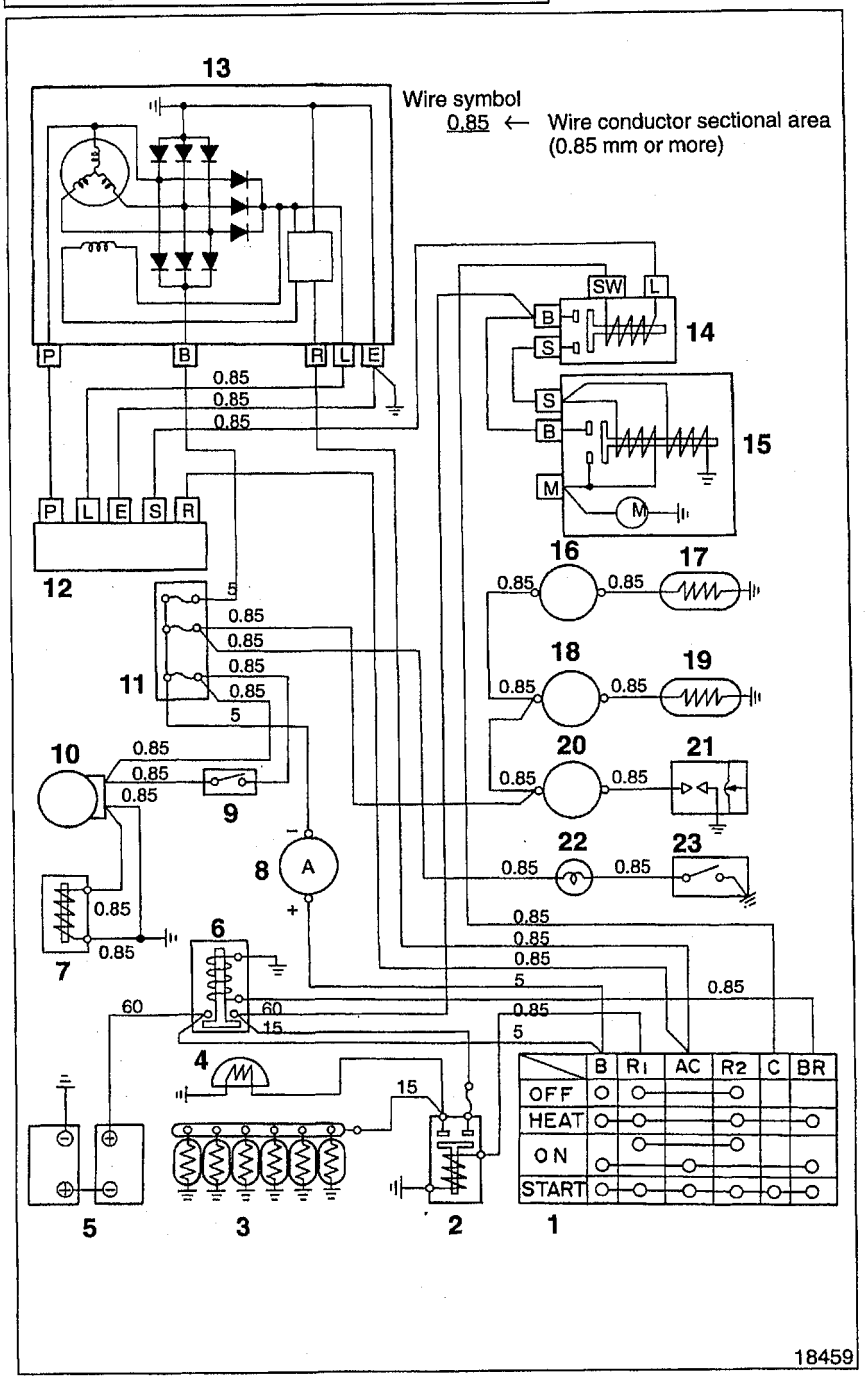
<24V (Air Heater) Specification>



1 Starter switch
2 Heater relay
3 Air heater
4 Heater indicator
5 Battery
6 Battery relay
7 Tachometer sensor
8 Ammeter
9 Lamp switch
10 Tachometer
11 Fuse box
12 Safety relay
13 Alternator
14 Starter relay
15 Starter
16 Thermometer (for oil)
17 Thermo sending unit
18 Thermometer (for coolant)
19 Thermo sending unit
20 Oil pressure gauge
21 Oil pressure gauge unit
22 Warning lamp
23 Oil bypass alarm switch

B: Terminal B
E: Terminal E
L: Terminal L
M: Terminal M
P: Terminal P
R: Terminal R
S: Terminal S
SW: Terminal SW

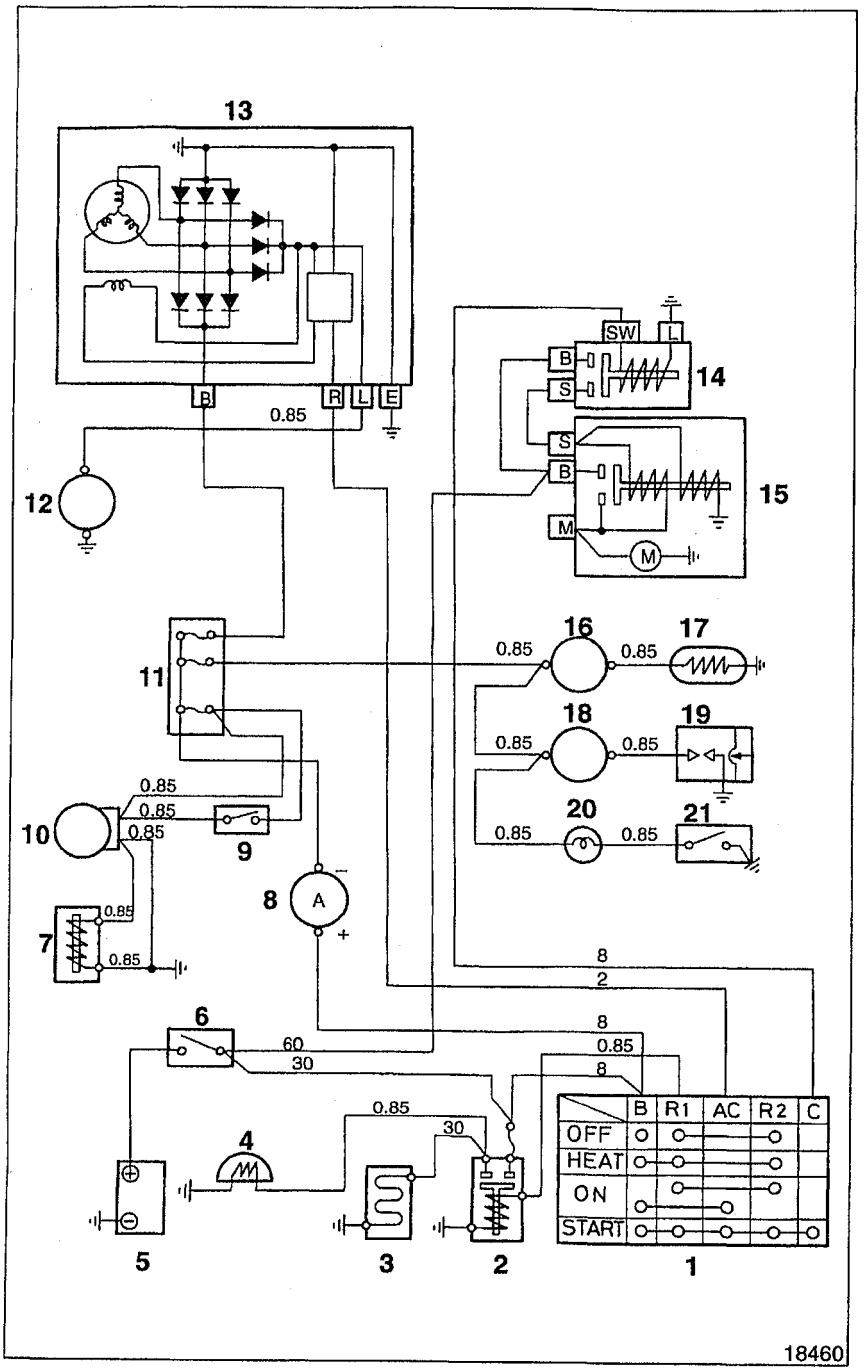
<24V (Glow Plug) Specification>



1 Starter switch
2 Glow relay
3 Glow plug
4 Glow indicator
5 Battery
6 Battery relay
7 Tachometer sensor
8 Ammeter
9 Lamp switch
10 Tachometer
11 Fuse box
12 Safety relay
13 Alternator
14 Starter relay
15 Starter
16 Thermometer (for oil)
17 Thermo sending unit
18 Thermometer (for coolant)
19 Thermo sending unit
20 Oil pressure gauge
21 Oil pressure gauge unit
22 Warning lamp
23 Oil bypass alarm switch

B: Terminal B
E: Terminal E
L: Terminal L
M: Terminal M
P: Terminal P
R: Terminal R
S: Terminal S
SW: Terminal SW

<12V Specification>

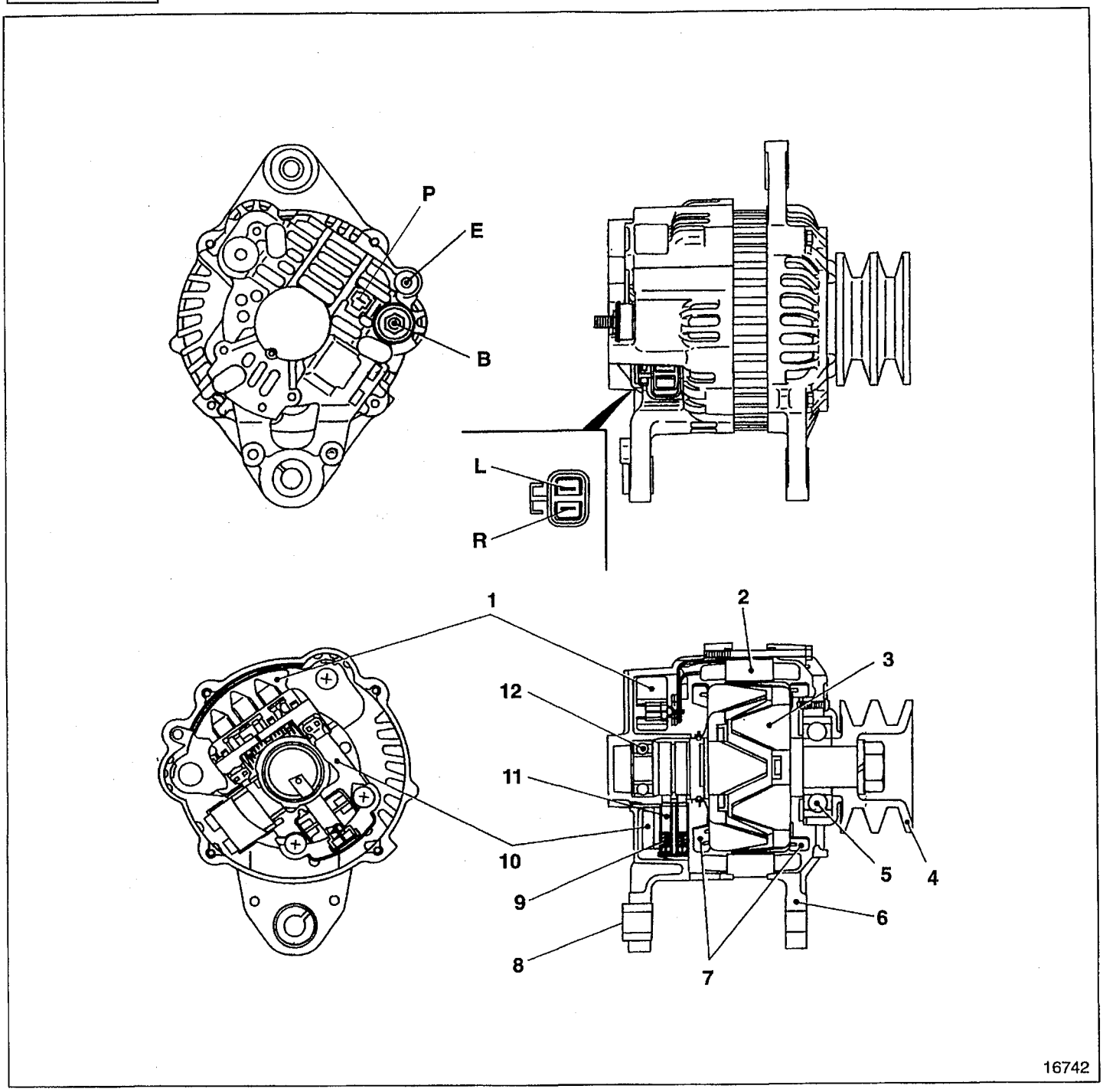


1 Starter switch
2 Heater relay
3 Air heater
4 Heater indicator
5 Battery
6 Battery switch
7 Tachometer sensor
8 Ammeter
9 Lamp switch
10 Tachometer
11 Fuse box
12 Hour meter
13 Alternator
14 Starter relay
15 Starter
16 Thermometer (for coolant)
17 Thermo sending unit
18 Oil pressure gauge
19 Oil pressure gauge unit
20 Warning lamp
21 Oil bypass alarm switch

B: Terminal B
E: Terminal E
L: Terminal L
M: Terminal M
R: Terminal R
S: Terminal S
SW: Terminal SW

2. Alternator

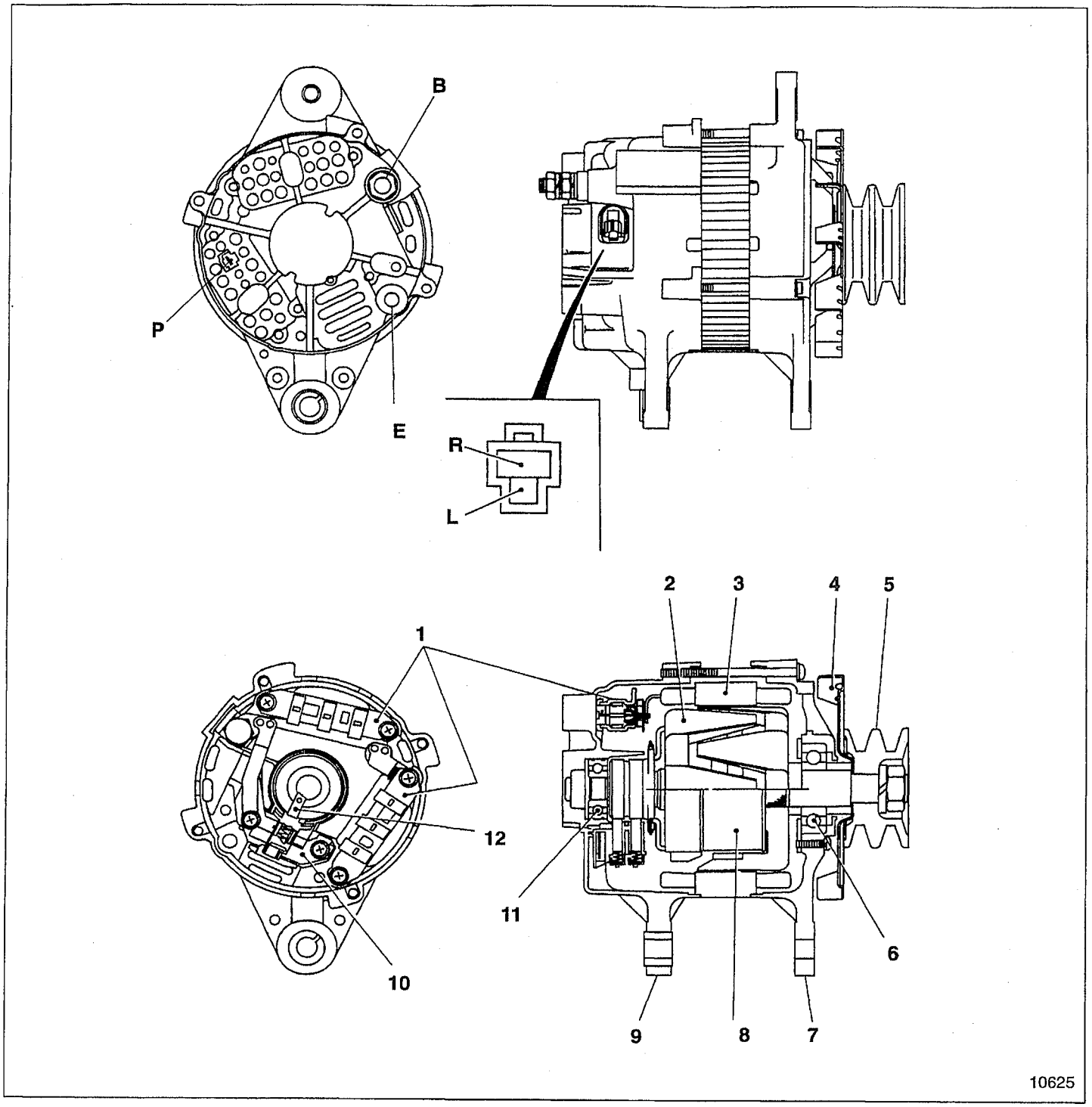
<24V–35A>



1	Rectifier	**7**	Fan	**B**:	Terminal B
2	Stator assembly	**8**	Rear bracket	**E**:	Terminal E
3	Rotor assembly	**9**	Brush spring	**L**:	Terminal L
4	Pulley	**10**	Regulator & brush holder	**P**:	Terminal P
5	Front bearing	**11**	Brush	**R**:	Terminal R
6	Front bracket	**12**	Rear bearing		

STRUCTURE AND OPERATION

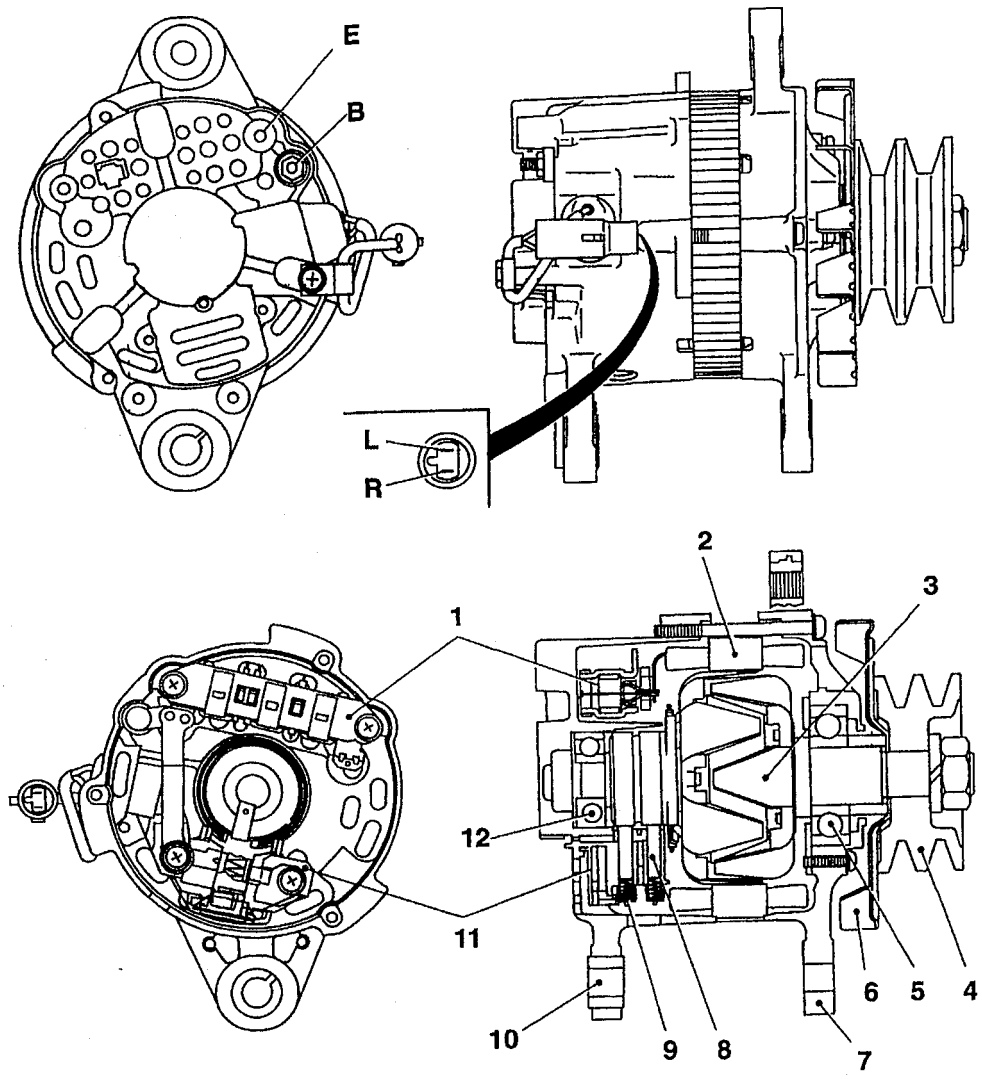
<24V–80A (with brush)>



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

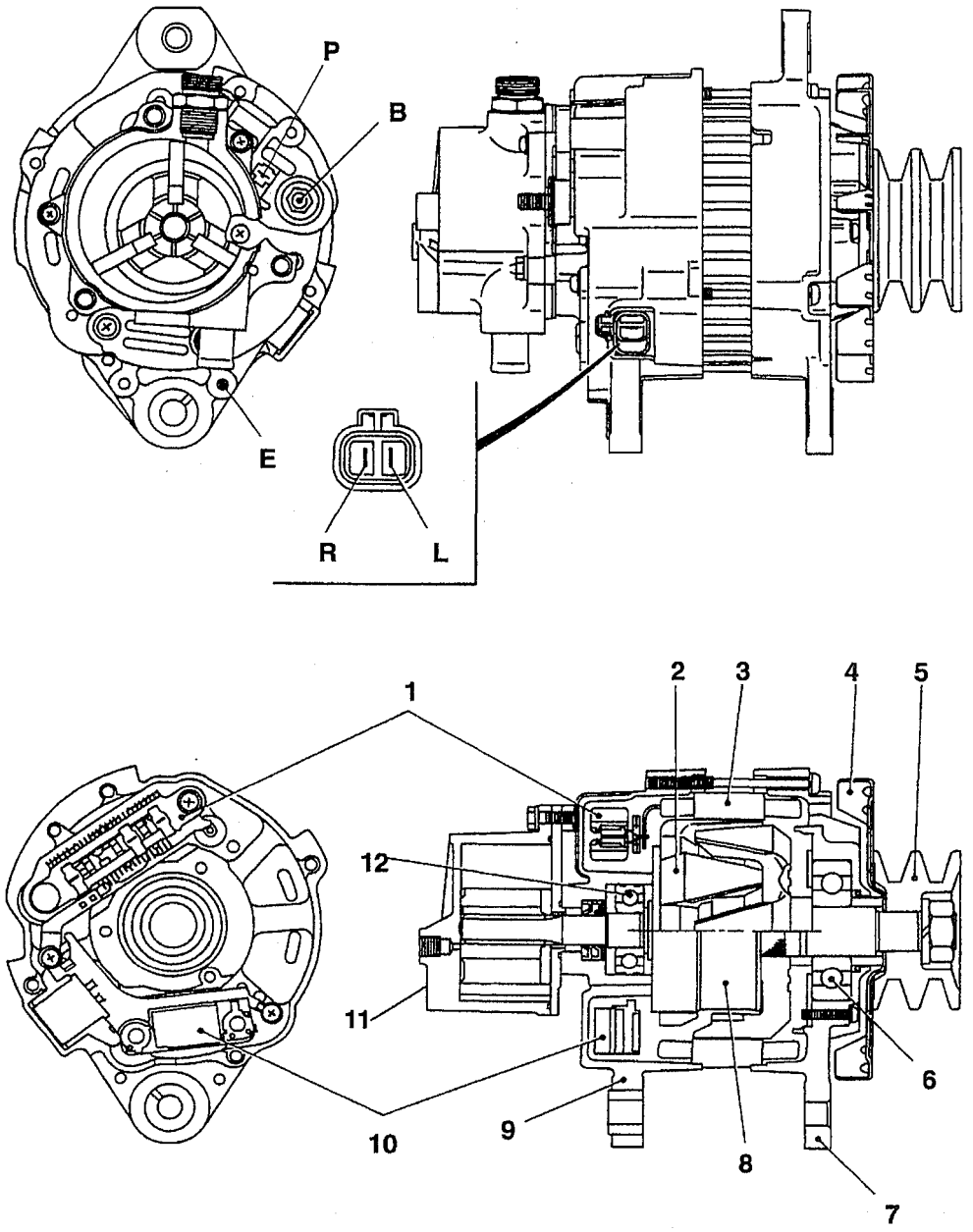
<12V–60A>



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

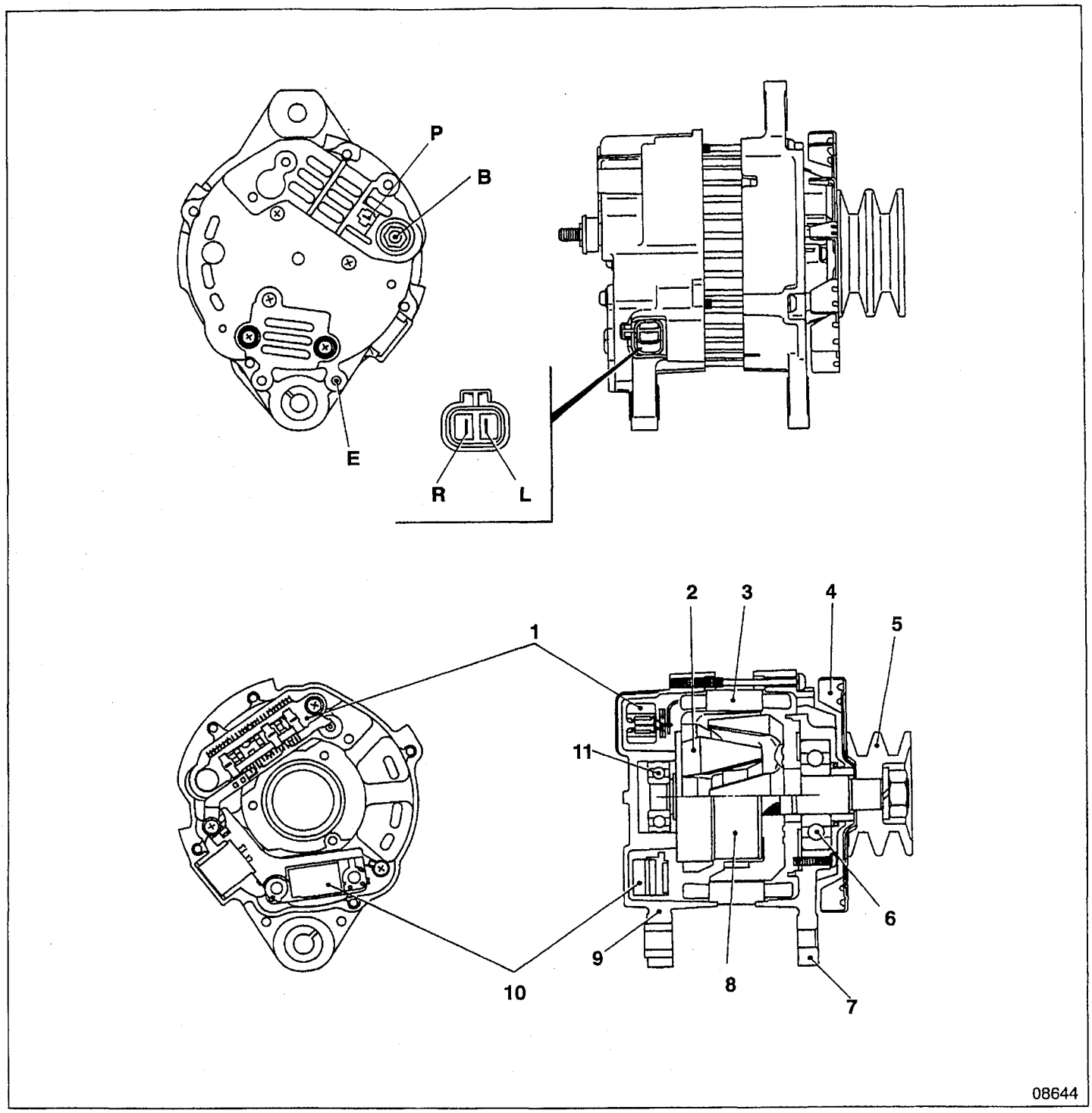
<24V–40A (with vacuum pump)>



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 Vacuum pump
12 Rear bearing

B: Terminal B
E: Terminal E
L: Terminal L
P: Terminal P
R: Terminal R

<24V–40A (without vacuum pump), 12V–80A>

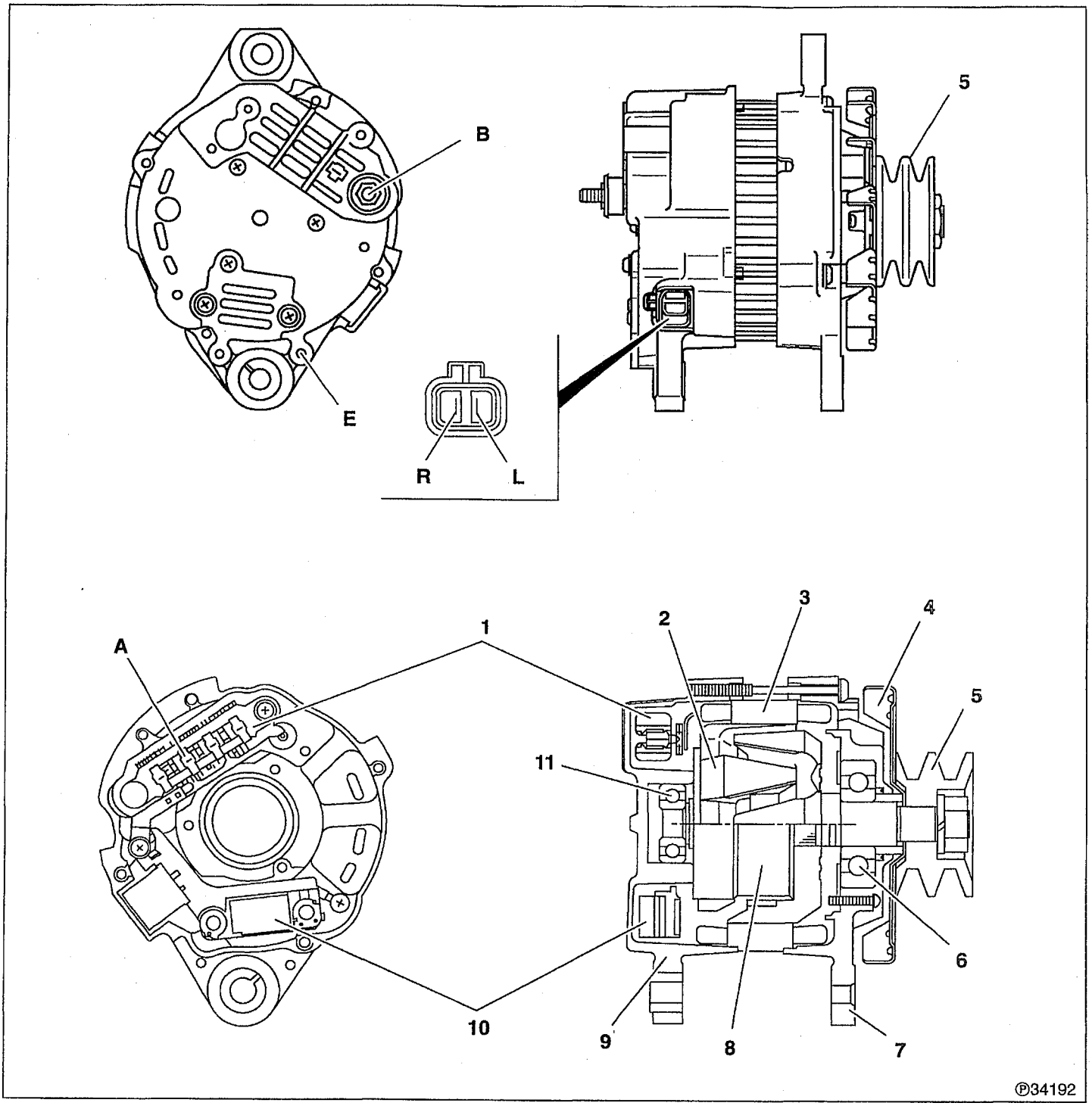


1 Rectifier
2 Rotor assembly
3 Stator assembly
4 Fan
5 Pulley
6 Front bearing
7 Front bracket
8 Field coil
9 Rear bracket
10 Regulator
11 Rear bearing

B: Terminal B
E: Terminal E
L: Terminal L
P: Terminal P
R: Terminal R

STRUCTURE AND OPERATION

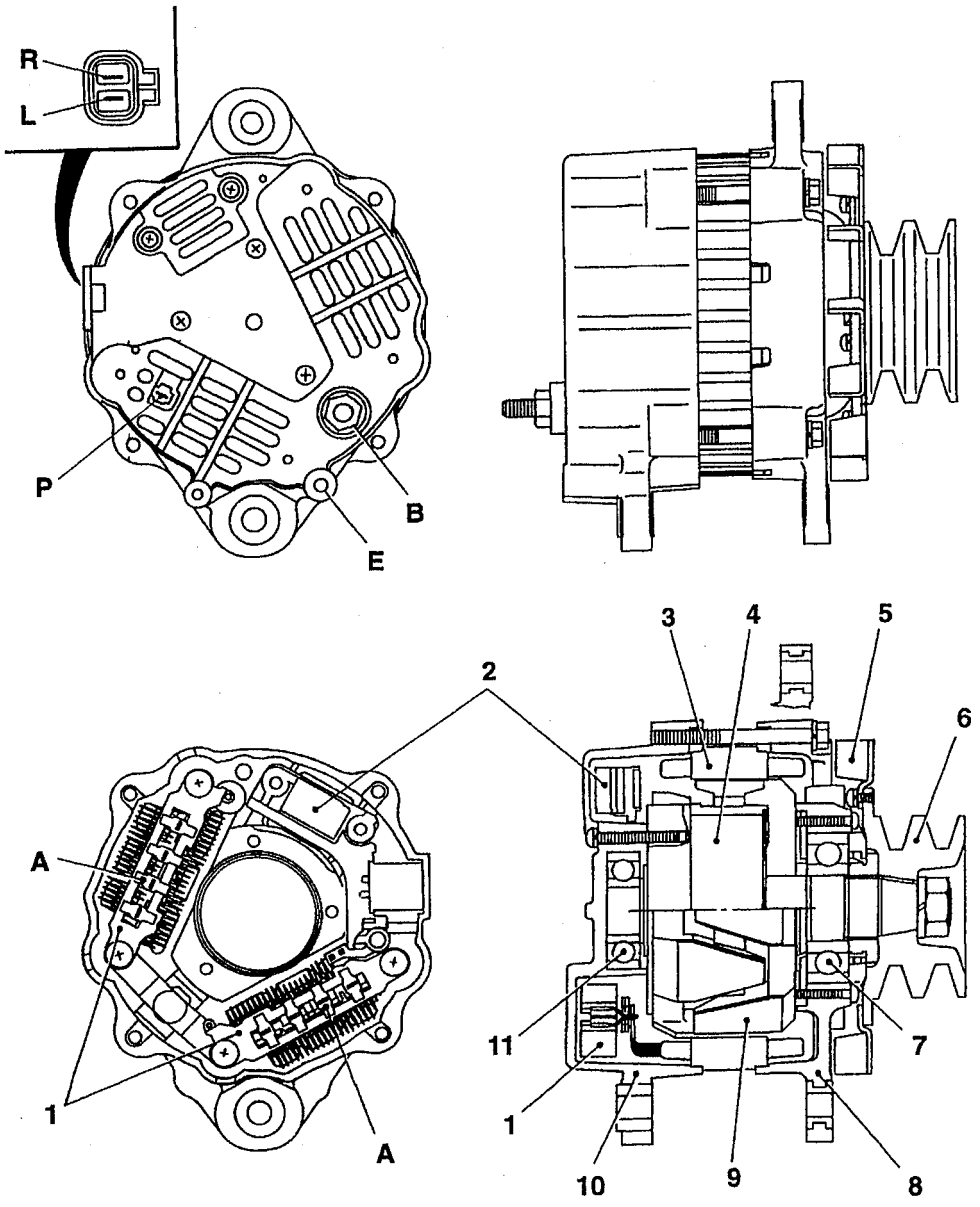
<24V–50A>



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

A: Neutral point diode
B: Terminal B
E: Terminal E
L: Terminal L
R: Terminal R

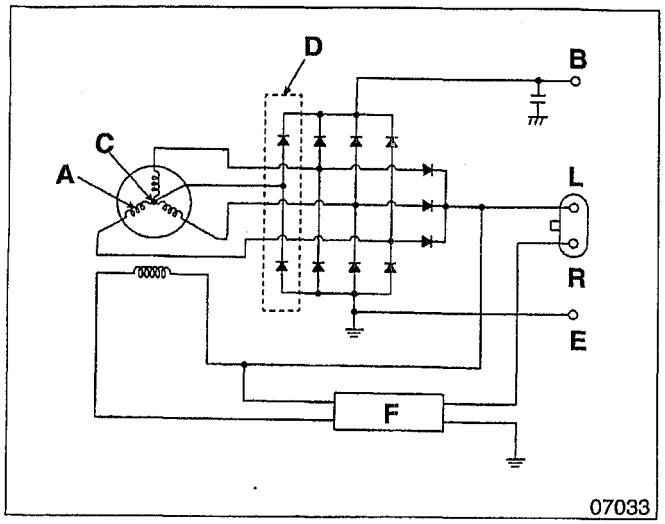
<24V–80A (brushless), 90A>



1 Rectifier
2 Regulator
3 Stator assembly
4 Field coil
5 Fan
6 Pulley
7 Front bearing
8 Front bracket
9 Rotor assembly
10 Rear bracket
11 Rear bearing

A: Neutral point diode <90A>
B: Terminal B
E: Terminal E
L: Terminal L
P: Terminal P
R: Terminal R

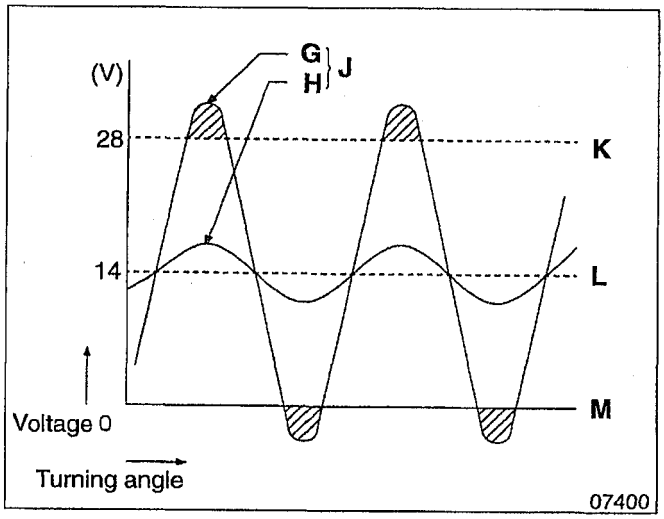
● Alternator with neutral point diode



Effectiveness of alternator with neutral point diode

The point where three stator coils **A** are coupled is called the neutral point **C**. Addition of two diodes **D** to the current alternator which uses six diodes makes it possible to provide a higher DC output than an alternator without neutral point diodes.

B: Alternator terminal B
E: Alternator terminal E
F: IC regulator
L: Alternator terminal L
R: Alternator terminal R



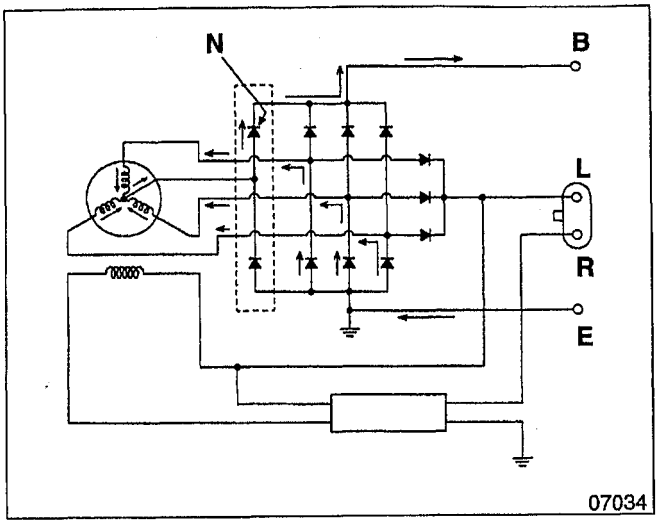
Variations in potential at neutral point, and operation of neutral point diode

- The potential at the neutral point **C** varies up and down as shown with the neutral point DC voltage (one half of the output voltage) as the center. When the alternator rotates at a very high speed, the peak values of the potential by far exceed the output voltage. (28V or more, 0V or less)

G: During high speed rotation
H: During low speed rotation
J: Neutral point voltage waveform
K: Output voltage
L: Mean voltage at neutral point
M: Ground potential

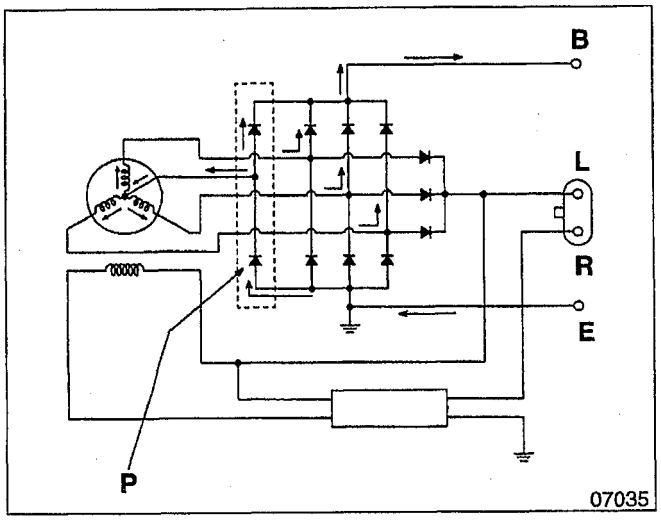
In each of the voltage and potential conditions, the neutral point diode operates as described below.

- 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**

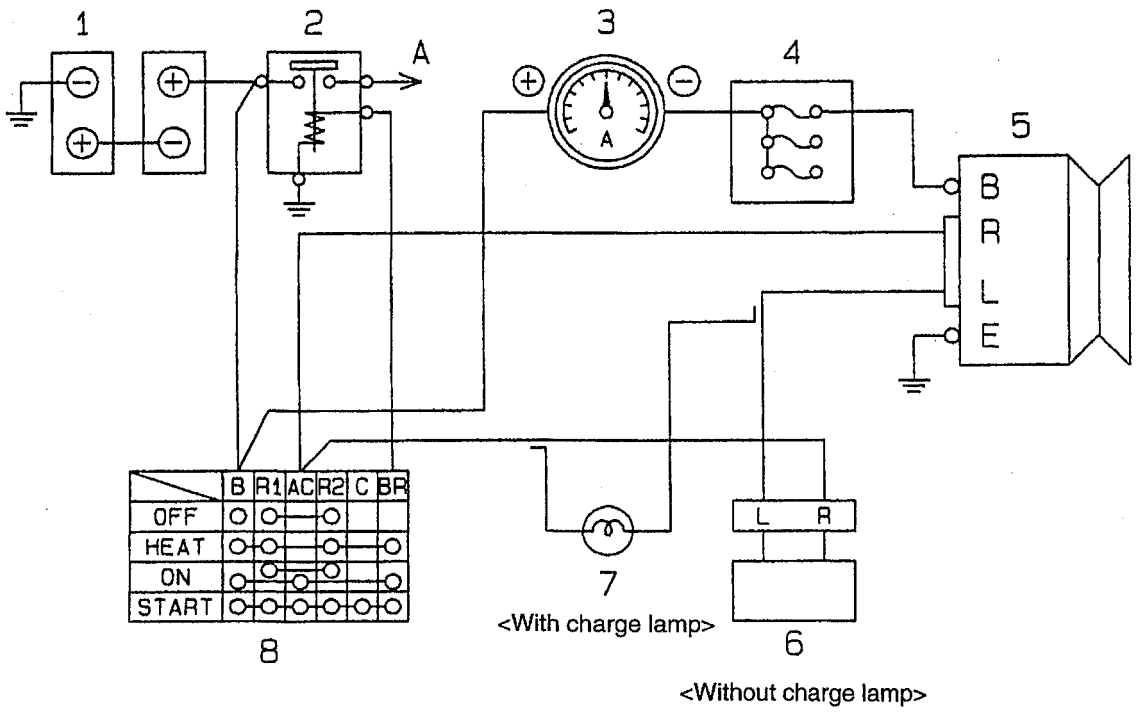
The positive side diode **N** conducts to add to the conventional DC output, so a higher DC voltage is output to each equipment.



● **When the neutral point voltage is less than 0V**

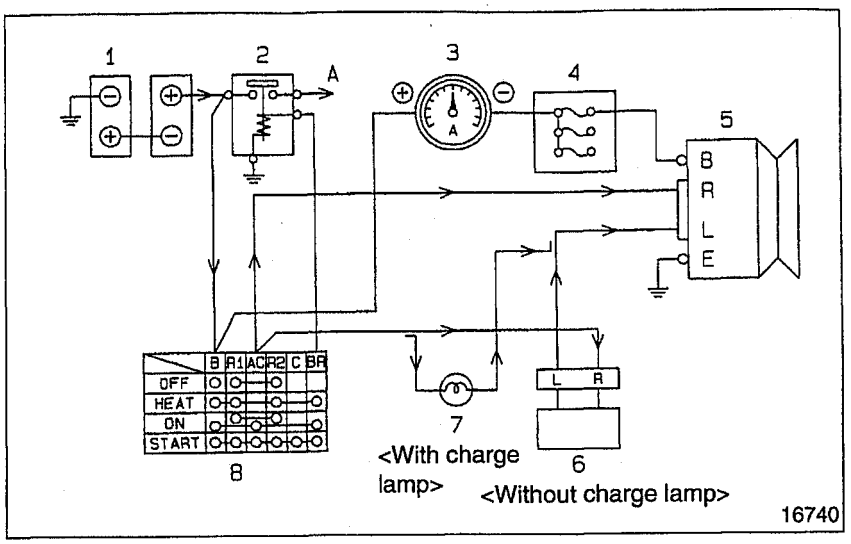
The negative side diode **P** conducts, and the neutral point output is supplied via the three conventional diodes.

3. Charging Circuit



1 Battery
2 Battery relay
3 Ammeter
4 Fuse box
5 Alternator
6 Safety relay <Circuit without charge lamp>
7 Charge lamp <Circuit with charge lamp>
8 Starter switch

A: To starter relay terminal B
B: Terminal B
E: Terminal E
L: Terminal L
R: Terminal R



When engine is stationary

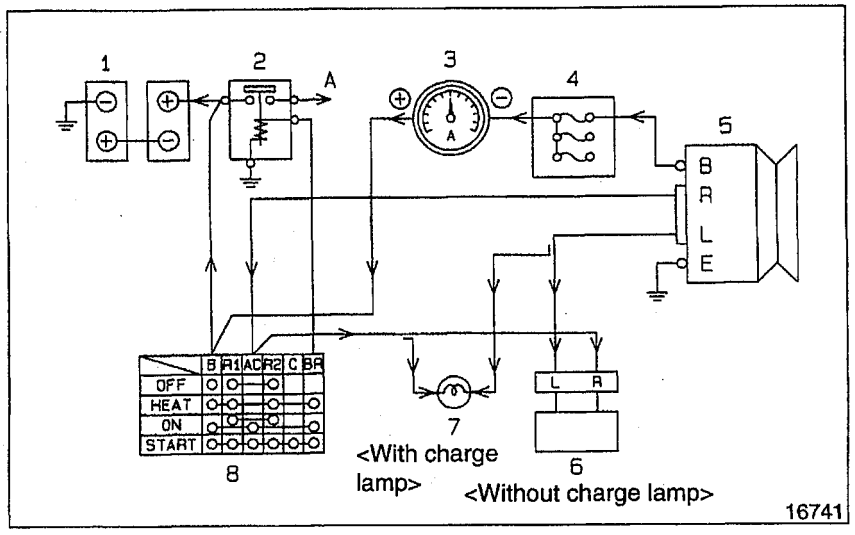
Position of starter switch **8**: ON

- To improve the performance of the alternator **5** in starting power generation at a low speed immediately after the engine has been started, current is set flowing to terminal R.

1 → 2 → 8 → 5 (R → E) → Earth
6 (R → L) → 5 (L → E) → Earth

- In the circuit with **A** charge lamp **7**, current flows as shown below.

1 → 2 → 8 → 5 (R → E) → Earth
7 → 5 (L → E) → Earth



After engine has been started

Position of starter switch **8**: ON

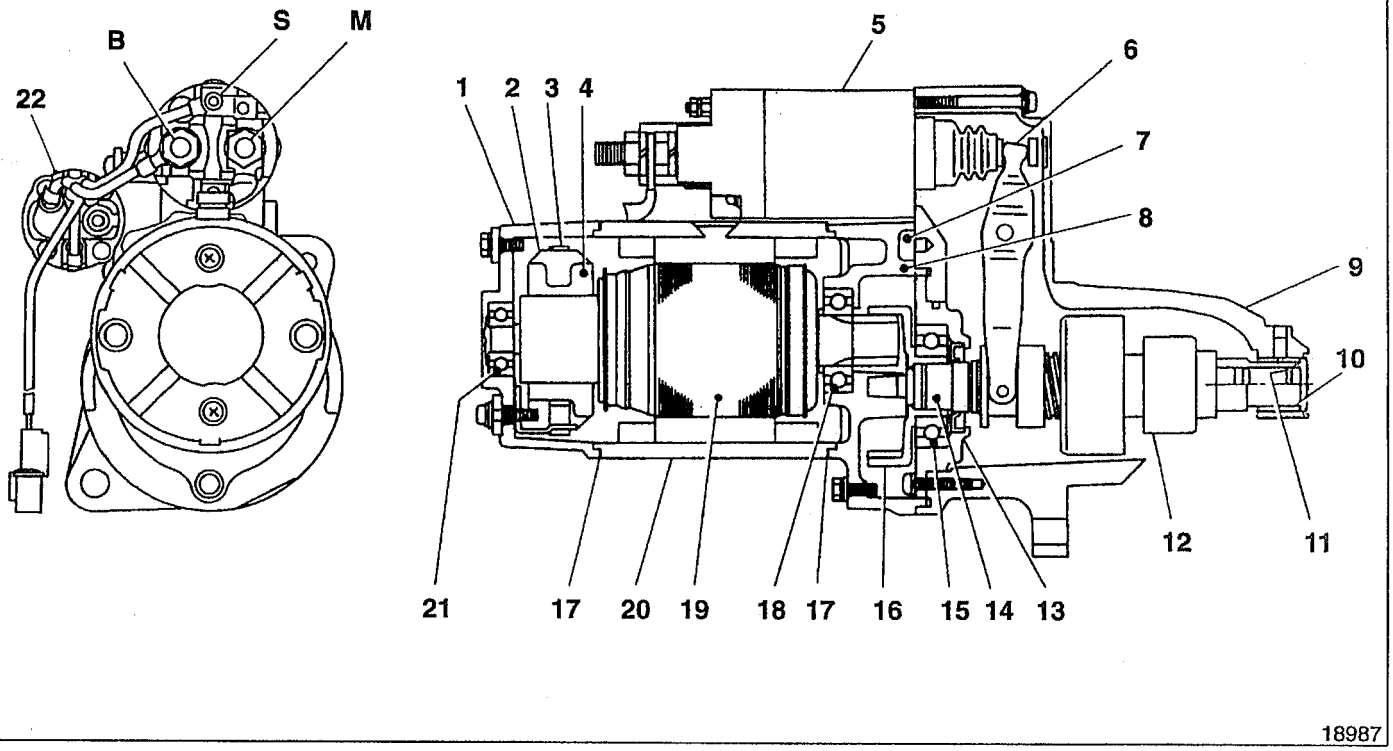
- The alternator **5** starts generating power.
- The output voltage at terminal B of the alternator **5** becomes higher than the voltage of the battery **1**.
- The alternator **5** starts charging the battery **1**.

5 (B) → 4 → 3 → 8 → 2 → 1

- In the case of the circuit with the charge lamp **7**, the charge lamp goes out, as there is no potential difference between the voltage at terminal L of the alternator **5** and the battery voltage.

4. Starter

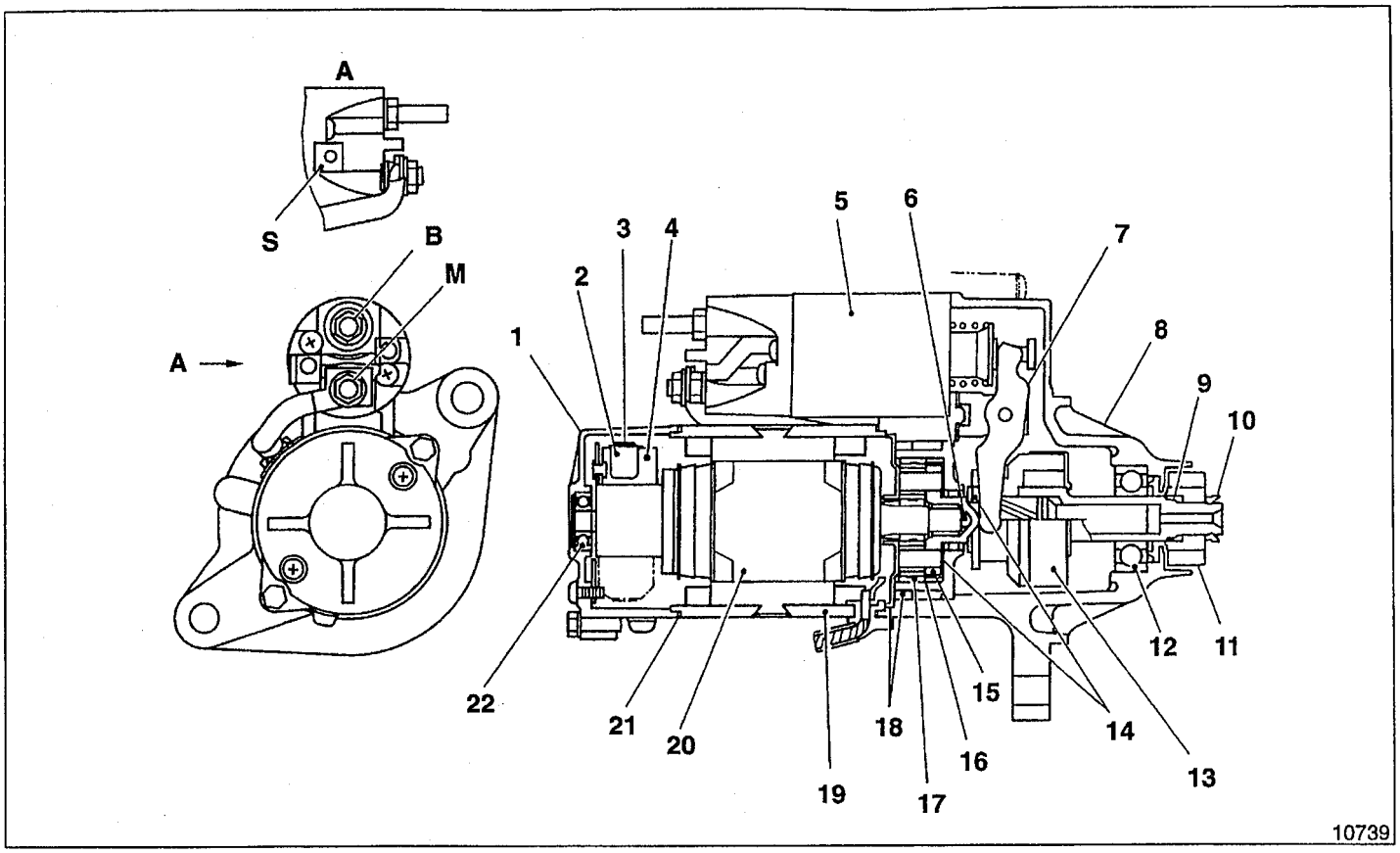
<24V–6kW>



1 Rear bracket
2 Brush
3 Brush spring
4 Brush holder assembly
5 Magnet switch
6 Lever
7 Guide
8 Center bracket
9 Front bracket
10 Sleeve bearing
11 Stopper ring
12 Overrunning clutch
13 Gear bracket
14 Gearshaft
15 Gearshaft bearing
16 Internal gear
17 Rubber packing
18 Front bearing
19 Armature
20 Yoke assembly
21 Rear bearing
22 Starter relay

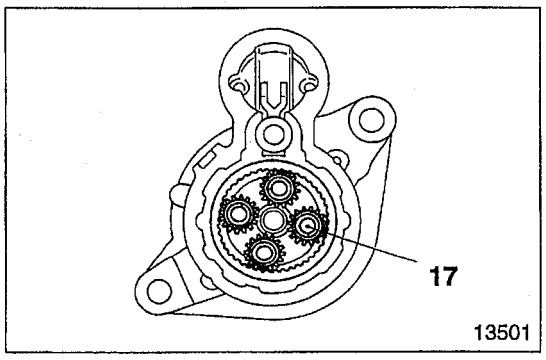
B: Terminal B
M: Terminal M
S: Terminal S

<24V-5kW>



1 Rear bracket
2 Brush
3 Brush spring
4 Brush holder assembly
5 Magnet switch
6 Ball
7 Lever
8 Front bracket
9 Spring
10 Pinion stopper
11 Pinion
12 Front bearing
13 Overrunning clutch
14 Washer
15 Gearshaft assembly
16 Internal gear assembly
17 Planetary gear
18 Packing
19 Yoke assembly
20 Armature assembly
21 Packing
22 Rear bearing

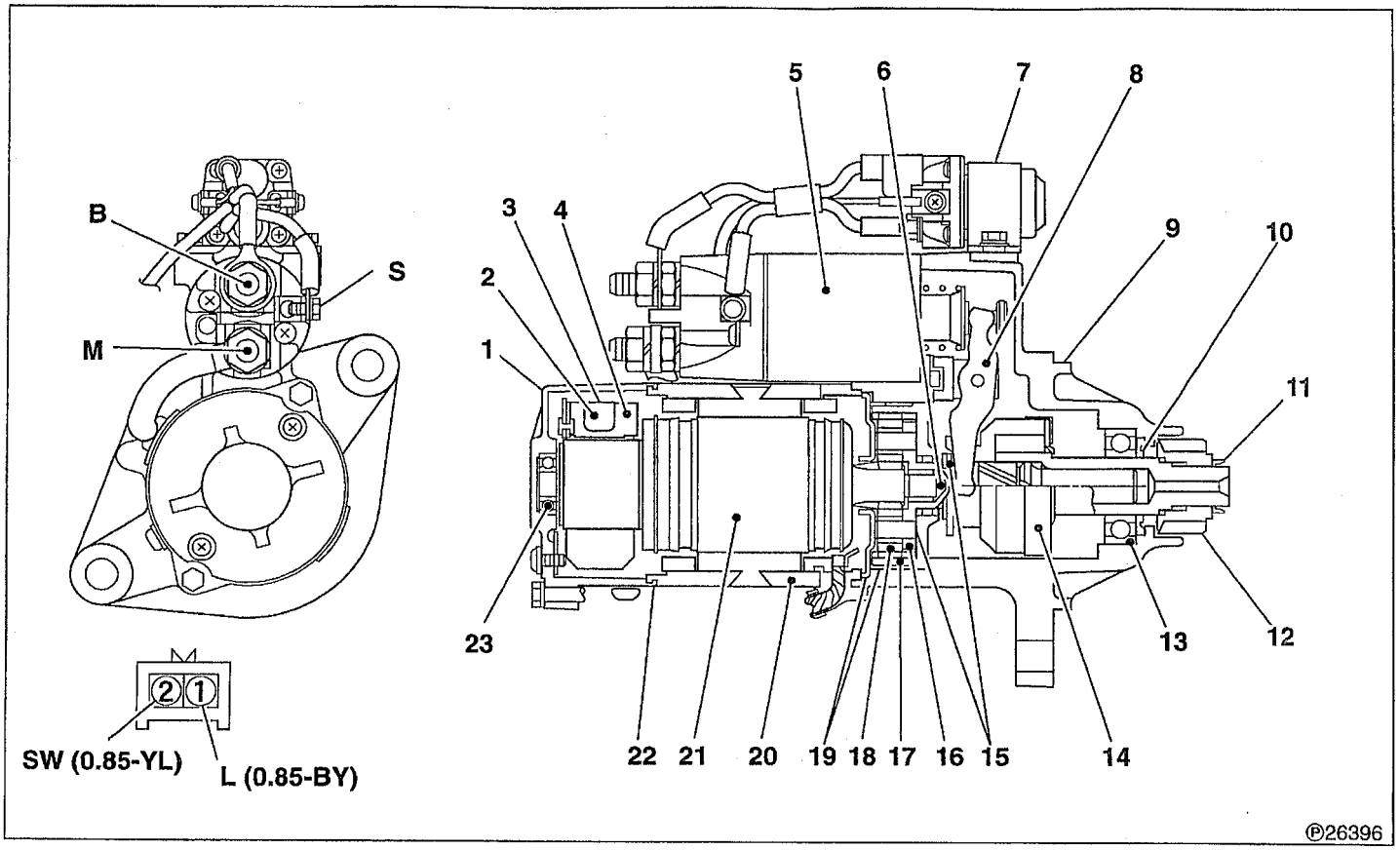
B: Terminal B
M: Terminal M
S: Terminal S



This starter uses planetary gear **17** in the reduction gear mechanism.

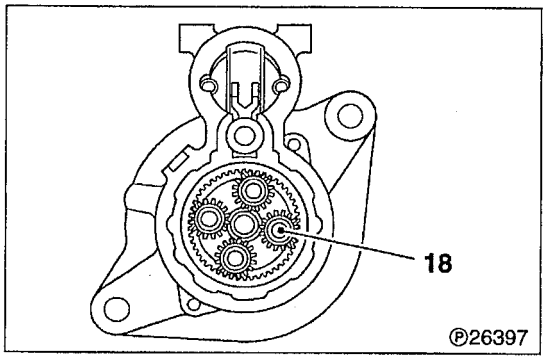
STRUCTURE AND OPERATION

<12V–5kW>



1 Rear bracket
2 Brush
3 Brush spring
4 Brush holder
5 Magnetic switch
6 Ball
7 Starter relay
8 Lever
9 Front bracket
10 Spring
11 Pinion stopper
12 Pinion
13 Front bearing
14 Overrunning clutch
15 Washer
16 Gear shaft
17 Internal gear assembly
18 Planetary gear assembly
19 Rubber packing
20 Yoke assembly
21 Armature assembly
22 Rubber packing
23 Rear bearing

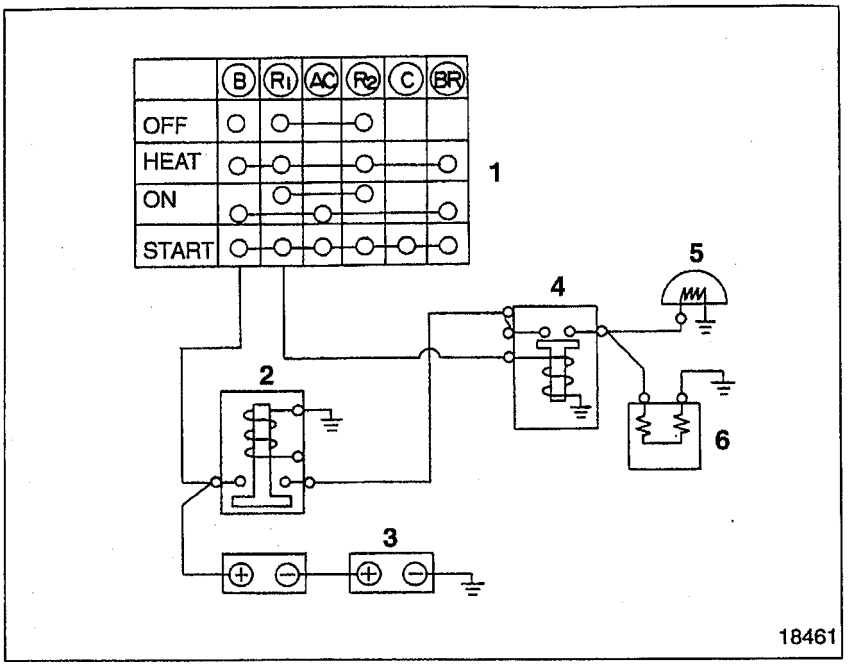
B: Terminal B
L: Terminal L
M: Terminal M
S: Terminal S
SW: Terminal SW



This starter uses planetary gear **18** for the reduction gear system.

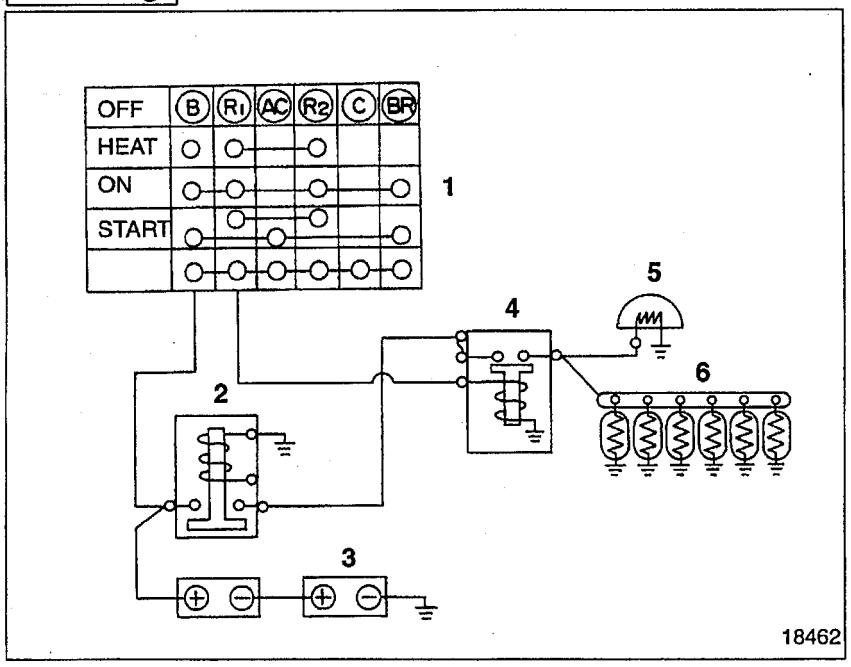
5. Preheating Circuit

<Intake Air Heater>



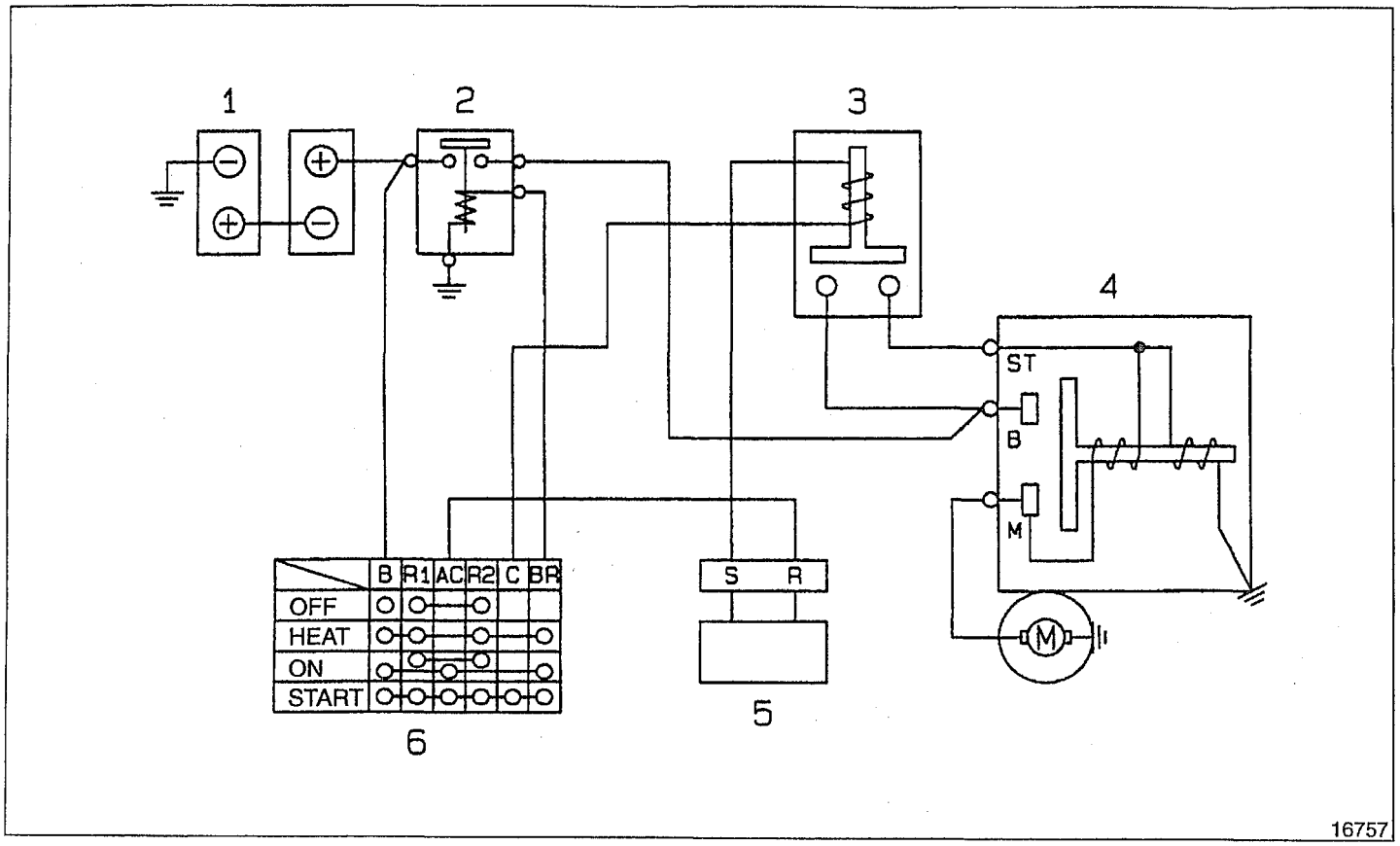
1 Starter switch
2 Battery relay
3 Battery
4 Heater relay
5 Heater indicator
6 Intake air heater

<Glow Plug>



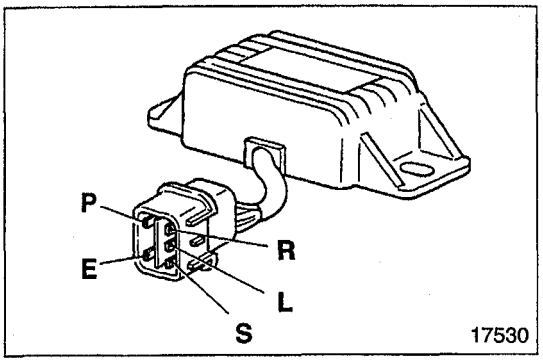
1 Starter switch
2 Battery relay
3 Battery
4 Heater relay
5 Glow indicator
6 Glow plug

6. Engine Starter Circuit



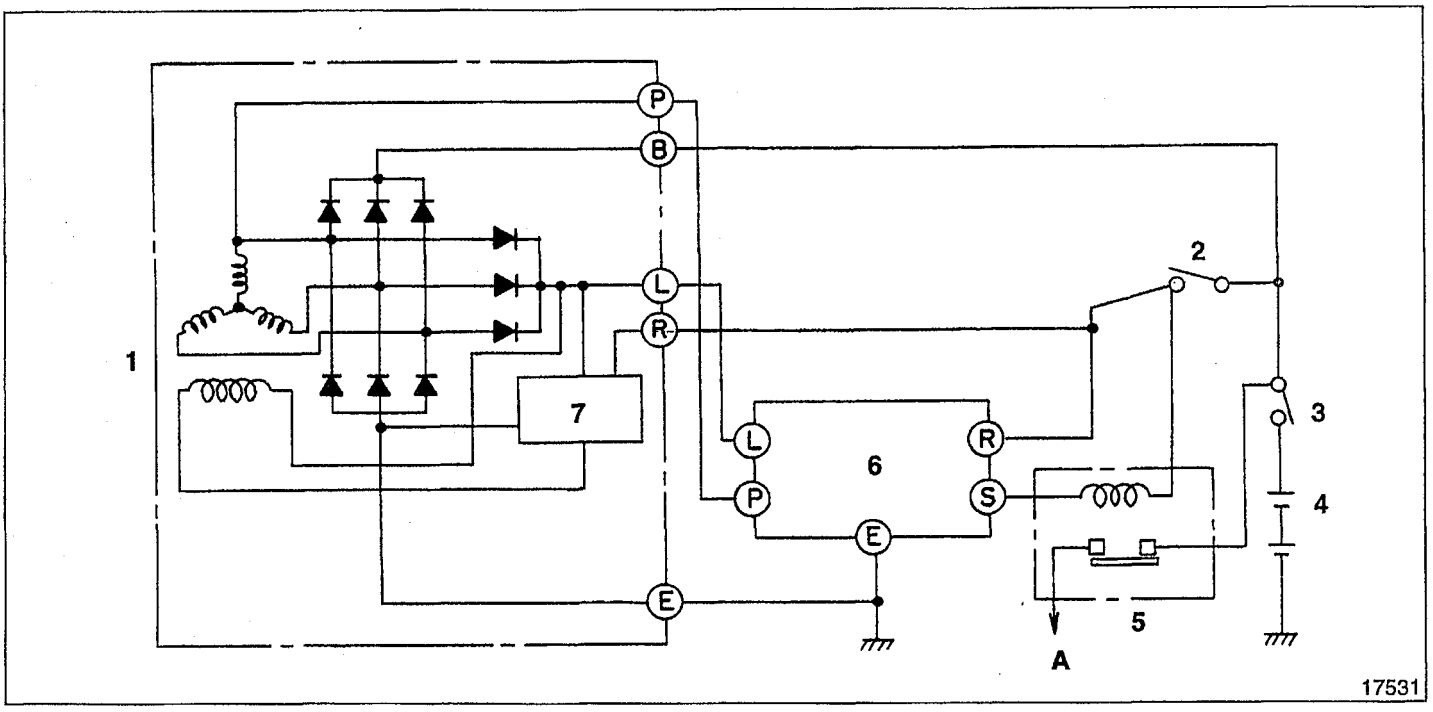
1 Battery
2 Battery relay
3 Starter relay
4 Starter
5 Safety relay
6 Starter switch

7. 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 the starter switch **2** is set to ON, current flows from the starter relay **5** through terminal S of the safety relay **6** to terminal E, and contact P_1 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 the alternator **1**.
- When the pulse frequency at terminal P of the alternator **1** exceeds the reference value, the continuity between terminals S and E is lost, and the starter remains inoperative even if the starter switch **2** is set to ON while the engine is running.

Alternator

Probable causes \ Defective conditions		Battery fluid decreases in a short time.	Battery temperature high	Battery is normal but is over-discharged.	With the engine stationary (the starter switch at ON), the charge lamp does not come on.	Alternator is in order but battery is over-discharged	Remarks
Connector incorrectly connected, harness open-circuited, defective grounding				○		○	
Blown fuse				○	○	○	
Weak tension of V belt				○		○	🕮 Gr 14
Broken V belt				○		○	🕮 Gr 14
Defective battery		○				○	
Alternator	Stator coil open-circuited			○			
	Stator coil and core short-circuited			○			
	Field coil defective			○			
	Rectifier defective			○			
	Regulator defective		○	○	○		
	Brush worn (if brush is provided)			○			
	Sagging brush spring (if brush is provided)			○			
	Defective wiring			○			

Starter

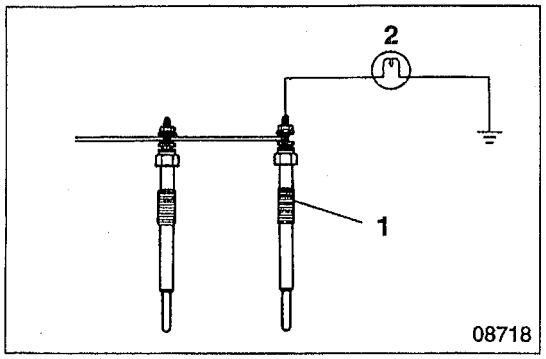
Possible causes \ Defective condition		Starter does not start	Starter starts but engine does not start: Pinion does not come in mesh with ring gear	Starter starts but engine does not start: Pinion comes in mesh with ring gear but does not rotate	Starter starts but engine does not start: Flywheel rotates but engine does not start	Engine does not stop	Engine cannot be preheated	Engine is hard to start	Remarks
Connector incorrectly connected, harness open-circuited, defective grounding		○			○	○	○	○	
Blown fuse		○							
Insufficient capacity of battery		○		○					
Starter	Contact of magnet switch binding or deposited	○							
	Coil of magnet switch open-circuited	○							
	Overrunning clutch in defective operation		○						
	Worn or damaged pinion		○						
Defective starter relay		○							
Defective starter switch		○				○			
Worn or damaged ring gear of flywheel			○						🕮 Gr 11

Starter, Preheater

Possible causes \ Defective condition	Engine hard to start	Engine cannot be preheated	Remarks
Defective heater relay or glow relay wiring	○	○	
Defective battery wiring	○	○	
Defective air heater or glow plug wiring	○	○	
Defective air heater or glow plug	○	○	
Defective coolant temperature sensor	○		🕮 Gr 14
Defective coolant temperature sensor wiring	○		

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Inspection of Preheater System <Glow Plug Specification>



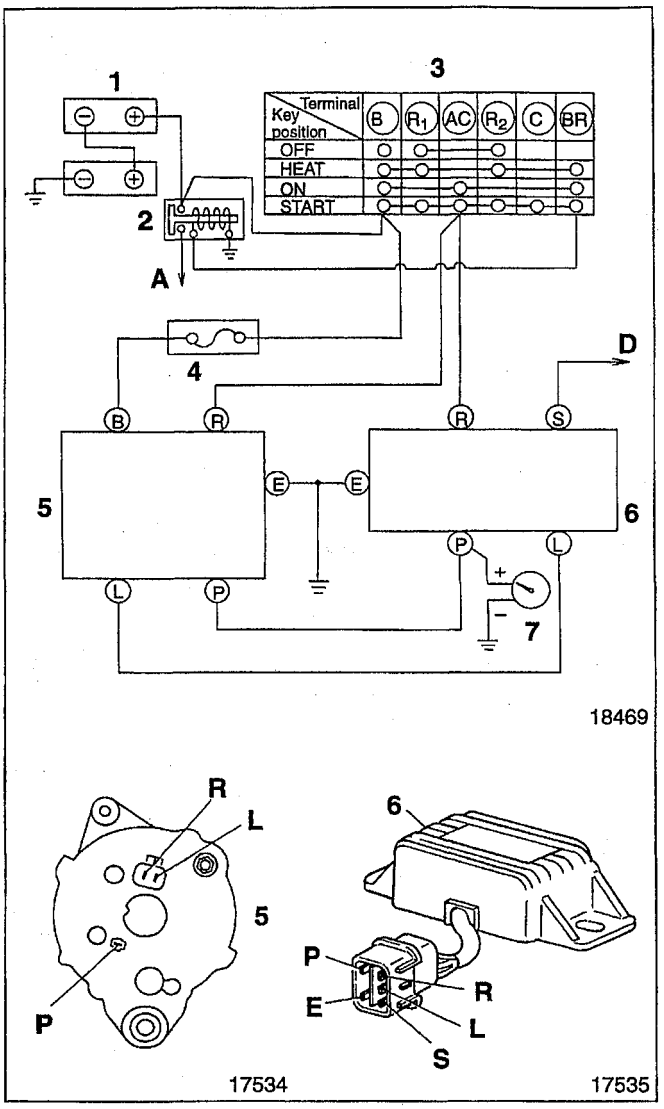
- Set the starter switch to OFF.
- Connect the inspection lamp **2** (24V–1.8W or thereabouts) to the glow plug **1**.
- Set the starter switch to the HEAT position.
- If the inspection lamp **2** does not come on, check the glow plug or heater relay.

2. Inspection of Safety Relay

Service standards

Unit: mm

Location	Maintenance item		Standard value	Limit	Remedy
6	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	—	◦ 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)	—	◦ Replace ◦ If the output voltage is close to the battery voltage, inspect the alternator and herness and replace if necessary.



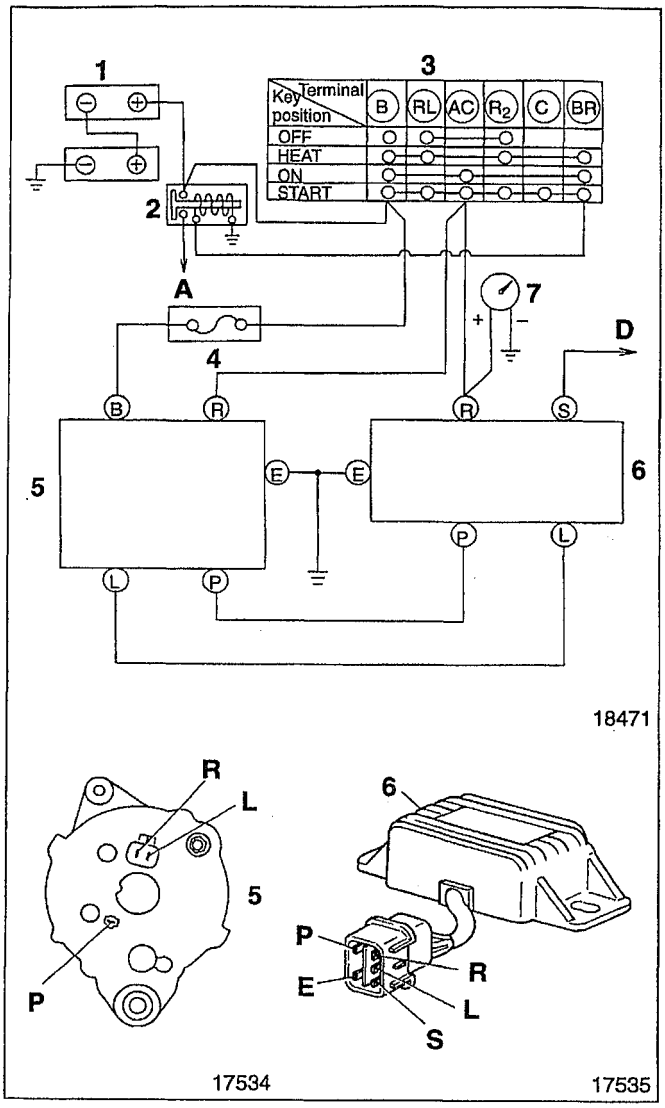
(1) Checking output voltage at terminal P

- 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)

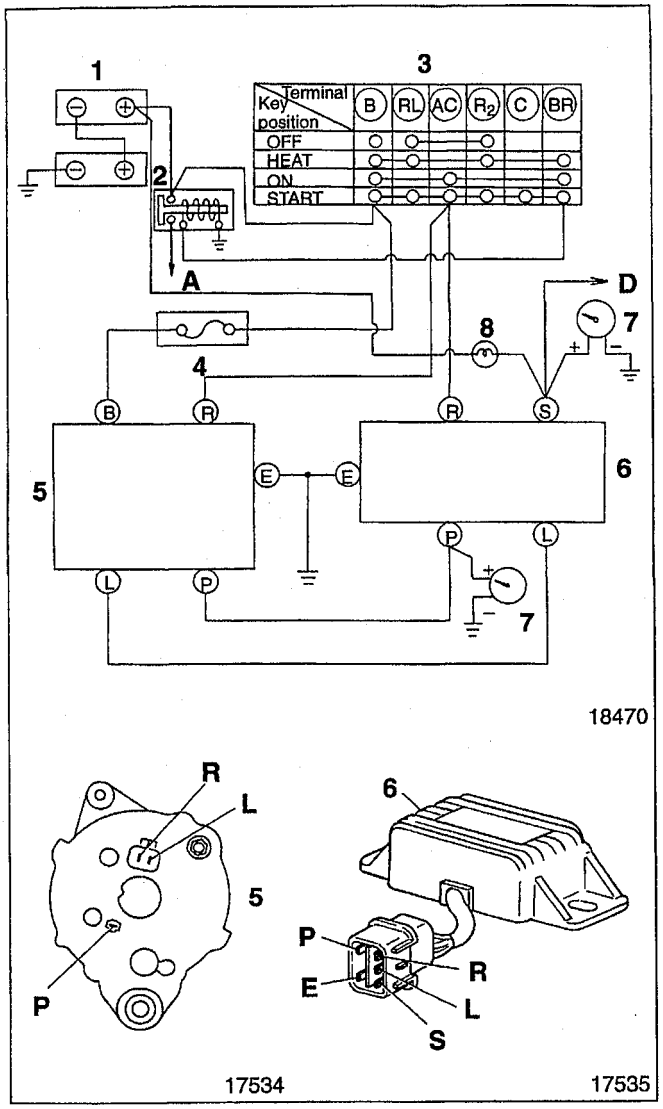
A: To terminal B of starter relay
D: To terminal L of starter relay
E: Terminal E
L: Terminal L
P: Terminal P
R: Terminal R
S: Terminal S

- Measure the voltage between terminal P in the illustration and the ground.
- If the reading is out of the standard value, the 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

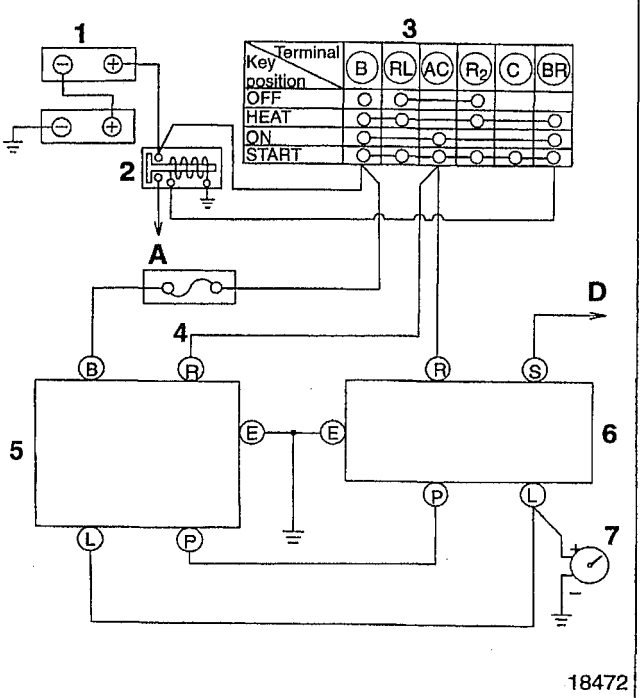
- Connect the voltmeter **7** as shown.
- Place the starter switch **3** in the ON position and measure the voltage.
- When the reading is out of the standard value, check the wiring. Replace if defective.



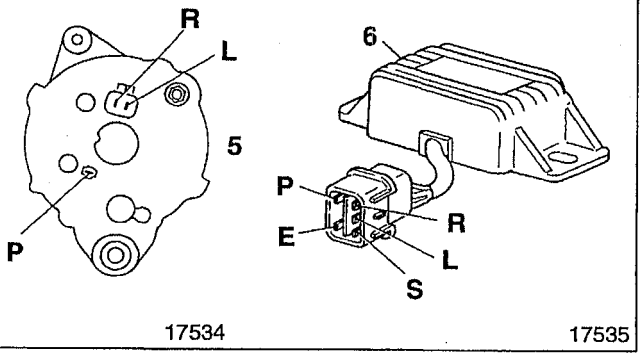
(3) Checking output voltage at terminal S

- Connect the voltmeter **7** and lamp **8** as shown.
- Set the starter switch **3** to the START position and measure the voltage between the 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, the 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 the alternator **5**.
- In the idling state, check to ensure that the lamp **8** does not come on.
  When the voltage at terminal P is normal and the lamp comes on, replace the safety relay **6**.



18472



17534 17535

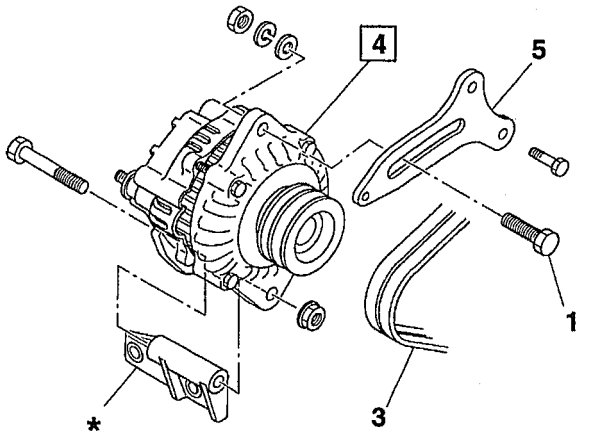
(4) Checking output voltage at terminal L (where no charge lamp is provided)

- Connect the voltmeter **7** as shown.
- Place the starter switch **3** at the ON position and measure the voltage.
- If the reading is out of the standard value, replace the safety relay **6**.
  If the reading is close to the battery voltage, check the alternator **5** and wiring, and replace if defective.

MEMO

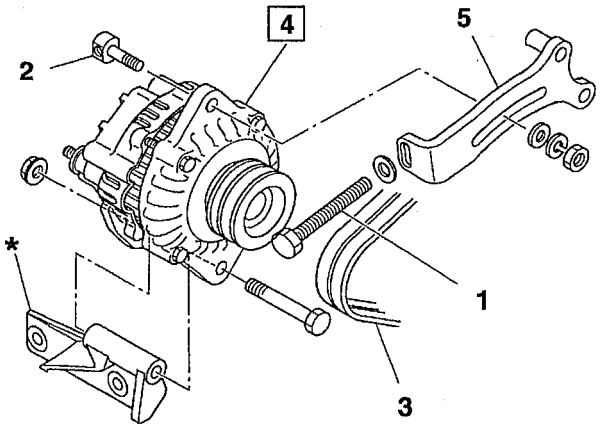
ALTERNATOR <24V–35A>

<Type A>



Ⓟ16745

<Type B>



Ⓟ46895

● **Removal sequence**

1 Adjust bolt
2 Adjust shaft <Type B>
3 V belt
4 Alternator assembly 🕮 P.54-48
5 Adjust plate

*: Alternator bracket

WARNING ⚠

Before removing the alternator 4, be sure to disconnect the negative ⊖ terminal of the battery and insulate it with a tape or something else. If the negative ⊖ terminal is not disconnected, the battery voltage is always available at terminal B and is dangerous.

● **Installation sequence**

Reverse the order of removal.

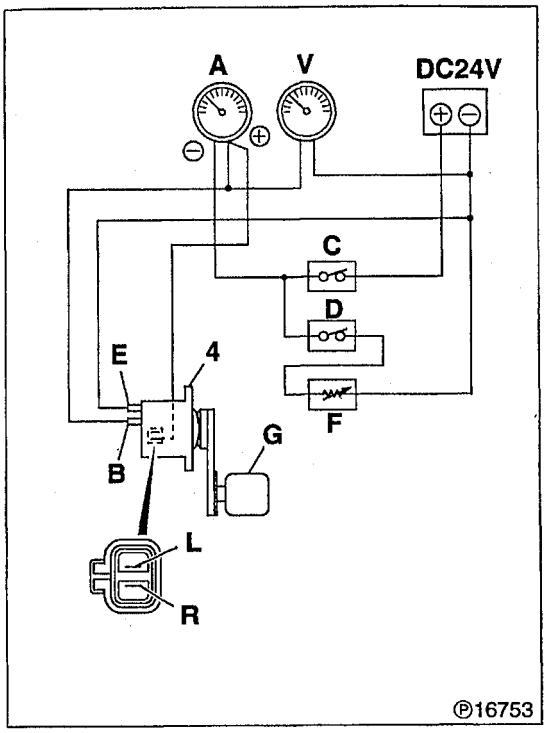
● **Adjustment after installation**

Adjust the tension of the V-belt 3. 🕮 Gr 14

Service standards

Location	Maintenance item			Standard value	Limit	Remedy
4	Alternator output current (* When hot, when 27V is generated)	Alternator speed	1500 rpm	20A or more	—	Check
			2500 rpm	29A or more	—	
			5000 rpm	33A 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

4 Inspection of alternator

(1) Inspection of performance of alternator

(Inspection by test bench)

- Wire the alternator **4** as shown.

NOTE

Each wire must be adequately thick and each connection must be properly secured.

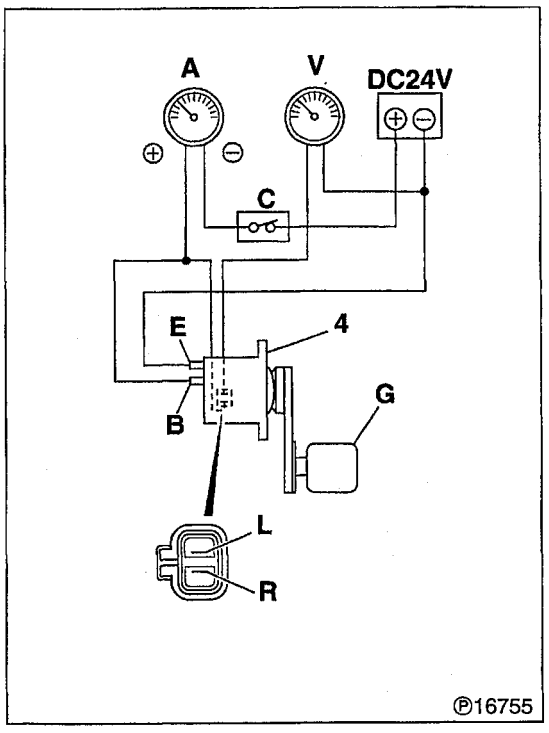
A: Ammeter
B: Alternator terminal B
C: Switch
D: Switch
E: Alternator terminal E
F: Load resistance (variable resistance)
G: Alternator drive motor
L: Alternator terminal L
R: Alternator terminal R
V: Voltmeter

- Increase the load resistance **F** to a maximum (where practically no load current flows).
- Set the switch **C** and switch **D** to ON.
- Operate the alternator **4** at 5000 rpm for 30 minutes with the load resistance **F** adjusted such that the output current is as specified in "Service standard".

Nominal value of alternator current

24V–35A

- Measure the current with the alternator **4** at each of the specified speeds.
- If the reading is out of the standard value, disassemble and check the alternator **4**. 📖 P.54-48



(2) Inspection of performance of regulator

(Inspection by test bench)

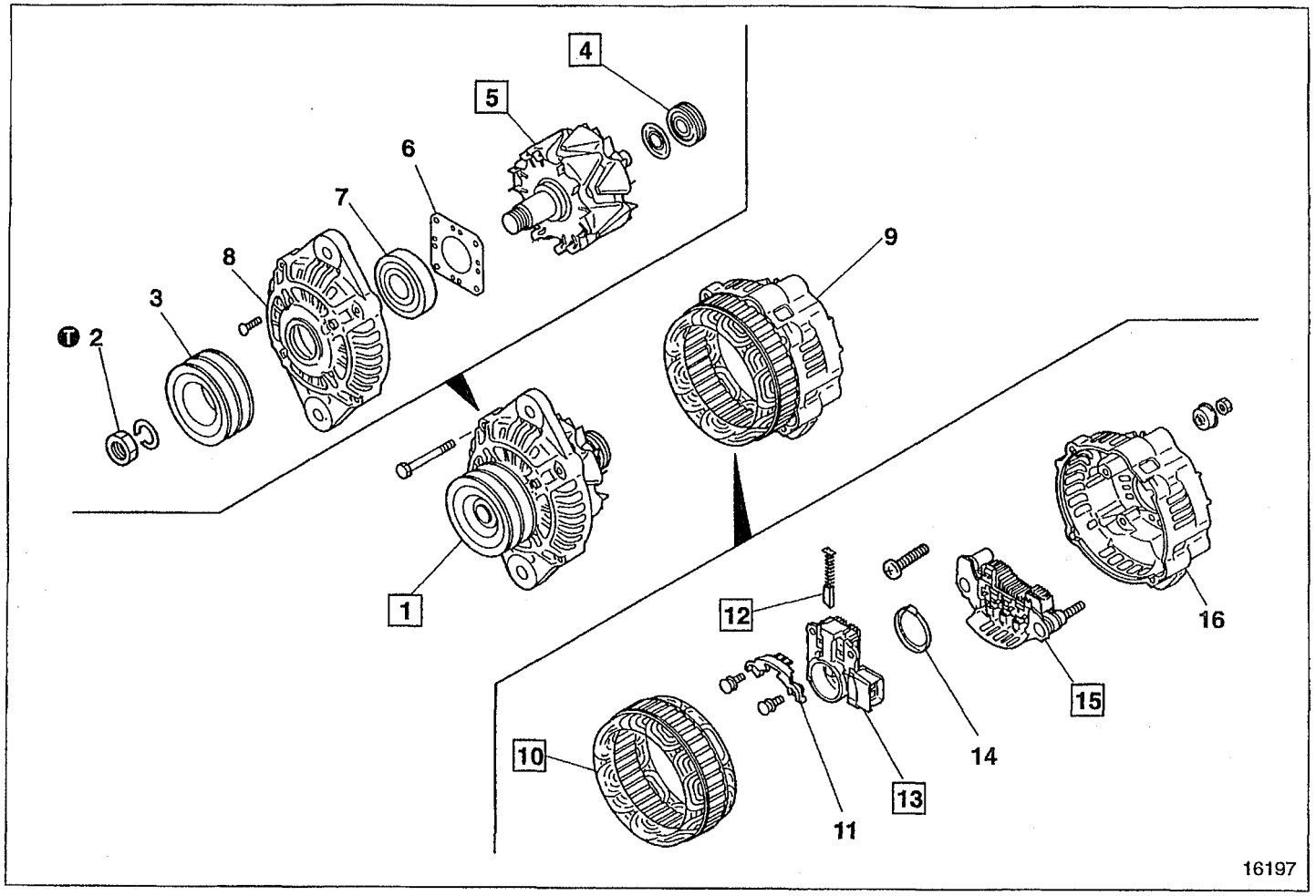
- Wire the alternator **4** as shown.

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 the switch **C** to ON.
- Let the alternator **4** rotate at a low speed.
- Increase the rotating speed of the alternator **4** 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 <24V–35A>

Alternator Assembly



● **Disassembly sequence**

1 Rotor and front bracket assembly
2 Nut
3 Pulley
4 Rear bearing
5 Rotor assembly
6 Cover
7 Front bearing
8 Front bracket
9 Stator and rear bracket assembly
10 Stator assembly
11 Cover
12 Brush
13 Regulator and brush holder
📖 P.54-47
14 Slinger
15 Rectifier
16 Rear bracket

NOTE

Do not remove parts 4, 7, 10 and 12 unless they are found to be defective.

● **Reassembly sequence**

9 → 1

9: 14 → 13 → 12 → 11 → 15 → 16 → 10

1: 8 → 7 → 6 → 5 → 4 → 3 → 2

Service standards

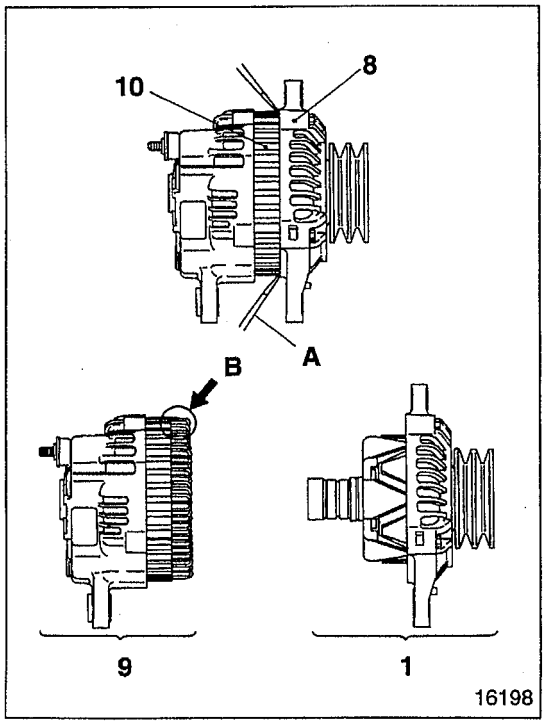
Unit: mm

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

❶ Tightening torques

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

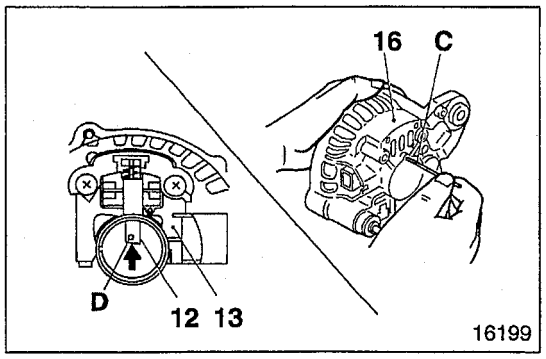
1 Rotor & front bracket assembly

[Removal]

- Insert a plain screwdriver **A** between the front bracket **8** and stator assembly **10**.
- While wrenching the plain screwdriver **A**, remove the rotor & front bracket assembly **1** from the stator & rear bracket assembly **9**.

CAUTION ⚠

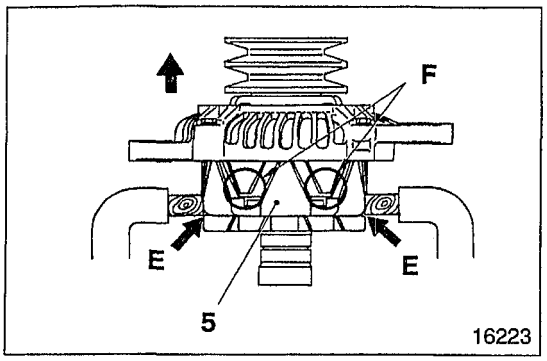
If the plain screwdriver A is inserted too far, the coil B of the stator assembly 10 might be damaged and short-circuited.



[Installation]

If the brush **12** is protruding from the regulator & brush holder **13**, the rotor assembly **5** cannot be mounted on the rear bracket **16**. Therefore, perform the following steps.

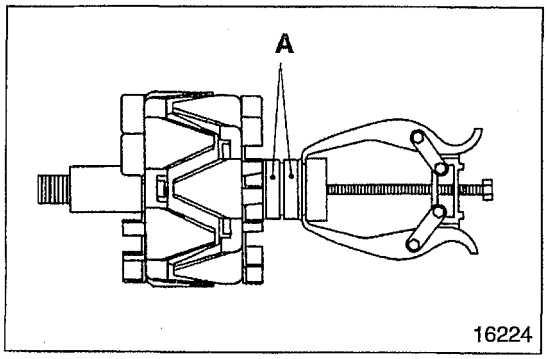
- Push the brush **12** into the regulator & brush holder **13**.
- Insert the pin **C** from the rear of the rear bracket **16** and press the pin **C** against the pin hole **D** to hold the brush **12**.
  If the brush **12** is worn and the pin hole **D** gone, hold the end of the brush **12** with the pin **C**.
- After installation, slowly remove the pin **C**.



[Disassembly]

CAUTION

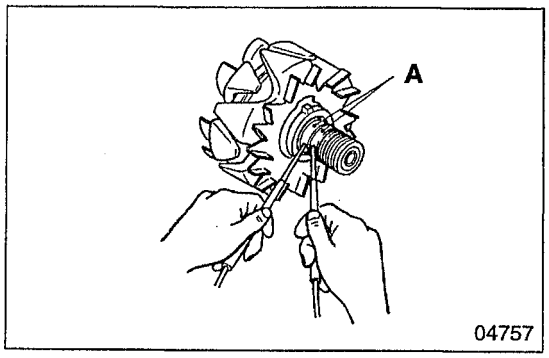
When the rotor assembly 5 is held in a vice, make sure that the base E of the lugs of the core is held.
If the lugs F of the core are held, they will be broken or damaged.



4 Removal of rear bearing

CAUTION

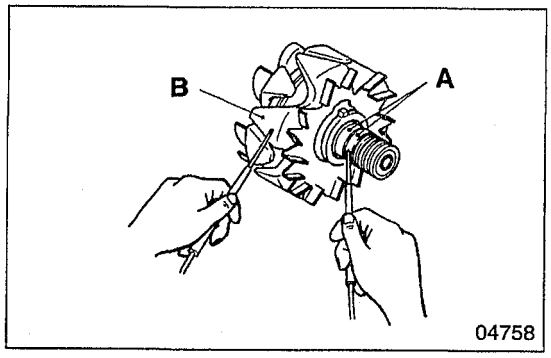
When the bearing puller is installed, use care to prevent damage to the slip ring A.
If the slip ring is damaged, the brush will fail to make good contact.



5 Inspection of rotor assembly

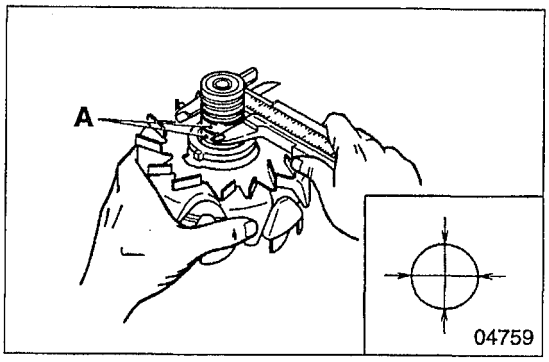
(1) Resistance of field coil

- Measure the resistance across the slip ring **A**.
- If the reading is out of the standard value, replace the 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 the rotor assembly **5**.

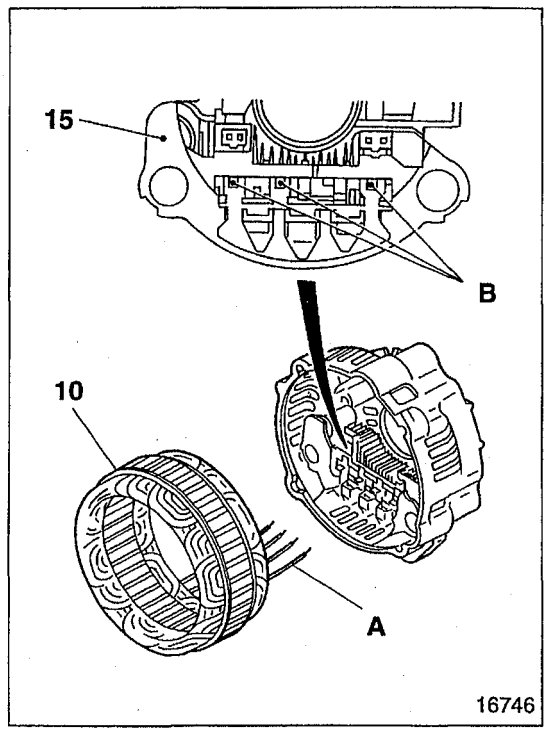


(3) Outside diameter of slip ring

- If the outside diameter of the slip ring **A** is below the limit, replace the rotor assembly **5**.
- If the outside diameter of the 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 the slip ring A does not exceed the limit.



10 Stator assembly

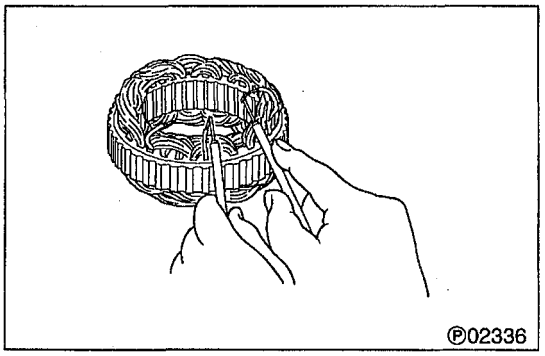
[Removal]

- Disconnect the leads **A** and remove the stator assembly **10** from the rectifier **15**.
  The leads are soldered to the 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.

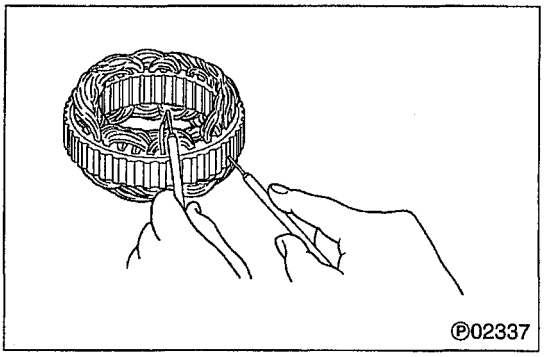
- For installation, reverse the order of removal.



[Inspection]

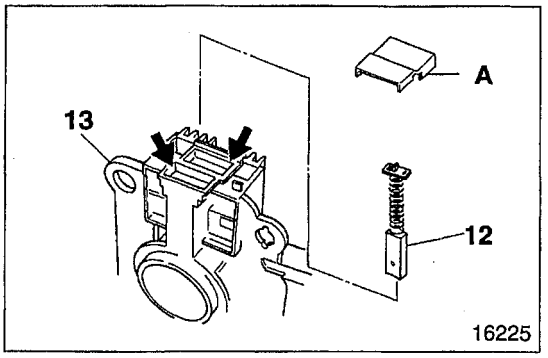
(1) Continuity between leads

- Check to ensure that there is continuity between each lead.
- If there is no continuity, the leads are open-circuited. Replace the stator assembly **10**.



(2) Continuity between each lead and core

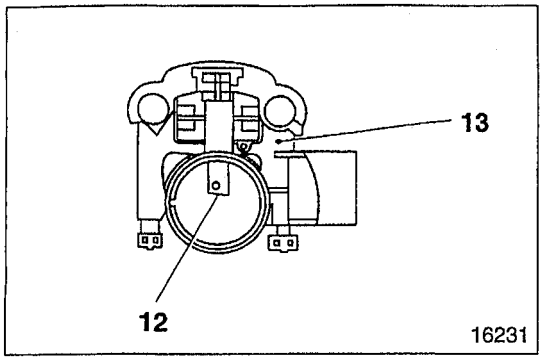
- Check to ensure that there is no continuity between each lead and the core.
- If there is continuity, it means a short circuit. Replace the stator assembly **10**.



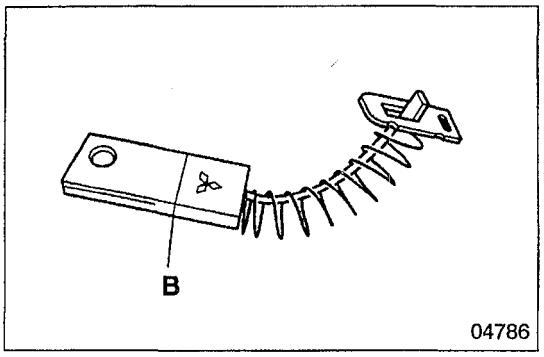
12 Brush

[Removal]

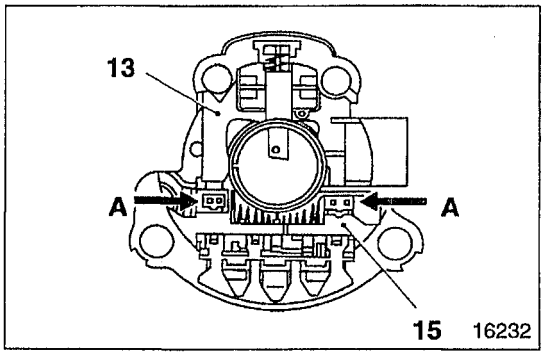
After removing the cover **A**, de-solder the leads of the brush **12** and remove the brush from the regulator & brush holder **13**.



[Installation]
- Install the brush **12** in the regulator & brush holder **13** in the direction shown.
- After installation, solder the leads of the brush **12** to the regulator & brush holder **13**.
  Thereafter, fit the cover **A** as before.

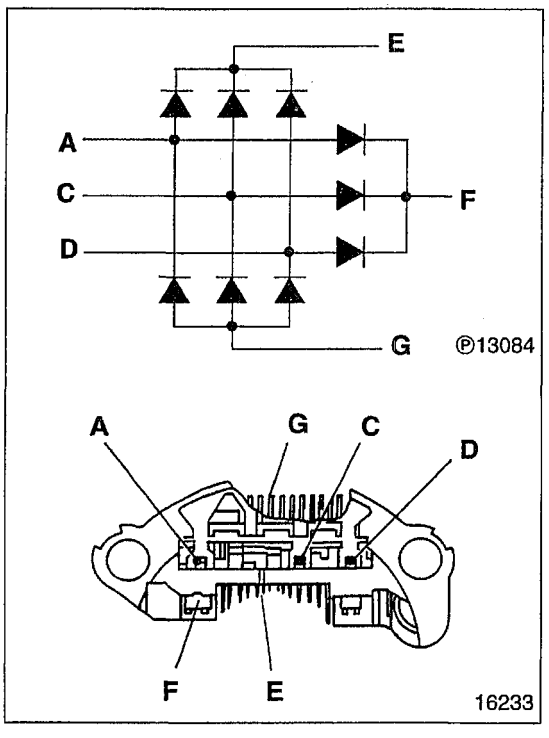


[Inspection]
If the length of the brush **12** is near the wear limit **B**, replace.



13 Removal of regulator & brush holder

- Remove the regulator & brush holder **13** by de-soldering the two illustrated points **A**.
- For installation, reverse the order of removal.



15 Inspection of rectifier

- Check the rectifier **15** to see if the internal diodes function properly.

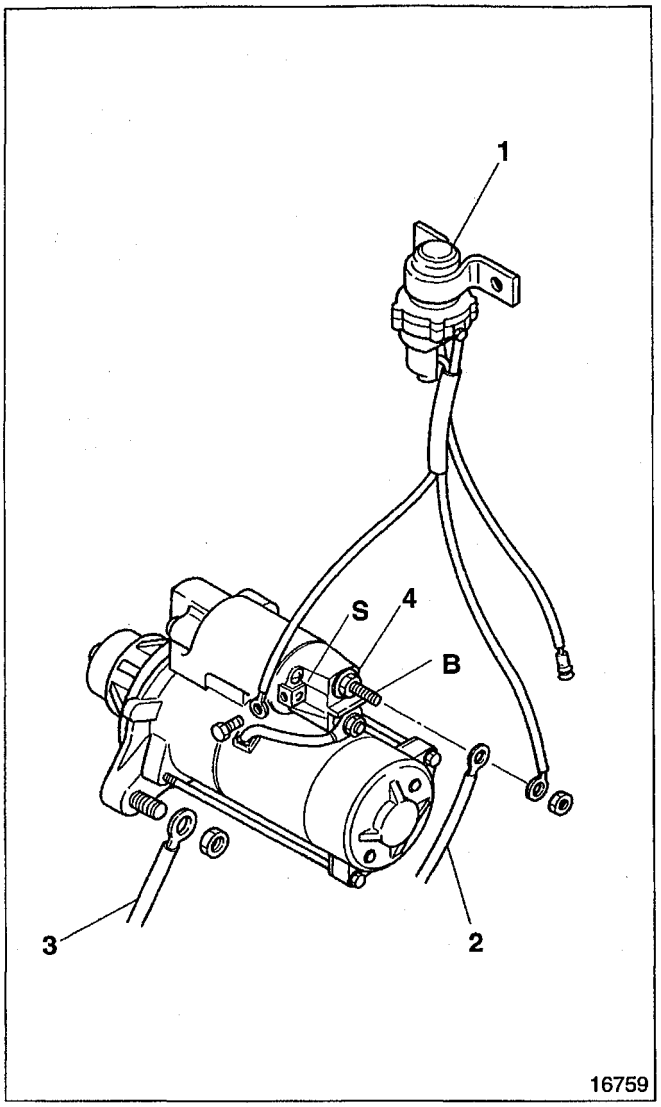
  Resistance infinite in both cases....Open
  Resistance close to Ω in both cases...Short

  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 the 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.



● **Removal sequence**

1 Starter relay 🕮 P.54-149
2 Battery cable ⊕
3 Earth strap
4 Starter assembly 🕮 P.54-110

B: Terminal B
S: Terminal S

WARNING ⚠

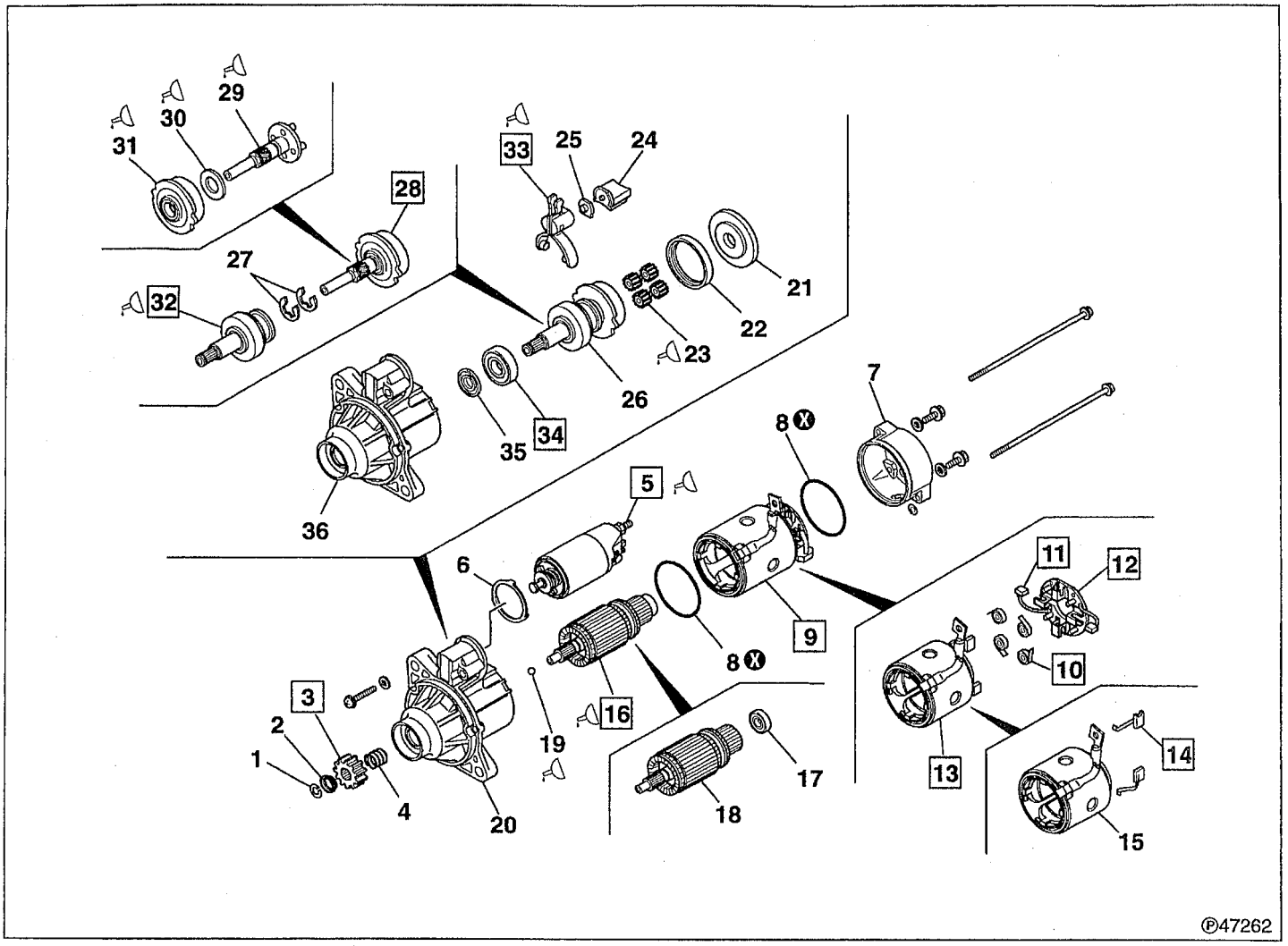
Before removing the starter assembly 4, be sure to disconnect the negative ⊖ terminal of the battery and insulate it with a tape or something else. If the negative ⊖ terminal is not disconnected, the battery voltage is always available at each of terminals B and is dangerous.

● **Installation sequence**

Reverse the order of removal.

STARTER <24V–5kW>

Starter Assembly



● **Disassembly sequence**

1 Stopper ring
2 Pinion stopper
3 Pinion
4 Spring
5 Magnet switch
6 Shim
7 Rear bracket
8 Packing
9 Yoke & brush holder assembly
10 Brush spring
11 Brush ⊖
12 Brush holder assembly
13 Yoke assembly
14 Brush ⊕
15 Yoke
16 Armature assembly
17 Rear bearing
18 Armature
19 Ball
20 Front bracket assembly
21 Cover
22 Packing
23 Planetary gear
24 Packing
25 Plate
26 Gearshaft & overrunning clutch assembly
27 E-ring
28 Gearshaft & Internal gear assembly
29 Gearshaft assembly
30 Washer
31 Internal gear
32 Overrunning clutch
33 Lever assembly
34 Front bearing
35 Oil seal
36 Front bracket

⊗: Non-reusable part

CAUTION ⚠

- **Do not remove the bearings 17 and 34 unless defects are evident.**
- **When the armature assembly 16 is removed, the ball 19 might come out with it. Take care not to lose the ball.**
- **It is not necessary to remove the pinion 3 when only the motor should be removed and inspected for inspection of the brushes and the related parts.**
- **Be sure to remove the pinion 3 before disassembling any other parts.**

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

Whenever the magnetic switch 5 is replaced, the pinion gap must be adjusted.

● Inspection after reassembly

📖 P.54-112

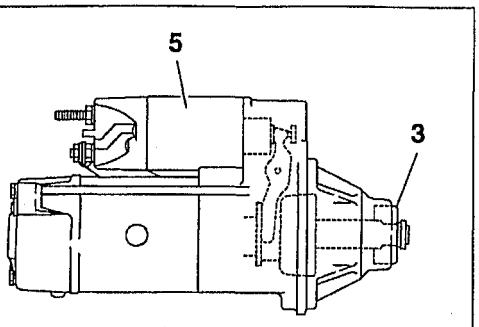
Service standards

Unit: mm

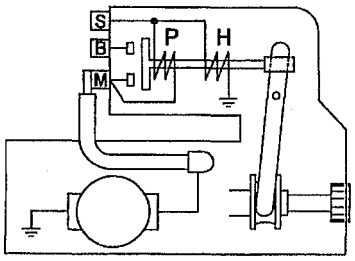
Location	Maintenance item			Standard value	Limit	Remedy
—	Pinion gap			0.5 to 2.0	—	Adjust
—	No-load characteristics	During 23V supply	Current	85A or less	—	Check
			Rotating speed	3300 rpm or more	—	
10	Spring pressure of brush spring			29 to 39 N {3 to 4 kgf}	20 N {2 kgf}	Replace
11, 14	Brush length			18	11	Replace
16	Outside diameter of commutator			32	31.4	Replace
	Commutator outer circumferential runout			—	0.05 or more	
	Depth of mica between segments			—	0.2 or less	Repair or replace

Lubricant

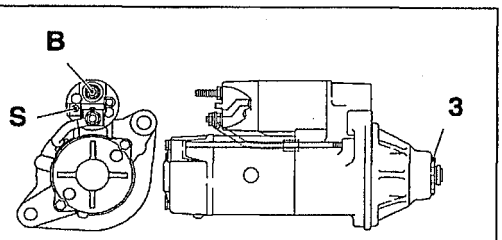
Location	Points of application	Specified lubricant	Quantity
5	Lever contact surface of magnetic switch	Multipurpose grease [NLGI No.2 (Li soap)]	As required
16	Teeth of armature assembly gear	MOLYKOTE ® AG650	As required
16, 29	Sliding surfaces of armature assembly and gear shaft assembly	MOLYKOTE ® AG650	As required
19	Ball	MOLYKOTE ® AG650	As required
23, 31	Teeth of planetary gear and internal gear	MOLYKOTE ® AG650	As required
29, 32	Sliding surfaces of gear shaft assembly and overrunning clutch	Multipurpose grease [NLGI No.2 (Li soap)]	As required
30	Washer	MOLYKOTE ® AG650	As required
32	Splines of overrunning clutch	Multipurpose grease [NLGI No.2 (Li soap)]	As required
33	Sliding surfaces of lever assembly and overrunning clutch	Multipurpose grease [NLGI No.2 (Li soap)]	As required



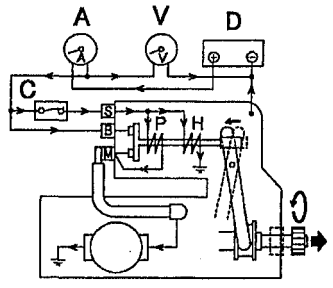
Ⓟ14266



Ⓟ14257



Ⓟ10767



Ⓟ14258

◆ Service procedure

● Inspection after reassembly

After reassembly, check the starter by supplying current.

WARNING ⚠

- **When current is supplied to the starter, the pinion 3 will spring out and rotate. Be careful not to touch it by hand.**
- **The 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 baked.**
- **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 23V DC.

CAUTION ⚠

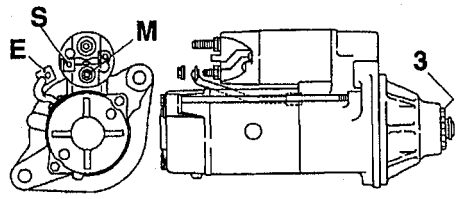
The voltage that is applied should be limited to 24V maximum.

- 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 the switch **C** to ON to supply current to the starter. At the time, the pinion **3** will spring out and rotate.

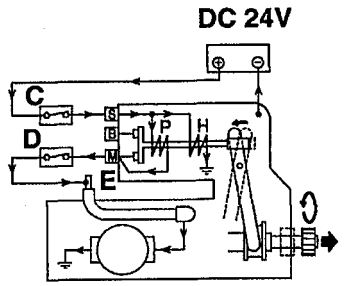
CAUTION ⚠

When the switch C is set to ON, current is supplied to both the 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 baking 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 the pinion **3** with a stroboscope.
  - Set the 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.



10768



Ⓟ14259

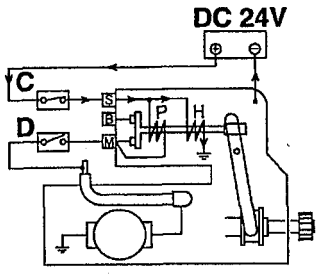
(2) Pinion gap

[Inspection]

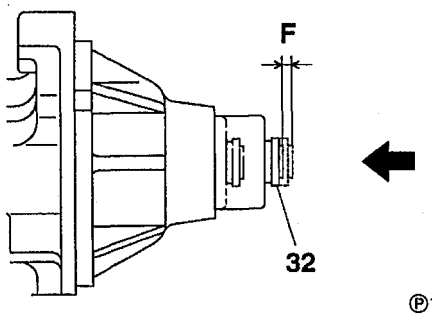
- Wire the starter as shown.

C: Switch
D: Switch
E: 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 is completed in less than 30 seconds.
  - Set the switch **C** and switch **D** to ON to supply current to the starter. At the time, the pinion **3** will spring out and rotate.



Ⓟ14260



Ⓟ10769

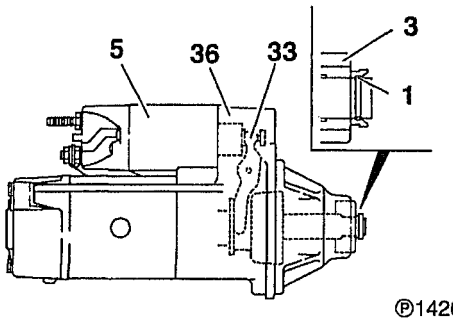
  - Immediately (in less than 5 seconds) after the pinion has started rotation, set the switch **D** to OFF to stop rotation of the pinion.

CAUTION ⚠

When the switch C and switch D are set to ON, current is supplied to both the 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 the pinion 3. To prevent baking the pull-in coil, therefore, it is necessary that the switch E is set to OFF immediately (in less than 5 seconds) after the pinion has started rotating.

  - Pull out the overrunning clutch **32** by hand, then push back its end lightly and measure the amount **F** the clutch moves in the axial direction (pinion gap).
  - Set the switch **C** to OFF to stop supplying current to the starter.
- If the reading is out of the standard value, replace the lever assembly **33**.

STARTER <24V–5kW>



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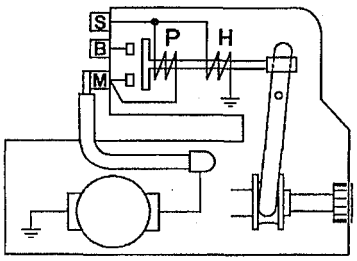


Ⓟ14257

3 Pinion

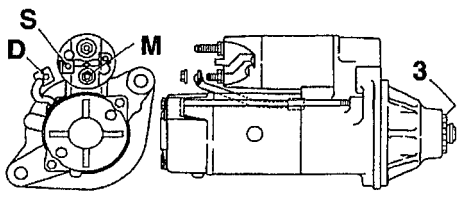
[Removal]
To remove the pinion **3**, it is necessary to supply current to the starter and let the pinion spring out.

WARNING ⚠

- **When current is supplied to the starter, the pinion 3 will spring out and rotate. Be careful not to touch it by hand.**
- **The magnet switch assembly 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 baked.**
- **Make sure that the pinion 3 is made to spring out by supplying current to the starter. If the pinion is forced out by pulling the lever assembly 33 without supplying current to the starter, the front bracket 36 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.**



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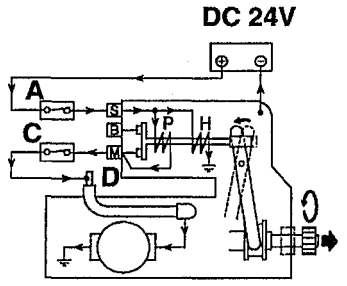
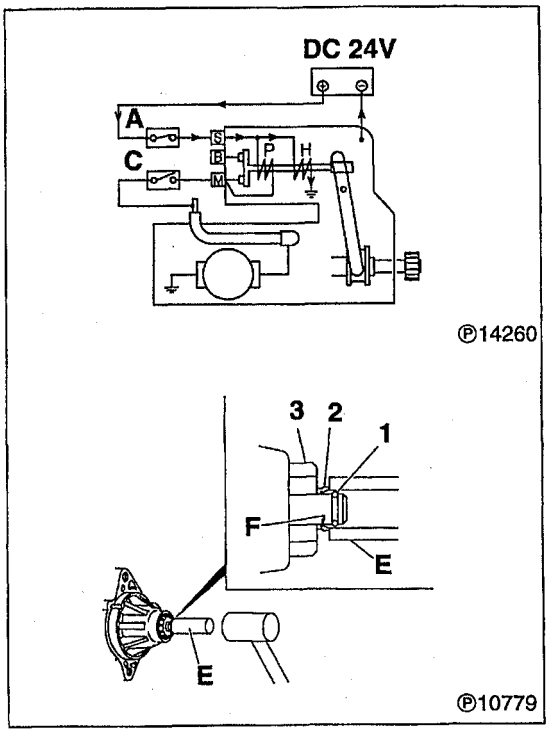


Ⓟ14259

- 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** is completed in less than 30 seconds.
  - Set the switch **A** and switch **C** to ON to supply current to the starter. At the time, the pinion **3** will spring out and rotate.



- Immediately (in less than 5 seconds) after the pinion **3** has started rotating, set the switch **C** to OFF to stop rotation of the pinion.

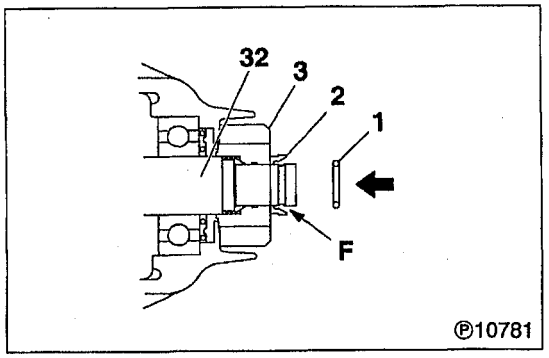
CAUTION ⚠

When the switch A and switch C are set to ON, current is supplied to both the 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 the pinion 3.
To prevent baking the pull-in coil, therefore, it is necessary that the switch C is set to OFF immediately (in less than 5 seconds) after the pinion has started rotating.

- Set the pipe-like tool **E** on the pinion stopper **2**.
- Lightly strike the tool **E** with a hammer to remove the stopper ring **1** from the ring groove **F** of the pinion stopper **2**.
- Remove the stopper ring **1** and remove the pinion **3**.
- Set the switch **A** to OFF to stop supplying current to the starter.

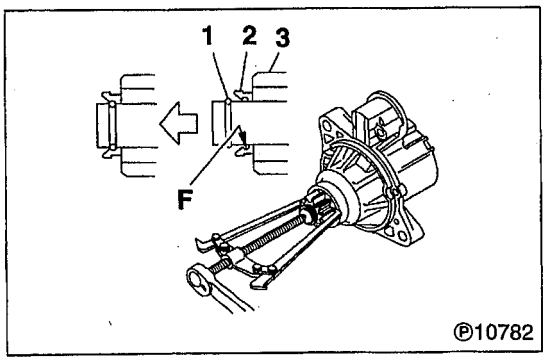
CAUTION ⚠

When the power supply to the starter is stopped, the pinion 3 may move in and the stopper ring 1 may fit in the ring groove F of the pinion stopper 2 again.
In this case, repeat the operations by supplying current to the starter.

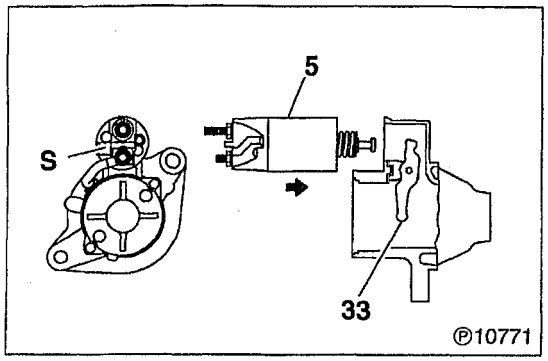


[Installation]
To install the pinion **3**, it is not necessary to supply current to the starter.

- Install the pinion stopper **2** and pinion **3** on the overrunning clutch **32** in the direction shown.
- Set the stopper ring **1** in the ring groove **F** of the overrunning clutch **32**.

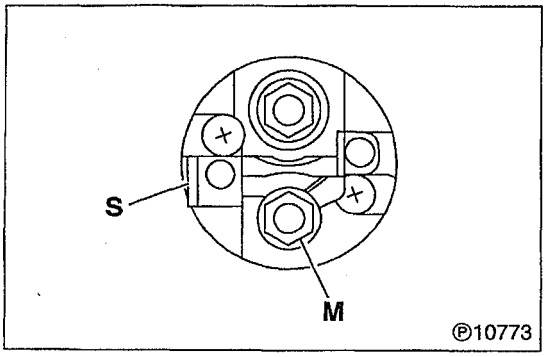


- Pull the pinion **3** strongly to make sure that the stopper ring **1** securely fits in the ring groove **F** of the pinion stopper **2**.



5 Magnet switch

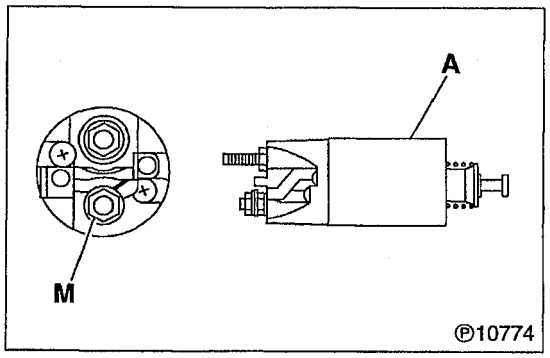
[Installation]
Install the magnet switch **5** on the lever assembly **33** with terminal **S** in the direction shown.



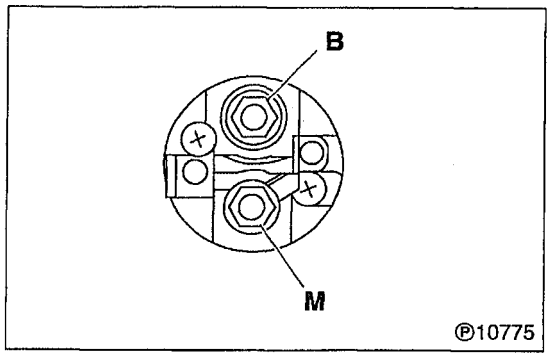
[Inspection]

(1) Open circuit test on coil

- Check to ensure that there is continuity between terminals **S** and **M**.
- If there is no continuity, replace the magnet switch **5**.

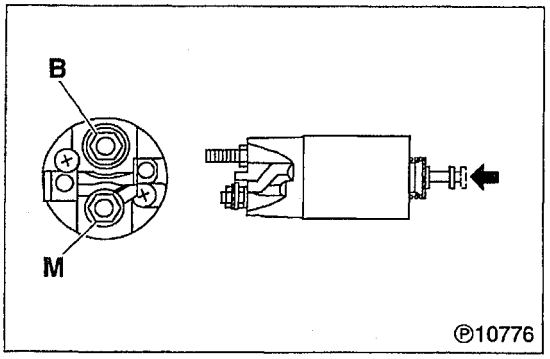


- Check to ensure that there is continuity between terminal **M** and body **A**.
- If there is no continuity, replace the magnet switch **5**.



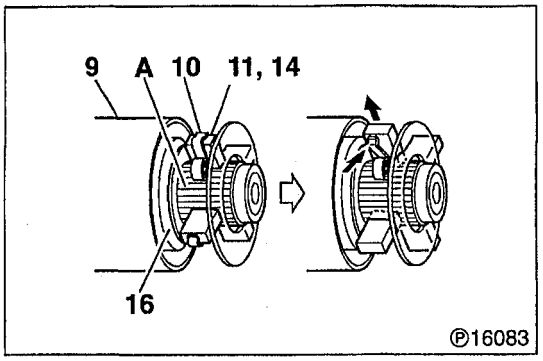
(2) Contact fusion check

- Check to ensure that there is no continuity between terminals **B** and **M**.
- If there is continuity, replace the magnet switch **5**.



(3) Contact contacting check

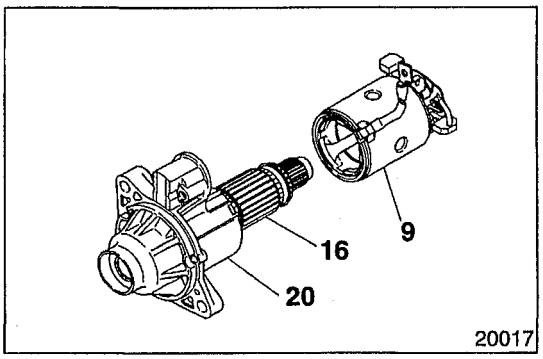
- Push the end of the magnet switch **5** in to close the internal contact. In this state, check to ensure that there is continuity between terminals **B** and **M**.
- If there is no continuity, replace the magnet switch **5**.



9 Removal of yoke & brush holder assembly

To remove the yoke & brush holder assembly **9**, proceed as described below, while using care to prevent damage to the commutator **A** of the armature assembly **16** by the brushes **11** and **14**.

- Keep the brushes **11** and **14** apart from the commutator **A** and hold the brush spring **10** alongside the brushes.

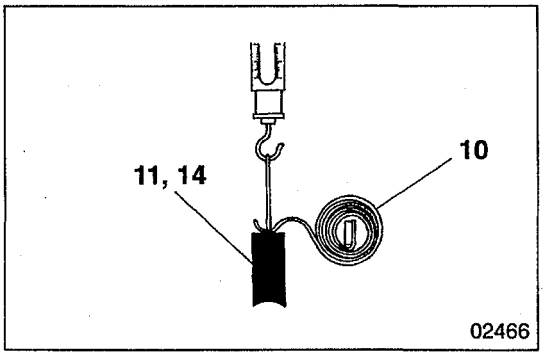


- Remove the yoke & brush holder assembly **9** from the front bracket assembly **20**.

CAUTION ⚠

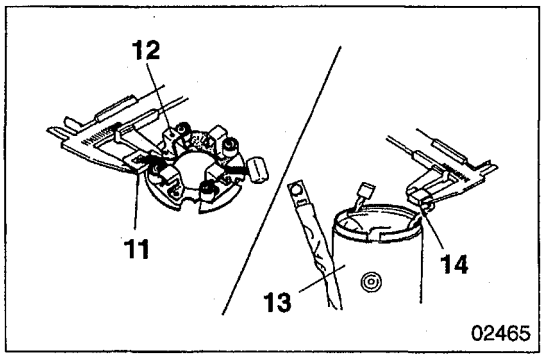
When the yoke & brush holder assembly 9 is removed, do not tilt it downward. Otherwise, the armature assembly 16 may fall down.

- 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 the brush spring **10**.



11 14 Inspection of brush

(1) Length of brush

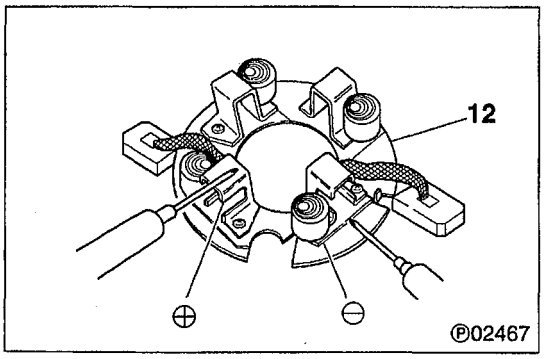
If the reading is less than the limit, replace the brushes **11** and **14**.

CAUTION ⚠

To replace the brush ⊖ 11, replace the brush holder assembly 12.

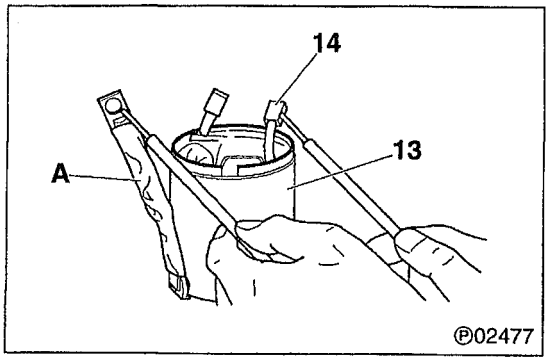
(2) Commutator contacting surfaces

If the contacting surfaces are rough or unevenly worn, repair with emery paper (#300 to 500).



12 Inspection of brush holder assembly

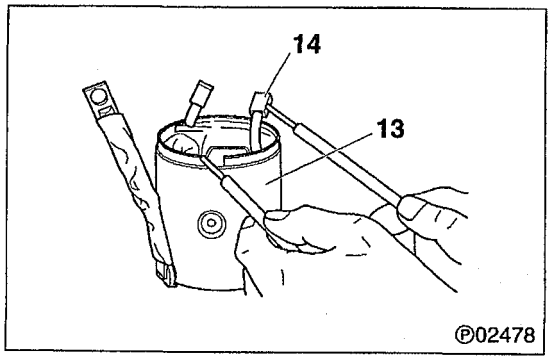
- Check to ensure that there is no continuity between the ⊕ side brush holder and ⊖ side holder plate.
- If there is continuity, it means a short circuit. Replace the brush holder assembly **12**.



13 Inspection of yoke assembly

(1) Open circuit test on coil

- Check to ensure that there is continuity between cable **A** and brush ⊕ **14**.
- If there is no continuity, it means an open circuit. Replace the brush ⊕ **14** or yoke assembly **13**.

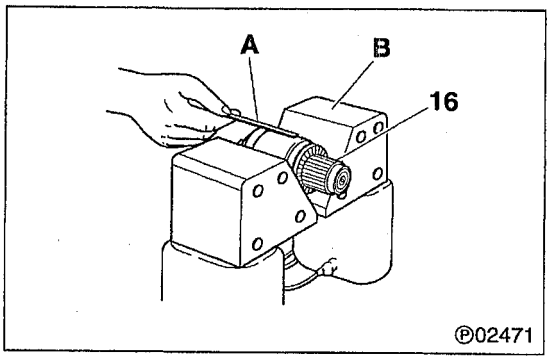


(2) Earth test on coil

- Check to ensure that there is no continuity between the yoke assembly **13** and brush ⊕ **14**.
- If there is continuity, it means a short circuit. Check the insulation. If repair is impossible, replace the brush ⊕ **14** or yoke assembly **13**.

CAUTION ⚠

The coil may be short-circuited to the yoke assembly 13 due to the accumulation of worn-off metal particles from the brushes and/or armature.



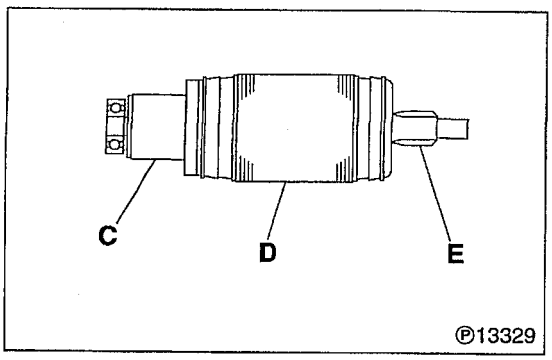
16 Inspection of armature assembly

(1) Short circuit test on coil

- Bring the iron piece **A** close to the armature assembly **16**, keeping it in parallel.

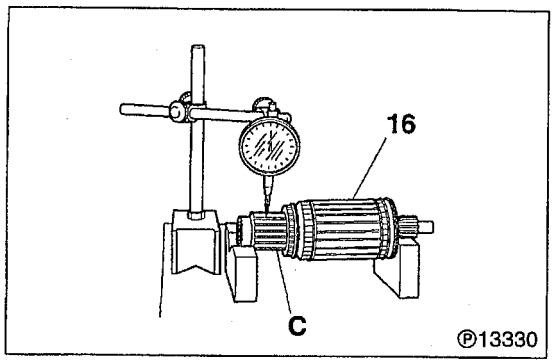
B: Armature tester

- Slowly rotate the armature assembly **16** by hand.
- If the iron piece **A** is attracted or vibrates, it means a short circuit. Replace the armature assembly **16**.



(2) Earth test on coil

- Check to ensure that there is no continuity between the commutator **C** and core **D** (or shaft portion **E**).
- If there is continuity, it means a short circuit. Replace the armature assembly **16**.

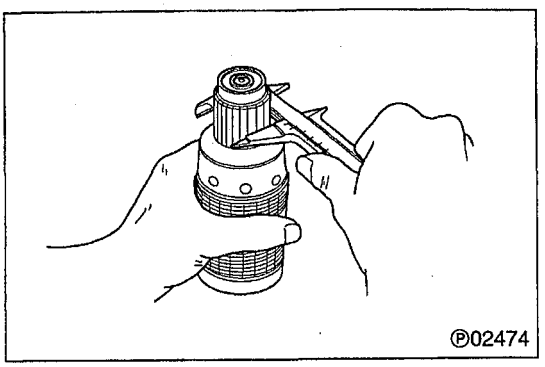


(3) Runout of commutator

If the reading is more than the limit, repair the outside diameter of the commutator portion **C** of the armature assembly **16** within the limit.

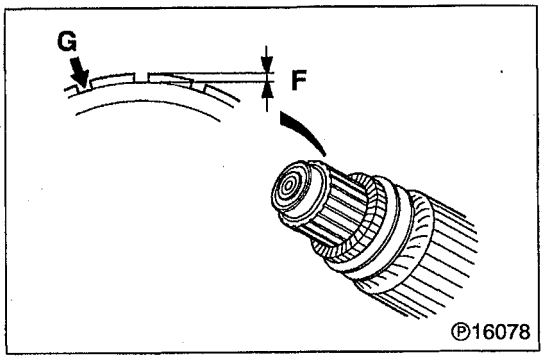
(4) Condition of commutator surface

- 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 the commutator portion **C**.



(5) Outside diameter of commutator

If the reading is more than the limit, replace the armature assembly **16**.



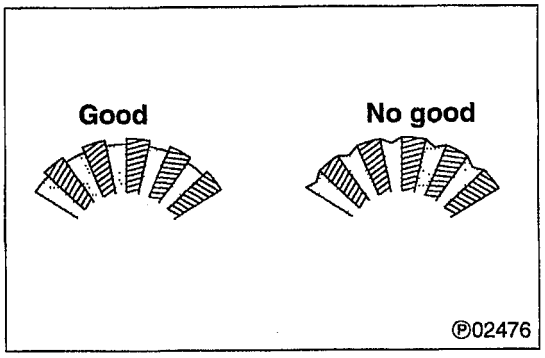
(6) Depth of mold between segments

Before inspection, clean the mold portions.

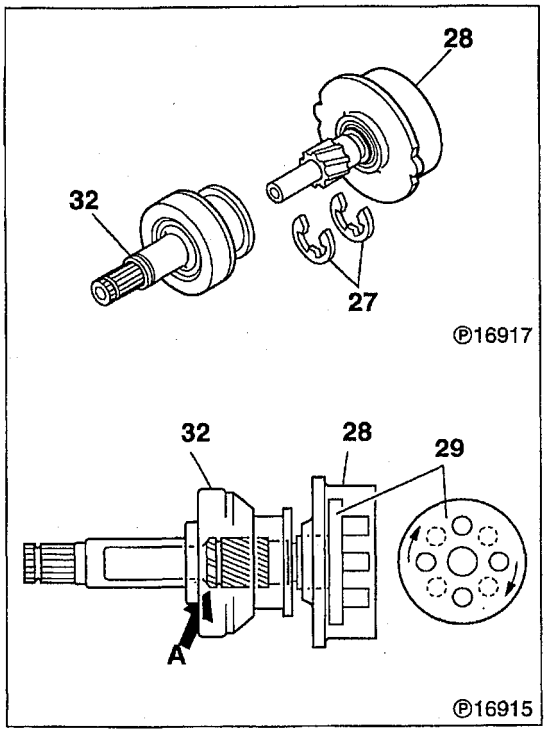
- If the reading is less than the limit, repair or replace the armature assembly **16**.

F: Depth of mold

- Make repairs by grinding the illustrated portion **G**.



- If the mold portion is as shown, repair or replace the armature assembly **16**.

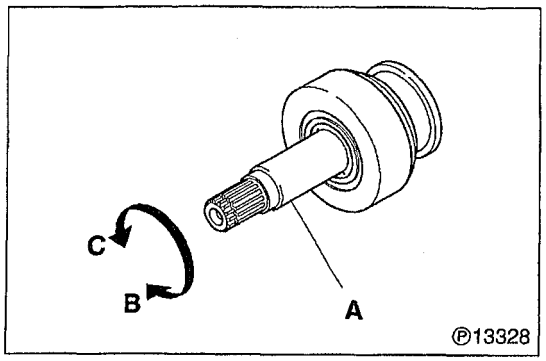


28 Removal of gear shaft and internal gear assembly

Remove the E-rings **27** and then the gear shaft and internal gear assembly **28** from the overrunning clutch **32**.

Proceed as follows if the assembly **28** cannot be removed due to interference of the splined section **A** of gear shaft assembly **29** with internal parts of the overrunning clutch.

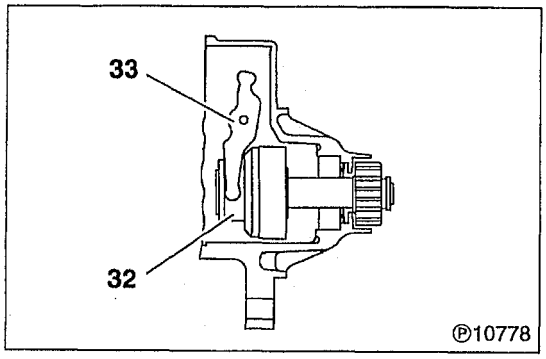
- Press the gear shaft assembly **29** against the overrunning clutch **32**.
- Turn the gear shaft assembly **29** approx. 1/8 of a turn to change the position of splined section **A**.



32 Inspection of overrunning clutch

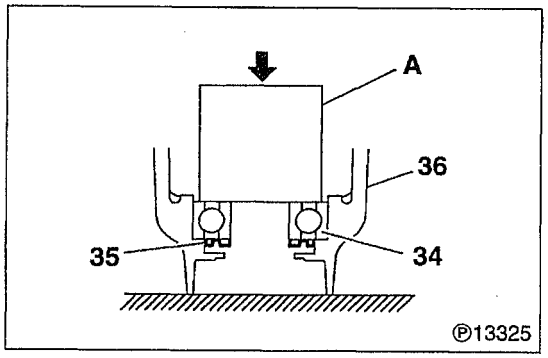
Perform the following checks. If there is anything wrong, replace the overrunning clutch **32**.

- Check to ensure that when the shaft **A** is made to rotate in the direction **B**, it rotates smoothly.
- Check to ensure that when the shaft **A** is made to rotate in the direction **C**, it is locked.



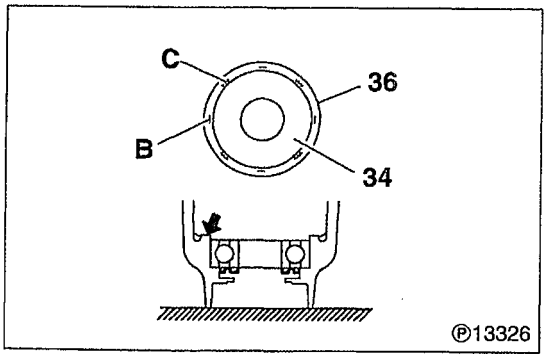
33 Installation of lever assembly

Install the lever assembly **33** in the illustrated direction on the overrunning clutch **32**.



34 Installation of front bearing

- Before the front bearing **34** is press-fitted, install the oil seal **35**.
- Press-fit the front bearing **34** in the front bracket **36** with a press, using the pipe-like tool **A**.



- Stake the front bracket **36** side.

CAUTION

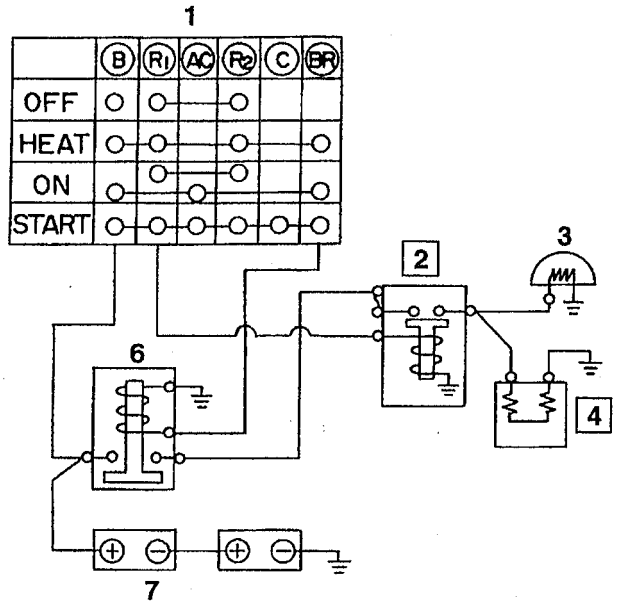
Avoid staking the previously staked points B.

C: Staking points (4 places)

MEMO

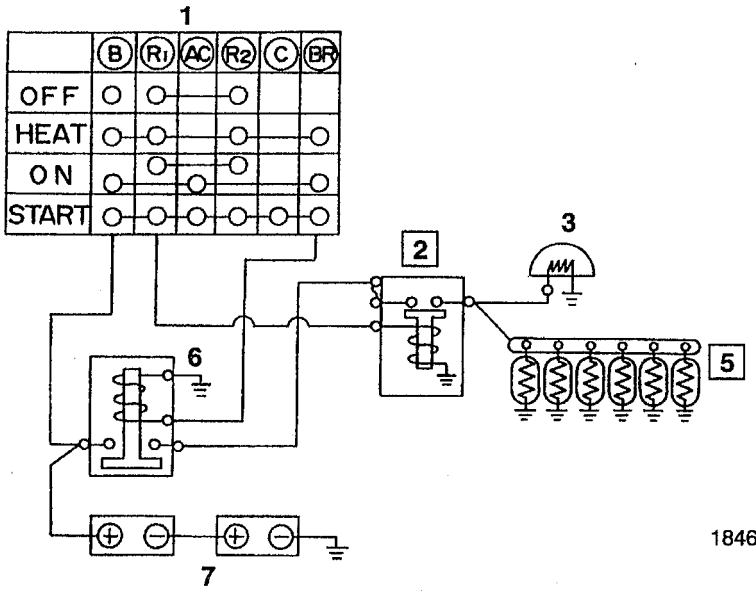
PREHEATER CIRCUIT

<24V (air heater) specification>



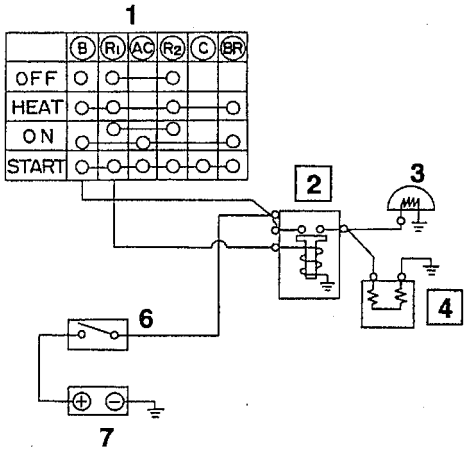
18461

<24V (glow plug) specification>



18462

<12V specification>

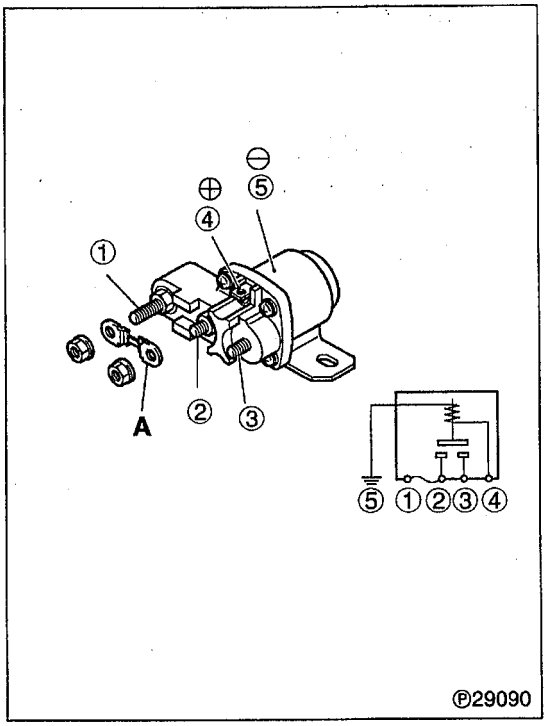


18463

1 Starter switch
2 Heater relay (or glow relay)
3 Heater indicator (vehicles with air heater)
Glow plug indicator
(vehicles with glow plugs)
4 Intake air heater
5 Glow plug
6 Battery relay (24V specification)
Battery switch (12V specification)
7 Battery

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
5	Resistance of glow plug at normal temperature	3.8 Ω	—	Replace



◆ Service procedure

2 Inspection of heater relay (or glow relay)

(1) Inspection of heater

If the fuse **A** is blown, replace it with one having the same amperage stamped on the fuse.

(2) Inspection of main body

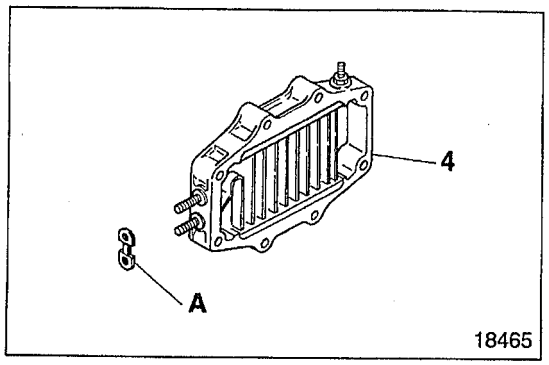
- Perform continuity checks according to the following table.

	①	②	③	④	⑤ (Body earth)
When no current is supplied	○—○			○—○	
When current is supplied	○—○	○—○	○—○	⊕—⊖	

○—○ There is continuity between terminals.
⊕—⊖ Terminals to which battery voltage is applied:
DC24V <24V system>
DC12V <12V system>

A: Fuse

- If there is anything wrong, replace the heater relay (or glow relay) **2**.



4 Inspection of intake air heater

(1) Inspection of fuse

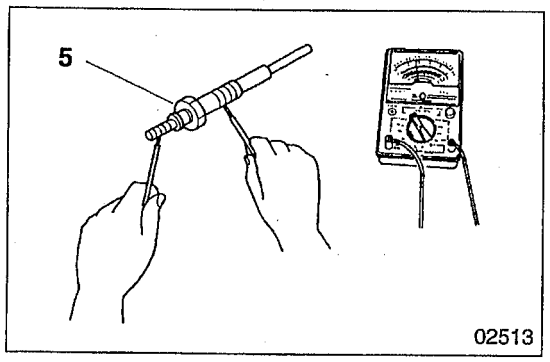
If there is anything wrong, replace the fuse **A** (127A).

A: Fuse (127A)

(2) Inspection of main body

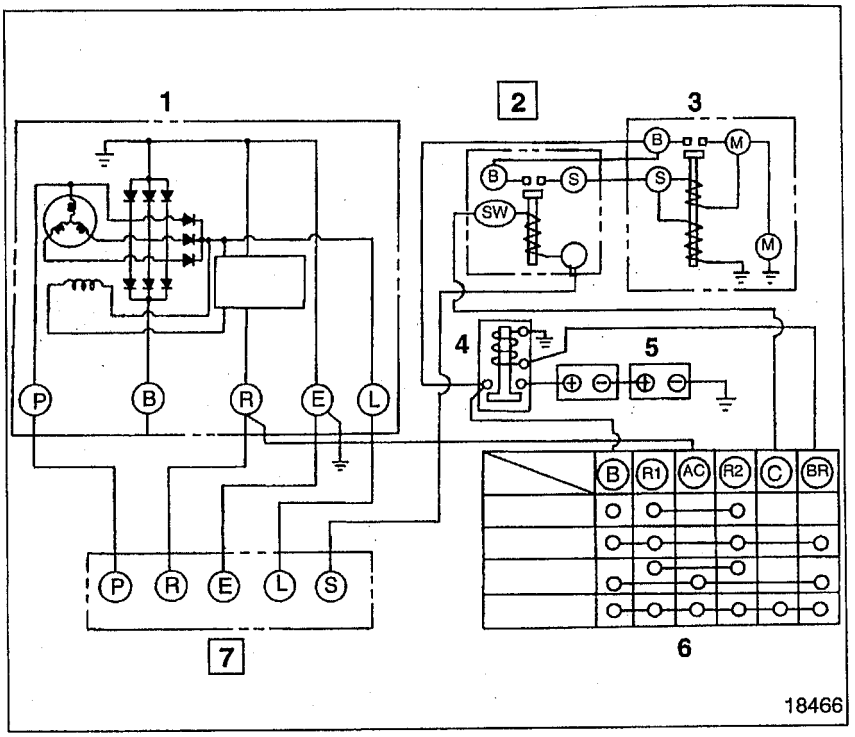
Check the terminals for looseness, and the heater element for damage and loose contact with the glass.

- If there is anything wrong, replace the intake air heater 4.



5 Inspection of glow plug

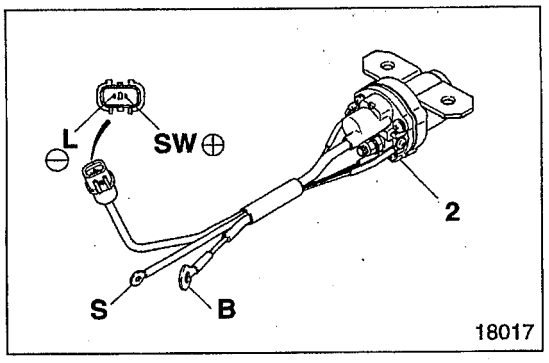
- Measure the resistance of the glow plug **5** as shown.
- If the reading is out of the standard value, replace the glow plug 7.
  Gr 11



1 Alternator
2 Starter relay
3 Starter
4 Battery relay (24V)
Battery switch (12V)
5 Battery
6 Starter switch
7 Safety relay

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
7	Safety relay	Approx. 200Ω	—	Replace



◆ Service procedure

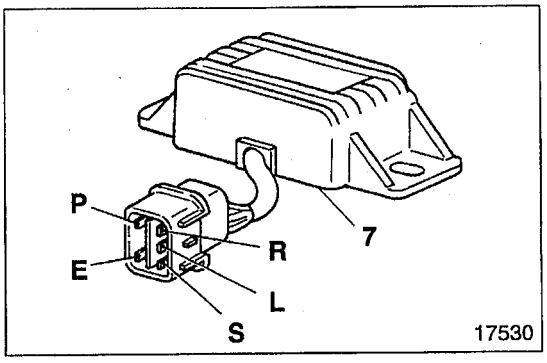
2 Inspection of starter relay

- 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 battery voltage is applied
DC24V <24V system>
DC12V <12V system>

- If there is anything wrong, replace the 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 the safety relay **7**.

GROUP 61 SPECIAL EQUIPMENT

NOTE ; The parts marked "※" are deleted as they are not applicable to the SK330(N)LC-6E.

6D1

diesel engine

Shop Manual

(for industrial use)

MITSUBISHI MOTORS CORPORATION

SEPTEMBER 2001

566 200 (H)