SERVICE MANUAL

MITSUBISHI DIESEL ENGINE

for BD2G/BS3G

CONTENTS

- CONSTRUCTION AND FUNCTION
- SPECIAL TOOLS
- MAINTENANCE STANDARDS
- DISASSEMBLY AND REASSEMBLY

MITSUBISHI HEAVY INDUSTRIES, LTD.

DEFINITION OF TERMS

In this manual, the following terms are used in the dimensional and other specifications:

NOMINAL VALUE	Indicates the standard dimension of a part.
ASSEMBLY STANDARD	Indicates the dimension of a part, the dimension to be attained at the time of reassembly or the standard performance. Its value is rounded to the nearest whole number needed for inspection and is different from the design value.
STANDARD CLEARANCE	Indicates the clearance to be obtained between mating parts at the time of reassembly.
REPAIR LIMIT	A part which has reached this limit must be repaired.
SERVICE LIMIT	A part which has reached this limit must be replaced.

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GENERAL

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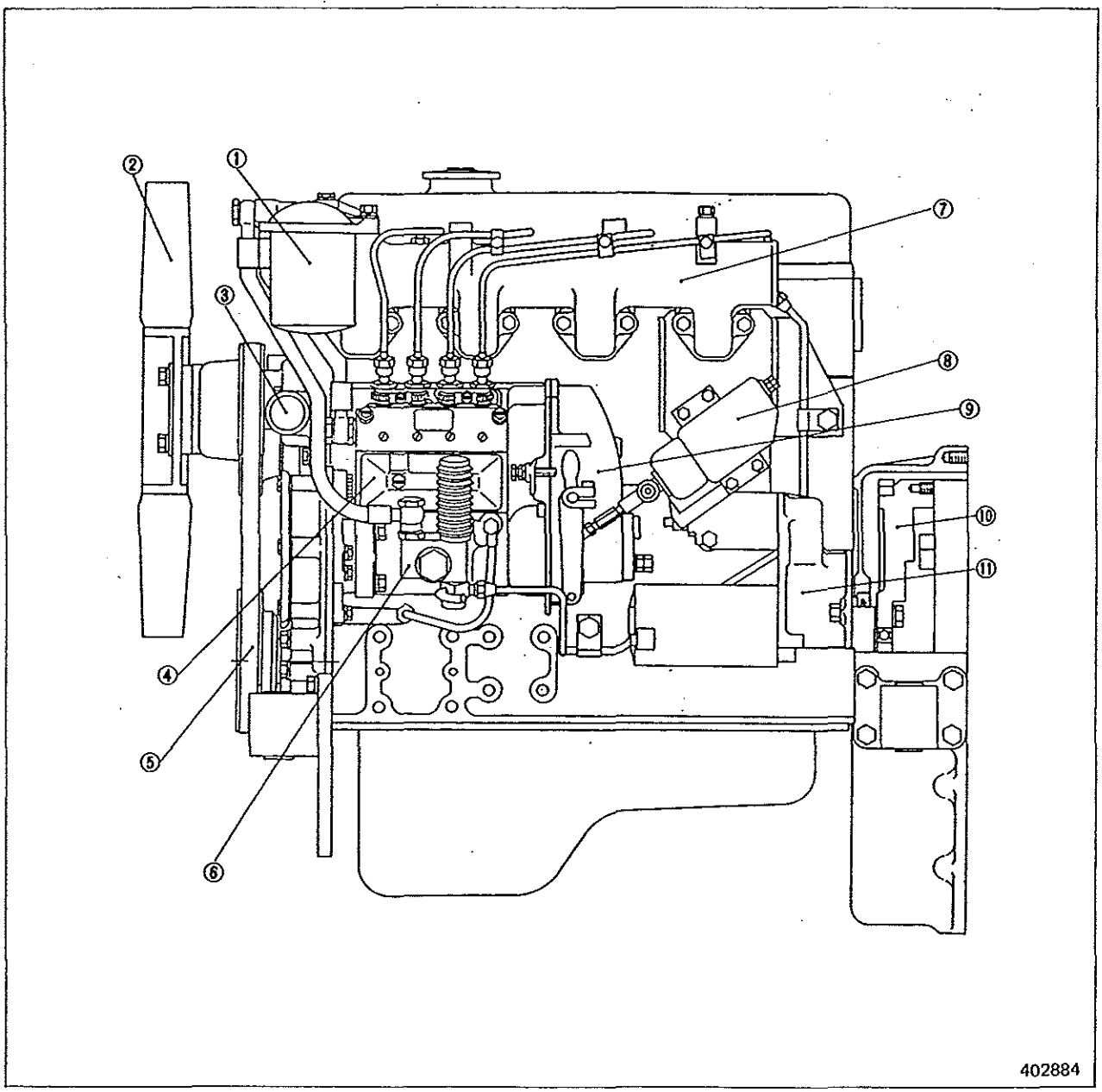
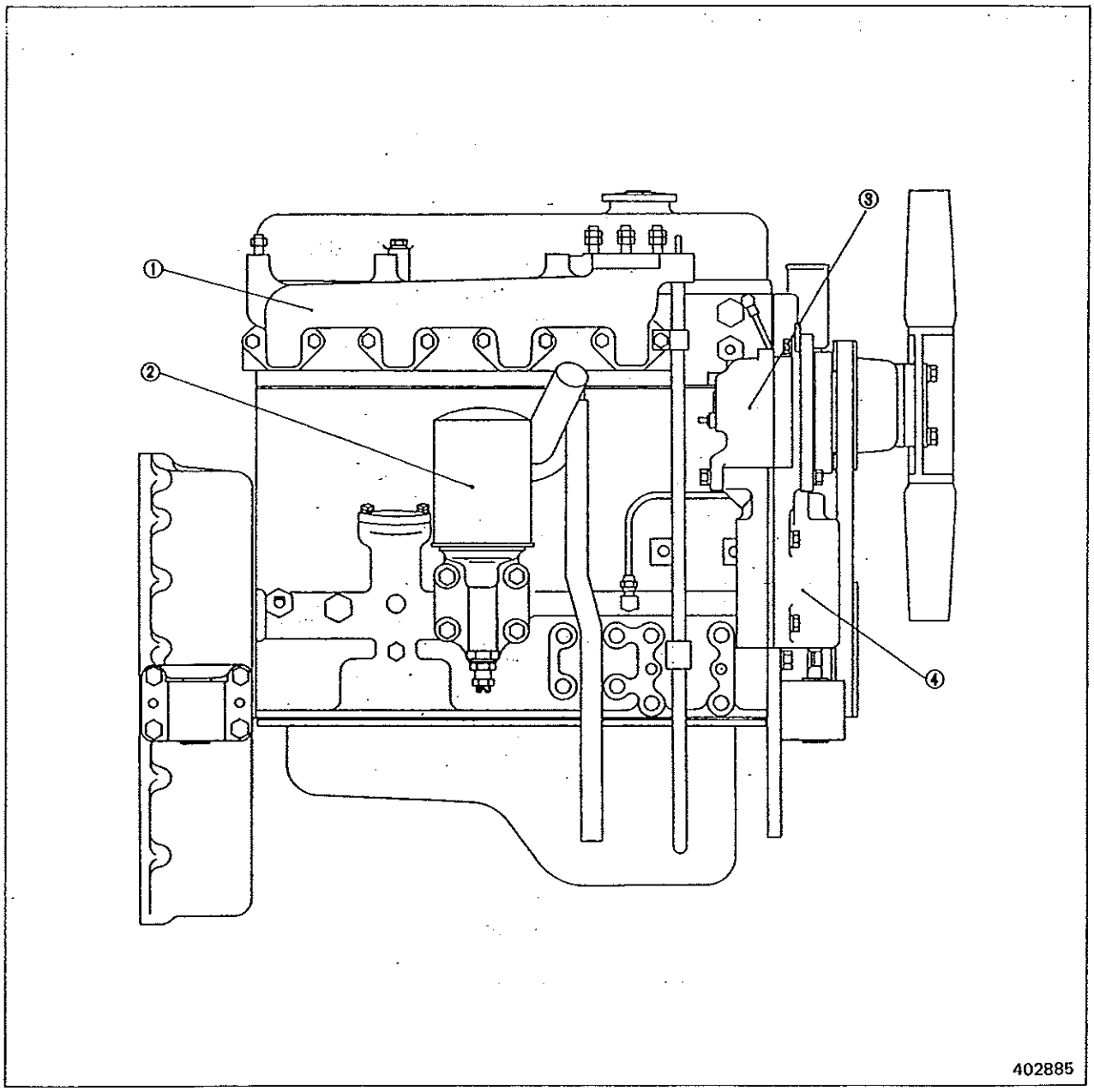
1. GENERAL

1.1 S4E2 diesel engine - External views



① Fuel filter
② Fan
③ Water pump
④ Fuel injection pump
⑤ Fuel feed pump
⑥ Fan belt
⑦ Intake manifold
⑧ Stop solenoid
⑨ Governor
⑩ Flywheel
⑪ Starter

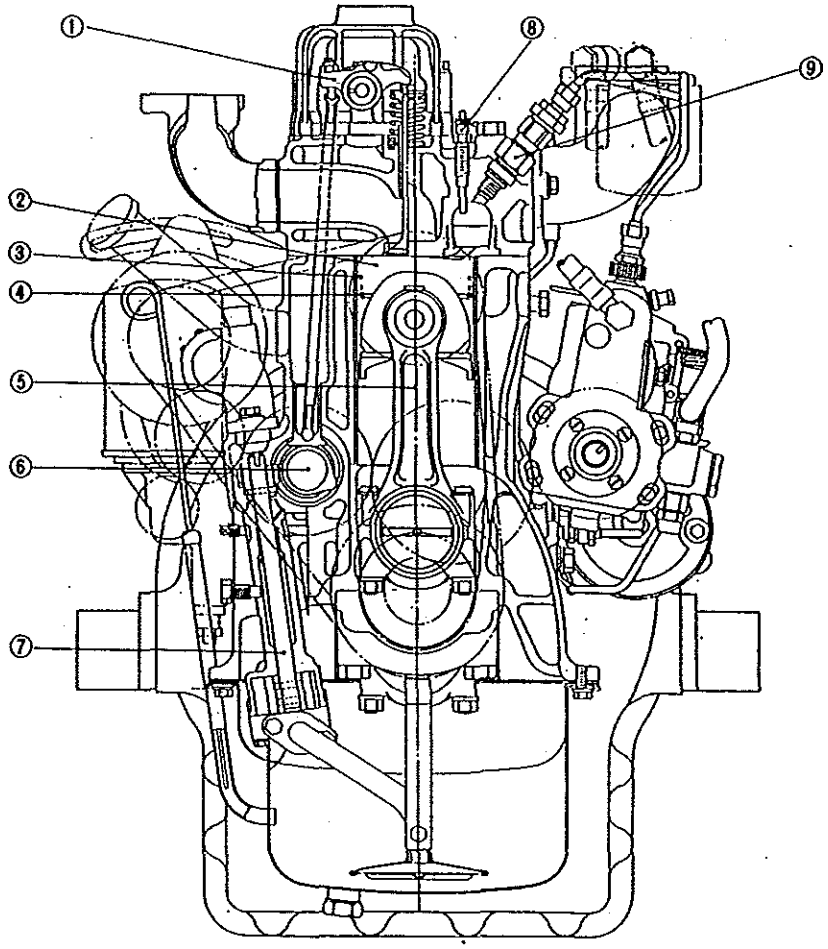
Left-hand side view



① Exhaust manifold
② Oil filter
③ Alternator
④ P.T.O. Gear

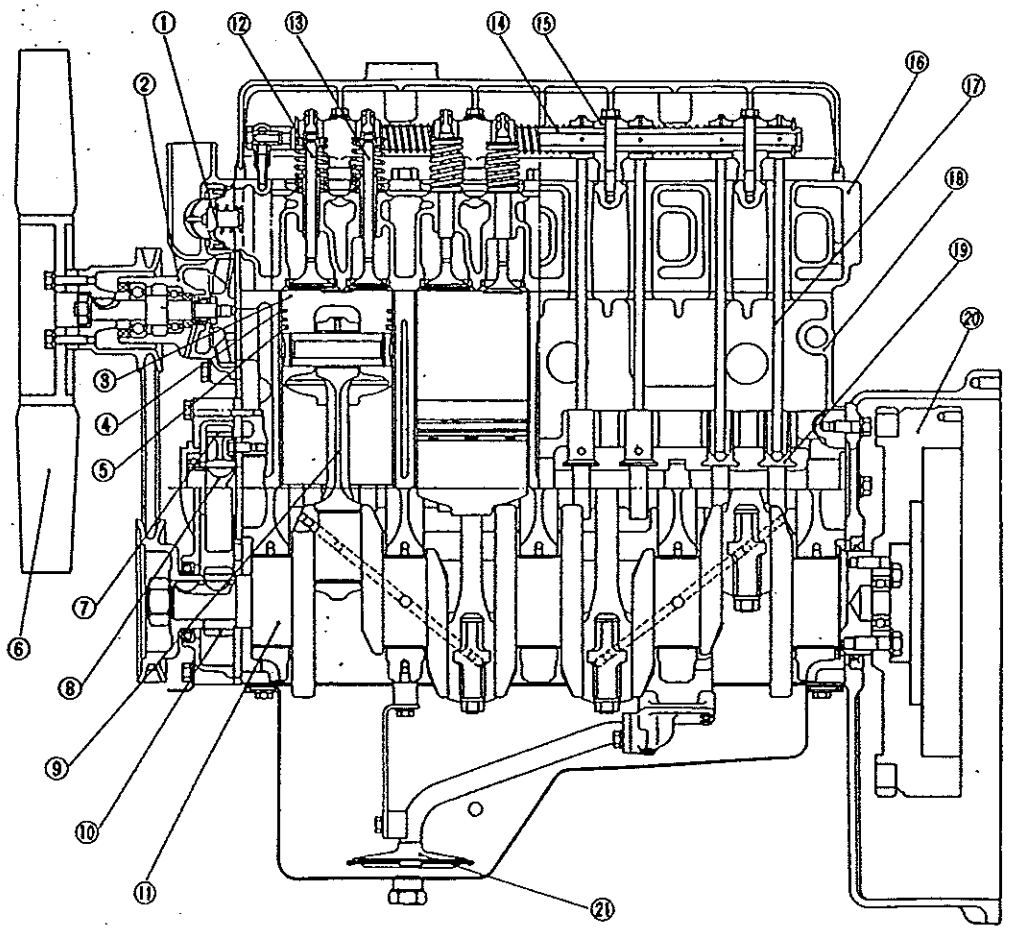
Right-hand side view

1.2 S4E2 diesel engine - Sectional views



① Rocker arm
② Piston
③ Compression ring
④ Oil ring
⑤ Connecting rod
⑥ Camshaft
⑦ Oil pump
⑧ Glow plug
⑨ Fuel injection nozzle

Transverse view

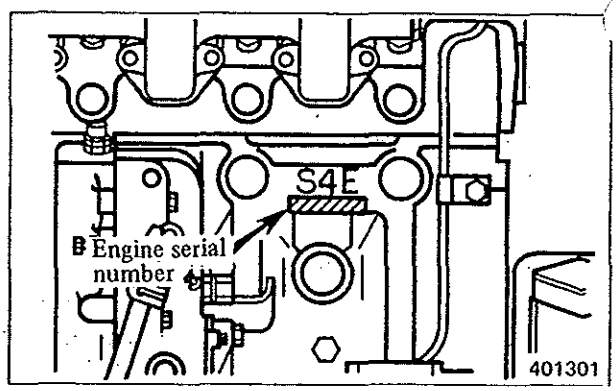


① Thermostat
② Water pump
③ Piston
④ Compression ring
⑤ Oil ring
⑥ Fan
⑦ Camshaft gear
⑧ Camshaft
⑨ Connecting rod
⑩ Crankshaft gear
⑪ Crankshaft
⑫ Intake valve
⑬ Exhaust valve
⑭ Rocker shaft
⑮ Rocker shaft bracket
⑯ Cylinder head
⑰ Valve pushrod
⑱ Crankcase
⑲ Valve pushrod
⑳ Flywheel
㉑ Oil strainer

Longitudinal view

1.3 Engine serial number location

The engine serial number is stamped on the side face of crankcase.



1.4 Engine model and application codes

S□□

- Series codes — E2: Swirl combustion chamber type
  Piston displacement per cylinder:
  739 cc (45.1 cu in.)
  Bore x stroke:
  98 mm x 98 mm (3.86 in. x 3.86 in.)
- No.-of-cylinders code (2, 3, 4 or 6)
- Sagamihara Machinery Works

2. SPECIFICATIONS

Model designation				S4E2
General	Type			Water-cooled, 4-stroke cycle, diesel
	No. of cylinders – arrangement			4-in line
	Type of combustion chamber			Swirl chamber
	Valve mechanism			Overhead
	Bore x stroke		mm (in.)	98 x 98 (3.86 x 3.86)
	Piston displacement		liter (cu in.)	2.956 (180.3)
	Compression ratio			20 : 1
	Fuel (ASTM specification)			Grade No. 2D diesel fuel
	Firing order			1-3-4-2
	Direction of rotation			Counterclockwise as viewed from flywheel side
	Dimensions	Overall length	mm (in.)	809 (31.85)
		Overall width	mm (in.)	528 (20.79)
		Overall height	mm (in.)	750 (29.53)
	Weight (dry)		kg (lb)	270 (595)
	Rated output		PS/rpm	40/2400
	Maximum torque		kgf·m (lbf·ft) [N·m]/rpm	15.5 (112.1) [152.0]/1200
	Compression pressure		kgf/cm^2 (psi) [MPa]/rpm	27 (384) [2.6]/150 – 200
	Maximum speed		rpm	2620 ± 20
	Minimum speed		rpm	870 ± 10
Engine proper	Type of cylinder sleeves			Dry, special cast iron
	No. of piston rings	Compression ring		2
		Oil ring		1 (w/spring expander)
	Valve timing	Intake valves	Open	B.T.D.C. 30°
			Close	A.B.D.C. 50°
		Exhaust valves	Open	B.B.D.C. 74°
			Close	A.T.D.C. 30°
	Starting system			Electric starter
	Starting aid			Glow plugs
Intake/ exhaust systems	Air cleaner	Type		Paper element
Lubrication system	Type			Pressure feed by gear pump
	Engine oil	API service classification		CC
		Refill capacity (incl. filter) liter (U.S. gal)		7 (1.8)

Model designation			S4E2
Lubrication system	Oil pump	Type	Trochoid
		Speed ratio to crankshaft	0.5
		Delivery capacity liter (U.S. gal)/min (at 1800 engine rpm)	14 (3.7)
	Relief valve	Type	Piston valve
		Opening pressure kgf/cm^2 (psi) [MPa]	3 ± 0.3 (43 ± 4.3) [0.3 ± 0.03]
	Oil filter	Type	Paper element
	Oil filter relief valve	Opening pressure kgf/cm^2 (psi) [MPa]	1.0 ± 0.2 (14.2 ± 2.8) [0.10 ± 0.02]
	Oil jet check valve	Opening pressure kgf/cm^2 (psi) [MPa]	—
Cooling system	Refill capacity (engine water jacket) liter (U.S. gal)		4.6 (1.2)
	Water pump	Type	Centrifugal
		Speed ratio to crankshaft	1.3
		Delivery capacity liter (U.S. gal)/min (at 2000 engine rpm)	115 (30.4)
	Fan belt	Type	Low-edge, cog, B type V-belt
		Manufacturer	MITSUBOSHI
	Thermostat	Type	Wax pellet
		Valve opening temperature °C (°F)	76.5 ± 2 (169.7 ± 3.6)
	Radiator	Type	Corrugated fin
	Fan	Type	Polypropylene-blade, circular-arc type
		No. of blades	6
		Diameter mm (in.)	440 (17.32)
		Speed ratio to crankshaft	1.3
Fuel system	Injection pump	Type	Bosch A
		Manufacturer	NIPPONDENSO
		Diameter of plunger mm (in.)	6.5 (0.256)
	Feed pump	Type	Bosch, piston
		Manufacturer	NIPPONDENSO
		Cam lift mm (in.)	6 (0.24)
	Governor	Type	Bosch RSV, centrifugal
		Manufacturer	NIPPONDENSO

Model designation			S4E2
Fuel system	Injection nozzles	Type of nozzle holder	Bosch, throttle
		Type of nozzle tip	Bosch ND-DN0SD
		Manufacturer	NIPPONDENSO
		No. of spray holes	1
		Diameter of spray hole mm (in.)	1.0 (0.04)
		Spray angle	0°
		Valve opening pressure kgf/cm^2 (psi) [MPa]	$120\ ^{+10}_{0}$ ($1706\ ^{+142}_{0}$) [$11.8\ ^{+1.0}_{0}$]
	Fuel filter	Type	Cartridge, paper element
		Manufacturer	NIPPON ROKAKI
Electrical system	Voltage – polarity		24V – negative ground
	Starter	Model	M002T65271 (dry)
		Manufacturer	MITSUBISHI ELECTRIC
		Type	Pinion shift
		Output V – kW	24 – 3.2
		No. of pinion teeth/No. of ring gear teeth	11/110
	Alternator	Type	3-phase, with rectifier
		Manufacturer	MITSUBISHI ELECTRIC
		Output V – A	24 – 20
		Rated voltage generating speed rpm	1100
		Rated output generating speed rpm	5000
		Maximum speed rpm	13500
		Speed ratio to crankshaft	1.7
	Glow plugs	Type	Sheathed
		Rated voltage – current V – A	22.5 – 4.8
		Resistance at normal temperature Ω	4.5 ± 0.5
	Air heater	Type	–
		Capacity kW	–
	Heater relay	Fuse capacity A	–

3. TIPS ON DISASSEMBLY AND REASSEMBLY

This Service manual deals with Mitsubishi's recommended procedures to be followed in servicing the Mitsubishi diesel engines and contains information on the special tools and basic safety precautions.

The safety precautions contained herein, however, are not the whole of work. It is the responsibility of the service personnel to know that specific requirements, precautions and work hazards exist and to discuss these with his foreman or supervisor.

Study this manual carefully and observe the following general precautions to help prevent serious injury to the personnel and damage to the engine.

3.1 Disassembly

(1) Use only right tools and instruments. Serious injury to the personnel and damage to the engine result from the wrong use of tools and instruments.

(2) Use an overhaul stand or work bench if necessary. Also, use assembly bins to keep the engine parts in order of removal.

(3) Lay down the disassembled and cleaned parts in the order in which they were removed to save time for reassembling work.

(4) Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid reassembly.

(5) Carefully check each part for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

(6) When lifting or carrying a part too heavy or too awkward for one person to handle, get another person's help and, if necessary, use a jack or chain block.

3.2 Reassembly

(1) Wash all engine parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.

(2) Use only right tools and instruments.

(3) Use only good-quality lubricating oils and greases. Be sure to apply a coat of oil, grease or sealant to parts as specified.

(4) Be sure to use a torque wrench to tighten parts for which tightening torque is specified. (Refer to 2, Group No. 2.)

(5) Replace gaskets and packings with new ones. Apply a proper amount of quick-drying cement to gaskets or packings, if necessary.

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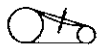
1. MAINTENANCE STANDARDS

Unit: mm (in.)

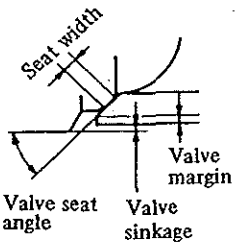
Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
General	Maximum rpm (no-load)		2620 ± 20				Adjust governor setting.
	Minimum rpm (no-load)		870 ± 10				
	Compression pressure		Nominal value: 27 kgf/cm² (384 psi) [2.6 MPa] at 150 – 200 rpm		24 kgf/cm² (341 psi) [2.4 MPa]		Oil and water temp. 20 – 30°C (68 – 86°F)
	Lube oil pressure		Nominal value: 3 – 4 kgf/cm² (43 – 57 psi) [0.3 – 0.4 MPa] at 1500 rpm		2 kgf/cm² (28 psi) [0.2 MPa]		Oil temperature 60 – 70°C (140 – 158°F)
			Nominal value: 1 kgf/cm² (14 psi) [0.1 MPa], minimum at idling		0.5 kgf/cm² (7 psi) [0.05 MPa]		
	Valve timing [with 3-mm (0.12-in.) clearance on valve side]	In. valves open In. valves close Ex. valves open Ex. valves close	14° A.T.D.C. 3° A.B.D.C. 24° B.B.D.C. 29° B.T.D.C. ±3° (crank angle)				Values are only for checking valve timing and are different from actual ones.
	Valve clearance (cold)			0.25 [(0.0098)]			Both intake and exhaust valves
	Fuel injection timing B.T.D.C.		22°				
	Fan drive belt tension			10 – 15 (3/8 – 5/8)			Measure sag at point indicated by arrows. 

In.: Intake Ex.: Exhaust

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Crankcase	Crankcase	Warpage of gasketed surface		0.05 (0.0020), maximum	0.20 (0.0079)		Regrind if warpage is minor.
	Cylinder sleeves	Inside diameter	98 (3.86)	98.000 – 98.035 (3.85826 – 3.85964)	98.200 (3.86613)	99.200 (3.90550)	Refinish sleeves to +0.25 (+0.0098) or +0.50 (+0.0197) oversize of nominal value by honing and use the same oversize pistons and piston rings
		Out-of-roundness		0.015 (0.00059), maximum			
		Taper		0.05 (0.0020), maximum			
	Main bearings	Clearance on journals	75 (2.95)	[0.050–0.115 (0.00197–0.00453)]	[0.200 (0.00787)]	–0.9 (–0.035) as journal diameter.	If repair limit is reached, replace bearings. If service limit is reached, regrind journals and use undersize bearrings: Undersize bearings: –0.25 (–0.0098), –0.50 (–0.0197) and –0.75 (–0.0295)
		Thrust journal length (end play)	2.45 (0.0965)	[0.100–0.264 (0.00394–0.01039)]	[0.300 (0.01181)]		Replace thrust plate.
	Tappet guides	Inside diameter		22.000 – 22.021 (0.86614 – 0.86697)		22.100 (0.87008)	
		Clearance on tappets	22 (0.87)	[0.035–0.086 (0.00138–0.00339)]	[0.120 (0.00472)]	+0.10 (+0.0039) as inside diameter	If repair limit is reached, replace tappets.
	Camshaft bushings	Clearance on journals		[0.04 – 0.09 (0.0016–0.0035)]	[0.15 (0.0059)]		If repair limit is exceeded, replace bushings. Ream if necessary.
Cylinder head	Cylinder head	Warpage of gasketed surface		0.05 (0.0020), maximum	0.20 (0.0079)		Regrind if warpage is minor.
		As-installed thickness of gasket	1.6 (0.063)	±0.15 (±0.0059)			
	Valves and valve guides	Diameter of valve stems: Intake valves		7.955 – 7.940 (0.31319 – 0.31260)		7.900 (0.31102)	
		Diameter of valve stems: Exhaust valves		7.940 – 7.920 (0.31260 – 0.31181)		7.850 (0.30905)	
		Stem clearance in guide: Intake valves	8 (0.31)	[0.055–0.085 (0.00217–0.00335)]		[0.150 (0.00591)]	
		Stem clearance in guide: Exhaust valves		[0.070–0.105 (0.00276–0.00413)]		[0.200 (0.00787)]	
		As-installed length of guides	17 (0.67)	±0.3 (±0.012)			

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clarance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Cylinder head	Valve seats	Angle	30°				
		Valve sinkage	0.7 (0.028)	±0.2 (±0.008)	1.3 (0.051)		
		Width	1.2 (0.047)	±0.14 (±0.0055)	1.6 (0.063)		
		Valve margin		2.13 (0.0839)	Refacing is permissible up to 1.2 (0.047).		
	Valve springs	Free length	48.85 (1.9232)			47.60 (1.8740)	
		Squareness		1.27 (0.0500), maximum			
		Test force/length under test force kgf (lbf) [N]		19 ± 1 (42 ± 2) [186 ± 10] / 43 (1.69)		15 (33) [147] / 43 (1.69)	
	Rocker arms	Inside diameter of rocker bushings		20.000 – 20.021 (0.78740 – 0.78823)			
		Diameter of rocker shafts		19.984 – 19.966 (0.78677 – 0.78606)			
		Clearance of bushings on shaft	20 (0.79)	0.016–0.055 [(0.00063–0.00217)]	0.070 [(0.00276)]		

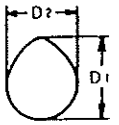
Unit: mm (in.)

Group	Inspection points		Nominal value	Assembly standard [standard clarance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Cylinder head	Valve pushrods	Runout (bend)		0.4 (0.016), maximum			Rounout measured with pushrod supported at centerlines of its spherical ends
Main moving parts	Crankshaft	Runout		0.02 (0.0008), maximum	0.05 (0.0020)		
		Diameter of journals	75 (2.95)	$-0.03\ (-0.0012)$ $-0.05\ (-0.0020)$	−0.15 (−0.0059)	−0.90 (−0.0354)	
		Diameter of crankpins	58 (2.28)	$-0.035\ (-0.00138)$ $-0.055\ (-0.00217)$	−0.20 (−0.0079)		
		Parallelism between journal and crankpin		Runout: 0.01 (0.0004), maximum (over crankpin length)			
		Out-of-roundness of journals and crankpins		0.01 (0.0004), maximum	0.03 (0.0012)		
		Taper of journals and crankpins		0.01 (0.0004), maximum	0.03 (0.0012)		
		Fillet radius of journals and crankpins	3R (0.12)	±0.2 (±0.008)			
		End play	37 (1.46)	[0.100 − 0.264 (0.00394 − 0.01039)]	[0.300 (0.01181)]		If repair limit is reached, replace thrust plates. If repair limit is exceeded, use oversize thrust plates. Oversize thrust plates: +0.15 (+0.0059), +0.30 (+0.0118) and +0.45 (+0.0177)
	Pistons	Outside diameter (at skirt) — Standard	98 (3.86)	97.875 − 97.845 (3.85334 − 3.85216)		97.660 (3.84487)	At right angles to piston pin at skirt
		Outside diameter (at skirt) — 0.25 (0.0098) oversize		98.125 − 98.095 (3.86318 − 3.86200)		97.910 (3.85472)	
		Outside diameter (at skirt) — 0.50 (0.0197) oversize		98.375 − 98.345 (3.87302 − 3.87184)		98.160 (3.86456)	

Unit: mm (in.)

Group	Inspection point			Nominal value	Assembly standard [standard clarance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Main moving parts	Pistons	Protrusion above crankcase			0.35 – 0.75 (0.0138 – 0.0295)			Check bearing clearance.
		Variance in weight per engine			±3 g (±0.1 oz)			
	Piston rings	Side clearance in ring grooves	No. 1 ring	2.5 (0.098)	[0.030–0.070 (0.00118–0.00276)]	[0.200 (0.00787)]		If repair limit is reached, replace piston rings. If repair limit is exceeded, replace piston.
			No. 2 ring	2.0 (0.079)	[0.025–0.060 (0.00098–0.00236)]	[0.150 (0.00591)]		
			Oil ring	4.5 (0.177)	[0.025–0.060 (0.00098–0.00236)]	[0.150 (0.00591)]		
		End gap			0.35–0.50 (0.0138–0.0197)		1.50 (0.0591)	
	Piston pins	Outside diameter			28.000 – 27.994 (1.10236 – 1.10212)			
		Clearance in piston		28 (1.10)	[0 – 0.016 (0 – 0.00063)]	[0.050 (0.00197)]		If repair limit is reached, replace pin. If repair limit is exceeded, replace piston.
		Clearance in bushing		28 (1.10)	[0.020–0.051 (0.00079–0.00201)]	[0.080 (0.00315)]		Replace pin or bushing. Ream if necessary.
	Connecting rod	Inside diameter of bushings			28.045 – 28.020 (1.10413 – 1.10315)			
		Twist/bend			0.05/100 (0.0020/3.94), maximum	0.15 (0.0059)		
		Clearance of connecting rod bearings on crankpins		58 (2.28)	[0.035–0.100 (0.00138–0.00394)]	[0.200 (0.00787)]		If repair limit is reached, replace bearings. If repair limit is exceeded, regrind crankpins and use undersize bearings.

Unit: mm (in.)

Group	Inspection point			Nominal value	Assembly standard [standard clarance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Main moving parts	Connecting rod	End play		40 (1.57)	0.15–0.35 [(0.0059–0.0138)]		0.50 [(0.0197)]	Replace connecting rod.
		Variance in weight per engine			±5 g (±0.2 oz), maximum			
	Flywheel	Radial runout			0.15 (0.0059), maximum	0.50 (0.020)		
		Face runout			0.15 (0.0059), maximum	0.50 (0.020)		
Timing gears	Camshaft	Runout			0.02 (0.0008), maximum	0.05 (0.0020)		Straighten by cold working or replace.
		Cam lift	Intake	D_1 $46.916^{+0.1}_{-0.3}$ $(1.84708^{+0.004}_{-0.012})$	$D_1 - D_2$ = 6.684 (0.26315)		$D_1 - D_2$ = 6.184 (0.24346)	
			Exhaust	D_1 $45.944^{+0.1}_{-0.3}$ $(1.80882^{+0.004}_{-0.012})$	$D_1 - D_2$ = 7.344 (0.28913)		$D_1 - D_2$ = 6.844 (0.26945)	
		Diameters of journals	No. 1, 2	54 (2.13)	53.96 – 53.94 (2.1244 – 2.1236)		53.90 (21.220)	
			No. 3	53 (2.09)	52.96 – 52.94 (2.0850 – 2.0842)		52.90 (2.0827)	
		End play		5 (0.20)	0.050 – 0.112 [(0.00197 – 0.00441)]	0.300 [(0.01181)]		Replace thrust plates.
	Idler	Clearance of shaft in bushing		36 (1.42)	0.025 – 0.075 [(0.00098 – 0.00295)]	0.100 [(0.00394)]		Replace bushing.
		End play			0 – 0.10 [(0 – 0.0039)]	0.35 [(0.0138)]		
		Length of thrust journal of shaft and boss		26 (1.02)	0.05 – 0.20 [(0.0020 – 0.0079)]	0.40 [(0.0157)]		Replace thrust plates.
		Fit of shaft in crankcase bore		30 (1.18)	0.009T–0.045T [(0.00035T–0.00177T)]			
	Backlash				[0.07 (0.0028)]	0.15 [(0.0059)]		Replace gears.

Unit: mm (in.)

Group	Inspection point			Nominal value	Assembly standard [standard clarance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Lubrication system	Oil pump	Outer rotor to inner rotor clearance			0.013–0.150 [(0.00051–0.00591)]		0.250 [(0.00984)]	
		Rotor to cover clearance			0.04–0.09 [(0.0016–0.0035)]	0.15 [(0.0059)]		
		Outer rotor to case clearance			0.20–0.28 [(0.0079–0.0110)]		0.50 [(0.0197)]	
		Diameter of main shaft			13.000 – 12.985 (0.51181 – 0.51122)			
		Clearance of main shaft in pump case			0.032–0.074 [(0.00126–0.00291)]		0.150 [(0.00591)]	
	Relief valve	Opening pressure kgf/cm² (psi) [MPa]		3.0 (42.7) [0.29]	±0.2 (±2.8) [±0.02]			Make shim adjustment. Pressure varies by 0.15 kgf/cm² (2.1 psi [0.015 MPa] per 1 mm (0.04 in.) thickness of shim.
Cooling system	Water pump	Fit of bearing inner races on pump shaft	Front	17 (0.67)	0.01T–0.017T [(0.0004T–0.00067T)]			Replace pump case or pump assembly.
			Rear					
		Fit of bearing outer races in pump case	Front	47 (1.85)	0.011L–0.025L [(0.00043L–0.00098L)]			
			Rear	40 (1.57)				
		Radial clearance of bearings		17 (0.67)	0.010 – 0.025 0.010 – 0.022 (0.00039 – 0.00098 0.00039 – 0.00087)		0.045 (0.00177)	Replace bearings if they fail to rotate smoothly when slowly turned.
		Inside diameter of spacer for shaft		17 (0.67)	0.001–0.017 [(0.00004–0.00067)]			
		Clearance of impeller on both sides		0.5 – 1.0 (0.020 – 0.039)				Replace impeller if any sign of rubbing contact is noted.
		Unit seal	Protrusion of carbon	1.5 (0.059)			0	
			Height (free state)	21.8 (0.858)	±1 (±0.04)			
	Thermostat	Valve opening temp./valve lift [at 90°C (194°F)]		76.5°C (169.7°F)/ 9 (0.35)	±2°C (±3.6°F)			

2. TIGHTENING TORQUE

2.1 Important bolts and nuts

Secured part or component	Thread dia.–pitch	Width across flats	Tightening torque			Remarks
			kgf·m	lbf·ft	N·m	
Cylinder head bolts	12 – 1.75	19	12 ± 0.5	87 ± 4	118 ± 5	[Wet]
Rocker shaft brackets	8 – 1.25	12	1.5 ± 0.5	11 ± 4	15 ± 5	
Main bearing caps	14 – 2	22	10.4 ± 0.5	75 ± 4	102 ± 5	[Wet]
Connecting rod caps	12 – 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5	
Flywheel	12 – 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5	
Camshaft thrust plate	8 – 1.25	12	1.8	13	18	
Front plate	10 – 1.5	14	1	7	10	
Timing gear case bolts	10 – 1.5	14	1	7	10	
Crankshaft pulley	24 – 1.5	36	40 ± 0.5	289 ± 4	392 ± 5	
Idler thrust plate	10 – 1.25	14	3.5	25	34	
Oil pan	8 – 1.25	12	0.7	5	7	
Oil pan drain plug	12 – 1.25	19	10 ± 0.5	72 ± 4	98 ± 5	
Oil pump mounting bolts	12 – 1.75	17	5.5 ± 0.5	40 ± 4	54 ± 5	
Injection pump gear			6 – 7	43 – 51	59 – 69	

Remarks: Apply engine oil to threads of parts specified as [Wet] in Remarks column.

2.2 General bolts and nuts

Screw thread		Tightening torque					
Diameter	Pitch	With spring washer			Without spring washer		
		kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
8	1.0	1.8	13	18	2.2	16	22
	1.25	1.8	13	18	2.1	15	21
10	1.25	3.6	26	35	4.2	30	41
	1.5	3.4	25	33	4.0	29	39
12	1.25	6.5	47	64	7.6	55	75
	1.75	6.0	43	59	7.1	51	70
14	1.5	10.4	75	102	12.2	88	120
	2.0	9.8	71	96	11.5	83	113
16	1.5	15.8	114	155	18.6	135	182
	2.0	15.0	108	147	17.6	127	173
18	1.5	22.9	166	225	26.9	195	264
	2.5	20.7	150	203	24.4	176	239

3. SEALANTS

Application point	Mating parts	Sealant	How to use
Oil pan gasket	Front and rear bearing cap seats of crankcase	ThreeBond 1104 (No. 4)	Apply to front and rear lower sides (bearing cap seats).
• Plugs for water and oil holes in crankcase • Plug for water hole in cylinder head	• Crankcase • Cylinder head	Hermeseal H-1	Apply to holes before installing plugs.
Screw plug for crankcase main oil gallery (taper plug)	Crankcase	Loctite 271	Apply to threads.
Water bypass hose and pipe	Thermostat cover, elbow and water pump	Loctite 271	Apply to threads.
Front and rear bearing cap side seals of crankcase	Bearing caps (front and rear side seal contact surfaces)	ThreeBond 1105D (No. 5)	Apply to crankcase before installing front and rear bearing caps.
Timing gear case gasket	Timing gear case	ThreeBond 1102 (NO. 2)	Apply to gasket surface of timing gear case.

SPECIAL TOOLS

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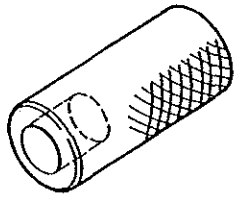
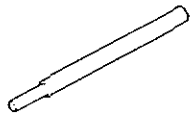
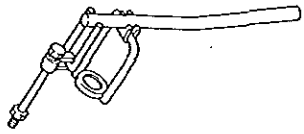
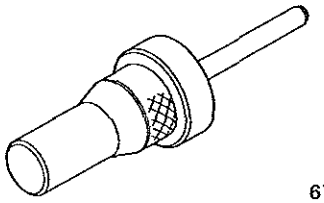
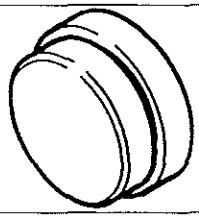
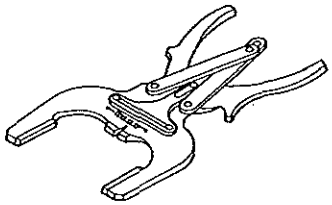
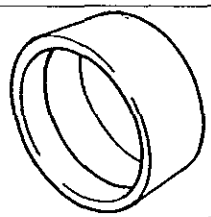
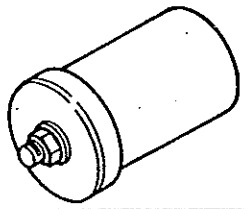
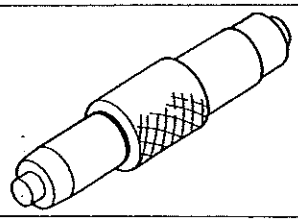
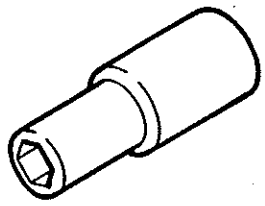
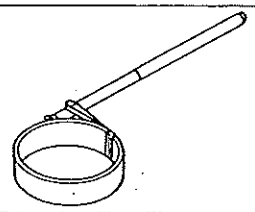
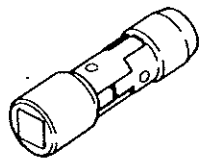
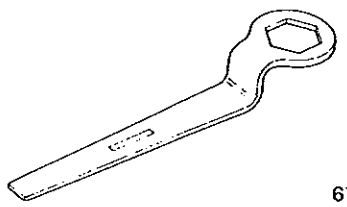
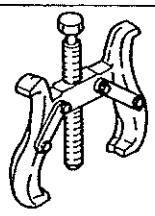
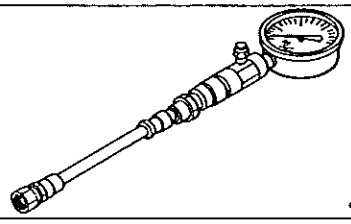
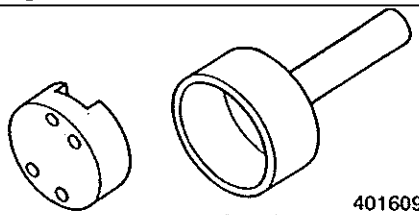
SPECIAL TOOL LIST

Tool name	Part No.	Shape	Use
Valve guide installer	34491-00400	 670228	Valve guide installation
Valve guide remover	31391-10500	 670230	Valve guide removal
Valve spring pusher	30691-04500	 401793	Valve spring removal/installation
Insert caulking tool	31391-13010 (For intake) 34491-01300 (For exhaust)	 670232	Valve seat installation
Sleeve installer	34491-02100	 670236	Cylinder sleeve installation
Piston ring pliers	31391-12900	 670240	Piston ring removal/installation
Piston guide	34491-02200	 670234	Piston installation

Tool name	Part No.	Shape	Use
Idler shaft puller	34491-02300	 670237	Idler shaft removal
Idler bushing puller	30091-07300	 670242	Idler bushing removal/installation
Socket	34491-00300	 670235	Camshaft thrust plate removal/ installation
Oil filter wrench	30691-53301	 401822	Cartridge type oil filter removal
Universal extension	30091-01101	 670239	PE-A type fuel injection pump removal/installation
Cranking handle	30691-11800	 670238	Engine cranking

Tool name	Part No.	Shape	Use
Adaptor	30691-21100	 670233	Engine compression pressure measurement
Puller assembly	64309-12900	 670241	Crankshaft gear, camshaft gear, crankshaft pulley and water pump pulley removal
Compression gauge	33391-02100	 401823	Compression pressure measurement
Crankshaft sleeve installer	30691-13010	 401609	Oil seal sleeve on crankshaft rear side installation

OVERHAUL INSTRUCTIONS

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2. TESTING THE COMPRESSION PRESSURE 29

1. DETERMINING WHEN TO OVERHAUL THE ENGINE

Generally, when to overhaul the engine is to be determined by taking into consideration a drop in compression pressure as well as an increase in lubricating oil consumption and excessive blowby gases.

Low power or loss of power, increase in fuel consumption, drop in lubricating oil pressure, hard starting and excessive abnormal noise are also engine troubles. These troubles, however, are not always the result of low compression pressure and give no valid reason for overhauling the engine.

The engine develops troubles of widely different varieties when the compression pressure drops in it. Following are the typical troubles caused by this compression pressure failure:

(a) Low power or loss of power

(b) Increase in fuel consumption

(c) Increase in lubricating oil consumption

(d) Excessive blowby through breather due to worn cylinder sleeves, pistons, etc.

(e) Excessive blowby due to poor seating of worn inlet and exhaust valves

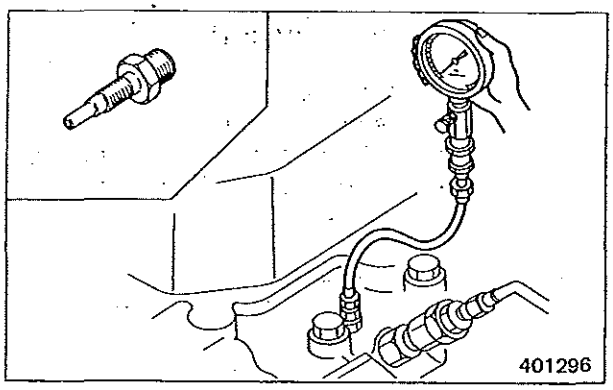
(f) Hard starting

(g) Excessive abnormal noise

In most cases, these troubles occur concurrently. Some of them are directly caused by low compression pressure, but others are not. Among the troubles listed above, (b) and (f) are caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, worn injection pump plungers, faulty injection nozzles, or poor care of the battery, starter and alternator.

The trouble to be considered as the most valid reason for overhauling the engine is (d) Excessive blowby through breather due to worn cylinder sleeves, pistons, etc.; in actually determining when to overhaul the engine, it is reasonable to take this trouble into consideration in conjunction with the other troubles.

2. TESTING THE COMPRESSION PRESSURE



(1) Remove the glow plug from a cylinder on which the compression pressure is to be measured.

(2) Attach the adaptor (30691-21100) to the threaded glow plug hole, and connect compression gauge (33391-02100) to the adaptor.

(3) Crank the engine by means of the starter, and read the compression gauge indication when the engine begins to run at the specified speed.

(4) If the compression pressure is lower than the Repair limit, overhaul the engine.

⚠ CAUTION

(a) Be sure to measure the compression pressure on all cylinders. It is not a good practice to measure the compression pressure on two or three cylinders and judge the compression pressure of the remaining cylinders therefrom.

(b) The compression pressure varies with change of engine rpm. This makes it necessary to check engine rpm at the time of measuring the compression pressure.

Unit: kgf/cm² (psi)[MPa]

Item	Assembly standard	Repair limit
Compression pressure	27 (384) [2.6], min.	24 (341) [2.4], max.

NOTE

Measure the compression pressure with the engine running at 150 -200 rpm.

CAUTION

(a) It is important to measure the compression pressure at periodical intervals to obtain the data on the gradual change of the pressure.

(b) The compression pressure would be slightly higher than the Assembly standard in a new or overhauled engine owing to breaking-in of the piston rings, valve seats, etc. It drops as the engine parts wear down.

ADJUSTMENTS, BENCH TEST, PERFORMANCE TESTS

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1. ADJUSTMENTS

1.1 Valve clearance

Inspect and adjust the valve clearance when the engine is cold or when it is warm in whole.

Unit: mm (in.)

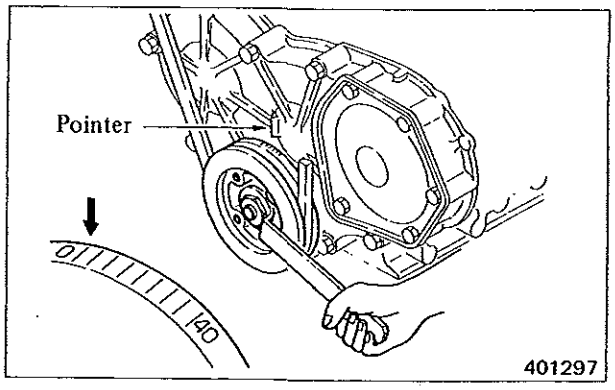
Item		Assembly standard
Valve clearance (cold)	Intake	0.25 (0.0098)
	Exhaust	

(1) Inspecting valve clearance

(a) Inspect the valve clearance by the firing order, by turning the crankshaft by the specified crank angle in normal direction at a time to bring the piston to its top dead center on compression stroke.

No. of cylinders	Firing order	Crank angle
4	1-3-4-2	180°

(b) The top dead center on compression stroke of the piston is identified by the timing mark "0" (on the crankshaft pulley) being aligned with the pointer on the gear case. With the piston so located, either intake and exhaust valve rocker arms are not being pushed up by their pushrods.

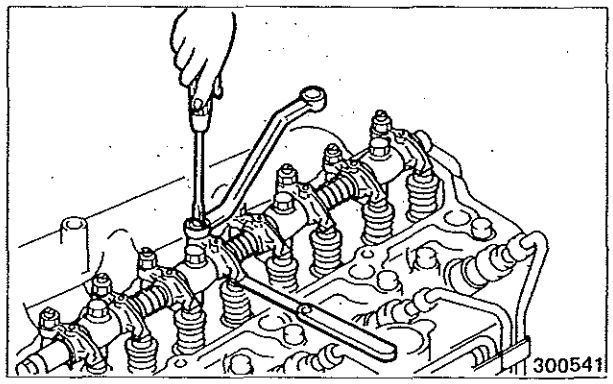


(c) Insert a feeler gauge into between the rocker arm and valve cap, and inspect the valve clearance.

(2) Adjusting valve clearance

(a) Loosen the lock nut for adjusting screw, and adjust the clearance by turning the screw in either direction to the extent that the gauge is slightly gripped between the rocker arm and valve cap.

(b) After adjusting the clearance, tighten the lock nut, and again inspect the clearance, making sure that it is correct.



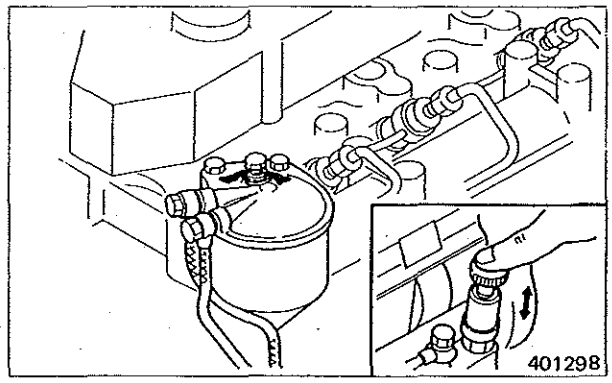
1.2 Fuel system priming

(1) Fuel filter

(a) Loosen air vent plug at the top of the filter (by turning it about 1.5 rotations).

(b) Unlock priming pump handle by turning it counterclockwise, and operate the priming pump.

(c) Tighten the air vent plug when fuel flows from the vent hole without bubbles.

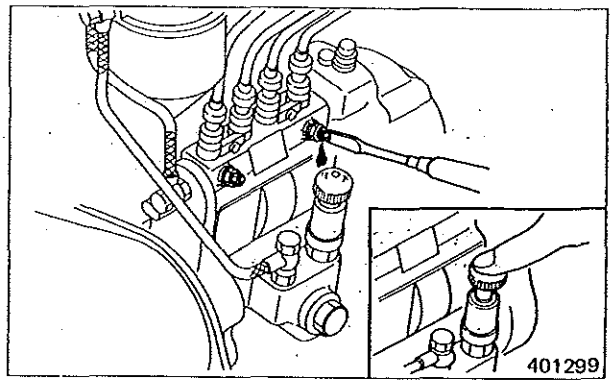


(2) Fuel injection pump

(a) Loosen air vent plug on the injection pump (by turning it about 1.5 rotations). If the pump has two air vent plugs, prime at these plugs.

(b) Operate the priming pump handle.

(c) Tighten the air vent plug when fuel flows from the vent hole without bubbles. Lock the priming pump by turning its handle clockwise while pushing it down before tightening the last vent plug.



NOTE

(a) If all vent plugs are tightened before the priming pump handle is locked, fuel pressure acts on the feed pump, making it impossible to restore the handle.

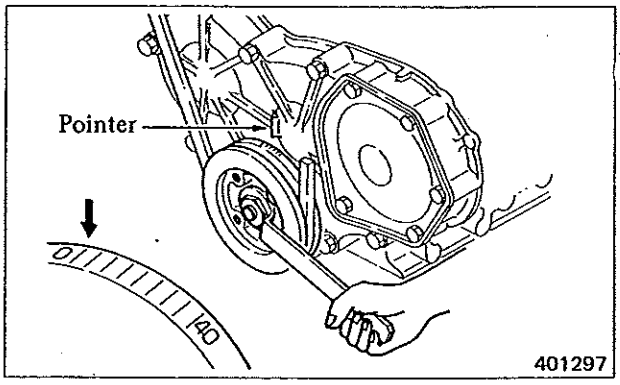
(b) Wipe off fuel spilt from the vent holes with cloth.

1.3 Fuel injection timing inspection and adjustment

The injection timing for each model of the engine varies according to its output, speed and specification. Be sure to verify the timing by referring to the specifications of each model.

(1) Bringing No. 1 piston to top dead center on compression stroke

(a) Using turning bar (30691-11800) at the crankshaft pulley, turn the crankshaft in normal direction (clockwise as viewed from the front side of the engine).



(b) Stop cranking the engine when the timing mark "0" on the crankshaft pulley is aligned with the pointer.

(c) Move the intake and exhaust valve rocker arms for the No. 1 cylinder up and down to make sure that they are not being pushed up by their pushrods.

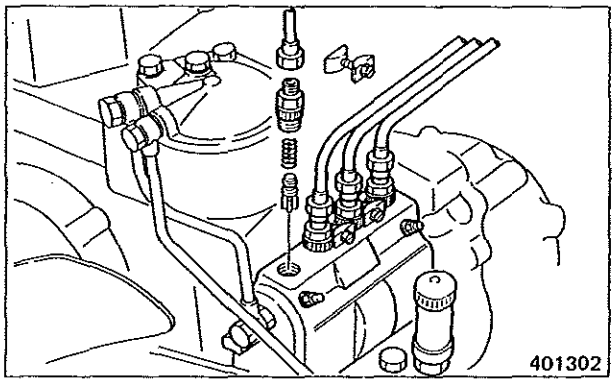
(2) Inspecting fuel injection timing

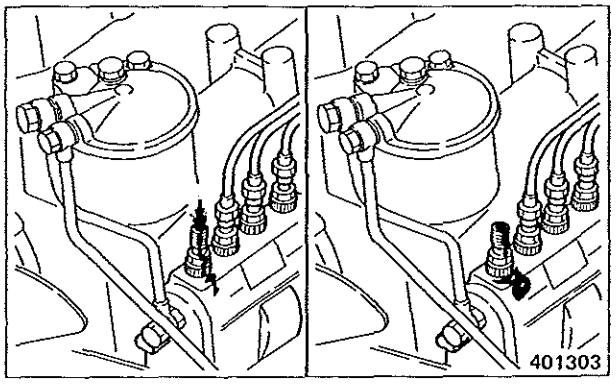
(a) Remove the delivery valve holder from No. 1 pumping element of injection pump. Take delivery valve and spring out of the holder, and restore the holder to the pump.

(b) Turn the crankshaft to bring No. 1 piston to about 60° position before top dead center on compression stroke.

(c) While operating the priming pump to allow fuel to flow from the delivery valve holder, crank the engine in normal direction. Reduce cranking speed when the fuel just starts to stop flowing. Stop cranking when the fuel stops flowing.

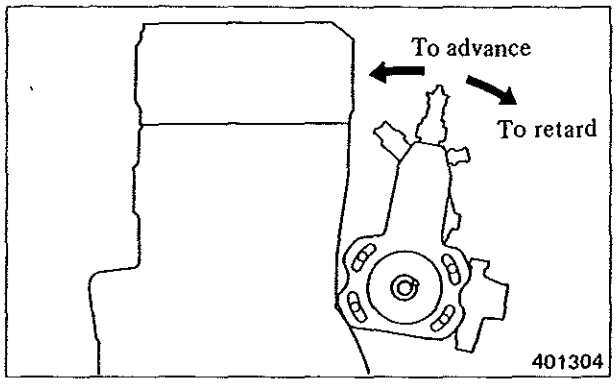
(d) Make sure that the timing mark on the crankshaft pulley is aligned with the pointer.



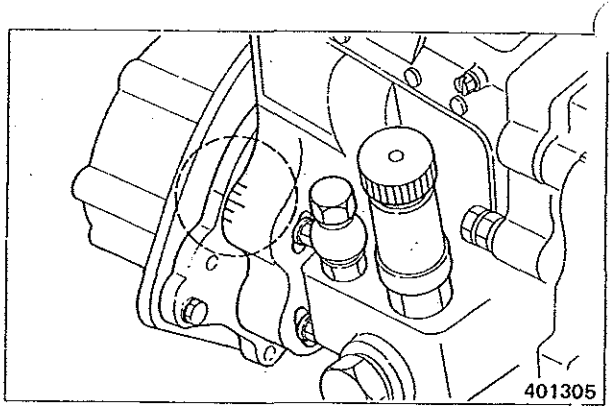


(3) Adjusting fuel injection timing

(a) If the timing is retarded, tilt the injection pump toward the crankcase. If it is advanced, tilt the pump away from the crankcase.



(b) One graduation of the scale on the injection pump coupling changes the timing by 6° in terms of crank angle.



1.4 No-load minimum (idling) speed and maximum speed setting inspection and adjustment

NOTE

For details of adjustment, refer to Fuel System in the separate volume.

⚠ CAUTION

(a) No-load minimum (idling) speed and maximum speed are set for each engine on the test bench at the factory and the set bolts are sealed. These settings are to be inspected and adjusted at Mitsubishi-authorized service shop only.

(b) When inspecting and adjusting these settings, be on standby to operate the engine stop lever manually in the event of engine overrun.

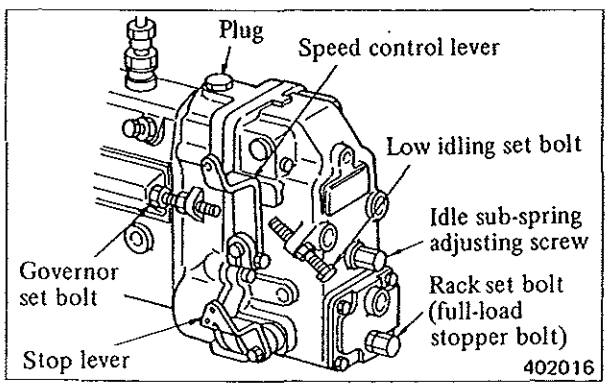
For inspection and adjustment, warm up the engine thoroughly until the coolant and oil temperature rises to 70°C (158°F).

RSV-type governor

(1) Engine starting

(a) Pull speed control lever to high-speed side. Operate starter switch to crank the engine.

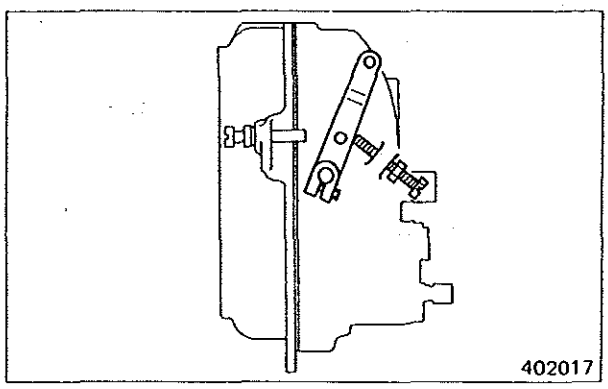
(b) At about 150 rpm of cranking speed, the engine will fire up to pick up speed. Immediately after the engine fires, move back speed control lever to hold the speed anywhere between 800 and 1000 rpm.



(c) When the engine is noted to be running with a steady speed, move speed control lever back to low idling speed position.

(2) Idling set (The setting for keeping the no-load minimum engine speed)

(a) Hold speed control lever at the position for permitting the engine to run at the specified low idling speed, and set the low idling set bolt.

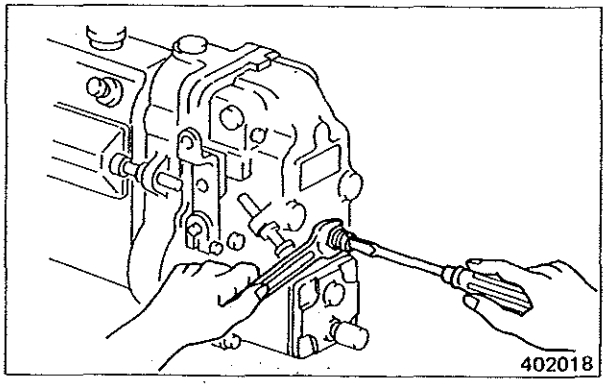


⚠ CAUTION

If a critical speed (the speed at which the engine exhibits excessive vibration due to torsional resonance) might exist, shift the idling set to a lower or higher idling level.

(b) Turning the set bolt clockwise raises the idling speed.

(c) If engine speed tends to fluctuate at a lowest idling speed set as above, turn the idle sub-spring adjusting screw clockwise to push in this spring, making it come in slight contact with tension lever. With idle sub-spring exerting some force to the lever, the speed will rise slightly but will stop fluctuating.



⚠ CAUTION

Tightening the idle sub-spring adjusting screw is likely to result in engine speeding when, during duty operation, the load is dumped.
When tightening the adjusting screw, be sure to tighten it just enough to eliminate the unstable condition.

(3) Rack set (The setting for limiting the maximum engine output)

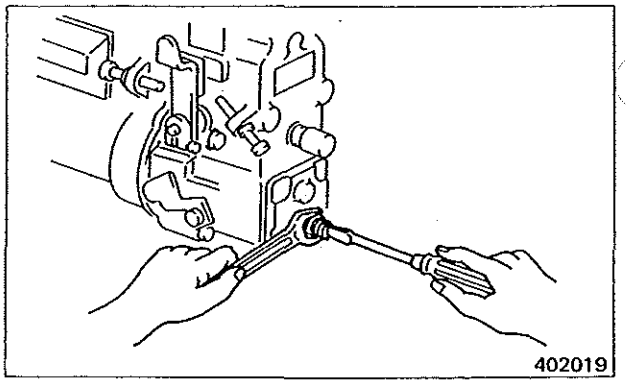
(a) Hold speed control lever at the position for the indicated output and speed (specified for purpose of governor adjustment).

(b) Under this condition, check to be sure that the engine is running in a steady state.

(c) With the engine running in a steady condition, adjust full-load stopper bolt, as follows:

(d) Reposition the full-load stopper bolt by tightening or loosening (to push or pull out the fuel control rack through the levers) in order to find out just where the engine produces the rated output.

(e) Having positioned the stopper bolt properly (for the rated output), back it off slowly while observing the speed. Stop backing it off just when the speed begins to fall from the rated level. Secure the stopper bolt (rack set bolt) in that position with its lock nut.

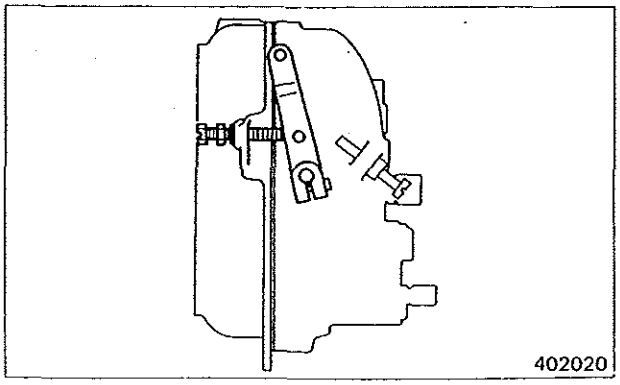


(f) At that time, the speed control lever should be at the position mentioned in (a), above.

(g) Turning the full-load stopper bolt clockwise will increase the injection quantity (engine output), and vice versa.

(4) Governor set (The setting for limiting the maximum engine speed)

(a) Hold speed control lever at the indicated maximum speed position while applying full load to the engine.



(b) Run in governor set bolt (maximum speed set bolt) slowly until its forward end comes in contact with speed control lever held as above. Secure the bolt right there by tightening its lock nut.

(5) Determination of the speed regulation (speed droop)

[1] Speed regulation upon removing load

(a) Run the engine with the speed control lever set for the rated condition (of load and speed).

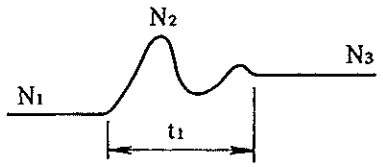
(b) With the control lever held there, remove the load instantaneously to bring the engine into no-load condition. Do not move speed control lever.

(c) The speed will increase once and decrease, as shown and settle at a new steady level. Read the highest speed (N_2) occurring in this transition and the speed (N_3) after settling, and the time (t_1) from the moment of removing the load at initial speed (N_1) to the speed settling at the new level (N_3).

[2] Speed regulation upon applying load

With the engine running in no-load condition subsequent to the condition mentioned in [1] (b) above, and with the speed control lever left in the same position as above, put the prescribed load instantaneously on the engine: the speed will decrease once and increase, as shown, and settle at a new steady level. Read the lowest speed (N_5) occurring in this transition and the speed (N_6) after settling, and the time (t_2) from N_4 to N_6.

Speed regulation upon removing load



Instantaneous speed regulation (%)	Steady-state speed regulation (%)
$\frac{N_2 - N_1}{N_1} \times 100$	$\frac{N_3 - N_1}{N_1} \times 100$

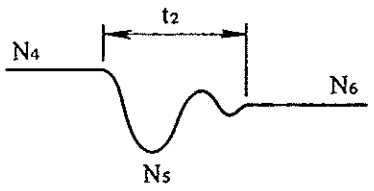
N_1 = initial speed, rpm, before load is removed

N_2 = highest speed, rpm, during transitional period

N_3 = speed, rpm, at which the engine settles after load is removed

t_1 = stabilization time

Speed regulation upon applying load



Instantaneous speed regulation (%)	Steady-state speed regulation (%)
$\frac{N_4 - N_5}{N_4} \times 100$	$\frac{N_4 - N_6}{N_4} \times 100$

N_4 = initial speed, rpm, before load is applied

N_5 = lowest speed, rpm, during transtional period

N_6 = speed, rpm, at which the engine settles after load is applied

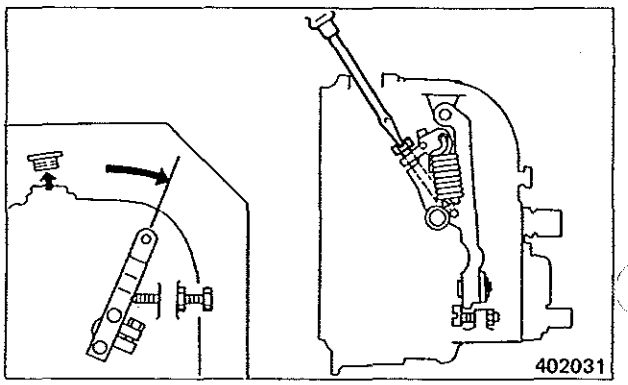
t_2 = stabilization time

[3] Computing the speed regulation

From the values obtained in [1] and [2], above, compute the speed regulation for each load change. A total of four percent values of speed regulation are to be determined by using the indicated formulas.

If the computed values are at variance with the prescribed values, "governor notch adjustment" must be carried out to eliminate the variance.

(6) Adjustment of speed regulation (governor notch adjustment)



(a) This adjustment is to be made by turning the adjusting screw for swivel lever to increase or decrease the pre-tension of governor spring.

(b) To gain access to the adjusting screw, remove the plug at the top of governor housing, and turn speed control lever all the way to the low idling set bolt: this will turn up the swivel lever, pointing the head of the adjusting acrew toward the plug hole. Insert a flat-tip screwdriver through the hole to catch the screw head.

(c) Tightening the adjusting screw increases the pre-tension of governor spring to narrow the speed regulation; loosening it decreases the governor spring pre-tension to widen the regulation. One notch corresponds to 1/4 turn of adjusting screw and to 3 to 5 rpm change of engine speed.

(d) Changing the setting of this adjusting screw changes the governor set (for limiting the maximum engine speed). After making a governor notch adjustment, be sure to re-adjust the governor set, as explained in (4), above.

(e) Tightening the adjusting screw, mentioned above, will increase the maximum speed, and vice versa.

⚠ CAUTION

The adjustable range is 20-notch (5 rotations) long. Never loosen the screw by more than 20 notches from the fully tightened position or the control action of the governor will become hazardous.

(7) Sealing

(a) The stoppers on the injection pump and its governor are adjusted and set through testing by using an injection pump tester or an engine test bench in the final stage of manufacture prior to shipment from the factory. All these stoppers visible on the injection pump are sealed with wires and punched pellets.

(b) After authorized adjustment of the governor, which has to be effected by breaking the seals, be sure to re-seal all visible stoppers, making them appear as if they were sealed at the factory.

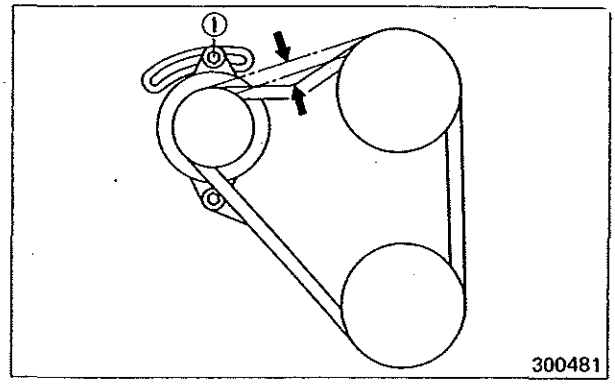
(c) The stoppers to be sealed are specified. Whether the seals are intact or not has important bearing on the validity of claims, if any, under warranty.

1.5 Fan drive belt inspection and adjustment

Apply thumb pressure to the belt midway between the pulleys to inspect the belt tension. If the tension is incorrect, make an adjustment by means of bolt (1).

Unit: mm (in.)

Item	Assembly standard
Fan drive belt tension (deflection)	10 – 15 (3/8 – 5/8)



2. BENCH TEST

An overhauled engine should be tested for performance on a dynamometer. This test is also for "breaking-in" of the major running parts of the engine. To test the engine, proceed as follows:

2.1 Starting up

(1) Check the levels in the radiator, oil pan and fuel tank. Prime the fuel and cooling systems to bleed air out.

(2) Crank the engine with the starter for about 15 seconds to permit lubricating oil to circulate through the engine. For this cranking, do not supply fuel to the engine.

(3) Slightly move the speed control lever in the direction of increasing fuel injection, and turn the starter switch to START for starting the engine. (Do not move the control lever to "full injection" position.)

(4) After the engine starts, let it idle by operating the speed control lever.

2.2 Inspection after starting up

After starting up the engine, check the following points. Upon discovery of any faulty condition, immediately stop the engine, and investigate for the cause.

(1) Lubricating oil pressure: It should be 3 to 4 kgf/cm^2 (43 to 57 psi) [0.3 to 0.4 MPa] at rated speed or 1 kgf/cm^2 (14 psi) [0.1 MPa] at idling speed.

(2) Coolant temperature: It should be 75°C to 85°C (167°F to 185°F).

(3) Lubricating oil temperature: It should be 60°C to 80°C (140°F to 176°F) when measured in oil pan.

(4) Leakage of oil, coolant and fuel.

(5) Knocking: It should die away as the coolant temperature rises. No other defects should be noted.

(6) Exhaust color and abnormal smell

2.3 Bench test (dynamometer test) conditions

Step	Speed (rpm)	Load (PS)	Time (min.)
1	1000	No-load	30
2	1500	25%	30
3	2000	25%	60
4	Rated (varies according to specifications)	25%	10
5		50%	10
6		75%	30
7		100%	20

2.4 Inspection and adjustment after bench test

(1) Retightening of cylinder head bolts

(2) Adjustment of valve clearance

(3) Adjustment of injection timing

3. PERFORMANCE TESTS

3.1 Standard equipment

The cooling fan, air cleaner and alternator are the standard equipment of an engine to be tested.

3.2 Test items

(1) Fuel consumption test

(2) No-load maximum speed test

(3) No-load minimum speed test

3.3 Test methods

(1) Fuel consumption test

(a) Engine speed (rpm)

(b) Fuel injection quantity

(c) Engine output

(2) No-load maximum speed test

For this test, the governor should be set for no-load maximum speed.

(3) No-load minimum speed test

(a) The control lever should be set to the stable minimum speed position. By "stable minimum speed" is meant a minimum speed to which the engine rpm can be quickly dropped from the maximum rpm without stalling.

(b) The no-load minimum speed is specified to be 870 $\pm$ 10 rpm.

(4) Others

During the performance test, inspect for leakage of gases, coolant, lubricating oil and fuel, noise or hunting.

ENGINE ACCESSORY REMOVAL AND INSTALLATION

1. PREPARATORY STEPS 46
2. ENGINE ACCESSORY REMOVAL 46
3. ENGINE ACCESSORY INSTALLATION 50

This section explains the procedures and tips for removal and installation of the accessories - the preliminary process to go through for overhauling the engine.

1. PREPARATORY STEPS

(a) Shut off fuel supply, and disconnect the starting system from the engine.

(b) Loosen the drain cock on left rear side of crankcase, and drain coolant.

(c) Loosen the oil pan drain plug, and drain engine oil.

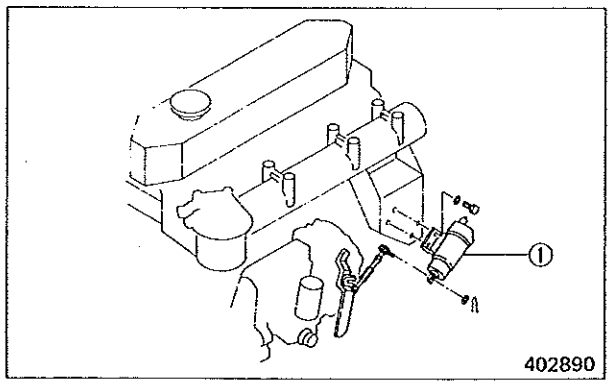
⚠ WARNING

Hot engine oil can cause personal injury if it contacts the skin. Use caution when draining the oil.

2. ENGINE ACCESSORY REMOVAL

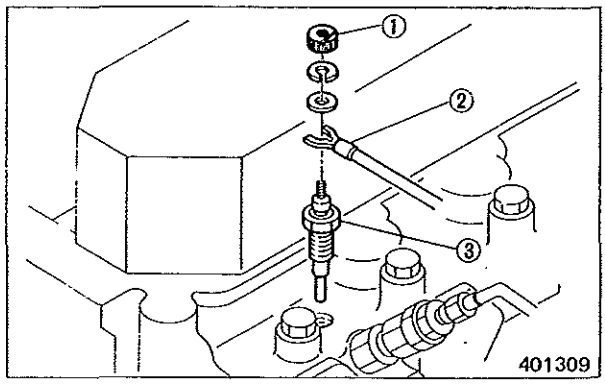
(1) Removing stop solenoid

Disconnect and remove stop solenoid (1) from governor.



(2) Removing glow plugs

Disconnect wire (2) by loosening nut (1), and remove glow plug (3).



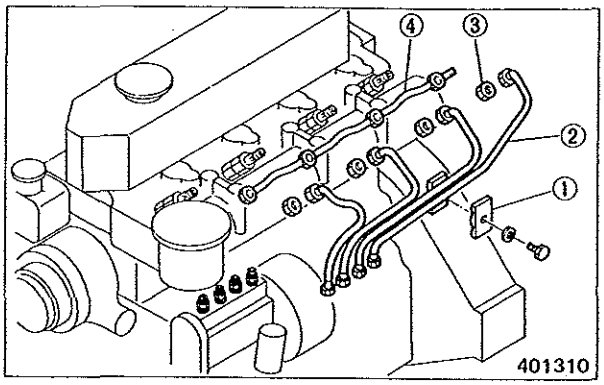
CAUTION

After removing each glow plug, cover the opening by taping to prevent dust from getting inside.

(3) Removing fuel injection pipes

(a) Remove pipe clamp (1), and disconnect injection pipes (2).

(b) Unscrew lock nut (3), and remove leak-off pipe (4).

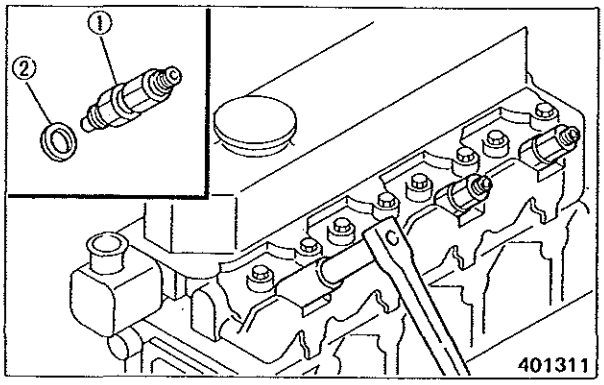


CAUTION

Be sure to fit rubber caps to the openings of the injection pumps and nozzle holders to prevent dust from getting inside the fuel system.

(4) Removing fuel injection nozzles

Using a box wrench, loosen nozzle retaining nut, and remove nozzle (1) complete with gasket (2).



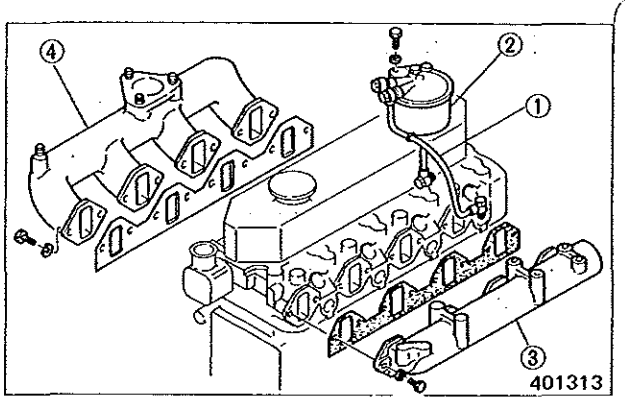
NOTE

Remove nozzle gaskets from the cylinder head, using a piece of wire or screwdriver, and discard them if damaged.

(5) Removing fuel filter and intake and exhaust manifolds

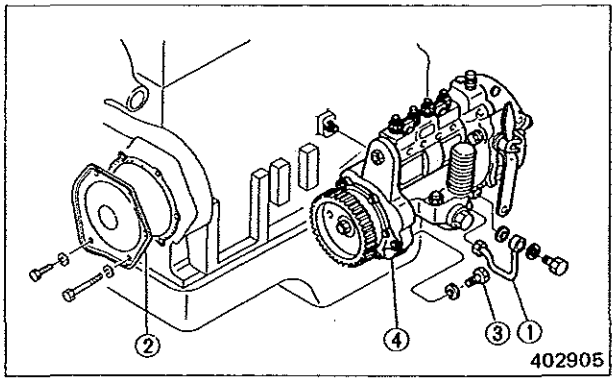
(a) Disconnect fuel hose (1) from fuel filter (1). Remove filter (2) by unscrewing its mounting bolts.

(b) Remove intake manifold (3) and exhaust manifold (4) by unscrewing mounting bolts.



(6) Removing fuel injection pump

Disconnect oil feed pipe (1) and remove cover (2). Remove injection pump (4) from the timing gear case by unscrewing two mounting bolts (3).



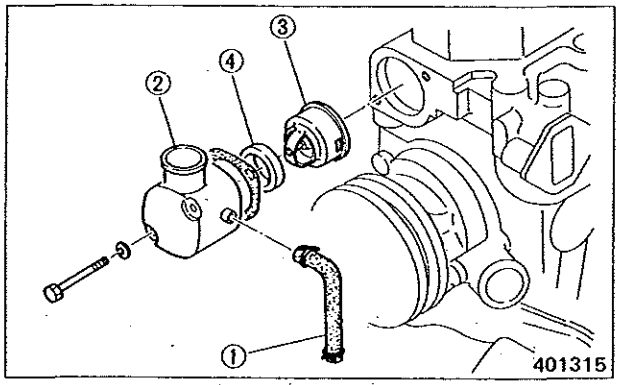
(7) Removing thermostat

(a) Disconnect bypass hose (1).

(b) Unscrew elbow attaching bolts, and remove elbow (2), thermostat (3) and gasket (4).

NOTE

At reassembly, install thermostat with its air vent hole facing upward.

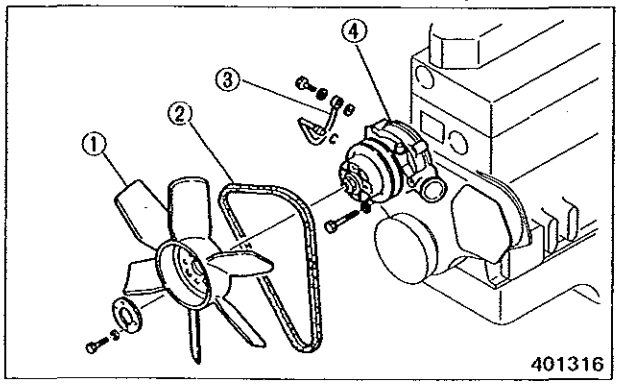


(8) Removing water pump

(a) Remove fan (1). Slacken fan belt (2), and remove it from water pump (4).

(b) Disconnect oil pipe (3).

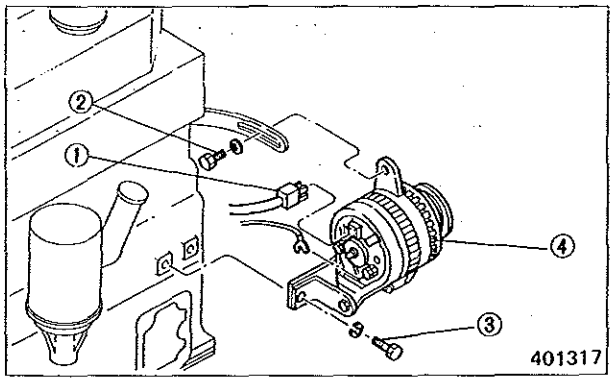
(c) Remove water pump by unscrewing its mounting bolts.



(9) Removing alternator

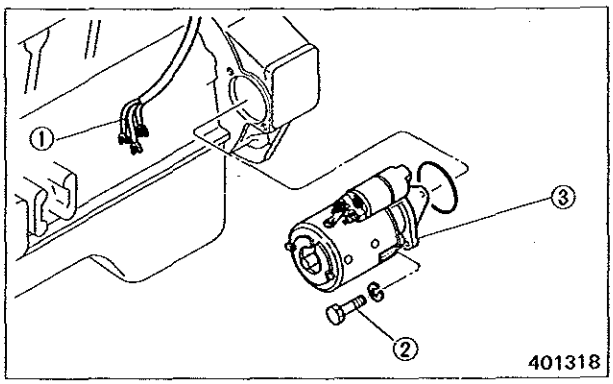
(a) Disconnect harness (1), and unscrew belt adjusting plate bolt (2).

(b) Remove alternator (4) by unscrewing munting bolts (3).



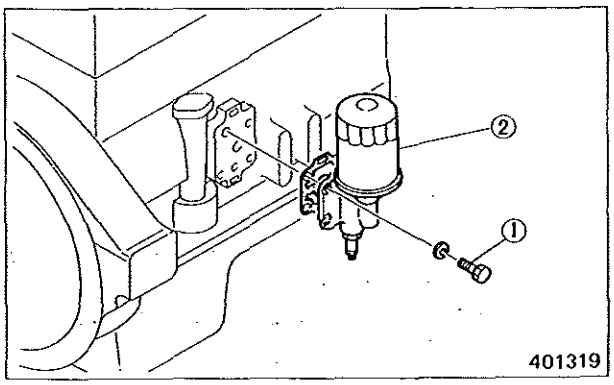
(10) Removing starter

Disconnect harness (1), and remove starter (3) by unscrewing mounting bolts (2).



(11) Removing oil filter

Remove oil filter (2) complete with its bracket by unscrewing mounting bolts (1).



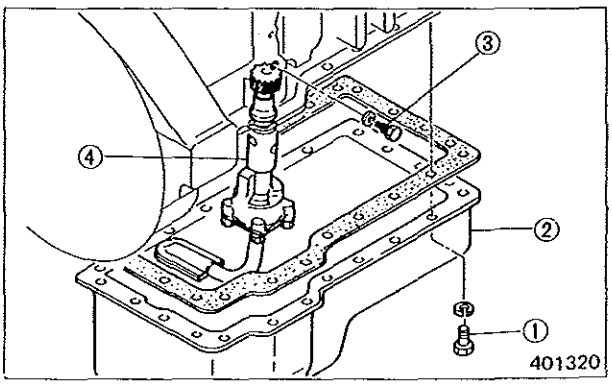
(12) Removing oil pan and oil pump

(a) Remove oil pan (2) by unscrewing mounting bolts (1).

(b) Remove oil pump (4) by unscrewing mounting bolt (3).

NOTE

Camshaft skew gear might interfere with pump drive gear. Remove pump by turning crankshaft slightly.



3. ENGINE ACCESSORY INSTALLATION

To install the engine accessories, use reverse of the removal procedures. After installing them, take the following steps:

(a) Installing fuel injection pump

When installing the pump, make sure that matching marks on pump drive gear and other gears are aligned with those on idler gear respectively, as shown.

NOTE

With these matching marks are all aligned, No. 1 cylinder piston is at top dead center on compression stroke.

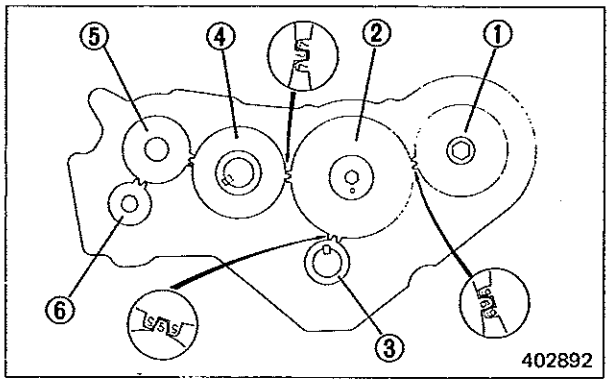
(b) Refill the engine with recommended oil up to the specified level.

(c) Refill the cooling system with coolant.

(d) Check each pipe connection for oil or coolant leaks.

(e) Prime the fuel system.

(f) After installing the fuel injection pumps, inspect and adjust the injection timing. (Refer to 1.3, Group No. 5.)



① Injection pump drive gear
② Idler gear
③ Crankshaft gear
④ Camshaft gear
⑤ P.T.O. idler gear
⑥ P.T.O. gear

Matching marks on timing gears

ENGINE PROPER

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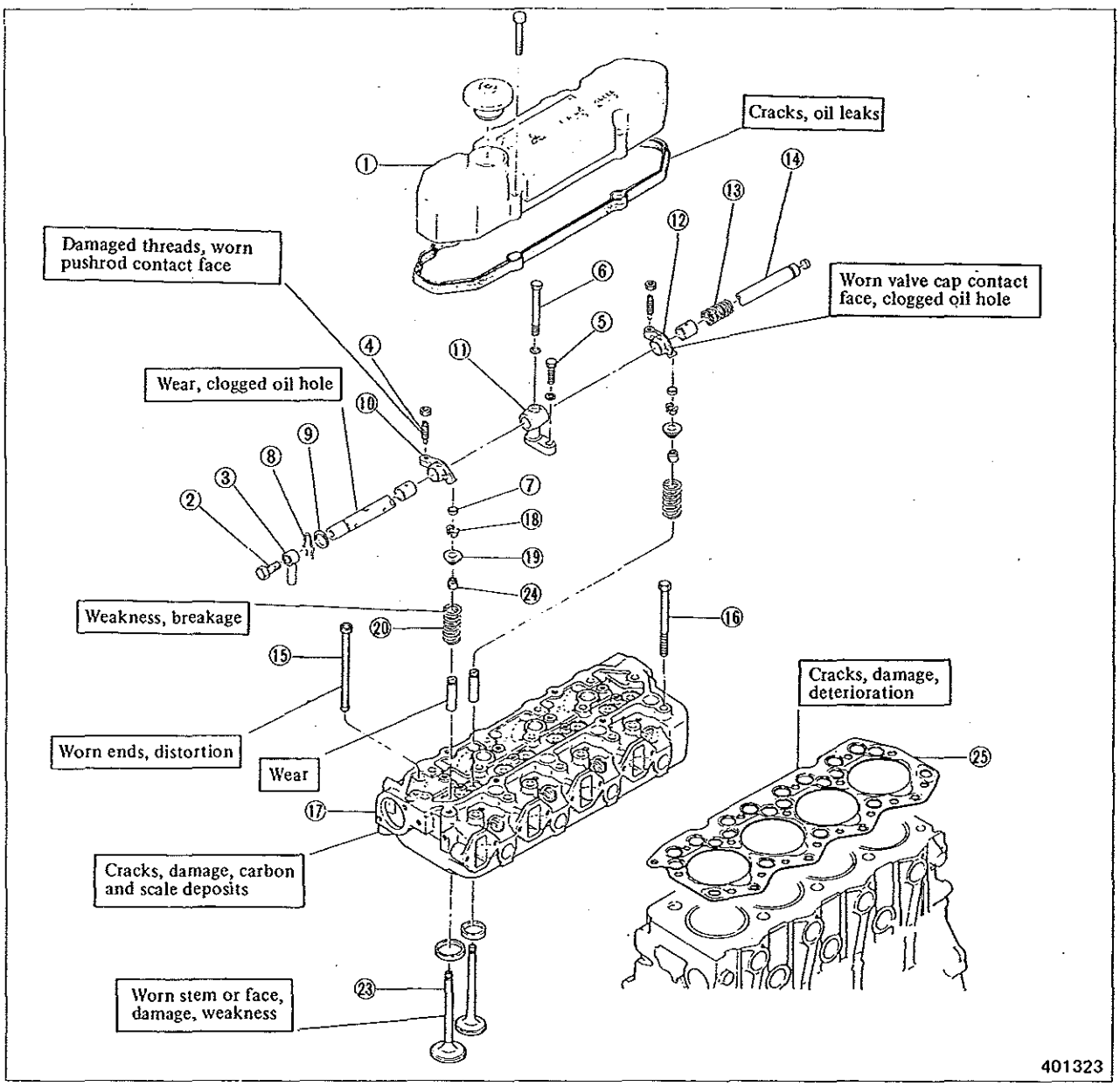
1. CYLINDER HEAD AND VALVE MECHANISM

1.1 Disassembly

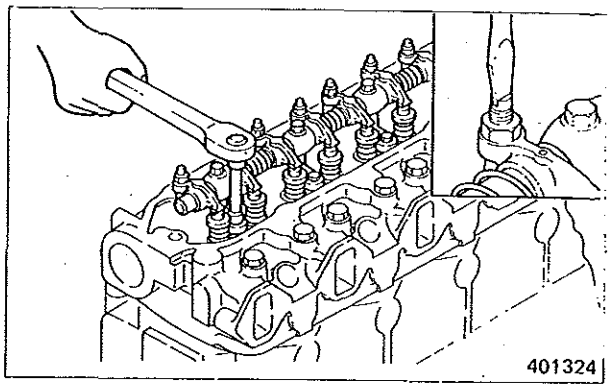


① Rocker cover
② Eye bolt
③ Oil pipe
④ Adjusting screw
⑤ Bolt (short)
⑥ Bolt (long)
⑦ Valve cap
⑧ Snap ring
⑨ Washer
⑩ Intake rocker arm
⑪ Rocker shaft bracket
⑫ Exhaust rocker arm
⑬ Rocker shaft spring
⑭ Rocker shaft
⑮ Valve pushrod
⑯ Cylinder head bolt
⑰ Cylinder head
⑱ Valve cotter
⑲ Upper retainer
⑳ Valve spring
㉓ Valve
㉔ Valve stem seal
㉕ Cylinder head gasket

(1) Removing rocker shaft assemblies

(a) Loosen the adjusting screw of each rocker about one rotation.

(b) Loosen the rocker bracket short bolt and long bolt in that order, and remove the rocker shaft assembly from the cylinder head.

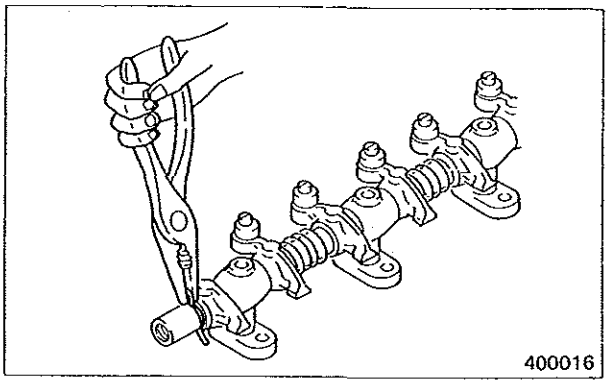


⚠ CAUTION

If these bolts are loosened in reverse order, the rocker shaft bracket might suffer damage.

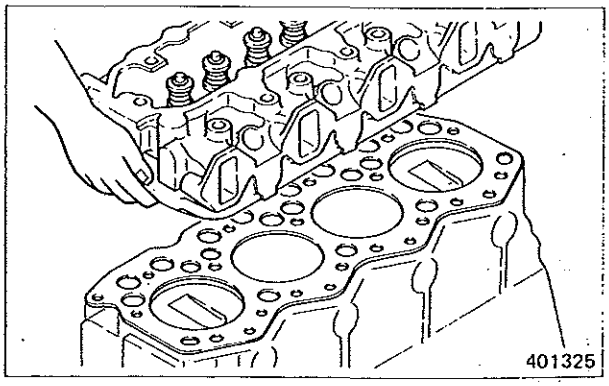
(2) Disassembling rocker shaft assemblies

Lay the disassembled rockers in the order removed, and install them in that order at the time of reassembly. This is for reproducing the same rocker shaft-to-rocker arm clearance as before.



(3) Removing cylinder head

Unscrew the cylinder head bolts, and lift the head off the crankcase.



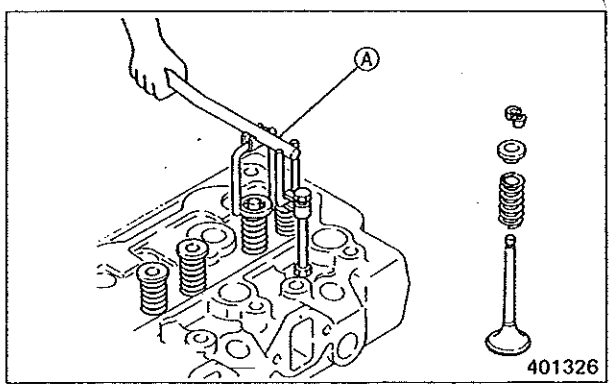
NOTE

(a) When removing the gasket from the crankcase, be careful not to damage the mounting face of crankcase.

(b) If any cylinder head parts are out of order, check the cylinder head bolts for tightening torque with a troque wrench before removing the head bolts.

(4) Removing valves and valve springs

Using valve spring pusher (A) (30691-04500), compress the valve spring squarely, and remove the valve cotters.



NOTE

If the valves are to be reused, mark them for their locations to aid installation at the time of reassembly.

1.2 Inspection and repair

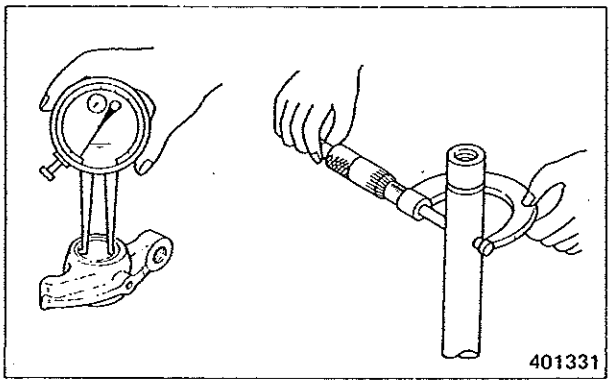
Rocker arms, rocker bushings and rocker shaft

(1) Measuring rocker bushing inside diameter and rocker shaft diameter

Compute the clearance between the bushing and shaft on the basis of the measurements. If the Repair limit is reached, replace the bushing. If it is exceeded, replace both bushing and shaft.

Unit: mm (in.)

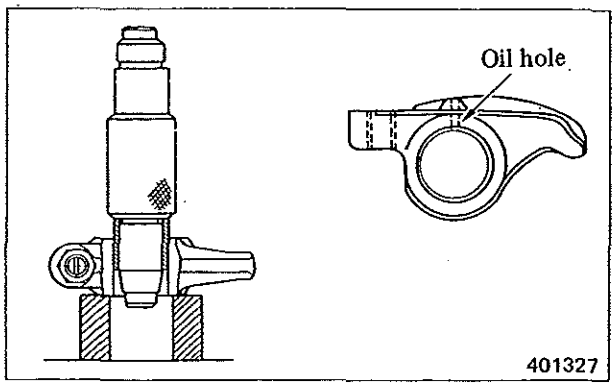
Item	Nominal value	Assembly standard	Repair limit
Rocker bushing inside diameter		20.000 – 20.021 (0.78740 –0.78823)	
Rocker shaft diameter		19.984 – 19.966 (0.78677 – 0.78606)	
Rocker shaft-to-bushing clearance	20 (0.79)	0.016 –0.055 (0.00063 –0.00217)	0.070 (0.00276)



Measuring rocker bushing and rocker shaft

(2) Replacing rocker bushings

When installing a replacement bushing, align the oil holes in the bushing and rocker arm.



Replacing rocker bushing

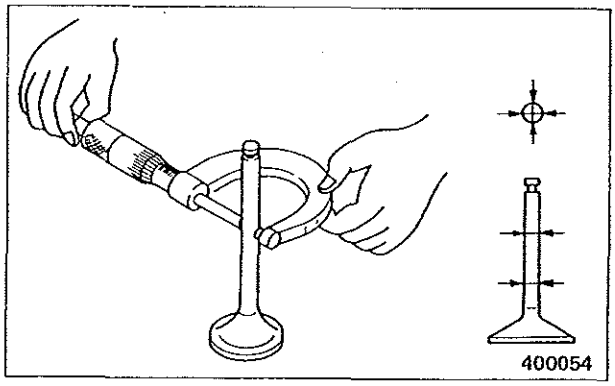
Valves, valve guides and valve seats

(1) Measuring valve stem diameter

If the Service limit is exceeded, or if the stem is abnormally worn excessively, replace the valve.

Unit: mm (in.)

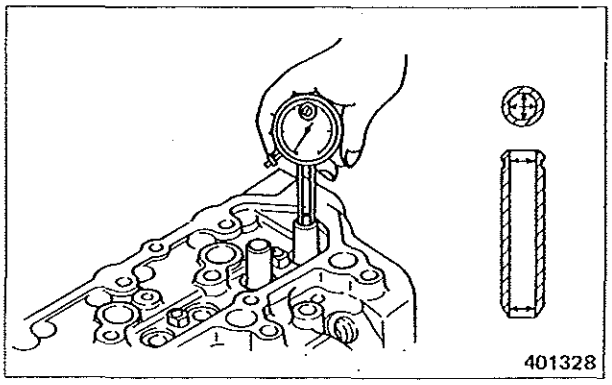
Item		Assembly standard	Service limit
Valve stem diameter	Intake	7.955 – 7.940 (0.31319 – 0.31260)	7.900 (0.31102)
	Exhaust	7.940 – 7.920 (0.31260 – 0.31181)	7.850 (0.30905)



Measuring valve stem diameter

(2) Measuring valve stem-to-guide clearance

The valve guide wears more rapidly at its both ends than at any other parts. Measure the guide at its ends and in two directions at right angles to each other. If the Service limit is exceeded, replace the guide.



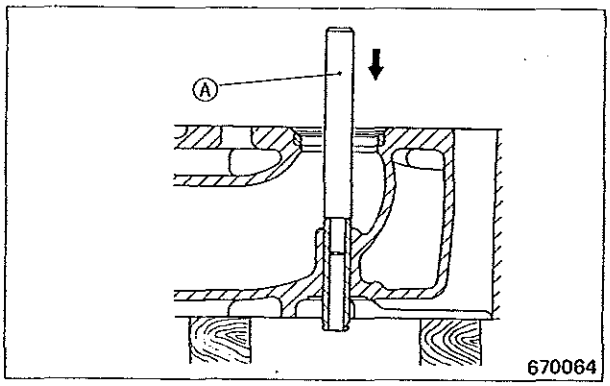
Measuring valve guide inside diameter

Unit: mm (in.)

Item		Nominal value	Assembly standard	Service limit
Valve stem-to-guide clearance	Intake	8 (0.31)	0.055 – 0.085 (0.00217 – 0.00335)	0.150 (0.00591)
	Exhaust		0.070 – 0.105 (0.00276 – 0.00413)	0.200 (0.00787)
As-installed depth of valve guide		17 (0.67)	±0.3 (±0.012)	

(3) Replacing valve guides

(a) Using valve guide remover (A) (31391-10500), remove the guide (worn) for replacement.

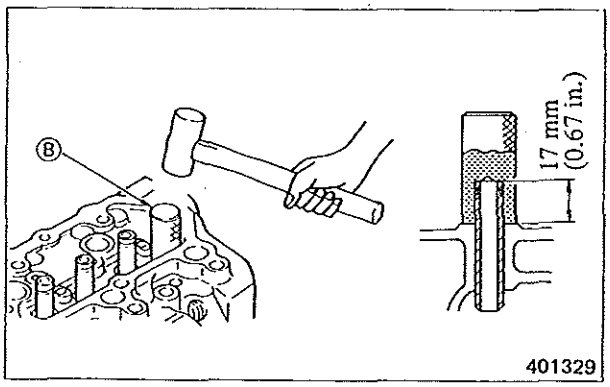


Removing valve guide

(b) To install a replacement guide, use valve guide installer (B) (34491-00400).

CAUTION

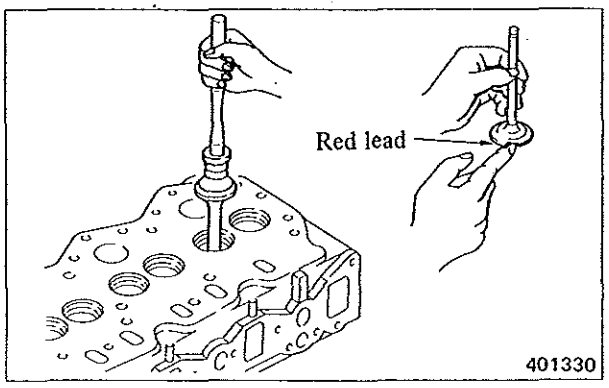
As-installed depth of the valve guide is specified; be sure to use the valve guide installer to insure this depth.



Installing valve guide

(4) Inspecting valve face

Coat the valve face lightly with red lead and, using valve lapper, check the valve contact with its seat. If the contact is not uniform, or if the valve is defective or the Repair limit is exceeded, repair or replace the valve and valve seat.



Inspecting valve face

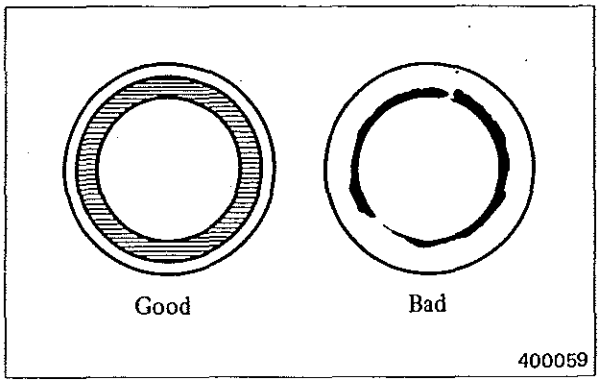
NOTE

(a) Check the valve face after inspecting or replacing the valve guide.

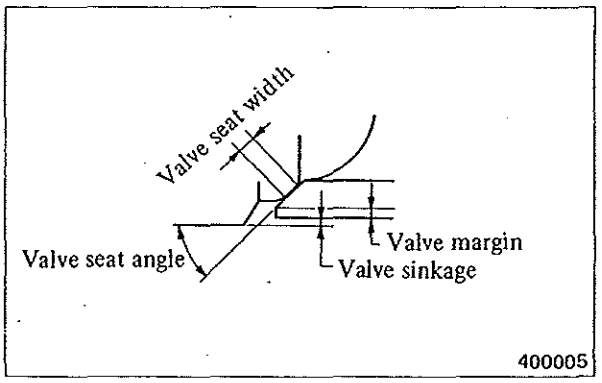
(b) Press the valve into the seat without rotating it.

Unit: mm (in.)

Item		Assembly standard	Repair limit
Valve seat	Angle deg	30	
	Valve sinkage	0.7 ± 0.2 (0.028 ± 0.008)	1.3 (0.051)
	Width	1.2 ± 0.14 (0.047 ± 0.0055)	1.6 (0.063)
Valve margin		2.13 (0.0839)	Up to 1.2 (0.047) by refacing



Valve contact with its seat



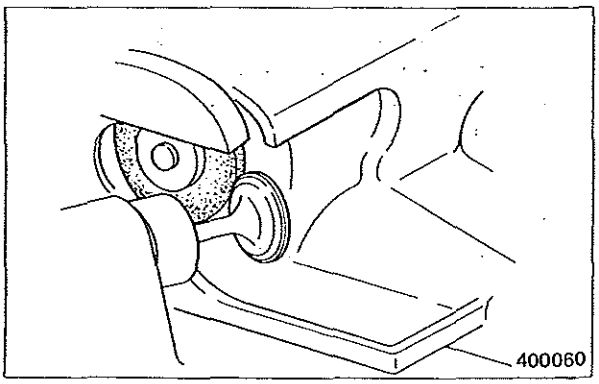
(5) Refacing valves

If the valve face is badly worn, reface it with a valve refacer.

NOTE

(a) Set a valve refacer at an angle of 30°.

(b) If the valve margin seems to be less than the Repair limit when ground, replace the valve.

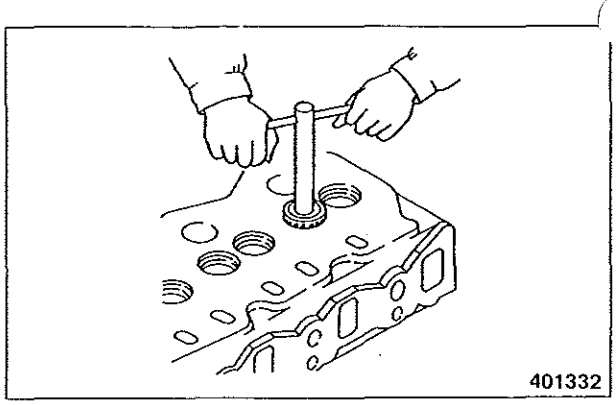


Refacing valve

(6) Refacing valve seats

(a) Using a valve seat cutter or valve seat grinder, cut the valve seat. After cutting, grind the seat lightly by using a sandpaper of #400 grade or so, inserted between the cutter and seat.

(b) Lap the valve in the seat.



Refacing valve seat

NOTE

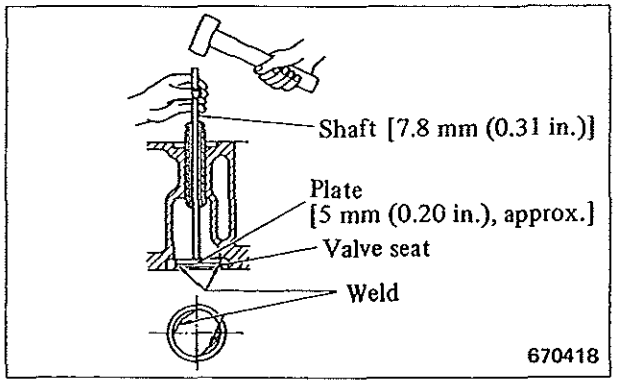
(a) Cut or grind the valve seat only as necessary for refacing.

(b) If the seat width is in excess of the Repair limit as a result of wear or cutting, replace the valve seat.

(c) If the valve sinkage exceeds the Repair limit after refacing, replace the valve seat.

(7) Replacing valve seats

(a) Weld a plate of about 5 mm (0.20 in.) thickness to the valve seat. Insert a shaft into the valve guide hole from the upper side of cylinder head, and drive the seat off the head as shown.

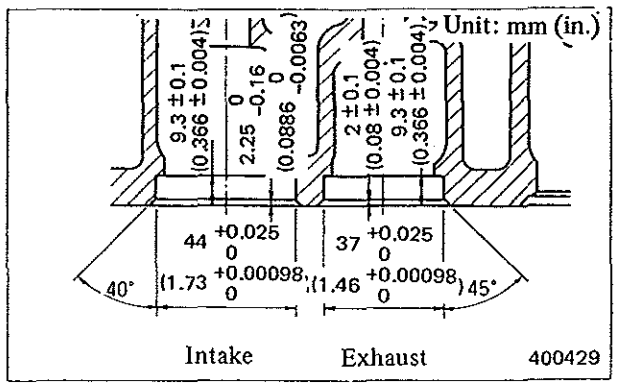


Removing valve seat

⚠ CAUTION

When welding the plate, be careful not to permit spatters to come in contact with the machined surfaces of cylinder head.

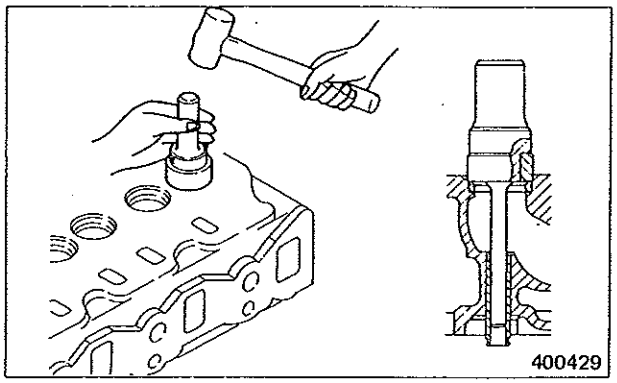
(b) Measure dimensions of valve seat holes in the cylinder head before installing valve seats and make sure that they are as specified.



Valve seat dimensions

(c) Chill the valve seat in liquid nitrogen [about -170°C (-274°F)] for more than 4 minutes with the cylinder head kept at normal temperature, or heat the cylinder head to 80°C to 100°C (176°F to 212°F) with the valve seat chilled in ether or alcohol containing dry ice.

(d) Using valve insert caulking tool (A), install the valve seat by caulking it there.



Installing valve seat

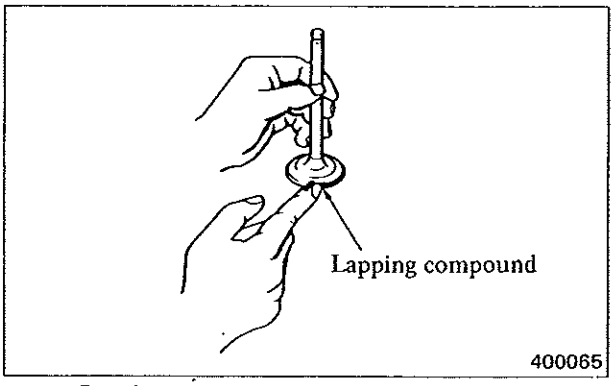
Valve insert caulking tool

Item	Part No.
Intake	31391-13010
Exhaust	34491-01300

(8) Lapping valves in valve seats

Be sure to lap the valves in the valve seats after the seats have been replaced.

(a) Coat the valve face lightly with a lapping compound.



Coating valve with lapping compound

NOTE

(a) Do not permit the compound to come in contact with the valve stem.

(b) Use the compound of 120 to 150 mesh for initial lapping and the compound of finer than 200 mesh for finish lapping.

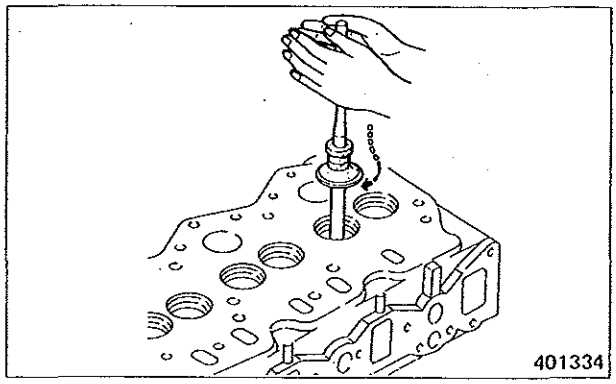
(c) Mixing the compound with a small amount of engine oil will facilitate coating.

(b) Using a valve lapper, lap the valve in the seat. To lap, raise the valve off the seat, rotate it only a part of turn to a new position and strike it against the valve seat.

(c) Wash off the compound with diesel fuel.

(d) Coat the valve face with engine oil, and again lap the valve.

(e) Check the valve face for contact.



Lapping valve in valve seat

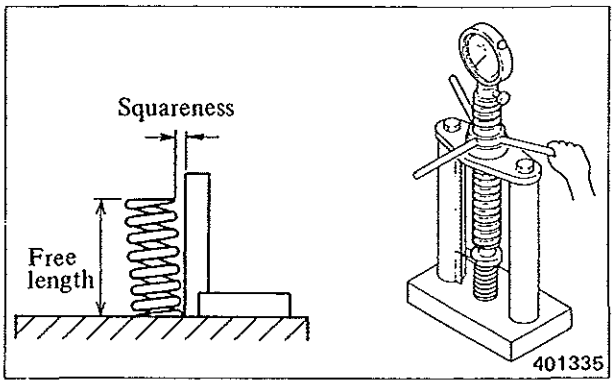
Valve springs

Measuring squareness and free length

If the squareness or free length exceeds the Service limit, replace the spring.

Unit: mm (in.)

Item	Assembly standard	Service limit
Free length	48.85 (1.9232)	47.60 (1.8740)
Squareness	1.27 (0.0500), maximum	
Test force/length under test force kgf (lbf)[N]/mm (in.)	19 ± 1 (42 ± 2) [186 ± 10]/43 (1.69)	15 (33) [147]/ 43 (1.69)



Measuring valve spring

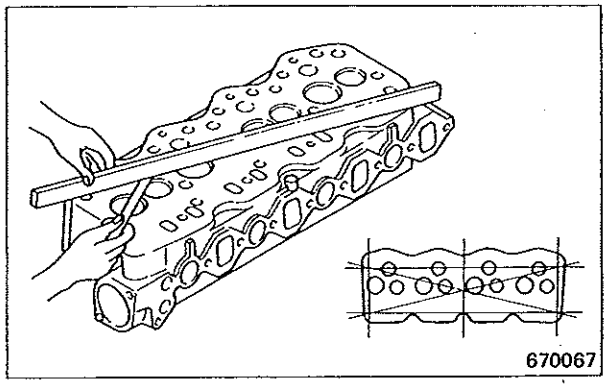
Cylinder head

Measuring gasketed surface warpage

Measure warpage with a straightedge and a feeler gauge. If the warpage exceeds the Repair limit, reface the gasketed surface with a surface grinder.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Cylinder head gasketed surface warpage	0.05 (0.0020), maximum	0.20 (0.0079)

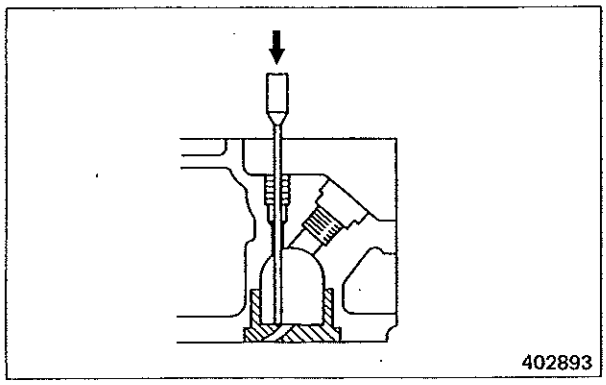


Measuring cylinder head gasketed surface warpage

Combustion jets

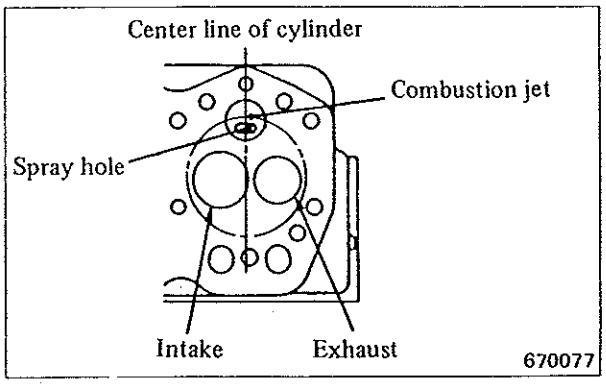
Replacing combustion jets

(a) Replace the jets only when they are cracked. To remove, insert a round rod of about 6 mm (0.24 in.) diameter into the glow plug hole, and give light blows to the periphery of the ject through the rod.



Removing combustion jet

(b) To install, align the spray hole of the jet with the center line of cylinder.



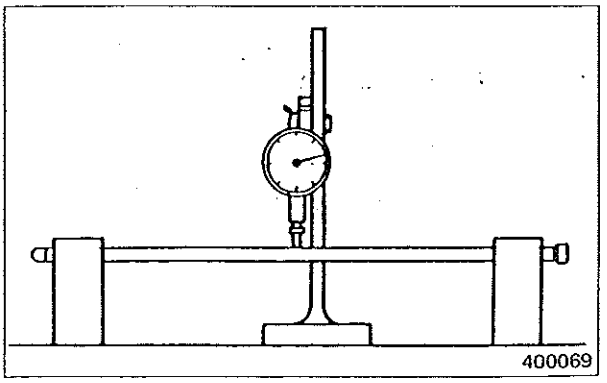
Installing combustion jet

Valve pushrods

If the runout exceeds the Assembly standard, replace the pushrods.

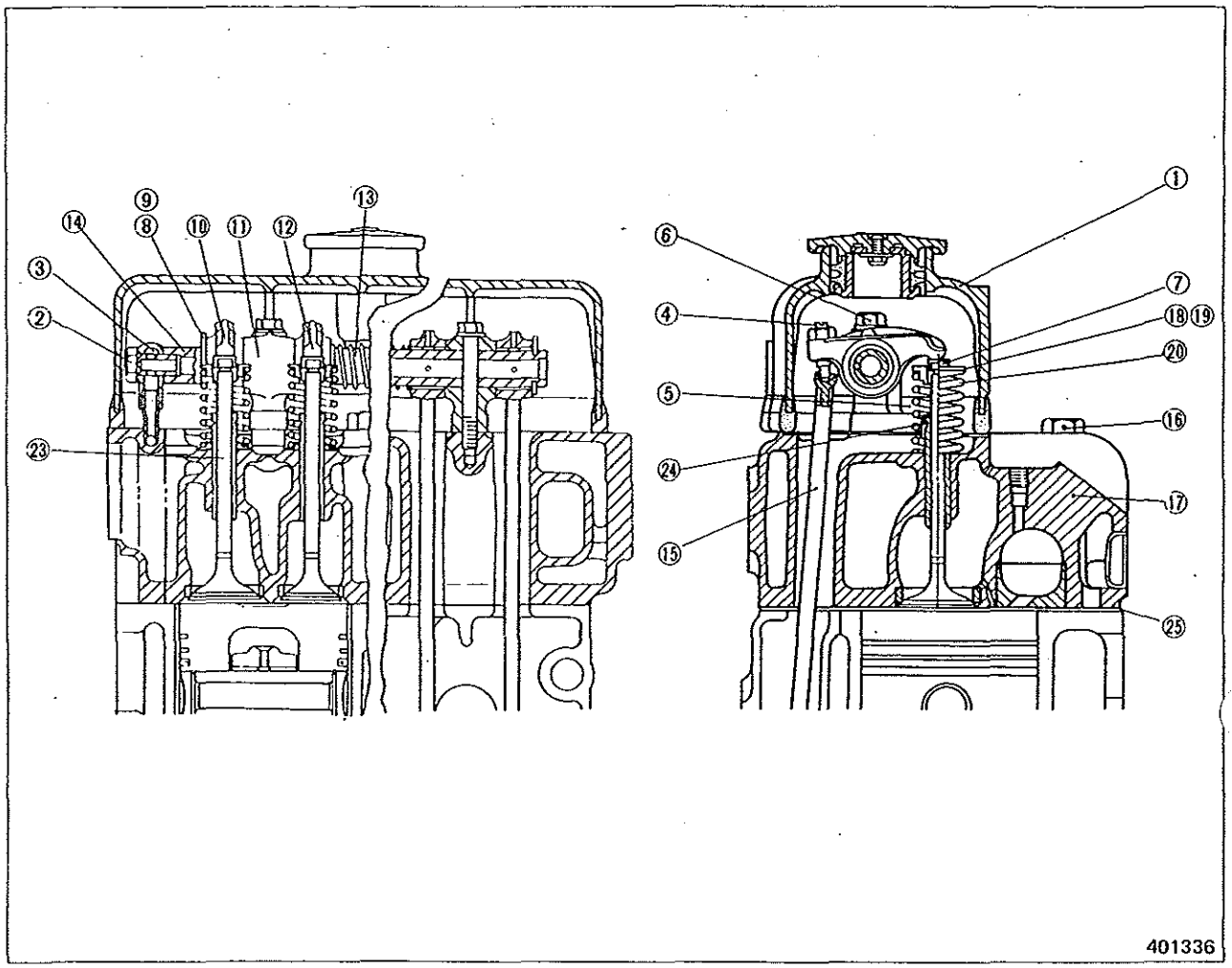
Unit: mm (in.)

Item	Assembly standard
Valve pushrod runout	0.4 (0.016), maximum

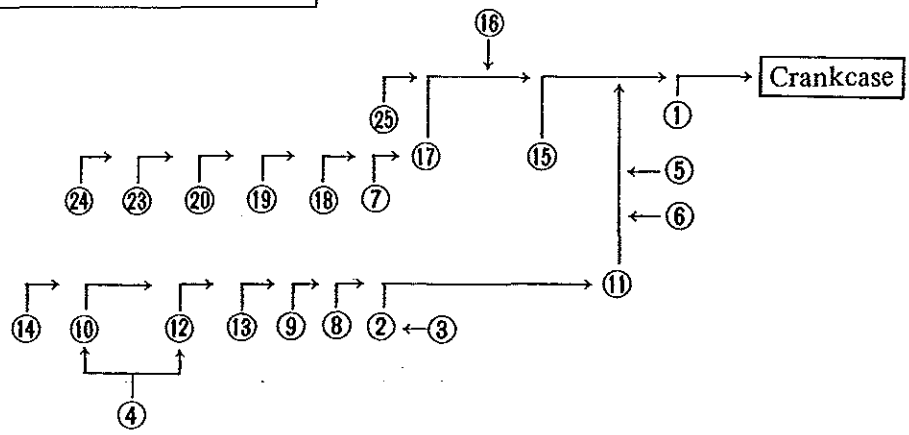


Measuring pushrod runout

1.3 Reassembly

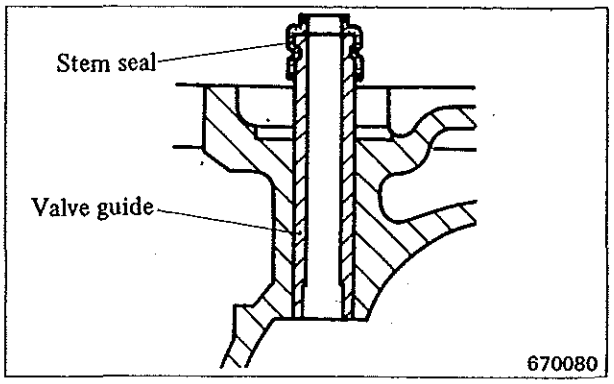


Reassembling sequence



(1) Installing valve stem seals

After installing the stem seal to the valve guide, make sure that the seal is properly fitted in the groove of the guide.

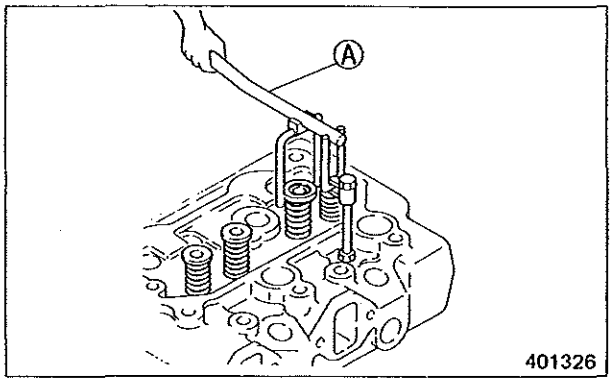


CAUTION

Do not apply any oil or sealant to the mating face of stem seal that comes in contact with the valve guide. When installing the stem seal, coat the seal rubbing surface of the stem with engine oil to insure initial lubrication of the stem seal lip.

(2) Installing valves and valve springs

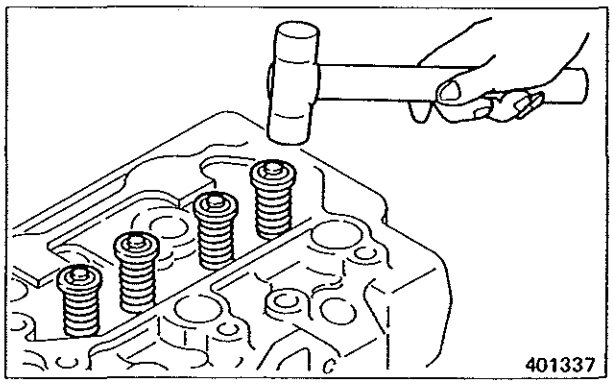
(a) Install the valve spring and retainer to the valve guide. Using valve spring pusher (A) (30691-04500), install the valve cotters.



NOTE

In case of the double spring (comprising inner and outer springs), install the outer spring with its smaller-coil-pitch end on the cylinder head side.

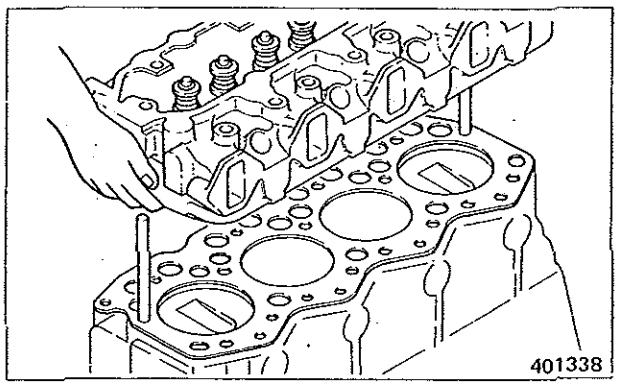
(b) Using a soft hammer, give light blows to the valve stem top several times to make sure that the spring and valve cotter are properly installed.



(3) Installing cylinder head

(a) Screw two guide bolts into the crankcase to hold the gasket in place.

(b) Place the cylinder head on the crankcase as guided by the two guide bolts. Apply engine oil to the threads of cylinder head bolts, and insert the bolts into the head.

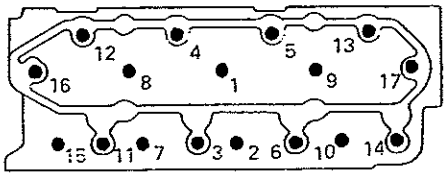


CAUTION

Do not apply any sealant to the cylinder head bolts.

(c) Tighten the cylinder head bolts to the specified torque in the sequence shown.

Front side ⇦



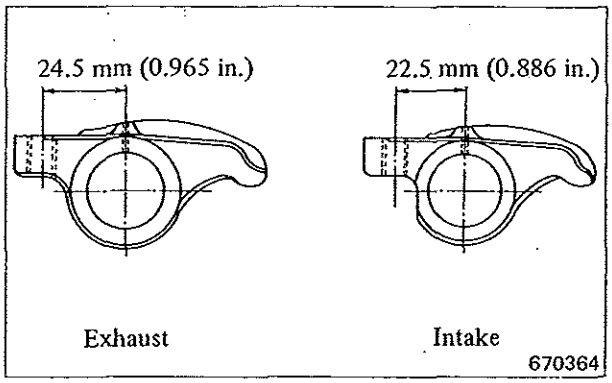
402894

Unit: kgf·m (lbf·ft) [N·m]

Tightening torque	12 ± 0.5 (87 ± 3.6) [118 ± 4.9]

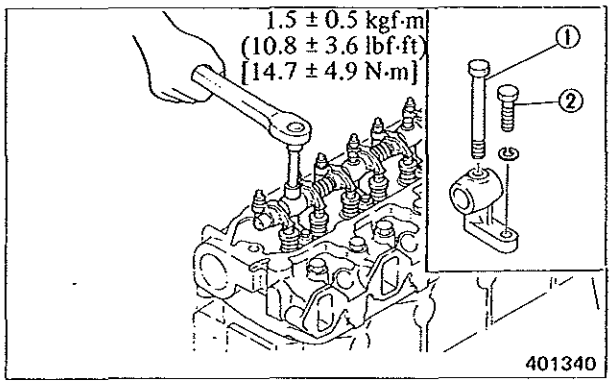
(4) Reassembling rocker shafts

The rocker arms for intake valves are different in dimension from those for exhaust valves. After installing the arms, make sure that they move freely.



(5) Installing rocker shaft assemblies

Tighten the long bolt and short bolt in that order (by following reverse of loosening order).

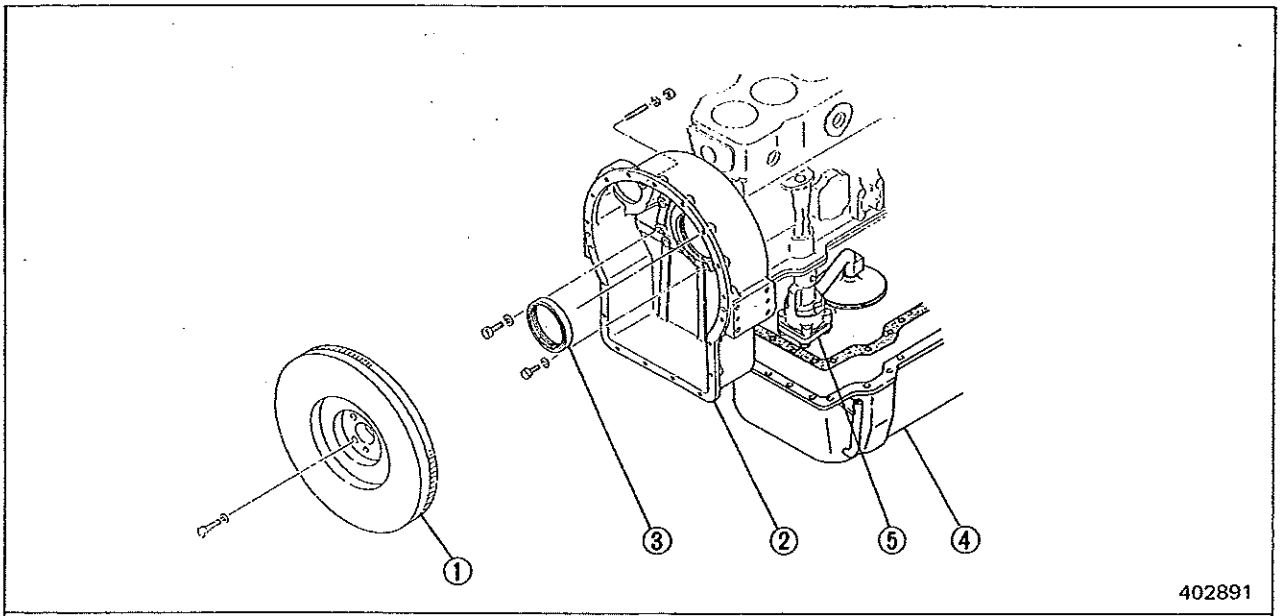


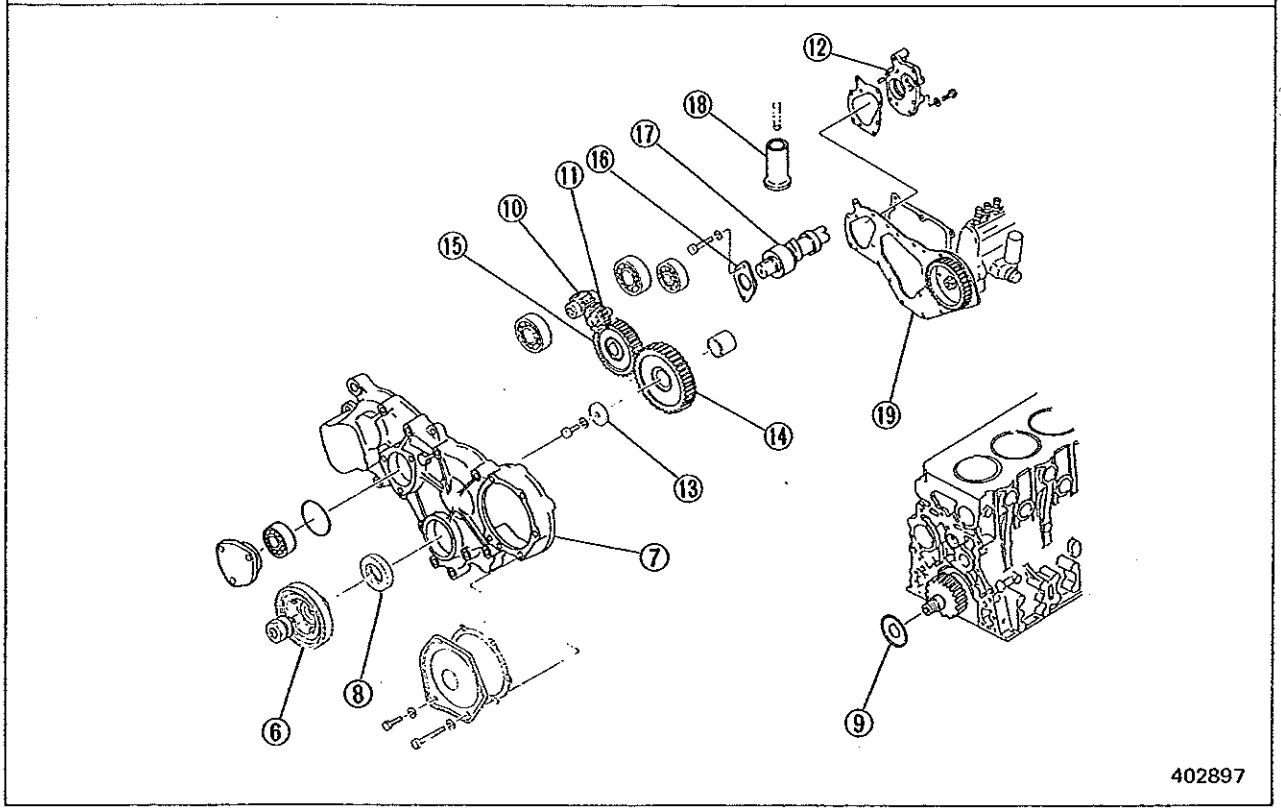
(6) Adjusting valve clearance

Refer to 1.1, Group No. 5.

2. FLYWHEEL, TIMING GEARS AND CAMSHAFT

2.1 Disassembly



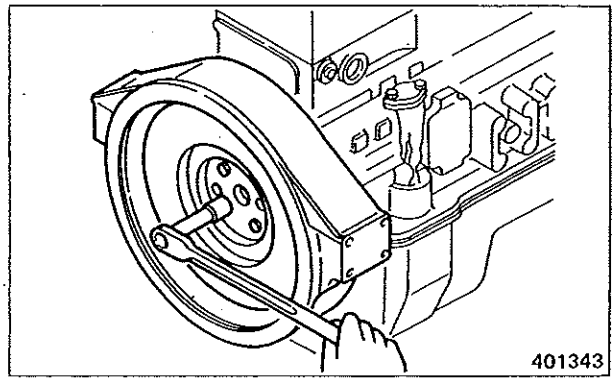


① Flywheel
② Flywheel housing
③ Oil seal
④ Oil pan
⑤ Oil pump
⑥ Crankshaft pulley
⑦ Timing gear case
⑧ Oil seal
⑨ Baffle plate
⑩ P.T.O. gear
⑪ Idler gear (P.T.O.)
⑫ Bearing case
⑬ Thrust plate
⑭ Idler gear
⑮ Camshaft gear
⑯ Thrust plate
⑰ Camshaft
⑱ Tappet
⑲ Front plate

(1) Removing flywheel

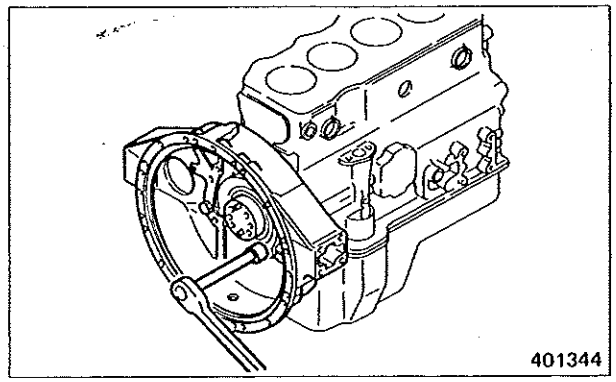
(a) Unscrew the flywheel mounting bolts.

(b) Screw the jacking bolts into the holes provided in the flywheel uniformly, and remove the flywheel.



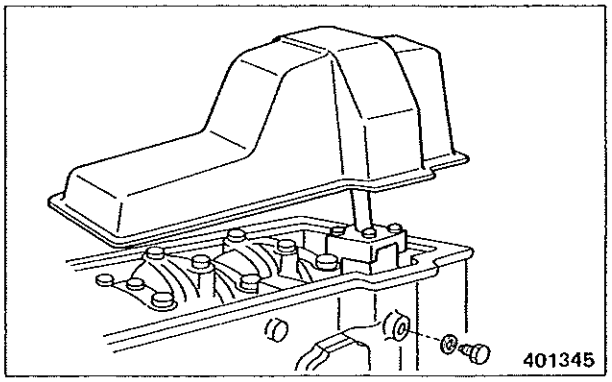
(2) Removing flywheel housing

Unscrew the housing mounting bolts, and remove the housing.



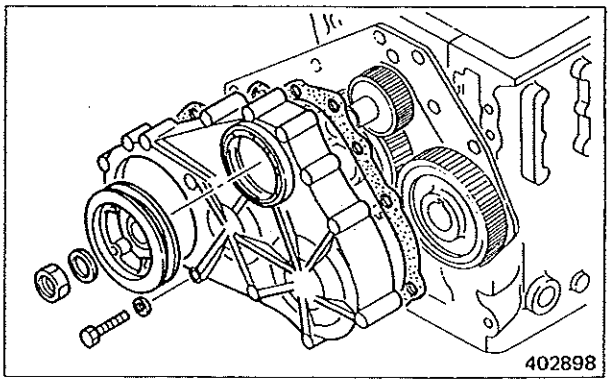
(3) Removing oil pan and oil pump

Unscrew the oil pan mounting bolts, and remove the oil pan. Then, remove the oil pump by unscrewing its bolt. (Refer to 2, Group No. 6.)



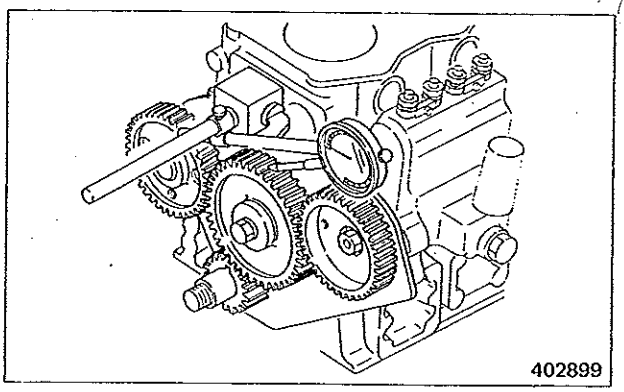
(4) Removing timing gear case

Remove the crankshaft pulley and timing gear case.



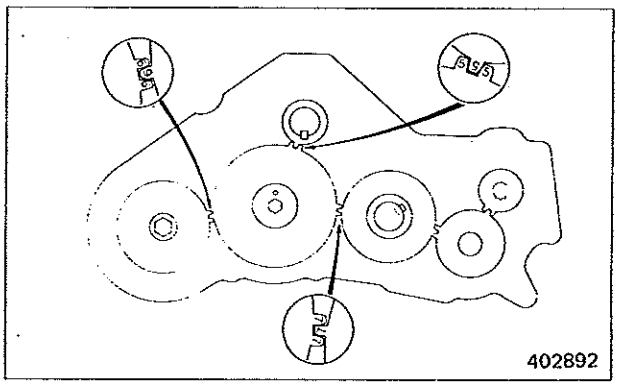
(5) Measuring backlash and end play

Measure the backlash and end play on each gear to obtain the data for parts replacement. (Refer to 2.2, Group No. 7.)



(6) Removing timing gears

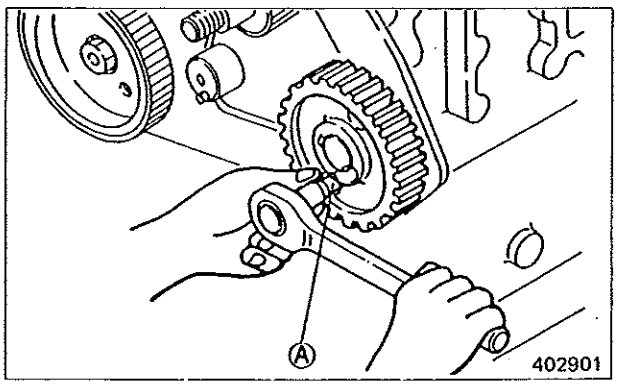
Be sure to align the timing marks for each pair of gears before removing or installing the gears.



(7) Removing camshaft

Position the camshaft gear so that its two jacking bolt holes come to top and bottom. Using socket A (34491-00300), unscrew the thrust plate bolts, and remove the camshaft from the crankcase.

After removing the camshaft, remove the tappets.

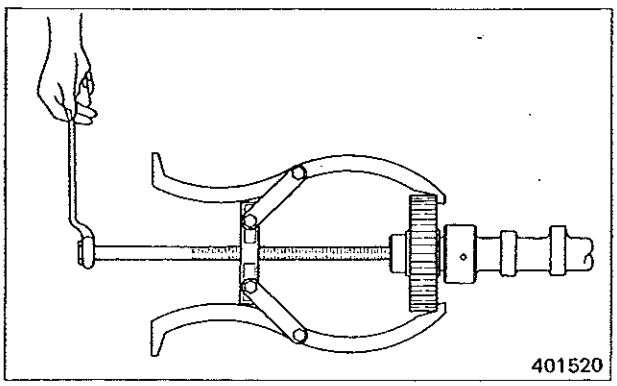


(8) Removing camshaft gear

Using a puller, remove the gear from the camshaft. Now, the thrust plate can be removed.

NOTE

It is not necessary to remove camshaft gear unless camshaft gear or thrust plate is detective.



2.2 Inspection and repair

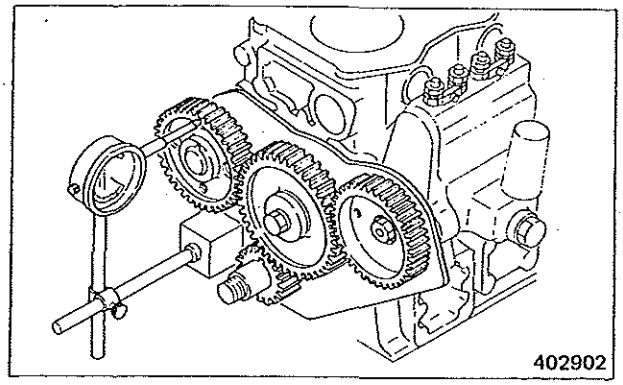
Camshaft and camshaft bushings

(1) Measuring camshaft end play

If the end play exceeds the Repair limit, replace the thrust plate.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Camshaft end play	0.050 – 0.112 (0.00197 – 0.00441)	0.300 (0.01181)



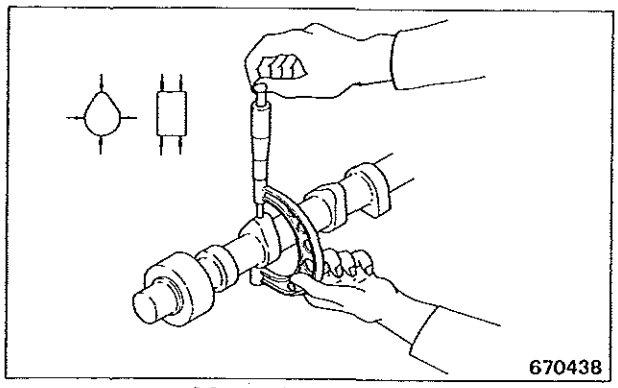
Measuring camshaft end play

(2) Measuring cam lift

Using a micrometer, measure the cam lift. If it exceeds the Service limit, replace the camshaft.

Unit: mm (in.)

Item		Nominal value	Assembly standard	Service limit
Cam lift	Intake	D_1 $46.916^{+0.1}_{-0.3}$ $(1.84708^{+0.004}_{-0.012})$	$D_1 - D_2$ = 6.684 (0.26315)	$D_1 - D_2$ = 6.184 (0.24346)
	Exhaust	D_1 $45.944^{+0.1}_{-0.3}$ $(1.80882^{+0.004}_{-0.012})$	$D_1 - D_2$ = 7.344 (0.28913)	$D_1 - D_2$ = 6.844 (0.26945)



Measuring cam lift

(3) Measuring camshaft runout

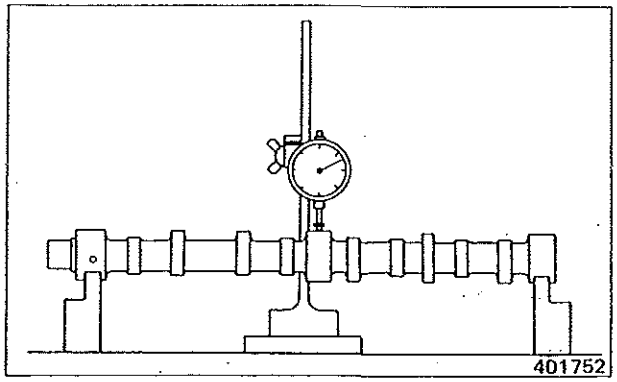
If the runout exceeds the Repair limit, straighten the camshaft by means of a press, or replace it with a new one.

⚠ CAUTION

Set up a dial gauge on the camshaft, and turn the camshaft. Take one half (1/2) of the gauge indication as the runout.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Camshaft runout	0.02 (0.0008), maximum	0.05 (0.0020)



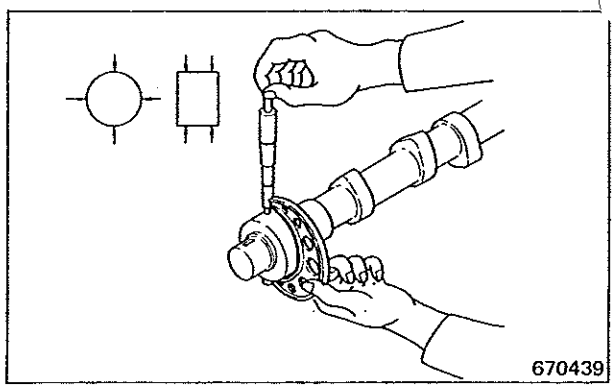
Measuring camshaft runout

(4) Measuring camshaft journal diameter

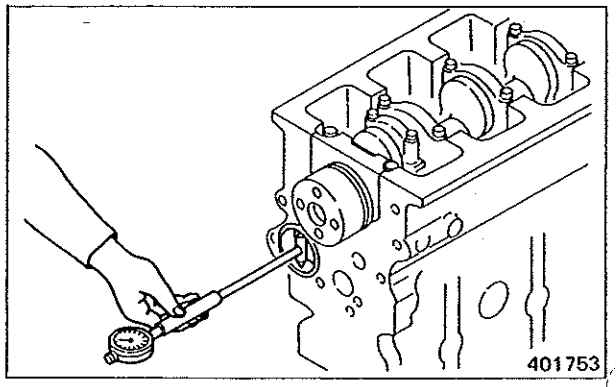
If the journals exceed the Service limit, replace the camshaft bushings.

Unit: mm (in.)

Item		Assembly standard	Service limit
Camshaft journal diameter	No. 1, 2	53.96 – 53.94 (2.1244 – 2.1236)	53.90 (2.1220)
	No. 3	52.96 – 52.94 (2.0850 – 2.0842)	52.90 (2.0827)
Camshaft journal-to-bushing clearance		0.04 – 0.09 (0.0016 – 0.0035)	0.15 (0.0059) (Repair limit)



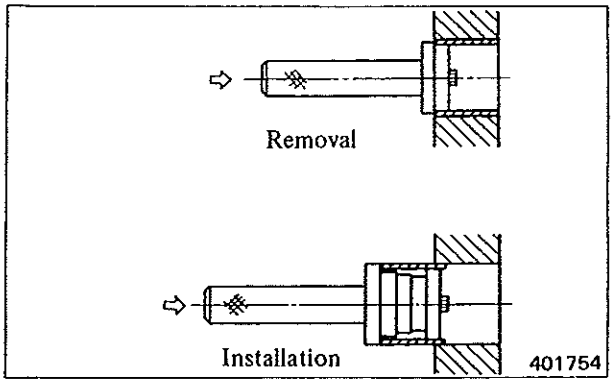
Measuring camshaft journal diameter



Measuring camshaft bushing inside diameter

(5) Replacing camshaft bushings

To install bushings, align their oil holes with those from oil gallery and drive bushings in.

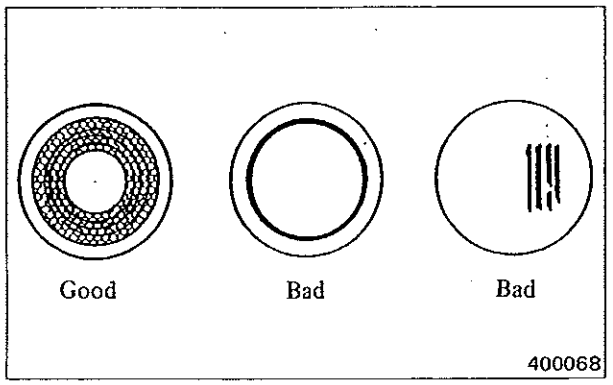


Replacing camshaft bushing

Tappets

(1) Inspection

Check the cam contact face of each tappet for abnormal wear, and replace it if necessary.



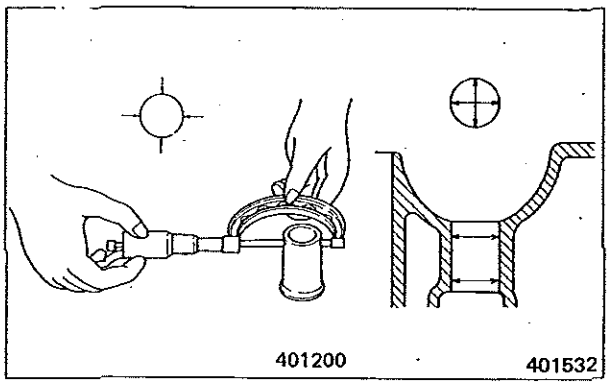
Cam contact face of tappet

(2) Measuring tappet-to-guide clearance

If the clearance exceeds the Assembly standard, replace the tappet.

Unit: mm (in.)

Item	Assembly standard	Repair limit	Service limit
Tappet guide inside diameter	22.000 – 22.021 (0.86614 – 0.86697)		22.100 (0.87008)
Tappet-to-guide clearance	0.035 – 0.086 (0.00138 – 0.00339)	0.120 (0.00472)	



Measuring tappet and guide

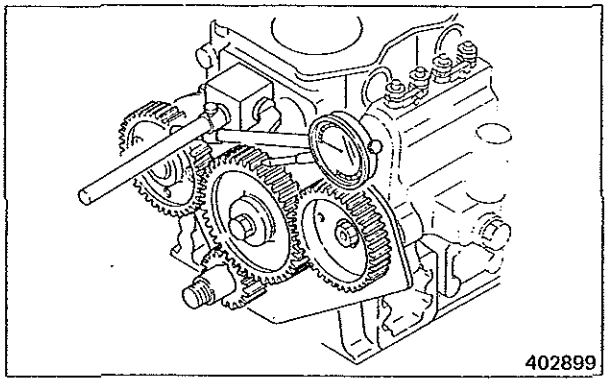
Timing gears

Measuring backlash

Set up a dial gauge so that it contacts the pitch circle of the gear, and move one gear back and forth to measure the backlash between the gears. If the backlash exceeds the Repair limit, replace the gears.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Timing gear backlash	0.07 (0.0028)	0.15 (0.0059)



Measuring timing gear backlash

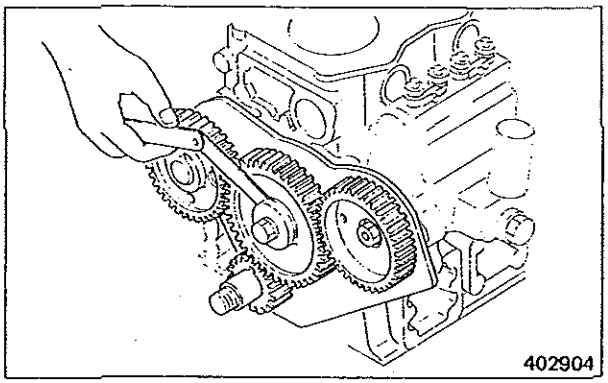
Idler, idler bushing and idler shaft

(1) Measuring idler end play

Measure the end play with a feeler gauge or dial gauge. If the end play exceeds the Repair limit, replace the thrust plate.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Idler end play	0 – 0.10 (0 – 0.0039)	0.35 (0.0138)



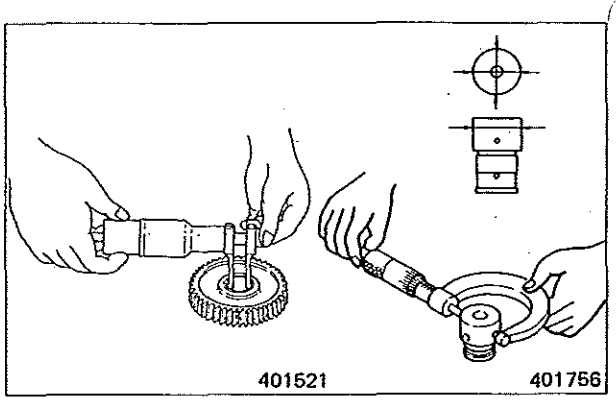
Measuring idler end play

(2) Measuring idler bushing inside diameter and idler shaft diameter

If the idler shaft-to-bushing clearance exceeds the Standard clearance, replace the bushing.

Unit: mm (in.)

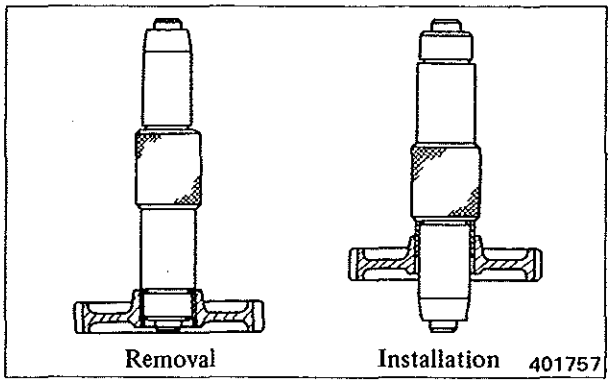
Item	Nominal value	Standard clearance	Repair limit
Idler shaft-to-bushing clearance	36 (1.42) [Diam.]	0.025 – 0.075 (0.00098 – 0.00295)	0.100 (0.00394)



Measuring idler shaft and bushing

(3) Replacing idler bushing

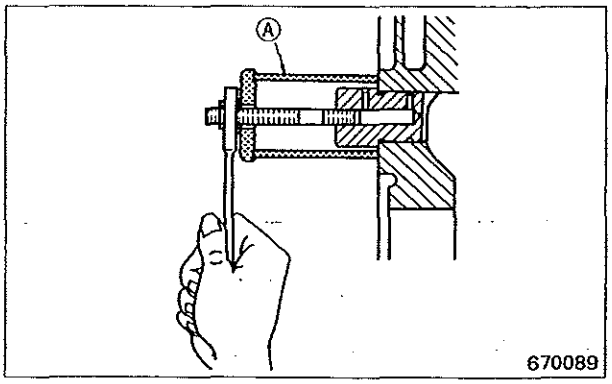
When installing the bushing, press it in until its end face is flush with that of gear boss.



Replacing idler bushing

(4) Replacing idler shaft

To remove the idler shaft for replacement, use idler shaft puller (A) (34491-02300).

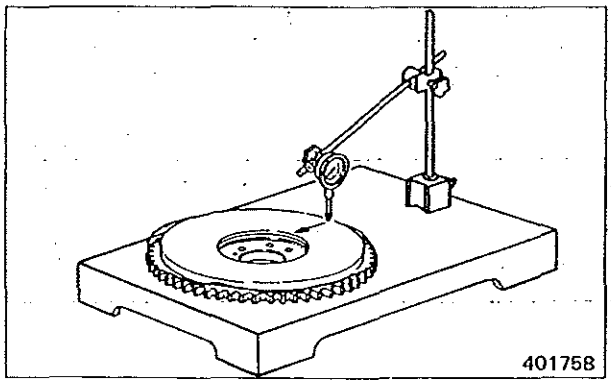


Removing idler shaft

Flywheel and ring gear

(1) Measuring flywheel radial runout

Set the flywheel on the surface plate and, measure the radial runout of the friction surface by moving a dial gauge on and along that surface. If the radial runout exceeds the Repair limit, refinish the friction surface.



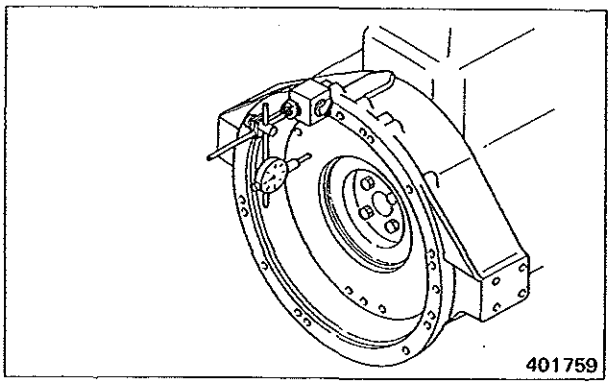
Measuring flywheel radial runout

(2) Measuring flywheel face runout

With the flywheel installed on the engine, measure its face runout. If the face runout exceeds the Assembly standard, check for improper installation or foreign matter lodged in the mounting face.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Radial runout	0.15 (0.0059), maximum	0.50 (0.020)
Face runout		



Measuring flywheel face runout

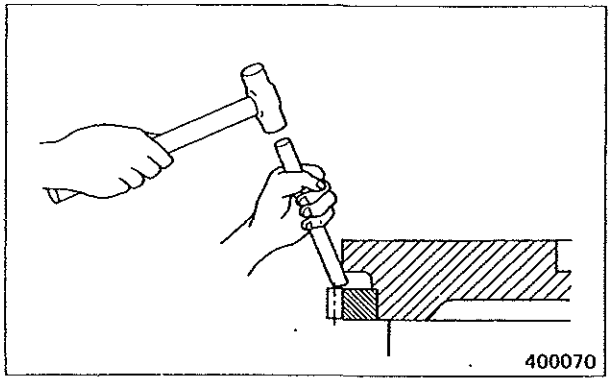
(3) Replacing ring gear

Check the ring gear for broken teeth, corrosive wear or other defects, and replace the gear if defective. To remove, proceed as follows:

(Removal)

(a) Heat the ring gear uniformly with an acetylene torch.

(b) Using a bar, give light hammer blows to the periphery of ring gear.



Replacing ring gear

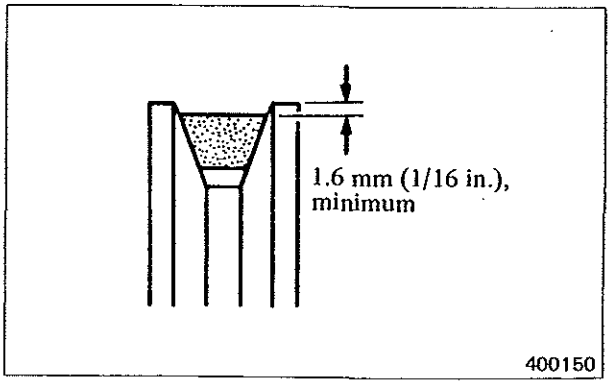
(Installation)

Heat a replacement ring gear up to about 100°C (212°F) in a piston heater, and press the gear onto the flywheel with its unchamfered teeth foremost.

Crankshaft pulley

Inspecting V-belt groove

Inspect the groove for wear. Wrap a new belt around the pulley, pressing it in the groove as far as it goes, and see if the top surface of the belt is above the top of the pulley.

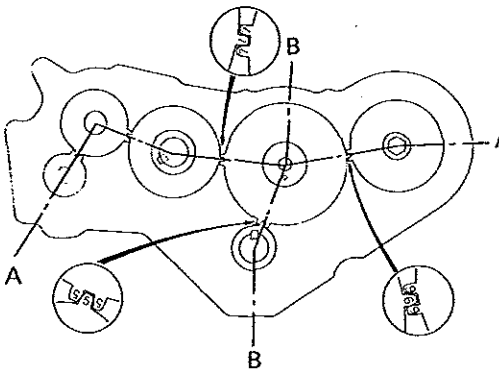


Inspecting V-belt groove in crankshaft pulley

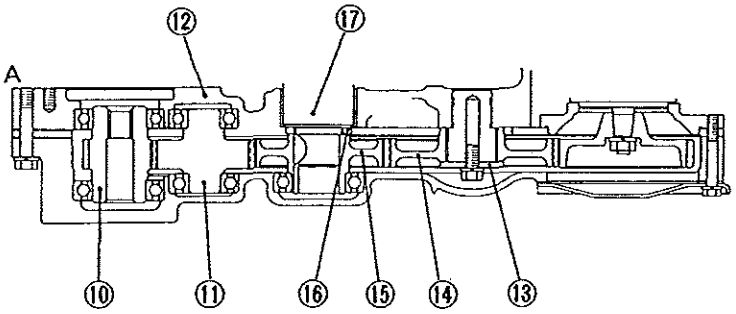
If the top surface of the belt is uniformly above the top of the pulley all the way around, it is not necessary to replace the pulley.

If the top surface of the belt sinks into the groove more than 1.6 mm (1/16 in.), replace the pulley.

2.3 Reassembly

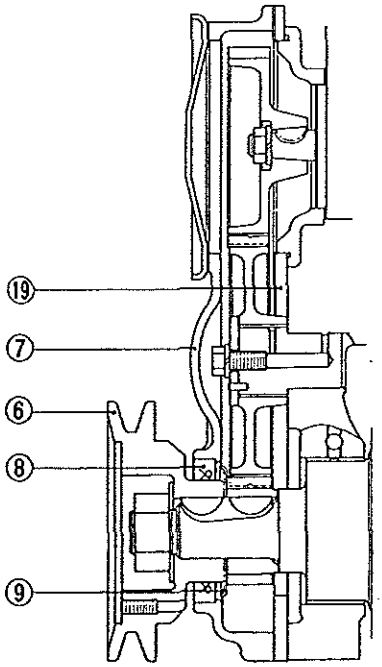


402892



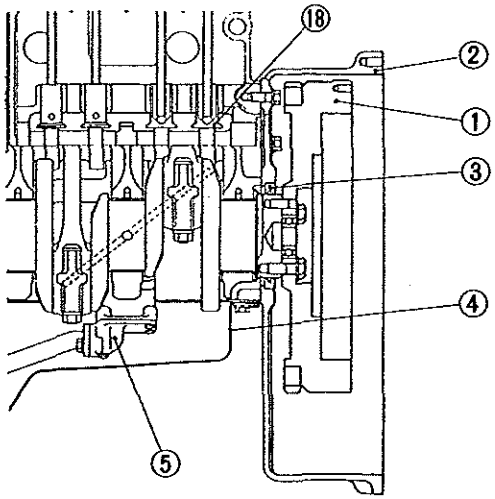
Section A-A

402906



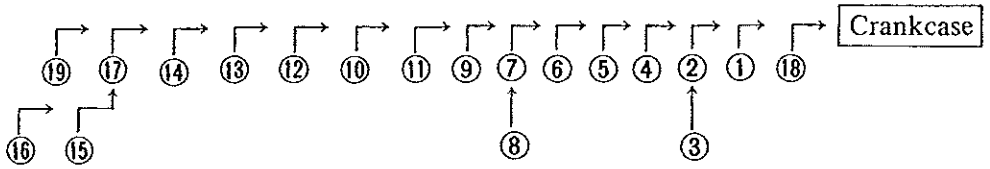
Section B-B

402903



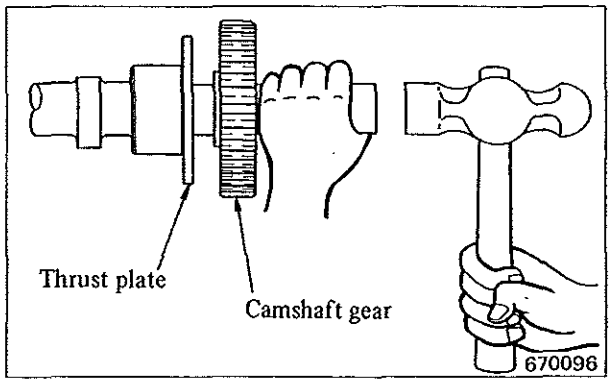
402887

Reassembling sequence



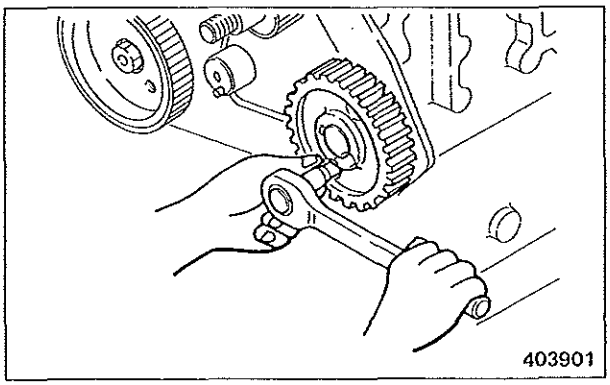
(1) Installing camshaft gear and thrust plate

Heat the gear for installation. Have the thrust plate installed in advance.



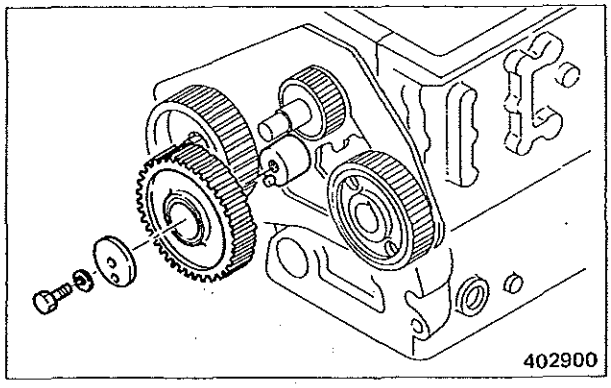
(2) Installing camshaft

Carefully insert the camshaft into the crankcase.



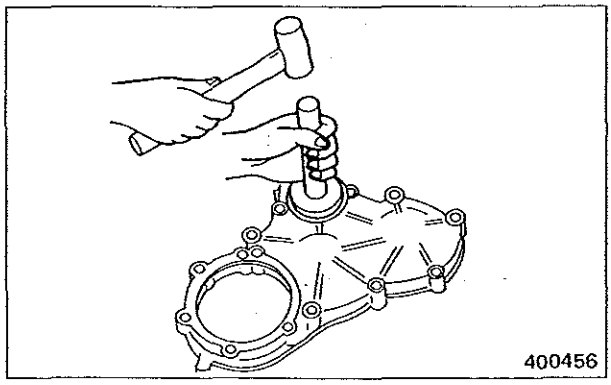
(3) Installing idler

Install the idler while aligning the timing marks each pair of gears, and install the thrust plate with bolt.



(4) Installing oil seal

To install the oil seal, use the installer.



(5) Inspecting and adjusting timing gears after installation.

After installing the timing gears, be sure to inspect and adjust them as follows:

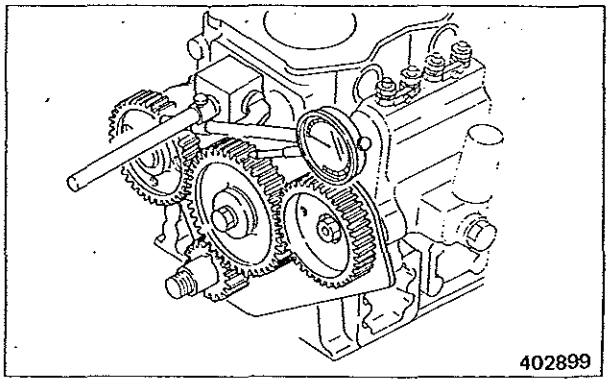
(Inspecting timing gear backlash and end play)

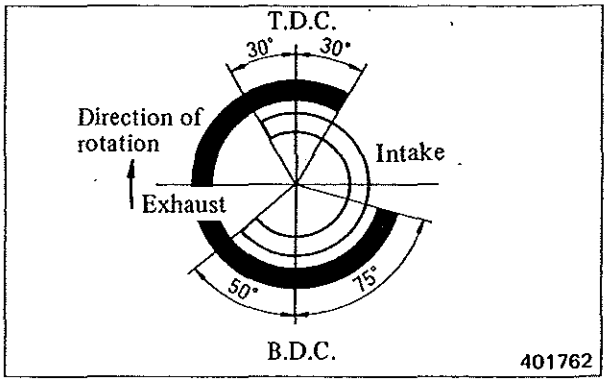
After installing the timing gears, inspect the backlash between the gears in mesh and the end play of each gear. (Refer to 2.2, Group No. 7.)

(Inspecting valve timing)

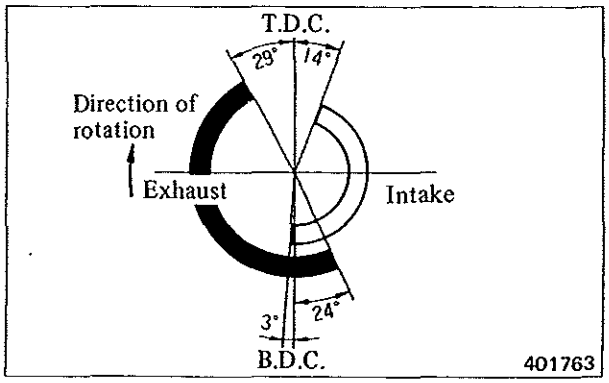
It is not necessary to inspect the valve timing, provided that all matching marks on the timing gears are aligned. Inspect the timing for verification as follows:

Using a 3 mm (0.12 in.) thick smooth steel plate, add 3 mm (0.12 in.) clearance to the intake and exhaust valves of No. 1 cylinder. Then, insert a 0.05 mm (0.0020 in.) feeler gauge into between the top of valve cap and rocker, and slowly turn the crankshaft, trying to find a position where the feeler gauge is firmly gripped (the valve starts opening) and a position where the gauge is just ungripped (the valve starts closing). Check to make sure that these positions coincide with the angular positions shown in the valve timing diagram with 3 mm (0.12 in.) clearance added to valves.





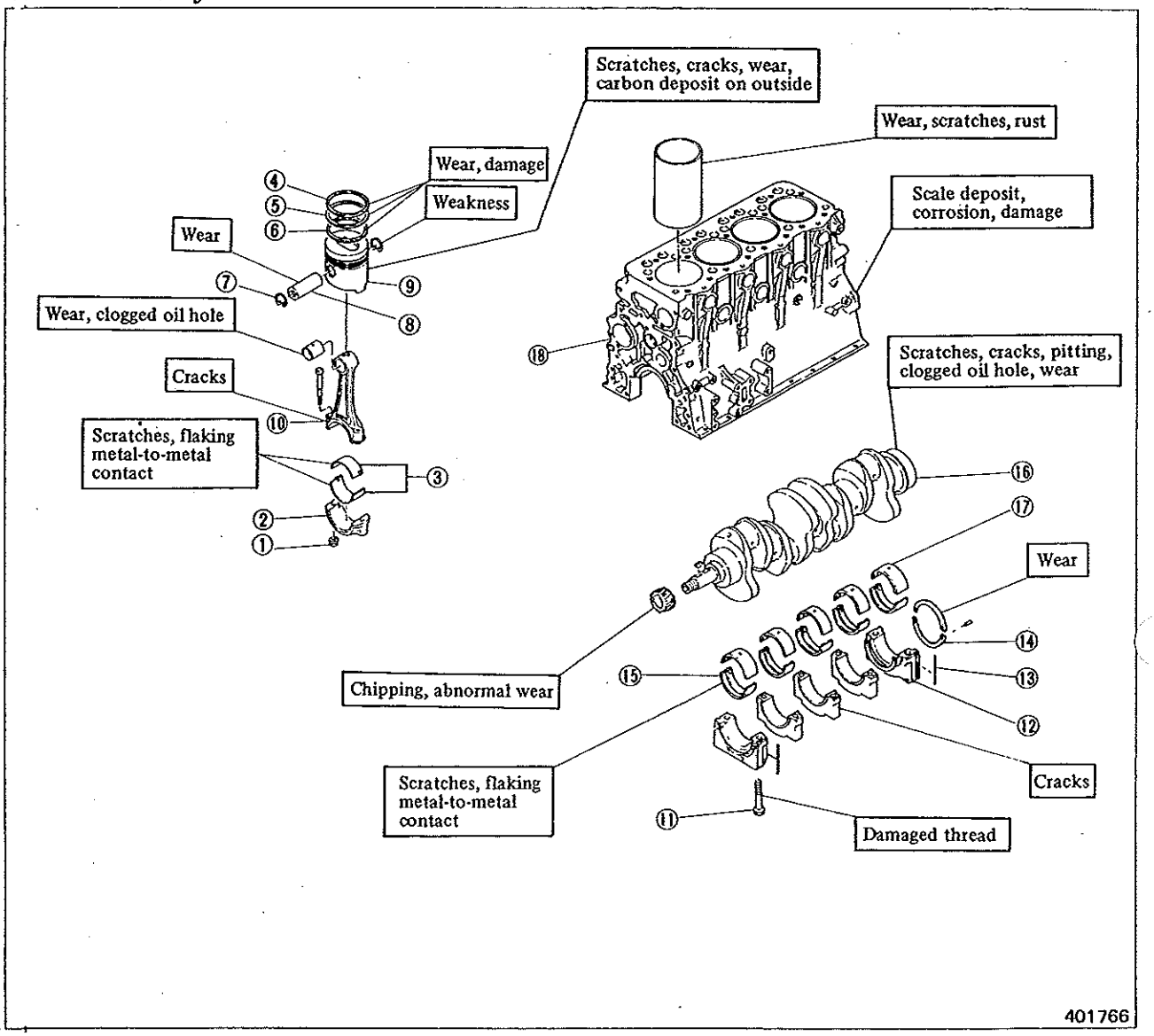
Valve timing diagram



Valve timing diagram with 3 mm (0.12 in.) clearance added to valves

3. PISTONS, CONNECTING RODS, CRANKSHAFT AND CRANKCASE

3.1 Disassembly

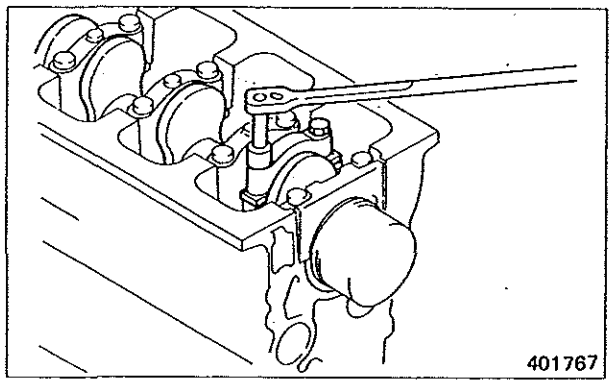


① Nut
② Connecting rod cap
③ Connecting rod bearing
④ Top compression ring
⑤ Second compression ring
⑥ Oil ring
⑦ Snap ring
⑧ Piston pin
⑨ Piston
⑩ Connecting rod
⑪ Bearing cap bolt
⑫ Main bearing cap
⑬ Side seal
⑭ Thrust plate
⑮ Main bearing (lower shell)
⑯ Crankshaft
⑰ Main bearing (upper shell)
⑱ Crankcase

(1) Removing connecting rod caps

(a) Unscrew the nuts securing the cap. Give hammer blows to the bolts squarely and evenly and, after the cap comes off the reamer bolt, take off the cap.

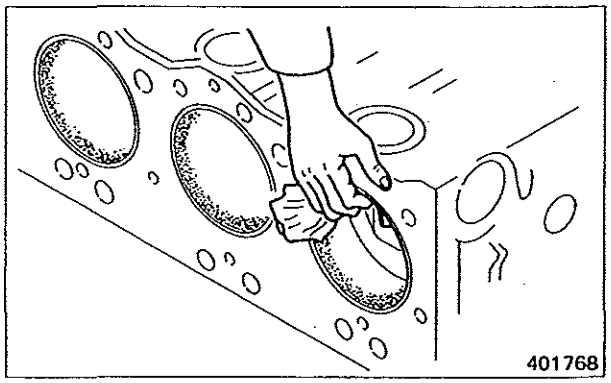
(b) Mark the removed connecting rod bearings for identification of cylinder numbers and kinds, upper shells and lower shells.



(2) Preparatory step for removing pistons

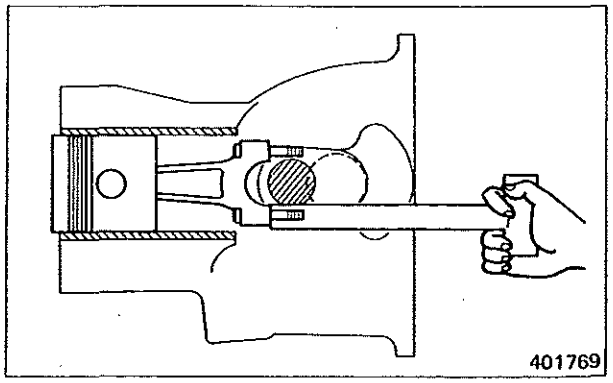
(a) Lay the crankcase on its side.

(b) Remove all carbon deposits from the upper areas of cylinder sleeves with cloth or oil paper. Carbon deposits, if any, will make it difficult to pull the pistons upward.



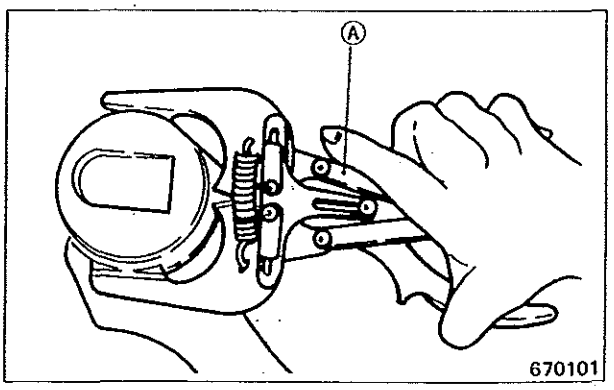
(3) Removing pistons

Bring the piston assembly (from which the connecting rod cap has been removed) to top dead center position. Put the hammer handle to the big end of the rod, and push the assembly off the crankcase.



(4) Removing piston rings

To remove the rings, use piston ring pliers (A) (31391-12900).

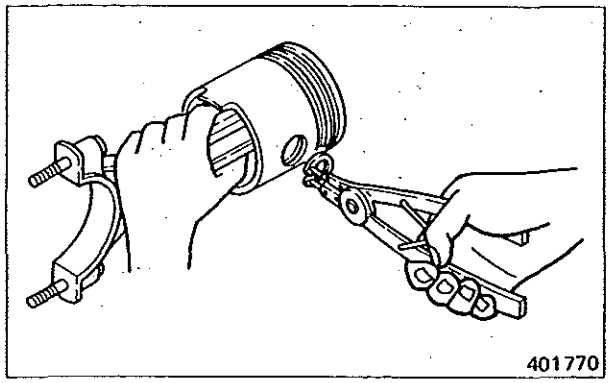


(5) Removing piston pin

(a) Using snap ring pliers, remove the snap rings.

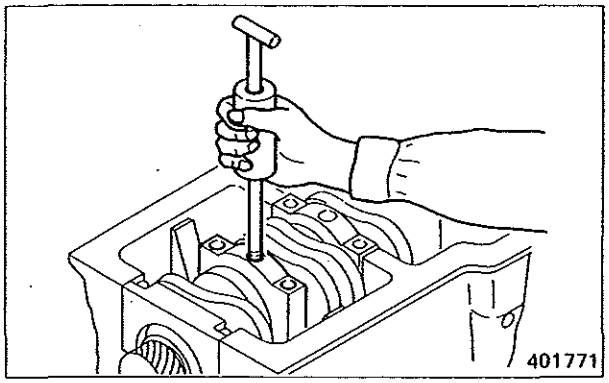
(b) Remove the piston pin, and separate the piston from the connecting rod.

(c) If it is difficult to pull out the pin, heat the piston in a piston heater or hot water to expand the pin bore.



(6) Removing main bearing caps

Unscrew the bolts securing the cap, and remove the cap complete with main bearing. To remove the front and rear main bearings, use a puller.

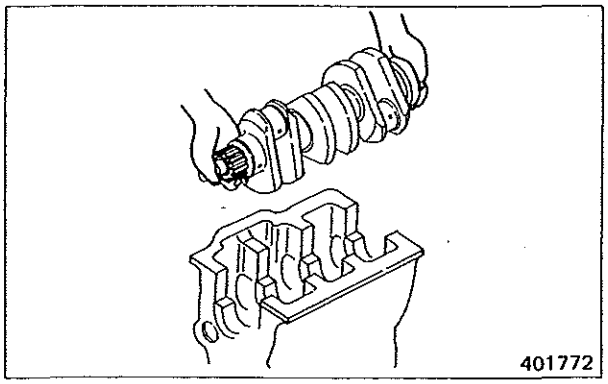


⚠ CAUTION

When removing the caps, be careful not to damage the bearings. After removing the caps and bearings, mark each combination for its location so that it is installed to the same crankshaft journal as before at the time of reassembly.

(7) Removing crankshaft

Slowly lift the crankshaft off the crankcase.

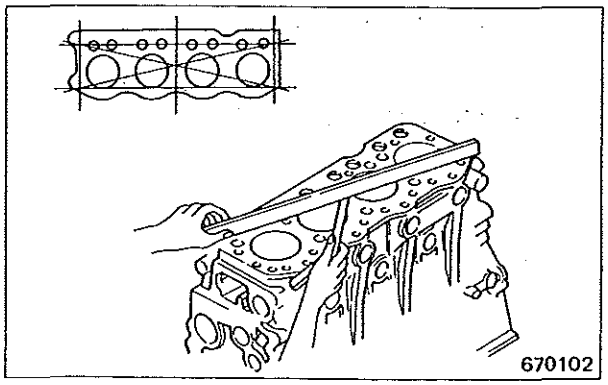


3.2 Inspection and repair

Crankcase and cylinder sleeves

(1) Measuring warpage of crankcase gasketed surface

Measure the warpage with a straightedge and feeler gauge. If the warpage exceeds the Assembly standard, grind the surface with a surface grinder. Grind the crankcase only enough to remove the warpage.



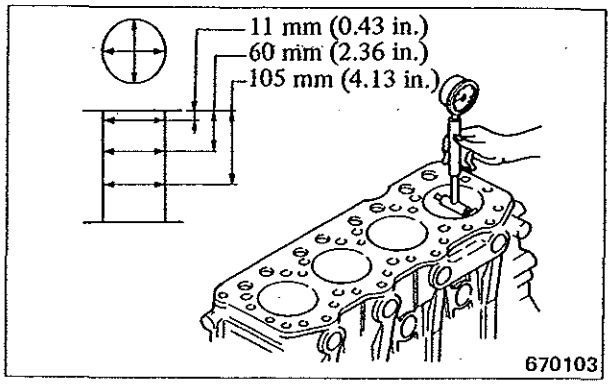
Measuring crankcase gasketed surface

Unit: mm (in.)

Item	Assembly standard	Repair limit
Warpage of crankcase gasketed surface	0.05 (0.0020), maximum	0.20 (0.0079)

(2) Measuring cylinder sleeve inside diameter

(a) Measure the sleeve in two directions, parallel and transverse to the crankshaft, at three positions, top (ridged area), middle and bottom as shown.



Measuring cylinder sleeve inside diameter

Unit: mm (in.)

Item	Assembly standard	Repair limit	Service limit
Cylinder sleeve inside diameter	98.000 – 98.035 (3.85826 – 3.85964)	98.200 (3.86613)	99.200 (3.90550)
Out of round	0.015 (0.00059), maximum		
Taper	0.05 (0.0020), maximum		

(b) If the inside diameter reaches the Repair limit within the Service limit, bore the sleeve to the specified oversize.

(c) Hone the sleeve to +0.25 mm (+0.0098 in.) or +0.5 mm (+0.0197 in.) oversize accurate within 0 to 0.035 mm (0.00138 in.). Use the piston and piston rings of the same oversize.

(d) If any sleeve is unevenly worn, determine the oversize on the basis of the maximum wear noted to ensure perfect roundness in the oversized bore.

NOTE

(a) Refinish all sleeves to the same oversize.

(b) If the sleeve is found in good condition, with the wear far less than the Repair limit, replace the piston rings, and ream off "ridge" at the top of the sleeve. Hone the bore if necessary.

(3) Replacing cylinder sleeve

If one sleeve exceeds the Service limit in inside diameter or it is defective, with the other sleeves in good condition, replace that sleeve only.

(Removing cylinder sleeve)

(a) Set up a boring machine on the crankcase by aligning it with the center of the less-worn area of the sleeve at the bottom.

(b) Bore the sleeve until its stock thickness is about 0.5 mm (0.02 in.).

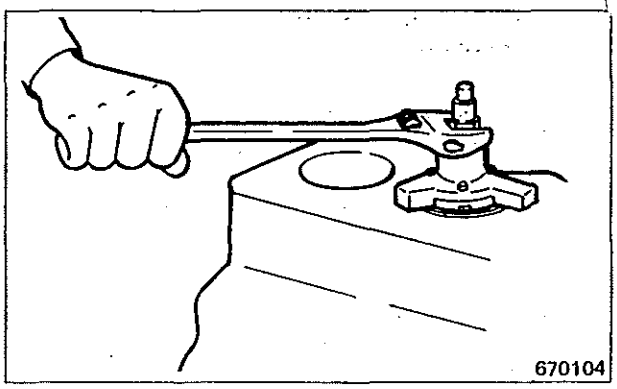
(c) Break and remove the sleeve, being careful not to damage the inside surface of the crankcase.

(Installing a new cylinder sleeve)

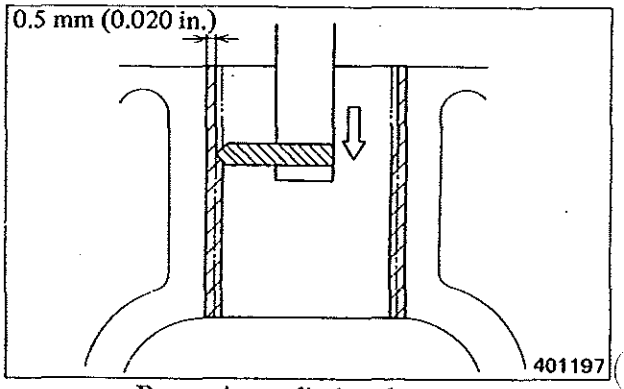
(a) Use cylinder sleeve installer (34491-02100).

(b) Press the sleeve into the crankcase, leaving a protrusion of 0.3 to 0.5 mm (0.012 to 0.020 in.) at the top. Then make it flush with the crankcase top.

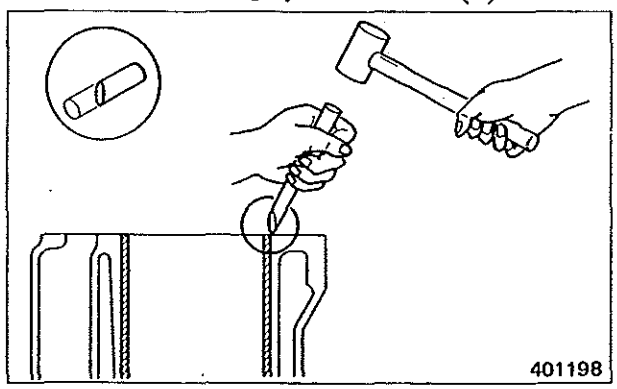
(c) Bore and hone the sleeve to $98\ ^{+0.035}_{0}$ mm ($3.86\ ^{+0.00138}_{0}$ in.).



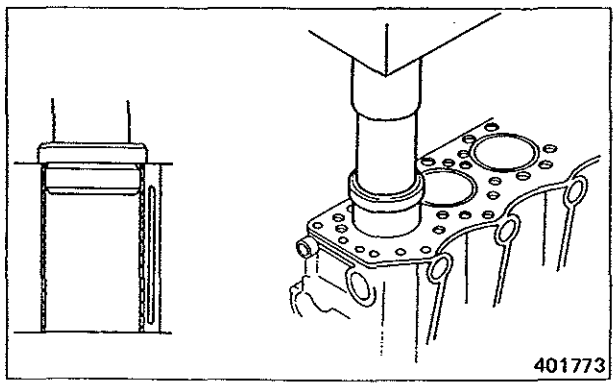
Ridge-reaming cylinder sleeve



Removing cylinder sleeve (1)



Removing cylinder sleeve (2)

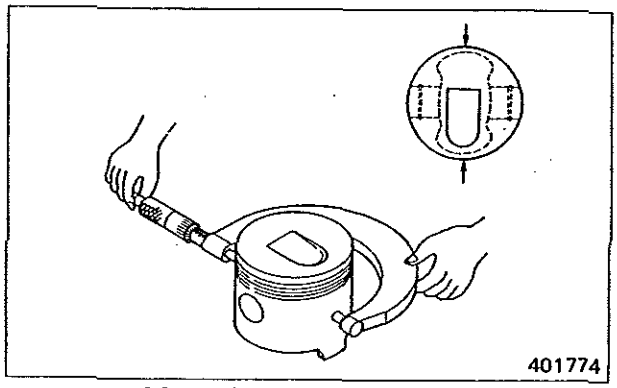


Installing cylinder sleeve

Pistons and piston rings

(1) Measuring piston diameter

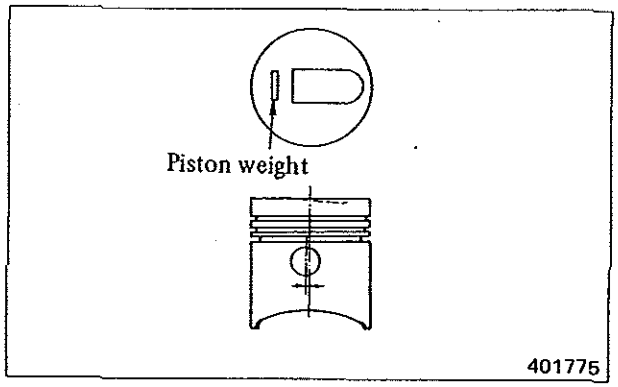
(a) Using a micrometer, measure each piston in the direction transverse to the piston pin. If the diameter exceeds the Service limit, replace the piston. If any pistons have to be replaced, select new pistons so that the variance in weight among pistons per engine is within the Assembly standard.



Measuring piston diameter

Unit: mm (in.)

Item		Assembly standard	Service limit
Piston diameter	Standard	97.875 – 97.845 (3.85334 – 3.85216)	97.660 (3.84487)
	0.25 (0.0098) oversize	98.125 – 98.095 (3.86318 – 3.86200)	97.910 (3.85472)
	0.50 (0.0197) oversize	98.375 – 98.345 (3.87302 – 3.87184)	98.160 (3.86456)
Variance in weight per engine gram (oz)		±3 (±0.1)	



Piston weight marking

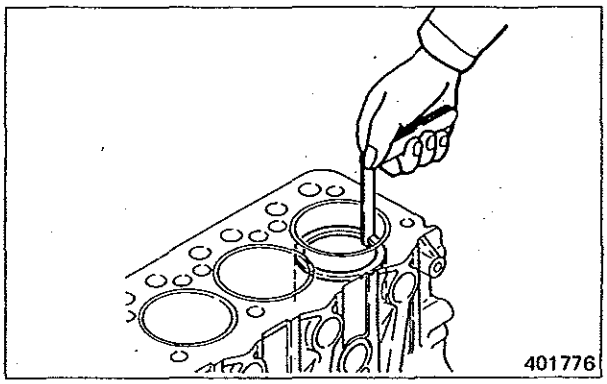
(b) Piston weight is stamped on the top of each piston.

(2) Measuring piston ring end gap

Place the ring in a new or master sleeve, and measure the gap. If the gap exceeds the Service limit, replace all rings as a set.

Inside diameter of master cylinder sleeve:

$98\ ^{+0.035}_{0}$ mm ($3.86\ ^{+0.00138}_{0}$ in.)



Measuring piston ring end gap

NOTE

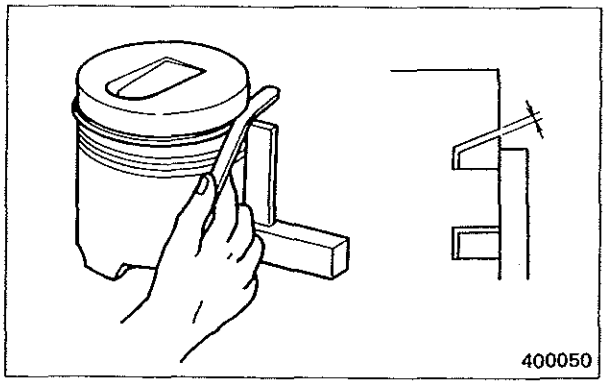
Place the piston ring in the master sleeve by pushing it squarely with the use of piston.

Unit: mm (in.)

Item	Assembly standard	Service limit
Piston ring end gap	0.30 – 0.50 (0.0118 – 0.0197)	1.50 (0.0591)

(3) Measuring piston ring side clearance

Insert new piston rings into the ring grooves in the piston, and measure the clearance of each ring with a feeler gauge and straightedge as shown.



Measuring piston ring side clearance

Unit: mm (in.)

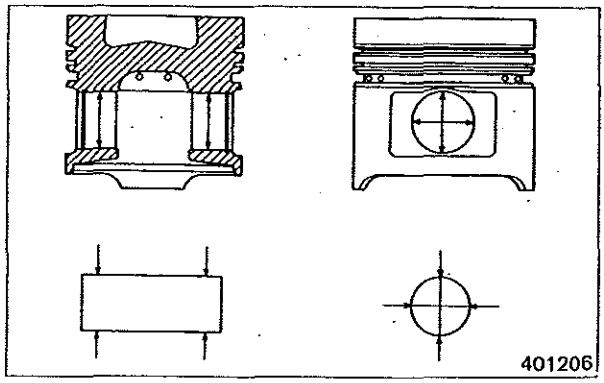
Item		Nominal value	Assembly standard	Repair limit
Piston ring side clearance	No. 1 ring	2.5 (0.098)	0.030 – 0.070 (0.00118 – 0.00276)	0.200 (0.00787)
	No. 2 ring	2.0 (0.079)	0.025 – 0.060 (0.00098 – 0.00236)	0.150 (0.00591)
	Oil ring	4.5 (0.177)		

(4) Measuring piston pin and hole diameters

If the Repair limit is reached, replace the piston pin. If it is exceeded, replace the piston.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Piston pin diameter	28.000 – 27.994 (1.10236 – 1.10212)	
Piston pin-to-hole clearance	0 – 0.016 (0 – 0.00063)	0.050 (0.00197)



Measuring piston pin and hole

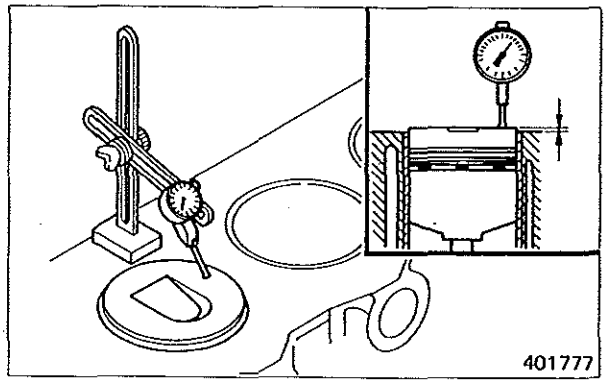
(5) Measuring piston protrusion

Measure protrusion of each piston and, if it is not within the Assembly standard, inspect the various parts for clearance.

(a) Determine the top dead center of piston with a dial gauge.

(b) Set up the dial gauge at the top of crankcase, and set the gauge pointer to zero (0).

(c) Measure the protrusion at three places on the piston head, and average the three measurements to determine the protrusion. Subtract the protrusion from the "as-installed" thickness of cylinder head gasket to determine the clearance between the piston top and cylinder head.



Measuring piston protrusion

Unit: mm (in.)

Item	Assembly standard
Piston protrusion	0.35 – 0.75 (0.0138 – 0.0295)
"As-installed" thickness of cylinder head gasket	1.6 ± 0.15 (0.063 ± 0.0059)

⚠ CAUTION

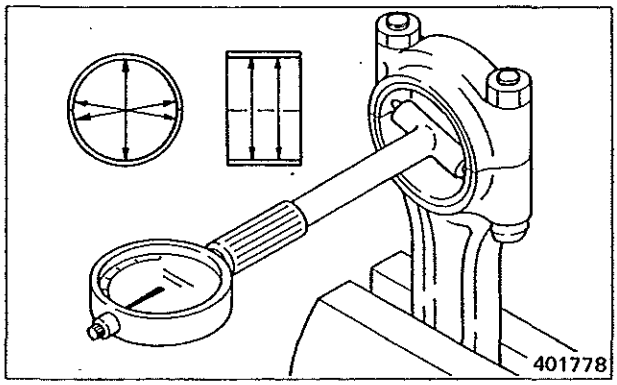
Keeping the piston protrusion within the Assembly standard is important not only for engine performance but also for prevention of interference of the valve with the piston.

Connecting rods, connecting rod bearings and small-end bushings

(1) Measuring connecting rod bearing-to-crankpin clearance

Measure the crankpin diameter and bearing inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the bearing. If the crankpin is worn excessively or unevenly, grind the crankpin, and use undersize bearing.

The two bearing undersizes are -0.25 mm (-0.0098 in.) and -0.50 mm (-0.0197 in.).



Measuring connecting rod bearing inside diameter

NOTE

To measure the bearing inside diameter, install upper and lower shells to the connecting rod properly, and tighten the cap bolts to the specified torque.

Unit: mm (in.)

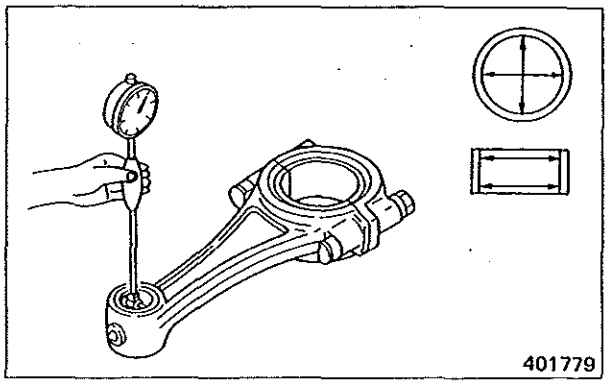
Item	Assembly standard	Repair limit
Crankpin diameter	$58\ ^{-0.035}_{-0.055}$ ($2.28\ ^{-0.00138}_{-0.00217}$)	–0.20 (–0.0079)
Connecting rod bearing-to-crankpin clearance	0.035 – 0.100 (0.00138 – 0.00394)	0.200 (0.00787)

(2) Measuring connecting rod bushing-to-piston pin clearance

Measure the piston pin diameter and bushing inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the pin or bushing whichever is badly worn.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Piston pin bushing inside diameter	28.045 – 28.020 (1.10413 – 1.10315)	
Connecting rod bushing-to-piston pin clearance	0.020 – 0.051 (0.00079 – 0.00201)	0.080 (0.00315)



Measuring connecting rod bushing inside diameter

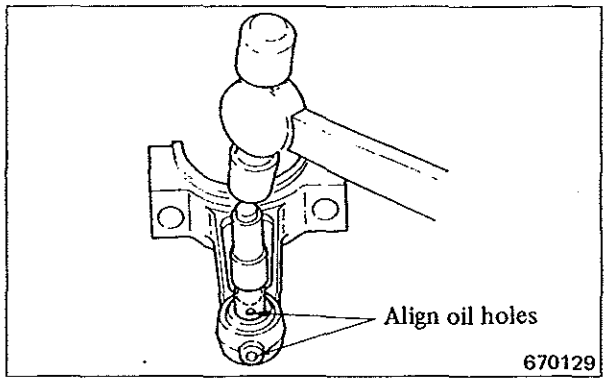
(3) Replacing connecting rod bushing

(a) To remove the bushing for replacement, use a connecting rod bushing puller as shown.

(b) Align the oil holes in the bushing and connecting rod.

(c) Press the bushing from the chamfered side of connecting rod.

(d) After installing the bushing, insert the piston pin to make sure that the pin rotates freely.



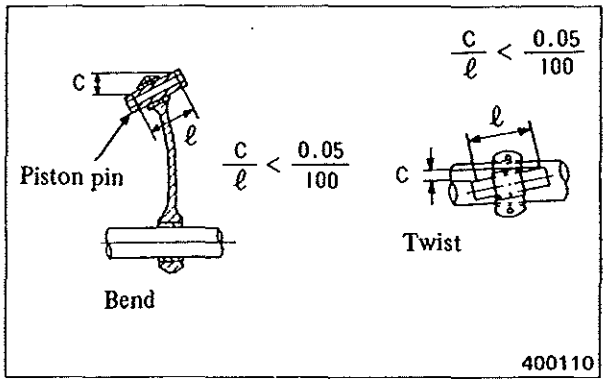
Installing connecting rod bushing

(4) Inspecting connecting rods for bend and twist

(a) Measure "C" and "ℓ." If the measurement at "C" is larger than 0.05 mm (0.0020 in.) per 100 mm (3.94 in.) of "ℓ," straighten the rod with a press.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Connecting rod bend and twist	0.05/100 (0.0020/3.94), maximum	0.15 (0.0059)

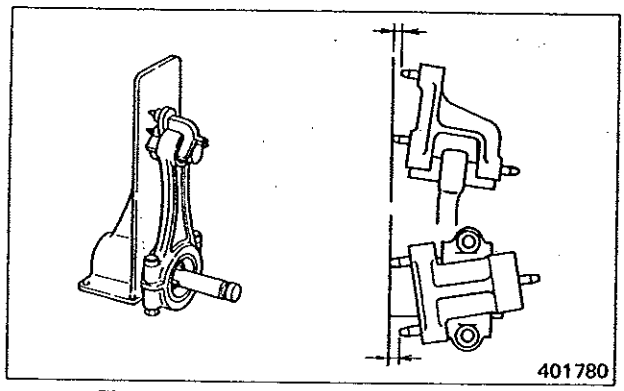


Inspecting connecting rod

(b) For inspecting connecting rod for bend and twist, the connecting rod aligner is generally used.

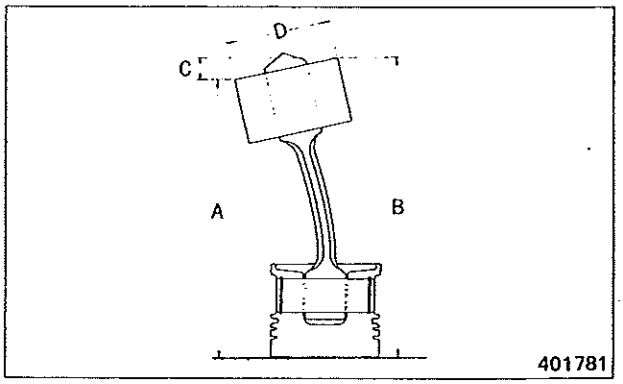
NOTE

To inspect for bend, install the bearing cap to connecting rod, and tighten the cap bolts to the specified torque.



Checking connecting rod on aligner

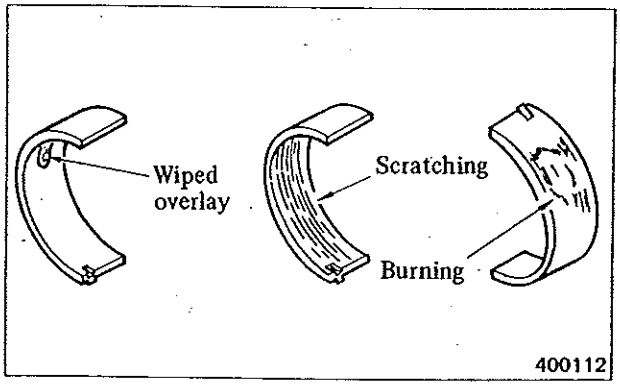
(c) To inspect the rod installed to the piston, place the piston on a surface plate, insert a round bar corresponding to the crankpin in diameter into the big end bore, and measure the heights "A" and "B" of the bar.



Inspecting connecting rod installed to piston

(5) Inspecting connecting rod bearings

Inspect each bearing shell for wiped overlay, scratching, burning, pitting and other defects. If any of these defects is present, replace the shell.

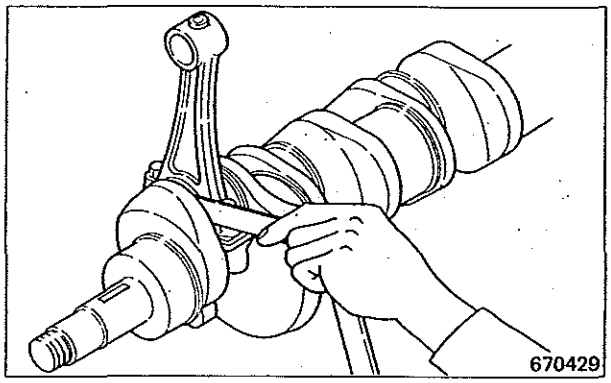


(6) Measuring connecting rod end paly

Install the connecting rod to the mating crankpin, and tighten its cap to the specified torque. Then, using a feeler gauge, measure the end play. If the end play exceeds the Service limit, replace the connecting rod.

Unit: mm (in.)

Item	Nominal value	Standard clearance	Service limit
Connecting rod end play [widths of connecting rod and crankpin]	40 (1.57)	0.15 – 0.35 (0.0059 – 0.0138)	0.50 (0.0197)

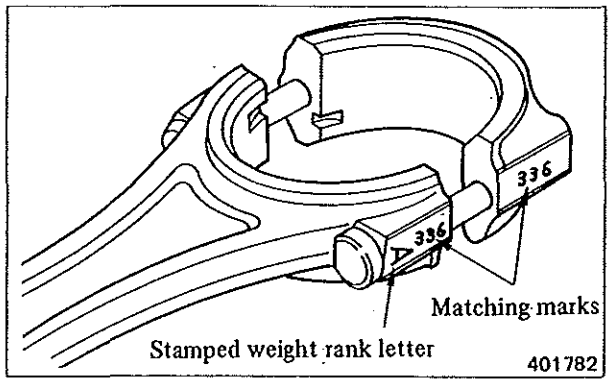


Measuring connecting rod end play

(7) Variance in weight among connecting rods per engine

When replacing connecting rods, make sure that the variance in weight among connecting rods per engine is within the Assembly standard shown below.

Item	Assembly standard
Variance in weight per engine	±5 g (±0.2 oz), maximum



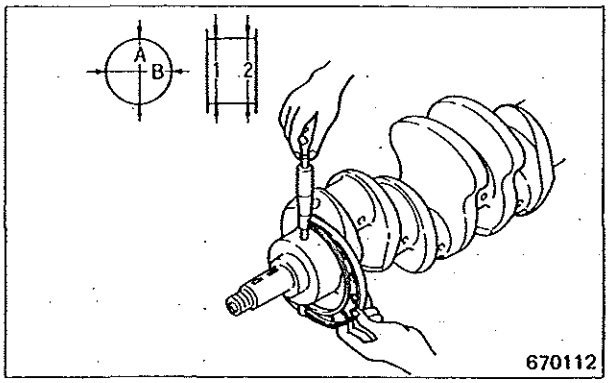
Crankshaft

(1) Measuring journal diameter

Using a micrometer, measure the journal in two positions, 1 and 2, and in two directions, A and B, to determine the wear, out of round and taper. If any of the Repair limits is exceeded, regrind the journal to the undersize or replace the crankshaft.

Unit: mm (in.)

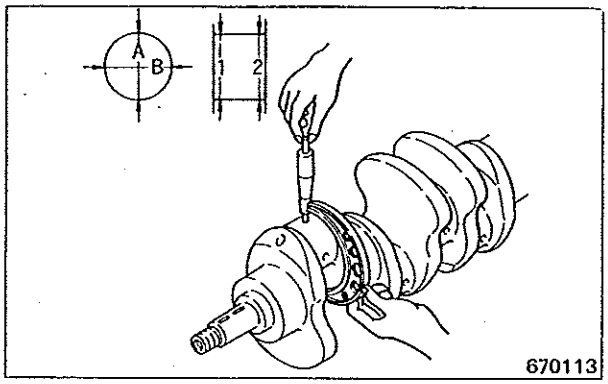
Item		Assembly standard	Repair limit	Service limit
Crankshaft journals	Diameter	$75\ ^{-0.03}_{-0.05}$ $(2.95\ ^{-0.0012}_{-0.0020})$	−0.15 (−0.0059)	−0.90 (−0.0354)
	Out of round	0.01 (0.0004), maximum	0.03 (0.0012)	
	Taper			



Measuring crankshaft journals

(2) Measuring crankpin diameter

Using a micrometer, measure the crankpin in two positions, 1 and 2, and in two directions, A and B, to determine the war, out of round and taper. If any of the Repair limits is exceeded, regrind the crankpin to the undersize or replace the crankshaft.



Measuring crankpins

Unit: mm (in.)

Item		Assembly standard	Repair limit
Crankpins	Diameter	$58\ ^{-0.035}_{-0.055}$ ($2.28\ ^{-0.00138}_{-0.00217}$)	−0.20 (−0.0079)
	Out of round	0.01 (0.0004), maximum	0.03 (0.0012)
	Taper		

(3) Grinding crankshaft

If the crankshaft is ground to any of the undersizes and refinished to a dimension which is 0.100 to 0.120 mm (0.00394 to 0.00472 in.) smaller than the undersize, it is not necessary to check the bearing contact pattern.

Crankshaft grinding dimensions

Unit: mm (in.)

	Undersize	Refinishing dimension
Crankshaft journal	0.25 (0.0098)	74.65 – 74.63 (2.9390 – 2.9382)
	0.50 (0.0197)	74.40 – 74.38 (2.9291 – 2.9283)
Crankpin	0.25 (0.0098)	57.65 – 57.63 (2.2697 – 2.2689)
	0.50 (0.0197)	57.40 – 57.38 (2.2598 – 2.2591)

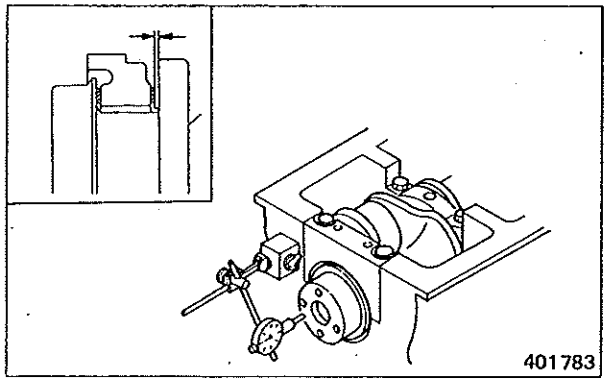
When grinding the journals and crankpins, be sure to produce the same fillet radius as the original one. They should have a hardness of 620 or more in terms of Vickers Hardness Number. If necessary, reharden the journals and crankpins, and inspect them for cracks by conducting a magnaflux (magnetic particle) test.

(4) Measuring crankshaft end play

Install the thrust plates in position, and secure the main bearing caps. Under this condition, measure the end play (the end clearance of thrust plates in the journal). If the end play exceeds the Assembly standard, replace the thrust plates.

Unit: mm (in.)

Item	Nominal value	Assembly standard	Repair limit
Crankshaft end play	37 (1.46)	0.100 – 0.264 (0.00394 – 0.01039)	0.300 (0.01181)



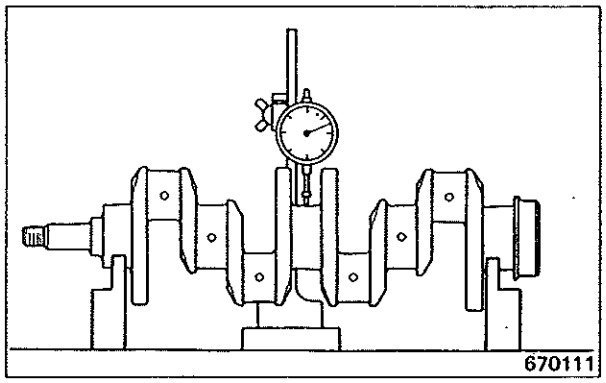
Measuring crankshaft end play

(5) Measuring crankshaft runout

Support the crankshaft on its front and rear journals in V-blocks, and measure the runout at the center journal, using a dial gauge. Depending on the amount of runout, repair the crankshaft by grinding or straightening with a press. If the runout exceeds the Repair limit, replace the crankshaft.

Unit: mm (in.)

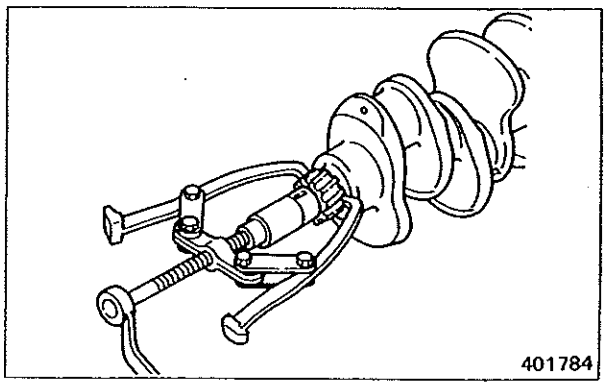
Item	Assembly standard	Repair limit
Crankshaft runout	0.02 (0.0008), maximum	0.05 (0.0020)



Measuring crankshaft runout

(6) Replacing crankshaft gear

(a) Using gear puller, remove the gear from the crankshaft.

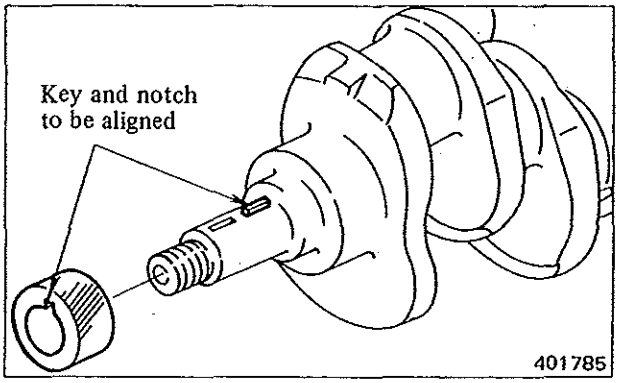


Replacing crankshaft gear

NOTE

Do not remove the gear by driving with a hammer.

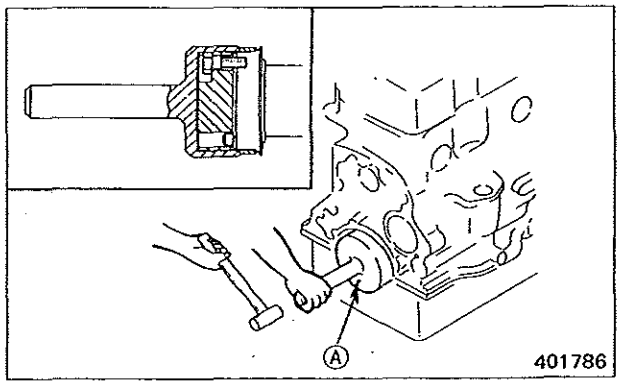
(b) To install, heat the gear up to about 100°C (212°F) with the heater. Place the new gear on the crankshaft by aligning the key with the notch of the gear and give light blows of a copper hammer to the end face of the gear.



(7) Replacing rear oil seal

If the seal shows a sign of oil leaks, replace it with a replacement oil seal with sleeve.

To install the sleeve, apply oil to the inside surface of the sleeve, and drive it onto the crankshaft, using crankshaft sleeve installer (A) (30691-13010), as shown.

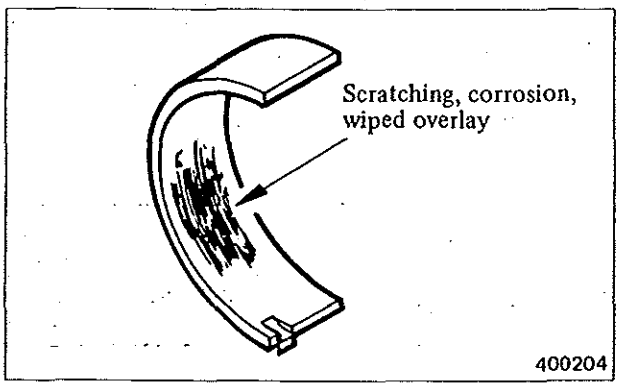


Replacing rear oil seal

Main bearings

(1) Inspection

Inspect each bearing shell for abnormal contact, scratching, corrosion, wiped overlay and other defects. Also check for a sign of poor seating in the bore of the crankcase or bearing cap.

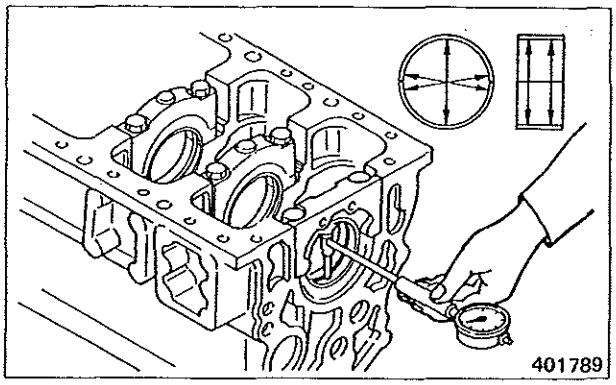


(2) Measuring main bearing clearance

Fit the bearing shells to the crankcase and bearing cap, and tighten the cap bolts to the specified torque. Measure the inside diameter of the bearing in two positions, front and back along the longitudinal axis of crankshaft, in the criss-cross directions to take an average. Obtain the difference between the journal diameter and this inside diameter to determine the clearance.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Main bearing-to-journal clearance	0.050 – 0.115 (0.00197 – 0.00453)	0.200 (0.00787)

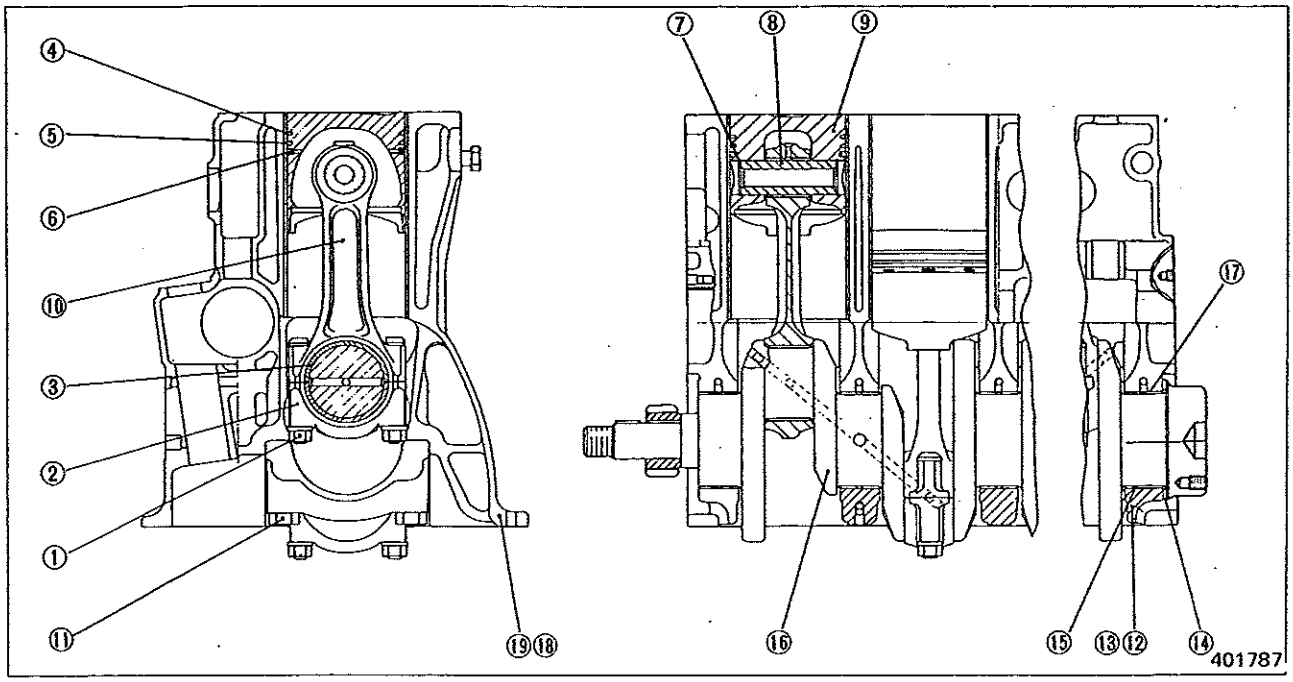


Measuring main bearing inside diameter

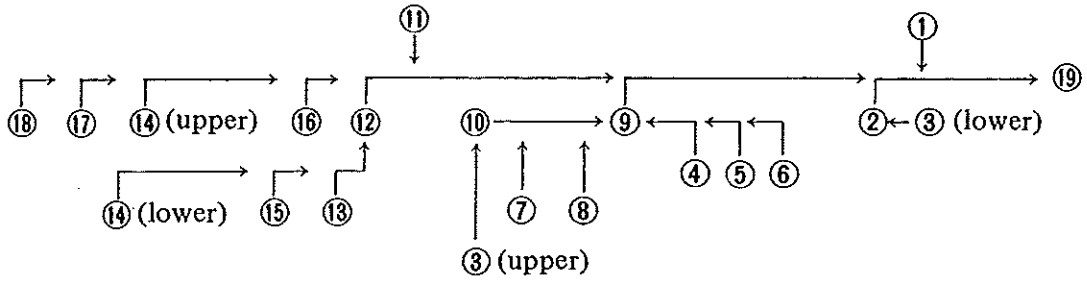
(3) Replacing main bearings

If the clearance exceeds the Repair limit, replace the bearings, or refinish the crankshaft and use undersize bearings. If the crankshaft is refinished in compiance with any of the undersizes, it is not necessary to inspect the bearing contact pattern.

3.3 Reassembly



Reassembling sequence

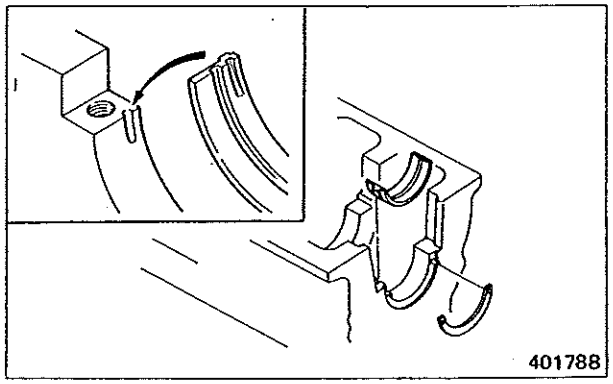


(1) Installing main bearings

(a) Install each upper shell in the crankcase by fitting its locking lip in the recess. The oil holes in the shell and crankcase will be aligned when the shell is so installed.

(b) Apply a thin coat of engine oil to the inside surface of each shell.

(c) Install the thrust plate in position.



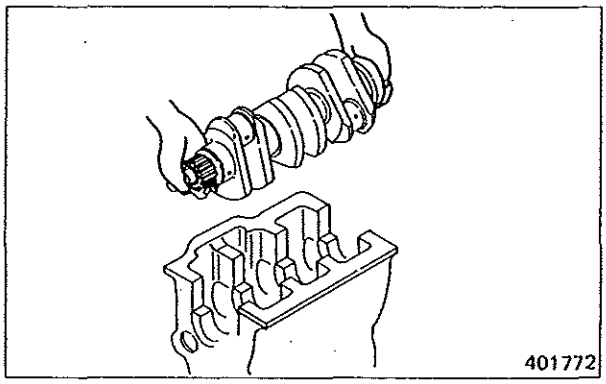
Installing main bearing upper shell

(2) Installing crankshaft

(a) Wash the crankshaft with cleaning solvent, and dry it by directing pressure air.

(b) Hold the crankshaft in horizontal position, and carefully put it on the crankcase.

(c) Apply a thin coat of engine oil to the journals of crankshaft.



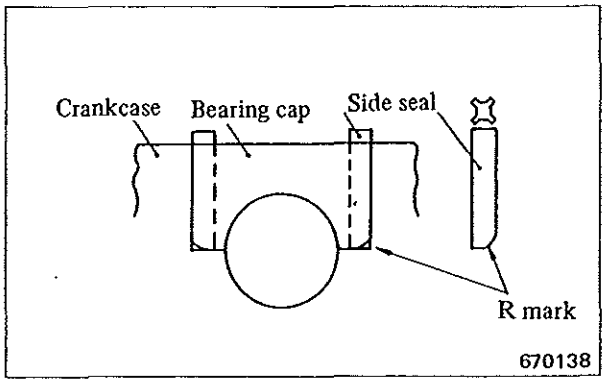
(3) Installing main bearing caps

(a) Apply engine oil to each lower shell, and fit it to the bearing cap.

(b) Apply ThreeBond 1105D to the mating face of the front and rear caps.

NOTE

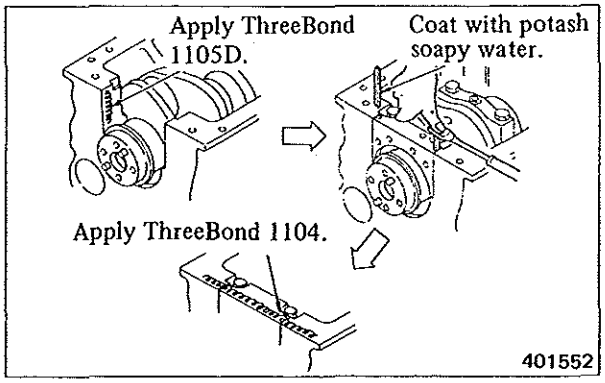
Apply ThreeBond 1105D to only front and rear caps to which side seals are to be installed.



(c) Install the bearing caps to the crankcase, making sure that they are flush with the crankcase walls on the front and rear sides.

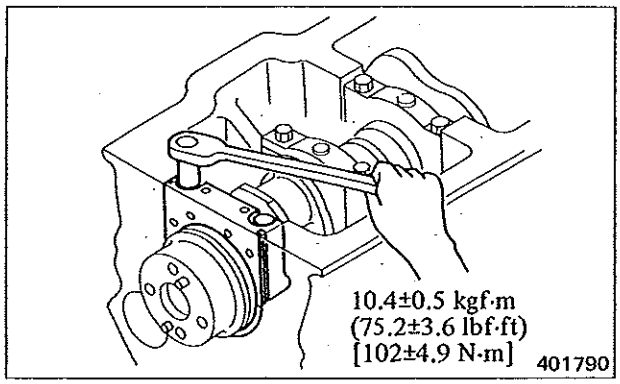
(d) Coat the side seals with potash soapy water, and insert them into the grooves in each bearing cap. Using the face of a screwdriver, push in the seals, bringing their rounded corners on the outer side and taking care not to twist the seals.

(e) Apply ThreeBond 1104 (grey in color) to the vicinity of the side seal joint.



(4) Installing bearing cap bolts

Apply engine oil to the bolts, and tighten them to the specified torque.

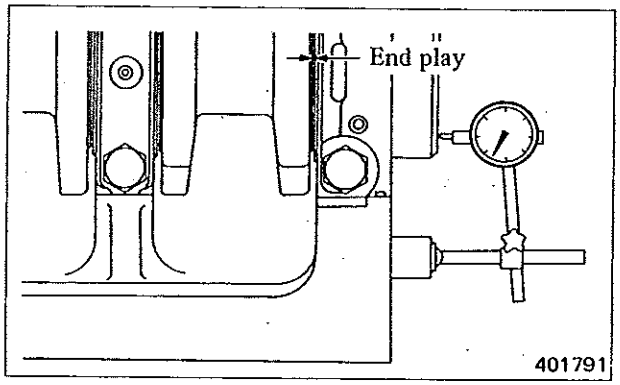


(5) Measuring crankshaft end play

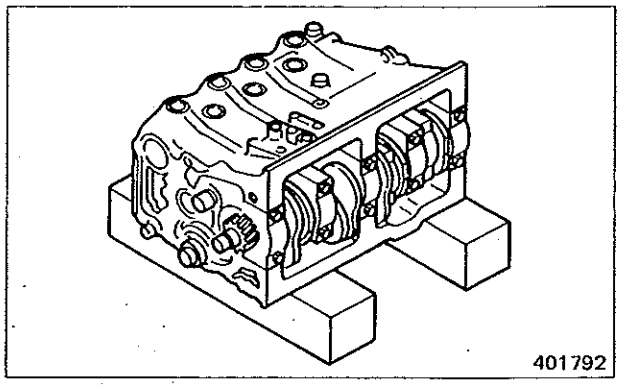
Install the thrust plates in position, and secure the main bearing caps. Under this condition, measure the end play (the end clearance of thrust plates in the journal). If the end play exceeds the Assembly standard, replace the thrust plates.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Crankshaft end play	0.100 – 0.264 (0.00394 – 0.01039)	0.300 (0.01181)



(6) Lay the crankcase on its side

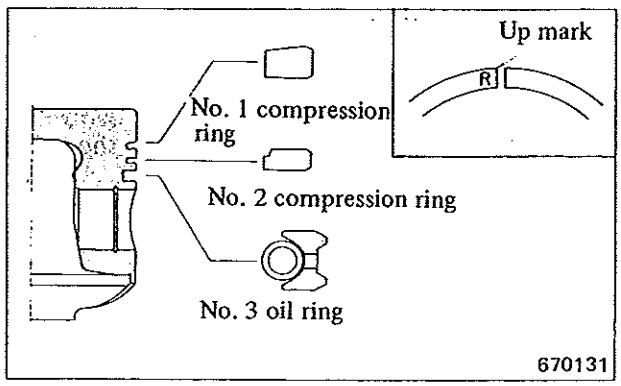


(7) Installing piston rings

(a) Using piston ring pliers (31391-12900), install the piston rings on the piston.

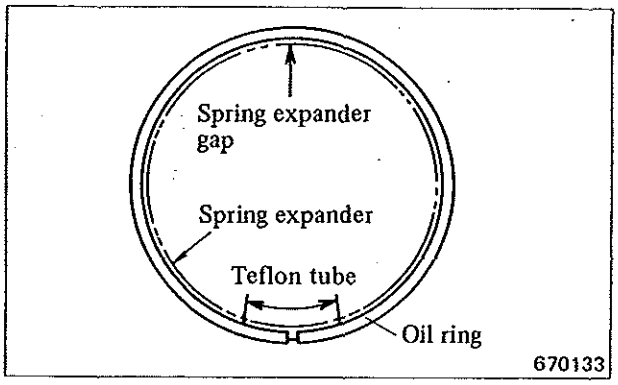
NOTE

Each piston ring is marked "R" on the side to be up when installed on the piston.



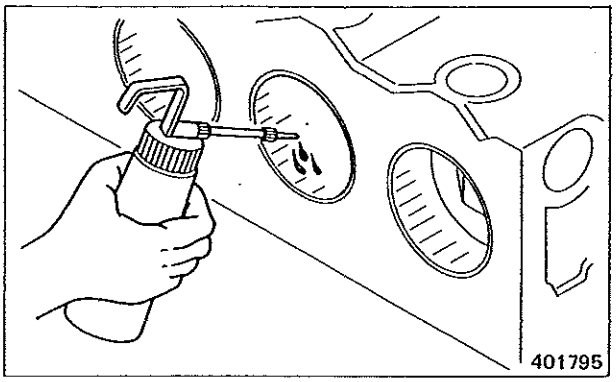
Piston rings

(b) Install the oil ring with its end gap positioned at 180° to that of spring expander. Attach teflon tube to the expander close to the oil ring end gap.



(8) Preparatory steps for installing pistons

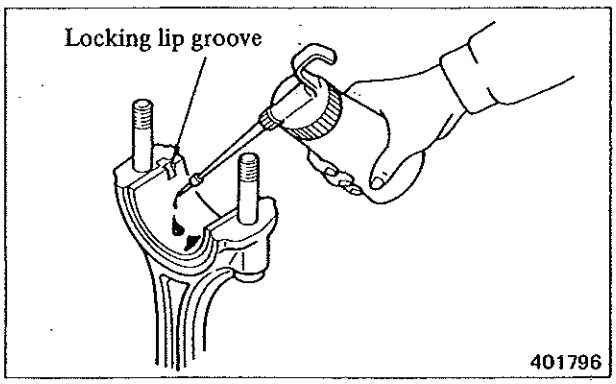
Clean the cylinder sleeve bore surface with a clean cloth, and apply engine oil to that surface.



(9) Installing connecting rod bearings and caps

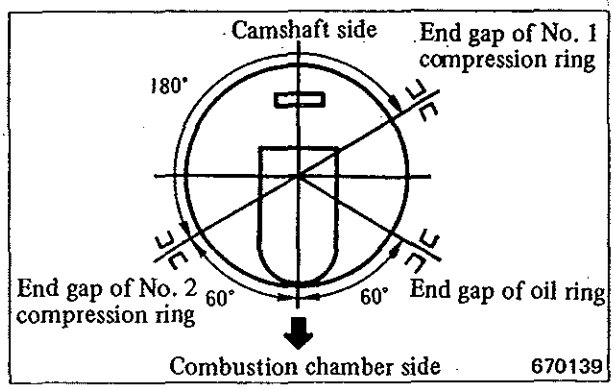
(a) Insert the bolts into the cap by settling the flat of bolt head in place on the cap.

(b) Install the upper shell of the bearing in the rod by fitting its locking lip in the groove, and apply engine oil to the inside surface of the shell.

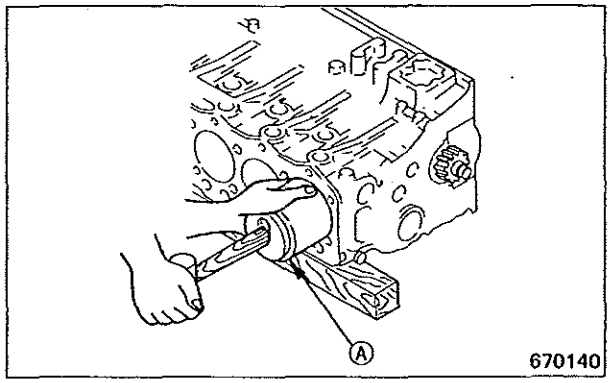


(10) Installing pistons

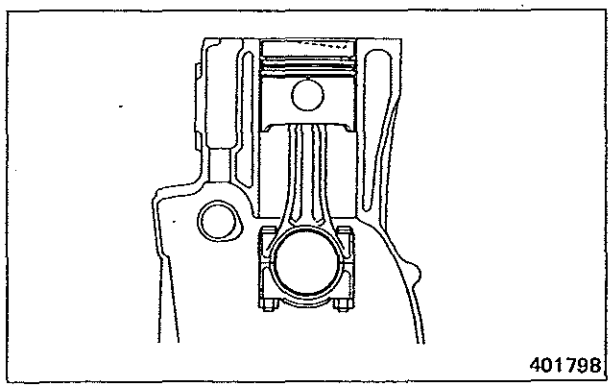
(a) Apply engine oil to the piston rings, and reposition the rings by keeping their end gaps away from the direction of piston pin and thrust side.



(b) Bring the crankpin to which the piston is to be installed to top dead center position. Using piston guide (A) (34491-02200), insert the piston assembly into the crankcase, with the matching mark of the connecting rod on the camshaft side.



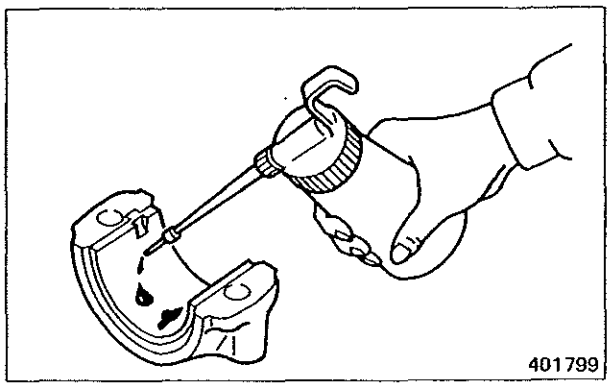
(c) After resting the big end of connecting rod on the crankpin, turn crankshaft by 180°, and install the cap.



(11) Installing connecting rod caps

(a) Install the lower shell of the bearing in the cap, apply engine oil to the inside surface of the shell.

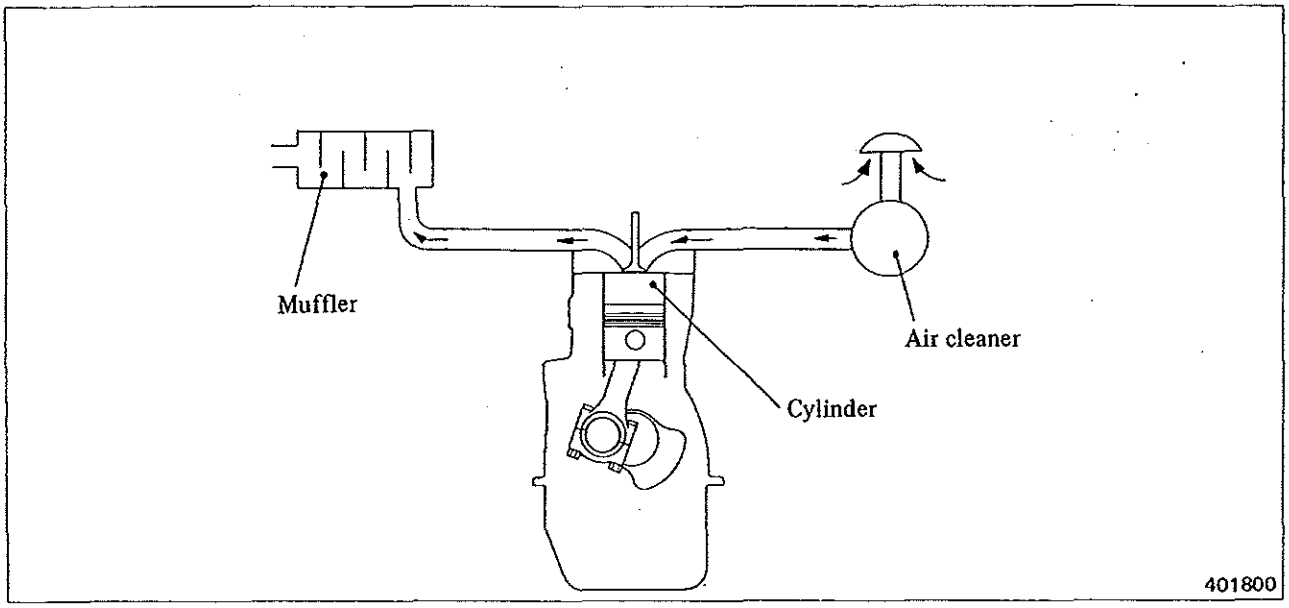
(b) Install the cap by tightening the nuts to the specified torque.



INTAKE & EXHAUST SYSTEMS

1. DESCRIPTION 100
2. EXHAUST MANIFOLD 100
Inspection 100

1. DESCRIPTION



2. EXHAUST MANIFOLD

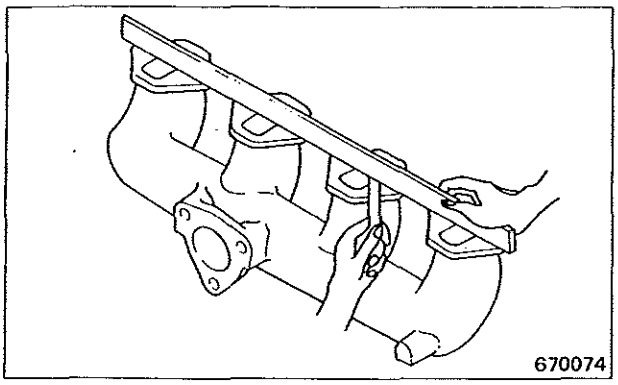
Inspection

(a) Inspect flanges for cracks.

(b) Inspect flanges for warpage. If the warpage exceeds the Assembly standard, repair the flanges.

Unit: mm (in.)

Item	Assembly standard
Warpage of exhaust manifold flanges	0.2 (0.008), maximum



Inspecting exhaust manifold flanges for warpage

LUBRICATION SYSTEM

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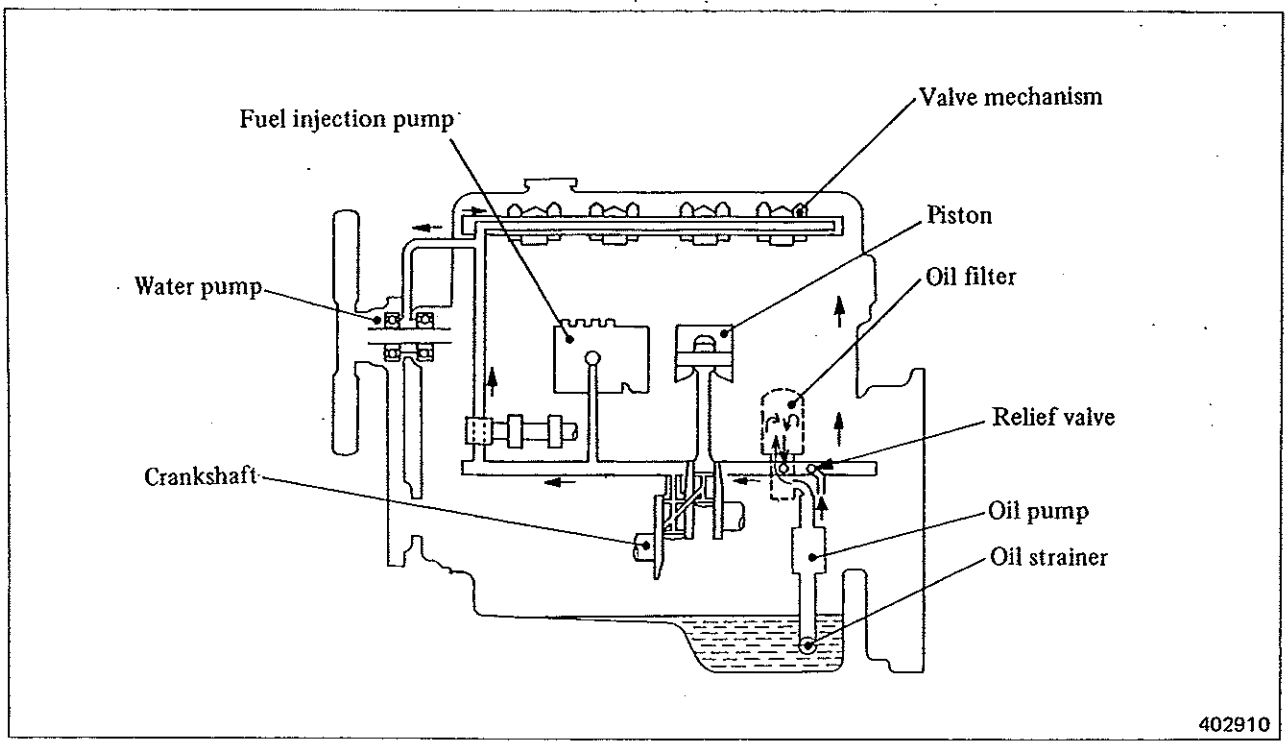
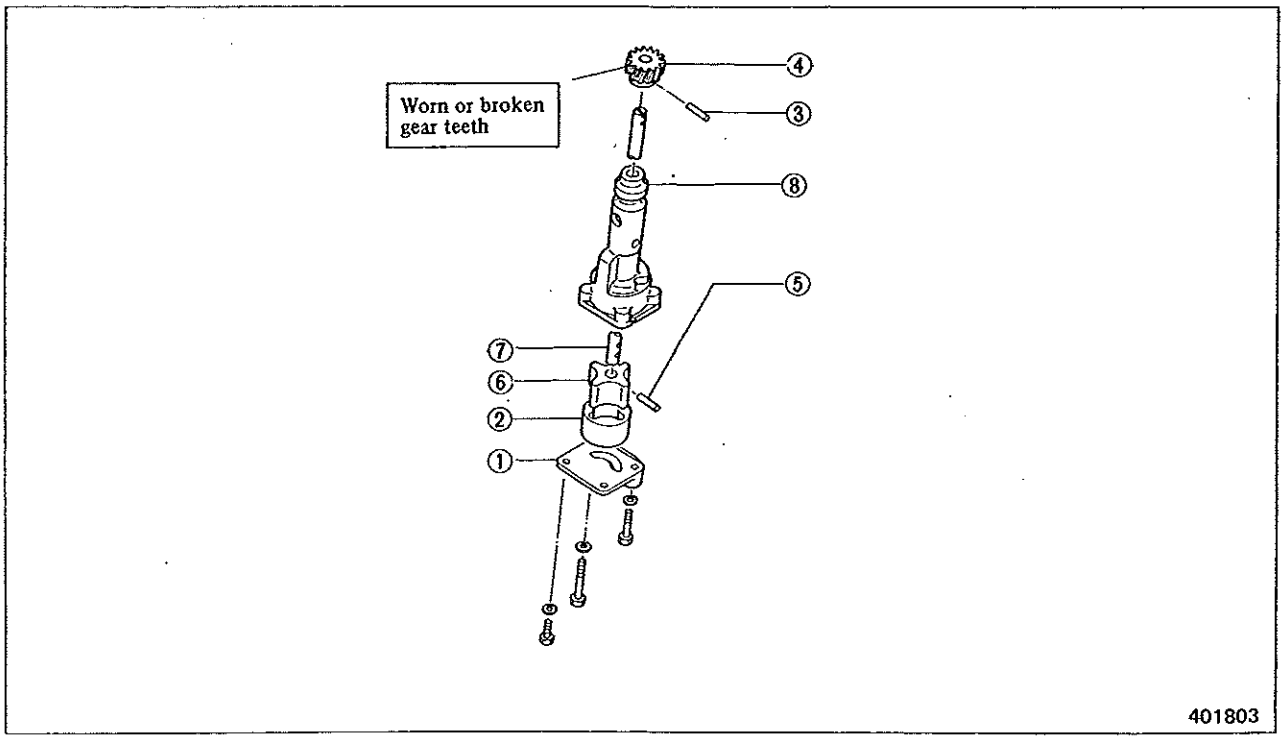
Inspection 107

1. DESCRIPTION



2. OIL PUMP

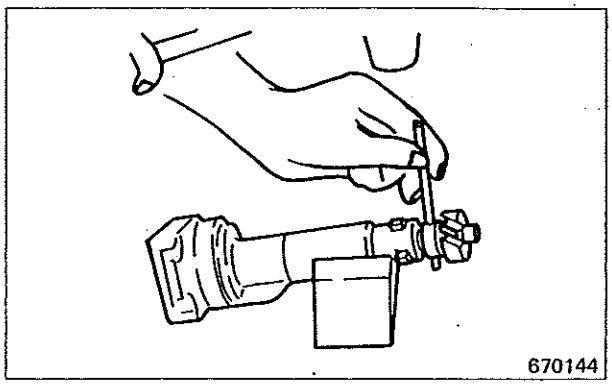
2.1 Disassembly



① Oil pump case cover
② Outer rotor
③ Taper pin
④ Pump drive gear
⑤ Pin
⑥ Inner rotor
⑦ Main shaft
⑧ Oil pump case

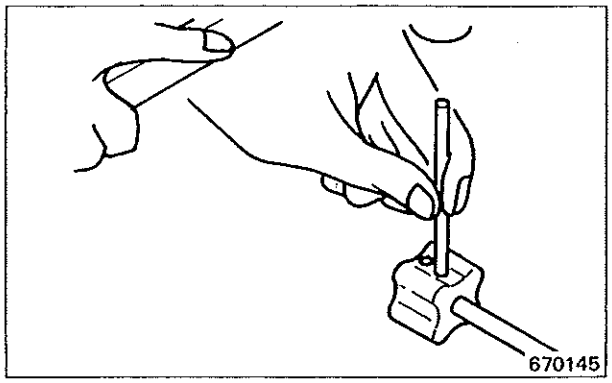
(1) Removing main shaft

Take off the taper pin, and remove the drive gear from the main shaft. Then, pull the main shaft complete with the inner rotor from the pump case.



(2) Removing inner rotor

Take off the pin, and separate the inner rotor from the main shaft.



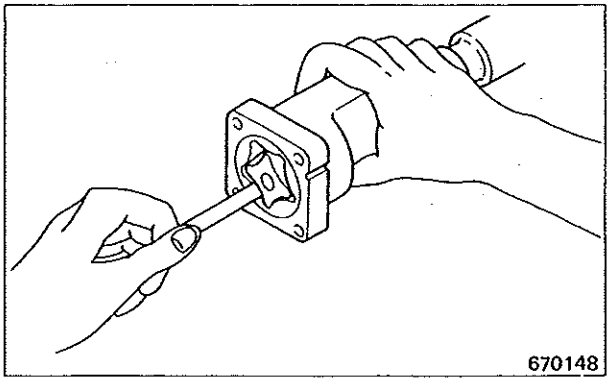
2.2 Inspection and repair

(1) Measuring outer rotor-to-inner rotor clearance

If the clearance exceeds the Service limit, replace the outer and inner rotors as an assembly.

Unit: mm (in.)

Item	Assembly standard	Service limit
Outer rotor-to-inner rotor clearance	0.013 – 0.150 (0.00051 – 0.00591)	0.250 (0.00984)



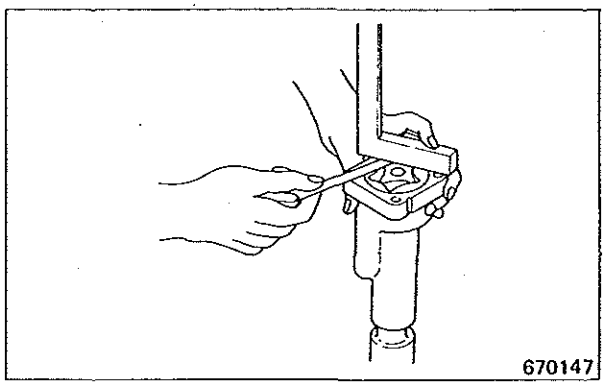
Measuring outer rotor-to-inner rotor clearance

(2) Measuring rotor-to-cover clearance (end play of rotors)

If the clearance exceeds the Repair limit, replace the rotors or grind the mating faces of the case and cover.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Rotor-to-cover clearance (end play of rotors)	0.04 −0.09 (0.0016 − 0.0035)	0.15 (0.0059)



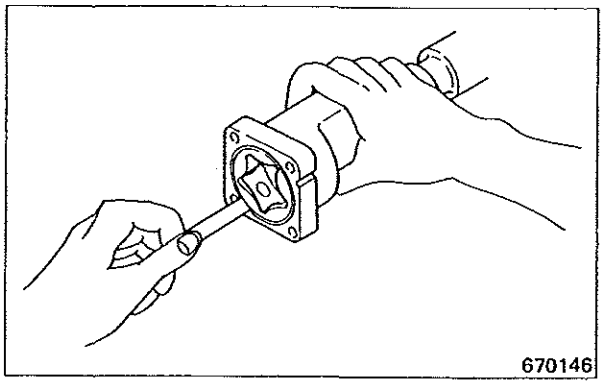
Measuring rotor-to-cover clearance

(3) Measuring outer rotor-to-pump case clearance

If the clearance exceeds the Service limit, replace the rotor or case whichever is badly worn.

Unit: mm (in.)

Item	Assembly standard	Service limit
Outer rotor-to-pump case clearance	0.20 − 0.28 (0.0079 − 0.0110)	0.50 (0.0197)



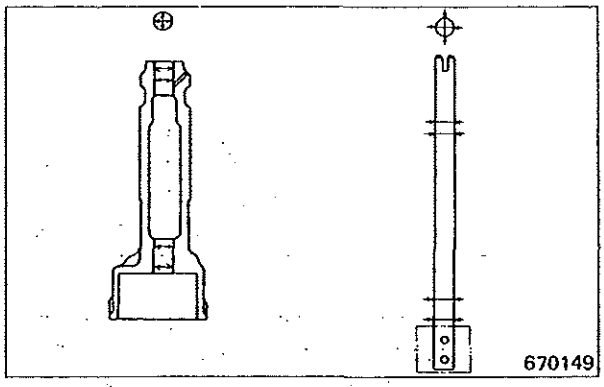
Measuring outer rotor-to-pump case clearance

(4) Measuring main shaft-to-pump case clearance

Measure the diameter of main shaft and the inside diameter of pump case to determine the clearance between the two. If the clearance exceeds the Service limit, replace the main shaft or the pump assembly.

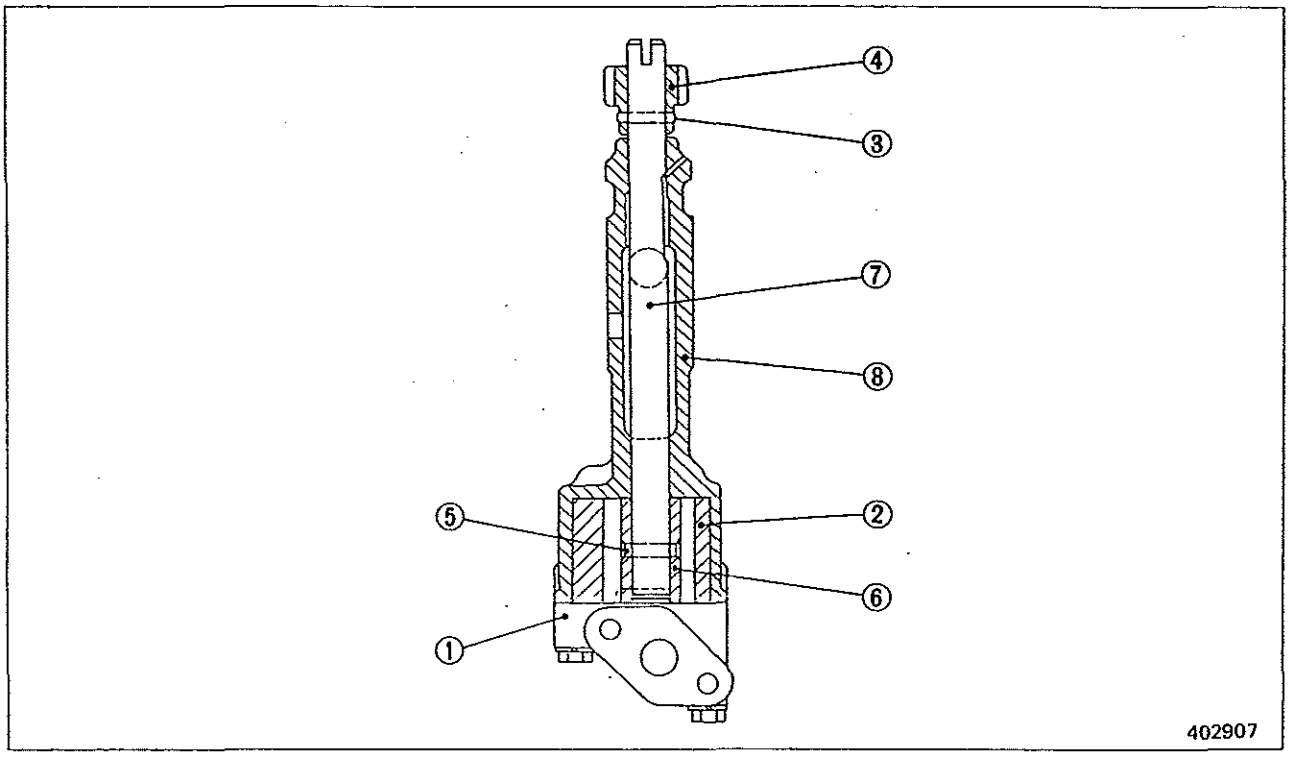
Unit: mm (in.)

Item	Assembly standard	Service limit
Diameter of main shaft	13.000 − 12.985 (0.51181 − 0.51122)	
Main shaft-to-pump case clearance	0.032 − 0.074 (0.00126 − 0.00291)	0.150 (0.00591)

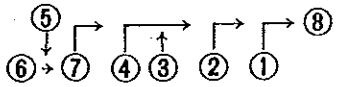


Measuring main shaft-to-pump case clearance

2.3 Reassembly



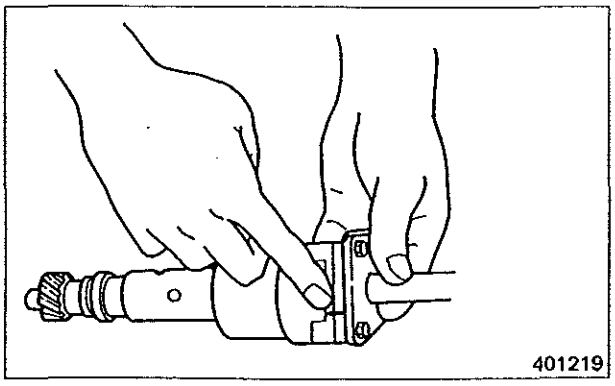
Reassembling sequence



NOTE

(a) When using replacement (new) main shaft and drive gear at the time of reassembling the pump, drill dowel pin hole in and through the shaft and gear.

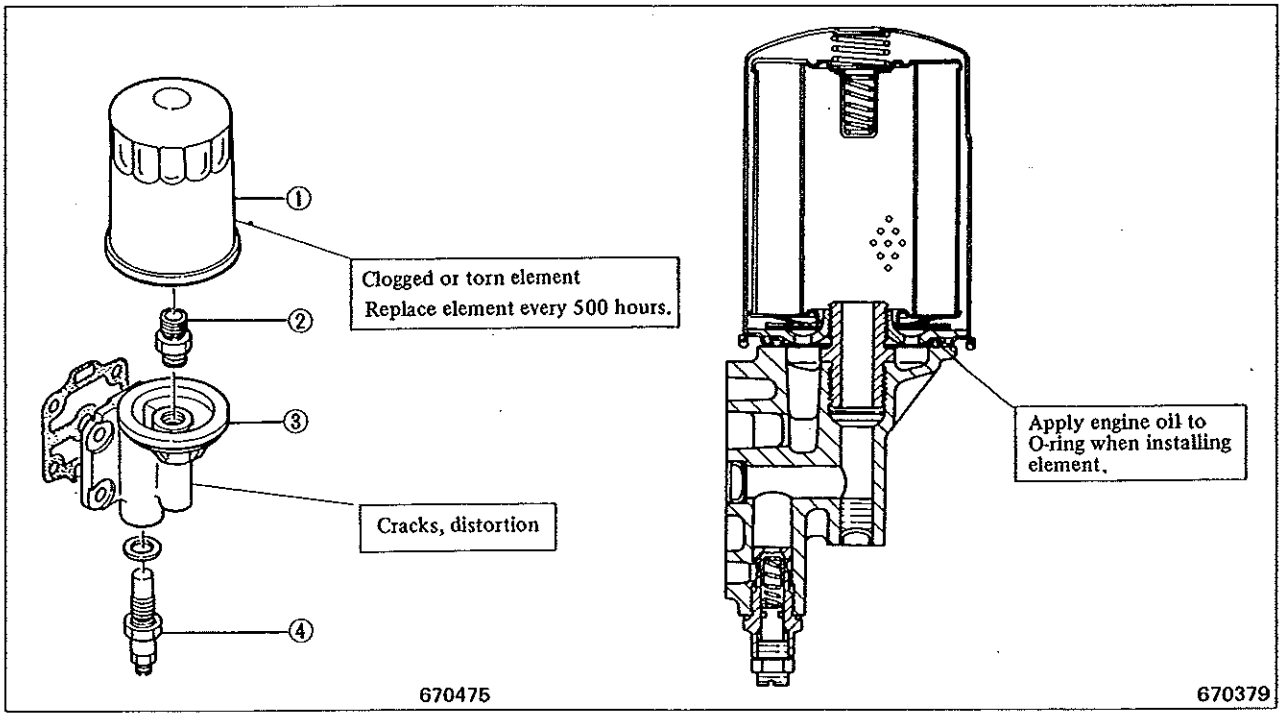
(b) When tightening the cover bolts, be sure to make sure that the matching marks on the cover and case are aligned. A failure to match the marks will result in malfunction.



Matching marks on pump case and cover

3. OIL FILTER

Disassembly and inspection



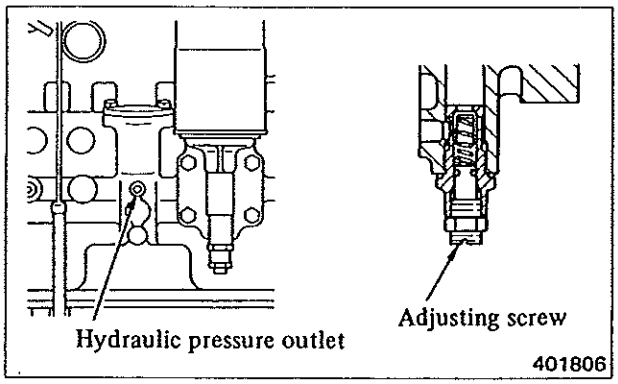
① Filter element
② Center screw
③ Filter case
④ Relief valve

4. RELIEF VALVE

Inspection

(1) Check the valve seat for abnormal contact. Also check the spring for weakness and breakage.

(2) Measure the relief valve opening pressure. If it exceeds the Assembly standard, make an adjustment by tightening or loosening the adjusting screw (varying the setting of the spring).



Unit: kgf/cm² (psi) [MPa]

Item	Assembly standard
Relief valve opening pressure	3.0 ± 0.2 (42.7 ± 2.8) [0.29 ± 0.02]

COOLING SYSTEM

1. DESCRIPTION 110
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   2.2 Inspection 111
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3. THERMOSTAT 113
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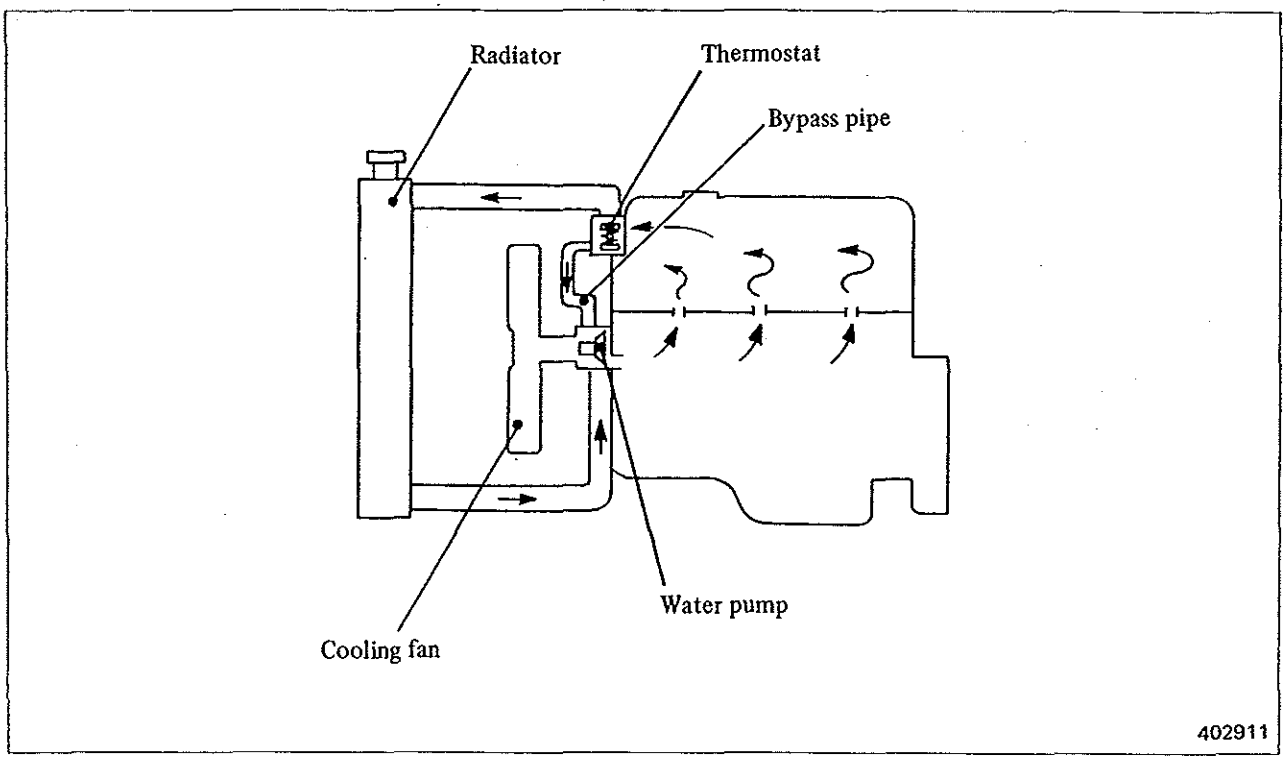
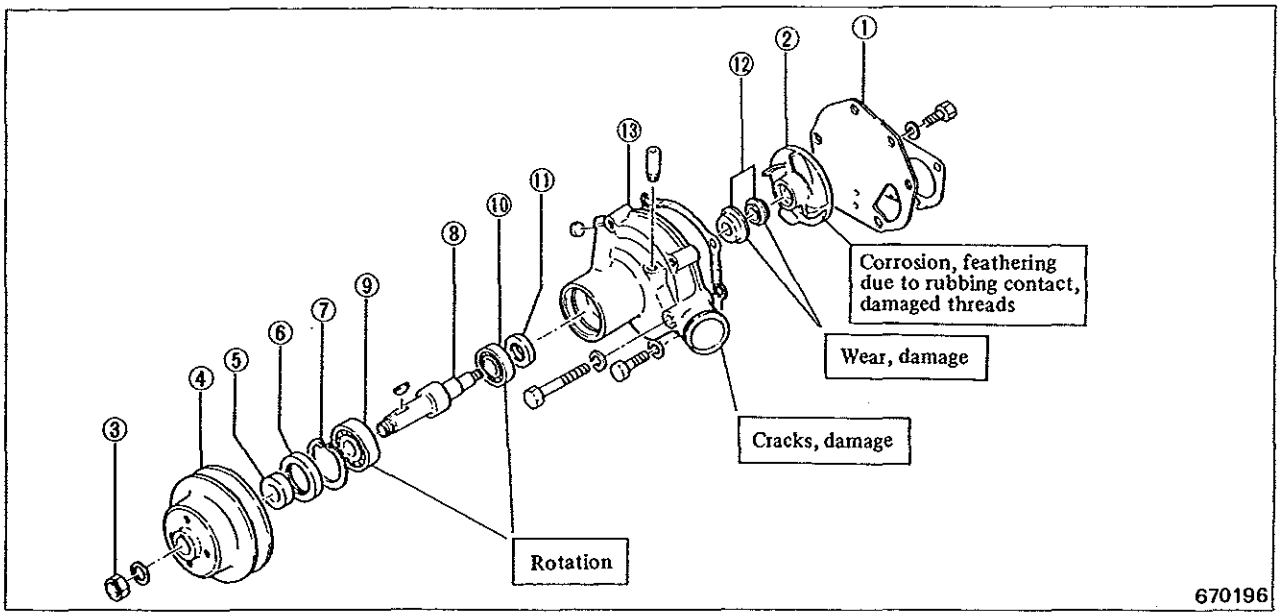
4. FAN AND FAN BELT 114
   Inspection 114

1. DESCRIPITION



2. WATER PUMP

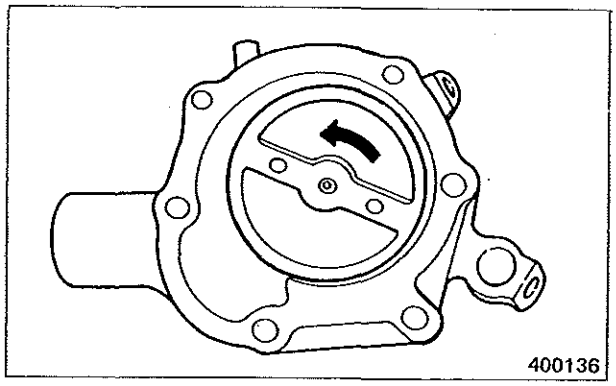
2.1 Disassembly



① Cover
② Impeller
③ Nut
④ Pump pulley
⑤ Spacer
⑥ Oil seal
⑦ Snap ring
⑧ Shaft
⑨ Bearing
⑩ Bearing
⑪ Oil seal
⑫ Unit seal
⑬ Case

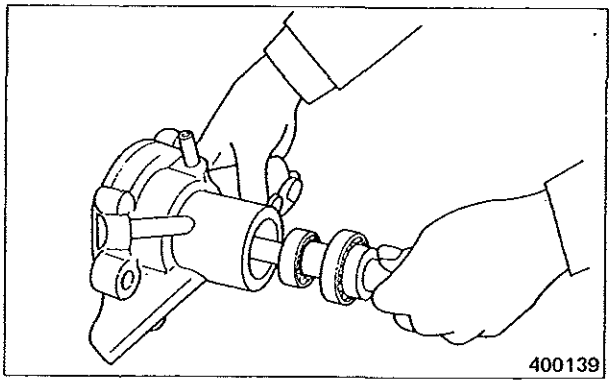
(1) Removing impeller

The impeller is right hand-threaded. To remove the impeller, turn it counterclockwise (in the direction of arrow).



(2) Removing shaft

Remove the oil seal and snap ring, and pull out the shaft complete with bearings to the pulley side.

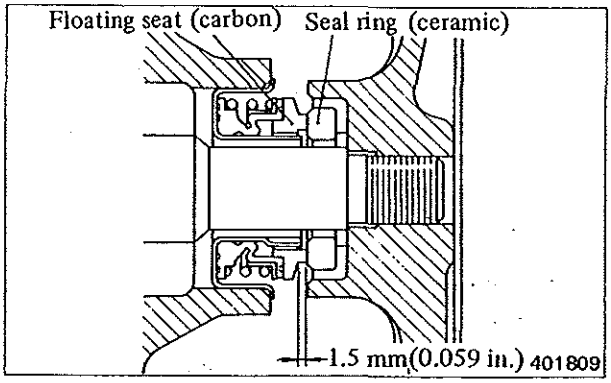


2.2 Inspection

(a) Inspect the pump operation by slowly rotating it. If it is erratic in rotation, replace the bearings.

(b) Visually inspect the impeller for corrosion or broken blade. Replace the impeller if defective. Also check the impeller for sign of rubbing contact with the pump case and rear cover. If such a contact is evident, replace the impeller and bearings.

(c) Inspect the unit seal for condition. Replace the seal if any sign of leakage is noted during operation.

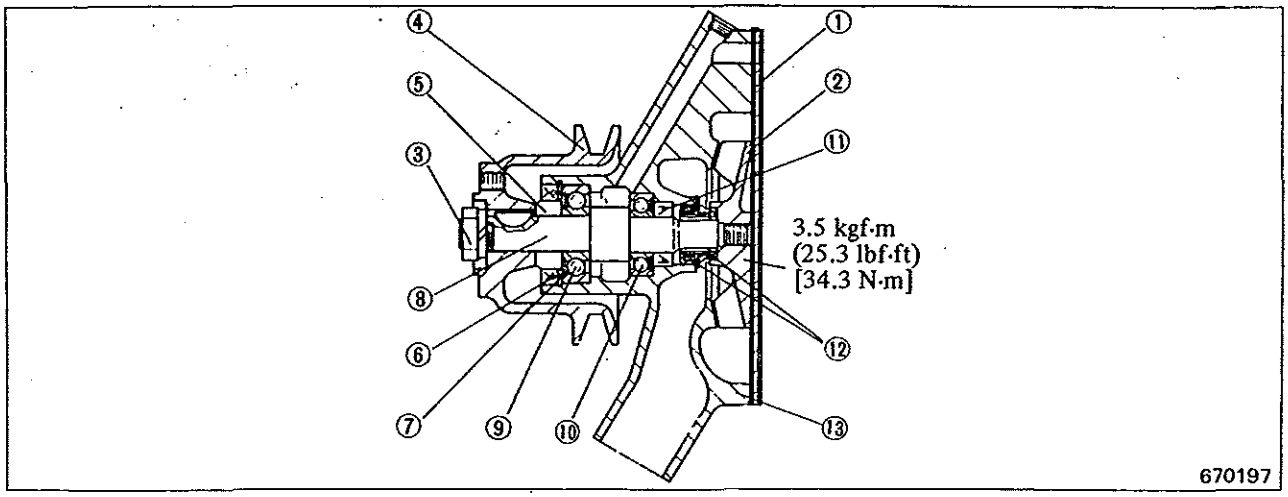


Unit seal

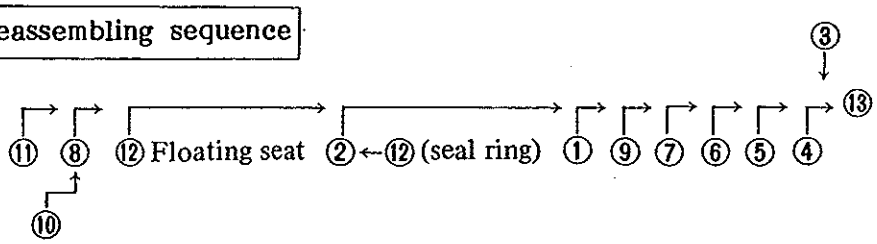
Unit: mm (in.)

Item	Assembly standard	Service limit
Carbon protrusion	1.5 (0.059)	0
Free-state height	21.8 ± 1 (0.858 ± 0.04)	

2.3 Reassembly



Reassembling sequence



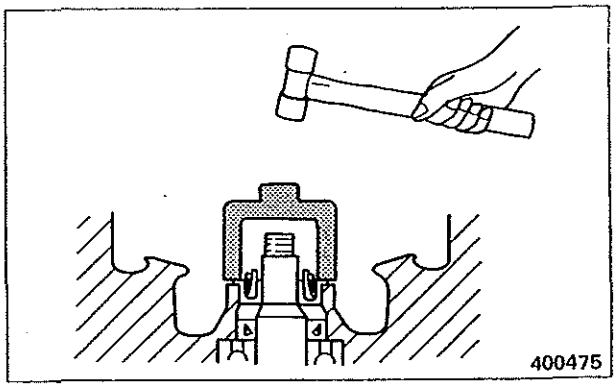
NOTE

After reassembling the pump, operate it by means of the pulley and belt, making sure that it runs smoothly without any sign of rubbing contact with the pump case or cover.

(1) Installing unit seal

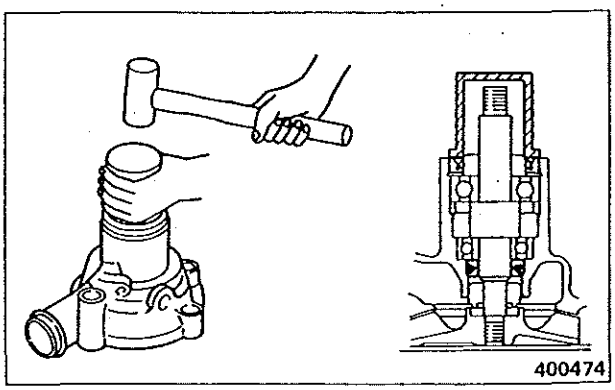
To install the seal, use a unit seal installer.

Do not reuse a unit seal which has been removed from the pump case.



(2) Installing oil seal

To install the seal, use an oil seal installer.



WORKSHOP THEORY

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1.3 Bearings 117
1.4 Lock plates 118
1.5 Split pins and spring pins 118

1. PRECAUTIONS FOR DISASSEMBLY AND REASSEMBLY

1.1 Oil seals

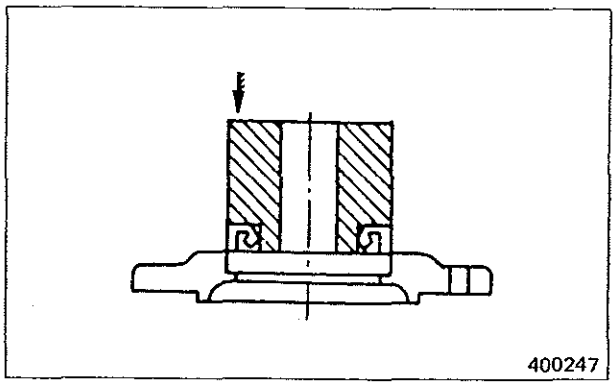
When installing oil seals, carefully observe the following points:

(1) Driving oil seals into housings

(a) Make sure that seal lip is not damaged, and position it correctly with respect to oil compartment.

(b) Apply a small amount of grease to the surface of oil seal to be fitted into housing bore.

(c) Using a tool of the type shown to guide seal lip, drive oil seal squarely. Never give any hammer blows directly to oil seal since this will damage the seal, resulting in oil leakage.

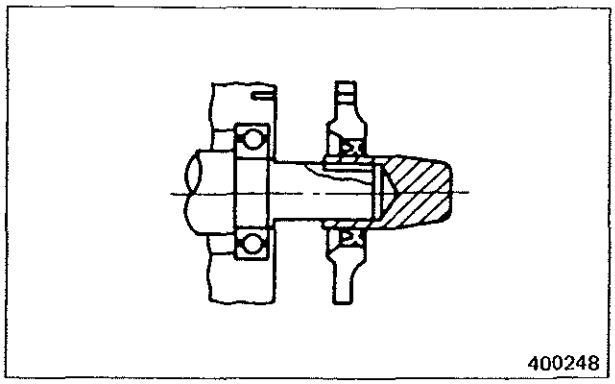


Oil seal driver

(2) Driving oil seals onto shafts

(a) Apply a thin coat of grease to oil seal lip.

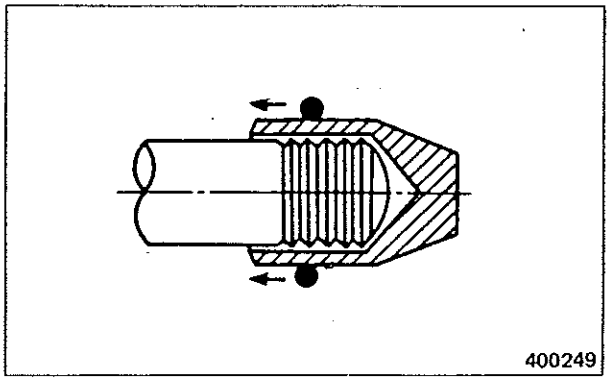
(b) Use an oil seal guide of the type shown when driving oil seal over stepped portion, splines, threads or keyway to prevent damage to seal lip.



Oil seal guide

1.2 O-rings

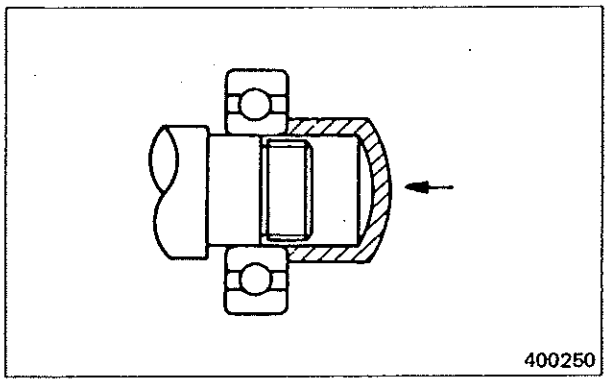
Use an O-ring guide of the type shown when installing O-ring over stepped portion, splines, threads or keyway to prevent damage to the ring. Apply a thin coat of grease to O-ring.



O-ring guidè

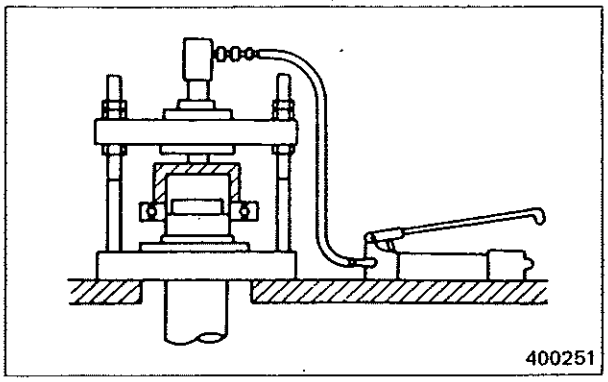
1.3 Bearings

(1) When installing a rolling bearing, be sure to give a push to the race, inner or outer, by which the bearing is fitted. Be sure to use a bearing driver of the type shown.



Bearing driver

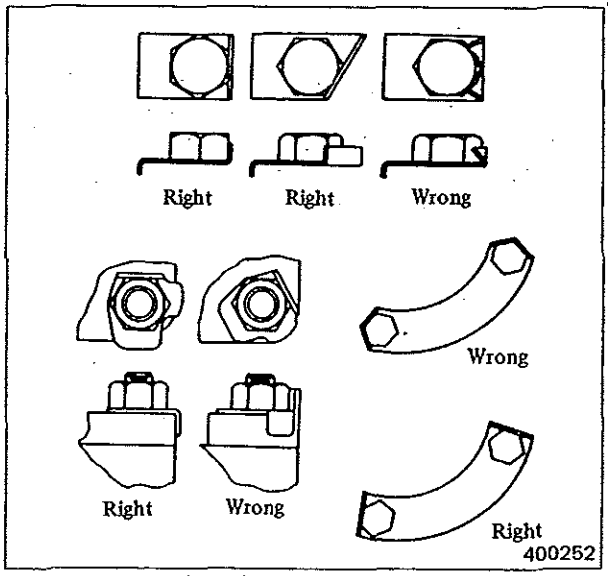
(2) Use a press whenever possible to minimize shock to bearing and to assure proper installation.



Bearing installation by a press

1.4 Lock plates

Bend lock plate against one of the flats of nut or bolt head as shown.



Bending lock plates

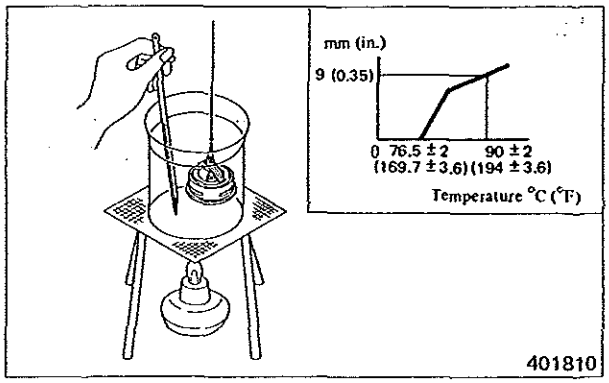
1.5 Split pins and spring pins

Generally, split pins are to be replaced at the time of disassembly. Be sure to insert the split pin fully and spread it properly. Drive each spring pin into position so that it may not get out of place after subsequent installation of parts has been completed.

3. THERMOSTAT

Inspection

Immerse the thermostat in a water bath, and test it for thermostatic action by heating the bath to raise the water temperature. If the valve fails to operate properly, replace the thermostat.



Unit: mm (in.)

Item	Assembly standard
Temperature at which valve starts opening	76.5 ± 2°C (169.7 ± 3.6°F)
Temperature at which valve opens fully	90 ± 2°C (194 ± 3.6°F)
Valve stroke	9 (0.35)

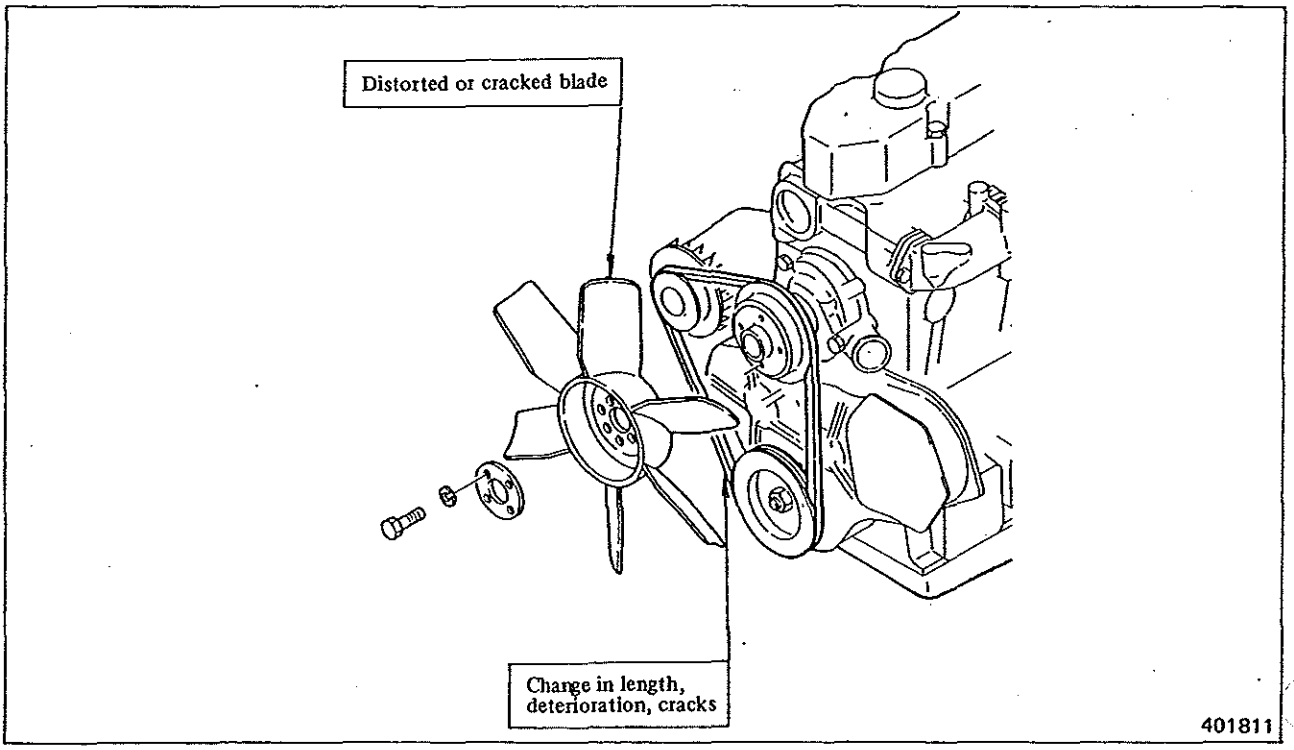
NOTE

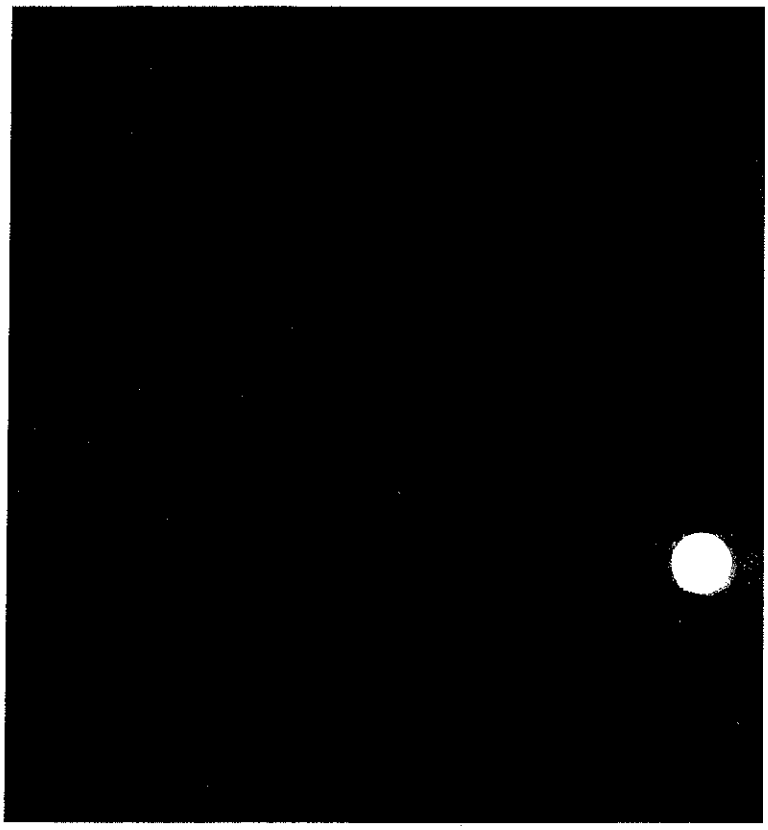
(a) Stir the water in the bath with a stick to maintain its temperature uniform during test.

(b) At reassembly, install thermostat with its air vent hole facing upward.

4. FAN AND FAN BELT

Inspection





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SERVICE MANUAL

MITSUBISHI DIESEL ENGINE

for BD2G/BS3G

CONTENTS

- FUEL SYSTEM
- ELECTRICAL SYSTEM

MITSUBISHI HEAVY INDUSTRIES, LTD.

INTRODUCTION

This Service Manual is written to familiarize you with the maintenance of the fuel system and electrical system of your Mitsubishi S4E2 Diesel Engine. This is edited as a separate volume to supplement the Service Manual of Mitsubishi S4E2 Diesel Engine (Pub. No. 99159-01110-1/). For groups other than those in this Manual, refer to that Service Manual.

Major equipment specifications

Equipment		S4E2 (BD2G, BS3G)
Fuel system	Injection nozzle Type of nozzle holder Type of nozzle tip	ND-DNOSD
	Feed pump	ND-EP/KS22A
	Injection pump	PES4A65B
	Governor	ND-EP/RSV
Electrical system	Starter	M002T65271
	Alternator	A001T70770

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Group	Contents	Group No.
Fuel system	Disassembly, inspection, reassembly and maintenance standards of fuel system: Fuel filter, fuel injection nozzles, fuel feed pump, fuel injection pump, governor	1
Electrical system	Disassembly, inspection, reassembly and maintenance standards of electrical system: Starter, alternator, glow plugs	2

FUEL SYSTEM

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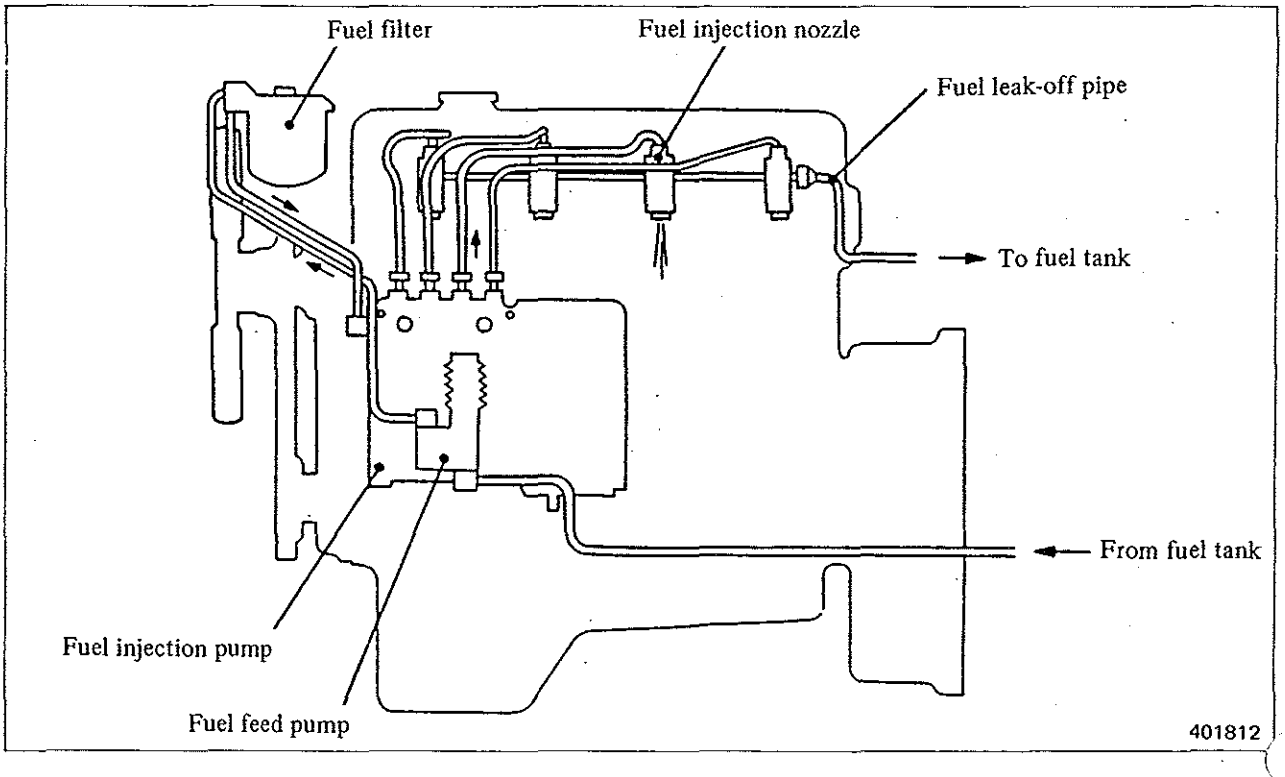
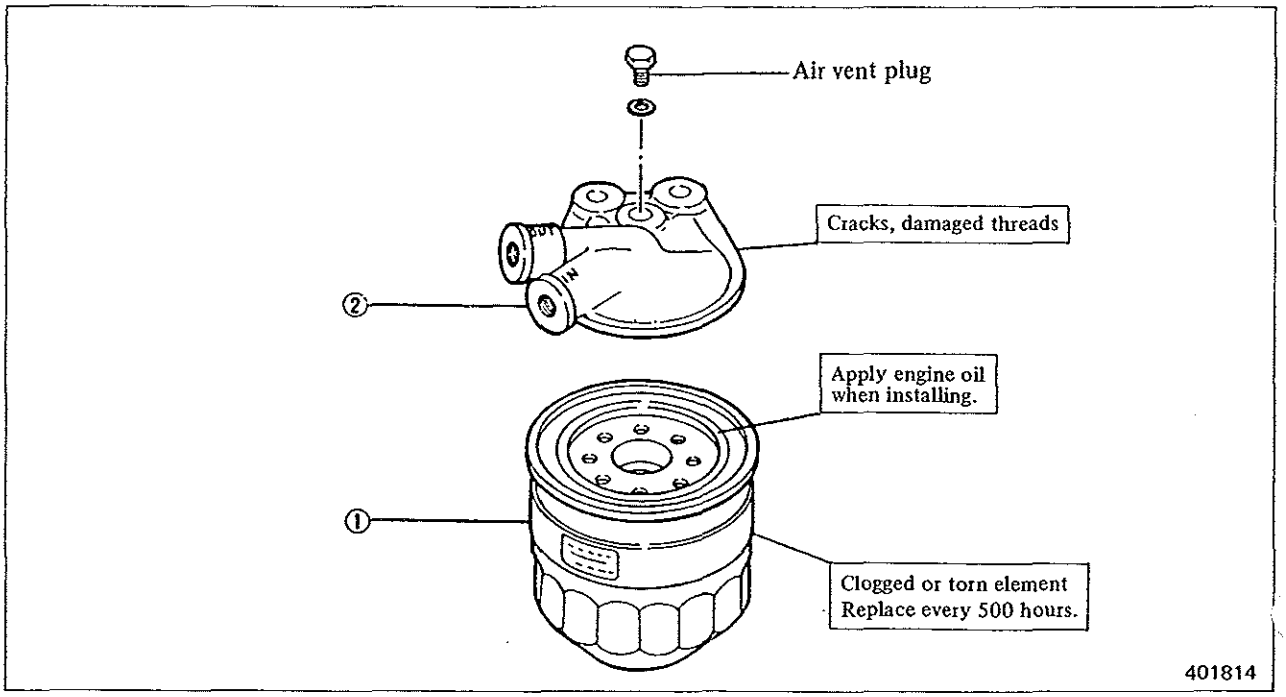
1. DESCRIPTION



2. FUEL FILTER

Disassembly and inspection

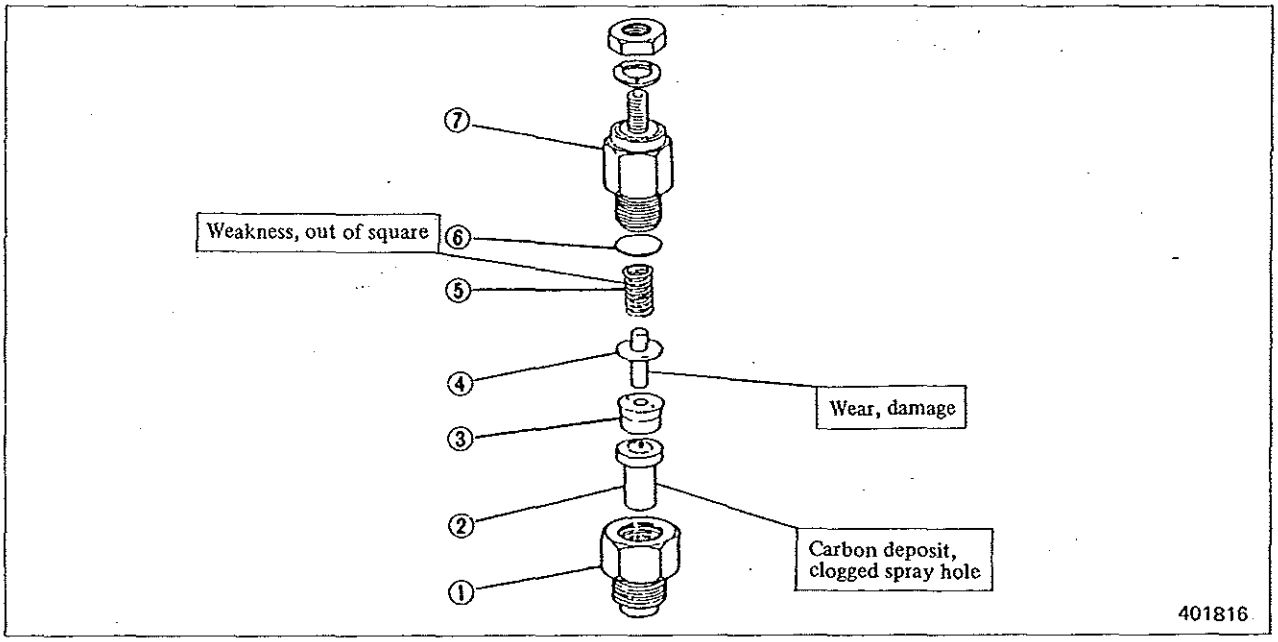
Cartridge type paper-element filter



① Element assembly ② Bracket

3 FUEL INJECTION NOZZLES

3.1 Disassembly



① Retaining nut
② Nozzle tip
③ Distance piece
④ Pressure pin
⑤ Spring
⑥ Washer
⑦ Nozzle holder

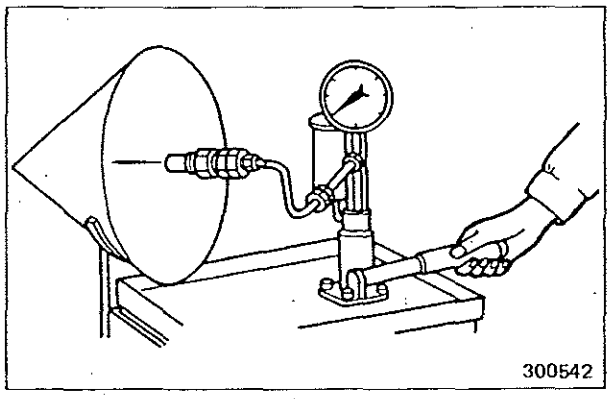
3.2 Inspection and adjustment

(1) Injection pressure

(a) Set up the nozzle on the tester. Operate the tester handle several times to prime the pipe and nozzle.

(b) Slowly operate the handle all the way up and down, completing each cycle in about a second, while observing the pressure gauge indication.

(c) As the nozzle beings to spray fuel, the needle of the gauge being deflected will start oscillating. Read the pressure right then as the injection pressure.



Testing injection nozzle

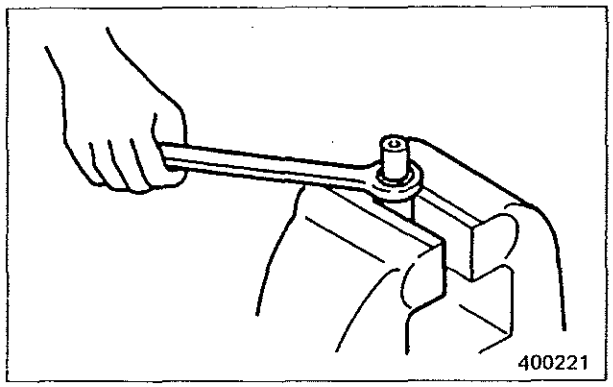
Unit: kgf/cm² (psi) [MPa]

Item	Assembly standard
Valve opening pressure	$120\ ^{+10}_{0}$ $(1706\ ^{+142}_{0})$ $[11.8\ ^{+1.0}_{0}]$

⚠ WARNING

Never expose the hand or other part of the body to fuel spray nor touch the spray hole during the test.

(d) If the pressure is out of specification, make a shim adjustment.



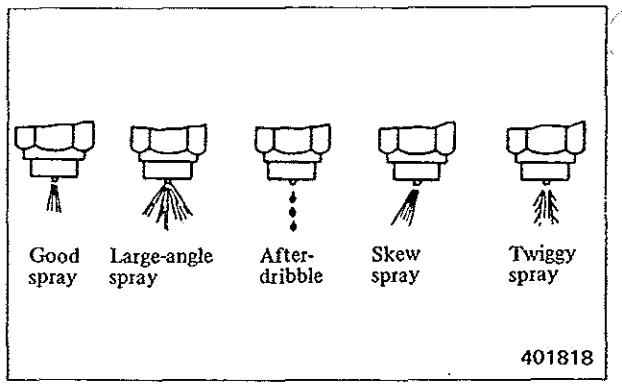
NOTE

Increasing or decreasing shim thickness by 0.1 mm (0.004 in.) raises or drops injection pressure by about 10 kgf/cm^2 (142 psi) [1.0 MPa]. Shims for this adjustment are available in 20 sizes, from 1.0 mm (0.039 in.) up to 1.95 mm (0.0768 in.) in an increment of 0.05 mm (0.0020 in.)

(2) Spray pattern

(a) At the time of testing the injection pressure, inspect each nozzle for clogged spray hole and fuel leaks from the hole. Also examine spray pattern.

(b) To test the nozzles move the tester handle at a rate of about 1 stroke per second to make sure that it sprays fuel in good straight pattern.



Spray patterns of throttle type nozzle

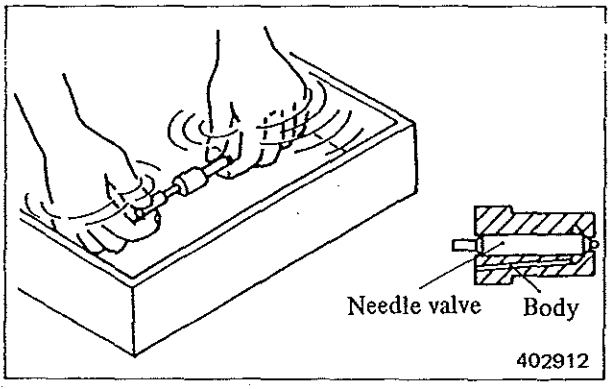
(3) Washing or replacing nozzle tip

(a) Loosen the retaining nut, and remove the nozzle tip. Wash the needle valve and body.

⚠ CAUTION

When pulling out the nozzle tip, be careful not to damage it. Never strike the nozzle tip.

(b) Wash the nozzle tip in clean gasoline. After washing, assemble the needle valve and body in clean diesel fuel.



⚠ CAUTION

The needle valve and body are finely finished. Do not change the combination or set of the valve and body.

(c) Tighten the retaining nut to the specified torque.

(d) If the spray pattern is still bad after the nozzle has been adjusted and cleaned, replace the nozzle tip.

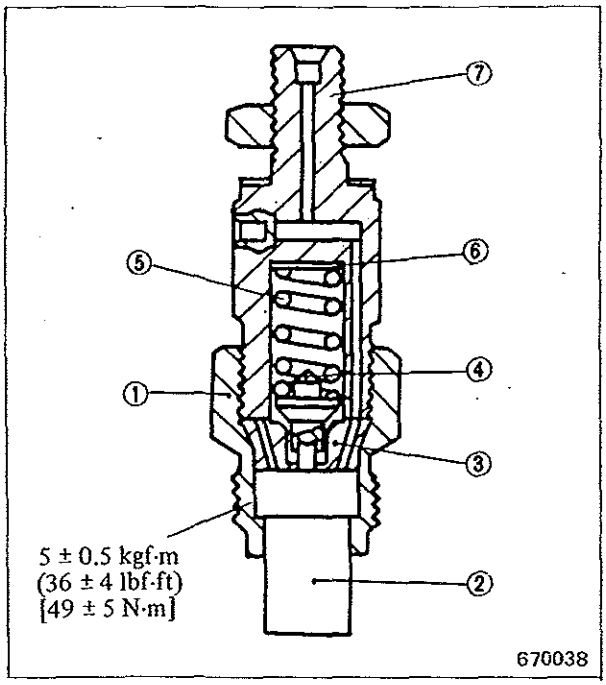
⚠ CAUTION

Never attempt to touch the sliding surface of needle valve.

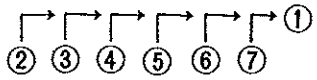
NOTE

To replace the nozzle tip, remove the sealpeel (plastic covering) and wash the new tip in clean gasoline by sliding the needle valve in the nozzle to remove the rust preventive oil completely.

3.3 Reassembly

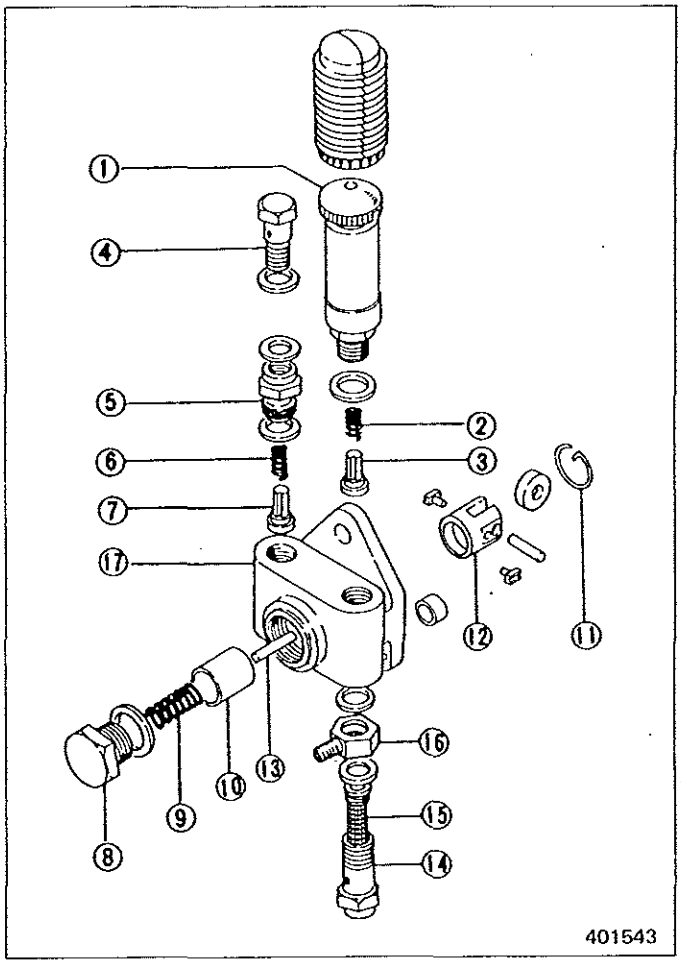


Reassembling sequence



4. FUEL FEED PUMP

4.1 Disassembly



① Priming pump
② Check valve spring
③ Check valve (inlet)
④ Hollow screw
⑤ Valve support
⑥ Check valve spring
⑦ Check valve (outlet)
⑧ Piston chamber plug
⑨ Piston spring
⑩ Piston
⑪ Ring
⑫ Tappet
⑬ Pushrod
⑭ Hollow screw
⑮ Filter gauze
⑯ Nipple
⑰ Pump housing

(Remove the parts in the order numbered for disassembly. To reassemble, follow the reverse of disassembling order.)

4.2 Inspection and adjustment

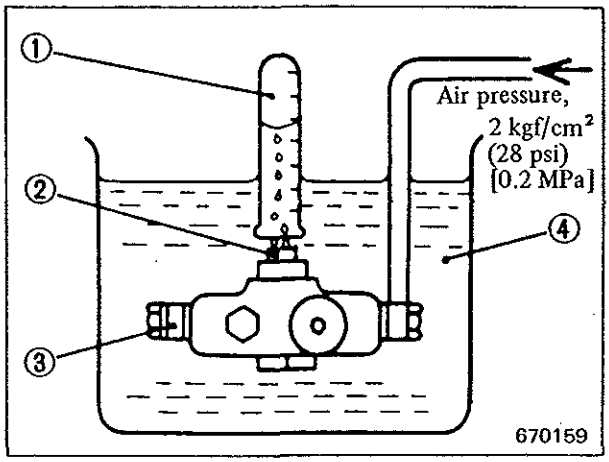
Airtightness

Immerse the feed pump in a pool of fuel, with its discharge side plugged up. Apply an air pressure of 2 kgf/cm^2 (28 psi) [0.2 MPa] to its suction to see if any bubbles come out of the pump. Some air, however, will leak out through the clearance between its pushrod and housing. The pump is sufficiently airtight if the amount of this leakage (with no leakage from any other part of the pump) is not greater than the value specified.

Specification

Item	Standard
Feed pump airtightness	Not greater than 50 cc (3.1 cu in.)/minute (with bubbles not larger than 2 mm (0.08 in.) in size) at an air pressure of 2 kgf/cm^2 (28 psi) [0.2 MPa]

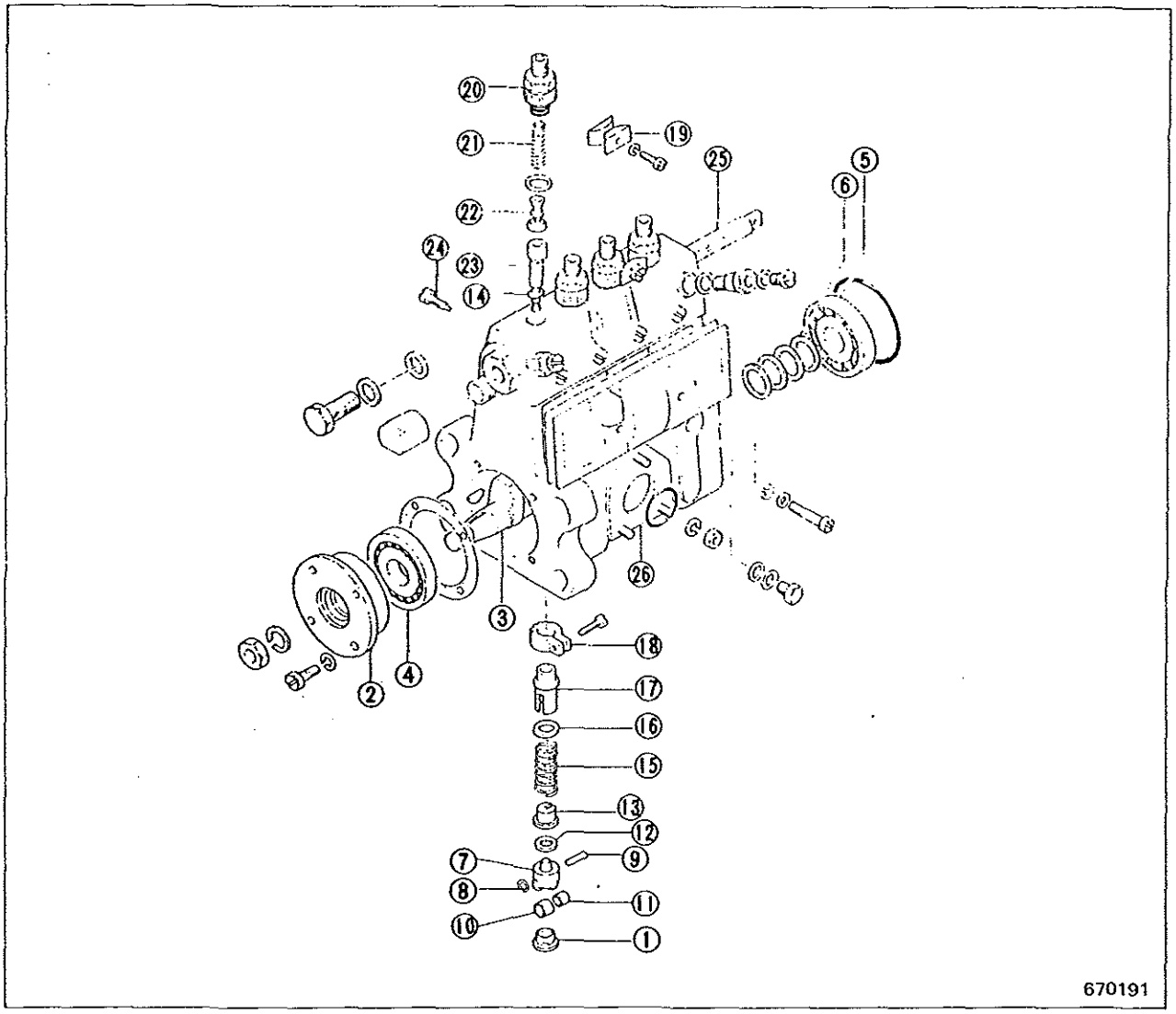
If the airtightness is poor, repair the pushrod bore in pump housing with a burnishing broach and install an oversize pushrod.



①Measuring cylinder
②Tappet
③Plug
④Diesel fuel oil

5. FUEL INJECTION PUMP

5.1 Disassembly

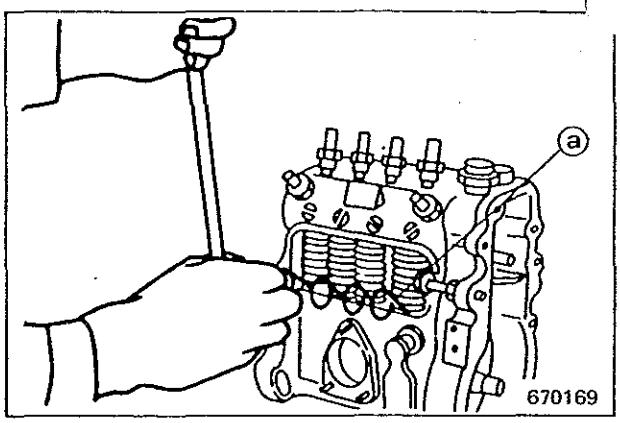


① Screw plug
② Bearing cover
③ Camshaft
④ Bearing
⑤ Bearing
⑥ Shim
⑦ Tappet
⑧ Circlip
⑨ Roller pin
⑩ Tappet roller
⑪ Roller bushing
⑫ Shim
⑬ Lower spring seat
⑭ Plunger
⑮ Plunger spring
⑯ Upper spring seat
⑰ Control sleeve
⑱ Control pinion
⑲ Lock plate
⑳ Delivery valve holder
㉑ Delivery valve spring
㉒ Delivery valve
㉓ Pump cylinder
㉔ Rack guide screw
㉕ Control rack
㉖ Pump body

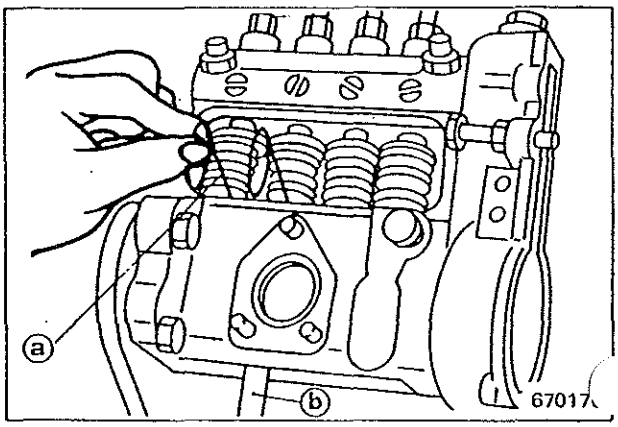
Fuel injection pump - Disassembled view

(Remove the parts in the order numbered for disassembly.)

(1) To remove camshaft (3), turn the camshaft by hand to raise each tappet (7) to its top dead center, and insert tappet insert (a) into tappet hole to make each tappet free of cam.



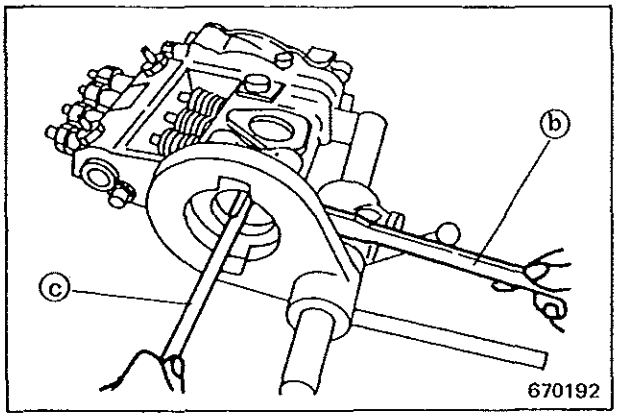
(2) To remove tappet insert (a), insert roller clamp (b) through the screw plug hole to pinch the tappet roller (10), give a push to tappet (7), and remove the tappet insert.



(3) To remove tappet (7), insert the tappet clamp (c) through bearing hole to pinch the tappet, take off the roller clamp (b), and remove the tappet.

NOTE

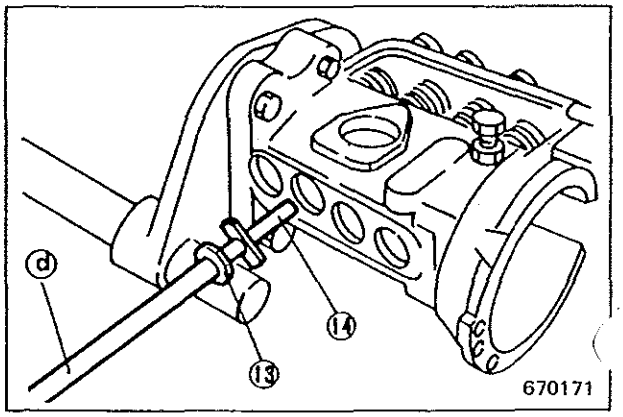
Tilt down the top (delivery valve holder side) of the pump so that the plungers and springs will not come off.



(4) To remove plunger (14), pinch the lower portion of the plunger with plunger clamp (d), and draw out the plunger together with its lower spring seat (13).

⚠ CAUTION

When removing the plunger, be careful not to scratch the plunger: pull the plunger straight out.

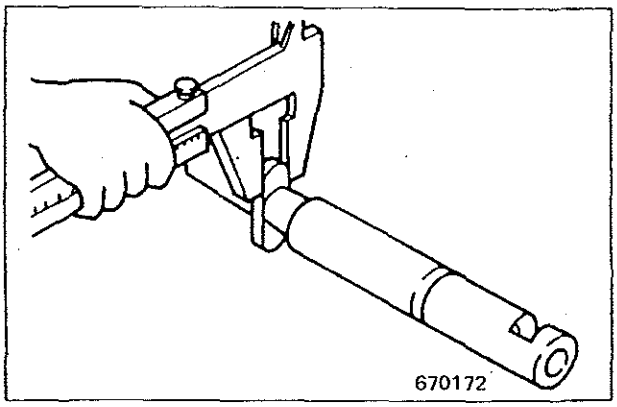


5.2 Inspection

(1) Measure the width of plunger flange. If this flange is worn down to exceed the assembly standard, replace the pump element assembly (plunger and barrel).

Unit: mm (in.)

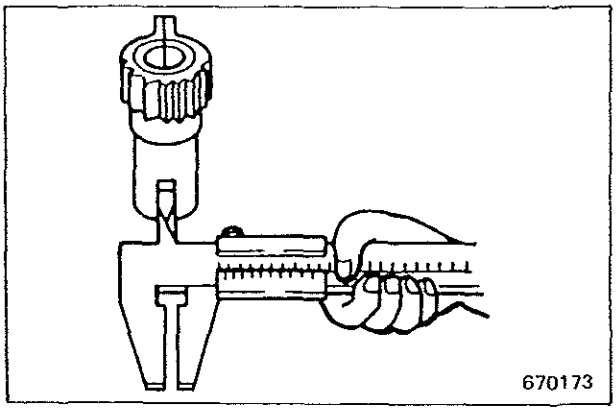
Item	Assembly standard
Width of pump element plunger flange	$7\ ^{-0.05}_{0}$ ($0.2756\ ^{-0.0020}_{0}$)



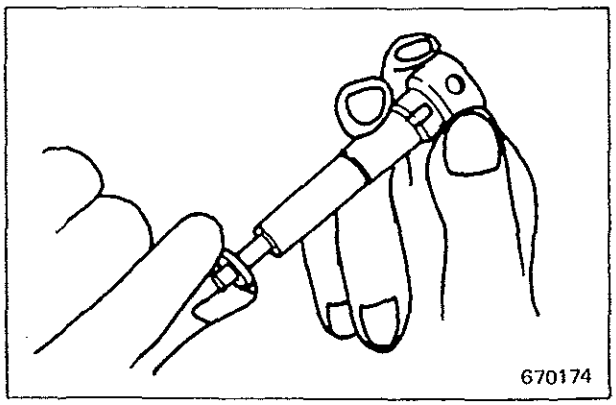
(2) Measure the width of the slot provided in the control sleeve. If this slot is worn down to exceed the assembly standard, replace the sleeve.

Unit: mm (in.)

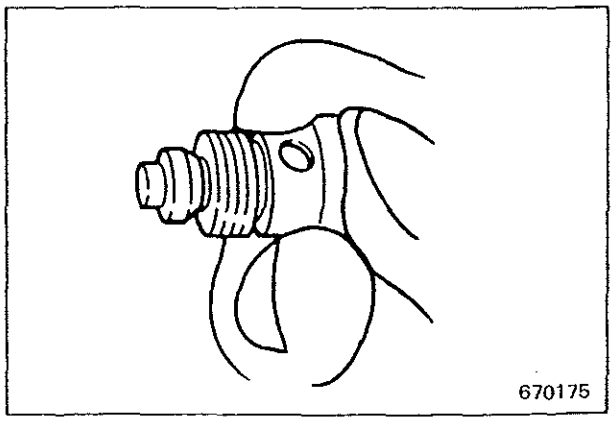
Item	Assembly standard
Width of control sleeve slot	$7.02\ ^{+0.1}_{0}$ ($0.2764\ ^{+0.004}_{0}$)



(3) Pull out the plunger from the barrel about two-thirds of the way, while holding the barrel horizontal; then angle up the barrel slowly by about 60°. This should cause the plunger to slide out all the way by its own weight to evidence a proper fit. If the plunger goes outward in a free-falling manner or becomes stuck on the way, then the pump element assembly must be replaced.



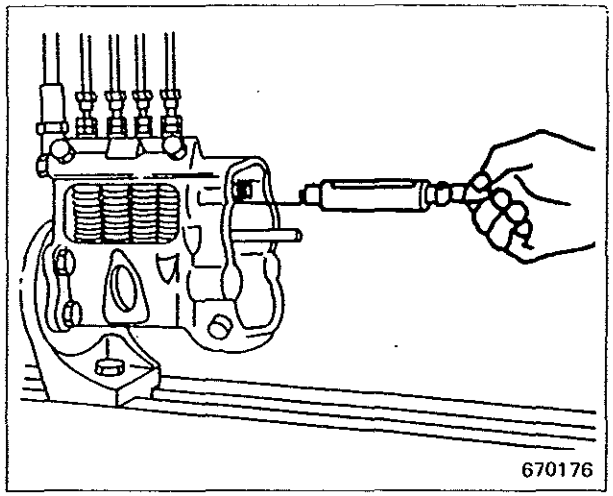
(4) Pull up the delivery valve piston, cover the bottom of the valve seat with thumb as shown and give finger pressure to the piston on its top lightly. If piston is not worn down, it should be pushed back when finger pressure is relieved. If it is seated without responding to the finger pressure relieved, it is worn down excessively.



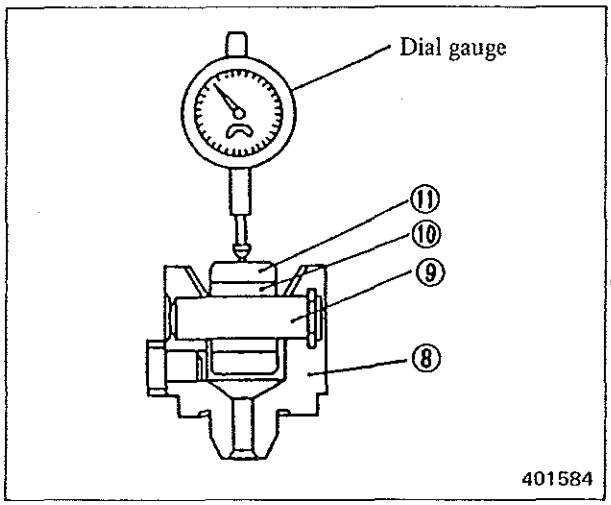
(5) Using a spring balance, check the force necessary to set the control rack in sliding motion. Repair or replace the control rack if it offers a resistance requiring a greater force to overcome than the assembly standard.

Unit: gf (ozf) [N]

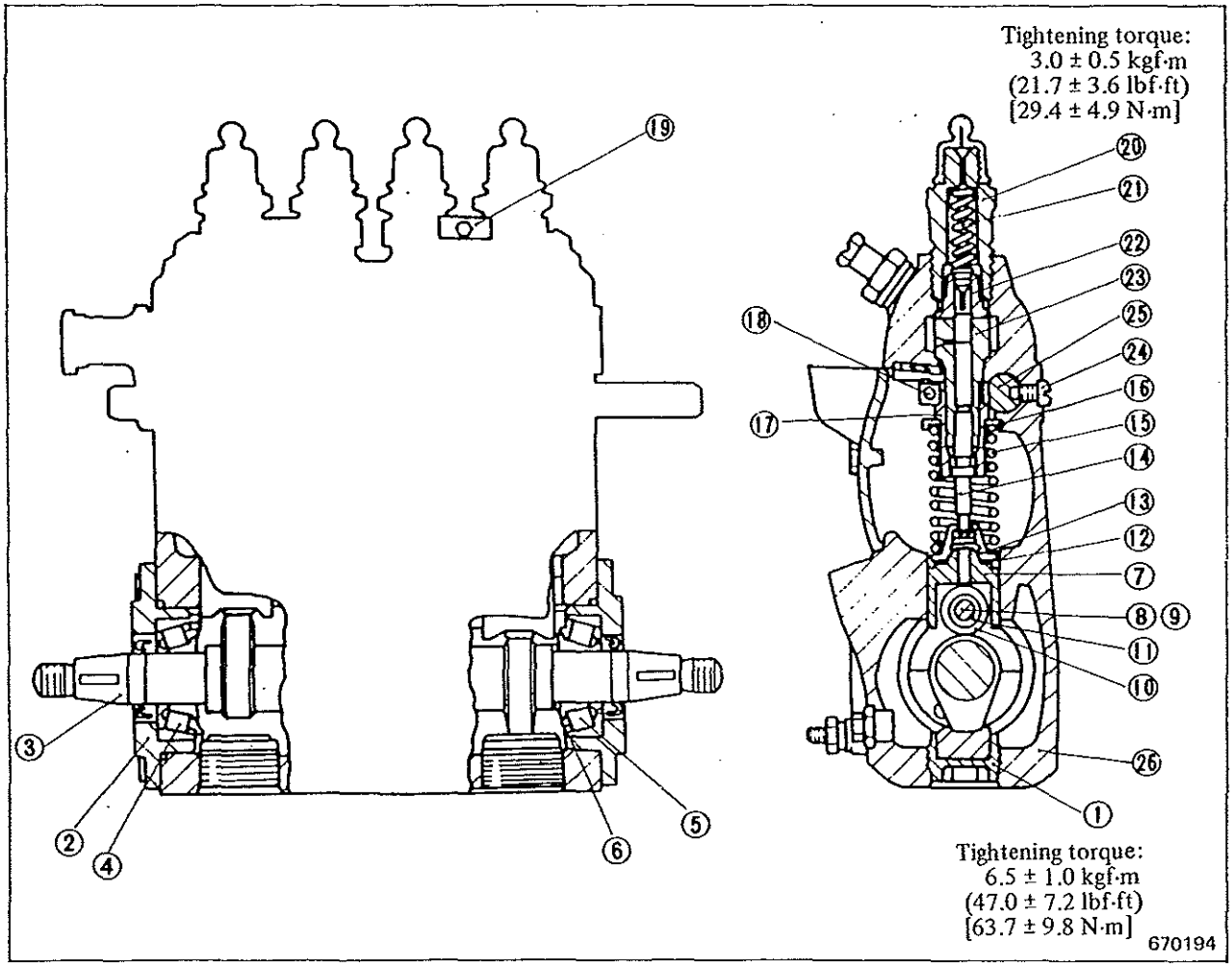
Item	Assembly standard
Sliding resistance of control rack	Not more than 120 (4.2) [1.2] as starting pull



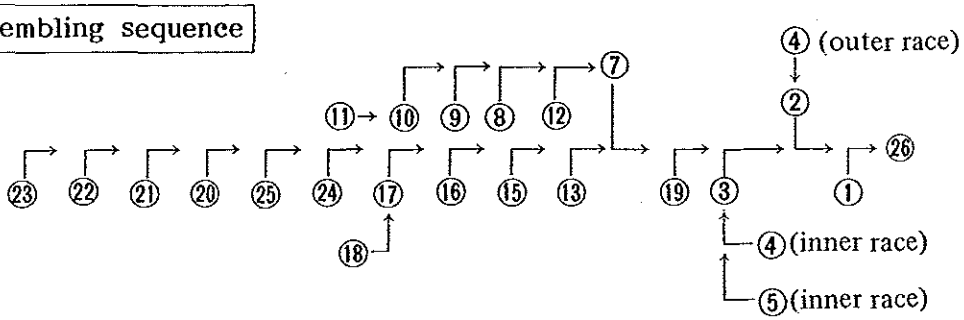
(6) Measure the overall radial play of tappet roller (10), roller bushing (11) and pin (9) with a dial gauge as shown. If it exceeds the assembly standard, replace the whole tappet sub-assembly (8).



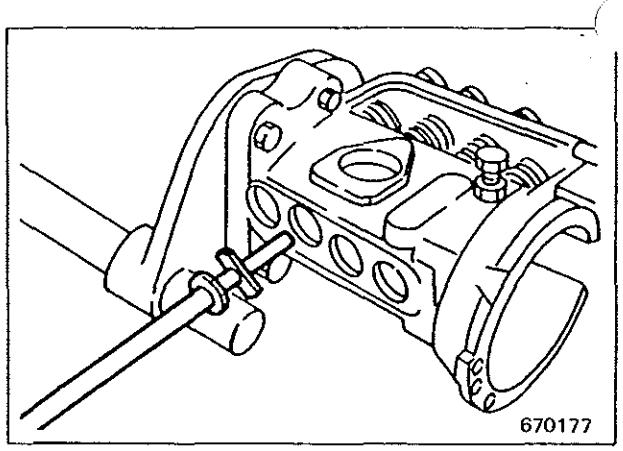
5.3 Reassembly



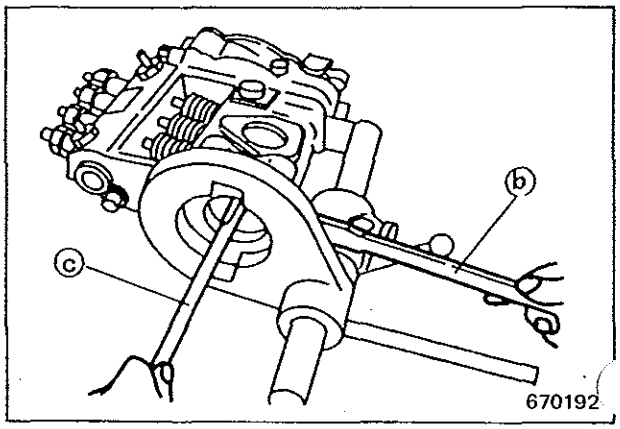
Reassembling sequence



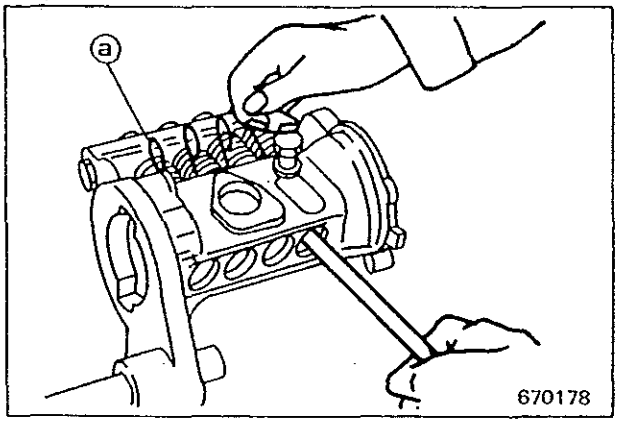
(1) When installing plunger (14), position it with the stamped figure on its driving face coming on top (cover plate side). If reversed, its lead and feed hole are not aligned and it cannot control fuel injection quantity.



(2) To install tappet (7), pick up the tappet with tappet clamp (c), feed the tappet into the camshaft chamber, and insert it into the bore with roller clamp (b).



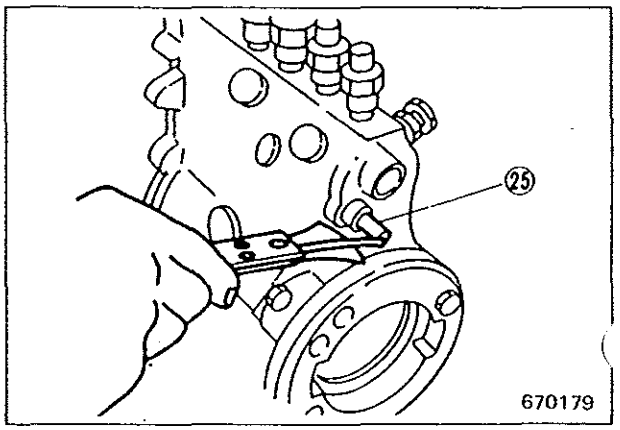
(3) To install camshaft (3), match the driving face of plunger and the slot in pump cylinder, push the tappets, and hold them with tappet inserts (a).



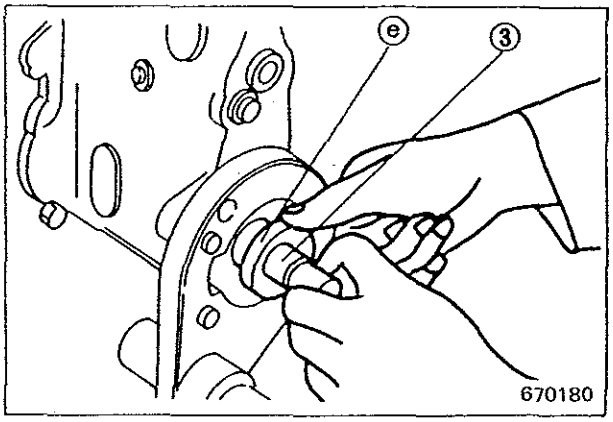
NOTE

Each time when the above step is completed on one cylinder, check the control rack if it slides smoothly.

(4) Check the sliding resistance of control rack (25). The rack is required to slide with a push or pull of not greater than 120 gf (4.2 ozf) [1.2 N].



(5) Install the governor housing temporarily, and check the axial play of camshaft (3) by using camshaft clearance gauge (e).



Unit: mm (in.)

Assembly standard	0.03 – 0.05 (0.0012 – 0.0020)

If the play noted is off the assembly standard indicated above, reduce or increase it by shimming: shim stock for this purpose is available in six thicknesses, 0.10 mm (0.0039 in.), 0.12 mm (0.0047 in.), 0.14 mm (0.0055 in.), 0.16 mm (0.0063 in.), 0.18 mm (0.0071 in.) and 0.50 mm (0.0197 in.).

NOTE

So that the camshaft will not be so displaced by shimming to one side as to offset the cams from the tappets, try to use equal amounts of shim on both sides.

5.4 Testing and adjustment

o Control rack sliding resistance test

o Injection timing adjustment

a. Pre-stroke adjustment

b. Checking and adjusting the angular position of the beginning of injection

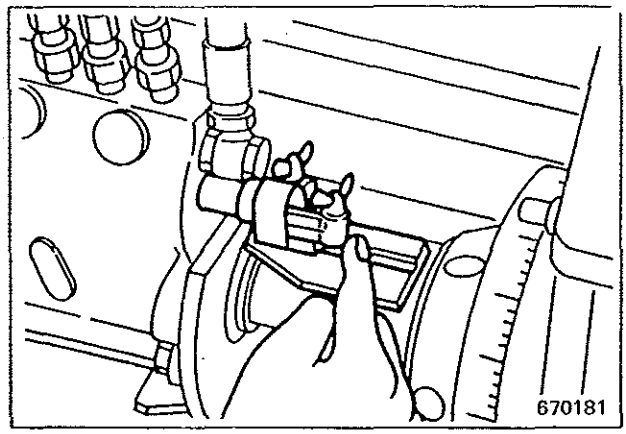
c. Tappet clearance measurement

o Injection quantity adjustment

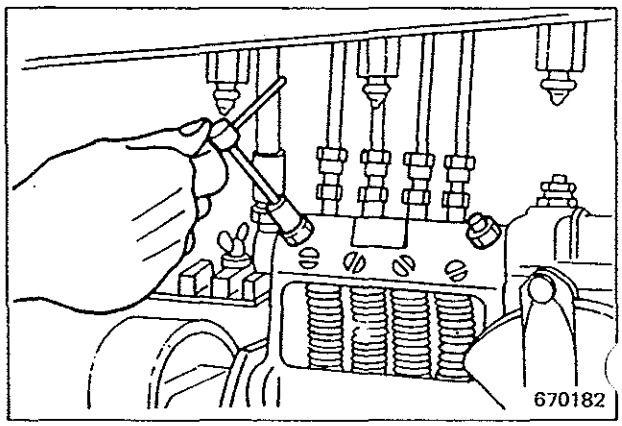
Before installing the reassembled fuel injection pump to the engine, be sure, in addition to the above tests, to carry out required tests on the governor, too.

(1) Preparation

(a) Attach the rack position measure. Remove from the governor these parts: maximum speed stopper, stop adjusting screw, idling spring, torque spring and adaptor spring. Push in the control rack toward the governor side as far as it will go, and set the rack position measure at the starting position (zero mm).



(b) Bleed air out of the injection pump, as follows:
First, move the selector lever of the pump tester into "injection quantity" position and turn on the motor switch to start up the motor.
Next, produce the prescribed delivery pressure by means of the pressure adjusting valve. Loosen the air bleeder screw on the pump to let out the trapped air, if any.

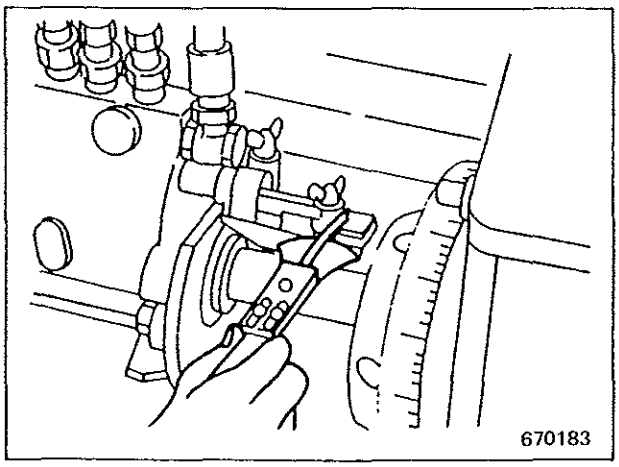


NOTE

It is not necessary to "run" the pump in order to bleed air out.

(2) Control rack sliding resistance test

Run the pump at 1000 rpm and measure the resistance with the hand spring balance. The control rack should be capable of sliding without offering any resistance greater than 50 gf (1.8 ozf) [0.5 N].



(3) Injection timing adjustment

(a) Pre-stroke adjustment
Loosen the nozzle holder overflow valve; move the selector lever of the tester to "injection timing" position; and start running the high-pressure pump of the tester by engaging the clutch; and, with the tappet clearance measuring device securely installed, turn the camshaft to bring No. 1 plunger to bottom dead center (lowest) position.

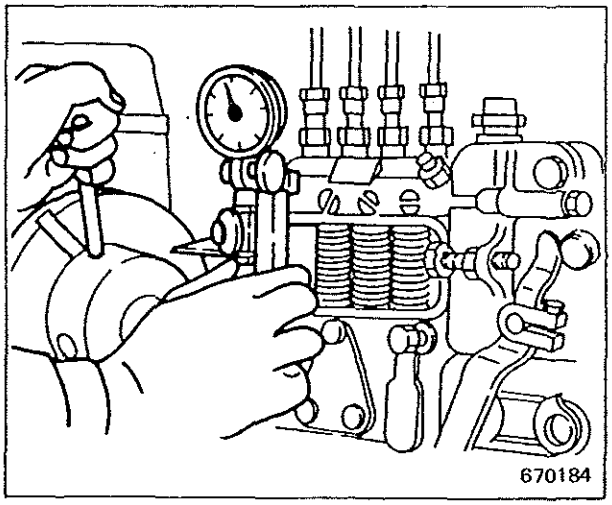
From this position of camshaft, rotate it gently in normal direction to raise the tappet (and hence the plunger). In the meantime, fuel will be overflowing. Stop turning the camshaft just when the fuel ceases to overflow, and read the distance traversed by the tappet from its lowest position.

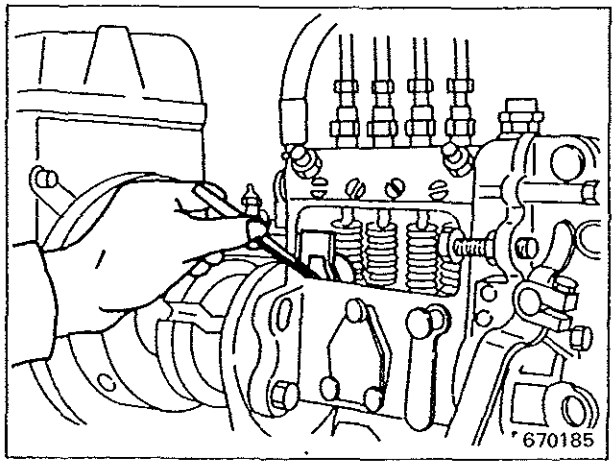
Unit: mm (in.)

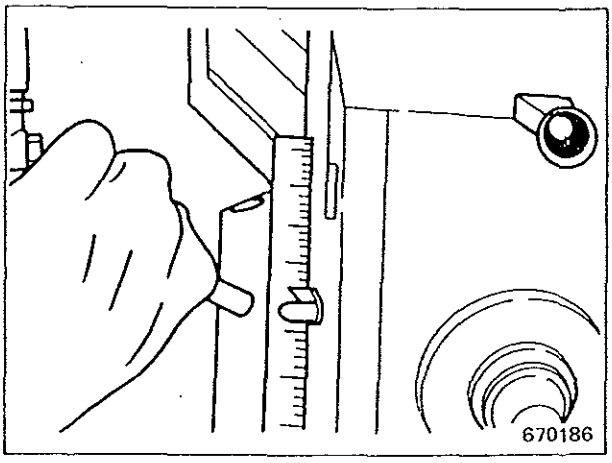
Item	Standard
Pre-stroke	1.9 – 2.0 (0.075 – 0.079)

If the pre-stroke is out of standard, bring the tappet to its top dead center position, insert spring holder into between the lower spring seat and tappet, and turn the camshaft in normal direction. Now there will be a clearance between the spring seat and tappet. Vary the thickness of shim plates by utilizing this clearance to adjust the pre-stroke.

(b) Checking and adjusting the angular position of the beginning of injection
The end of pre-stroke corresponds to the beginning of injection: the plunger begins to pressurize the fuel in the barrel when it has just closed the feed hole.





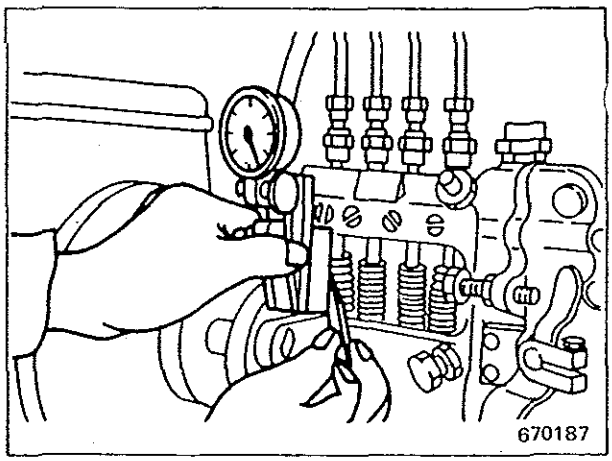


Take the position of No. 1 plunger at its beginning of injection as the reference angular position (0 deg.), and check the angular position at which each of the rest of the plunger begins to inject. Make sure that the beginning of injection comes within the 1 deg. tolerance of the angular value prescribed:

Cylinder No.	1	3	4	2
Angular position of beginning of injection	0	89°30′ – 90°30′	179°30′ – 180°30′	269°30′ – 270°30′

If the angular position is out of the prescribed range, adjust it by shimming as in (a) Pre-stroke adjustment.

(c) Tappet clearance measurement
Turn the camshaft and bring the tappet to its top dead center position. Keeping the tappet in this position, lever up the tappet with a screwdriver and measure the clearance.



Unit: mm (in.)

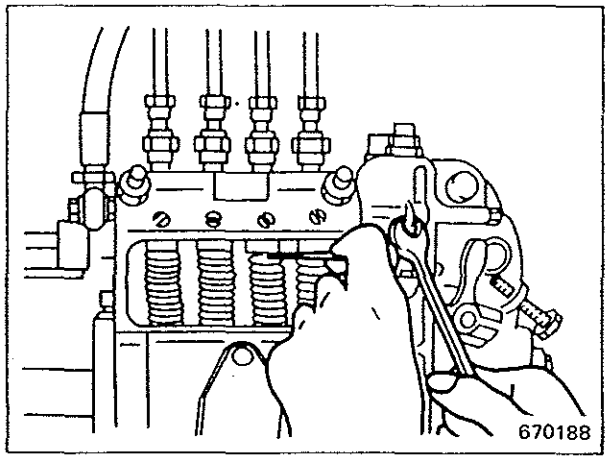
Item	Standard
Tappet clearance	0.2 (0.008), min.

This clearance is prescribed to be not less than the value specified above, and normally should not require any adjustment. Thus, the purpose of this measurement just for making sure that some clearance greater than the specified minimum is available.

If the reading happens to be less than the minimum, increase it by means of the tappet adjusting bolt, without causing the injection timing (beginning of injection) to deviate from the 1-deg. tolerance. Increasing the tappet clearance will increase the pre-stroke: be sure not to exceed the upper limit [2.0 mm (0.0787 in.)].

(4) Measurement of injection quantity

The injection quantity varies according to the position of the control rack and the pump rpm. The injection quantity should be measured under the conditions where the pump is set to a certain rpm.



(a) Attach the injection pump on the tester and connect the injection pipes to the tester. Remove the control rack cover. Attach the rack position measuring device in place.

(b) Bleed air from the fuel system by operating the tester handle.

(c) Keep the fuel supply pressure at 2.0 kgf/cm^2 (28.4 psi) [0.2 MPa] on tester gauge, run the injection pump at the specified speed by the tester, keep the control rack at the standard position, and measure the injection quantity by a measuring cylinder for each pump element.

Adjust it to bring its injection quantity into the specified range.

NOTE

For specified injection quantity, refer to the Maintenance standards.

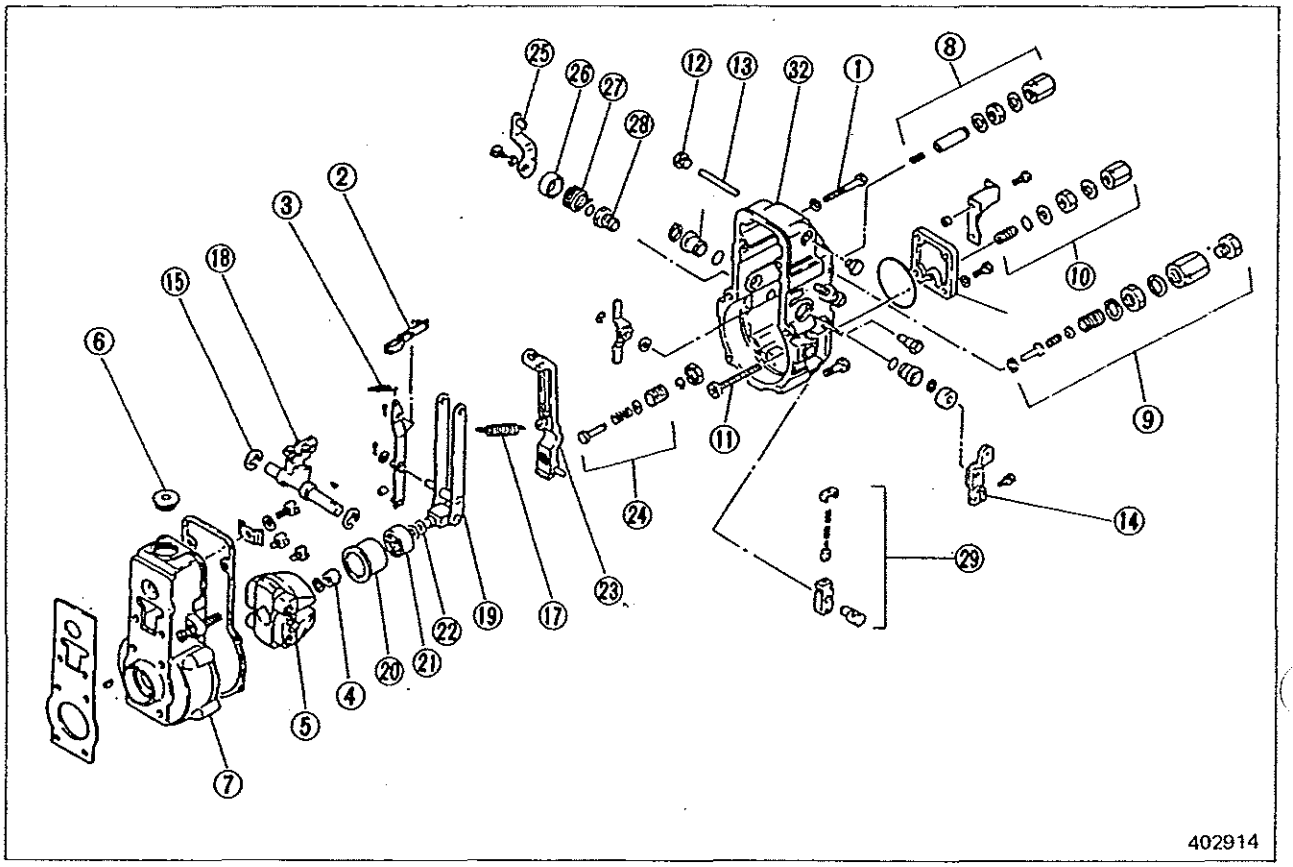
If injection quantity of any cylinder is out of the specified range, adjust it by loosening the pinion clamp screw and slightly turning the control sleeve.

Turning the control sleeve toward the governor side will increase the injection quantity, and vice versa.

After adjustment, be sure to tighten the clamp screw on the pinion.

6. RSV GOVERNOR

6.1 Disassembly

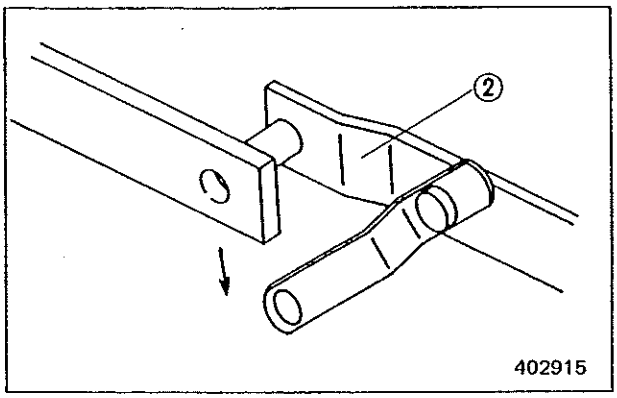


① Bolt
② Shackle
③ Start spring
④ Round nut
⑤ Flyweight
⑥ Screw plug
⑦ Governor housing
⑧ Adjusting screw set
⑨ Adjusting screw set
⑩ Adjusting nut set
⑪ Full-load stopper
⑫ Screw plug
⑬ Lever supporting shaft
⑭ Adjusting lever
⑮ Snap ring
⑯ Lever bushing
⑰ Control spring
⑱ Swiveling lever
⑲ Guide lever
⑳ Sleeve
㉑ Ball bearing
㉒ Plate washer
㉓ Tension lever
㉔ Adjusting set assembly
㉕ Stop lever
㉖ Spring cover
㉗ Return spring
㉘ Bearing bushing
㉙ Governor shaft assembly
㉚ Control lever
㉛ Cover plate
㉜ Governor cover

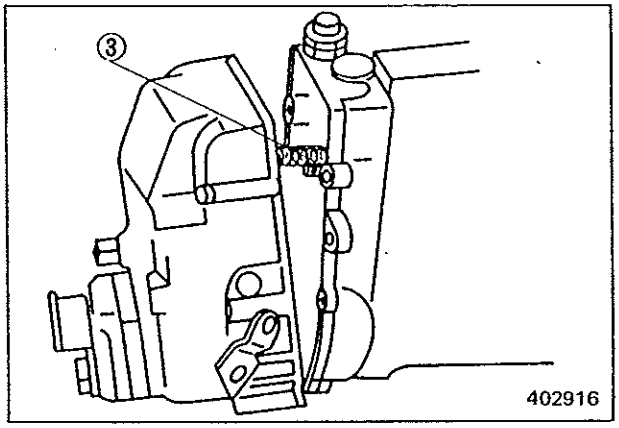
Governor - Disassembled view

(Remove the parts in the order numbered for disassembly.)

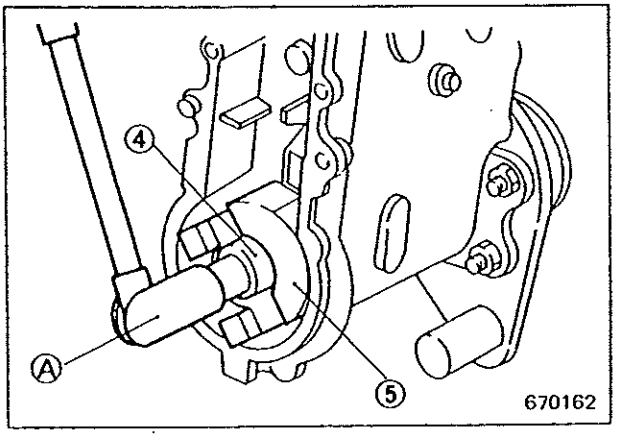
(1) Detach the cover by pulling it a little backward. Insert the screwdriver, move the shackle clasp downward with the tip of screwdriver and undo the pinned connection between control rack and shackle (2).



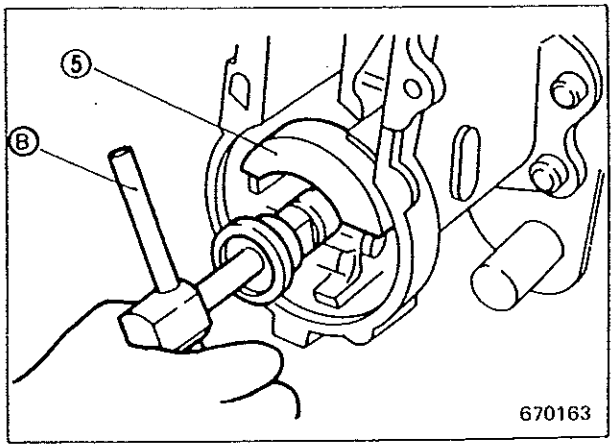
(2) Unhook the start spring (3). Remove the governor cover complete with the lever mechanism.



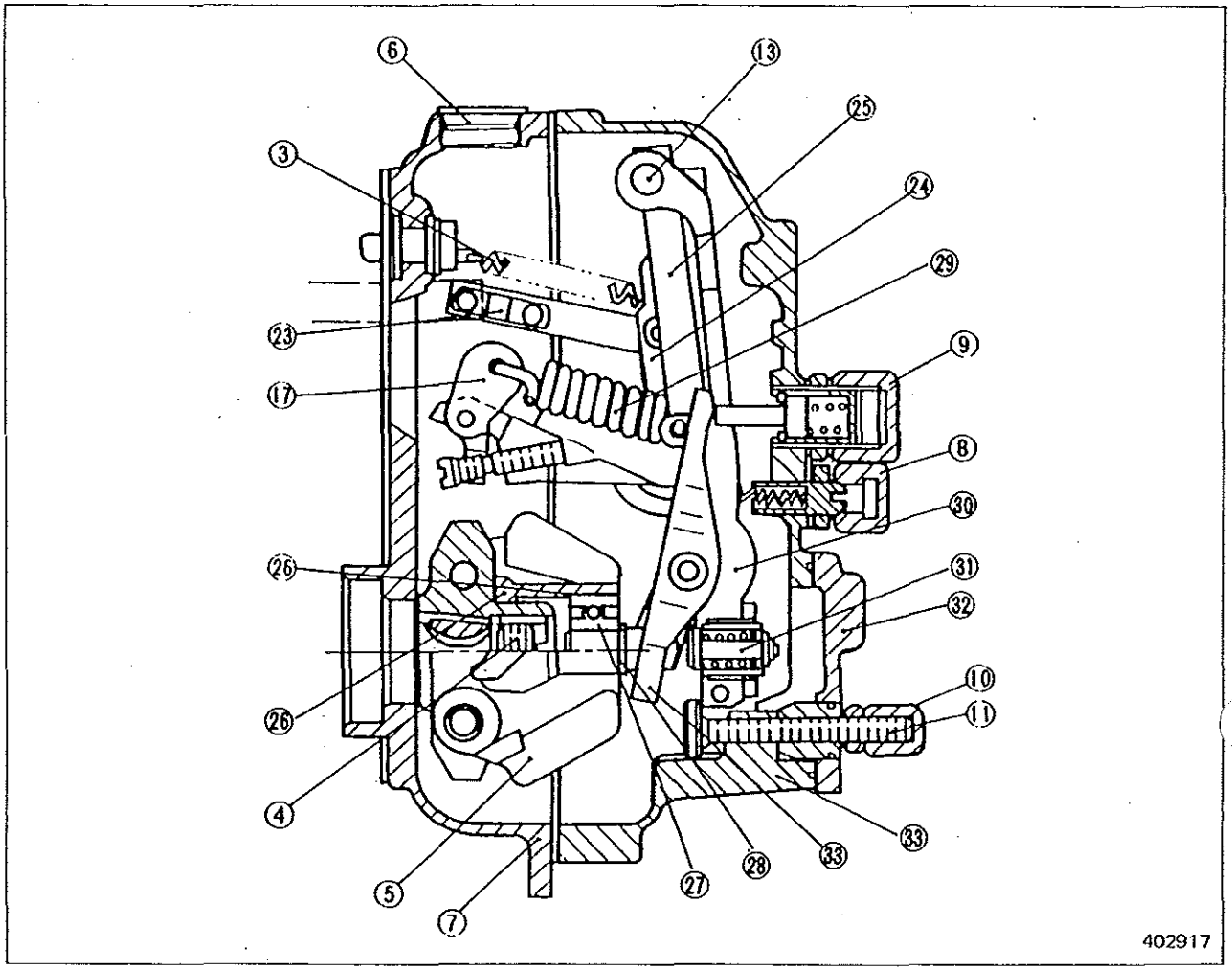
(3) Remove round nut (4) securing flyweight (5) by loosening it with round nut wrench (A).



(4) Run the flyweight extractor (B) into the threaded hole, as shown, and force the flyweights (5) off the camshaft by jacking action.



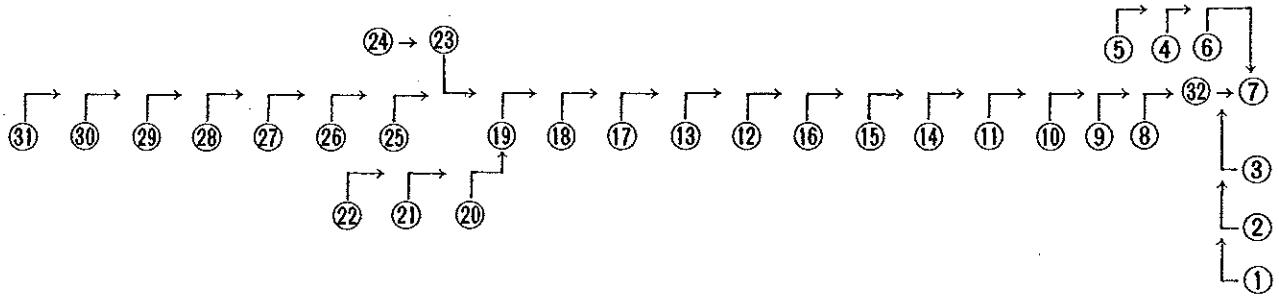
6.2 Reassembly



Governor - Sectional view

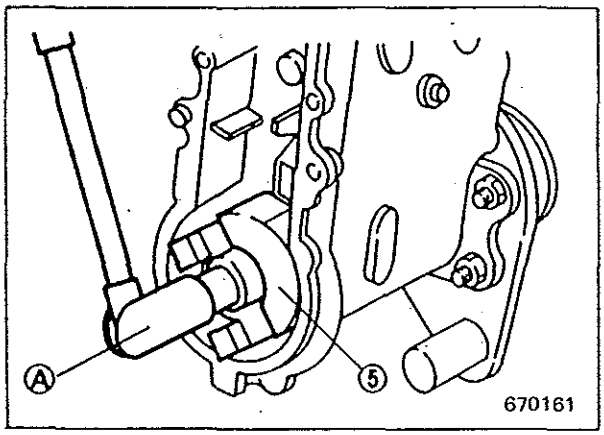
(For the parts not numbered, refer to the disassembled view.)

Reassembling sequence

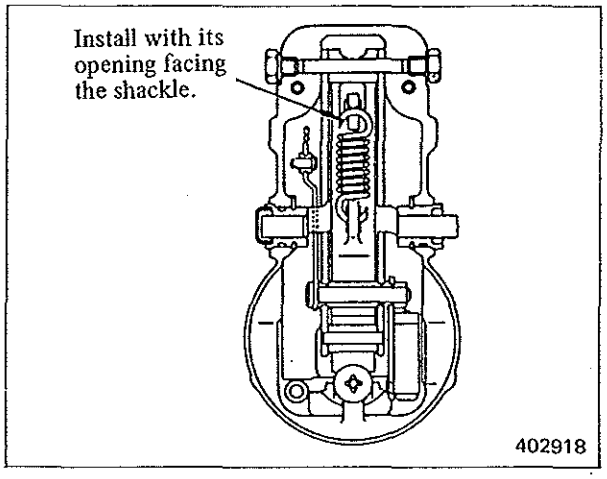


(1) After positioning the flyweights (5) on camshaft, secure it by tightening the round nut to the specified torque with round nut wrench (A).

Tightening torque	5 – 6 kgf·m (36 – 43 lbf·ft) [49 – 59 N·m]



(2) Install the control spring with its opening facing the shackle.



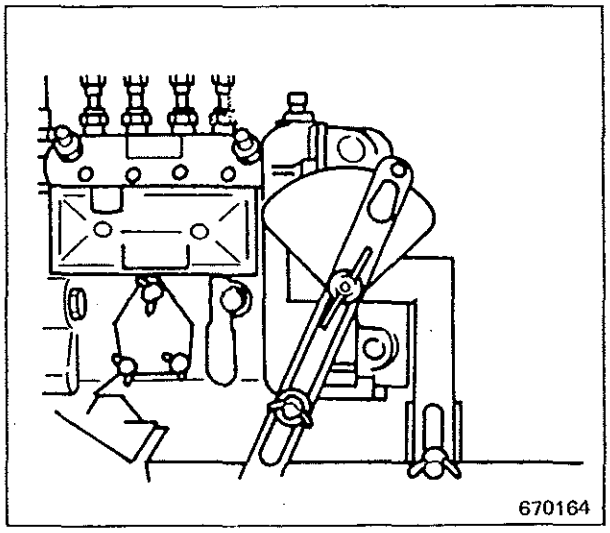
6.3 Testing and adjustment

After assembling the governor properly, the adjustments described below should be effected on the test bench.

(1) Fuel injection pump injection quantity adjustment

Before adjusting the governor, be sure to carry out the required injection timing and injection quantity adjustments on the fuel injection pump.

For the adjustments, refer to 5.4 Testing and adjustment, Fuel Injection Pump.



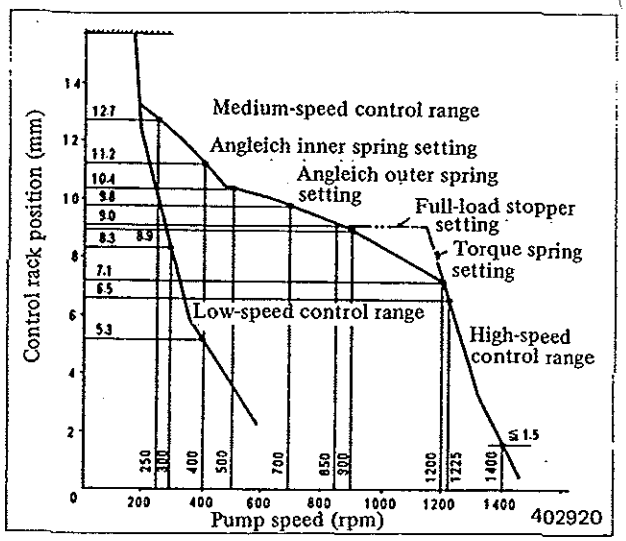
(2) Governor adjustments

After checking the governor for the various linkage and sliding part conditions, make the following adjustments in that order.

1 Medium-speed control adjustment
2 Angleich control adjustment
3 Low-speed control adjustment
4 High-speed control adjustment
5 Torque spring setting
6 Matching to engine

(a) Install the angular scale plate (protractor) on the governor housing to read the angular position of the adjusting lever.

(b) Carry out each adjustment in reference to the characteristic curves.



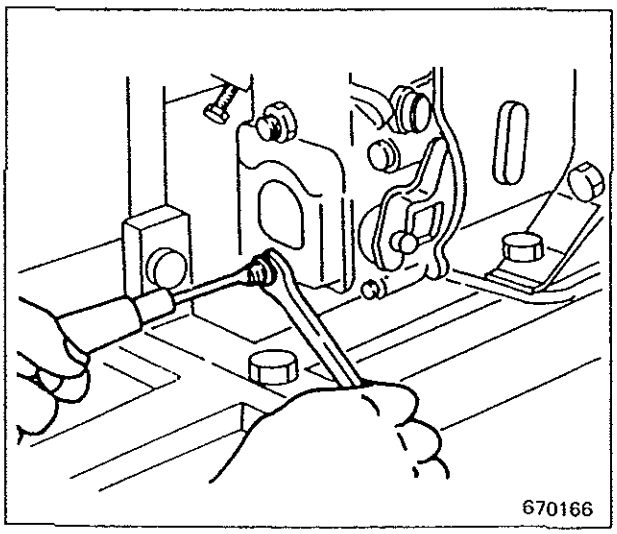
Governor characteristic curves

Medium-speed control adjustment

Setting the full-load stopper

Run the injection pump at the speed corresponding to "Nc," turn the adjusting lever to give the control spring a fairly tight tension, and secure the adjusting lever there temporarily. Turn the full-load stopper with the screwdriver until the rack comes to the position corresponding to "Rc," and secure the stopper there with lock nut. Turning the full-load stopper clockwise as seen from the rear of the governor increases the rack position, and turning it counterclockwise decreases the rack position.

Nc (rpm)	Rc (mm)
850	9.0



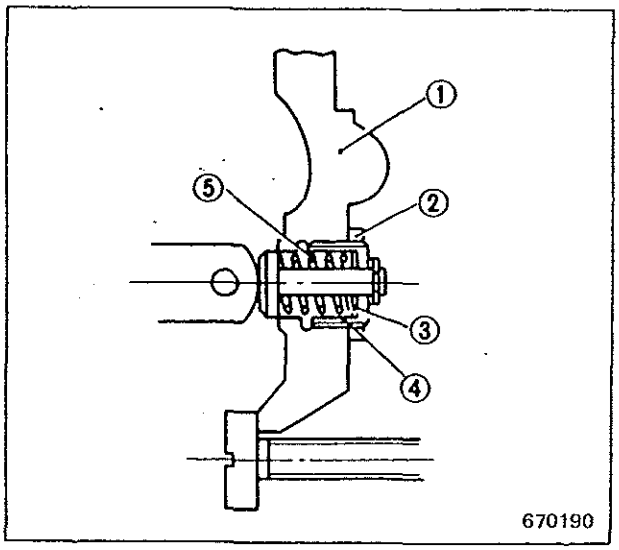
Angleich control adjustment

For the governor with the adaptor spring, adjust it as follows:

(1) Move the adjusting lever to make it bear against the maximum-speed stopper, and secure it there, and install the adaptor complete to the lower portion of the tension lever.

(2) Raise the pump speed from "Na" to "Nd." This should move the control rack from "Ra" to "Rd"; if not, tighten or loosen adaptor screw (4). The rack movement from "Ra" to "Rd" corresponds to the amount of compression of adaptor spring (5), which is referred to as "adaptor stroke." Tightening (or driving inward) adaptor screw (4) elongates this spring to increase the stroke, and vice versa.

(3) Run the pump at "Na." This should move the control rack to "Ra"; if not, change the thickness of shim plate (3) indicated in this illustration (preload adjustment of adaptor spring).

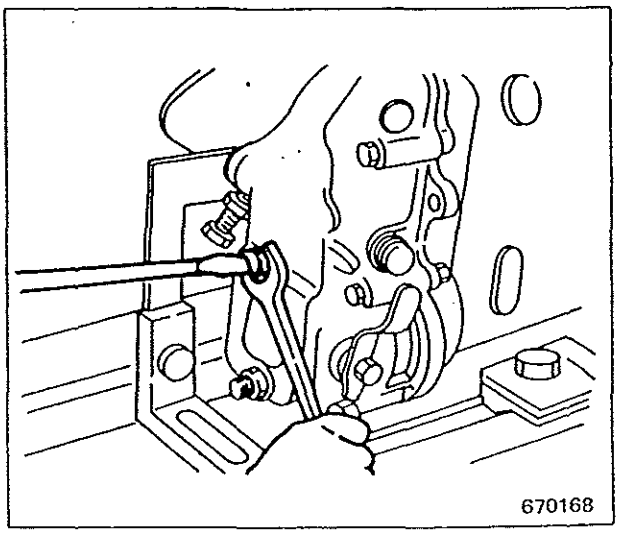


①Tension lever
②Lock nut
③Shim plate
④Adaptor screw
⑤Adaptor spring

	Na (rpm)	Ra (mm)	Nd (rpm)	Rd (mm)
Inner spring	250	12.7	400	11.2
Outer spring	500	10.4	700	9.8

Low-speed control adjustment

(1) Run the pump at "Ni," with the adjusting lever bearing against the maximum-speed stopper; turn back the adjusting lever until the control rack comes to "Ri"; and secure the adjusting lever there.



(2) Lower the speed, and make sure that the control rack is at above "Rg" when pump speed is at "Ng."

(3) After completing the foregoing adjustments, stop running the pump and turn the adjusting lever all the way in the stopping direction and turn the stop adjusting screw until the control rack comes to 1 mm (0.0394 in.) position. Set the stop adjusting screw to limit the stopping end of adjusting lever stroke, and secure the screw by tightening its lock nut.

Ni (rpm)	Ri (mm)	Ng (rpm)	Rg (mm)
300	8.3	200	11

High-speed control adjustment

(1) Setting the maximum-speed stopper

Turn back the adjusting lever to determine the maximum speed to be controled by the governor. The maximum speed stopper sets this position of the adjusting lever. Slowly raise the speed from "Nc." Upon locating that position of adjusting lever at which the control rack begins to move in from "Re" at "Ne" speed, bring the maximum-speed stopper into contact with the lever, thereby setting the maximum-speed position of adjusting lever. Secure the stopper there with lock nut.

(2) Speed regulation adjustment

What "speed regulation" signifies was explained previously: it refers to the difference between two governed speeds: no-load speed and full-load speed for a given position of the adjusting lever. It is expressed as a percentage of full-load speed:

Speed regulation

$$= \frac{Nh - Ng}{Ng} \times 100 \ (\%)$$

Nh = No-load maximum speed at a certain position of the adjusting lever

Ng = Full-load maximum speed at the same position of the adjusting lever

As an example, where full-load maximum speed is 1300 rpm and no-load maximum speed is 1360 rpm,

Speed regulation

$$= \frac{1360 - 1300}{1300} \times 100 = 4.6\ (\%)$$

Generally speaking, the smaller the speed regulation, the better is the engine control; but some regulation is necessary for the sake of running stability and the smallest regulation for the type of all-speed governor as the present one is limited by the governor mechanism. Moreover, each engine runs best when the governor is set to provide the regulation specified for the engine.

For the maximum speed position of adjusting lever, speed regulation is represented by that portion of the characteristic curve from point "Re" to point "Rf" for the differential speed from "Ne" to "Nf."

In the present governor, the regulation can be changed by means of the adjusting screw provided in the swiveling lever. Tightening this screw increases the tension of control spring to reduces the value of regulation, and vice versa.

"X" in the standard adjustment data in the Maintenance standards means the number of rotations of the adjusting screw to be turned back from the fully driven position.

"X=1" is the position of the adjusting screw turned back one (1) rotation. Four notches of this screw correspond to one (1) rotation.

Nc (rpm)	Re (mm)	Ne (rpm)	Nf (rpm)	Rf (mm)
850	7.1	1200	1225	6.5

⚠ CAUTION

Never back away the screw by more than 24 notches (6 rotations), or the threaded engagement of the screw will be so small as to invite a hazardous condition.

(3) Re-adjustment of maximum-speed stopper setting

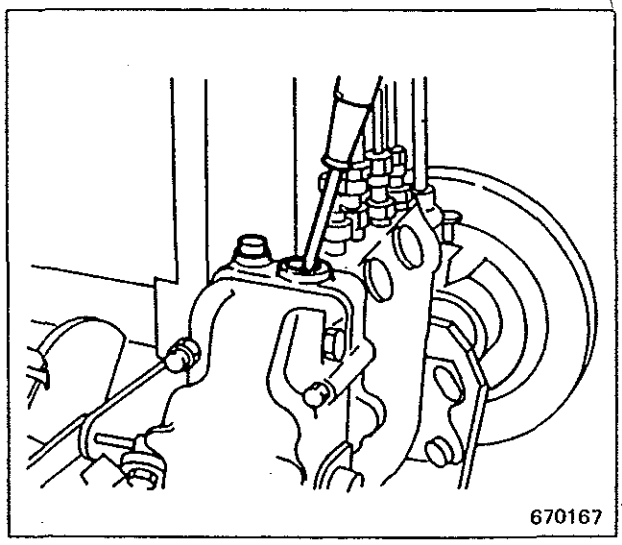
Changing the speed regulation by tightening or loosening the adjusting screw is, in substance, changing the tension of the control spring. For this reason, after each repositioning of the adjusting screw, the positin of maximum-speed stopper for determining "Ne" must be changed to raise or lower "Ne" to a proper level by repeating the process described in (1) above.

NOTE

In the table of standard adjustment data, the angular position of the adjusting lever assumes that 40° is vertical. Turning the adjusting lever from this position to the maximum-speed stopper side increases degree and vice versa.

Matching the pump to the engine

After adjusting the governor according to the procedures set forth above, check the injection quantity by running the injection pump at the same angular position of the adjusting lever as that for the high-speed control according to the standard adjustment data. Use a 100-cm^3 (6.1-cu in.) measuring cylinder to receive and collect the fuel delivered by the four pumping elements.



7. MAINTENANCE STANDARDS

7.1 Maintenance standards

Group		Inspection point	Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Fuel system	Injection nozzles	Valve opening pressure kgf/cm² (psi) [MPa]	120 (1706) [11.8]	0 – +10 (0 – +142) [0 – +1.0]			Make shim adjustment. Pressure varies by 10 kgf/cm² (142 psi) [1.0 MPa] per 0.1 mm (0.004 in.) thickness of shim.
		Spray angle	0°				Test by means of hand tester, using diesel fuel, at 20°C (68°F). If spray pattern is poor even after nozzle is washed in clean diesel fuel, replace nozzle tip.
		Oil-tightness of needle valve seat	Seat shall hold a test pressure 20 kgf/cm² (284 psi) [2.0 MPa] lower than valve opening pressure for 10 seconds.				Wash or replace nozzle tip.
	Fuel feed pump	Outside diameter of tappets Inside diameter of tappet holes	7 (0.276)			0.1 (0.004)	
		Outside diameter of tappet roller	15 (0.591)	$0\ \ {}^{0}_{-0.027}\ (^{0}_{-0.00106})$		-0.075 (-0.00295)	
		Delivery pressure kgf/cm² (psi) [MPa]	1.8 – 2.2 (25.6 – 31.3) [0.18 – 0.22]				Injection pump speed: 600 rpm
		Delivery capacity		900 cm³ (55 cu in.)/ min, min	600 cm³ (37 cu in.)/ min, min		Check displacement with injection pump operated at 1000 rpm with a discharge pressure of 1.5 kgf/cm² (21 psi) [0.15 MPa].
		Airtightness	No parts shall show any evidence of air leaks.				Close pump discharge port with a plug. Apply an air pressure of 2 kgf/cm² (28 psi) [0.2 MPa] to the pump, and keep the pump immersed in diesel fuel longer than 1 minute.

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Fuel system	Fuel injection pump	Plunger oil-tightness kgf/cm² (psi) [MPa]	150 – 200 (2133 – 2844) [14.7 – 19.6], min		150 (2133) [14.7], max		Pump speed: 200 rpm
		Delivery valve seating tightness				See Remarks.	10 kgf/cm² (142 psi) [1.0 MPa] pressure drop should not exceed 5 seconds.
		Backlash between pinion and rack		[0.15 (0.0059)]		[0.25 (0.0098)]	
		Rack sliding resistance	120 gf (4.2 ozf) [1.2 N], max with pump at stand-still; 50 gf (1.8 ozf) [0.5 N], max with pump running at 1000 rpm				
		Fit of tappets in pump housing		[0.03 – 0.07 (0.0012 – 0.0028)]		[0.2 (0.0079)]	
		Outside diameter of tappet rollers	17 (0.669)	0 / -0.027 (0 / -0.00106)		-0.075 (-0.00295)	
		Free length: Plunger spring	49 (1.929)	+1 / 0 (+0.039 / 0)		-0.5 (-0.020)	
		Free length: Delivery valve spring	32 (1.260)	±0.5 (±0.020)		-1 (-0.039)	
		Cam height (major diam)	32 (1.260)	+0.1 / 0 (+0.0039 / 0)		-0.2 (-0.0078)	
		Inside diameter of tappet holes in pump housing	24 (0.945)			0.15 (0.0059)	
		Pre-stroke	1.95 (0.0768)	±0.05 (±0.0020)			
		Beginning of injection		90° ± 30′			
		Tappet clearance		[0.2 (0.008)], min			

Injection quantity adjustment:

Pump speed rpm	Rack position mm (in.)	Plunger strokes	Injection quantity cm³ (cu in.)	Variance cm³ (cu in.)
1000	8.5 (0.335)	1000	37 ± 1.5 (2.26 ± 0.09)	2 (0.12), max
1000	8.0 (0.315)	1000	33 ± 1.5 (2.01 ± 0.09)	2 (0.12), max
200	5.7 (0.224)	1000	13 ± 3 (0.79 ± 0.18)	2 (0.12), max

Test conditions

Nozzle tip: 093400-0090 (ND-DN40SDND32)
Injection pressure: 120 kgf/cm² (1706 psi) [11.8 MPa]
Test oil: ASTM Diesel fuel No. 2D
Delivery pressure: 2.0 kgf/cm² (28.4 psi) [0.2 MPa]
Injection pipe: 2 x 6 x 600 mm (1/16 x 1/4 x 23-5/8 in.)
Test oil temperature: 40 – 45°C (104 – 113°F)

Group	Inspection point	Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks

Fuel system — Governor

Governor: Speed control range: 325 – 1200 rpm Speed regulation ≒ 5.0

Item	Adjusting lever angle	Pump speed rpm	Control rack position mm (in.)	Total injection quantity cm^3 (cu in.)/1000 strokes, 1 cyl
High-speed control	53° ± 5°	1400 1300 1225 1200	1.5 (0.059), max 3 ± 1.0 (0.118 ± 0.039) 6.5 ± 0.1 (0.256 ± 0.004) {7.1 ± 0.1 (0.280 ± 0.004) {8.9 ± 0.2 (0.351 ± 0.008) (Set by torque spring)	
Medium-speed control	53° ± 5°	850	9.0 ± 0.1 (0.354 ± 0.004) (Set by full-load stopper)	
Low-speed control	25° ± 5°	300 200 400	8.3 ± 0.1 (0.354 ± 0.004) 11.0 (0.433), min 5.3 ± 0.1 (0.209 ± 0.004) (Set by idle sub-spring)	
Matching to engine	53° ± 5°	400 500 900 1200		{52 ± 2 (3.17 ± 0.12) {47 ± 1 (2.87 ± 0.06) (by means of Angleich spring) {39 ± 2 (2.38 ± 0.12) {29 ± 1 (1.77 ± 0.06) (by means of torque spring)

7.2 Tightening torque

Important bolts and nuts

Securred part of component	Tightening torque			Remarks
	kgf·m	lbf·ft	N·m	
Nozzle retaining nut	5 ± 0.5	36 ± 4	49 ± 5	
Injection pump delivery valve holder	2.5 – 3.5	18 – 25	25 – 34	
Injection pump delivery valve clamp bolt	0.8 – 1.1	5.8 – 8.0	7.8 – 10.8	

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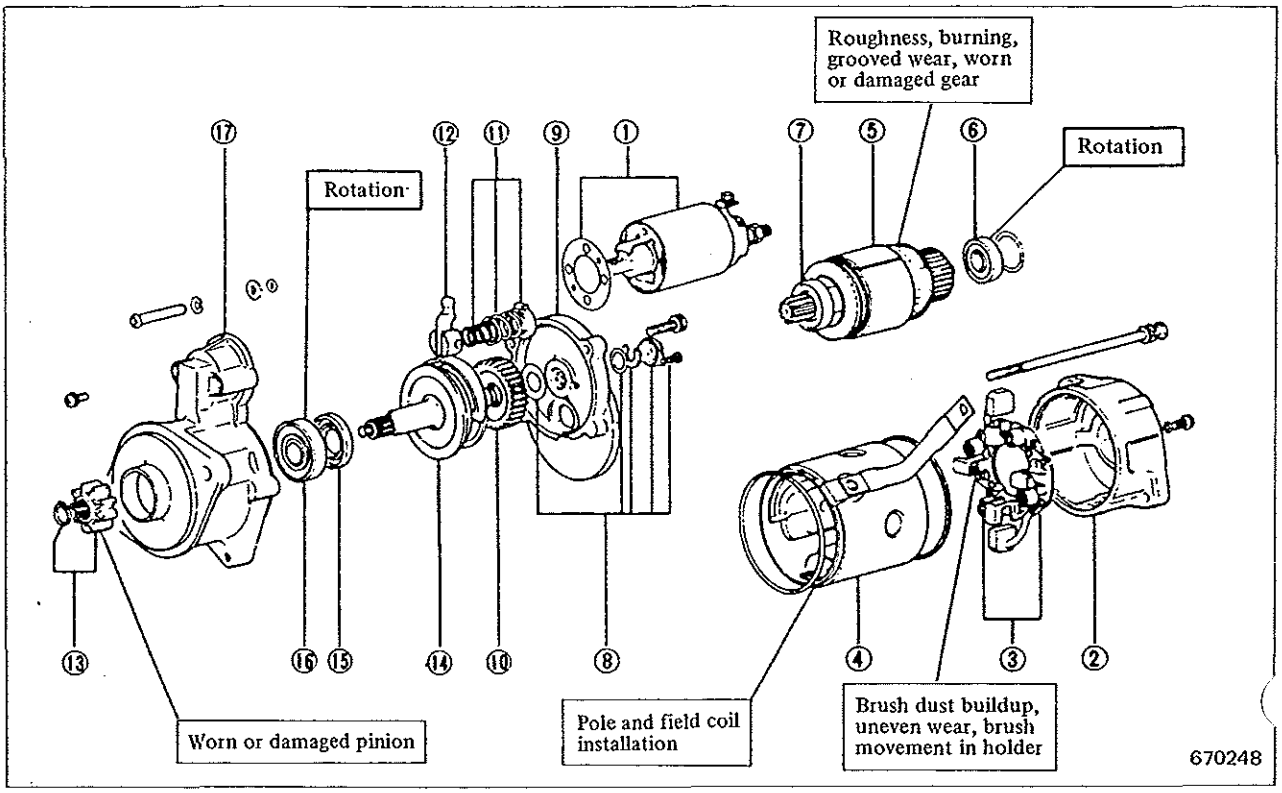
1. STARTER

1.1 Disassembly



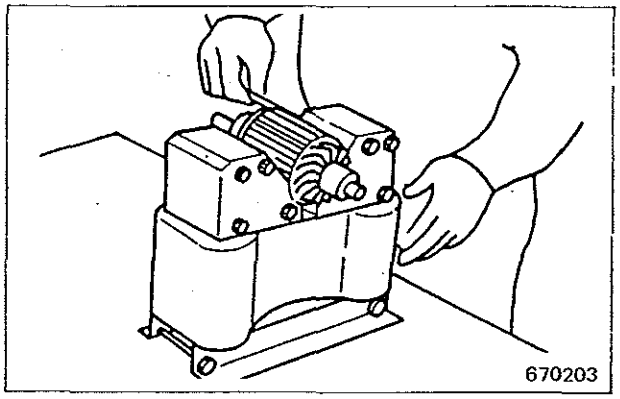
① Switch
② Rear bracket
③ Brush holder
④ Yoke
⑤ Armature
⑥ Ball bearing
⑦ Ball bearing
⑧ Cover set
⑨ Center bracket
⑩ Gear
⑪ Spring set
⑫ Lever
⑬ Pinion set
⑭ Pinion shaft
⑮ Oil seal
⑯ Ball bearing
⑰ Front bracket

1.2 Inspection and repair

(1) Armature

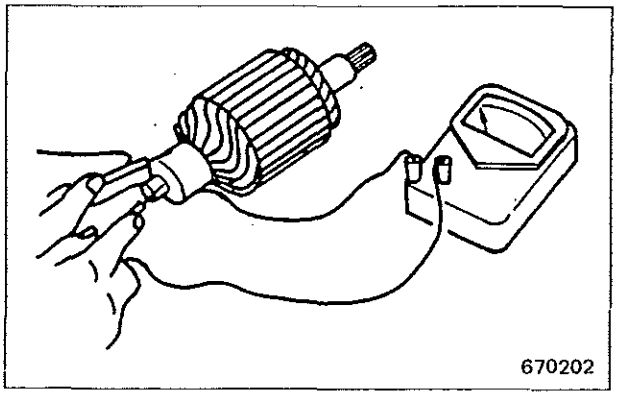
(a) Testing armature for short circuits

Place the armature on a growler, and slowly revolve it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. Replace the armature if shorted.



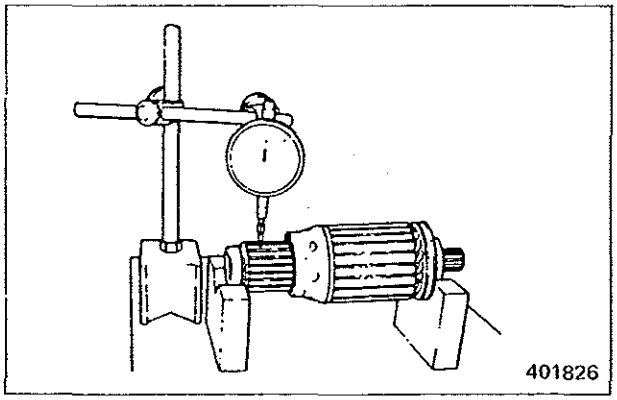
(b) Testing armature for grounded circuits

If there is continuity between the commutator and shaft (or core), the armature is grounded and should be replaced.



(c) Inspecting commutator

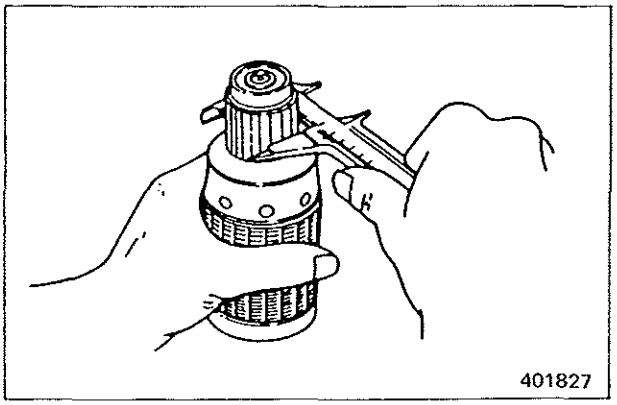
1) Support the armature in V-blocks, and measure the runout of commutator with a dial gauge. If the runout exceeds the Repair limit, repair the commutator by turning it in a lathe within Service limit for the outside diameter. If the commutator surface is rough, smoothen it with a sandpaper pf #300 to #500.



Unit: mm (in.)

Item	Assembly standard	Repair limit	Service limit
Commutator runout	0.03 (0.0012)	0.05 (0.0020)	0.05 (0.0020)

2) Measure the outside diameter of commutator. If it is smaller than the Service limit, replace the armature.



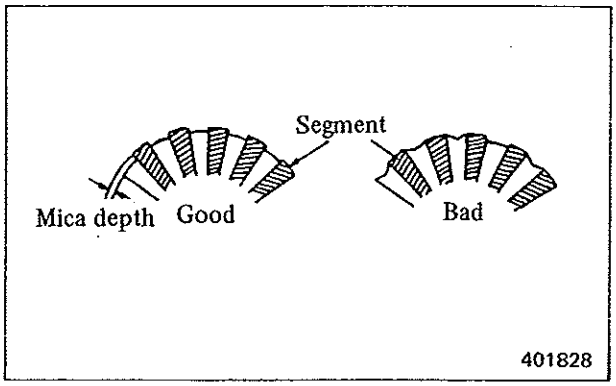
Unit: mm (in.)

Item	Assembly standard	Service limit
Outside diameter of commutator	32 (1.26)	31 (1.22)

3) Measure the depth of each mica between segments with a depth gauge. If the depth exceeds the Repair limit, recondition the mica.

Unit: mm (in.)

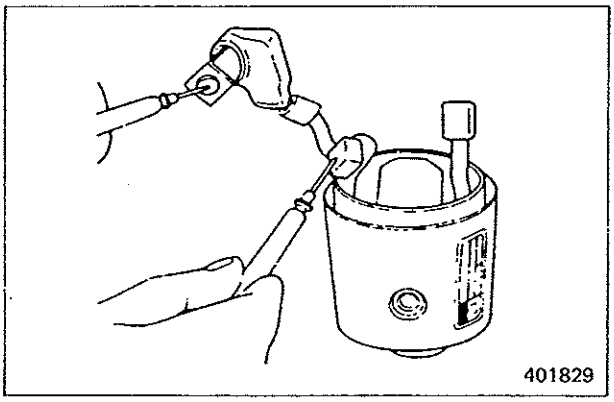
Item	Reapir limit
Commutator mica depth	0.2 (0.008), maximum



(2) Field coil

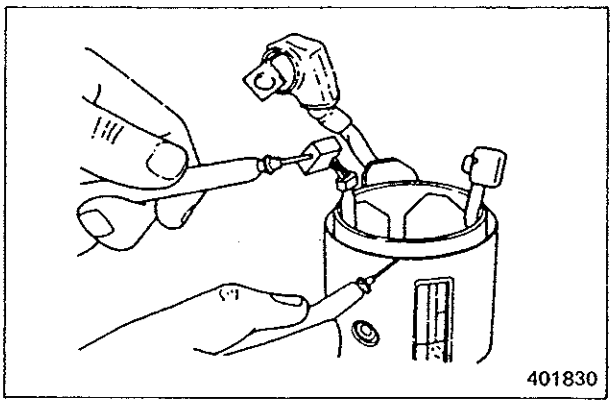
(a) Testing for open circuits

If there is no continuity between the lead wire and positive (+) brush, the field coil is open and the yoke assembly should be replaced.



(b) Testing for grounded circuits

If there is continuity between the yoke and positive (+) brush, check the insulation, and repair or replace the yoke assembly.



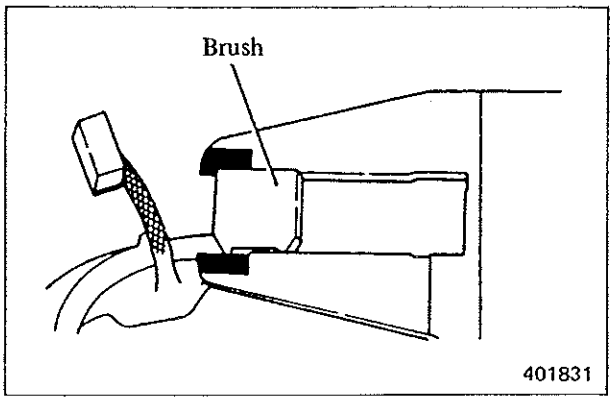
(3) Brushes and holders

(a) Wear of brushes

Measure the brush length and, if it is less than the Service limit, replace the brushes. If the brushes are unevenly worn or rough, recondition them with a sandpaper of #300 to #500.

Unit: mm (in.)

Item	Assembly standard	Service limit
Brush length	18 (0.71)	11 (0.43)

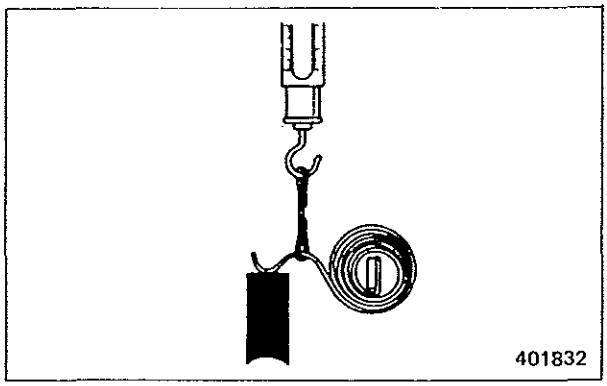


(b) Brush spring tension

Test the spring tension (test force) using a new brush. In this test, read the load at the moment that the spring moves off the brush. If the tension is below the Service limit, replace the spring.

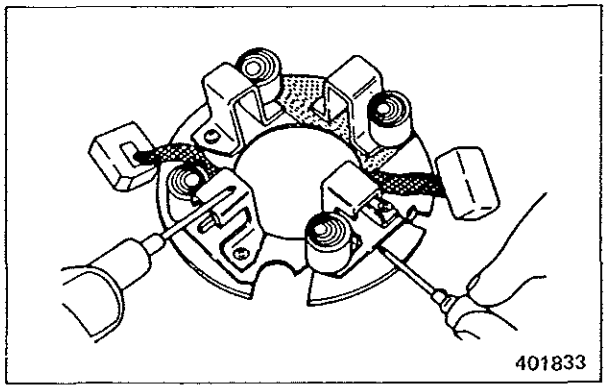
kgf (lbf) [N]

Item	Assembly standard	Service limit
Brush spring tension	3.5 (7.7) [34.3]	2.3 (5.1) [22.6]



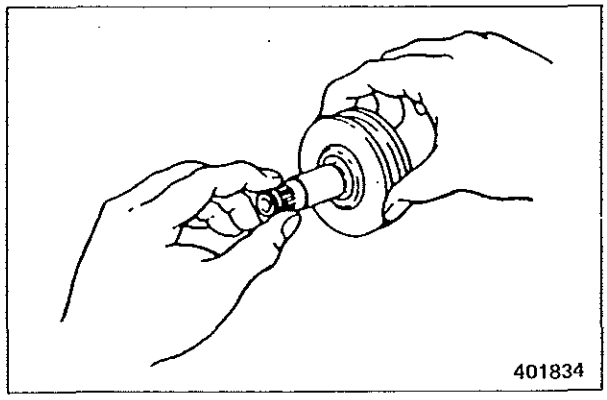
(c) Testing brush holders for insulation

If there is continuity between the positive (+) brush holder and negative (-) holder plate, replace the brush holder assembly.



(4) Overrunning clutch

Make sure that the pinion shaft turns smoothly when turned in the direction of driving (clockwise) and that it locks when turned in the opposite direction. If not, replace the overrunning clutch.



(5) Pinion thrust gap

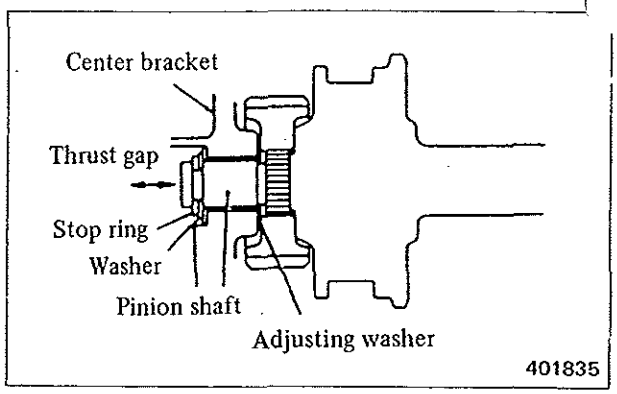
The pinion shaft thrust gap is the play exhibited by the pinion shaft when it is moved in the thrust direction. Measure the thrust gap in the following manner. If it is out of specification, select the adjusting washer and adjust the gap.

(a) When the pinion is removed:

Install the gear on the pinion shaft, insert the shaft into the center bracket, and lock the shaft with the washer and ring. Under this condition, move the shaft in the axial direction, and measure the thrust gap.

(b) When the pinion is installed:

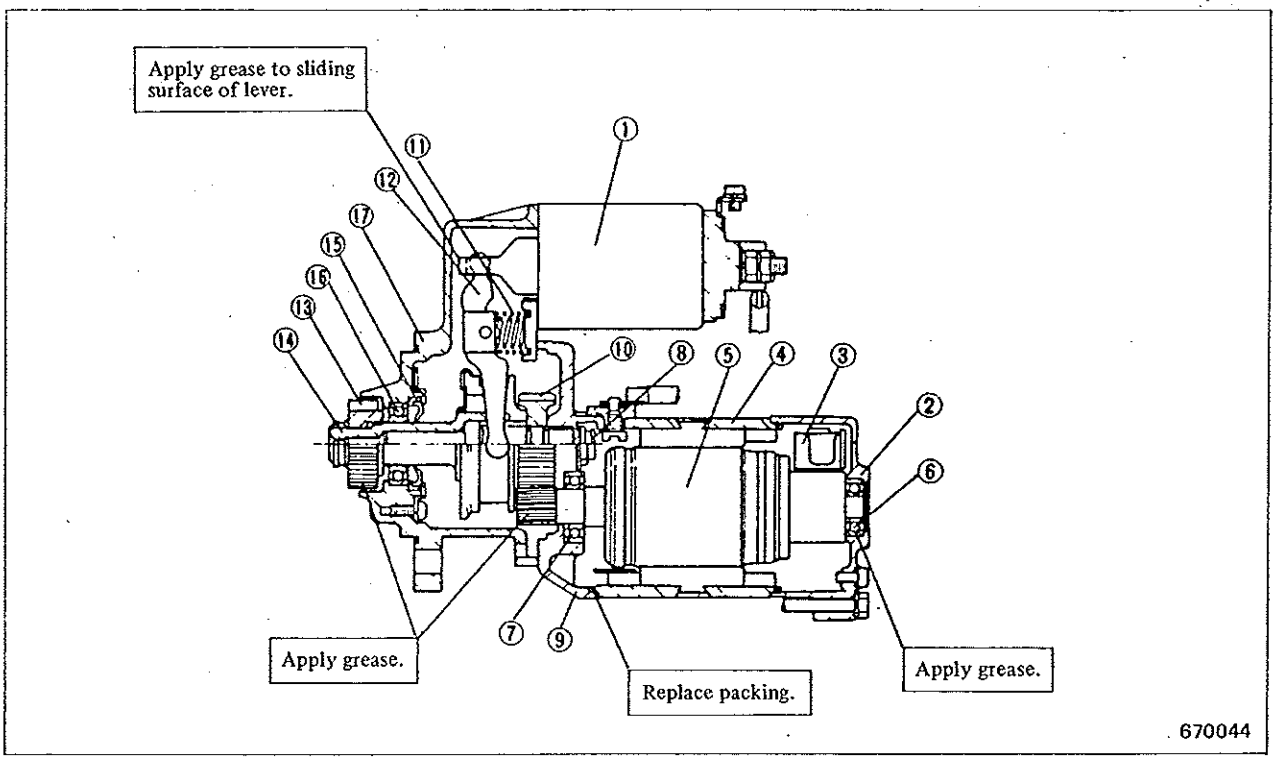
Install the pinion shaft and gear between the front and center brackets, and temporarily tighten the bolt. Under this condition, move the shaft in the axial direction, and measure the thrust gap.



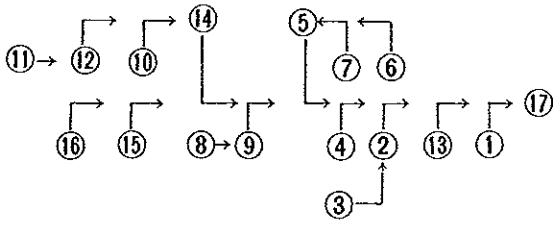
Unit: mm (in.)

Item	Assembly standard
Pinion thrust gap	0.5 (0.020), maximum [Below 0 not permissible]

1.3 Reassembly



Reassembling sequence



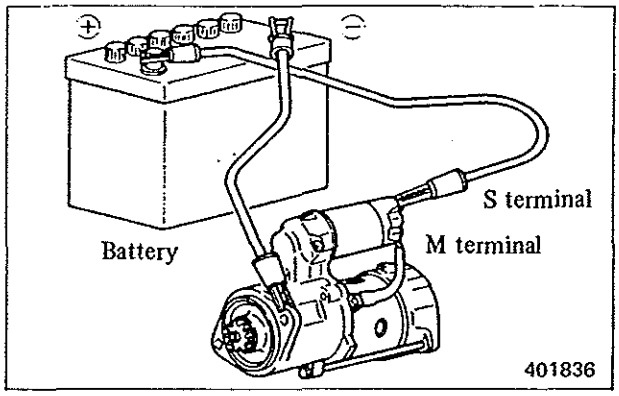
Inspection and testing after reassembly

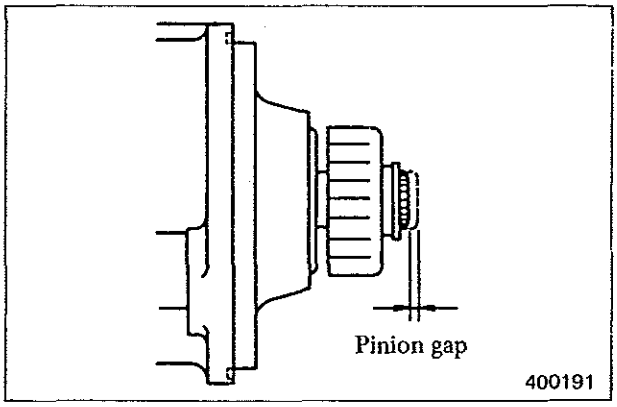
(1) Pinion gap adjustment

(a) If the assembled starter is wired as shown, the pinion will shift and turn slowly. Remove the connector from the M terminal to stop the pinion.

(b) Under this condition, lightly push in the pinion toward the armature, and measure the movement (gap) of the pinion.

(c) To adjust the gap, increase or decrease the packings fitted to the magnetic switch. Increasing the packings decreases the pinion gap.





Unit: mm (in.)

Item	Assembly standard
Pinion gap	0.5 – 2.0 (0.020 – 0.079)

⚠ CAUTION

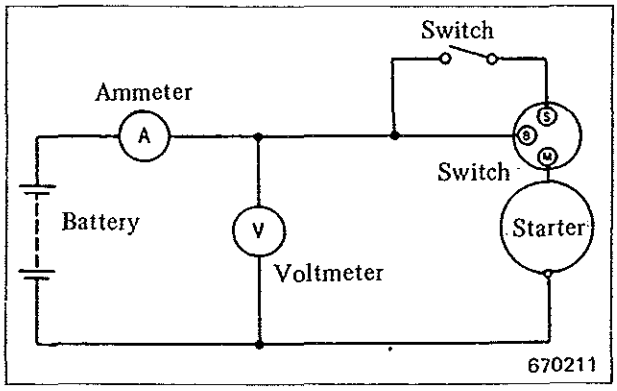
Do not test the starter continuously for more than 20 seconds to prevent the switch coil from overheating.

(2) No-load test

After adjusting the pinion gap, hook up the starter as shown, and test it for no-load characteristics.

NOTE

Use wires as thick as possible and tighten each terminal securely.



Voltage (V)	Current (A)	Speed (rpm)
23	80, maximum	3400

(3) Magnetic switch

(a) Testing coil for open circuits

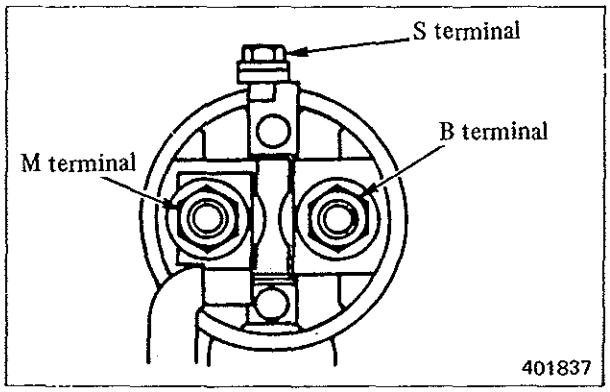
If there is no continuity between S and M terminals and between S terminal and body (ground), replace the switch.

(b) Inspecting contactors for fusion

If there is continuity between B and M terminals, replace the switch.

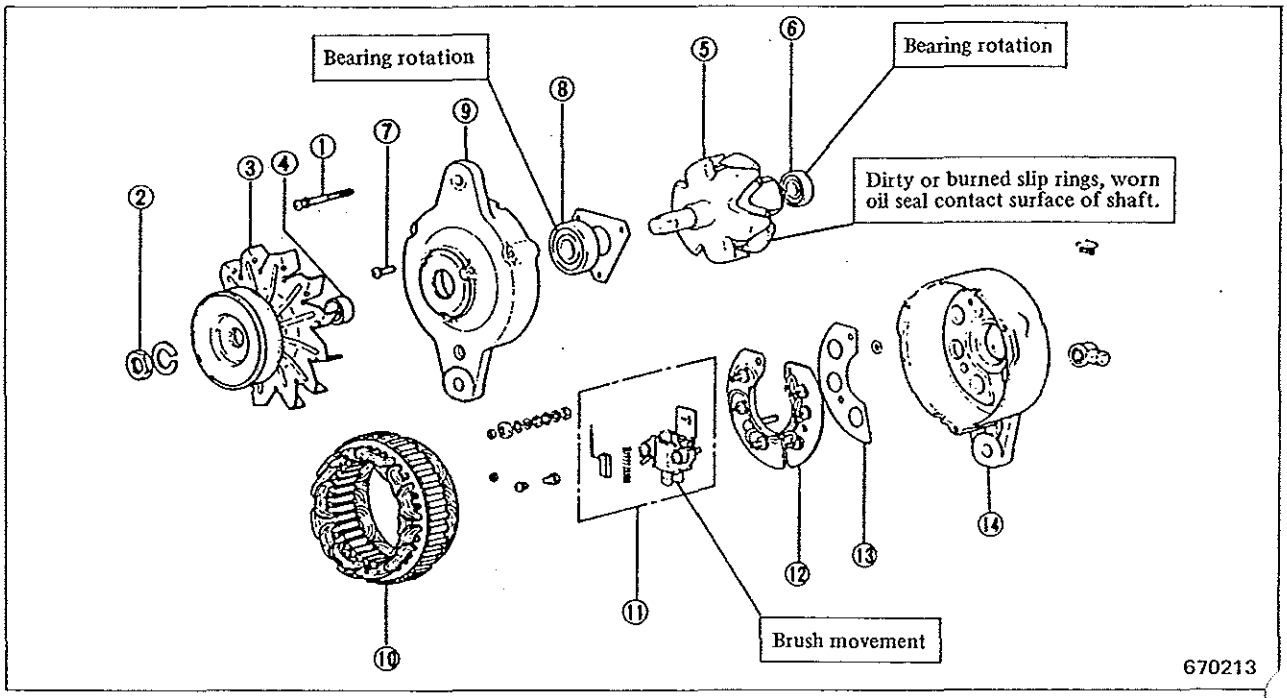
(c) Inspecting contactors for poor contact action

Inspect for voltage drop between contactors. If voltage drop is excessive, the contactors are defective.



2. ALTERNATOR

2.1 Disassembly



① Screw
② Nut
③ Pulley (with fan)
④ Spacer
⑤ Rotor
⑥ Bearing
⑦ Screw
⑧ Bearing
⑨ Front bracket
⑩ Stator
⑪ Brush holder set
⑫ Rectifier assembly
⑬ Plate
⑭ Rear bracket

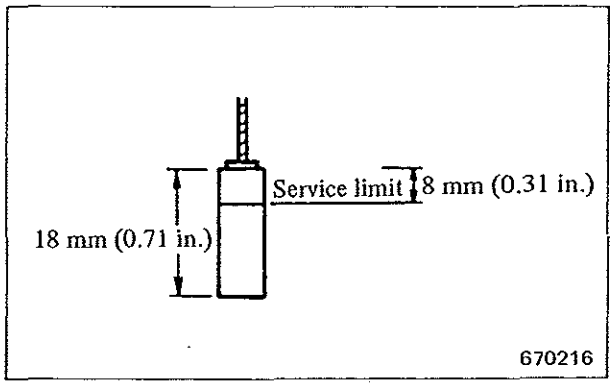
2.2 Inspection and repair

(1) Brushes

Replace the brushes if they are worn down to the wear limit line.

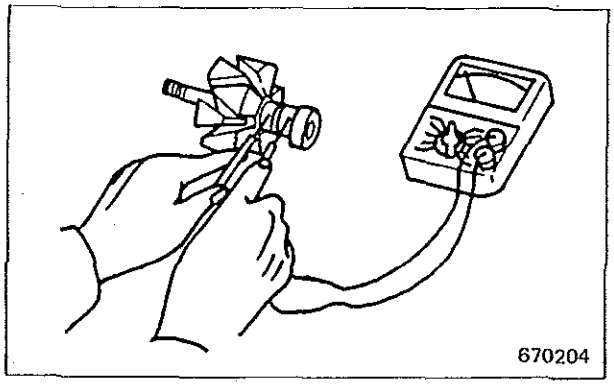
Unit: mm (in.)

Item	Assembly standard	Service limit
Brush length	18 (0.71)	8 (0.31)



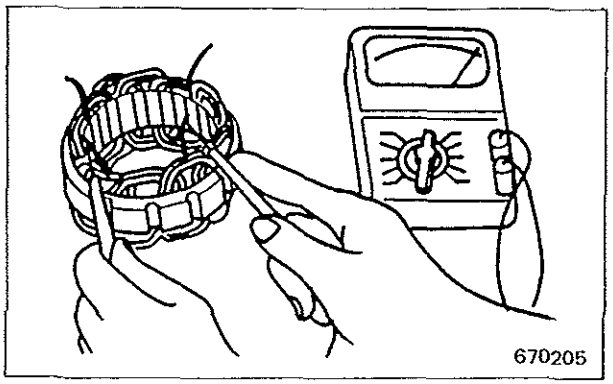
(2) Field coil

Measure the resistance between the slip rings. If the resistance is out of specification, replace the rotor.



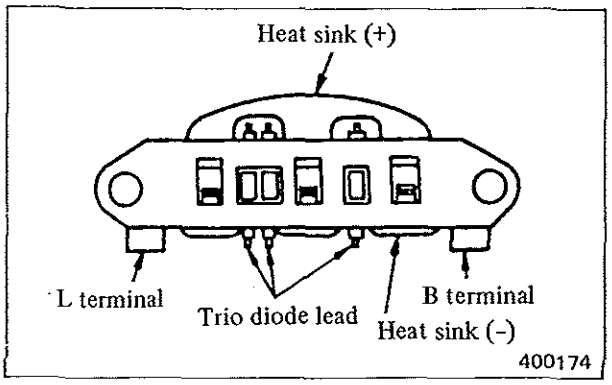
(3) Stator coil

Inspect for continuity between the lead wires. If no continuity is noted, the coil is open-circuited. Also check for continuity between the lead wire and coil. If any continuity is noted, the coil is grounded.

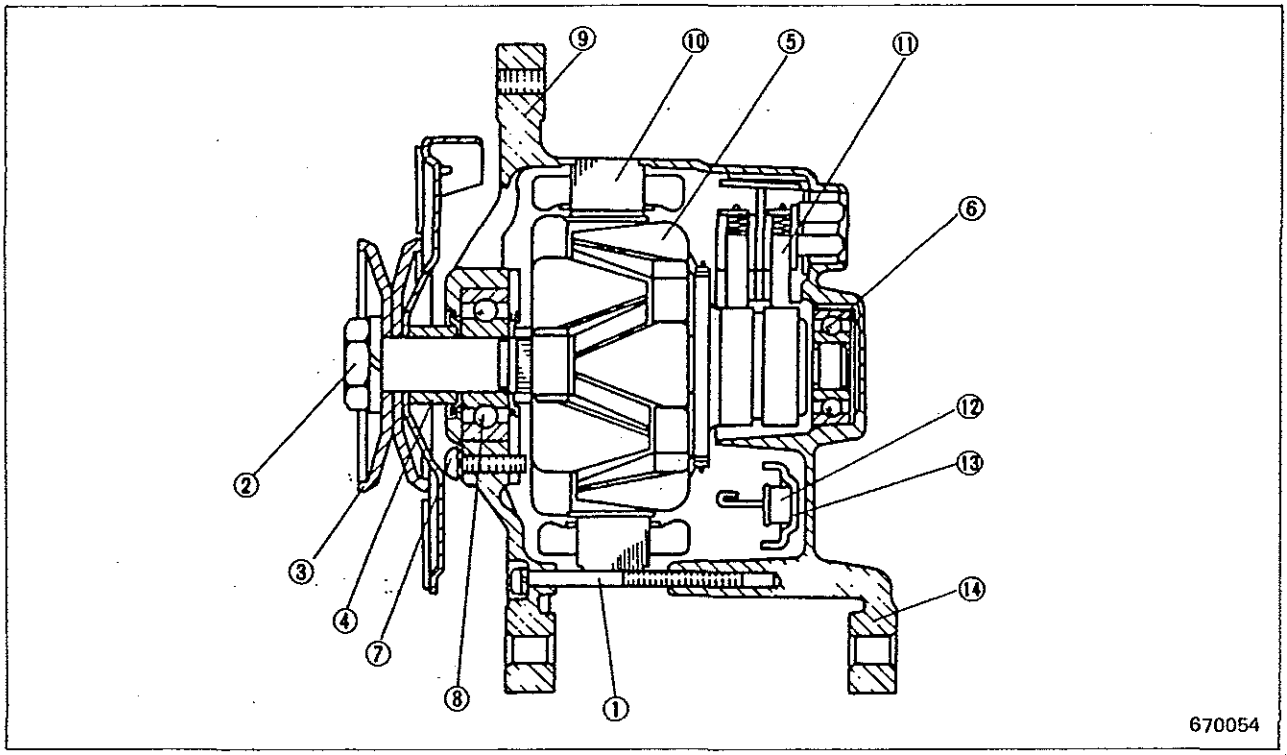


(4) Rectifier

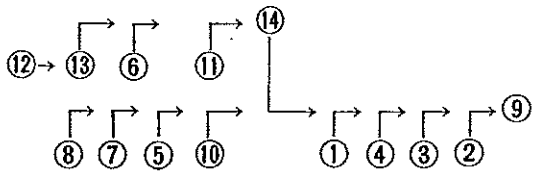
Inspect the resistance between the lead wire and heat sink on each diode by connecting the positive (+) side lead wire and negative (-) side lead wire of the tester to the diode. If the resistance is infinite in both cases, the diode is open-circuited. If it is nearly zero in both cases, the diode is short-circuited. If the diode is open- or short-circuited, replace the rectifier.



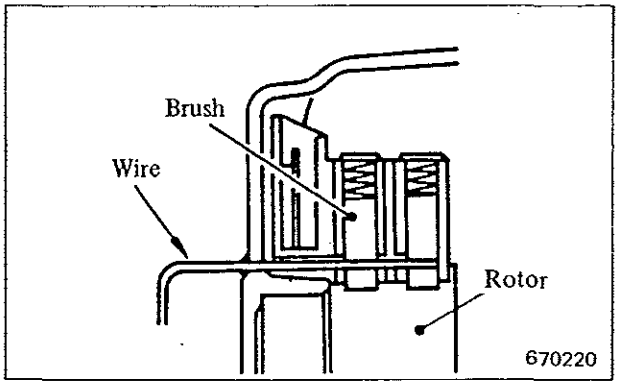
2.3 Reassembly



Reassembling sequence



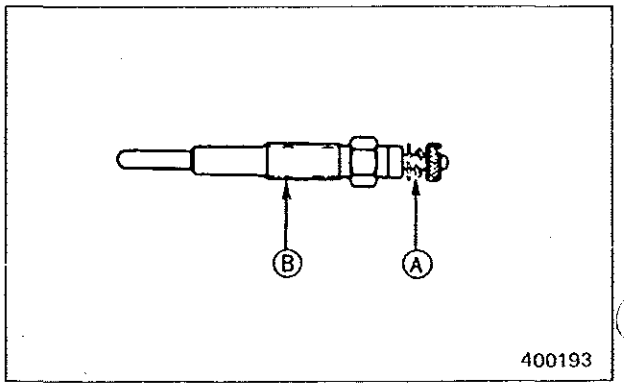
Push the brush into the holder, and hold it there by inserting a 2 mm (0.08 in.) diameter wire into the hole in the brush. Then, install the rotor. Remove the wire after installing the rotor.



3. GLOW PLUGS

Inspection

If the glow plug glows red when the positive (+) wire is connected to the portion (A) with the portion (B) grounded, the plug is in satisfactory condition.



Testing glow plug

4. MAINTENANCE STANDARDS

4.1 Maintenance standards

Group	Inspection point			Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Electrical system	Starter	Diameter of commutator		32 (1.26)			31 (1.22)	
		Brush	Length	18 (0.71)			11 (0.43)	
			Spring pressure kgf(lbf)[N]	3.5 (7.7) [34.3]			2.3 (5.1) [22.6]	
		Thrust gap of pinion shaft		0.5 (0.020)	0, minimum			
		Pinion gap		0.5 – 2.0 (0.020 – 0.079)				

No-load characteristics			Locked characteristics			Magnetic switch operating voltage	
Voltage V	Current A	Speed rpm	Voltage V	Current A	Torque kgf·m (lbf·ft) [N·m]	Switch-in voltage V	Switching off
23	80, max.	3400	8	730, max.	4.5 (32.5) [44.1], min.	16, max.	Shall turn off upon turning off of starter switch.

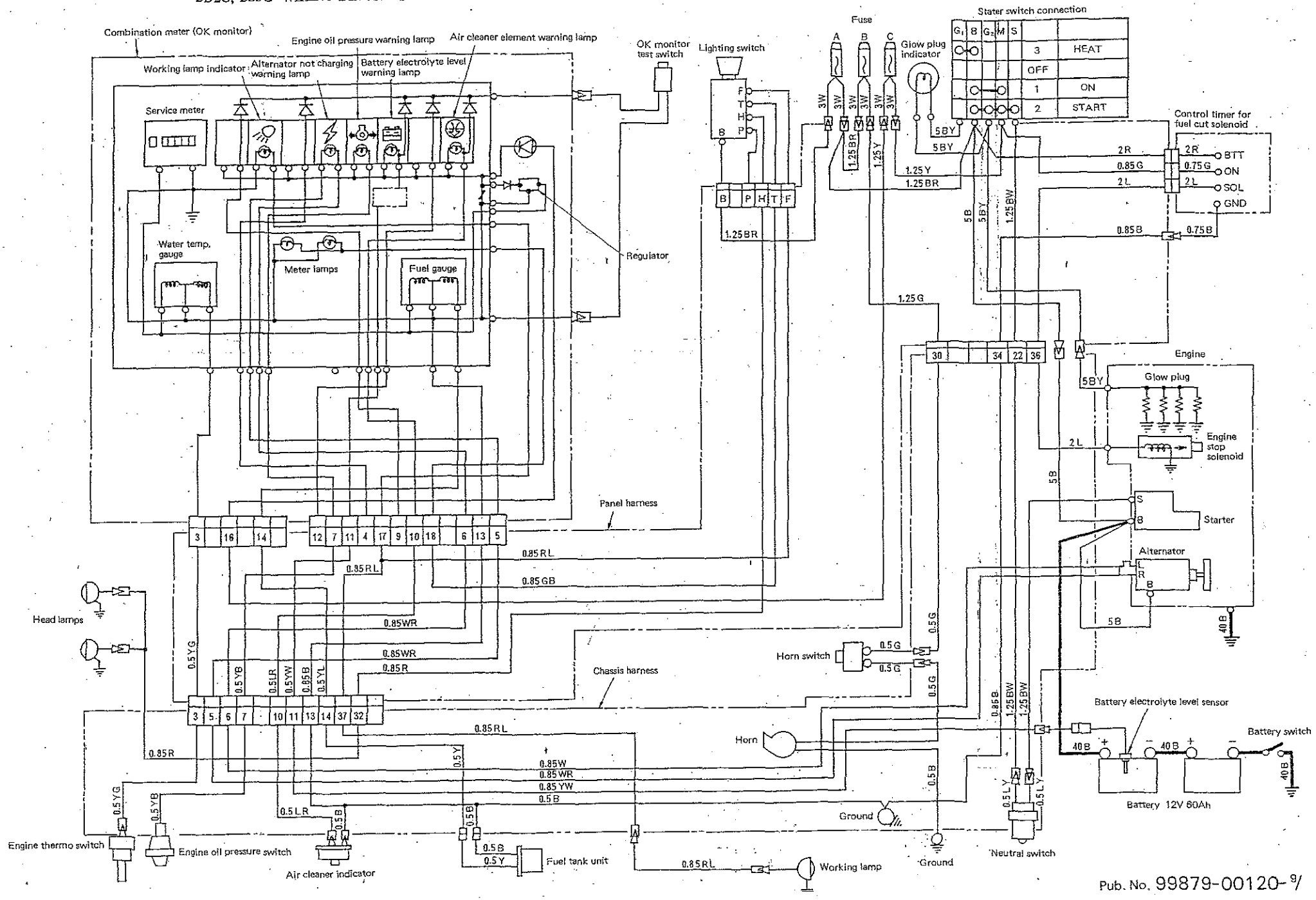
Alternator	Brush spring tension gf (lbf) [N]						210 (0.5) [2.1]
	Outside diameter of slip ring	33 (1.30)					32.4 (1.276)
	Brush length	18 (0.71)					8 (0.31)

4.2 Tightening torque

Important nut

Securred part of component	Thread dia. – pitch	Width across flats	Tightening torque			Remarks
			kgf·m	lbf·ft	N·m	
Starter B terminal	8 – 1.25	12	1.0 – 1.2	7 – 9	10 – 12	

BD2G, BS3G WIRING DIAGRAM



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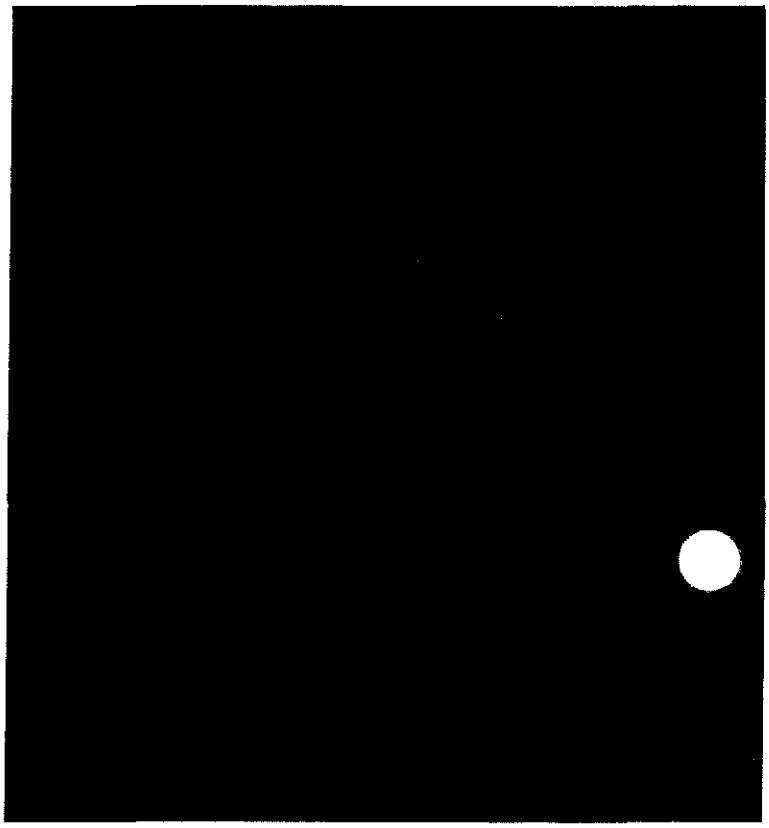

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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G TRACTOR SHOVEL BS3G

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POWER TRAIN/HYDRAULIC SYSTEM
MAINTENANCE STANDARDS

MITSUBISHI HEAVY INDUSTRIES, LTD.

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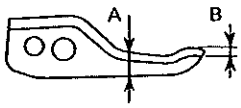
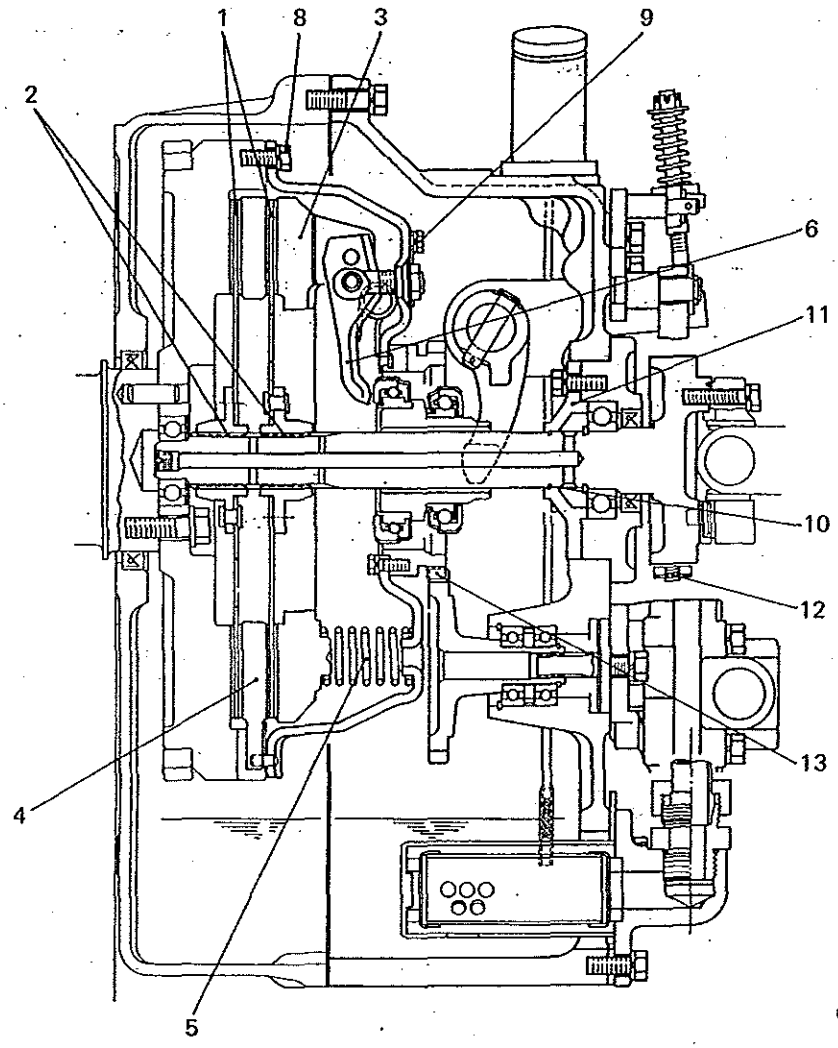
Bucket and linkage (BS3G) 33
Tightening torques 34

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Flywheel clutch	1	Clutch discs	Facing thickness	5.7 – 6.3 (0.224 – 0.248)	One side: –0.4 (–0.016) Both sides: –0.8 (–0.031)	
			Runout	0.7 (0.028), max.	0.7 (0.028), min.	
	2	Hub splines	Minor diameter	26.67 – 26.70 (1.0500 – 1.0512)		
			Fit of hub splines	0.05 – 0.15 (0.0020 – 0.0059)	0.30 (0.0118)	
	3	Pressure plate	Friction surface thickness	20.2 (0.795)	19.7 (0.776), max.	
			Friction surface flatness	0.05 – 0.15 (0.0020 – 0.0059)	0.30 (0.0118)	
			Strut bolt holes	10.20 – 10.25 (0.4016 – 0.4035)	10.50 (0.4134)	
			Release lever pin bushings		See Remarks.	Bushing are said to have reached the service limit if "teflon" overlay coating is worn away.
	4	Mating plate	Friction surface thickness	13.0 (0.512)	12.5 (0.492), max.	
			Friction surface flatness	0.05 – 0.10 (0.0020 – 0.0039)	0.20 (0.0079)	
	5	Pressure springs	Free length	70.6 (2.780)	68.5 (2.697)	
			Test force/length under test force kgf (lbf)[N]/mm (in.)	43.5±2.2(95.9±4.9) [426.6 ± 21.6]/48.2 (1.898)	39.2 (86.4) [384.4]/ 48.2 (1.898)	
			Squareness	2°, max.	3°, min.	
	6	Release levers	Fit on bearing	1.9 (0.075)	 A – B = 0.5 (0.020), min.	
			Stroke	18 (3/4)		
	7	Strut bolts	Tightening torque kgf·m (lbf·ft) [N·m]	4 – 6 (28.9 – 43.4) [39.2 – 58.8]		
	8	Clutch cover mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	1.7 (12.3) [16.7]		
	9	Lock plate mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	1.7 (12.3) [16.7]		
	10	Seal ring	Surface		Cuts or breakage	
	11	Cover	Surface making contact with seal ring		Grooves or scratches	
	12	Brake band	Lining thickness	5.0 (0.197)	3.0 (0.118), max.	
	13	Pump drive gear	Backlash with mating gear	0.35 – 0.42 (0.0138 – 0.0165)	0.70 (0.0276), min.	



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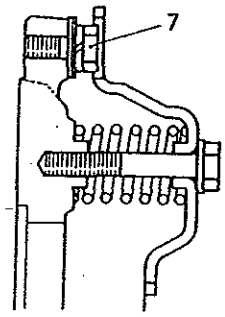
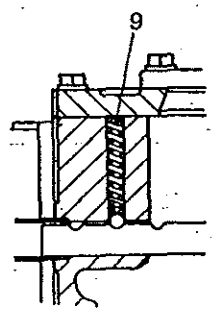


602279

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Direct drive transmission (F3-R2)	1	1st-sliding gear	Backlash with 1st-reverse gear	0.12 – 0.28 (0.0047 – 0.0110)	0.60 (0.0236)	
	2		Backlash with 1st-drive gear	0.12 – 0.28 (0.0047 – 0.0110)	0.60 (0.0236)	
	3	2nd-sliding gear	Backlash with 2nd-reverse gear	0.12 – 0.28 (0.0047 – 0.0110)	0.60 (0.0236)	
	4		Backlash with 2nd-drive gear	0.12 – 0.28 (0.0047 – 0.0110)	0.60 (0.0236)	
	5	Counter gear	Backlash with input gear	0.12 – 0.28 (0.0047 – 0.0110)	0.60 (0.0236)	
	6		Backlash with 3rd-sliding gear	0.12 – 0.30 (0.0047 – 0.0118)	0.60 (0.0236)	
	7	Shift rails (shifter shafts)	Fit in forks	0.020 – 0.062 (0.00079 – 0.00244)	0.500 (0.01969)	
			Bend			Should slide smoothly.
	8	Shift forks	Clearance of shift fork in groove	0.1 – 0.3 (0.004 – 0.012)	0.5 (0.020)	
	9	Detent springs (poppet springs)	Free length	62 (2.44)	60.5 (2.382)	
			Test force/length under test force kgf (lbf)[N]/min.	9.80±0.49(21.6±1.08) [96.11 ± 4.81]/55 (2.17)	7.5 (16.5) [73.5]/ 55 (2.17)	
	10	Sliding gears	Width of shifter fork grooves	7.1 – 7.2 (0.280 – 0.283)	7.7 (0.303)	
	11	Countershaft end securing bolts/bevel pinion shaft securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	2.7 ± 0.3 (19.5 ± 2.2) [26.5 ± 2.9]		



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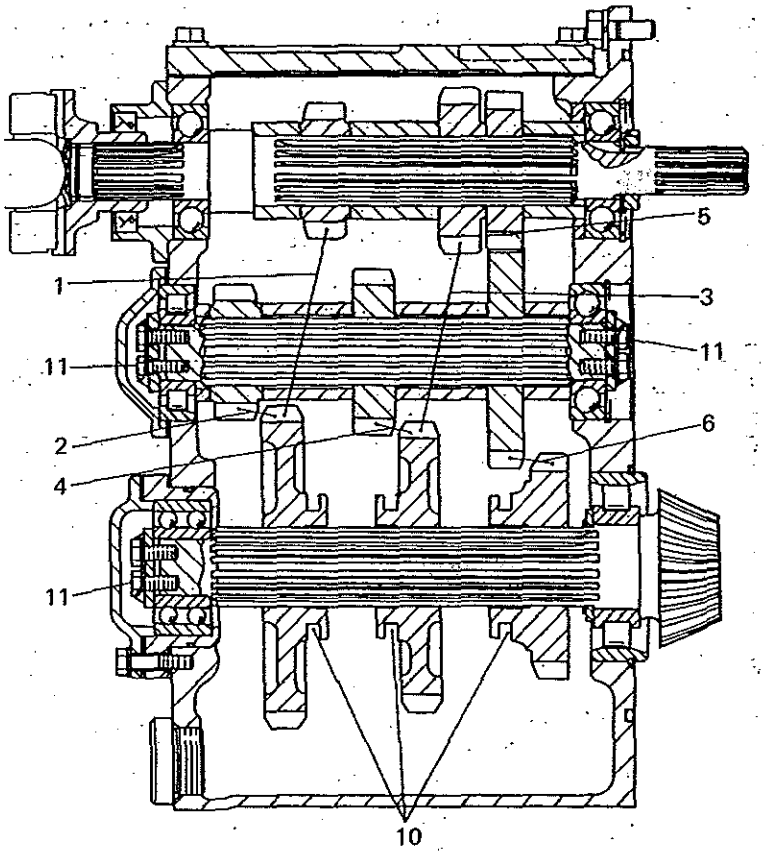

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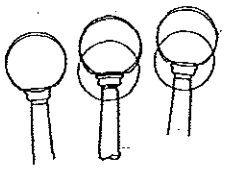

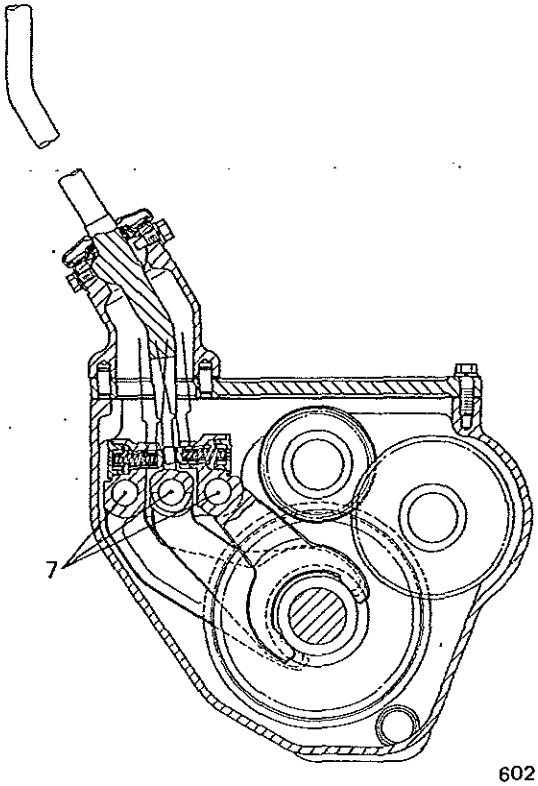

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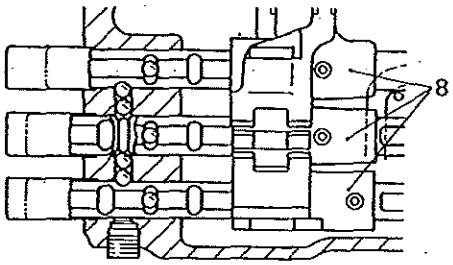
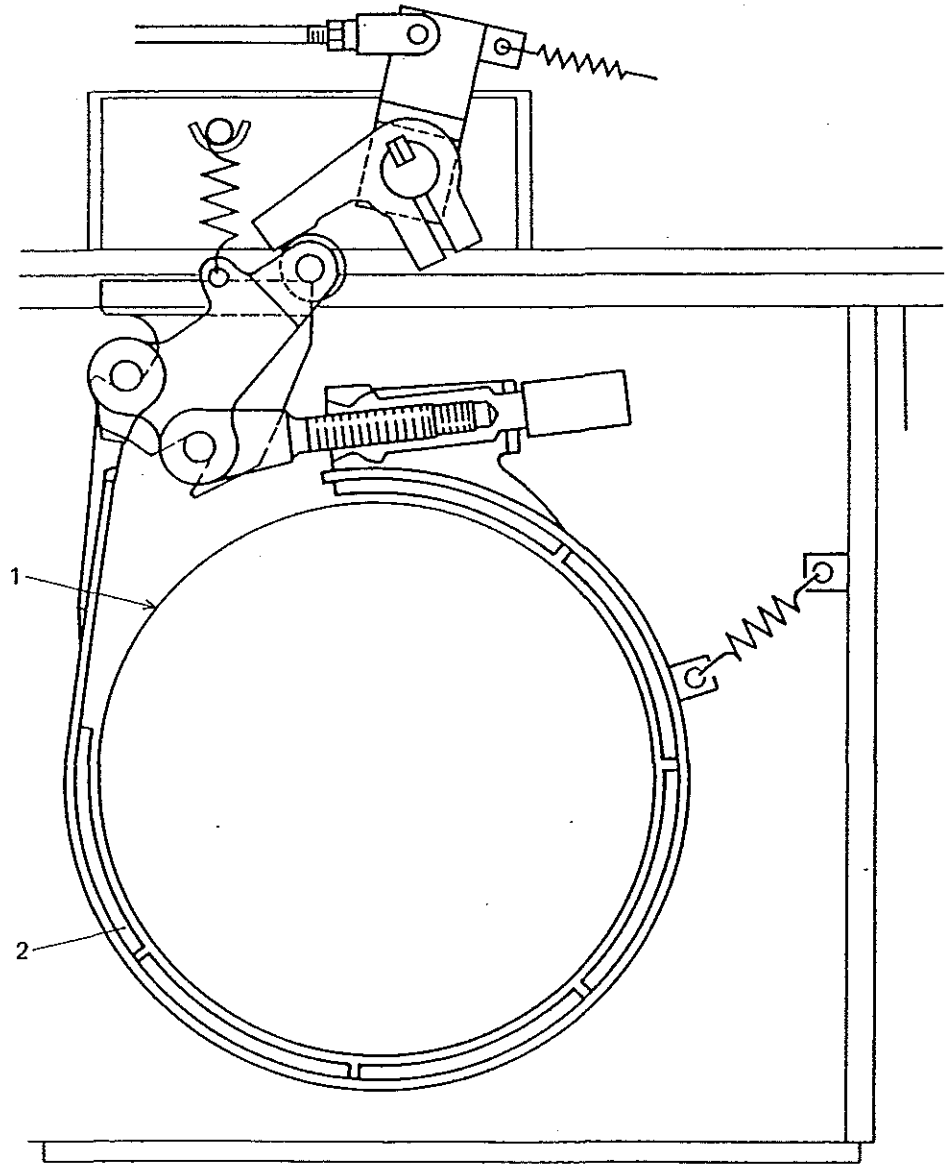


602243

Unit: mm (in.)

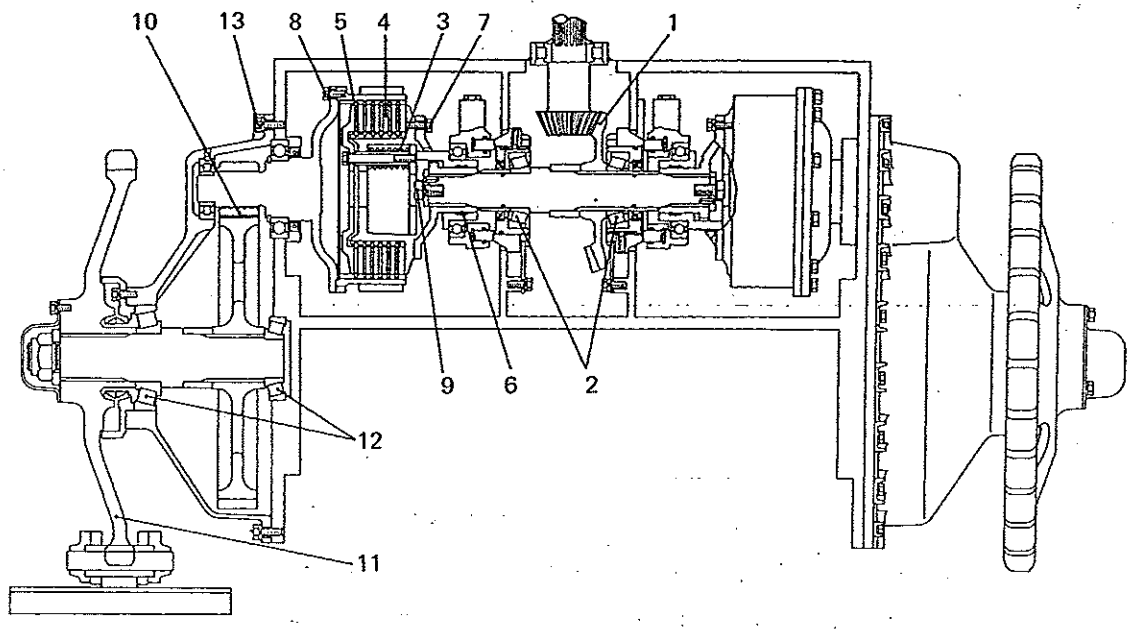
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Brake	1	Drum	Outside diameter	252 (9.92)	250 (9.84)	
			Clearance in linings	0.8 (0.031)		
	2	Linings	Thickness	6.5 (0.256)	4.5 (0.177)	



602244

Unit: mm (in.)

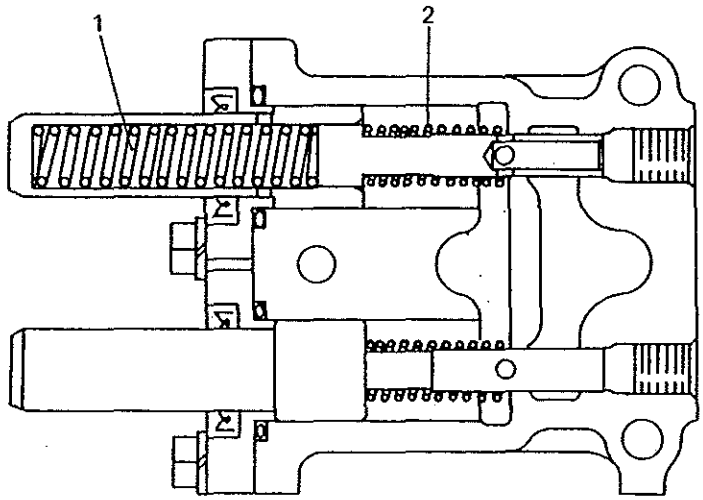
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Steering clutches	1	Bevel gear	Backlash with pinion	0.15 – 0.20 (0.0059 – 0.0079)	0.50 (0.0197)	
	2	Tapered roller bearings	Preload (bevel gear) kgf·m (lbf·ft) [N·m]	0.7–0.9 (5.1–6.5) [6.9 – 8.8]		
	3	Clutch springs	Free length	77.5 (3.051)		
			Test force/length under test force kgf (lbf) [N]/mm (in.)	66.5 ± 5 (146.6±11.0) [652.1 ± 49.0]/ 63 (2.48)		
	4	Friction plates	Thickness	8.7 (0.343)	6.0 (0.236)	
			Fit in outer drum splines	0.16 – 0.52 (0.0063 – 0.0205)	0.80 (0.0315)	
	5	Disc plates	Thickness	2.8 (0.110)	2.3 (0.091)	
			Fit in inner drum splines	0.14 – 0.30 (0.0055 – 0.0118)	0.60 (0.0236)	
			Total thickness of friction plates (6 pcs) and disc plates (6 pcs)	69 (2.72)	66 (2.60)	
	6	Shifter	Fit in flange	0.200 – 0.324 (0.00787 – 0.01276)		
	7	Inner drum securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	3.5 ± 0.3 (25.3 ± 2.2) [34.3 ± 2.9]		
	8	Outer drum and pinion securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	3.5 ± 0.3 (25.3 ± 2.2) [34.3 ± 2.9]		
	9	Drive shaft/ clutch shaft securing bolts (16-mm diam)	Tightening torque kgf·m (lbf·ft) [N·m]	16 – 19 (115.7 – 137.4) [157 – 186]		
Final drives	10	Pinons	Backlash with driven gear	0.17 – 0.37 (0.0067 – 0.0146)	1.00 (0.0394)	
	11	Sprockets	Tooth width	40 (1.57)	36 (1.42)	
	12	Tapered roller bearings	Preload kgf·m (lbf·ft) [N·m]	0.29 – 0.37 (2.10 – 2.68) [2.84 – 3.63]		
	13	Final drive case mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	7.6 – 9.2 (55.0 – 66.5) [74.5 – 90.2]		



602177

Unit: mm (in.)

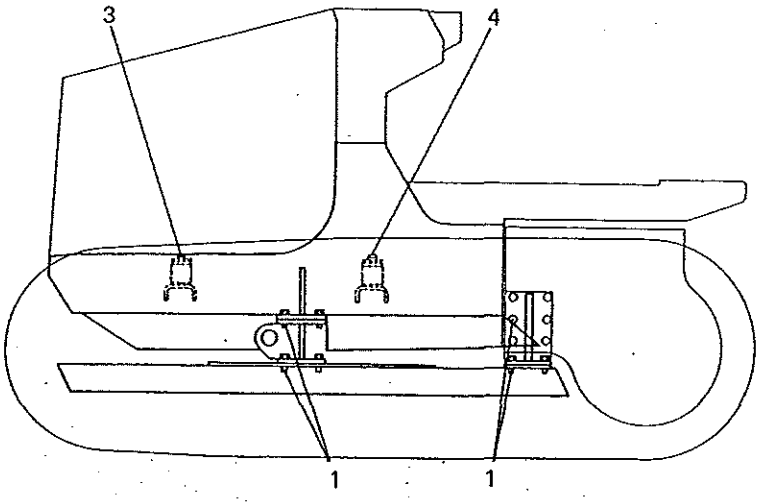
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Steering valve	1	Valve springs	Free length	66 (2.60)		
			Test force/length under test force kgf (lbf) [N]/mm (in.)	9.8 ±1 (21.6 ± 2.2) [96.1 ± 9.8]/56 (2.20)		
	2	Return springs	Free length	36.5 (1.44)		
			Test force/length under test force kgf (lbf) [N]/mm (in.)	0.9 ± 0.1 (2.0 ± 0.2) [8.8 ± 1.0]/32.9 (1.30)		



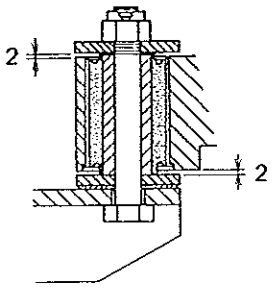
602278

Unit: mm (in.)

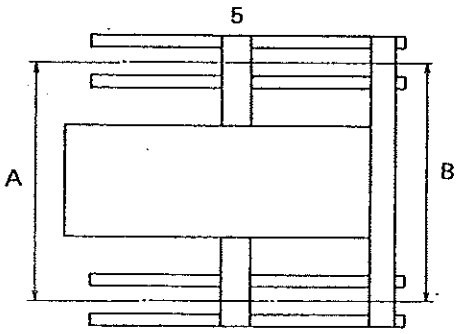
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Frame	1	Steering clutch case/frame/rigid bar mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	26 ± 2 (188 ± 14) [255 ± 20]		
	2	Engine front mount/flywheel housing mount	Bracket-to-stopper clearance	Upper: 1.2 – 2.2 (0.047 – 0.087) Lower: 1.8 – 2.8 (0.071 – 0.110)	1.0 (0.039)	
	3	Engine front mount attaching bolts	Tightening torque kgf·m (lbf·ft) [N·m]	15.9 ± 1.6 (115.0 ± 11.6) [155.9 ± 15.7]		
	4	Flywheel housing mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	15.9 ± 1.6 (115.0 ± 11.6) [155.9 ± 15.7]		
	5	Center to center of tracks	Standard models	1200 (47-1/4)	10 (3/8)	Difference between "A" and "B"
			Swamp models	1400 (55-1/8)		
			Super-swamp models	1590 (62-5/8)		
			Ultra super-swamp models	1880 (74)		



602245



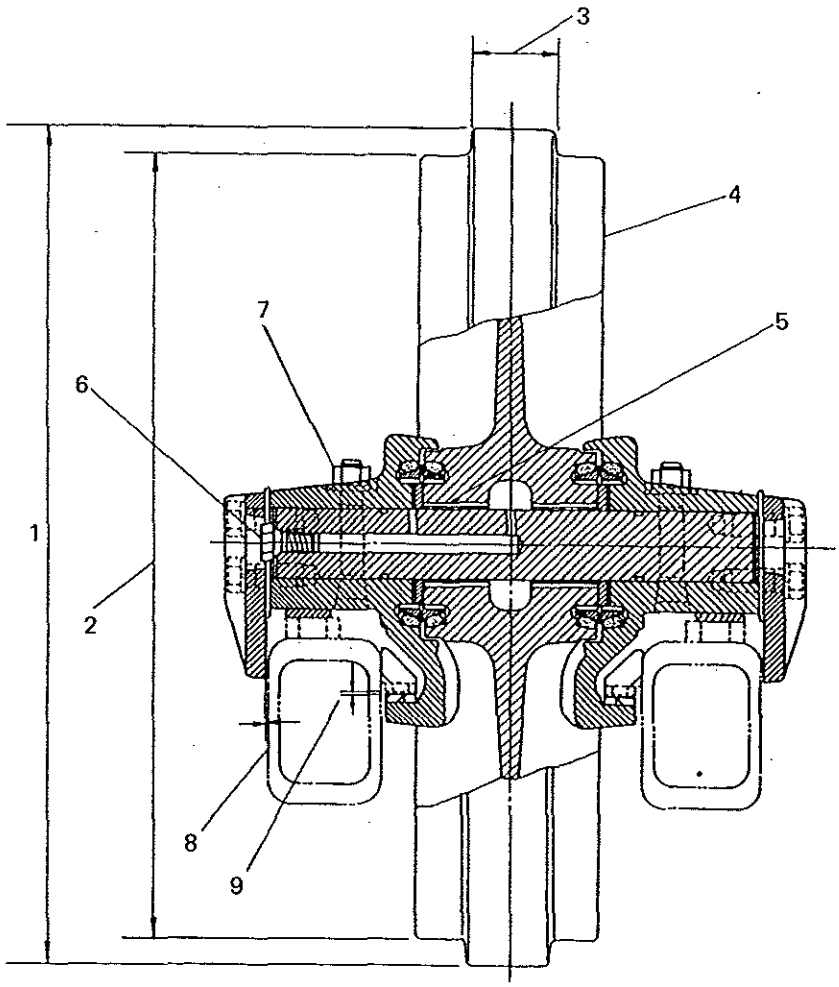
602246



602247

Unit: mm (in.)

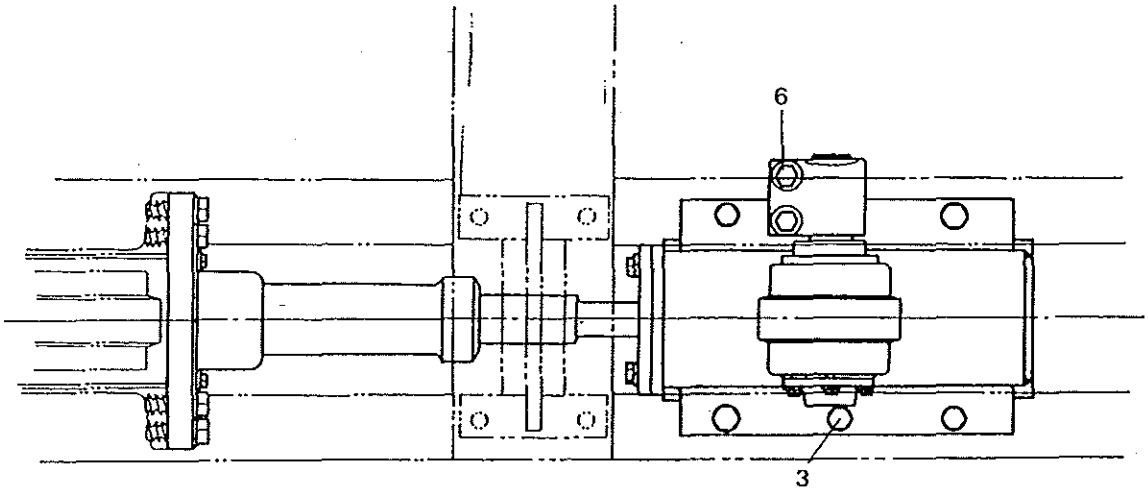
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Front idlers	1	Idlers	Diameter	448 (17.64)		
	2		Diameter	420 (16.54)	411 (16.18)	Repair limit: 413 (16.26)
	3		Width	42 (1.65)	35 (1.38)	
	4		Axial play	0.20 – 0.25 (0.0079 – 0.0098)	1.40 (0.0551)	
	5	Shafts	Fit in bushing	0.155 – 0.235 (0.00610 – 0.00925)	1.000 (0.03937)	
	6	Filler plugs	Tightening torque kgf·m (lbf·ft) [N·m]	7.6 ± 0.8 (55 ± 5.8) [74.5 ± 7.8]		
	7	Bearing-shaft securing taper pin bolts	Tightening torque kgf·m (lbf·ft) [N·m]	6.5 ± 0.7 (47 ± 5.1) [63.7 ± 6.9]		
	8	Guides/track frames	Lateral clearance	1 (0.04)	3 (0.12)	
	9		Vertical clearance	1 (0.04)	3 (0.12)	



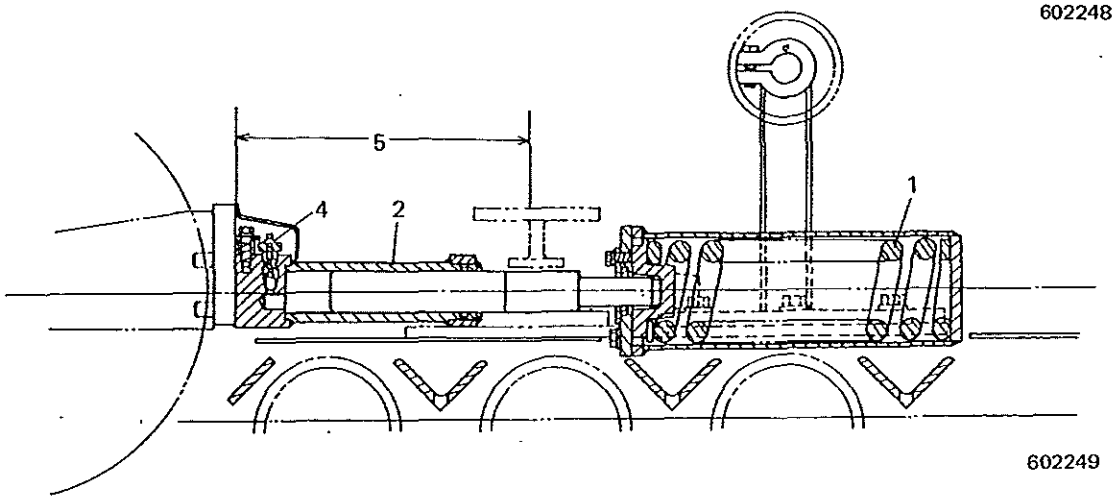
602187

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Hydraulic adjuster cylinders and recoil springs	1	Recoil springs	Free length	381.5 (15.020)		
			Test force/length under test force kgf (lbf) [kN]/mm (in.)	2610 ± 210 (5755 ± 463) [25.6 ± 2.1]/ 326 (12.83)	2300 (5072) [22.6]/ 326 (12.83)	
	2	Cylinders	Fit on piston	0.075 – 0.164 (0.00295 – 0.00646)	0.800 (0.03150)	
	3	Track carrier roller bracket mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	26 ± 2 (188 ± 14) [255 ± 20]		
	4	Filler valves	Tightening torque kgf·m (lbf·ft) [N·m]	3.5 ± 0.5 (25.3 ± 3.6) [34.3 ± 4.9]		
	5	Track adjuster cylinders	Adjustment limit	370 (14.57)	450 (17.7)	
	6	Roller shaft and bracket securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	14.7 ± 2.2 (106.3 ± 15.9) [144.1 ± 21.6]		



602248

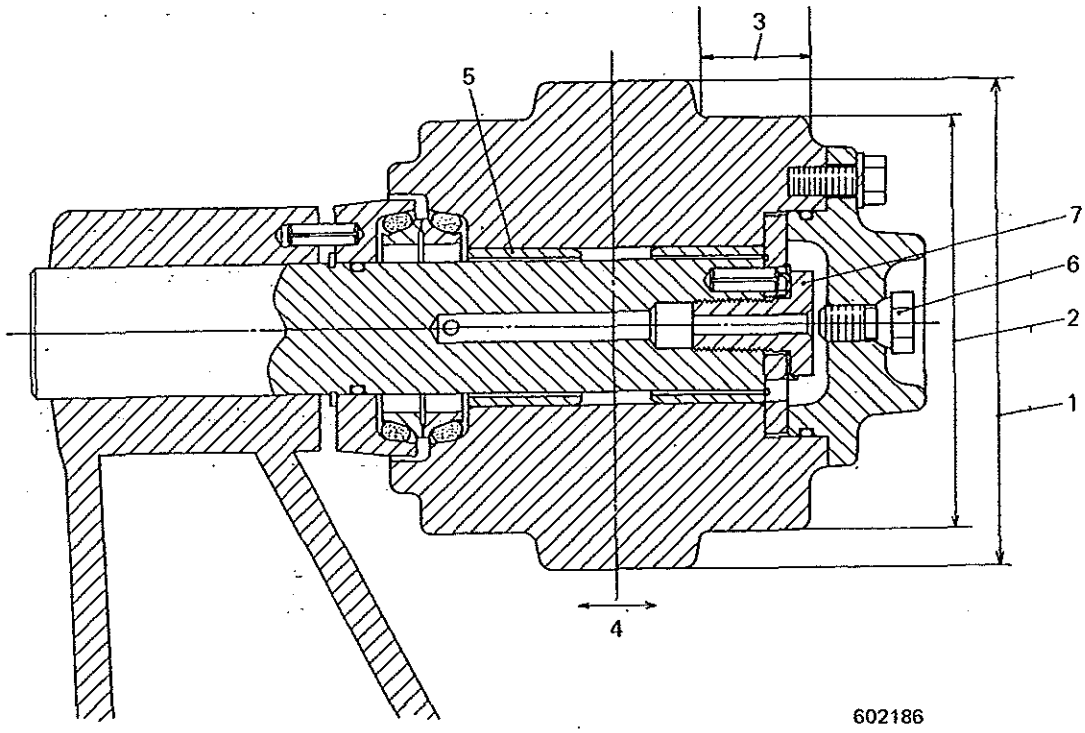


602249

TRACK CARRIER ROLLERS

Unit: mm (in.)

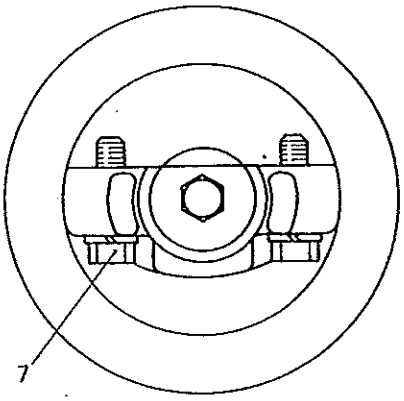
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Track carrier rollers	1	Rollers	Diameter	140 (5.51)	118 (4.65)	
	2		Diameter	120 (4.72)	98 (3.86)	Repair limit: 104 (4.09)
	3		Width	30 (1.18)	35 (1.38)	
	4		Axial play	0.2 – 0.5 (0.008 – 0.020)	1.0 (0.039)	
	5	Roller shafts	Fit in bushings	0.185 – 0.226 (0.00728 – 0.00890)	1.600 (0.06299)	
	6	Filler plugs	Tightening torque kgf·m (lbf·ft) [N·m]	4.2 ± 0.4 (30.4 ± 2.9) [41.2 ± 3.9]		
	7	Roller shaft securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	12.2 ± 1.2 (88.2 ± 8.7) [119.6 ± 11.8]		



602186

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Track rollers	1	Rollers	Diameter	164 (6.46)	152 (5.98)	
	2		Diameter	140 (5.51)	128 (5.04)	Repair limit: 132 (5.20)
	3		Flange width	9 (0.35)	4 (0.16)	
	4		Axial play	0.30 – 0.90 (0.0118 – 0.0354)	1.40 (0.0551)	
	5	Roller shafts	Fit in bushings	0.20 – 0.25 (0.0079 – 0.0098)	1.60 (0.0630)	
	6	Filler plugs	Tightening torque kgf·m (lbf·ft) [N·m]	7.6 ± 0.8 (55.0 ± 5.8) [74.5 ± 7.8]		
	7	Roller mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	6 ± 0.6 (43.4 ± 4.3) [58.5 ± 5.9]		



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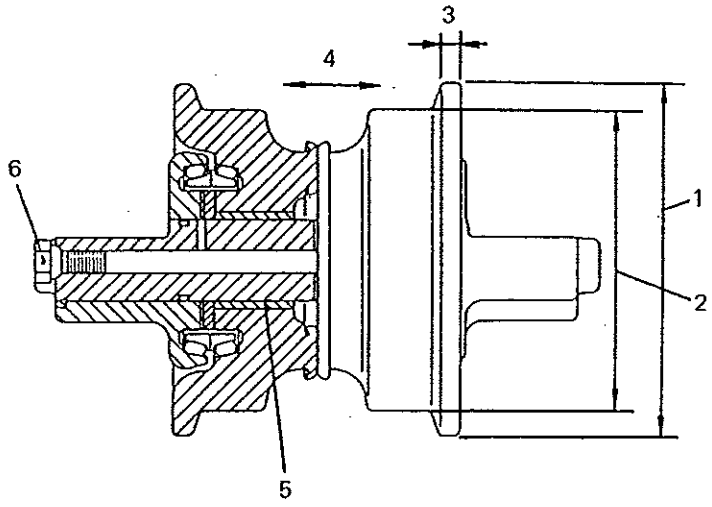
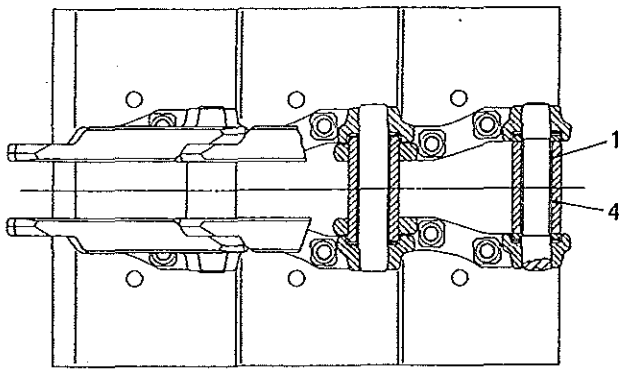


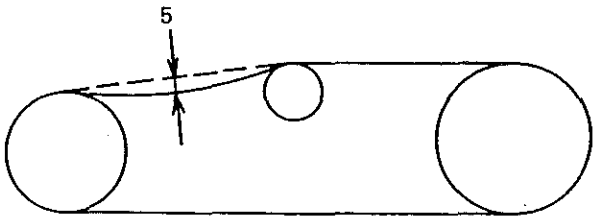
602188

Unit: mm (in.)

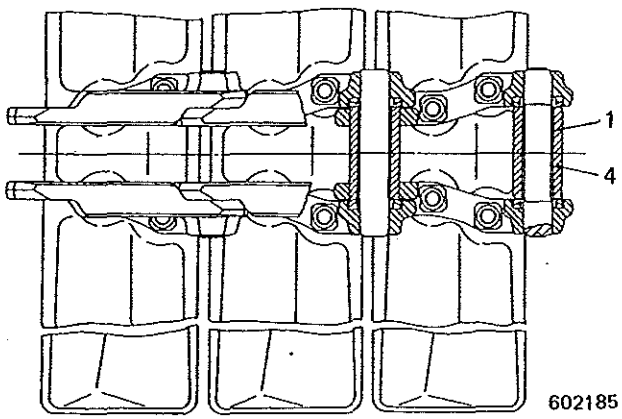
Group	Ref. No.	Item			Assembly standard	Service limit	Remarks
Tracks	1	Bushings	Outside diameter		41 (1.61) (Limit for reversing 38 (1.50))	37.2 (1.465)	Limit for reversing: 38 (1.50) (maximum wear)
	2	Links	a	Height	75 (2.95)	68 (2.68)	Repair limit: 70 (2.76)
			b	Link pitch (for 4 links)	540 (21.3)	550 (21.65)	Limit for reversing: 552 (21.73)
	3	Track pins	Fit in bushings		0.450 – 0.734 (0.01772 – 0.02890)	2.5 (0.098)	
	4	Shoes	Grouser height	Standard models	38.5 (1.516) (BD2G)	11 (0.43)	
				Standard models	30 (1.18) (BS3G)	10 (0.39)	
				Swamp models	67.5 (2.657)	55.5 (2.185)	Repair limit: 57.5 (2.264)
				Super-swamp models	57.5 (2.264)	52.5 (2.067)	Repair limit not specified
				Ultra super-swamp models	57.5 (2.264)	52.5 (2.067)	
	5	Tracks	Sag		20 – 30 (3/4 – 1-1/8)		
	6	Shoe bolts	Tightening torque kgf·m (lbf·ft) [N·m]		17 – 20 (123 – 145) [167 – 196]		



Standard/swamp model track 602184

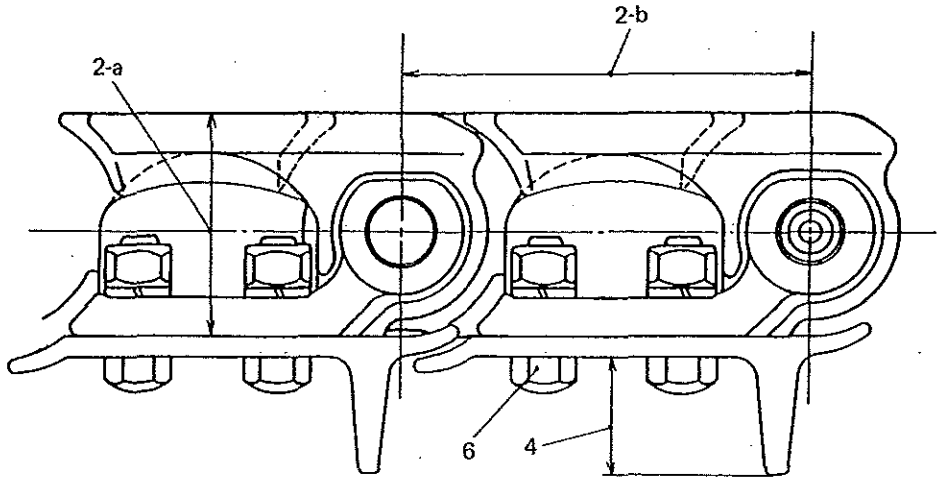


602252



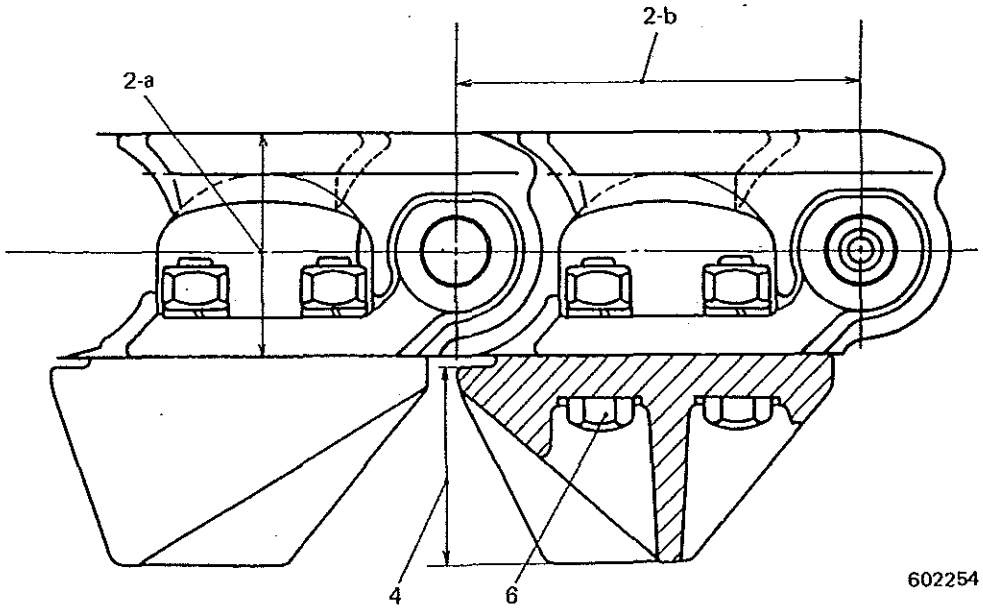
602185

Super-swamp/ultra super-swamp model track



602253

Standard model track

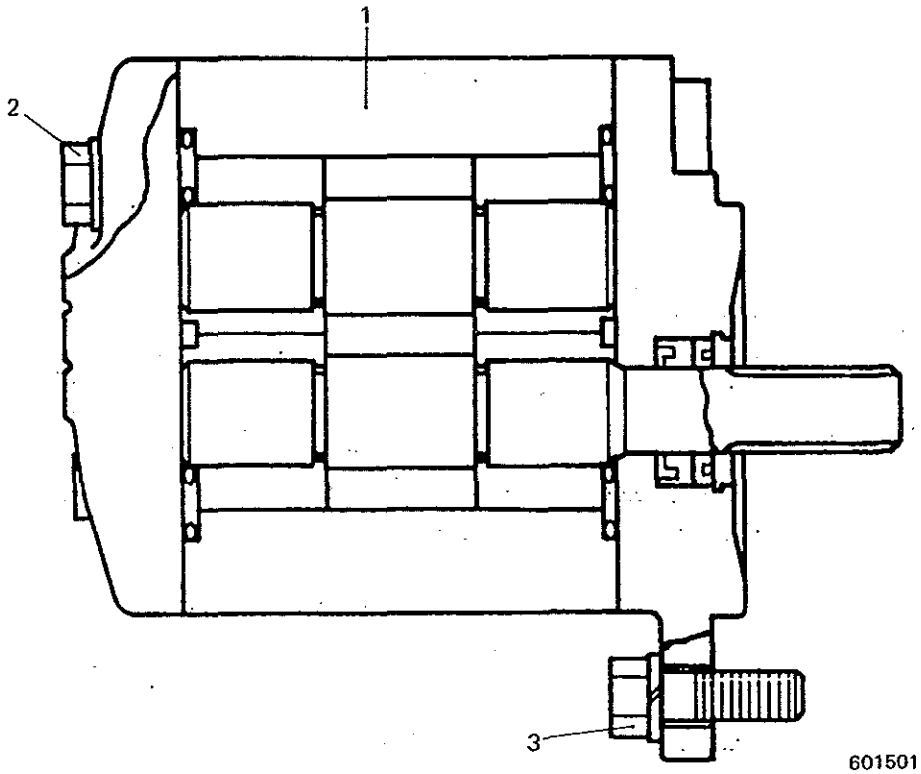


602254

Swamp model/super-swamp model/ultra super-swamp model track

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Hydraulic pump	1	Pump performance	Rpm	2400		
			Delivery pressure kg/cm² (psi) [MPa]	180 (2560) [17.7]		
			Capacity liter (cu in.)/min	54 (3295)		
	2	Through bolts	Tightening torque kgf·m (lbf·ft) [N·m]	4.7 – 5.0 (34.0 – 36.2) [46.1 – 49.0]		
	3	Pump mounting bolts	Tightening torque kgf·m (lbf·ft) [N·m]	4.2 (30.4) [41.2]		

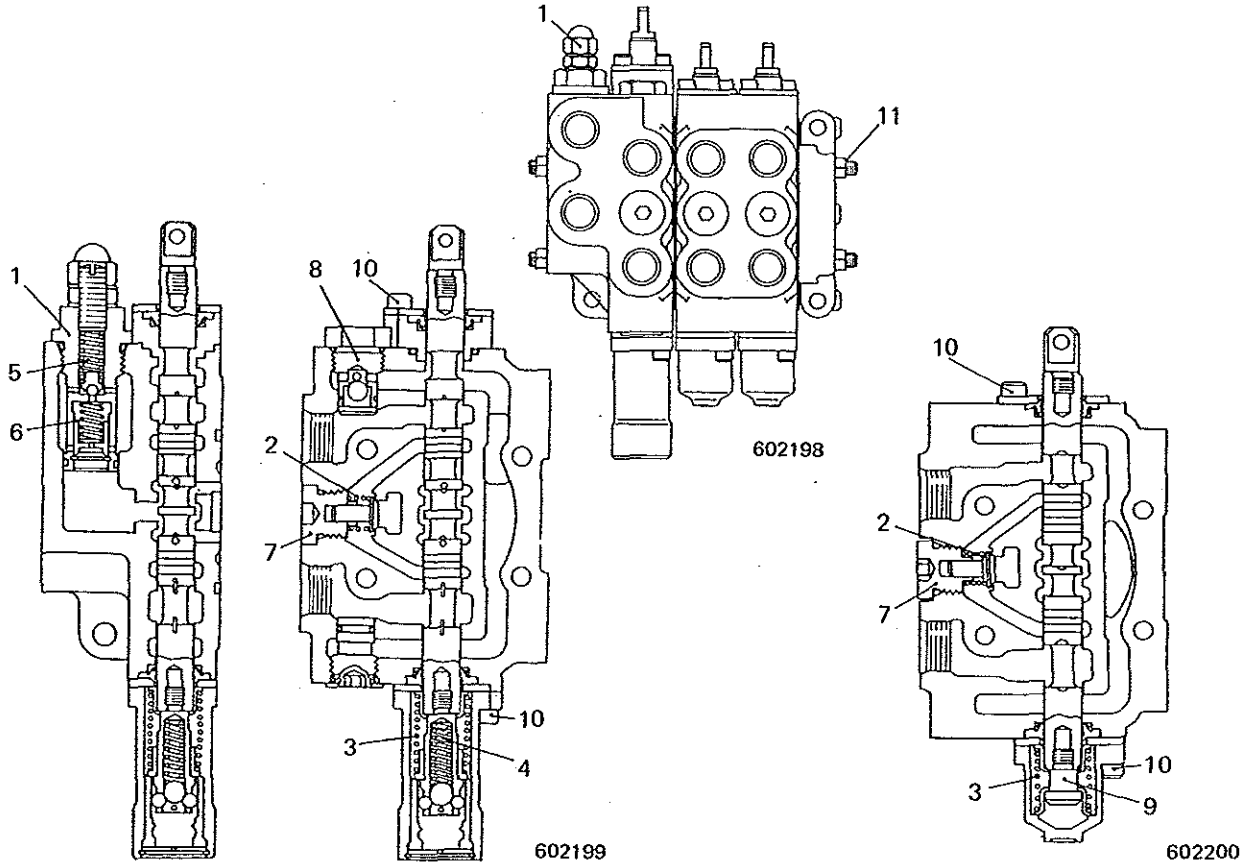


Unit: mm (in.)

Group	Ref. No.	Item			Assembly standard	Service limit	Remarks
Control valve (BD2G with power angling/tilt blade)	1	Main relief valve		Pressure that makes relief valve open kgf/cm² (psi) [MPa]	180 ± 3 (2560 ± 43) [17.7 ± 0.3]		
				Flow rate liter (cu in.)/min.	50 ± 2 (3051 ± 122)		
				Valve tightening torque kgf·m (lbf·ft) [N·m]	10 ± 1 (72.3 ± 7.2) [98.1 ± 9.8]		
	2	Check valve springs		Free length	20 (0.79)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	0.2 ± 0.02 (0.44 ± 0.04) [2.0 ± 0.2]/ 10.5 (0.413)		
	3	Plunger centering springs	Angling	Free length	51 (2.01)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 10.5 (0.413)		
			Tilt	Free length	51 (2.01)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 10.5 (0.413)		
			Lift	Free length	57 (2.24)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	13.8 ± 1.0 (30.4 ± 2.2) [135.3 ± 9.8]/ 10.5 (0.413)		
	4	Plunger detent spring		Free length	35 (1.38)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	7 ± 0.7 (15.4 ± 1.5) [68.6 ± 6.9]/ 27 (1.06)		
	5	Relief valve outer spring		Free length	26 (1.02)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 22 (0.87)		
	6	Relief valve inner spring		Free length	23 (0.91)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	1.4 ± 0.1 (3.1 ± 0.2) [13.7 ± 1.0]/ 18.4 (0.724)		
	7	Check valve plugs		Tightening torque kgf·m (lbf·ft) [N·m]	3.5 ± 0.4 (25.3 ± 2.9) [34.3 ± 3.9]		
	8	Makeup valves		Tightening torque kgf·m (lbf·ft) [N·m]	5.0 ± 0.5 (36.2 ± 3.6) [49.0 ± 4.9]		

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Control valve (BD2G with power angling/tilt blade)	9	Plunger plug & plunger detent plug	Tightening torque kgf·m (lbf·ft) [N·m]	2.0 ± 0.2 (14.5 ± 1.4) [19.6 ± 2.0]		
	10	Seal cover plates & cap securing bolts	Tightening torque kgf·m (lbf·ft) [N·m]	1.1 ± 0.1 (8.0 ± 0.7) [10.8 ± 1.0]		
	11	Tie rods	Tightening torque kgf·m (lbf·ft) [N·m]	2.7 ± 0.3 (19.5 ± 2.2) [26.5 ± 2.9]		
		Control lever	Operating force kgf (lbf)[N] N → Raise	1.5 – 3.0 (3.3 – 6.6) [14.7 – 29.4]		With engine shut off
			N → Lower	1.0 – 2.0 (2.2 – 4.4) [9.8 – 19.6]		
			Lower → Float	4.5 – 5.0 (9.9 – 11.0) [44.1 – 49.0]		
			Float → Lower	2.5 – 3.0 (5.5 – 6.6) [24.5 – 29.4]		
			N → RH angling N → LH angling	2.0 – 3.0 (4.4 – 6.6) [19.6 – 29.4]		
			N → RH tilt N → LH tilt	2.5 – 3.5 (5.5 – 7.7) [24.5 – 34.3]		

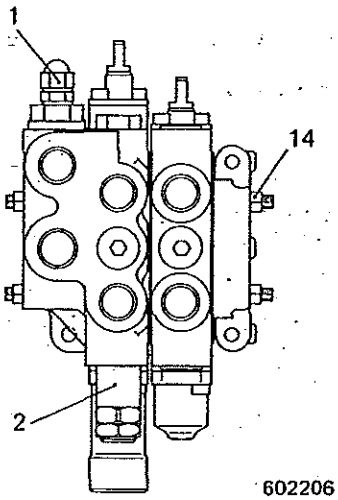


Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Control valve (BD2G with power tilt blade)	1	Main relief valve	Pressure that makes relief valve open kgf/cm² (psi)[MPa]	180 ± 3 (2560 ± 43) [17.6 ± 0.3]		
			Flow rate liter (cu in.)/min	50 ± 2 (3051 ± 122)		
			Valve tightening torque kgf·m (lbf·ft)[N·m]	10 ± 1 (72 ± 7) [98 ± 10]		
	2	Safety valve	Pressure that makes relief valve open kgf/cm² (psi)[MPa]	200 ± 2 (2844 ± 28) [19.6 ± 0.2]		
			Flow rate liter (cu in.)/min	15 ± 2 (915 ± 122)		
			Valve tightening torque kgf·m (lbf·ft)[N·m]	5.0 ± 0.5 (36.2 ± 3.6) [49 ± 4.9]		
	3	Check valve springs	Free length	20 (0.79)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	0.20 ± 0.02 (0.44 ± 0.04) [2.0 ± 0.2]/ 10.5 (0.41)		
	4	Plunger centering springs (Lift)	Free length	57 (2.24)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	13.8 ± 1.0 (30.4 ± 2.2) [135.3 ± 9.8]/ 27.6 (1.09)		
		Plunger centering springs (Tilt)	Free length	51 (2.01)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 27.6 (1.09)		
	5	Plunger detent spring	Free length	35 (1.38)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	7.0 ± 0.7 (15.4 ± 1.5) [68.6 ± 6.9]/ 27.6 (1.09)		
	6	Relief valve outer spring	Free length	26 (1.02)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 22 (0.87)		
	7	Relief valve inner spring	Free length	23 (0.91)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	1.4 ± 0.1 (3.1 ± 0.2) [13.7 ± 1.0]/ 18.4 (0.72)		
	8	Safety valve spring	Free length	39.5 (1.56)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)	20.8 ± 1.5 (45.9 ± 3.3) [204 ± 15]/ 34.5 (1.36)		

Unit: mm (in.)

Group	Ref. No.	Item			Assembly standard	Service limit	Remarks
Control valve (BD2G with power tilt blade)	9	Check valve plugs	Tightening torque kgf·m (lbf·ft)[N·m]		3.5 ± 0.4 (25.3 ± 2.9) [34.3 ± 3.9]		
	10	Makeup valve	Tightening torque kgf·m (lbf·ft)[N·m]		5.0 ± 0.5 (36.2 ± 3.6) [49.0 ± 4.9]		
	11	Plunger plug & plunger detent plug	Tightening torque kgf·m (lbf·ft)[N·m]		2.0 ± 0.2 (14.5 ± 1.4) [19.6 ± 2.0]		
	12	Plugs	Tightening torque kgf·m (lbf·ft)[N·m]		10 ± 1 (72.3 ± 7.2) [98.1 ± 9.8]		
	13	Seal cover plates & cap securing bolts	Tightening torque kgf·m (lbf·ft)[N·m]		1.1 ± 0.1 (8.0 ± 0.7) [10.8 ± 1.0]		
	14	Tie rods	Tightening torque kgf·m (lbf·ft)[N·m]		2.7 ± 0.3 (19.5 ± 2.2) [26.5 ± 2.9]		
		Control lever	Operating force kgf (lbf) [N]	N → Raise	1.5 – 3.0 (3.3 – 6.6) [14.7 – 29.4]		With engine shut off
				N → Lower	1.0 – 2.0 (2.2 – 4.4) [9.8 – 19.6]		
				Lower → Float	4.5 – 5.0 (9.9 – 11.0) [44.1 – 49.0]		
				Float → Lower	2.5 – 3.0 (5.5 – 6.6) [24.5 – 29.4]		
				N → RH tilt N → LH tilt	2.5 – 3.5 (5.5 – 7.7) [24.5 – 34.3]		



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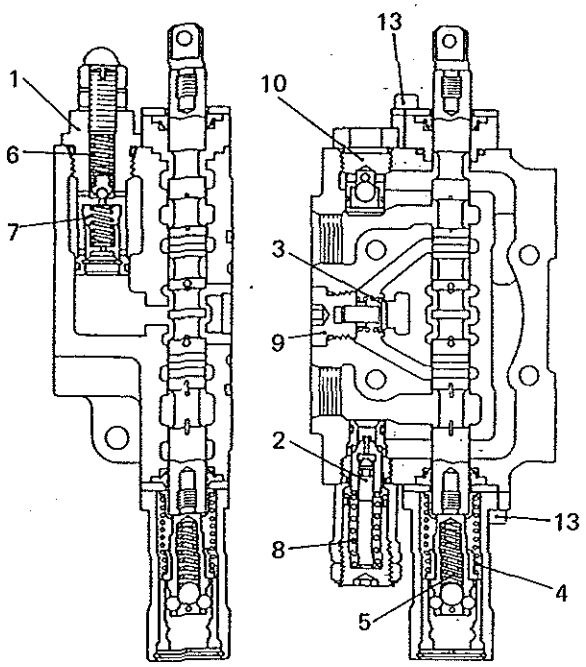

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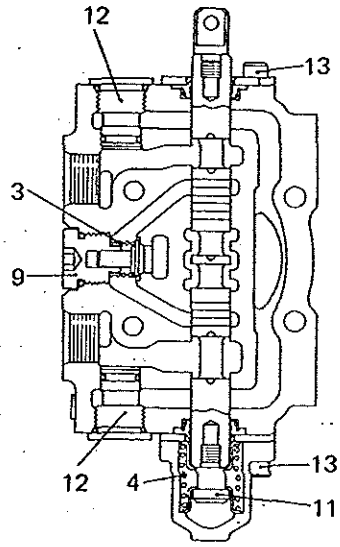


602208

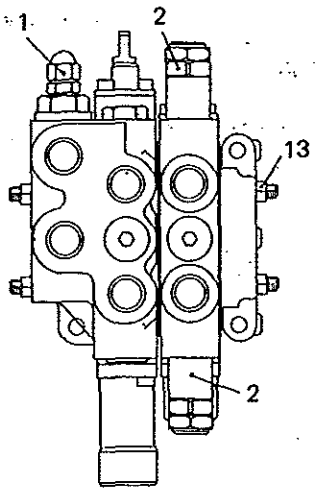
Unit: mm (in.)

Group	Ref. No.	Item			Assembly standard	Service limit	Remarks
Control valve (BS3G)	1	Main relief valve		Pressure that makes relief valve open kgf/cm² (psi)[MPa]	160 ± 3 (2275 ± 43) [15.7 ± 0.3]		
				Flow rate liter (cu in.)/min	50 ± 2 (3051 ± 122)		
				Valve tightening torque kgf·m (lbf·ft)[N·m]	10 ± 1 (72 ± 7) [98 ± 10]		
	2	Safety valves	Head side	Pressure that makes relief valve open kgf/cm² (psi)[MPa]	200 ± 2 (2844 ± 28) [19.6 ± 0.2]		
				Flow rate liter (cu in.)/min	23 ± 2 (1404 ± 122)		
			Rod side	Pressure that makes relief valve open kgf/cm² (psi)[MPa]	160 ± 2 (2275 ± 28) [15.7 ± 0.2]		
				Flow rate liter (cu in.)/min	23 ± 2 (1404 ± 122)		
	3	Check valve springs		Free length	20 (0.79)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	0.20 ± 0.02 (0.44 ± 0.04) [2.0 ± 0.2]/ 10.5 (0.413)		
	4	Plunger centering springs	Lift	Free length	57 (2.24)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	13.8 ± 1 (30.4 ± 2.2) [135.8 ± 9.8]/ 27.6 (1.09)		
			Dump	Free length	51 (2.01)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 27.6 (1.09)		
	5	Makeup valve springs		Free length	21 (0.83)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	0.16 ± 0.02 (0.35 ± 0.04) [1.6 ± 0.2]/ 17.5 (0.69)		
	6	Relief valve outer spring		Free length	26 (1.02)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	11.0 ± 1.1 (24.3 ± 2.4) [107.9 ± 10.8]/ 22 (0.87)		
	7	Relief valve inner spring		Free length	23 (0.91)		
				Test force/length under test force kgf (lbf)[N]/mm (in.)	1.4 ± 0.1 (3.09 ± 0.2) [13.7 ± 1.0]/ 18.4 (0.72)		

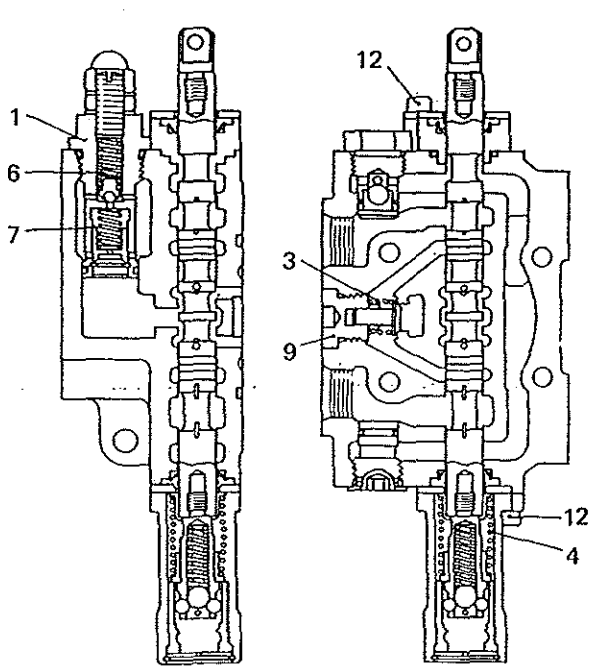
Unit: mm (in.)

Group	Ref. No.	Item			Assembly standard	Service limit	Remarks
Control valve (BS3G)	8	Safety valve springs	Free length		39.5 (1.56)		
			Test force/length under test force kgf (lbf)[N]/mm (in.)		20.8 ± 1.5 (45.9 ± 3.3) [204.0 ± 14.7]/ 34 (1.34)		
	9	Check valve plugs	Tightening torque kgf·(lbf·ft)[N·m]		3.5 ± 0.4 (25.3 ± 2.9) [34.3 ± 3.9]		
	10	Makeup valves	Tightening torque kgf·m (lbf·ft)[N·m]		5.0 ± 0.5 (36.2 ± 3.6) [49.0 ± 4.9]		
	11	Plunger plug & plunger detent plug	Tightening torque kgf·m (lbf·ft)[N·m]		2.0 ± 0.2 (14.5 ± 1.4) [19.6 ± 2.0]		
	12	Seal cover plates & cap securing bolts	Tightening torque kgf·m (lbf·ft)[N·m]		1.1 ± 0.1 (8.0 ± 0.7) [10.8 ± 1.0]		
	13	Tie rods	Tightening torque kgf·m (lbf·ft)[N·m]		2.7 ± 0.3 (19.5 ± 2.2) [26.5 ± 2.9]		
		Control valve	Operating force kgf (lbf) [N]	N → Raise	1.5 – 3.0 (3.3 – 6.6) [14.7 – 29.4]		With engine shut off
				N → Lower	1.0 – 2.0 (2.2 – 4.4) [9.8 – 19.6]		
				Lower → Float	4.5 – 5.0 (9.9 – 11.0) [44.1 – 49.0]		
				Float → Lower	2.5 – 3.0 (5.5 – 6.6) [24.5 – 29.4]		
				N → Tilt N → Dump	2.5 – 3.5 (5.5 – 7.7) [24.5 – 34.3]		

CONTROL VALVE



602214



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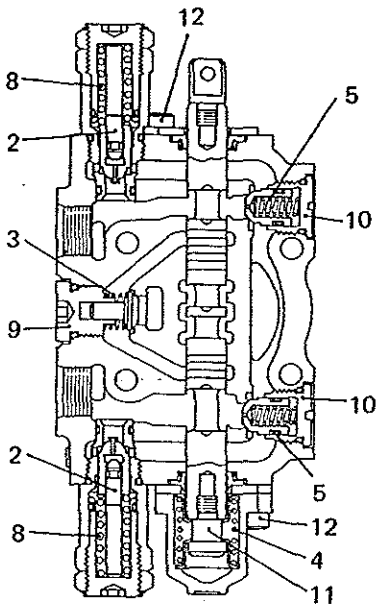
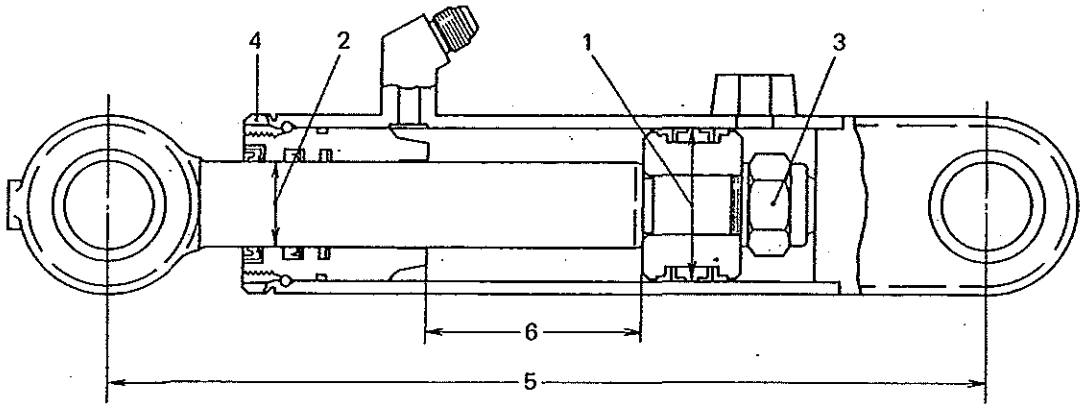


602215

Unit: mm (in.)

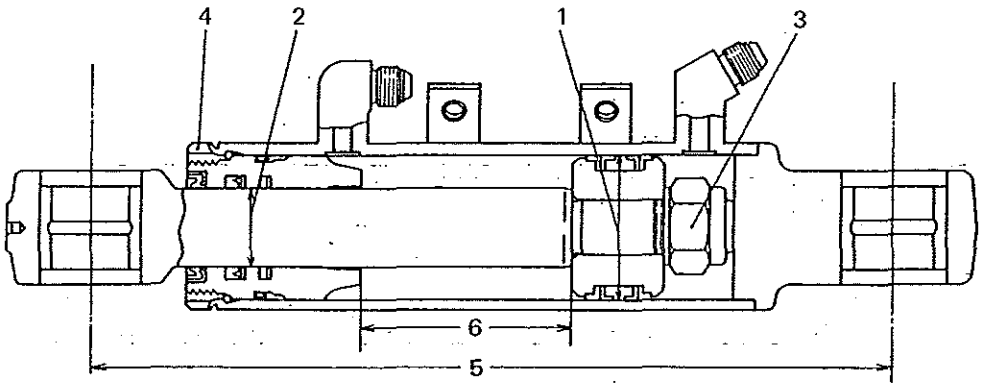
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Lift cylinders (BD2G with power angling/ tilt blade and power tilt blade)	1	Cylinder and piston	Fit of cylinder on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft) [N·m]	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft) [N·m]	15.0 ± 1.5 (108.5 ± 10.8) [147.1 ± 14.7]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	640 (25.20)		
	6		Stroke	370 (14.57)		



602256

Unit: mm (in.)

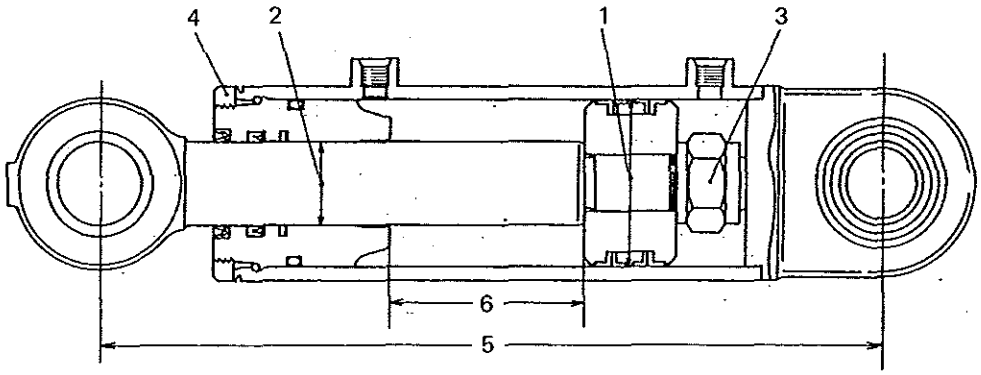
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Angling cylinders (BD2G with power angling/tilt blade)	1	Cylinder and piston	Fit of cylinder on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft)[N·m]	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft)[N·m]	15.0 ± 1.5 (108.5 ± 10.8) [147.1 ± 14.7]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	579.5 (22.815)		
	6		Stroke	321 (12.64)		



602255

Unit: mm (in.)

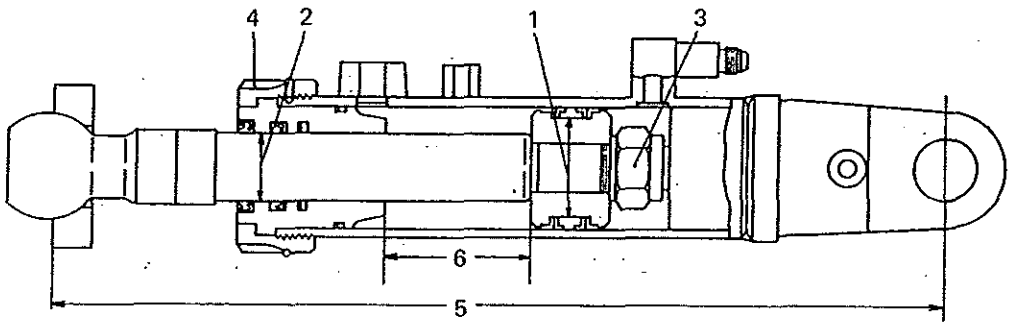
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Tilt cylinder (BD2G with power angling/tilt blade)	1	Cylinder and piston	Fit of cylinder on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft)[N·m]	70.0 ± 3.5 (506.3 ± 25.3) [686.5 ± 34.3]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft)[N·m]	24.0 ± 2.4 (173.6 ± 17.4) [235.4 ± 23.5]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	390 (15.35)		
	6		Stroke	110 (4.33)		



602257

Unit: mm (in.)

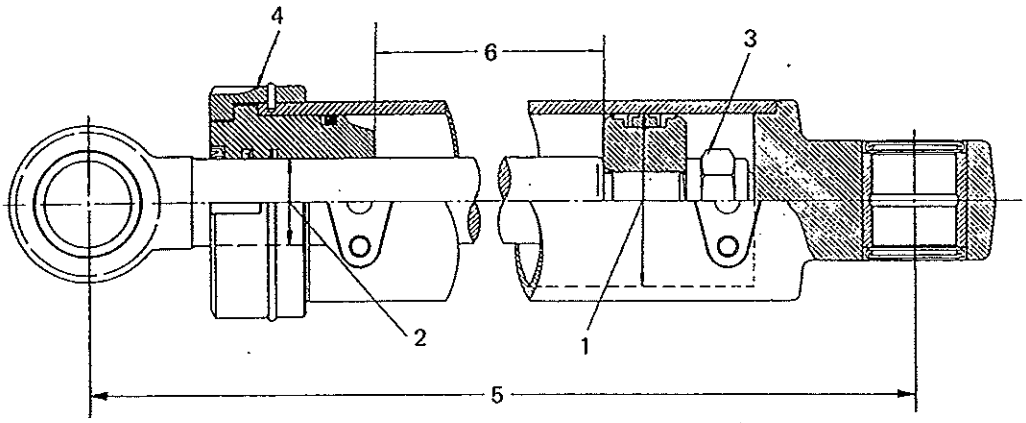
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Tilt cylinder (BD2G with power tilt blade)	1	Cylinder and piston	Fit of cylinder on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft)[N·m]	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft)[N·m]	45.0 ± 4.5 (325.5 ± 32.5) [441.3 ± 44.1]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	500 (19.69)		
	6		Stroke	115 (4.53)		



602258

Unit: mm (in.)

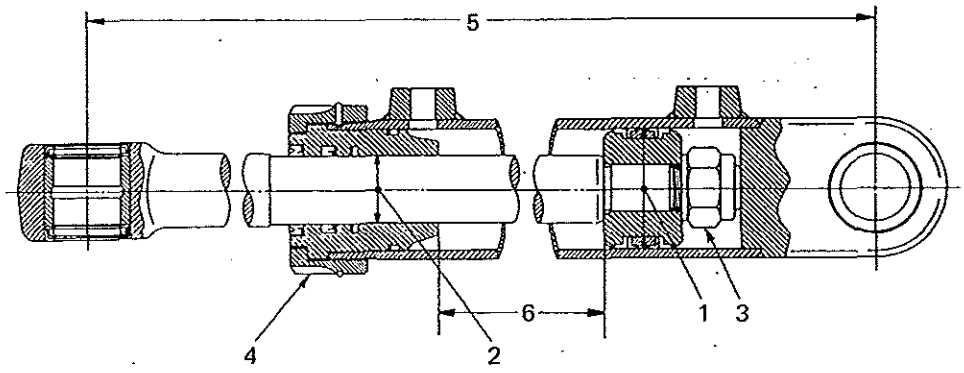
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Lift cylinders (BS3G)	1	Cylinder and piston	Fit of guide bushing on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft)[N·m]	95.0 ± 5.0 (687.1 ± 36.2) [931.6 ± 49.0]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft)[N·m]	75.0 ± 8.0 (542.5 ± 57.9) [735.5 ± 78.5]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	700 (27.56)		
	6		Stroke	386 (15.20)		



602259

Unit: mm (in.)

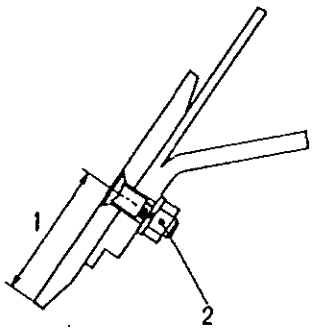
Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Dump cylinders (BS3G)	1	Cylinder and piston	Fit of cylinder on piston		0.350 (0.01378)	
	2	Guide bushing	Fit of guide bushing on piston rod	0.075 – 0.139 (0.00295 – 0.00547)	0.350 (0.01378)	
	3	Piston securing nut	Tightening torque kgf·m (lbf·ft) [N·m]	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]		
	4	Gland screw	Tightening torque kgf·m (lbf·ft) [N·m]	45.0 ± 4.5 (325.5 ± 32.5) [441.3 ± 44.1]		
	5	Piston rod	Center to center of pins with cylinder fully retracted	866.5 (34.11)		
	6		Stroke	423.5 (16.67)		



602260

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Power angling/tilt blade (BD2G)	1	Cutting edges/ end bits	Distance from center of bolt hole to edge tip/bit tip	75 (2.95)	45 (1.77)	
	2	Cutting edge mounting plow bolts	Tightening torque kgf·m (lbf·ft)[N·m]	6.5 ± 0.7 (47.0 ± 5.1) [63.7 ± 6.9]		
	3	Cap mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	38 – 43 (274 – 311) [373 – 422]		
	4	Outer and inner plates mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	12 – 14 (87 – 101) [118 – 137]		
	5	Swing bracket mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	12.2 – 14.8 (88.2 – 107.0) [119.6 – 145.1]		
	6	Plate mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	7.6 – 9.2 (55.0 – 66.5) [74.5 – 90.2]		



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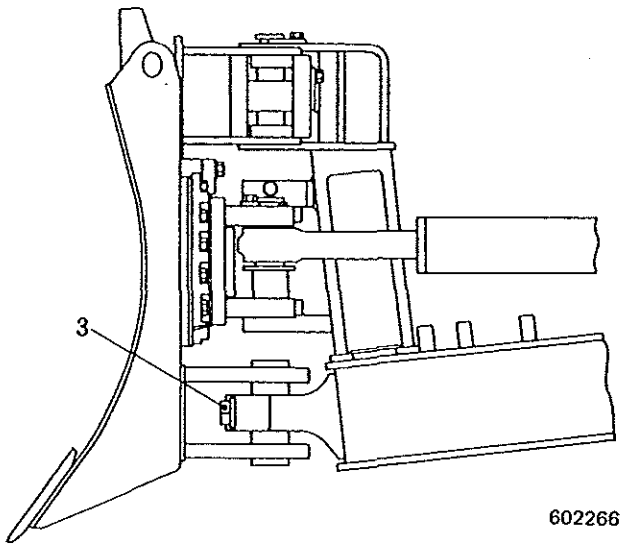

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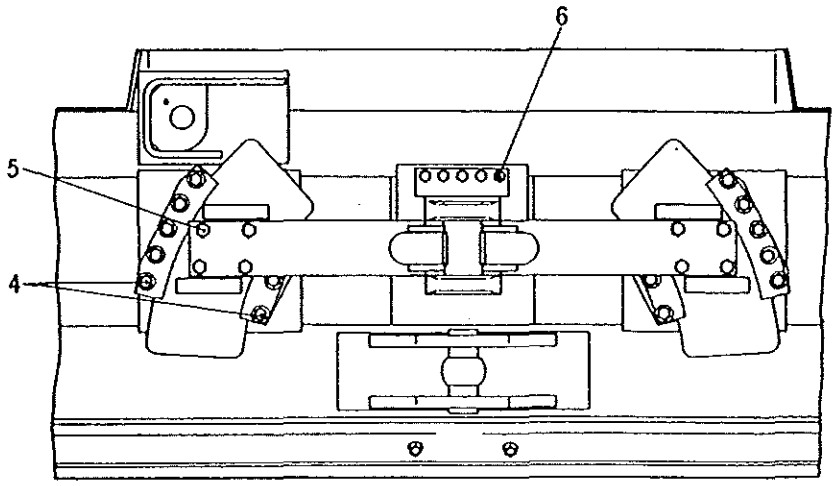

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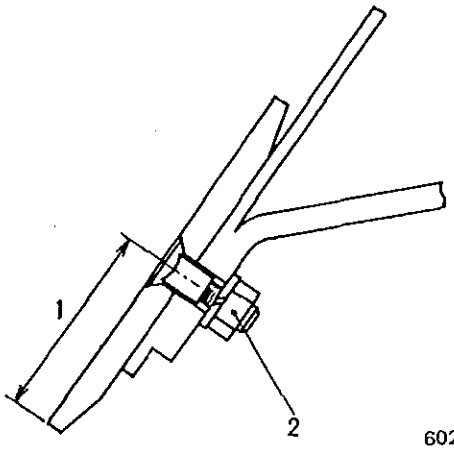
POWER TILT BLADE (BD2G)

Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Power tilt blade (BD2G)	1	Cutting edges/ end bits	Distance from center of bolt hole to edge tip/bit tip	75 (2.95)	45 (1.77)	
	2	Cutting edge mounting plow bolts	Tightening torque kgf·m (lbf·ft)[N·m]	6.5 ± 0.7 (47.0 ± 5.1) [63.7 ± 6.9]		
	3	Trunnion mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	10.4 ± 1.0 (75.2 ± 7.2) [102.0 ± 9.8]		
	4	Trunnion cap mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	15.8 ± 1.6 (114.3 ± 11.6) [154.9 ± 15.7]		



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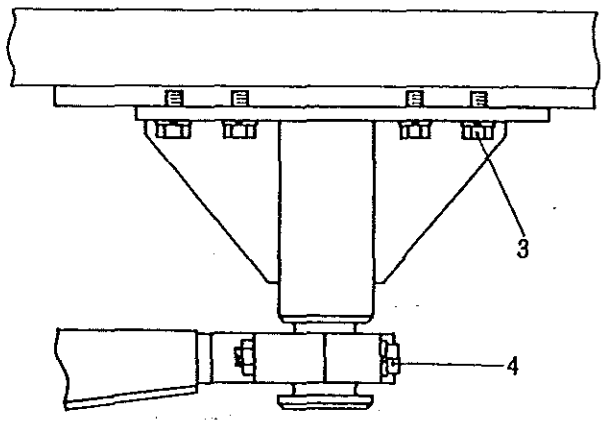

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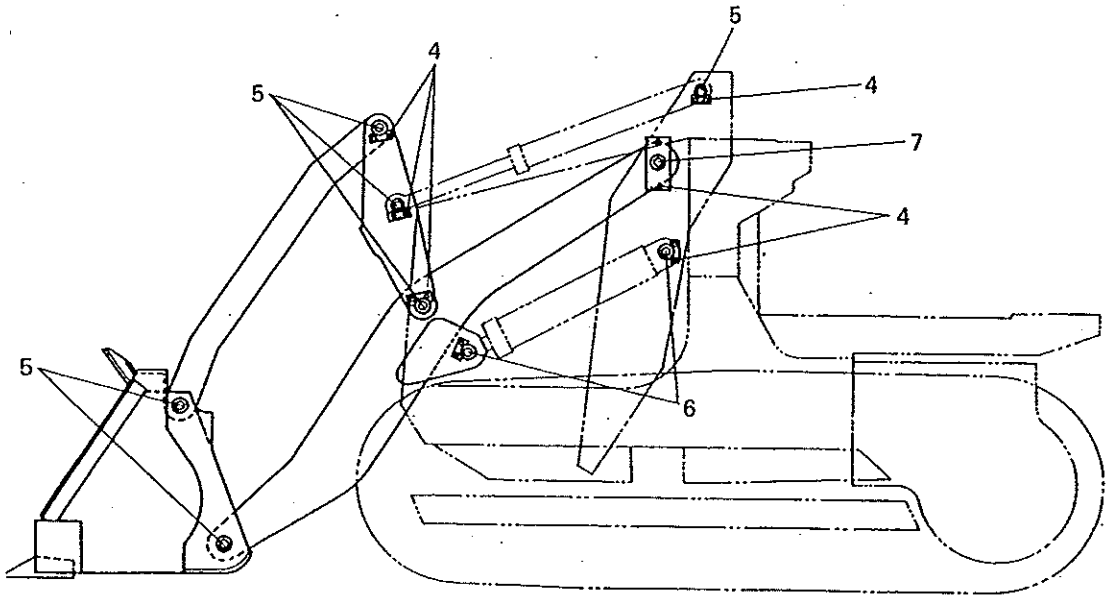
Unit: mm (in.)

Group	Ref. No.	Item		Assembly standard	Service limit	Remarks
Bucket and linkage (BS3G)	1	Tooth	Length	160 (6.30)	100 (3.94)	
	2		Tightening torque for securing bolts kgf·m (lbf·ft)[N·m]	29 – 32 (210 – 231) [284 – 314]		
	3	Cutting edges	Width	159 (6.26)	120 (4.72)	
	4	Lock plate mounting bolts	Tightening torque kgf·m (lbf·ft)[N·m]	3.5 ± 0.3 (25.3 ± 2.2) [34.3 ± 2.9]		
	5	Clearance of each pin in bushing	35 (1.38)	0.100 – 0.175 (0.00394 – 0.00689)	0.600 (0.02362)	
	6		45 (1.77)	0.200 – 0.275 (0.00787 – 0.01083)	0.600 (0.02362)	
	7		50 (1.97)	0.130 – 0.219 (0.00512 – 0.00862)	0.600 (0.02362)	



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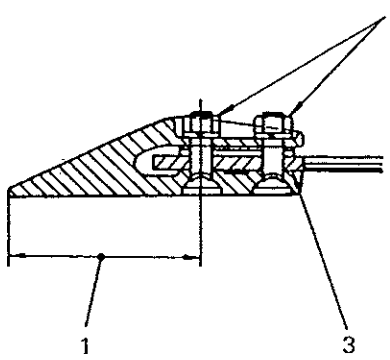

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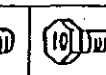
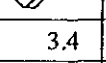
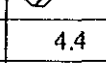
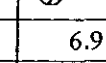
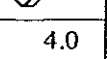
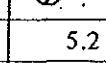
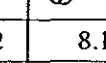
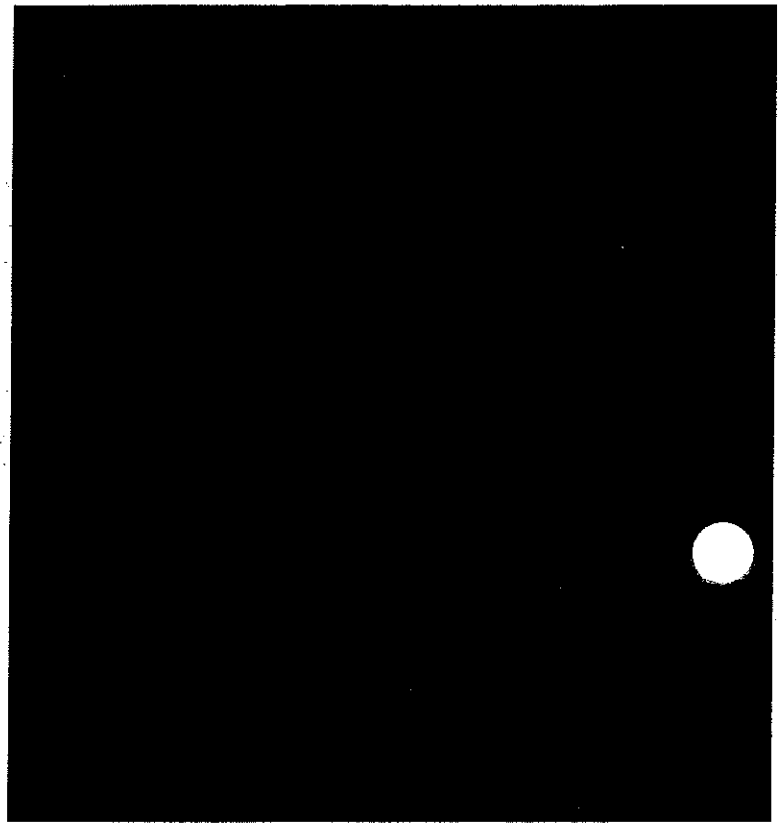
TIGHTENING TORQUE FOR STANDARD BOLTS

Unit: kgf·m

	Nominal size (mm)	Pitch (mm)	With spring washer			Without spring washer		
								
Metric fine thread	6	1	0.75	0.98	1.3	0.88	1.1	1.5
	8	1.25	1.7	2.3	3.1	2.0	2.7	3.7
	10	1.25	3.5	4.6	7.1	4.2	5.4	8.3
	12	1.25	6.5	8.4	12.5	7.6	9.9	14.7
	14	1.5	10.4	13.5	19.6	12.2	15.9	23.1
	16	1.5	15.8	20.6	29.3	18.6	24.2	34.5
	18	1.5	22.9	29.8	42.2	26.9	35.0	49.7
	20	1.5	31.7	41.2	58.5	37.3	48.5	68.8
	22	1.5	42.2	54.8	77.8	49.6	64.5	91.5
	24	1.5	55.8	72.5	102.6	65.6	85.3	120.7
	27	1.5	81.0	105.3	148.0	95.3	123.9	174.1
	30	1.5	112.2	145.9	205.2	132.0	171.6	241.4
	33	1.5	149.6	194.5	273.3	176.0	228.8	321.6
	36	1.5	195.6	254.3	356.6	230.1	299.2	419.6
	39	1.5	251.0	326.2	455.8	295.3	383.8	536.2
	Nominal size (mm)	Pitch (mm)	With spring washer			Without spring washer		
								
Metric coarse thread	10	1.5	3.4	4.4	6.9	4.0	5.2	8.1
	12	1.75	6.0	7.8	11.8	7.1	9.2	13.8
	14	2	9.8	12.7	18.6	11.5	14.9	22.0
	16	2	15.0	19.5	28.0	17.6	22.9	33.0
	18	2.5	20.7	27.0	39.1	24.4	31.8	46.0
	20	2.5	29.2	37.9	54.7	34.3	44.6	64.3
	22	2.5	39.1	50.9	73.0	40.0	59.9	85.9
	24	3	50.2	65.3	94.3	59.0	76.8	111.0
	27	3	73.9	96.1	137.7	86.9	113.0	162.0
	30	3.5	98.9	128.4	188.0	116.3	151.1	221.1
	33	3.5	135.5	176.1	252.6	159.4	207.2	297.3
	36	4	170.9	222.3	326.3	201.1	261.5	384.0
	39	4	226.3	294.1	420.0	266.2	346.0	494.1
	42	4.5	280.9	365.2	523.9	330.5	429.6	616.4

Remarks:

1. This chart gives the torques for standard bolts and nuts.
2. The tolerance for these torques is ±10%.
3. Unless otherwise specified, use these torques.
4. These torques are for "dry" condition.



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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G TRACTOR SHOVEL BS3G (DIRECT DRIVE MODEL)

CONTENTS

POWER TRAIN

- OPERATING PRINCIPLE
- TESTING AND ADJUSTMENTS

MITSUBISHI HEAVY INDUSTRIES, LTD.

FOREWORD

This service manual has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations used in this manual are based on information that was current at the time this issue was written.

Correct servicing will give these machines a long productive life. Before attempting to start a test, repair or rebuild job, be sure that you have studied the respective sections of this manual, and know all the components you will work on.

Safety is not only your concern but everybody's concern. Safe working habits cannot be bought or manufactured; they must be learned through the job you do. By learning what CAUTION or WARNING symbol emphasizes, know what is safe – what is not safe. Consult your foreman, if necessary, for specific instructions on a job, and the safety equipment required.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

CAUTION ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of machine.

WARNING ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

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TESTING AND ADJUSTMENT

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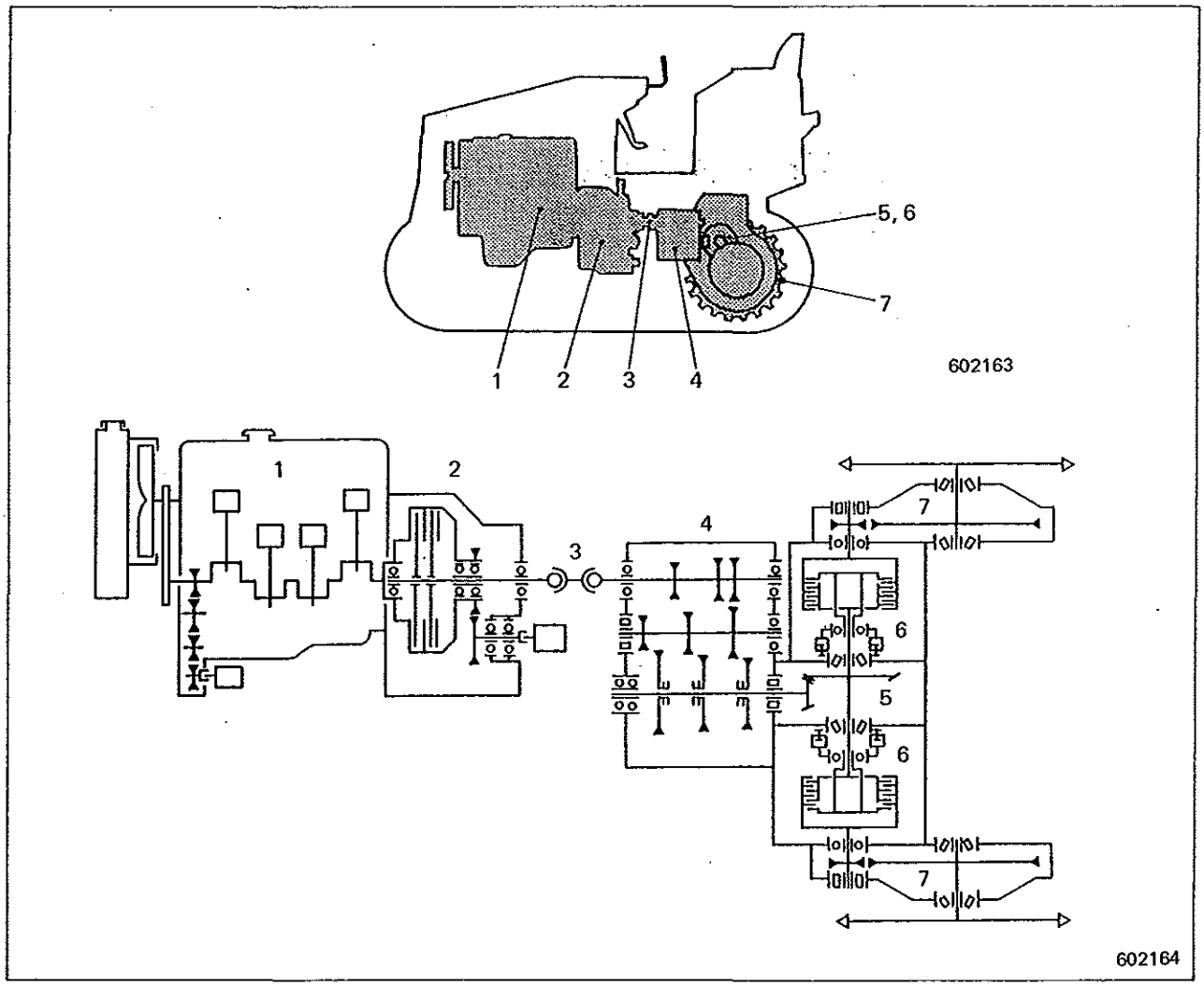
OPERATING PRINCIPLE

GENERAL DESCRIPTION

Direct-drive (DD) model

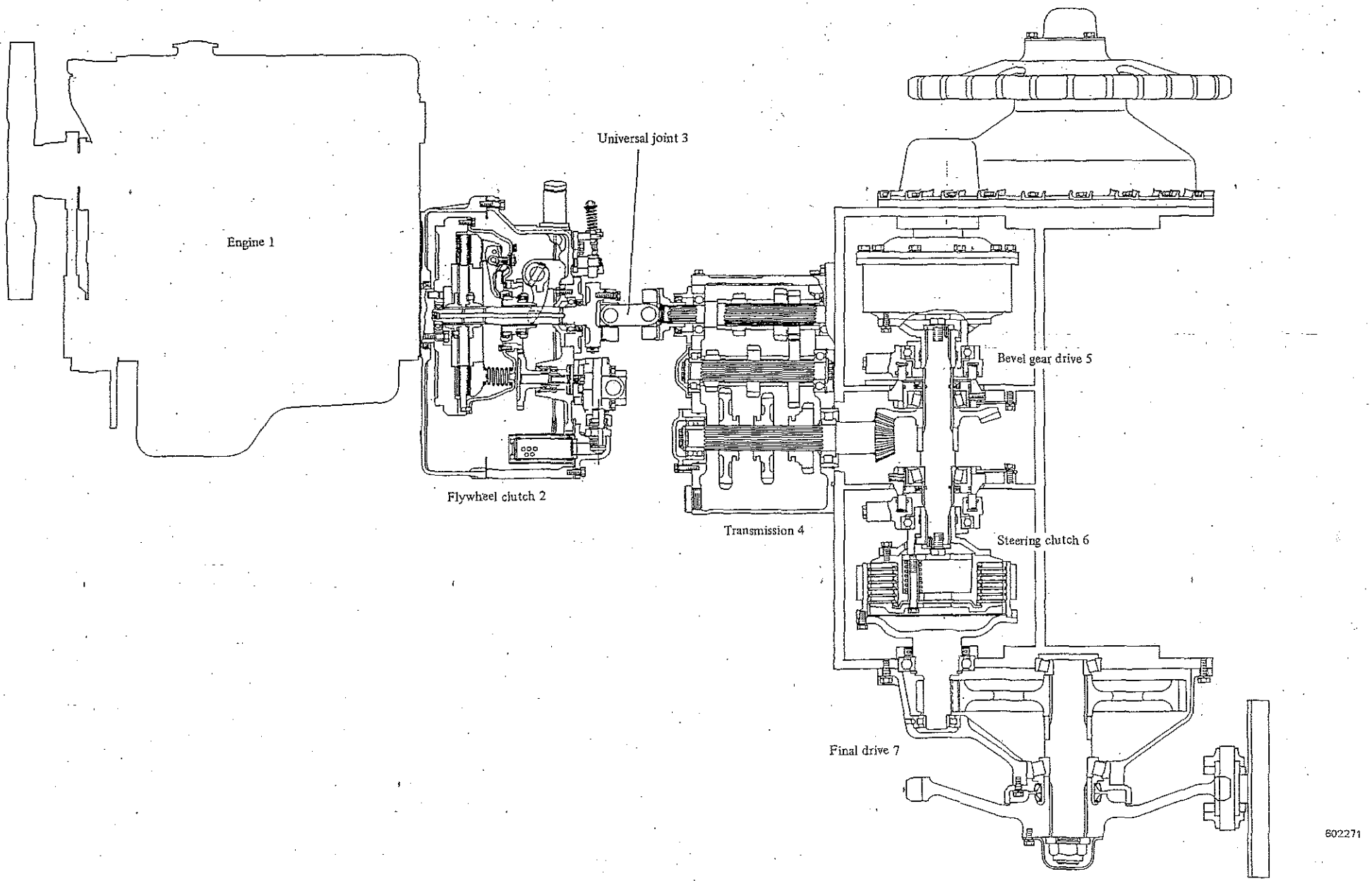


1 Engine
2 Flywheel clutch
3 Universal joint
4 Transmission
5 Bevel gear drive
6 Steering clutch
7 Final drive

Major components of this power train are, from engine "1" to the tracks, flywheel clutch "2," universal joint "3," transmission "4," bevel gear drive "5," steering clutches "6" and final drives "7" including sprockets.

The engine and flywheel clutch are bolted together and are mounted on the frame by a total of four mounts fitted with barrel-shaped vibration-insulating rubber pads.

The transmission which provides a selection of three forward and two reverse speeds is housed in an independent case bolted to the front face of steering clutch case.


Engine 1
Universal joint 3
Flywheel clutch 2
Transmission 4
Bevel gear drive 5
Steering clutch 6
Final drive 7
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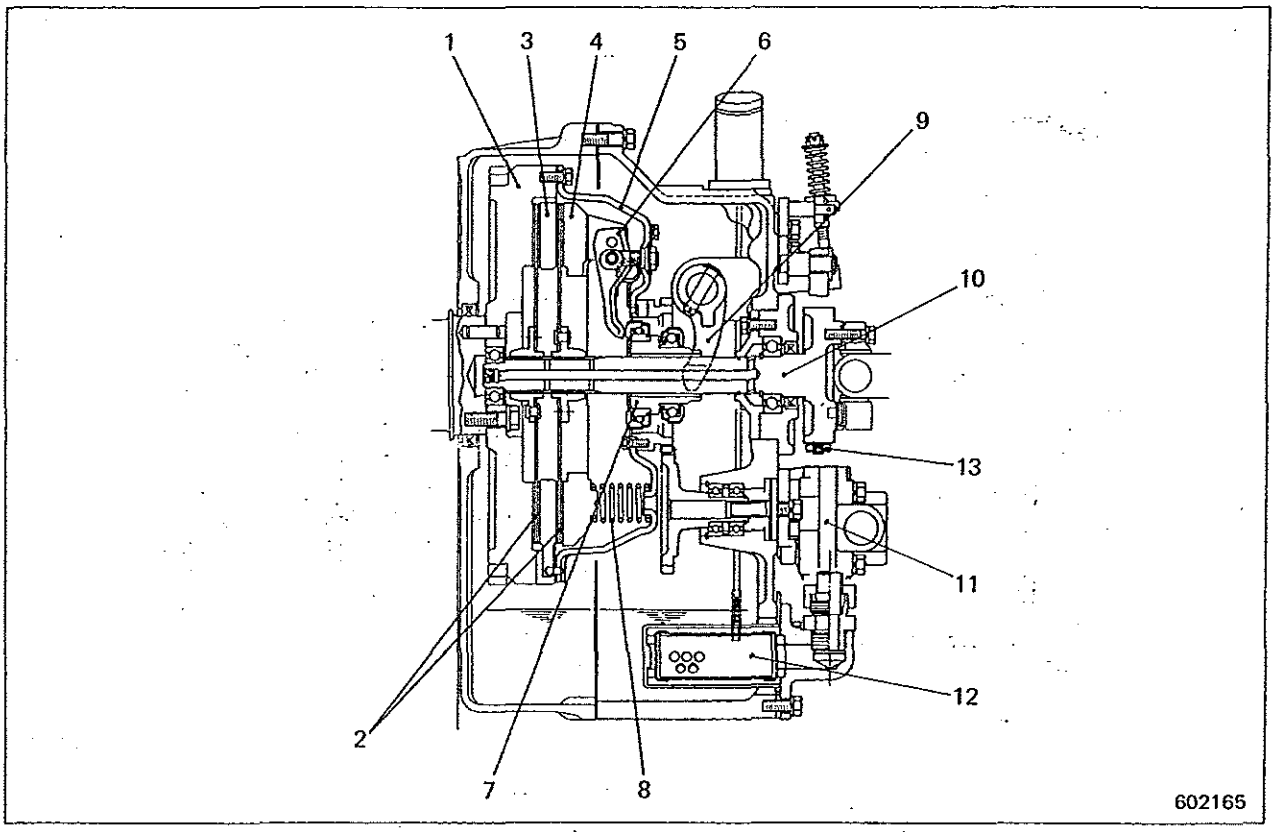
FLYWHEEL CLUTCH



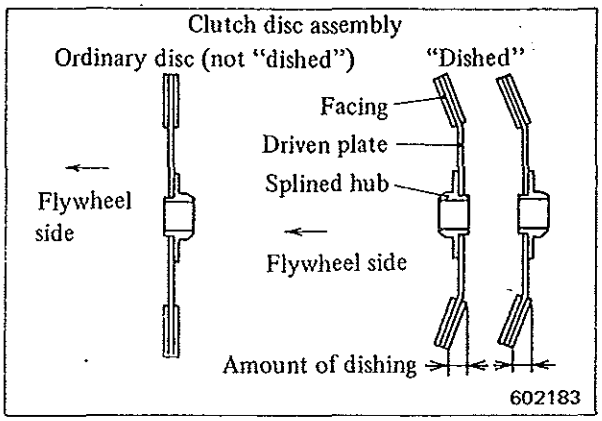
1 Flywheel	6 Release lever	11 Oil pump
2 Clutch disc	7 Release hub	12 Oil strainer
3 Mating plate	8 Release spring	13 Clutch brake
4 Pressure plate	9 Fork	
5 Clutch cover	10 Main shaft	

This flywheel clutch is of wet (oil-cooled), multi-disc type and is housed in the clutch case which also serves as a flywheel housing.

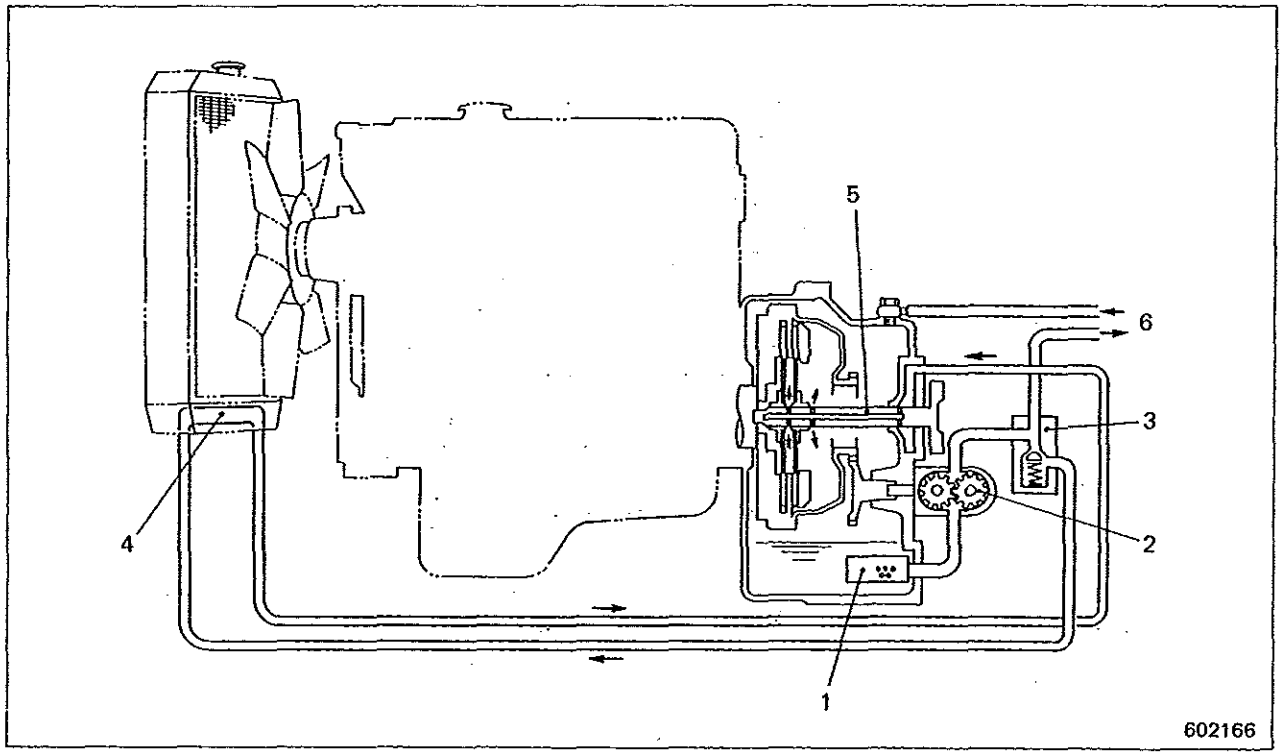
The clutch is normally kept in engaged condition and is disengaged by the clutch pedal connected through a linkage to the release lever.

Clutch discs (driven members) "2" have checkered oil grooves to increase the torque capacity of the clutch in oil-sprayed condition.

This wet clutch, unlike a dry clutch, tends to grab in disengagement due to presence of oil film between the driving and driven members. To prevent this grabbing and to facilitate smooth engagement, the discs are slightly "dished." When in engaged position, the discs are pressed flat and act as cushion springs to serve the purpose.



CLUTCH OIL LINE

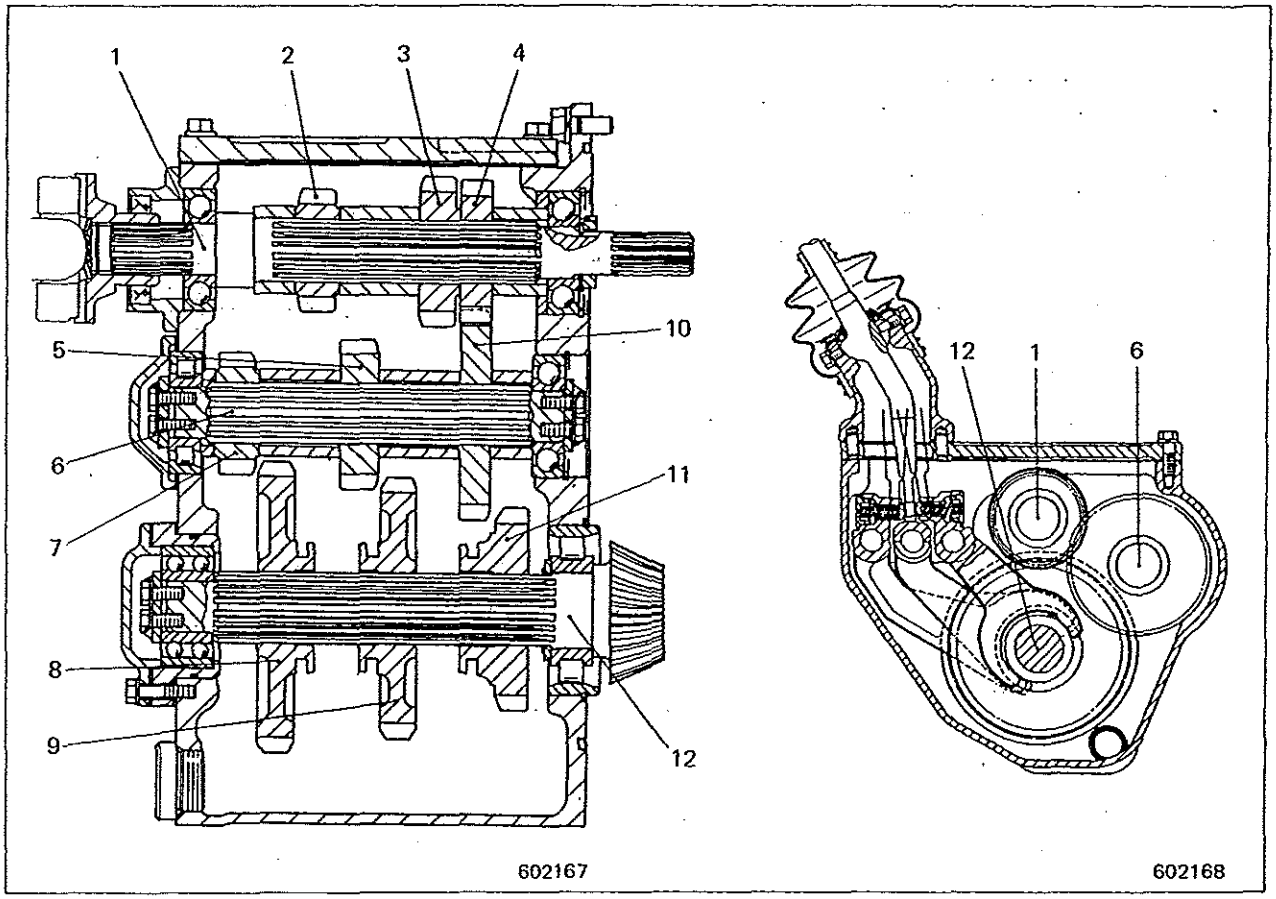


1 Oil strainer
2 Gear pump
3 Relief valve
4 Oil cooler
5 Clutch main shaft
6 To and from steering valve

This oil line is for actuating the steering valve and for cooling and lubricating the clutch discs and related parts.

Oil drawn by gear pump "2" through strainer "1" flows through relief valve "3" into oil cooler "4" where it is cooled, and then into the oil bypass drilled in clutch main shaft "5." From this bypass the oil is sprayed over the friction surfaces of clutch discs.

DIRECT-DRIVE (DD) TRANSMISSION



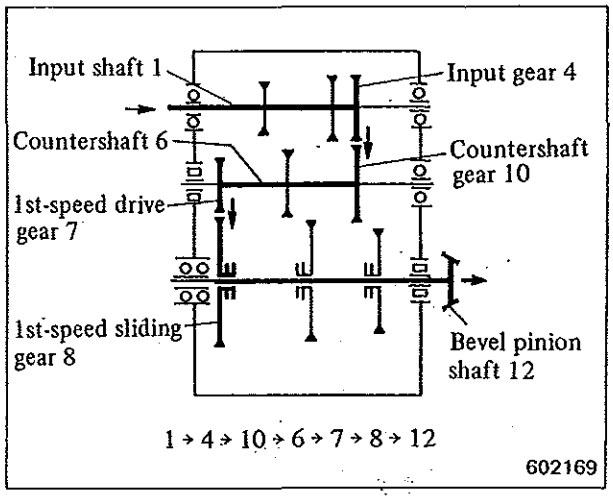
1 Input shaft
2 1st-speed reverse gear
3 2nd-speed reverse gear
4 Input gear
5 2nd-speed drive gear
6 Countershaft
7 1st-speed drive gear
8 1st-speed sliding gear
9 2nd-speed sliding gear
10 Counter gear
11 3rd-speed sliding gear
12 Bevel pinion shaft

This transmission is of manual-shift, sliding gear countershaft type, and provides a selection of three forward and two reverse speeds.

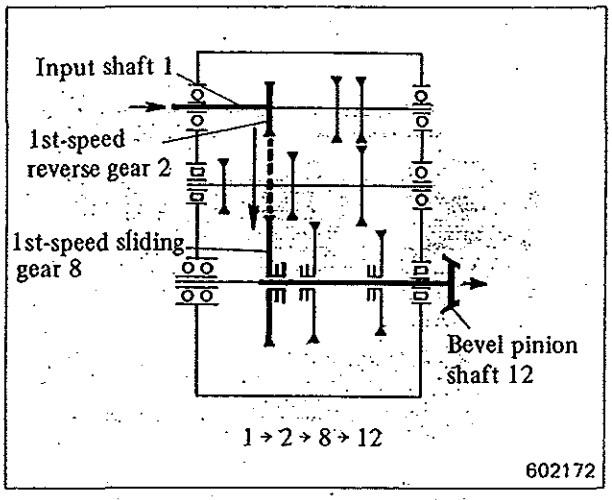
The arrangement of its shifting and gearing is as shown above. The bevel pinion shaft (third) carries three sliding gears. These gears are shifted into mesh with three gears mounted on the countershaft (second) for forward ratio selection, or with two gears on the input shaft (first) for reverse ratio selection.

Power flow in transmission

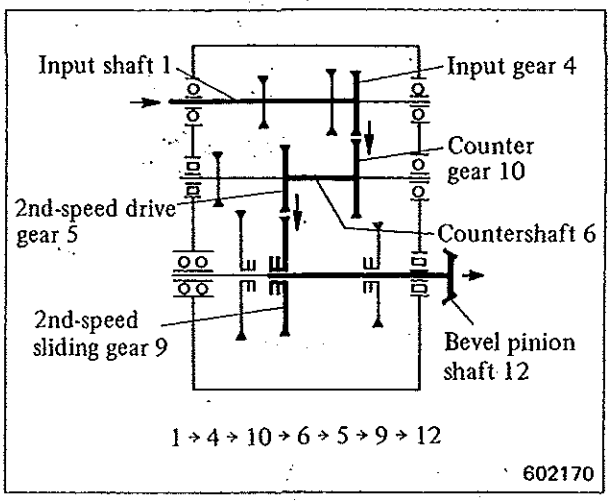
Forward 1st-speed position



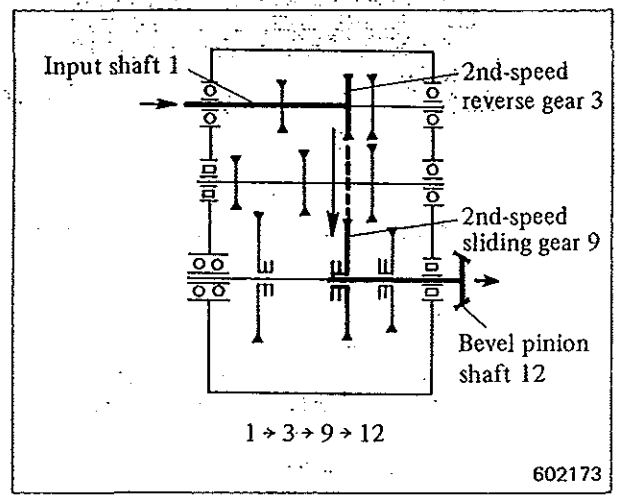
Reverse 1st-speed position



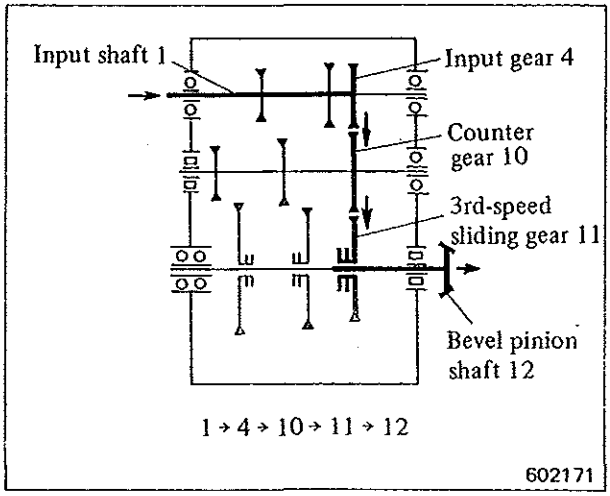
Forward 2nd-speed position



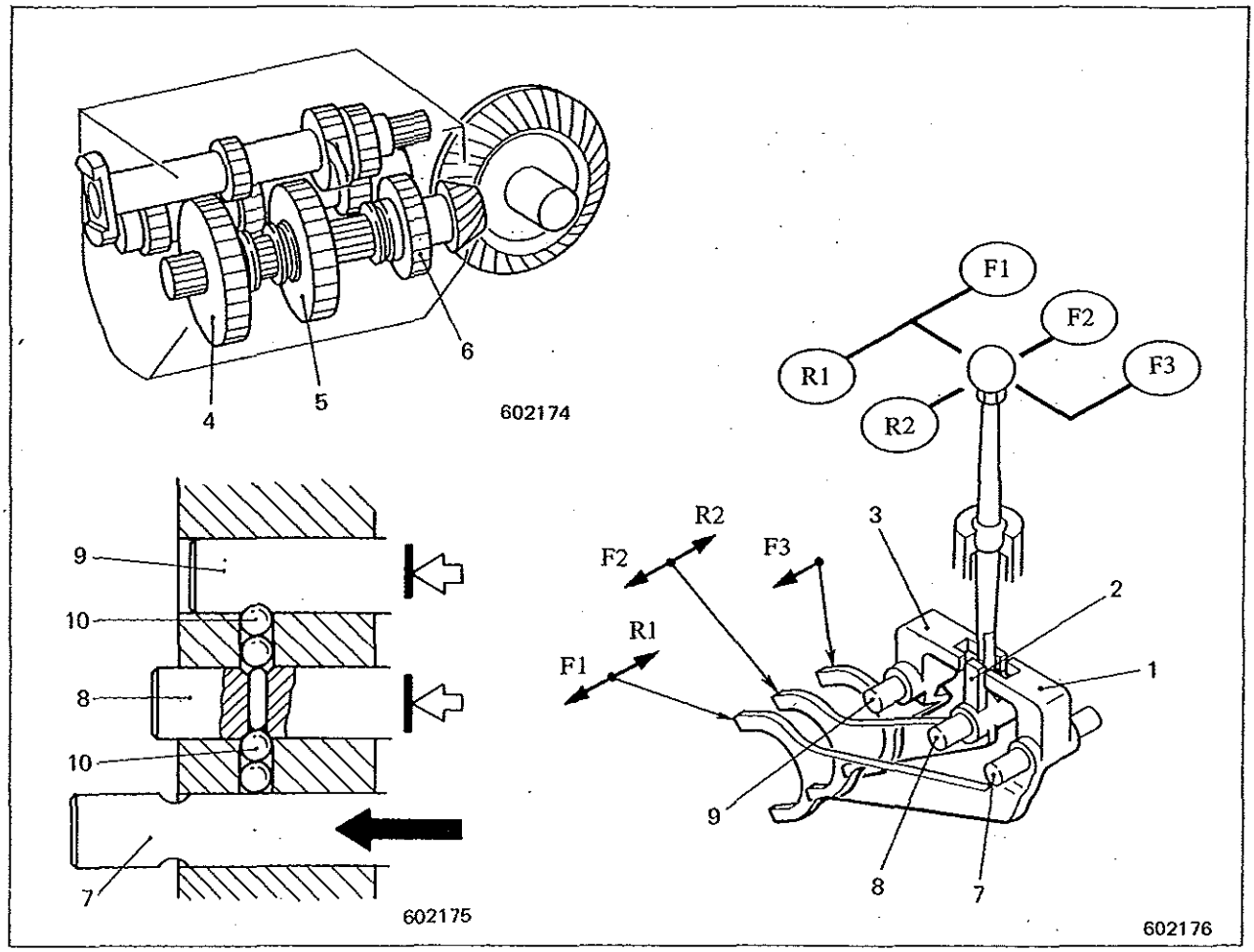
Reverse 2nd-speed position



Forward 3rd-speed position



TRANSMISSION CONTROL

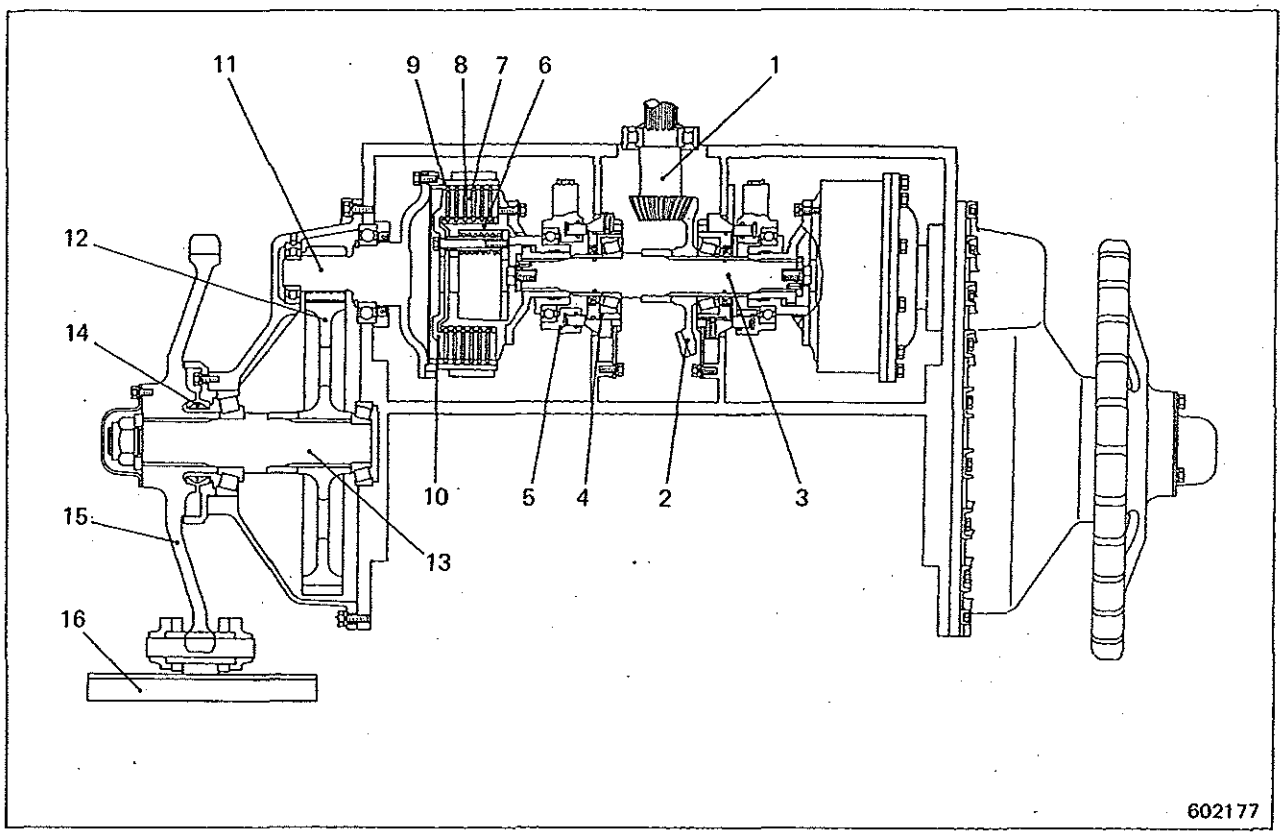


1 1st-speed shift fork
2 2nd-speed shift fork
3 3rd-speed shift fork
4 1st-speed sliding gear
5 2nd-speed sliding gear
6 3rd-speed sliding gear
7 1st-speed shift rail
8 2nd-speed shift rail
9 3rd-speed shift rail
10 Steel (detent) ball

When the gearshift lever is moved into the desired speed position, one of the three forks is moved to shift the desired sliding gear on the third shaft into mesh with the gear on the countershaft or input shaft.

The control is provided with an interlocking mechanism involving spring-loaded steel (detent) balls. Because of this interlocking mechanism, it is only possible to engage one gear reduction at a time. For instance, when 1st-speed shift rail "7" is moved, 2nd-speed shift rail "8" and 3rd-speed shift rail "9" are locked by steel balls "10."

STEERING CLUTCHES, BRAKES AND FINAL DRIVES



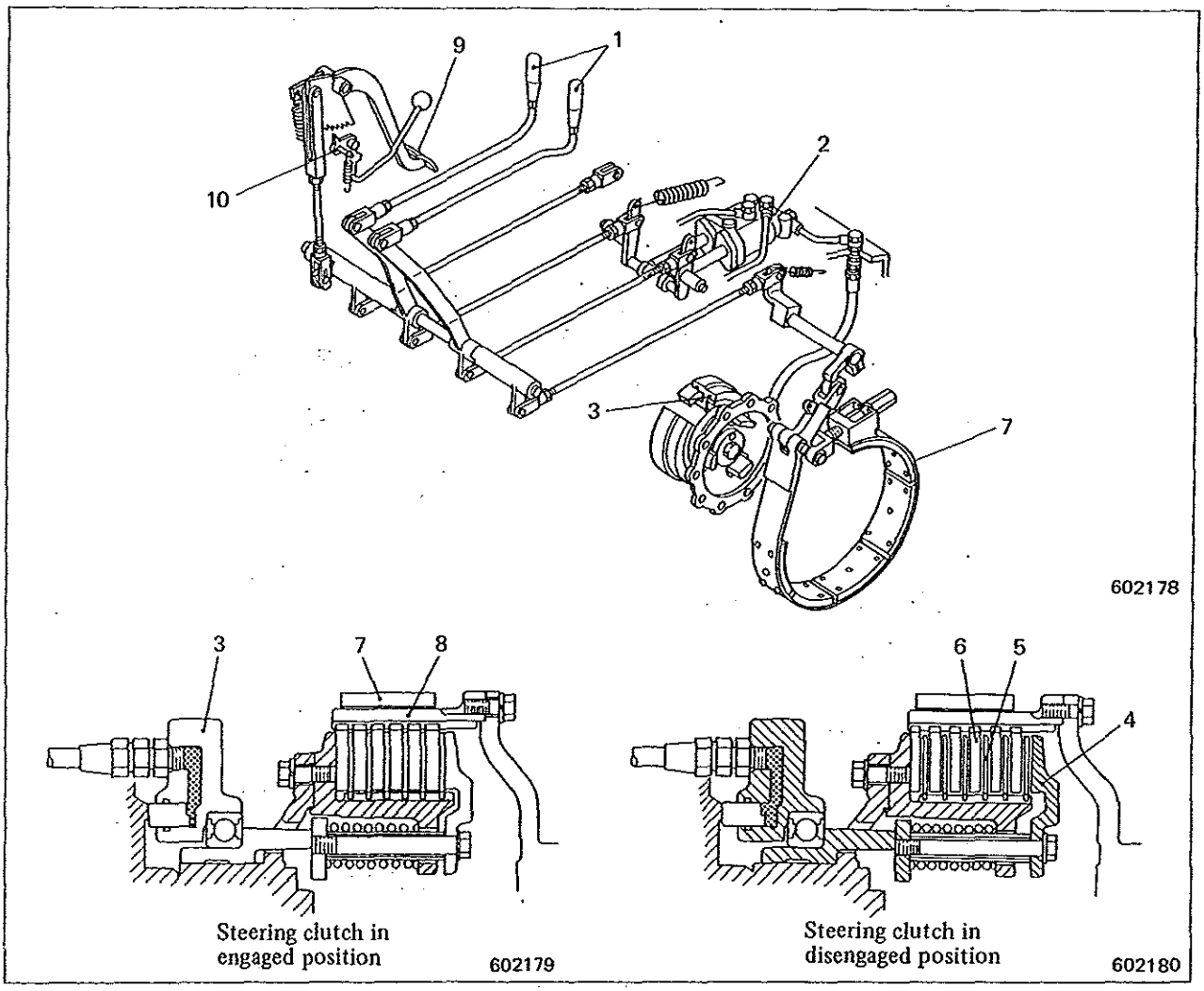
1 Bevel pinion
2 Bevel gear
3 Drive shaft
4 Bearing cage
5 Steering clutch cylinder
6 Inner drum
7 Disc plate
8 Friction plate
9 Outer drum
10 Pressure plate
11 Final drive pinion
12 Final driven gear
13 Shaft
14 Floating seal
15 Sprocket
16 Track

The steering clutch is of dry multi-disc type controlled from steering clutch lever.

Outer (driven) drum "9" is bolted to the flange of final drive pinion. Inner (driving) drum "6" to the flange of drive shaft "3." Friction plates "8" are engaged with the outer drum and disc plates "7" with the inner drum. The stack of these plates is normally kept compressed by spring-loaded pressure plate "10" to transmit the power to the final drive involving pinion "11" and gear "12." When disengaged, the pressure plate is moved away from the stack.

The outer drum is surrounded by a brake band which is actuated (contracted) from the steering clutch lever to brake the drum.

STEERING CLUTCH AND BRAKE CONTROLS



1 Steering clutch lever
2 Steering valve
3 Steering clutch cylinder
4 Pressure plate
5 Disc plate
6 Friction plate
7 Brake band
8 Outer drum
9 Brake pedal
10 Ratchet (brake lock)

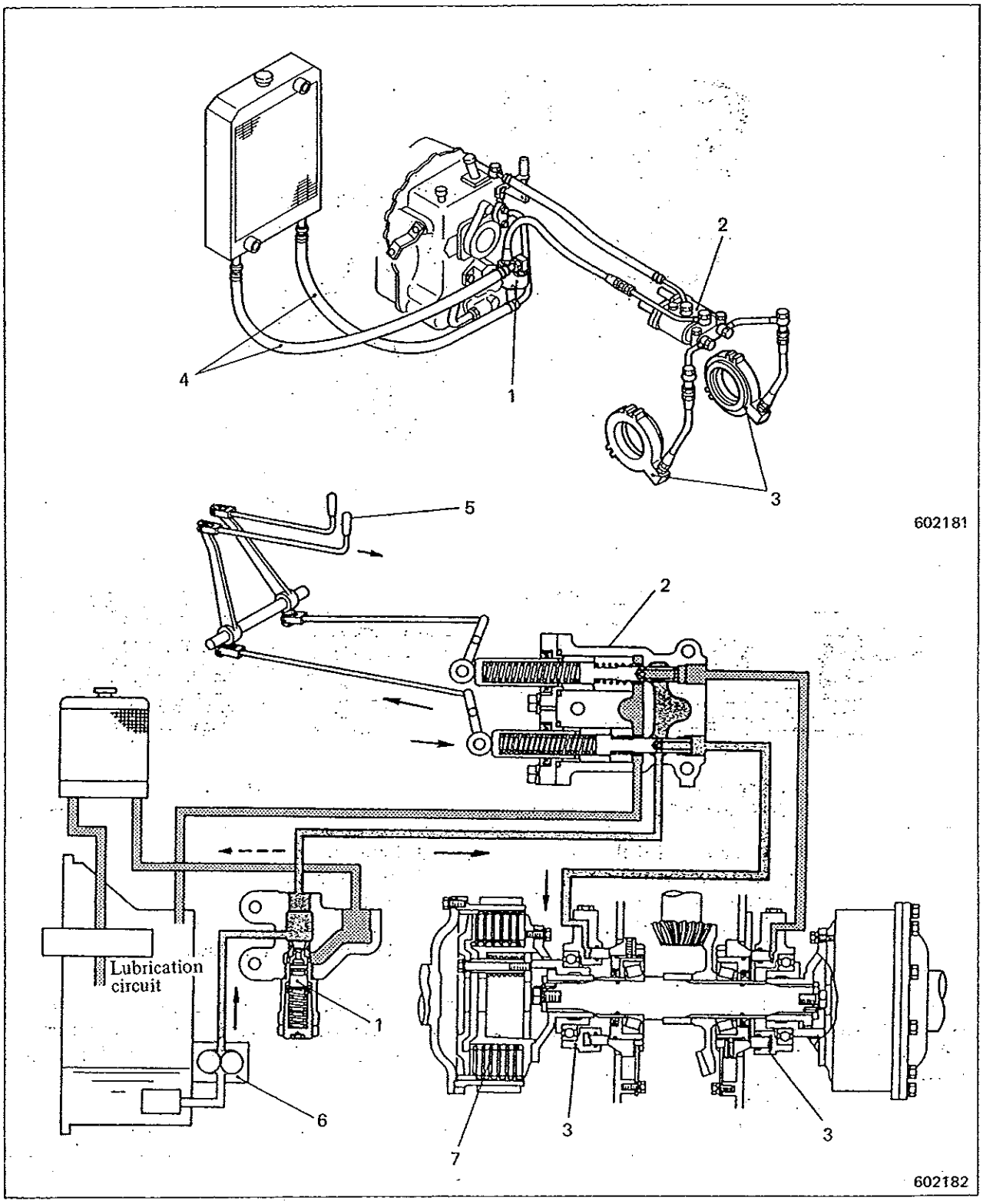
As steering clutch lever "1" is pulled, the piston of steering valve "2" is moved in such a direction as to apply hydraulic pressure to steering clutch cylinder "3." By this hydraulic pressure, pressure plate "4" is moved away from the stack of disc plates "5" and friction plates "6" to disengage the clutch.

When the lever is further pulled, brake band "7" is contracted to brake outer drum "8" to interrupt the flow of power to the final drive.

It is possible to disengage the steering clutch without braking for gradual turn or to disengage it with braking for sharp turn.

As brake pedal "9" is depressed, the brake bands of right-hand and left-hand clutches are simultaneously contracted for braking independently of the clutch control. This pedal can be used as a parking brake if locked in fully depressed position by means of ratchet "10."

Steering clutch control hydraulic circuit



1 Relief valve
2 Steering valve
3 Steering clutch cylinder
4 Oil cooler hose
5 Steering clutch lever
6 Oil pump
7 Steering clutch

UNDERCARRIAGE

Tracks

The track consists of shoes, pins, links and bushings. Each link "8" overlaps the preceding link, thus forming a continuous or endless chain.

Master pin "1" is to be positioned in front of the front idler for removal of the entire track from the tractor.

The shoes are available in two types, standard shoe "9" for the standard specification model and curved apex shoe "12" for the swamp, super-swamp and ultra-super-swamp specification models. The swampier the conditions under which the tractor may be operating, the shoes are longer, that is, the ground pressure is lower.

Links "8" are fitted with seal washers "5" for the standard and swamp specification models; they are fitted with rubber seals "11" for the super-awamp and ultra-super-swamp specification models.

Track rollers

The track rollers are mounted on the lower side of track frame to support the tractor and distribute its weight along the track.

A total of five track rollers are used; they are unequally pitched to reduce vibration occurring during operation.

Each track roller is factory-filled with gear oil. Floating seal "2" keeps this oil in and dirt out under all operating conditions.

Front idlers

Front idler "9" guides the track into position in front of the track rollers.

It rolls around and on shaft "3" which is rigidly held at both ends by bearings "4." Wear strips "7" are welded to the bearings; they can be replaced when they are worn down to the limit.

The whole idler assembly is capable of sliding forward and backward on the rail strips on the top of track frame.

The idler is filled with gear oil which is kept in by the floating seal.

Carrier rollers

The carrier roller supports the weight of track between the sprocket and front idler.

Roller "3" is supported by shaft "5" through bushing "4." The bracket supporting the shaft is of cantilever type.

Like the track rollers and front idlers, the carrier rollers are filled with gear oil and are fitted with floating seals.

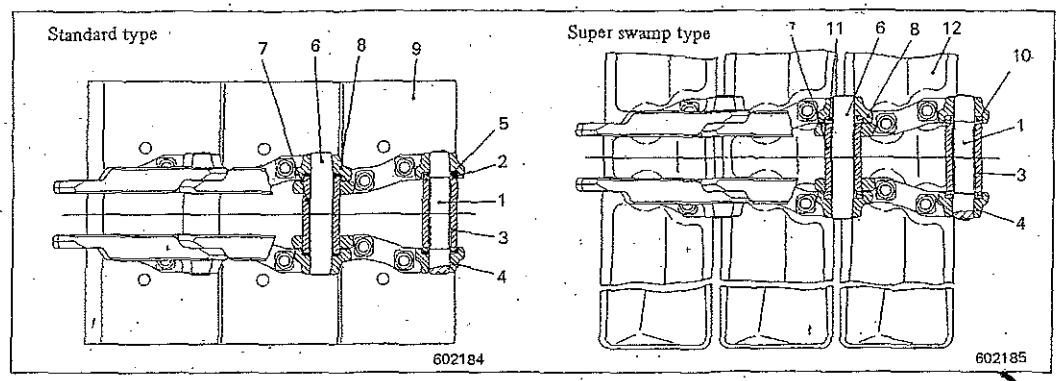
Recoil springs and hydraulic adjuster cylinders

Cylinder "3" is rigidly connected to the front idler and is secured to the track frame by carrier roller bracket "7."

The space inside the cylinder is filled with grease; the grease is pumped into or released from the cylinder through fill valve "1."

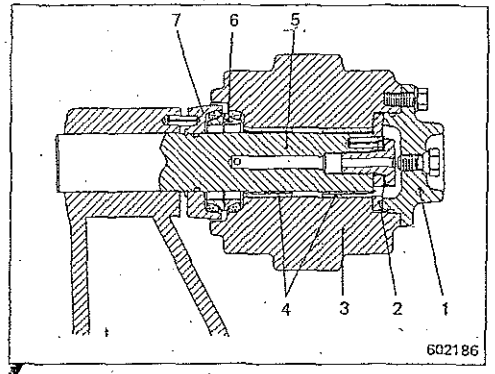
The recoil spring is compressed and held to a definite length. Normally, the pressure of the spring is not exerted against the track. However, should rocks or other obstructions get between the track and rollers, idler or sprocket, cylinder "3" and shaft "4" will move backward and spring "6" will recoil still farther to avoid overstressing the track.

Tracks

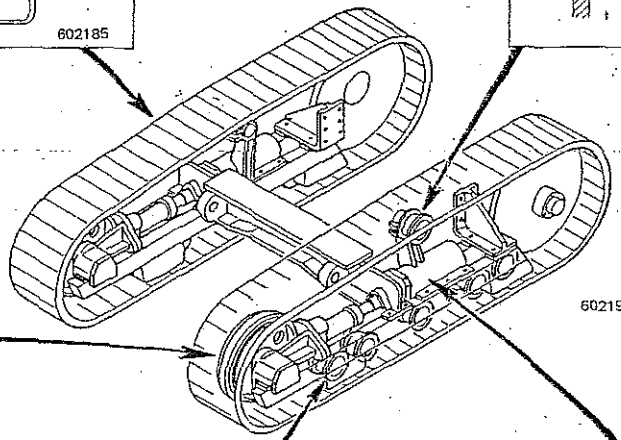


1 Master pin
2 Spacer
3 Master bushing
4 Master link
5 Seal washer
6 Pin
7 Bushing
8 Link
9 Standard shoe
10 Master seal
11 Seal
12 Curved apex shoe

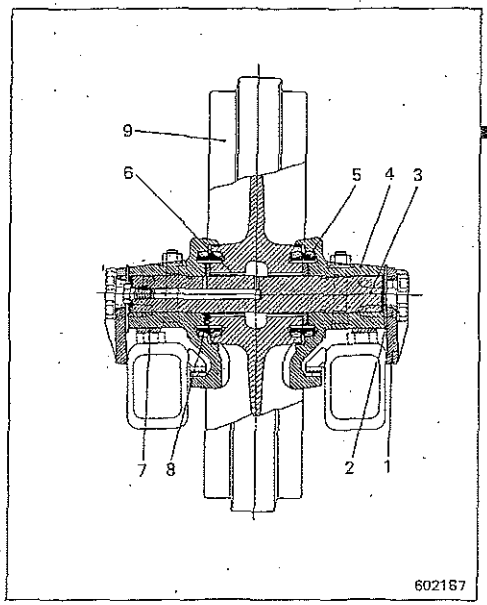
Carrier roller



1 Cover
2 Washer
3 Roller
4 Bushing
5 Shaft
6 Floating seal
7 Seal support

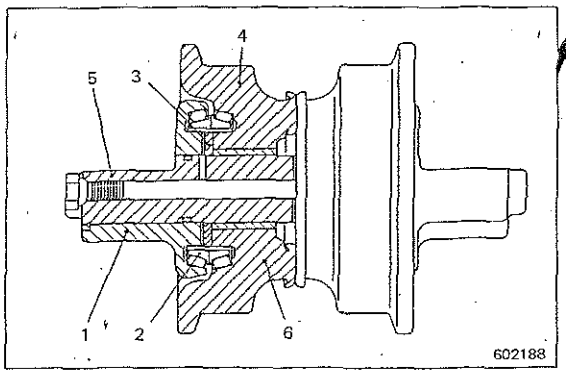


Front idler



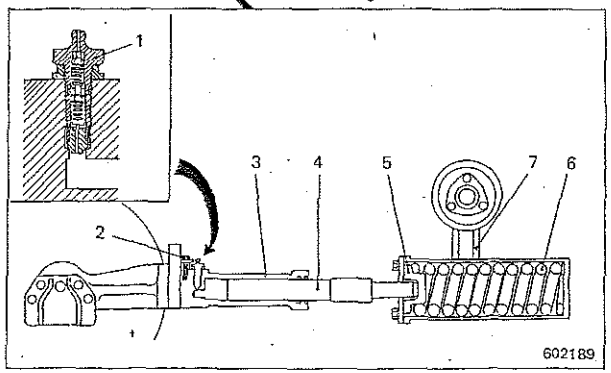
1 Guide
2 Shim
3 Shaft
4 Bearing
5 Floating seal
6 Bushing
7 Wear strip
8 Thrust washer
9 Idler

Track roller



1 Collar
2 Floating seal
3 Thrust washer
4 Bushing
5 Shaft
6 Roller

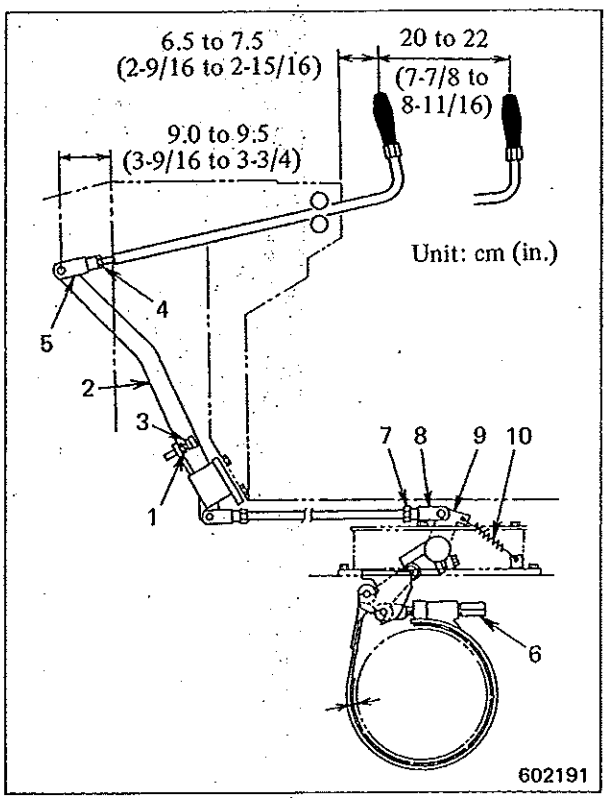
Recoil spring and hydraulic adjuster cylinder



1 Fill valve
2 Stopper bolt
3 Cylinder
4 Cylinder shaft
5 Spring retainer
6 Spring
7 Carrier roller bracket

TESTING AND ADJUSTMENT

ADJUSTING THE STEERING CLUTCHES AND BRAKES



NOTE

The steering clutches and brakes are interrelated with each other. This means that they must be adjusted at one time. Make adjustments (A) thru (D) in that order.

(A) Adjusting the "released" position of steering clutch levers

1. Loosen lock nut "1."
2. Set lever "2" by means of stopper bolt "3" so that it is 9.0 to 9.5 cm (3-9/16 to 3-3/4 in.) as measured from the front end of dashboard. (Equalize the right-hand and left-hand lever positions.)
3. Loosen lock nut "4."
4. Set the knob of steering clutch lever by means of clevis "5" so that it is 6.5 to 7.5 cm (2-9/16 to 2-15/16 in.) as measured from the end of instrument panel.

(B) Adjusting the clearance between brake band and outer drum

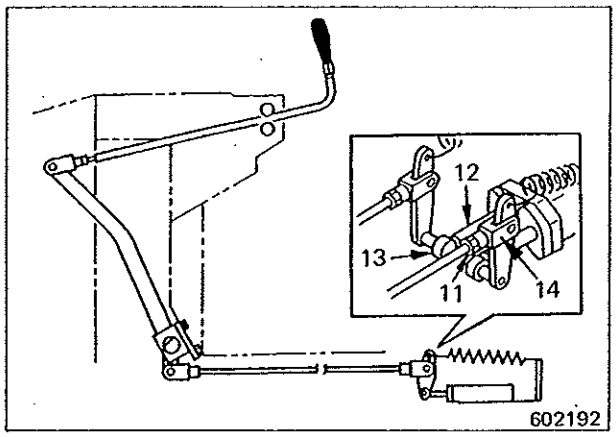
1. Screw adjusting nut "6" all the way.
2. Back off the nut 2-2/3 rotations.

(C) Adjusting the stroke of steering clutch levers

1. Loosen lock nut "7."
2. Set the stroke by means of clevis "8" so that it is 20 to 22 cm (7-7/8 to 8-11/16 in.) from released position to fully pulled position.

NOTE

When making a connection to lever "9," lightly push lever "9" forward until it encounters a resistance, with return spring "10" unhitched.



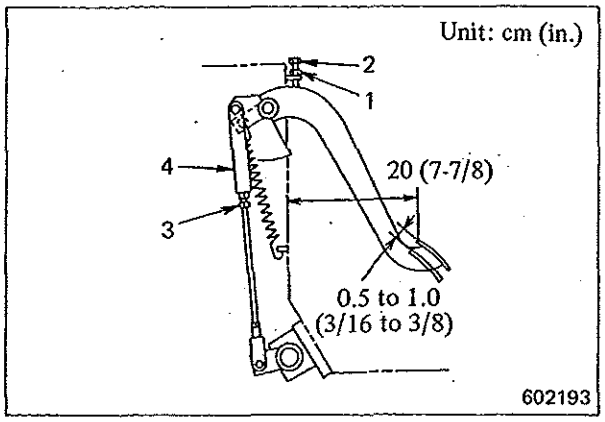
(D) Making a connection to steering valve

1. Loosen lock nut "11."
2. Bring roller "13" into contact with the end of plunger (piston) "12" of steering valve by means of clevis "14."

NOTE

Do not push in the plunger.

ADJUSTING THE BRAKE PEDAL



NOTE

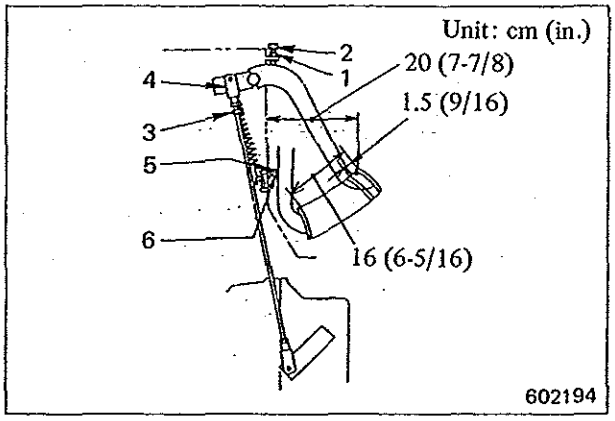
There is no need of adjusting the brake pedal stroke after the steering clutch has been adjusted properly. To be adjust on the pedal is its free play.

1. Loosen lock nut "1."
2. Set the released position of the pedal by means of stopper bolt "2" so that it is 20 cm (7-7/8 in.) as measured from the dashboard wall.
3. Loosen lock nut "3."
4. Set the free play of the pedal by means of clevis "4" so that it is 0.5 to 1.0 cm (3/16 to 3/8 in.).

NOTE

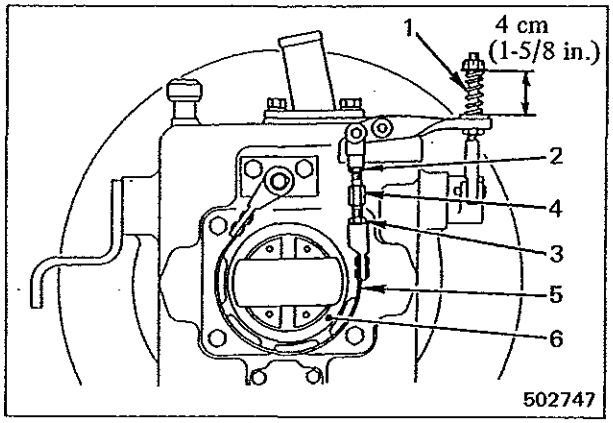
Make sure that the RH and LH brakes are applied simultaneously.

ADJUSTING THE CLUTCH PEDAL



1. Loosen lock nut "1."
2. Set the released position of the pedal by means of stopper bolt "2" so that it is 20 cm (7-7/8 in.) as measured from the dashboard wall.
3. Loosen lock nut "3."
4. Set the free play of the pedal by means of clevis "4" so that it is 1.5 cm (9/16 in.).
5. Loosen lock nut "5."
6. Set the stroke of the pedal by means of stopper bolt "6" so that it is 16 cm (6-5/16 in.).

ADJUSTING THE CLUTCH BRAKE

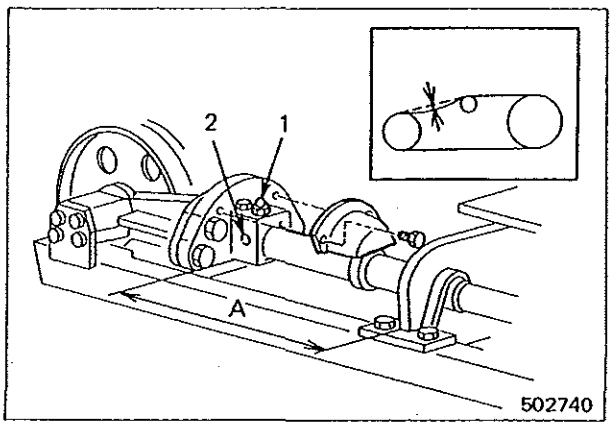


NOTE

The clutch brake should be capable of stopping a rotating univeral joint in about 2.5 seconds when the clutch pedal is depressed all the way with the engine running at maximum speed.

1. Adjust the length under test force of spring "1" to 4 cm (1-5/8 in.).
2. Loosen lock nuts "2" and "3."
3. Screw adjusting bolt "4" until brake band "5" comes in full-face contact with drum "6."
4. Back off adjusting bolt "4" 2.5 to 3 rotations.

ADJUSTING THE TRACKS



- To loosen:

1. Remove the cover, and gradually turn fill valve "1" counterclockwise to allow grease to escape from vent hole "2."
2. If grease does not appear at the vent hole, loosen the fill valve until it is limited by the stopper.
3. If grease does not appear at the vent hole and the vent hole appears to be open and the track appears to have tension, start the engine, and move the machine back and forth slightly.
4. If the track still appears to have tension even after such a backward and forward movement of the machine, insert a wood block into between the sprocket and track, and move the machine backward slightly. This will strain the track to force grease out of the vent hole.

⚠ WARNING

Never look into the vent hole to see if the pressure in the track adjuster cylinder is released. Make sure of relief of the pressure by observing the backward movement of front idler.

- To adjust:

1. Apply grease, with a grease gun, into the fill valve until the slack or sag in the track is 20 to 30 mm (3/4 to 1-3/16 in.).
2. Operate the machine backward and forward to equalize the adjustment.

⚠ CAUTION

When applying grease into the fill valve, keep the dimension "A" (between cylinder shaft flange and rigid bar) within 450 mm (17-3/4 in.).

TROUBLESHOOTING GUIDE

Flywheel clutch

Complaint	Possible cause	Remedy	Remarks
Clutch slips	(1) No pedal free play	• Adjust.	
	(2) Worn down clutch facings	• Replace.	
	(3) Clutch facings burnt, resulting in reduced coefficient of friction	• Replace.	
	(4) Dirty friction surfaces of clutch discs	• Clean by washing, or replace.	
	(5) Weakened or broken clutch springs	• Replace.	
Clutch drags	(1) Pedal free play too large	• Adjust.	
	(2) Not enough pedal stroke	• Adjust.	
	(3) Release levers not set for uniform lever height	• Adjust.	
	(4) Binding or sticky splines of clutch shaft	• Disassemble and repair, or replace.	
	(5) Dirty friction surfaces of clutch discs	• Clean by washing.	
Clutch chatters when disengaged	Release bearing seized, poorly lubricated or damaged	Disassemble and repair, lubricate or replace.	
Incomplete disengagement, resulting in hard shifting	Oil is too viscous	Change with oil of proper viscosity.	
Hard gear shifting on transmission	Clutch brake maladjusted, or band linings worn	Adjust, or replace linings.	

Clutch oil line

Complaint	Possible cause	Remedy	Remarks
Oil pump is not lifting oil, that is, not discharging oil	(1) Suction strainer clogged	• Clean.	
	(2) Oil viscosity too high	• Change with oil of proper viscosity.	
	(3) Loose joint in connector	• Retighten.	
	(4) Broken drive shaft of oil pump	• Replace.	
	(5) Rotors worn or seized	• Replace.	

Transmission

Complaint	Possible cause	Remedy	Remarks
Gears slip out of mesh	(1) Incomplete meshing action due to improperly assembled shift control mechanism	• Disassemble and repair or replace.	
	(2) Inner end of shift lever worn down or loose	• Repair or replace.	
	(3) Gear teeth unevenly worn	• Replace.	
	(4) Too much backlash	• Replace gears.	
	(5) Shaft splines badly worn, resulting in loose fit	• Replace.	
Hard shifting	(1) Dragging clutch	• Adjust clutch.	
	(2) Shift lever or forks loose or worn	• Repair or replace.	
	(3) Foreign matter lodged between gears	• Clean by washing.	
	(4) Oil viscosity too high	• Change with oil of proper viscosity.	
	(5) End faces of gear teeth damaged	• Repair or replace.	
	(6) Distorted or broken forks	• Repair or replace.	
Noisy	(1) Not enough oil, or oil is dirty	• Add or change.	
	(2) Too much backlash	• Change gears.	
	(3) Worn, damaged or rattling bearings	• Adjust or replace.	
	(4) Excessively worn shaft splines	• Repair or replace.	
	(5) Damaged or worn gear teeth, or improper tooth contact	• Repair or replace.	
	(6) Bevel gear out of adjustment	• Adjust.	
	(7) Gears out of alignment, or teeth distorted	• Adjust, or replace.	

Bevel gear

Complaint	Possible cause	Remedy	Remarks
Excessive gear noise	(1) Gear oil wanting or dirty	• Add or change.	
	(2) Too much backlash	• Adjust.	• Noise on turning to one side means some rattling condition due to worn splines, loose bearings or excessive backlash.
	(3) Bearings worn down, damaged or loose	• Adjust or replace.	
	(4) Damaged or worn gear teeth or poor tooth contact	• Repair or replace.	
	(5) Bevel gear improperly installed	• Adjust.	• Misalignment could be the cause.
Oil becomes too hot	(1) Gear oil wanting or dirty, or of wrong kind	• Add or change.	
	(2) Backlash too much or too little	• Adjust or replace.	
	(3) Bearings too tight, too loose, or damaged	• Adjust or replace.	• Raceways could be in cracked, spalled or otherwise damaged condition.
	(4) Bearings out of alignment	• Adjust.	
Oil leakage	(1) Too much gear oil, or oil viscosity too low	• Remove excess oil to hold oil level as prescribed, or change oil by one meeting viscosity specification.	• Leakage of oil into steering clutch side incapacitates this device.
	(2) Defective oil seal	• Replace.	
	(3) Portions of shaft in contact with oil seals worn	• Repair or replace.	• Loose bearings cause shaft to wobble and thus promote oil leakage even if oil seals are in sound condition.
	(4) Cracked case	• Repair or replace.	
Abnormal wear	(1) Gear oil not enough, dirty or of wrong kind	• Add or change.	• Change oil if metal particles are noted in oil. Such particles or gritty matter promotes wear.
	(2) Bevel gear out of adjustment	• Adjust.	

Steering clutches and brakes

Complaint	Possible cause	Remedy	Remarks
Clutch slips (overheats)	(1) Control linkage out of adjustment	• Adjust.	• Check lever free play.
	(2) Linings dirty	• Wash with gasoline, or replace the disc plates.	• Investigate to locate a point through which oil is entering clutch case. Wash case interior clean, as necessary.
	(3) Disc plates and friction plates not capable of smooth sliding movement	• Repair drums and plates, eliminating offsets or any irregularity interfering with smooth axial sliding movement.	• Be sure that each disc plate moves smoothly in or on drum.
	(4) Spalled, flaked or damaged linings of disc plates	• Replace plates.	
	(5) Weakened or broken clutch springs	• Replace.	• Habitual "half-clutch" operation tends to overheat clutch and thus weakens springs.
	(6) Disc plates and friction plates warped	• Repair or replace.	• Warped plates are usually a result of overheating, for which habitual "half-clutch" operation is usually to blame.
	(7) Defective clutch cylinder		• See the topic, "Steering clutch cylinder."
Clutch drags	(1) Clutch out of adjustment	• Adjust.	
	(2) Excessive rattle in steering control linkage	• Adjust.	
	(3) Worn or damaged release bearing	• Replace.	• Grease bearing fully at the time of reassembly.
	(4) Dirty disc linings.	• Clean by washing, or replace.	
	(5) Disc plates and friction plates sticking or warped	• Repair or replace.	• Warped disc plates are caused by overheating resulting from habitual "half-clutch" operation.
	(6) Defective clutch cylinder		• See the topic, "Steering clutch cylinder."

Complaint	Possible cause	Remedy	Remarks
Not enough braking force	(1) Brake out of adjustment	• Adjust.	
	(2) Brake lining dirty	• Clean by washing.	• Be aware of possibility of oil leaking in from final drive case and bevel gear case. Drain out oil and water, if any, now and then.
	(3) Lining worn down, with rivet heads in rubbing condition	• Replace.	
	(4) Brake band warped, broken or otherwise damaged	• Repair or replace.	
	(5) Dragging clutch	• Adjust or repair.	• Dragging clutch is often cause of apparent poor braking.
Dragging brake	(1) Maladjustment	• Adjust as prescribed.	• Uneven or inadequate band-to-drum clearance is likely to result in overheating. Readjustment is necessary if pulling steering clutch lever just a little causes machine to turn.
	(2) Return spring weakened	• Readjust or replace.	
	(3) Brake band distorted	• Repair or replace.	

Steering valve

Complaint	Possible cause	Remedy	Remarks
Jerky movement	(1) Foreign particles lodged between valve (plunger) and bore	• Disassemble and clean. Change hydraulic oil if dirty.	
	(2) Weakened or broken return spring	• Replace.	
	(3) Valve (plunger) and bore worn	• Replace.	
Poor returning action of piston	(1) Foreign particles lodged between piston and bore	• Disassemble and clean.	
	(2) Weakened or broken valve spring	• Replace.	

Steering clutch cylinder

Complaint	Possible cause	Remedy	Remarks
Clutch drags or grabs	(1) Oil leaks inside cylinder	• Repair or replace.	
	(2) Valve (plunger) and bore worn	• Repair or replace.	
	(3) Relief valve out of adjustment	• Adjust.	
	(4) Air leaks at pipe joints	• Retighten.	
Clutch slips, resulting in no power flow	Steering control valve defective	Repair or replace.	

Final drives

Complaint	Possible cause	Remedy	Remarks
Noisy	(1) Not enough gear oil, or dirty gear oil	• Add or change.	• After working machine on muddy or flooded ground, check oil for contamination by examining oil sampled out of drain point.
	(2) Too much backlash	• Repair or replace.	• Loose bearings or worn shaft promotes tooth wear, resulting in excessive backlash.
	(3) Worn or damaged shaft or teeth	• Repair or replace.	
Overheating	(1) Not enough gear oil, wrong kind of oil or dirty oil	• Add or change.	
	(2) Damaged bearings	• Replace.	• "Damage" here means spalled or chipped balls, rollers or raceways or broken cages. Inspect bearings very carefully, for bearing trouble can result in costly major repair.
Oil leakage	(1) Too much gear oil, or oil viscosity too low	• Remove excess oil or use gear oil of proper viscosity.	• Oil leakage into steering clutch case results in slipping clutch.
	(2) Faulty oil seals	• Replace.	
	(3) Bolts securing case or cover are loose, or packings are broken	• Retighten. Replace broken packings.	

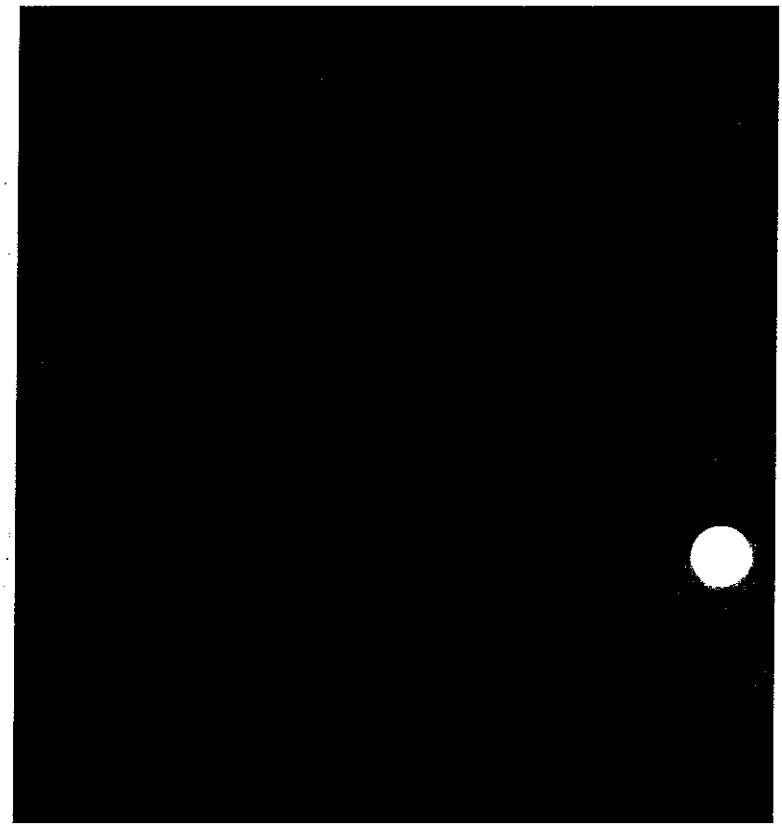
Complaint	Possible cause	Remedy	Remarks
Sprocket rattles	(1) Worn or damaged bearings	• Replace.	• Damaged bearings escape notice because their effects usually show up when machine is running. If the sprocket is suspected to rattle, check its bearings immediately.
	(2) Worn splines in fit of sprocket to its shaft	• Replace.	
Sprocket teeth wear abnormally	(1) Track chain stretched (due to permanent elongation)	• Replace pins and bushings.	
	(2) Master pin worn	• Replace.	
	(3) Side faces of sprocket teeth worn	• Repair by welding or replace.	• Abnormal sprocket tooth wear is often due to misalignment of sprocket, track rollers and front idler or of the track frame. When checking these for alignment, check track frame, too, for misalignment particularly at its front end.
Side faces of sprockets wear	(1) Track frame misalignment relative to sprocket	• Realign frame.	
	(2) Front idler mispositioned in place, or its wear strips excessively worn	• Reposition and adjust idler, or replace wear strips.	• Front idler, track rollers and sprocket wheel must be in perfect alignment in fore-aft direction or side faces of sprocket and links or track roller flanges will rapidly wear off.
	(3) Track chain insufficiently tensioned	• Adjust.	
	(4) Track pin bushings badly worn	• Repair by welding or replace.	• With pin bushings badly worn, track moves in wavy fashion to rub side faces of sprocket.
	(5) Too much axial play of track rollers	• Repair or replace.	
	(6) Track frame distorted	• Repair.	

Undercarriage

Complaint	Possible cause	Remedy	Remarks
Front idlers, track rollers and carrier rollers wear abnormally	(1) Improper installation or misalignment	• Check position of each and set it correctly.	• So that track chain will move straight, front idler and other rollers must be lined up straight. This is particularly important for front idler.
	(2) Track frame misaligned relative to chassis	• Adjust.	• Track frame must be trued up with respect to sprocket, and two frames, right and left, must be perfectly parallel.
	(3) Distorted track frame	• Repair.	• Refer to (4).
	(4) Worn link pins and bushings	• Repair or replace.	• Track chain will move in wavy fashion to rub rollers and sprocket if pins and bushings are worn down.
	(5) Front idler and track rollers have too much axial play	• Repair or replace.	• Track chain will oscillate sidewise to promote wear of flange parts of rollers if idler and rollers have too much sidewise play.
	(6) Track links worn	• Repair or replace. (Secure specified link height.)	• This malcondition allows roller flanges to rub link bosses.
	(7) Loose track chain	• Tension track.	• An insufficiently tensioned track promotes flange wear.
Rollers tend to overheat, or will not roll	(1) Inadequate lubrication	• Disassemble and lubricate.	• Loss of lubricant is often accompanied by presence of muddy water in rolling clearance. Such muddy water means that floating seal has failed.
	(2) Rolling clearance between bushing and shaft too small, or roller has little or no axial play	• Repair or replace.	

Complaint	Possible cause	Remedy	Remarks
	(3) Interference between track roller and track frame, or foreign matter lodged between the two	• Adjust axial play of shaft, or remove foreign matter.	• Interference is likely to occur when bushing end faces are worn, resulting in excessive axial play of shaft.
	(4) Unevenly worn rollers	• Repair.	• "Uneven wear" means here localized wear due to abrasive contact between a stuck roller and track.
	(5) Track tensioned too tight	• Adjust.	• This condition is often due to recoil spring being fouled up with dirt, sand, etc.
	(6) Bolts securing roller shaft bushings broken	• Disassemble and repair.	
Abnormal noise from undercarriage	(1) Loose shoe bolts	• Retighten.	• This retightening should be carried out as early as possible; otherwise the whole shoe assembly would fail beyond repair.
	(2) Bolts securing roller shaft collar loose	• Retighten.	
	(3) Bolts securing roller shaft bushing broken or missing	• Disassemble and repair.	
	(4) Track pitch elongation	• Replace link pins and bushings.	• This condition not only gives rise to noise but also promotes wear of rollers.
	(5) Interference of track chain with roller flanges	• Repair.	• This condition is evidenced by shiny metal surfaces on roller flanges and side faces of sprocket teeth and, if left unheeded, will result in the kinds of wear already mentioned.

Complaint	Possible cause	Remedy	Remarks
Track chain tends to get off idler and rollers	(1) Track tension not enough	• Adjust.	
	(2) Front idler mispositioned	• Relocate idler to correct position.	
	(3) Recoil spring insufficiently preloaded or broken	• Adjust or replace.	
	(4) Roller flanges worn	• Repair or replace.	• Refer to Complaint "Front idlers, track rollers and carrier rollers wear abnormally."
	(5) Abusive steering by operator	• Avoid backing and sharp turning on rough ground.	
	(6) Sprocket teeth worn	• Repair by welding.	



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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G TRACTOR SHOVEL BS3G

CONTENTS

DIRECT POWERSHIFT TRANSMISSION

- OPERATING PRINCIPLE
- TESTING AND ADJUSTMENTS
- MAINTENANCE STANDARDS
- DISASSEMBLY AND REASEMBLY

MITSUBISHI HEAVY INDUSTRIES, LTD.

FOREWORD

This service manual has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations used in this manual are based on information that was current at the time this issue was written.

Correct servicing will give these machines a long productive life. Before attempting to start a test, repair or rebuild job, be sure that you have studied the respective sections of this manual, and know all the components you will work on.

Safety is not only your concern but everybody's concern. Safe working habits cannot be bought or manufactured; they must be learned through the job you do. By learning what CAUTION or WARNING symbol emphasizes, know what is safe – what is not safe. Consult your foreman, if necessary, for specific instructions on a job, and the safety equipment required.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

⚠ **CAUTION** ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of machine.

⚠ **WARNING** ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

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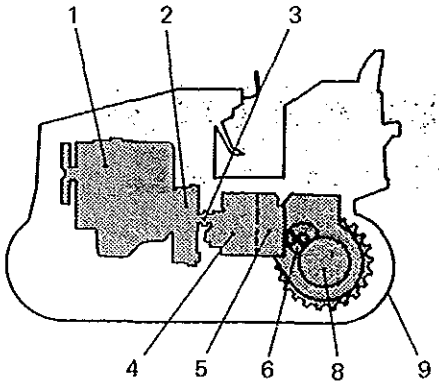
OPERATING PRINCIPLE

GENERAL DESCRIPTION

POWER TRAIN



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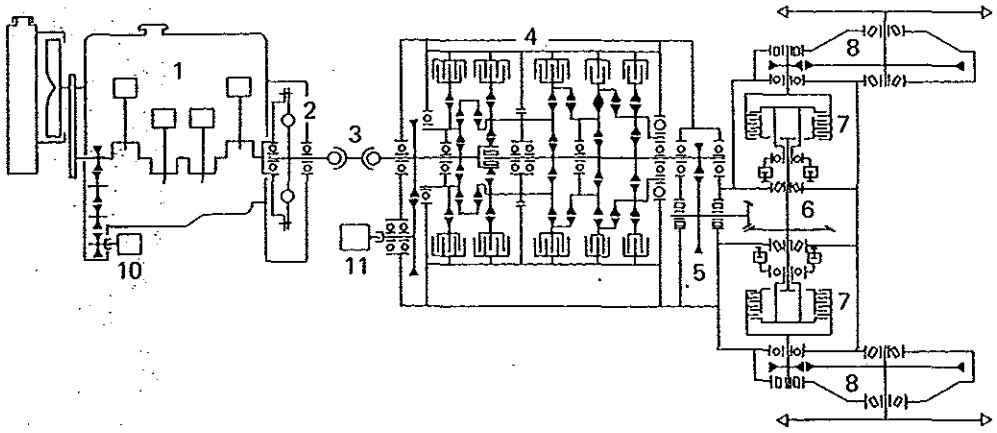


602307

1 Engine
2 Damper
3 Universal joint
4 Transmission
5 Transfer
6 Bevel gear
7 Steering clutch
8 Final drive gear
9 Track
10 Hydraulic pump
11 Transmission oil pump

Power train

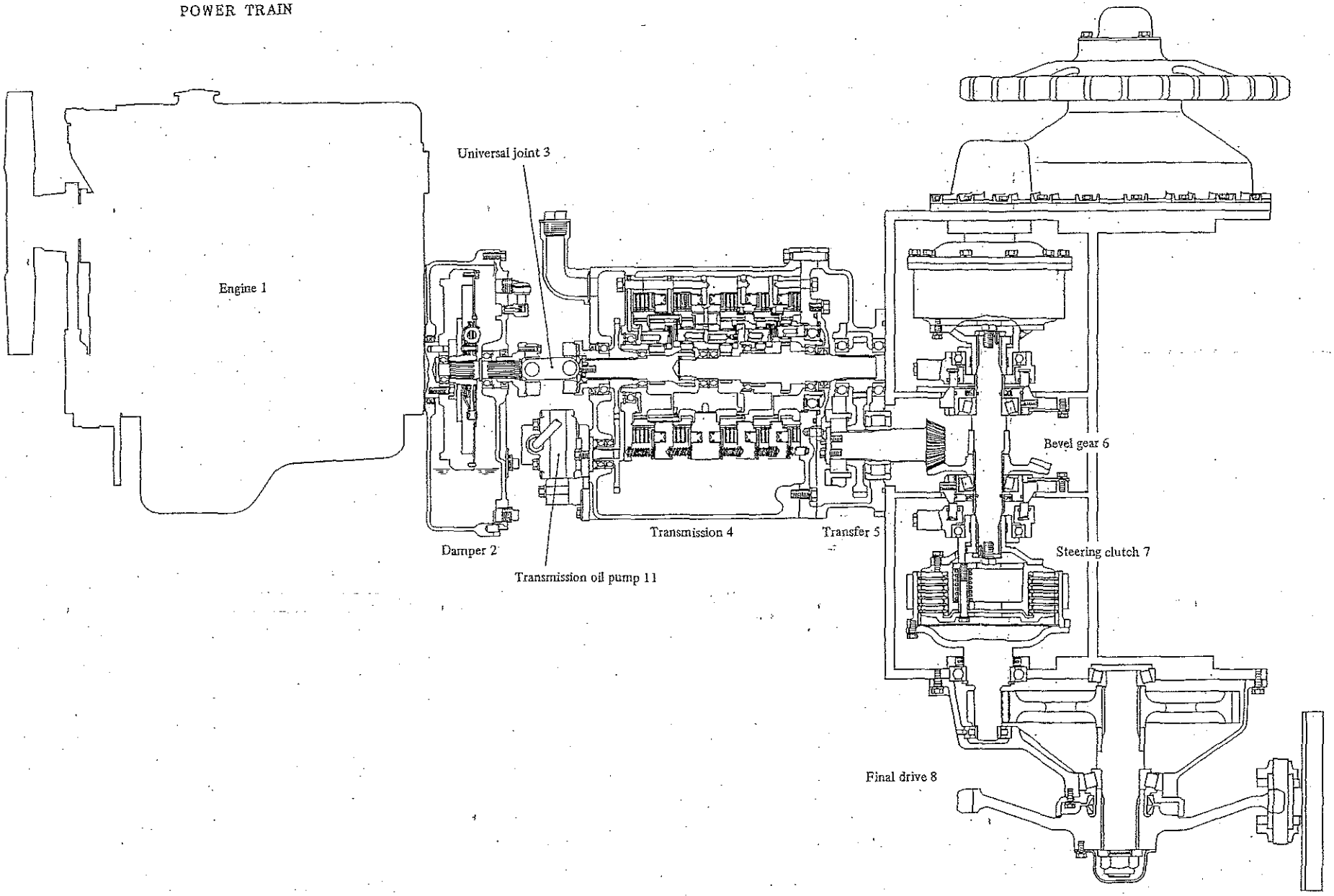
The power train of direct powershift model consists of, from engine "1" to track "9," damper "2," universal joint "3," transmission "4," transfer "5," bevel gear "6," steering clutch "7" and final drive gear "8."

Power developed by the engine is transmitted through damper and universal joint to the transmission. The transmission has three forward speeds and three reverse. From the transmission output shaft, power flows to the final drives, right and left, through transfer, bevel gear and steering clutches, right and left. The tracks are driven by the sprockets of final drives.

The engine and damper are coupled together integrally and are mounted on the frame by four mounts fitted with barrel-shaped vibration-insulating rubber pads.

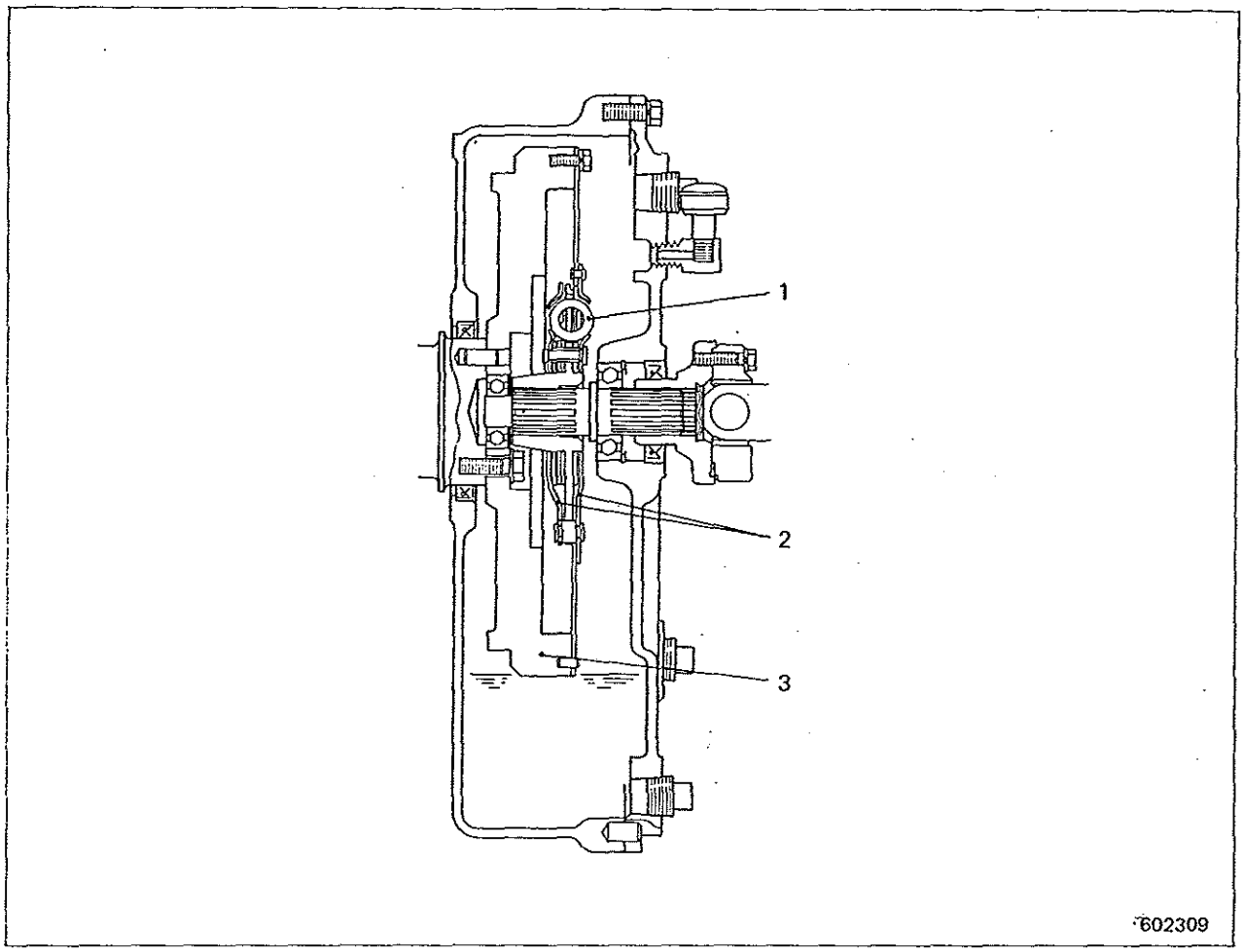
The transmission and transfer are housed in a single case, which is rigidly bolted to the front face of steering clutch case.

POWER TRAIN



Direct Transmission

DAMPER



1 Coil spring
2 Friction plate
3 Flywheel

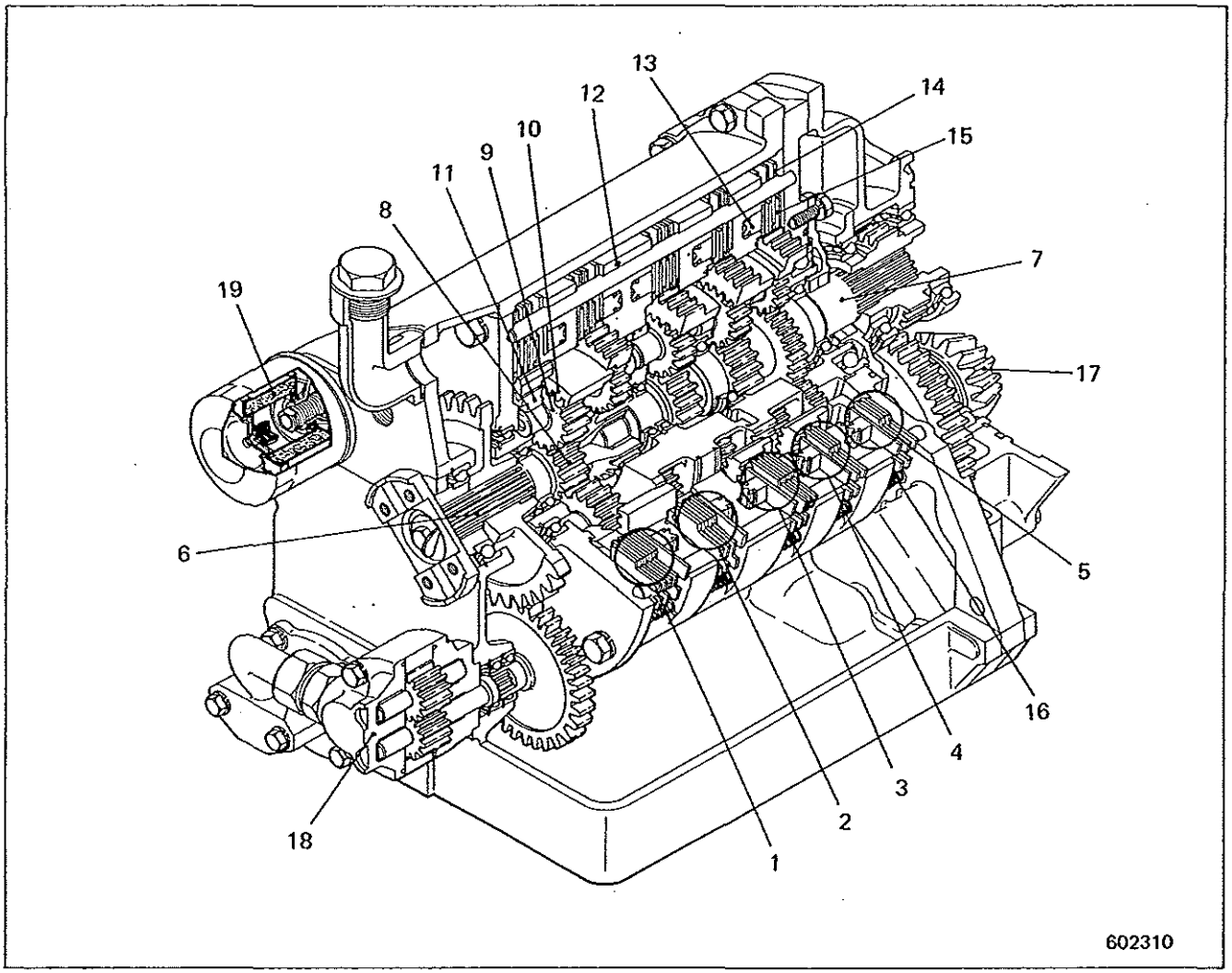
Damper

The damper consists essentially of six coil springs "1" and two friction plates "2." Its hub is splined to the shaft and one of the friction plates is bolted to the flywheel.

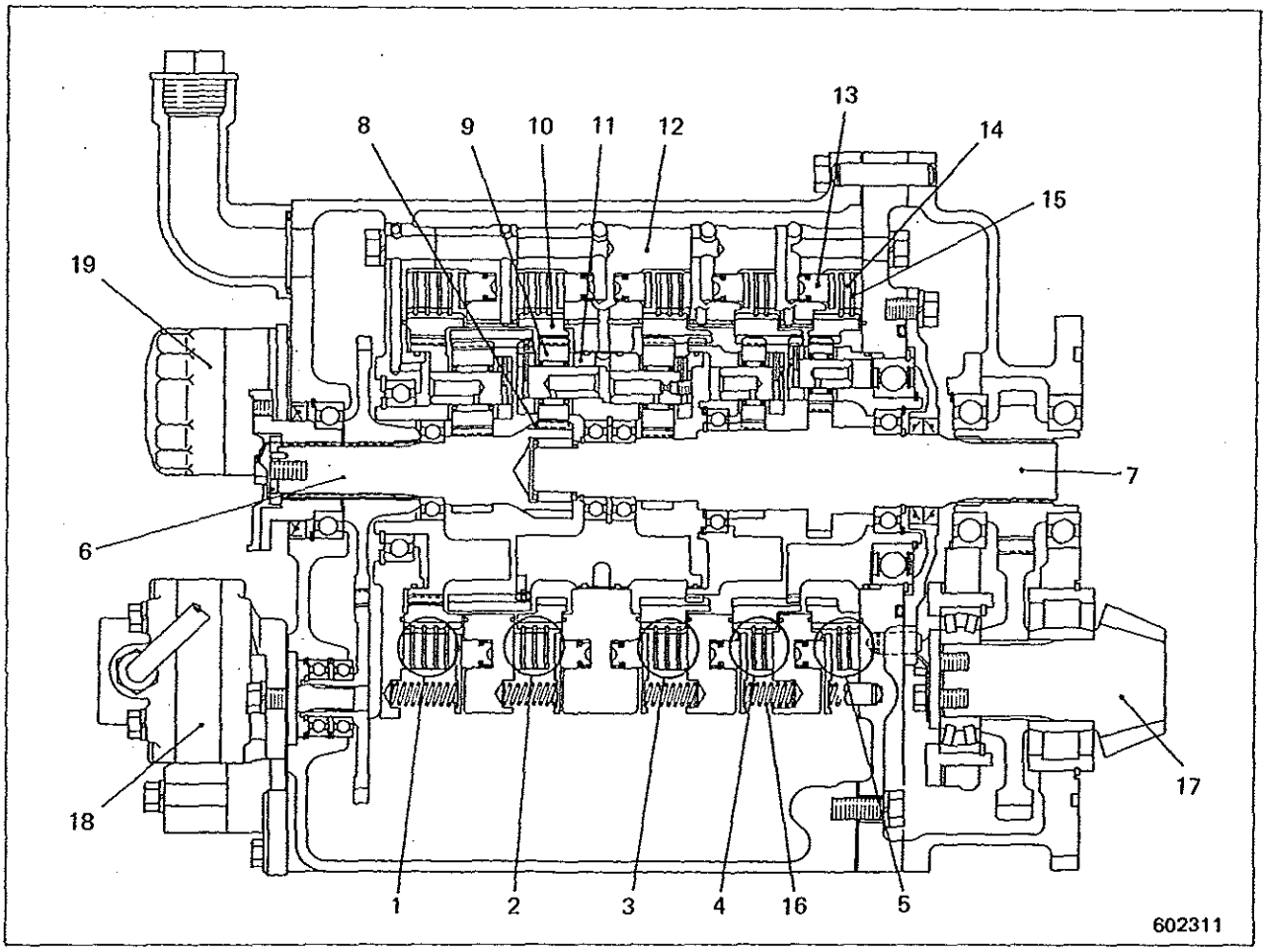
The combination of coil springs and friction plates absorbs power impulse from the engine which would otherwise be transmitted directly to the gears in the transmission as when the engine is quickly accelerated or decelerated and shocks from the ground through power train.

DPS TRANSMISSION

Description



1 Reverse clutch
2 Forward clutch
3 3rd-speed clutch
4 2nd-speed clutch
5 1st-speed clutch
6 Input shaft
7 Output shaft
8 Sun gear
9 Planet gear
10 Ring gear
11 Carrier
12 Piston housing
13 Piston
14 Mating plate
15 Friction plate
16 Return spring
17 Bevel pinion
18 Gear pump
19 Oil filter



1 Reverse clutch
2 Forward clutch
3 3rd-speed clutch
4 2nd-speed clutch
5 1st-speed clutch
6 Input shaft
7 Output shaft
8 Sun gear
9 Planet gear
10 Ring gear
11 Carrier
12 Piston housing
13 Piston
14 Mating plate
15 Friction plate
16 Return spring
17 Bevel pinion
18 Gear pump
19 Oil filter

This transmission consists of five sets of planetary gear train, each having a hydraulically controlled clutch pack, control valve, oil pump, oil filter and their related parts.

The two planetary gear sets on the input side are for directional control — forward or reverse drive - and the remaining three sets on the output side are for speed selection — 1st-speed, 2nd-speed or 3rd-speed drive.

Each planetary gear set comprises sun gear "8," planet gears "9," carrier "11" and ring gear "10." The sun gear rotates; the carrier revolves; and the planet gears rotate on their own shafts or pins and revolve with the carrier, on which they are mounted.

Let us see the paths of power flow in the transmission in forwrd 1st speed position and in reverse position.

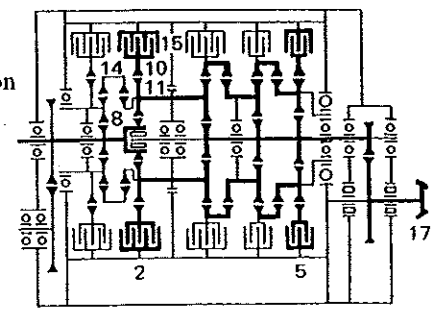
Friction plates "15" are engaged with the external splines of ring gear "10" and mating plates "14" with the internal splines of housing "12." "To engage the clutch" is to admit the pressure oil from the control valve into the piston chamber of housing "12." By the admitted oil, piston "13" pushes the stack of the friction and mating plates to compact them together. "To disengage the clutch" is to relief this pressure. When the pressure is removed from the piston, return springs "16" push the piston back to loosen the stack of the plates.

In forward 1st speed position, forward clutch "2" and 1st-speed clutch "5" are engaged. Because forward ring gear "10" is locked, power from input shaft "6" flows to carrier "11" through sun gear "8." From this carrier "11," the power flows to the sun gear of 1st-speed clutch through carrier and then to output shaft "7."

In reverse position, reverse clutch "1" is engaged. In this case, the reverse carrier is locked, and the reverse sun gear and ring gear rotate in reverse direction. The flow of power from this ring gear is similar to that in forward 1st speed drive.

From the output shaft, power flows through single-stage-reduction transfer gear to the bevel pinion.

Forward 1st speed position



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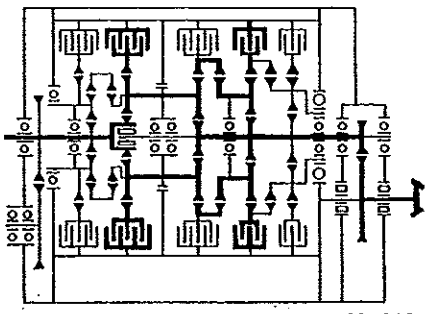
Forward 2nd speed position



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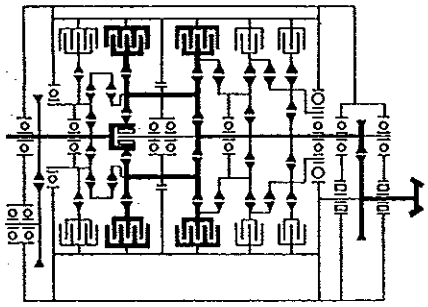
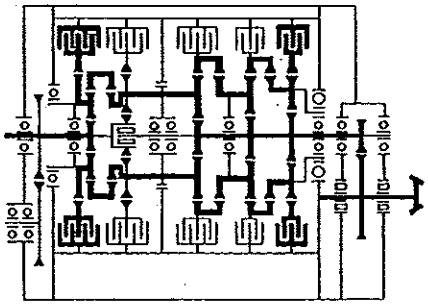
Forward 3rd speed position



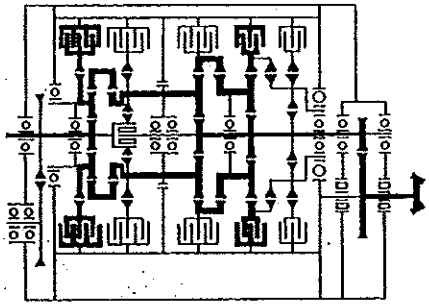
602314

Reverse 1st speed position



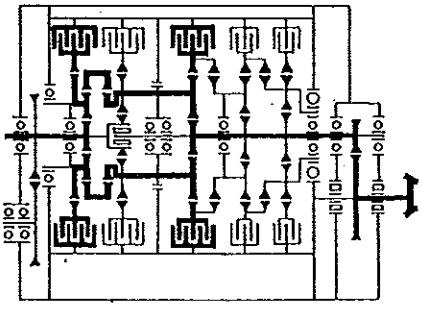
602315

Reverse 2nd speed position



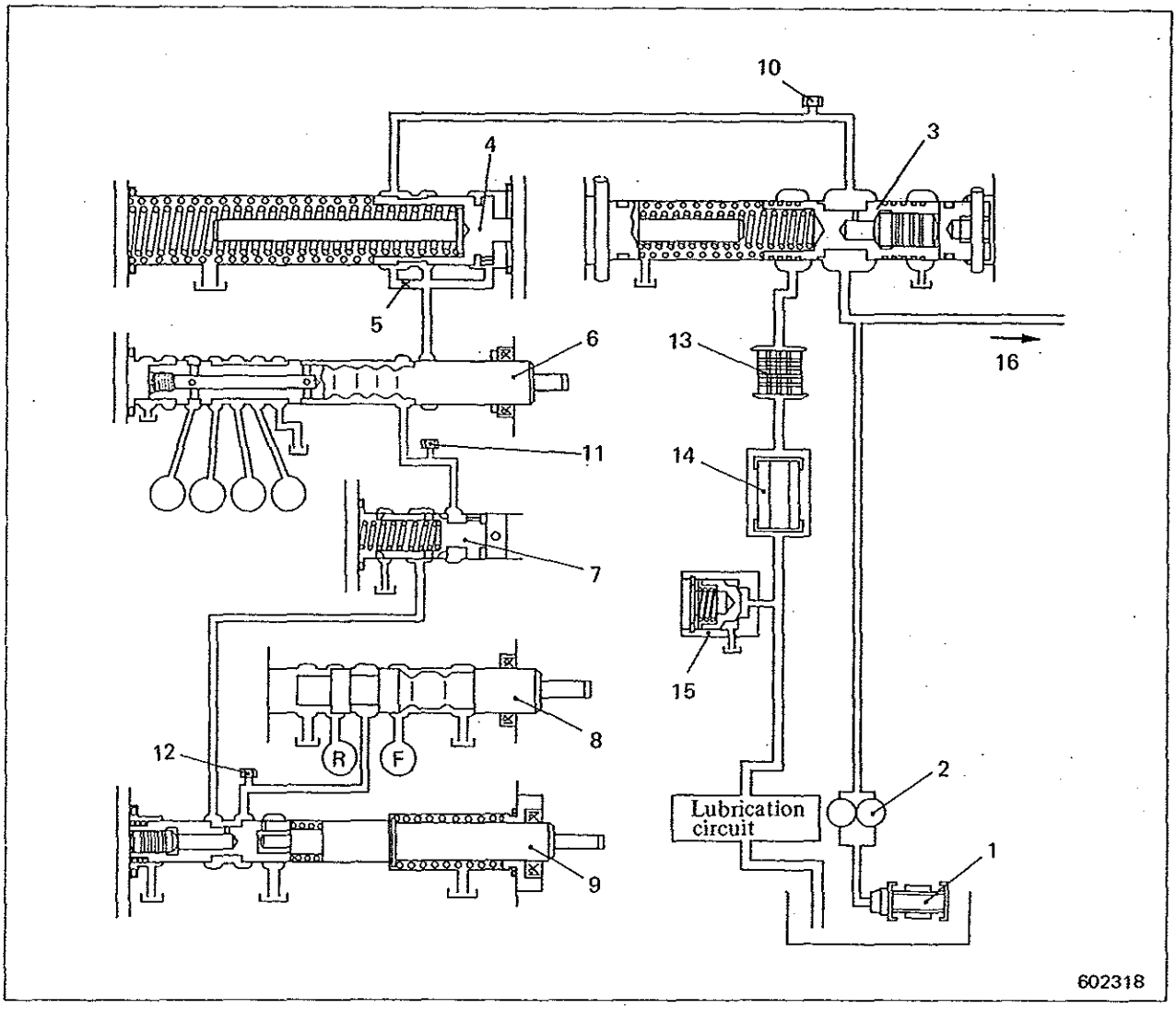
602316

Reverse 3rd speed position



602317

Hydraulic control circuit



1 Suction strainer (with magnet)
2 Oil pump
   39.3 liters (10.4 U.S. gal)/min at 2400 rpm
3 Main relief valve
   19 – 22 kgf/cm² (270 – 313 psi) [1.86 – 2.16 MPa]
4 Accumulator valve
   3 – 13 kgf/cm² (42.7 – 185 psi) [0.29 – 1.27 MPa]
5 Main orifice
6 Speed selector valve
7 Differential valve
   Differential pressure: 2 kgf/cm² (28.4 psi) [0.20 MPa]
8 Directional selector valve
9 Inching valve
   0 – 5 kgf/cm² (0 – 71 psi) [0 – 0.49 MPa]
10 Main relief pressure test port ("M")
11 Speed clutch pressure test port ("S")
12 Directional clutch pressure test port ("D")
13 Oil cooler
14 Oil filter
   Bypass pressure: 1 kgf/cm² (14.2 psi) [0.10 MPa]
15 Lubrication relief valve
   1 – 2 kgf/cm² (14.2 – 28.4 psi) [0.10 – 0.20 MPa]
16 To steering valve

The hydraulic control circuit consists essentially of suction strainer "1," oil pump "2," main relief valve "3," oil cooler "13," oil filter "14," lubrication relief valve "15," control valve and steering clutch circuit.

Suction strainer "1" is a 100-mesh stainless type element with a magnet and serves to protect oil pump "2."

Oil pump "2" is of external gear type and is driven by the gear to which drive is transmitted from the transmission input shaft.

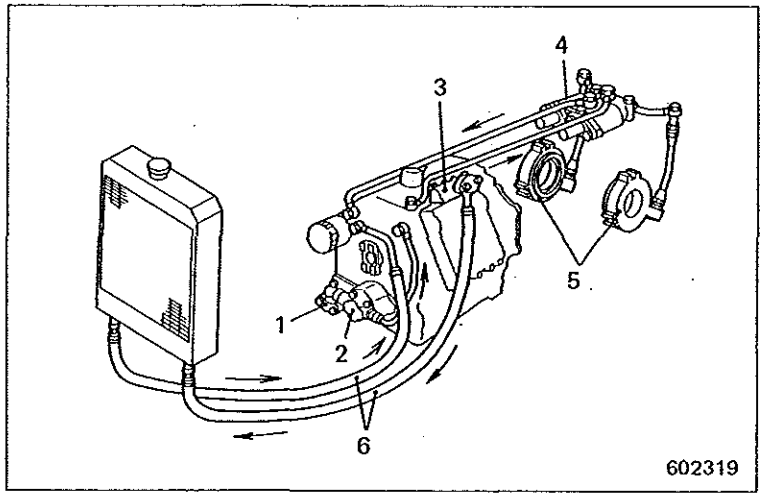
Oil cooler "13" is of multi-plate type and is mounted on the bottom side of engine radiator.

Oil filter "14" is of cartridge type. It opens its bypass circuit when its element is clogged and the pressure difference across it exceeds 1.0 kgf/cm^2 (14.2 psi) [0.10 MPa] to maintain constant flow of oil to the lubrication circuit.

Lubrication relief valve "15" maintains the oil pressure in the lubrication circuit at 1 to 2 kgf/cm^2 (14.2 to 28.4 psi) [0.10 to 0.20 MPa] for protection.

The oil in the oil sump is lifted by oil pump "2" through suction strainer "1." Oil from the pump flows into two circuits, one leading to the steering valve for actuating the steering clutches and the other to main relief valve "3" for actuating the clutch pistons of planetary gears.

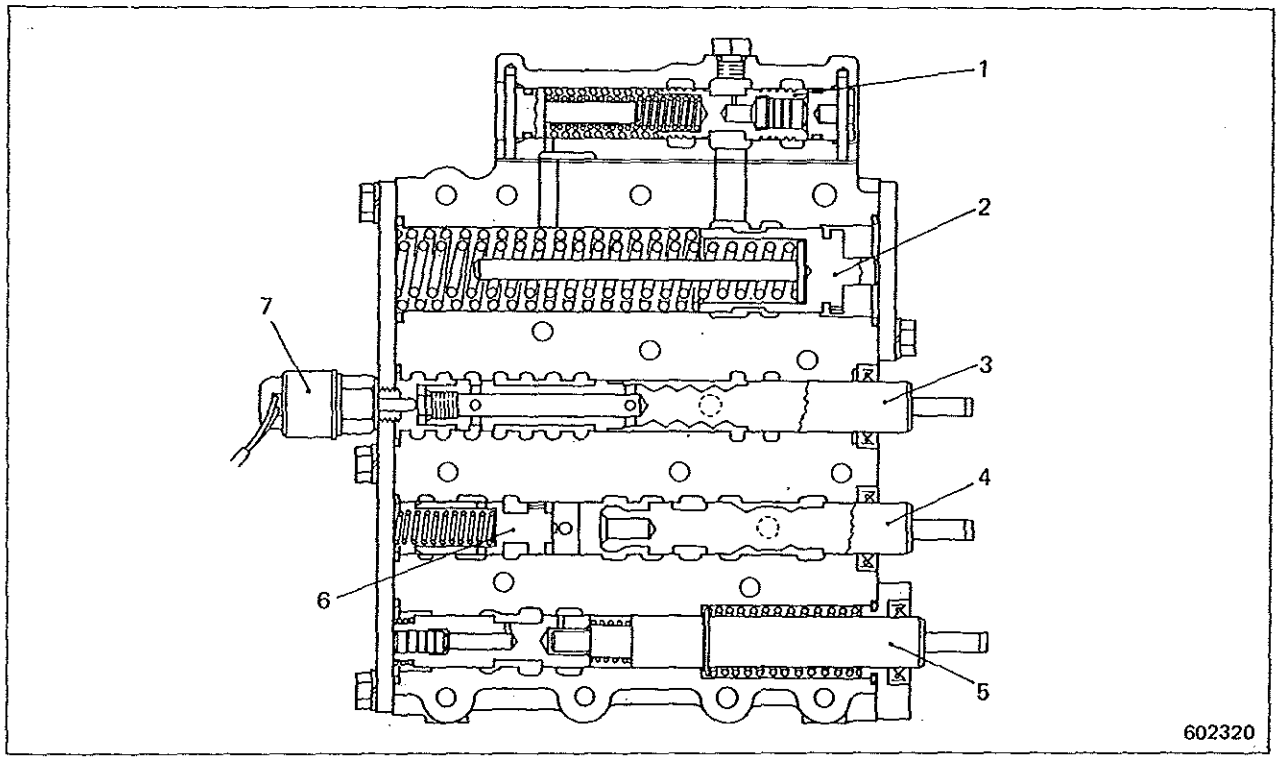
After delivering the main pressure, the excess oil is cooled by oil cooler "13," flows through oil filter "14," lubricates planetary gears and transmission parts, and gravity-returns to the oil sump for recirculation.



1 Oil strainer
2 Oil pump
3 Main relief valve
4 Steering valve
5 Steering clutch cylinders
6 Oil cooler hoses

Transmission control valve

o Description



1 Main relief valve
2 Accumulator valve
3 Speed selector valve
4 Directional selector valve
5 Inching valve
6 Differential valve
7 Neutral switch

This control valve comprises accumulator valve "2," inching valve "5," differential valve "6," directional selector valve "4" and speed selector valve "3."

(1) Accumulator valve "1" gradually rises the oil pressure in the clutch piston chamber to insure smooth clutch engagement (smooth starting).

(2) Differential valve "6" keeps the pressure applied to the directional clutches (forward and reverse clutches) lower than the pressure applied to the speed clutches (1st-speed, 2nd-speed and 3rd-speed clutches) by 2 kgf/cm^2 (28.4 psi) [0.20 MPa]. Consequently, the speed clutch is engaged earlier than the directional clutch and the directional clutch serves to transmit the power.

(3) Directional selector valve "4" directs the oil to either forward clutch piston chamber or reverse clutch piston chamber.

(4) Speed selector valve "3" directs the oil to any of the 1st-speed, 2nd-speed and 3rd-speed clutch ports.

(5) Inching valve "5," actuated by the inching pedal, reduces the pressure in the forward or reverse clutch piston chamber to control the clutch in transition from full engagement to full disengagement for moving the machine in an inching manner.

(6) Main relief valve "1" maintains the pressure of oil discharged from the pump. Because of this valve, the pressure applied to the clutch piston chambers is always constant and full-flow oil is supplied to the lubrication circuit except when oil is supplied to clutch piston chambers.

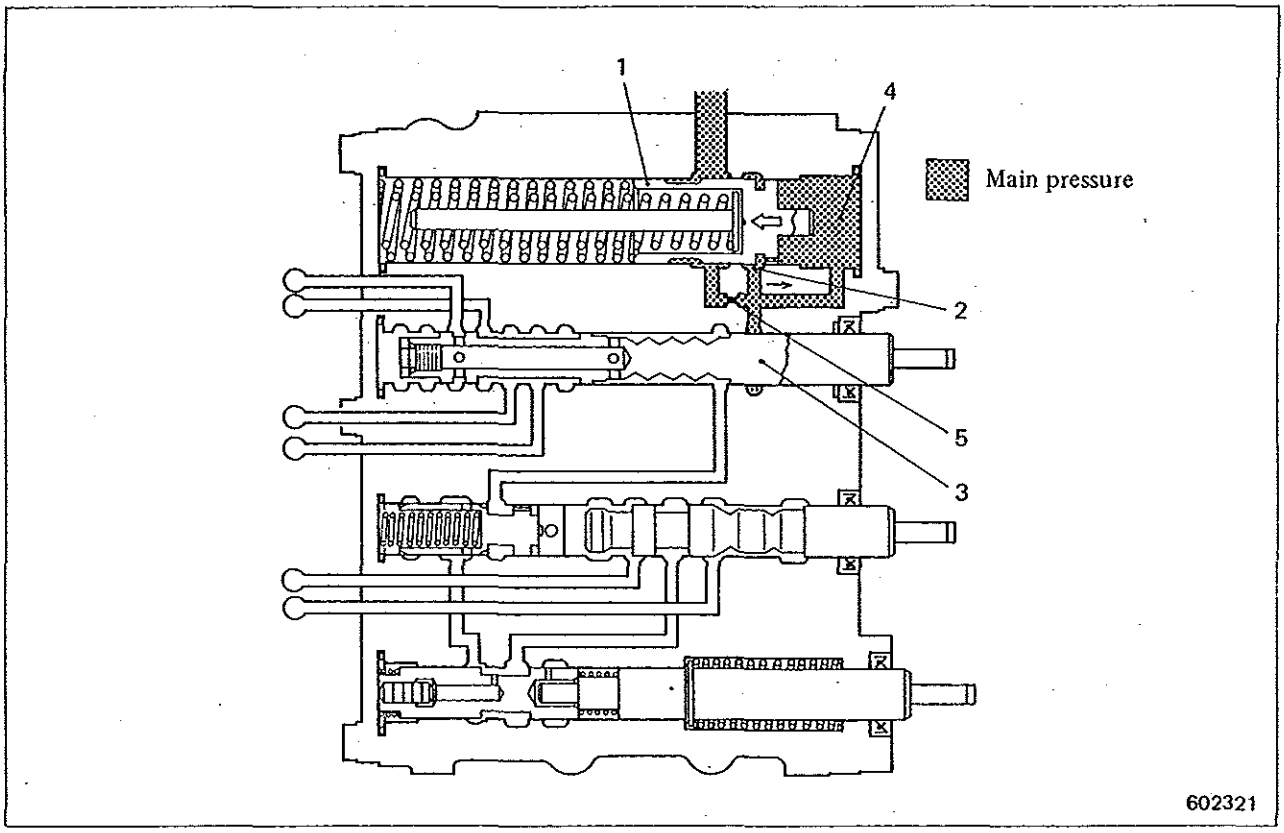
o Operation

The control valve operation will be described on the assumption that the transmission control lever is moved from neutral to forward 1st speed position.

[NEUTRAL position]

As the engine starts, main pressure is applied through main port "2" to speed selector valve "3" and accumulator valve pressure chamber "4."

Speed selector valve "3" is in neutral position, covering the port leading to the 1st-speed clutch piston chamber. As the pressure rises in the chamber "4," accumulator valve "1" moves to the left to cover main port "2." Now, a circuit through main orifice "5" is formed to allow the oil from the pump to flow into the chamber "4" for pressure accumulation. This pressure accumulation continues until the accumulator valve comes to the left end of its stroke.



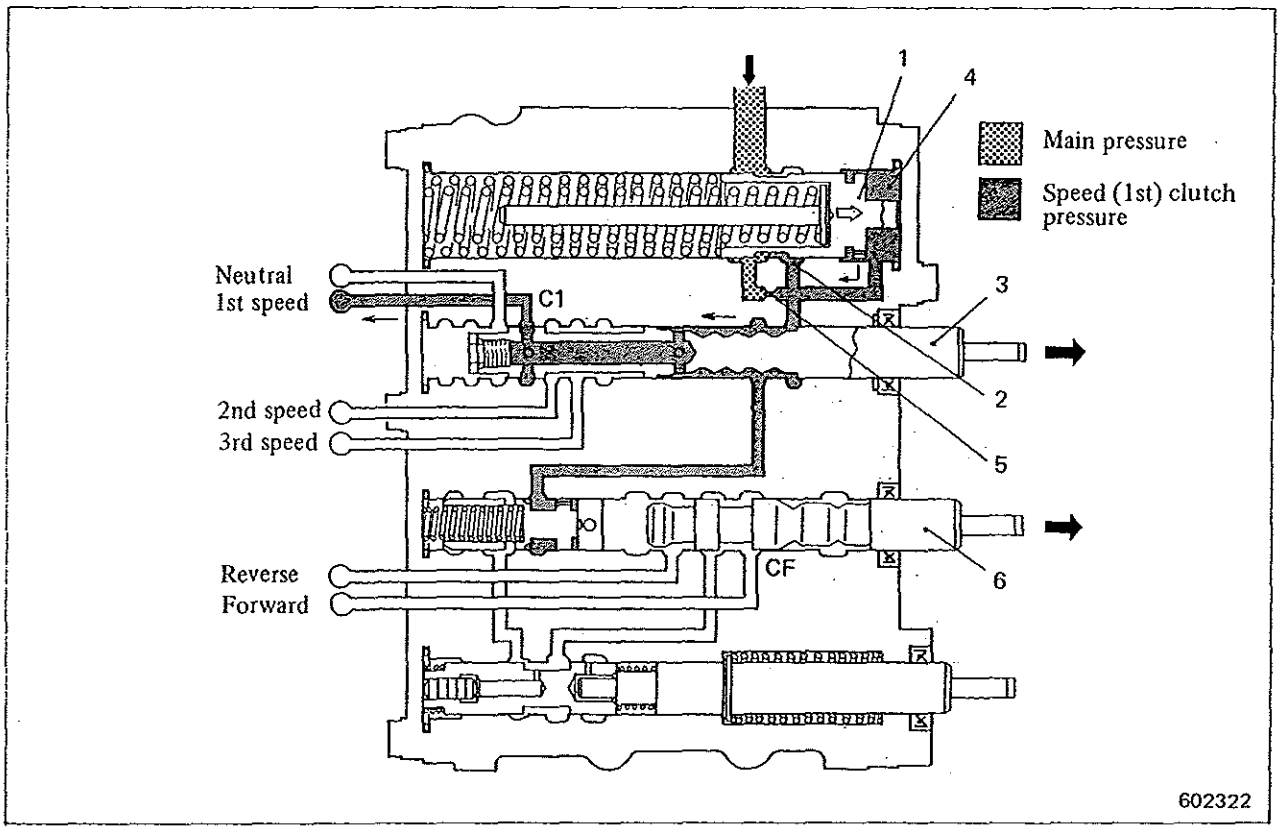
[FORWARD 1ST SPEED position]

1. Prefilling of 1st-speed clutch piston chamber

When the transmission control lever is moved from neutral to forward 1st speed position, speed selector valve "3" moves to "1st speed" position and directional selector valve "6" to "forward" position, uncovering 1st-speed clutch port (C1) and forward clutch port (CF) respectively.

Under this condition, the pressure is being applied to the 1st speed clutch piston chamber but it is not applied to the forward clutch piston chamber yet.

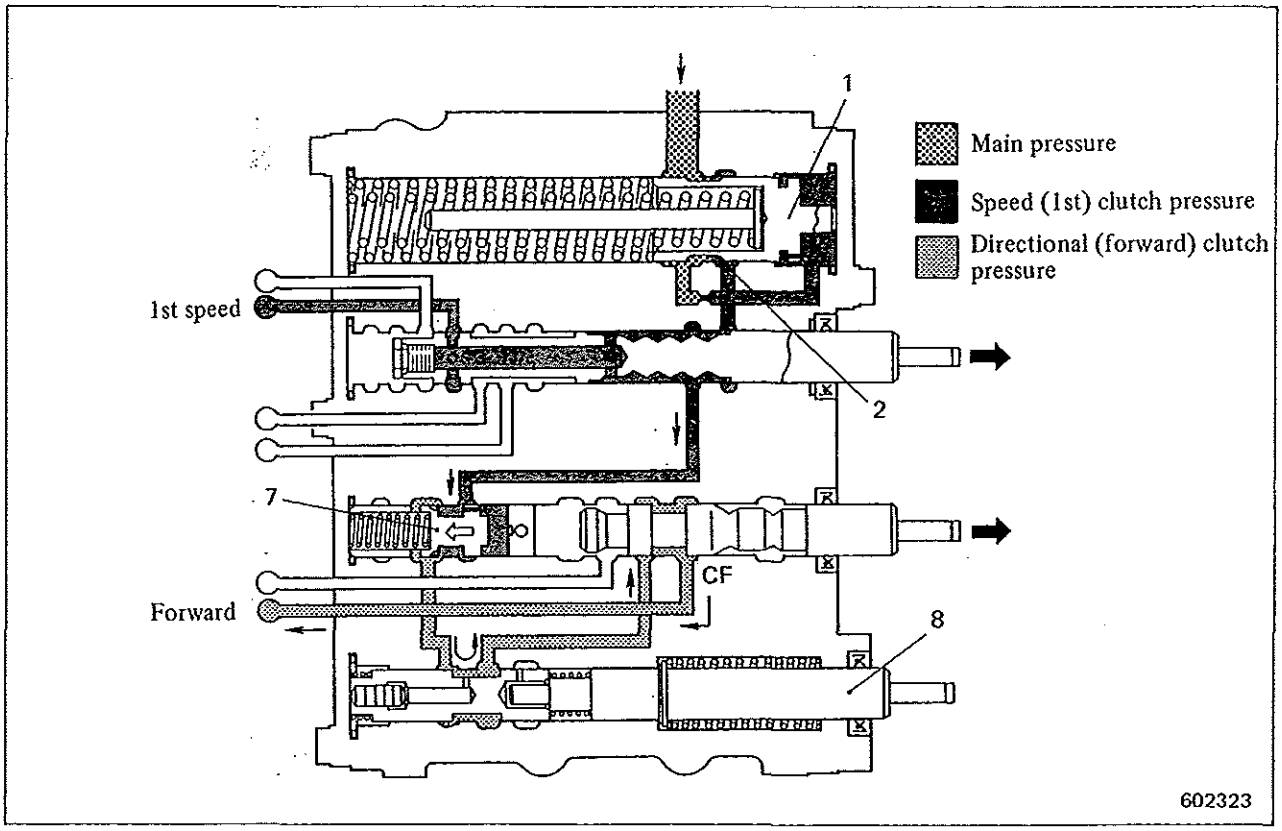
The moment the oil in accumulator valve pressure chamber "4" enters the 1st-speed clutch piston chamber for prefilling, accumulator valve "1" returns to the right end to uncover main port "2." Now, a circuit bypassing main orifice "5" is formed to assist in prefilling the 1st-speed clutch piston chamber.



2. Prefilling of forward clutch piston chamber

Upon completion of prefilling the 1st-speed clutch piston chamber, the speed clutch pressure rises beyond 2 kgf/cm^2 (28.4 psi) [0.20 MPa]. This pressure moves differential valve "7" to the left end, allowing the speed clutch pressure oil to enter forward clutch pressure port (CF) through inching valve "8."

Since accumulator valve "1" does not move yet, keeping main port "2" uncovered, the oil from the pump flows into the forward clutch piston chamber without being metered.

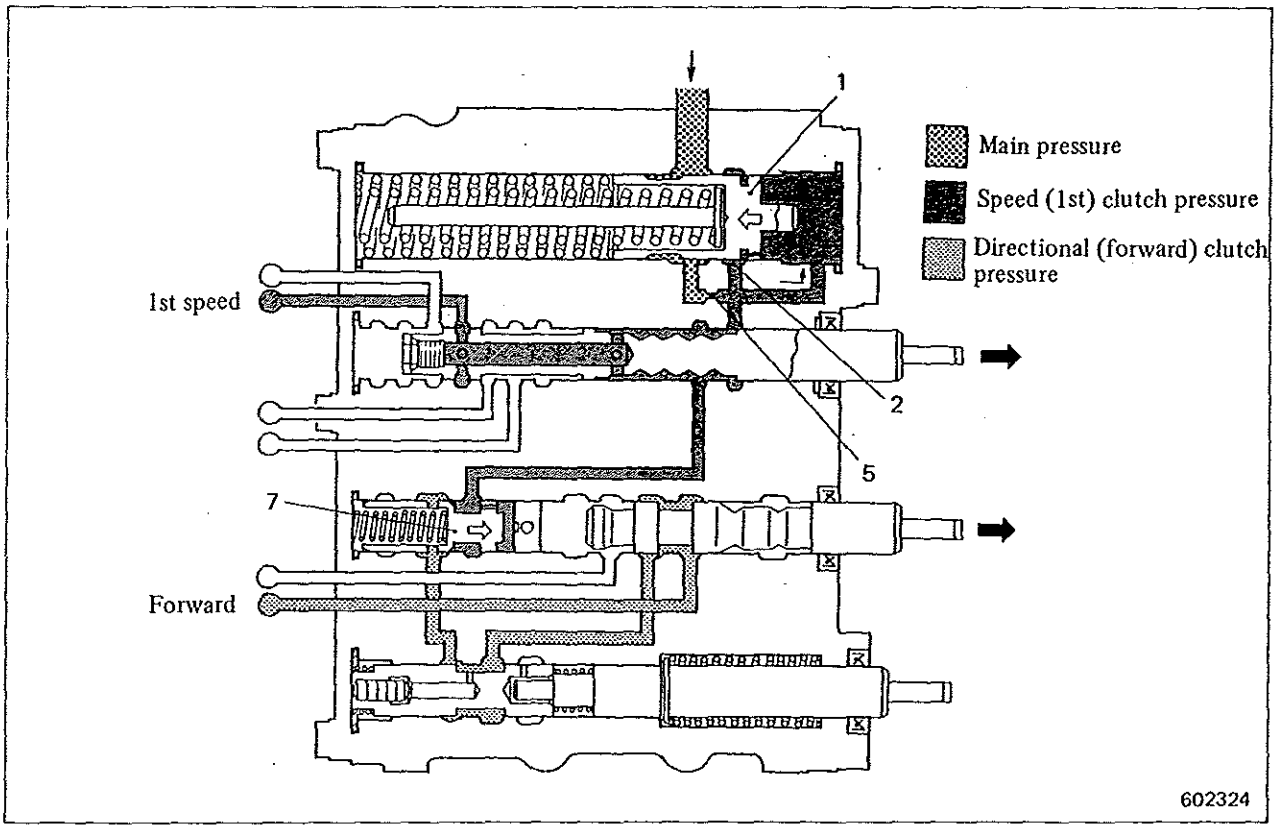


3. Modulation action

Upon prefilling the forward clutch piston chamber, differential valve "7" is returned to its pressure regulating position for maintaining the difference between the 1st-speed clutch pressure and forward clutch pressure at constant level (2 kgf/cm^2 (28.4 psi) [0.20 MPa]) and, at the same time, accumulator valve "1" starts moving to the left to cover main port "2."

Then, only the oil metered by main orifice "5" flows into the 1st-speed clutch circuit to move accumulator valve "1" slowly and to increase both forward and 1st-speed clutch pressures gradually. This is called "modulation action."

Since the speed clutch pressure is always higher than the directional clutch pressure, the 1st-speed clutch and forward clutch are engaged in that sequence. This means that shock produced during shifting is arrested by the forward clutch. Both forward and 1st-speed clutches are engaged during this modulation action to insure smooth shifting.

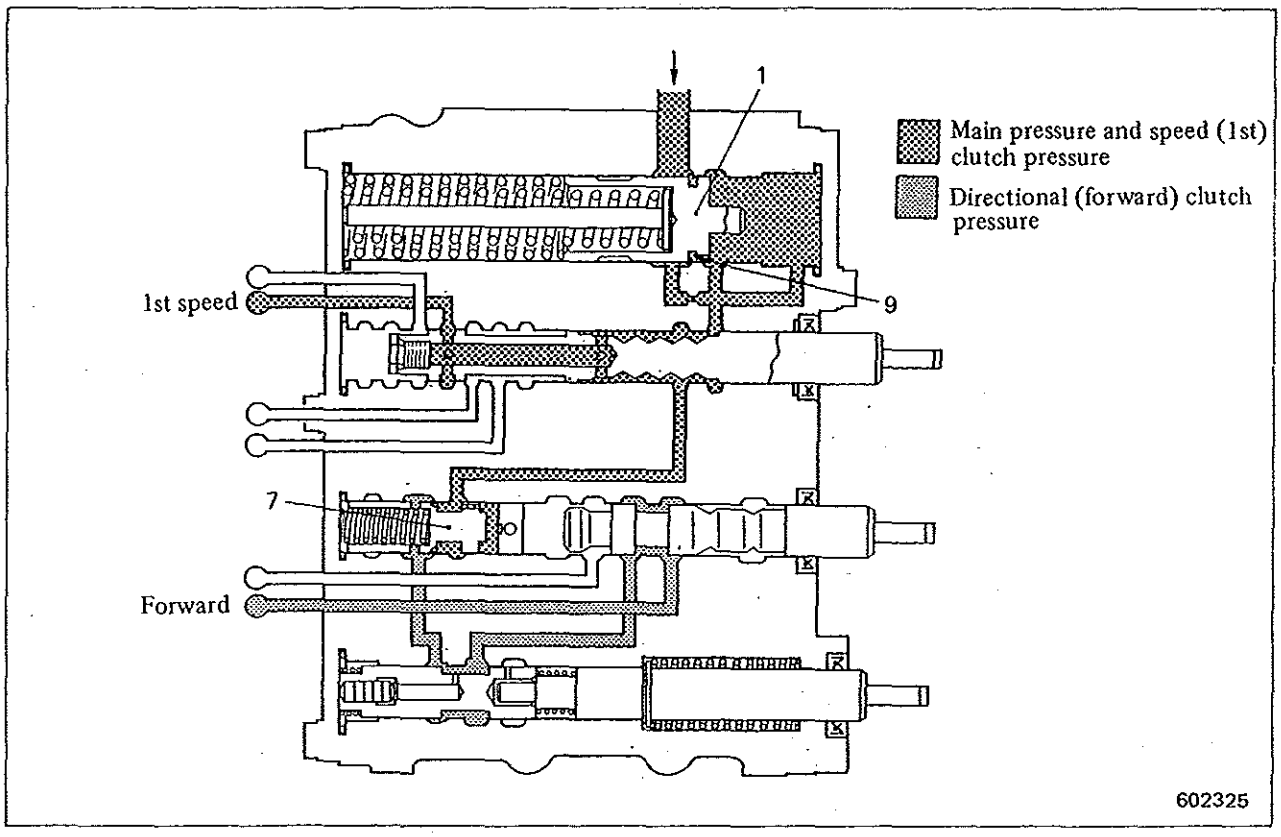


4. Completion of shifting

When accumulator valve "1" comes to the left end of its stroke, bypass orifice "9" opens again and the 1st-speed clutch pressure rises rapidly to the level of main pressure. Thus, shifting into forward 1st speed is completed.

Differential valve "7" still remains in the pressure regulating position. This keeps the forward clutch pressure lower than the 1st-speed clutch pressure by 2 kgf/cm^2 (28.4 psi) [0.20 MPa].

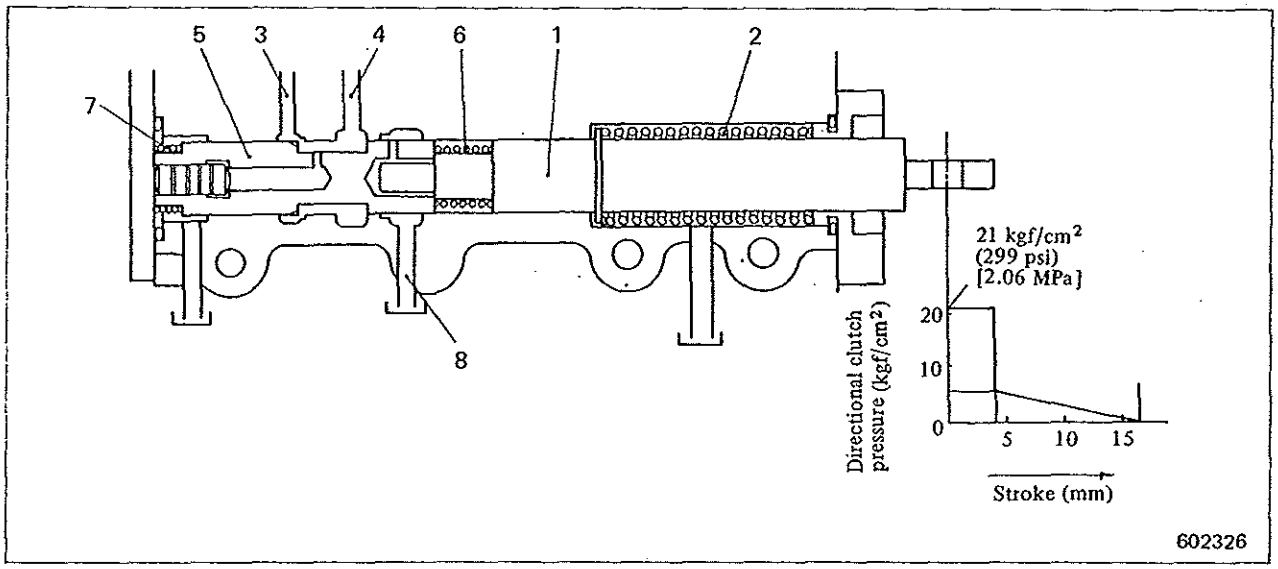
In the operation for shifting into other speeds, too, differential valve "7" is returned to the right end of its stroke for draining the directional clutch pressure, because the speed clutch pressure decreases in advance. Susequent actions are the same as those described for neutral to forward 1st speed shifting.



5. Inching action

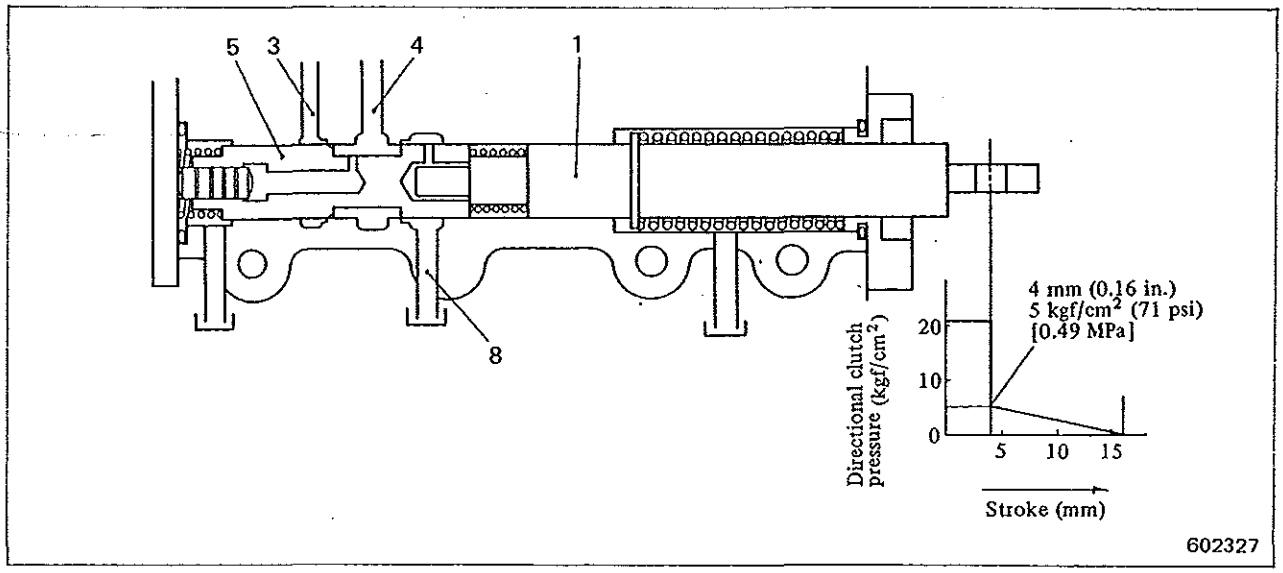
The inching valve regulates the directional clutch pressure for driving the machine in an inching manner or extremely slowly. Inching valve plunger "1" is connected to the inching pedal (left pedal) through rod.

As long as the inching pedal is in released position, plunger "1" is kept pushed to the left end of its stroke by return spring "2." Under this condition, primary pressure in passage "3" is admitted into secondary pressure passage "4," thus maintaining 21 kgf/cm^2 (299 psi) [2.06 MPa] pressure there.

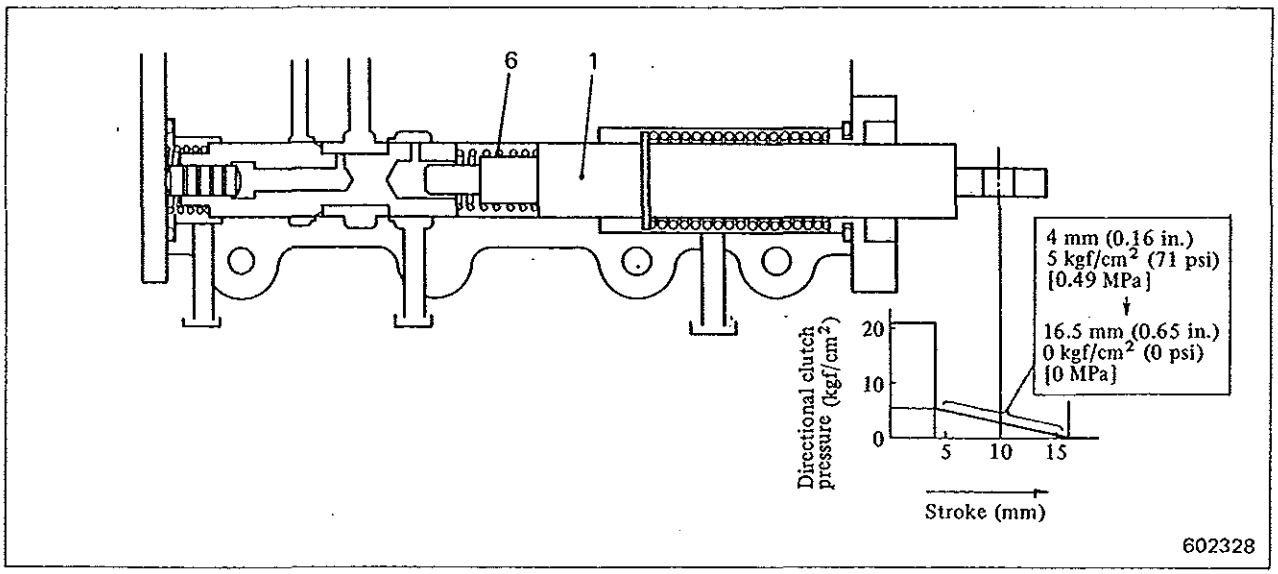


1 Plunger
2 Return spring
3 Primary pressure passage (from differential valve)
4 Secondary pressure passage (to directional selector valve)
5 Valve
6 Pressure regulating spring
7 Spring
8 Oil passage

As the inching pedal is depressed, plunger "1" is moved to the right. When it is moved 4 mm (0.16 in.), valve "5" meters the oil flowing into passage "4" from passage "3" and, at the same time, starts draining oil from passage "4" to the oil sump through passage "8" to reduce the directional clutch secondary pressure down to 5 kgf/cm^2 (71 psi) [0.49 MPa].

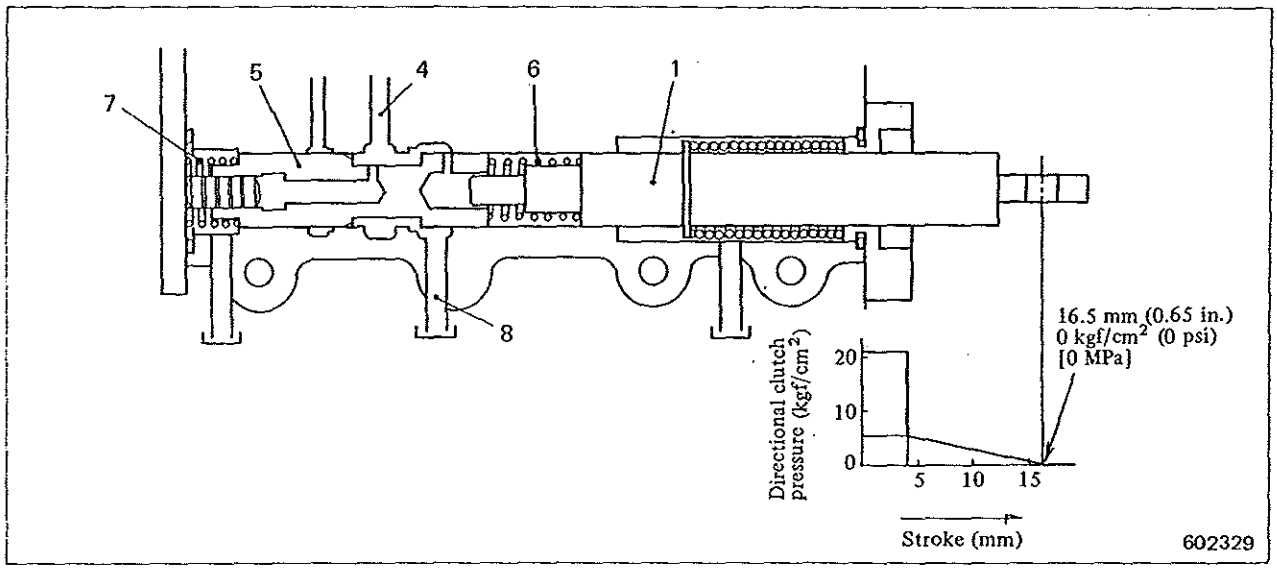


As the inching pedal is farther depressed, plunger "1" is moved to the position indicated. Now, pressure regulating spring "6" becomes expanded and pressure proportional to the load this spring so expanded is built in the pressure chamber, decreasing secondary pressure (P_{D2}). Thus secondary pressure (P_{D2}) varies from 5 to 0 kgf/cm^2 (71 to 0 psi) [0.49 to 0 MPa] within the range of 4 to 16.5 mm (0.16 to 0.65 in.) stroke of plunger "1."



When the inching pedal is depressed all the way and plunger "1" is moved 16.5 mm (0.65 in.) of its stroke, pressure regulating spring "6" restores to free state, causing spring "7" to move valve "5" to the right. This will completely stop oil flow to passage "4," and passage "4" and passage "8" are communicated to each other without being metered. Consequently, secondary pressure falls to zero and the machine is brought into a complete stop as in neutral.

In summary, the inching pedal may be used like the clutch pedal of a direct-drive model. The machine can be started smoothly by depressing the inching pedal quickly all the way to the end of its stroke and then releasing it gradually to a position within the range of 4 to 16.5 mm (0.16 to 0.65 in.) of the stroke of plunger "1," depending on the load, to gradually increase the pressure acting on the directional clutch piston.



TESTING AND ADJUSTMENT

DPS TRANSMISSION

Inspection

A good program of diagnosing and testing has three basic steps.

1. Asking the operator

You can get the full story from the operator; he will tell you how the system or the machine acted when it began to fail, what was abnormal about it. Ask about how the machine was used, when it was finally serviced. Remember, most failure are usually traced to poor servicing or abuse of the machine.

2. Checking the machine

(1) Check the oil level in the transmission.

(2) Check the transmission case and oil lines for any sign of leaks.

(3) Check the inching pedal and transmission control lever linkages for adjustment.

3. Operating the machine

Get on the machine and operate it for testing. During the test, shift the transmission into all gears, forward and reverse, and operate the inching pedal. If the machine fails to start smoothly, or if inching or shifting is hard, see Troubleshooting guide, which follows.

Testing the clutches for slippage

(1) Start the engine, depress and lock the brake pedal.

(2) Run the engine at maximum speed, and move the transmission control lever into forward 2nd speed position.

(3) If the engine stalls as soon as the transmission control lever is shifted, all clutches are not slipping. If it does not stall for more than 3 seconds, or if it does not stall at all, any of the clutches (forward 2nd-speed) is slipping.

Trouble diagnosis by oil pressure readings

1. If transmission shifts hard:

Complaint	Possible cause	Remedy
No shift to some speeds. "M" port pressure: Normal "D" and "S" port pressures: Abnormally low – not higher than 10 kgf/cm^2 (142 psi) [0.98 MPa]	(1) Clutch piston sealing ruptured (2) Control valve gasket ruptured (3) Absence of O-ring or broken O-ring in pipe between transmission case and clutch case (4) Oil hole blanking ball off	• Disassemble and replace. • Disassemble and replace. • Disassemble and install O-ring or replace broken one. • Fit ball by driving.
No shift to all speeds. "M," "D" and "S" port pressures: All low – not higher than 10 kgf/cm^2 (142 psi) [0.98 MPa]	(1) Defective oil pump (2) Clogged oil passage between strainer and pump, between pump and line filter or between filter and control valve; or leakage (3) Main relief valve sticking	• Replace. • Check and clean clogged part by flushing; or repair leaking point. • Disassemble and clean.
No shift to all gears. "M" port pressure: Normal "D" and "S" port pressures: Both gone (0 kgf/cm^2)	Neutral safety valve in malcondition due to weakened spring, foreign matter stuck on valve seat, or sticky valve	Disassemble, clean by washing and repair or replace. Weakened spring must be replaced.
No shift to some speeds. "M," "D" and "S" port pressures all normal.	Clutch plates burnt or friction-material surfaces lost due to peeling If forward clutch plates burnt and seized: Machine starts on F1, F2 and F3 but engine stalls on R1, R2 and R3. If 1st-speed clutch plates burnt and seized: Machine starts on F1 and R1 but engine stalls on F2, R2, F3 and R3.	Disassemble and replace.

2. If shock is felt when shifted:

Complaint	Possible cause	Remedy
Indicating hand of pressure gauge jumps momentarily from 0 to 21 kgf/cm² (299 psi) [2.06 MPa] on shifting to any speed.	Accumulator valve sticking	Wash valve body, check bore for damage and, as necessary, replace valve and bore, if valve does not move sliding smoothly.
Indicating hand of pressure gauge jumps momentarily from 0 to 21 kgf/cm² (299 psi) [2.06 MPa] on shifting to some speeds.	(1) Clutch piston sticking (2) Accumulator valve sticking	• Disassemble and repair or replace. • Refer to above. (The same trouble occurs unless slug is inserted properly.)

3. If time lag in shifting is excessive:

NOTE: Normally machine starts within 0.9 second in standing start.

Complaint	Possible cause	Remedy
Lag is large in shifting from N to 1 and from N to 2, but is normal in shifting from 1 to 2 and 2 to 1. Indicating hand takes 2 seconds or more in deflecting from 0 to 21 kgf/cm² (299 psi) [2.06 MPa].	(1) Accumulator valve sticking (2) Accumulator valve spring weakened	• Wash valve body, check bore for damage and, as necessary, replace valve and bore, if they do not move sliding smoothly. • Replace.
Indicating hand takes longer time than normal to deflect from 0 to 21 kgf/cm² (299 psi) [2.06 MPa] upon shifting to any speed.	(1) Accumulator valve sticking (2) Accumulator valve spring weakened (3) Main orifice clogged (4) Insufficient pump output	• Refer to above. • Replace. • Disassemble and clean. • Disassemble and clean clogged parts of lines.
Indicating hand takes longer time than normal to deflect from 0 to 21 kgf/cm² (299 psi) [2.06 MPa] upon shifting to some speeds.	(1) Clutch piston sealing ruptured (2) Absence of O-ring or broken O-ring in pipe between transmission case and clutch case	• Disassemble and replace. • Disassemble and install O-ring or replace broken one.

4. If inching pedal malfunctions:

Complaint	Possible cause	Remedy
Clutch grabs even if inching pedal is depressed. "M," "S" and "D" port pressures: Normal	Clutch plates in forward or reverse clutch seized	Disassemble and replace.
Clutch grabs even if inching pedal is depressed. "M" and "S" port pressures: Normal "D" port pressure: Does not drop to 0 kgf/cm^2	(1) Control linkage maladjusted (2) Clutch valve defective	• Check and adjust. • Disassemble, wash and repair or replace.
Releasing inching pedal after fully depressing causes machine to jerk in standing start. "M" and "S" port pressures: Normal "D" port pressure: Rises but not smoothly as pedal moves in releasing direction.	Clutch valve sticking NOTE: If 8-mm (0.31-in.) dia. rod is positioned the other way around, clutch valve will not function properly.	Disassemble and clean by washing. Replace 3-piece spool as necessary. Be sure 8-mm (0.31-in.) dia. rod is correctly positioned.
Releasing inching pedal quickly fails to make machine pick up speed quickly: machine starts off slowly. "M" port pressure: Normal "D" port pressure: Changes in the normal manner. "S" port pressure: Normal (does not drop).	Pilot valve sticking NOTE: Be sure slug is correctly positioned. With slug mispositioned, pilot valve behaves as it were sticky.	Wash valve body. Check accumulator valve orifice for damage. Replace valve and body as necessary.

5. If transmission overheats:

Complaint	Possible cause	Remedy
"M," "D" and "S" port pressures are normal or slightly lower.	(1) Oil level too high (2) Oil level too low	• Lower oil level. • Raise oil level.
"M," "D" and "S" port pressures are normal	(1) Clutch plates seized (2) Mechanical trouble inside transmission	• Disassemble and replace. • Overhaul and replace defective parts.

6. If output power is not enough:

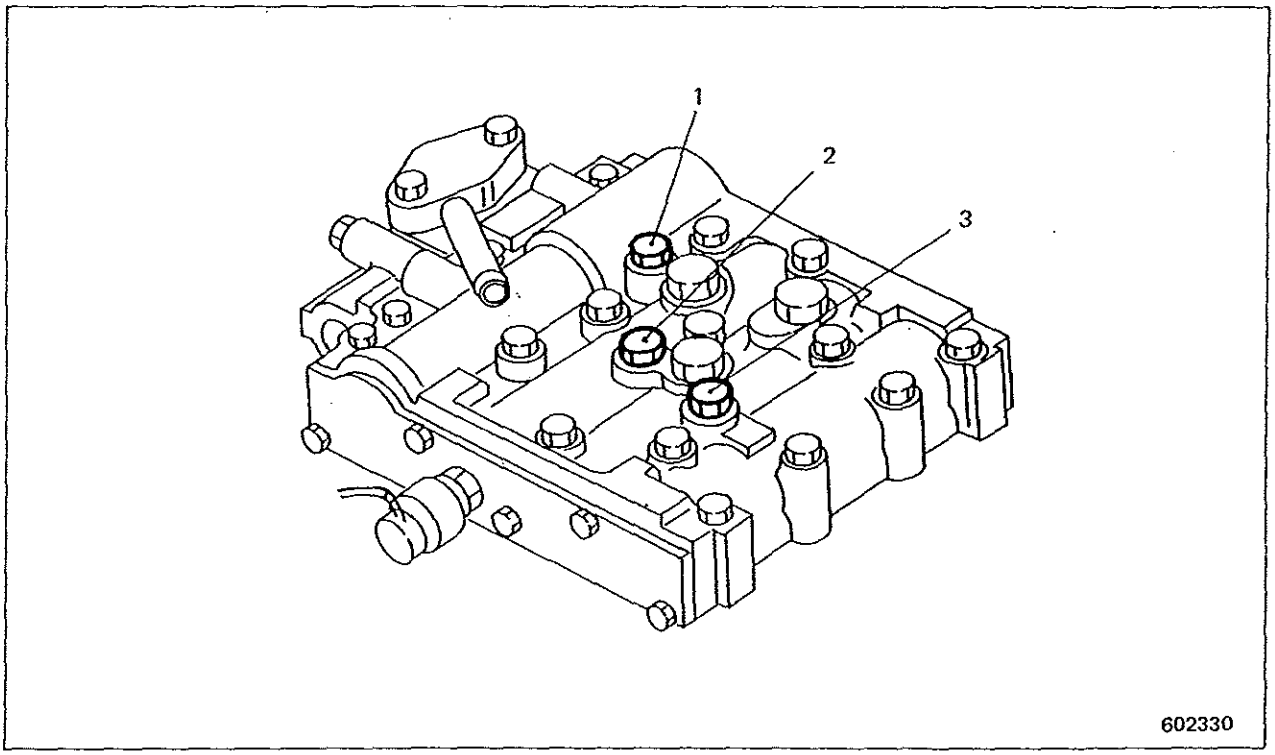
Complaint	Possible cause	Remedy
"M," "D" and "S" port pressures are low.	Oil level too low	Add oil.
"M," "D" and "S" port pressures are normal.	(1) Engine lacks power (2) Mechanical trouble inside transmission	• Tune up engine. • Overhaul and replace defective parts.

7. If oil pressures are high:

Complaint	Possible cause	Remedy
"M," "D" and "S" port pressures rise above 21 kgf/cm^2 (299 psi) [2.06 MPa].	(1) Main relief valve sticking (2) Main relief valve spring defective or shim adjustment improper	• Disassemble and wash. • Replace or readjust by shimming.

Testing the control valve

Connect an oil pressure gauge to each of "M," "S" and "D" ports in testing the hydraulic pressures with the control valve mounted on the transmission. When running the transmission and control valve on the bench in order to break them in, be sure to form an oil cooler bypassing circuit by connecting two rubber hoses, one leading to the cooler inlet and the other from the cooler outlet.



1 Main pressure: "M" port
2 Speed clutch (1st-speed, 2nd-speed and 3rd-speed) pressure: "S" port
3 Directional clutch (forward and reverse) pressure: "D" port

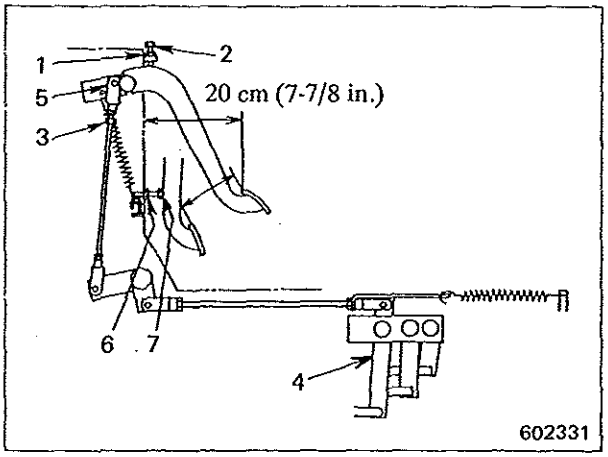
Pressure designation	Port and gauge connection	Pressure requirement
Main pressure	M port; PF 1/8" connection with O-ring	With engine running at high idling speed and control lever kept in neutral, this pressure is required to take the following value: 21 kgf/cm² (299 psi) [2.06 MPa] If not, adjust setting of main relief valve by increasing or decreasing thickness of its shim.
1st-speed, 2nd-speed and 3rd-speed clutch pressure	S port; PF 1/8" connection with O-ring	With engine running at high idling speed, this pressure is required to remain at a level equal to main pressure.
Forward and reverse clutch pressure	D port; PF 1/8" connection with O-ring	With engine running at high idling speed, this pressure is required to take the following value: 0 kgf/cm² for both clutches with control lever in neutral. Not lower than main pressure by 2 kgf/cm² (28.4 psi) [0.20 MPa], with control lever in 1st, 2nd or 3rd speed position.
Speed clutch pressure	S port; PF 1/8" connection with O-ring	Measure time required for pressure to change and residual pressure when control lever is shifted from neutral to any position, or from one position to another.

Shifting	Time
N ⟶ 1	0.7 – 1.3 sec.
1 ⇄ 2	0.4 – 1.0 sec.
2 ⇄ 3	0.4 – 1.0 sec.

Bench test criteria for transmission oil pump

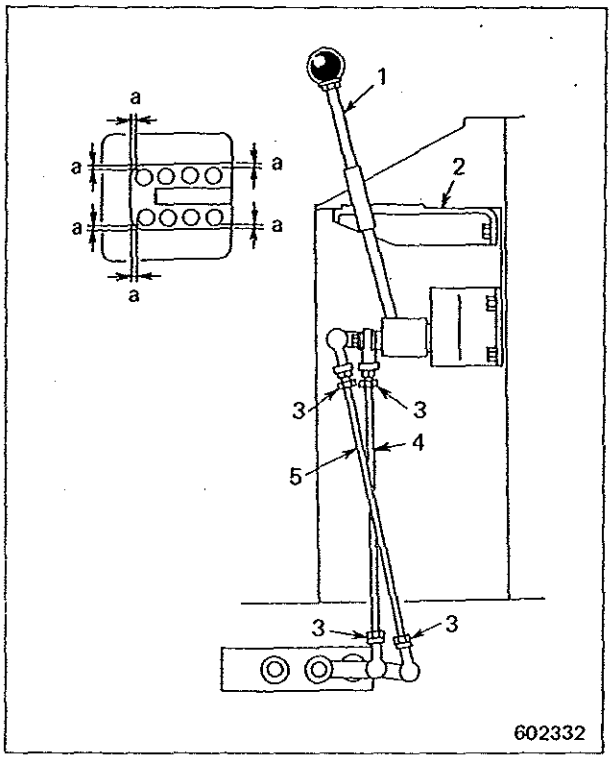
Direction of rotation	Clockwise (as viewed from drive gear side)
Hydraulic oil	Engine oil, SAE 10W, 50° ± 5°C (122° ± 9°F)
Pump drive speed	2600 rpm
Discharge flow	40 liters (10.6 U.S. gal)/minute

ADJUSTING THE INCHING PEDAL



1. Loosen lock nut "1."
2. Reposition stopper bolt "2" so that the inching pedal is 20 cm (7-7/8 in.) as measured from the dashboard wall.
3. Loosen lock nut "3."
4. Adjust the length of rod by turning clevis "5" so that lever "4" starts moving when the inching pedal is depressed.
5. Loosen lock nut "6."
6. Reposition stopper bolt "7" so that the pedal stroke is 14.5 cm (5-11/16 in.).

ADJUSTING THE TRANSMISSION CONTROL LEVER



NOTE

Clearance "a" between guide "2" and lever "1" should be 0.5 to 2.0 mm (0.02 to 0.08 in.) in any lever position.

1. Loosen lock nut "3."
2. Turn rods "4" and "5" to adjust clearance "a."

TROUBLESHOOTING GUIDE

Transmission

Complaint	Possible cause	Remedy
Machine does not move in one or more speeds or all clutches slip.	A. Low oil pressure	
	(1) Not enough oil	• Refill.
	(2) Loose, broken or maladjusted control linkage	• Repair or readjust.
	(3) Oil pump or its drive defective	• Overhaul or replace.
	(4) Air being sucked into pump	• Check packed joint in pump suction and repair or replace.
	(5) Internal oil leakage in control valve unit due to wear or failure of sealing members such as piston seals and O-rings	• Disassemble and repair or replace defective parts.
	(6) Main relief valve internally dirty with foreign matter stuck in sliding clearance, or out of adjustment	• Overhaul. Correct its pressure setting.
	(7) Oil too low in viscosity	• Use Class CD oil (engine oil) of API classification, whose viscosity rating is SAE 10W.
	B. Mechanical failure	
	(1) Transmission shaft damaged	• Disassemble and replace.
	(2) Seized or bound clutch piston, friction plates or mating plates, resulting in reduced clutch capacity	• Disassemble, repair or replace.
	(3) Friction plates or mating plates worn or damaged	• Disassemble and replace.
	(4) Bevel gears or other gears defective	• Disassemble and replace.
	C. Neutral safety valve malfunctions	Overhaul or replace.
Machine jolts on shifting.	(1) Accumulator valve not working properly	• Disassemble and repair or replace.
	(2) Pilot valve malfunctioning	• Disassemble and repair or replace
	(3) Oil viscosity too high	• Use SAE 10W oil.
Slow response of transmission to shifting.	(1) Clogged orifice in control valve unit	• Disassemble and clean.
	(2) Not enough oil	• Refill.
	(3) Control linkage maladjusted	• Readjust.
	(4) Air being sucked into oil pump due to loose packed joint in suction line	• Retighten or replace packing.
	(5) Faulty seal ring on clutch piston	• Disassemble and replace.
	(6) Damaged O-ring in path of oil to clutch piston	• Disassemble and replace.

Complaint	Possible cause	Remedy
Not enough output.	(1) Engine not delivering enough power	• Re-tune engine.
	(2) Not enough oil	• Refill.
	(3) Air being sucked into oil pump	• Check joint and replace packing as necessary.
	(4) Sticking or bound spool in main relief valve	• Disassemble and repair or replace.
	(5) Weakened spring in main relief valve.	• Disassemble and replace the spring.
	(6) Worn-down oil pump	• Replace.
	(7) Strainer or filter clogged	• Clean or replace.
	(8) Badly worn clutch piston ring or O-ring	• Disassemble and replace.
	(9) Water in oil	• Change oil.
	(10) Control linkage maladjusted	• Readjust.
	(11) Slipping clutches due to low main pressure	• Readjust.
	(12) Damaged clutch piston	• Disassemble and replace.
	(13) Dragging wheel brakes	• Readjust.
Transmission does not shift into neutral, or remains	(1) Control linkage maladjusted	• Readjust.
	(2) Burnt clutches	• Disassemble and replace burnt parts.
	(3) Clutch piston, friction plates or mating plates binding.	• Disassemble, repair or replace.
	(4) Clutch valve seized, resulting in no pressure drop	• Disassemble, repair or replace.
	(5) Oil level too high or too low	• Adjust to the prescribed level.
Abnormal oil temperature rise.	(1) Air being drawn into oil circuit	• Retighten joints and connections, replace gaskets, or check oil level and add oil, as necessary.
	(2) Water in oil	• Change oil.
	(3) Burnt or worn bearings	• Disassemble and repair or replace.
	(4) Instrument out of order	• Replace.
	(5) Dragging clutches	• Replace friction and mating plates.
	(6) Clutch valve linkage maladjusted	• Readjust.
	(7) Dragging wheel brakes	• Readjust.
	(8) Continuous overloading of machine	• Avoid abusive use of machine.
Loss of safety function of hydraulic interlock (safety valve).	(1) Safety valve not functioning	• Disassemble and repair or replace.
	(2) Shift control linkage maladjusted	• Readjust.

Complaint	Possible cause	Remedy
Main pressure is too high. (This is not a symptom; it is a finding obtained by checking with pressure gauge.)	(1) Main relief valve maladjusted	• Overhaul and adjust.
	(2) Internal oil passage in main relief valve clogged	• Overhaul and clean.
	(3) Bound or sticking main relief valve	• Overhaul and clean.
	(4) Wrong kind of hydraulic oil	• Use oil meeting the specifications.
Transmission responds too slow to shifting. (This is the symptom of main pressure being too low.)	(1) Clogged oil strainer or filter	• Clean or replace.
	(2) Worn-down oil pump	• Replace.
	(3) Main relief valve maladjusted	• Readjust.
	(4) Bound or sticking main relief valve	• Overhaul or replace.
	(5) Air being drawn into oil circuit	• Retighten joints and connections, replace gaskets, or add oil to oil pan.
	(6) Not enough oil	• Add oil.
	(7) Oil leakage from loose joint or connection.	• Inspect and repair, replacing O-rings and seals as necessary.
Clutch oil pressure is abnormally low when inching pedal is in released condition. (This is not a symptom; it shows up as slow response of transmission or as slipping clutch.)	(1) Main pressure too low	• Refer to the procedure immediately above. (Transmission responds too slow to shifting.)
	(2) Clutch valve spool defective	• Repair or replace.
	(3) Clutch piston seal ring defective	• Replace.
	(4) Inching pedal control linkage maladjusted	• Readjust.
Machine jolts even when inching pedal is pressed gently.	(1) Inching pedal control linkage maladjusted	• Readjust.
	(2) Clutch valve out of order	• Repair or replace.
Machine picks up speed too slowly even when inching pedal is released sharply.	(1) Clutch pedal control linkage maladjusted	• Readjust.
	(2) Clutch valve out of order	• Repair or replace.

Transfer

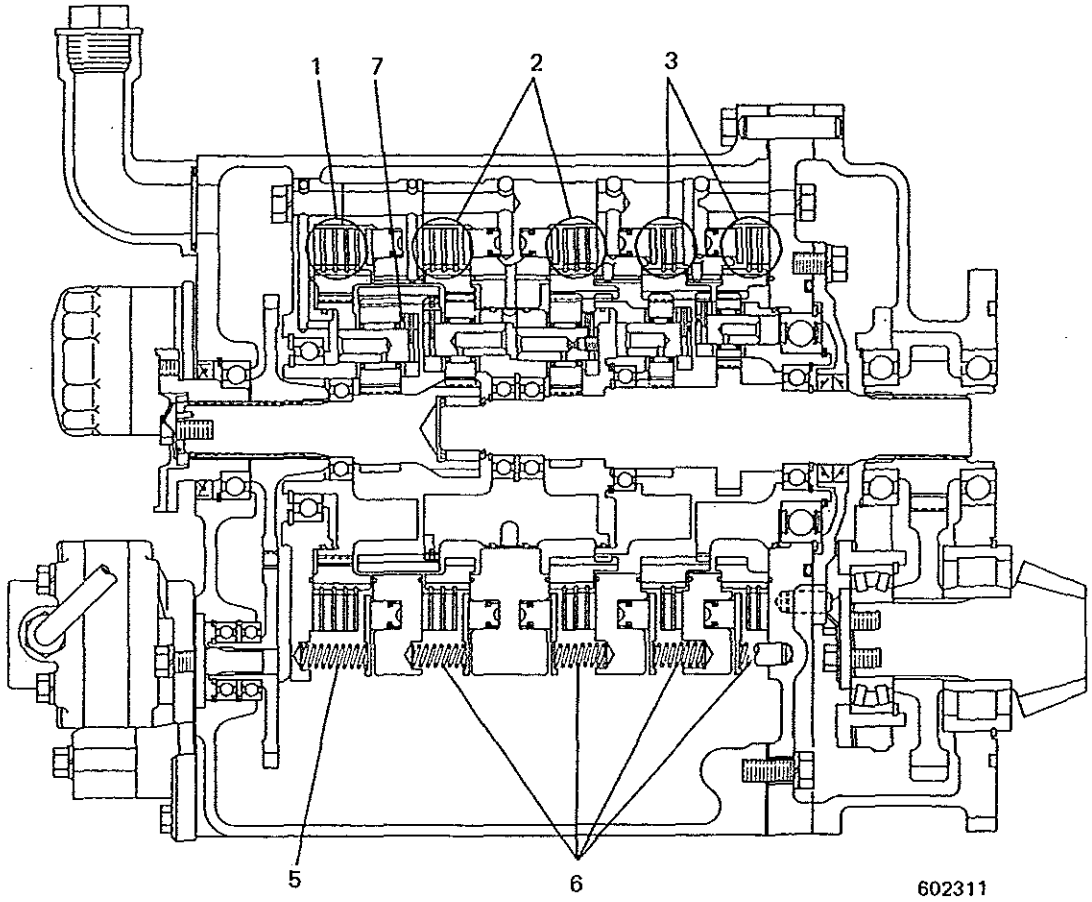
Complaint	Possible cause	Remedy	Remarks
Machine does not move in any speed	Machanical trouble inside transfer	Repair or replace.	
Machine does not move in one or more speeds, forward or backward.	One or more gears damaged	Replace.	
Noisy operation	(1) Not enough oil	• Add oil.	
	(2) Backlash too large	• Readjust or replace parts.	• Check bearings, shaft and gears for wear – cause of excessive backlash.
	(3) Bearings worn or damaged	• Replace.	
	(4) Shaft splines worn	• Replace.	
	(5) Gear tooth contact incorrect, or teeth worn or damaged	• Readjust or replace.	
Oil leakage	(1) Oil level too high	• Lower oil level.	
	(2) O-rings damaged	• Replace.	
	(3) Oil seals damaged	• Replace.	
	(4) Transfer case installation loose or packing defective	• Retighten or replace packing.	
Overheating	(1) Oil level too low	• Add oil.	
	(2) Backlash too large or too small	• Repair or replace.	• Check bearings for spalled or cracked races.
	(3) Bearings misaligned	• Repair or replace.	
Abnormal wear	(1) Oil insufficient or dirty	• Add or change oil.	• Check oil for presence of metal chips.
	(2) Abuse	• Avoid abuse of machine.	

MAINTENANCE STANDARDS

DPS TRANSMISSION

Unit: mm (in.)

Ref. No.	Item		Assembly standard (Standard clearance)	Service limit	Remarks
1	Reverse clutch	Total thickness (new parts) Friction plates (4 pcs) Mating plates (4 pcs) Pressure plate (1 pc)	27.70 ± 0.80 (1.0905 ± 0.0315)	26.10 (1.0276)	
2	Forward and 3rd-speed clutches	Total thickness (new parts) Friction plates (3 pcs) Mating plates (3 pcs) Pressure plate (1 pc)	21.57 ± 0.62 (0.8492 ± 0.0244)	20.40 (0.8031)	
3	2nd- and 1st-speed clutches	Total thickness (new parts) Friction plates (2 pcs) Mating plates (2 pcs) Pressure plate (1 pc)	15.44 ± 0.44 (0.6079 ± 0.0173)	14.60 (0.5748)	
4	Friction plates of Ref. Nos. 1 thru 3	Thickness (new parts)	2.95 ± 0.10 (0.1161 ± 0.0039)	2.45 (0.0965)	Thickness of each friction plate
5	Return springs of reverse clutch piston	Free length	41 (1.61)		Diameter: 13.5 (0.531)
		Test force/length under test force kgf (lbf) [N] /mm (in.)	6.6 ± 0.5 / 36 (14.6 ± 1.1) / (1.42) [64.7 ± 4.9]	5.5 / 36 (12.1) / (1.42) [54.0]	
6	Return springs of forward, 3rd-, 2nd- and 1st-speed clutches	Free length	33 (1.30)		Diameter: 13.5 (0.531)
		Test force/length under test force kgf (lbf) [N] /mm (in.)	6.01 ± 0.5 / 29 (13.25 ± 1.1) / (1.14) [59.0 ± 4.9]	5 / 29 (11) / (1.14) [49]	
7	Thrust plates	Thickness	2.00 ± 0.05 (0.0787 ± 0.0020)	1.80 (0.0709)	Total 30 pcs
8	Spring of lubrication relief valve	Free length	53 (2.09)		
		Test force/length under test force, kgf (lbf) [N] /mm (in.)	1.49 ± 0.12 / 21.5 (3.29 ± 0.26) / (0.846) [14.6 ± 1.2]		Diameter: 13 (0.51)



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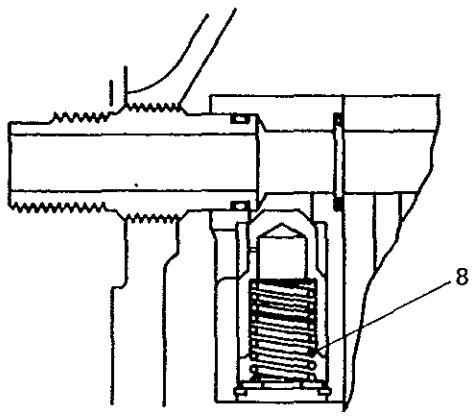

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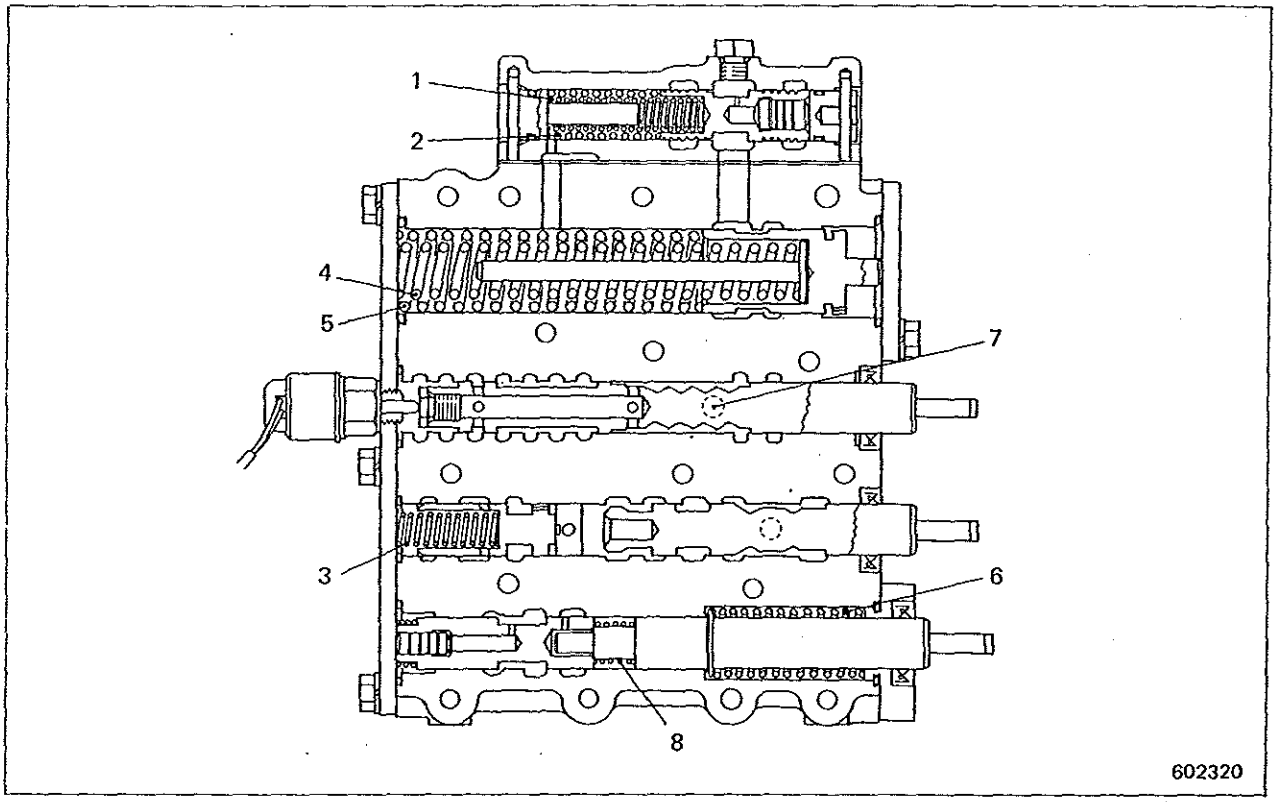
TRANSMISSION CONTROL VALVE

Unit: mm (in.)

Ref. No.	Item		Assembly standard (Standard clearance)	Service limit	Remarks
1	Main relief valve spring (inner)	Free length	82.5 (3.248)		Diameter: 13.3 (0.524)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	7.6 ± 0.5 (16.8 ± 1.1)/55.0 (2.165) [74.5 ± 4.9]		
2	Main relief valve spring (outer)	Free length	68.0 (2.677)		Diameter: 18.5 (0.728)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	10.0 (22.1)/37.0 (1.457) [98.1]		
3	Differential valve spring	Free length	59.5 (2.343)		Diameter: 13.5 (0.531)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	5.6 ± 0.6 (12.3 ± 1.3)/35.5 (1.398) [54.9 ± 5.9]		
4	Accumulator valve spring (inner)	Free length	151.0 (5.945)		Diameter: 22 (0.87)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	50.4 ± 5.0 (111.1 ± 11)/120.0 (4.724) [494.3 ± 49]		
5	Accumulator valve spring (outer)	Free length	132.0 (5.197)		Diameter: 31 (1.22)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	61.1 ± 6.1 (134.7 ± 13.5)/78.0 (3.071) [599.2 ± 59.8]		
6	Inching valve return spring	Free length	78.0 (3.071)		Diameter: 25 (0.98)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	8.1 ± 0.8 (17.7 ± 1.8)/59.0 (2.323) [79.4 ± 7.8]		
7	Speed selector plunger detent spring	Free length	17.0 (0.669)		Diameter: 7.5 (0.30)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	5.2 ± 0.2 (11.5 ± 0.4)/15.0 (0.591) [51 ± 2.0]		
8	Inching valve spring	Free length	31.5 (1.240)		Diameter: 15 (0.59)
		Test force/length under test force kgf (lbf) [N]/mm (in.)	3.3 (7.3)/15.0 (0.591) [32.4]		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DISASSEMBLY AND REASSEMBLY

DPS TRANSMISSION

REMOVAL AND INSTALLATION

Removal

Preparatory steps

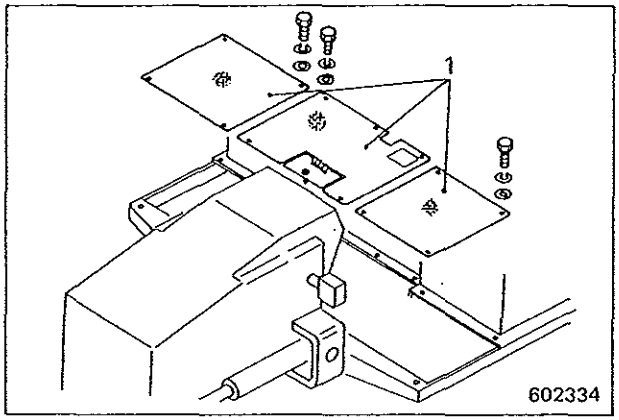
(1) Remove the under guard.

(2) Drain the oil from the transmission. [11 liters (2.9 U.S. gal), approx.]

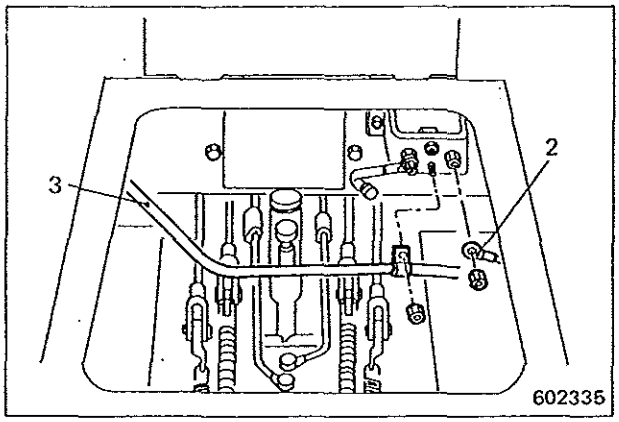
(3) Drain the oil from the transfer and bevel ger cases. [7 liters (1.8 U.S. gal), approx.]

1. Remove the following parts:

1 Floor plates (platform) (3 pcs)

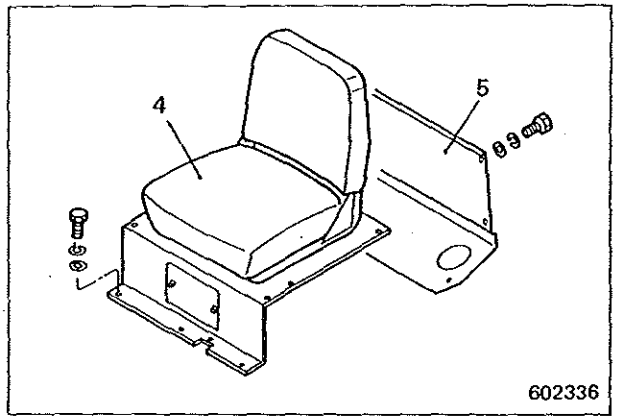


2 Electrical wire between battery switch and battery
3 Clamp for electrical wire between battery and starter

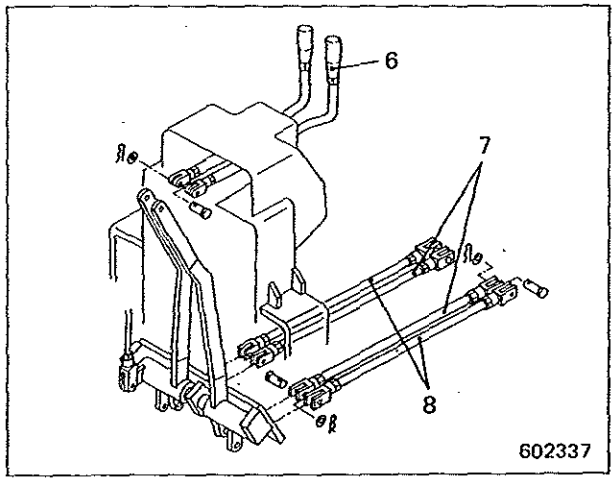


4 Operator's seat and seat plate
5 Rear cover

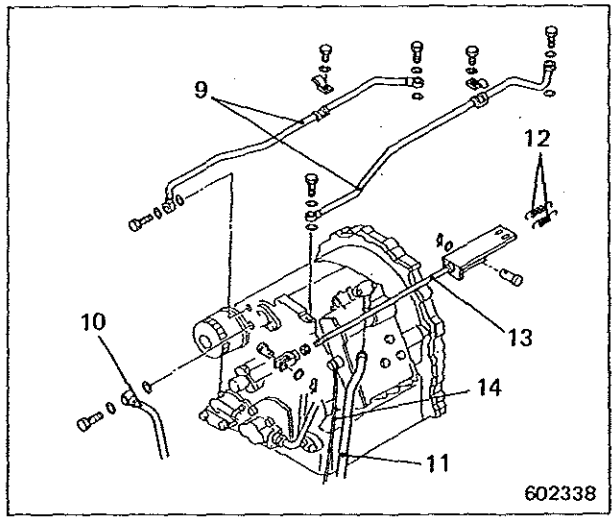
Weight of operator's seat and seat plate	31 kg (68 lb), approx.



6 Steering clutch levers
7 Steering control rods
8 Brake control rods

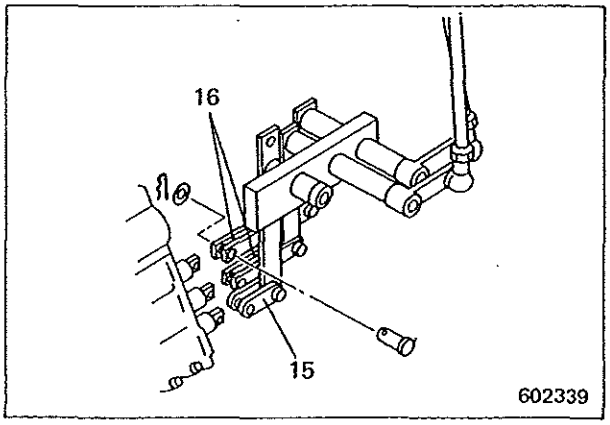


9 Steering clutch oil pipes (2 pcs)
10 Oil cooler pipe
11 Oil cooler hose
12 Springs (2 pcs)
13 Inching control rod
14 Electrical wire for neutral switch



2. Disconnect the following parts:

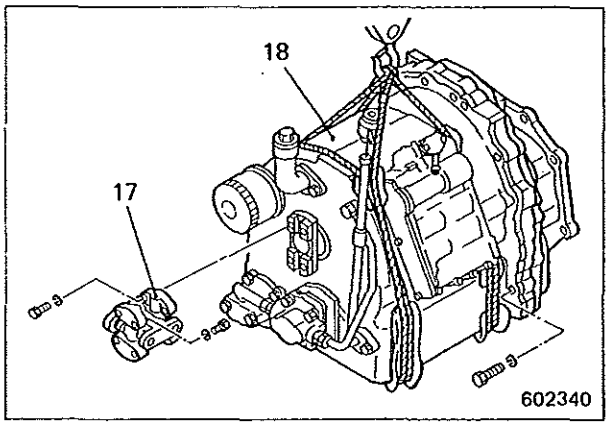
15 Inching valve link
16 Speed selector valve and directional selector valve links



3. Remove the following parts:

17 Universal joint
18 Transmission

Weight of transmission and transfer	182 kg (400 lb), approx.



NOTE

Before lifting off the transmission, shift it forward to pull the pinion back out of mesh with the bevel gear.

Installation

To install the transmission, follow the reverse of removing procedure, and proceed as follows:

(1) Make sure that the electrical wires, pipes and hoses are connected properly.

(2) Adjust the inching pedal. (Refer to the topics, Adjusting the inching pedal, TESTING AND ADJUSTMENT.)

(3) Fill the transmission and transfer cases with recommended oil.

DISASSEMBLY AND REASSEMBLY

Disassembly

Preparatory steps

(1) Remove the transfer assembly.

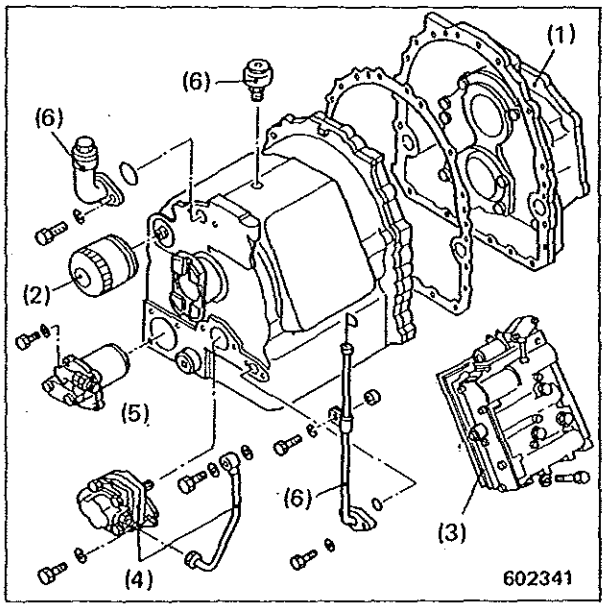
(2) Remove the oil filter.

(3) Remove the transmission control valve and main relief valve.

(4) Remove the oil pump and oil pipe.

(5) Remove the suction strainer.

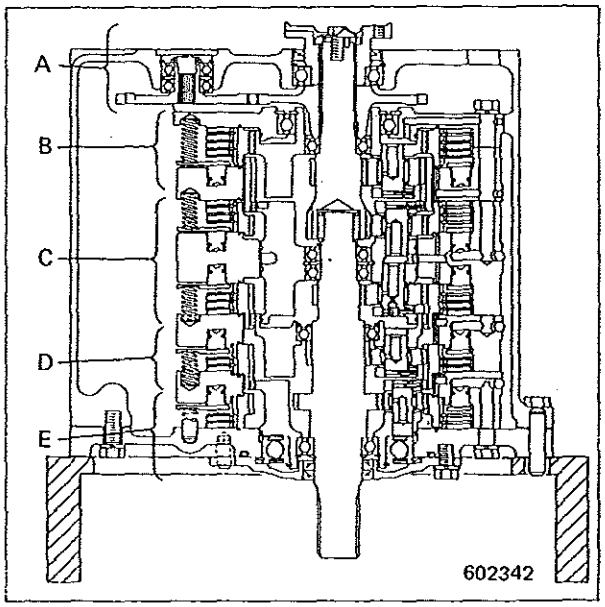
(6) Remove the air breather, oil filler and oil level gauge.



Remove the groups in the order listed below for disassembly.

A Transmission case and flange group
B Reverse clutch group
C Forward clutch group and 3rd-speed clutch group
D 2nd-speed clutch group
E 1st-speed clutch group and cover group

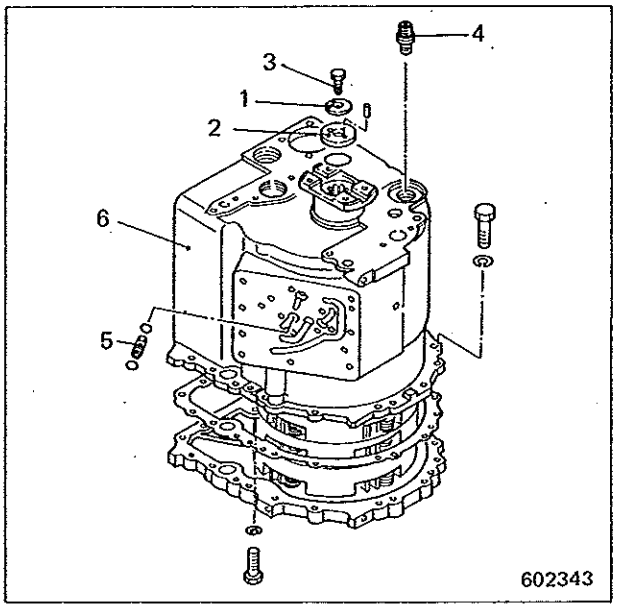
When disassembling the transmission, place it on a workbench having a hole for admitting the output shaft and cover mounting bolts, with the front (engine) side up.



A Transmission case and flange group

1. Remove the following parts:

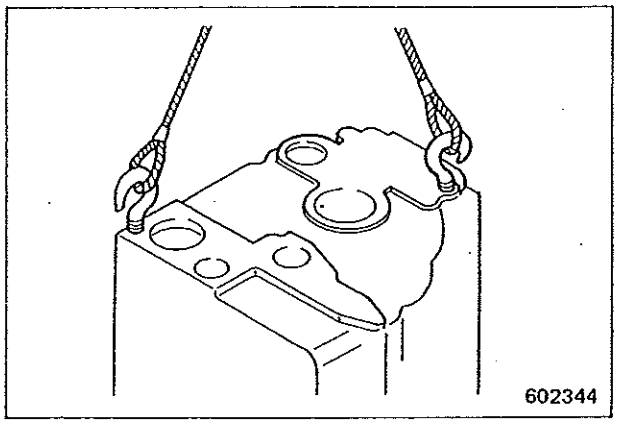
1 Lock washer
(to be straightened for removal)
2 Washer
3 Bolt (1 pc)
4 Oil filter screw
5 Oil pipe (4 pcs)
6 Transmission case



NOTE

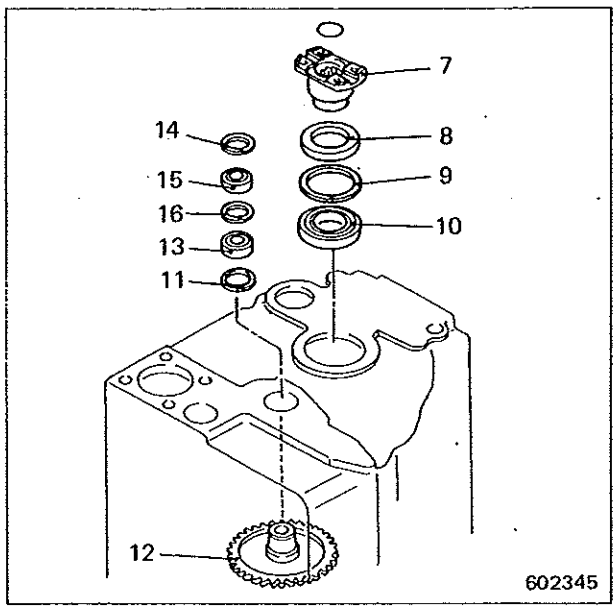
To remove transmission case "6," attach the hangers to its front face, and lift it off with that face up.

Thread size of hangers	M10 x 1.25 mm

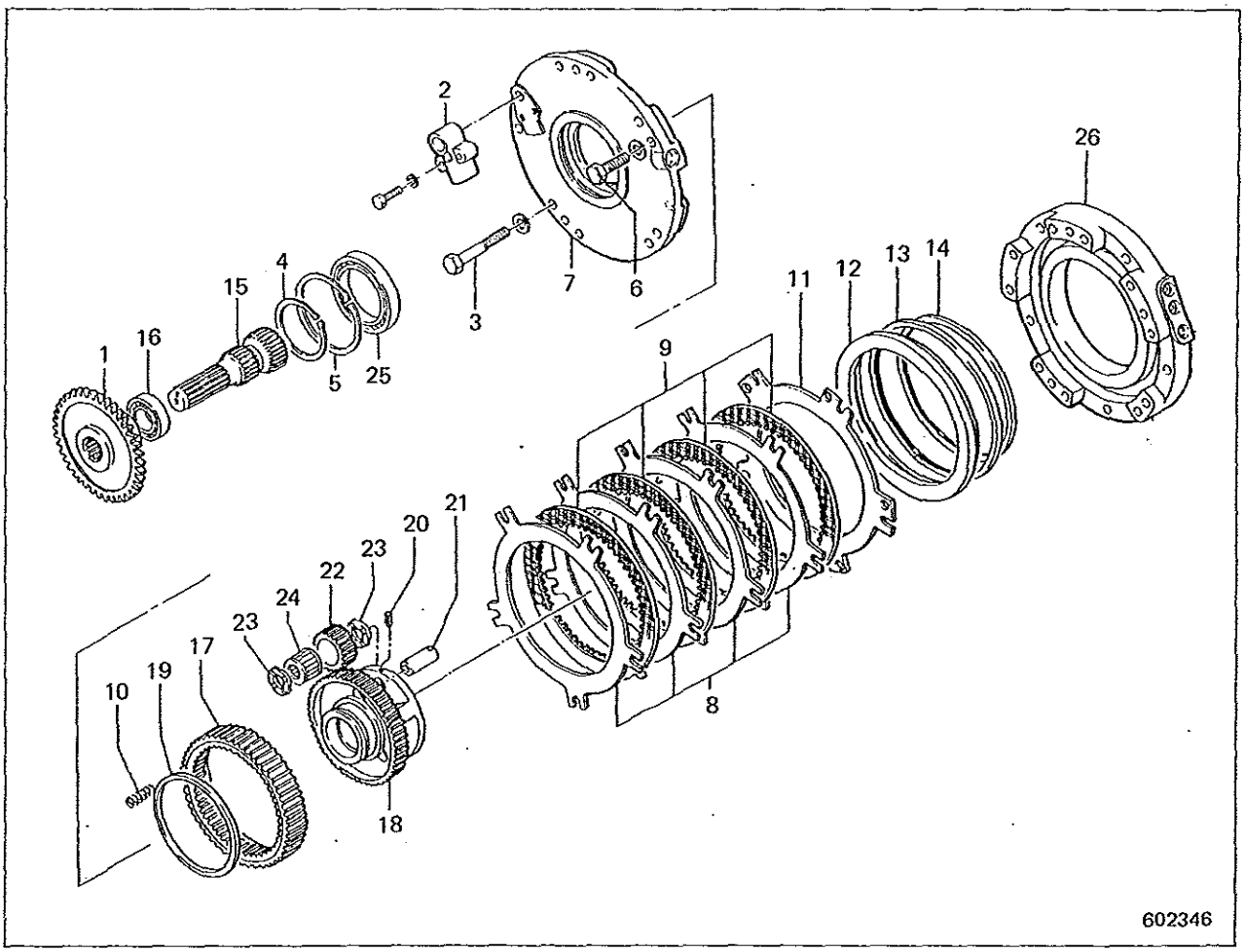


2. Remove the following parts from case "5":

7 Flange
8 Oil seal
9 Retaining ring
10 Ball bearing
11 Snap ring
12 Oil pump driven gear
13 Ball bearing
14 Retaining ring
15 Ball bearing
16 Retaining ring



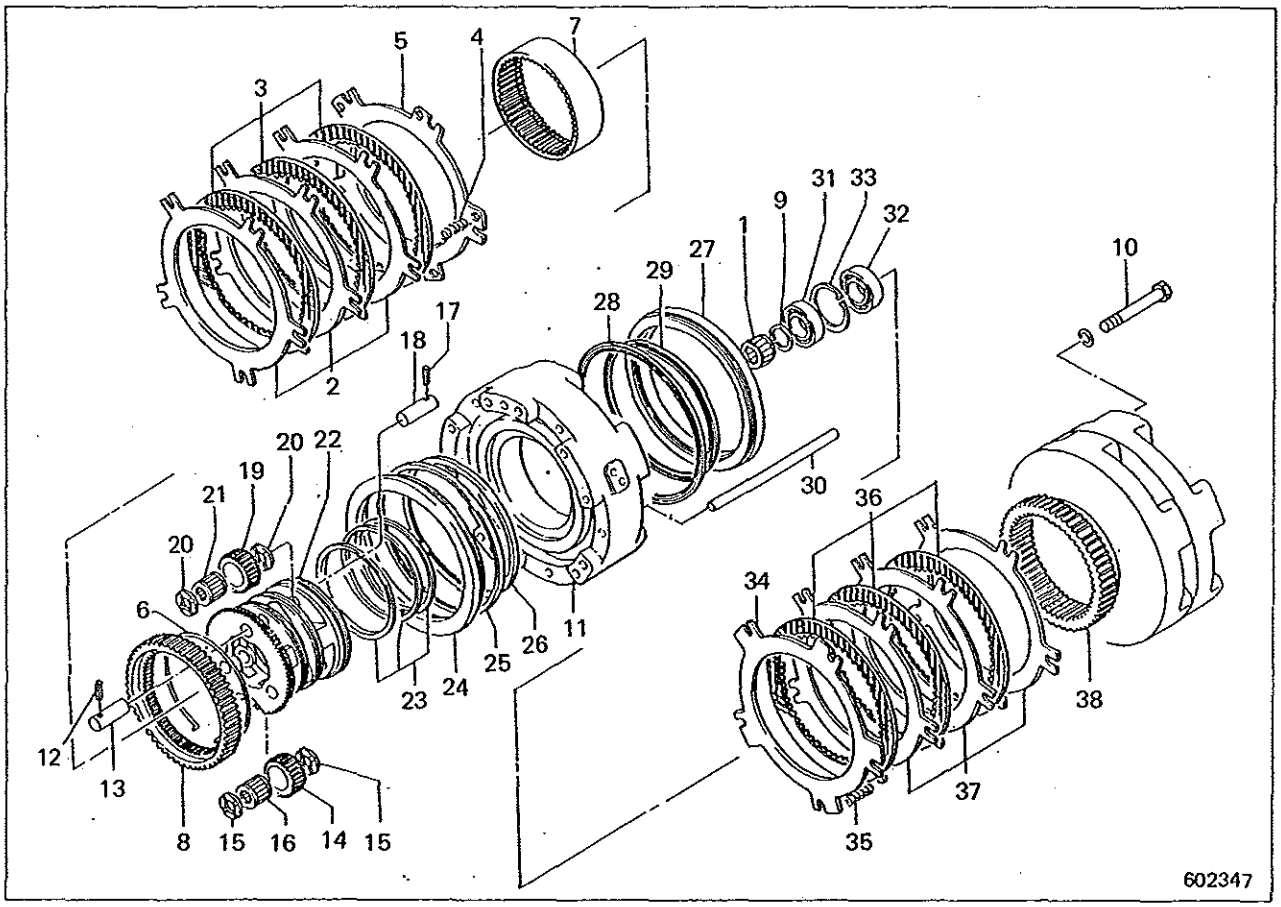
B Reverse clutch group



1 Pump drive gear
2 Lubrication relief valve
3 Bolt (8 pcs)
4 Snap ring
5 Snap ring
6 Bolt
7 End housing
8 Mating plates (4 pcs)
9 Friction plates (4 pcs)
10 Return spring (5 pcs)
11 Pressure plate
12 Piston
13 Piston seal
14 Piston seal
15 Input shaft
16 Ball bearing
17 Ring gear
18 Reverse planet carrier
(to be removed as an assembly including "19" thru "24")
19 Seal ring
20 Spring pin (3 pcs)
21 Pin (3 pcs)
22 Planet gear (3 pcs)
23 Thrust plates (6 pcs)
24 Needle roller bearing (3 pcs)
25 Ball bearing
26 Reverse clutch piston housing

(Remove the parts in the order numbered for disassembly.)

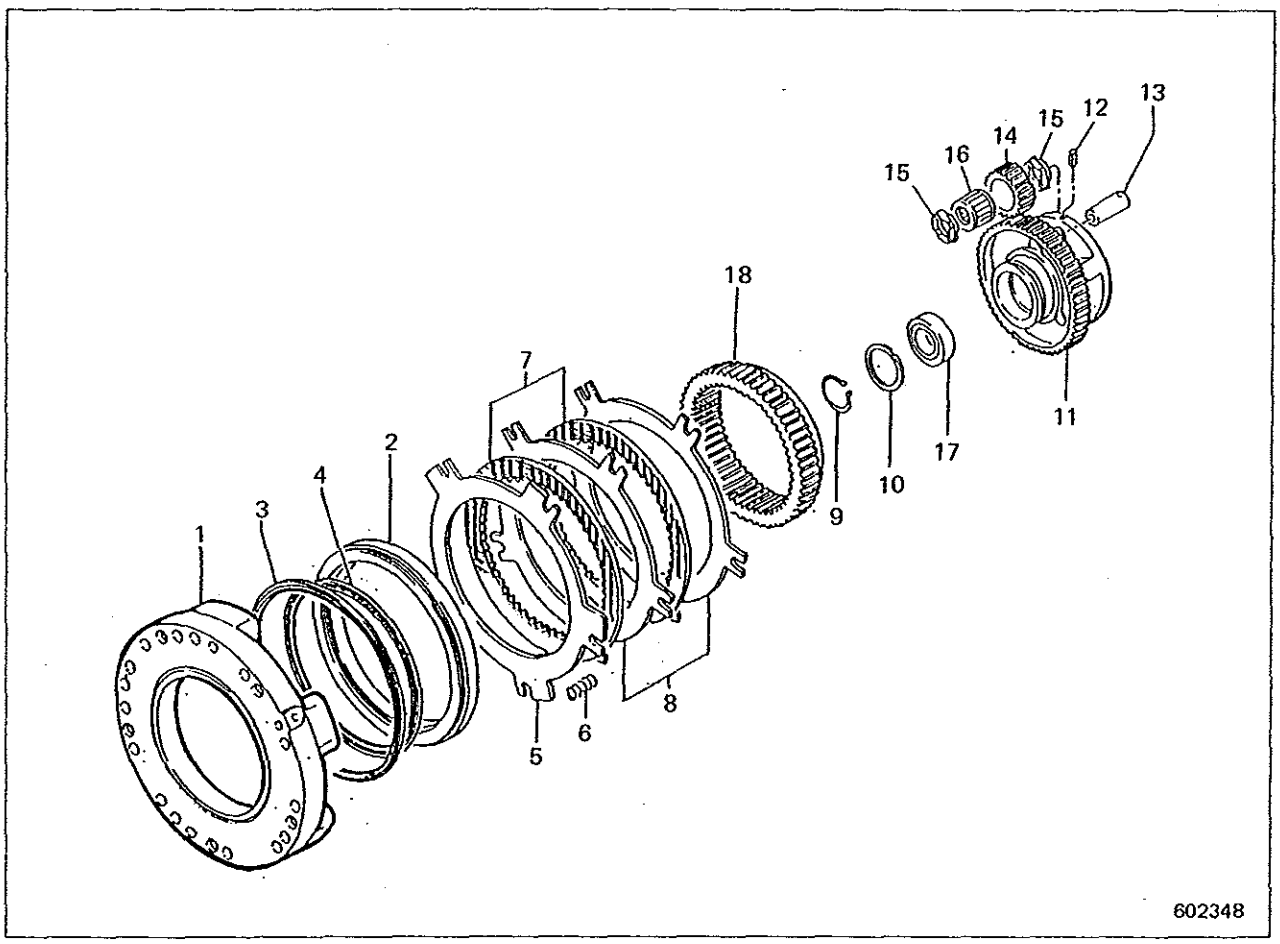
C Forward clutch group and 3rd-speed clutch group



1 Needle roller bearing
2 Mating plates (3 pcs)
3 Friction plates (3 pcs)
4 Return spring (5 pcs)
5 Pressure plate
6 Snap ring
7 Ring gear
8 Ring gear
9 Snap ring
10 Bolt (9 pcs)
11 Forward & 3rd-speed clutch piston housing (to be removed as an assembly including "12" thru "30")
12 Spring pin (3 pcs) (to be removed as an assembly including "13" thru "23")
13 Pin (3 pcs)
14 Planet gear (3 pcs)
15 Thrust plate (6 pcs)
16 Needle roller bearing (3 pcs)
17 Spring pin (3 pcs)
18 Pin (3 pcs)
19 Planet gear (3 pcs)
20 Thrust plates (6 pcs)
21 Needle roller bearing (3 pcs)
22 Forward & 3rd-speed planet carrier
23 Seal rings (3 pcs)
24 Piston
25 Piston seal
26 Piston seal
27 Piston
28 Piston seal
29 Piston seal
30 Pin (5 pcs)
31 Ball bearing
32 Ball bearing
33 Snap ring
34 Pressure plate
35 Return spring (5 pcs)
36 Friction plates (3 pcs)
37 Mating plates (3 pcs)
38 Ring gear

(Remove the parts in the order numbered for disassembly.)

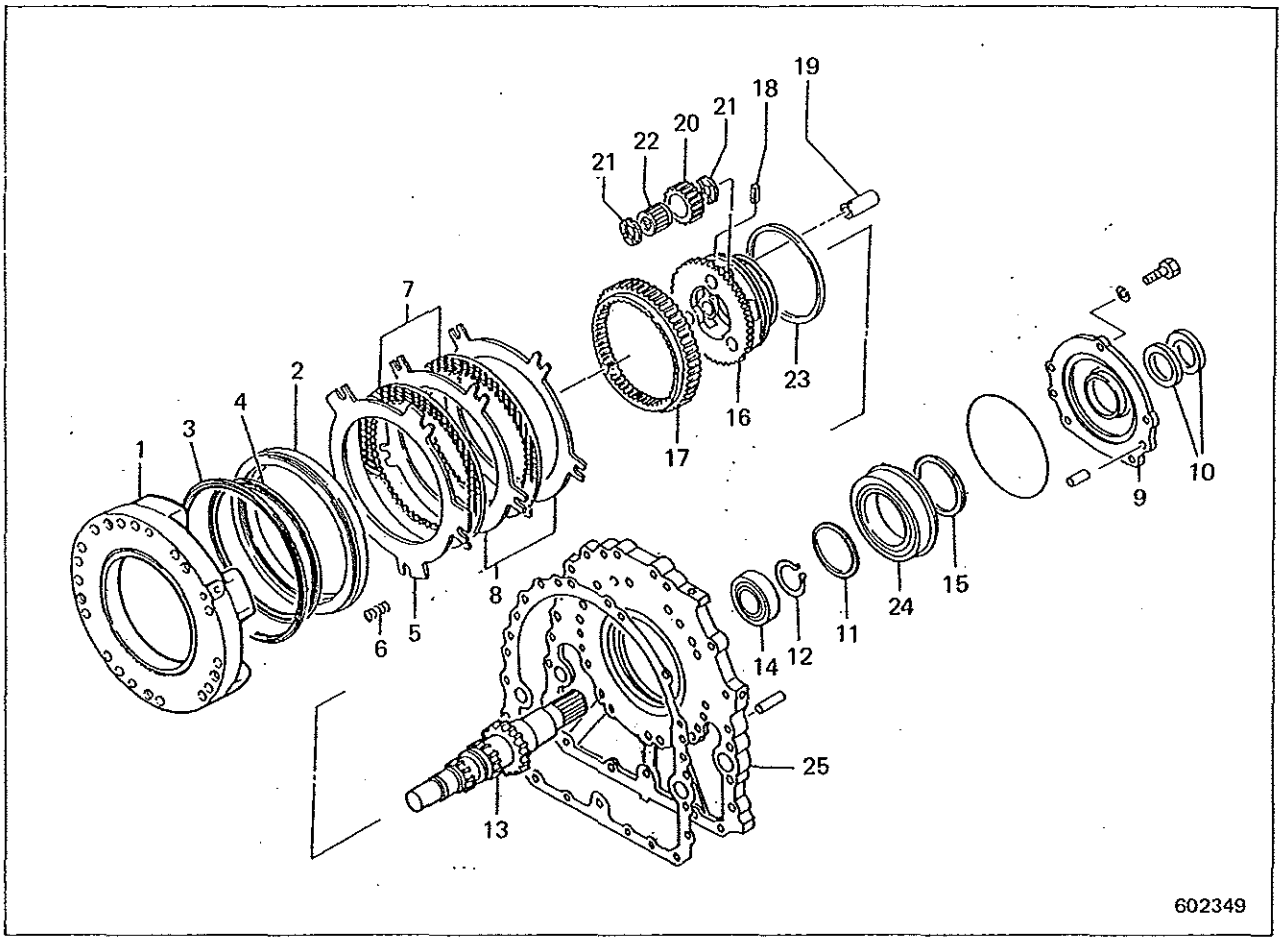
D 2nd-speed clutch group



1 2nd-speed clutch piston housing
(to be removed as an assembly including "2" thru "4")
2 Piston
3 Piston seal
4 Piston seal
5 Pressure plate
6 Return spring (5 pcs)
7 Friction plates (2 pcs)
8 Mating plates (2 pcs)
9 Snap ring
10 Snap ring
11 2nd-speed planet carrier
(to be removed as an assembly including "12" thru "17")
12 Spring pin (3 pcs)
13 Pin (3 pcs)
14 Planet gear (3 pcs)
15 Thrust plate (6 pcs)
16 Needle roller bearing (6 pcs)
17 Ball bearing
18 Ring gear

(Remove the parts in the order numbered for disassembly.)

E 1st-speed clutch group and cover group



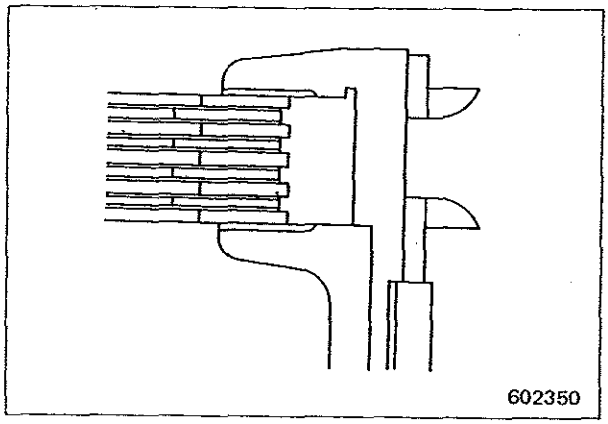
1 1st-speed clutch piston housing (to be removed as an assembly including "2" thru "4")
2 Piston
3 Piston seal
4 Piston seal
5 Pressure plate
6 Return spring (5 pcs)
7 Friction plates (2 pcs)
8 Mating plates (2 pcs)
9 Oil seal retainer
10 Oil seals (2 pcs)
11 Retaining ring
12 Snap ring
13 Output shaft
14 Ball bearing
15 Retaining ring
16 1st-speed planet carrier (to be removed as an assembly including "17" thru "23")
17 Ring gear
18 Spring pin (3 pcs)
19 Pin (3 pcs)
20 Planet gear (3 pcs)
21 Thrust plates (6 pcs)
22 Needle roller bearing (3 pcs)
23 Seal ring
24 Ball bearing
25 Cover

(Remove the parts in the order numbered for disassembly.)

Inspection

1. Friction, mating and pressure plates

Measure the assembled (total) thickness of the plates. Replace the plates if the measurement exceeds the service limit.

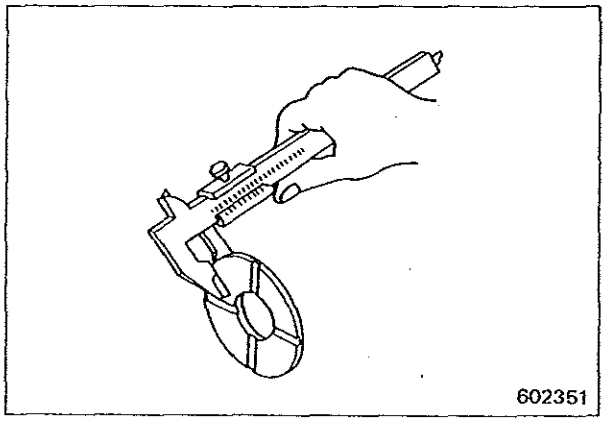


Unit: mm (in.)

Item	Assembly standard	Service limit
Assembled (total) thickness of reverse clutch plates: Friction plates (4 pcs) Mating plates (4 pcs) Pressure plate (1 pc)	27.70±0.80 (1.0905±0.0315)	26.10 (1.0276)
Assembled (total) thickness of forward and 3rd-speed clutch plates: Friction plates (3 pcs) Mating plates (3 pcs) Pressure plate (1 pc)	21.57±0.62 (0.8492±0.0244)	20.40 (0.8031)
Assembled (total) thickness of 2nd- and 1st-speed clutch plates: Friction plates (2 pcs) Mating plates (2 pcs) Pressure plate (1 pc)	15.44±0.44 (0.6079±0.0173)	14.60 (0.5748)
Thickness of friction plate	2.95±0.10 (0.1161±0.0039)	2.45 (0.0965)

2. Thrust plates

Measure the thickness of each thrust plate. Replace the plate if the measurement exceeds the service limit.



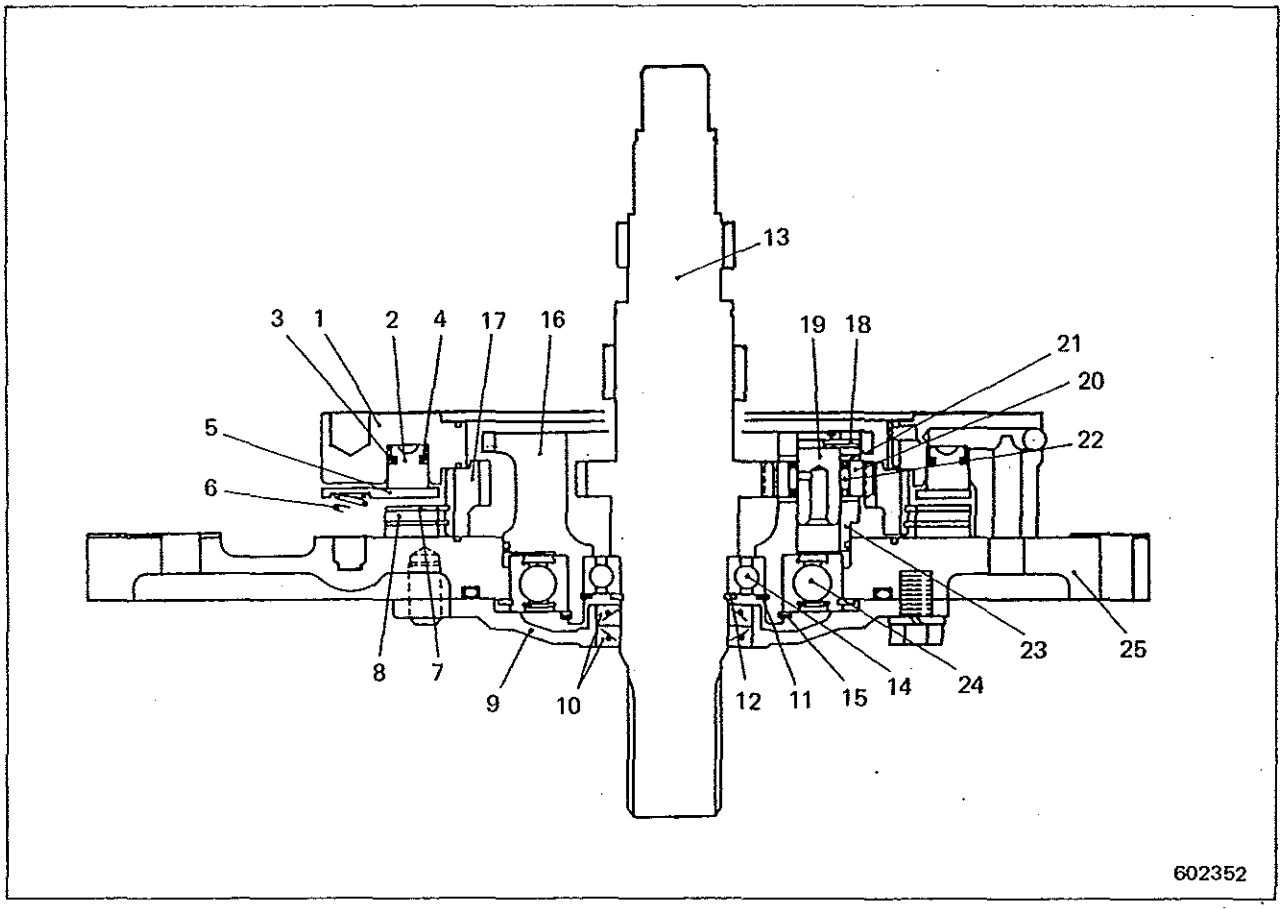
Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness of thrust plate	2.00±0.05 (0.0787±0.0020)	1.80 (0.0709)

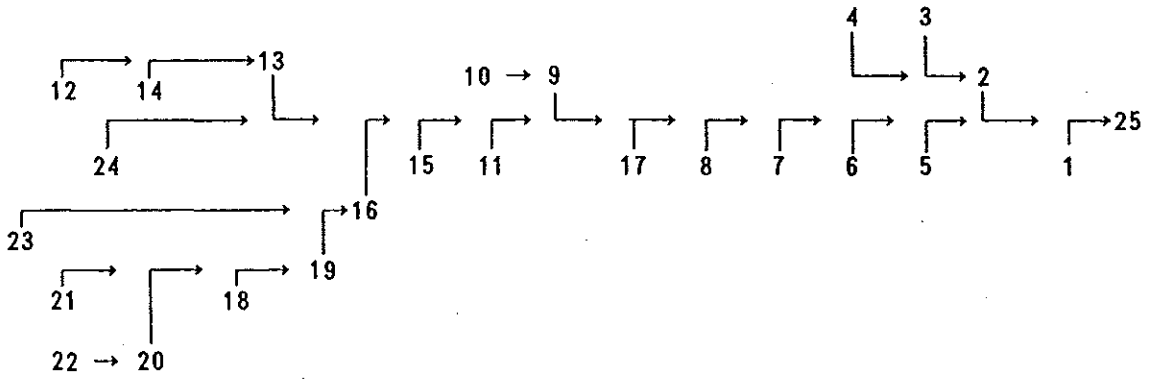
Reassembly

To reassemble the transmission, install the groups in the reverse order ("E" thru "A").

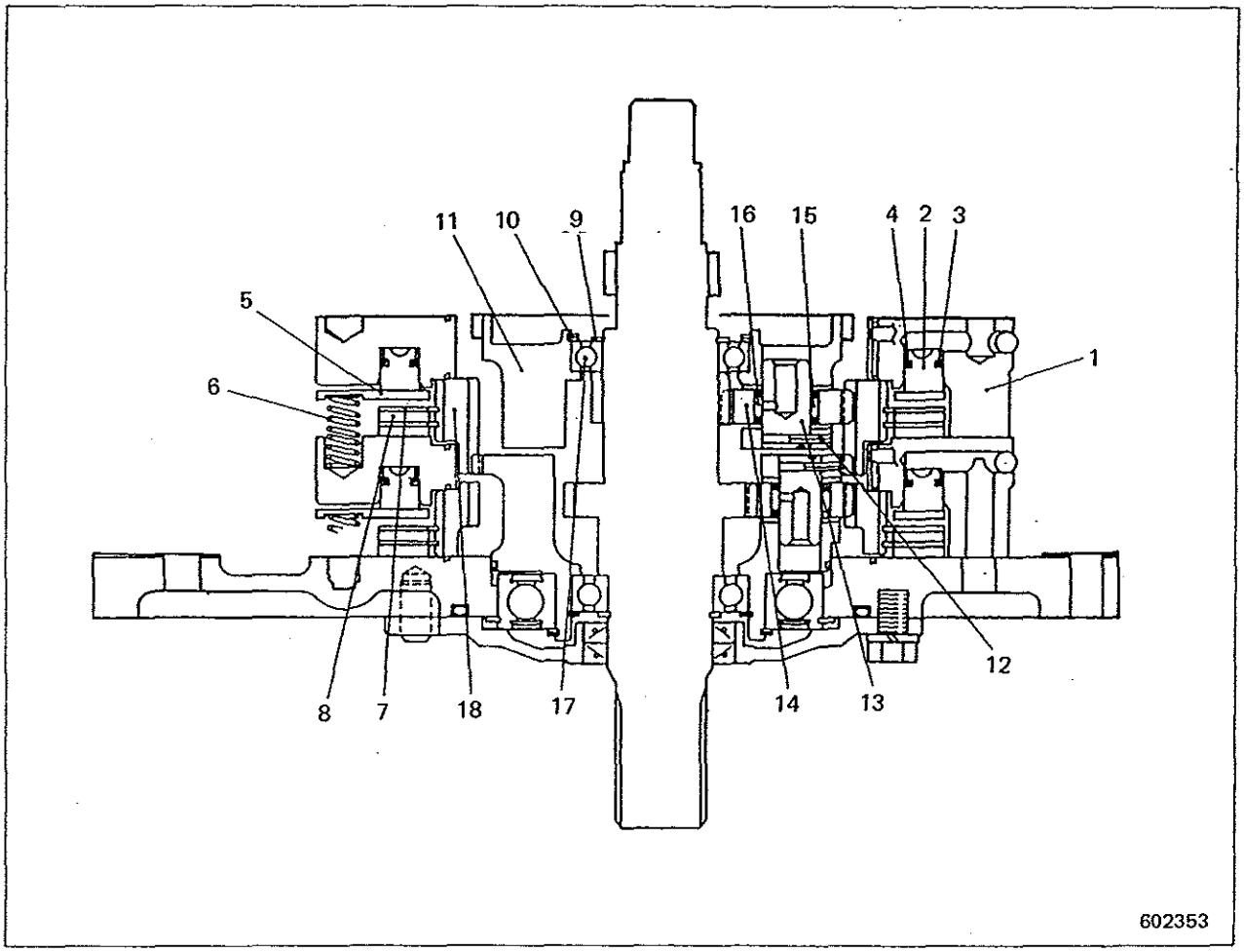
E 1st-speed clutch group and cover group



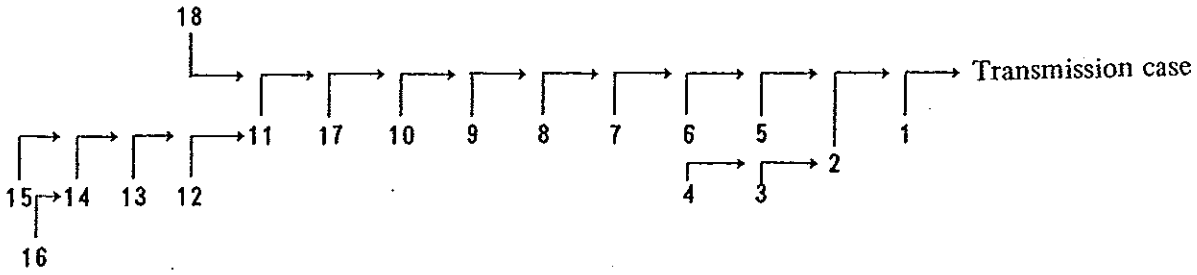
Reassembling order



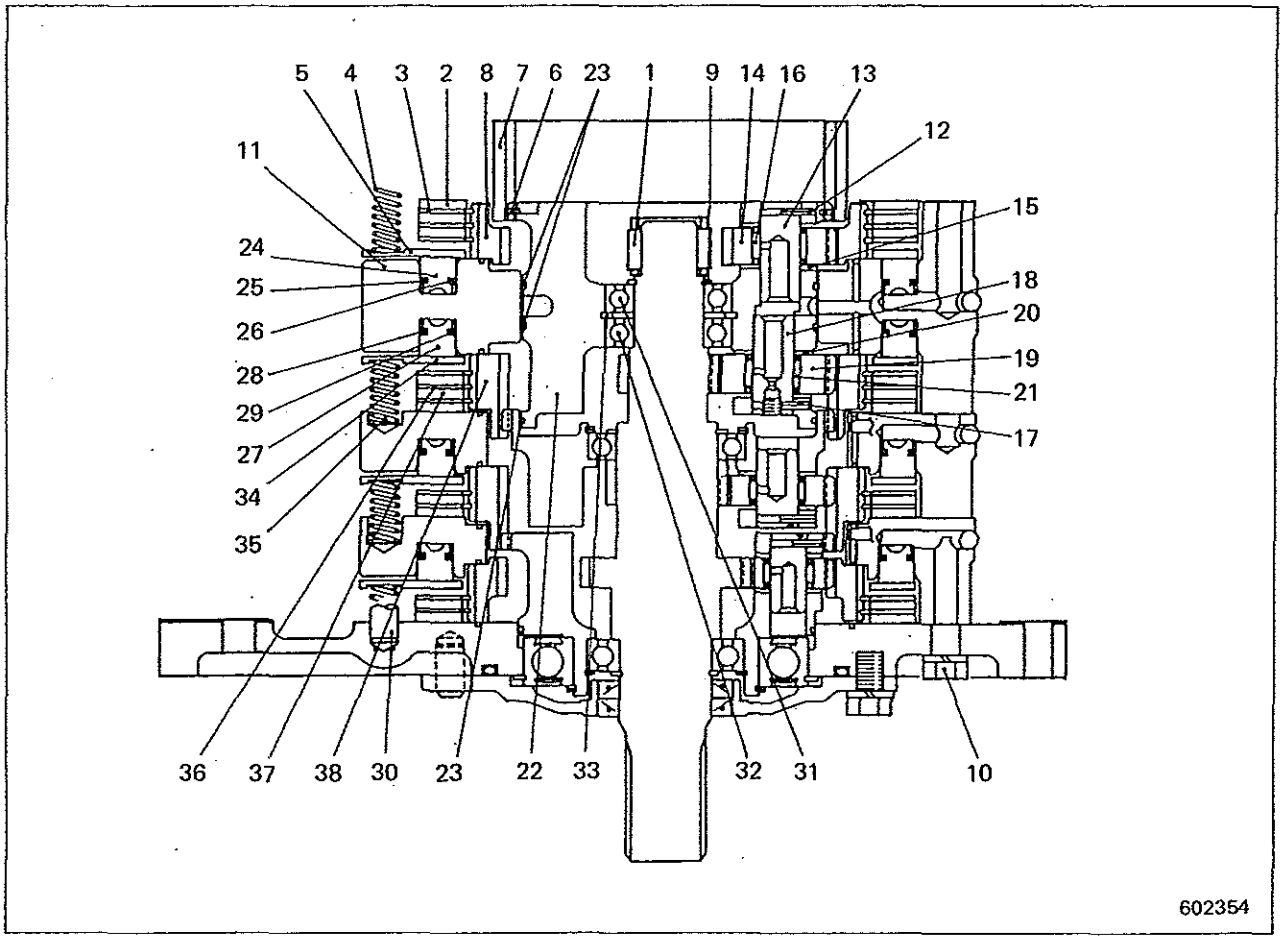
D 2nd-speed clutch group



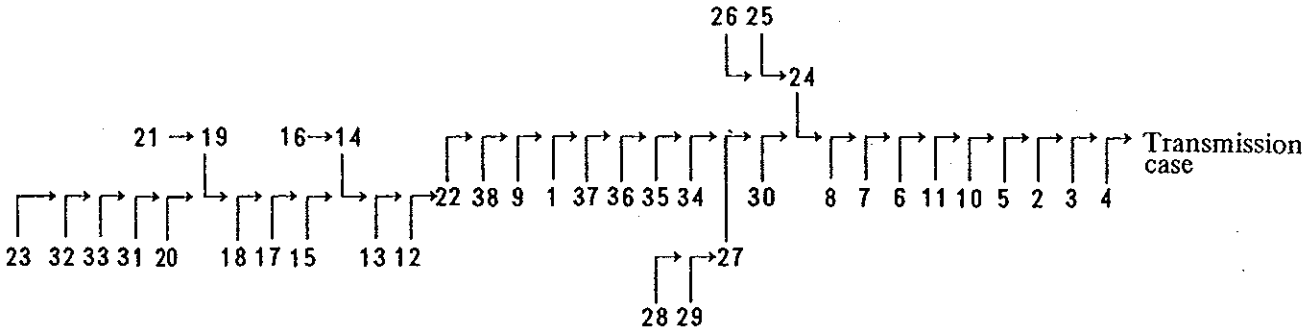
Reassembling order



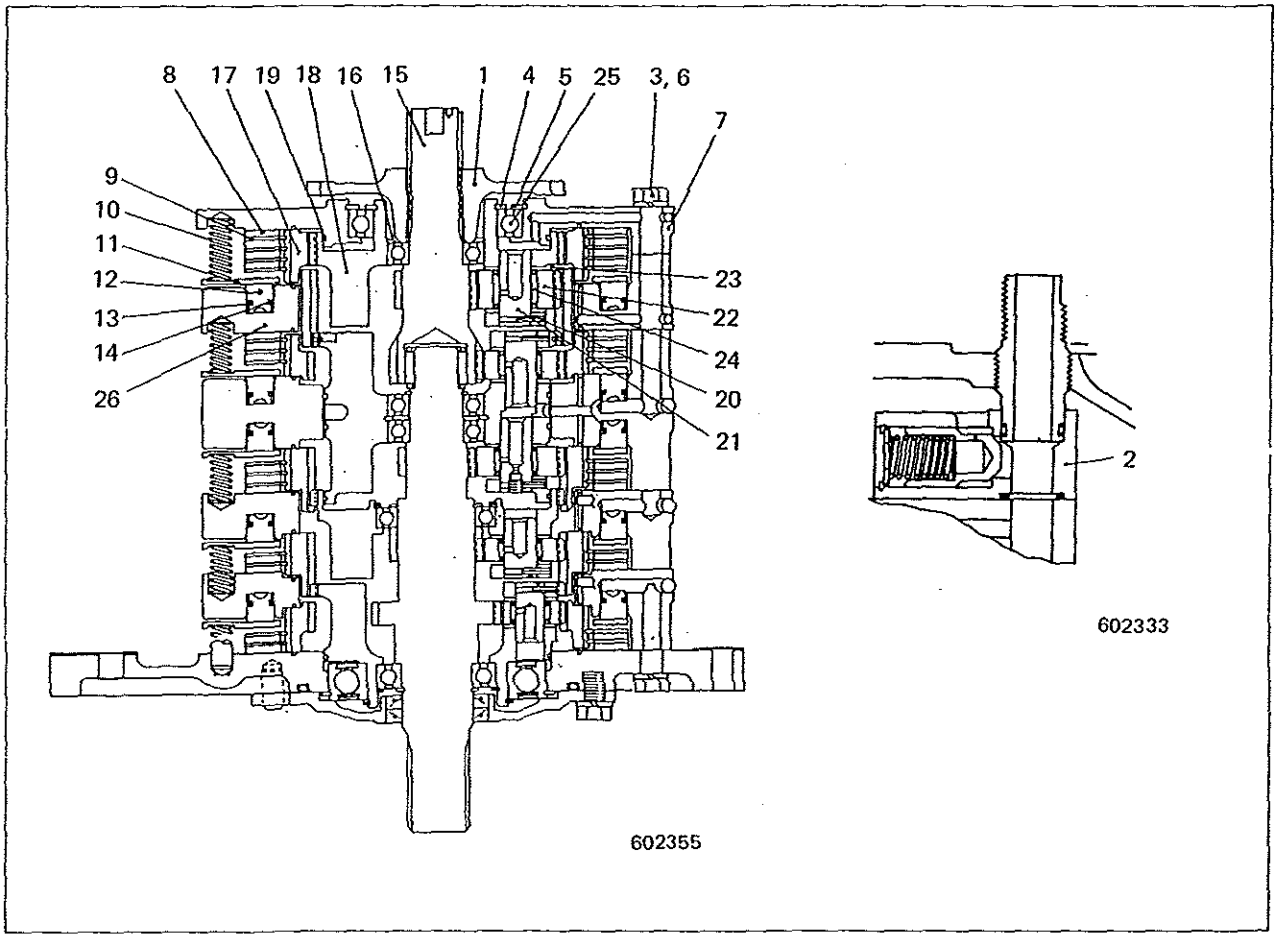
C Forward clutch group and 3rd-speed clutch group



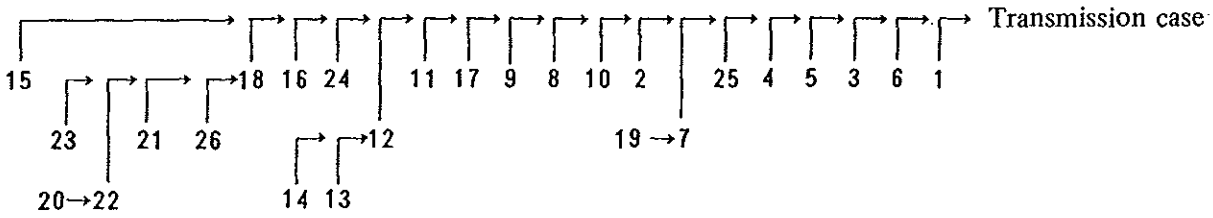
Reassembling order



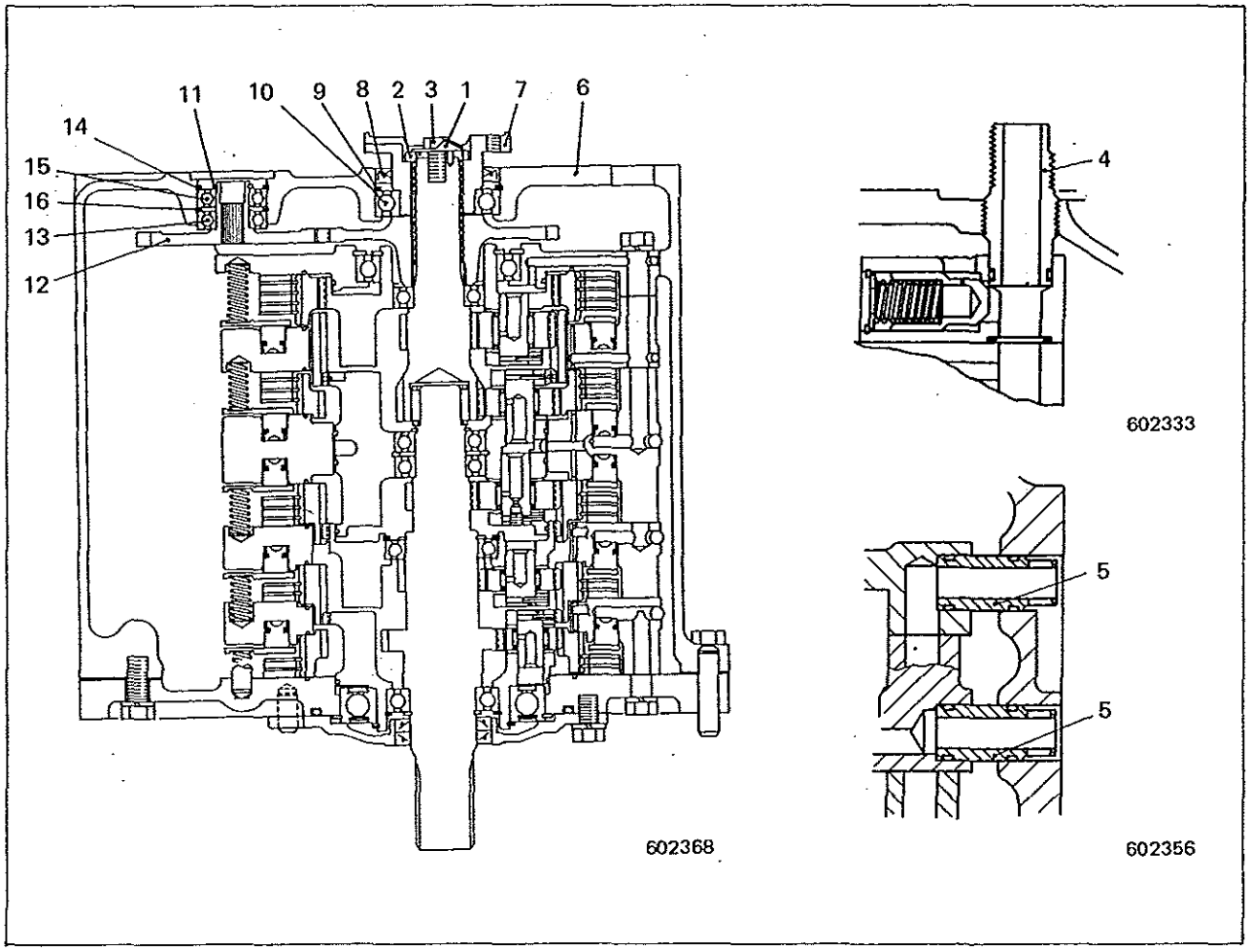
B Reverse clutch group



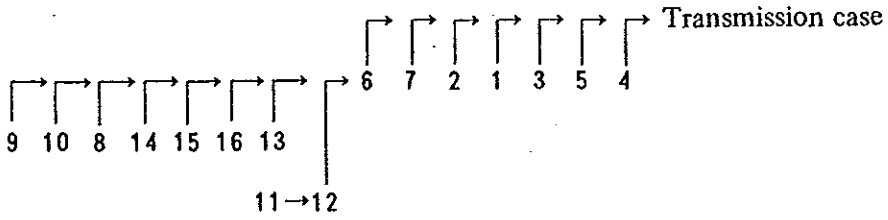
Reassembling order



A Transmission case and flange group



Reassembling order



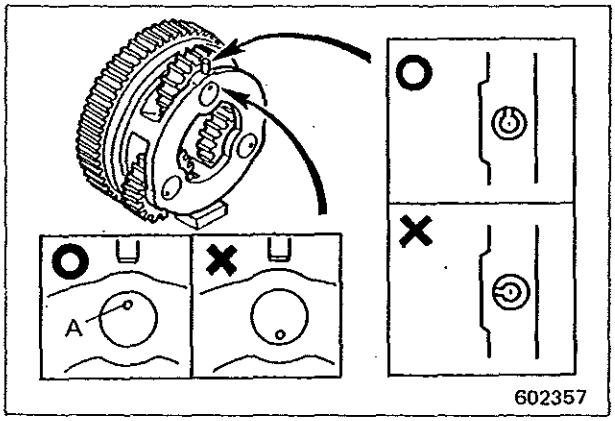
Tips for reassembly

1. Apply a coat of engine oil to the O-ring of oil filter screw.

2. Bend each lock washer properly – against the flat of bolt.

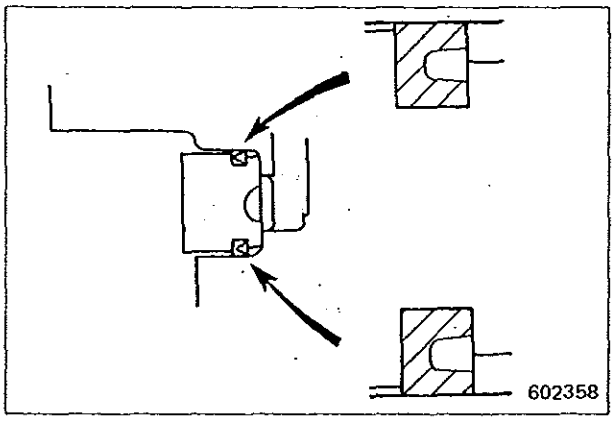
3. Planet carrier spring pin installation

Drive in the spring pin with its gap positioned in the direction of carrier rotation. Drive in the planet pin with its mark "A" outside.



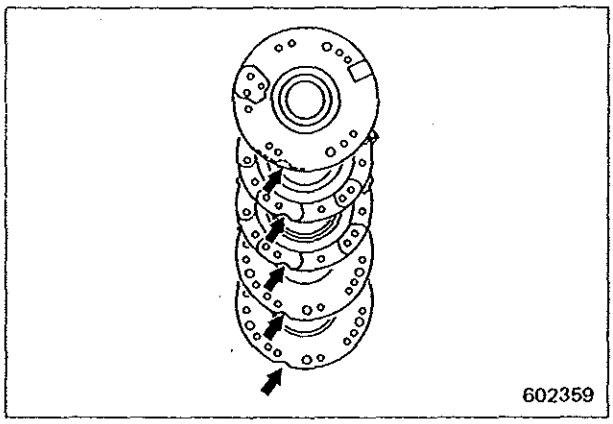
4. Clutch piston installation

Apply a coat of hydraulic oil (SAE 10W) to the sliding surface of each piston seal before installing the seal to the clutch piston.



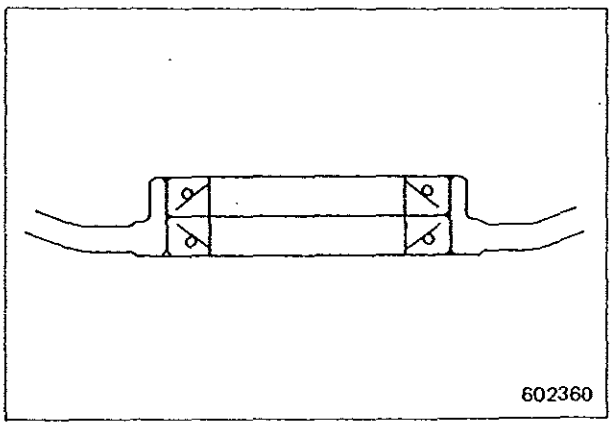
5. Piston housing installation

Install the piston housings (5 pcs) with their recessed portions alined as shown. This illustration shows the piston housings viewed from the engine side.



6. Oil seal installation to retainer

Install the oil seal to the retainer as shown.

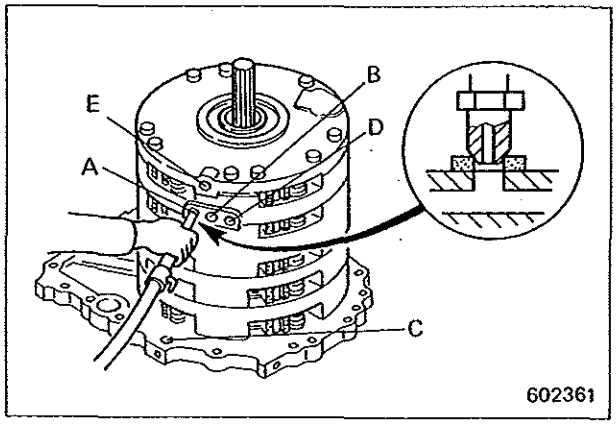


7. Testing after reassembly

Apply dirt-free pressure air to the oil holes in the transmission case to make sure that the clutch pistons move smoothly in the housings

A Oil hole for reverse clutch
B Oil hole for forward clutch
C Oil hole for 1st-speed clutch
D Oil hole for 2nd-speed clutch
E Oil hole for 3rd-speed clutch

Air pressure	2 – 3 kgf/cm² (28.4 – 42.7 psi) [196 – 294 kPa]



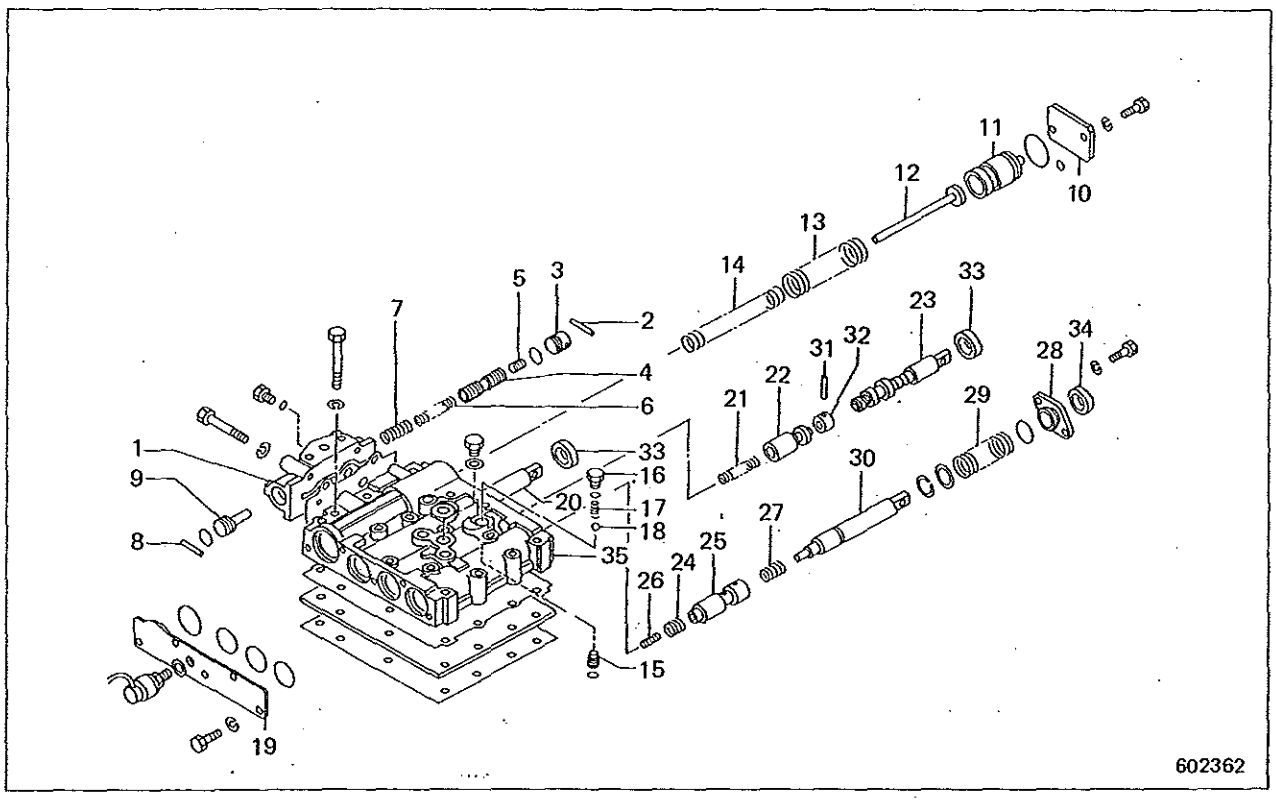
TRANSMISSION CONTROL VALVE

Removal and installation

1. Dismount the transmission assembly including the control valve from the machine, and remove the valve from the transmission. (Refer to the topics, Removal, DPS TRANSMISSION.)

2. To install the control valve, follow the reverse of removing procedure.

Disassembly

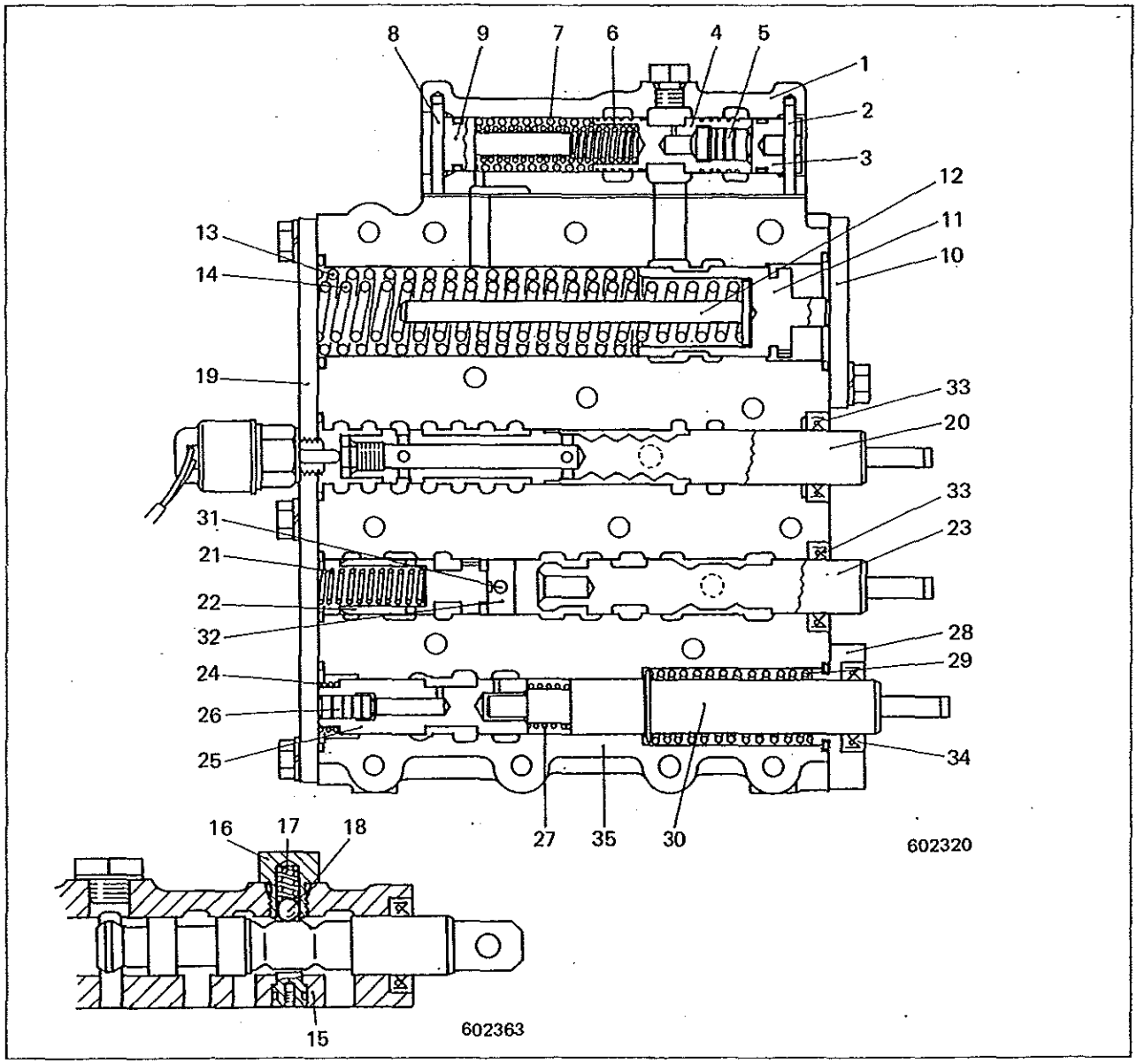


1 Regulator valve body
2 Roller pin
3 Plug
4 Relief valve
5 Slug
6 Inner spring
7 Outer spring
8 Roller pin
9 Plug
10 Cover
11 Accumulator piston
12 Seat
13 Outer spring
14 Inner spring
15 Pin (3 pcs)
16 Plug (2 pcs)
17 Spring (2 pcs)
18 Detent ball (2 pcs)
19 Cover
20 Speed selector plunger
21 Spring
22 Differential valve
23 Directional selector plunger
24 Spring
25 Inching valve
26 Slug
27 Spring
28 Cover
29 Spring
30 Inching valve plunger
31 Roller pin
32 Plug
33 Oil seal (2 pcs)
34 Oil seal
35 Valve housing

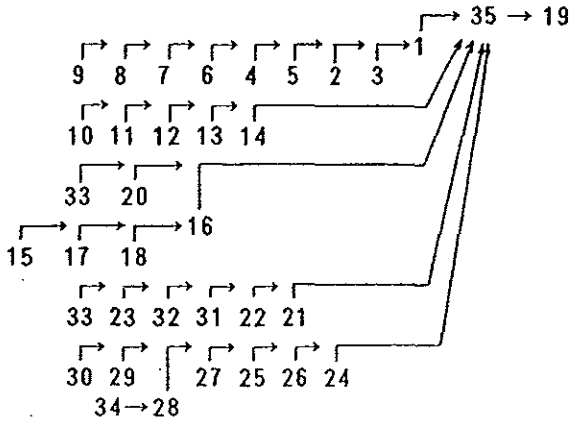
(Remove the parts in the order numbered for disassembly.)

Reassembly

(Clean all control valve parts except for seals by alkali washing before installing them for reassembly.)



Reassembling order

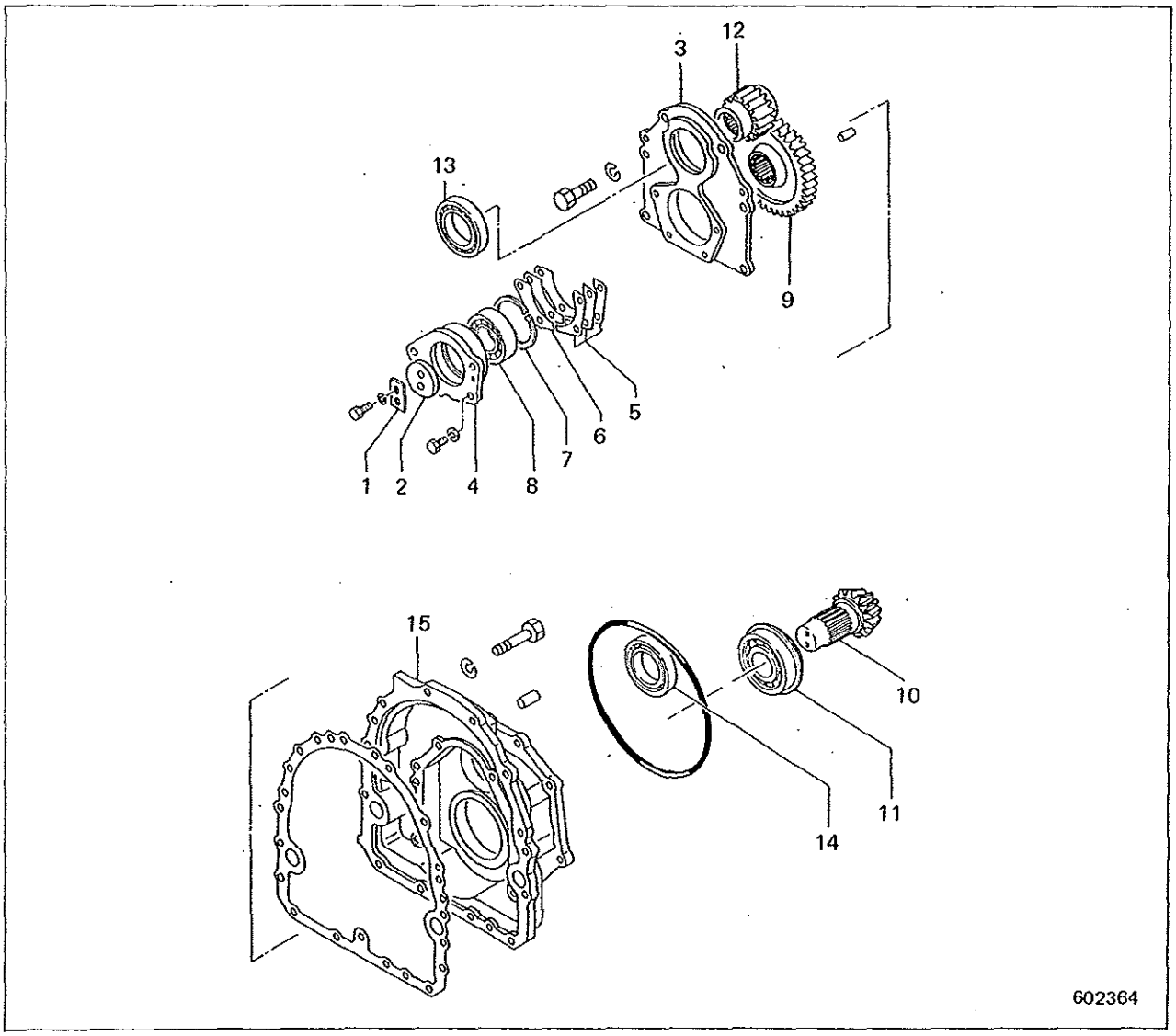


TRANSFER

Removal and installation

Refer to the topics, DPS TRANSMISSION.

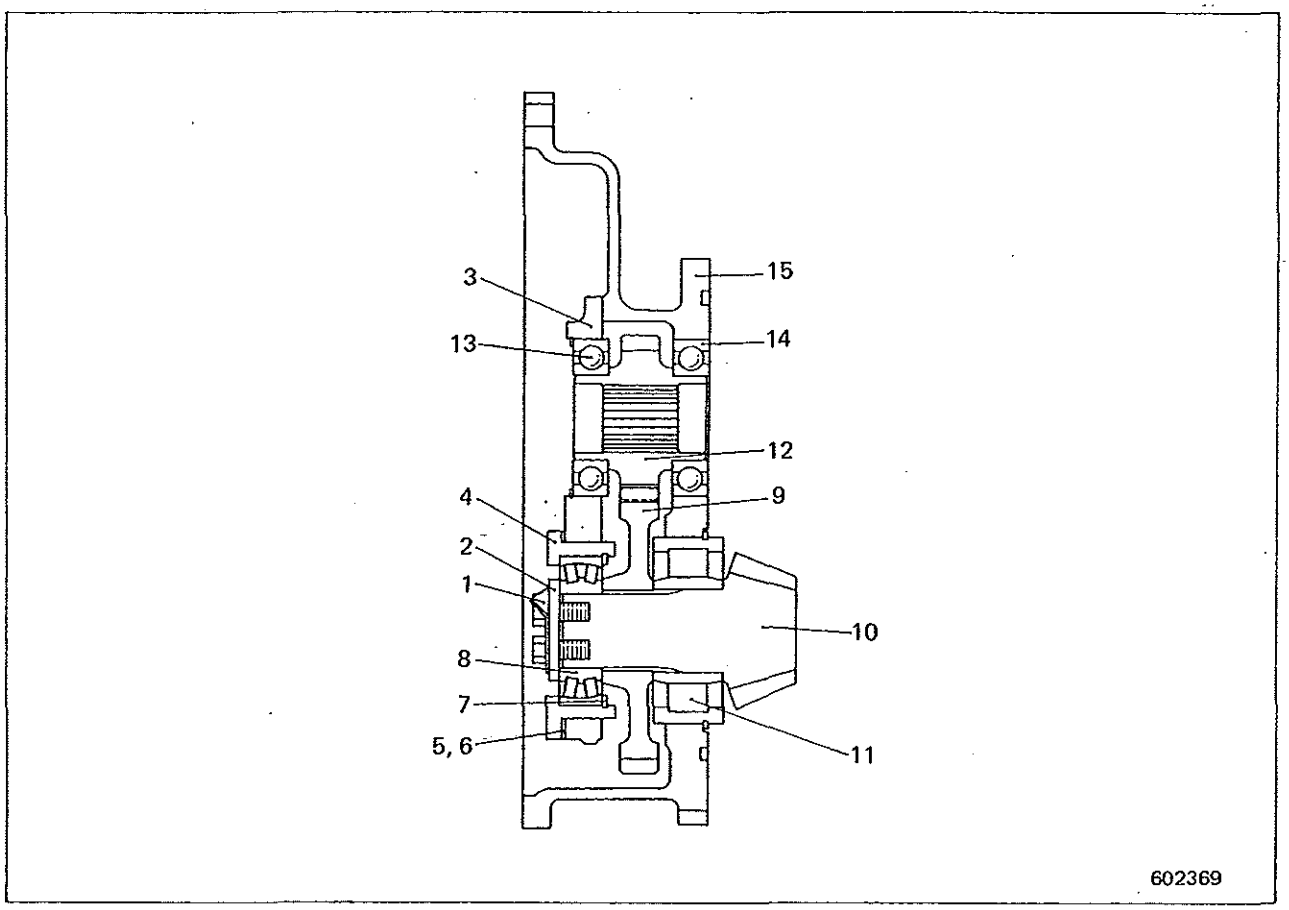
Disassembly



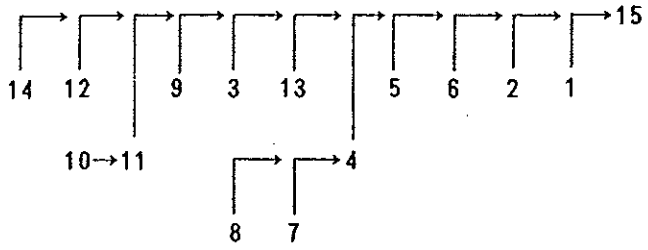
1 Lock washer
2 Washer
3 Cover
4 Bearing cage
5 Shims (1 set)
6 Shim (1 set)
7 Snap ring
8 Roller bearing
9 Driven gear
10 Bevel pinion
11 Roller bearing
12 Drive gear
13 Ball bearing
14 Ball bearing
15 Case

(Remove the parts in the order numbered for disassembly.)

Reassembly



Reassembling order



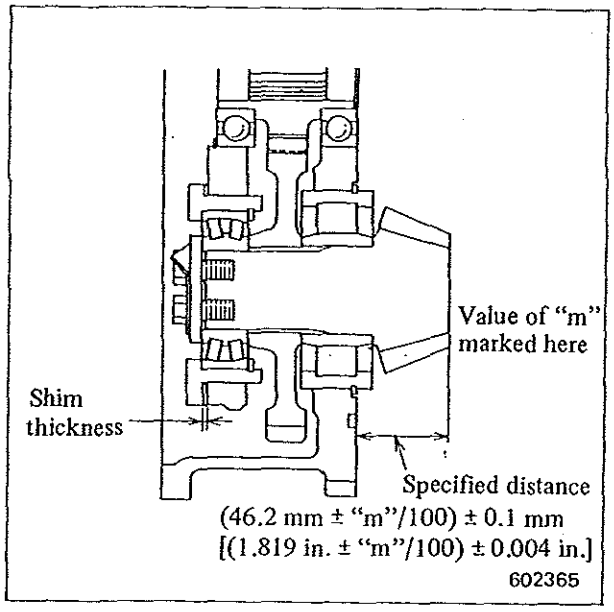
Tips for reassembly

Pinion adjustment

The distance from the end face of bevel pinion and the outer face of transfer case is specified for each transfer because of the selective assembly. The specification is formed by a certain value (represented by the letter "m" and marked on the end face of pinion) per cent and 46.2 mm (1.819 in.). The per-cent value is either positive (+) or negative (-). To bring this distance into ±0.1 mm (±0.004 in.) of the specification, the thickness of shims (58827-10900 and 58827-11000) must be adjusted.
The shims are available in these thicknesses:

Unit: mm (in.)

Part number	Shim thicknesses
58827-10900	0.1 (0.004), 0.4 (0.016), 1.0 (0.039)
58827-11000	0.1 (0.004), 0.4 (0.016), 1.0 (0.039)

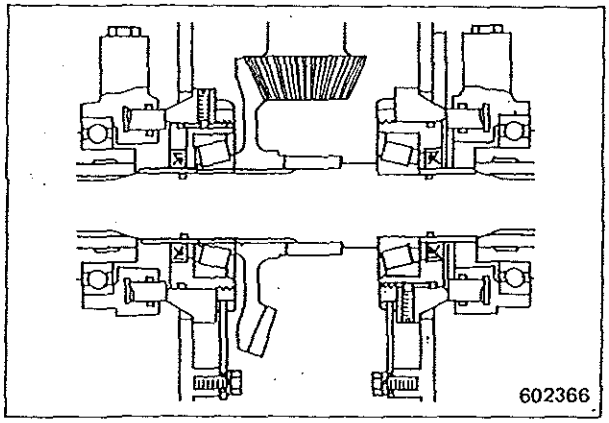


BEVEL GEAR

Installation

NOTE

Install the bevel gear on the left side in case of DPS transmission; install it on the right side in case of DD transmission.



DAMPER

Removal

The damper resembles a conventional disc clutch and is to be removed together with the engine. For removal of the damper, refer to the topics, FLYWHEEL CLUTCH, DISASSEMBLY and REASSEMBLY volume, except for the following items:

(1) Clutch control rod

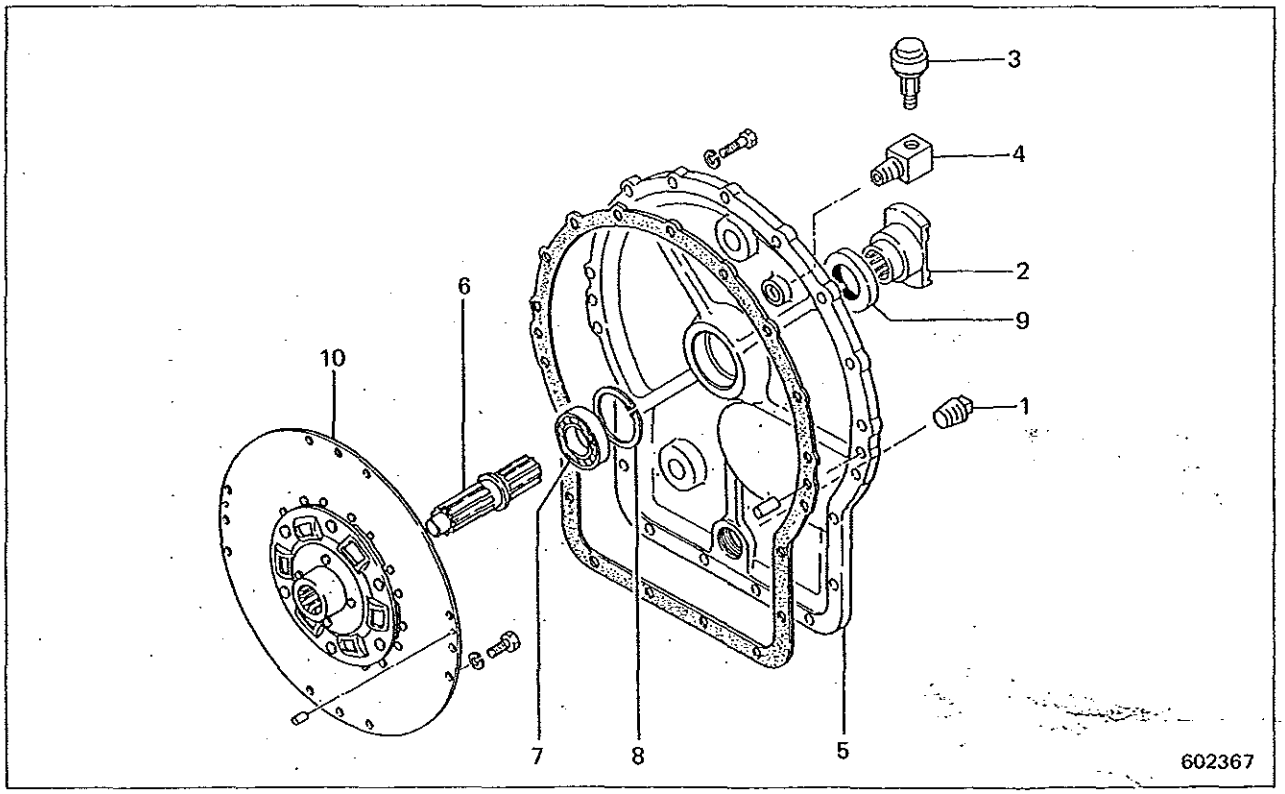
(2) Rubber hose for steering clutch oil

(3) Rubber hose for oil cooler (flywheel clutch group)

Installation

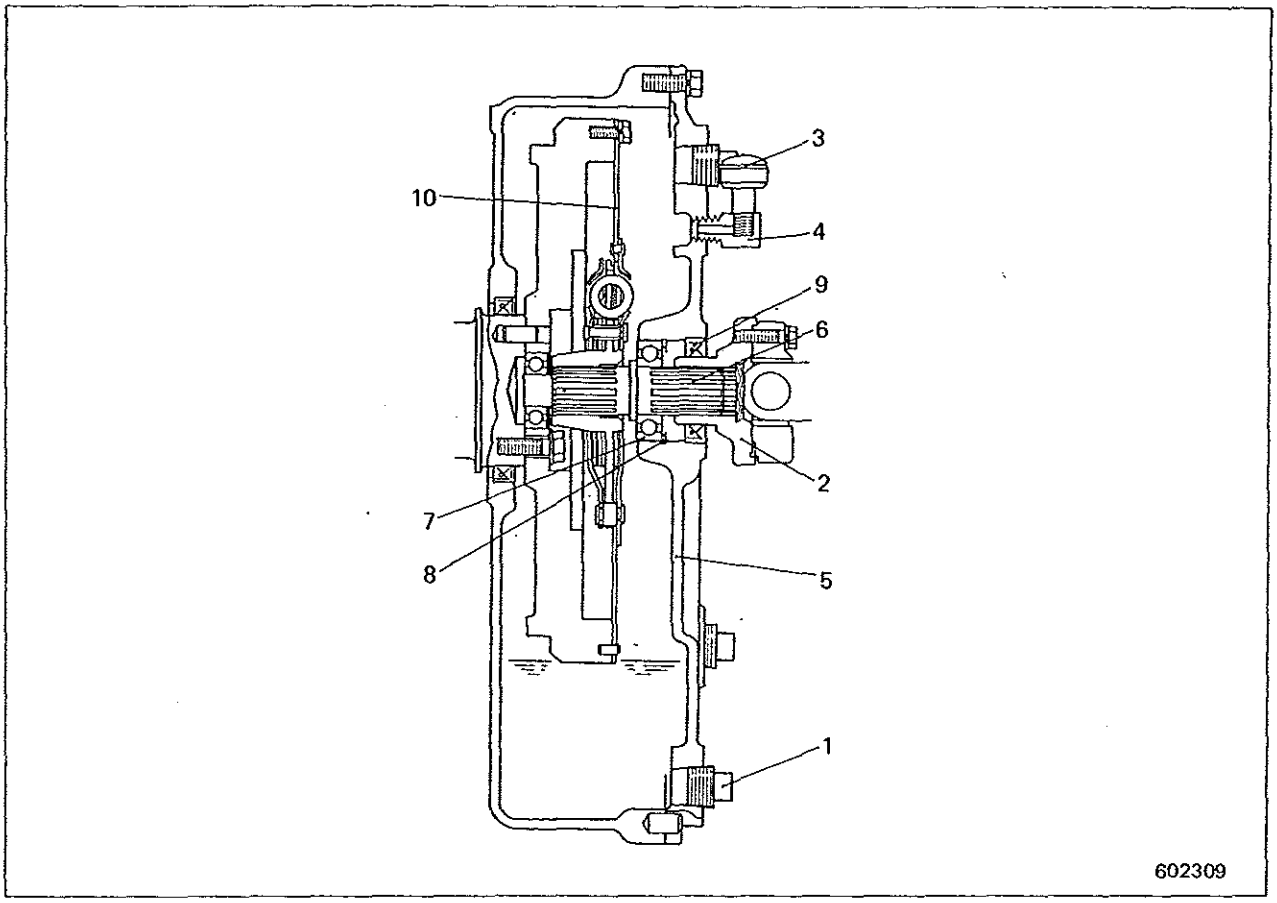
To install the damper, follow the reverse of removing procedure.

Disassembly

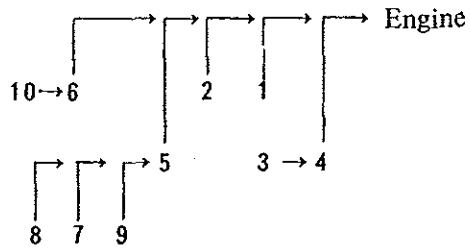


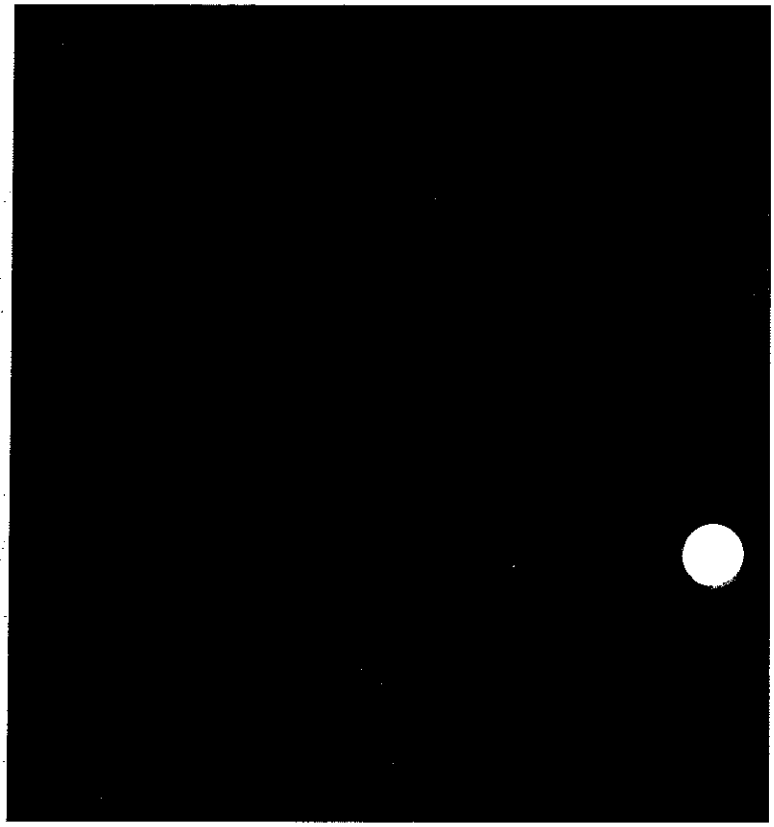
1 Drain plug
2 Flange
3 Air breather
4 Connector
5 Damper cover
6 Shaft
7 Ball bearing
8 Snap ring
9 Oil seal
10 Damper

Reassembly



Reassembling order





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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G TRACTOR SHOVEL BS3G

CONTENTS

HYDRAULIC SYSTEM

- OPERATING PRINCIPLE
- TESTING AND ADJUSTMENTS

MITSUBISHI HEAVY INDUSTRIES, LTD.

FOREWORD

This service manual has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations used in this manual are based on information that was current at the time this issue was written.

Correct servicing will give these machines a long productive life. Before attempting to start a test, repair or rebuild job, be sure that you have studied the respective sections of this manual, and know all the components you will work on.

Safety is not only your concern but everybody's concern. Safe working habits cannot be bought or manufactured; they must be learned through the job you do. By learning what CAUTION or WARNING symbol emphasizes, know what is safe – what is not safe. Consult your foreman, if necessary, for specific instructions on a job, and the safety equipment required.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

⚠ **CAUTION** ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of machine.

⚠ **WARNING** ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

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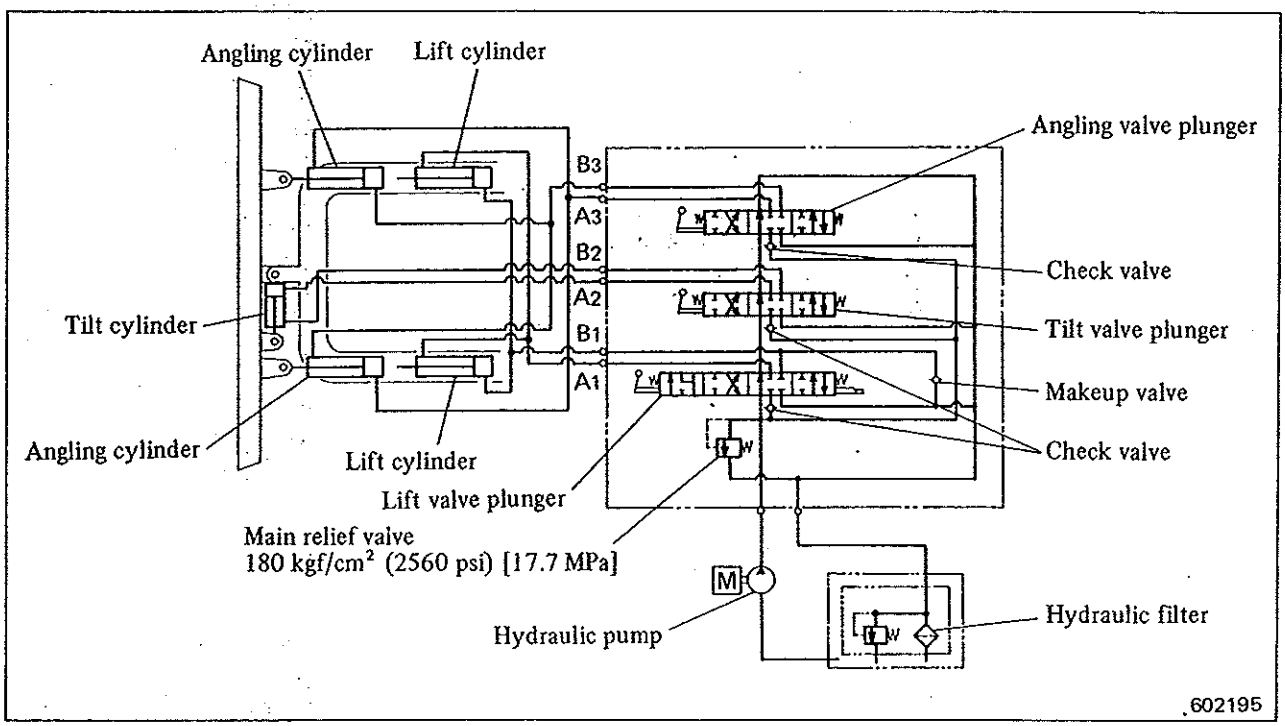
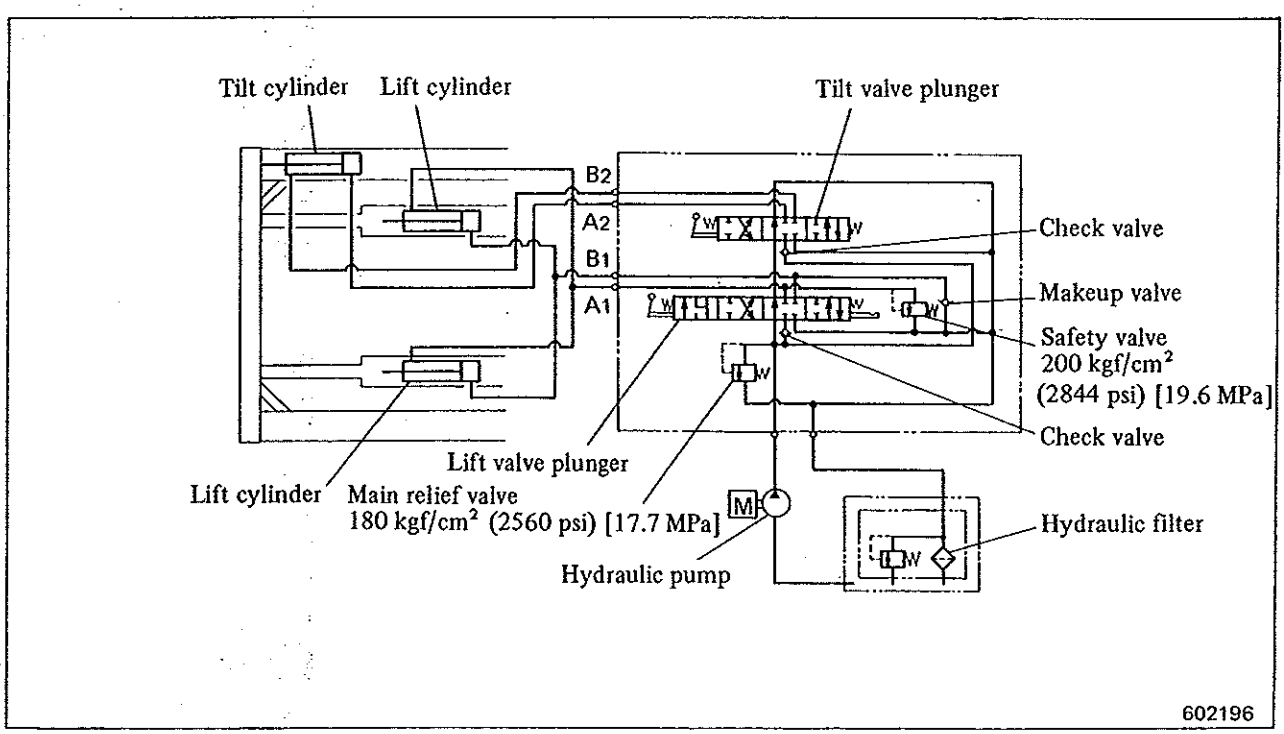
OPERATING PRINCIPLE

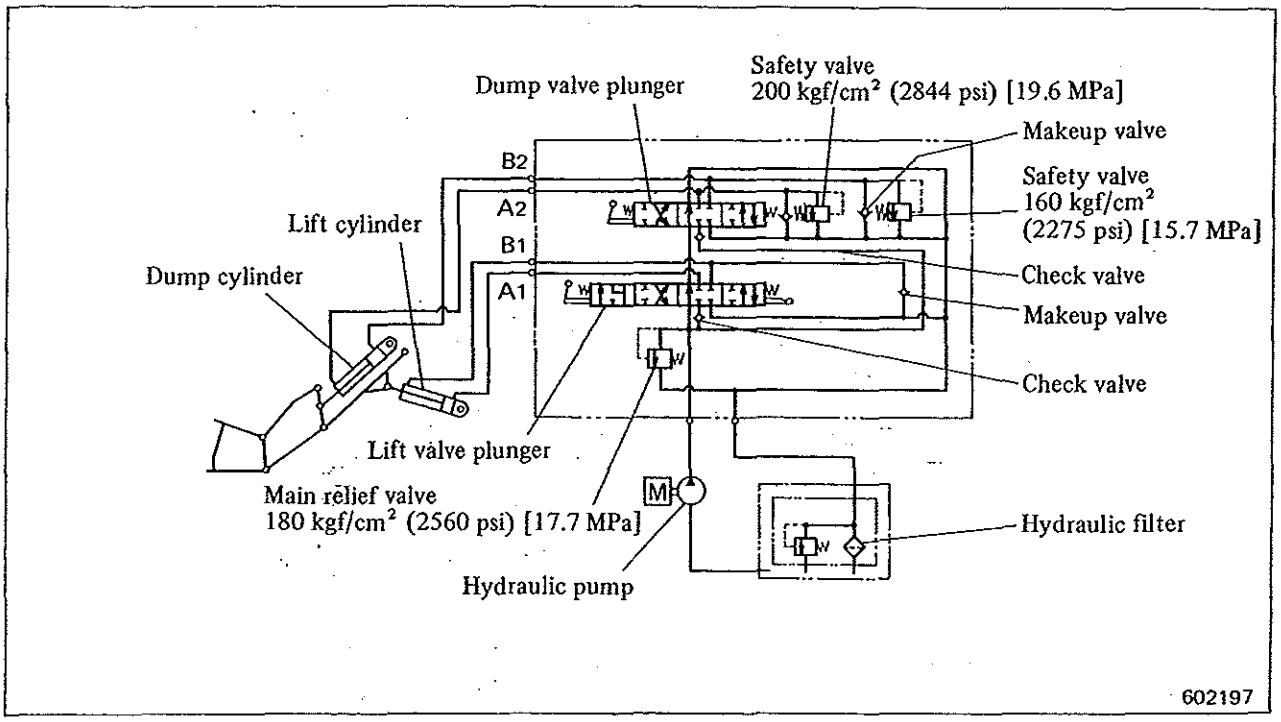
GENERAL DESCRIPTION



BD2G-PAT hydraulic circuit diagram



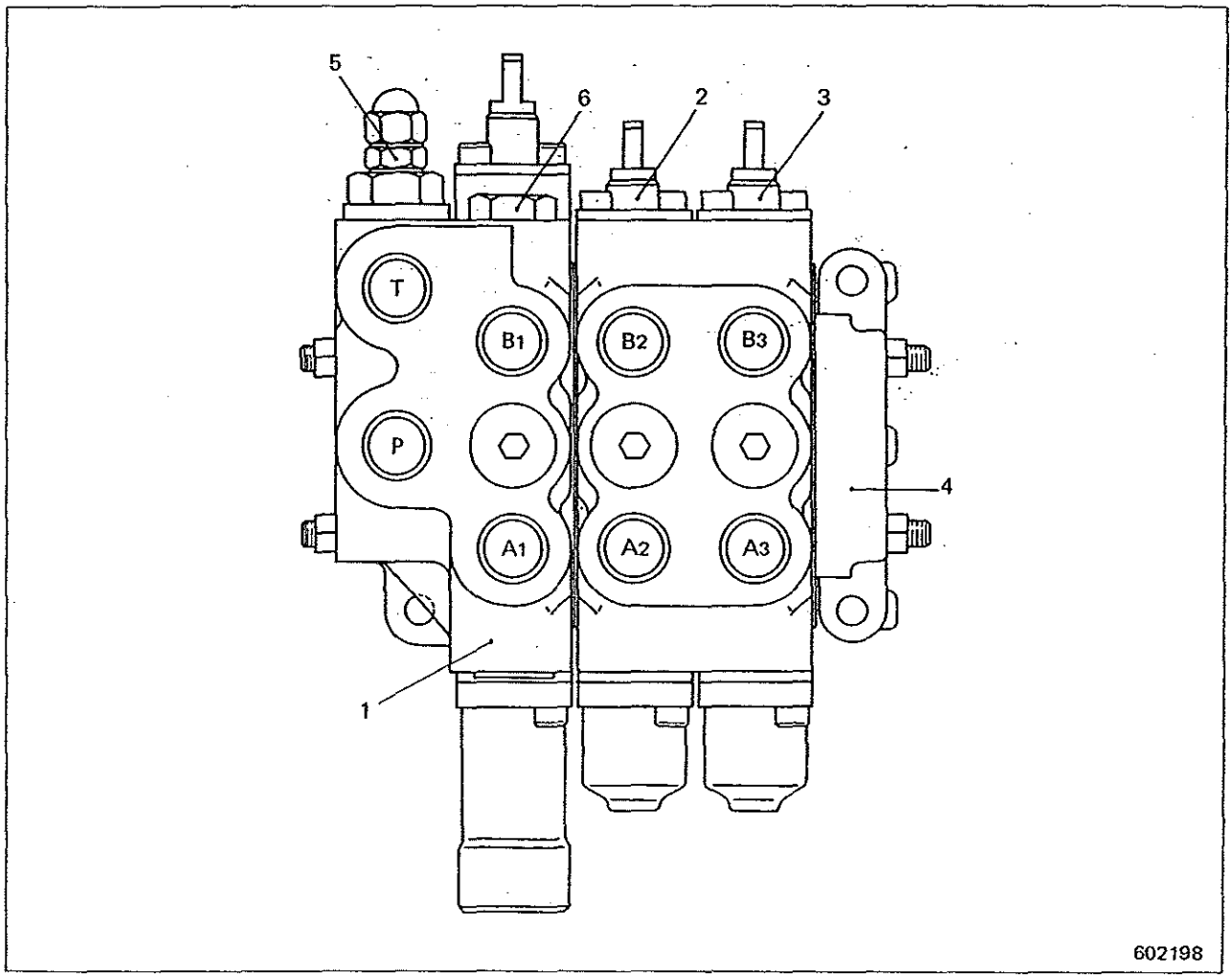
BD2G-PT hydraulic circuit diagram



BS3$_G$ hydraulic circuit diagram

CONTROL VALVE

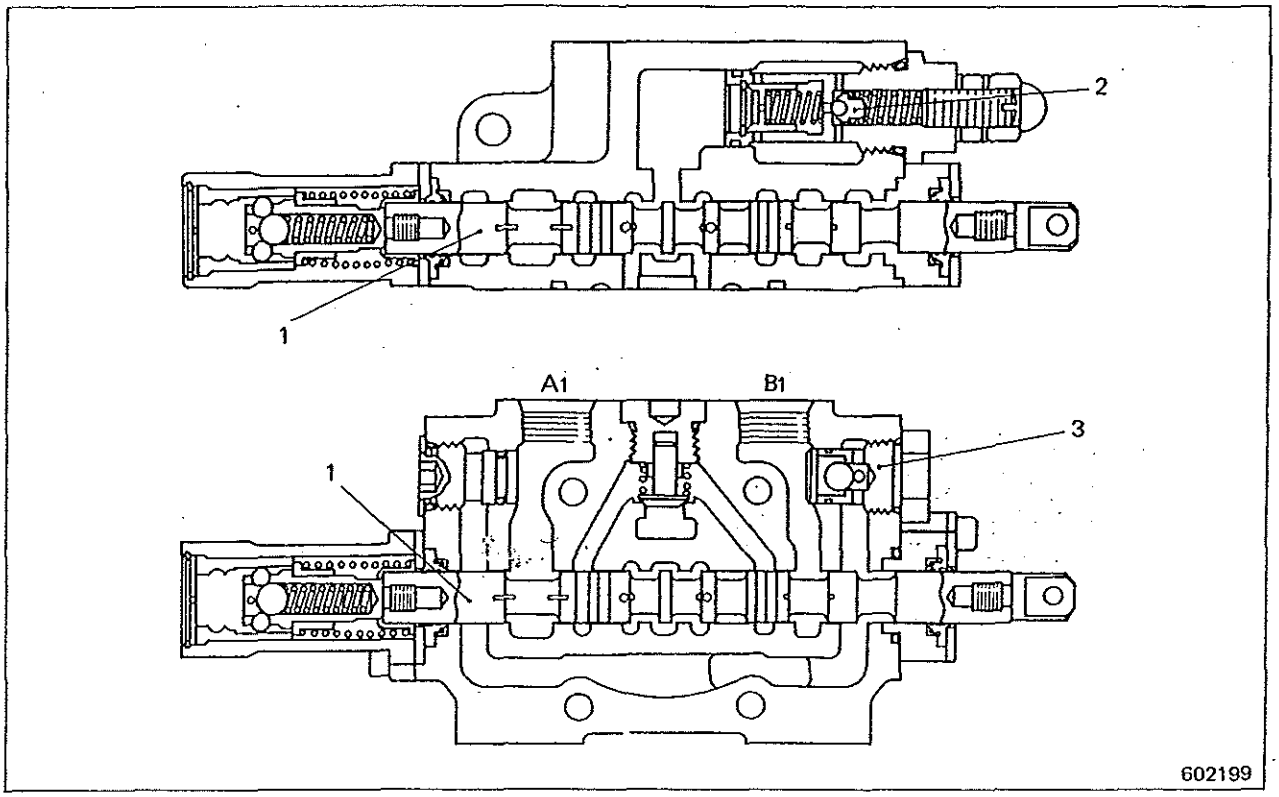
3-SECTION CONTROL VALVE ($BD2_G$-PAT)



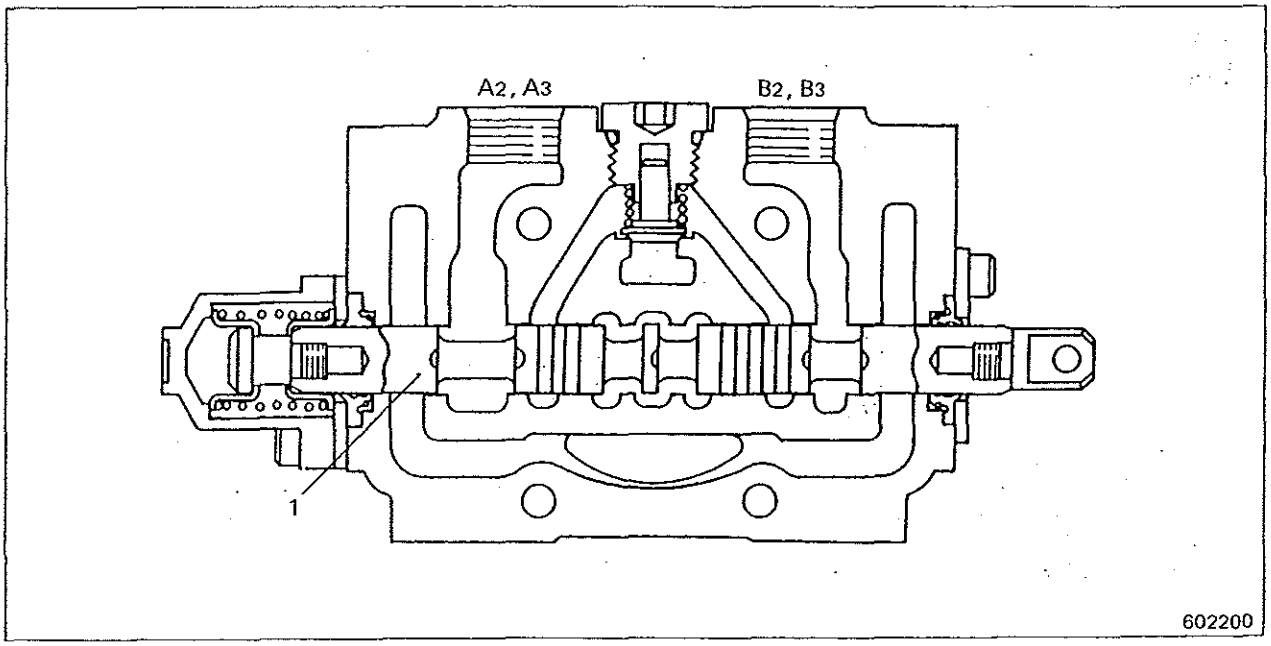
1 Inlet & lift valve plunger section
2 Tilt valve plunger section
3 Angling valve plunger section
4 End plate
5 Main relief valve
180 kgf/cm^2 (2560 psi) [17.7 MPa]
6 Makeup valve

T Tank port
P Pump port
A_1 Lift cylinder (rod side)
B_1 Lift cylinder (head side)
A_2 Tilt cylinder (head side)
B_2 Tilt cylinder (rod side)
A_3 Angling cylinder
(RH rod side and LH head side)
B_3 Angling cylinder
(RH head side and LH rod side)

Control valve sections



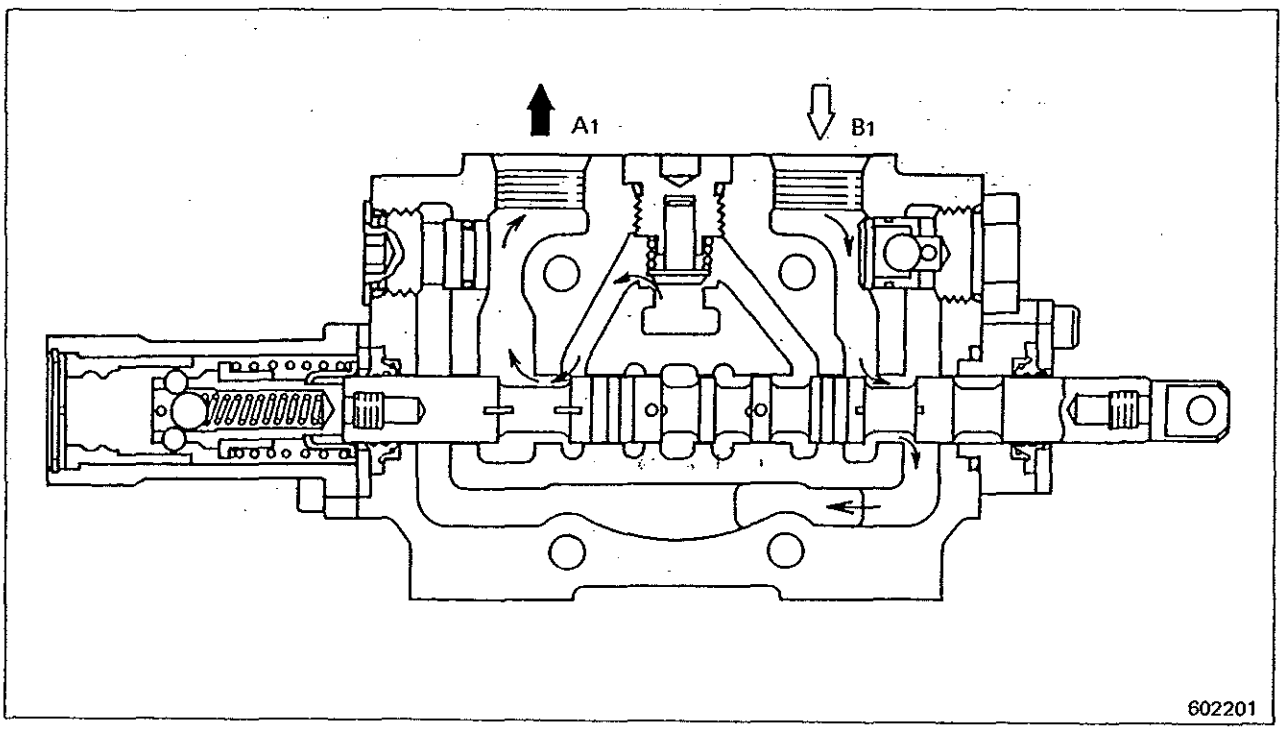
Lift valve plunger section



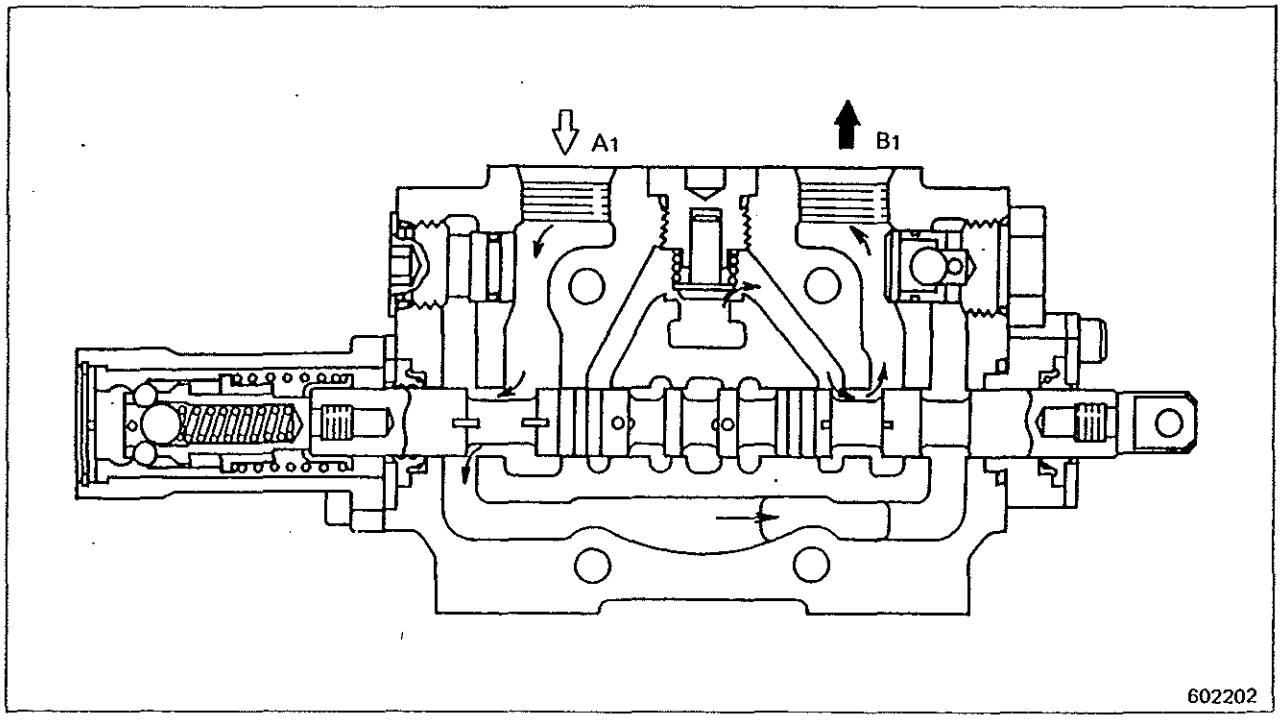
Tilt/angling valve plunger section

1 Plunger
2 Main relief valve
3 Makeup valve

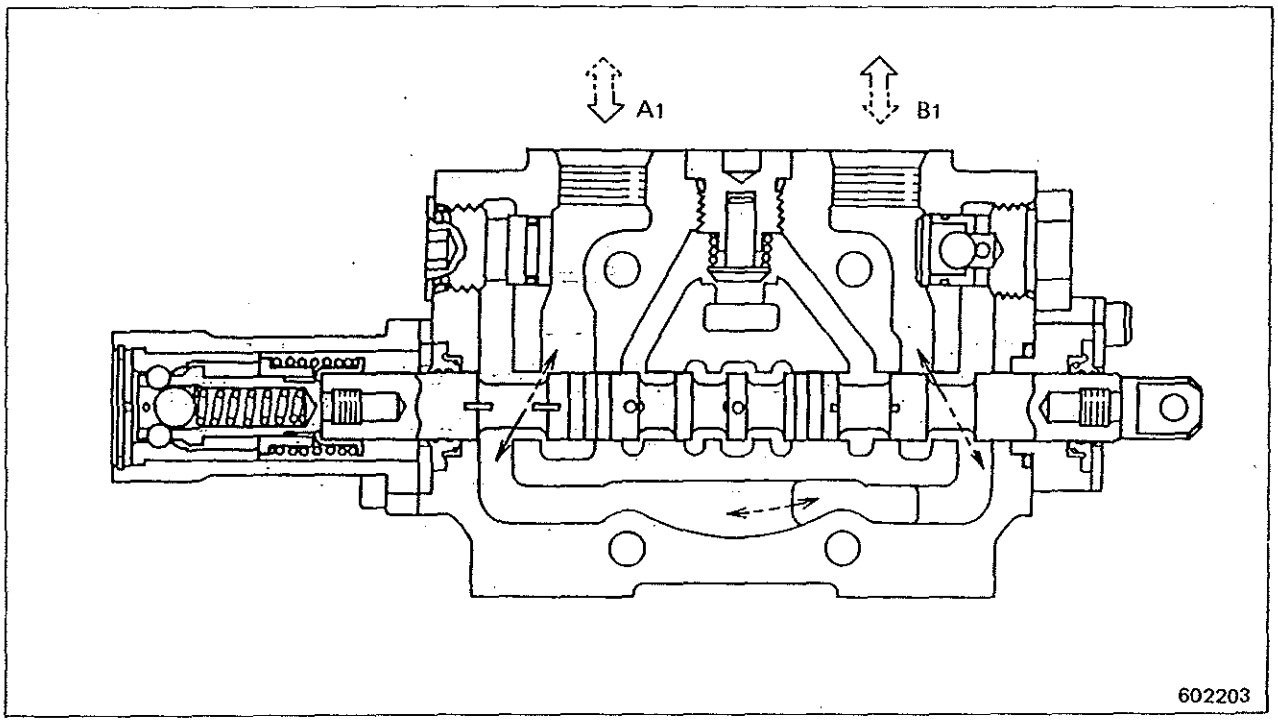
Lift valve plunger in pulled-out [RAISE] position



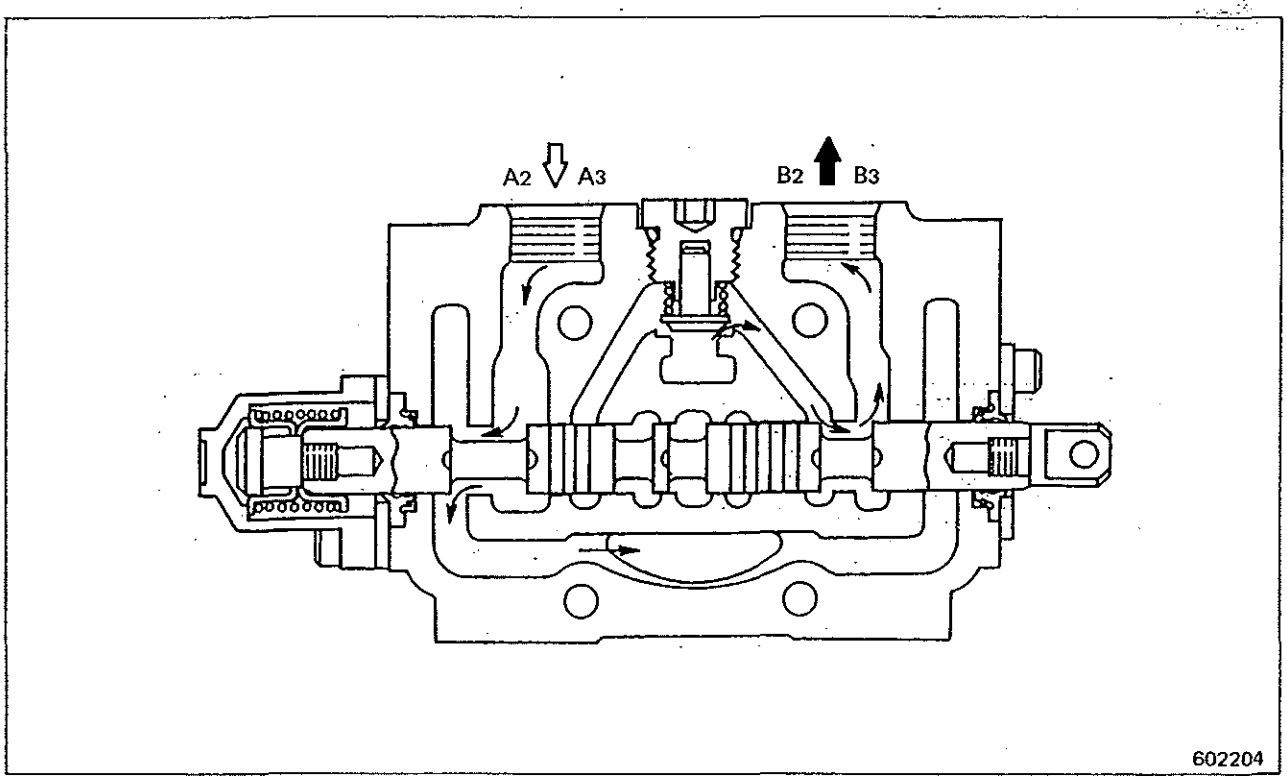
Lift valve plunger in pushed-in [LOWER] position



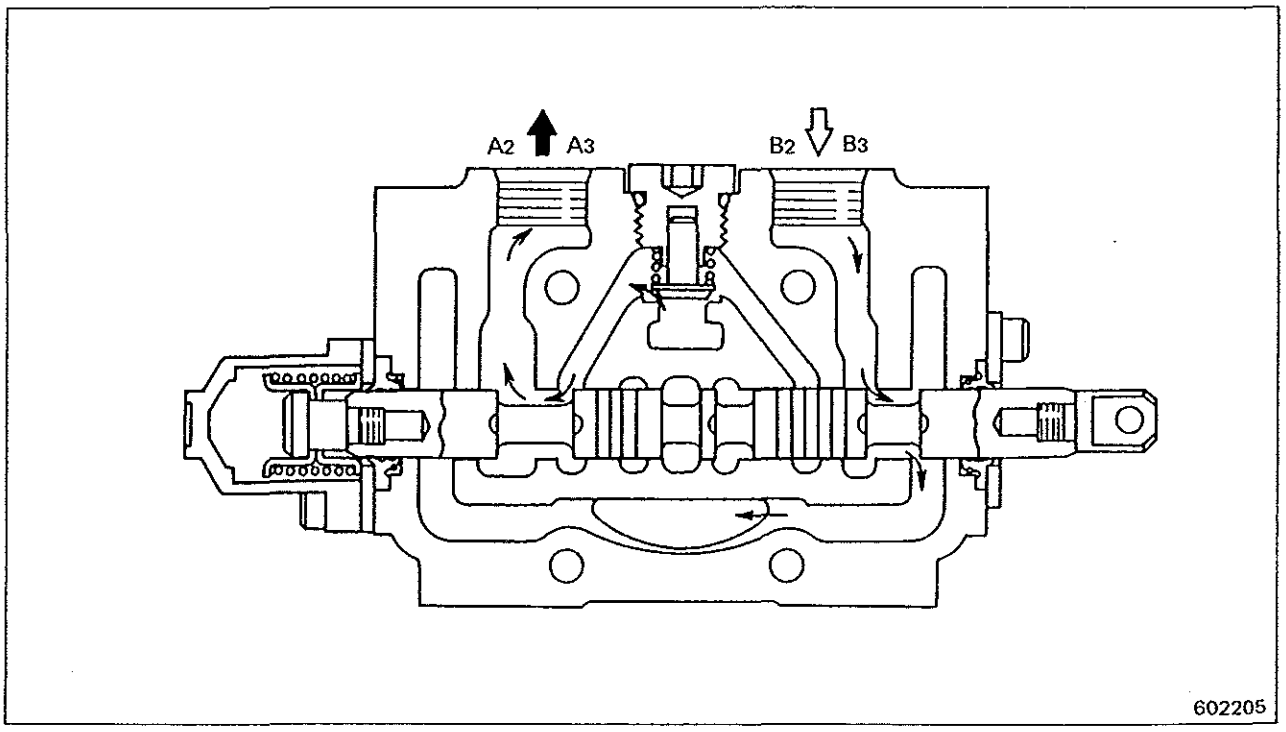
Lift valve plunger in pushed-in [FLOAT] position



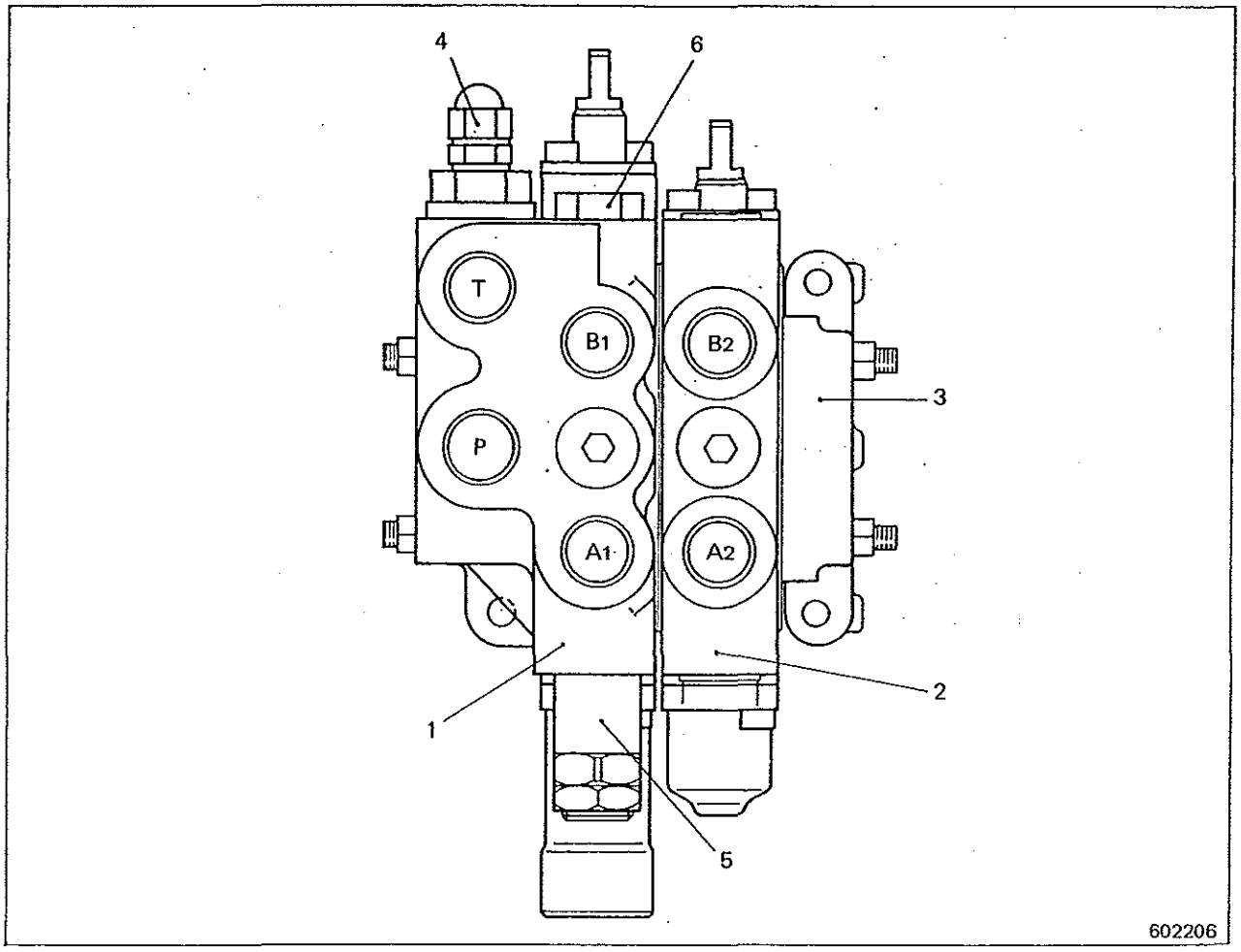
Tilt valve plunger in pushed-in [RIGHT TILT] position
Angling valve plunger in pushed-in [LEFT ANGLING] position



Tilt valve plunger in pulled-out [LEFT TILT] position
Angling valve plunger in pulled-out [RIGHT ANGLING] position



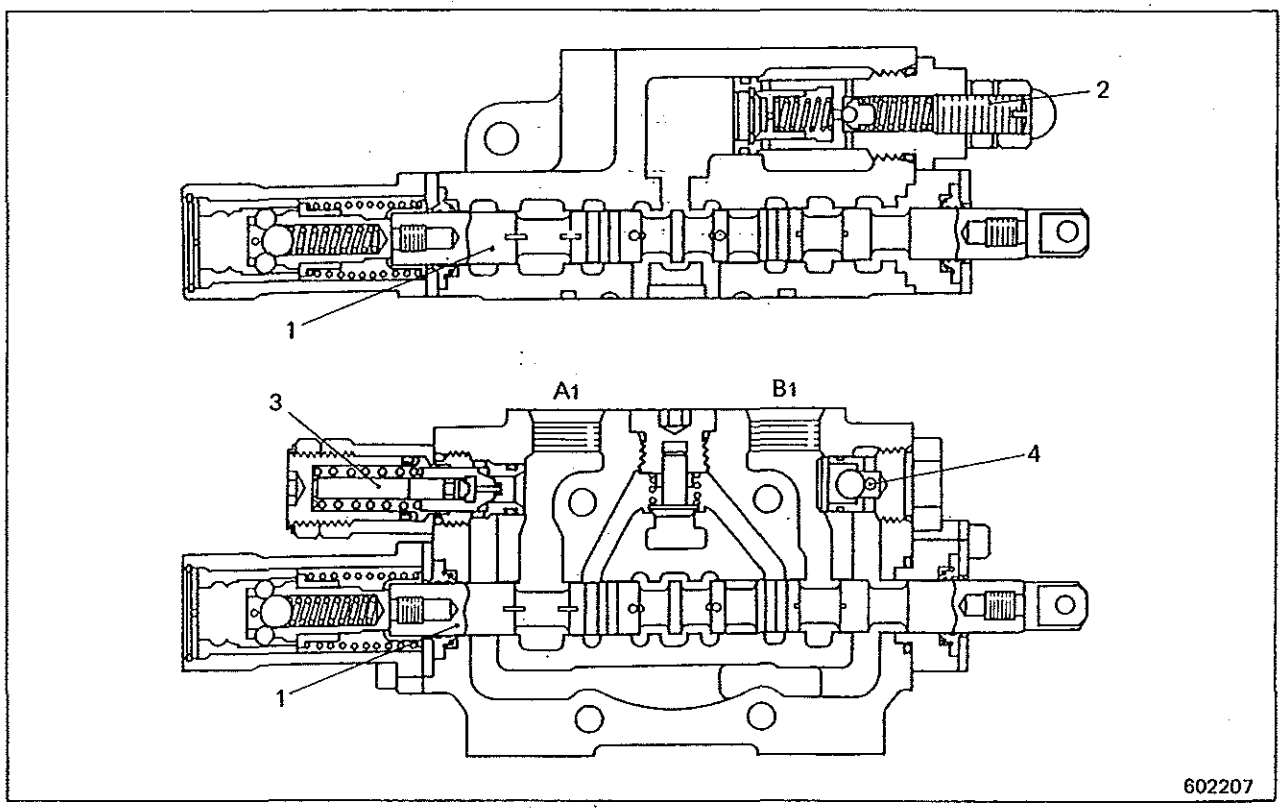
2-SECTION CONTROL VALVE ($BD2_G$-PT)



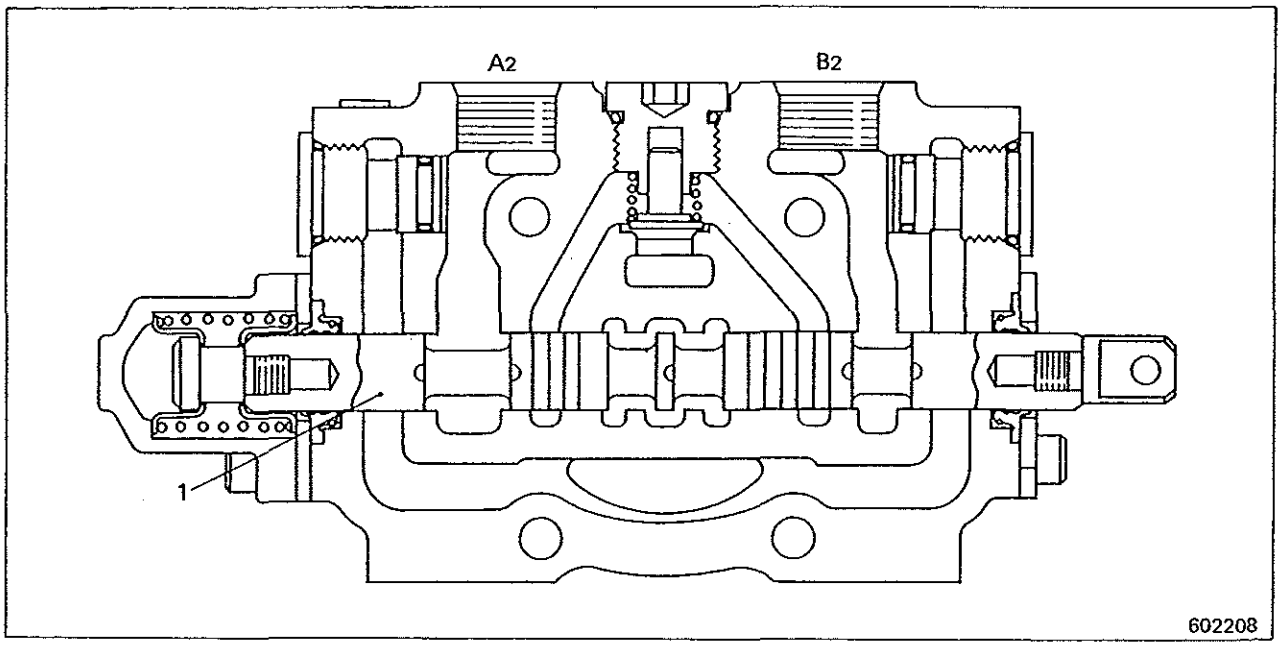
1 Inlet & lift valve plunger section
2 Tilt valve plunger section
3 End plate
4 Main relief valve
180 kgf/cm² (2560 psi) [17.7 MPa]
5 Safety valve
200 kgf/cm² (2844 psi) [19.6 MPa]
6 Makeup valve

T Tank port
P Pump port
A_1 Lift cylinder (rod side)
B_1 Lift cylinder (head side)
A_2 Tilt cylinder (head side)
B_2 Tilt cylinder (rod side)

Control valve sections



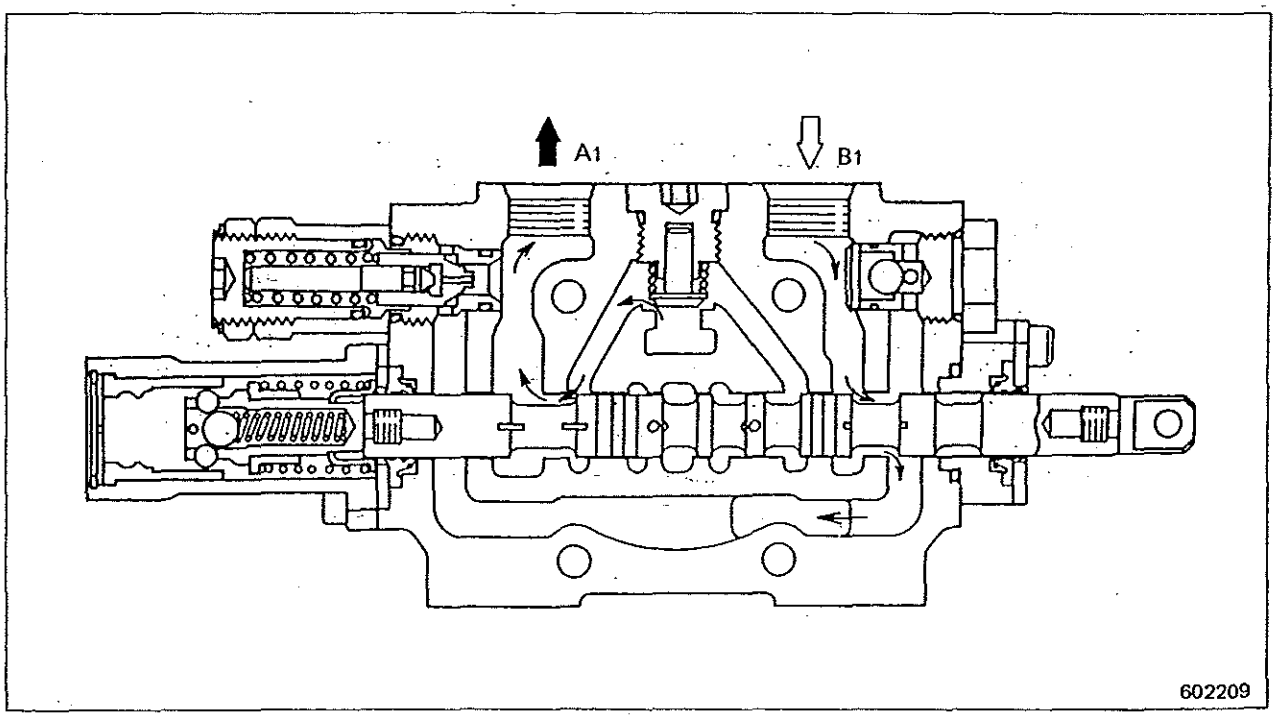
Lift valve plunger section



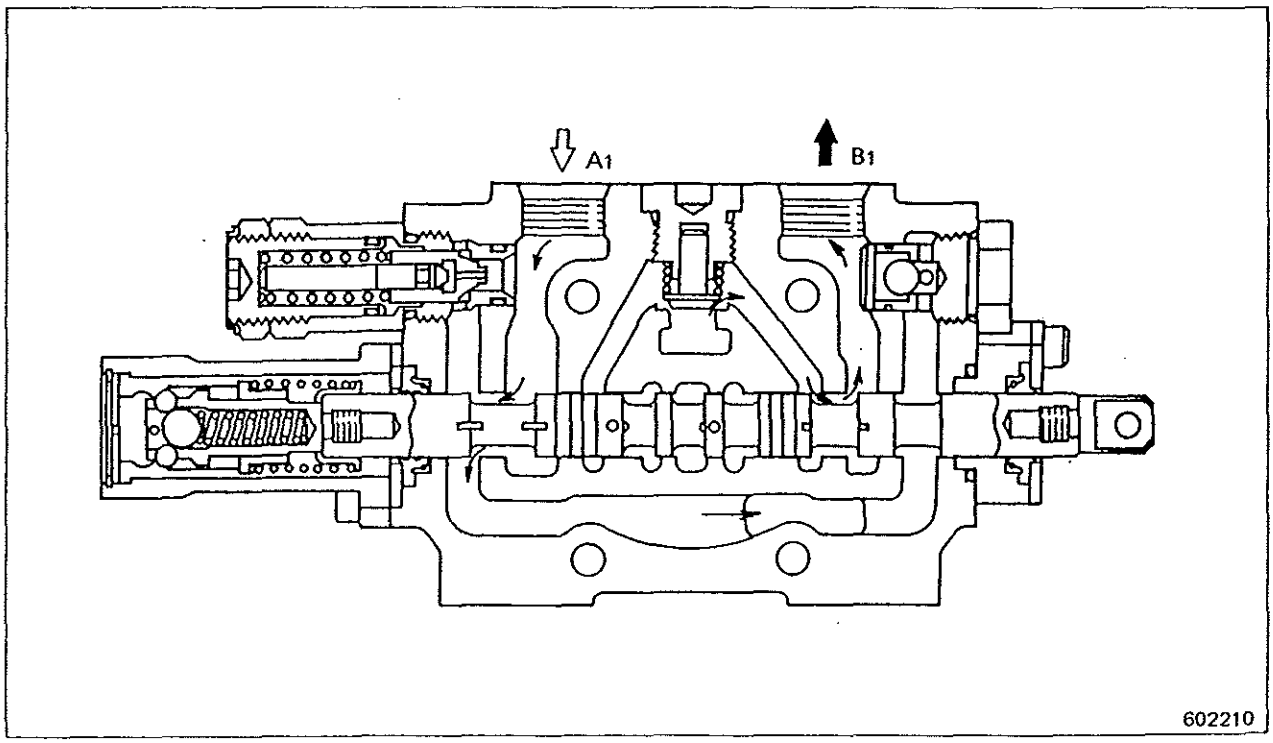
Tilt valve plunger section

1 Plunger
2 Main relief valve
3 Safety valve
4 Makeup valve

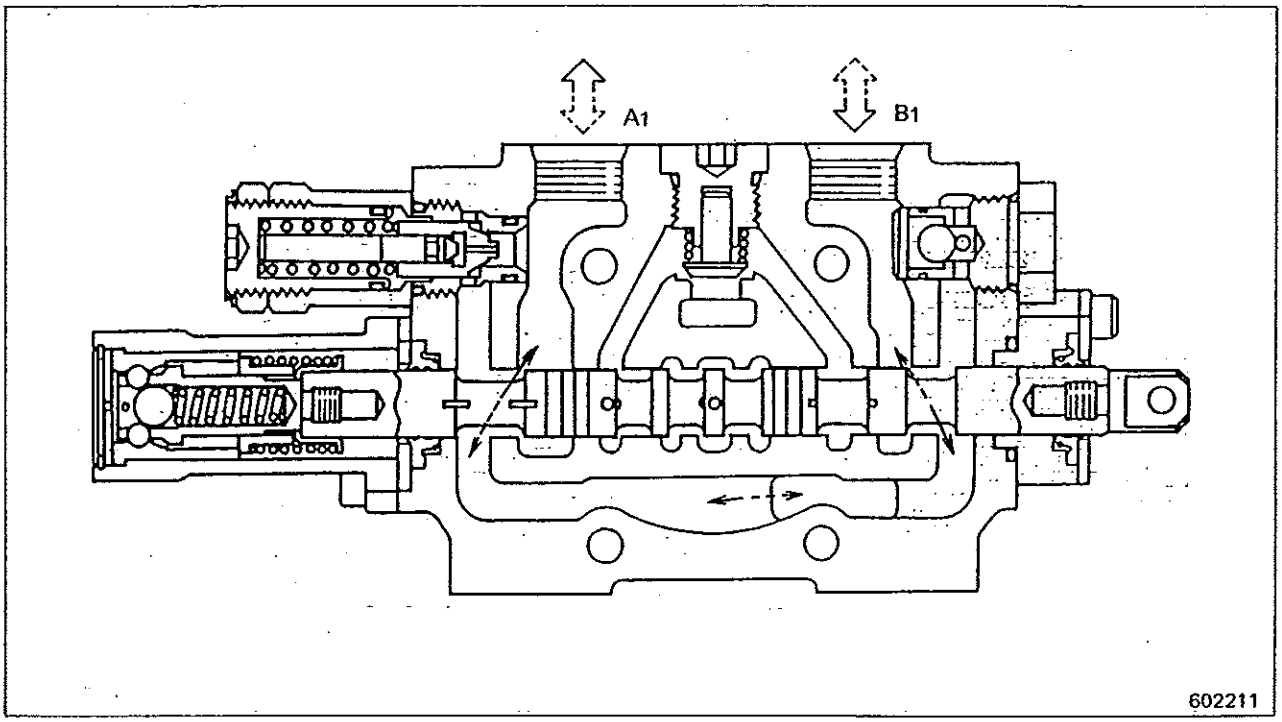
Lift valve plunger in pulled-out [RAISE] position



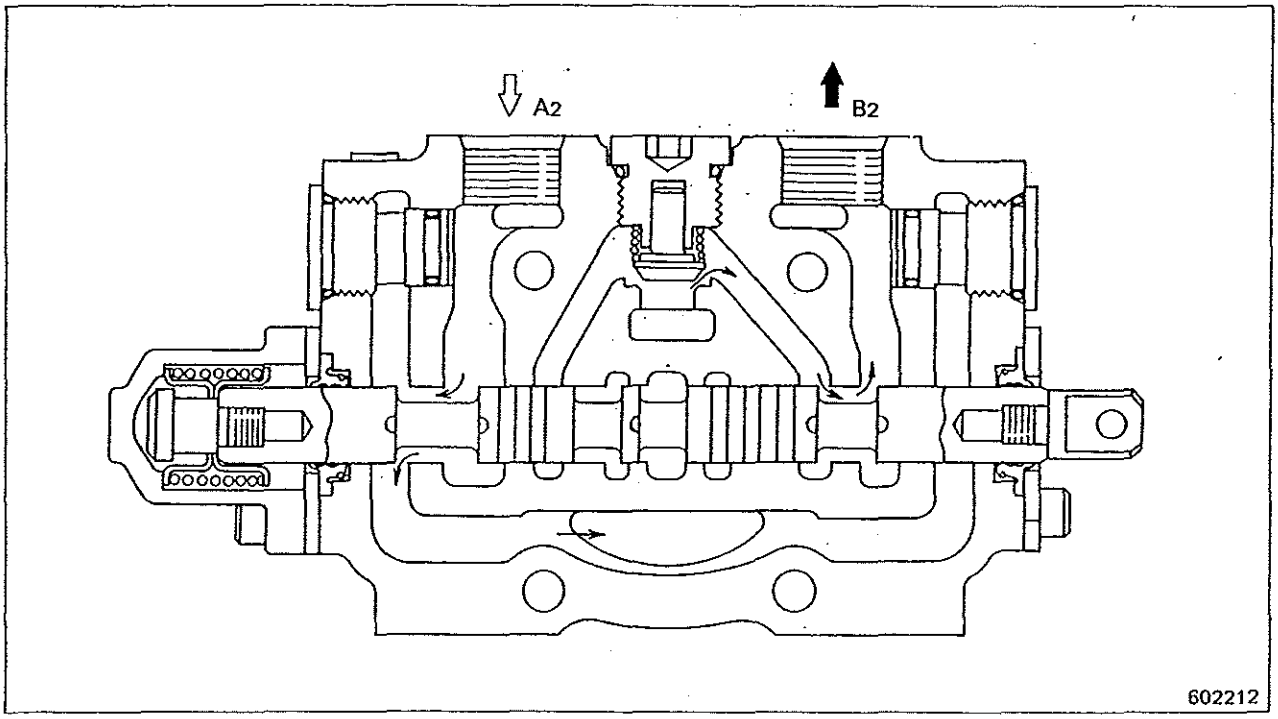
Lift valve plunger in pushed-in [LOWER] position



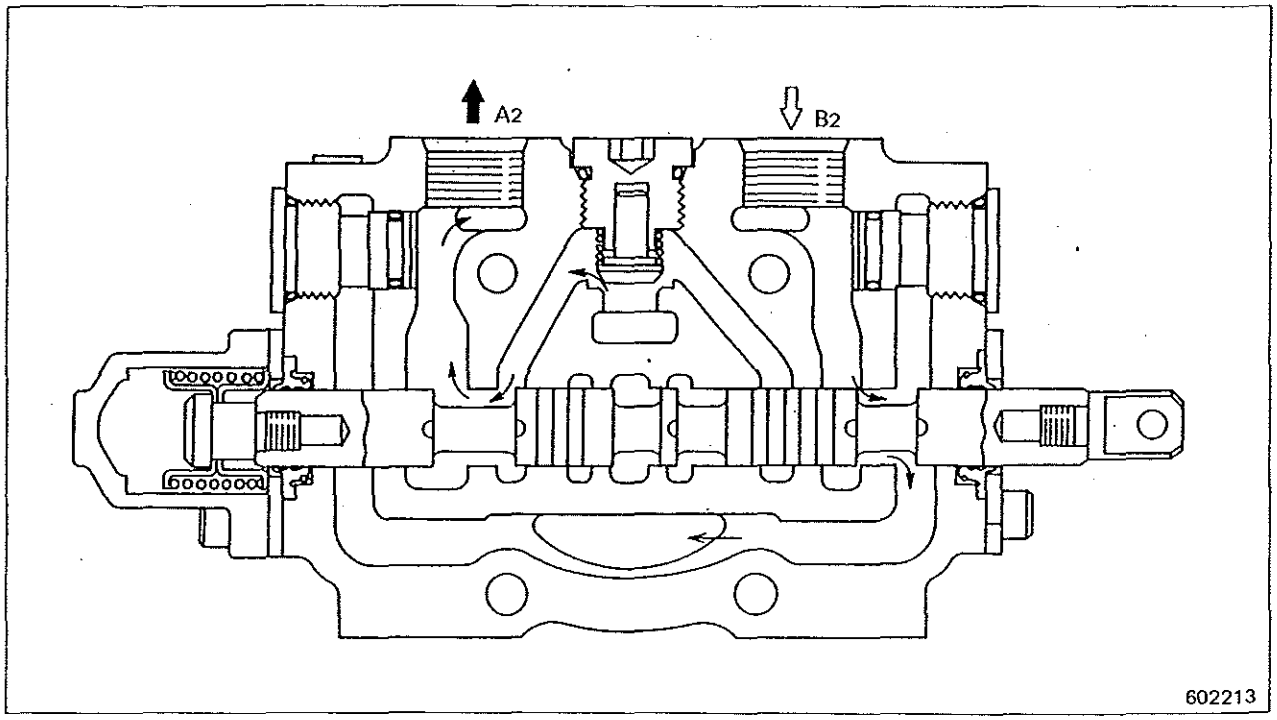
Lift valve plunger in pushed-in [FLOAT] position



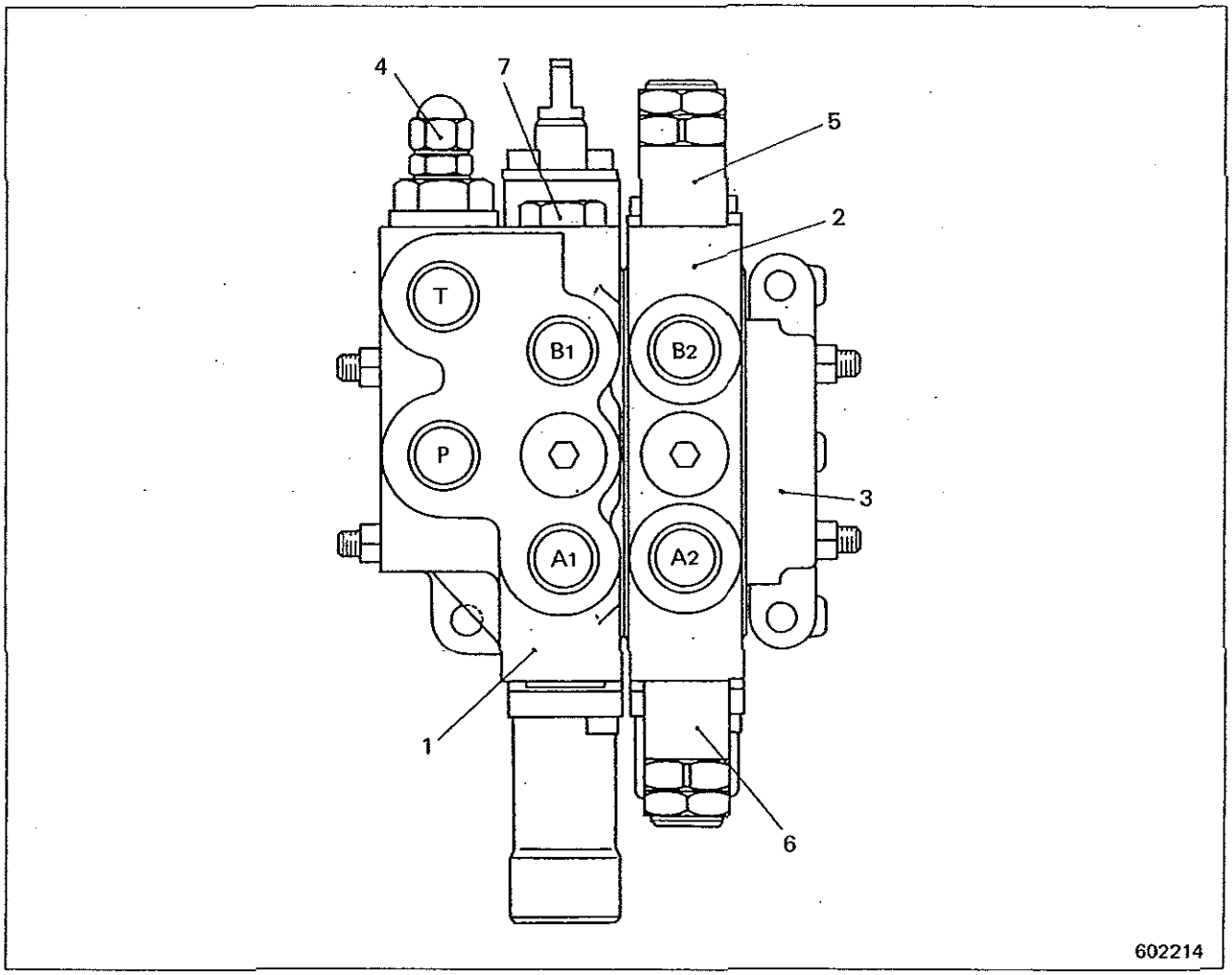
Tilt valve plunger in pushed-in [RIGHT TILT] position



Tilt valve plunger in pulled-out [LEFT TILT] position



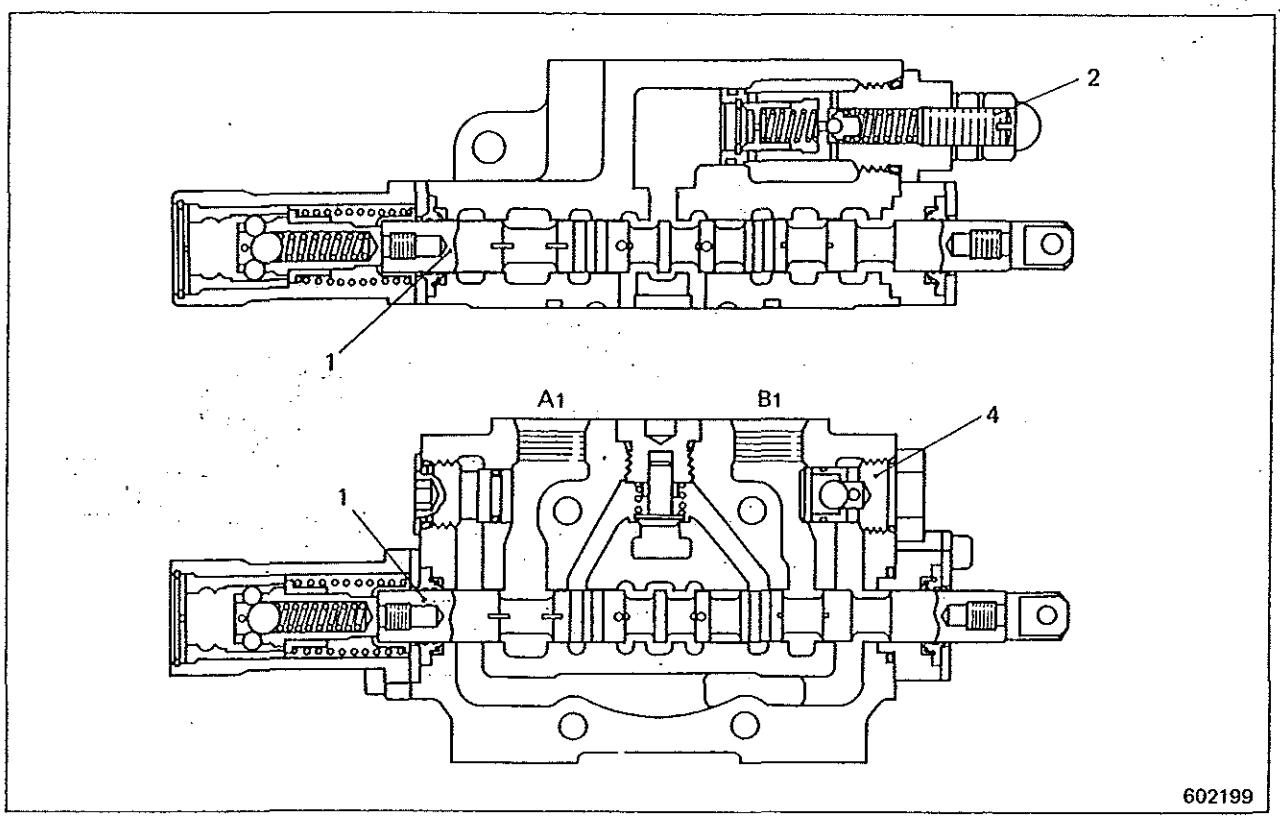
2-SECTION CONTROL VALVE ($BS3_G$)



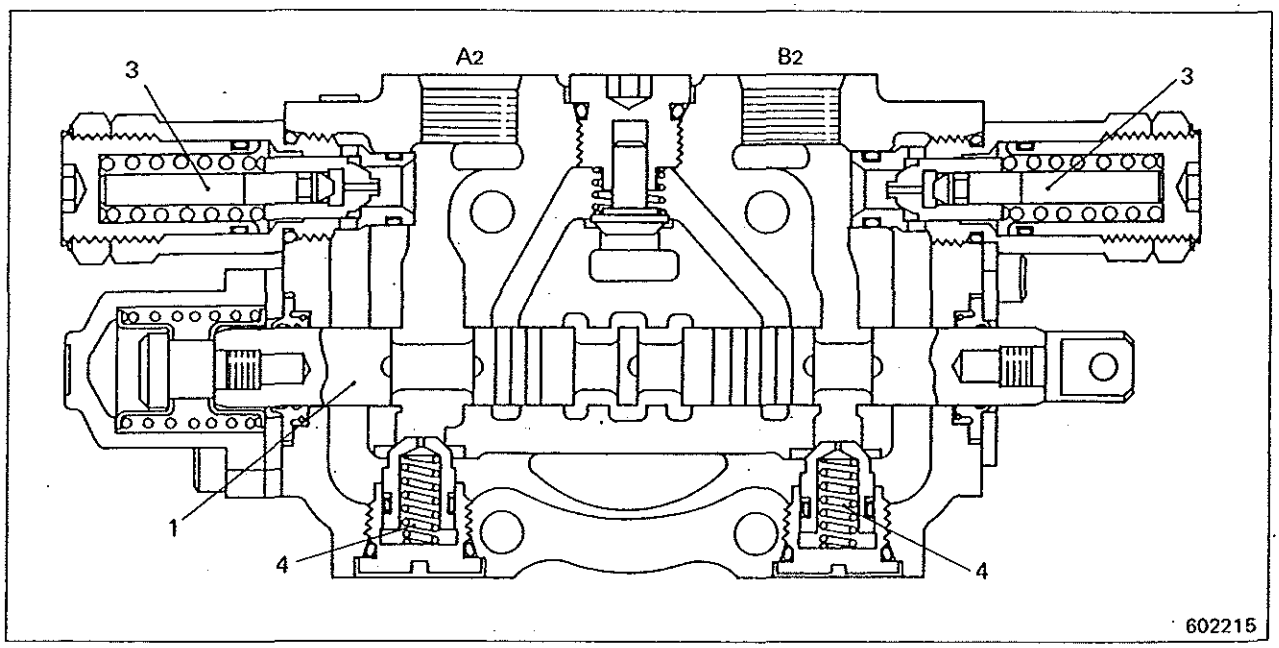
1 Inlet & lift valve plunger section
2 Dump valve plunger section
3 End plate
4 Main relief valve
180 kgf/cm (2560 psi) [17.7 MPa]
5 Safety valve
160 kgf/cm (2275 psi) [15.7 MPa]
6 Safety valve
200 kgf/cm (2844 psi) [19.6 MPa]
7 Makeup valve

T Tank port
P Pump port
A_1 Lift cylinder (head side)
B_1 Lift cylinder (rod side)
A_2 Dump cylinder (rod side)
B_2 Dump cylinder (head side)

Control valve sections



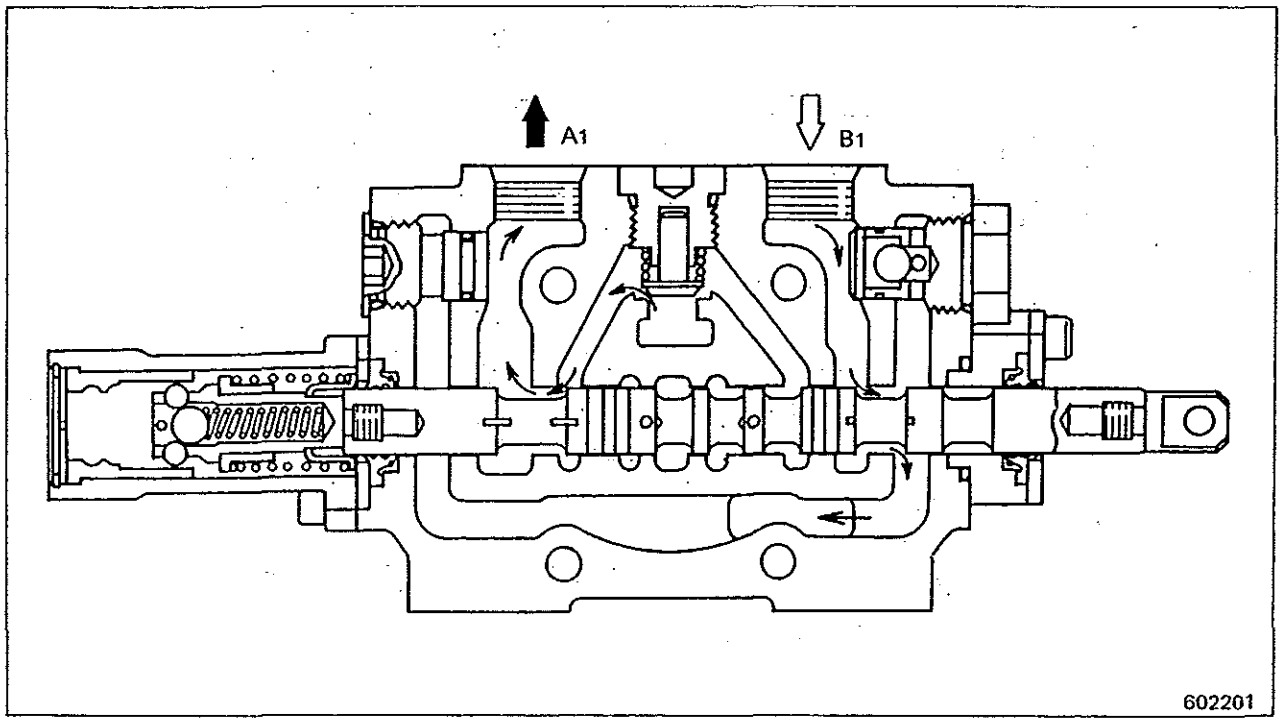
Lift valve plunger section



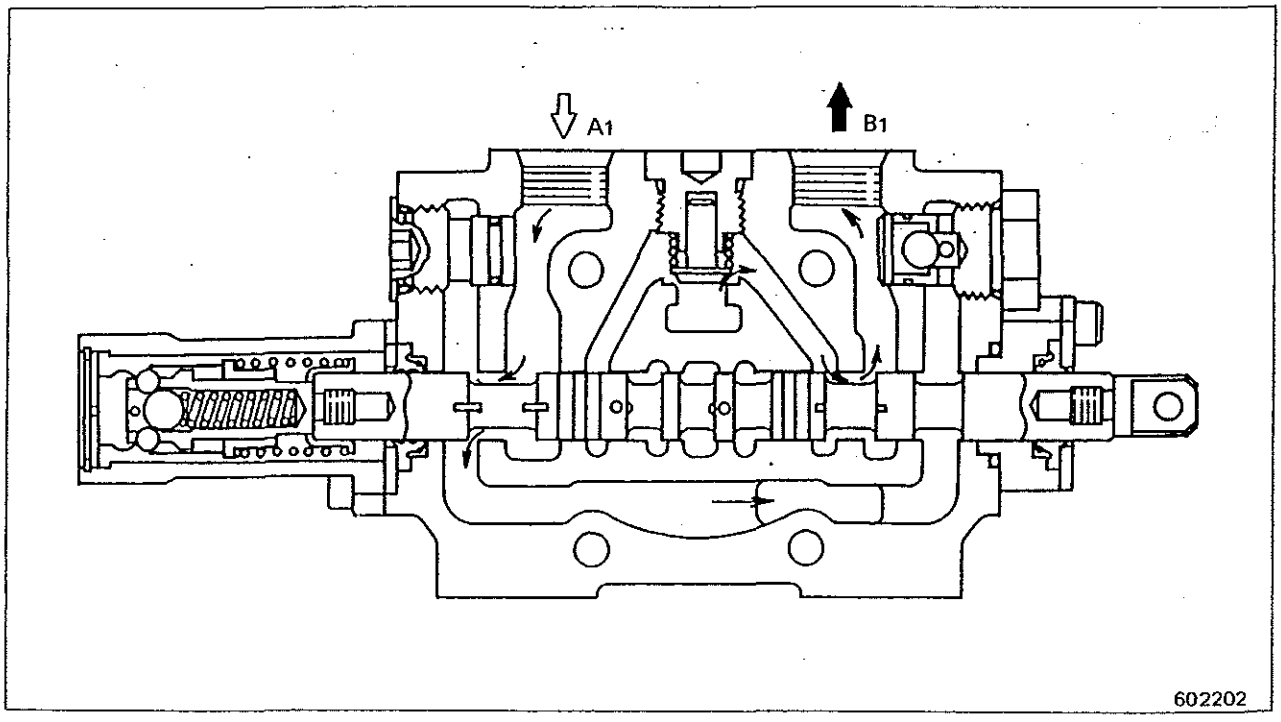
Dump valve plunger section

1 Plunger
2 Main relief valve
3 Safety valve
4 Makeup valve

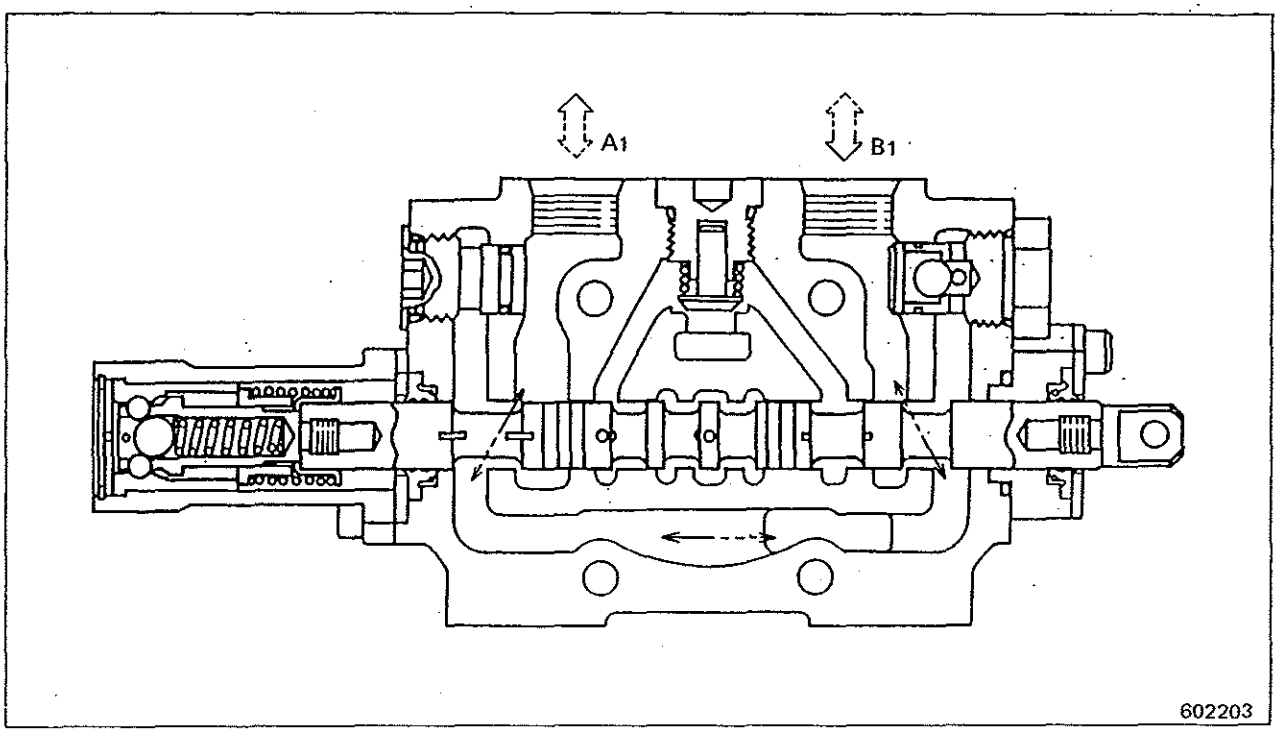
Lift valve plunger in pulled-out [RAISE] position



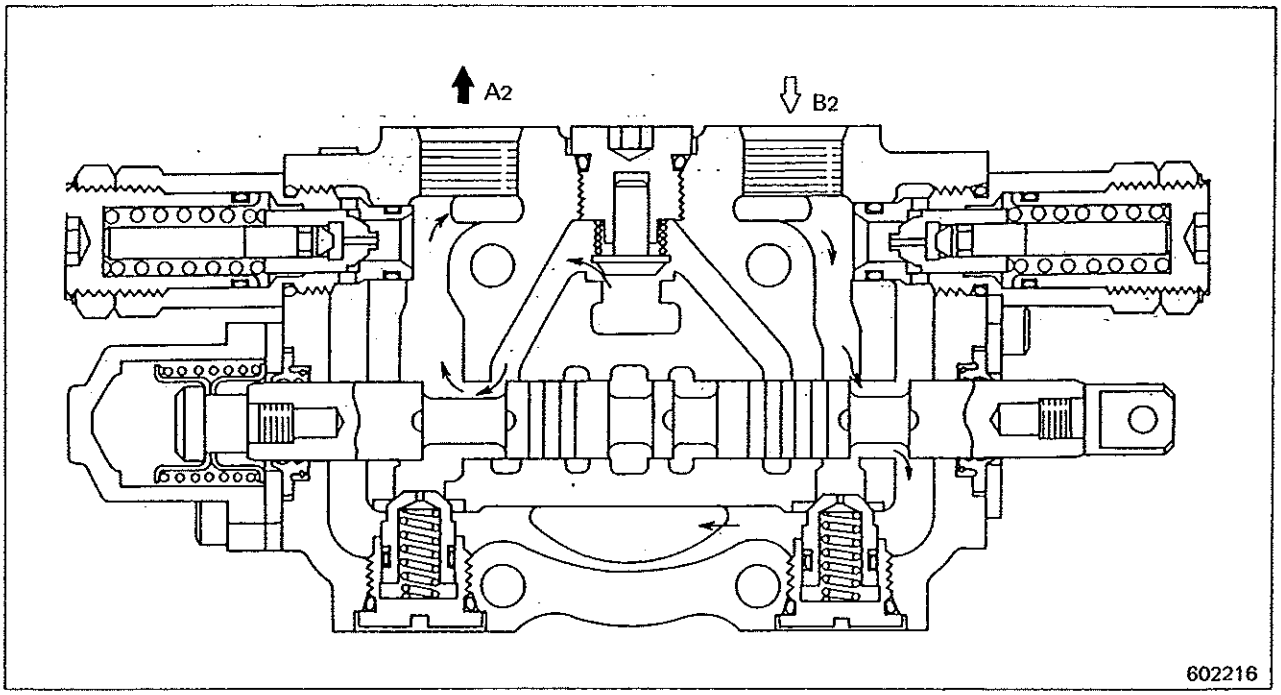
Lift valve plunger in pushed-in [LOWER] position



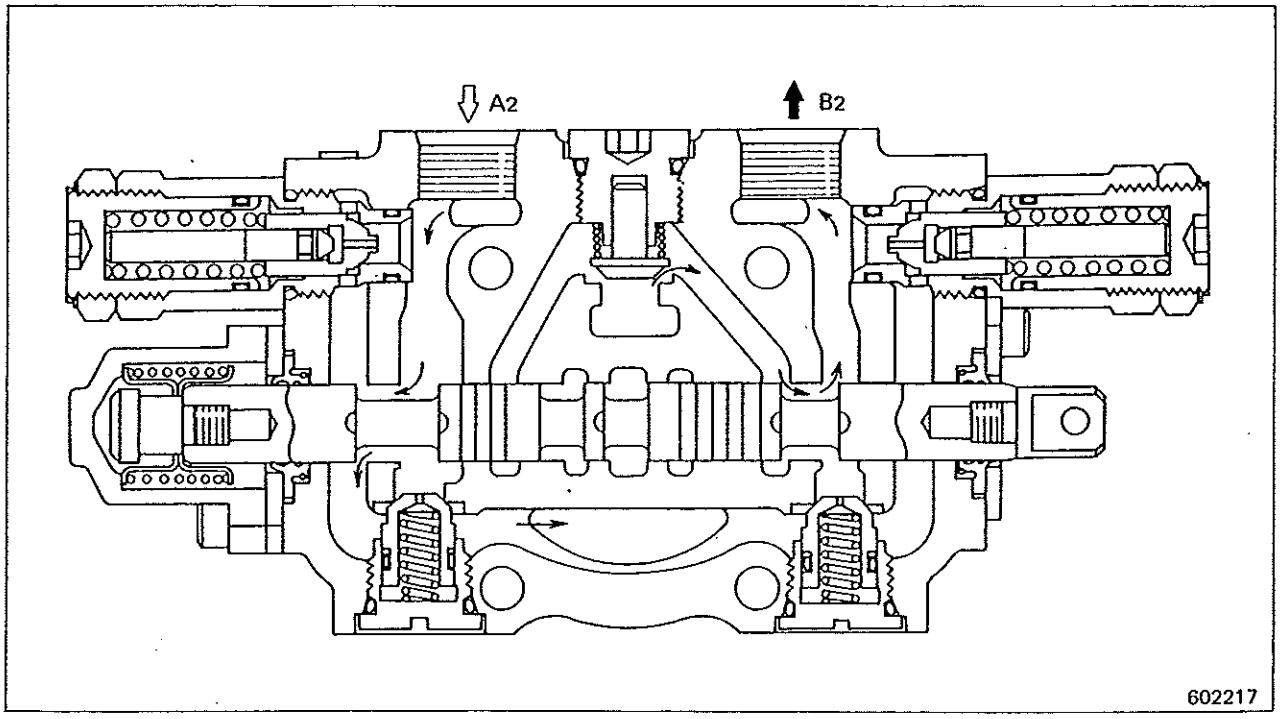
Lift valve plunger in pushed-in [FLOAT] position



Dump valve plunger in pulled-out [ROLLBACK] position



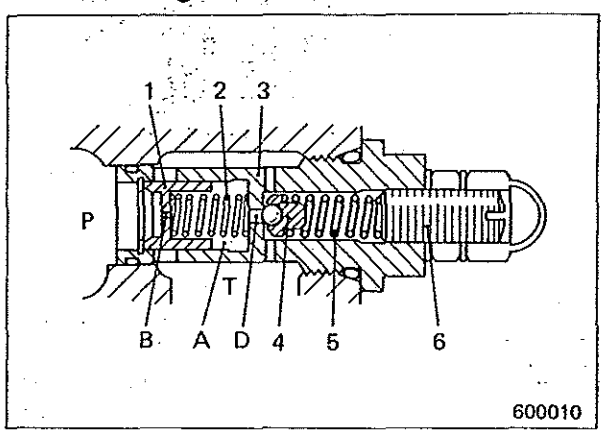
Dump valve plunger in pushed-in [DUMP] position



MAIN RELIEF VALVE

This valve protects hydraulic components by limiting the line pressure to a preset value. It is a sort of safety valve, and limits the line pressure by relieving through two-stage action.

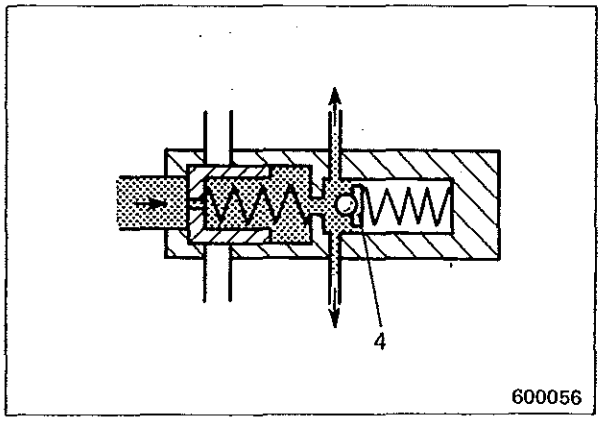
Non-relieving state



1 Valve
2 Spring
3 Valve body
4 Pilot valve
5 Spring
6 Adjusting screw

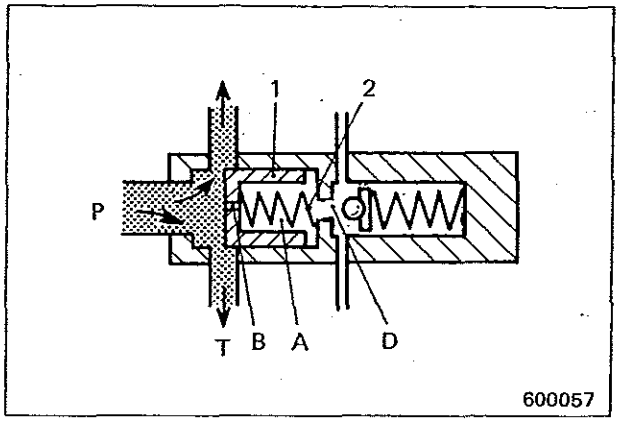
A Chamber
B Orifice
D Pilot valve port
P Pump port
T Tank port

Start of relieving action



As the line pressure rises to and above the preset value, it pushes pilot valve "4" off its seat by overcoming the force of pilot valve spring. This bleeds the oil out through outlet port to the tank port, creating a large pressure difference across valve "1."

Relieving action

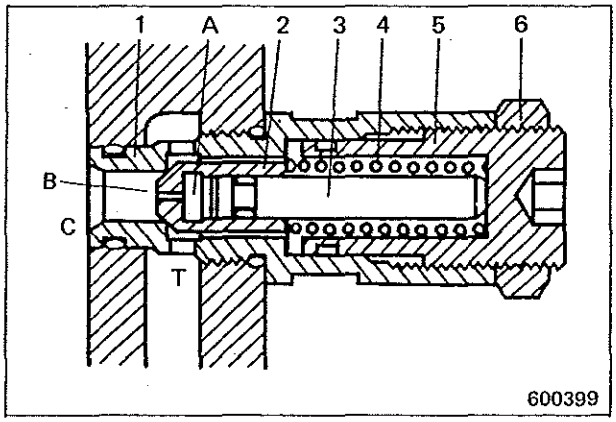


Because of the pressure difference (drop of the pressure in chamber "A" occurring because pilot valve port "D" is larger than orifice "B"), valve "1" slides to the right, thereby opening tank port "T," through which a large amount of oil flows into the tank to lower the line pressure.

SAFETY VALVE

This valve is used in the circuit leading to the cylinder. When an external force acts on the cylinder and the pressure in the circuit to that cylinder rises abnormally, it opens to relieve such a high pressure for protection of hydraulic components.

Normal (closed) state

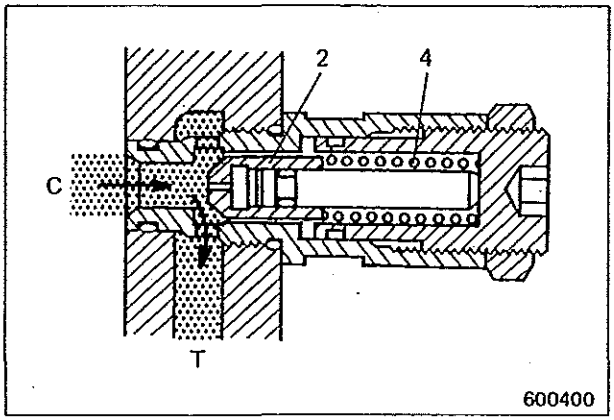


1 Valve body
2 Valve
3 Piston
4 Spring
5 Adjusting screw
6 Nut

A Chamber
B Orifice
C Cylinder port
T Tank port

The pressure in the circuit leading to the cylinder acts on piston "3" through orifice "B." In the normal state, this pressure is lower than the force of spring "4," and valve "2" is kept closed by the force of this spring.

Safety valve action



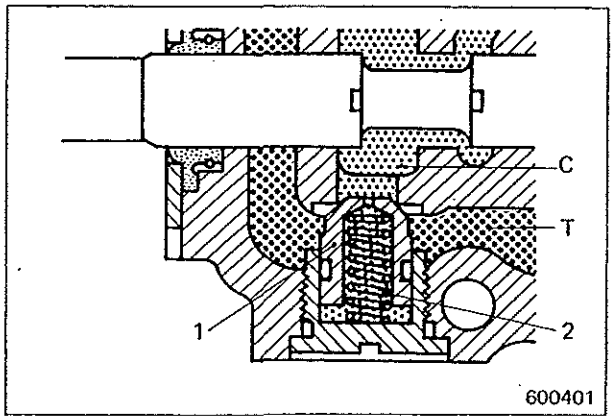
When the pressure rises above the preset value, it pushes valve "2" overcoming the force of spring "4." Under this condition, the oil from cylinder port "C" flows into tank port "T."

MAKEUP VALVE

This valve is used in the circuit leading to the cylinder to prevent the cylinder from moving erratically.

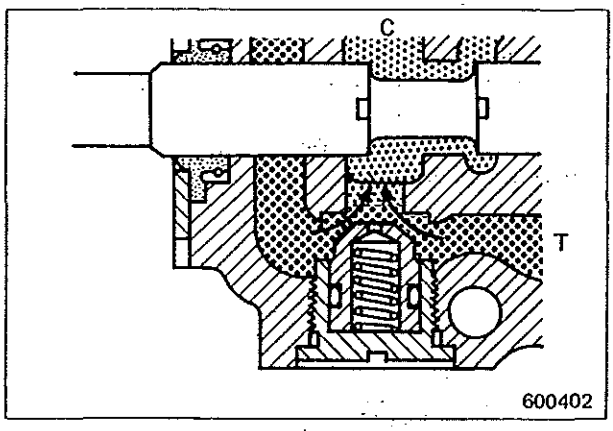
a. Makeup valve for dump cylinder

Normal (closed state)



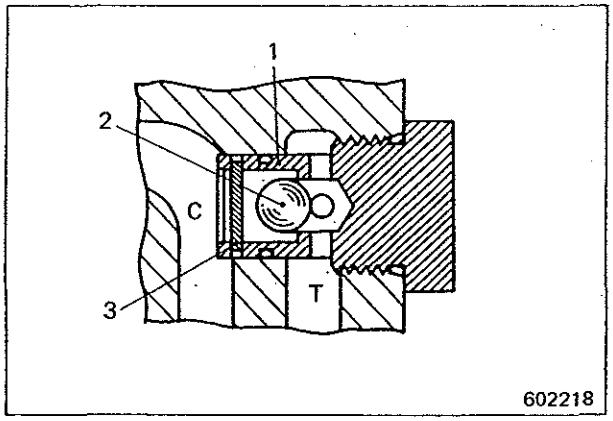
1 Valve
2 Spring
C Cylinder port
T Tank port

Making-up action



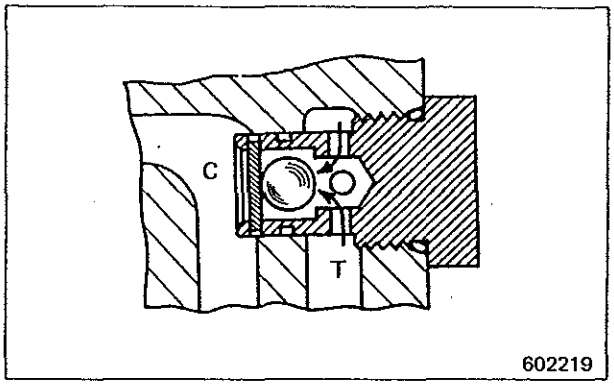
Valve "1" is kept closed by the force of spring "2" and hydraulic pressure acting on it. When an external force acts on the cylinder to move it faster as in LOWER position, the pressure in the circuit leading to cylinder port "C" drops lower than the pressure in the circuit leading to tank port "T." In such a case, the tank port pressure opens valve "1" to allow oil to flow back into cylinder port "C" for making up for the want of oil in the circuit leading to the cylinder.

b. Makeup valve for lift cylinder



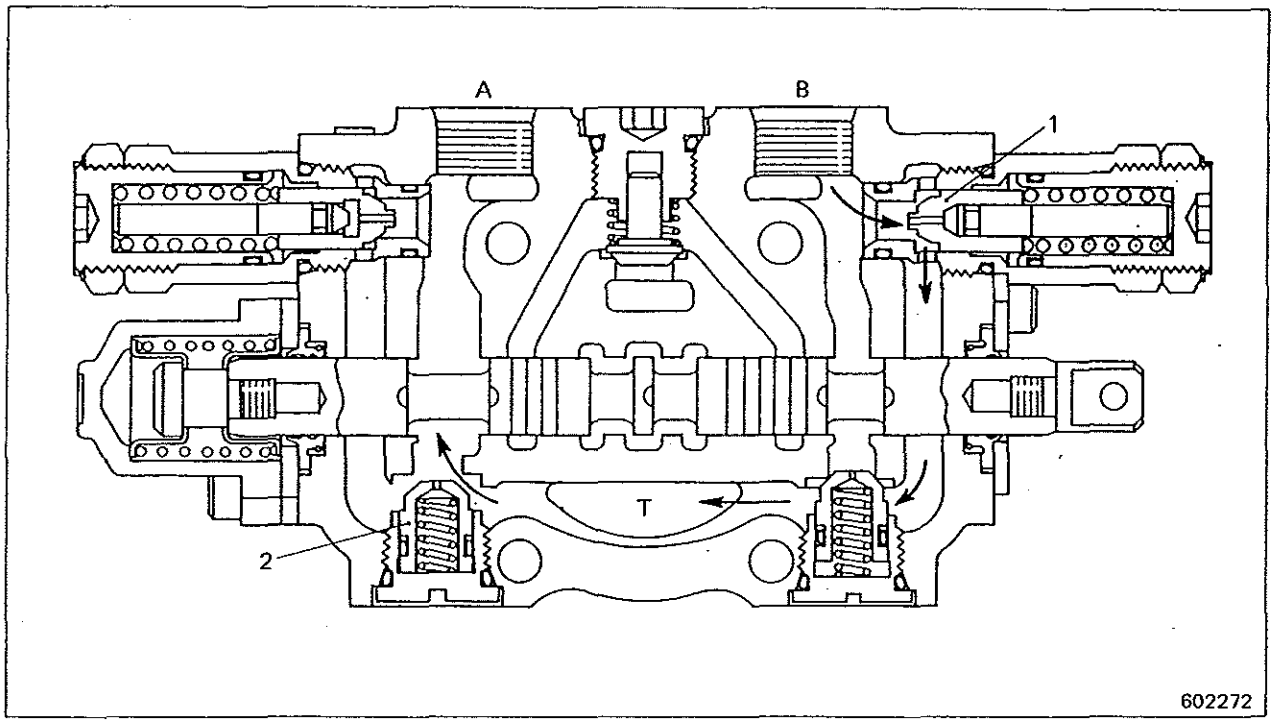
1 Valve
2 Steel ball
3 Spring pin
C Cylinder port
T Tank port

Making-up action



Function of safety valve and makeup valve

When control valve plunger is in neutral position



A Port A
B Port B
T Tank port

1 Safety valve
2 Makeup valve

When cylinder is loaded

Assume that the pressure in port "B" rises. Safety valve "1" in that port will be forced to open, thereby bleeding out the excess pressure. Now, such a pressure rise means that the cylinder piston is moved by an external force and that, because the piston will move slightly, the pressure in port "A" drops to create a vacuum condition. Under this condition, the makeup valve on that side acts to admit some make-up oil from tank port "T" into port "A."

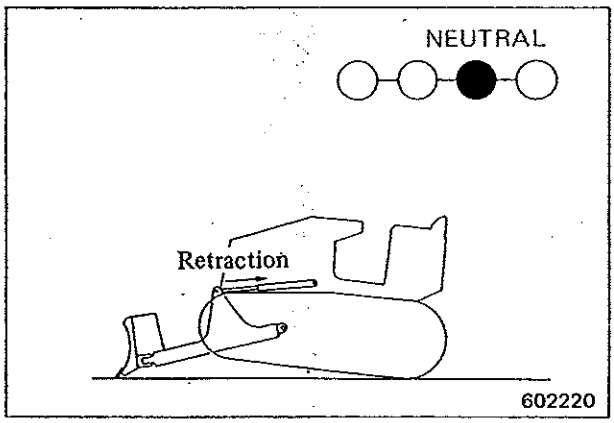
TESTING AND ADJUSTMENT

BD2$_G$ TRACTOR

TESTING CYLINDER RODS FOR DRIFT

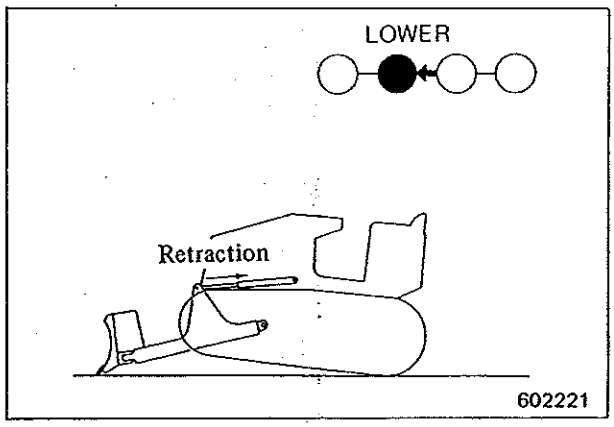
A. Blade lift cylinders (BD2$_G$-PAT, PT)

Test 1



Extend the lift cylinders to push on the ground with the blade to raise the front end of the machine. Move the control lever to NEUTRAL, stop the engine, and observe the retraction of each lift cylinder rod.

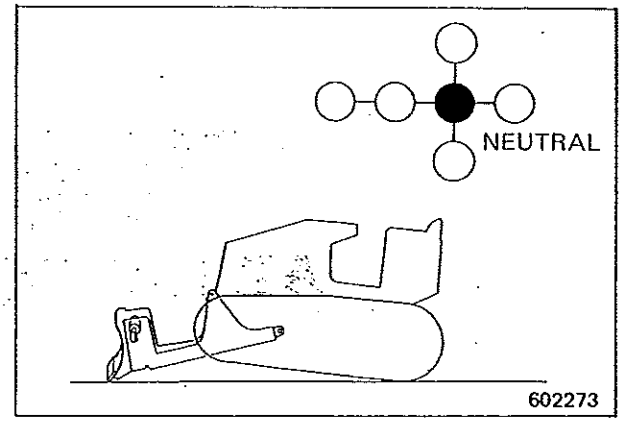
Test 2



With the front end of the machine raised as in Test 1, stop the engine, move the control lever to LOWER, and observe the retraction of each lift cylinder rod.

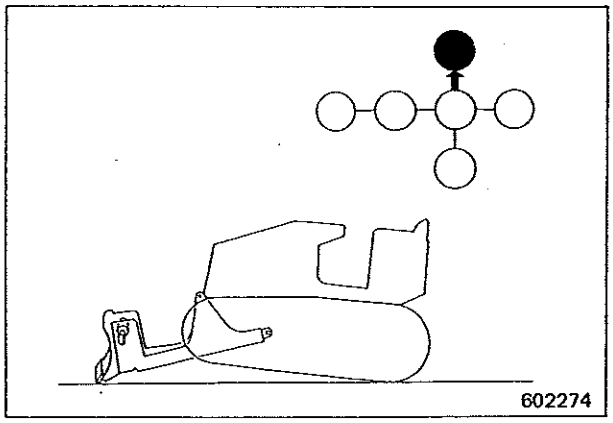
B. Blade tilt cylinder (BD2$_G$-PTA, PT)

Test 1



Raise the front end of the machine with the blade tilted left, move the control lever to NEUTRAL, stop the engine, and observe the retraction of tilt cylinder rod.

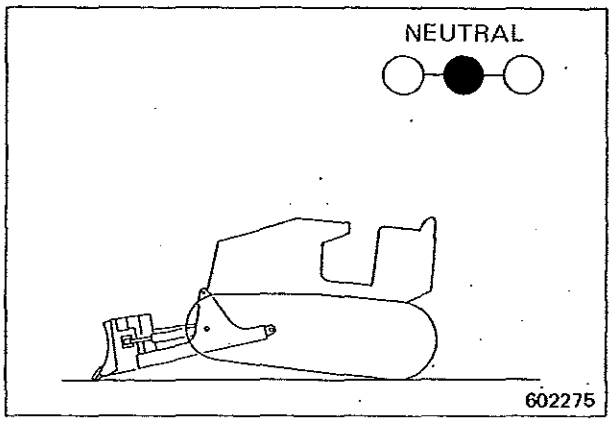
Test 2



Raise the front end of the machine with the blade tilted left, stop the engine, move the control lever to RIGHT TILT, and observe the retraction of tilt cylinder rod.

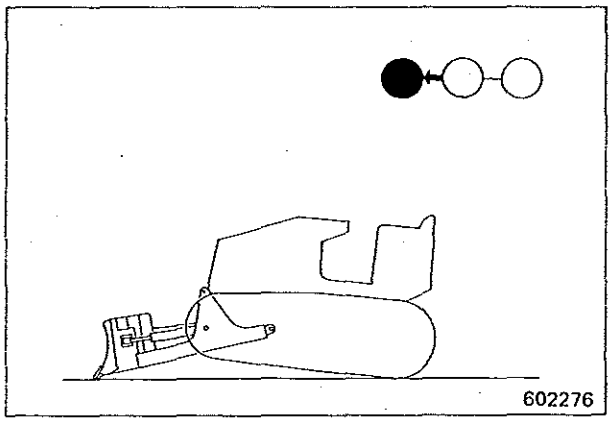
C. Blade angling cylinders ($BD2_G$-PAT)

Test 1



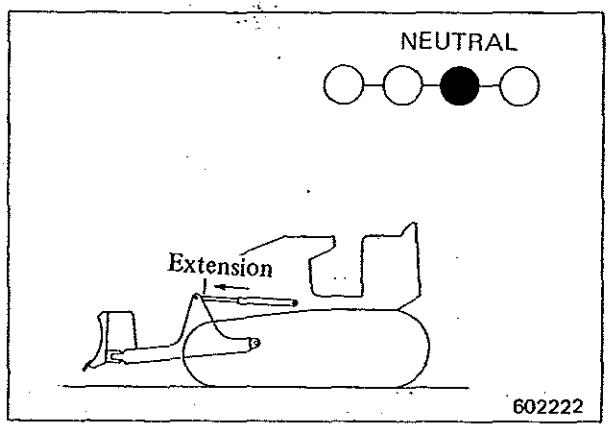
Raise the front end of the machine with the blade angled right or left, move the control lever to NEUTRAL, stop the engine, and observe the retraction of angling cyinder rod.

Test 2



Raise the front end of the machine with the blade angled right or left, stop the engine, move the control lever to the opposite angling side, and observe the retraction of angling cylinder rod.

TESTING LIFT CYLINDERS FOR BLADE HOLDING ABILITY ($BD2_G$-PAT, PT)



Raise the blade until the C frame is parallel to the ground, move the control lever back to NEUTRAL, stop the engine, and measure the extension of lift cylinder rod.

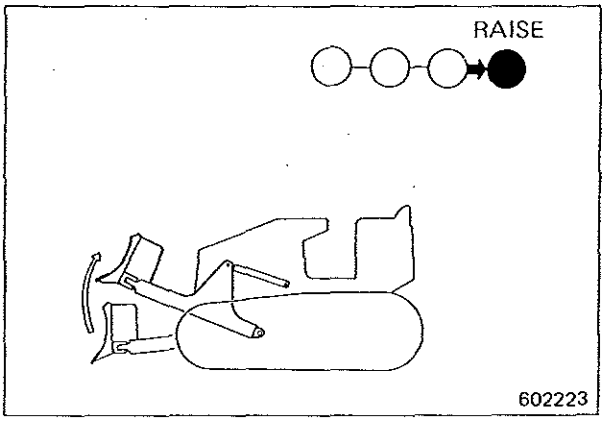
Rod extension: 20 mm (0.8 in.), max. in 5 minutes at oil temperature 30 to 40°C (86°to 104°F)

TESTING CYLINDERS FOR ACTUATING SPEED

Run the engine at idling (about 800 rpm) speed.

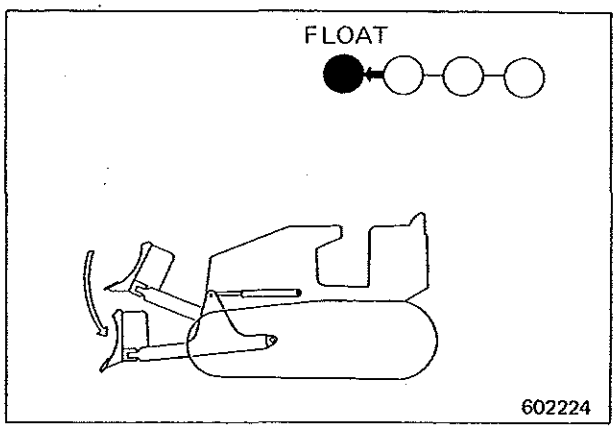
A. Blade lift cylinders ($BD2_G$-PAT, PT)

Test 1



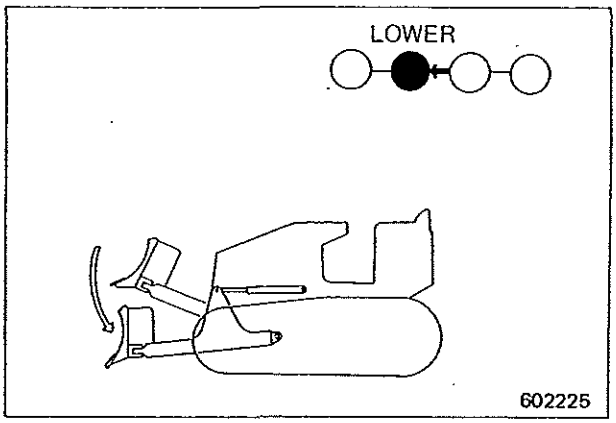
Lift circuit actuating speed test – 1	Specification
Time required for raising blade to maximum height from ground	4.0 sec.

Test 2



Lift circuit actuating speed test – 2	Specification
Time required for allowing blade to lower to ground from maximum height with control lever in FLOAT	0.8 sec.

Test 3



Lift circuit actuating speed test – 3	Specification
Time required for lowering blade to ground from maximum height with control lever in LOWER	2.4 sec.

B. Blade tilt cylinder ($BD2_G$-PAT)

Tilt circuit actuating speed test	Specification
Time required for altering raised blade from right (or left) tilt to left (or right) tilt	RH→LH 2.0 sec. LH→RH 1.6 sec.

C. Blade angling cylinders ($BD2_G$-PAT)

Angling circuit actuating speed test	Specification
Time required for altering raised blade from right (or left) angling to left (or right) angling	5.4 sec.

D. Blade lift cylinders ($BD2_G$-PT)

Test 1

Lift circuit actuating speed test – 1	Specification
Time required for raising blade to maximum height from ground	4.0 sec.

Test 2

Lift circuit actuating speed test – 2	Specification
Time required for allowing blade to lower to ground from maximum height with control lever in FLOAT	0.8 sec.

Test 3

Lift circuit actuating speed test – 3	Specification
Time required for lowering blade to ground from maximum height with control lever in LOWER	2.4 sec.

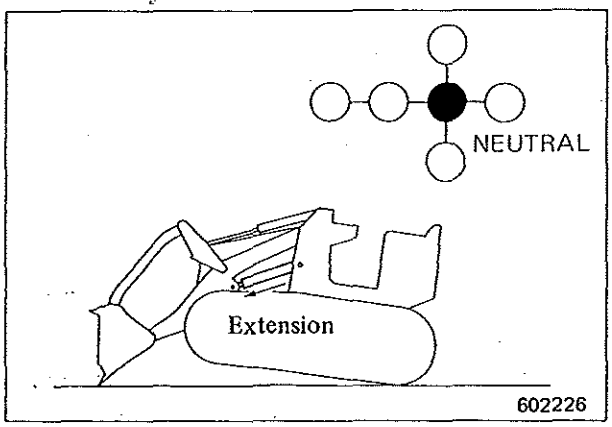
E. Blade tilt cylinders ($BD2_G$-PT)

Tilt circuit actuating speed test	Specification
Time required for altering raised blade from right (or left) tilt to left (or right) tilt.	RH→LH 1.8 sec. LH→RH 2.2 sec.

TESTING CYLINDER RODS FOR DRIFT

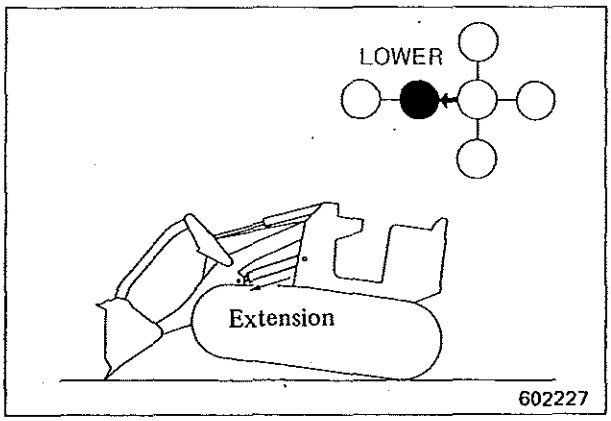
A. Bucket lift cylinders

Test 1



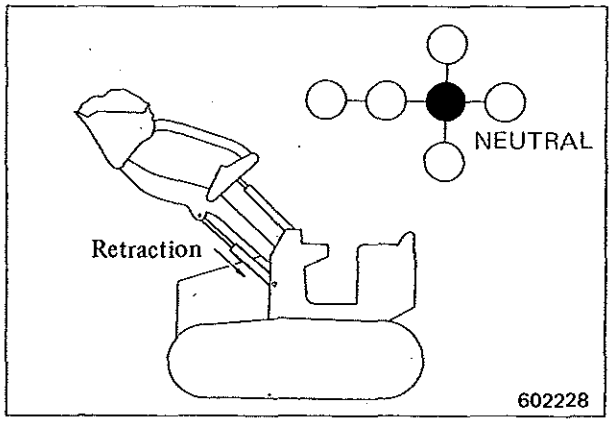
Raise the front end of the machine by pushing on the ground with the bucket, move the control lever back to NEUTRAL, stop the engine, and observe the extension of lift cylinder rod.

Test 2



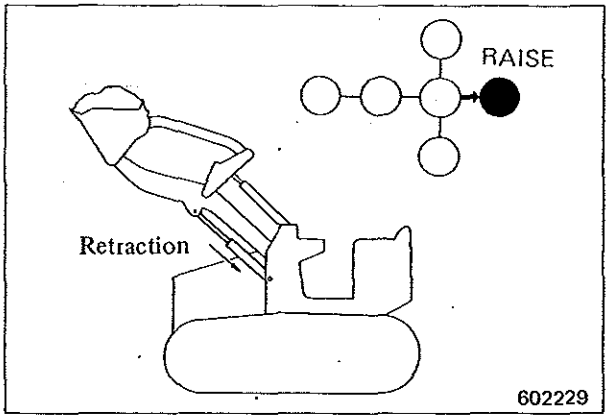
With the front end of the machine raised as in Test 1, stop the engine, move the control lever to LOWER, and observe the extension of lift cylinder rod.

Test 3



Fill up the bucket with material, raise the bucket to maximum height, stop the engine, move the control lever back to NEUTRAL, and observe the retraction of lift cylinder rod.

Test 4

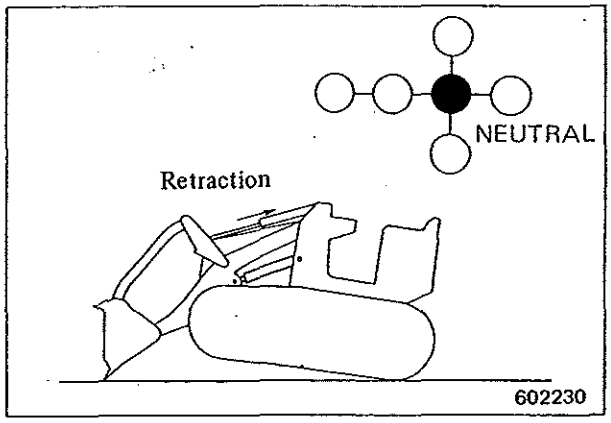


Fill up the bucket with material, raise the bucket to maximum height, stop the engine, move the control lever to RAISE, and observe the retraction of lift cylinder rod.

Test results	Possible cause
In Test 1 alone, lift cylinders yield to load and extend.	Makeup valve in rod-side circuit is leaky.
In Tests 1 and 3, lift cylinders yield to load and extend or retract.	1. Leakage past piston inside cylinder. 2. Leakage through sliding clearance around plunger inside control valve.
In Tests 2 and 4, lift cylinders yield to load and extend or retract.	Leaky check valve (leakage through between valve and seat or between seat and valve body).

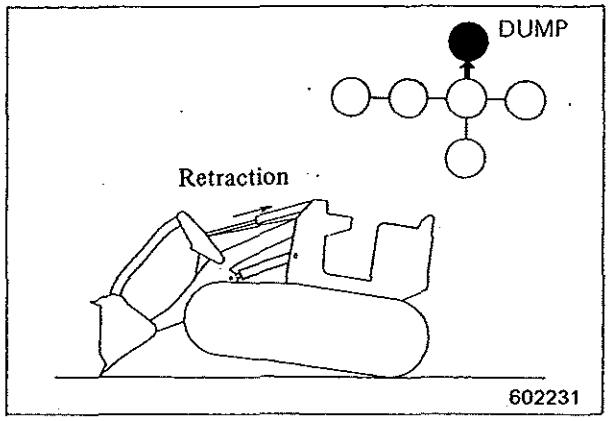
B. Bucket dump cylinders

Test 1



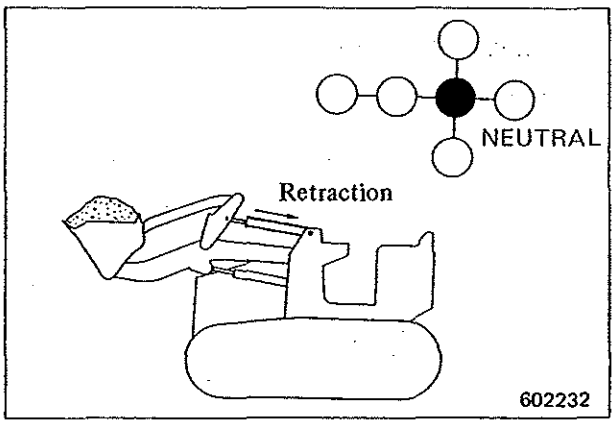
Raise the front end of the machine by pushing on the ground with the bucket being fully dumped, move the control lever to NEUTRAL, stop the engine, and observe the retraction of dump cylinder rod.

Test 2



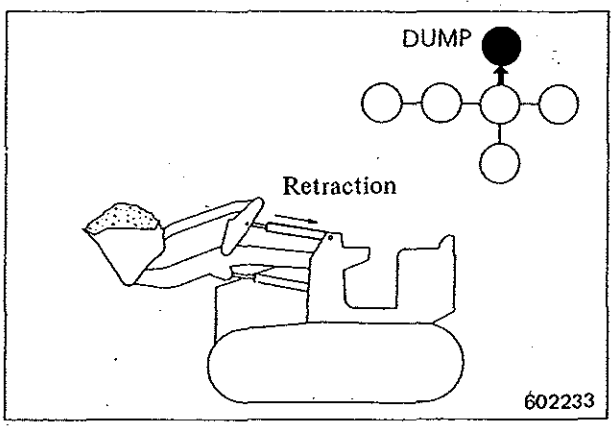
With the front end of the machine raised as in Test 1, stop the engine, move the control lever to DUMP, and observe the retraction of dump cylinder rod.

Test 3



Fill up the bucket with material, raise the bucket until the arms become nearly parallel to the ground, move the control lever to NEUTRAL, stop the engine, and observe the retraction of dump cylinder rod.

Test 4

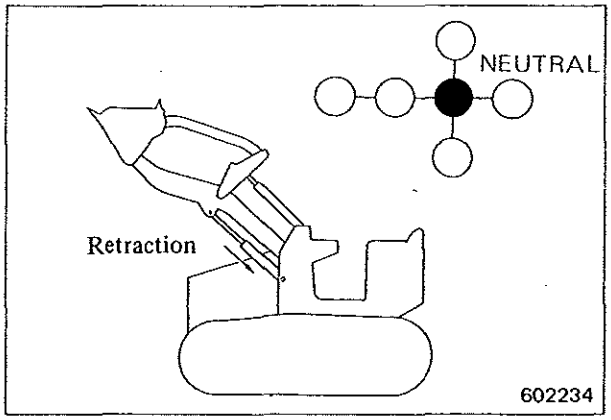


Fill up the bucket with material, raise the bucket until the arms become nearly parallel to the ground, stop the engine, move the control lever to DUMP, and observe the retraction of dump cylinder rod.

Test results	Possible cause
In Test 1 alone, dump cylinders yield to load and retract.	1. Safety valve in head-side circuit is leaky or damaged. 2. Makeup valve in rod-side circuit is leaky.
In Test 3 alone, dump cylinders yield to load and retract.	1. Safety valve in rod-side circuit is leaky or damaged. 2. Makeup valve in head-side circuit is leaky.
In Tests 1 and 3, dump cylinders yield to load and retract.	1. Leakage past piston inside cylinder. 2. Leakage through sliding clearance around plunger inside control valve.
In Tests 2 and 4, dump cylinders yield to load and retract	Leaky check valve (leakage through between valve and seat or between seat and valve body).

TESTING CYLINDERS FOR HOLDING ABILITY

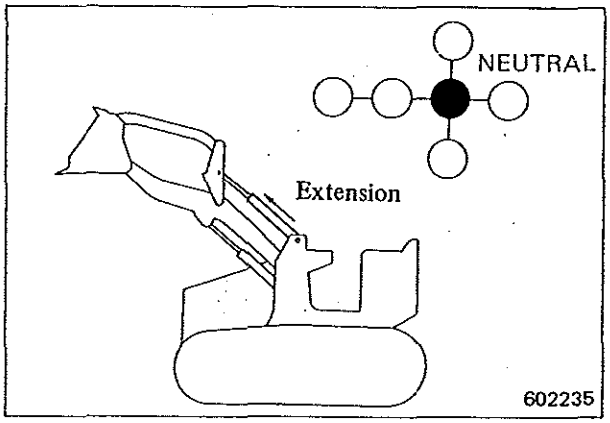
A. Bucket lift cylinders



Raise the bucket fully, move the control lever to NEUTRAL, stop the engine, and measure the retraction of lift cylinder rod.

Rod retraction:
5 mm (0.20 in.), max. in 5 minutes at oil temperature 30 to 40°C (86 to 104°F)

B. Bucket dump cylinders



Raise the bucket fully, dump it until its cutting edge is parallel to the ground, move the control lever to NEUTRAL, stop the engine, and measure the extension of dump cylinder rod.

Rod extension:
7 mm (0.28 in.), max. in 5 minutes at oil temperature 30 to 40°C (86 to 104°F)

NOTE

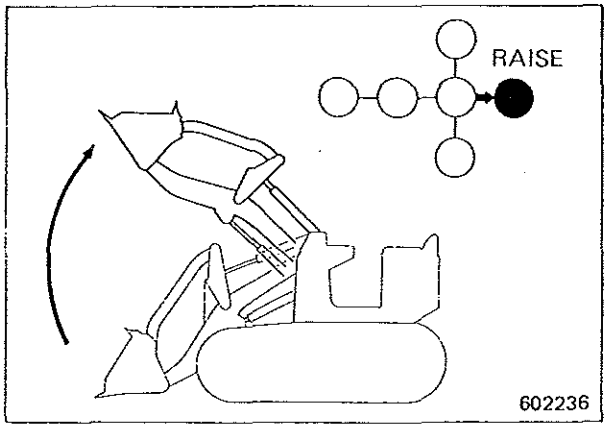
The test criteria cited above are for a new machine at shipping from the factory. A machine working in field may be permissible up to nearly twice these values.

TESTING CYLINDERS FOR ACTUATING SPEED

A. Bucket lift cylinders

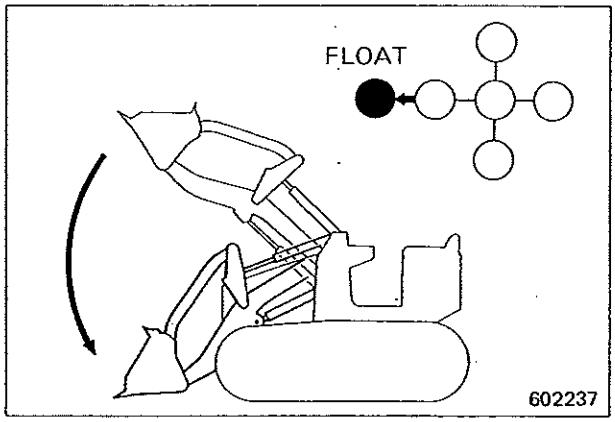
Run the engine at idling (about 800 rpm) speed.

Test 1



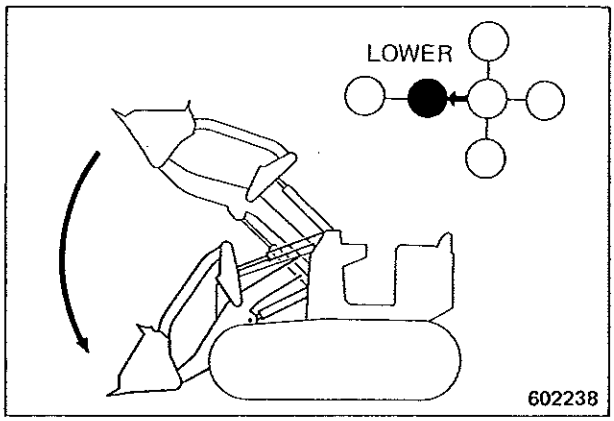
Lift circuit actuating speed test – 1	Specification
Time required for raising empty bucket to maximum height from ground	15.7 sec.

Test 2



Lift circuit actuating speed test – 2	Specification
Time required for allowing empty bucket to lower to ground from maximum height with control lever in FLOAT	3.9 sec.

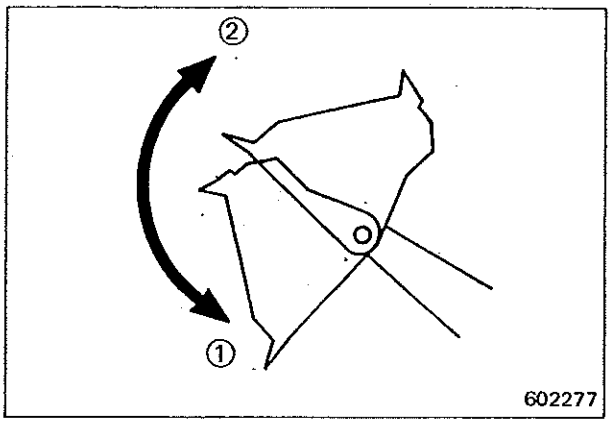
Test 3



Lift circuit actuating speed test – 3	Specification
Time required for lowering empty bucket to ground from maximum height with control lever in LOWER	5.3 sec.

B. Bucket dump cylinders

Run the engine at minimum speed (low idling speed).

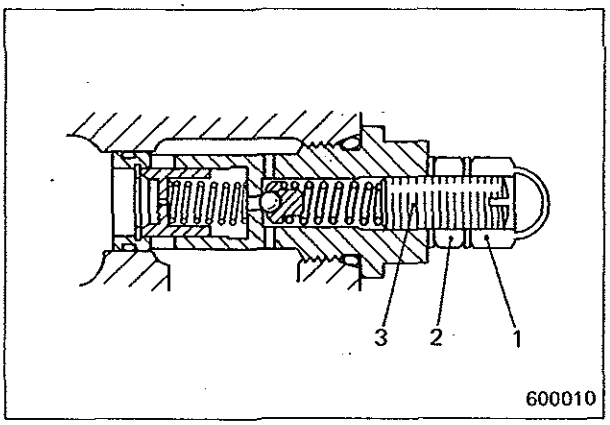


Dump circuit actuating speed test –①	Specification
Time required for dumping empty bucket fully from full rollback position (with lift cylinders fully extended)	3.1 sec.

Dump circuit actuating speed test –②	Specification
Time required for rolling back empty bucket fully from full dump position	3.3 sec.

ADJUSTING MAIN RELIEF VALVE

Relief pressure	180 kgf/cm² (2560 psi) [17.7 MPa]



1. Install a test pressure gauge on the inlet port.

Pressure gauge range	0 to 250 kgf/cm² (0 to 3555 psi) [0 to 25 MPa]

2. Remove cap nut "1" from main relief valve, and loosen jam nut "2."

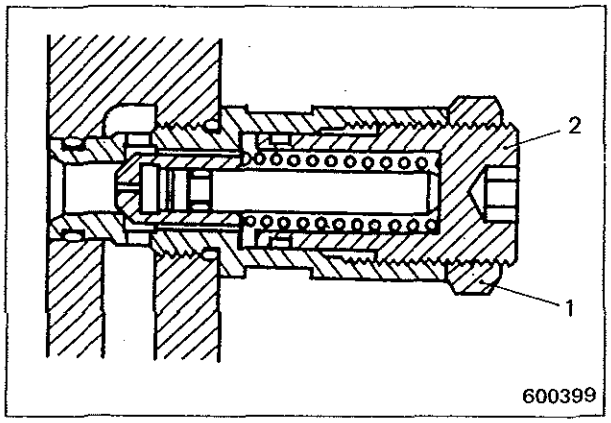
3. Start the engine, and run it at maximum speed.

4. Move the control lever to RAISE: this will raise the line pressure. See if the test gauge reads the specified relief pressure; if not, make an adjustment by means of adjusting screw "3."

Pressure change resulting from 1/4 rotation of adjusting screw	11 to 13 kgf/cm² (156 to 185 psi) [1.1 to 1.3 MPa]

ADJUSTING SAFETY VALVE

Safety valve location	Setting
BD2G-PT A1 port in lift cylinder rod-side circuit	200 kgf/cm² (2844 psi) [19.6 MPa]
BS3G B2 port in dump cylinder head-side circuit	160 kgf/cm² (2275 psi) [15.7 MPa]
BS3G A2 port in dump cylinder rod-side circuit	200 kgf/cm² (2844 psi) [19.6 MPa]



1. Install a test pressure gauge on each port.

Pressure gauge range	0 to 250 kgf/cm² (0 to 3555 psi) [0 to 25 MPa]

2. Loosen lock nut "1."

3. Apply hydraulic pressure due to an external force to each port, and see if the test gauge reads the specified pressure; if not, make an adjustment by means of adjusting screw "2."

Pressure change resulting from 1/4 rotation of adjusting screw	10 to 11 kgf/cm² (142 to 156 psi) [1.0 to 1.1 MPa]

NOTE

Do not attempt to adjust main relief valve and safety valve in field whenever possible. Replace them with properly adjusted ones.

TROUBLESHOOTING GUIDE

HYDRAULIC SYSTEM

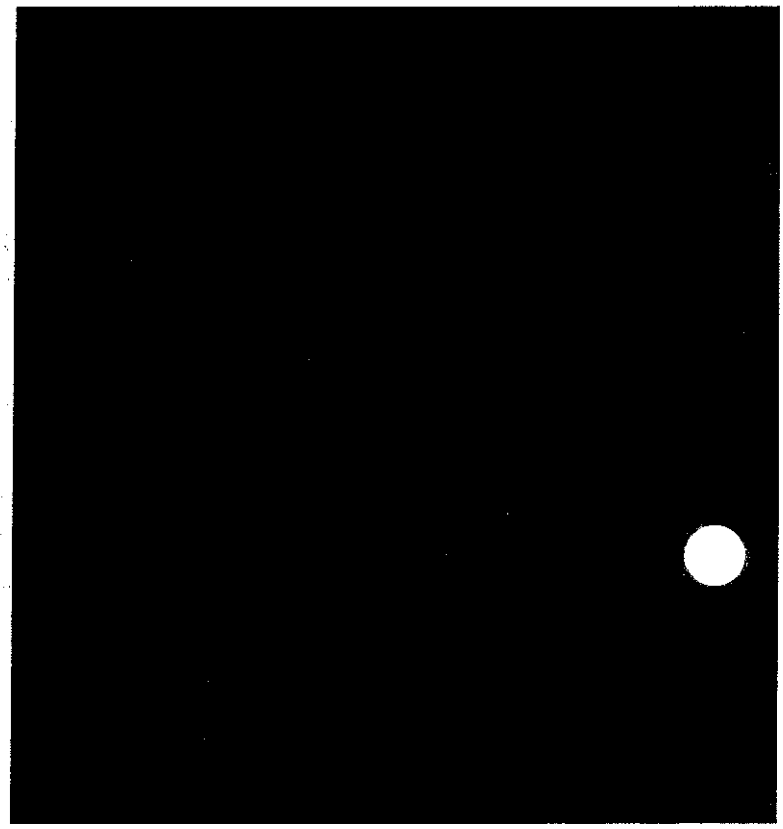
Complaint	Possible cause	Remedy
1. Pump noisy, cylinder action jerky and abnormal oil foaming	(1) Air in hydraulic system	• Prime.
	(2) Air leaks at pump inlet	• Prime.
	(3) Pump parts worn	• Replace.
	(4) Oil viscosity too heavy	• Change oil.
2. Oil temperature too high	(1) Oil viscosity too heavy	• Change oil.
	(2) Tendency to overloading	• Reduce load.
	(3) Pump parts worn	• Replace.
3. Pump not delivering enough oil	(1) Oil level low in tank	• Add.
	(2) Oil viscosity too heavy	• Change oil.
	(3) Pump speed low	• Disassemble and inspect.
	(4) Pump performance low	• Disassemble and inspect.
4. Cylinder motion slow	(1) Pump not delivering enough oil because of:	
	(a) Worn pump parts	• Replace.
	(b) Improperly assembled pump	• Reassemble.
	(2) Cylinder piston seals defective	• Replace.
	(3) O-ring seals in circuits defective	• Replace.
5. Cylinder motion erratic	(1) Piston seal rings worn	• Replace.
	(2) Control valve plungers worn	• Replace.
	(3) Makeup valve or safety valve not seating properly	• Repair or replace.
	(4) Main relief valve maladjusted or inoperative	• Disassemble and inspect.
	(5) O-rings in circuits defective	• Replace.

BLADE ($BD2_G$)

Complaint	Possible cause	Remedy
1. Blade (PAT)	(1) Cracks, distortion, dents or broken welds	• Repair or replace.
	(2) Pin holes worn	• Repair or replace bushings.
	(3) Blade surface worn	• Repair (reinforce by welding steel plate of about 3.2 mm (0.13 in.) thickness.
	(4) Cutting edge mounting seats distorted	• Repair.
	(5) Guide worn	• Replace.
	(6) Ball studs worn	• Repair or replace.
2. Blade (PT)	(1) Cracks, distortion, dents or broken welds	• Repair or replace.
	(2) Pin holes worn	• Repair or replace.
	(3) Blade surface worn	• Repair (reinforce by welding steel plate of about 3.2 mm (0.13 in.) thickness.
	(4) Cutting edge mounting seats distorted	• Repair.
3. Cutting edges and end bits	(1) Cracks, distortion or dents	• Repair or replace.
	(2) Abnormal wear	• Repair or replace.
4. Frame	(1) Twist, cracks, distortion, dents or broken welds	• Repair or replace.
	(2) Pin holes and trunnion bearings (PT) worn	• Replace.
5. Trunnions (PT)	(1) Abnormal wear	• Repair or replace.
	(2) Mounting bolts loose or damaged	• Retighten or replace.
6. Braces (PT)	(1) Distortion or wear	• Repair or replace.
	(2) Adjusting screw threads damaged or worn	• Repair or replace.

SHOVEL ($BS3_G$)

Complaint	Possible cause	Remedy
1. Bucket	(1) Cracks, distortion, dents or broken welds	• Repair or replace.
	(2) Pin holes worn	• Repair.
	(3) Cutting edge abnormally worn	• Repair.
	(4) Teeth broken or badly worn	• Repair or replace.
2. Lift arms and control arms	(1) Cracks or distortion	• Repair or replace.
	(2) Pin holes worn	• Repair.



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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G

TRACTOR SHOVEL BS3G

CONTENTS

POWER TRAIN
DISASSEMBLY AND REASSEMBLY

MITSUBISHI
HEAVY INDUSTRIES, LTD.

FOREWORD

This service manual has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations used in this manual are based on information that was current at the time this issue was written.

Correct servicing will give these machines a long productive life. Before attempting to start a test, repair or rebuild job, be sure that you have studied the respective sections of this manual, and know all the components you will work on.

Safety is not only your concern but everybody's concern. Safe working habits cannot be bought or manufactured; they must be learned through the job you do. By learning what CAUTION or WARNING symbol emphasizes, know what is safe – what is not safe. Consult your foreman, if necessary, for specific instructions on a job, and the safety equipment required.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

CAUTION ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of machine.

WARNING ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

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ENGINE DISMOUNTING AND MOUNTING

Dismounting

Preparatory steps

(1) Drain the oil from the engine and flywheel clutch case. [Engine oil: 7 liters (1.8 U.S. gal), approx., clutch oil: 5.5 liters (1.5 U.S. gal), approx.]

It may be possible to drain the oil with the engine and clutch lifted.

(2) Drain the coolant. [13 liters (3.4 U.S. gal), approx.]

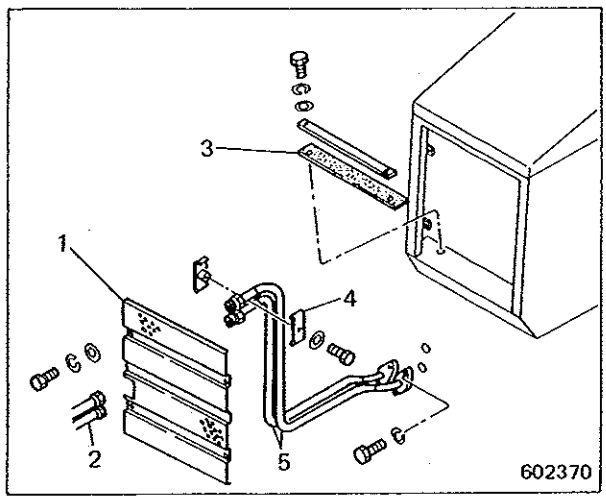
(3) Raise the bucket fully, and support the lift cylinders there by the brackets to prevent the bucket from lowering accidentally. Lower the bucket to the ground after removing the radiator guard and side covers ($BS3_G$).

(4) Disconnect the hoses and pipes from the blade tilt cylinder ($BD2_G$-PT).

1 Front guard
2 Rubber hoses (2 pcs)
3 Shield rubber
4 Clamp
5 Pipes (2 pcs)

NOTE

Disconnect pipes "5" after removing the side covers.

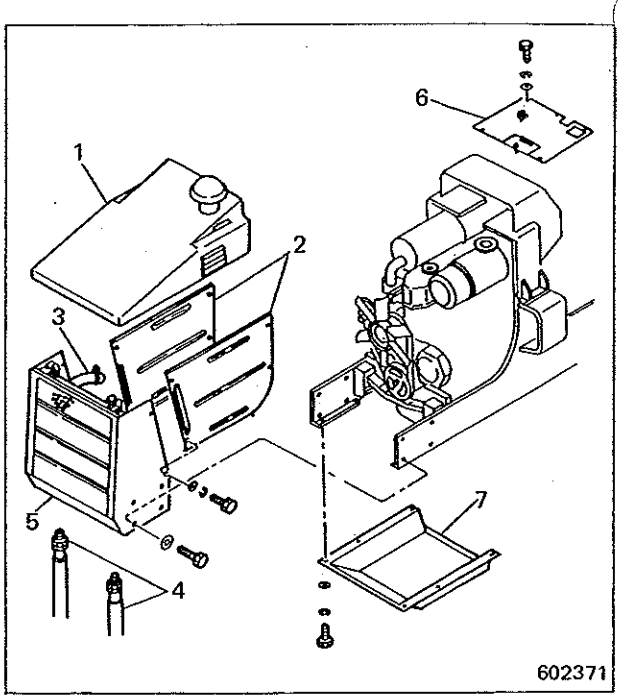


1. Remove the following parts:

1 Engine hood
2 Side covers (both sides)
3 Upper hose and lower hose
4 Oil cooler pipes (2 pcs)
5 Radiator and radiator guard
6 Floor plate (platform)
7 Under guard

NOTE

When unscrewing the bolts securing radiator guard "5" on BD2G-PAT, raise or lower the C-frame for access to the bolts.

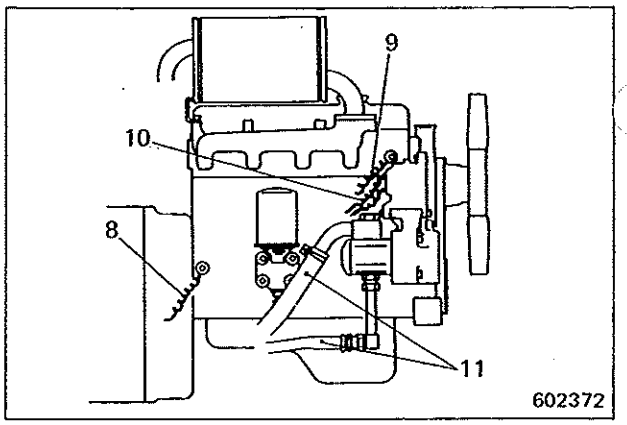


2. Remove the following electrical wires and parts on and around the engine:

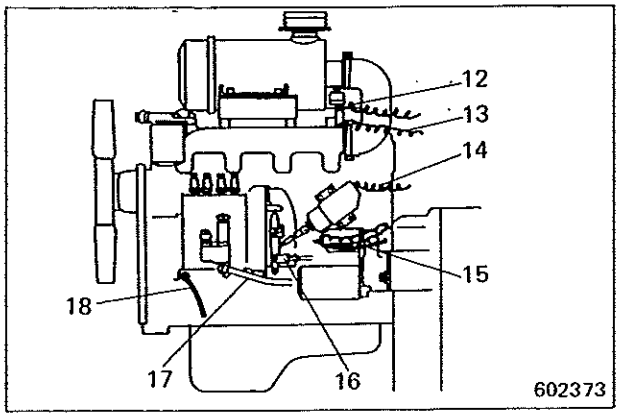
8 Oil pressure switch wire
9 Thermo switch wire
10 Alternator wire
11 Hydraulic rubber hoses (2 pcs)

NOTE

Before disconnecting the wires, mark them for the components to which they are to be reconnected at the time of installation.

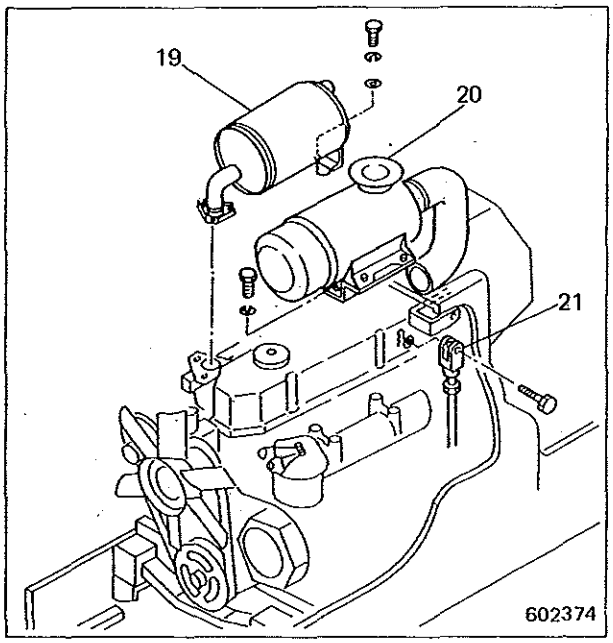


12 Air cleaner indicator wire
13 Glow plug wire
14 Stop solenoid wire
15 Starter wire
16 Engine control cable
17 Fuel hose
18 Ground wire



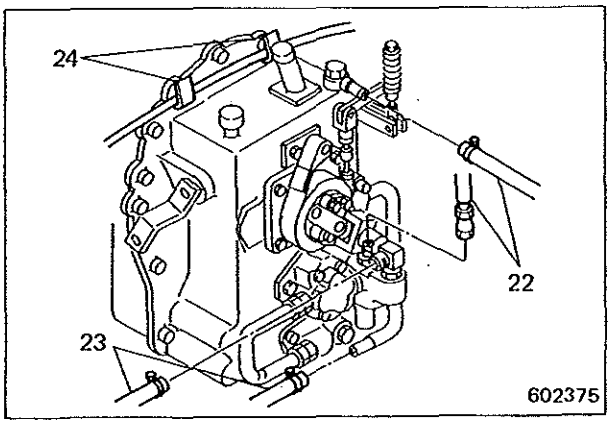
3. Remove the following parts:

19 Muffler
20 Air cleaner
21 Clutch control rod

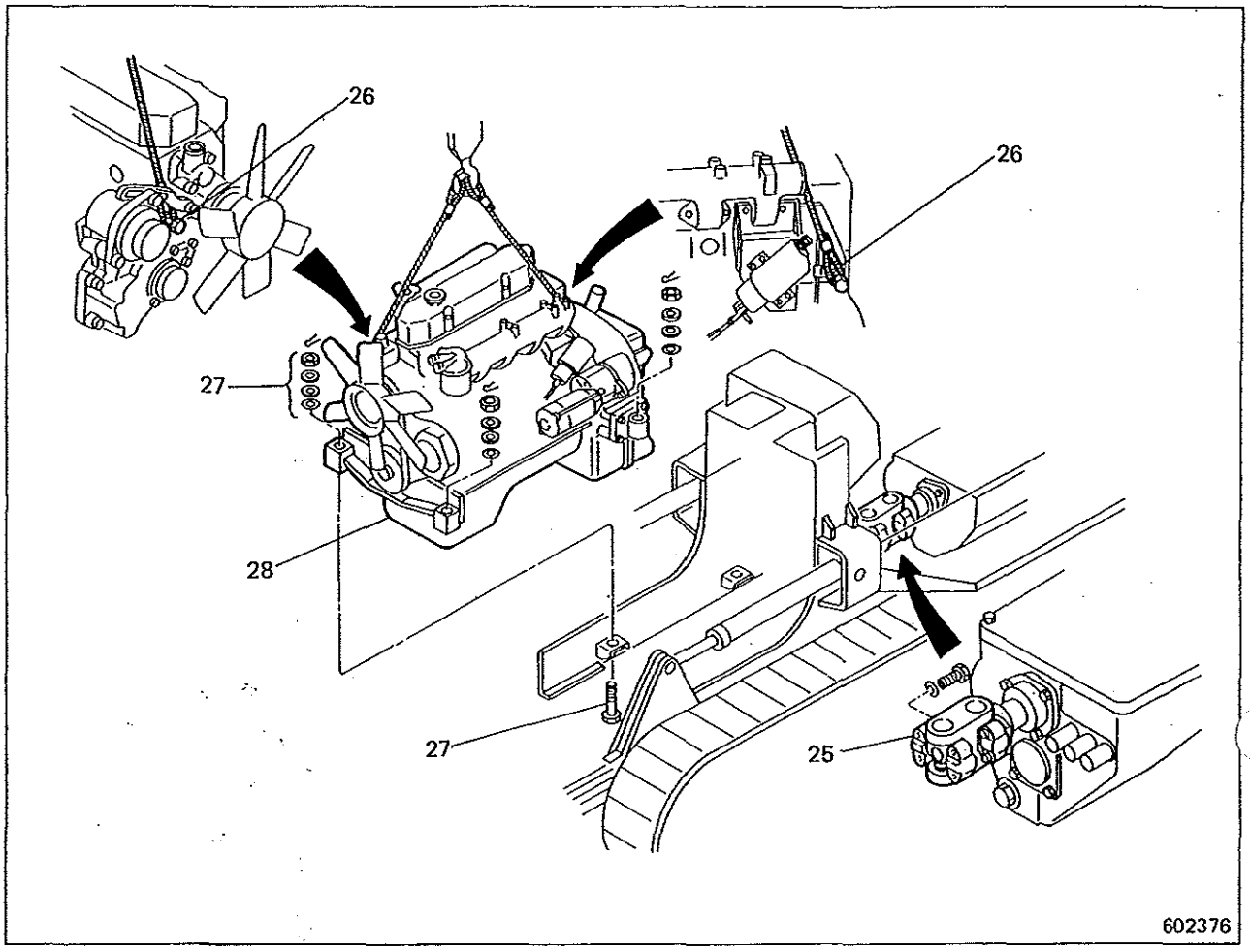


4. Remove the following parts:

22 Steering clutch oil rubber hoses (2 pcs)
23 Oil cooler rubber hoses (2 pcs)
24 Electrical wire (by loosening clamps)



5. Remove the following parts:



25 Disconnect the universal joint.
26 Attach lifting slings to the engine hitching bolts.
27 Remove the castle nuts, washers and bolts.
28 Lift off the engine and flywheel clutch.

NOTE

To leave the engine proper alone, remove the following parts:

a) Flywheel clutch
b) Hydraulic pump

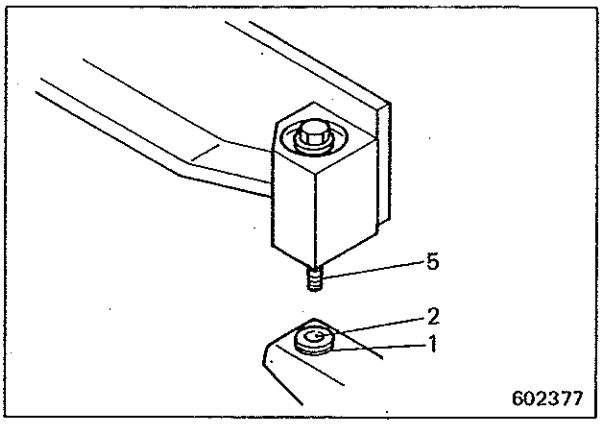
Weight of engine and flywheel clutch assembly	340 kg (750 lb), approx.

Mounting

To mount the engine and flywheel clutch, follow the reverse of dismounting procedure.

Tips for mounting

1. Insert bolt "5" into its hole in each mount bracket, and locate the brackets relative to the frame.



1 Shim 2 Washer 5 Bolt

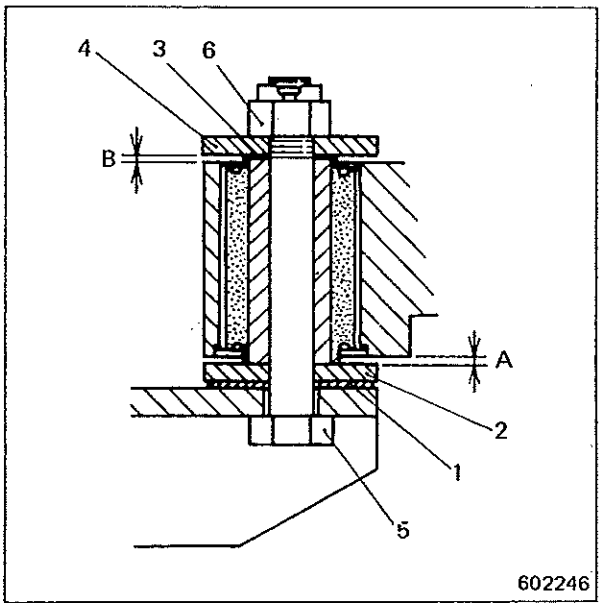
2. After the engine has been lowered onto the brackets, check top clearance "B" and bottom clearance "A."

(1) Locate shim "1" and washer "2" on bottom side and shim "3" and washer "4" on top side.

(2) Check to make sure that clearance "A" between the bottom end of mount bracket and washer "2" is 1.8 to 2.8 mm (0.07 to 0.11 in.).
If this clearance is zero (0) at one or more brackets, replace all brackets.

(3) With mount bolt "5" in place, see if clearance "B" is 1.2 to 2.2 mm (0.05 to 0.09 in.); if not reduce or increase the thickness of shim "3" to set the clearance within this range at each bracket.

(4) Tighten castle nut "6" to the specified torque.



(5) After tightening all the brackets, check to make sure that the engine clutch are level.
Use the following replacement parts as necessary.

Washers: 58611-11200,
4-mm (0.16-in.) thickness
58611-02400,
6-mm (0.24-in.) thickness
Shims: 58611-02500
(64361-74611,
1-mm (0.04-in.) thickness
64361-74612,
0.5-mm (0.02-in.) thickness)
64361-17516,
0.5-mm (0.02-in.) thickness

3. After mounting the engine and clutch on the frame:

(1) Make sure that the electrical wires, pipes and hoses are connected properly.

(2) Adjust the clutch pedal. (Refer to TESTING AND ADJUSTMENT volume.)

(3) Adjust the engine control.

(4) Fill the engine and clutch with recommended oil and coolant.

FLYWHEEL CLUTCH

The flywheel clutch can be disassembled after it is dismounted from the machine together with the engine, or on the machine. For dismounting of the clutch from the machine, refer to the topic, ENGINE DISMOUNTING AND MOUNTING.

Disassembly of the clutch on the machine

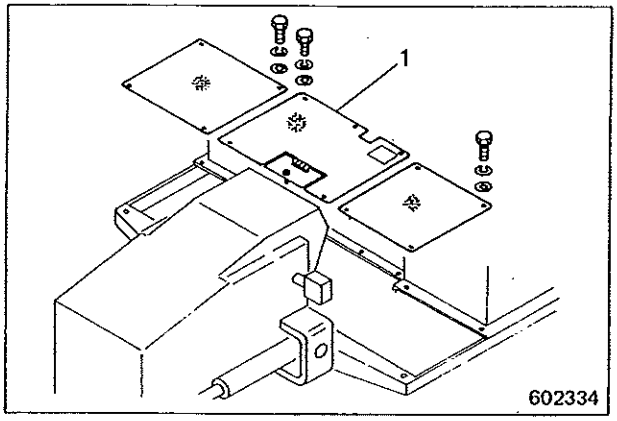
Preparatory steps

(1) Remove the under guard.

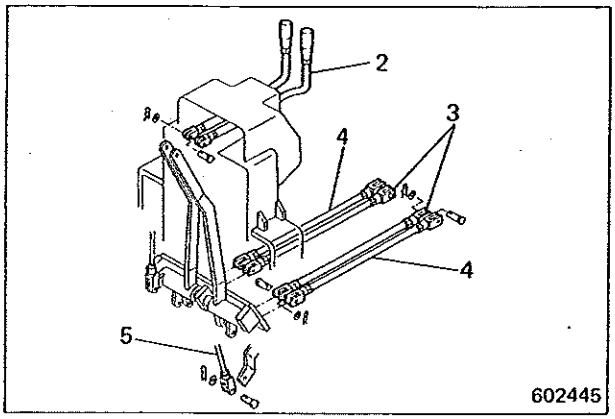
(2) Drain the oil from the clutch. [5.5 liters (1.5 U.S. gal), approx.]

1. Remove the following parts:

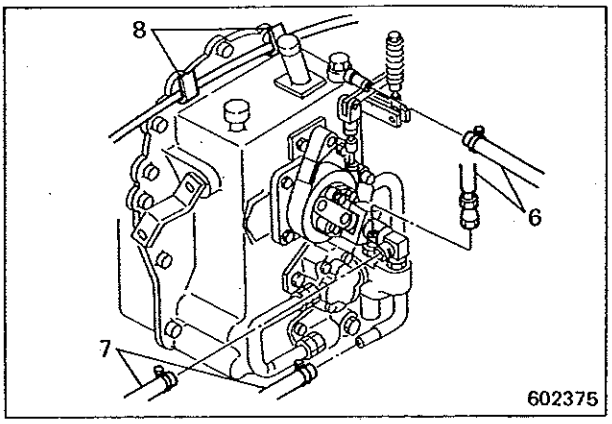
1 Floor plate (platform) (center, 1 pc)



2 Steering clutch levers (2 pcs)
3 Steering control rods (2 pcs)
4 Brake control rods (2 pcs)
5 Clutch control rod (1 pc)



6 Rubber hoses for steering clutches (2 pcs)
7 Rubber hoses for oil cooler (2 pcs)
8 Electrical wire (by loosening clamps)



2. After removing the universal joint, remove the following parts from the clutch case:

(1) Oil pump
(2) Relief valve
(3) Oil strainer
(4) Clutch brake

NOTE

Remove the universal joint together with the flange attached to the front end of input shaft.

3. Remove the oil filler from the threaded hole (M10 x 1.25) at the top of clutch case "9." Attach hook "A" in that threaded hole, and lift off the case.

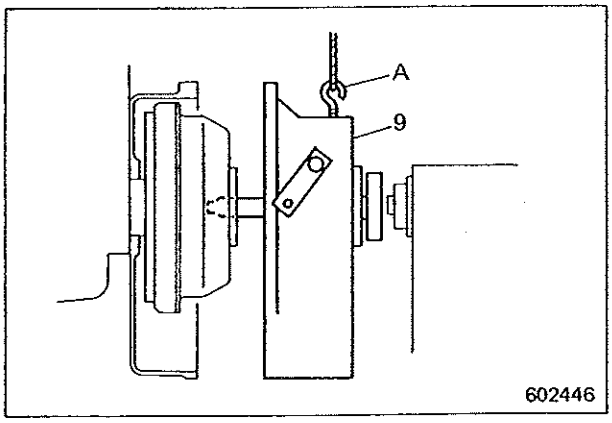
NOTE

When lifting off the clutch case, cover the dashboard for protection against damage.

4. Unscrew the bolts securing the clutch case, and move the case backward until it is possible to pull the main drive shaft out of the clutch cover.

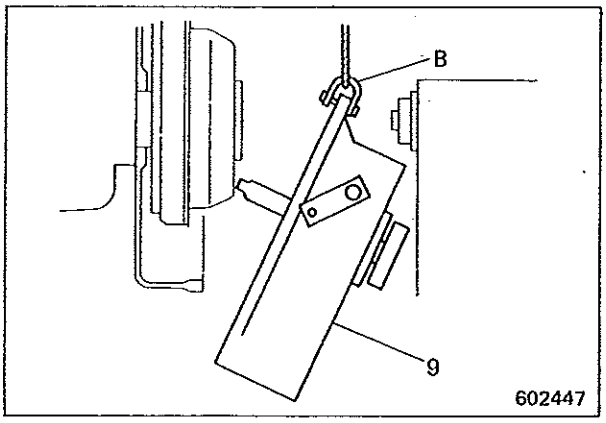
NOTE

Shift the lifting sling hitching point from hook "A" to shackle "B" attached to one of the case mounting bolt holes.



5. Tilt clutch case "9" with its rear (transmission) side lower than its front side, as shown, and take the case down.

6. For removal of the parts from the clutch case and removal of the pressure plate assembly from the engine flywheel, refer to the topic, Disassembly.



Reassembly

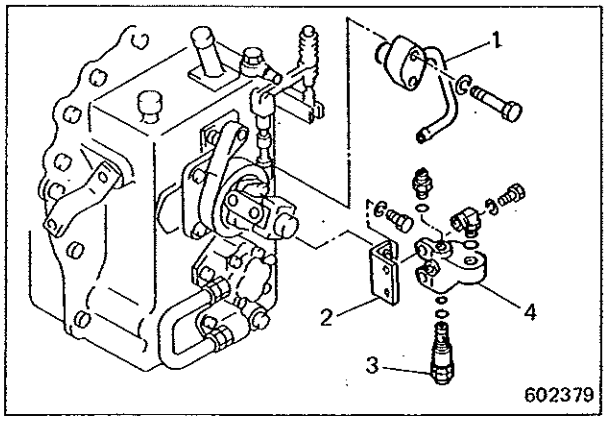
To reassemble the clutch, follow the reverse of disassembling procedure.

Disassembly of the clutch dismounted with the engine

Relief valve removal and installation

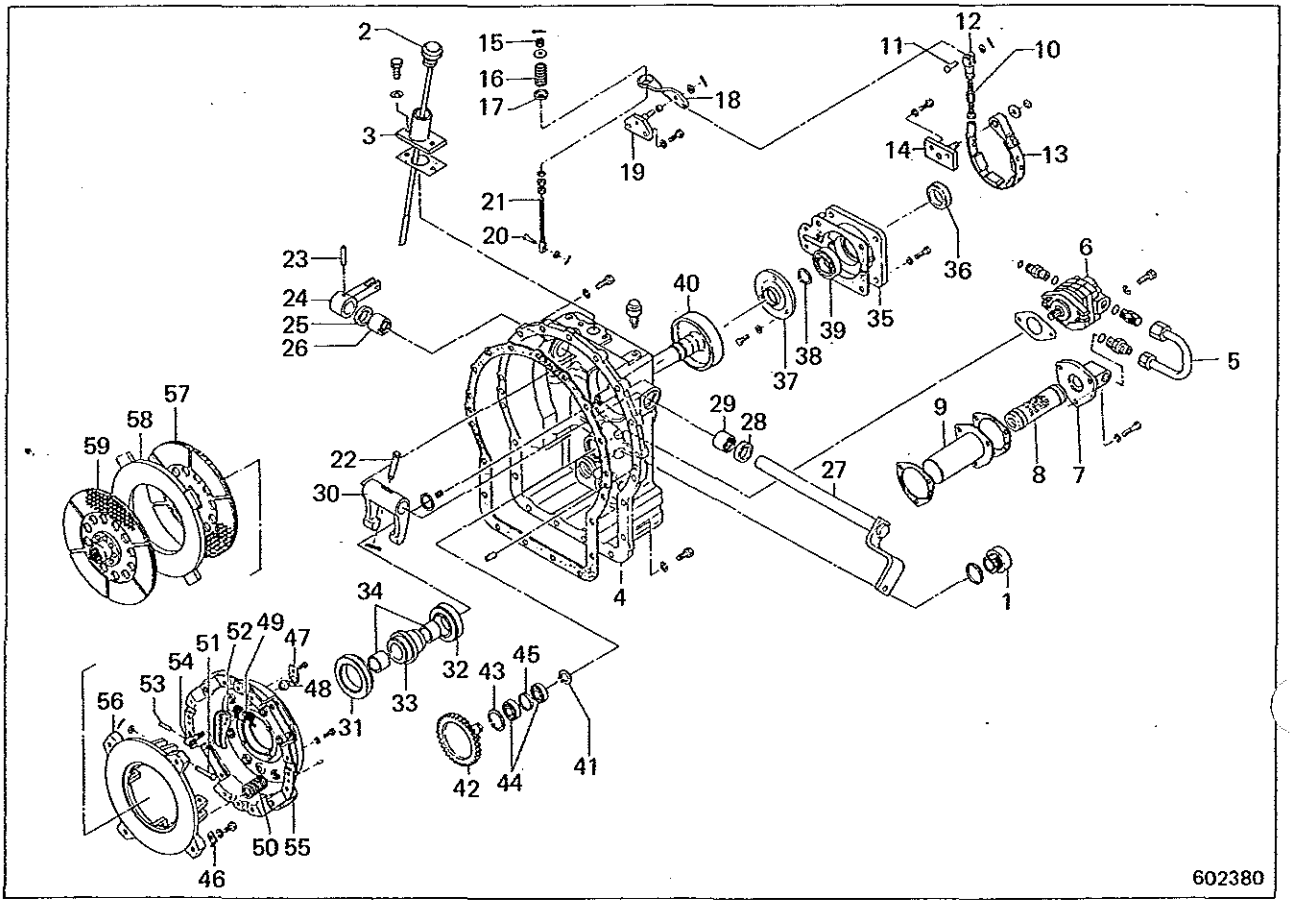
1. Remove the following parts:

   1 Pipe
   2 Bracket
   3 Relief valve
   4 Block



2. When installing the valve to the block, apply a coat of oil to the O-ring of the oil pump-side connector.

Disassembly (The following procedure assumes that the clutch is dismounted with the engine but it may be followed in disassembling the clutch on the machine.)



(Remove the parts in the order numbered for disassembly.)

1 Drain plug
2 Oil level gauge
3 Oil filler
4 Clutch case (to be removed as an assembly including "5" thru "45")
5 Suction pipe
6 Oil pump
7 Filter cover
8 Filter
9 Filter case
10 Adjusting bolt
11 Pin
12 Clevis
13 Brake band
14 Support
15 Castle nut
16 Spring
17 Spring seat
18 Lever
19 Support
20 Pin
21 Bolt
22 Pin
23 Pin
24 Lever
25 Oil seal
26 Needle roller bearing
27 Shaft
28 Oil seal
29 Needle roller bearing
30 Release lever (fork)
31 Bearing
32 Bearing
33 Release hub
34 Bushing
35 Cover
36 Oil seal
37 Cover
38 Snap ring
39 Bearing
40 Main drive shaft
41 Snap ring
42 Gear
43 Snap ring
44 Bearing
45 Spacer
46 Washer (to be removed as an assembly including "47" thru "56")
47 Lock plate
48 Nut
49 Return spring
50 Pressure spring
51 Pin
52 Release lever
53 Pin
54 Lever support
55 Clutch cover
56 Pressure plate
57 Clutch disc
58 Mating plate
59 Clutch disc

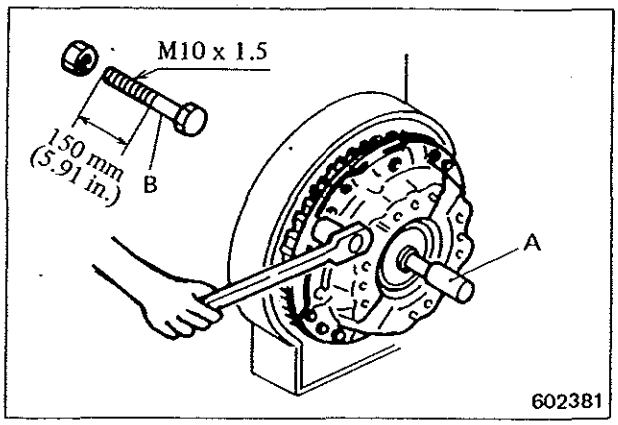
Tips for disassembly

1. Clutch case removal

Remove oil filler "3" from the threaded hole (M10 x 1.25) at the top of clutch case "4." Attach the hook in that threaded hole, and lift off the case.

2. Pressure plate assembly removal

Before removing pressure plate assembly, mark pressure plate "56" and clutch cover "55." Install clutch disc arbor "A" (special tool) in the splined hole of clutch disc, and run guide bolt "B" into each clutch spring hole. Tighten the guide bolts to compress the clutch springs lightly, and remove the pressure plate assembly.



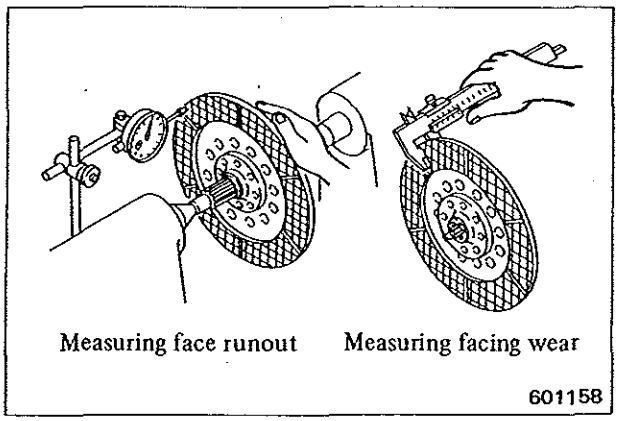
Inspection

1. Clutch discs

Measure the face runout, facing wear and fit of hub splines. Replace the disc if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness of facing	5.7 – 6.3 (0.224 – 0.248)	-0.4 (-0.016) for one side -0.8 (-0.031) for both sides
Face runout	0.7 (0.028), max.	0.7 (0.028), min.
Fit of hub splines	0.05 – 0.15 (0.0020 – 0.0059)	0.30 (0.0118)

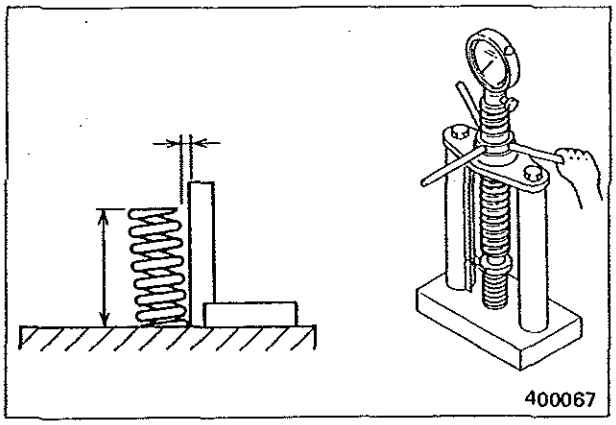


2. Pressure springs

Measure the free length, test force and squareness. Replace the spring if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Free length	70.6 (2.780)	68.5 (2.697)
Test force/length under test force kgf (lbf) [N]/ mm (in.)	43.5 ± 2.2 (95.9 ± 4.9) [426.6 ± 21.6]/ 48.2 (1.898)	39.2 (86.4) [384.4]/ 48.2 (1.898)
Squareness	2°, max.	3°, min.

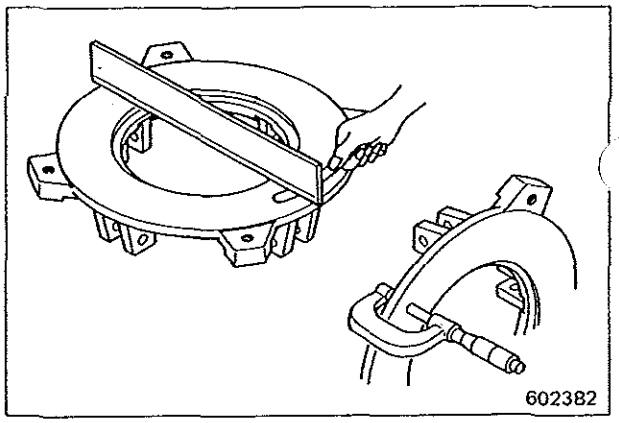


3. Pressure plate

Measure the flatness and wear of the friction surface. Replace the pressure plate if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness of friction surface	20.2 (0.795)	19.7 (0.776), max.
Flatness	0.05 – 0.15 (0.0020 – 0.0059)	0.30 (0.0118)

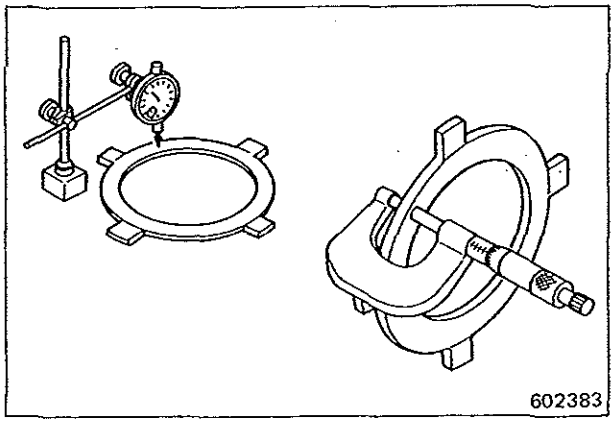


4. Mating plates

Measure the flatness and wear of the friction surface. Replace the mating plate if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness of friction surface	13.0 (0.512)	12.5 (0.492), max.
Flatness	0.05 – 0.10 (0.0020 – 0.0039)	0.20 (0.0079)

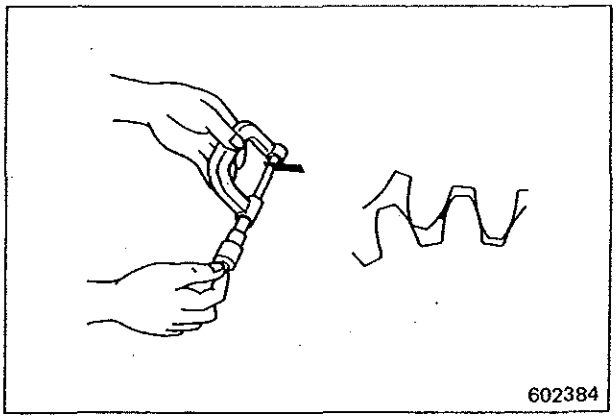


5. Pump drive gear

Measure the pump drive gear backlash. Replace the gear if the measurement exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Backlash	0.35 – 0.42 (0.0138 – 0.0165)	0.70 (0.0276), min.

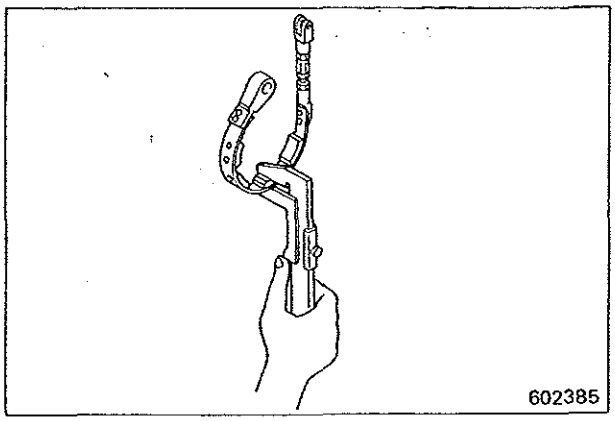


6. Brake band

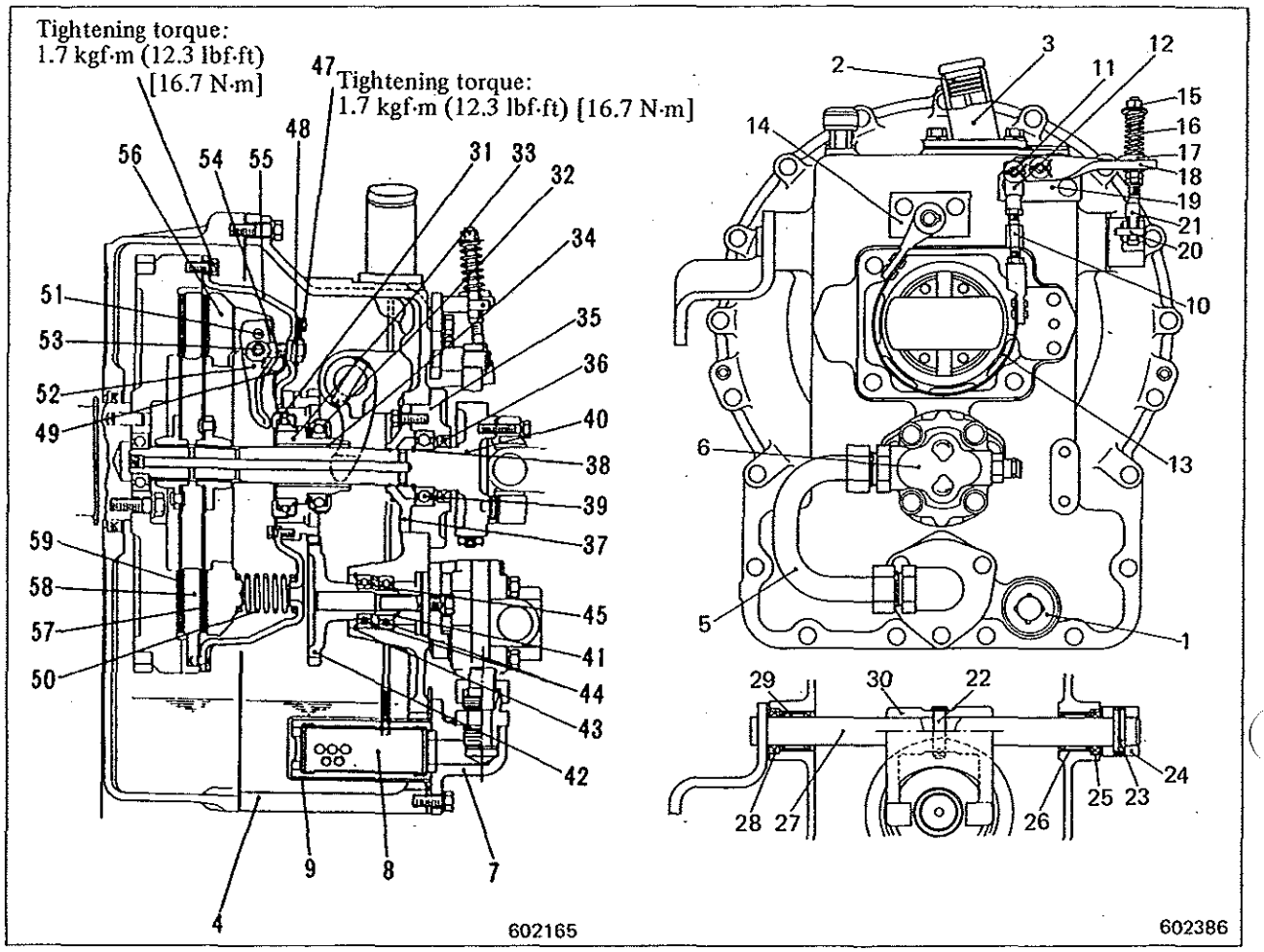
Measure the thickness of the facing. Replace the band if the measurement exceeds the service limit.

Unit: mm (in.)

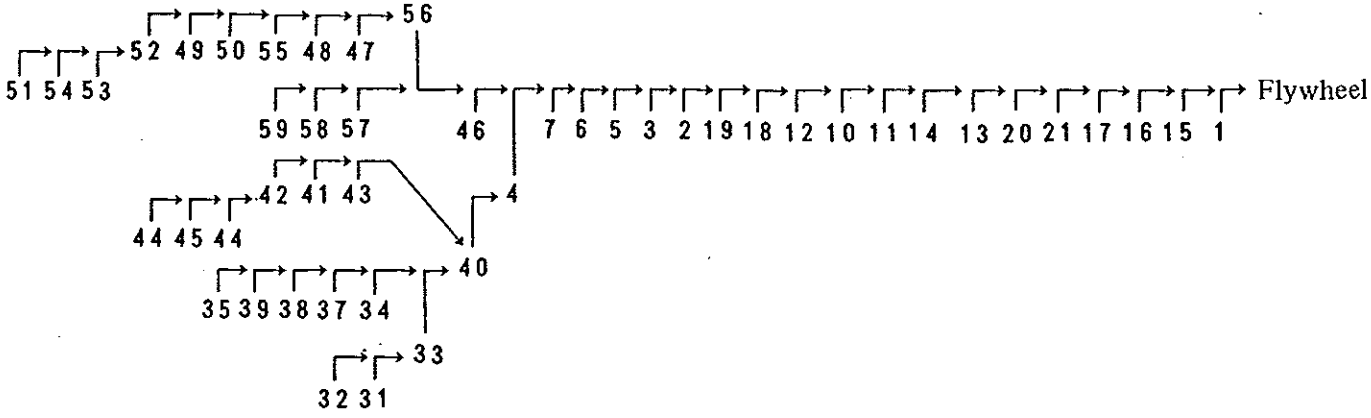
Item	Assembly standard	Service limit
Thickness of facing	5.0 (0.197)	3.0 (0.118), max.



Reassembly



Reassembling order

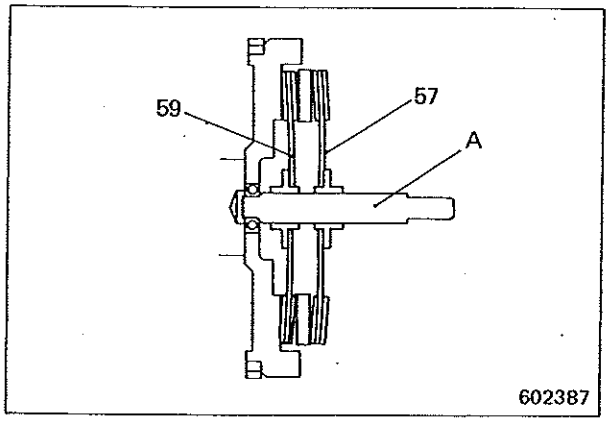


Tips for reassembly

1. Clutch disc installation

Use clutch disc arbor "A" (special tool) to install pressure plate assembly including parts "46" thru "56," mating plate "58" and clutch discs "57" and "59." When installing them, note that the clutch discs are "dished."

Tighten the mounting bolts to the specified torque in a criss-cross pattern.

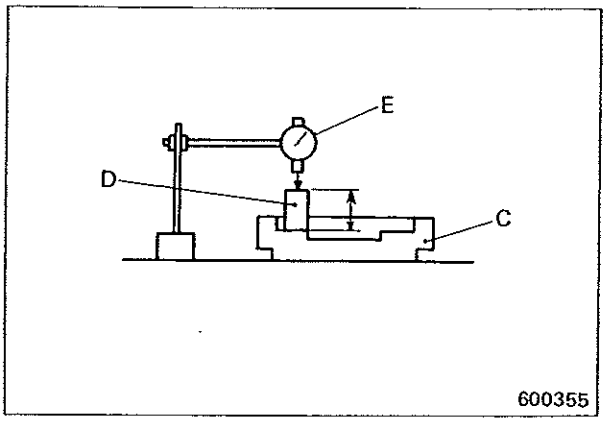


2. Release lever height adjustment

(1) Place flywheel "C" (or a jig equivalent to the flywheel) on a surface plate, and set up dial gauge "E" as shown. Place 74-mm (2.91-in.) block gauge "D" on the friction surface of the flywheel, and set the dial gauge to indicate 0 mm for the 74-mm (2.91-in.) height.

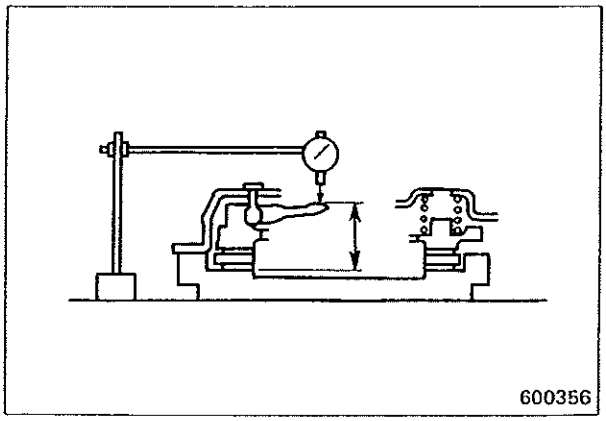
NOTE

Support the dial gauge solidly to retain the original setting.



(2) Install the clutch disc, mating plate, clutch disc and clutch cover assembly in that order on flywheel "C" (or the jig). Then, remove guide bolts "B."

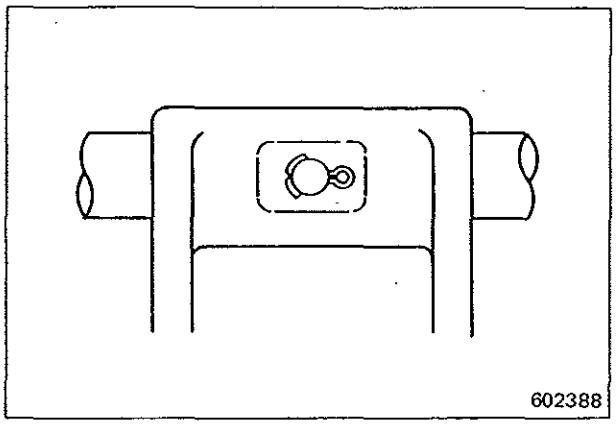
(3) Point the dial gauge spindle to the tip of release lever, read its indication, and tighten or loosen the lever nut until the gauge indicates 0 mm. After repeating this process on the other three release levers, give mallet blows to the tip of each release lever at least 50 times, giving it 14-mm (0.6-in.) stroke at each blow. This is for setting the release levers in their adjusted conditions.
Check the lever height once again and, if necessary, adjust it, making sure that the difference in height between any two levers is below 0.7 mm (0.028 in.).



(4) Install lock plate "47" to lever nut "48," holding the nut so it does not rotate, and secure the release lever to clutch cover "55" with bolt.

3. Split pin installation

Insert the split pin into release lever "30" in parallel with the shaft and spread its ends properly to avoid interference with the pump drive gear.



4. Oil seal installation

Apply a coat of ThreeBond 1104 to the periphery of oil seal "36" before installation.

DIRECT-DRIVE (DD) TRANSMISSION

Removal

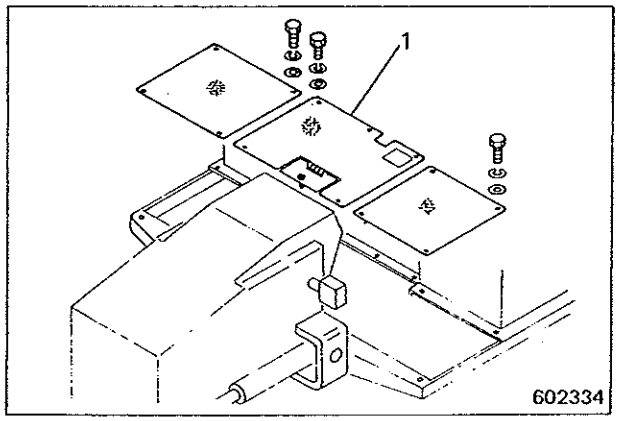
Preparatory steps

(1) Remove the under guard.

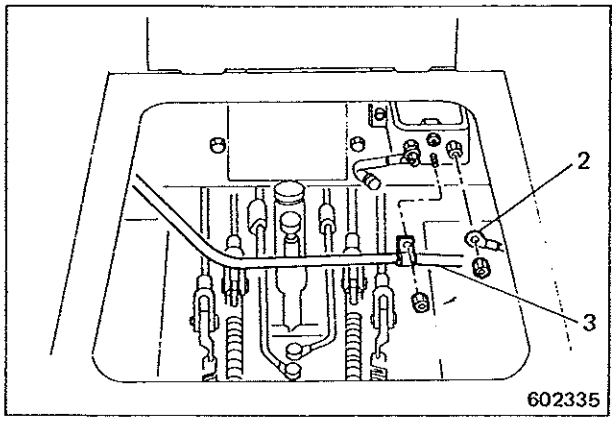
(2) Drain the oil from the transmission case and bevel gear case. [9.5 liters (2.5 U.S. gal), approx.]

1. Remove the following parts:

1 Floor plate (platform) (center, 1 pc)

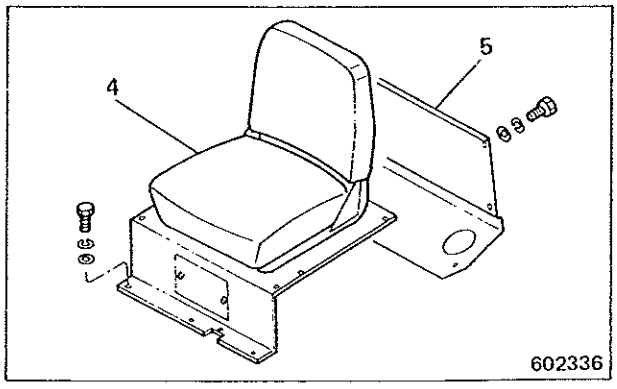


2 Electrical wire between battery switch and battery
3 Clamp for electrical wire between battery and starter

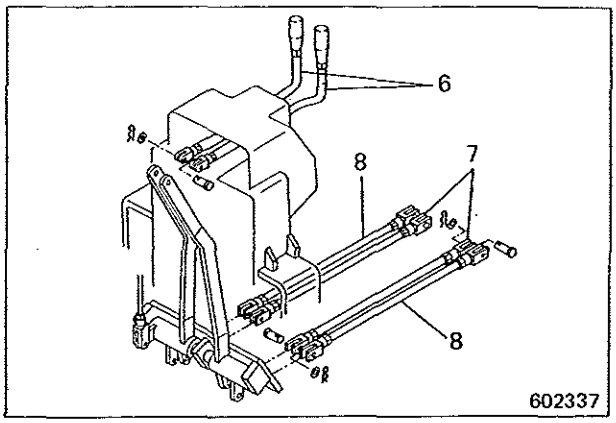


4 Operator's seat and seat plate
5 Rear cover

Weight of operator's seat and seat plate	31 kg (68 lb), approx.

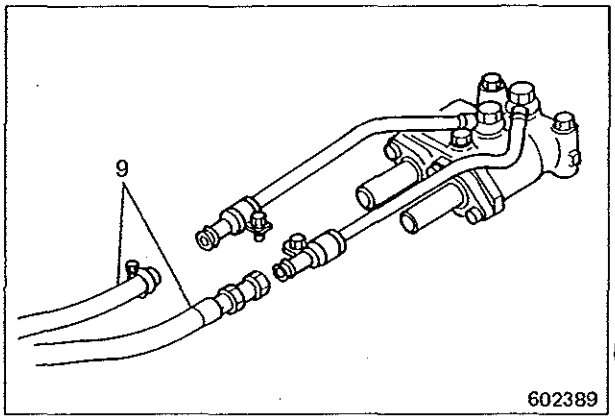


6 Steering clutch levers
7 Steering control rods
8 Brake control rods



2. Disconnect the following parts:

9 Steering clutch oil hoses (2 pcs)



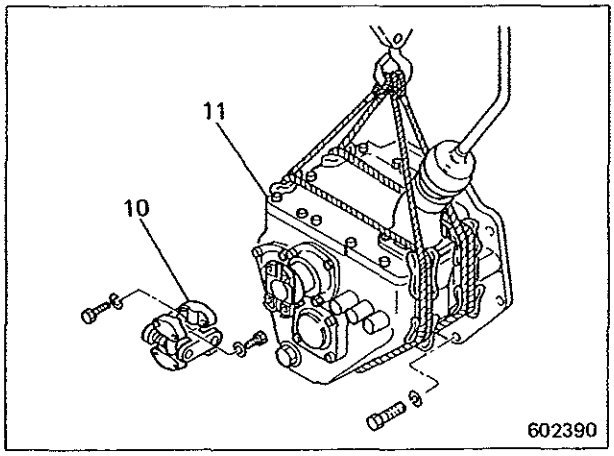
3. Remove the following parts:

10 Universal joint
11 Transmission

Weight of universal joint	2 kg (4 lb), approx.
Weight of transmission	73 kg (161 lb), approx.

NOTE

Before lifting off the transmission, shift it forward to pull the pinion back out of mesh with the bevel gear.



Installation

To install the transmission, follow the reverse of removing procedure, and proceed as follows:

(1) Make sure that the electrical wires, pipes and hoses are connected properly.

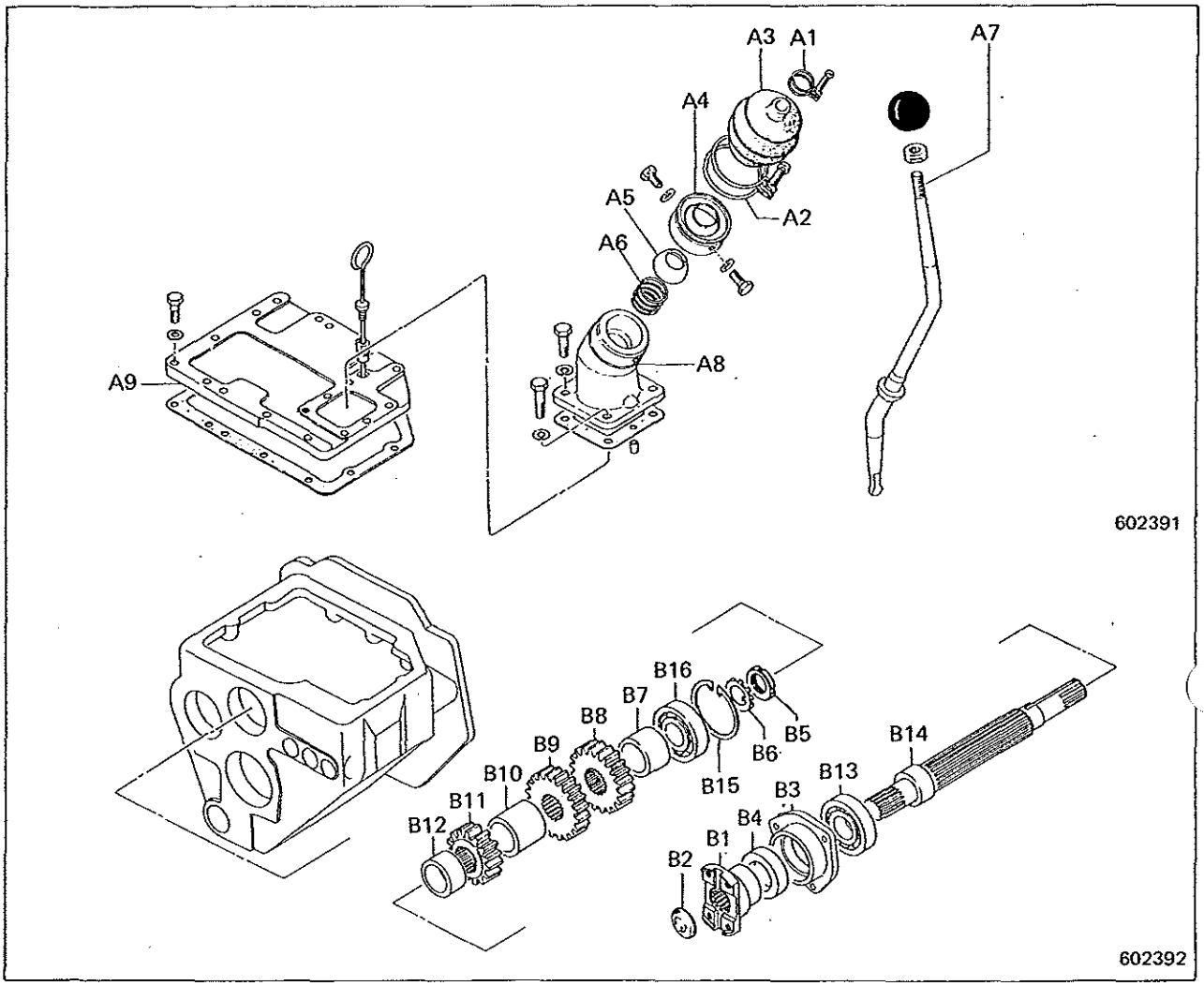
(2) Fill the transmission case and bevel gear case with recommended oil.

Disassembly

Remove the groups in the order listed below for disassembly:

A Gearshift lever (transmission control lever) group
B Main drive shaft (input shaft) group
C Shift fork group
D Countershaft group
E Bevel gear shaft group

A Gearshift lever (transmission control lever) group and
B Main drive shaft (input shaft) group

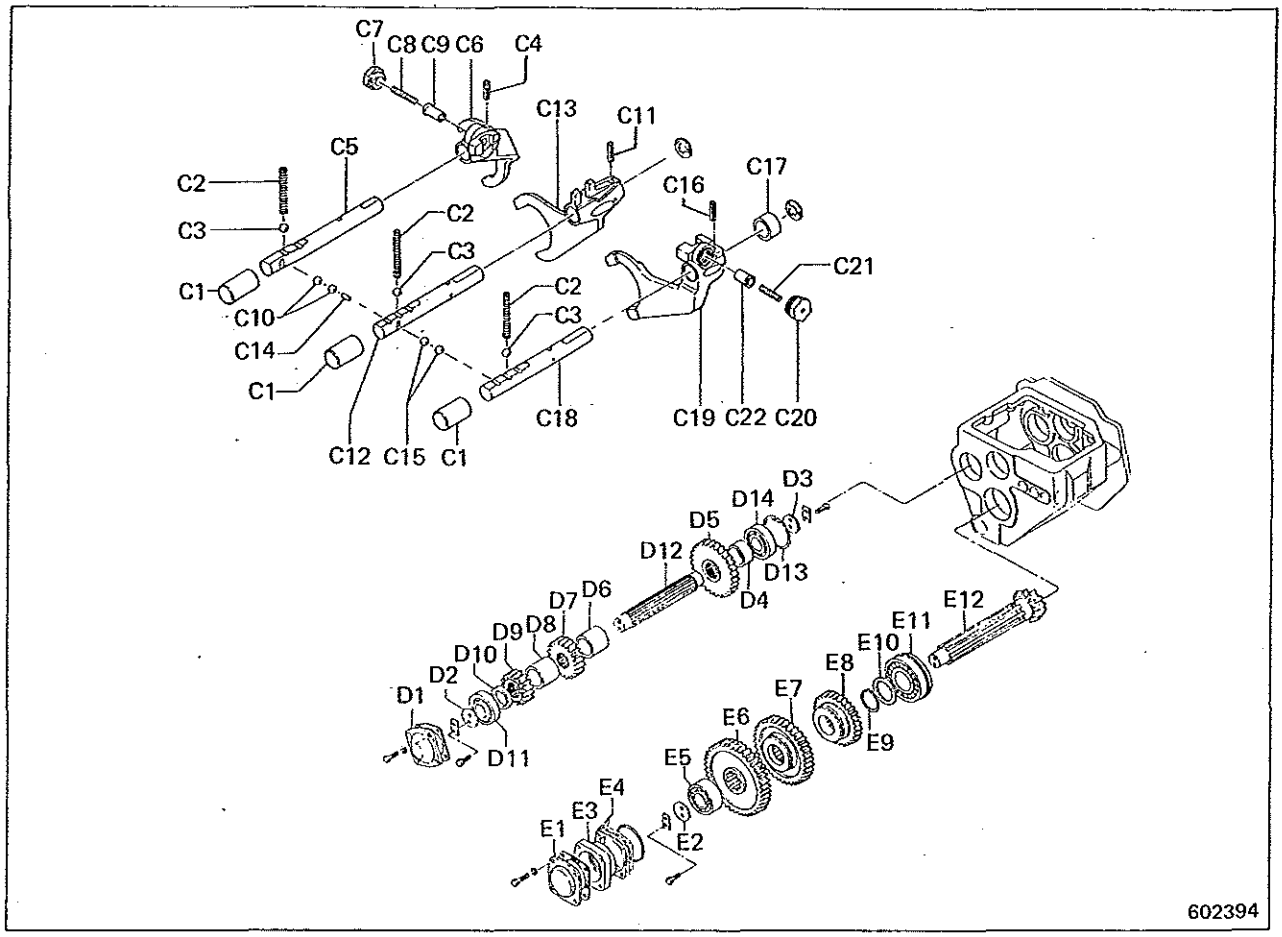


(Remove the parts in the order numbered for disassembly.)

A1, A2 Hose clamps
(to be loosened; "A1" thru "A7" to be removed as an assembly)
A3 Cover
A4 Cover
A5 Retainer
A6 Spring
A7 Control lever
A8 Lever case
A9 Transmission cover

B1 Flange
(to be removed as an assembly including "B2")
B2 Plug
B3 Cover
(to be removed as an assembly including "B4")
B4 Oil seal
B5 Lock nut
B6 Lock washer
B7 Spacer
(to be removed as an assembly including "B8" thru "B14")
B8 Input gear
B9 2nd-speed reverse gear
B10 Spacer
B11 1st-speed reverse gear
B12 Spacer
B13 Ball bearing
B14 Input shaft
B15 Snap ring
B16 Ball bearing

C Shift fork group, D Countershaft group and E Bevel gear shaft group



(Remove the parts in the order numbered for disassembly.)

C1 Expansion plug
C2 Spring
C3 Steel (detent) ball
C4 Spring pin
C5 3rd-speed shift rail
C6 3rd-speed shift fork (to be removed as an assembly including "C7" thru "C9")
C7 Spring retainer
C8 Spring
C9 Plunger
C10 Steel (detent) balls (2 pcs)
C11 Spring pin
C12 2nd-speed shift rail
C13 2nd-speed shift fork
C14 Interlock pin
C15 Steel (detent) ball (2 pcs)
C16 Spring pin
C17 Collar
C18 1st-speed shift rail
C19 1st-speed shift fork (to be removed as an assembly including "C20" thru "C22")
C20 Spring retainer
C21 Spring
C22 Plunger

D1 Cover
D2 Washer
D3 Washer
D4 Spacer (to be removed as an assembly including "D5" thru "D12")
D5 Counter gear
D6 Spacer
D7 2nd-speed drive gear
D8 Spacer
D9 1st-speed drive gear
D10 Spacer
D11 Roller bearing
D12 Countershaft
D13 Snap ring
D14 Ball bearing

E1 Cover
E2 Washer
E3 Bearing cage (to be removed as an assembly including "E4" thru "E5")
E4 Shim
E5 Ball bearing
E6 1st-speed sliding gear (to be removed as an assembly including "E7" thru "E12")
E7 2nd-speed sliding gear
E8 3rd-speed sliding gear
E9 Snap ring
E10 Spacer
E11 Roller bearing
E12 Bevel pinion shaft

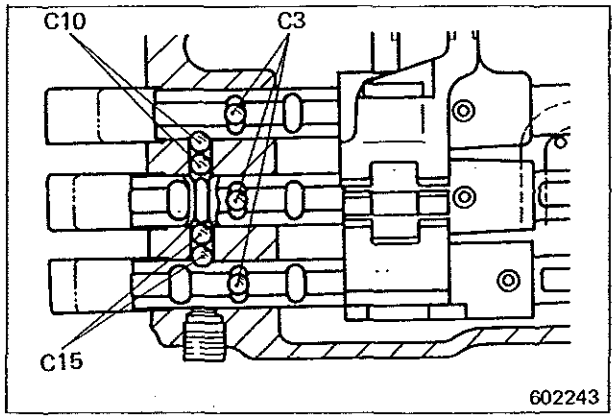
Tips for disassembly

1. Detent group (interlock mechanism) removal

To remove the detent group, place the gearshift lever in NEUTRAL.

NOTE

Carefully handle steel (detent) balls "C3," "C10" and "C15" to prevent them from getting lost.



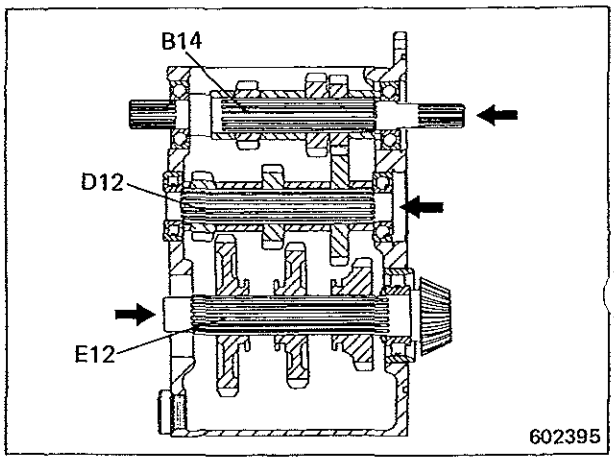
2. Shaft removal

Drive the transmission shafts off the case in the following directions:

(1) Drive off input shaft (main drive shaft) "B14" to the steering clutch case side.

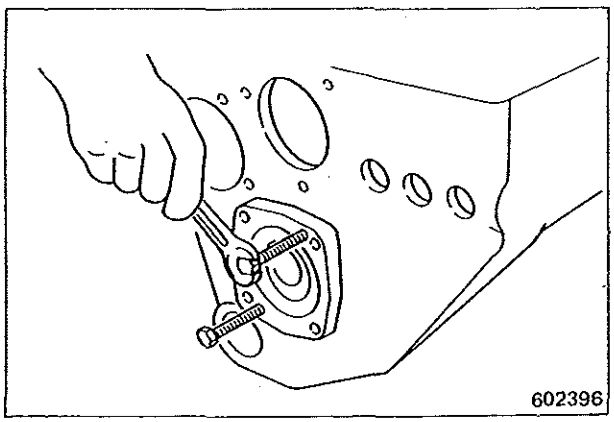
(2) Drive off countershaft "D12" to the steering clutch case side.

(3) Drive off bevel pinion shaft "E12" to the universal joint side.



3. Bevel pinion shaft bearing cage removal

Using jacking bolts, remove bearing cage "E3" together with bearing "E5" and shim "E4."



4. Bevel pinion shaft bearing removal

Remove the inner race and rollers of bearing "E11." Remove the outer race if necessary.

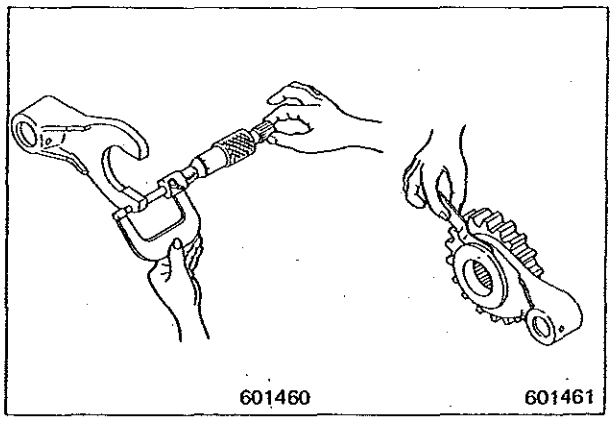
Inspection

1. Shift forks

Measure the clearance of each shift fork in its groove in the sliding gear. Replace the fork if the measurement exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Clearance of shift fork in groove	0.1 – 0.3 (0.004 – 0.012)	0.5 (0.020)

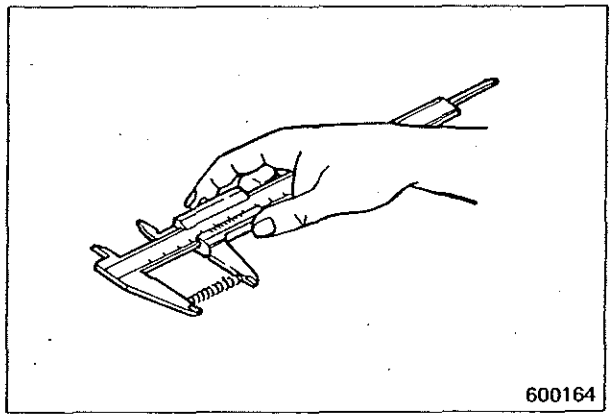


2. Detent springs

Measure the free length and test force of each spring. Replace the spring if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Free length	62 (2.44)	60.5 (2.382)
Test force/ length under test force kgf (lbf) [N]/ mm (in.)	9.80 ± 0.49 (21.61 ± 1.08) [96.11 ± 4.81]/ 55 (2.17)	7.5 (16.5) [73.5]/ 55 (2.17)

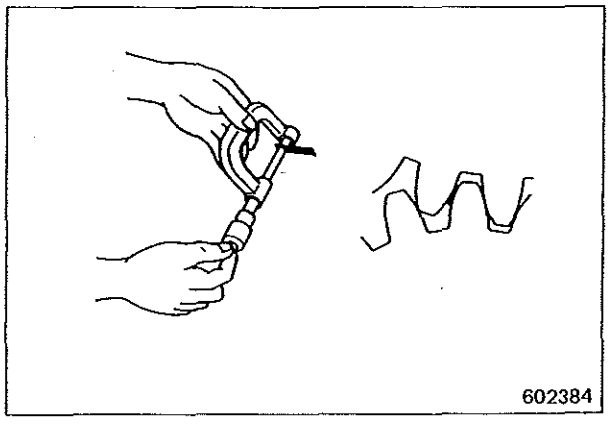


3. Gear backlash

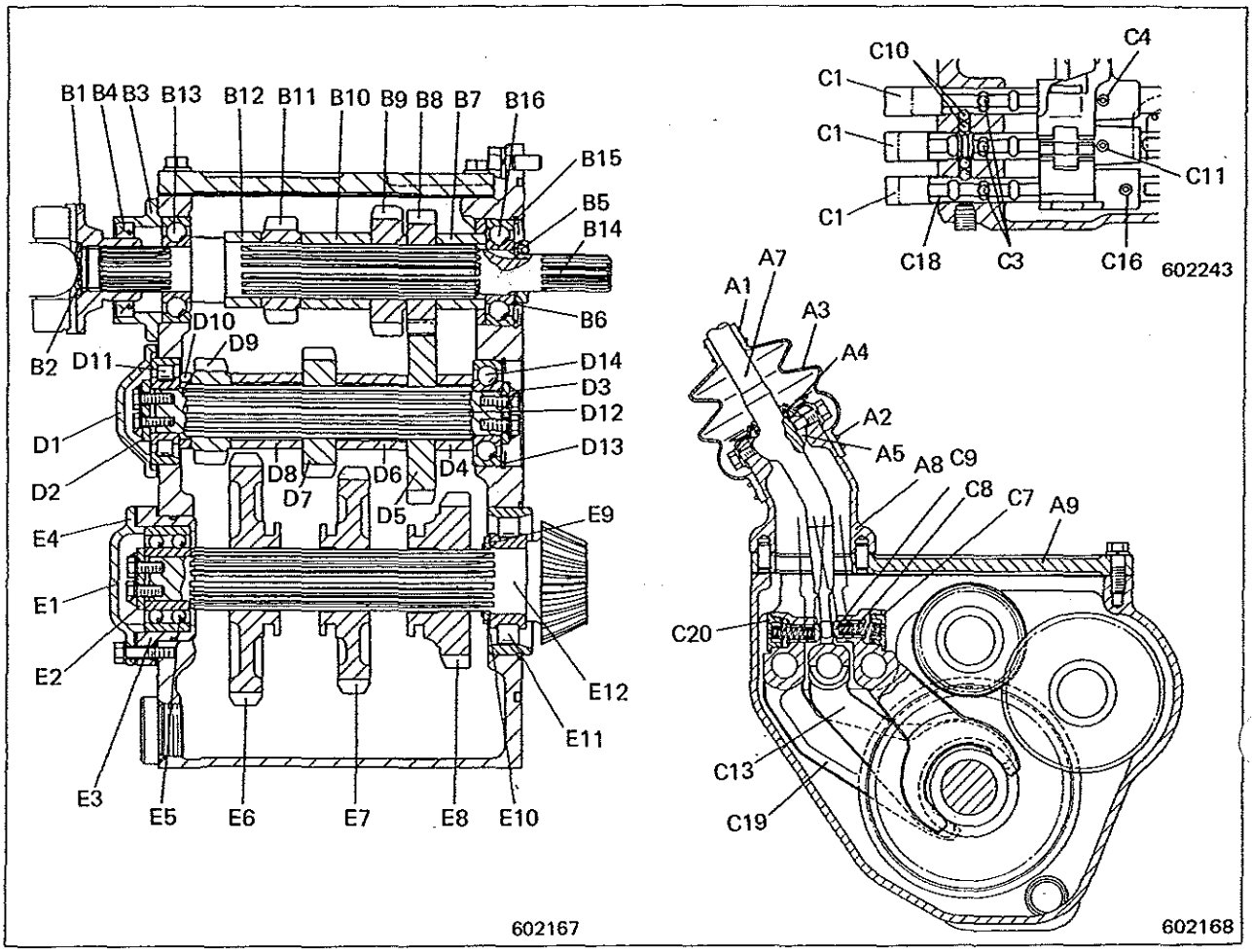
Measure the backlash of gears. Replace the gears if the measurement exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Gear backlash	0.12 – 0.28 (0.0047 – 0.0110)	0.6 (0.024)



Reassembly



Reassembling order

E3 E5 | E8 E7 E6 E2 E4 E1 | D10 D9 D8 D7 D6 D5 D4 D14 D13 D3 D1

E11 E10 E9 → E12

D11 D2 → D12

B7 B8 B9 B10 B11 B12 B13 B3 B4 B1 B2 → Transmission case

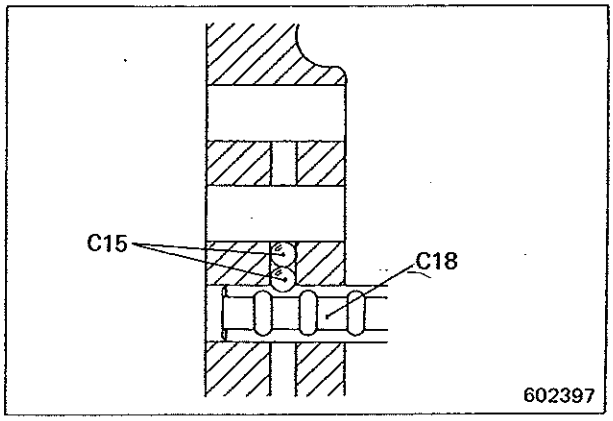
B16 B15 | B5 → B14

B6

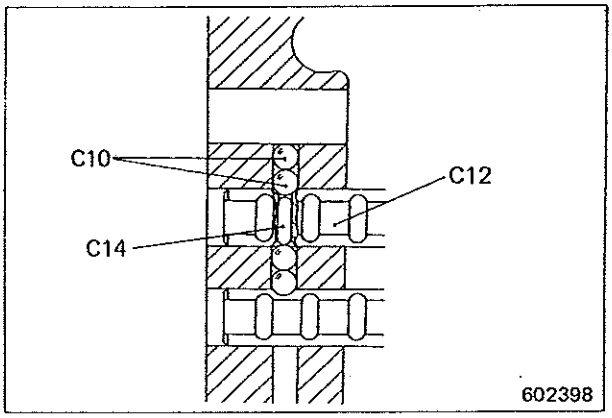
Tips for reassembly

1. Detent group (interlock mechanism) installation

(1) Install 1st-speed shift rail "C18" and steel balls "C15" in that order.



(2) Insert interlock pin "C14" into the hole of 2nd-speed shift rail "C12", and put steel balls "C10" and 3rd-speed shift rail "C5" in that order.



NOTE

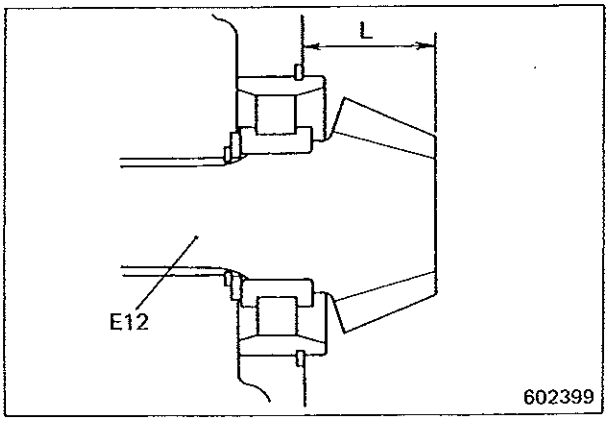
Install the detent parts with each shift rail held in NEUTRAL.

2. Bevel pinion shaft installation

(1) Measure dimension "L" from the end face of pinion to that of transmission case, making sure that it is as specified below:

$L = 46.2 \pm 0.1$ mm
$(1.819 \pm 0.004$ in.)

(2) The standard value of this dimension is indicated on the end face of pinion. Referring to that value, increase or decrease the thickness of shim "E4" to be fitted to pinion shaft "E12" on the opposite side of the pinion if the dimension is greater or smaller than the specification.



STEERING CLUTCHES AND BRAKES

Removal

Preparatory steps

(1) Drain the oil from the bevel gear case and transmission case. [9.5 liters (2.5 U.S. gal), approx.]

(2) Remove the tracks (on both sides). It is not necessary to remove the tracks unless they engage the sprockets. (Refer to the topic, Removal, TRACKS.)

1. Disconnect the following electrical wires:

(1) Wire between battery switch and battery

(2) Clamp for wire between battery and starter

2. Remove the following parts:

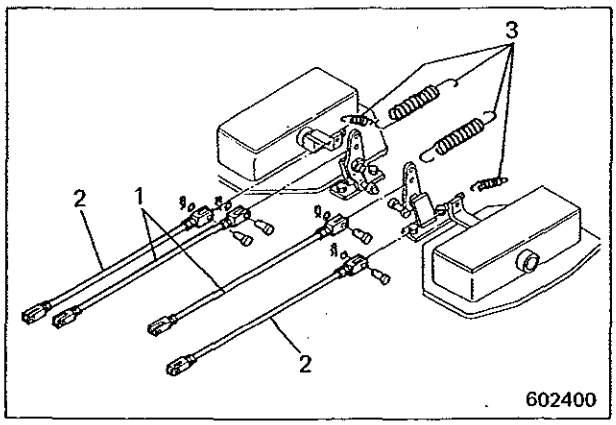
(1) Floor plate

(2) Operator's seat and seat plate

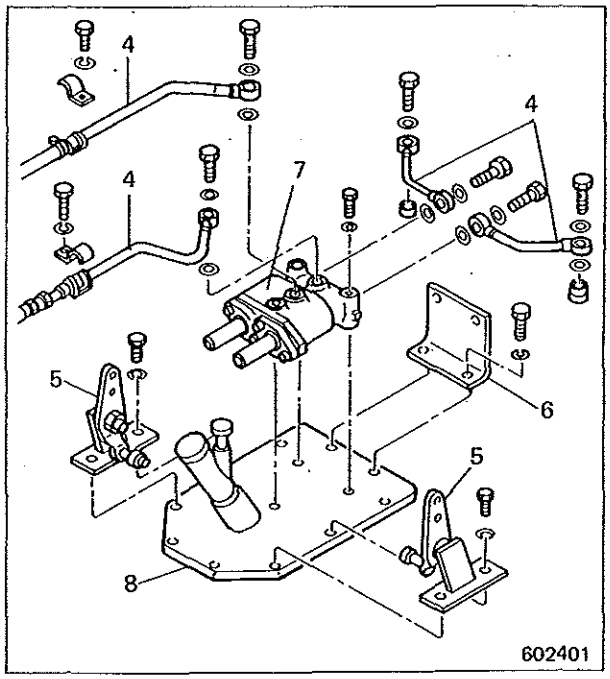
(3) Rear cover

3. Remove the following parts:

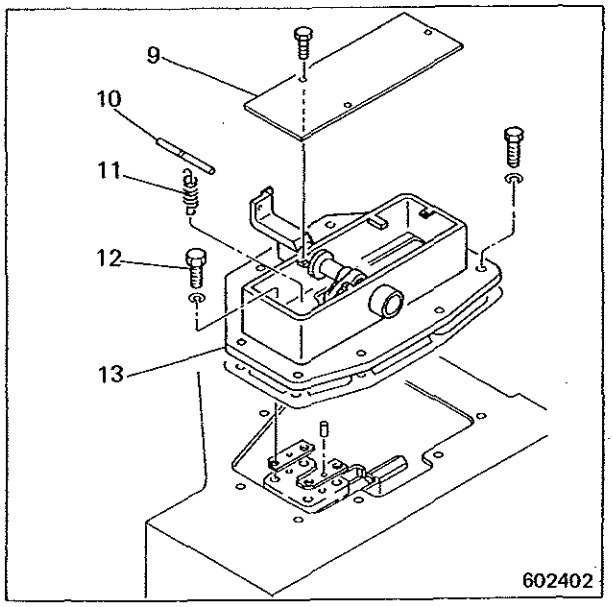
1 Steering control rods (2 pcs)
2 Brake control rods (2 pcs)
3 Springs (4 pcs)



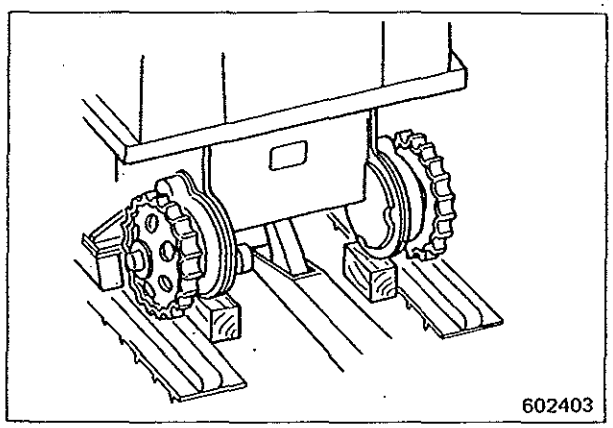
4 Steering clutch oil pipes (4 pcs)
5 Levers (2 pcs)
6 Bracket
7 Steering valve
8 Cover



9 Cover
10 Shaft
11 Spring
12 Steering brake mounting bolts (4 pcs)
13 Bracket

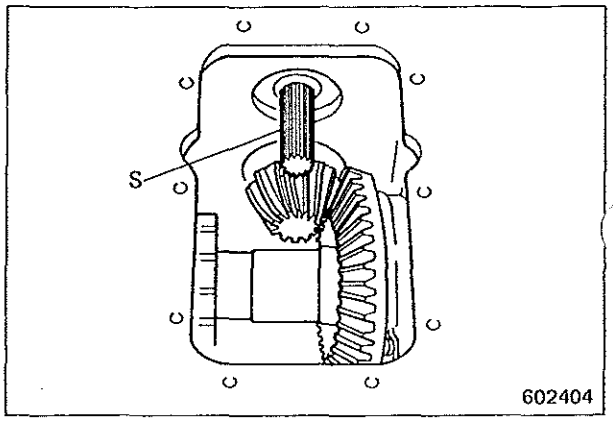


4. Lift the rear end of the machine by positioning a jack under the steering clutch case so that the sprockets can be rotated, and block the final drive cases, using wood blocks, as shown.



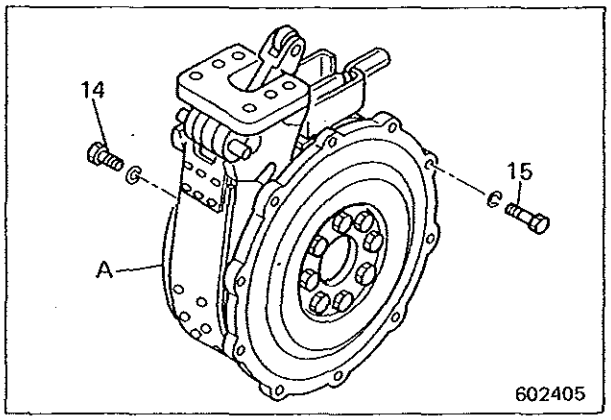
5. Hold the clutch pedal in depressed position, and place the gearshift lever in forward 1st position.

6. Unscrew bolts "14" and "15" securing the steering clutch & brake assembly. To do this, turn the splined portion of transmission input shaft "S" to rotate that assembly to remove the bolts one by one.

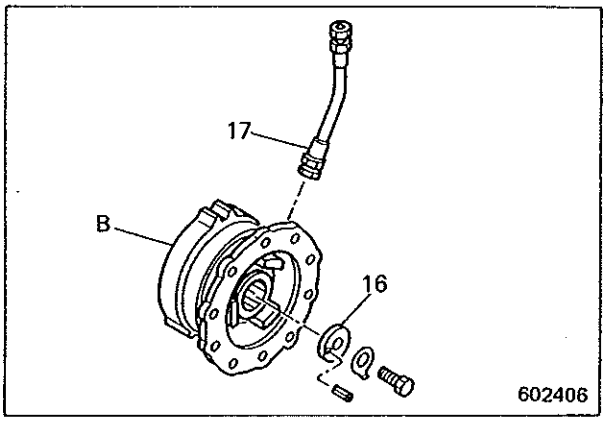


7. Remove the following parts:

14 Mounting bolts
15 Mounting bolts
A Steering clutch & brake assembly



16 Washer
17 Hose
B Steering clutch & brake assembly



Installation

To install the steering clutch & brake assembly, follow the reverse of removal procedure, and proceed as follows:

(1) Make sure that the oil pipes are connected properly.

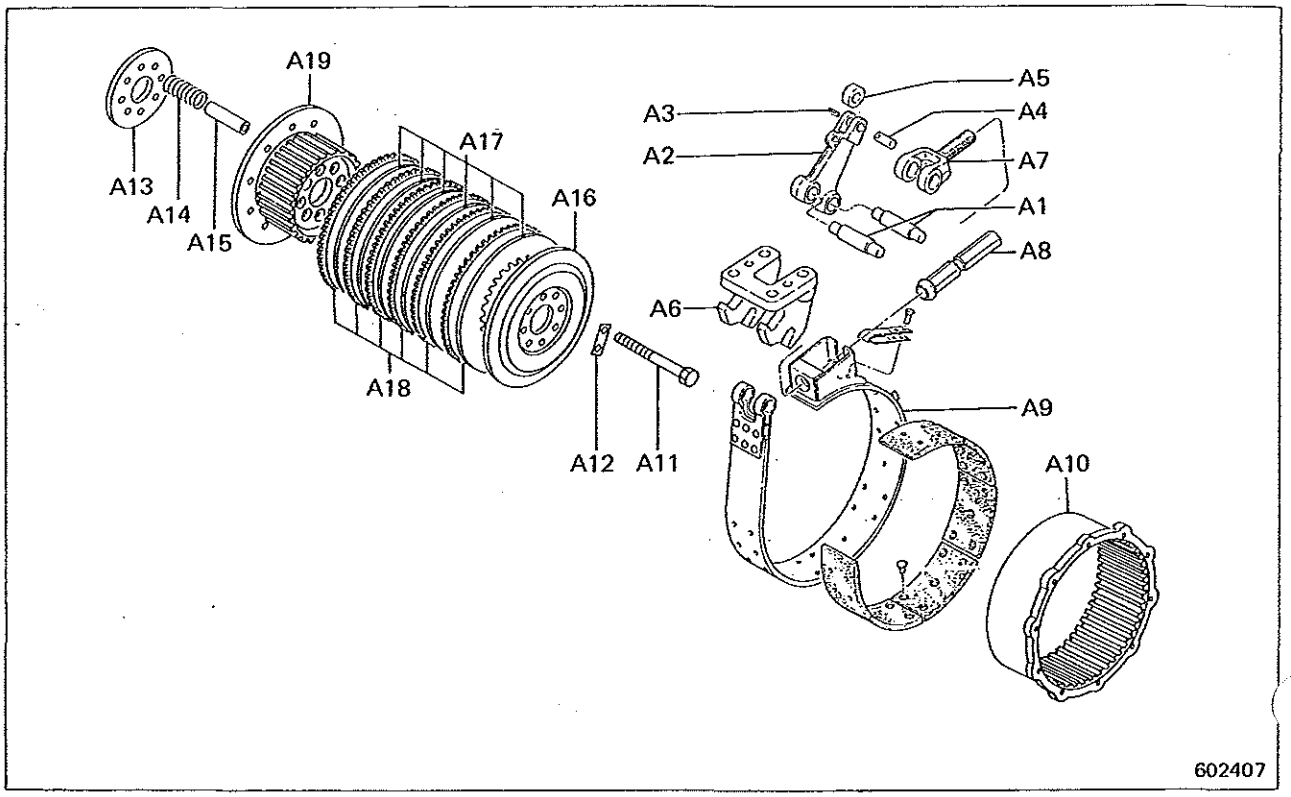
(2) Fill the bevel gear case and transmission case with recommended oil.

Tips for steering clutch & brake assembly and cylinder assembly removal

These assemblies can be taken out of the steering clutch case with the operator's seat tilted forward by removing bracket "13" and its related parts without removing the operator's seat and seat plate.

Diassembly

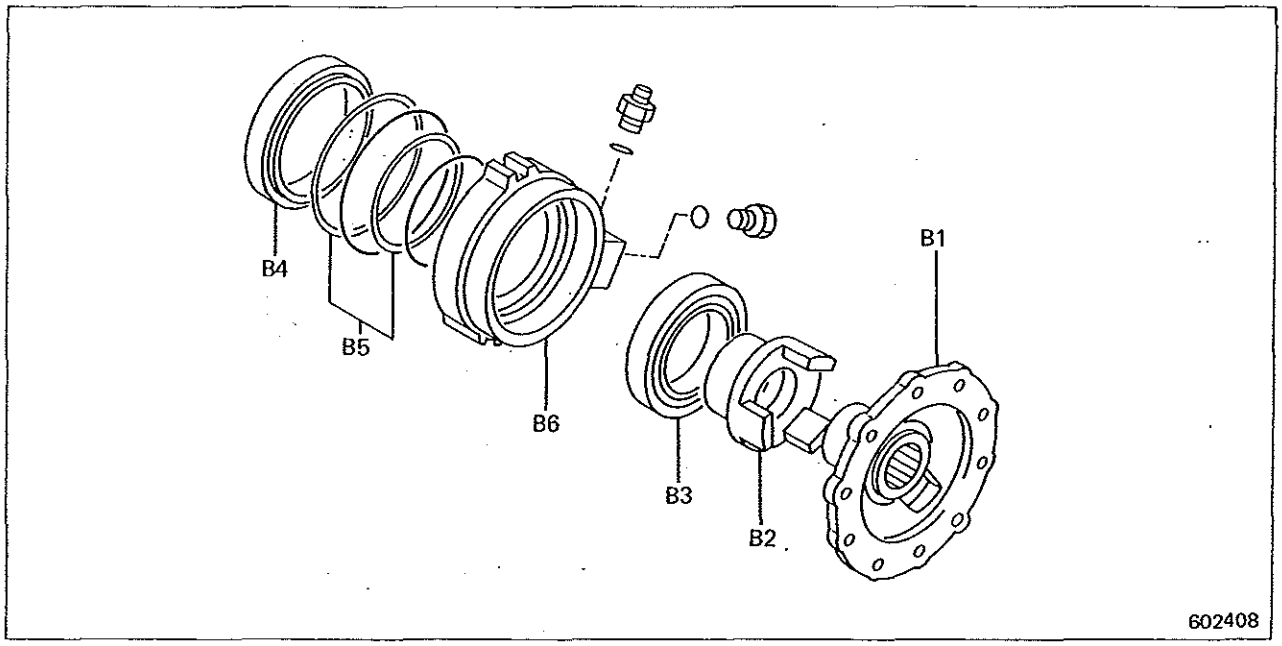
A Steering clutch & brake assembly



(Remove the parts in the order numbered for disassembly.)

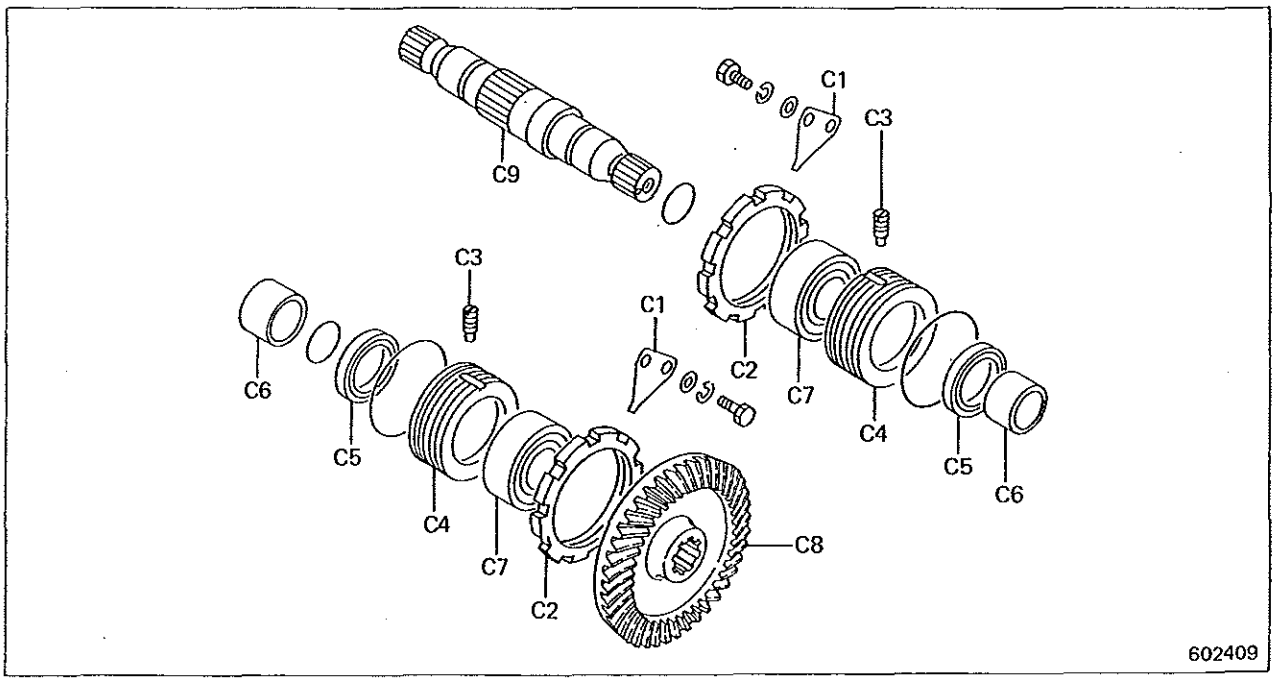
A1 Pin
(to be removed as an assembly including "A2" thru "A9")
A2 Lever
(to be removed as an assembly including "A3" thru "A5")
A3 Spring pin
A4 Pin
A5 Roller
A6 Anchor
A7 Clevis
A8 Adjusting nut
A9 Brake band assembly
A10 Outer drum
A11 Bolt
A12 Plate
A13 Plate
A14 Spring
A15 Spacer
A16 Pressure plate
A17 Disc plate
A18 Friction plate
A19 Inner drum

B Steering clutch cylinder assembly



B1 Flange
B2 Shifter
B3 Bearing
B4 Piston
B5 Backup ring
B6 Cylinder

C Bevel gear assembly



C1 Locking plate
C2 Nut
C3 Set screw
(to be loosened)
C4 Bearing cage
(to be removed as an assembly including "C5" and outer race of "C7")
C5 Oil seal
C6 Collar
C7 Roller bearing
C8 Bevel gear
C9 Drive shaft

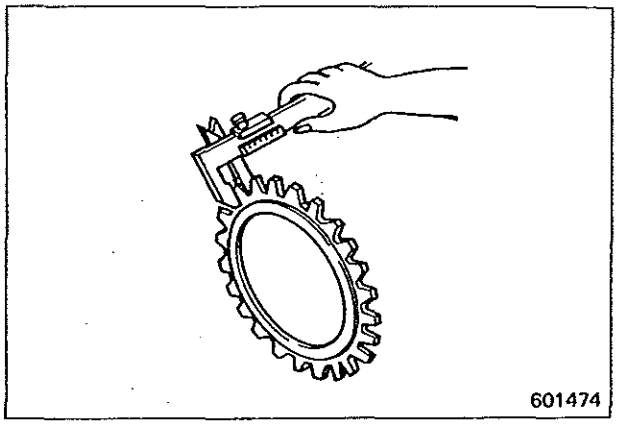
Inspection

1. Friction plates

Measure the thickness and fit of its teeth in outer drum splines. Replace the plate if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness	8.7 (0.342)	6.0 (0.236)
Fit in outer drum splines	0.16 – 0.52 (0.0063 – 0.0205)	0.80 (0.0315)

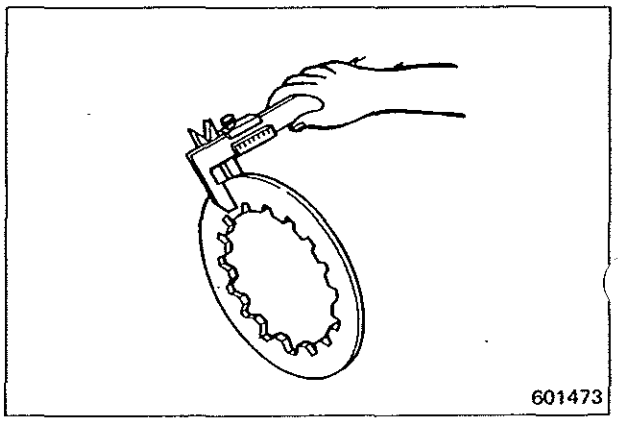


2. Disc plates

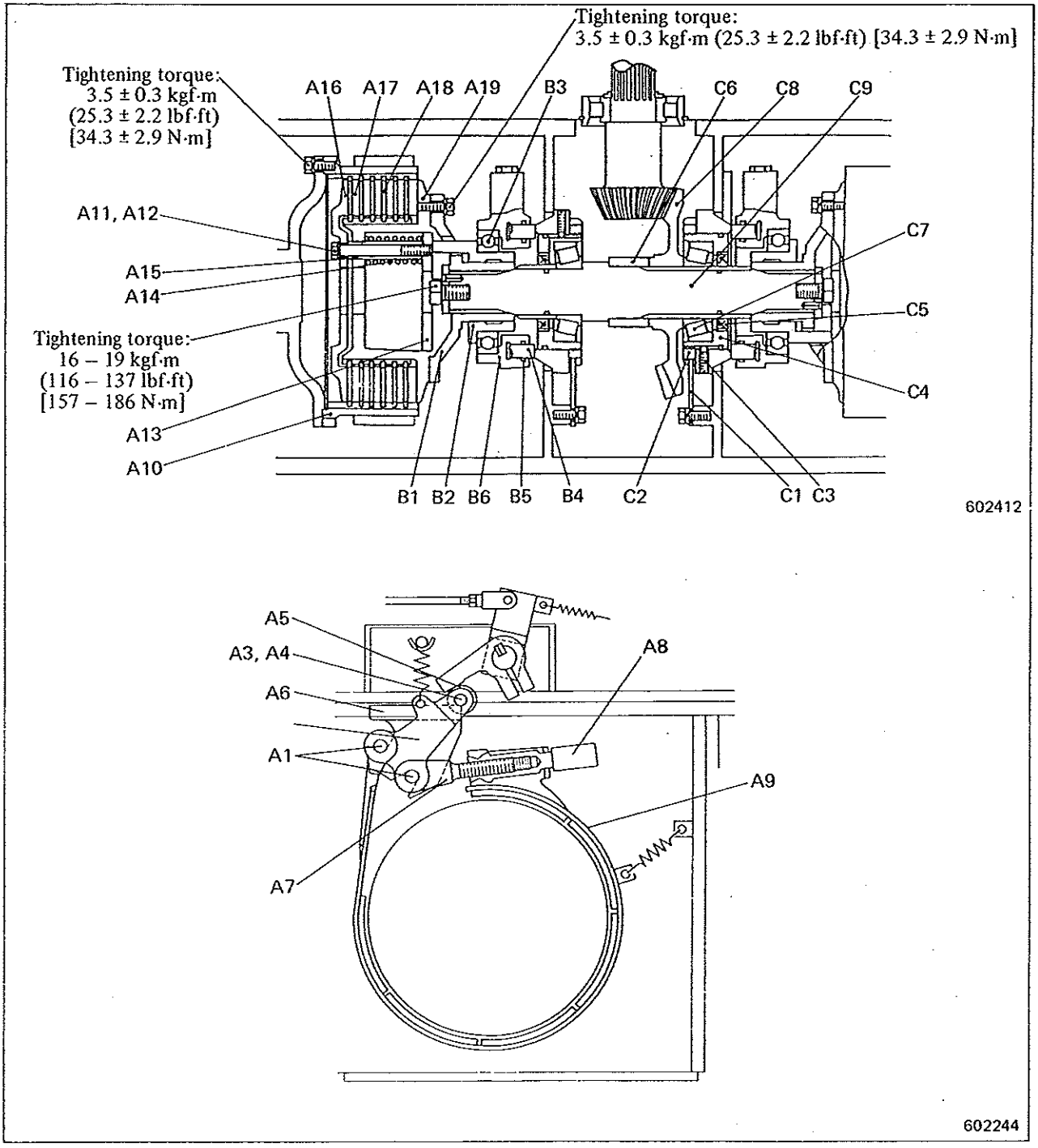
Measure the thickness, fit of its teeth in inner drum splines and total thickness of friction plate and disc plates. Replace the disc plate if any of these measurements exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Thickness	2.8 (0.110)	2.3 (0.091)
Fit in inner drum splines	0.14 – 0.30 (0.0055 – 0.0118)	0.60 (0.0236)
Total thickness of friction plates and disc plates	69 (2.72)	66 (2.60)

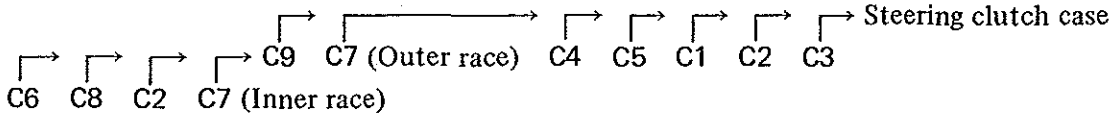


Reassembly

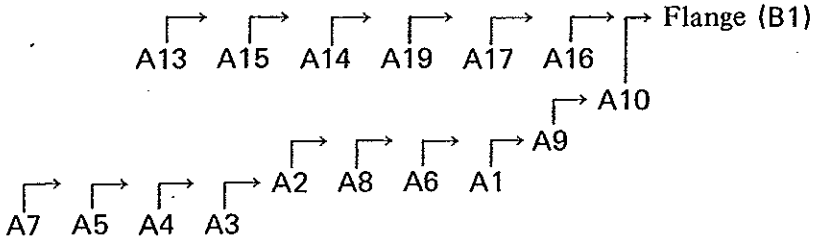

Tightening torque:
3.5 ± 0.3 kgf·m (25.3 ± 2.2 lbf·ft) [34.3 ± 2.9 N·m]
Tightening torque:
3.5 ± 0.3 kgf·m
(25.3 ± 2.2 lbf·ft)
[34.3 ± 2.9 N·m]
A16 A17 A18 A19 B3 C6 C8 C9
A11, A12
A15
A14
C7
C5
Tightening torque:
16 – 19 kgf·m
(116 – 137 lbf·ft)
[157 – 186 N·m]
C4
A13
A10
B1 B2 B6 B5 B4 C2 C1 C3
602412
A5
A3, A4
A6
A1
A8
A9
A7
602244

Reassembling order

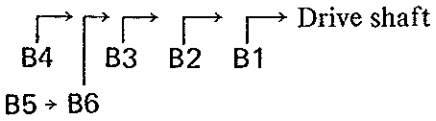
C Bevel gear assembly



A Steering clutch & brake assembly



B Steering clutch cylinder assembly



Tips for reassembly

1. Drive shaft installation

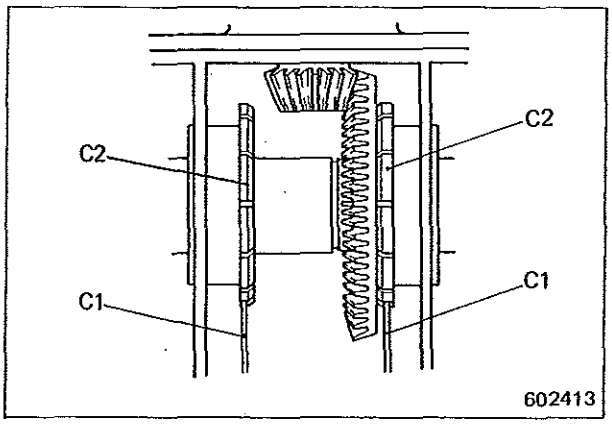
(1) Before installing drive shaft "C9," fit the inner race of left-hand roller bearing "C7" and collar "C6" to the shaft.

(2) After installing shaft "C9" and bevel gear "C8" in the steering clutch case, fit the inner race of right-hand roller bearing "C7" to the shaft.

2. Tapered roller bearing preload adjustment

(1) Tighten two adjusting nuts "C2," right and left, to settle them in place. Lock one of the nuts with its lock plate "C1," and tighten or loosen the other nut to adjust the preload. (Tightening the nut increases the preload.)

(2) Hook a spring balance to the tooth of bevel gear in mesh with the pinion with a wire, pull the balance in the tangential direction, and read the balance indication.



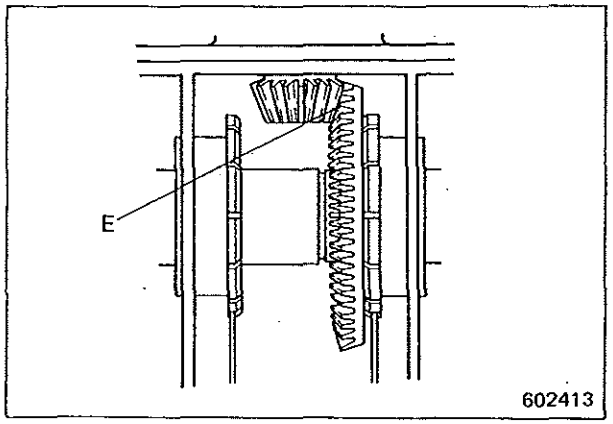
Item	Assembly standard
Preload	0.72 – 0.88 kgf·m (5.21 – 6.37 lbf·ft) [7.06 – 8.63 N·m]
Spring balance indication	6.55 – 8.00 kgf (14.44 – 17.64 lbf) [64.23 – 78.45 N]

3. Bevel gear and pinion backlash adjustment

(1) Put a fuse stock into between the bevel gear and pinion at the place indicated as "E," roll it and measure the amount of flattening.

(2) Measure the backlash at a total of four places by turning the bevel gear 90° at a time, and take the smallest measurement for comparison with the assembly standard.

(3) To adjust the backlash, tighten or loosen the adjusting nuts, right and left.



Unit: mm (in.)

Item	Assembly standard
Backlash	0.15 – 0.20 (0.0059 – 0.0079)

NOTE

If one nut in loosened, for instance, the other nut must be tightened by the same amount to keep the preload unchanged.

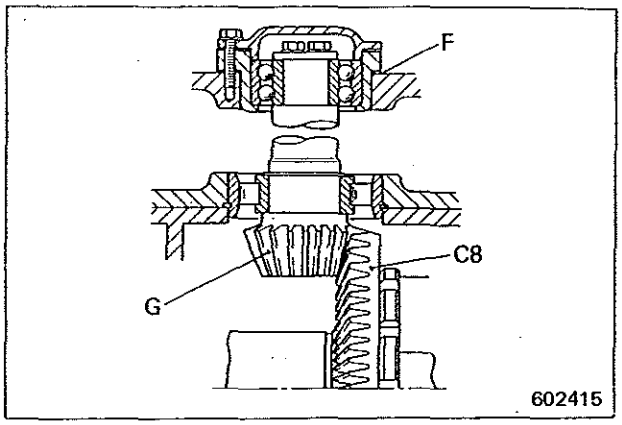
4. Tooth contact adjustment

(1) To move the bevel pinion "G" toward or away from the bevel gear "C8" for tooth contact adjustment, decrease or increase shims "F" between the bearing cage and transmission case.

(2) To determine the tooth contact pattern, brush red lead sparingly on the bevel gear teeth, and rotate the pinion backward and forward until a contact pattern is noted on both concave and convex faces of the gear teeth.

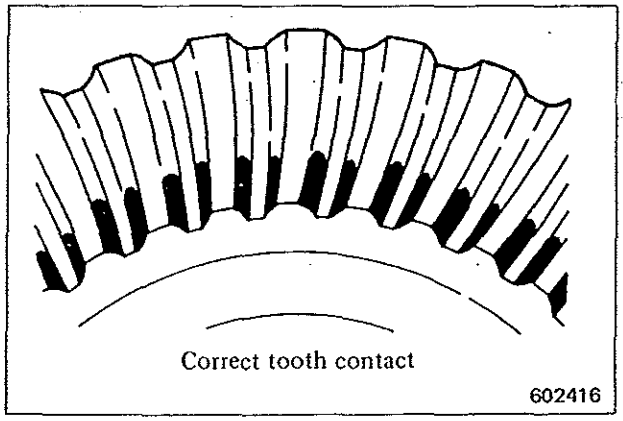
NOTE

To make the tooth contact pattern more visible, lightly press the gear when rotating the pinion.



Correct tooth contact

Contact (indicated by the dark areas on the tooth faces) is heaviest toward the toe-end and extends about 30% of the tooth length on both convex and concave faces.

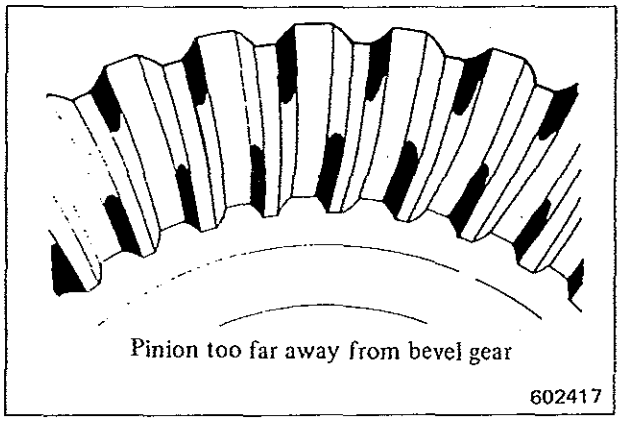


Incorrect tooth contact

- Pinion too far away from bevel gear

(1) Contact extends toward the toe-end of concave faces and toward the heel-end of convex faces.

(2) To correct this contact, decrease the thickness of shims "F," and turn adjusting nuts "C2" to move pinion "G" away from gear "C8." Again brush red lead on the gear teeth, and check the contact pattern.



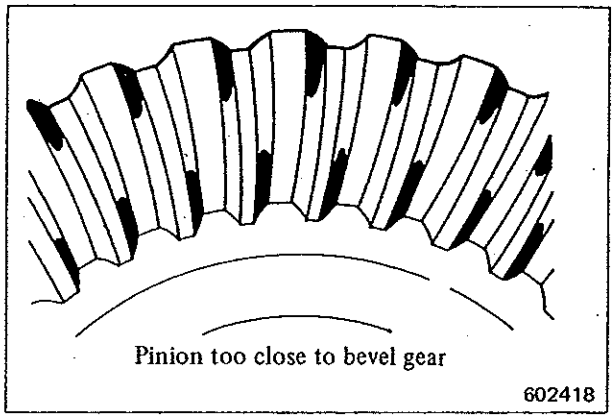
- Pinion too close to bevel gear

(1) Contact extends toward the heel-end of concave faces and toward the toe-end of convex faces.

(2) To correct this contact, increase the thickness of shims "F," and turn adjusting nuts "C2" to move gear "C8" toward pinion "G." Recheck the contact pattern by brushing red lead.

NOTE

The foregoing tooth contact adjustments are meaningless unless the bevel gear and pinion backlash has been adjusted properly.



Pinion too close to bevel gear

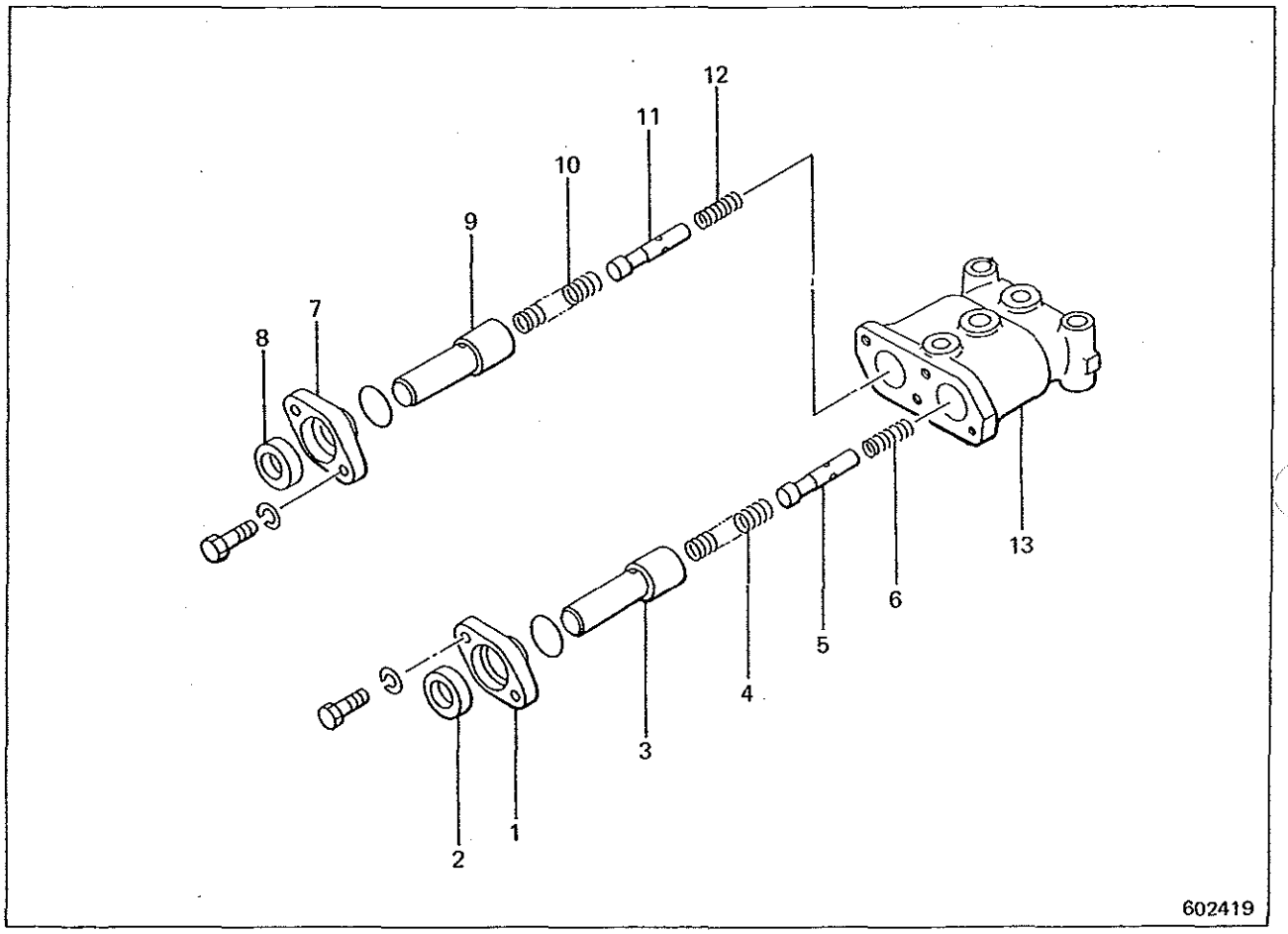
602418

STEERING VALVE

Removal and installation

For removal and installation of the steering valve, refer to the topic, Removal, STEERING CLUTCHES AND BRAKES.

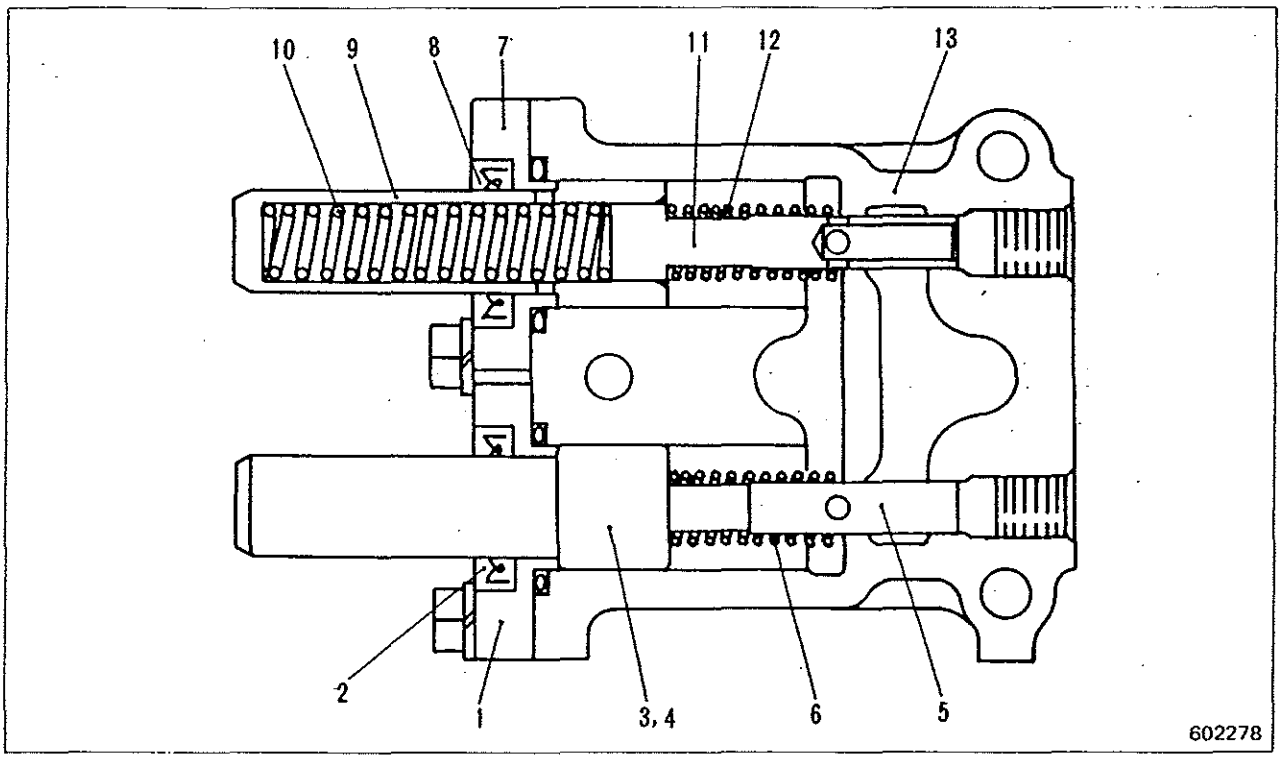
Disassembly



(Remove the parts in the order numbered for disassembly.)

1 Cover
2 Oil seal
3 Pison
4 Valve spring
5 Plunger valve
6 Return spring
7 Cover
8 Oil seal
9 Piston
10 Valve spring
11 Plunger valve
12 Return spring
13 Valve housing

Reassembly



Reassembling order

12→11 10→9 8→7 13 1←2 3←6 5←4

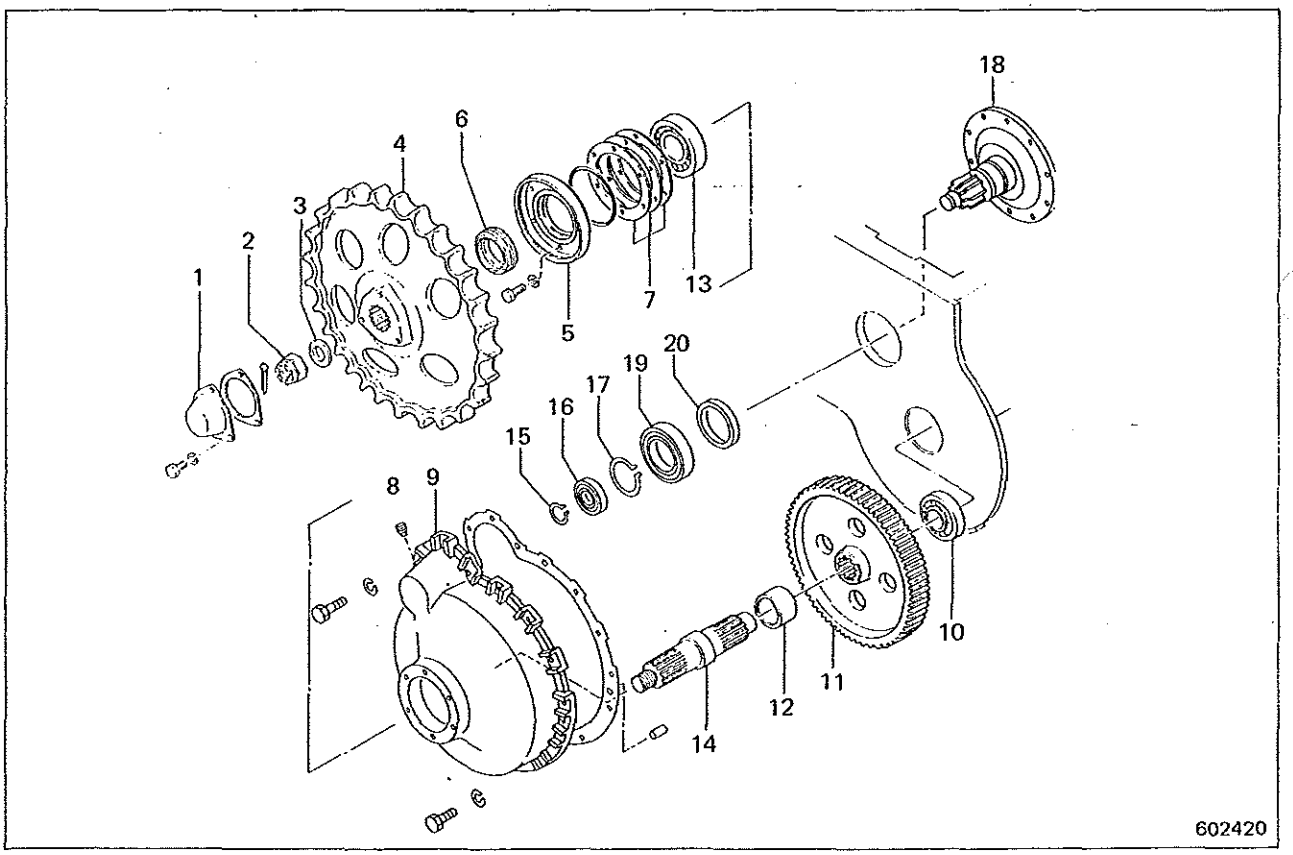
Removal (disassembly)

Preparatory steps

(1) Separate the tracks. (Refer to the topic, Removal, TRACKS.)

(2) Drain the oil from the final drive gear cases.

(3) When it is necessary to remove pinion "18," remove the steering clutch & brake assembly. (Refer to the topic, Removal.)



(Remove the parts in the order numbered for disassembly.)

1 Cover
2 Castle nut
3 Washer
4 Sprocket
5 Seal case
6 Floating seal
7 Shim
8 Screw
9 Gear case (to be removed as an assembly including "10" thru "14")
10 Tapered roller bearing (to be removed as an assembly including "11" through "14")
11 Gear
12 Spacer
13 Tapered roller bearing
14 Shaft
15 Snap ring
16 Tapered roller bearing
17 Snap ring
18 Pinion
19 Ball bearing
20 Oil seal

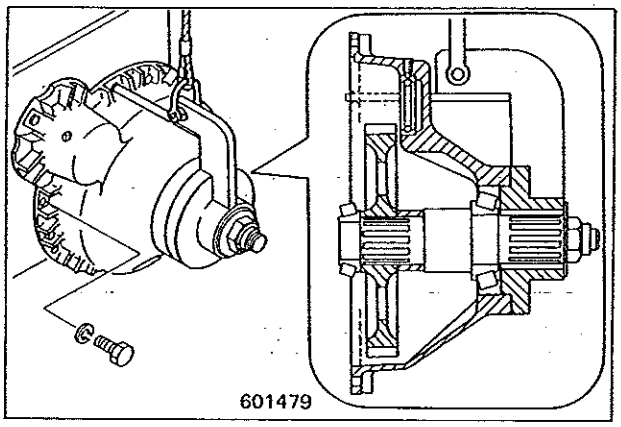
Tips for removal

1. Gear case removal

Using a jig, remove gear case "9" together with shaft subassembly comprising parts "10" thru "14."

Unit: kg (lb)

Weight of gear case and shaft subassembly	Standard and swamp models	60 (132), approx.
	Super-swamp model	70 (154), approx.
	Ultra-super-swamp model	90 (198), approx.



⚠ WARNING

The final drive shaft and its gear are supported by the gear case on one side and by the frame on the other. Thus, pulling the gear case alone from the frame is not only dangerous but also harmful to the shaft subassembly. Be sure to remove the case to which the shaft subassembly is installed.

2. Tapered roller bearing removal

(1) Remove the inner race and rollers of tapered roller bearing "10" as the components of the shaft subassembly. Remove the outer race of this bearing from the steering clutch case when required.

(2) Similarly remove tapered roller bearing "13." Remove its outer race from the gear case "9."

(3) The outer race of tapered roller bearing "16" comes off together with gear case "9" when removed. Remove it from the gear case by loosening the screw when required.

Inspection

1. Pinion and gear backlash

Measure the backlash, and replace the pinion and gear if the measurement exceeds the service limit.

Unit: mm (in.)

Item	Assembly standard	Service limit
Backlash	0.17 – 0.37 (0.0067 – 0.0146)	1.00 (0.0394)

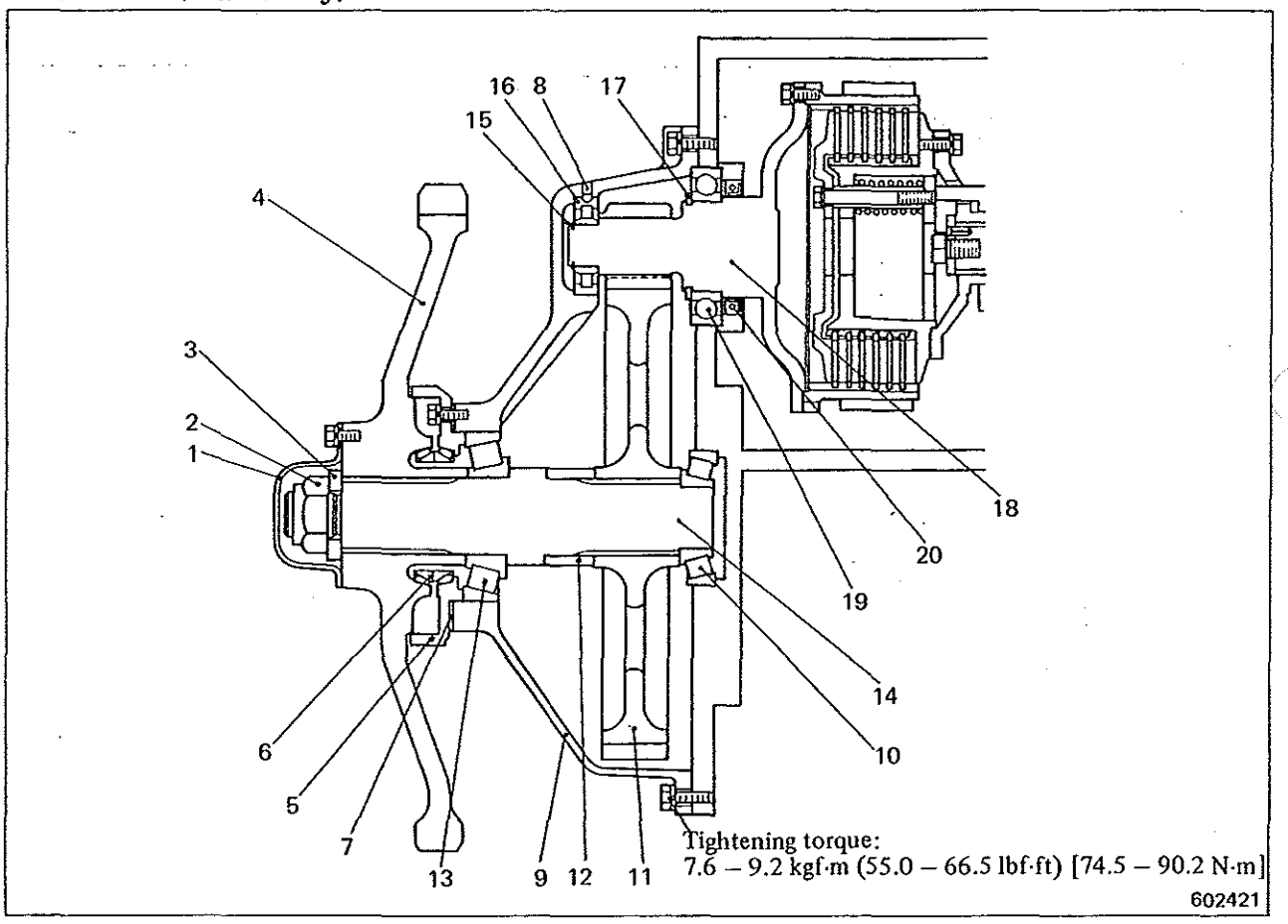
2. Sprockets

Measure the tooth width, and replace the sprocket if the measurement exceeds the service limit.

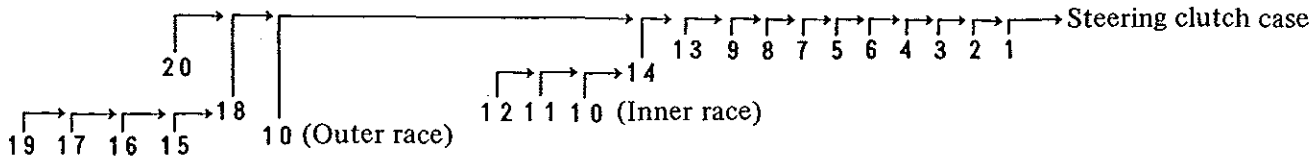
Unit: mm (in.)

Item	Assembly standard	Service limit
Sprocket tooth width	40 (1.57)	36 (1.42)

Installation (reassembly)



Reassembling order



Tips for reassembly

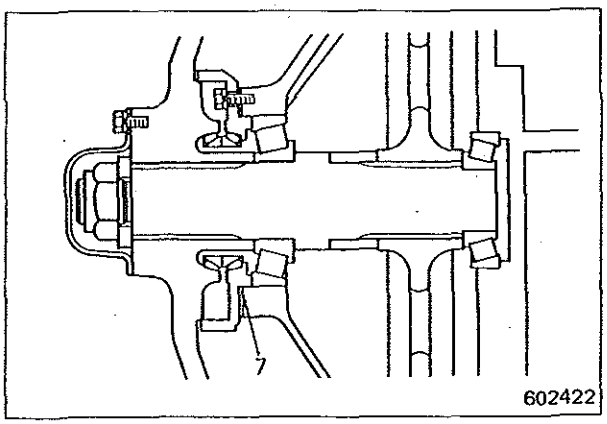
Tapered roller bearing preload adjustment

(1) To adjust the preload of tapered roller bearing, decrease or increase the thickness of shims "7" between the gear case and oil seal cover.

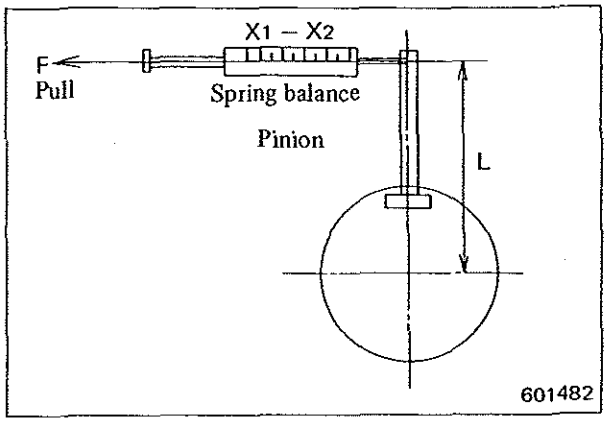
(2) Decreasing the thickness of the shims increases the preload of the bearing.

Unit: kgf·m (lbf·ft) [N·m]

Item	Assembly standard
Tapered roller bearing (pinion) preload	0.29 – 0.37 (2.10 – 2.68) [2.84 – 3.63]



Starting torque "T" of pinion
= "F" kgf (lbf) [N] x "L" m (in.)
(distance from center of pinion)



[Example]
If "L" is 25 cm (9.84 in.), balance reading should be 1.16 kgf (2.56 lbf) [11.4 N] to 1.48 kgf (3.26 lbf) [14.5 N] as calculated below:

0.29 kgf·m (2.10 lbf·ft) [2.8 N·m]
= 0.25 m (9.84 in.) x X_1

X_1 = 1.16 kgf (2.56 lbf) [11.4 N]

0.37 kgf·m (2.68 lbf·ft) [3.6 N·m]
= 0.25 m (9.84 in.) x X_2

X_2 = 1.48 kgf (3.26 lbf) [14.5 N]

Removal

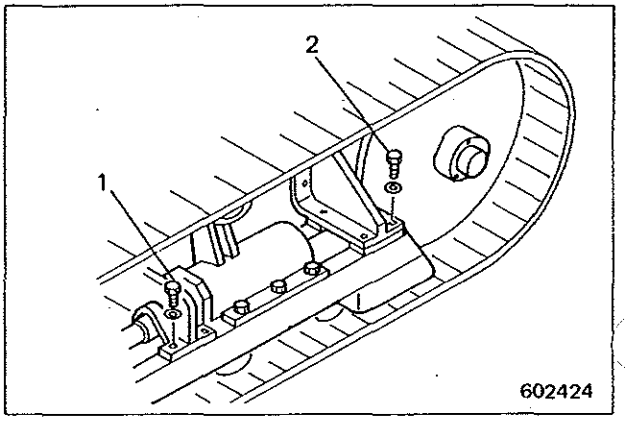
Preparatory steps

(1) Separate the tracks. (Refer to the topic, Removal, TRACKS.)

(2) On the PT model, disconnect the hydraulic hoses from the tilt cylinder, and remove the blade and blade arms.

1. Remove the following parts:

   1 Bolts securing rigid bar
   2 Bolts securing rear support



2. Lift or jack up the machine a little, and securely block the rigid bars and steering clutch cases, using wood blocks, as shown.

3. Remove the under carriage.

Installation

To install the undercarriage, follow the reverse of removing procedure.

FRONT IDLERS

Removal and installation

Preparatory steps

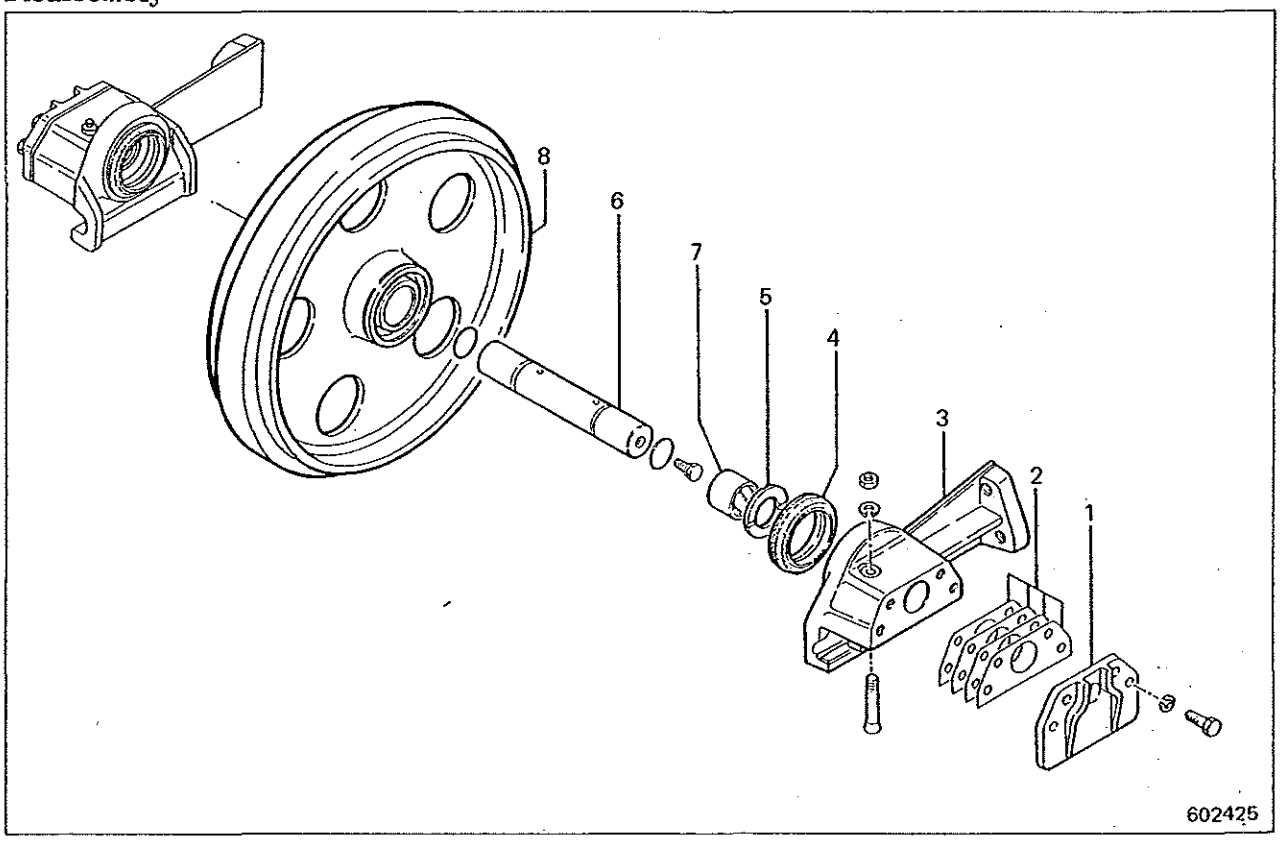
(1) Separate the tracks.

(2) Drain the oil from the idler.

1. Unscrews the bolts (4 pcs). Hitch a wire to the idler, and pull the idler assembly off the track frame.

2. After installing the idler, center it in the track frame.

Disassembly

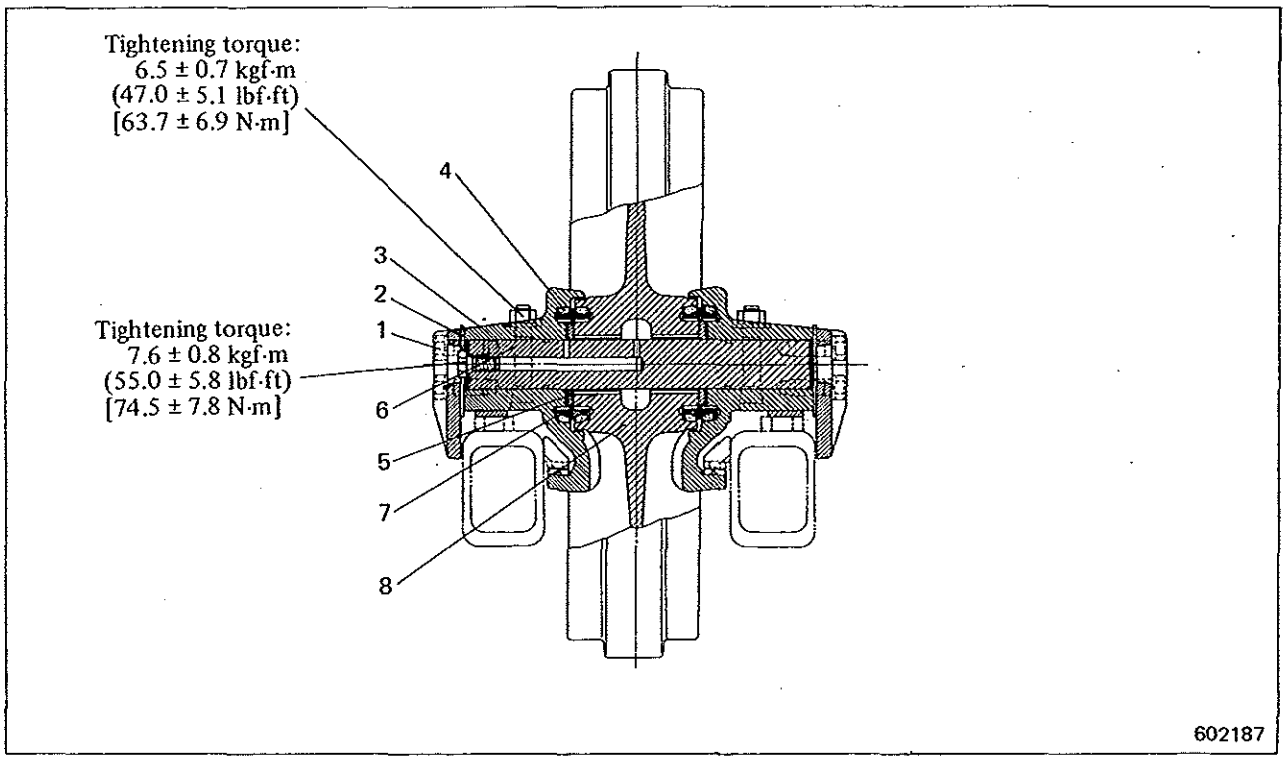


(Remove the parts in the order numbered for disassembly.)

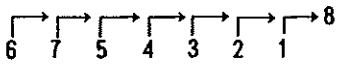
1 Guide
2 Shim
3 Bearing
4 Floating seal
5 Thrust washer
6 Shaft
(to be removed as an assembly including "7" and "8")
7 Bushing
8 Idler

Weight of front idler	38 kg (84 lb), approx.

Reassembly



Reassembling order



Tips for reassembly

Lubrication

(1) Fill the idler with recommended oil through the plug hole in the shaft.

(2) Use an adaptor and volume pump for this filling.

Capacity (approx.)	60 cc (3.7 cu in.) (SAE 90 gear oil)

Part name	Part number
Adaptor	58809-15100
Volume pump	58309-03100

RECOIL SPRINGS AND HYDRAULIC ADJUSTER CYLINDERS

Removal and installation

Preparatory step

Release the pressure in the hydraulic adjuster cylinder completely.

1. Remove hydraulic adjuster cylinder assembly "1."

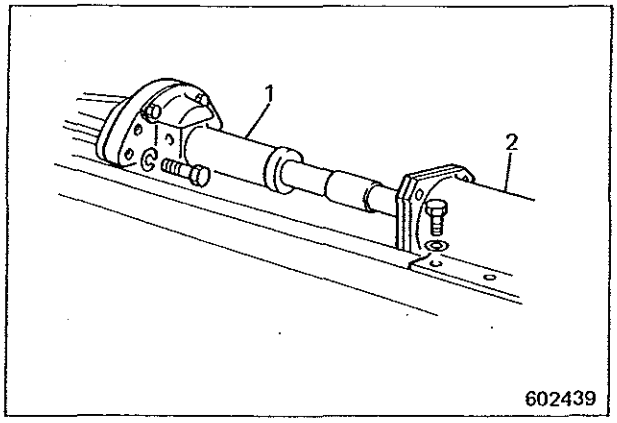
Weight of hydraulic adjuster cylinder assembly	15 kg (33 lb), approx.

2. Remove carrier roller bracket assembly (recoil spring assembly) "2."

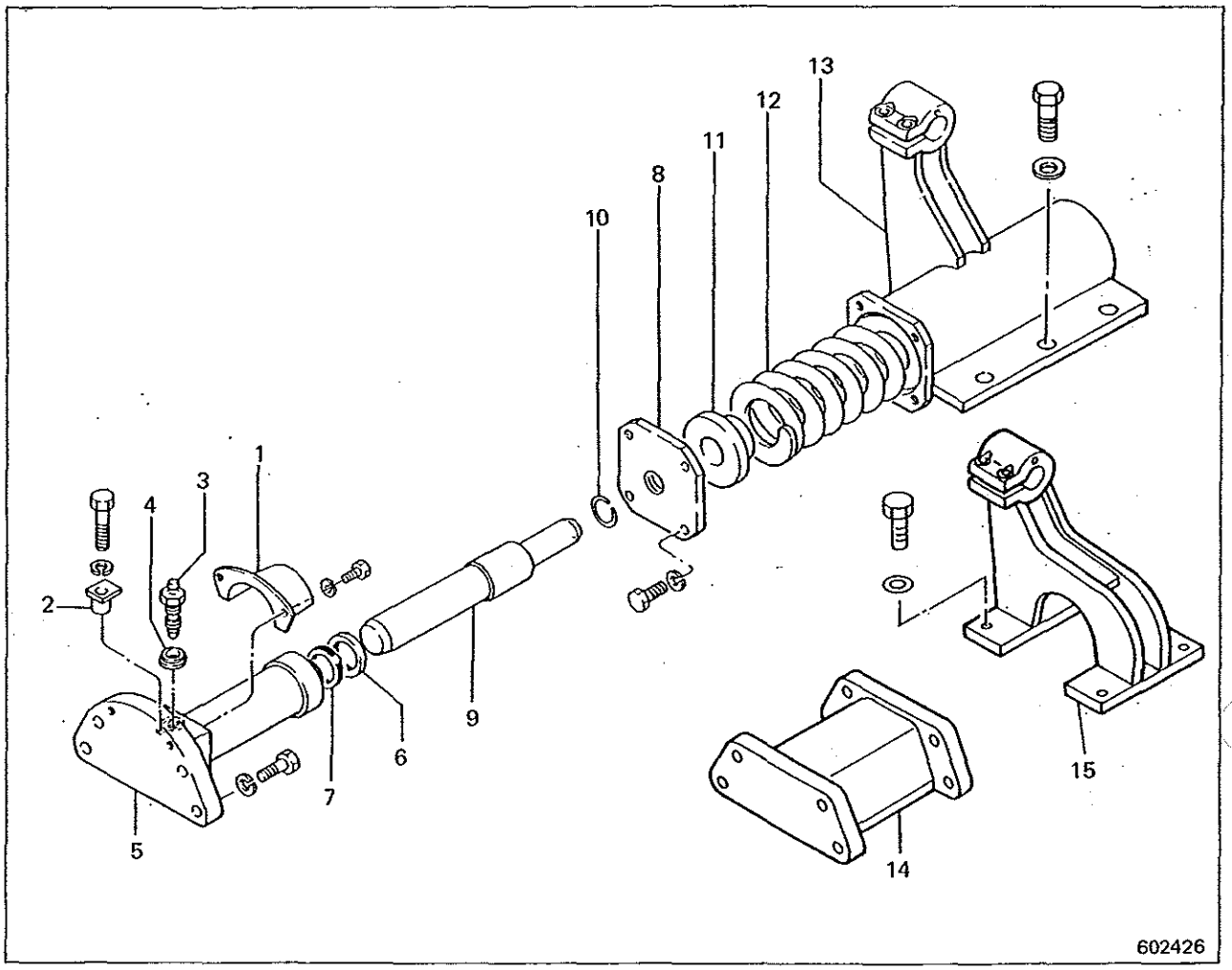
Weight of carrier roller bracket assembly (with carrier roller)	42 kg (93 lb), approx.

3. Remove the track carrier roller assembly. (Refer to the topic, Removal, TRACK CARRIER ROLLERS.)

4. After installing the track, adjust its tension.



Disassembly

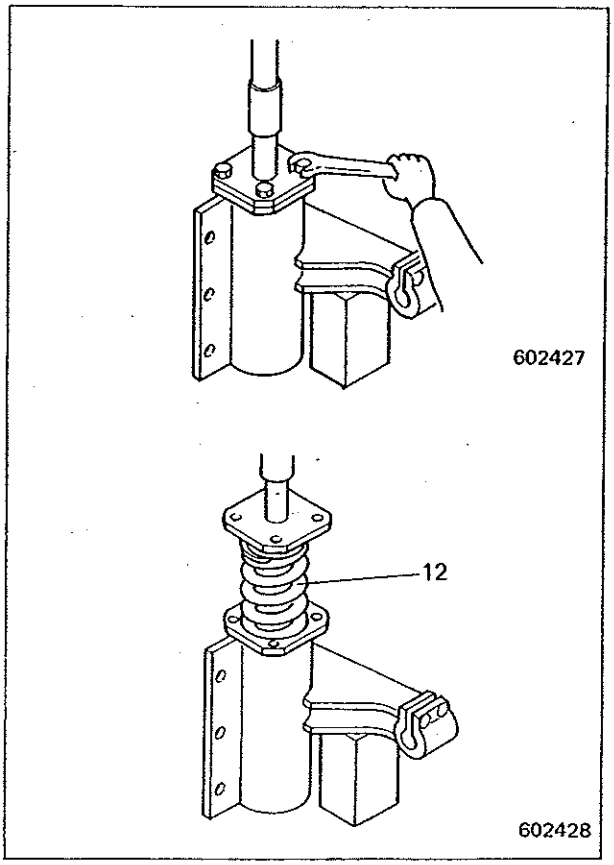


(Remove the parts in the order numbered for disassembly.)

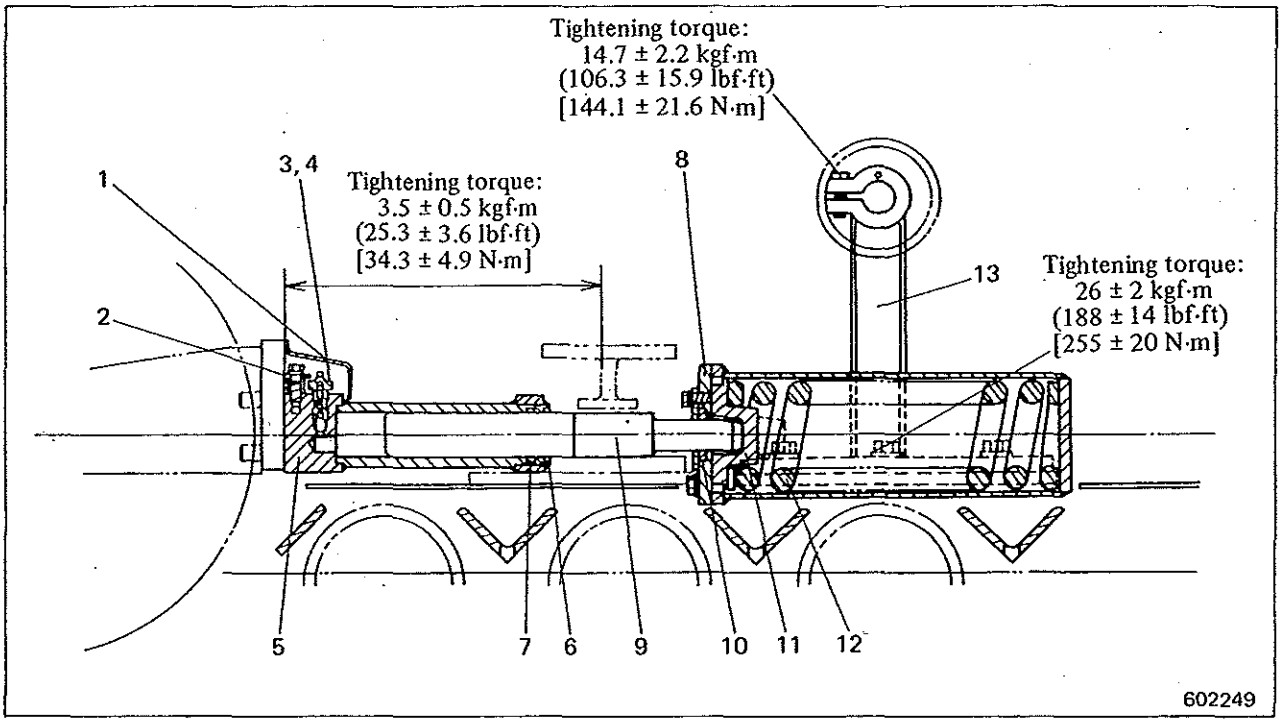
1 Cover
2 Stopper
3 Fill valve
4 Washer
5 Cylinder
(to be removed as an assembly including "6" and "7")
6 Dust seal
7 Rod packing
8 Plate
9 Shaft
10 Ring
11 Spring retainer
12 Spring
13 Carrier roller bracket
14 Bracket
(for ultra-super-swamp model)
15 Carrier roller bracket
(for ultra-super-swamp model)

Tips for disassembly

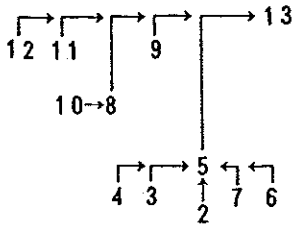
To remove recoil spring "12," hold plate "8" with the arbor of a press having a capacity of 3 tons (6615 lb) as shown, unscrew four bolts, and gradually back off the press arbor to let the spring expand. Take out the plate, spring retainer "11" and spring.



Reassembly



Reassembling order



Tips for reassembly

Recoil spring installation

Compress spring "12" as in case of disassembly, and install plate "8" to the spring.

TRACK ROLLERS

Removal

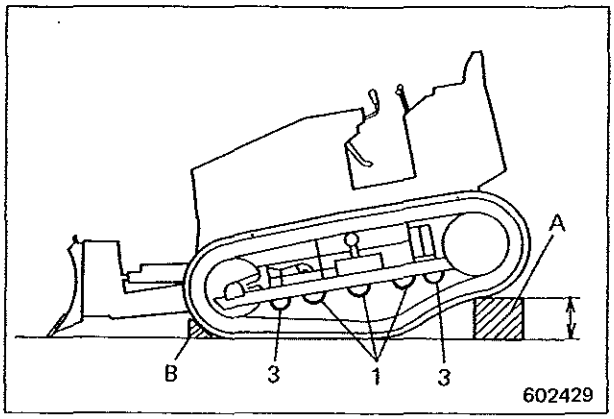
Preparatory steps

(1) Loosen the tracks.

(2) Drain the oil from the track rollers.

1. Place two wood blocks "A" of 300-mm (12-in.) square section behind the sprockets in a chocking manner, and move the machine to ride onto these blocks until the track rollers "1" and "3" float up and away from the track.

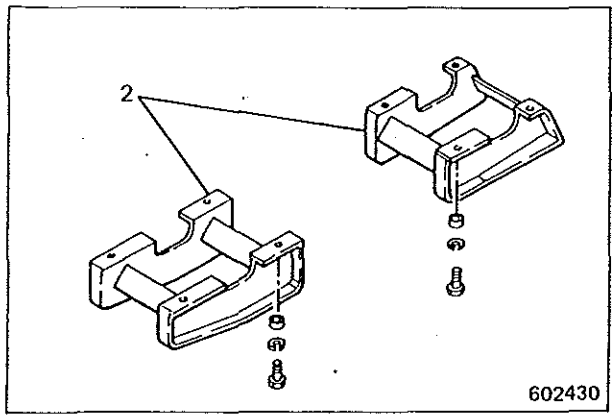
2. Apply the brake lock, and chock the tracks at front end with blocks "B."



3. Remove the following parts:

1 Track roller (center, 3 pcs)
2 Track roller guard (front and rear)
3 Track roller (front and rear)

Weight of track roller	15 kg (33 lb), approx.



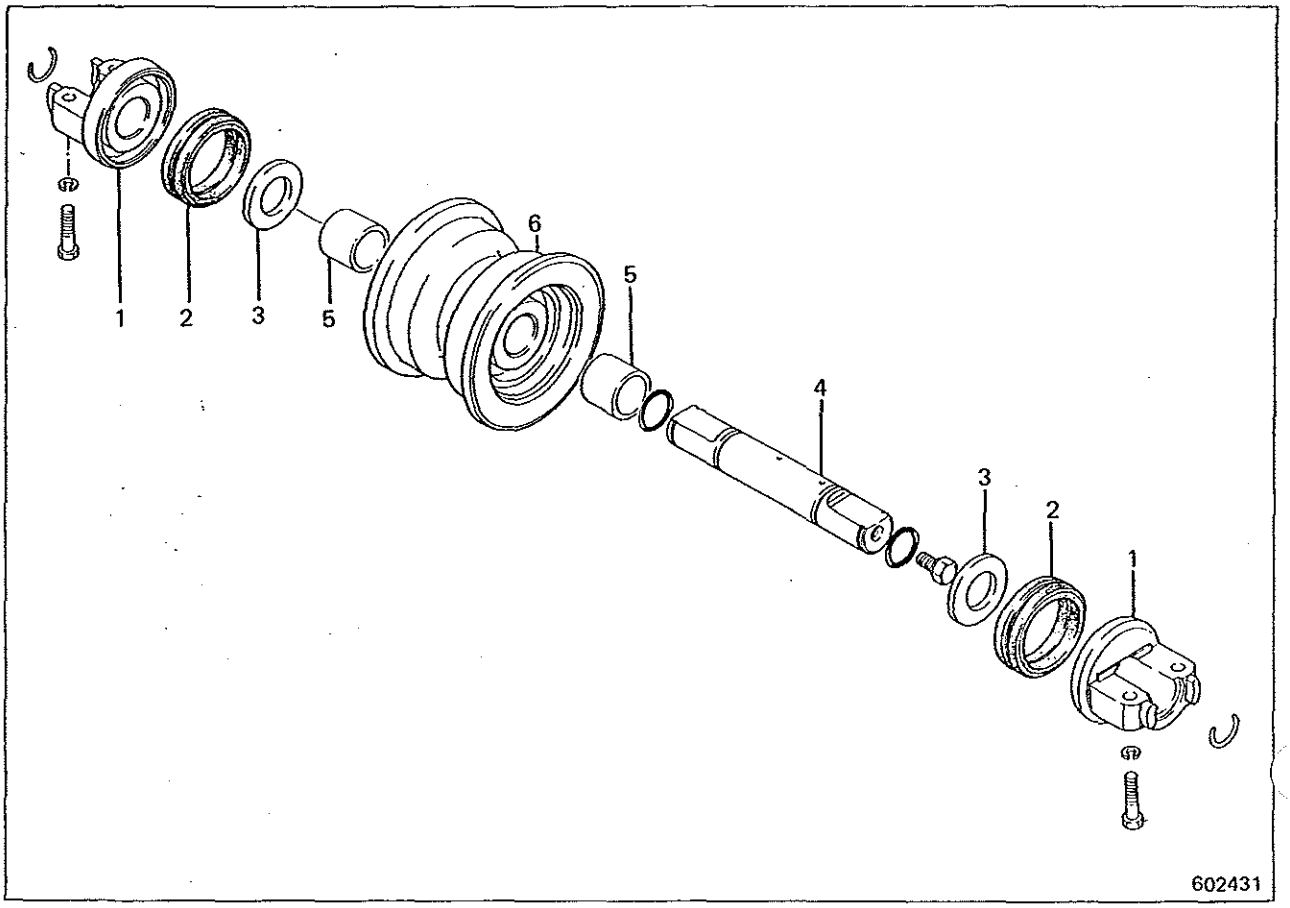
Installation

1. To install the track rollers, follow the reverse of removing procedure.

2. Drive the machine forward out of its chocked condition.

Tightening torque for track roller bolts	6.0 ± 0.6 kgf·m (43.4 ± 4.3 lbf·ft) [58.8 ± 5.9 N·m]

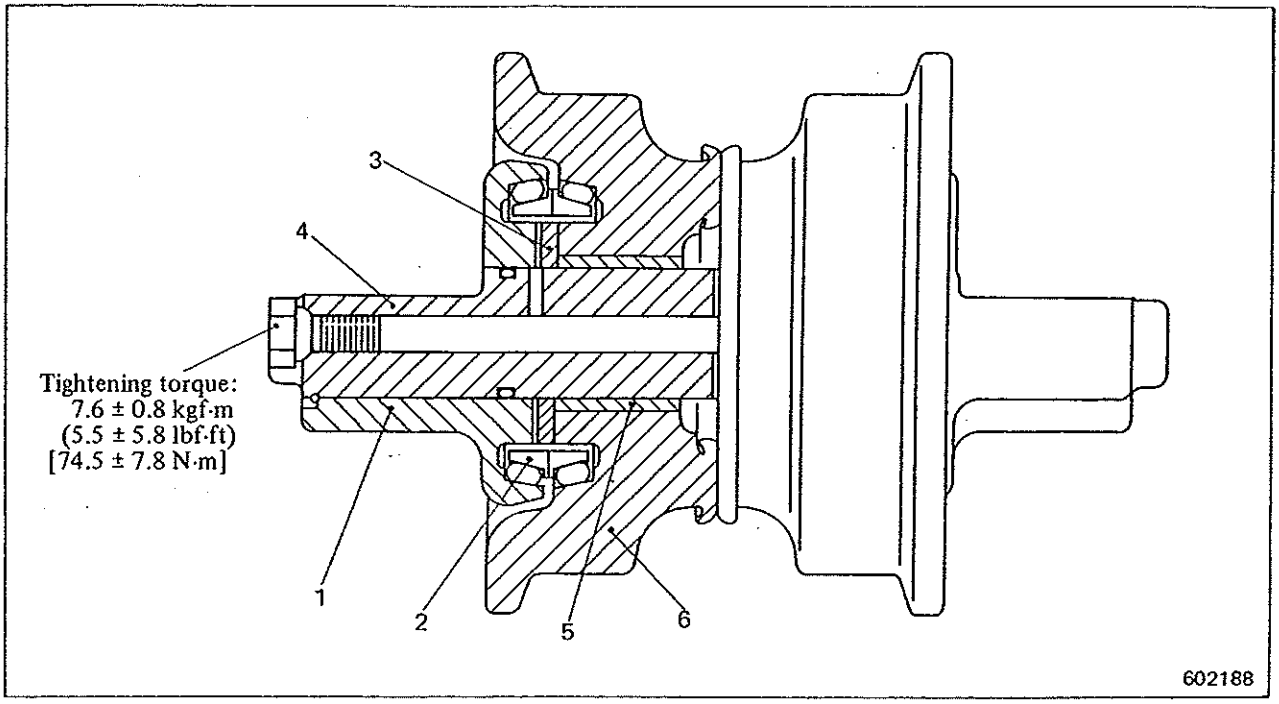
Disassembly



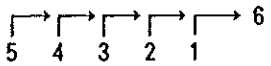
(Remove the parts in the order numbered for disassembly.)

1 Collar
2 Floating seal
3 Thrust washer
4 Shaft
5 Bushing
6 Flanged roller

Reassembly



Reassembling order



Tips for reassembly

1. Floating seal installation

(1) When fitting the floating seals, use a properly sized round bar or the special tool to prevent damage to the seals and O-rings.

CAUTION

Never use a screwdriver or a sharp-edged tool to fit the floating seals.

(2) Using a lint-free cloth or a brush and washing fluid, clean the surfaces of metal rings of floating seals, making sure that these rings are free of any grime.

2. Lubrication

(1) After reassembling the roller, fill it with recommended oil through plug hole in the shaft.

(2) Use an adaptor and volume pump for this filling.

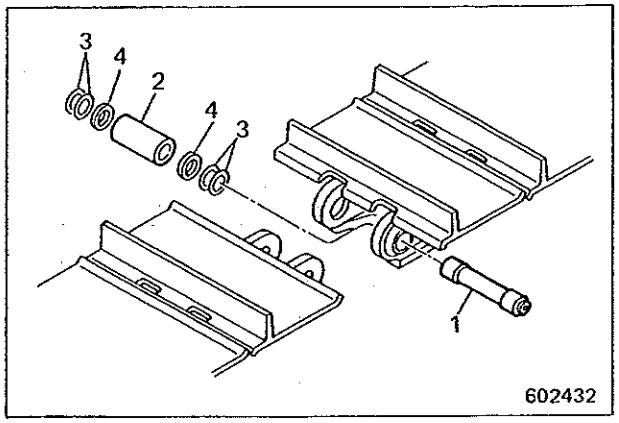
Capacity approx.	75 cc (4.6 cu in.) (SAE90 gear oil)

Part name	Part number
Adaptor	58809-15100
Volume pump	58309-03100

TRACKS

Removal

1. Move the machine until the master pin comes to the rear upper part of sprocket.
2. Loosen the tracks. (Refer to the topic, Track, adjustment.)
3. Drive out master pin "1."
4. Remove bushing "2," seal washers "3" and spacers "4" (standard and swamp models). Remove the bushing and seal (super-swamp and ultra-super-swamp models).
5. Insert a bar into the link and, while holding the bar, move the machine slowly forward to lay out the track.
6. Lift the side of the machine, and remove the track.
7. After lifting the side of the machine, place wood blocks under the rigid bar and steering clutch case.

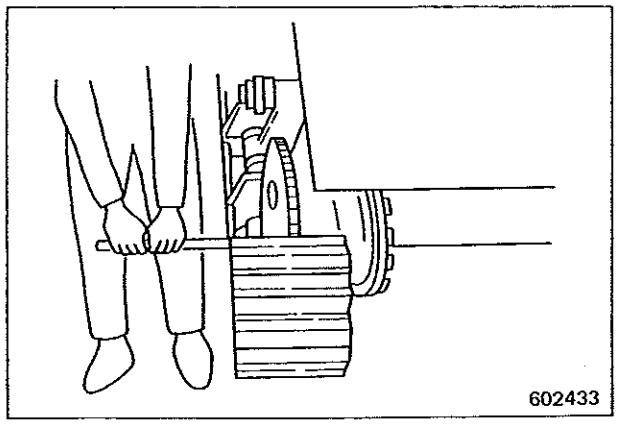


Track weight — Unit: kg (lb)

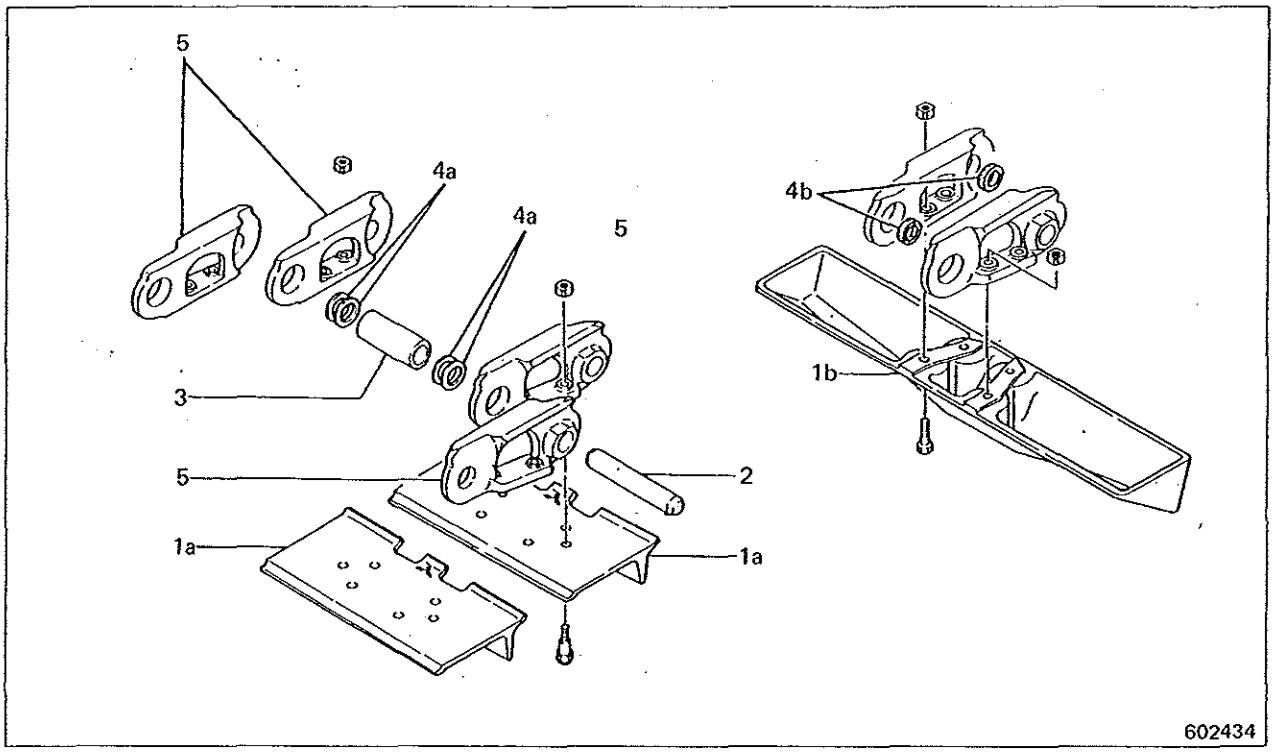
Standard model	BD2G (P)	280 (620), approx.
	BS3G (F)	310 (680), approx.
Swamp model (S)		420 (930), approx.
Super-swamp model (SS)		470 (1040), approx.
Ultra-super-swamp model (SSS)		600 (1320), approx.

Installation

1. To install the track, follow the reverse of removing procedure.
2. Insert a bar into the link, and aid the track to climb over the sprocket, carrier roller and front idler, as the machine is moved slowly forward.
3. Install the seal washers properly. Drive in the master pin with its center hole outside. (For detail of seal washer installation, refer to the topic, Reassembly.)
4. To drive in the master pin, insert the guide bar, bushing, seal washers, etc. into the link, and drive in the pin in a manner of driving out the guide bar.



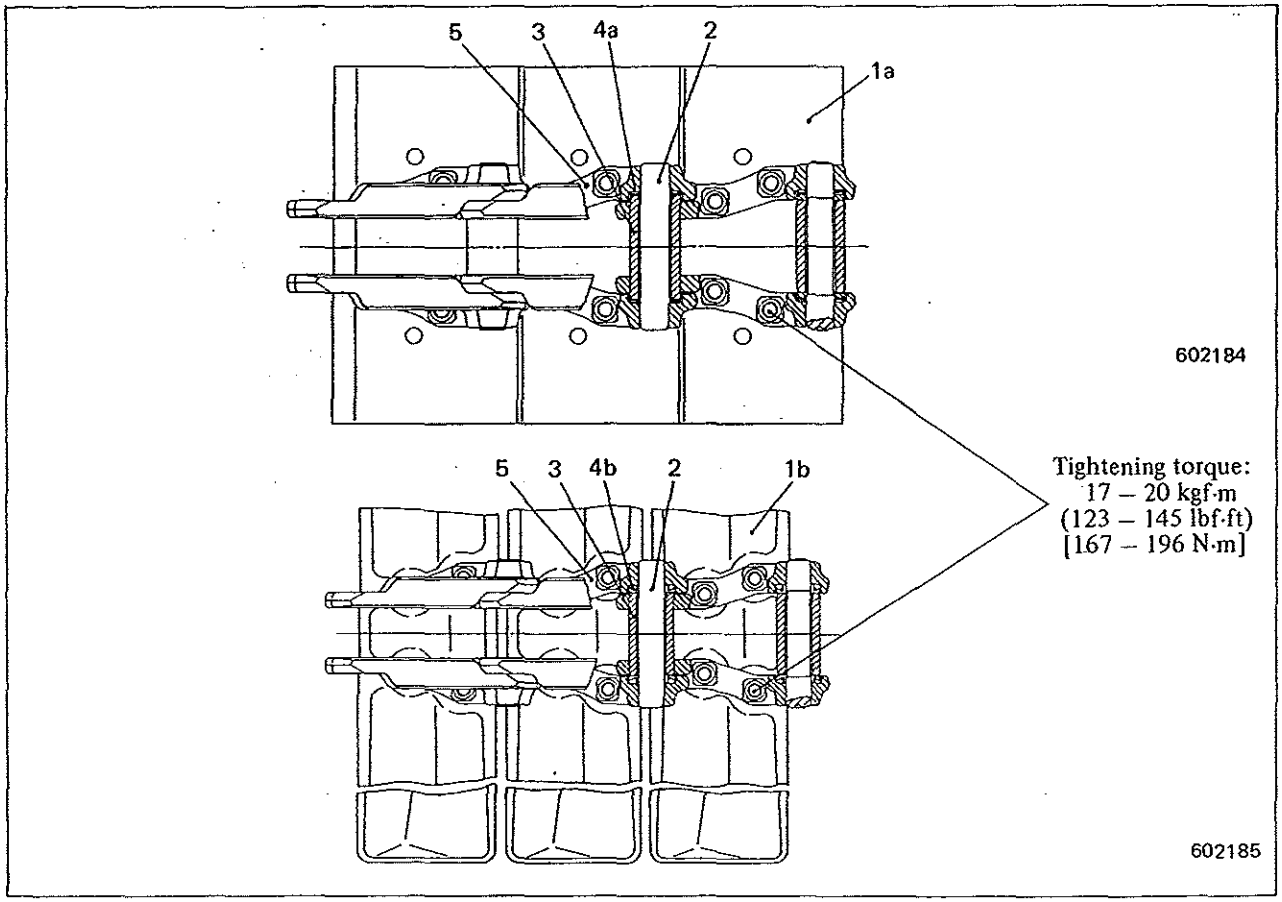
Disassembly



(Remove the parts in the order numbered for disassembly.)

1a Standard shoe
1b Swamp shoe (curved apex shoe)
2 Pin
3 Bushing
4a Seal washer
4b Seal
5 Link

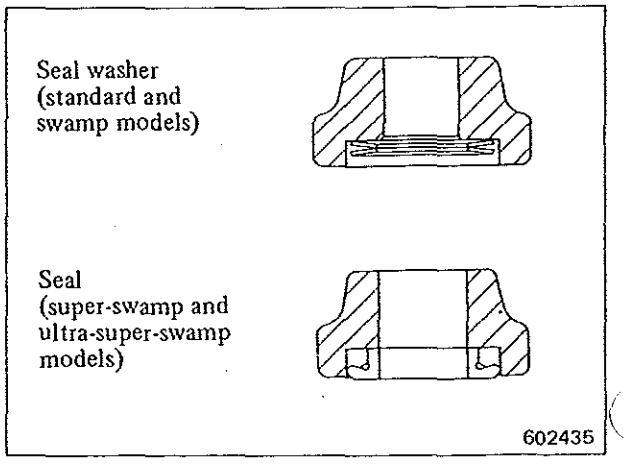
Reassembly



Reassembling order

Tips for reassembly

Install the seal washers and seals as shown.



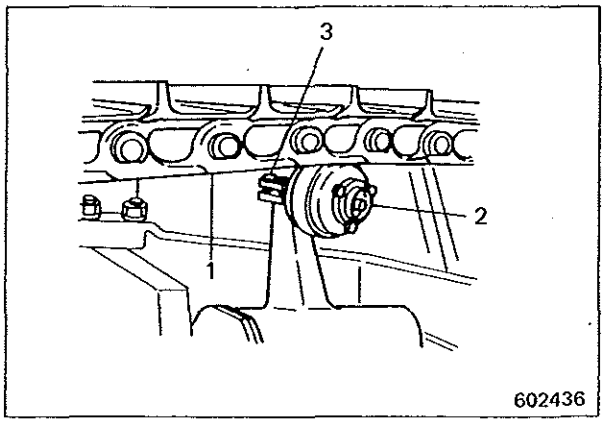
TRACK CARRIER ROLLERS

Removal

Preparatory steps

(1) Loosen the tracks.

(2) Drain the oil from the track carrier rollers.



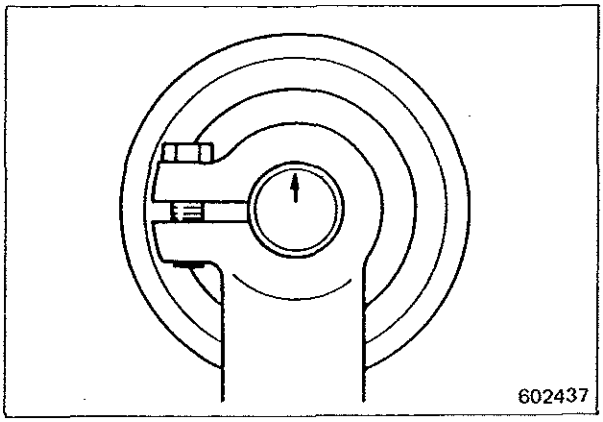
Push up the track above the carrier roller to produce some clearance between track "1" and carrier roller "2," and remove the following parts:

3 Bolts (2 pcs)
2 Track carrier roller

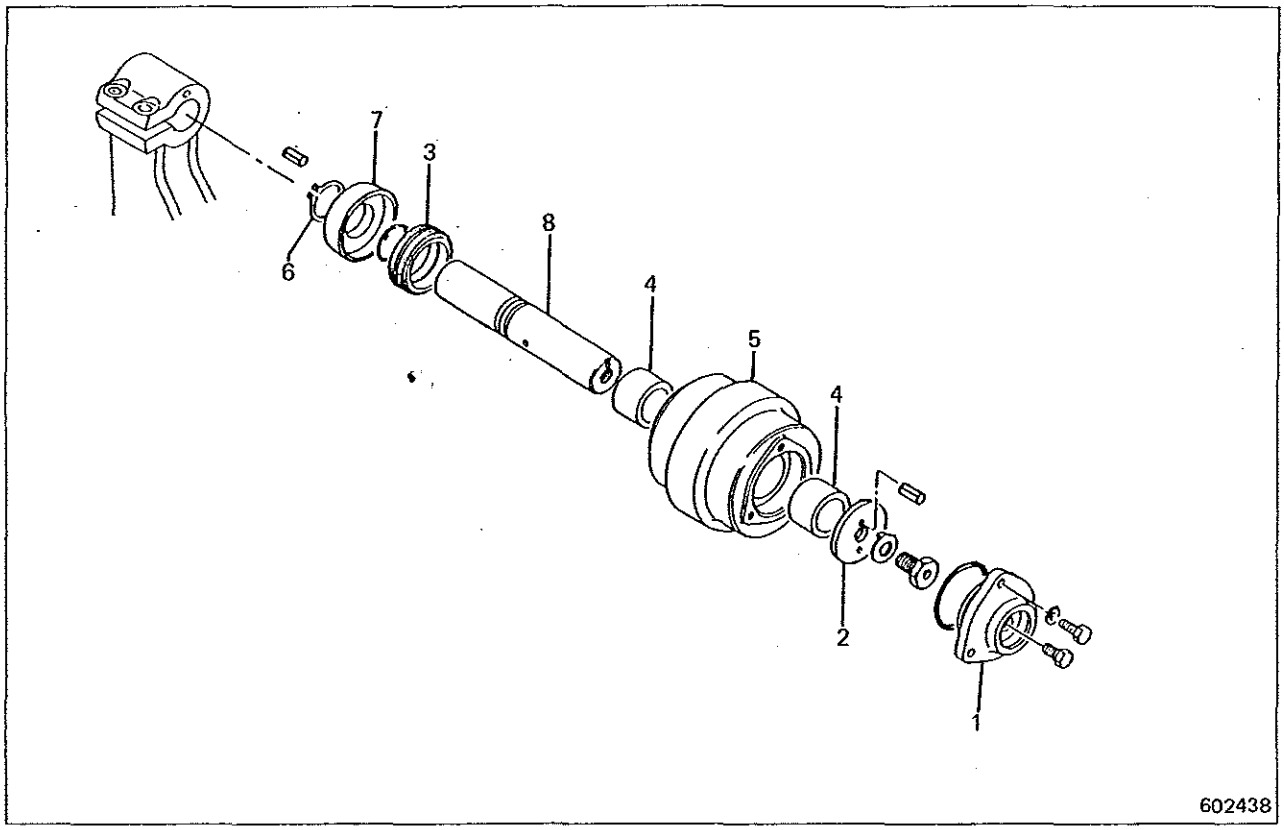
Weight of track carrier roller	11 kg (24 lb), approx.

Installation

1. To install the track carrier roller, follow the reverse of removing procedure.
2. Insert the shaft into the bracket so that the arrow mark on one end points upward and the spring pin hole on the other comes to the top side.
3. Adjust the tension of tracks.



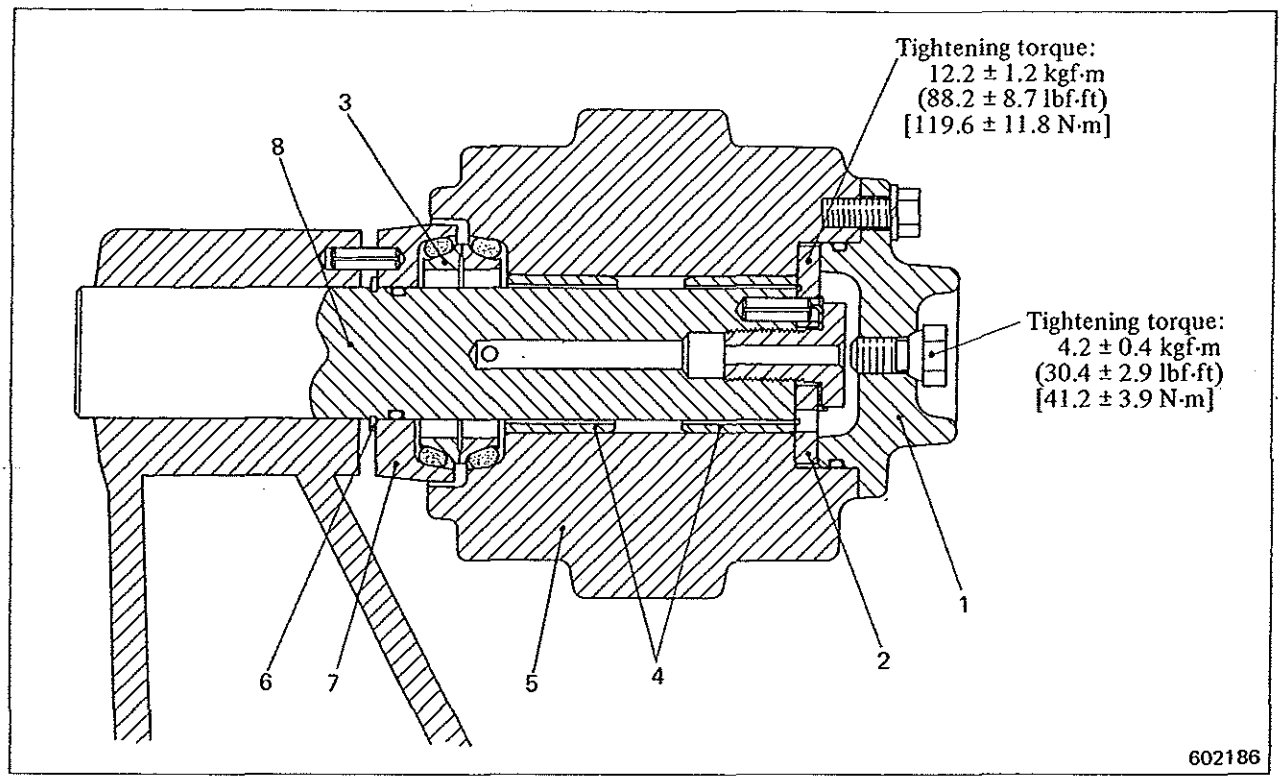
Disassembly



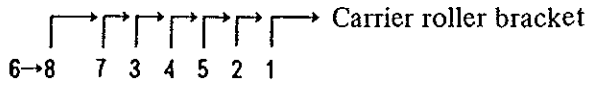
(Remove the parts in the order numbered for disassembly.)

1 Cover
2 Washer
3 Floating seal (to be removed as an assembly including "4" and "5")
4 Bushing
5 Roller
6 Snap ring
7 Seal support
8 Shaft

Reassembly



Reassembling order



Tips for reassembly

Lubrication

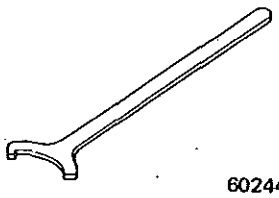
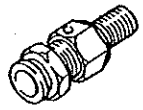
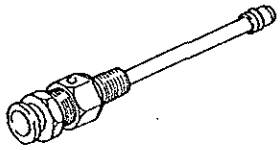
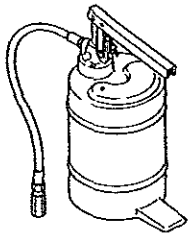
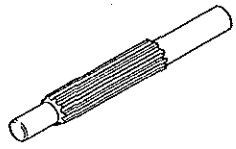
(1) After reassembling the roller, fill it with recommended oil through plug hole in the cover.

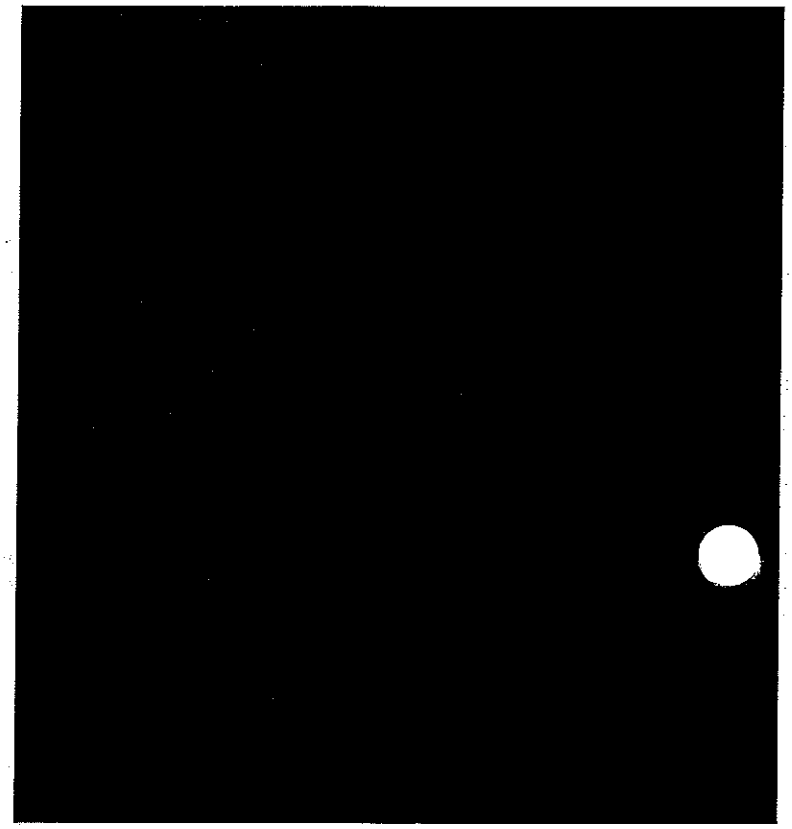
(2) Use an adaptor and volume pump for this filling.

Capacity approx.	35 cc (2.1 cu in.) (SAE 90 gear oil)

Part name	Part number
Adaptor	58609-00300
Volume pump	58309-03100

SPECIAL TOOLS

Part number	Part name	Shape	Use
58809-10200	Wrench	 602440	Bevel gear adjustment
58609-00300	Adaptor	 602441	Carrier roller lubrication
58809-15100	Adaptor	 602442	Front idler and track roller lubrication
58309-03100	Volume pump	 602443	Carrier roller, front idler and track roller lubrication
58809-15600	Clutch disc arbor	 602444	Flywheel clutch installation (clutch disc assembly aligning)



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SERVICE MANUAL

MITSUBISHI TRACTOR BD2G

TRACTOR SHOVEL BS3G

CONTENTS

HYDRAULIC SYSTEM
DISASSEMBLY AND REASSEMBLY

MITSUBISHI HEAVY INDUSTRIES, LTD.

FOREWORD

This service manual has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations used in this manual are based on information that was current at the time this issue was written.

Correct servicing will give these machines a long productive life. Before attempting to start a test, repair or rebuild job, be sure that you have studied the respective sections of this manual, and know all the components you will work on.

Safety is not only your concern but everybody's concern. Safe working habits cannot be bought or manufactured; they must be learned through the job you do. By learning what CAUTION or WARNING symbol emphasizes, know what is safe – what is not safe. Consult your foreman, if necessary, for specific instructions on a job, and the safety equipment required.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

CAUTION ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of machine.

WARNING ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

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Hydraulic pump 1
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Power tilt blade 16
Bucket and linkage 18
Hydraulic cylinders 20
Special tools 32

HYDRAULIC PUMP

Removal

Preparatory step

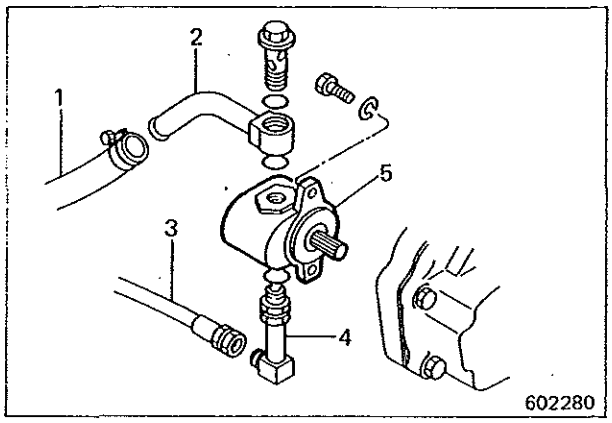
Remove the side cover (RH) from the engine room.

WARNING

Raise the bucket all the way, and securely support it by external means. (BS3$_G$)

1. Remove the following parts:

1 Rubber hose (suction side)
2 Pipe
3 Rubber hose (discharge side)
4 Pipe and connector
5 Hydraulic pump

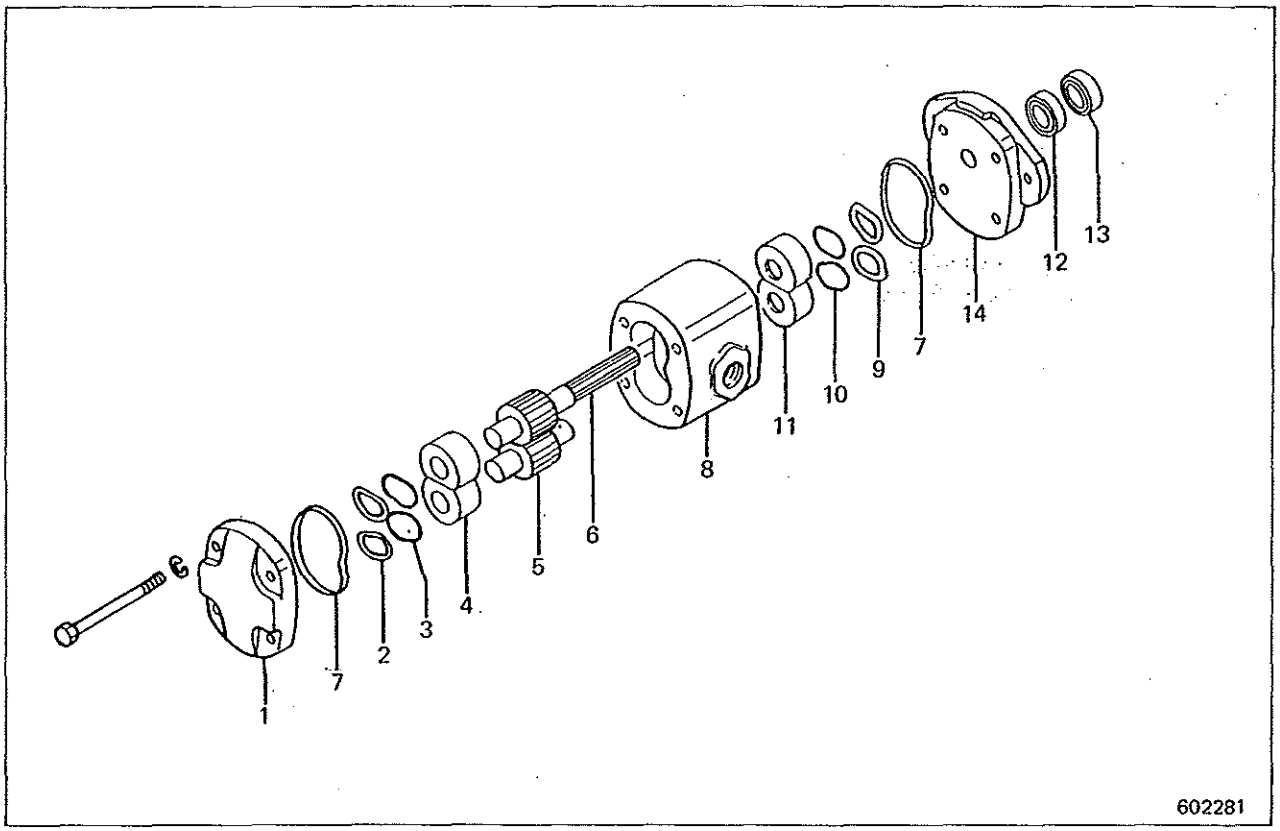


Installation

To install the pump, follow the reverse of removing procedure.

Tightening torque for hydraulic pump mounting bolts	4.2 kgf·m (30.4 lbf·ft) [41.2 N·m]

Disassembly



1 Cover	6 Drive gear	11 Bushing (2 pcs)
2 Packing ring	7 Body seal (2 pcs)	12 Oil seal
3 Bushing seal (2 pcs)	8 Body	13 Dust seal
4 Bushing (2 pcs)	9 Packing ring	14 Mounting flange
5 Driven gear	10 Bushing seal (2 pcs)	

(Remove the parts in the order numbered for disassembly.)

Tips for disassembly

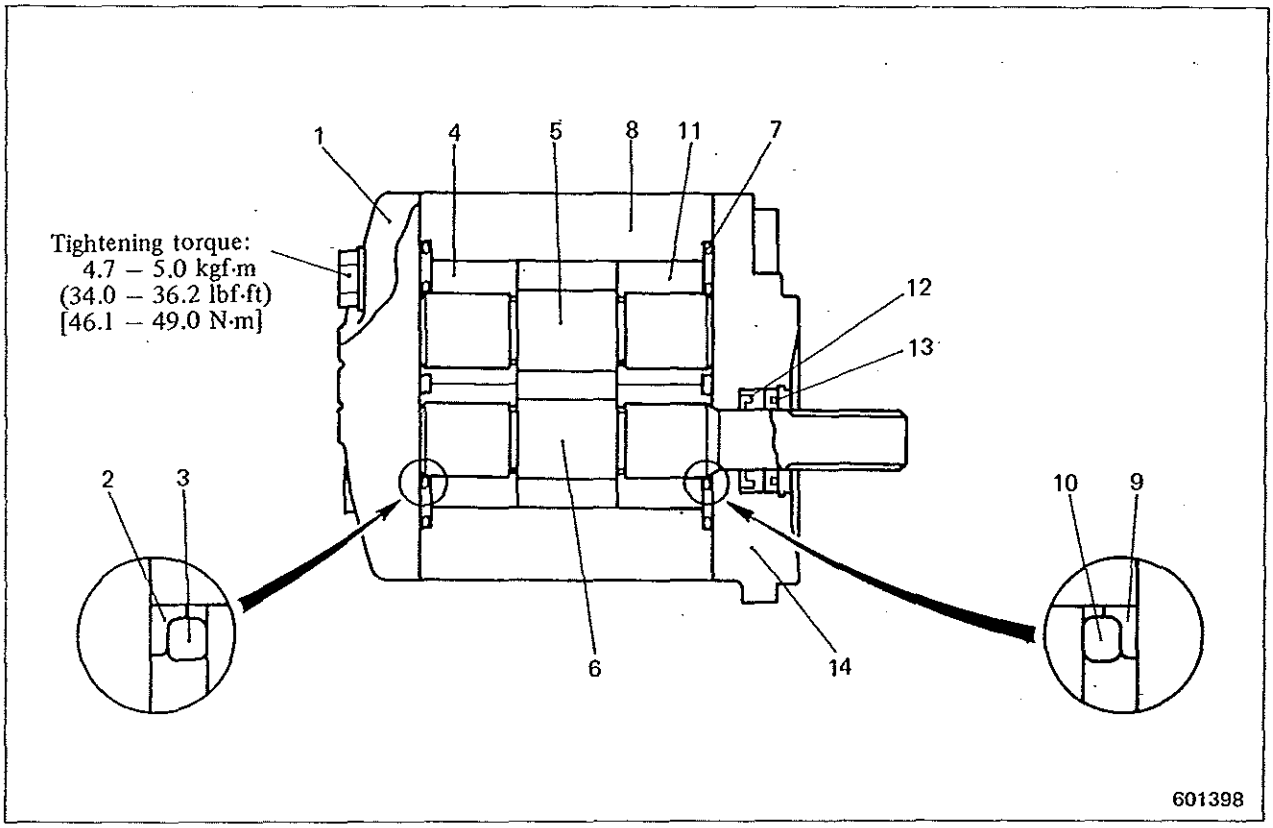
1. Lay down the pump body. Pull out the drive gear by hand, and remove the bushings.

2. Lay out the disassembled parts neatly in the order in which they came out, identifying each for its position. Particularly, the shaft and its bushings must be identified positionally by marking or otherwise so that they will be restored to their original position in reassembly.

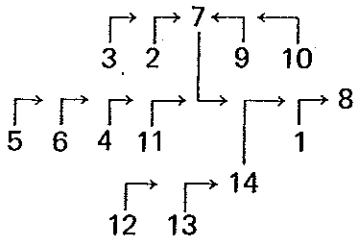
NOTE

If the bushings will not come out, tap on the pump body with a plastic hammer to shake the bushings loose. Be sure to place the pump body on a wood top bench and tap lightly.

Reassembly



Reassembling order



Tips for reassembly

Attach packing rings and bushing seals to the bushings, apply a coat of high-grade grease to the bushings, and insert them into the pump body.

NOTE

1) When inserting a pair of bushings "4" and "11," hold them squarely to the bore to avoid scuffing.

2) If the outside surface of the bushing is found with scratch marks, remove high spots on the surface by lightly polishing with an oil stone.

3) When reinstalling the gears, mesh drive gear "6" with the driven gear in the same tooth position as before.

4) Before installing the cover, wrap the splined portion of the drive gear shaft with one or two layers of cellophane tape to prevent damage to the oil seal.

CONTROL VALVE

Removal

Preparatory steps

(1) Lower the implement to the ground, and stop the engine.

(2) Move the control lever to all operating positions to relieve the pressure in the hydraulic circuits.

1. Remove the following parts:

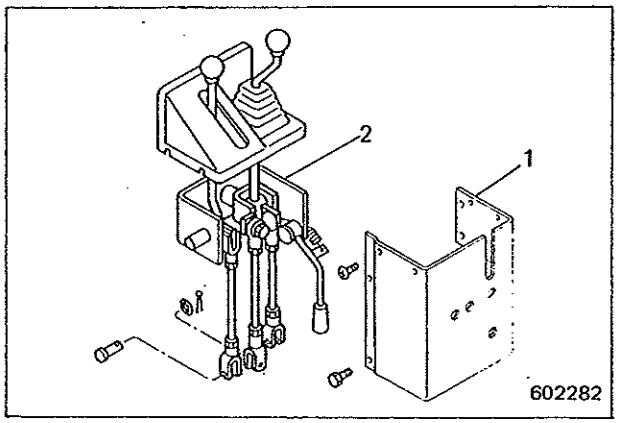
1 Cover
2 Control linkage assembly
3 Oil pipes
4 Control valve

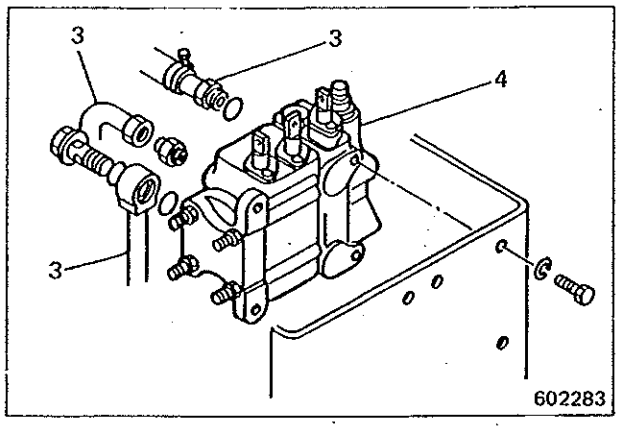
NOTE

Loosen the return oil hose clamps, and push the hose toward the hydraulic tank.

Weight of control valves

BD2G	Control valve for power angling/tilt blade	13.5 kg (30 lb), approx.
	Control valve for power tilt blade	10.0 kg (22 lb), approx.
Control valve for BS3G		10.0 kg (22 lb), approx.





Installation

To install the control valve, follow the reverse of removing procedure.

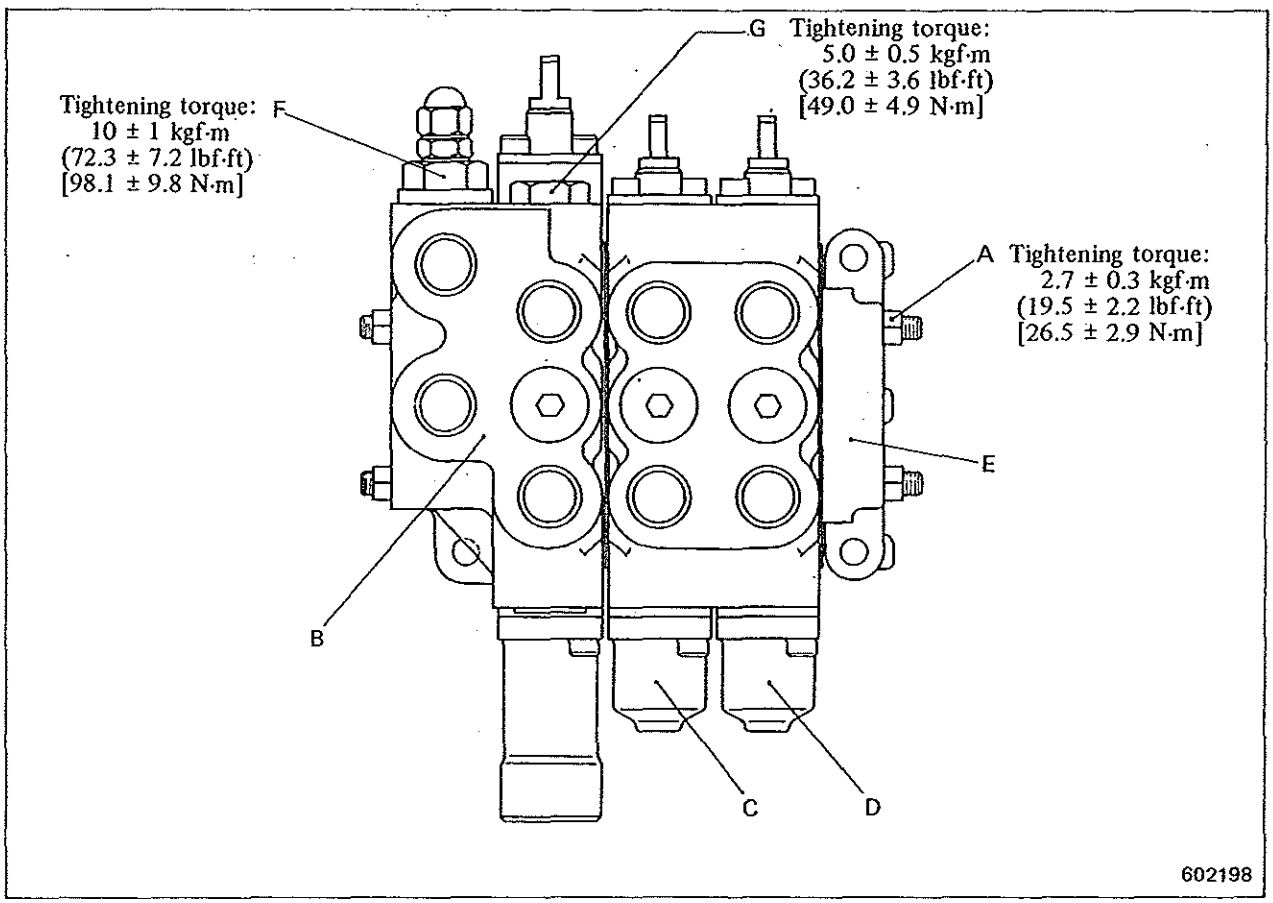
Tips for installation

When installing the control valve, check to make sure that the clevis of each control linkage and the plunger of control valve are properly installed. The clevis and plunger should be at a right angle to the adjacent ones when installed, as shown.

BD2G	Control valve for power angling/tilt blade	Tilt plunger section (center)
	Control valve for power tilt blade	Tilt plunger section (left as viewed from front side)
Control valve for BS3G		Dump plunger section (left as viewed from front side)

3-section control valve ($BD2_G$ with power angling/tilt blade)

Disassembly and reassembly



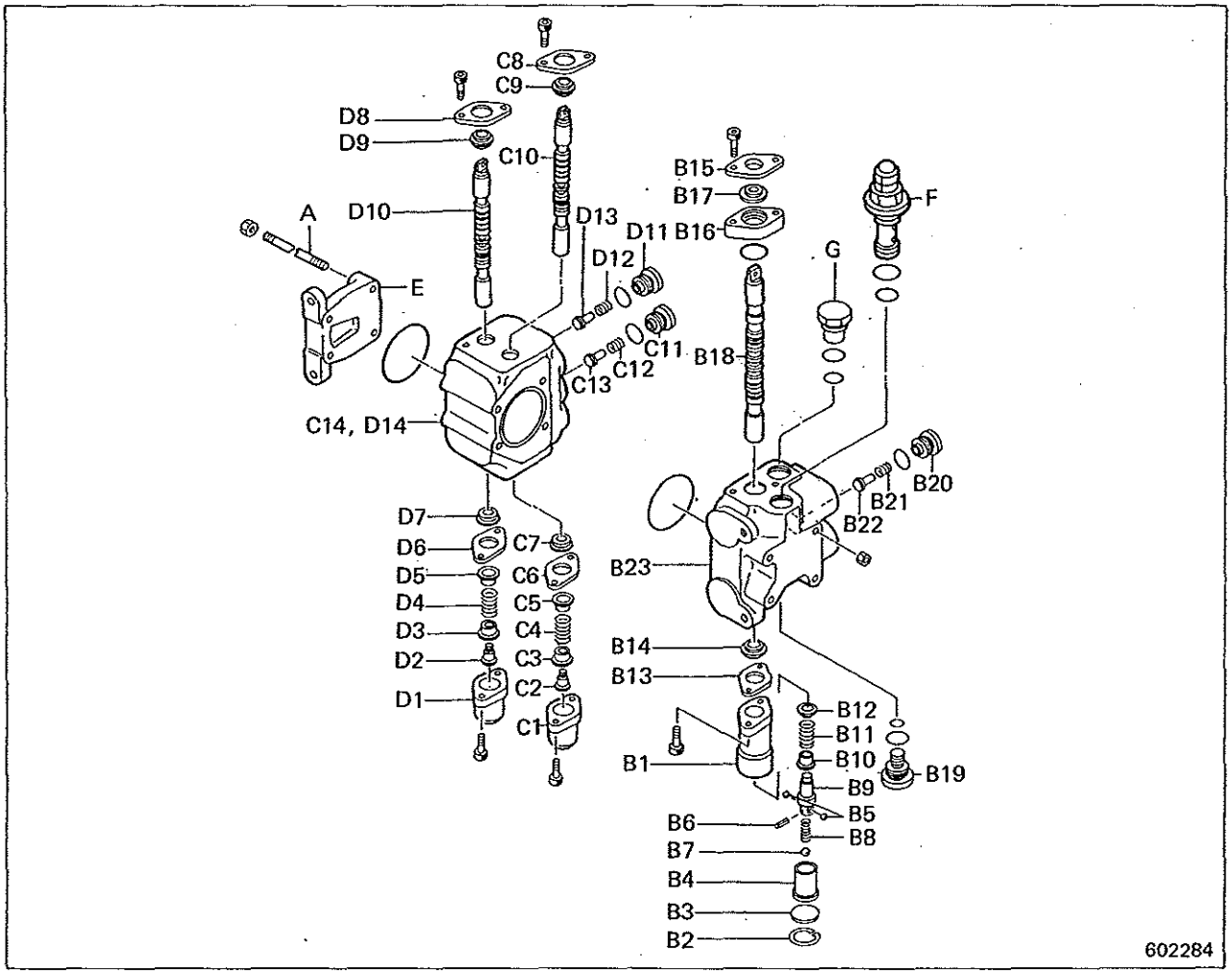
A Tie rod
B Inlet and lift valve plunger section
C Tilt valve plunger section
D Angling valve plunger section
E End plate
F Main relief valve
G Makeup valve

NOTE

1) Be sure to tighten the tie rods to the specified torque, or the plungers will not move smoothly and the implement will drift excessively.

2) After reassembly, make sure that the plungers move smoothly.

Disassembly

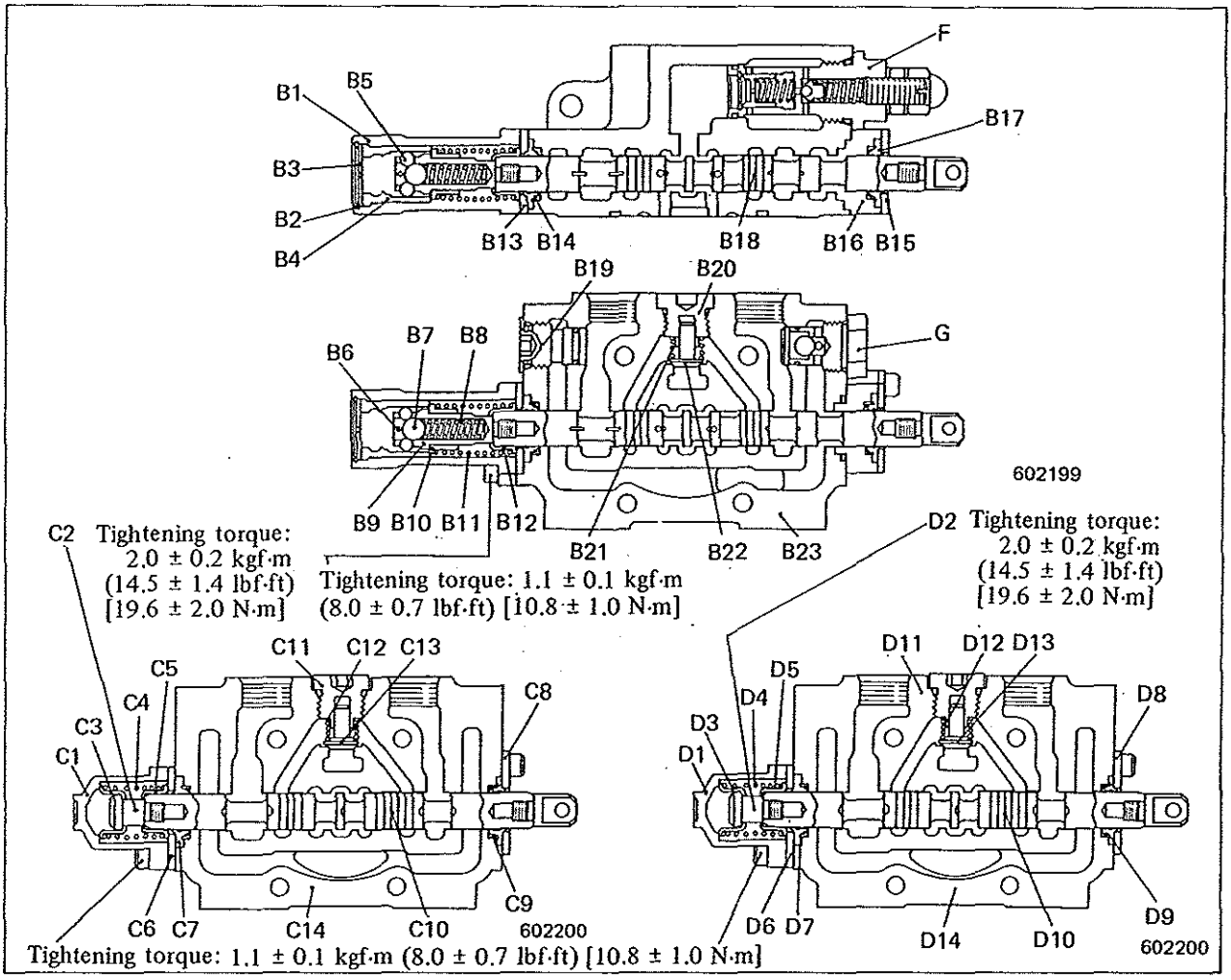


B1 Cap (to be removed as an assembly including "B2" thru "B4")
B2 Snap ring
B3 Plate
B4 Detent sleeve
B5 Steel (detent) balls
B6 Spring pin
B7 Steel (detent) ball
B8 Spring
B9 Plunger plug
B10 Spring guide
B11 Spring
B12 Spring guide
B13 Seal cover plate
B14 Oil seal
B15 Plate
B16 Spacer
B17 Oil seal
B18 Plunger
B19 Plug
B20 Plug
B21 Spring
B22 Check valve
B23 Housing

C1, D1 Cap
C2, D2 Plunger plug
C3, D3 Spring guide
C4, D4 Spring
C5, D5 Spring guide
C6, D6 Seal cover plate
C7, D7 Oil seal
C8, D8 Seal cover plate
C9, D9 Oil seal
C10, D10 Plunger
C11, D11 Plug
C12, D12 Spring
C13, D13 Check valve
C14, D14 Housing

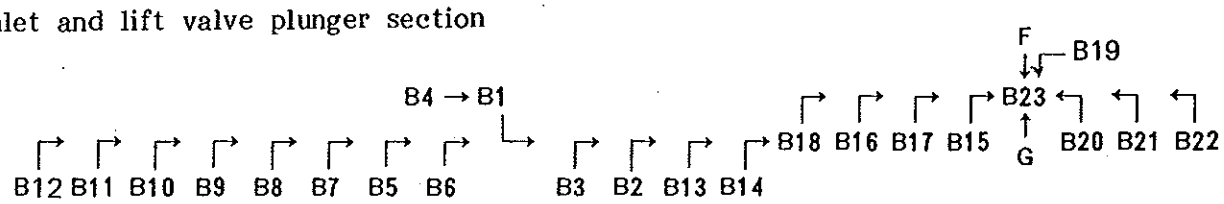
(Remove the parts in the order numbered for disassembly.)

Reassembly

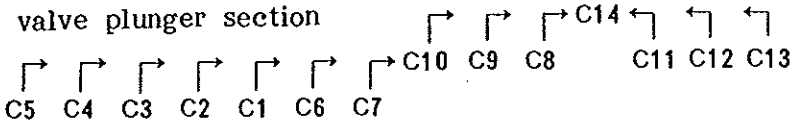


Reassembling order

B Inlet and lift valve plunger section



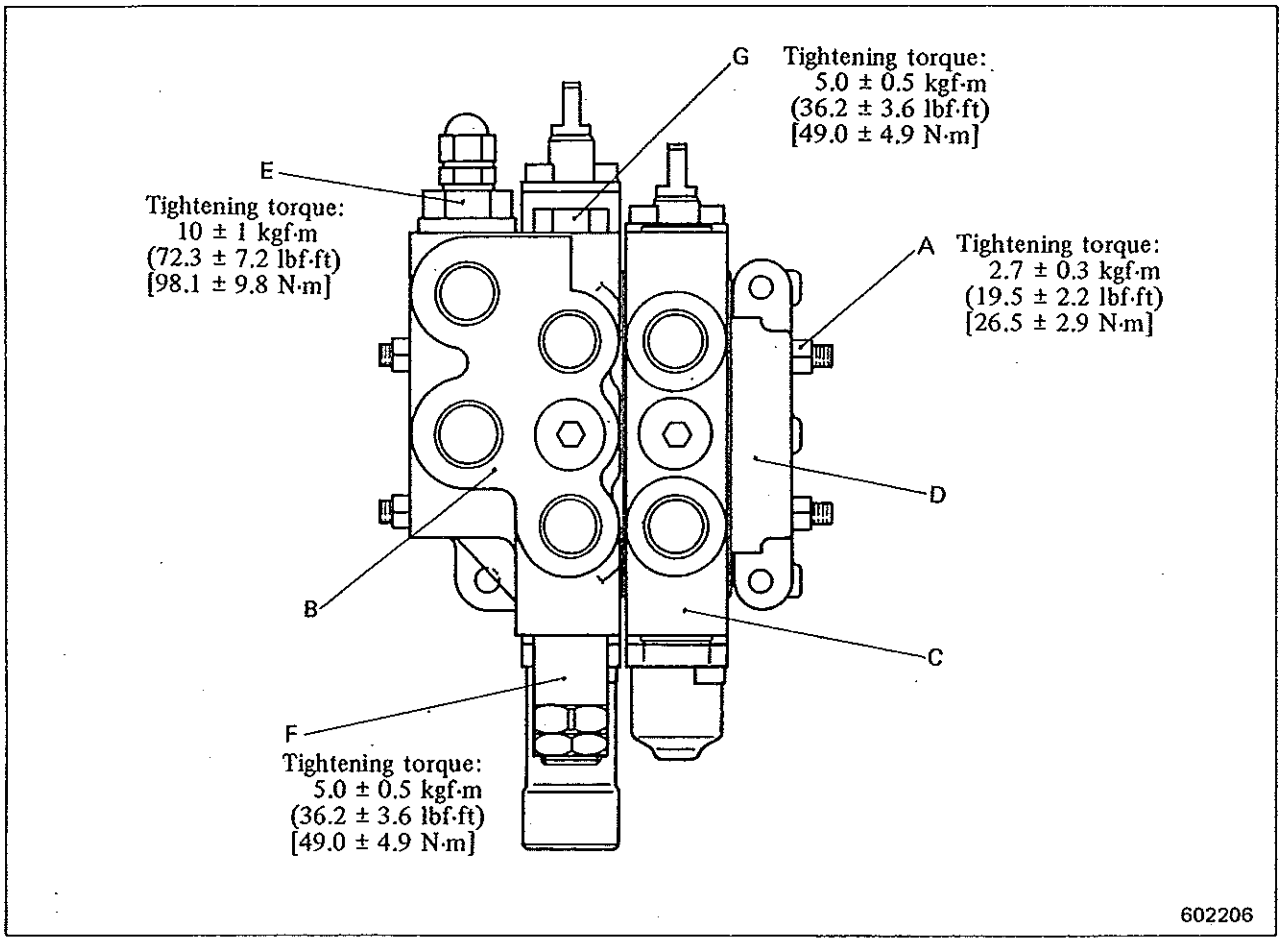
C Tilt valve plunger section



D Angling valve plunger section
(Identical with C Tilt valve plunger section)

2-section control valve ($BD2_G$ with power tilt blade)

Disassembly and reassembly



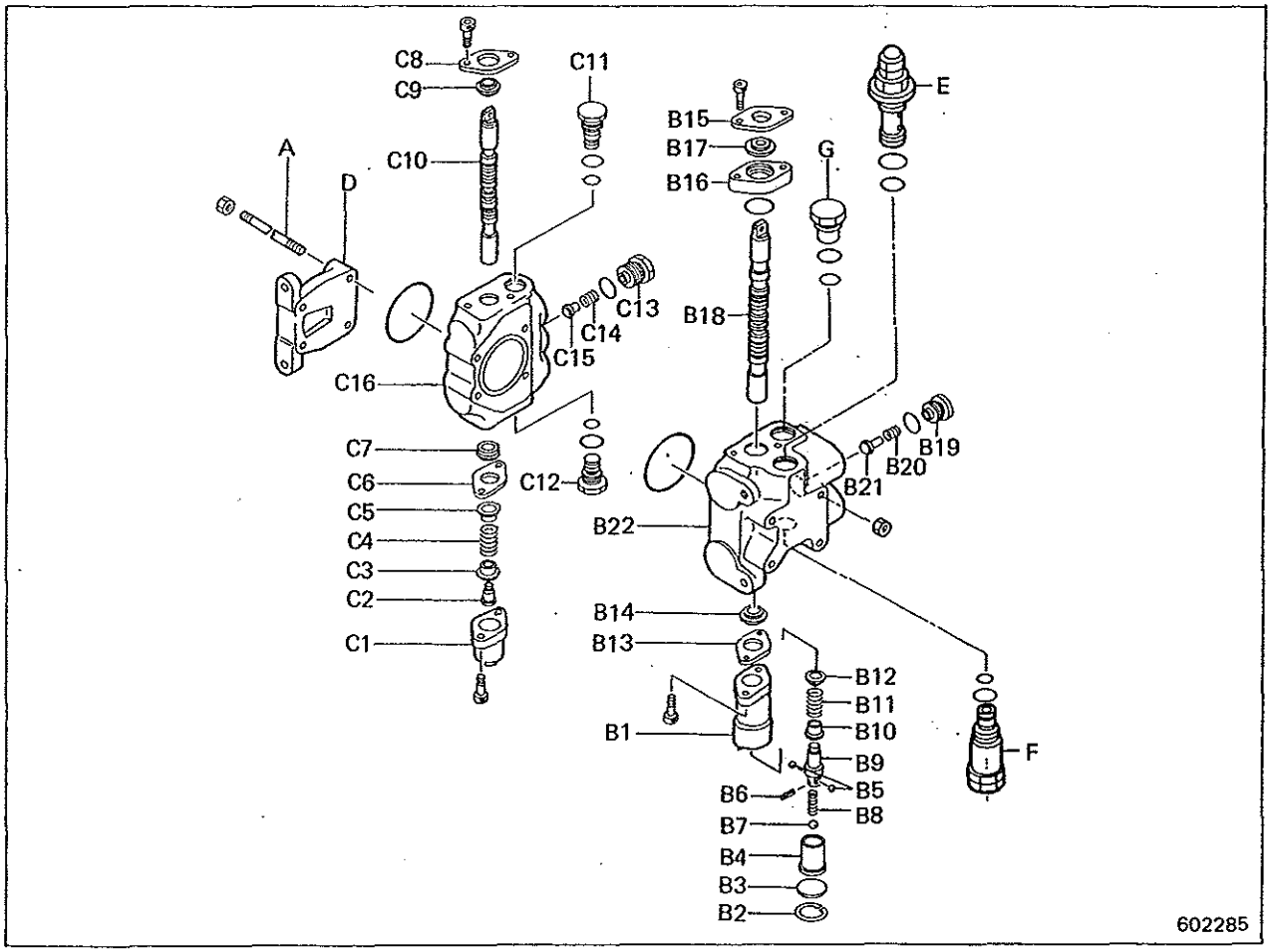
A Tie rod
B Inlet and lift valve plunger section
C Tilt valve plunger section
D End plate
E Main relief valve
F Safety valve
G Makeup valve

NOTE

1) Be sure to tighten the tie rods to the specified torque, or the plungers will not move smoothly and the implement will drift excessively.

2) After reassembly, make sure that the plungers move smoothly.

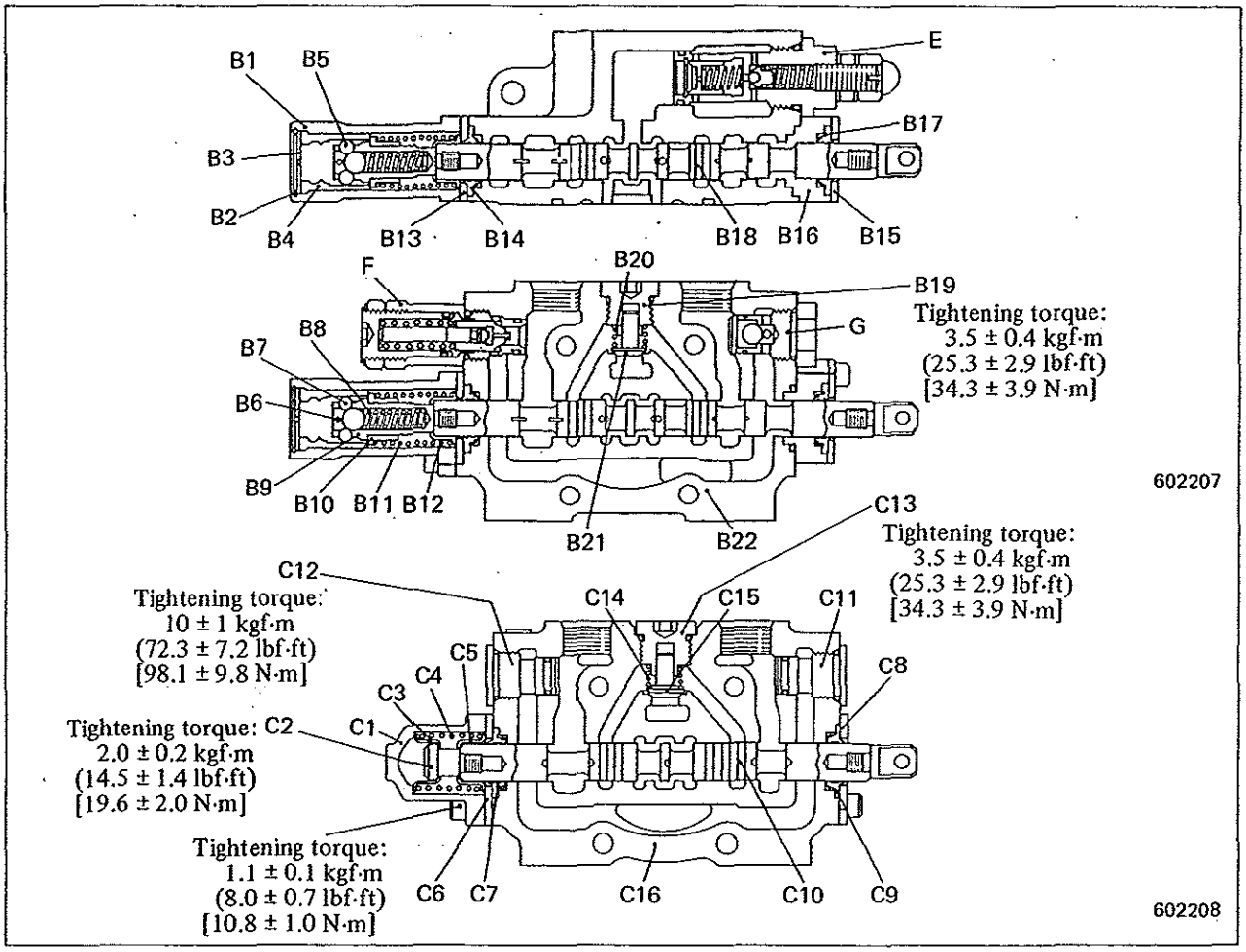
Disassembly



B1 Cap (to be removed as an assembly including "B2" thru "B4")
B2 Snap ring
B3 Plate
B4 Detent sleeve
B5 Steel (detent) balls
B6 Spring pin
B7 Steel (detent) ball
B8 Spring
B9 Plunger plug
B10 Spring guide
B11 Spring
B12 Spring guide
B13 Seal cover plate
B14 Oil seal
B15 Plate
B16 Spacer
B17 Oil seal
B18 Plunger
B19 Plug
B20 Spring
B21 Check valve
B22 Housing
C1 Cap
C2 Plunger plug
C3 Spring guide
C4 Spring
C5 Spring guide
C6 Seal cover plate
C7 Oil seal
C8 Seal cover plate
C9 Oil seal
C10 Plunger
C11 Plug
C12 Plug
C13 Plug
C14 Spring
C15 Check valve
C16 Housing

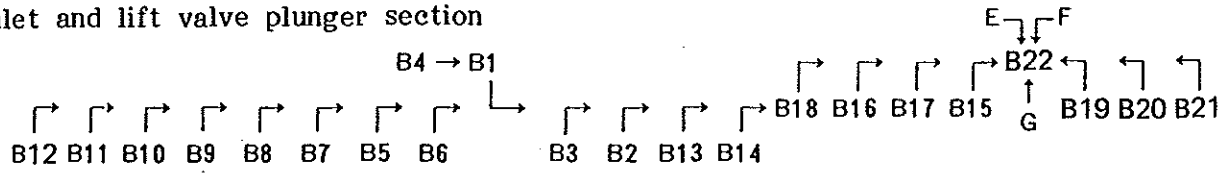
(Remove the parts in the order numbered for disassembly.)

Reassembly

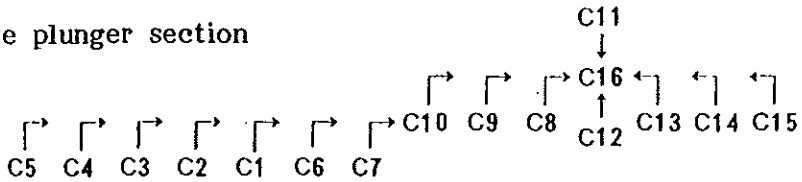


Reassembling order

B Inlet and lift valve plunger section

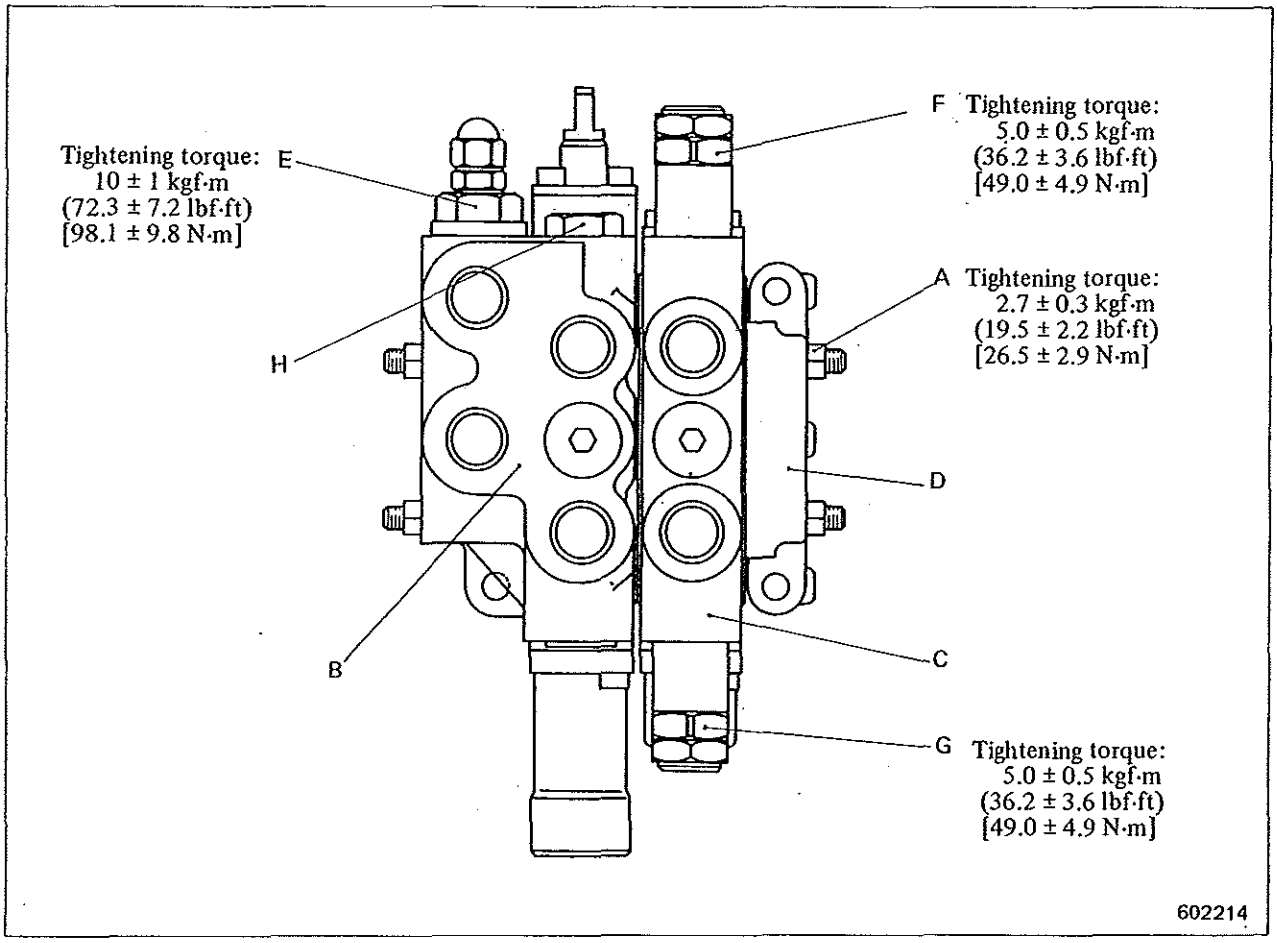


C Tilt valve plunger section



2-section control valve ($BS3_G$)

Disassembly and reassembly



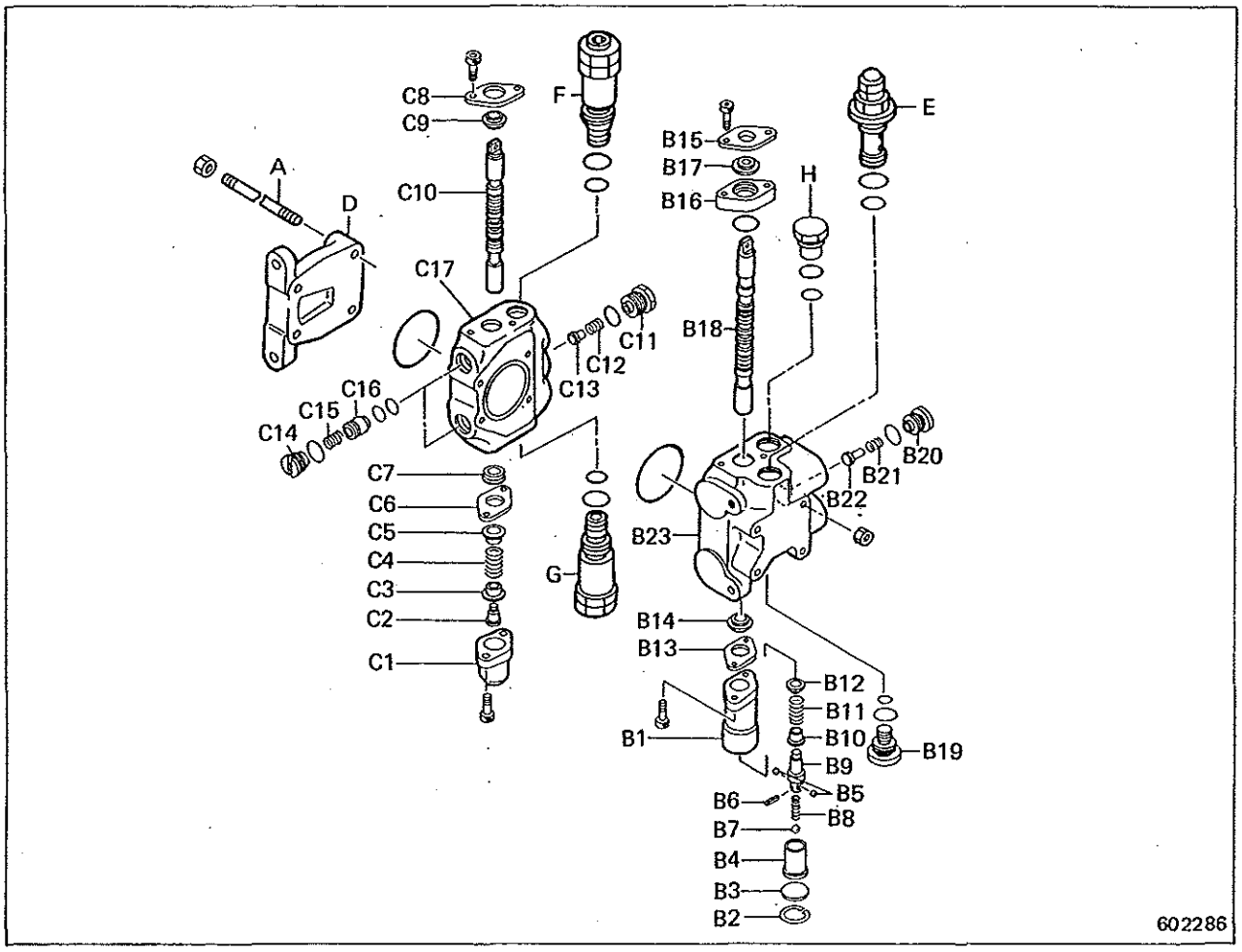
A Tie rod
B Inlet and lift valve plunger section
C Dump valve plunger section
D End plate
E Main relief valve
F Safety valve
G Safety valve
H Makeup valve

NOTE

1) Be sure to tighten the tie rods to the specified torque, or the plungers will not move smoothly and the implement will drift excessively.

2) After reassembly, make sure that the plungers move smoothly.

Disassembly

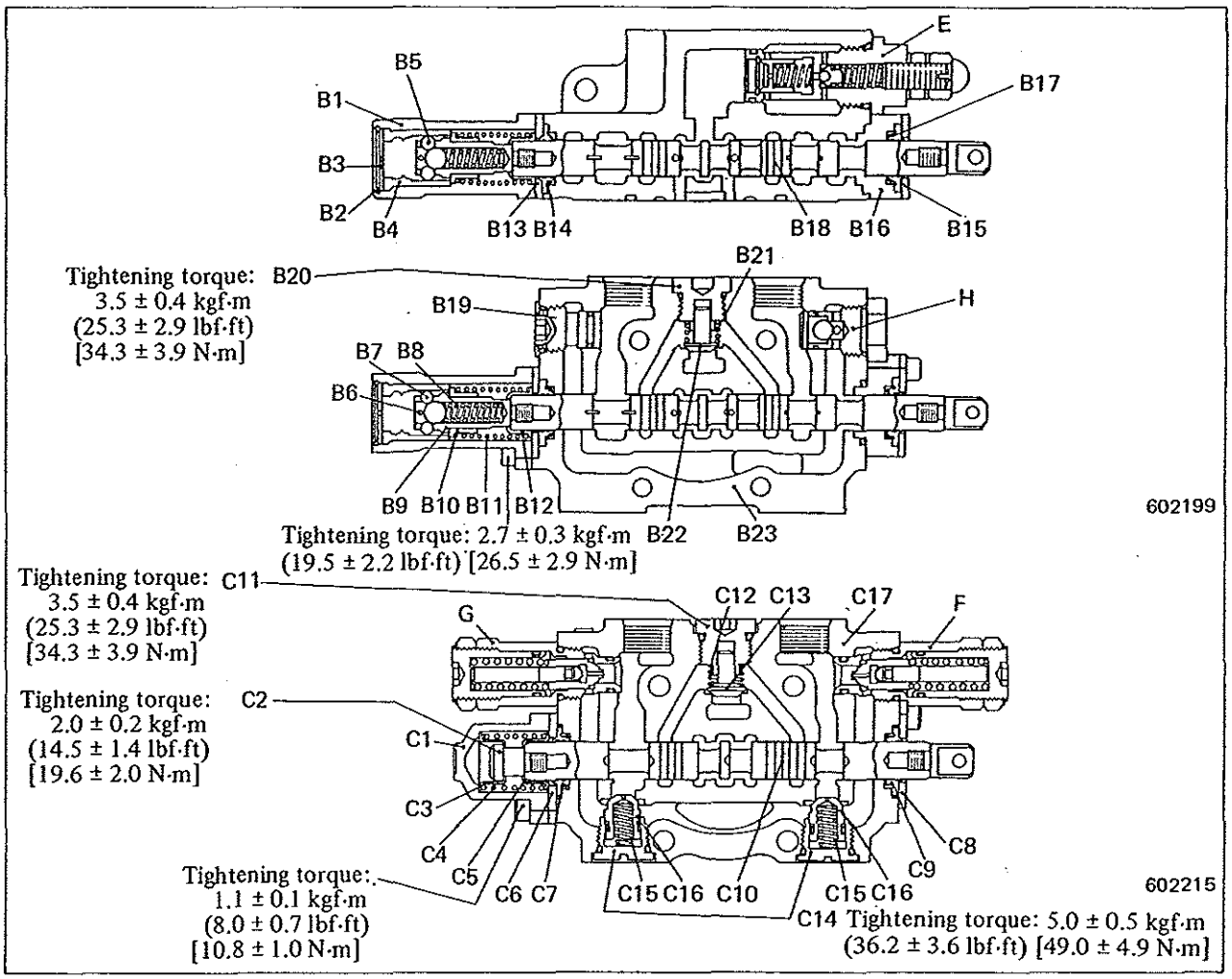


B1 Cap (to be removed as an assembly including "B2" thru "B4")
B2 Snap ring
B3 Plate
B4 Detent sleeve
B5 Steel (detent) balls
B6 Spring pin
B7 Steel (detent) ball
B8 Spring
B9 Plunger plug
B10 Spring guide
B11 Spring
B12 Spring guide
B13 Seal cover plate
B14 Oil seal
B15 Plate
B16 Spacer
B17 Oil seal
B18 Plunger
B19 Plug
B20 Plug
B21 Spring
B22 Check valve
B23 Housing

C1 Cap
C2 Plunger plug
C3 Spring guide
C4 Spring
C5 Spring guide
C6 Seal cover plate
C7 Oil seal
C8 Seal cover plate
C9 Oil seal
C10 Plunger
C11 Plug
C12 Spring
C13 Check valve
C14 Plug
C15 Spring
C16 Makeup valve
C17 Housing

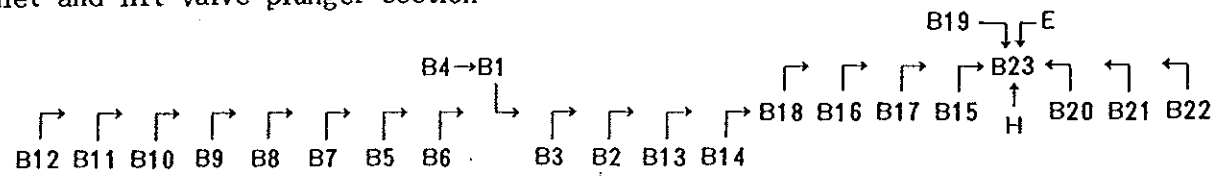
(Remove the parts in the order numbered for disassembly.)

Reassembly

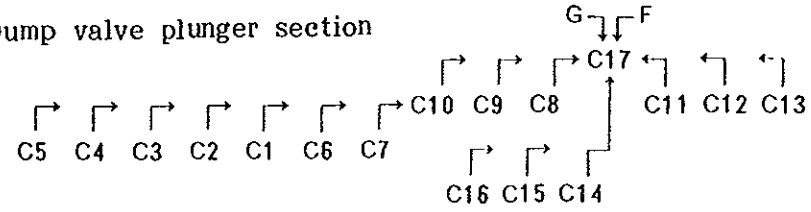


Reassembling order

B Inlet and lift valve plunger section



C Dump valve plunger section



POWER ANGLING/TILT BLADE

Removal

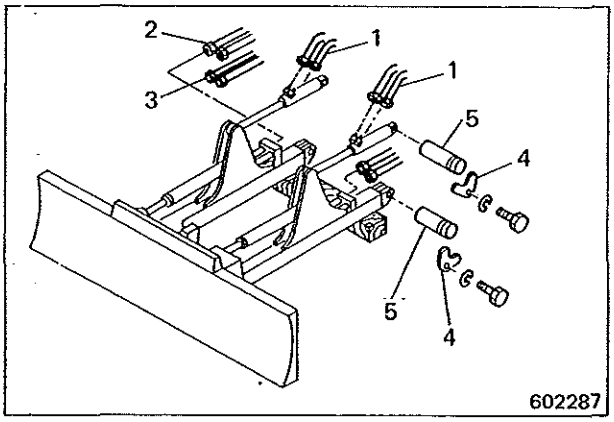
Preparatory steps

(1) Place wood blocks under the blade frame.

(2) Lower the blade to the ground, stop the engine, and move the control levers to all operating positions to relieve the pressure in the hydraulic circuits.

1. Remove the following parts:

1 Rubber hoses (for lift cylinders, 4 pcs)
2 Rubber hoses (for angling cylinders, 4 pcs)
3 Rubber hoses (for tilt cylinder, 2 pcs)
4 Lock plate
5 Pin



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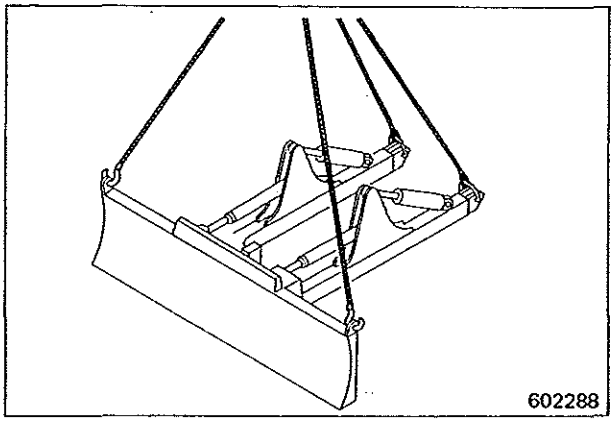
2. Move the machine backward, leaving the blade on the ground.

3. The blade may be lifted off with a hoist and slings.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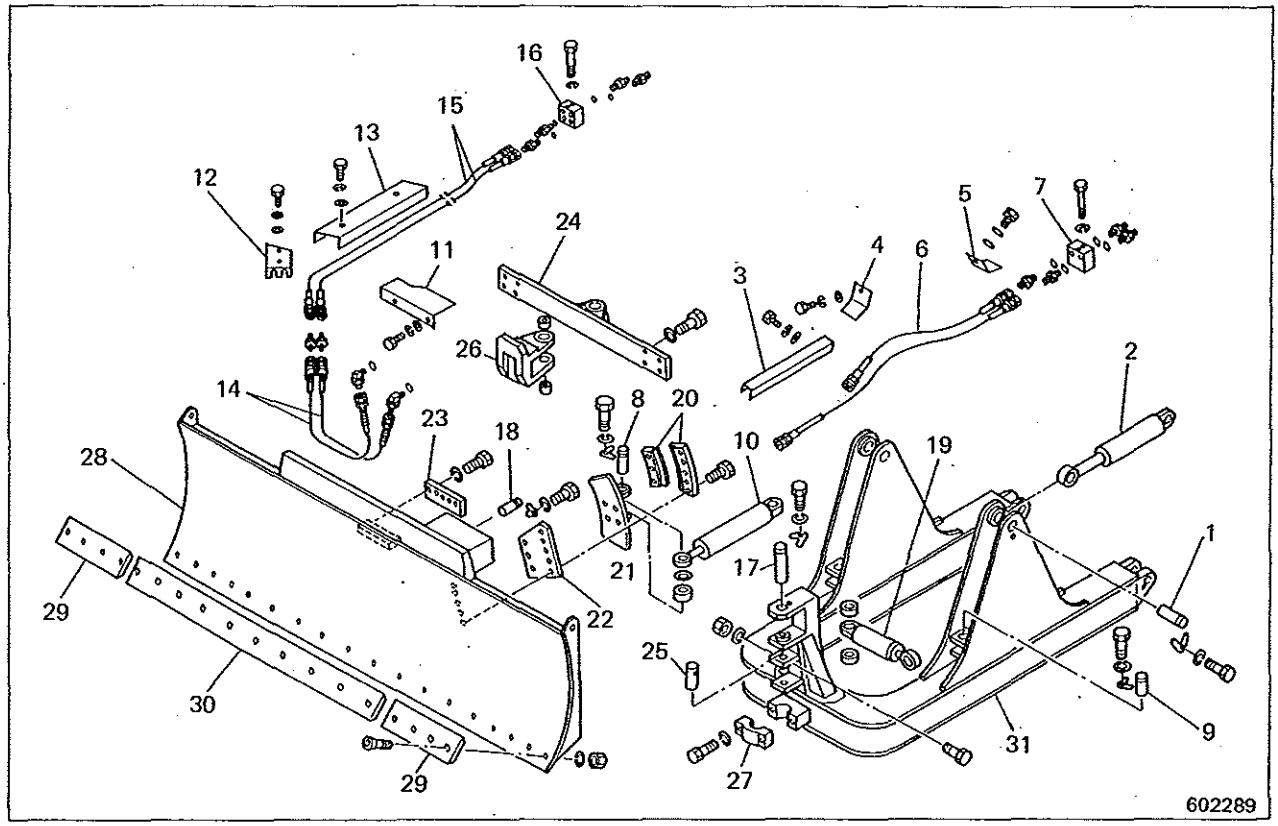
Weight of power angling/tilt blade	550 kg (1213 lb), approx.

Installation

To install the blade, follow the reverse of removing procedure.

Disassembly and reassembly



1 Pin	12 Cover	23 Plate
2 Lift cylinder	13 Cover	24 Bar
3 Cover	14 Hoses	25 Pin
4 Plate	15 Hoses	26 Bracket
5 Plate	16 Block	27 Cap
6 Hose	17 Pin	28 Blade
7 Block	18 Pin	29 End bit
8 Pin	19 Tilt cylinder	30 Cutting edge
9 Pin	20 Plates	31 C-frame
10 Angling cylinder	21 Bracket	
11 Cover	22 Plate	

Power angling/tilt blade - Disassembled view

(Remove the parts in the order numbered for disassembly.)

Reassembly

To reassemble the blade, follow the reverse of disassembling procedure.

Removal

Preparatory steps

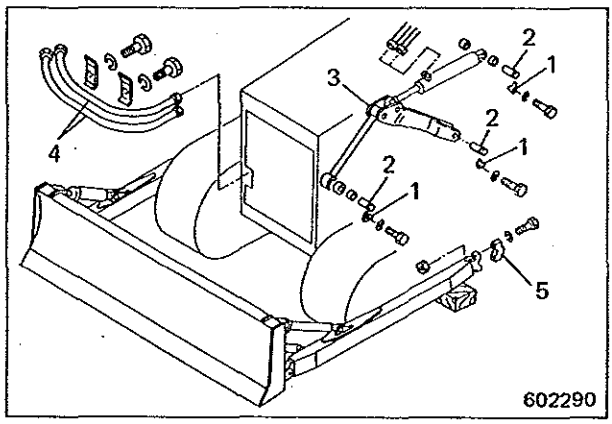
(1) Lower the blade to the ground, stop the engine, and move the control lever to all operating positions to relieve the pressure in the hydraulic circuits.

(2) Place wood blocks under the blade arms.

1. Remove the following parts:

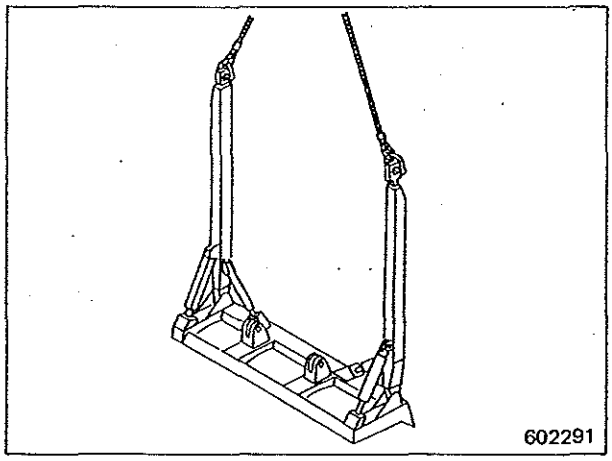
   1 Lock plate
   2 Pin
   3 Lift cylinder and lever
   4 Rubber hoses (for tilt cylinder, 2 pcs)

2. Remove cap "5," separate the blade arm from the trunnion, and reinstall the cap on each side.



3. Lift off the blade and arms.

Weight of power tilt blade	400 kg (882 lb), approx.

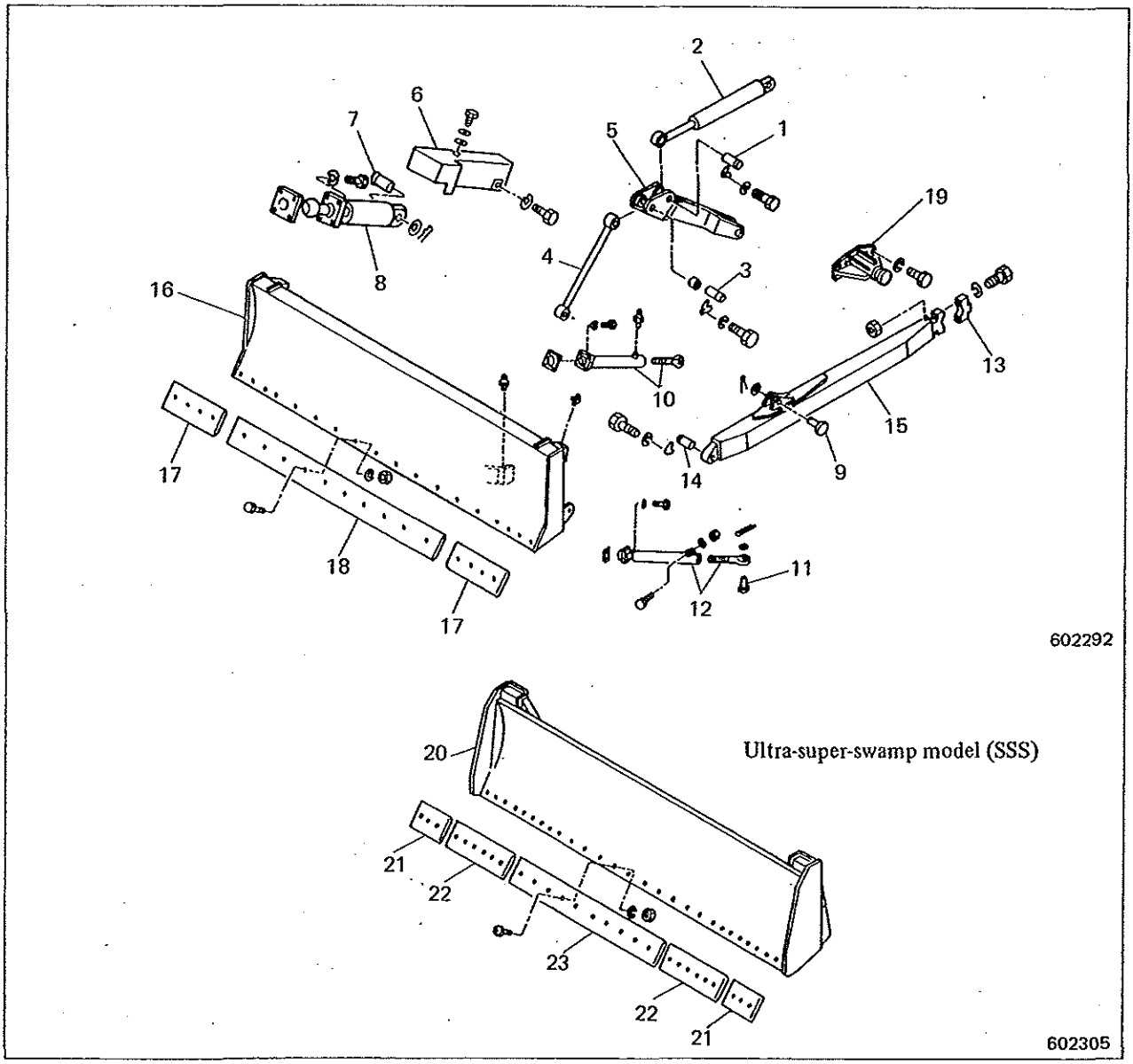


4. The blade may be removed by moving the machine backward, leaving the blade on the ground.

Installation

To install the blade, follow the reverse of removing procedure.

Disassembly and reassembly



1 Pin	9 Pin	17 End bit
2 Lift cylinder	10 Tilt braces	18 Cutting edge
3 Pin	11 Pin	19 Trunnion
4 Rod	12 Braces	20 Blade
5 Lever	13 Cap	21 End bit
6 Cover	14 Pin	22 Bit
7 Pin	15 Arm	23 Cutting edge
8 Tilt cylinder	16 Blade	

Power tilt blade - Disassembled view

(Remove the parts in the order numbered for disassembly.)

Removal

Preparatory steps

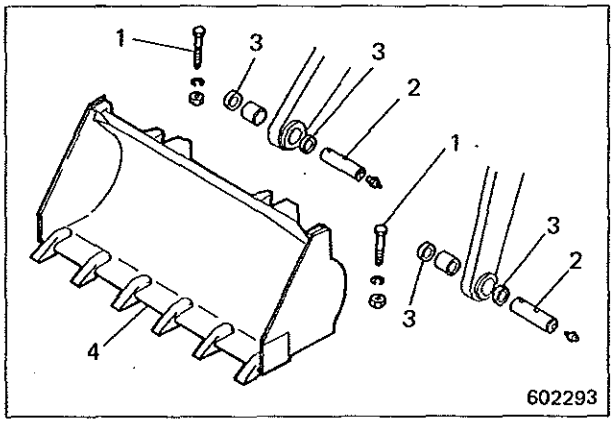
(1) Lower the bucket to the ground, stop the engine, and move the control lever to all operating positions to relieve the pressure in the hydraulic circuits.

(2) Fasten the lift cylinders to the lift arms with wires.

1. Remove the following parts at four bucket mounts:

1 Bolt
2 Pin
3 Seal
4 Bucket

Weight of bucket	240 kg (529 lb), approx.

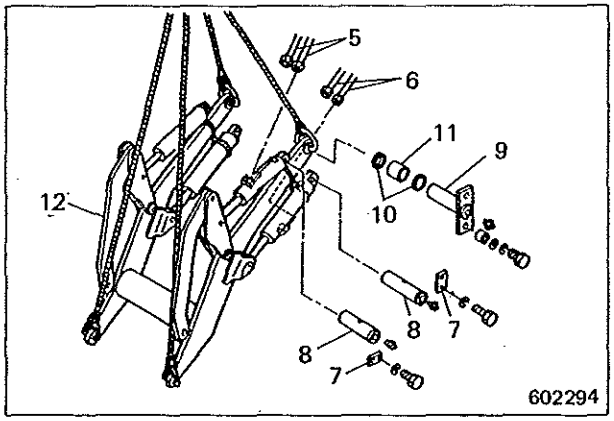


2. Attach slings to the lift arms.

3. Remove the following parts:

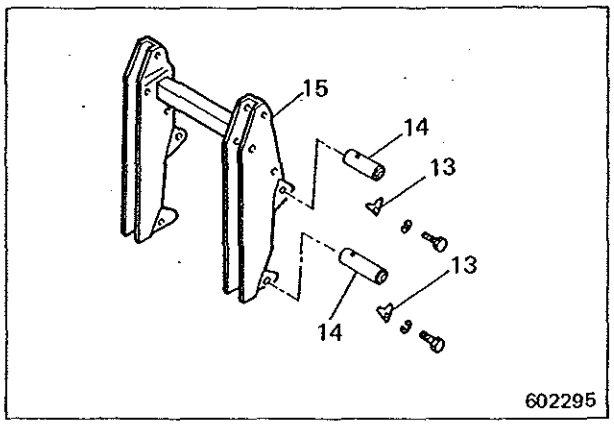
5 Rubber hoses (for dump cylinders, 4 pcs)
6 Rubber hoses (for lift cylinders, 4 pcs)
7 Lock plates (4 pcs)
8 Pin (4 pcs)
9 Pin (2 pcs)
10 Seals
11 Bushing
12 Bucket linkage

Weight of bucket linkage	400 kg (882 lb), approx.

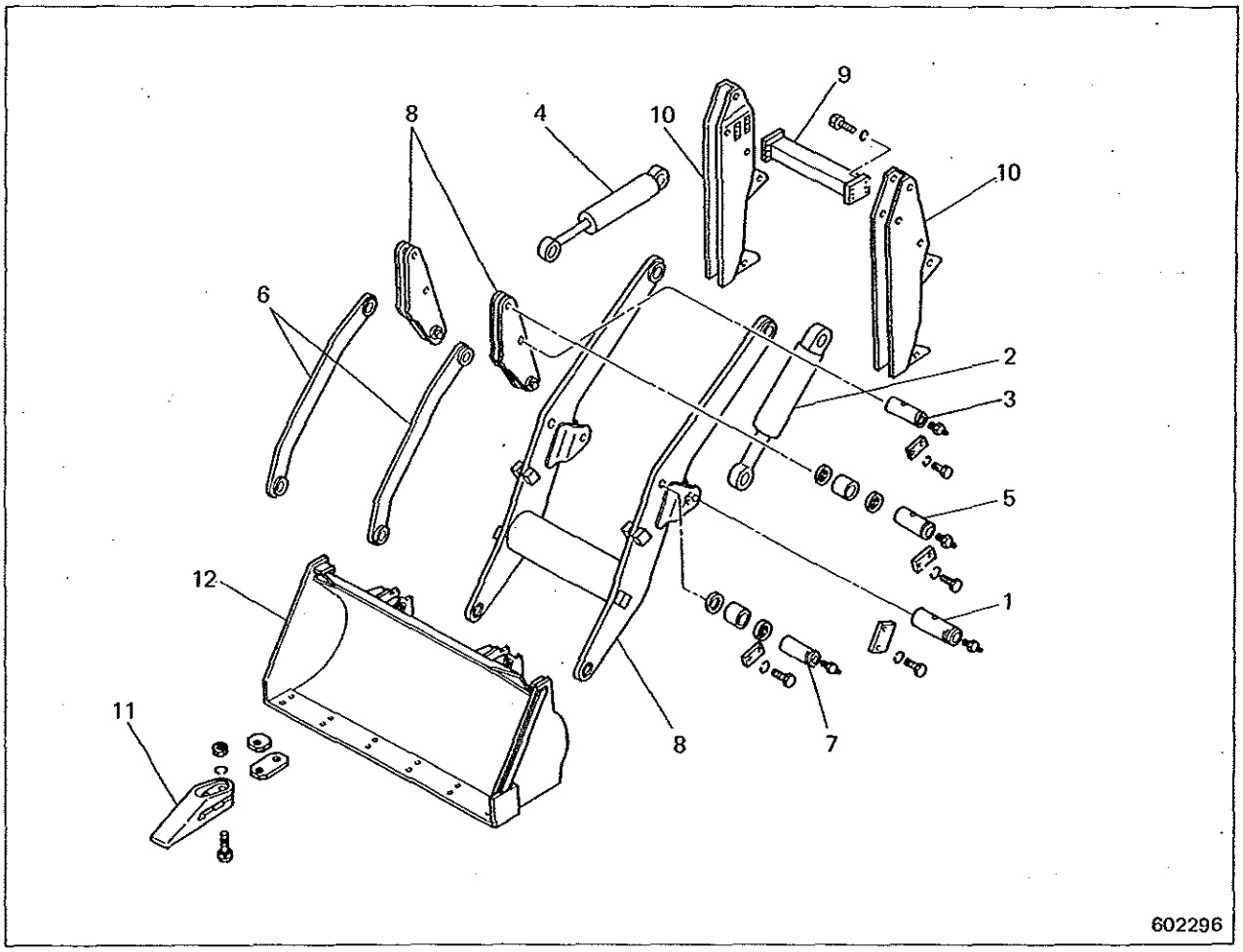


4. Remove the following parts:

13 Lock plate (4 pcs)
14 Pin (4 pcs)
15 Tower



Disassembly and reassembly



1 Pin	5 Pin	9 Pipe
2 Lift cylinder	6 Arms	10 Frame
3 Pin	7 Pin	11 Tooth
4 Dump cylinder	8 Arms	12 Bucket

Bucket and linkage - Disassembled view

(Remove the parts in the order numbered for disassembly.)

Removal

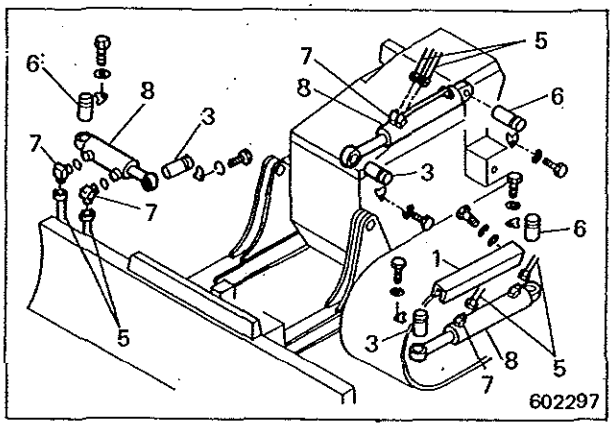
Preparatory steps

(1) Lower the blade or bucket to the ground.

(2) Lift the cylinders with slings.

1. Remove the following parts

1 Covers for angling cylinders of power angling/tilt blade
2 Cover for tilt cylinder of power tilt blade



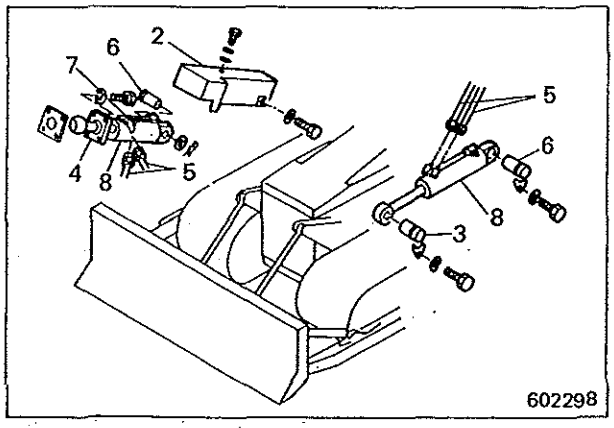
Power angling/tilt blade

2. Remove the following parts:

3 Piston rod-side pins of cylinders
4 Piston rod-side cap of cylinder (tilt cylinder of power tilt blade)
5 Rubber hoses
6 Head-side pins of cylinders

NOTE

Before disconnecting the rubber hoses, be sure to stop the engine, and move the control levers to all operating positions to relieve the pressure in the hydraulic circuits.



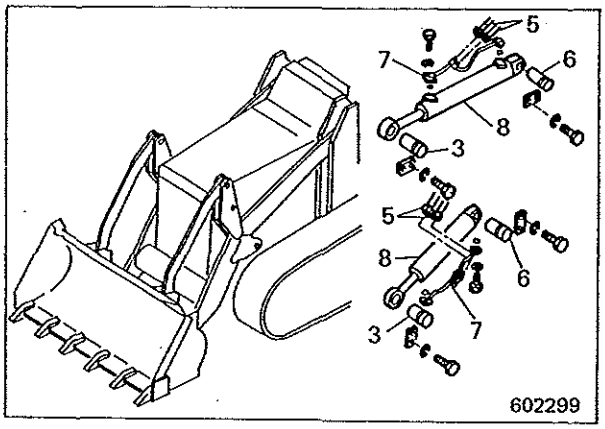
Power tilt blade

3. Remove the following parts:

   7 Pipes and connectors for each cylinder
   8 Cylinders

Weight of cylinders (approx.) Unit: kg (lb)

BD2G	Power angling/ tilt blade	Lift cylinder	13.5 (30)
		Angling cylinder	12.5 (28)
		Tilt cylinder	13.8 (30)
	Power tilt blade	Lift cylinder	13.5 (30)
		Tilt cylinder	15.0 (33)
BS3G	Bucket	Lift cylinder	29.0 (64)
		Dump cylinder	17.0 (37)



Bucket

Installation

1. To install the cylinders, follow the reverse of removing procedure.

2. Insert the head-side pin, and connect the rubber hoses to the cylinder. While extending the piston rod, insert the rod-side pin.

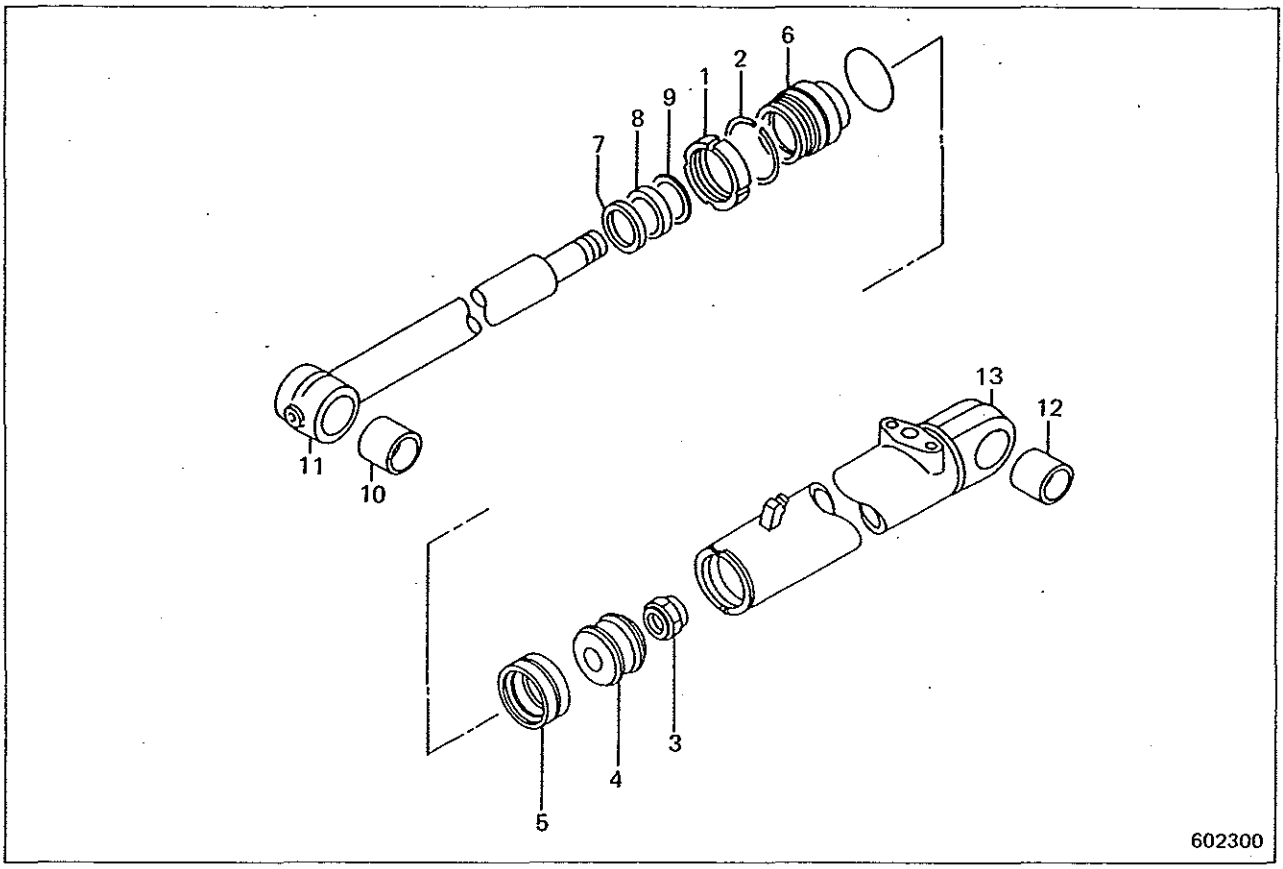
Disassembly

NOTE

Two types of hydraulic cylinders - ring nut type and gland screw type - are used. These types differ from each other in disassembling and reassembling procedures.

BD2G	Power angling/ tilt blade	Lift cylinders	Ring nut type
		Angling cylinders	
		Tilt cylinder	
	Power tilt blade	Lift cylinders	
		Tilt cylinder	Gland screw type
BS3G	Bucket	Lift cylinders	
		Dump cylinders	

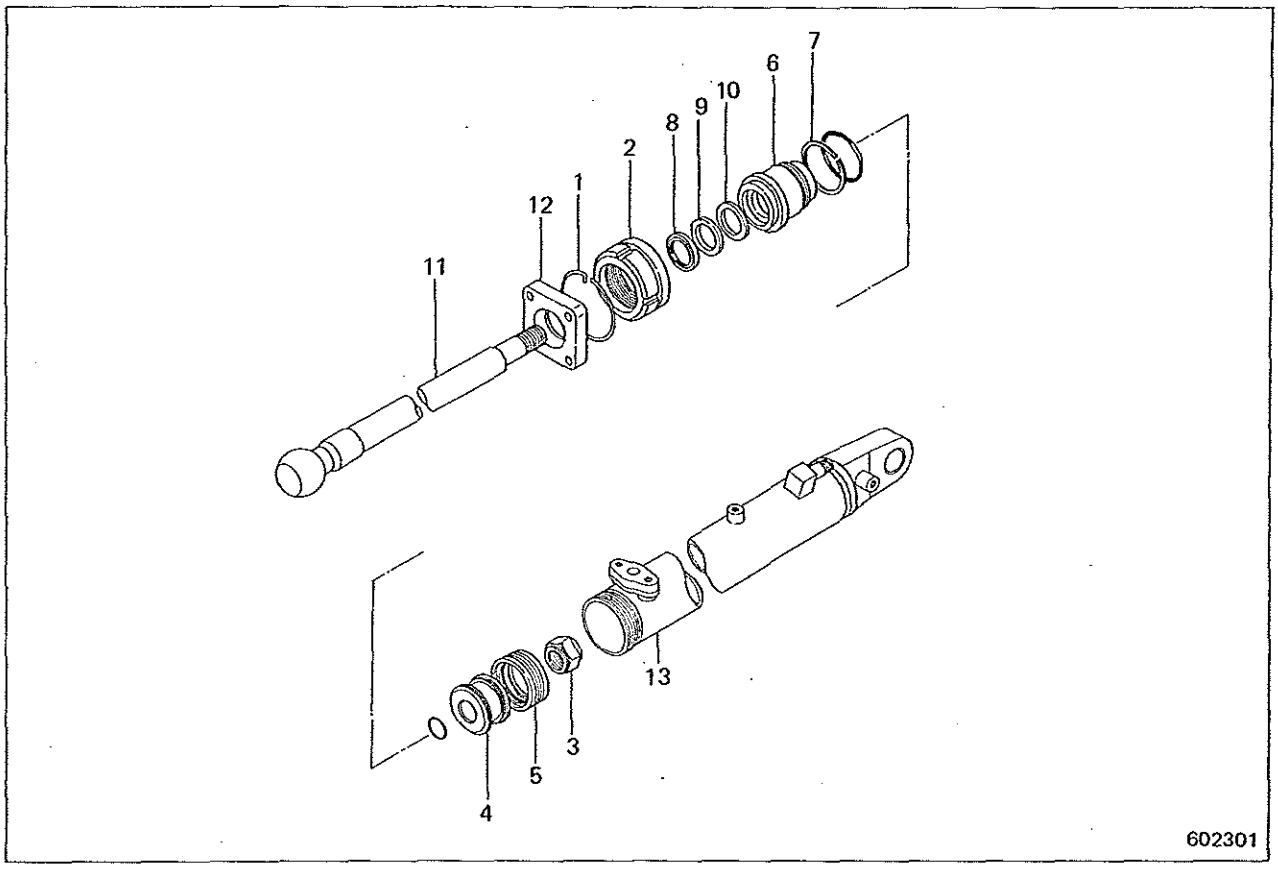
Ring nut type
(Example: Lift cylinder for power angling/tilt blade and power tilt blade for $BD2_G$)



1 Ring nut
2 Ring
3 Nut (to be removed as an assembly including "4" thru "11")
4 Piston (to be removed as an assembly including "5")
5 Piston seal
6 Guide bushing (to be removed as an assembly including "7" thru "11")
7 Dust seal
8 Rod packing
9 Buffer ring
10 Bushing
11 Piston rod
12 Bushing
13 Cylinder tube

(Remove the parts in the order numbered for disassembly.)

Gland screw type
(Example: Tilt cylinder for power tilt blade for $BD2_G$)

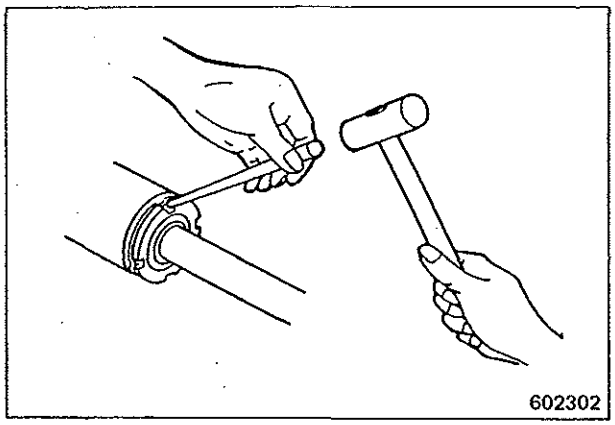


1 Ring
2 Gland screw
3 Nut (to be removed as an assembly including "4" thru "12")
4 Piston (to be removed as an assembly including "5")
5 Piston seal
6 Guide bushing (to be removed as an assembly including "7" thru "10")
7 Backup ring
8 Dust seal
9 Rod packing
10 Buffer ring
11 Piston rod
12 Cap
13 Cylinder tube

(Remove the parts in the order numbered for disassembly.)

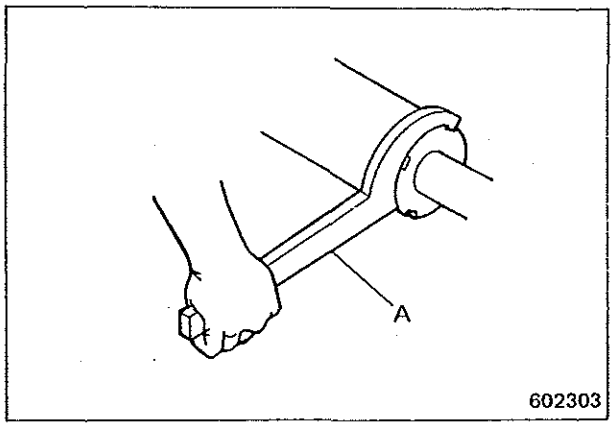
Tips for disassembly

1. On the ring nut type cylinder, use a chisel and a hammer, and loosen the portion of cylinder upset on the nut at juncture.



2. Using a hook wrench "A" (special tool), remove the gland screw or ring nut.

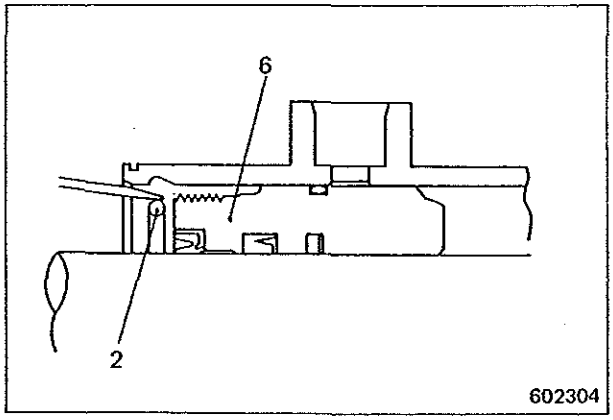
Cylinder			Hook wrench part number
BD2G	Power angling/ tilt blade	Lift cylinder	05312-10500
		Angling cylinder	
		Tilt cylinder	05312-10600
	Power tilt blade	Lift cylinder	05312-10500
		Tilt cylinder	05312-10600
BS3G	Bucket	Lift cylinder	05312-10800
		Dump cylinder	05312-10600



3. On the ring nut type cylinder, slightly push in guide bushing "6," and remove ring "2" with a screwdriver.

NOTE

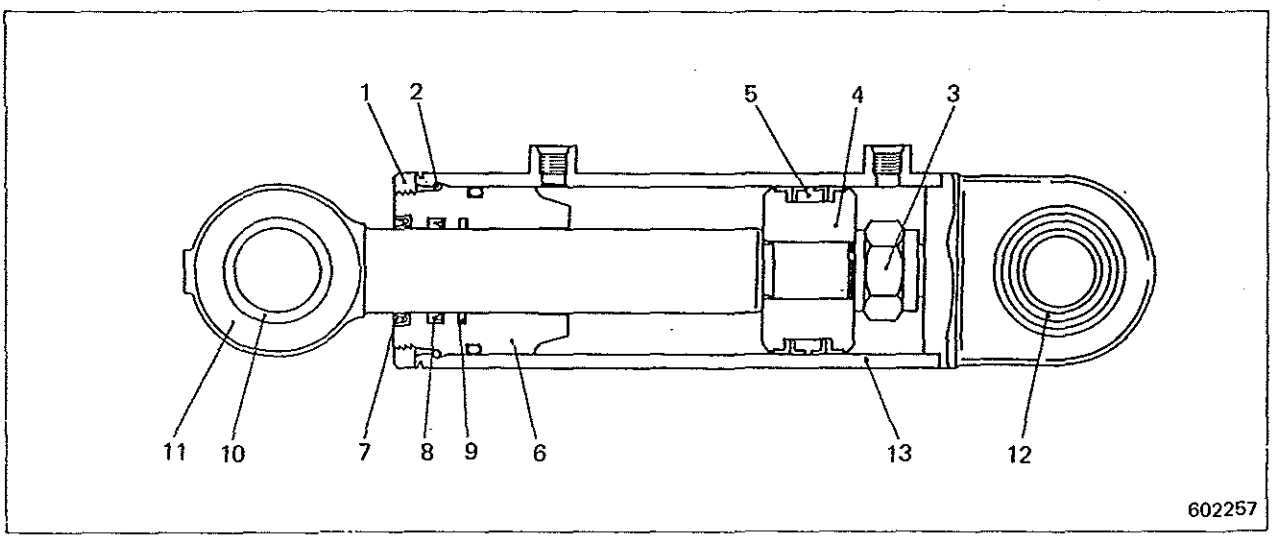
Do not use a sharp-edged tool to remove ring "2." When removing the ring, be careful not to scratch the bore surface of the cylinder.

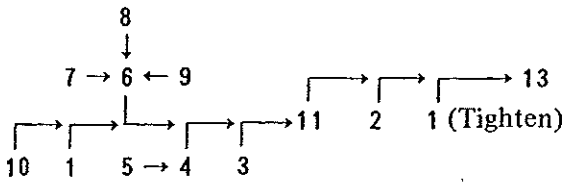


Reassembly

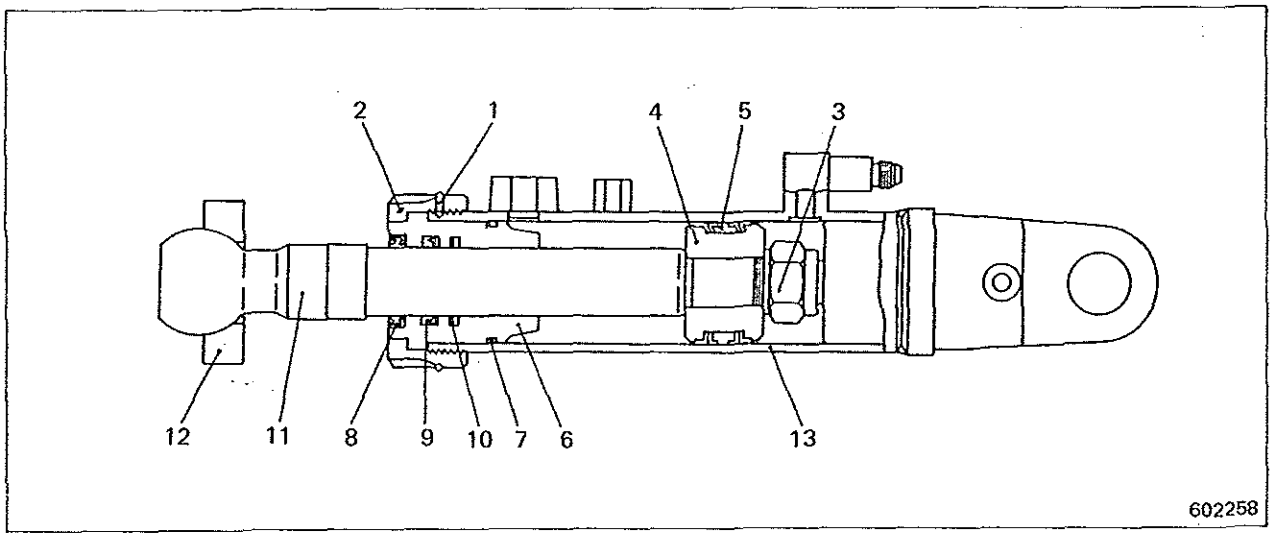
Reassembling order

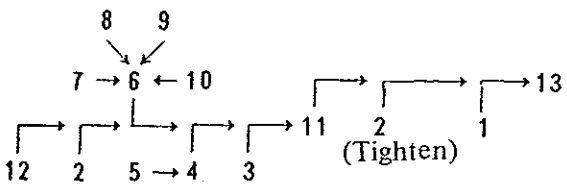
Ring nut type cylinder



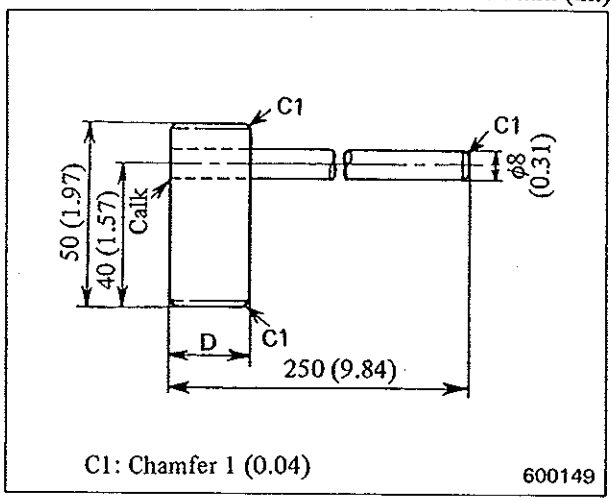


Gland screw type cylinder





Unit: mm (in.)



C1: Chamfer 1 (0.04)

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Tips for reassembly

1. Piston seal installation

(1) Have a tool shown in the sketch and chart below to fit the piston seal.

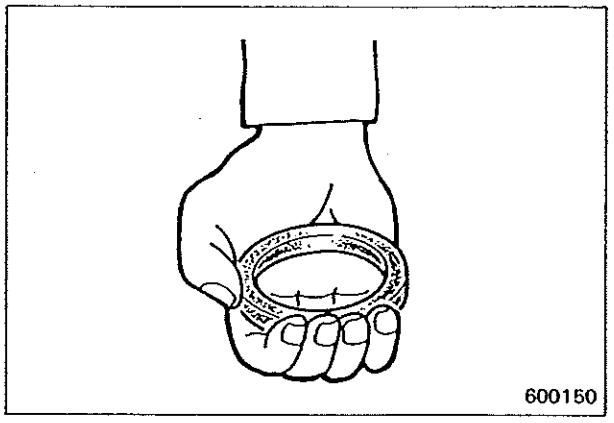
NOTE

Dimension "D" must be 0.5 to 1.0 mm (0.02 to 0.04 in.) smaller than the inside diameter of the piston.

Unit: mm (in.)

Cylinder			Piston I.D.		
			24 (0.94)	27 (1.06)	30 (1.18)
BD2G	Power angling/ tilt blade	Lift cylinder	○		
		Angling cylinder	○		
		Tilt cylinder		○	
	Power tilt blade	Lift cylinder	○		
		Tilt cylinder	○		
BS3G	Bucket	Lift cylinder			○
		Dump cylinder	○		

(2) Squeeze the seal in the palm of the hand three or four times to soften it.



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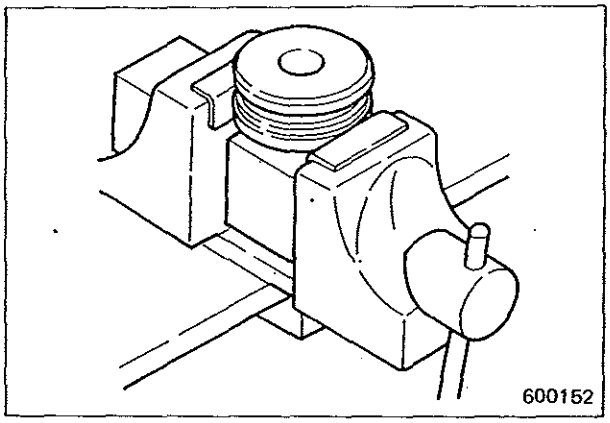
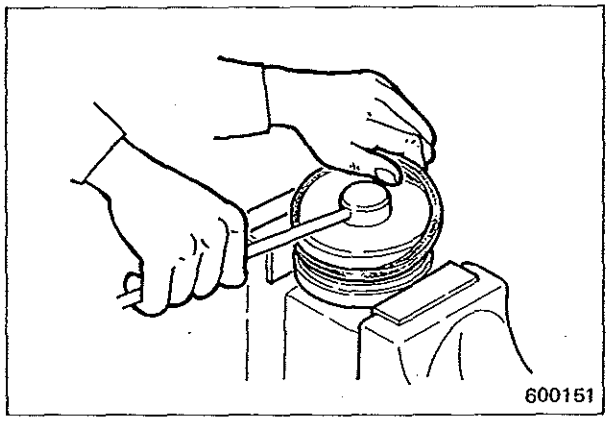
(3) Hold the piston in a vise, with protective (copper) caps fitted to the vise jaws.

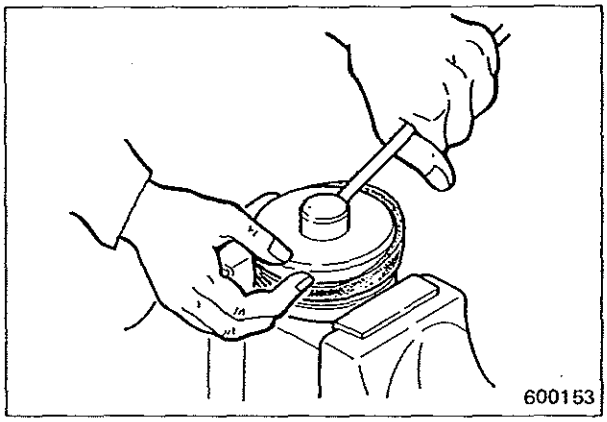


(4) Apply a thin coat of hydraulic oil to the seal. Fit the seal into the groove as much as it will go in, and insert the tool into the piston.

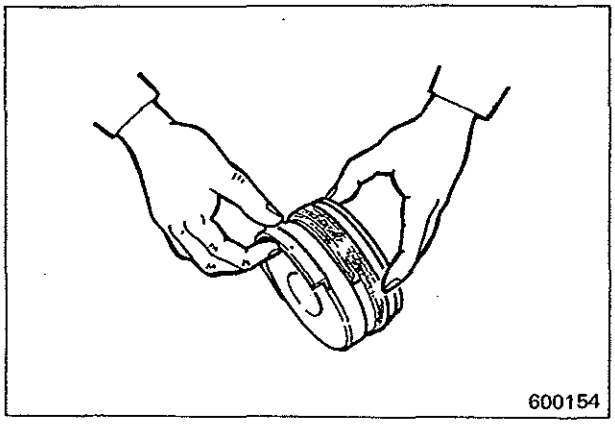
(5) Hold down the seal by left hand, and turn the arm of the tool by right hand while pushing it down. After about 3/4 of the seal has been forced onto the piston, hold down the seal by right hand.



(6) Turn the arm by left hand to force the remaining 1/4 onto the piston.



(7) Install the backup ring to the piston.



2. Piston nut tightening

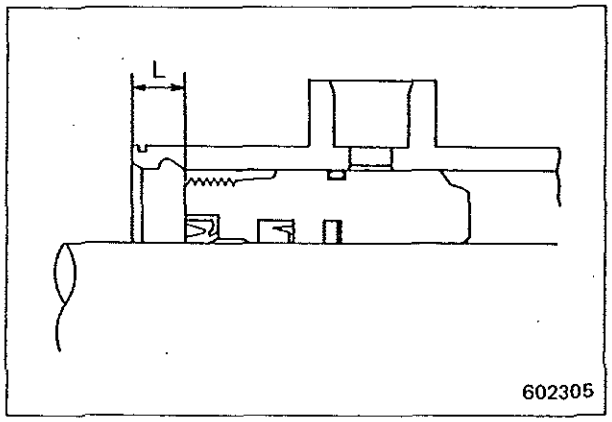
Tighten the piston nut to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Cylinder			Tightening torque
BD2G	Power angling/ tilt blade	Lift cylinder	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]
		Angling cylinder	
		Tilt cylinder	70.0 ± 3.5 (506.3 ± 25.3) [686.5 ± 34.3]
	Power tilt blade	Lift cylinder	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]
		Tilt cylinder	
BS3G	Bucket	Lift cylinder	95 ± 5 (687.1 ± 36.2) [931.6 ± 49.0]
		Dump cylinder	50.0 ± 2.5 (361.7 ± 18.1) [490.3 ± 24.5]

3. Ring installation

If the guide bushing is pushed in the cylinder more than is necessary, the O-ring would be damaged by the sharp edge of the port when the bushing is pulled out. Do not push in the bushing more than "L" dimension.



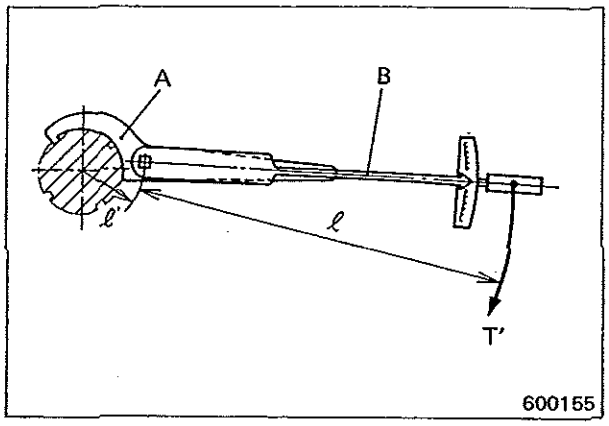
Unit: mm (in.)

Cylinder			Dimension "L"
BD2G	Power angling/ tilt blade	Lift cylinder	16 (0.63)
		Angling cylinder	
		Tilt cylinder	14 (0.55)
	Power tilt blade	Lift cylinder	16 (0.63)

4. On the ring nut type cylinder, install the ring nut to the cylinder with its small chamfer on the head side of the cylinder and, using a hook wrench "A" (special tool) and a torque wrench "B," tighten it to the specified torque.

5. On the gland screw type cylinder, tighten gland screw to the specified torque with a hook wrench "A" and a torque wrench "B."

   Torque wrench reading $T' = \frac{\ell}{\ell + \ell'} T$



Unit: kgf·m (lbf·ft) [N·m]

Cylinder			Tightening torque "T"
BD2G	Power angling/ tilt blade	Lift cylinder	15.0 ± 1.5 (108.5 ± 10.8) [147.1 ± 14.7]
		Angling cylinder	
		Tilt cylinder	24.0 ± 2.4 (173.6 ± 17.4) [235.4 ± 23.5]
	Power tilt blade	Lift cylinder	15.0 ± 1.5 (108.5 ± 10.8) [147.1 ± 14.7]
		Tilt cylinder	45.0 ± 4.5 (325.5 ± 32.5) [441.3 ± 44.1]
BS3G	Bucket	Lift cylinder	75.0 ± 8 (542.5 ± 57.9) [735.5 ± 78.5]
		Dump cylinder	45.0 ± 4.5 (325.5 ± 32.5) [441.3 ± 44.1]

6. On the ring nut type cylinder, upset the cylinder to the ring nut by chiseling.

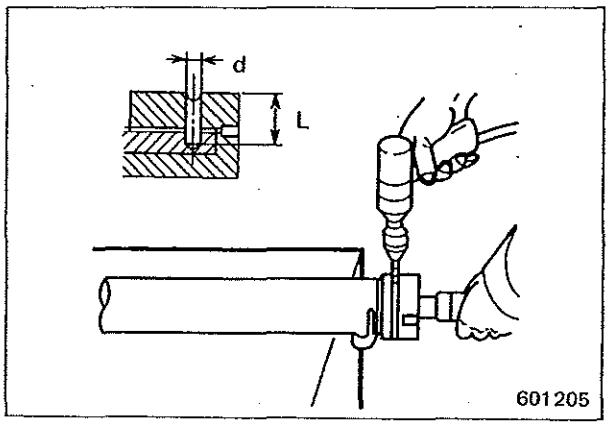
NOTE

Replace the ring nut after it has been used two or three times.

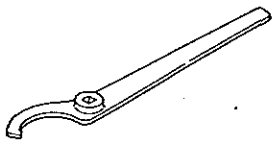
7. After tightening the gland screw to the specified torque on the gland screw type cylinder, drill a hole in the screw, and install a locking ring to prevent the screw from loosening. The diameter and depth of this hole are as shown below:

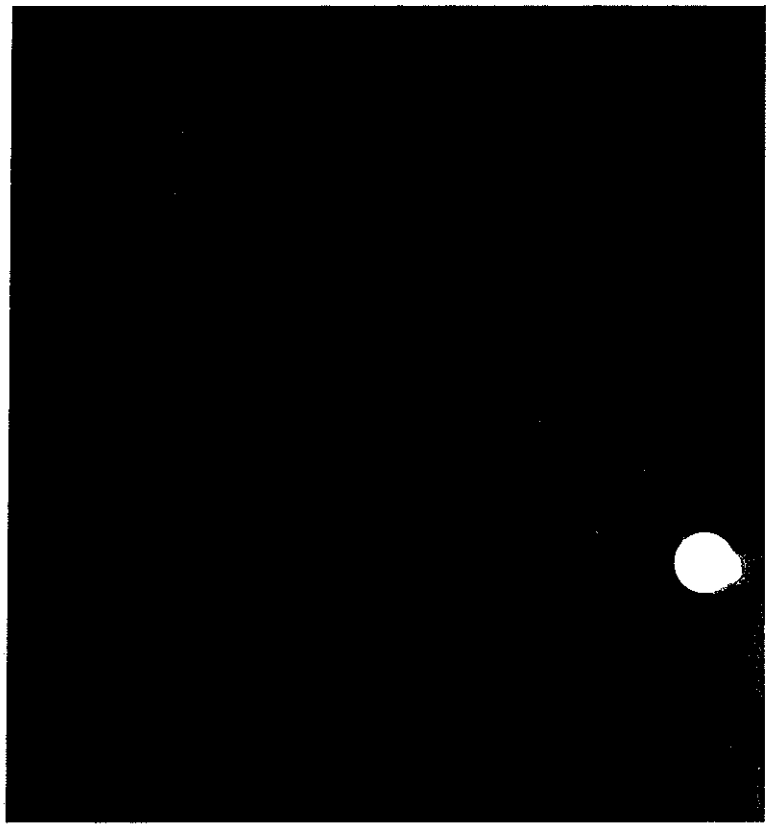
Unit: mm (in.)

Cylinder			Locking ring hole	
			Diameter "d"	Depth "L"
BD2G	Power tilt blade	Tilt cylinder	3.5 (0.14)	10.5 (0.41)
BS3G	Bucket	Lift cylinder	4.5 (0.18)	12.5 (0.49)
		Dump cylinder	3.5 (0.14)	10.5 (0.41)



SPECIAL TOOLS

Part number	Part name	Shape	Use
05312-10500	Hook wrench	 600328	Ring nut or gland screw removal and installation BD2G – Power angling/tilt blade Lift cylinders Angling cylinders BD2G – Power tilt blade Lift cylinders
05312-10600			BD2G – Power angling/tilt blade Tilt cylinder BD2G – Power tilt blade Tilt cylinder BS3G – Bucket Dump cylinders
05312-10800			BS3G – Bucket Lift cylinders



DEC. '86
Printed in Japan

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MITSUBISHI BD2G TRACTOR AND BS3G TRACTOR SHOVEL

Applicable Model: 00001–UP

Pub. No. 99879-00120

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	7	Power Train Disassembly and Reassembly	99879-00120-7/						
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