



# Group 11A

## Engine

**< 4M5 >**

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**HOME**

 **MITSUBISHI FUSO TRUCK OF AMERICA, Inc.**

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# SPECIFICATIONS

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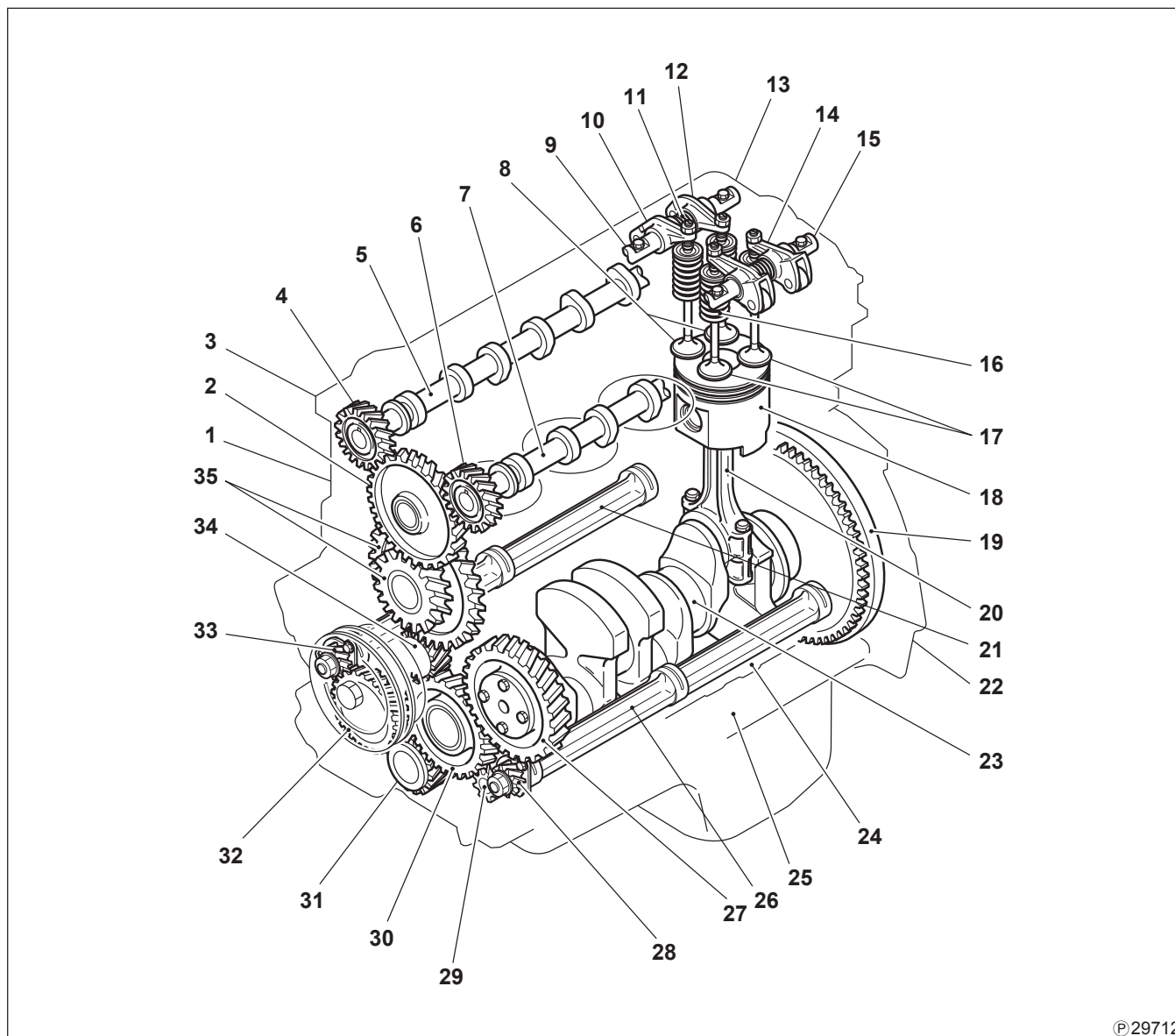
Item	Specifications
Engine model	4M50T2
Type	4-cylinder, in-line, water-cooled, 4-cycle diesel
Combustion chamber type	Direct injection
Valve mechanism	Double overhead camshaft
Max. power output	175/2700
Max. torque	347/1800
Cylinder bore × stroke	φ 114 × 120 {4.49 × 4.72}
Total displacement	4.899 (299)
Compression ratio	17.5

**MEMO**

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# STRUCTURE AND OPERATION

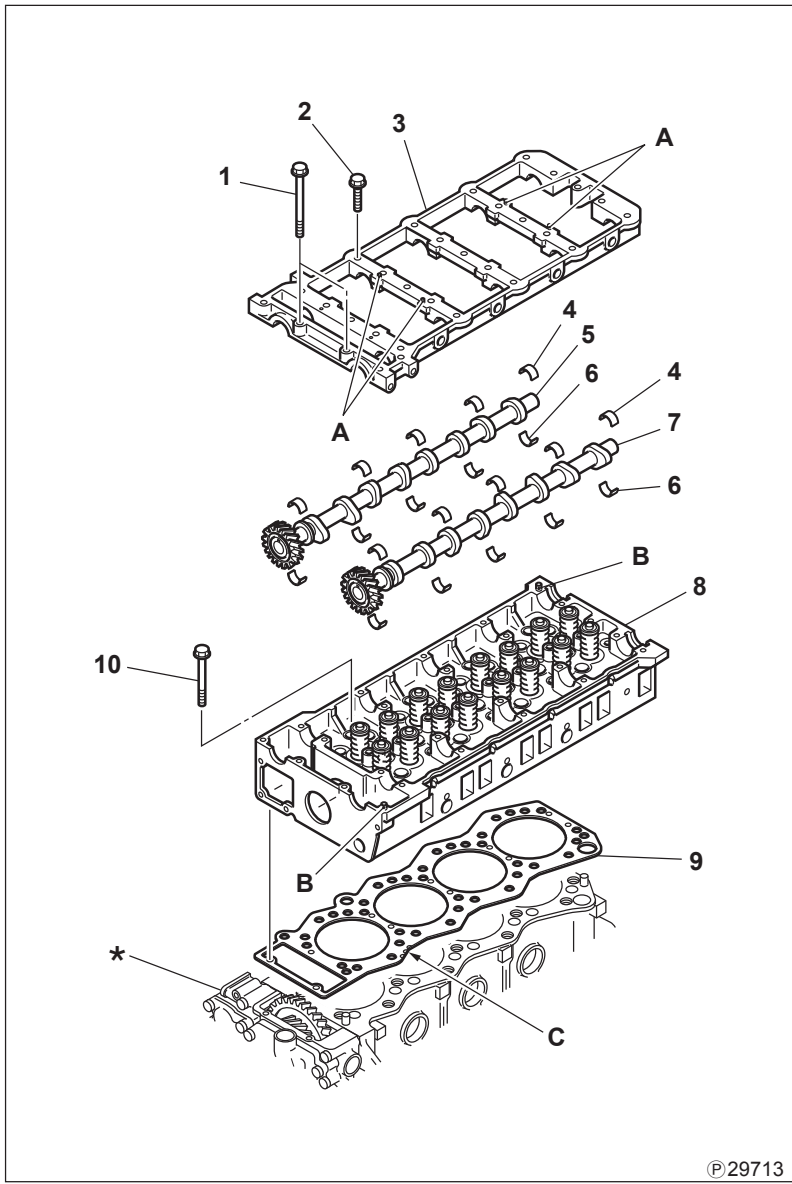
## Engine-proper



- |                                |                       |                          |
|--------------------------------|-----------------------|--------------------------|
| 1 Cylinder head                | 13 Rocker cover       | 25 Lower crankcase       |
| 2 Head idler gear              | 14 Short rocker       | 26 Balance shaft LH      |
| 3 Camshaft frame               | 15 Inlet rocker shaft | 27 Injection pump gear   |
| 4 Camshaft gear (Exhaust side) | 16 Valve spring       | 28 Balance shaft gear LH |
| 5 Exhaust camshaft             | 17 Inlet valve        | 29 Vacuum pump gear      |
| 6 Camshaft gear (Inlet side)   | 18 Piston             | 30 No. 1 idler gear      |
| 7 Inlet camshaft               | 19 Flywheel           | 31 Crankshaft gear       |
| 8 Exhaust valve                | 20 Connecting rod     | 32 Oil pump gear         |
| 9 Exhaust rocker shaft         | 21 Balance shaft RH   | 33 Balance shaft gear RH |
| 10 Short rocker                | 22 Rear plate         | 34 Fan shaft assembly    |
| 11 Rocker shaft spring         | 23 Crankshaft         | 35 Idler gear assembly   |
| 12 Long rocker                 | 24 Upper crankcase    |                          |

The 4M50T2 engine is of the double overhead camshaft (DOHC) type. The valve mechanism and timing gear arrangement is illustrated above.

Cylinder Head, Cylinder Head Gasket, Camshaft and Camshaft Frame



- 1 Bolt (× 2)
- 2 Bolt (× 13)
- 3 Camshaft frame
- 4 Camshaft bearing (Upper)
- 5 Exhaust camshaft
- 6 Camshaft bearing (Lower)
- 7 Inlet camshaft
- 8 Cylinder head
- 9 Cylinder head gasket
- 10 Cylinder head bolt

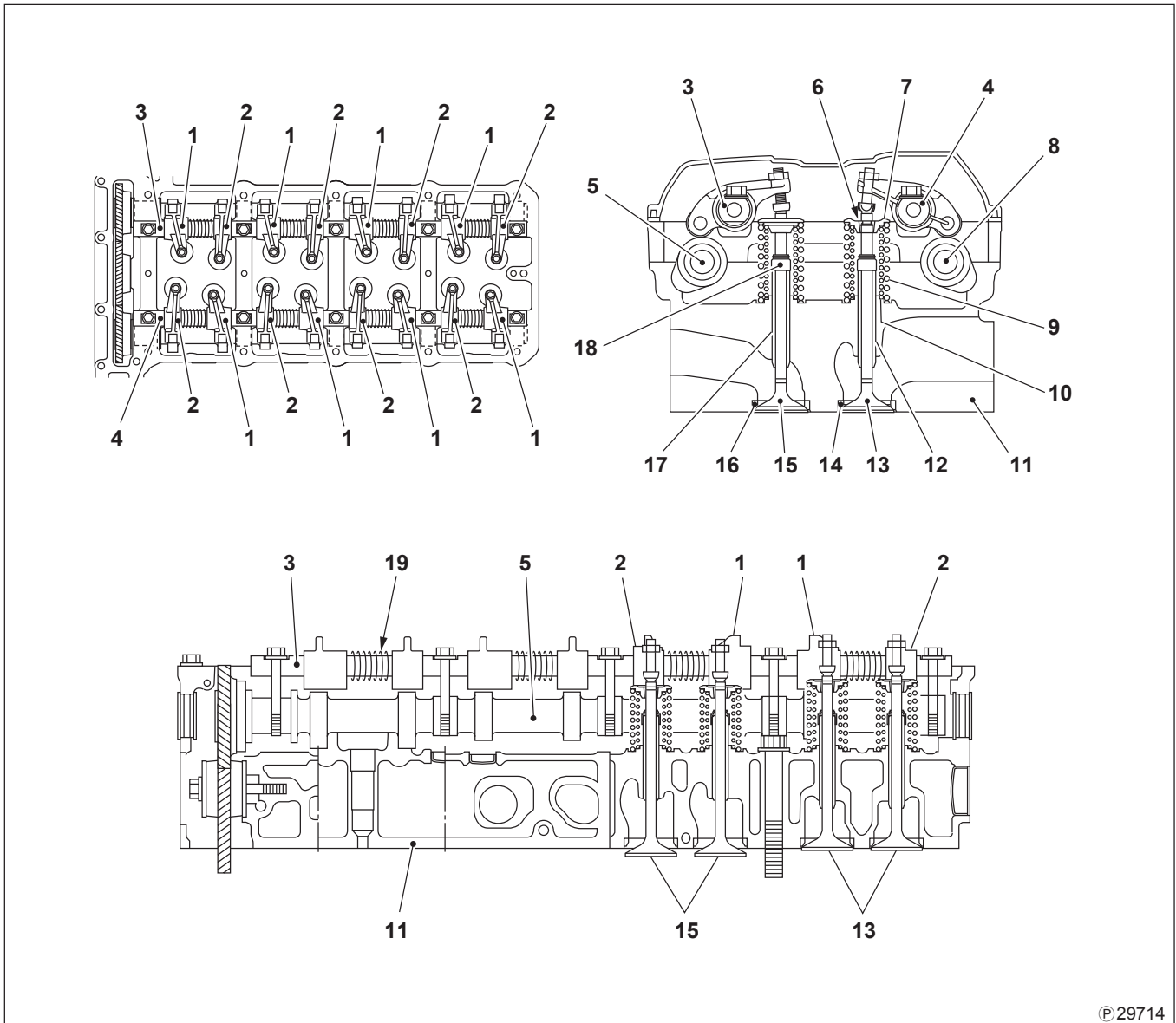
- A : Locating pin
- B : Locating pin
- C : Notched portion
- \* : Front

- The camshafts **5** and **7** have their journals supported by the cylinder head **8**, and are held down from above by the camshaft frame **3**.
- The camshaft bearings **4** and **6**, both upper and lower, are identical parts. When they are reassembled, however, be sure to reinstall them in their original positions, as they were before disassembly.
- The exhaust camshaft **5** and the inlet camshaft **7** have the same gears but use different cams. Use care not to confuse them at reassembly.
- As for the cylinder head gasket **9**, select and use one of proper thickness suitable for the projection of the piston. The thickness of gaskets is identifiable by a difference in the shape of the notched portion **C**.
- The bolts **2** (× 13) are threaded into the cylinder head **8**, whereas the bolts **1** (× 2) are threaded into the front case **\***.

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# STRUCTURE AND OPERATION

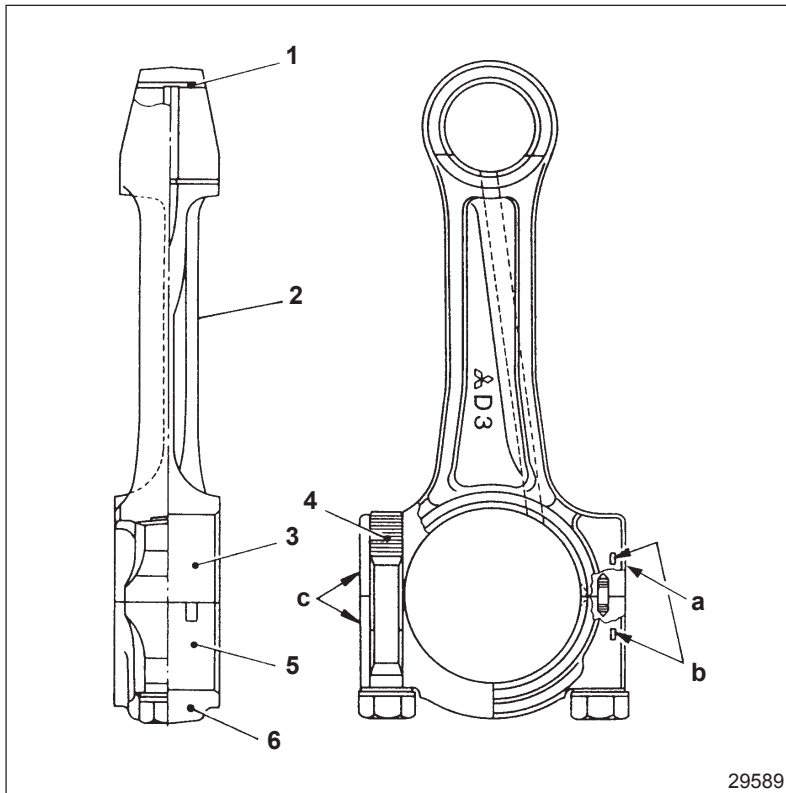
## Valve Mechanism



- |                               |                       |                        |
|-------------------------------|-----------------------|------------------------|
| 1 Short rocker                | 8 Inlet camshaft      | 15 Exhaust valve       |
| 2 Long rocker                 | 9 Outer valve spring  | 16 Exhaust valve seat  |
| 3 Exhaust rocker shaft        | 10 Inner valve spring | 17 Exhaust valve guide |
| 4 Inlet rocker shaft          | 11 Cylinder head      | 18 Valve stem seal     |
| 5 Exhaust camshaft            | 12 Inlet valve guide  | 19 Rocker shaft spring |
| 6 Valve collet (keepers)      | 13 Inlet valve        |                        |
| 7 Upper valve spring retainer | 14 Inlet valve seat   |                        |

- The rockers come in two types; short rockers **1** and long rockers **2**, and are mounted in different directions as illustrated.
- The valve springs include the outer springs **9** and inner springs **10**. A pair of outer and inner springs are used for each valve.

### Connecting Rods

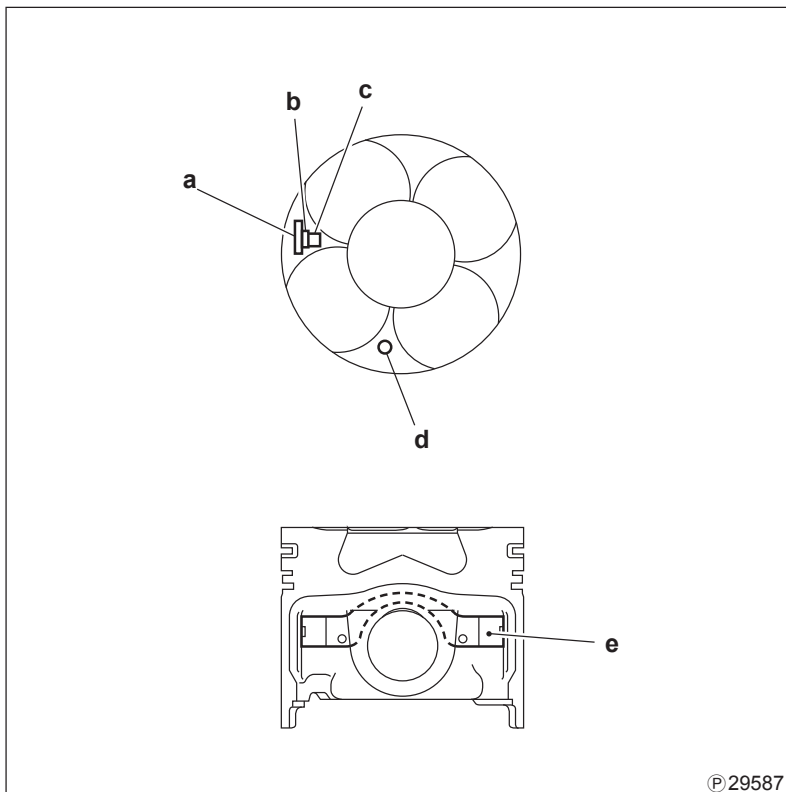


- 1 Connecting rod bushing
- 2 Connecting rod
- 3 Upper connecting rod bearing
- 4 Connecting rod bolt
- 5 Lower connecting rod bearing
- 6 Connecting rod cap

- \*a : Weight mark stamp  
"A" to "G"  
(where "A" indicates the maximum connecting rod weight.)
- \*b : Alignment mark
- \*c : Alignment mark

29589

### Pistons



- a : Part number
- b : Weight mark
- c : Size mark  
"A", "B"  
Pistons marked "B" are larger than those marked "A" at the outside diameter.
- d : Front mark  
Indicated by "O".
- e : Strut

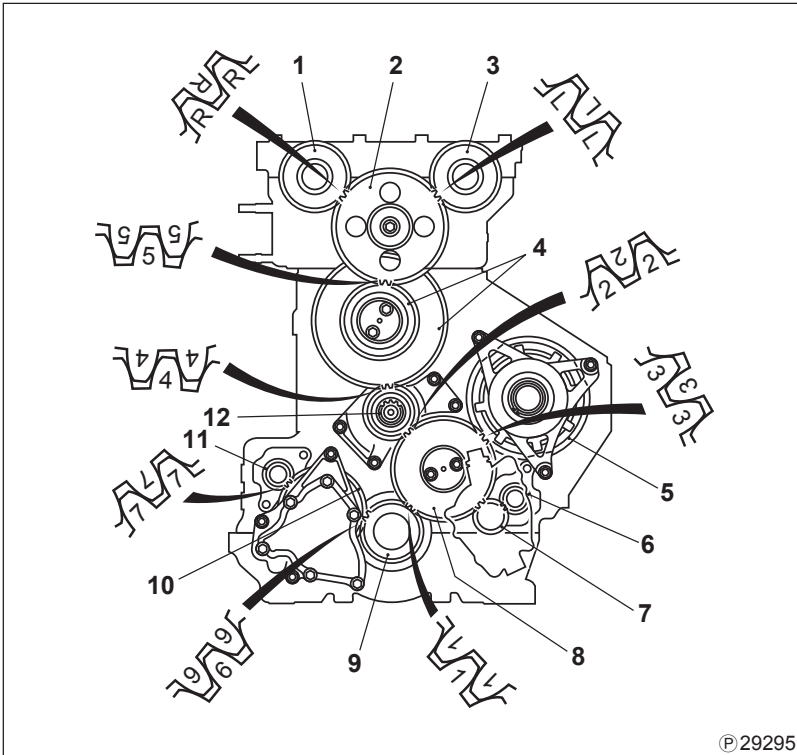
- Pistons to be used can be selected by matching the size mark of the piston with that of the cylinder liner. P11A-11
- The piston is made of special aluminum alloy. Its total height is relatively low and both end faces of the piston in the direction of the piston pin are concaved for weight reduction.
- The piston is an autothermic piston reinforced with strut e.

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# STRUCTURE AND OPERATION

## Timing Gears

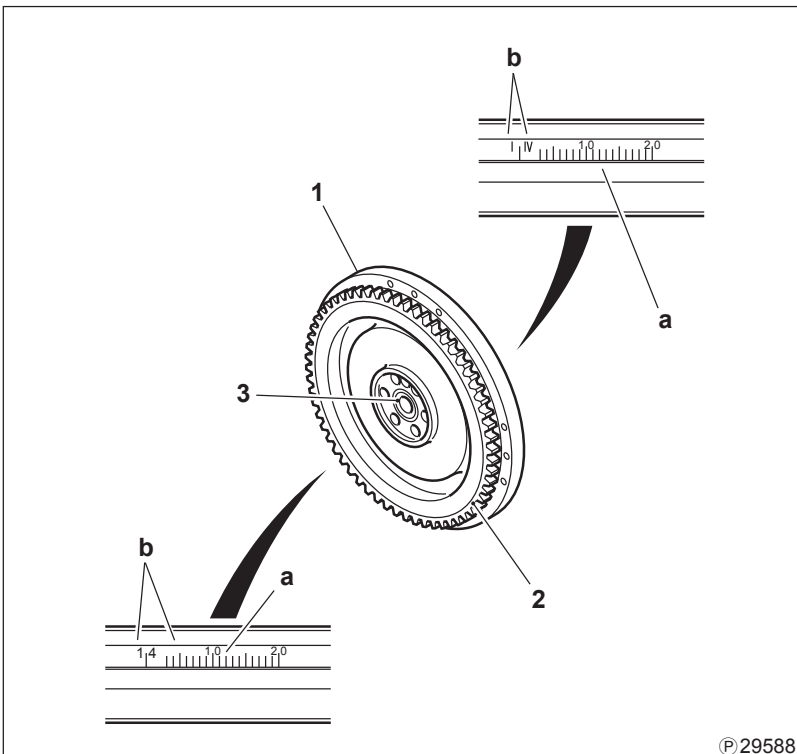


- 1 Camshaft gear(exhaust) RH (32)
  - 2 Head idler gear (54)
  - 3 Camshaft gear (intake) LH (32)
  - 4 Idler gear (63, 36)
  - 5 Injection pump gear (56)
  - 6 Balance shaft gear LH (14)
  - 7 Vacuum pump gear (15)
  - 8 No. 1 idler gear (49)
  - 9 Crankshaft gear (28)
  - 10 Oil pump gear (41)
  - 11 Balance shaft gear RH (14)
  - 12 Fan shaft (25)
- Number of teeth shown in parentheses

Each of the timing gears (except the vacuum pump gear) has alignment marks to ensure correct assembly.

Refer to P11A-63 for balance shaft positioning.

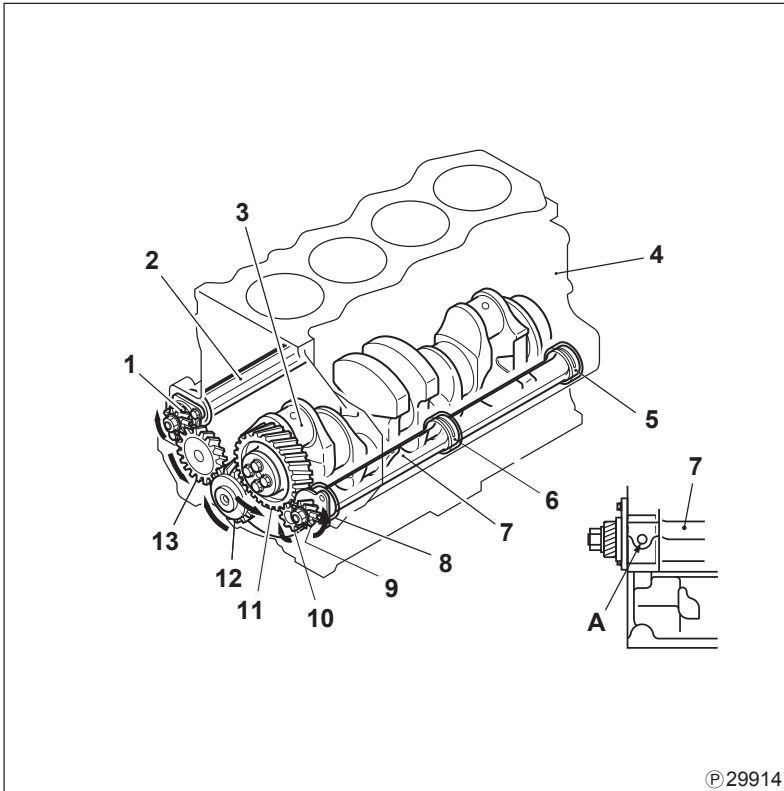
## Flywheel



- 1 Flywheel
- 2 Ring gear
- 3 Pilot bearing

a : Angle scale  
b : Cylinder No. ("1 4", "1 IV")

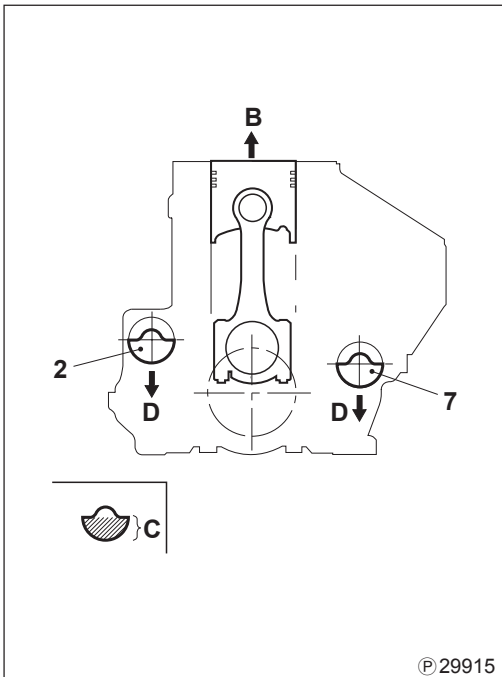
**Balance Shaft**



- 1 Balance shaft gear RH
- 2 Balance shaft RH
- 3 Crankshaft
- 4 Upper crankcase
- 5 No. 3 balance shaft bushing
- 6 No. 2 balance shaft bushing
- 7 Balance shaft LH
- 8 No. 1 balance shaft bushing
- 9 Balance shaft gear LH
- 10 Vacuum pump gear
- 11 No. 1 idler gear
- 12 Crankshaft gear
- 13 Oil pump gear

© P29914

- The balance shafts RH 2 and LH 7 are mounted in the upper crankcase 4 with the crankshaft 3 sandwiched in between, and serve to reduce the engine vibration caused by rotation of the crankshaft.
- Both balance shafts RH 2 and LH 7 are supported by the three balance shaft bushings 5, 6 and 8 mounted in upper crankcase 4 and driven by the timing gears (P11A-8).
- The balance shaft LH 7 is provided with a positioning hole A to ensure correct assembly. P11A-63



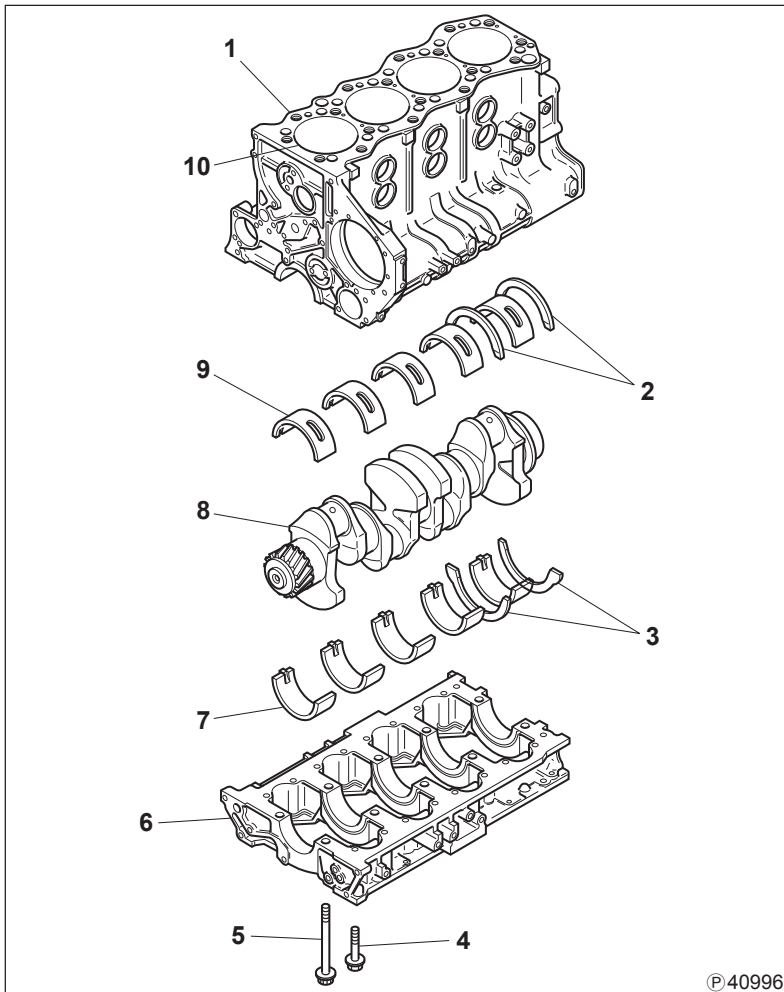
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● **Reduction of vertical vibration (Secondary components)**

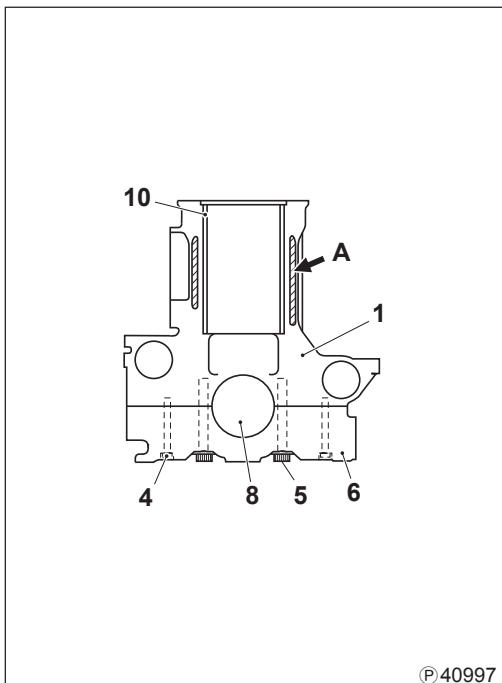
- The reciprocating motion of the piston produces inertial force B, the source of vertical vibration, at the top and bottom dead centers of the piston.
- The balance shafts RH 2 and LH 7 rotate in such a way that at the top and bottom dead centers of the piston, the semi-circular weight portion C will always be placed opposite to the piston head in terms of top or bottom position.
- As a result, at the top and bottom dead centers of the piston, both balance shafts RH 2 and LH 7 produce equal centrifugal force D to offset inertial force B of the piston, thereby reducing vertical vibration.
- In addition, in the medium and high engine speed ranges, the crankshaft rotation moments (secondary components) are also reduced by the balance shafts.

# STRUCTURE AND OPERATION

## Crankcase and Main Bearings

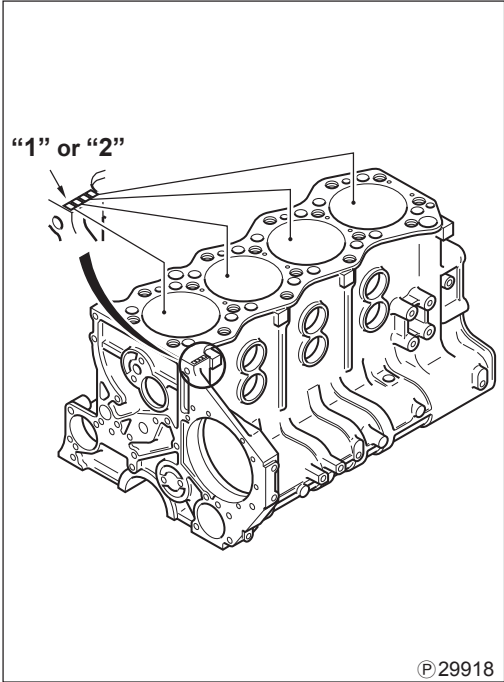


- 1 Upper crankcase
- 2 Upper thrust plate
- 3 Lower thrust plate
- 4 Bolt
- 5 Main cap bolt
- 6 Lower crankcase
- 7 Lower main bearing
- 8 Crankshaft
- 9 Upper main bearing
- 10 Cylinder liner

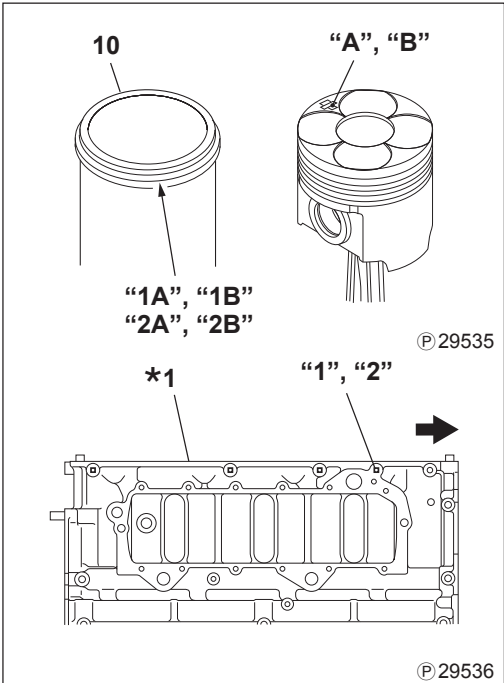


### ● Crankcase

- The crankcase is composed of two parts; upper crankcase **1** and lower crankcase **6**, which are coupled together with crankshaft **8** in between.
- The upper crankcase **1** has four cylinder bores provided into which cylinder liners **10** are fitted.
- Water jacket **A** is provided around the cylinders to cool down the cylinder liners **10**.
- The bolts **4** used to couple the upper crankcase **1** and the lower crankcase **6** and the main cap bolts **5** require the specified procedure to be followed when tightened. 📖 P11A-83

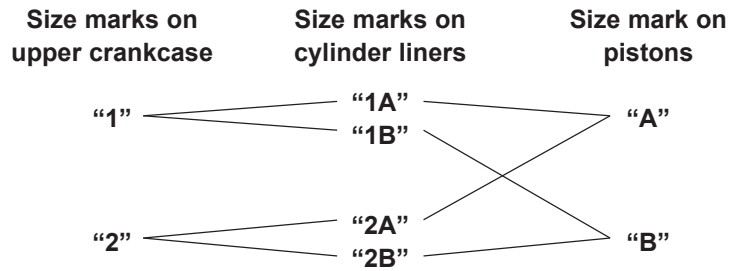


- Size mark "1" or "2" is stamped on the upper crankcase 1 for selective fitting of pistons in the crankcase.
- The size marks for the four cylinders are collectively stamped at a single location, and indicate the sizes of the respective cylinder liners as illustrated. P11A-7

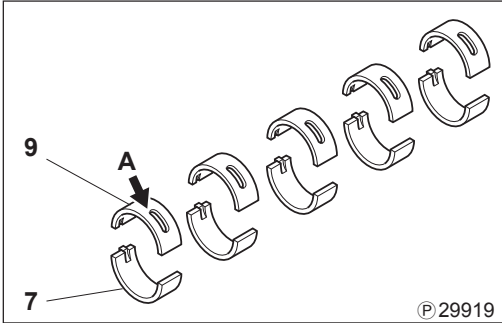


● Cylinder liner

- Select a cylinder liner 10 which has the same size mark as those stamped on the upper crankcase \*1 the piston.
- The size marks on the upper crankcase \*1 are arranged in the order of No. 1, 2, 3 and 4 cylinders starting from the engine front C.

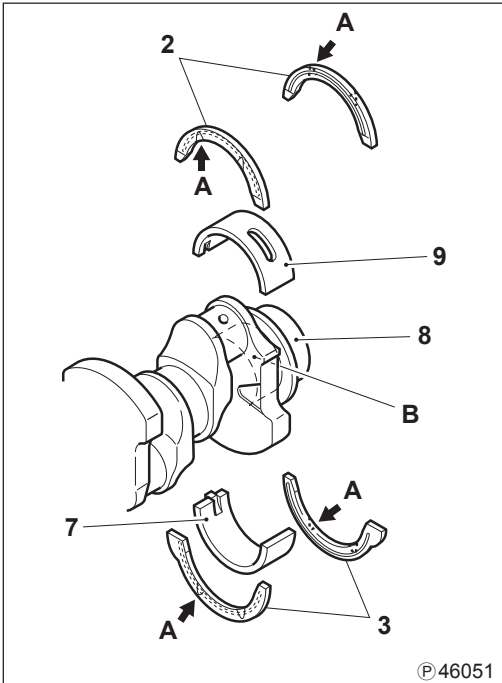


# STRUCTURE AND OPERATION



## ● Main bearings

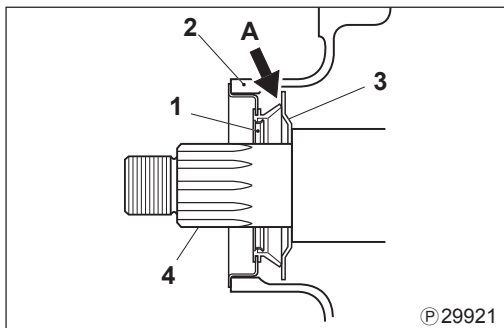
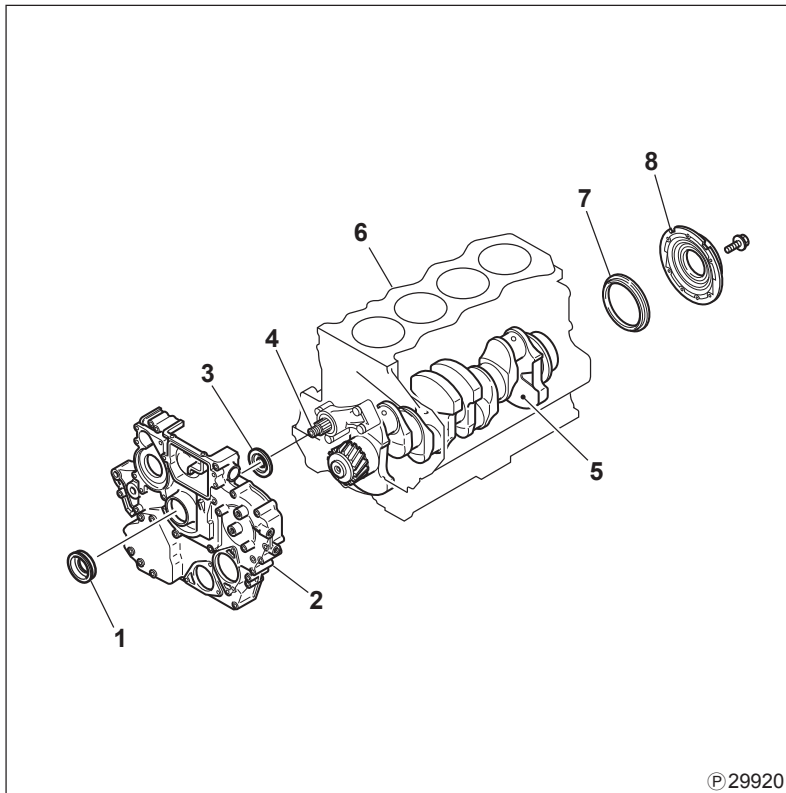
The upper main bearing **9** has an oil hole **A** through which engine oil is supplied to the journal of the crankshaft **8**.



## ● Thrust plates

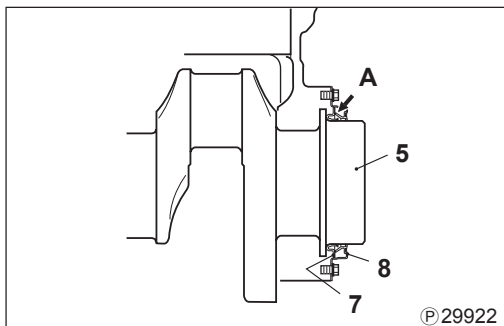
- The thrust plates include upper thrust plates **2** and lower thrust plates **3**. They are mounted at both ends of the upper main bearing **9** and the lower main bearing **7** at the rearmost portion of the crankshaft **8**.
- The thrust plates to be used should have a proper thickness suitable to maintain the end play specification of the crankshaft **8**. Each thrust plate has an oil groove in two places to assure its smooth sliding on the journal **B** of the crankshaft **8**.

### Oil Seals



#### ● Front Oil Seal

- The front oil seal 1 is mounted in the front case 2. Its lip A is in contact with the front oil seal slinger 3 for sealing.
- The front oil seal slinger 3 is fitted on the fan shaft 4.



#### ● Rear Oil Seal

- The rear oil seal 8 is mounted to the crankcase 6. Its lip A is in contact with the rear oil seal slinger 7 for sealing.
- The rear oil seal slinger 7 is press-fitted on the rear end of the crankshaft 5.

# TROUBLESHOOTING

Possible Causes		Symptoms	Low power output	Abnormal engine noise	Remarks
Cylinder head and valve mechanism	Incorrect valve clearance		×	×	
	Defective cylinder head gasket		×	×	
	Worn valve and valve seat, and deposited carbon		×	×	
	Weakened valve spring		×	×	
	Defective rocker shaft and bracket			×	
	Poor lubrication of rocker shaft bracket			×	
Timing gears	Incorrect backlash in timing gears			×	
	Poor lubrication of timing gear peripheries and idler shafts			×	
Camshaft	Excessive end play in camshaft			×	
	Worn camshaft			×	
Pistons and connecting rods	Worn/damaged piston ring groove(s)		×	×	
	Worn/damaged piston ring(s)		×	×	
	Worn piston pin and connecting rod small end bushing			×	
Crankshaft	Excessive end play in crankshaft			×	
	Incorrectly fitted fan pulley			×	
	Worn/damaged crankshaft pin and connecting rod bearing			×	
	Worn/damaged crankshaft journal and main bearing			×	
Fuel	Defective bearing in injection pump bearing housing			×	
	Faulty injection nozzle spray condition		×	×	☐ Gr 13A
	Incorrect injection timing		×	×	☐ Gr 13A
	Air trapped in fuel system		×		☐ Gr 13A
Cooling	Defective cooling system		×		☐ Gr 14A
	Loose/damaged V belt			×	
Intake and exhaust	Clogged air cleaner		×	×	☐ Gr 15A
	Clogged muffler		×	×	
Incorrect oil viscosity			×		
Improper fuel			×		
Incorrectly fitted piping, hose, etc.				×	
Defective/incorrectly fitted auxiliaries like injection pump and alternator				×	

# MEMO

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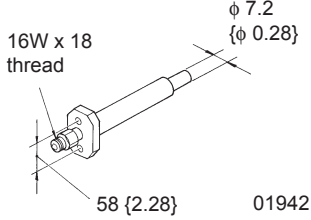
# ON-VEHICLE INSPECTION AND ADJUSTMENT

## Measuring Compression Pressure Service standards

Location	Maintenance item	Standard value	Limit	Remedy	
-	Compression pressure	Each cylinder (at 200 rpm)	2550kPa {370 psi, 26 kgf/cm <sup>2</sup> }	1960 kPa {285 psi, 20 kgf/cm <sup>2</sup> }	Inspect
		Cylinder-to-cylinder pressure difference	-	0.4 kPa {57 psi, 4 kgf/cm <sup>2</sup> }	Inspect

### Special tools

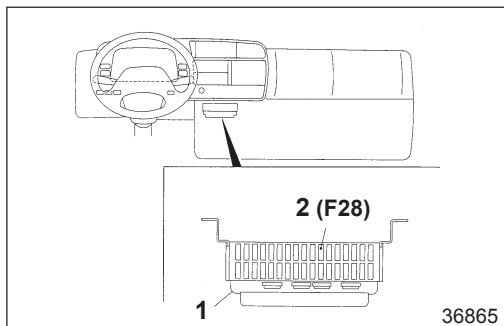
Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
-	 <p>Compression Gauge Adapter</p>	MH063434	Measuring compression pressure

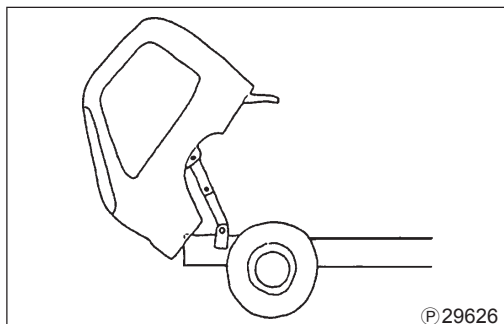
A drop in compression pressure should be used as a guide in determining a time to overhaul the engine.

Measure the compression pressure at regular intervals, and keep track of its transition which will provide a useful tool for troubleshooting. On a new vehicle, or for a while after replacement of parts with new ones, the compression pressure will be somewhat higher, depending on the break-in condition of piston rings, valve seats, etc., but will return to normal as the parts wear down.

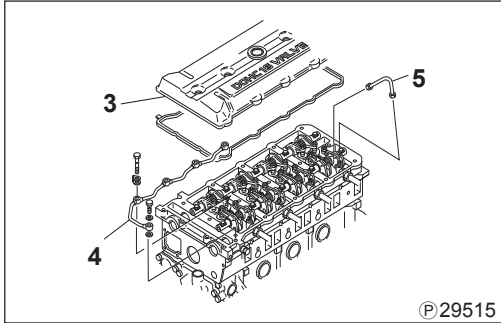
- Prior to an inspection, check to ensure that the engine oil, starter and battery are in normal condition.
- Place the vehicle in the following condition.
  - Warm up the engine until the coolant temperature reaches approx. 75 to 85 °C {167 to 185 °F}.
  - Turn off the lights and auxiliaries.
  - Place the transmission in neutral.
  - Place the steering wheel in the straight-ahead position.



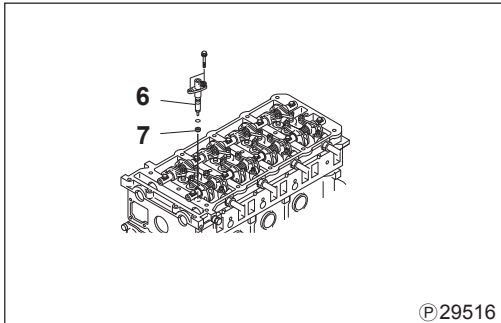
- Remove the fuel cut motor fuse **2** from the fuse box **1** in the cab to make sure that the fuel is not injected when the engine is cranked by the starter.



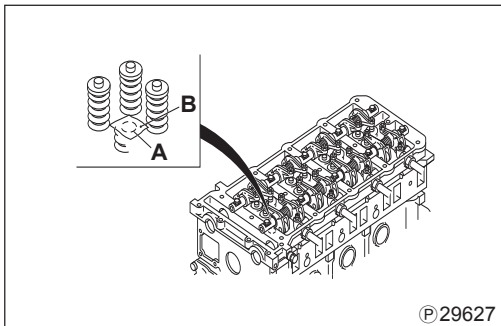
- Tilt the cab.



- Remove the rocker cover **3**, fuel leak-off pipe **4** and injection pipe **5**.  
 P11A-24



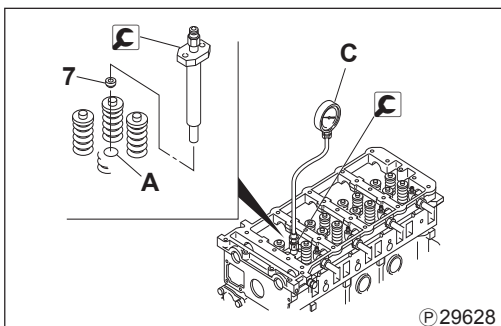
- Remove all glow plugs.  
 P11A-38



- Cover the glow plug mounting holes with pieces of waste cloth **B**. After cranking the engine by the starter, check to ensure that no foreign substances are deposited on the waste cloth.

## WARNING

**If there is a crack in any of the cylinders, some of the coolant, engine oil, fuel, etc. will enter the cylinder through the crack. If the engine is cranked in such a condition, these substances heated to high temperatures will blow out from glow plug holes A and can be very dangerous. When the engine is cranked, therefore, stay away from the glow plug holes.**



- Fit the glow plug adapter for the Compression Gauge onto the glow plug mounting hole **A** and mount the compression gauge **C**.
- Crank the engine and measure the compression pressure.
- On all of the cylinders, measure the compression pressure and determine the pressure difference between cylinders.
- If any compression pressure or cylinder-to-cylinder pressure difference is out of the limits, pour in a small amount of engine oil into glow plug mounting hole **A** and check by measuring the compression pressure again.
  - If the compression pressure increases:  
Worn/damaged piston rings and cylinder inner surfaces are suspected.
  - If the compression pressure remains unchanged:  
A seized valve, incorrectly seated valve or defective cylinder head gasket is suspected.

# ON-VEHICLE INSPECTION AND ADJUSTMENT

## Inspecting and Adjusting Valve Clearances

### Service standards

Unit: mm {in.}

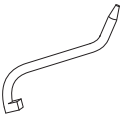
Location	Maintenance item	Standard value	Limit	Remedy	
-	Valve clearance (when cold)	Inlet	0.4 {0.016}	-	Adjust
		Exhaust	0.5 {0.020}	-	Adjust

### Tightening torques

Unit: N·m {ft.lbs, kgf·m}


Location	Parts to be tightened	Tightening torque	Remarks
2	Lock nut (adjusting screw tightening)	11.2 {8.25, 1.14}	-

### Special tools

Location	Tool name and shape	Part No.	Application
-	Cranking handle 	MH063568 < without refrigerator > MH063569 < with refrigerator >	Turning fan pulley


Valve clearances should be checked and adjusted as follows while the engine is cold.

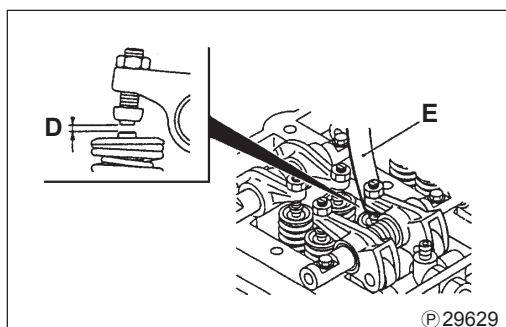
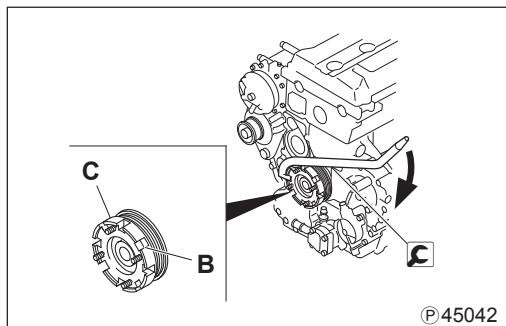
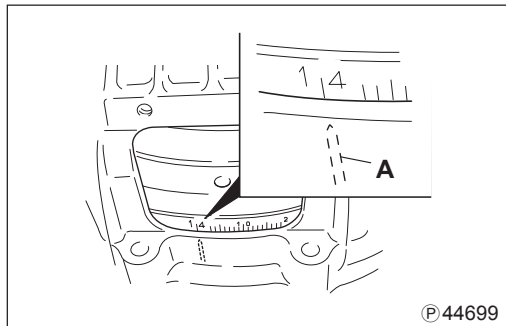
[Inspection]

- Tilt the cab.
- Remove the rocker cover.  P11A-24
- To place the piston No. 1 or No. 4 at the top dead center on the compression stroke, crank the engine until the pointer **A** in the converter housing (on automatic transmission) inspection window is aligned with the mark between "1 and 4" inscribed in the flywheel.

### NOTE

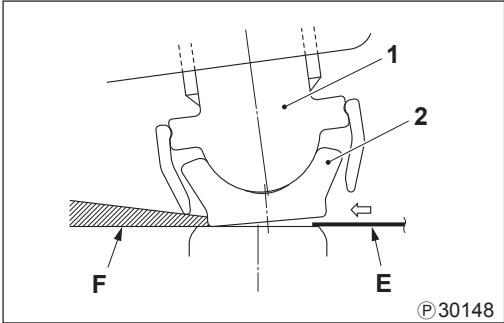
**Find the cylinder where the rocker arms for both the inlet and exhaust valves can be pushed down. The piston of the cylinder is at the top dead center (TDC) on the compression stroke.**

- Use the  cranking handle to crank the engine: set it in the groove **B** located on the outer circumference of the fan pulley **C** to turn the crank shaft.

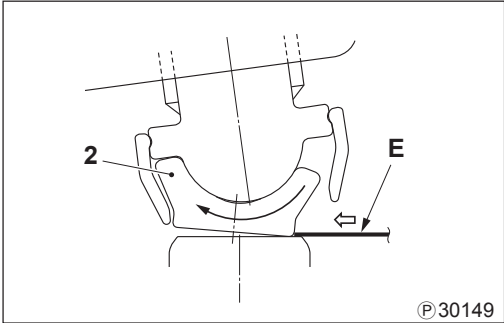


- With the piston No. 1 or No. 4 at the top dead center (TDC) on the compression stroke, measure the valve clearance **D** at the valves marked x in the following table.

Cylinder No.	1		2		3		4	
Valve arrangement	IN	EXH	IN	EXH	IN	EXH	IN	EXH
Piston No. 1 at TDC on compression stroke	x	x	x	-	-	x	-	-
Piston No. 4 at TDC on compression stroke	-	-	-	x	x	-	x	x



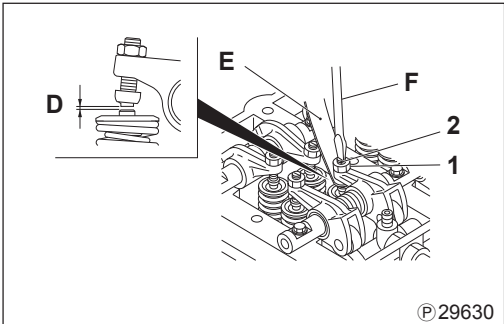
- When measuring the clearances, push the pad 2 of the adjusting screw 1 with the tip of a plain screwdriver F or something else from opposite the side where the feeler gauge E is to be inserted to open a gap as illustrated, then insert the feeler gauge in the gap.



- If an attempt is made to insert a feeler gauge E without opening a gap, the pad will be tilted as illustrated, making it impossible to insert the feeler gauge.

**NOTE**

- The feeler gauge E must have a slight drag when taking a measurement.
- If the feeler gauge moves without any resistance, the measurement is incorrect (too loose).

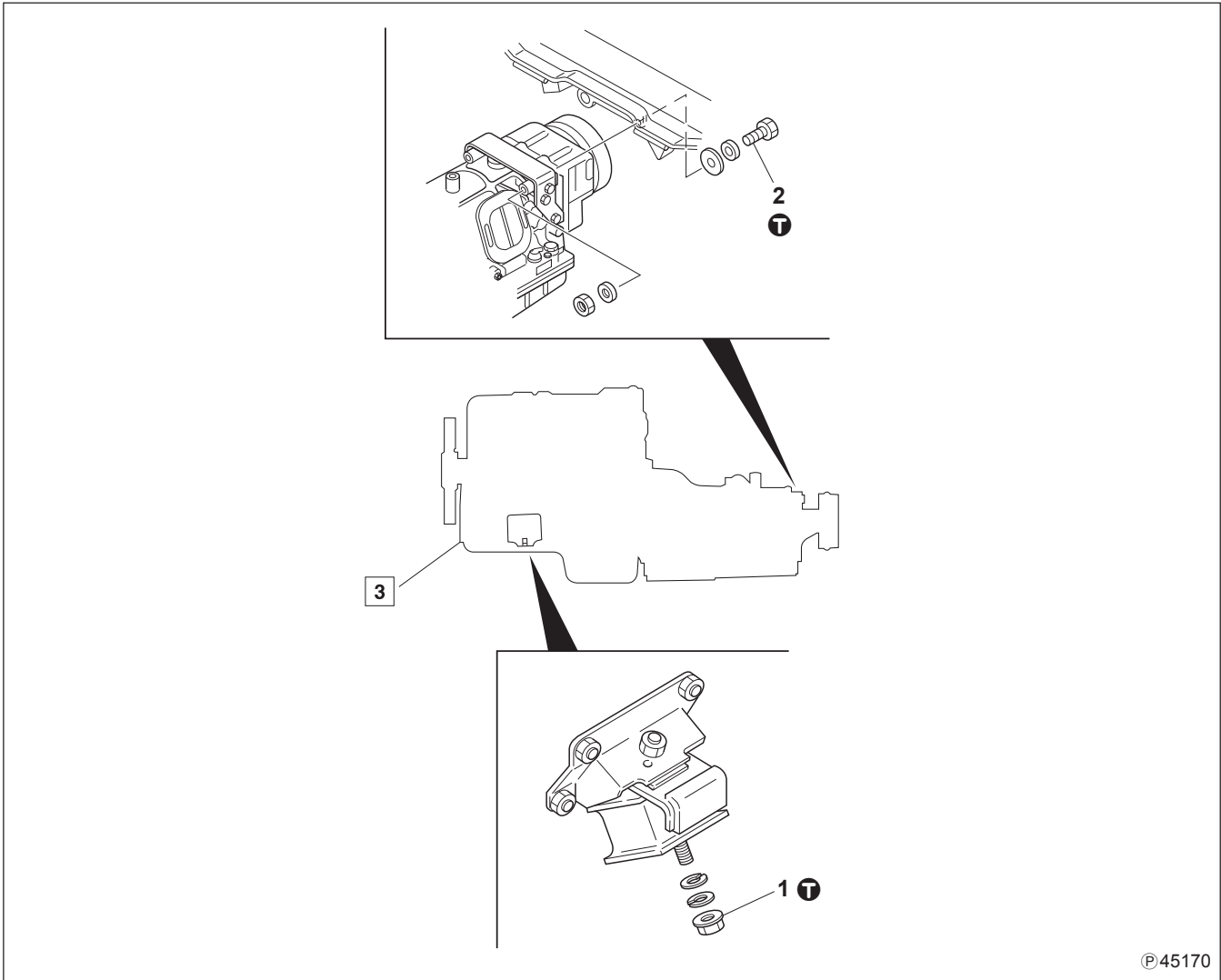


- If the reading is out of specification, adjust by the following procedures.

[Adjustment]

- To adjust the valve clearance D, loosen the lock nut 1 and rotate the adjusting screw 2 to adjust the clearance to the extent that the feeler gauge E is somewhat hard to move.
- After the adjustment, hold the adjusting screw 2 in position with a screwdriver F and tighten the lock nut 1 to the specified torque. Thereafter, re-check the valve clearance D with the feeler gauge E.

# REMOVAL AND INSTALLATION OF ENGINE



© 45170

## ● Removal Sequence

- 1 Nut
- 2 Bolt

3 Engine and automatic transmission assembly

## WARNING

When lifting the engine and automatic transmission assembly 3, be sure to use a lifting gear or engine hoist capable of lifting an engine of 3.9 to 4.7 kN {880 to 1060 lbs, 400 to 480 kg}

## ● Intallation sequence

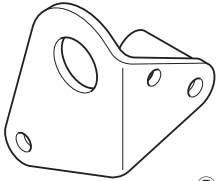
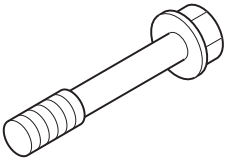
Follow the removal sequence in reverse.

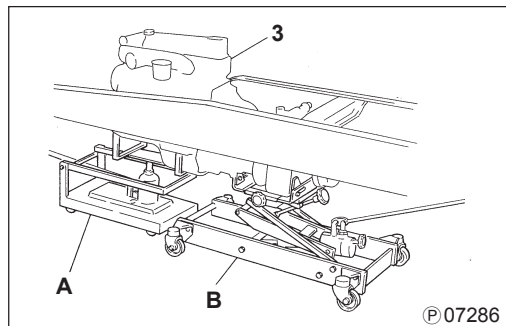
## Tightening torque

Unit: N·m{ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Nut (For attaching front mounting)	69 to 99 {51 to 65, 7 to 9}	—
2	Bolt (For attaching rear mounting)	83 to 105 {61 to 80, 8.5 to 11.0}	—

**Special tools**

Location	Tool name and shape	Part No.	Application
4	Engine front hanger < Tilt cab > 	MH062781	Removal and installation of engine
4	Flange bolt < Tilt cab > 	MF140234 MF140235	Mounting of hanger



**◆ Service procedure**

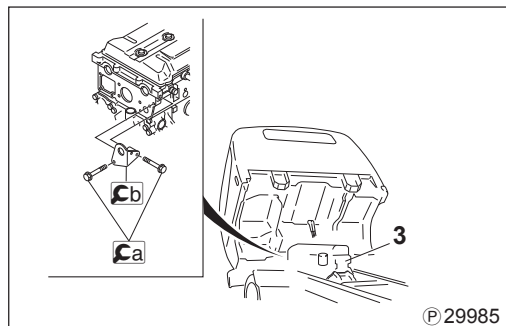
**● Preparatory operation for removal < Fixed cab >**

- Support engine and transmission assembly 3 on engine lifter A and transmission jack B.
- Make sure that all wiring and hoses are disconnected.

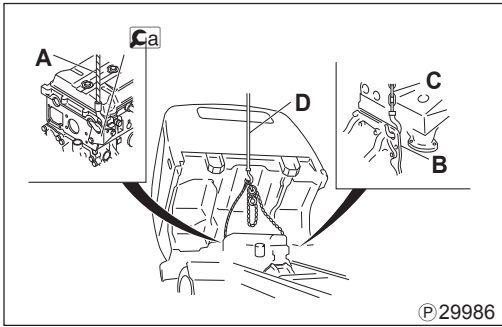
**3 Removal of engine and transmission assembly**

**< Tilt cab >**

Using **ca** flange bolts, install **cb** engine front hanger to engine and automatic transmission assembly 3.



# REMOVAL AND INSTALLATION OF ENGINE

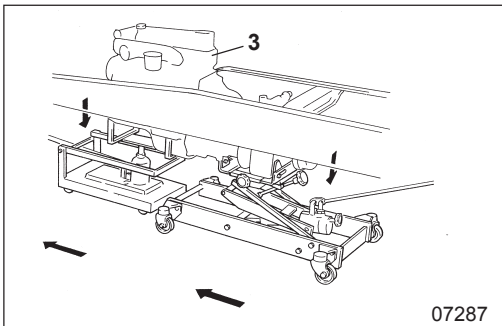


- Attach wire rope **A** to **Ca** engine front hanger, and chain block **C** to rear plate **B**. Use crane **D** to make the ropes taut.

## WARNING

To lift engine and automatic transmission assembly **3**, use hanging hardware suitable for hoisting an engine weighing 3.9 to 4.7 kN {880 to 1060 lbs, 400 to 480 kg}.

- Make sure that all wiring harnesses and pipes are disconnected.
- Slowly lift engine and automatic transmission assembly **3**, making sure that the assembly does not contact the frame or cab.



### < Fixed cab >

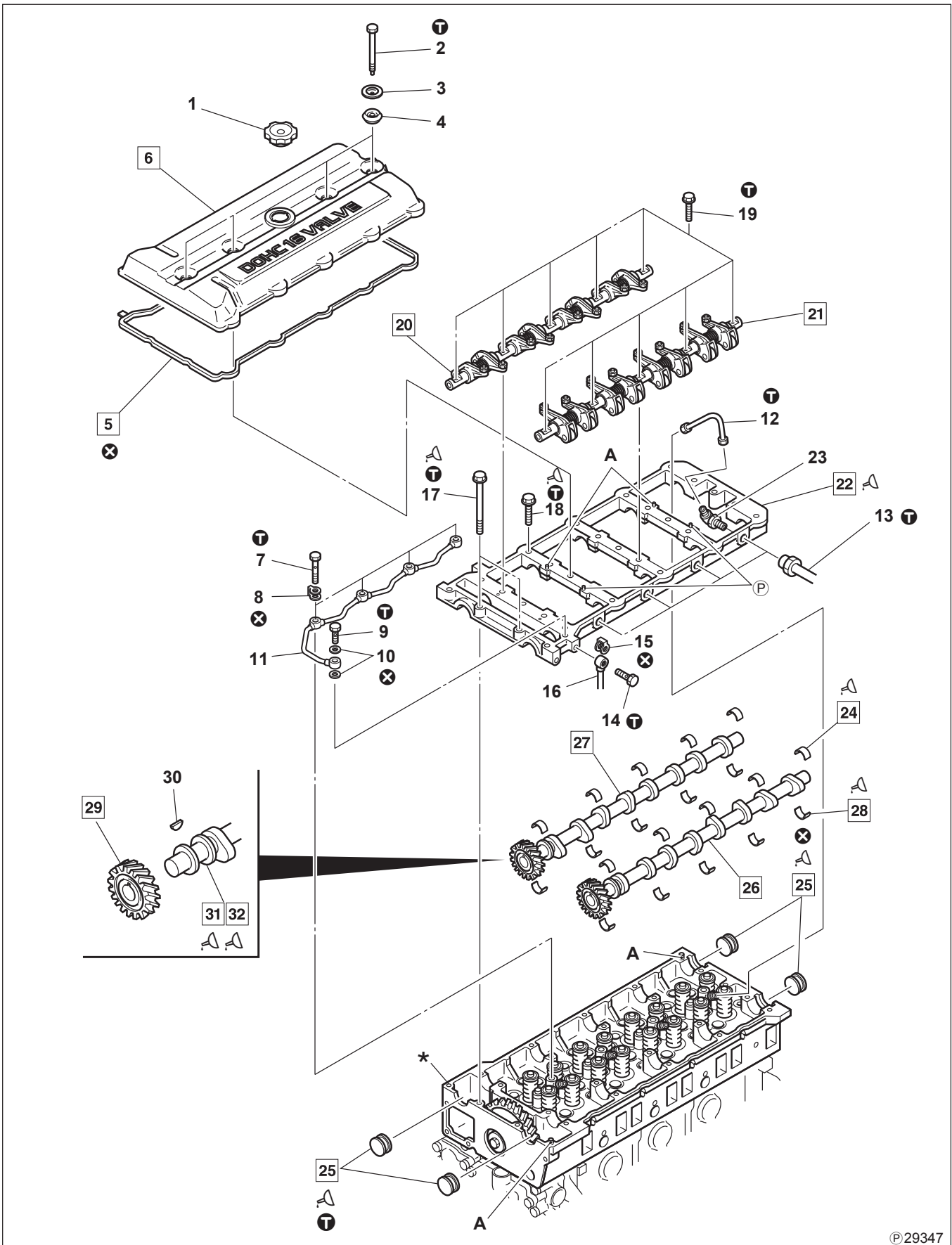
- Lower engine and transmission assembly **3** to fullest extent keeping it horizontal.
- Lift the vehicle using a jack, and move engine and transmission assembly **3** forward.

**MEMO**

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# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS



© 29347

● Pre-disassembly inspection

📖 P11A-27

● Pre-disassembly work

Some work is necessary before disassembly. 📖 P11A-27

● Disassembly sequence

- |                       |                                  |                              |
|-----------------------|----------------------------------|------------------------------|
| 1 Oil filler cap      | 14 Eye bolt                      | 25 Packing                   |
| 2 Bolt                | 15 Gasket                        | 26 Inlet camshaft assembly   |
| 3 Plate               | 16 Fuel return pipe              | 27 Exhaust camshaft assembly |
| 4 Rubber grommet      | 📦 Gr13A                          | 28 Camshaft bearing (lower)  |
| 5 Rocker cover gasket | 17 Bolt (× 2)                    | 29 Camshaft gear             |
| 6 Rocker cover        | 18 Bolt (× 13)                   | 30 Key                       |
| 7 Eye bolt            | 19 Bolt (× 10)                   | 31 Inlet camshaft            |
| 8 Gasket              | 20 Exhaust rocker shaft assembly | 32 Exhaust camshaft          |
| 9 Eye bolt            | 📖 P11A-34                        |                              |
| 10 Gasket             | 21 Inlet rocker shaft assembly   | * : Cylinder head assembly   |
| 11 Fuel leak-off pipe | 📖 P11A-34                        | 📖 P11A-38                    |
| 12 Injection pipe     | 22 Camshaft frame                | Ⓟ : Locating pin             |
| 📦 Gr 13A              | 23 Injection pipe connector      | ⊗ : Non-reusable part        |
| 13 Injection pipe     | 24 Camshaft bearing (upper)      |                              |
| 📦 Gr 13A              |                                  |                              |

**NOTE**

- Avoid removing the camshaft gear 29 unless something wrong is evident.
- The camshaft frame 22 and the cylinder head assembly \* have been machined jointly when manufactured. It is impossible to replace only either of the parts. Be sure not to change the combination.

● Assembly sequence

Follow the disassembly sequence in reverse.

**Service standards**

Unit: mm {in.}

Location	Maintenance item	Standard value	Limit	Remedy	
-	Backlash	Between head idler gear assembly and camshaft gear	0.09 to 0.12 {0.0035 to 0.0047}	0.3 {0.012}	Replace
		Between head idler gear assembly and idler gear assembly	0.11 to 0.14 {0.0043 to 0.0055}	0.3 {0.012}	
	End play	Camshaft assembly	0.10 to 0.20 {0.0039 to 0.0079}	0.3 {0.012}	Check all the parts.
		Head idler gear assembly	0.10 to 0.20 {0.0039 to 0.0079}	0.3 {0.012}	
24, 28	Camshaft bearing free span	-	35.5 {1.39} or more	Replace	

# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS

## Service standards

Unit: mm {in.}

Location	Maintenance item		Standard value (Basic diameter in [ ])	Limit	Remedy	
26	Inlet camshaft	Cam lift	For long rocker	7.157 {0.281}	7.107 {0.297}	Lobe height: 42.157 {1.66} Base circle diameter: 35 {1.38}
			For short rocker	9.202 {0.36}	9.152 {0.36}	Lobe height: 44.201 {1.74} Base circle diameter: 35 {1.38}
	Bend		0.01 {0.00039}	0.03 {0.0012}	Replace	
	Journal oil clearance		0.07 to 0.12 {0.0028 to 0.0047}	0.16 {0.0063}	Replace	
27	Exhaust camshaft	Cam lift	For long rocker	7.217 {0.284}	7.167 {0.282}	Lobe height: 42.217 {1.66} Base circle diameter: 35 {1.38}
			For short rocker	9.279 {0.365}	9.229 {0.363}	Lobe height: 44.279 {1.74} Base circle diameter: 35 {1.38}
	Bend		0.01 {0.00039}	0.03 {0.0012}	Replace	
	Journal oil clearance		0.07 to 0.12 {0.0028 to 0.0047}	0.16 {0.0063}	Replace	
29, 31, 32	Camshaft gear and camshaft interference		[30 {1.18}] 0.007 to 0.041 {0.00028 to 0.00160}	–	Replace	

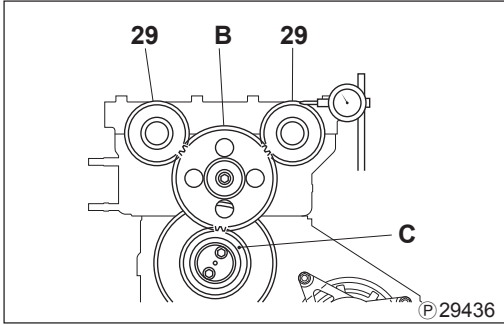
## Tightening torques

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2	Bolt (mounting rocker cover)	2.0 {14.0, 0.2}	–
7, 9	Eye bolt (mounting fuel leak-off pipe)	20.6 {15.0, 2.1}	
12, 13	Injection pipe	38.2 {28, 3.9}	–
14	Eye bolt (mounting fuel return pipe)	20.6 {15.0, 2.1}	–
17	Bolt (mounting camshaft frame)	23.5 {17.0, 2.4}	Wet
18	Bolt (mounting camshaft frame)	27.5 {20.0, 2.8}	Wet
19	Bolt (mounting rocker shaft assembly)	27.5 {20.0, 2.8}	Wet

## Lubricant and sealant

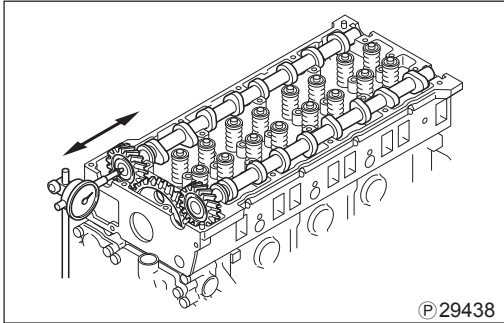
Location	Points of application	Specified lubricant and/or sealant	Quantity
17, 18	Bolt threads and seating surface	Engine oil	As required
22	Surface of camshaft frame which makes contact with cylinder head	THREEBOND 1207C or D	As required
24, 28	Inside surface of camshaft bearing	Engine oil	As required
25	Circumference of packing	THREEBOND 1207C or D	As required
31, 32	Journal and cam portions of camshaft	Engine oil	As required



● Pre-disassembly inspection

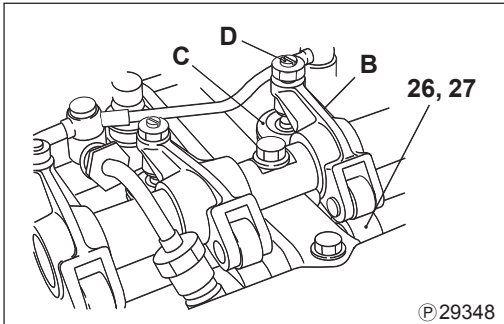
(1) Backlash between head idler gear B and camshaft gear 29 and idler gear assembly C

On a pair of gears, measure backlash at more than three positions. If the reading is more than the limit, replace defective parts.



(2) End play of camshaft

If the reading is more than the limit, replace defective parts.



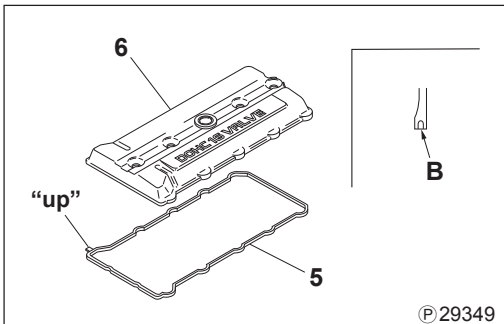
● Pre-disassembly work

If the rocker B forced up by the camshaft 26 or 27 is pressing the valve spring C down, loosen the adjusting screw D of the rocker to set the valve spring free.

◆ Service procedure

5 6 Installation of rocker cover and rocker cover gasket

- Before installing the rocker cover 6, remove oil and other deposits thoroughly from the gasket groove B.
- Face the rocker cover gasket 5 as illustrated when it is installed on the rocker cover 6.



CAUTION ⚠

Make sure that the rocker cover gasket 5 is not twisted when installed.

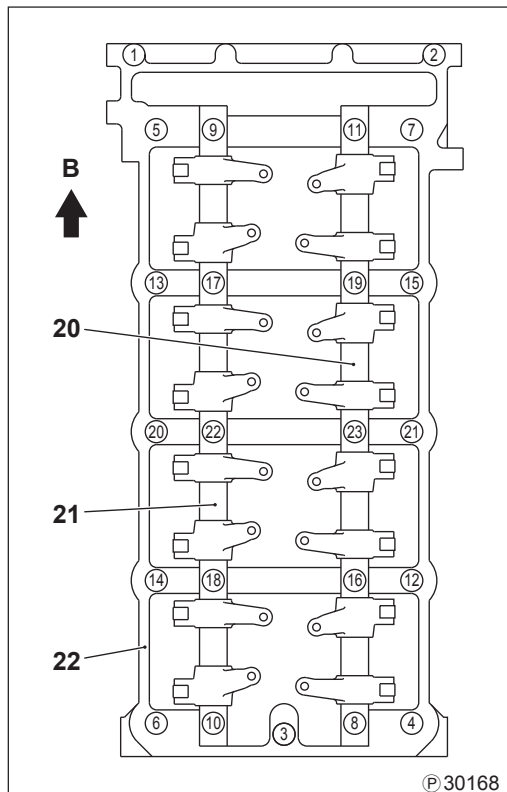
# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS

**20 to 22** , **25** Rocker shaft assemblies, camshaft frame and packing

[Removal]

Loosen the bolts **18** and **19** (① through ③) one after another, a small amount at a time, in the numbered sequence shown in the illustration. Then remove the rocker shaft assemblies **20** and **21** and the camshaft frame **22**.

**B** : Front of engine



P 30168

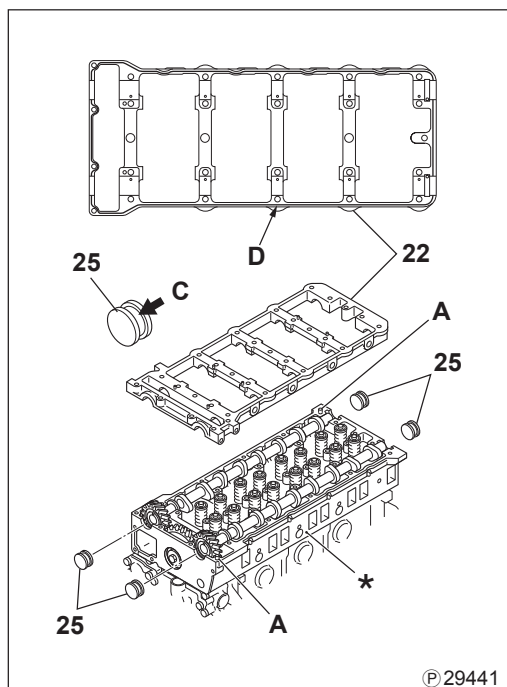
[Installation]

- Apply an even bead of sealant ( $\phi 2 \pm 1 \text{ mm}$  { $\phi 0.079 \pm 0.039$ }) without any break to all around the illustrated portion **C** of the four packings **25**.
- Apply an even bead of sealant ( $\phi 1 \text{ mm}$  { $0.039$ }) without any break on the circumference **D** of the camshaft frame **22**.
- After the sealant application, install the camshaft frame **22** and the packings **25** on the cylinder head assembly \* in less than three minutes.

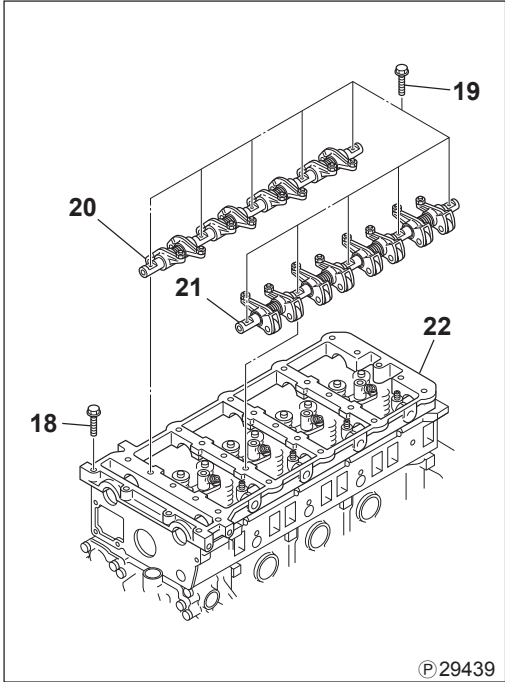
**CAUTION** ⚠

- Check to ensure that the sealant application surfaces **C** and **D** are clean and free from any oil or other deposits.
- When installing the parts, make sure that the sealant is not forced out of position.
- Do not start the engine in less than an hour after installation.

**A** : Locating pin



P 29441



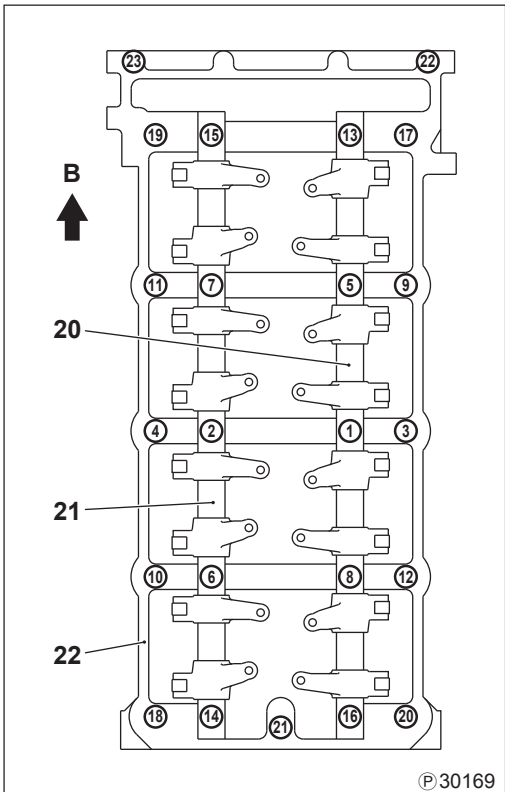
- The bolts **18** (× 13) and **19** (× 10) must be tightened in the following sequence. Therefore, secure the rocker shaft assemblies **20** and **21** together with the camshaft frame **22**.

**CAUTION** ⚠

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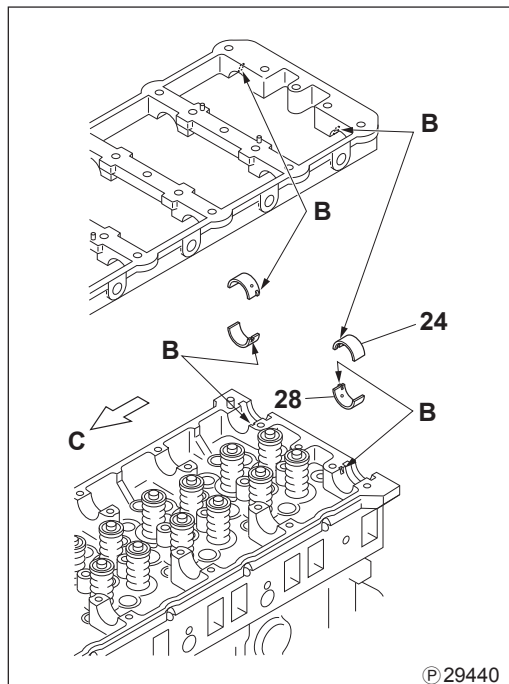
When the bolts **18** and **19** were loosened or removed after installation, be sure to re-apply sealant.

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- Tighten the bolts **18** and **19** (① through ③) to the specified torque in the numbered sequence shown in the illustration.

# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS



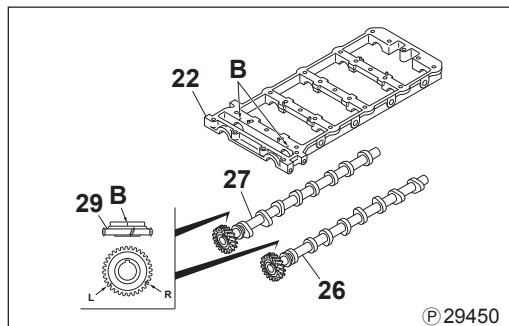
## 24 28 Installation of camshaft bearings

Be sure to fit the lugs **B** of the camshaft bearings **24** and **28** in the mating notches.

**C** : Front of engine

## 26 27 Installation of camshaft assemblies

- Place the piston of No. 1 cylinder at the top dead center on the compression stroke.
- Install the camshaft assemblies **26** and **27** with the alignment marks **B** on the camshaft gear **29** and on the camshaft frame **22** in alignment.



## NOTE

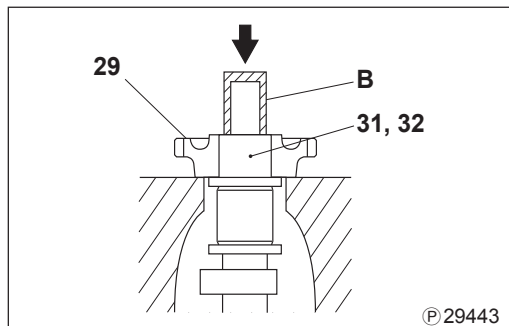
The alignment marks "L" and "R" on the camshaft gear **29** and those on the head idler gears need not always be in alignment, because the alignment mark of the head idler gears, depending on their mounted condition, does not always match that of the camshaft gear.

## 29 Camshaft gear

[Removal]

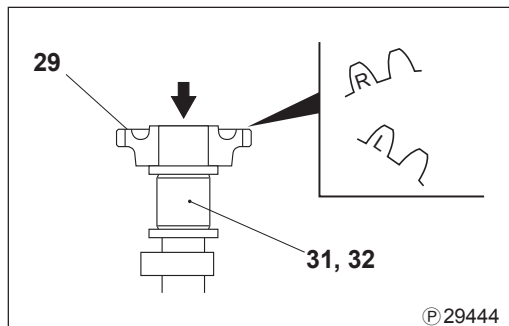
Remove the camshaft gear **29** by pressing the camshaft end with a press.

**B** : Removal block



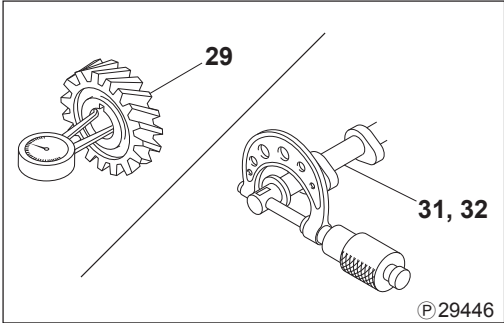
## CAUTION

Never strike the camshaft gear **29** with a hammer to remove it. Be sure to use a press or a similar tool.



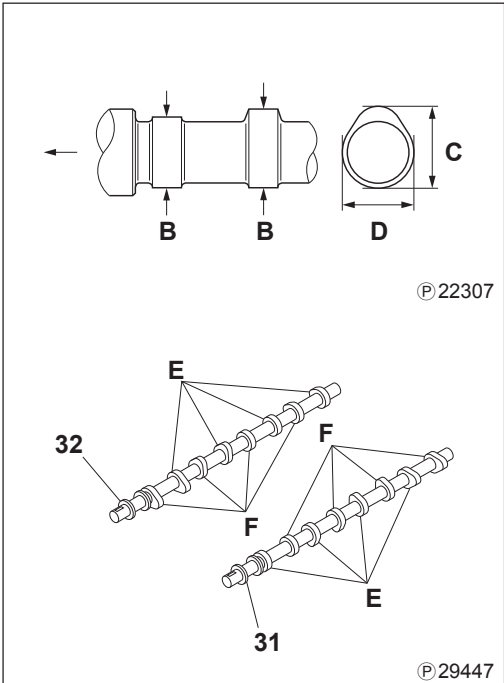
[Installation]

- Heat the camshaft gear **29** to 150 °C {302°F} by a piston heater or a similar tool and install it with the alignment mark "R" or "L" directed as shown.
- Install the camshaft gear **29** such that it is held tightly against the camshaft **31** or **32**.



**29 31 32 Camshaft gear and camshaft interference**

If the reading is out of the standard values, replace defective parts.



**31 32 Inspection of camshafts**

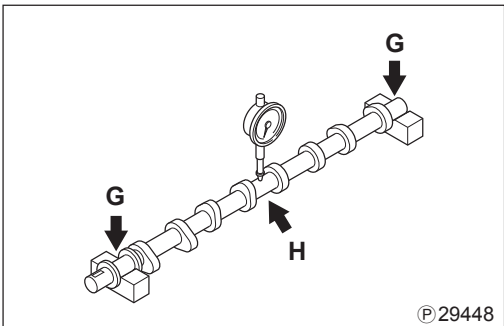
**(1) Cam lift (Difference between lobe height and base circle diameter)**

If the reading is less than the limit, replace the camshafts 31 and 32.

- B:** Measuring position
- C:** Cam lobe height
- D:** Base circle diameter
- E:** Long rocker side cam
- F:** Short rocker side cam

**NOTE**

The cam dimensions are different between the long rocker side cams E and the short rocker side cams F.



**(2) Bend**

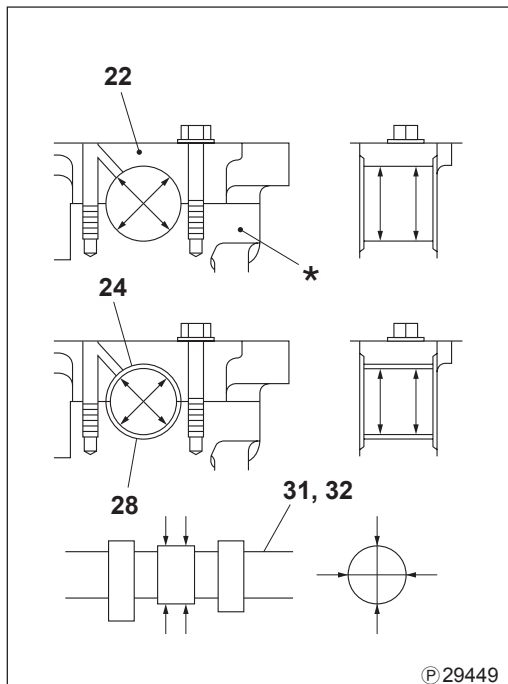
Measure the bend of the camshafts 31 and 32 at the journal H with the journals G supported. If the reading is in excess of the limit, replace the camshaft.

**NOTE**

The bend of the camshafts 31 and 32 is one half of the reading of the dial indicator taken after turning the camshaft through a rotation.



# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS



## (3) Oil clearance between journals and bearings

Measure the oil clearance. If the reading is in excess of the limit, replace defective parts.

### CAUTION

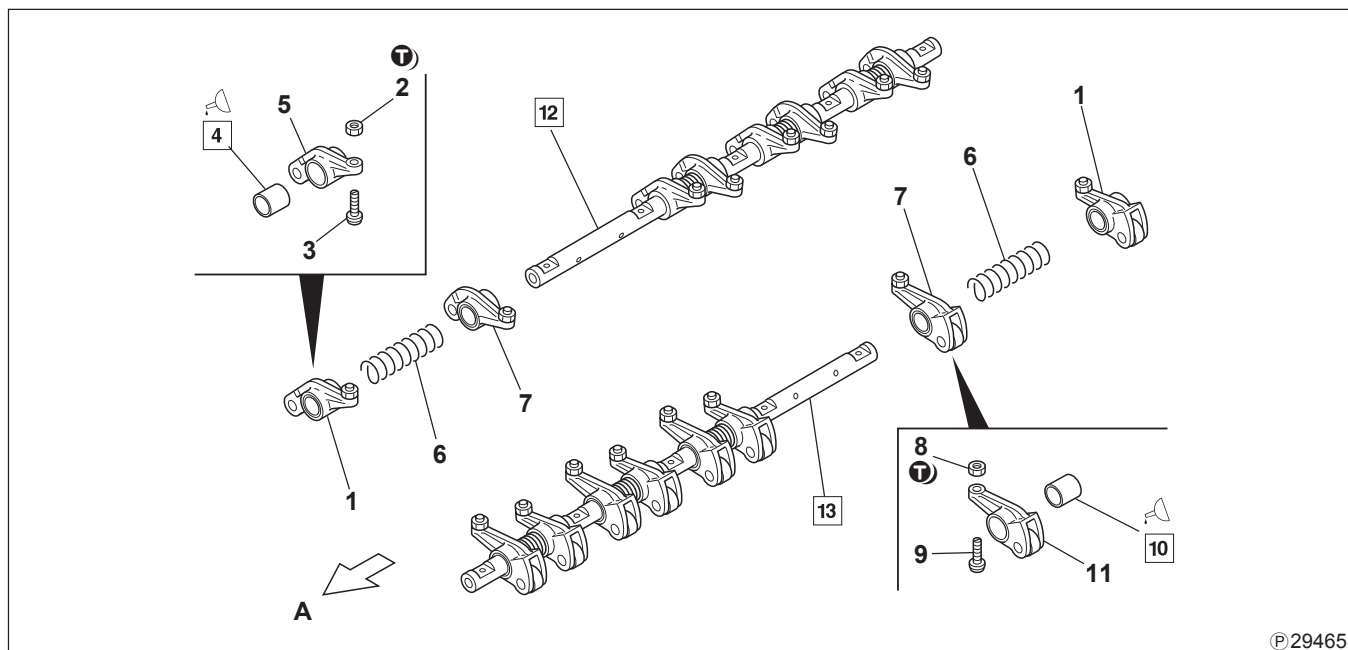
If a camshaft bearing 24 or 28 is to be replaced, make sure that both upper and lower halves are simultaneously replaced as a pair.

# MEMO

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# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS

## Rocker Shaft and Rocker Assembly



⒫ 29465

### ● Disassembly sequence

- |                         |                        |                         |
|-------------------------|------------------------|-------------------------|
| 1 Short rocker assembly | 6 Rocker shaft spring  | 11 Long rocker          |
| 2 Lock nut              | 7 Long rocker assembly | 12 Exhaust rocker shaft |
| 3 Adjusting screw       | 8 Lock nut             | 13 Inlet rocker shaft   |
| 4 Rocker bushing        | 9 Adjusting screw      |                         |
| 5 Short rocker          | 10 Rocker bushing      |                         |
- A:** Front of engine

### ● Assembly sequence

Follow the disassembly sequence in reverse.

### CAUTION ⚠

The rockers come in two types; short rocker assembly 1 and long rocker assembly 7. Note the difference in mounting sequence between the inlet and exhaust rocker shafts.

### Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
1, 7	Radial play of rocker assembly rollers	0.038 to 0.100 {0.0014 to 0.0039}	–	Replace
4, 10, 12, 13	Clearance between rocker bushing and rocker shaft	[22 {0.87}] 0.01 to 0.08 {0.0039 to 0.0031}	0.12 {0.0047}	Replace

### ⒫ Tightening torque

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
2, 8	Lock nut (securing adjusting screw)	11.2 {8.24, 1.14}	

**Lubricant**

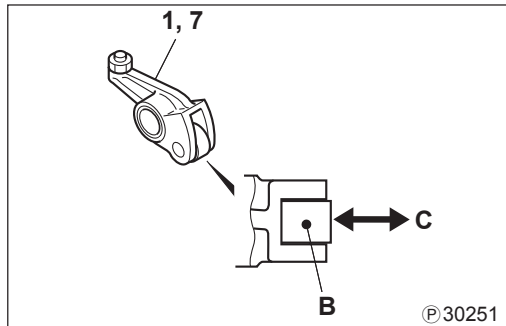
Location	Points of application	Specified lubricant	Quantity
4, 10	Inside of rocker bushing	Engine oil	As required

**Special tools**

Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
4, 10	<p>Rocker Bushing Puller</p>	Use Equivalent	Installation and removal of rocker bushing

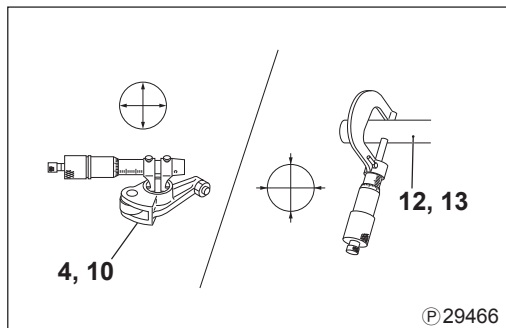
**Service procedure**



**1 7 Inspection of rocker assemblies**

If the play **C** of the roller **B** of the rocker assembly **1** or **7** are out of the standard values, replace the assembly.

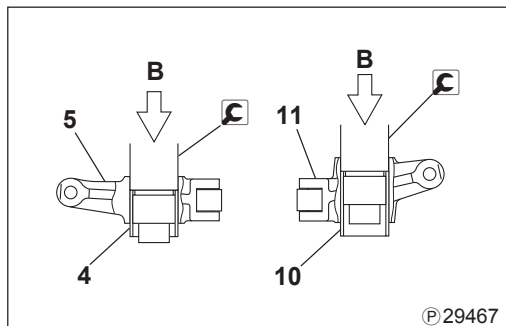
**C** : Radial play



**4 10 12 13 Rocker bushing and rocker shaft**

[Inspection]

If the clearance is in excess of the limit, replace defective parts.



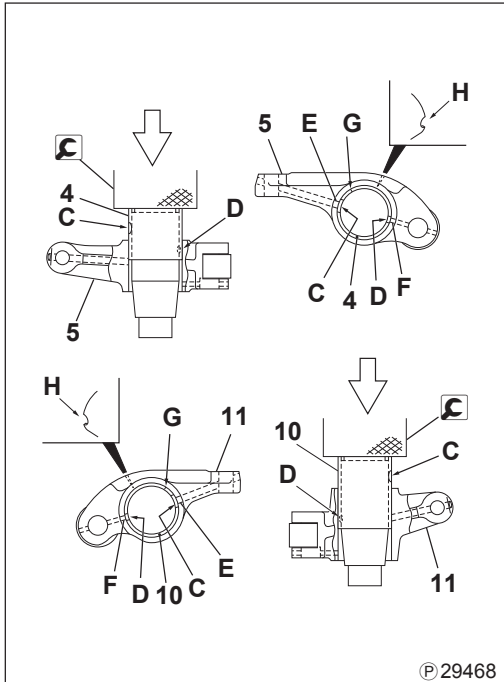
**Rocker bushing**

[Removal]

**C** : Rocker Bushing Puller

**B** : Press

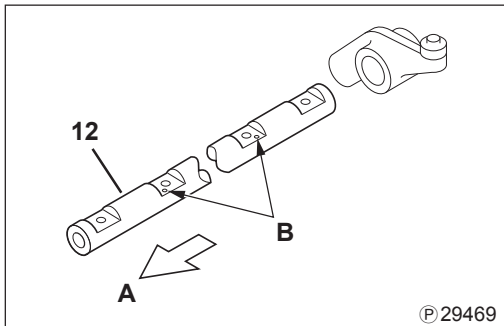
# ROCKER COVER, ROCKER ASSEMBLIES AND CAMSHAFTS



## [Installation]

Install the rocker bushings **4** and **10** on the rockers **5** and **11** in the illustrated direction.

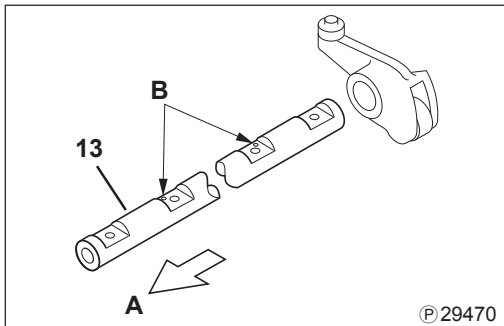
- C** : Rocker Bushing Puller
- D** : Rocker bushing oil hole
- E** : Rocker oil hole
- F** : Rocker oil hole
- G** : Rocker bushing clinch (seam)
- H** : Rocker bushing notch (rear side)



## **12** Installation of exhaust rocker shaft

Install the exhaust rocker shaft **12** in the illustrated direction.

- A** : Front of engine
- B** : Camshaft frame locating pin mounting hole



## **13** Installation of inlet rocker shaft

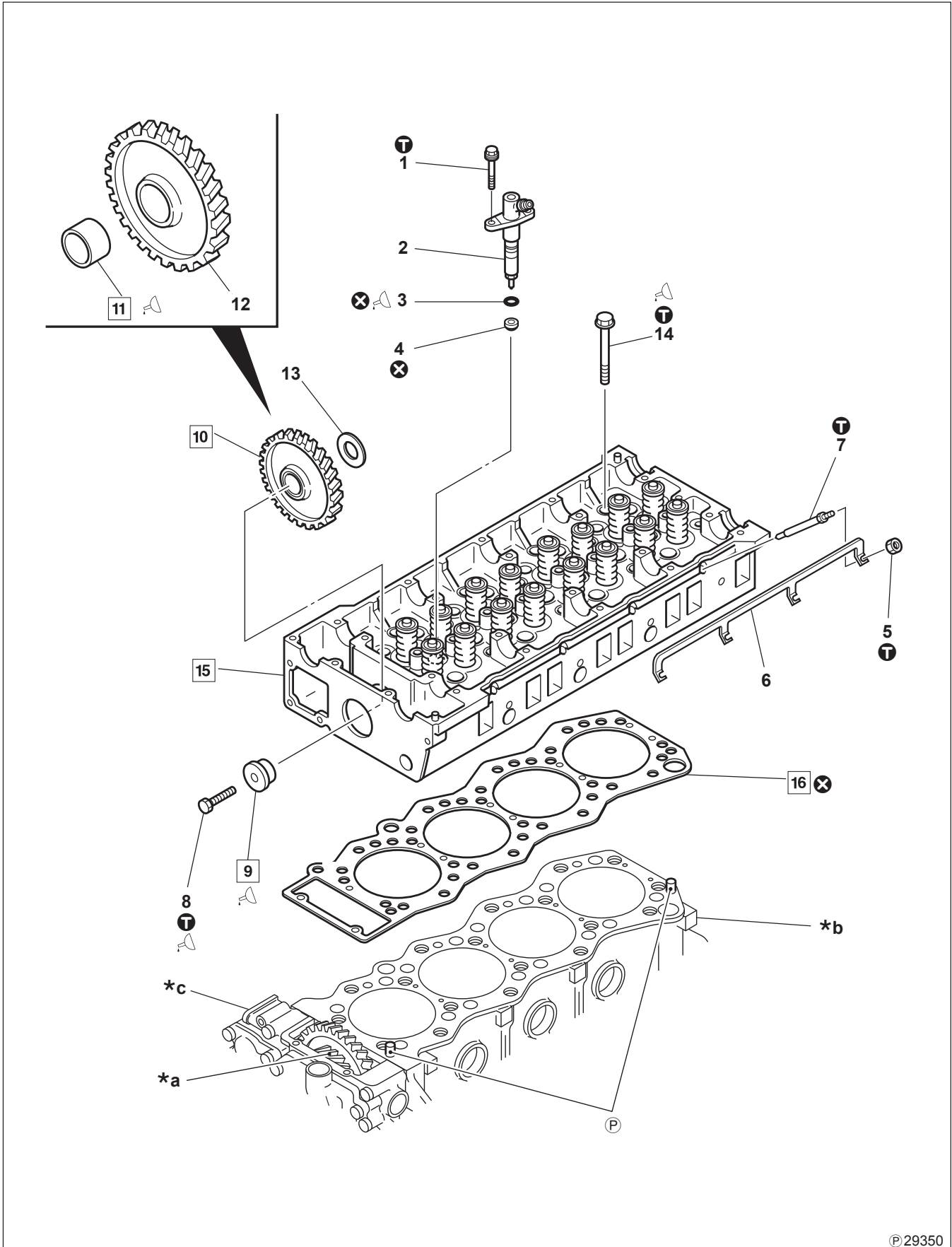
Install the inlet rocker shaft **13** in the illustrated direction.

- A** : Front of engine
- B** : Camshaft frame locating pin mounting hole

# MEMO

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# CYLINDER HEAD AND VALVE MECHANISM



● Pre-disassembly inspection

📖 P11A-40

● Disassembly sequence

- |                            |                             |                         |
|----------------------------|-----------------------------|-------------------------|
| 1 Bolt                     | 10 Head idler gear assembly | *a: Idler gear assembly |
| 2 Injection nozzle 📦 Gr13A | 11 Head idler gear bushing  | 📖 P11A-56               |
| 3 O-ring                   | 12 Head idler gear          | *b: Upper crankcase     |
| 4 Nozzle tip gasket        | 13 Thrust plate             | 📖 P11A-80               |
| 5 Nut                      | 14 Cylinder head bolt       | *c: Front case assembly |
| 6 Connecting plate         | 15 Cylinder head assembly   | 📖 P11A-52               |
| 7 Glow plug                | 📖 P11A-44                   |                         |
| 8 Bolt                     | 16 Cylinder head gasket     | Ⓟ : Locating pin        |
| 9 Head idler shaft         |                             | ⊗ : Non-reusable part   |

CAUTION ⚠

The cylinder head bolts 13, 14 utilize the torque-turn tightening method. Any cylinder head bolt that has apparently been tightened three times already must be replaced with a new one. 📖 P11A-41

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
9, 11	Head idler shaft and head idler gear bushing clearance	[32 {1.26}] 0.01 to 0.05 {0.00039 to 0.002}	0.1 {0.0039}	Replace

T Tightening torques

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (injection nozzle installation)	14.7 {11, 1.5}	–
5	Nut (connection plate installation)	1.0 to 1.5 {0.7 to 1.1, 0.1 to 0.15}	–
7	Glow plug	22.6 {17, 2.3}	–
8	Bolt (Head idler shaft installation)	44.1 {33, 4.5}	Wet
14	Cylinder head bolt	147 {110, 15} + 90°	Wet

🔧 Lubricant and/or sealant

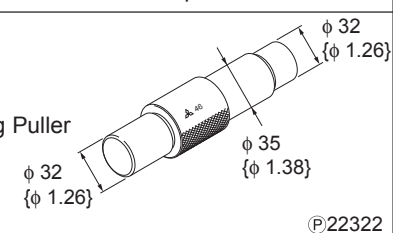
Location	Points of application	Specified lubricant and/or sealant	Quantity
3	O-ring	Engine oil	As required
8	Thread and bearing surface of bolt	Engine oil	As required
9	Outer surface of head idler shaft	Engine oil	As required
*c	Upper surface of joint section between front case assembly and crankcase assembly and cylinder head gasket contacting surface	Threebond 1211	As required

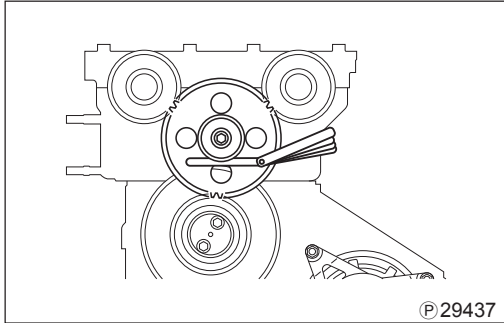


# CYLINDER HEAD AND VALVE MECHANISM

## Special tools

Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
11	 <p>Idler Gear Bushing Puller</p> <p>Part No. MH061779 (Obtain Locally)</p> <p>©22322</p>		Removal and installation of idler gear bushing

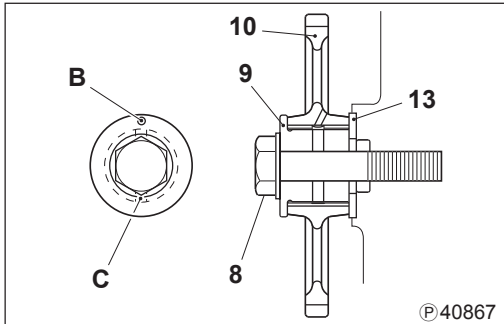


### ◆ Service procedure

#### ● Pre-disassembly inspection

##### End play of head idler gear assembly

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



#### 9 Installing head idler shaft

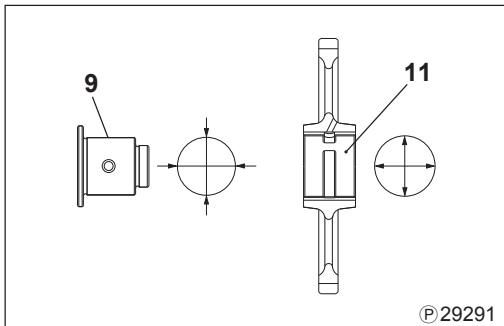
Install the head idler shaft 9 as illustrated.

**B**: Depression

**C**: Oil hole

### CAUTION ⚠

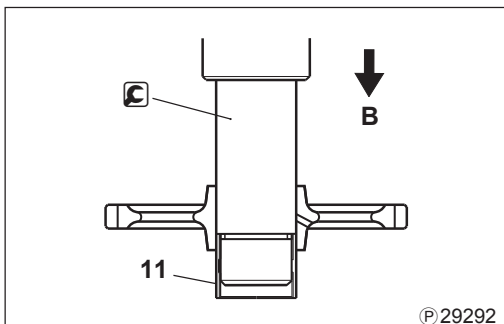
Don't forget to install the thrust plate 13.



#### 9 11 Head idler shaft and head idler gear bushing

[Inspection]

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

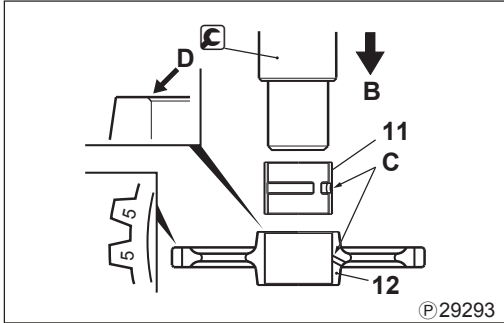


#### Head idler gear bushing


[Removal]

**B** : Press

**C** : Idler Gear Bush Puller

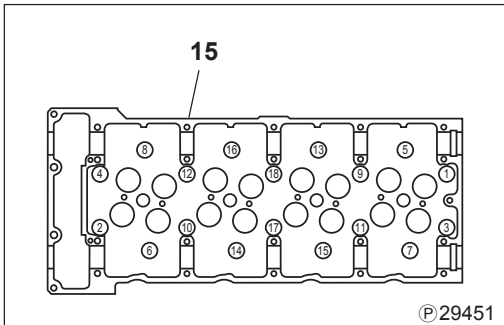


[Installation]

- Fit the idler gear bushing 11 in the head idler gear 12 in the illustrated direction so that the oil holes C may be aligned with each other when press-fitted.
- Using the  Idler Gear Bush Puller, press the bushing into the head idler gear 12 until its end face becomes flush with the chamfered end D of the gear.

**B** : Press

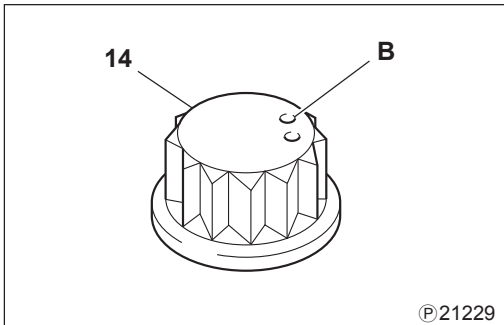
- After press-fitting, measure the clearance again. If the measurement is below the specified limit, ream the head idler gear bushing 11 to the standard value.



**15** Cylinder head assembly

[Removal]

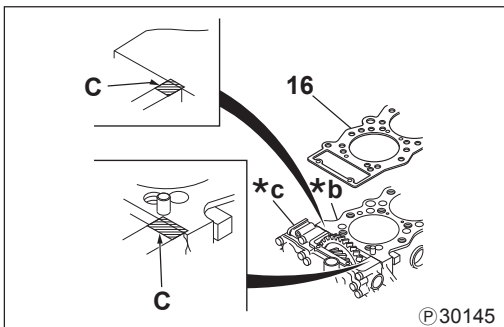
Loosen and remove the cylinder head bolts 14 in the sequence shown (① to ②). Each cylinder head bolt should be loosened a little at a time.




[Fitting]

**CAUTION** 

- Before fitting any cylinder head bolt 14, check the punch marks B on its head. Do not use bolt if there are more than two punch marks.
- The punch marks indicate the number of times each bolt has been tightened using the torque-turn tightening method. Any bolt that already has three punch marks must be replaced.

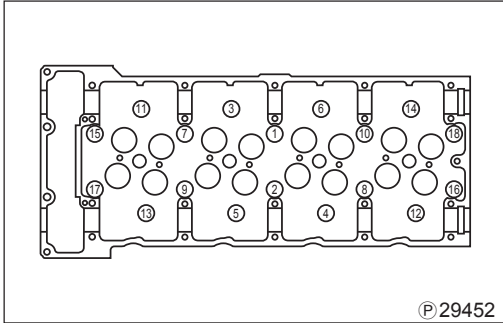


- Select an appropriate cylinder head gasket 16.  P11A-42
- Apply a coat of specified sealant to the upper surface C of the joint section between the frontcase assembly \*c and the crankcase assembly \*b.
- Within 3 minutes after the sealant application, install the cylinder head assembly to the crankcase assembly \*b together with the cylinder head gasket 16.

**CAUTION** 

- Check to ensure that the sealant application surface C is clean and free of oil and other foreign matter.
- During installation of the cylinder head assembly, use care to ensure that the sealant is kept in place.
- Do not start the engine for at least 1 hour after the cylinder head assembly is installed.
- Whenever the cylinder head bolt 14 is loosened or removed after the cylinder head assembly has been installed, always apply a fresh coat of specified lubricant.

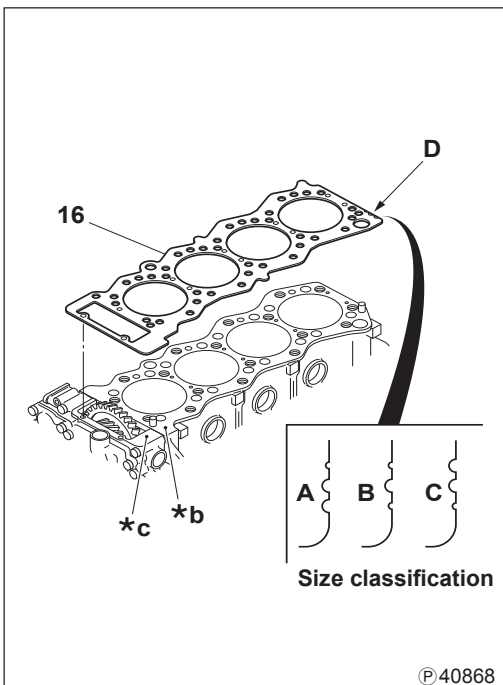
# CYLINDER HEAD AND VALVE MECHANISM



- Tighten the cylinder head bolts **14** (① through ⑱) to a torque of 145 N·m {110 ft.lbs, 15 kgf·m}(wet) in the sequence shown. After tightening, give the bolts an additional 90 degree turn in the sequence of the numbers shown.
- After tightening the cylinder head bolts **14** using the torque-turn tightening method, make a punch mark on the head of each one to indicate the times of use.

## CAUTION ⚠

Since the cylinder head bolts utilize the torque-turn tightening method, they must not be tightened further after the angular tightening procedure has been performed.



## 16 Cylinder head gasket

[Removal]

## CAUTION ⚠

Be careful not to scratch cylinder head assembly **15**, the crankcase assembly **\*b** and the front case assembly **\*c** when removing cylinder head gasket **16**.

[Installation]

Cylinder head gasket **16** installed must be the one which can accommodate the piston projection. Select such a gasket as follows:

- Measure the piston projection at each cylinder. P11A-66
- Select a cylinder head gasket **16** appropriate for the piston projection average value from the following table.
- If any of the piston projection measurements is more than 0.05 mm {0.002 in.} larger than the average value, then use the gasket one rank higher than that rank (**A** → **B**, **B** → **C**).

Unit: mm {in.}

Average value of piston projection	Cylinder head gasket	
	Size classification	Thickness when tightening
-0.088 to -0.027 {-0.0034 to 0.0106}	A	0.75 ± 0.03 {0.029 ± 0.0012}
-0.027 to -0.033 {-0.0106 to 0.0129}	B	0.80 ± 0.03 {0.031 ± 0.0012}
-0.035 to -0.094 {-0.0129 to 0.0370}	C	0.85 ± 0.03 {0.033 ± 0.0012}

- The classification (size) of the cylinder head gasket **16** can be known from the shape of the notches **D** cut in the gasket edge.
- Install the cylinder head gasket **16** on the crankcase **\*b** in the direction as illustrated.

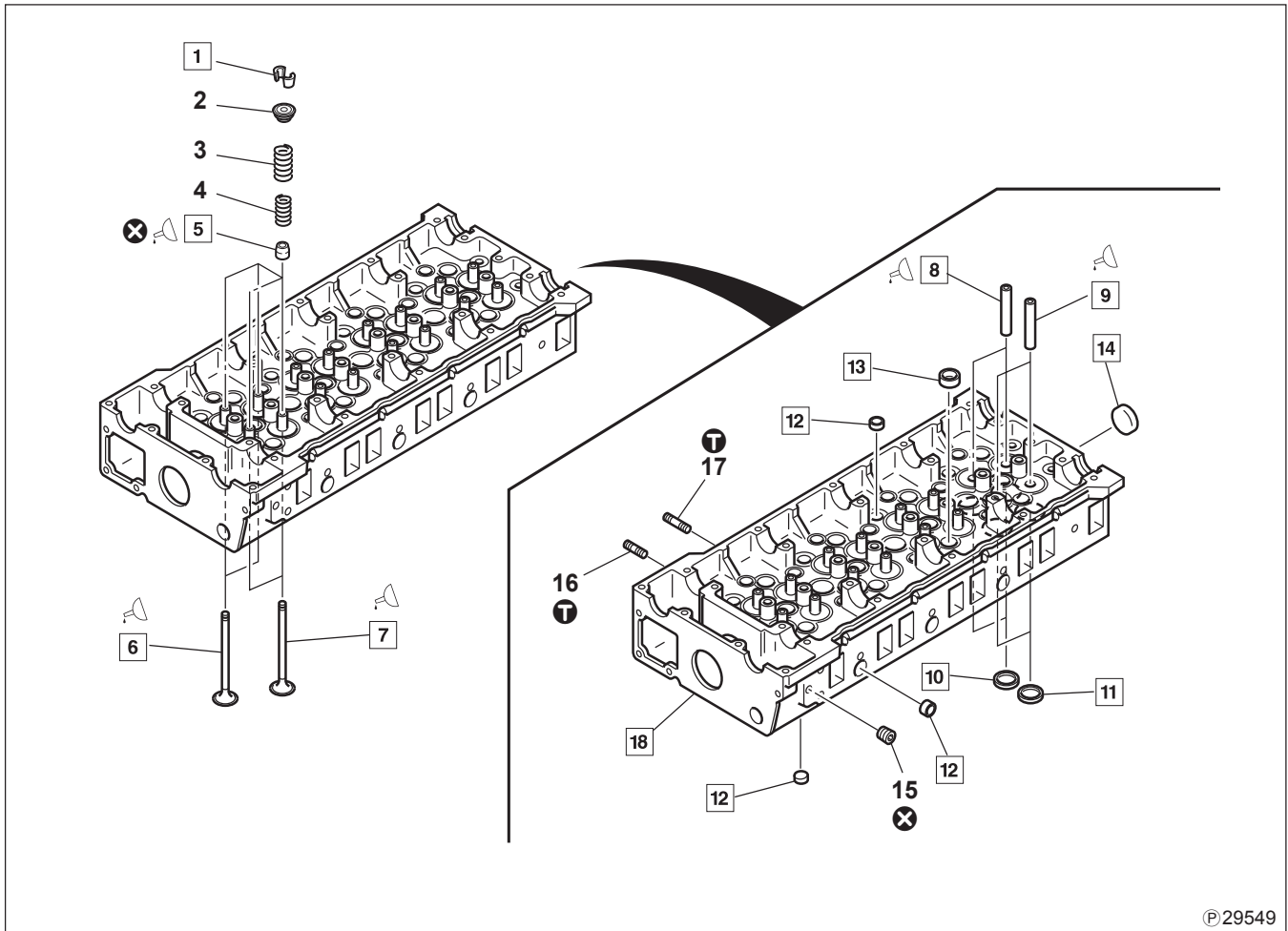
**E** : Part number

# MEMO

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# CYLINDER HEAD AND VALVE MECHANISM

## Cylinder Head Assembly



© 29549

### ● Disassembly sequence

- 1 Valve collets
- 2 Upper retainer
- 3 Outer valve spring
- 4 Inner valve spring
- 5 Valve stem seal
- 6 Exhaust valve
- 7 Inlet valve
- 8 Exhaust valve guide
- 9 Inlet valve guide

- 10 Exhaust valve seat
- 11 Inlet valve seat
- 12 Sealing cup plug  
(22 mm { $\phi$  0.87 in.})
- 13 Sealing cup plug  
(30 mm { $\phi$  1.18 in.})
- 14 Sealing cup plug  
(40 mm { $\phi$  1.57 in.})
- 15 Taper plug

- 16 Stud (short)
- 17 Stud (long)
- 18 Cylinder head

⊗ : Non-reusable part

### ● Assembly sequence

Follow the disassembly sequence in reverse.

### CAUTION

Any valve stem seal 5 removed from an exhaust valve 6 or inlet valve 7 must be replaced.

## Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy	
3	Outer valve spring	Free length	87.8 {3.45}	–	Replace
		Installed load (at 57 {2.24} installed length)	360N {36.7 kgf}	–	Replace
		Squareness	–	2.5 {0.098}	Replace
4	Inner valve spring	Free length	78.8 {3.10}	–	Replace
		Installed load (at 52.3 {2.05} installed length)	168N {17.1 kgf}	–	Replace
		Squareness	–	2.5 {0.098}	Replace
6	Exhaust valve	Stem outside diameter	$\phi 8 \begin{matrix} -0.060 \\ -0.075 \end{matrix} \{ \phi 0.31 \begin{matrix} -0.0024 \\ -0.0029 \end{matrix} \}$	–	Replace
		Sinkage from cylinder head bottom surface	$0.2 \pm 0.25 \{0.0079 \pm 0.00098\}$	–	Inspect
		Valve margin	1.5 {0.059}	–	Reface or replace
		Seat angle	45°	–	Correct
6, 8	Exhaust valve stem-to-valve guide clearance	$[8 \{0.31\}] 0.07 \text{ to } 0.10$ $\{0.0028 \text{ to } 0.0039\}$	0.2 {0.0079}	Replace	
7	Inlet valve	Stem outside diameter	$\phi 8 \begin{matrix} -0.025 \\ -0.040 \end{matrix} \{ \phi 0.31 \begin{matrix} -0.00098 \\ -0.00160 \end{matrix} \}$	–	Replace
		Sinkage from cylinder head bottom surface	$0.2 \pm 0.25 \{0.0079 \pm 0.00098\}$	–	Inspect
		Valve margin	1.5 {0.059}	–	Reface or replace
		Seat angle	45°	–	Correct
7, 9	Inlet valve stem-to-valve guide clearance	$[8 \{0.31\}] 0.03 \text{ to } 0.06$ $\{0.0012 \text{ to } 0.0024\}$	0.2 {0.0079}	Replace	
10	Exhaust valve seat width	$2.5 \pm 0.2 \{0.098 \pm 0.0079\}$	3.5 {0.13}	Correct or replace	
11	Inlet valve seat width	$2 \pm 0.2 \{0.079 \pm 0.0079\}$	2.8 {0.11}	Correct or replace	
18	Cylinder head	Bottom surface distortion	0.05 {0.0020} or less	0.2 {0.0079}	Correct or replace
		Height from top to bottom surface	$107 \pm 0.5 \{4.21 \pm 0.02\}$	106.5 {4.19}	Replace

 Tightening torque

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
15	Taper plug	14 {10, 1.4}	–
16, 17	Stud	20 {14, 2.0}	–

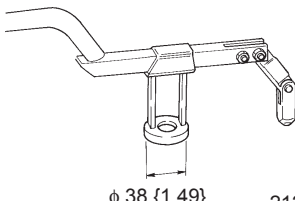
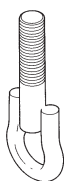
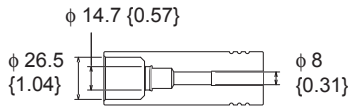
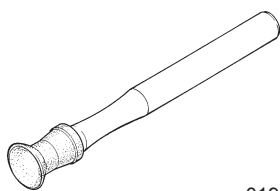
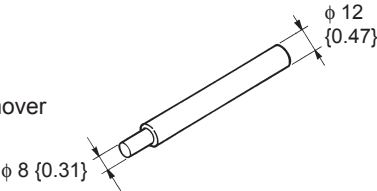
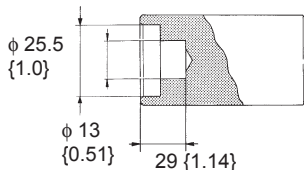
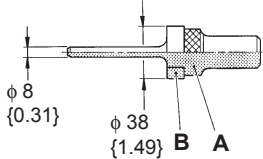
 Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
5	Lip of valve stem seal	Engine oil	As required
6,7	Valve stem	Engine oil	As required

# CYLINDER HEAD AND VALVE MECHANISM

## Special tools




Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
1	<p>A: Valve Lifter B: Valve Lifter Seat</p>  <p>φ 38 {1.49}      21239</p>	Obtain Locally	Removing and installing valve cotters
	<p>Valve Lifter Hook</p>  <p>21240</p>	Use Equivalent	
5	<p>Valve Stem Seal Installer</p>  <p>φ 26.5 {1.04}      φ 14.7 {0.57}      φ 8 {0.31}</p> <p>⒫29931</p>	Use Equivalent	Installing valve stem seals
6, 7	<p>Valve Lapper</p>  <p>01958</p>	Obtain Locally	Lapping inlet and exhaust valves and valve seats
8, 9	<p>Valve Guide Remover</p>  <p>φ 12 {0.47}      φ 8 {0.31}</p> <p>01959</p>	Obtain Locally	Removing valve guides
	<p>Valve Guide Installer</p>  <p>φ 25.5 {1.0}      φ 13 {0.51}      29 {1.14}</p> <p>01960</p>	MH063604	Installing valve guides
10, 11	<p>A: Caulking Tool Body B: Caulking Ring</p>  <p>φ 8 {0.31}      φ 38 {1.49}      B      A</p> <p>01961</p>	Use Equivalent	Installing inlet and exhaust valve seats

◆ Service procedures

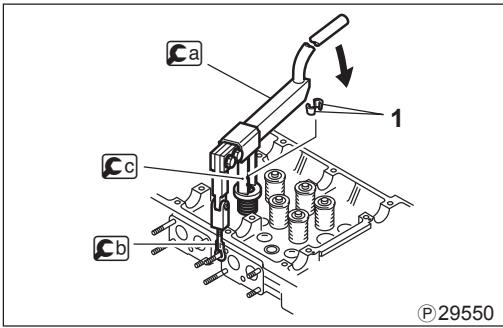
1 Valve keepers

[Removal]



To remove the valve keepers 1, use the  Valve Lifter,  Valve Lifter Hook and  Valve Lifter Seat to evenly compress the valve springs 3, 4.

[Installation]

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

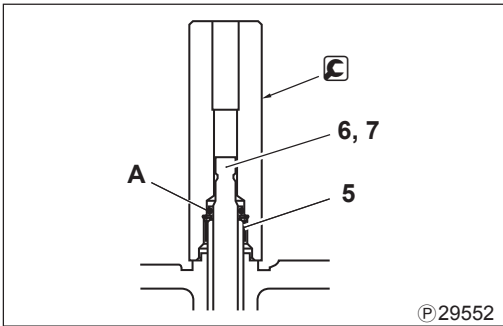


5 Installing valve stem seals

- Apply engine oil to the lip A of the valve stem seal 5.
- Install the valve stem seal 5 using the  Valve Stem Seal Installer.
- Strike the  Valve Stem Installer until it sits snugly on the cylinder head 18.

CAUTION 

After installing the valve stem seal 5, check that its spring area is neither deformed nor damaged.




6 7 Inlet and exhaust valves

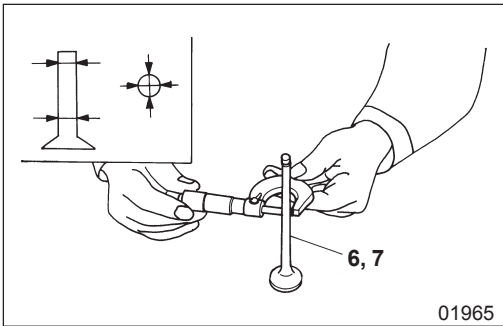
[Inspection]

(1) Valve stem outside diameter

Replace the valve 6, 7 if its stem's outside diameter is below specification or severely worn.

CAUTION 

Whenever a valve 6, 7 is replaced, be sure to lap the valve and valve seat 10, 11.  P11A-49

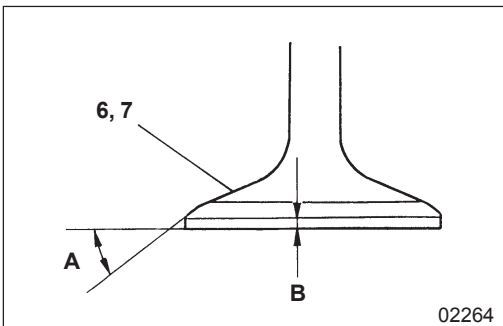


(2) Valve seat angle and valve margin

Reface or replace the valve 6, 7 if the valve seat angle or valve margin exceeds the specified limits.

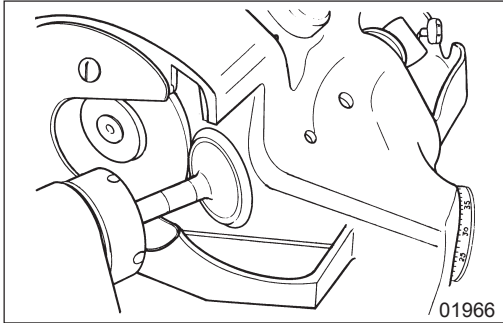
A : Valve seat angle

B : Valve margin





# CYLINDER HEAD AND VALVE MECHANISM

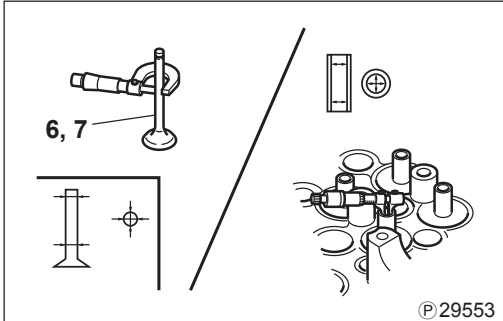


[Refacing]

## NOTE

- Keep grinding to a minimum.
- If the valve margin is below specification after grinding, replace the valve 6, 7.
- After grinding, be sure to lap the valve 6, 7 and valve seat 10, 11.

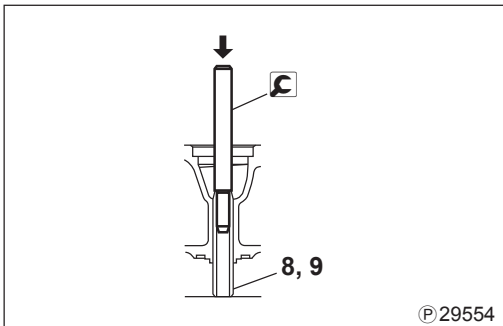
 P11A-45



## 6 to 9 Valve and valve guides

[Inspection]

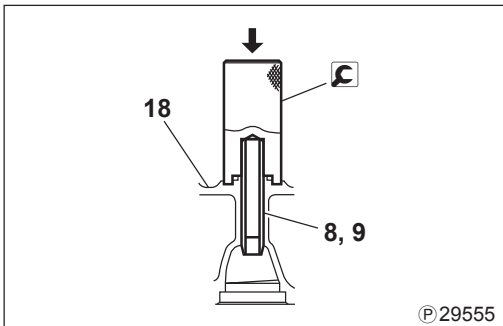
If any clearance exceeds the specified limit, replace the defective part(s).




## Valve guides

[Removal]


 : Valve Guide Remover

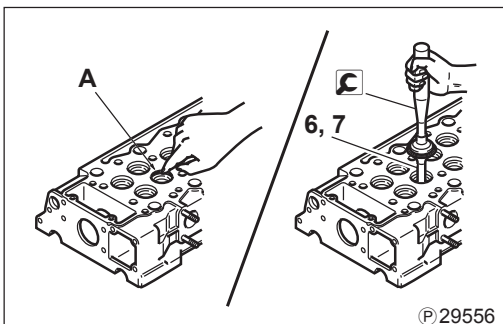


[Installation]

Using the  Valve Guide Installer, install the valve guide 8, 9 until the tool sits snugly on the cylinder head 18.

## CAUTION

- The valve guides 8, 9 must be pressed in to the specified depth. Be sure to use the  Valve Guide Installer for this operation.
- Exhaust valve guides 8 are longer than inlet valve guides 9. Be sure to install the correct type of guide in each location.



## 6 7 10 11 Valves and valve seats

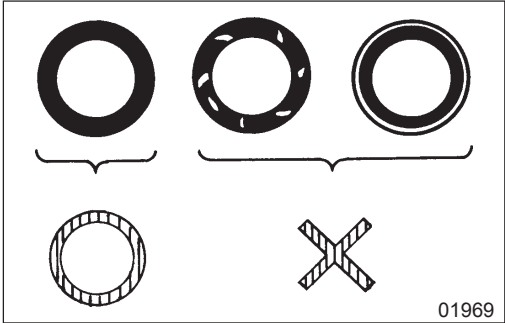
[Inspection]

- Apply an even coat of prussian blue to the valve seat 10, 11 surface A that makes contact with the valve 6, 7.
- Strike the valve 6, 7 against the valve seat 10, 11 once. Do not rotate the valve during this operation.

 : Valve Lapper

## NOTE

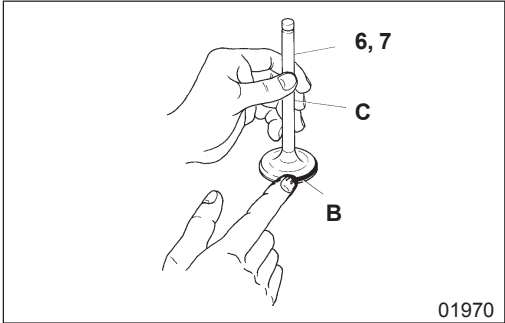
Carry out these inspections after inspecting the valves 6, 7 and valve guides 10, 11.



01969

- If the prussian blue deposited on the valve **6, 7** 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



01970

[Lapping]

Lap the valve in accordance with the following procedure:

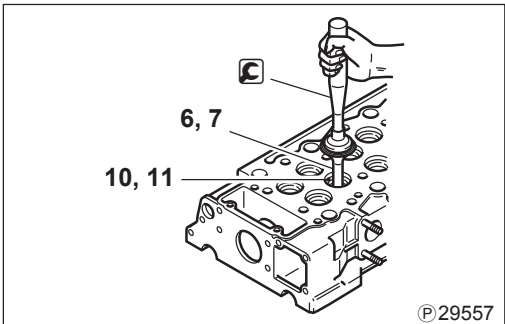
- Apply a thin, even coat of lapping compound to the surface **B** of the valve **6, 7** that makes contact with valve seat **10, 11**.

**CAUTION** ⚠

- Ensure that no compound adheres to the stem **C** of the valve **6, 7**.

**NOTE:**

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

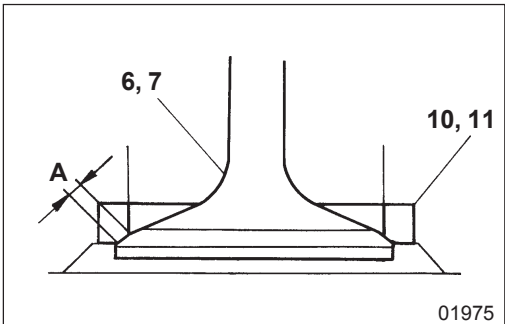


©29557

- Strike the valve **6, 7** against the valve seat **10, 11** while turning it little by little.

**C** : Valve Lapper

- Wash away the compound with cleaning fluid.
- Apply engine oil to the contact surfaces of the valve seat **10, 11** and rub it in so that the contact surfaces are lubricated and mate together snugly.
- Inspect the contact pattern of the valve **6, 7** and valve seat **10, 11** once more.
- If the contact pattern is still defective, replace the valve seat **10, 11**.



01975

**10 11 Valve seats**

[Inspection]

**(1) Valve seat width**

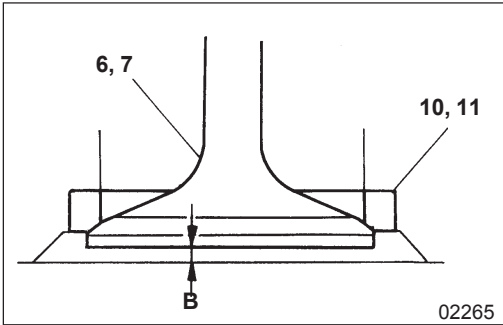
If the measurement exceeds the specified limit, rectify or replace the valve seat **10, 11**.

**A** : Valve seat width

**NOTE**

Whenever a valve seat **10, 11** is rectified or replaced, be sure to lap the valve seat and valve **6, 7**.

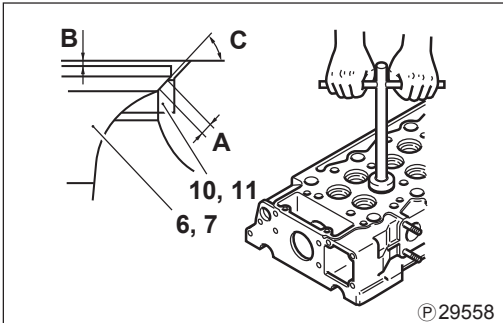
# CYLINDER HEAD AND VALVE MECHANISM



## (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



### [Grinding]

- Grind the valve seat **10, 11** using a valve seat cutter or valve seat grinder.
- Use a 15° or 75° cutter to achieve the specified valve seat width **A** of the valve **6, 7**.
- After grinding, put some sandpaper of around #400 grade between the cutter and valve seat and grind the valve seat lightly.

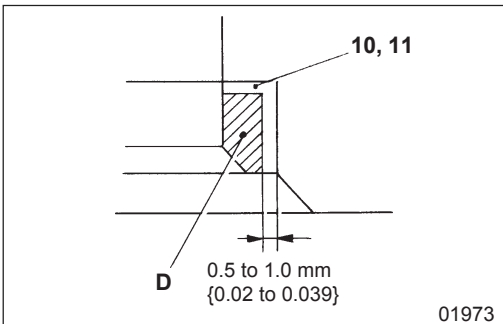
**C** : Valve seat angle

### CAUTION

**Ensure that grinding does not cause the sinkage B of the valve 6, 7 to exceed the specified limit.**

- After grinding, lap the valve **6, 7** and valve seat **10, 11**.

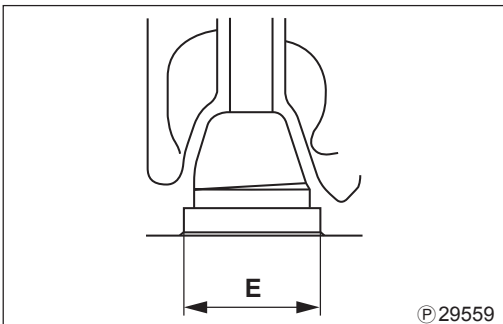
P11A-49



### [Removal]

Valve seats **10, 11** 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 be ground

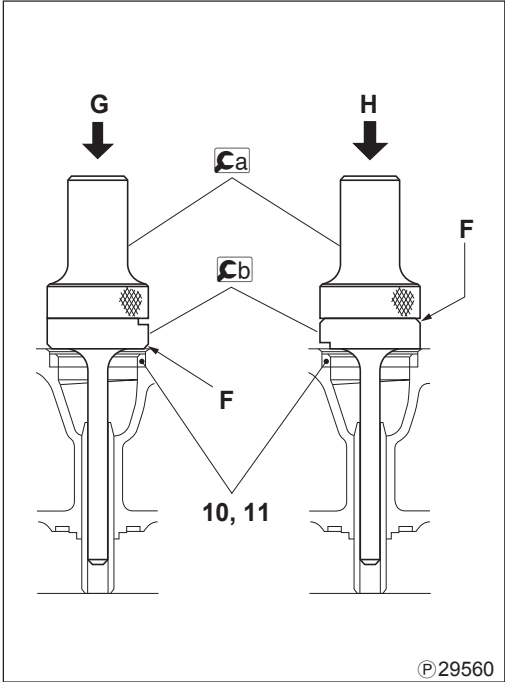


### [Installation]

- Check that the valve seat hole diameter **E** in the cylinder head **18** conforms with the value shown below.

Unit: mm {in.}

	Hole diameter
Valve seat hole: <b>E</b>	$38 \begin{matrix} +0.025 \\ 0 \end{matrix} \{1.49 \begin{matrix} +0.00098 \\ 0 \end{matrix} \}$



P29560

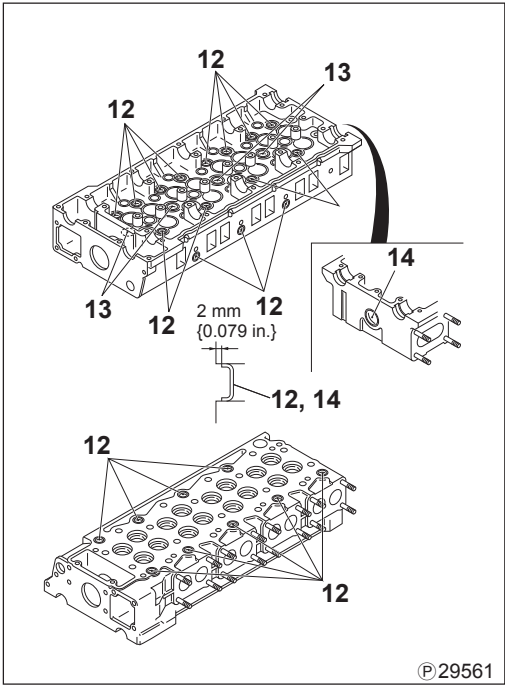
- Cool the valve seat **10, 11** by immersing it in liquid nitrogen.
- Install the valve seat **10, 11** in the cylinder head **18** using the **Ca** Caulking Tool Body and the **Cb** Caulking Ring.

**CAUTION** ⚠

- For installation, the chamfered side **F** of the **Cb** Caulking Ring must be against the valve seat **10, 11**.

- G** : Configuration for installation
- Invert the **Cb** Caulking Ring such that its chamfered side **F** is against the **Ca** Caulking Tool Body, then caulk the valve seat **10, 11**.
- H** : Configuration for caulking
- After installing the valve seat **10, 11**, lap the valve seat and valve **6, 7**.

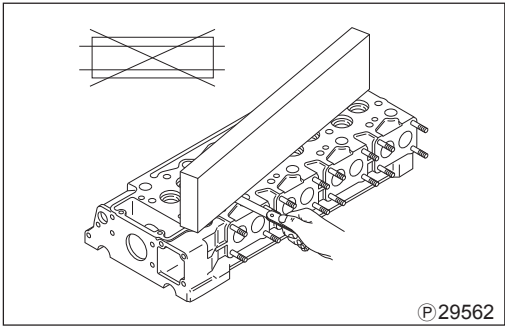
📖 P11A-49



P29561

**12 to 14** Installing sealing cup plugs

Drive the sealing cups **12 to 14** in the cylinder head **18** until the specified depth is reached.



P29562

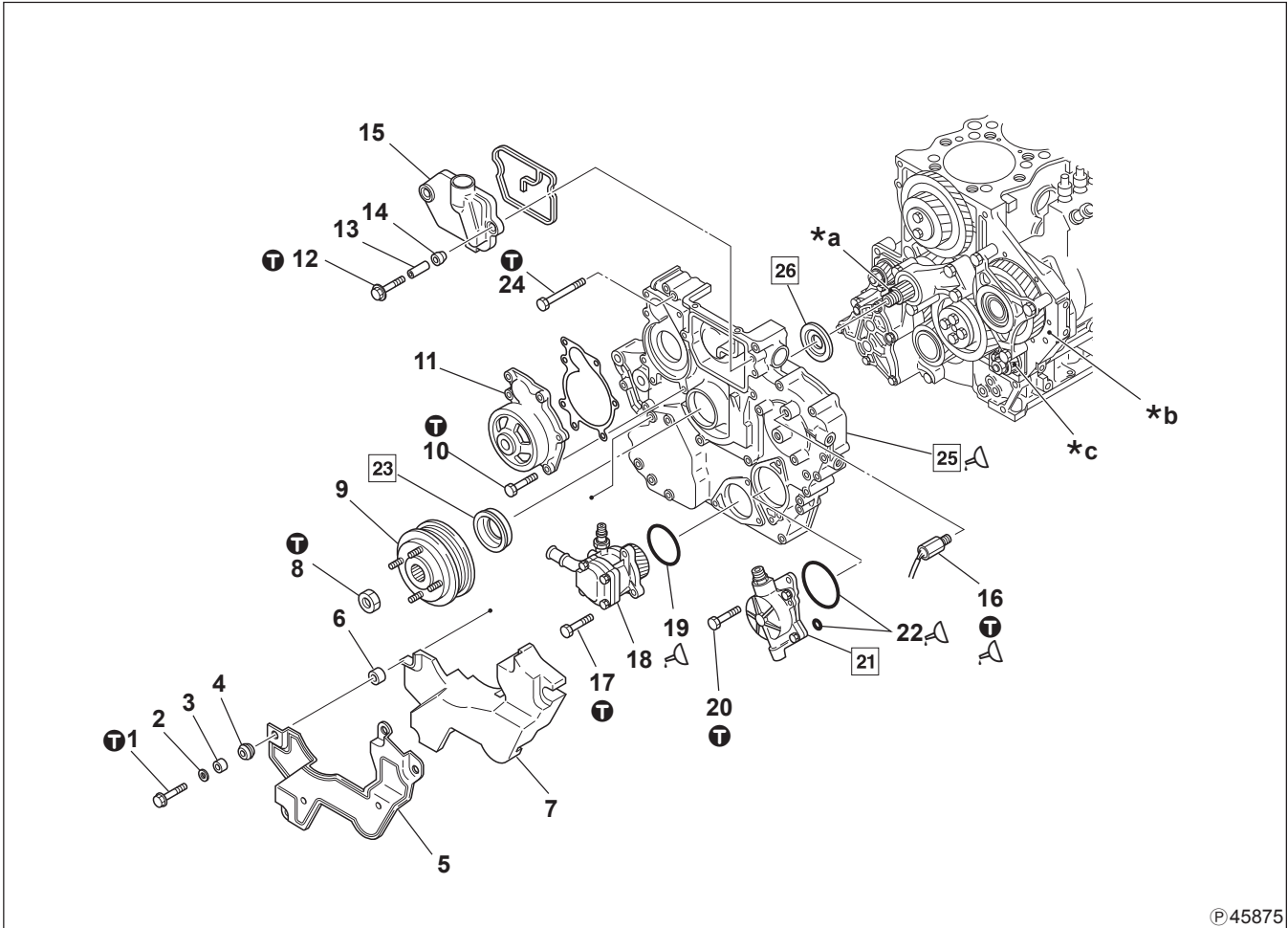
**18** Inspecting cylinder head

Measure the extent of distortion in the cylinder head **18** 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 **18** top surface-to-bottom surface distance to fall below the specified limit.

# FRONT CASE



P45875

## ● Disassembly sequence

- |                                |                                     |                               |
|--------------------------------|-------------------------------------|-------------------------------|
| 1 Bolt                         | 13 Spacer                           | 22 O-ring                     |
| 2 Washer                       | 14 Rubber                           | 23 Front oil seal             |
| 3 Spacer                       | 15 Breather cover                   | 24 Bolt                       |
| 4 Insulator                    | 16 Engine speed sensor              | 25 Front case                 |
| 5 Front case cover             | Gr 54                               | 26 Front oil seal slinger     |
| 6 Spacer                       | 17 Bolt                             |                               |
| 7 Front case rubber insulation | 18 Power steering oil pump assembly | *a: Fan shaft assembly        |
| 8 Nut                          | Gr 37                               | Gr 56                         |
| 9 Fan pulley                   | 19 O-ring                           | *b: Upper crankcase           |
| 10 Bolt                        | 20 Bolt                             | Gr 80                         |
| 11 Water pump assembly         | 21 Vacuum pump assembly             | *c: Balance shaft assembly LH |
| Gr 14A                         | Gr 35A                              | Gr 56                         |
| 12 Bolt                        |                                     | X: Non-reusable part          |

## CAUTION

- When the vacuum pump assembly 21 is removed, be sure to follow the specified procedure. Blind removal will result in failure of the assembly being positioned with the balance shaft assembly LH \*c.
- Do not remove the front oil seal 23 unless something wrong is evident.

## ● Assembly sequence

Follow the disassembly sequence in reverse.

**T Tightening torques**

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (mounting front case cover)	2.9 to 3.9 {2.2 to 2.9, 0.3 to 0.4}	–
8	Nut (mounting fan pulley)	196.1 {145, 20.0}	–
10	Bolt (mounting water pump assembly)	23.5 {17, 2.4}	–
12	Bolt (mounting breather cover)	2.9 {2.2, 0.3}	–
16	Engine speed sensor	29.4 {22, 3.0}	–
17	Bolt (mounting power steering oil pump assembly)	23.5 {17, 2.4}	–
20	Bolt (mounting vacuum pump assembly)	23.5 {17, 2.4}	–
24	Bolt (mounting front case)	23.5 {17, 2.4}	–

**Lubricant and sealant**

Location	Points of application	Specified lubricant and/or sealant	Quantity
16	Threaded portion of engine speed sensor	THREEBOND 1104J	As required
19, 22	All around O-ring	Engine oil	As required
23	Lip of front oil seal	Engine oil	As required
25	Front case mounting surface	THREEBOND 1207C or D	As required

**◆ Service procedure**

**21 Installation of vacuum pump assembly**

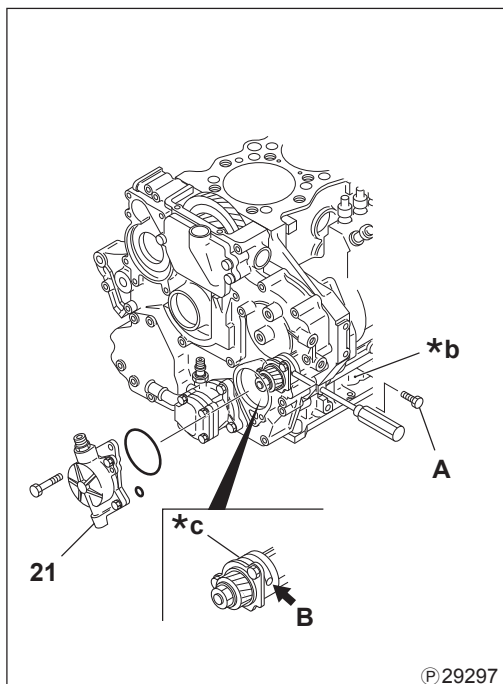
The vacuum pump assembly **21** serves also to position the balance shaft assembly LH **\*c**. For this reason, before the assembly is installed, the balance shaft assembly must be kept in the right position by the following procedure.

- Place the piston of cylinder No. 1 at the top dead center on the compression stroke.
- Remove plug **A** from the upper crankcase **\*b**.
- Insert a screwdriver into the hole from which the plug **A** was removed until it slightly touches the balance shaft assembly LH **\*c**.

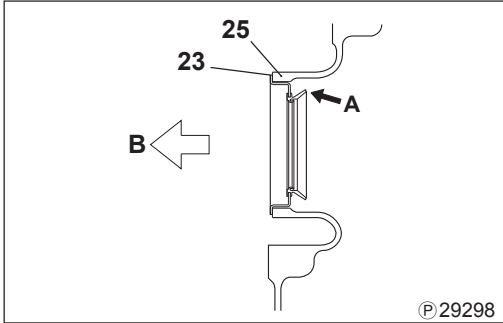
**CAUTION** ⚠

**Be sure not to force the screwdriver in, as there is danger of damage to the No. 1 journal of the balance shaft assembly LH **\*c**.**

- Slowly rotate the balance shaft assembly LH **\*c** to align the tip of the screwdriver with the shaft support hole **B** in the No. 1 journal of the balance shaft.
- Supporting the balance shaft by inserting the screwdriver in the hole, install the vacuum pump assembly **21**.
- After the installation, remove the screwdriver.



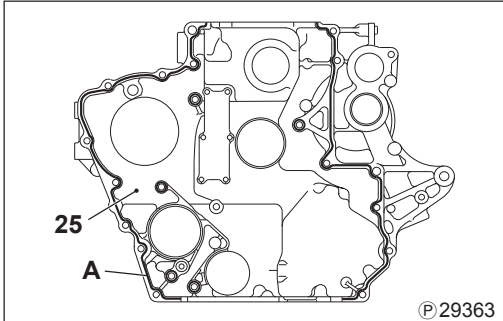
# FRONT CASE



## 23 Installation of front oil seal

Install the front oil seal 23 on the front case 25 in the illustrated direction after applying engine oil to the lip A.

**B** : Front of vehicle

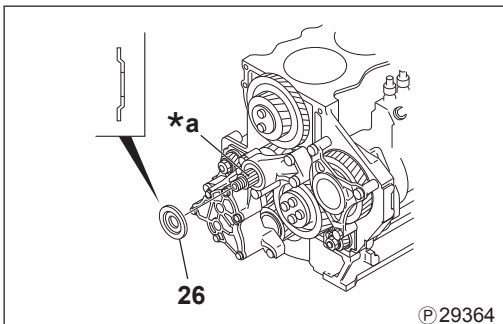


## 25 Installation of front case

- Apply sealant A evenly without any break to the mounting surface of the front case 25 as shown. (Approximately  $\phi$  1 mm { $\phi$  0.0393})
- After application of sealant A, install the front case 25 in less than three minutes.

## CAUTION

- Check to ensure that the sealant application surface is clean and free from any oil and other deposits.
- When installing the parts, make sure that the sealant is not forced out of position.
- Do not start the engine less than an hour after installation.
- If the mounting bolts were loosened or removed after installation of the front case 25, be sure to re-apply sealant A.



## 26 Installation of front oil seal slinger

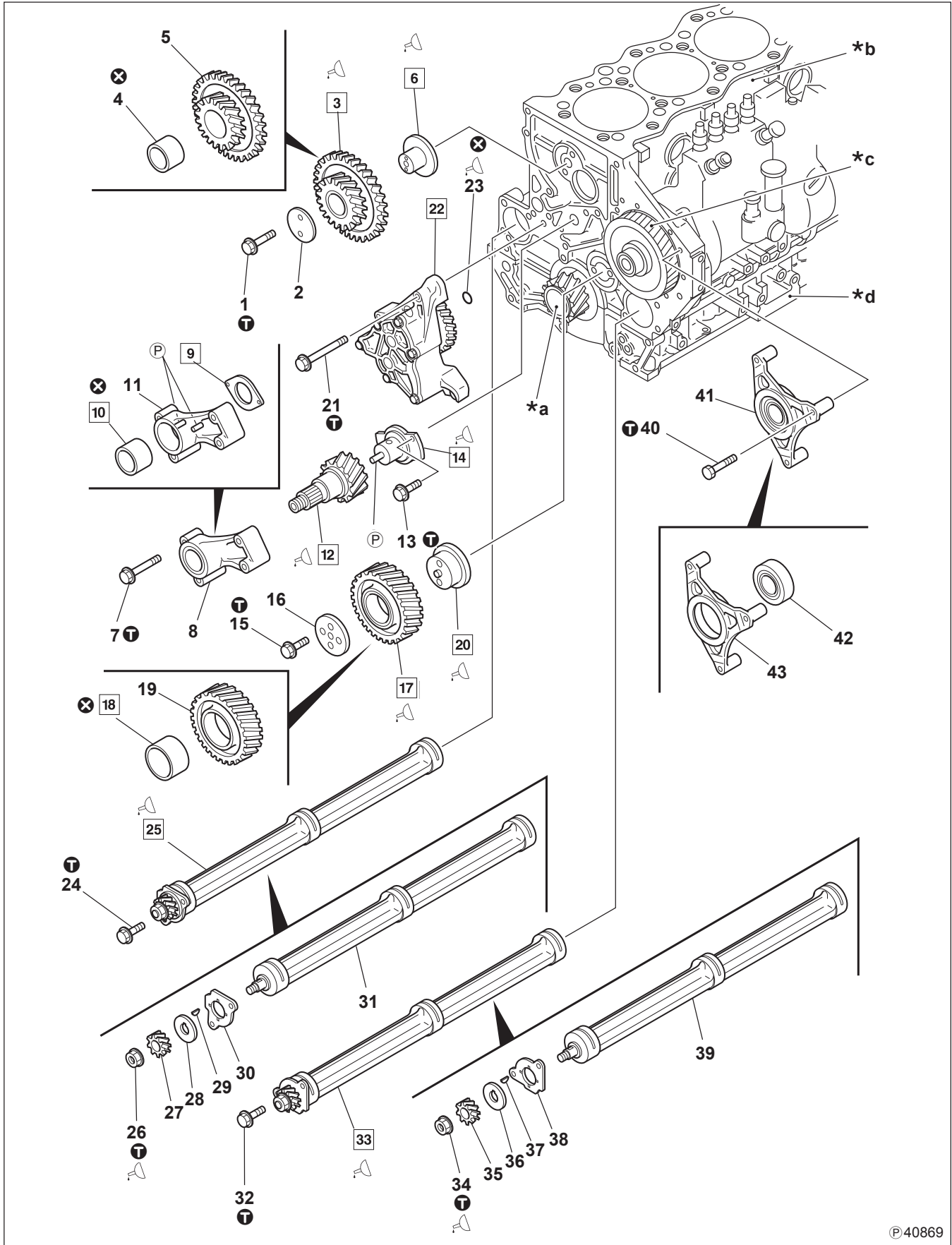
Install the front oil seal slinger 26 on the fan shaft assembly \*a in the illustrated direction.

# MEMO

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# TIMING GEARS AND BALANCE SHAFTS



© 40869

## ● Pre-disassembly inspection

📖 P11A-59

## ● Disassembly sequence

- |                              |                              |  |
|------------------------------|------------------------------|--|
| 1 Bolt                       | 20 No. 1 idler shaft         | 39 Balance shaft LH                        |
| 2 Thrust plate               | 21 Bolt                      | 40 Bolt                                    |
| 3 Idler gear assembly        | 22 Oil pump assembly         | 41 Injection pump bearing housing assembly |
| 4 Idler gear bushing         | 📦 Gr 12A                     | 42 Bearing                                 |
| 5 Idler gear                 | 23 O-ring                    | 43 Injection pump bearing housing          |
| 6 Idler shaft                | 24 Bolt                      |  |
| 7 Bolt                       | 25 Balance shaft assembly RH |  |
| 8 Fan shaft case assembly    | 26 Nut                       |  |
| 9 Thrust plate               | 27 Balance shaft gear RH     | *a : Crankshaft gear 📖 P11A-80             |
| 10 Fan shaft case bushing    | 28 Thrust spacer             | *b : Upper crankcase                       |
| 11 Fan shaft case            | 29 Key                       | 📖 P11A-80                                  |
| 12 Fan shaft assembly        | 30 Thrust plate              | *c : Injection pump gear                   |
| 13 Bolt                      | 31 Balance shaft RH          | 📦 Gr 13A                                   |
| 14 Fan gear shaft            | 32 Bolt                      | *d : Lower crankcase                       |
| 15 Bolt                      | 33 Balance shaft assembly LH | 📖 P11A-80                                  |
| 16 Thrust plate              | 34 Nut                       |  |
| 17 No. 1 idler gear assembly | 35 Balance shaft gear LH     | Ⓟ : Locating pin                           |
| 18 No. 1 idler gear bushing  | 36 Thrust spacer             | ⊗ : Non-reusable part                      |
| 19 No. 1 idler gear          | 37 Key                       |  |
|                              | 38 Thrust plate              |  |

## CAUTION ⚠

For details on the balance shaft removal and installation procedures, refer to 📖 P11A-88.

## ● Assembly sequence

Follow the disassembly sequence in reverse.

# TIMING GEARS AND BALANCE SHAFTS

## Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
-	Idler gear assembly and fan shaft assembly	0.09 to 0.13 {0.0035 to 0.0051}	0.3 {0.012}	Replace
	Fan shaft assembly and No. 1 idler gear assembly	0.06 to 0.10 {0.0024 to 0.0039}	0.3 {0.012}	
	No. 1 idler gear assembly and crankshaft gear	0.11 to 0.13 {0.0043 to 0.0051}	0.3 {0.012}	
	No. 1 idler gear assembly and injection pump gear	0.09 to 0.12 {0.0035 to 0.0047}	0.3 {0.012}	
	Crankshaft gear and oil pump gear	0.12 to 0.15 {0.0047 to 0.0059}	0.3 {0.012}	
	Balance shaft gear RH and oil pump gear	0.19 to 0.22 {0.0075 to 0.0087}	0.3 {0.012}	
-	Idler gear assembly	0.10 to 0.20 {0.0039 to 0.0079}	0.3 {0.012}	Replace
	Fan shaft assembly	0.07 to 0.19 {0.0028 to 0.0075}	0.3 {0.012}	
	No. 1 idler gear assembly	0.15 to 0.25 {0.0059 to 0.0098}	0.3 {0.012}	
	Balance shaft RH	0.1 to 0.2 {0.0039 to 0.0079}	0.3 {0.012}	
	Balance shaft LH	0.1 to 0.2 {0.0039 to 0.0079}	0.3 {0.012}	
4, 6	Clearance between idler gear bushing and idler shaft	[51 {2.0}] 0.02 to 0.06 {0.00079 to 0.0024}	0.1 {0.0039}	Replace
10, 12	Clearance between fan shaft case bushing and fan shaft assembly	[41 {1.61}] 0.03 to 0.07 {0.0012 to 0.0028}	0.1 {0.0039}	Replace
12, 14	Clearance between fan shaft assembly and fan gear shaft	[36 {1.41}] 0.01 to 0.05 {0.00039 to 0.0020}	0.1 {0.0039}	Replace
18, 20	Clearance between No. 1 idler gear bushing and No. 1 idler shaft	[59 {2.32}] 0.03 to 0.07 {0.0012 to 0.0028}	0.1 {0.0039}	Replace
25	Bend of balance shaft assembly RH	0.025 {0.00098}	0.05 {0.002}	Replace
33	Bend of balance shaft assembly LH	0.025 {0.00098}	0.05 {0.002}	Replace

## Tightening torques

Unit: N·m {ft.lbs, kgf·m}

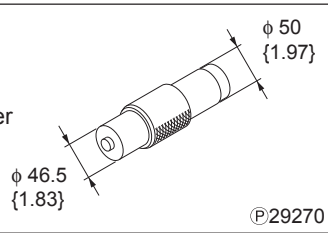
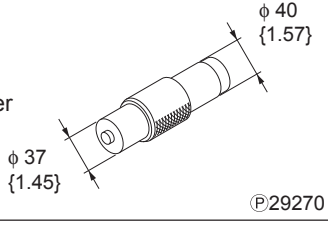
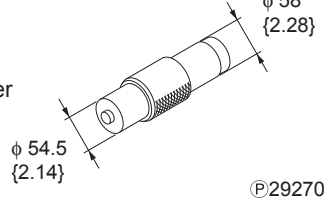
Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (mounting idler shaft)	23.5 {17, 2.4}	-
7	Bolt (mounting fan shaft case assembly)	23.5 {17, 2.4}	-
13	Bolt (mounting fan gear shaft)	23.5 {17, 2.4}	-
15	Bolt (mounting No. 1 idler shaft)	53.9 {40, 5.5}	-
21	Bolt (mounting oil pump assembly)	27.4 {20, 2.8}	-
24	Bolt (mounting balance shaft assembly RH)	23.5 {17, 2.4}	-
26	Nut (mounting balance shaft gear RH)	96.1 {71, 9.8}	Wet
32	Bolt (mounting balance shaft assembly LH)	23.5 {17, 2.4}	-
34	Nut (mounting balance shaft gear LH)	96.1 {71, 9.8}	Wet
40	Bolt (mounting injection pump bearing housing assembly)	27.4 {20, 2.8}	-

 **Lubricant**

Location	Points of application	Specified lubricant	Quantity
3, 17	Inside surface of bushing of each gear	Engine oil	As required
6, 12, 14, 20	Outside circumference of each shaft	Engine oil	As required
23	All around O-ring	Engine oil	As required
25, 33	Journal portions of balance shaft	Engine oil	As required
26, 34	Threaded portion of nut	Engine oil	As required

 **Special tools**

Unit: mm {in.}

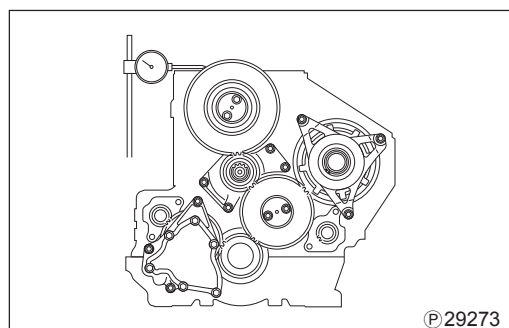
Location	Tool name and shape	Part No.	Application
4	Idler Gear Bushing Puller 	Use Equivalent	Installation and removal of idler gear bushing
10	Idler Gear Bushing Puller 	Use Equivalent	Installation and removal of fan shaft case bushing
18	Idler Gear Bushing Puller 	Use Equivalent	Installation and removal of No. 1 idler gear bushing

◆ **Service procedure**

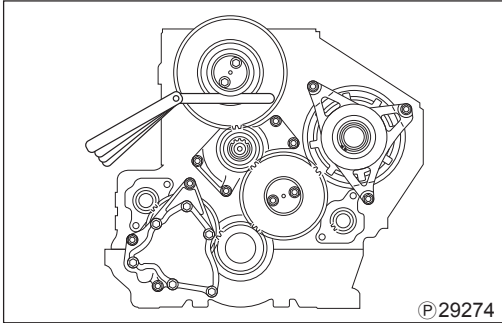
● **Pre-disassembly inspection**

(1) **Backlash between gears**

On a pair of gears, measure backlash at more than three positions. If the reading is more than the limit, replace defective parts.

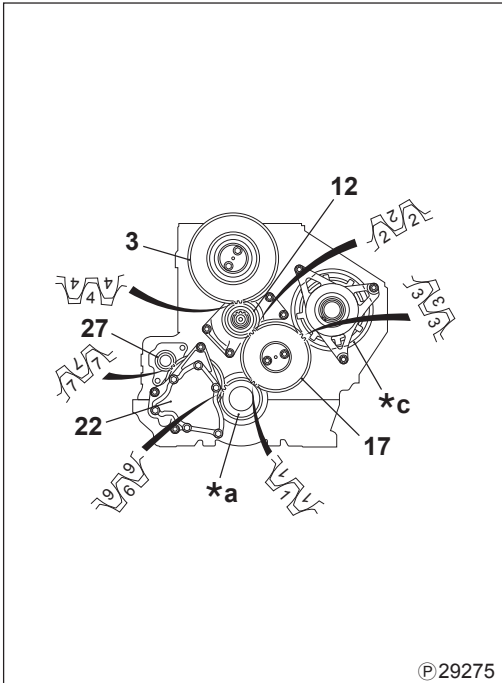


# TIMING GEARS AND BALANCE SHAFTS



## (2) End play of each gear and shaft

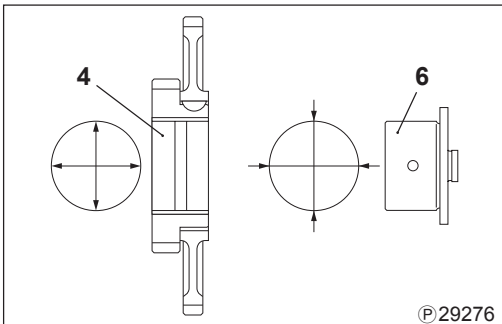
If the reading is more than the limit, replace defective parts.



## 3 12 17 22 Installation of timing gears

Install the timing gears in the following sequence.

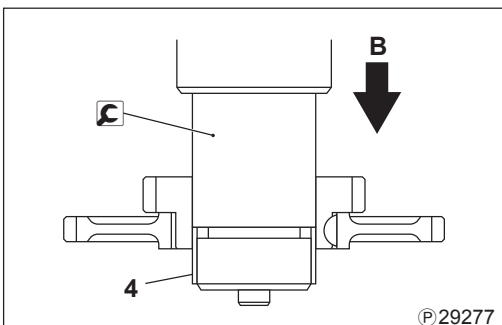
- Place the piston of No. 1 cylinder at the top dead center to position the crankshaft gear \*a.
- Install the gear of the oil pump assembly 22 while aligning the alignment marks "6" and "7" with those on the crankshaft gear \*a and balance shaft gear RH 27, respectively.
- Install No. 1 idler gear assembly 17 while aligning the alignment marks "1" and "3" with those on the crankshaft gear \*a and injection pump gear \*c, respectively.
- Install the fan shaft assembly 12 while aligning the alignment mark "2" with that of No. 1 idler gear assembly 17.
- Install the idler gear assembly 3 while aligning the alignment mark "4" with that of the fan shaft assembly 12.



## 4 6 Idler gear bushing and idler shaft

[Inspection]

If the reading is more than the limit, replace defective parts.

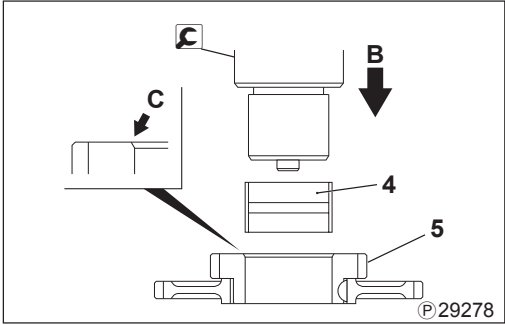


## Idler gear bushing


[Removal]

B : Press

C : Idler Gear Bushing Puller

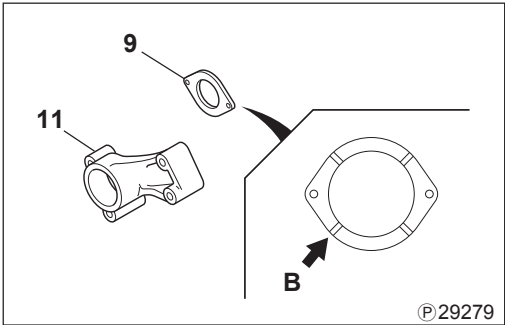


[Installation]

- Face the idler gear 5 in the illustrated direction. Using  Idler Gear Bushing Puller, press-fit the idler gear bushing 4 into the idler gear up to the chamfered portion C.

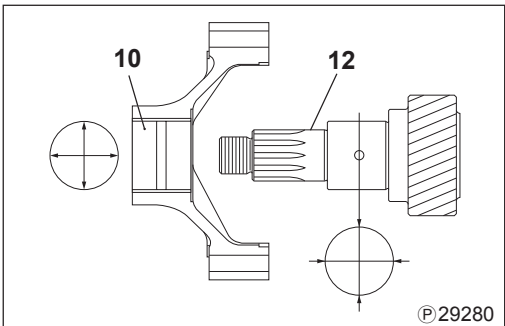
**B** : Press

- After press-fitting the bushing, re-measure the clearance. If the reading is less than the standard limits, ream the idler gear bushing 4 until the clearance falls within the standard limits.



**9** Installation of thrust plate

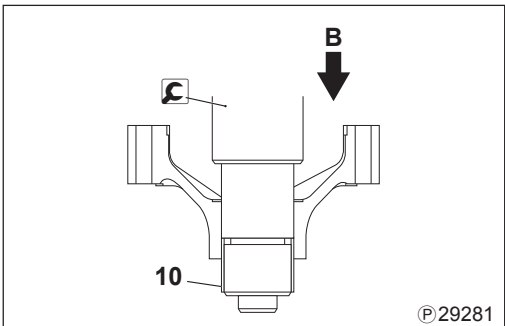
Install the thrust plate 9 with that side which does not have oil grooves B toward the fan shaft case 11.



**10** **12** Fan shaft case bushing and fan shaft assembly

[Inspection]


If the clearance is more than the limit, replace defective parts.

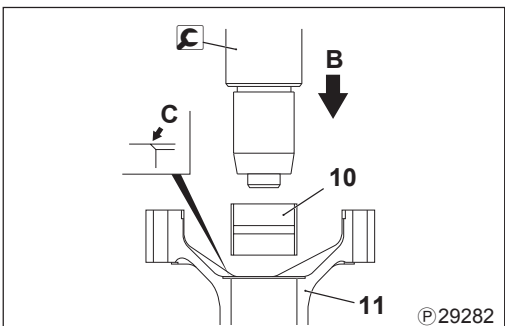


Fan shaft case bushing


[Removal]

**B** : Press

 : Idler Gear Bushing Puller



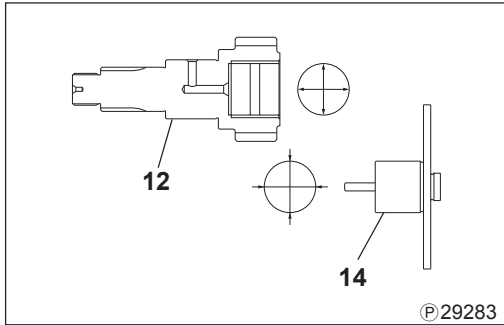
[Installation]

- Face the fan shaft case in the illustrated direction. Using  Idler Gear Bushing Installer, press-fit the fan shaft case bushing up to the chamfered portion C of the fan shaft case.

**B** : Press

- After press-fitting the bushing, re-measure the clearance. If the reading is less than the standard limits, ream the fan shaft case bushing 10 until the clearance falls within the standard limits.

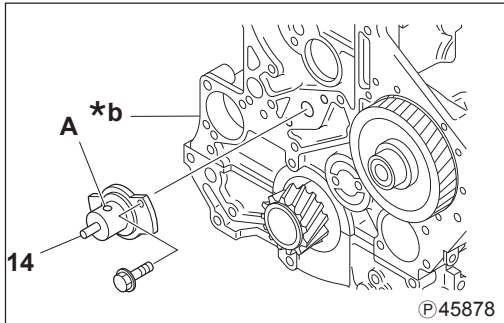
# TIMING GEARS AND BALANCE SHAFTS



## 12 14 Fan shaft assembly and fan gear shaft

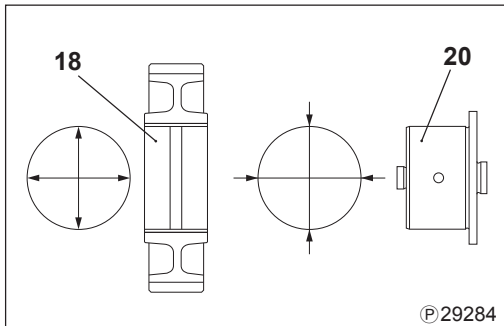
[Inspection]

If the clearance is more than the limit, replace defective parts.



## 14 Installation of fan gear shaft

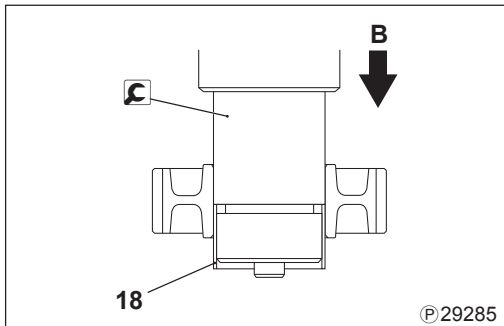
With oil hole **A** in fan gear shaft **14** facing up, install the fan gear shaft to upper crankcase **\*b**.



## 18 20 No. 1 idler gear bushing and No. 1 idler shaft

[Inspection]

If the clearance is more than the limit, replace defective parts.

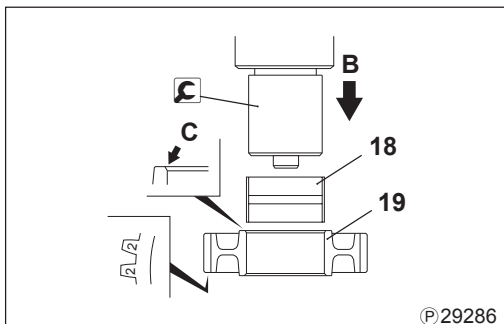


## Idler gear bushing

[Removal]

**B** : Press

**C** : Idler Gear Bushing Installer

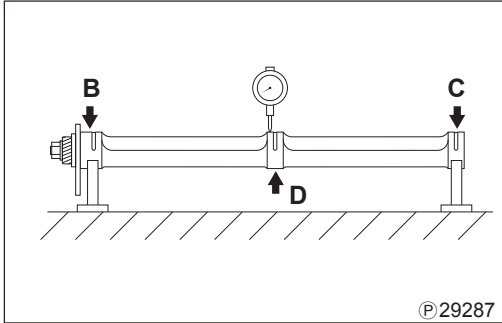


[Installation]

- Face the No. 1 idler gear **19** in the illustrated direction. Using **C** Idler Gear Bushing Installer, press-fit the idler gear bushing up to the chamfered portion **C** of the No. 1 idler gear.

**B** : Press

- After press-fitting the bushing, re-measure the clearance. If the reading is less than the standard limits, ream the No. 1 idler gear bushing **18** until the clearance falls within the standard limits.



## 25 33 Balance shaft assembly

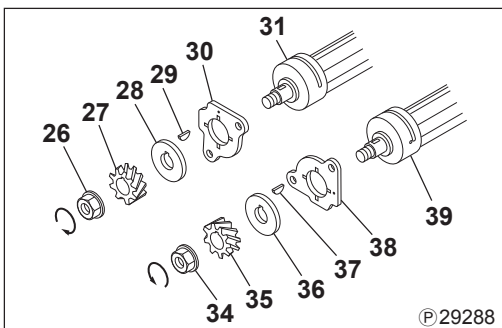
[Inspection]

- Check the balance shaft assemblies RH **25** and LH **33** for bend.
- Measure the balance shaft bend at No. 2 journal **D** while supporting the shaft at No. 1 journal **B** and No. 3 journal **C**.

### NOTE

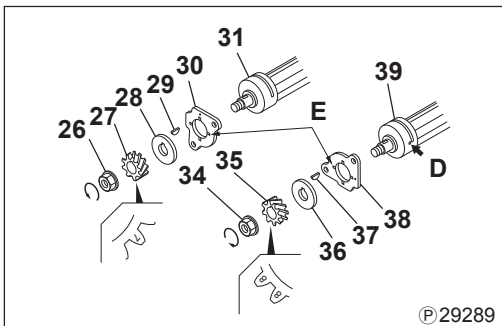
The bend of the balance shaft assemblies RH **25** and LH **33** is one half of the reading of the dial indicator taken after turning the balance shaft assembly through a rotation.

- If the reading exceeds the limit, disassemble the balance shaft assembly RH **25**, LH **33**, and replace the balance shaft RH **31**, LH **39**.



[Disassembly]

- The nut **26** of the balance shaft RH **31** and the nut **34** of the balance shaft LH **39** are different in the thread cutting direction.
- Remove the nut **26** by turning counter-clockwise. Remove the nut **34** by turning clockwise.



[Assembly]

- Of the balance shaft RH **31** and LH **39**, one with a shaft support hole **D** ( $\phi$  5 mm { $\phi$  0.2 in.}) in No. 1 journal is the balance shaft LH **39**.
- Install the thrust plates **30** and **38** in the illustrated direction.

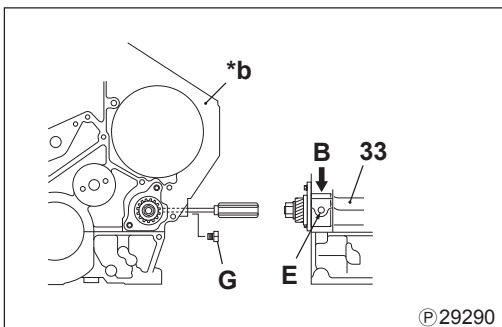
**E** : Oil groove

- Install the balance shaft gears RH **27** and LH **35** in the illustrated direction.
- Install the nut **26** by turning clockwise. Install the nut **34** by turning counter-clockwise.

[Installation]

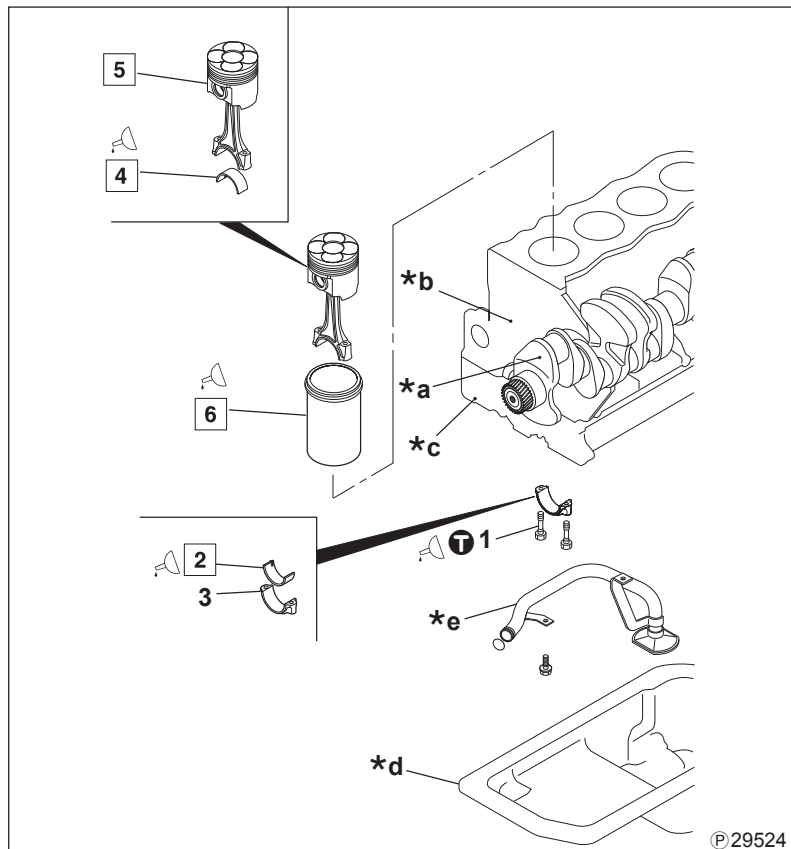
- The installation position of the balance shaft assembly RH **25** is determined by the gears being put in mesh when the oil pump assembly **22** is installed. (P11A-60)
- The balance shaft assembly LH **33** is not brought in mesh with any gear until when the vacuum pump assembly is installed with the front case attached. Therefore, the following steps must be performed before installation.

- Remove the plug **G** from the upper crankcase **\*b**.
- Insert a screwdriver in the hole from which the plug **G** was removed and into the shaft support hole **E** ( $\phi$  5 mm { $\phi$  0.2 in.}) provided in the No. 1 journal **B** of the balance shaft assembly LH **33** to support the balance shaft assembly.
- Align the alignment marks of all the timing gears. (P11A-60)
- By so doing, the balance shaft assembly LH **33** can be positioned. Keep it in position until the vacuum pump assembly is installed (P11A-53).





# PISTONS, CONNECTING RODS AND CYLINDER LINERS



## ● Pre-disassembly inspection

📖 P11A-65

## ● Removal sequence

- 1 Bolt
- 2 Lower connecting rod bearing
- 3 Connecting rod cap
- 4 Upper connecting rod bearing
- 5 Piston and connecting rod assembly

📖 P11A-71

- 6 Cylinder liner

\*a : Crankshaft assembly 📖 P11A-80

\*b : Upper crankcase 📖 P11A-80

\*c : Lower crankcase 📖 P11A-80

\*d : Oil pan 📦 Gr 12A

\*e : Oil strainer 📦 Gr 12A

## NOTE

Since the bolts 1 (for installing connecting rod cap 3) utilize the torque-turn tightening method, they must not be removed unless it is absolutely necessary.

## ● Installation sequence

Follow the removal sequence in reverse.

## Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy	
-	Piston protrusion	-0.09 to 0.09 {-0.0035 to 0.0035}	-	Inspect each location	
	Connecting rod end play	0.15 to 0.45 {0.0039 to 0.018}	0.6 {0.024}	Replace	
2, 4	Connecting rod bearing	Oil clearance	[65 {2.56}] 0.04 to 0.09 {0.0016 to 0.0035}	0.2 {0.0079}	Replace
		Span when free	-	Less than 69.5 {2.73}	
5, 6	Piston and connecting rod assembly-to-cylinder Liner clearance	[114 {4.49}] 0.135 to 0.155 {0.0053 to 0.0061}	-	Replace	
6	Cylinder liner	Flange projection	0.01 to 0.07 {0.00039 to 0.0028}	-	Replace
		Inside diameter	φ 114 to 114.02 {φ 4.4881 to 4.4889}	φ 114.25 {φ 4.498}	Replace
		Cylindricity	0.03 {0.0012} or less	-	Replace
		Difference in cylinder liner flange projection from adjacent cylinders	0.04 {0.0016} or less	-	Replace

## Tightening torques

Unit: N·m {ft.lbs, kgf·m}

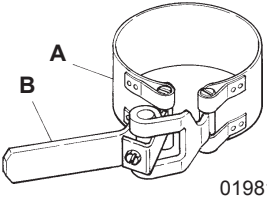
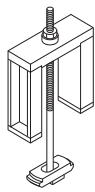
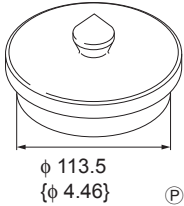
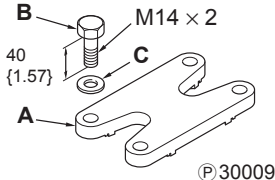
Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (connecting rod cap installation)	29 {22, 3} +90°	Wet

 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	Portions of cylinder liner held by upper crankcase	Engine oil	As required

 Special tools

Unit: mm {in.}

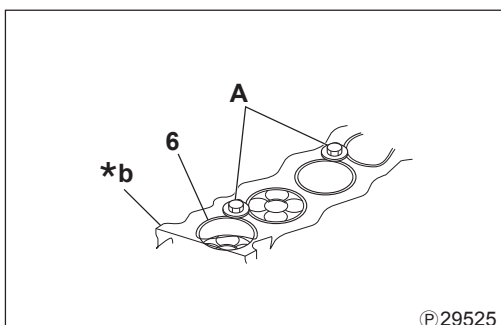
Location	Tool name and shape	Part No.	Application
5	<p>A: Piston Guide Clamp B: Piston Guide Lever</p>  <p>01981</p>	<p>A: MH063432 B: MH061658 (Obtain Locally)</p>	Installing piston and connecting rod assembly
6	<p>Cylinder Liner Extractor</p>  <p>Ⓟ 30008</p>	<p>MH062537 (Obtain Locally)</p>	Removing cylinder liners
	<p>Cylinder Liner Installer</p>  <p>φ 113.5 {φ 4.46} Ⓟ 30010</p>	<p>MH063606 (Obtain Locally)</p>	Installing cylinder liners
	<p>A: Adapter B: Bolt C: Washer</p>  <p>M14 × 2 40 {1.57} Ⓟ 30009</p>	<p>A: MH063433 B: MF130625 C: MH005012 (Obtain Locally)</p>	Measuring cylinder liner flange projection amount and their difference from adjacent cylinders.

◆ Service procedure

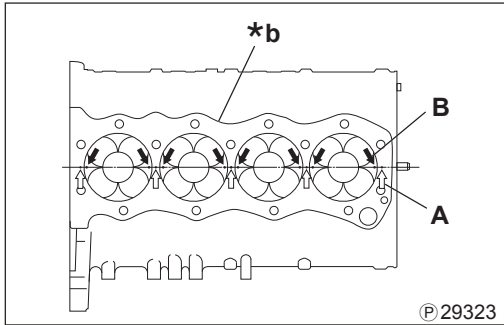
● Pre-disassembly inspection

**CAUTION** 

The cylinder liners 6 may be forced out if the upper crankcase \*b is turned over or if the crankshaft assembly \*a is rotated with the pistons inserted. Before beginning with inspection procedures, be sure to hold each cylinder liner at its flange section using a washer A or a similar tool.



# PISTONS, CONNECTING RODS AND CYLINDER LINERS



## (1) Piston protrusion from crankcase top surface

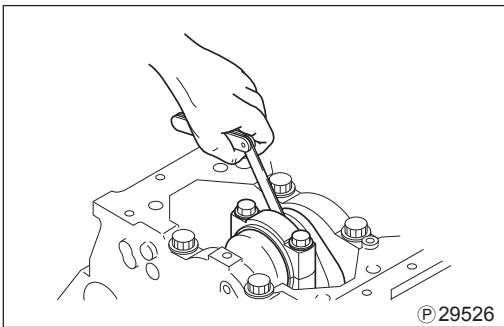
### NOTE

The piston protrusion affects engine performance and must therefore be checked.

- Set the piston at top dead center.
- Make standard points **A** (five points) on upper crankcase assembly \*b the 0 (zero) point and measure any protrusion relative to this point.
- Measure at four points on each piston at the nearest standard point from the zero point and produce the average value.

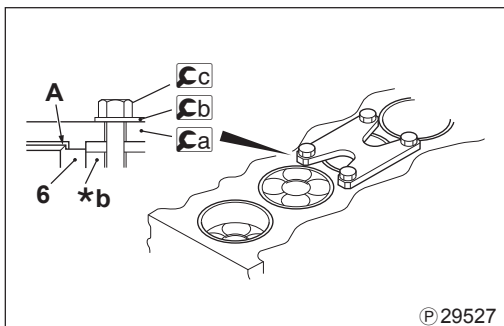
**B** : Measurement point (16 points)

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



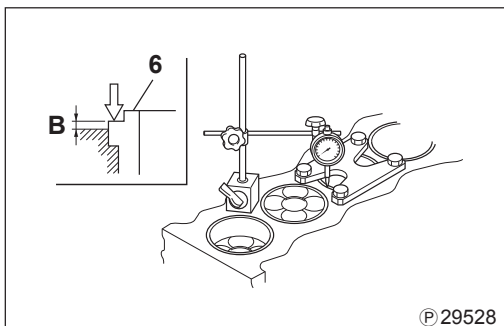
## (2) Connecting rod end play

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



## (3) Cylinder liner flange protrusion amount and its difference between adjacent cylinders.

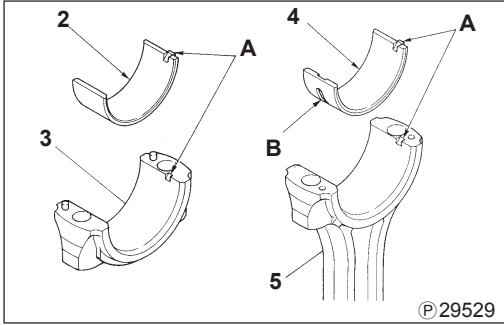
- Install the **Ca** Adapter on the upper crankcase in such a way that it may not ride on the flange **A** of the cylinder liner **6** and secure it by tightening the **Cb** Washer and **Cc** Bolt to a torque of 49 N·m {36 ft.lbs, 5 kgf·m}.



- Measure the protrusion amount **B** of flange of the cylinder liners **6**.
- If the measurement is out of specification, replace the defective part(s).
- Calculate the differences of the protrusion amounts between adjacent cylinders. If any difference is out of specification, check the mounting condition of the liners and replace the defective part(s).

### CAUTION

If the cylinder liner **6** flange protrusion 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]

Fit the lower connecting rod bearing **2** into the connecting rod cap **3**, and fit the upper connecting rod bearing **4** into the piston and connecting rod assembly **5**. Make sure the lugs **A** on the bearings are fitted into their respective grooves.

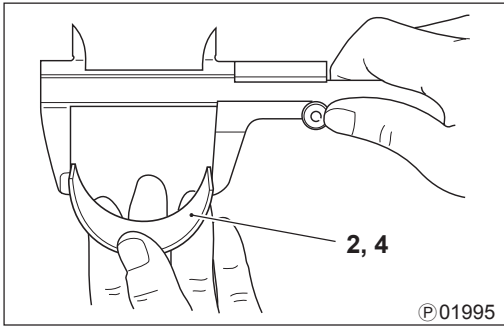
**CAUTION** ⚠

The upper connecting rod bearing **4** has an oil hole **B**. The lower connecting rod bearing **2** has no oil hole. Take care not to confuse the upper and lower parts.

[Inspection]

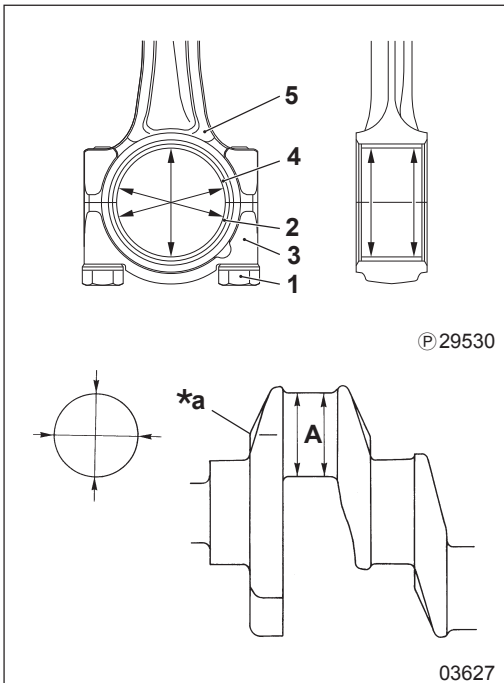
**CAUTION** ⚠

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



**(1) Span when free**

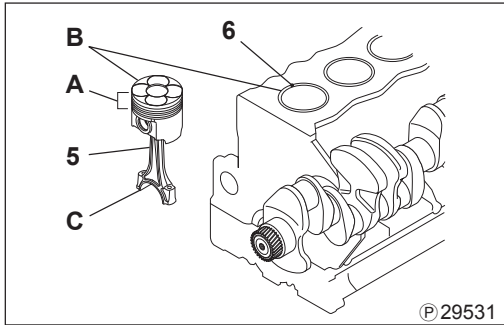
If the span is less than the specified requirement, replace the upper and lower connecting rod bearings **2, 4** as a set.



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

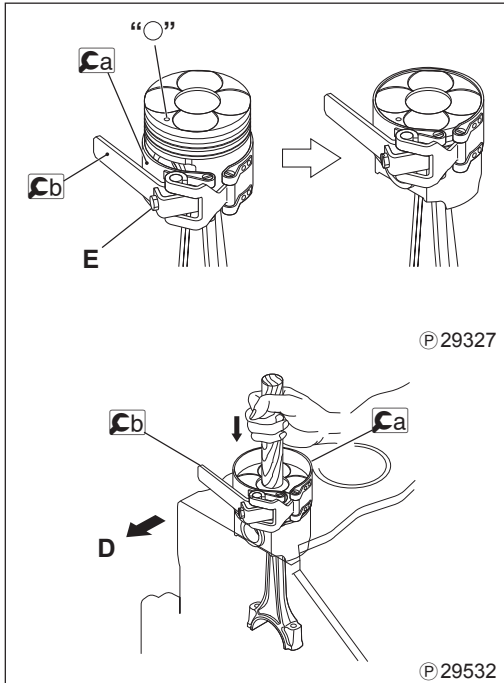
- Fit the lower connecting rod bearing **2** into the connecting rod cap **3**, and fit the upper connecting rod bearing **4** into the piston and connecting rod assembly **5**. Then, tighten the bolts **1** to the specified torque.
- Measure the inside diameter of the connecting rod bearings **2, 4** and the outside diameter of the crankshaft **\*a** pin **A**. If the clearance exceeds the specified limit, replace the defective part(s).
- If the connecting rod bearing **2, 4** have to be changed to undersized ones, adjust crankshaft **\*a** pin outer diameter **A** in accordance with the specified procedure to fit the undersized dimensions. P11A-86

# PISTONS, CONNECTING RODS AND CYLINDER LINERS



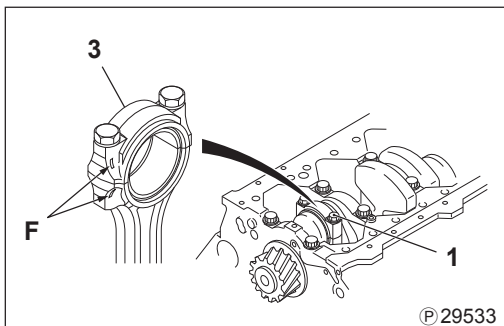
## 5 Installing piston and connecting rod assembly

- Ensure the gaps of the piston rings **A** remain in their correct positions. P11A-74
- Check that the size marks **B** on the piston and cylinder liner are the same. P11A-69
- Use care to prevent the connecting rod **C** from damaging the cylinder liner **6** and crankshaft pin.



- With the piston's front mark "O" facing the front of the engine **D**, carefully insert the piston and connecting rod assembly into the cylinder liner.
- Using the bolt **E** of the **Cb** Piston Guide Lever, adjust the inside diameter of the **Ca** Piston Guide Clamp such that it matches the piston's outside diameter.
- After adjustment, remove it from the piston and smear engine oil over the following items:
  - Outside of piston
  - Inside of the **Ca** Piston Guide Clamp
  - Inside of the cylinder liner

- Install piston and connecting rod assembly by tapping top of piston with wooden dowel.



- With the piston installed, align the mating marks **F** on the connecting rod and connecting rod cap **3** and tighten the bolts **1** to the specification.
- Tighten bolts **1** alternately in the following manner.
  - First tighten to a torque of 29 N·m {22 ft.lbs, 3 kgf·m}.
  - Then tighten further  $90^\circ \pm 5^\circ$ .

## NOTE

After installation of connecting rod cap **3**, inspect the following points:

- End play of the connecting rod: P11A-66
- Piston Protrusion: P11A-66

**5 6 Piston-and-connecting rod assembly and cylinder liners**

[Inspection]

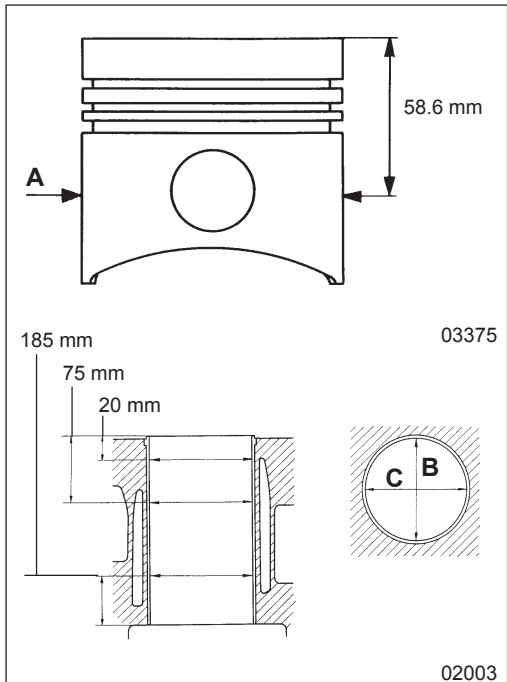
- Take measurements to determine the clearance between the piston and cylinder liner **6**.

**A** : Outside diameter measurement position of piston

**B** : Direction of crankshaft axis

**C** : Perpendicular to crankshaft axis

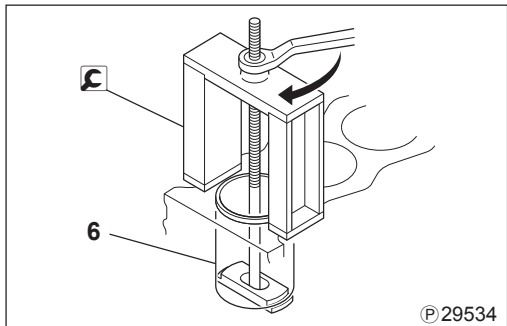
- If the clearance is out of specification, replace the defective part(s).



**Cylinder liners**

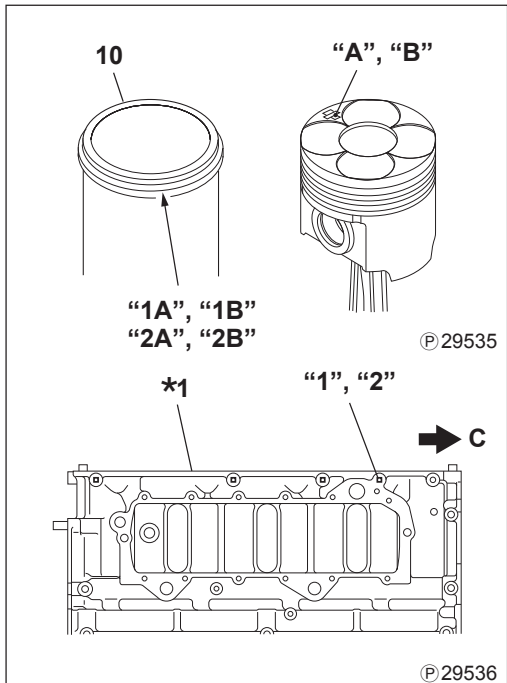
[Removal]

- ☒ : Cylinder Liner Extractor



[Installation]

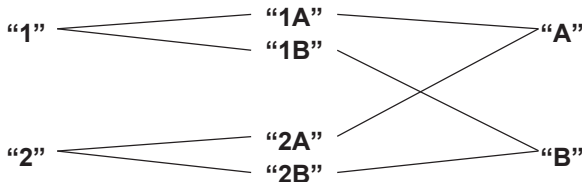
- Select a cylinder liner **6** which has the same size mark as those stamped on the upper crankcase **\*b** and the piston.
- The size marks on the upper crankcase **\*b** are arranged in the order of No. **1, 2, 3** and **4** cylinders starting from the engine front **C**.



Size marks on upper crankcase

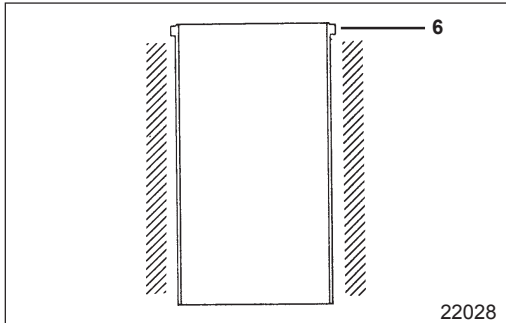
Size marks on cylinder liners

Size mark on pistons

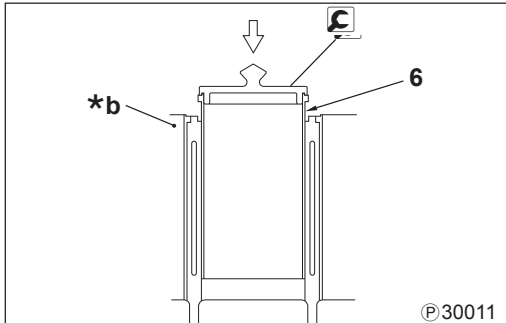



# PISTONS, CONNECTING RODS AND CYLINDER LINERS

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- Apply engine oil to the indicated  parts of the cylinder liner 6.



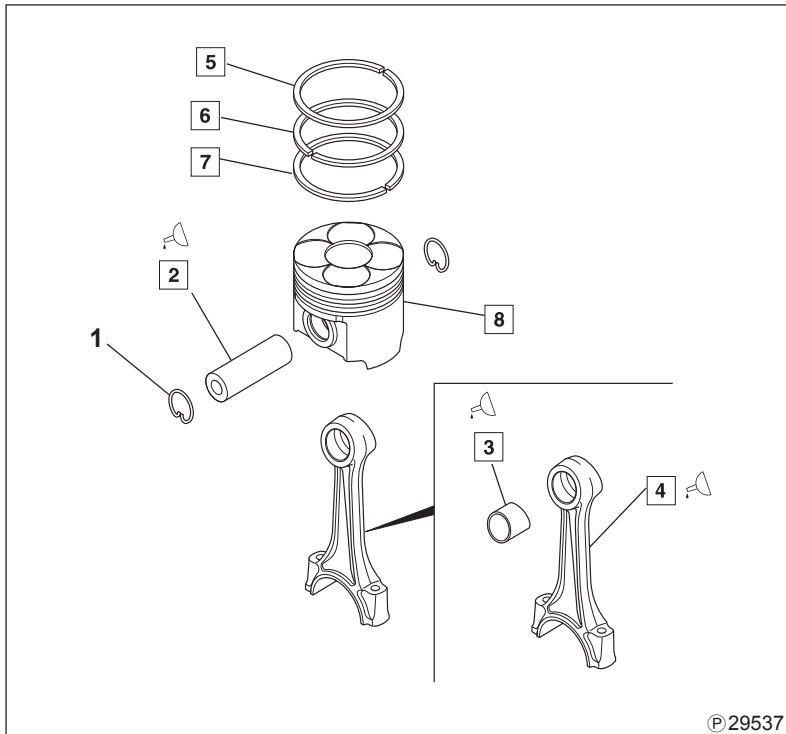
- Using the  Cylinder Liner Installer, gently tap down the cylinder liner 6 until it is snugly seated on the upper crankcase \*b.

## CAUTION

The cylinder liner 6 is thin in wall thickness.  
Use utmost care when handling it.

---

### 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**

Follow the disassembly sequence in reverse.

### Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value	Limit	Remedy	
2, 3	Piston pin-to-connecting rod small end bushing clearance	[36 {1.42}] 0.03 to 0.04 {0.0012 to 0.0016}	0.1 {0.0039}	Replace	
2, 8	Piston pin-to-piston clearance	[36 {1.42}] 0.007 to 0.021 {0.00028 to 0.00083}	0.05 {0.002}	Replace	
4	Connecting rod bend	–	0.05 {0.002}	Replace	
	Connecting rod twist	–	0.1 {0.0039}	Replace	
5 to 7	Piston ring end gap	1st compression ring	0.3 to 0.45 {0.012 to 0.018}	1.5 {0.059}	Replace
		2nd compression ring	0.4 to 0.55 {0.016 to 0.022}		
		Oil ring	0.3 to 0.5 {0.012 to 0.02}		
5 to 8	Piston ring-to-piston ring groove clearance	1st compression ring	0.02 to 0.10 {0.00079 to 0.0039}	0.2 {0.0079}	Replace
		2nd compression ring	0.07 to 0.10 {0.0028 to 0.0039}		
		Oil ring	0.03 to 0.06 {0.0012 to 0.0024}		

### Lubricant

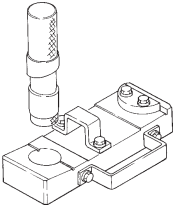
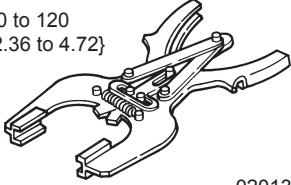
Location	Points of application	Specified lubricant	Quantity
2	Piston pin outer surface	Engine oil	As required
3	Connecting rod bushing outer surface	Engine oil	As required
4	Bushing installation surface of connecting rod	Engine oil	As required

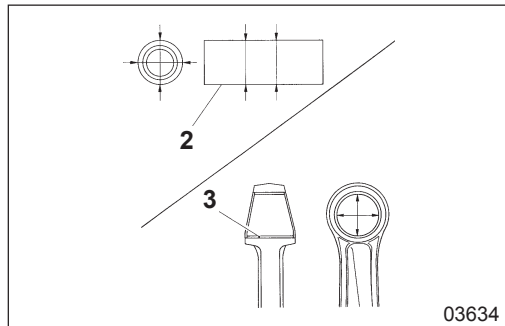


# PISTONS, CONNECTING RODS AND CYLINDER LINERS

## Special tools

Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
3	Connecting Rod Bushing Puller Kit 	Use Locally Manufactured Equivalent 02015	Removing and installing connecting rod bushings
5 to 7	Piston Ring Tool $\phi$ 60 to 120 { $\phi$ 2.36 to 4.72} 	Obtain Locally 02013	Removing and installing rings

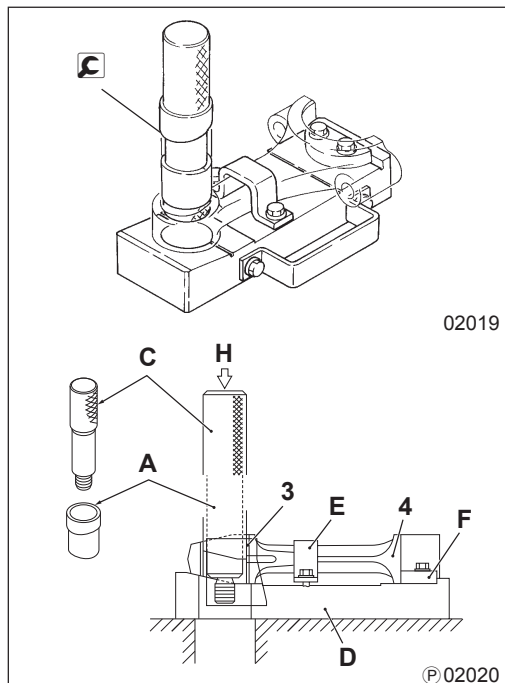


## Service procedure


### 2 3 Piston pin and connecting rod

[Inspection]

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



### Connecting rod bushing

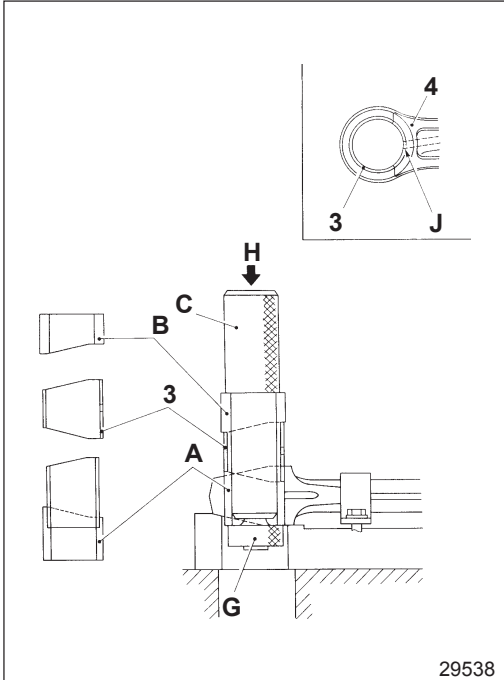
Replace the connecting rod bushing **3** using the  Connecting Rod Bushing Puller Kit.

(Components of the  Connecting Rod Bushing Puller Kit)

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

[Removal]

- Remove the upper 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 place **F**.
- Fit the Collar **A** over the Puller **C** in the direction shown. Then, slowly apply pressure of approximately 49 kN (11020 lbf, 5,000 kgf) **H** until the connecting rod bushing **3** is pressed out.

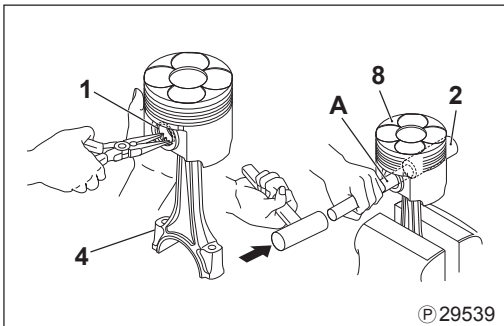


[Installation]

- 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 B over the Puller C, position the connecting rod bushing 3 and the Collar A, and lock this arrangement together with the Nut G.
- Align the oil holes J in the connecting rod bushing 3 and in the small end of the connecting rod 4. Then, use a press to slowly apply pressure of approximately 49 kN (11020 lbf, 5,000 kgf) H until the bushing is pressed into place.
- After press-fitting the connecting rod bushing 3, ream it to achieve the specified normal clearance between the bushing and piston pin 2.

**NOTE**

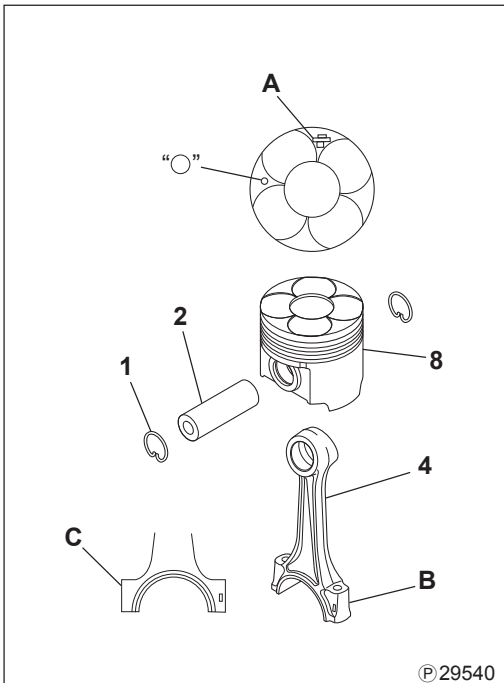
**After reaming the connecting rod bushing 3, insert the piston pin 2 and check that it turns smoothly and without play.**



**2 4 8 Piston Pin, connecting rod, and piston.**

[Removal]

- Removal the snap ring 1 and tap out the piston pin 2 using a rod A 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 and aligned as illustrated, insert the piston pin to hold these components together.

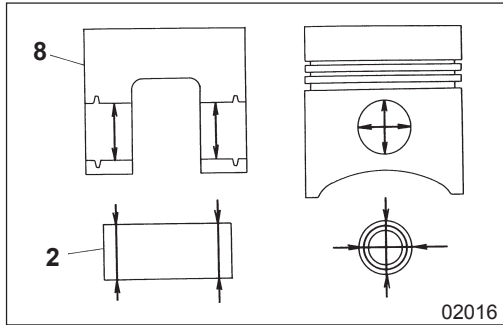
- A** : Weight mark
- B** : Weight mark (**A** through **G**: "**A**" stands for the largest weight)
- C** : Alignment mark for connecting rod cap
- "○": Front mark

- If the piston pin 2 is difficult to insert, heat the piston 8 in hot water or use a piston heater.

**CAUTION** ⚠

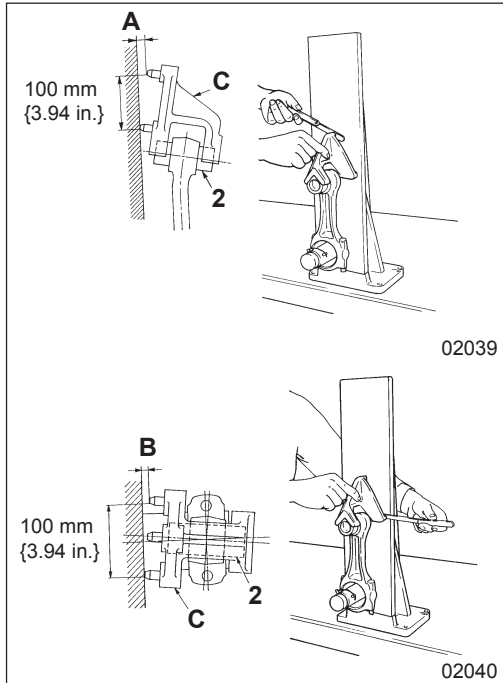
- **Make sure that all pistons have the same weight mark.**
- **The connecting rods must all have the same weight mark.**
- **After inserting the pin 2, check that it turns smoothly and without play.**

# PISTONS, CONNECTING RODS AND CYLINDER LINERS



## 2 8 Piston pin-to-piston clearance

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



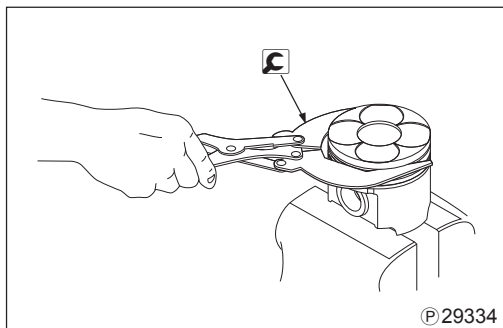
## 4 Connecting rod bend and twist

- Fit the connecting rod bushing 3 and piston pin 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.

C : Connecting rod 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. P11A-67
- Measurements must be made with the connecting rod cap mounting bolts tightened to the specification. P11A-67

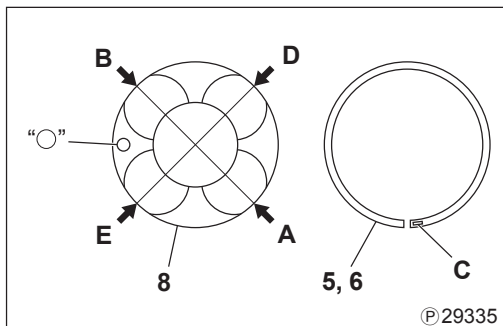


## 5 to 8 Piston rings and piston

### Piston rings

[Removal]

: Piston Ring Tool



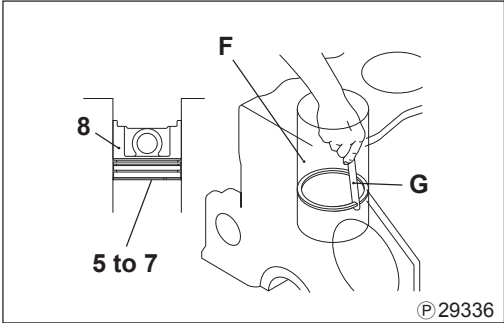
[Installation]

- Fit the oil ring onto the piston 8 with its gap A and the expander spring end joint B in the position illustrated.
- Fit the piston ring 5, 6 onto the piston 8 such that the manufacturer's marks C near the gaps face upward.
- Align the gaps D, E of the piston ring 5, 6 as illustrated.

D : 1st compression ring gap

E : 2nd compression ring gap

"O" : Front mark



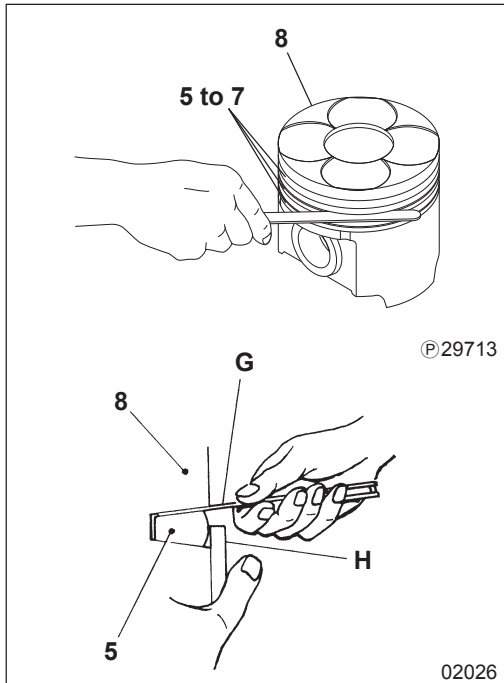
[Inspection]

**(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** in the upper crankcase for measurement.
- Taking care not to move the piston ring **5**, **6** or **7**, measure the end gap using a thickness gauge **G**. Replace all the rings of 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.



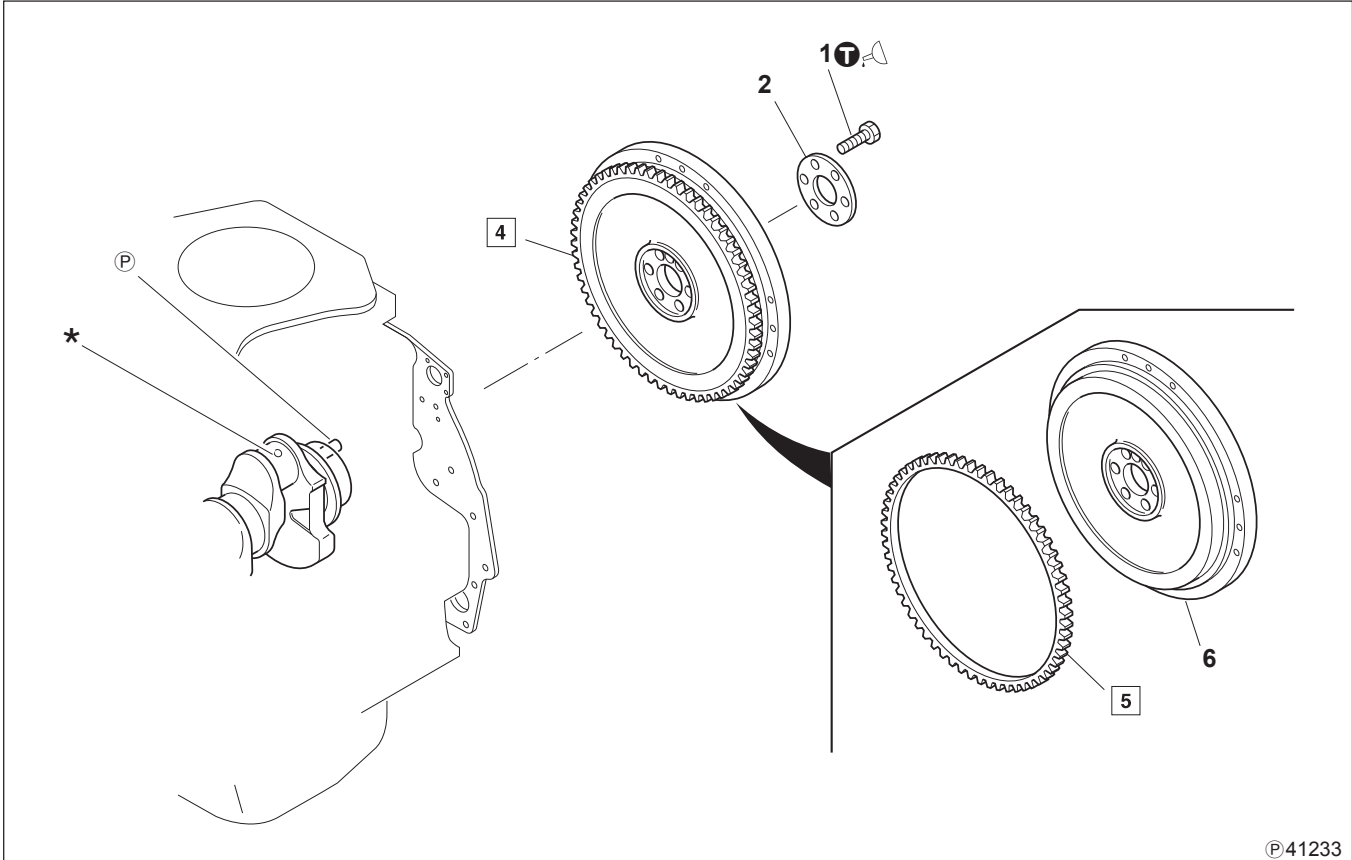
**(2) Piston ring-to-piston ring groove clearance**

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

**NOTE**

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

# FLYWHEEL



©41233

## ● Disassembly sequence

- |                 |                     |                         |
|-----------------|---------------------|-------------------------|
| 1 Bolt          | 4 Flywheel assembly | * : Crankshaft assembly |
| 2 Plate         | 5 Ring gear         | 📖 P11A-80               |
| 3 Pilot bearing | 6 Flywheel          | Ⓟ : Locating pin        |

## ● Assembly sequence

Follow the disassembly sequence in reverse.

## CAUTION ⚠

- Make sure that the mounting surface of the flywheel assembly 4 is free from any foreign substances, oil and detrimental flaws.
- After installing flywheel assembly 4, check for runout.

## NOTE

- Do not remove the pilot bearing 3 or ring gear 5 unless an abnormality is evident.

## T Tightening torques

Unit: N·m {ft.lbs, kgf·m}

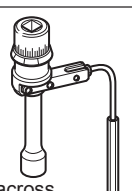
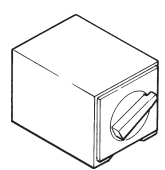
Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (flywheel assembly installation)	39.0 {29.0, 4.0} +40°	Wet

 Lubricant

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

 Special tools

Unit: mm {in.}

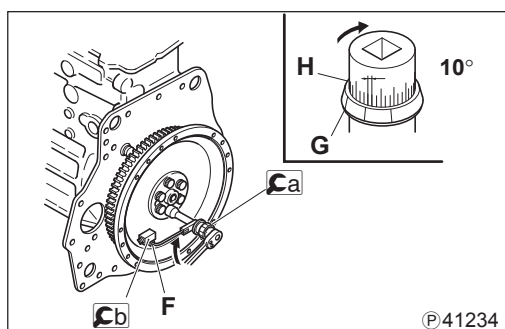
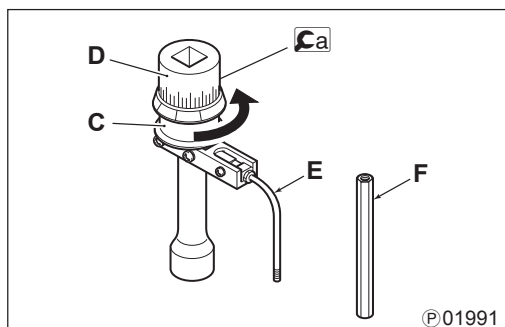
Location	Tool name and shape	Part No.	Application
4	 Socket Wrench Width across flats: 22 {0.87} P01984	Obtain Locally	Installation of flywheel
	 Magnet Base 00471	Obtain Locally	



◆ Service procedure

5 Installation of flywheel assembly

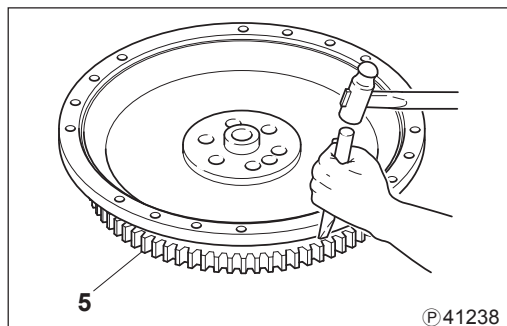
- Tighten the bolts 1 to the specified torque (39.0 N·m {29 ft.lbs, 4.0 kgf·m}). After that, turn the bolts further in accordance with the following procedure.
- Turn the holder C of the  Socket Wrench counterclockwise to the tension the built-in spring.

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



- Fit the  Magnet Base on the flywheel at a position where it can come in contact with the Rod F (for extension) as shown in the illustration.
- Set the rod F (for extension) such that it may be pressed against the  Magnet Base by the spring force.
- Align any inscribed line G on the holder C with any inscribed line H on the socket D. (Use this point as reference 0° position.)
- From the above reference position, turn the socket D clockwise by 40° to tighten the bolt to the proper specification.

# FLYWHEEL



## 5 Ring gear

[Inspection]

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

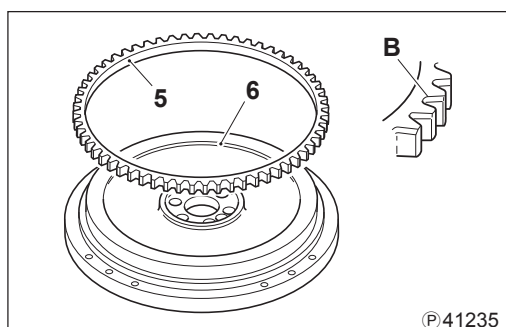
[Removal]

Heat the ring gear **5** evenly with an acetylene torch or the like.

**WARNING** ⚠

**Be careful not to get burned.**

- Remove the ring gear **5** from the flywheel by tapping around its entire periphery.



[Installation]

Using an acetylene torch or the like, heat the ring gear **5** to approximately 100 °C {212 °F} for 3 minutes.

**WARNING** ⚠

**Be careful not to get burned.**

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

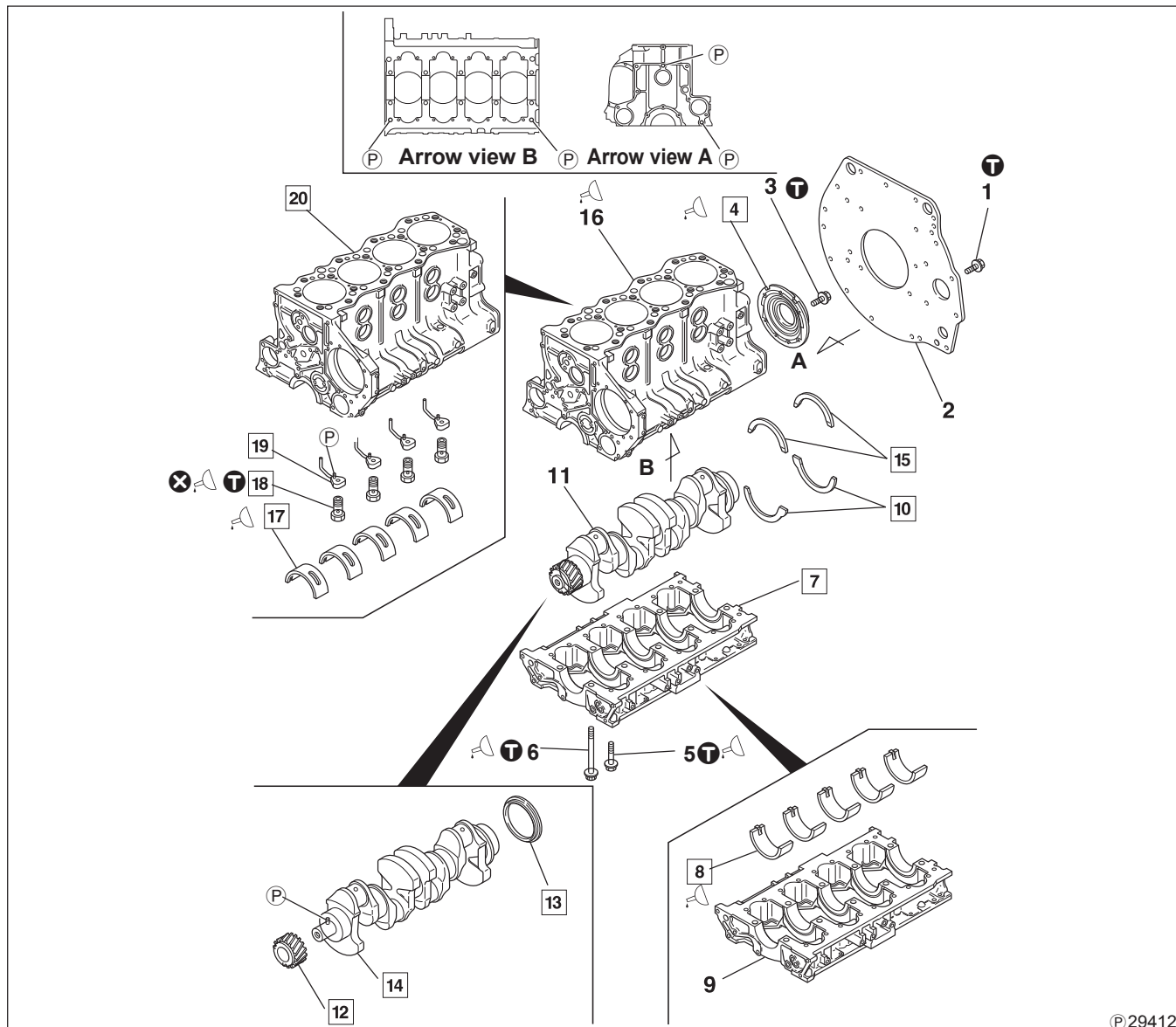
**B** : Chamfered side of ring gear **5**.

# MEMO

---



# CRANKSHAFT AND CRANKCASE



## ● Pre-disassembly inspection

📖 P11A-82

## ● Disassembly sequence

- |                            |                             |                       |
|----------------------------|-----------------------------|-----------------------|
| 1 Bolt                     | 9 Lower crankcase           | 17 Upper main bearing |
| 2 Rear plate               | 10 Lower thrust plate       | *18 Check valve       |
| 3 Bolt                     | 11 Crankshaft assembly      | 19 Oil jet            |
| 4 Rear oil seal            | *12 Crankshaft gear         | 20 Upper crankcase    |
| 5 Bolt                     | *13 Rear oil seal slinger   |                       |
| 6 Main cap bolt            | 14 Crankshaft               |                       |
| 7 Lower crankcase assembly | 15 Upper thrust plate       |                       |
| 8 Lower main bearing       | 16 Upper crankcase assembly |                       |

Ⓟ : Locating pin

⊗ : Non-reusable part

## NOTE

- Do not remove parts marked \* unless defects are evident.
- The lower crankcase 9 and upper crankcase 20 have been machined in a pair. Therefore, replacing either one of the pair is not allowed.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

**CAUTION** ⚠

- If the main cap bolt shows evidence of having been tightened three times, replace it. 📖 P11A-83
- Do not overtighten the check valve 18. If the tightening torque exceeds the specified one, the check valve may malfunction, resulting in damage to the engine.

**Service standards**

Unit: mm {in.}

Location	Maintenance item		Standard value (Basic diameter in [ ])	Limit	Remedy	
–	Crankshaft end play		0.10 to 0.28 {0.0039 to 0.0110}	0.4 {0.016}	Replace thrust plate	
8, 17	Main bearing	Oil clearance	No. 1, 2, 4, 5 [86 {3.385}] 0.04 to 0.11 {0.0016 to 0.0043}	0.15 {0.0059}	Replace	
			No. 3 [86 {3.385}] 0.06 to 0.13 {0.0024 to 0.0051}			
		Span when free	–	Less than 91.5 {3.60}	Replace	
14	Crankshaft	Bend	0.02 {0.00079} or less	0.05 {0.002}	Correct or replace	
		Pin and journal	Roundness	0.01 {0.00039} or less	0.03 {0.0012}	Correct or replace
			Cylindricity	0.06 {0.00024} or less	–	Correct or replace
20	Distortion of upper crankcase top surface		0.07 {0.0028} or less	0.2 {0.0079}	Replace	

**T** **Tightening torques**

Unit: N·m {ft.lbs, kgf·m}

Location	Parts to be tightened	Tightening torque	Remarks
1	Bolt (rear plate installation)	63,7 {47, 6.5}	—
3	Bolt (rear oil seal installation)	9.8 {7.2, 1.0}	—
5	Bolt (lower crankcase installation)	23.5 {17, 2.4}	Wet
6	Main cap bolt (lower crankcase installation)	49 {36, 5.0} + 90°	• Wet • Reusable 3 times
18	Check valve	29.4 {22, 3.0}	Wet

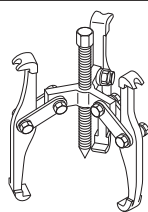
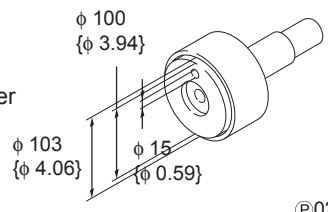
**Lubricant and sealant**

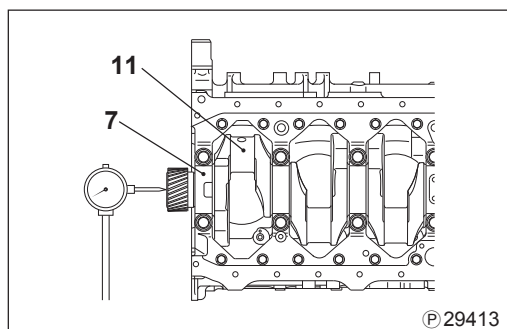
Location	Points of application	Specified lubricant/sealant	Quantity
4	Rear oil seal lip	Engine oil	As required
	Upper and lower crankcase contracting surface of rear oil seal	Threebond 1207	As required
5, 6	Bolt threads and seating surface	Engine oil	As required
8, 17	Main bearing inside surfaces	Engine oil	As required
16	Lower crankcase attaching surface of upper crankcase	Threebond 1207	As required
18	Check valve threads	Engine oil	As required

# CRANKSHAFT AND CRANKCASE

## Special tools

Unit: mm {in.}

Location	Tool name and shape	Part No.	Application
12	Gear Puller 	Obtain Locally	Removing crankshaft gear
13	Rear Oil Seal Slinger Installer 	MH061470A	Installing rear oil seal slinger

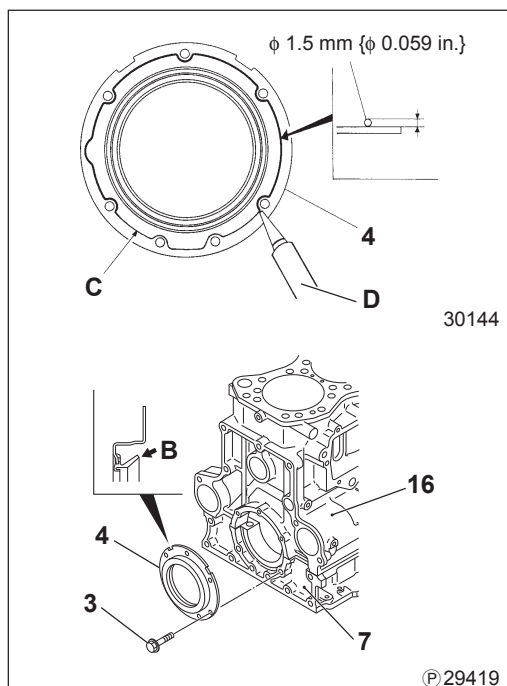


## ◆ Service procedure

### ● Pre-disassembly inspection

#### Crankshaft end play

- Before removing the lower crankcase assembly 7, measure the extent of crankshaft end play.
- If the measurement exceeds the specified limit, replace the thrust plates with oversize ones. P11A-85

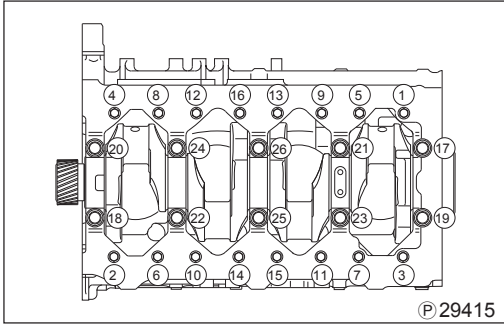


### 4 Mounting of rear oil seal

- Apply engine oil to lips B of rear oil seal 4.
- Apply sealant D along black line C stamped on the rear oil seal 4 evenly without break. (φ 1.5 mm {φ 0.059 in.})
- After applying sealant D, install the rear oil seal 4 between the lower crankcase assembly 7 and upper crankcase assembly 16 within three minutes.

### CAUTION

- **Make sure that the sealant application surfaces are clean and free from grease and oil.**
- **Use care not to let the applied sealant slip out of place during installation.**
- **After fitting rear oil seal, wait at least an hour before starting the engine.**
- **Apply a new bead of sealant D whenever mounting bolts 3 of rear oil seal have been loosened.**

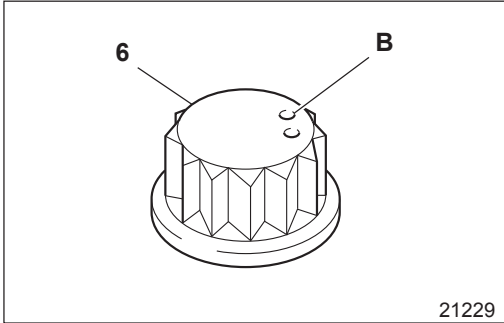


**7 Lower crankcase assembly**

- ① – ⑯ : Bolt 5
- ⑰ – ⑳ : Main cap bolt 6

[Removal]

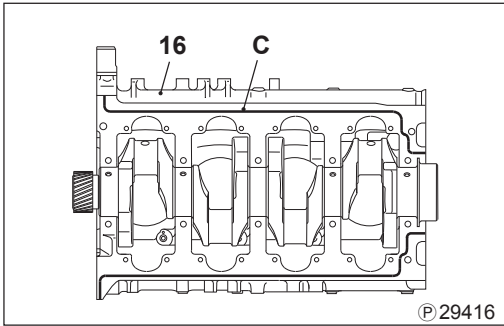
- Gradually loosen the bolts 5 in the sequence of numbers ① – ⑯ shown in the illustration.
- Then, gradually loosen the main cap bolts 6 in the sequence of numbers ⑰ – ⑳ shown, and remove.



[Installation]

**CAUTION** ⚠

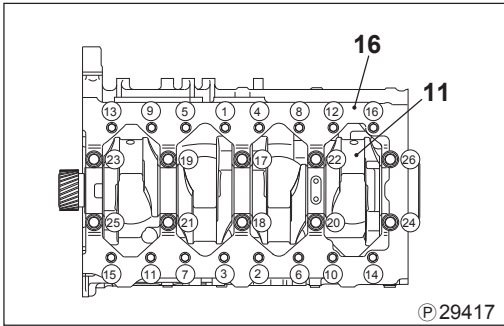
- Before installing the lower crankcase assembly check the head of the main cap bolt 6 for punch marks B.
- The number of punch marks corresponds to the number of times the bolt has been tightened using torque-turn method (bolts with two or less punch marks are reusable). If there are three, replace the main cap bolt.



- Apply  $\phi$  2 mm { $\phi$  0.079 in.} thick bead of specified sealant C to the fitting surface of the upper crankcase assembly 16 as shown.
- After applying sealant C, install the lower crankcase assembly 7 to the upper crankcase assembly 16 within three minutes and secure with the main cap bolts 6 and the bolts 5 as follows:

**CAUTION** ⚠

- Make sure that the sealant application surfaces are clean and free from grease and oil.
- Use care not to let the applied sealant C slip out of place during installation.



- Apply a thin coat of engine oil to the threaded part and seating surface of each main cap bolt 6, then tighten the bolts to a torque of 49 N·m {36 ft.lbs, 5.0 kgf·m} in the sequence of the numbers shown (⑰ – ⑳)
- After tightening, give the bolts an additional 90° turn in the same sequence.
- Following the main cap bolts 6, tighten the bolts 5 to the specified torque in the sequence of the numbers shown (① – ⑯).

**CAUTION** ⚠

- After installation, wait at least an hour before starting the engine.
- Apply a new bead of sealant C whenever the bolts 5 or the main cap bolts 6 have been loosened.

- After tightening the main cap bolts 6 using the torque-turn tightening method, make a punch mark on the head of each one to indicate the number of times used.

**NOTE**

Since bolts 1 utilize the torque-turn tightening method, they must not be tightened further after this procedure.

# CRANKSHAFT AND CRANKCASE

- After installing the lower crankcase assembly, check the following:
  - Smooth rotation of crankshaft assembly **11**
  - End play of the crankshaft assembly **11** P11A-82

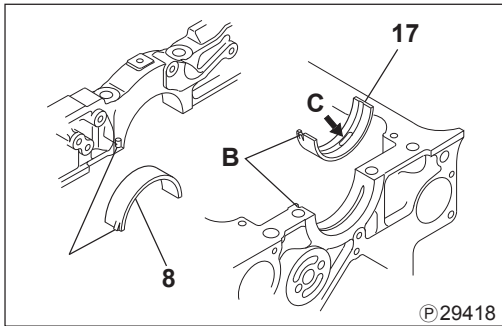
## **8** **17** Main bearings

[Installation]

Install the main bearings **8**, **17** such that their lugs **B** fit into the corresponding grooves.

### CAUTION

The upper main bearing **17** has an oil hole **C**. The lower main bearing **8** has no oil hole. Take care not to confuse the upper and lower parts.



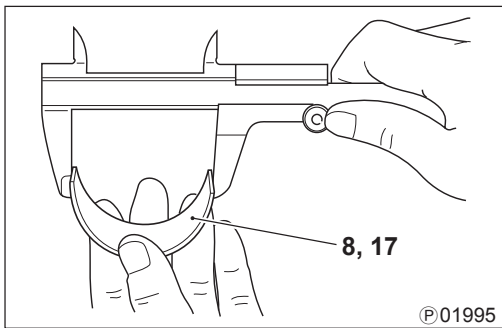
[Inspection]

### CAUTION

- Do not attempt to manually expand either bearing **8**, **17** if its span is insufficient.
- Upper and lower bearings **8**, **17** must be replaced as a set.

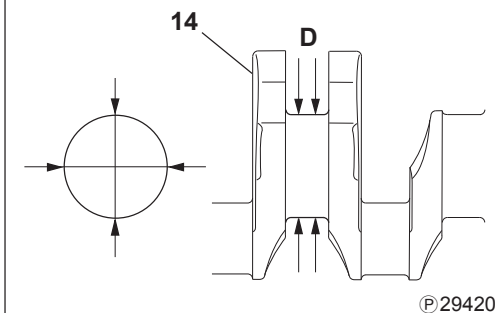
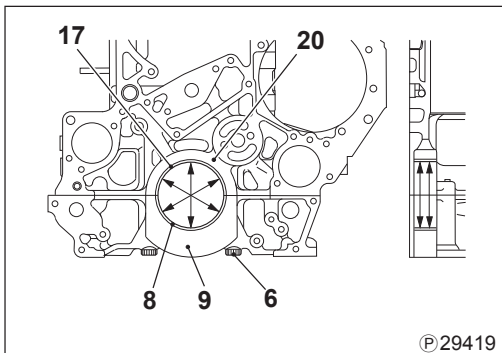
#### (1) Span when free

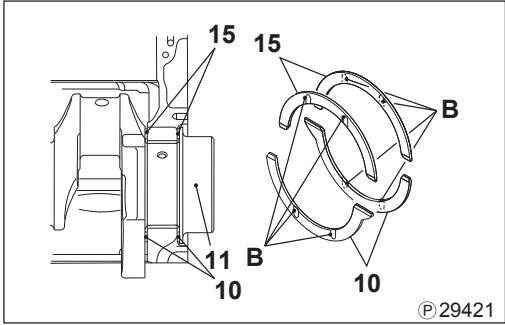
If either bearing's span when free exceeds the specified limit, the bearings **8**, **17** must be replaced.



#### (2) Main bearing-to-crankshaft clearance

- Fit the upper main bearing **17** into the upper crankcase **20** and the lower main bearing **8** into the lower crankcase **9**. Then, tighten the main cap bolts **6** to their specified torque (49 N·m {36 ft.lbs, 5.0 kgf·m}).
- Measure the internal diameters of the main bearings **8**, **17** and the journal outside diameter **D** of the crankshaft **14**. If the clearance exceeds the specified limit, replace the defective part(s).





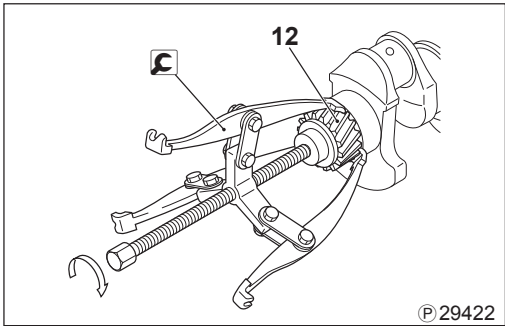
**10 15 Thrust plate**

Install the thrust plates **10**, **15** to the crankshaft assembly **11** at No. 5 journal only. Install all halves of the thrust plates with the oil groove **B** oriented outward.

**NOTE**

If any **oversize thrust plates** are to be used, be sure to use an upper thrust plate **15** and lower thrust plate **10** of the same size at one side. However, using the same size upper (or lower) thrust bearings on both sides is not necessary.

Available oversize: 0.15, 0.30, 0.45 mm {0.0059, 0.012, 0.018 in.}



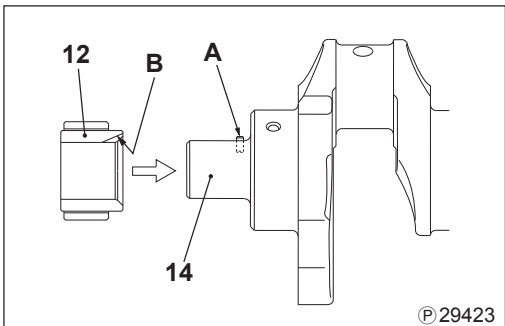
**12 Crankshaft gear**

[Removal]

: Gear Puller

**CAUTION**

Do not tap off the crankshaft gear **12** since this could damage it.



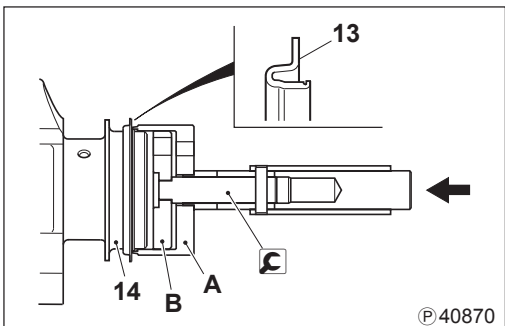
[Installation]

- Using a piston heater or the like, heat the crankshaft gear **12** to a temperature of approximately 150 °C {302 °F}.

**WARNING**

Be careful not to get burned.

- Align the location pin **A** on the crankshaft **14** with the notch **B** in the crankshaft gear **12**. Then, drive the gear into position by striking its end face with a plastic mallet.



**13 Rear oil seal slinger**

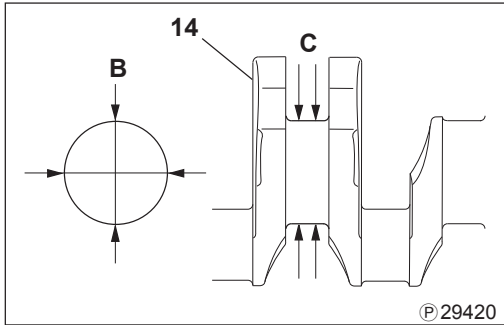
[Removal]

Taking care not to damage the crankshaft **14**, split the oil seal slinger using a chisel or the like.

[Installation]

With the rear oil seal slinger **13** directed as illustrated, drive it onto the crankshaft using the Rear Oil Slinger Installer until the tools end face **A** is pressed firmly against the guide **B**.

# CRANKSHAFT AND CRANKCASE



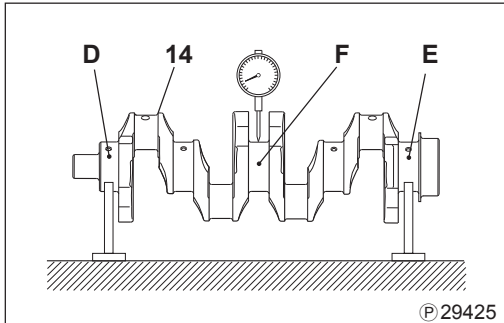
## 14 Crankshaft

[Inspection]

### (1) Roundness and cylindricity of crankshaft journal and pin

If either measurement exceeds the specified limit, grind it to undersize or replace the crankshaft 14.

**B** : Roundness  
**C** : Cylindricity

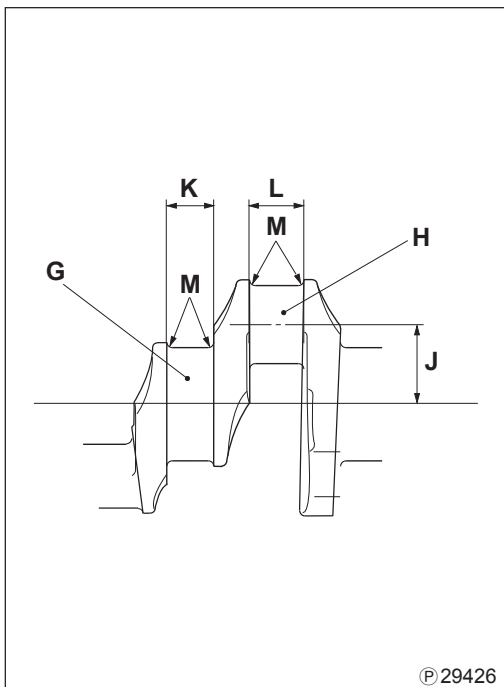


### (2) Bend

- Support the crankshaft 14 at its No. 1 journal D and No. 5 journal E. Measure the extent of bending in the crankshaft at the center of the No. 3 journal F.
- If the measurement exceeds the specified limit, replace the crankshaft 14.

## NOTE

Turn the crankshaft 14 through one revolution. One-half of the dial indicator reading represents the extent of bending.



[Rectification]

## NOTE

If the crankshaft 14 is rectified by grinding, the main bearings 8, 17 must be replaced with undersized ones.

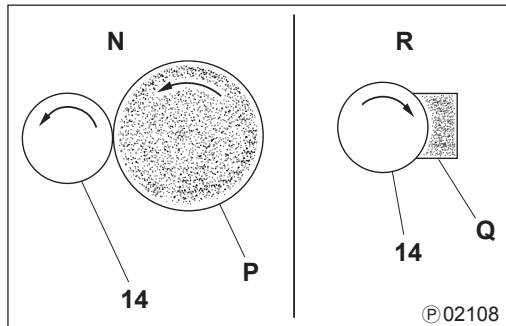
Available undersizes: 0.25 mm, 0.50 mm, 0.75 mm, 1.00 mm  
{0.0098, 0.02, 0.03, 0.039 in.}

- Grind such that the center-to-center distance J between the journal G and pin H never be changed.  
**J** : 60 ± 0.05 mm {2.36 ± 0.002 in.}
- Grind such that the journal width K and pin width L do not change.  
**K** : 33.5 mm {1.32 in.} (No. 1 journal)  
35 mm {1.38 in.} (No. 2 to No. 4 journals)  
 $35^{+0.039}_0$  mm { $1.38^{+0.0015}_0$  in.} (No. 5 journal)  
**L** :  $41^{+0.2}_0$  mm { $1.61^{+0.0079}_0$  in.}
- Finish the corner fillet smoothly and to the specified radius M.  
**M** : 5 mm {0.2 in.}
- 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.

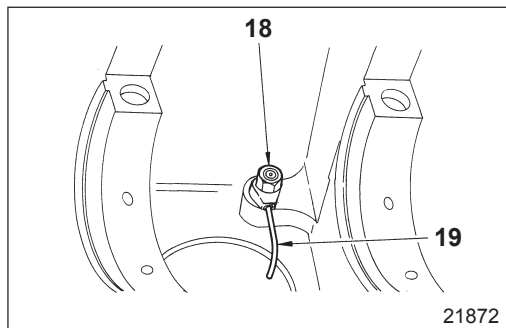
**Crankshaft undersize dimensions**

Unit: mm {in.}

		Degree of undersize			
		0.25 {0.0098}	0.50 {0.020}	0.75 {0.030}	1.00 {0.039}
Finished journal diameter	No. 1, 2, 4, 5	85.68 to 85.70 {3.373 to 3.374}	85.43 to 85.45 {3.363 to 3.364}	85.18 to 85.20 {3.353 to 3.354}	84.93 to 84.95 {3.343 to 3.344}
	No. 3	85.66 to 85.68 {3.372 to 3.373}	85.41 to 85.43 {3.362 to 3.363}	85.16 to 85.18 {3.352 to 3.353}	84.91 to 84.93 {3.342 to 3.343}
Finished pin diameter		64.69 to 64.71 {2.546 to 2.547}	64.44 to 64.46 {2.537 to 2.5378}	64.19 to 64.21 {2.527 to 2.528}	63.94 to 63.96 {2.517 to 2.518}
Roundness		0.01 {0.00039} or less			
Cylindricity		0.006 {0.00024} or less			



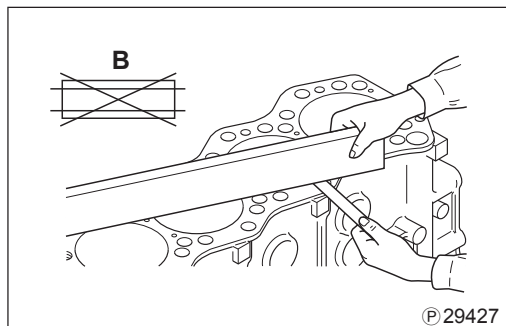
- When grinding **N**, turn the crankshaft **14** counter-clockwise as viewed from its front end. The grinder **P** should rotate in the same direction.
- When finishing **R** the crankshaft **14** with whetstone or sandpaper **Q**, rotate the crankshaft clockwise.



**18 19 Installation of check valve and oil jet**

**CAUTION** ⚠

Do not overtighten the check valve **18**. If the tightening torque exceeds the specified one, the check valve may malfunction, resulting in seizure of the engine.



**20 Inspecting upper crankshaft**

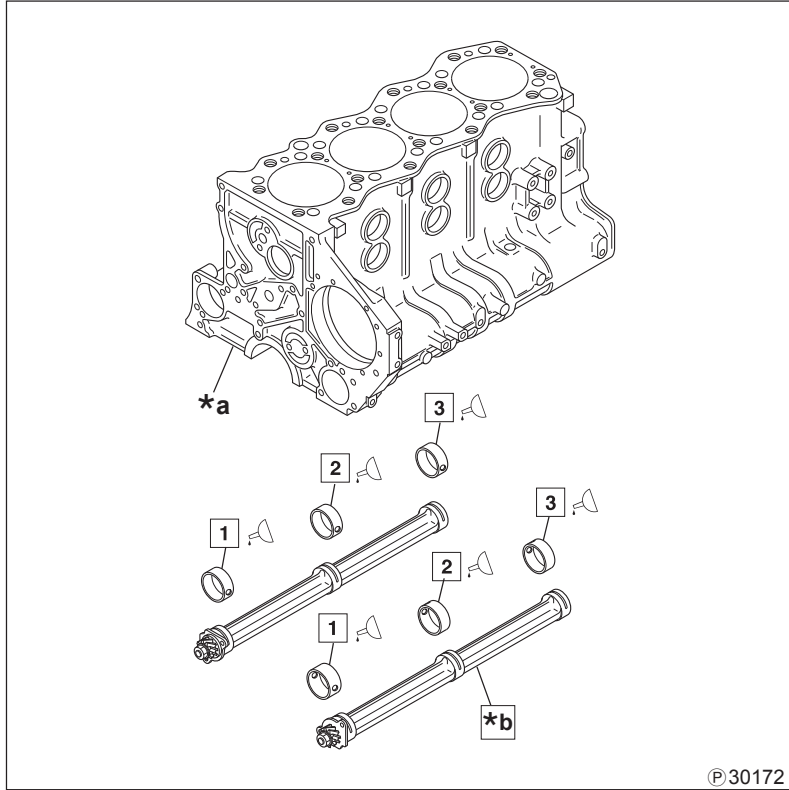
- Measure the upper surface distortion of the upper crankcase **20**.
  - If distortion exceeds the specified limit, correct it with a surface grinder.
- B** : Measurement positions

**CAUTION** ⚠

When grinding the crankcase **20**, take care that the piston protrusions stay within specification.



# BALANCE SHAFT BUSHINGS



## Disassembly sequence

- 1 No. 1 balance shaft bushing
- 2 No. 2 balance shaft bushing
- 3 No. 3 balance shaft bushing

\*a : Upper crankcase P11A-80

\*b : Balance shaft P11A-56

## CAUTION

Do not remove the balance shaft bushings 1 through 3 unless something wrong is evident.

## Assembly sequence

Follow the disassembly sequence in reverse.

## Service standards

Unit: mm {in.}

Location	Maintenance item	Standard value (Basic diameter in [ ])	Limit	Remedy
<b>*b, 1 to 3</b>	No. 1 journal	[51.5 {2.027}] 0.055 to 0.099 {0.0021 to 0.0039}	0.15 {0.0059}	Replace
	No. 2 journal	[51 {2.0}] 0.075 to 0.119 {0.0029 to 0.0046}		
	No. 3 journal	[50.5 {1.98}] 0.055 to 0.099 {0.0021 to 0.0039}		

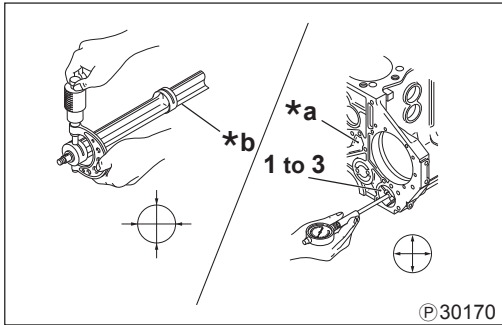
## Lubricant

Location	Points of application	Specified lubricant and/or sealant	Quantity
<b>1 to 3</b>	Inside surface of balance shaft bushing	Engine oil	As required

## Special tools

Unit: mm {in.}

Location	Tool name and shape	Part No.	Application													
<b>1 to 3</b>	Balance shaft bushing installer and extractor 	MH062782 (Obtain Locally)	Installation and removal of balance shaft bushing													
				<table border="1"> <thead> <tr> <th></th> <th>Dimensions A and C</th> <th>Dimension B</th> </tr> </thead> <tbody> <tr> <td>No. 1</td> <td>φ 55.25 {φ 2.175}</td> <td>φ 51.5 {φ 2.027}</td> </tr> <tr> <td>No. 2</td> <td>φ 55 {φ 2.165}</td> <td>φ 51 {φ 2.007}</td> </tr> <tr> <td>No. 3</td> <td>φ 55.75 {φ 2.155}</td> <td>φ 50.5 {φ 1.988}</td> </tr> </tbody> </table>		Dimensions A and C	Dimension B	No. 1	φ 55.25 {φ 2.175}	φ 51.5 {φ 2.027}	No. 2	φ 55 {φ 2.165}	φ 51 {φ 2.007}	No. 3	φ 55.75 {φ 2.155}	φ 50.5 {φ 1.988}
					Dimensions A and C	Dimension B										
				No. 1	φ 55.25 {φ 2.175}	φ 51.5 {φ 2.027}										
No. 2	φ 55 {φ 2.165}	φ 51 {φ 2.007}														
No. 3	φ 55.75 {φ 2.155}	φ 50.5 {φ 1.988}														
02083																



◆ Service procedure

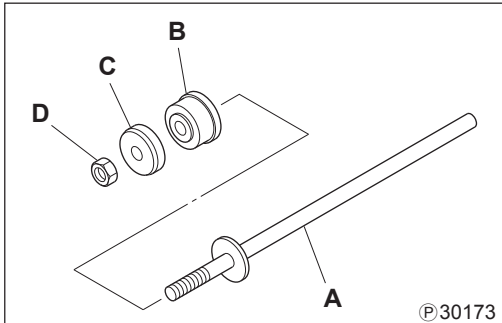
\*b 1 to 3 Balance shaft and balance shaft bushing

[Inspection]

If the clearance is more than the limit, replace defective parts.

NOTE

Measure the inner diameter of the balance shaft bushings 1 through 3 with the bushings installed on the upper crankcase \*a.

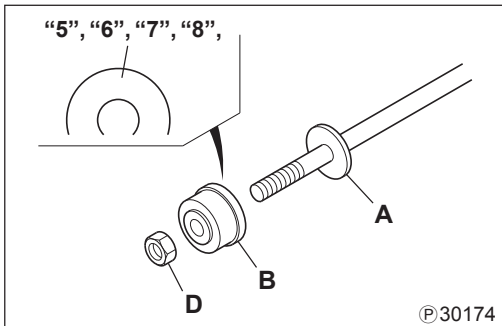


Balance shaft bushing

Use the Balance Shaft Bushing Installer & Extractor to replace the balance shaft bushings 1 through 3.

(Components of Balance Shaft Bushing Installer & Extractor)

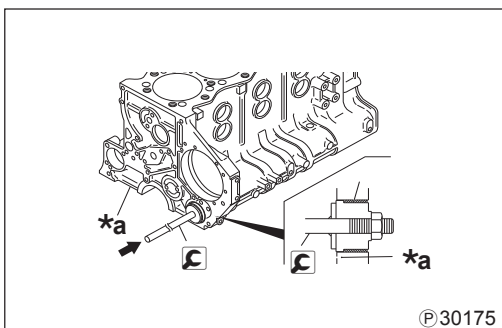
- A : Rod
- B : Adapter
- C : Guide piece
- D : Nut



[Removal]

- Drive out the balance shaft bushings 1 to 3 using the Balance Shaft Bushing Installer & Extractor consisting of the adapter B appropriate to each bushing secured on rod A with nut D.

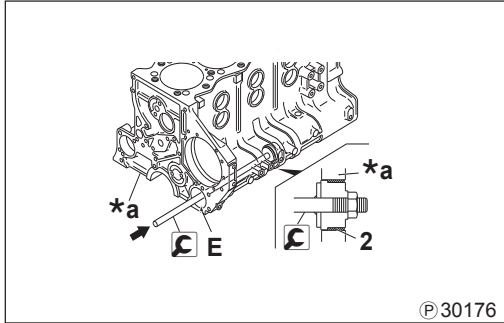
Balance shaft bushing		Identification mark of adapter B
No. 1	Left	5
	Right	6
No. 2		7
No. 3		8



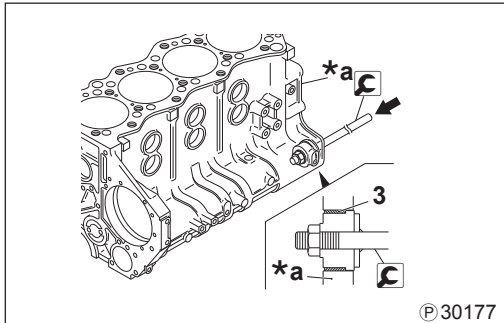
- Remove the No. 1 balance shaft bushing 1 from the front side of the upper crankcase \*a.

: Balance Shaft Bushing Installer & Extractor

# BALANCE SHAFT BUSHINGS

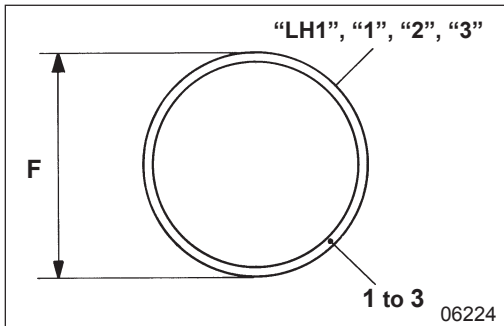


- Remove the No. 2 balance shaft bushing **2** from the upper crankcase **\*a** by inserting the Balance Shaft Bushing Installer & Extractor through the hole **E** from which the No. 1 balance shaft bushing was removed.



- Remove the No. 3 balance shaft bushing **3** from the rear side of the upper crankcase **\*a**.

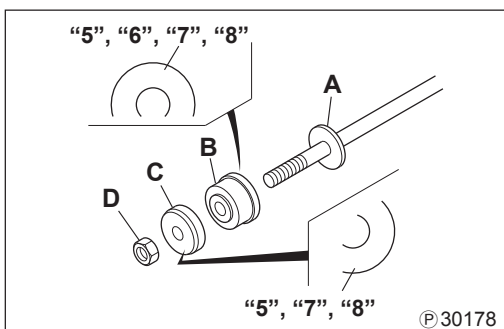
: Balance Shaft Bushing Installer & Extractor



## [Installation]

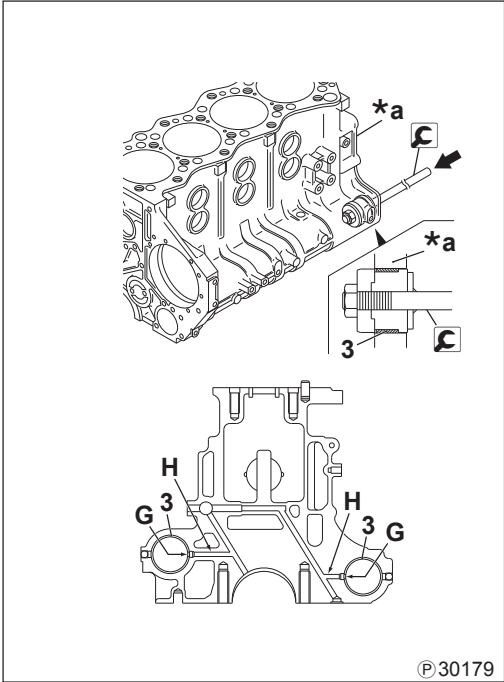
- Identify balance shaft bushings **1** through **3** by the marks "1", "2", "3" or "LH1" stamped on each bushing. If the mark on a bushing is unclear, identify the bushing by measuring the outside diameter **F** of the bushing.

Balance shaft bushing (from front of engine)		Mark	Outside diameter (mm {in.})
No. 1	Left (two oil holes)	LH1	φ 55.25 {φ 2.175}
	Right (one oil hole)	1	
No. 2		2	φ 55 {φ 2.165}
No. 3		3	φ 54.75 {φ 2.155}



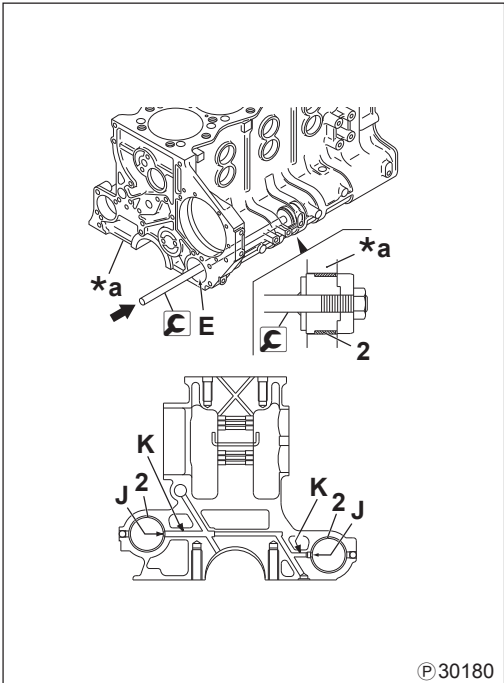
- Drive the balance shaft bushings **1** through **3** in position by hammering on the Balance Shaft Bushing Installer & Extractor consisting of the adapter **B** and guide piece **C** appropriate to each bushing secured on the rod **A** with nut **D**.

Balance shaft bushing		Identification mark of adapter <b>B</b>	Identification mark of guide piece <b>C</b>
No. 1	Left	5	5
	Right	6	
No. 2		7	7
No. 3		8	8



- Install the No. 3 balance shaft bushing **3** from the rear side of the upper crankcase **\*a**.  
In this case, make sure that the oil hole **G** in the bushing matches the oil passage **H** in the crankcase.

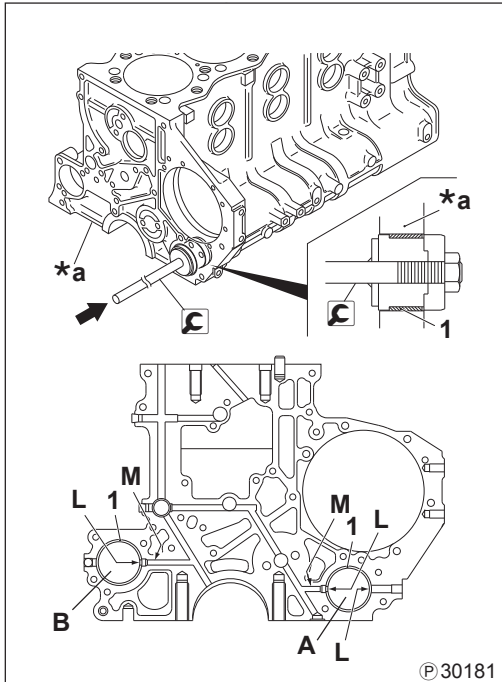
**C** : Balance Shaft Bushing Installer & Extractor




- Install the No. 2 balance shaft **2** by inserting the **C** Balance Shaft Bushing Installer & Extractor through the No. 1 balance shaft bushing mounting hole **E** of the upper crankcase **\*a**.  
In this case, make sure that the oil hole **J** in the bushing matches the oil passage **K** in the crankcase.

**C** : Balance Shaft Bushing Installer & Extractor

# BALANCE SHAFT BUSHINGS



- Install the No. 1 balance shaft bushing 1 from the front side of the upper crankcase \*a.  
In this case, make sure that the oil hole L in the bushing matches the oil passage M in the crankcase.

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## CAUTION

- The No. 1 balance bushings 1 include the right and left ones which are different from each other. Use care to prevent confusion when installing them.  
The left one A has two oil holes L, whereas the right one B has one oil hole L.
- Before installing No. 1 balance bushing 1, check to ensure that No. 2 balance shaft bushing 2 has been installed.