3-228E-05

3

CHAPTER 3

ENGINE

Models: J08C-TP and J08C-TR

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TROUBLESHOOTING (ENGINE)

Symptom	Possible cause	Remedy/Prevention
Engine overheating	**Coolant**	
	● Insufficient coolant	Add coolant
	● Defective thermostat	Replace the thermostat
	● Overflow of coolant due to leakage of exhaust into cooling system	Repair
	● Damaged rubber hose	Replace rubber hose
	● Coolant leakage due to deteriorated rubber hose	Replace rubber hose
	● Coolant leakage from coolant pump	Replace the coolant pump
	● Coolant leakage from rubber hose connection	Retighten or replace clamp
	● Coolant leakage from cylinder head gasket	Replace gasket
	Coolant pump	
	● Bearing seizure	Replace
	● Damaged (corroded) vane	Replace vane
	Radiator	
	● Clogged with rust and scale	Clean radiator
	● Clogged with iron oxide due to leakage of exhaust into cooling system	Clean coolant passage and correct exhaust leakage
	● Coolant leakage	Repair or replace radiator
	● Damaged cooling fan	Replace cooling fan
	● Clogged radiator core due to mud or other debris	Clean radiator
	● Defective radiator cap pressure valve	Replace radiator cap
	Abnormal combustion	
	● Incorrect injection timing	Adjust injection timing
	● Reduced injection pressure	Adjust injection pressure
	● Poor fuel	Use good quality fuel
	● Poor nozzle spray	Adjust or replace nozzle
	● Unsatisfactory automatic timer advance angle	Repair or replace timer

Symptom	Possible cause	Remedy/Prevention
Engine overheating	**Other problems**	
	● Defective or deteriorated engine oil	Change engine oil
	● Unsatisfactory operation of oil pump	Replace or repair
	● Insufficient oil	Add oil
	● Brake drag	Adjust
	Severe operating conditions	
	● Lugging the engine	Operate engine properly
Excessive oil consumption	**Pistons, cylinder liners and piston rings**	
	● Wear of piston rings and cylinder liner	Replace piston rings and cylinder liner
	● Worn, sticking or broken piston rings	Replace piston rings and cylinder liner
	● Insufficient tension on piston rings	Replace piston rings and cylinder liner
	● Unsatisfactory break-in of piston rings	Replace piston rings and cylinder liner
	● Unsuitable oil (viscosity too low)	Change oil as required and replace piston rings and cylinder liner
	● Incorrectly fitted piston rings (upside down)	Replace piston rings
	● Gaps of piston rings in line with each other	Reassemble piston rings
	Valves and valve guides	
	● Worn valve stem	Replace valve and valve guide
	● Worn valve guide	Replace valve guide
	● Incorrectly fitted valve stem seal	Replace the stem seal
	● Excessive lubricant on rocker arm	Check clearance of rocker arm and shaft
	Excess oil feed	
	● Defective oil level gauge	Replace oil level gauge
	● Oil level too high	Drain excess oil

Symptom	Possible cause	Remedy/Prevention
Excessive oil consumption	**Oil leakage from miscellaneous parts**	
	● Oil leakage from oil seal	Replace oil seal
	● Cracks or blowhole in cylinder block	Replace cylinder block
	● Oil leakage from connections of oil lines	Tighten connections of oil lines
	● Oil leakage from oil cooler	Replace oil cooler
	● Oil leakage from oil pan gasket	Replace oil pan gasket
	● Oil leakage from O-ring	Replace O-ring
	Other problems	
	● Overcooled engine (low temperature wear)	Warm up engine before moving vehicle Check cooling system

NOTE: If oil consumption is excessive, the problems above will occur. Complaints from the customer are often related to such problems.

1. **White smoke is emitted continuously when the engine is run at high speed.**
2. **White smoke is emitted only immediately after the engine speed is abruptly raised when idling.**
3. **The tail pipe is blackened with oil.**
4. **Oil leaks from the flanges of the exhaust manifold.**
5. **Lack of power.**
6. **Excessive blow-by gas.**

Piston seizure	**Pistons, cylinder liners and piston rings**	
	● Incorrect clearance between piston and cylinder liner	Replace piston, piston rings and cylinder liner
	● Unsatisfactory installation of piston pin	Replace piston, piston rings, cylinder liner and piston pin as required
	● Broken piston ring	Replace piston, piston rings and cylinder liner
	● Difference in expansion due to use of wrong piston	Replace piston, piston rings and cylinder liner

Symptom	Possible cause	Remedy/Prevention
Piston seizure	**Coolant**	
	● Reduction in capacity of coolant pump (due to vane corrosion)	Replace the coolant pump
	● Leakage of coolant	Repair
	● Insufficient coolant	Add coolant
	● Dirty coolant	Clean and replace coolant
	● Defective radiator (coolant leakage, clogging)	Repair or replace the radiator
	● Defective rubber hose (leakage)	Replace rubber hose
	● Defective thermostat	Replace the thermostat
	● Leakage of exhaust into cooling system	Repair
	Operation	
	● Abrupt stoppage of engine after running at high speed	Operate engine properly
	● Hill climbing using unsuitable gear	Select suitable gear
	Oil	
	● Insufficient oil	Add oil
	● Dirty oil	Change oil
	● Poor quality oil	Replace with proper engine oil
	● High oil temperature	Repair
	● Low oil pressure	Repair
	● Defective oil pump	Repair oil pump
	● Reduced performance due to worn oil pump	Replace oil pump
	● Suction strainer sucking air	Add oil and/or repair strainer
	Abnormal combustion	
	● Use of defective fuel	Change fuel
	● Incorrect injection timing	Adjust injection timing
	● Engine overheating	See Symptom: “Engine overheating”

NOTE: If piston seizure occurs, the problems above will occur. Complaints from the customer are often related to these problems.

1. **White smoke is emitted.**
2. **Lack of power**
3. **Excessive blow-by gas**

Symptom	Possible cause	Remedy/Prevention
Lack of power	Injection pump	Refer to “FUEL INJECTION PUMP”
	Intake	
	● Clogged air cleaner	Clean element or replace element
	Overheating	See Symptom: “Engine overheating”
	Fuel and nozzle	
	● Poor nozzle spray	Adjust or replace injection nozzle
	● Nozzle clogged with carbon	Clean nozzle
	● Wear or seizure of nozzle	Replace nozzle
	● Air in fuel system	Repair and bleed air from fuel system
	● Clogged fuel filter	Replace element
	● Use of poor fuel	Use good quality fuel
	Pistons, cylinder liners and piston rings	
	● Seized or wear of piston	Replace the piston, piston rings and liner
	● Worn or broken piston rings, piston and cylinder liner	Replace piston rings, piston and liner

Symptom	Possible cause	Remedy/Prevention
Lack of power	Other problems	
	● Exhaust brake butterfly valve stuck in half-open position	Replace or repair exhaust brake
	● Connecting rod bent	Replace or repair connecting rod
	● Exhaust pipe or muffler crushed (increased back-pressure)	Replace exhaust pipe or muffler
	● Breakage of turbine or blower	Refer to TURBOCHARGER in CHAPTER 51
Leakage of exhaust	Head gasket	
	● Fatigued gasket (aging)	Replace gasket
	● Damage	Replace gasket
	● Improper installation	Replace gasket
	Head bolts	
	● Loose bolts	Tighten bolts
	● Elongated bolts	Replace bolts
	● Improper tightening torque or tightening sequence	Tighten properly
	Cylinder block	
	● Cracking	Replace cylinder block
	● Surface distortion	Repair or replace
	● Fretting of cylinder liner insertion portion (insufficient projection of cylinder liner)	Replace cylinder block
	Cylinder head	
	● Cracking	Replace cylinder head
	● Surface distortion	Repair or replace
	Cylinder liners	
	● Cracking	Replace cylinder liner
	● Corrosion	Replace cylinder liner
	● Insufficient projection of cylinder liner	Replace cylinder liner

Symptom	Possible cause	Remedy/Prevention
Leakage of exhaust	Other problems	
	● Incorrect injection timing	Adjust injection timing

NOTE: If leakage of the exhaust occurs, the problems above will occur. Complaints from the customer are often related to these problems.

1. Lack of power.
2. The engine overheats.
3. The coolant is discolored.

Difficulty starting engine	Electrical system	
	● Discharged battery	Charge battery
	● Defective wiring in starter-circuit	Repair wiring of starter
	● Loose or open-circuit battery cable	Tighten battery terminal connections or replace battery cable
	● Breakdown of starter	Replace starter
	● Broken glow plug	Replace
	Injection pump	Refer to “FUEL INJECTION PUMP”
	Air cleaner	
	● Clogged element	Clean the element or replace the element
	Fuel system	
	● No fuel in tank	Supply fuel
	● Clogged fuel line	Clean fuel line
	● Air sucked into fuel system through fuel line connections	Tighten fuel line connections
	● Clogged fuel filter	Replace element
	● Loose connection in high-pressure line	Tighten sleeve nut of high pressure line
	● Water in fuel	Drain and clean fuel system

Symptom	Possible cause	Remedy/Prevention
Difficulty starting engine	**Nozzles**	
	● Seized nozzle	Replace nozzle
	● Broken or fatigued nozzle spring	Replace spring
	Oil system	
	● Oil viscosity too high	Use proper viscosity oil, or install an oil immersion heater and warm up oil
	Other problems	
	● Seized piston	Replace piston, piston rings, and liner
	● Seized bearing	Replace bearing and crankshaft
	● Reduced compression pressure	Overhaul engine
	● Ring gear damaged or worn accelerator cable	Replace the ring gear and/or starter pinion
	● Improperly adjusted or broken	Adjust or replace the accelerator cable
Rough idling	**Injection pump**	Refer to “FUEL INJECTION PUMP”
	Nozzles	
	● Uneven injection pressure	Adjust
	● Poor nozzle spray	Adjust or replace nozzle
	● Carbon deposit on nozzle tip	Remove carbon
	● Seized needle valve	Replace nozzle
	Engine proper	
	● Improper valve clearance	Adjust valve clearance
	● Improper contact of valve seat	Replace or repair valve and valve seat
	● Idling speed too low	Adjust idling speed
	● Coolant temperature too low	Warm up engine
	● Compression pressure of cylinders markedly different from one another	Overhaul engine

Symptom	Possible cause	Remedy/Prevention
Rough idling	Other problems	
	● Clogged high pressure injection line	Replace line
	● Leakage due to improper tightening of high pressure injection line	Tighten sleeve nut
	● Improperly adjusted or broken accelerator cable	Adjust or replace accelerator cable
	● Engine seizure	Replace pistons, piston rings and liners
	● Incorrect valve timing	Replace camshaft
Diesel knock	Injection pump	Refer to “FUEL INJECTION PUMP”
	Nozzles	
	● Incorrect injection pressure	Adjust
	● Poor nozzle spray	Adjust or replace nozzle
	● Sticking of nozzle	Check and/or replace
	● Fatigued or broken nozzle spring	Replace spring
	Fuel system	
	● Use of poor fuel	Use good quality fuel
	● Fuel leakage into combustion chamber (during engine starting)	Adjust nozzles
	Other problems	
	● Excessively cooled or heated engine	Warm up or cool engine
	● Insufficient air intake	Correct
	● Insufficient compression pressure	Repair
	● Compression pressure leaks at cylinder head gasket	Replace head gasket
	● Improper valve clearance or valve sticking	Adjust or repair
	● Tappet sticking	Replace tappet and camshaft

Symptom	Possible cause	Remedy/Prevention
Unusual engine noise	**Piston**	
	● Wear of piston pin boss or piston pin	Replace piston and/or piston pin
	● Seized, damaged, or worn piston pin bushing	Replace piston pin bushing.
	● Worn pistons or cylinder liners	Replace piston or cylinder liner
	● Damaged or seized piston	Replace piston and cylinder liner
	● Foreign matter on top surface of the piston	Remove foreign matter and repair or replace piston, cylinder liner, and/or cylinder head
	Valve mechanism	
	● Incorrect valve clearance	Adjust valve clearance
	● Valve cotter out of place	Replace valve cotter
	● Seized valve stem	Replace valve and valve guide
	● Broken valve	Replace valve
	● Damaged rocker arm support	Replace rocker arm support
	● Broken valve spring	Replace valve spring
	Bearings seizure	
	● Insufficient lubricating oil	Add oil
	● Excessive or insufficient tightening of bearing housings	Retighten to specified torque
	● Pits and scratches on bearing surface	Replace bearing and crankshaft
	● Oil film formed on back of bearing	Replace bearing
	● Improper installation of bearing	Replace bearing
	● Reduction of spread dimension of bearing	Replace bearing
	● Distorted bearing housing	Replace or correct bearing housing
	● Excessive oil clearance	Replace bearing

Symptom	Possible cause	Remedy/Prevention
Unusual engine noise	**Various other parts**	
	● Exhaust gas leakage from exhaust pipe joints	Retighten joints
	● Loosen or missing intake manifold flange gasket	Retighten or replace
	● Intake valve seating is not concentric	Replace or correct the valve and valve seat
	● Intake gas leakage	Retighten
	Other problems	
	● Loose cooling fan mounting bolts or fan pulley nut	Tighten the fan and crankshaft pulley
	● Lack of lubricating oil (coolant pump, valves, etc.)	Lubricate
	● Worn timing gear	Replace the timing gear
	● Breakage of turbine or blower	Refer to TURBOCHARGER in CHAPTER 51

NOTE: The items on this page concern unusual engine noise which is due to causes other than those given for diesel knock.

(FUEL INJECTION PUMP)

Symptom	Possible cause	Remedy
Engine does not start	**Fuel not reaching injection pump**	
	● Fuel lines clogged or damaged	Clean or replace fuel lines
	● Fuel filter clogged	Clean or replace the filter element
	● Air in fuel caused by improper connections of fuel line between fuel tank and feed pump	Repair connections
	● Filter incorporated in inlet side of feed pump clogged	Remove foreign material
	● Faulty feed pump check valve	Repair or replace it
	● Feed pump piston spring broken	Replace it
	● Feed pump push rod or tappet sticking	Repair or replace it
	Fuel reaching injection pump	
	● Faulty connection of accelerator cable to pump adjusting lever	Repair connection
	● Control rack faulty or sticking	Repair it
	● Damaged camshaft bearing	Repair it
	● Plunger worn or sticking	Correct or replace it
	● Faulty connection of engine stop cable to pump stop lever	Repair it
	Nozzle faulty	
	● Fuel leakage caused by loosened nozzle holder	Inspect and tighten it
	● Low opening pressure of nozzle	Adjust it
	● Nozzle pressure spring broken	Replace it
	● Nozzle needle sticking to nozzle body	Correct or replace it
	Pump out of timing	
	● Improperly retarded injection timing	Correct injection timing
	● Incorrect timing caused by improper installation of pump	Check engine timing and correct it
	● Woodruff key for pump camshaft cut off.	Replace it
	● Improper pre-stroke adjustment	Correct it to obtain specified injection timing

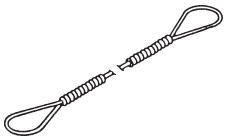
Symptom	Possible cause	Remedy
Engine starts and stops	Fuel lines clogged	Clean or replace fuel lines
	Air in fuel caused by damaged fuel lines or improper connection of fuel lines	Repair fuel lines or replace fuel lines and gaskets
Engine has low power	**Pump out of timing**	
	● Excessive advanced timing resulting in loud knocking	Check and correct it
	● Excessively retarded timing resulting in black smoke	Check and correct it
	● Defective injection pump overflow valve	Repair or replace it
	● Feed pressure too low	Repair the feed pump
	● Improper accelerator cable adjustment	Adjust it
	Nozzle faulty	
	● Fuel leakage from nozzle holder	Check and repair nozzle holder
	● Bad nozzle spray characteristic	Repair or replace it
	● Loosened adjusting screw in nozzle holder, resulting in low opening pressure	Adjust it
	● Nozzle pressure spring broken	Replace it
	Pump faulty	
	● Fuel leakage from delivery valve holder	Retighten the delivery valve holder if it is loosened or replace O-ring if the O-ring is defective
	● Defective seat of delivery valve assembly	Repair or replace it
	● Delivery valve spring broken	Replace the spring
	● Plunger worn	Replace it
	● Large spread in fuel delivery	Adjust it
	● Wear of tappet roller	Replace the roller
	● Camshaft bearing worn or broken	Replace it
	● Improper adjustment of governor full load stopper screw	Adjust it

Symptom	Possible cause	Remedy
Excessive smoke	Black smoke	
	● Excessive fuel delivery caused by incorrect adjustment of full load stopper screw	Adjust fuel delivery on test stand
	● Excessively advanced injection timing.	Correct it
	● Large spread in fuel delivery	Adjust it
	● Bad nozzle fuel spray characteristics	Check and correct them
	White smoke	
	● Unused after glow system	Use it
	● Improperly retarded injection timing	Advance injection timing
	● Water in fuel	Check and clean fuel lines
	● Glow plug not operating	Check glow plug circuit. Refer to ELECTRICAL EQUIPMENT in CHAPTER 20
Low idle speed irregular	Improper adjustment of throttle control knob	Correct it
	Bad fuel spray characteristic of nozzles.	Check and repair them
	Incorrect injection timing	Correct it
	Incorrect initial tension setting of idling spring or the spring broken.	Adjust or replace it
	Control rack does not move smoothly	Disassemble pump and repair it
	Large spread in fuel delivery	Adjust it
	Plunger worn	Replace it
	Governor linkage does not move smoothly	Correct it
	Defective feed pump	Disassemble and repair it
Engine always runs at high speed	Accelerator cable sticking	Check and correct it
	Governor linkage sticking	Disassemble and repair the governor
	Control rack sticking	Check and correct it
Loud knocking	Improper injection timing	Correct it
	Bad fuel nozzle spray pattern . after-dribble	Check and correct it
	High nozzle opening pressure	Adjust the opening pressure
	Incorrect fuel deliveries to some nozzles.	Readjust the fuel deliveries

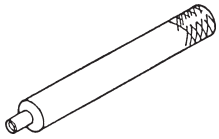
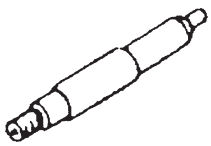
SPECIAL TOOLS

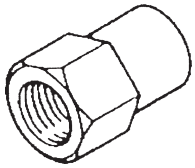
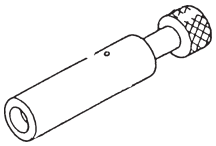
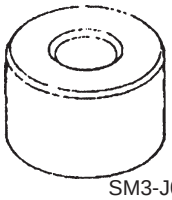
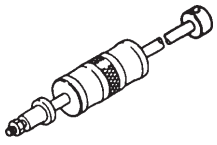
Prior to starting an engine overhaul, it is necessary to have the following.

(1) Lifting parts

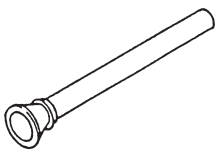
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J052	09491 - 1010	Wire cable	1	Lifting engine
SM3-J048	09433 - 1070	Eye bolt	2	Lifting cylinder head

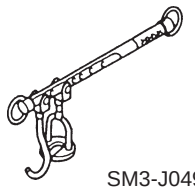
(2) Related parts of cylinder head

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J050	09472 - 1210	Bar	1	Caulking nozzle seat (Use together with 9800 - 06100)
SM3-J054	9800-06100	(Steel ball)	1	Caulking nozzle seat (Use together with 09472-1210)
 SM3-J021	09552-1090	Compression gauge adaptor	1	Measuring compression (for size PF3/8)

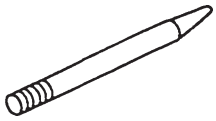
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J022	09552 - 1060 09552 - 1030	Press gauge adaptor	1	Measuring compression
 SM3-J055	09472 - 2100	Bar	1	Strike-fitting valve stem seal
 SM3-J051	09471 - 1520	Guide	1	Strike-fitting valve guide
SM3-J131	09420 - 1100	Sliding hammer	1	Removing main idle gear shaft
 SM3-J132	09420 - 1442 (Same as tool for pulling out injection nozzle)	Sliding hammer	1	Removing sub- and cam idle gear shafts (Remove the adaptor from the top before use)

(3) Related parts of valve

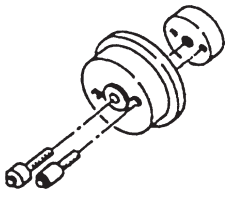
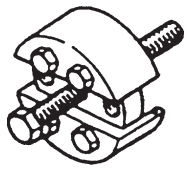
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J053	09431 - 1020	Valve wrapping tool	1	Valve wrapping

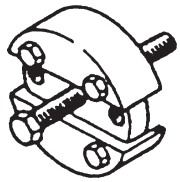
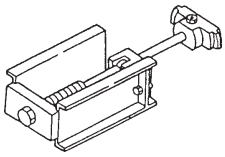
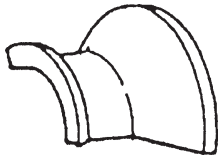
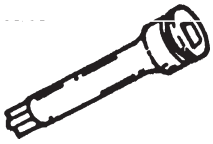
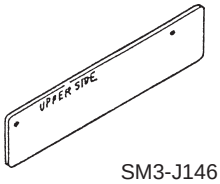
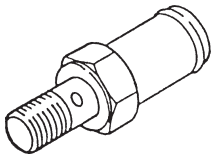
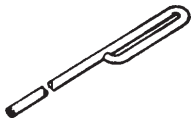
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J049	09470 - 1170	Valve spring press	1	Removing and installing valve spring

(4) Related parts of flywheel

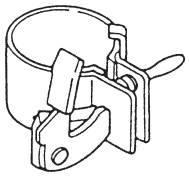
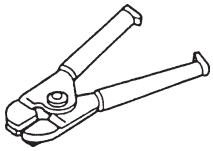
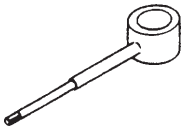
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J116	09481 - 1340	Guide	1	Removing and installing flywheel

(5) Related parts of cylinder block

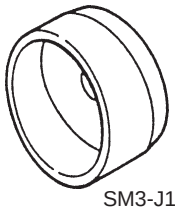
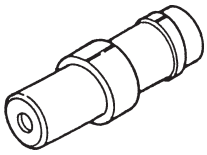
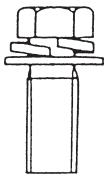
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J118	09407 - 1030	Oil seal press	1	Press-fitting front oil seal
	09407 - 1040	Oil seal press	1	Press-fitting rear oil seal
 SM3-J115	09420 - 1731	Oil seal puller	1	Pulling out front oil seal

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J117	09420 - 1742	Oil seal puller	1	Pulling out rear oil seal
 SM3-J148	09420 - 1720	Cylinder liner puller	1	Pulling out cylinder liner
 SM3-J149	09471 - 1490	Guide	1	Insert guide for cylinder liner
 SM3-J133	09411 - 1300	Socket wrench	1	Rear end plate TORX® bolt
 SM3-J146	09444 - 1630	Gauge	1	Cooling jet check
 SM3-J151	9001 - 24262	Check bolt	1	Cooling jet check
 SM3-J780	09472 - 1620	Tool	1	Cooling jet check (Fixture for correction)

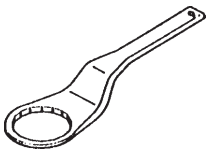
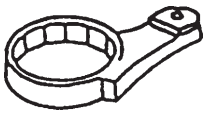
(6) Related parts of piston

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J153	09441 - 1320	Piston ring holder	1	Used when inserting piston into cylinder block
 SM3-J145	09442 - 1011	Piston ring expander	1	Removing and installing piston ring
SM3-J781	09481-1130	Guide	1	For replacing the piston pin bushing
 SM3-J782	09402-1530	Press sub assembly	1	
SM3-J783	9233-10360	Wing nut	1	

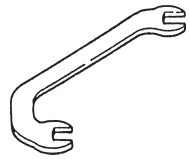
(7) Related parts of connecting rod

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J147	09481 - 1540	Guide	1	Replacing connecting rod bushing
 SM3-J152	09402-1540	Press sub assembly	1	
 SM3-J150	9191 - 08252	Bolt	1	

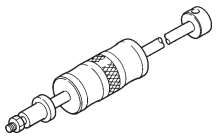
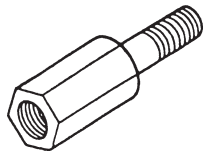
(8) Related parts of filter

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J784	09553 - 1021	Oil filter wrench	1	Removing and installing oil filter
 SM3-J785	09553 - 1010	Fuel filter wrench	1	Removing and installing fuel filter

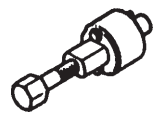
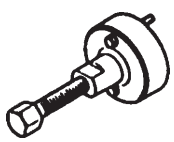
(9) Related parts of injection pump

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J200	09511 - 2500	Wrench	1	Injection pump coupling

(10) Related parts for injection nozzle

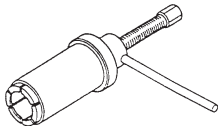
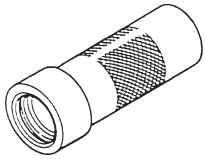
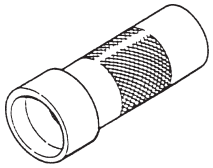
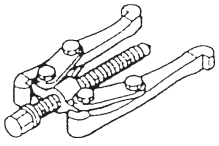
Shape	Parts No.	Parts name	No./unit	Application
 SM3-J132	09420 - 1442 (Same as the parts to remove idler gear shaft)	Sliding hammer	1	Pulling out injection nozzle (Use together with 09462 - 1130)
 SM3-J172	09462 - 1130	Adaptor	1	Pulling out injection nozzle (Use together with 09420 - 1442)

(11) Related parts of coolant pump

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J786	09420 - 1820	Puller assembly	1	Coolant pump vane
 SM3-J787	09420 - 1810	Puller assembly	1	Coolant pump pulley center

Shape	Parts No.	Parts name	No./unit	Application
SM3-J788	09444 - 1210	Belt tension gauge	1	Adjusting V-belt tension

(12) Related parts of air compressor

Shape	Parts No.	Parts name	No./unit	Application
 SM3-J002	09420 - 1670	Puller assembly	1	Pulling out air compressor sleeve
 SM3-J003	09482 - 2220	Press	1 sleeve	Strike-fitting air compressor
 SM3-J004	09482 - 2230	Press	1 seal	Strike-fitting air compressor oil
 SM3-J005	09420 - 1680	Puller assembly	1	Pulling out air compressor gear

GENERAL

WARNING

The following items should be observed to prevent injury to yourself and others when servicing the engine or vehicle;

- ○ **Stop the engine and keep the engine off during checks and adjustments.**
- ○ **Place the starter key in the "LOCK" position.**
- ○ **Leave the engine stop knob pulled out fully. (For model equipped with manual engine stop control)**
- ○ **Place the transmission shift lever in "NEUTRAL".**
- ○ **Apply the parking brake firmly.**
- ○ **Block the wheels.**

ENGINE OVERHAUL CRITERIA

FACTORS TO DETERMINE THE ENGINE OVERHAUL

1. LOW COMPRESSION PRESSURE

(1) Before measurement

1. Charge the battery completely.
2. Set the valve clearance to the correct value.

Intake : 0.30 mm (0.0118 in.)
Exhaust : 0.45 mm (0.0177 in.)
(when engine is cold)

NOTE: Refer to page 3-18-4.

3. Idle the engine (to 80 °C {176°F}).
4. While the starter switch is at the LOCK position, disconnect the engine stop motor.
5. Remove all nozzle holders.

NOTE: Refer to page 3-6-3.

6. Remove the air cleaner hose.

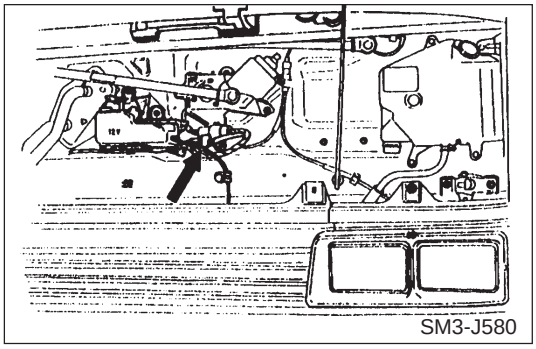


Fig. 1

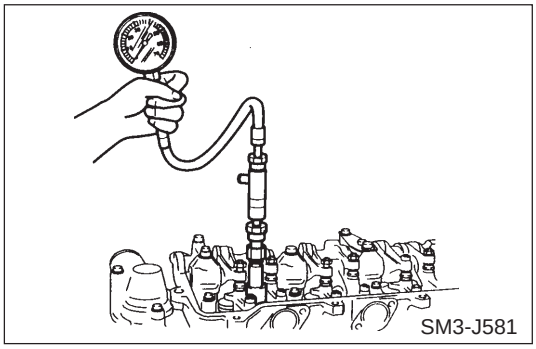


Fig. 2

(2) Measurement

1. Insert the gauge adaptor into the nozzle holder hole.

Special tool: Compression gauge adaptor
(09552 - 1090)
(09552 - 1060)
(09552 - 1030)

2. Run the engine with the starter and measure the compression pressure.

NOTE: Do not operate the starter for more than 15 seconds.

3. Measure the compression pressure of each cylinder.

NOTE: Do not allow gas leakage from the seal face.

Unit: kg/cm² (lb/sq.in.)

Assembly standard	Assembly limit	Difference among individual cylinders	Engine speed (rpm)
35 - 38 (498-540)	28 (398)	Less than 3 (43)	180 - 220

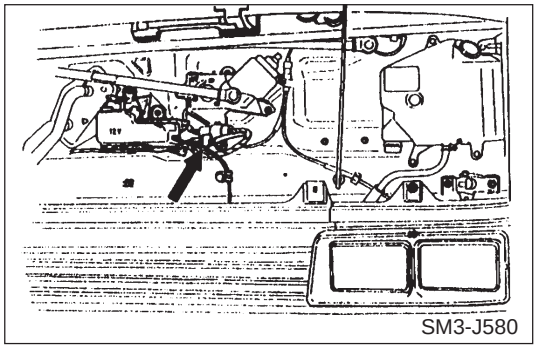


Fig. 3

(3) After measurement

1. Install the removed parts.

WARNING

Do not connect the electric harness with the engine stop motor while the engine starter key is at ON position as this may operate the engine stop motor instantaneously and the link lever of the engine stop motor and the engine stop lever of the fuel injection pump will move, resulting in your fingers caught by the lever.

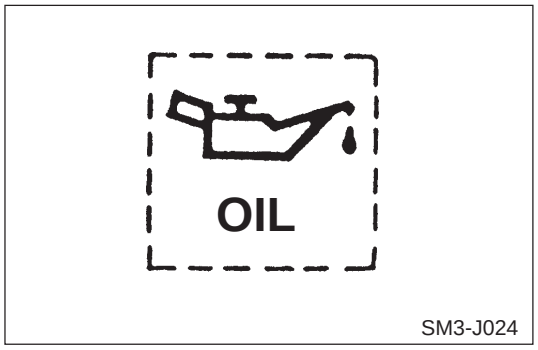


Fig. 4

S.A.E. GRADE	ATMOSPHERIC TEMPERATURE								
	-10	0	32	50	70	90	100	˚F	
	-23	-18	0	10	21	32	39	˚C	
40					■	■	■	■	
30				■	■	■	■		
20W/20		■	■	■	■				
15W/40		■	■	■	■	■	■	■	
10W/30	■	■	■						

Fig. 5

2. DECREASED OIL PRESSURE

Check the oil pressure warning lap when the oil and coolant temperature is hot [about 80°C (176°F)].

a. If the warning lamp is lit, check the oil level.
b. Check oil deterioration.
   If oil quality is poor, replace with a suitable grade oil.
c. Remove the oil pressure switch and install the oil pressure gauge.
d. Measure the oil pressure at oil temperature 100°C (212°F).

Standard oil Pressure:

At 2,500 (rpm) 5.7 kg/cm² (81.05 lb/sq.in.)

Service Limit:

At idle speed 0.5 kg/cm² (7.11 lb/sq.in.)

3. OTHER FACTORS

a. Blow-by gas increases.
b. Engine does not start easily.
c. Engine output decreases.
d. Fuel consumption increases.
e. Engine makes greater noise.
f. Excessive oil consumption.

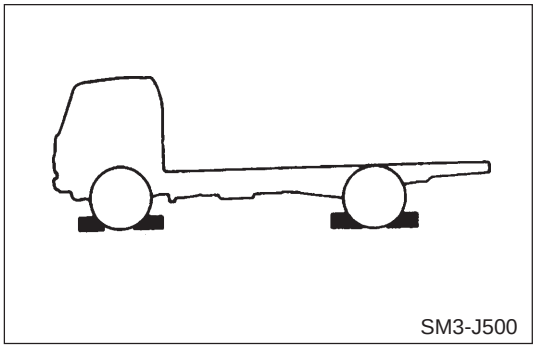

SM3-J500

Fig. 1

DISMOUNTING THE ENGINE ASSEMBLY

1. BLOCK THE WHEELS OF THE VEHICLE.

1. Park the vehicle on level ground.
2. Block the wheels.

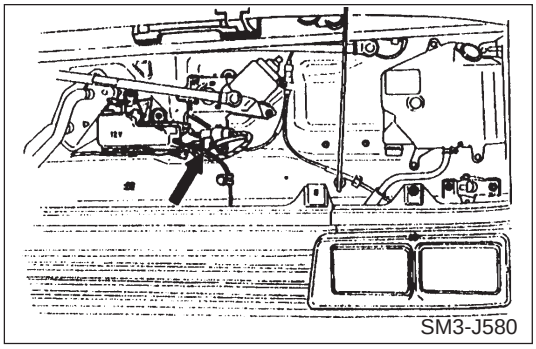

SM3-J580

Fig. 2

2. DISCONNECT THE ENGINE CONTROL AND THE STOP CABLE.

1. Set the starter switch to the ON position.
2. Disconnect the wires of the engine stop motor at the connector.
3. Set the starter switch to the LOCK position.

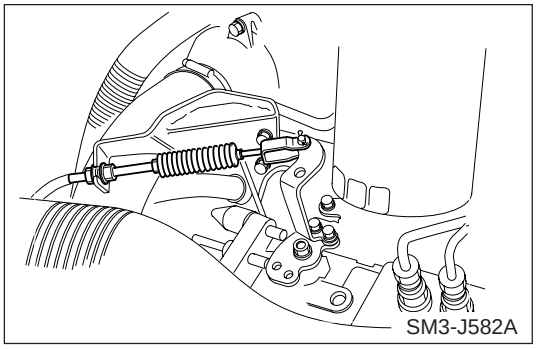

SM3-J582A

Fig. 3

4. Tilt up the cab.
5. Disconnect the engine control and the stop cable at the injection pump.

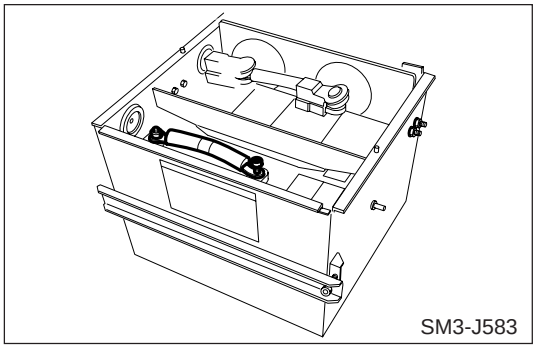

SM3-J583

Fig. 4

3. DISCONNECT THE NEGATIVE TERMINAL OF THE BATTERY.

WARNING

Always disconnect the battery cable when servicing the engine.

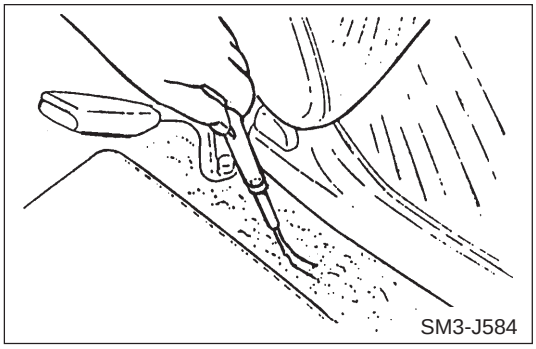

SM3-J584

Fig. 5

4. DISCONNECT THE PARKING BRAKE CABLE (1).

1. Remove the center console.
2. Disconnect the parking brake cable at the lever.

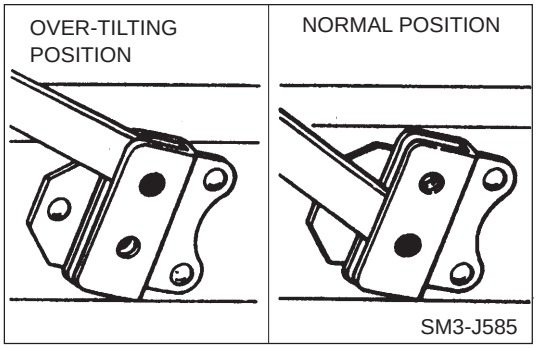


Fig. 6

5. OVER-TILT THE CAB

NOTE: Refer to CAB in CHAPTER 19.

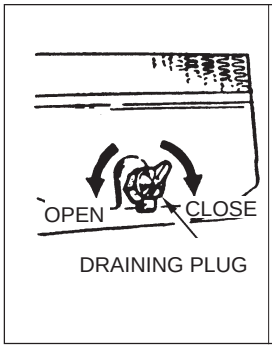


Fig. 7

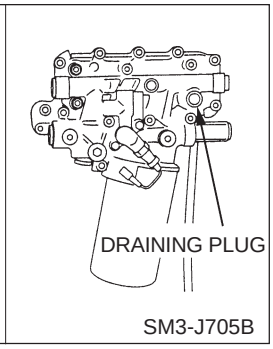


Fig. 8

6. DRAIN THE COOLANT AND ENGINE OIL.

WARNING

To avoid the danger of burns do not drain the engine oil and coolant while the engine and radiator are still hot.

1. Drain the coolant from the radiator. (Fig. 7)

NOTE: The coolant can be drained more easily by removing the filler cap.

2. Drain the coolant from the cylinder block. (Fig. 8)

Coolant capacity: 21 L (22.19 US qt)
23 L (24.30 US qt)
(with transmission oil cooler only)

3. Drain the engine oil through the drain plug.

Engine oil capacity: 13.5 L (14.27 US qt)

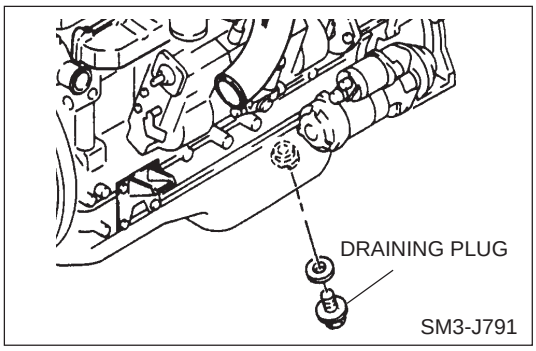


Fig. 9

7. DISCONNECT THE POWER STEERING LINES AT THE GEAR UNIT.

NOTE: Place a container under the gear unit.

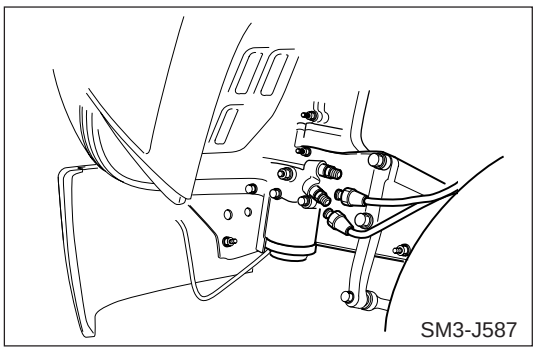


Fig. 10

8. DISCONNECT THE PARKING BRAKE CABLE (2).

1. Remove the bracket behind the cab, then pull out the parking brake cable.

NOTE: Pull out the cable straight and slowly. If pulled out forcefully, the gasket will crack. Cracked cables must be replaced with new ones.

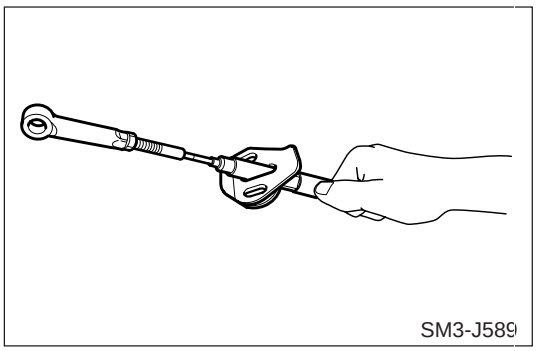


Fig. 11

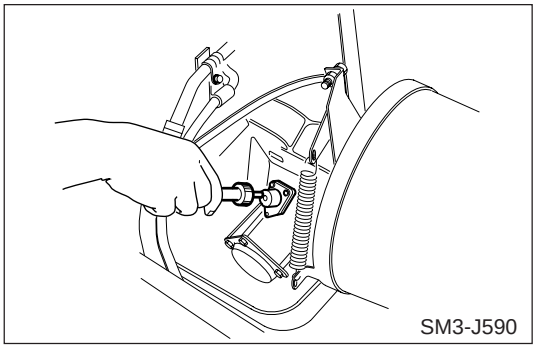


Fig. 12

9. DISCONNECT THE SPEEDOMETER CABLE AT THE TRANSMISSION.

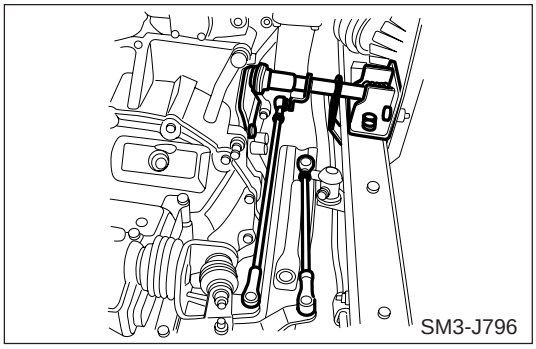


Fig. 13

10. REMOVE THE TRANSMISSION CONTROL ROD TOGETHER WITH THE BRACKET AT THE TRANSMISSION.

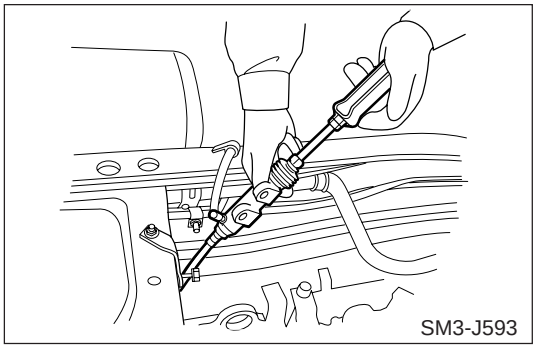


Fig. 14

11. REMOVE THE CLUTCH SLAVE CYLINDER.

1. Remove the connecting clip of the clutch hose.
2. Remove the return spring and the clevis of the lever.
3. Remove the slave cylinder together with the lines.

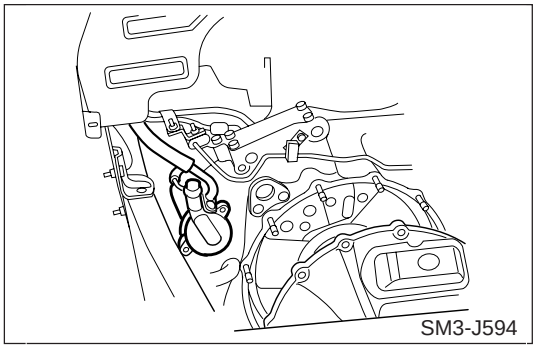


Fig. 15

12. DISCONNECT THE POWER STEERING LINES AT THE PUMP.

NOTE: Be careful of oil leakage from the removed lines at the gear unit

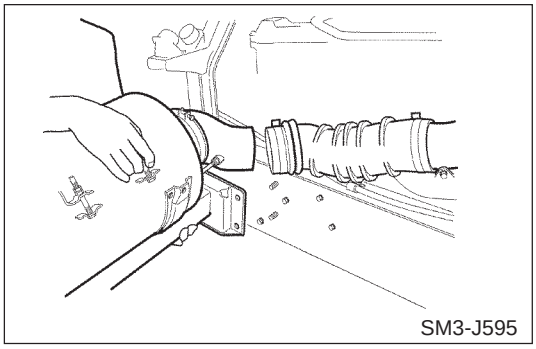


Fig. 16

13. DISCONNECT THE AIR HOSES WHICH CONNECT THE AIR CLEANER AND ENGINE.

14. REMOVE THE SPLASH BOARD.

15. REMOVE THE AIR CLEANER TOGETHER WITH THE BRACKET.

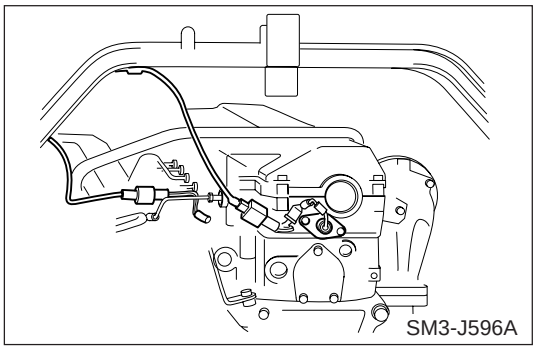


Fig. 17

16. DISCONNECT THE ELECTRICAL WIRES (1).

1. Engine speed sensor
2. Glow plug
3. Rack sensor, pre-stroke actuator
4. Starter terminals B and C and grounding (frame end)

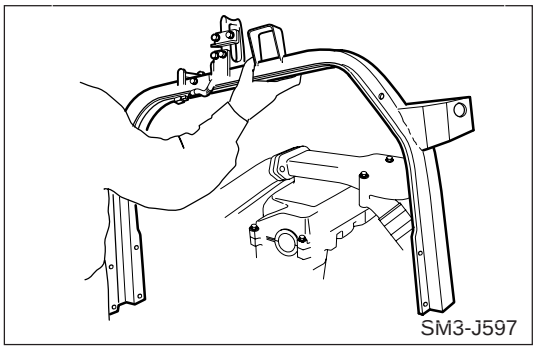


Fig. 18

17. REMOVE THE REAR CAB MOUNTING BRACKET.

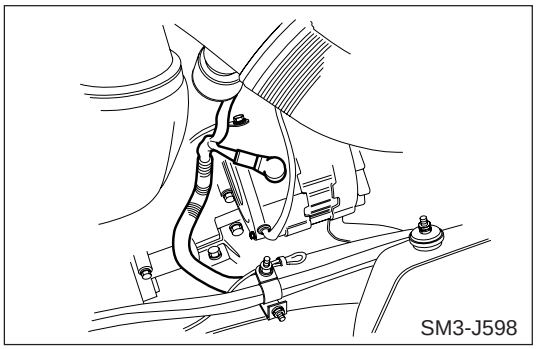


Fig. 19

18. DISCONNECT THE ELECTRICAL WIRES (2).

1. Water temperature sensor (2 parts)
2. Alternator
3. Magnetic clutch of the air conditioner

19. DISCONNECT THE HEATER HOSES.

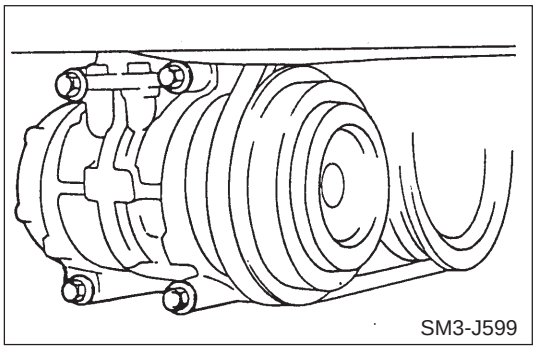


Fig. 20

20. DISCONNECT THE GAS LINES OF THE AIR CONDITIONER.

1. Use the refrigerant collector to discharge refrigerant.
2. Disconnect the gas lines of the air conditioner at the compressor.

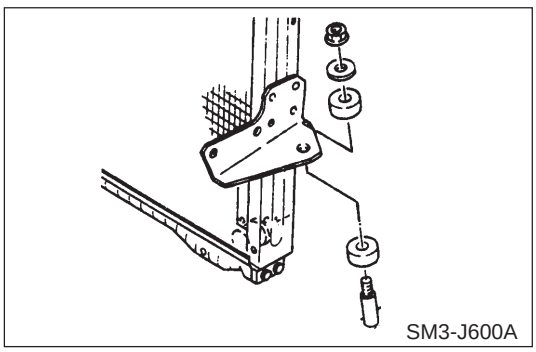


Fig. 21

21. DISCONNECT THE RADIATOR FROM THE FRAME.

1. Disconnect the reservoir hose.
2. Remove the radiator mounting.

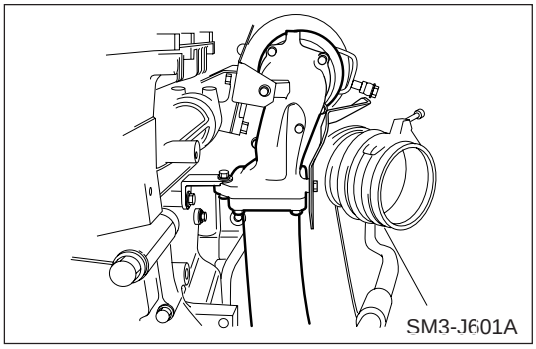


Fig. 22

22. REMOVE THE EXHAUST PIPE AND MUFFLER.

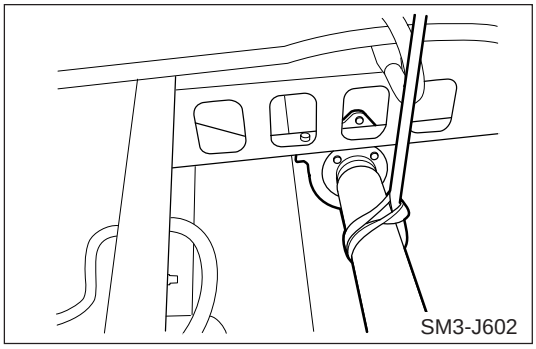


Fig. 23

23. REMOVE THE PROPELLER SHAFT.

1. Remove the center bearing support.

NOTE: Attach a hoist to the propeller shaft.

2. Loosen the flange, then remove the propeller shaft.

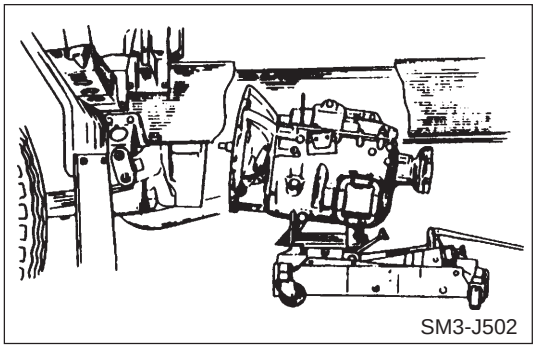


Fig. 24

24. REMOVE THE TRANSMISSION.

1. Place a jack under the bottom of the flywheel housing.
2. Place a transmission jack under the transmission.

WARNING

The engine must be suspended with a hoist until completion of disassembly of the transmission assembly.

3. Remove the mounting bolt of the mounting rubber behind the transmission.
4. Remove the mounting bolt of the transmission at the clutch housing, then remove the transmission.

NOTE: Jack up and align the transmission with the engine, then pull the transmission straight out.

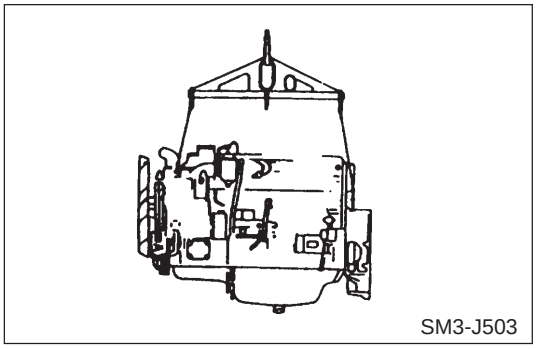

SM3-J503

Fig. 25

25. REMOVE THE ENGINE ASSEMBLY.

1. Attach hoists to the engine hangers at the front and rear ends of the engine, and lift slightly.
2. Remove the engine mounting at the frame.
3. Remove the engine assembly together with the radiator and inter cooler.
4. Mount the engine assembly on a work stand.

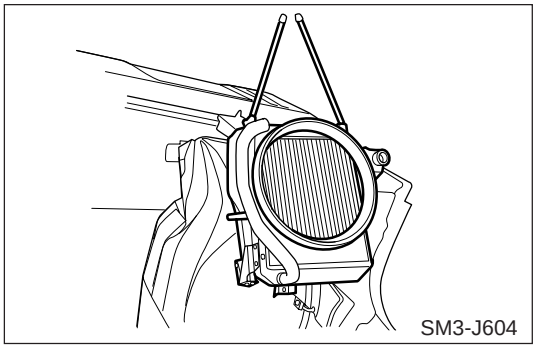

SM3-J604

Fig. 26

26. REMOVE THE RADIATOR AND INTER COOLER.

1. Loosen the tightening band of the fan shroud.
2. Disconnect the radiator hoses and inter cooler hoses at the engine.
3. Remove the radiator and inter cooler.

NOTE: Attach a hoist to the radiator.

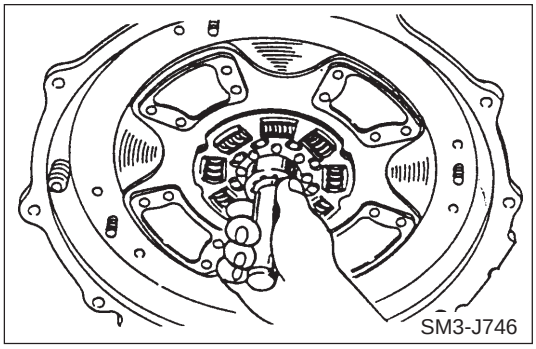

SM3-J746

Fig. 27

27. REMOVE THE CLUTCH COVER AND CLUTCH DISC.

NOTE: Refer to CLUTCH in CHAPTER 5.

28. REMOVE THE AIR CONDITIONER COMPRESSOR.

1. Loosen the tension pulley, then remove the V-belt.
2. Remove the air conditioner compressor.

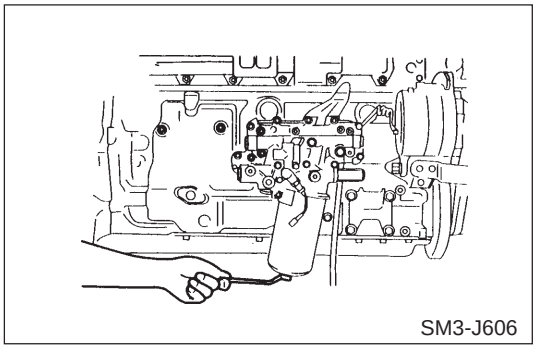

SM3-J606

Fig. 1

REMOVAL OF THE ENGINE COMPONENT PARTS

1. PREPARATION

1. Loosen the coolant drain cock of the oil cooler, then discharge coolant.
2. Loosen the oil drain plug of the oil filter, then discharge oil.

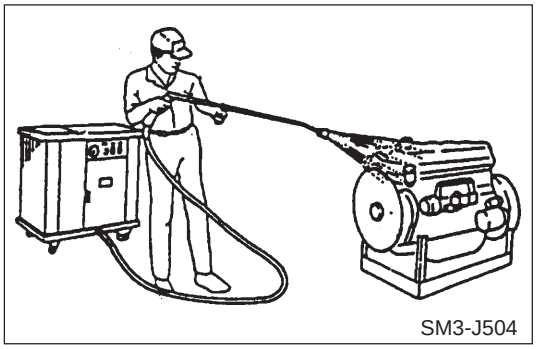

SM3-J504

Fig. 2

3. Clean the engine assembly.
   a. Cover openings with tape.
   b. Clean the engine assembly with a steam cleaner.

NOTE: Do not apply steam directly to the electrical components. (Alternator, starter, etc.)

4. Mount the engine assembly on a work stand.

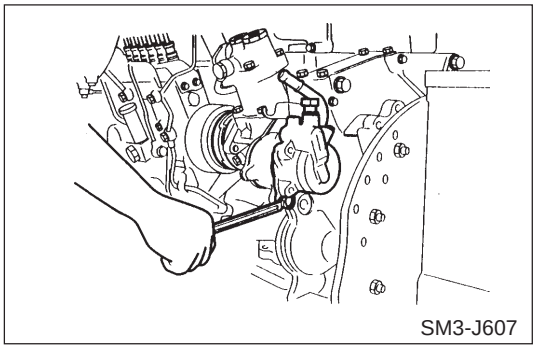

SM3-J607

Fig. 3

2. REMOVE THE POWER STEERING OIL PUMP.

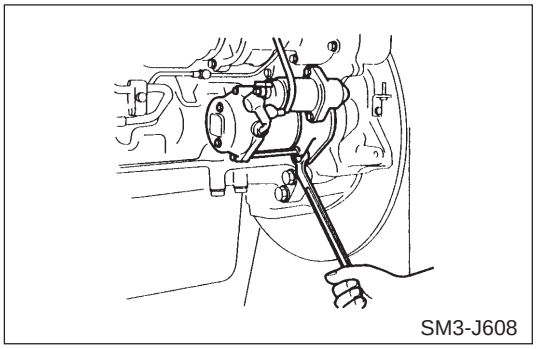

SM3-J608

Fig. 4

3. REMOVE THE STARTER.

1. Put alignment marks on the harness and the starter terminal, then remove the harness.
2. Remove the starter from the engine.

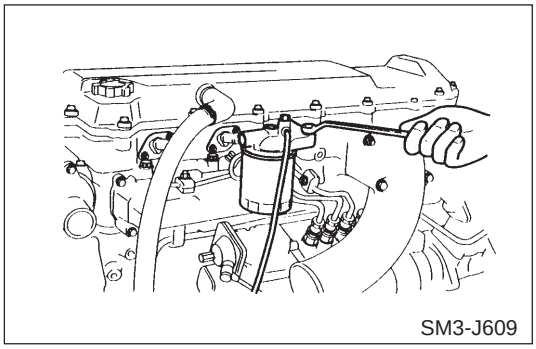

SM3-J609

Fig. 5

4. REMOVE THE FUEL FILTER AND FUEL LINES.

Remove the fuel lines, oil lines and fuel leakage lines.

NOTE:

- **Cover openings to prevent foreign matter from entering.**
- **Refer to page 3-12-1.**

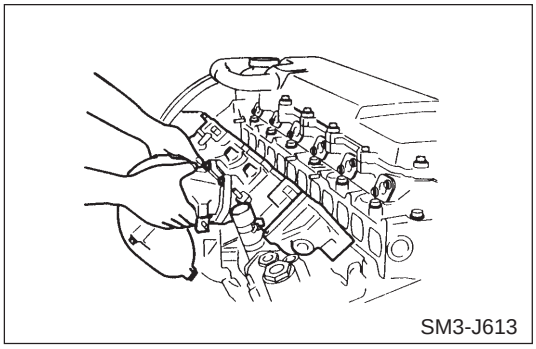


Fig. 6

5. REMOVE THE INTAKE MANIFOLD.

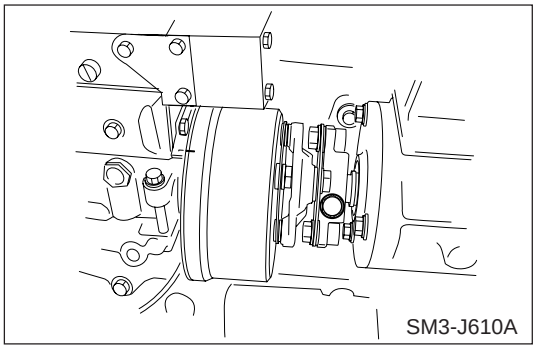


Fig. 7

6. REMOVE THE INJECTION PUMP.

1. Remove the through bolt of the coupling.

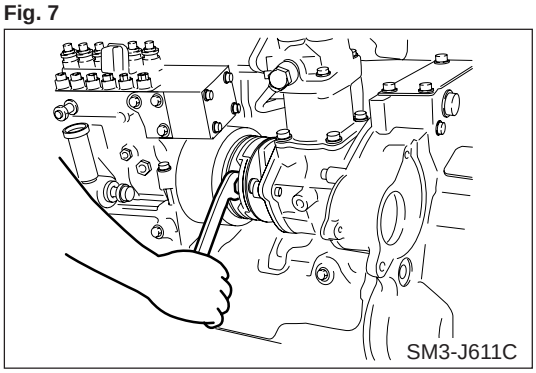


Fig. 8

2. Use the following special tool and loosen the adjusting bolt.

Special tool: Injection pump coupling wrench (09511 - 2500)

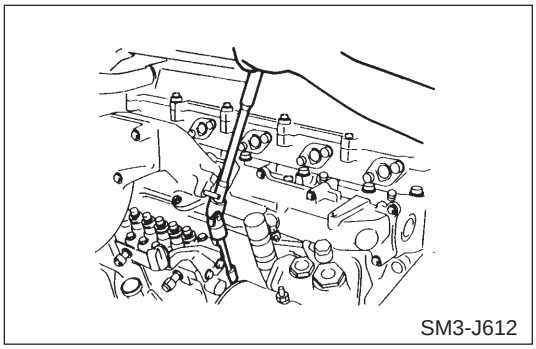


Fig. 9

3. Remove the mounting bolt of the injection pump, then remove the pump assembly.

NOTE: Cover openings to prevent foreign matter from entering.

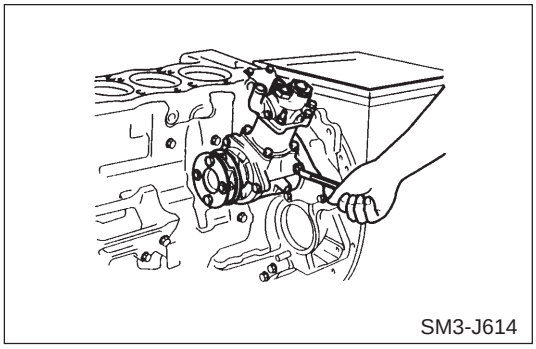


Fig. 10

7. REMOVE THE AIR COMPRESSOR.

1. Remove the oil lines, refrigerant lines and air lines.
2. Remove the air compressor.
3. Remove the mounting bolt of the air compressor, then remove the air compressor.

NOTE: Do not remove the air compressor forcefully. The spigot may be damaged, or oil leakage may occur due to removal of liquid gasket between the flywheel housing and the rear end plate.

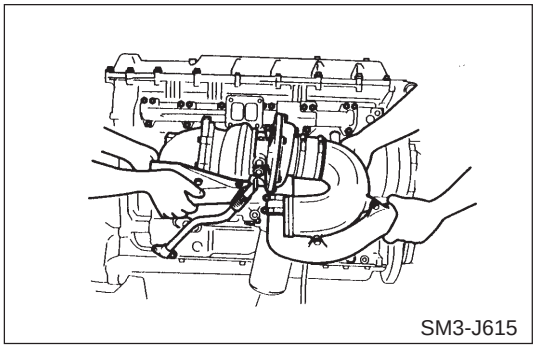

SM3-J615

Fig. 11

8. REMOVE THE TURBOCHARGER.

NOTE: Refer to TURBOCHARGER in CHAPTER 51.

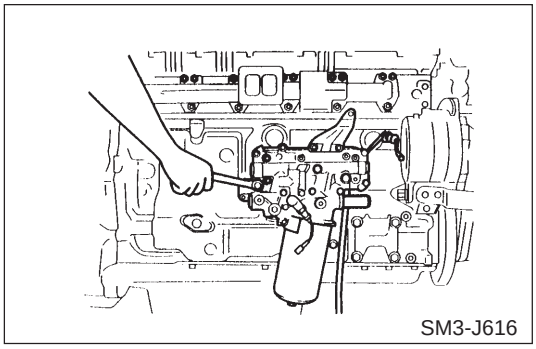

SM3-J616

Fig. 12

9. REMOVE THE OIL FILTER AND OIL COOLER.

1. Remove the oil lines.
2. Remove the oil filter.

Special tool: Oil filter wrench (09553 - 1021)

3. Remove the oil cooler.

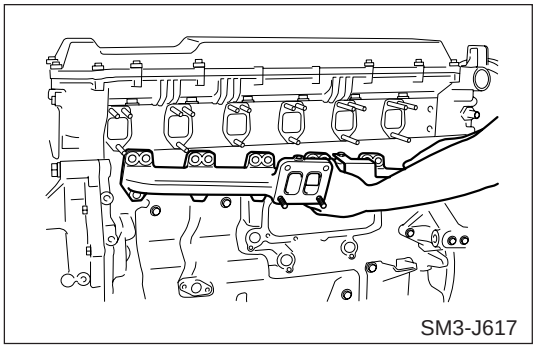

SM3-J617

Fig. 13

10. REMOVE THE EXHAUST MANIFOLD.

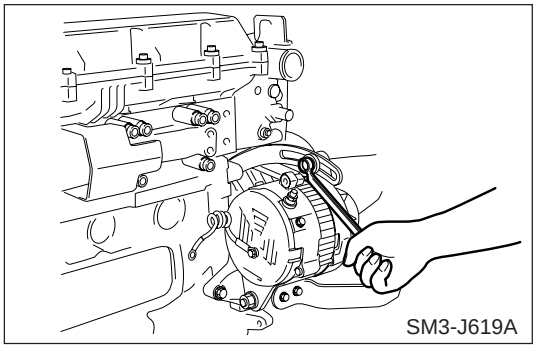

SM3-J619A

Fig. 14

11. REMOVE THE V-BELT AND THE ALTERNATOR.

1. Loosen the V-belt adjustment bolt.
2. Loosen the through bolt.
3. Remove the V-belt, then remove the alternator.

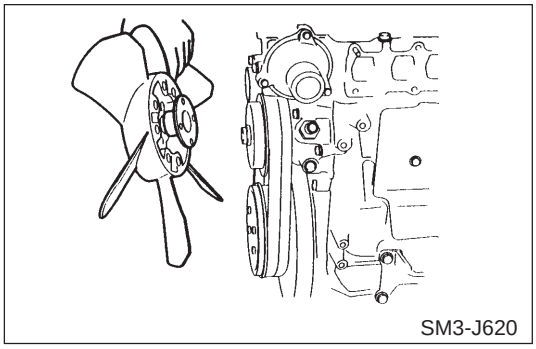

SM3-J620

Fig. 15

12. REMOVE THE FAN CLUTCH TOGETHER WITH THE COOLING FAN.

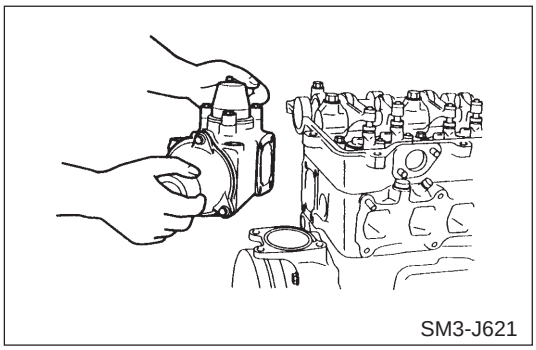


Fig. 16

13. REMOVE THE THERMOSTAT CASE.

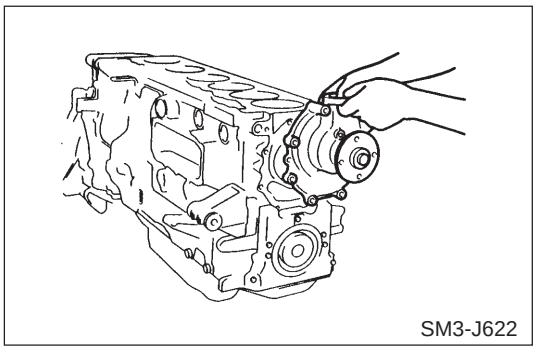


Fig. 17

14. REMOVE THE COOLANT PUMP.

CAMSHAFT HOUSING AND CYLINDER HEAD

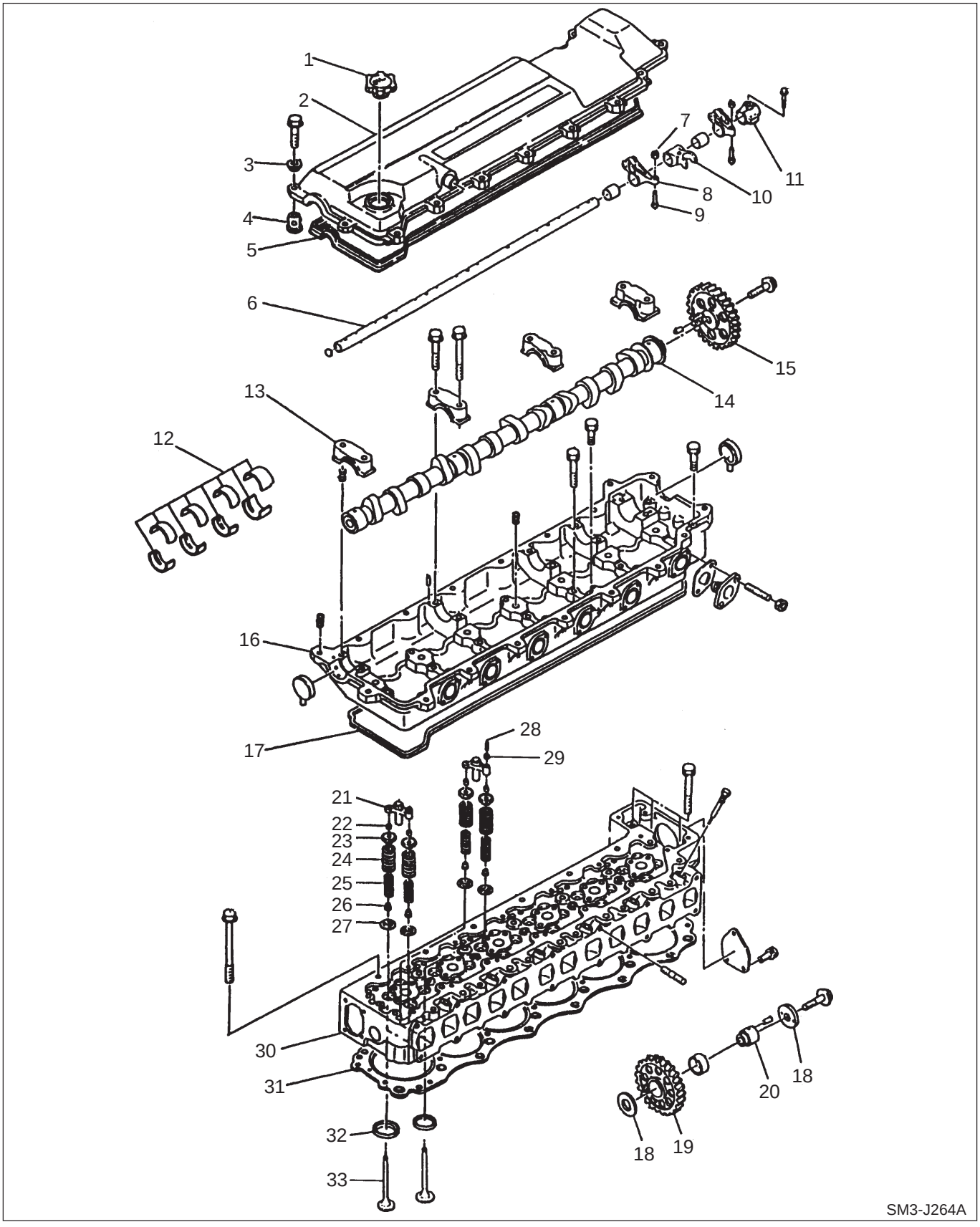
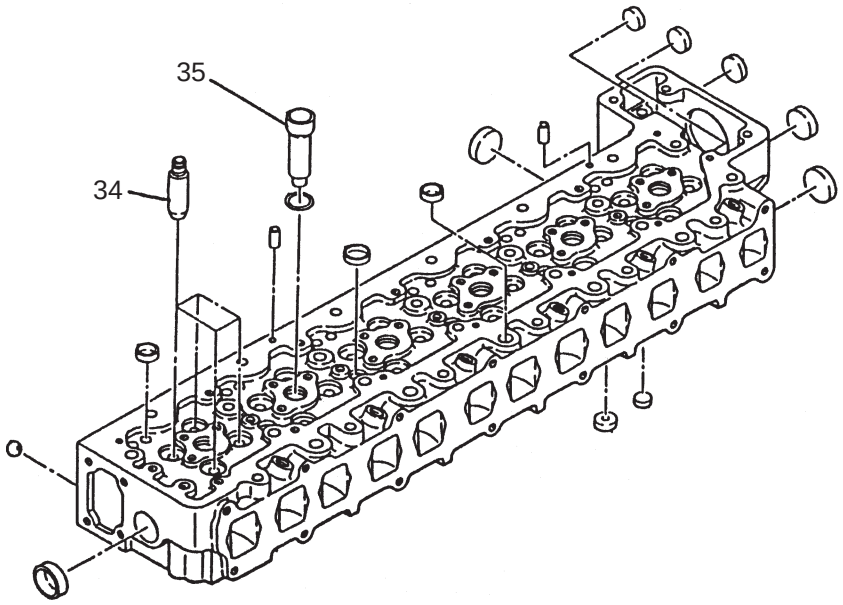


Fig. 1



1. Oil filler cap
2. Cylinder head cover
3. Silent block
4. Spacer
5. Head cover gasket
6. Valve rocker shaft
7. Lock nut
8. Valve rocker arm
9. Adjusting screw
10. Nozzle clamp
11. Valve rocker support
12. Camshaft bearing
13. Camshaft bearing cap
14. Camshaft
15. Camshaft drive gear
16. Camshaft housing
17. Camshaft housing gasket
18. Idler gear thrust plate
19. Camshaft idler gear
20. Idler gear shaft
21. Cross head
22. Valve spring retainer
23. Valve spring seat upper
24. Valve spring outer
25. Valve spring inner
26. Valve stem seal
27. Valve spring seat lower
28. Cross head adjusting screw
29. Lock nut
30. Cylinder head
31. Cylinder head gasket
32. Valve seat
33. Valve
34. Valve stem guide
35. Nozzle seat

SM3-J265

Fig. 2

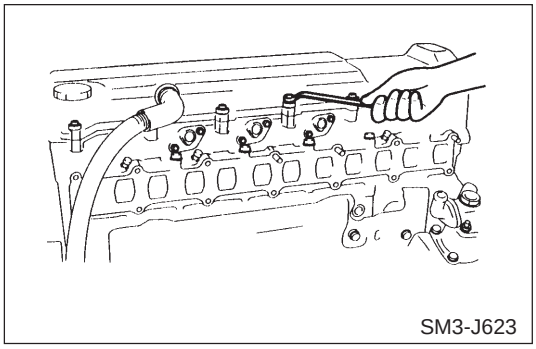
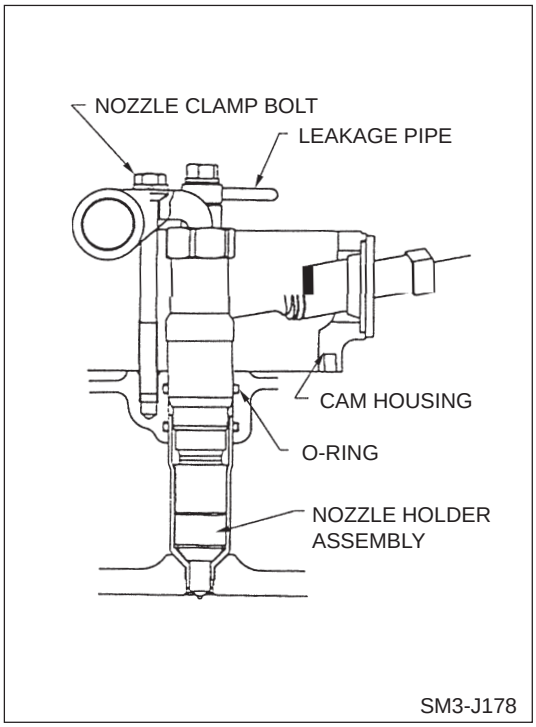

SM3-J623

Fig. 3

DISMOUNTING

1. REMOVE THE CYLINDER HEAD COVER.

NOTE: Clean all dust from around the cylinder head cover before removing it to prevent foreign particles from getting in.



SM3-J178

Fig. 4

2. REMOVE THE INJECTION NOZZLE.

1. Remove the leakage pipe.
2. Loosen the injection pipe nut.
3. Remove the injection pipe seal mounting bolts. Remove the injection pipe seal together with the injection pipe out of the cam housing.
4. Remove the nozzle clamp bolt.

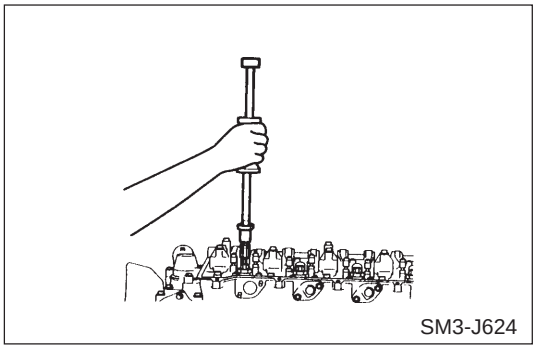

SM3-J624

Fig. 5

5. Pull out the nozzle holder assembly, avoiding any interference.

NOTE: If difficult, use a special tool, sliding hammer (09420 - 1442), for easier removal.

6. Remove the O-ring.

NOTE: Replace the O-ring with a new one.

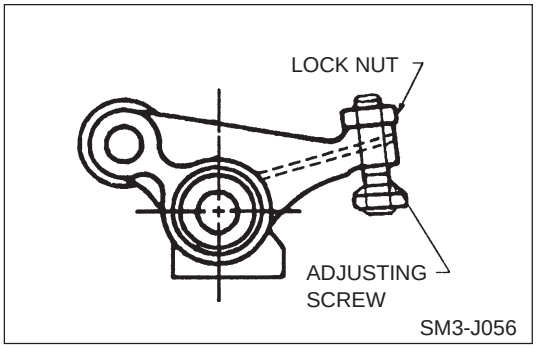


Fig. 6

3. LOOSEN THE VALVE CLEARANCE ADJUSTING SCREW.

1. Loosen the lock nut at the top of the rocker arm, then wind up the adjusting screw completely.

NOTE: If the adjusting screw is left unwound, the rocker shaft may bend when the rocker arm support is loosened.

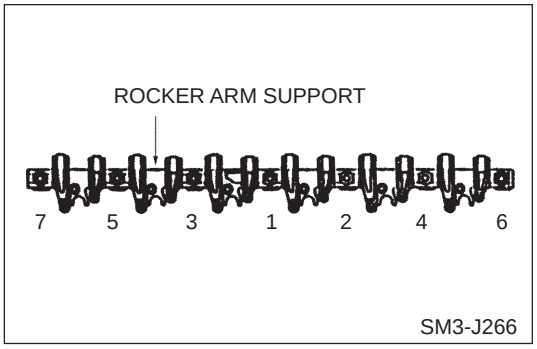


Fig. 7

4. REMOVE THE ROCKER ARM ASSEMBLY.

1. Remove the rocker arm support bolt in the order as shown in the figure.

NOTE: When the rocker arm assembly is removed, the rocker arm and rocker arm support tend to come off the rocker shaft. Be careful in handling.

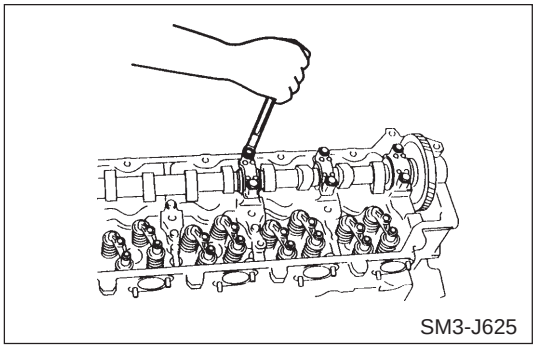


Fig. 8

5. REMOVE THE CAMSHAFT.

1. Remove the cam bearing cap bolt.
2. Remove the camshaft together with the gear.

NOTE: Be extremely careful not to drop any part into the interior of the engine.

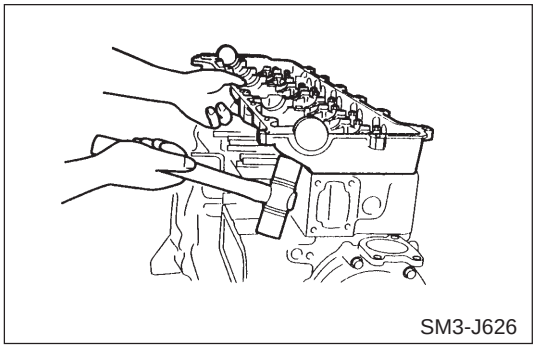


Fig. 9

6. REMOVE THE CAM HOUSING.

1. Remove the cam housing bolts.
2. Tap and remove the cam housing with a plastic hammer.

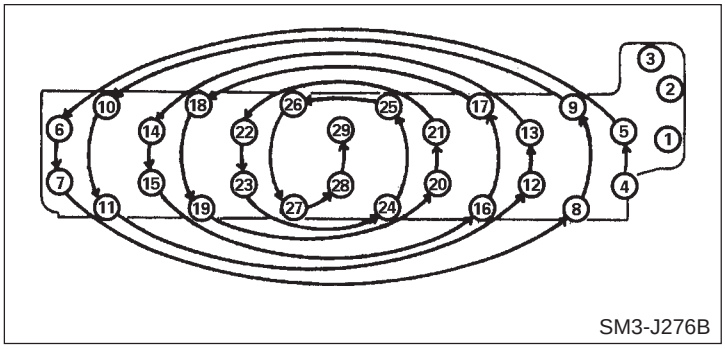


Fig. 10

7. REMOVE THE CYLINDER HEAD BOLTS.

Remove the cylinder head bolts in the order as shown in the figure.

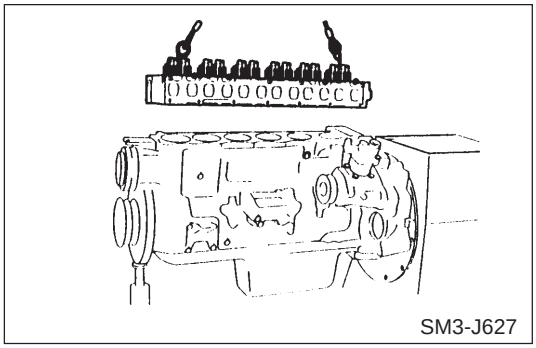


Fig. 11

8. LIFT AND REMOVE THE CYLINDER HEAD FROM THE CYLINDER BLOCK.

Special tool: Eye bolt (09433 - 1070)

NOTE:

- **Place a piece of wood between the cylinder head and table.**
- **When removing the cylinder head together with the injection nozzle, avoid contact between the injection nozzle and a piece of wood.**
- **Check that there is no oil, water or gas leakage in the cylinder head gasket if overheated or not.**

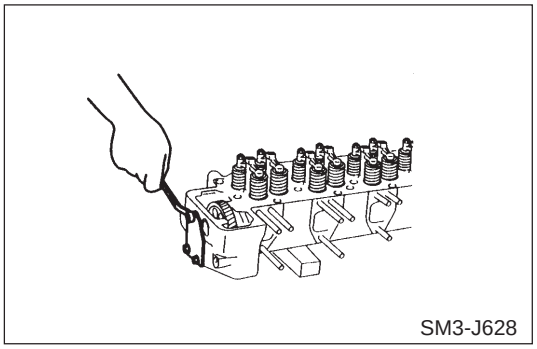

SM3-J628

Fig. 12

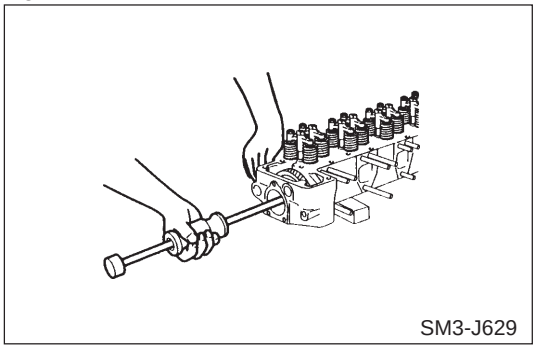

SM3-J629

Fig. 13

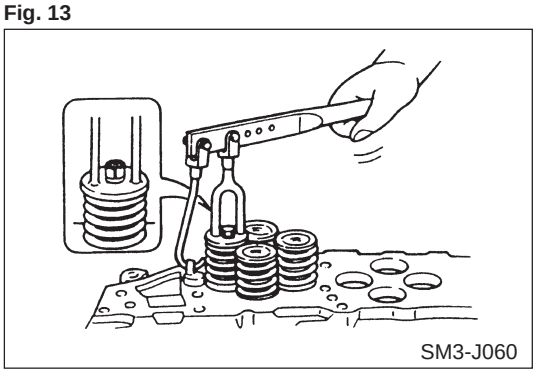
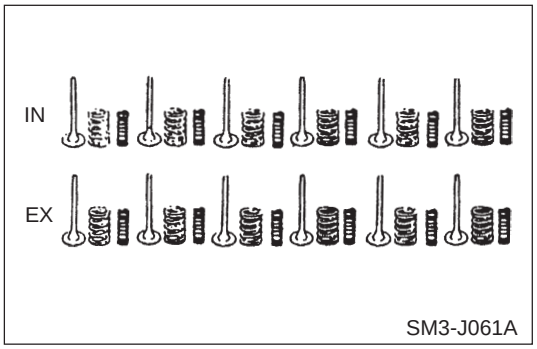

SM3-J060

Fig. 14



SM3-J061A

Fig. 15

DISASSEMBLING

REMOVE THE CAM IDLER GEAR.

1. Remove the cam idler gear.
2. Using the special tool, remove the cam idler gear.

Special tool: Sliding hammer (09420 - 1830)

DISASSEMBLE THE VALVE SYSTEM.

1. Using the special tool, press fit the valve spring seat upper, then remove the valve spring retainer.

Special tool: Valve spring press (09470 - 1170)

2. Remove the valve spring seat upper, valve spring outer and inner.
3. Remove the intake and exhaust valves from the cylinder head.

NOTE:

- **Do not remove the valve guide and valve spring seat lower unless they need to be replaced.**
- **Align the removed parts in the order of the cylinder No.**

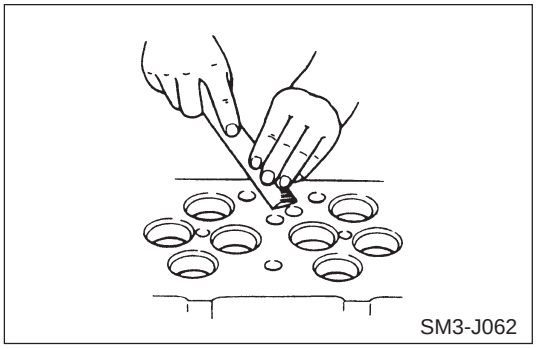

SM3-J062

Fig. 16

INSPECTION AND REPAIR

CYLINDER HEAD

NOTE:

- **Clean the cylinder head thoroughly with a commercial cleaning agent before inspection.**
- **Do not damage the lower surface of the cylinder head.**

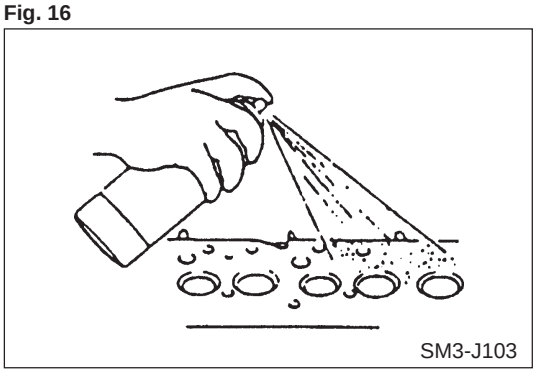

SM3-J103

Fig. 17

INSPECT THE CYLINDER HEAD FOR CRACKS.

Check the head surface and intake and exhaust valve seats, for cracks, using a dye penetrant. If cracks are found, replace the cylinder head.

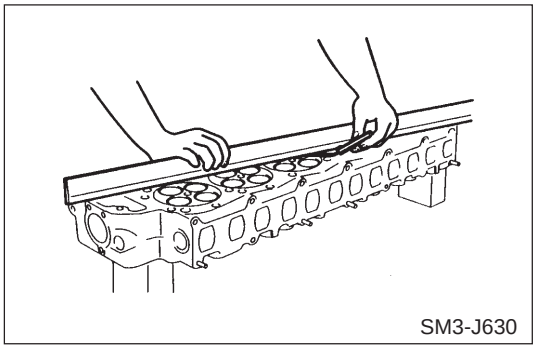

SM3-J630

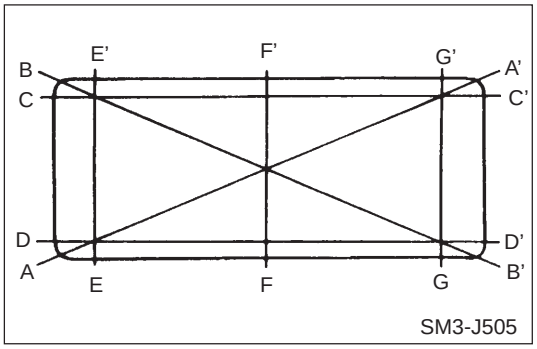
Fig. 18

CHECK THE CYLINDER HEAD FLATNESS.

1. Check the cylinder head surface for flatness with a straight edge and a thickness gauge. If the measurements exceed service limits, replace the cylinder head.

Standard: 0.06 mm (0.0024 in.) or less for longitudinal direction
0.03 mm (0.0012 in.) or less for lateral direction

Service limit: 0.20 mm (0.0079 in.)



SM3-J505

Fig. 19

2. Check the flatness of the intake and exhaust manifolds mounting surfaces.

Standard: 0.06 mm (0.0024 in.) or less for longitudinal direction
0.03 mm (0.0012 in.) or less for lateral direction

Service limit: 0.20 mm (0.0079 in.)

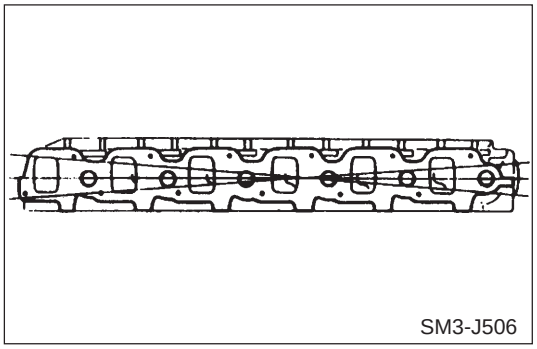

SM3-J506

Fig. 20

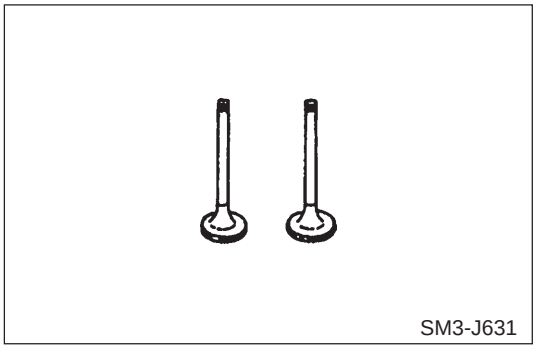

SM3-J631

Fig. 21

INSPECT THE VALVE CONTACT SURFACES FOR PROPER CONTACT.

1. Visually check valves for damage, burn marks, carbon accumulation, warpage, or cracks in valve heads, valve stems, and valve stem grooves. Replace valves which are excessively worn, burnt, warped or cracked.

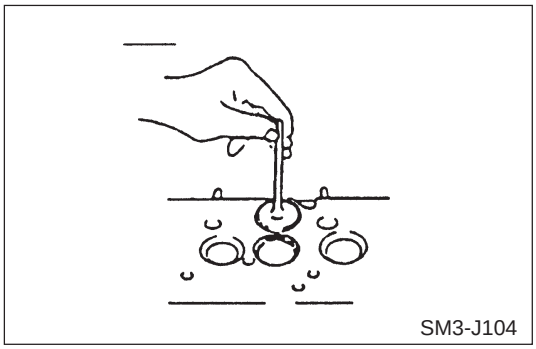

SM3-J104

Fig. 22

2. Check the valve seating condition.

   Lightly apply red lead marking compound to the valve face. Install the valve with a special tool, tap and rotate the valve against the seat. Check the valve face and valve seat for seating. When the red lead mark is not concentric or even all around the valve face or seat, correct the valve face or the valve seat.

Special tool: Valve lapping tool (09431 - 1020)

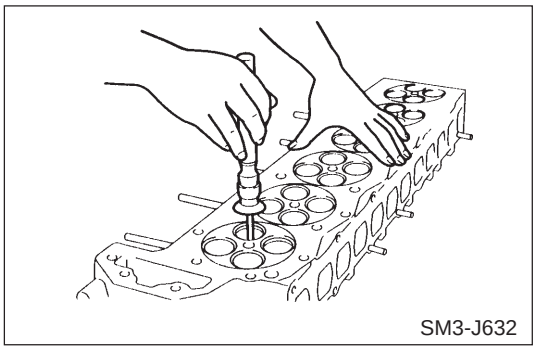

SM3-J632

Fig. 23

HAND-LAP THE VALVE AND VALVE SEAT.

Lightly apply lapping compound to the valve face. Install the valve with a special tool, tap and rotate the valve against the seat.

NOTE:

- **Following completion of hand-lapping, clean off any lapping compound which has adhered to the valves and valve seats.**
- **Following hand-lapping, always recheck the seating condition.**

Special tool: Valve lapping tool (09431 - 1020)

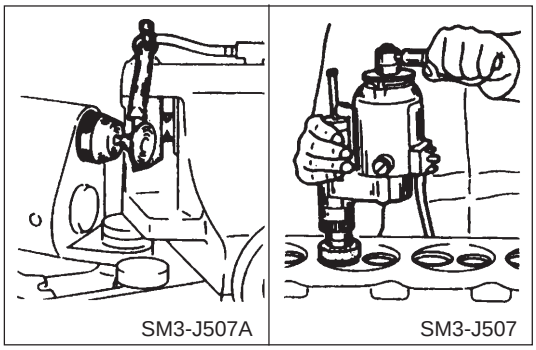

SM3-J507A SM3-J507

Fig. 24

GRIND VALVES

NOTE:

- **Grinding of valves should only be performed when hand-lapping does not result in proper seating.**
- **Following hand-lapping, always recheck the seating condition.**

WARNING

When grinding, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.

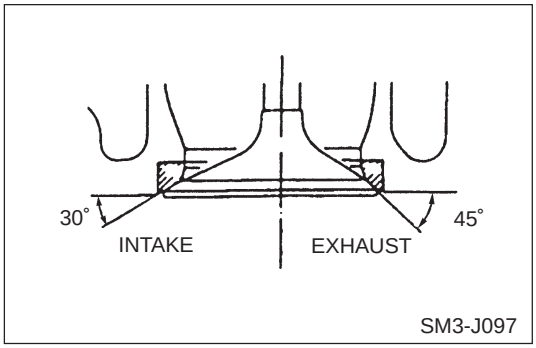


Fig. 25

Assembly standard:

Valve seat (Intake):	**30°00' - 30°35'**
Valve face (Intake):	**29°30' - 30°00'**
Valve seat (Exhaust):	**45°00' - 45°30'**
Valve face (Exhaust):	**44°30' - 45°00'**

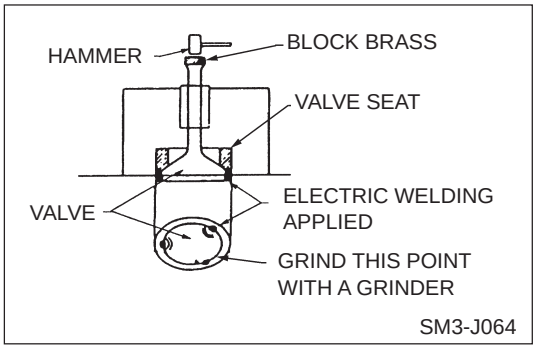


Fig. 26

IF NECESSARY, REPLACE THE VALVE SEAT.

1. Cut three places on the circumference of an unwanted valve and weld it to the valve seat.

NOTE: To protect the lower surface of the cylinder head from welding spatter, be sure to apply grease before welding.

2. Place a back plate at the top of the valve stem and strike it with a hammer to remove the valve seat.

NOTE: When striking, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.

3. Machine the valve seat according to the specified valve seat dimensions.

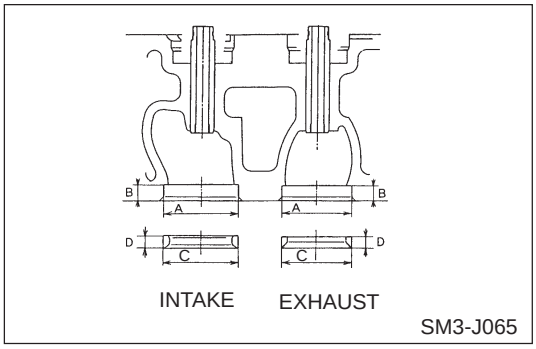


Fig. 27

Dimensions of the valve seat machining:

		Intake		Exhaust	
		Unit:mm	Unit:in.	Unit:mm	Unit:in.
Clynder head side	A	41-41.016	1.6142-1.6148	39-39.016	1.5355-1.5360
	B	9.4-9.6	0.3701-0.3779	8.6-8.8	0.3386-0.3464
Valve seat side	C	41.085-41.1	1.6176-1.6181	39.12-39.135	1.5402-1.5407
	D	7-7.2	0.2756-0.2834	6-6.2	0.2363-0.2440

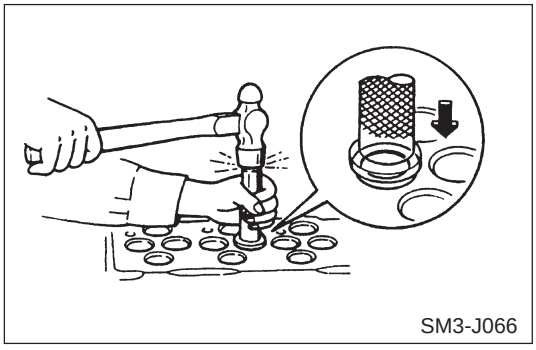


Fig. 28

4. Heat the cylinder head to approx. 80°C (176°F) - 90°C (194°F) with hot water. Cool the valve seat with dry ice for approx. 30 minutes. Hold the seat with pincers and place it into the heated cylinder head. The valve seat can be easily made to fit by lightly hitting it.

WARNING

- **Never touch the cooled valve seat with your bear hands.**
- **When striking, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.**
- **Following valve grinding, always recheck the seating condition.**

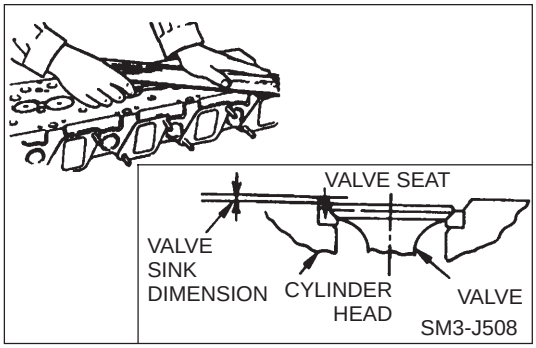


Fig. 29

MEASURE THE VALVE SINK.

Assembly standard:

Intake: 0.55 - 0.85 mm (0.0217 - 0.0334 in.)

Exhaust: 1.05 - 1.35 mm (0.0414 - 0.0531 in.)

Repair limit:

Intake: 1.1 mm (0.0433 in.)

Exhaust: 1.6 mm (0.0630 in.)

NOTE:

- **If the valve heads are protruding from cylinder head surface, the valve heads may hit against the pistons while the engine is running.**
- **Following replacement of valve and valve seat, always recheck the seating condition.**

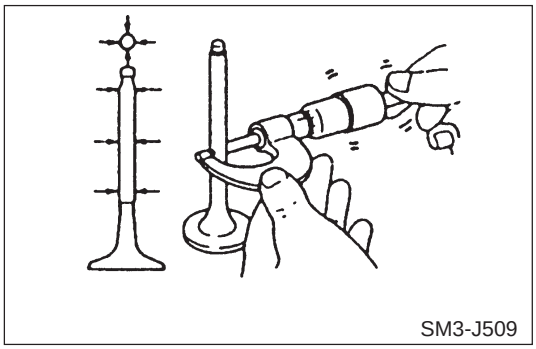


Fig. 30

MEASURE THE CLEARANCE BETWEEN THE VALVE STEM AND VALVE GUIDE.

1. Measure the outside diameter of the valve stem with a micrometer. If the value exceeds the service limit, replace the valve.

Nominal dimension: 7.0 mm (0.2756 in.)

Service limit: Intake 6.92 mm (0.2724 in.)

Exhaust 6.84 mm (0.2693 in.)

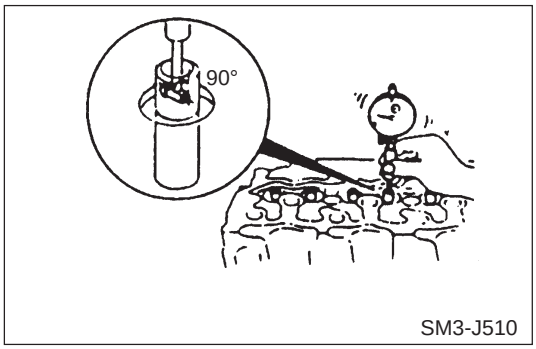


Fig. 31

2. Calculate the clearance between the valve stem and valve guide. If the clearance exceeds the service limit, replace the valve or valve guide.

Nominal dimension:

Intake: 0.023 - 0.058 mm (0.0010 - 0.0022 in.)

Exhaust: 0.037 - 0.067 mm (0.0015 - 0.0026 in.)

Service limit:

Intake: 0.10 mm (0.0039 in.)

Exhaust: 0.12 mm (0.0047 in.)

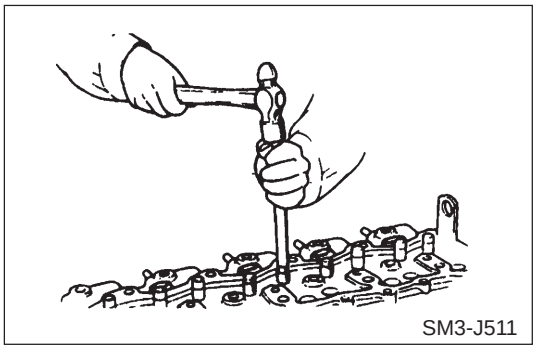


Fig. 32

IF NECESSARY, REPLACE THE VALVE GUIDE.

1. Remove the valve stem seal.
2. Strike the valve guide out with a brass bar and a hammer.

WARNING

When striking, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.

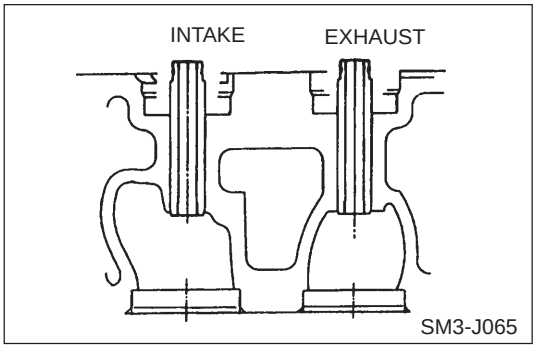


Fig. 33

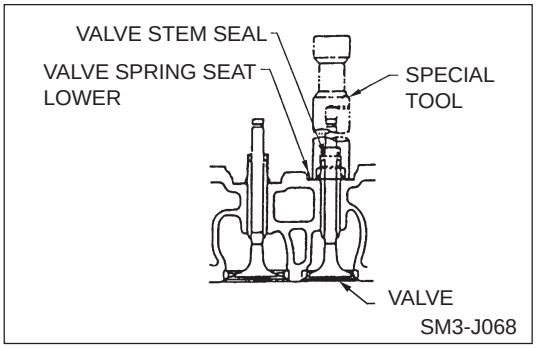


Fig. 34

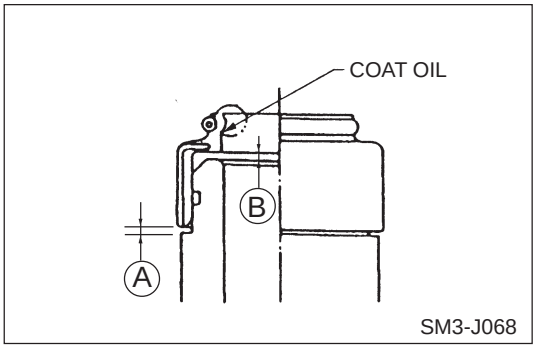


Fig. 35

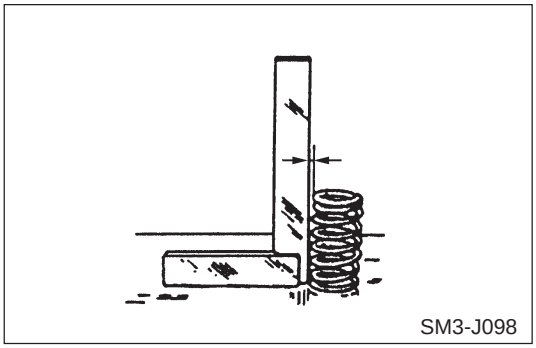


Fig. 36

3. Press fit a new valve guide straight allowing it to protrude as shown in the figure.

NOTE: Apply engine oil lightly to the valve guide outer circumference before installation.

IF NECESSARY, REPLACE THE VALVE STEM SEAL.

Replace the valve stem seal when the valve guide is replaced or when seal clearance is excessive or the stem seal has been worn or damaged.

First, install the lower spring seat and valve to the cylinder head (for guide of special tool), then apply engine oil to the lip of the stem seal and drive the guide with a special tool.

Special tool: Valve stem seal press (09472 - 2100)

WARNING
When striking, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.

NOTE:

- **After installing the valve stem seal, make sure there is a gap (A) and (B) as shown in the figure.**
- **Do not use the special tool if its surface contacting the valve spring lower seat is deformed.**

INSPECT THE VALVE SPRINGS.

1. Check the valve springs for squareness using a square and a thickness gauge. If a spring is out of square beyond the service limit, replace it.

Limit: 2.0 mm (0.078 in.) or more

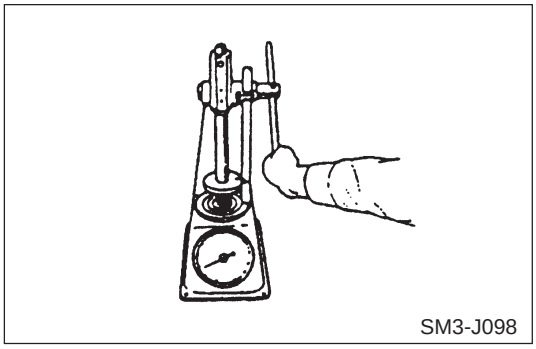

SM3-J098

Fig. 37

2. Measure the valve spring tension at a specified length with the valve spring tester. If the spring force is lower than the service limit, replace it.

		Free length mm (in.)		Setting height mm (in.)	Setting load kg (lb)	
		Nominal dimension	Service limit		Nominal dimension	Service limit
Outer spring	Intake	75.7 (2.980)	75.4 (2.968)	46.8 (1.843)	46.4 (102.23)	—
	Exhaust	75.7 (2.980)	75.4 (2.968)	46.8 (1.843)	44.2 (97.44)	—
Inner spring	Intake	64.6 (2.543)	64.3 (2.531)	44.8 (1.764)	21.7 (47.85)	—
	Exhaust	64.6 (2.543)	64.3 (2.531)	44.8 (1.764)	20.4 (44.98)	—

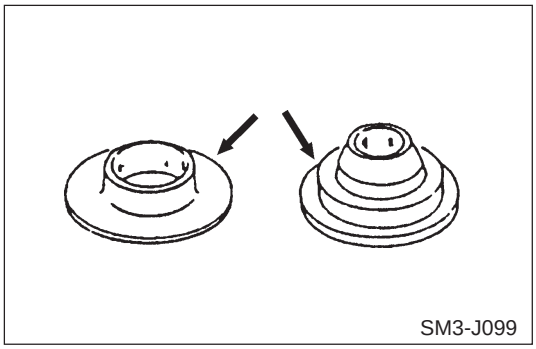

SM3-J099

Fig. 38

3. Visually check the contact surface of the upper and lower valve spring seats. Replacement is necessary if damage such as wear and scratches is excessive.

INSPECT THE CYLINDER HEAD COOLANT GALLERY FOR LEAKS.

Close all coolant holes and apply air pressure of about 2.5 kg/cm^2 (36 lb/sq. in.) from one of the coolant holes. Immerse the cylinder head into the water, then check for air leakage. If any leakage is found, replace the cylinder head.

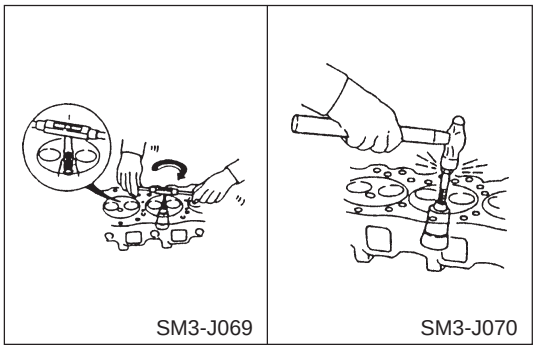

SM3-J069 SM3-J070

Fig. 39

IF NECESSARY, REPLACE THE NOZZLE SLEEVE.

1. Engage a tap to the nozzle sleeve from the bottom of the cylinder head. Screw in an appropriate bolt, then strike the bolt head with a hammer and drive out the nozzle sleeve.

WARNING
When striking, a metal tip may fly off on impact. Wear safety glasses to protect your eyes.

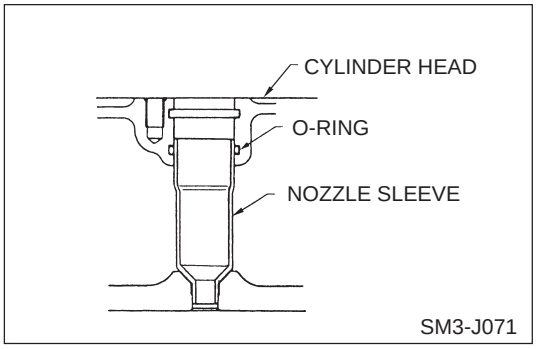


Fig. 40

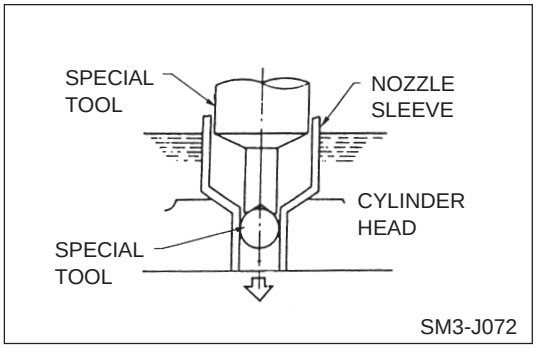


Fig. 41

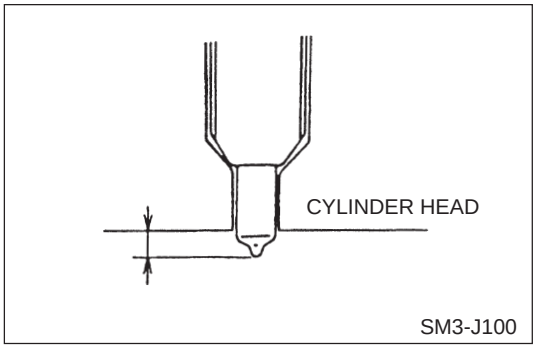


Fig. 42

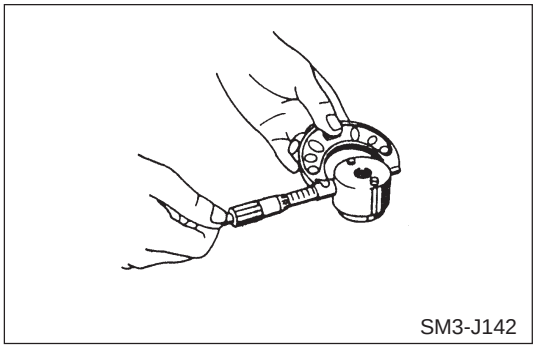


Fig. 43

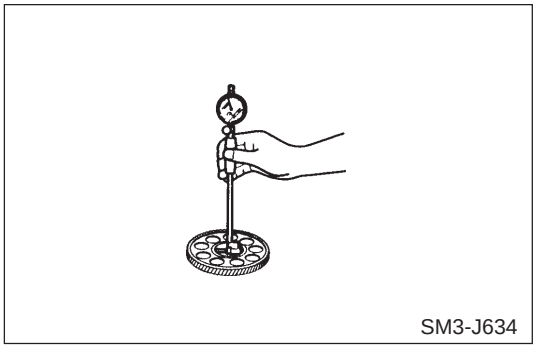


Fig. 44

2. Install an O-ring to the nozzle sleeve insert hole of the cylinder head. Then apply liquid gasket (Three Bond No. 1211 or equivalent) to the bottom of a new nozzle sleeve, and insert it to the nozzle sleeve insert hole of the cylinder head.

NOTE: Be sure to install a new O-ring. Reused O-rings may cause water or gas leakage and lead to overheating or cracked heads.

3. Caulk the nozzle sleeve with the special tool.

Special tool: Sleeve bar (09472 - 1210)
Steel ball (9800 - 06100)

4. Install the injection nozzle to the cylinder head. Then measure the protrusion of the injection nozzle from the lower surface of the cylinder head with a vernier caliper. If the value exceeds the service limit, replace the injection nozzle.

NOTE: Refer to page 3-12-5.

Assembly standard: 2.25 - 2.75 mm (0.0886 - 0.1082 in.)

Service limit: 2.75 mm (0.1082 in.)

MEASURE THE CLEARANCE BETWEEN THE CAM IDLER GEAR SHAFT AND CAM IDLER GEAR BUSHING.

1. Measure the outside diameter of the cam idler gear shaft with a micrometer. If the value exceeds the service limit, replace the cam idler gear shaft.

Assembly standard: 34.0 mm (1.3386 in.)

Service limit: 33.95 mm (1.3366 in.)

2. Measure the inside diameter of the cam idler gear bushing with a cylinder gauge. If the value exceeds the service limit, replace the cam idler gear.

Assembly standard: 34.0 mm (1.339 in.)

Service limit: 34.025 mm (1.340 in.)

3. Calculate the clearance between the idler gear shaft and idler gear bushing. If the value exceeds the service limit, replace the idler gear shaft and/or idler gear bushing.

Assembly standard: 0.025 - 0.075 mm (0.0010-0.0029 in.)

Service limit: 0.20 mm (0.0079 in.)

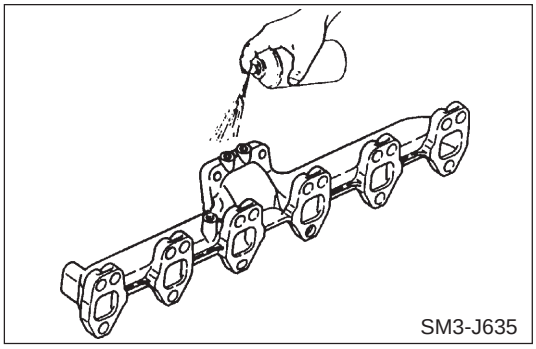


Fig. 45

INSPECT THE INTAKE AND EXHAUST MANIFOLDS.

NOTE: Clean the intake and exhaust manifolds with a commercial cleaning agent before inspection.

1. Check the intake and exhaust manifolds for cracks, using a dye penetrant. If cracks are found, replace the manifold.

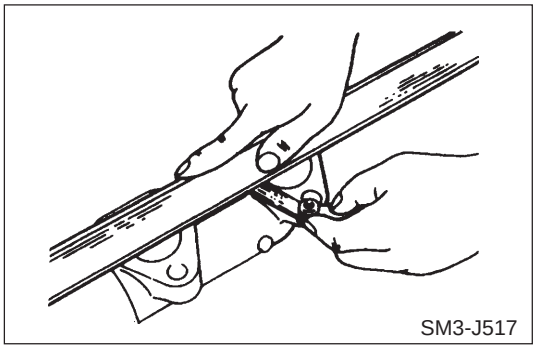


Fig. 46

2. Measure the intake manifold flatness with a straight edge and a thickness gauge. If the value exceeds the service limit, replace the intake manifold.

Service limit: 0.2 mm (0.0079 in.)

3. Measure the exhaust manifold flatness with a straight edge and a thickness gauge. If the value exceeds the service limit, correct the exhaust manifold by grinding it to become within 0.14 mm (0.006 in.) per 2 flanges or 0.1 mm (0.004 in.) per flange.

Service limit: 0.2 mm (0.0079 in.)

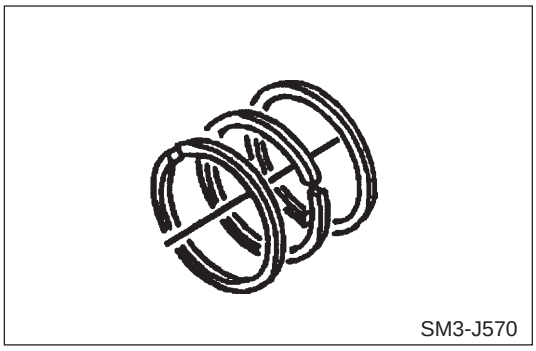


Fig. 47

4. Visually check the seal ring of the exhaust manifold for deformation or wear. Replacement is necessary if damage such as deformation and wear is excessive.

INSPECT THE CAMSHAFT.

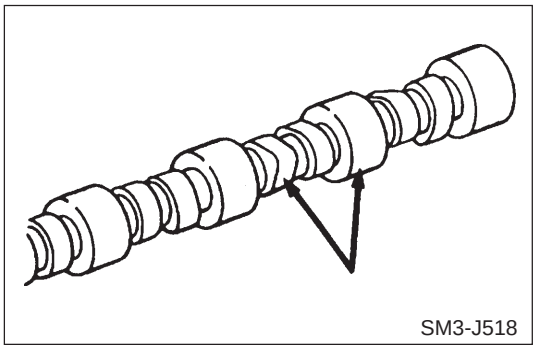


Fig. 48

1. Visually check the camshaft surface for wear and scratches.

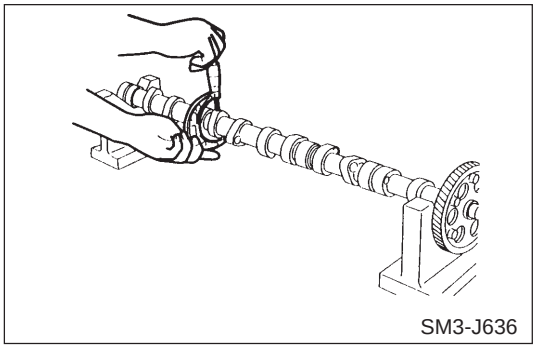
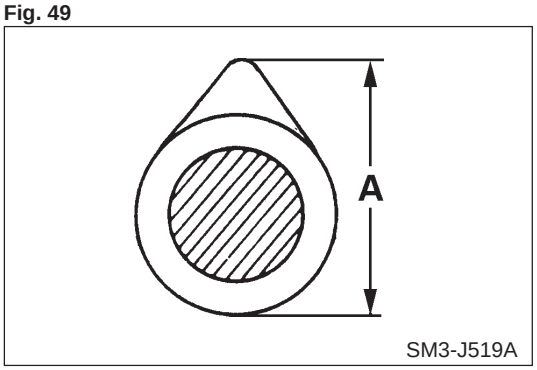

SM3-J636

Fig. 49



SM3-J519A

Fig. 50

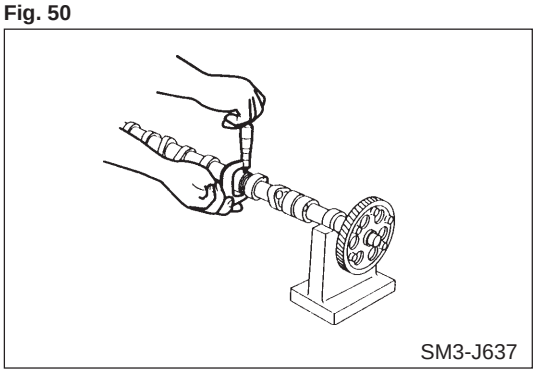

SM3-J637

Fig. 51

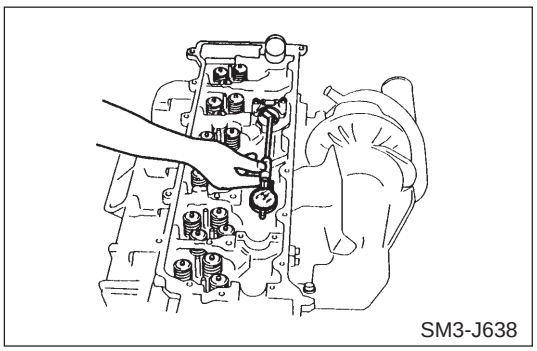

SM3-J638

Fig. 52

2. Measure the cam height.
   Measure the dimensions (A) shown in the figure with a micrometer. If the value exceeds the service limit, replace the camshaft.

Nominal dimension A : Intake = 50.0667 ± 0.15 mm (1.9711 ± 0.0059 in.)
Exhaust = 52.1038 ± 0.15 mm (2.0513 ± 0.0059 in.)
Service limit: –0.5 mm (–0.0197 in.)

3. Measure the clearance of camshaft journal.
   a. Measure the outside diameter of camshaft journal with a micrometer. If the value exceeds the service limit, replace the camshaft.

Nominal dimension: 40.0 mm (1.575 in.)
Service limit: 39.85 mm (1.569 in.)

   b. Measure the inside camshaft bearing with a cylinder gauge. If the value exceeds the service limit, replace the camshaft bearing.

Nominal dimension: 40.0 mm (1.575 in.)
Service limit: 40.15 mm (1.581 in.)

   c. Calculate the clearance from the above measurement. If the clearance is greater than the limit, replace the camshaft or camshaft bearing.

Nominal dimension: 0.020 - 0.063 mm (0.0008 - 0.0024 in.)
Service limit: 0.1 mm (0.0039 in.)

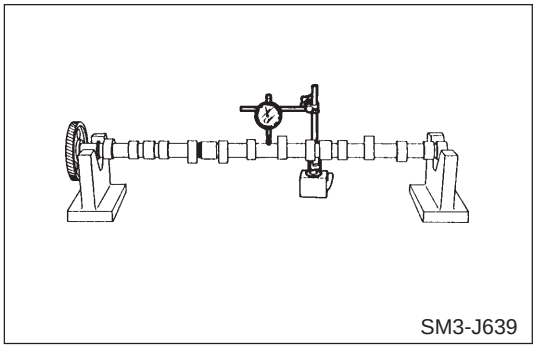
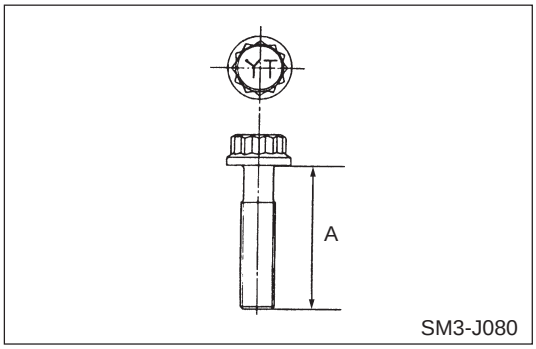

SM3-J639

Fig. 53

4. Measure the camshaft end play.
   Support the camshaft with V-blocks and measure the run out at the center journal with a dial gauge. If the value exceeds the service limit, replace it.

Service limit: 0.10 mm (0.0039 in.)



SM3-J080

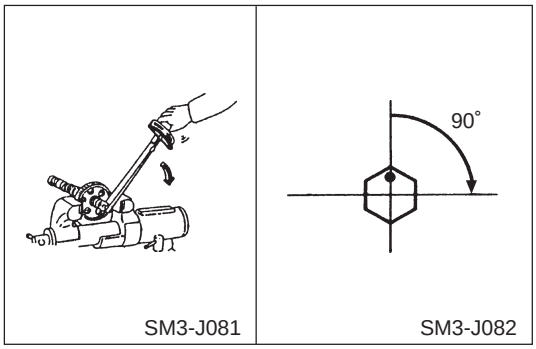
Fig. 54

IF NECESSARY, REPLACE THE CAMSHAFT GEAR.

1. Measure the length of the cam gear bolts, if the length is A or more, replace with new bolts.

A = 51 mm (2.0078 in.)

2. Make sure there is no dirt or scratch on the camshaft gear or tightening surface of the camshaft.



SM3-J081 SM3-J082

Fig. 55

3. Apply clean engine oil to the bolt seating and bolt thread, then tighten the bolt to the specified torque below.

Tightening torque: 600 kg·cm (43 lb·ft)

4. Retighten them 90° (1/4 turn).

NOTE: When adding torque, never untighten the nuts, even it they have been overtightened.

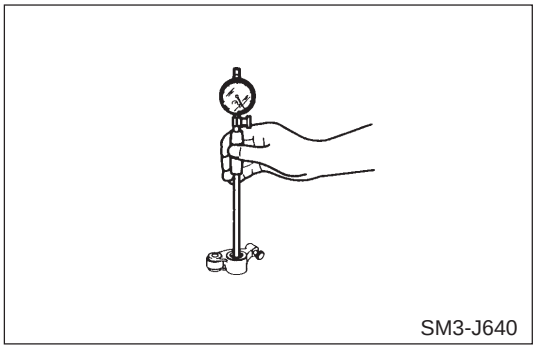

SM3-J640

Fig. 56

INSPECT THE ROCKER ARM ASSEMBLY AND ROCKER ARM SHAFT.

1. Measure the inside diameter of the rocker arm bushing with a cylinder gauge. If wear exceeds the service limit, replace it.

Nominal dimension: 22.0 mm (0.8661 in.)

Service limit: 22.08 mm (0.8693 in.)

NOTE: When installing a bushing into the rocker arm, align the bushings with the oil holes of the rocker arm.

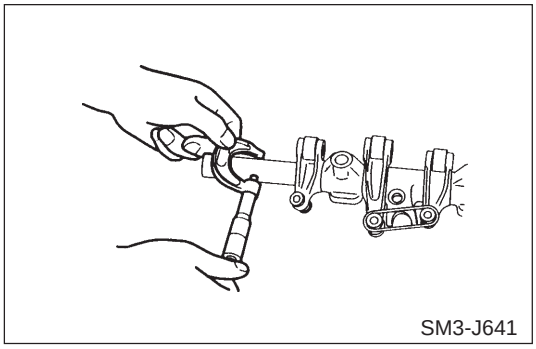

SM3-J641

Fig. 57

2. Measure the outside diameter of the rocker arm shaft with a micrometer. If wear exceeds the service limit, replace the rocker arm.

Nominal dimension: 22.0 mm (0.8661 in.)
Service limit: 21.92 mm (0.8630 in.)

3. Calculate the clearance between the rocker arm bushing and rocker arm shaft. If the clearance is greater than the specified limit, replace the rocker arm bushing.

Assembly standard: 0.03 - 0.101 mm (0.0012 - 0.0039 in.)
Repair limit: 0.15 mm (0.0059 in.)

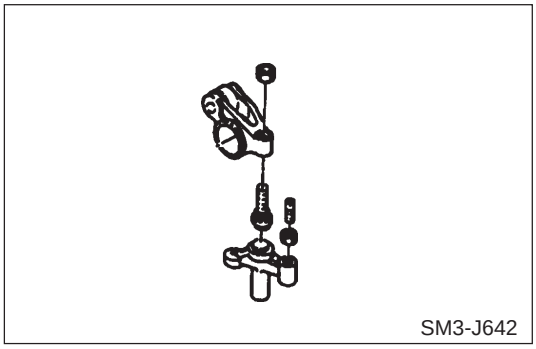

SM3-J642

Fig. 58

INSPECT THE ROCKER ARM AND CROSS HEAD.

Visually check the contact between the rocker arm and cross head. Replace the rocker arm and the cross head if damage such as wear and scratches is excessive. If there is only a minimal amount of wear, correct the surface with a resurfacer.

Visually check the adjusting screw thread. Replace the adjusting screw if damage such as wear and scratches is excessive.

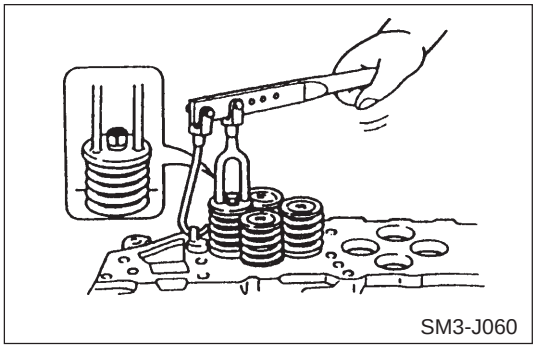

SM3-J060

Fig. 59

ASSEMBLING

ASSEMBLE THE VALVE SYSTEM.

NOTE: If parts are reused, install them to their initial position.

1. Apply engine oil to the intake and exhaust valve stems. Then insert them to the valve guide installed to the cylinder head.
2. Install the valve inner and outer springs and valve spring seat upper.
3. Press fit the valve spring seat upper with the special tool, then securely fit the valve spring retainer.

Special tool: Valve spring press (09470 - 1022)

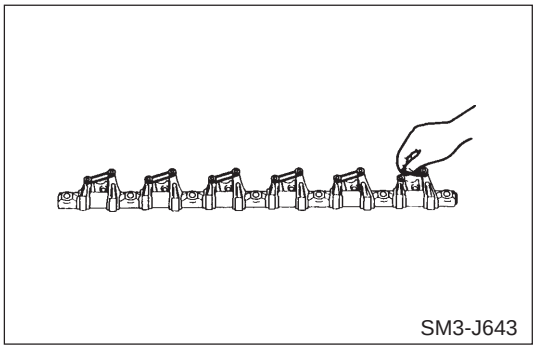

SM3-J643

Fig. 60

ASSEMBLE THE ROCKER ARM ASSEMBLY.

1. Make sure of the correct direction of the rocker arm support and assemble the rocker arm assembly.

NOTE: Wrong mounting of the rocker arm support results in seizure of the valve mechanism due to incorrect lubrication.

2. Wind up the adjusting screw of the rocker arm completely.

NOTE: If the adjusting screw is left unwound, the rocker shaft may bend when the rocker arm support is tightened.

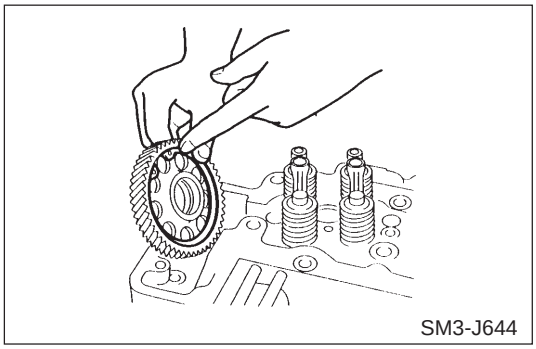

SM3-J644

Fig. 61

INSTALL THE CAM IDLER GEAR.

1. Install the cam idler gear with the snap ring side facing the cylinder head.
2. Install the cam idler gear shaft through a thrust plate, with the oil filler facing downward.

NOTE: Refer to page 3-6-1.

3. Tighten the idler gear shaft bolt to the specified torque below.

Tightening torque: 1,100 kg·cm (80 lb·ft)

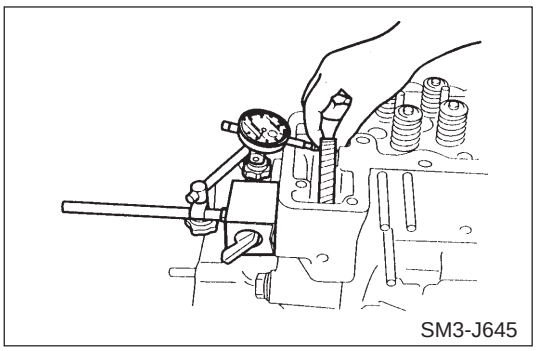

SM3-J645

Fig. 62

MEASURE THE CAM IDLER GEAR END PLAY.

After installing the cam idler gear, measure the clearance between the cam idler gear and thrust bearing with a dial gauge. If the clearance exceeds the service limit, replace the thrust bearing.

Nominal clearance: 0.040 - 0.095 mm (0.0016 - 0.0037 in.)

Service limit: 0.30 mm (0.0118 in.)

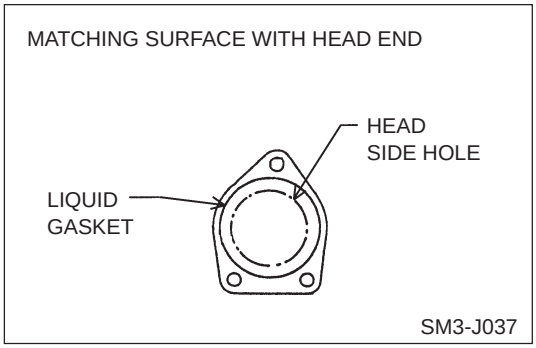


Fig. 63

INSTALL THE IDLER GEAR COVER.

1. Clean the cylinder head mounting surface of the idler gear cover.
2. Apply liquid gasket to the idler gear cover, then install it to the cylinder head within 20 minutes.

Liquid gasket: ThreeBond No.1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE:

- **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**
- **Refer to page 3-20-1.**

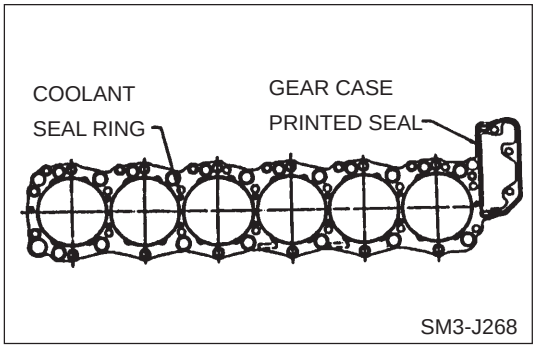


Fig. 64

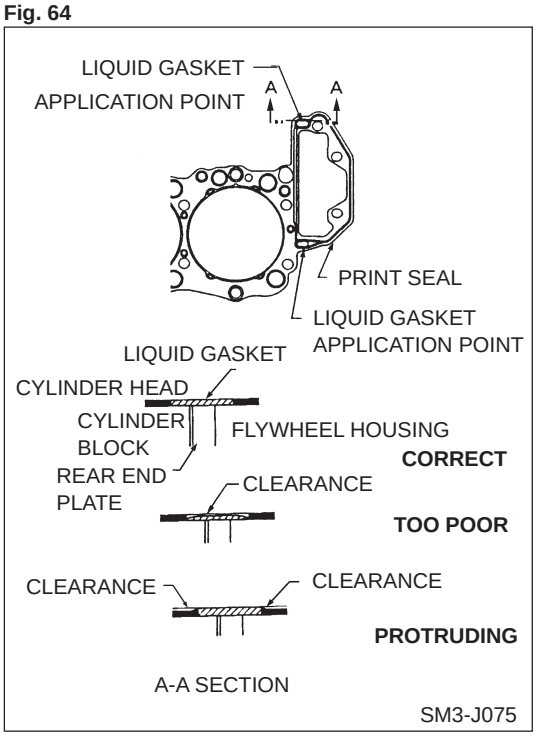


Fig. 65

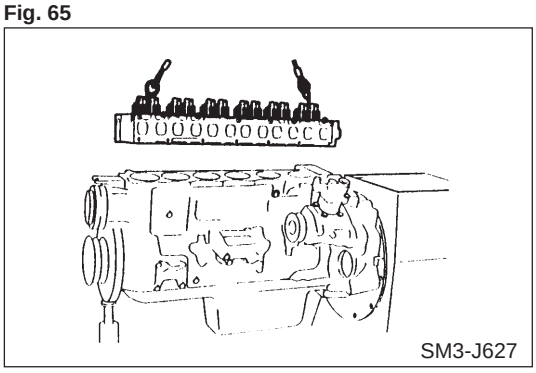


Fig. 66

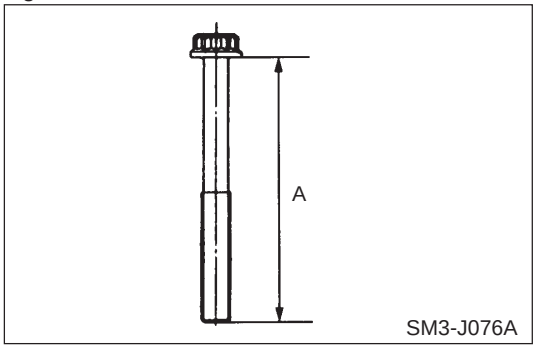


Fig. 67

MOUNTING

1. INSTALL THE CYLINDER HEAD GASKET.

NOTE:

- **Never reuse the cylinder head gasket as it may cause engine damage.**
- **Before installing the cylinder head gasket, remove dirt, moisture and oil on the cylinder head and cylinder block surface.**
- **The coolant seal rings between the bores are easily damaged. Do not touch them with your hands or other objects. Make sure that the seal rings are not loose or damaged.**
- **Since silicon material is used for the gear case print seal, make sure that there is no peeling before assembly.**

1. Install the cylinder head gasket on the cylinder block and flywheel housing.
2. Fill the hole at the back of the cylinder head gasket with liquid gasket.

NOTE: Make sure that the liquid gasket surface is flush with the cylinder head gasket upper surface.

2. INSTALL THE CYLINDER HEAD ON THE CYLINDER BLOCK.

3. INSTALL THE CYLINDER HEAD BOLT.

1. Preparation

a. Measure the length of the M12 head bolts, if the length is A or more, replace with new bolts.

A = 126 mm (4.9606 in.)

b. Make sure that no dirt or scratch is on the tightening surface of the cylinder head bolt.

c. Apply clean engine oil to the bolt surface and bolt threads.

NOTE: Since the cylinder head bolts are unique to this engine, do not substitute ordinary bolts.

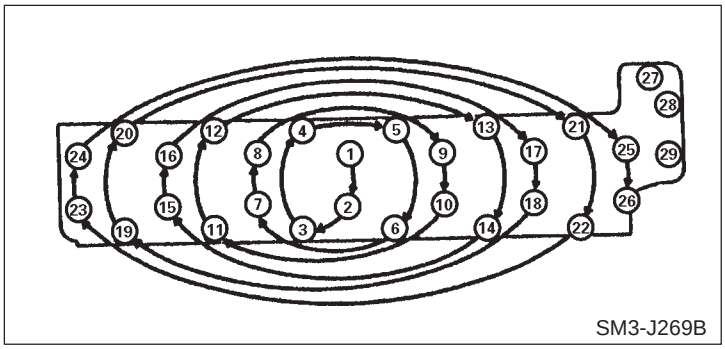


Fig. 68

2. Tighten the cylinder head bolt.

a. Tighten No.1 - No.26 (M12) bolts in the order shown in the figure to the specified torque below.

Tightening torque: 600 kg·cm (43 lb.in.)

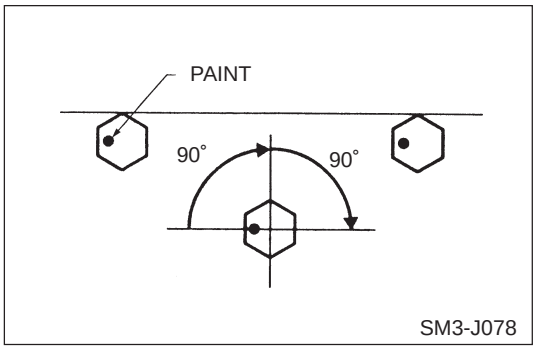


Fig. 69

b. Mark the bolts with paint to indicate the same directions as shown in the figure.

c. Turn No.1 - No.26 bolts 90° (1/4 turn).

d. Retighten them 90° (1/4 turn).

NOTE: Total tightening amounts to 180°. It must not become 200° or more.

e. Make sure that all paint marks face the same direction.

NOTE: When adding torque, never untighten the nuts, even if they have been overtightened.

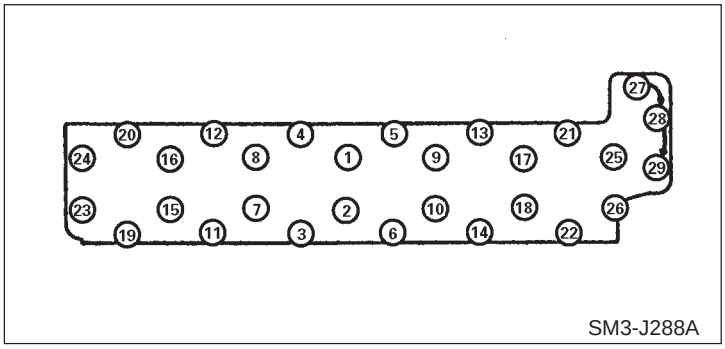


Fig. 70

f. Tighten No.27 - No.29 (M10) bolts in the order shown in the figure to the specified torque below.

Tightening torque: 600 kg·cm (43 lb·ft)

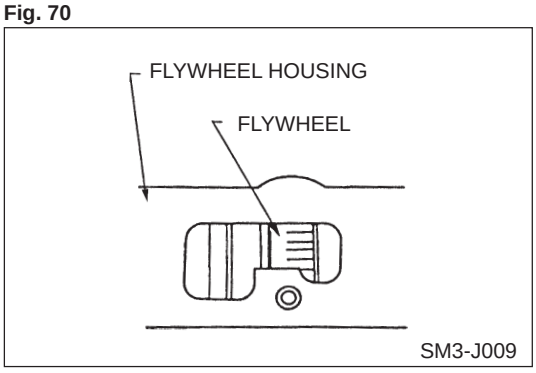


Fig.71

4. INSTALL THE CAM HOUSING.

1. Using the timing line on the flywheel, align No.1 cylinder with the upper dead point.

NOTE: Refer to page 3-18-1.

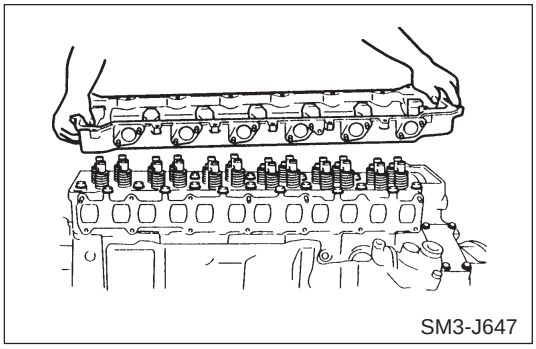
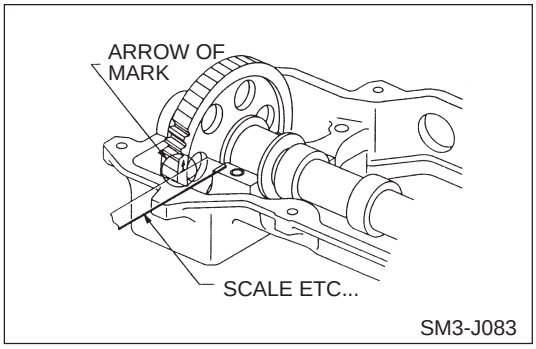

SM3-J647

Fig. 72



SM3-J083

Fig. 73

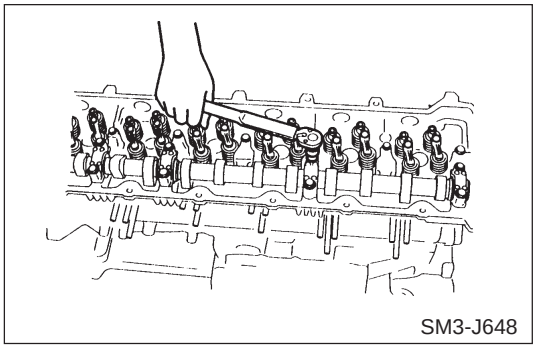

SM3-J648

Fig. 74

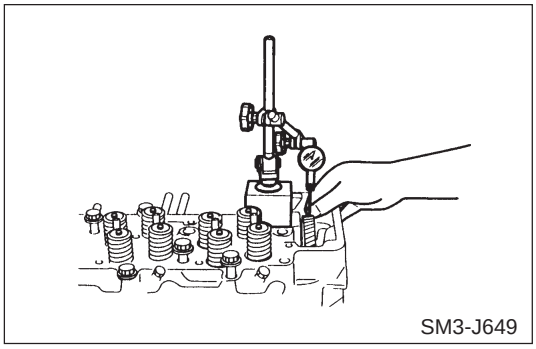

SM3-J649

Fig. 75

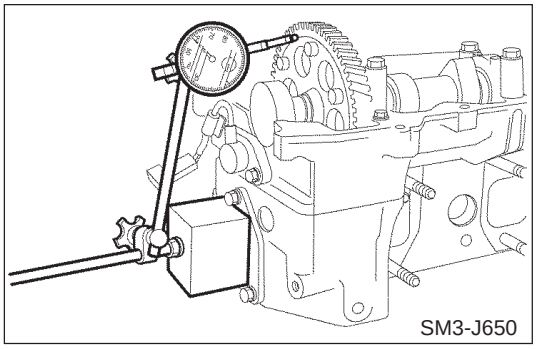

SM3-J650

Fig. 76

2. Install the cam housing on the cylinder head.

NOTE: When installing the cam housing, make sure the cam housing gasket is correctly fitted and is free of uneven deformation.

5. ASSEMBLE THE CAMSHAFT.

1. Install the camshaft into the cam housing so that the arrow stamped on the front of the camshaft gear faces upward and that the lower line is level.

NOTE: Incorrect installation may damage of the engine.

2. Install the camshaft bearing cap to the cam housing. Make sure there is no dirt or scratch on the tightening surfaces.
3. Apply clean engine oil to the bolt seating and bolt thread, then tighten the bolt to the specified torque below.

Tightening torque: 320 kg·cm (23 lb·ft)

6. MEASURE THE BACKLASH BETWEEN THE CAMSHAFT GEAR AND CAMSHAFT IDLER GEAR.

Measure the backlash between the camshaft gear and camshaft idler gear with a dial gauge. If the value exceeds the service limit, replace the camshaft gear.

Nominal backlash: 0.030 - 0.253 mm (0.0012 - 0.0099 in.)
Service limit: 0.30 mm (0.0118 in.)

7. MEASURE THE CAMSHAFT END PLAY.

Measure the thrust clearance between the camshaft and camshaft bearing with a dial gauge. If the clearance exceeds the service limit, replace the camshaft.

Nominal clearance: 0.10 - 0.178 mm (0.0040 - 0.007 in.)
Service limit: 0.3 mm (0.0118 in.)

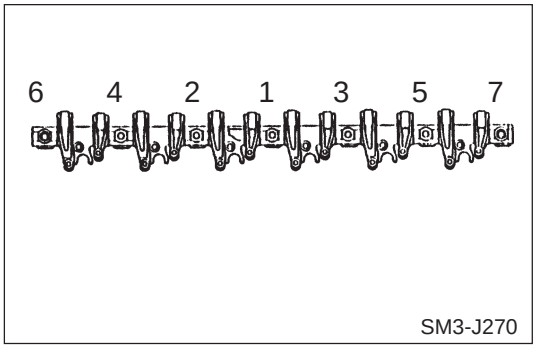


Fig. 77

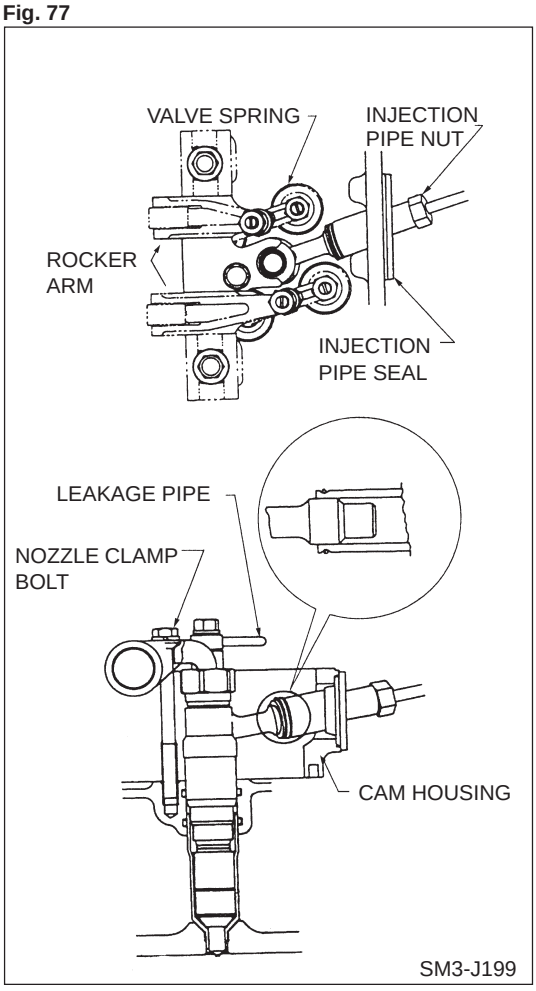


Fig. 78

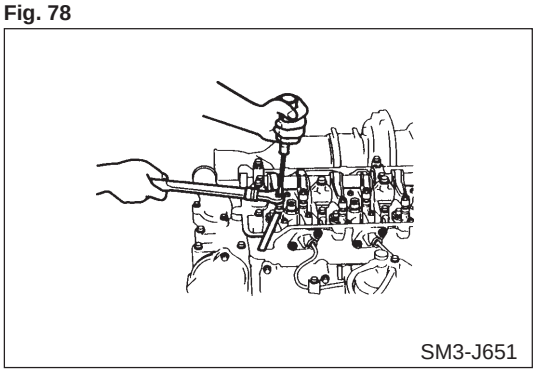


Fig. 79

8. INSTALL THE ROCKER ARM ASSEMBLY.

1. Install the rocker arm assembly to the cylinder head. Make sure that the cross head is on each valve.

NOTE: If the cross head is assembled off the valve, the valve may fall off, resulting in engine damage.

Tightening torque: 480 kg·cm (35 lb·ft)

9. INSTALL THE INJECTION NOZZLE.

1. Install a new O-ring into the groove of the cylinder head.
2. Make sure that there is no dirt or foreign particles at the sealing part between the nozzle holder and related parts (O-ring, nozzle sleeve and injection pipe seal), and connecting part between the nozzle holder and nut of the injection pipe.
3. Insert the nozzle holder taking care not to contact the valve spring as shown in the figure.

NOTE: Apply clean engine oil to the O-ring and be careful that the O-ring is not caught.

4. Cover the end of the injection pipe seal with the nozzle holder as shown in the figure and tighten the bolts to fasten the injection pipe seal to the cam housing.
5. Tighten the nut of the injection pipe provisionally.
6. Tighten the nozzle clamp bolt to the specified torque.

Tightening torque: 250 kg·cm (18 lb·ft)

NOTE: After tightening the bolt, make sure that the rocker arm moves smoothly.

7. Tighten the nut of the injection pipe to the specified torque.

Tightening torque: 400 kg·cm (28 lb·ft)

8. Install the leakage pipe.

10. ADJUST THE VALVE CLEARANCE.

NOTE: Refer to page 3-18-4.

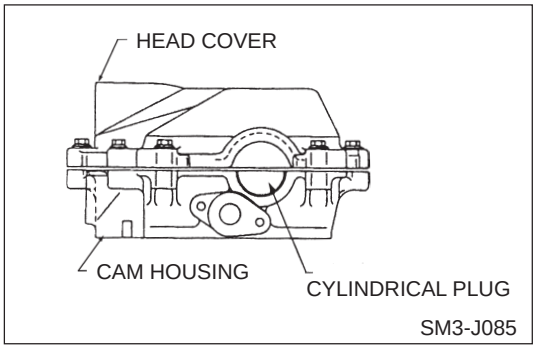


Fig. 80

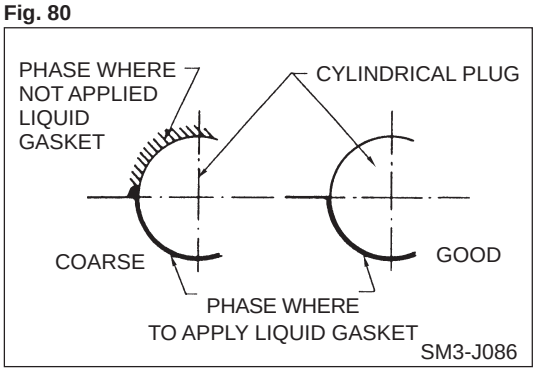


Fig. 81

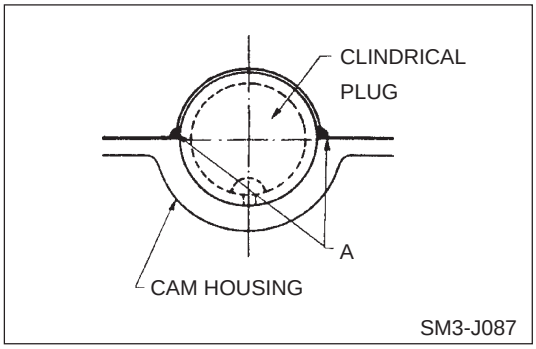


Fig. 82

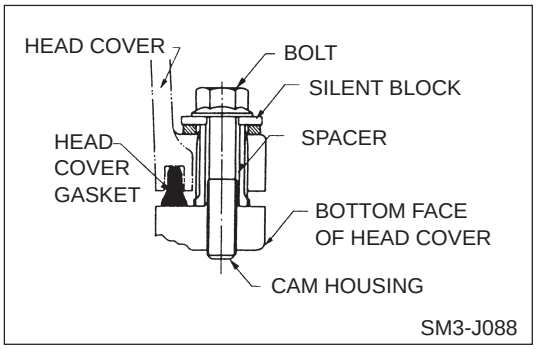


Fig. 83

11. INSTALL THE CYLINDER HEAD COVER

1. Remove the cylindrical plugs at the front and rear ends of the cam housing. Clean the cylindrical plugs and the mounting surfaces of the cam housing.

2. Apply liquid gasket to the front and rear half circles of the cam housing, then install the cylinder plug within 20 minutes.

Liquid gasket: ThreeBond No.1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE:

- **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**
- **Make sure to wipe off excessive liquid gasket.**
- **Refer to page 3-20-1.**

3. Apply liquid gasket to plug corner A at the front and rear ends of the cam housing.

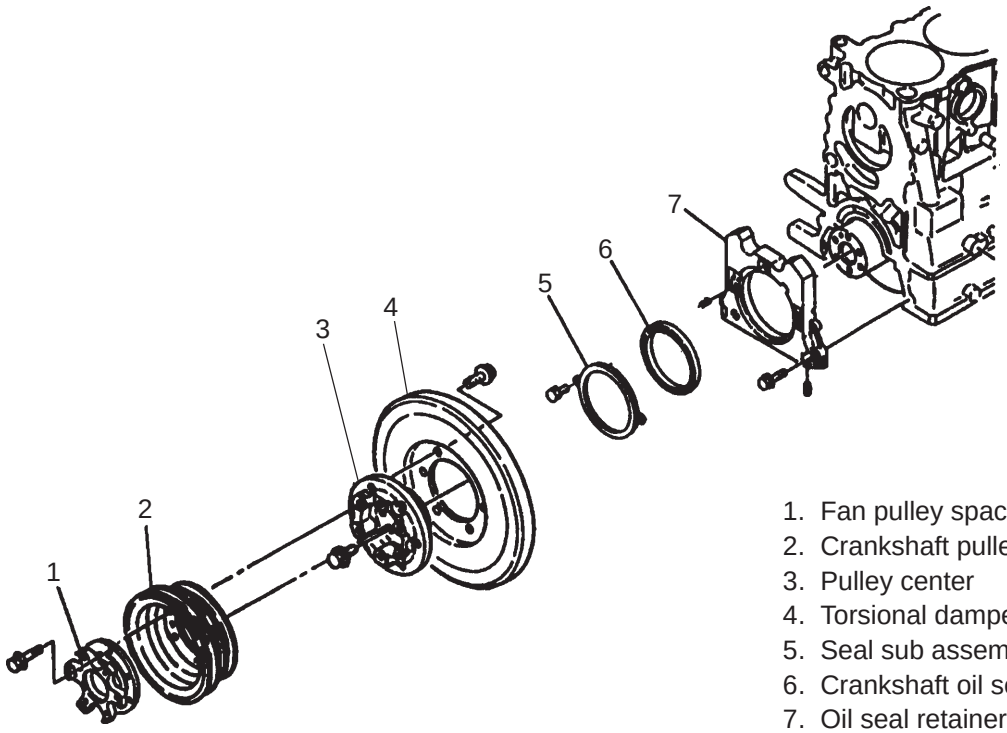
4. Install the cylinder head cover gasket into the gasket groove at the head cover lower surface.
5. Insert the spacer from the head cover lower surface.
6. Install the cylinder head cover to the cam housing.

NOTE: If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.

7. Tighten the mounting bolt of the head cover through the silent block to the specified torque below and fix the head cover on the cam housing.

Tightening torque: 250 kg·cm (18 lb·ft)

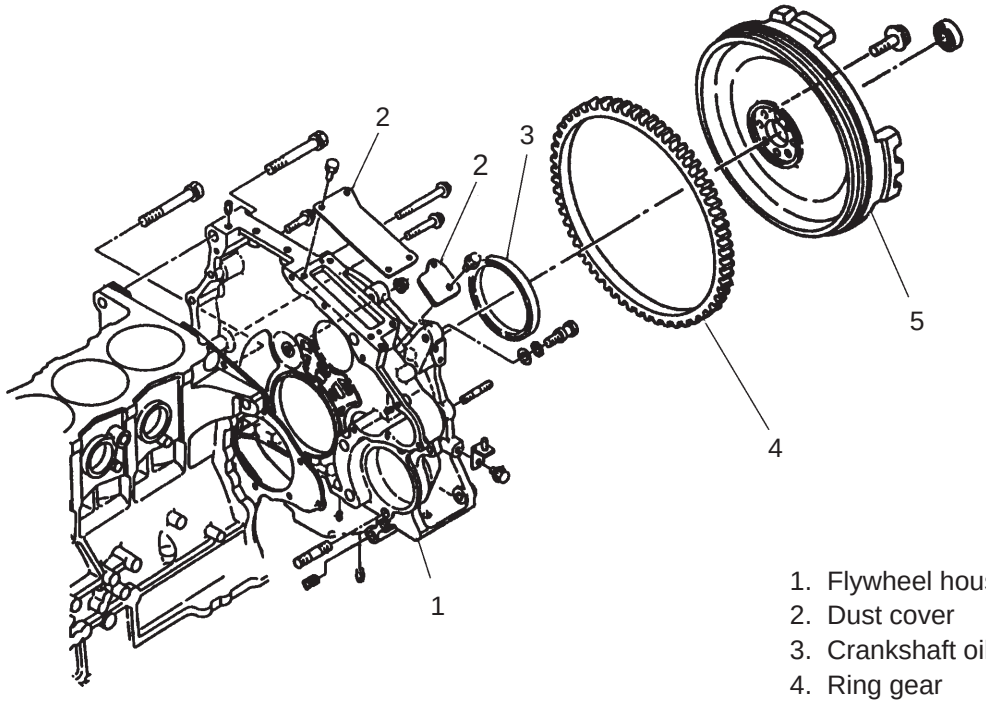
CRANKSHAFT FRONT END, OIL PAN, FLYWHEEL AND FLYWHEEL HOUSING



1. Fan pulley spacer
2. Crankshaft pulley
3. Pulley center
4. Torsional damper
5. Seal sub assembly
6. Crankshaft oil seal
7. Oil seal retainer

SM3-J274B

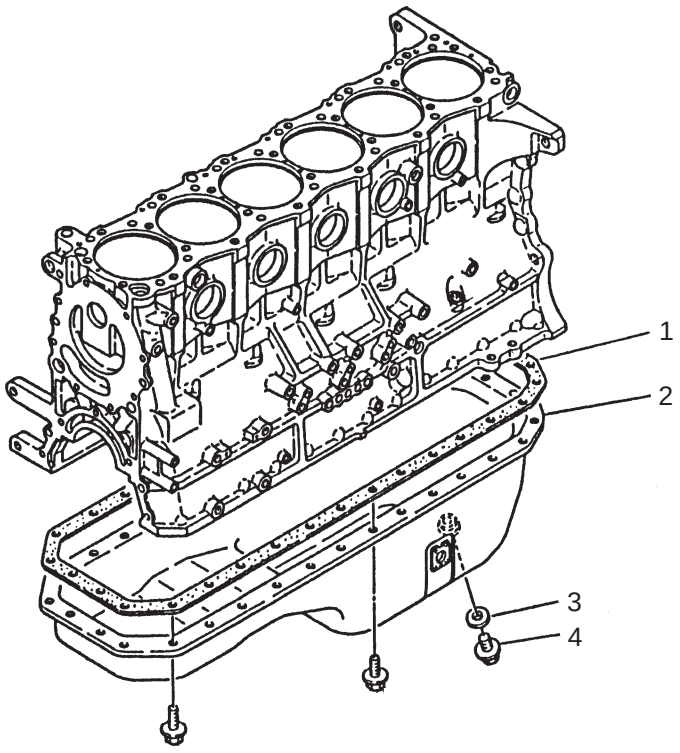
Fig. 1



1. Flywheel housing
2. Dust cover
3. Crankshaft oil seal
4. Ring gear
5. Flywheel

SM3-J274A

Fig. 2



1. Oil pan gasket
2. Oil pan
3. Soft washer
4. Drain plug

SM3-J273A

Fig. 3

DISMOUNTING

1. REMOVE THE CRANKSHAFT PULLEY.

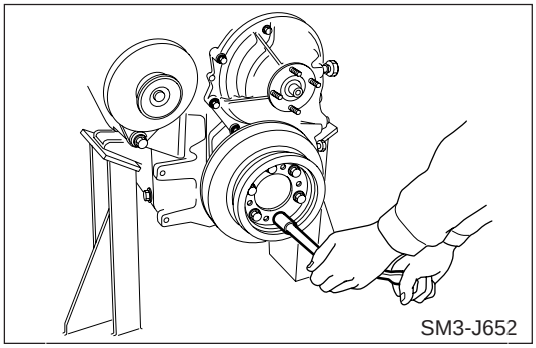


Fig. 4

2. REMOVE THE TORSIONAL DAMPER.

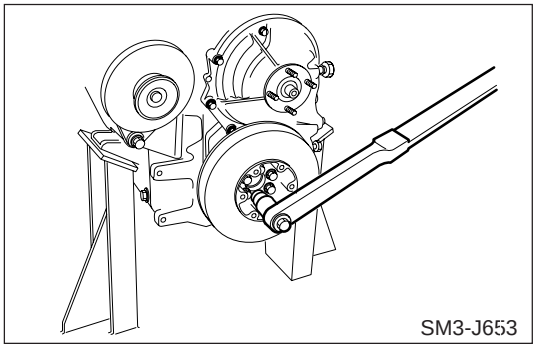


Fig. 5

3. REMOVE THE FLYWHEEL HOUSING STAYS.

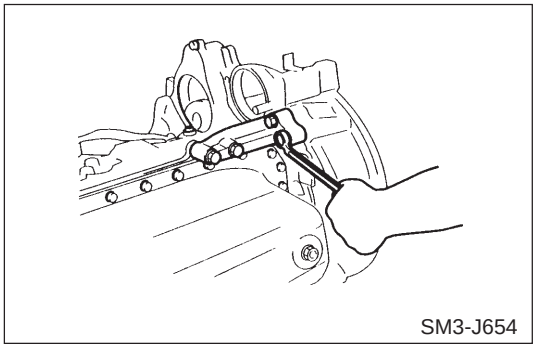


Fig. 6

4. REMOVE THE OIL PAN AND OIL STRAINER.

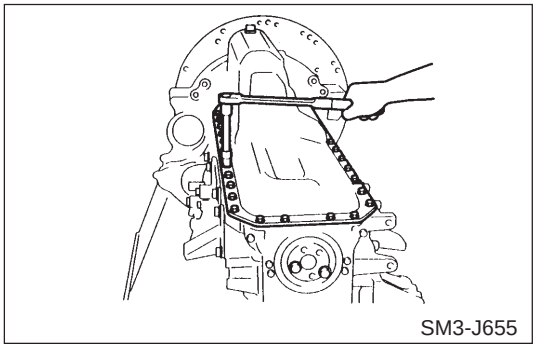


Fig. 7

5. REMOVE THE FLYWHEEL ASSEMBLY.

1. Remove the pilot bearing.

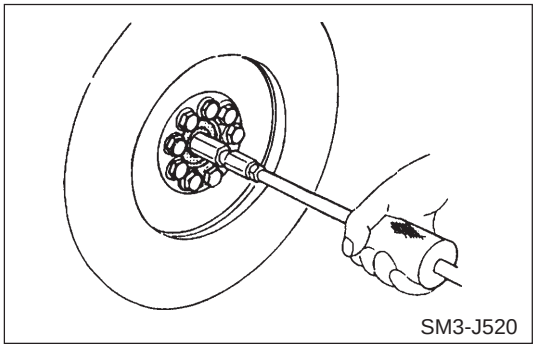


Fig. 8

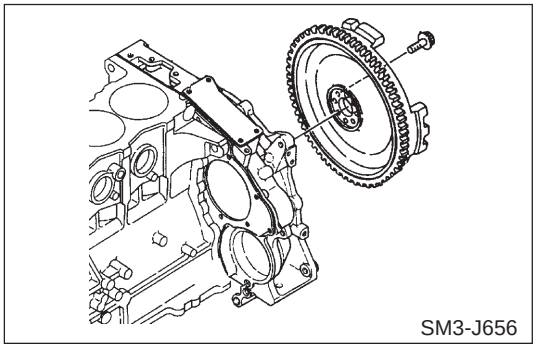
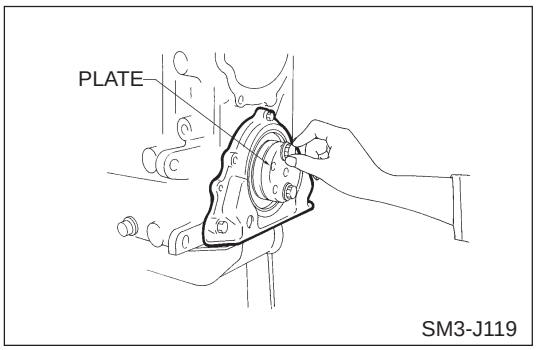
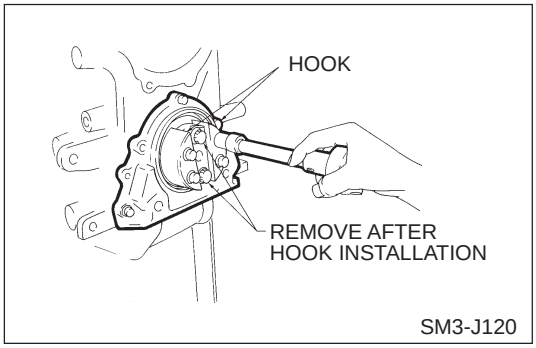

SM3-J656

Fig. 9



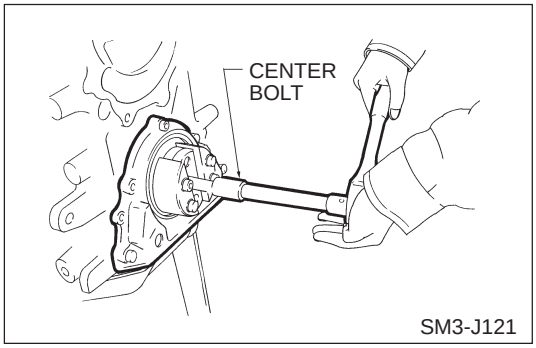
SM3-J119

Fig. 10



SM3-J120

Fig. 11



SM3-J121

Fig. 12

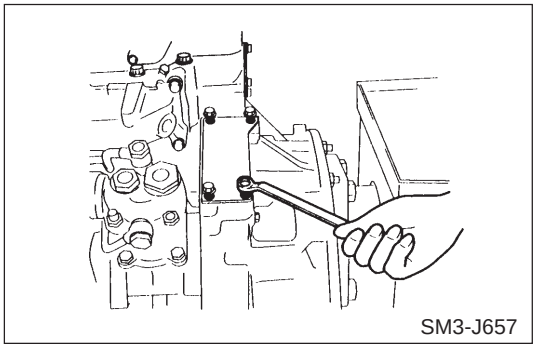

SM3-J657

Fig. 13

2. Remove the flywheel mounting bolts.
3. Hold a copper rod through the starter hole against the flywheel and drive the rod lightly with a hammer to remove the flywheel from the crankshaft while rotating the crankshaft.

WARNING
The flywheel is heavy. When removing, be careful not to drop it on your feet.

6. REMOVE THE CRANKSHAFT OIL FRONT AND REAR SEALS.

1. Remove the crankshaft oil seals with the special tool.

Special tool: Oil seal puller (09420 - 1731) for front
(09420 - 1742) for rear

a. Place the plate at the crankshaft end using the crank pulley mounting bolts (front) or the flywheel mounting bolts (rear).

b. Install the hook to the crankshaft end using the bolt supplied.

NOTE: Engage the hook with the oil seal notch.

c. Remove the installed bolt in step a.

d. Install the center bolt and tighten it to remove the oil seal.

7. REMOVE THE DUST COVER.

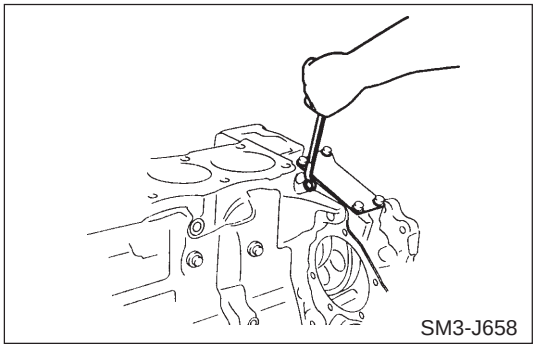

SM3-J658

Fig. 14

8. REMOVE THE FLYWHEEL HOUSING.

1. Remove the two front mounting bolts of the flywheel housing.

2. Remove the rear mounting bolts of the flywheel housing.

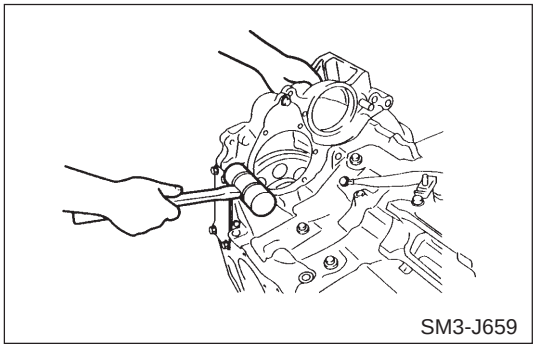

SM3-J659

Fig. 15

3. Remove the flywheel housing by driving it lightly with a plastic hammer.

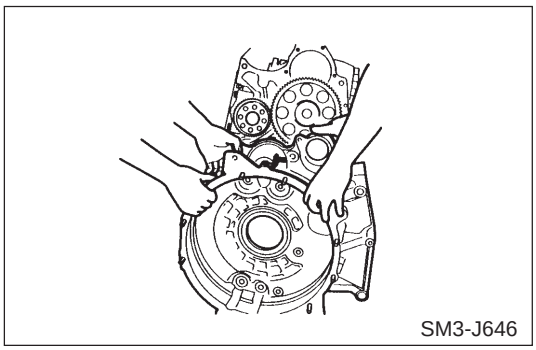

SM3-J646

Fig. 16

WARNING

The flywheel is heavy. When removing, be careful not to drop it on your feet.

9. REMOVE THE OIL SEAL RETAINER.

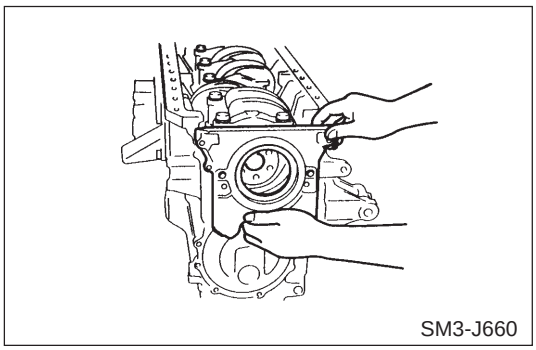

SM3-J660

Fig. 17

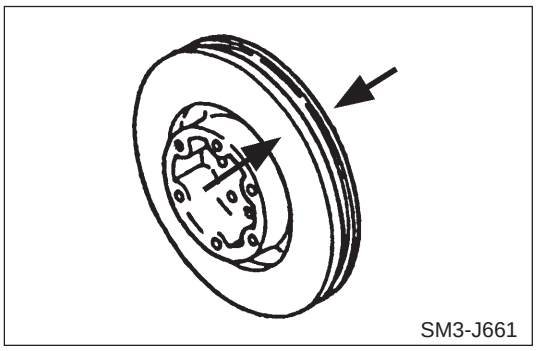


Fig. 18

INSPECTION AND REPAIR

INSPECT THE TORSIONAL DAMPER.

NOTE: Clean the torsional damper with a commercial cleaning agent before inspection.

1. Check if there are any cracks in the damper rubber section. If the cracks are excessive, replacement is necessary.

INSPECT THE FLYWHEEL (MODELS: FD, FE, FF)

1. Check the friction surface for scoring or heat cracking.

   If necessary, grind the friction surface or replace the flywheel.

Grind limit: 1 mm (0.039 in)

Deflection limit: 0.04 mm (0.00157 in.)

NOTE: Do not grind the flywheel over than the limit.

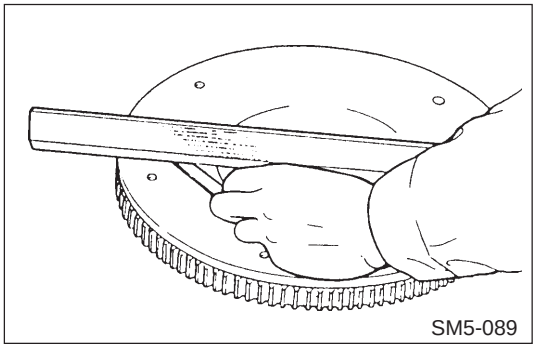


Fig. 19

2. Using a straight edge and a feeler gauge, check the friction surface ware.

   If the wear is greater than the sevice limit, replace the flywheel.

Standard: 0.05 mm (0.0020 in.) or less

Service limit: 1.0 mm (0.039 in.)

INSPECT THE FLYWHEEL (MODEL: SG)

1. Check the friction surface for scoring or heat cracking.

   If necessary, grind the friction surface or replace the flywheel.

Grind limit: 1 mm (0.039 in)

Deflection limit: 0.04 mm (0.00157 in.)

NOTE: Do not grind the flywheel over than the limit.

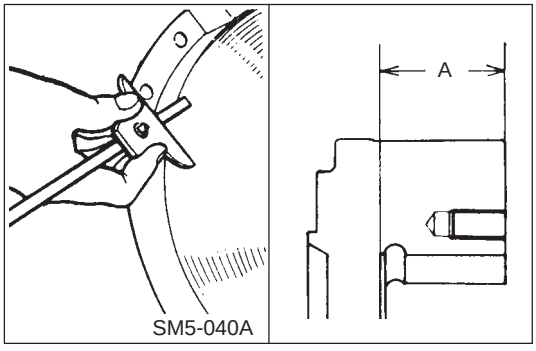


Fig. 20

2. Using a vernier caliper, check the friction surface ware.

   If the wear is greater than the sevice limit, replace the flywheel.

Standard: 48 mm (1.890 in.)

Service limit: 49 mm (1.929 in.)

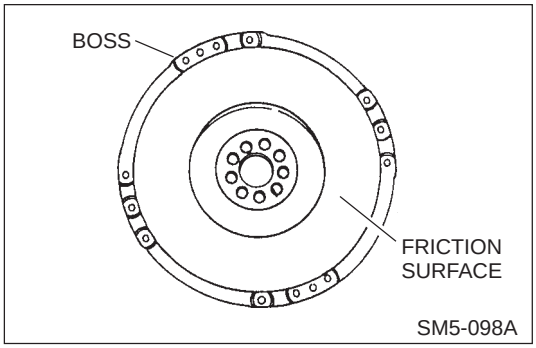


Fig. 21

3. After grind the friction surface, adjust the friction surface depth of the flywheel within the service standard by grind the outer bosses of the flywheel.

Fly wheel depth: 48 mm (1.890 in.)

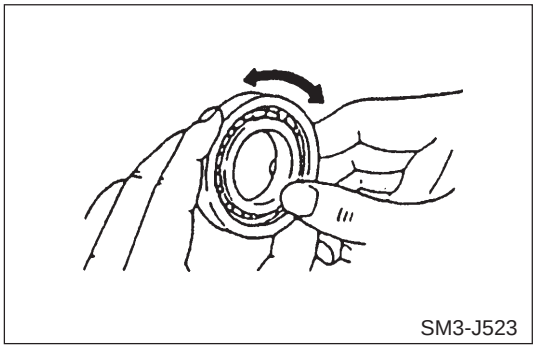


Fig. 22

INSPECT THE PILOT BEARING.

Rotate the bearing lightly by hand, and check whether there is any abnormal noise or chatter, and whether the balls run smoothly. If there is any fault, replace the pilot bearing.

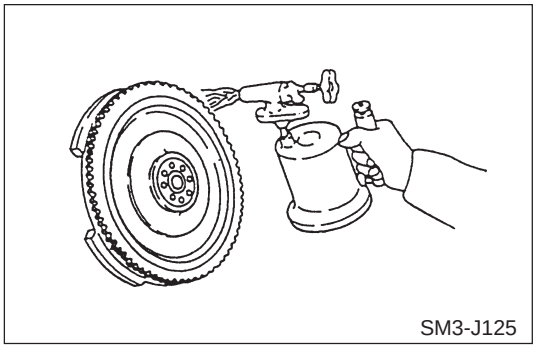


Fig. 23

INSPECT THE FLYWHEEL RING GEAR.

Visually check the flywheel ring gear. Replace the parts if damage such as wear and scratches is excessive.

REPLACE THE FLYWHEEL RING GEAR.

1. Heat the ring gear evenly to about 200°C (392°F) with a blow torch. Tap the ring gear periphery lightly using a cushion bar to remove the gear.

WARNING

Never touch the ring gear or flywheel when they are hot with your bare hands.

2. Heat the ring gear evenly to about 200°C (392°F) with a torch. Insert the ring gear into the flywheel so that the chamfered side is upward.

NOTE: Do not overheat the ring gear.

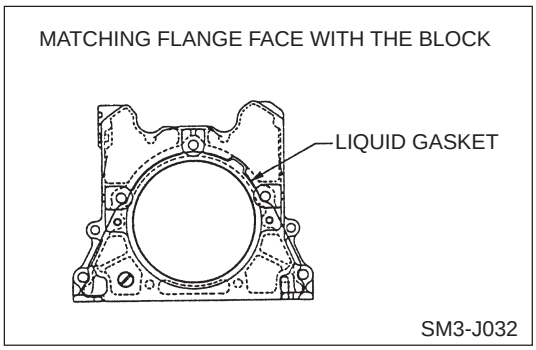


Fig. 24

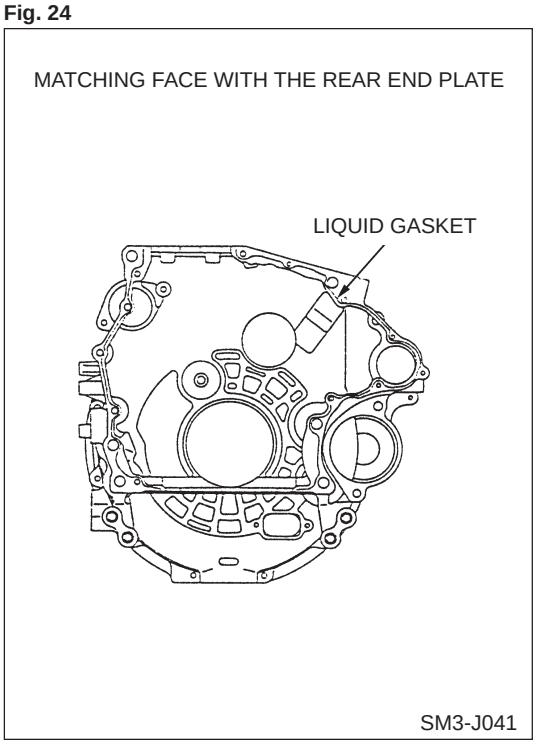


Fig. 25

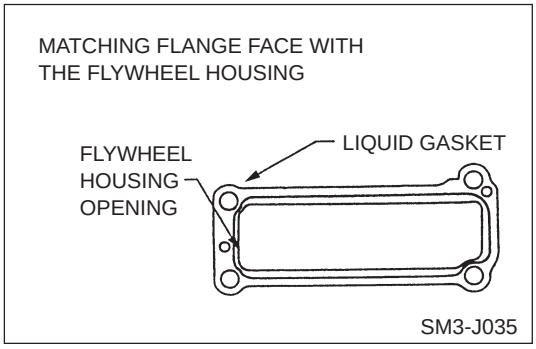


Fig. 26

MOUNTING

1. INSTALL THE OIL SEAL RETAINER.

1. Clean the cylinder block mounting surface of the oil seal retainer.
2. Apply liquid gasket to the oil seal retainer, then install it to the cylinder block within 20 minutes.

Liquid gasket: ThreeBond No.1207B
Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)
NOTE:

- **Refer to page 3-20-1.**
- **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**

2. INSTALL THE FLYWHEEL HOUSING.

1. Clean the rear end plate mounting surface of the flywheel housing.
2. Apply liquid gasket to the flywheel housing, then install it to the rear end plate within 20 minutes.

Liquid gasket: ThreeBond No.1207B
Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)
NOTE:

- **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**
- **Refer to page 3-20-1.**

WARNING
The flywheel is heavy. When installing, be careful not to drop it on your feet.

3. INSTALL THE DUST COVER.

1. Clean the flywheel housing mounting surface of the dust cover.
2. Apply liquid gasket to the dust cover, then install it to the flywheel housing within 20 minutes.

Liquid gasket: ThreeBond No.1207B
Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)
NOTE:

- **Refer to page 3-20-1.**
- **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**

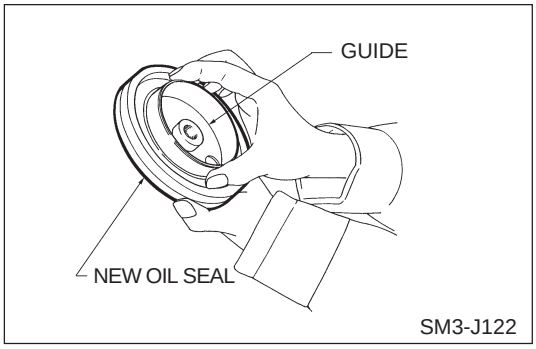


Fig. 27

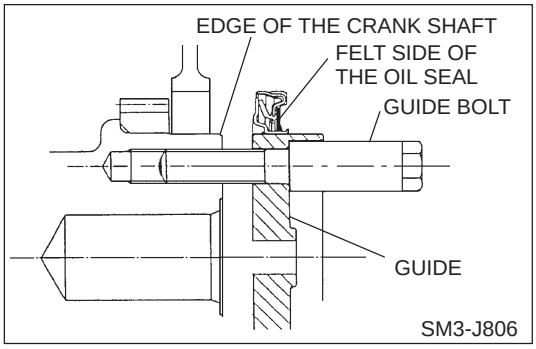


Fig. 28

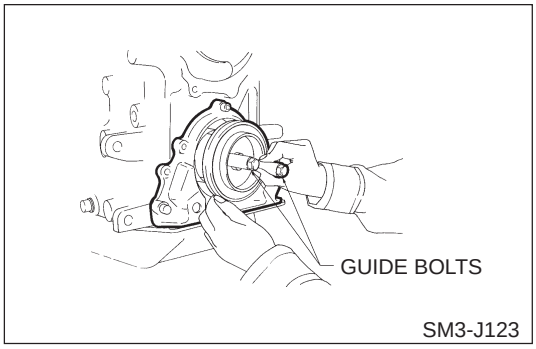


Fig. 29

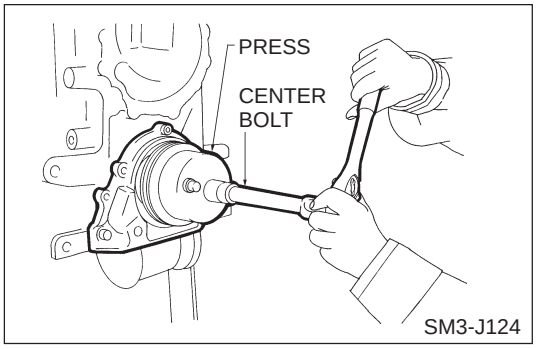


Fig. 30

4. CRANK SHAFT OIL SEALS INSTALLATION (FRONT AND REAR).

Special tools: Oil seal press (09407-1030) Front
(09407-1040) Rear

1. Clean the edges and surface of the crank shaft and the special tools.
2. Insert a new crank shaft oil seal into the guide of the oil seal press.

NOTE: Pay attention to the orientation of the crank shaft oil seal (The felt side should face the outside of the cylinder block).

3. Apply a little engine oil to the seal portion of the crank shaft oil seal.
4. Attach the oil seal press guide with the new crank shaft oil seal onto the crank shaft using the attached guide bolt.
5. Insert the oil seal press by adjusting the oil seal press hole to the guide bolt.
6. Press the crank shaft oil seal inside by attaching the accompanying center bolt onto the oil seal press and tightening it until it stops.

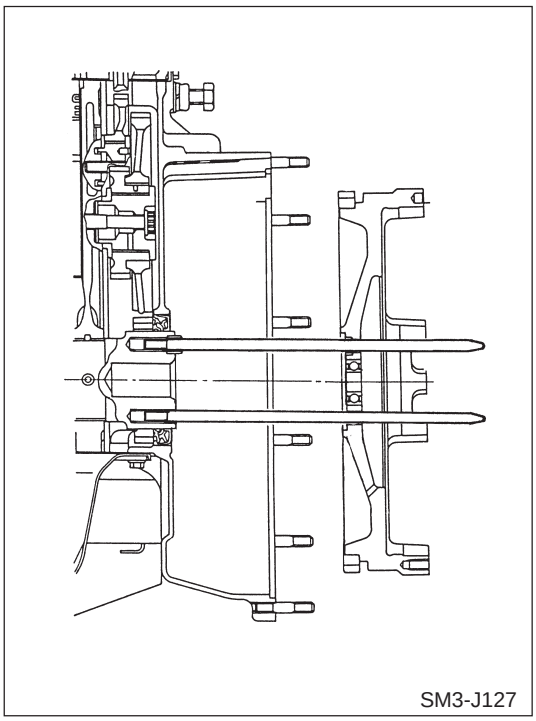

SM3-J127

Fig. 31

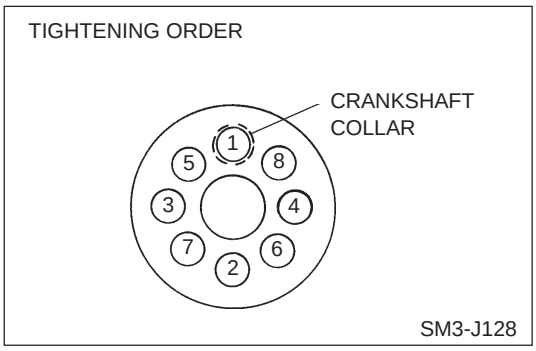


Fig. 32

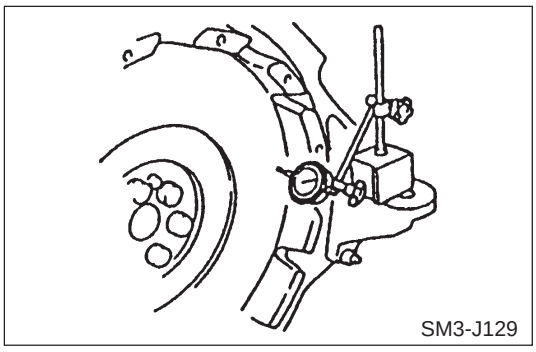

SM3-J129

Fig. 33

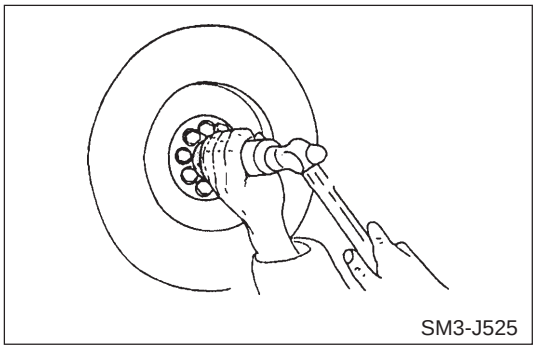

SM3-J525

Fig. 34

5. INSTALL THE FLYWHEEL ASSEMBLY.

1. Make sure that there are no burns or dirt on the contact surface or in the threaded holes of the crankshaft or fly-wheel.
2. Insert the special tool onto the crankshaft.

Special tool: Guide bar (09481 - 1340)

NOTE: Place one guide bar at the collar knock and another at the opposite side of the collar knock.

3. Insert the flywheel slowly until it contacts the collar knock to prevent impact on the guide bar. Adjust the position. Then, insert it completely.

WARNING

The flywheel is heavy. When installing, be careful not to drop it on your feet.

4. Apply clean engine oil to the threads of the flywheel bolt and the flywheel bolt seat. Be sure to tighten two or three threads provisionally by hand. Then, tighten the flywheel bolts (8) with a low-torque impact wrench.
5. Pull out the guide bar and tighten the remaining two fly-wheel bolts provisionally as in step 4.
6. Tighten the flywheel bolts in the order shown in the figure to the specified torque below.

Tightening torque: 1,900 kg·cm (137 lb·ft)

7. Loosen all bolts and tighten them again to the specified torque.

Tightening torque: 1,900 kg·cm (137 lb·ft)

8. Measure the sliding surface play of the flywheel.
   Measure the sliding surface play of the flywheel with a dial gauge. If the play exceeds the service limit, resurface the sliding surface.

Service limit: 0.2 mm (0.0079 in.)
0.3 mm (0.0118 in.) for model SG only

9. Install the pilot bearing.

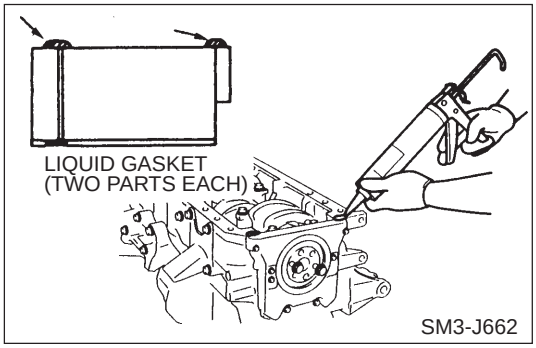


Fig. 35

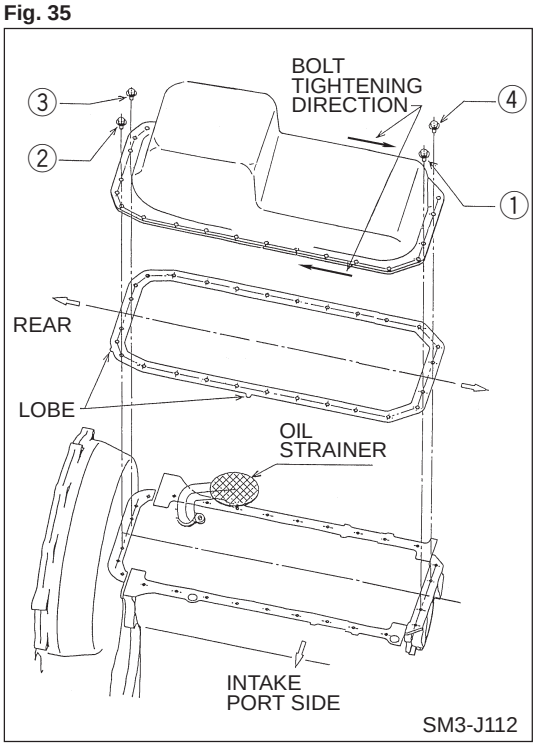


Fig. 36

6. INSTALL THE OIL PAN.

1. Make sure that there is no deformation, impact marks or foreign particles on the mounting surface and stiffener surface of the oil pan.
2. Place a guide pin of 70 mm(2.7559 in.) or longer in the cylinder block.
3. Apply liquid gasket to the front and back ends of the cylinder block lower surface.

Liquid gasket: ThreeBond No.1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

4. Install the oil pan gasket so that the protrusion is at the flywheel housing side and the print seal surface is at the cylinder block side.
5. Install the oil pan.

NOTE:

- ○ **Install the oil pan along the guide pin.**
- ○ **If left more than 20 minutes, clean off the liquid gasket completely and reapply the liquid gasket.**
- ○ **Refer to page 3-20-1.**

6. Tighten the oil pan installation bolts in the order ①-②-③-④ as shown in the figure with an impact wrench.

Tightening torque: 250 - 300 kg·cm (18 - 21 lb·ft)

7. Finish tightening the bolts in the order shown in the figure with a torque wrench to the specified torque.

Tightening torque: 300 kg·cm (22 lb·ft)

NOTE: Make sure that the washer is not on the flange.

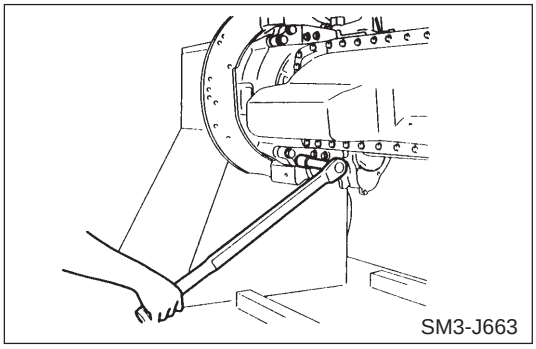


Fig. 37

7. INSTALL THE FLYWHEEL HOUSING STAYS.

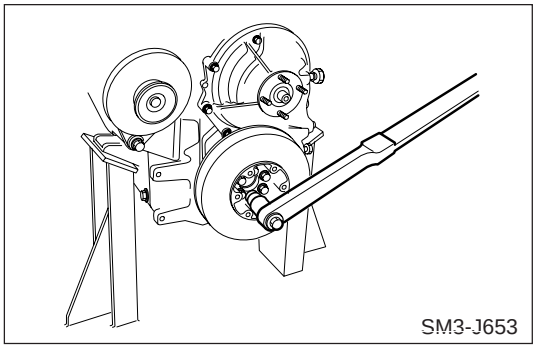


Fig. 38

8. INSTALL THE TORSIONAL DAMPER.

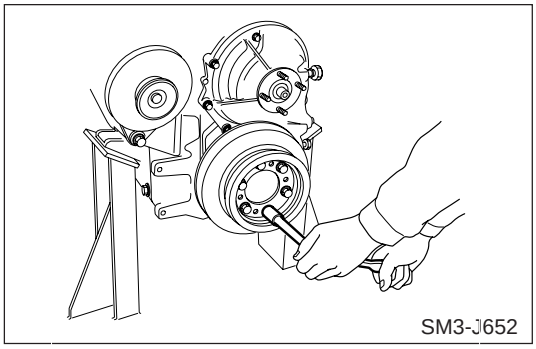
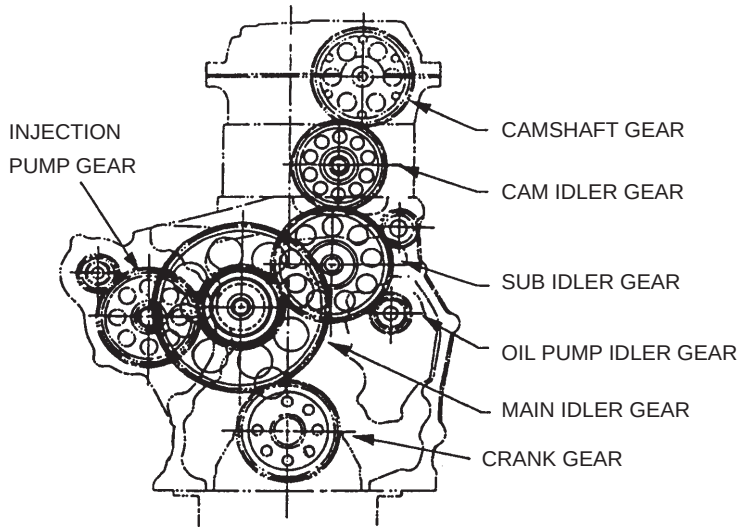


Fig. 39

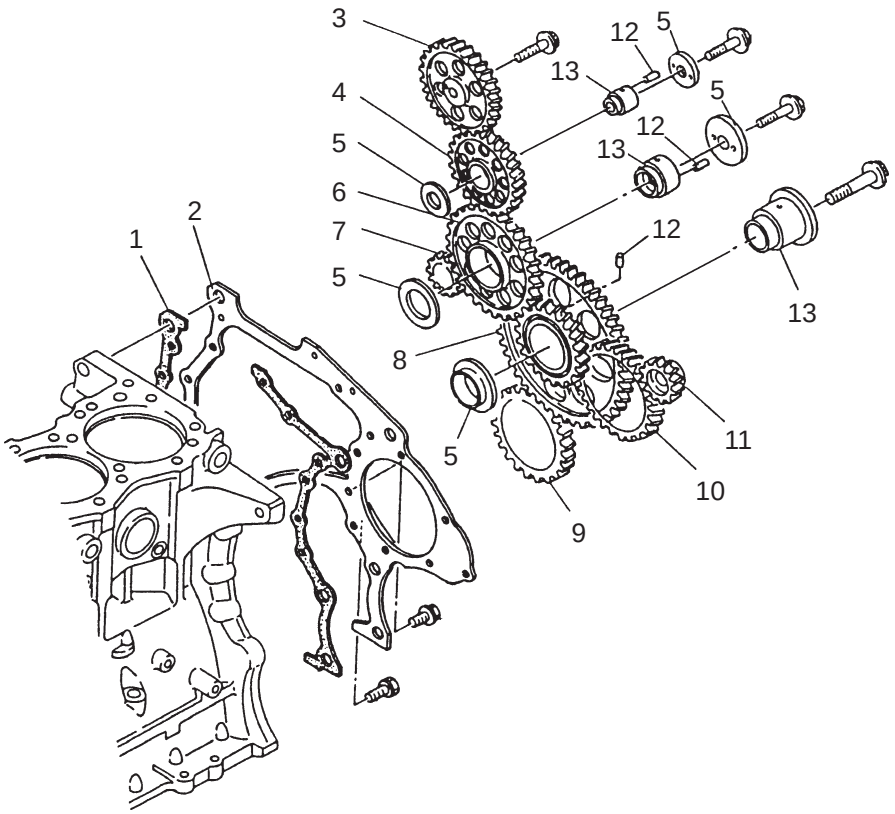
9. INSTALL THE CRANKSHAFT PULLEY.

TIMING GEAR



SM3-J136

Fig. 1



1. Gasket
2. Rear end plate
3. Camshaft gear
4. Camshaft idler gear
5. Idler gear thrust plate
6. Sub idler gear
7. Oil pump gear
8. Main idler gear
9. Crankshaft gear
10. Injection pump drive gear
11. Power steering pump drive gear
12. Pin
13. Idler gear shaft

SM3-J130

Fig. 2

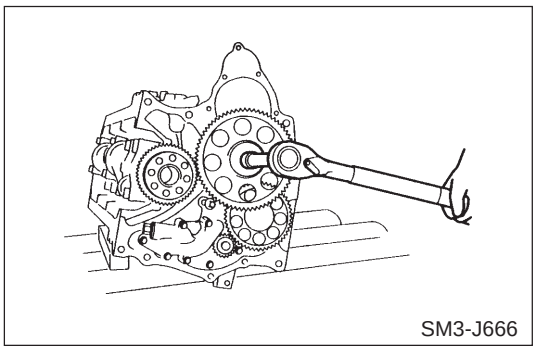

SM3-J666

Fig. 3

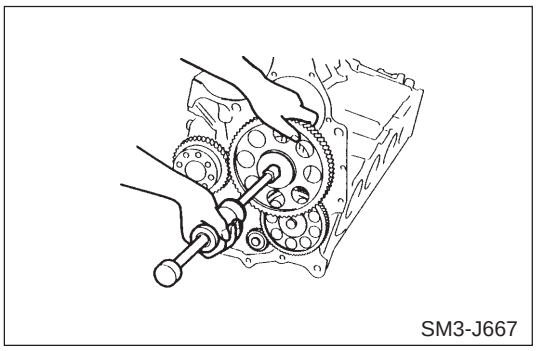

SM3-J667

Fig. 4

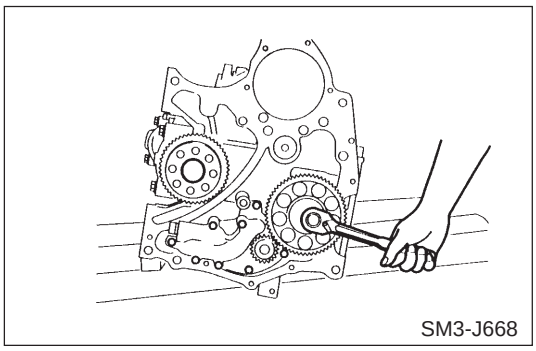

SM3-J668

Fig. 5

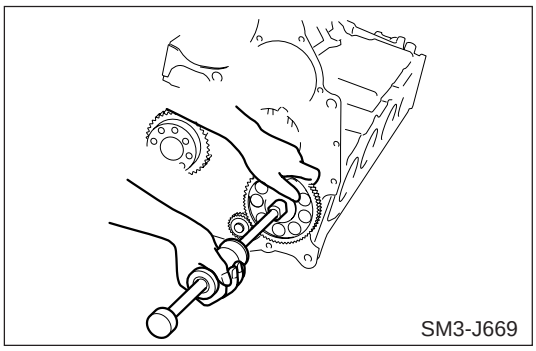

SM3-J669

Fig. 6

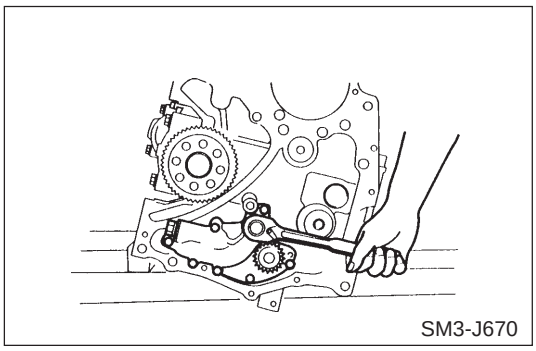

SM3-J670

Fig. 7

DISMOUNTING

1. REMOVE THE MAIN IDLER GEAR.

1. Remove the mounting bolts of the main idler gear shaft.
2. Remove the main idler gear.
3. Remove the main idler gear shaft with the special tool.

Special tool: Sliding hammer (09420 - 1100)

2. REMOVE THE SUB IDLER GEAR.

1. Remove the mounting bolts of the sub idler gear shaft.
2. Remove the sub idler gear.
3. Remove the sub idler gear shaft with the special tool.

Special tool: Sliding hammer (09420 - 1100)

3. REMOVE THE OIL PUMP ASSEMBLY.

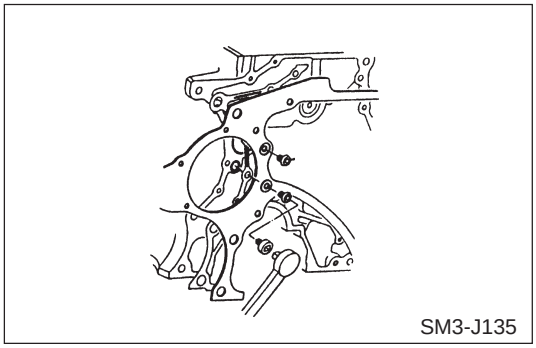


Fig. 8

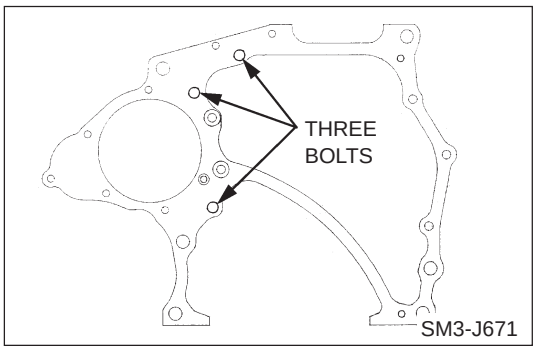


Fig. 9

4. REMOVE THE REAR END PLATE.

1. Remove two torx bolts adjacent to the air compressor mounting section using the special tool.

Special tool: Socket wrench (09411 - 1300)

2. Remove three bolts shown in the figure.

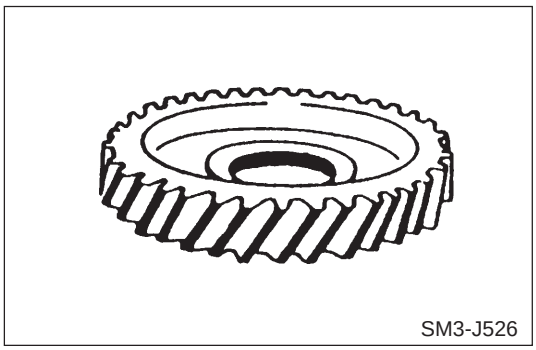

SM3-J526

Fig. 10

INSPECTION AND REPAIR

INSPECT THE GEAR TEETH FOR PITTING OR WEAR.

Visually check the gears for pitting or wear. If a gear is damaged, replace the gear.

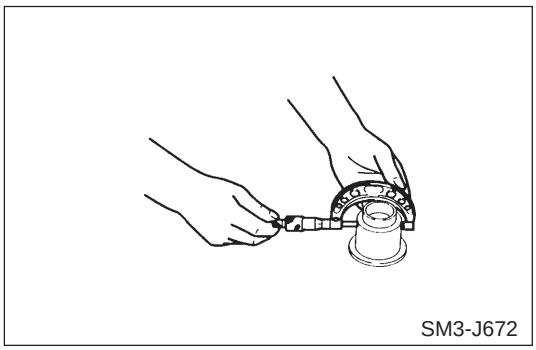

SM3-J672

Fig. 11

MEASURE THE CLEARANCE BETWEEN THE IDLER GEAR BUSHING AND SHAFT.

1. Using a micrometer, measure the outside diameter of the main idler gear shaft. If the diameter exceeds the service limit, replace the main idler gear shaft.

Nominal dimension: $57.0^{-0.03}_{-0.06}$ mm ($2.2441^{-0.0012}_{-0.0024}$ in.)
Service limit: 56.94 mm (2.2417 in.)

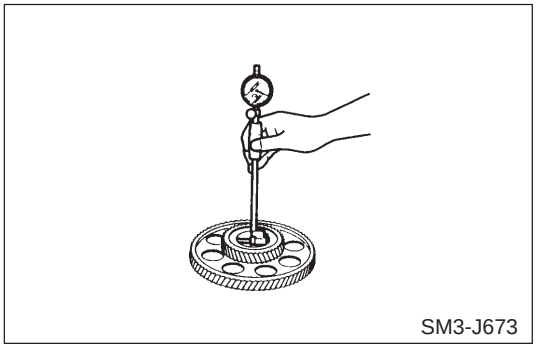
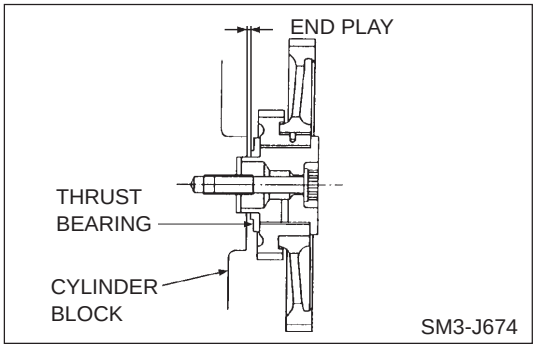

SM3-J673

Fig. 12

2. Using a cylinder gauge, measure the inside diameter of the main idler gear bushing.
3. Calculate the clearance from the above measurement.

If the clearance exceeds the repair limit, replace the main idler gear shaft and/or main idler gear bushing.

Assembly standard: 0.030 - 0.090 mm (0.0012 - 0.0035 in.)
Repair limit: 0.20 mm (0.0079 in.)



SM3-J674

Fig. 13

MEASURE THE IDLER GEAR END PLAY OF THE MAIN IDLER GEAR.

Using a dial gauge, measure the clearance between the main idler gear and thrust bearing. If the clearance exceeds the repair limit, replace the thrust bearing.

Assembly standard: 0.114 - 0.160 mm (0.0045 - 0.0062 in.)
Repair limit: 0.20 mm (0.0079 in.)

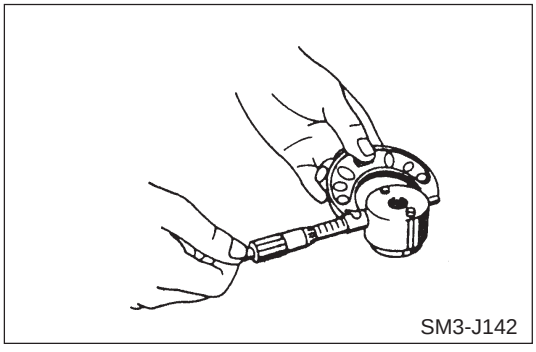

SM3-J142

Fig. 14

MEASURE THE CLEARANCE BETWEEN THE SUB IDLER GEAR SHAFT AND SUB IDLER GEAR BUSHING.

1. Using a micrometer, measure the outside diameter of the sub idler gear shaft. If the diameter exceeds the service limit, replace the sub idler gear shaft.

Nominal dimension: $50.0^{-0.025}_{-0.05}$ mm ($1.969^{-0.0010}_{-0.0020}$ in.)
Service limit: 49.95 mm (1.967 in.)

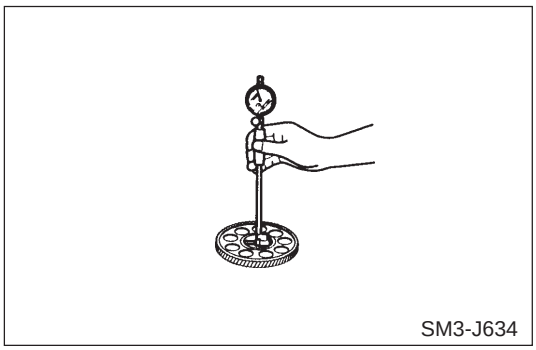


Fig. 15

2. Using a cylinder gauge, measure the inside diameter of the sub idler gear bushing. If the diameter exceeds the service limit, replace the sub idler gear.

Nominal dimension: 50.0 $^{+\ 0.03}_{+\ 0}$ mm (1.969 $^{+\ 0.0012}_{+\ 0}$ in.)

Service limit: 50.03 mm (1.970 in.)

3. Calculate the clearance from the above measurement.

If the clearance exceeds the repair limit, replace the sub idler gear shaft and/or sub idler gear bushing.

Assembly standard: 0.025 - 0.075 mm (0.0010 - 0.0029 in.)

Repair limit: 0.20 mm (0.0079 in.)

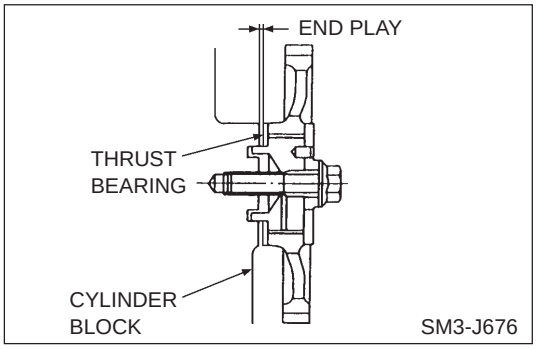


Fig. 16

MEASURE THE IDLER GEAR END PLAY OF THE SUB IDLER GEAR.

Using a dial gauge, measure the clearance between the sub idler gear and thrust bearing. If the clearance exceeds the repair limit, replace the thrust bearing.

Assembly standard: 0.040 - 0.095 mm (0.0016 - 0.0037 in.)

Repair limit: 0.30 mm (0.0118 in.)

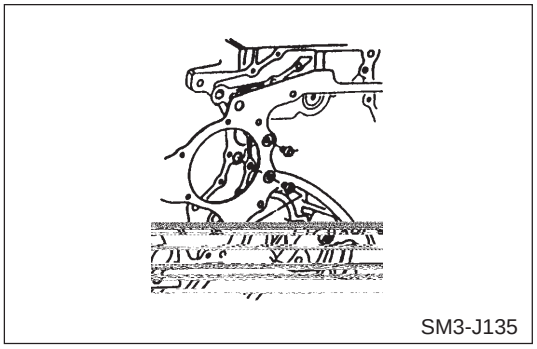

SM3-J135

Fig. 17

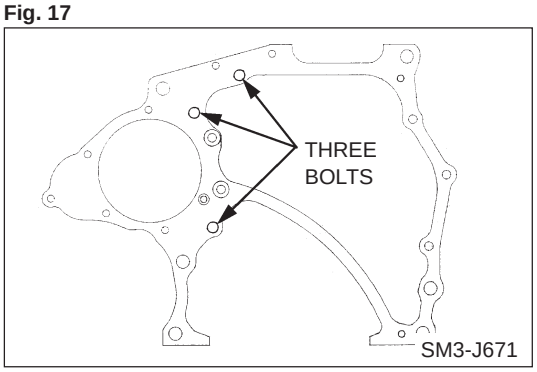


Fig. 18

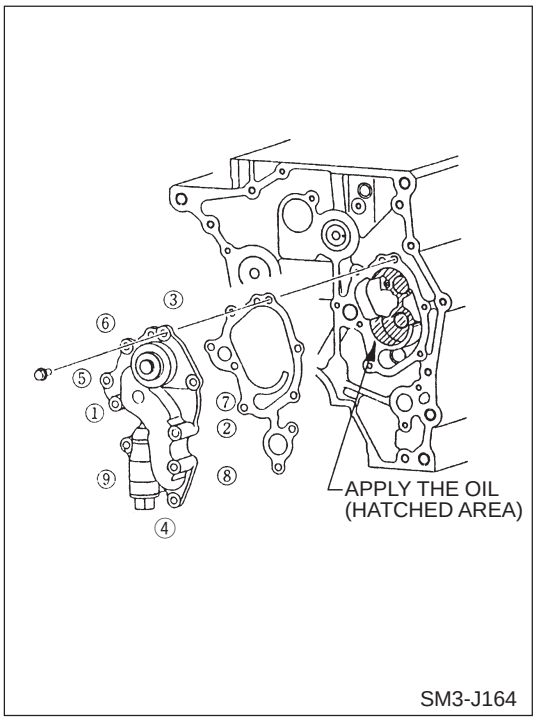


Fig. 19

MOUNTING

1. INSTALL THE REAR END PLATE.

1. Using the special tool, tighten two torx bolts adjacent to the air compressor mounting section to the specified torque below.

Special tool: Socket wrench (09411 - 1300)

Tightening torque: 560 kg·cm (41 lb·ft)

2. Tighten the three bolts shown in the figure to the specified torque below.

Tightening torque: 560 kg·cm (41 lb·ft)

2. INSTALL THE OIL PUMP ASSEMBLY.

1. Apply oil to the pump case and bearings of the block (hatched area) before installing the oil pump.

NOTE: Not applying oil may cause oil suction failure at start-up, resulting in seizure and abnormality.

2. To prevent misalignment of the gasket, apply grease to the gasket matching face of the block. Then, place and fix the gasket.
3. Tighten the oil pump mounting bolts provisionally in the order as shown in the figure. Then retighten them to the specified torque below.

Tightening torque: 290 kg·cm (21 lb·ft)

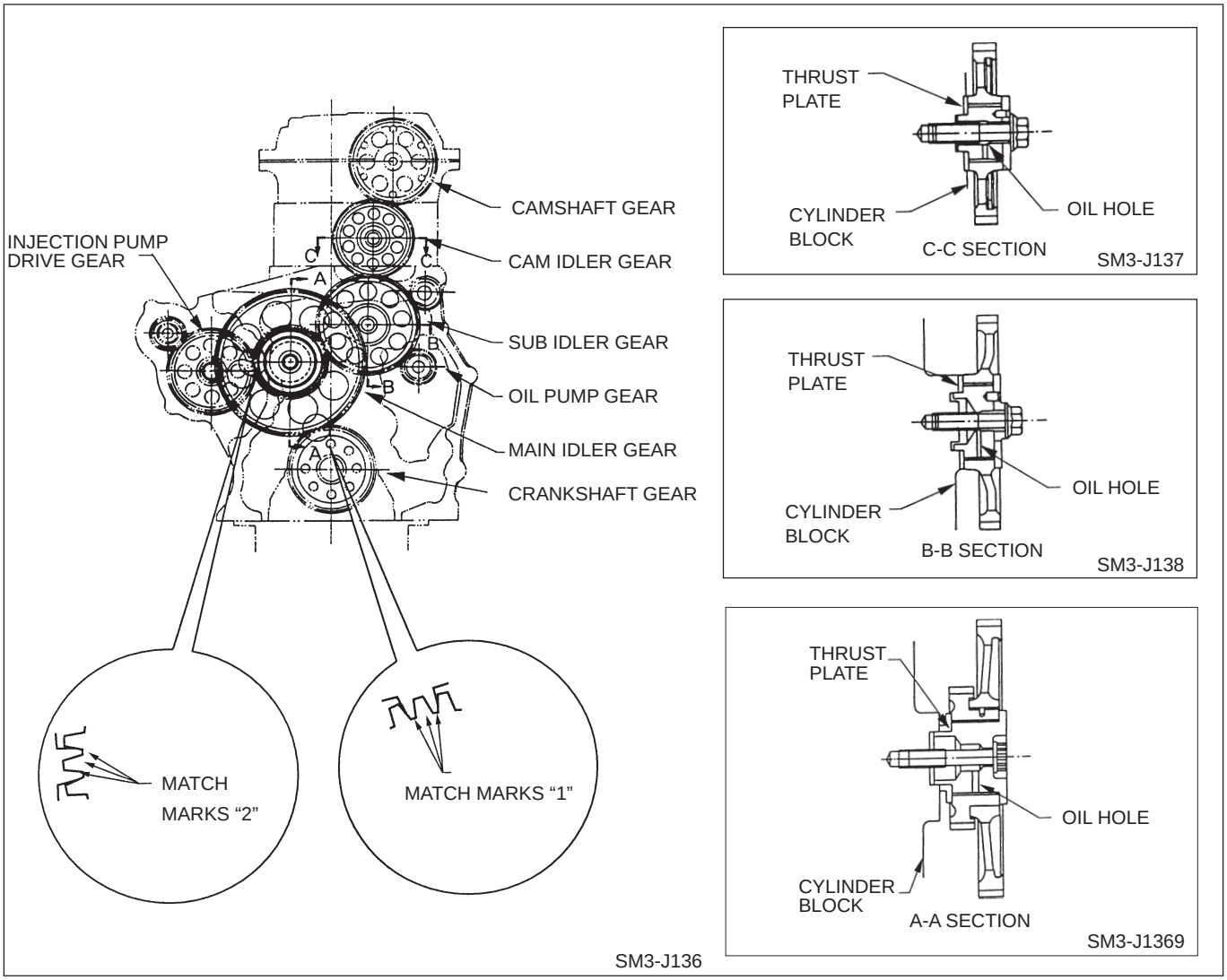


Fig. 20

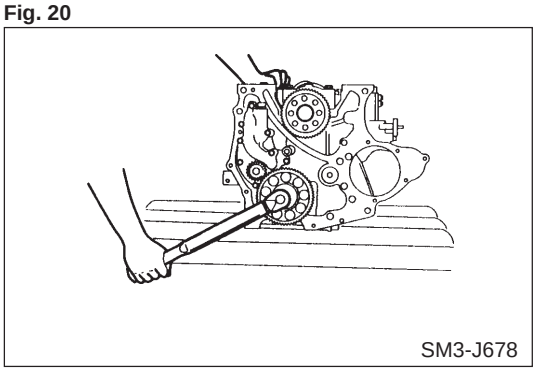


Fig. 21

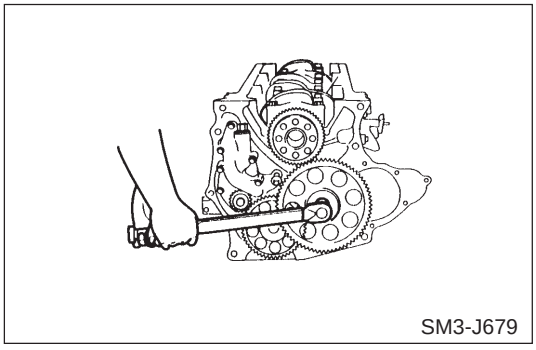


Fig. 22

3. INSTALL THE SUB IDLER GEAR.

1. Install the sub idler gear shaft through the thrust plate so that the lubrication hole faces downward.
2. Install the sub idler gear.
3. Tighten the mounting bolts of the sub idler gear shaft to the specified torque below.

Tightening torque: 1,100 kg·cm (80 lb·ft)

4. INSTALL THE MAIN IDLER GEAR.

1. Install the main idler gear shaft through the thrust plate so that the lubrication hole faces downward.
2. Install the main idler gear.

NOTE:

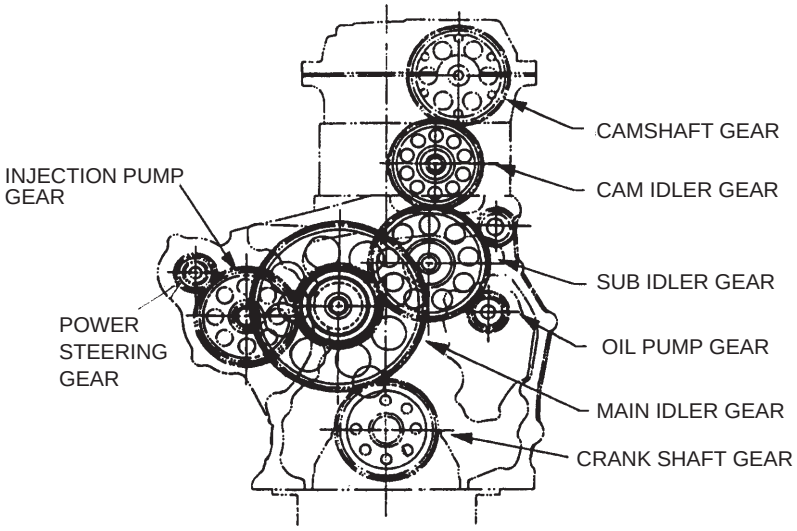
- **Apply engine oil to the contact surface of the idler gear and idler gear shaft before installation.**
- **Adjust the timing of the main idle gear to align with the injection pump gear (air compressor gear).**

3. Tighten the mounting bolts of the main idler gear shaft to the specified torque below.

Tightening torque: 1,750 kg·cm (127 lb·ft)

5. MEASURE THE TIMING GEAR BACKLASH

Using a dial gauge, measure the backlash between the gears. If the backlash exceeds the limit, replace the gear.



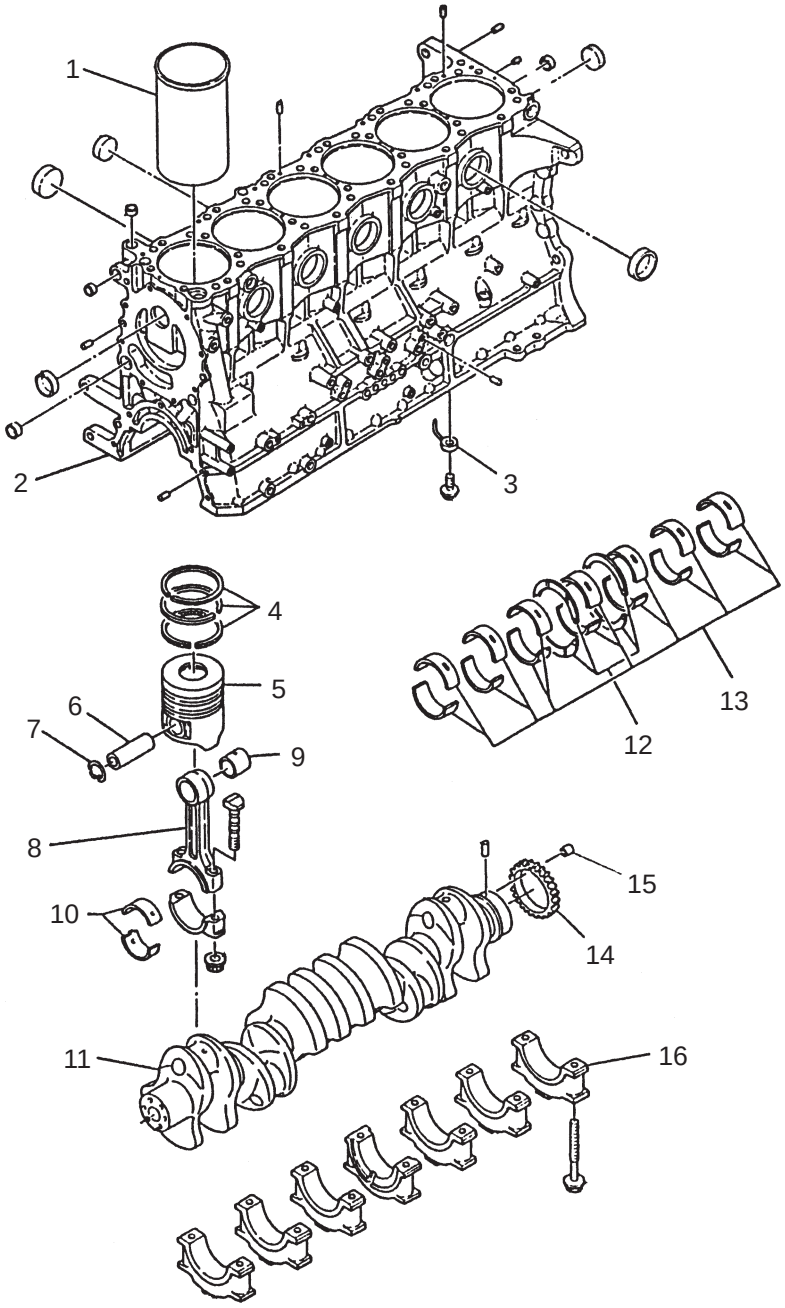
SM3-J136A

Fig. 23

Unit: mm (in.)

Inspection item	Standard	Limit
Crankshaft - Main idle	0.030 - 0.132 (0.0012 - 0.0051)	0.30 (0.0118)
Main idle - Injection pump	0.030 - 0.218 (0.0012 - 0.0085)	0.30 (0.0118)
Injection pump - PS pump	0.030 - 0.183 (0.0012 - 0.0072)	0.30 (0.0118)
Main idle - Sub idle	0.030 - 0.162 (0.0012 - 0.0063)	0.30 (0.0118)
Sub idle - Oil pump	0.030 - 0.131 (0.0012 - 0.0051)	0.30 (0.0118)
Sub idle - Cam idle	0.050 - 0.218 (0.0020 - 0.0085)	0.30 (0.0118)
Cam idle - Cam	0.030 - 0.253 (0.0012 - 0.0099)	0.30 (0.0118)

PISTON, CRANKSHAFT AND CYLINDER BLOCK



1. Cylinder liner
2. Cylinder block
3. Oil jet pipe
4. Piston ring
5. Piston
6. Piston pin
7. Retainer ring
8. Connecting rod
9. Connecting rod bushing
10. Connecting rod bearing
11. Crankshaft
12. Crankshaft thrust bearing
13. Crankshaft main bearing
14. Crankshaft gear
15. Collar
16. Main bearing cap

SM3-J276

Fig. 1

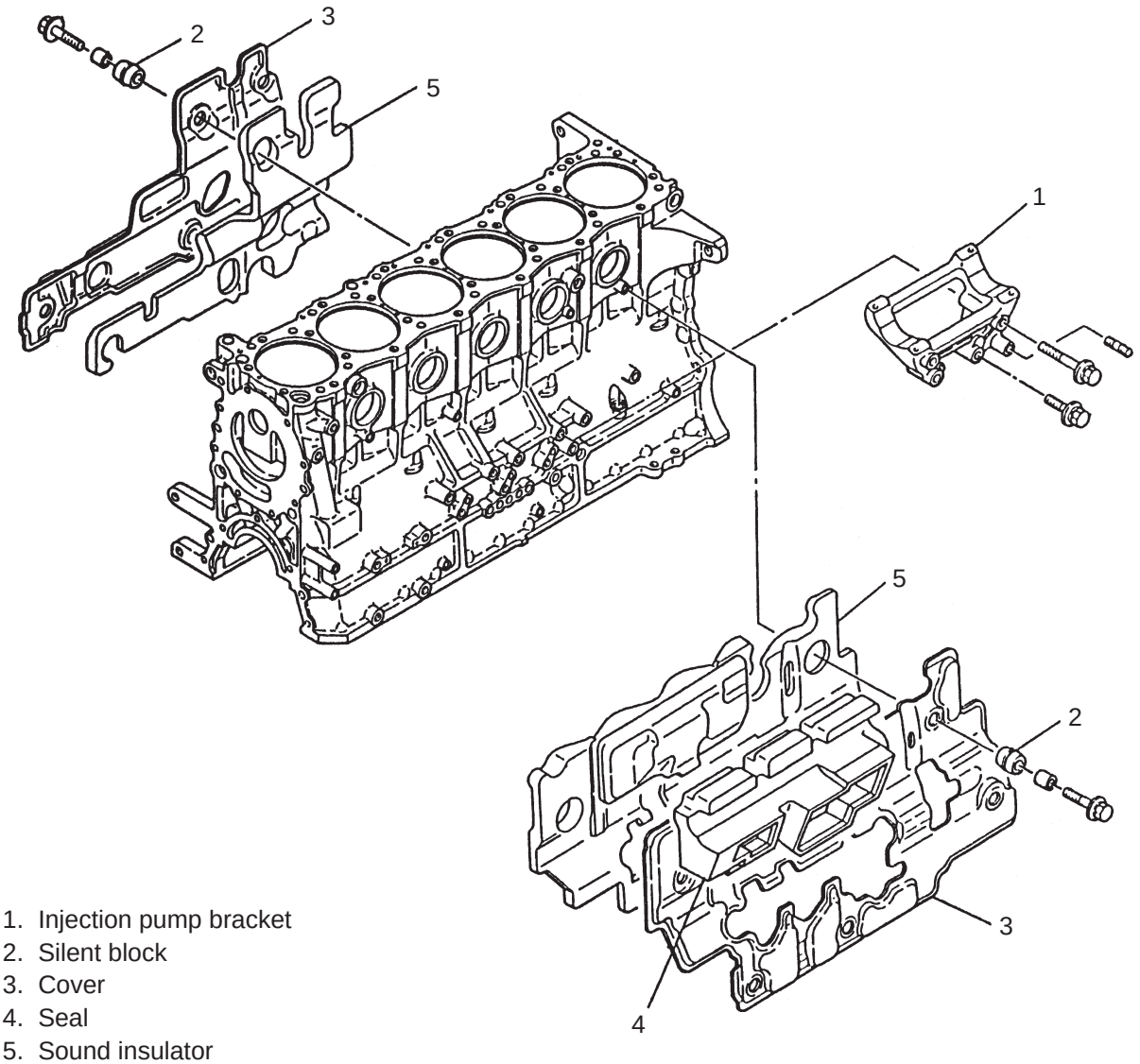

2
3
5
1
5
2
3
4
1. Injection pump bracket
2. Silent block
3. Cover
4. Seal
5. Sound insulator
SM3-J277

Fig. 2

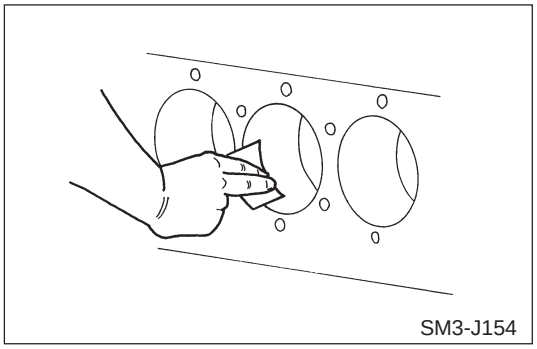

SM3-J154

Fig. 3

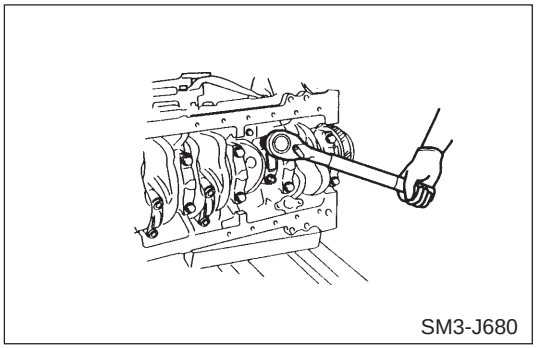

SM3-J680

Fig. 4

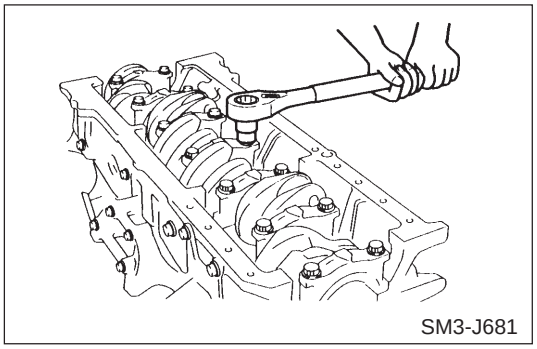

SM3-J681

Fig. 5

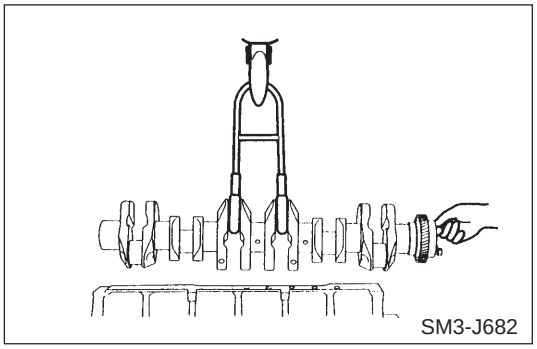

SM3-J682

Fig. 6

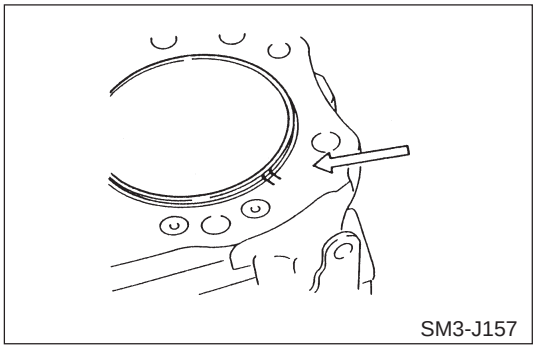

SM3-J157

Fig. 7

DISMOUNTING

1. REMOVE THE PISTONS ALONG WITH THE CONNECTING RODS.

Remove the connecting rod bearing cap mounting bolts and pull out the pistons along with the connecting rods from the cylinder block upper side.

NOTE:

- **Before pulling out the pistons, remove carbon deposits from the upper end inside the cylinder liner with a scraper or emery paper (recommended: No. 150), working in a circular direction.**
- **When pulling out the pistons, be careful that the insides of the cylinder liners are not damaged by the connecting rod big ends.**
- **When pulling out the pistons, be careful that the nozzle of the cooling jet is not bent by the connecting rod big ends. If the nozzle is bent, be sure to readjust the cooling jet sight.**
- **When pulling out the pistons, be careful not to drop the crankpin bearings from the connecting rod big ends, which may cause deformation or damage.**
- **Arrange the removed parts in order of the cylinder numbers. Be careful not to change the combination of the connecting rod and cap.**
- **Two pistons can be removed at a time. (Nos. 1 and 6, Nos. 2 and 5, and Nos. 3 and 4).**

2. REMOVE THE CRANKSHAFT.

Remove the main bearing cap mounting bolts, then remove the crankshaft.

3. REMOVE THE CYLINDER LINER.

NOTE: Before removing the piston, put alignment marks on the cylinder liner and cylinder block using a marking pen. The cylinder liner is bent by "run-in". When reusing the cylinder liner, misalignment with the cylinder block may concentrate stress on the thin part of the cylinder liner and it may break.

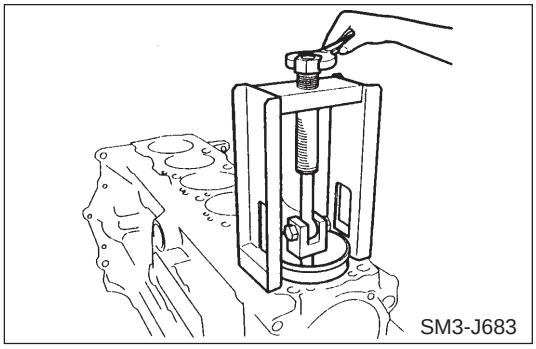


Fig. 8

1. The cylinder liner can be pulled out by hand. If this is difficult, use the special tool.

NOTE: Arrange the removed parts in order of the cylinder numbers.

4. CLEAN THE CYLINDER BLOCK AS FOLLOWS.

1. Rinse the cylinder block in a hot commercial alkaline solution, and remove oil from the cylinder block.

2. Remove the alkaline solution from the cylinder block using a steam cleaner.

3. If the water jacket is very dirty, clean it as follows:

a. Rinse the cylinder block in a commercial acid solution.

b. After rinsing it for a while, leave it in the solution for approximately 30 minutes.

c. Pull out the cylinder block. After the solution has drained off, re-immerse the cylinder block in the solution and leave it for approximately 10 minutes.

d. Repeat step c until deposits are removed.

e. Remove the acid solution with hot water.

f . Immerse the cylinder block in the alkaline solution to neutralize the acid.

g. Finish by cleaning with the steam cleaner.

4. When the cooling water passage and oil passage are cleaned completely, dry the cylinder block, press-fit a new blank cap and apply liquid gasket.

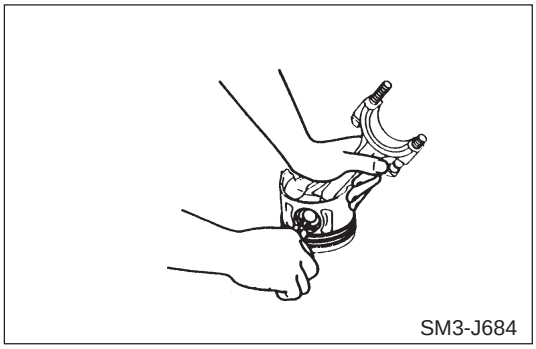

SM3-J684

Fig. 9

DISASSEMBLING

REMOVE THE CONNECTING ROD.

1. Remove the retainer rings from both ends of the piston pin using snap ring pliers.

WARNING
Removing the retainer rings may cause the retainer rings to fly up. Be sure to wear protective goggles.

2. Apply the reinforcing plate to the piston pin and punch out the piston pin using a hammer.

WARNING
Never touch the piston with your bare hands when it is hot.

NOTE: If it is difficult to punch out the piston pin, first immerse the piston and piston pin in hot water, 80 - 90°C (176 - 194°F), for approximately five minutes to facilitate removal.

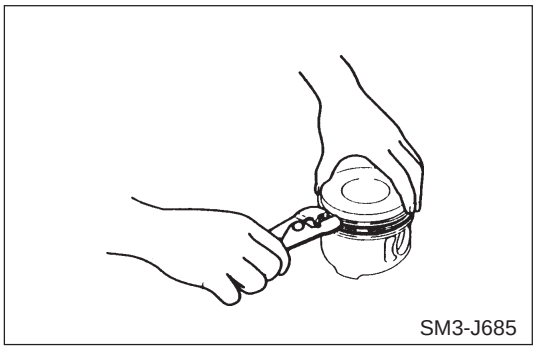

SM3-J685

Fig. 10

REMOVE THE PISTON RINGS.

1. Remove the piston ring using the special tool.

Special tool: Piston ring expander (09442 - 1011)

NOTE:

- **Handle the piston rings carefully because they are made of a special casting which is easily broken.**
- **Arrange the piston rings in order of cylinder numbers.**

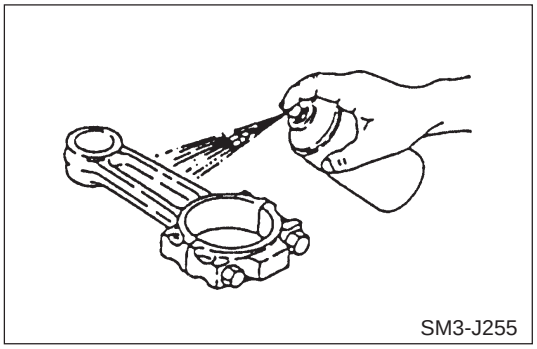

SM3-J255

Fig. 11

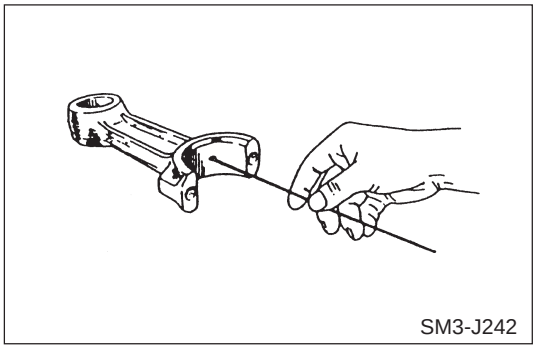

SM3-J242

Fig. 12

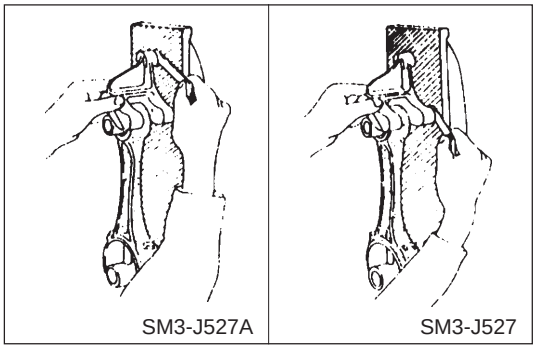

SM3-J527A SM3-J527

Fig. 13

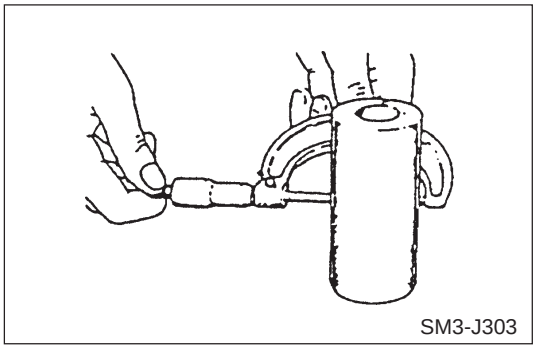

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Fig. 14

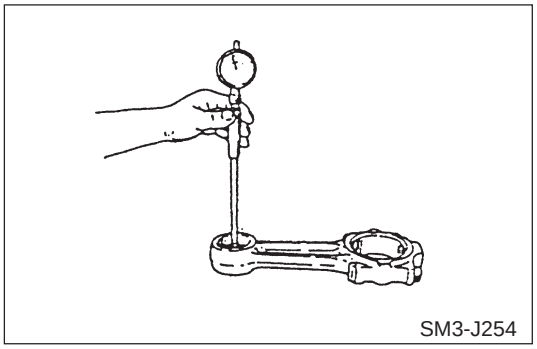
SM3-J254

Fig. 15

INSPECTION AND REPAIR

INSPECT THE CONNECTING ROD.

1. Check the connecting rod for cracks or damage using dye penetrant examination or magnetic particle examination. If there are any cracks or damage, replace the connecting rod with a new one.

2. Check that there is no clogging in the lubrication passage to the connecting rod small end. If there is any clogging, blow air through the lubrication passage using an air gun, or clean by inserting a wire.

3. Measure bend or distortion of the connecting rod using a connecting rod aligner. If the value exceeds the limit, replace the connecting rod with a new one.

Limit:

Bend of connecting rod: 0.05 mm (0.0020 in.) for each 100 mm (3.94 in.)

Distortion of connecting rod: 0.05 mm (0.0020 in.) for each 100 mm (3.94 in.)

INSPECT THE PISTON PIN AND CONNECTING ROD BUSHING.

1. Measure the piston pin outside diameter using a micrometer. If the value exceeds the limit, replace the piston pin with a new one.

NOTE: Never grind the piston pin because the surface is treated.

Standard: 37 mm (1.4567 in.)

Limit: 36.96 mm (1.4551 in.)

2. Measure the connecting rod bushing inside diameter using a cylinder gauge. If the value exceeds the limit, replace the connecting rod bushing with a new one.

Standard: 37 mm (1.4567 in.)

Limit: 37.1 mm (1.4606 in.)

3. Calculate the clearance between the piston pin and piston pin bushing.
   If the value exceeds the limit, replace the piston pin with a new one.

Standard: 0.015 - 0.036 mm (0.0006 - 0.0014 in.)

Limit: 0.08 mm (0.0031 in.)

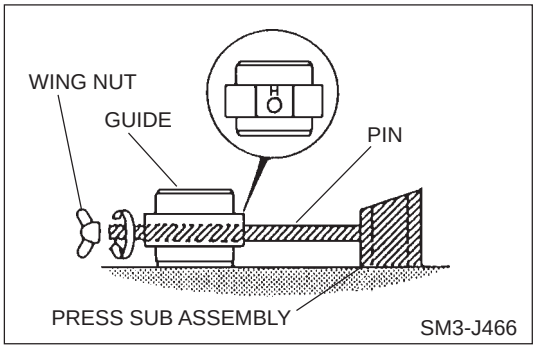

Fig. 16

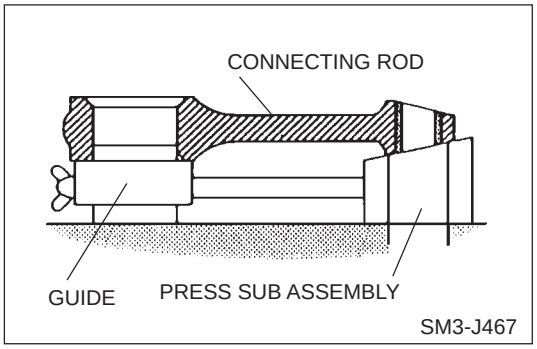

Fig. 17

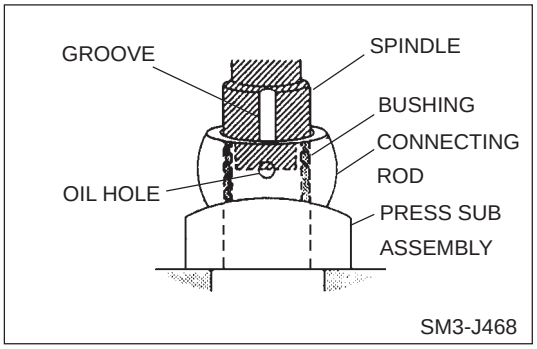

Fig. 18

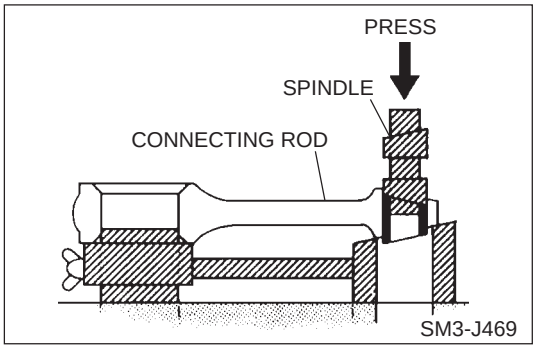

Fig. 19

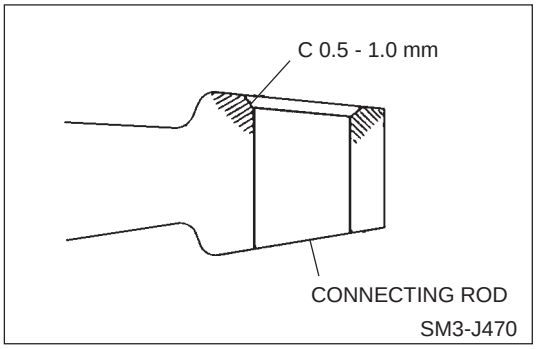

Fig. 20

REPLACE THE PISTON PIN BUSHING.

1. Prepare the special tools.
   Assemble the guide and press sub-assembly inserting its pin into the guide then secure them with the wing nut.

Special tool: Guide (09481 - 1130)
Press sub - assembly (09402 - 1530)
Wing nut (9233 - 10360)

NOTE:

- **Bring lever “H” punched on the guide above the pin.**
- **Making sure to align both supporting surfaces of the guide and press sub-assembly flush on a flat plane.**

2. Using the special tool, remove the piston pin bushing.

a. Set the connecting rod assembled without crank pin bore bearing on the guide and press sub-assembly.

b. Install the spindle into the bushing.

Special tool: Spindle (09402 - 1540)

NOTE: Align the grooving of the spindle with the oil hole of the bushing.

c. Using a hydraulic press, remove the bushing.

NOTE: Always operate the press slowly and smoothly.

3. Assemble the piston pin bushing.
   Chamfer one edge of the bushing hole at the small end of the connecting rod uniformly by C 0.5 - 1.0 mm (0.0196 - 0.0393 in.).

NOTE:

- **Irregular chamfering can cause out-of-roundness of the pressed bushing, which may result in jamming during insertion.**
- **Remove dust from the inner surface of the smaller hole.**

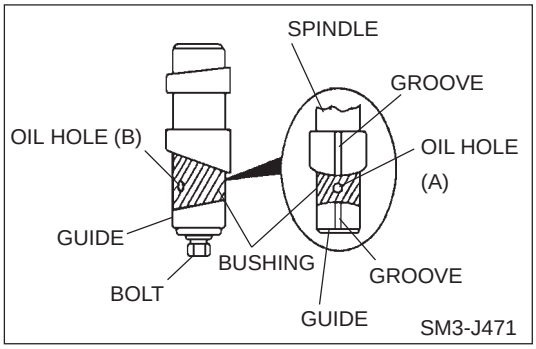

Fig. 21

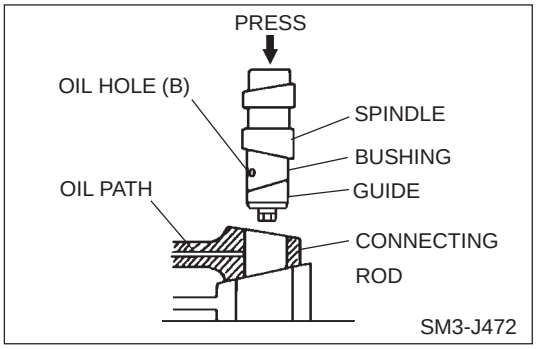

Fig. 22

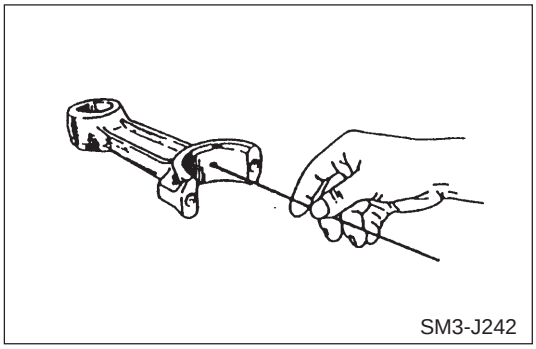

Fig. 23

4. Mount the bushing on the spindle

a. Set the bushing and guide on the spindle, then secure them with the bolt.

Special tool: Spindle (09402 - 1540)
Guide (09481 - 1540)
Bolt (9191 - 08252)

NOTE: Align oil hole (A) in the bushing with both groove or the spindle and guide, making sure oil hole (B) will meet with oil path in the connecting rod led from crank pin bore in the rod.

Tightening torque: 50 - 70 kg·cm (3.61 - 5.06 lb·ft)

b. Apply fresh engine oil around the bushing and guide.

5. Install the bushing in the connecting rod.

Position the bushing tool assembly so that oil hole (B) align with the oil path through the connecting rod.

Before installing, fully coat the bore in the connecting rod with fresh engine oil.

6. Inspect the bushing positioning after installation.

a. Make sure that the oil hole of the bushing and the oil path of the connecting rod are suitably aligned allowing a 6 mm (0.23 in.) diameter rod to penetrate.

NOTE: Misalignment can lead to insufficient lubrication, which may result in seizure.

b. Make sure that with a new piston pin inserted in the piston pin, the bushing can be rotated by hand without rattling.

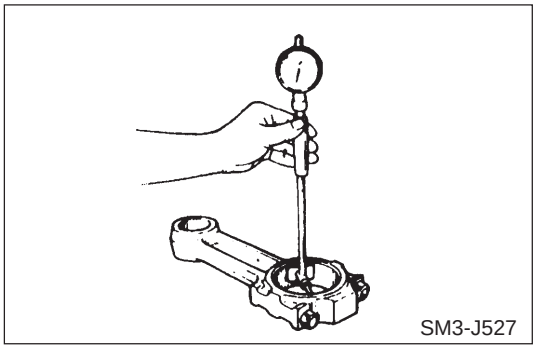
SM3-J527

Fig. 24

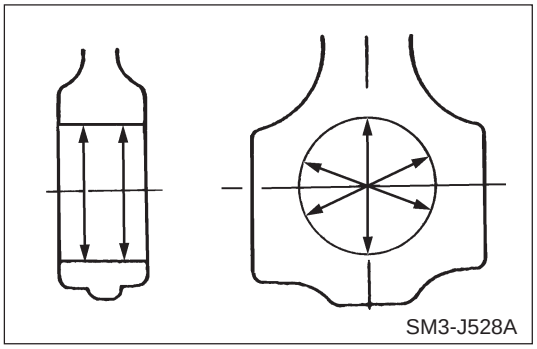
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Fig. 25

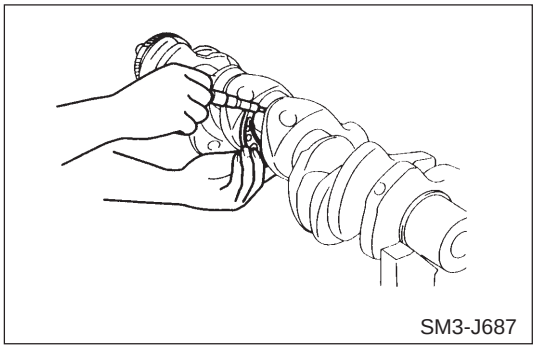
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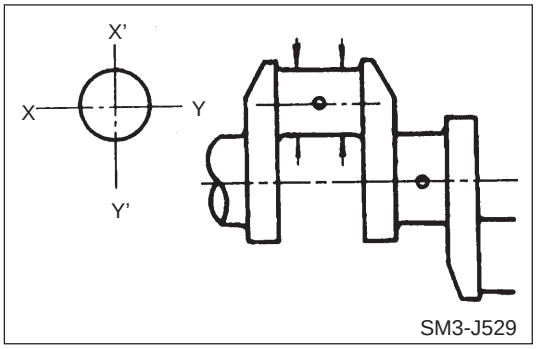
Fig. 26



SM3-J529

Fig. 27

MEASURE THE ROUNDNESS OF THE CONNECTING ROD BIG END.

After tightening the connecting rod cap, measure the inside diameter of the connecting rod big end using a cylinder gauge to calculate the roundness.

Standard: 68.985 - 69 mm (2.7159 - 2.7165 in.)

Limit: 0.06 mm (0.0024 in.)

NOTE: For tightening of the connecting rod cap, refer to page 3-9-22.

MEASURE THE CLEARANCE BETWEEN THE CRANKPIN AND CONNECTING ROD BEARING.

1. Measure the crankpin outside diameter using a micrometer.

Standard: 65.0 mm (2.559 in.)

Limit: 64.30 mm (2.5315 in.)

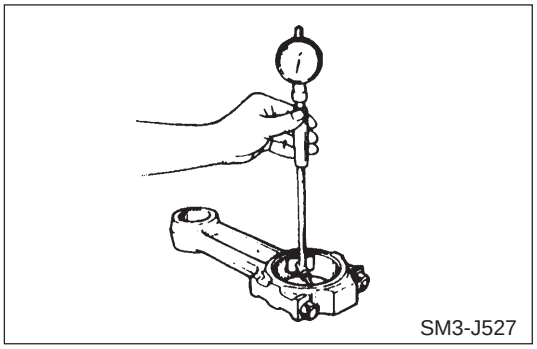

SM3-J527

Fig. 28

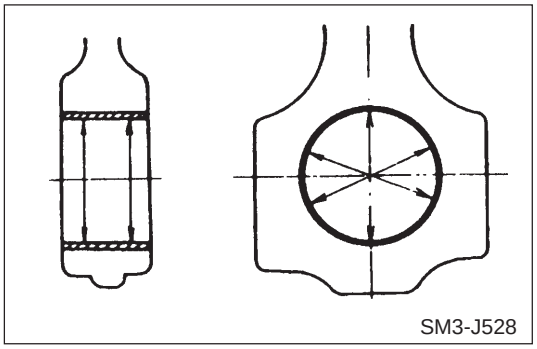

SM3-J528

Fig. 29

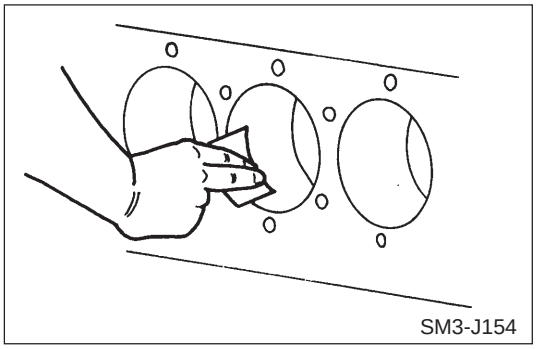

SM3-J154

Fig. 30

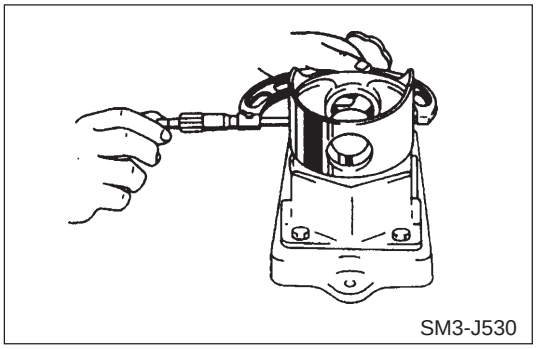
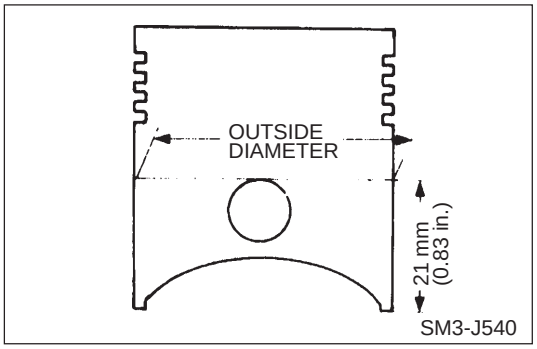

SM3-J530

Fig. 31



SM3-J540

Fig. 32

2. Measure the connecting rod bearing inside diameter using a cylinder gauge.

Standard: 65 mm (2.559 in.)

3. Calculate the clearance between the crankpin and connecting rod bearing. If the value exceeds the limit, grind the crankpin to the specified undersize below to correct. Replace the connecting rod bearing with the correct one.

Standard: 0.031 - 0.082 mm (0.0012 - 0.0032 in.)

Limit: 0.2 mm (0.0079 in.)

Undersize machining dimension: Two sizes below 0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.)

NOTE: Make sure you replace the top and bottom connecting rod bearings as one set. The top and bottom connecting rod bearings must be profiled by roundness.

MEASURE THE CLEARANCE BETWEEN THE PISTON AND THE CYLINDER LINER.

NOTE: Before measurement, remove carbon deposits from the upper end inside the cylinder liner with a scraper or emery paper (recommended: No. 150), working in a circular direction. Make sure that there are no scratches inside the cylinder liner.

1. Measure the piston outside diameter at the following points using a micrometer. If the value exceeds the limit, replace the piston with a new one.

Standard: 114 mm (4.4882 in.)

Limit: 113.92 mm (4.4850 in.)

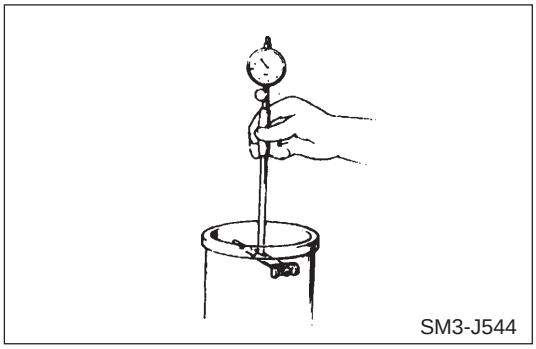

SM3-J544

Fig. 33

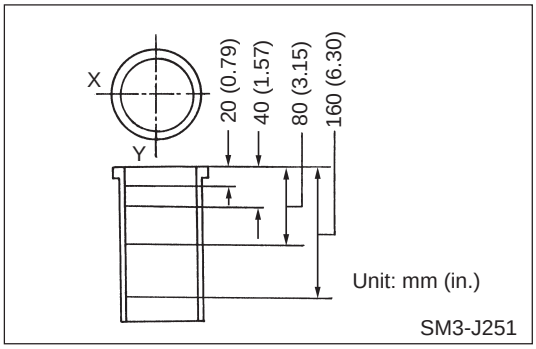


Fig. 34

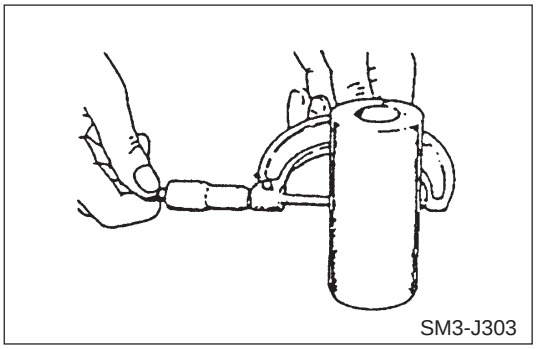

SM3-J303

Fig. 35

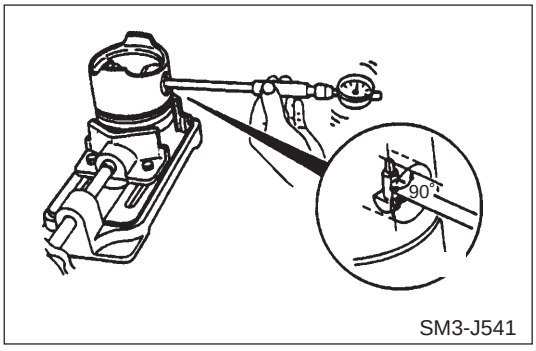


Fig. 36

2. Measure the cylinder liner inside diameter at the four points in the piston boss and thrust direction as shown in the figure using a cylinder gauge. If the value exceeds the limit, replace the cylinder liner with a new one.

Standard: 114 mm (4.4882 in.)
Limit: 114.15 mm (4.4941 in.)
NOTE:

- **Apply the value obtained at the most worn point to the cylinder liner inside diameter.**
- **If the cylinder liner is hardly worn, and when only the piston ring must be replaced, correct the corrugation at the top of cylinder liner.**

3. Measure the clearance between the piston and cylinder liner. If the value exceeds the limit, replace the cylinder liner with a new one.

NOTE: Apply the value obtained at the most worn point to the cylinder liner inside diameter.
Standard: 0.056 - 0.088 mm (0.0022 - 0.0034 in.)
Limit: 0.15 mm (0.0059 in.)

MEASURE THE CLEARANCE BETWEEN THE PISTON PIN AND THE PISTON PIN BOSS.

1. Measure the piston pin outside diameter using a micrometer. If the value exceeds the limit, replace the piston pin with a new one.

Standard: 37 mm (1.4567 in.)
Limit: 36.96 mm (1.4551 in.)

2. Measure the piston pin boss inside diameter using a cylinder gauge. If the value exceeds the limit, replace the piston with a new one.

Standard: 37 mm (1.4567 in.)
Limit: 37.05 mm (1.4587 in.)

3. Calculate the clearance between the piston pin and the piston pin boss. If the value exceeds the limit, replace the piston or piston pin.

Standard: -0.013T - 0.014L mm (-0.00051T - 0.00055L in.)
Limit: 0.05 mm (0.0019 in.)
NOTE: T = tightening allowance, L = clearance

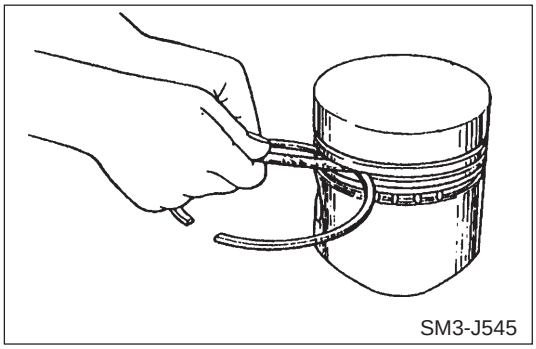

SM3-J545

Fig. 37

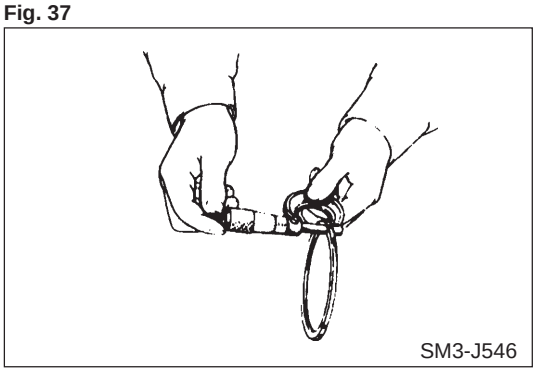

SM3-J546

Fig. 38

MEASURE THE CLEARANCE BETWEEN THE PISTON RING AND THE PISTON RING GROOVE.

Insert the piston ring into the piston ring groove and measure the clearance between the piston ring and piston ring groove using a feeler gauge. If the value exceeds the limit, measure the width of the piston ring and piston ring groove individually and replace any parts not meeting the limit with new ones.

Unit: mm (in.)

	Clearance		Ring thickness		Groove width	
	Assembly standard	Repair limit	Dimension	Service limit	Dimension	Service limit
Top ring	0.06-0.10 (0.0024-0.0039)	0.25 (0.0098)	2.5 (0.0984)	2.4 (0.0945)	2.5 (0.0984)	2.7 (0.1063)
2nd ring	0.04-0.08 (0.0016-0.0031)	0.25 (0.0098)	2.0 (0.0787)	1.9 (0.0748)	2.0 (0.0787)	2.2 (0.0866)
Oil ring	0.02-0.06 (0.0008-0.0023)	0.15 (0.0059)	4.0 (0.1575)	3.9 (0.1535)	4.0 (0.1575)	4.1 (0.1614)

Fig. 39

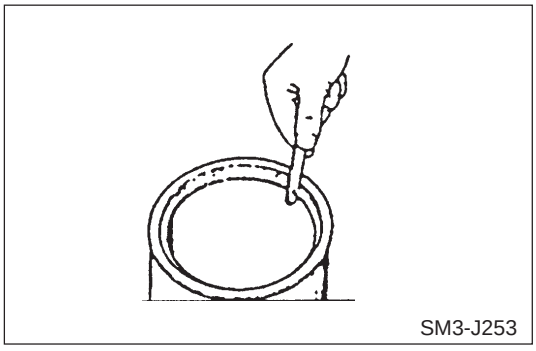

SM3-J253

Fig. 40

MEASURE THE MATCHING POINT CLEARANCE OF THE PISTON RING.

Fit the piston ring into the cylinder liner and measure the matching point clearance of the piston ring using a feeler gauge. If the value exceeds the limit, replace the piston ring with a new one.

Piston Ring Gap; Unit: mm (in.)

	Assembly standard	Service limit
Top ring	0.3 - 0.40 (0.0119 - 0.0157)	1.5 (0.0590)
2nd ring	0.3 - 0.45 (0.0119 - 0.0177)	1.2 (0.0472)
Oil ring	0.3 - 0.45 (0.0119 - 0.0177)	1.2 (0.0472)

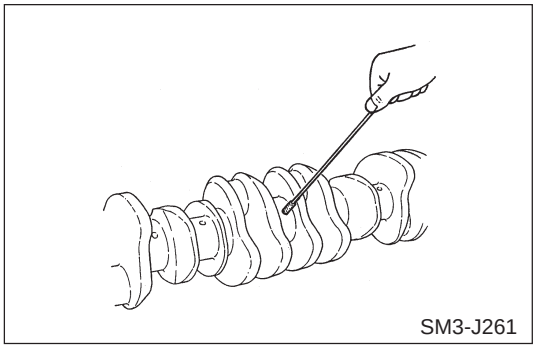

SM3-J261

Fig. 41

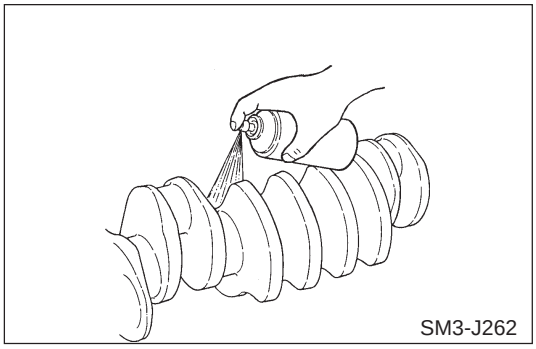

SM3-J262

Fig. 42

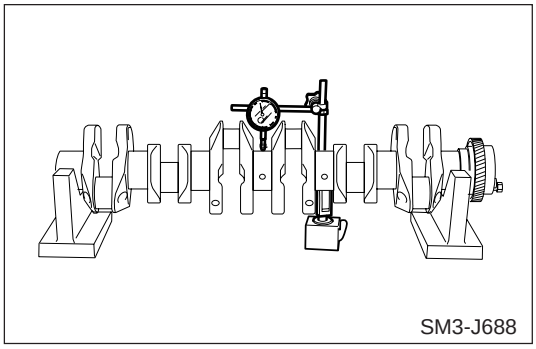

SM3-J688

Fig. 43

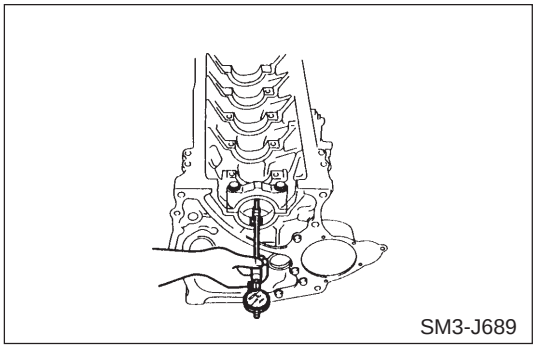
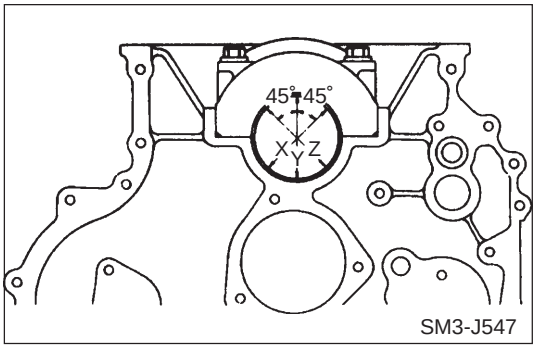

SM3-J689

Fig. 44



SM3-J547

Fig. 45

INSPECT THE CRANKSHAFT.

NOTE: Before inspection, clean the crankshaft with a commercial cleaning agent and clean the lubrication passage using an air gun.

1. Check the crankshaft for cracks using the dye penetrant test. If any are found, replace the crankshaft with a new one.

NOTE: Pay special attention to the finished R section and oil hole of the crank journal and crankpin.

2. Check the condition of the crank journal and crankpin visually for damage or wear. Grind the crank journal and crankpin to correct as required, or replace the crankshaft with a new one.

3. Support both end journals of the crankshaft with V blocks and measure the deflection of the crankshaft at the center journal using a dial gauge. If the value exceeds the limit, replace the crankshaft with a new one.

Limit: 0.15 mm (0.0059 in.)

MEASURE THE ROUNDNESS OF THE MAIN BEARING CAPS

After tightening the main bearing caps, measure the inside diameter of the main bearing caps using a cylinder gauge to calculate the roundness. If the value exceeds the limit, carry out boring after overlay welding or replace the cylinder block with a new one.

Standard: 85 mm (3.3465 in.)

Limit: 0.06 mm (0.0024 in.)

NOTE:

- **When installing the main bearing caps, make sure to return them to the original position with reference to the number stamped on the caps. The main bearing caps together with the cylinder block are profiled by roundness.**
- **For tightening of the main bearing caps, refer to page 3-9-18.**

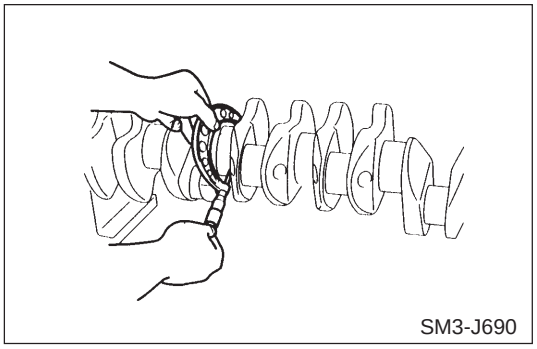
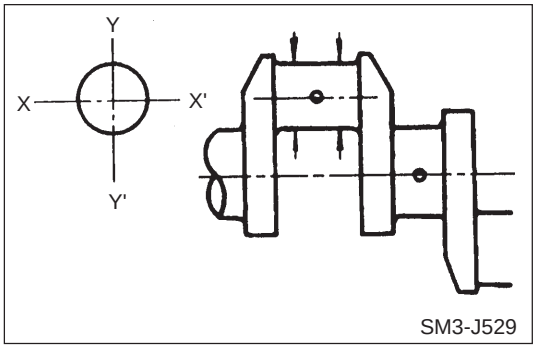

SM3-J690

Fig. 46



SM3-J529

Fig. 47

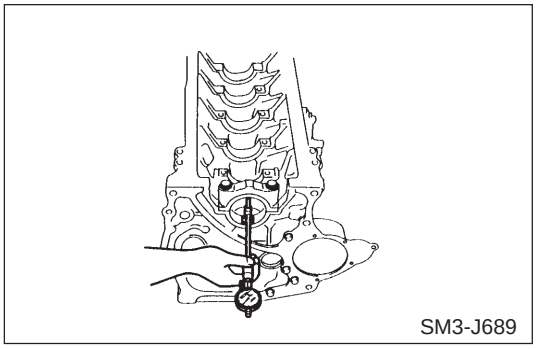
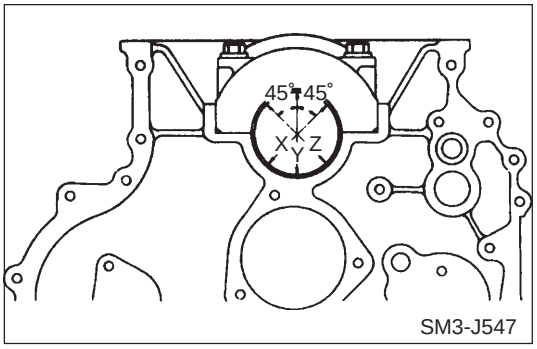

SM3-J689

Fig. 48



SM3-J547

Fig. 49

Under size	Outside diameter	
	Pin	Journal
STD	64.940 - 64.960	79.940 - 79.960
0.25US	64.690 - 64.710	79.690 - 79.710
0.50US	64.440 - 64.460	79.440 - 79.460

Fig. 50

MEASURE THE CLEARANCE BETWEEN THE CRANK JOURNAL AND THE MAIN BEARING.

1. Measure the crank journal outside diameter using a micrometer. If the value exceeds the limit for repair, grind the crank journal to correct. If the value exceeds the limit for use, replace the crankshaft with a new one.

Standard: 80 mm (3.1496 in.)
Limit for repair: 79.80 mm (3.1417 in.)
Limit for use: 78.80 mm (3.1024 in.)

2. After installing and tightening the main bearing caps, measure the main bearing inside diameter using a cylinder gauge. If the value exceeds the limit, replace the main bearing with a new one.

Standard: 80 mm (3.1496 in.)
Limit: 0.3 mm (0.0118 in.)
NOTE:

- **When installing the main bearing caps, make sure to return them to the original position with reference to the number stamped on the caps. The main bearing caps together with the cylinder block are profiled by roundness.**
- **For tightening of the main bearing cap, refer to page 3-9-18.**

3. Calculate the clearance between the crank journal and the main bearing. If the value exceeds the limit, grind the crank journal to the specified undersize below to correct. Replace the main bearing with a correct one.

Standard: 0.051 - 0.102 mm (0.0020 - 0.0040 in.)
Limit: 0.20 mm (0.0079 in.)
Undersize machining dimension: Two sizes below.
0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.)
NOTE: Make sure you replace the top and bottom main bearings as one set. The top and bottom main bearings must be profiled by roundness.

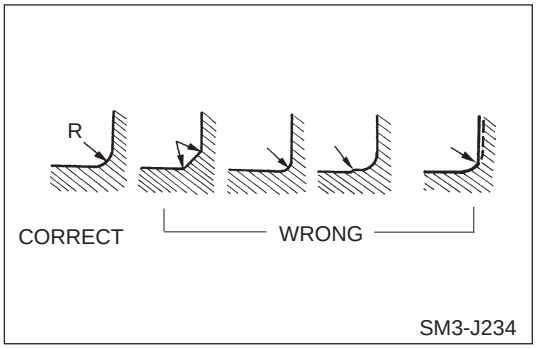


Fig. 51

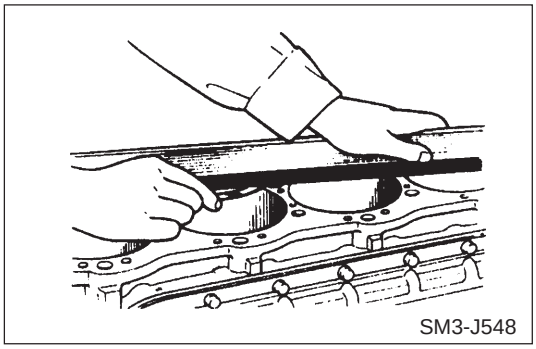


Fig. 52

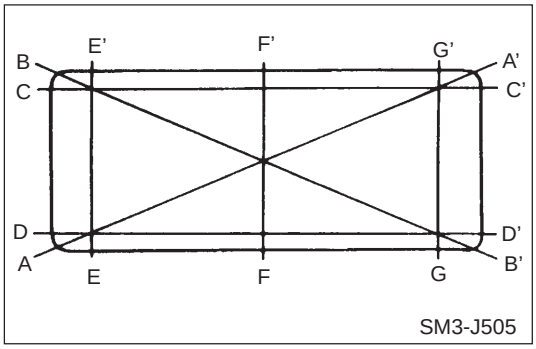


Fig. 53

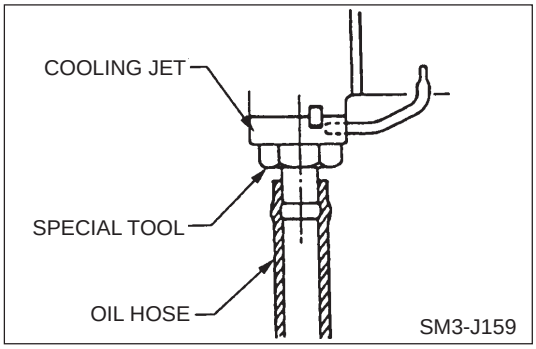


Fig. 54

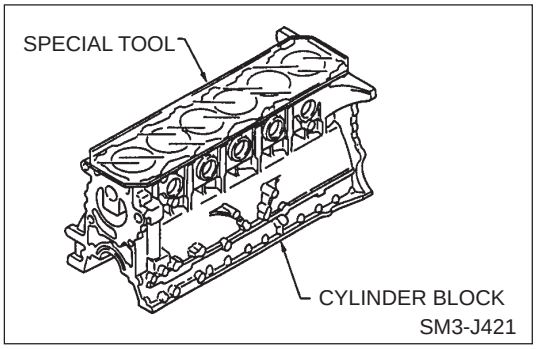


Fig. 55

NOTE: Machined dimension of fillet "R"
Crank pin: 5.0 - 5.5 mm (0.1968 - 0.2165 in.)
Crank journal: 5.0 - 5.5 mm (0.1968 - 0.2165 in.)

CYLINDER BLOCK MAIN BODY

1. Remove the water gallery plug, and check the condition of the worm hole visually. If the wear is excessive, replace the part with a new one. Also inspect inside the cylinder block, and clean the cylinder block main body with a commercial cleaning agent as required.

NOTE: Refer to page 3-9-4.

2. Check the cylinder block for cracks.
   Check the cylinder block for cracks using the dye penetrant test. If any are found, replace the cylinder block with a new one.
3. Check the flatness of the cylinder block upper surface.
   Check the flatness of the cylinder block upper surface in the direction as shown in the figure using a straight edge and feeler gauge. If the value exceeds the limit, replace the cylinder block with a new one.
   Flatness of the cylinder block upper surface:

Standard: 0.05 mm (0.0020 in.) or less
Limit: 0.20 mm (0.0079 in.)

INSPECT AND ADJUST THE COOLING JET.

1. After removing the cooling jet checking bolt, reinstall the cooling jet on the cylinder block using the special tool.

Special tool: Checking bolt (9001 - 24262)

2. Connect a commercial oil pump (hydraulic pressure: 2 kg/cm^2 (28 lb/sq.in.)) to the special tool using a hose.

3. Set the special tool on the cylinder block upper surface against the dowel pin.

Special tool: Gauge (09444 - 1630)

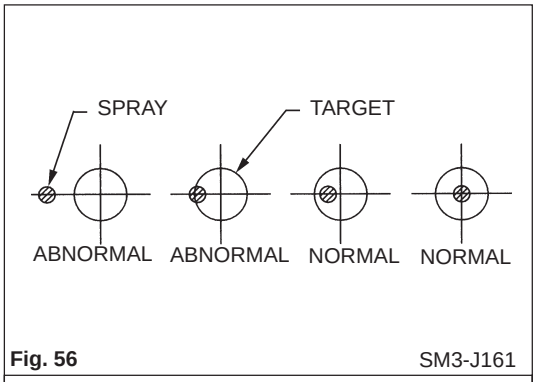


Fig. 56

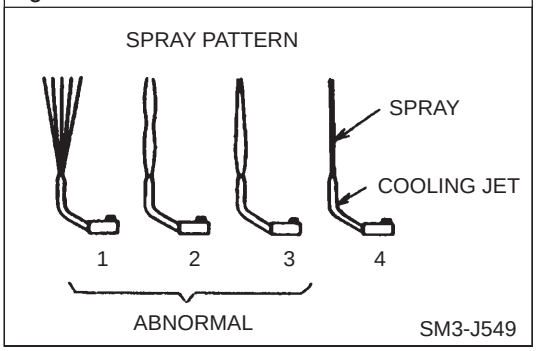


Fig. 57

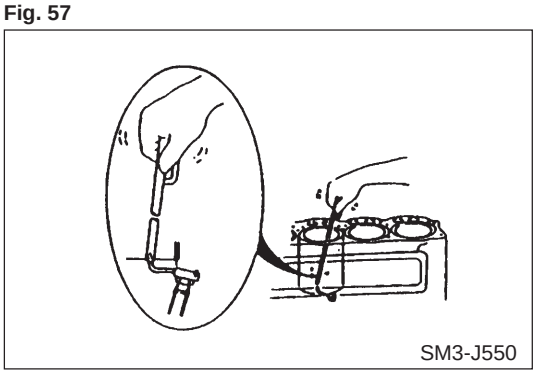


Fig. 58

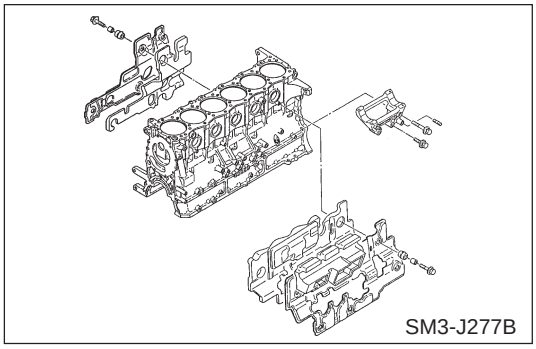


Fig. 59

4. Start the oil pump, let the engine oil spray out the cooling jet nozzle to check that the center of the jet flow is within the ∅7 mm (∅0.27 in.) reference line of the gauge as well as to judge whether the jet flow is good based on the figure.

NOTE: Use new engine oil.

WARNING

Engine oil is flammable.
This spray test should be done in a well ventilated room and away from any open flames or electric sparks.

7. If the center of the jet flow is out of the ∅7 mm (∅0.27 in.) reference line of the gauge, adjust the nozzle sight using the special tool.

Special tool: Adjusting bar (09672 - 1620)

8. Remove the checking bolt after inspection, install the cooling jet onto the cylinder block using the cooling jet checking bolt.

NOTE:

- **Always install the soft washer.**
- **When installing the piston, make sure that the cooling jet is not struck by the piston when at bottom dead center.**

INSPECT THE ENCLOSURE COVER.

Check the sound insulator for damage or wear visually. If there is any damage or wear, replace the parts with new ones.

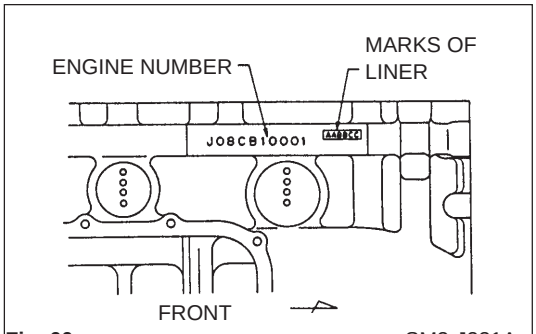


Fig. 60 SM3-J231A

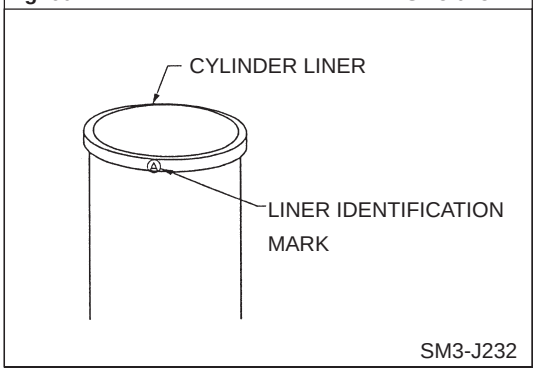


Fig. 61

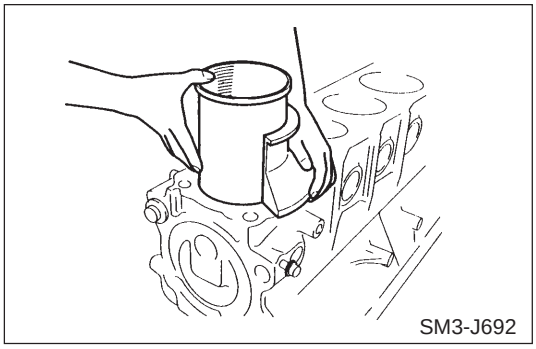


Fig. 62

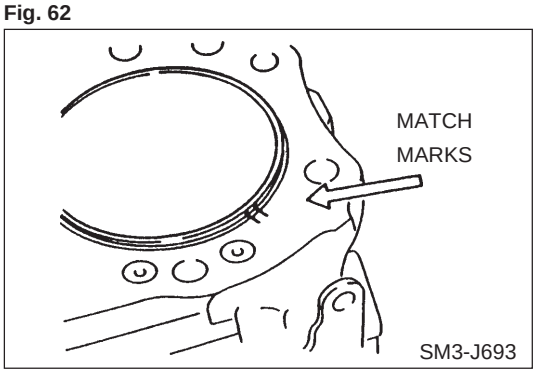


Fig. 63

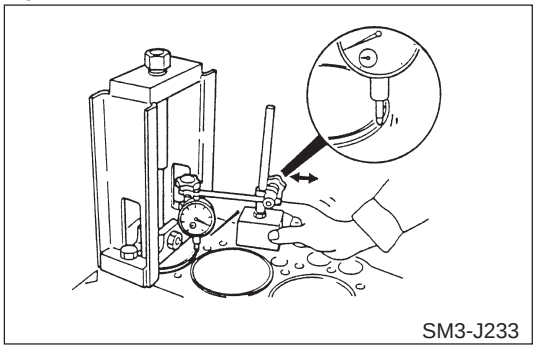


Fig. 64

MOUNTING

1. ASSEMBLE THE CYLINDER LINER.

NOTE:

- **When assembling the cylinder liner with the cylinder block, clearance can be set to three levels.**
- **When using a new cylinder liner, the upper surface and side surface of the cylinder block are stamped A, B or C. Insert a matching cylinder liner having the same symbol.**

1. Insert a cylinder liner into the cylinder block using the special tool.

Special tool: Guide (09471 - 1490)

NOTE:

- **Handle the cylinder liner carefully because it is thin. If it falls on the floor, it cannot be used.**
- **Install the cylinder liner after engine oil has been applied to the inner surface of the cylinder block bore.**
- **When reusing a cylinder liner, install it according to the alignment marks made during removal. The cylinder liner is bent by "run-in". When reusing the cylinder liner, misalignment with the cylinder block may concentrate stress on the thin part of the cylinder liner and it may break.**

2. MEASURE THE PROTRUSION AT THE CYLINDER LINER.

1. Install the special tool onto the cylinder block.

Special tool: Cylinder liner puller (09420 - 1720)

2. Tighten the center bolt to the specified torque below to set the cylinder liner in the normal installation condition.

Tightening torque: 100 kg·cm (7.23 lb·ft)

3. Measure the protrusion at the cylinder liner using the dial gauge. If the value exceeds the limit, replace the cylinder liner.

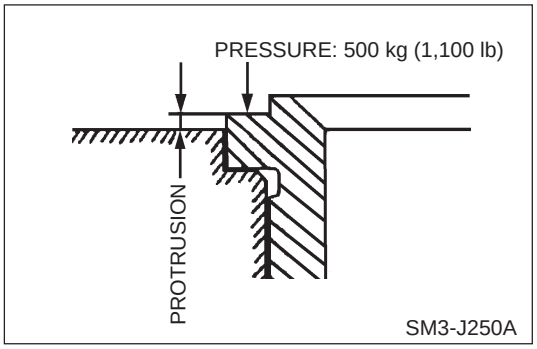


Fig. 65

Standard: 0.01 - 0.08 mm (0.0004 - 0.0031 in.)
Limit: 0.08 mm (0.0031 in.)

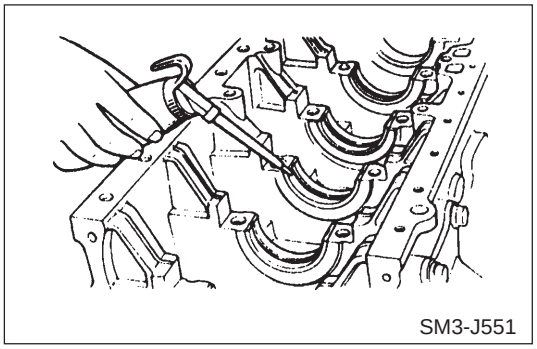


Fig. 66

3. INSTALL THE CRANKSHAFT.

1. Install the main bearings onto the cylinder block and main bearing caps.

NOTE:

- **When reusing a bearing, make sure you reassemble the removed bearing as it was originally installed.**
- **Install the bearing with the oil hole on the block side and the bearing without the oil hole on the cap side.**
- **Match the bearing protrusion with the notch of the block or cap.**
- **After installation, apply engine oil to the journal surfaces of the bearings.**

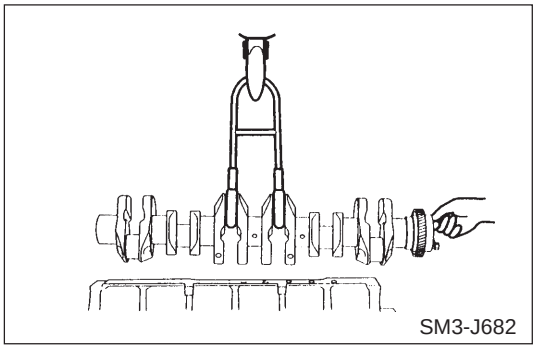


Fig. 67

2. Install the crankshaft onto the cylinder block.

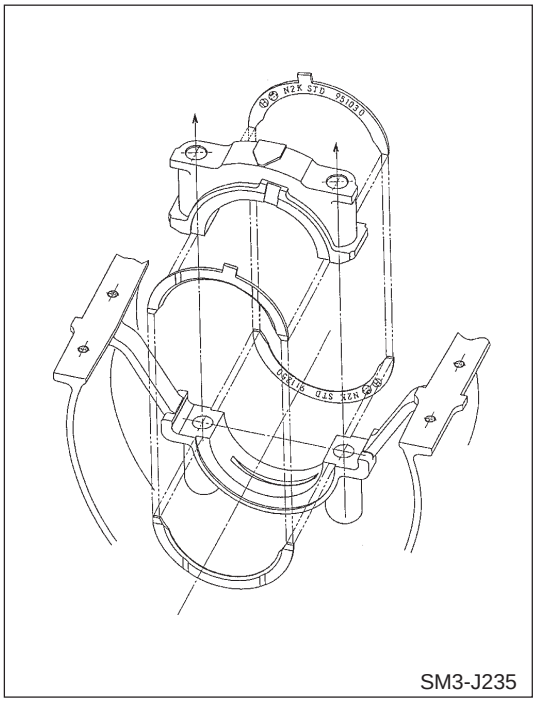


Fig. 68

3. Install the thrust bearings onto the four points of the No. 4 journal of the cylinder block and either side of the main bearing caps.

NOTE:

- **When reusing a bearing, make sure you reassemble the removed bearing as it was originally installed.**
- **Install the thrust bearing with the groove side (front) toward the crankarm and with the part number stamp (back) toward the main bearing cap or cylinder block.**
- **Apply engine oil or grease to the back of the bearing to prevent loosening during installation.**
- **Fit the bearing to the mounting groove of the block and cap side.**

4. Install the main bearing cap.

NOTE: Facing the arrow stamped on the cap forward, install in the order of stamped numbers.

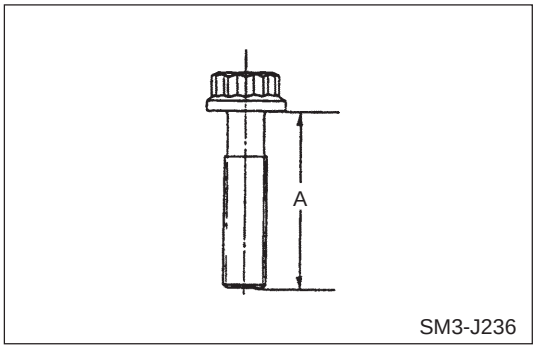


Fig. 69

a. Measure the length of the bearing cap bolts, if the length is A or more, replace with new bolts.

A = 108 mm (4.2520 in.)

b. Apply clean engine oil to the bolt seat and bolt threads.

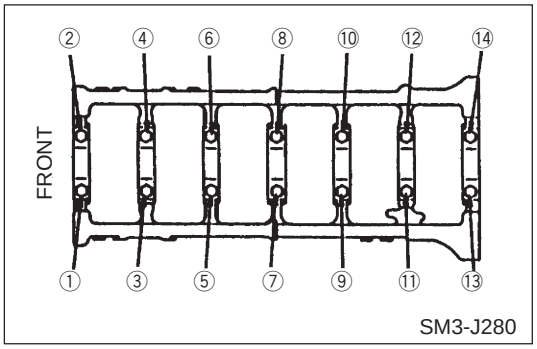


Fig. 70

c. Tighten the bolts in the order as shown in the figure to the specified torque below.

Tightening torque for preload: 700 kg·cm (51 lb·ft)

d. Loosen all bolts.

e. Tighten the bolts as in step c.

Tightening torque for preload: 700 kg·cm (51 lb·ft)

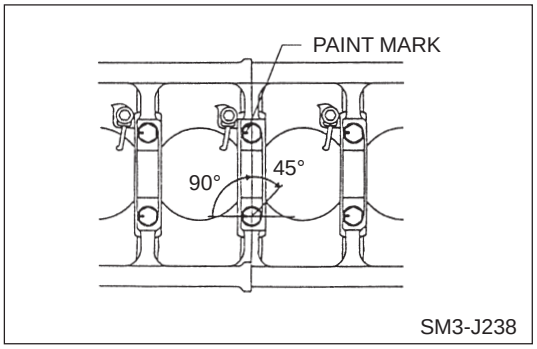


Fig. 71

f . Mark the bolts with paint to indicate the same direction.

g. Tighten the bolts 90° (1/4 turn) in the same order as in step c.

h. Finally, retighten the bolts 45° (1/8 turn) as in step g.

i. Make sure that all paint marks face the same direction.

NOTE: When adding torque, never untighten the nuts, even it they have been overtightened.

j. After tightening, tap the front and back ends of the crankshaft using a plastic-faced hammer to allow complete fit.

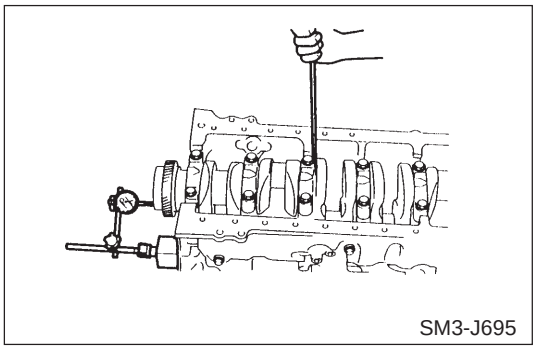


Fig. 72

5. MEASURE THE CRANKSHAFT END PLAY.

Measure the crankshaft end play using a dial gauge. If the value exceeds the limit, replace the thrust bearing with the oversize one of 0.25 mm (0.0098 in.).

Standard: 0.050 - 0.219 mm (0.0020 - 0.0086 in.)

Limit: 0.50 mm (0.0196 in.)

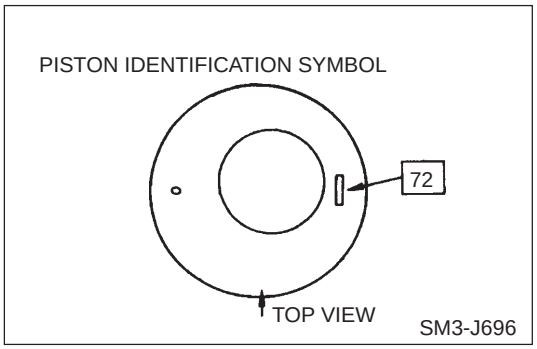


Fig. 73

6. CHECK THE PISTON.

Before assembling the piston with the connecting rod, check whether the piston is specified for this engine.

NOTE: Check using the engine compatible identification code on the top of the piston.

Engine compatible identification code: 72

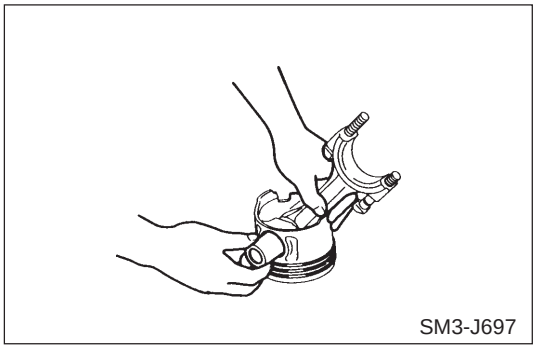


Fig. 74

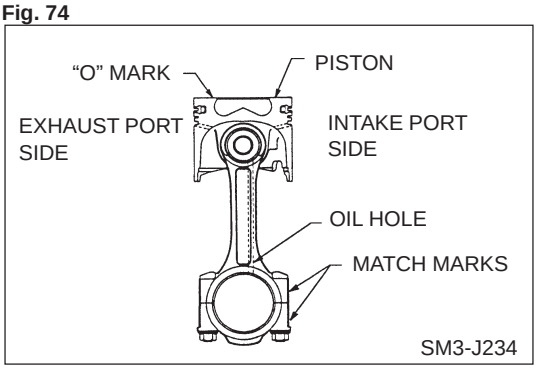


Fig. 75

7. ASSEMBLE THE PISTON WITH THE CONNECTING ROD.

1. Install a new retainer ring onto one end of the piston boss.

NOTE: Installing the retainer ring may cause it to fly up. Be sure to wear protective goggles.

2. Immerse the piston in hot water, 80 - 90°C (176 - 194°F) for approximately five minutes.
3. Assemble the piston O-mark to be opposite the connecting rod alignment mark.

WARNING
Never touch the piston when it is hot with your bare hands.

4. Insert the piston pin into the piston.

NOTE:

- **Never touch the piston when it is hot with your bare hands.**
- **Insert the piston pin from the piston boss attached to the retainer ring so that the ring groove is not damaged.**

5. Install a new retainer ring to the other end of the piston boss.

WARNING
Installing the retainer ring may cause it to fly up. Be sure to wear protective goggles.

NOTE:

- **When using an oversize piston, hone so that clearance between the cylinder liner and the piston is the standard value.**
- **Prevent parts from damage by wrapping them in a cloth while they are being installed onto the cylinder block.**
- **Measure the entire length of the connecting rod bolt. (Refer to page 3-9-22.)**

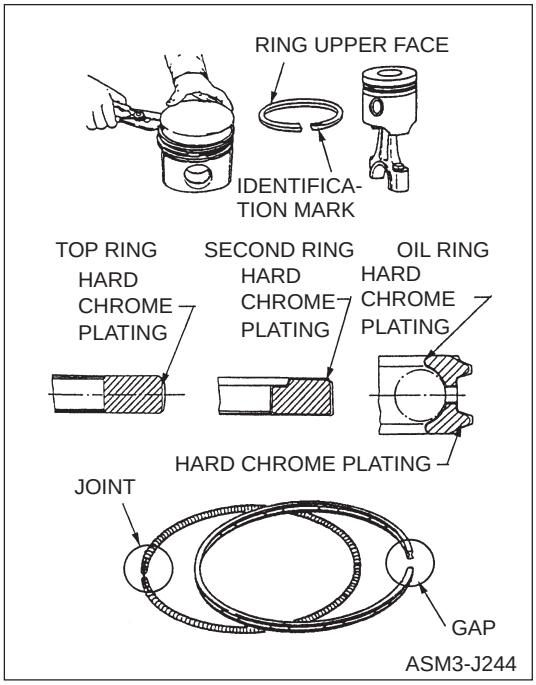


Fig. 76

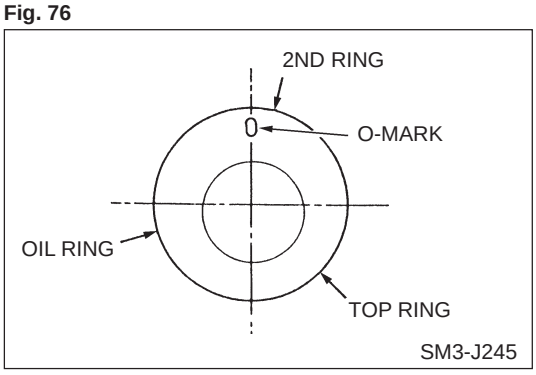


Fig. 77

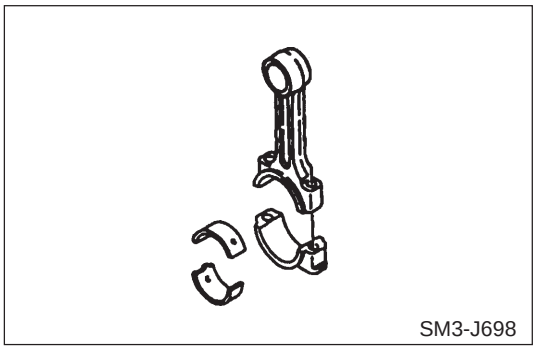


Fig. 78

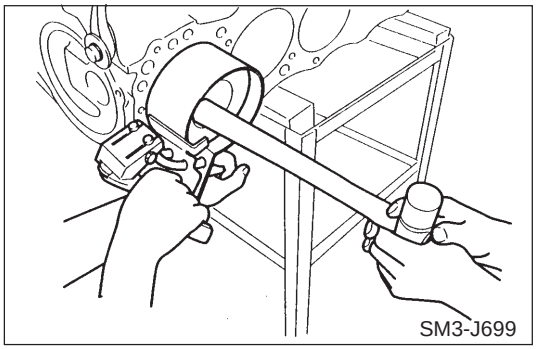


Fig. 79

8. ASSEMBLE THE PISTON RING.

1. Facing the identification marks on the piston ring upper surface, install in the order of oil ring (4N), second ring (2N) and top ring (1N) using the special tool.

Special tool: Piston ring expander (09442 - 1011)

NOTE:

- **Never change the combination of the coil and oil ring.**
- **Connect the joint of the coil expander for the oil ring and install it inside the piston ring. Assemble the ring with the joint 180° opposite to the matching point of the ring.**

sition the matching points of the piston ring at an even distance without the piston boss and thrust direction.

9. ASSEMBLE THE CONNECTING ROD BEARING.

NOTE:

- **When reusing the bearing, make sure you reassemble the removed bearing as it was originally installed.**
- **Install the bearing with the oil hole on the connecting rod side and the bearing without the oil hole on the cap side.**
- **Match the bearing protrusion with the notch of the connecting rod or cap.**

10. INSTALL THE PISTON THROUGH THE CONNECTING ROD ASSEMBLY ONTO THE CYLINDER BLOCK.

1. Insert the piston through the connecting rod assembly into the cylinder block using the special tool and a hammer handle.

Special tool: Piston ring holder (09441 - 1320)

NOTE:

- **Before installation, apply engine oil to the piston pin, piston ring, cylinder liner and connecting rod bearing.**
- **Recheck the matching point of each piston ring.**
- **Make sure that the 0-mark on the piston is at the exhaust side.**

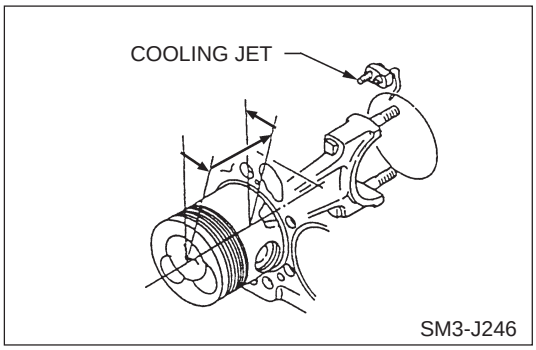


Fig. 80

NOTE: When inserting the piston, be careful that the cooling jet is not struck by the connecting rod. If struck, make sure you recheck the sight of the cooling jet.

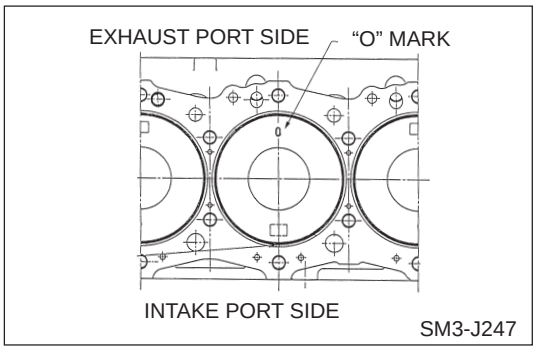


Fig. 81

11. INSTALL THE CONNECTING ROD CAP.

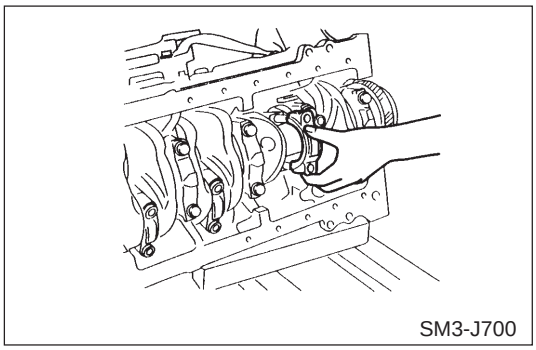


Fig. 82

1. Measure the length of the bolts, if the length is A or more, replace with new bolts.

A = 83.5 mm (3.2874 in.)

2. Apply clean engine oil to the nut seat surface and bolt thread of the connecting rod cap.

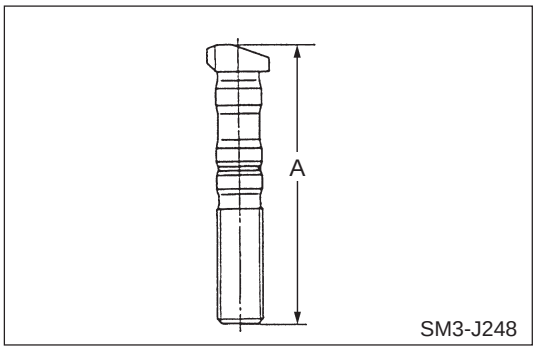


Fig. 83

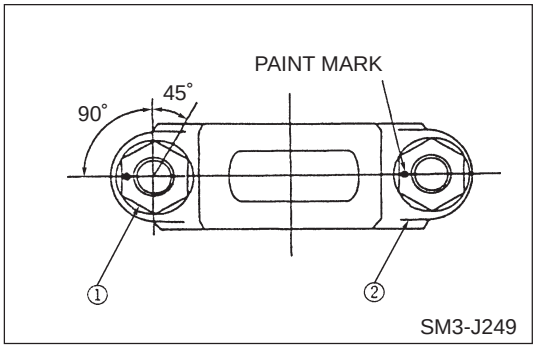


Fig. 84

3. Tighten the connecting rod nut in the order as shown in the figure to the specified torque below.

Tightening torque: 700 kg·cm (51 lb·ft)

4. Mark the cap nut with paint to indicate the same direction.
5. Tighten the cap nut 90° (1/4 turn) in the same order as in step 3.
6. Tighten the cap nut 45° (1/8) turn as in step 5.
7. Make sure that all paint marks face the same direction.

NOTE: When adding torque, never untighten the nuts, even it they have been overtightened.

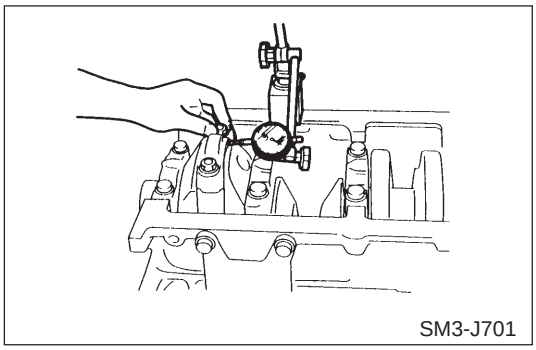


Fig. 85

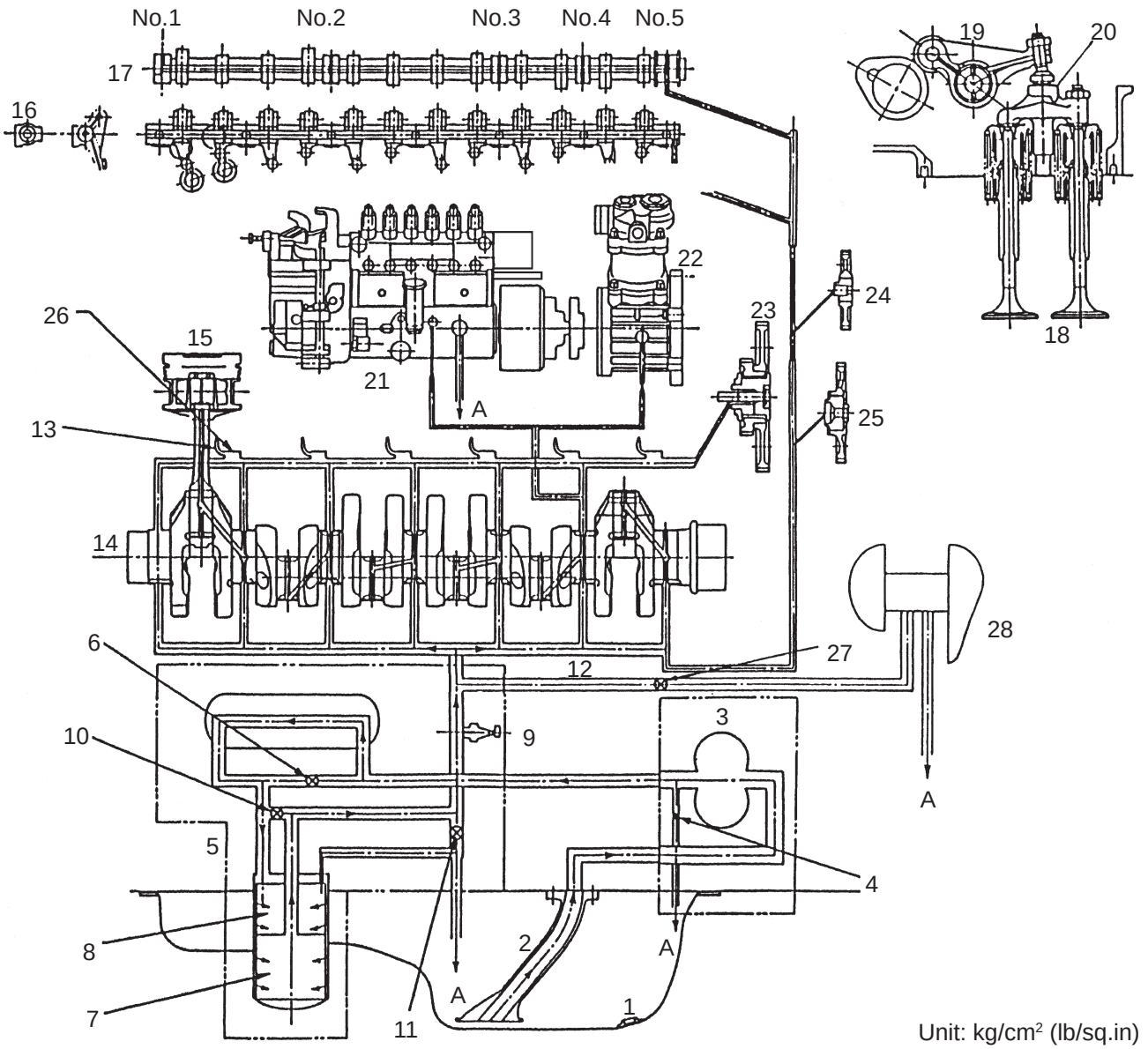
12. MEASURE THE CONNECTING ROD END PLAY.

Measure the clearance between the connecting rod and crankpin end surface using a dial gauge. If the value exceeds the limit, replace the connecting rod.

Standard: 0.20 - 0.53 mm (0.0079 - 0.0208 in.)

Limit: 0.5 mm (0.0197 in.)

LUBRICATING SYSTEM



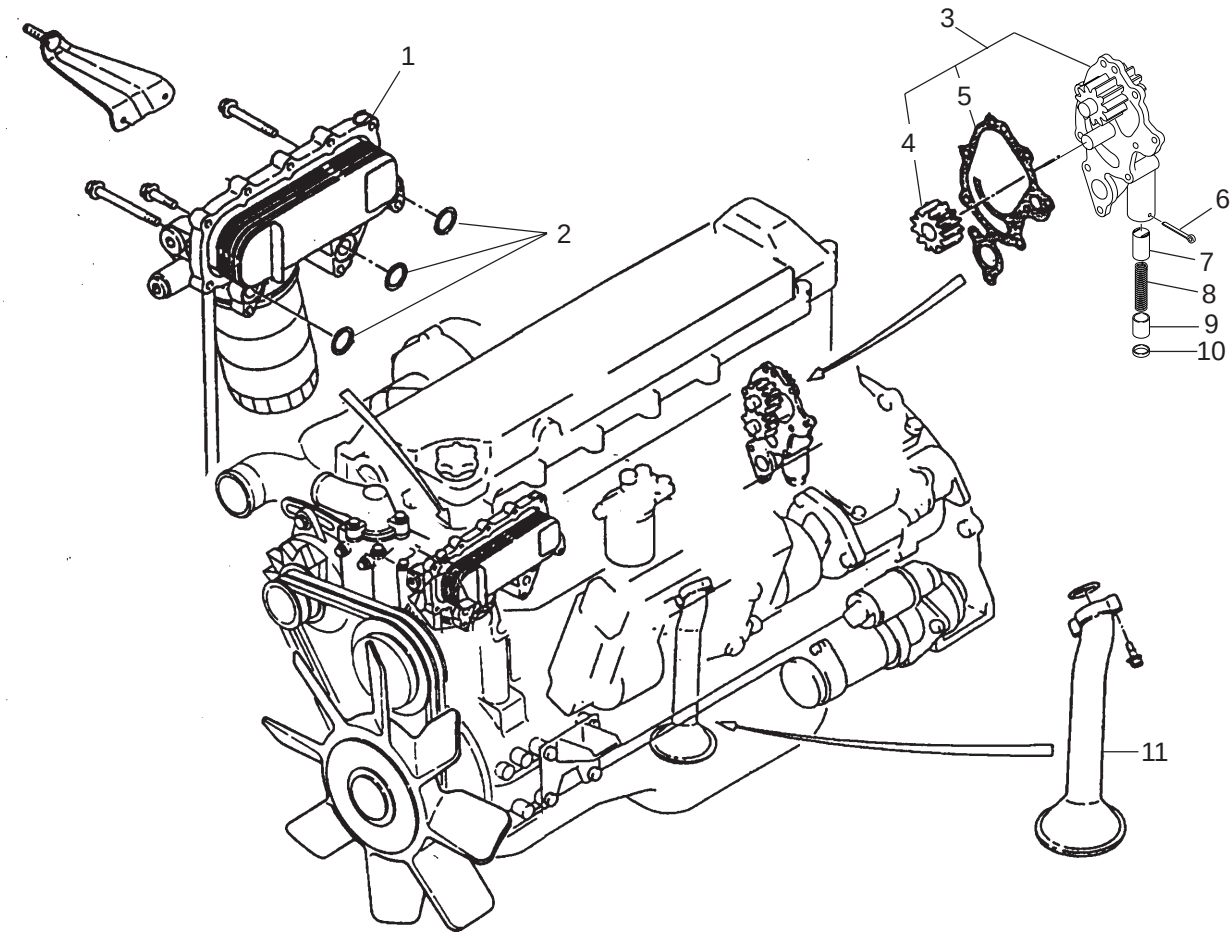
Unit: kg/cm² (lb/sq.in)

1. Oil pan
2. Oil strainer
3. Oil pump
4. Oil pump safety valve
   16.8 - 17.8 (235 - 250)
5. Oil cooler and oil filter
6. Oil cooler safety valve
   5 - 5.8 (71 - 82)
7. Oil filter (full flow)
8. Oil filter (by-pass)
9. Pressure switch
10. Oil filter safety valve
    1.8 - 2.2 (22 - 31)
11. Regulator valve
    5 - 5.8 (71 - 82)
12. Main oil hole
13. Piston cooling jet
14. Crankshaft
15. Piston
16. Rocker arm shaft
17. Camshaft
18. Valve
19. Valve rocker arm
20. Cross head
21. Fuel injection pump
22. Air compressor
23. Main idler gear
24. Cam idler gear
25. Sub idler gear
26. Check valve 2.5 (35)
27. Check valve for turbocharger
28. Turbocharger

A. To oil pan

SM3-J281A

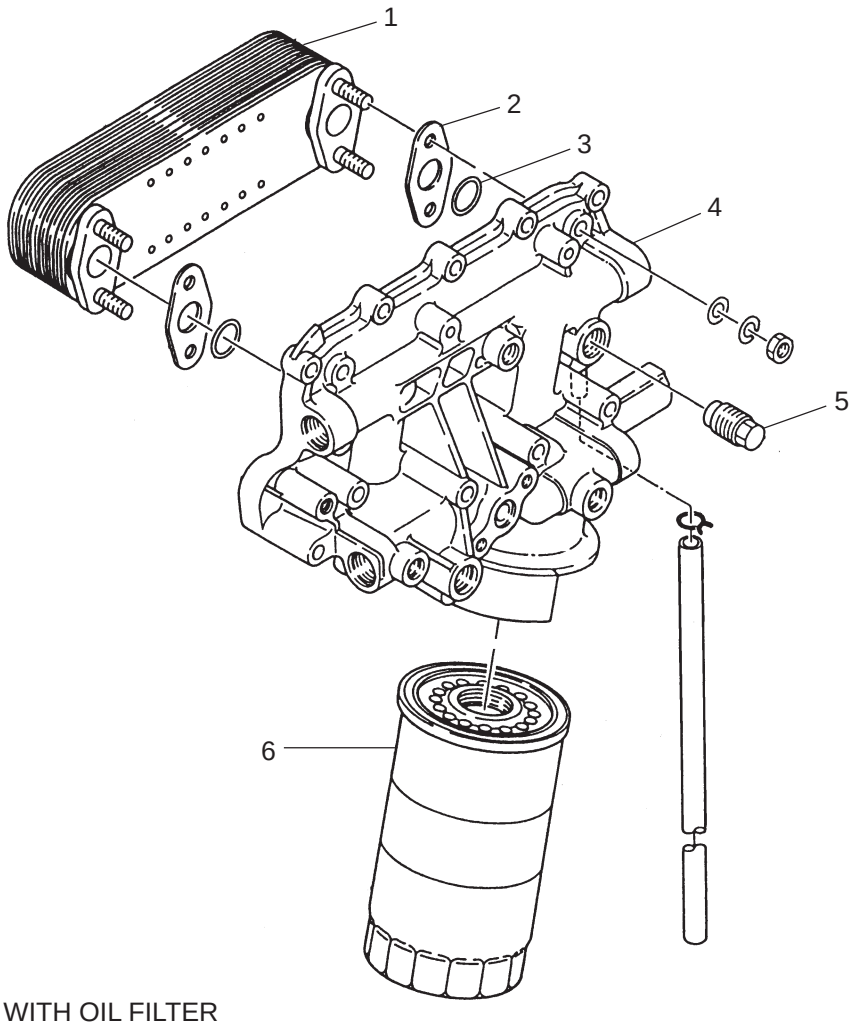
Fig. 1



1. Oil cooler with oil filter
2. D-ring
3. Oil pump assembly
4. Driven gear
5. Gasket
6. Cotter pin
7. Safety valve
8. Relief valve spring
9. Seat 1
10. Seat 2
11. Oil strainer

SM44-0044
SM3-J163C

Fig. 2



OIL COOLER WITH OIL FILTER

1. Oil cooler element
2. Gasket
3. O-ring
4. Oil cooler element cover
5. Coolant drain cock
6. Oil filter

SM3-J165B

Fig. 3

REMOVAL OF COMPONENT PARTS

REMOVE THE OIL FILTER

Special tool: Oil filter wrench (09553 - 1021)

REMOVE THE OIL COOLER

NOTE: Refer to page 3-5-3.

REMOVE THE OIL PUMP

NOTE: Refer to page 3-8-2.

OIL PUMP

DISASSEMBLING

1. Remove the driven gear from the shaft.

NOTE: Since the drive gear is a press-fit type, it cannot be disassembled.

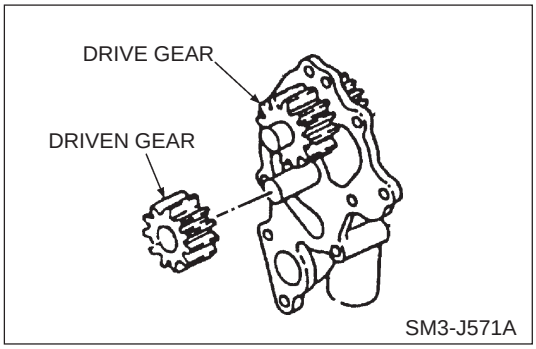


Fig. 4

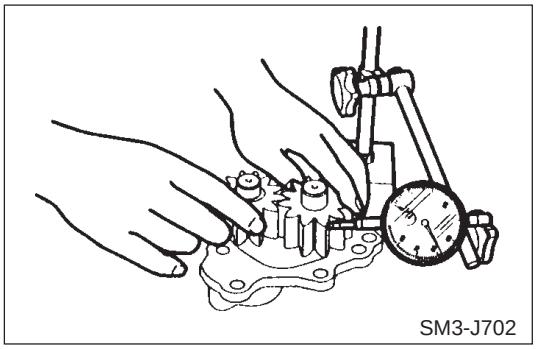


Fig. 5

INSPECTION AND REPAIR

Inspect each part for damage or wear visually. If damage or wear is excessive, replace the oil pump assembly with a new one.

MEASURE THE BACKLASH BETWEEN THE DRIVE GEAR AND THE DRIVEN GEAR.

Measure the backlash between the drive gear and the driven gear using a dial gauge. If the value exceeds the limit, replace the oil pump assembly with a new one.

Standard: 0.073 - 0.207 mm (0.0029 - 0.0081 in.)

Limit: 0.3 mm (0.0118 in.)

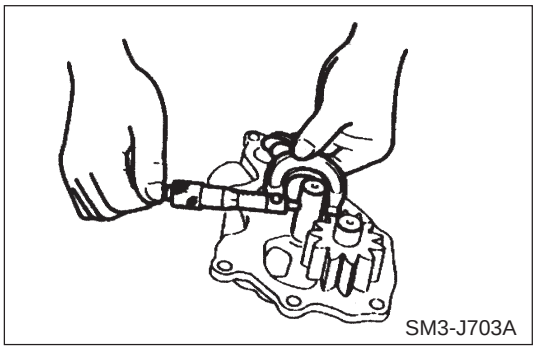


Fig. 6

MEASURE THE CLEARANCE BETWEEN THE DRIVEN GEAR SHAFT AND THE DRIVEN GEAR BUSHING.

1. Measure the clearance between the driven gear shaft and the driven gear bushing using a micrometer. If the value exceeds the limit, replace the oil pump assembly with a new one.

Standard: 0.040 - 0.083 mm (0.0016 - 0.0032 in.)

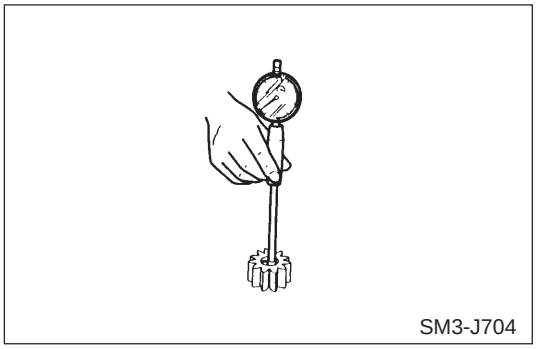

SM3-J704

Fig. 7

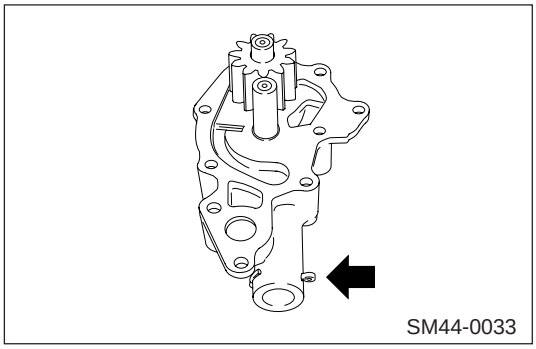

SM44-0033

Fig. 8

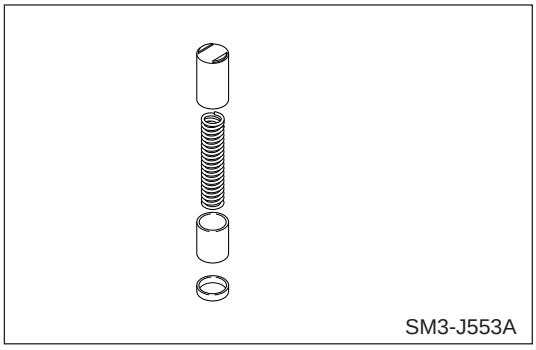

SM3-J553A

Fig. 9

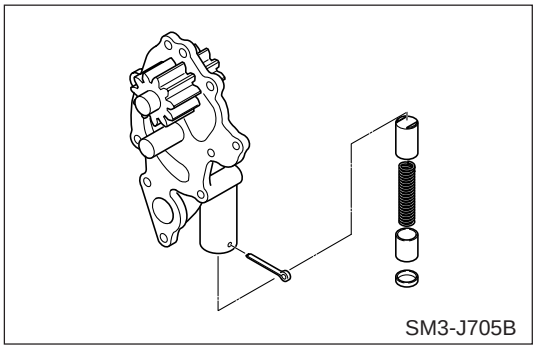

SM3-J705B

Fig. 10

2. Measure the inside diameter of driven gear bushing using a cylinder gauge.
3. Calculate the clearance between the driven gear shaft and the driven gear bushing.
   If the value exceeds the limit, replace the idler gear shaft or oil pump assembly with a new one.

Standard: 0.040 - 0.083 mm (0.0016 - 0.0032 in.)
Limit: 0.15 mm (0.0059 in.)

OIL PUMP SAFETY VALVE

DISASSEMBLING

1. Remove the cotter pin and then remove Seat 2, Seat 1, the relief valve spring and the safety valve.

WARNING
Removing the cotter pin may cause Seat 2 and the relief valve spring to spring out. Be sure to wear protective goggles.

INSPECTION AND REPAIR

NOTE: Before inspection, be sure to clean metal parts using treated oil.

1. Inspect each part for damage or wear visually. If damage or wear is excessive, replace the safety valve with a new one.
2. If the spring is flattened, replace the safety valve with a new one.

ASSEMBLING

1. Attach the safety valve, the relief valve, Seat 1 and Seat 2 onto the oil pump cover assembly using the cotter pin.

WARNING
When assembling, the spring and the spring seal may spring out. Be sure to wear protective goggles.

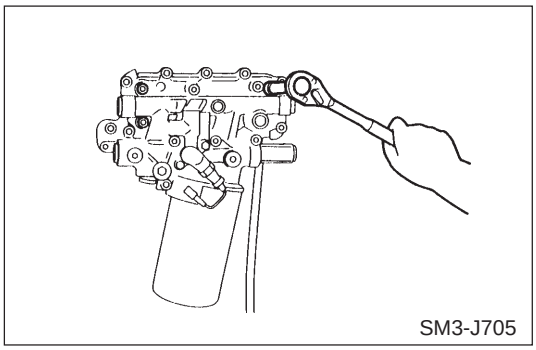


Fig. 11

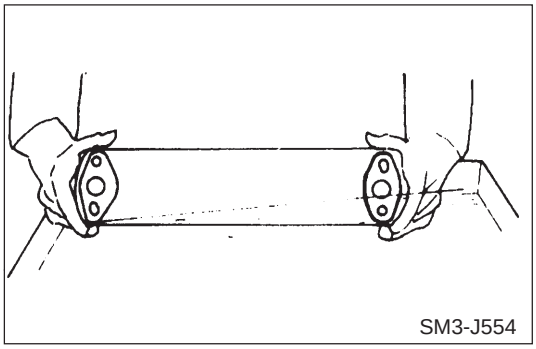


Fig. 12

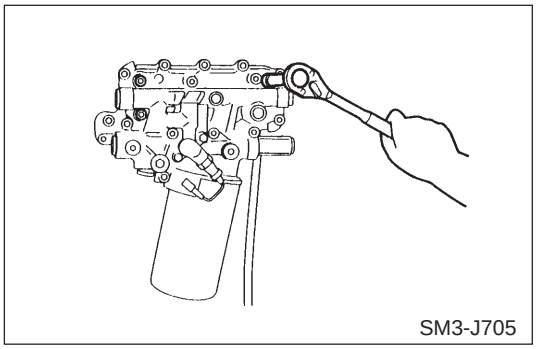


Fig. 13

OIL COOLER ELEMENT

DISASSEMBLING

Remove the nut, and remove the oil cooler element from the oil cooler element cover.

INSPECTION AND REPAIR

NOTE: Before inspection, be sure to clean the oil cooler element oil passage using a commercial cleaning agent.

Carry out a pneumatic test for the oil cooler element. If defective, replace the oil cooler element with a new one.

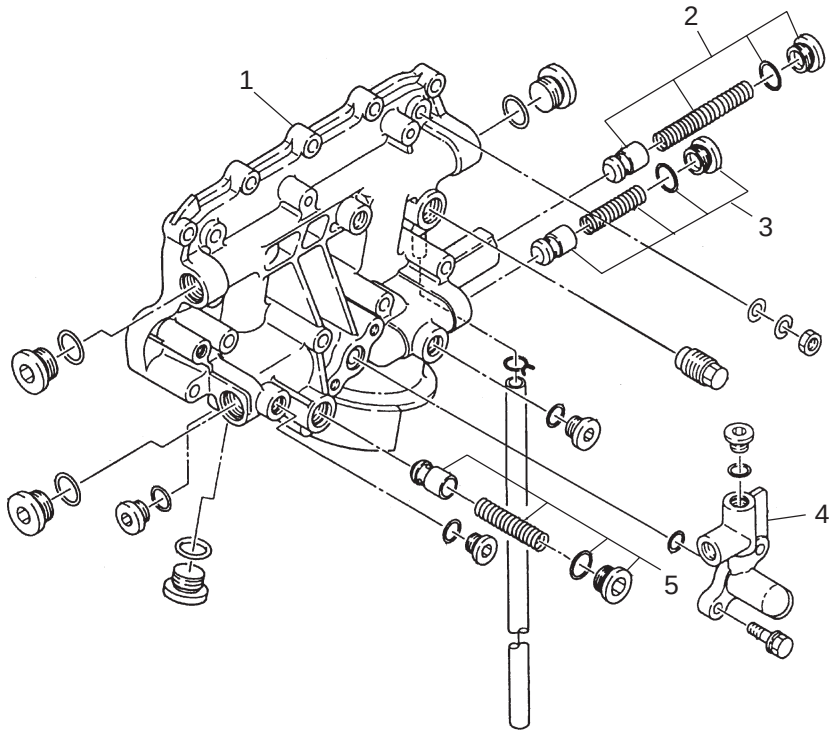
Test pressure: 6 kg/cm² (85.3 lb/sq.in.)

Test time: 1 minute

ASSEMBLING

Tighten the nut and install the oil cooler element onto the oil cooler element cover.

Tightening torque: 200 - 300 kg·cm (15 -21 lb·ft)



OIL COOLER ELEMENT COVER
1. Oil cooler element cover
2. Regulator valve
3. Oil filter safety valve
4. Check valve for turbocharger
5. Oil cooler safety valve

SM3-J573A

Fig. 14

OIL COOLER ELEMENT COVER

DISASSEMBLING

Remove the plug and remove each valve and spring from the oil cooler element cover.

INSPECTION AND REPAIR

NOTE: Before inspection, clean the metal parts using treated oil.

1. Inspect each part for damage or wear visually. If the damage or wear is excessive, replace the safety valve with a new one.
2. If the spring is flattened, replace the safety valve with a new one.

ASSEMBLING

Install each valve and spring onto the oil cooler element cover and tighten the plug.

Tightening torque:

Regulator valve and safety valve: 250 - 350 kg·cm (18 - 25 lb·ft)

INSTALLATION OF COMPONENT PARTS

INSTALL THE OIL PUMP

NOTE: Refer to page 3-8-6.

INSTALL THE OIL COOLER

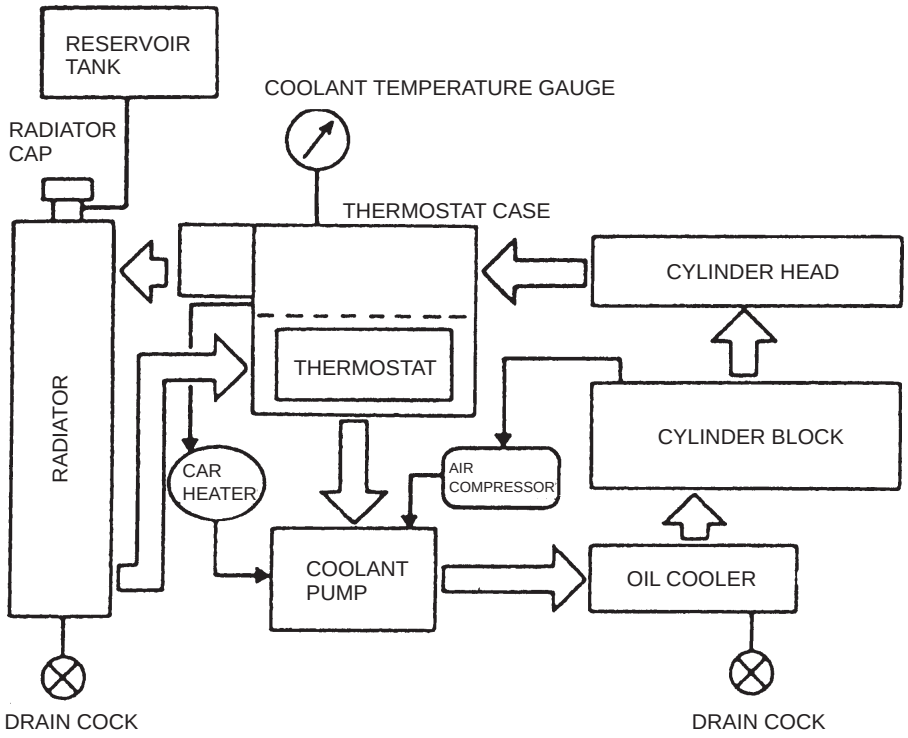
NOTE: Refer to page 3-17-3.

INSTALL THE OIL FILTER

Special tool: Oil filter wrench (09553 - 1021)

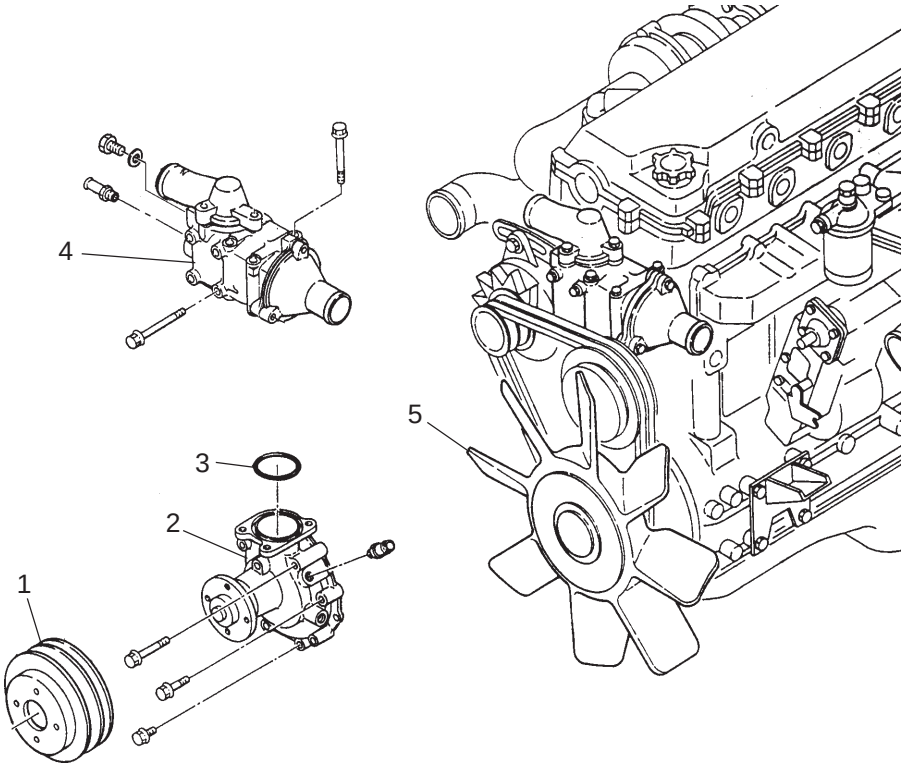
NOTE: Refer to page 3-17-4.

COOLING SYSTEM



SM3-J207

Fig. 1



1. Coolant pump pulley
2. Coolant pump
3. O-ring
4. Thermostat case
5. Cooling fan

SM3-J574B

Fig. 2

REMOVAL OF COMPONENT PARTS

REMOVE THE COOLING FAN AND FAN CLUTCH

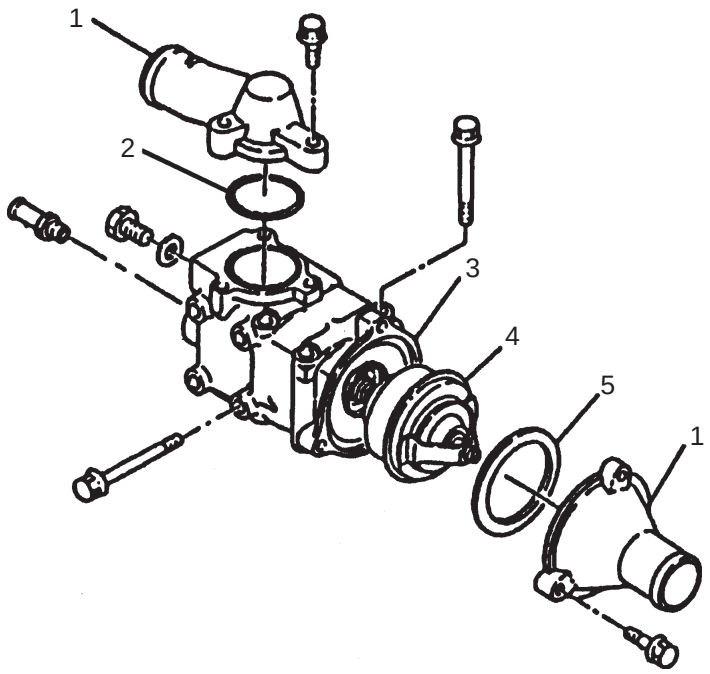
NOTE: Refer to page 3-5-3.

REMOVE THE THERMOSTAT CASE

NOTE: Refer to page 3-5-4.

REMOVE THE COOLANT PUMP

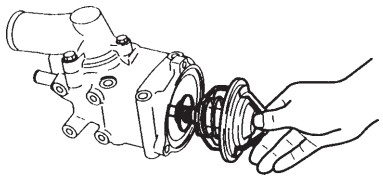
NOTE: Refer to page 3-5-4.



THERMOSTAT
1. Thermostat case cover
2. O-ring
3. Thermostat case
4. Thermostat
5. Gasket

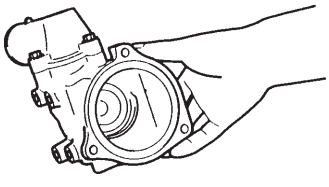
SM3-J284

Fig. 3



SM3-J706

Fig. 4



SM3-J707

Fig. 5

THERMOSTAT

DISASSEMBLING

1. Remove the three mounting bolts from the thermostat case cover, then remove the thermostat case cover from the thermostat case.
2. Remove the thermostat from the thermostat case.

INSPECTION AND REPAIR

1. Check the thermostat mounting surface of thermostat case for deterioration or damage visually. If the damage or wear is excessive, replace the thermostat case with a new one.

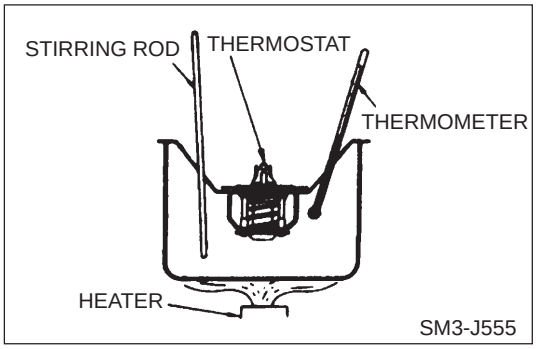


Fig. 6

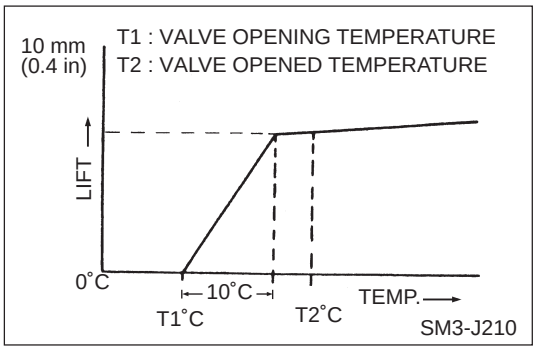


Fig. 7

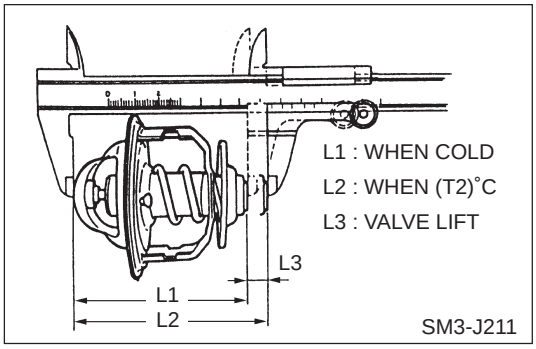


Fig. 8

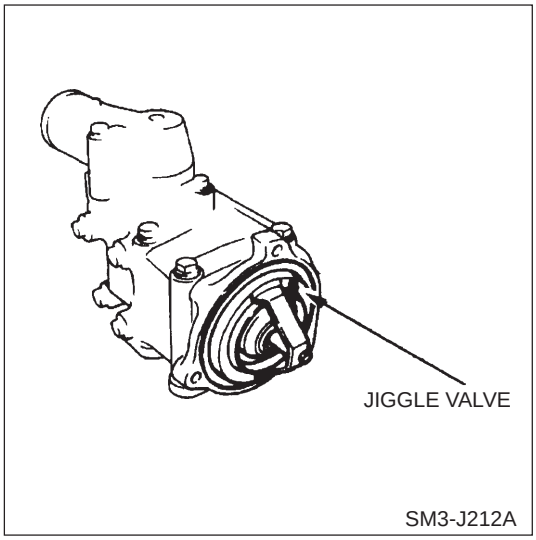


Fig. 9

2. Inspect the thermostat function
   Place the thermostat in hot water and check the valve opening temperature and valve lift.

WARNING
Never touch hot water and heated thermostat with your bare hands. This can result in personal injury.

a. Measure the valve opening temperature using a coolant temperature gauge. If the value exceeds the limit, replace the thermostat with a new one.

Standard: 74.5 - 78.5°C (166 - 173°F)

NOTE: Check that the thermostat valve opening temperature (T1) is engraved on the thermostat seat.

b. After immersing the thermostat in hot water, 90°C (194 °F), for five minutes, measure the valve lift using vernier calipers. If the value does not meet the standard value, replace the thermostat with a new one.

Standard: 10 mm (0.3937 in.) or more

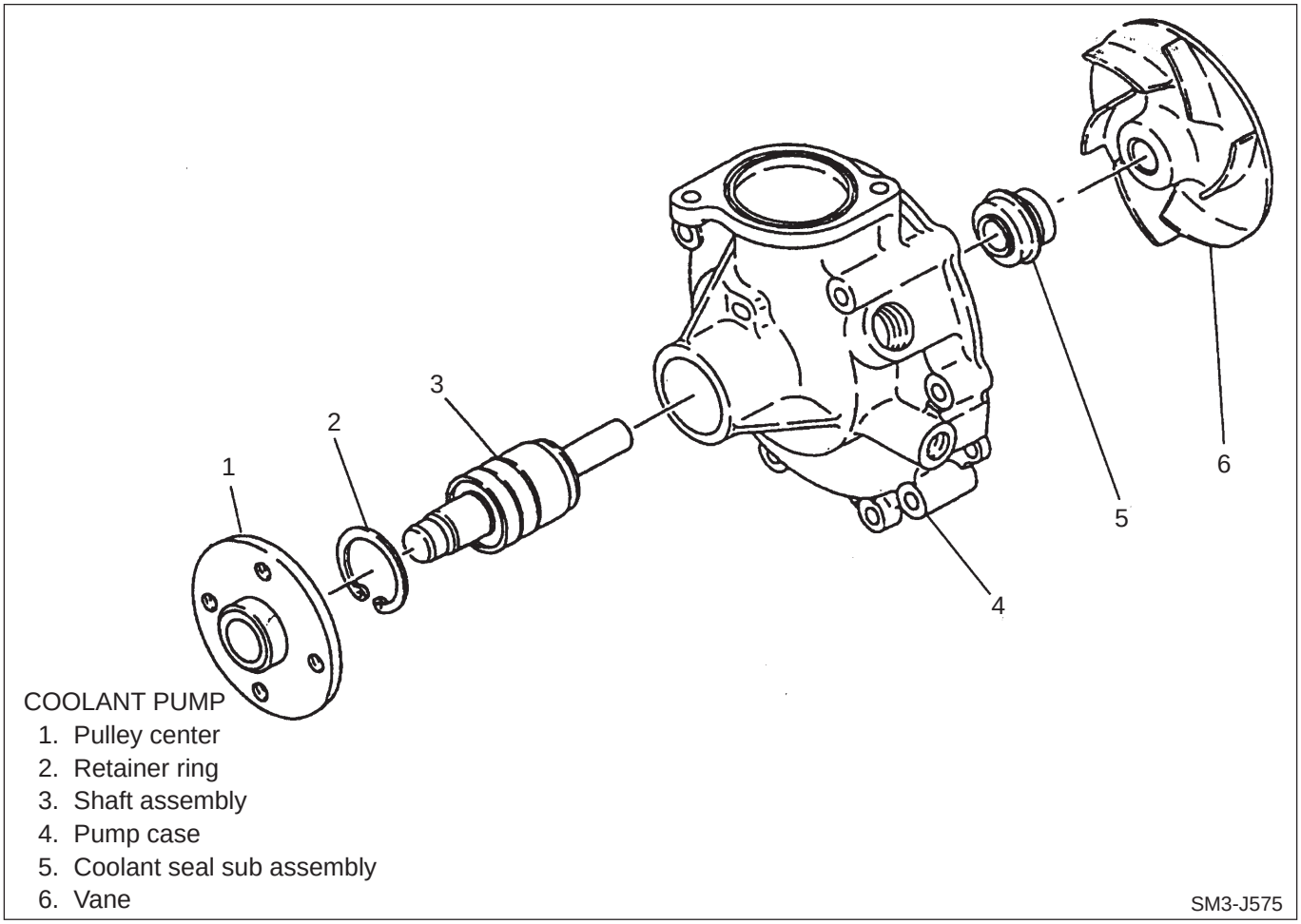
c. Immerse the opened thermostat in water at normal temperature. If it completely closes within five minutes, it is satisfactory. If it remains slightly open, it is defective and must be replaced.

ASSEMBLING

1. Assemble the thermostat case.

NOTE:

- **Remove water or dust adhering to the thermostat case.**
- **Check that the gasket is not corroded, damaged or flattened. Be sure to install it onto the thermostat seat.**
- **Be sure that the jiggle valve faces upward when installing the thermostat.**



COOLANT PUMP
1. Pulley center
2. Retainer ring
3. Shaft assembly
4. Pump case
5. Coolant seal sub assembly
6. Vane

Fig. 10

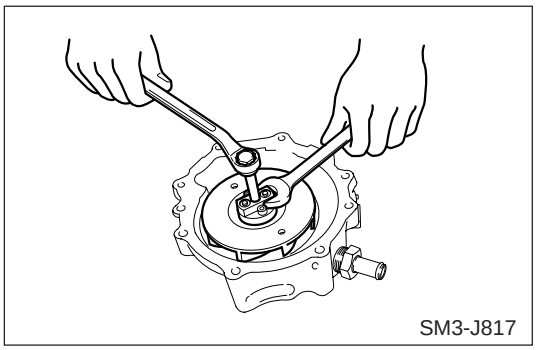


Fig. 11

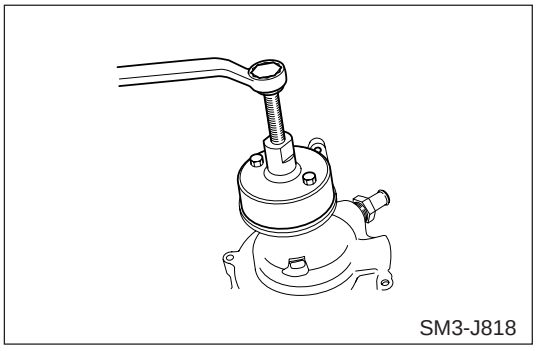


Fig. 12

COOLANT PUMP

DISASSEMBLING

1. Remove the vane from the shaft using the special tool.

Special tool: Puller (09420 - 1820)

2. Remove the pulley center from the shaft using the special tool.

Special tool: Puller (09420 - 1810)

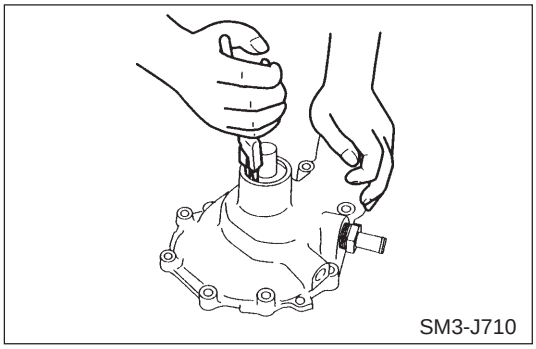

SM3-J710

Fig. 13

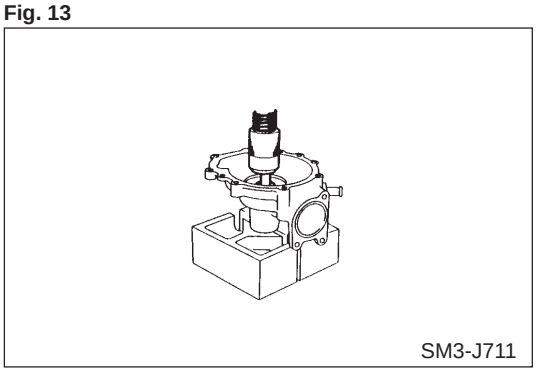

SM3-J711

Fig. 14

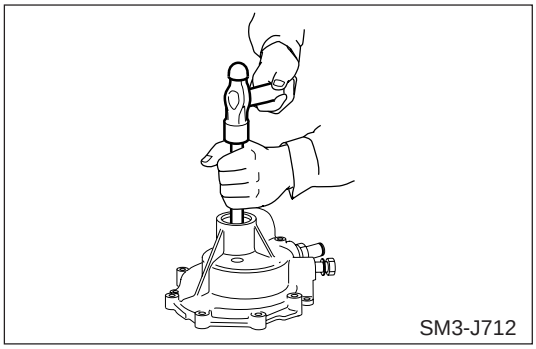

SM3-J712

Fig. 15

3. Remove the retainer ring from the pump case using snap ring pliers.

4. Push the shaft from the vane side using a hydraulic press, and remove the bearing, collar and shaft from the pump case.

NOTE:

- **Before pressing, recheck that the retainer ring is removed completely.**
- **Replace the removed bearing with a new one. Never reuse it.**

5. Remove the coolant seal from the pump case using a hammer and brass bar.

WARNING
Impact due to punching may cause metal chips to fly up. Be sure to wear protective goggles.

NOTE: Replace the removed coolant seal with a new one. Never reuse it.

INSPECTION AND REPAIR

INSPECT THE VANE.

Check the vane for corroded or damaged condition visually. If it is defective, replace the vane with a new one.

NOTE: Pay special attention to the vane blade during inspections.

INSPECT THE PUMP CASE.

Check the vane side of the coolant seal mount and bearing mount on the pump case for corrosion, wear or damage visually. If defective, replace the pump case with a new one.

INSPECT THE SHAFT.

Check the threads and bearing inner race mount of the shaft for wear or damage visually. If defective, replace the shaft with a new one.

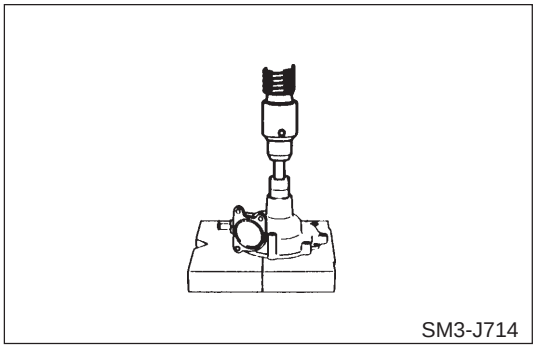

SM3-J714

Fig. 16

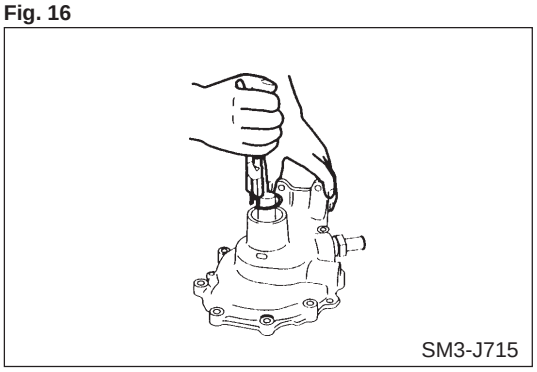

SM3-J715

Fig. 17

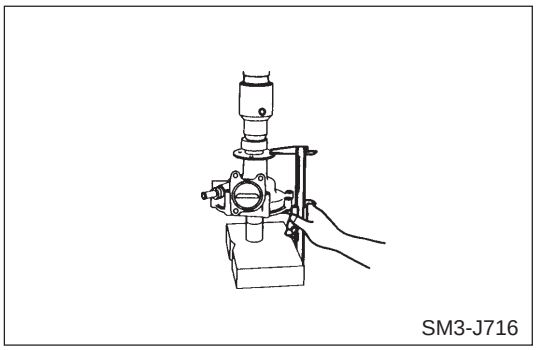

SM3-J716

Fig. 18

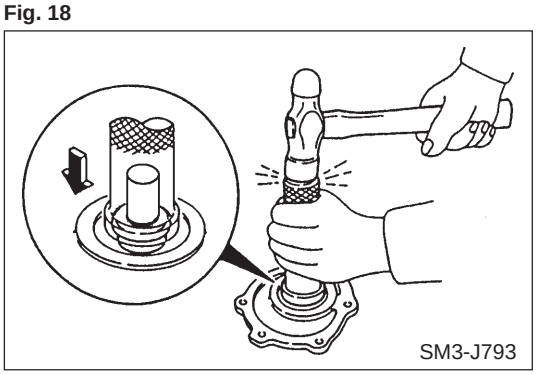

SM3-J793

Fig. 19

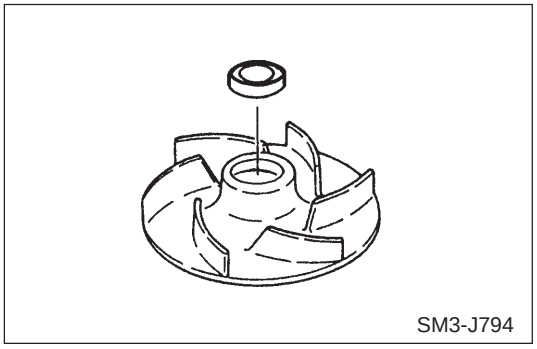

SM3-J794

Fig. 20

ASSEMBLING

1. Install the bearing collar and shaft onto the pump case using a hydraulic press.

NOTE:

- **Make sure you use a new bearing.**
- **Press until the bearing upper end surface comes into contact with the retainer ring groove lower end surface.**

2. Install the retainer ring onto the pump case using snap ring pliers.

3. Install the pulley center onto the shaft using a hydraulic press.

Standard: 129.0 - 129.8 mm (5.0788 - 5.1102 in.) from the pulley center mounting surface to the pump case end surface

4. Install the new coolant seal.

a. Apply a little sealer to the coolant seal outer circumference and coolant pump body.

b. Install the slinger and coolant seal.

NOTE: Replace the coolant seal with a new one.

c. Install the coolant seal to the vane.

NOTE: Replace the coolant seal with a new one.

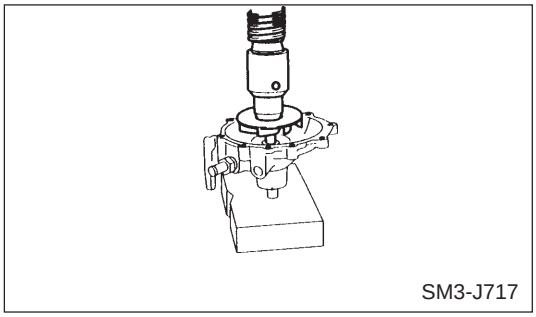


Fig. 21

5. Install the vane onto the shaft using a hydraulic press.

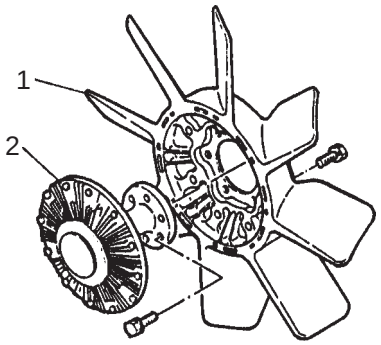
NOTE:

- **Press until the vane end face comes into contact with the shaft end surface.**
- **The clearance between the vane and pump case must be 0.6 - 1.2 mm (0.0236 - 0.0472 in.).**

6. After assembly, turn the shaft by hand and make sure that there is no noise, catching or rough movement in the shaft direction and that it rotates smoothly.

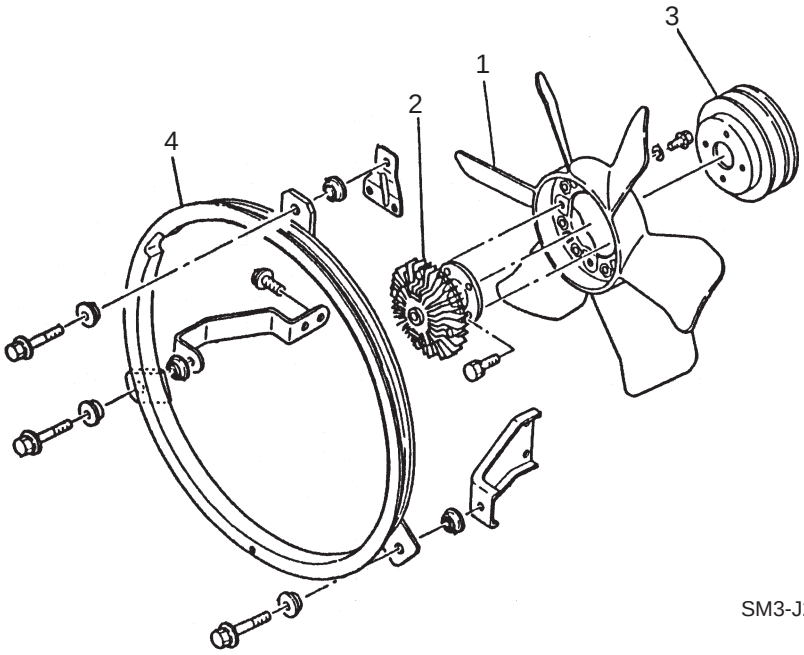
COOLING FAN AND FAN CLUTCH

CRANKSHAFT PULLEY MOUNTING TYPE



SM3-J285A

COOLANT PUMP PULLEY MOUNTING TYPE



SM3-J285

1. Cooling fan
2. Fan clutch
3. Coolant pump pulley
4. Fan shroud (If so equipped)

Fig. 22

COOLING FAN AND FAN CLUTCH

INSPECTING THE FAN AND FAN CLUTCH

1. Shock to the fan coupling and fan

   During maintenance and inspection, be careful not to drop or strike the fan coupling or fan itself. The resulting damage may lower the performance of the fan. Also, note that the fan is made of plastic and may become damaged or deformed if force is applied to it.

2. Replacing the fan

   Do not replace the fan unless it is faulty. When replacing the fan, replace it with the same type as the one which was removed. If the fan is replaced with one of a larger capacity due to overheating or, conversely is replaced with one of a smaller capacity due to overcooling, the cooling performance may be in fact reduced and durability may be jeopardized.

3. Other items

   Check the temperature detector (bimetal) to see if there is any mud or dust on it.

   If the bimetal is covered with mud or dust, the fan performance will be erratic, and may result in overheating or overcooling. In such case, carefully remove, mud and dust adhering to the surface of the bimetal, using a wire brush, or the like.

   Take particular care not to apply excessive force. Do not paint the fan or fan clutch.

   Do not place any paint or other reagents which are likely to dissolve plastic in contact with the fan.

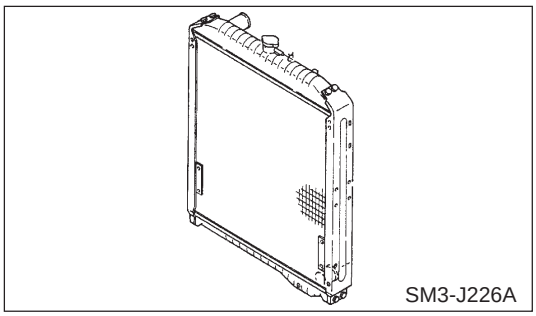


Fig. 23

RADIATOR AND INTERCOOLER

CHECK THE RADIATOR.

Check the radiator for coolant leakage and clogging of the fins.

NOTE : When carrying out high pressure washing to remove fin clogging, do not apply excessive pressure to the fins which may cause deformation and consequent performance deterioration.

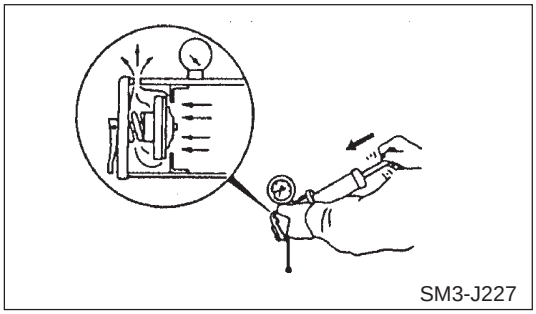


Fig. 24

INSPECT THE RADIATOR CAP.

Check the filler cap pressure using a cap tester.

Cap Pressure : 0.4 - 0.6 kg/cm^2 (5.69 - 8.53 lb/sq. in.)

NOTE : If the cap pressure is incorrect, there is a risk of abnormally high pressure being generated in the cooling system, which may cause the hose to drop off or burst and, in turn, damage the engine.

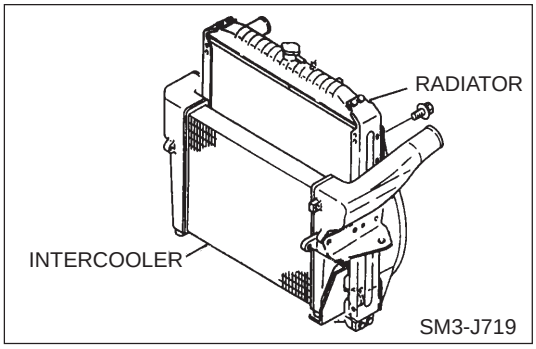


Fig. 25

CHECK THE INTERCOOLER.

The intercooler is used to cool the overheated intake air charged by the turbocharger, and is installed at the front of the radiator.

When mud, debris, etc. becomes attached to the front of the core, the passage of cooling air is impaired, so such matter should be removed completely by washing with water. Deformed fins also can impair cooling, and should be repaired.

when changing intercooler hoses, clean the inside by blowing with air.

NOTE : Do not use water to clean the inside of the intercooler body. Using water will cause engine trouble, etc.

INSTALLATION OF COMPONENT PARTS

INSTALL THE COOLANT PUMP.

NOTE: Refer to page 3-17-1.

INSTALL THE THERMOSTAT CASE.

NOTE: Refer to page 3-17-1.

INSTALL THE COOLING FAN AND FAN CLUTCH.

NOTE: Refer to page 3-17-2.

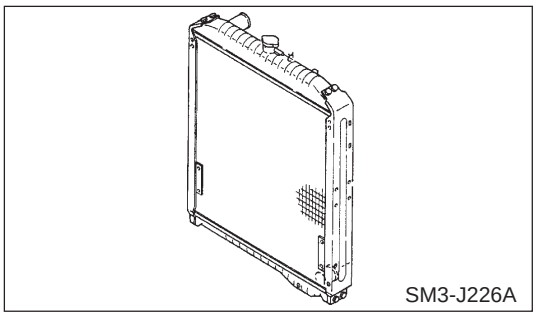


Fig. 24

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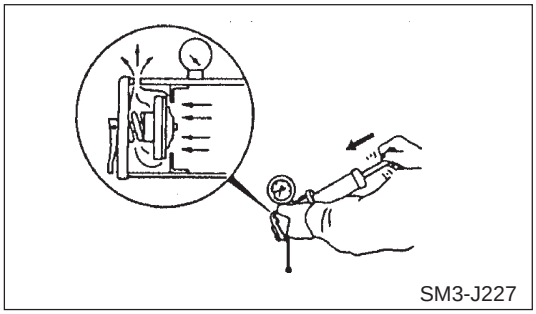

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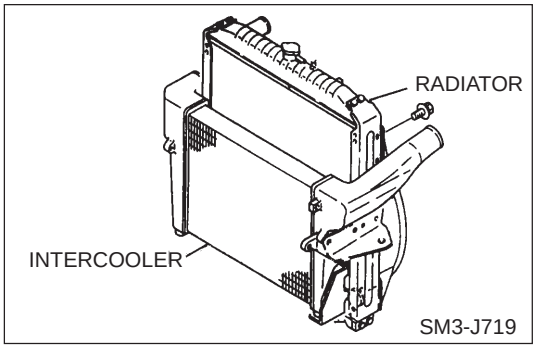


Fig. 26

CHECK THE INTERCOOLER.

The intercooler is used to cool the overheated intake air charged by the turbocharger, and is installed at the front of the radiator.

When mud, debris, etc. becomes attached to the front of the core, the passage of cooling air is impaired, so such matter should be removed completely by washing with water. Deformed fins also can impair cooling, and should be repaired.

when changing intercooler hoses, clean the inside by blowing with air.

NOTE : Do not use water to clean the inside of the intercooler body. Using water will cause engine trouble, etc.

INSTALLATION OF COMPONENT PARTS

INSTALL THE COOLANT PUMP.

NOTE: Refer to page 3-17-1.

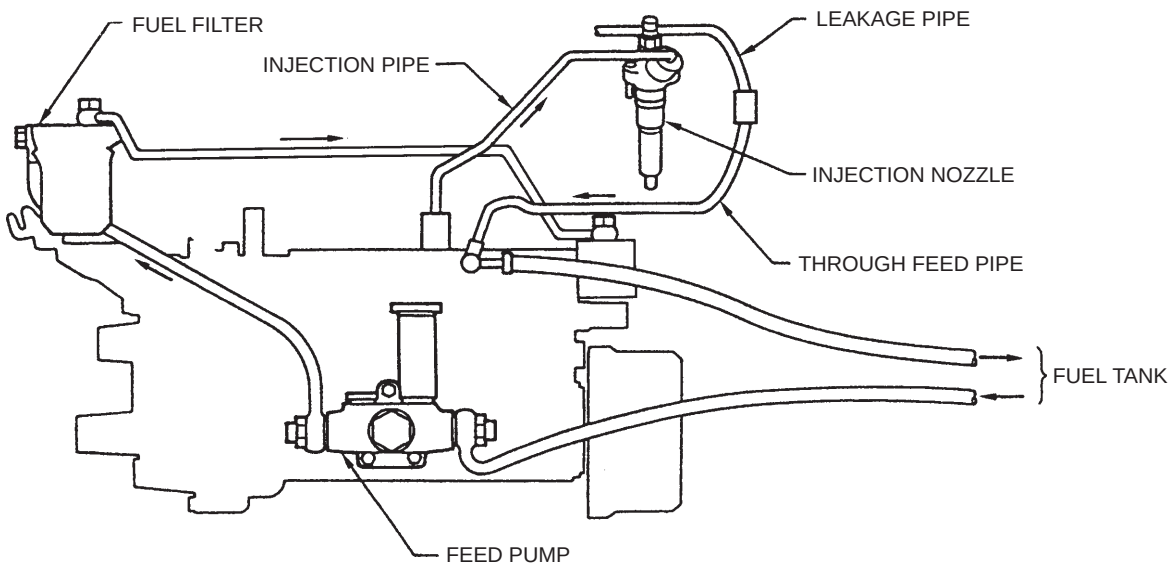
INSTALL THE THERMOSTAT CASE.

NOTE: Refer to page 3-17-1.

INSTALL THE COOLING FAN AND FAN CLUTCH.

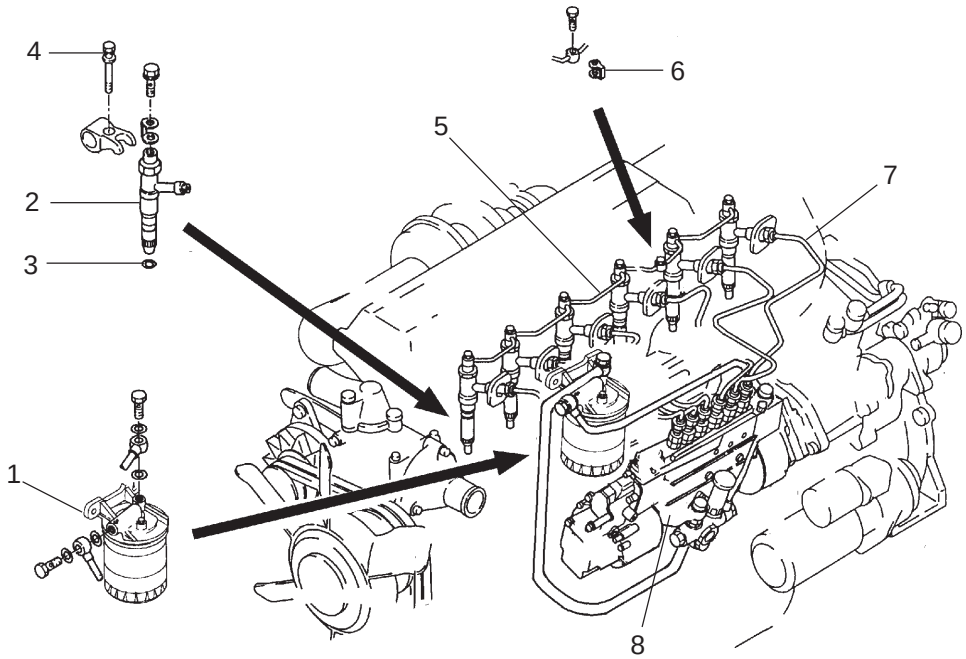
NOTE: Refer to page 3-17-2.

FUEL SYSTEM



SM3-J167A

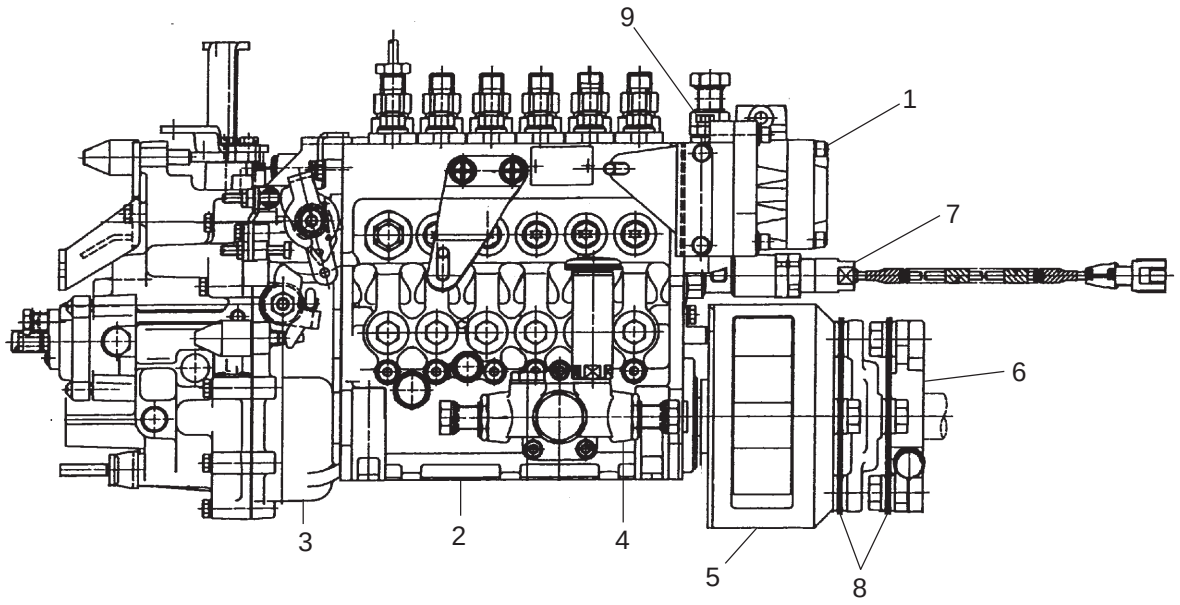
Fig. 1



1. Fuel filter
2. Injection nozzle
3. O-ring
4. Nozzle clamp bolt
5. Leakage pipe
6. Gasket
7. Injection pipe
8. Injection pump

SM3-J167E

Fig. 2



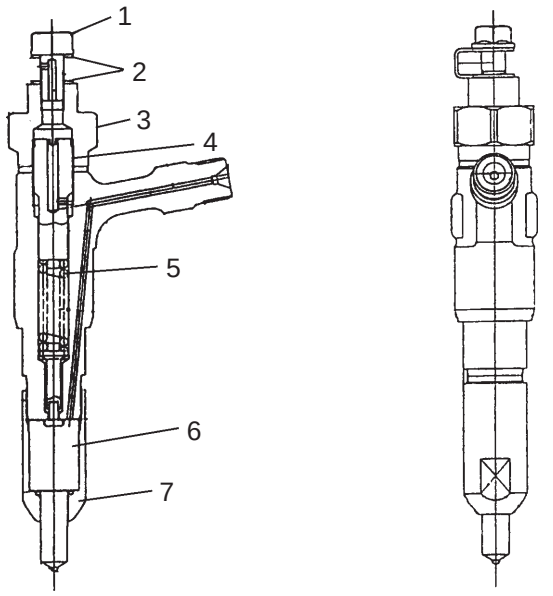
FUEL INJECTION PUMP

1. Pre-stroke actuator
2. Pump body
3. Governor
4. Feed pump
5. Timer
6. Coupling flange
7. Rack sensor
8. Lamination coupling
9. Air bleeder screw

SM3-J720B

Fig. 3

NOTE : Functional structure and system checking methods are reviewed in CHAPTER 78, TOTAL ELECTRONIC SYSTEM.

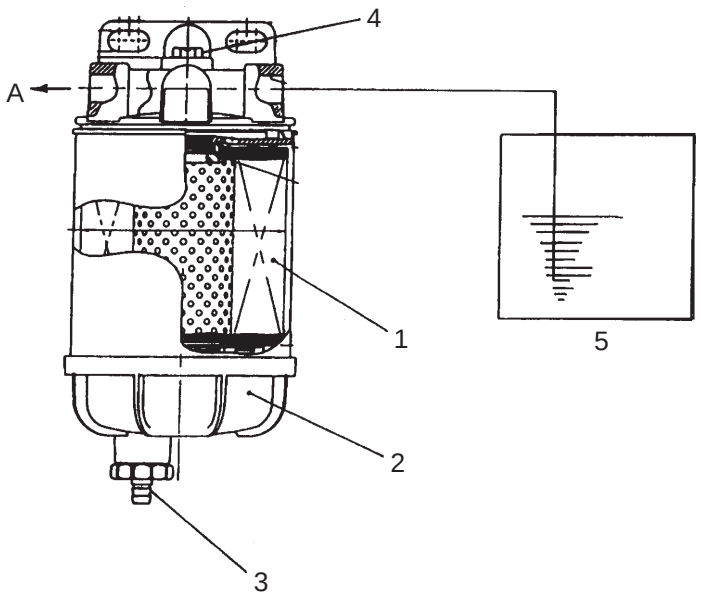


NOZZLE HOLDER

1. Joint bolt
2. Gasket
3. Nozzle holder cap nut
4. Adjusting screw
5. Pressure spring
6. Nozzle
7. Nozzle retaining nut

SM3-J721A

Fig. 4



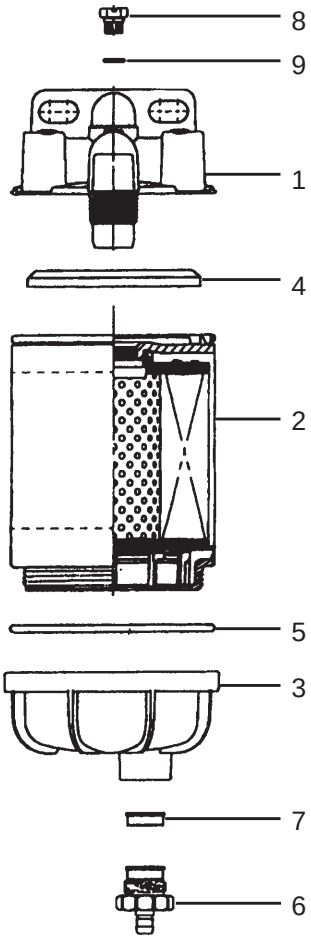
WATER SEPARATOR AND FUEL FILTER (PRIMARY)

1. Element
2. Drain bowl
3. Drain plug
4. Vent plug
5. Fuel tank

A : To feed pump and injection pump

SM3-J722

Fig. 5

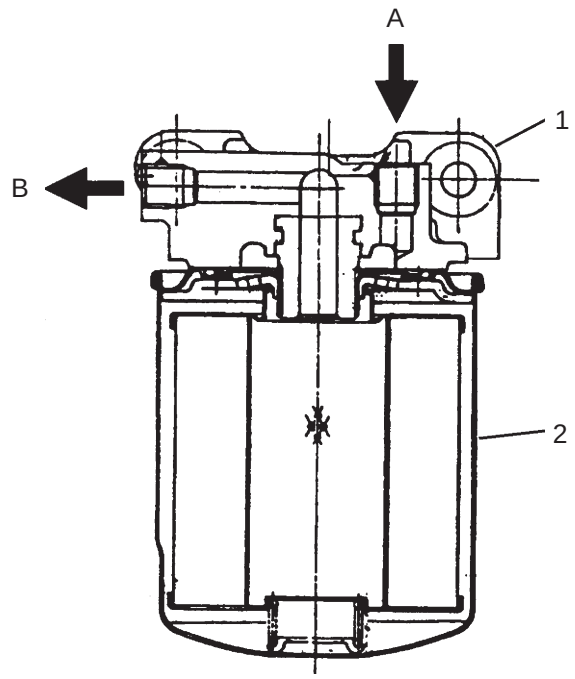


PRIMARY FUEL FILTER WITH WATER SEPARATOR

1. COVER
2. ELEMENT
3. DRAIN BOWL
4. GASKET
5. O-ring
6. DRAIN PLUG
7. GASKET
8. VENT PLUG
9. O-ring

SM3-J723

Fig. 6

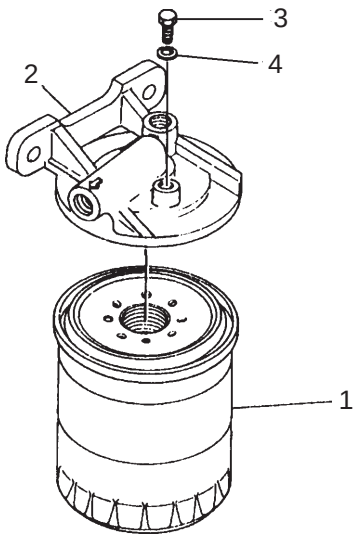


FUEL FILTER
1. Fuel filter cover
2. Fuel filter element

A : From fuel feed pump
B : To fuel injection pump

SM3-J724

Fig. 7



FUEL FILTER (SECONDARY)
1. Fuel filter element assembly
2. Fuel filter cover
3. Bleeder screw
4. Soft washer

SM3-J725

Fig. 8

REMOVAL OF COMPONENT PARTS

REMOVE THE INJECTION NOZZLE.

NOTE: Refer to page 3-6-3.

REMOVE THE INJECTION PUMP.

NOTE: Refer to page 3-5-2.

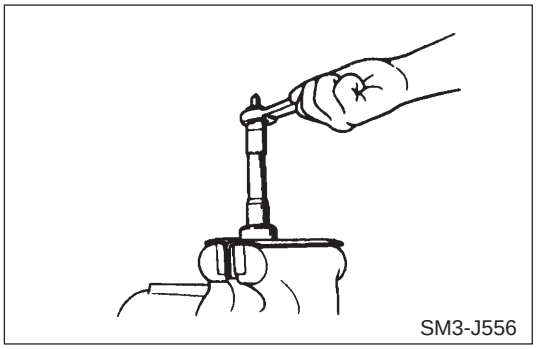


Fig. 9

INJECTION NOZZLE

DISASSEMBLING

1. Remove the adjusting screw from the nozzle holder upper part, then pull the nozzle spring and pressure pin out of the nozzle holder.
2. Mount the nozzle holder in a vise, remove the retaining nut from the nozzle holder lower part and remove the nozzle assembly.

NOTE:

- **When disassembling a nozzle holder, take care to prevent adherence of dust or dirt. Always be sure to clean the work place and tools.**
- **When removing a retaining nut, take care not to drop the nozzle assembly, which may cause damage.**
- **Be sure to put the disassembled parts in order, according to the combination in which they were.**

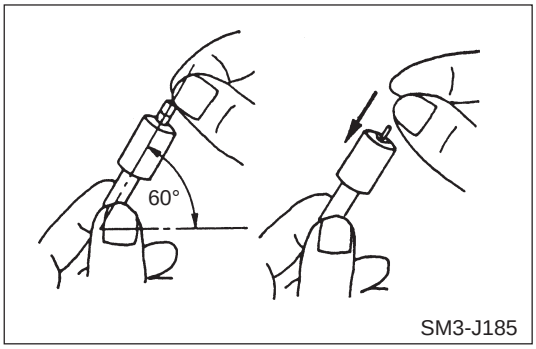


Fig. 10

INSPECTION AND REPAIR

INSPECT THE NOZZLE ASSEMBLY.

NOTE: Before inspection, clean the nozzle assembly by immersing in clean diesel oil.

Hold the needle valve in your fingers, slide it inside the nozzle body, then check that the valve moves smoothly. When the nozzle body is tilted at approximately 60°, the nozzle assembly is good if the needle valve is not caught and slips down smoothly under its own weight. If there is any malfunction or catching, replace the nozzle assembly with a new one.

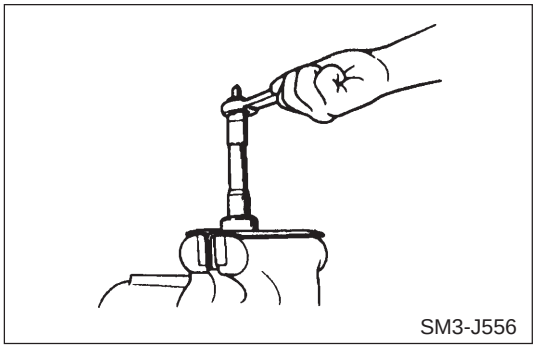


Fig. 11

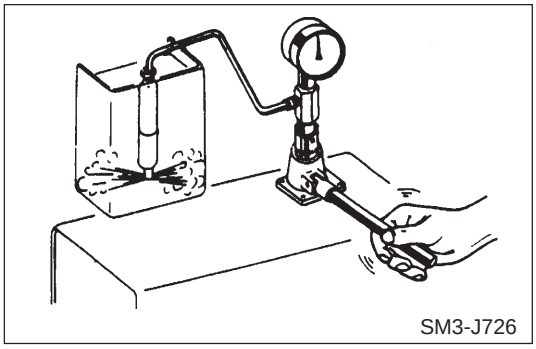


Fig. 12

ASSEMBLING

1. Assemble the pressure pin and nozzle spring onto the nozzle holder upper part.
2. Mount the nozzle holder in a vise, assemble the nozzle assembly onto the nozzle holder lower part, and tighten the retaining nut to the specified torque below.

Tightening torque: 650 kg·cm (47 lb·ft)

NOTE:

- **When assembling the nozzle holder, take care to prevent adherence of dust or dirt. Always be sure to clean the work place and tools.**
- **Take care not to drop the nozzle assembly, which may cause damage.**

CHECK THE INJECTION OPENING PRESSURE.

Operate the lever at the rate of 15 to 16 strokes per minute using a nozzle hand tester to read the injection start pressure. If the injection opening pressure is out of the standard value, adjust the injection opening pressure.

Injection opening pressure: 220 kg/cm² (3,129 lb/sq. in.)

WARNING

- **Since diesel oil is flammable, check and adjust the nozzle in a well ventilated room. Never use naked lights in the room.**
- **Since injected fuel is highly pressurized, direct contact with the body may be harmful to health. Provide a screen to prevent scattering of fuel.**

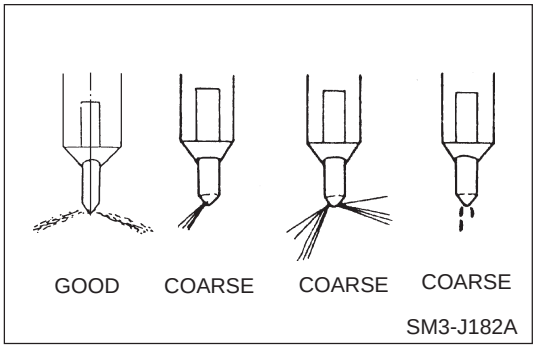


Fig. 13

ADJUST THE INJECTION OPENING PRESSURE.

Turn and adjust the adjusting screw so that the opening valve pressure is within the standard value using the nozzle hand tester.

Injection opening pressure: 220 kg/cm² (3,129 lb/sq. in.)

NOTE: Tightening the adjusting screw ..... increases pressure.
Loosening the adjusting screw ..... decreases pressure.

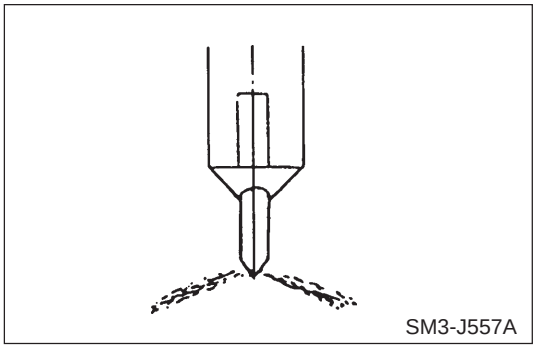


Fig. 14

INSPECT THE SPRAY PROFILE.

Inspect the spray profile using a nozzle hand tester. If the spray is coarse, inspect it again after cleaning. If it is still coarse, replace the nozzle assembly with a new one.

NOTE: In the case of a new nozzle, operate the lever at the rate of 30 to 60 strokes per minute, and for a used nozzle, operate the lever at the rate of 15 to 16 strokes per minute.

TEST THE FUEL LEAKAGE.

When checking for fuel leakage from the nozzle, apply a pressure about 10 - 20 kg /cm^2 (142 - 284 lb/sq.in.) lower than the correct injection pressure to the nozzle using a nozzle hand tester.

If defective, test it again after cleaning. If still defective, replace the nozzle assembly with a new one.

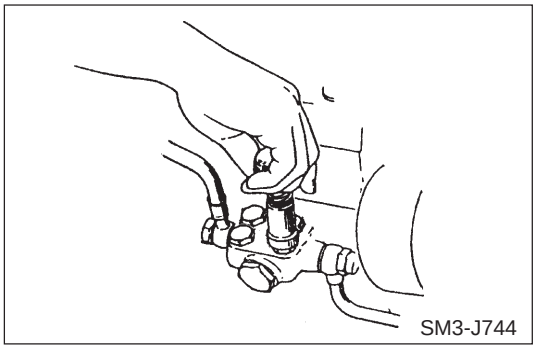


Fig. 15

AIR BLEEDING FROM FUEL SYSTEM

1. Loosen the bleeder plug on the fuel filter.
2. Turn the priming pump counterclockwise to come to the surface, then move it up and down.
3. Operate the priming pump until fuel, without bubbles, comes out of the bleeder plug.
4. Tighten the bleeder plug.
5. Move the priming pump up and down 5 to 6 times again.
6. Tighten the priming pump clockwise completely while it is pushed back.

NOTE: Wipe up any splashed fuel after finishing the work, and recheck that there is no fuel leakage after engine start-up.

INSTALLATION OF COMPONENT PARTS

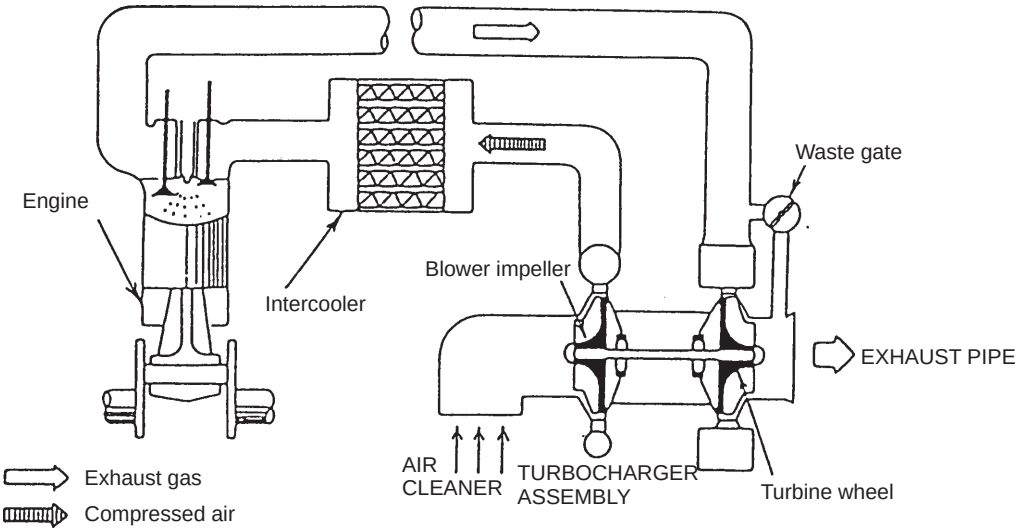
INSTALL THE INJECTION PUMP.

NOTE: Refer to page 3-17-5.

INSTALL THE INJECTION NOZZLE.

NOTE: Refer to page 3-6-23.

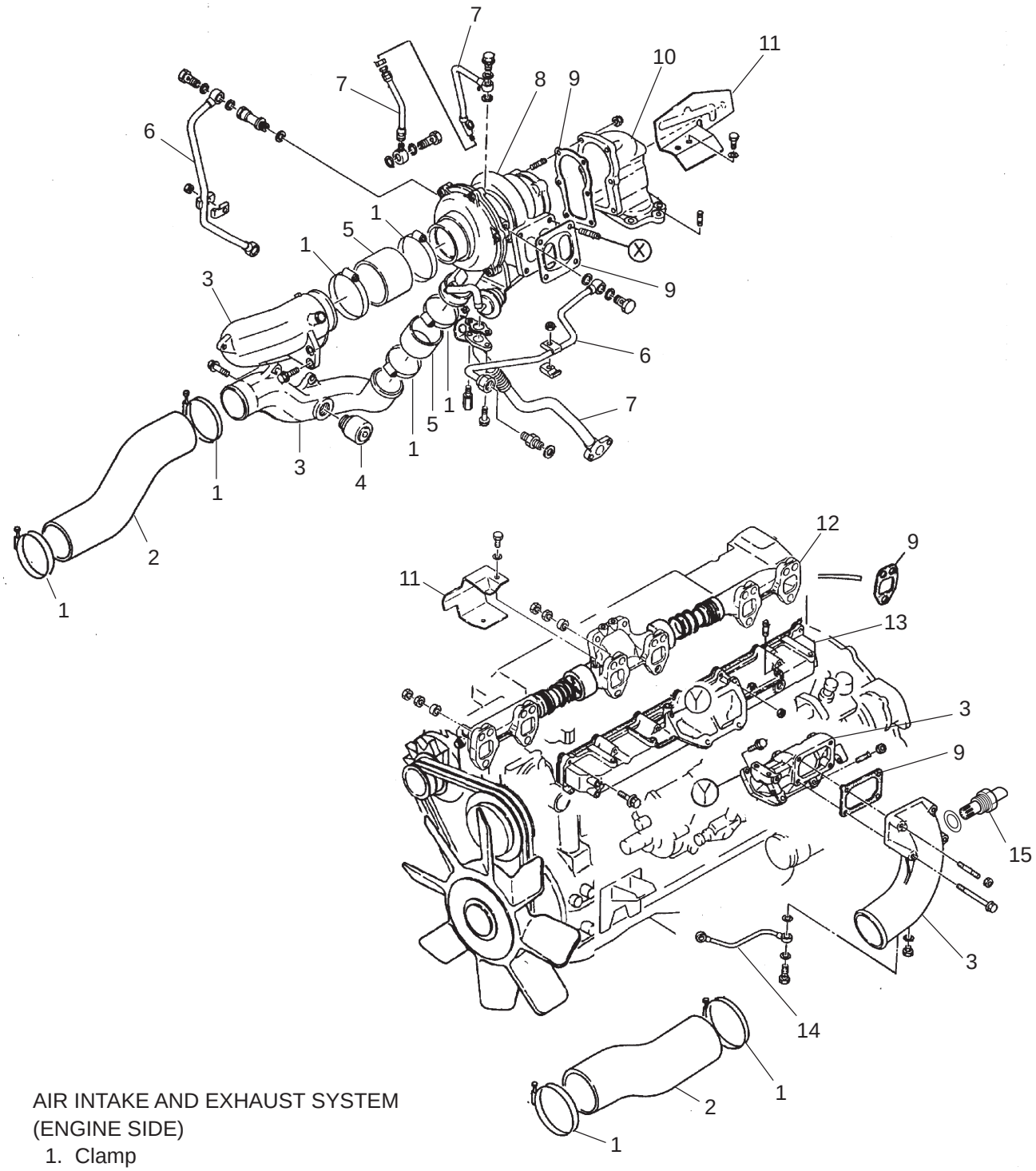
AIR INTAKE AND EXHAUST SYSTEM



AIR INTAKE AND EXHAUST SYSTEM DIAGRAM

SM3-J728

Fig. 1

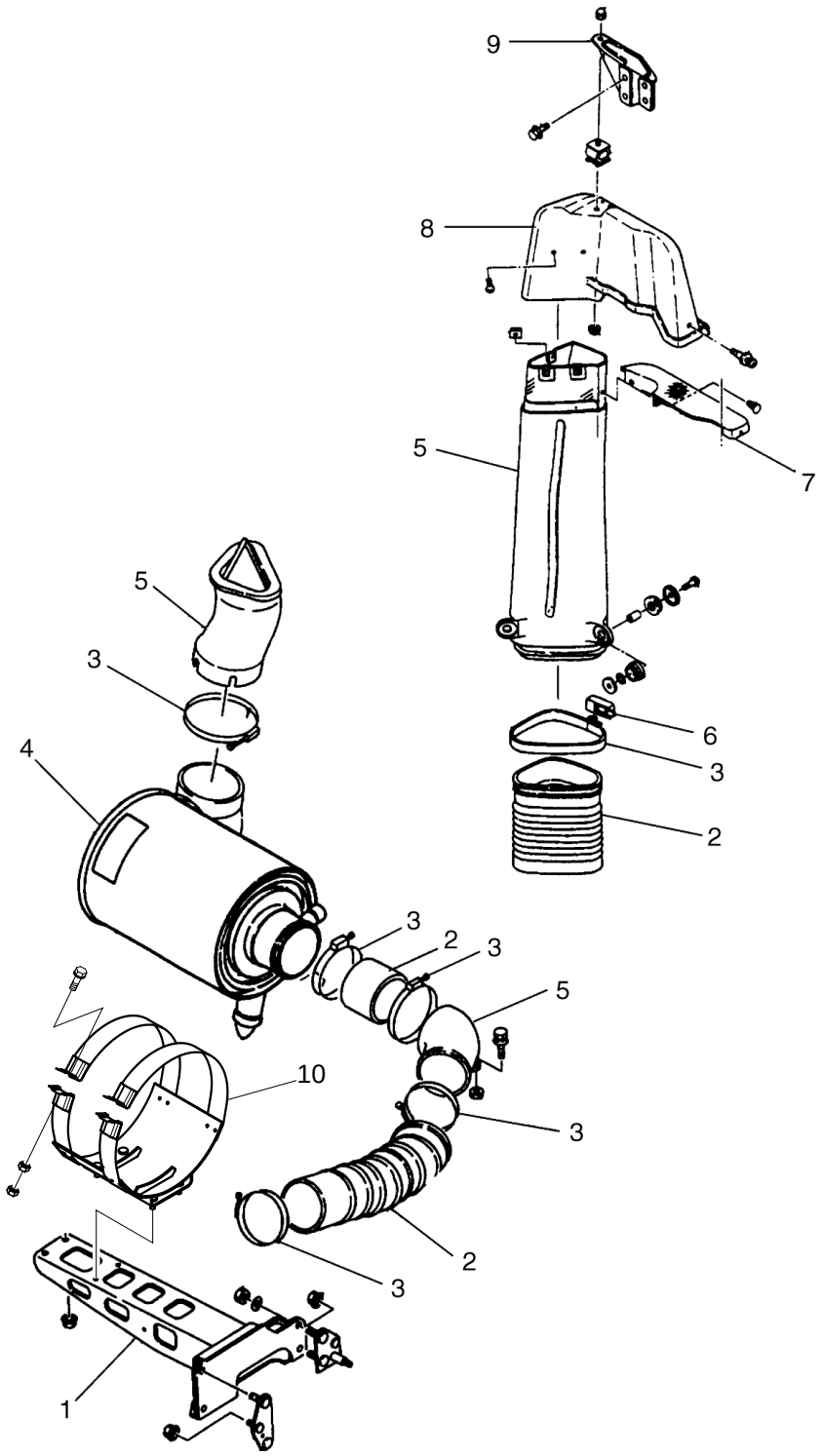


AIR INTAKE AND EXHAUST SYSTEM
(ENGINE SIDE)

1. Clamp
2. Inter cooler hose
3. Intake pipe
4. Safety valve
5. Hose
6. Coolant pipe
7. Oil pipe
8. Turbo charger
9. Gasket
10. Exhaust connector
11. Heat insulator
12. Exhaust manifold
13. Intake manifold
14. Boost compensator pipe
15. Intake air temperature sensor

SM3-J405B

Fig. 2

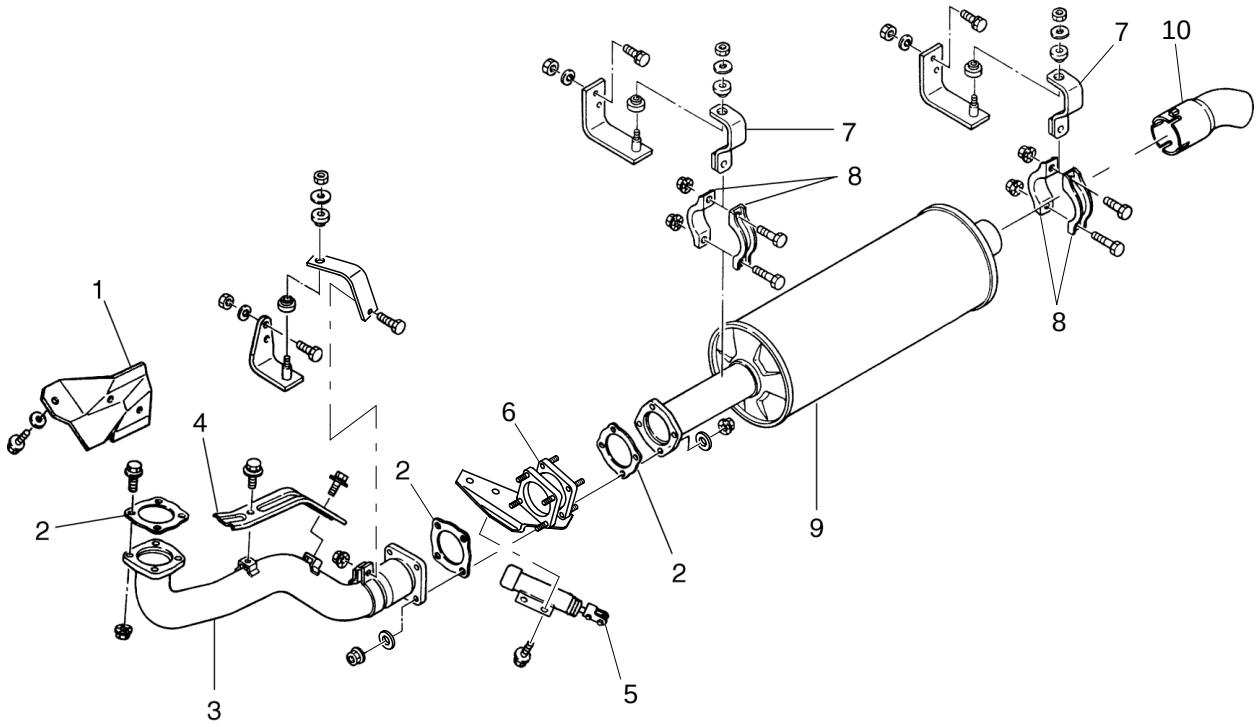


AIR INTAKE SYSTEM (CHASSIS SIDE)

1. Air cleaner bracket
2. Hose
3. Clamp
4. Air cleaner
5. Pipe
6. Insulator
7. Mesh
8. Hood
9. Bracket
10. Band

ASM3-159

Fig. 3



EXHAUST SYSTEM (CHASSIS SIDE)

1. Insulator
2. Gasket
3. Exhaust pipe
4. Heat insulator
5. Control cylinder assembly
6. Exhaust brake valve
7. Exhaust pipe support
8. Exhaust pipe clamp
9. Muffler sub-assembly with catalyst
10. Exhaust tail pipe

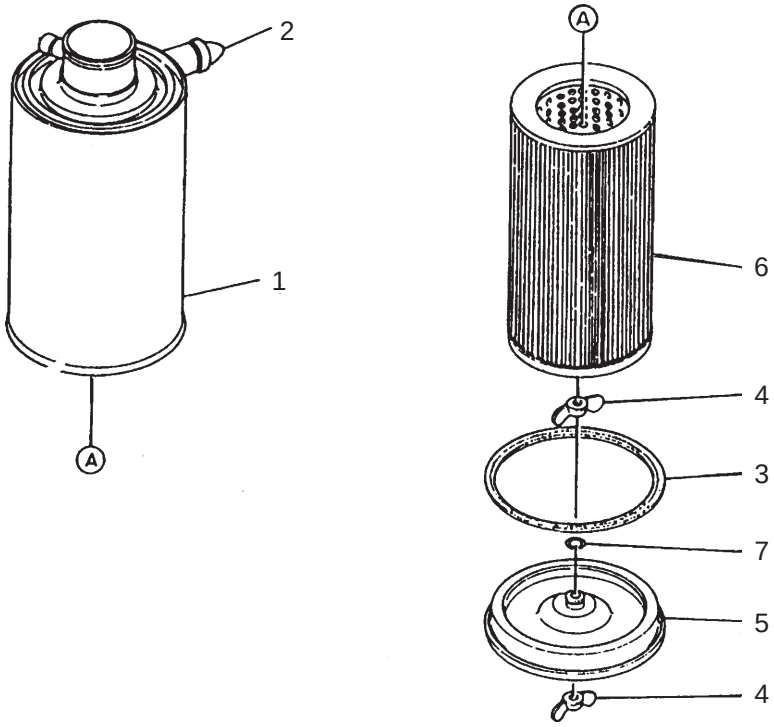
ASM3-160

Fig. 4

NOTE: ABOUT THE CATALYTIC CONVERTER

- ○ **It is a device to clean the exhaust fumes.**
- ○ **It is a device that has a significant effect on exhaust performance.**

AIR CLEANER



AIR CLEANER
1. Air cleaner body
2. Unloader valve
3. Gasket
4. Wing nut
5. Cover
6. Element
7. Clamp

SM3-J731

Fig. 5

INSPECTING AND CLEANING AIR CLEANER

NOTE: The element can be washed to clean it.

Proper maintenance interval:

Every 36,000 miles or 12 months

1. **CHECK THE ELEMENT TO SEE IF IT IS FLATTENED OR DEFORMED, OR WHETHER THE FILTER PAPER OF THE ELEMENT IS TORN.**
2. **CHECK TO SEE IF THE SEALING OF THE GASKET IS COMPLETE.**

NOTE: If an abnormality is found during the above inspection, replace the element with a new one. If dust is taken into the engine, the engine will wear and its performance will deteriorate.

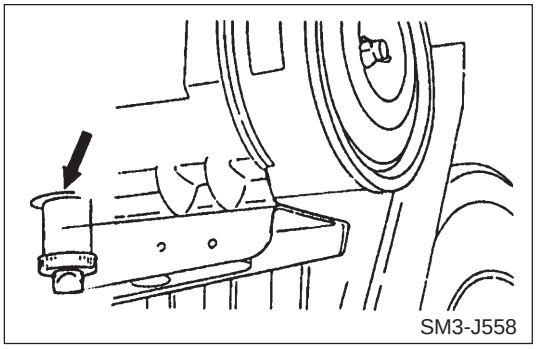


Fig. 6

3. INSPECT THE UNLOADER VALVE.

Check to see if the unloader valve is damaged or missing, water and dirt will get into the filter and damage the element.

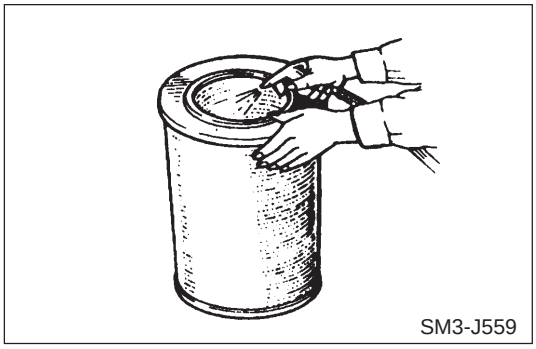


Fig. 7

4. CLEAN THE ELEMENT ACCORDING TO ONE OF THE FOLLOWING METHODS, DEPENDING ON THE DEGREE TO WHICH IT IS SOILED.

1. When the element is fouled by dry dust.

   Remove dust by blowing dry compressed air from the inside of the element towards the outside, then compressed air from the outside in the longitudinal direction of the filter.

WARNING

To prevent injury, always select appropriate type of safety glasses for the job.

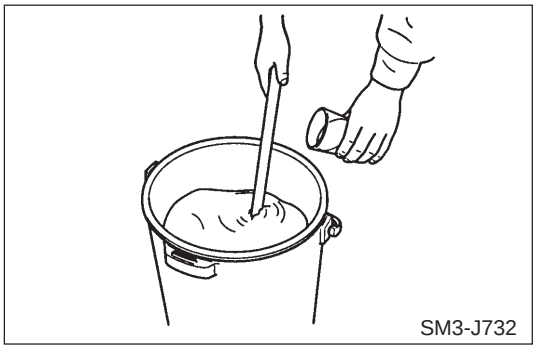


Fig. 8

NOTE:

- **When cleaning the element, do not strike, knock or drop it, as this will cause damage.**
- **To prevent damaging the element, keep the air pressure below 7 kg/cm² (99.6 lb/sq.in).**

2. When the element is fouled by soot or oil mist, wash the element thoroughly with 300 g (0.66 lb) of element detergent (Donaldson type ND-1500 or D-1400) dissolved in 5 liters (5.3 US.qts) of hot water diluted to 20 liters (21.1US.qts).

NOTE: Never clean the element with gasoline, fuel oil, kerosene, or solutions containing any of these.

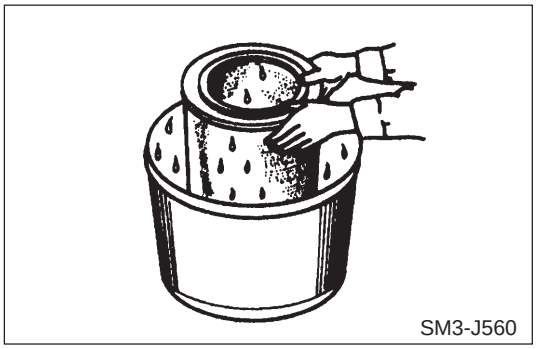


Fig. 9

a. Immerse the element in the solution for 30 minutes.

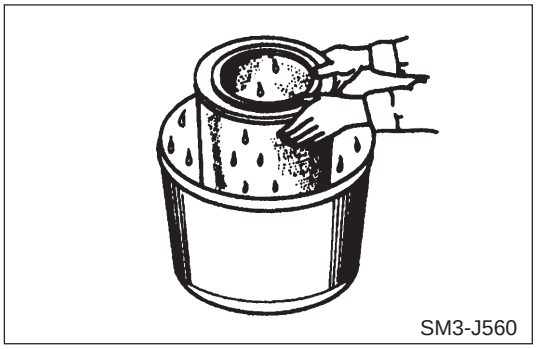

SM3-J560

Fig. 10

b. After immersing the element, rinse it in fresh solution.

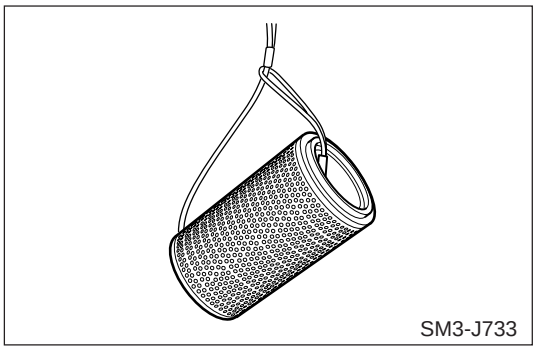

SM3-J733

Fig. 11

5. DRY THE ELEMENT WITH AIR.

1. Dry the element after thoroughly draining off the solution. If time is limited, dry the element using a fan or air draft.

   Do not use compressed air or apply direct heat to it. The element will dry in about 3 to 4 days during the summer or in a heated room.
2. When using a drying oven, keep the temperature below 80˚C (176˚F). Do not use an electric light bulb to dry the element.

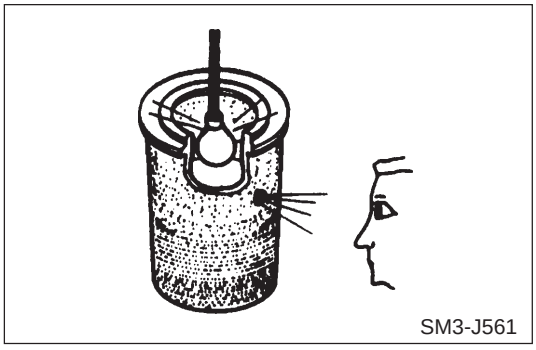

SM3-J561

Fig. 12

6. INSPECT THE ELEMENT FOR DAMAGE USING AN INSPECTION LAMP.

After washing and drying the element, thoroughly inspect it in accordance with the instructions pasted on the element or the Owner's and Driver's Manual. Ensure that the filter paper is not torn and the packing is undamaged.

EXHAUST MUFFLER DISMOUNTING

WARNING
Do not touch the exhaust manifold when it is hot. You can be severely burned.

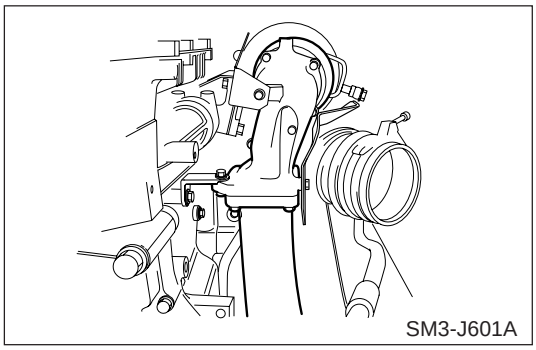


Fig. 13

1. DISCONNECT THE EXHAUST PIPE FROM THE EXHAUST MANIFOLD.

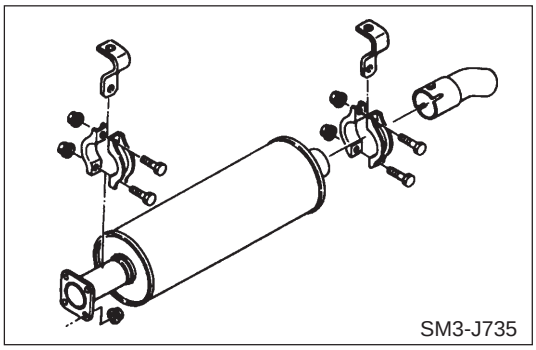


Fig. 14

2. DISCONNECT THE EXHAUST MUFFLER AND TAIL PIPE.

NOTE: Removal and installation should be done completely.

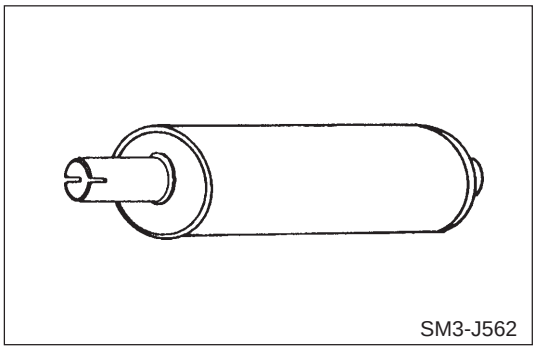


Fig. 15

INSPECTION

EXHAUST MUFFLER AND PIPES

Be particularly careful of rust holes and dents caused by flying stones.

NOTE:

- **If there are holes or cracks in the exhaust muffler and pipe, the exhaust noise will increase and may exceed the EPA noise regulation values. In addition, hot gas may blow out, resulting in the risk of fire.**
- **If the exhaust muffler and pipe is severely dented by flying stones, etc., the exhaust resistance will increase, causing the output decrease and resulting in increase of fuel consumption.**

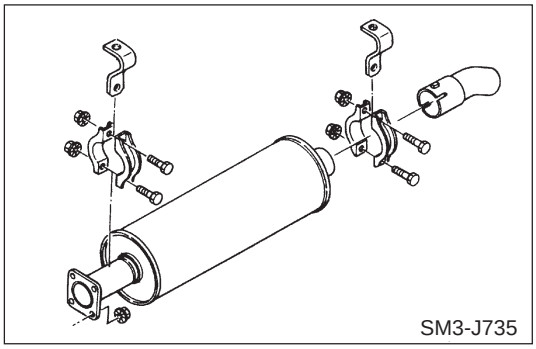


Fig. 16

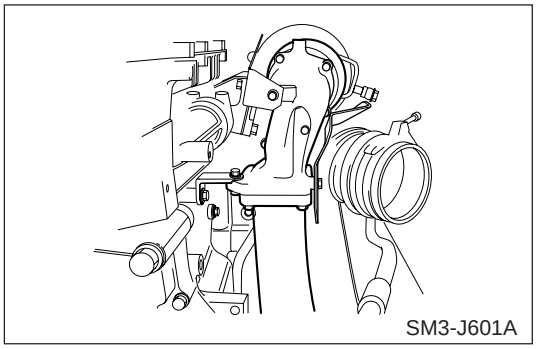


Fig. 17

MOUNTING

1. EXHAUST PIPE AND MUFFLER

1. Connect the exhaust pipe and muffler.

NOTE : Removal and installation should be done completely.

WARNING

If the position of the tail pipe is incorrect, exhaust fumes may blow onto passers by and burns may also result.

2. Connect the exhaust pipe to the exhaust manifold.

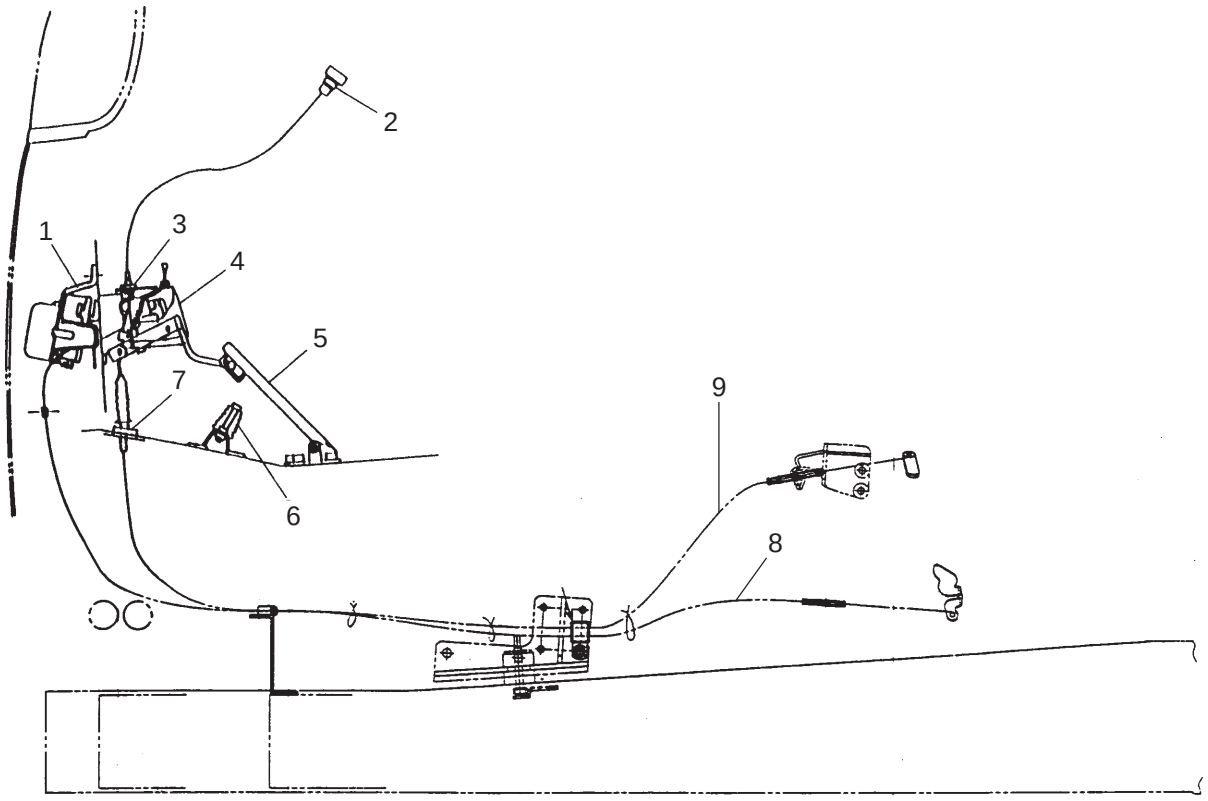
NOTE:

- **Replace the gasket with new one.**
- **The mounting portion of the exhaust manifold is subjected to heat and is likely to come loose, so special nuts are employed. Be sure to use the correct nuts.**
- **When tightening the clamp, arrow mark on the clamp or rounded part must direct upward.**
- **Tightening torque:**

  M8 ····· T = 222-226 kg·cm (16.0-16.3 lb·ft)

  M10 ····· T = 515-525 kg·cm (37.2-38.0 lb·ft)

ENGINE CONTROL SYSTEM



ENGINE CONTROL LINKAGE

1. Engine stop motor
2. Throttle control knob
3. Adjusting nut
4. Accelerator link lever sub-assembly
5. Accelerator pedal
6. Stopper bolt
7. Clamp
8. Engine stop cable
9. Accelerator cable

SM3-J563A

Fig. 1

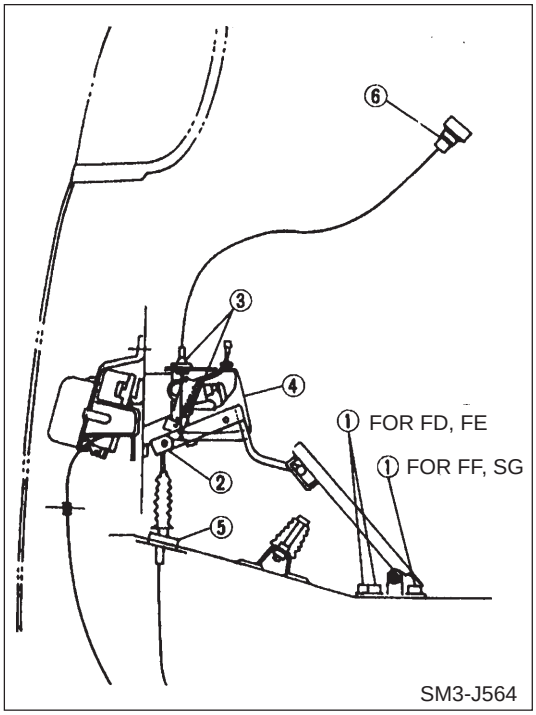


Fig. 2

DISASSEMBLY

1. ACCELERATOR CONTROL MECHANISM

1. Remove the bolts from the bracket at the neck of the pedal ①, then remove the accelerator pedal together with the bracket.
2. Disconnect the accelerator cable ② and throttle cable ③ from the accelerator link lever.
3. Remove the clamping bolt and remove the accelerator link lever assembly ④.
4. Remove the clamp at the bottom of the accelerator cable ⑤, then pull the cable from the frame side, and remove the clamp fixing the cable to the frame.
5. Tilt the cab, then remove the clevis pin connecting the fuel control lever of the injection pump and the cable end, then remove the accelerator cable.
6. Loosen the screw of the throttle control knob ⑥, then loosen the link and remove the throttle cable after pushing it through to the rear of the instrument panel.

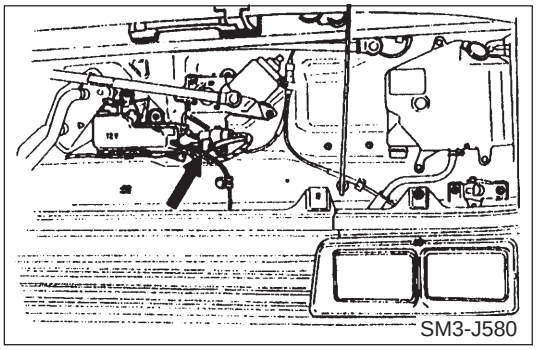


Fig. 3

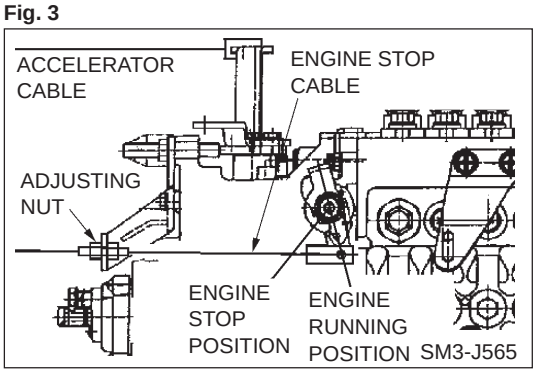


Fig. 4

3. ENGINE STOP MECHANISM

1. Set the engine starter key at ON position.

WARNING
Do not start the engine.

NOTE : Slacking the engine stop inner cable by setting the engine starter key at ON position facilitate dismounting, mounting and adjustment of the cable.

2. Tilt the cab.
3. Make sure that the engine stop lever of the fuel injection pump is at engine running position as shown in Fig. 4, then disconnect the connectors of the engine stop motor harness.
4. Set the engine starter key at LOCK position.
5. Remove the pin from the engine stop lever, and disconnect the cable.
6. Remove the clip bands fixing the cable to the frame, then remove the cable.
7. Remove the engine stop motor.

INSPECTION

1. CHECK THE PEDAL AND LINK LEVER.

Inspect the accelerator pedal and link lever for damage, deformation and wear.

2. CHECK THE CABLES.

1. Check the throttle and accelerator cable for smooth movement, and also inspect these parts for damage and rust.

WARNING
If the sliding resistance of the accelerator cable increases, and the cable does not return promptly, panic braking performance will be adversely affected, which is extremely dangerous.
Replace the accelerator cable of which sliding resistance has once increased to such an extent.

2. Check the engine stop cable for smooth movement and inspect it for damage and rust.

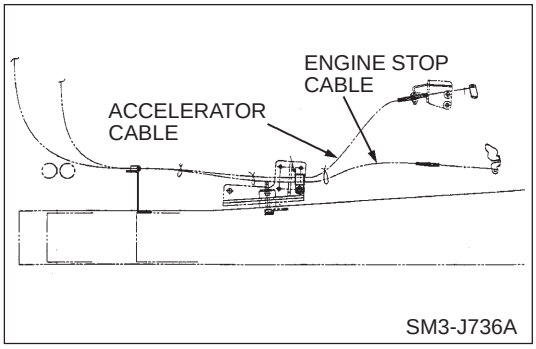


Fig. 5

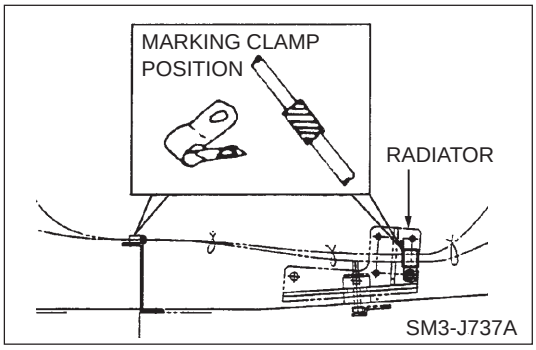


Fig. 6

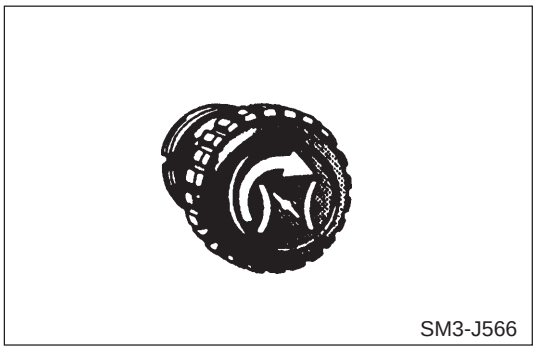


Fig. 7

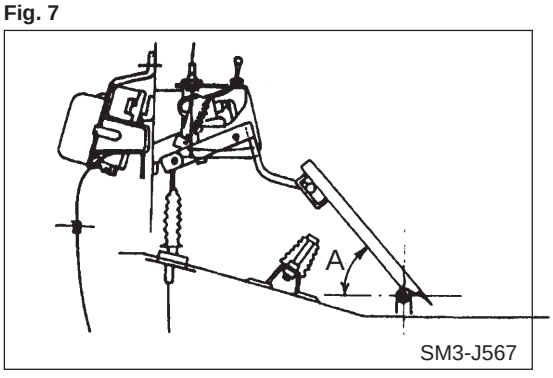


Fig. 8

INSTALLATION AND ADJUSTMENT

NOTE : Install the cables in the reverse sequence of removal, and be careful of the following points.

1. INSTALLATION OF ACCELERATOR CONTROL MECHANISM

Both the accelerator cable and engine stop cable are taped in order to facilitate identification during installation. After being sure to connect the correct cable, successively clip the cables, ensuring that they do not sag.

NOTE: Ensure that the bending radius of the cable is no less than 150 mm (5.91 in), otherwise the sliding resistance will become excessively high and cable durability will also be adversely affected.

Provide a suitable amount of slack in the cable between the engine and frame. This is because of the danger of the cable breaking due to relative motion between the engine and frame.

2. ADJUSTING THE ACCELERATOR CONTROL MECHANISM

1. Prior to fitting the throttle cable, turn the knob counter-clockwise until it stops, then back off 4 turns from the position.
2. Set the accelerator pedal at an angle of A° with respect to the floor surface.

Accelerator pedal angle (A°) : 50°

3. Eliminate slack in the cable of the control lever of the injection pump.
4. Adjust the stopper bolts so that the clearance between the pedal and the stopper is 2 - 5 mm (0.079 - 0.196 in)
5. For the model equipped with a manual transmission ; confirm that the amount of force applied on the pedal (measured point P) is 4 kg (9 lb) at the initial stage [2 - 3 mm (0.079 - 0.11 in)] and 7 kg (15 lb) at full stroke.

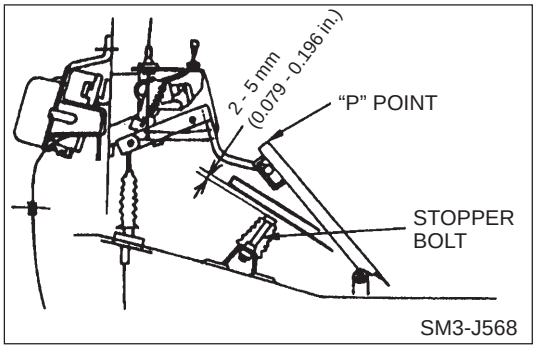


Fig. 9

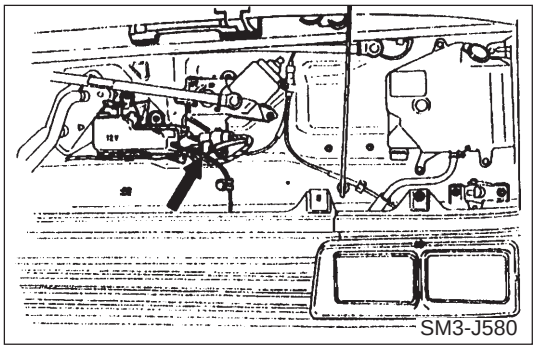


Fig. 10

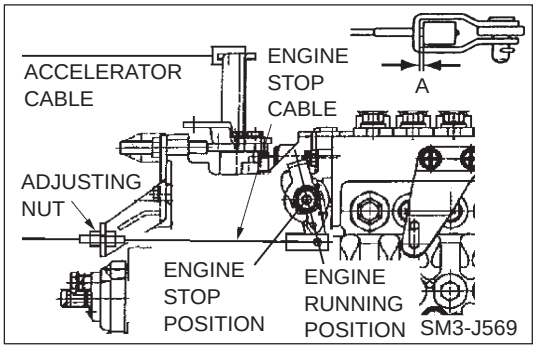


Fig. 11

6. For the model equipped with an automatic transmission ; confirm that the amount of force applied on the pedal is 7 kg (15 lb) at the initial stage and 11 kg (24 lb) at full stroke.
7. Check the engine idle speed (700 - 750 rpm).

4. INSTALLING AND ADJUSTING THE ENGINE STOP MECHANISM

1. Install the engine stop motor.
2. Connect the engine stop cable to the link lever of the engine stop motor and then install the motor cover.
3. Install the clip bands and engine stop cable on the frame.

4. Set the engine starter key at ON position.

WARNING

Do not start the engine.

5. Connect the connectors of the engine stop motor harness.

WARNING

Do not connect the electric harness with the engine stop motor while the engine starter key is at LOCK or ACC position as this operates the engine stop motor instantaneously and the link lever of the engine stop motor and the engine stop lever of the injection pump will move, resulting in your fingers being caught by the lever.

6. Connect and adjust the engine stop cable with adjusting nut so that the clearance "A" between the clevis and cable stopper is 1 - 3 mm (0.04 - 0.11 in.).
7. After adjustment, confirm correct execution of engine start and stop.

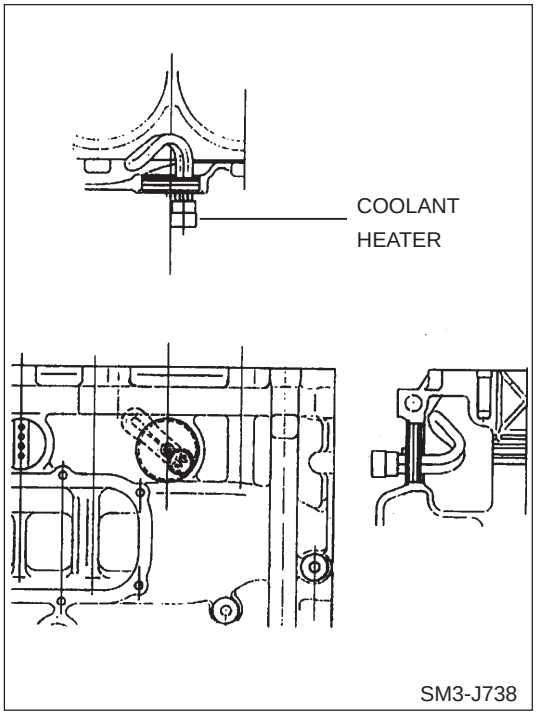


Fig. 12

5. STARTING THE ENGINE IN COLD WEATHER

In a diesel engine, fuel injected into the combustion chamber ignites by the temperature itself resulting from the compressed air in the cylinder. This temperature is high enough to ignite the fuel under normal operating conditions; however, when the ambient temperature is low, the temperature resulting from the compressed air may be insufficient to ignite the injected fuel.

1. This engine is provided with glow plugs as standard equipment, in order to facilitate engine starting when the ambient temperature is low. It is also possible to install the following devices to assist starting at low temperature.

a. An approx. 2" threaded hole is provided at the front of the right hand side of the cylinder block to permit installation of an immersion type coolant heater.

b. It is also possible to install four batteries as an option in order to improve starting performance.

2. Installation of coolant heater.

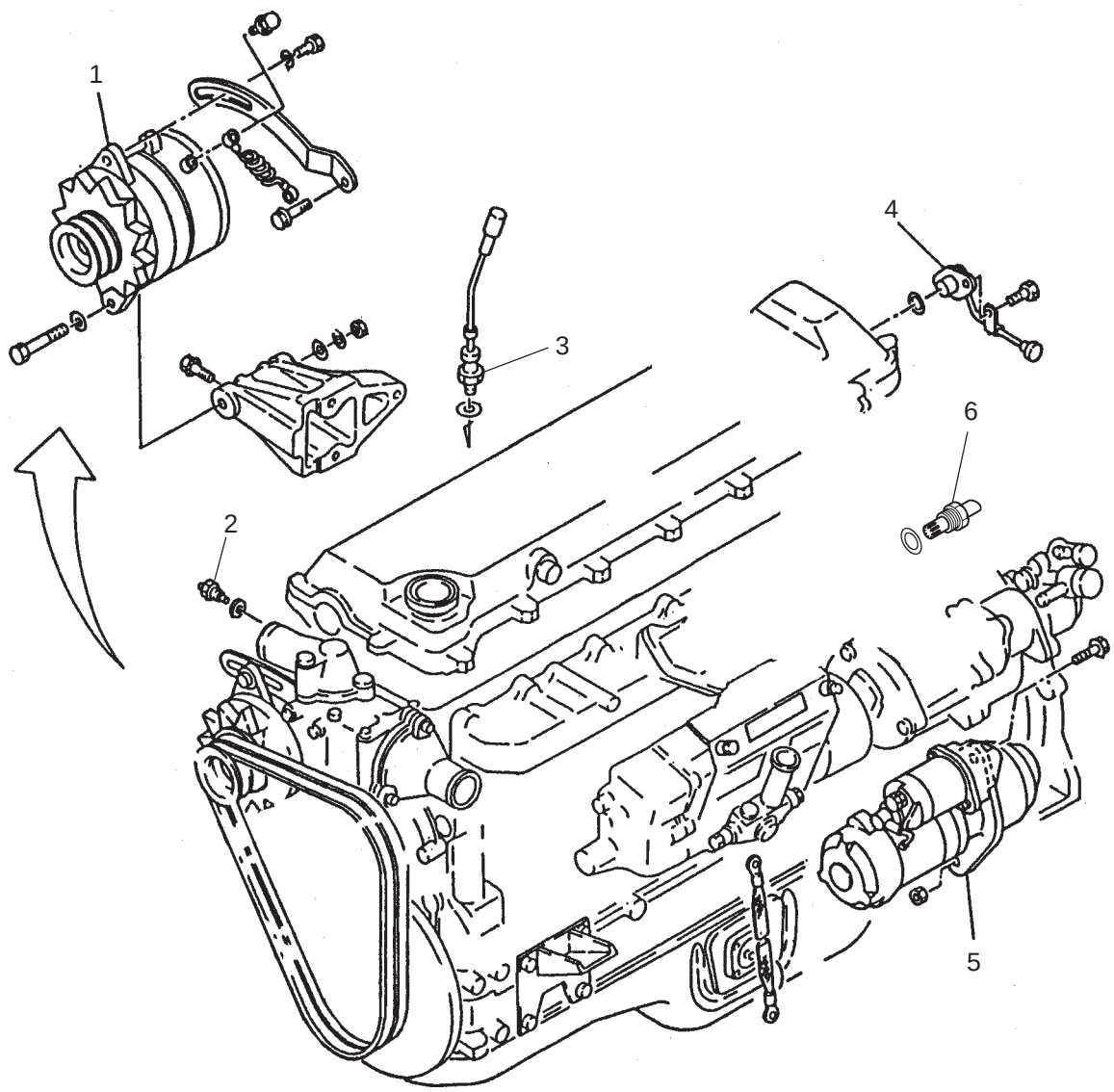
When installing a coolant heater on the engine, first drain off the engine coolant. After installing the respective heaters, again supply suitable quantities of coolant, and then start the engine and confirm that there is no leakage of coolant from the respective mounting faces.

WARNING

When a coolant immersion heater is used, carefully read the manufacturer's instructions.

NOTE: When not using the coolant heater for summer, remove it from the engine and keep it.

ELECTRICAL PARTS



ELECTRICAL PARTS
1. Alternator
2. Coolant temperature gauge
3. Oil pressure switch
4. Engine speed sensor
5. Starter
6. Intake air temperature sensor

SM3-J286A

Fig. 1

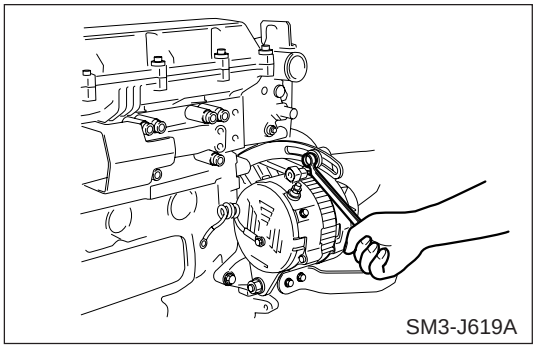

SM3-J619A

Fig. 2

ALTERNATOR

DISMOUNTING

NOTE: Refer to page 3-5-3.

DISASSEMBLING AND ASSEMBLING

NOTE: Refer to ALTERNATOR in CHAPTER 21.

MOUNTING

NOTE: Refer to page 3-17-2.

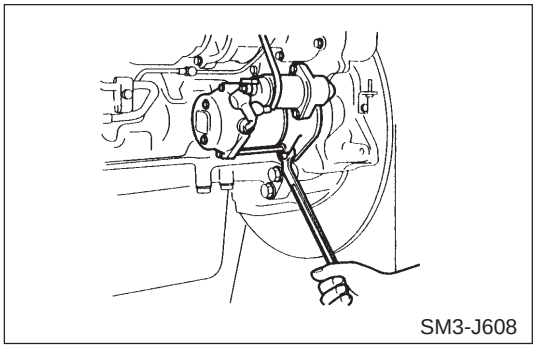

SM3-J608

Fig. 3

STARTER

DISMOUNTING

NOTE: Refer to page 3-5-1.

DISASSEMBLING AND ASSEMBLING

NOTE: Refer to STARTER in CHAPTER 22.

MOUNTING

NOTE: Refer to page 3-17-6.

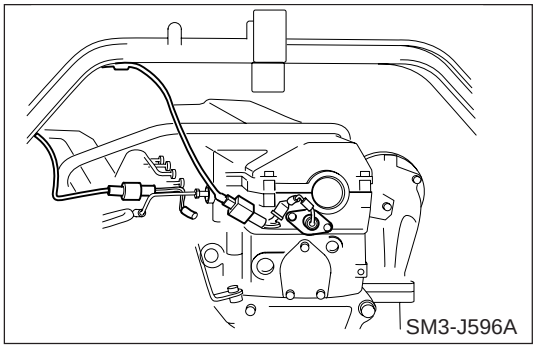

SM3-J596A

Fig. 4

ENGINE SPEED SENSOR

DISMOUNTING

NOTE: Refer to TOTAL ELECTRONICS SYSTEM in CHAPTER 78.

INSPECTION AND REPAIR

NOTE: Refer to ELECTRICAL EQUIPMENT in CHAPTER 20.

MOUNTING

NOTE: Refer to TOTAL ELECTRONICS SYSTEM in CHAPTER 78.

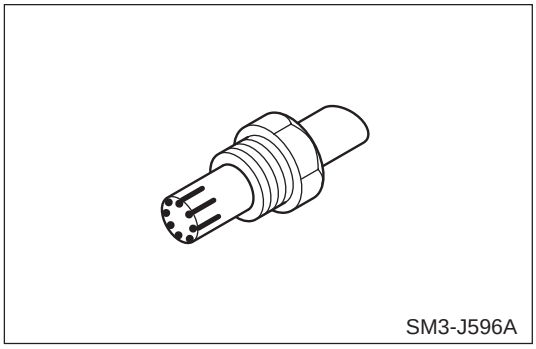

SM3-J596A

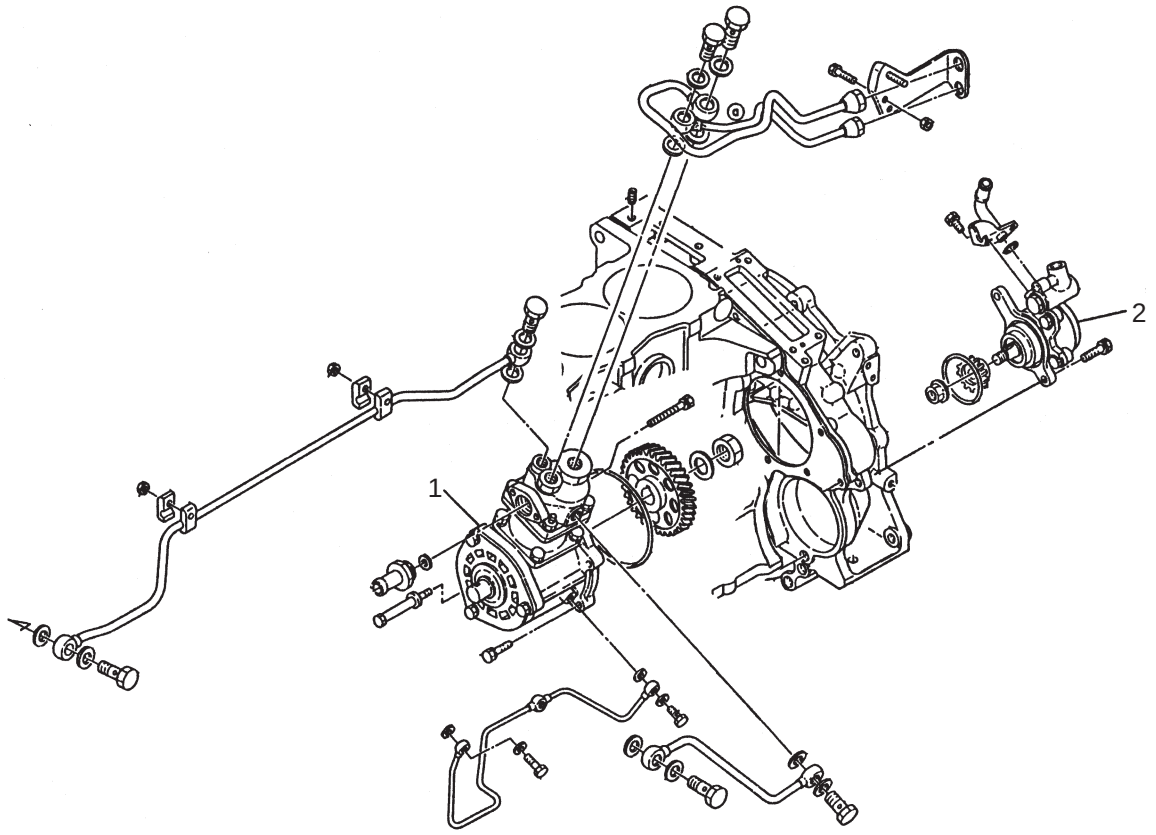
Fig. 5

INTAKE AIR TEMPERATURE SENSOR

MOUNTING

Tightening torque: 300 - 400 kg·cm (22 - 28 lb·ft)

AIR COMPRESSOR AND POWER STEERING PUMP



AIR COMPRESSOR AND POWER STEERING PUMP
1. Air compressor
2. Power steering pump

SM3-J287

Fig. 1

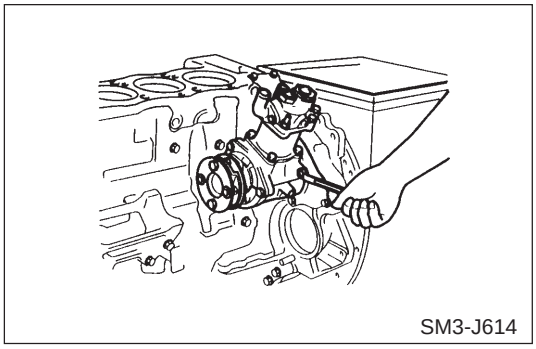

SM3-J614

Fig. 2

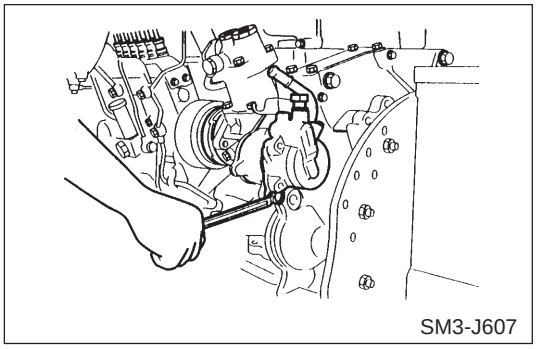

SM3-J607

Fig. 3

AIR COMPRESSOR

DISMOUNTING

NOTE: Refer to page 3-5-2.

DISASSEMBLING AND ASSEMBLING

NOTE: Refer to AIR COMPRESSOR in CHAPTER 23.

MOUNTING

NOTE: Refer to page 3-17-4.

POWER STEERING PUMP

DISMOUNTING

NOTE: Refer to page 3-5-1.

DISASSEMBLING AND ASSEMBLING

NOTE: Refer to POWER STEERING in CHAPTER 67.

MOUNTING

NOTE: Refer to page 3-17-6.

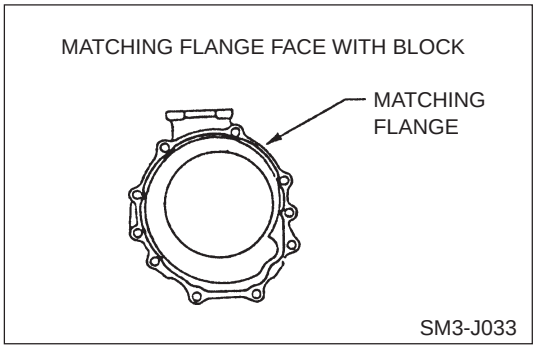


Fig. 1

INSTALLATION OF THE ENGINE COMPONENT PARTS

1. INSTALL THE COOLANT PUMP.

1. Clean the cylinder block mounting surface of coolant pump.
2. Apply liquid gasket to the coolant pump and install it onto the cylinder block within 20 minutes.

Liquid gasket: ThreeBond No. 1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE:

- ○ **If more than 20 minutes have passed since the liquid gasket was applied, do not assemble. After removing the liquid gasket completely, reapply it to assemble.**
- ○ **Refer to page 3-20-1.**

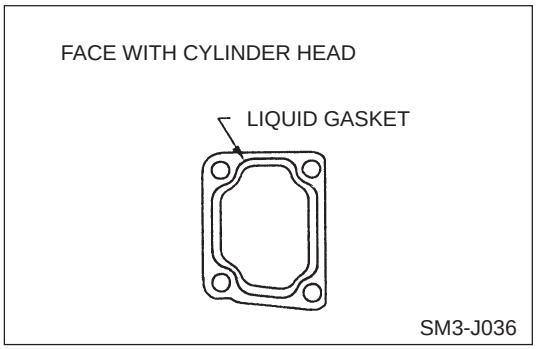


Fig. 2

2. INSTALL THE THERMOSTAT CASE.

1. Make sure that the O-ring is attached to the upper flange face of the coolant pump.
2. Clean the cylinder block mounting surface of the thermostat case.
3. Apply liquid gasket to the thermostat case and install it onto the cylinder block within 20 minutes.

Liquid gasket: ThreeBond No. 1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE:

- ○ **If more than 20 minutes have passed since the liquid gasket was applied, do not assemble. After removing the liquid gasket completely, reapply it to assemble.**
- ○ **Refer to page 3-20-1.**

4. Attach the three upper bolts of the thermostat mounting bolts provisionally.
5. Tighten the four side bolts of the thermostat case mounting bolts to the specified torque below.

Tightening torque: 290 kg·cm (21 lb·ft)

6. Tighten the three upper bolts of the coolant pump mounting bolts to the specified torque below.

Tightening torque: 560 kg·cm (41 lb·ft)

7. Install the cooling line.

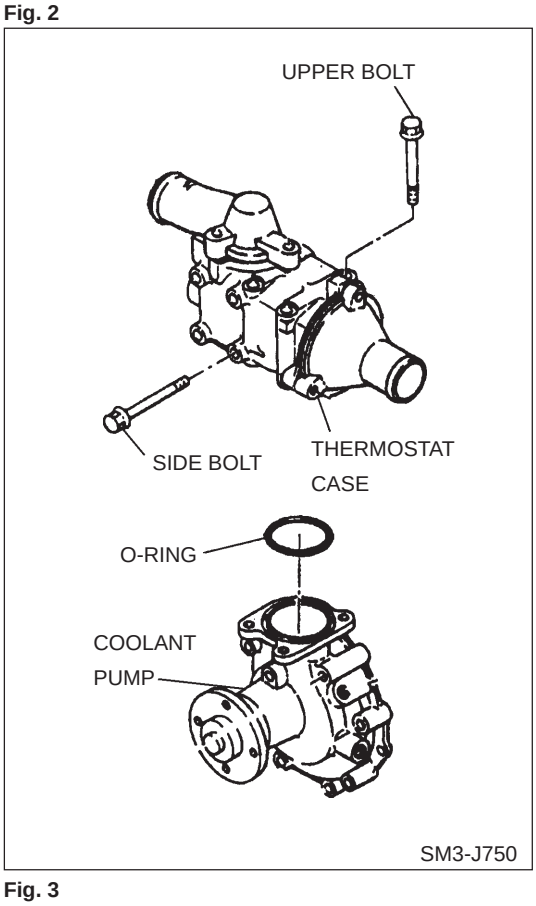


Fig. 3

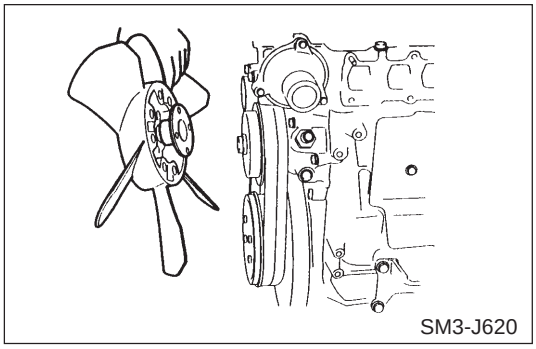


Fig. 4

3. INSTALL THE FAN CLUTCH WITH COOLING FAN.

Tightening torque: 560 kg·cm (41 lb·ft)

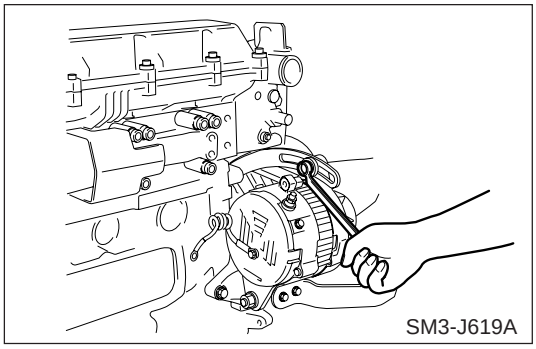


Fig. 5

4. INSTALL THE ALTERNATOR AND V-BELT.

1. Attach the alternator provisionally and install the V-belt.
2. Apply a load of about 10 kg (22 lb) by pressing the center point of V-belt and adjust the V-belt deflection so it is within the standard value.

Standard: 8 - 10 mm (0.317 - 0.394 in.)

Special tool: V-belt tension gauge (09444 - 1210)

3. Tighten the V-belt adjusting bolt.
4. Tighten the through bolt.

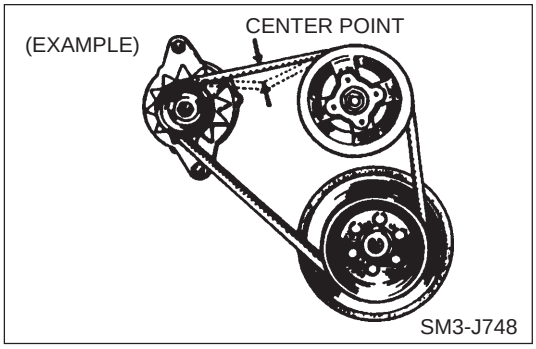


Fig. 6

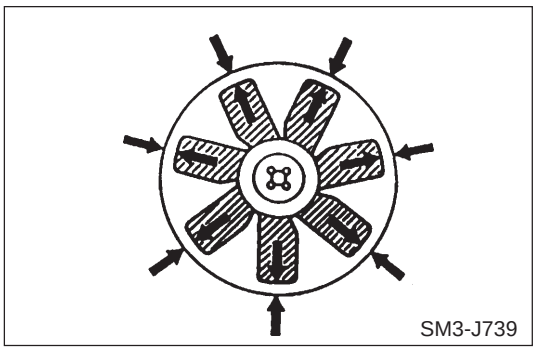


Fig. 7

5. INSTALL THE FAN SHROUD.

NOTE: When installing the fan shroud, the tip clearance for the whole circle must be within the standard value.

Standard: 5 mm (0.2 in.)

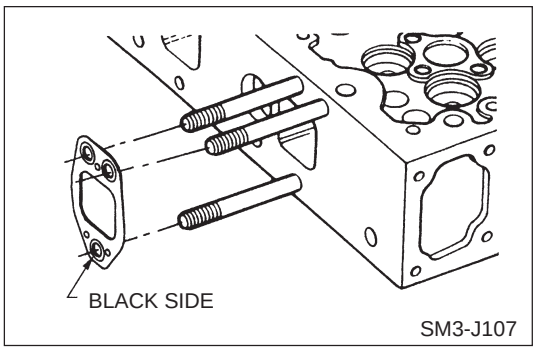


Fig. 8

6. INSTALL THE EXHAUST MANIFOLD.

1. Install the exhaust manifold gasket so that the black side faces the exhaust manifold.

NOTE: Be sure to use new exhaust manifold gaskets.

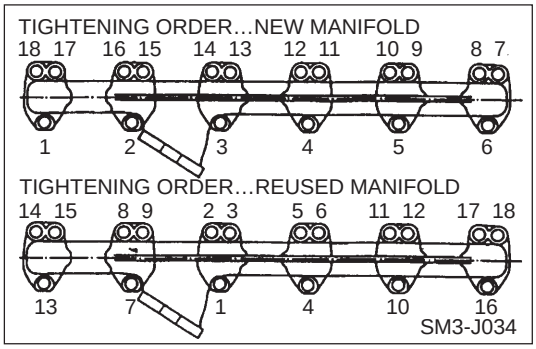


Fig. 9

2. Install the exhaust manifold onto the cylinder head and tighten the inner mounting nuts (WAF 17 mm) in the order shown in the figure to the specified torque below.

Tightening torque: 540 kg·cm (39 lb·ft)

3. Tighten the same nuts according to the same procedure again.

Tightening torque: 540 kg·cm (39 lb·ft)

NOTE: Be sure to carry out the tightening order procedure.

4. Tighten the outer mounting nuts (WAF 14 mm), in the order shown in the figure, to the specified torque below.

Tightening torque: 620 kg·cm (45 lb·ft)

NOTE: Be sure to hold the inner nut when tightening the outer nut.

7. INSTALL THE OIL COOLER.

1. Clean the cylinder block mounting surface of oil cooler.

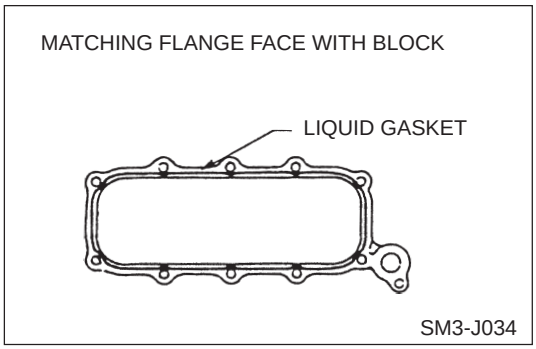


Fig. 10

2. Insert the D-ring into the D-ring groove of the oil cooler.

NOTE: Face the flat area of the D-ring toward the oil cooler for installation.

3. Apply liquid gasket to the oil cooler housing and install it onto the cylinder block within 20 minutes.
4. Install the oil line.

Liquid gasket: ThreeBond No. 1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE:

- **If more than 20 minutes have passed since the liquid gasket was applied, do not assemble. After removing the liquid gasket completely, reapply it to assemble.**
- **When installing the oil cooler, the earth wire of alternator must be tightened with the coolant pipe bracket for turbocharger.**
- **Refer to page 3-20-1.**

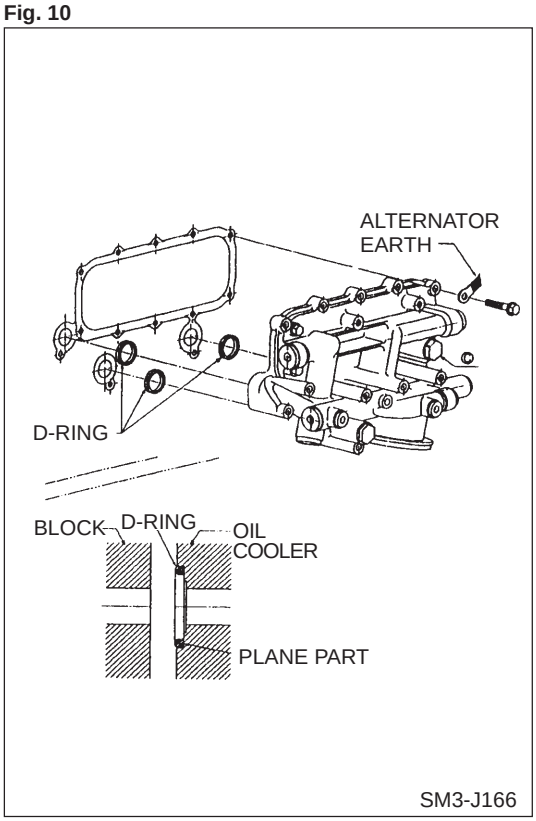


Fig. 11

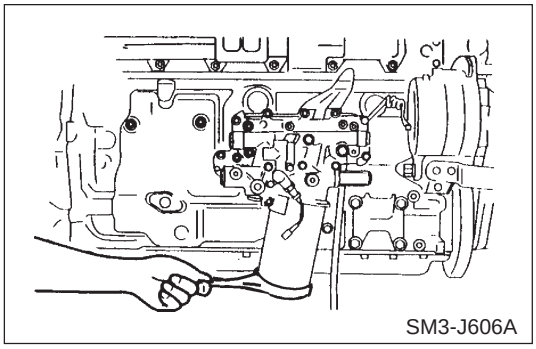


Fig. 12

8. INSTALL THE OIL FILTER ELEMENT.

1. Apply engine oil to the gasket of oil filter element, and tighten the element by hand until the gasket contacts the body.
2. Tighten the oil filter element 3/4 turn to one turn from the condition of step 1.

Special tool: Oil filter wrench (09553 - 1021)

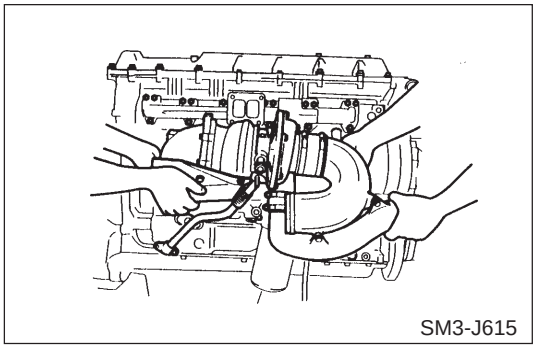


Fig. 13

9. INSTALL THE TURBOCHARGER.

NOTE: Refer to TURBOCHARGER in CHAPTER 51.

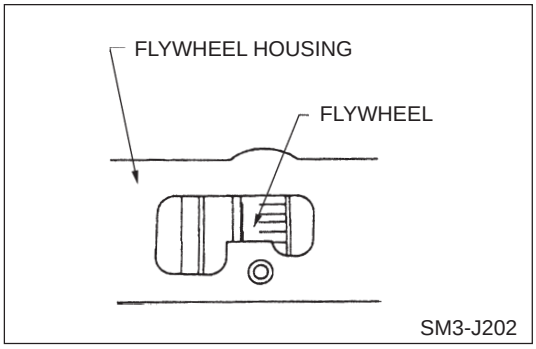


Fig. 14

10. INSTALL THE AIR COMPRESSOR.

1. Match the No. 1 cylinder to the top dead center of compression stroke.

NOTE: Refer to page 3-18-1.

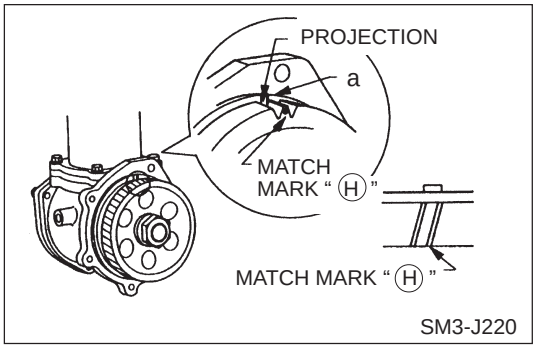


Fig. 15

2. Match the projection of the air compressor housing with the opposite side of the tooth with the drive gear alignment mark (original Hino mark).
3. Place a guide stud bolt (M8 x 1.25, length: 50 mm (1.968 in) or more) in the flywheel housing as shown in the figure and insert the compressor onto the stud bolt.

NOTE: Applying excessive force to the air compressor may damage the mounting spigot or may cause oil leakage due to flaking of liquid gasket between the flywheel housing and plate.

4. Tighten the mounting bolts (other than the stud bolt), then remove the stud bolt. Insert a bolt in the place of the stud bolt.

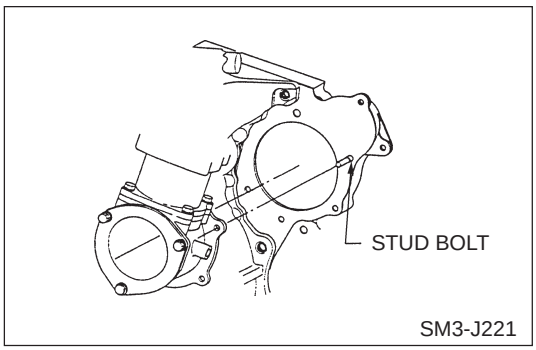


Fig. 16

5. Install the oil lines, cooling lines and air lines.

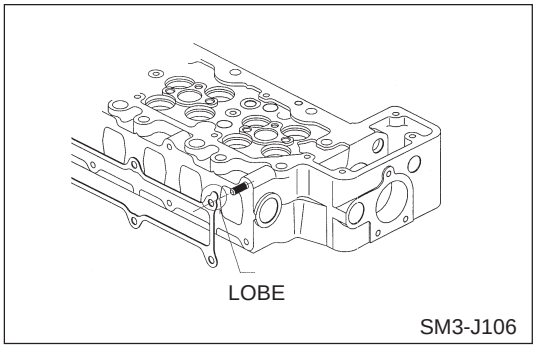


Fig. 17

11. INSTALL THE INTAKE MANIFOLD.

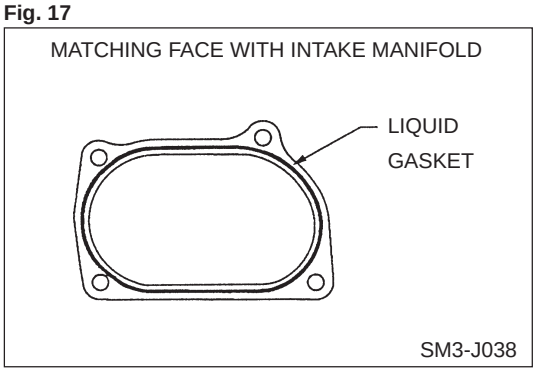


Fig. 18

12. INSTALL THE INTAKE PIPE.

1. Clean the matching face of intake manifold and the intake pipe.
2. Apply liquid gasket to the intake manifold and install it onto the cylinder head within 20 minutes.

Liquid gasket: ThreeBond No. 1207B

Coating width: 1.5 - 2.5 mm (0.06 - 0.10 in.)

NOTE: If more than 20 minutes have passed since the liquid gasket was applied, do not assemble. After removing the liquid gasket completely, reapply it to assemble.

NOTE: Refer to page 3-20-1.

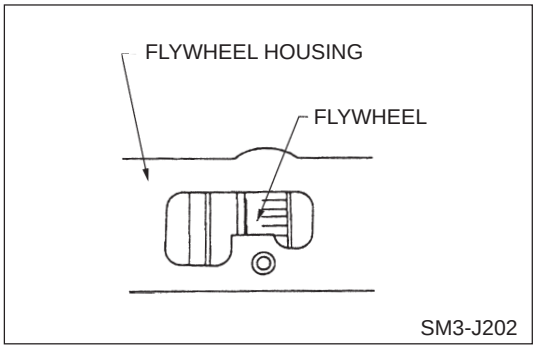


Fig. 19

13. INSTALL THE FUEL INJECTION PUMP.

1. To adjust the injection timing, turn the flywheel in the rotation direction (counterclockwise viewed from the flywheel side).

Injection timing:3° before top dead center in the compression cycle.

NOTE: Refer to page 3-18-1.

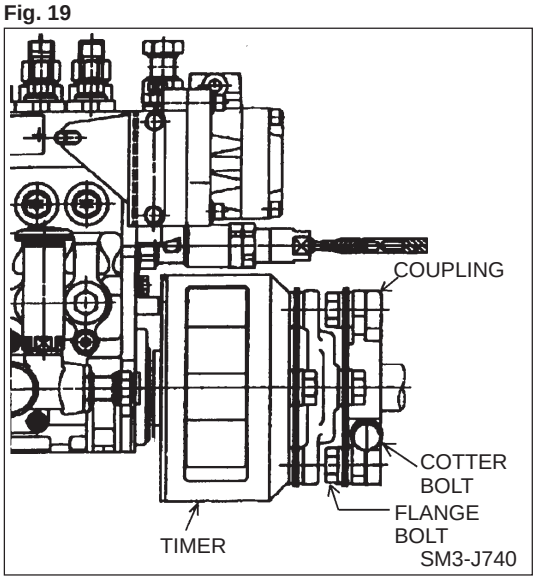


Fig. 20

2. Turn the injection pump timer counterclockwise slowly viewed from the coupling (normal direction of engine) and align the mark on the timer with the mark on the injection pump.
3. Put the injection pump on the pump bracket and tighten the injection pump mounting bolt evenly to the torque below.

Tightening torque: 950 kg·cm (68 lb·ft)

4. Tighten the flange bolt using the special tool.

Tightening torque: 950 kg·cm (68 lb·ft)

Special tool: Injection pump coupling wrench (09511 - 2500)

5. Tighten the cotter bolt at the flange.

Tightening torque: 950 kg·cm (68 lb·ft)

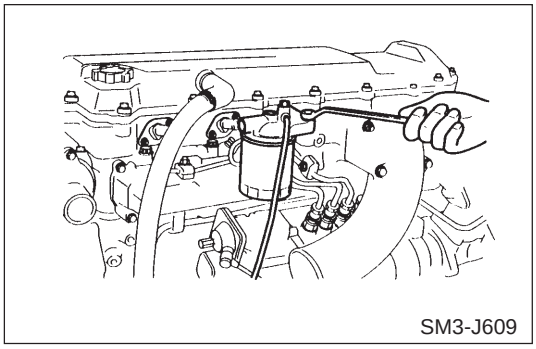

SM3-J609

Fig. 21

14. INSTALL THE FUEL FILTER AND FUEL LINES.

Install the fuel lines, oil lines and fuel leakage lines.

NOTE: The cylinder number is stamped on the flare nut at the pump side of the injection pipe.

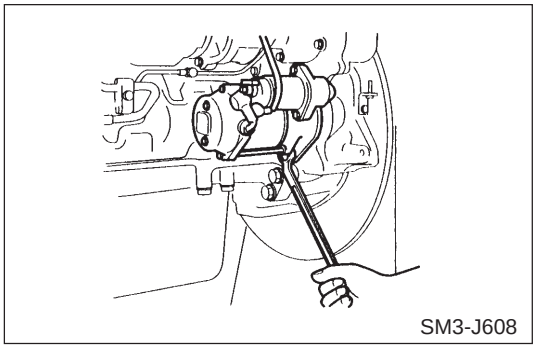

SM3-J608

Fig. 22

15. INSTALL THE STARTER.

1. Tighten the bolts and nuts to the specified torque.

Tightening torque: 1,570 kg·cm (113 lb·ft)

2. Connect the harness at the alignment marks.

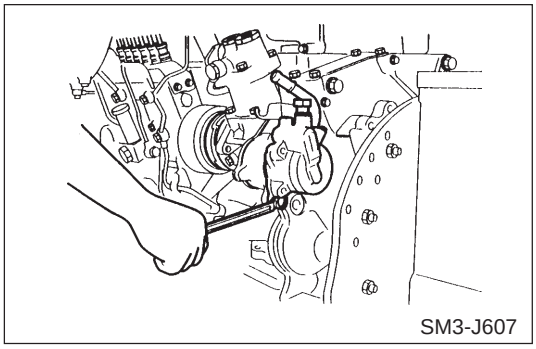

SM3-J607

Fig. 23

16. INSTALL THE POWER STEERING OIL PUMP.

Tighten the bolts to the specified torque.

Tightening torque : 560 kg·cm (40 lb·ft)

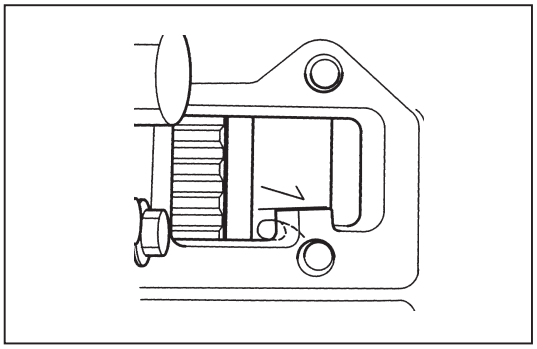


Fig. 1

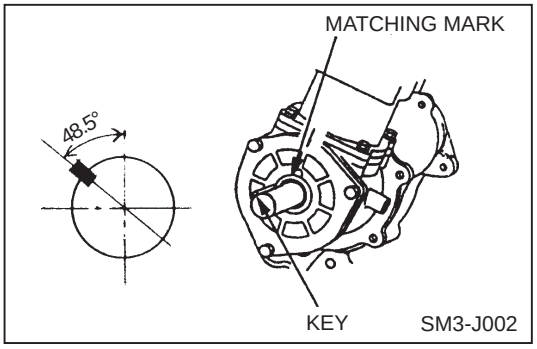


Fig. 2

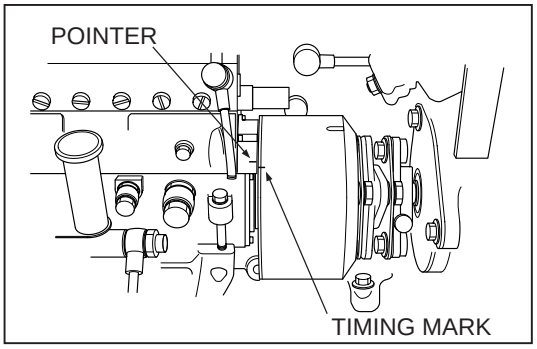


Fig. 3

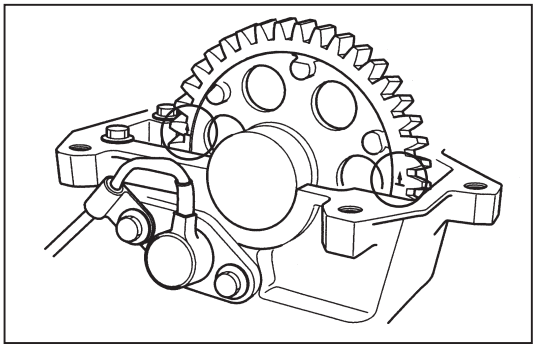


Fig. 4

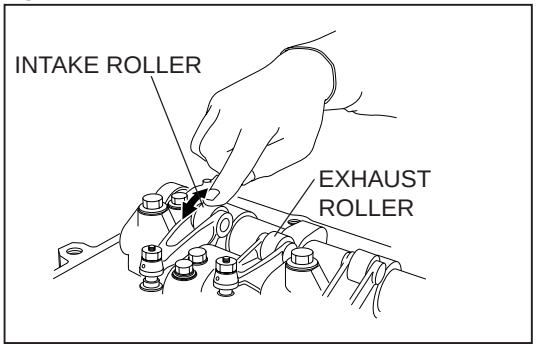


Fig. 5

ENGINE TUNEUP

HOW TO GET THE TOP DEAD CENTER OF THE COMPRESSION STROKE FOR NO.1 PISTON

1. Turn the crankshaft to align mark 1-6 on the outer periphery of the flywheel with the pointer of the flywheel housing.

NOTE: In this position the No. 1 and No. 6 pistons are at the top dead center.

○ Before installing the injection pump, the No. 1 piston is at the top dead center of the compression stroke when the coupling mounting key of the air compressor is at the upper side.

○ After installing the injection pump, if the timer timing mark is nearly aligned with the pointer, the No. 1 piston is at the top dead center of the compression stroke.

NOTE: If not, turn the crankshaft one complete revolution and align marks as shown above.

○ The No.1 piston is at the top dead center of the compression stroke when the arrow printed on the camshaft points up and the underline is horizontal.

○ The piston, whose intake and exhaust rollers both rotate easily when the roller of the rocker arm is moved with a finger, is at the top dead center of the compression stroke.

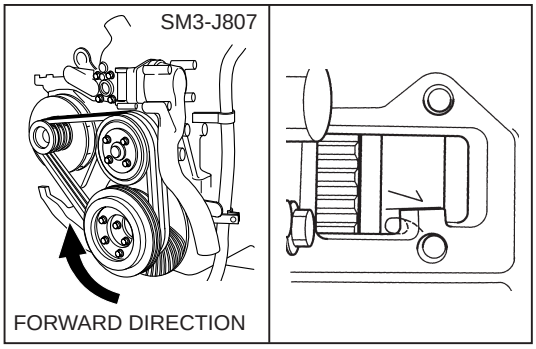


Fig. 6

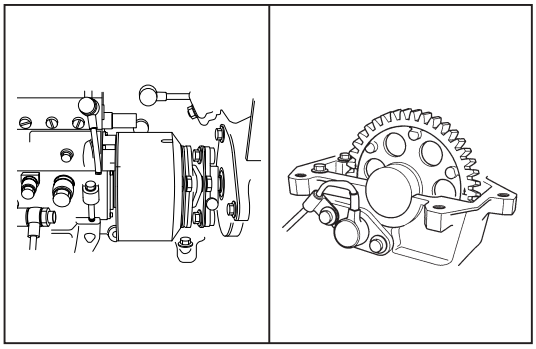


Fig. 7

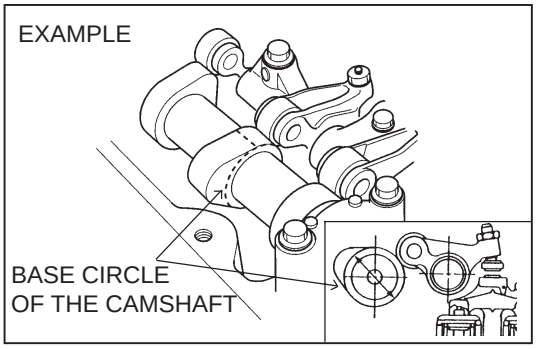


Fig. 8

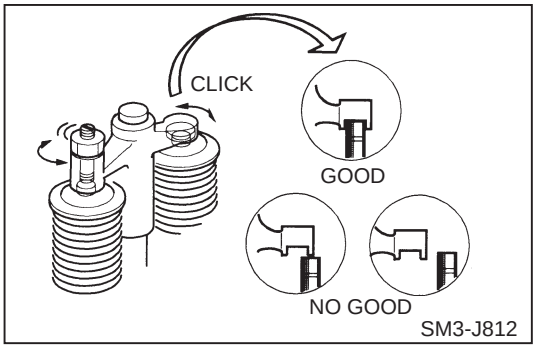


Fig. 9

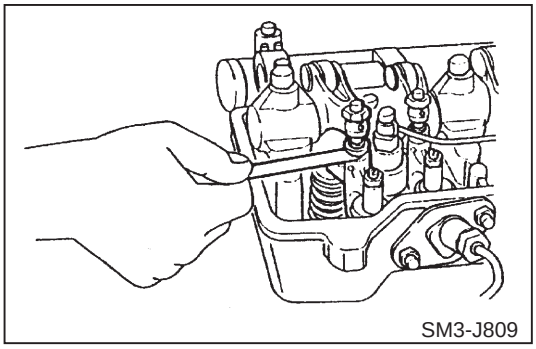


Fig. 10

VALVE CLEARANCE CHECKING AND ADJUSTING PROCEDURES

1. Before checking, make sure that the tightening bolts of the cylinder head, rocker support, nozzle clamp, cam housing and cam bearing cap are tightened to the specified torque.
2. Make sure that there are no foreign particles or dust between the cross head and the valve stem.
3. Turn the crankshaft in the forward direction to align the No. 1 piston to the top dead center of the compression stroke.

NOTE: ○ Make sure that the roller is on the base circle of the camshaft.

○ In order to avoid that the cross head runs on the valve stem or that it comes off from the valve stem, turn the cross head to the right and left to ensure that the cross head correctly covers the valve stem by listening for the clicking sound.

4. Insert the feeler gauge between the rocker arm and the cross head and check that the valve clearance is within the standard range.

Valve clearace (when cold) ; Intake valve : 0.30mm (0.0118 in.)
Exhaust valve : 0.45mm (0.0177 in.)

If it out of the standard range, adjust the valve clearance using the following.

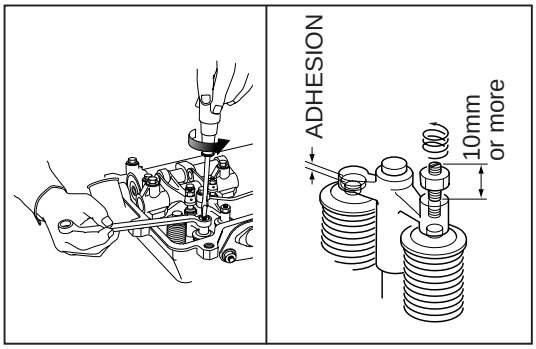


Fig. 11

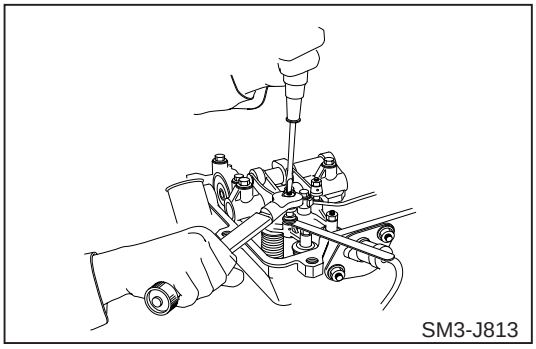


Fig. 12

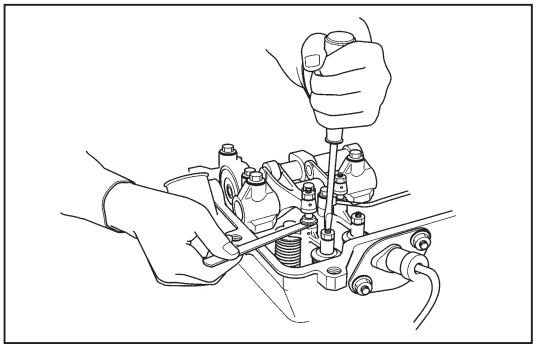


Fig. 13

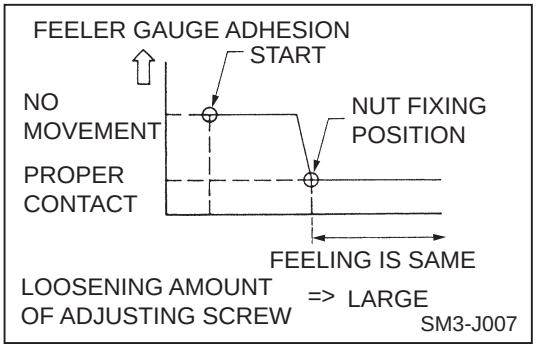


Fig. 14

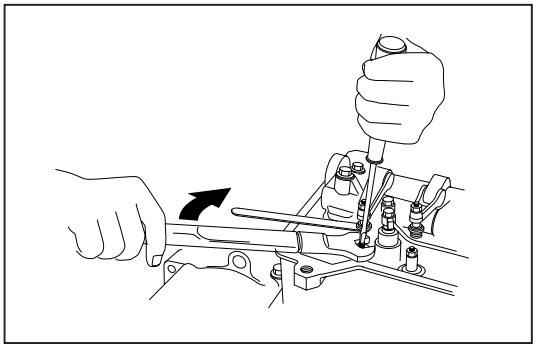


Fig. 15

5. Loosen the adjusting screw nut of the cross head completely.

NOTE:○ The adjusting screw must protrude 10 mm (0.3937 in.) or more from the cross head upper face.

○ Unless the adjusting screw is completely loose to the valve stem, the following adjustments may be adversely affected.

6. Insert a feeler gauge between the rocker arm and cross head. Adjust clearance with the adjusting screw of the rocker arm. Tighten the lock nut with the following torque.

Tightening torque : 250 kg·cm (18 lb·ft)

NOTE: The feeling of the feeler gauge during clearance adjustment is the same as before.

7. With the feeler gauge inserted, loosen the adjusting screw of the cross head. Make sure that the feeler gauge does not feel loose.

NOTE: If it is loose, repeat these steps from 5.

8. Tighten the adjusting screw of the cross head until the feeler gauge does not move.

9. While loosening the adjusting screw of the cross head gradually, adjust the valve clearance. Tighten the lock nut of the cross head when the feeler gauge feels correct.

NOTE:○ The feeling of the feeler gauge during clearance adjustment is same as before.

○ Do not overloosen the adjusting screw. Overloosening of the adjusting screw will cause the same condition as in 5 again. The feeler gauge may feel correct, but there may be excessive clearance between the adjusting screw of the cross head and the valve. This does not allow for correct adjustment.

Tightening torque : 250 kg·cm (18 lb·ft)

○ The adjustable valve clearances when either the No.1 or No.6 piston is at the top dead center of the compression stroke are shown in the following chart. After completing the valve clearance adjustment when the No.1 piston is at the top dead center of the compression stroke, turn the crankshaft one complete revolution and make the No.6 piston be at the top dead center of the compression stroke (The arrow printed on the camshaft points down and the underline is horizontal) and adjust the rest of the valve clearances.

● : Adjustable valve clearance

	Cylinder		1		2		3		4		5		6	
	Valve		IN	EX	IN	EX	IN	EX	IN	EX	IN	EX	IN	EX
With No.1 piston at T.D.C. on compression stroke	Camshaft gear condition	Arrow points up and underline is horizontal.	●	●		●	●			●	●			
With No.6 piston at T.D.C. on compression stroke	Camshaft gear condition	Arrow points down and underline is horizontal.			●			●	●			●	●	●

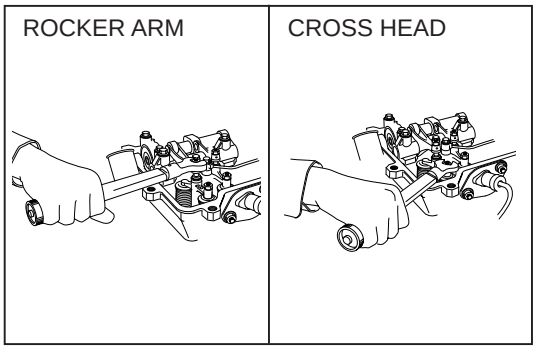


Fig. 16

10. Finally, tighten all the lock nuts of the rocker arm and the cross head with the following torques and make sure that they are all tight (the nuts do not turn).

NOTE: Never overtighten with more than the following torque.

Final confirmed torque : 280 kg·cm (20 lb·ft)

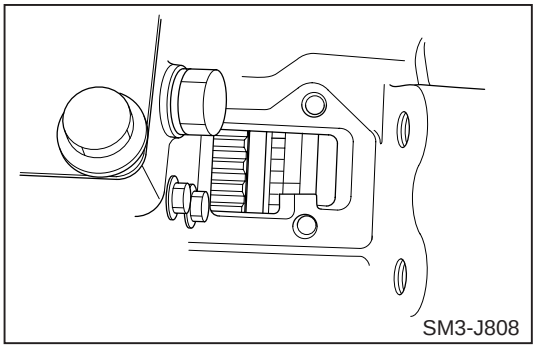


Fig. 17

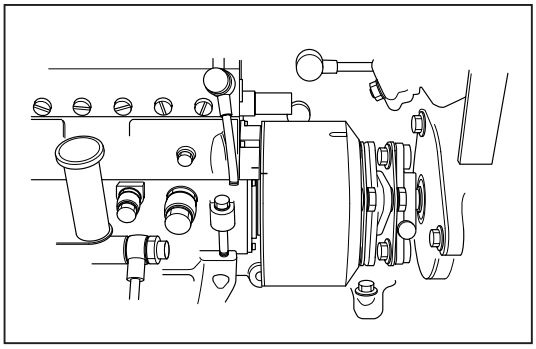


Fig. 18

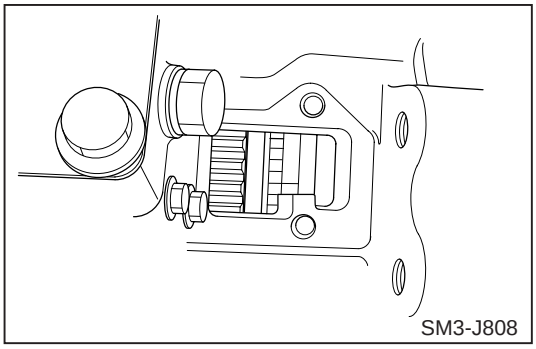


Fig. 19

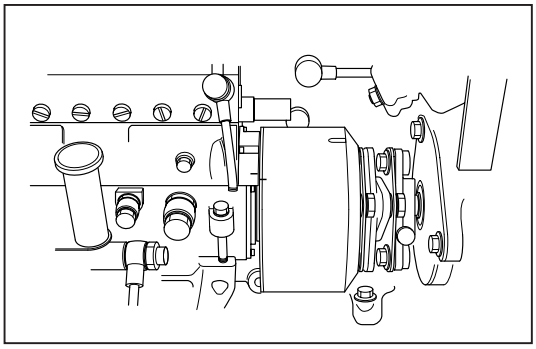


Fig. 20

INJECTION TIMING ADJUSTING PROCEDURES

INSPECT THE INJECTION TIMING

1. Turn the crankshaft clockwise (viewed from the crankshaft pulley side) to align the timing mark on the outer periphery of the flywheel at 3° before the top dead center of the compression stroke with the pointer of the flywheel housing.

2. Check that the injection timing mark on the automatic timer is aligned with the pointer of the pump.
   If not, adjust the injection timing as described on the following page.

ADJUST THE INJECTION TIMING

1. Make sure that the timing mark on the outer periphery of the flywheel is aligned with the timing pointer.

2. Loosen the two adjusting bolts of the injection pump coupling. Do not remove the bolts.
3. Turn the automatic timer to the left (counterclockwise viewed from the drive shaft) to align the automatic timer mark with the pointer of the pump.
4. Tighten the coupling bolt to the specified torque.

Tightening torque: 950 kg·cm (69 lb·ft)

NOTE: No clearance is allowed between thin plates. No deformation of the flange is allowed due to distortion of a thin plate.

Special tool: Injection pump coupling wrench (09511-2500)

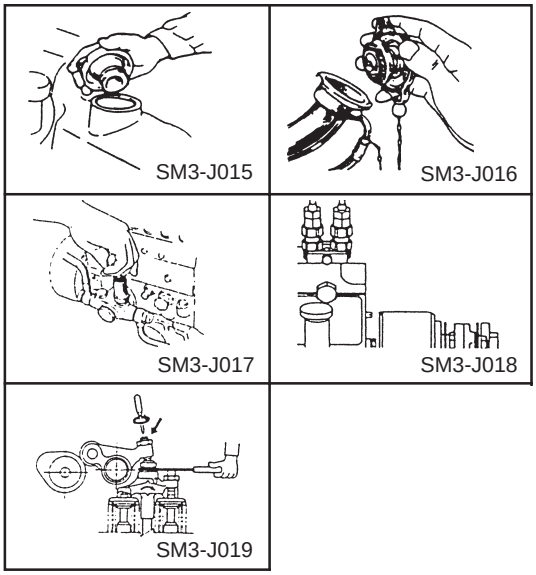


Fig. 21

START THE ENGINE

WARNING
Do not leave tools on or around the engine. Contact of tools with moving parts may result in injury or damage to equipment.

PREPARATION

1. Supply engine oil.
2. Supply cooling water and bleed air from it.
3. Bleed air from the fuel system. (Refer to FUEL SYSTEM.)
4. Check the injection timing.
5. Check the valve clearance.
6. Check connection to the alternator.

NOTE: Starting the engine without the wiring in place may burn out the alternator.

7. Check the engine stopping performance.

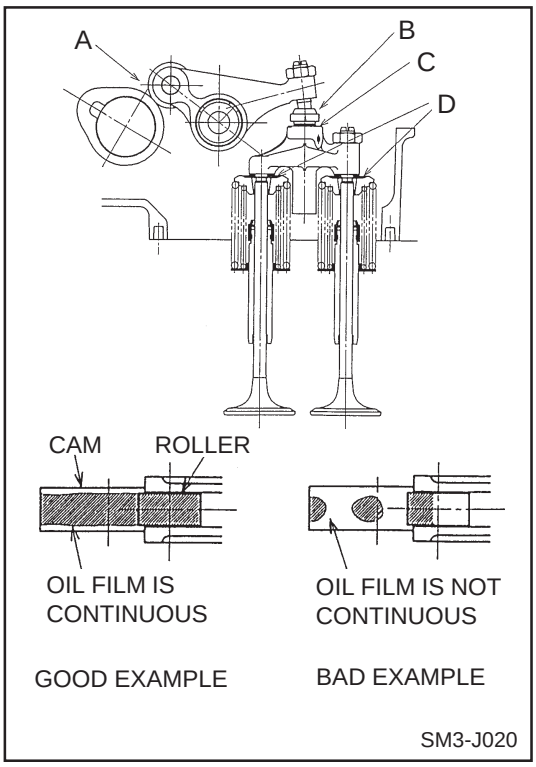


Fig. 22

CHECK THE ROCKER ARM LUBRICATION

1. Remove the head cover.
2. Set the engine revolution to the specified idling revolution.
3. After the engine starts, check that oil is supplied to the following locations of all rocker arms within approximately 10 seconds.

1) Roller and cam face A
2) Cross head top C and spring upper seat top face D through adjusting screw B

NOTE: If the supply of oil is delayed or not happening, hydraulic pressure may be low or the oil gallery may be clogged. Insufficient supply of oil may lead to seizure, abnormal wear or abnormal noise. Recheck the assembly.

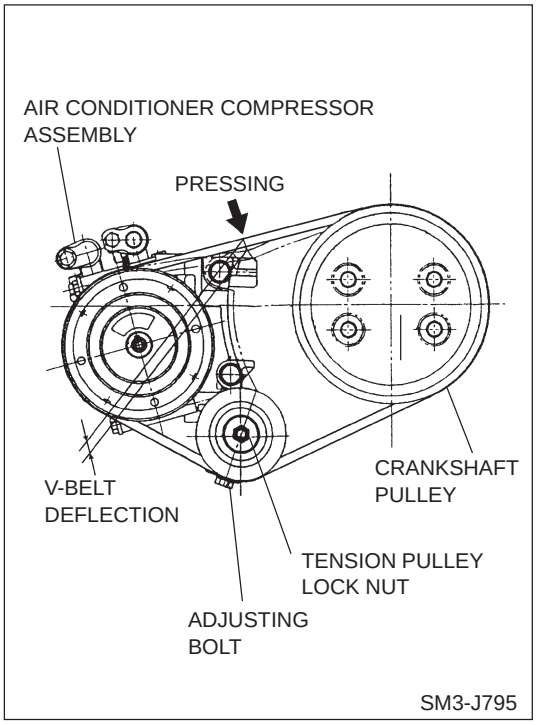


Fig. 1

MOUNTING OF THE ENGINE ASSEMBLY

1. INSTALL THE AIR CONDITIONER COMPRESSOR.

1. Install the air conditioner compressor assembly.

Tightening torque : 300 kg·cm (21 lb·ft)

2. Install the V-belt, and adjust the belt tension.
   Turn the adjusting bolt until the V-belt is taut, then tighten the tension pulley lock nut.

Tightening torque : 420 kg·cm (30 lb·ft)

3. V-belt deflection
   Apply a load of about 10 kg (22 lb) by pressing with your thumb (or special tool).

Assembly standard: 11 mm (0.434 in.)

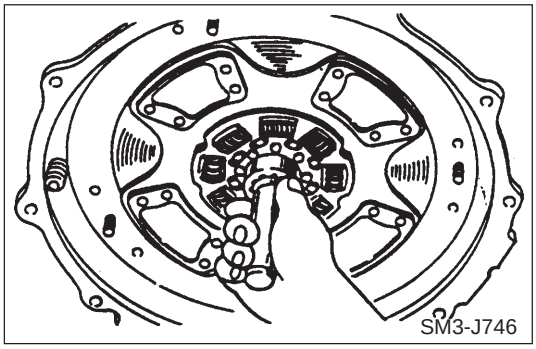


Fig. 2

2. INSTALL THE CLUTCH DISC AND CLUTCH COVER.

NOTE:

- **Center the clutch disc.**
- **Refer to CLUTCH in CHAPTER 5.**

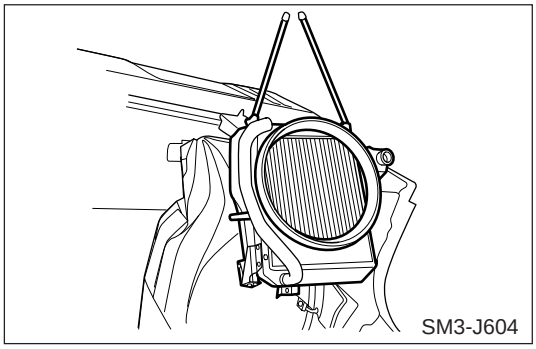


Fig. 3

3. INSTALL THE RADIATOR AND INTERCOOLER.

1. After installing the radiator hose and intercooler hose at the engine side, fix them with clamps.

NOTE: Place a hoist on the radiator.

2. After inserting the radiator side fan shroud into the engine side securely, fix it with the clamp.

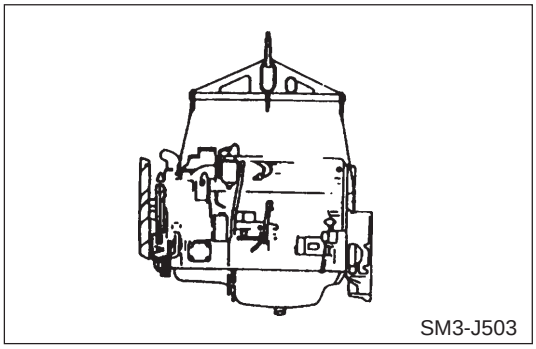


Fig. 4

4. INSTALL THE ENGINE ASSEMBLY.

1. Lift up the engine hanger at the front and rear end of the engine using a hoist and install it on the frame.
2. Tighten the engine mounting nut to the following torque.

Tightening torque: Engine side: 1,200 kg·cm (87 lb·ft)
Chassis side: 750 kg·cm (54 lb·ft)

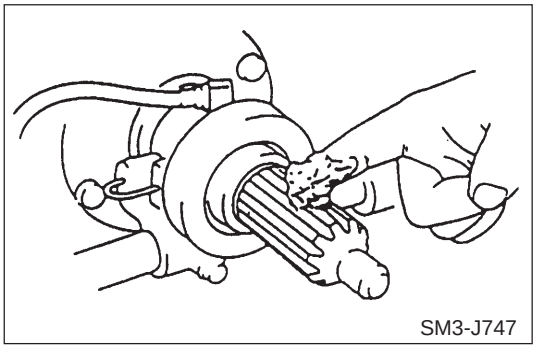


Fig. 5

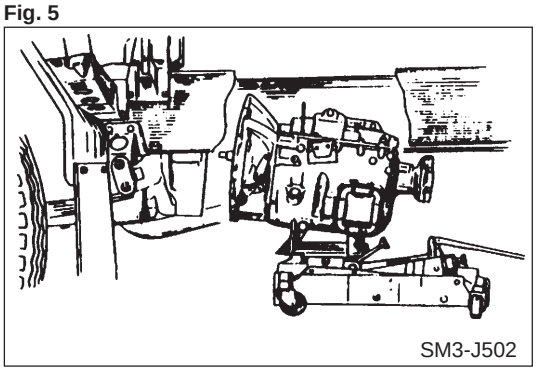


Fig. 6

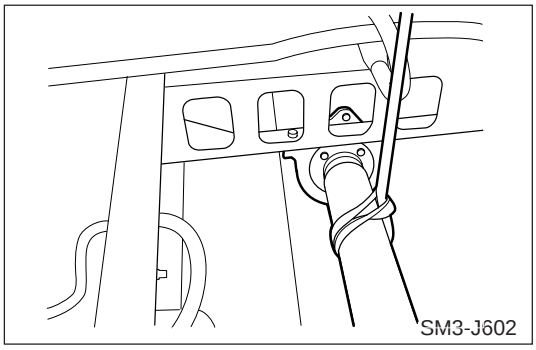


Fig. 7

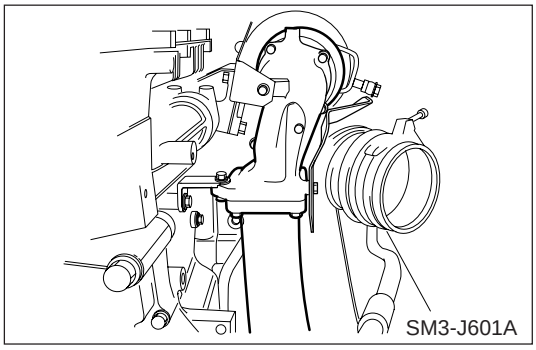


Fig. 8

5. INSTALL THE TRANSMISSION.

1. Engage the jack in the flywheel housing bottom surface.
2. Engage the transmission jack in the transmission.
3. Mount the transmission to the engine, and tighten the clutch housing mounting bolt to the specified torque.

NOTE:

- **Apply grease to the input shaft spline.**
- **Refer to TRANSMISSION in CHAPTER 7.**
- **Be sure to install the transmission straight while matching the engine angle with the transmission angle using a jack.**

6. INSTALL THE PROPELLER SHAFT.

1. Tighten the flange nut to the specified torque below.

NOTE: Use a hoist for the propeller shaft.

Tightening torque: 650 - 870 kg·cm (47 - 62 lb·ft)
1,300 - 1,600 kg·cm (94 - 115 lb·ft) for model SG only

2. Tighten the center bearing support mounting nut to the following torque.

Tightening torque: 380 - 500 kg·cm (28 - 36 lb·ft)
650 - 870 kg·cm (47 - 62 lb·ft) for model SG only

7. INSTALL THE EXHAUST PIPE AND MUFFLER.

NOTE: Refer to EXHAUST SYSTEM in CHAPTER 15.

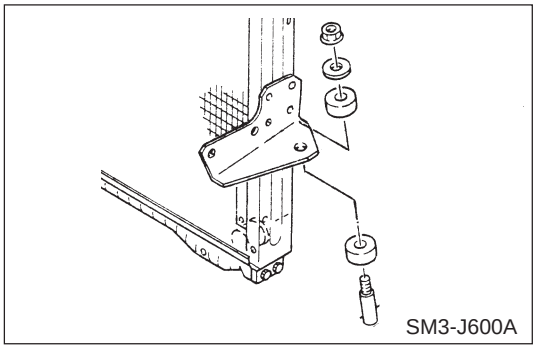


Fig. 9

8. MOUNT THE RADIATOR TO THE FRAME.

1. Install the radiator mounting.
2. Install the reservoir hose.

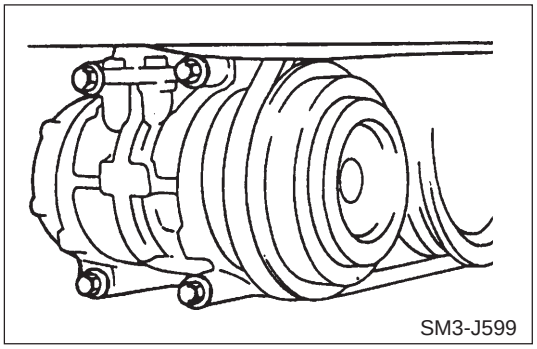


Fig. 10

9. INSTALL THE GAS LINE OF THE AIR CONDITIONER.

1. Install the gas line of the air conditioner on the compressor.

NOTE: For the coolant charging procedure (gas charging), observe the air conditioner manufacturer's instructions.

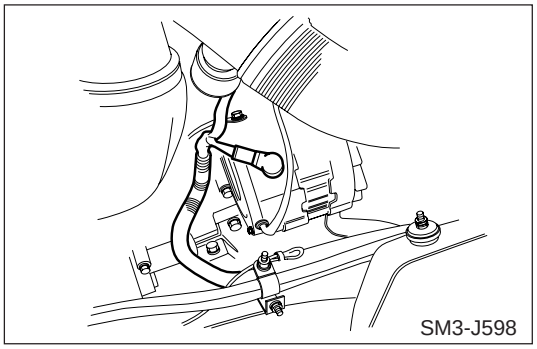


Fig. 11

10. INSTALL THE HEATER HOSE.

11. CONNECT THE ELECTRIC WIRING (1).

1. Coolant temperature sensor (at two points)
2. Alternator
3. Magnetic clutch of air conditioner

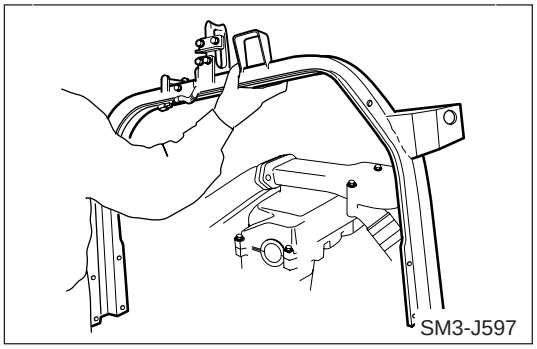


Fig. 12

12. INSTALL THE REAR CAB MOUNTING BRACKET.

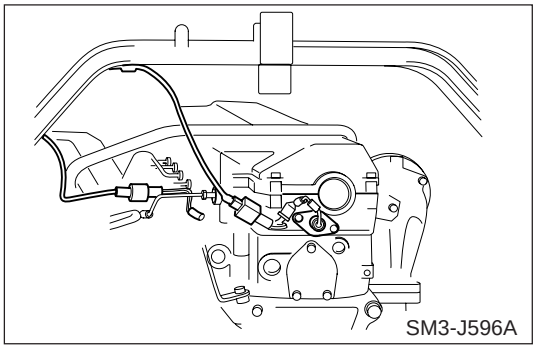


Fig. 13

13. CONNECT THE ELECTRIC WIRING (2).

1. Engine speed sensor
2. Glow plug
3. Rack sensor, pre-stroke actuator
4. Starter C, B terminal and earth (frame side)

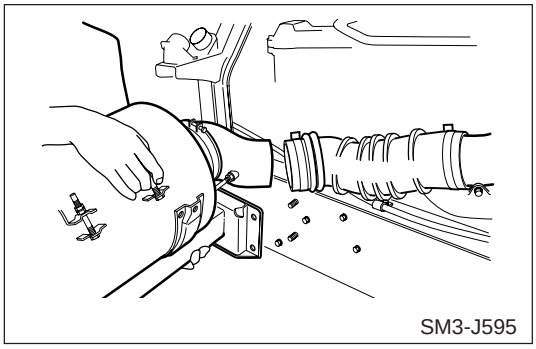


Fig. 14

14. INSTALL THE AIR CLEANER TO THE BRACKET.

15. INSTALL THE SPLASH BOARD.

16. INSTALL THE AIR CLEANER WITH THE AIR HOSE CONNECTED TO THE ENGINE.

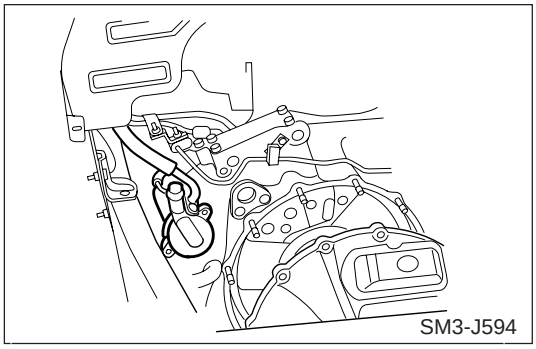


Fig. 15

17. INSTALL THE POWER STEERING LINES AT THE PUMP.

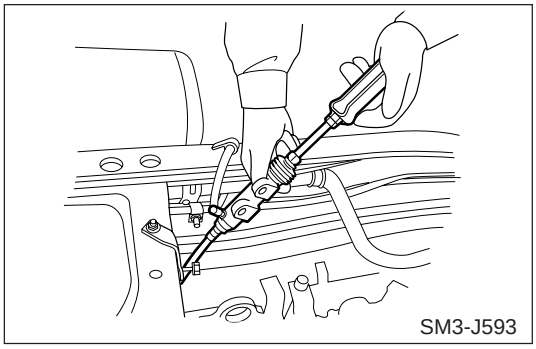


Fig. 16

18. INSTALL THE CLUTCH SLAVE CYLINDER.

1. Install the slave cylinder to the lines.

NOTE:

- **Check and adjust the push rod dimension.**
- **Refer to CLUTCH CONTROL in CHAPTER 6 in CHASSIS MANUAL.**

2. Install the clevis pin and return spring at the lever.
3. Install the wiring clip of the clutch hose.

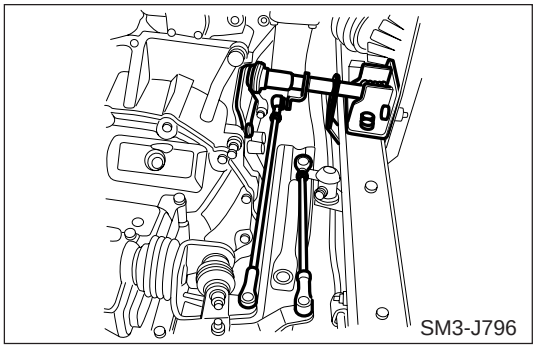


Fig. 17

19. CONNECT THE TRANSMISSION CONTROL ROD ALONG WITH THE BRACKET TO THE TRANSMISSION.

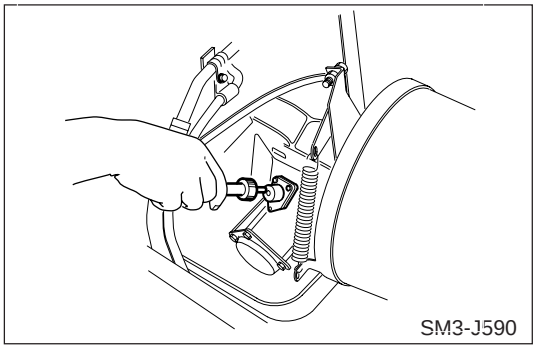


Fig. 18

20. CONNECT THE SPEEDOMETER CABLE TO THE TRANSMISSION.

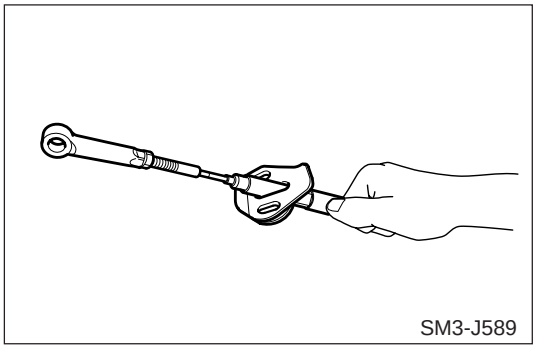


Fig. 19

21. CONNECT THE PARKING BRAKE CABLE (1).

1. Connect the cable wiring to the frame.
2. Insert the parking brake cable from the back of the cab and install the bracket.

NOTE: Be sure to insert the cable straight and slowly. Excessive force during insertion may crack the gasket as shown in the figure. A cracked cable must be replaced with a new one.

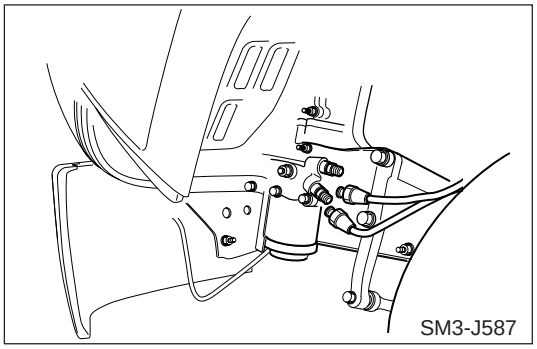


Fig. 20

22. CONNECT THE POWER STEERING LINE TO THE GEAR UNIT.

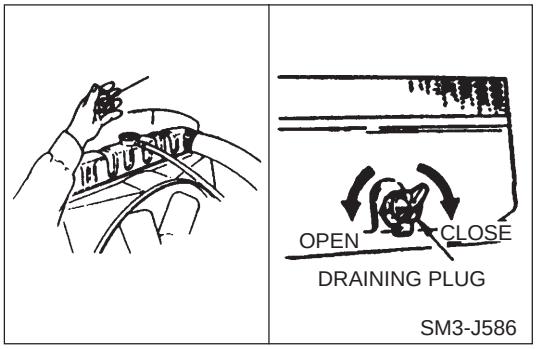


Fig. 21

23. FILL THE COOLANT RESERVOIR.

Add coolant slowly until the system is filled up to the filler opening, then install the cap securely.

Coolant capacity: 21 L (22.19 US qt)
23 L (24.30 US qt)
(with transmission oil cooler only)

NOTE: Trapped air in the cooling system can cause overheating.

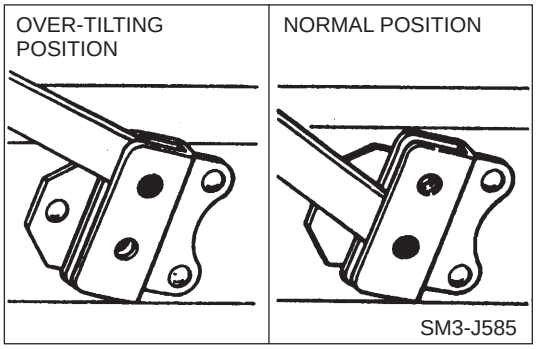


Fig. 22

24. RELEASE OVERTILTING OF THE CAB.

NOTE: Refer to CAB in CHAPTER 19.

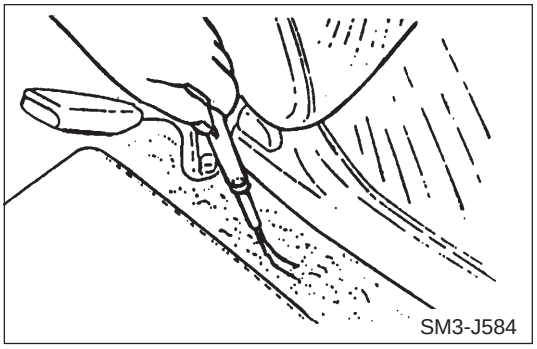


Fig. 23

25. CONNECT THE PARKING BRAKE CABLE (2).

1. Connect the parking brake cable to the lever.
2. Connect the center console.

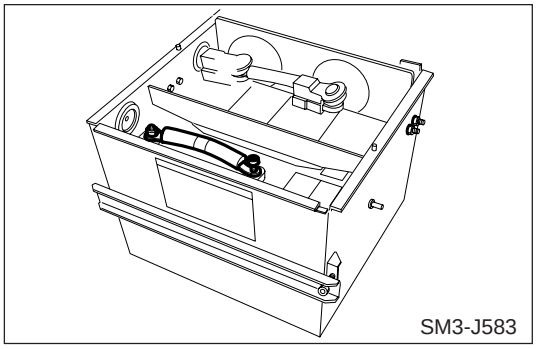


Fig. 24

26. CONNECT THE BATTERY CABLE TO THE NEGATIVE. (-) TERMINAL

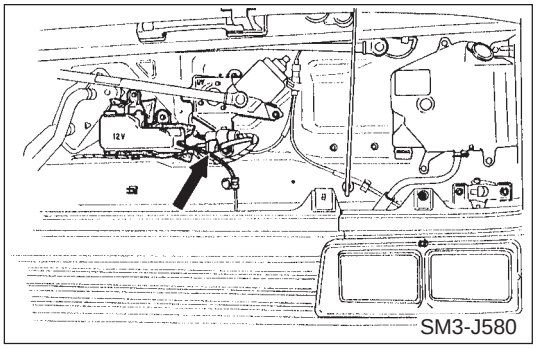


Fig. 25

27. CONNECT THE ENGINE CONTROL AND STOP CABLE.

1. Set the starter switch to the ON position.
2. Connect the stop cable inner to the lever of engine stop motor.
3. Set the starter switch to the LOCK position.

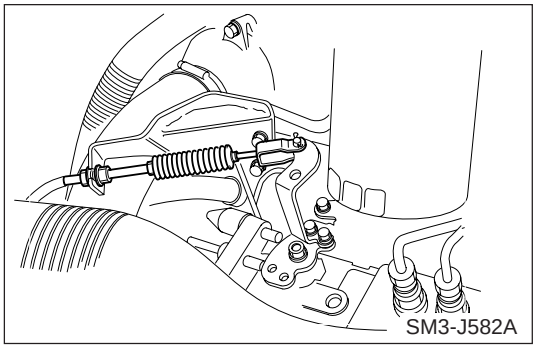


Fig. 26

4. Tilt the cab.
5. Connect the engine control and stop cable to the injection pump.

LIQUID GASKET AND APPLICATION POINTS

The following liquid gasket is used for this engine.

Liquid gasket specification

ThreeBond TB1207B (04132-1217): Black
ThreeBond TB1211 (04132-1211): White

1. COATING LIQUID GASKET AND PARTS ASSEMBLY PROCEDURE

1. Completely remove old liquid gasket from each part and the respective mating part, and remove oil, water, and dirt using a cloth.

2. Be careful not to apply excessive or insufficient liquid gasket. Also, be sure to overlap the start and end of each coating.

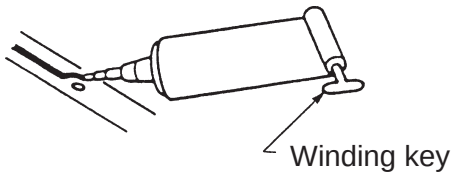
3. When assembling coated parts, be careful that there is no misalignment between mating parts. If there is any misalignment, coat the parts again.

4. Assemble the various parts within 20 minutes after applying liquid gasket. If more than 20 minutes have elapsed, remove the liquid gasket and apply it again.
5. After assembling the various parts, wait for at least 15 minutes before starting the engine.

2. REMOVING PARTS

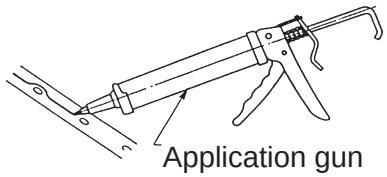
When removing each part, do not attempt to pry one portion of the flange alone but use flange collar or clearance to pry the flange at several points alternately.

When using a tube of liquid gasket, use the winding key provided. In the case of a catridge type, use commercially available application gun.



Tube 100 g (0.22 lb)

Fig. 1 SM3-J029

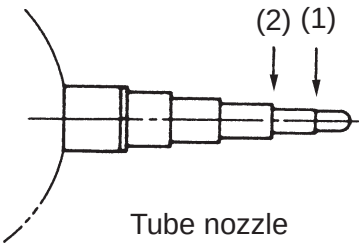


Cartridge type 300 g (0.66 lb)

Fig. 2 SM3-J030

Also, when using a tube, you can regulate the coating width by cutting the end of the nozzle at a suitable position.

(1): Coating width approx. 2 mm (0.08 in.) when nozzle cut at 1st step
(2): Coating width approx. 5 mm (0.20 in.) when nozzle cut at 2nd step

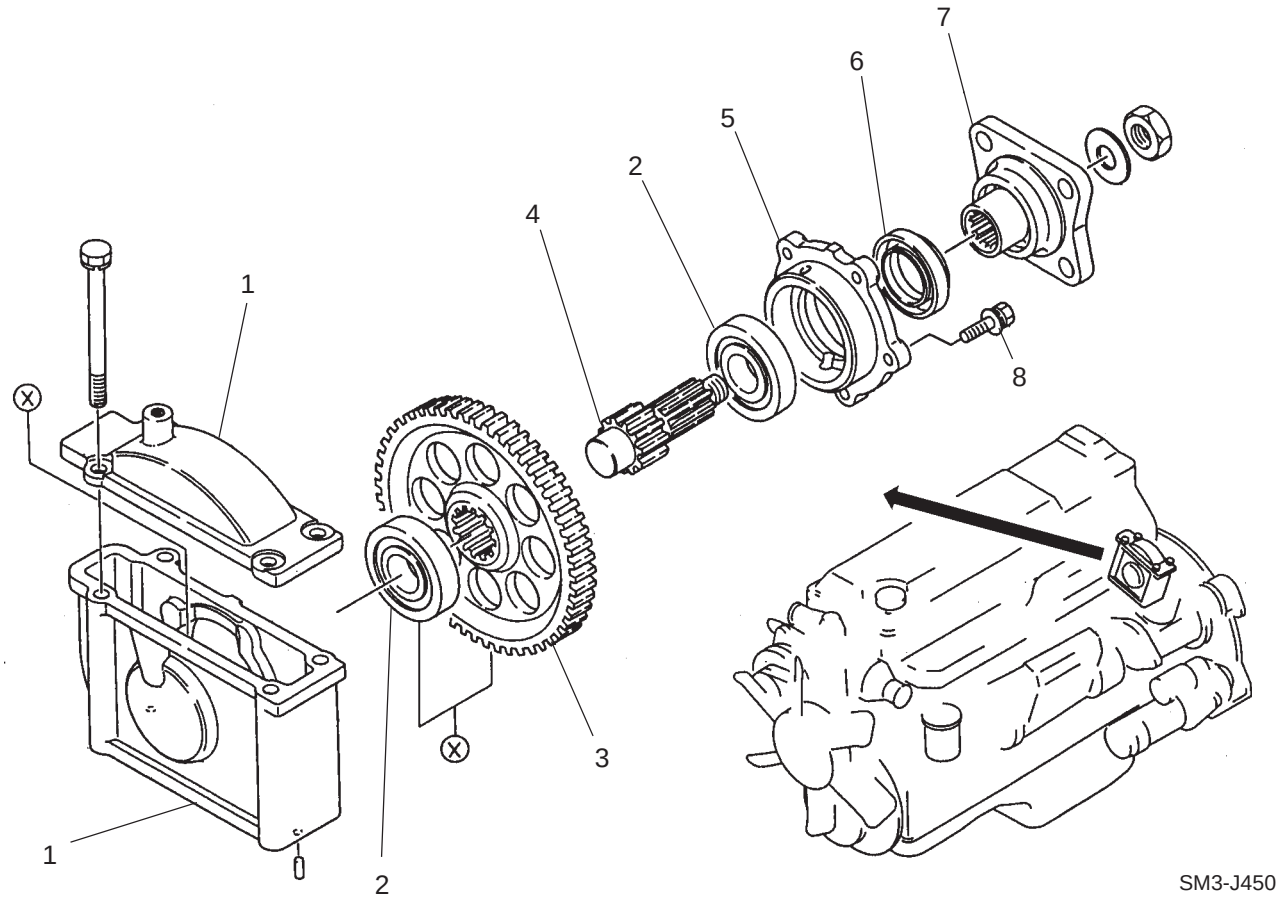


Tube nozzle

SM3-J031

Fig. 3

POWER TAKE-OFF



POWER TAKE-OFF

1. Gear case
2. Ball bearing
3. Drive gear subassembly
4. Driven shaft
5. Gear cover
6. Oil seal
7. Output coupling
8. Flange bolt

Fig. 1

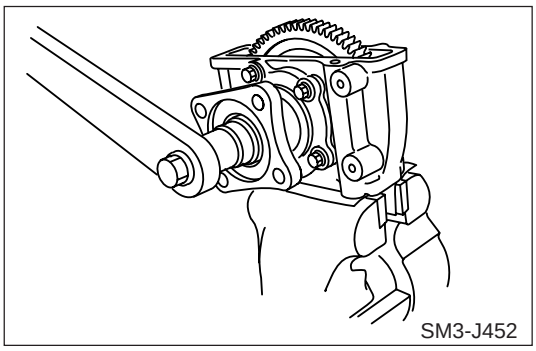


Fig. 2

REMOVING

1. REMOVE THE OUTPUT COUPLING.

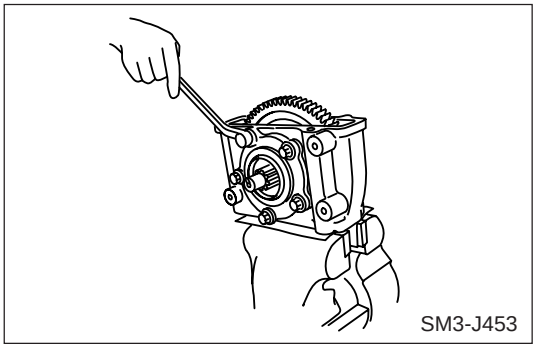


Fig. 3

2. REMOVE THE GEAR COVER.

1. Remove the flange bolt.
2. Use flathead screwdrivers to pry up the rim of the gear cover from the gear case at the gaps, making sure to pry up by an even amount at each gap until the gear cover comes off.

NOTE: When removing the gasket, be careful to ensure that no dirt from the gasket gets inside the case.

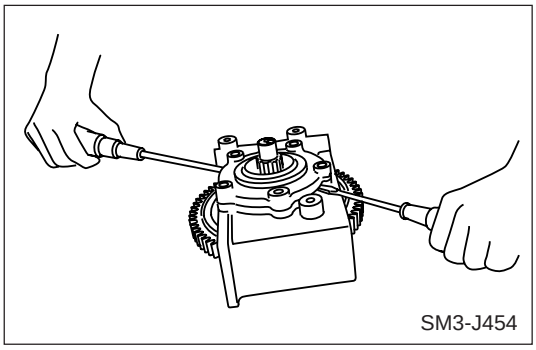


Fig. 4

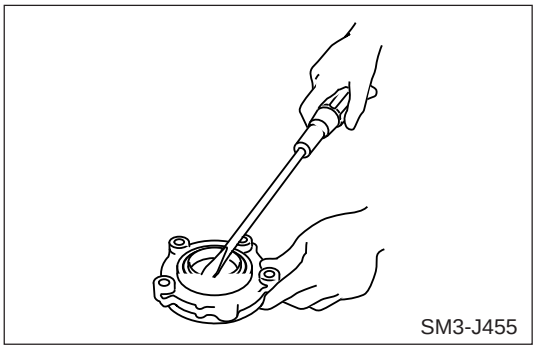


Fig. 5

3. USE A FLATHEAD SCREWDRIVER TO PRY OFF EVENLY THE BASE OF THE OIL SEAL UNTIL THE OIL SEAL COMES OFF.

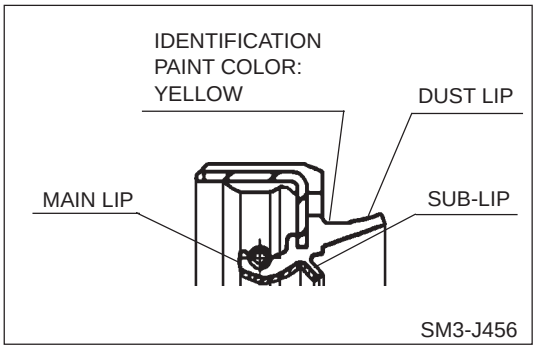


Fig. 6

INSTALLING THE NEW OIL SEAL

1. USING THE SPECIAL TOOL, PRESSURE MOUNT A NEW OIL SEAL ON THE GEAR COVER.

Special tool: Press (09482-2120)

NOTE:

- **Apply lithium grease between the main lip and sub-lip of the new oil seal and to the back of the main lip.**
- **Do not use too much grease. Also, apply grease evenly around entire circumference.**

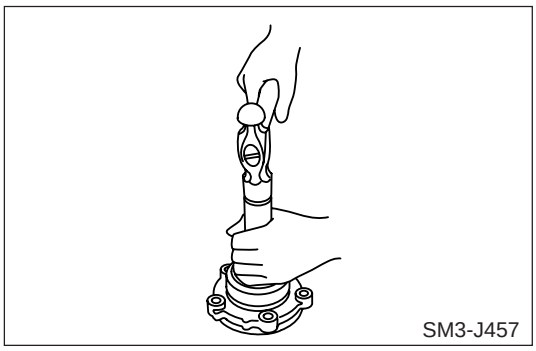


Fig. 7

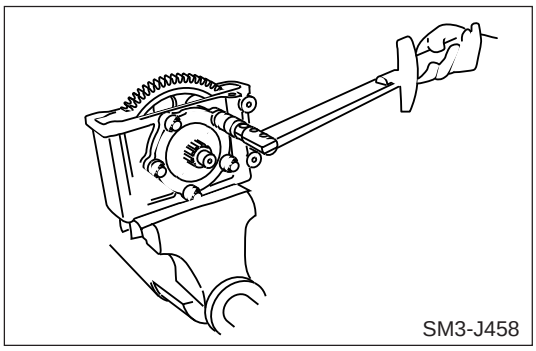


Fig. 8

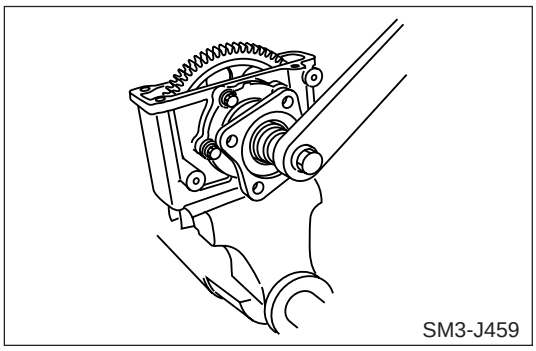


Fig. 9

NOTE:

- **To prevent gouging of the rubber around the outside edge of the oil seal, apply engine oil to the portion of the gear cover where the oil seal will be pressure mounted.**
- **Align the edges of the oil seal and gear cover.**
- **After inserting the oil seal, completely wipe away any oil that has oozed out using a rag.**

2. MOUNTING THE GEAR COVER

1. While paying careful attention to the position of the gear case, mount the gear cover.

NOTE: Mount the gear cover within 20 minutes of applying liquid gasket to the gear cover. (See "Liquid Gasket and Application.")

2. Tighten the flange bolts evenly.

Tightening torque: 290 kg·cm (20.5 lb·ft)

3. MOUNT THE OUTPUT COUPLING.

Tightening torque: 2,300 kg·cm (165 lb·ft)

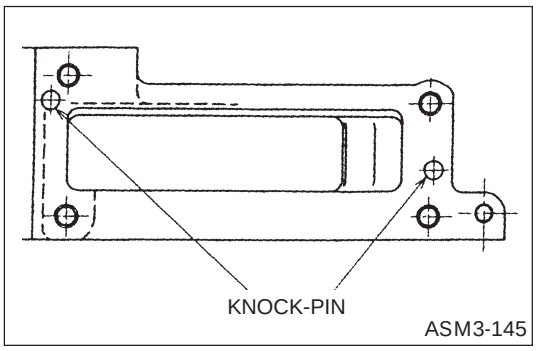


Fig. 10

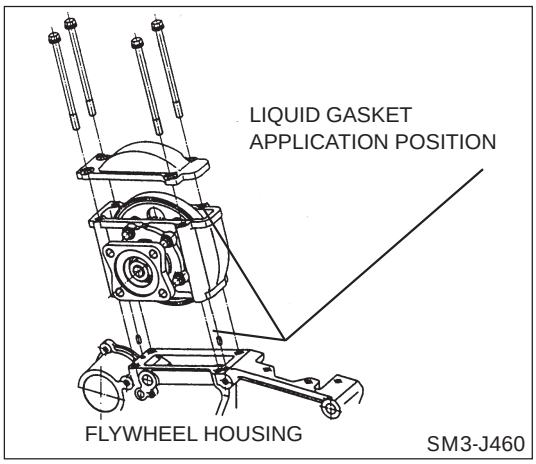


Fig. 11

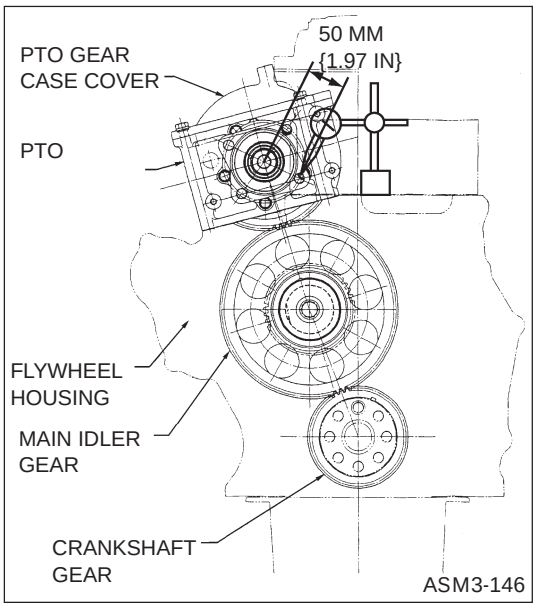


Fig. 12

MOUNTING THE POWER TAKE-OFF ASSEMBLY

1. Insert two knock-pins.
2. Coat the face of PTO assembly and gear case cover with liquid gasket. (Refer to "LIQUID GASKET AND APPLICATION POINTS".)

NOTE:

- ○ **Mount the power take-off assembly within 20 minutes of applying liquid gasket to the joint surface of the PTO assembly of the PTO gear case and the joint surface of the flywheel housing of the PTO assembly. (See "Liquid Gasket and Application.")**
- ○ **When mounting, make sure the PTO assembly and PTO gear case do not shift.**
- ○ **The liquid gasket must be Three Bond TB 1207D (Silver).**
- ○ **The trace of the liquid gasket must be continuous.**

3. Install the PTO assembly and gear case cover with 4 bolts.

Tightening torque: 480 kg·cm (34.7 lb·ft)

MEASUREMENT OF GEAR BACKLASH

Measure the backlash between the gears with a dial gauge. (Refer to the section "TIMING GEAR".)

Unit: mm (in.)

Inspection item	Standard	Limit
Crankshaft gear-PTO gear (Measure at the coupling bolt. P.C.D = ø100 {3.94})	0.035 - 0.211 (0.0014 - 0.0083)	0.30 (0.0118)