

**YAMAHA**

**Service Manual**

**TS190(R)  
TS230(R)**

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# **YANMAR**

# **SERVICE MANUAL**

**Model**

**TS190(R)**

**TS230(R)**

# FOREWORD

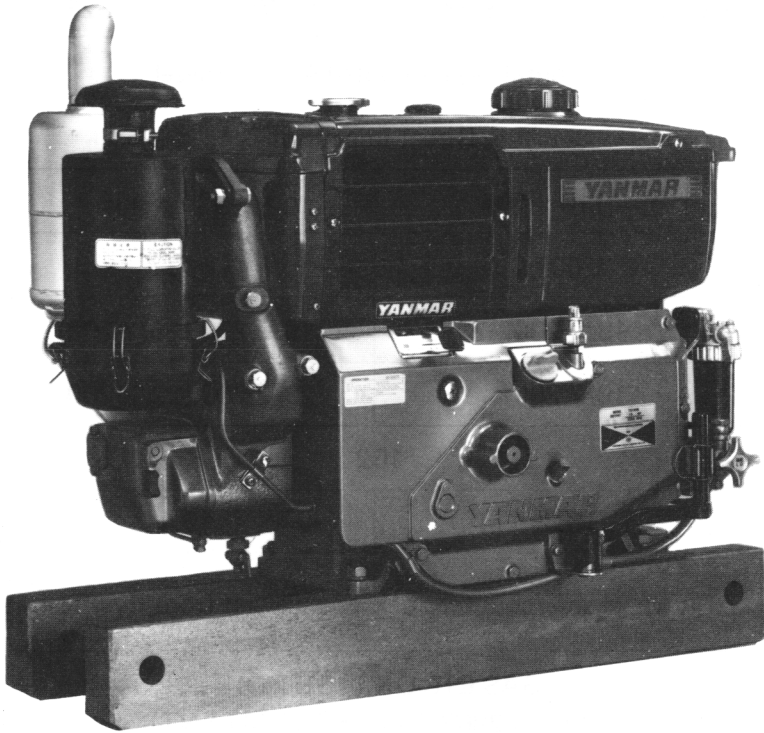
*This service manual covers the main section of the TS190(R) and TS230(R) Series engines. It explains the construction and function of the engines, followed by standard servicing instructions for disassembly and reassembly. Before starting servicing of your engine, you are recommended to read through this manual until you fully understand the construction and function of the engine components.*

*The engine construction and servicing procedures are subject to change for the improvement of quality and performance. If you have questions or suggestions, please feel free to call us.*

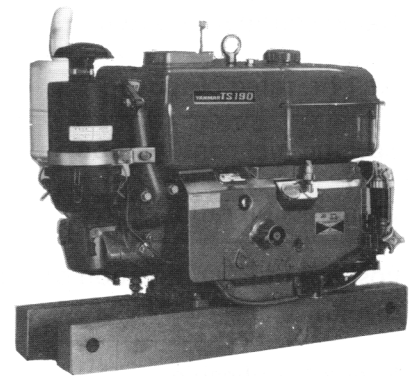
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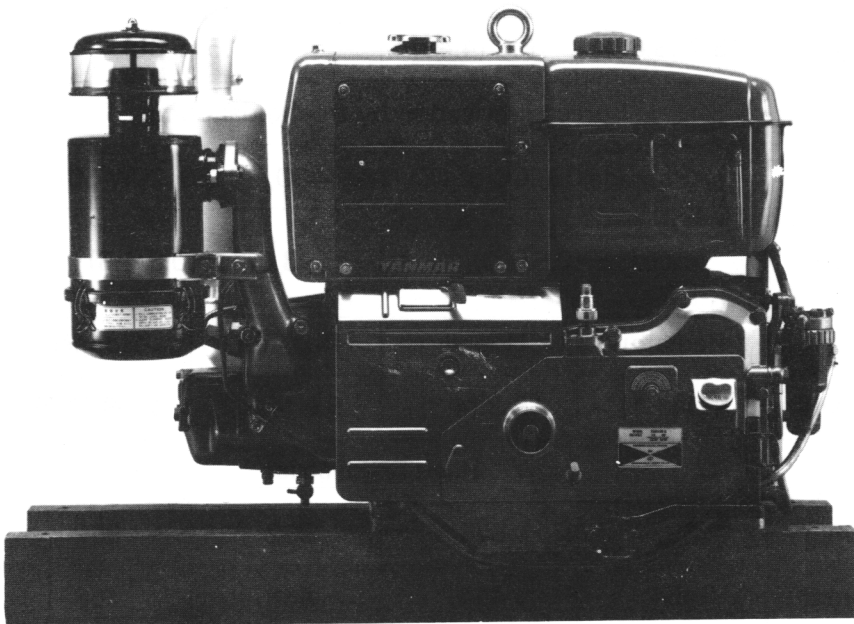
# 1. External View



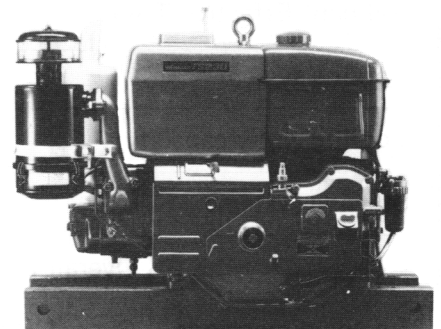
TS190R (RADIATOR)



TS190 (Hopper)



TS230R (RADIATOR)

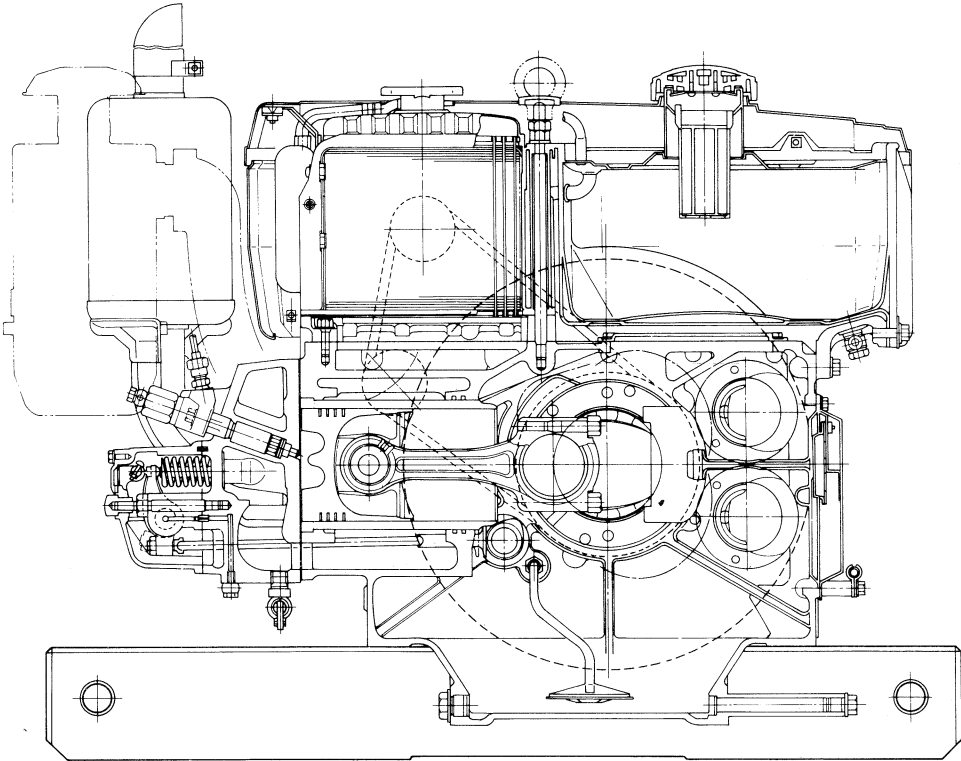


TS230 (Hopper)

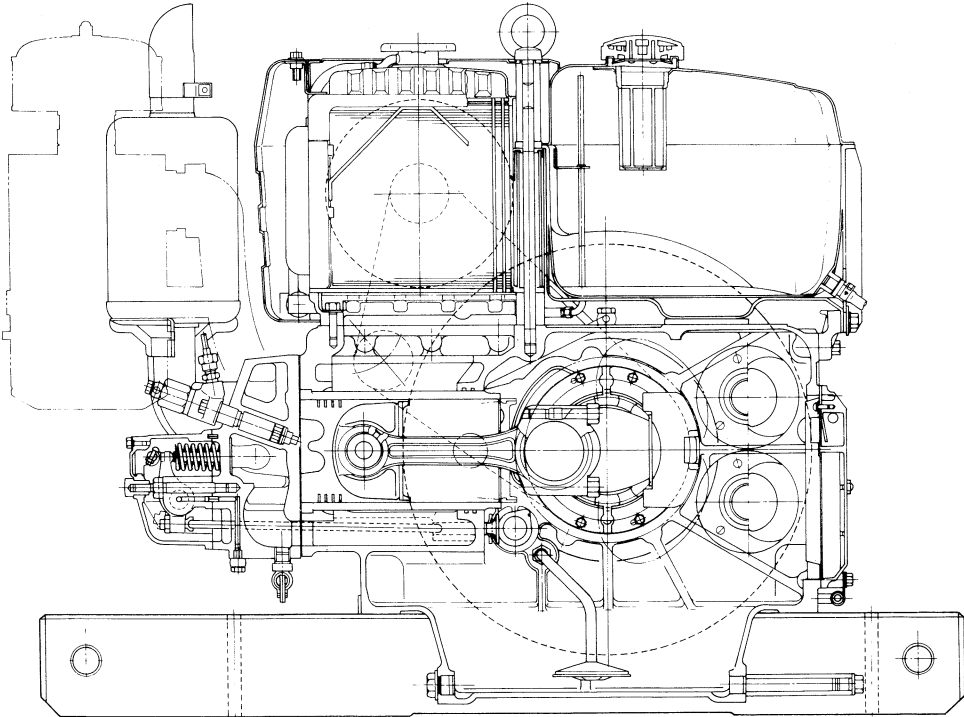
## 2. Specifications

Model		TS190R	TS190	TS230R	TS230	
Type		Horizontal, water-cooled 4-cycle diesel				
Combustion system		Direct injection				
No. of cylinders – bore x stroke	mm	1 – 110 x 106		1 – 112 x 115		
Displacement	ℓ	1,007		1,132		
Rated continuous output	HP/rpm	16/2,200		19/2,200 (18/2,200)		
At 1-hr. rated output	HP/rpm	19/2,200		23/2,200 (22/2,200)		
Specific fuel consumption	g/HP·hr	162				
Compression ratio		16.3		16.1		
Position of PTO/direction of crankshaft revolution		Flywheel side/counterclockwise viewed from flywheel				
Fuel oil applicable		GAS-OIL OR LIGHT OIL (UK BS 2869 A1 or EQUIVALENT)				
Fuel injection pump		Bosch type				
Injection timing		BTDC 19°±1				
Injection pressure		200 <sup>+5</sup> <sub>-0</sub> kg/cm <sup>2</sup>				
F.O. tank capacity	ℓ(US gal)	13.7 (3.62)	16.6 (4.48)	21.5 (5.68)		
Lubrication system		Forced lubrication by trochoidal pump				
Lubricating oil applicable		API grade CB, CC or CD (SAE #30, 40, 50, 20W-50)				
Lubricating oil capacity (oil pan) Effective/Total	ℓ (US gal)	2.0/3.6 (0.5/1.0)		3.0/6.0 (0.8/1.6)		
Cooling system		Radiator	Hopper	Radiator	Hopper	
Cooling water capacity	ℓ (US gal)	4.0 (1.1)	16.3 (4.3)	5.9 (1.6)	22.8 (6.0)	
Starting system		Hand or Electric				
Engine dimensions	Overall Length	mm	887	874	962	962
	Overall Width	mm	454	454	468	468
	Overall Height	mm	736	736	753	753
Engine dry weight	kg (lb)	182 (401)	181 (399)	203 (447)	196 (432)	

### 3. Cross Sectional View



TS190R



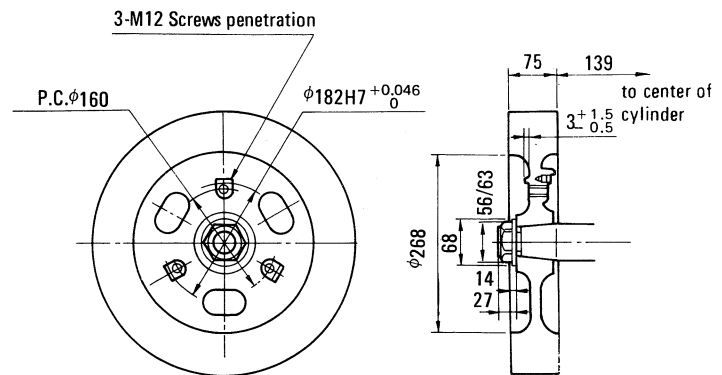
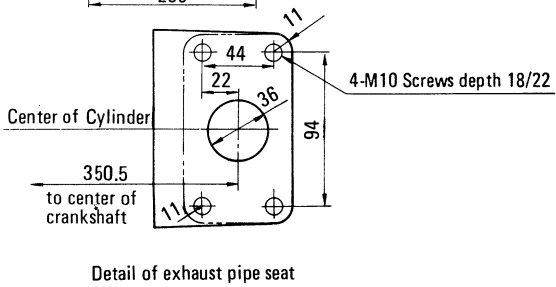
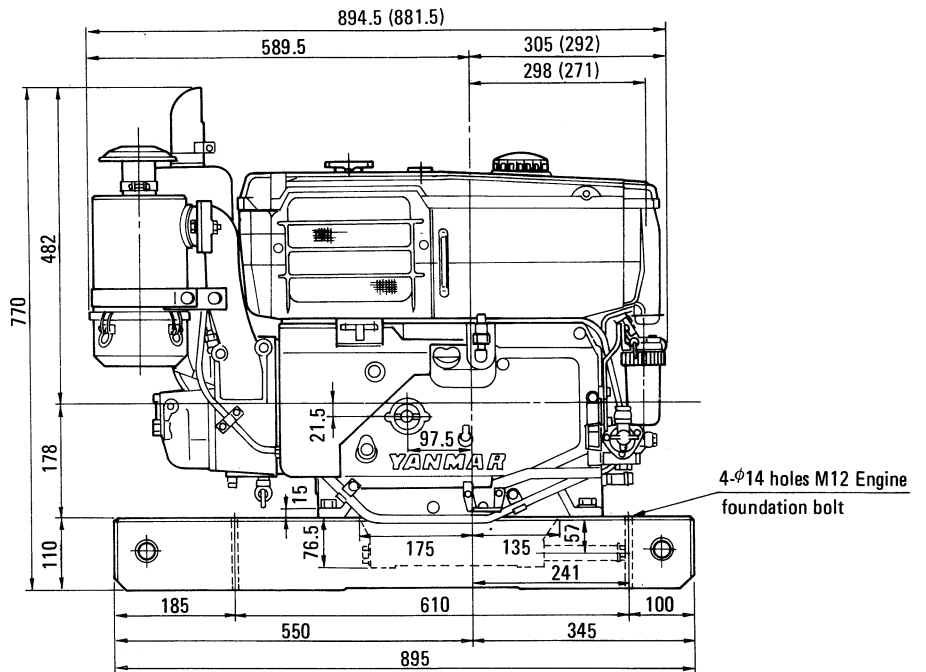
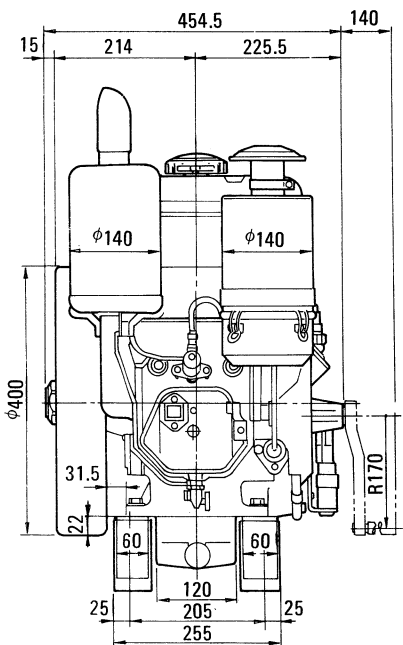
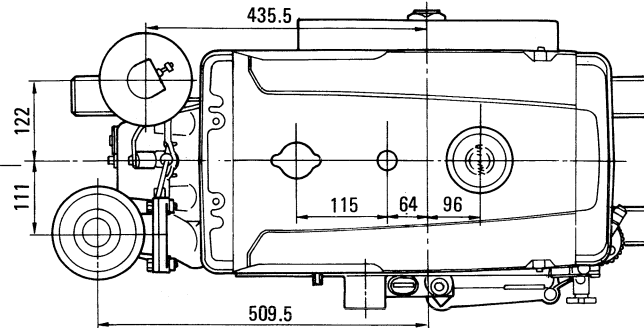
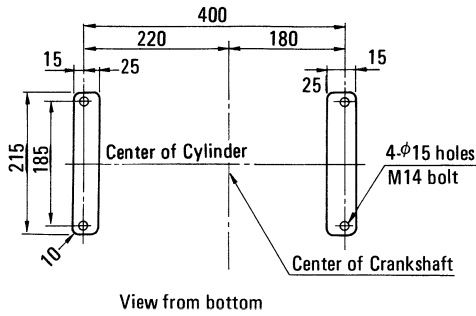
TS230R

# 4. Installation Dimensions

(Unit: mm)

TS190/TS190R

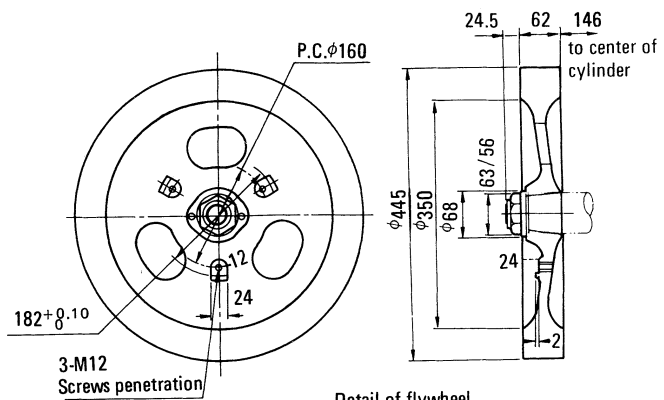
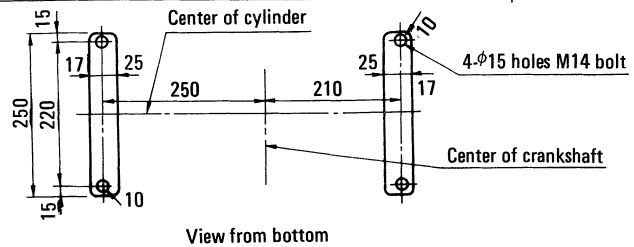
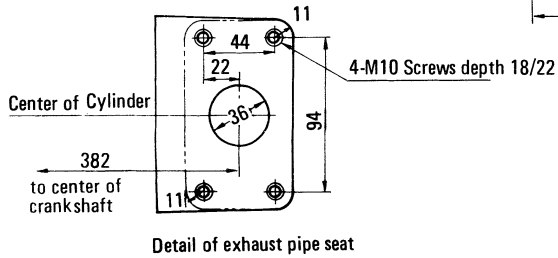
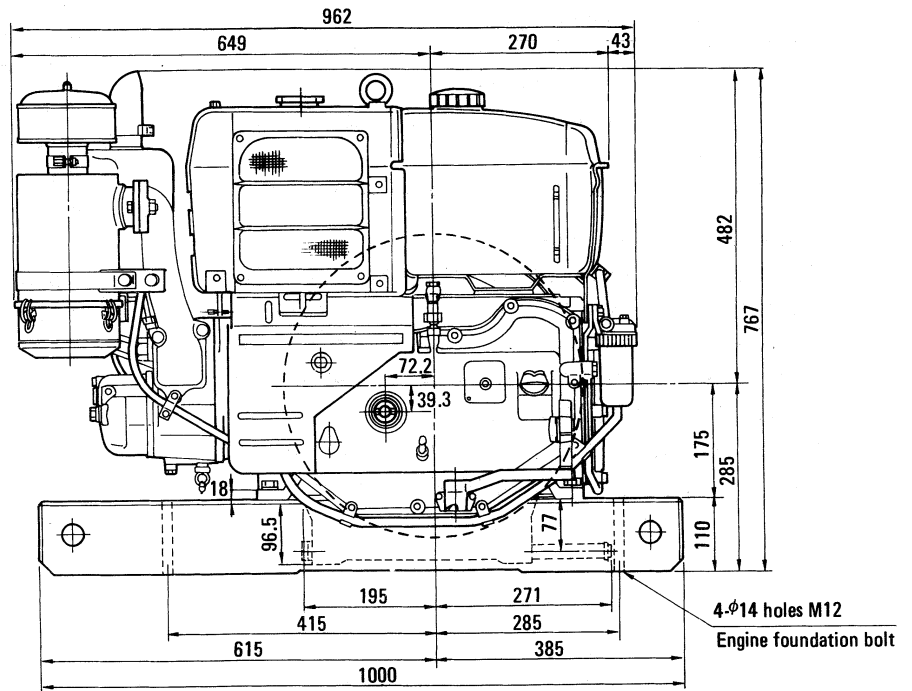
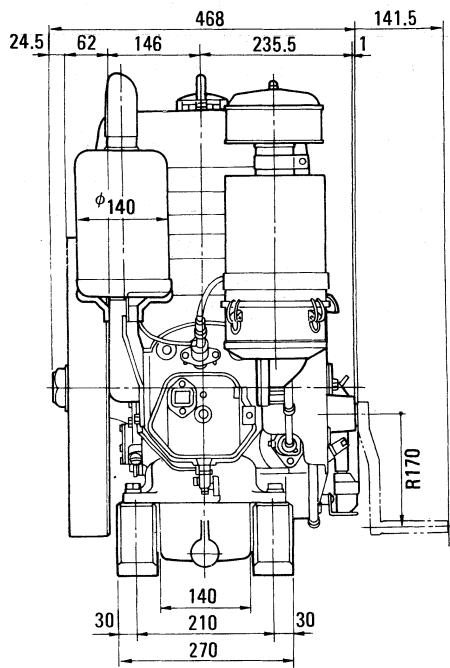
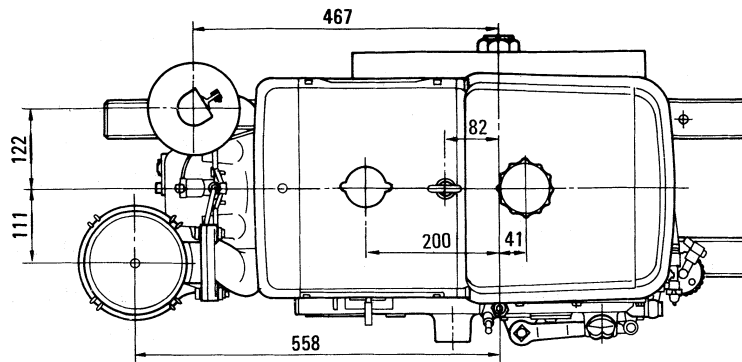
( ) : TS190





TS230/TS230R

(Unit: mm)



## 5. Installation and Engine Performance

Care should be taken that the engine is properly installed, as this greatly influences its performance. The procedure for mounting the engine is as follows.

### 1) Unpacking inspection

Unpacking work should be carried out carefully to avoid damage to the engine and common base. While unpacking, the following should be checked:

1. Bolts and nuts have not become loosened or lost during shipment.
2. Engine surfaces have not been stained by moisture during shipment.
3. The engine has not been damaged during shipment.
4. All accessories are furnished and unbroken.

### 2) Common base and engine

When mounting the engine, attention should be paid to the alignment of the pulleys and to the clearance between the common base and engine feet. If the clearance is large, be sure to adjust the mounting surface with shims, then fasten the bolts securely to uniform tightness. Do not tighten the bolts with excessive force.

### 3) Setup for remote control of regulator

The working machine to be driven by your engine may require remote control of the regulator. The engine cannot supply its full performance if the wires are improperly set. When setting the wires, the following instructions should be observed.

1. Place the remote control lever in the stop position.
2. After inserting the end of the inner wire into the regulator handle knob and turning the handle knob to the stop position, tighten the clamp screw (M4 x 35) to set the wire.
3. Start the engine to make certain that it runs throughout the full range (from lowest to highest speed) and can be stopped. The handle movement is adjustable to a desired smoothness by changing the tightness of the lock nut inside the handle.

## 6. V-pulley and V-Belt

### 6.1 V-belt installation and tension adjustment

#### 1) Belt installation method

- a) When installing a new belt, be sure first to narrow the center distance of the pulleys. After placing the belt over the pulleys, stretch it.
- b) To stretch the belt, see instructions under "Recommended belt stretching method".
- c) It takes a few days for the belt to adapt itself to the pulleys. If the belt becomes loose after a few days running, restretch it. A simple way to check belt tension is to put your hand on a pulley and bearing, the heat felt being a rough guide to the tension:
  - A hot pulley is a sign that the belt is not tight enough and is slipping.
  - A hot bearing indicates that the belt tension is excessive.

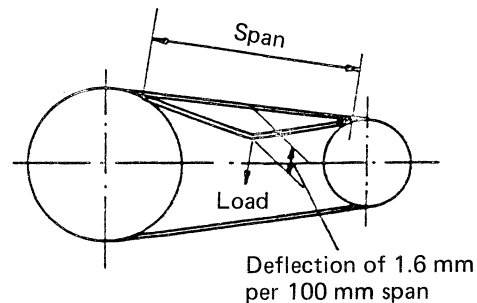


Fig. 6-1 Stretching a belt

### 6.2 Recommended belt stretching method

#### (Procedure 1)

Determine the belt span. "Span" refers to the length of the portion of the belt which is not in contact with the pulleys. It is equal to the center distance of the pulleys if the driving pulley and the driven pulley have the same diameter.

#### (Procedure 2)

1. Determine the center of the belt span.
2. Apply a load to the belt span center perpendicularly to the belt, using a spring scale or similar means.
3. Adjust so that the amount of deflection caused by the load is 1.6 mm per 100 mm span. (For a 500 mm span, for example, the deflection is to be 8 mm.) Select the load which causes the above deflection from the table below.

#### (Procedure 3)

Adjust the belt to a tension such that the load determined in procedure 2 above falls between the maximum and minimum values shown in the table.

Table of loads for Applying Optimum Tension to Belt  
(applicable only to standard type V-belts)

Belt type	Range of smaller pulley (mm)	Minimum deflective load		When a new belt is stretched		When a belt is restretched	
		Deflective load (kg/belt)	Axial load (kg/belt)	Deflective load (kg/belt)	Axial load (kg/belt)	Deflective load (kg/belt)	Axial load (kg/belt)
HM	38 – 50	0.5	14	0.7	20	0.6	17
A	65 – 80	0.8	23	1.2	34	1.0	29
	81 – 90	0.9	26	1.4	39	1.2	34
	91 – 105	1.1	31	1.7	46	1.4	40
	106 –	1.2	35	1.8	53	1.6	46
B	115 – 135	1.4	45	2.1	68	1.8	59
	136 – 160	1.8	54	2.7	81	2.3	70
	161 –	1.9	58	2.9	86	2.5	75

6.3 V-pulley and V-belt

Engine power has a great influence on rotational speed, which in turn greatly affects the performance of the working machine. For the engine to run most efficiently and offer its full performance, the pulley of the engine must have appropriate proportions for the working machine.

1) Pulley size selection

An engine is run most efficiently at its rated number of revolutions (N); the working machine is operated most efficiently at its recommended number of revolutions (R). For a given pulley size (D) of the working machine, the pulley size required for the engine is calculated as

$$d = \frac{R \times D}{N}$$

where d is the engine pulley diameter.

Suppose the pulley of a working machine is to be selected. If the engine pulley is 90 mm in diameter and 2,200 rpm in rotational speed, and the working machine's pulley has a rotational speed of 1,000 rpm, then

$$(90 \times 2,200) / 1,000 = 198$$

Thus the pulley diameter of the working machine is 198 mm. It is important to limit the pulley ratio to 3 : 1.

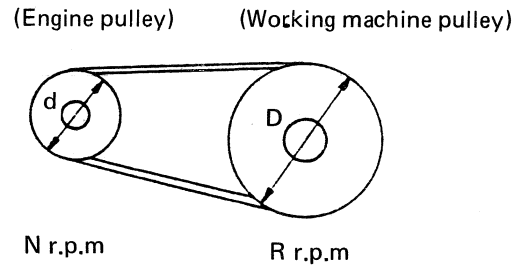


Fig. 6-2 Selection of pulley diameters

Engine		Working machine's pulley diameter (mm)																Rotational speed of working machine rpm
Rotational speed	Pulley diameter	75	90	100	115	125	135	150	180	200	250	275	300	325	350	375		
2200 rpm	75	2200	1830	1650	1440	1320	1220	1100	920	830	660							
	90	2640	2200	1980	1720	1590	1470	1320	1100	990	790	720						
	100	2930	2440	2200	1910	1760	1630	1470	1220	1100	880	800	735					
	115	3370	2810	2530	2200	2020	1870	1690	1410	1270	1010	920	840	780				
	125	3670	3060	2750	2390	2200	2040	1840	1530	1380	1100	1000	920	850	790	730		
	135	3960	3300	2970	2580	2380	2200	1980	1650	1480	1190	1080	990	920	850	790		
	150	4400	3670	3300	2870	2640	2440	2200	1830	1650	1320	1200	1100	1020	940	880		

2) Centering of pulleys

Place the engine's crankshaft and the working machine's driving shaft parallel to each other. The parallelism is easily achieved by stretching a string along the side face of both the engine's pulley and the working machine's pulley, then making an adjustment so that the string is simultaneously in contact with the points 1, 2, 3 and 4 as shown in Fig. 6-3.

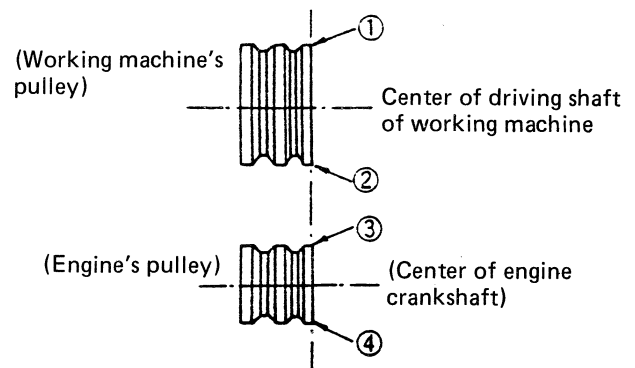


Fig. 6-3 Centering of pulleys

# 7. Disassembly and Reassembly

## 7.1 Preparation for Disassembly

Make the following preparations prior to disassembling the engine.

**1) Selection of work area**

Select a clean area – well organised, and free of dirt and rubbish.

**2) Preparation of parts storage area and parts containers**

Prepare a suitable area and containers to ensure that the parts will not be stained or damaged.

**3) Preparation of cleaner or cleaning can**

Prepare a parts washing cleaner. Otherwise, make use of half of an 18-liter can, prepared by cutting the can vertically.

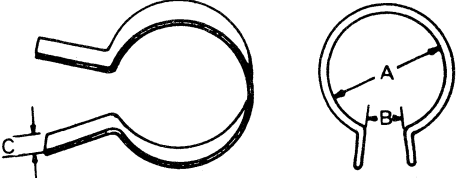
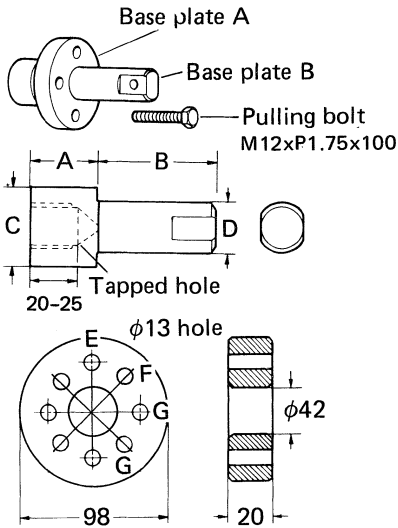
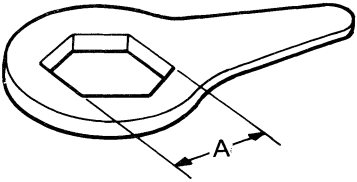
**4) Preparation and check of tools and instruments**

The following listings show the tools and instruments required for disassembling and reassembling engines. Suitable items should be used selectively according to the complexity and sections of the engine to be disassembled.

*Note: The tools for both TS190(R) and TS230(R), the model name is not given.*

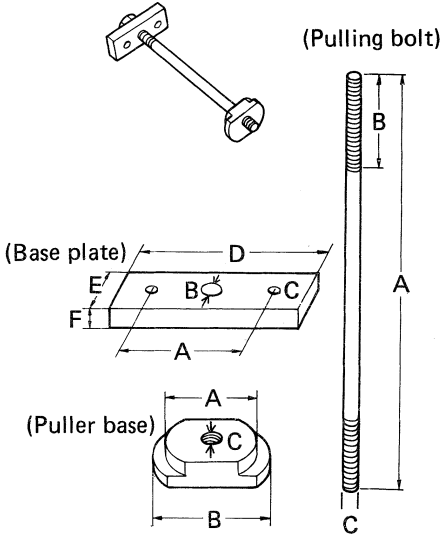
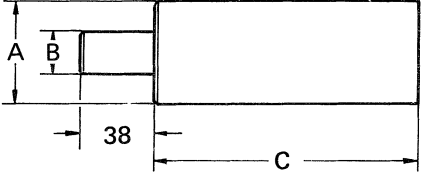
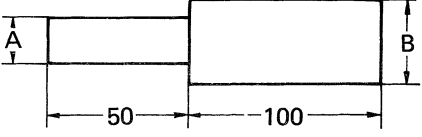
## 7.2 Disassembling/assembling tools

Unit: mm

Tool (Yanmar code No.)	Size	Illustration														
Piston insertion tool (optional) (TS190: 105890-92140) (TS230: 105990-92140)	<table border="1"> <thead> <tr> <th></th> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>TS190</td> <td>110</td> <td>20</td> <td>30</td> </tr> <tr> <td>TS230</td> <td>112</td> <td>20</td> <td>30</td> </tr> </tbody> </table>		A	B	C	TS190	110	20	30	TS230	112	20	30			
	A	B	C													
TS190	110	20	30													
TS230	112	20	30													
Flywheel puller (optional) Base plate-A (104300-92120) Base plate-B (104300-92110) Pulling bolt (104200-92130)	<table border="1"> <tbody> <tr> <td>A</td> <td>40</td> </tr> <tr> <td>B</td> <td>90</td> </tr> <tr> <td>C</td> <td><math>\phi 52</math> Pulling bolt M36 x 2</td> </tr> <tr> <td>D</td> <td>42</td> </tr> <tr> <td>E</td> <td>72</td> </tr> <tr> <td>F</td> <td>77</td> </tr> <tr> <td>G</td> <td>65</td> </tr> </tbody> </table>	A	40	B	90	C	$\phi 52$ Pulling bolt M36 x 2	D	42	E	72	F	77	G	65	
A	40															
B	90															
C	$\phi 52$ Pulling bolt M36 x 2															
D	42															
E	72															
F	77															
G	65															
End nut wrench (optional) (103338-92100)	A ..... 57															

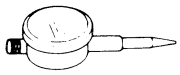

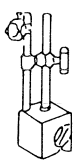
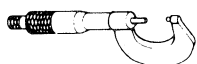
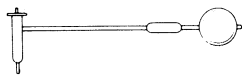
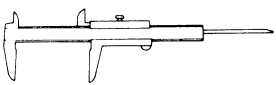




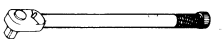
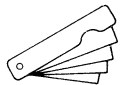
7. Disassembly and Reassembly

Unit: mm

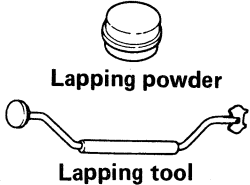
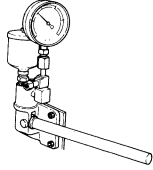
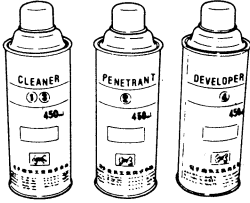
Tool (Yanmar code No.)	Size	Illustration																								
Liner puller (optional) Base plate (105990-92020) Puller base (105990-92010) Pulling bolt (105990-92030) Hexagonal nut (26712-160002)	<p>Base plate</p> <table border="1" data-bbox="570 363 907 464"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> </tr> <tr> <td>163</td> <td>18</td> <td>20</td> <td>203</td> <td>38</td> <td>19</td> </tr> </table> <p>Puller base</p> <table border="1" data-bbox="570 543 907 669"> <tr> <td>A</td> <td>B</td> <td>C</td> </tr> <tr> <td>109.9 ~ 109.4</td> <td>123.9 ~ 123.4</td> <td>18</td> </tr> </table> <p>Pulling bolt</p> <table border="1" data-bbox="570 764 907 869"> <tr> <td>A</td> <td>B</td> <td>C</td> </tr> <tr> <td>400</td> <td>45</td> <td>M = 16 P = 2.0</td> </tr> </table> <p>Hexagonal nut M16 P = 2.0</p>	A	B	C	D	E	F	163	18	20	203	38	19	A	B	C	109.9 ~ 109.4	123.9 ~ 123.4	18	A	B	C	400	45	M = 16 P = 2.0	
A	B	C	D	E	F																					
163	18	20	203	38	19																					
A	B	C																								
109.9 ~ 109.4	123.9 ~ 123.4	18																								
A	B	C																								
400	45	M = 16 P = 2.0																								
Connecting rod small-end bush puller (made by user)	<table border="1" data-bbox="570 1089 907 1251"> <tr> <td>A</td> <td>B</td> <td>C</td> </tr> <tr> <td>39.5 ~ 39</td> <td>35.5 ~ 35</td> <td>100</td> </tr> </table>	A	B	C	39.5 ~ 39	35.5 ~ 35	100																			
A	B	C																								
39.5 ~ 39	35.5 ~ 35	100																								
Intake/exhaust valve guide pulling/insertion tool (made by user)	<table border="1" data-bbox="570 1329 907 1465"> <tr> <td>A</td> <td>B</td> </tr> <tr> <td>φ8.8~8,3</td> <td>φ13.8~13.6</td> </tr> </table>	A	B	φ8.8~8,3	φ13.8~13.6																					
A	B																									
φ8.8~8,3	φ13.8~13.6																									

Note: • The connecting rod small-end bush puller and the intake/exhaust valve guide pulling/insertion tool are made by the user according to the reference dimensions shown on their right.

## 7.3 Meters, Instruments and Service Accessories

Instrument	Remarks		Illustration						
Dial gauge	1 div.: 0.01 mm Range: 0–5 mm 0–10 mm	To measure the straightness of shafts, flatness of planes, and gap widths.							
Test indicator	1 div.: 0.01 mm Range: 0–0.8 mm	To measure positions too narrow and too deep for normal dial indicators.							
Magnet stand	<table border="1"> <thead> <tr> <th>Trunk bar (dia. x length) (mm)</th> <th>Branch bar (dia. x length) (mm)</th> </tr> </thead> <tbody> <tr> <td>12 x 176</td> <td>10 x 165</td> </tr> <tr> <td>14 x 183</td> <td>12 x 165</td> </tr> </tbody> </table>	Trunk bar (dia. x length) (mm)	Branch bar (dia. x length) (mm)	12 x 176	10 x 165	14 x 183	12 x 165	To attach dial indicators to various positions for easy accurate viewing.	
Trunk bar (dia. x length) (mm)	Branch bar (dia. x length) (mm)								
12 x 176	10 x 165								
14 x 183	12 x 165								
Micrometer	Range (mm) 0–25 50–75 25–50 50–100	To measure the O.D. of the crankshaft, pistons, and piston pins.							
Cylinder gauge	Range (mm) 10–18 35–60 18–35 50–100	To measure the I.D. of the cylinder liners and main bearings.							
Vernier calipers	1 div.: 0.05 mm Range: 0–150 mm 0–200 mm	To measure various O.D., depths, thicknesses, and widths.							
Depth micrometer	Range (mm) 0–25	To measure valve sinkage and liner projection.							
Square	Size: 100 mm	To measure the inclination of valve springs and squareness of various parts.							
V-block	Size: 100x50x55 mm	To be used when measuring the straightness of a shaft.							
Torque wrench	<table border="1"> <thead> <tr> <th>Bolt/nut size (mm)</th> <th>Range (kg-cm)</th> </tr> </thead> <tbody> <tr> <td>6 – 14</td> <td>4 – 30 31 – 80</td> </tr> <tr> <td>17, 19, 21</td> <td>31 – 160</td> </tr> </tbody> </table> Range (kg-cm): 40 – 120, 100 – 450, 400-1, 800, 400-2, 800, 600 – 4,200, 1,000 – 5,500	Bolt/nut size (mm)	Range (kg-cm)	6 – 14	4 – 30 31 – 80	17, 19, 21	31 – 160	To be used when tightening bolts and nuts with specified torques.	 
Bolt/nut size (mm)	Range (kg-cm)								
6 – 14	4 – 30 31 – 80								
17, 19, 21	31 – 160								
Feeler gauge	Length 75 x 9 sheets	To measure clearances between piston rings and piston grooves or between shaft couplings during installation.							

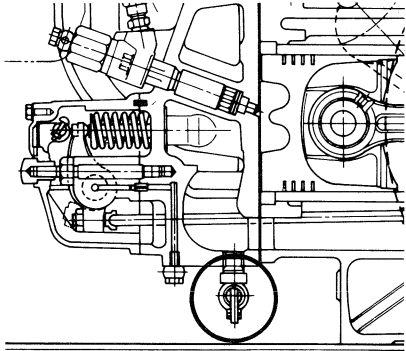
**7. Disassembly and Reassembly**

Instrument (Yanmar code No.)	Remarks	Illustration
Valve lapping handle 28210-000031  Valve lapping powder 28210-000070	<p><b>To lap intake/exhaust valve seats.</b></p>	 <p><b>Lapping powder</b></p> <p><b>Lapping tool</b></p>
Nozzle tester (737600- 93401)  High pressure Injection pipe (135400- 93401) (124223- 93400)	<p>Pressure gauge 0 – 500 kg/cm<sup>2</sup></p> <p>To inspect spray condition and the injection pressure of the fuel injection valve.</p> <p>Injection valve side nut M14 x 1.5 capnut</p> <p>M14 x 1.5 pusher fitting</p>	
Color check (for flaw detection)  Set product (6 bottles) (97550- 004560)	<p>Penetrant (450 cc) (97550-00451)</p> <p>Developer (450 cc) (97550-004520)</p> <p>Cleaning agent (450 cc) (97550-004530)</p> <p>To be used in detecting flaws.</p>	



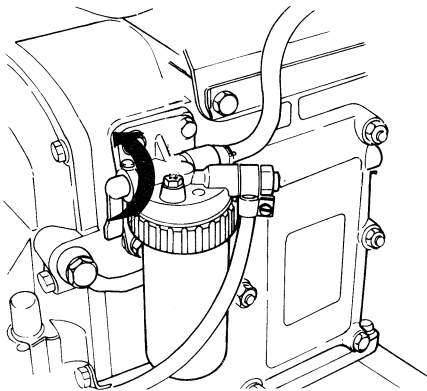
**7.4 Disassembling procedure**

1. Drain the cooling water  
Open the drain cock at the bottom of the cylinder head.



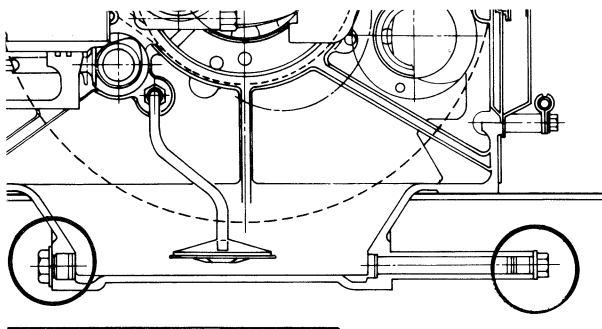
Drain cock

2. Cut off the fuel oil  
Close the F.O. filter cock.



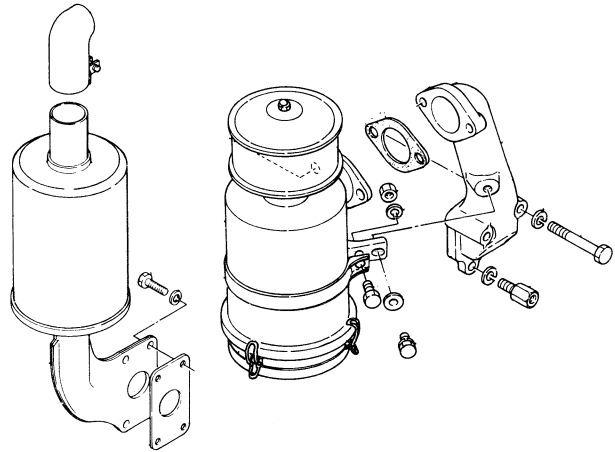
Fuel oil filter

3. Drain the lubricating oil  
Remove the drain plug at the bottom of the cylinder block.



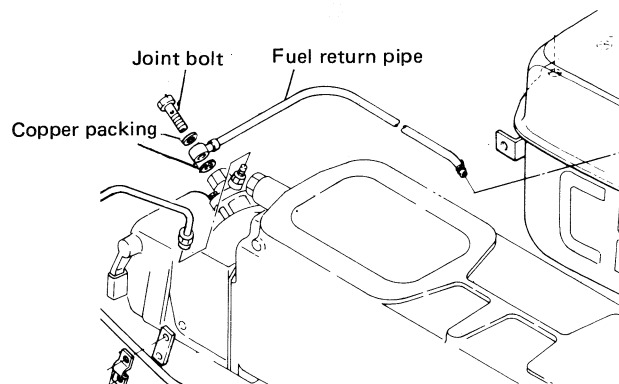
Lubricating oil drain plug

4. Remove the muffler
5. Remove the air cleaner and air intake pipe  
Be careful so that the spring washer for positioning the high-pressure pipe does not fall out.



Remove the air cleaner and muffler

6. Disconnect the fuel return pipe on the injection valve side only.  
There are two copper packings:  
One on body side, 2 mm  
One on outside, 1 mm

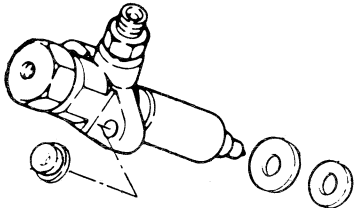


Disconnect the fuel return pipe

7. Remove the bonnet on cylinder side cover

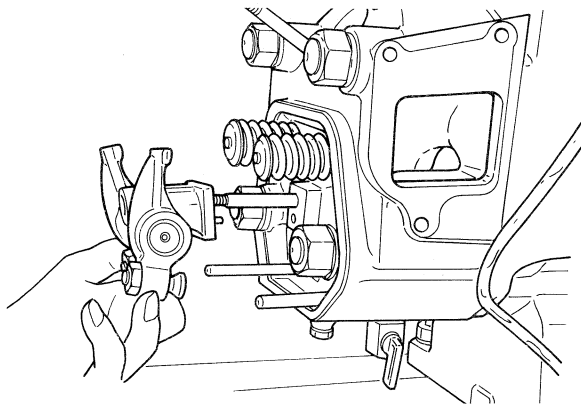
## 7. Disassembly and Reassembly

8. Dismount the fuel injection valve
- 1) Disconnect the fuel injection pipe.
  - 2) Pull out the fuel injection valve by removing its retaining nut.
  - 3) When the nozzle is removed, take particular care of its tip and protect it with soft cloth.



Dismount the fuel injection valve

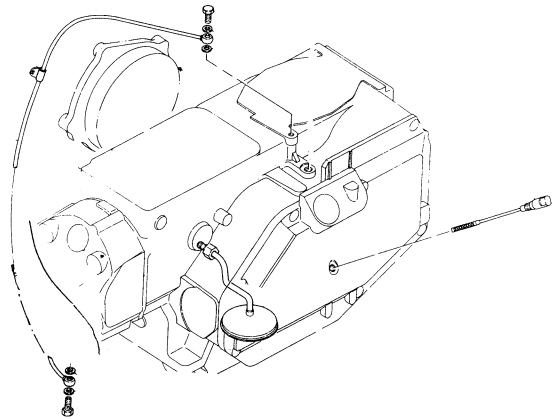
9. Take off the bonnet on cylinder head
10. Detach the valve rocker arm supports  
Distinguish between the intake and exhaust sides. (The exhaust valve rocker arm has a machined surface.)



Detach the valve rocker arm

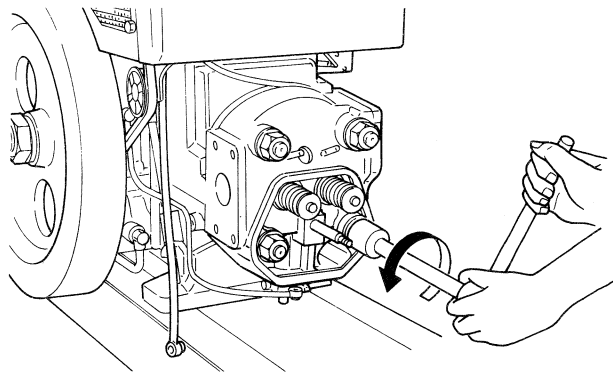
11. Slide the push rod out  
The rod is usable in either direction.

12. Free the lubricating oil pipe from the cylinder head.  
Be careful of the upper and lower copper packings.



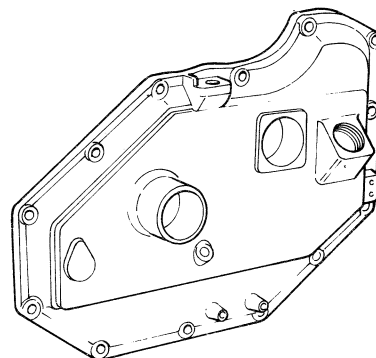
Free the lubricating oil pipe

13. Remove the cylinder head
- 1) Loosen the head clamp nuts, loosening opposite pairs of nuts at the same time.
  - 2) The nuts have upper and lower sides. (The lower side faces the head.)



Remove the cylinder head

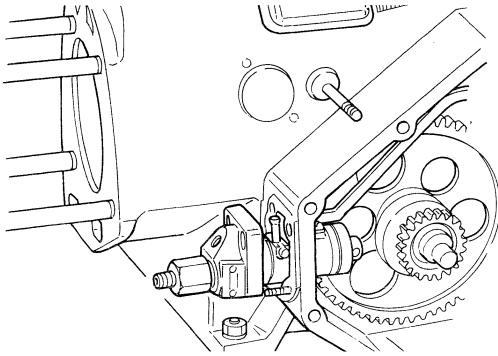
14. Take off the cylinder side cover.
- 1) First detach the start cover.
  - 2) Remove the oil level gauge.



Cylinder side cover

15. Dismount the fuel injection pump

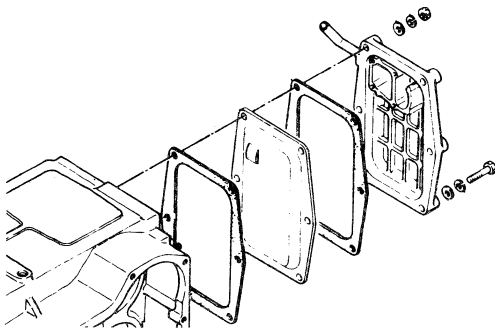
- 1) Check the thickness and number of fuel injection timing adjustment shims.
- 2) Pull out the rack pin without interfering with the cylinder.



Dismount the fuel injection pump

16. Take off the cylinder rear cover

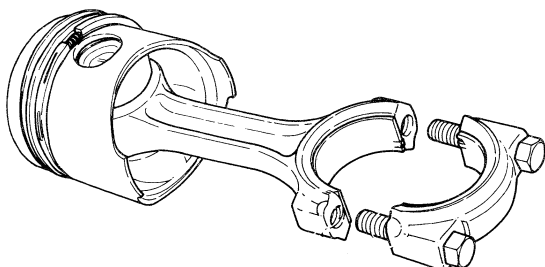
- 1) Notice the position of the lubricating oil pipe clamp. (Two halves of vinyl cushion are provided.)
- 2) Remove the shield plate.



Take off the cylinder rear cover

17. Remove the piston and the connecting rod

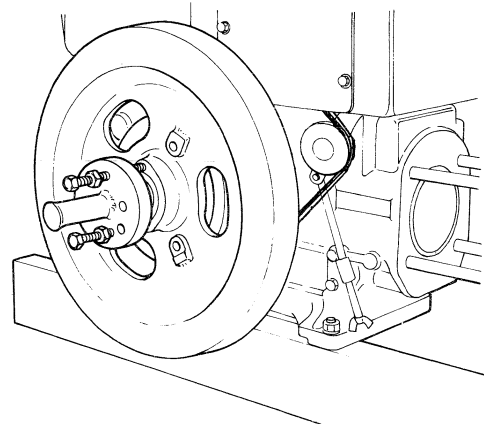
- 1) With the piston at bottom dead center, remove the connecting rod bolts, then remove the caps.
- 2) Taking care of the crank pin, push out the connecting rod and pull out the piston.



Remove the piston and the connecting rod

18. Dismount the flywheel

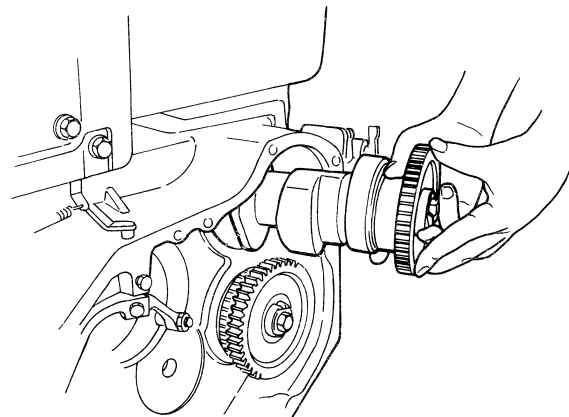
- 1) Loosen tension adjustment wing bolts (only Radiator type).
- 2) Remove the tension pulley bolts (Radiator type).
- 3) Remove the end nut using the end nut wrench.
- 4) Dismount the flywheel using the flywheel puller.



Dismount the flywheel

19. Pull out the balancer

- 1) Remove the idle gear together with the idle gear shaft.
- 2) Take off the balancer side cover.
- 3) Remove the bearing retaining ring of the balancer shaft.
- 4) Tap the end of the balancer with a hammer to move it out from the pump side.

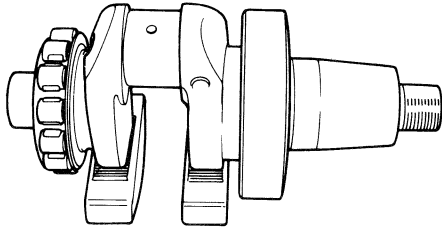


Pull out the balancer

## 7. Disassembly and Reassembly

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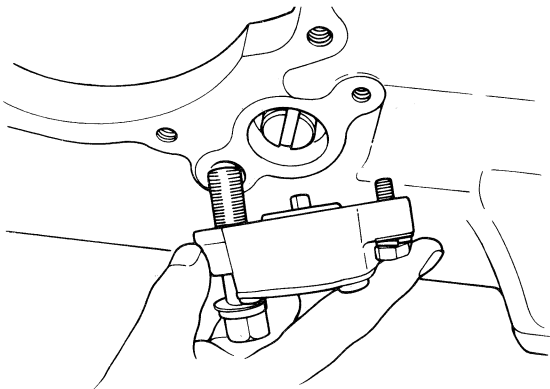
20. Remove the crankshaft assembly  
Turn the crankshaft so it fits with the notch in the cylinder body, then pull it out.



Remove the crankshaft

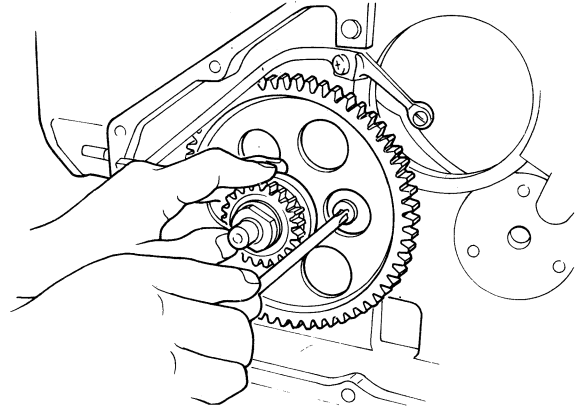
21. Disconnect the lubricating oil suction pipe  
Take care that the lubricating oil pump clamp bolts do not become loose.

22. Dismount the lubricating oil pump



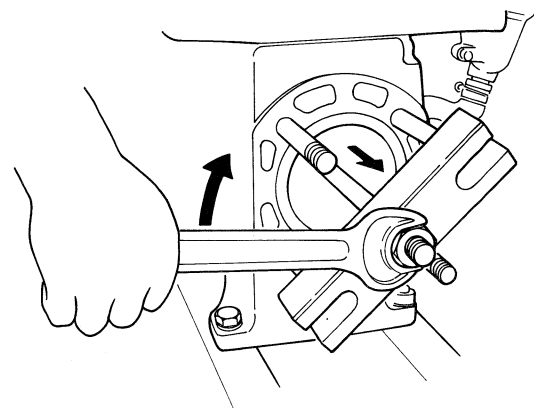
Lubricating oil pump and suction pipe

23. Remove the camshaft and tappet .
- 1) Slacken off the camshaft bearing retaining bolt.
  - 2) Slacken off the governor lever set bolt.
  - 3) Tap the camshaft out to the fuel pump side.
  - 4) Take out the tappet.



Remove the camshaft and tappet

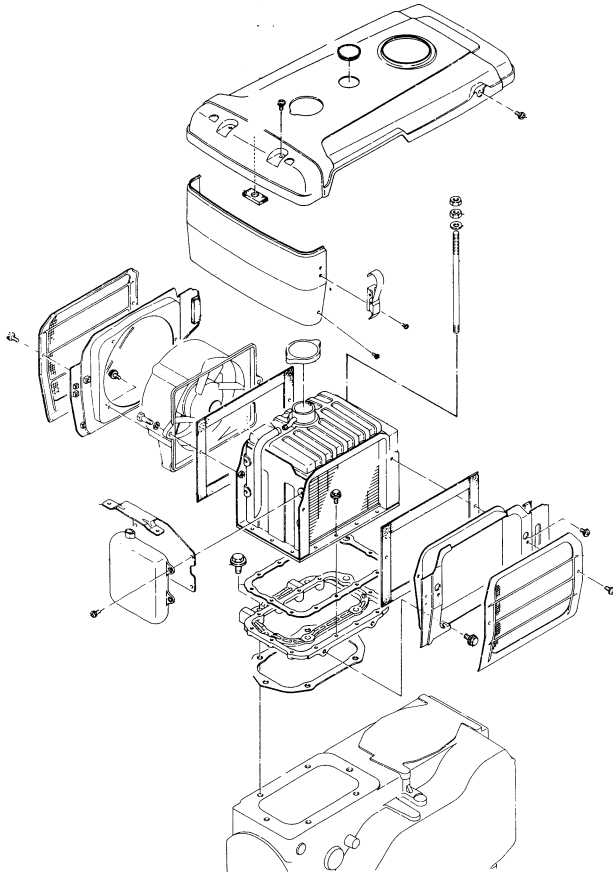
24. Pull out the liner.



Pull out the liner

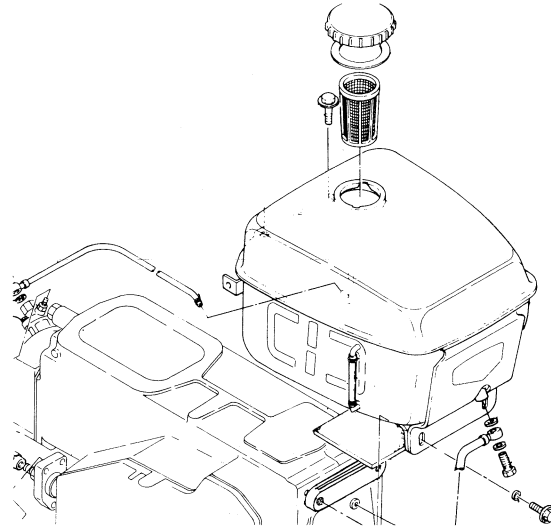
### 7.5 Disassembly of radiator

1. Take off the radiator cover
  - 1) Slacken off the cap.
  - 2) Take off the radiator cover.
  - 3) Take off the screen duct and front covers on the right and left.



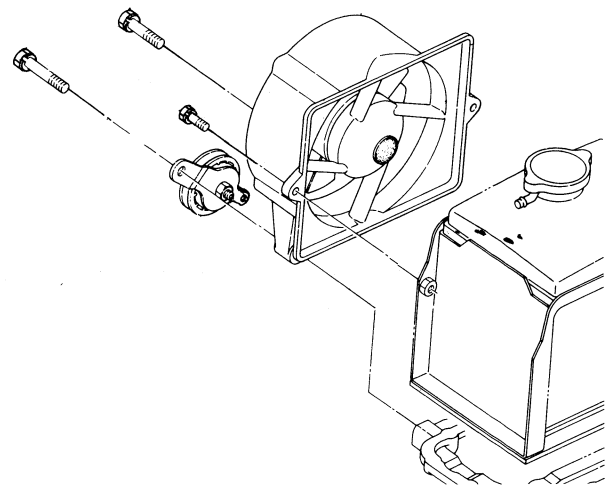
(Model: TS190R)

2. Dismount the fuel tank.
  - 1) Slacken off the pipe coupling bolt on the fuel tank outlet.
  - 2) Slacken off the fuel tank clamp bolt. Remove the self-locking nut.
  - 3) Remove the fuel tank.

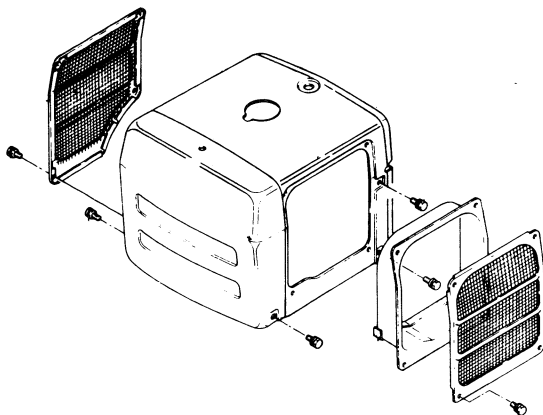


Dismount the fuel tank

3. Detach the fan case assembly.
  - 1) Take off the belt.
  - 2) Slacken off the tension pulley bolt.
  - 3) Remove the fan case by slackening off the four bolts.



Remove the fan case

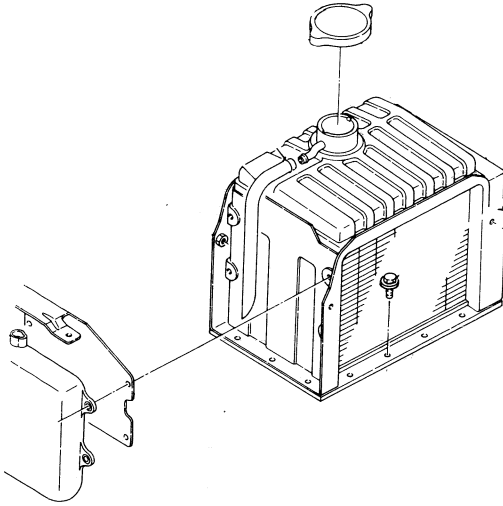


(Model: TS230R)

## 7. Disassembly and Reassembly

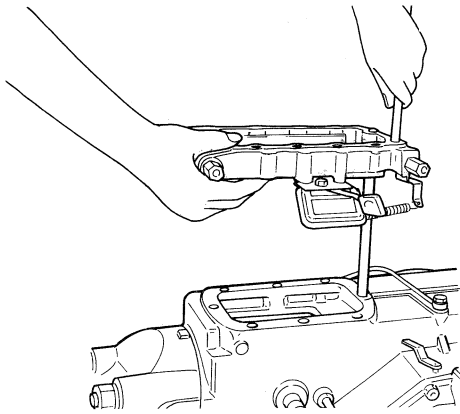
### 4. Detach the radiator.

- 1) Detach the sub-tank. (When removing the bolts, take care to avoid damage to the fins.)



**Remove the radiator**

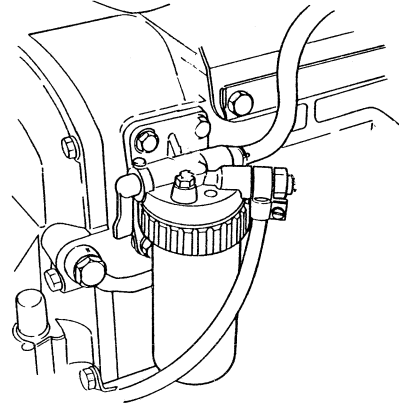
5. Remove the regulator spring.
6. Remove the radiator bracket.
7. Slacken off the governor lever shaft set bolt.



**Remove the radiator bracket and governor shaft set bolt**

### 8. Slacken off the fuel filter clamp bolt.

9. Slacken off the fuel filter mount clamp bolt.



**Fig. 26 Remove the fuel filter**

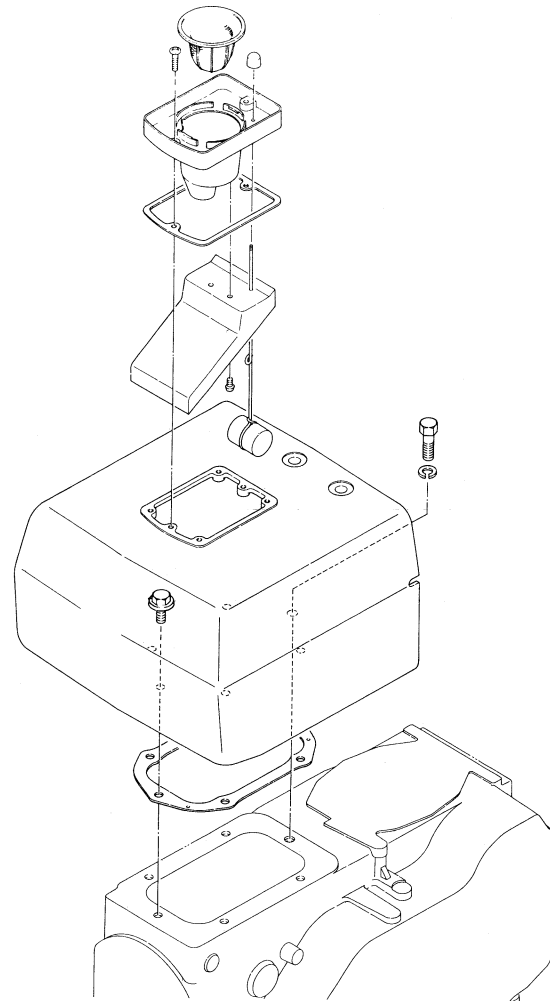
## 7.6 Disassembly of hopper

1. Dismount the fuel tank as follows:

- 1) Slacken off the pipe coupling bolt on the fuel tank outlet.
- 2) Slacken off the fuel tank clamp bolt.
- 3) Remove the fuel tank.

2. Detach the hopper.

3. Remove the regulator spring.



Hopper component parts

### 7.7 Reassembling procedure

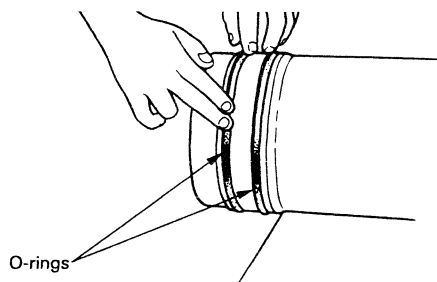
*Note: Tightening torque and dimensions indicate the specifications for both TS290(R) and TS230(R), the model name is not given.*

#### Before starting assembly

- Thoroughly wash and inspect all the parts to be assembled.
- Apply fresh engine oil to rubbing or rotating surfaces before assembly.
- Replace gaskets and O-rings with new ones.
- Apply, if necessary, liquid sealant to prevent water or oil leakage.
- Assemble parts after inspecting oil clearances and thrust clearances.
- Assemble parts with matching marks so that the marks align correctly. Take care that the matching pairs are correctly assembled.
- Do not use wrong bolts, nuts, and washers. Tighten standard bolts and nuts to the specified tightening torques. Take special care when assembling aluminum-alloy parts.
- Apply engine oil to the thread and seat of principal bolts before tightening them.

#### 1. Insert the liner.

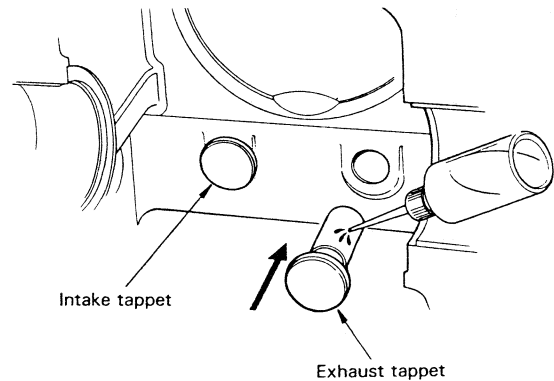
- 1) After cleaning the O-ring grooves inside the body, put the O-rings into the grooves. Care should be taken to avoid twisting of the O-rings. (The liner may be positioned in either direction.)



Put the O-rings into the grooves

#### 2. Put the tappet into place.

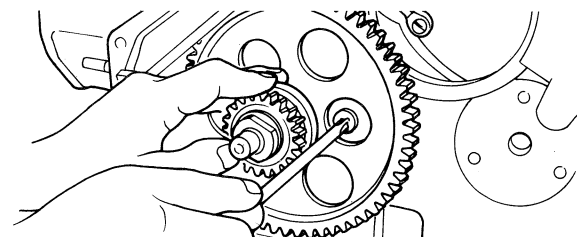
- 1) Apply a coating of lubricating oil.
- 2) With the tappet in place, check if they move smoothly.



Assemble the tappet

#### 3. Assemble the camshaft assembly into place.

- 1) Coat the shaft bearing with lubricating oil.
- 2) Install the camshaft bearing set bolt. (Do not knock the camshaft directly.)



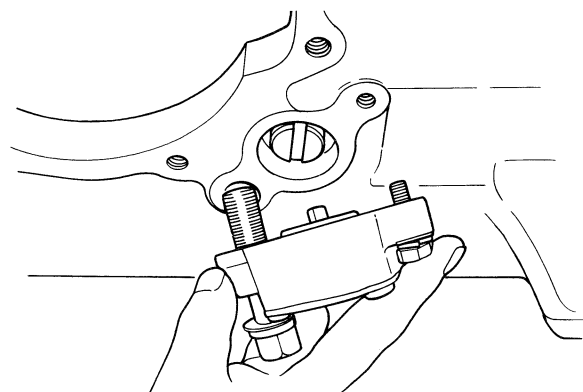
Bearing set Bolt Tightening Torque

150 kg-cm

Assemble the camshaft assembly

#### 4. Install the lubricating oil pump.

- 1) With packing placed around the body, assemble the pump into place by properly positioning the groove the camshaft end. The camshaft must be able to turn lightly.
- 2) Check the pump body bolt to ensure it contains copper packing.



Assemble the lubricating oil pump

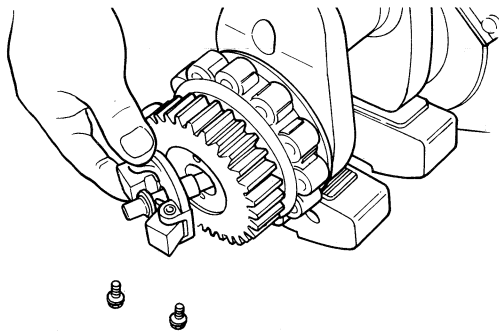


**5. Install the lubricating oil suction pipe.**

- 1) Care should be exercised so that the pump body bolt will not become loose.
- 2) Ensure that the bell shape end is horizontal, facing down.

**6. Assemble the crankshaft assembly into place.**

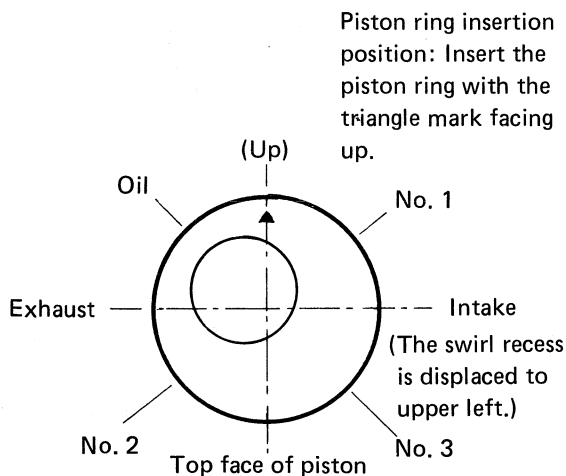
- 1) Install the crankshaft and the main bearing assembly.
- 2) Align the matchmark on the cam gear with that on the crank gear.
- 3) Mount the governor spindle and governor weight assembly into place.



Mount the governor weight assembly

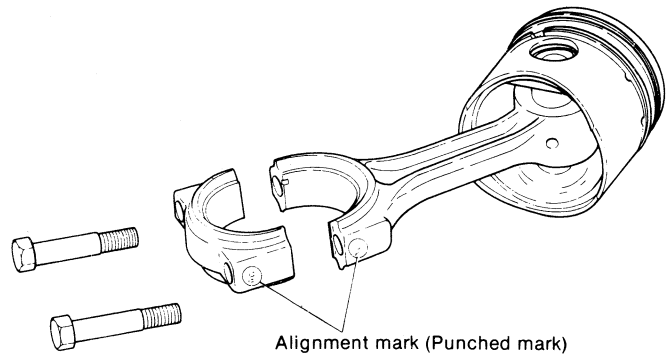
**7. Assemble the piston and the connecting rod into place.**

- 1) Set the piston ring with its end gaps at four equiangular positions around the piston.
- 2) Make sure that the oil port in the connecting rod small end faces up so that the oil port is positioned on the piston front. If assembled upside down, the piston pin bearing may be burnt.



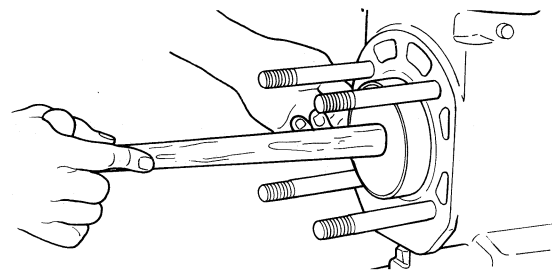
Set the piston ring and gaps positions

- 3) Direct the connecting rod large end with the marked number upward.



Assembling the piston and connecting rod

- 4) Insert the piston into place using the piston insertion tool.



Inserting the piston

*Connecting rod tightening torque:*

*TS190(R) 580 – 620 kg-cm*

*TS230(R) 780 – 820 kg-cm*

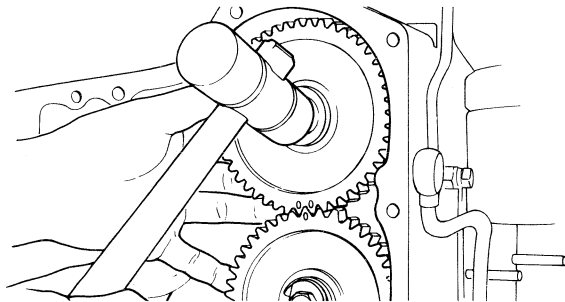
- 5) When the large end has been brought into close contact with the crank pin, turn the flywheel slowly until the piston is pushed to the bottom dead center.
- 6) After coating lubricating oil on the threaded part of the connecting rod bolts, assemble the connecting rod into place with the cap matchmark facing up.
- 7) Tighten the connecting rod bolts to the specified torque. (After assembly, check for an axial gap between the connecting rod and the crankshaft. Also check for smooth rotation of the crankshaft.)

**8. Install the No. 1 balancer shaft (lower one) into place.**

- 1) When the balancer is put in the crankcase, insert the shaft by shifting the shaft center backward. (The No. 1 balancer shaft has two gears attached.)

*Bolt tightening torque*

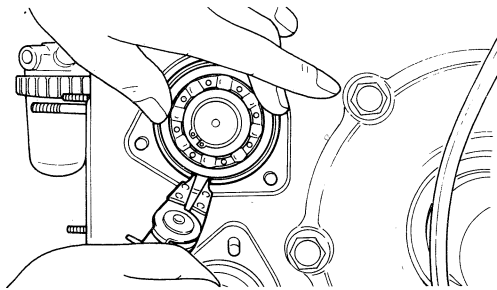
*450 – 550 kg-cm*



**Installing the balancer shaft**

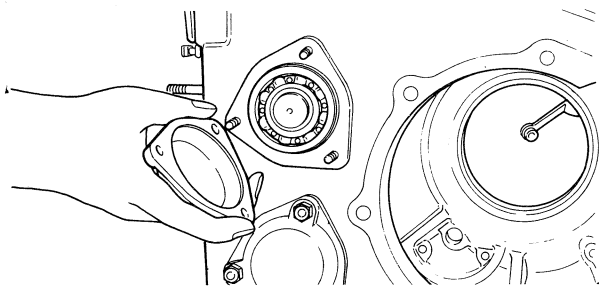
**9. Install the No. 2 balancer shaft (the upper one) into place, and attach the side cover.**

- 1) Install the No. 2 balancer shaft by aligning the matchmark on the No. 1 balancer gear with that on the No. 2 balancer gear.



**Attach the bearing retaining ring**

- 2) Attach the bearing retaining ring to the balancer shaft ball bearing.
- 3) Mount the balancer side cover in place. (Attach the support for the lubricating oil pipe.)

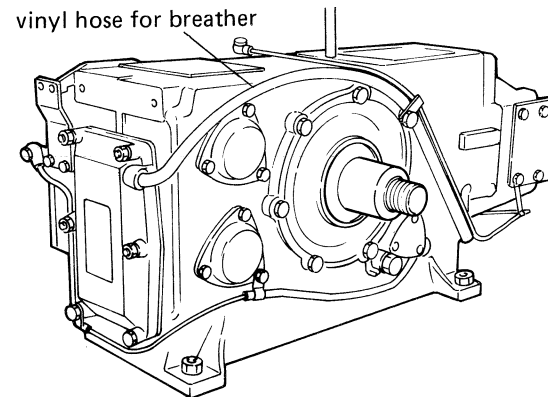


**Mount the balancer side cover**

**10. Connect the lubricating oil pipe.**

**11. Install the cylinder rear cover.**

- 1) Also install the shield plate (RK + shield plate + PK).
- 2) To connect the vinyl hose for the breather, lead it behind the oil pipe and then into the space between the lubricating oil pipe and cylinder block. (Check for possible distortion of the hose.)



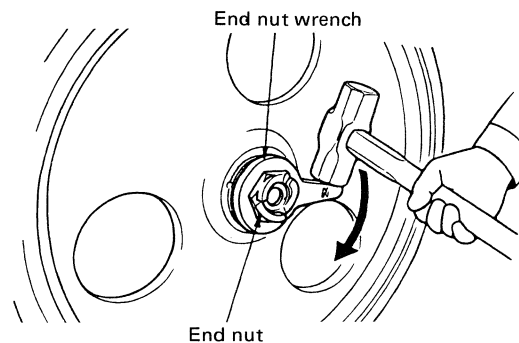
**Lubricating oil pipe for breather**

**12. Mount the flywheel.**

- 1) After cleaning the tapered end, mount the flywheel (by using the mounting tool).
- 2) Install the fan belt. (Radiator type)
- 3) Tighten the end nut to the specified torque (by using the mounting tool).

*End-nut tightening torque:*

*3000 – 3500 kg-cm*



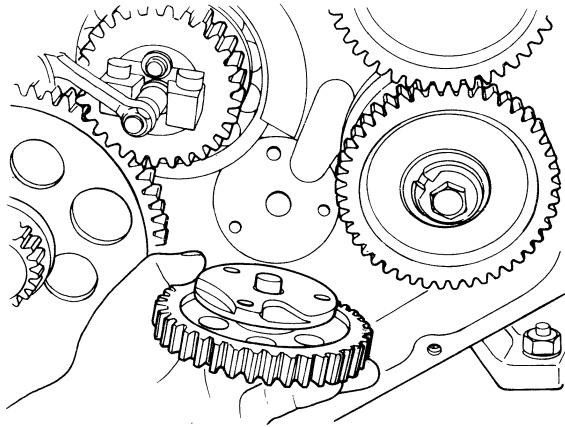
**Mount the flywheel**

**13. Mount the idle gear.**

- 1) Install the idle gear, together with the idle gear shaft, by aligning the matchmarks on the gears.
- 2) Check that all the timing marks are correct.

*Idle gear Bolt tightening torque:*

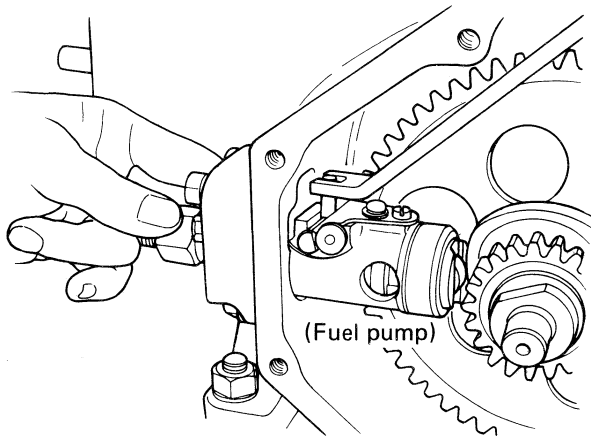
*250 kg-cm*



Idle gear and idle gear shaft

**14. Install the fuel pump assembly.**

- 1) Insert the fuel injection timing adjusting shims into place.
- 2) Install the fuel pump assembly. (An anti-spill screw of chromium-molybdenum steel is provided to protect the pump from fuel injected at high pressure. If necessary, check for corrosion of the screw tip.)



Install the fuel pump assembly

**15. Mount the cylinder side cover.**

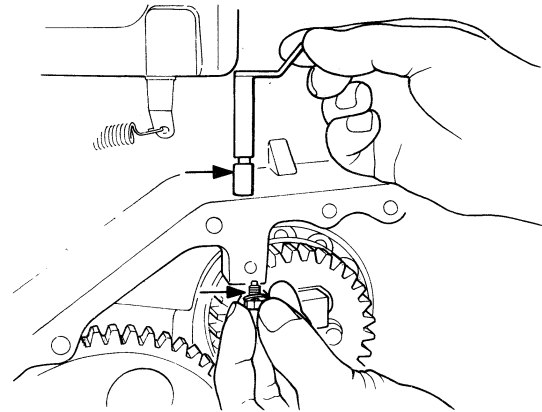
- 1) Set the packing correctly.
- 2) Do not confuse the long and short bolts.

*Tightening torque:*

*240 – 270 kg-cm*

**16. Install the governor assembly.**

- 1) Check the governor link assembly and make sure that the governor lever moves smoothly.



Adjust the governor linkage

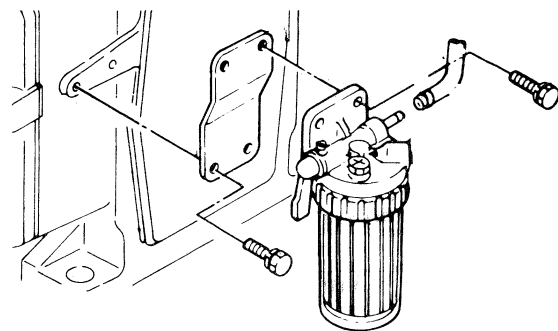
- 2) Check the governor lever No. 1 to see that its stopper bolt is at the correct position. (If not correct, adjust it to the position where, when the governor lever is lightly pulled into contact with the fuel limiting metal, the governor spindle has a clearance of 1 to 1.5 mm.)

*Notes: 1) Do not loosen the adjusting screw of the governor link except for checking or readjustment purposes.*

*2) After each readjustment, tighten the adjusting screw tight enough to ensure that it will not become loose.*

**17. Mount the fuel filter.**

- 1) Set the fuel filter mount in place.
- 2) Mount the fuel filter.



Mount the fuel filter

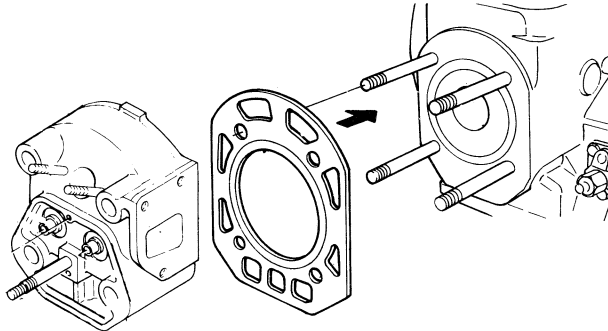
**18. Connect the fuel oil pipe.**

Connect the fuel oil pipe to the injection pump.

**19. Mount the cylinder head.**

- 1) Seat the head gasket. (There is no distinction between front and back faces.)
- 2) Mount the cylinder head (by tightening the torque of each pair of opposite bolts to the specified torque).

*Cylinder head nut tightening torque:*  
2700 – 2900 kg-cm



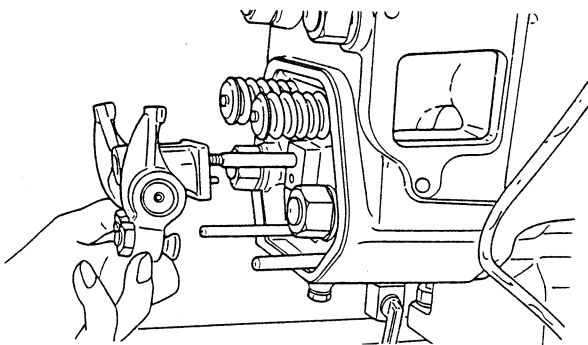
**Mount the cylinder head gasket**

3) Install the oil pipe coupling bolt under the cylinder head.

**20. Attach the push rod and the intake/exhaust valve rocker arm assembly.**

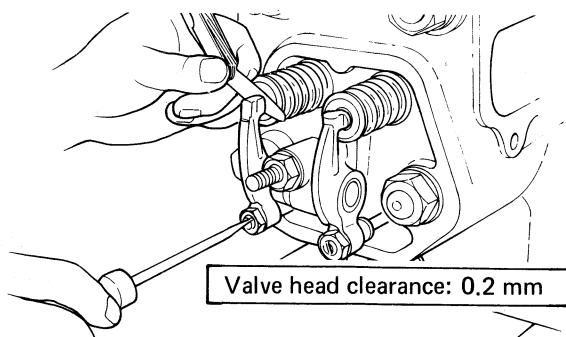
- 1) Place the push rod fully into the tappet hole. (The rod needs no distinction between right and left sides.)
- 2) Mount the intake/exhaust valve rocker arm assembly. (The rocker arm on the exhaust side has another machined surface for the decompression unit.)

*Valve rocker arm support tightening torque*  
550 kg-cm



**Attach the intake/exhaust valve rocker arm assembly**

**21. Adjust intake/exhaust valve head clearance.**  
Use the thickness gauge.

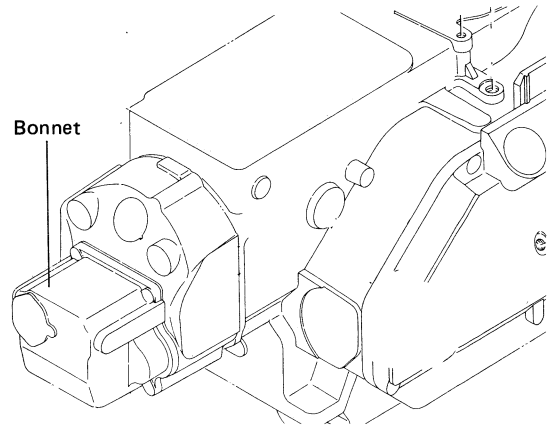


Valve head clearance: 0.2 mm

**Adjust the valve clearance**

**22. Mount the bonnet.**

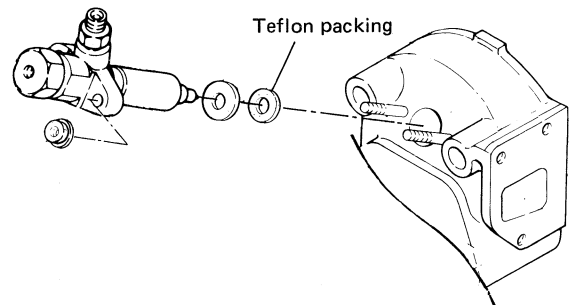
- 1) Set the packing on the positioning pin. (Distinguish the front and back surfaces of the packing.)
- 2) Mount the bonnet on the positioning pin. (Do not tighten the bolt excessively.)



**Mount the bonnet**  
(Positioning pin)

**23. Install the fuel injection valve.**

- 1) Replace the insulating teflon packing with a new one.
- 2) Tighten the lock nuts to a uniform torque.



**Install the fuel injection valve assembly**  
(Insulating teflon packing)

*Fuel injection valve nut tightening torque:*  
130 – 170 kg-cm

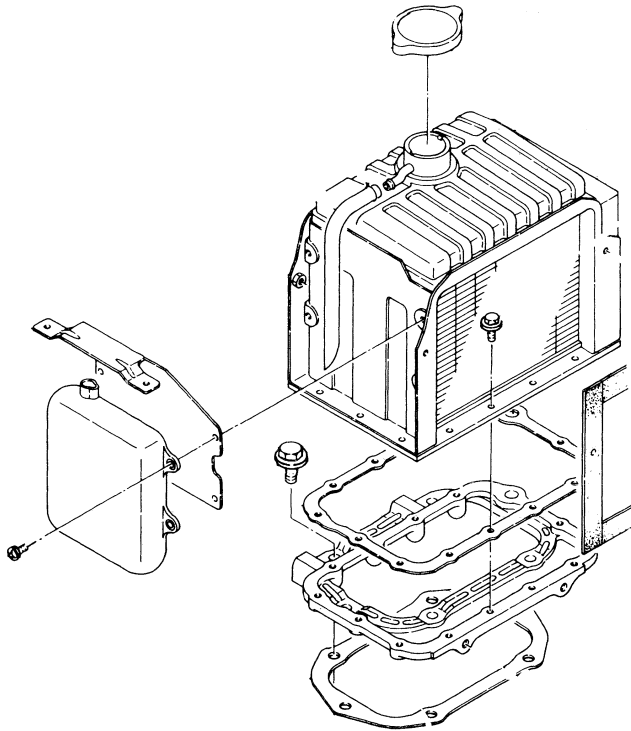
**24. Attach the radiator and hopper.**

- 1) Set the radiator bracket. Remember to change the packing.

*Note: Do not allow anything down into the jacket. Take care that the tube will not be crushed.*

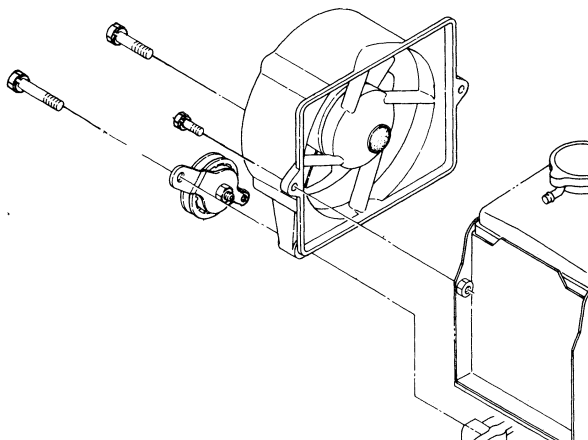
- 2) Place the radiator into position (by seating the rubber packing.)

*Note: Avoid damaging the fins when tightening the bolts.*



Attach the radiator components

- 3) Attach the sub-tank. Feed the rubber hose of the radiator overflow pipe into the sub-tank until it reaches the bottom.
- 4) Install the fan case assembly and the tension pulley. The lower bolt, temporarily attached to the case, should be inserted under the wheel. The longer tightening bolt should be installed through the tension pulley.



Install the fan case assembly and tension pulley

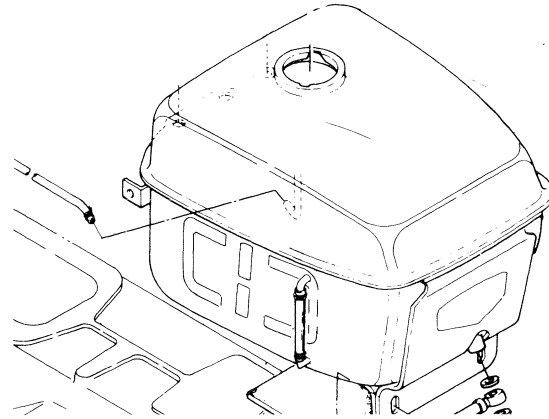
- 5) After adjusting the V-belt tension with the bolt, lock the tension pulley locking bolt. The wing bolt should be tightened firm enough for it not to become loose.

*Radiator bracket tightening torque*

*130 – 170 kg-cm*

## 25. Attach the fuel tank.

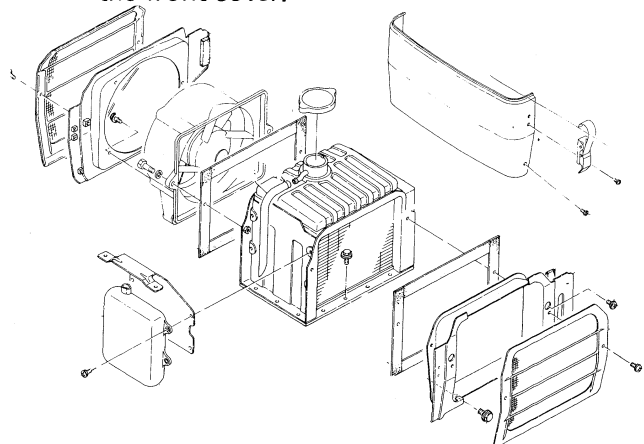
- 1) Insert the plain washer.
- 2) Insert the self-locking nut and tighten it temporarily.
- 3) Insert the eye nut. (TS230)
- 4) Tighten the three rear-side bolts alternately.
- 5) Connect the fuel oil pipe.



Attach the fuel tank

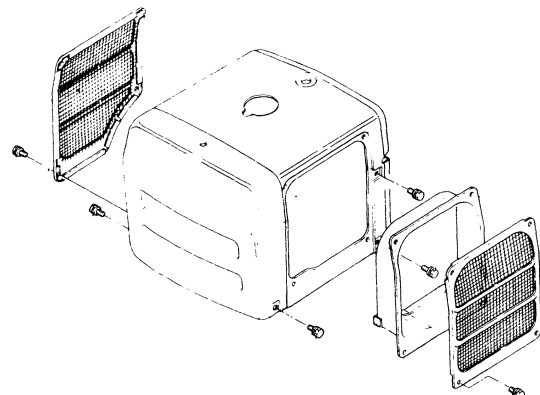
## 26. Mount the screens and front cover (Radiator type)

Mount the right and left screens, as well as the front cover.



Mount the screens and front cover

## 27. Put the radiator bonnet just above the radiator and set it. (Radiator type)



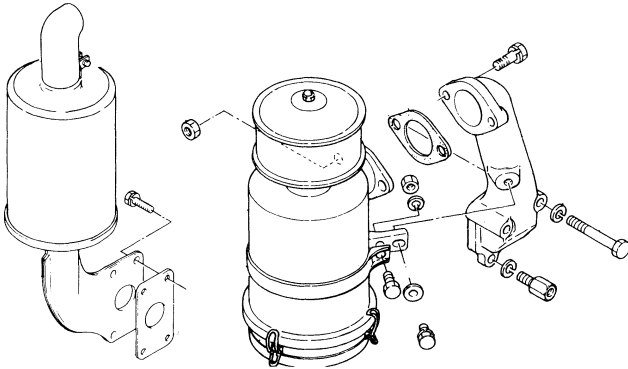
Attach the radiator cover

**28. Connect the fuel oil return pipe.**

- 1) Change the copper packing if damaged.
- 2) Raise the pipe right up to avoid interference with the muffler.

**29. Attach the exhaust muffler and the air cleaner.**

- 1) After checking the lubricating oil pipe support, attach the exhaust muffler.
- 2) Attach the air cleaner. Connect the suction pipe and check the support for the injection pipe.



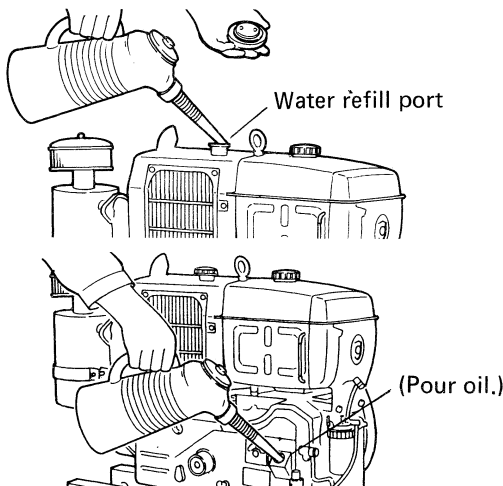
Install the muffler and air cleaner

**30. Add lubricating oil, cooling water, and fuel.**

- 1) Close the drain cock (by turning the lever down).
- 2) Fill with fresh water up to the bottom face of the pressure cap.
- 3) Remove the oil refill cap and pull out the oil level gauge. Feed in oil using the oil jug. To observe the oil level, first fill with oil up to the upper limit; measure the oil level without screwing in the oil level gauge. After measurement, tightly close the cap and replace the oil level gauge.

For the oil pan of the air cleaner, fill with oil up to the arrow mark.

- 4) Remove the fuel tank cap and feed in fuel up to the upper surface of the filter.



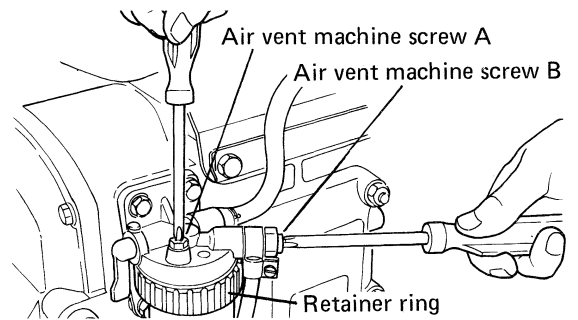
Add lubricating oil, cooling water and fuel oil

**31. Bleed air from the fuel system.**

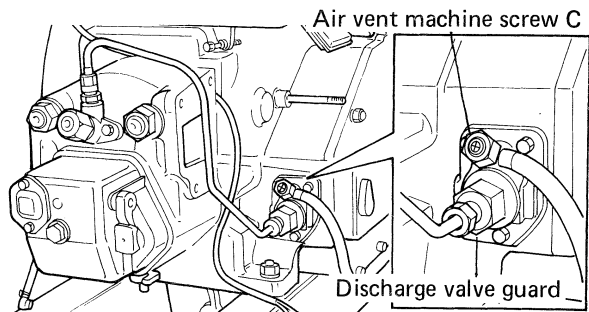
- 1) Loosen the air vent plug on top of the fuel filter to bleed the air in the filter.
  - Check the quantity of oil in the fuel tank.
  - Make sure that the fuel cock is open.
  - Do not tighten the air vent bolt more than necessary.
  - Make sure that the air has been completely discharged.

(Air vent screws are provided in three positions.)

- 2) Bleed the air left in the pipe through the air vent plug by the coupling bolt on the filter outlet side.
- 3) Bleed the air left in the pump through the air vent plug on the fuel injection pump.
- 4) With the decompression unit in operation, turn the pump to bleed the air in the pump outlet side. An injection sound should be heard. This turning should spread the oil throughout the engine.



(Air bleeding from fuel filter)



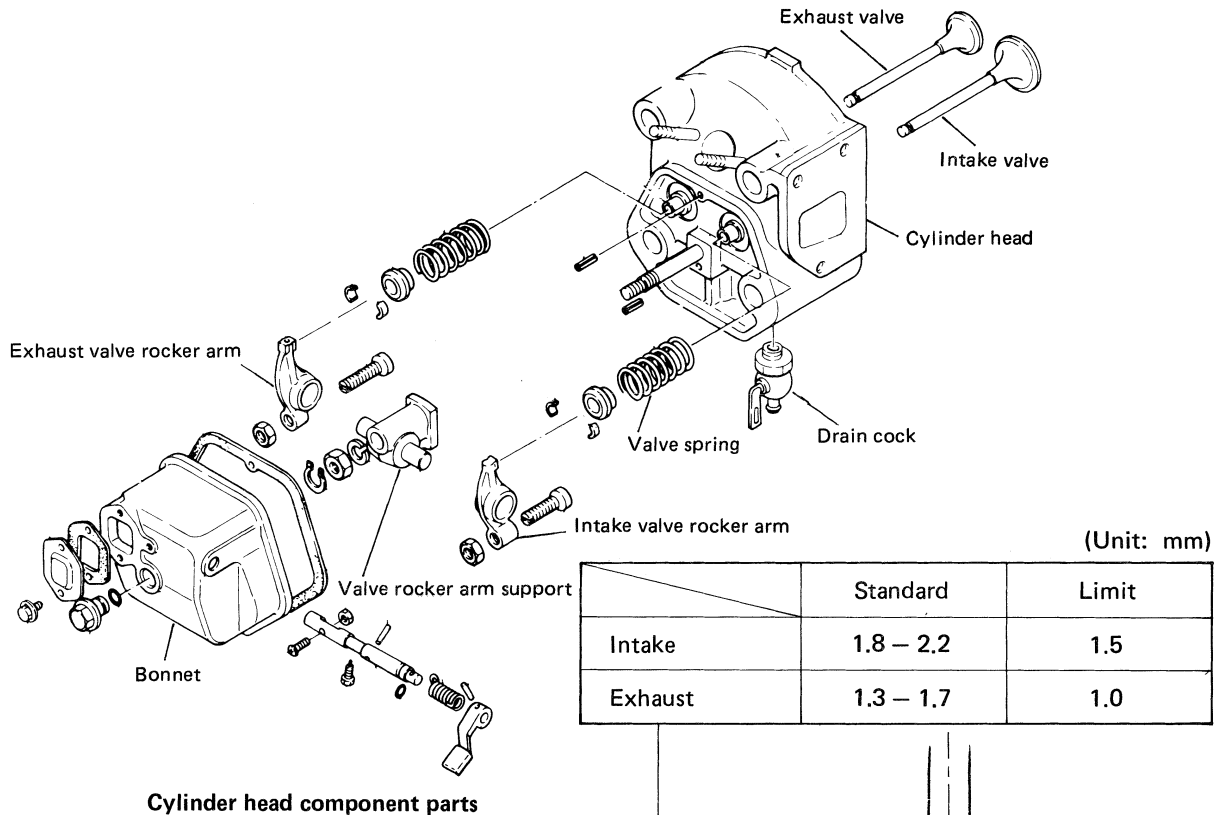
(Air bleeding from fuel pump)

**Bleed air from the fuel system  
(Fuel filter and fuel pump)**

# 8. Inspection and Servicing

## 8.1 Cylinder head

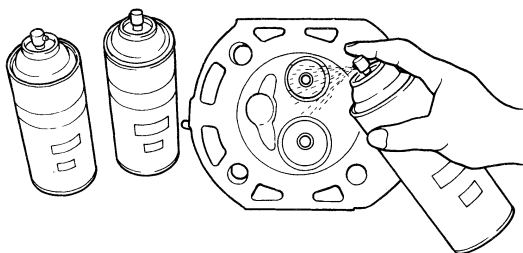
*Note: Tightening torque and dimensions indicated the specifications for both TS190(R) and TS230(R), the model name is not given.*



Cylinder head component parts

### 1. Check of combustion surface

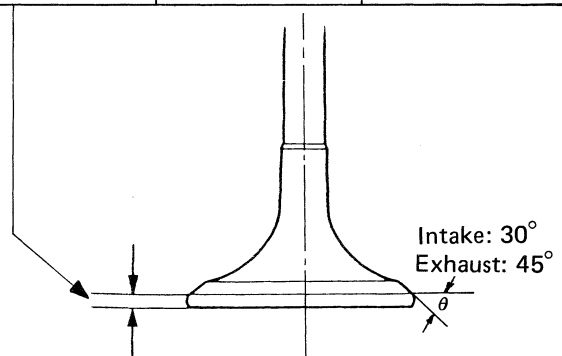
Remove the fuel, intake, and exhaust valves. After cleaning check the combustion surface for damage due to burning or cracking. For cracks not visible with the naked eye, use the color check.



Combustion surface colour check

### 2. Check of intake and exhaust valves

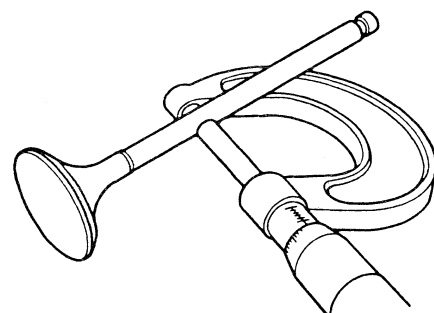
- 1) Check the head and stem of the intake and exhaust valves. Replace if excessively worn, burnt, or deformed.
- 2) Replace if head thickness is below the specification.



Check of intake/exhaust valve

### 3. Check of intake and exhaust valve guides

For each of the intake and exhaust valves, measure the clearance between stem and valve guide. If the measurement is in excess of the specified limit, replace the valve and its guide.



Measuring the valve stem

## 8. Inspection and Servicing

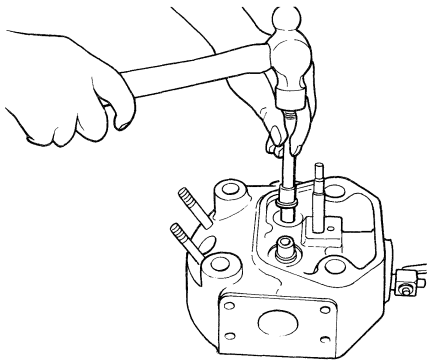
Unit: mm

Item		Standard	Limit
Outside diameter of intake and exhaust valve stem		$\phi 8.96 - \phi 8.945$	$\phi 8.85$
Inside diameter of valve guide	Intake	$\phi 9.0 - \phi 9.015$	$\phi 9.1$
	Exhaust	$\phi 9.0 - \phi 9.015$	$\phi 9.1$
Clearance between valve and valve guide	Intake	0.04 – 0.07	0.15
	Exhaust	0.04 – 0.07	0.15

*Note: The clearance of intake and exhaust valves between the valve guide and the stem is to be measured as the difference between the guide's inside diameter and the stem's outside diameter.*

### 4. Replacement of intake/exhaust valve guide

- 1) Draw the valve guide out toward the valve rocker arm chamber, using the special tool (puller).



Replace the valve guide

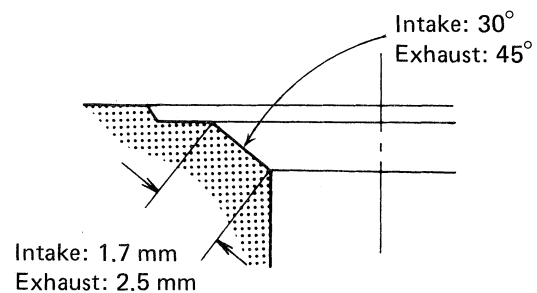
- 2) Using the same puller, press the valve guide from the spring side, and ream out the inside diameter with a reamer. The guide should be pressed down to the position shown above.

### 5. Valve seat

- 1) If the check on the valve seat finds damage or defects on the contact surface, etc., repair the seat.

*Notes: 1) If the valve seat needs repair, always check for wear on the valve guide. If worn, replace the guide, then repair the seat.*

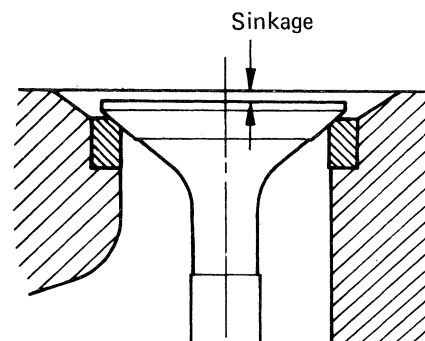
- 2) Resurface the seat face using a valve seat cutter or valve grinder to the dimensions shown at right. After lapping with a compound, make sure that proper contact is obtained all around the circumference and the seat width of the valve, using red lead or similar means.



Valve contact surface

### 2) Valve sinkage

As valves are used over long periods and subjected to lapping a number of times, they will eventually sink and combustion performance will deteriorate. Measure valve sinkage and, if it exceeds the specified limit, replace the cylinder head.



Valve sinkage

(Unit: mm)

Valve sinkage	Standard dimension	Limit
Intake	0.25 – 0.55	1.4
Exhaust	0.65 – 0.95	1.8

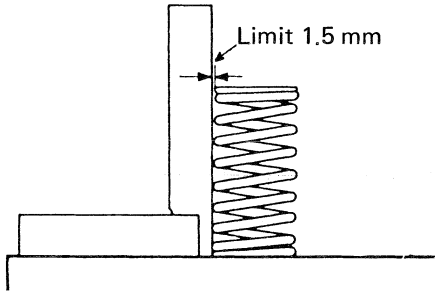


**6. Intake/exhaust valve spring**

- 1) Check the squareness of the valve spring on a surface plate using a square. Replace any spring with an inclination greater than the specified limit.

(Unit: mm)

	Limit
Squareness	1.5

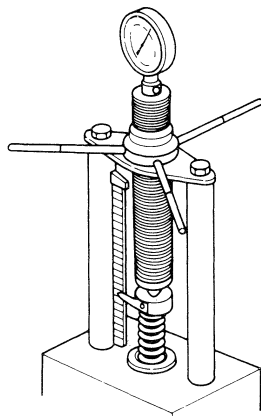


Valve spring squareness

- 2) Measure the spring dimensions and spring load, using a spring tester. If the values are less than the limits, replace the spring.

(Unit: mm)

Specifi- cation	Free length	Mounted length	Spring load
Spring	53	48.0	12.9 kg



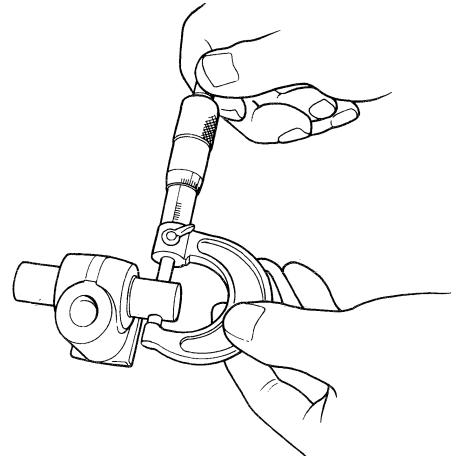
Measuring the valve spring tension

**7. Intake/exhaust valve rocker arm, and rocker arm support assembly**

- 1) Blow air through the oil hoses to check for obstructions against oil passage.
- 2) Check each part. Repair or replace any if damaged or worn.

*Note: If a contact surface of an intake/exhaust valve rocker arm shows slightly uneven wear, repair the surface with oil-stone or other suitable means.*

- 3) Measure the clearance between the inside surface of the hole in the intake/exhaust valve rocker arm and the valve rocker arm shaft. If the clearance exceeds the limit, replace the valve rocker arm.



Measuring the valve rocker arm shaft O.D.

(Unit: mm)

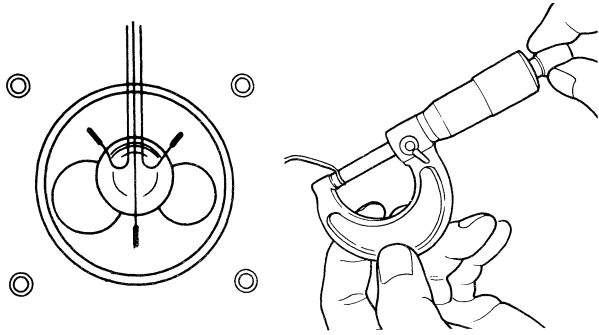
	Standard dimension	Limit
Outside diameter of intake & exhaust valve rocker arm shaft	$\phi 19.959 - \phi 19.98$	-0.1
Inside diameter of valve rocker arm hole	$\phi 20 - \phi 20.021$	+0.1
Clearance between valve rocker arm shaft and valve rocker arm hole	0.02 - 0.062	0.15

**8. Top clearance**

- 1) The top clearance requires checking as it greatly affects the engine performance.

(Unit: mm)

	TS190(R)	TS230(R)
Top clearance	0.8 - 1.0	0.85 - 1.05
Fuse used	$\phi 1.5 - 2.0$	



Measuring the top clearance

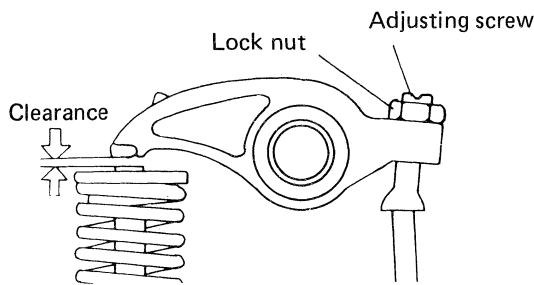
2) If the top clearance is larger than the specification, locate the cause. Possible causes which should be checked are listed here.

- (1) Improperly tightened cylinder head
- (2) Wear in crank pin bearing or piston pin bearing
- (3) Bent connecting rod

Replace any responsible parts.

**9. Adjustment of intake/exhaust valve head clearance**

Check this clearance at the time of disassembly/reassembly and after every 300 hours of operation. Correct the clearance as necessary.



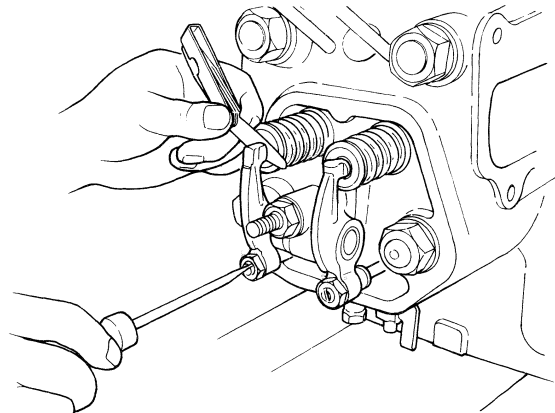
Adjusting the valve clearance

(Unit: mm)

Intake/exhaust valve head clearance	0.2
-------------------------------------	-----

(cold state)

*Note: When adjusting the clearance, make sure that the piston is at the top dead center of the compression stroke. With the piston in this position, the intake/exhaust rocker arm will not move when the crank shaft is swung right and left about TDC.*



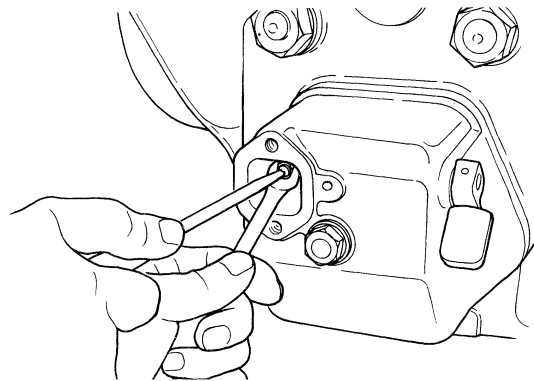
Valve clearance adjustment

**10. Adjustment of decompression unit**

- 1) Turn the engine so that the intake/exhaust valves are completely closed.
- 2) Remove the decompression adjusting hole cover.
- 3) Loosen the lock nut, and operate the decompression lever so that the decompression adjusting bolt is set to the position of zero valve clearance. Then screw in the decompression adjusting bolt to obtain a decompression clearance of about 0.6 – 1.0(TS190(R)), 0.8 – 1.2 (TS230(R)).

(Unit: mm)

	TS190(R)	TS230(R)
Clearance standard	0.6 – 1.0	0.8 – 1.2
Adjusting screw	M = 5, P = 0.8	



Adjusting the decompression clearance

- 4) After adjustment, turn the flywheel by hand to check that the valve and piston do not touch because of improper decompression clearance. Being sure of this, then keep this clearance by tightening the lock nut.

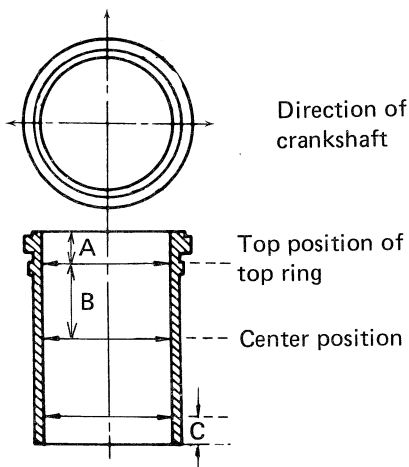
### 8.2 Cylinder liner

The cylinder liner is of special cast iron with good wear resistance. It has the bore surface honed, further enhancing the wear resistance of both piston ring and cylinder liner.

#### 1. Check of cylinder liner

##### 1. Measurement of cylinder liner bore diameter

Measure the bore diameter with the cylinder gauge. Rebore or replace the liner if wear exceeds the specified limit.



(Unit: mm)

	TS190(R)	TS230(R)
A	22	23
B	53	57.5
C	63.3	79.3

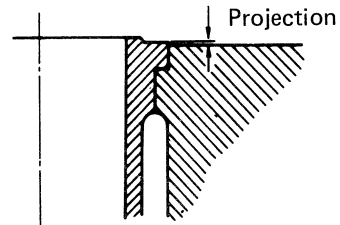
Liner measurement position

(Unit: mm)

Cylinder liner		Bore diameter	
		TS190(R)	TS230(R)
Wear	Standard	$\phi 110.0 - \phi 110.035$	$\phi 112.0 - \phi 112.035$
	Limit	$\phi 0.25$	
Roundness	Standard	0.015	
	Limit	0.1	

##### 2. Measurement of cylinder liner projection

Check that the top edge of the cylinder liner projects slightly from the block surface.



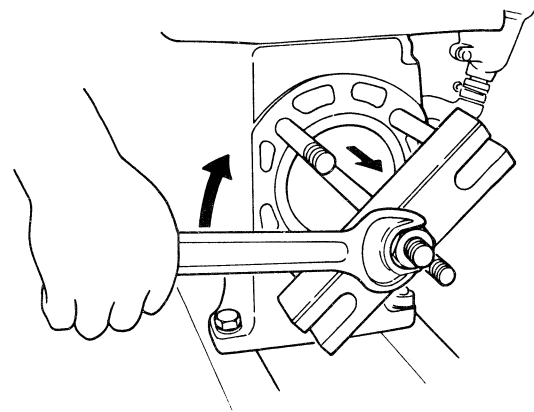
(Unit: mm)

Cylinder liner projection	0.03 – 0.10
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Liner projection

#### 2. Replacement of cylinder liner

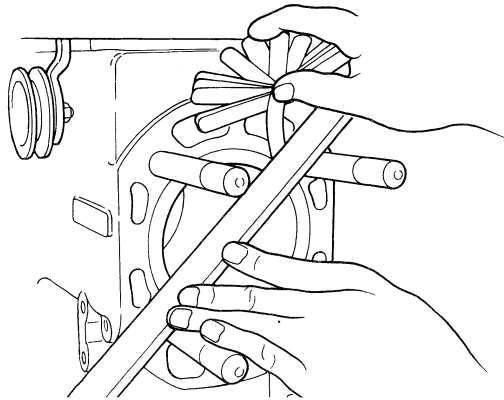
Replace the cylinder liner if its bore surface is badly damaged or if it is worn to a mirror surface.



Replacing the liner

##### (Replacement procedure)

- 1) Draw out the cylinder liner using the cylinder liner puller.
- 2) Use sandpaper to remove the rust on the inside of the cylinder block where the liner touches it.
- 3) Insert the rubber packing for the cylinder liner into the groove of the body.
- 4) Coat oily white paint on the outer wall of the cylinder liner which comes in contact with the cylinder block. This is to prevent rusting and to provide lubrication. Then press the liner into the cylinder bore with both hands.



Measuring the liner projection

5) The top edge of the inserted cylinder liner should project 0.03 to 0.100 from the cylinder block surface.

*Notes: 1) Before inserting the liner, check if the liner without the cylinder liner rubber packing can be readily inserted into the cylinder bore.*

*2) Do not apply undue force to insert the liner. If the liner will not go in smoothly, remove the rust on the cylinder block.*

*3) Ensure that the cylinder liner rubber packing is new.*

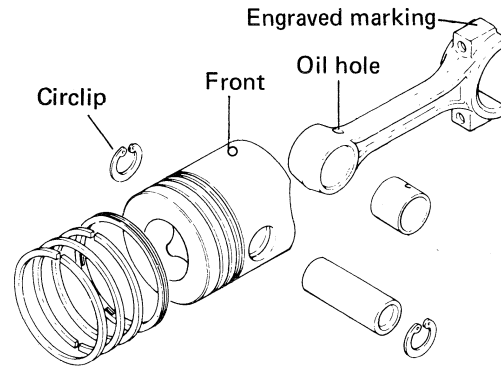
6) After insertion, check for distortion with a cylinder gauge.

### 8.3 Piston and Piston Ring

The piston is made of cast aluminum alloy with low thermal expansion and good cooling properties. It is elliptically formed so that good contact is made with the cylinder wall and oil consumption is minimized. In addition, the suitable ring configuration, coupled with the lower lands between the third ring and the oil ring, ensures effective oil retention, proper lubrication of the piston and cylinder, and reduced oil consumption.

There are four rings on the piston: three compression rings and one oil ring. The absence of an oil ring on the piston skirt results in increased oil retention on the thrust surface and better lubrication. This also improves skirt rigidity, which causes less deformation of the piston, assuring steady contact with the wall.

The piston pin is of the floating type, with its ends fitted with circlips.



Piston and piston ring components

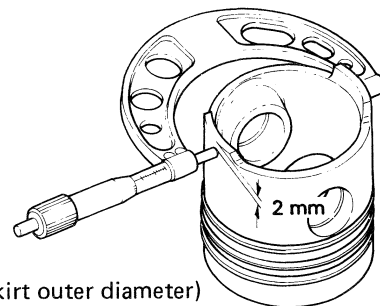
#### 1. Check of piston and piston ring

1) Check the outer circumference of the piston skirt, as well as the ring grooves. Replace the piston if it is worn, damaged, or otherwise defective.

(Unit: mm)

Piston dimension	Standard dimension	Limit
Skirt outer diameter		
TS190(R)	$\phi 109.94 - \phi 109.835$	0.4
TS230(R)	$\phi 111.82 - \phi 109.835$	

(As measured perpendicular to piston pin axis)



(Skirt outer diameter)

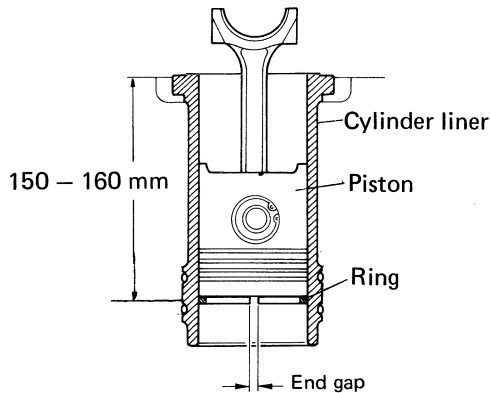
Measuring the piston O.D.

2) Measure the end gap in the piston rings, and also the clearance between each piston ring and its mating groove. Replace any ring with wrong dimensions.

To make this measurement, press a piston ring under the piston head and into the cylinder. Measure the end gap in the piston ring with a thickness gauge. The ring being measured should be positioned 150 to 160 mm from the end of the liner.

(Unit: mm)

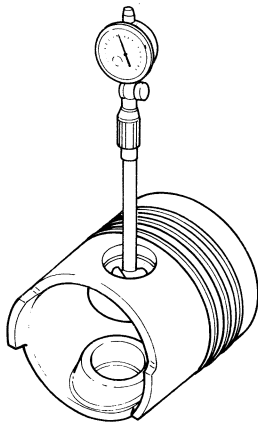
Piston ring dimensions	Limit of end gap	Limit of ring-to-groove clearance
No. 1 ring	1.8	0.3
No. 2 ring	1.8	0.25
No. 3 ring	1.8	0.25
Oil ring	1.8	0.20



Measuring the piston ring end gap

## 2. Piston replacement

The piston pin and piston pin bore fit together as shown in the following table. When replacing the piston pin, the piston pin bore should be just large enough to allow the piston pin to be pressed into the bore by thumb pressure when the piston is warmed to between 50 and 60°C.



Measuring the piston pin hole I.D.

- Notes: 1) Before inserting the piston pin, check that it can be inserted into the connecting rod.  
 2) Coating the piston pin with oil will help insertion of the piston pin.  
 3) Check that the connecting rod can be moved easily.  
 4) Insert the piston pin promptly before the piston cools off.

(Unit: mm)

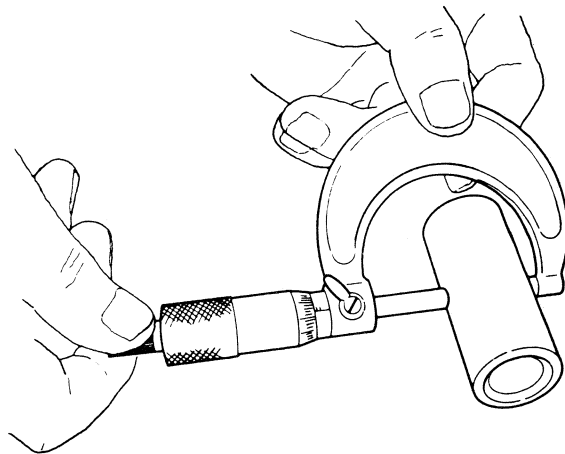
Fitting of piston pin in piston pin hole	
Piston pin bore inside diameter	$\phi 36.0 - \phi 36.011$
Piston pin outside diameter	$\phi 35.989 - \phi 36.00$
Clearance in piston pin hole	0 - 0.022
Pin insertion temperature	50 - 60°C

## 3. Piston pin

If the piston pin is worn beyond its specified outside diameter or is unevenly worn, replace it.

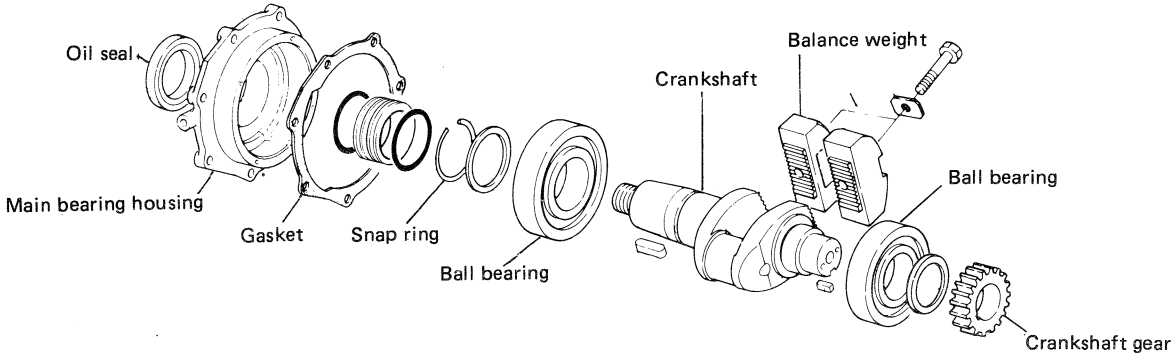
(Unit: mm)

	Standard dimension	Limit
Piston pin outside diameter	$\phi 35.989 - \phi 36.00$	-0.05



Measuring the piston pin O.D.

8.4 Crankshaft



Crankshaft component parts

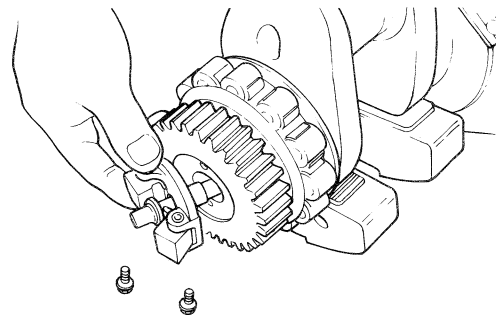
The crankshaft is a forged assembly. It is provided with a ball-and-roller bearing at each end to reduce the torque needed at engine startup. Furthermore, a cylindrical roller bearing is used on the gearcase side, while a deep-groove type ball bearing is used on the flywheel side to make the thrust standard. The ball bearing is made of carburized steel for better durability. In replacement, the substitute bearings at both ends are specifically designed for use on this crankshaft. The pins are induction-hardened for increased wear resistance.

1. Disassembly and reassembly of crankshaft bearing

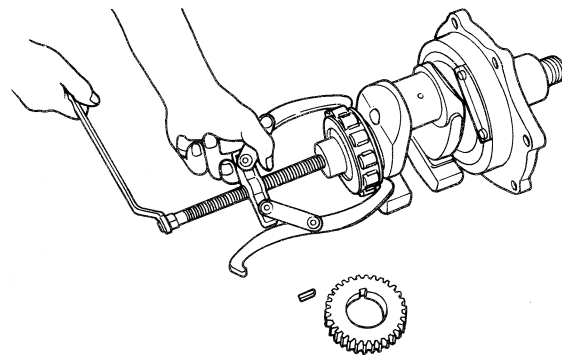
Normally, the ball-and-roller bearings are semi-permanent, practically eliminating the need for replacement. If, however, they produce odd sounds or become loose, they must be replaced immediately. Should they be disassembled, observe the following procedures. It should be noted, however, that even a good bearing, once it has been taken apart, never recovers its original precision and invariably requires replacement with a new bearing. Therefore, bearing disassembly should be avoided as far as possible.

1) Disassembly of gear side

Step	Description
1	Remove the governor.
2	Remove the crank gear.
3	Remove the roller bearing with the bearing puller.
4	Draw out the outer race of the roller bearing on the cylinder block side into the cylinder body. (At reassembly, the bearing must be replaced with a new one.)



Removing the governor balance weight



Removing the ball-and-roller bearing

2) Reassembly of gear side

(1) Reassemble the roller bearing.

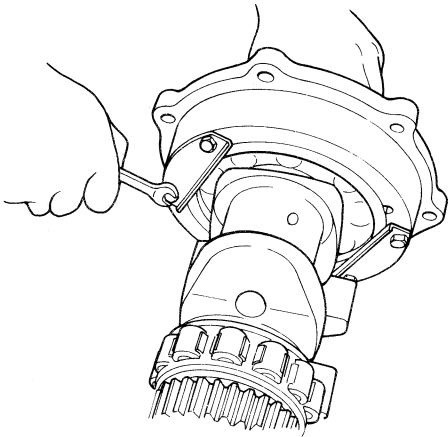
- a. Press the outer race all the way into the cylinder body until it can enter no further.
- b. Press the roller bearing, with the open end of the retainer facing inside (i.e., with the marking facing outside), onto the crankshaft.  
(Grease the crankshaft where the bearing slides on it.)

Notes: 1) Always place a support under the load to prevent crankshaft bending.  
2) Always use the tool on the inner race of the roller bearing when pressing the bearing in. Never put pressure on the rollers and retainer.

- (2) Seat the crank gear spacer.
  - Outside diameter: 65 mm
  - Inside diameter: 45.2 mm
  - Thickness: 5.5 mm
 (Direct the chamfered side toward the wheel.)
- (3) Install the crank gear (with the "0" mark facing outside).
- (4) Install the governor.

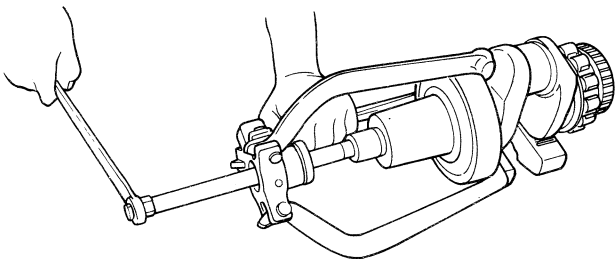
### 3) Disassembly of flywheel side

- (1) Remove the flywheel key. (Take care not to damage the key.)
- (2) Remove the two bearing retainers from the main bearing housing.



Removing the main bearing retainer

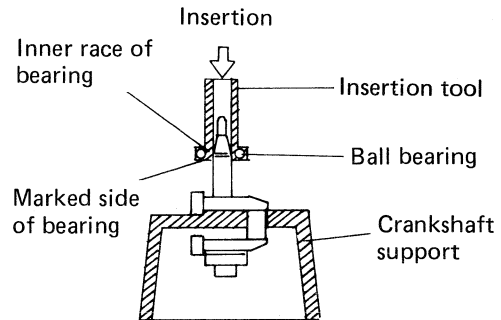
- (3) Remove the main bearing housing from the crankshaft. (Take care not to damage the oil seal.)
- (4) Remove the snap ring for the stopper plate.
- (5) Remove the bearing stopper plate.
- (6) Remove the bearing. (Do not reuse the bearing once it is removed.)



Removing the ball bearing

### 4) Reassembly of flywheel side

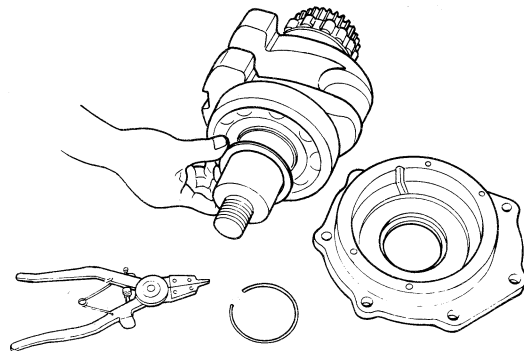
- (1) Reassemble the ball bearing. (Grease the crankshaft where the bearing slides on it.)



How to insert the bearing

- Notes:*
- 1) Always place the support under the load to prevent crankshaft bending.
  - 2) Only use the tool on the inner race of the bearing when pressing the bearing in.

- (2) Install the bearing stopper ring and fix it in place with the snap ring.
- (3) Install the main bearing housing: (After inserting the crankshaft, check that the housing turns easily.)
- (4) Install the two bearing retainers to the inside of the main bearing housing.
- (5) Knock the flywheel key into the crankshaft. (Take care not to damage the key or the flywheel.)



Installing the flywheel side

**2. Check of crankshaft**

Crankshaft outside diameter and out-of-roundness

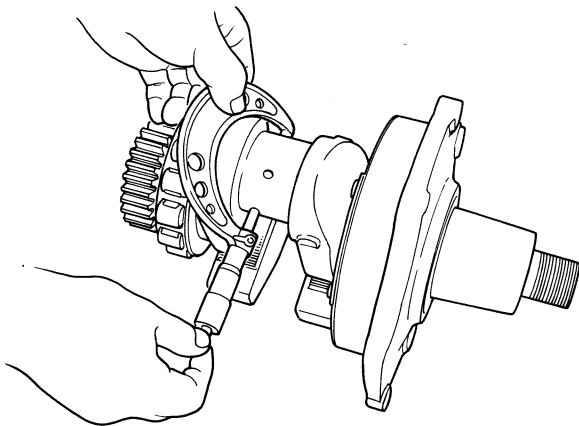
Check the crankshaft pin for damage and uneven wear (out-of-roundness and degree of taper). Grind, repair, or replace if the specified limit is exceeded.

(Unit: mm)

Crankshaft pin		Standard dimension	Limit
Shaft outside diameter	TS190(R)	$\phi 57.978 - \phi 57.953$	-0.10
	TS230(R)	$\phi 61.978 - \phi 61.953$	
Out-of-roundness		0.008	0.02
Oil clearance		0.022 - 0.092	0.1

**3. Crankshaft side gap**

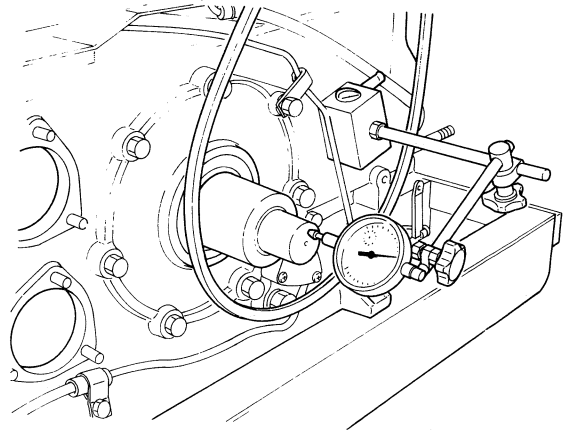
Shift the crankshaft to one side, set a dial gauge to one end of the crankshaft, and measure the side gap play of the crankshaft. If the gap exceeds the specified limit, replace the roller bearing or deep-groove ball bearing, or both, with a new one.



Measuring the crankshaft pin O.D.

(Unit: mm)

	Limit
Crankshaft side gap	0.5



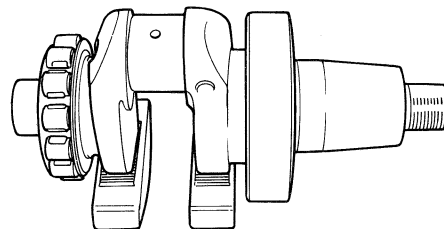
Measuring the crankshaft side gap

**4. Check of crankshaft bearing**

Check the bearing components such as the balls, rollers, inner and outer races, and case for defects such as damaged or dented surface, uneven rotation, unusual noise, play, or discoloration due to seizure. Replace the whole bearing if it has any defect.

- 1) Check that the bearing turns smoothly when it is turned with the fingers.
- 2) Check that the bearing does not produce any unusual noise when it is turned rapidly.

- Notes:*
- 1) For the methods and precautions concerning bearing replacement, refer to the section under "Disassembly and reassembly of crankshaft bearing".
  - 2) New bearings should not be unpacked until just before their installation in order to protect them from dirt and other foreign matter.



Crankshaft assembly

**5. Crankshaft oil seal**

- 1) To remove the oil seal, knock it out toward the flywheel.
- 2) When installing the oil seal, ensure that it is installed evenly.



### 8.5 Connecting Rod

The connecting rod is forged from carbon steel and has great strength. Its big end is separated horizontally, and is lined with three-layer Kelmet metal, while the small end is filled with a rolled bushing of two-layer copper alloy.

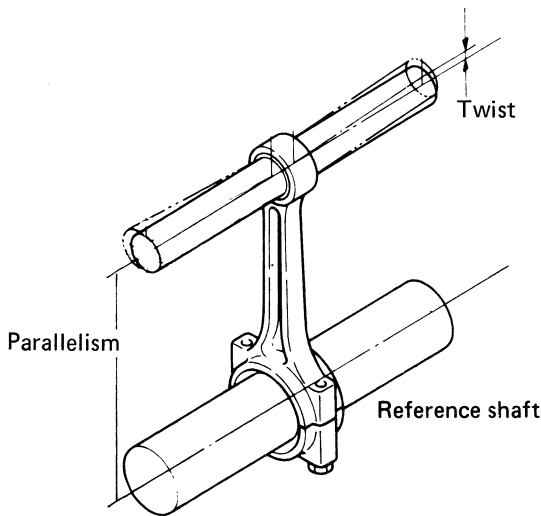
#### 1. Checking of connecting rod

##### 1) Twist and parallelism of big and small ends

Measure the bend and twist of the holes using a connecting rod aligner. If the specified limit is exceeded, make corrections so that the three points of the V-block have correct contact with the face plate, or replace the connecting rod.

(Unit: mm)

Bend and twist of connecting rod	Standard	Limit
Bend	0.03	0.05
Twist	0.03	0.05



Check of bend and twist

##### 2) Connecting rod thrust clearance

Fix the connecting rod to the crankpin and measure the thrust clearance. Replace the connecting rod if the thrust clearance is too great or if the thrust surface at either end is damaged.

(Unit: mm)

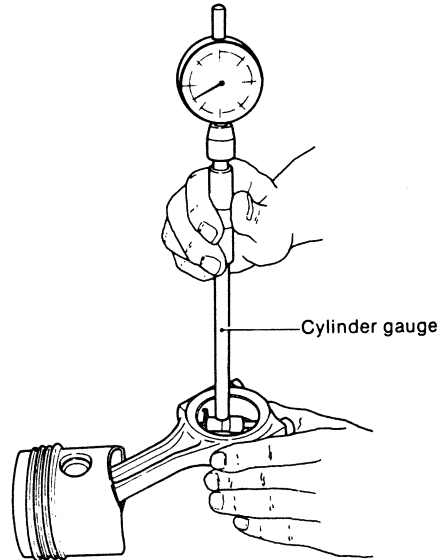
Thrust clearance	Standard dimension	Limit
	0.2 – 0.4	0.5

#### 3) Replacement of piston pin bearing

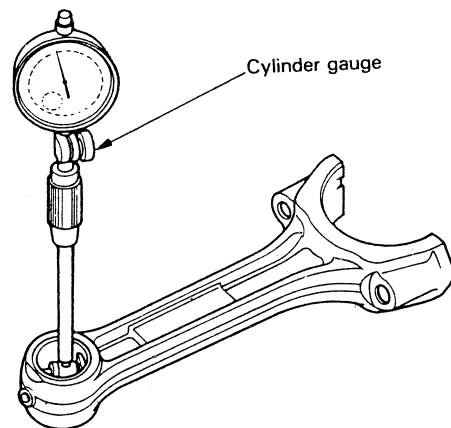
- (1) If the piston pin bearing of the connecting rod is worn or damaged, replace the piston pin bearing using the special tool for piston pin bearing removal.

(Unit: mm)

Piston pin bearing	Standard dimension	Limit
Piston pin bearing inside diameter	36.025 – 36.040	0.12
Clearance between piston pin and bearing	0.025 – 0.051	0.15



Measuring the crank pin inside diameter



Measuring the piston pin bearing I.D.

*Note: Press in the piston pin bearing so that its oil hole is aligned with the oil hole in the connecting rod small end.*

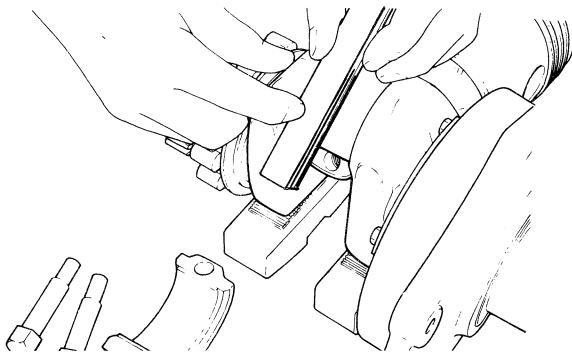
## 8. Inspection and Servicing

- (2) After pressing in the piston pin, finish the inside face of the bearing with a honing tool or reamer so that the piston pin fits correctly.

*Note: The bearing and piston pin should fit so that when coated with engine oil the piston pin can be inserted by thumb pressure at room temperature.*

### 4) Crankpin bearing

- (1) Check for flaking, seizure, scuffing, bearing surface condition, etc. Replace the crankpin bearing if found defective.



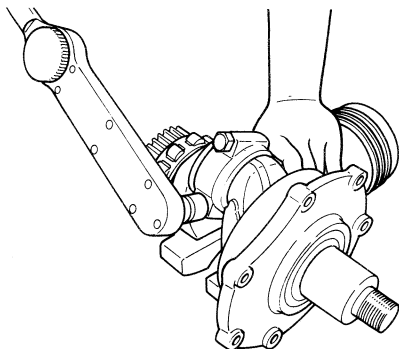
Reshape the crank pin metal surface by oil stone

(Unit: mm)

Crankpin bearing		Standard dimension	Limit
Inside diameter	TS190(R)	$\phi 58.0 - \phi 58.045$	0.1
	TS230(R)	$\phi 60.0 - \phi 60.045$	
Clearance		0.022 - 0.092	0.1

*Note: The crankpin bearing inside diameter should be measured after tightening the bolt to the specified torque.*

( TS190(R) 580 - 620 kg-cm )  
( TS230(R) 780 - 820 kg-cm )



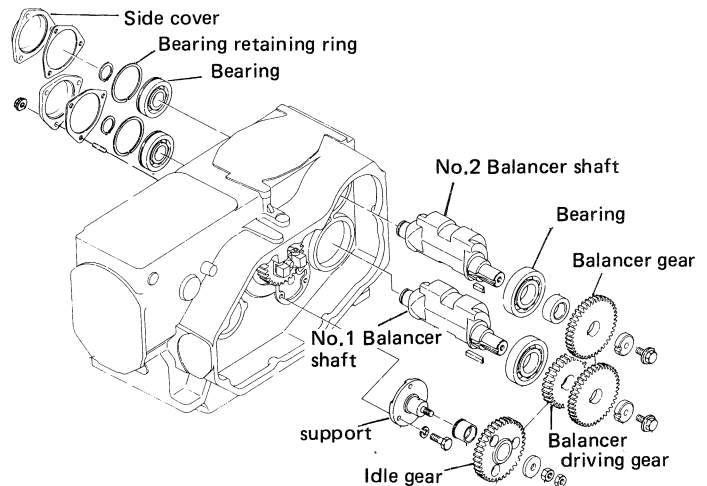
Tighten the connecting rod cap bolt

- (2) Precautions for replacement of crankpin bearing
  - a) Clean off the crankpin bearing surface, as well as its back.
  - b) The crankpin bearing must be in tight contact with the connecting rod cap.
  - c) When installing the connecting rod, confirm the match with the number marked on the big end, and tighten the bolt to the specified torque after coating it with engine oil.

## 8.6 Balancer Mechanism

A two-shaft balancer mechanism is provided to remove the inertia force from the engine's reciprocal motion; the inertia force is a cause of engine vibration. The engine is thus less subject to vibration.

The balancer consists of two semicircular shafts which are installed in parallel above and below the rear crankshaft section and which are driven by the crankshaft via a gear.



Balancer component parts

### Check of balancer

#### 1) Check of bearing

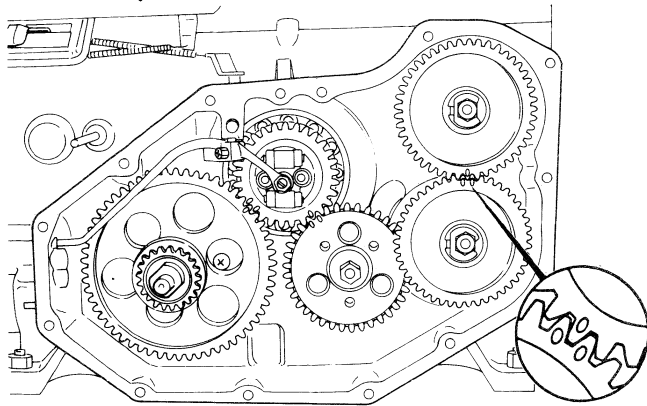
Check the bearing components such as the balls, inner and outer races, and cage, for defects such as damaged or dented surfaces uneven rotation, unusual noise and play. Replace the whole bearing if it has any defect.

- (1) Check that the bearing turns smoothly when it is turned with the fingers.
- (2) Check that the bearing does not produce any unusual noise when it is turned rapidly.

*Note: A new bearing should not be unpacked until just before installation in order to protect it from dirt and foreign matter.*

(3) Balancer gear timing

When installing the balancer shafts, the timing marks on the gears should be aligned accurately. Failure to observe this will result in cranking failure or cause breakage of associated parts due to excessive vibration.

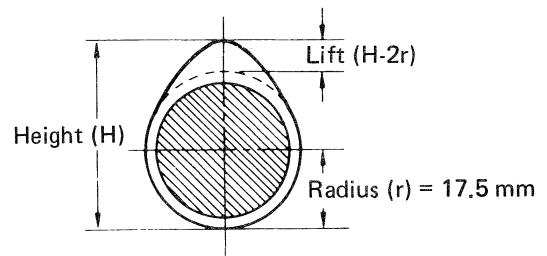


Balancer gear matching mark

(Unit: mm)

	Standard dimension	Limit
Intake/exhaust valve cam height	41.96 – 42.04	-0.5
Fuel injection pump cam height	65.98 – 66.02	-0.3

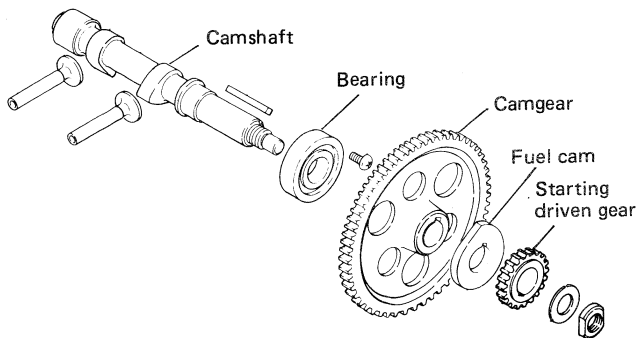
Note: When fitting the fuel injection pump cam onto the camshaft, direct it as shown in the following figure.



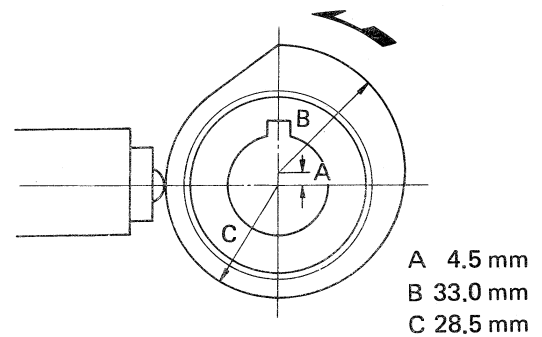
Cam height

8.7 Camshaft and Tappet

The camshaft is made of carbon steel. It is supported on the gear side by a ball bearing, and on the wheel side directly by the block. Fitted to the camshaft on the gear side is a cam for driving the fuel injection pump. The cam and bearing sections are treated with induction hardening.



Camshaft components



Install the fuel injection cam

- A 4.5 mm
- B 33.0 mm
- C 28.5 mm

1. Check of camshaft

Measure the height of the cam on each camshaft. If the wear exceeds the limit, replace the camshaft.

2. Check of camshaft bearing

Check the camshaft bearing for damage or dents in the balls and inner/outer races, uneven rotation, unusual noise and play. If any defect is found, replace the bearing.

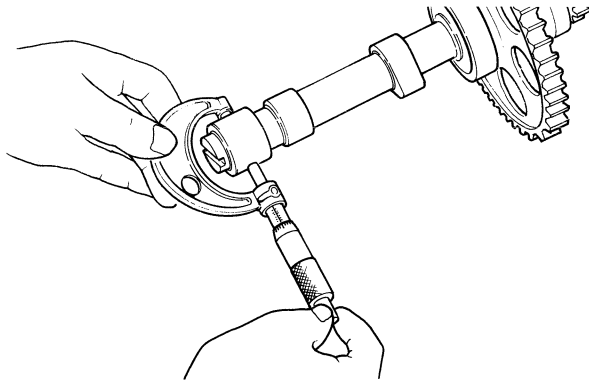
3. Check of camshaft and cylinder body journal bore

Measure the camshaft outside diameter at its journal end, as well as the diameter of the cylinder body journal bore. If the clearance determined from this measurement exceeds the limit, replace the camshaft or cylinder body.

## 8. Inspection and Servicing

(Unit: mm)

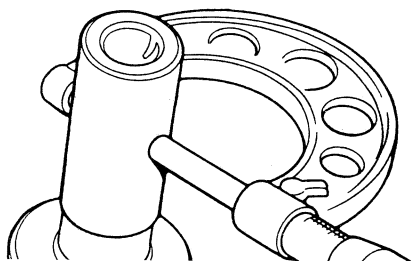
	Standard dimension	Limit
Camshaft outside diameter	$\phi 35.95 - \phi 35.925$	0.1
Cylinder body bore diameter	$\phi 36.0 - \phi 36.025$	0.15
Shaft-to-bore clearance	0.05 - 0.1	0.2



Checking the camshaft bearing

### 4. Tappet

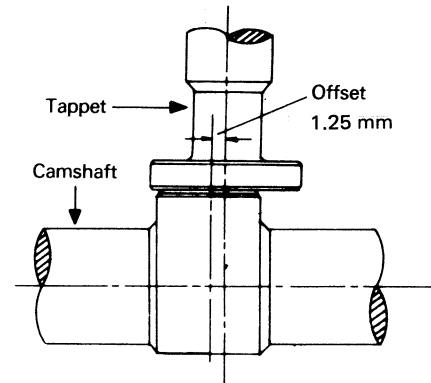
- 1) The tappet foot is offset from the cam centerline. This is to avoid the lopsided wear which would otherwise result from the rotation of the tappet. Check the tappet foot for wear on the contacting surface. If the wear is excessive, replace the tappet.
- 2) Check the tappet diameter for wear and damage, and replace it if necessary.



Tappet O.D. measurement

(Unit: mm)

	Standard dimensions	Limit
Tappet diameter	$\phi 12.984 - \phi 12.966$	0.05
Tappet bore diameter (cylinder block)	$\phi 13.020 - \phi 13.040$	0.08
Oil clearance	0.036 - 0.074	0.15

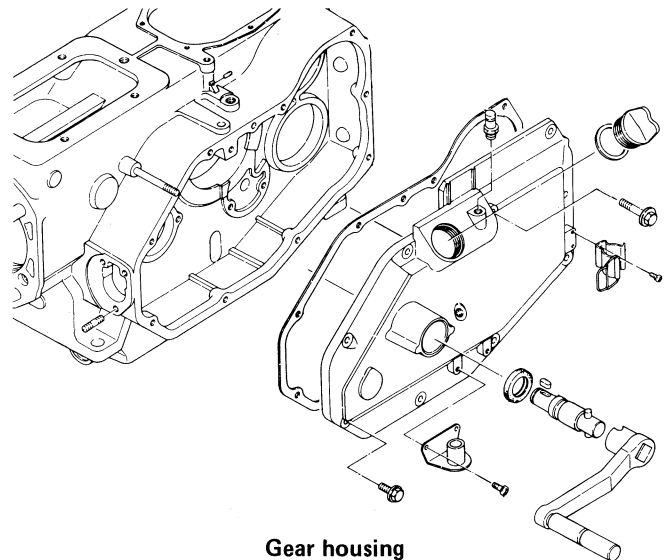


Contacting surface of the cam and tappet

### 8.8 Gearcase and Gears

The gearcase is made of aluminum alloy, fitted with many internal ribs for improved rigidity. This structure effectively muffles noise produced by the mechanical motion of the gears. The gearcase incorporates an oil-pressure regulating valve and an oil signal to maintain optimum oil pressure.

The gear ratio of the camshaft forward-end gear and the starting gear meshing with it is 1 : 1, which means that the gear gives a transmission ratio of 1 : 2 for starting acceleration. By virtue of this gear arrangement, the compression resistance at start-up can be easily overcome.



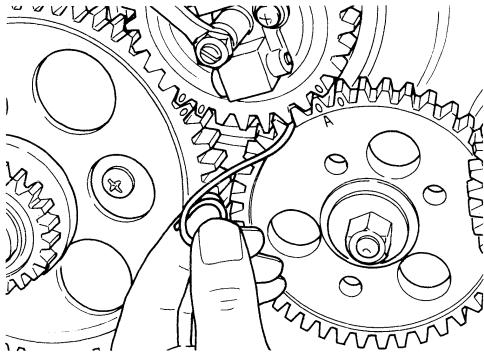
Gear housing

#### 1) Check of gears

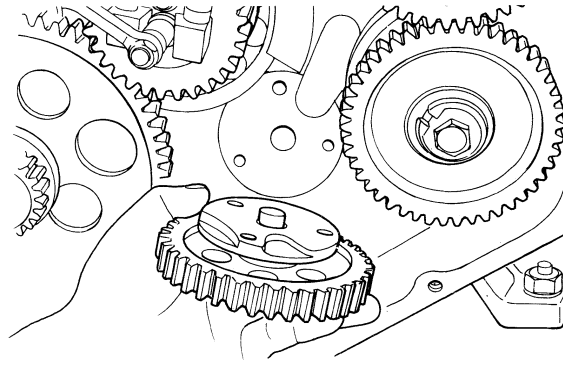
- (1) Check the gears for damage and wear on the tooth surfaces and meshing points. Replace any gear that is defective.
- (2) Check pairs of meshing gears for backlash. If backlash exceeds the limit, replace the defective gear pairs.

(Unit: mm)

	Standard dimension	Limit
Crankshaft and camshaft gears	0.08 – 0.16	0.3
Idle and crankshaft gears	0.08 – 0.16	0.3
First balancer and second balancer gears	0.08 – 0.16	0.3



Backlash measurement



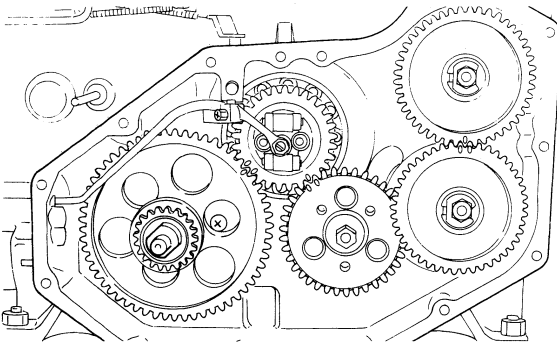
Reassembling the idle gear

## 3) Check of starting shaft

1. If there is oil leakage at the starting shaft, disassemble the shaft to replace the oil seal, and also check the bearing for wear.
2. Check for wear on the starting shaft and its bearing. If the wear is excessive, replace the gearcase and the starting shaft.

## 2) Timing mark

On each gear the point at which the gear meshes with its opposite gear to provide the correct valve timing is marked on one of the teeth. When reassembling, always make sure that these timing marks are aligned.



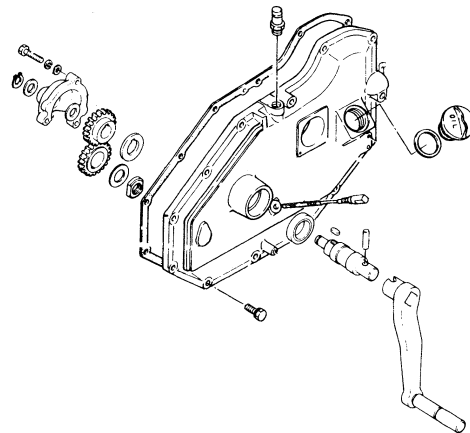
Timing marks

Steps for aligning gear timing marks

- a) Align the timing marks between the crankshaft gear and camshaft gear.
- b) Align the timing marks between the first and second balancer gears.
- c) Aligning the timing mark on the crankshaft gear with that on the first balancer gear's outer surface, install the idle gear of the first balancer. (This should result in alignment between the mark on the inside surface of the first balancer gear and that on the balancer tooth.)

(Unit: mm)

	Standard dimension		Limit
	TS190(R)	TS230(R)	
Starting shaft outside diameter	$\phi 25.972$ – $\phi 25.993$	$\phi 31.991$ – $\phi 31.996$	–0.03
Gearcase journal bore diameter	$\phi 26.03$ – $\phi 26.06$	$\phi 32.03$ – $\phi 32.06$	0.08
Shaft-to-bore clearance	0.037– 0.088	0.039– 0.094	0.12



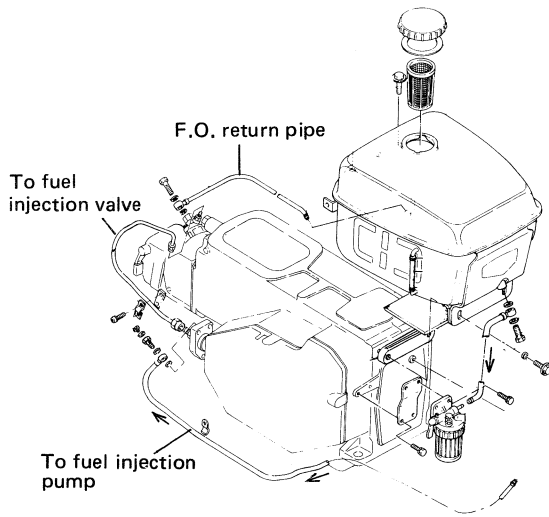
Starter shaft assembly

8.9 Fuel System

The diesel engine fuel injection pump and associated components are all machined to very precise tolerance so that they can efficiently function under high pressure.

Minute foreign particles and water in the fuel will cause considerable damage to the fuel injection pump and injection nozzle, the essential components of a diesel engine.

Therefore ensure both that the oil tank is filled with clean fuel, and the engine itself is equipped with a fuel filter of high filtration capability.

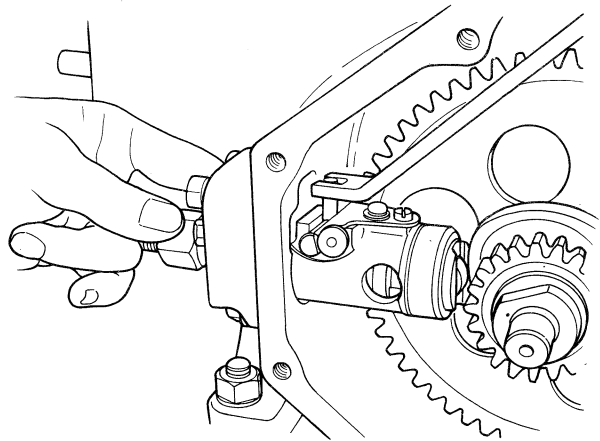


Fuel system

1. Fuel injection pump

The fuel injection pump used is the PFR1-1AW type of Bosch construction. This pump is simple in structure, and is capable of supplying fuel in proper amounts whether at starting or at peak load.

The amount of fuel delivered to the engine is controlled by balancing the spring force of the regulator spring against the centrifugal force developed in the governor weight during engine rotation.

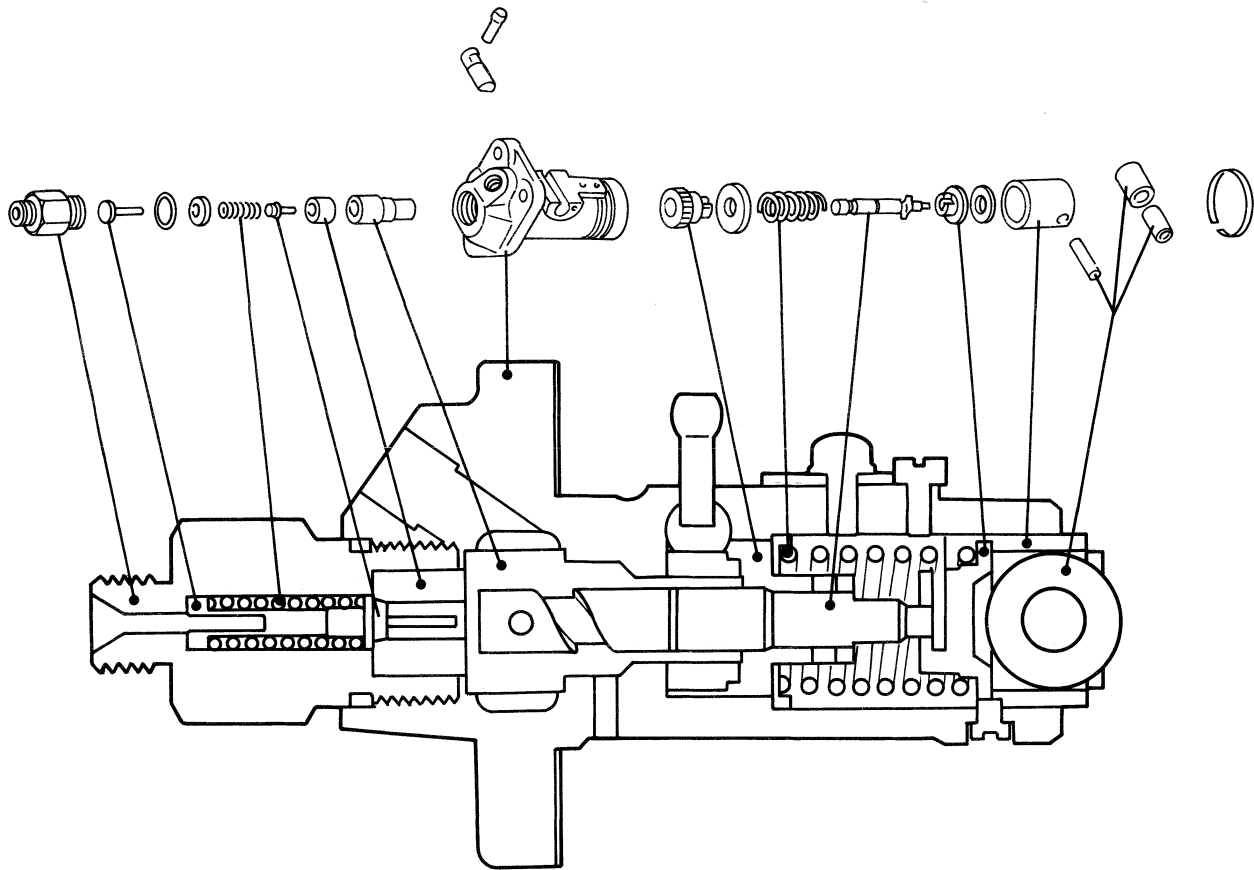


Fuel injectin pump

1) Specifications

Cam lift		9 mm
Plunger	Outside diameter x stroke	φ9.5 x 9 mm
	Injection pattern	to be primed at initial start-up
Resistance in control rack sliding; engine not running		less than 80 g
Clearance at plunger top (factory preset to 86 ± 0.05)		1.15 – 1.25 mm
Plunger position adjusting shim thickness		0.1, 0.2, 0.3 mm
Plunger spring	Free length	45.0 mm
	Mounted length	31.7 mm
	Spring load	11.15 – 13.55 kg
Delivery valve spring	Free length	26.4 mm
	Mounted length	24.0 mm
	Spring load	3.88 kg

2) Fuel injection pump component parts.



Fuel injection pump sectional view

*Note: Assembling the fuel injection pump delivery valve for model TS190/TS230 engines*

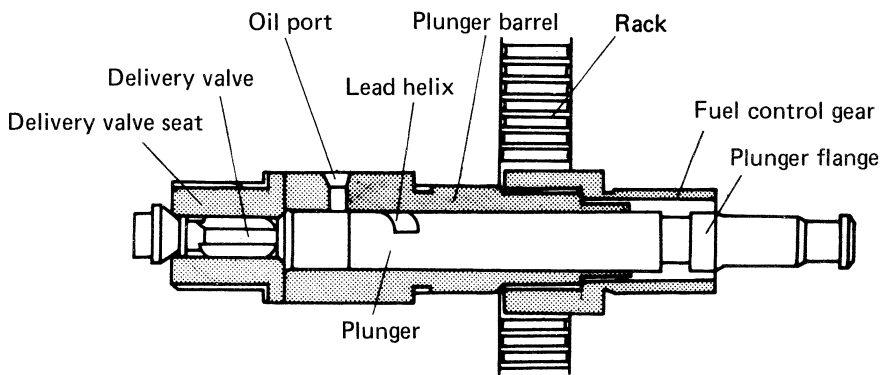
With the introduction of the direct fuel injection system, TS190/TS230 engines are equipped with a Bosch type fuel injection pump. We believe you are familiar with the method of inserting the Deckel pumps delivery valve in our older models, but please be careful that the delivery valve of the Bosch type pump can be inserted from either plunger side or holder side. It can then be assembled upside down after the pump is disassembled.

Good and bad examples of delivery valve assembly are illustrated on the next page.

If the delivery valve is assembled as shown in the bad example, it could result in the following problems

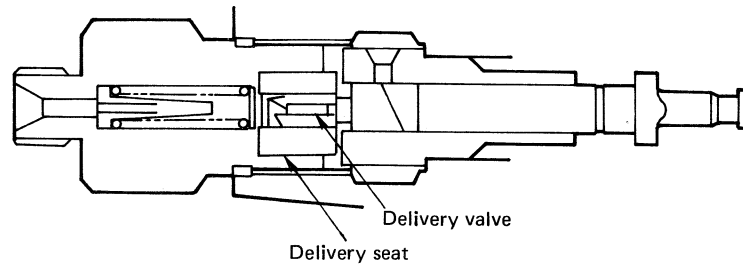
- 1) Cracks in the fuel injection pump body
- 2) Loss of the delivery valve collar

We request you ensure correct assembly.

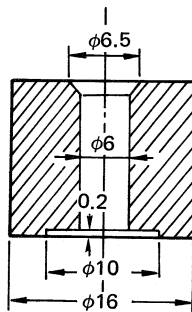
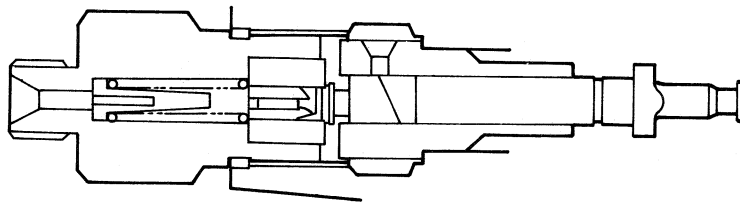


Cutaway view of plunger and barrel

(1) Correct insertion

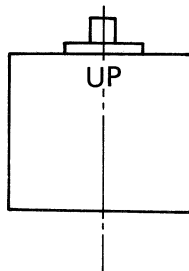


(2) Incorrect insertion



\* Caution

1) Insert the delivery valve so that the chamber of the valve seat faces the plunger side as shown in the picture.

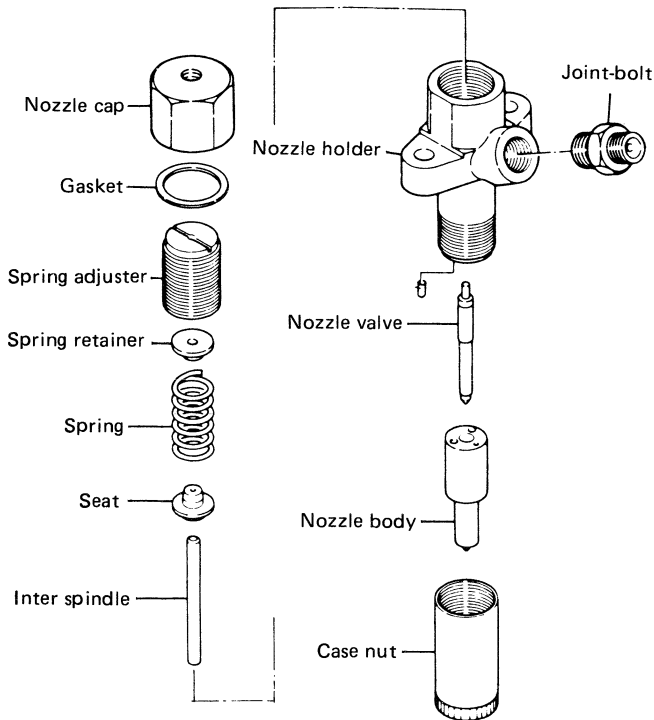


2) On delivery valves manufactured in May, 1984 and thereafter "UP" is marked as shown in the picture.



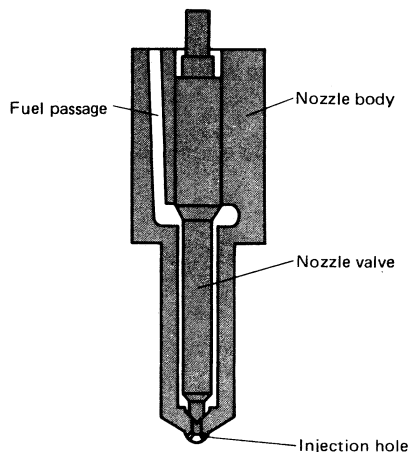
## 2. Fuel injection valve

### 1) Specifications



**Injection Valve Component Parts**

Combustion chamber type	Direct injection
Nozzle type No.	YDLLA150S334SO
Cracking pressure	200 kg/cm <sup>2</sup>
Injection hole diameter x hole number	φ0.33 x 4
Valve seat form	Single cone
Injection angle	150°
Part code	105990-53001



**Nozzle sectional view**

### 2) Check

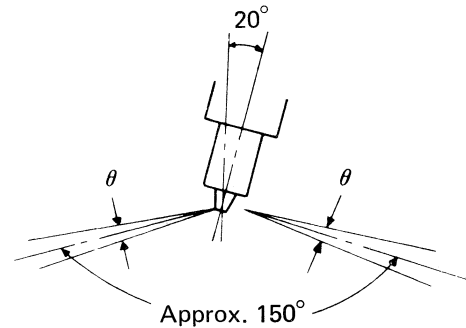
#### a) Carbon flower

When carbon is deposited on the injection hole in the form of a flower, it is known as a carbon flower. Carbon flowers result in the deterioration of engine performance. If a large amount of carbon has been deposited, clean it out.

#### b) Spray pattern

Check the spray pattern by operating the nozzle tester lever at a rate of 1 to 2 swings per second. The normal spray pattern is illustrated on the right. In words, the pattern is correct if:

- (1) The injection angle variation ( $\theta$ ) is limited to a reasonable range.
- (2) The spray consists entirely of minute atomized fuel.
- (3) There is little or no variation between each injection hole.



**Normal spray pattern**

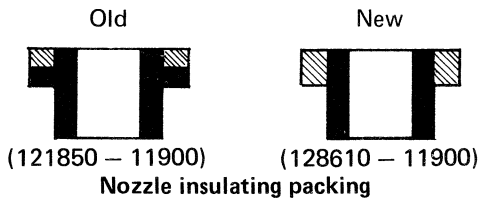
### 3) Precautions for installaing the injection valve

- (1) The clamp nut and case nut of the fuel injection valve should be tightened to the their specified torques.

(Unit: mm)

Valve clamp nut tightening torque	130 – 180 kg-cm
Case nut tightening torque	700 – 750 kg-cm

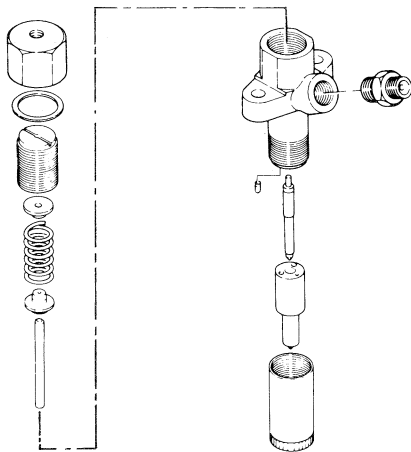
- (2) Clean the sleeve face. Also, remember to replace the insulating packing.
- (3) Apply a coating of molybdenum disulfide over the circumferential surface of the fuel injection valve body to prevent seizure.



(121850 – 11900) (128610 – 11900)  
Nozzle insulating packing

**4) Disassembly and reassembly**

The fuel injection valve can be broken into individual component parts by removing the nozzle clamp nut. Be sure to use a torque wrench as the entire valve is a thin-wall structure. Normally, the positioning pin of the valve need not be removed.



Fuel injection valve component parts

*Note:* As with the fuel injection pump, the fuel injection valve should be disassembled in a clean environment. Care should be exercised so that the internal parts will not drop out of place.

**5) Adjustment instructions**

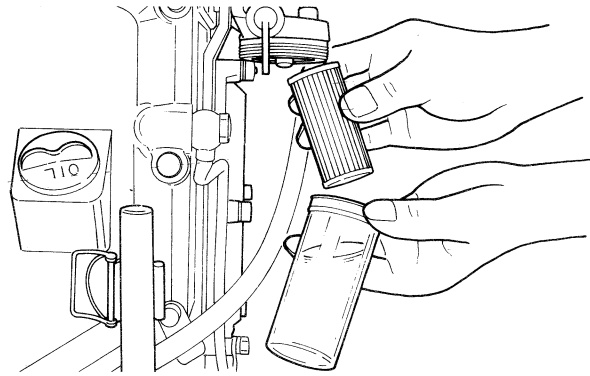
The injection cracking pressure is 200 kg/cm<sup>2</sup>. To adjust the pressure to the specified amount, remove the nozzle clamp nut and spring housing cover and then turn the spring retainer screw with a minus screwdriver.

**3. Check of fuel filter**

The fuel filter should be cleaned from time to time. If water or sediment is found in the sediment bowl of the fuel filter, disassemble the filter, and clean it with clean fuel oil until the foreign matter is completely removed.

The filter element should be replaced regularly after every 600 hours of service. It should be replaced earlier if the filter shows signs of internal contamination, deformation, or damage.

Internal cleaning of fuel filter	Every 300 hours of service
Replacement of filter element	Every 600 hours of service

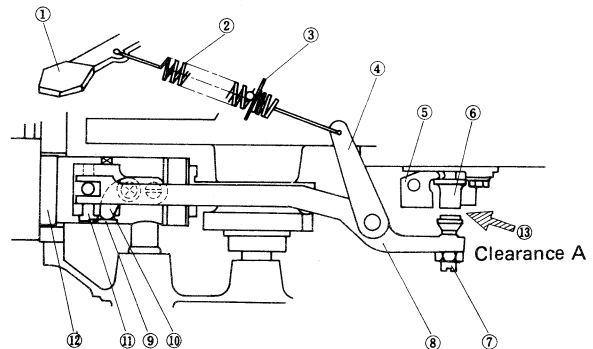


Replacing the fuel filter element

**8.10 Governor System**

The governor system operates like the human nervous system. It has the function of accurately grasping the load condition on the engine and thereby issuing orders to the fuel injection pump. Specifically, the opening and closing motion of the governor weight is transmitted via the governor lever to the internal mechanism of the governor, which accordingly controls the rate of fuel injection automatically.

If the governor linkage is poorly adjusted, the engine will not provide adequate revolutions. Proper adjustment of the linkage is thus important.



- 1. Regulator handle
- 2. Regulator spring
- 3. Spring hook
- 4. Governor lever shaft
- 5. Governor weight
- 6. Governor spindle
- 7. Adjusting screw
- 8. Governor lever
- 9. Fuel control shaft
- 10. Fuel control plate
- 11. Fuel control rack
- 12. Fuel injection pump

Governor linkage mechanism

**1. Governor**

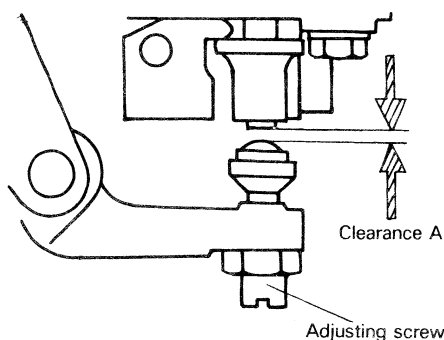
The clearance between the governor spindle and the adjusting screw affects the engine performance, especially in low speed operation. This clearance should be adjusted as illustrated belows.

**2. Adjustment of governor linkage**

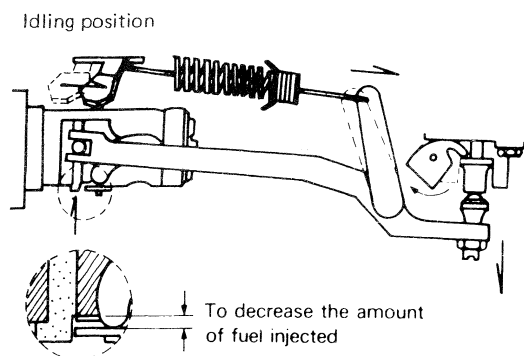
The adjusting screw should not be loosened even at the time of governor linkage adjustment, except when it requires readjustment as the result of a check.

- 1) Remove the cylinder side cover, starting handle, and oil level gauge.
- 2) Remove the cylinder side cover.
- 3) Check the governor lever clearance (clearance A).

- (1) Shift the governor lever to reduce the gap between the fuel control plate and fuel control shaft to zero.
- (2) With the governor lever held in the position determined in 1 above, check the governor lever clearance (A).

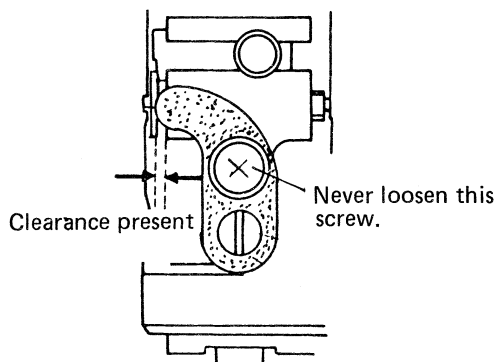


**Adjust the governor lever clearance**



**Clearance between control plate and shaft**

- 4) If clearance A exceeds the standard range, adjust it with the adjusting screw.



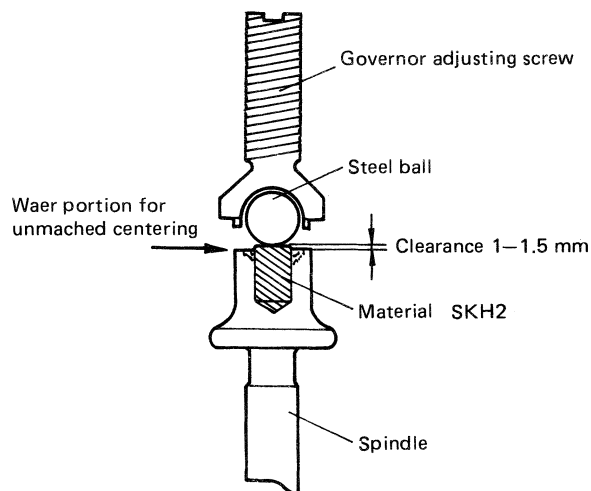
**Adjusting of standard clearance**

*Note: The length of the regulator spring, although adjustable, must not be adjusted.*

Standard clearance A	1.2 – 1.5 mm
----------------------	--------------

**3. Check of governor linkage**

- 1) The sliding resistance of the regulator handle is adjustable using the bolt located at the fulcrum of the handle. If a weaker or stronger force is required to move the handle, adjust the tightness of the spring retaining nut accordingly.
- 2) Check the sliding resistance of the governor lever shaft. The governor lever shaft, once assembled, must move smoothly. If it does not performance after adjustment will be adversely affected (e.g., hunting).



**Inspecting the governor linkage**

## 8. Inspection and Servicing

(Unit: mm)

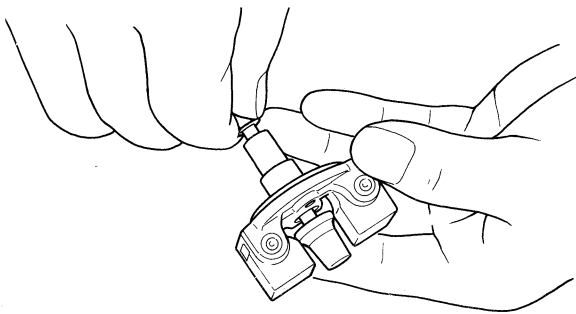
		Standard dimension	Limit
Governor lever shaft diameter	TS190(R)	$\phi 9.955 - \phi 10.00$	-0.05
	TS230(R)	$\phi 9.987 - \phi 9.972$	
Cylinder block bore diameter		$\phi 10.0 - \phi 10.015$	0.05
Clearance between lever shaft and lever shaft bore		0 - 0.060	0.1

Notes: 1) When assembling the governor lever shaft, check to be sure that (a) the front end of the governor lever shaft set-bolt is completely in the lever shaft groove and (b) after the bolt is tightened, the lever shaft moves smoothly.

2) Check to be sure of center alignment between the end of the governor spindle and the steel ball on top of the adjusting screw.

### 3. Check of governor

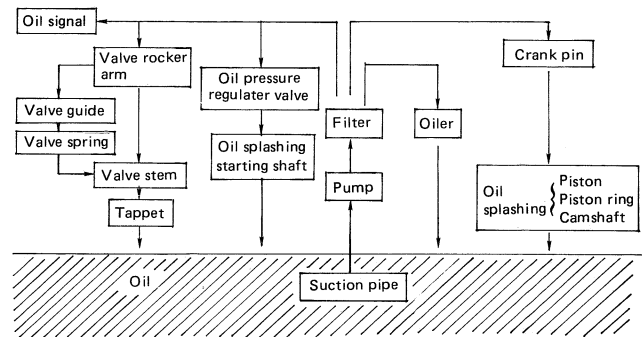
Check the governor spindle for proper movement in various positions. If faulty, repair or replace it. Check the governor weight for smooth movement, and also check the E-section governor retaining ring on the spindle tip for deformation or breakage.



Checking the governor

### 8.11 Lubrication System

The engine is lubricated by forced circulation, using a trochoidal pump. Lubricating oil is controlled by an oil-pressure regulating valve. The routing of lubricating oil is illustrated in the following diagram.

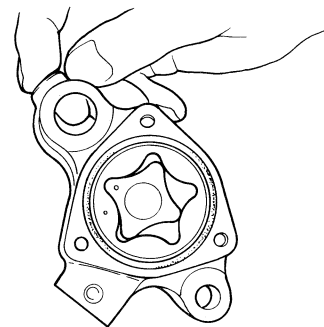


Lubricating oil bypass flow

#### 1. Lubrication oil pump

The lubricating oil pump is of trochoidal type, compact in size and small in pressure fluctuation. Driven by the camshaft, the pump delivers lubricating oil at about  $3 \text{ kg/cm}^2$  to various parts.

Pump performance	Delivery	Approx. 6.2 l/min
	Pump speed	1200 r.p.m.
	Oil temperature	60°C



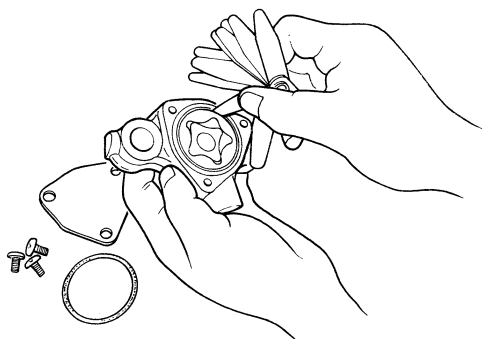
Lubricating oil pump

#### 2. Check of lubricating oil pump

1) Check the clearance between the outer rotor and the body. If it exceeds the limit, replace both the rotor and body.

(Unit: mm)

	Standard value	Limit
Clearance	0.10 - 0.15	0.15



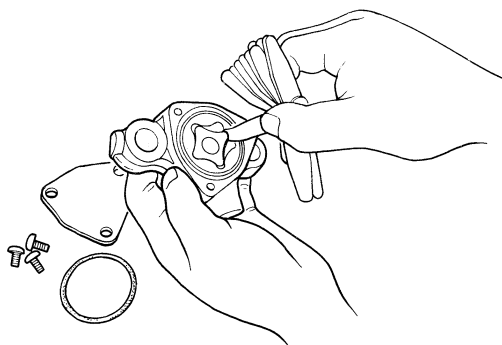
Clearance between outer rotor and pump body

### 2) Clearance between outer rotor and inner rotor

Press the convex part of the inner rotor fully into the concave part of the outer rotor, and insert a thickness gauge in the space where convex parts of both rotors are in contact with each other. If this measurement, representing the outer-to-inner rotor clearance, exceeds the limit, replace the pump as well as the rotors.

(Unit: mm)

	Standard value	Limit
Clearance	0.14 max.	0.2

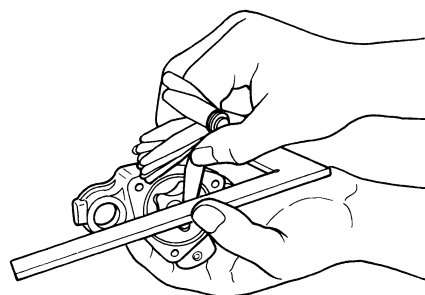


Clearance between inner and outer rotors

### 3) Side clearance between body and inner/outer rotors

If the side clearance between the body and inner/outer rotors exceeds the limit, replace the pump as well as the rotors.

	Standard value	Limit
Clearance	0.01 – 0.05	0.15

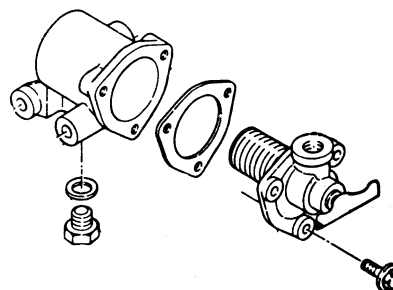


Clearance between body and inner/outer rotors

### 3. Lubricating oil filter

Oil is filtered at the pump suction side by means of a perforated steel plate filter element which removes large particles, and at the pump discharge side by an auto-clean filter to filter out all remaining foreign matter. The auto-clean filter is of mesh-150 for the TS190(R) and mesh-120 for the TS230(R). Normally, only auto-clean filter is checked.

- 1) Carry out servicing of the auto-clean filter by turning the handle 2 to 3 times a day. Either the right or left one may be used.



Oil filter Auto-clean TS190(R)

### 2) Check of lubricating oil filter

Remove the lubricating oil filter during oil change. The filter recovers the original filtration power when it is cleaned with a clean liquid like kerosene.

### 3) Oil signal

The TS Engine is equipped with an oil signal to allow visual check of the oil pressure. The oil signal is normally blue; it changes to red if the oil pressure drops extremely. If the color changes to red, stop the engine immediately and check the oil, etc.

8.12 Cooling System

The cooling system incorporates a multiblade axial fan. The radiator is combined with the sub-tank, and this eliminates the need for the time-consuming addition of cooling water and provides a higher cooling efficiency, free from the danger of overheating.

(Unit: kg/cm<sup>2</sup>)

Radiator cap setting pressure	Pressure regulating valve	0.9
	Negative-pressure valve	0.05

1. Check of cooling system

1) V-belt

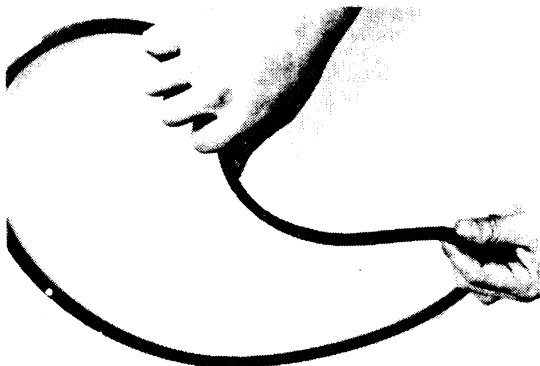
The V-belt needs to be replaced if its edge rubbed shiny against the pulley. Locate the cause by checking the rubber for deterioration, cracking, wear, and oil deposition, among others.

2) Check of V-belt tension

Check belt deflection at the midpoint between the fan and tension pulley. The amount of deflection, which varies with the load on the belt, is generally measured by applying a finger pressure of 3 to 5 kg.

(Unit: mm)

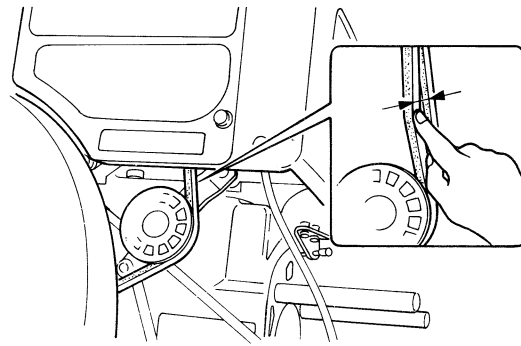
Standard deflection amount	15 – 20
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Inspecting the V-belt

3) Check for dirt trapped between the radiator fins

Check the radiator fins for trapped dirt and deformation. Clean the fins for smooth passage of cooling air.

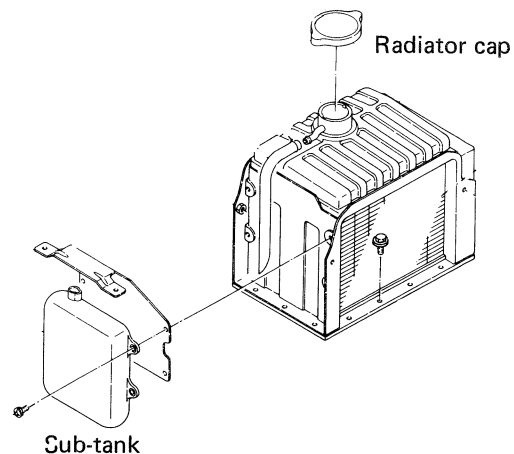


Installing the V-belt

4) Check fo radiator cap and sub-tank hose

Check the pressure regulation valve and the negative-pressure valve of the radiator cap to make sure that the spring is at the proper tension and firmly anchored. Replace the cap if defective.

Check the hose connecting the radiator and sub-tank to see if it is cracked, deformed, or otherwise damaged. Replace the hose if faulty. Hose cracking often occurs when the clamp is tightened. The hose should be replaced soon after it is found to be cracked since cracking is a sign of rubber deterioration.



Radiator cap and sub-tank

**2. Check of cooling-water quality**

The quality of cooling water is acceptable if there is no appreciable rust or foreign matter deposited on and around the radiator cap, and if the cooling water itself is not contaminated with red rust, oil, etc. When re-filling use clean, soft water.

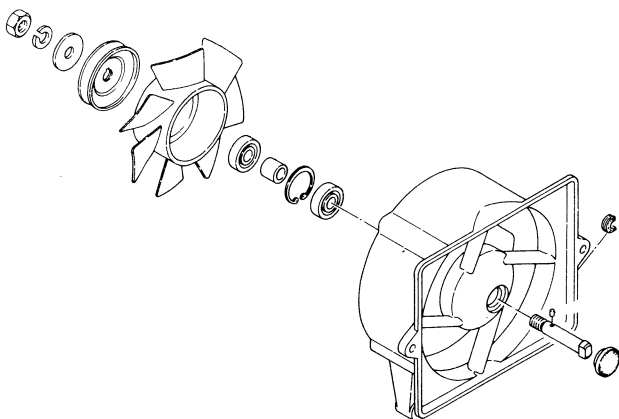
**3. Check of cooling water quantity**

To check the cooling water quantity, fill with water up to the upper limit in the cooling water refill port. In winter when the cooling water might freeze, remember to either put of the following precautions: (a) mix anti-freeze into the water to prevent breakage by freezing, or drain the cooling water whenever a job is finished.

**4. Check of cooling fan bearing**

- 1) Check the cooling fan bearing for loose fit or unusual noises, and replace it if necessary.
- 2) When replacing bearings fill with grease  
Whenever any of the following bearings are replaced, apply the proper grease as shown below.

Fan bearing	Lithium grease: consistency 280 at 25°C, Brand: Shell Alvania Grease No. 2, or equivalent
Tension roller bearing	Lithium grease: consistency 235 at 25°C Brand: Shell Alvania Grease No. 3, or equivalent



Inspecting the cooling fan bearings

**3) Tightening of cooling fan shaft nut**

After fitting the cooling fan shaft, tighten the fan nut M12(TS190), M10(TS230) to the specified torque, and then check the shaft for proper rotation.

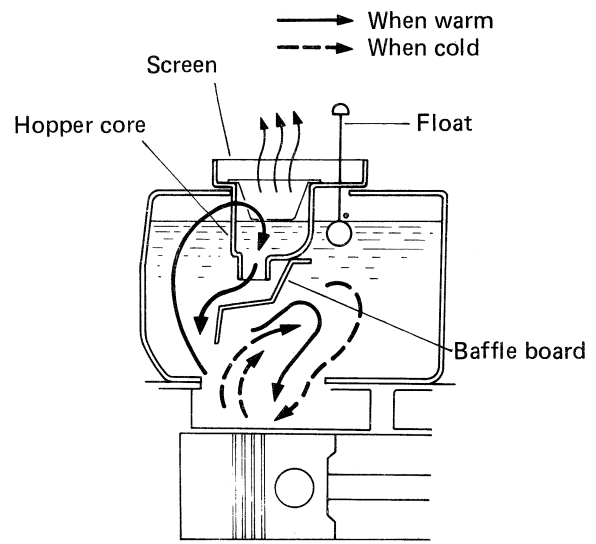
**Tightening torque for fan shaft nuts**

TS190	400 – 500 kg-cm
TS230	300 kg-cm

**5. Engine of hopper type cooling system**

The hopper contains a hopper core and baffle board. This structure makes use of convection in the cooling water produced with rising temperatures in the hopper. The result is further improvement in cooling.

When the cooling water warms up, but to relatively low temperatures, it is guided by the baffle board for even cooling. If the water temperature rises still higher, then part of the water goes up through the opening in the top of the hopper core and into the hopper core itself. As the water in the hopper core radiates heat into the atmosphere, the water goes down in the hopper core and is guided by the baffle board to flow into the relatively warmer region nearer to the cylinder head, and cools it.



Water behavior in hopper

**1) Handling precautions**

1. The cooling water should normally be filled to the level of the bottom of the screen. The hopper should be filled with additional water before the float sinks completely due to evaporation of the convected water.
2. Use only clean, softwater. If used badly contaminated water will result in clogging of the water passage in the cylinder head

or cylinder block, or cause entrapment of the contaminants, which weakens the cooling effect.

3. Be sure to drain the cooling water whenever the engine has been stopped after operation.

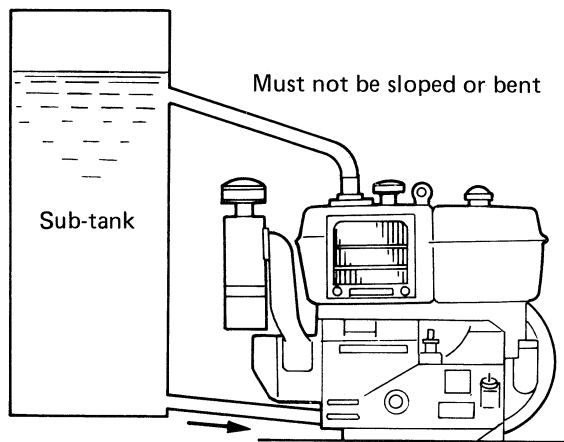
2) Thermo siphon type

Where the hopper type cooling system is operated for an extended period, a sub-tank is installed and connected with tubing to the engine. The cooling water is then circulated by the convection,

During warmup of the engine, cooling is effected primarily by the cooling water in the engine hopper. Consequently, good warmup is provided. At higher temperatures, the cooling water is then cooled as it is circulated to and from the sub-tank, which results in an extended cooling time without the resupplying of water.

Precautions

1. The connecting hose should be as thick and as gently bent as possible.
2. When supplying water to the sub-tank, open the p-cock on top of the hopper to release the air.

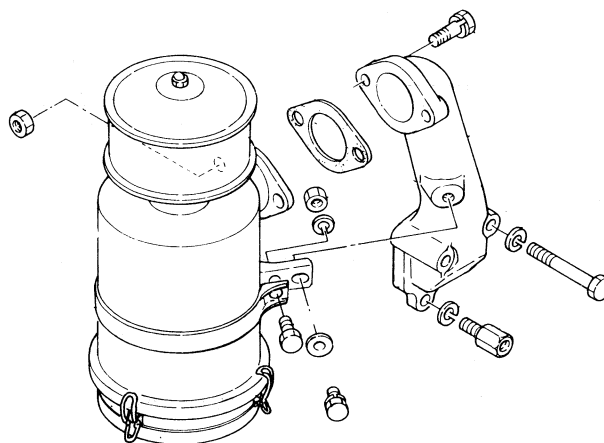


Thermo-siphon installation method

Note: Refer to the TS190(R)/TS230(R) Production Information, for detailed descriptions of the preceding instructions.

8.13 Air Cleaner

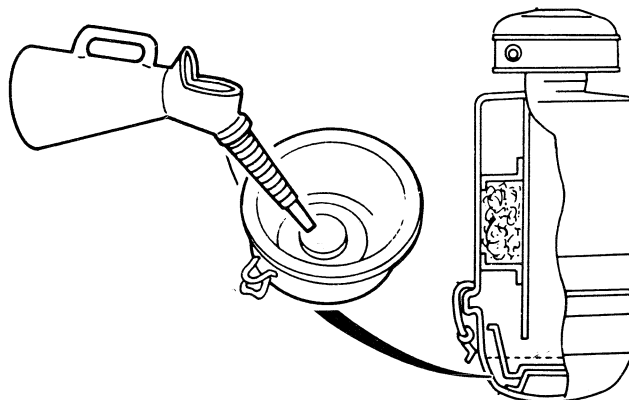
The air is heavily laden with dust particles of various kinds. When breathed into a cylinder, these minute particles mix with the oil in the cylinder, piston, piston ring, and bearing, accelerating wear of these components and thus shortening the engine life. The engine is therefore equipped with an air cleaner to block contamination by dust particles.



Air cleaner components

1. Check of air cleaner element

- 1) Check the air cleaner element for contamination and clogging.
- 2) Check the oil in the air cleaner oil pan for the degree of contamination.



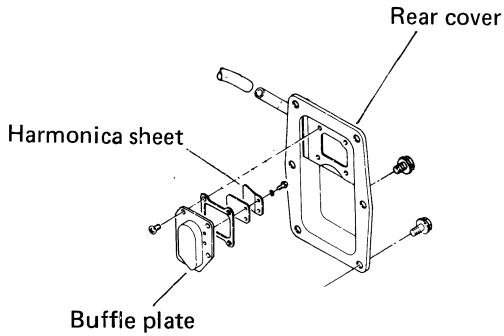
Inspecting the air cleaner oil

- Notes:
- 1) Do not fill oil into the oil pan to more than the standard level. Failure to observe this may cause very rapid rotation during engine running.
  - 2) If the engine has been continuously operated in the rain, check the oil in the air cleaner oil pan. If the oil in the pan has water in it, change it with new engine oil.



### 8.14 Breather

If oil oozes from the main bearing housing, starting shaft, oil seal, oil feeding port cap, governor lever spindle, crankshaft oil seal, or packings, it is a sign that foreign matter is trapped between harmonica sheets. In that case, remove the foreign matter with cleaning oil.



Inspecting the breather and rear cover

### 8.15 Other Accessories

The following description applies to electrically started engines.

#### 1) Specifications of electrical starter and charger

Capacity of starting dynamo	Generating capacity of dynamo	Capacity of associated battery
12V 1.25 kW	12V 7.5A	12V 100 – 70AH

#### 2) Wiring diagram

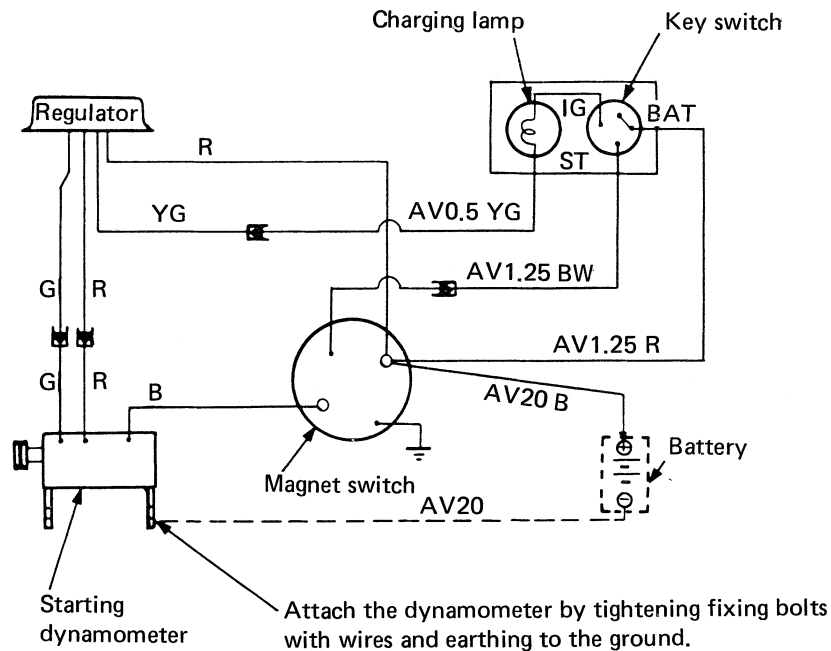
The solid lines in the wiring diagram denote shop-connected wires.

Be sure to use a battery of the specified capacity.

Make sure that the electric wiring for continuity is as shown in the following diagram.

TS type

- A panel board on the engine side.



- YG: Yellow Green
- R: Red
- B: Black
- G: Green
- BW: Black/White

# 9. Maintenance Schedule

	Item	Daily	Every 100 hrs.	Every 300 hrs.	Every 600 hrs.
Fuel system	Fuel level check and refill	○			
	Fuel tank draining		○		
	Fuel filter element cleaning			○	(Replace) ○
	Crank-case oil level check and refill	○			
Lubricating oil system	Lubricating oil change	Note 1.	○		
Cooling water system	Lubricating oil strainer cleaning		○		
	Cooling water refill	○ Ensure that the floating level of the hopper type, usually.			
	Water leakage check	○			
	Radiator screen cleaning		○		
	Radiator fin cleaning		○		
	V-belt tension adjustment	(10–50 hrs. after installation of new belt)		○	
Air cleaner	Element cleaning		○		
	Oil change		○		
Items associated with cylinder head	Tightening of bolts & nuts	Note. 2	○		
	Valve clearance adjustment			○	
	Valve seat reconditioning				○
	Valve rocker arm check			○	
	Fuel injection valve cleaning				○
	Tightening of main bolts	Note. 2	○		

*Note 1: In case of the initial operation, replace the oil at 20 hours. (50 hrs. or shorter for places laden with dust and foreign matter).*

*Note 2: In case of the initial operation, retighten the bolts and nuts at 50 hours.*

# 10. Service Standards

Division	Component	Item	TS190(R)		TS230(R)		Action	
			Standard	Limit	Standard	Limit		
Cylinder Head	Cylinder head	Combustion surface	For 100 mm cylinder head	0.05	←	0.05	Replace if distorted or cracked. Page 28	
		Intake/exhaust valve stem diameter	φ8.945 – φ8.960	φ8.85	←	φ8.85	If beyond the limit, replace both valve and valve guide. Page 29	
		Valve guide inner diameter bore	Intake	φ9 – φ9.015	φ9.1	←		←
			Exhaust					
		Valve stem-to-guide clearance	Intake	0.04 – 0.07	0.15	←	0.15	Page 29
			Exhaust					
	Valve seat width	Intake	1.73	—	←	—	Repair seat. If appreciably worn or damaged, replace cylinder head. Page 29	
		Exhaust	2.47	—	←	—		
	Top clearance		0.8 – 1.0	0.85–1.05	←	←	Measure with fuse diameter φ1.5 – φ2.0 Page 30	
	Intake/exhaust valve	Intake/exhaust valve sinkage	Intake	0.25 – 0.55	1.4	←	1.4	If beyond the limit, replace or recondition. Page 29
			Exhaust	0.65 – 0.95	1.8	←	1.8	
		Valve head thickness	Intake	1.8 – 2.2	1.5	←	1.5	Page 28
			Exhaust	1.3 – 1.7	1.0	←	1.0	
	Valve spring	Free length	53	—	←	—	Replace if badly damped or inclined. Page 30	
		Mounted length	48	—	←	—		
		Spring load	12.9 kg	—	←	—		
		Squareness	—	1.5	←	1.5		
	Intake/exhaust valve rocker arm	Intake/exhaust valve rocker arm shaft outer diameter	φ19.959 – φ19.980	-0.1	←	-0.1	Replace if beyond limit. Page 30	
Rocker arm bushing inside diameter		φ20 – φ20.021	+0.1	←	-0.1			
Shaft-to-bore clearance		0.02 – 0.062	0.15	←	0.15			
Intake/exhaust valve head clearance		0.2	—	←	—	Measure and adjust, in cool state. Page 31		
Decompression lift		0.6 – 1.0	—	0.8 – 1.2	—	If associated parts are disassembled, check and adjust the lift when the parts are reassembled. Page 31		
Piston and Piston Rings	Piston maximum diameter (at skirt)		φ109.94 – φ109.835	-0.4	φ111.82–φ109.835	-0.4	Replace if beyond limit (as measured perpendicular to pin). Page 33	
	Piston ring	Piston ring end gaps	No. 1	0.3 – 0.5	1.8	←	1.8	If ring is beyond limit, replace ring. If both piston and ring are beyond their limits, replace them as a unit. Page 34
			No. 2	0.3 – 0.5	1.8	←	1.8	
			No. 3	0.3 – 0.5	1.8	←	1.8	
			Oil ring	0.3 – 0.5	1.8	←	1.8	
		Ring-to-groove clearance	No. 1	0.095 – 0.130	0.30	←	0.30	
			No. 2	0.05 – 0.085	0.25	←	0.25	
			No. 3	0.05 – 0.085	0.25	←	0.25	
	Piston pin	Piston pin diameter		φ35.989 – φ36	-0.05	←	-0.05	Replace if beyond limit. When pin is pulled out and inserted, do it by warming oil. Page 34
		Piston-to-piston pin clearance		0 – 0.022	—	←	—	
Pin inserting temperature		50 – 60°C	—	←	—			
Connecting Rod	Connecting rod	Bent or twisted connecting rod	0.03	0.05	←	0.05	Replace if beyond limit.	
		Thrust clearance of connecting rod	0.2 – 0.4	0.5	←	0.5	Replace if beyond limit.	
		Piston pin bearing metal inside diameter	φ36,025 – φ36,040	0.12	←	0.12	Page 38	
		Piston pin-to-bearing clearance	0.025 – 0.051	0.15	←	0.15		
		Crankpin bearing surface		—	—	←	—	Replace if flaked, damaged, or discolored.
		Crankpin bearing inside diameter		φ58 – φ58,045	0.1	φ60 – φ60,045	0.1	Replace if beyond limit.
		Crankpin-to-bearing clearance		0.022 – 0.092	0.1	←	0.1	Page 39
Cylinder Liner	Cylinder liner	Cylinder liner inside diameter	φ110 – φ110,035	0.25	112 – 112,035	0.25	Replace if beyond limit.	
		Cylinder liner out-of-roundness	0.015	0.1	←	0.1	Re-fit if beyond limit.	
		Cylinder liner projection	0.03 – 0.10	—	←	—	Page 32	

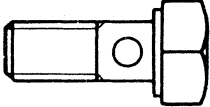
## 10. Service Standards

Division	Component	Item		TS190(R)		TS230(R)		Action	
				Standard	Limit	Standard	Limit		
Crankshaft	Crankshaft	Crankshaft pin	Shaft diameter	$\phi 57,953 - \phi 57,978$	-0.10	$\phi 61,953 - \phi 61,978$	-0.10	Replace if beyond clearance. Page 37	
			Out-of-roundness	0.008	0.02	←	0.02		
			Oil clearance	0.022 - 0.092	0.1	←	0.1		
		Side gap		0.2 - 0.4	0.5	←	0.5	Replace if bearing is damaged, dented, or produces noise. Page 37	
Cam shaft & Tappet	Camshaft	Cam height	Intake/exhaust valve cam	41.96 - 42.04	-0.5	←	-0.5	If beyond limit, replace camshaft. Page 40	
			Fuel cam	65.98 - 66.02	-0.3	←	-0.3	If beyond limit, replace cam. Page 40	
		Camshaft diameter		$\phi 35,925 - \phi 35,950$	0.1	←	0.1	If beyond limit, replace camshaft. Page 41	
		Camshaft journal bore diameter (cylinder block)		$\phi 36 - \phi 36,025$	0.15	←	0.15		
	Shaft-to-bore clearance		0.05 - 0.10	0.2	←	0.2			
	Tappet	Tappet diameter		$\phi 12,966 - \phi 12,984$	0.05	←	0.05	Replace if damaged or dented.	
		Tappet guide inside diameter		$\phi 13,020 - \phi 13,040$	0.08	←	0.08	If beyond limit, replace tappet. Page 41	
		Oil clearance		0.036 - 0.074	0.15	←	0.15		
Tappet-to-cam contacting surface			—	—	—	—	Make sure of uniform contact.		
Gearcase & Gear	Gears	Backlash	Crankshaft gear to camshaft gear	0.08 - 0.16	0.3	←	0.3	If beyond limit, replace pair of meshed gears. Page 42	
			Idle gear to crankshaft gear	0.08 - 0.16	0.3	←	0.3		
			Balancer gear	0.08 - 0.16	0.3	←	0.3		
	Starter shaft	Starter shaft bearing inside diameter		$\phi 25,972 - \phi 25,993$	-0.03	31,966 - 31,991	-0.03	If beyond limit, replace gearcase or starter shaft. Page 42	
		Gearcase shaft bore inside diameter		$\phi 26,030 - \phi 26,060$	0.08	32,030 - 32,060	0.08		
		Starter shaft-to-bearing clearance		0.037 - 0.088	0.12	0.039 - 0.094	0.12		
Lubricating Oil System	Lubricating oil pump	Outer rotor-to-housing clearance		0.10 - 0.15	0.15	←	0.15	If beyond limit, replace pump as a unit. Page 48, 49	
		Outer rotor-to-inner rotor clearance		Less than 0.14	0.2	Less than 0.14	0.2		
		Side clearance of each rotor-to-housing		0.01 - 0.05	0.15	←	0.15		
Fuel System	Fuel injection pump	Wear on plunger		9.5	—	—	—	Replace.	
		Control rack sliding resistance		Less than 80g	—	Less than 80g	—	—	Replace if rack does not slide down smoothly when it is brought to the vertical.
		Tappet roller total clearance		—	0.3	—	0.3	Replace	
		Plunger spring	Free length		45	—	←	—	Replace.
			Mounted length		31.4 - 32	—	←	—	
			Spring load		12.35 kg	—	←	—	
		Delivery valve spring	Free length		26.4	—	←	—	Replace.
			Mounting length		24.0	—	←	—	
Spring load			3.88	—	←	—			

# 11. Main Bolt/Nut Tightening Torques

Bolt/nut	Thread dia. (mm)	Width across flat (mm)	Tightening torque (kg-cm)	Remarks
Cylinder head stud bolt	M18	—	1400 – 1600	Apply lubricating oil to thread bearing surface.
Cylinder head clamping nut	M18	29	2700 – 2900	"
Connecting rod bolt	M11	17	580 – 620	TS190
	M12		780 – 820	TS230
Flywheel end nut	M36	56	300 – 3500	"
Fan clamping nut	M12	17	400 – 500	TS190
			300	TS230
Main bearing housing clamping bolt	M10	14	450 – 550	
Gearcase clamping bolt	M8	12	200 – 300	
Lubricating oil pump clamping bolt	M8	12	240 – 280	
Fuel pump clamping nut	M8	12	200 – 300	
Injection valve clamping nut	M8	12	130 – 170	
Valve rocker arm support clamping bolt	M12	17	550	
Governor cleaner support	M6	10	90 – 130	

## Pipe joint bolt tightening torque

	M8	14	120 ~ 170	Do not put a pipe joint bolt to reuse if its oil hole is deformed. A deformed hole is evidence that the bolt is fatigued.
	M12	17	250 ~ 300	

## Standard bolt tightening torque

M6	10	80 ~ 100
M8	12	250 ~ 270
M10	14	450 ~ 500
M12	17	700 ~ 750

# 12. Troubleshooting

Trouble and possible cause	Remedy
<p>Insufficient output</p> <ol style="list-style-type: none"> <li>1. Reduction in compression pressure               <ol style="list-style-type: none"> <li>(1) Improper intake/exhaust valve head clearance</li> <li>(2) Pressure leak at valve seat</li> <li>(3) Valve stem seizing</li> <li>(4) Damaged or broken valve spring</li> <li>(5) Pressure leak through cylinder head gasket</li> <li>(6) Broken or sticking piston ring</li> <li>(7) Worn piston ring or liner</li> </ol> </li> <li>2. Incorrect fuel injection system               <ol style="list-style-type: none"> <li>(1) Poor injection timing</li> <li>(2) Defective nozzle</li> </ol> </li> <li>3. Incorrect fuel system               <ol style="list-style-type: none"> <li>(1) Clogging in fuel strainer element</li> <li>(2) Air bubbles in fuel system</li> <li>(3) Contamination in tank</li> <li>(4) Oil leakage in fuel injection pipe</li> <li>(5) Poor fuel flow in fuel injection pump</li> <li>(6) Poor fuel injection caused by improperly adjusted governor linkage.</li> </ol> </li> <li>4. Poor air inflow               <ol style="list-style-type: none"> <li>(1) Clogging in air cleaner element</li> <li>(2) Excessive intake/exhaust valve head clearance</li> </ol> </li> <li>5. Overheating               <ol style="list-style-type: none"> <li>(1) Wrong engine oil</li> <li>(2) Insufficient cooling water</li> <li>(3) Worn or broken V-belt</li> <li>(4) Clogging or leakage in condenser</li> <li>(6) Improper intake/exhaust valve head clearance</li> <li>(7) Excess back pressure in exhaust system</li> <li>(8) Inaccurate injection timing</li> </ol> </li> <li>6. Excessive engine oil consumption               <ol style="list-style-type: none"> <li>(1) Loose gearcase bolt or drain plug</li> <li>(2) Deteriorated crankshaft oil seal</li> <li>(3) Defective cylinder head cover gasket</li> <li>(4) Loose lubrication pipe joint bolt</li> <li>(5) Loosen oil filter mounting bolt</li> <li>(6) Wear of intake/exhaust valve or valve guide</li> <li>(7) Broken piston ring</li> <li>(8) Incorrect position of piston ring end gaps</li> <li>(9) Worn or sticking piston ring</li> <li>(10) Piston ring fitted in opposite position</li> <li>(11) Worn piston or cylinder liner</li> </ol> </li> </ol>	<p>Adjust to the proper clearance (0.2 mm)            Remove cylinder head, and re-fit valve and seat.            Repair or replace valve stem.            Replace spring.            Replace gasket.            Replace piston ring.            Disassemble and repair engine.</p> <p>Adjust injection timing.            Repair or replace nozzle.</p> <p>Replace element.            Bleed the fuel lines.            Clean the tank.            Tighten or replace injection pipe.            Repair the pump by disassembly.            Readjust the governor linkage.</p> <p>Clean or replace element.            Adjust to the proper clearance (0.2 mm).</p> <p>Switch to the specified engine oil.            Add water.            Adjust or replace belt.            Repair, clean or replace condenser.            Adjust to the proper clearance (0.2 mm).            Clean out or replace exhaust system.            Adjust the injection timing after checking.</p> <p>Increase the tightening torque.            Replace oil seal.            Replace gasket.            Increase the tightening torque.            Increase the tightening torque.            Replace valve or valve guide.            Replace piston ring.            Adjust ring position.            Replace piston or piston rings.            Fit to the correct position            Replace piston or cylinder liner</p>

Trouble and possible cause	Remedy
<p>Difficult starting</p> <p>1. Starting speed too low</p> <ul style="list-style-type: none"> <li>(1) Engine oil with too high a viscosity</li> <li>(2) Clutch remains in</li> <li>(3) Too much V-belt tension</li> </ul> <p>2. Incorrect fuel injection system</p> <ul style="list-style-type: none"> <li>(1) Fuel leak in fuel injection pipe</li> <li>(2) Defective nozzle</li> <li>(3) Air bubbles in the system</li> <li>(4) Delay in fuel injection timing</li> <li>(5) Poor fuel control rack performance</li> </ul> <p>3. Insufficient compression pressure</p> <ul style="list-style-type: none"> <li>(1) Intake/exhaust valve burned or improper in contact</li> <li>(2) Wear in piston, cylinder liner, or ring</li> <li>(3) Broken cylinder head gasket</li> <li>(4) Defective anti-chamber gasket packing</li> <li>(5) Incorrectly assembled fuel injection nozzle</li> </ul>	<p>Switch to the specified oil. Release the clutch. Adjust tension.</p> <p>Tighten or replace fuel injection pipe. Repair or change nozzle. Bleed the system. Adjust the injection timing. Clean or repair rack.</p> <p>Fit or replace valve. Repair the engine by overhauling. Replace gasket. Replace gasket. Correct by tightening.</p>
<p>Wrong idling speed</p> <p>1. Fuel injection pump system</p> <ul style="list-style-type: none"> <li>(1) Poor fuel control rack performance</li> <li>(2) Poor governor linkage performance</li> </ul> <p>2. Fuel injection valve</p> <ul style="list-style-type: none"> <li>(1) Non-uniformity in injection pressure or injection spray pattern between nozzles</li> </ul> <p>3. Engine block</p> <ul style="list-style-type: none"> <li>(1) Improper intake/exhaust valve head clearance</li> <li>(2) Loose contact of valve seat</li> <li>(3) Engine speed too low</li> <li>(4) The engine is not sufficiently warmed up</li> </ul>	<p>Clean or repair the rack by disassembly. Repair or replace governor linkage.</p> <p>Repair or replace nozzle.</p> <p>Adjust to the proper clearance (0.2 mm). Fit valve. Adjust idle speed. Warm up the engine.</p>

#### Engine knock

Engine knock may occur due to mechanical reasons from the rotating or sliding parts, or it may be fuel knock. The source of the knock must first be identified. Locate the cause by loosening the fuel injection pipe nut and stopping the injection.

Trouble and possible cause	Remedy
<p>1. Crankshaft bearing</p> <ul style="list-style-type: none"> <li>(1) Worn bearing</li> <li>(2) Seized bearing</li> </ul> <p>2. Connecting rod and crankpin bearing metal</p> <ul style="list-style-type: none"> <li>(1) Worn crankpin bearing metal</li> <li>(2) Worn crankshaft pin</li> <li>(3) Bent connecting rod</li> <li>(4) Burnt crankpin bearing metal</li> </ul>	<p>Replace bearing. Replace bearing.</p> <p>Replace bearing metal Replace pin. Replace connecting rod. Replace crankpin bearing metal.</p>

## 12. Troubleshooting

Trouble and possible cause	Remedy
3. Piston, piston pin, and piston ring (1) Too much clearance in cylinder liner because of wear (2) Worn piston or piston pin (3) Seized piston (4) Broken piston ring	Repair the engine by disassembly.  Replace piston or piston pin. Replace piston or piston pin ring. Replace ring and check each part of the engine.
4. Other (1) Worn tappet (2) Improper intake/exhaust valve head clearance. (3) Worn timing gear	Change tappet. Adjust to the proper clearance (0.2 mm). Replace gear.

### Fault diagnosis by exhaust smoke

Trouble and possible cause	Remedy
Engine is difficult to start or starts without exhaust smoke 1. No fuel at the injection pump (1) Air bubbles in the fuel pipe (2) Clogging in fuel filter element or fuel system  2. No pressurized fuel at either injection nozzle (1) Looseness or cracks in fuel injection pipe (2) Fuel control rack will not move to the injection position (3) Fuel pump delivery valve will not function	Bleed the fuel system. Clean element and fuel system, or replace element.  Tighten or replace fuel injection pipe. Clean or replace the rack by disassembly.  Replace delivery valve.
Engine will not start but emits a little exhaust smoke 1. Insufficient fuel injection (1) Incorrect governor linkage adjustment	Adjust or replace governor linkage.
Engine will not start but emits much exhaust smoke 1. Incorrect timing in fuel injection  2. Injection spray is improper (1) Nozzle seizing (2) Carbon deposit on nozzle tip  3. Compressed air does not rise to ignition temperature (1) Improper intake/exhaust valve head clearance (2) Loose contact of intake/exhaust valve seat (3) Insufficient engine starting rpm  4. Wrong fuel used (1) Cetane value too low (2) Water in the fuel	Adjust injection timing.  Clean or replace nozzle. Clean the nozzle.  Adjust the clearance. Fit valve. Check and adjust the belt tension: check oil.  Change to the specified fuel oil. Change fuel oil.



Trouble and possible cause	Remedy
<p>Engine starts, but doesn't reach required rpm</p> <ol style="list-style-type: none"> <li>1. Too low compression temperature or compression pressure               <ol style="list-style-type: none"> <li>(1) Worn piston, piston ring, or cylinder liner</li> <li>(2) Improper contact of intake/exhaust valve</li> <li>(3) Intake/exhaust valve head clearance improperly adjusted</li> <li>(4) Loose fuel injection valve</li> </ol> </li> <li>2. Wrong fuel used: fuel deteriorated or contaminated               <ol style="list-style-type: none"> <li>(1) Fuel cetane value too low or viscosity too high</li> <li>(2) Water in the fuel</li> </ol> </li> </ol>	<p>Repair engine by disassembly. Fit intake/exhaust valve. Adjust the clearance.</p> <p>Tighten valve.</p> <p>Change to the specified fuel. Change fuel.</p>
<p>Black exhaust smoke at starting</p> <ol style="list-style-type: none"> <li>1. Injection occurring too early               <ol style="list-style-type: none"> <li>(1) Fuel control plate improperly installed</li> </ol> </li> <li>2. Improper spraying               <ol style="list-style-type: none"> <li>(1) Nozzle valve seizing</li> <li>(2) Carbon deposit on needle valve tip</li> </ol> </li> <li>3. Uneven air supply to the engine               <ol style="list-style-type: none"> <li>(1) Clogging in air cleaner</li> <li>(2) Excessive intake/exhaust valve head clearance</li> </ol> </li> </ol>	<p>Adjust plate.</p> <p>Nozzle needle valve. Clean or replace needle valve.</p> <p>Clean or change element. Adjust to the proper clearance.</p>
<p>Too much exhaust during operation</p> <ol style="list-style-type: none"> <li>1. White exhaust smoke               <ol style="list-style-type: none"> <li>(1) Delayed injection</li> <li>(2) Leak in compression pressure</li> <li>(3) Water in the fuel</li> <li>(4) Engine oil rise or drop (sometimes blue-whitish or dark brown)</li> </ol> </li> </ol>	<p>Check and adjust injection timing. Repair the engine by disassembly. Change fuel oil. Check oil level, repair the engine by disassembly.</p>
<p>Black exhaust smoke</p> <ol style="list-style-type: none"> <li>(1) Too much fuel injected to the cylinders</li> <li>(2) Air starvation</li> <li>(3) Wrong fuel</li> <li>(4) Fuel injection too early</li> <li>(5) Engine oil rise or drop</li> <li>(6) Overloading</li> </ol>	<p>Adjust the fuel injection pump. Clean or replace air cleaner element. Switch to the specified fuel. Adjust injection timing. Change oil level, or repair the engine by disassembly. Decrease the load.</p>
<p>Fuel injection nozzle</p> <ol style="list-style-type: none"> <li>1. Fuel leakage               <ol style="list-style-type: none"> <li>(1) Defective nozzle spring retainer O-ring</li> <li>(2) Loose nozzle spring retainer or nozzle mounting nut</li> <li>(3) Loose fuel return pipe joint bolt</li> <li>(4) Cracks in fuel return pipe</li> </ol> </li> </ol>	<p>Replace O-ring Increase the tightening torque</p> <p>Increase the tightening torque Replace pipe</p>
<ol style="list-style-type: none"> <li>2. Improper spraying               <ol style="list-style-type: none"> <li>(1) Leakage or foreign matter in valve seat</li> <li>(2) Nozzle tip damage or distortion, or nozzle valve distortion</li> </ol> </li> </ol>	<p>Clean or replace seat Replace nozzle or nozzle valve</p>

## 12. Troubleshooting

Trouble and possible cause	Remedy
3. Insufficient injection pressure (1) Incorrect injection pressure setting (2) Deteriorated nozzle spring or distorted pressure control plate. (3) Worn nozzle valve. (4) Improper sliding in mated parts (5) Fuel leakage	Adjust to the specified pressure of 200 kg/cm <sup>2</sup> . Adjust or replace spring or plate.  Replace nozzle valve. Repair or replace mating parts. Increase the tightening torque or change whole unit.

### Fuel Injection Pump

Before checking the fuel injection pump, make sure that all the components and systems are in perfect condition.

- |  |                               |
|--|-------------------------------|
| (1) Engine cooling water temperature                             | (9) Cleaning the air cleaner  |
| (2) Compression pressure   | (10) Bleeding the fuel system |
| (3) Checking the fuel filter                                     |                               |
| (4) Operating condition of the fuel injection valve              |                               |
| (5) Checking the fuel oil  |                               |
| (6) Operating condition of the governor linkage                  |                               |
| (7) Leak (or cracks) in the fuel injection pipe                  |                               |
| (8) Checking the top clearances on the intake and exhaust valves |                               |

Trouble and possible cause	Remedy
Engine will not start 1. No exhaust smoke (1) Fuel control rack will not move from neutral (2) Air bubbles in the fuel injection pipe  2. Exhaust smoke occurs (1) Delayed fuel injection	Clean and repair the rack by disassembly Bleed the pipes   Adjust fuel injection timing

Trouble and possible cause	Remedy
<p>Incorrect engine idling</p> <p>1. Hunting</p> <p>(1) Inaccurate injection timing</p> <p>(2) Fuel control rack moves heavily</p> <p>(3) Poor delivery valve function</p> <p>2 Engine can not be run at low rpm.</p> <p>(1) Control rack is difficult to move smoothly</p>	<p>Adjust injection timing</p> <p>Repair the pump by disassembly</p> <p>Replace delivery valve</p> <p>Repair the pump by disassembly</p>
<p>Engine will not run at high rpm:</p> <p>1. At no-load</p> <p>(1) Delayed fuel injection timing</p> <p>(2) Poor pump plunger operation (broken spring)</p> <p>2. At full-load running</p> <p>(1) Insufficient fuel injected to the engine (rack set)</p> <p>(2) Poor pump plunger operation (broken spring)</p> <p>(3) Delayed fuel injection</p>	<p>Adjust injection</p> <p>Repair the pump by disassembly</p> <p>Adjust the pump by disassembly</p> <p>Repair the pump by disassembly</p> <p>Adjust fuel injection timing</p>
<p>Insufficient engine output</p> <p>(1) Insufficient fuel injected to the engine (rack set)</p> <p>(2) Inaccurate fuel injection timing</p> <p>(3) Plunger operates improperly (broken spring)</p>	<p>Adjust the pump by disassembly</p> <p>Adjust injection timing</p> <p>Repair the pump by disassembly</p>
<p>Too much black exhaust smoke</p> <p>(1) Inaccurate fuel injection timing</p>	<p>Adjust injection timing</p>
<p>Too much white exhaust smoke</p> <p>(1) Delayed fuel injection timing</p>	<p>Adjust injection timing</p>
<p>Cooling System</p>	
<p>Overheating</p> <p>(1) Insufficient cooling water</p> <p>(2) Slack in V-belt</p> <p>(3) Contamination on V-belt</p> <p>(4) Clogging in radiator screen</p> <p>(5) Clogging in radiator fins</p> <p>(6) Defective packing or looseness in filter tap</p> <p>(7) Leak in cooling pipe</p> <p>(8) Inaccurate injection timing</p> <p>(9) Leak in radiator</p> <p>(10) Leak because of defective cylinder head gasket</p>	<p>Replenish water; check the system for leaks and repair if required</p> <p>Adjust the V-belt tension</p> <p>Replace V-belt</p> <p>Clean the radiator fins</p> <p>Tighten the tap or replace packing</p> <p>Repair or replace pipe</p> <p>Adjust injection timing</p> <p>Repair or replace</p> <p>Repair by checking</p>

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