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POWER DIRECTION CLUTCH PROPER

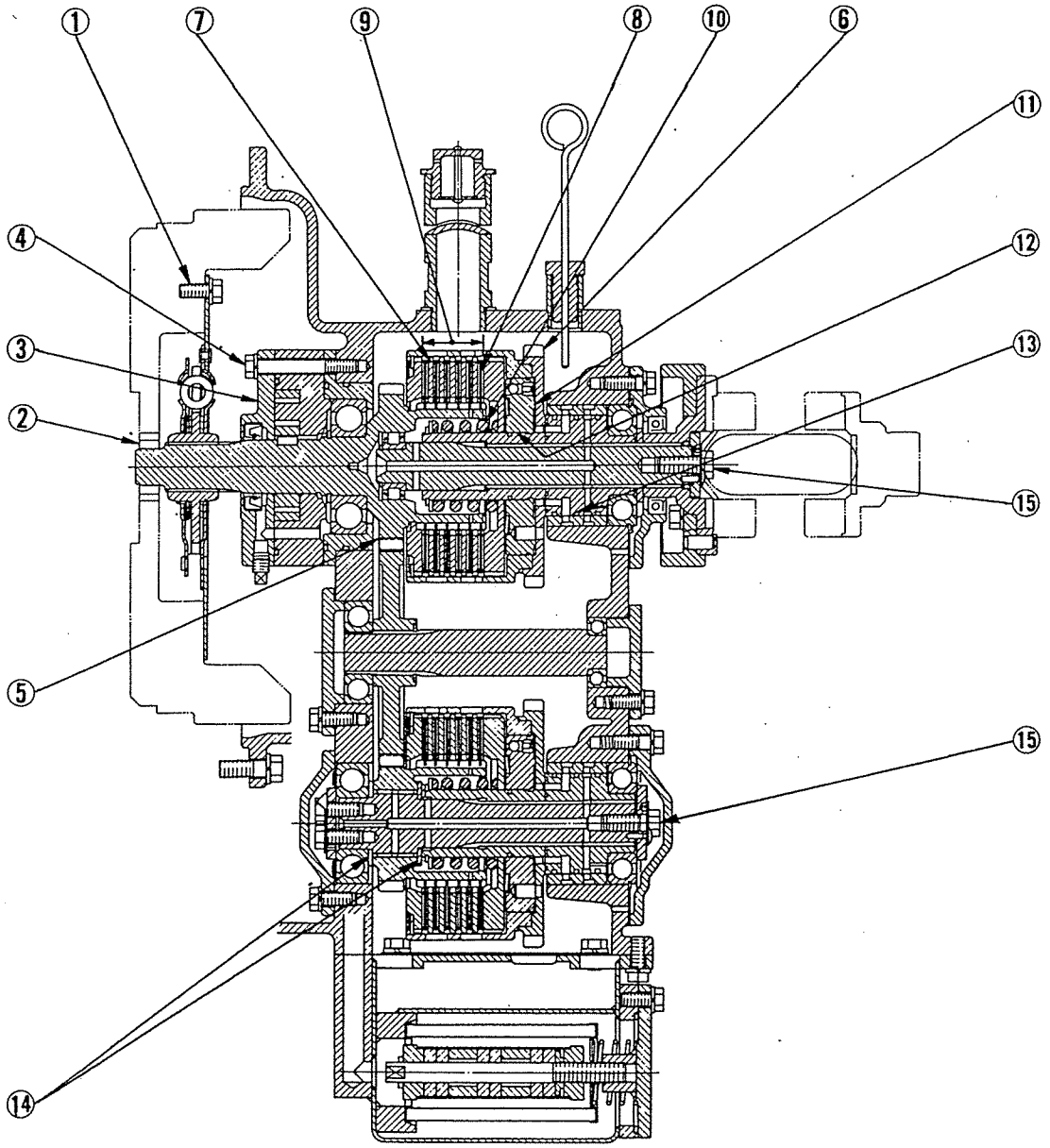
Unit: mm (in.)

Ref. No.	Point of measurement			Standard clearance (Assembly standard)	Service limit
1	Torque for damper attaching bolts			1.7 ± 0.2 kg-m (12.3 ± 1.4 ft-lb)	
2	Fit of pilot bushing on input shaft			0.025 ~ 0.138 (0.00098 ~ 0.00543)	0.20 (0.0079)
3	Internal gear pump	Fit of internal gear in pump body		0.060 ~ 0.109 (0.00236 ~ 0.00429)	0.30 (0.0118)
		Fit of internal gear on crescent-shaped separator of pump body		0.124 ~ 0.200 (0.00488 ~ 0.00787)	0.40 (0.0157)
		Fit of pinion in pump body		0.060 ~ 0.111 (0.00236 ~ 0.00437)	0.30 (0.0118)
		Clearance between end of gear and pump body		0.030 ~ 0.066 (0.00118 ~ 0.00260)	0.15 (0.0059)
		Performance	Speed	2500 rpm	
			Pressure	13 kg/cm² (184.9 psi)	
			Displacement	20 liters/min (1221 cu in.)/min	
4	Torque for pump attaching bolts			1.7 ± 0.2 kg-m (12.3 ± 1.4 ft-lb)	
5	Backlash of input gear with mating gear			0.11 ~ 0.24 (0.0043 ~ 0.0094)	0.5 (0.0197)
6	Backlash of output gear with mating gear			0.12 ~ 0.26 (0.0047 ~ 0.0102)	0.5 (0.0197)
7	Backlash of clutch plate with drum (all plates)			0.20 ~ 0.40 (0.0079 ~ 0.0157)	0.6 (0.0236)
8	Clutch facings	Backlash with pinion		0.14 ~ 0.30 (0.0055 ~ 0.0118)	0.6 (0.0236)
		Thickness		2.95 ~ 3.05 (0.1161 ~ 0.1201)	2.4 (0.0945)
9	As-assembled thickness of clutch facings (6 pcs) and clutch plates (5 pcs)			32.45 ~ 33.55 (1.2776 ~ 1.3209)	29 (1.1417)
10	Clutch springs	Free length		55 (2.165)	
		Load kg (lb)/as-installed length		90 ± 5/39 (198 ± 11/1.535)	75/39 (165/1.535)
11	Clutch pistons	Fit of piston in drum		0.036 ~ 0.144 (0.0014 ~ 0.0057)	0.25 (0.0098)
		Fit of piston on drum		0.120 ~ 0.221 (0.0047 ~ 0.0087)	0.40 (0.0157)
		Fit of smaller piston ring in piston		0.11 ~ 0.23 (0.0043 ~ 0.0091)	0.40 (0.0157)
12	Piston rings (for clutch pistons)	Clearance between ends of ring in free state		4 ~ 6 (0.157 ~ 0.236)	
		Clearance between ends of ring installed in bore of $40\ ^{+0.039}_{0}$ mm ($1.575\ ^{+0.00154}_{0}$ in.)		0.1 ~ 0.3 (0.0039 ~ 0.0118)	0.8 (0.0315)

POWER DIRECTION CLUTCH PROPER

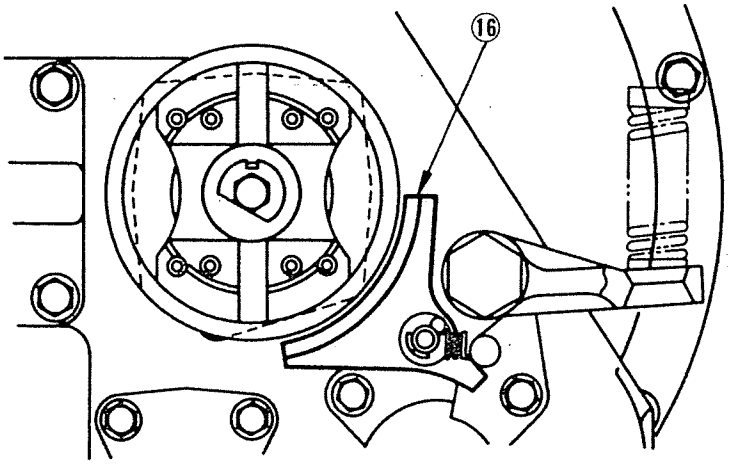
Unit: mm (in.)

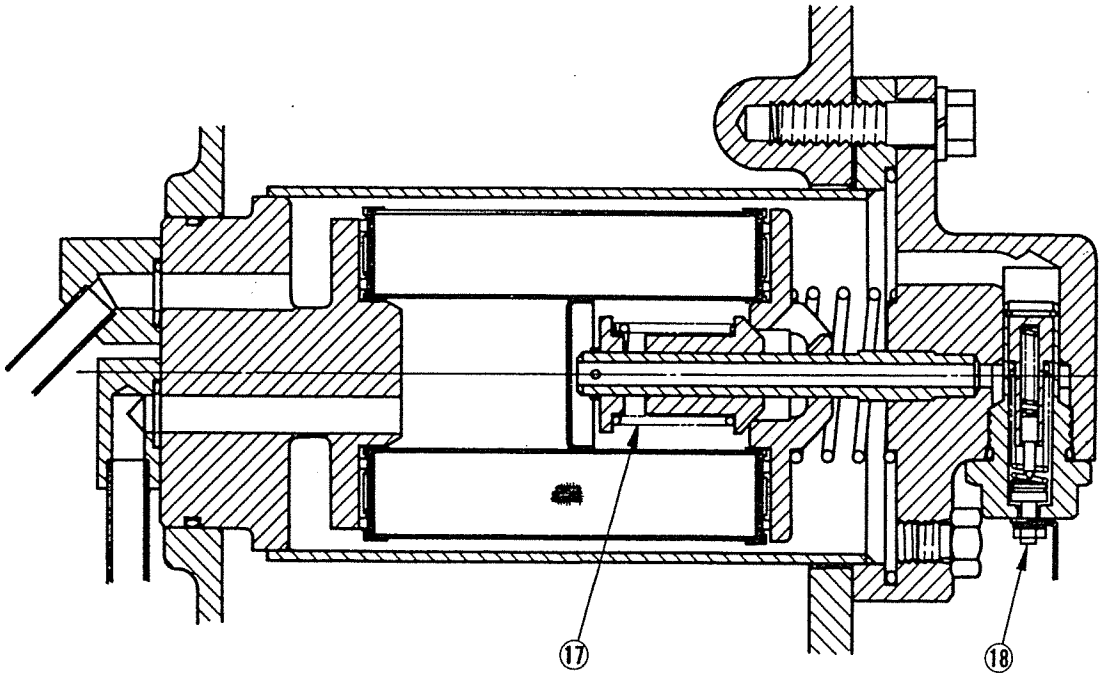
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
13	Piston rings (for bearing retainers)	Width	0.11 ~ 0.23 (0.0043 ~ 0.0091)	0.4 (0.0157)
		Clearance between ends of ring installed in bore of $60\ ^{+0.030}_{0}$ mm ($2.362\ ^{+0.0018}_{0}$ in.)	0.2 ~ 0.4 (0.0079 ~ 0.0157)	0.9 (0.0354)
14	Thickness of reverse drive pinion thrust washer		2.5 (0.098)	2.2 (0.087)
15	Torque for output shaft and countershaft fixing bolts		5.4 ± 0.5 kg-m (39 ± 3.6 ft-lb)	



Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
16	Clutch brake	Diameter of drum	120 (4.724)	118 (4.646)
		Thickness of lining	6.35 (0.2500)	3.5 (0.1378)
17	Safety valve spring	Free length	55 (2.165)	
		Load kg (lb)/as-installed length	4.2 ± 0.4/30 (9.3 ± 0.9/1.18)	3.4/30 (7.5/1.18)
18	Pressure difference that makes oil bypass alarm switch close		1.3 ~ 1.5 kg/cm² (18.5 ~ 21.3 psi)	



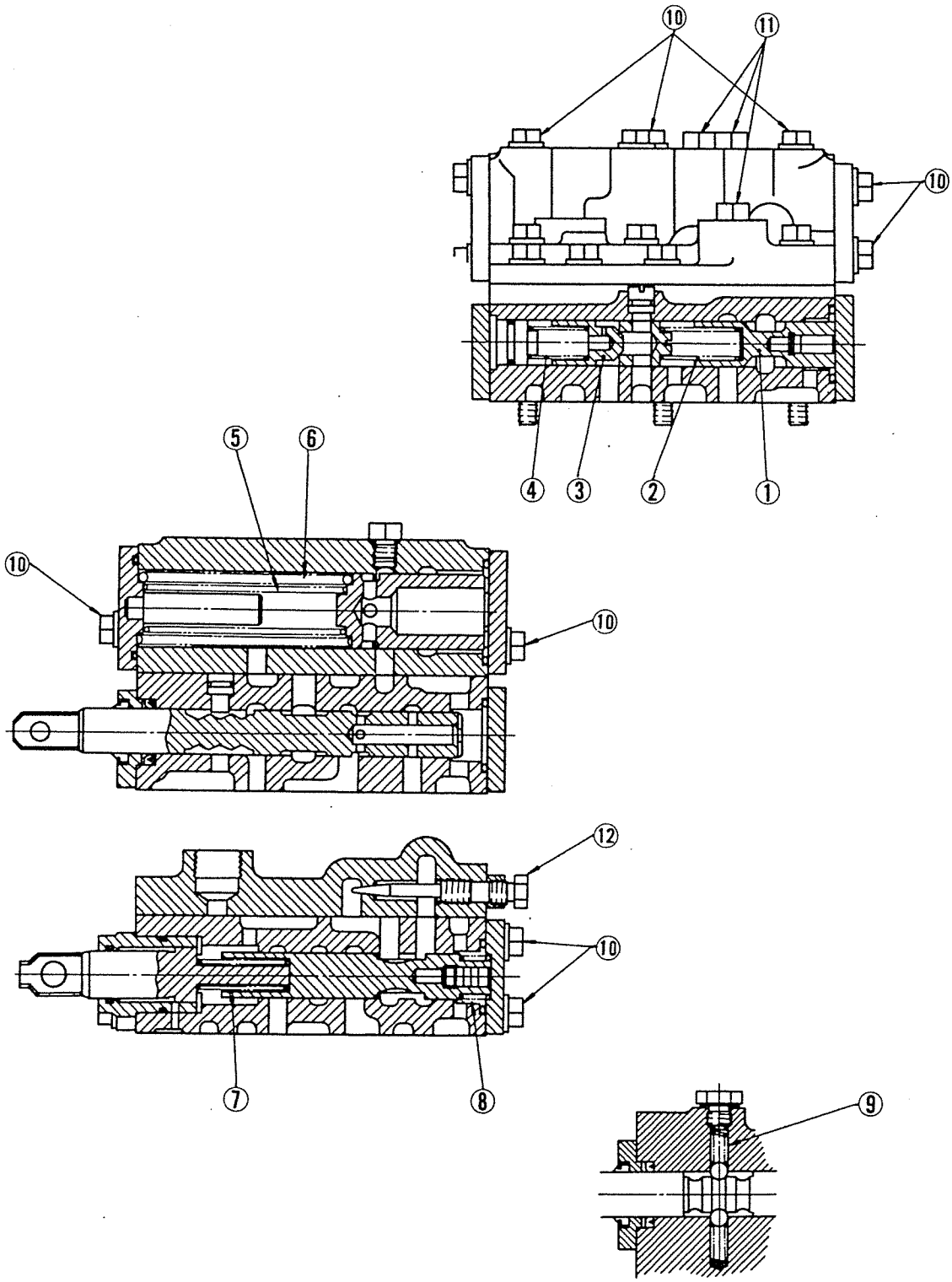


POWER DIRECTION CLUTCH CONTROL VALVE

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Main relief valve	Pressure that makes relief valve open	10 kg/cm² (142 psi)	
		Flow rate	20 ± 1 liters/min (1221 ± 61 cu in.)/min	
2	Main relief valve spring	Free length	39 (1.535)	
		Load kg (lb)/as-installed length	4.14 ± 0.4/33 (9.13 ± 0.9/1.30)	
3	Lubrication relief valve	Pressure that makes relief valve open	1.3 ± 0.5 kg/cm² (18.5 ± 7 psi)	
		Flow rate	20 ± 1 liters/min (1221 ± 61 cu in.)/min	
4	Lubrication relief valve spring	Free length	34 (1.339)	
		Load kg (lb)/as-installed length	1.5 ± 0.1/21.5 (3.3 ± 0.2/0.846)	1.1/21.5 (2.4/0.846)
5	Accumulator valve inner spring	Free length	91 (3.583)	
		Load kg (lb)/as-installed length	1.4 ± 0.1/88 (3.1 ± 0.2/3.465)	1.0/88 (2.2/3.465)
6	Accumulator valve outer spring	Free length	96 (3.780)	
		Load (lb)/as-installed length	3.44 ± 0.3/93 (7.6 ± 0.7/3.661)	2.8/93 (6.2/3.661)
7	Clutch valve spring	Free length	56.6 (2.228)	
		Load kg (lb)/as-installed length	3.44 ± 0.28/38 (7.6 ± 0.6/1.496)	
8	Clutch valve return spring	Free length	30 (1.181)	
		Load kg (lb)/as-installed length	1.22 ± 0.12/13 (2.7 ± 0.3/0.512)	1.0/13 (2.2/0.512)
9	Plunger detent springs	Free length	19.5 (0.768)	
		Load kg (lb)/as-installed length	2.76 ± 0.3/17.5 (6.1 ± 0.7/0.689)	
10	Torque for valve housing and cover attaching bolts		1.7 ± 0.1 kg-m (12.3 ± 0.7 ft-lb)	
11	Torque for hydraulic pressure inspection plug		2.5 ± 0.3 kg-m (18 ± 2.2 ft-lb)	
12	Length of time required for engaging clutch (N-F, N-R)		0.7 ± 0.1 sec	

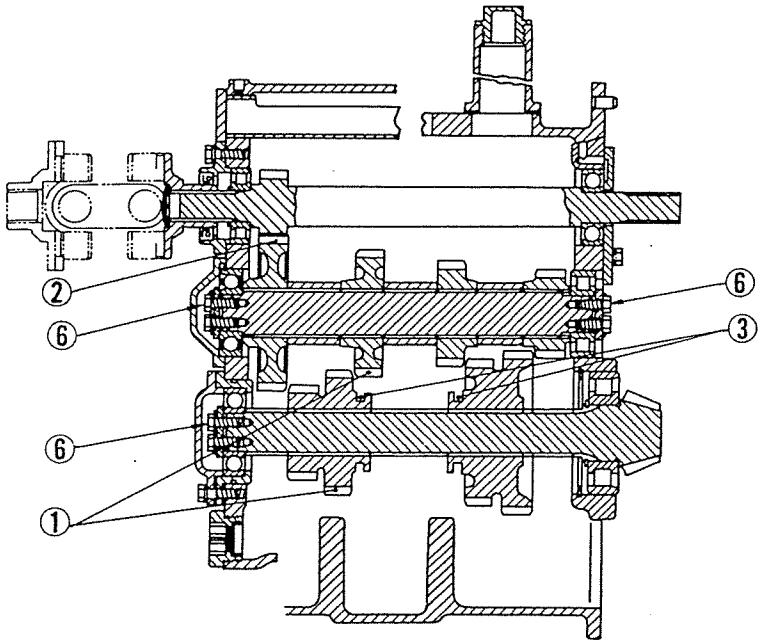
POWER DIRECTION CLUTCH CONTROL VALVE

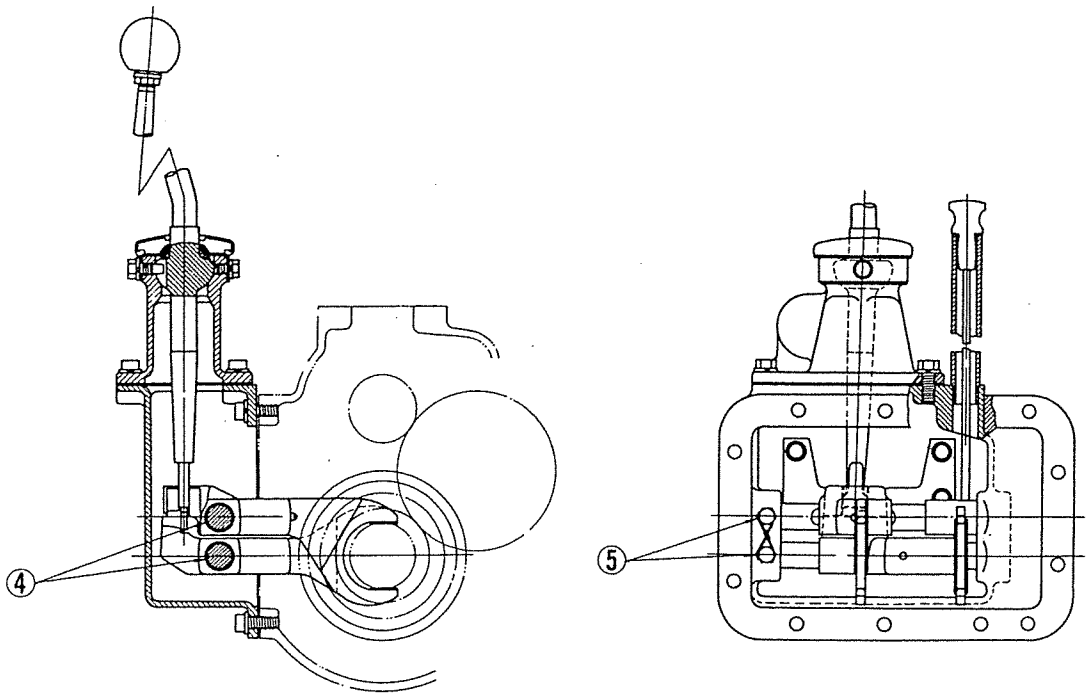


TRANSMISSION

Unit: mm (in.)

Ref. No.	Point of measurement	Standard clearance (Assembly standard)	Service limit
1	Backlash of 3rd-speed gear with idler	0.10 ~ 0.22 (0.0039 ~ 0.0087)	0.6 (0.0236)
2	Backlash of other gears (all gears)	0.11 ~ 0.24 (0.0043 ~ 0.0094)	0.6 (0.0236)
3	Fit of shifter fork in groove of sliding gear	0.15 ~ 0.35 (0.0059 ~ 0.0138)	0.80 (0.0315)
4	Fit of shifter shaft in shifter fork	0.020 ~ 0.062 (0.00079 ~ 0.00244)	0.50 (0.0197)
5	Torque for shifter shaft fixing bolt	2.9 ± 0.3 kg-m (21 ± 2.2 ft-lb)	
6	Torque for countershaft, bevel pinion shaft and reverse idler shaft fixing bolts	2.7 ± 0.3 kg-m (19.5 ± 2.2 ft-lb)	

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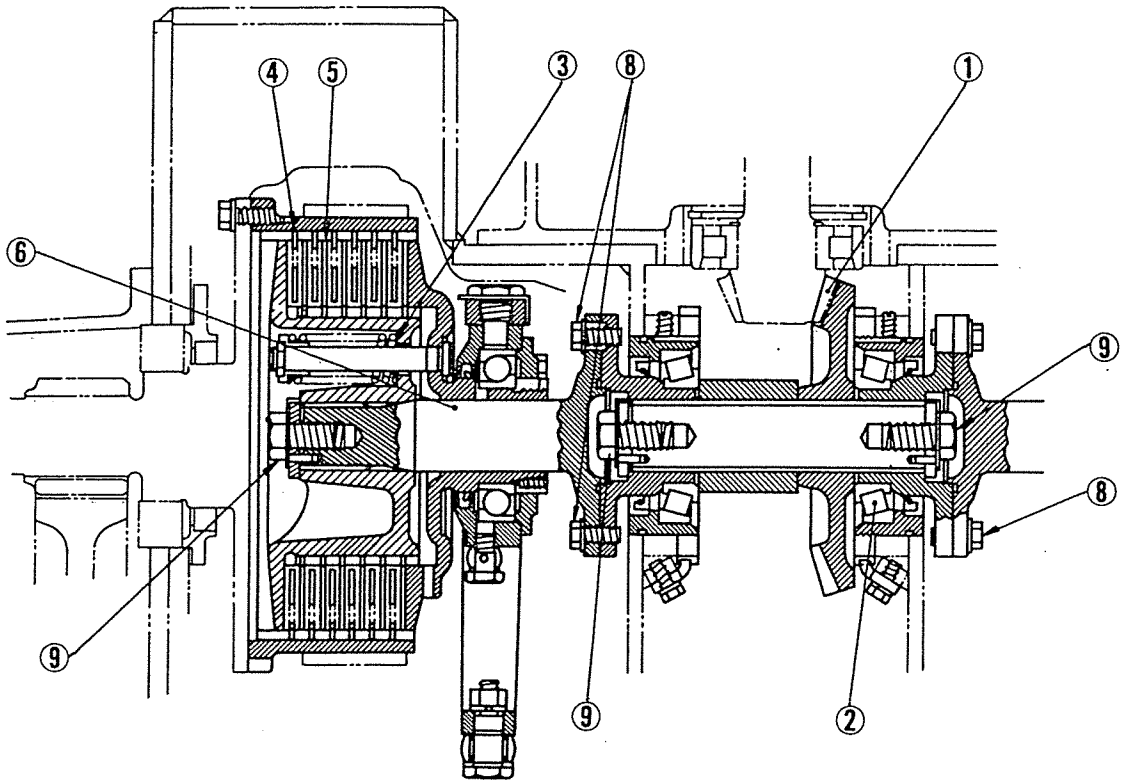
STEERING CLUTCHES

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Backlash of bevel gear with pinion		0.18 ~ 0.30 (0.0071 ~ 0.0118)	
2	Preload of tapered roller bearing (bevel gear)		0.7 ~ 0.9 kg-m (5.1 ~ 6.5 ft-lb)	
3	Steering clutch springs	Free length	88.5 (3.484)	
		Load kg (lb)/as-installed length	72.5 ± 5/62.5 (159.9 ± 11/2.461)	
4	Clutch facings	Thickness	8.7 (0.343)	6 (0.236)
		Backlash with outer drum	0.16 ~ 0.52 (0.0063 ~ 0.0205)	0.8 (0.0315)
5	Clutch plates	Thickness	2.8 (0.110)	2.3 (0.091)
		Backlash with inner drum	0.14 ~ 0.30 (0.0055 ~ 0.0118)	0.6 (0.0236)
		As-assembled thickness of plates (6 pcs) and facings (6 pcs)	69 (2.717)	66 (2.598)
6	Fit of clutch shaft in pressure plate		0.050 ~ 0.114 (0.00197 ~ 0.00449)	0.35 (0.0138)
7	Clearance between cam and roller		2.7 (0.1063)	
8	Torque for drive shaft and clutch shaft bolts [10 mm (0.394 in.) diameter bolts]		4.2 ± 0.4 kg-m (30.4 ± 2.9 ft-lb)	
9	Torque for drive shaft and clutch shaft bolts [16 mm (0.630 in.) diameter bolts]		19 ± 2 kg-m (137 ± 14 ft-lb)	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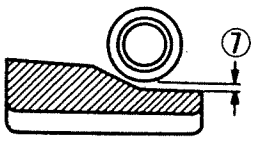
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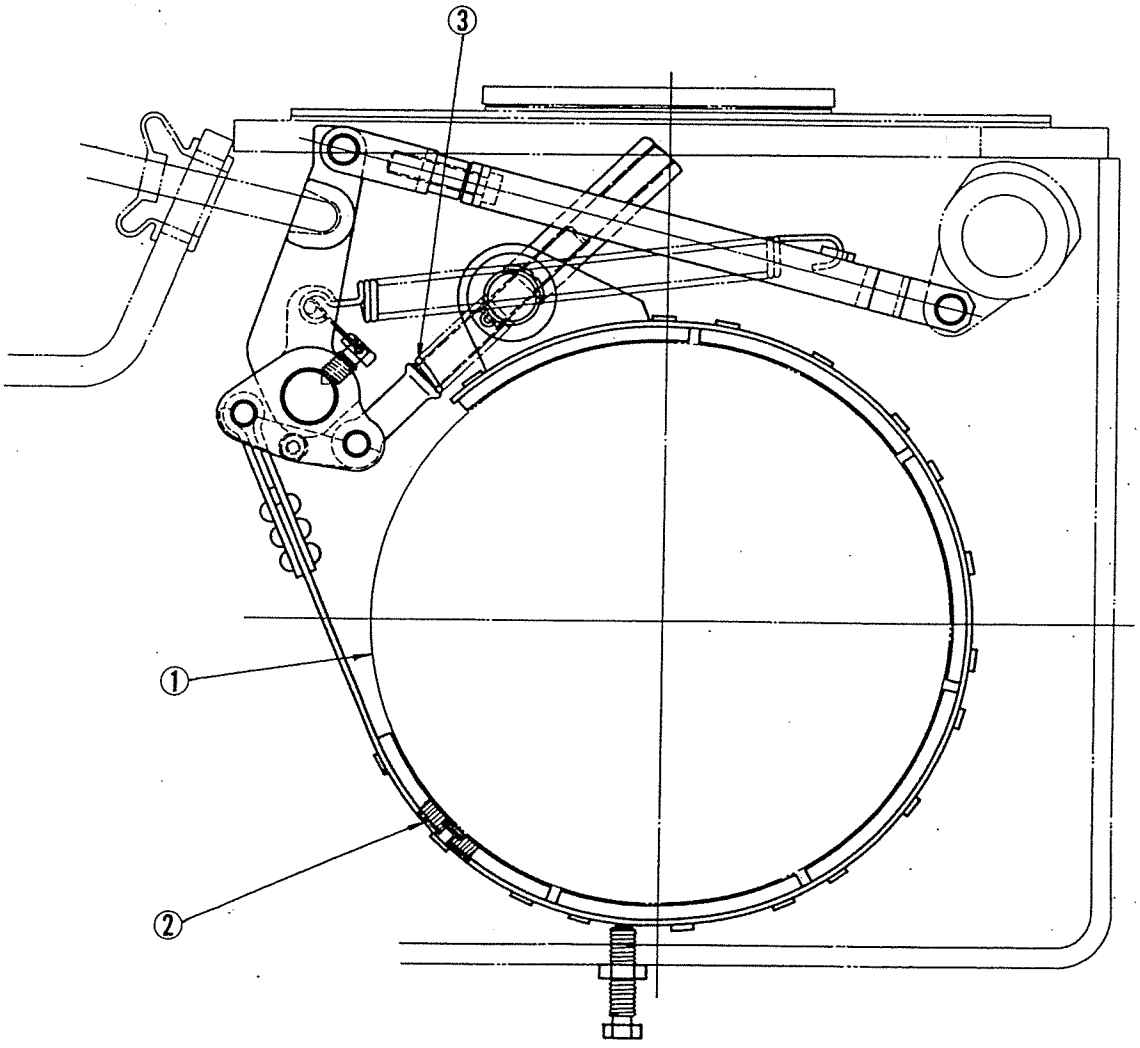
STEERING CLUTCH BRAKES

Unit: mm (in.)

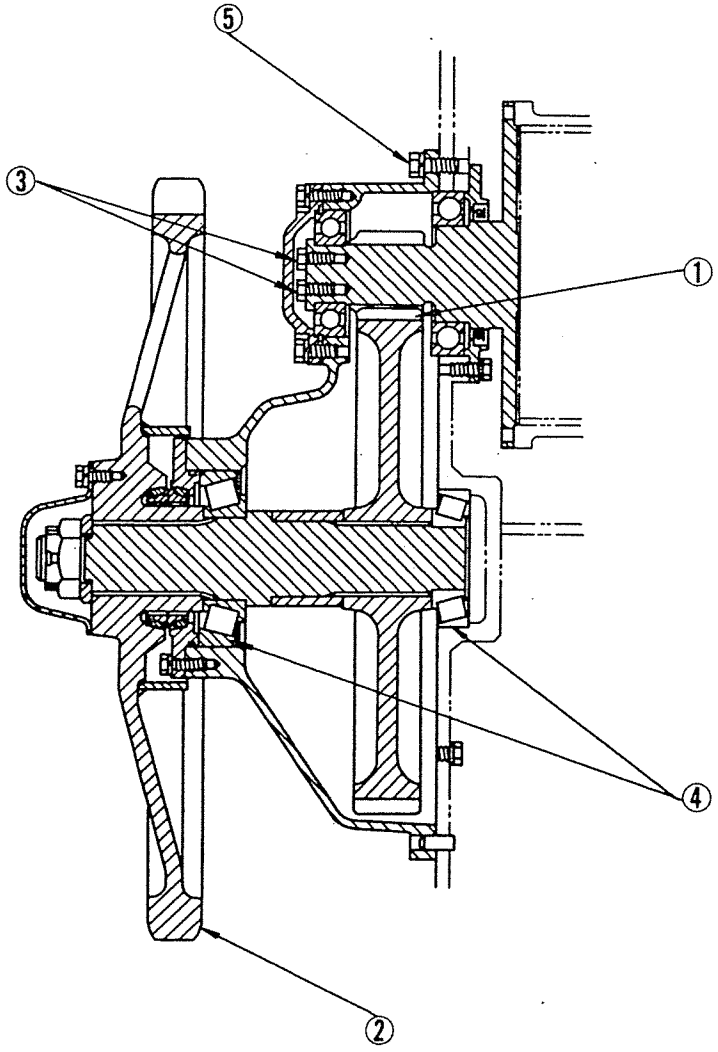
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Drums	Outside diameter	252 (9.921)	250 (9.843)
		Drum-to-lining clearance	0.8 (0.0315)	
2	Thickness of linings		6.5 (0.2559)	4.0 (0.1575)
3	Anchor springs	Free length	61.5 (2.4213)	
		Load kg (lb)/as-installed length	12 ± 1.2/45 (26 ± 2.6/1.8)	9/45 (19.8/1.8)



FINAL DRIVE

Unit: mm (in.)

Ref. No.	Point of measurement	Standard clearance (Assembly standard)	Service limit
1	Backlash (all gears)	0.14 ~ 0.32 (0.0055 ~ 0.0126)	1.0 (0.0394)
2	Face width of sprocket teeth (all sprockets)	40 (1.575)	36 (1.417)
3	Torque for pinion lock plate attaching bolts	4.2 ± 0.4 kg-m (30 ± 2.9 ft-lb)	
4	Preload of tapered roller bearing (all bearings)	0.28 ~ 0.36 kg-m (2.03 ~ 2.60 ft-lb)	
5	Torque for final drive gear case attaching bolts	29 ~ 32 kg-m (210 ~ 231 ft-lb)	

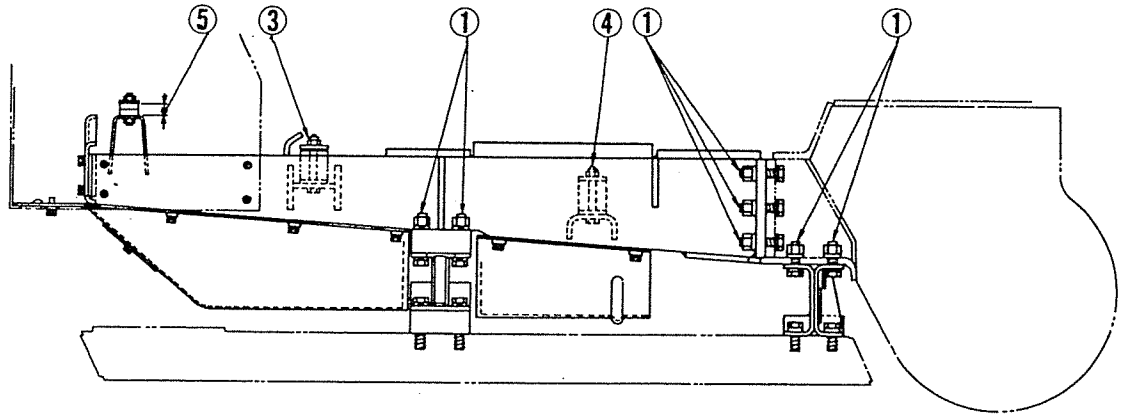


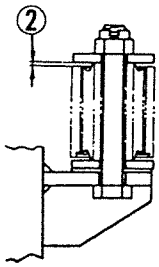
TRACK ROLLER FRAME

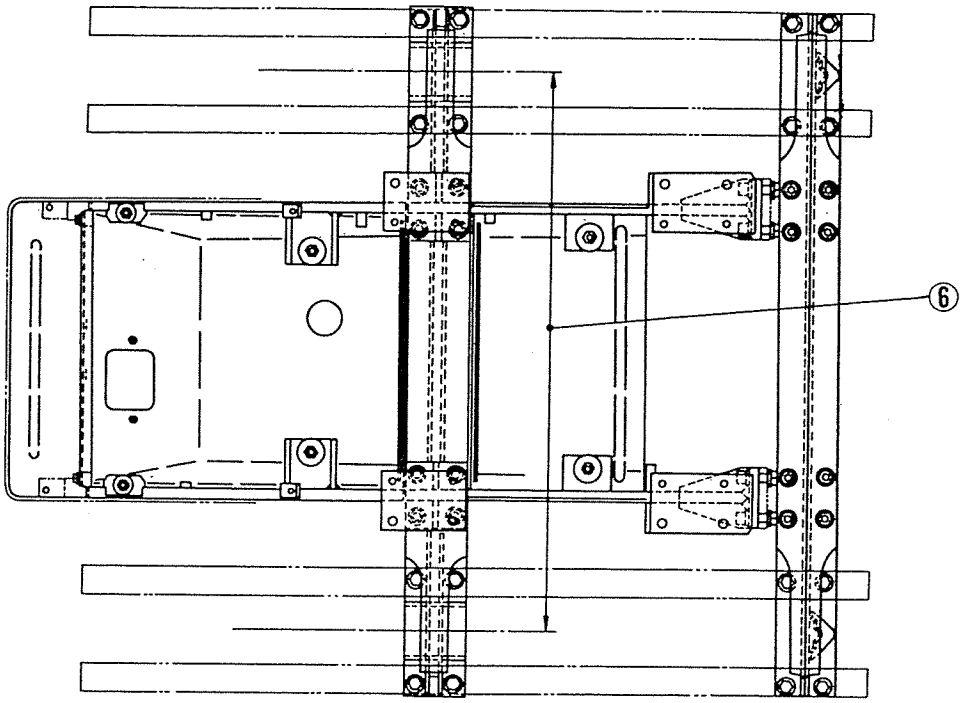
Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Torque for steering clutch case, frame and rigid bar attaching bolts		29 ~ 32 kg-m (210 ~ 231 ft-lb)	
2	Clearance between engine front mount and power direction clutch case mount and their respective stoppers		1.2 ~ 2.2 (0.0472 ~ 0.0866)	
3	Torque for engine front mount attaching bolts		15.9 ± 1.6 kg-m (115 ± 11.6 ft-lb)	
4	Torque for power direction clutch mount attaching bolts		15.9 ± 1.6 kg-m (115 ± 11.6 ft-lb)	
5	Clearance between washer of radiator attaching bolt and bracket (all bolts)		25.5 (1.0039)	
6	* Tread (center to center of tracks)	Standard tractor	1130 (44.49)	10 (0.394)
		Swamp tractor	1330 (52.36)	
		Super-swamp tractor	1540 (60.63)	

* Difference between front and rear sides



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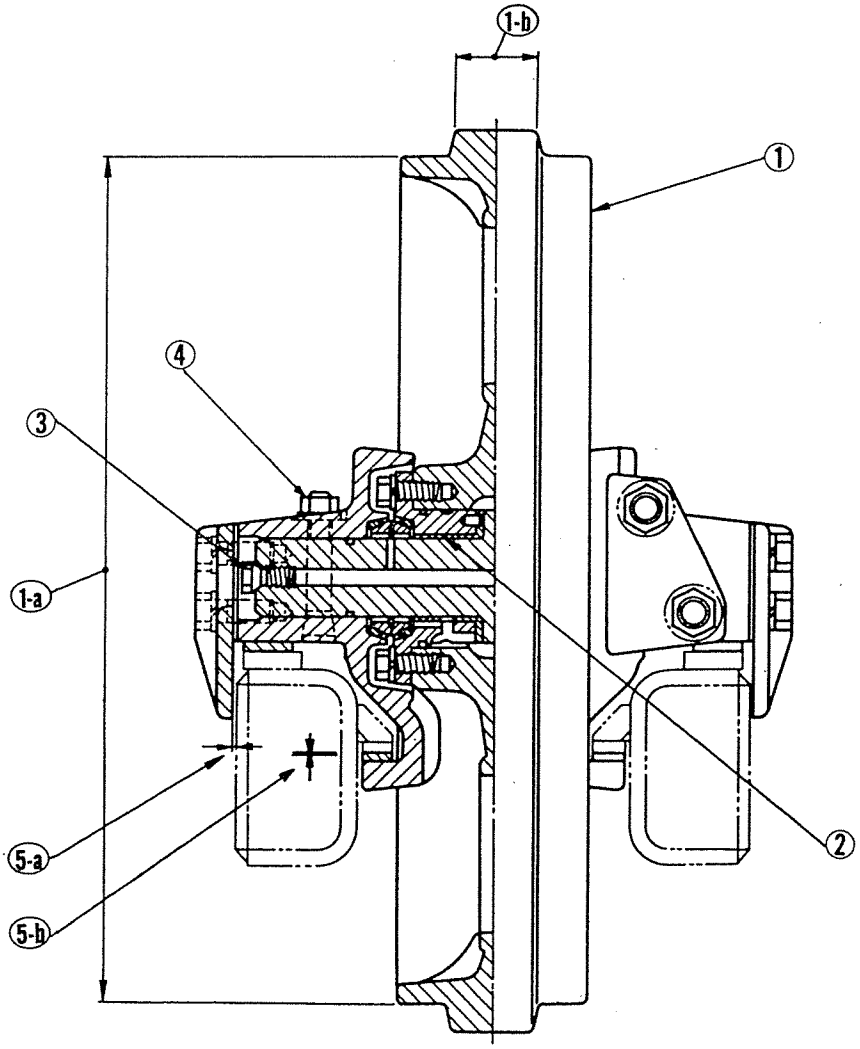
FRONT IDLERS

Unit: mm (in.)

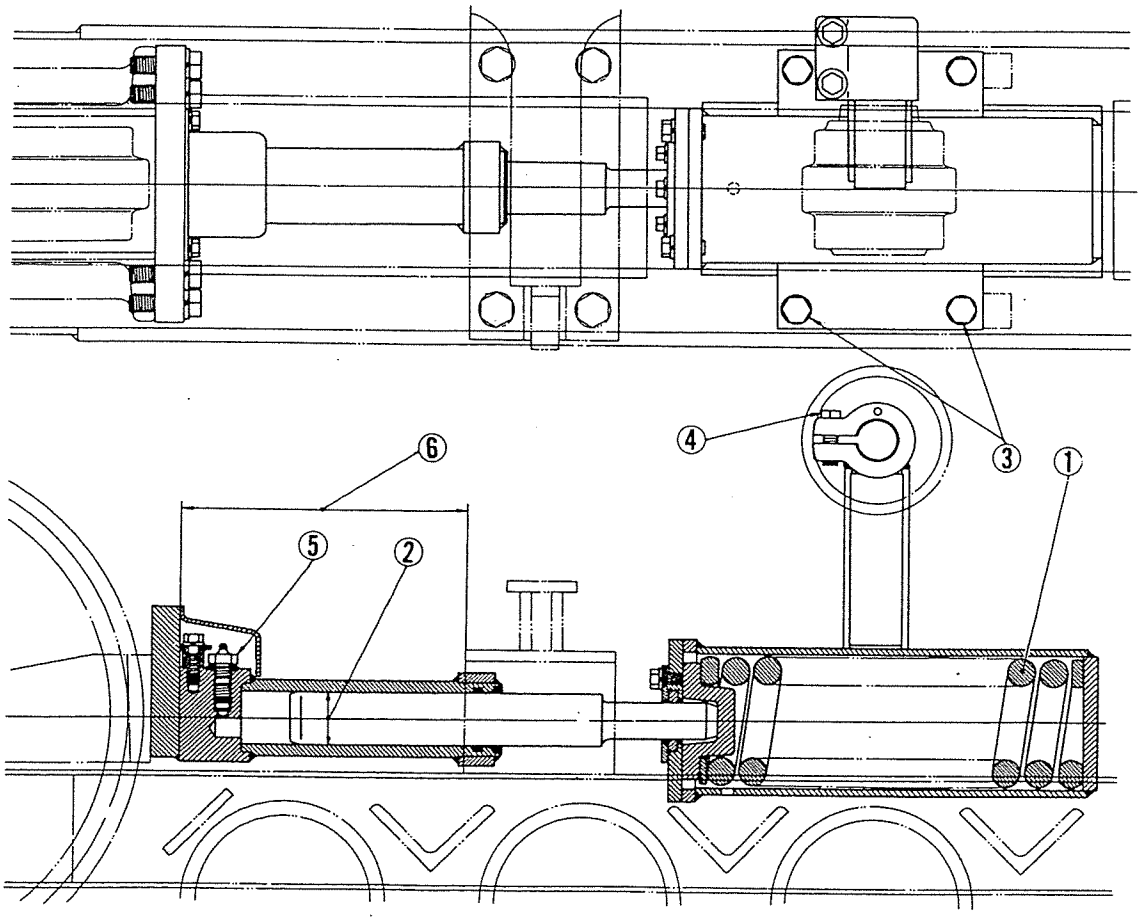
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Idlers	Outside diameter at (1-a)	434 (17.087)	425 (16.732)
		Width at (1-b)	42 (1.654)	35 (1.378)
2	Idler shaft (all idlers)	End play	0.20 ~ 0.80 (0.0079 ~ 0.0315)	1.2 (0.0472)
		Fit in bushing	0.155 ~ 0.235 (0.00610 ~ 0.00925)	1.0 (0.0394)
3	Torque for filler plug (all idlers)		4.8 ± 0.5 kg-m (34.7 ± 3.6 ft-lb)	
4	Torque for taper pin bolt holding shaft to bracket (all idlers)		6.5 ± 0.7 kg-m (47 ± 5.1 ft-lb)	
5	Track roller guides and frames	Clearance at (5-a)	1 (0.0394)	3 (0.1181)
		Clearance at (5-b)		



RECOIL SPRINGS

Unit: mm (in.)

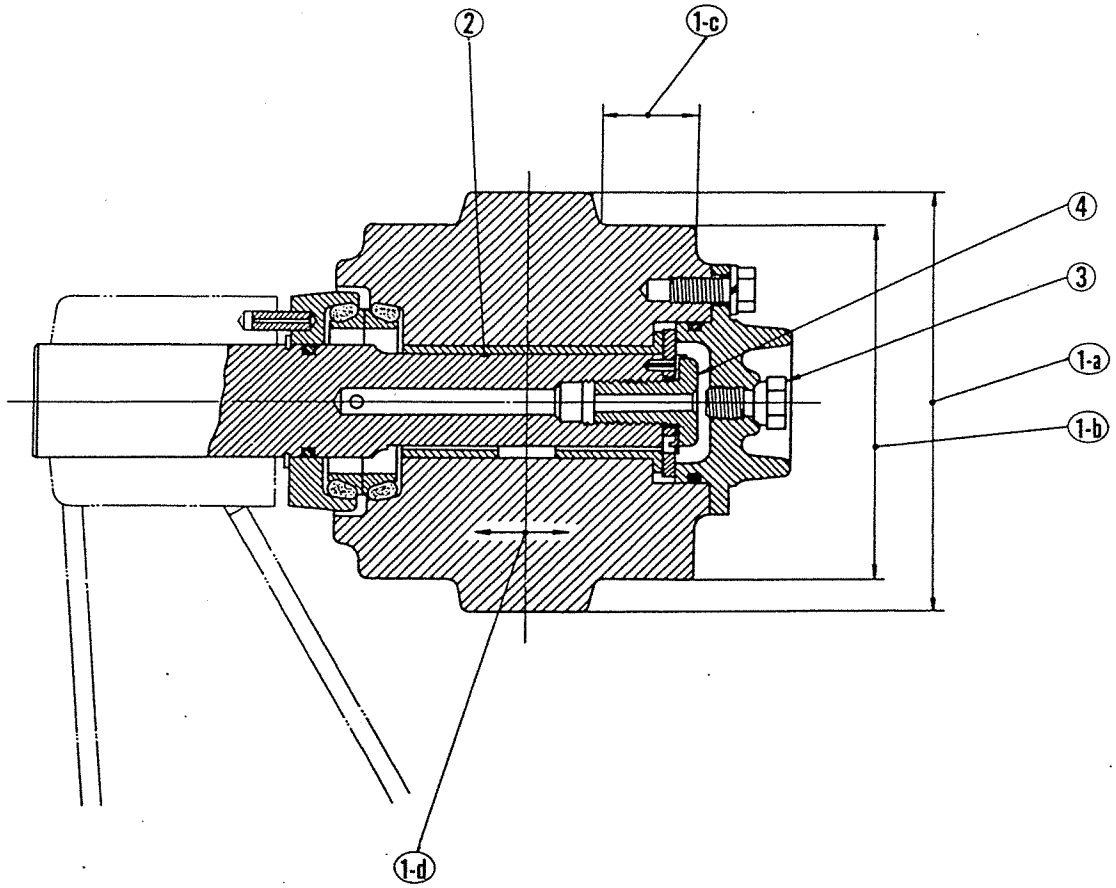
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Recoil springs	Free length	381.5 (15.020)	
		Load kg (lb)/as-installed length	2600 ± 210/326 (5733 ± 463/12.835)	2300/326 (5072/12.835)
2	Fit of piston in cylinder (all cylinders)		0.075 ~ 0.164 (0.00295 ~ 0.00646)	0.8 (0.0315)
3	Torque for track carrier roller bracket attaching bolts		13.5 ± 1.4 kg-m (97.6 ± 10 ft-lb)	
4	Torque for bolt holding roller shaft to bracket (all bolts)		7.6 ± 0.8 kg-m (55 ± 5.8 ft-lb)	
5	Torque for filler valve (all valves)		3.5 ± 0.4 kg-m (25.3 ± 2.9 ft-lb)	
6	Maximum adjustable range of hydraulic track adjuster cylinder		241.5 (1746.770)	300 (2169.9)



TRACK CARRIER ROLLERS

Unit: mm (in.)

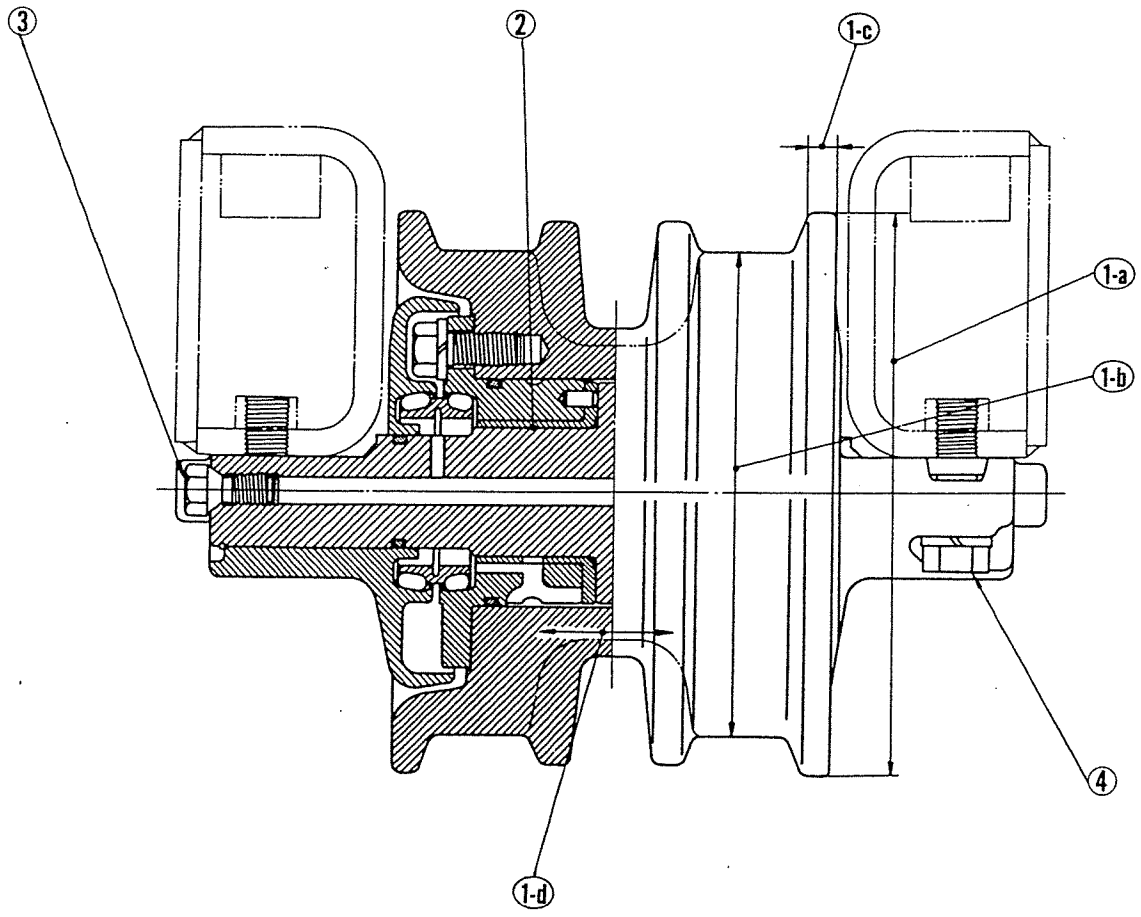
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Rollers	Outside diameter at (1-a)	130 (5.118)	118 (4.646)
		Outside diameter at (1-b)	110 (4.331)	98 (3.858)
		Width at (1-c)	30 (1.181)	35 (1.378)
		End play (1-d)	0.15 ~ 0.55 (0.0059 ~ 0.0217)	1.2 (0.0472)
2	Fit of roller shaft in bushing (all rollers)		0.165 ~ 0.211 (0.00650 ~ 0.00831)	1.0 (0.0394)
3	Torque for filler plug (all rollers)		4.8 ± 0.5 kg-m (34.7 ± 3.6 ft-lb)	
4	Torque for bolt holding roller shaft (all rollers)		12.2 ± 1.2 kg-m (88.2 ± 8.7 ft-lb)	



TRACK ROLLERS

Unit: mm (in.)

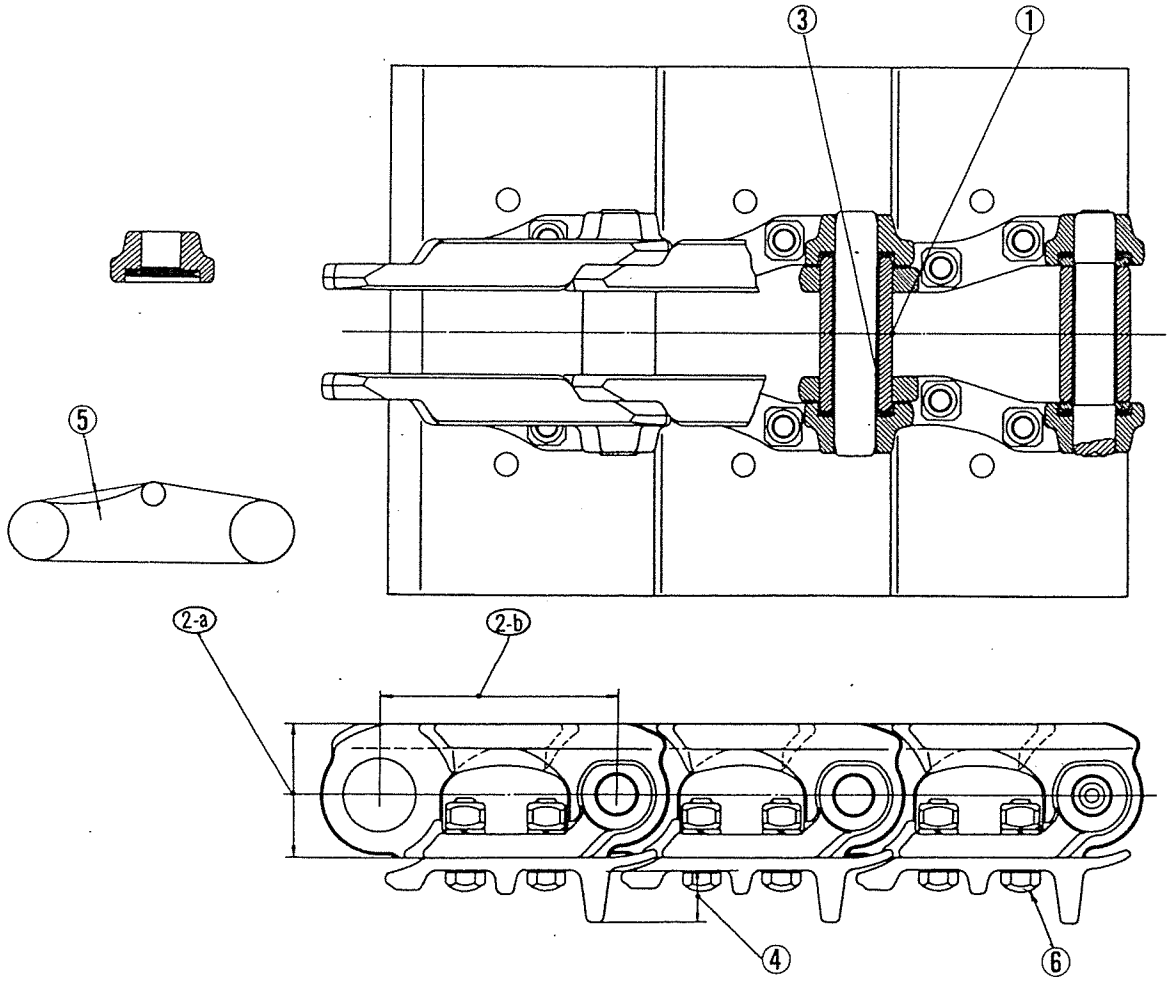
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Rollers	Outside diameter of flange (1-a)	172 (6.772)	162 (6.378)
		Outside diameter at (1-b)	148 (5.827)	138 (5.433)
		Width of flange (1-c)	9 (0.354)	4 (0.157)
		End play (1-d)	0.20 ~ 0.80 (0.0079 ~ 0.0315)	1.2 (0.0472)
2	Fit of roller shaft in bushing (all rollers)		0.155 ~ 0.235 (0.00610 ~ 0.00925)	1.0 (0.0394)
3	Torque for filler plug (all rollers)		4.8 ± 0.5 kg-m (34.7 ± 3.6 ft-lb)	
4	Torque for roller attaching bolt (all rollers)		6.5 ± 0.6 kg-m (47.0 ± 4.3 ft-lb)	



TRACK

Unit: mm (in.)

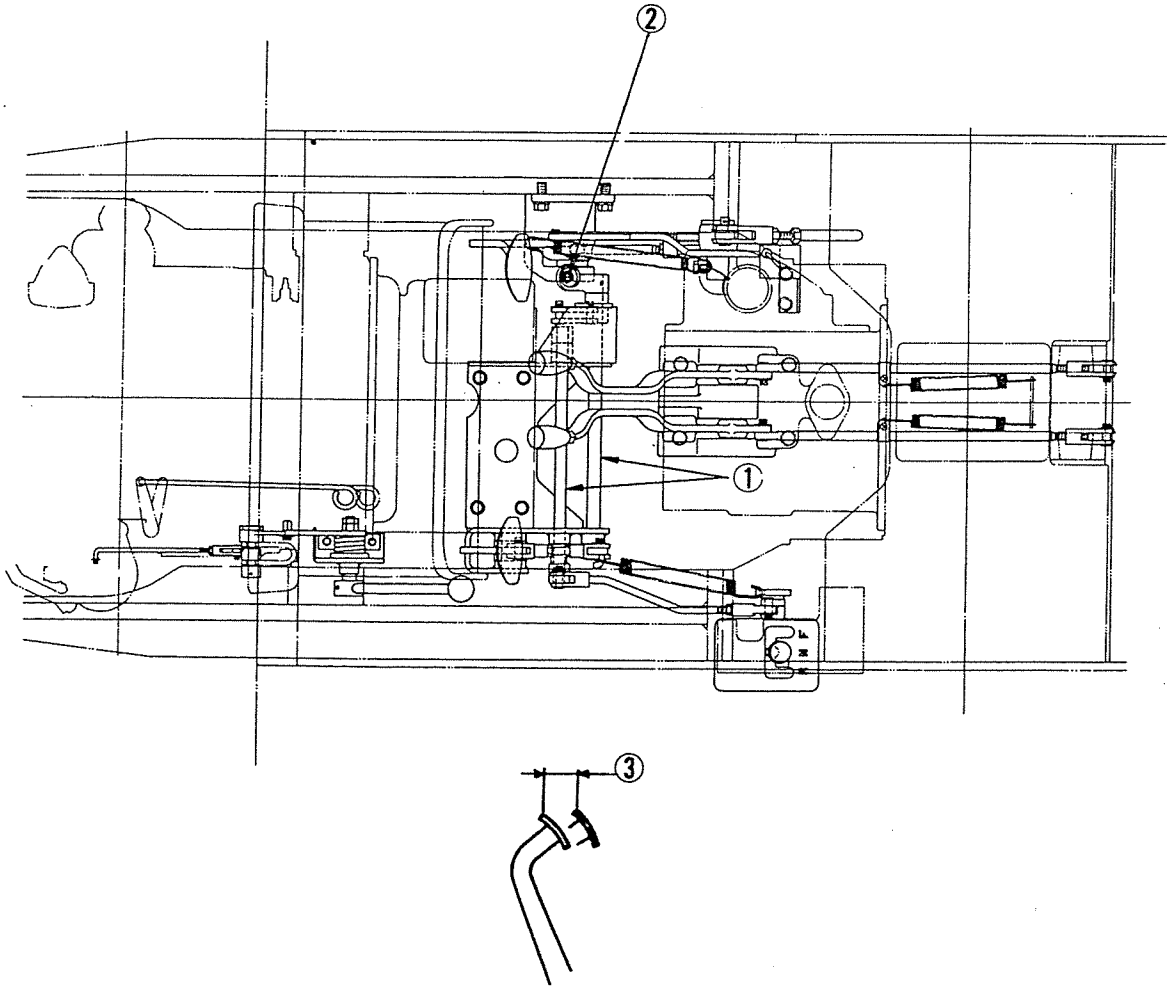
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Outside diameter of bushing		41 (1.614) [Limit for a inverted bushing: 38 (1.496)]	37.2 (1.465)
2	Links	Height (2-a)	75 (2.953)	68 (2.677)
		Pitch (2-b)	135 (5.315) [Limit for a inverted bushing: 138 (5.433)]	138.5 (5.453)
3	Fit of track pin in bushing (all links)		0.45 ~ 0.734 (0.0177 ~ 0.02890)	2.5 (0.0984)
4	Height of grouser (all links)		BD2E: 38.5 (1.516) BS3E : 30 (1.181)	11 (0.433)
5	Track adjustment (sag)		20 ~ 30 (0.79 ~ 1.18)	
6	Torque for shoe attaching bolts (all links)		17 ~ 20 kg-m (123 ~ 145 ft-lb)	



CONTROL

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of shaft in bushing (all shafts)	12 (0.47)	0.025 ~ 0.143 (0.00098 ~ 0.00563)	0.3 (0.0118)
		15 (0.59)	0.025 ~ 0.154 (0.00098 ~ 0.00606)	0.3 (0.0118)
		18 (0.71)	0.025 ~ 0.159 (0.00098 ~ 0.00626)	0.3 (0.0118)
		25 (0.98)	0.030 ~ 0.172 (0.00118 ~ 0.00677)	0.3 (0.0118)
		32 (1.26)	0.011 ~ 0.153 (0.00043 ~ 0.00602)	0.3 (0.0118)
2	Load kg (lb)/as-installed length of power direction clutch brake spring (all springs)		36 ± 3/61.5 (79 ± 6.6/2.421)	30/61.5 (66/2.421)
3	Play of brake pedal		25 (0.984)	



HYDRAULIC PUMP

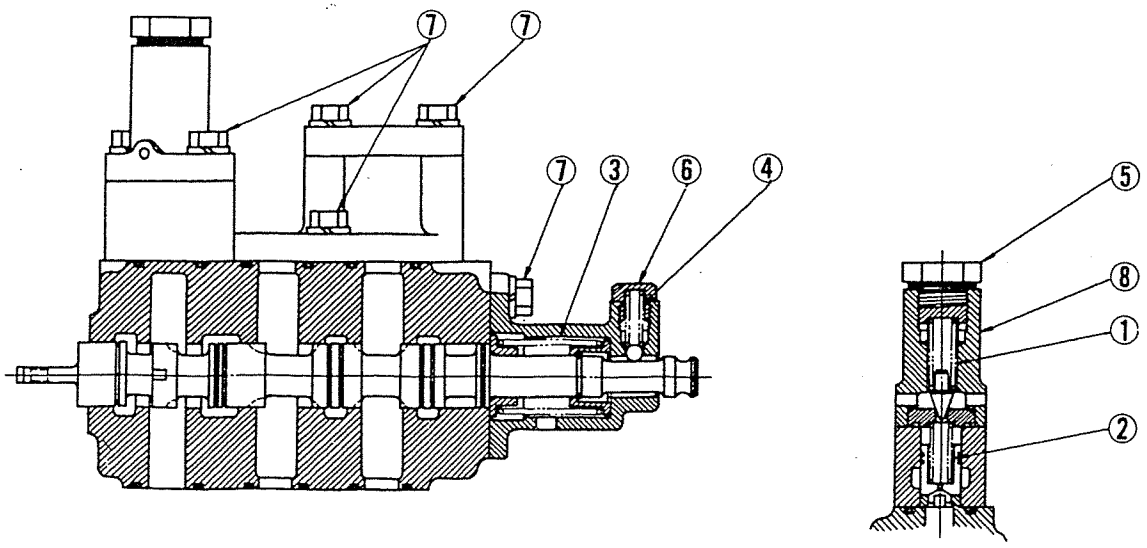
Unit: mm (in.)

Ref. No.	Point of measurement			Standard clearance (Assembly standard)	Service limit
1	Gear pump	Performance (BD2E)	Speed	2500 rpm	
			Pressure	70 kg/cm^2 (995.4 psi)	
			Displacement	51 liters/min (3112 cu in.)/min	
		Performance (BS3E)	Speed	2500 rpm	
			Pressure	70 kg/cm^2 (995.4 psi)	
			Displacement	65 liters/min (3966 cu in.)/min	
2	Torque for cover attaching bolts			6 ~ 7 kg-m (43 ~ 51 ft-lb)	

HYDRAULIC CONTROL VALVE (BD2E)

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Pilot valve spring	Free length	42.9 (1.689)	
		Load kg (lb)/as-installed length	24.7 ± 2/34.1 (54.5 ± 4/1.343)	
2	Relief valve spring	Free length	39 (1.535)	
		Load kg (lb)/as-installed length	3.82 ± 0.3/26.5 (8.42 ± 0.7/1.043)	3/26.5 (6.6/1.043)
3	Plunger centering spring	Free length	88.5 (3.484)	
		Load kg (lb)/as-installed length	10 ± 1/47 (22 ± 2/1.850)	8/47 (17.6/1.850)
4	Plunger detent spring	Free length	29 (1.142)	
		Load kg (lb)/as-installed length	7.94 ± 0.8/22.8 (17.5 ± 1.8/0.898)	6/22.8 (13.2/0.898)
5	Torque for relief valve plug		20 ± 2 kg-m (145 ± 14 ft-lb)	
6	Torque for plunger detent plug		5 ± 0.5 kg-m (36 ± 3.6 ft-lb)	
7	Torque for plugs		4.4 ± 0.4 kg-m (32 ± 2.9 ft-lb)	
8	Main relief valve	Pressure that makes relief valve open	140 ± 2 kg/cm^2 (1991 ± 28 psi)	
		Flow rate	65 ± 5 liters/min (3967 ± 305 cu in.)/min	



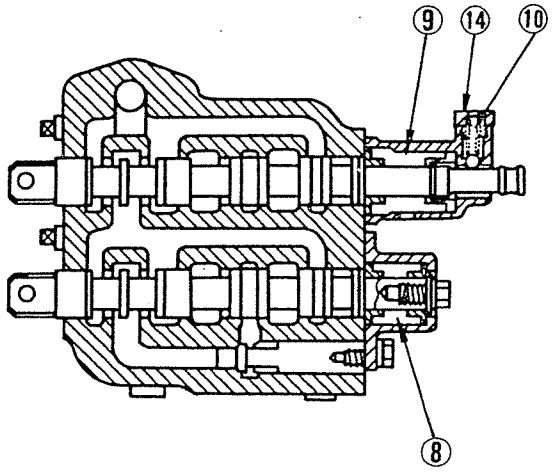
HYDRAULIC CONTROL VALVE (BS3E)

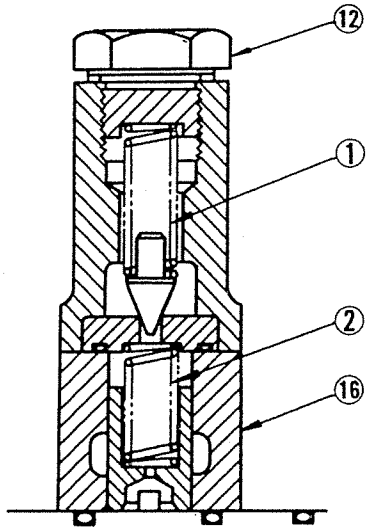
Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Pilot valve spring	Free length	42.9 (1.689)	
		Load kg (lb)/as-installed length	24.7 ± 2/34.1 (54.5 ± 4.4/1.343)	
2	Relief valve spring	Free length	39 (1.535)	
		Load kg (lb)/as-installed length	3.82 ± 0.3/26.5 (8.4 ± 0.7/1.043)	3/26.5 (6.6/1.043)
3	Inner safety valve spring	Free length	64.9 (2.555)	
		Load kg (lb)/as-installed length	19.2 ± 1.5/54 (42.3 ± 3.3/2.126)	
4	Outer safety valve spring	Free length	63.8 (2.512)	
		Load kg (lb)/as-installed length	61.1 ± 4.9/54 (134.7 ± 10.8/2.126)	
5	Check valve spring	Free length	34.5 (1.358)	
		Load kg (lb)/as-installed length	0.11 ± 0.01/30 (0.24 ± 0.02/1.181)	0.09/30 (0.20/1.181)
6	Make-up valve (dump) spring	Free length	34.5 (1.358)	
		Load kg (lb)/as-installed length	0.11 ± 0.01/30 (0.24 ± 0.02/1.181)	0.09/30 (0.20/1.181)
7	Make-up valve (lift) spring	Free length	50 (1.969)	
		Load kg (lb)/as-installed length	0.22 ± 0.03/37 (0.49 ± 0.07/1.457)	0.17/37 (0.37/1.457)
8	Plunger (dump) centering spring	Free length	60 (2.362)	
		Load kg (lb)/as-installed length	10 ± 1/30 (22 ± 2/1.181)	8/30 (17.6/1.181)
9	Plunger (lift) centering spring	Free length	88.5 (3.484)	
		Load kg (lb)/as-installed length	10 ± 1/47 (22 ± 2/1.850)	8/47 (17.6/1.850)
10	Plunger detent spring	Free length	29 (1.142)	
		Load kg (lb)/as-installed length	7.94 ± 0.8/22.8 (17.5 ± 1.8/0.898)	6/22.8 (13.2/0.898)
11	Torque for safety valve body		20 ± 2 kg-m (145 ± 14 ft-lb)	
12	Torque for relief valve plug		20 ± 2 kg-m (145 ± 14 ft-lb)	
13	Torque for safety valve plug		20 ± 2 kg-m (145 ± 14 ft-lb)	
14	Torque for plunger detent plug		5 ± 0.5 kg-m (36 ± 3.6 ft-lb)	
15	Torque for all bolts		4.4 ± 0.4 kg-m (31.8 ± 2.9 ft-lb)	

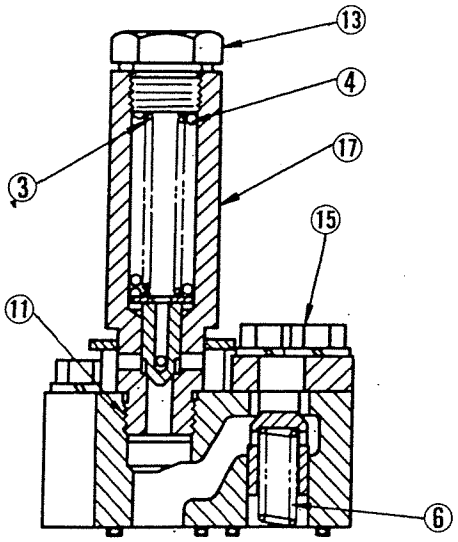
Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
16	Main relief valve	Pressure that makes relief valve open	140 ± 2 kg/cm^2 (1991 ± 28 psi)	
		Flow rate	65 ± 5 liters/min (3967 ± 305 cu in.)/min	
17	Safety valve	Pressure that makes safety valve open	160 ± 2 kg/cm^2 (2275 ± 28 psi)	
		Flow rate	23 liters/min (1404 cu in.)/min	

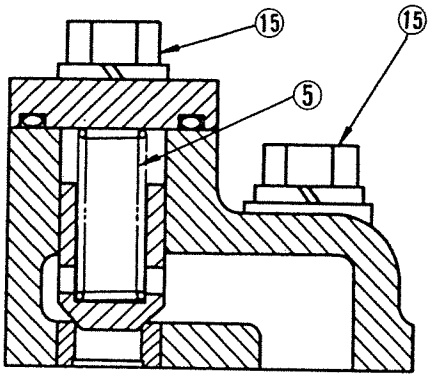




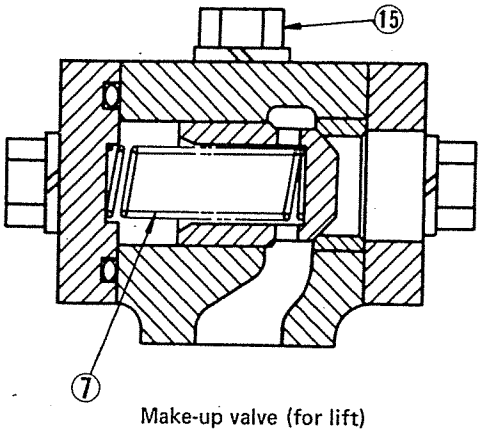
HYDRAULIC CONTROL VALVE (BS3E)



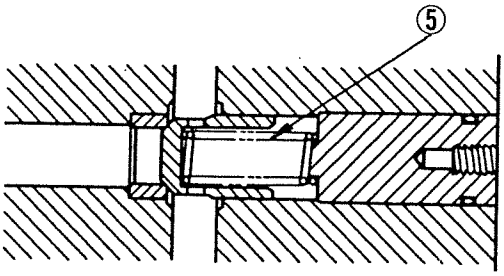
Safety and make-up valves (for dump)



Check valve (for lift)



Make-up valve (for lift)

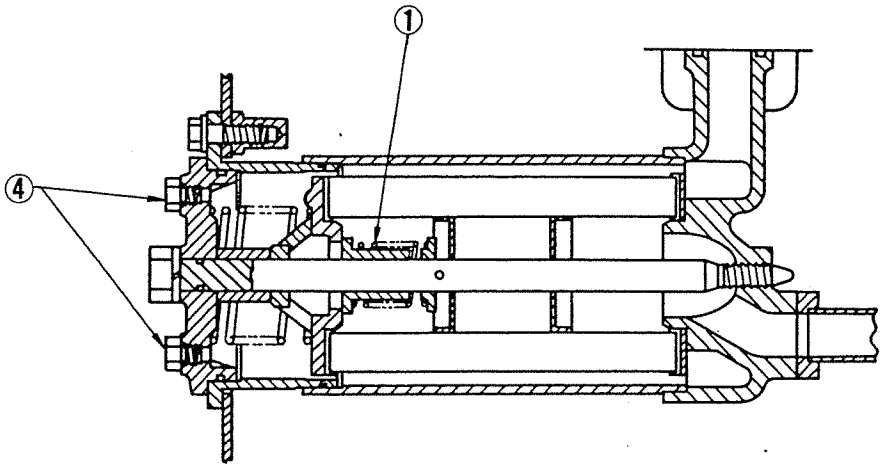


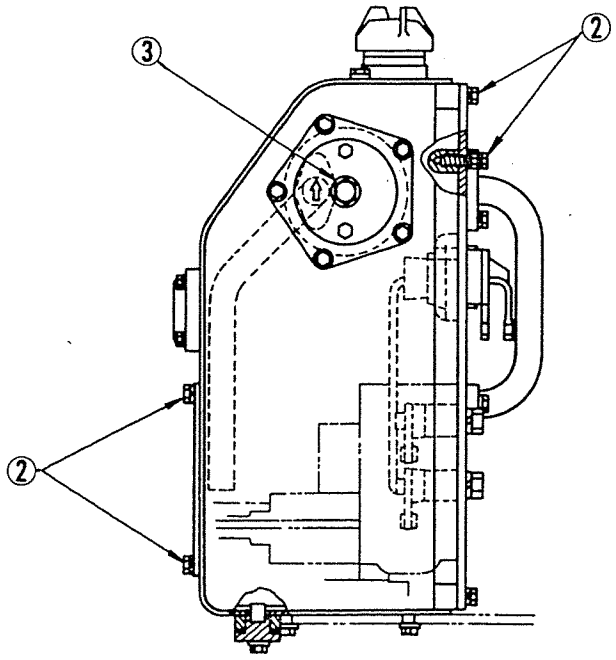
Check valve (for dump)

HYDRAULIC TANK

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Safety valve spring in filter	Free length	106.2 (4.181)	
		Load kg (lb)/as-installed length	7.07 ± 0.7/38 (15.6 ± 1.5/1.496)	6/38 (13.2/1.496)
2	Torque for tank cover attaching bolts		3.5 ± 0.3 kg-m (25.3 ± 2.2 ft-lb)	
3	Torque for filter cover center bolt		4.8 ± 0.5 kg-m (34.7 ± 3.6 ft-lb)	
4	Torque for bleeder plug and drain plug of filter		2.5 ± 0.2 kg-m (18.1 ± 1.4 ft-lb)	

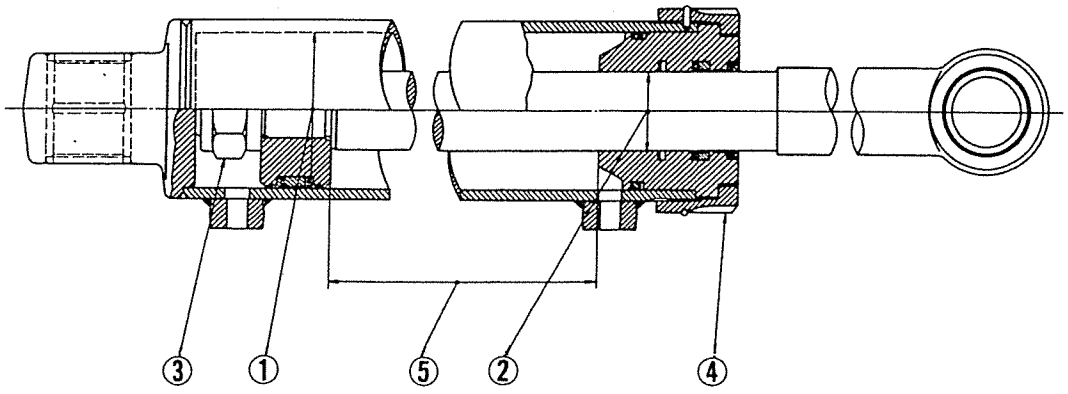




LIFT CYLINDERS (BS3E)

Unit: mm (in.)

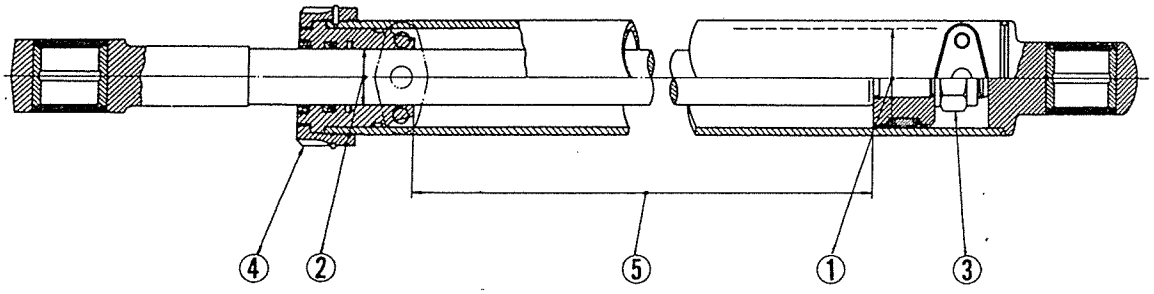
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of piston in cylinder (all cylinders)			0.5 (0.0197)
2	Fit of guide bushing on piston rod (all cylinders)		0.075 ~ 0.139 (0.00295 ~ 0.00547)	0.35 (0.0138)
3	Torque for nut holding piston (all cylinders)		111 ± 15 kg-m (803 ± 108 ft-lb)	
4	Torque for grand screw (all cylinders)		87 ± 9 kg-m (629 ± 65 ft-lb)	
5	Piston rod (all cylinders)	Stroke	477 (18.78)	
		Center to center of pins (with cylinder fully retracted)	809 (31.85)	



DUMP CYLINDERS (BS3E)

Unit: mm (in.)

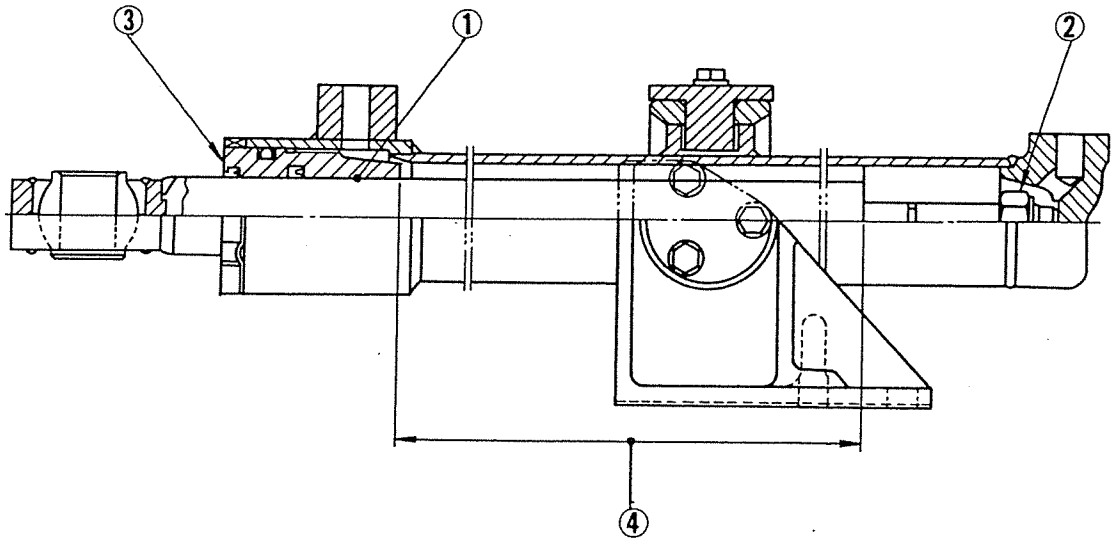
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of piston in cylinder (all cylinders)			0.35 (0.0138)
2	Fit of guide bushing on piston rod (all cylinders)		0.075 ~ 0.139 (0.00295 ~ 0.00547)	0.35 (0.0138)
3	Torque for nut holding piston (all cylinders)		60 ± 6 kg-m (434 ± 43 ft-lb)	
4	Torque for grand screw (all cylinders)		45 ± 4.5 kg-m (325 ± 32.5 ft-lb)	
5	Piston rod (all cylinders)	Stroke	422 (16.61)	
		Center to center of pins (with cylinder fully retracted)	763 (30.04)	



BLADE LIFT CYLINDERS (BD2E)

Unit: mm (in.)

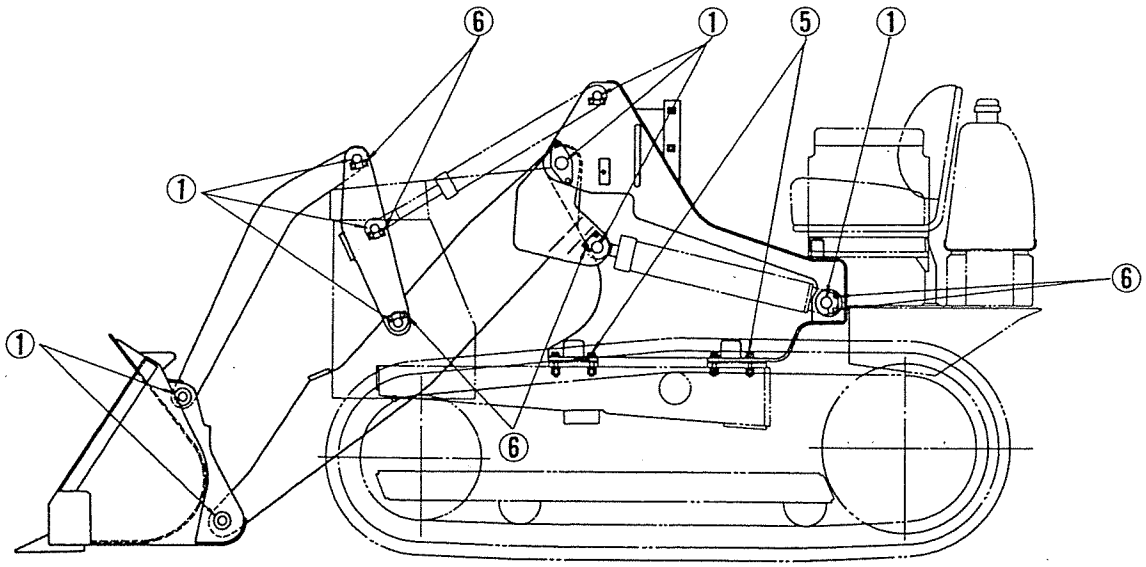
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of guide bushing on piston rod (all cylinders)		0.08 ~ 0.18 (0.00315 ~ 0.00709)	0.4 (0.0157)
2	Torque for nut holding piston (all cylinders)		25.5 ~ 37.2 kg-m (184.4 ~ 269.1 ft-lb)	
3	Torque for cylinder head (all cylinders)		40 ± 4 kg-m (289 ± 29 ft-lb)	
4	Piston rod (all cylinders)	Stroke	675 (26.57)	
		Center to center of pins (with cylinder fully retracted)	500 (19.69)	

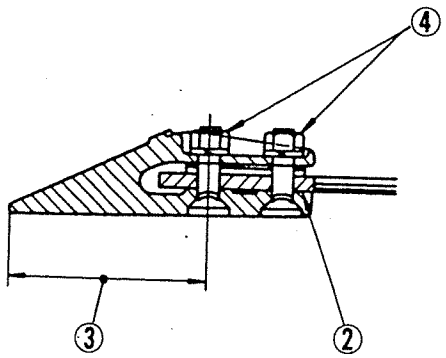


BUCKET AND LINKAGE (BS3E)

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of pin in bushing (all pins)	35 (1.38)	0.073 ~ 0.164 (0.00287 ~ 0.00646)	0.6 (0.024)
		45 (1.77)	0.065 ~ 0.160 (0.00256 ~ 0.00630)	0.6 (0.024)
		50 (1.97)	0.095 ~ 0.204 (0.00374 ~ 0.00803)	0.6 (0.024)
2	Width of cutting edge (all cutting edges)		159 (6.26)	120 (4.72)
3	Length of tooth (all teeth)		160 (6.30)	100 (3.94)
4	Torque for tooth attaching bolts (all teeth)		29 ~ 32 kg-m (210 ~ 231 ft-lb)	
5	Torque for cylinder support attaching bolts (all supports)		29 ~ 32 kg-m (210 ~ 231 ft-lb)	
6	Torque for lock plate attaching bolts (all lock plates)		3.5 ± 0.3 kg-m (25.3 ± 2.2 ft-lb)	

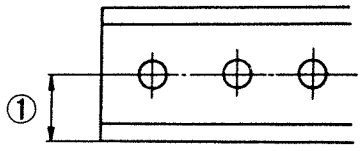


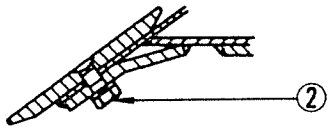


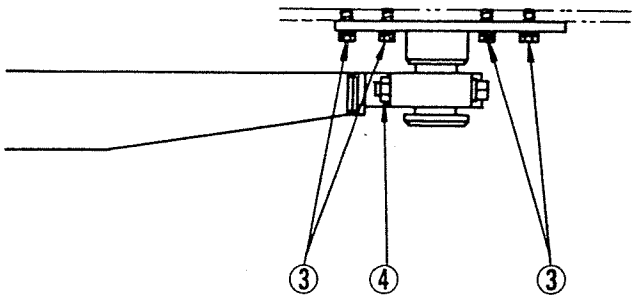
BLADE (BD2E)

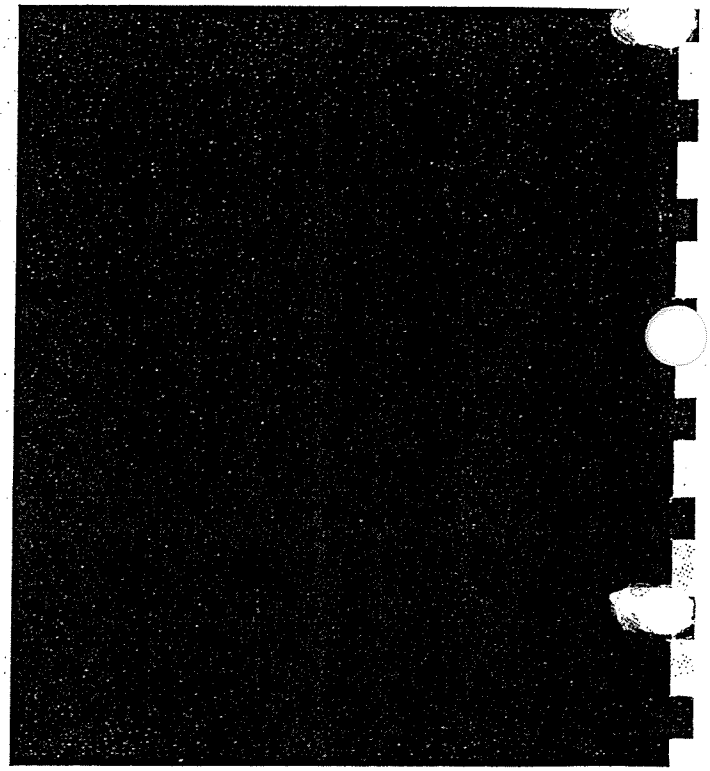
Unit: mm (in.)

Ref. No.	Point of measurement	Standard clearance (Assembly standard)	Service limit
1	Dimension of cutting edge and end bits (from center to edge)	75 (2.95)	45 (1.77)
2	Torque for plow bolts holding cutting edge (all plow bolts)	6.5 ± 0.7 kg-m (47 ± 5.1 ft-lb)	
3	Torque for trunnion attaching bolts (all trunnions)	6.5 ± 0.7 kg-m (47 ± 5.5 ft-lb)	
4	Torque for trunnion cap attaching bolts (all trunnion caps)	15.8 ± 1.6 kg-m (114.3 ± 11.6 ft-lb)	









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FOREWORD

The Mitsubishi 4DQ50C Diesel Engine – the fruit of many years of experience in the manufacture of power packs and other engineering products – is built with the up-to-date engineering techniques and modern metallurgy. Offering easier handling, greater durability and higher productivity, the 4DQ50C will earn you more profit.

This SERVICE MANUAL is written to give essential information regarding the procedures for cleaning, inspecting, repairing and adjusting engine components. Strict adherence to the instructions given in this manual will result in maximum production and economy built in your Mitsubishi engine. It is requested that the operator's manual and parts list separately issued for this engine be cross-referred to so as to get a thorough understanding of the material complied herein.

For information on any service other than those described in this manual, contact the nearest Mitsubishi Service Station in your territory.

TABLE OF CONTENTS

PREPARATORY STEPS

Components or parts affected and what to do / Service point	Universal joint	Hydraulic pump	Hydraulic control valve	Transmission	Transmission control	Steering clutch brakes	Bevel gear	Steering clutches	Steering clutch and brake controls	Final drive pinion	Final drive group	Track	Front idlers	Recoil springs	Track carrier rollers	Track roller frame	Track rollers
Platform, removal	●			●	●			●	●								
Seat cushion, removal				●	●	●	●	●	●	●							
Seat cover, removal				●	●	●	●	●	●	●							
Seat bracket, removal				●	●	●		●									
Steering clutch and brake pedals, removal				●				●									
Steering clutch and brake control rods, removal				●		●		●		●							
Hydraulic pump pipelines, removal		●	●														
Universal joint, removal				●													
Transmission case, draining				●													
Hydraulic tank, draining		●	●														
Final drive gear case, draining										●	●						
Steering clutch case covers, removal						●	●	●		●							
Steering clutch brakes, removal								●		●							
Track, separation										●	●						
Track roller guards, removal													●	●		●	●
Track, loosening												●	●	●	●	●	●
Track, removal												●	●	●		●	
Disconnecting from rigid bar																●	

ENGINE DISMOUNTING AND MOUNTING

Preparatory steps for dismounting

(a) Raise bucket fully, and securely support it by installing lift arm support bracket to lift cylinder.

(b) Drain engine oil pan and cooling system completely.

(c) Dismount power direction clutch (page 4).

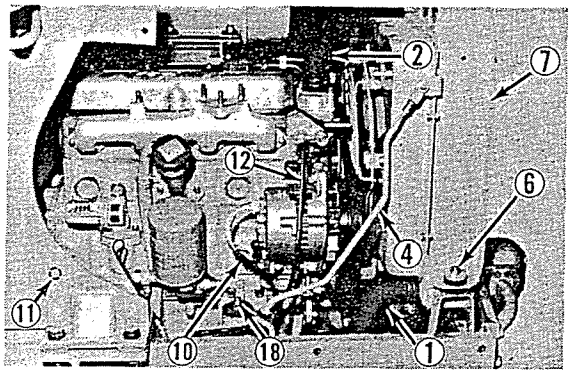
(d) Remove engine room.

⚠ WARNING

Insert a piece of hardwood between engine and front rigid bar on each side of oil pan to support engine.

Procedure

(1) Disconnect coolant rubber hoses (1) thru (3).

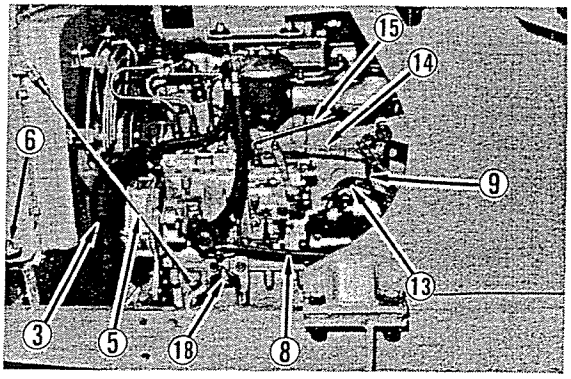


(2) Remove rods (4) (5) and bolt (6) (drilled for split pin) on each side, and dismount radiator (7).

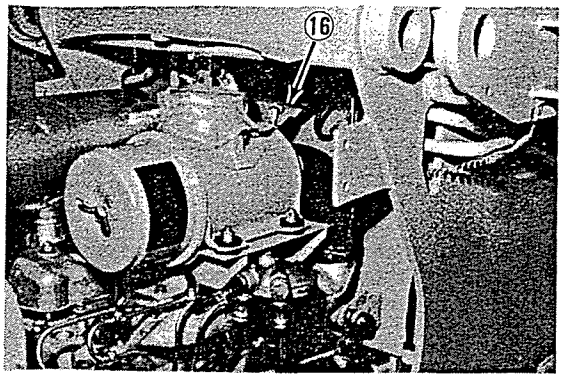
(3) Disconnect fuel pipe (8) and fuel return pipe (9).

(4) Disconnect wire (10) for alternator, wire (11) for oil pressure gauge unit, wire (12) for water temperature gauge unit and wire (13) for starter.

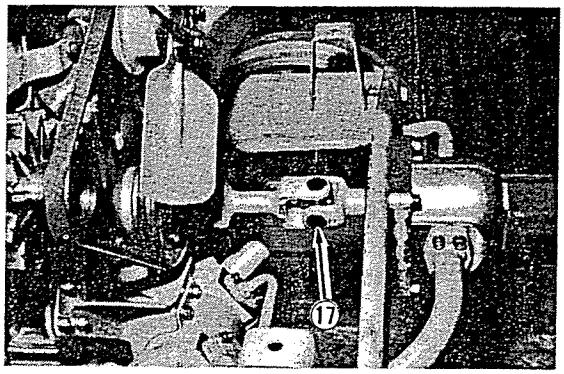
(5) Disconnect engine control rods (14) (15).



(6) Disconnect vinyl hose (16).



(7) Remove universal joint (17).



(8) Remove two bolts (18) at each engine mount, and dismount engine.

(9) To mount engine, follow reverse of dismounting procedure.

Important

(1) Place standard 2-mm (0.079-in.) shim on engine and power direction clutch mount brackets.

(2) Upon mounting engine and power direction clutch, make sure no gap is noted between shim A (1) and bracket. If any gap is noted there, add shims.

(3) Check to make sure these two universal joints – one for hydraulic pump and the other located between power direction clutch and transmission – are mounted nearly horizontally.

(4) Clearance "X" should be 1.2 to 2.2 mm (0.047 to 0.087 in.) when nut of bolt (2) is tightened. If the clearance is out of this range, add shims B (3).

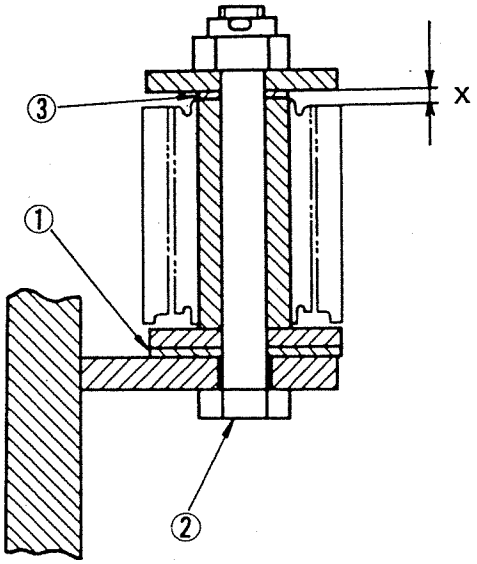
(5) Tighten nut to 15.9 ± 1.6 kg-m (115 ± 12 ft-lb).

(6) Make sure engine and power direction clutch are mounted nearly horizontally.

REFERENCE

Shim A (58611-02500): 1 mm (0.039 in.) and 0.5 mm (0.020 in.)

Shim B (64361-17516): 0.5 mm (0.020 in.)



POWER DIRECTION CLUTCH

Removal

Tool required

Tool name	Tool number	Qt.
Hook (A)	58609-04200	1

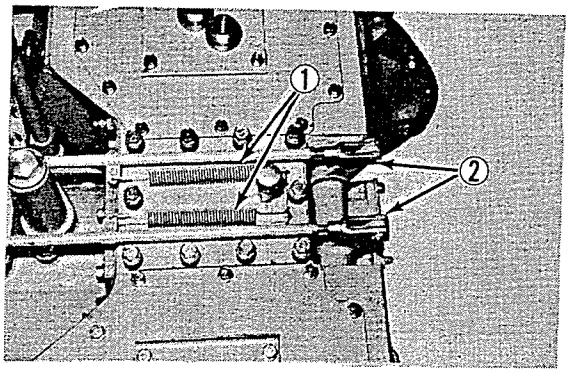
Preparatory steps

(a) Drain power direction clutch case of lube oil.

(b) Remove platform and side guards.

Procedure

(1) Remove return springs (1) and clevis pins (2) located under the operator's seat, and pull steering clutch levers all the way backward.



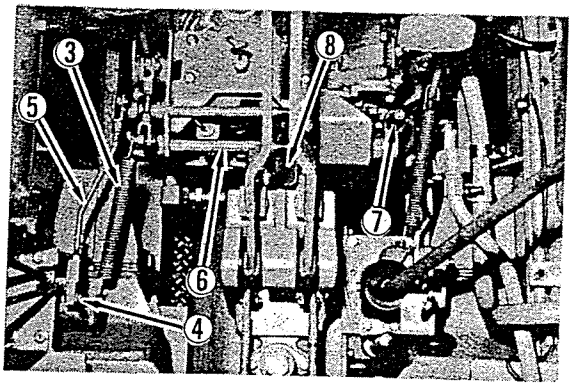
(2) Remove rear under guard.

(3) Remove return spring (3) and clevis pin (4), and disconnect rod (5) from each steering clutch lever.

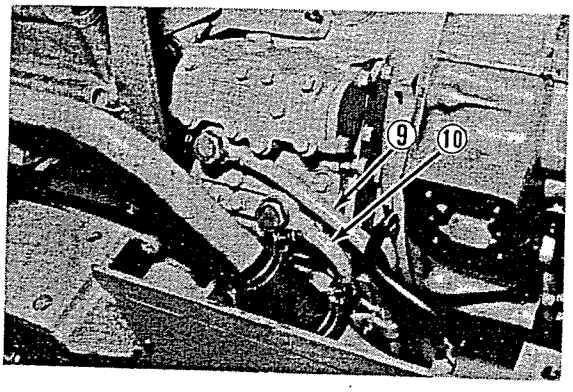
(4) Disconnect directional control valve spool from link.

(5) Remove clutch pedal assembly (6) and brake rod assembly (7).

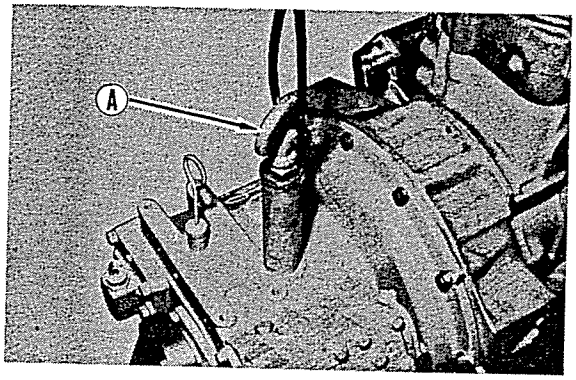
(6) Remove universal joint (8) (page 26).



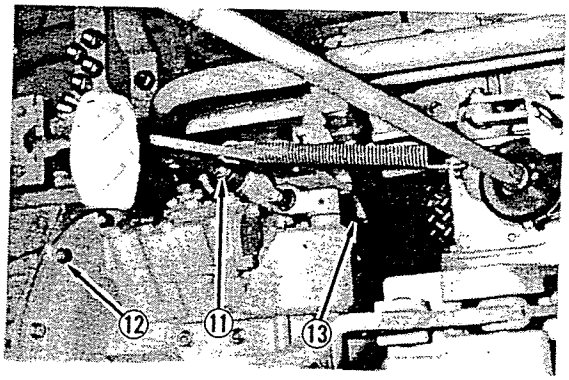
(7) Disconnect oil cooler pipes (9) (10) from control valve side of power direction clutch.



(8) Remove breather plug from power direction clutch case, and attach hook (A).

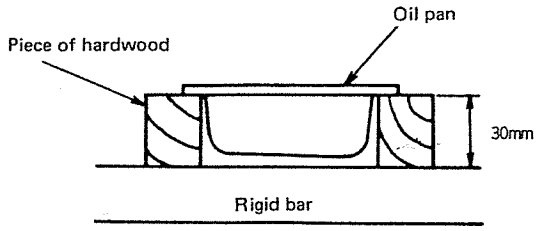


(9) Loosen off bolts (11) securing power direction clutch to frame, and lift off the clutch.



⚠ WARNING

Insert a piece of 30 by 30 mm (1-1/4 by 1-1/4 in.) hardwood between engine and front rigid bar on each side of oil pan to support engine.



(10) Loosen off ten bolts (12) securing power direction clutch to engine.

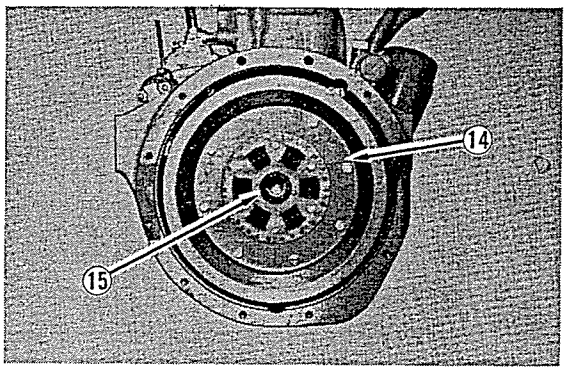
(11) Remove brake pedal bracket (13).

(12) Lift off power direction clutch.

(13) Remove clutch disc assembly (14).

NOTE

Check bushing (15) fitted to flywheel for abnormal wear, and replace it if necessary.



Installation

Tools required

Tool name	Tool number	Qt.
Clutch disc aligning tool	58609-21400	1
Hook	58609-04200	1

Procedure

(1) Using a clutch disc aligning tool, install clutch disc assembly.

(2) Lift power direction clutch by using a hook at breather plug pipe, and install it to engine and to frame.

(3) Remove the hook, and install breather plug.

(4) Connect oil cooler pipes to control valve side of power direction clutch.

(5) Install universal joint.

(6) Install brake rod assembly and clutch pedal assembly.

(7) Connect directional control valve spool to link.

(8) Connect clutch pedal link to control lever.

(9) Connect steering clutch lever rods to brake cam levers.

Disassembly and assembly

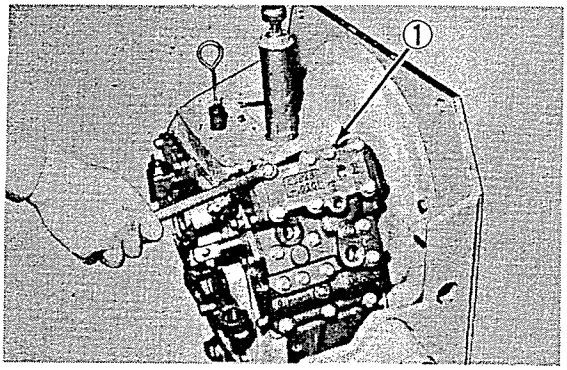
Tools required

Tool name	Tool number	Qt.
Clutch assembling tool	58609-00020	1
Seal stabilizing tool	58609-21300	1
Seal inserting tool	58609-21200	1

Preparatory steps for disassembly

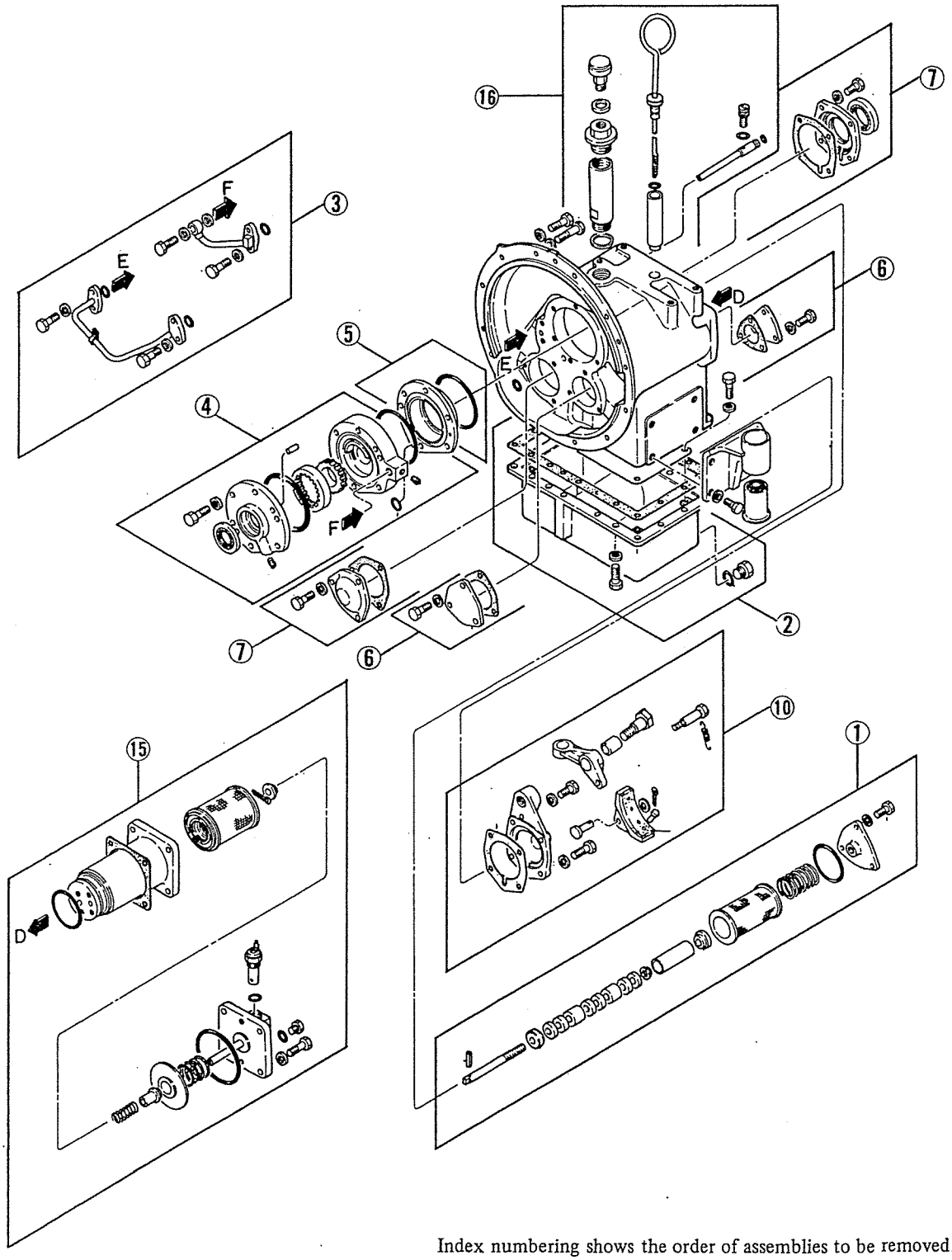
(a) Pull out oil level gauge.

(b) Remove control valve assembly (1).



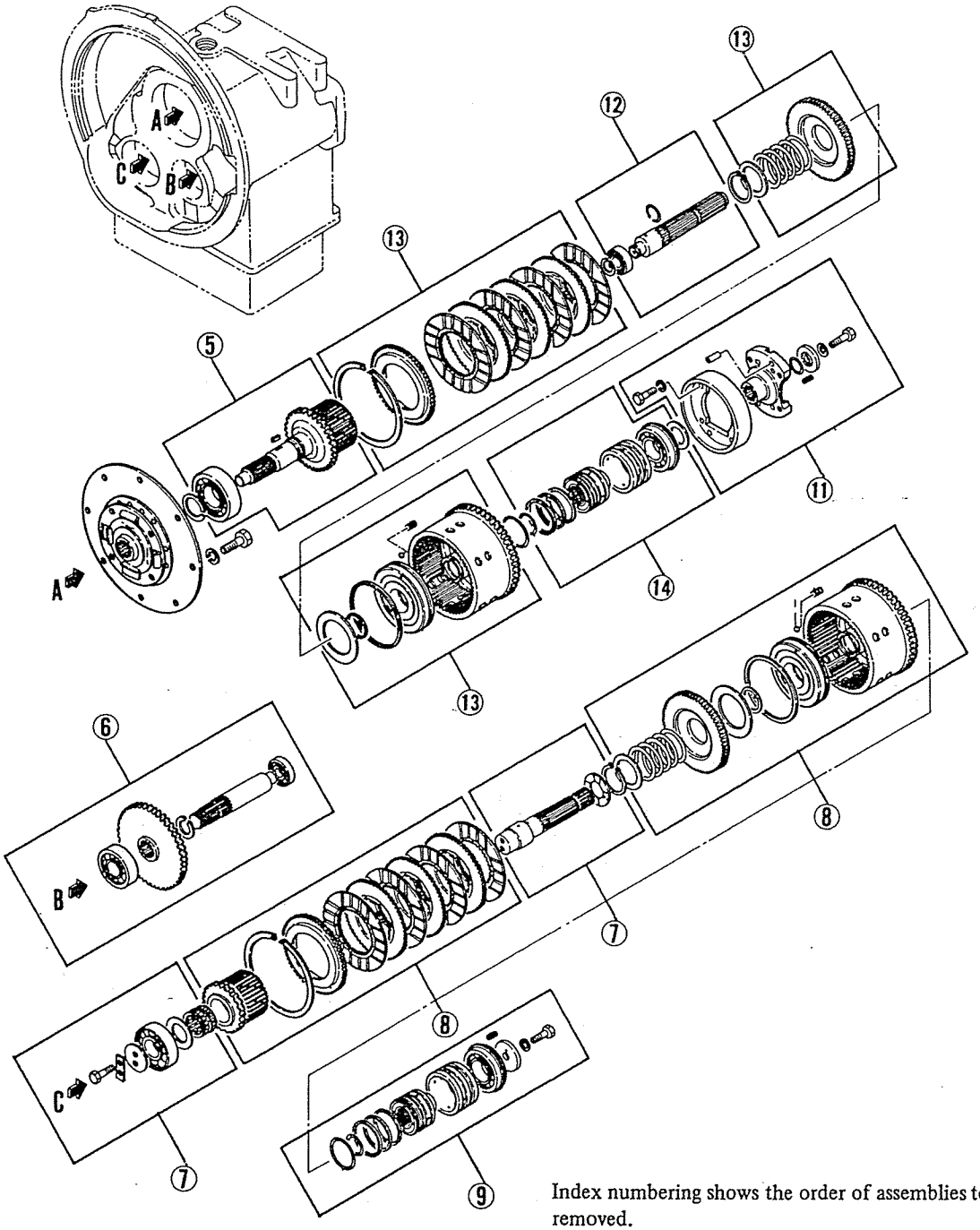
POWER DIRECTION CLUTCH

Procedure



Index numbering shows the order of assemblies to be removed.

Power direction clutch — disassembled view (1)



Index numbering shows the order of assemblies to be removed.

Power direction clutch — disassembled view (2)

Sequential steps for disassembly and assembly

Remove major assemblies and related parts in the order listed below when disassembling power direction clutch and install them in the reverse order when assembling the clutch:

(1) Strainer assembly and magnet assembly
(2) Tank assembly
(3) Oil pipes
(4) Gear pump assembly
(5) Input shaft assembly
(6) Idler gear shaft assembly

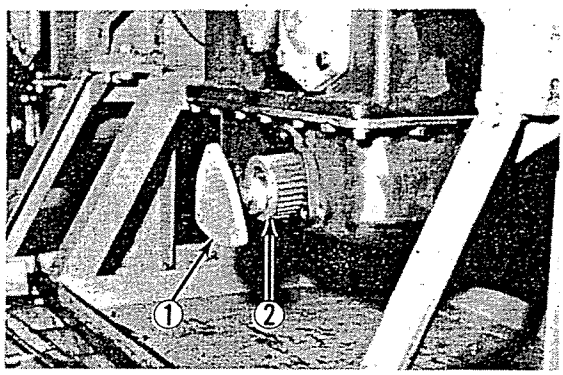
(7) Countershaft assembly
(8) Reverse clutch drum assembly
(9) Reverse clutch bearing retainer assembly
(10) Clutch brake assembly
(11) Clutch brake drum assembly
(12) Output shaft assembly
(13) Forward clutch drum assembly
(14) Forward clutch bearing retainer assembly
(15) Filter cover assembly
(16) Related parts

Strainer assembly and magnet assembly

Removal

(1) Loosen off three bolts.
(2) Take out strainer (2) complete with cover (1).

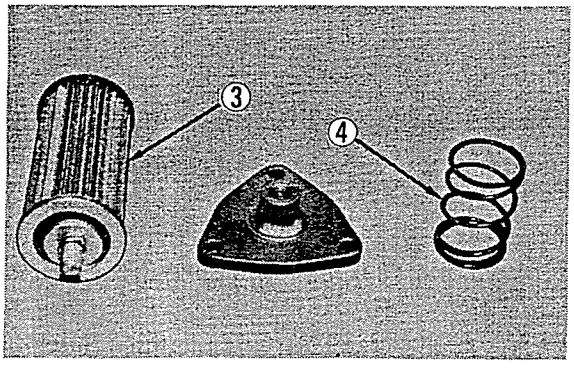
NOTE
Be careful not to damage "O" ring.



Disassembly

(1) Remove strainer element (3), spring (4) and "O" ring from cover by turning stud.

NOTE
Wash strainer in warm water and non-sudsing household detergent.



(2) Take out magnet assembly, and wash it by brushing in warm water and non-sudsing household detergent.

Assembly

Place spring (4) on cover, and attach magnet assembly.

Installation

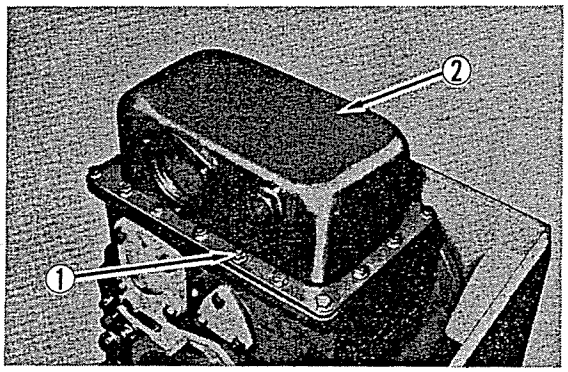
(1) Place "O" ring on tank.
(2) Apply a coat of grease to "O" ring.
(3) Install strainer to tank complete with cover, and secure it in place by tightening bolts.

NOTES
a) The effective range of spring (4) is about 3 mm (0.12 in.).
b) When inserting strainer, make sure it seats in tank properly.

Tank assembly

Removal

(1) Loosen off eighteen bolts (1) securing tank in place.
(2) Remove tank (2).



(3) Remove gasket.

NOTE
Discard gasket which has been in service.

Disassembly

To remove plate from tank, loosen off four plate attaching bolts.

Assembly

(1) To install plate to tank, secure it in place with bolts and spring washers.

NOTE
When installing plate to tank, make sure level gauge hole in plate is correctly positioned.

(2) Install seal and plug to tank.

Installation

Place tank on case together with gasket, and secure it with bolts and washers.

NOTE

Align oil holes in gasket and tank.

Oil pipes

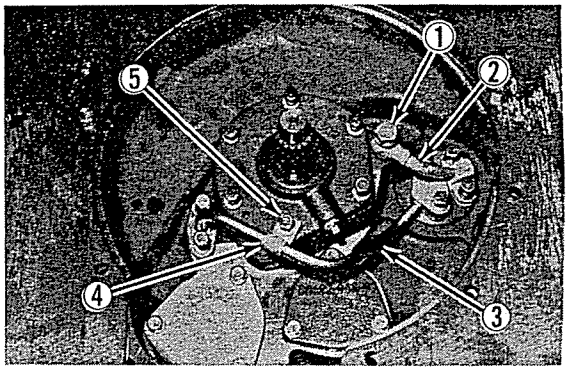
Removal

(1) Remove joint bolt (1), and disconnect oil pipe B (2) (shorter pipe).

NOTE

Be careful not to permit "O" ring to fall.

(2) Loosen off four bolts. Loosen off bolt (5) at clamp (4), and disconnect oil pipe A (3).



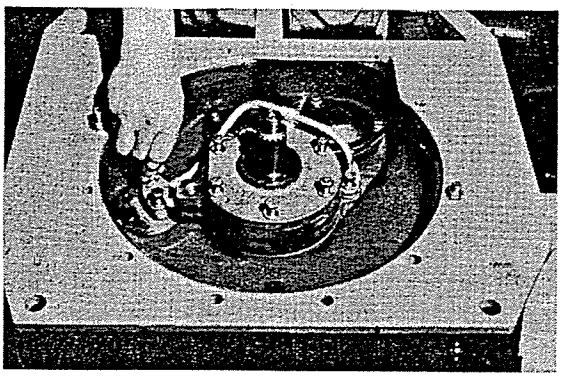
Installation

(1) Place "O" ring on oil pipe A, and apply a coat of grease to "O" ring.

(2) Connect oil pipe A by tightening bolts.

(3) Place "O" ring on oil pipe B, and apply a coat of grease to "O" ring.

(4) Connect oil pipe B.



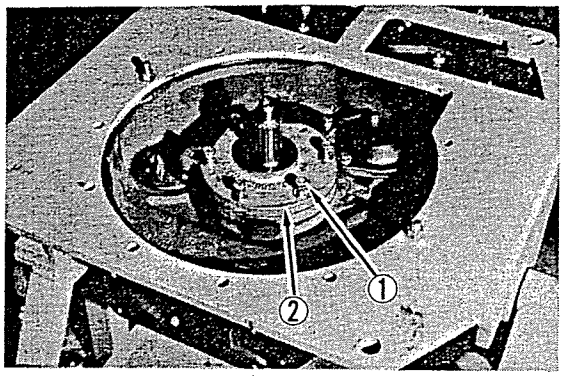
NOTE

When re-using copper packing, be sure to anneal it before installation.

Gear pump assembly

Removal

(1) Loosen off five bolts (1) securing pump cover (2) in place, and remove the cover.

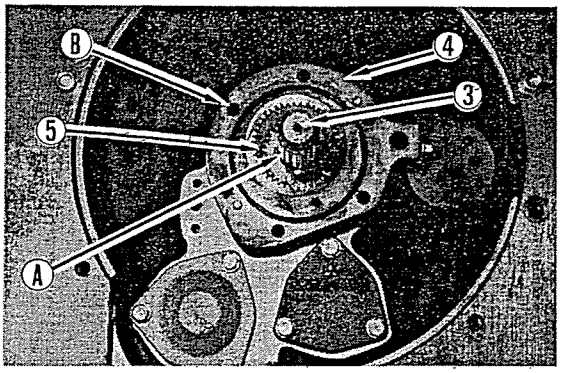


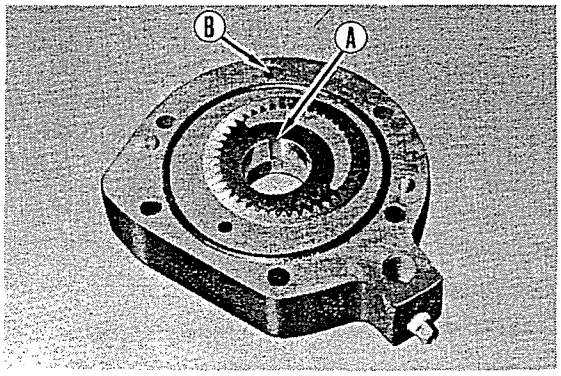
(2) Align key fitted to input shaft gear (3) with keyway in pump body (4), and carefully remove pump body assembly.

NOTES

a) Before removing pump body, bring keyway (A) in pinion over to bolt hole (B) as shown.

b) Be careful not to permit "O" ring to fall.



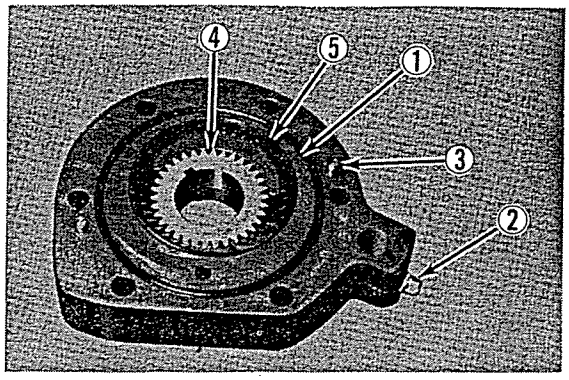


Disassembly

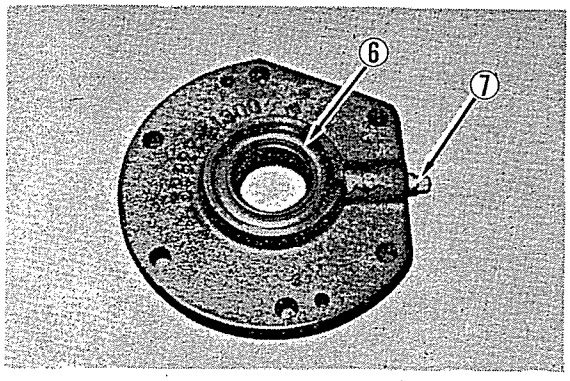
(1) Remove "O" ring (1) from pump body.

(2) Remove taper plug (2), and, if necessary, remove dowel pin (3).

(3) Remove pinion (4) and internal gear (5).



(4) Remove oil seal (6) and taper plug (7) from cover.

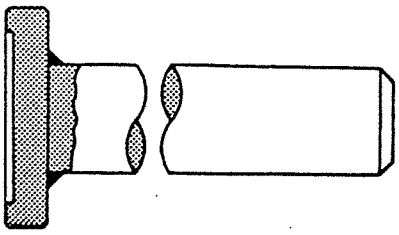


Assembly

(1) Apply a coat of grease to pump cover, and insert oil seal.

NOTE

Use an oil seal inserting tool (58609-04300) of the type shown to install oil seal. Install oil seal, taking care not to twist or fold it.



Oil seal inserting tool (58609-04300)

(2) Install snap ring and taper plug.

(3) Install dowel pin and taper plug to pump body.

NOTES

a) When installing pinion, make sure its chamfered-addendum side faces downward.

b) Hand rotate pump shaft, making sure pump rotates smoothly without any sign of binding.

(4) Place internal gear and pinion in pump body.

(5) Place "O" ring on pump body, and apply a coat of grease to "O" ring.

NOTE

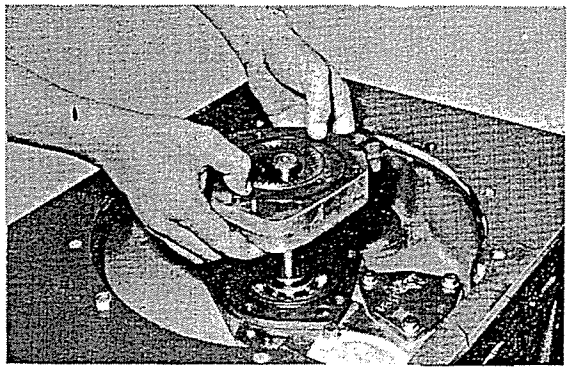
When screwing taper plug, wrap seal tape around its threaded portion.

(6) Place "O" ring on back of pump, and apply a coat of grease to "O" ring.

Installation

(1) Slide pump body onto input shaft.

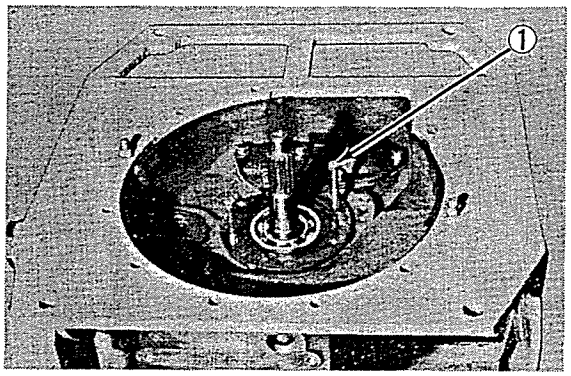
(2) Slide pump cover onto input shaft, and secure the cover in place with bolts.



Input shaft assembly

Removal

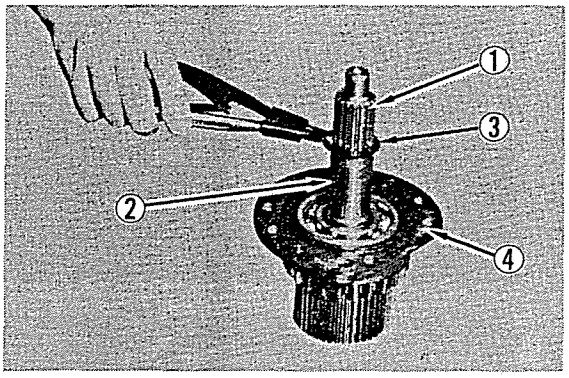
Using two bolts (1) (for securing gear pump), withdraw input shaft assembly.



Disassembly

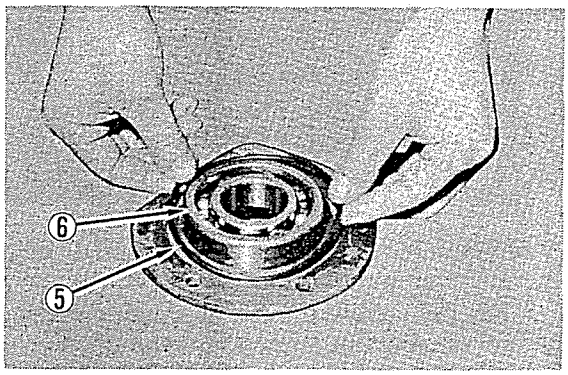
(1) Remove key (2) from input shaft (1).

(2) Remove snap ring (3), using a snap ring pliers, and remove bearing cage (4) from input shaft.



(3) Remove "O" ring (5) from bearing cage.

(4) Pull bearing (6) from bearing cage.



Assembly

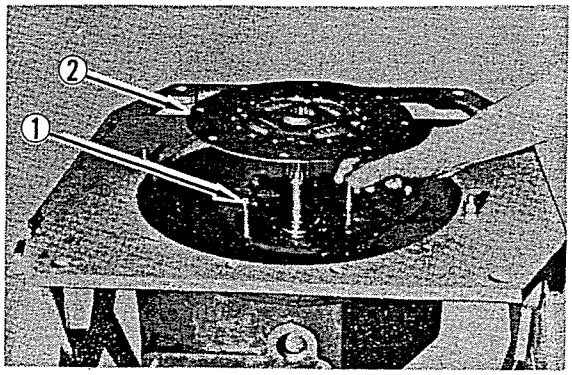
(1) Press bearing into bearing cage, and place "O" ring.

(2) Press bearing onto input shaft.

(3) Install key to input shaft.

Installation

Place input shaft assembly in drum, and position it by using gear pump attaching bolts (1) as guides.



NOTE

Place input shaft proper in drum, and align the teeth of clutch facings and clutch plates by means of clutch disc (2).

Idler gear shaft assembly

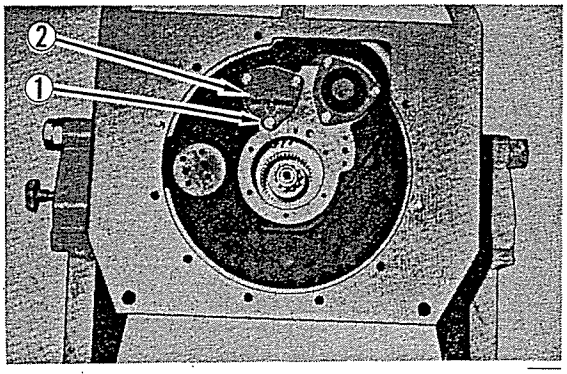
Removal

(1) Loosen off three bolts (1), and remove cover (2).

(2) Remove cover by loosening off three bolts.

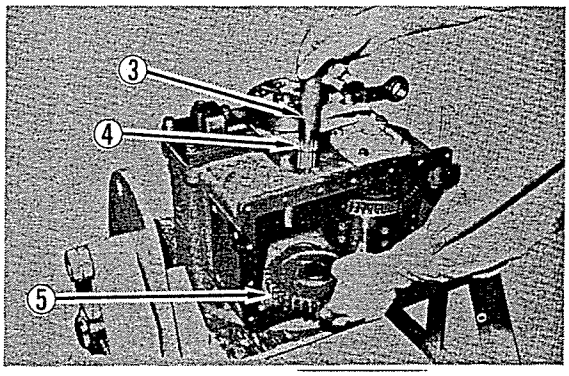
NOTE

When removing cover, take care not to damage gasket.



(3) Remove idler gear shaft (3) complete with snap ring (4) and bearing by giving blows of a mallet to the shaft.

(4) Pull out idler gear shaft, and remove idler gear (5). Pull bearing from the front side of case.



Disassembly

(1) Pull bearing from idler gear shaft.

NOTE

Use a bearing puller to remove bearing.

(2) Using a snap ring pliers, remove snap ring from idler gear shaft.

Assembly

Using a snap ring pliers, fit snap ring to idler gear shaft.

Installation

(1) Place idler gear in case, and install idler gear shaft in place.

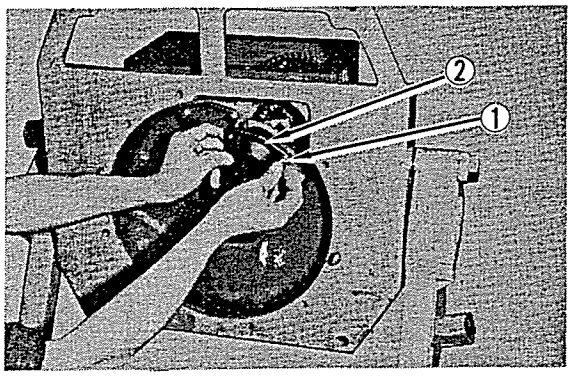
(2) Press bearing into case.

(3) Place spacer, and install cover.

Countershaft assembly

Removal

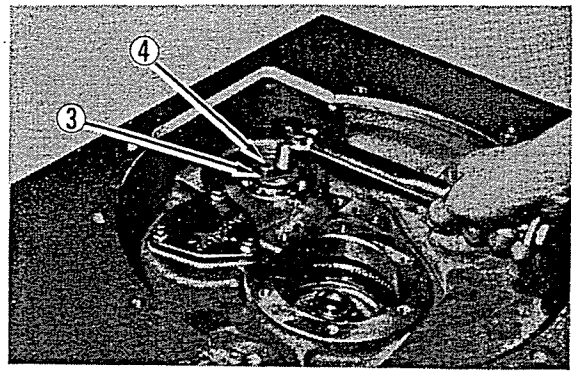
(1) Loosen off three bolts (1), and remove cover (2).



(2) Straighten lock washer (3), and loosen off bolts (4).

NOTE

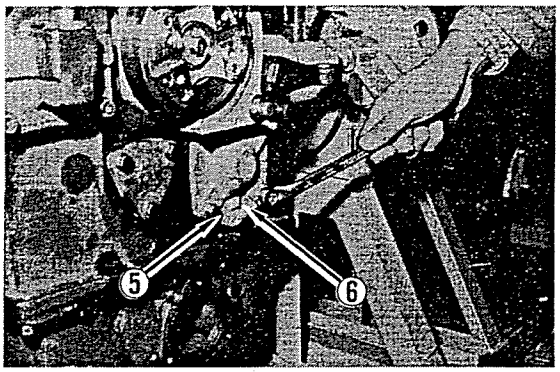
When loosening bolts (4), hold drum to prevent countershaft from rotating, as shown.

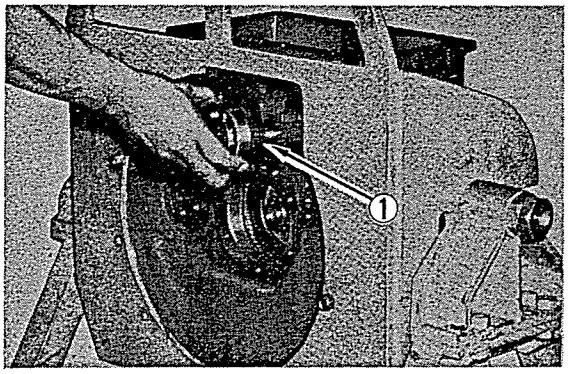


(3) Loosen off four bolts (5), and remove cover (6) on the reverse output side.

(4) Loosen off bolt by straightening its lock washer.

(5) Remove countershaft (1).





Disassembly

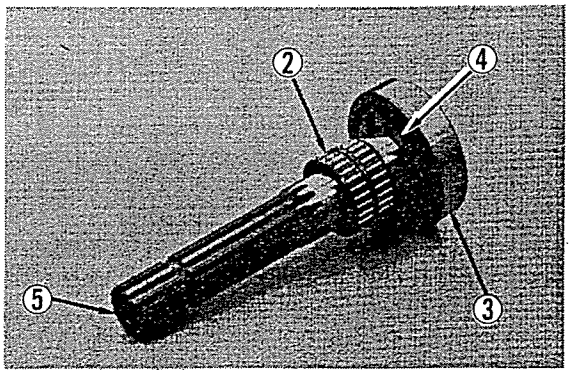
(1) Remove needle roller bearing (2).

(2) Using a bearing puller, pull ball bearing (3) from countershaft, together with thrust washer (4).

(3) Remove spring pin (5).

NOTE

Do not remove spring pin unless it need be replaced by a new one.



Assembly

Drive spring pin in countershaft.

Installation

(1) Install countershaft assembly to reverse drum.

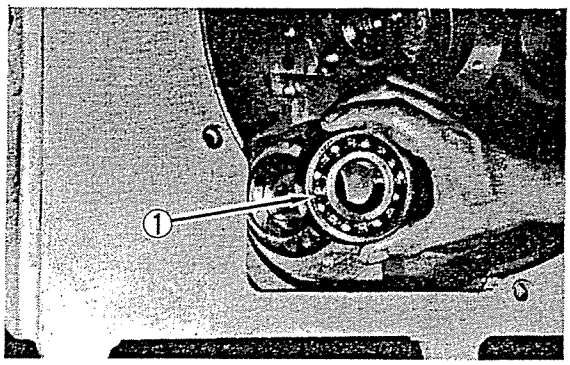
(2) Press needle roller bearing between countershaft and reverse pinion.

(3) Place thrust washer on countershaft.

(4) Install washer and lock washer to the output side of countershaft, and properly bend lock washer.

(5) Install output-side cover.

(6) Press input-side ball bearing (1) in place.



(7) Install washer and lock washer to the input side of countershaft, and properly bend lock washer.

(8) Install input-side cover.

NOTE

Check to make sure reverse pinion rotates smoothly.

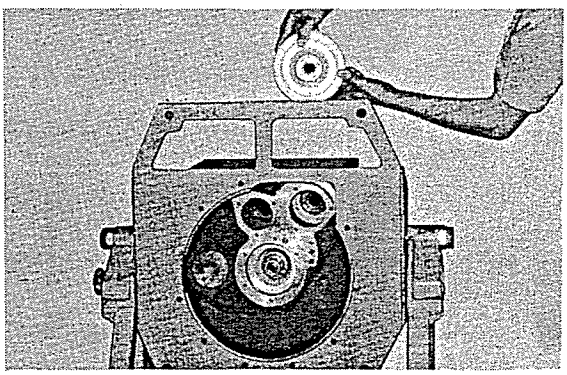
Reverse clutch drum assembly

Removal

Remove reverse clutch drum assembly from clutch case.

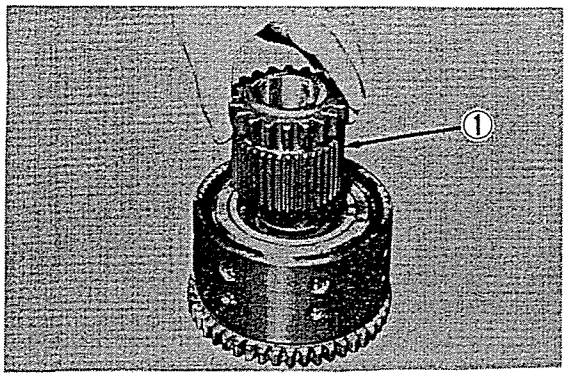
NOTE

When removing reverse clutch drum, take care not to permit two "O" rings to fall.

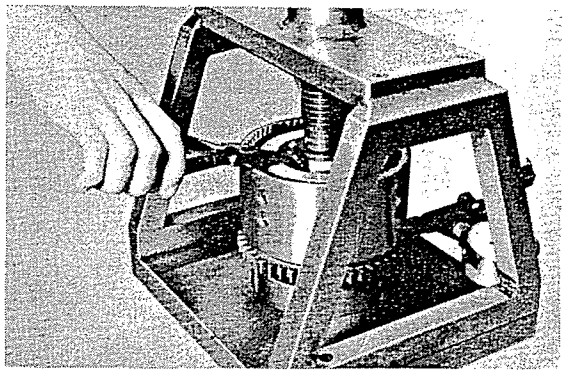


Disassembly

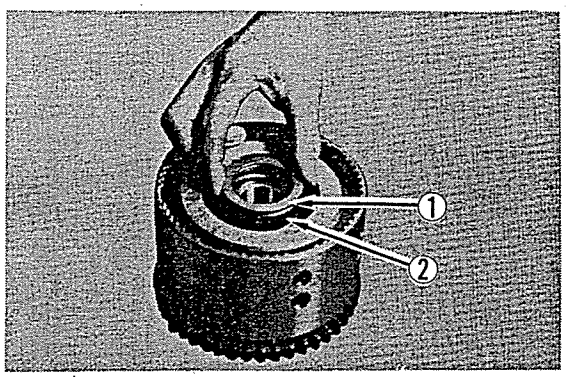
(1) Remove reverse pinion (1).



(2) Set up reverse clutch drum assembly in a clutch assembling tool (58609-00020) as shown, and remove snap ring, using a snap ring pliers.

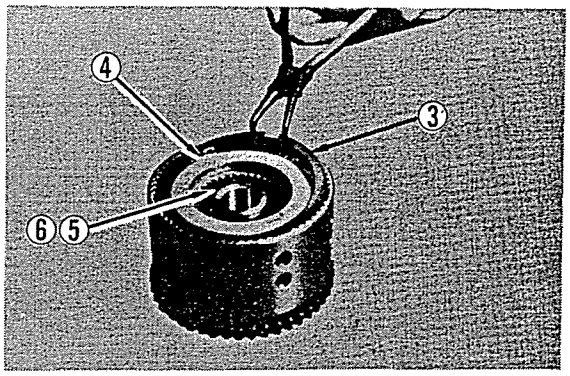


(3) Remove spring retainer (1) and clutch spring (2).

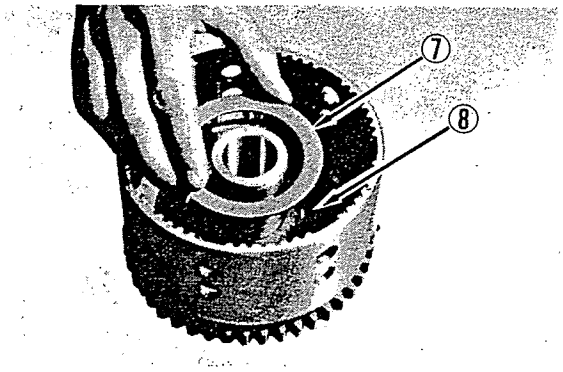


(4) Using a snap ring pliers, remove snap ring (3).

(5) Remove pressure plate (4), six clutch facings (5), five clutch plates (6) and pressure plate.



(6) Remove belleville (initially coned) spring (7) and clutch piston assembly (8).



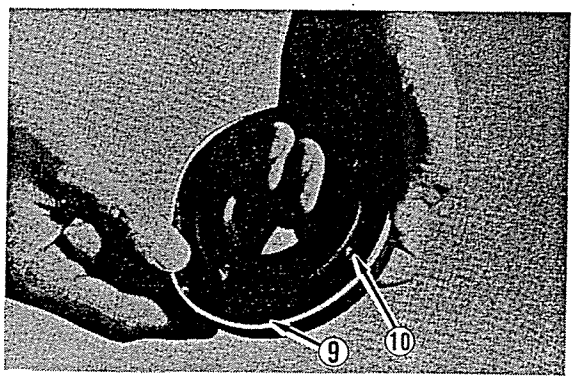
(7) Using a ring pliers, remove piston ring from reverse clutch drum.

(8) Remove piston ring (teflon seal) (9).

NOTE

When removing piston ring (teflon seal), take care not to damage it.

(9) Loosen off set screw (10), and remove steel ball.



NOTES

a) Clean steel ball hole.

b) Check piston ring for condition, and replace it by a new one if necessary.

c) In some power direction clutches, no set screw is used.

Assembly

(1) Install piston ring to clutch piston.

NOTE

When installing piston ring to clutch piston, use a seal inserting tool (58609-21200). Take care not to damage the ring when installing it. Upon installing the ring to the piston, apply a coat of grease to the ring, and keep the piston in a seal stabilizing tool (58609-21300) longer than 30 minutes to let the ring restore itself to the state as it should be in.

(2) Put steel ball in clutch piston, and secure it by tightening set screw.

NOTES

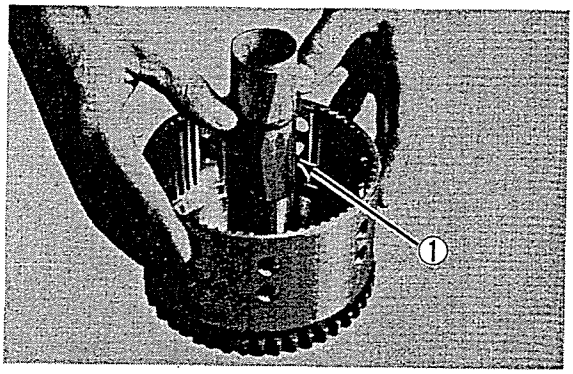
a) After putting steel ball, lap the ball against sealing surface so that the ball makes a good sealing contact.

b) In case no set screw is used, calk steel ball thoroughly.

(3) Install piston ring to drum.

NOTE

Piston ring is brittle: be sure to use a guide (1) when installing the ring.



(4) Apply a coat of grease to the internal surface of clutch drum, and place piston in the drum.

(5) Place belleville spring in clutch drum with its convex side facing the clutch piston side.

(6) Place pressure plate, clutch facings and clutch plates in clutch drum.

(7) Using a snap ring pliers, fit snap ring to clutch drum.

NOTE

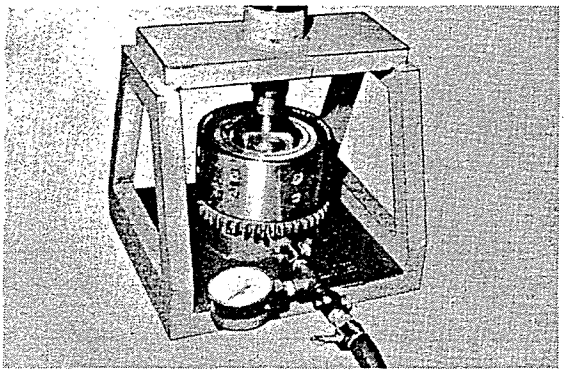
Assembling work should be performed with the gear side of clutch drum facing downward to prevent belleville spring from coming off.

(8) Place clutch spring and spring retainer in clutch drum.

(9) Set up clutch drum in a clutch assembling tool (58609-00020), and install snap ring, using a snap ring pliers.

NOTE

Apply an air pressure of about 6 kg/cm^2 (85 psi) to clutch drum, and check for piston movement and air-tightness.



(10) Place thrust washer in clutch drum assembly.

NOTE

Place thrust washer with its grooved side facing the input side of clutch drum.

(11) Place pinion in clutch drum assembly while rotating it.

Installation

Place clutch drum assembly in clutch case, and install countershaft.

NOTE

Do not take forward clutch drum for reverse clutch one when assembling power direction clutch. The number of gear teeth varies between the two as shown below:

Reverse clutch drum	.....	47 teeth
Forward clutch drum	.....	46 teeth

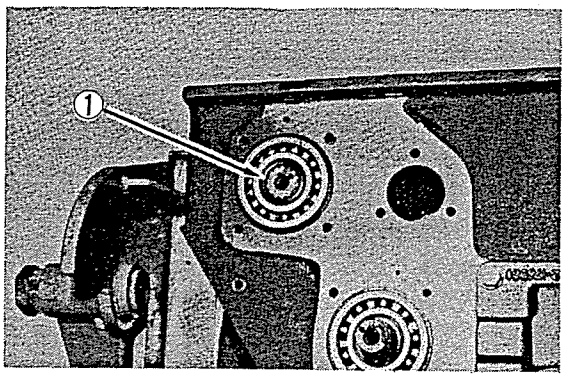
Reverse clutch bearing retainer assembly

Removal

Remove bearing retainer assembly (1) from clutch case.

NOTE

When removing the retainer assembly, take care not to permit "O" rings to fall.

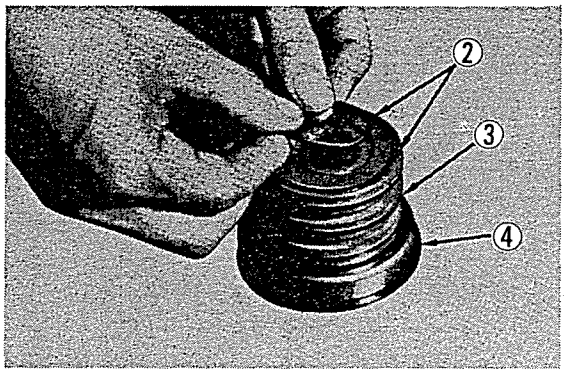


Disassembly

(1) Remove two "O" rings (2) from bearing retainer.

(2) Using a bearing puller, pull bearing (4) from bearing retainer.

(3) Remove three piston rings (3) from bearing retainer.



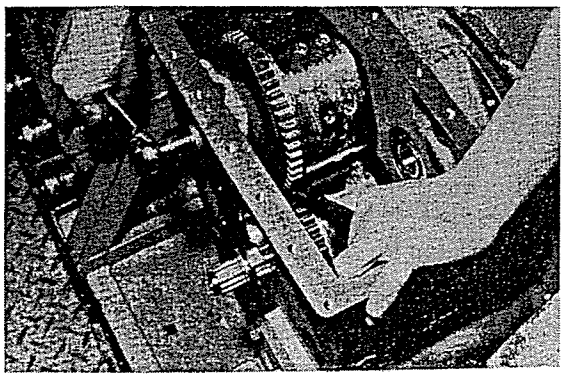
Assembly

(1) Install piston rings to bearing retainer.

(2) Using a bearing installer, press bearing into bearing retainer, and place "O" rings.

Installation

Place bearing retainer assembly in clutch case, and secure it with bolts and lock washers.



NOTES

a) It is advisable to install bearing retainer after installing countershaft.

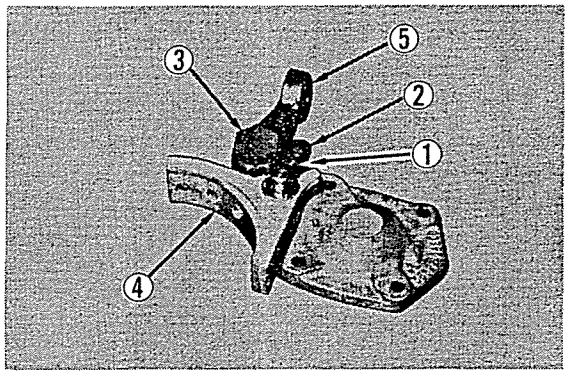
b) When assembling bearing retainer assembly and drum assembly, take care not to permit "O" rings to fall.

Clutch brake assembly

Removal

(1) Remove return spring (1), and take off brake lever stopper (2).

(2) Pull out brake lever shaft (3), and remove brake shoe (4) and brake lever (5).

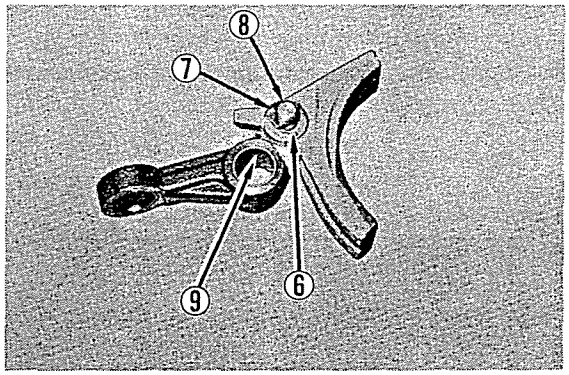


(3) Remove split pin (6), and take off washer (7) and brake shoe pin (8).

(4) Remove bushing (9) from brake lever.

NOTE

Check shoe bushing for wear, and replace it by a new one if necessary.



Installation

(1) Press bushing into brake lever.

(2) Install brake shoe and brake lever to clutch brake with brake shoe pin.

(3) Install brake lever assembly to cover, and secure brake lever shaft.

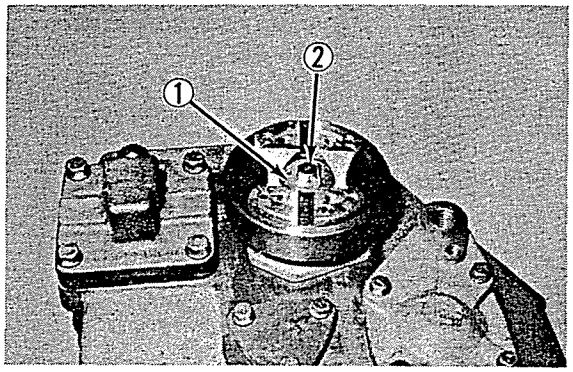
NOTE

Check brake lever for smooth movement.

Clutch brake drum assembly

Removal

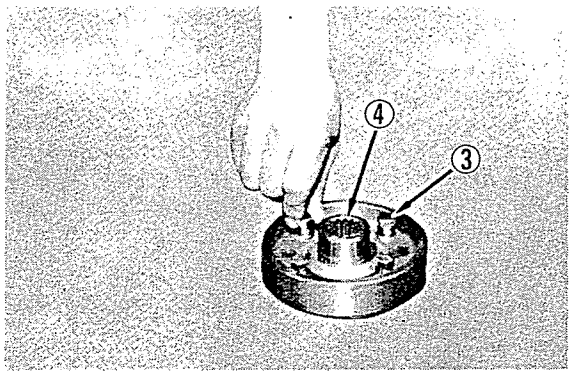
(1) Straighten lock washer (1), and loosen off bolt (2). Then, remove washer and "O" ring.



(2) Remove brake drum assembly from output shaft.

NOTE

Remove drum from coupling (4) where drum is worn and has to be replaced.



Installation

(1) Slide drum assembly onto output shaft, and put "O" ring.

(2) Place washers, tighten bolts good and hard to secure drum assembly, and bend lock washer.

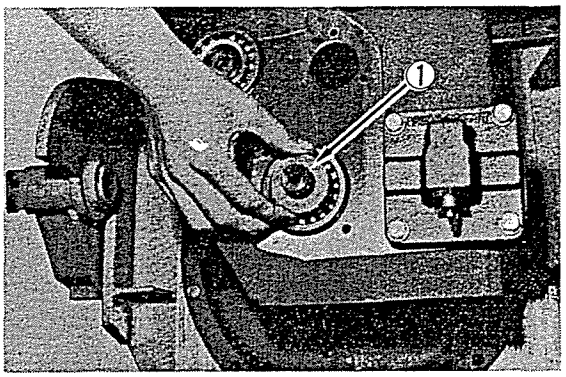
NOTE

When installing coupling, take care not to damage oil seal lip.

Output shaft assembly

Removal

(1) Loosen off four bolts securing cover in place, and remove cover and washer (1).



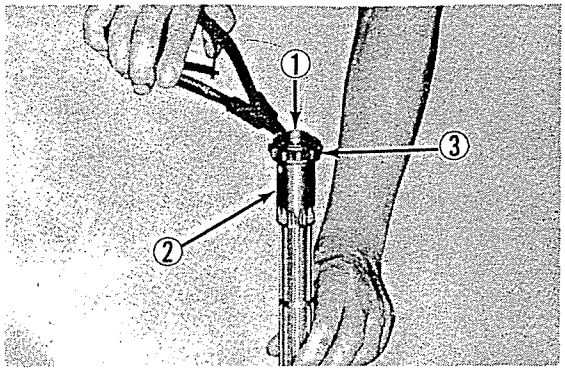
(2) Withdraw output shaft toward the input side of the clutch while holding drum.

Disassembly

(1) Remove oil seal from cover assembly.

(2) Using a snap ring pliers, remove snap ring (1) from output shaft (2).

(3) Pull bearing (3) from output shaft.



(4) Remove spring pin at the end of output shaft.

NOTE

Do not remove spring pin unless needed to be replaced by a new one.

Assembly

(1) Place oil seal in cover.

(2) Drive spring pin into output shaft.

(3) Using a bearing installer, press bearing onto output shaft.

(4) Place snap ring on output shaft.

(5) Using a snap ring pliers, install snap ring to output shaft.

Forward clutch drum assembly

This assembly may be removed, disassembled, assembled and installed by using the same procedure as for reverse clutch drum assembly.

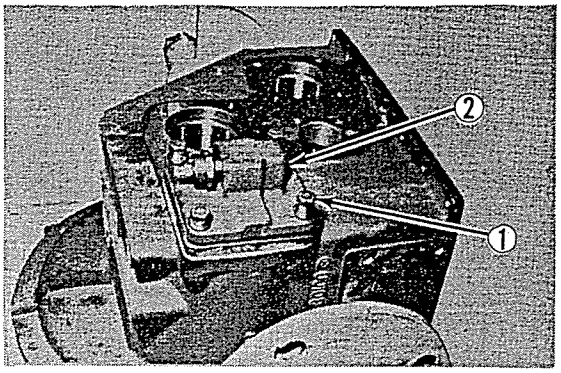
Forward clutch bearing retainer assembly

This assembly may be removed, disassembled, assembled and installed by using the same procedure as for reverse clutch bearing retainer assembly.

Filter cover assembly

Removal

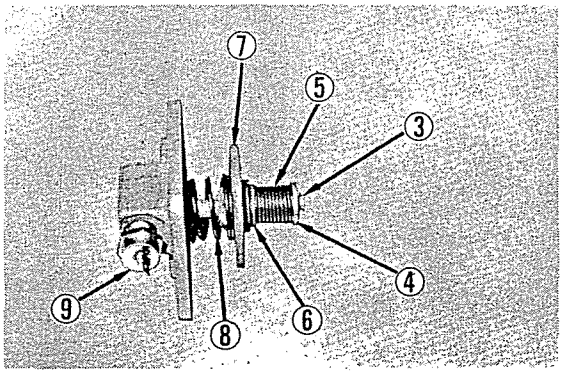
Loosen off four bolts (1), and remove filter cover assembly (2).



Disassembly

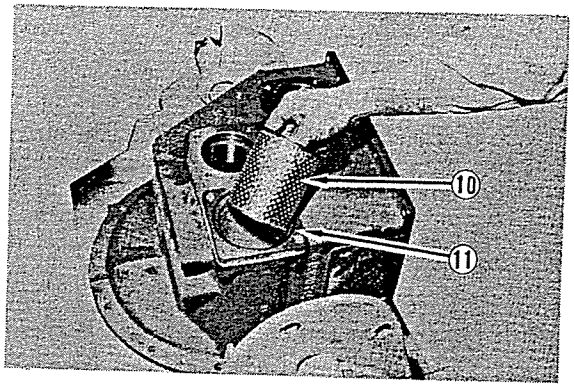
(1) Pull off split pin (3), and remove spring retainer (4), safety valve spring (5), safety valve (6), retainer (7) and spring (8).

(2) Remove oil bypass alarm switch (9) and "O" ring.



(3) Take out filter element (10).

(4) Remove filter body (11), and take two "O" rings out of the body.



Assembly

(1) Install "O" ring and oil bypass alarm switch to filter cover.

(2) Place spring on filter cover; then place retainer, safety valve, safety valve spring and spring retainer in that order, and secure them by installing split pin.

(3) Place "O" rings on filter body, and install the body to the clutch case.

(4) Place filter element in filter body.

(5) Install filter cover assembly in place.

NOTE

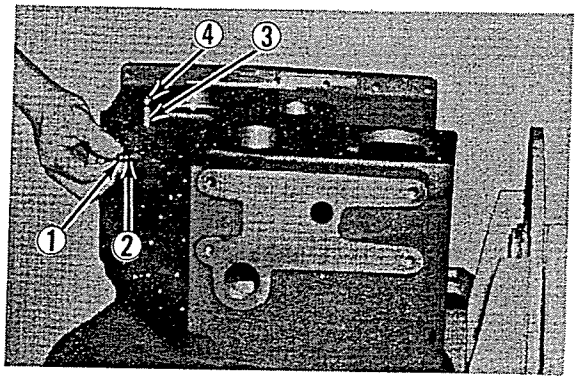
Install filter cover assembly with its marking "UP" facing upward.

Related parts

Lube oil pipe removal

(1) Remove connector (1) and "O" ring (2).

(2) Disconnect lube oil pipe (3), and remove "O" ring (4).



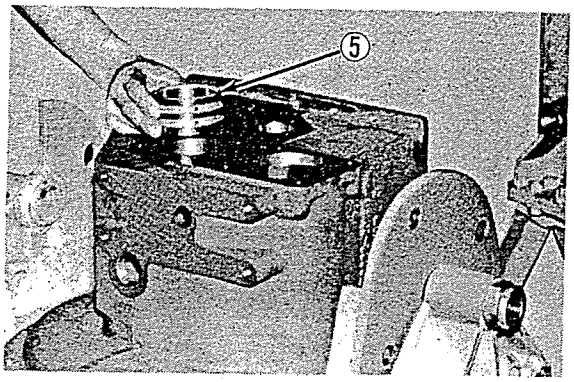
Lube oil pipe installation

(1) Place "O" ring on lube oil pipe, and connect the pipe to clutch case.

(2) Place "O" ring on connector, and connect the pipe to connector.

Piston ring race removal

Remove two piston ring races (5) from case.



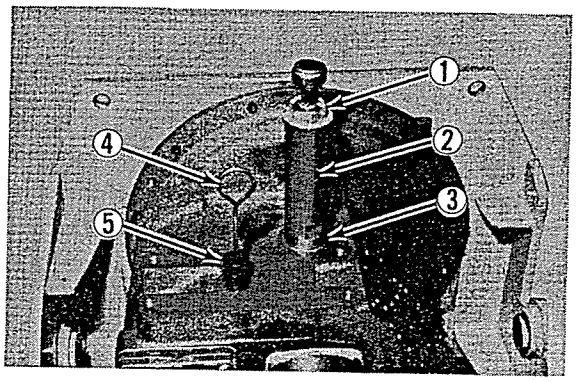
Piston ring race installation

Apply a coat of grease to the periphery of each piston ring race, and press the race into clutch case.

Plug base removal

(1) Remove breather plug (1), and take off plug base (2) and packing (3).

(2) Pull out level gauge (4), and remove pipe (5).



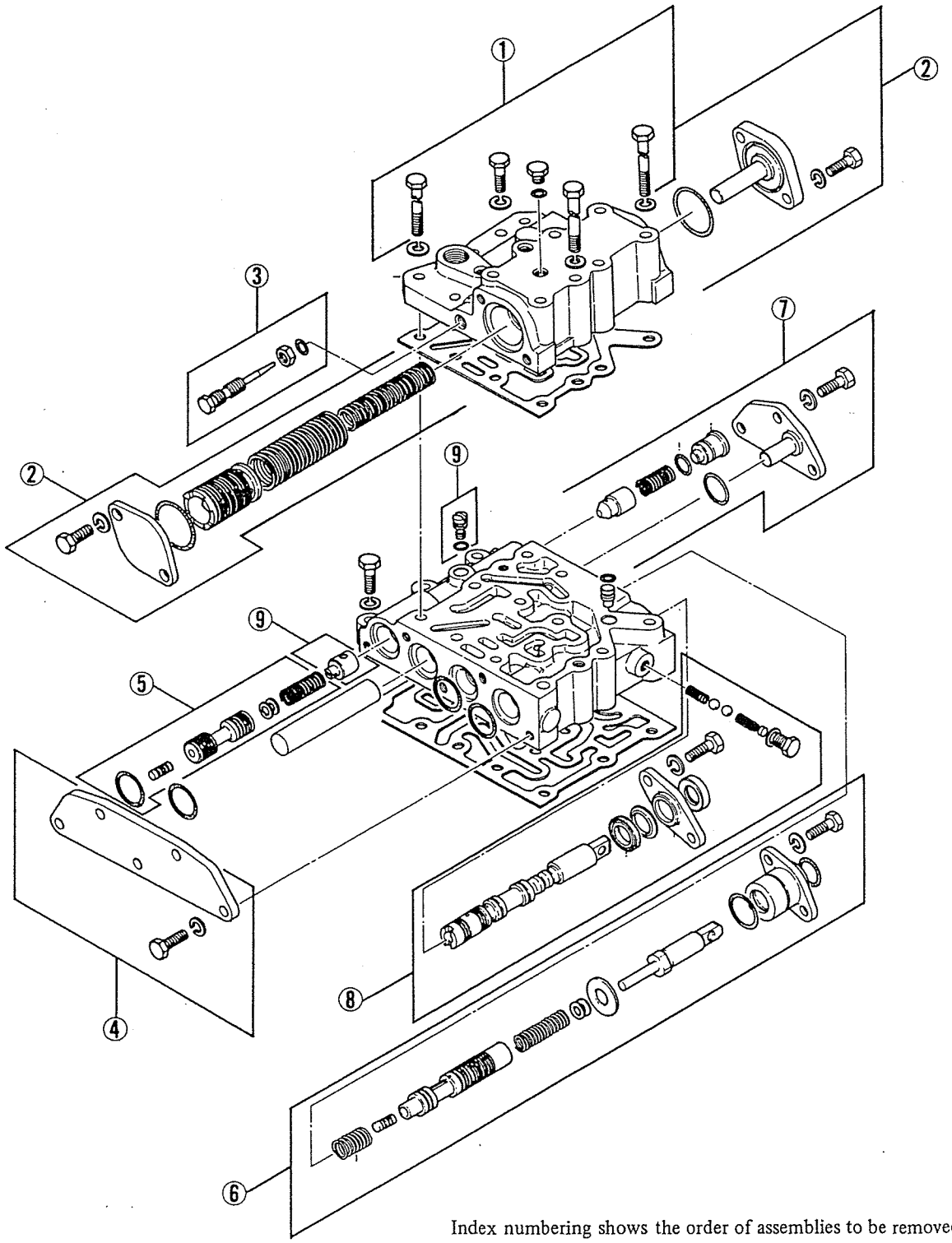
Plug base installation

(1) Place packing on plug base, and screw the base into clutch case.

(2) Temporarily screw breather plug into plug base.

(3) Apply a coat of lube oil to pipe, and press pipe into clutch case. Insert level gauge.

CONTROL VALVE



Index numbering shows the order of assemblies to be removed.

Control valve — disassembled view

Sequential steps for disassembly and assembly

Remove assemblies in the order listed below when disassembling control valve and install them in the reverse order when assembling the valve:

(1) Valve housing assembly
(2) Accumulator valve assembly
(3) Orifice assembly
(4) Cover assembly
(5) Main relief valve assembly
(6) Clutch valve assembly
(7) Lubricating relief valve assembly
(8) Directional control valve assembly
(9) Lubricating relief valve seat assembly

⚠ CAUTIONS

a) More than seventy per cent of all hydraulic system failures is caused by dirt. Dirt can ruin the close tolerances of finely finished surfaces; and a grain of sand in a small orifice can put a whole system out of operation. Assemble control valve in clean condition to keep dirt out of every part.

b) Valves and plungers are very important parts: take good care to avoid damaging them.

c) Bolts, nuts, screws and other fasteners used on control valve are all prescribed with respect to tightening torque. Be sure to use a torque wrench when tightening them and to tighten them to the prescribed torque.

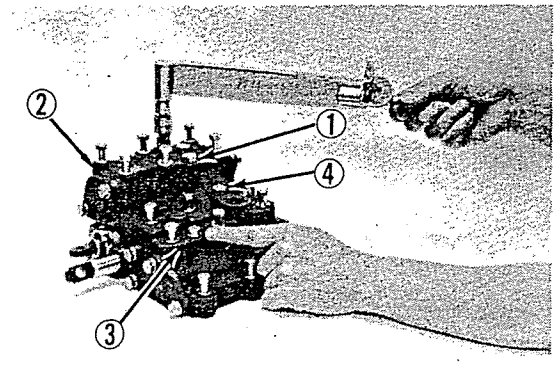
Valve housing assembly

Removal

Loosen off two bolts (1) securing upper housing (2), and remove the housing.

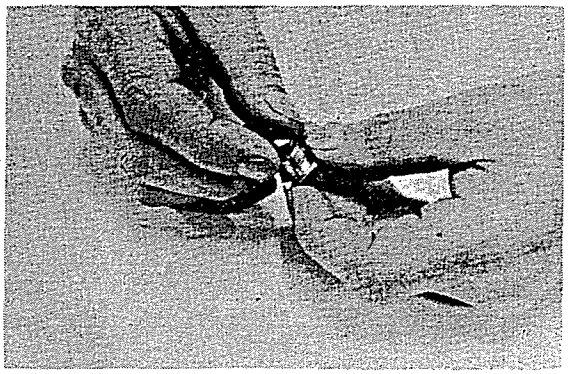
Disassembly

Remove gasket (3); then remove three "O" ring seal plugs (4) and "O" rings.



Installation

(1) Place "O" ring on each "O" ring seal plug.
(2) Install "O" ring seal plugs to valve housing.
(3) Place gasket on valve housing.
(4) Place housing, and tighten two bolts to the prescribed torque.



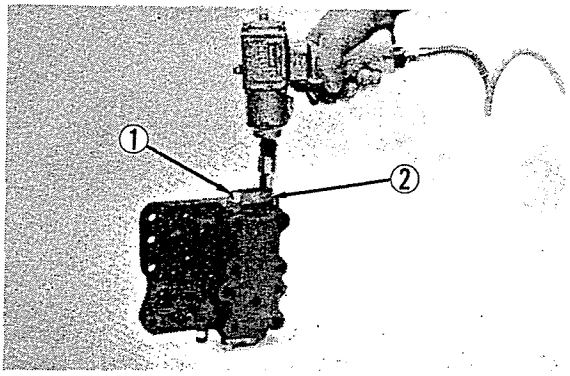
Accumulator valve assembly

Removal

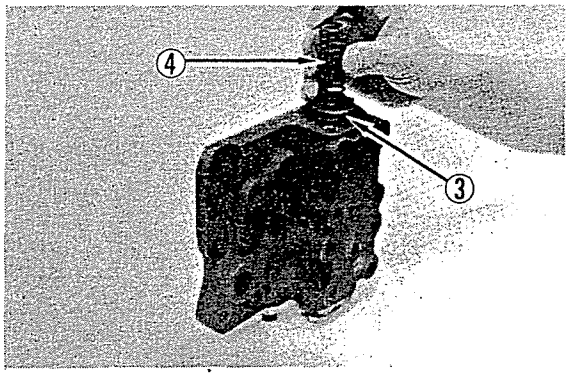
(1) Loosen two bolts (1) securing accumulator cover (A) (2), and remove the cover and "O" ring.

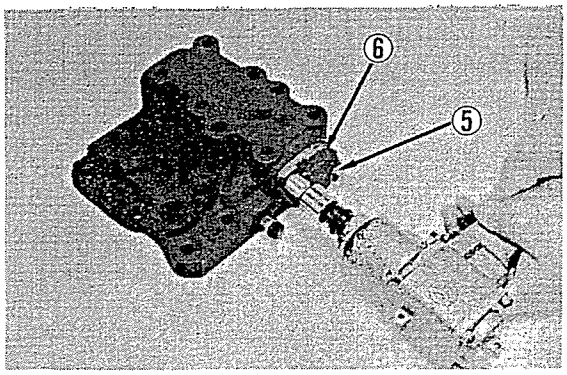
⚠ CAUTION

Two valve springs are used in accumulator valve. Remove cover (A), taking care not to allow these springs to jump out.



(2) Take out valve springs A, B (3), (4).
(3) Loosen off two bolts (5) securing cover B (6), and remove the cover and "O" ring.





Installation

(1) Place "O" ring in upper housing, and install accumulator cover B to valve housing with two bolts.

(2) Insert accumulator valve into valve housing from the side opposite to cover B.

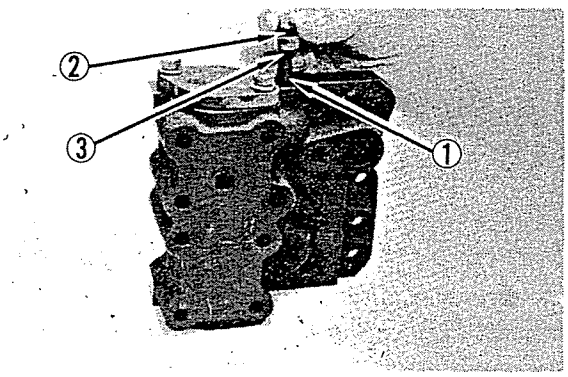
(3) Place valve springs A, B in valve housing.

(4) Place "O" ring on cover A, and install the cover to valve housing with two bolts.

Orifice assembly

Removal

Take out needle orifice (1), and remove nut (2) and "O" ring (3).



Installation

Place "O" ring and nut on needle orifice, and install orifice to valve housing.

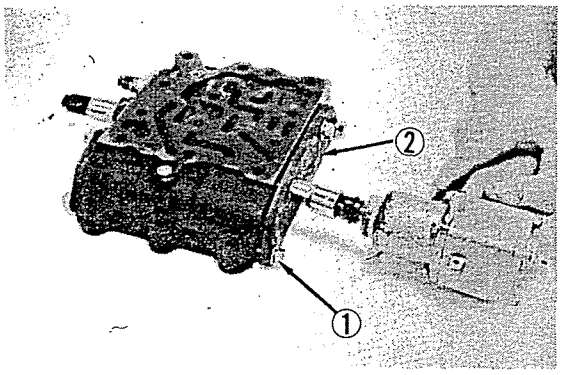
Cover assembly

Removal

Loosen off five bolts (1) securing cover (2), and remove the cover. Take out four "O" rings from inside valve housing.

NOTE

When removing cover, take care not to allow valve to jump out.



Installation

Place "O" rings in valve housing, and install cover (2) to valve housing with five bolts.

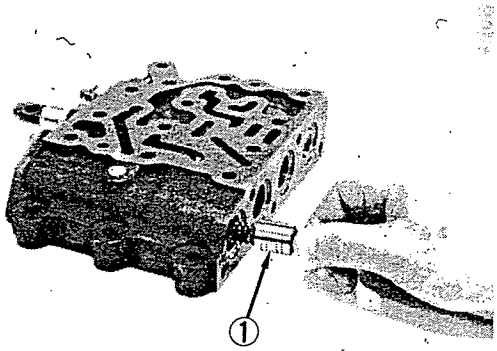
Main relief valve assembly

Removal

Take out main relief valve (1).

NOTE

When taking out main relief valve, take care not to prevent shims inside of relief valve from dropping out.

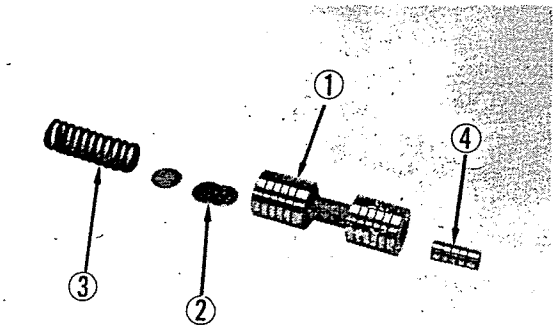


Disassembly

(1) Remove spring (3) from main relief valve (1).

(2) Remove shims (2) from main relief valve.

(3) Remove plug (4) from main relief valve.



Assembly

(1) Place plug in main relief valve.

(2) Place shims in main relief valve.

(3) Place spring in main relief valve.

Installation

Place main relief valve assembly in valve housing.

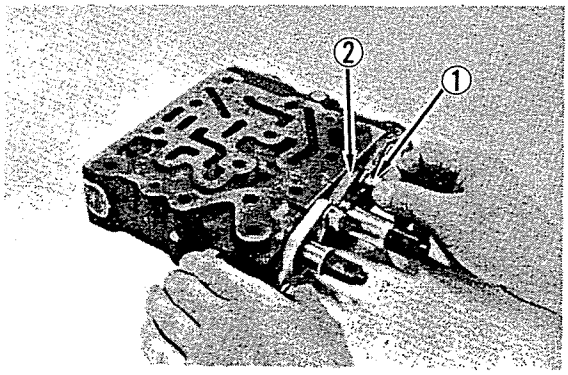
NOTE

Upon inserting main relief valve, check to make sure main relief valve moves smoothly without any sign of binding.

Clutch valve assembly

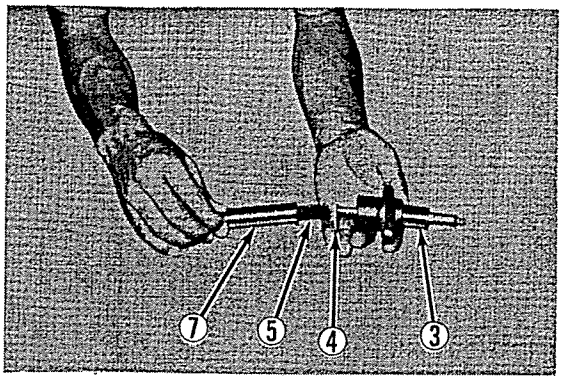
Removal

(1) Loosen off two bolts (1) securing clutch valve cover (2), and remove the cover.

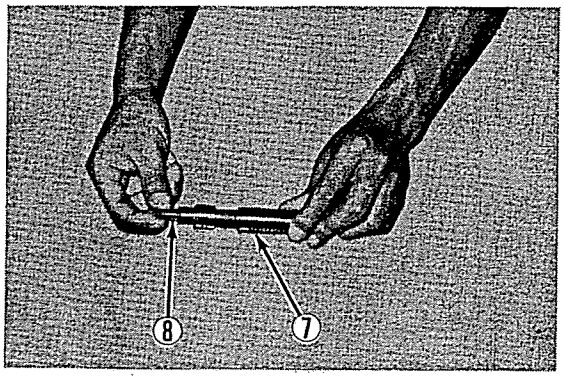


(2) Take out clutch plunger (3), spacer (4), shims, clutch valve spring A (5) and "O" rings.

(3) Remove clutch valve (7) and valve spring B.



(4) Remove plug (8) from clutch valve.

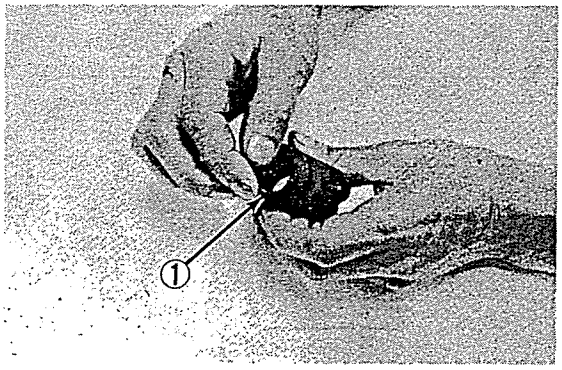


Installation

(1) Place plug in clutch valve.

(2) Place spring B in clutch valve.

(3) Place "O" rings, inside and outside, in clutch valve cover.



(4) Insert clutch valve plunger into clutch valve cover.

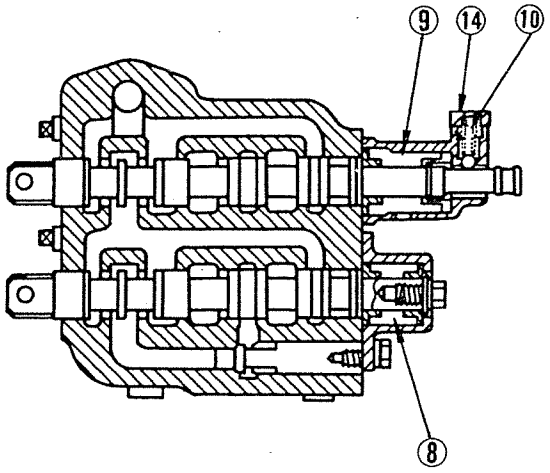
(5) Place shims on plunger.

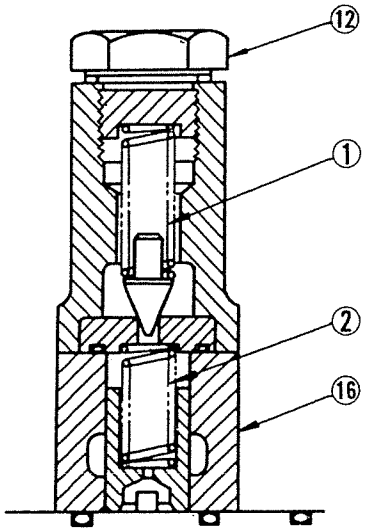
(6) Place valve spring A in plunger together with spacer.

(7) Insert clutch valve into valve housing.

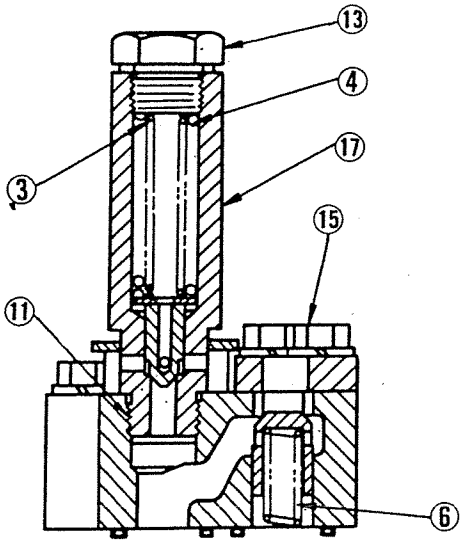
Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
16	Main relief valve	Pressure that makes relief valve open	140 ± 2 kg/cm^2 (1991 ± 28 psi)	
		Flow rate	65 ± 5 liters/min (3967 ± 305 cu in.)/min	
17	Safety valve	Pressure that makes safety valve open	160 ± 2 kg/cm^2 (2275 ± 28 psi)	
		Flow rate	23 liters/min (1404 cu in.)/min	

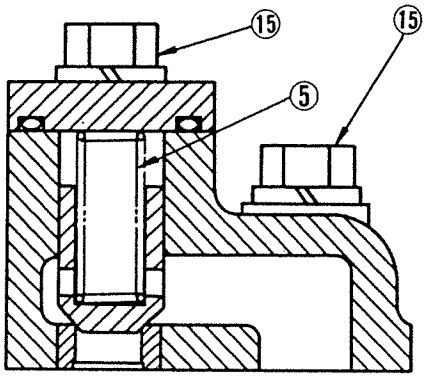




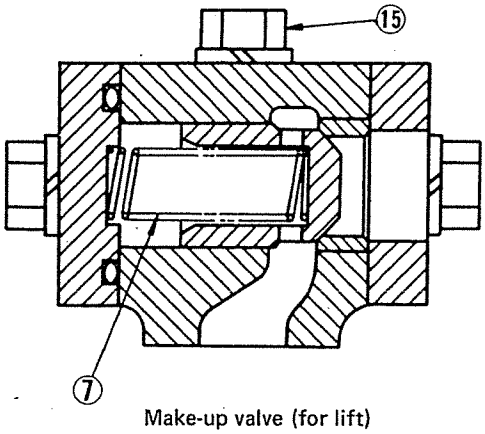
HYDRAULIC CONTROL VALVE (BS3E)



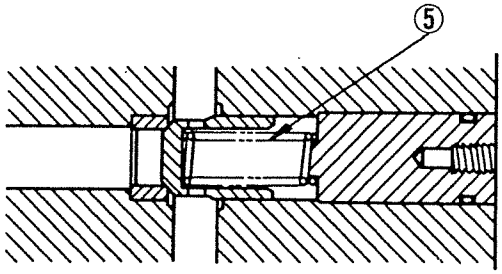
Safety and make-up valves (for dump)



Check valve (for lift)



Make-up valve (for lift)

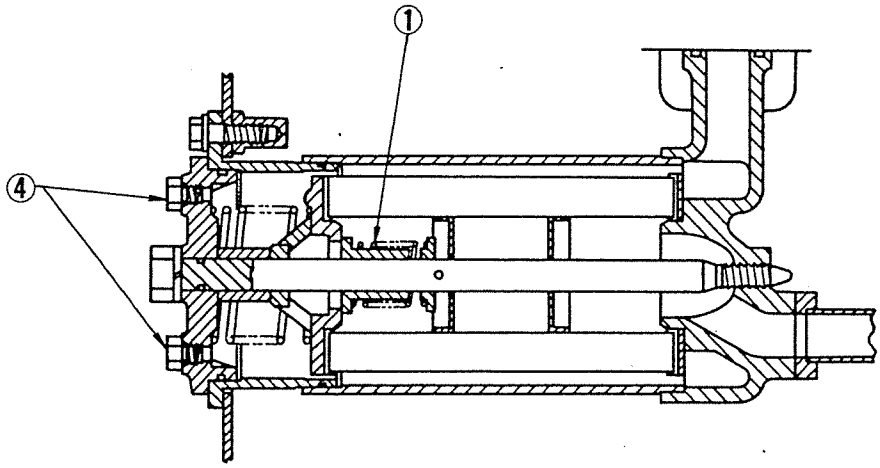


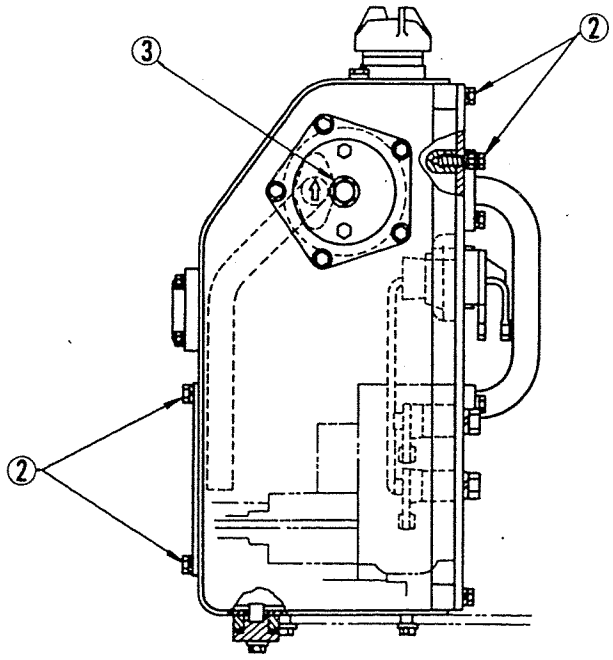
Check valve (for dump)

HYDRAULIC TANK

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Safety valve spring in filter	Free length	106.2 (4.181)	
		Load kg (lb)/as-installed length	7.07 ± 0.7/38 (15.6 ± 1.5/1.496)	6/38 (13.2/1.496)
2	Torque for tank cover attaching bolts		3.5 ± 0.3 kg-m (25.3 ± 2.2 ft-lb)	
3	Torque for filter cover center bolt		4.8 ± 0.5 kg-m (34.7 ± 3.6 ft-lb)	
4	Torque for bleeder plug and drain plug of filter		2.5 ± 0.2 kg-m (18.1 ± 1.4 ft-lb)	

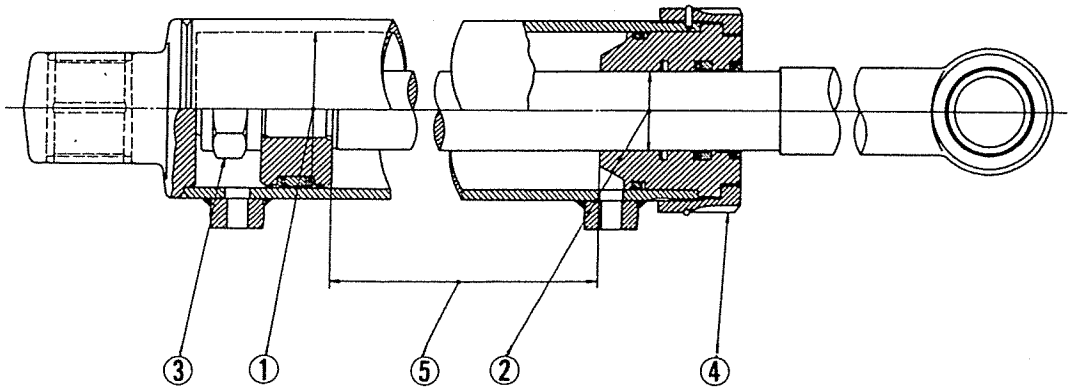




LIFT CYLINDERS (BS3E)

Unit: mm (in.)

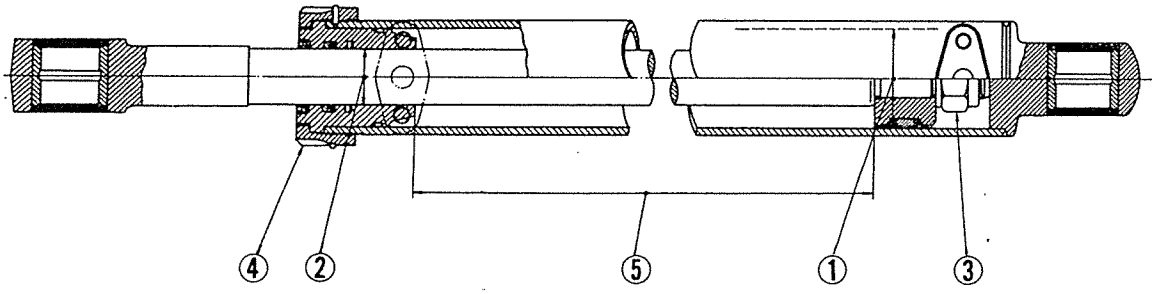
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of piston in cylinder (all cylinders)			0.5 (0.0197)
2	Fit of guide bushing on piston rod (all cylinders)		0.075 ~ 0.139 (0.00295 ~ 0.00547)	0.35 (0.0138)
3	Torque for nut holding piston (all cylinders)		111 ± 15 kg-m (803 ± 108 ft-lb)	
4	Torque for grand screw (all cylinders)		87 ± 9 kg-m (629 ± 65 ft-lb)	
5	Piston rod (all cylinders)	Stroke	477 (18.78)	
		Center to center of pins (with cylinder fully retracted)	809 (31.85)	



DUMP CYLINDERS (BS3E)

Unit: mm (in.)

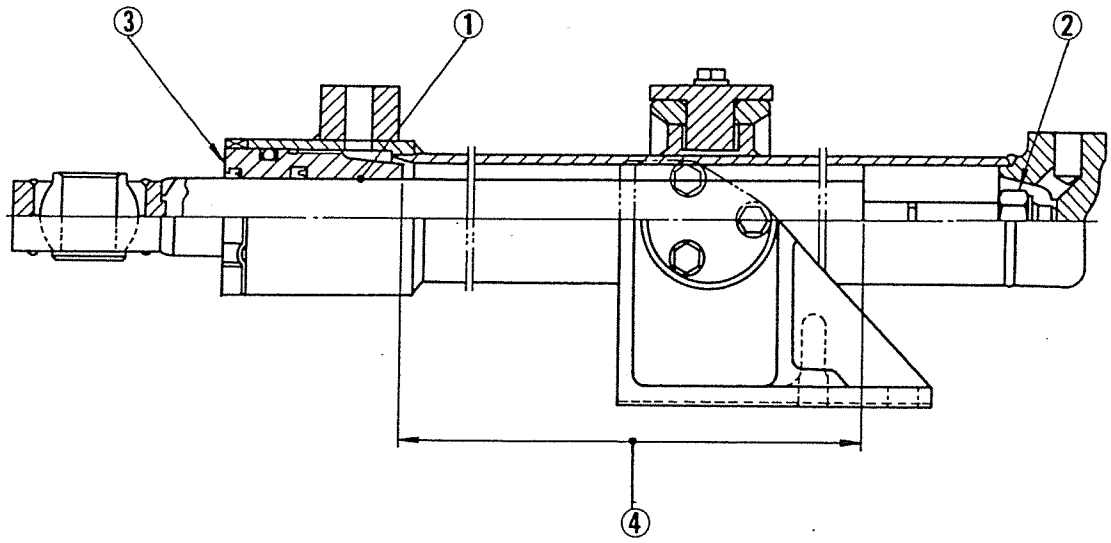
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of piston in cylinder (all cylinders)			0.35 (0.0138)
2	Fit of guide bushing on piston rod (all cylinders)		0.075 ~ 0.139 (0.00295 ~ 0.00547)	0.35 (0.0138)
3	Torque for nut holding piston (all cylinders)		60 ± 6 kg-m (434 ± 43 ft-lb)	
4	Torque for grand screw (all cylinders)		45 ± 4.5 kg-m (325 ± 32.5 ft-lb)	
5	Piston rod (all cylinders)	Stroke	422 (16.61)	
		Center to center of pins (with cylinder fully retracted)	763 (30.04)	



BLADE LIFT CYLINDERS (BD2E)

Unit: mm (in.)

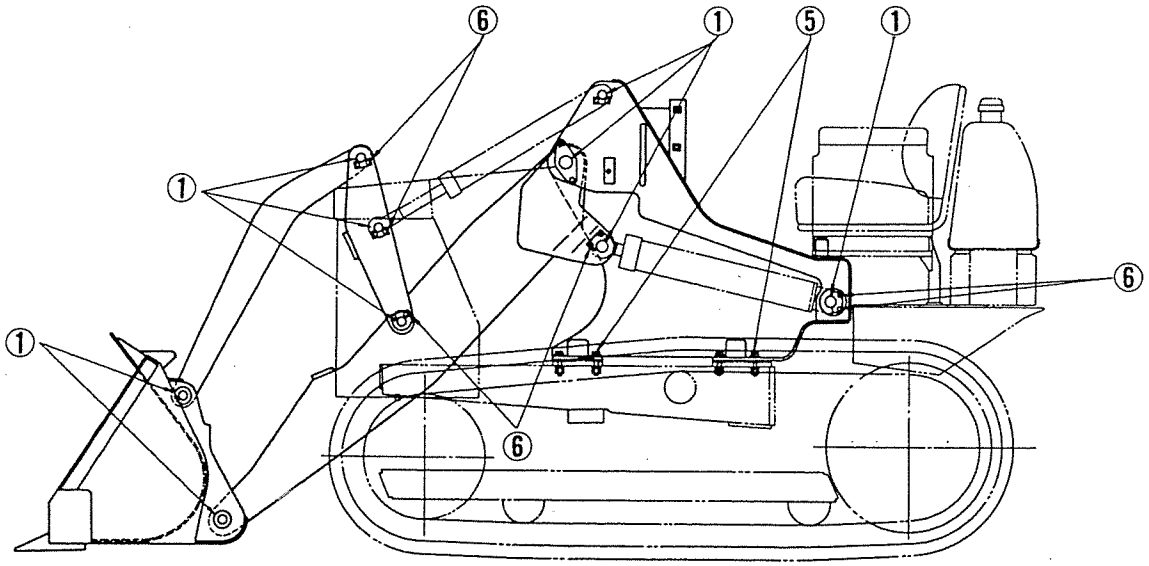
Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of guide bushing on piston rod (all cylinders)		0.08 ~ 0.18 (0.00315 ~ 0.00709)	0.4 (0.0157)
2	Torque for nut holding piston (all cylinders)		25.5 ~ 37.2 kg-m (184.4 ~ 269.1 ft-lb)	
3	Torque for cylinder head (all cylinders)		40 ± 4 kg-m (289 ± 29 ft-lb)	
4	Piston rod (all cylinders)	Stroke	675 (26.57)	
		Center to center of pins (with cylinder fully retracted)	500 (19.69)	

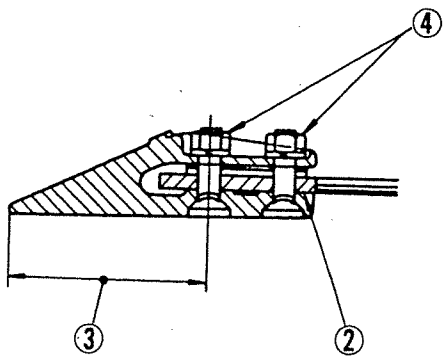


BUCKET AND LINKAGE (BS3E)

Unit: mm (in.)

Ref. No.	Point of measurement		Standard clearance (Assembly standard)	Service limit
1	Fit of pin in bushing (all pins)	35 (1.38)	0.073 ~ 0.164 (0.00287 ~ 0.00646)	0.6 (0.024)
		45 (1.77)	0.065 ~ 0.160 (0.00256 ~ 0.00630)	0.6 (0.024)
		50 (1.97)	0.095 ~ 0.204 (0.00374 ~ 0.00803)	0.6 (0.024)
2	Width of cutting edge (all cutting edges)		159 (6.26)	120 (4.72)
3	Length of tooth (all teeth)		160 (6.30)	100 (3.94)
4	Torque for tooth attaching bolts (all teeth)		29 ~ 32 kg-m (210 ~ 231 ft-lb)	
5	Torque for cylinder support attaching bolts (all supports)		29 ~ 32 kg-m (210 ~ 231 ft-lb)	
6	Torque for lock plate attaching bolts (all lock plates)		3.5 ± 0.3 kg-m (25.3 ± 2.2 ft-lb)	

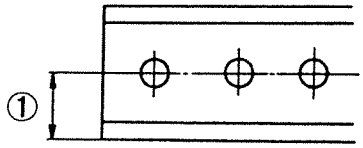


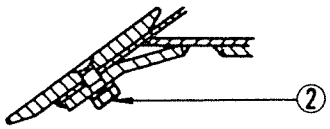


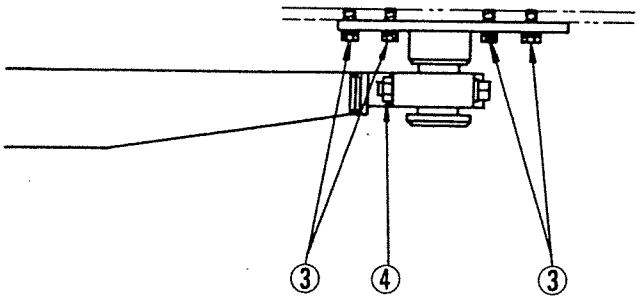
BLADE (BD2E)

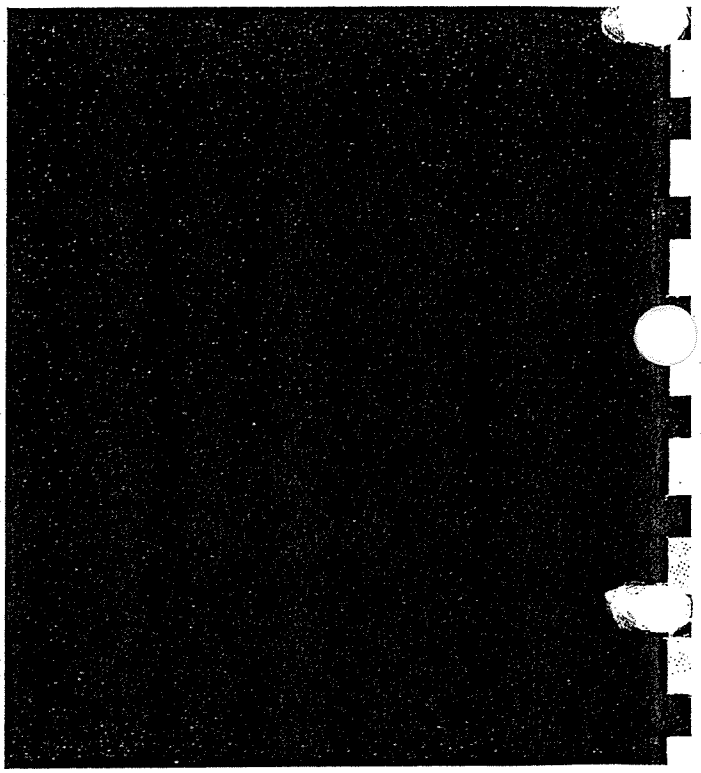
Unit: mm (in.)

Ref. No.	Point of measurement	Standard clearance (Assembly standard)	Service limit
1	Dimension of cutting edge and end bits (from center to edge)	75 (2.95)	45 (1.77)
2	Torque for plow bolts holding cutting edge (all plow bolts)	6.5 ± 0.7 kg-m (47 ± 5.1 ft-lb)	
3	Torque for trunnion attaching bolts (all trunnions)	6.5 ± 0.7 kg-m (47 ± 5.5 ft-lb)	
4	Torque for trunnion cap attaching bolts (all trunnion caps)	15.8 ± 1.6 kg-m (114.3 ± 11.6 ft-lb)	









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FOREWORD

The Mitsubishi 4DQ50C Diesel Engine – the fruit of many years of experience in the manufacture of power packs and other engineering products – is built with the up-to-date engineering techniques and modern metallurgy. Offering easier handling, greater durability and higher productivity, the 4DQ50C will earn you more profit.

This SERVICE MANUAL is written to give essential information regarding the procedures for cleaning, inspecting, repairing and adjusting engine components. Strict adherence to the instructions given in this manual will result in maximum production and economy built in your Mitsubishi engine. It is requested that the operator's manual and parts list separately issued for this engine be cross-referred to so as to get a thorough understanding of the material complied herein.

For information on any service other than those described in this manual, contact the nearest Mitsubishi Service Station in your territory.

TABLE OF CONTENTS

PREPARATORY STEPS

Service point / Components or parts affected and what to do	Universal joint	Hydraulic pump	Hydraulic control valve	Transmission	Transmission control	Steering clutch brakes	Bevel gear	Steering clutches	Steering clutch and brake controls	Final drive pinion	Final drive group	Track	Front idlers	Recoil springs	Track carrier rollers	Track roller frame	Track rollers
Platform, removal	●			●	●			●	●								
Seat cushion, removal				●	●	●	●	●	●	●							
Seat cover, removal				●	●	●	●	●	●	●							
Seat bracket, removal				●	●	●		●									
Steering clutch and brake pedals, removal				●				●									
Steering clutch and brake control rods, removal				●		●		●		●							
Hydraulic pump pipelines, removal		●	●														
Universal joint, removal				●													
Transmission case, draining				●													
Hydraulic tank, draining		●	●														
Final drive gear case, draining										●	●						
Steering clutch case covers, removal						●	●	●		●							
Steering clutch brakes, removal								●		●							
Track, separation										●	●						
Track roller guards, removal													●	●		●	●
Track, loosening												●	●	●	●	●	●
Track, removal												●	●	●		●	
Disconnecting from rigid bar																●	

ENGINE DISMOUNTING AND MOUNTING

Preparatory steps for dismounting

(a) Raise bucket fully, and securely support it by installing lift arm support bracket to lift cylinder.

(b) Drain engine oil pan and cooling system completely.

(c) Dismount power direction clutch (page 4).

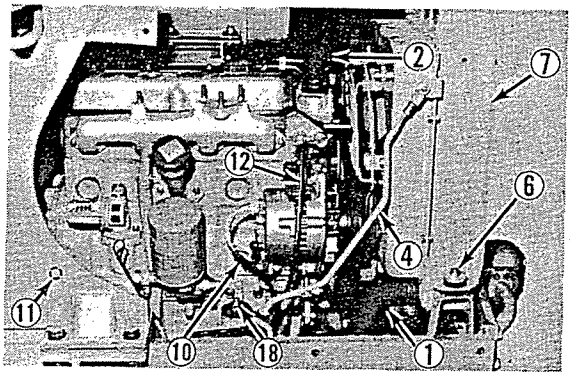
(d) Remove engine room.

⚠ WARNING

Insert a piece of hardwood between engine and front rigid bar on each side of oil pan to support engine.

Procedure

(1) Disconnect coolant rubber hoses (1) thru (3).

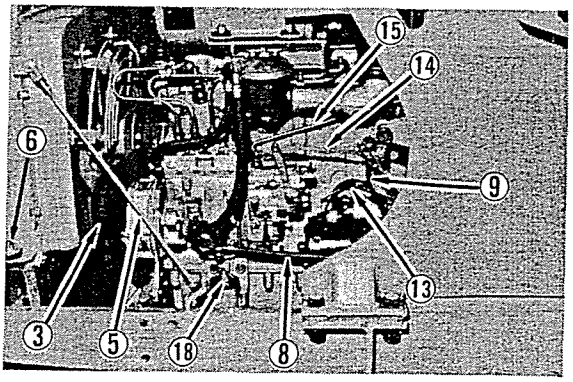


(2) Remove rods (4) (5) and bolt (6) (drilled for split pin) on each side, and dismount radiator (7).

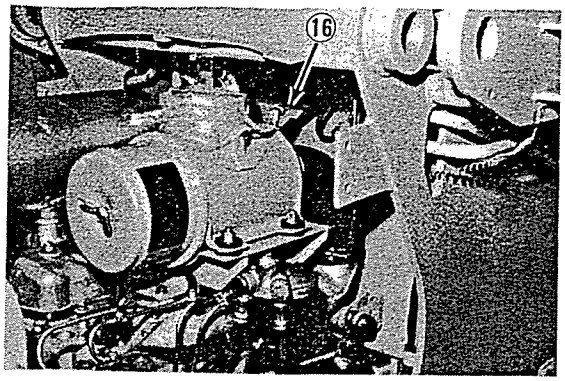
(3) Disconnect fuel pipe (8) and fuel return pipe (9).

(4) Disconnect wire (10) for alternator, wire (11) for oil pressure gauge unit, wire (12) for water temperature gauge unit and wire (13) for starter.

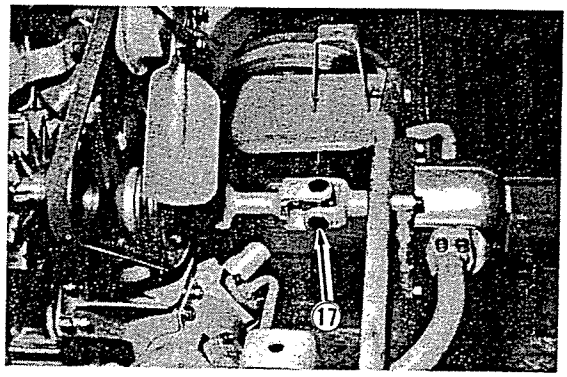
(5) Disconnect engine control rods (14) (15).



(6) Disconnect vinyl hose (16).



(7) Remove universal joint (17).



(8) Remove two bolts (18) at each engine mount, and dismount engine.

(9) To mount engine, follow reverse of dismounting procedure.

Important

(1) Place standard 2-mm (0.079-in.) shim on engine and power direction clutch mount brackets.

(2) Upon mounting engine and power direction clutch, make sure no gap is noted between shim A (1) and bracket. If any gap is noted there, add shims.

(3) Check to make sure these two universal joints – one for hydraulic pump and the other located between power direction clutch and transmission – are mounted nearly horizontally.

(4) Clearance "X" should be 1.2 to 2.2 mm (0.047 to 0.087 in.) when nut of bolt (2) is tightened. If the clearance is out of this range, add shims B (3).

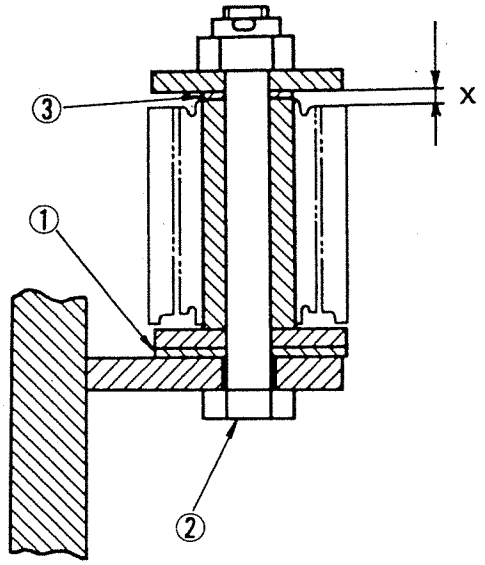
(5) Tighten nut to 15.9 ± 1.6 kg-m (115 ± 12 ft-lb).

(6) Make sure engine and power direction clutch are mounted nearly horizontally.

REFERENCE

Shim A (58611-02500): 1 mm (0.039 in.) and 0.5 mm (0.020 in.)

Shim B (64361-17516): 0.5 mm (0.020 in.)



POWER DIRECTION CLUTCH

Removal

Tool required

Tool name	Tool number	Qt.
Hook (A)	58609-04200	1

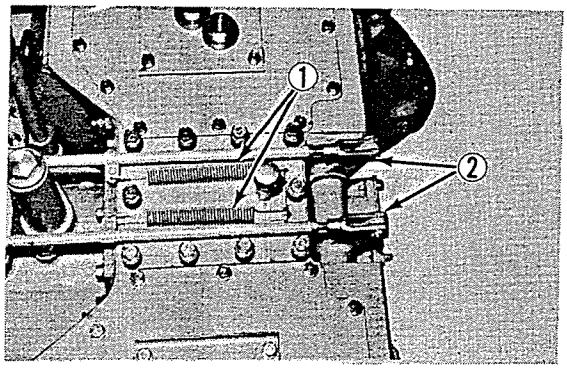
Preparatory steps

(a) Drain power direction clutch case of lube oil.

(b) Remove platform and side guards.

Procedure

(1) Remove return springs (1) and clevis pins (2) located under the operator's seat, and pull steering clutch levers all the way backward.



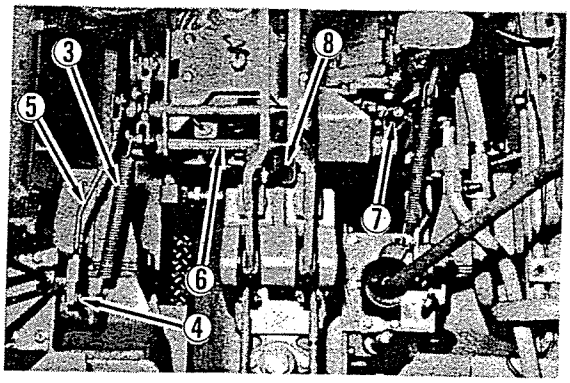
(2) Remove rear under guard.

(3) Remove return spring (3) and clevis pin (4), and disconnect rod (5) from each steering clutch lever.

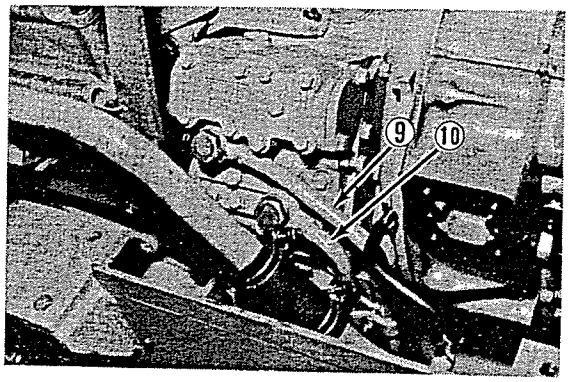
(4) Disconnect directional control valve spool from link.

(5) Remove clutch pedal assembly (6) and brake rod assembly (7).

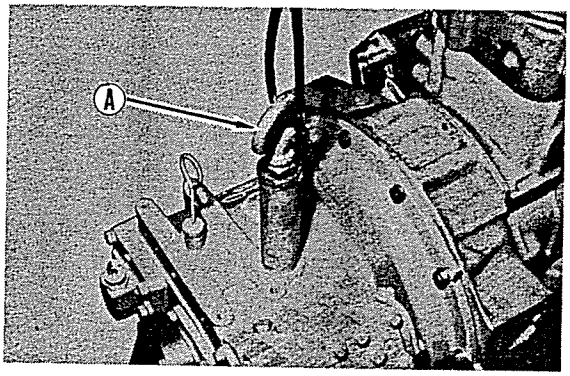
(6) Remove universal joint (8) (page 26).



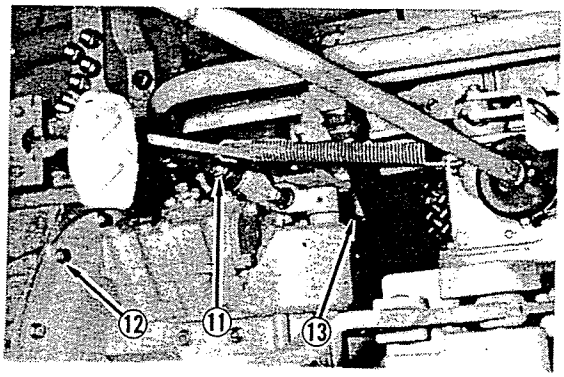
(7) Disconnect oil cooler pipes (9) (10) from control valve side of power direction clutch.



(8) Remove breather plug from power direction clutch case, and attach hook (A).

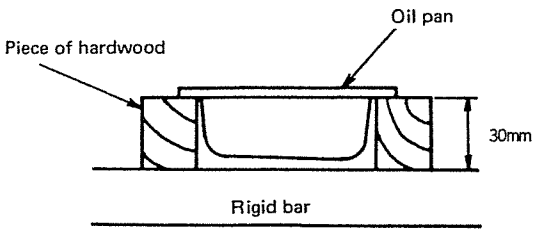


(9) Loosen off bolts (11) securing power direction clutch to frame, and lift off the clutch.



⚠ WARNING

Insert a piece of 30 by 30 mm (1-1/4 by 1-1/4 in.) hardwood between engine and front rigid bar on each side of oil pan to support engine.



(10) Loosen off ten bolts (12) securing power direction clutch to engine.

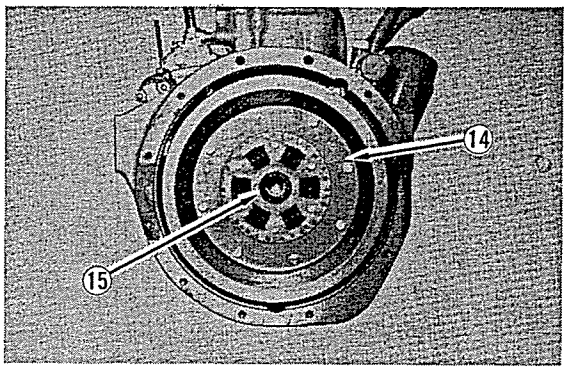
(11) Remove brake pedal bracket (13).

(12) Lift off power direction clutch.

(13) Remove clutch disc assembly (14).

NOTE

Check bushing (15) fitted to flywheel for abnormal wear, and replace it if necessary.



Installation

Tools required

Tool name	Tool number	Qt.
Clutch disc aligning tool	58609-21400	1
Hook	58609-04200	1

Procedure

(1) Using a clutch disc aligning tool, install clutch disc assembly.

(2) Lift power direction clutch by using a hook at breather plug pipe, and install it to engine and to frame.

(3) Remove the hook, and install breather plug.

(4) Connect oil cooler pipes to control valve side of power direction clutch.

(5) Install universal joint.

(6) Install brake rod assembly and clutch pedal assembly.

(7) Connect directional control valve spool to link.

(8) Connect clutch pedal link to control lever.

(9) Connect steering clutch lever rods to brake cam levers.

Disassembly and assembly

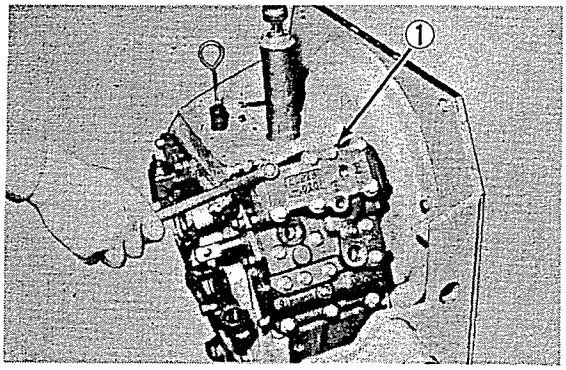
Tools required

Tool name	Tool number	Qt.
Clutch assembling tool	58609-00020	1
Seal stabilizing tool	58609-21300	1
Seal inserting tool	58609-21200	1

Preparatory steps for disassembly

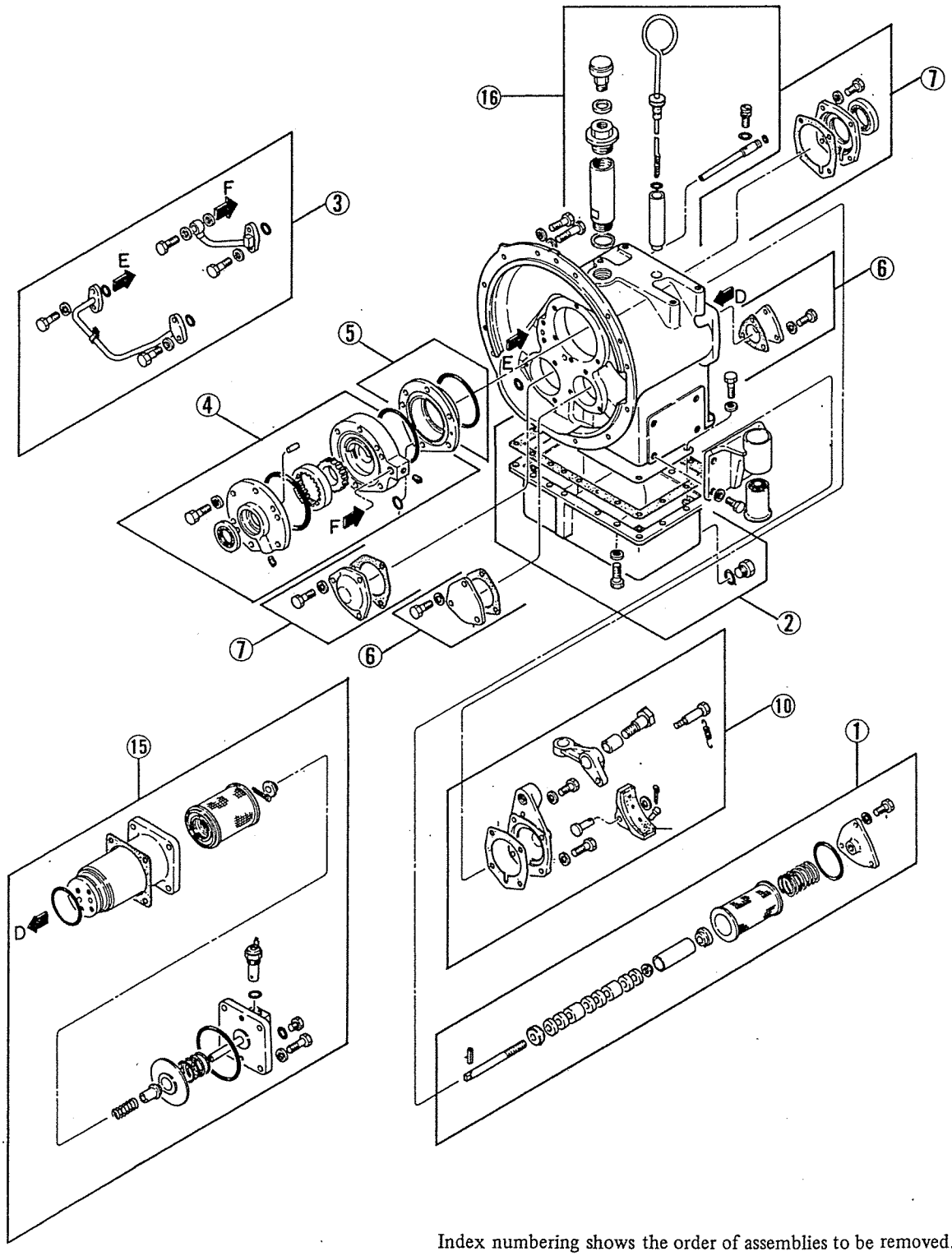
(a) Pull out oil level gauge.

(b) Remove control valve assembly (1).



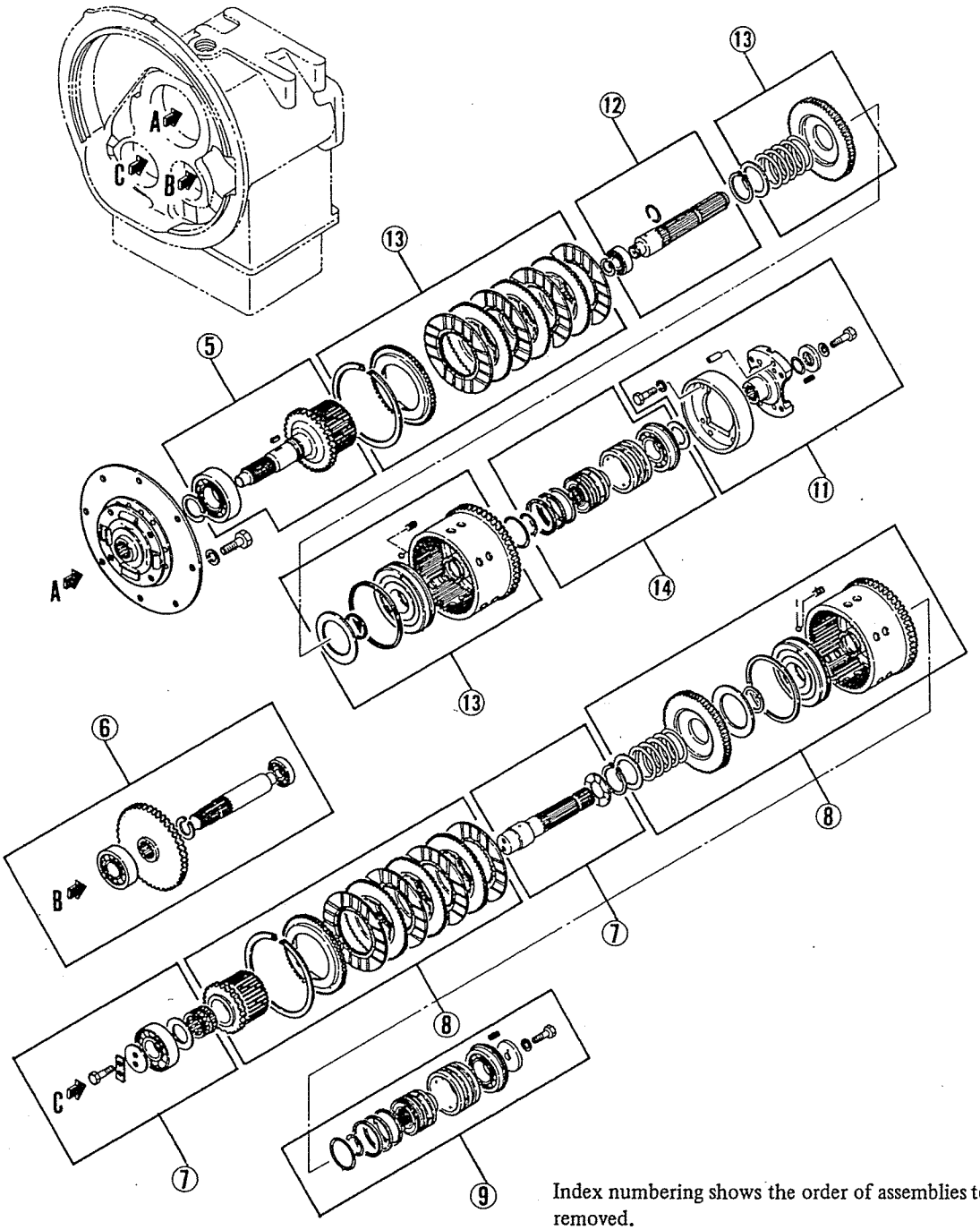
POWER DIRECTION CLUTCH

Procedure



Index numbering shows the order of assemblies to be removed.

Power direction clutch — disassembled view (1)



Index numbering shows the order of assemblies to be removed.

Power direction clutch — disassembled view (2)

Sequential steps for disassembly and assembly

Remove major assemblies and related parts in the order listed below when disassembling power direction clutch and install them in the reverse order when assembling the clutch:

(1) Strainer assembly and magnet assembly
(2) Tank assembly
(3) Oil pipes
(4) Gear pump assembly
(5) Input shaft assembly
(6) Idler gear shaft assembly

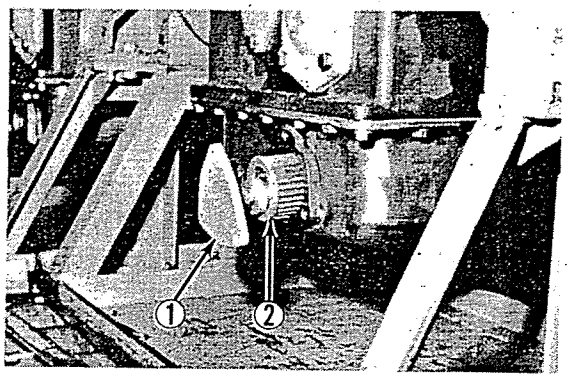
(7) Countershaft assembly
(8) Reverse clutch drum assembly
(9) Reverse clutch bearing retainer assembly
(10) Clutch brake assembly
(11) Clutch brake drum assembly
(12) Output shaft assembly
(13) Forward clutch drum assembly
(14) Forward clutch bearing retainer assembly
(15) Filter cover assembly
(16) Related parts

Strainer assembly and magnet assembly

Removal

(1) Loosen off three bolts.
(2) Take out strainer (2) complete with cover (1).

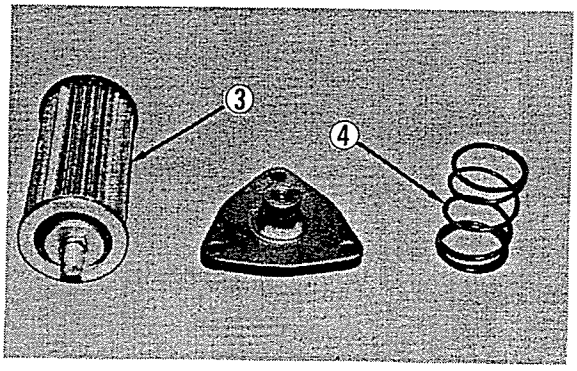
NOTE
Be careful not to damage "O" ring.



Disassembly

(1) Remove strainer element (3), spring (4) and "O" ring from cover by turning stud.

NOTE
Wash strainer in warm water and non-sudsing household detergent.



(2) Take out magnet assembly, and wash it by brushing in warm water and non-sudsing household detergent.

Assembly

Place spring (4) on cover, and attach magnet assembly.

Installation

(1) Place "O" ring on tank.
(2) Apply a coat of grease to "O" ring.
(3) Install strainer to tank complete with cover, and secure it in place by tightening bolts.

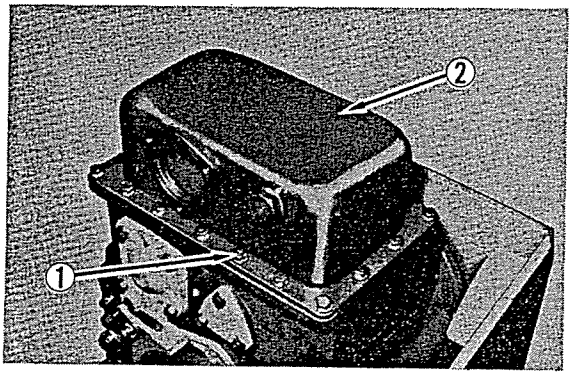
NOTES

a) The effective range of spring (4) is about 3 mm (0.12 in.).
b) When inserting strainer, make sure it seats in tank properly.

Tank assembly

Removal

(1) Loosen off eighteen bolts (1) securing tank in place.
(2) Remove tank (2).



(3) Remove gasket.

NOTE
Discard gasket which has been in service.

Disassembly

To remove plate from tank, loosen off four plate attaching bolts.

Assembly

(1) To install plate to tank, secure it in place with bolts and spring washers.

NOTE
When installing plate to tank, make sure level gauge hole in plate is correctly positioned.

(2) Install seal and plug to tank.

Installation

Place tank on case together with gasket, and secure it with bolts and washers.

NOTE

Align oil holes in gasket and tank.

Oil pipes

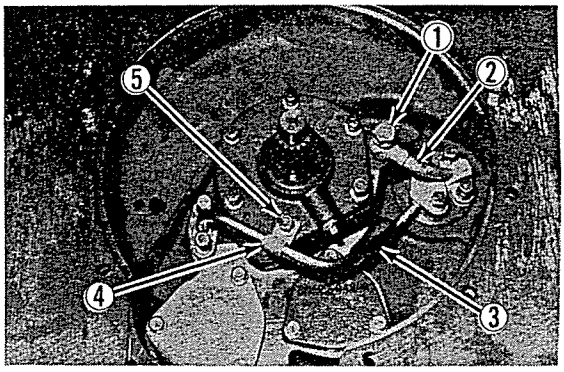
Removal

(1) Remove joint bolt (1), and disconnect oil pipe B (2) (shorter pipe).

NOTE

Be careful not to permit "O" ring to fall.

(2) Loosen off four bolts. Loosen off bolt (5) at clamp (4), and disconnect oil pipe A (3).



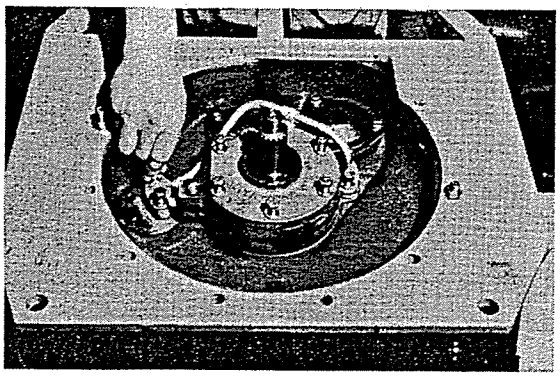
Installation

(1) Place "O" ring on oil pipe A, and apply a coat of grease to "O" ring.

(2) Connect oil pipe A by tightening bolts.

(3) Place "O" ring on oil pipe B, and apply a coat of grease to "O" ring.

(4) Connect oil pipe B.



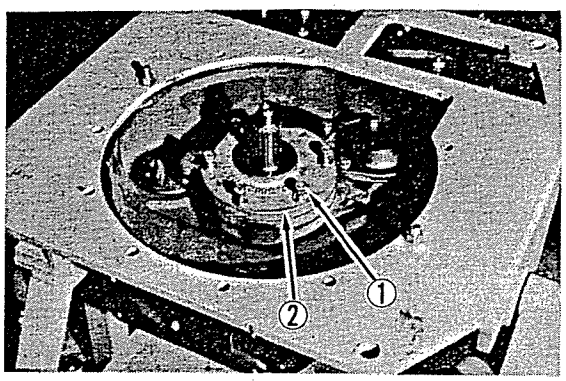
NOTE

When re-using copper packing, be sure to anneal it before installation.

Gear pump assembly

Removal

(1) Loosen off five bolts (1) securing pump cover (2) in place, and remove the cover.

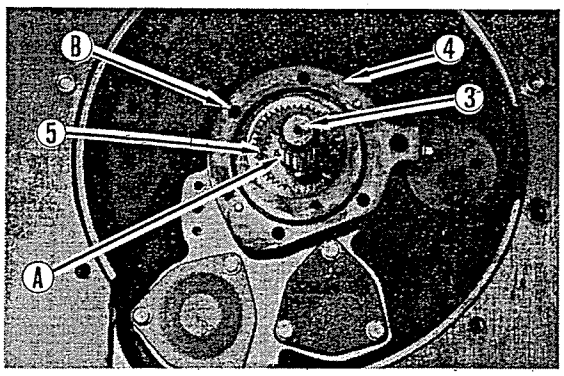


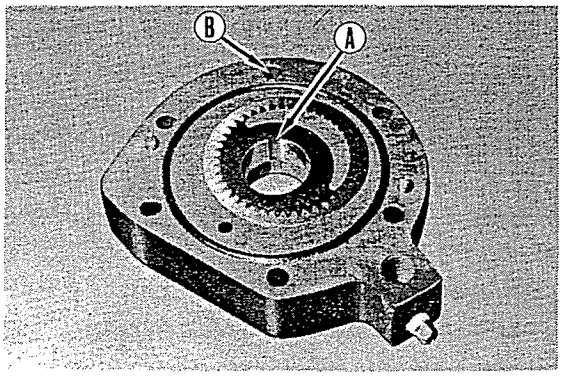
(2) Align key fitted to input shaft gear (3) with keyway in pump body (4), and carefully remove pump body assembly.

NOTES

a) Before removing pump body, bring keyway (A) in pinion over to bolt hole (B) as shown.

b) Be careful not to permit "O" ring to fall.



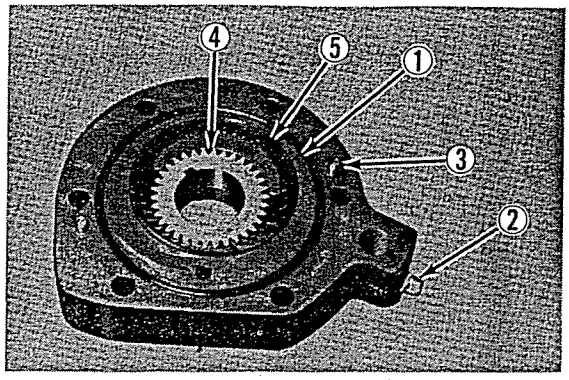


Disassembly

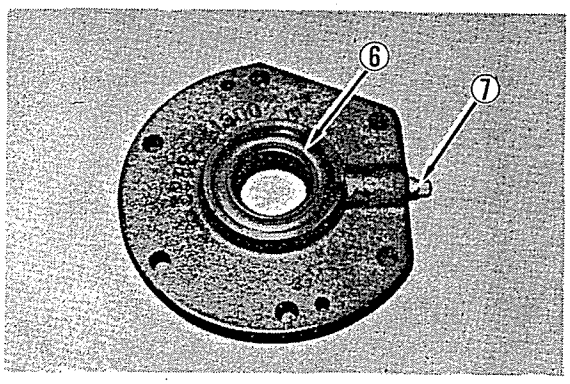
(1) Remove "O" ring (1) from pump body.

(2) Remove taper plug (2), and, if necessary, remove dowel pin (3).

(3) Remove pinion (4) and internal gear (5).



(4) Remove oil seal (6) and taper plug (7) from cover.

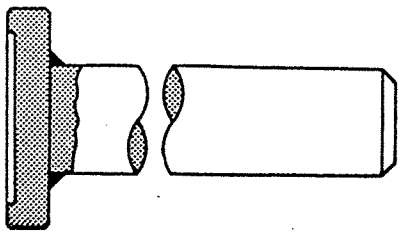


Assembly

(1) Apply a coat of grease to pump cover, and insert oil seal.

NOTE

Use an oil seal inserting tool (58609-04300) of the type shown to install oil seal. Install oil seal, taking care not to twist or fold it.



Oil seal inserting tool (58609-04300)

(2) Install snap ring and taper plug.

(3) Install dowel pin and taper plug to pump body.

NOTES

a) When installing pinion, make sure its chamfered-addendum side faces downward.

b) Hand rotate pump shaft, making sure pump rotates smoothly without any sign of binding.

(4) Place internal gear and pinion in pump body.

(5) Place "O" ring on pump body, and apply a coat of grease to "O" ring.

NOTE

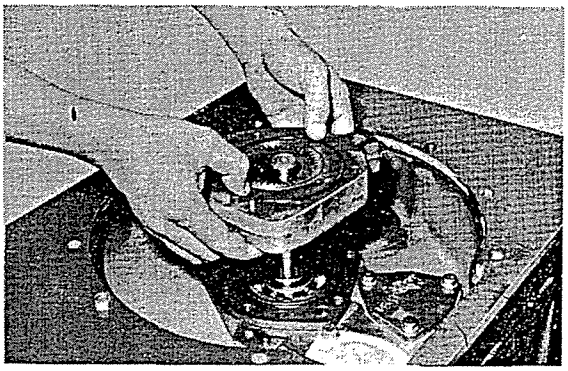
When screwing taper plug, wrap seal tape around its threaded portion.

(6) Place "O" ring on back of pump, and apply a coat of grease to "O" ring.

Installation

(1) Slide pump body onto input shaft.

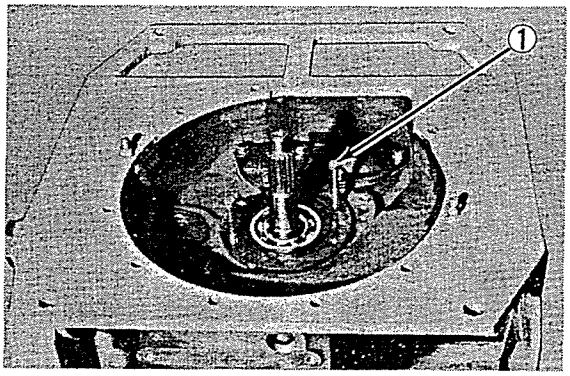
(2) Slide pump cover onto input shaft, and secure the cover in place with bolts.



Input shaft assembly

Removal

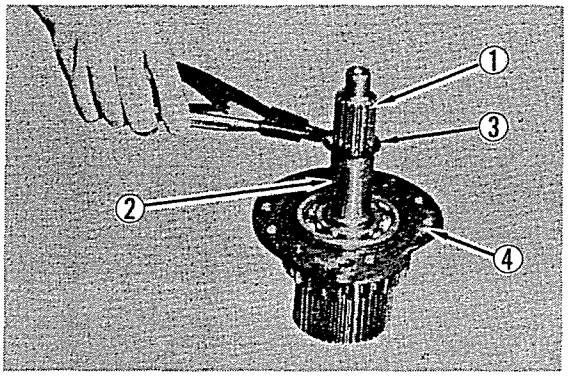
Using two bolts (1) (for securing gear pump), withdraw input shaft assembly.



Disassembly

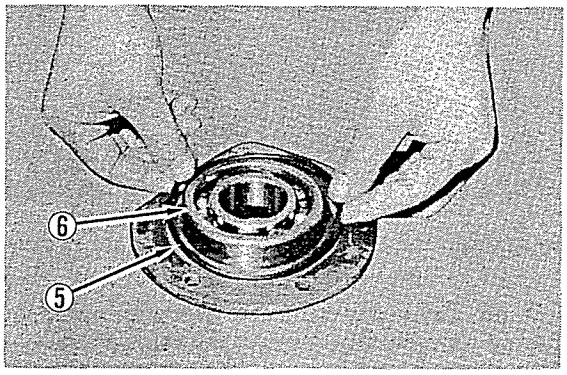
(1) Remove key (2) from input shaft (1).

(2) Remove snap ring (3), using a snap ring pliers, and remove bearing cage (4) from input shaft.



(3) Remove "O" ring (5) from bearing cage.

(4) Pull bearing (6) from bearing cage.



Assembly

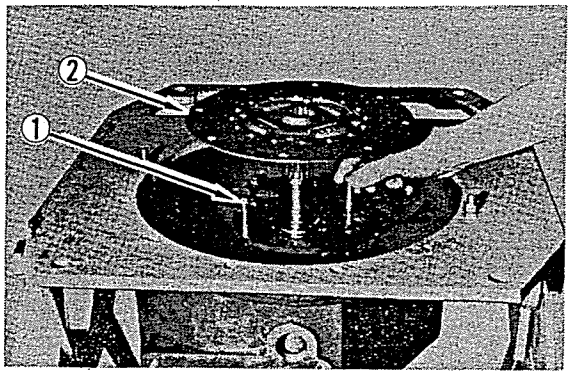
(1) Press bearing into bearing cage, and place "O" ring.

(2) Press bearing onto input shaft.

(3) Install key to input shaft.

Installation

Place input shaft assembly in drum, and position it by using gear pump attaching bolts (1) as guides.



NOTE

Place input shaft proper in drum, and align the teeth of clutch facings and clutch plates by means of clutch disc (2).

Idler gear shaft assembly

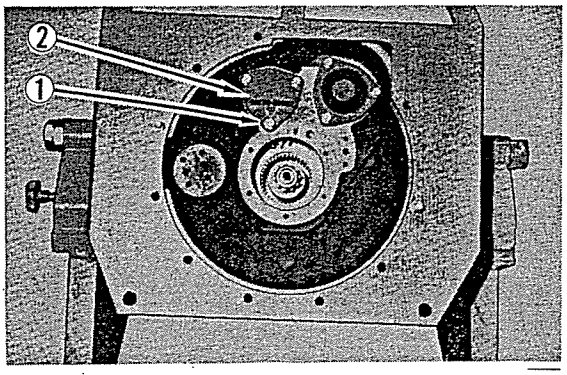
Removal

(1) Loosen off three bolts (1), and remove cover (2).

(2) Remove cover by loosening off three bolts.

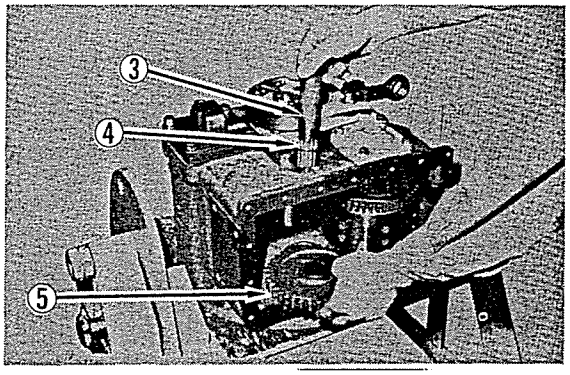
NOTE

When removing cover, take care not to damage gasket.



(3) Remove idler gear shaft (3) complete with snap ring (4) and bearing by giving blows of a mallet to the shaft.

(4) Pull out idler gear shaft, and remove idler gear (5). Pull bearing from the front side of case.



Disassembly

(1) Pull bearing from idler gear shaft.

NOTE

Use a bearing puller to remove bearing.

(2) Using a snap ring pliers, remove snap ring from idler gear shaft.

Assembly

Using a snap ring pliers, fit snap ring to idler gear shaft.

Installation

(1) Place idler gear in case, and install idler gear shaft in place.

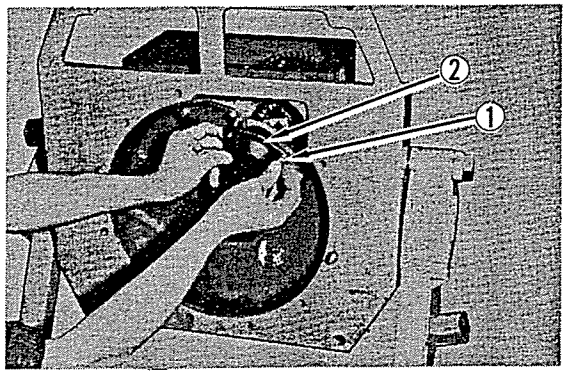
(2) Press bearing into case.

(3) Place spacer, and install cover.

Countershaft assembly

Removal

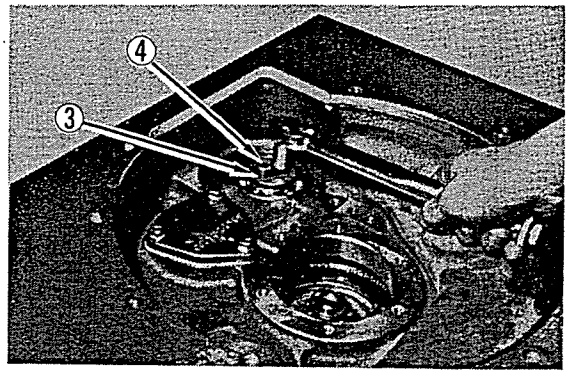
(1) Loosen off three bolts (1), and remove cover (2).



(2) Straighten lock washer (3), and loosen off bolts (4).

NOTE

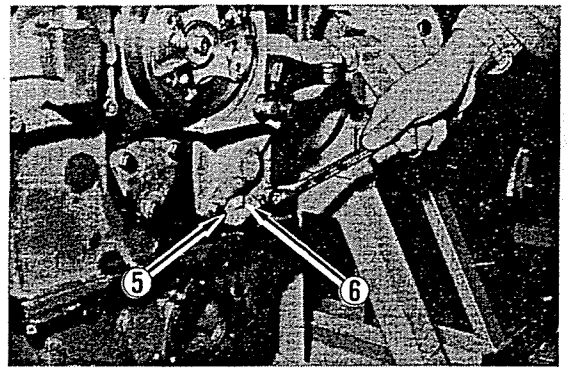
When loosening bolts (4), hold drum to prevent countershaft from rotating, as shown.

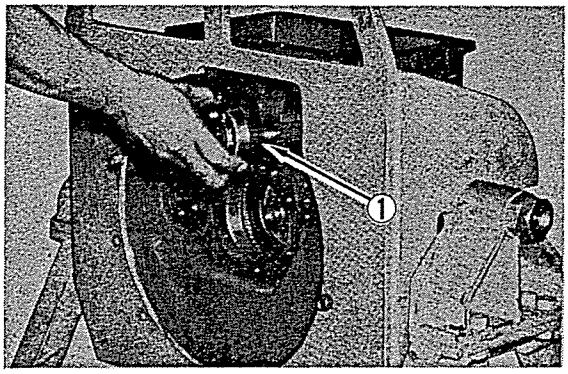


(3) Loosen off four bolts (5), and remove cover (6) on the reverse output side.

(4) Loosen off bolt by straightening its lock washer.

(5) Remove countershaft (1).





Disassembly

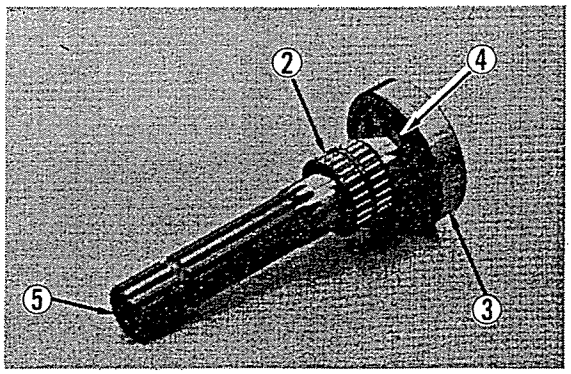
(1) Remove needle roller bearing (2).

(2) Using a bearing puller, pull ball bearing (3) from countershaft, together with thrust washer (4).

(3) Remove spring pin (5).

NOTE

Do not remove spring pin unless it need be replaced by a new one.



Assembly

Drive spring pin in countershaft.

Installation

(1) Install countershaft assembly to reverse drum.

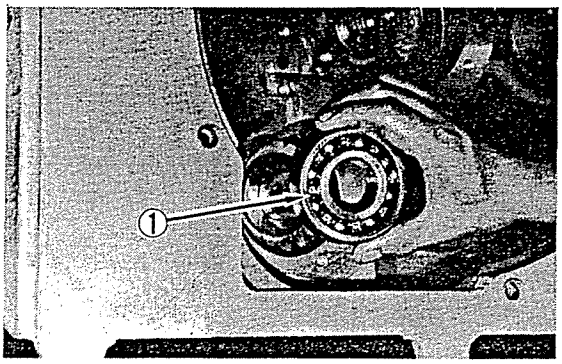
(2) Press needle roller bearing between countershaft and reverse pinion.

(3) Place thrust washer on countershaft.

(4) Install washer and lock washer to the output side of countershaft, and properly bend lock washer.

(5) Install output-side cover.

(6) Press input-side ball bearing (1) in place.



(7) Install washer and lock washer to the input side of countershaft, and properly bend lock washer.

(8) Install input-side cover.

NOTE

Check to make sure reverse pinion rotates smoothly.

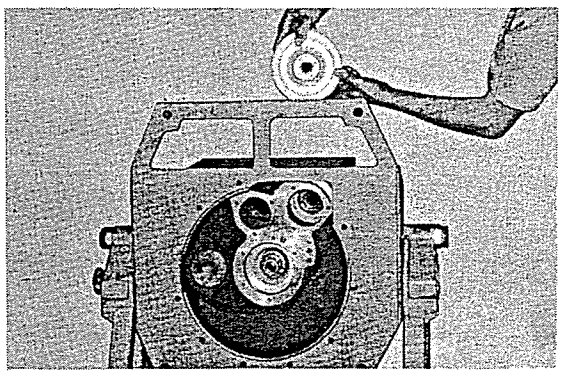
Reverse clutch drum assembly

Removal

Remove reverse clutch drum assembly from clutch case.

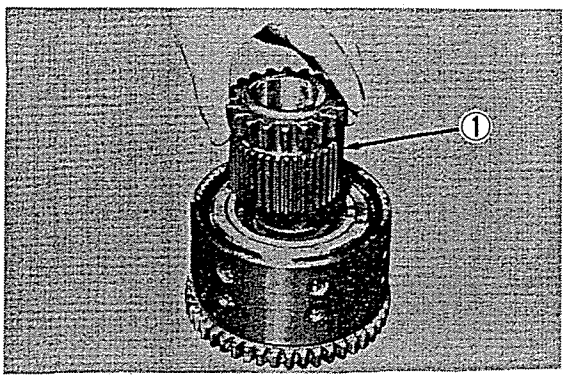
NOTE

When removing reverse clutch drum, take care not to permit two "O" rings to fall.

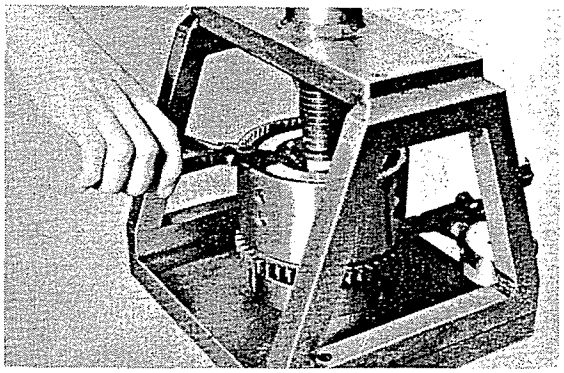


Disassembly

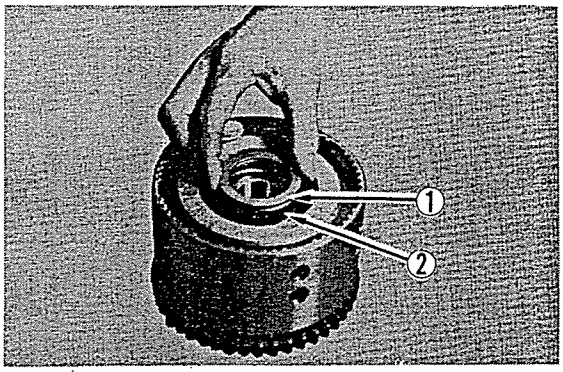
(1) Remove reverse pinion (1).



(2) Set up reverse clutch drum assembly in a clutch assembling tool (58609-00020) as shown, and remove snap ring, using a snap ring pliers.

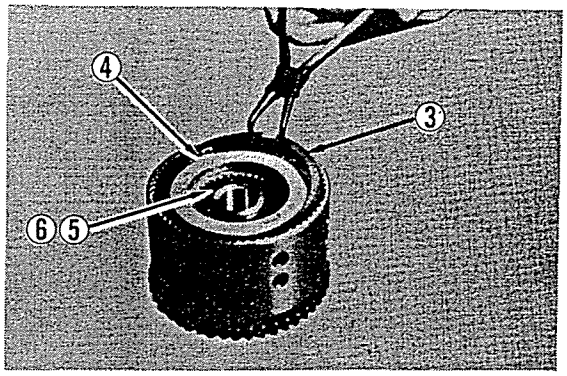


(3) Remove spring retainer (1) and clutch spring (2).

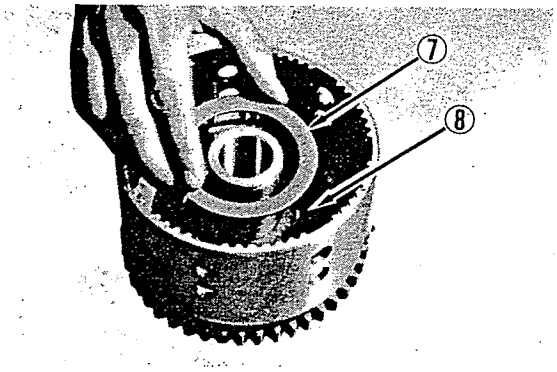


(4) Using a snap ring pliers, remove snap ring (3).

(5) Remove pressure plate (4), six clutch facings (5), five clutch plates (6) and pressure plate.



(6) Remove belleville (initially coned) spring (7) and clutch piston assembly (8).



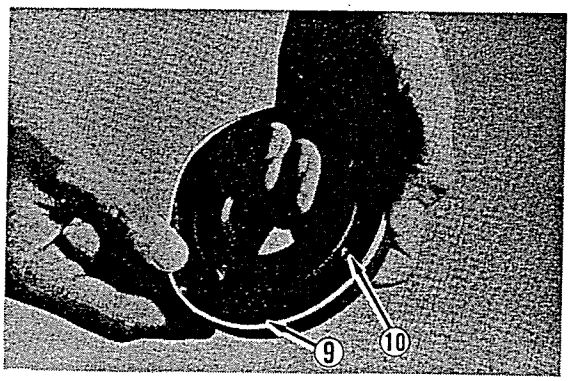
(7) Using a ring pliers, remove piston ring from reverse clutch drum.

(8) Remove piston ring (teflon seal) (9).

NOTE

When removing piston ring (teflon seal), take care not to damage it.

(9) Loosen off set screw (10), and remove steel ball.



NOTES

a) Clean steel ball hole.

b) Check piston ring for condition, and replace it by a new one if necessary.

c) In some power direction clutches, no set screw is used.

Assembly

(1) Install piston ring to clutch piston.

NOTE

When installing piston ring to clutch piston, use a seal inserting tool (58609-21200). Take care not to damage the ring when installing it. Upon installing the ring to the piston, apply a coat of grease to the ring, and keep the piston in a seal stabilizing tool (58609-21300) longer than 30 minutes to let the ring restore itself to the state as it should be in.

(2) Put steel ball in clutch piston, and secure it by tightening set screw.

NOTES

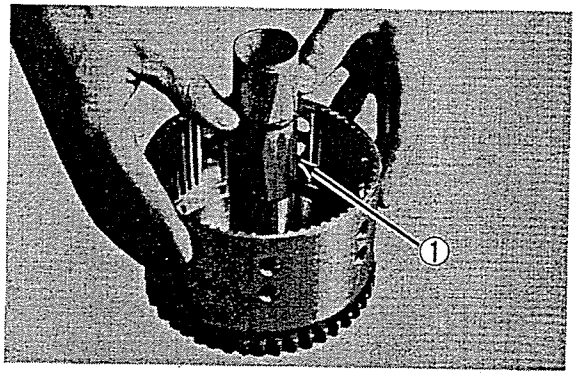
a) After putting steel ball, lap the ball against sealing surface so that the ball makes a good sealing contact.

b) In case no set screw is used, calk steel ball thoroughly.

(3) Install piston ring to drum.

NOTE

Piston ring is brittle: be sure to use a guide (1) when installing the ring.



(4) Apply a coat of grease to the internal surface of clutch drum, and place piston in the drum.

(5) Place belleville spring in clutch drum with its convex side facing the clutch piston side.

(6) Place pressure plate, clutch facings and clutch plates in clutch drum.

(7) Using a snap ring pliers, fit snap ring to clutch drum.

NOTE

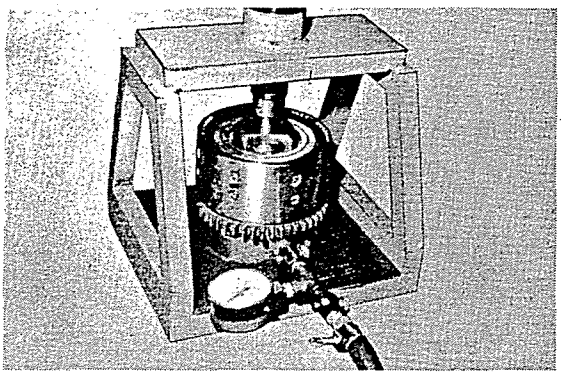
Assembling work should be performed with the gear side of clutch drum facing downward to prevent belleville spring from coming off.

(8) Place clutch spring and spring retainer in clutch drum.

(9) Set up clutch drum in a clutch assembling tool (58609-00020), and install snap ring, using a snap ring pliers.

NOTE

Apply an air pressure of about 6 kg/cm^2 (85 psi) to clutch drum, and check for piston movement and air-tightness.



(10) Place thrust washer in clutch drum assembly.

NOTE

Place thrust washer with its grooved side facing the input side of clutch drum.

(11) Place pinion in clutch drum assembly while rotating it.

Installation

Place clutch drum assembly in clutch case, and install countershaft.

NOTE

Do not take forward clutch drum for reverse clutch one when assembling power direction clutch. The number of gear teeth varies between the two as shown below:

Reverse clutch drum	.....	47 teeth
Forward clutch drum	.....	46 teeth

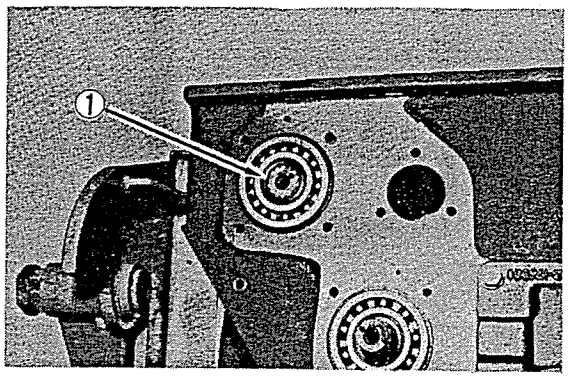
Reverse clutch bearing retainer assembly

Removal

Remove bearing retainer assembly (1) from clutch case.

NOTE

When removing the retainer assembly, take care not to permit "O" rings to fall.

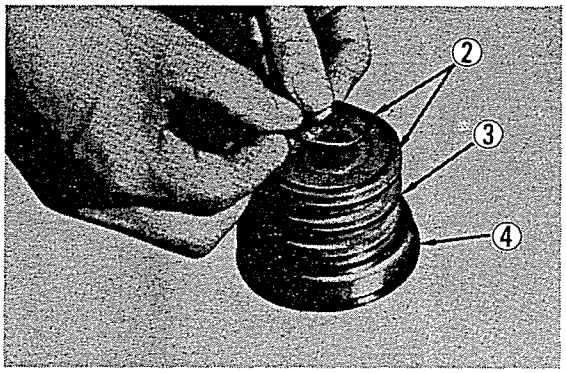


Disassembly

(1) Remove two "O" rings (2) from bearing retainer.

(2) Using a bearing puller, pull bearing (4) from bearing retainer.

(3) Remove three piston rings (3) from bearing retainer.



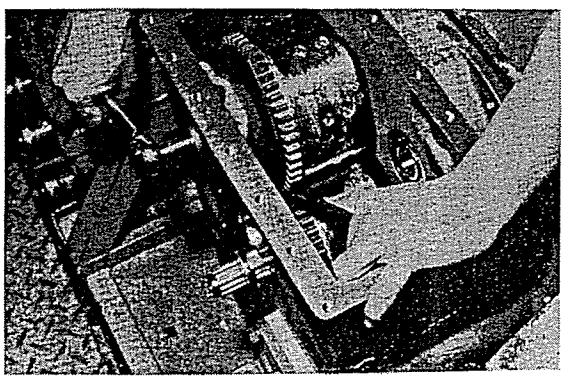
Assembly

(1) Install piston rings to bearing retainer.

(2) Using a bearing installer, press bearing into bearing retainer, and place "O" rings.

Installation

Place bearing retainer assembly in clutch case, and secure it with bolts and lock washers.



NOTES

a) It is advisable to install bearing retainer after installing countershaft.

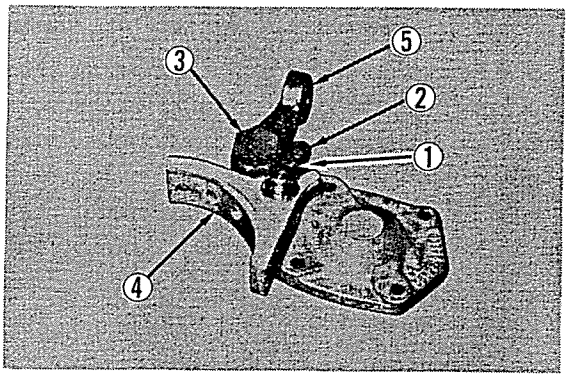
b) When assembling bearing retainer assembly and drum assembly, take care not to permit "O" rings to fall.

Clutch brake assembly

Removal

(1) Remove return spring (1), and take off brake lever stopper (2).

(2) Pull out brake lever shaft (3), and remove brake shoe (4) and brake lever (5).

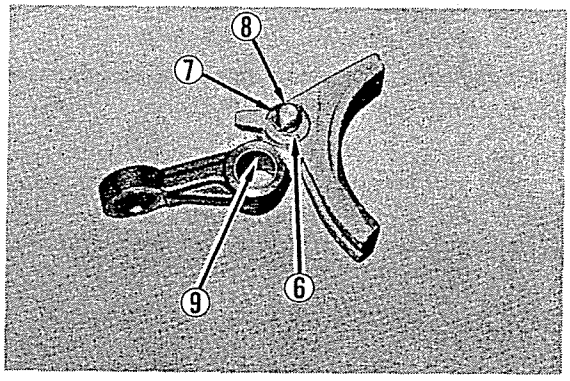


(3) Remove split pin (6), and take off washer (7) and brake shoe pin (8).

(4) Remove bushing (9) from brake lever.

NOTE

Check shoe bushing for wear, and replace it by a new one if necessary.



Installation

(1) Press bushing into brake lever.

(2) Install brake shoe and brake lever to clutch brake with brake shoe pin.

(3) Install brake lever assembly to cover, and secure brake lever shaft.

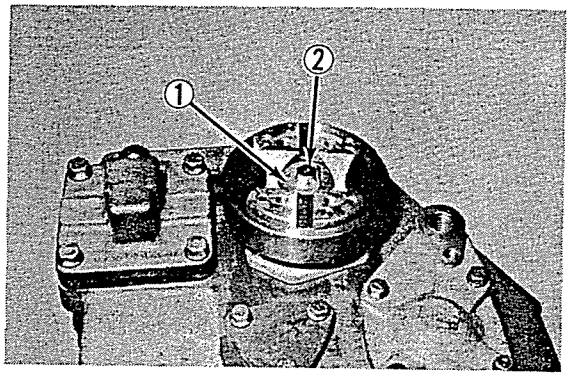
NOTE

Check brake lever for smooth movement.

Clutch brake drum assembly

Removal

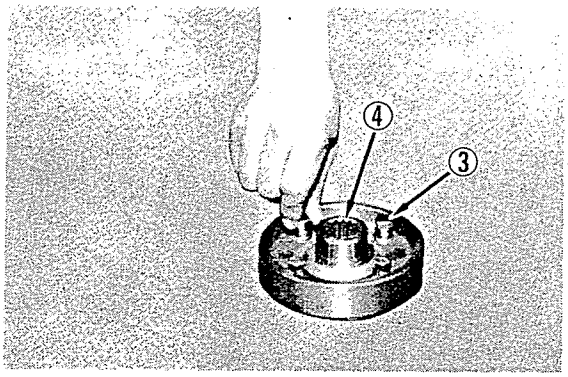
(1) Straighten lock washer (1), and loosen off bolt (2). Then, remove washer and "O" ring.



(2) Remove brake drum assembly from output shaft.

NOTE

Remove drum from coupling (4) where drum is worn and has to be replaced.



Installation

(1) Slide drum assembly onto output shaft, and put "O" ring.

(2) Place washers, tighten bolts good and hard to secure drum assembly, and bend lock washer.

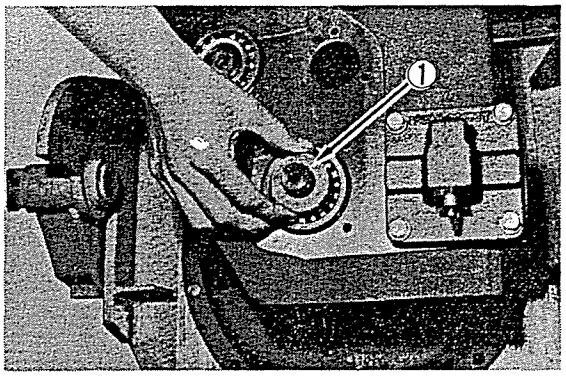
NOTE

When installing coupling, take care not to damage oil seal lip.

Output shaft assembly

Removal

(1) Loosen off four bolts securing cover in place, and remove cover and washer (1).



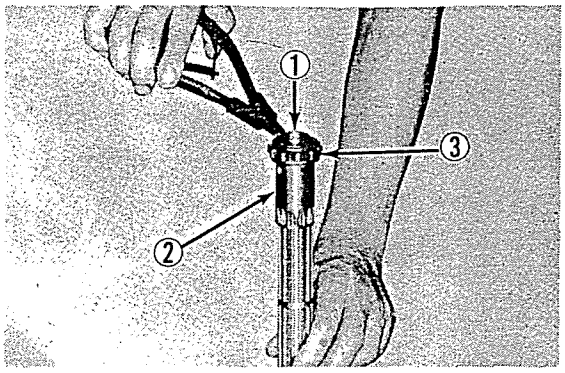
(2) Withdraw output shaft toward the input side of the clutch while holding drum.

Disassembly

(1) Remove oil seal from cover assembly.

(2) Using a snap ring pliers, remove snap ring (1) from output shaft (2).

(3) Pull bearing (3) from output shaft.



(4) Remove spring pin at the end of output shaft.

NOTE

Do not remove spring pin unless needed to be replaced by a new one.

Assembly

(1) Place oil seal in cover.

(2) Drive spring pin into output shaft.

(3) Using a bearing installer, press bearing onto output shaft.

(4) Place snap ring on output shaft.

(5) Using a snap ring pliers, install snap ring to output shaft.

Forward clutch drum assembly

This assembly may be removed, disassembled, assembled and installed by using the same procedure as for reverse clutch drum assembly.

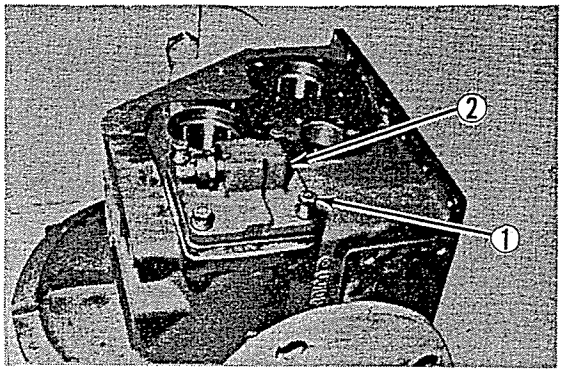
Forward clutch bearing retainer assembly

This assembly may be removed, disassembled, assembled and installed by using the same procedure as for reverse clutch bearing retainer assembly.

Filter cover assembly

Removal

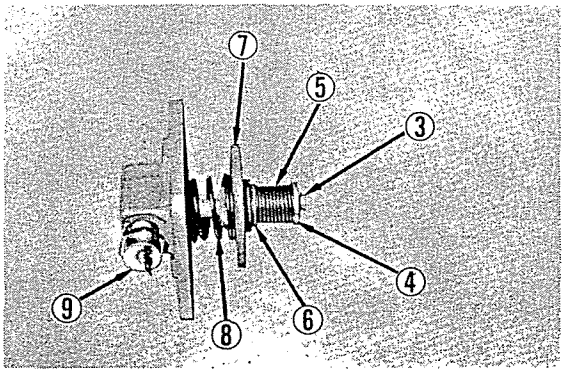
Loosen off four bolts (1), and remove filter cover assembly (2).



Disassembly

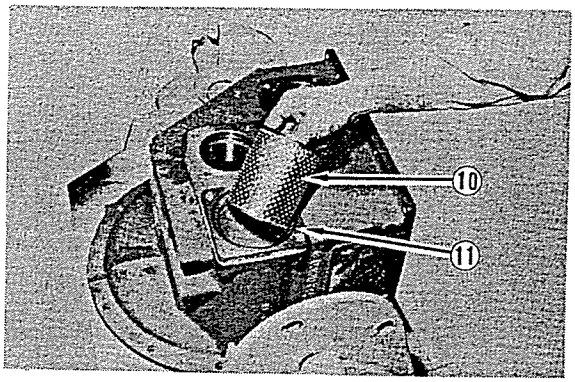
(1) Pull off split pin (3), and remove spring retainer (4), safety valve spring (5), safety valve (6), retainer (7) and spring (8).

(2) Remove oil bypass alarm switch (9) and "O" ring.



(3) Take out filter element (10).

(4) Remove filter body (11), and take two "O" rings out of the body.



Assembly

(1) Install "O" ring and oil bypass alarm switch to filter cover.

(2) Place spring on filter cover; then place retainer, safety valve, safety valve spring and spring retainer in that order, and secure them by installing split pin.

(3) Place "O" rings on filter body, and install the body to the clutch case.

(4) Place filter element in filter body.

(5) Install filter cover assembly in place.

NOTE

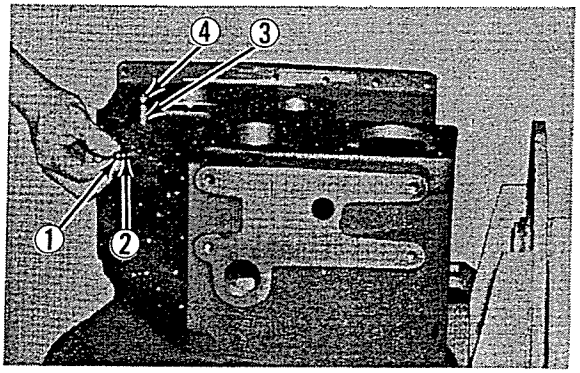
Install filter cover assembly with its marking "UP" facing upward.

Related parts

Lube oil pipe removal

(1) Remove connector (1) and "O" ring (2).

(2) Disconnect lube oil pipe (3), and remove "O" ring (4).



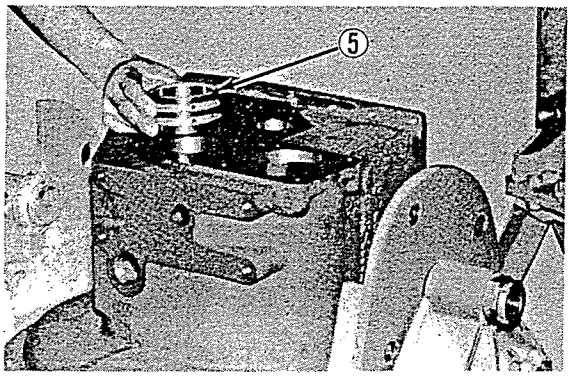
Lube oil pipe installation

(1) Place "O" ring on lube oil pipe, and connect the pipe to clutch case.

(2) Place "O" ring on connector, and connect the pipe to connector.

Piston ring race removal

Remove two piston ring races (5) from case.



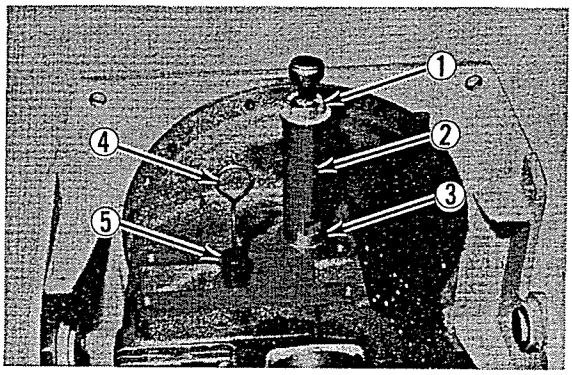
Piston ring race installation

Apply a coat of grease to the periphery of each piston ring race, and press the race into clutch case.

Plug base removal

(1) Remove breather plug (1), and take off plug base (2) and packing (3).

(2) Pull out level gauge (4), and remove pipe (5).



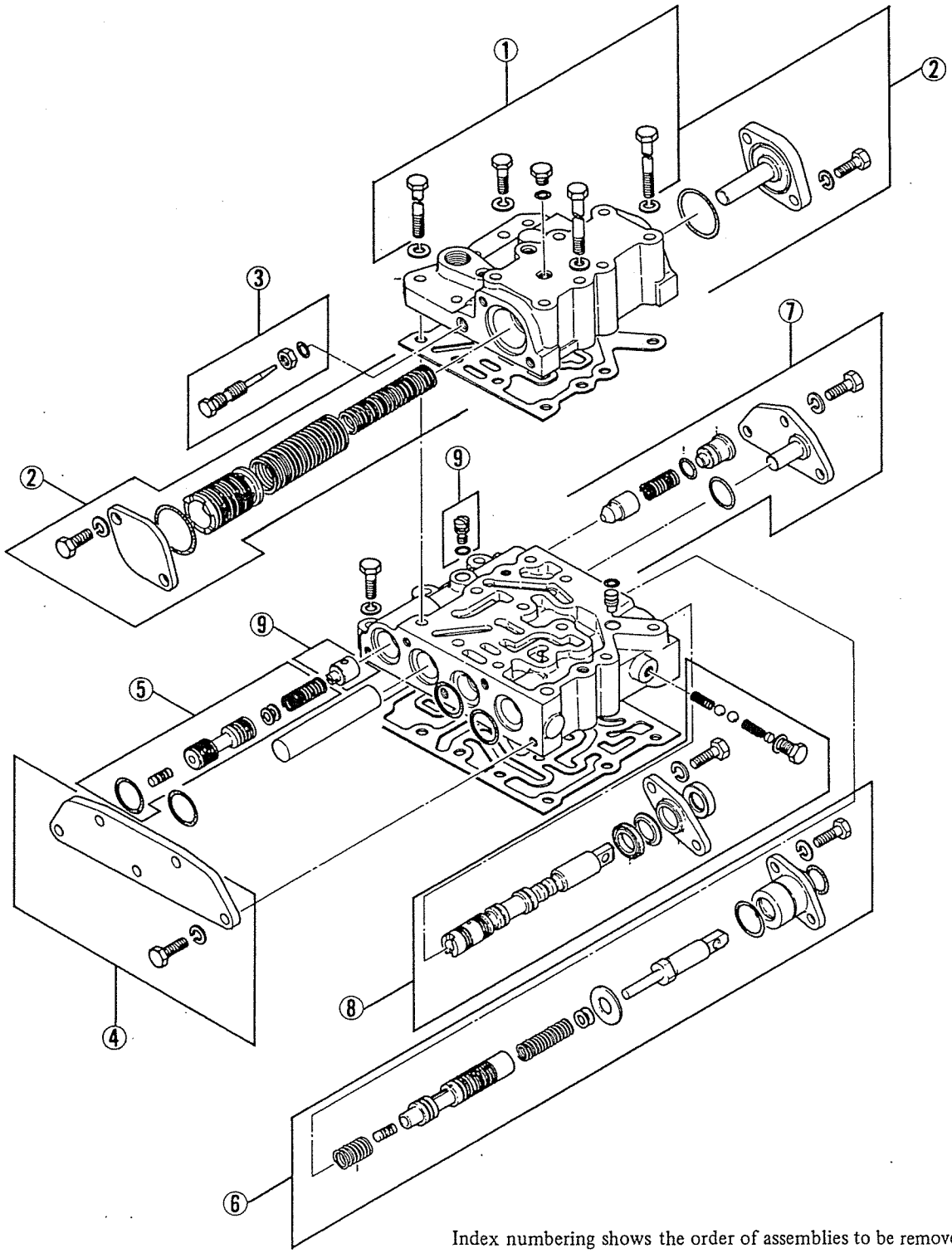
Plug base installation

(1) Place packing on plug base, and screw the base into clutch case.

(2) Temporarily screw breather plug into plug base.

(3) Apply a coat of lube oil to pipe, and press pipe into clutch case. Insert level gauge.

CONTROL VALVE



Index numbering shows the order of assemblies to be removed.

Control valve — disassembled view

Sequential steps for disassembly and assembly

Remove assemblies in the order listed below when disassembling control valve and install them in the reverse order when assembling the valve:

(1) Valve housing assembly
(2) Accumulator valve assembly
(3) Orifice assembly
(4) Cover assembly
(5) Main relief valve assembly
(6) Clutch valve assembly
(7) Lubricating relief valve assembly
(8) Directional control valve assembly
(9) Lubricating relief valve seat assembly

⚠ CAUTIONS

a) More than seventy per cent of all hydraulic system failures is caused by dirt. Dirt can ruin the close tolerances of finely finished surfaces; and a grain of sand in a small orifice can put a whole system out of operation. Assemble control valve in clean condition to keep dirt out of every part.

b) Valves and plungers are very important parts: take good care to avoid damaging them.

c) Bolts, nuts, screws and other fasteners used on control valve are all prescribed with respect to tightening torque. Be sure to use a torque wrench when tightening them and to tighten them to the prescribed torque.

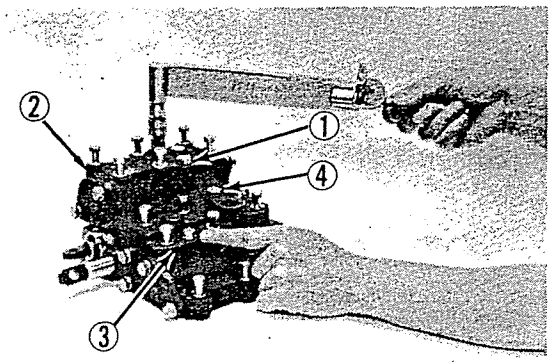
Valve housing assembly

Removal

Loosen off two bolts (1) securing upper housing (2), and remove the housing.

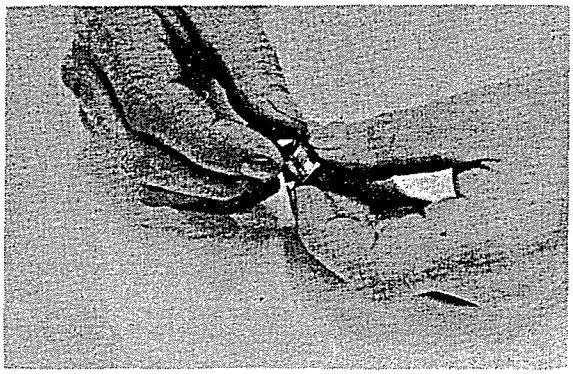
Disassembly

Remove gasket (3); then remove three "O" ring seal plugs (4) and "O" rings.



Installation

(1) Place "O" ring on each "O" ring seal plug.
(2) Install "O" ring seal plugs to valve housing.
(3) Place gasket on valve housing.
(4) Place housing, and tighten two bolts to the prescribed torque.



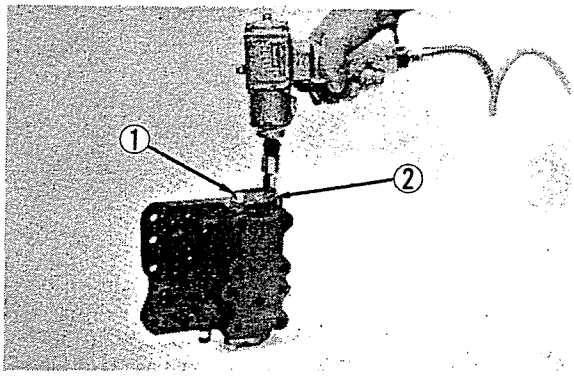
Accumulator valve assembly

Removal

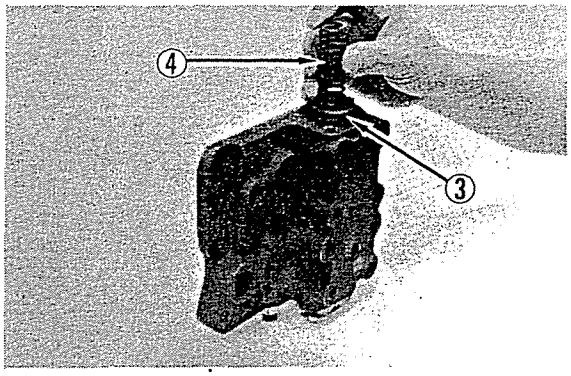
(1) Loosen two bolts (1) securing accumulator cover (A) (2), and remove the cover and "O" ring.

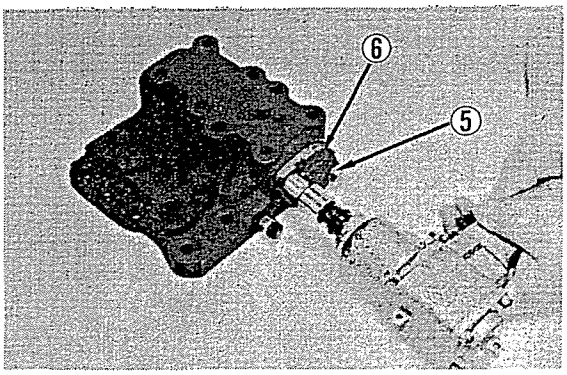
⚠ CAUTION

Two valve springs are used in accumulator valve. Remove cover (A), taking care not to allow these springs to jump out.



(2) Take out valve springs A, B (3), (4).
(3) Loosen off two bolts (5) securing cover B (6), and remove the cover and "O" ring.





Installation

(1) Place "O" ring in upper housing, and install accumulator cover B to valve housing with two bolts.

(2) Insert accumulator valve into valve housing from the side opposite to cover B.

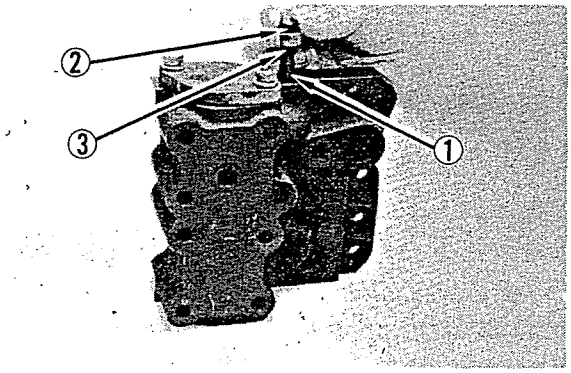
(3) Place valve springs A, B in valve housing.

(4) Place "O" ring on cover A, and install the cover to valve housing with two bolts.

Orifice assembly

Removal

Take out needle orifice (1), and remove nut (2) and "O" ring (3).



Installation

Place "O" ring and nut on needle orifice, and install orifice to valve housing.

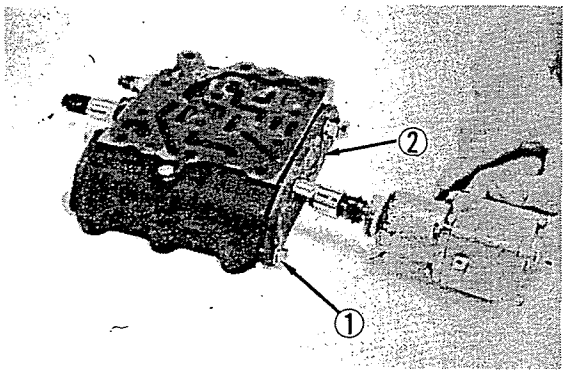
Cover assembly

Removal

Loosen off five bolts (1) securing cover (2), and remove the cover. Take out four "O" rings from inside valve housing.

NOTE

When removing cover, take care not to allow valve to jump out.



Installation

Place "O" rings in valve housing, and install cover (2) to valve housing with five bolts.

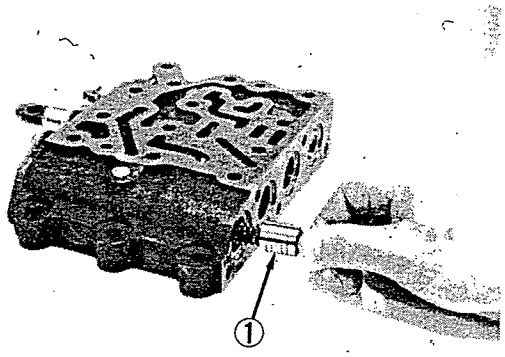
Main relief valve assembly

Removal

Take out main relief valve (1).

NOTE

When taking out main relief valve, take care not to prevent shims inside of relief valve from dropping out.

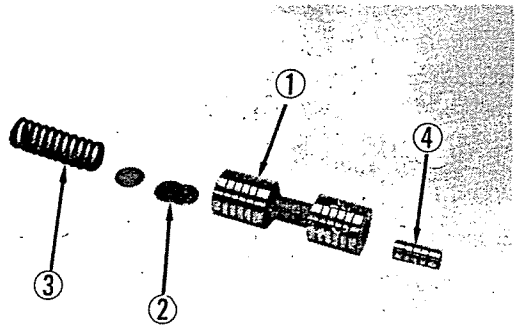


Disassembly

(1) Remove spring (3) from main relief valve (1).

(2) Remove shims (2) from main relief valve.

(3) Remove plug (4) from main relief valve.



Assembly

(1) Place plug in main relief valve.

(2) Place shims in main relief valve.

(3) Place spring in main relief valve.

Installation

Place main relief valve assembly in valve housing.

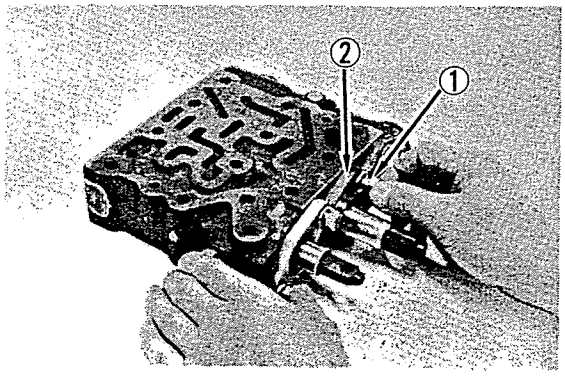
NOTE

Upon inserting main relief valve, check to make sure main relief valve moves smoothly without any sign of binding.

Clutch valve assembly

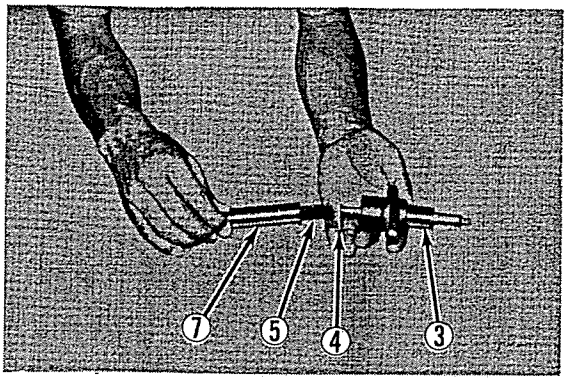
Removal

(1) Loosen off two bolts (1) securing clutch valve cover (2), and remove the cover.

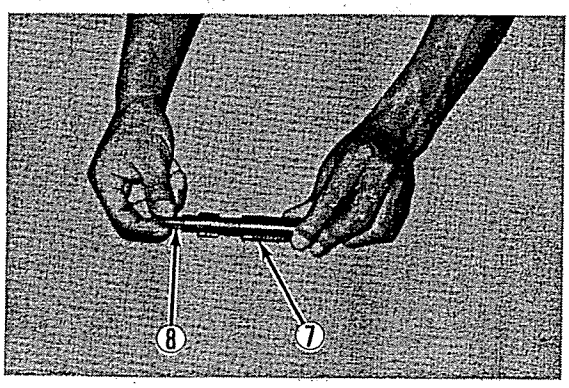


(2) Take out clutch plunger (3), spacer (4), shims, clutch valve spring A (5) and "O" rings.

(3) Remove clutch valve (7) and valve spring B.



(4) Remove plug (8) from clutch valve.

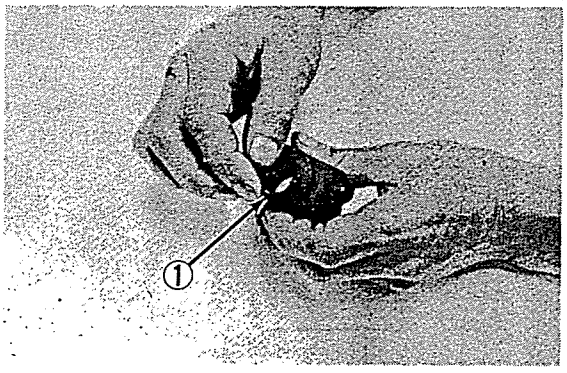


Installation

(1) Place plug in clutch valve.

(2) Place spring B in clutch valve.

(3) Place "O" rings, inside and outside, in clutch valve cover.



(4) Insert clutch valve plunger into clutch valve cover.

(5) Place shims on plunger.

(6) Place valve spring A in plunger together with spacer.

(7) Insert clutch valve into valve housing.

NOTE

Make sure, upon inserting clutch valve into valve housing, that the valve moves smoothly without any sign of binding.

(8) Install cover assembly to valve housing.

NOTES

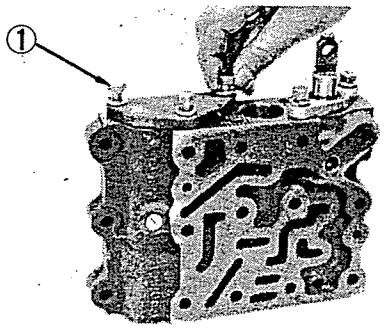
a) Install cover assembly with its hole side facing down.

b) Make sure, after installing plunger, that plunger slides smoothly within housing.

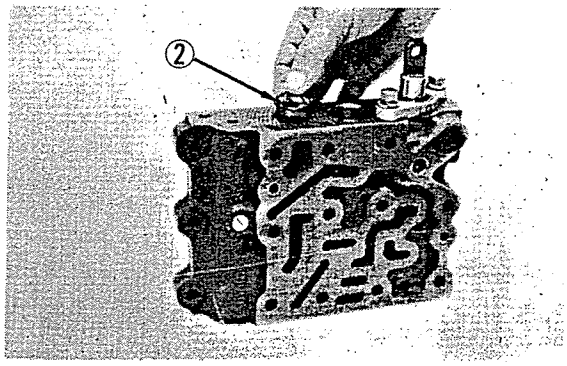
Lubricating relief valve assembly

Removal

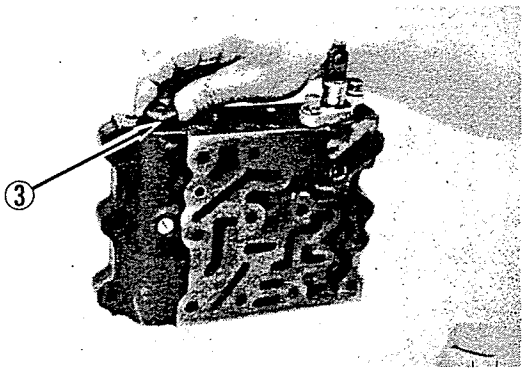
(1) Loosen off three bolts (1) securing cover, and remove cover.



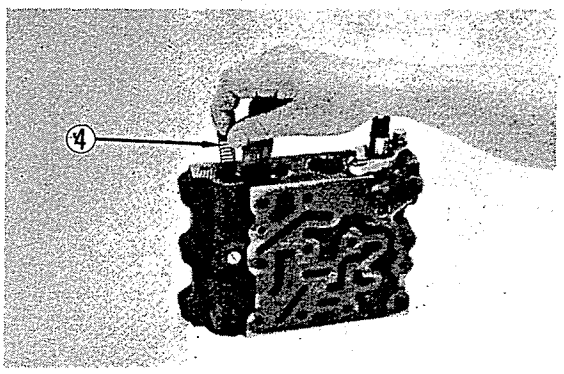
(2) Remove "O" ring (2) from valve.



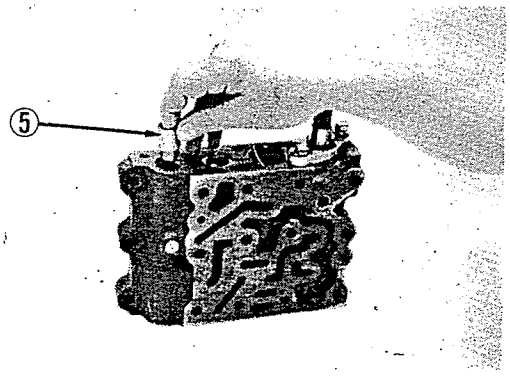
(3) Remove stopper (3) from valve.



(4) Take out relief valve spring (4) from valve housing.



(5) Take out relief valve (5).



Installation

(1) Place relief valve in housing.

NOTE

Lap relief valve in valve seat to obtain good valve seating.

(2) Place valve spring in housing.

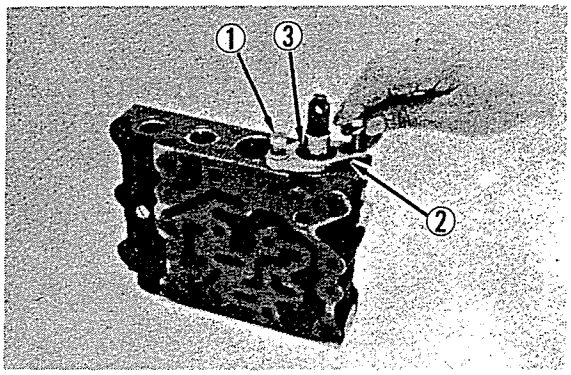
(3) Put "O" ring on stopper, and place stopper in housing.

(4) Place "O" ring in housing, and install pilot valve cover to housing.

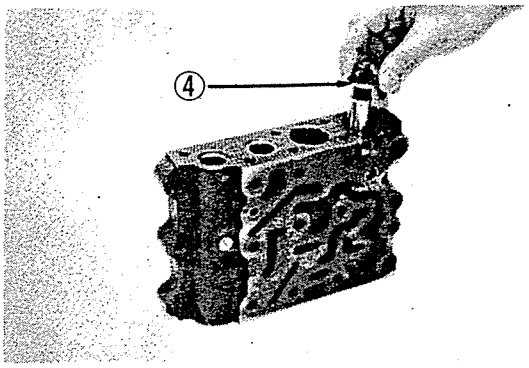
Directional control valve assembly

Removal

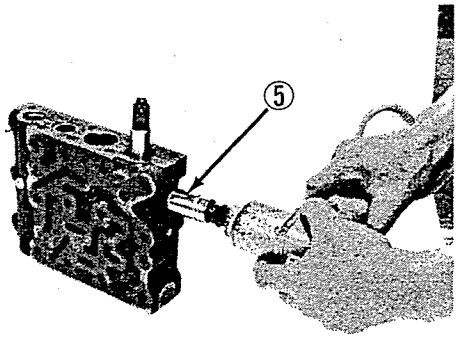
(1) Loosen off two bolts (1) securing cover (2), and remove the cover and dust seal (3).



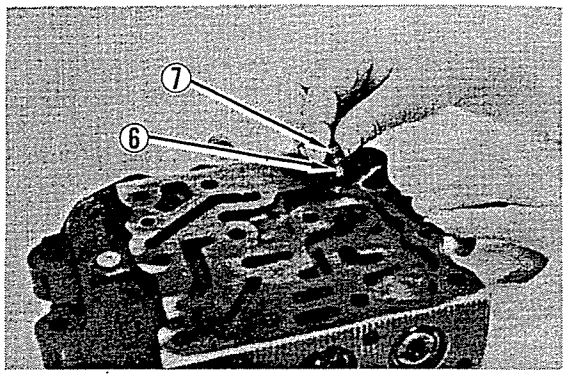
(2) Remove back-up ring (4) from relief valve.



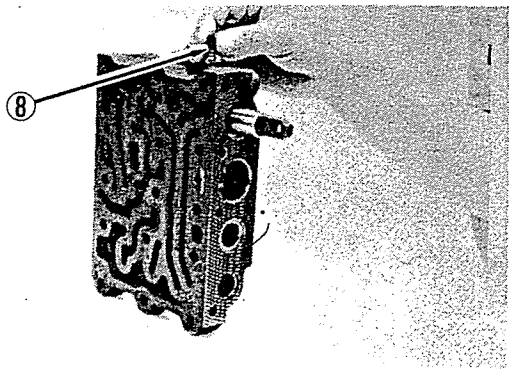
(3) Remove drain plug (5).



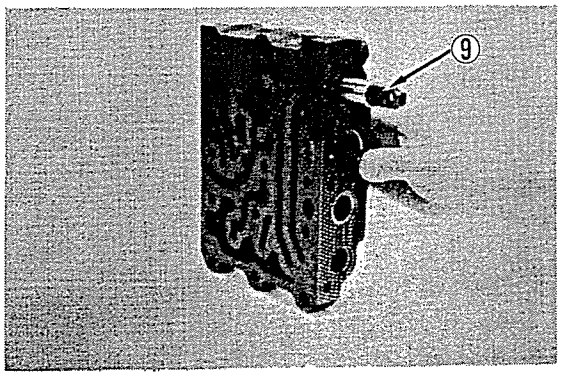
(4) Take off stopper (6), and remove "O" ring (7) from the stopper.



(5) Take out spacer and plunger lock spring (outer) (8).



(6) Push out operating plunger (9). Remove packing from valve housing, and take out two steel balls and plunger lock spring (inner).



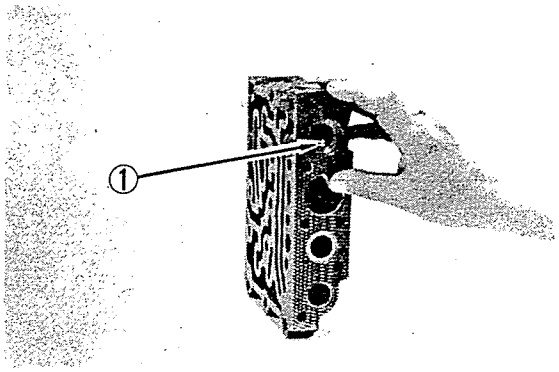
Installation

(1) Insert operating plunger into valve housing halfway, and place plunger lock spring (inner) and one steel ball (1). While pressing steel ball, slowly insert operating plunger.

NOTE

Before placing lock springs and steel balls, temporarily insert operating plunger into valve housing, and slide the plunger therein, making

sure that it moves smoothly without any sign of binding.



(2) Place another steel ball, plunger lock spring (outer) and spacer in valve housing, and install drain plug with packing.

(3) Install stopper complete with "O" ring to valve housing.

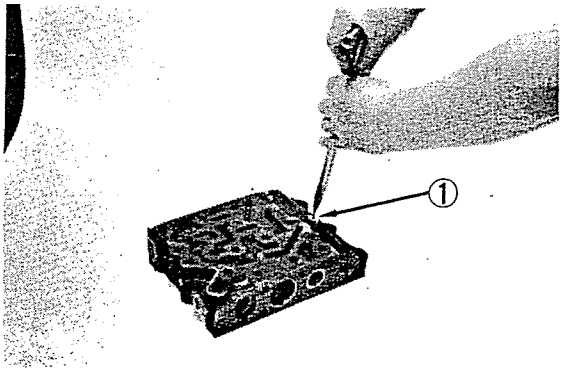
(4) Install packing and back-up ring.

(5) Install cover complete with dust seal to valve housing.

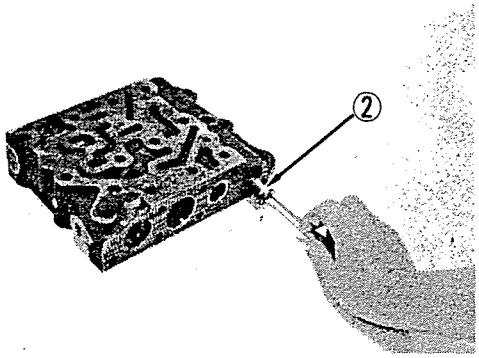
Lubricating relief valve seat assembly

Removal

(1) Loosen off screw pin (1), and take out "O" ring.



(2) Take out valve seat (2).



Installation

Place valve seat in valve housing, and run in screw pin complete with "O" ring.

UNIVERSAL JOINT

Removal

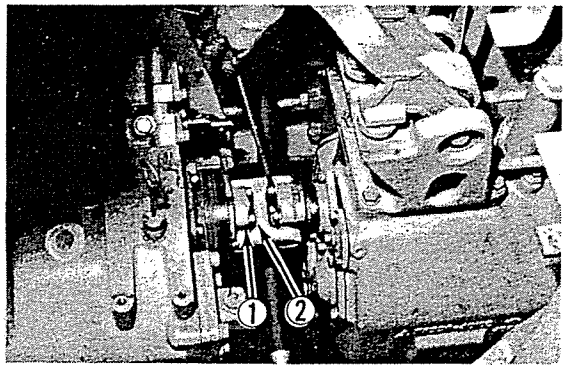
Preparatory steps

(a) Remove platform, operator's seat and seat bracket.

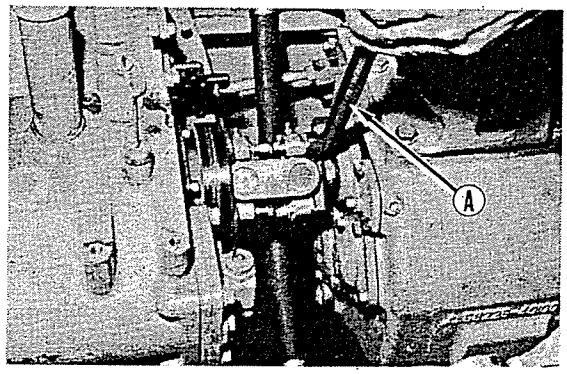
(b) Remove clutch pedal.

Procedure

(1) Loosen off eight bolts (2) at coupling (1).



(2) Insert a bar (A) into between coupling and universal joint bearing, and separate universal joint.



Installation

Procedure

Connect coupling by tightening eight bolts.

Subsequent steps

(a) Install clutch pedal.

(b) Install platform, operator's seat and seat bracket.

CAUTION

Do not press universal joint excessively toward the transmission side; otherwise the expansion plug will come out of coupling.

TRANSMISSION

Removal

Preparatory steps

(a) Drain transmission case.

(b) Remove platform, operator's seat and seat bracket.

(c) Disconnect linkages from steering clutch levers (1), universal joint (2) and brake pedal (3).

CAUTION

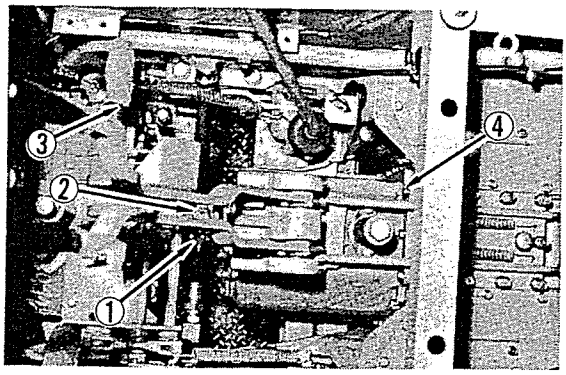
After removing steering clutch levers, cover up transmission case to prevent foreign matter from getting inside the case.

Procedure

Attach lifting slings to transmission. Loosen off bolts (4), and lift transmission off the chassis.

WARNING

When lifting off transmission, make sure the slings are attached securely. Severe injury to personnel and destruction of transmission will result if transmission breaks away from the slings.



Installation

Procedure

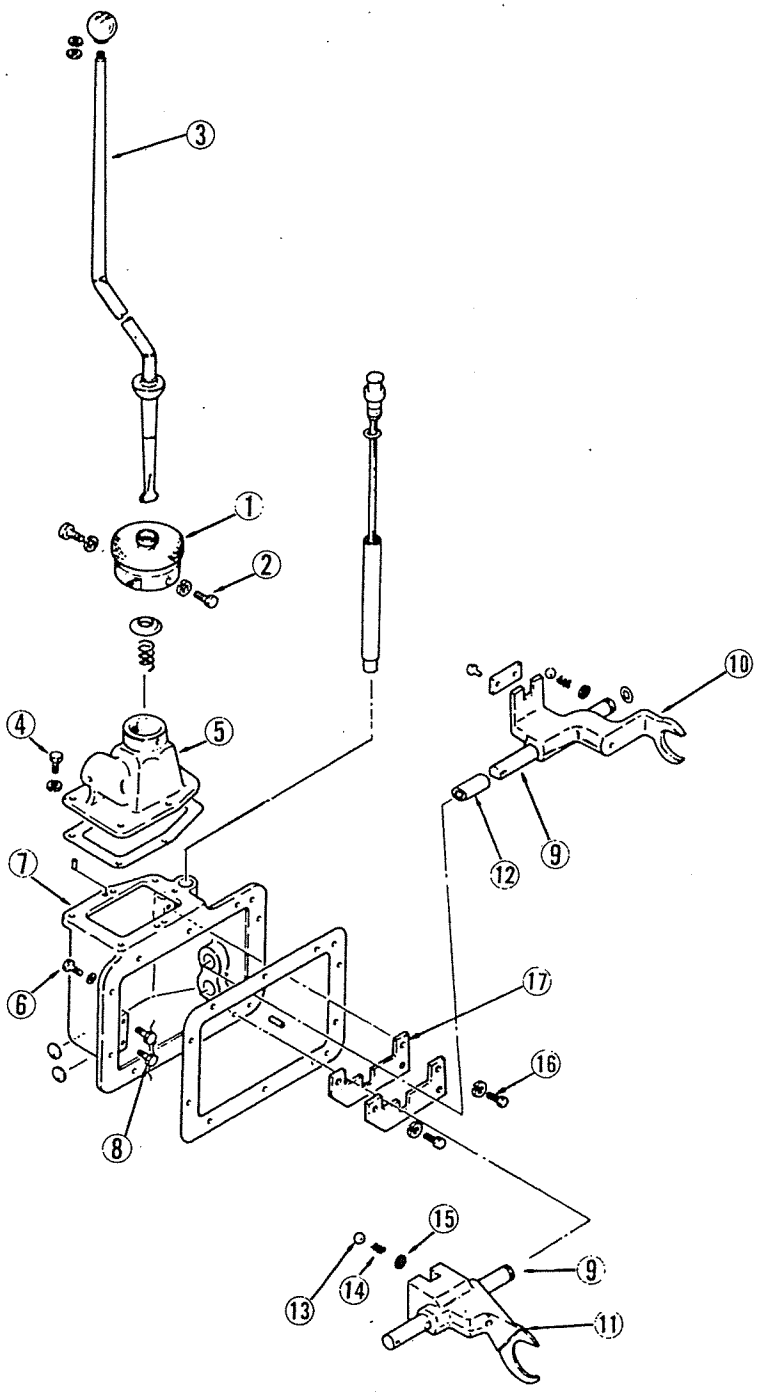
Install transmission to steering clutch case.

Subsequent steps

(a) Connect brake pedal linkage, universal joint and steering clutch levers.

(b) Install platform, operator's seat and seat bracket.

Disassembly



1-Dust cover
2-Bolt with washer (2 pcs each)
3-Gearshift lever
4-Bolt with washer (6 pcs each)
5-Bracket
6-Bolt with washer (10 pcs each)
7-Lever case
8-Set bolt (2 pcs)
9-Shaft (2 pcs)
10-Fork
11-Fork
12-Pipe
13-Steel ball
14-Spring
15-Strainer
16-Bolt with washer (3 pcs each)
17-Guide

Transmission control – disassembled view

NOTE

Gearshift lever and lever case can be removed with transmission on the machine.

Preparatory step

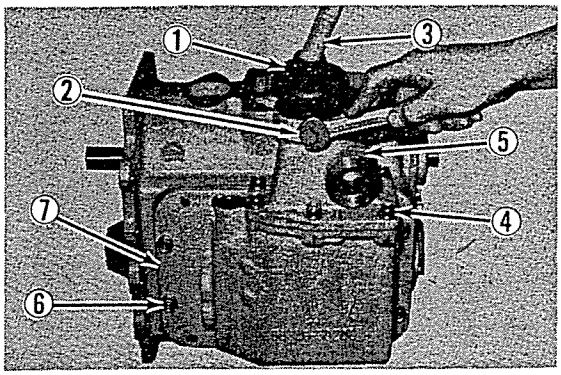
Mount transmission on an overhaul stand or, if the stand is not available, on wooden blocks to have disassembling work done safer and better.

Procedure

(1) Loosen off two bolts (2) at dust cover (1), and remove gearshift lever (3).

(2) Loosen off six bolts (4) securing bracket (5), and remove the bracket.

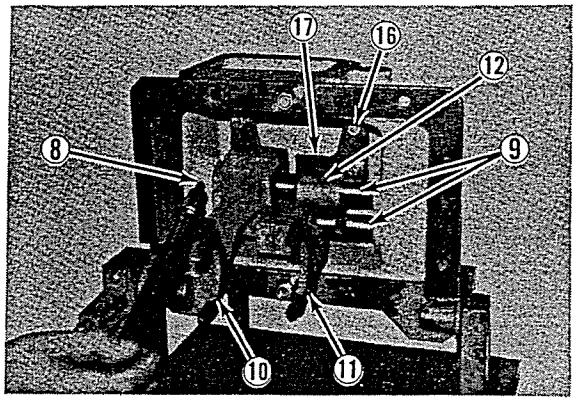
(3) Loosen off ten bolts (6) (the two among these bolts are located inside the transmission case) securing lever case (7), and remove the case.



(4) Loosen off two set bolts (8); pull out two shafts (9); and remove forks (10) (11) and pipe (12). Remove "O" ring from one end of each shaft if necessary.

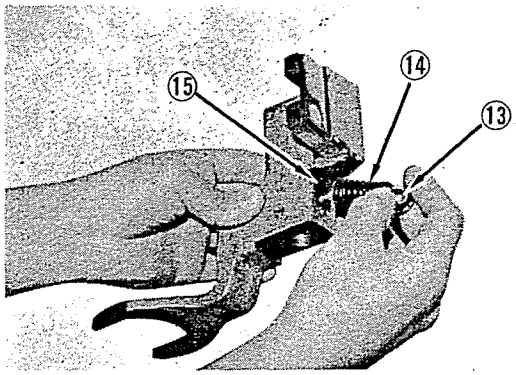
NOTE

Shafts and forks are set aside in groups respectively so that the same combination or set as before can be reproduced at the time of assembly.



(5) Loosen off three bolts (16) securing guide (17), and remove the guide.

(6) Take out steel ball (13), spring (14) and strainer (15).



Assembly

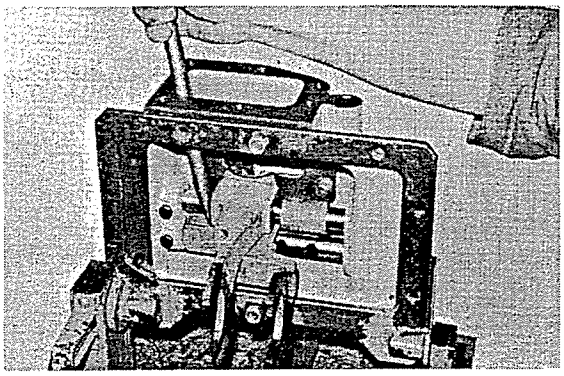
(1) Place strainer, spring and steel ball in fork.

(2) Install guide to lever case, and install fork, pipe and shaft to the case.

(3) Secure each shaft by tightening set bolt.

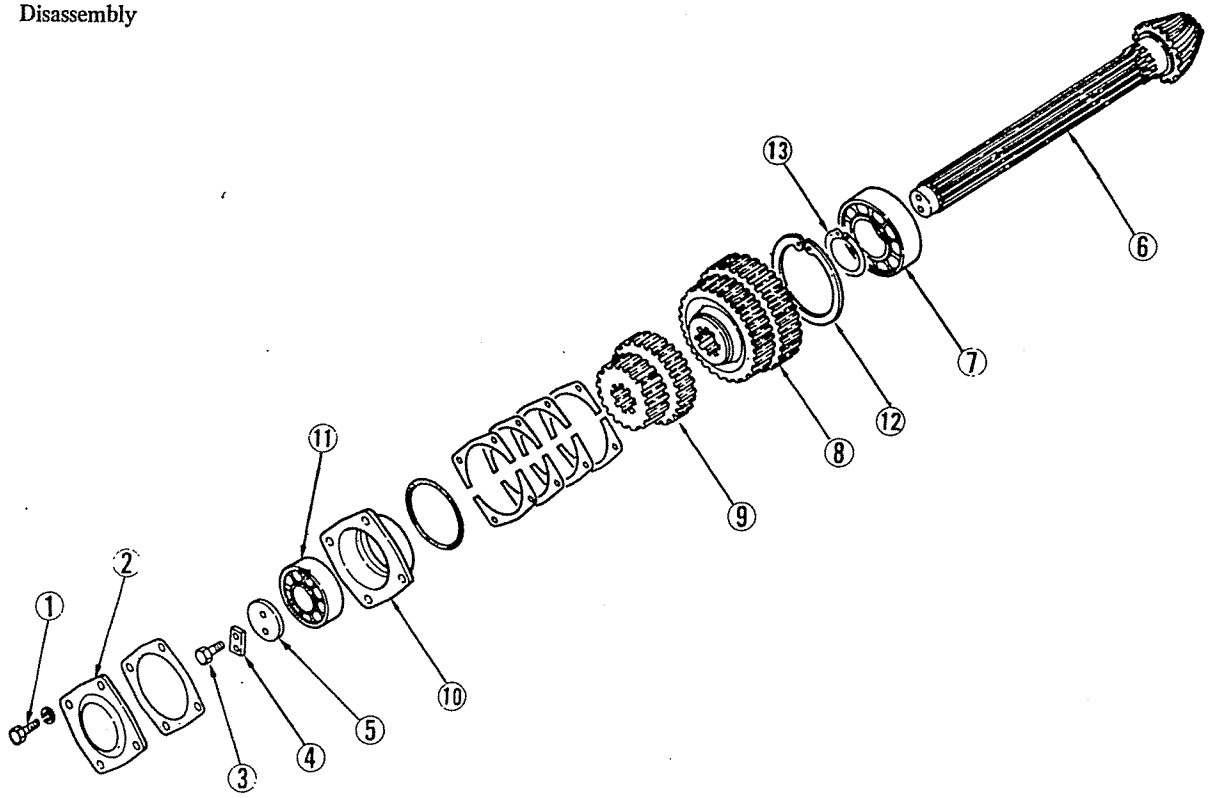
(4) Install each fork to shaft in alignment with groove in shaft so that it is held in neutral position.

(5) Install lever case to transmission case, and attach gearshift lever complete with bracket.



Bevel pinion shaft assembly

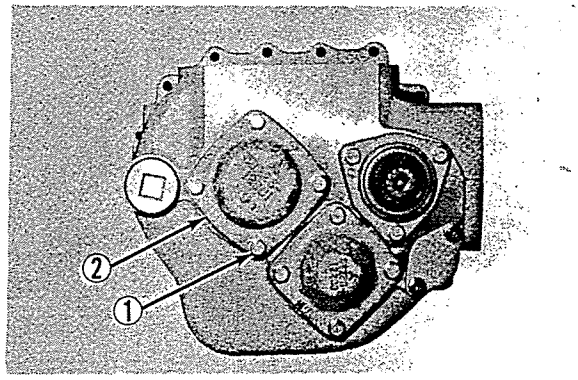
Disassembly



1-Bolt with washer (4 pcs each)
2-Cover
3-Bolt (2 pcs)
4-Lock plate
5-Washer
6-Bevel pinion shaft
7-Roller bearing
8-1st-speed & 2nd-speed sliding gear
9-3rd-speed & 4th-speed sliding gear
10-Bearing cage
11-Ball bearing
12-Snap ring
13-Snap ring

Bevel pinion shaft — disassembled view

(1) Loosen off four bolts (1) securing cover (2), and remove the cover.



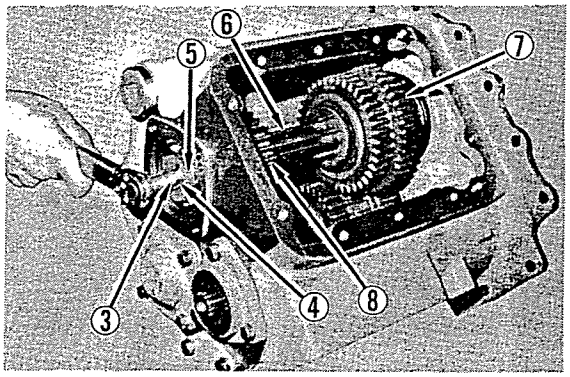
(2) Loosen off two bolts (3), and remove lock plate (4) and washer (5).

(3) Pull out bevel pinion shaft (6).

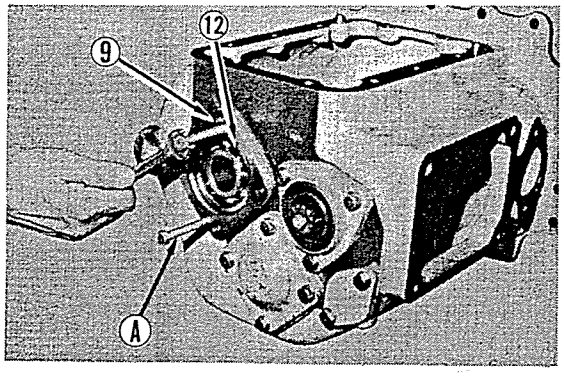
CAUTION

Be careful not to damage sliding gears when pulling out bevel pinion shaft.

(4) Remove 1st-speed & 2nd-speed gear (7) and 3rd-speed & 4th-speed gear (8) from bevel pinion shaft.



(5) Using service bolts (A), pull out bearing cage (9) complete with ball bearing (12). Remove the bearing from the cage if necessary.



(6) Take out snap ring and roller bearing outer race from inside the transmission case.

(7) Pull roller bearing inner race from bevel pinion shaft by removing snap ring.

Assembly

(1) Place snap ring in transmission case, and press roller bearing outer race in position.

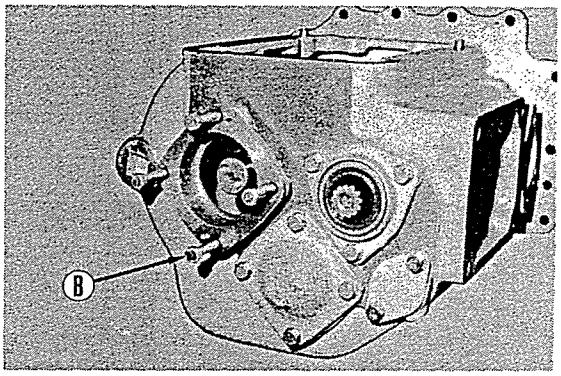
(2) Press roller bearing inner race onto bevel pinion shaft, and secure the race with snap ring.

(3) Place bevel pinion shaft in transmission case from the clutch-case side while installing two sliding gears to the shaft.

(4) Place "O" ring on bearing cage, and press the cage, with shims, into transmission case.

NOTE

Before pressing bearing cage, correctly align bolt holes in the cage with those in transmission case, using a service bolt (B).

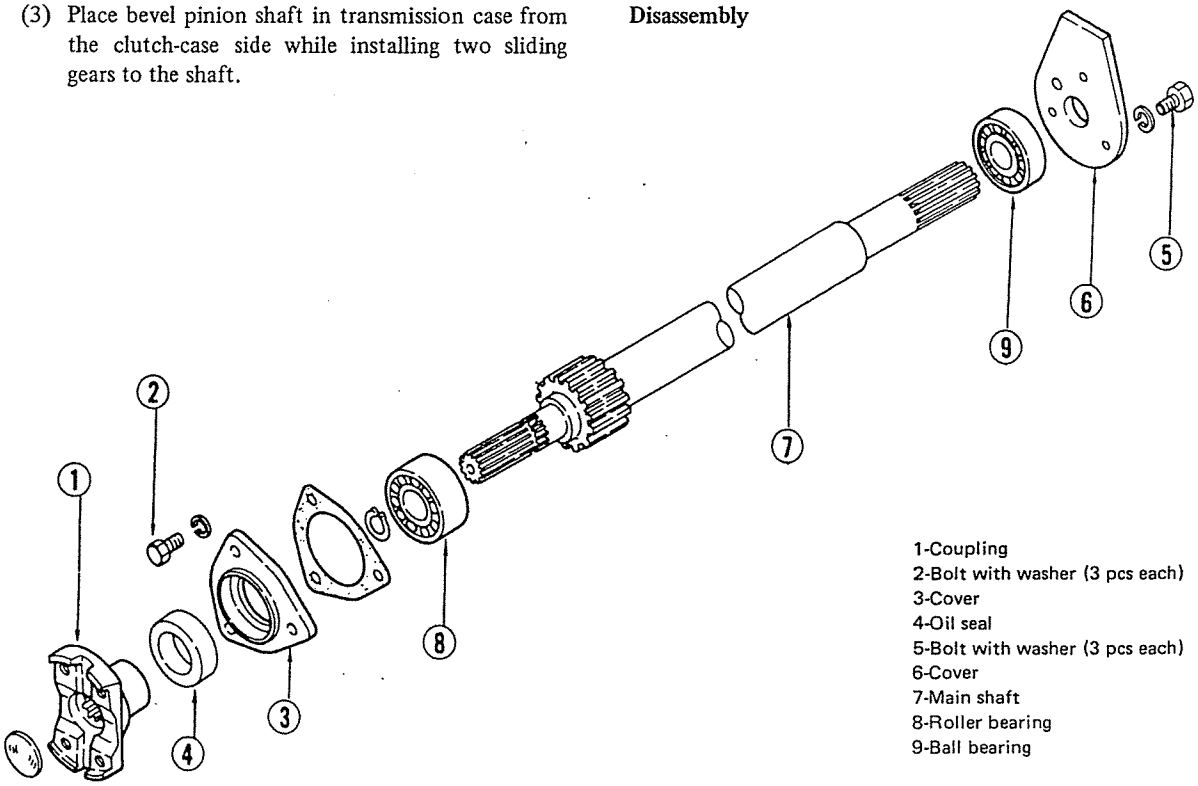


(5) Press ball bearing into cage, and secure bevel pinion shaft with bolts, lock plate and washer.

(6) Install cover complete with gasket to transmission case with four bolts.

Main shaft assembly

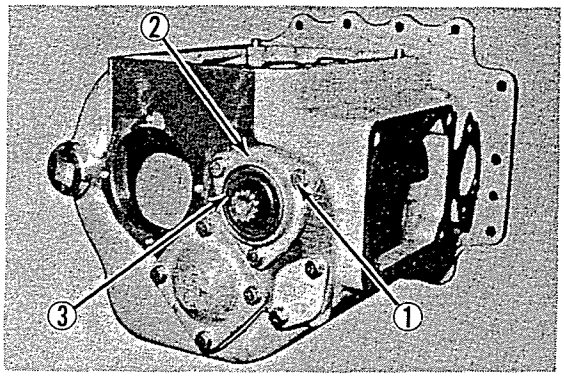
Disassembly



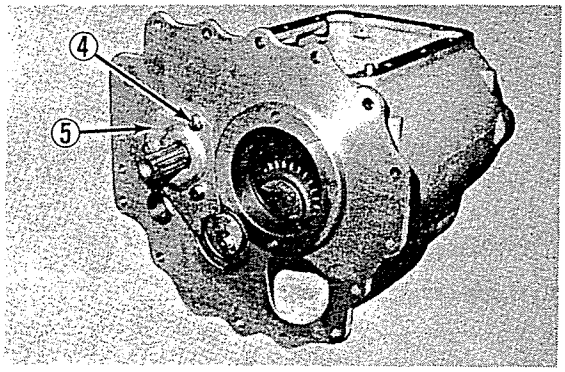
1-Coupling
2-Bolt with washer (3 pcs each)
3-Cover
4-Oil seal
5-Bolt with washer (3 pcs each)
6-Cover
7-Main shaft
8-Roller bearing
9-Ball bearing

Main shaft – disassembled view

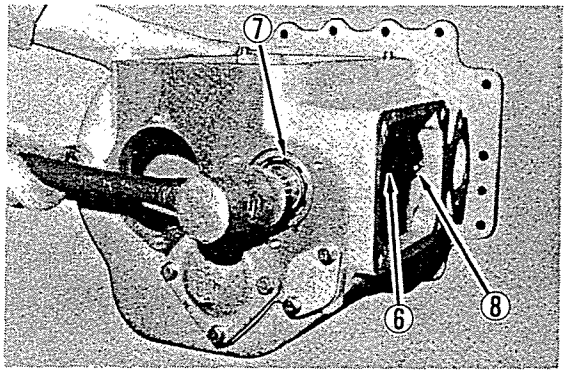
(1) Loosen off three bolts (1) securing cover (2) in place, and remove the cover and oil seal (3).



(2) Loosen off three bolts (4) securing cover (5) in place, and remove the cover.



(3) Using a soft-faced hammer or a mallet, give blows to the engine-side end of main shaft (6), thereby removing the shaft complete with inner race of roller bearing (7) and ball bearing (8) from transmission case.



(4) Remove roller bearing and ball bearing from main shaft.

(5) Pull roller bearing outer race from transmission case.

CAUTION

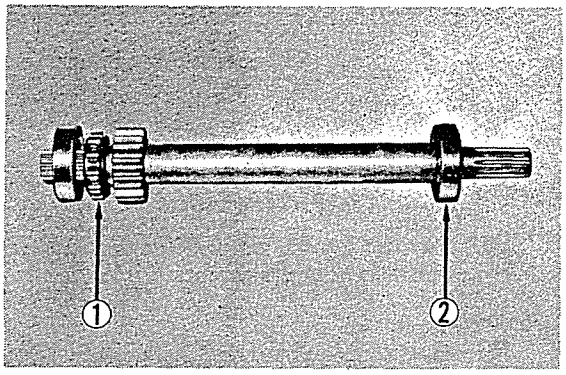
When removing main shaft, take care not to damage the bearings.

Assembly

(1) Press roller bearing and ball bearing onto main shaft.

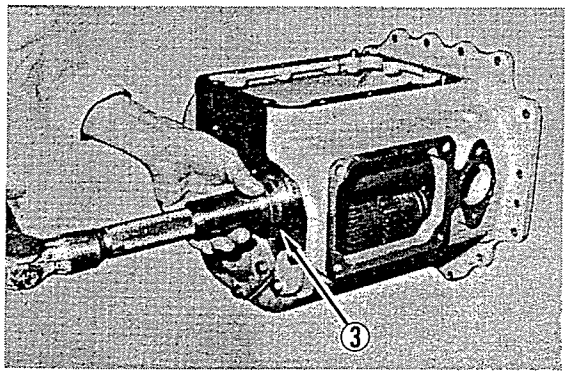
NOTE

Install roller bearing (1) to the gear side of main shaft and ball bearing (2) to another side.



(2) Using a soft-faced hammer or a mallet, drive main shaft into transmission case until roller bearing inner race is pressed in but not completely.

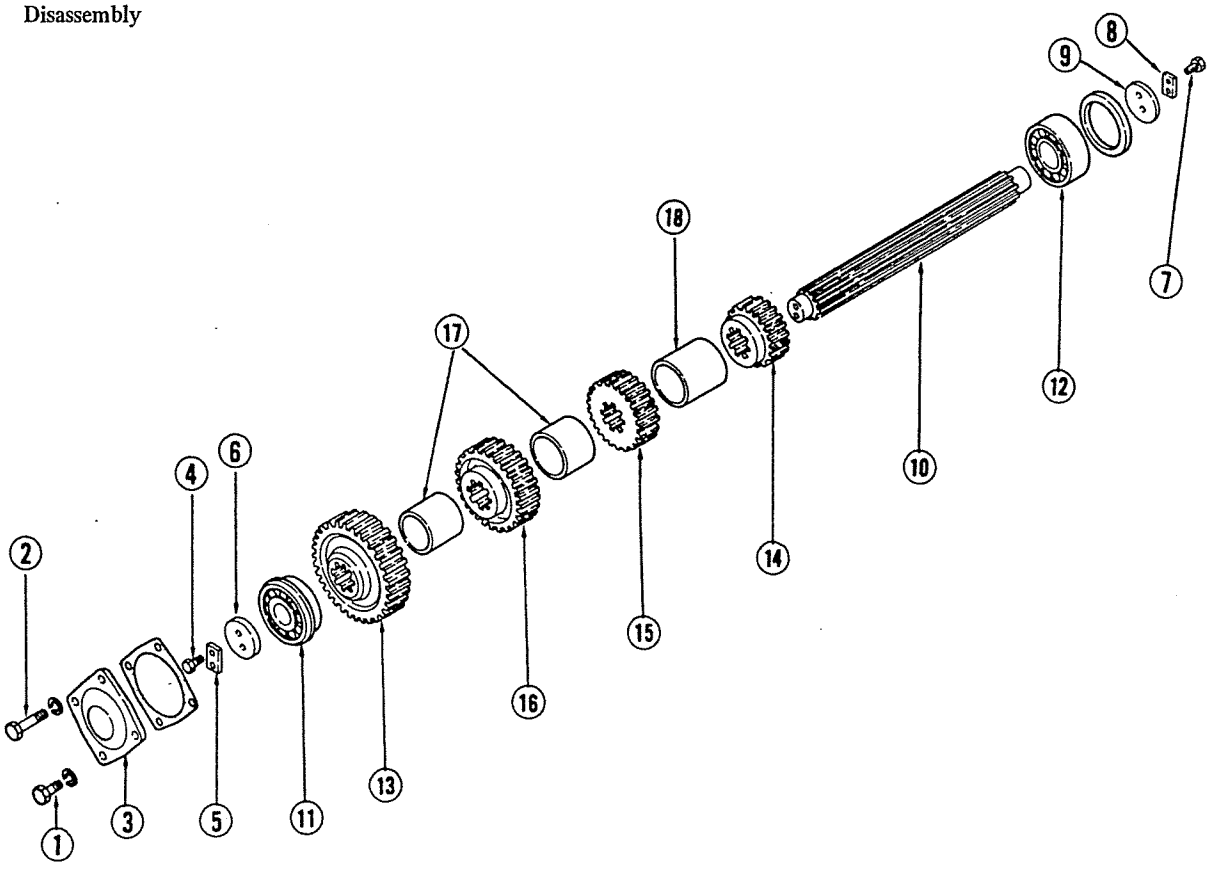
(3) Press roller bearing outer race (3) into transmission case.



(4) Install front and rear covers and coupling.

Countershaft assembly

Disassembly



1-Bolt with washer (3 pcs each)
2-Bolt with washer
3-Cover
4-Bolt (2 pcs)
5-Lock plate
6-Washer
7-Bolt (2 pcs)
8-Lock plate
9-Washer
10-Countershaft
11-Ball bearing
12-Roller bearing
13-Drive gear
14-1st-speed gear
15-2nd-speed gear
16-3rd-speed gear
17-Spacers (2 pcs)
18-Spacer

Countershaft — disassembled view

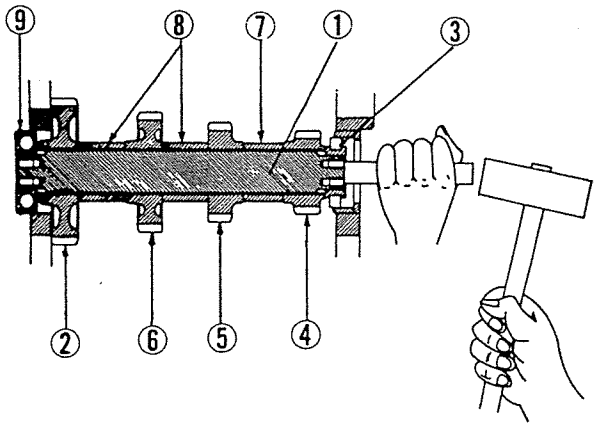
(1) Remove cover, and take off lock plate and washer at both ends of countershaft.

(2) Using a hammer and a tool, give a push to the clutch case-side end of countershaft (1) as shown. Drive gear (2) will be pressed against the inner wall of transmission case and, at the same time, the inner race of roller bearing (3) will be removed from the shaft.

(3) Take out countershaft from transmission case, and remove 1st-speed gear (4), 2nd-speed gear (5), 3rd-speed gear (6), drive gear (2) and spacers (7) (8) from the shaft.

(4) Remove ball bearing (9) from countershaft.

(5) Remove spacer and outer race of roller bearing (3) from transmission case.



Assembly

(1) Place countershaft in transmission case, and install four gears and three spacers to the shaft therein.

(2) Press ball bearing and roller bearing inner races onto countershaft from the engine side and from the clutch-case side, respectively.

(3) Press roller bearing outer race and spacers.

(4) Secure countershaft in place with lock plates and washers, and install cover complete with gasket by bolting.

STEERING CLUTCHES AND BRAKES

Removing brake drums and clutch shifters

Preparatory steps

(a) Remove operator's seat and seat bracket.

(b) Remove steering clutch levers and brake pedal.

Procedure

(1) Loosen off twelve bolts securing cover, and remove cover.

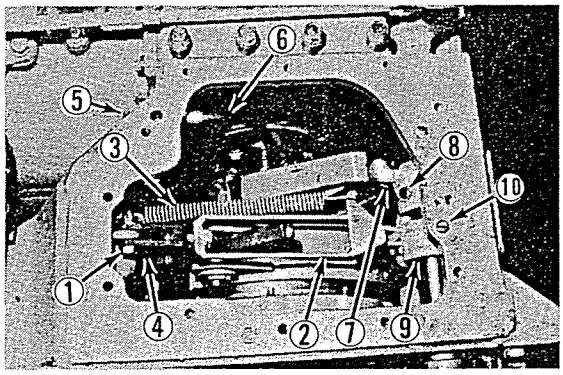
NOTE

Take out desiccant from inside the clutch case.

(2) Remove bolt (1), and separate arm (2) and spring (3). Loosen off set bolt (4).

(3) Remove grease fitting (nipple) (5), and disconnect hose (6) from clutch case.

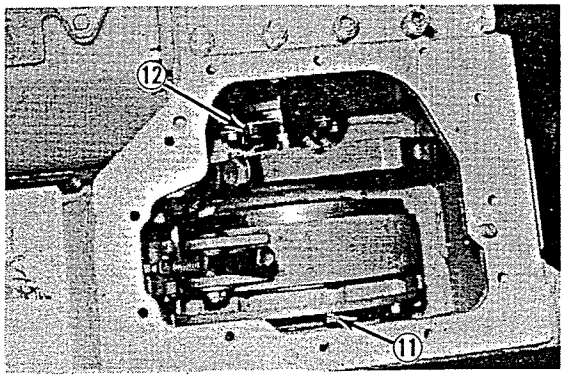
(4) Remove set bolt (8) of cam (7) and set screw (10) of lever (9).



(5) Attach a lifting sling to tie pin, and have clutch drum and shifter suspended.

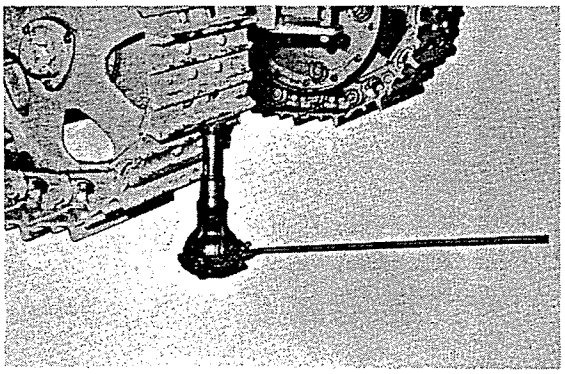
(6) Loosen off ten bolts (11) to separate final drive pinion from drum.

(7) Loosen off eight bolts (12) to separate drive shaft from shaft.

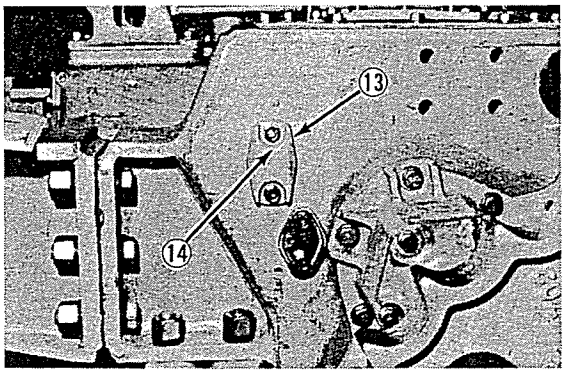


NOTE

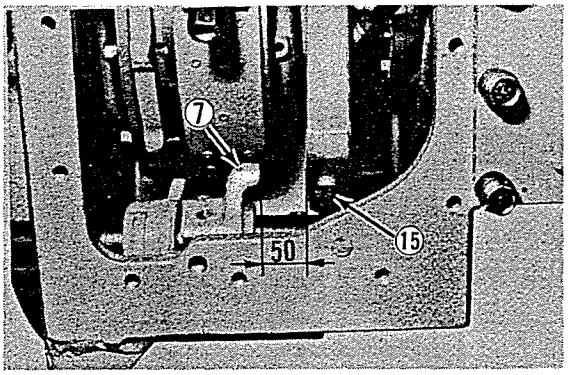
It is advisable, when removing bolts (11) (12), to move the track with a jack as shown to facilitate removal of the bolts.



(8) Remove cover (13), and pull out shaft (14).

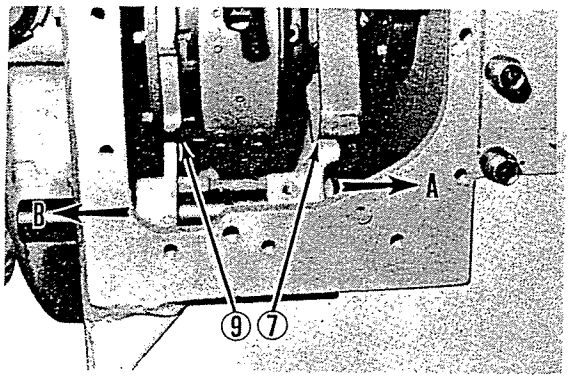


(9) Displace cam (7) in the direction of arrow to obtain about 50 mm (2 in.) in the clearance between the cam yoke roller (15).



(10) Lift clutch assembly within clutch case. Remove bolt from socket, and plumb up yoke. Displace cam (7) all the way in the direction of arrow A (toward the bevel gear side) and lever (9) in the

direction of arrow B (toward the final drive side), and lift off steering clutch complete with brake and yoke.



Installing brake drums and clutch shifters

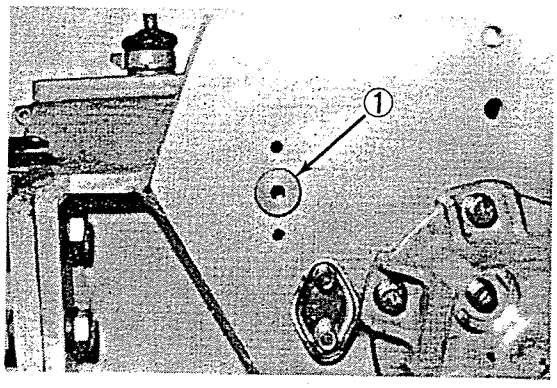
Procedure

(1) Place steering clutch complete with brake and yoke in clutch case.

(2) Install shaft (1) to brake lever.

(3) Install final drive pinion to drum.

(4) Connect drive shaft to shaft.



(5) Install set bolt and set screw.

(6) Connect hose to clutch case, and install grease fitting.

(7) Screw set bolt, and install arm and spring.

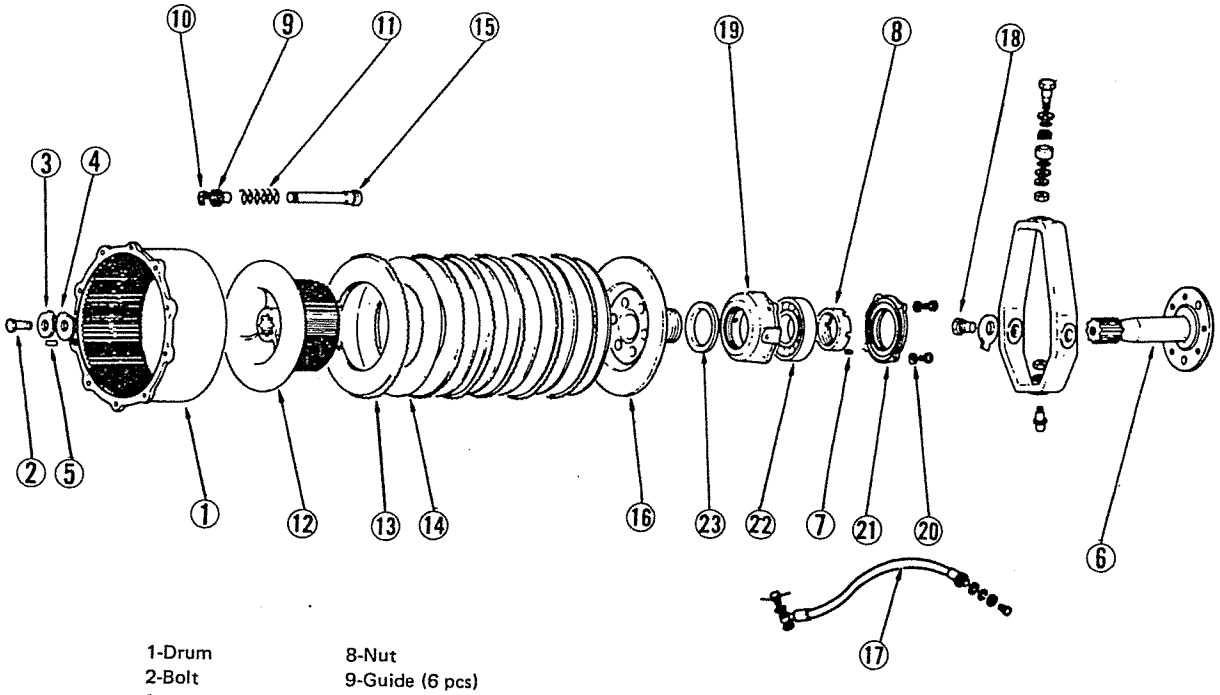
(8) Install cover with twelve bolts.

Subsequent steps

(a) Install steering clutch levers and brake pedal.

(b) Install operator's seat bracket and seat.

Disassembling clutch and yoke



1-Drum
2-Bolt
3-Lock washer
4-Washer
5-Spring pin
6-Shaft
7-Set screw
8-Nut
9-Guide (6 pcs)
10-Retainer (6 pcs)
11-Spring (6 pcs)
12-Drum
13-Plate (6 pcs)
14-Plate (6 pcs)
15-Pin (6 pcs)
16-Plate
17-Hose
18-Bolt (2 pcs)
19-Shifter
20-Bolt with washer (4 pcs each)
21-Seal case
22-Bearing
23-Seal

Clutch and yoke — disassembled view

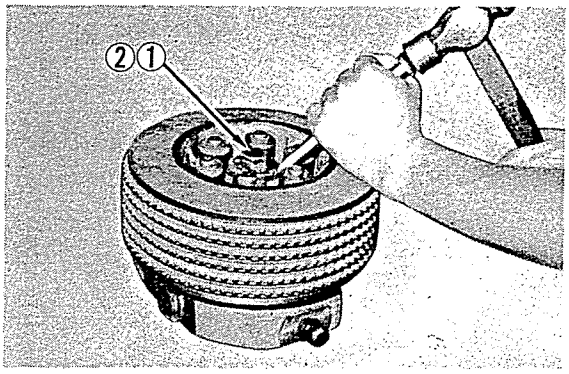
Tool required

Tool name	Tool number	Qt.
Steering clutch tool	58609-01900	1

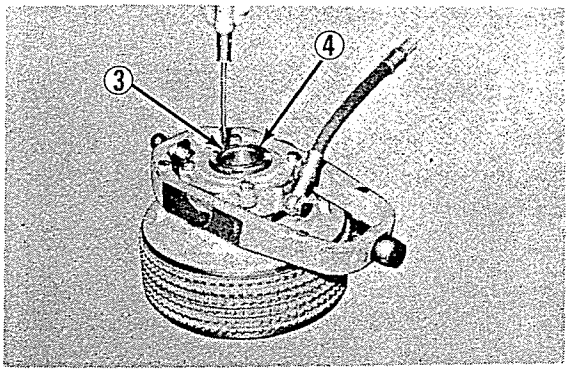
Procedure

(1) Remove drum and brake band.

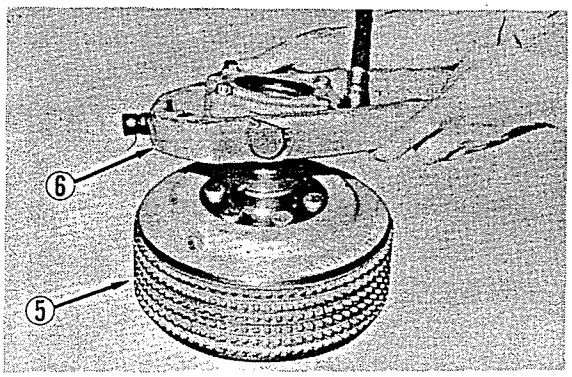
(2) Straighten lock washer under bolt (1). Loosen off the bolt, and pull out shaft (2).



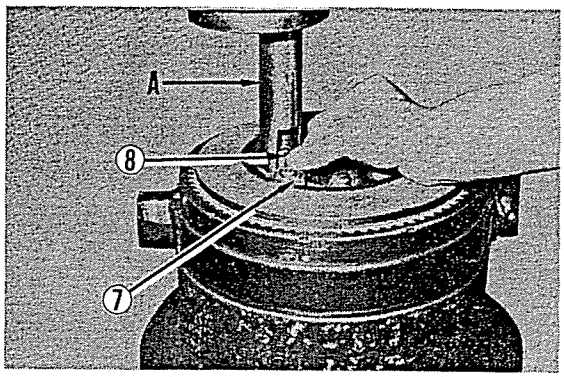
(3) Loosen off set screw (3), and remove nut (4).



(4) Remove yoke assembly (6) from clutch plate assembly (5).



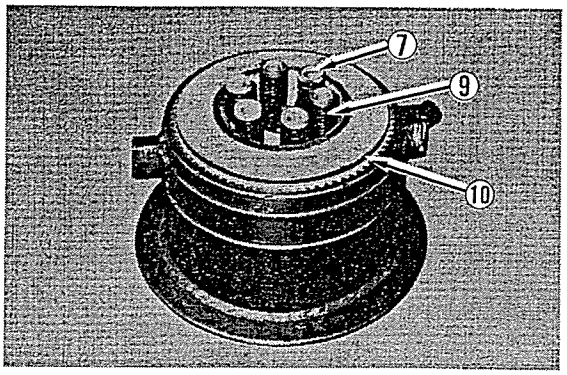
(5) With clutch plate assembly held on a bench, give a push to guide (7) (to compress spring under the guide), using a tool (A), and remove retainer (8).



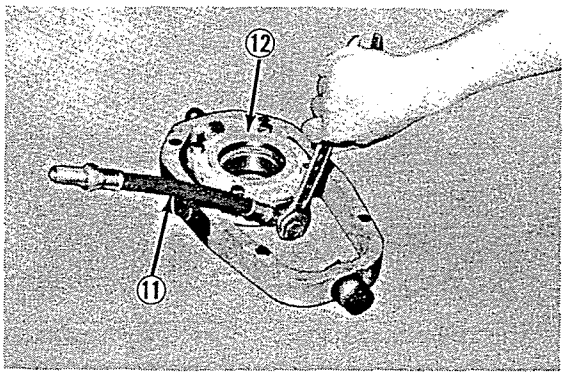
(6) Remove guide (7), spring (9) and plate (10).

NOTE

A total of six retainers, six guides and six springs are used in each clutch.



(7) Disconnect hose (11) from clutch case, and remove shifter (12).



Assembling clutch and yoke

Tool required

Tool name	Tool number	Qt.
Steering clutch tool	58609-01900	1

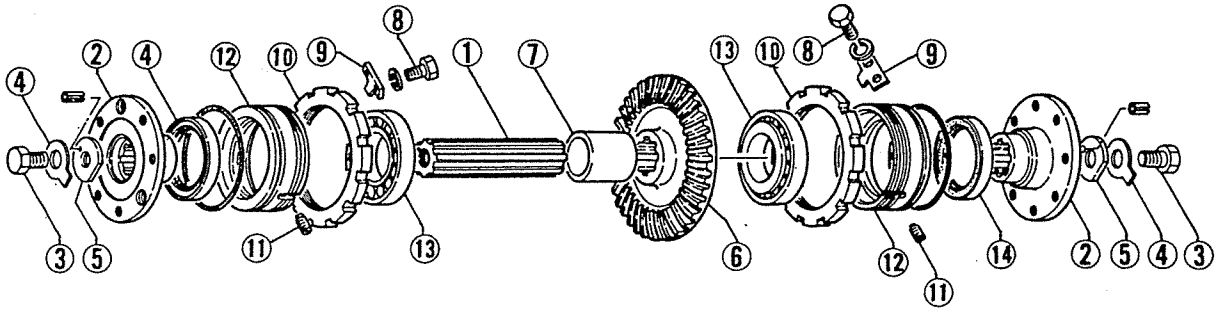
Procedure

Assembly is the reverse of disassembly procedure.

NOTE

Align drive and driven plates with respect to their teeth.

Disassembling bevel gear and shaft



1-Drive shaft
2-Coupling (2 pcs)
3-Bolt (2 pcs)
4-Lock washer (2 pcs)
5-Washer (2 pcs)
6-Bevel gear
7-Spacer
8-Bolt with washer (2 pcs each)
9-Locking plate (2 pcs)
10-Nut (2 pcs)
11-Set screw
12-Bearing cage
13-Bearing
14-Oil seal

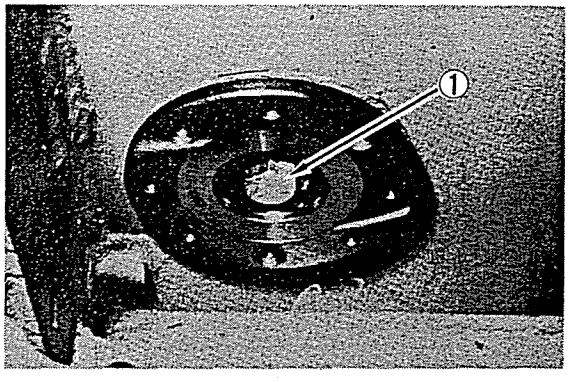
Bevel gear and shaft — disassembled view

Tool required

Tool name	Tool number	Qt.
Wrench	58309-01900	1

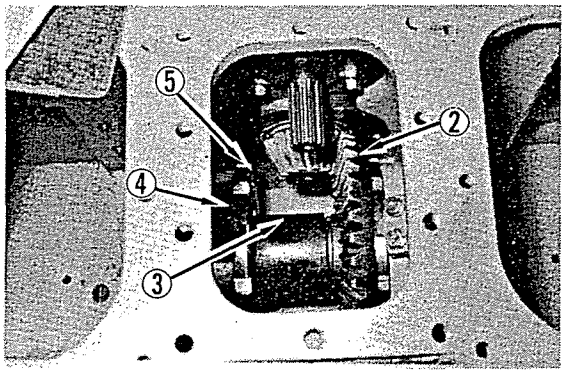
Procedure

(1) Loosen off bolt (1), and remove lock washer and washer at each end of drive shaft.



(2) Give blows of a soft-faced hammer or mallet to drive shaft, and remove bevel gear (2) and spacer (3).

(3) Remove right and left locking plates (4), and, using a wrench (A), loosen off right and left nuts (5).



(4) Remove bearing cages, each complete with bearing, oil seal and coupling, from gear case by loosening off set screws.

(5) Remove bearing, oil seal and coupling from each bearing cage.

Assembling bevel gear and shaft

Tool required

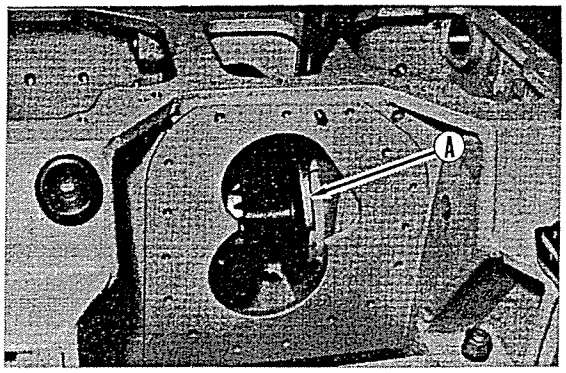
Tool name	Tool number	Qt.
Wrench	58309-01900	1

Procedure

(1) Install oil seal, bearing and coupling to each bearing cage.

(2) Screw set screws into tapped holes in case, and press bearing cages into case from the clutch housing side with the screws in alignment with screw holes in the cages. After pressing the cages, upset the screws.

(3) Using a wrench (A), tighten lock nuts.



(4) Place bevel gear complete with spacer on shaft.

(5) Secure bevel gear shaft in place with bolts and washers.

(6) Locate bevel gear properly with respect to bevel pinion (mounted on transmission output shaft) to obtain the correct backlash; then tighten right-hand and left-hand lock nuts, and lock the nuts by bending lock plates.

NOTE

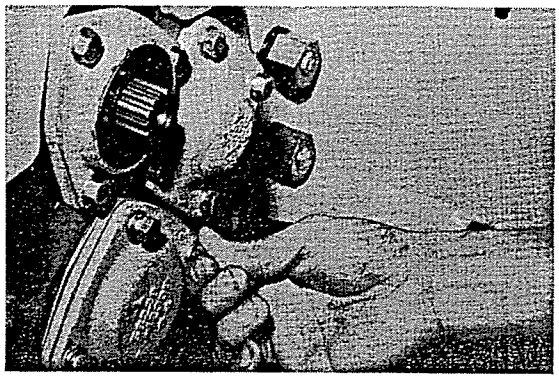
When installing bearing cages to case, apply a coat of grease to "O" rings fitted to the cages and a coat of lube oil to the inside surface of case.

Setting bevel gear and shaft

The bevel gear and pinion should be adjusted to the proper location to obtain the correct tooth contact. Shims are provided between the pinion bearing cage flange and the wall in transmission case so that the pinion can be moved toward or away from the centerline of the gear shaft. Adjusting nuts permit moving the gear toward or away from the centerline of the pinion shaft, thereby changing the backlash. Moving either the gear or pinion affects both backlash and tooth contact so the two should be adjusted at the same time.

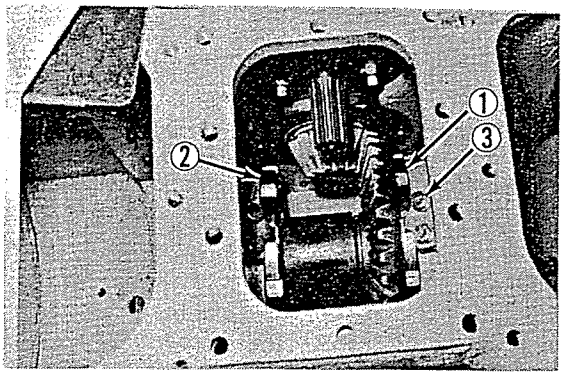
The recommended backlash for this bevel gearing is 0.18 ~ 0.30 mm (0.0071 ~ 0.0118 in.). The gear and pinion should be replaced at the same time; replacing either the gear or pinion is a bad practice.

When adjusting the backlash or moving the pinion, adjust the preload of bevel gear shaft bearing in advance.



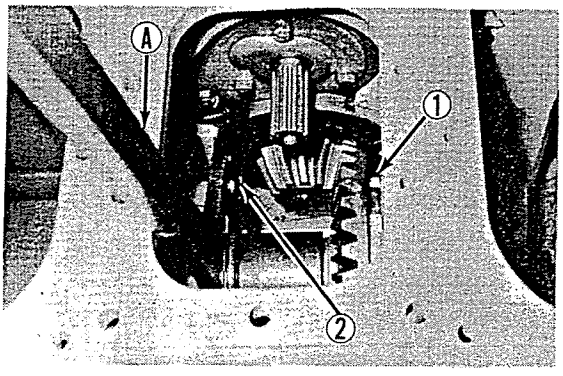
Adjusting bevel gear shaft bearing preload

Adjust the bevel gear to the proper location to obtain the required amount of backlash, and tighten adjusting nuts (1) (2). Then secure the right-hand adjusting nut (1) with lock plate (3), and tighten the left-hand adjusting nut (2).



Then tighten both the right-hand and left-hand adjusting nuts to a torque of 0.7 ~ 0.9 kg-m (5.1 ~ 6.5 ft-lb), and check the bearing preload, using a spring balancer.

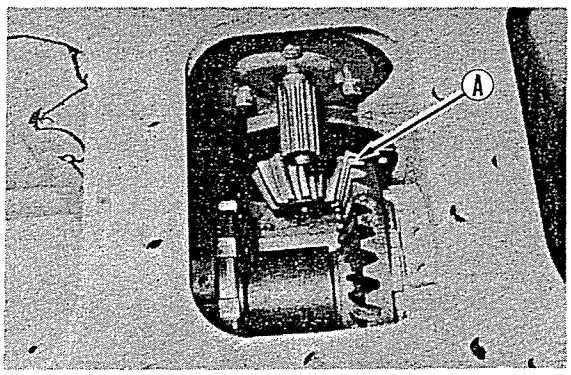
Remember, loosening one adjusting nut with another nut tightened will not vary the bearing preload. (Refer to the topic, FINAL DRIVE.)

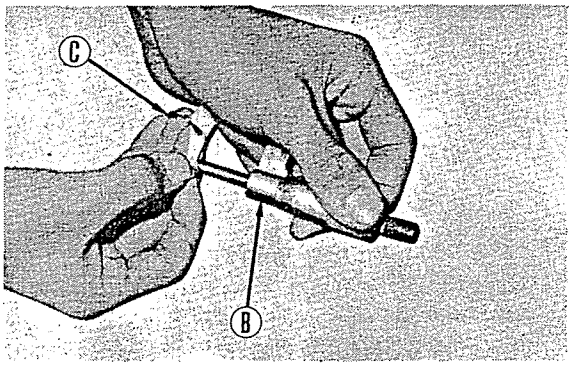


Adjusting bevel gear backlash

Place a piece of fuse stock or plastic material (C) at position (A) between the bevel gear and pinion, and rotate the gear backward and forward. Take out the fuse stock flattened between the two, and measure its thickness, using a micrometer (B). The reading represents the backlash. Repeat this process at least in four positions along the gear, and take the minimum reading of all as the backlash. The recommended backlash is 0.18 ~ 0.30 mm (0.0071 ~ 0.0118 in.).

If this minimum reading is too large, loosen the left-hand adjusting nut, and tighten the right-hand adjusting nut equally, and vice versa.





Adjusting bevel pinion

Whether the bevel pinion is properly located or not can be determined by the tooth contact pattern. Brush Prussian blue pigment or red lead sparingly on the bevel gear teeth. Press forward on the pinion, and rotate the gear backward and forward until a contact pattern is noted on both the concave and convex faces of the gear teeth.

NOTE

Use the existing bevel gear and pinion with the existing shims (between the bearing cage and transmission case).

The tooth contact must be heaviest toward the toe-end and extend about 30 per cent of the length of the tooth on both the convex and concave faces.

Fig. A shows the ideal tooth contact pattern.

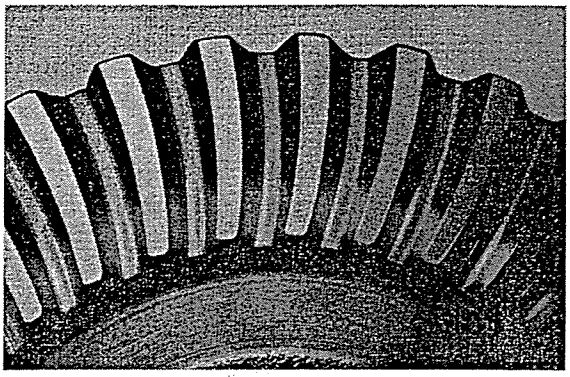


Fig. A. Correct tooth contact

Fig. B illustrates an incorrect tooth contact pattern. The pinion is too far away from the centerline of bevel gear shaft, causing the teeth to bear on the toe-ends of convex faces and toward the heel-ends of the concave faces. To correct this condition, move the pinion toward the gear by adding shims to the bevel pinion bearing cage. Recheck the backlash, adjusting it by means of the adjusting nuts (on the bevel gear shaft), and again check the tooth contact pattern.

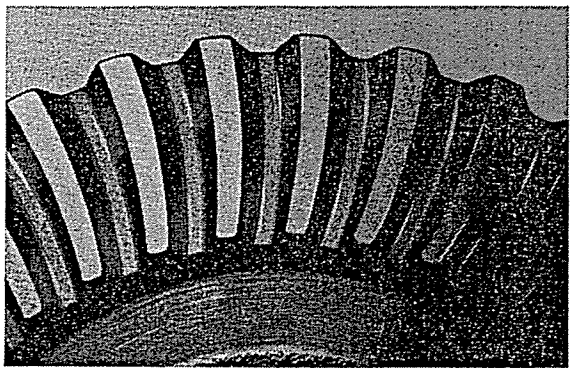


Fig. B. Incorrect tooth contact (pinion too far away from bevel gear shaft centerline)

Fig. C shows an incorrect tooth contact pattern. In this pattern the pinion is too close to the centerline of bevel gear shaft, causing the teeth to bear on the toe-ends of the concave faces and the heel-ends on the convex faces. To correct this condition, remove shims from the bevel pinion bearing cage. Similarly recheck the backlash and tooth contact patterns.

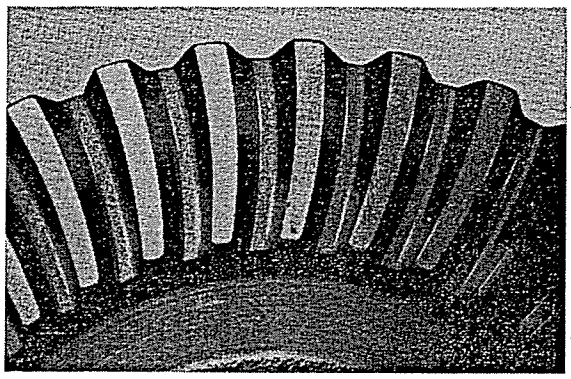
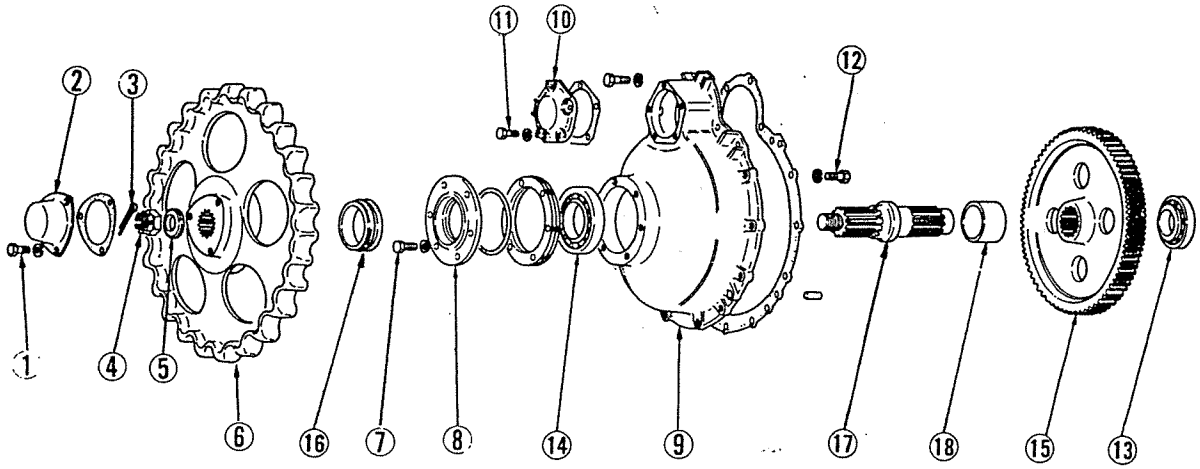


Fig. C. Incorrect tooth contact (pinion too close to bevel gear shaft centerline)

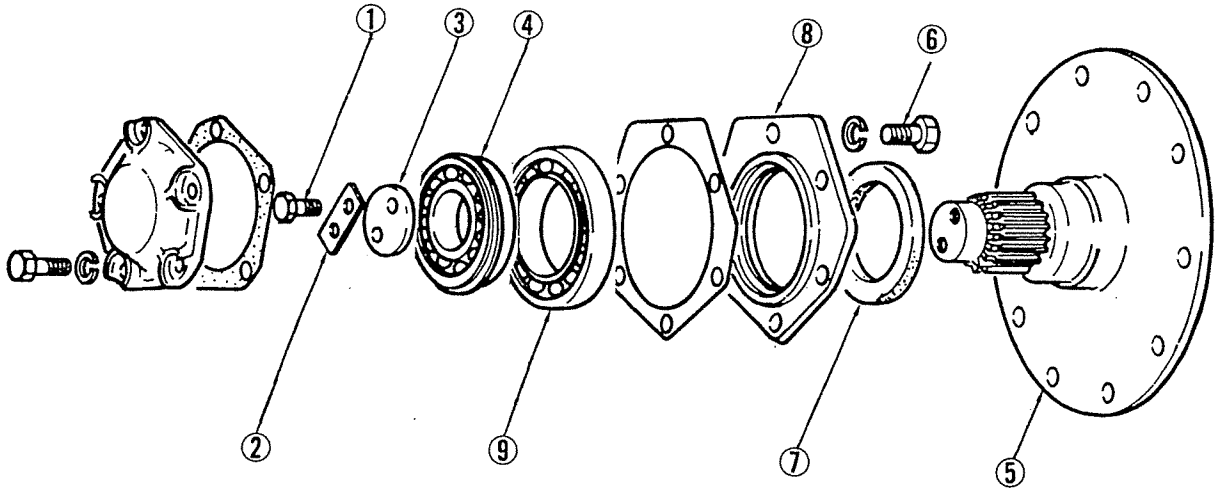
FINAL DRIVE

Removal (disassembly)



1-Bolt with washer (3 pcs each)
2-Cover
3-Split pin
4-Castellated nut
5-Washer
6-Sprocket
7-Bolt with washer
8-Oil seal case
9-Gear case
10-Cap
11-Bolt with washer (5 pcs each)
12-Bolt with washer (16 pcs each)
13-Roller bearing
14-Roller bearing
15-Gear
16-Floating seal
17-Shaft
18-Spacer

Final drive — disassembled view



1-Bolt (2 pcs)
2-Lock plate
3-Washer
4-Ball bearing
5-Pinion
6-Bolt with washer (6 pcs each)
7-Oil seal
8-Oil seal case
9-Ball bearing

Final drive pinion — disassembled view

Preparatory steps

(a) Separate track and lay it out flat.

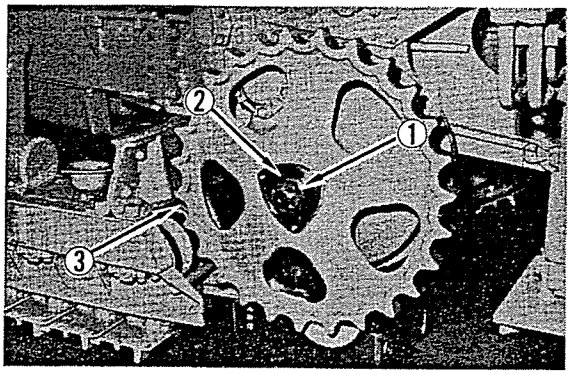
(b) Drain final drive gear case.

(c) Remove steering clutch drum

Procedure

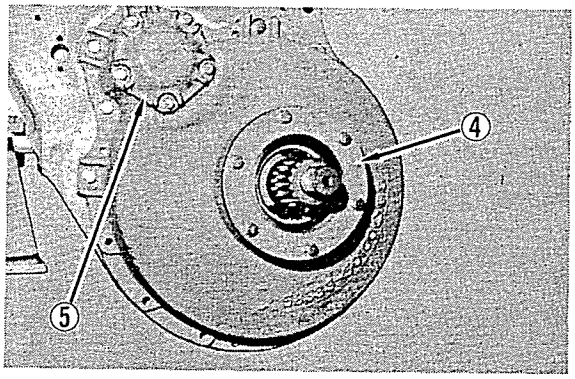
(1) Loosen off three bolts securing cover, and remove the cover.

(2) Loosen off castellated nut (1) together with washer (2), and remove sprocket (3).

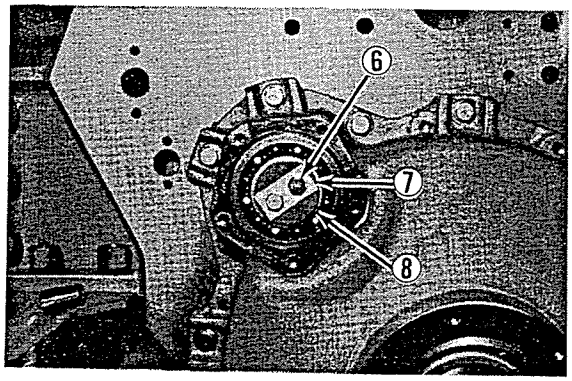


(3) Loosen off six bolts securing oil seal case (4), and remove the case.

(4) Loosen off five bolts securing cap (5), and remove the cap.



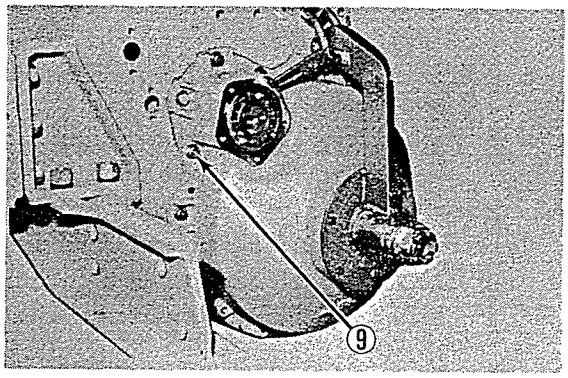
(5) Loosen off two bolts (6), and remove lock plate (7) and washer (8).



(6) Attach a lifting jig to final drive gear case. Loosen off sixteen bolts (9), and lift off the case complete with shaft sub-assembly.

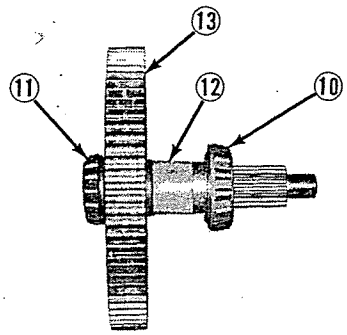
⚠ WARNING

Do not attempt to lift final drive gear case only or shaft sub-assembly may break away from steering clutch case, resulting in severe injury to personnel and destruction of the sub-assembly.



(7) Remove ball bearing and shaft sub-assembly from final drive gear case.

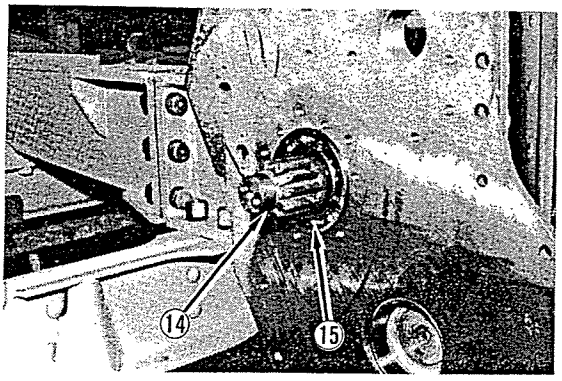
(8) Pull the outer races of roller bearings (10) (11), spacer (12) and gear (13) from the shaft sub-assembly.



(9) Remove pinion (14) by driving it toward the steering clutch case side with a soft-faced hammer or a mallet.

(10) Loosen off six bolts securing oil seal case, and remove the case.

(11) Pull ball bearing (15) from steering clutch case.



Assembly (installation)

Procedure

(1) Install ball bearing and oil seal case to steering clutch case.

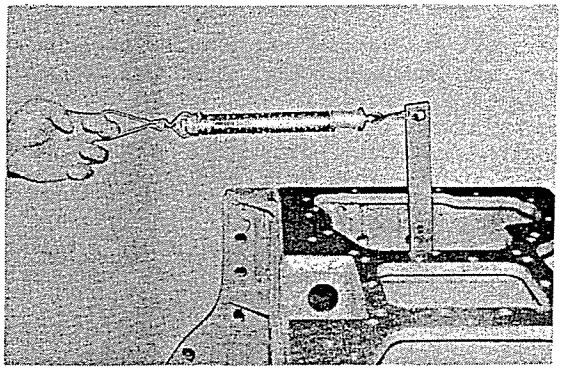
(2) Place gear and spacer on shaft, and press the inner races of roller bearings onto shaft.

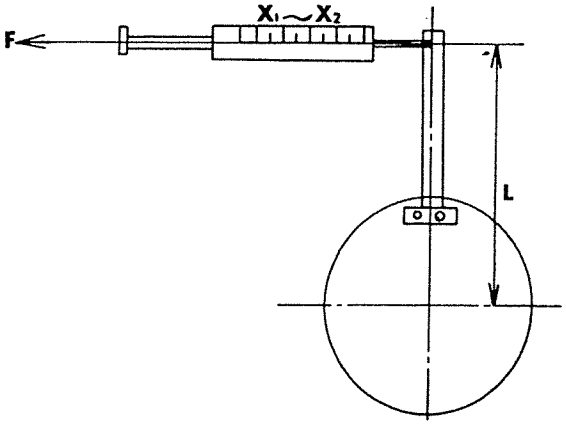
(3) Install shaft sub-assembly to final drive gear case and, using a lifting jig, install the case to steering clutch case.

(4) Press ball bearing onto pinion.

(5) Place shims [whose standard thickness is 1.8 mm (0.071 in.)] on final drive gear case, and install oil seal case.

(6) Using a spring balancer and a special tool, measure the preload of roller bearings (pinion).





Pinion preload	0.28 ~ 0.36 kg-m (2.0 ~ 2.6 ft-lb)

The preload can be computed by the following formula:

T (kg-m or ft-lb) = F (kg or lb) x L (m or in.)

where T = preload
F = pull exerted to a spring balancer
L = distance between pinion center and spring balancer hook point

(Example)

If L is 0.25 m, the reading range of the balancer is:

$0.28 = 0.25 \times X_1$

$X_1 = 1.12$ kg (2.47 lb)

$0.36 = 0.25 \times X_2$

$X_2 = 1.14$ kg (2.51 lb)

The recommended preload, therefore, is 1.12 ~ 1.14 kg (2.47 ~ 2.51 lb).

(7) Install sprocket in place.

Subsequent steps

(a) Install steering clutch drum.

(b) Fill final drive gear case with correct lubricant.

(c) Reconnect track.

TRACK AND TRACK ROLLER FRAME

Loosening track adjustment

Thoroughly clean the front idler, idler bearings and track frame, removing dirt that prevents free movement of the idler. Also, clean the vent hole in the hydraulic track adjuster cylinder.

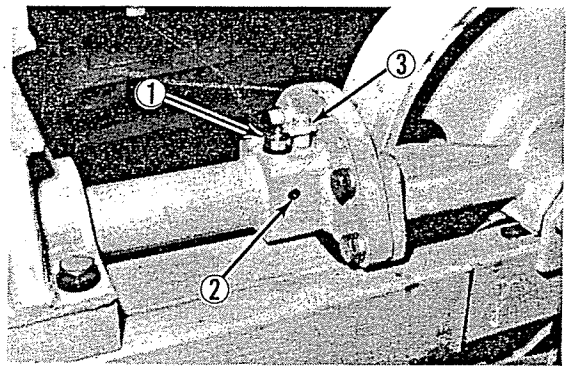
⚠ WARNING

Never get a direct look into the vent hole to ascertain releasing of the pressure in the cylinder; ascertain by seeing whether the idler has stopped backward movement or not.

Procedure

(1) Gradually loosen fill valve (1) by turning it counterclockwise to allow grease to escape from vent hole (2) just below the fill valve.

(2) If grease does not appear when this fill valve is backed off one turn, further loosen the fill valve until it touches stopper (3).

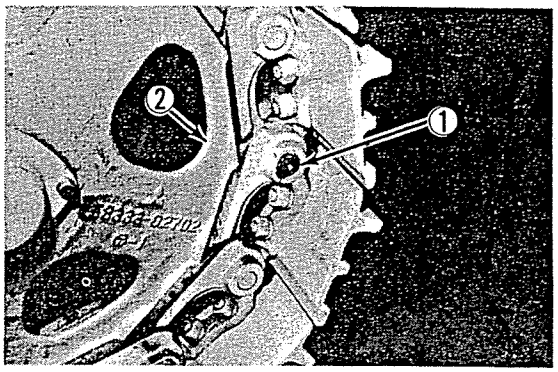


(3) If grease does not appear at the vent hole and the vent hole appears to be open and the track appears to have tension, start the engine and move the machine forward and backward slightly.

(4) If the track still appears to have tension after the machine has been so moved, place a wooden block between the track and sprocket, and move the machine backward slightly. This will give more tension to the track, causing the cylinder to force out grease through the vent hole.

Separating track

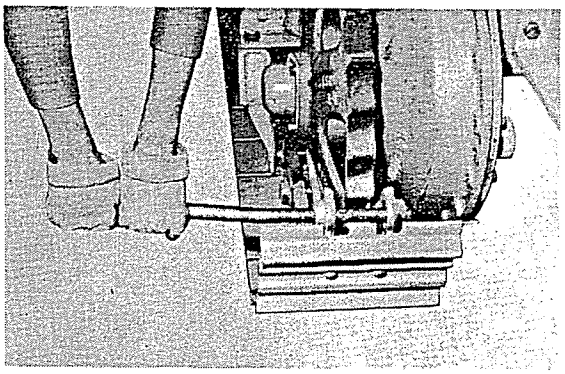
(1) Move the machine until master pin (1) is in the rear of sprocket (2).



(2) Loosen track adjustment.

(3) Using a guide bar and a sledge or a hydraulic press, drive out master pin.

(4) Insert a bar into the link, and aid the track to go down over the sprocket as the machine is driven slowly forward.



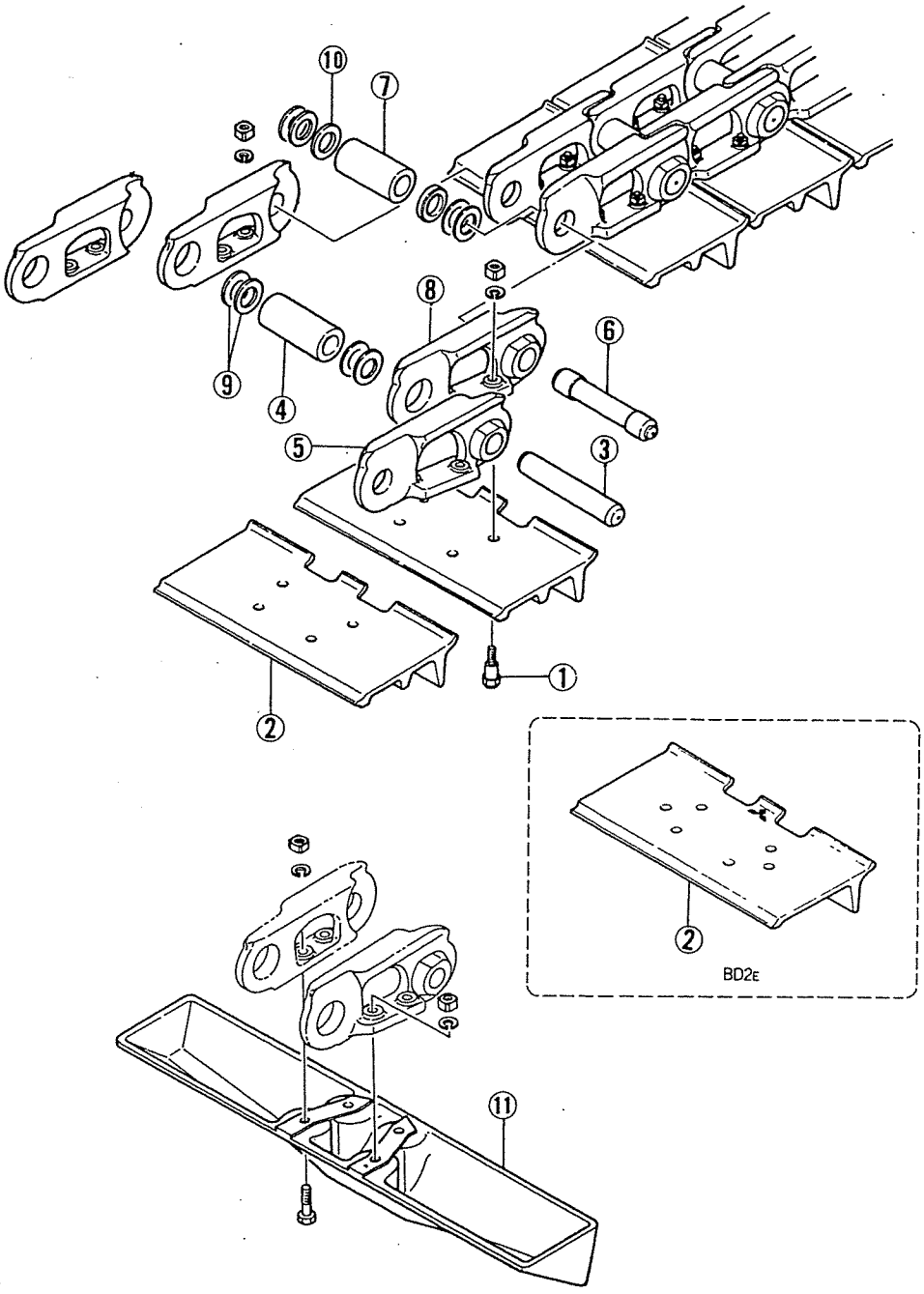
Reconnecting track

(1) Back the machine until the final drive is just above the rear end (link) of the track.

(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 driven slowly forward.

(3) Drive in master pin, and give a tension to the track.

Disassembling track



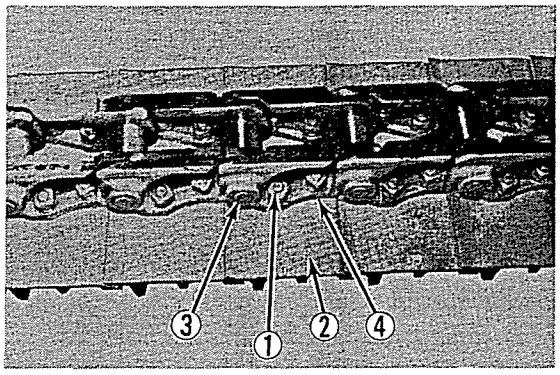
1-Bolt and nut with washer (4 pcs each)
2-Shoe
3-Pin
4-Bushing
5-Link
6-Master pin
7-Master bushing
8-Master link
9-Seal washer
10-Spacer
11-Swamp shoe

Track — disassembled view

(1) Loosen off four bolts (1), and remove shoe (2).

(2) Drive pin (3) out of link (4).

(3) Remove bushing and link.



Assembling track

Install seal washer and bushing to link, and secure them with pin.

Removing track rollers

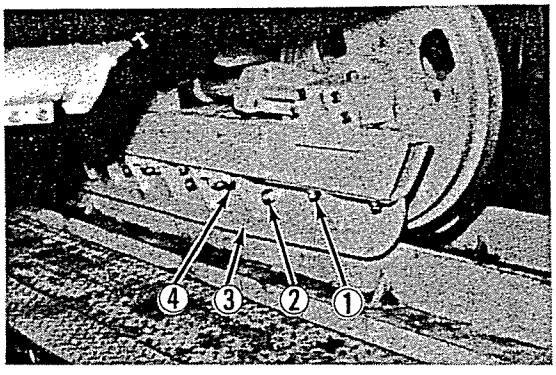
Preparatory step

Loosen track adjustment.

Procedure

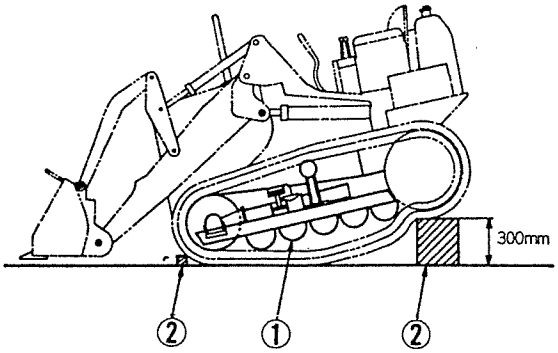
(1) Place a block (2) approximately 300 mm (12 in.) at the rear of the machine. Back the machine up on the block until a roller to be removed clears the track.

(2) Apply and lock the brake, and place a block at the idler on the other side to prevent the machine from moving accidentally.



(3) Loosen off twelve bolts (1) and six bolts (2) securing track roller guard (3), and remove the guard.

(4) Loosen off four bolts (4) from under the frame, and remove track roller assembly.



Installing track rollers

Procedure

(1) Install track roller to frame.

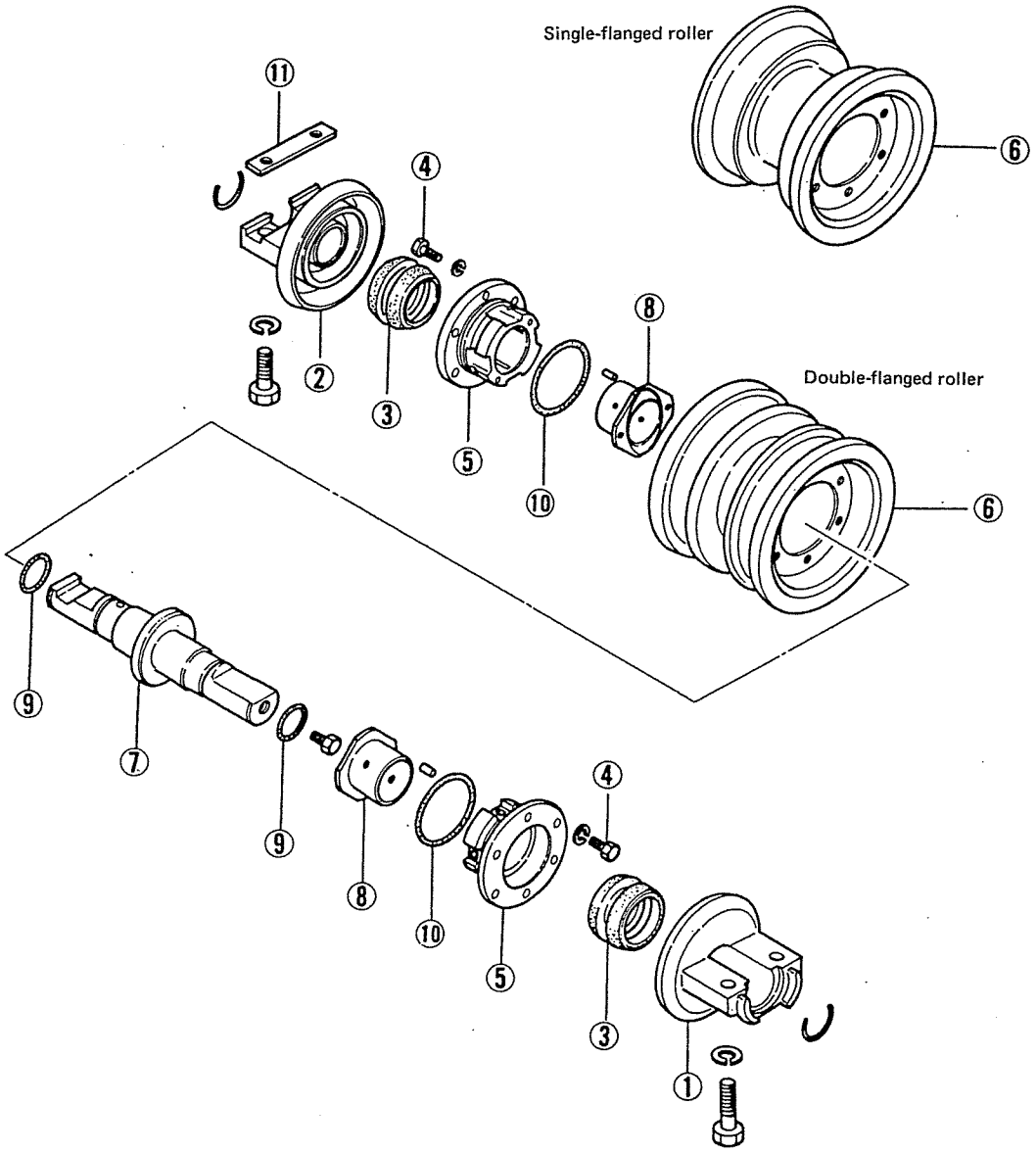
(2) Install track roller guard in place.

(3) Remove the block at the front end of the machine, and drive the machine down from the rear block.

Subsequent step

Tighten track adjustment.

Disassembling track rollers



1-Collar
2-Collar
3-Floating ring seal
4-Bolt with washer (6 pcs each)
5-Bushing
6-Track roller
7-Shaft
8-Gun-metal bushing
9-"O" ring
10-"O" ring
11-Lock

Track roller — disassembled view

Preparatory step

Have the roller emptied of lube oil.

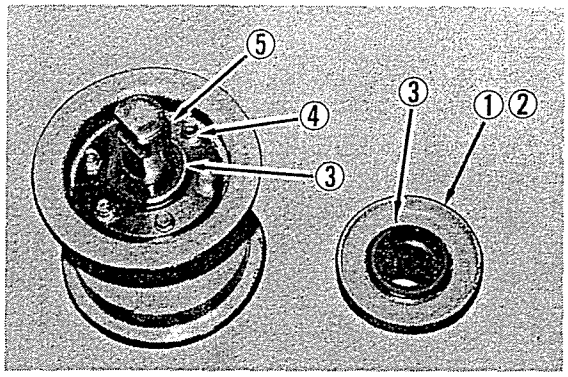
Procedure

(1) Remove collars (1)·(2).

(2) Remove floating ring seal (3) from collar and from roller.

(3) Loosen off six bolts (4) securing bushing (5), and remove the bushing.

(4) Remove gun-metal bushing from bushing.



Assembling track rollers

Tool required

Tool name	Tool number	Qt.
Adaptor	58609-10200	1

Procedure

(1) Install gun-metal bushing to bushing.

(2) Place shaft and bushing in track roller, and secure them with bolts.

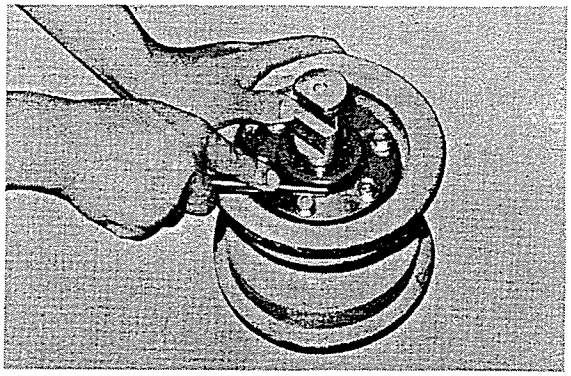
(3) Install floating ring seal.

NOTE

When installing a floating ring seal, use a special tool, and install the seal, taking care not to damage its "O" rings.

NOTE

Never use a screwdriver when installing a floating ring seal.



(4) Wash the sliding surfaces of floating ring seal metal rings, using a cloth or a brush, making sure they are free of any foreign matter.

(5) Install collars.

Subsequent step

Fill the roller with correct lube oil, using an adaptor.

Track roller refill capacity	60 cc (3.7 cu in.)

Removing track carrier rollers

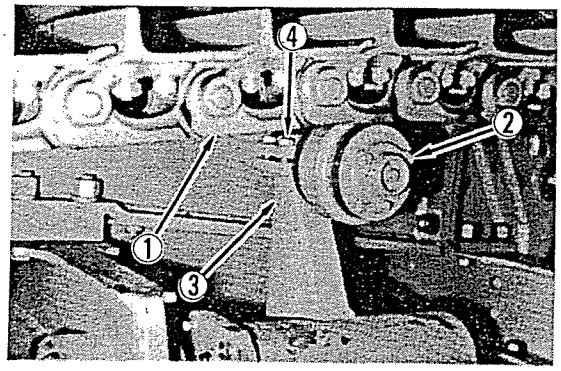
Preparatory step

Loosen track adjustment.

Procedure

(1) Push up the upper span of track (1) so that it clears the roller (2), permitting removal of the roller.

(2) Loosen off two bolts (4) securing the roller to bracket (3), and remove the roller.

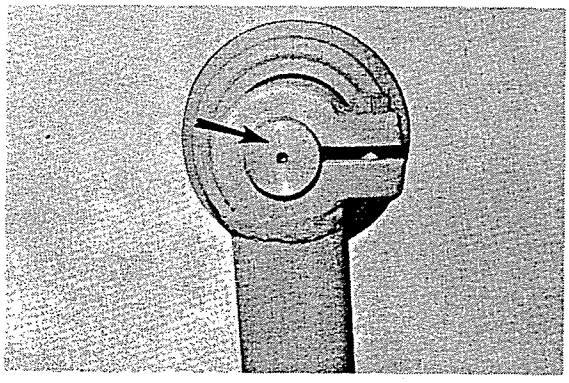


Installing track carrier rollers

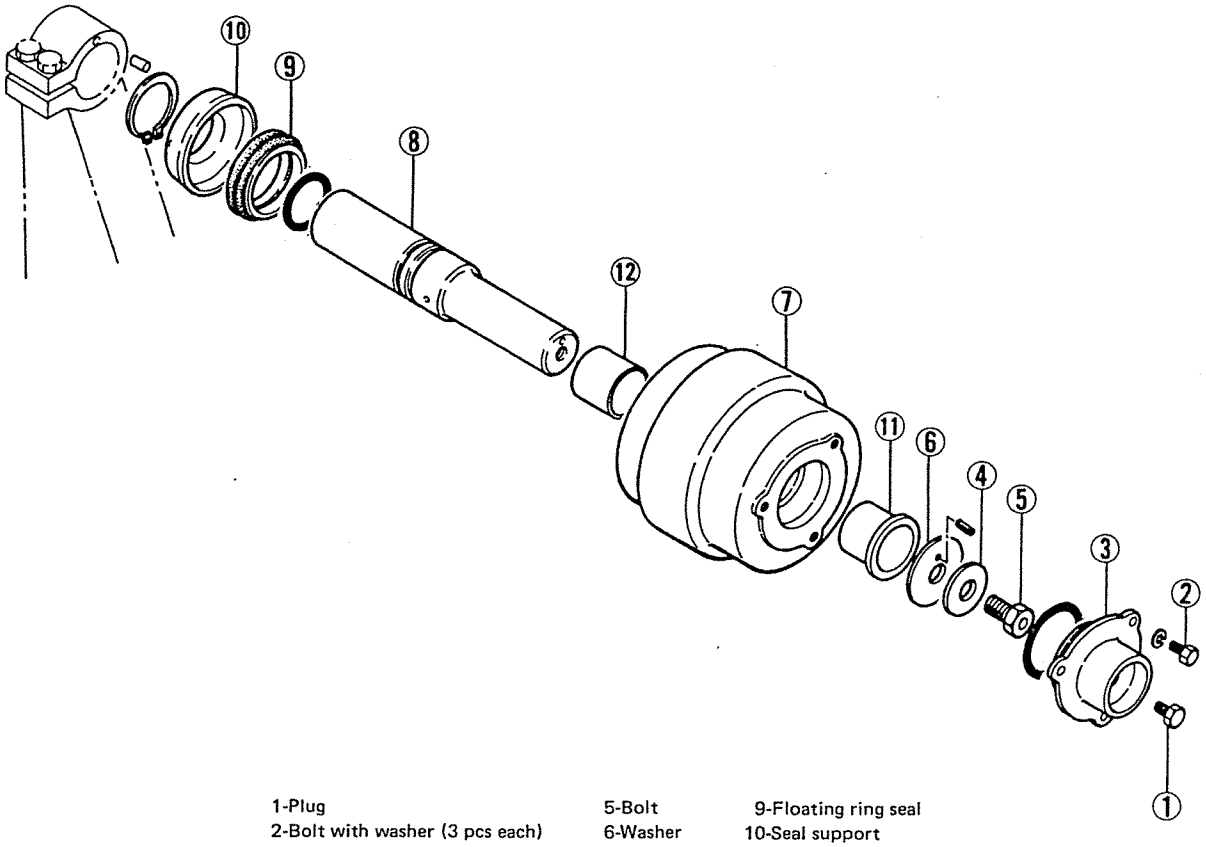
Install the roller to the bracket with two bolts.

CAUTION

Arrow mark on the end of roller shaft must point up when the roller is installed, as shown.



Disassembling track carrier rollers



1-Plug	5-Bolt	9-Floating ring seal
2-Bolt with washer (3 pcs each)	6-Washer	10-Seal support
3-Cover	7-Roller	11-Gun-metal bushing
4-Lock washer	8-Shaft	12-Bushing

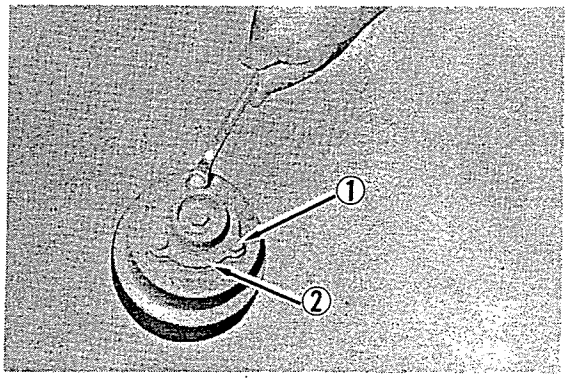
Track carrier roller — disassembled view

Preparatory step

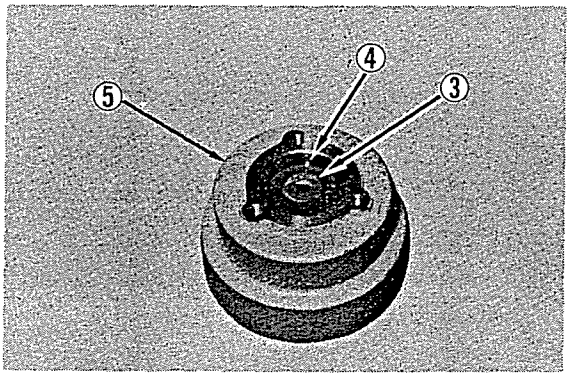
Have the roller emptied of lube oil.

Procedure

(1) Loosen off three bolts (1) securing cover (2), and remove the cover.



(2) Remove bolt (3), and drive shaft (4) out of roller (5).



(3) Remove floating ring seal from roller and from seal support.

(4) Remove seal support and "O" rings from shaft.

(5) Remove gun-metal bushing and bushing from roller.

Assembling track carrier rollers

Tool required

Tool name	Tool number	Qt.
Adaptor	58609-00300	1

Procedure

(1) Install bushing and gun-metal bushing to roller.

(2) Install shaft to roller, securing it with bolt.

(3) Install cover with three bolts.

Subsequent step

Fill the roller with correct lube oil, using an adaptor.

Track carrier roller refill capacity	75 cc (4.6 cu in.)

Removing recoil springs

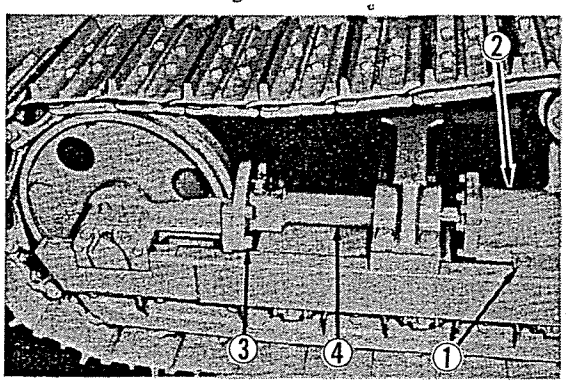
Preparatory step

Release the pressure in the hydraulic track adjuster cylinder as indicated in the topic. Loosening track adjustment.

Procedure

(1) Loosen off four bolts (1) securing roller bracket (2), and remove the bracket.

(2) Loosen off four bolts (3) and separate cylinder (4) from idler bearings.



Installing recoil springs

Procedure

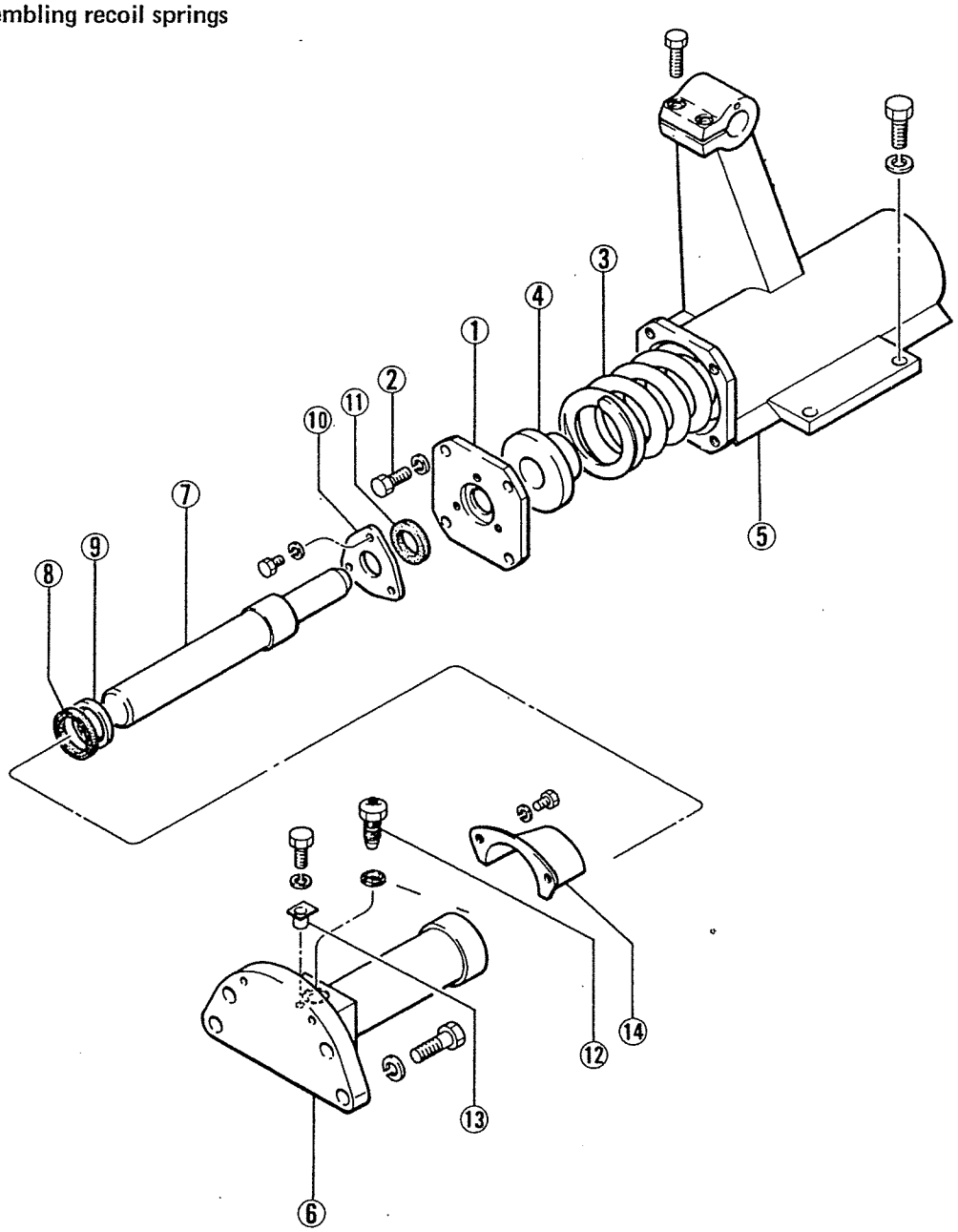
(1) Install cylinder to front idler bearings.

(2) Install roller bracket.

Subsequent step

Tighten track adjustment

Disassembling recoil springs



1-Plate
2-Bolt with washer (2 pcs each)
3-Spring
4-Spring retainer
5-Carrier roller bracket
6-Cylinder
7-Shaft
8-Packing
9-Dust seal
10-Plate
11-Seal
12-Fill valve
13-Stopper
14-Cover

Recoil spring – disassembled view

Preparatory step

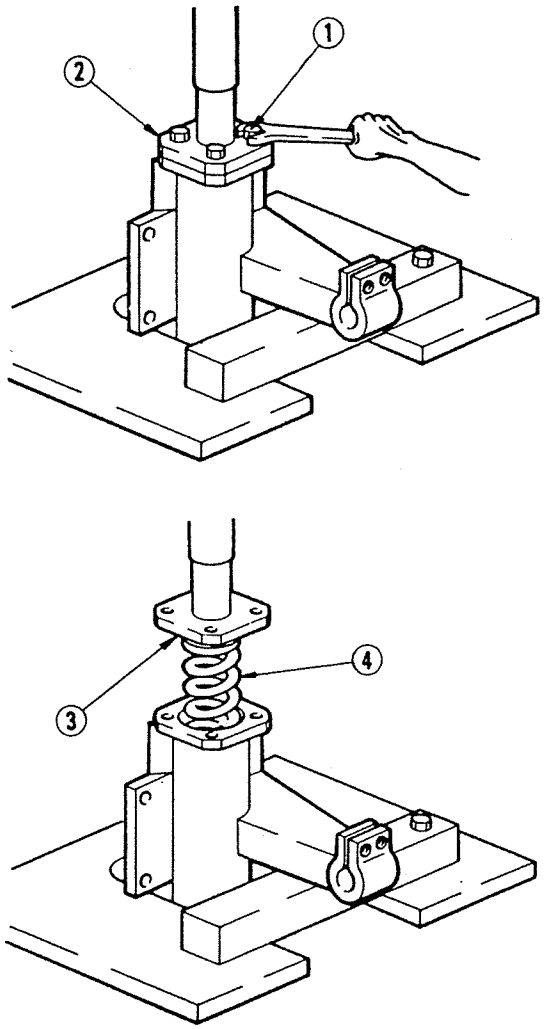
Remove track carrier roller.

Procedure

(1) Loosen off three bolts, and remove plate and seal.

(2) Using a hydraulic press, hold plate (2) (against which the spring pressure is exerted), and loosen off four bolts (1) securing plate (2).

(3) Slowly release the press to decompress spring (4).



(4) Pull shaft off cylinder, and remove packing and dust seal from shaft.

Assembling recoil springs

Procedure

(1) Place packing and dust seal on shaft, and insert shaft into cylinder.

(2) Place spring in carrier roller bracket.

Subsequent step

Install track carrier roller.

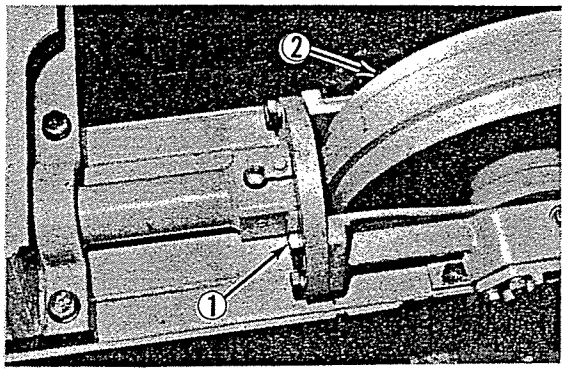
Removing front idlers

Preparatory step

Separate track as indicated in the topic, Separating track.

Procedure

Loosen off four bolts (1) at the flange of shaft. Attach a sling to idler (2) and slide idler forward off track roller frame.

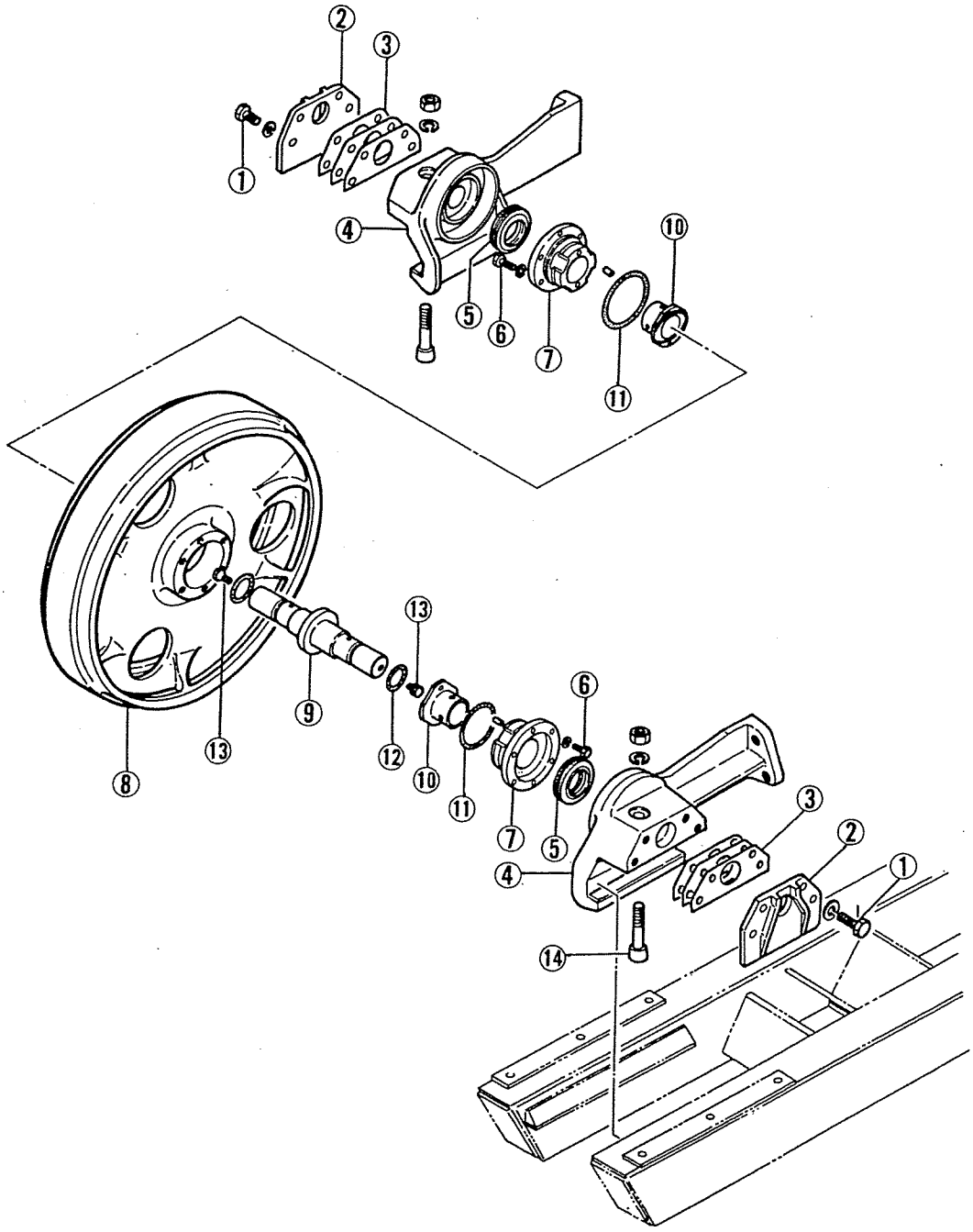


Installing front idlers

(1) Install the idler.

(2) Center the idler in track roller frame so that it will guide track between the flanges of track rollers.

Disassembling front idlers



1-Bolt with washer (4 pcs each, right and left)
2-Guide (2 pcs)
3-Shims (1 set each)
4-Bearing (2 pcs)
5-Floating ring seal (2 sets)
6-Bolt with washer (6 pcs each, right and left)
7-Bushing
8-Idler
9-Shaft
10-Gun-metal bushing (2 pcs)
11-"O" ring (2 pcs)
12-"O" ring (2 pcs)
13-Plug (2 pcs)
14-Pin and nut with washer (2 pcs each)

Front idler – disassembled view

Preparatory step

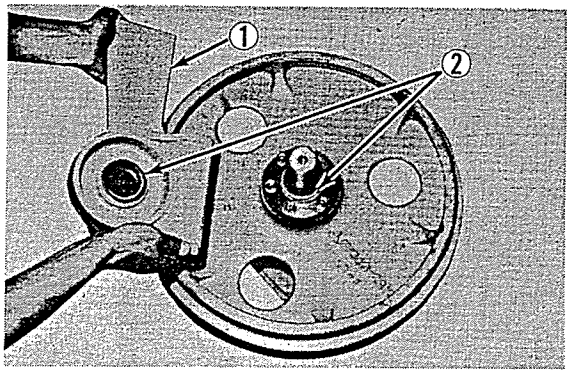
Have the idler emptied of lube oil.

Procedure

(1) Loosen off four bolts on each side of the idler, and remove guides and shims.

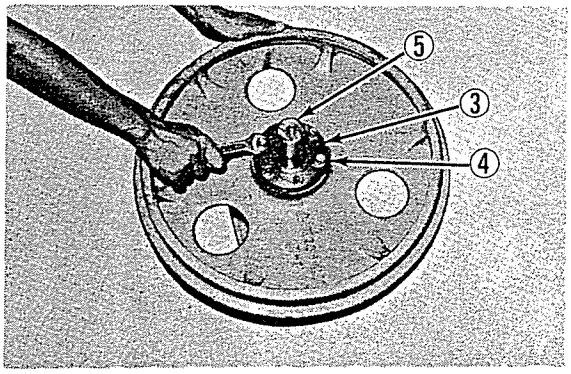
(2) Pull out pin on each side of the idler, and remove bearings (1).

(3) Take out two sets (right and left) of floating ring seals (2).



(4) Loosen off six bolts (3) on each side of the idler, and remove bushings (4).

(5) Pull out shaft (5) complete with gun-metal bushings.



Assembling front idlers

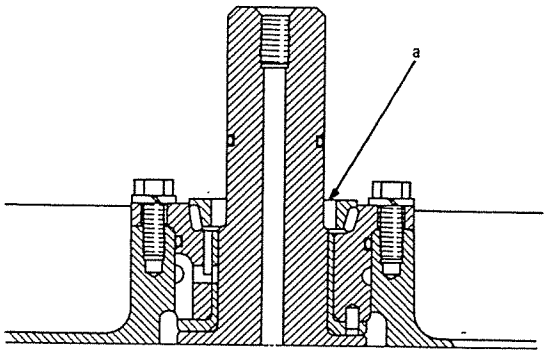
Tool required

Tool name	Tool number	Qt.
Adaptor	58609-10200	1

Procedure

(1) Press gun-metal bushings onto shaft, and insert shaft into idler.

(2) Install each set of floating ring seal in place, and fill the seal with lube oil up to the level "a" by using an adaptor.



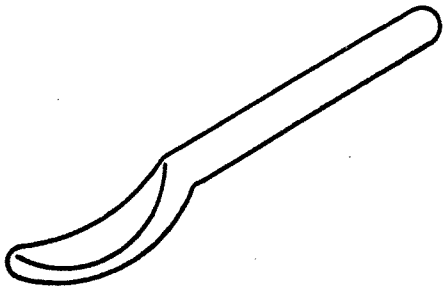
(3) Place bearing on each side of idler, and seucre it to shaft with pin.

(4) Place shim [whose standard thickness is 2 mm (0.08 in.)], and install guides.

Floating ring seals

Disassembly and assembly

(1) To take out floating ring seal, carefully lift it off with fingers. A special tool of the type sketched here – a rod 5 mm (0.2 in.) in diameter and 100 mm (approximately 4 in.) in length, whose one end is flattened and finished by filing – may be used for removal of the seal.



CAUTION

Never use a screwdriver to remove floating ring seal.

(2) Upon removing each set of floating ring seal, remove rubber "O" rings from metal rings, and tie the metal rings together, using a tape, with their lapped sealing faces face to face so that the same combination or set as before can be reproduced at the time of assembly. In each front idler, two sets of floating ring seal, that is, a total of four metal rings, two for one set, are used; never interchange the rings between the sets.

Inspection

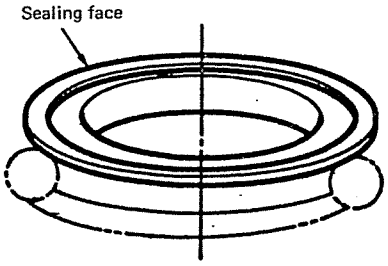
(1) Visually check the metal rings for defective conditions, and replace them as a set —

(a) If the ring is chipped, flaked or pitted at any part.

(b) If any of these defects are present on the lapped sealing face of the ring:

- Sign of abnormal sliding contact
- Scratching
- Corrosion, rust or fretting
- Warpage or abnormal wear

(c) If the stepped portion of the sealing face is worn down.



(2) Do not reuse rubber "O" rings which have been in service; be sure to use new "O" rings.

Cleaning

(1) Clean metal rings, collars and seal support of bushings (which accomodates floating ring seal) in solvent.

(2) Clean metal rings with a brush or a fine crocus cloth and solvent to remove dust and foreign matter.

NOTE

When cleaning the collars and bushings, use a wire brush to help remove dust and minor red stains. Make sure that the parts that come in contact with floating ring seal are thoroughly cleaned and free of foreign matter.

(3) After cleaning the rings, collars and bushings, dry them with compressed air.

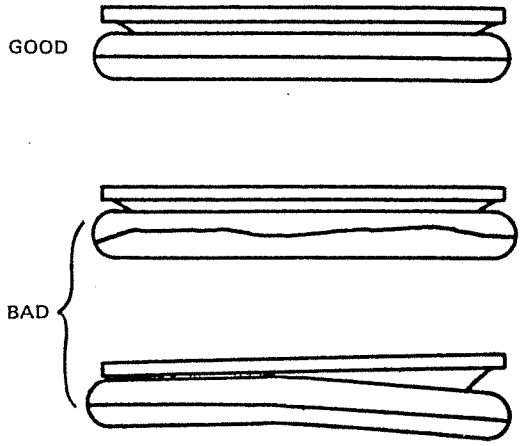
(4) When installing a new floating ring seal, separate rubber "O" rings from metal rings, and thoroughly clean them in solvent to remove the rust and corrosion inhibitors from them. In cleaning the "O" rings, do not have them dipped in solvent longer than 3 minutes.

Placing rubber "O" rings on metal rings

(1) When placing rubber "O" rings on metal rings, be careful not to stretch, tear or cut them.

(2) After placing the "O" rings on metal rings, make certain the "O" rings are fully seated in grooves without twisting.

(3) When reusing the metal rings which have been removed, do not change the combination.



HYDRAULIC SYSTEM

Removing gear pump

Preparatory steps

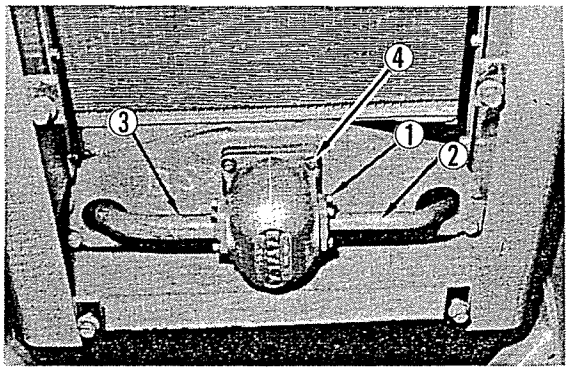
(a) Remove engine room and front guard.

(b) Completely drain hydraulic tank.

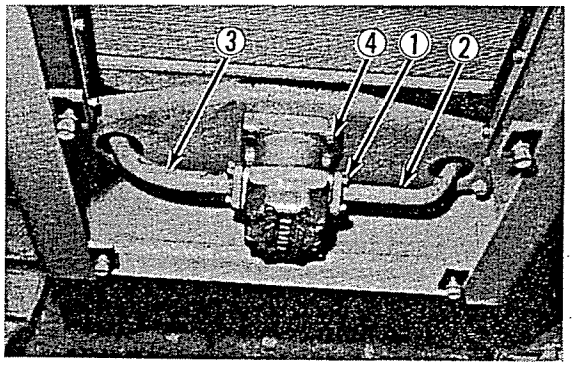
Procedure

(1) Loosen off four bolts (1) at the flanges of oil pipes (2) (3), and disconnect the pipes from the pump.

(2) Loosen off four bolts (4) securing the pump, and remove the pump.



BS3E



BD2E

Installing gear pump

Procedure

(1) Install the pump to the frame.

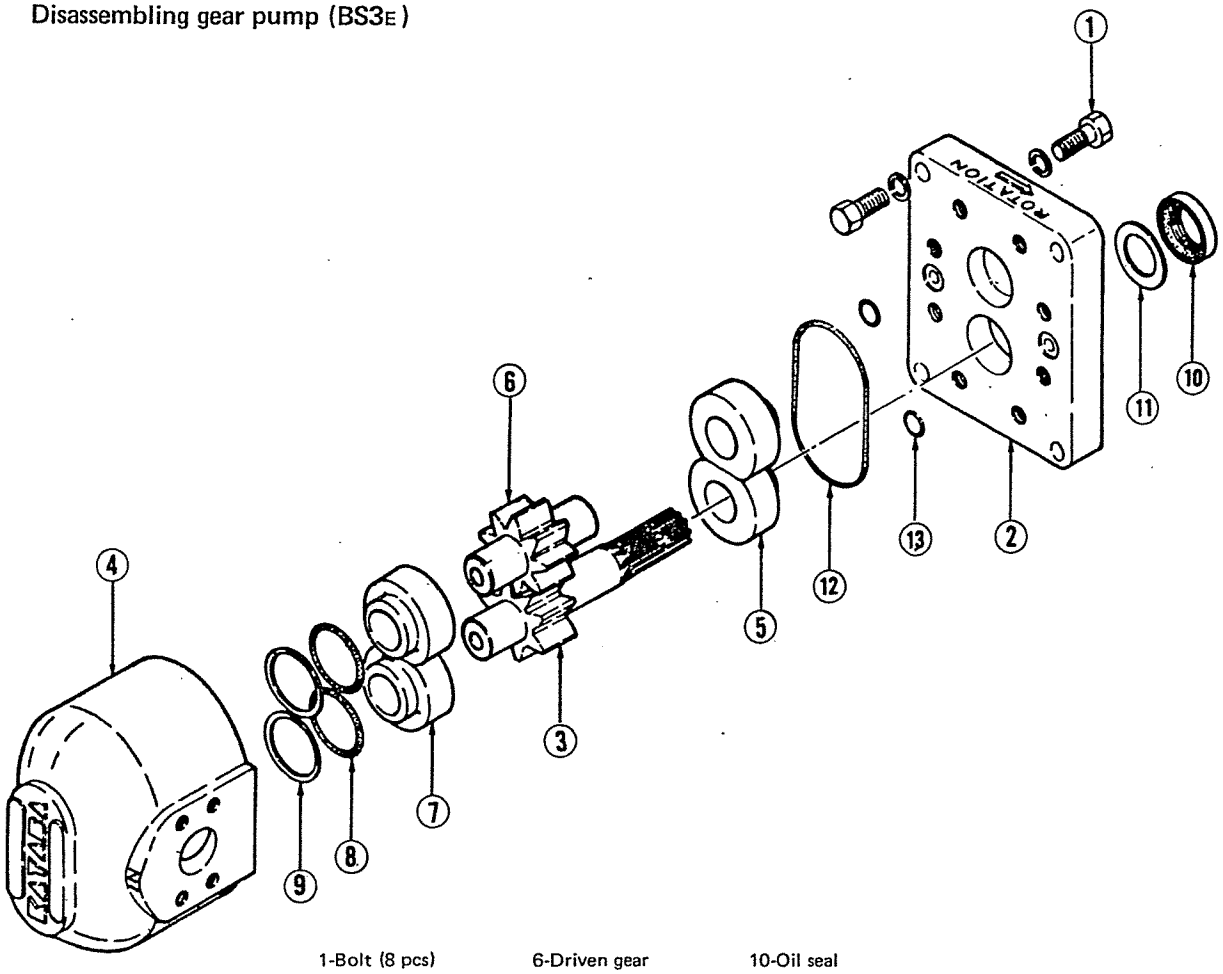
(2) Connect the oil pipes to the pump.

Subsequent steps

(a) Fill hydraulic tank up to level.

(b) Install engine room and front guard.

Disassembling gear pump (BS3E)

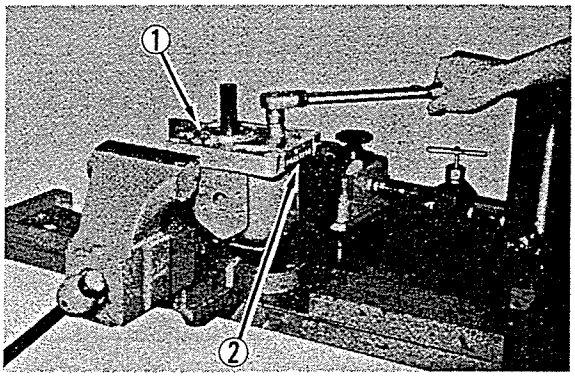


1-Bolt (8 pcs)
2-Cover
3-Drive gear
4-Body
5-Bushing (2 pcs)
6-Driven gear
7-Bushing (2 pcs)
8-"O" ring (2 pcs)
9-"O" ring (2 pcs)
10-Oil seal
11-Special washer
12-"O" ring
13-"O" ring (2 pcs)

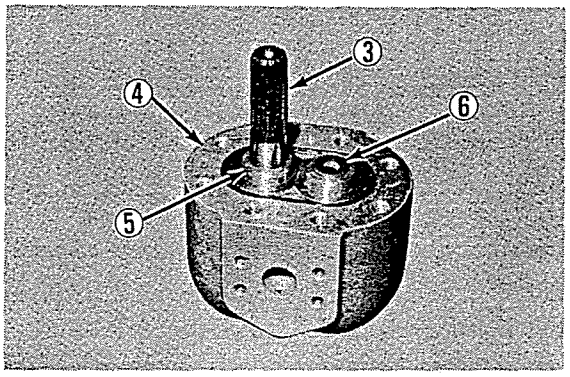
Gear pump (BS3E) — disassembled view

(1) Hold gear pump in a vise.

(2) Loosen off eight bolts (1), securing cover (2), and remove the cover.



(3) Slide drive gear (3) out of body (4), and take out two bushings (5) (indicated as "A").

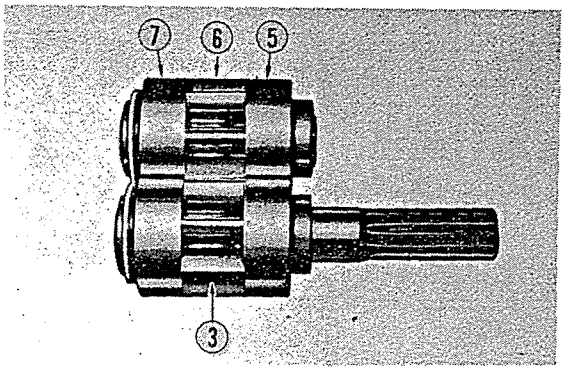


NOTE

If the bushings cannot be removed, place gear pump on a wooden bench, and give blows of a soft-faced hammer or a mallet to pump body.

(4) Slide driven gear (6) out of body (4).

(5) Take out two bushings (7) (indicated as "C"), and remove "O" rings and rings.



(6) Remove oil seal and special washer from cover (2).

(7) Put disassembled pump parts side by side in the order removed. Identify gears and bushings so that they may be returned to their original positions in reassembly.

Assembling gear pump (BS3E)

(1) Install special washer and oil seal to cover.

(2) Install rings and "O" rings to bushings (indicated as "C"). Apply a coat of a good-quality grease to the bushings and place them in pump body.

CAUTIONS

a) Place the bushings in pump body at right angles to the bore, being careful not to damage them.

b) If the bushing is scratched or pitted, use an oil stone on a damaged bushing to dress out any slight imperfections.

(3) Place drive and driven gears in pump body.

NOTE

When installing the existing gears, make sure that they are meshed as they were before.

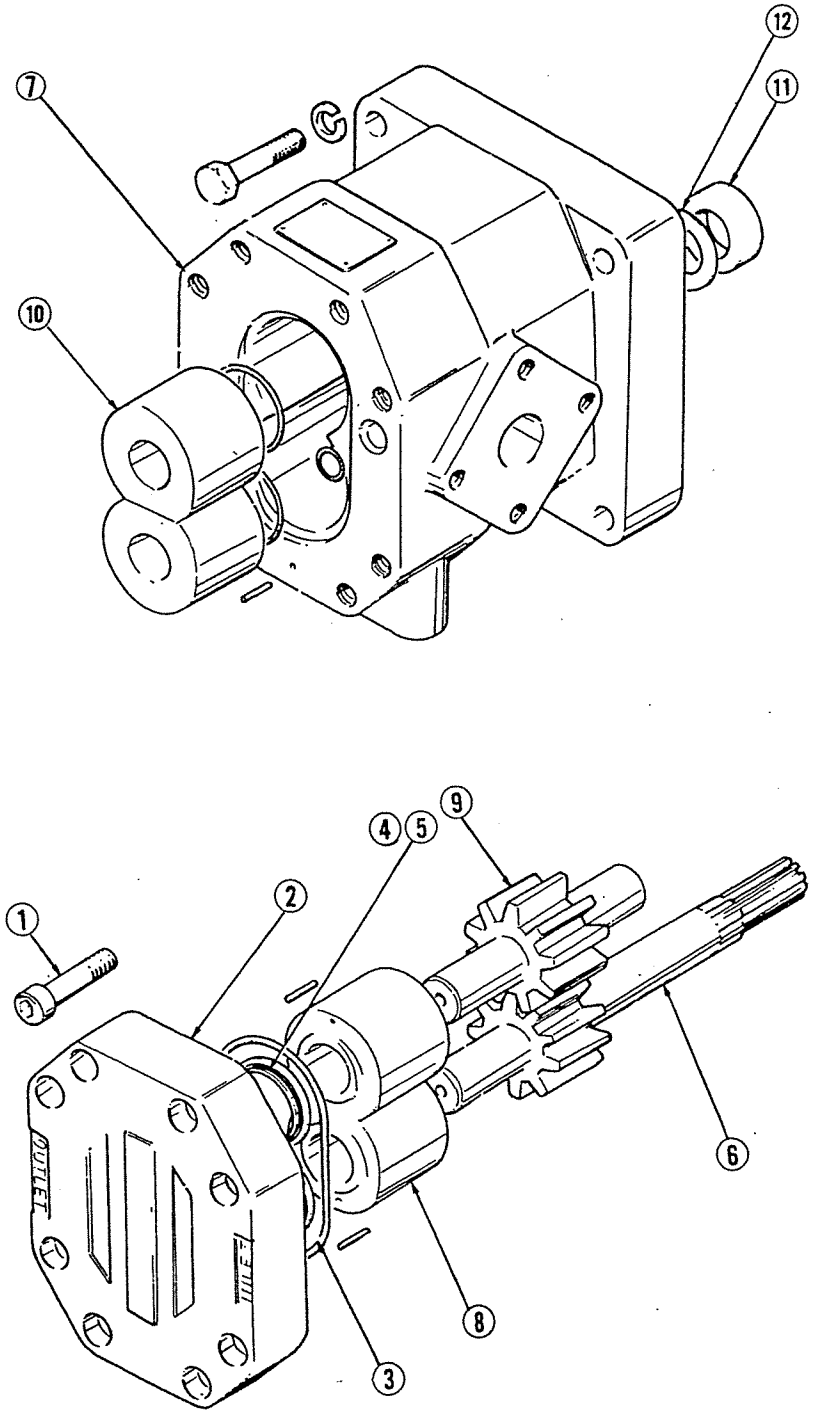
(4) Place bushings (indicated as "A").

(5) Install cover in place.

CAUTION

Cover up the splines of drive gear shaft with 1 or 2 windings of a vinyl tape to avoid damaging oil seal when placing drive gear in pump body.

Disassembling gear pump (BD2E)

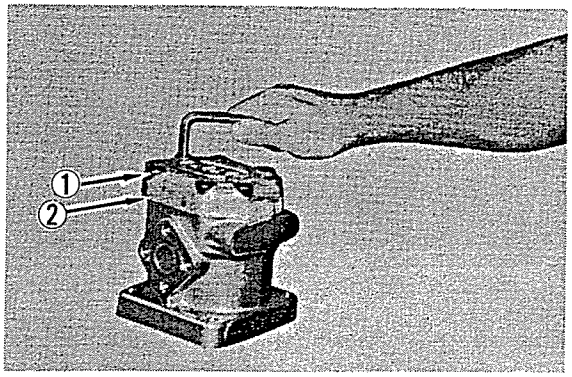


1-Bolt (8 pcs)
2-Cover
3-"O" ring
4-Sealing ring (2 pcs)
5-Support ring (2 pcs)
6-Drive gear
7-Body
8-Bushing (2 pcs)
9-Driven gear
10-Bushing (2 pcs)
11-Oil seal
12-Special washer

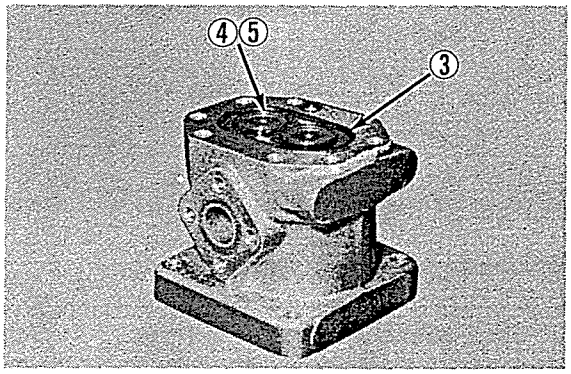
Gear pump (BD2E) — disassembled view

(1) Hold gear pump in a vise.

(2) Loosen off eight bolts (1) securing cover (2), and remove the cover.



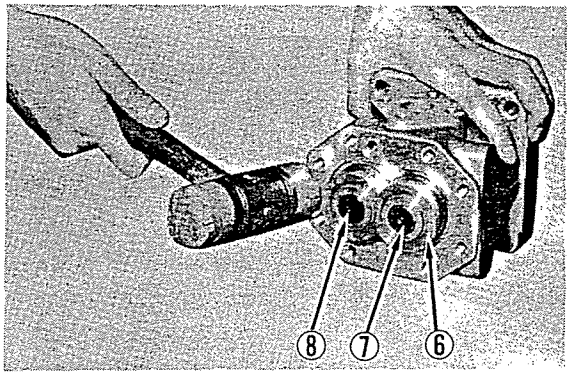
(3) Remove "O" rings (3), sealing rings (4) and support rings (5).



(4) Remove two bushings (6) (indicated as "A"), drive gear (7) and driven gear (8).

NOTE

If the bushings cannot be removed, place gear pump on a wooden bench, and give blows of a soft-faced hammer or a mallet to pump body.



(5) Remove two bushings (indicated as "C") and "O" ring.

(6) Remove oil seal and special washer from pump body.

Assembling gear pump (BD2E)

(1) Place special washer and oil seal in pump body.

(2) Attach "O" ring to bushings (indicated as "C"). Apply a coat of a good-quality grease to the bushings and place them in pump body.

CAUTIONS

a) Place the bushings in pump body at right angles to the bore, being careful not to damage them.

b) If the bushing is scratched or pitted, use an oil stone on a damaged bushing to dress out any slight imperfections.

(3) Place drive and driven gears in pump body.

CAUTIONS

a) When installing the existing gears, make sure that they are meshed as they were before.

b) Cover up the splines of drive gear shaft with 1 or 2 windings of a vinyl tape to avoid damaging oil seal when placing drive gear in pump body.

(4) Attach sealing rings and support rings to bushings (indicated as "A"), and press bushings into pump body.

(5) Install cover in place, being careful not to damage "O" ring placed on body.

Removing hydraulic tank (BS3E)

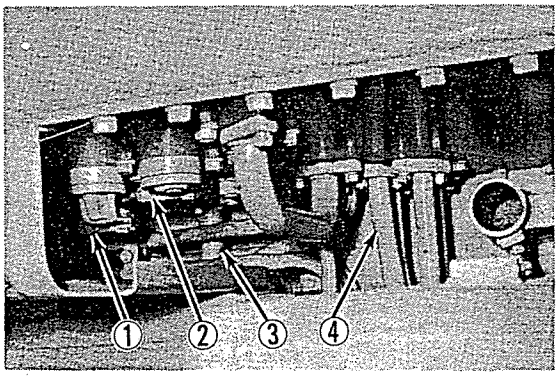
Preparatory steps

(a) Drain the tank.

(b) Remove operator's seat and right-hand side plate.

Procedure

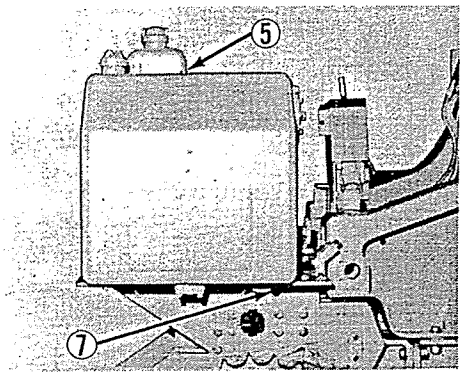
(1) Disconnect control lever rods (1) (2).

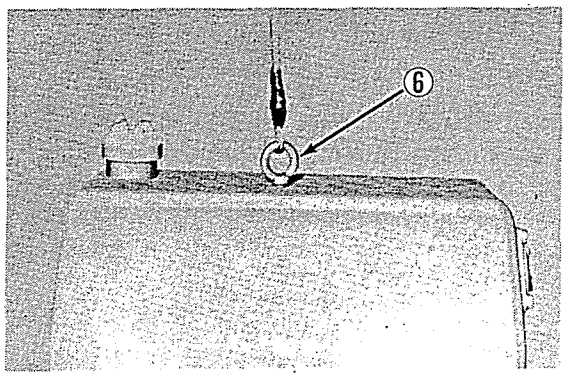


(2) Disconnect two oil pipes (3) (for gear pump) and four oil pipes (4) (for hydraulic cylinders).

(3) Screw anchor bolt (6) into tapped hole (5) in the top of the tank, and attach a sling to the bolt.

(4) Loosen off four bolts (7), and lift off the tank.





Installing hydraulic tank (BS3E)

Procedure

(1) Install the tank on fender.

(2) Connect pipes and control lever rods.

Subsequent steps

(a) Install right-hand side plate and operator's seat.

(b) Fill the tank up to level.

Removing hydraulic tank (BD2E)

Preparatory steps

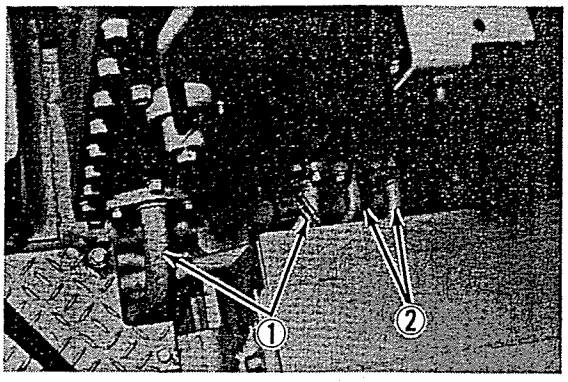
(a) Drain the tank.

(b) Remove operator's seat.

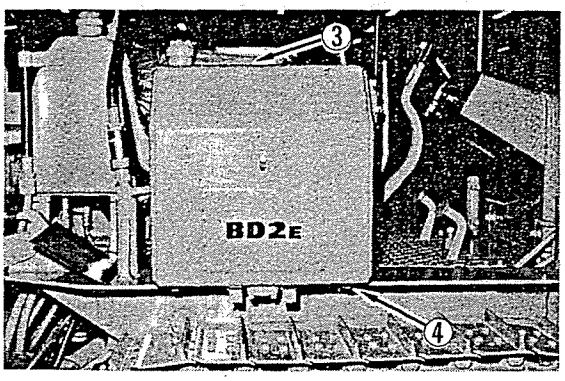
Procedure

(1) Disconnect two oil pipes (1) (for gear pump) and two oil pipes (2) (for control valve).

(2) Screw anchor bolt into tapped hole (3) in the top of the tank, and attach a sling to the bolt.



(3) Loosen off four bolts (4), and lift off the tank.



Installing hydraulic tank (BD2E)

Procedure

(1) Install the tank on fender.

(2) Connect the oil pipes.

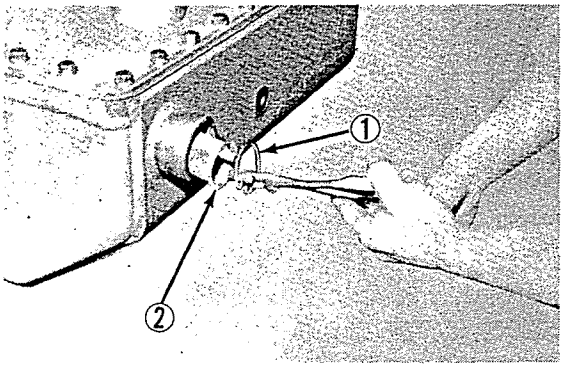
Subsequent steps

(a) Install operator's seat.

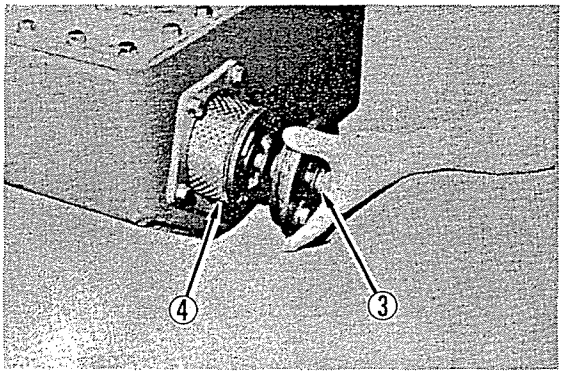
(b) Fill the tank up to level.

Disassembling hydraulic tank

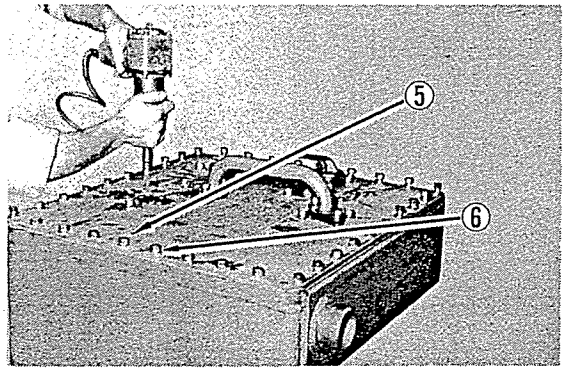
(1) Remove filler cap, and take out snap ring (1) and strainer (2).



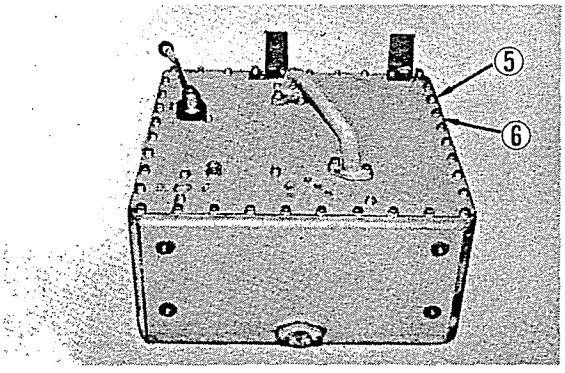
(2) Loosen filter stud (3), and take out element (4).



(3) Loosen off thirty six (36) bolts (5) securing tank cover (6), and remove the cover.

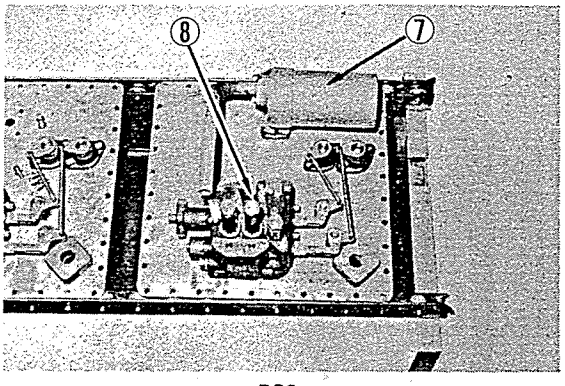


BS3E

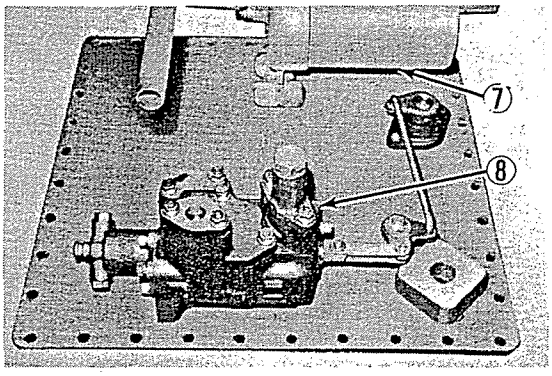


BD2E

(4) Remove filter body (7) and control valve (8) from tank cover (6).



BS3E



BD2E

Assembling hydraulic tank

(1) Install control valve and filter body on cover.

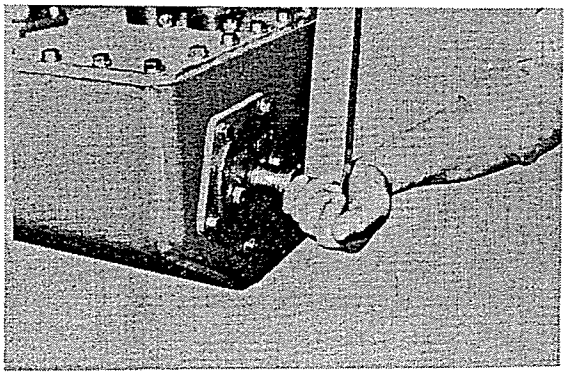
(2) Install cover on the tank.

(3) Place element in the tank.

Filter stud tightening torque	4.8 ± 0.5 kg-m (35 ± 3.6 ft-lb)

NOTE

Make sure that the arrow mark on the element cover faces up.

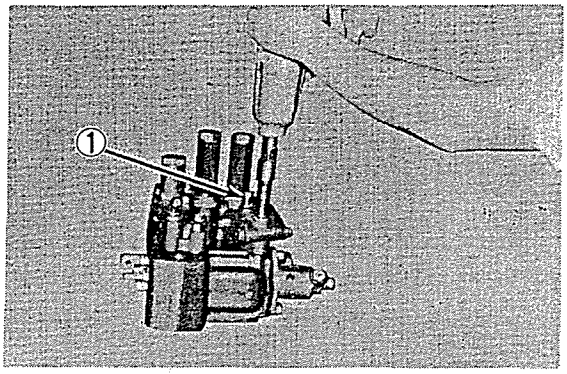


(4) Install strainer.

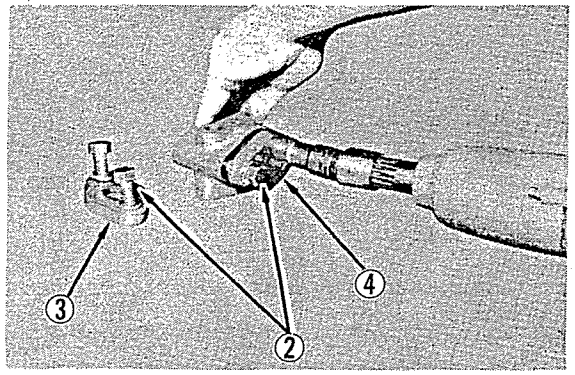
Disassembling control valve (BS3E)

Make-up valve

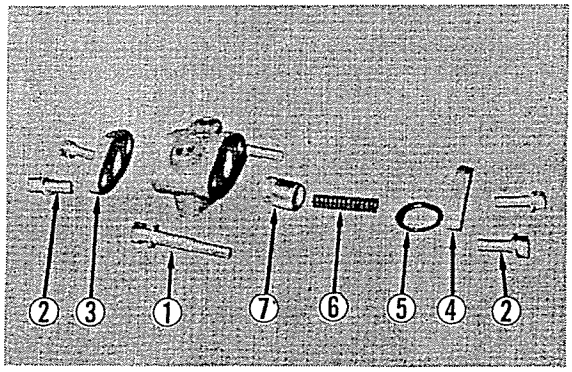
(1) Loosen off two bolts (1) securing make-up valve assembly, and remove the assembly.



(2) Loosen off four bolts (2) securing covers (3) (4), and remove the covers.

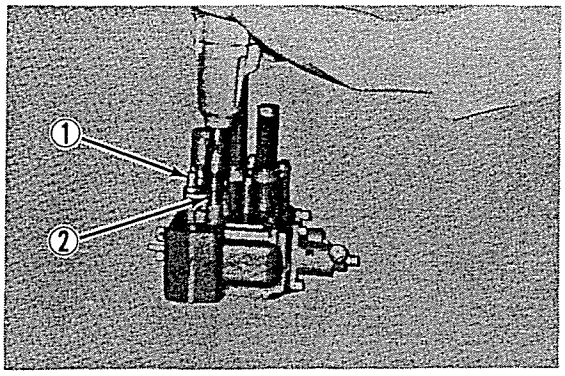


(3) Take out "O" ring (5), spring (6) and valve (7).

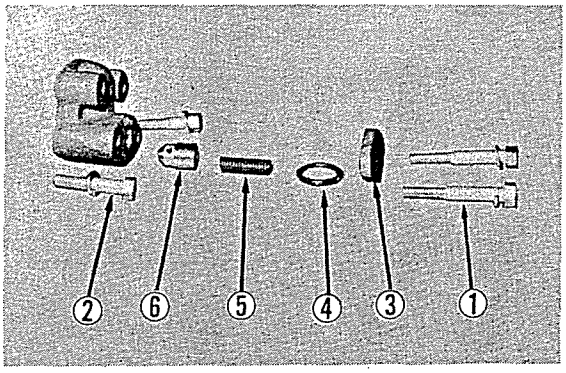


Check valve (for lift cylinders)

(1) Loosen off two bolts (1) and two bolts (2), and remove check valve assembly.

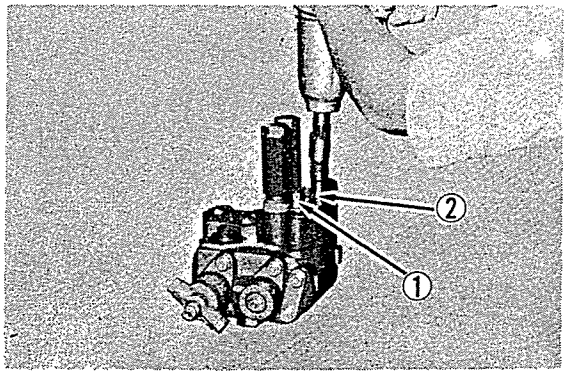


(2) Remove cover (3), "O" ring (4), spring (5) and valve (6).



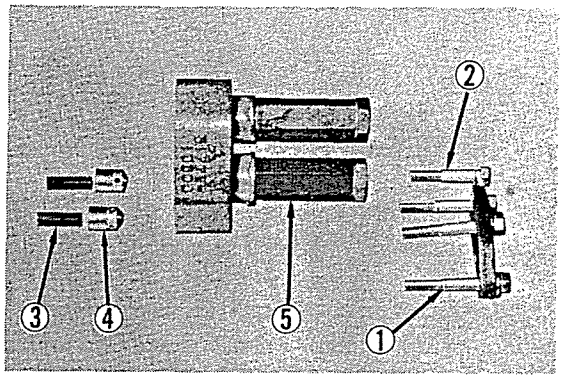
Safety and safety make-up valves

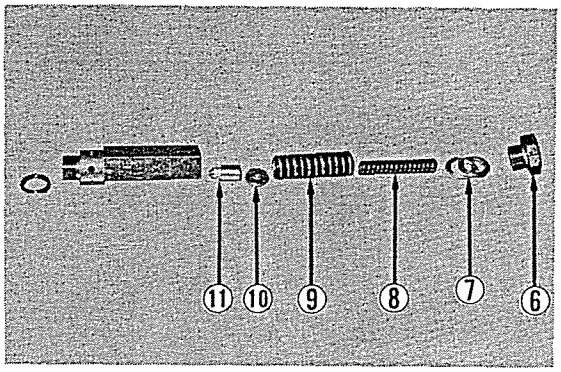
(1) Loosen off three bolts (1) and one bolt (2) securing safety and safety make-up valves, and remove the valves.



(2) Take out springs (3) and valves (4).

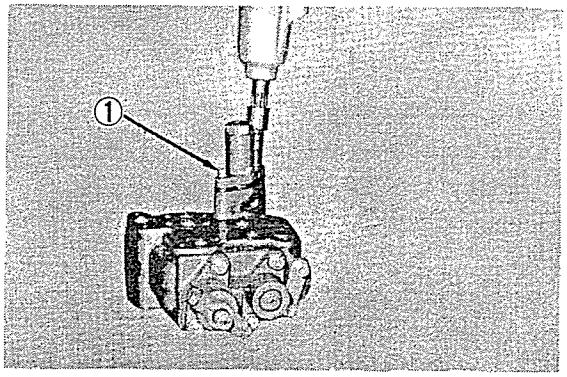
(3) Remove safety valve body (5), and take out plug (6), shims (7), springs (8) (9), washer (10) and valve (11).



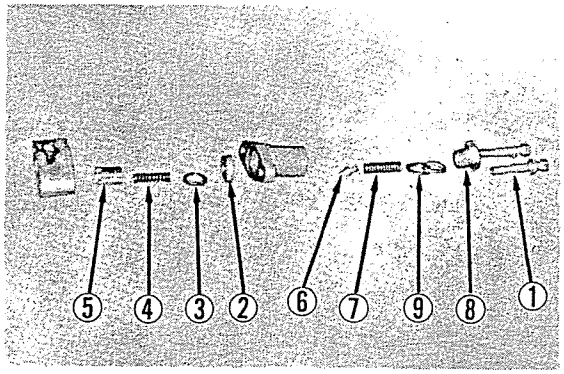


Relief and pilot valve

(1) Loosen two bolts (1) securing relief and pilot valve assembly, and remove the assembly.

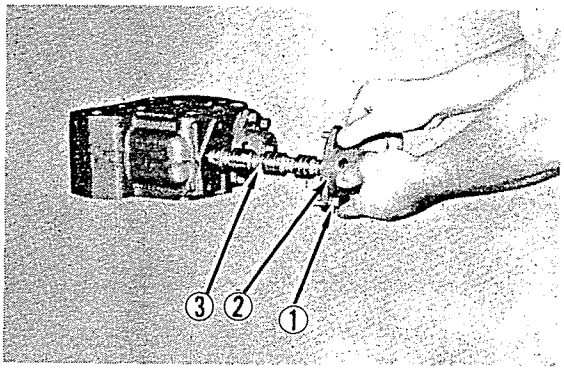


(2) Remove seat (2), "O" ring (3), spring (4), piston (5), valve (6), spring (7), screw plug (8) and shims (9).

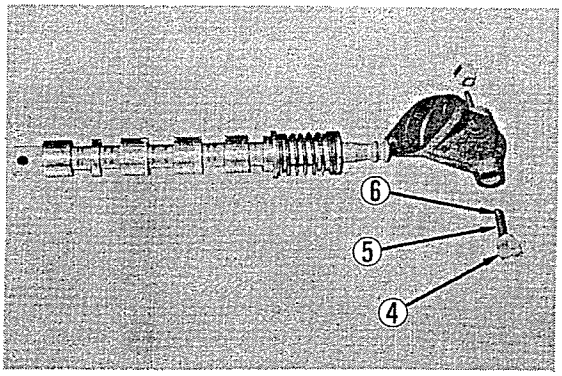


Lift plunger

(1) Loosen off two bolts (1) securing cap (2), and remove the cap complete with plunger (3).

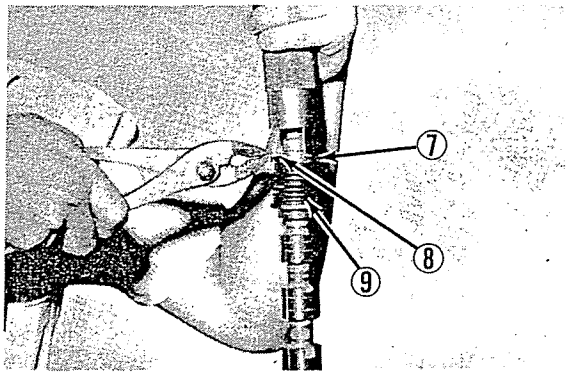


(2) Remove two plugs (4), and take out spring (5) and steel ball (6).



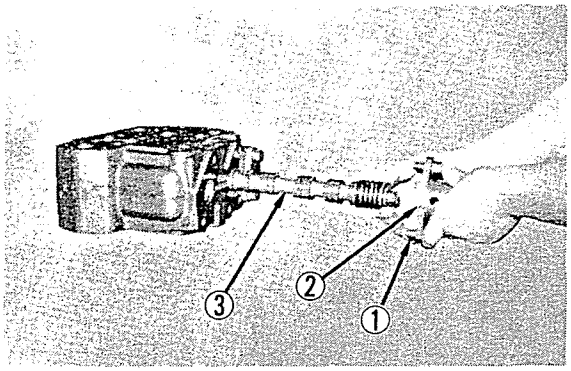
(3) Separate plunger from cap.

(4) With plunger held, push down on spring retainer (7) to compress spring (9), and remove washer (8) from plunger.



Dump plunger

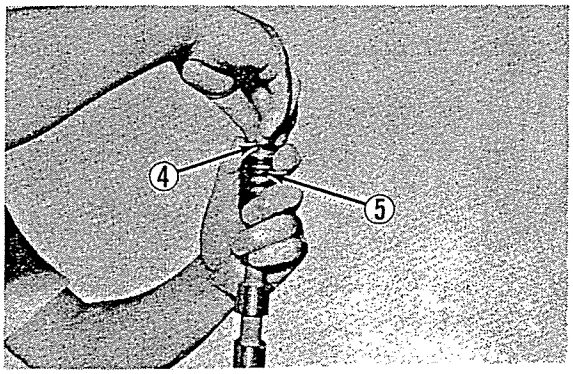
(1) Loosen off two bolts (1) securing cap (2), and remove the cap complete with plunger (3).



(2) Remove bolt (4) at the end of plunger.

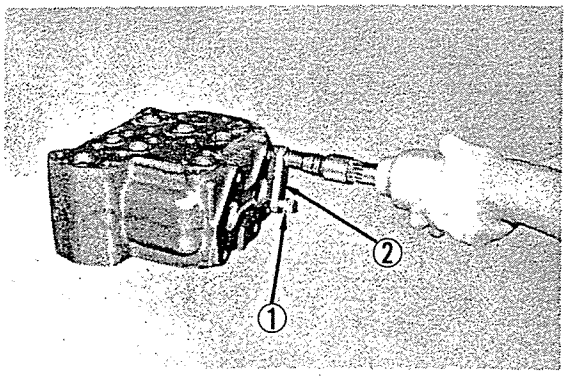
NOTE

This bolt is spring-loaded but slightly. Compressing spring (5) a little will facilitate removal of the bolt.

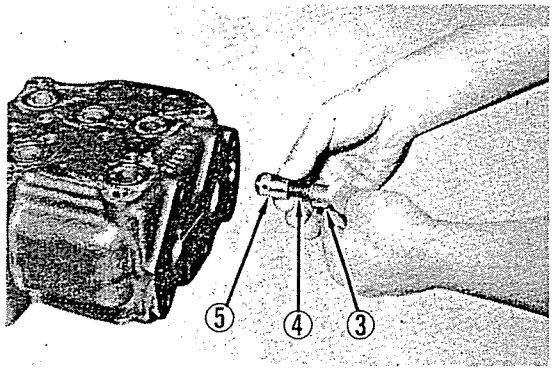


Check valve (for dump cylinders)

(1) Loosen off two bolts (1) securing stopper (2), and remove the stopper.



(2) Take out plug (3), spring (4) and valve (5).



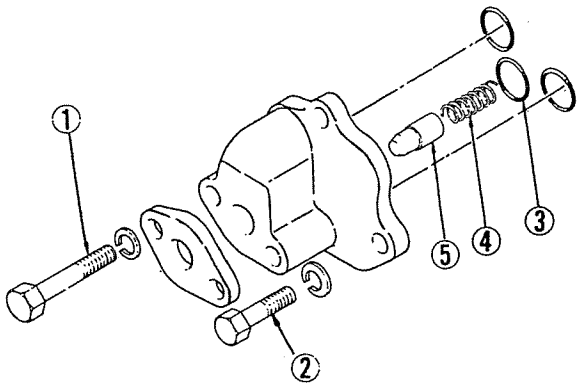
Assembling control valve (BS3E)

(1) Install check valve (for dump cylinders).
(2) Install dump plunger.
(3) Install lift plunger.
(4) Install relief and pilot valve.
(5) Install safety and safety make-up valves.
(6) Install check valve (for lift cylinders).
(7) Install make-up valve.

Disassembling control valve (BD2E)

Make-up valve

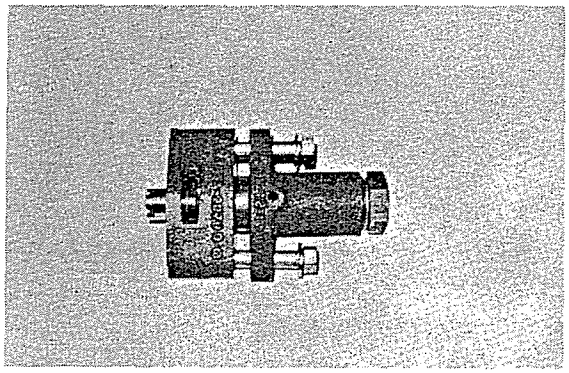
(1) Loosen off two bolts (1) and two bolts (2) securing make-up valve assembly, and remove the assembly.
(2) Remove "O" ring (3), spring (4) and valve (5).



Relief and pilot valve (See the topic for BS3E.)

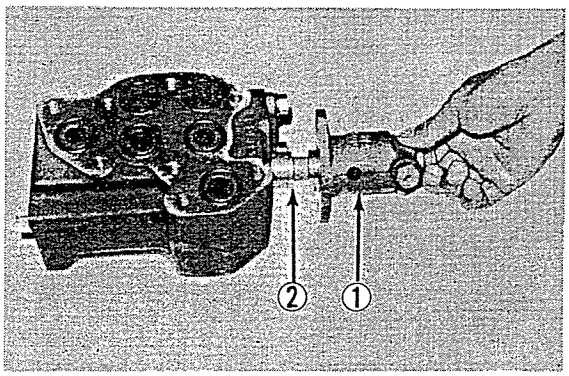
(1) Loosen off two bolts securing relief and pilot valve assembly, and remove the assembly.

(2) Remove seat, "O" ring, spring, piston, valve, spring, screw plug and shims.

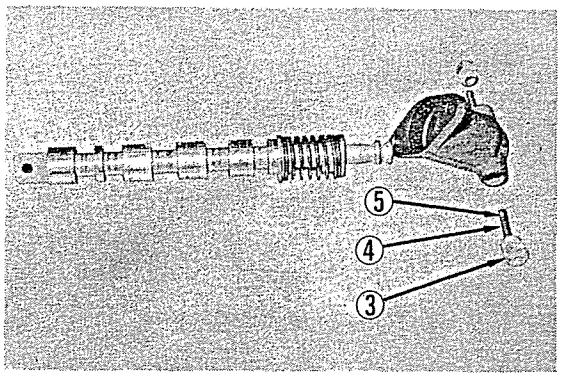


Plunger

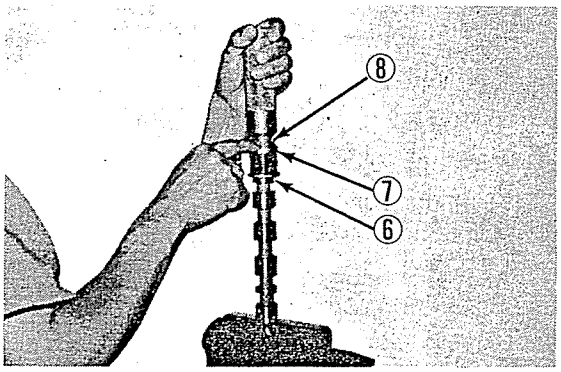
(1) Loosen off two bolts securing cap (1), and remove the cap complete with plunger (2).



(2) Remove two plugs (3), and take out spring (4) and steel ball (5).



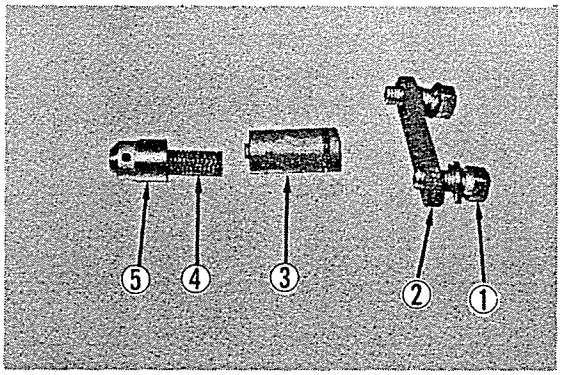
(3) With plunger held, push down on spring retainer (6) to compress spring (7), and remove washer (8) from plunger.



Check valve (See the topic for BS3E.)

(1) Loosen off two bolts (1), and remove stopper (2).

(2) Take out plug (3), spring (4) and valve (5).



Assembling control valve (BD2E)

(1) Install check valve.

(2) Install plunger.

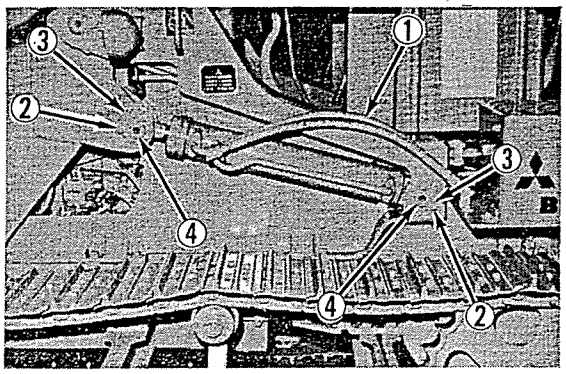
(3) Install relief and pilot valve.

(4) Install make-up valve.

Removing lift cylinders (BS3E)

Preparatory step
Lower the bucket to the ground.

Procedure
(1) Disconnect two oil pipes (1).
(2) Support the cylinder with a wire.
(3) Loosen off two bolts (2) and remove lock plate (3) and pin (4) at each end of cylinder.



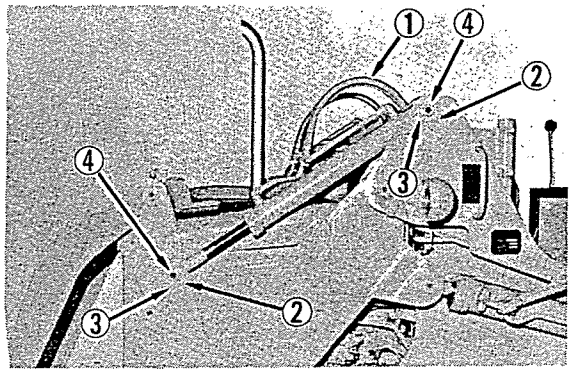
Installing lift cylinders (BS3E)

(1) Install the cylinder in position.
(2) Connect oil pipes.

Removing dump cylinders (BS3E)

Preparatory step
Lower the bucket to the ground.

Procedure
(1) Disconnect two oil pipes (1).
(2) Support the cylinder with a wire.
(3) Loosen off two bolts (2) and remove lock plate (3) and pin (4) at each end of cylinder.



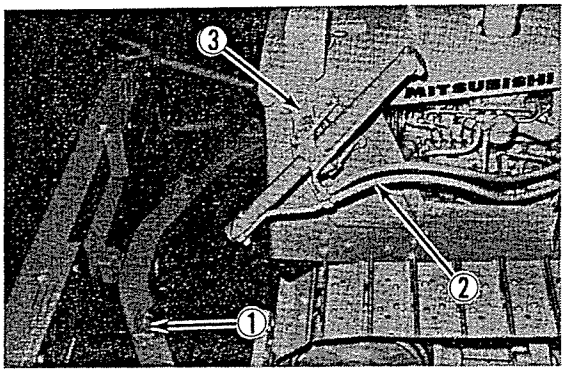
Installing dump cylinders (BS3E)

(1) Install the cylinder in position.
(2) Connect oil pipes.

Removing blade lift cylinders (BD2E)

Preparatory step
Lower the blade to the ground.

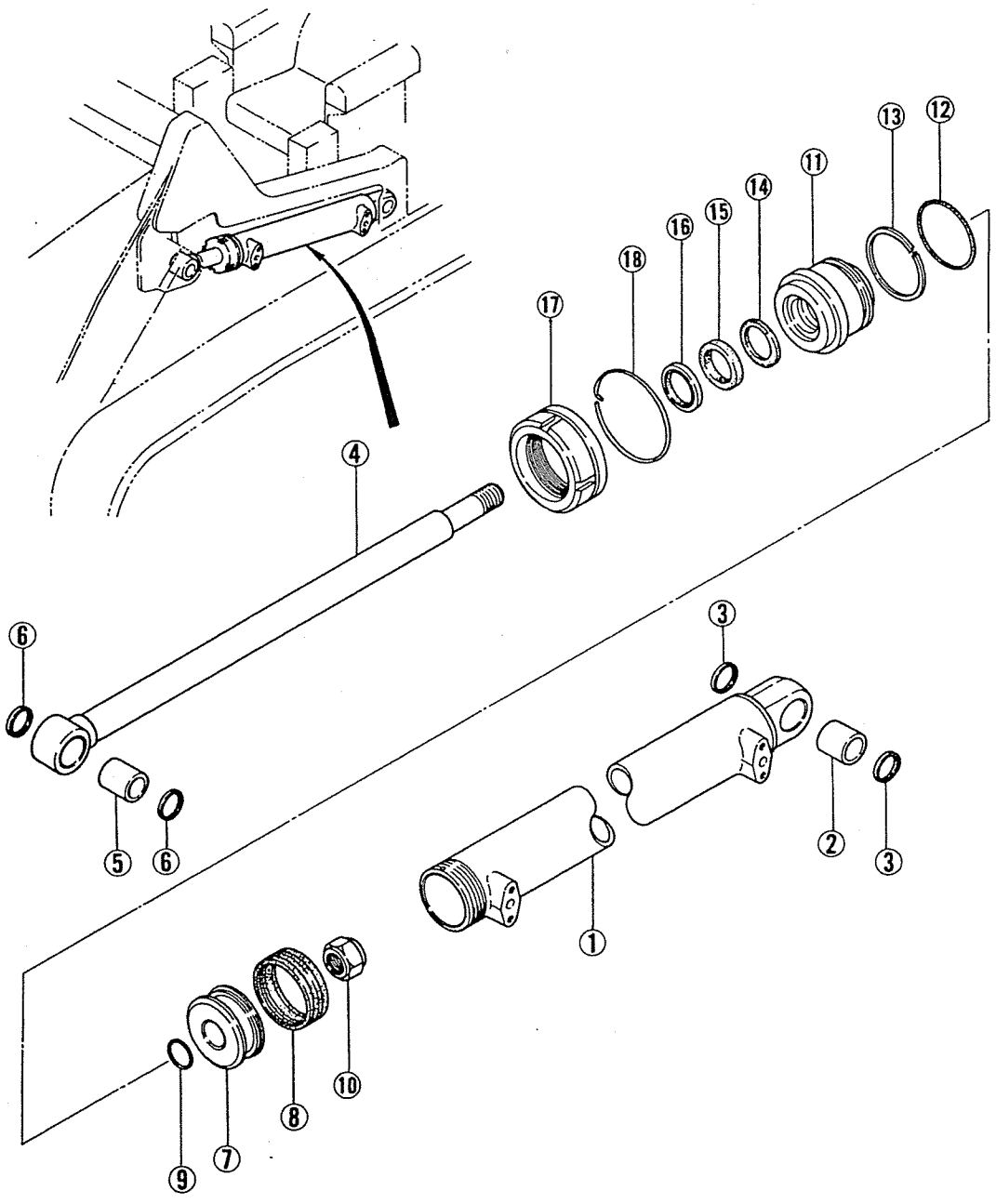
Procedure
(1) Pull out pin (1) at the end of piston rod, and fully retract the rod.
(2) Support the cylinder with a wire.
(3) Disconnect two oil pipes (2).
(4) Loosen off four bolts (3) securing the cylinder, and remove the cylinder.



Installing blade lift cylinders (BD2E)

(1) Install the cylinder to radiator guard.
(2) Connect oil pipes.
(3) Fully extend piston rod, and connect it to "C" frame with pin.

Disassembling cylinders



1-Cylinder	7-Piston	13-Back-up ring
2-Bushing	8-Piston seal	14-Buffer ring
3-Dust seal	9-"O" ring	15-Packing
4-Piston rod	10-Self-locking nut	16-Dust seal
5-Bushing	11-Guide bushing	17-Grand screw
6-Dust seal	12-"O" ring	18-Ring

Lift cylinder — disassembled view

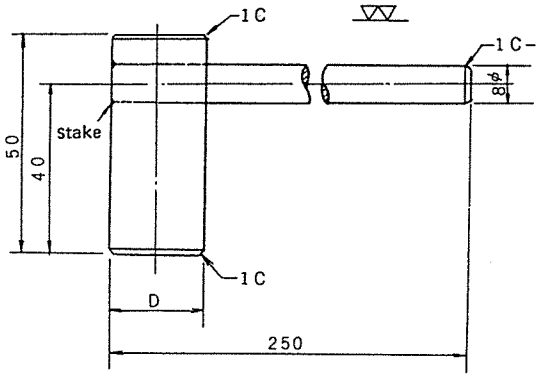
Installing piston seal

Preparatory step

Prepare the following jig:

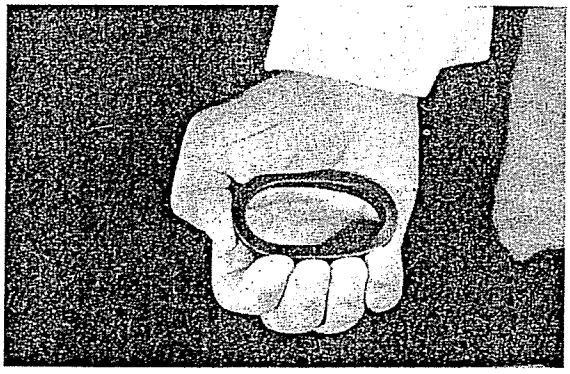
Unit: mm (in.)

Cylinder	Piston I.D.	Dimension "D"
Lift	30 (1.181)	29.5 (1.161)
Dump	24 (0.945)	23.5 (0.925)

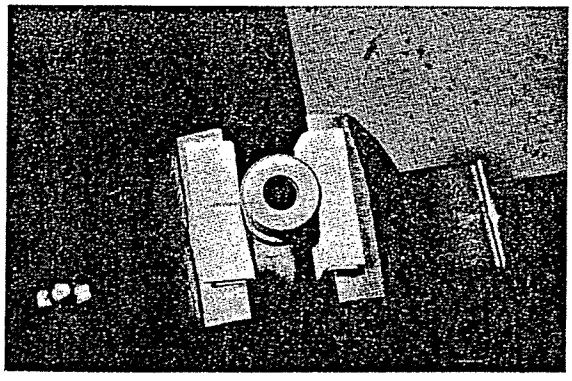


Procedure

(1) Lightly squeeze piston seal with the hand three or four times to soften the seal, as shown.

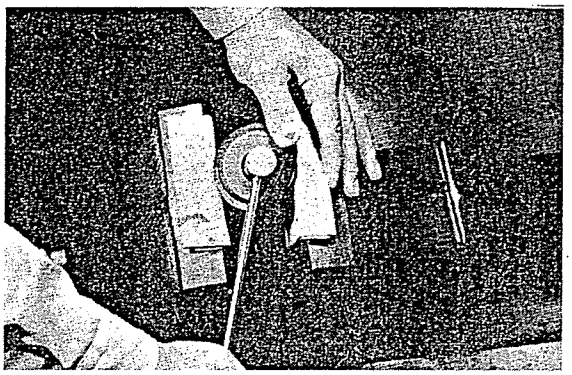


(2) Hold piston in a vise, using copper jaw caps which protect piston surface.

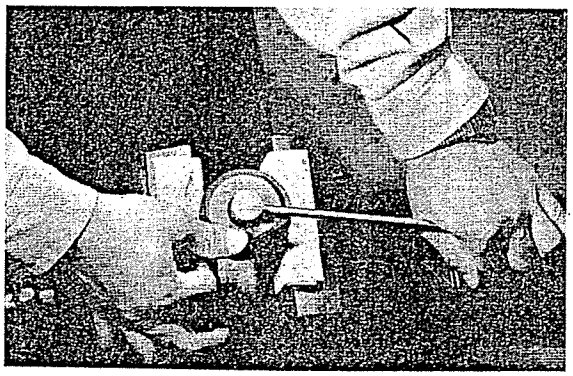


(3) Apply a thin coat of hydraulic oil to piston seal, and place one side of the seal in the groove in the piston; then set up a jig by inserting it into the bore of the piston.

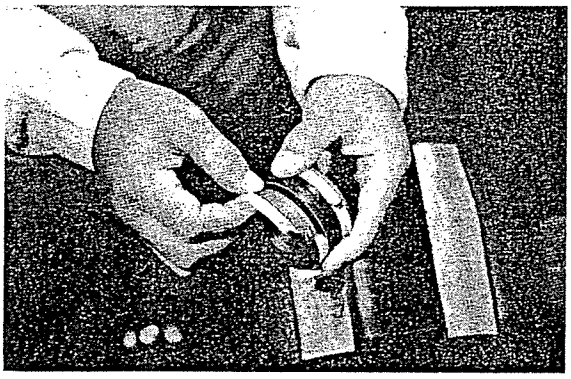
(4) With the seal held with the left-hand, press down the seal with the arm of the jig while rotating the jig. As the seal is seated about 3/4 in the groove, rotate the jig to a new position, pressing another part of the seal.



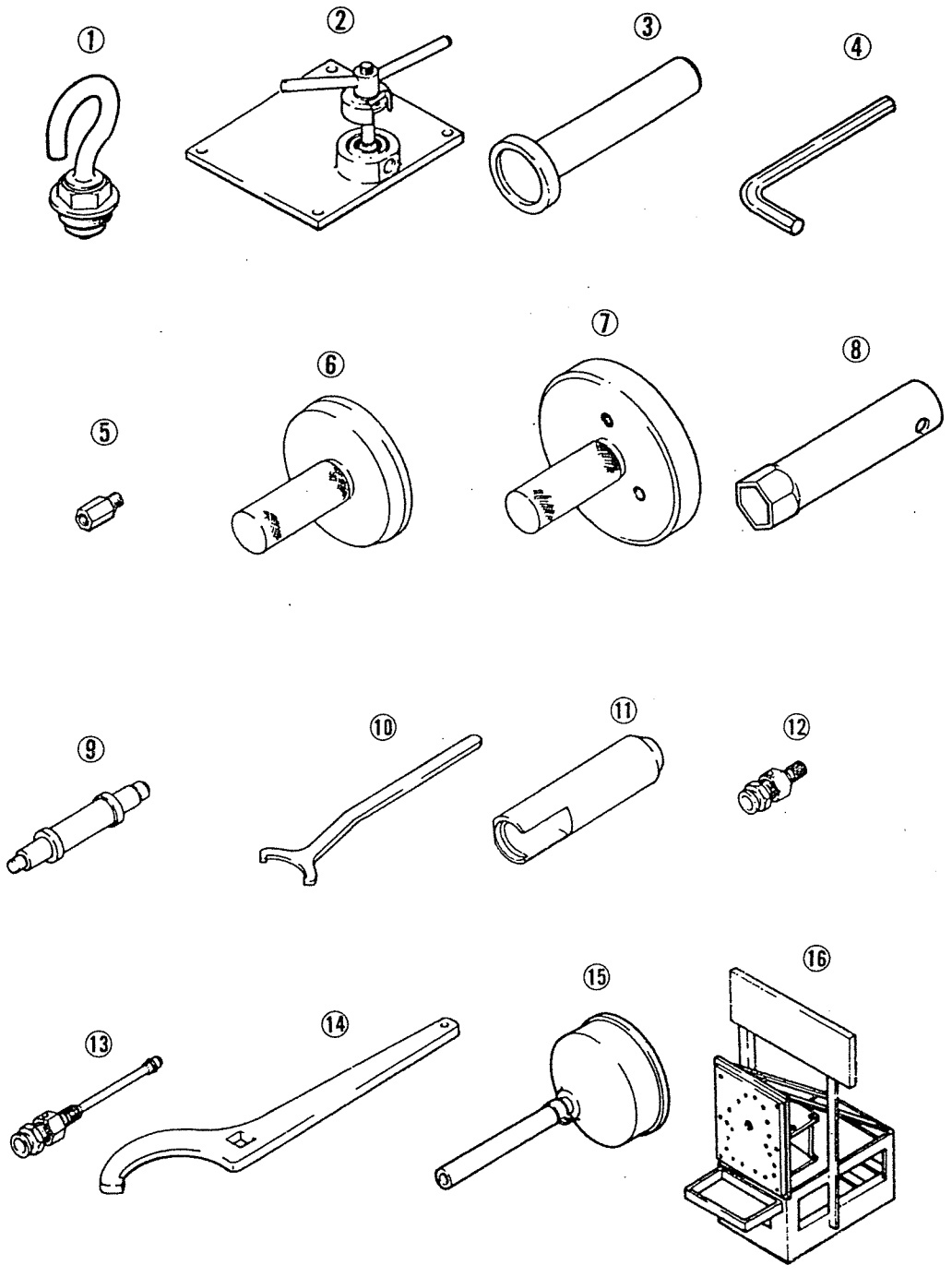
(5) Rotate the jig one complete turn to allow the seal to fully seat in the groove.



(6) Place back-up ring in position.



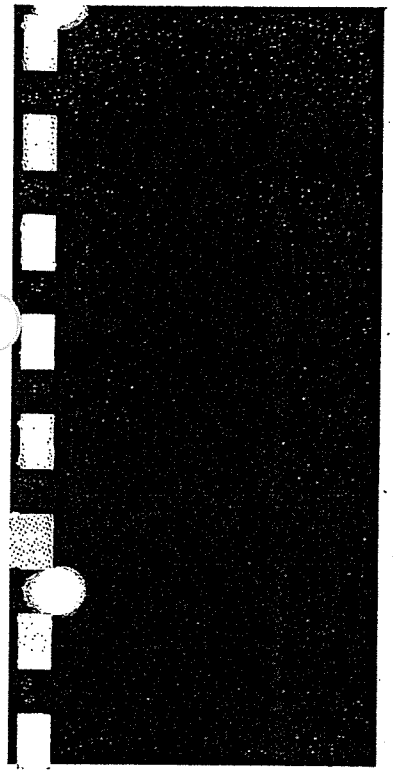
SPECIAL TOOLS



SPECIAL TOOLS

No.	Tool number	Tool name	Used for:
1	58609-04200	Hook	Lifting power direction clutch
2	58609-00020	Clutch assembling tool	Disassembling and assembling power direction clutch and testing power direction clutch piston for oiltightness
3	58609-04300	Seal inserting tool	Installing seals on power direction clutch
4	58609-00400	Wrench	Disassembling and assembling hydraulic pump
5	58609-02600	Connector	Pressure gauge connection for testing of power direction clutch control valve (complete with "O" ring 05500-19008)
6	58609-21200	Seal inserting tool	Installing teflon seals on power direction clutch
7	58609-21300	Seal stabilizing tool	Installing teflon seals on power direction clutch
8	30691-02300	Socket wrench	Installing injection nozzles
9	58609-21400	Clutch disc aligning tool	Installing power direction clutch discs
10	58309-01900	Wrench	Adjusting steering clutch round nuts
11	58609-01900	Steering clutch tool	Assembling steering clutch
12	58609-00300	Adaptor	Lubricating track carrier rollers
13	58609-10200	Adaptor	Lubricating front idlers and track rollers
14	58609-01500	Hook wrench	Tightening tilt cylinder grand screw
	58609-01600	Hook wrench	Tightening lift cylinder grand screw.
15	58309-02100	Funnel	Lubrication service
16	58609-00030	PDC driving test bench	Testing power direction clutch operation

SERVICE MANUAL



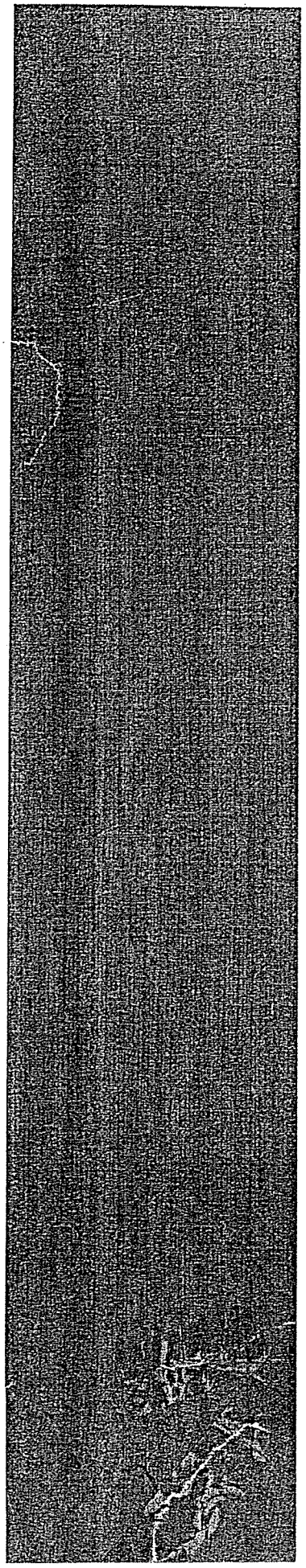
MITSUBISHI DIESEL ENGINE

4DQ50 C

(for BD2E · BS3E)

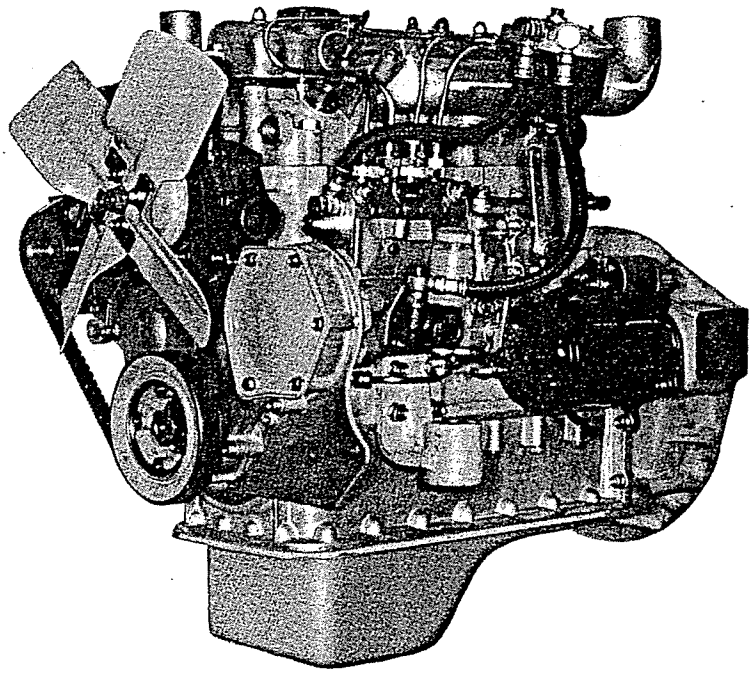
MITSUBISHI
HEAVY INDUSTRIES, LTD.

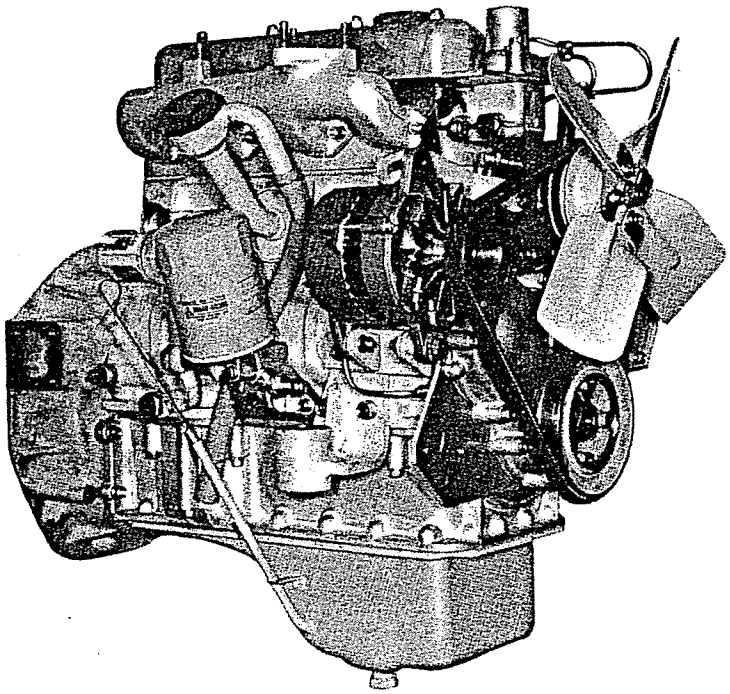
CONSTRUCTION AND FUNCTION



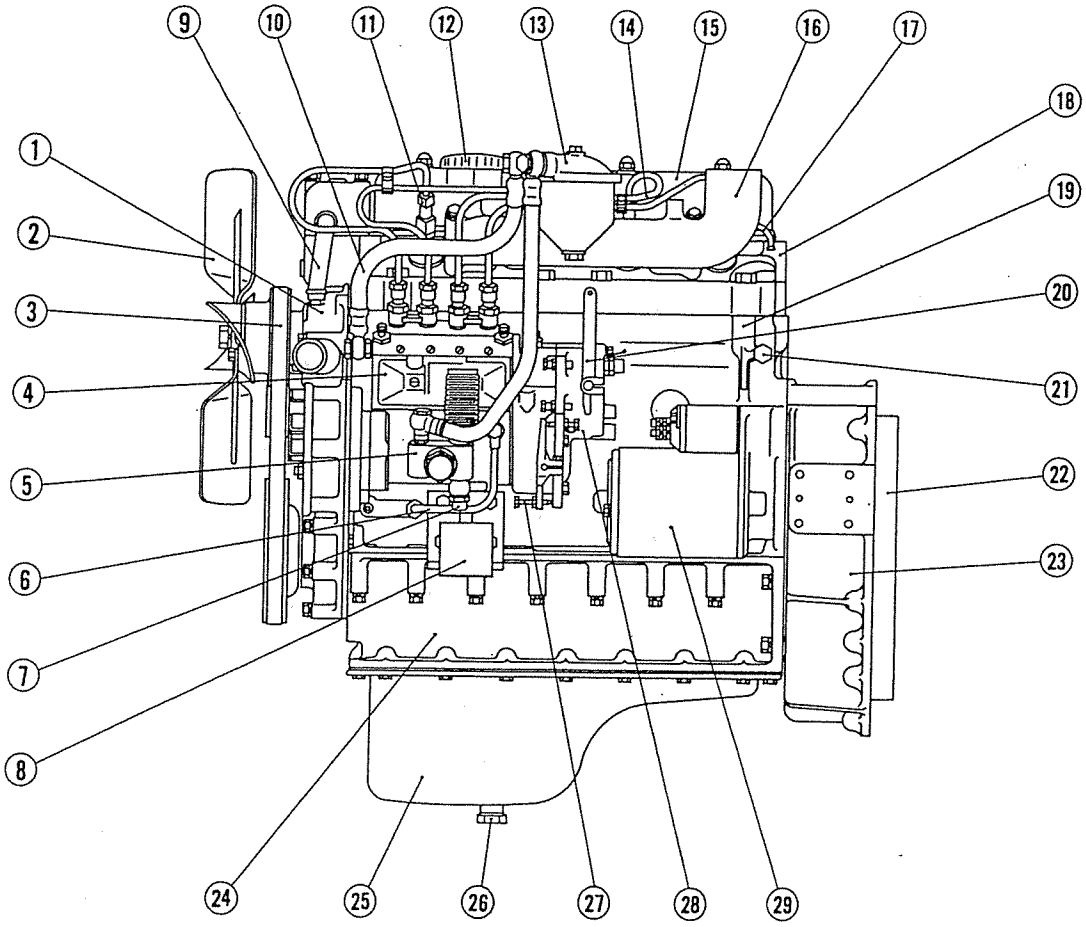
1. Description

Exterior views



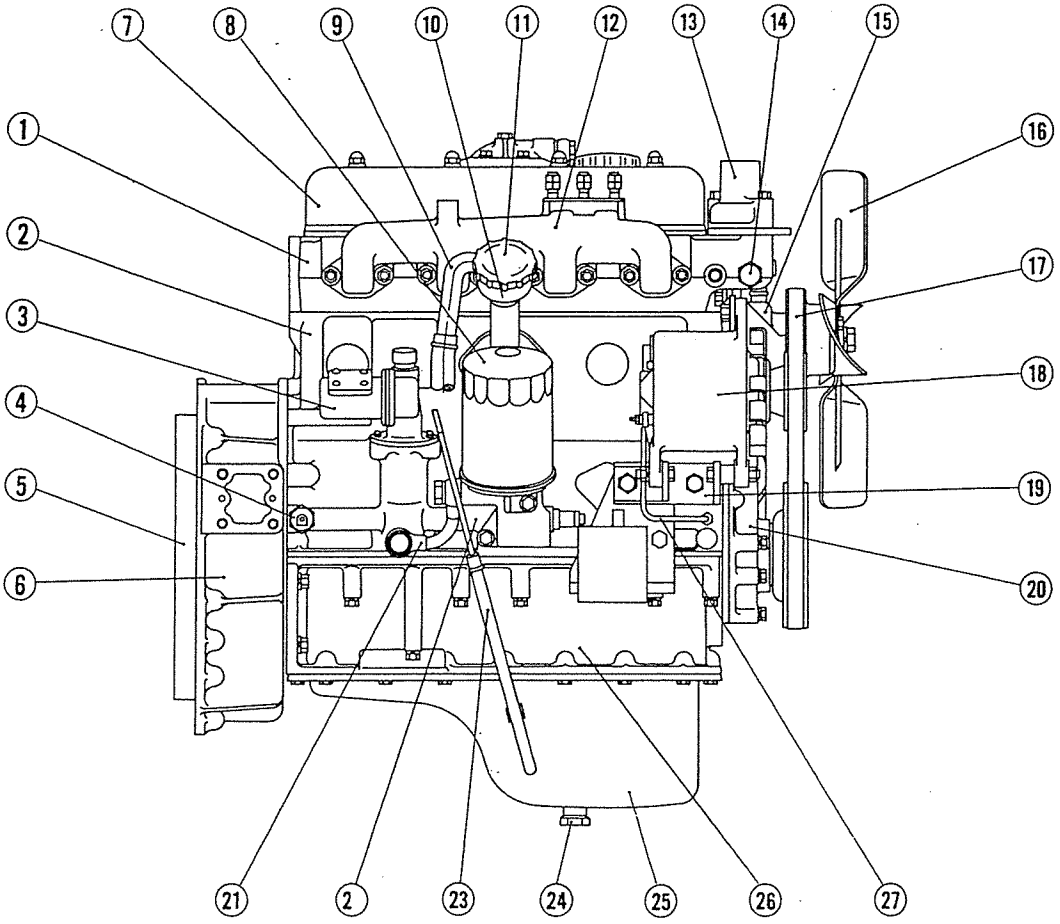


Engine components



Left-hand side

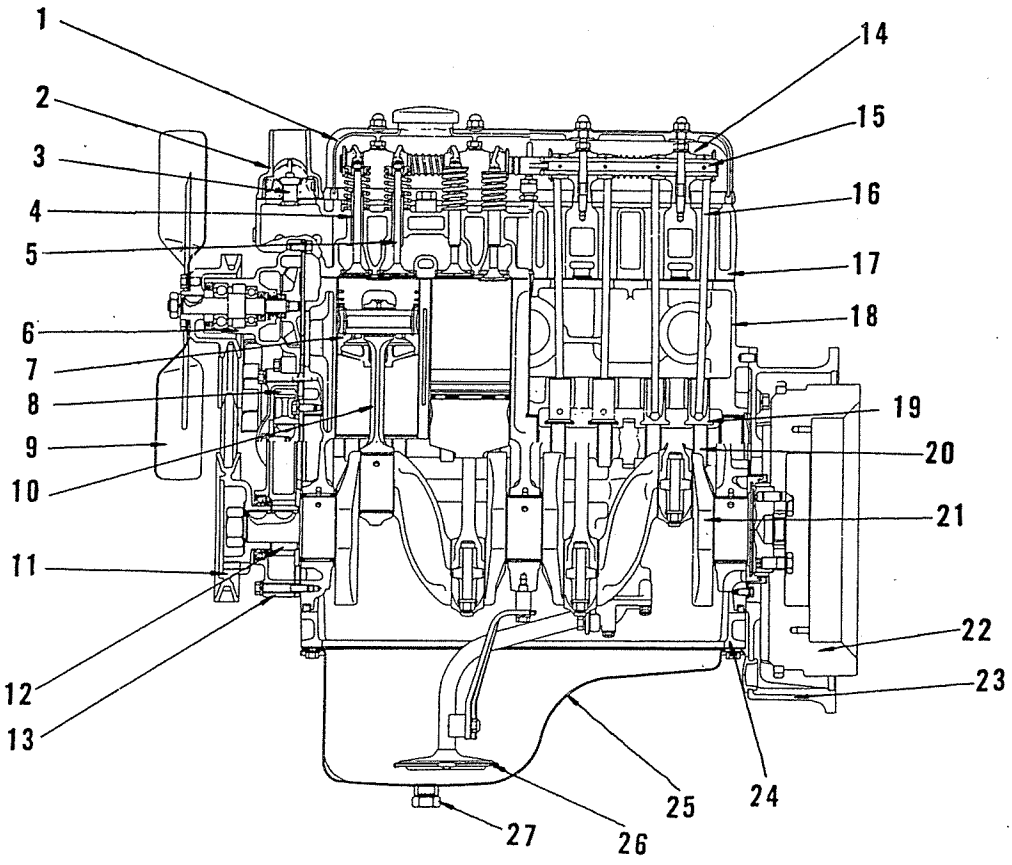
1-Water pump
2-Fan
3-Fan belt
4-Fuel injection pump
5-Fuel feed pump
6-Oil pipe
7-Fuel inlet nipple
8-Mounting bracket
9-Bypass hose
10-Fuel feed pipe
11-Injection nozzle
12-Oil cap
13-Fuel filter
14-Fuel injection pipe
15-Rocker arm case cover
16-Intake manifold
17-Fuel leak-off pipe
18-Cylinder head
19-Crankcase
20-Adjusting lever
21-Hanger
22-Flywheel
23-Flywheel housing
24-Oil case
25-Oil pan
26-Drain plug
27-Rack stopper
28-Governor
29-Starter



Right-hand side

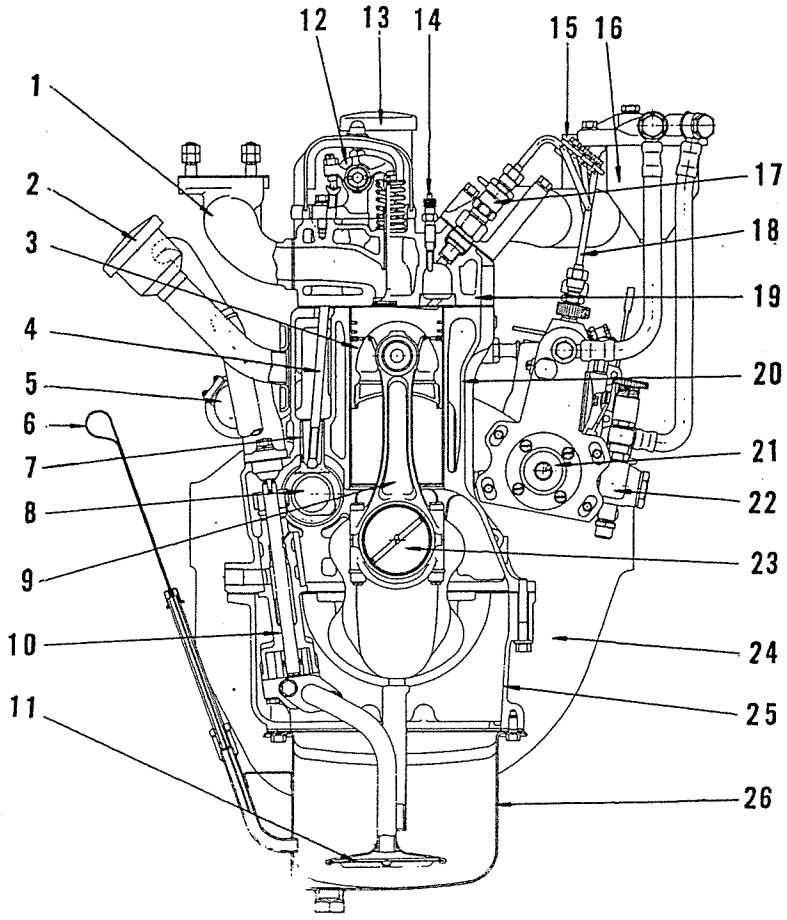
1-Cylinder head	8-Oil filter	15-Water pump	22-Oil bypass alarm
2-Crankcase	9-Breather pipe	16-Fan	23-Oil level gauge
3-Service meter	10-Oil filler	17-Fan belt	24-Drain plug
4-Indicator switch	11-Oil filler cap	18-Alternator	25-Oil pan
5-Flywheel	12-Exhaust manifold	19-Alternator bracket	26-Oil case
6-Flywheel housing	13-Elbow	20-Timing gear case	27-Oil pipe
7-Rocker case	14-Screw plug	21-Oil pipe	

Engine cross sections



Longitudinal cross section

1-Rocker arm cover	8-Camshaft gear	15-Rocker arm shaft	22-Flywheel
2-Thermostat elbow	9-Fan	16-Valve push rod	23-Flywheel housing
3-Thermostat	10-Connecting rod	17-Cylinder head	24-Oil case
4-Exhaust valve	11-Crankshaft pulley	18-Crankcase	25-Oil pan
5-Intake valve	12-Crankshaft gear	19-Tappet	26-Oil strainer
6-Water pump	13-Timing gear case	20-Camshaft	27-Drain plug
7-Piston	14-Rocker arm shaft bracket	21-Crankshaft	



Transverse cross section

1-Exhaust manifold	8-Camshaft	15-Intake manifold	21-Fuel injection pump
2-Oil filler	9-Connecting rod	16-Fuel filter	22-Fuel feed pump
3-Piston	10-Oil pump	17-Fuel injection nozzle	23-Crankshaft
4-Valve push rod	11-Oil strainer	18-Fuel injection pipe	24-Flywheel housing
5-Service meter	12-Rocker arm	19-Cylinder head	25-Oil case
6-Oil level gauge	13-Oil filler cap	20-Crankcase	26-Oil pan
7-Tappet	14-Glow plug		

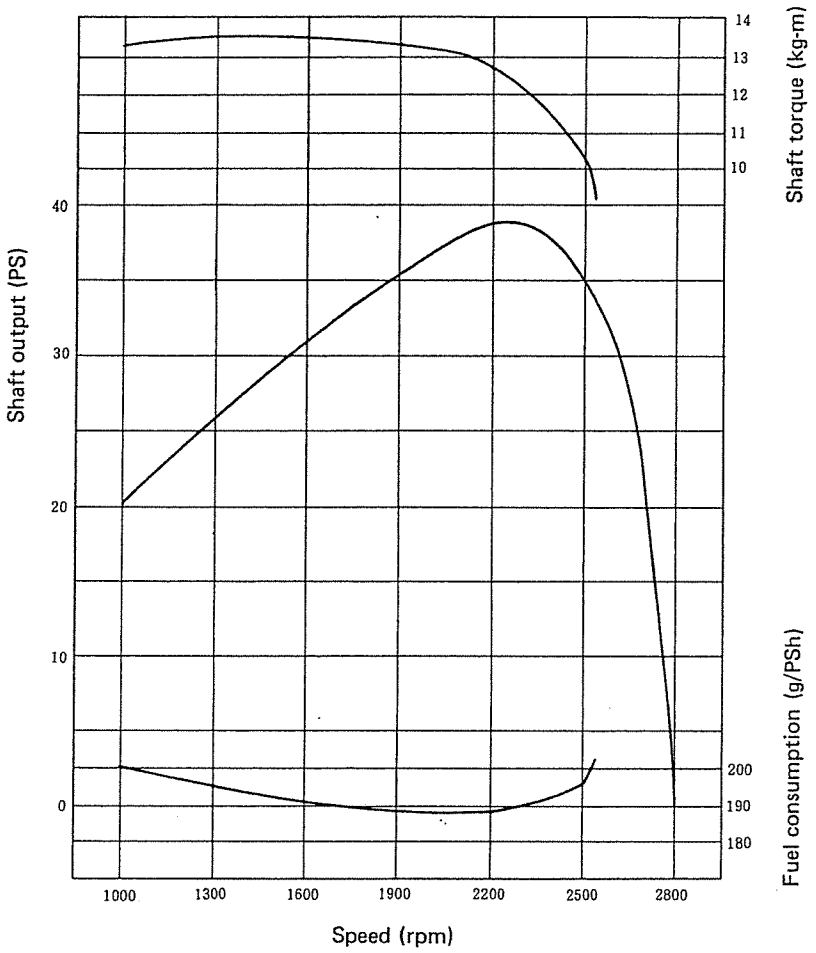
Specifications

General data	Model designation		4DQ50C
	Type		Water-cooled, 4-stroke cycle, in-line, turbulence-chamber type diesel
	Number of cylinders		4
	Bore x stroke, mm (in.)		84 x 94 (3.307 x 3.701)
	Piston displacement, cc (cu in.)		2084 (127)
	Compression ratio		21 : 1
	Firing order		1 - 3 - 4 - 2
	Direction of rotation		Clockwise as viewed from timing gear case side
	Fuel		ASTM No. 2-D diesel fuel
	Crankcase lubricating oil		API service classification CC - class
	Dimensions	Overall length, mm (in.)	745 (29.331)
		Overall width, mm (in.)	572 (22.520)
		Overall height, mm (in.)	730 (28.740)
	Weight (dry), kg (lb)		220 (485)
	Maximum output, PS/rpm		35/2500
	Maximum torque, kg-m (ft-lb)/rpm		13.5 (97.6)/1200
	Compression pressure, kg/cm^2 (psi) (rpm)		20 (284.4) (150 ~ 200), minimum
	Minimum speed, rpm		650 ~ 700
	Maximum speed, rpm		2800 ± 20
	Cylinder liner		Dry type, special cast iron
	Number of piston rings	Compression rings	2
		Oil	1 (with spring expander)
	Valve arrangement		Overhead type
	Valve timing	Intake valve Opens Closes	 30° before TDC 50° after BDC
		Exhaust valve Opens Closes	 74° before BDC 30° after TDC
	Valve clearance	Intake, mm (in.)	0.25 (0.0098) (cold)
		Exhaust, mm (in.)	0.25 (0.0098) (cold)
	Starting system		Starting motor
Fuel system	Fuel feed pump	Model	ND - EP/KS22A
		Manufacturer	Nippon Denso Co., Ltd.
		Cam lift, mm (in.)	6 (0.236)
	Fuel injection pump	Model	PES4A65B
		Manufacturer	Nippon Denso Co., Ltd.
		Plunger diameter, mm (in.)	6.5 (0.256)
		Plunger lead	Right hand
		Cam lift, mm (in.)	8 (0.315)

Fuel system — cont.	Injection timing		25 ± 1° (before TDC)
	Governor	Type Model Manufacturer	Centrifugal, flyweight, all-speed type RUV Nippon Denso Co., Ltd.
	Injection nozzles	Manufacturer Nozzle holder Nozzle tip Type Spray hole diameter, mm(in.) Spray cone angle Injection pressure, kg/cm² (psi)	Nippon Denso Co., Ltd. Bosch type, KCA17SD Bosch type, ND – DN40SD Throttle type 1 (0.039) 40° 120 (1706)
	Fuel filter	Filter element Manufacturer	Paper-element type Nippon Rokaki Co., Ltd.
Lubrication system	Capacity	Oil pan, liter (gal) Oil filter, liter (pt)	6.0 (1.6) 0.7 (1.5)
	Oil pressure	When operating, kg/cm² (psi) When idling, kg/cm² (psi)	3 ~ 4 (42.7 ~ 56.9) 1.5 (21.3), minimum
	Oil pump	Type Speed ratio to crankshaft Displacement, liter (cu in.)/min/rpm	Trochoid type 1/2 10.5 (641)/min/2500 Oil temperature: 50°C (122°F) Discharge pressure: 3kg/cm² (42.7 psi)
	Oil filter	Type	Paper element type
	Relief valve	Type Opening pressure, kg/cm² (psi)	Piston-valve type 3 ± 0.3 (42.7 ± 4.3)
	Oil bypass valve	Type Opening pressure, kg/cm² (psi)	Piston-valve type 0.8 ~ 1.2 (11.4 ~ 17.1)
Cooling system	Capacity (excl. radiator), liter (gal)		5.5 (1.45)
	Water pump	Type Speed ratio to crankshaft Displacement, liter (cu in.)/min/rpm	Centrifugal type 1.46 : 1 105 (6408)/4000
	Belt	Type Manufacturer	Low-edge cog B-type "V" belt Mitsuboshi Belt Co., Ltd.
	Thermostat	Type Manufacturer Valve opening temperature, °C (°F)	Wax type Fuji Seiko Co., Ltd. 76.5 ± 2° (169.7 ± 36°F) (Fully opens at 90°C (194°F))

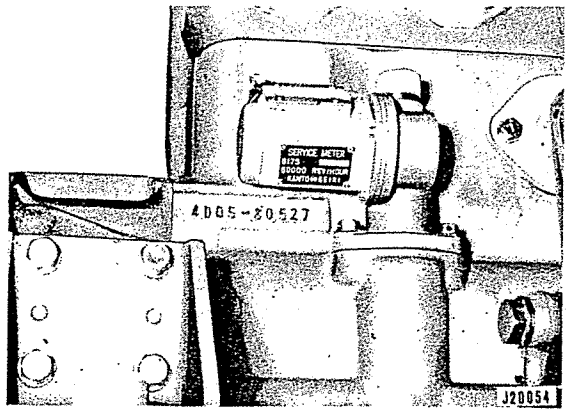
Cooling system – cont.	Fan	Type Number of blades Outside diameter, mm (in.) x pitch Speed ratio to crankshaft	Steel blade, pusher type 4 360 (14.173) x 30° 1.46 : 1
Electrical system	Voltage		24V
	Ground		Negative
	Glow plugs	Type Rated voltage-current Resistance value (at normal temperature),	Sheathed type 22.5 volts - 4.8 amperes 4.5 ± 0.5 ohms
	Starting motor	Model Manufacturer Type Voltage - output Pinion / ring gear (no. of teeth)	M5T25171 Mitubishi Electric Co., Ltd. Pinion-shift type 24 volts - 2 kilowatts 10/121
	Alternator	Model Manufacturer Type Voltage - output Rated voltage generating speed, rpm Rated output generating speed, rpm Allowable speed, rpm Speed ratio to crankshaft	AR4012B Mitsubishi Electric Co., Ltd. 3 - phase 24 volts - 300 watts 1100 1900 7000 1.87
	Relay	Model Manufacturer Type Voltage regulator cut-in voltage Lamp relay cut-in voltage	RMS2C4 Mitsubishi Electric Co., Ltd. Voltage regulator 27.5 ~ 30.5 volts 6.5 ~ 7.5 volts
	Service meter	Type Manufacturer Speed ratio to crankshaft	Integrating type Kanto Seiki Co., Ltd. 1/2

Performance curves



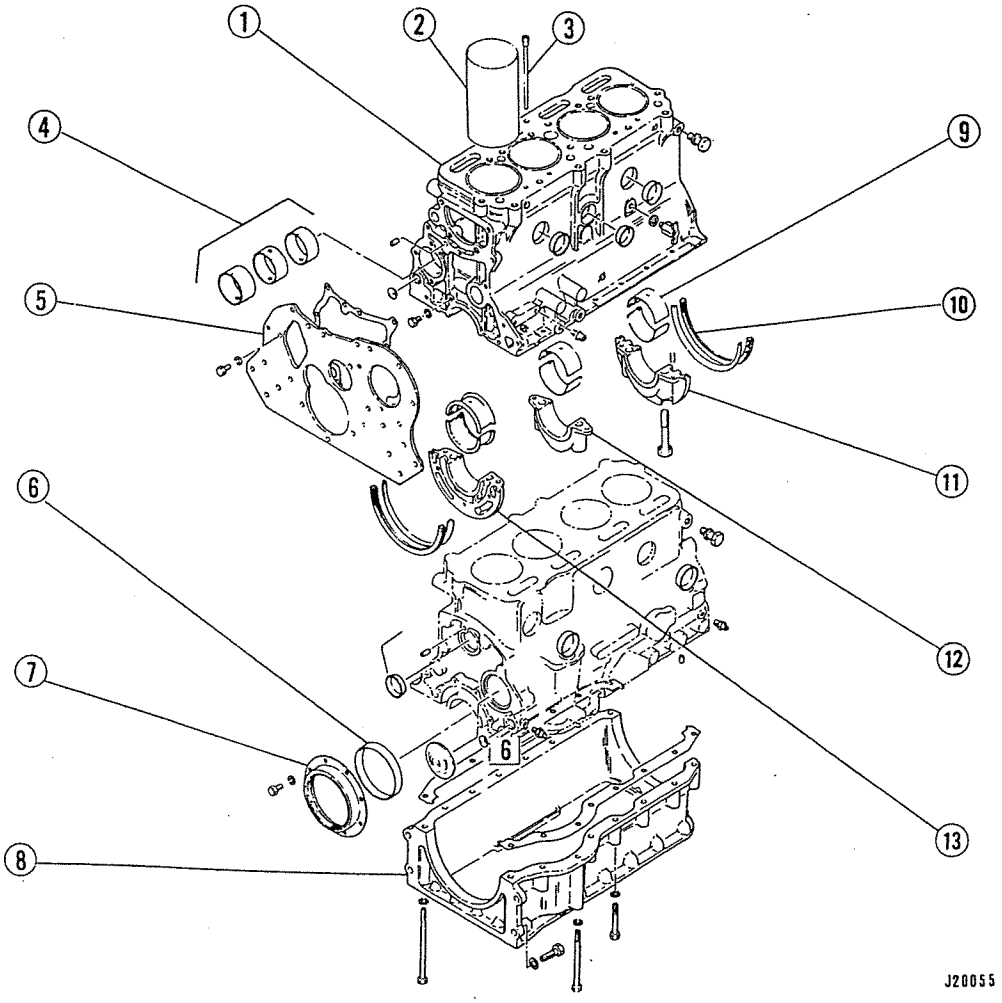
Engine serial number

The engine serial number is stamped on the upper right-hand side of the crankcase, as shown.



Location of engine serial number

2. Crankcase



1-Crankcase	5-Front plate	8-Oil case	11-Bearing cap No. 3
2-Cylinder liner	6-Oil seal sleeve	9-Main bearing	12-Bearing cap No. 2
3-Oil pipe	7-Oil seal	10-Gasket	13-Bearing cap No. 1
4-Camshaft bushing			

Crankcase components

Crankcase

(1) The crankcase is cast in one piece to which dry type special cast iron cylinder liners providing higher wear resistance are fitted.

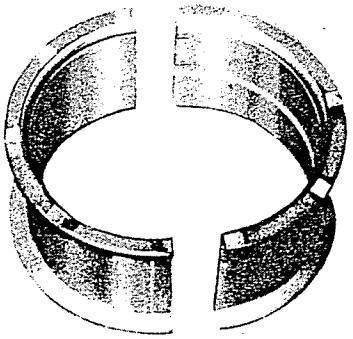
(2) The crankshaft is supported by three main bearings and the camshaft by three bushings. Each of these crankshaft bearings and camshaft bushings are provided with an oil hole.

Main bearings and thrust bearing

(1) No. 1 main bearing carries the thrust or axial load.

(2) The upper shell of each bearing has an oil groove through which lubricating oil is supplied from the passage provided in the crankcase. The upper and lower bearing shells have a fixing lug.

(3) The thrust bearing on No. 1 journal carries the thrust or axial load of the crankshaft during operation.



J8725

Thrust bearing

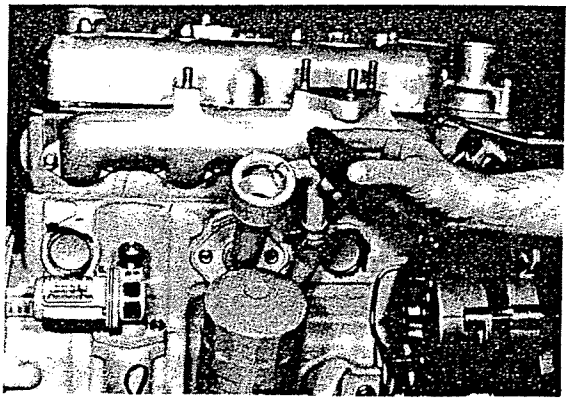
(4) All the main bearings use steel-backed trimetal bearing inserts with kelmet (a copper-lead alloy) lining and a thin lead-tin overlay.

Camshaft bushings

The camshaft bushings are, in material, white metal (Babbitt metal). They become larger in inside diameter one by one toward the front to facilitate removal and installation of the camshaft.

Air breather

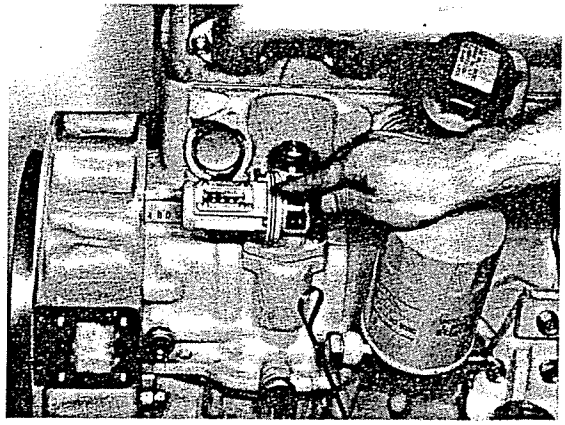
The air breather which serves as an oil filler is located on the right-hand side of the crankcase. It provides a means of ventilating the crankcase and of preventing leakage of lubricating oil.



Air breather

Service meter

The service meter is located on the right-hand side of the crankcase. It registers engine operating hours, on which recommended service intervals rely..



Service meter

Engine mounting brackets

The engine is supported by a total of four engine mounting brackets, two on the engine side and two on the power direction clutch side. A rubber bushing is fitted to each bracket to absorb vibrating shocks during engine operation.

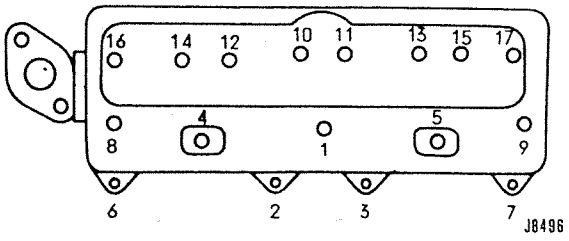
3. Cylinder head

Cylinder head

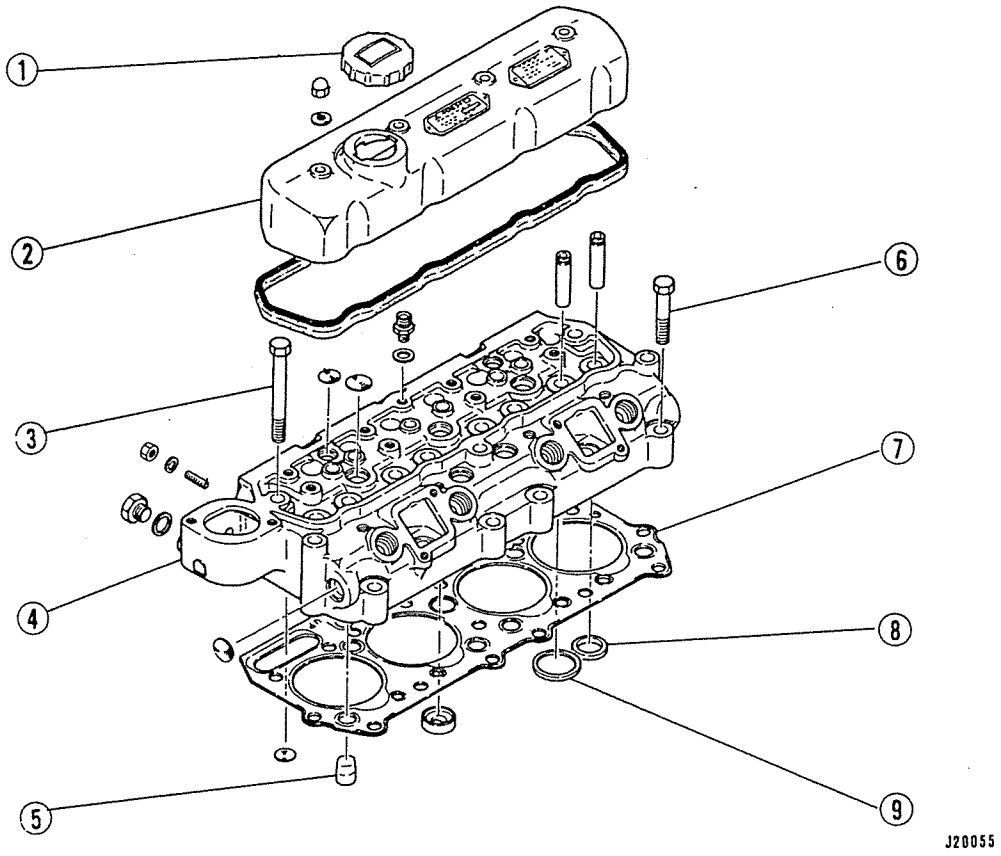
(1) The cylinder head too is a one-piece casting. It contains cast-out water jackets and passages which conduct the air and exhaust gases to and from all of the air intake and exhaust ports in the cylinders. The intake manifold is attached to the left-hand side of the head and the exhaust manifold to the right-hand side. Two inlet ports and four exhaust ports are provided.

(2) The directors (coolant guides) are fitted to the head from the bottom side. They, as implied by the name, provide a means of directing the flow of coolant to improve cooling efficiency.

(3) The cylinder head is attached to the top of the crankcase with seventeen bolts.



Cylinder head bolt tightening sequence



1-Oil filler cap	4-Cylinder head	7-Gasket
2-Rocker arm cover	5-Director	8-Combustion chamber jet
3-Head bolt	6-Head bolt	9-Valve seat insert

Cylinder head components

Combustion chambers

The combustion chambers are of low-speed turbulence type. From the bottom side of the head are fitted the combustion chamber jets. The glow plugs are diagonally inserted into the precombustion chambers to insure easy engine starting in cold weather.

Cylinder head gasket

A steel-clad-asbestos gasket, that is, a gasket made up of asbestos sandwiched between thin steel plates, is used. The edges of the bores in the gasket are covered with stainless steel grommets to eliminate the possibility of excessive blow-by.

Rocker arm case cover

The rocker arm case cover is an aluminum alloy casting and is provided with an oil filler.

Valves, valve seats and valve springs

(1) The intake valves are larger than the exhaust valves in diameter to improve air intake efficiency.

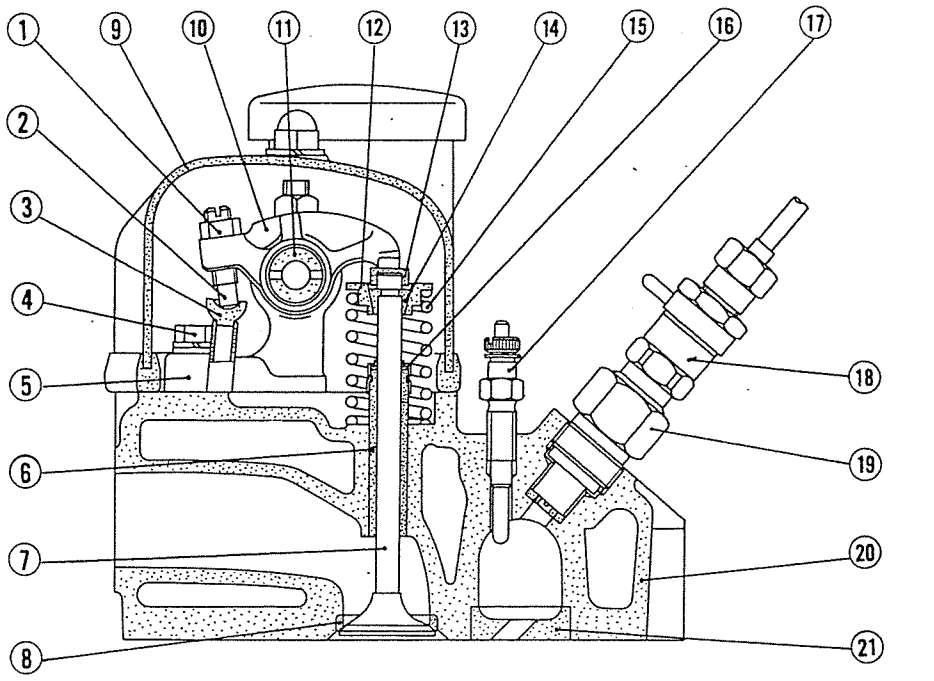
(2) Both intake and exhaust valves are, in material, heat-resistant steel.

(3) Valve guides are provided with stem seals to prevent excessive oil from flowing down along the valve guides.

(4) Both intake and exhaust valve seats too are, in material, heat-resistant steel.

(5) Single regular-pitch valve springs are used.

(6) The upper end of each valve is provided with a cap to prevent the valve from directly coming in contact with the rocker arm during operation, thereby minimizing wear occurring on the valve.

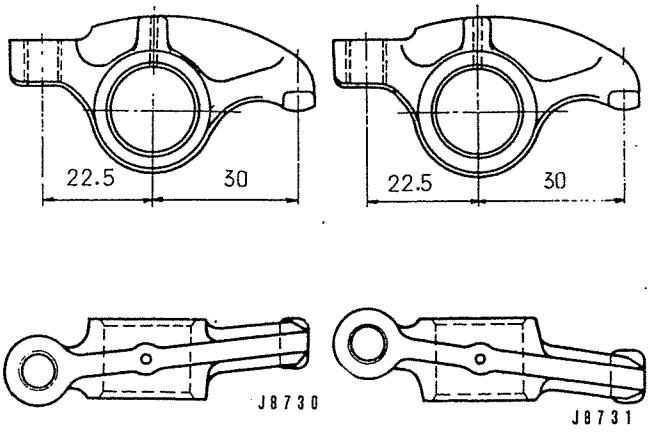


1-Lock nut
2-Adjusting screw
3-Valve push rod
4-Cylinder head bolt
5-Rocker arm shaft bracket
6-Valve guide
7-Exhaust valve
8-Valve seat
9-Rocker arm case cover
10-Rocker arm
11-Rocker arm shaft
12-Spring retainer
13-Valve cap
14-Valve cotter
15-Valve spring
16-Valve stem seal
17-Glow plug
18-Leak-off pipe
19-Injection nozzle
20-Cylinder head
21-Combustion chamber jet

Cylinder head cross section

Rocker arms, rocker arm shafts and rocker arm shaft brackets

(1) The rocker arms are made by forging. The ends of the arms are induction-hardened for increased wear resistance. Two kinds of rocker arms, one being symmetrical to another, are used.



Rocker arm A Rocker arm B

(2) The rocker arm shaft is made up of a hollow shaft. Both ends of this shaft are covered with blind plugs to form an internal oil passage. The external surface is chromium-plated for wear resistance.

(3) The rocker arm shaft brackets are aluminum die-casting. They are provided with an oil hole through which the lubricating oil is fed to the rocker arm shaft.

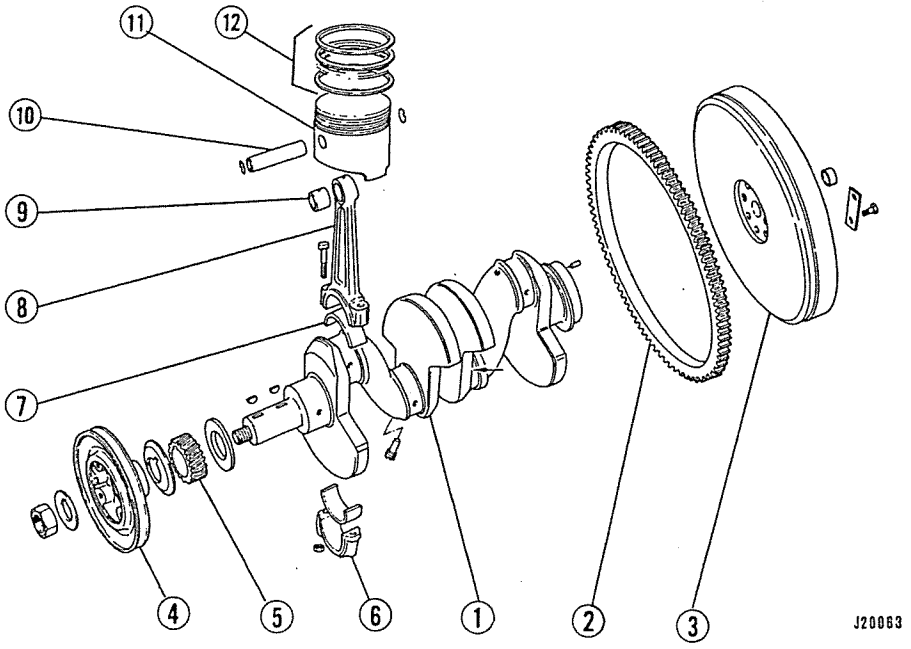
4. Main moving parts

Crankshaft

The crankshaft is a one-piece forging. Its journals and crankpins are case-hardened by high-frequency induction heating in order to provide high wear resistance. The rear end of the crankshaft is provided with an oil seal sleeve to facilitate the replacement of oil seal.

Flywheel

The flywheel, which has a ring gear for meshing with the drive pinion of the starting motor, is secured to the crankshaft with a dowel and four reamer bolts.



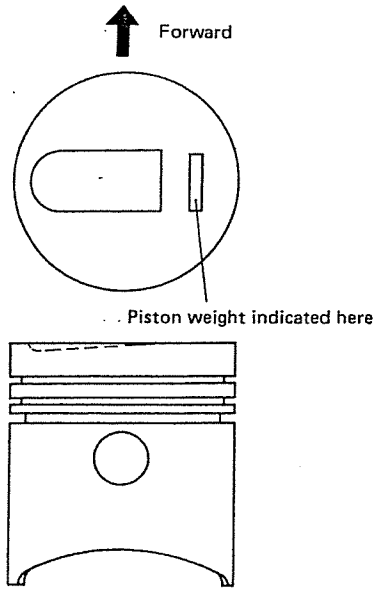
1-Crankshaft	4-Crankshaft pulley	7-Connecting rod bearing	10-Piston pin
2-Ring gear	5-Crankshaft gear	8-Connecting rod	11-Piston
3-Flywheel	6-Connecting rod bearing cap	9-Piston pin bushing	12-Piston rings

Main moving parts

Ring gear

The ring gear which is shrinkage fitted to the flywheel is made of high carbon steel and is induction-hardened. It has 121 teeth which are chamfered on one side to permit easy meshing of the starting motor drive pinion.

Pistons



The pistons are, in material, heat-resistant aluminum alloy. They are slightly tapered and cam-ground to compensate for thermal expansion during operation. The crown of each piston is concaved to provide a better fuel-air mixing swirl. It has the marking for indicating the piston weight.

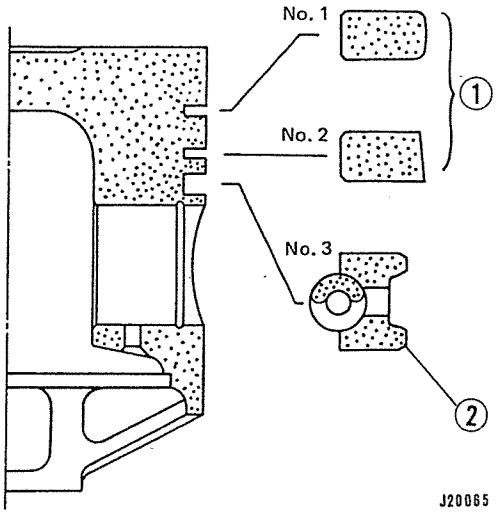
Piston rings

The relationship between three piston rings and their grooves in the piston is as shown below:

The No. 1 and No. 2 rings are compression rings and the No. 3 ring is an oil control ring. No. 1 ring and oil control ring are chromium plated. The No. 2 is a taper-face ring. The oil control ring is provided with an expander to increase the tension of the ring relative to the cylinder wall.

Piston pins

The piston pins, case-hardened by carburizing, are of full-floating type (meaning that the pins are capable of rotating in both piston and connecting-rod small end bushing). Both ends of each pin are locked with snap rings.



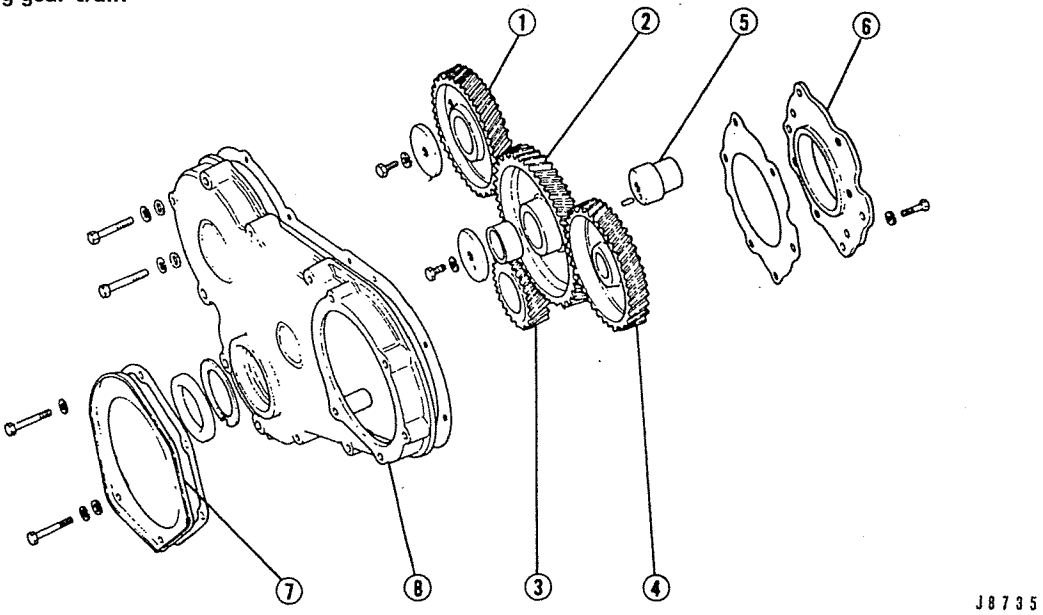
1-Compression rings 2-Oil ring

Piston rings and piston ring grooves

Connecting rods

The connecting rods are made by die-forging and has an I-section. The small ends use lead-bronze bushings and the big ends use kelmet bearing to carry loads more effectively during operation.

5. Timing gear train



1-Camshaft gear
2-Idler
3-Crankshaft gear
4-Injection pump drive gear
5-Idler shaft
6-Flange plate
7-Cover
8-Timing gear case

Timing gear components

Timing gear case

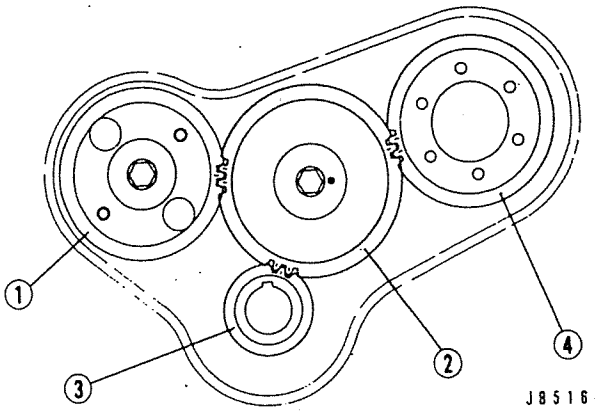
(1) The timing gear case which houses the gears for driving injection pump, lubricating oil pump and camshaft is made of aluminum alloy. It is located at the front end of the crankcase, together with front plate.

(2) The front plate is correctly located relative to the crankcase with two dowel pins to hold the injection pump.

(3) The gear case is provided with an oil seal, which is held by dowel pins to prevent oil leakage from the front end of the crankshaft.

Timing gears

The timing gear train uses helical gears made of high-carbon steel. The teeth of each gear are precisely machined by shaving for minimized gear noise and improved durability. The gear arrangement is as shown below:



1-Camshaft gear (No. of teeth: 38)
2-Idler (No. of teeth: 43)
3-Crankshaft gear (No. of teeth: 19)
4-Injection pump drive gear (No. of teeth: 38)

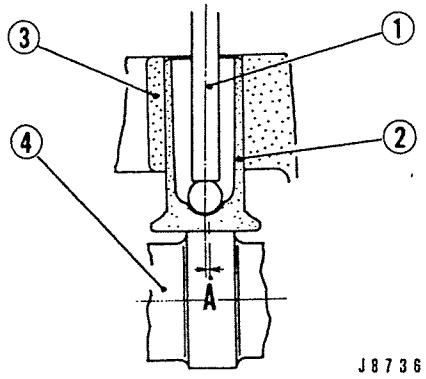
Timing gear arrangement

Camshaft

(1) The camshaft is, in material, high-carbon steel and is made by forging. Its journals, cams and oil pump drive gear tooth face are case-hardened by high frequency induction heating for increased wear resistance.

(2) The front end journal is provided with an oil hole from which the lubricating oil is fed to camshaft thrust surface and also to the rocker arm shaft through the rocker arm lubricating oil pipe and cylinder head.

Tappets



1-Push rod
2-Tappet
3-Crankcase
4-Camshaft
A-Offset

Tappet

The tappets, which are made by casting, are offset with respect to the cams so that they rotate during operation to prevent abnormal wear. The bottom end of each tappet is chill-hardened for increased wear resistance. The tappets for intake and exhaust valves are of the same type and size, and form a ball-and-socket joint with the valve push rods as shown.

Valve push rods

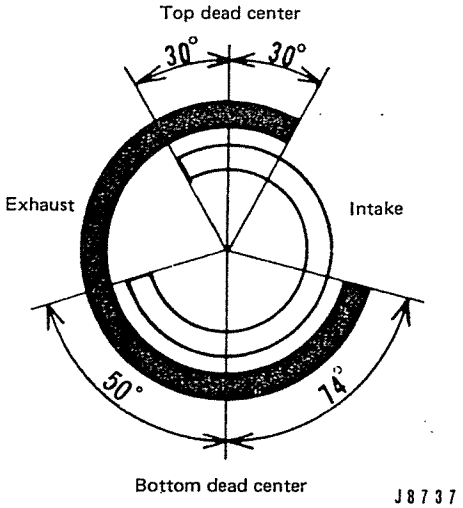
The valve push rods are provided to transmit the cam motion to the rocker arms for opening and closing the valves. They are made of a hollow steel shaft. To the bottom (tappet side) ends of the rods are welded the steel balls and to the top (adjusting screw side) ends the sockets, both ends being hardened by carburizing.

Valve clearance and valve timing

The valve clearance is specified to be 0.25 mm (0.0098 in.) for both intake and exhaust valves and is to be set when the engine is cold.

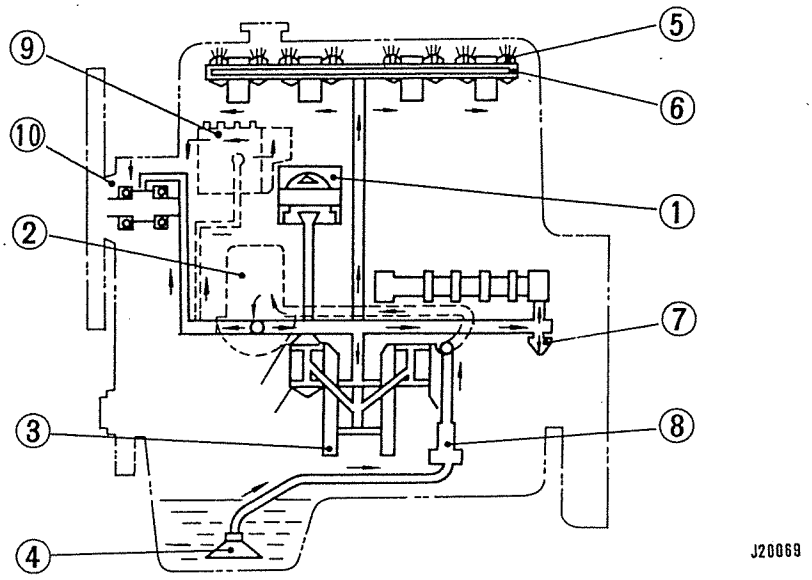
The valve timing is as illustrated and described below:

Intake valve opens at 30° before top dead center (B.T.D.C.)
Intake valve closes at 50° after bottom dead center (A.B.D.C.)
Exhaust valve opens at 74° before bottom dead center (B.B.D.C.)
Exhaust valve closes at 30° after top dead center (A.T.D.C.)



Valve timing diagram

6. Lubrication system



1-Piston
2-Oil filter
3-Crankshaft
4-Oil strainer
5-Rocker arm
6-Rocker arm shaft
7-Oil pressure alarm lamp switch
8-Oil pump
9-Injection pump
10-Water pump

Lubrication system

Lubricating oil circuit

The oil circuit is schematically illustrated above. The lubricating system is of a pressure-feed type using a trochoid type oil pump. The oil pump which is driven by the camshaft lifts the oil from the oil pan through the strainer and delivers it under pressure through oil filter to the main oil gallery provided in the crankcase. The oil is then distributed from this gallery to all the running parts within the engine. When the filter element is clogged and begins to present an abnormally large resistance to the flow of oil, the bypass valve opens to cause the oil to bypass the filter and directly flow to the engine parts, thus preventing interruption of the supply of the oil. Under this condition, the alarm lamp switch built in the filter head is closed by the pressure to permit the alarm lamp to come on.

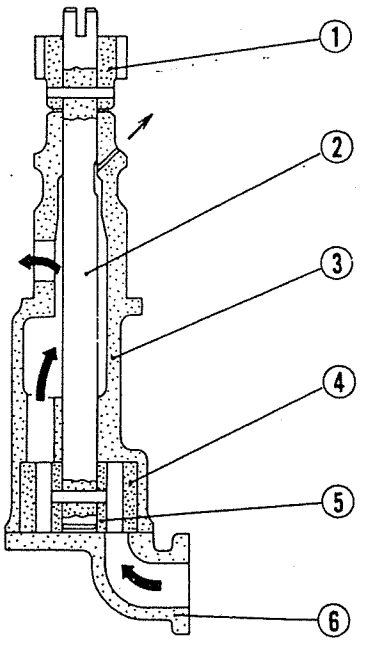
Oil pan

The oil pan is an aluminum casting, and is provided with an oil level gauge on its right-hand side. The gasket placed between the crankcase and oil pan is made of rubber and cork.

Oil strainer

The oil strainer attached to the suction side of the oil pump is provided with a screen to remove large abrasive particles.

Oil pump



1-Pump drive gear
2-Pump main shaft
3-Oil pump case
4-Outer rotor
5-Inner rotor
6-Oil pump cover

Oil pump cross section

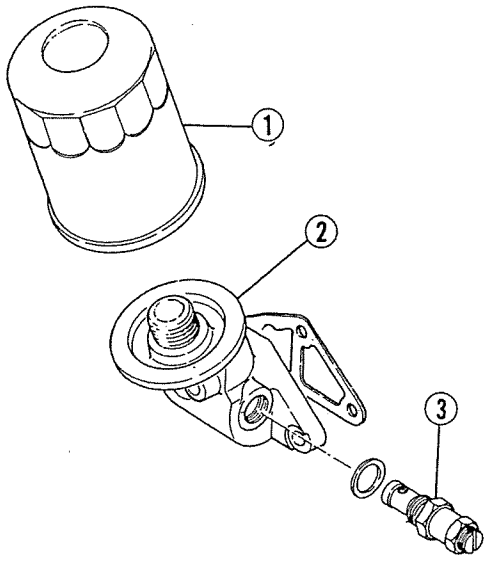
(1) The oil pump is located on the rear right-hand side of the crankcase and is driven by the skew gear mounted on the camshaft.

(2) The rotors of the pump are of trochoid type and retain high efficiency performance even in long-duration service.

(3) The performance data of the oil pump are as follows:

Pump speed, rpm	Displacement, liter (cu in.)/min	Delivery pressure, kg/cm² (psi)
1250	10.5 (641)	3 (42.7) [Oil temperature: 50°C (122°F)]

Oil filter



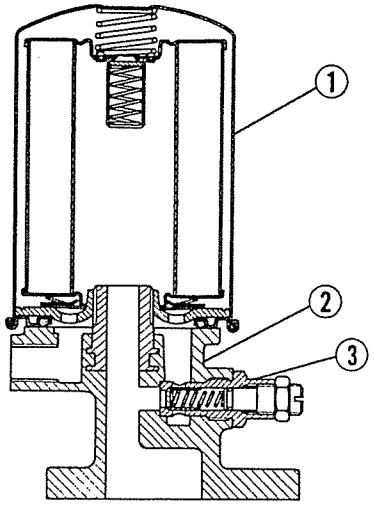
1-Element 3-Relief valve
2-Filter bracket

Oil filter

(1) The oil filter is of cartridge type; it is located on the right-hand side of the crankcase.

(2) The filter element is provided with a bypass valve. This valve opens when the pressure difference across the element is anywhere between 0.8 and 1.2 kg/cm² (11 and 17 psi), permitting the oil to bypass the element and directly flow to the main oil gallery. The oil bypassing the element, however, is not filtered. In such a case, the element (cartridge) should be replaced by a new one as soon as possible.

The relief valve, which is provided in the filter head, opens when the oil pressure reaches 3 ± 0.3 kg/cm² (43 ± 4 psi) to return excessive oil to the oil pan, thereby maintaining the pressure of oil fed to engine parts at constant pressure level.



1-Element 3-Relief valve
2-Filter bracket

Oil filter cross section

7. Fuel system

Fuel oil circuit

The fuel oil circuit is schematically illustrated in the figure on the next page.

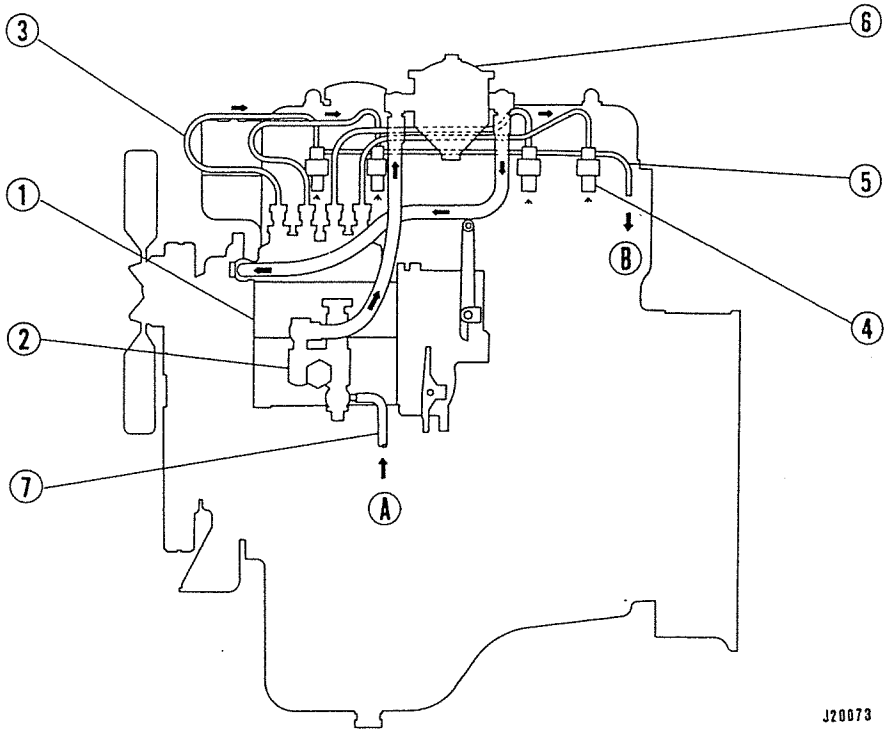
The feed pump draws fuel oil from the fuel tank and delivers it through a fuel filter to the injection pump which intermittently discharges the fuel into the respective injection pipes leading to the injection nozzles. The amount of fuel to be injected is controlled by means of the accelerator connected to the control lever of the governor. The injection nozzles are of a throttle type, in which the valve is normally held closed by a coil spring and is set to open at a pressure of 120 kg/cm² (1706 psi).

The governor mounted on the rear side of the injection pump is a mechanical, all-speed governor designed to maintain the engine rpm constant at any speed level desired within a range limited by the minimum and the maximum speed.

Fuel filter

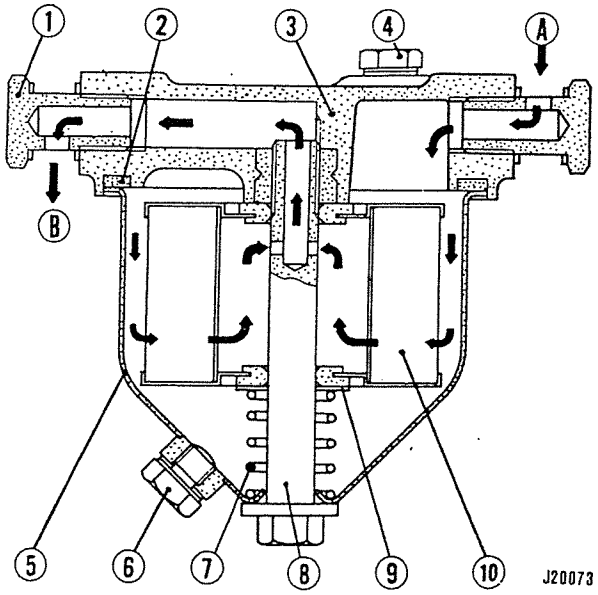
The fuel filter is mounted on the center of the intake manifold and uses specially-treated paper element.

Filtration area, cm² (in²)	850 (131.75)
Cleaning ability	2μ



1-Fuel injection pump
2-Fuel feed pump
3-Injection pipe
4-Nozzle holder
5-Fuel leak-off pipe
6-Fuel filter
7-Fuel feed pipe
A-From fuel tank
B-To fuel tank

Fuel system

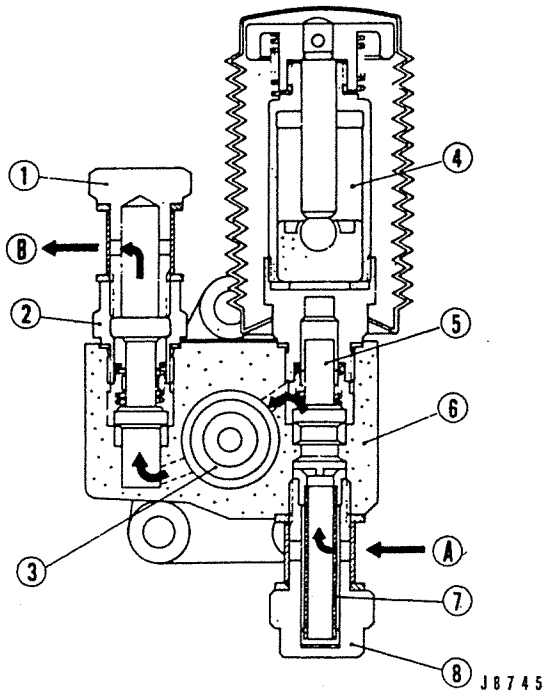


1-Bolt
2-Cover gasket
3-Cover
4-Air vent plug
5-Case
6-Drain plug
7-Set spring
8-Bolt
9-Spring seat
10-Element
A-From fuel feed pump
B-To fuel injection pump

Fuel filter cross section

Fuel feed pump

The fuel feed pump is a plunger type pump and is actuated by means of one of the cams of the injection pump camshaft. The delivery pressure of this pump is set to 2 kg/cm^2 (28.4 psi). A priming handle is provided on this pump so as to enable the pump to be manually actuated. This provision of manual pumping is to be utilized in priming the fuel circuit prior to an engine start-up operation or in bleeding air from the fuel system.



1-Hollow screw	6-Feed pump housing
2-Valve support	7-Filter
3-Piston spring	8-Hollow screw
4-Priming pump	A-From fuel tank
5-Check valve	B-To fuel filter

Fuel feed pump cross section

Fuel injection pump

Cam lift, mm (in.)	8 (0.315)
Plunger diameter, mm (in.)	6.5 (0.256)
Delivery valve bore diameter, mm (in.)	6 (0.236) [Retraction volume: 51 mm^3 (0.003 cu in./st)]
Injection order	1 – 3 – 4 – 2
Injection timing	90° ± 30′

(1) General description

The injection pump has two functions; namely, 1) to intermittently discharge the fuel at a high pressure to the injection nozzles, each injection being properly timed to the operating cycle of the piston, and 2) to meter the injection quantity – the amount of fuel injected into the precombustion chambers.

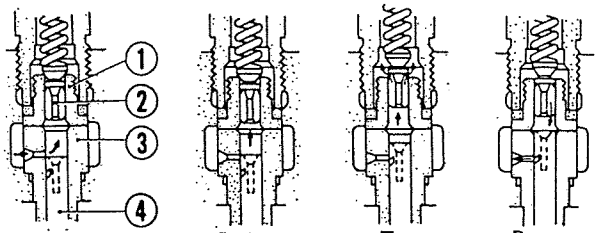
(2) Pumping elements

The injection pump contains 4 pumping elements, one element for one cylinder of the engine. Each element comprises a plunger and a barrel which are made of nitriding steel and are precision-machined to close tolerances. In operation, the cam and return spring give a reciprocating motion to the plunger. The injection pump camshaft rotates at 1/2 the crankshaft speed in the clockwise direction as viewed from the drive side. Fuel oil enters the barrel through the inlet port as soon as the port is uncovered by the plunger on its downward stroke.

When the plunger rises on upward stroke, the fuel in the barrel is pushed out through the port until it is covered by the plunger. Further movement of the plunger pressurizes fuel oil remaining in the barrel, lifts the delivery valve off its seat, overcoming the force (12 kg/cm^2 or 171 psi) of the valve spring and delivers the fuel oil through the injection pipe to the injection nozzle and then into the precombustion chamber. The stroke of the plunger is 8 mm (0.315 in.). As the plunger rises further, its helical recess comes over the inlet port to communicate the space ahead of the plunger through the center hole, helical recess and inlet port to the reservoir outside of the barrel. This communication defeats the pressurizing action of the plunger, and the delivery valve seats itself immediately after the port is so uncovered, thus terminating a fuel injection.

(3) Effective plunger stroke and amount of fuel delivery per stroke

The duration from the moment the top end of the plunger covers up the port to the moment the helical recess uncovers the port, during the upward stroke, corresponds to the effective stroke of the plunger. This effective stroke can be lengthened or shortened by rotating the plunger on its axis for varying the amount of fuel delivery per stroke to suit varying load and speed conditions. This rotational movement of the plunger is obtained by means of the control sleeve having a gear segment, mounted on the lower part of the plunger, and the control rack, which is engaged with six such gear segments and which is actuated by the governor and also from the engine control through a system of linkage.



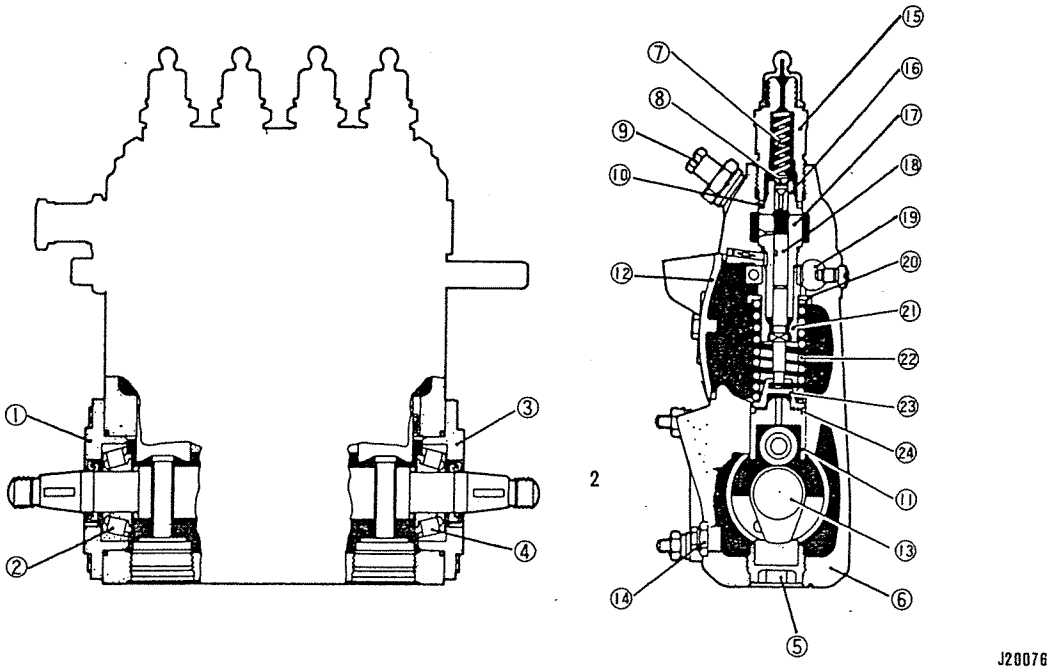
1-Seat
2-Delivery valve
3-Plunger barrel
4-Plunger

Plunger operation

(4) Delivery valves

The delivery valve is fitted to the barrel by means of the delivery valve holder, and consists of a spring and a

valve having a piston. The piston is so constructed that, as the spring forces the valve down to its seat at the end of pressurizing action within the barrel, a small amount of fuel oil is sucked into the barrel from the injection pipe. This amount is referred to as "retraction volume" (about 51 mm^3 or 0.003 cu in.) and plays an important part in preventing the injection nozzle from dribbling at the end of each fuel injection.



1-Bearing cover	7-Delivery valve spring	13-Camshaft	19-Control rack
2-Tapered roller bearing	8-Delivery valve	14-Drain plug	20-Upper spring seat
3-Governor housing	9-Air vent screw	15-Delivery valve holder	21-Control sleeve
4-Tapered roller bearing	10-Delivery valve seat gasket	16-Delivery valve seat	22-Spring
5-Screw plug	11-Tappet	17-Plunger barrel	23-Lower spring seat
6-Pump housing	12-Cover	18-Plunger	24-Shim

Injection pump cross section

Governor

(1) Description

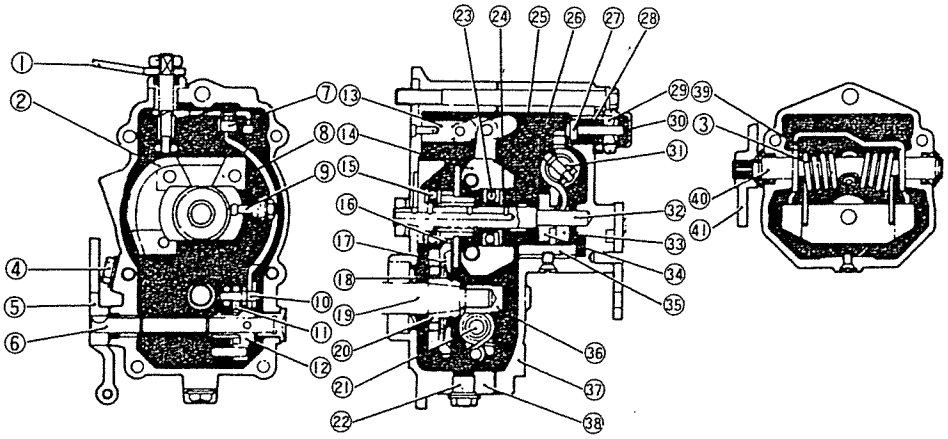
The construction of the governor is as illustrated in the figure below:

The governor consists essentially of governor gear (16), flyweights (14), governor sleeve (25) and speed control springs (3).

The governor gear is mounted on camshaft bushing (20) attached to the rear end of the injection pump camshaft with round nut (36) and is pressed by slip disc (17), so that it is not damaged even when the engine output torque varies.

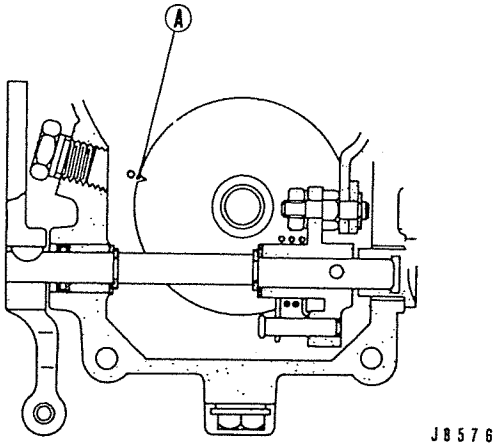
The flyweights are mounted on governor shaft. The radial movement of the flyweights due to centrifugal force is transmitted to arm (12) to push governor sleeve (25) through thrust bearing. To this sleeve is attached adapter spring (26). This spring opposes the force of control springs (3) through spring seat so as to compensate for a decrease in torque when the engine is running at low speeds. Floating lever (8) is hinged at its lower end to supporting lever (11) mounted on control lever shaft (6) and is connected at its upper end to control rack through shackle (13). To the mid-part of this floating lever is fitted connecting pin (9) through which the movement of the flyweights is transmitted to the control rack. Damper spring, which is mounted on the end of control rod, serves to prevent engine hunting as when the engine speed is suddenly decreased. Stopper lever (1) is provided to move the control rack to "stop" position.

Engine stalling, which may often occur when the load is suddenly increased, is prevented by torque spring. The timing mark provided on the camshaft bushing and the timing pointer on the governor housing are conveniently utilized in determining the beginning of injection in the No. 1 cylinder during assembly job.



1-Stopper lever	12-Arm	22-Drain plug	32-Governor shaft
2-Oil inlet	13-Shackle	23-Bearing	33-Spring seat
3-Control springs	14-Governor flyweights	24-Shim plate	34-Spring seat
4-Screw plug	15-Bearing	25-Governor sleeve	35-Torque control lever
5-Stopper	16-Governor gear	26-Adapter spring	36-Round nut
6-Control lever shaft	17-Slip disc	27-Adapter	37-Governor cover
7-Shackle pin	18-Shim plate	28-Torque spring	38-Governor housing
8-Floating lever	19-Camshaft	29-Adjusting nut	39-Torque control lever
9-Connecting pin	20-Camshaft bushing	30-Cap nut	40-Shaft
10-Connecting bolt	21-Control lever shaft	31-Shaft	41-Adjusting lever
11-Supporting lever			

Governor cross section



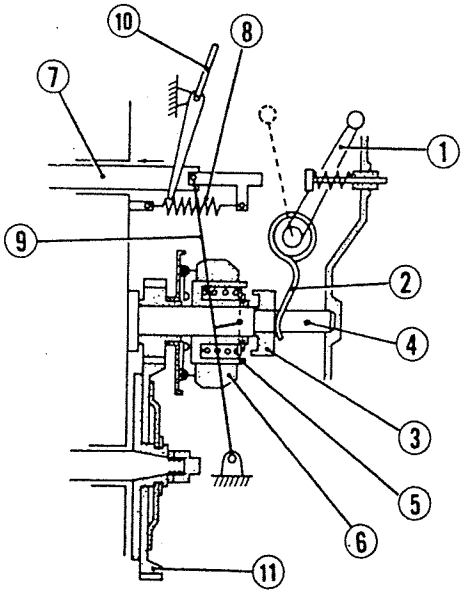
A-Timing mark

Timing mark on injection pump

(2) Operation

(a) Starting up

Prior to starting up, the adjusting lever (1) is to be moved to its "start (full load)" position. When this lever is so moved, the spring seat (3) is moved by the control spring (2) until it bears on the stepped part of the governor shaft (4). The governor sleeve is pushed by the spring seat so moved to cause the floating lever (9) to push in the control rack (7).

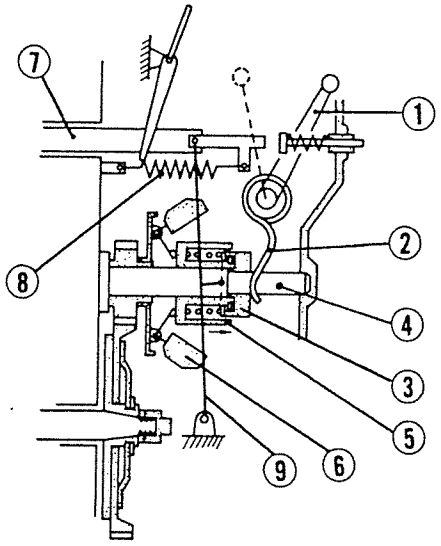


1-Adjusting lever	7-Control rack
2-Control spring	8-Start spring
3-Spring seat	9-Floating lever
4-Governor shaft	10-Stop lever
5-Governor sleeve	11-Governor gear
6-Flyweights	

Governor in start position

(b) Engine idling

As the engine fires up and runs to a sufficiently high speed, the adjusting lever (1) should be moved to its "idling" position. When the control lever is so moved, the control spring (2) no longer pushes on the spring seat (3), permitting the governor sleeve (5) to move toward the spring seat freely. Under this condition, the flyweights (6) expand out even if the engine is running at a low speed to move the governor sleeve, pushing on the floating lever (9) and pulling the control rack (7) out in the "decrease" direction against the force of start spring (8) and control spring (2). The latter spring backs the floating lever which has been pushed by the spring seat. A chain of reactions takes places in the feed-back loop and, in a short while, a state of equilibrium is introduced between the centrifugal force of the flyweights on one hand and the force of start spring and control spring on the other, holding the control rack in the position corresponding to the idling speed of the engine.



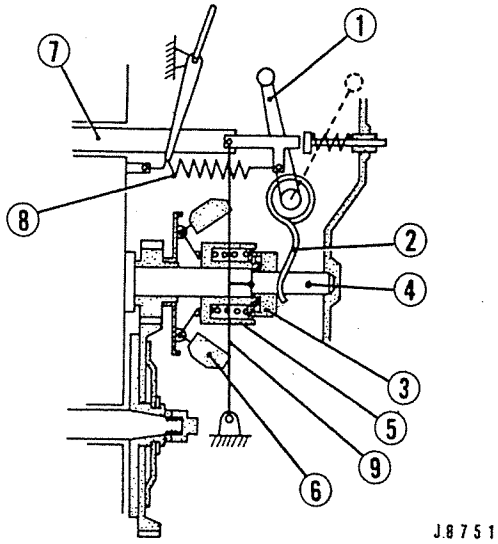
J8750

1-Adjusting lever
2-Control spring
3-Spring seat
4-Governor shaft
5-Governor sleeve
6-Flyweights
7-Control rack
8-Start spring
9-Floating lever

Governor in idling position

(c) Maximum speed operation

When the engine is running at maximum speed with the governor adjusting lever (1) kept in the "full load" position, the force of the control spring (2) acts upon the governor sleeve through the spring seat. When the engine speed increases suddenly due to a decrease in load, the centrifugal force of the flyweights (6) overcomes the force of the control spring to move the governor sleeve (5) toward the spring seat. This causes the floating lever (9) to move in the "decrease" direction so as to maintain the engine rpm at a give speed level within a range limited by the maximum speed.



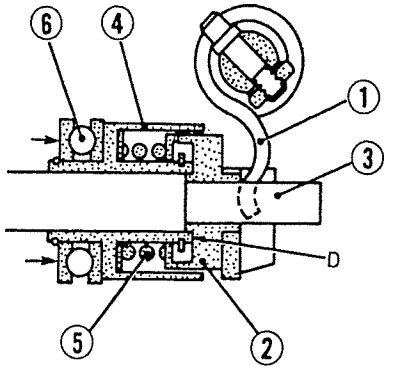
J8751

1-Adjusting lever
2-Control spring
3-Spring seat
4-Governor shaft
5-Governor sleeve
6-Flyweights
7-Control rack
8-Start spring
9-Floating lever

Governor in maximum speed operation

(d) Adapter operation

When the engine is running at near maximum speed (the adapter is not acting), the spring seat (2) is pressed against the stepped part of the camshaft (3) by the control spring (1). On the other hand, the governor sleeve (4) is pressed against the spring seat by the flyweights, compressing the the adapter spring (5), and the part "D" of the sleeve bears on the bottom face of the seat.

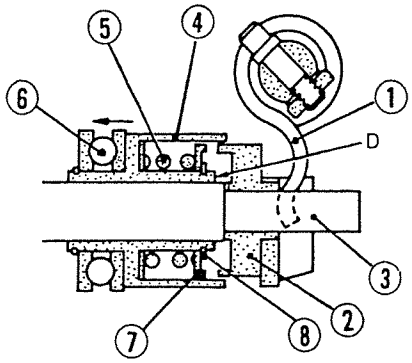


J8752

1-Control spring
2-Spring seat
3-Camshaft
4-Governor sleeve
5-Adapter spring
6-Bearing

Adapter operation (1)

When the engine rpm is decreased and the force of adapter spring overcomes the centrifugal force of the flyweights, the governor sleeve is moved toward left by the adapter spring, causing the floating lever to move the control rack in the "increase" direction so as to increase the torque at low speed operation. The adapter spring becomes stretched out until the spring plate (7) bears on snap ring (8).



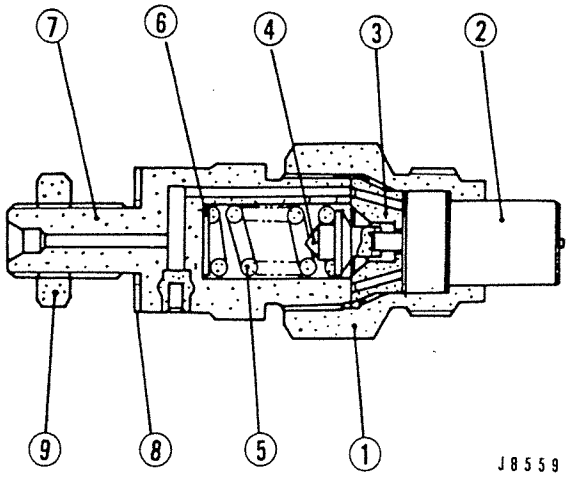
1-Control spring
2-Spring seat
3-Camshaft
4-Governor sleeve
5-Adapter spring
6-Bearing
7-Spring plate
8-Snap ring

Adapter operation (2)

Injection nozzles and nozzle holders

The injection nozzle provides a means of spraying into the precombustion chamber the fuel oil delivered under pressure from the injection pump. It sprays oil out in a conical pattern consisting of finely atomized droplets of oil. The mating surfaces of the nozzle holder body, distance piece and nozzle are precision-finished to from an oil-tightness.

The injection pressure adjustment may be made by means of adjusting washer, Increasing the thickness of the washer will increase the spring tension and, hence, the injection pressure, and vice versa.



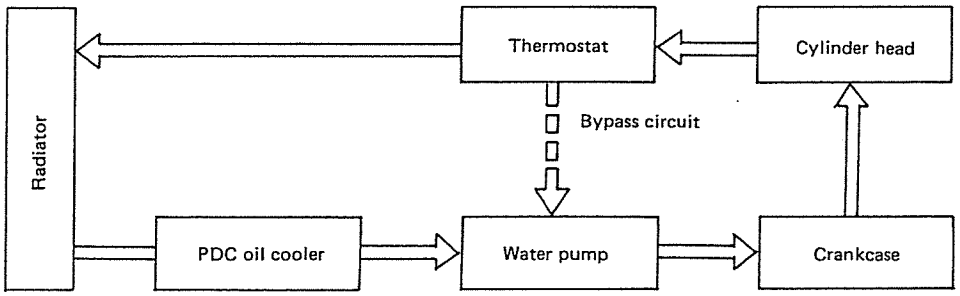
1-Retaining nut
2-Nozzle tip
3-Distance piece
4-Pressure pin
5-Pressure spring
6-Washer
7-Nozzle holder
8-Gasket
9-Nut

Injection nozzle cross section

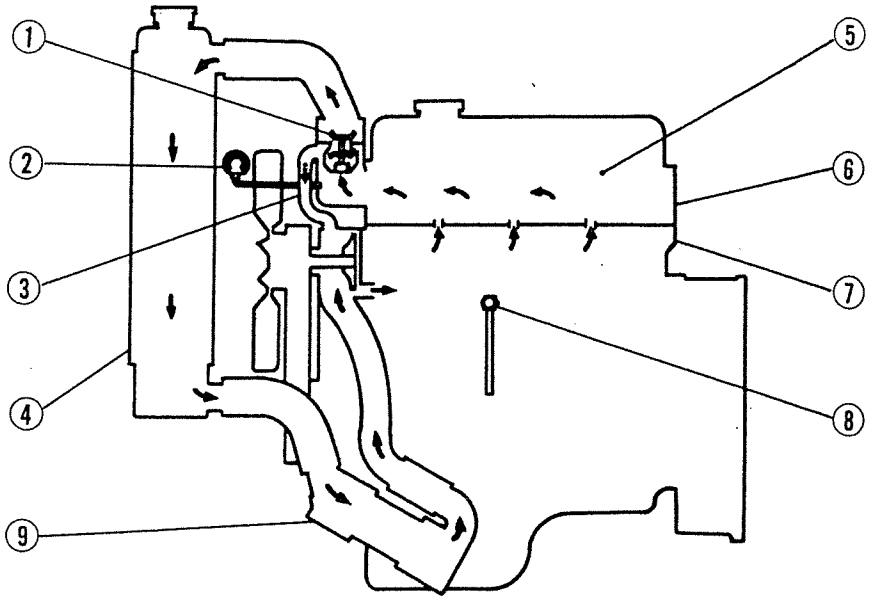
Nozzle model	NP–DN40SDN4
Needle valve opening pressure	120 ± 10 kg/cm^2 (1706 ± 142 psi)
Spray angle	40°

8. Cooling system

Cooling water circuit



Cooling water circuit diagram (1)



1-Thermostat
2-Water temperature gauge connection
3-Bypass hose
4-Radiator
5-Water jacket
6-Cylinder head
7-Crankcase
8-Drain plug
9-PDC oil cooler

Cooling water circuit diagram (2)

Cooling water is circulated by means of a centrifugal type water pump located to the front of the crankcase. The water cooled in the radiator is drawn from the lower tank by the water pump and is pressure-fed in the crankcase, wherein it flows around the cylinder liners and then rises into the cylinder head through the water holes in the upper face of the crankcase to cool the parts around the precombustion chambers and valves. Then the water is pushed out of the outlet port provided in the front of the cylinder head. The cylinder head is provided with water directors (coolant guides) which direct the flow of water to the precombustion chambers and exhaust port more effectively, thereby increasing the cooling efficiency. The thermostat is located in the front of the cylinder head. Its valve is kept closed when the returning water is cold, permitting it to bypass the radiator and enter the line connected directly to the water pump. The valve begins to open when the water temperature reaches 76.5°C (169.7°F) to permit some of the water to circulate through the radiator. It opens fully at a water temperature of 90°C (194°F) to close the bypass line completely and all of the water circulates through the radiator. The water temperature gauge connection (sensing unit) is located in the front of the cylinder head and is connected to the water temperature gauge on the instrument panel.

Water pump

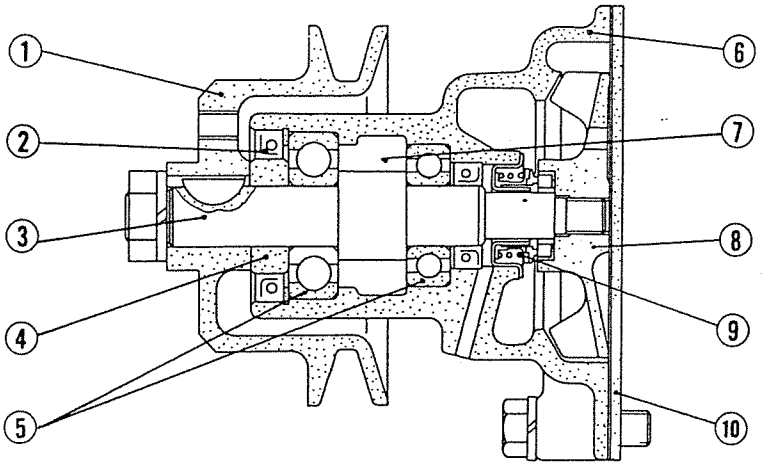
(1) The water pump is of a centrifugal, impeller type. The impeller is threaded to the pump shaft.

(2) The pump shaft is supported by ball bearings having a large capacity at its both ends. The bearings are pressure-lubricated with crankcase lubricating oil. They are also provided with an oil seal to prevent oil leakage.

(3) Between the impeller and housing is provided a unit seal.

(4) The speed ratio between the crankshaft pulley and pump pulley is 1: 1.46.

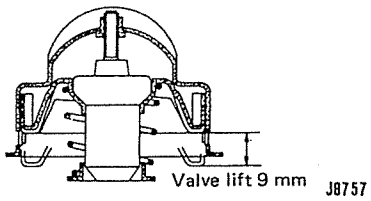
(5) The pump capacity is 105 liters (6408 cu in.)/ min/4000 rpm.



1-Pulley 4-Spacer 7-Lubricant 9-Unit seal
2-Oil seal 5-Ball bearings 8-Impeller 10-Cover
3-Shaft 6-Case

Water pump cross section

Thermostat



Thermostat

The thermostat is of a wax type and is located in the front of the cylinder head. Its valve begins to open at 76.5 ± 2°C (169.7 ± 3.6°F) and fully opens at 90°C (194°F) with a valve lift of 9 mm (0.354 in.).

Cooling fan

(1) The cooling fan is of a pusher type and has 4 blades made by plate working. It is mounted on the front side of the water pump pulley.

(2) The outside diameter of the fan is 360 mm (14.173 in.) and the pitch angle is 30°.

Fan belt

(1) The fan belt is of a low-edge cog B type.

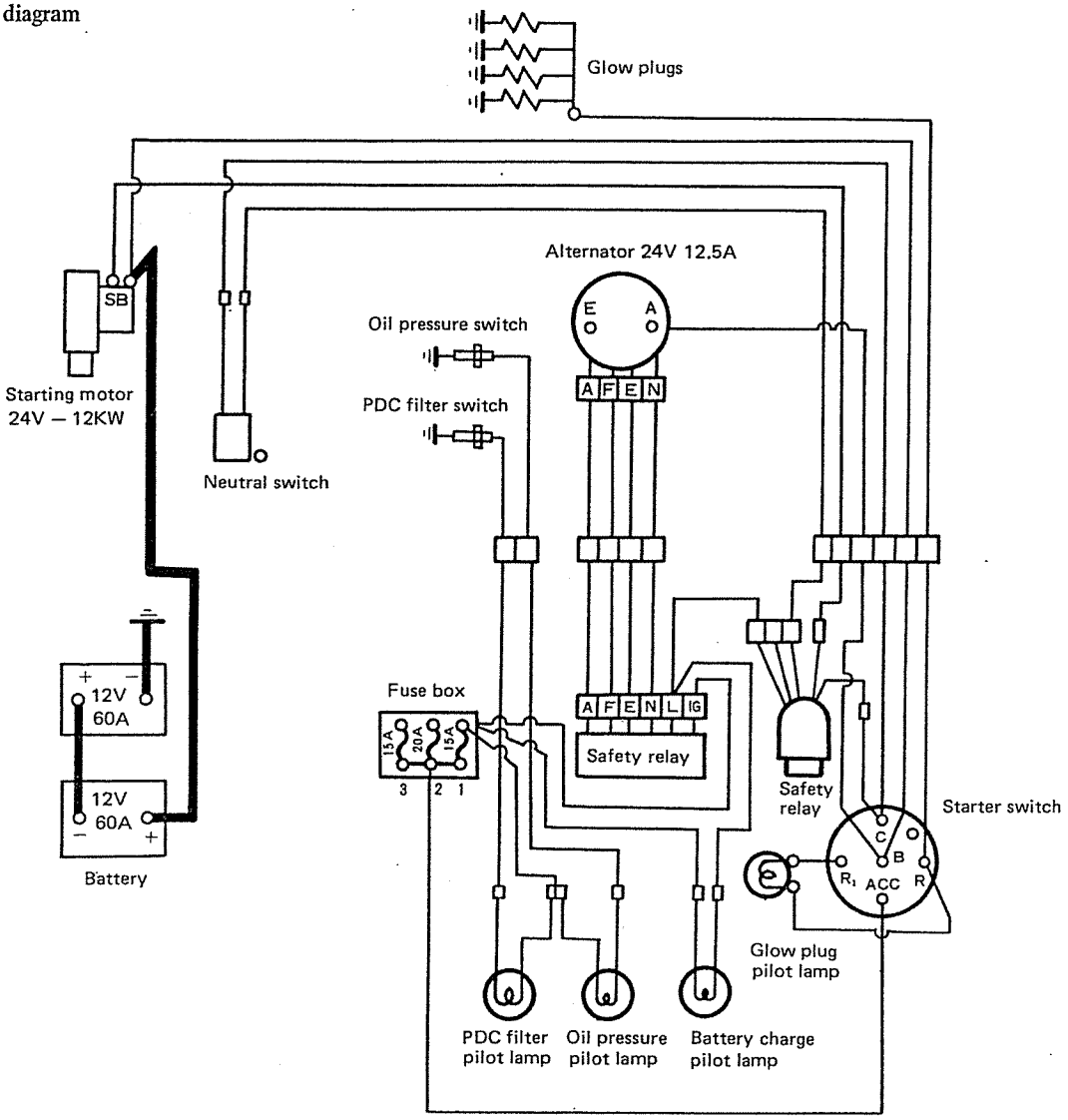
(2) The length of the belt is 41 in.

9. Electrical system

Electrical component specifications

	Model or type	Manufacturer
Starting motor	M5T25171	Mitsubishi Electric Co., Ltd.
Alternator	AR4012B	Mitsubishi Electric Co., Ltd.
Regulator	RMS2C4	Mitsubishi Electric Co., Ltd.
Glow plugs	Sheathed type	Hiyoshi Denso Co., Ltd.

Circuit diagram



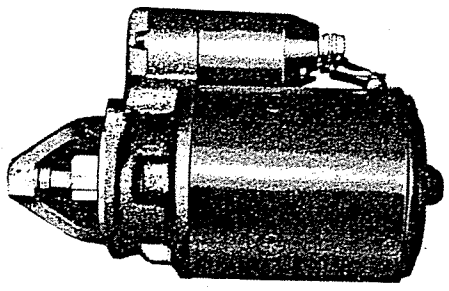
Circuit diagram

Starting motor

(1) Performance data

Model and type	M5T25171 pinion-shift type (Totally enclosed with overrunning clutch)
Voltage rating	24volts
Output rating	2 kilowatts
Type of winding	Series
Yoke diameter	118 mm (4.646 in.)
Time rating	30 seconds
Direction of rotation	CW as viewed from pinion side
Weight	11 kg (24.3 lb), approx.

Test	Voltage level	Specification
No-load test	23 V	Current: 55A, max. Rpm: 4500
Torque test	9 V	Current: 710A, max. Torque: 3.5 kg-m (25.3 ft-lb), min.
Switch-in voltage		16 V, max.

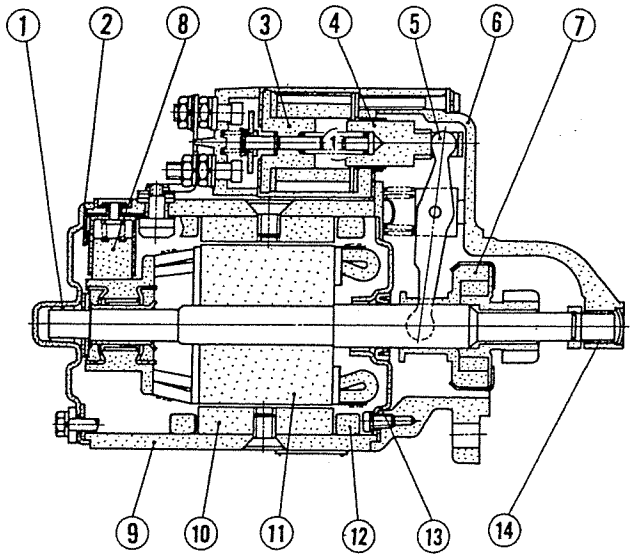


J20090

Starting motor

(2) Construction

The starting motor is of a totally-enclosed, drip-proof type, and is provided with an engage magnetic switch complete with a pinion shift type pinion drive mounted on an overrunning clutch.



1-Bushing
2-Rear bracket
3-Magnetic switch
4-Plunger
5-Lever
6-Front bracket
7-Overrunning clutch
8-Brush
9-Yoke
10-Pole piece
11-Armature
12-Field coil
13-Bracket
14-Bushing

Starting motor cross section

(a) Overrunning clutch

The major components of overrunning clutch are an inner race which is fabricated in one piece with the drive pinion, an outer race (thrust spline) and five rollers. The rollers are spring-loaded against the cam surface of the outer race. The outer race is made in one piece with the thrust spline whose ten internal helical splines are in mesh with the external splines of the armature shaft.

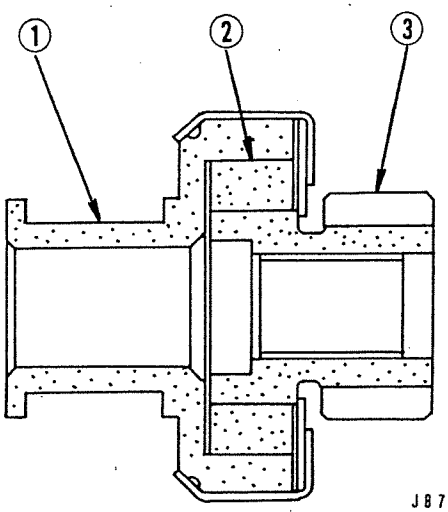
(b) Operation of overrunning clutch

1. Starting up

The torque of the armature shaft is transmitted through the helical lead of the thrust spline to the outer race. When the outer race is so rotated, the rollers are pressed into between the outer and inner races to give a wedge action. By this wedge action of the rollers, the torque of the motor is transmitted from the outer race to the inner race and then to the drive pinion in mesh with the flywheel ring gear of the engine for cranking.

2. After starting

After the engine fires up and picks up a speed, the inner race (pinion) rpm (engine rpm x gear ratio) exceeds the outer race (armature) rpm. Now the rollers are pushed back by the inner race, against the force of roller springs, and no longer



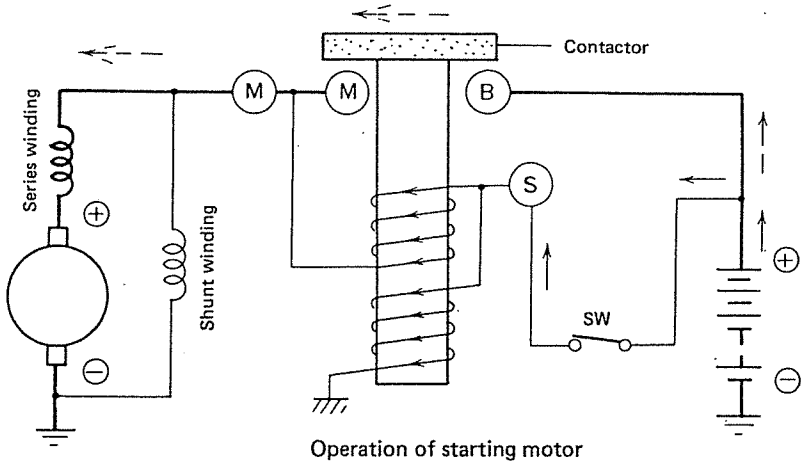
1-Thrust spline 2-Roller 3-Pinion

Overrunning clutch cross section

give a wedge action, thereby disconnecting the outer race from the inner race. Thus the clutch prevents overrunning of the armature shaft of the drive pinion.

(c) Operation of engage magnetic switch

1. When the starter switch is closed to initiate a cranking operation, the current from the battery flows into the current coil and into the voltage coil of the electromagnetic switch as shown by the arrows of full lines in the diagram. Subsequently the core is magnetized and attracts the plunger. As one end of the lever connected to the plunger is connected to the floating ring of the overrunning clutch, the clutch goes forward along the grooves in the armature shaft, causing the pinion to engage with the ring gear of the flywheel.
2. As the plunger is completely attracted and the contactor is closely contacted with terminals (B) and (M), great amount of current flows from the battery to field coil and to the armature, as shown by the arrows of broken lines in the diagram, actuating the starting motor to start the engine. No current flows to the current coil while the contactor contacts terminals (B) and (M). In this case, contact between the contactor and the terminals is maintained by the voltage coil only.
3. When the engine fires up and the starter switch is opened, reverse current flows through the current coil to de-energize the voltage coil. Thus, the plunger is allowed to return to the original position by spring force, causing the starting motor to stop.



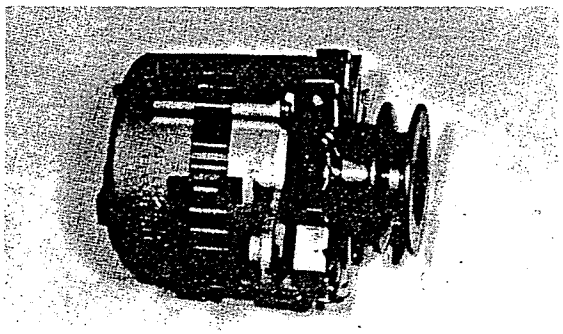
Operation of starting motor

Alternator and regulator

(1) Performance data

(a) Alternator

Model and type	AR4012B Totally-enclosed, drip-proof
Nominal output	24V – 300W
Ground	Negative
Outside dia.	128 mm (5.039 in.)
Direction of rotation	CW as viewed from pulley side
Weight	6.4 kg (14.1 lb), approx.

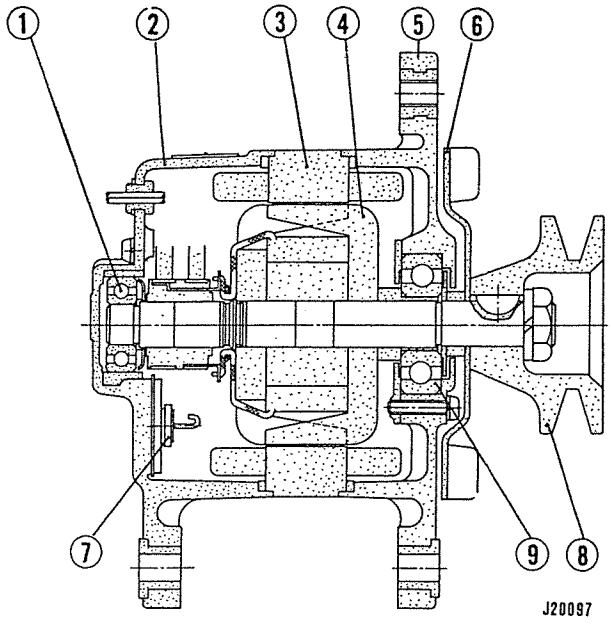


Alternator

(b) Regulator

Model	RMS2C4 With built-in voltage regulator lamp relay
Weight	0.45 kg (1 lb)

(2) Construction of alternator



1-Bearing
2-Rear bracket
3-Stator coil
4-Rotor
5-Front bracket
6-Fan
7-Diode
8-Pulley
9-Bearing

Alternator cross section

The charging alternator consists of moving parts such as rotor whose shaft is supported by ball bearing at both ends, fan which is mounted on the input side of the rotor shaft and pulley, and stationary parts such as armature, front bracket, rear bracket, and end cover. Three positive diodes are fitted to heat sink and three negative diodes to the rear bracket.

(3) Operation of alternator

(a) Circuit description

The voltage regulator is a device for maintaining the alternator output voltage constant regardless of alternator rpm and does so operate by controlling the alternator field current. The circuit to the pilot lamp is controlled by the neutral voltage (the voltage across the terminal N) generated by the alternator. This is why the pilot lamp goes out when the alternator begins to charge the battery.

(b) Operation

1. When the battery switch is turned on and the key switch is turned to ON position, the pilot lamp comes on, making the following circuit:

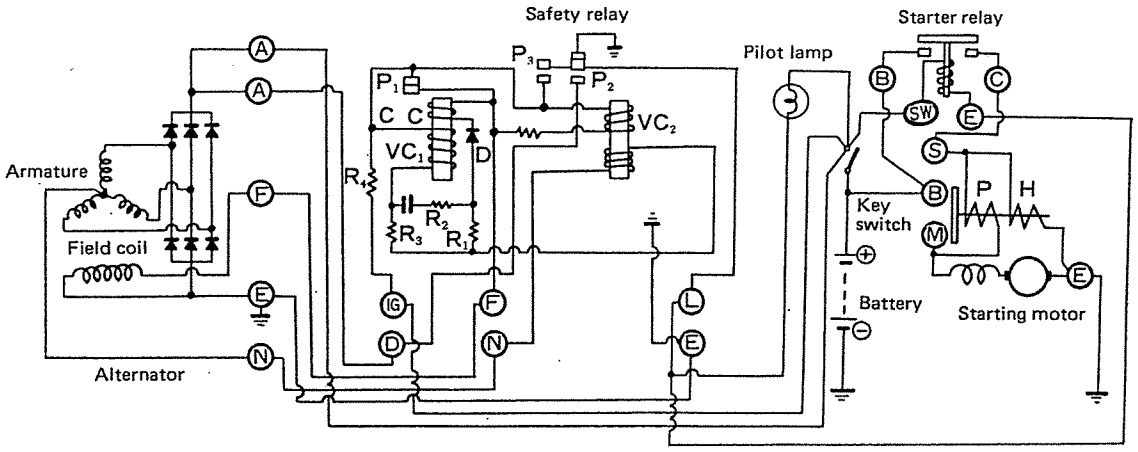
Key switch — Terminal (IG) — Resistor R_4 — Pilot lamp — Terminal (L)

Points P_1 — Terminal (F) — Field coil — Terminal (E)

Voltage coil VC_1 — Resistor R_3 — Terminal (E)

NOTE

The voltage applied to the coil VC_1 is not high enough to open the points P_1.



Charging—starting circuit diagram

2. When the motor starts to crank the engine, the current flows in the following circuit:

Key switch — Starter relay — Terminal SW — Terminal L —
Key switch — Starter relay — Terminal B — Terminal C —
Points P_2 — Ground
Terminal S on starter

3. After the engine starts and picks up speed, the alternator begins to charge the battery. Now the coil VC_2 is excited by the voltage of the terminal N to open the points P_2, causing the pilot lamp to go out. At this time the starter relay opens, and the current flows in the following circuit:

Terminal N on alternator — Terminal N on regulator —
Voltage coil VC_2 — Terminal E

4. The closure of the points P_2 closes the points P_3, permitting the alternator to supply field current to the voltage regulator.

Terminal A on alternator — Terminal D on regulator —
Points P_3 — Points P_1 — Terminal F — Field coil
Points P_3 — Voltage coil VC_1 — Resistor R_3 — Terminal E

If the alternator output voltage rises under this condition, the voltage coil VC_1 is excited by the voltage applied to the voltage detecting circuit — the series circuit involving the voltage coil VC_1 and resistor R_3 — to produce a magnetic pull large enough to open the points P_1. Field current at this time is reduced and this reduction in turn reduces the output voltage; and the reduced output voltage weakens the magnetic pull of the coil VC_1 to close the points P_1. This process repeats itself endlessly, and, in this manner, the alternator output voltage is maintained constant.

5. When the engine is stopped, the voltage across the terminal N is decreased to open the points P_2, permitting the pilot lamp to come on.

6. Operation of capacitor C and resistor R_2

The circuit including capacitor C and resistor R_2 is provided to assist in opening the points P_1 and also to increase the contact pressure of the points when they are closed for decreasing the contact resistance, and thereby extending the service life of the points.

7. Operation of excitation coil CC

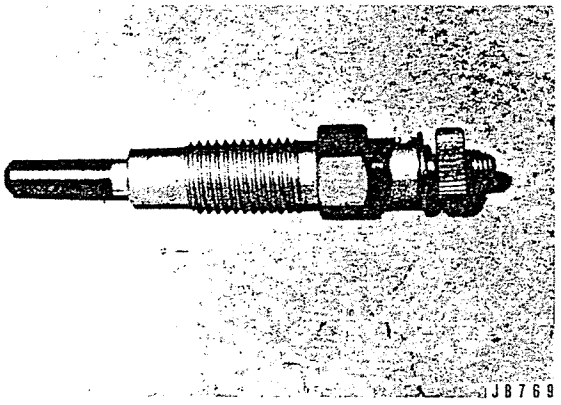
The excitation coil is provided to reduce the ripple on the voltage generated by the alternator.

8. Operation of diode D

The diode acts to prevent the flow of reverse current to the resistor R_1 and excitation coil CC.

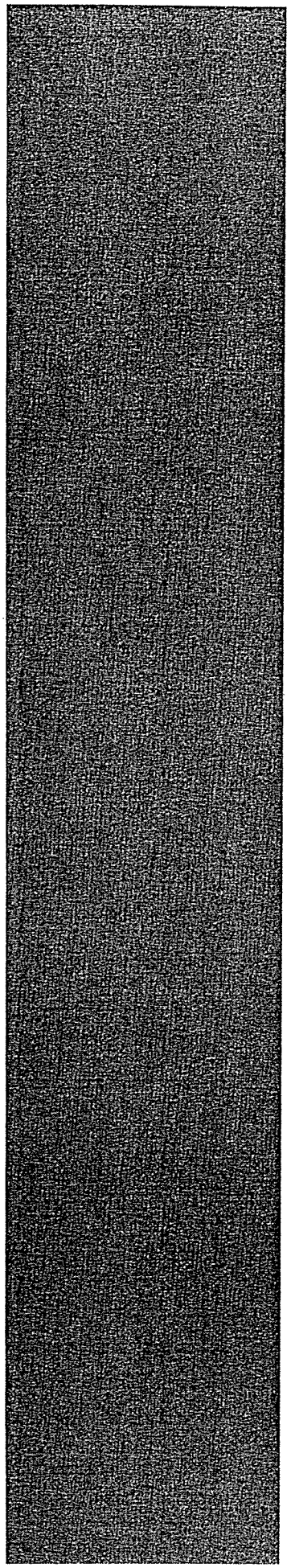
Glow plugs

The glow plugs are of sheathed type and are located in the precombustion chambers. The plugs when energized heat the chambers to insure cold starting. They are connected in parallel with negative ground, and are rated to operate at 12 volts.



Glow plug

MAINTENANCE AND ADJUSTMENT



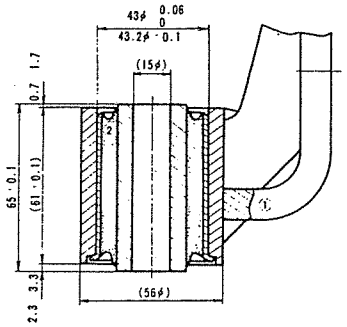
1. Inspection and adjustment

Rubber bushings of engine mounting brackets

Check the rubber bushings for deterioration or cracks. Replace them if found in defective condition. The load rate of the rubber bushing is specified to be 160 kg (353 lb)/mm (0.04 in.) ± 10 %.

NOTE

When removing and installing the rubber bushing, use a special tool. The bushing, when installed, should meet the following dimensional requirements:

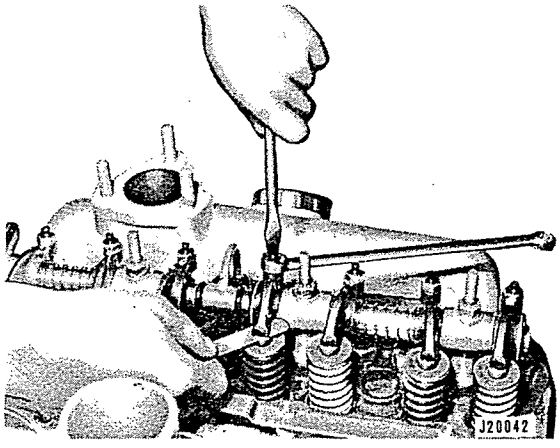


1-Bracket 2-Rubber bushing

Rubber bushing dimensions

Valve clearance adjustment

(1) The intake and exhaust valve clearance is prescribed to be 0.25 mm (0.0098 in.) when the engine is cold.



Adjusting valve clearance

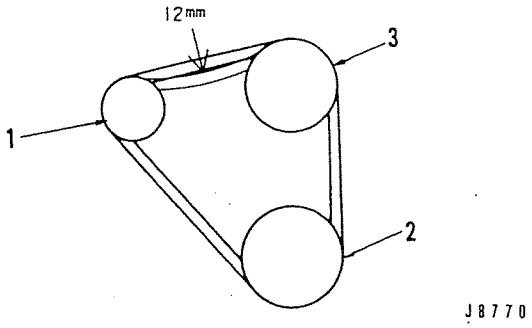
(2) Slightly tighten the adjusting screw lock nuts. First bring the No. 1 cylinder piston to its top dead center position on compression stroke. To do this, hand-rotate the crankshaft, noting movement of the intake and exhaust valve rocker arms of the No. 4 cylinder which is angularly displaced 360° with respect to the No. 1 cylinder. The moment the valve stem end of exhaust valve rocker arm begins to rise and the valve stem end of intake rocker arm begins to lower may be considered to be the top dead center of the No. 1 cylinder piston. Then adjust the clearance as shown in photo above. The top dead center position of the No. 2 cylinder piston may be similary determined by means of the No. 3 cylinder rocker arm.

(3) After tightening the adjusting screw lock nuts in step (2) above securely, again measure the valve clearance by using a thickness gauge.

(4) The valve clearance adjustment, when necessary, should be made by the firing order, 1-3-4-2.

Fan belt adjustment

Check the fan belt for correct adjustment, seeing if it has about 12 mm (1/2 in.) sag when measured by being finger-depressed at a point half way between the alternator pulley and water pump pulley. To adjust, loosen nut on bolt securing the alternator to the adjusting plate and move the alternator in such a manner as to obtain the correct belt tension.



1-Alternator pulley 3-Fan pulley
2-Crankshaft pulley

Adjusting fan belt tension

Crankshaft rotation

Using the cranking handle, hand-crank the engine to make sure that it rotates smoothly without any sign of binding.

2. Crankcase

Crankcase

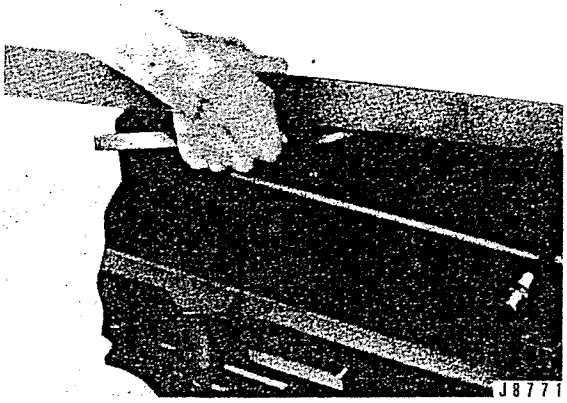
(1) Visually check the crankcase for rust formation, cracks or any other damage, or accumulation of sludge or scale in the water jacket.

(2) Using a straightedge and thickness gauge, check the crankcase gasketed surface for warpage in longitudinal and transverse directions as shown

below. If the repair limit is found to be reached or exceeded in the warpage, reface the crankcase by using a surface grinder. The amount of stock to be removed from the crankcase by grinding for refacing should be held to 1 mm (0.04 in.) in thickness.

Unit: mm (in.)

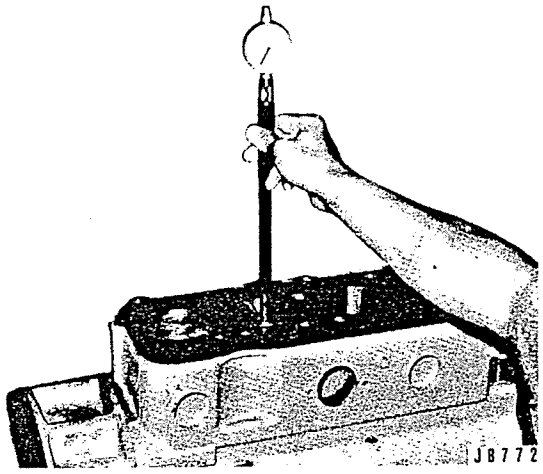
Item	Standard	Repair limit
Crankcase gasketed surface warpage	0.05 (0.0020), max.	0.2 (0.0079)



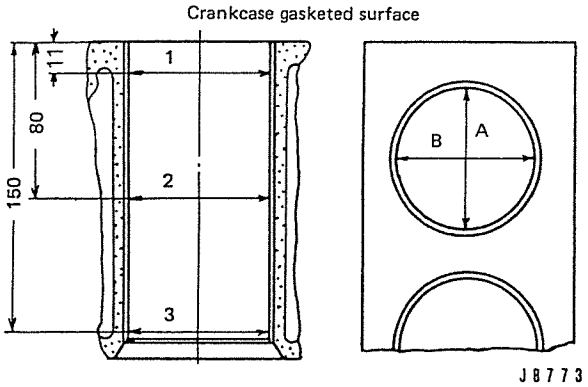
Checking crankcase gasketed surface for warpage

Cylinder liners

(1) Check the inside surface of each cylinder liner for score or scratch marks. Using a cylinder gauge, check the liner for wear by measuring its inside diameter in two directions, parallel and transverse, respectively, to engine centerline, at three elevations, as shown here.



Measuring cylinder liner inside diameter



Cylinder liner measuring diagram

Compute the amount of wear, that is, the difference between the maximum and the minimum reading of the 6 readings. If the difference exceeds the repair limit within the service limit, rebore the liner to the next oversize.

Unit: mm (in.)

Item	Standard	Repair limit	Service limit
Cylinder liner I.D.	$84\ ^{+0.035}_{0}$ ($3.307\ ^{+0.0014}_{0}$)	+0.20 (+0.0079)	+1.20 (+0.0472)
Out-of-roundness	0.015 (0.0006), max.		
Taper	0.015 (0.0006), max.		

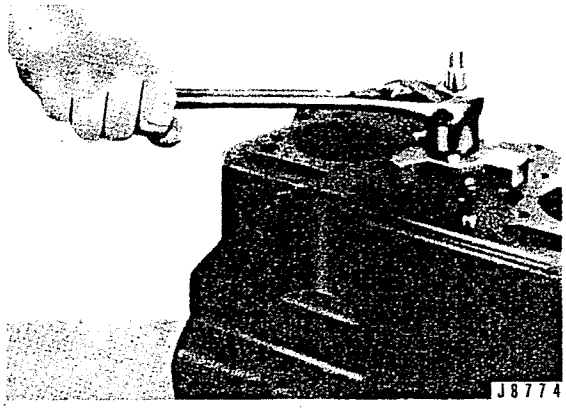
(2) There are four oversizes for cylinder liners, namely, +0.25 mm (0.0098 in.), +0.50 mm (0.0197 in.), +0.75 mm (0.0295 in.) and +1.00 mm (0.0394 in.). The tolerance to which the liners should be refinished by boring is 0 - 0.035 mm (0.0014 in.). When the liners are rebored, oversize pistons and piston rings should be used.

(3) An oversize to which any liner worn taper and/or out of round is to be rebored should be determined by relying on the most worn part of the liner. A cylinder liner whose abnormal wear is 0.4 mm (0.0157 in.) should be rebored to 1 mm (0.0394 in.) oversize, for example.

NOTES

a) All cylinders should be rebored to one and the same oversize.

b) When the liners are not worn beyond the repair limit, but the piston rings have to be renewed, correct stepped wear on the top part of the liner by using a ridge reamer and, if necessary, refinish the liners by honing.



Repairing stepped wear with a ridge reamer

(4) When the liners are worn beyond the service limit, or when any cylinder bore is found to be defective, the liner should be replaced with a new one. When the inside surfaces of one of more cylinder bores in the crankcase are found to be defective, it is necessary to refinish the bores by boring. In this case, too, the liners should be replaced with new ones. To replace, proceed as follows:

(a) Removal

1. Fix a boring machine to the crankcase in alignment with the cylinder bore from which a liner is to be removed. Aligning should be made at the bottom part of the liner where less abnormal wear has occurred.
2. Bore the liner until it reaches 0.5 mm (0.0197 in.) in stock thickness.
3. Break the liner, exercising care not to damage the inside surface of the cylinder bore.

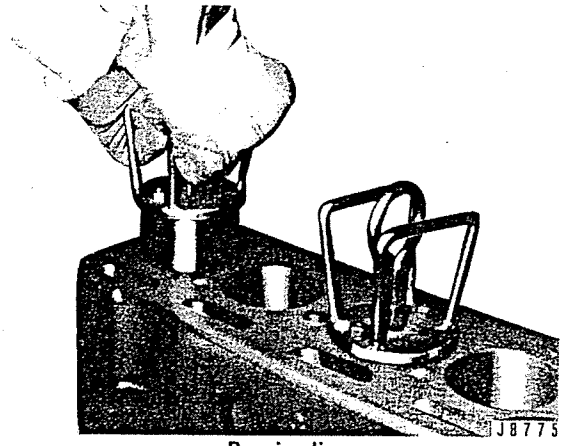
(b) Installation

1. Visually check the inside surfaces of the cylinder bores for condition. It is necessary to rebore the bores if they are damaged.
2. When it is unnecessary to rebore the cylinder bores, proceed as in steps below.

a. Measure the diameter of cylinder bore and the outside diameter of cylinder liner. Select oversize liner so that the clearance between the liner and the bore is 0.08 mm (0.0031 in.) to 0.145 mm (0.0057 in.).

b. Heat the crankcase to about 300°C (572°F). Press the cylinder liners into the bores in the crankcase by using a cylinder liner installer and a hydraulic press in such a manner to make the top of liner flush with the gasketed surface of the crankcase.

c. After pressing the cylinder liners, rebore and hone them to $84\ ^{+0.035}_{0}$ mm ($3.307\ ^{+0.0014}_{0}$ in.).



Pressing liner

3. When it is necessary to rebore the cylinder bores, press the cylinder liners into position as in b above, and proceed as follows:

a. Prepare 0.5 mm (0.0197 in.) oversize cylinder liners.

b. Rebore the cylinder bores so that the clearance between the liner and the bore is 0.08 mm (0.0031 in.) to 0.145 mm (0.0057 in.).

c. After pressing the cylinder liners, rebore and hone them to $84\ ^{+0.035}_{0}$ mm ($3.307\ ^{+0.0014}_{0}$ in.).

Unit: mm (in.)

Cylinder liner	Cylinder boring dimension
Standard	$87\ ^{-0.010}_{-0.045}$ ($3.425\ ^{-0.0004}_{-0.0018}$)
0.5-oversize	$87.5\ ^{-0.010}_{-0.045}$ ($3.445\ ^{-0.0004}_{-0.0018}$)

4. When replacing the cylinder liners, use the liners of the following part numbers.

Unit: mm (in.)

Part No.	O.D.	I.D.	Remarks
30607-50300	$87\ ^{+0.10}_{+0.07}$ ($3.425\ ^{+0.0004}_{+0.0028}$)	$83.5\ ^{0}_{-0.2}$ ($3.287\ ^{0}_{-0.008}$)	Standard
30607-50400	$87.5\ ^{+0.10}_{+0.07}$ ($3.445\ ^{+0.0004}_{+0.0028}$)	$83.5\ ^{0}_{-0.2}$ ($3.287\ ^{0}_{-0.008}$)	Oversize

Main bearings

(1) Check the bearings for scores, scratches, rust formation or any other damage. Also check for

contact with the crankcase and bearing caps. Replace a damaged bearing, if any.

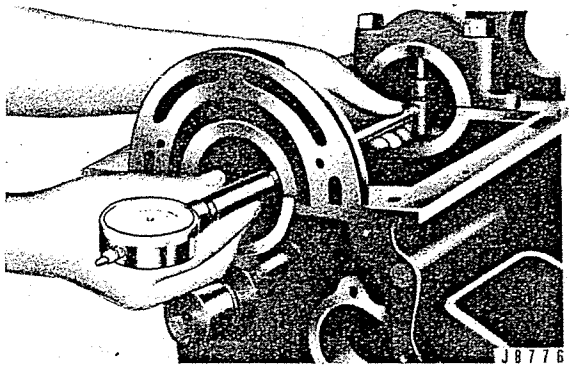
(2) To measure the inside diameter of bearing, proceed as follows:

Install the bearings to the crankcase and tighten the bearing cap bolts to the prescribed torque (8.5 kg-m or 61.5 ft-lb).

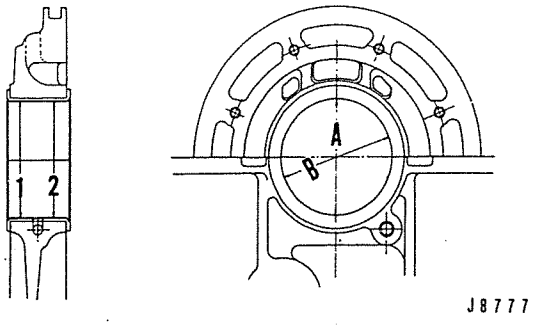
Measure the inside diameter of bearing in two directions (A) and (B), as shown in the figure J8777, by using a cylinder gauge. Measure the diameter of crankshaft journal. Then compute the clearance between the two. When the clearance exceeds the repair limit, replace the bearings, or regrind the crankshaft and use the undersize bearings. There are three undersizes, namely, 0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.) and 0.75 mm (0.0295 in.).

Unit: mm (in.)

Item	Standard	Repair limit
Crankshaft-to-main bearing clearance		0.20 (0.008)

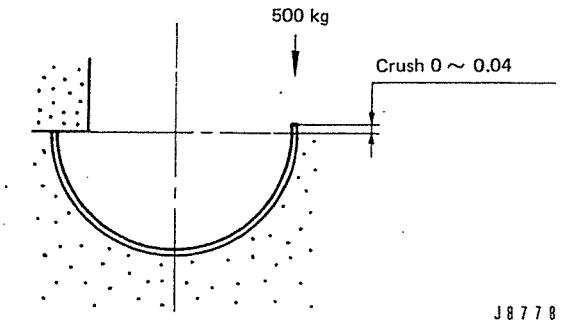


Measuring main bearing inside diameter



Main bearing inside diameter measuring diagram

(3) Check main bearings for crush and replace them if necessary.



Checking crush on main bearing

Tappets and tappet holes

(1) Check the surfaces of tappet which come in contact with push rod and cam for wear or cracks. Replace a damaged tappet, if any.

(2) Measure the clearance between tappet and tappet hole. When it exceeds the service limit, replace tappet or crankcase whichever is badly worn.

Unit: mm (in.)

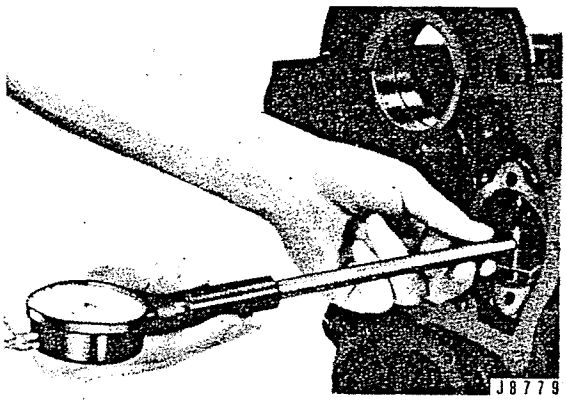
Item	Standard	Repair limit	Service limit
Tappet-to-hole clearance	0.035 ~ 0.086 (0.0014 ~ 0.0034)	0.12 (0.0047)	+0.1(+0.004) in crankcase tappet hole dia.
Crankcase tappet hole dia.	$22\ ^{+0.021}_{0}$ ($0.866\ ^{+0.0008}_{0}$)		+0.1 (0.004)

Camshaft bushings

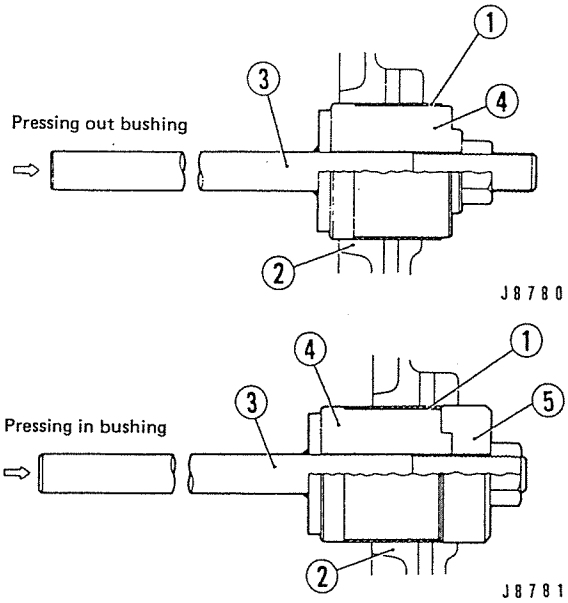
(1) Check the interior surface of bushing for wear or cracks.

(2) Measure the inside diameter of bushing and the diameter of camshaft journal to check the clearance between the two. When the clearance exceeds the service limit, replace the damaged bushing or the camshaft whichever is badly worn.

(3) When reinstalling the camshaft bushings for replacement, use a camshaft bushing installer furnished for this purpose.



Measuring camshaft bushing inside diameter



1-Camshaft bushing
2-Crankcase
3-Rod
4-Adapter
5-Piece

Replacing camshaft bushing

Unit: mm (in.)

Item		Standard	Repair limit	Service limit
Camshaft bushing-to-journal clearance		0.04 ~ 0.09 (0.0016 ~ 0.0035)	0.15 (0.0059)	
Bushing I.D.	No. 1, 2	$54H7\ ^{+0.030}_{0}$ $(2.126\ ^{+0.0012}_{0})$		
	No. 3	$53H7\ ^{+0.030}_{0}$ $(2.087\ ^{+0.0012}_{0})$		
Camshaft journal O.D.	No. 1, 2	$54\ ^{-0.04}_{-0.06}$ $(2.126\ ^{-0.0016}_{-0.0024})$		−0.1 (−0.0039)
	No. 3	$53\ ^{-0.04}_{-0.06}$ $(2.087\ ^{-0.0016}_{-0.0024})$		−0.1 (−0.0039)

3. Cylinder head

Cylinder head proper

(1) Using a straightedge and thickness gauge, check the cylinder head gasketed surface for warpage in longitudinal and transverse directions as shown.

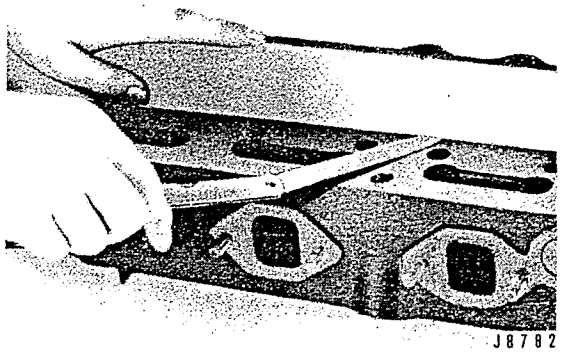
If the warpage is found to be reached or in excess of the repair limit, reface the cylinder head by using a surface grinder.

Unit: mm (in.)

Item	Standard	Repair limit
Cylinder head gasketed surface warpage	0.05 (0.0020), max.	0.2 (0.0079)

NOTE

Before checking for the warpage, be sure to remove the precombustion chambers from the cylinder head.



Checking cylinder head gasketed surface for warpage

(2) Check the directors for rust formation. Replace a rusty director, if any.

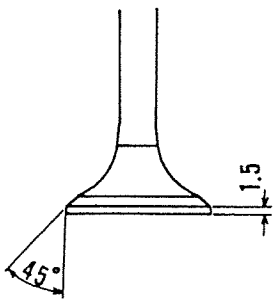
Valves, valve guides and valve seat inserts

(1) Reconditioning of valves

Decarbon the valves. Check the stem and face of the valve for wear or any other damage. When the wear is within the service limit, recondition the valve using a valve refacer to remove stepped wear on face.

Unit: mm (in.)

Item		Standard	Service limit
Valve stem O.D.	Intake	$8\ ^{-0.045}_{-0.060}$ ($0.315\ ^{-0.0018}_{-0.0024}$)	
	Exhaust	$8\ ^{-0.060}_{-0.080}$ ($0.315\ ^{-0.0024}_{-0.0031}$)	
Valve head thickness		1.5 (0.059)	0.5 (0.020)



Valve head thickness

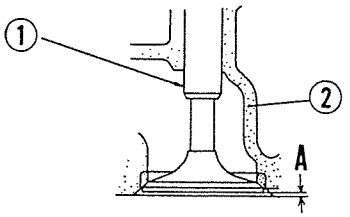
(2) Replacement of valves

(a) Replace the valve when its stem is worn beyond the service limit or when the head is worn down to 0.5 mm (0.020 in.) in thickness.

(b) Check each valve for cracks. Replace a cracked valve, if any.

(c) When the amount of valve sinkage is found to be reached or in excess of 1.3 mm (0.051 in.), replace the valve or the valve seat insert, whichever is badly worn.

(d) Check the wear on the top face of valve cap. Replace a badly worn cap, if any.



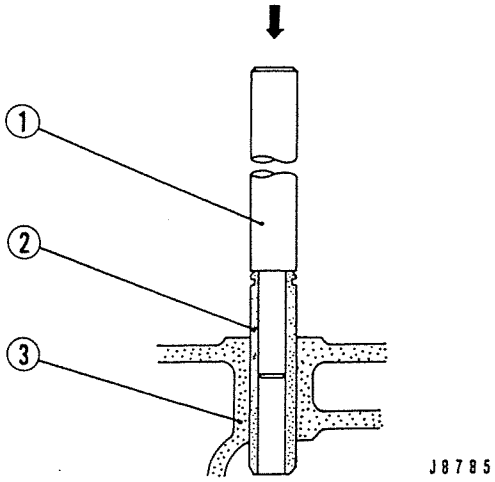
1-Valve A-Amount of sinkage
2-Cylinder head

Valve sinkage

(3) Replacement of valve guides

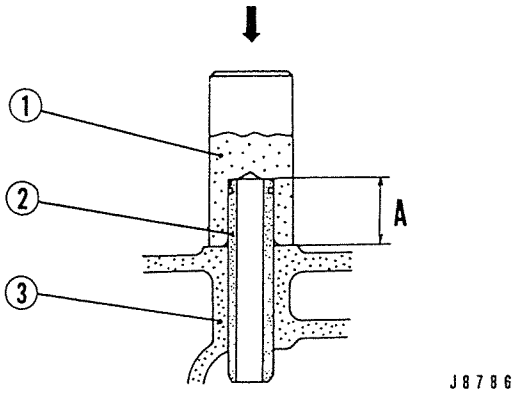
When the clearance between valve stem and guide is found to be reached or in excess of the service limit, replace the valve and valve guide as an assembly. Also replace the valve guide when the upper and lower ends of the guide are found to be excessively worn.

When removing and installing the valve guides, use a guide remover (31391-10500) and a guide installer (30691-10200).



1-Valve guide remover 3-Cylinder head
2-Valve guide

Removing valve guide



1-Valve guide installer
2-Valve guide
3-Cylinder head
A-As-installed length (18 mm or 0.71 in.)

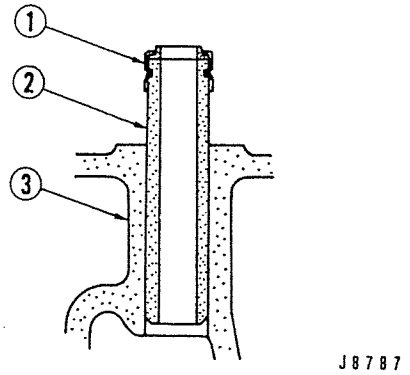
Installing valve guide

Unit: mm (in.)

Item		Standard	Service limit
Valve stem-to-guide clearance	Intake	0.055 ~ 0.085 (0.0022 ~ 0.033)	0.15 (0.006)
	Exhaust	0.070 ~ 0.095 (0.0028 ~ 0.0037)	0.20 (0.008)
Valve guide as-installed length		18 ± 0.3 (0.709 ± 0.012)	

(4) Replacement of valve stem seals

The valves are provided with the valve stem seals to prevent excessive oil from flowing down. Replace a stem seal if necessary. When installing new seals, check to be sure that the seals are properly fitted with valve guide. If a stem seal is defective and valve must be removed, do not remove the valve to prevent damage to the seal lip. In such a case, be sure to replace a defective seal with new one.



1-Stem seal
2-Valve guide
3-Cylinder head

Replacing stem seal

(5) Reconditioning of valve seats

When the valve seats are excessively worn, reface them by using a valve seat grinder or a valve seat cutter.

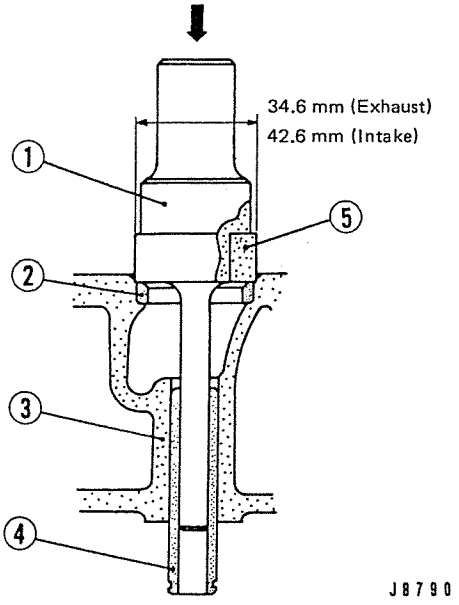
When using a valve seat cutter, apply a uniform pressure to valve seat to prevent uneven cutting. After cutting, reface the surface of seat by rotating the cutter with 400 grit emery cloth placed between the cutter and the seat.

(6) Installation of valve seat inserts

Cool the valve seat inserts in ether or alcohol containing dry ice. Heat the cylinder head to a temperature of 80°C to 100°C (176°F to 212°F). Press the inserts in the cylinder head by using the insert calking tools (30691-02700 for intake valve, 30691-02800 for exhaust valve). Leave the cylinder head and the inserts in the air until shrinkage-expansion fit is obtained between the two. Calk around the inserts with the insert calking tool to machine the seat width.

NOTE

The insert calking tool may be used both for pressing and calking the valve seat inserts by reversing the calking ring.



1-Calking tool body
2-Valve seat insert
3-Cylinder head
4-Valve guide
5-Calking ring

Pressing and calking valve seat insert

(7) Lapping

(a) Lap the valves against the valve seat inserts by using a proper grade of lapping or grinding compound.

(b) After lapping, apply a coat of Prussian blue or similar paste to the valve seats to check for proper contact. If improper, re-lap the valves.

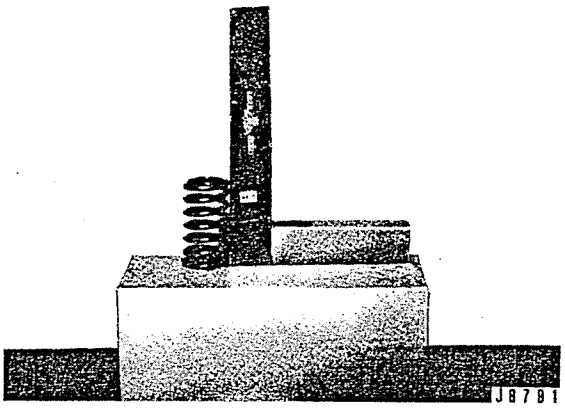
Valve springs

Check the valve springs for breakage, out of squareness or any other damage.

A spring which is found damaged beyond the repair limit should be replaced.

Unit: mm (in.)

Item	Standard	Repair limit
Free length	48.85 (1.923)	47.6 (1.874)
Squareness	0.4/25 (0.016/1), max.	
As-installed length	43 (1.693)	44 (1.732)



Checking valve spring

Rocker arm bushings and rocker arm shaft

(1) Check the part of rocker arm that comes in contact with each valve. A rocker arm which is badly worn should be replaced.

(2) Measure the bushing bore diameter of rocker arm and the outside diameter of rocker arm shaft to check the clearance between the two. When the clearance is found to be reached the repair limit, provided that the shaft is not badly worn, replace the damaged bushing.

(3) Check the oil hole in the front rocker arm for condition.

NOTE

Use the rocker arm bushing adaptor (special tool) when removing and installing the bushing. Make sure, when installing the bushing, that the oil holes in the arm and bushing are properly aligned.

Unit: mm (in.)

Item	Standard	Repair limit
Rocker arm bushing I.D.	$18\ ^{+0.061}_{0}$ ($0.7087\ ^{+0.0024}_{0}$)	
Rocker arm shaft O.D.	$18\ ^{-0.0016}_{-0.034}$ ($0.7087\ ^{-0.0006}_{-0.0013}$)	
Rocker arm bushing-to-shaft clearance	0.016 ~ 0.095 (0.0006 ~ 0.0037)	0.10 (0.0039)

Valve clearance adjusting screws

Replace the adjusting screw when the part of the screw that bears on each push rod is worn excessively or when the threaded part is damaged.

Valve push rods

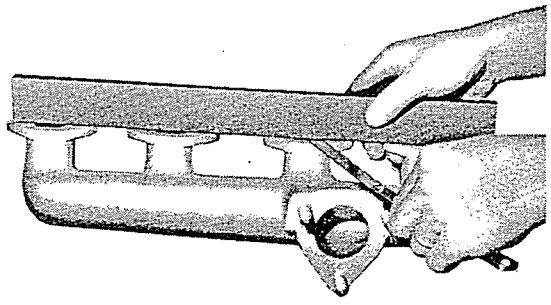
Check the end of push rod that comes in contact with adjusting screw for wear. Also check for bend. Replace a damaged rod, if any.

Unit: mm (in.)

Item	Standard
Push rod bend	0.4 (0.016), max.

Exhaust manifold

Check the flanges for cracks or warpage. Correct if the warpage is over 0.2 mm (0.008 in.)



Checking warpage on exhaust manifold flanges

4. Main moving parts

Crankshaft

(1) Bend of crankshaft

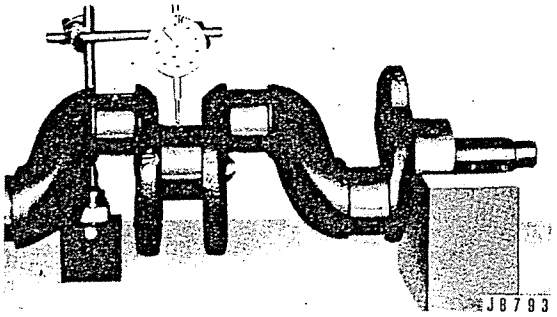
Hold the crankshaft with V-blocks at both ends and measure the runout by putting a dial guage

spindle to the center journal. The amount by which the shaft is bent from its theoretical axis is one half of the runout (as read on the dial guage).

When the bend is within the repair limit, straighten the crankshaft with a power press or the similar tool. The crankshaft which is worn beyond the repair limit should be replaced.

Unit: mm (in.)

Item	Standard	Repair limit
Crankshaft bend	0.02 (0.0008)	0.05 (0.0020)



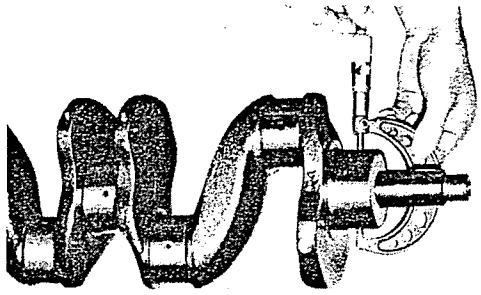
Measuring crankshaft bend

(2) Main bearing journals

(a) Check the surfaces of the journals for wear, scores, scratches or any other damage. Regrind or replace the crankshaft if necessary.

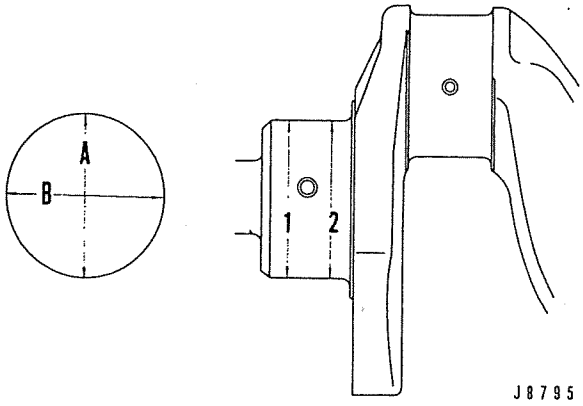
(b) Measure the diameter, out-of-round and/or taper on journal in two directions at right angles to each other as shown in the figure J8795.

When the journals exceed the repair limit, regrind them to undersize. The crankshaft whose journals are worn beyond the service limit should be replaced.



J8794

Measuring main bearing journal diameter



Main bearing journal diameter measuring diagram

Unit: mm (in.)

Item		Standard	Repair limit	Service limit
Main bearing journal	Diameter	$65\ ^{-0.015}_{-0.035}$ ($2.559\ ^{-0.0006}_{-0.0014}$)	−0.15 (−0.006)	−0.9 (−0.035)
	Out-of-roundness	0.01 (0.0004), max.	0.03 (0.0012)	
	Taper	−0.01 (−0.0004), max.	0.03 (0.0012)	

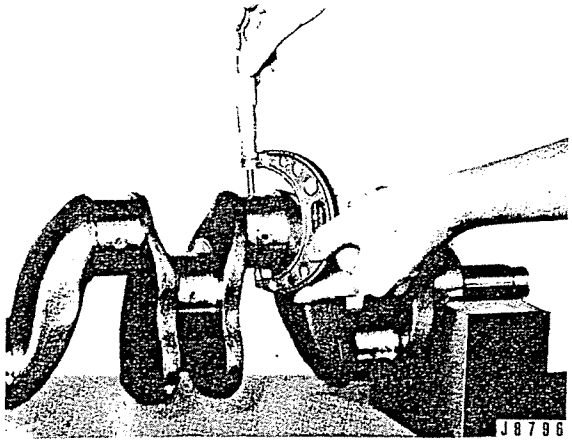
(c) Regrind the journals to undersize in accordance with the table below:

Unit: mm (in.)

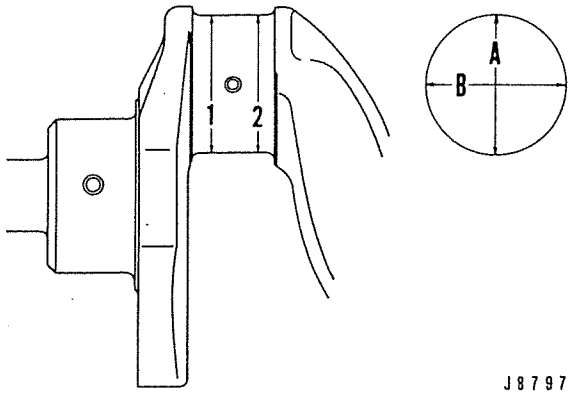
Size	Journal finishing dimension
0.25 (0.010) -undersize	$64.75\ ^{-0.015}_{-0.035}$ ($2.549\ ^{-0.0006}_{-0.0014}$)
0.50 (0.020) -undersize	$64.50\ ^{-0.015}_{-0.035}$ ($2.539\ ^{-0.0006}_{-0.0014}$)
0.75 (0.030) -undersize	$64.25\ ^{-0.015}_{-0.035}$ ($2.530\ ^{-0.0006}_{-0.0014}$)

(3) Crankpins

(a) Check the surfaces of the crankpins for wear, scores, scratches or any other damage. Regrind or replace the crankshaft if necessary.



Measuring crankpin diameter



Crankpin diameter measuring diagram

(b) Measure the diameter, out-of-round and taper on crankpin in two directions at right angles to each other as shown in the figure J8797.

When the crankpins exceed the repair limit, regrind them to undersize. The crankshaft whose crankpins are worn beyond the service limit should be replaced.

Unit: mm (in.)

Item		Standard	Repair limit
Crankpin	Diameter	$58\ ^{-0.035}_{-0.055}$ ($2.283\ ^{-0.0014}_{-0.0021}$)	0.20 (0.008)
	Out-of-roundness	0.01 (0.0004), max.	
	Taper	0.01 (0.0004), max.	

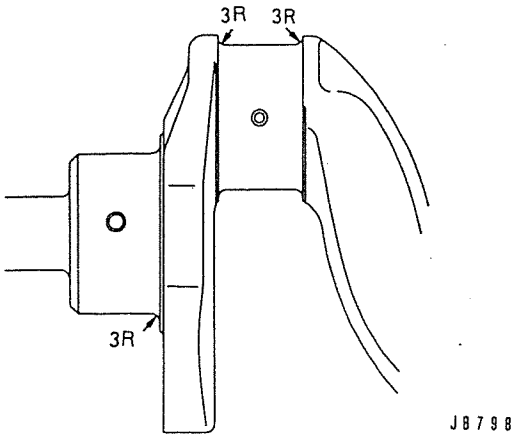
(c) Regrind crankpins to undersize in accordance with the table below:

Unit: mm (in.)

Item	Crankpin finishing dimension
0.25 (0.010) -undersize	$57.75\ ^{-0.035}_{-0.055}$ ($2.274\ ^{-0.0014}_{-0.0022}$)
0.50 (0.020) -undersize	$57.50\ ^{-0.035}_{-0.055}$ ($2.264\ ^{-0.0014}_{-0.0022}$)
0.75 (0.030) -undersize	$57.25\ ^{-0.035}_{-0.055}$ ($2.254\ ^{-0.0014}_{-0.0022}$)

NOTES

a) Regrind the crankpins and journals evenly so that the center-to-center distance between journal and crankpin is 47 ± 0.05 mm (1.85 ± 0.0020 in.).



Journal and crankpin fillets

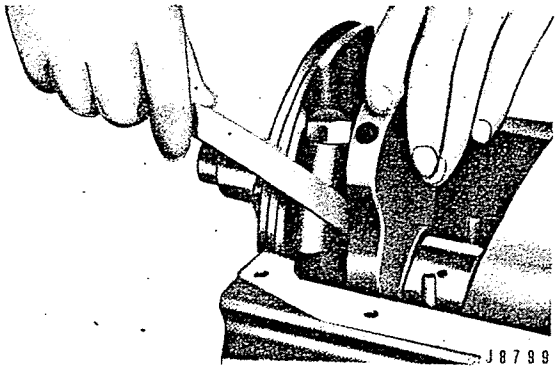
b) When regrinding, a special care should be taken to the radius of journal and crankpin fillets.

(4) End play of crankshaft

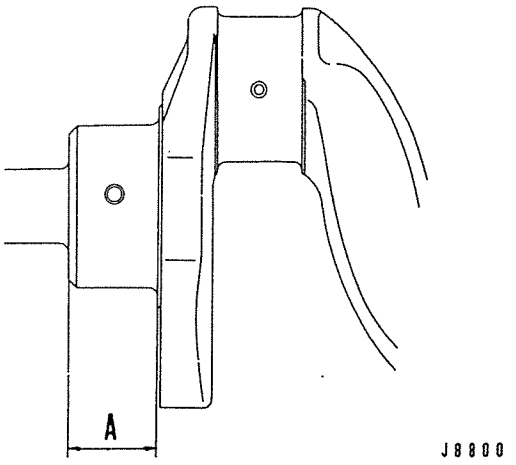
Measure the width of crankshaft thrust journal and the thickness of the thrust plates to check the clearance between the two. This clearance is referred to as "end play." When the end play exceeds the repair limit, replace the thrust plates.

Unit: mm (in.)

Item	Standard	Repair limit
Crankshaft end play	0.1 ~ 0.189 (0.0040 ~ 0.0074)	0.30 (0.012)



Measuring crankshaft end play



A-Thrust journal width

Thrust journal width

(5) Oil seals

Check the oil seal threaded bead lips for uneven wear, deterioration due to overheating or any other damage. Replace a damaged oil seal, if any. Carefully check the oil seal of the part from which oil has leaked excessively during operation.

(6) Oil seal sleeves

The outer surfaces of the sleeves are precision machined to a close tolerance and chromium-plated and, hence, should be handled carefully.

- Replacement of crankshaft rear oil seal sleeve

(a) Removal of sleeve

Using a chisel, give hammer blows to the sleeve in the axial direction until the sleeve becomes stretched sufficiently, and remove the sleeve. Be careful not to damage the sleeve during removal.

(b) Installation of sleeve

To install the sleeve, proceed as follows:

1. Install the guide to the rear end of the crankshaft with the flywheel attaching bolts. Slightly install the sleeve onto the shaft for centering.
2. Coat the sleeve inner surface and crankshaft outer surface with engine oil. When scores or scratches are noted on the crankshaft surface, apply with non-drying sealant such as "Three Bond No. 2."
3. Install the sleeve to the guide, apply a coat of adhesive to the guide and press it onto the crankshaft using the sleeve installer. The sleeve should be pressed squarely onto the shaft. Use the guide and sleeve installer for positioning the sleeve onto shaft.

(7) Others

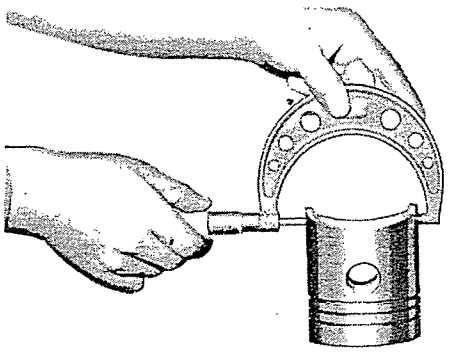
Check the threads and keyway in the front end of the crankshaft for damage. Repair them if necessary.

Pistons and piston rings

(1) Pistons

(a) Check the pistons for condition. Replace the damaged piston, if any. The piston whose ring grooves are worn stepped or unevenly should also be replaced.

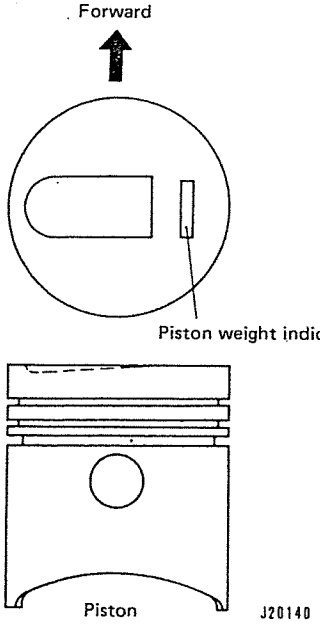
(b) Measure the outside diameter of piston and the inside diameter of cylinder liner to check the clearance between the two. When the clearance exceeds the service limit, replace piston.



Measuring piston outside diameter

Unit: mm (in.)

Item		Standard	Repair limit
Piston O.D. (at skirt)	Standard	83.9 ± 0.015 (3.303 ± 0.0006)	–0.2 (–0.008)
	0.25 (0.010) oversize	84.15 ± 0.015 (3.313 ± 0.0006)	–0.2 (–0.008)
	0.50 (0.020) oversize	84.40 ± 0.015 (3.323 ± 0.0006)	–0.2 (–0.008)
	0.75 (0.030) oversize	84.65 ± 0.015 (3.333 ± 0.0006)	–0.2 (–0.008)
	1.00 (0.039) oversize	84.90 ± 0.015 (3.343 ± 0.0006)	–0.2 (–0.008)
Cylinder-to-piston clearance	At piston crown	0.545 ~ 0.610 (0.0215 ~ 0.0240)	–0.2 (–0.008)
	At upper part of 2nd land	0.425 ~ 0.490 (0.0167 ~ 0.0193)	–0.2 (–0.008)
	At lower part of 3rd land	0.365 ~ 0.435 (0.0144 ~ 0.0171)	–0.2 (–0.008)
	Oil rind lower end	0.245 ~ 0.310 (0.0096 ~ 0.0122)	–0.2 (–0.008)
	9.5 (0.374) from oil ring lower end	0.205 ~ 0.270 (0.0080 ~ 0.0106)	–0.2 (–0.008)
	At piston skirt	0.085 ~ 0.150 (0.0034 ~ 0.0059)	–0.2 (–0.008)



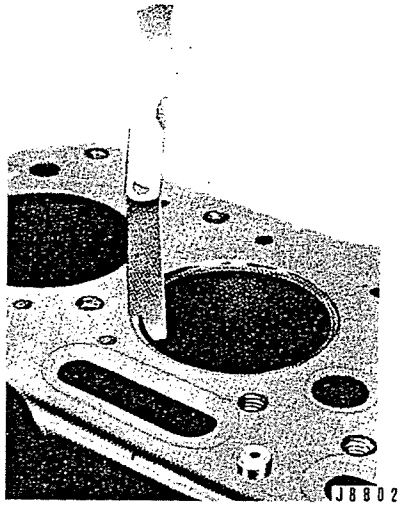
Punching piston weight

NOTES

a) The variance in weight among the piston assemblies should be within ± 3 g (±0.1 oz). On each crown the alphabetical marking is punched for indicating the piston weight.

b) Pistons should be rebored to one and the same oversize.

(2) Piston rings



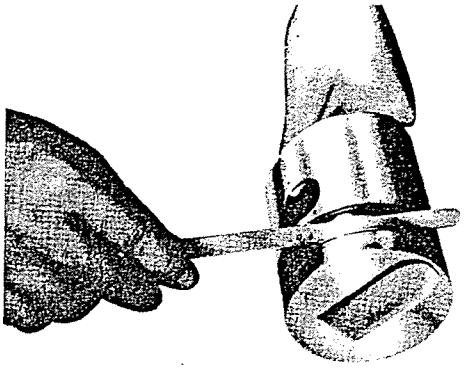
Measuring piston ring gap

(a) Using a thickness gauge, measure ring gap with rings inserted in new liner as shown.

Unit: mm (in.)

Item	Standard	Service limit
Piston ring gap	0.3 ~ 0.5 (0.012 ~ 0.020)	1.5 (0.060)

(b) Check the side clearance as illustrated in the figure (8803). When a ring is replaced, the gap will exceed the standard value, but it should not exceed the service limit.



J8803

Measuring piston ring side clearance

Unit: mm (in.)

Item		Standard	Repair limit
Piston ring side clearance	No. 1 ring	0.05 ~ 0.085 (0.0020 ~ 0.0033)	0.21 (0.008)
	No. 2 ring	0.025 ~ 0.060 (0.0010 ~ 0.0024)	0.15 (0.006)
	No. 3 ring	0.025 ~ 0.060 (0.0010 ~ 0.0024)	0.15 (0.006)

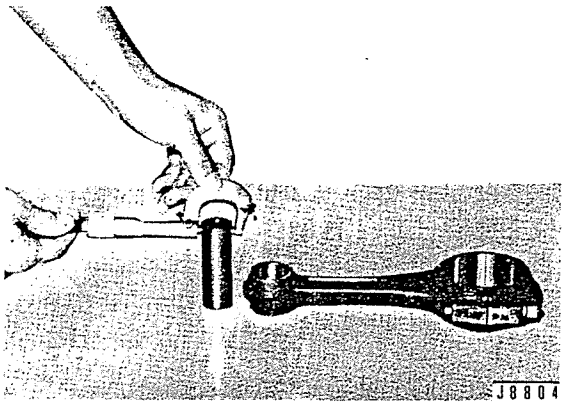
Connecting rods

(1) Measure the inside diameter of the piston pin bosses and the outside diameter of piston pin to check the clearance between the two. When the clearance exceeds the repair limit, replace a worn part.

Unit: mm (in.)

Item	Standard	Repair limit
Piston pin O.D.	$25\ ^{0}_{-0.006}\ (0.984\ ^{0}_{-0.0002})$	
Pin-to-piston clearance	0 ~ 0.016 (0 ~ 0.0006)	0.05 (0.0020)

(2) Measure the inside diameter of connecting rod bushing and the outside diameter of piston pin to check the clearance between the two. When the clearance exceeds the repair limit, replace piston pin or bushing.



J8804

Measuring connecting rod bushing and piston pin diameters

NOTE

When removing and installing the bushings, use the connecting rod bushing adapter and a press. When installing, make sure that the oil holes in the connecting rods are aligned with those in the bushings.

Unit: mm (in.)

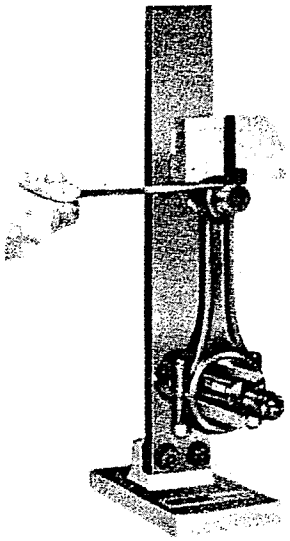
Item	Standard	Repair limit
Piston pin O.D.	$25\ ^{0}_{-0.006}\ (0.984\ ^{0}_{-0.0002})$	
Connecting rod bushing I.D.	$25\ ^{+0.020}_{+0.045}\ (0.984\ ^{+0.0008}_{+0.0018})$	
Bushing-to-pin clearance	0.020 ~ 0.051 (0.0008 ~ 0.0020)	0.08 (0.003)

(3) Check the connecting rods, especially the "fillets" of the small-and big-ends of rods and the holes in spray nozzles of the rod bushings for crack.

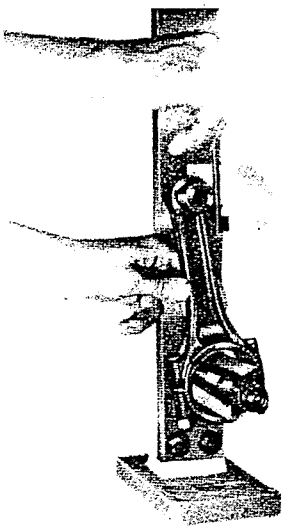
(4) Check the connecting rods for bend, offset and/or twist using a connecting rod aligner. When the bend exceeds the repair limit, straighten the bent rod using a press.

Unit: mm (in.)

Item	Standard	Repair limit
Connecting rod bend (twist)	0.05 (0.002), max.	0.15 (0.006)



Checking connecting rod for bend



Checking connecting rod for twist

(5) Crankpin bearings

(a) Check the bearings for wear, scores or any other damage. Replace a damaged bearing, if any.

(b) Clearance between crankpin and bearing

Measure the diameter of crankpin and the inside diameter of the bearing to check the clearance between the two. When the clearance exceeds the repair limit, replace the damaged bearing.. When crankpins are badly worn, regrind them and use undersize bearings.

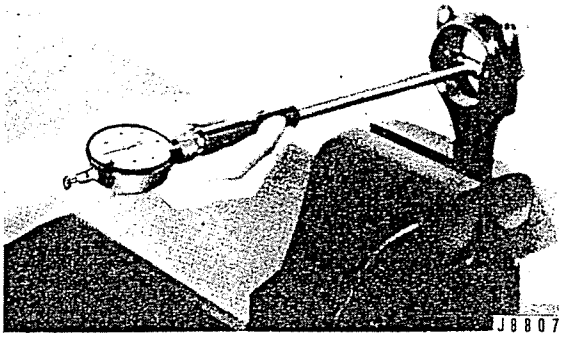
The 0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.) and 0.75 mm (0.0295 in.) undersize bearings are available.

Unit: mm (in.)

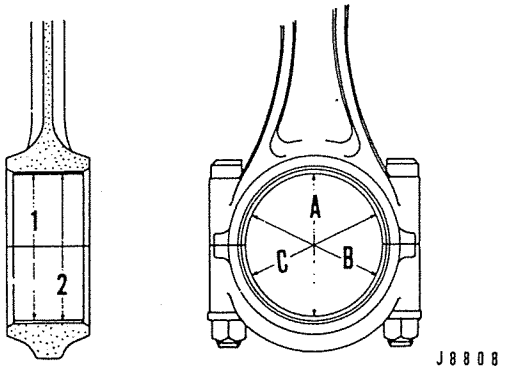
Item	Standard	Repair limit
Crankpin O.D.	$58\ ^{-0.035}_{-0.055}$ ($2.283\ ^{-0.0014}_{-0.0022}$)	
Crankpin-to-bearing clearance	0.035 ~ 0.100 (0.0014 ~ 0.0039)	0.20 (0.008)

NOTE

To measure the inside diameter of bearing, proceed as follows: Install the bearing to the connecting rod properly and tighten the cap to the prescribed torque (5.5 kg-m or 40 ft-lb). Then measure the inside diameter.



Measuring crankpin bearing inside diameter



Crankpin bearing inside diameter measuring diagram

(c) Contact of bearings

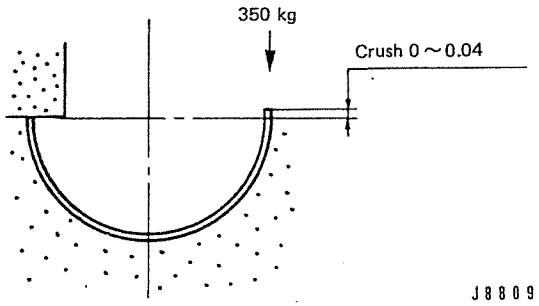
Coat crankpin surface with Prussian blue or the like. Put the bearing on the crankpin and install a connecting rod, tightening the cap to the prescribed torque. If the contact area of the bearing is above 75%, bearing is in a good condition.

NOTE

The bearings are precision-machined to a close tolerance. When installing new bearings, it is unnecessary to reface the bearings as long as the crankpins are ground to the prescribed dimension.

(d) Crush of bearings

If the connecting rods and the bearings are not uniformly tight, local overload may occur due to bearing jump, causing seizure and scores to shorten the service life of bearings. The crush of crankpin bearings is specified as 0 to 0.04 mm (0 to 0.0016 in.). It becomes zero when the connecting rod bolts are tightened to 5.5 kg-m (40 ft-lb), resulting in complete contact of rod body and cap.

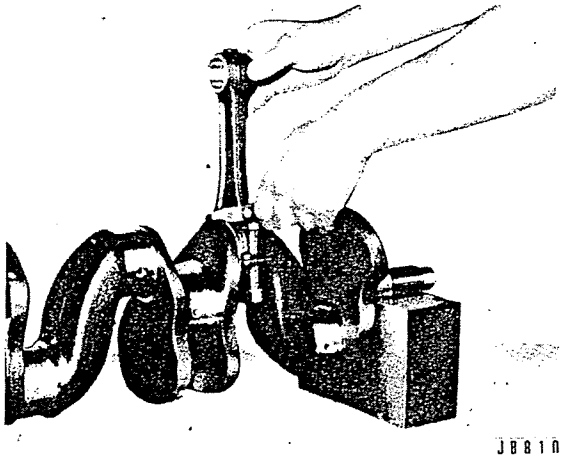


Crush of connecting rod bearing

(6) End play of crankpins

To measure the end play, proceed as follows: Install the connecting rod on the crankpin and tighten the cap to a torque of 5.5 kg-m (40 ft-lb). Measure the end play with a thickness gauge as illustrated in the figure (J8810)

When the end play exceeds the service limit, replace the bearing or connecting rod whichever is badly worm.



Measuring connecting rod end play

Unit: mm (in.)

Item	Standard	Service limit
Connecting rod end play	0.15 ~ 0.35 (0.006 ~ 0.014)	0.50 (0.020)

(7) Replacement of connecting rods

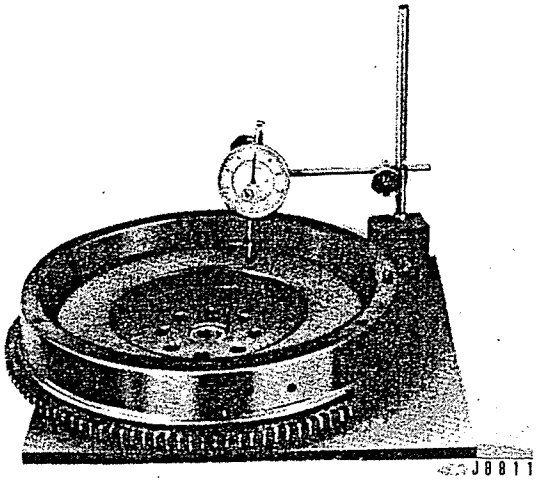
When installing new connecting rod, it is advisable to use the rod having the same weight marking as that of the existing rod. When such a rod is unavailable, the rod whose weight is within next three ranges may be used. The connecting rod assembly (including bolts, nuts and rod bushing) is available in twelve different weights, the difference in weight being 10 g (0.35 oz). The marking is located on the side face of the connecting rod big end.

Unit: g (oz)

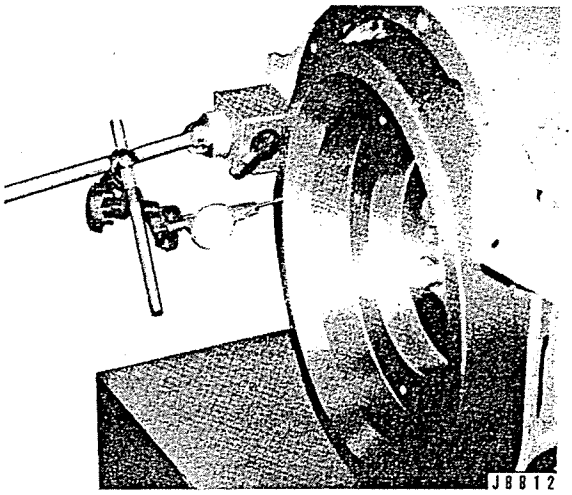
Marking	Weight	Marking	Weight
A	1108 ~ 1117 (38.8 ~ 39.1)	M	1168 ~ 1177 (40.9 ~ 41.2)
B	1098 ~ 1107 (38.4 ~ 38.7)	N	1158 ~ 1167 (40.5 ~ 40.8)
C	1088 ~ 1097 (38.1 ~ 38.4)	P	1148 ~ 1157 (40.2 ~ 40.5)
D	1078 ~ 1087 (37.7 ~ 38.0)	Q	1138 ~ 1147 (39.8 ~ 40.1)
E	1068 ~ 1077 (37.4 ~ 37.7)	R	1128 ~ 1137 (39.5 ~ 39.8)
F	1058 ~ 1067 (37.0 ~ 37.3)	S	1118 ~ 1127 (39.1 ~ 39.4)

Flywheel

(1) Check the flywheel for scoring or a sign of overheating of the friction surface, cracks, or any other damage. When any of these damages are presented, repair or replace the flywheel.



Checking flywheel friction surface for warpage



Checking flywheel friction surface for face runout

(2) Check the friction surface for warpage and/or face runout. When warpage or face runout exceeds the repair limit, repair or replace the flywheel. The face runout may be measured by means of a dial gauge with the flywheel installed on the crankshaft.

Unit: mm (in.)

Item	Standard	Repair limit
Warpage	0.1 (0.004), max.	0.5 (0.020)
Face runout	0.2 (0.008), max.	0.5 (0.020)

(3) Check the flywheel attaching bolt threads for condition and replace a damaged bolt, if any.

(4) Check the ring gear for condition and replace it if damaged.

(5) Clean the pilot bushing which is fitted into the center bore in the flywheel, and check it for condition. Replace the bushing if damaged.

5. Timing gear train

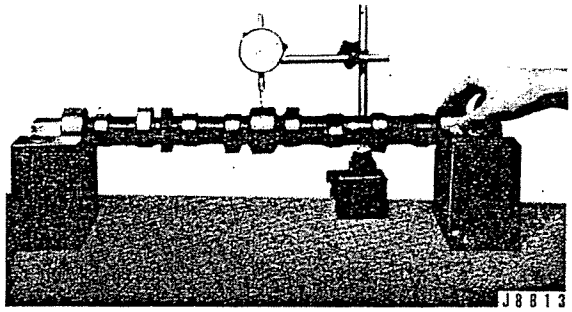
Camshaft

(1) Bend of camshaft

Support No. 1 and No. 3 journals with V-blocks and put a dial gauge on No. 2 journal for checking the runout. When the runout exceeds the repair limit, repair the damaged shaft with a press or replace it if necessary. The amount of bend is one half of the runout.

Unit: mm (in.)

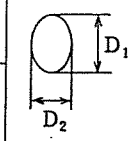
Item	Standard	Repair limit
Camshaft bend	0.02 (0.0008), max.	0.05 (0.0020)



Checking camshaft for bend

(2) Measure the cam height with a micrometer. When it exceeds the service limit, replace a worn cam, if any.

Unit: mm (in.)

Item		Standard	Service limit
Exhaust valve cam profile		D_1: $45.944^{+0.1}_{-0.3}$ ($1.8088^{+0.0039}_{-0.0118}$) $D_1 - D_2 = 7.344$ (0.2891)	$D_1 - D_2 = 6.84$ (0.269)
Intake valve cam profile		D_1: $46.916^{+0.1}_{-0.3}$ ($1.8471^{+0.0039}_{-0.0118}$) $D_1 - D_2 = 6.684$ (0.2631)	$D_1 - D_2 = 6.18$ (0.243)

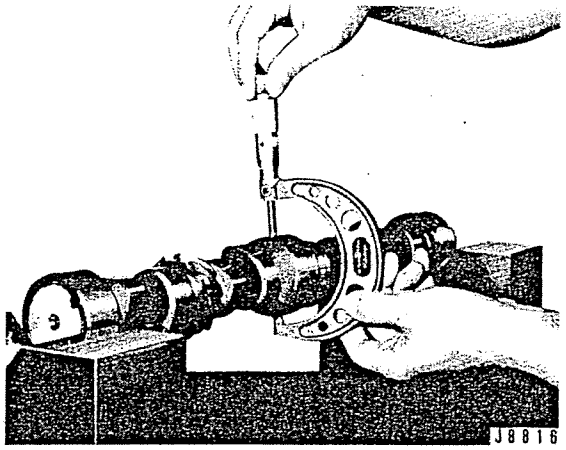
(3) Wear on journals

(a) Check the journals for scoring, uneven wear or any other damage. When the journals are badly damaged, replace the camshaft.

(b) Measure the diameter of journal in two directions at the front and rear parts. Also measure the inside diameter of the camshaft bushing with the shaft installed in the crankcase. Compute the clearance from the two readings. When the clearance exceeds the repair limit, replace the bushing.

Unit: mm (in.)

Item		Standard	Repair limit
Camshaft journal O.D.	No. 1, 2	$54\ ^{-0.04}_{-0.06}$ ($2.126\ ^{-0.0016}_{-0.0024}$)	
	No. 3	$53\ ^{-0.04}_{-0.06}$ ($2.087\ ^{-0.0016}_{-0.0024}$)	
Camshaft journal-to-bushing clearance		0.04 ~ 0.09 (0.0016 ~ 0.0035)	0.15 (0.006)



Measuring camshaft journal diameter

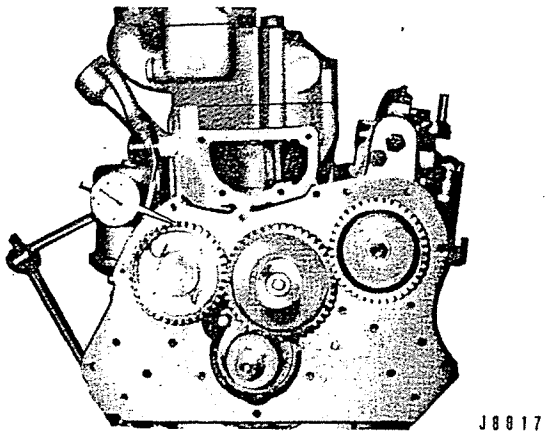
Timing gear

(1) Backlash of timing gears

Check the timing gears for backlash. When the backlash exceeds the repair limit, replace the damaged gear. To measure the backlash, perform by putting a dial gauge on the gear circular pitch as illustrated in the figure (J8817).

Unit: mm (in.)

Item	Standard	Repair limit
Backlash	0.12 ~ 0.24 (0.0047 ~ 0.0094)	0.3 (0.012)



Measuring timing gear backlash

(2) Idler, idler bushing and shaft

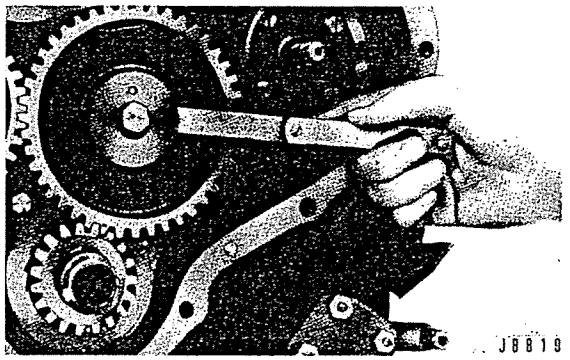
(a) Check the idler for wear, spalling or any other damage. Replace the idler, if damaged.

(b) Measure the inside diameter of the idler bushing and the outside diameter of the idler shaft for checking the clearance between the two. When the clearance exceeds the repair limit, replace the bushing.

Unit: mm (in.)

Item	Standard	Repair limit
Idler bushing I.D.	$36\ ^{+0.025}_{0}$ ($1.417\ ^{+0.0010}_{0}$)	
Idler shaft O.D.	$36\ ^{-0.025}_{-0.050}$ ($1.417\ ^{-0.0010}_{-0.0020}$)	
Bushing-to-shaft clearance	0.025 ~ 0.075 (0.0010 ~ 0.0030)	0.1 (0.004)

(c) Measure the end play of the idler with a thickness gauge. When the end play exceeds the repair limit, replace the thrust plate.



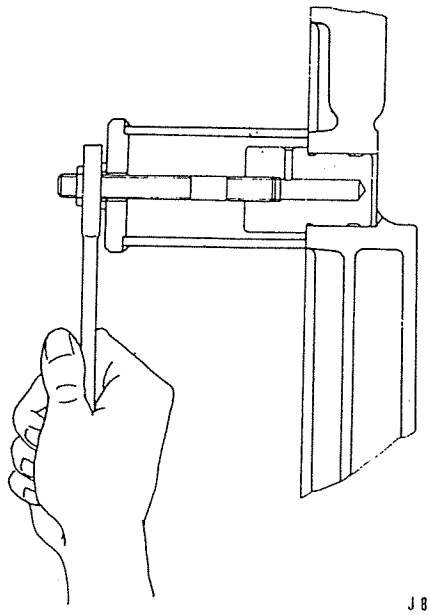
Measuring idler end play

Unit: mm (in.)

Item	Standard	Repair limit
Idler end play	0 ~ 0.1 (0 ~ 0.004)	0.35 (0.014)

(d) Check oil jets in the idler shaft and idler for condition.

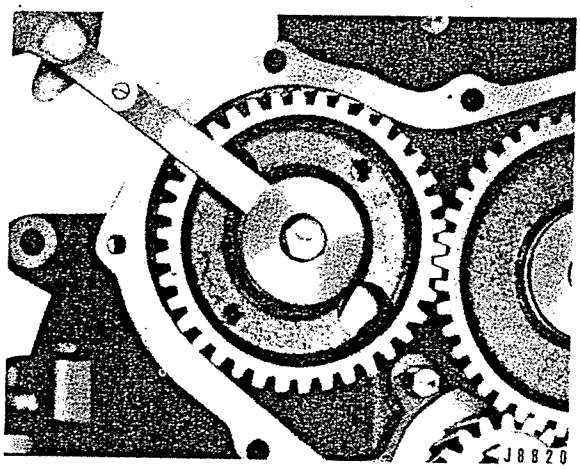
(e) When removing the idler shaft for replacement, use the idler shaft puller (30891-02400).



Pulling idler shaft

(3) Camshaft gear

Check the tooth face for wear, spalling or any other damage and the groove between teeth for condition. Replace the gear, if damaged.



Measuring camshaft end play

(4) Using a dial gauge, measure the end play of the camshaft with the camshaft gear installed on the shaft. When the end play exceeds the repair limit, replace the thrust plate.

Unit: mm (in.)

Item	Standard	Repair limit
Camshaft end play	0.050 ~ 0.112 (0.0020 ~ 0.0044)	0.3 (0.012)

(5) Injection pump gear

Check the tooth face and attaching bolt holes for condition. Replace the pump gear, if damaged.

(6) Crankshaft gear

Check the gear for the condition of tooth face and for the backlash. Replace the gear, if damaged.

(7) Timing gear case

Check the case for cracks or any other damage and the front oil seal in the crankshaft for leakage.

(8) Crankshaft pulley

Check the oil seal contact face and pulley surface for condition. Replace the pulley, if damaged.

6. Lubrication system

Oil level check

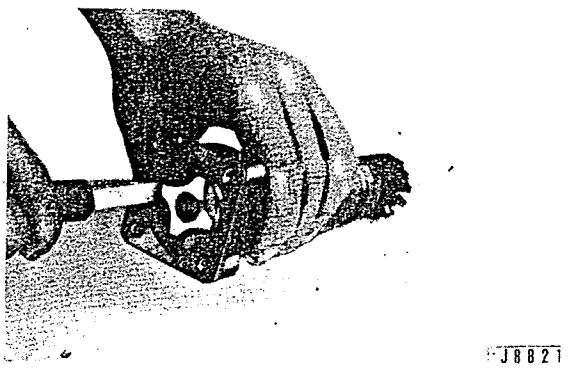
Check the oil level by means of an oil level gauge located on the right side of the crankcase. The oil level should be anywhere between the maximum and the minimum mark on the gauge for proper lubrication, but it is advisable to keep the level at the maximum mark by refilling from time to time.

The maximum oil capacity is about 6 liters (1.6 gal.) and the minimum oil capacity about 5 liters (1.3 gal.). The oil is supplied at the oil filler, located on the right side of the crankcase, through the oil screen. It may also be supplied at the oil fillers provided on the front and rear of the rocker cover.

Oil pump

(1) Clearance between outer and inner rotors

Measure the clearance between the outer and inner rotors. If it exceeds the service limit, replace the rotors as an assembly.



Measuring inner rotor-to-outer rotor clearance

Unit: mm (in.)

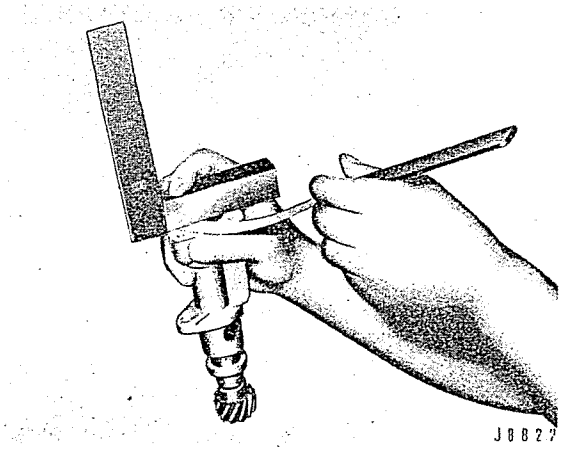
Item	Standard
Inner rotor-to-outer rotor clearance	0.013 ~ 0.015 (0.0005 ~ 0.0006)

(2) Clearance between outer rotor and cover

Measure the clearance between the outer rotor and the cover. If it exceeds the service limit, replace the rotor or grind the mating surface of the pump body.

Unit: mm (in.)

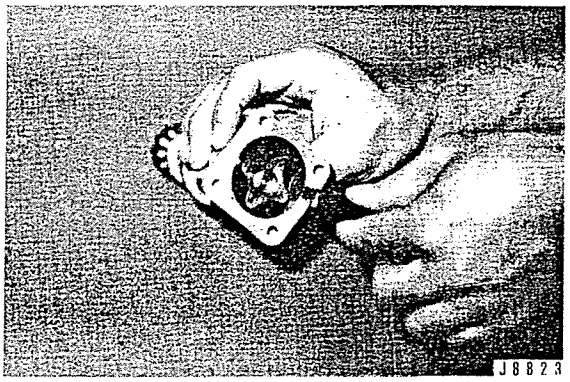
Item	Standard	Repair limit
Outer rotor-to-cover clearance	0.04 ~ 0.09 (0.0016 ~ 0.0035)	0.15 (0.0059)



Measuring outer rotor-to-cover clearance

(3) Clearance between outer rotor and body

Measure the clearance between the outer rotor and the body. Replace the rotor if the clearance exceeds the service limit.



Measuring outer rotor-to-body clearance

Unit: mm (in.)

Item	Standard	Repair limit
Outer rotor-to-body clearance	0.2 ~ 0.275 (0.008 ~ 0.0108)	0.5 (0.020)

(4) Rotor shaft

Measure the outside diameter of the shaft. If excessively damaged or worn, replace the shaft with a new one.

Unit: mm (in.)

Item	Standard	Service limit
Rotor shaft O.D.	$12.6\ ^{+0.06}_{+0.04}$ $(0.496\ ^{+0.0024}_{+0.0016})$	
Shaft-to-pump body clearnce	0.100 ~ 0.121 (0.0039 ~ 0.0048)	0.2 (0.008)

Relief valve

(1) Check the relief valve and the valve seat for their contact. Check the spring for damage or breakage.

(2) Measure the relief valve opening pressure. When it exceeds the standard value, adjust it by means of setting bolt.

Unit: kg/cm^2 (psi)

Item	Standard
Valve opening pressure	3 ± 0.3 (43 ± 4.3)

7. Fuel system

Fuel feed pump

(1) Check valve

Check the seat for excessive wear and replace the valve with a new one if damaged.

(2) Tappets

(a) Measure the tappet and tappet hole diameters. If they are found in excess of the service limit, replace a worn part.

Unit: mm (in.)

Item	Standard	Service limit
Tappet O.D.	20 (0.787)	0.1 (0.004)
Tappet hole I.D.	20 (0.787)	0.1 (0.004)

(b) When the overall clearance in the tappet roller pin hole, roller pin and roller hole is found in excess of 0.3 mm (0.012 in.), replace a tappet assembly with a new one.

(c) Measure the outside diameter of the roller. If it is found in excess of the service limit, replace the roller with a new one.

Unit: mm (in.)

Item	Standard	Service limit
Tappet roller O.D.	$15\ ^{0}_{-0.027}$ ($0.591\ ^{0}_{-0.0011}$)	−0.075 (−0.0030)

(3) Check the feed pump housing for crack and its threaded parts for damage.

(4) Priming pump

(a) Check the pump piston and cylinder for defects such as score or scratch marks.

(b) Check the check valve seat for excessive wear or any other damage. Replace the valve if damaged.

Tests of fuel feed pump

(1) Suction test

When the fuel injection pump is operated at 150 rpm, the fuel feed pump should start delivering of fuel oil within 40 seconds.

(2) Delivery pressure test

When the injection pump is operated at 600 rpm with the feed pump delivery side closed, the feed pump delivery pressure should be 1.8 to 2.2 kg/cm² (25.6 to 31.3 psi).

Item	Pump rpm	Delivery pressure kg/cm² (psi)
Fuel feed pump delivery pressure	600	1.8 ~ 2.2 (25.6 ~ 31.3)

(3) Displacement test

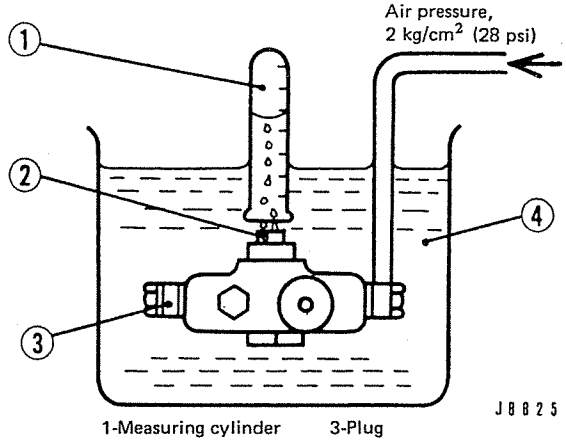
When the delivery pressure is adjusted to 1.5 kg/cm² (21.3 psi) and the feed pump is operated under the test conditions stated below, the amount of fuel oil to be delivered shoudl be not less than 900 cc (55 cu in.)/min. when measured by using a measuring cylinder.

Item	Pump rpm	Standard cc (cu in.)/min.	Repair limit cc (cu in.)/min.
Displacement	1000	900 (55), min.	600 (37)

(4) Airtightness test

Apply an air pressure of 2 kg/cm² (28 psi) to the suction side of feed pump with delivery side closed, and immerse the feed pump in kerosene, making sure that no part is leaking. There should also be no air leakage between pump housing and push rod.

If airtightness is poor, replace the feed pump housing sub-assembly (housing, push rod and oil seal).



1-Measuring cylinder 3-Plug
2-Tappet 4-Oil container

Testing feed pump airtightness

Injection pump

(1) Pumping elements

(a) Measure the plunger lug width. If it is less than $7\ ^{-0.05}_{0}$ mm ($0.276\ ^{-0.0020}_{0}$ in.), replace the plunger assembly with a new one.

(b) Measure the control sleeve slot width. If it is in excess of 7.02 mm (0.276 in.), replace the control sleeve with a new one.

(c) Check the surface of the plunger and the inside surface of the plunger barrel for score or scratch marks or excessive wear. Replace the plunger assembly with a new one if found in bad condition. The amount of wear on the plunger may be judged by observing its surface under the light. Loss of gloss is an indication that wear has occurred on the plunger. It is advisable that all four plungers and barrels are replaced at one time. The oiltightness between the plunger and the plunger barrel should be checked under the test conditions stated below. Replace the plunger assembly with a new one if found in bad condition.

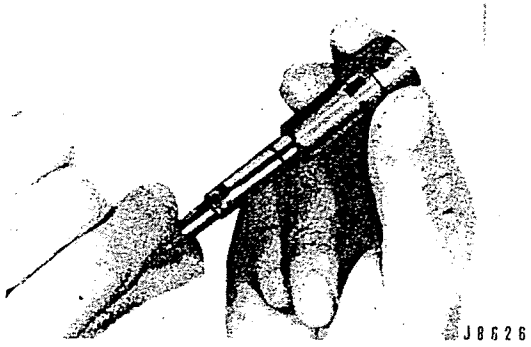
(d) Oiltightness test for plunger

Install plunger and barrel to be tested in the injection pump with delivery valve already tested. Then attach a pressure gauge (calibrated to 300 to 400 kg/cm² or 4266 to 5688 psi) onto the delivery valve holder. When the injection pump is operated at 200 rpm with the control rack set in "no-load" position, the gauge pointer should be indicating within the standard value.

Unit: kg/cm² (psi)

Item	Standard	Repair limit
Oiltightness	150 ~ 200 (2133 ~ 2844), min. (at 200 rpm)	150 (2133), max.

Pull the plunger out of the barrel about 2/3 the full length, and hold the barrel by tilting it about 60°, thereby permitting the plunger to go down in the barrel. A plunger which goes down smoothly in the barrel may be considered to be in good condition. Any binding noted in the movement of the plunger is the cause for replacing the plunger and barrel as an assembly.



Testing plunger

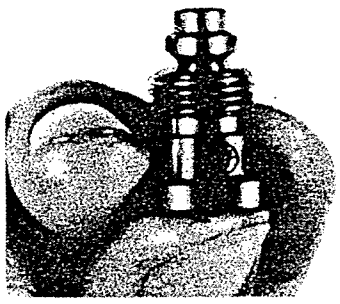
(2) Delivery valve

(a) Check the piston for excessive wear and the valve seat for contact. If found defective, replace both delivery valve and delivery valve seat.

(b) Oiltightness test for delivery valve

Install the delivery valve to be tested on the injection pump and attach a pressure gauge (calibrated to 300 to 400 kg/cm^2 or 4266 to 5688 psi) to the delivery valve holder. Operate the injection pump and stop it when the pressure in the delivery valve holder exceeds 150 kg/cm^2 (2133 psi), and reduce the pressure in the barrel to the atmospheric pressure with the control rack set in the 0 mm position. Measure with a stop watch the time required for dropping the pressure in the valve holder to 10 kg/cm^2 (142.2 psi). If it is found in excess of the service limit, replace the valve with a new one.

Check the oiltightness of the delivery valve by conducting the test stated below and replace the valve if found in bad condition.



Testing delivery valve for oiltightness

Item	Service limit
Oiltightness	Time required for pressure to drop to 10 kg/cm^2 (142.2 psi): 5 sec., min.

Lift the piston and finger-close the bottom of the valve seat and lightly press the top of the delivery valve with another finger. The valve will return by itself when the finger is released as long as the piston is not worn.

(3) Control rack and pinion

(a) Check the control rack for bend or twist and its teeth for excessive wear. Replace the rack if necessary.

(b) If the backlash between the control rack and pinion is found in excess of the service limit, replace the rack or pinion whichever is badly worn.

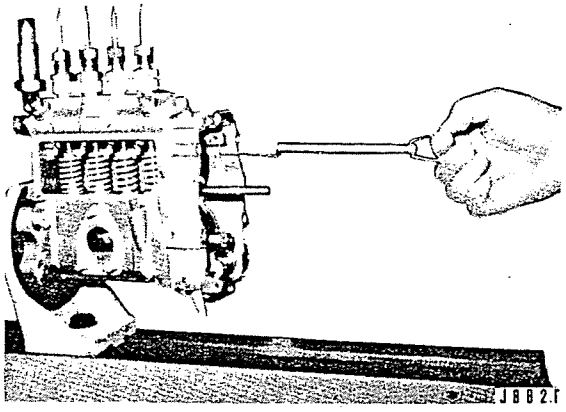
Unit: mm (in.)

Item	Standard	Service limit
Control rack-to-pinion backlash	0.15 (0.0059)	0.25 (0.0098)

(c) Measure the sliding resistance of the control rack with a spring balancer. If it exceeds the standard value, repair or replace the control rack.

Unit: g (oz)

Item	Standard
Control rack sliding resistance	150 (5.3), max (at standstill)



Measuring control rack sliding resistance

(4) Tappets and rollers

(a) The tappet roller assembly comprises a roller, roller bushing and roller pin. To check for excessive wear on these three parts, a dial gauge may be used. Move the roller up and down with a push rod, reading the gauge. If a total clearance exceeds

0.3 mm (0.012 in.), replace the tappet complete with a new one.

(b) Check the clearance between the tappet and pump housing. If it is found in excess of the service limit, replace the tappet with a new one.

Unit: mm (in.)

Item	Standard	Service limit
Tappet-to-pump housing clearance	0.02 ~ 0.062 (0.0008 ~ 0.0024)	0.25 (0.0098)

(c) Check the surface of the tappet roller for wear, and measure its outside diameter. Replace it with a new one if necessary.

Unit: mm (in.)

Item	Standard	Service limit
Tappet roller O.D.	15 (0.591)	−0.075 (−0.0030)

(5) Delivery valve springs, plunger springs and seats

(a) Carefully check the delivery valve springs, plunger springs and seats for cracks and measure their free length. If it exceeds the limit shown in the table below, replace the springs with new ones.

Unit: mm (in.)

Item		Standard	Service limit
Free length	Plunger spring	49.4 ±1 (1.94 ±0.04)	−0.5 (−0.02)
	Delivery valve spring	32 ± 0.5 (1.26 ± 0.02)	−1 (−0.04)

(b) Replace the plunger spring seats with new ones if recessed more than 0.1 mm (0.004 in.).

(6) Camshaft and tapered roller bearings

(a) Check the cam profile for damage and excessive wear. Check the keyway and the threads on both ends of camshaft for condition. Replace the camshaft with a new one if found in bad condition.

Unit: mm (in.)

Item	Standard	Service limit
Cam height	$32\ ^{+0.1}_{0}$ ($1.26\ ^{+0.004}_{0}$)	−0.2 (−0.008)

(b) Check the tapered roller bearing races for excessive wear and fatigue, and replace the bearing if necessary.

(7) Pump housing

(a) Check the pump housing for cracks and its threaded parts for damage. Replace it with a new one if found in bad condition.

(b) Measure the inside diameter of the tappet holes in the housing and replace the housing with a new one if found in excess of the service limit.

Unit: mm (in.)

Item	Standard	Service limit
Tappet hole I.D.	24 (0.945)	−0.15 (−0.006)

Tests and adjustments of injection pump

The performance and output of the engine depends to a great extent on the care exercised in testing and adjusting the injection pump and governor. Following are the four items for which the pump has to be tested and adjusted. In the tests, an injection pump tester should be used. For the tests and adjustments to be effected on the governor, refer to the instructions given for it.

- Measurement of sliding resistance of control rack
- Measurement of injection timing
- Measurement of tappet clearance
- Measurement of injection quantity

Before installing the reassembled injection pump on the engine, the above tests should also be effected on the governor.

(1) Control rack sliding resistance

Remove the control rack scale from the injection pump and, operate the injection pump at 100 rpm. Then measure the control rack sliding resistance with a hand spring balancer. The control rack when pulled with the hand spring balancer should move smoothly without any binding with a sliding resistance of below 50 g (1.75 oz).

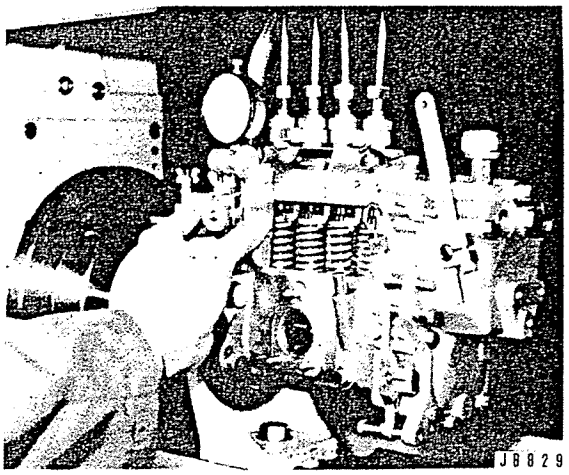
(2) Injection timing

(a) Measurement of prestroke

1. Set the control rack at a position of 21 mm (0.827 in.), and place the plunger lift measuring device (31391-16100) on the cover plate of the pump housing with its leg on the No. 1 tappet guide.
2. Set the No. 1 plunger at the bottom dead center, and deliver fuel to the injection pump by operating the pump of tester with the over-flow pipe opened.
3. When the driving coupling on the tester is turned, the flow of fuel through the feed hole in the plunger barrel toward the overflow pipe is interrupted as the hole is covered by the plunger. In other words, fuel injection begins when the fuel is so interrupted. The travel of the plunger from the bottom dead center to the beginning of injection is called prestroke. This prestroke may be measured with a dial gauge. It should not be in excess of the standard value.

Unit: mm (in.)

Item	Standard
Prestroke	1.95 ± 0.05 (0.077 ± 0.002)

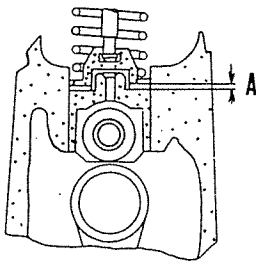


Measuring prestroke

(b) Adjustment of prestroke

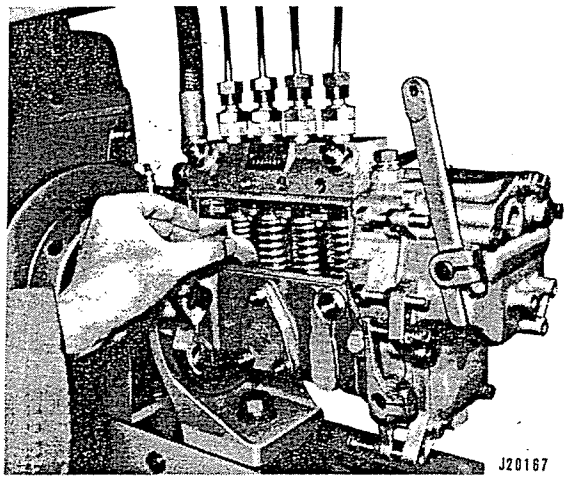
1. Raise the plunger in a barrel to be adjusted to the top dead center. Then insert a spring holder (31391-16400) under the lower spring seat.

2. Bring the cam to the bottom dead position to lower the tappet. Then adjust the prestroke by adding or subtracting shim plates with a tweezers.



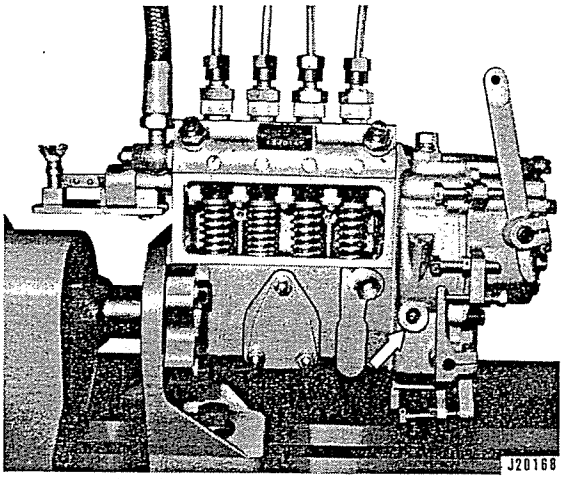
A-Shim

Inserting prestroke adjusting shim



Adjusting prestroke

3. After adjusting the No. 1 plunger prestroke, set the governor pointer to this prestroke.



Checking injection beginning mark

(c) Measurement of injection timing

1. When the driving coupling of the tester is further turned after the measurement of No. 1 plunger prestroke, the flow of fuel in the over-flow pipe of the No. 3 plunger is interrupted. An angular displacement of the cam from the moment the fuel to the No. 1 plunger is interrupted to the moment the No. 3 plunger ceases delivery of fuel oil is the injection timing. The angle scale on the driving coupling cover may be read as this displacement. Correct the injection timing if found out of specification.

Item	Standard
Injection timing	90° ± 30′

2. The No. 2 and No. 4 plungers should also be measured in the manner outlined above.

3. Adjustment

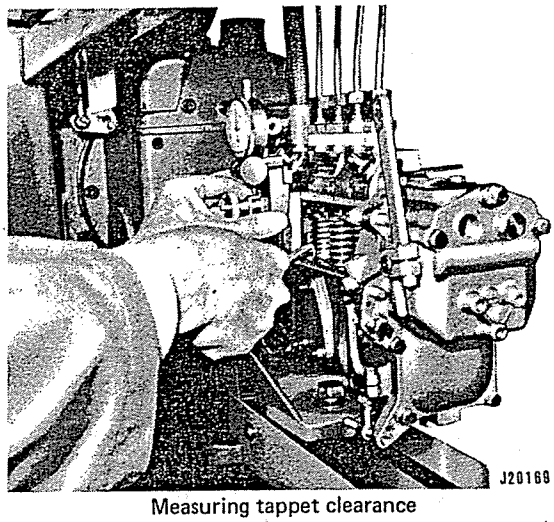
Set the injection timing to the standard value by adjusting the No. 3 plunger prestroke on the basis of the No. 1 plunger one.

(3) Measurement of tappet clearance

Turn the camshaft to raise the tappet to the top dead center. Further lift the tappet with a tappet clearance bar (31391-16300) until the plunger lug comes in contact with the bottom face of the plunger barrel, and measure the lift with a tappet clearance tool (31391-16100). Correct the clearance if found in excess of the standard value.

Unit: mm (in.)

Item	Standard	Service limit
Injection pump tappet clearance	0.2 (0.008)	0.2 (0.008), max.



Measuring tappet clearance

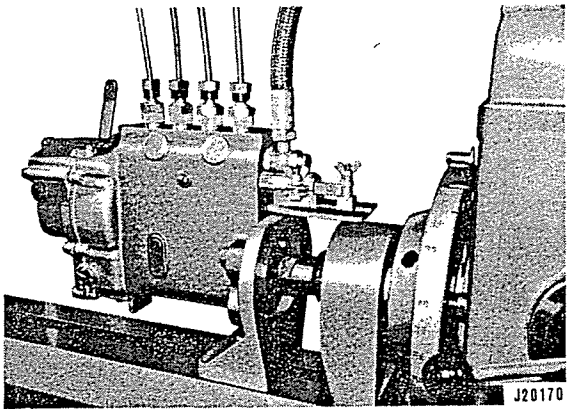
When the clearance is below 0.2 mm (0.008 in.), it should be readjusted with the prestroke set to 21 mm (0.83 in.).

(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) Test method

1. Attach the injection pump on the tester and connect the injection pipes to the tester.
2. Remove the control rack limit sleeve.
3. Attach the rack position measuring device (31391-17900) in such a place as shown in photo (J20170).



Attaching rack position measuring device

4. Bleed air from the fuel system by operating the tester handle.
5. Set the control rack to the standard position.
6. Drive the pump at a prescribed rpm by operating the governor of the tester.
7. Set the delivery pressure to 2 kg/cm^2 (28.44 psi) (gauge pressure), and measure the injection quantity at a prescribed stroke by using a measuring cylinder.

(b) Standards

Injection quantity should be adjusted in accordance with the following table.

Pump rpm	Rack position mm (in.)	Injection quantity mm^3 (cu in.)/ rev. cyl.	Variance mm^3(cu in.)/ rev. cyl.
2000	8.5 (0.335)	36 ~ 39 (0.0022 ~ 0.0024)	3 (0.0002), max.
1000	8.5 (0.335)	36 ~ 39 (0.0022 ~ 0.0024)	2 (0.0001), max.
1000	8.0 (0.315)	32 ~ 35 (0.0020 ~ 0.0021)	2 (0.0001), max.
200	6.0 (0.236)	10 ~ 16 (0.0006 ~ 0.0010)	2 (0.0001), max.

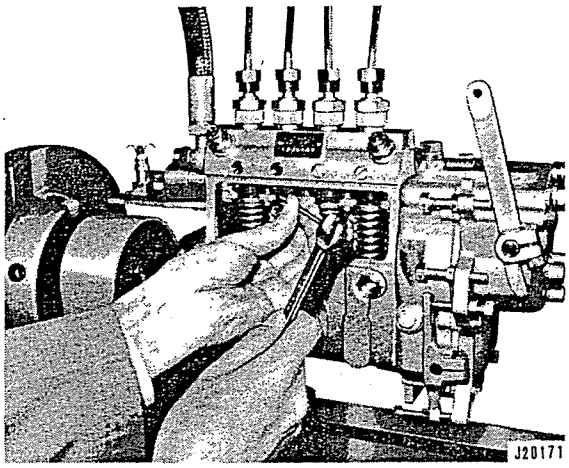
NOTE

The "non-injection position" of the control rack is a zero (0) point.

Nozzle tip: ND-DN40SDN32
Injection pressure: 120 kg/cm^2 (1706 psi)
Injection pipe: 1.6 x 6 x 600 mm (1/16 x 1/4 x 23-5/8 in.)
Delivery pressure: 2.0 kg/cm^2 (28.4 psi)
Test oil: ASTM diesel fuel No. 2

(c) Adjustment

1. Fix the control rack and loosen the clamp screw on the pinion.



Adjusting injection quantity

2. Insert an adjusting bar through a hole in the control sleeve.
3. Slightly turn the control sleeve by giving light hammer blows to the adjusting bar. This permits the plunger to change injection quantity. Turning the control sleeve toward the governor side will increase the injection quantity, and vice versa.
4. Tighten the clamp screw on the pinion.
5. Measure the injection quantity with the tester. Repeat the test until the injection quantity is within the injection standard prescribed above.

Inspection of governor

(1) Check the races of the thrust ball bearing for score or scratch marks or excessive wear. Replace them with new ones if found in bad condition.

(2) Measure the clearance between the flyweight bushing and the weight supporting shaft, and replace worn parts with new ones if the clearance is found in excess of the repair limit.

Unit: mm (in.)

Item	Standard	Repair limit
Flyweight bushing-to-governor shaft clearance	0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.10 (0.004)

(3) Measure the clearance between the lower end (hole) of floating lever and the connecting bolt, the clearance between the floating lever upper end (hole) and the shackle pin and the clearance between the shackle (hole) and shackle pin. Replace worn parts with new ones if the clearances are found in excess of the repair limit.

Unit: mm (in.)

Item	Standard	Repair limit
Floating lever-to-shackle pin clearance	0.010 ~ 0.052 (0.0004 ~ 0.0020)	0.08 (0.0031)

(4) Measure the clearance between the shackle hole and bushing on the control rack side. Replace worn parts with new ones if the clearance is found in excess of the repair limit.

Unit: mm (in.)

Item	Standard	Repair limit
Shackle hole-to-bushing clearance	0.010 ~ 0.055 (0.0004 ~ 0.0022)	0.08 (0.0031)

(5) Measure the clearance between the control shaft and the bearing bushing. Replace the bearing bushing with a new one if the clearance is found in excess of the repair limit.

Unit: mm (in.)

Item	Standard	Repair limit
Control shaft-to-bearing bushing clearance	0.025 ~ 0.07 (0.0010 ~ 0.0028)	0.2 (0.008)

(6) Measure the clearance between the adapter capsule and the adapter, and check the adapter for smooth movement in the axial direction. Replace the parts with new ones if the clearance is found in excess of the repair limit.

Unit: mm (in.)

Item	Standard	Repair limit
Adapter capsule-to-adapter clearance	0.02 ~ 0.13 (0.0008 ~ 0.0051)	0.18 (0.0071)

(7) Check the springs for deterioration, and replace them with new ones if found defective.

(8) Measure the accelerating gear backlash. If it is found in excess of the repair limit, replace the flyweight assembly or gear with a new one.

Unit: mm (in.)

Item	Standard	Repair limit
Accelerating gear backlash	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.20 (0.0079)

(9) Measure the clearance between the governor sleeve complete and the governor shaft. Replace the parts with new ones if the clearance is found in excess of the limit value shown in the following table. Also, check the sleeve for smooth movement in the axial direction.

Unit: mm (in.)

Item	Standard	Repair limit
Governor sleeve complete-to-governor shaft clearance	0.006 ~ 0.059 (0.0002 ~ 0.0023)	0.15 (0.0059)

Tests and adjustments of governor

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

(1) Injection quantity adjustment

Prior to the adjustment of the governor, be sure to conduct adjustment of the injection timing and injection quantity. (See "Tests and adjustments of injection pump.")

(2) Adjustment of governor

After checking the parts of the governor for their connection and sliding parts for condition, adjust the governor in the following sequence according to the specifications:

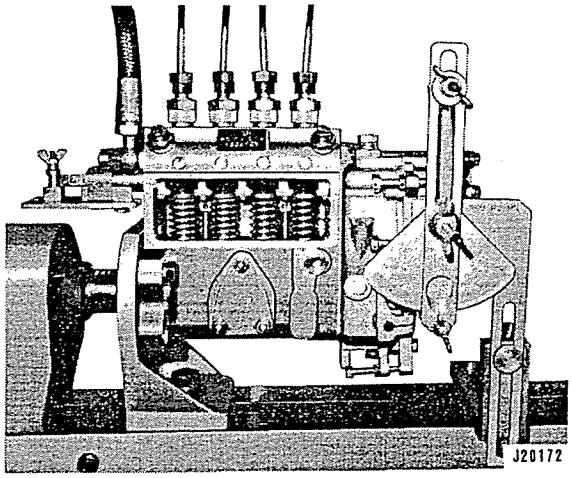
- Adjustment of adapter
- Adjustment of medium and high speed control
- Adjustment of low speed control
- Measurement of injection quantity under full load
- Adjustment of torque spring
- Inspection of stop lever operation

(3) Preparation

(a) Install the injection pump on the test bench, and loosen the maximum speed stopper and adjusting screw on the governor.

(b) Loosen the lock nut, and remove the damper spring and torque spring.

(c) Attach an angle scale plate to fix the adjusting lever.



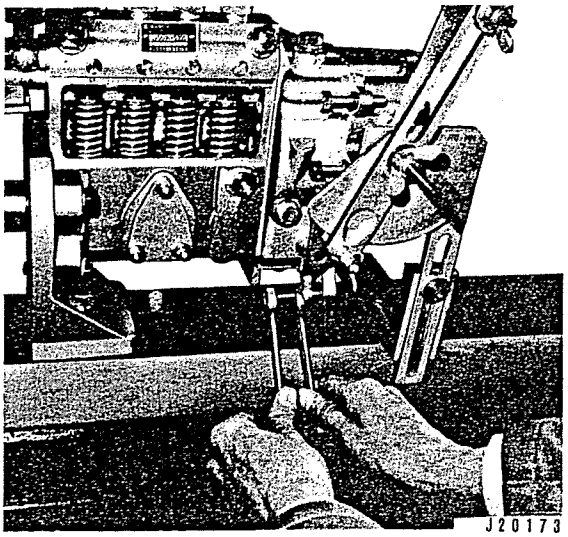
Installing angle scale plate

(4) Adjustment of rack set

Operate the pump at a prescribed rpm, and turn the adjusting lever to the right to a prescribed lever angle according to the specifications shown below:

Specifications for rack set

Adjusting lever angle VH°	Pump rpm	Injection quantity mm^3 (cu in.)/rev.cyl
4° ± 5° to right side from vertical	600	36.5 ± 1.5 (0.0022 ± 0.00009)



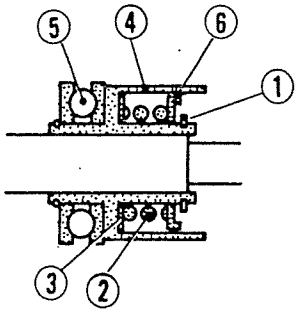
Adjusting stopper

(5) Adjustment of adapter stroke

(a) Place the control lever in a prescribed position, and measure the control rack position with the pump operated at the rpm shown below:

Adjusting lever angle VH°	Pump rpm	Control rack position mm(in.)
⊕4° ±5° to right from vertical position	350	9.0 ~ 9.6 (0.35 ~ 0.38)
	600	8.7 ~ 9.3 (0.34 ~ 0.37)
	700	8.4 ~ 9.0 (0.33 ~ 0.35)

(b) If the control rack fails to return to a prescribed position, replace the stroke plate with a new one.



1-Snap ring
2-Adapter spring
3-Shim
4-Governor sleeve
5-Bearing
6-Stroke plate

Adjusting adapter

Unit: mm (in.)

Item	S
Stroke plate	0.2 (0.008) 0.3 (0.012) 0.4 (0.016)

(c) If the control rack does not come to a prescribed position when the injection pump is operated at a prescribed rpm, adjust the preload of adapter spring with shim(s).

(6) Adjustment of medium and high speed control

(a) Set the control lever to the same lever angle as that for adjusting the adapter, and see whether or not the control rack comes to a prescribed position when the injection pump is operating at a prescribed rpm.

(b) The rack position varies more or less according to whether the governor is adjusted by increasing the speed or by reducing it. This is due to hysterisis.

(c) Increase or decrease the pump rpm according to the specifications, and make sure that the hysterisis is within 0.5 mm (0.020 in.) in high speed control.

Specifications for medium and high speed control

Item	Adjusting lever angle VH°	Pump rpm	Rack position mm (in.)
Medium and high speed control	⊕4° ±5° to right from vertical position	1150	*8.5 ± 0.2 (0.335 ± 0.008)
Hysterisis in high speed control		1150	8.3 ~ 8.7 (0.327 ~ 0.343)
		1400	3.3 ~ 3.9 (0.130 ~ 0.154)
		1300	5.9 ~ 6.9 (0.232 ~ 0.272)
Speed fluctuation	10%, max.		

(7) Adjustment of low speed control

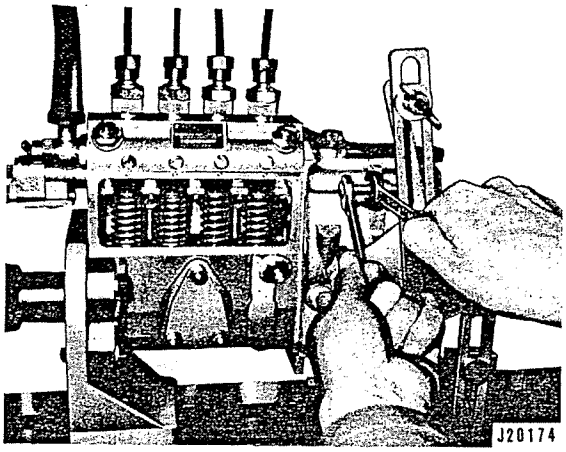
(a) Operate the pump at a prescribed rpm, and turn the control lever to the left to a prescribed rack position.

(b) Check to see whether or not the control rack comes to a prescribed rack position when the injection pump is operated at a prescribed rpm.

(c) Check to make sure that the hysterisis is within 0.3 mm (0.012 in.) in low speed control.

Specifications for low speed control

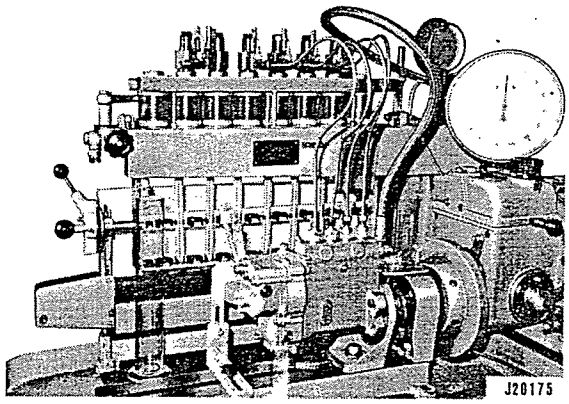
Adjusting lever angle VH°	Pump rpm	Control rack position mm (in.)
⊖6° ±5° to left from vertical position	300	5.5 ~ 6.1 (0.217 ~ 0.240)
	400	4.1 ~ 5.5 (0.161 ~ 0.217)
	100	≧14.8 (0.583)



Adjusting low speed control

(8) Measurement of total injection quantity under full load

Measure the total injection quantity (under full load) of all the cylinders using a 500 cc (30.5 cu in.) measuring cylinder as shown in the figure below.



Testing total injection quantity

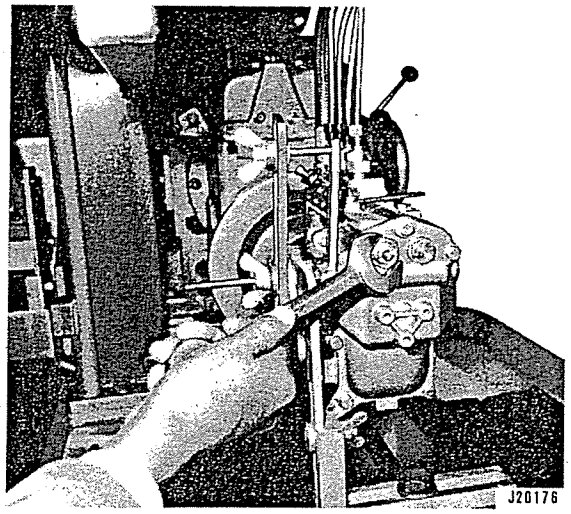
Determine the control lever position in such a manner that the total injection quantity meets the specification when the pump is operated at a prescribed rpm. Fix the full-load stopper.

Measurement of full-load injection quantity

Adjusting lever angle VH°	Pump rpm	Injection quantity mm³ (cu in.)/rev. cyl
⊕4° ±5° to right from vertical position	600	36.5 ± 1.5 (0.0022 ± 0.00009)
	1150	36.0 ± 1.5 (0.0022 ± 0.00009)
	1400	5 ~ 7 (0.0003 ~ 0.00043)

(9) Adjustment of torque spring

Adjust the preload of torque spring in such a way that full-load injection quantity and injection quantity at a pump rpm of 1150 meet the specifications. After adjustment, fix with lock nut.



Adjusting torque spring

(10) Inspection of stop lever operation

When the adjusting lever is set to the low speed control position with the pump at standstill, operate the stop lever, making sure that the rack position is below 2 mm (0.08 in.).

Inspection of injection nozzles

(1) Nozzles and needle valves

(a) Move needle valve in nozzle immersed in clean kerosene and check for smooth movement. Replace them with new ones if found in bad condition.

(b) Check nozzles for condition with a magnifying glass of proper magnifications (4 ~ 5).

(c) Check the clearance between the needle valve and needle valve hole. Replace whichever is in bad condition with a new one.

(d) Check the needle valve point for distortion or breakage and the pressure pin contact point for excessive wear. Replace it with a new one if found in bad condition.

(e) If the movement of the needle valve in the nozzle and contact of the valve seat are improper, they may be reused by lapping with good and clean lubricating oil.

(2) Nozzle holders and distance pieces

Check nozzle holders and distance pieces for proper contact by applying red lead to them. Improper contact may result in increase of retraction volume of fuel oil.

(3) Pressure spring and pressure pin

(a) Check the pressure spring for breakage or excessive wear and out of squareness. Replace it with a new one if found in bad condition.

(b) Pressure pin

Check the pressure spring seat surface and its needle valve contact face for excessive wear. Replace the pressure pin with a new one if found excessively worn.

(4) Check the leak-off pipe packings for condition.

Replace them with new ones if found in bad condition.

(5) Check retaining nuts for condition, and replace them if necessary.

Tests and adjustments of injection nozzles

(1) Inspection and adjustment of injection pressure

(a) Attach the nozzle to a nozzle tester and, manually move the handle up and down to bleed air out of the pipe and nozzle.

(b) Move the lever with a full arm stroke, and check for the fluctuation of the pressure gauge pointer during injection.

(c) When the nozzle tester lever is moved up and down with 60 strokes per minute, the pressure gauge of the tester deflects slowly and then moves quickly. It is normal that the pressure gauge pointer deflects slightly during injection. The injection pressure is a pressure indicated at the beginning of the gauge pointer deflection. Adjust the injection pressure by using shim(s) if found in excess of the repair limit.

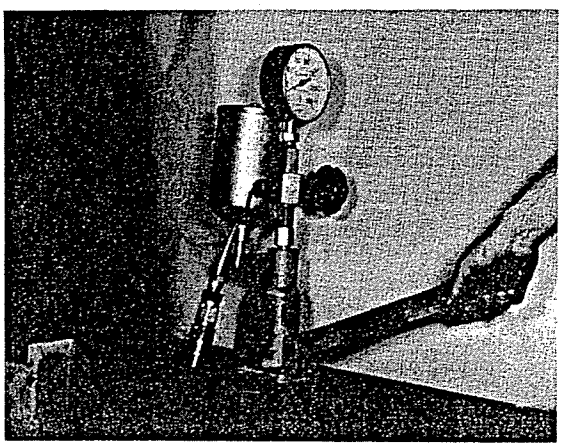
Unit: kg/cm² (psi)

Item	Standard	Repair limit
Injection pressure	120 ± 5 (1706.4 ± 71)	110 (1564.2), max.

NOTE

The injection pressure varies 10 kg/cm² (142 psi) when shim thickness varies 0.1 mm (0.004 in.). 20 kinds of shim thickness are available from 1 mm (0.04 in.) to 1.95 mm (0.077 in.), with 0.05 mm (0.002 in.) between.

(2) Inspection of spray condition

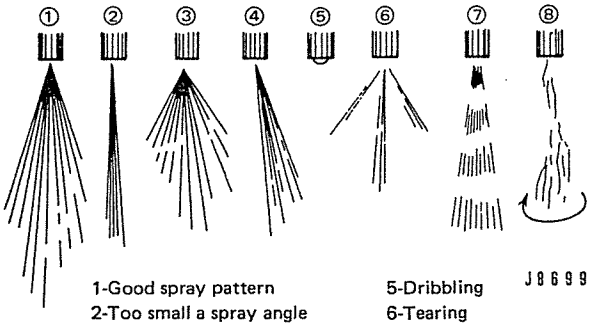


Checking nozzle with nozzle tester

The injection nozzles are of a throttle type whose injection quantity is small in initial stage and then increases suddenly.

The initial injection is called "throttle injection" and the subsequent injection "main injection."

Observe these patterns of injection in checking. For checking the spray condition of nozzle, it is best to use a stroboscope. Following is a guide for the test using a nozzle tester which is generally used.



Spray condition of nozzle

(a) Throttle injection

The throttle injection is an injection when the tester handle is operated at a speed of 1 stroke per second. In throttle injection, the spray is rod like and rough due to throttled nozzle and fuel oil may be left unsprayed from the spray hole at the end of injection. However, this spray is normal for throttle injection.

Item to be checked for throttle injection

- Movement of needle valve

  During tester handle operation, the nozzle should spray fuel oil with some intermittent sound. A good needle valve gives smooth pulsation.
- Spray direction

  The spray direction should not be offset from the axial line of the nozzle.
- Spray pattern

  Fuel oil should be sprayed in one direction. If not, carefully clean the nozzle and re-test it.

(b) Main injection

The main injection is an injection when the tester handle is operated at a speed of 4 to 6 strokes per second.

Items to be checked for main injection

- Spray angle

  Spray angle should be 40° in conical pattern.
- Spray direction

  The axial line of each spray should be in line with that of nozzle.
- Spray condition

  Fuel should be finely atomized without droplets.
- Dribbling

  Dribbling means that a drop of fuel is left on the nozzle tip after injection. There should be no dribbling from the nozzle tip at the end of main injection when the tester handle is moved 3 or 4 times.

(3) Oiltighteness test of injection nozzles

Adjust the injection nozzles so that fuel is sprayed at a pressure of 120 kg/cm² (1706.4 psi), and attach the nozzle on the nozzle tester. Fuel should not leak from the bottom of the nozzle when the pressure is increased to 100 or 110 kg/cm² (1422 or 1564 psi).

NOTE

Check the injection nozzle for spray condition every 500 service hours and decarbon the nozzle seat valve part.

8. Cooling system

Flushing

Accumulation of sludges and scales in the water circuits reduces cooling efficiency, resulting in overheating of the engine. From time to time, flush the

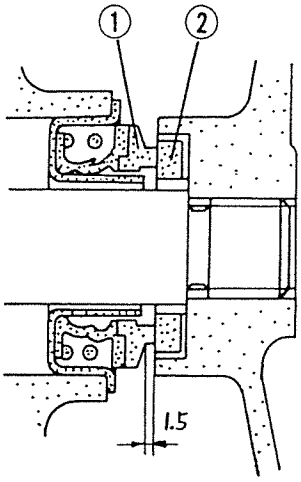
system using a flushing compound. Use SOFT WATER in the system whenever possible. If hard water has to be used, it should be treated with a water softener.

Inspection of water pump

(1) Rotate the bearings to make sure that they rotate smoothly without any sign of binding. If not, replace damaged bearing with a new one.

(2) Check the impeller for corrosion or any other damage. Replace the impeller, if damaged. If the impeller is rubbing the pump case or the rear cover, replace the impeller and bearings.

(3) If the unit seal is badly worn, or if water leaks from the seal excessively, replace the seal with a new one.



J8842

1-Floating seat (carbon) 2-Seal ring (ceramic)

Unit seal

Unit: mm (in.)

Item	Nominal value	Service limit
Free height	25.1 ± 1 (0.988 ± 0.04)	
Carbon protrusion	1.5 (0.06)	0

(4) Check the fit between the pump shaft and bearings. Replace the shaft or the bearings whichever are badly worn.

Unit: mm (in.)

Item	Standard	
Bearing inner race-to-pump shaft fit	Front	0.002T ~ 0.021T (0.00008T ~ 0.00083T)
	Rear	0.001T ~ 0.017T (0.00004T ~ 0.00067T)

(5) Check the fit between the pump case and bearings. Replace the case or the pump assembly, if damaged.

Unit: mm (in.)

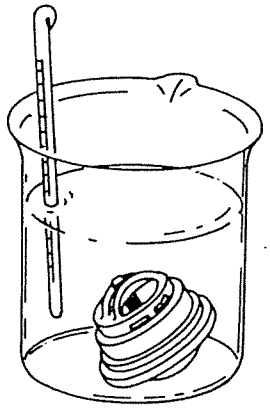
Item	Standard	
Bearing outer race-to-case fit	Front	0.011T ~ 0.025T (0.00043T ~ 0.00098T)
	Rear	0.011T ~ 0.027T (0.00043T ~ 0.00106T)

(6) Check the threaded part of impeller for condition. Replace the impeller, if damaged.

Inspection of thermostat

To check the thermostat for condition, proceed as follows: Place the thermostat in a water tub, and test it for thermostatic action by heating the tub to raise the water temperature.

If the valve of the thermostat starts opening at 76.5 ± 2°C (169.7 ± 35.6°F) and is fully open at 90 ± 2°C (194.0 ± 35.6°F), the thermostat is in satisfactory condition. The thermostat whose valve fails to operate in this manner in the test should be replaced with a new one.



J8704

Checking the thermostat

Inspection of fan and fan belt

(1) Check the fan belt for tension, cracks caused by deterioration or any other damage. Replace the belt, if damaged.

(2) Check the fan blades for distortion, cracks, or any other damage. Replace a damaged blade, if any.

9. Electrical system

Inspection of starting motor

(1) Inspection before disassembly

(a) Starting circuit

If the engine fails to be cranked even when the

starter switch is closed, check the starting motor and its circuit for condition without removing the motor from the engine. If the motor is in good condition, check as follow:

1. Check the battery for charged condition and check the cell plates for any sign of defect.
2. Check the battery terminal connections for tightness or rust formation.
3. Check the starting motor terminal connections for tightness.
4. Check the wiring for mis-connection, poor insulation, gounding or open-circuit.
5. Check the starter switch for operation.

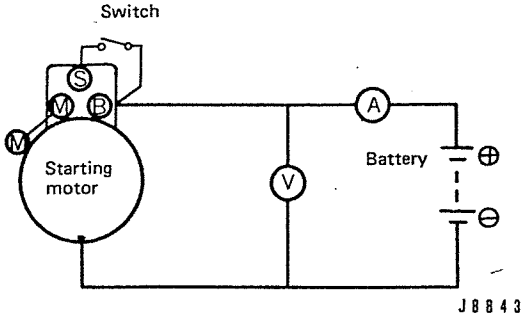
(b) No-load test

When the starting motor is found defective in the foregoing inspections, it should be removed from the engine and be tested under no-load condition.

NOTE

Be sure to turn off the battery switch before testing. Two methods are suggested for testing the starting motor; no-load and load tests. Load test needs larger number of testing equipment. The motor can be fully examined by the no-load test. This section briefly describes the no-load test on the starting motor.

Connect the motor in a test circuit and start it by closing the switch. A good motor will run up to 4500 rpm or higher, drawing current not exceeding 55 amperes at 23 volts.



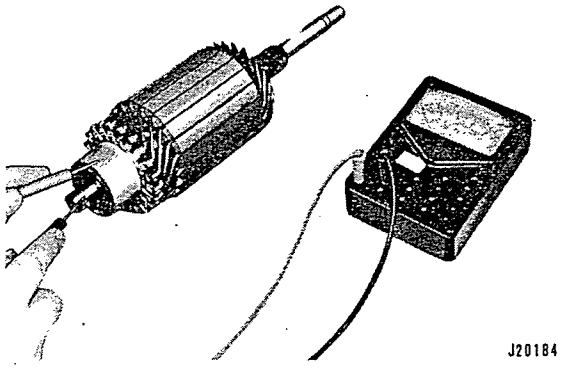
No-load test

Diagnosis chart

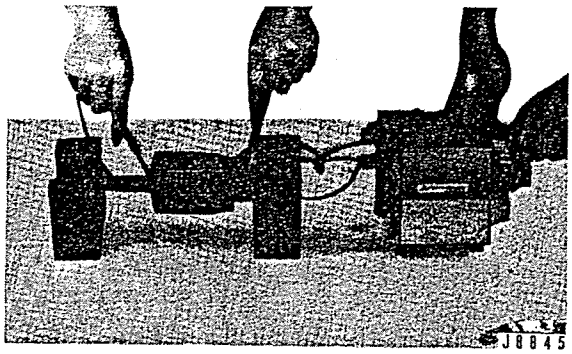
Complaint	Possible cause
Starting motor draws large current, but fails to pick up speed (giving less torque).	1) Bearings are poorly lubricated or dirty. 2) Armature is rubbing pole piece. 3) Armature winding or field winding is shorted or open. 4) Short-circuit in armature winding.
Starting motor draws large current, but it will not run.	1) Magnetic switch has shorted or open circuit. 2) Armature winding or field winding is shorted or open. 3) Bearings are seized.
Starting motor will not run, and draws no current	1) Armature winding or field winding is shorted or open. 2) Brush pigtails are broken off. 3) Commutator surface is too dirty, or brushes are not seating on commutator properly due to "high mica" condition.
Starting motor draws small current, and runs at low speed, giving less torque.	Field circuit is shunted or shorted.
Starting motor draws large current, and runs too fast (but torque is relatively small).	Short-circuit in field winding.

(2) Inspection after disassembly

(a) Armature coil and commutator



Checking armature with ground tester

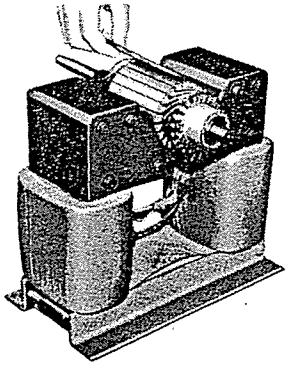


Checking armature with meggar

Check the circuit between the armature coil and commutator for short-circuit, using a ground tester or meggar. If there is any continuity between the commutator and armature shaft, it is an indication that there is a short-circuit between the armature coil and commutator.

(b) Armature

A growler is generally used to test the armature for short-circuit in the winding. Place the armature on a growler and rotate it slowly while holding a steel strip over the armature. If there is any short circuit between the cores, the strip will vibrate and be attracted to the armature. If so, repair or replace the armature.



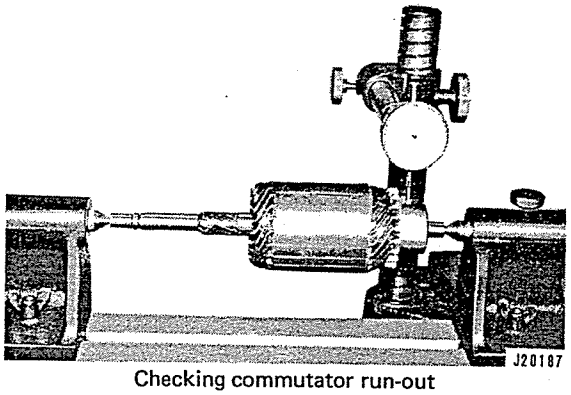
Checking armature with growler

(c) Commuator

Check the commutator surface and soldered connections for condition. Check the mica between the segments for undercut. If defective, replace with a new one or recondition the commutator surface by grinding or sanding, and undercut the mica to the value described.

Unit: mm (in.)

Item	Standard	Repair limit	Max. allowable O.D.
Commutator run-out	0.05 (0.0020)	0.3 (0.012)	43.2 ~ 1 (1.700 ~ 0.039)



Checking commutator run-out

(d) Field coil

Check to see if there is any continuity between "M" terminal and coil. Also, check insulation between the terminal and yoke. Repair or replace the field coil, if defective. Prior to checking the field coil, disconnect shunt-wound coil end soldered to yoke.

(e) Brushes

1. Inspection of brushes

Any brush which is worn beyond the service limit should be replaced with a new one.

Unit: mm (in.)

Item	Standard	Service limit
Brush height	19 (0.748)	13 (0.512)

2. Insulation test of brush holders

Clean dust or other foreign matter off the brush holders and brackets. Check to see if there is continuity between the brush holder (positive side) and bracket with a tester. If there is any continuity, it is an indication that the insulation between the brush holder and bracket is poor.

(f) Inspection of armature shaft and metals

Unit: mm (in.)

Item		Nominal dimension	Standard	Repair limit
Armature shaft-to-metal clearance	At commutator side	14.2 (0.559)	0.034 ~ 0.104 (0.0013 ~ 0.0041)	0.2 (0.008)
	At pinion side	12.2 (0.480)	0.034 ~ 0.104 (0.0013 ~ 0.0041)	0.2 (0.008)
	At intermediate bracket side	20.3 (0.799)	0.220 ~ 0.353 (0.0087 ~ 0.0139)	

Check the armature and its journal for wear. Replace the parts, if excessively worn. Replace a metal if the clearance between the metal and shaft journal exceeds the limit value.

(3) Inspection and testing of starting motor after assembly

To inspect the starting motor for operation, proceed as follows:

No-load test

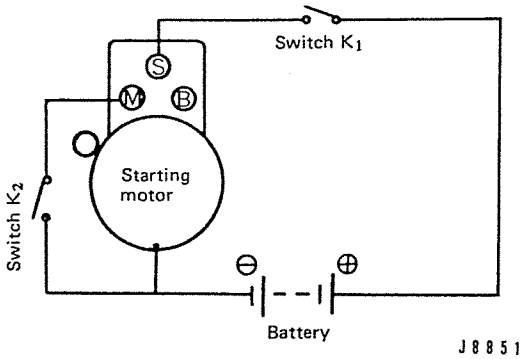
Check the pinion for operation with the starting motor off the engine in the following manner.

(a) Pinion operation

Check the pinion for smooth operation by closing and opening the motor switch several times in succession. If the pinion is faulty, disassemble the motor for inspection. Then, install the motor to the engine and engage the pinion with the flywheel ring gear or with the ring gear of a tester about ten times to check the meshing condition.

(b) Pinion plunging-out position

Disconnect the connector from terminal "M" on the magnetic switch and from the motor. Connect the switch "K_2" between terminal "M" and the starting motor as shown in the test circuit. Close the switches "K_1" and "K_2" to permit the pinion to plunge out. Open the switch "K_2" to hold the pinion in the plunged-out position. Under this condition, measure the clearance between the stopper and pinion. If the clearance exceeds the standard value, adjust it by loosening the plunger set screw to vary the plunger stroke.



Starting motor test circuit

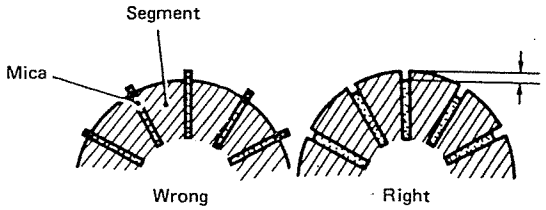
Unit: mm (in.)

Item	Standard
Pinion-to-stopper clearance	0.5 ~ 2 (0.02 ~ 0.08)

Brushes and commutator

(1) Check the brushes for wear. A brush worn down excessively should be replaced by a new one. When the brush is replaced, grind the brush against the commutator surface by using 250 sandpaper so that it makes a full-face contact with the commutator.

(2) Check the mica insulation for condition. It should be "undercut," that is, the segment between two adjacent mica should be slightly proud of the mica surface, as viewed in the cross section. Since the commutator surface is subject to gradual wear, a point will be reached in the course of service, where the segments become flush with the mica. If the commutator in such a condition is kept in service, the mica will tend to interfer with the satisfactory commutation. Before this point is reached, it is necessary to recondition the commutator surface by regrinding or sanding and to undercut the mica properly, as shown below:



Checking mica insulation

Alternator and regulator

(1) Inspection of alternator before disassembly

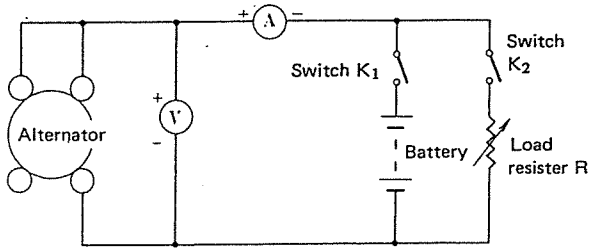
If the charging system is found defective, check the system for the items below and make necessary adjustment or repair.

- Checking of fan belt tension
- Checking charging system wiring for loose connections, or open or short-circuit
- Checking charging system for troubles due to defective battery
- Troubles in the charging system may cause the battery to be overcharged. Check and adjust the system in accordance with the following trouble shooting guide.

Symptom	Possible cause
Battery will be overcharged.	1) Voltage regulator setting is too high. 2) Open circuit in voltage coil. 3) Terminal A is disconnected. 4) Internal short circuit in battery.
Battery is run-down.	1) Voltage regulator setting is too low. 2) Defective contact points. 3) Insufficient output of alternator. 4) Overloading.

(a) Inspection of alternator output

Remove the alternator from the engine. Connect it in a test circuit as shown below and operate it by a motor for inspection.



J20192

1. No-load test

Close the switch "K_1" to permit field current to flow from the battery to the alternator. Gradually increase the alternator speed until reverse current no longer flows in the field coil, that is, until the ammeter pointer deflects to zero. Then open the switch "K_1" so that the alternator field is excited to generate voltage. Gradually increase the alternator speed again and read an rpm at which a voltage of 28 volts is generated as read on the voltmeter. This rpm is a rated voltage generating rpm. A good alternator will not run up to 1100 rpm for generating the rated voltage.

2. Load test

Close the switch "K_2" under the state where very little current flows in the test circuit by varying the load resistance R to a maximum. Gradually reduce the resistance so as to increase the alternator speed.

Measure the alternator output current. The generator can be said to be in good operating condition if the voltage so generated meets the standard value. If not, investigate every possible part of the alternator for trouble.

NOTE

Sudden increase in the alternator speed will cause damage to the built-in diodes due to very high voltage generated by the alternator, while sudden decrease in the load resistance will reduce the voltage so generated to zero, resulting in poor alternator operation. In this case, repeat the procedure mentioned above for generation of voltage.

(b) Inspection of diodes

Diodes are divided into two types by the method of installing silicon in case, one being positive in polarity and permitting the current to flow from the case to the wire lead and the other being negative in polarity and permitting the current to flow from the wire lead to the case. The diode polarity can be identified by referring to the color of the letter on the heat sink; red letter signifies positive polarity and black letter negative polarity.

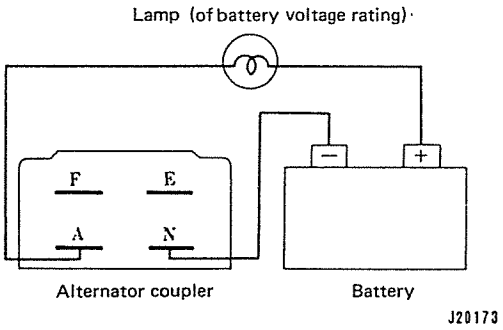
In the present alternator, three positive diodes are soldered to the positive side of the heat sink and three negative diodes to the negative side.

Diodes rupture in two ways, open or short. An open diode does not conduct the current and a shorted diode conduct the current in the reverse direction.

1. Inspection with a lamp bulb

Connect the diode and a lamp bulb to the battery in series as in a test circuit and inspect the diode for condition, in accordance with the chart below:

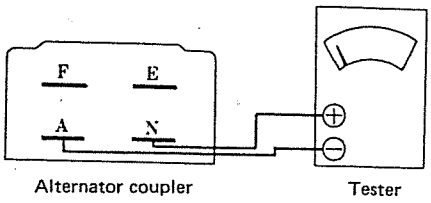
Inspection point	Battery		Diagnosis	
	Positive (thru lamp)	Negative (thru lamp)	When alternator is in good condition:	Conclusion
Positive side diode	Terminal N	Terminal A	Lamp comes on.	If lamp does not come on, all the three diodes are open.
	Terminal A	Terminal N	Lamp does not come on.	If lamp comes on, one or more diodes are shorted.
Negative side diode	Terminal E	Terminal N	Lamp comes on.	If lamp does not come on, all the three diodes are open.
	Terminal N	Terminal E	Lamp does not come on.	If lamp comes on, one or more diodes are shorted.



Testing circuit with a lamp bulb

2. Inspection with a tester

Check the diodes for continuity with a tester as shown below, diagnosing the diodes in accordance with the trouble shooting chart below. The positive (+) terminal of the tester is connected to the negative (–) terminal of the battery; the negative (–) terminal of the tester is connected to the positive (+) terminal of the battery.



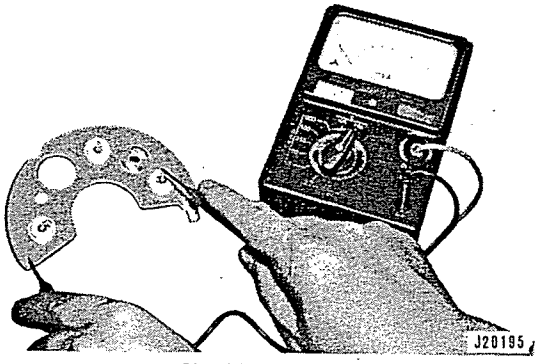
Testing circuit with a tester

Inspection point	Tester		Diagnosis	
	Positive lead	Negative lead	When alternator is in good condition:	Conclusion
Positive side diode	Terminal A	Terminal N	Continuity is noted.	If there is no continuity, the three diodes are open.
	Terminal N	Terminal A	No continuity is noted.	If there is continuity, one or more diodes are shorted.
Negative side diode	Terminal N	Terminal E	Continuity is noted.	If there is no continuity, the three diodes are open.
	Terminal E	Terminal N	No continuity is noted.	If there is continuity, one or more diodes are shorted.

(2) Inspection of alternator after disassembly

(a) Diodes

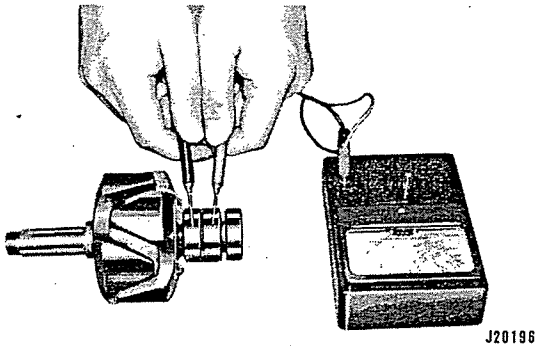
Check for continuity between the wire lead and the heat sink. Any continuity, if noted, means that the diode is shorted; no continuity means an open diode.



Checking diodes

(b) Field coil

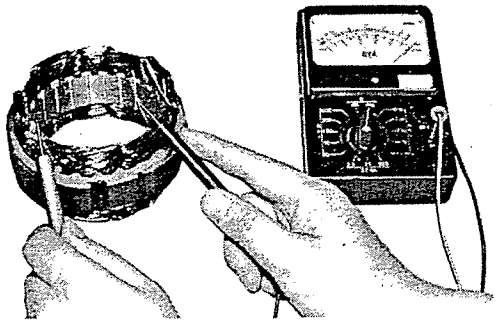
The field coil is in good condition if the resistance between the slip rings is approximately 27 ohms at a temperature of 20°C (68°F).



Checking field coil

(c) Armature

Alternatively check four wire leads of the armature coil for continuity with a tester as shown.



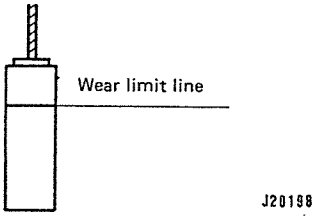
J20197

Checking armature

If there is no continuity between the wire leads, it is an indication that the armature has open circuit. Replace the armature with a new one. Then, check the armature for continuity between the wire lead and core. If there is continuity, it is an indication that there is any grounded circuit between the wire and core. In this case, too, the armature should be replaced.

(d) Brushes

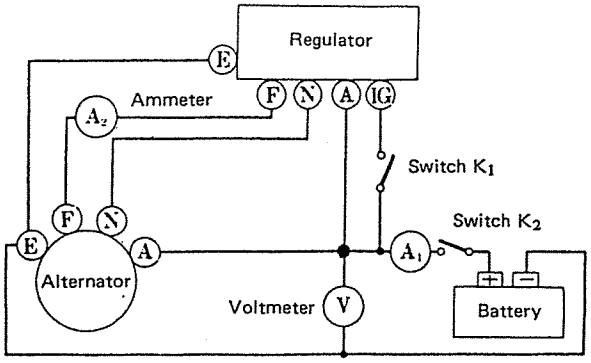
Any brush which is worn beyond the service limit should be replaced with a new one.



J20198

(e) Regulator

Check the regulator for the resistance across the terminals "GI" and "F." If the resistance is about 35 to 41 ohms, the regulator is serviceable. If the continuity across these terminals is poor, it is assumed that the resistance R_4 is disconnected or the contact point P_1 is worn or damaged. In such a case, field current will not flow, resulting in a failure of the alternator to generate voltage.



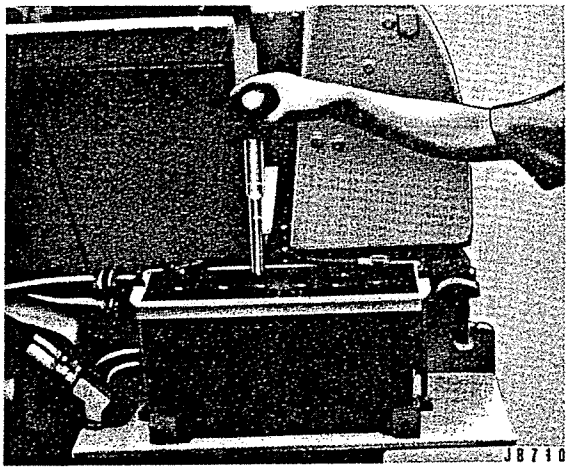
Checking regulator

J20199

1. Inspection of adjustment value

Close the switches "K_1" and "K_2" and operate the alternator with a variable-speed motor. Gradually increase the motor speed until the ammeter (A_1) pointer deflects to zero, that is, the voltage is generated in the alternator, and open the switch "K_2" to permit the alternator to operate under no load. Gradually increase the speed of the alternator again, and read an rpm at which a voltage of 28.0 to 31.0 volts is generated as read on the voltmeter. A good alternator will develop the rated voltage at 3000 rpm.

Battery electrolyte level and specific gravity



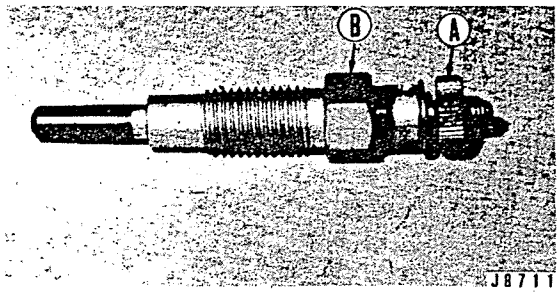
J8710

Checking specific gravity of electrolyte

The electrolyte level in the battery should be 10 mm (about 3/8 in.) above the cell plates. Add distilled water if the level is low. Check the specific gravity of the electrolyte. If the S.G. is below 1.260 (as corrected to 20°C or 68°F) and the electrolyte level is low, add diluted sulfuric acid to adjust the S.G. to 1.260. An S.G. below 1.190 means 1/2 discharge of the battery; in such a case, the battery should be recharged.

Glow plugs

Connect the positive (+) lead to the portion A of the plug with the portion B grounded to see if the plug glows red. The plug is in good condition if it glows red.



Checking glow plug

10. Bench tests

When the engine is overhauled, it is advisable to conduct the bench tests for checking the engine performance. The purpose of bench tests is to make sure that each major component has been properly serviced.

Visual inspection

Couple the engine to the dynamometer and inspect as follows:

(1) Starting the engine

(a) Check the amounts of cooling water, lubricating oil and fuel oil. Bleed air out of the fuel system.

(b) Place the starter switch in PREHEAT position to preheat the combustion chambers. The glow plug pilot lamp will glow red within 20 seconds. If not, check the preheating system for condition.

(c) Place the starter switch in START position to start the engine. Do not move the governor control lever to INCREASE position.

(d) After starting the engine, manipulate the governor control lever to run the engine at idling speed.

(2) After starting the engine

Check the following items and repair if necessary.

(a) Abnormal oil pressure and oil leakage.

(b) Abnormal noise.

If knocking is heard while water temperature is low and the noise dies away as water temperature rises, the engine is in good condition.

(c) Color of exhaust gases.

(d) Leakage of cooling water.

(e) Leakage of fuel oil.

(f) Fuel injection.

(3) Running-in the engine

While running-in the engine, check the following items and repair if necessary.

(a) Oil pressure (3 ~ 4 kg/cm^2 or 42.7 ~ 56.9 psi).

(b) Temperature of cooling water (75 ~ 85°C or 167 ~ 185°F).

(c) Temperature of lubricating oil (60 ~ 70°C or 140 ~ 158°F in oil pan).

(d) Abnormal noise.

(e) Excessive blow-by, water leakage and oil leakage.

(f) The relationship between the load and running-in period is as follows:

After running-in the engine, check the valve clearance.

Engine speed rpm	Load PS	Time min
1000	0	30
1500	7.5	30
2000	15	60
2500	20	60

Performance tests

(1) Test condition

The engine must be equipped with the air cleaner and alternator.

(2) Test items

- No-load maximum speed test (governor set)
- Fuel injection quantity test (control rack set)
- No-load minimum speed test (idling speed set)

(3) Test procedures (with dynamometer pointer in OFF position)

(a) No-load maximum speed test (governor set)

While the temperatures of cooling water and oil are still high after engine running-in, set the no-load maximum speed to a speed not to exceed 2800 ± 20 rpm. The rated output will be obtained at 2500 rpm, provided that the no load maximum speed is set to the prescribed value.

(b) Fuel injection quantity test (control rack set)

The fuel injection quantity can be set by means of the governor fuel set lever. Loosening the set screw at the top of the fuel set lever will increase the fuel injection quantity, and vice versa.

Engine test speed: 1200 rpm

Fuel injection quantity: 5.0 ~ 5.5 liters (305 ~ 336 cu in.)/hr

(c) Move the control lever toward LOW SPEED position and adjust the stop screw to set the idling rpm to 650 to 700.

(d) Tune-up of engine output

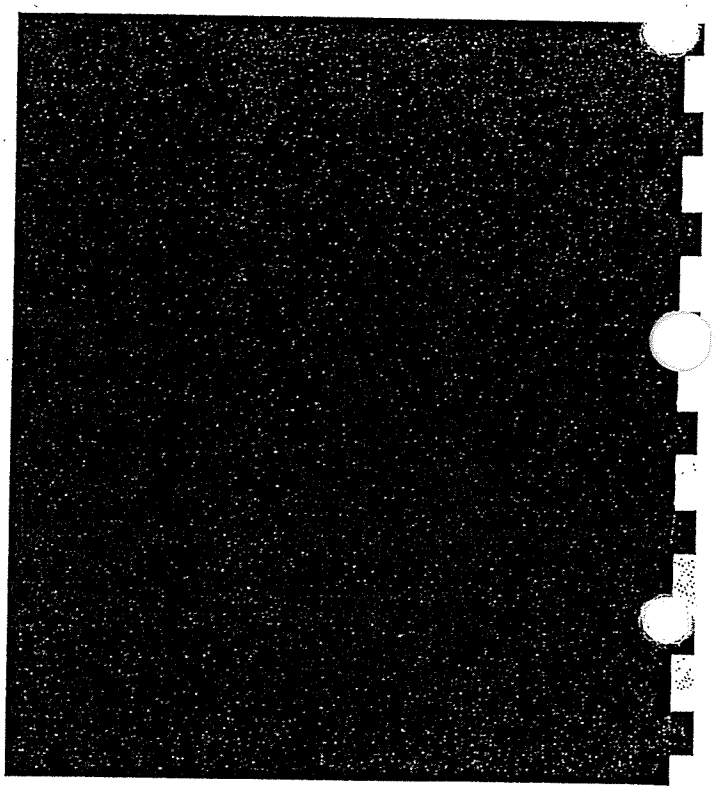
The diesel engine output is based on the atmospheric pressure and temperature. Therefore, the output must be tuned up under standard conditions. Multiply the output measured by the factor. This factor can be computed by the following equation:

$$K = \frac{760}{H - Hw} \sqrt{\frac{273 + t}{293}}$$

Where: H = atmospheric pressure in mmHg

Hw = partial pressure of vapor in atmosphere in mmHg

t = room temperature in °C (°F)



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DISASSEMBLY AND ASSEMBLY

1. General precautions for disassembly and assembly

Precautions for disassembly

(1) Prepare an overhaul stand, parts dollys or trays, and cleaning equipment. All the parts disassembled should be set aside in groups separately, each marked for its mating part or location, so that the same combination as before can be reproduced at the time of reassembly.

(2) Carefully inspect every possible part for condition during disassembling and cleaning in order to prevent reuse of defective parts when reassembling the engine.

(3) Be sure to use right tools in the correct manner instructed by the engine or tool manufacturers, so as to prevent damage to the parts or tools.

(4) Take care not to damage bushings and bearings.

Precautions for assembly

(1) Thoroughly clean the parts, especially critical parts such as oil seals, bearings, bearing caps, cylinders, etc.

(2) Discard the existing gaskets and use new ones.

(3) Lubricate each moving part with superior-quality lubricant.

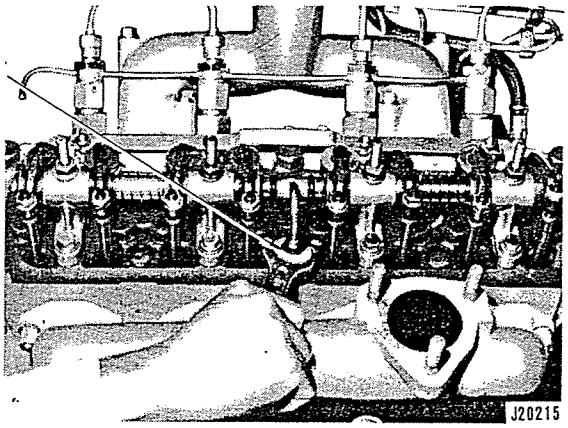
(4) Apply a coat of sealer to the parts which need such a coat when assembled.

(5) Be sure to follow the tightening torque or sequence of fastening parts, if prescribed.

2. Rocker arm shafts

Removal

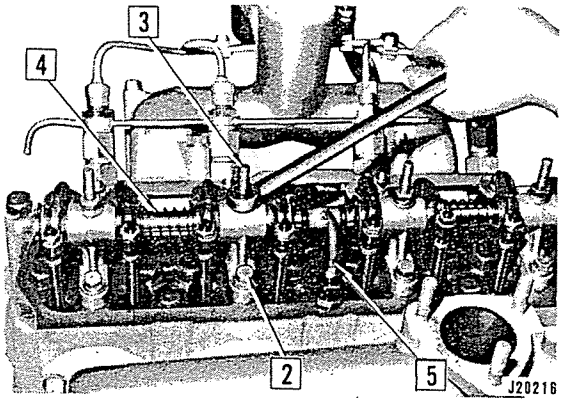
(1) Remove oil pipe union nut (1) from connector after removing the rocker arm case cover.



1-Union nut

Removing union nut

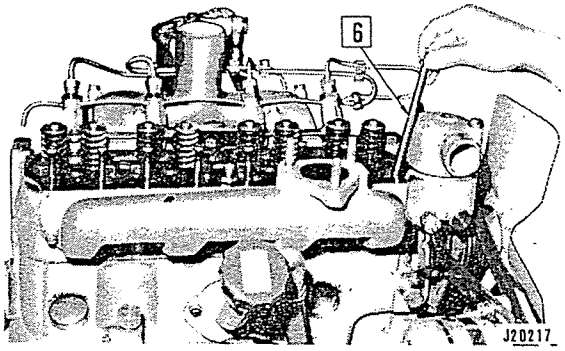
(2) Loosen short bolts (2) of the rocker bracket and long bolts (3), and remove rocker arm shaft assembly (4) and oil pipe (5) from the cylinder head.



2-Bolt and washer (4 pcs each)
3-Bolt and washer (4 pcs each)
4-Rocker arm shaft assembly
5-Oil pipe

Removing rocker arm shaft assembly

(3) Pull out valve push rods (6).



6-Push rods (8 pcs)

Pulling out push rods

Installation

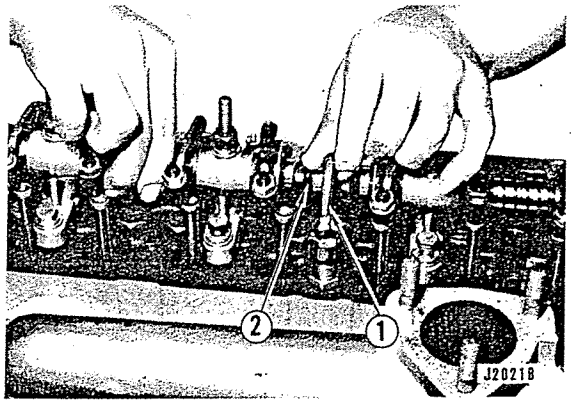
(1) Insert the push rods into the tappets. Place O-rings (2) on oil pipe (1) and connect the oil pipe to the front and rear rocker arm shafts. Then temporarily install each bracket to the cylinder head.

(2) Temporarily tighten two or three threads on the oil pipe union nut and connector.

(3) Secure the brackets placed by tightening four bolts at the front and rear sides uniformly to a torque of 1.5 kg-m (11 ft-lb). Tighten the long bolts first.

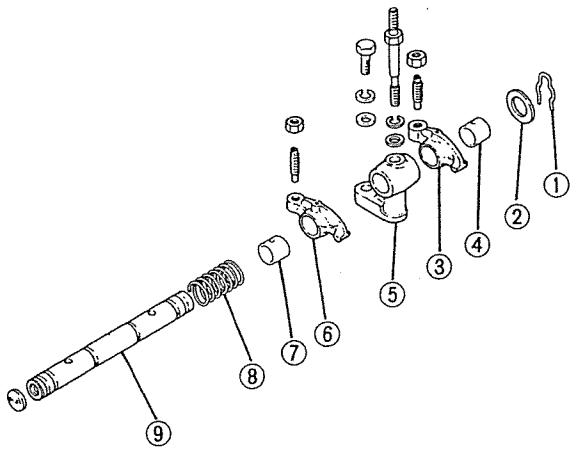
(4) Connect oil pipe to connector securely. After installation, start the engine to check each rocker arm shaft for lubrication, any abnormal noise, uneven tightening of attaching bolts or oil leakage at the connection between oil pipe and

rocker arm shafts. Then adjust valve clearance to 0.25 mm (0.0098 in.) for both intake and exhaust valves by cold setting. (See "Valve clearance adjustment," MAINTENANCE AND ADJUSTMENT.)

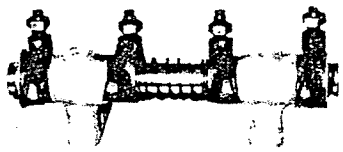


1-Oil pipe 2-"O" ring
Installing rocker arm shaft and oil pipe

Disassembly and assembly

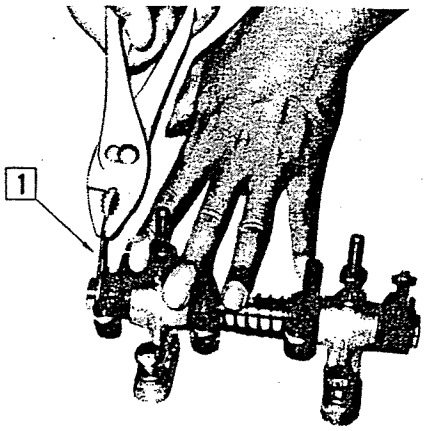


1-Snap ring
2-Washer
3-Rocker arm (B)
4-Bushing
5-Rocker arm shaft bracket
6-Rocker arm (A)
7-Bushing
8-Spring
9-Rocker arm shaft
Rocker arm shaft assembly—exploded view



J8491
Rocker arm shaft assembly

(1) Remove snap ring (1) from both ends of rocker arm shaft with a pliers after removing rocker arm shaft assembly from cylinder head.



J8492
1-Snap ring
Removing snap ring

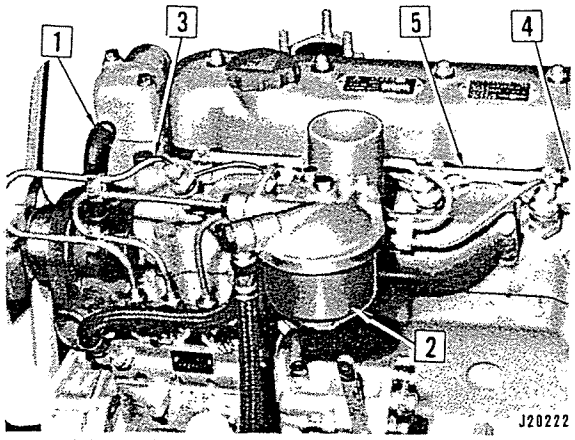
(2) Remove washer (2) and then remove rocker arm (B) (3), rocker arm shaft bracket (5), rocker arm (A) (6), bushing (7) and spring (8) from rocker arm shaft (9) in that order.

(3) To assemble rocker arm shaft, follow the reverse of disassembly procedure. Check to see that each rocker arm operates smoothly.

3. Cylinder head

Removal

(1) Disconnect bypass hose (1) running between thermostat elbow and water pump by removing clamp. Remove fuel filter (2) and then disconnect injection pipes (3) and leak-off pipe (4). Remove connection plates (5) from the glow plugs.

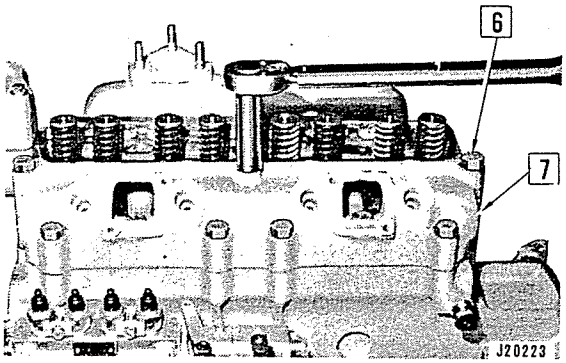


1-Bypass hose
2-Fuel filter
3-Injection pipe (4 pcs)
4-Leak-off pipe
5-Connection plate

(2) Loosen intake manifold attaching bolts and remove the manifold from cylinder head.

(3) Remove rocker arm cover and then remove rocker arm shaft assembly and push rods. (See "Removal of rocker arm shaft assembly.")

(4) Loosen cylinder head bolts (6) and lift off cylinder head (7).



6-Cylinder head bolt (17 pcs) 7-Cylinder head

Loosening cylinder head bolts

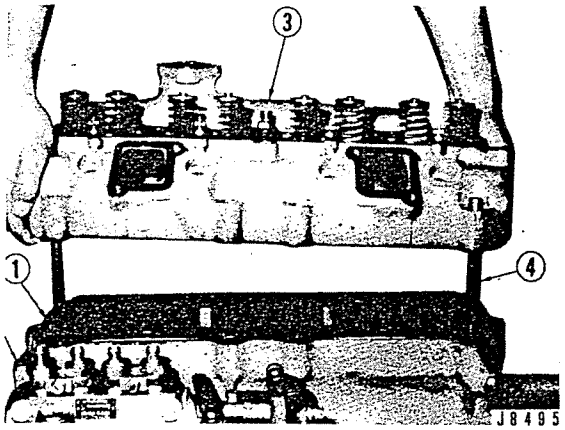
NOTES

a) Cover up the connections of the injection pipes and air intake pipe to prevent entry of dust.

b) Exercise care not to damage the gasketed surfaces of cylinder head and crankcase when removing the gasket from the head.

c) If any defect is found on the cylinder head, check the cylinder head bolts for looseness with a torque wrench.

Installation

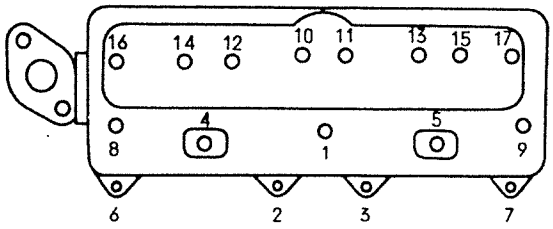


1-Gasket 3-Cylinder head
2-Crankcase 4-Guide bolt (2 pcs)

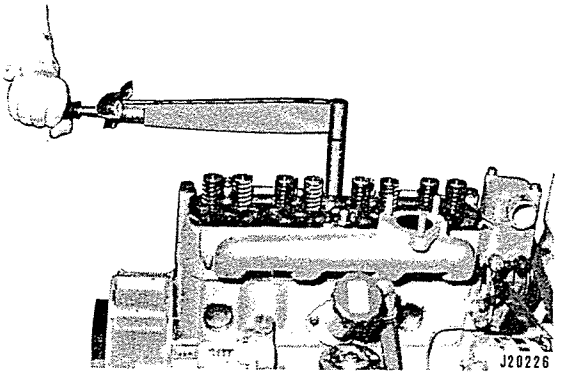
Installing cylinder head

(1) Apply sealer (Three Bond No. 2) to both surfaces of new gasket (1) with a brush or spray gun. Place the gasket on crankcase (2) after a wait of 3 or 4 minutes, and install cylinder head (3). Use two guide bolts (4) to prevent the gasket from moving when placing cylinder head on the crankcase.

(2) Tighten the cylinder head bolts to a torque of 12 kg-m (87 ft-lb) in the sequence shown below.



Cylinder head bolt tightening sequence



Tightening cylinder head bolts

(3) Insert valve push rods, place caps on valves and install rocker arm shaft assembly. (See "Installation of rocker arm shaft assembly.")

(4) Install intake manifold and securely connect rubber hose and air pipe.

(5) Install leak-off pipe to each nozzle holder and connect injection pipes.

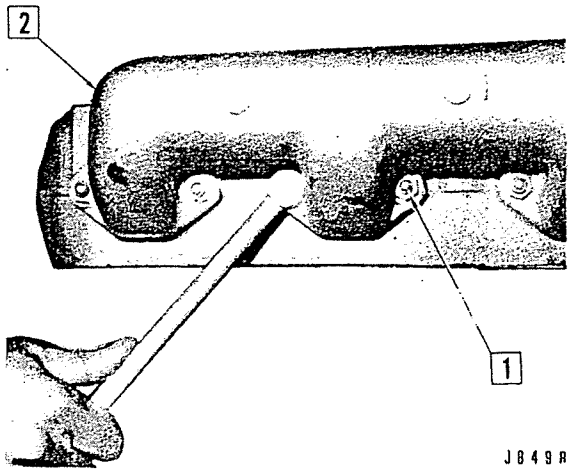
(6) Connect wire leads to glow plugs.

(7) Connect bypass hose.

Adjust the valve clearance properly and install rocker arm cover. (See "Valve clearance adjustment," MAINTENANCE AND ADJUSTMENT.)

Disassembly

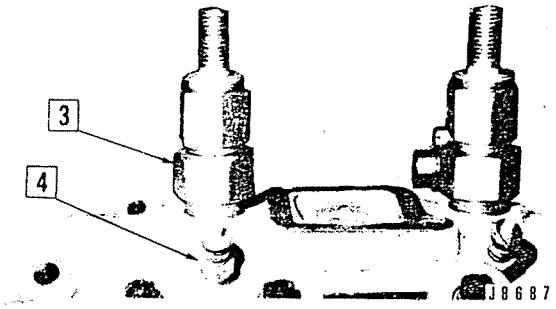
(1) Loosen exhaust manifold nuts (1) and remove exhaust manifold (2).



1-Nut and washer (8 pcs each) 2-Exhaust manifold

Removing exhaust manifold

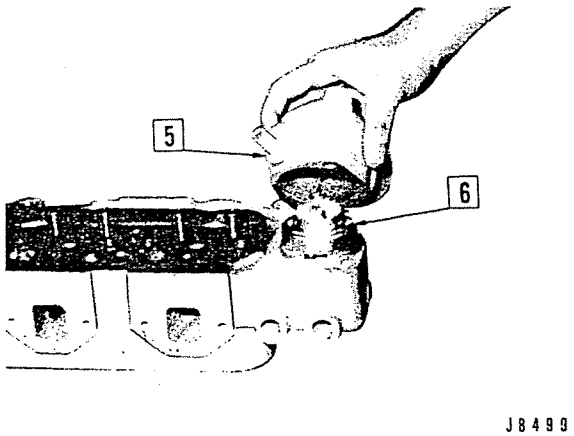
(2) Remove nozzle holders (3) and glow plugs (4).



3-Nozzle holder (4 pcs) 4-Glow plug (4 pcs)

Removing nozzle holder and glow plug

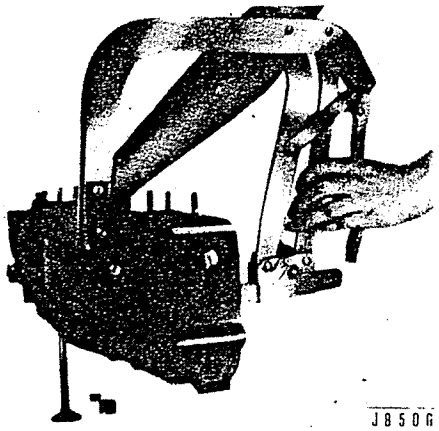
(3) Remove thermostat elbow (5) and take out thermostat (6).



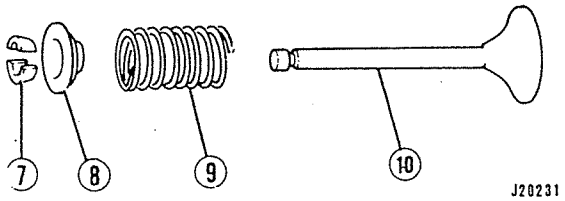
5-Thermostat elbow 6-Thermostat

Removing thermostat

(4) Compress valve spring by using valve lifter. Remove valve cotter (7), and take off retainer (8), valve spring (9) and valve (10) in that order.



Removing valve cotter

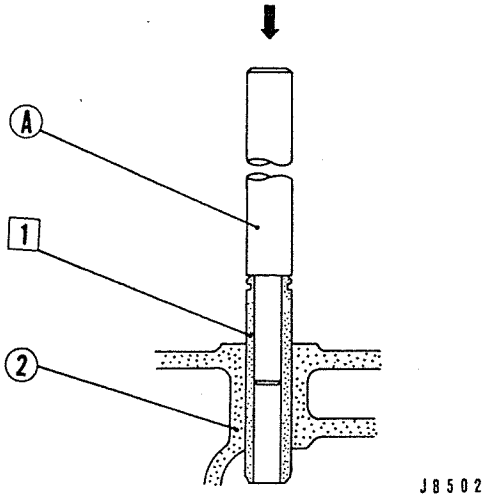


7-Valve cotter 9-Valve spring
8-Retainer (upper) 10-Valve

Valve assembly – exploded view

NOTES

a) Carefully decarbon cylinder head gasketed surface, ports and valves.



A-Valve guide remover 1-Valve guide
2-Cylinder head

Driving out valve guide

b) Thoroughly wash all parts except for glow plugs and nozzle holder assemblies, and dry them with compressed air.

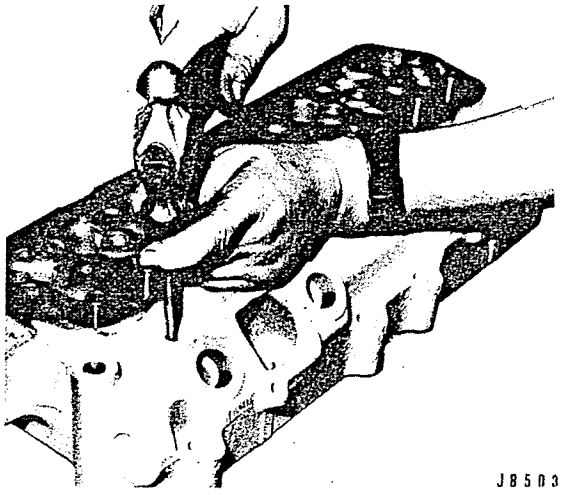
c) Exercise care not to damage the needle valve when removing nozzle holders.

d) Intake and exhaust valves have no marking for their guides. Be sure to install each valve to the valve guide from which it was removed.

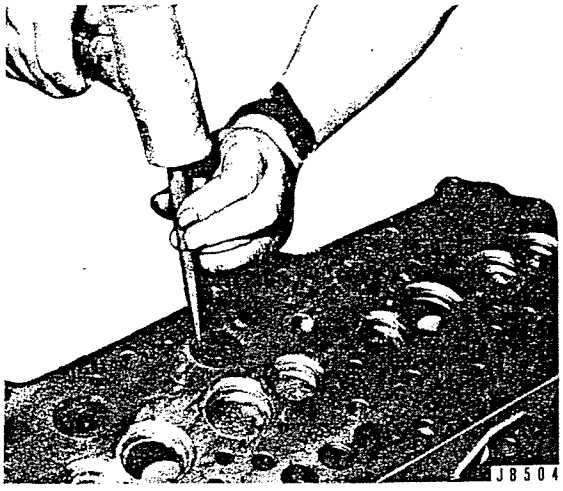
e) Handle two valve cotters as a pair.

f) Valve guides must not be removed without valid reason.

g) Check combustion chamber side of cylinder head, valves, intake ports and exhaust ports for carbon accumulation prior to washing.



Removing combustion chamber jet

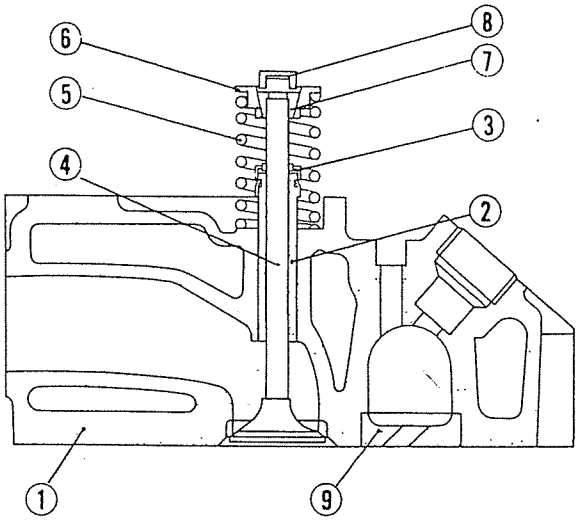


Installing combustion chamber jet

h) Remove combustion chamber jets only when they are found to be defective. When removing the jet for replacement, insert a screw driver through glow plug hole, and drive the jet out by slightly tapping around the inner surface of the jet.

When installing, thoroughly clean the combustion chamber and press the jet with the opening in the jet directed to the center of the cylinder, and calk it on the left-hand side with a punch.

Assembly



1-Cylinder head
2-Valve guide
3-Stem seal
4-Valve
5-Valve spring
6-Retainer
7-Valve cotter
8-Valve cap
9-Combustion chamber jet

Cylinder head — assembled view

NOTE

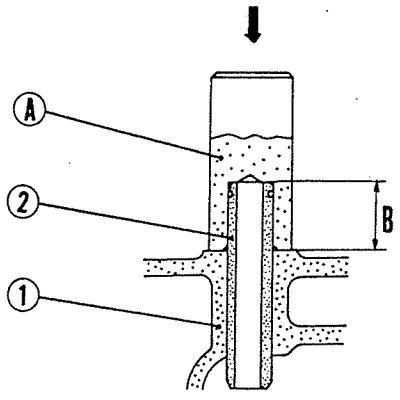
Thoroughly wash all parts after inspecting and repairing, and install them after completely drying them.

(1) Press valve guide (2) into cylinder head (1) as shown.

Install stem seal (3) to the valve guide by fitting it in the groove of the guide.

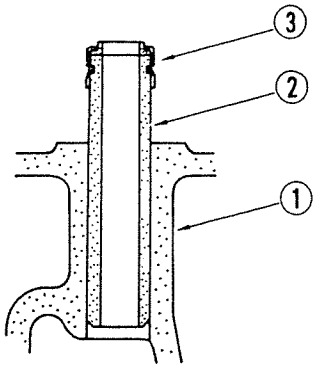
(2) Install valve (4), valve spring (5) and retainer (6) in that order. Compress the spring with a valve lifter to install valve cotter (7) securely. Install cap (8) when installing rocker arm shaft assembly.

(3) Install thermostat, nozzle holders, glow plugs and exhaust manifold to the cylinder head.



1-Cylinder head
2-Valve guide
A-Valve guide installer
B-As-installed length: 18 mm (0.709 in.)

Pressing valve guide

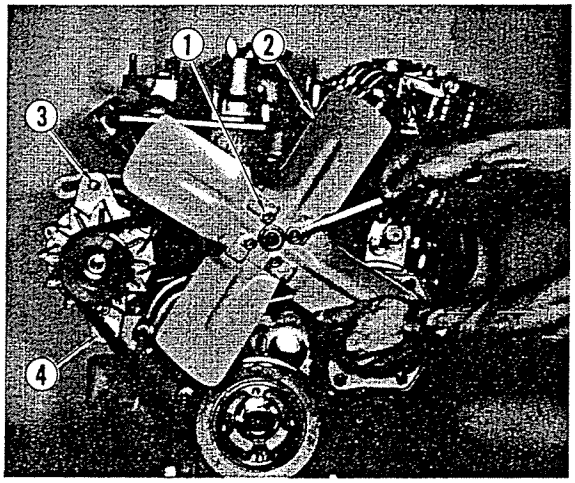


1-Cylinder head
2-Valve guide
3-Stem seal

Installing stem seal

4. Timing gears

Removal

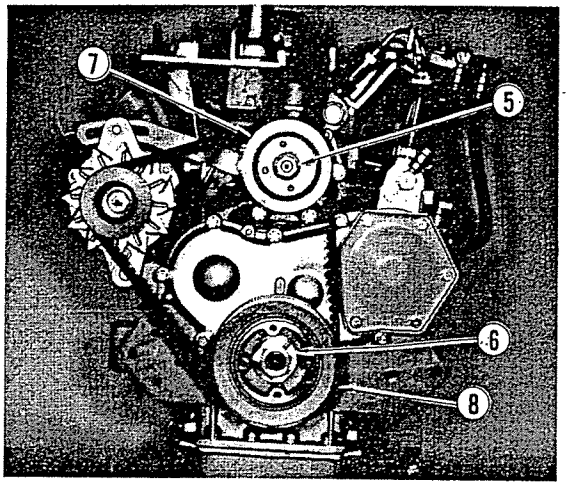


1-Bolts and washer (4 pcs each)
2-Fan
3-Bolt
4-Fan belt

Removing fan

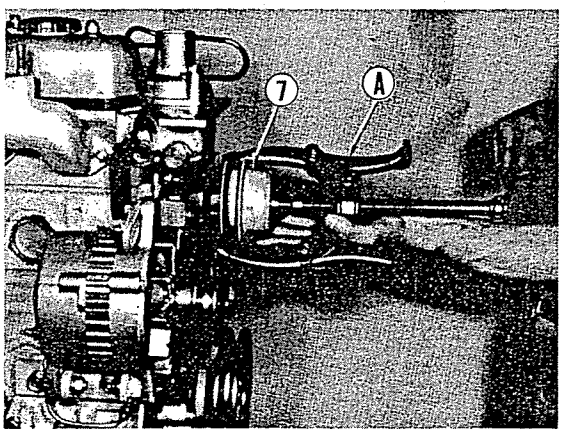
(1) Loosen fan attaching bolts (1) and remove fan (2). Loosen adjusting plate and alternator attaching bolt (3), and remove fan belt (4).

(2) Loosen water pump shaft nut (5) and crankshaft nut (6), and remove water pump pulley (7) and crankshaft pulley (8).



5-Nut and washer
6-Nut and washer
7-Water pump pulley
8-Crankshaft pulley

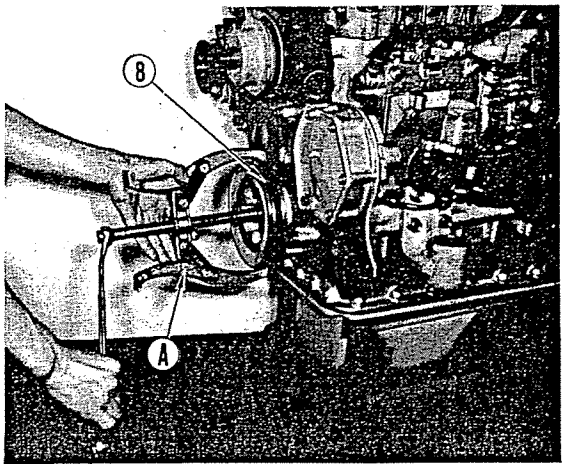
To remove water pump pulley (7), screw puller (A) in the tapped hole in the pulley, and turn in the bolt of the puller.



7-Water pump pulley
A-Puller

Removing water pump pulley

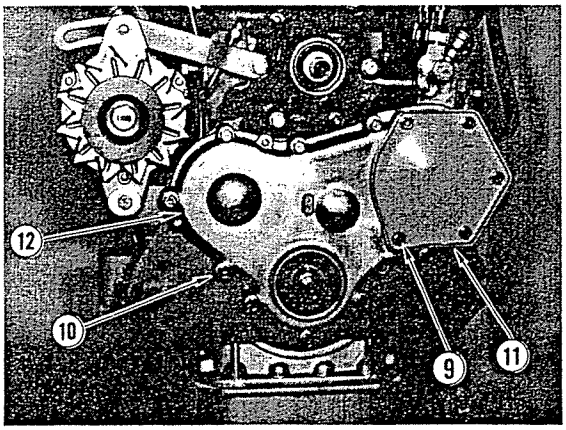
Similarly remove crankshaft pulley (8).



8-Crankshaft pulley A-Puller

Removing crankshaft pulley

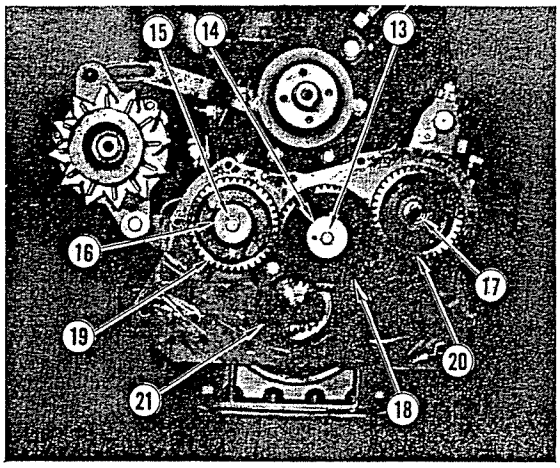
(3) Loosen cover bolts (9) and timing gear case bolts (10), and remove cover (11) and timing gear case (12).



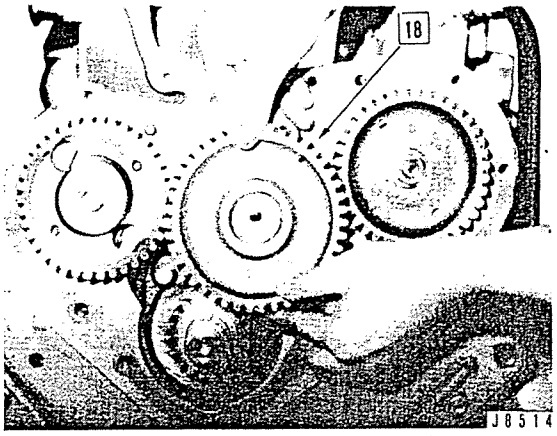
9-Bolt and washer (5 pcs each) 11-Cover
10-Bolt and washer (9 pcs each) 12-Timing gear case

Removing timing gear case

(4) Remove idler gear bolt (13) and thrust plate (14), camshaft gear bolt (15) and washer (16), and injection pump gear nut (17) from each shaft. Remove idler gear (18) by turning it in the direction of the helix angle. Screw a puller in the tapped hole in camshaft gear (19) and remove the gear by turning in the center bolt of the puller. Similarly remove injection pump gear using a puller.

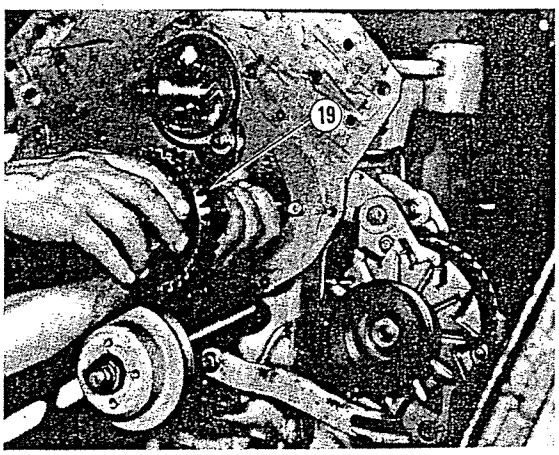


13-Bolt
14-Thrust plate
15-Bolt
16-Washer
17-Nut and washer
18-Idler gear
19-Camshaft gear
20-Injection pump gear
21-Crankshaft gear



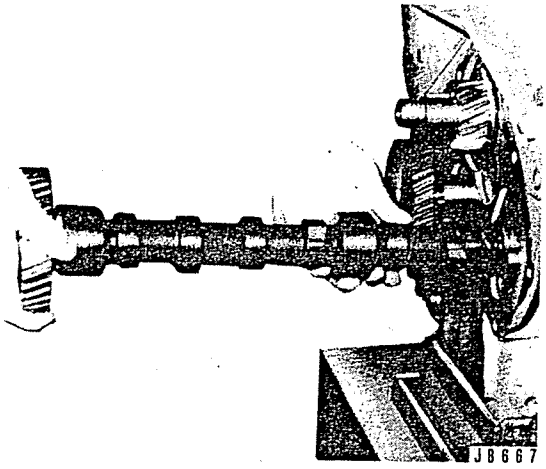
18-Idler gear

Removing idler gear



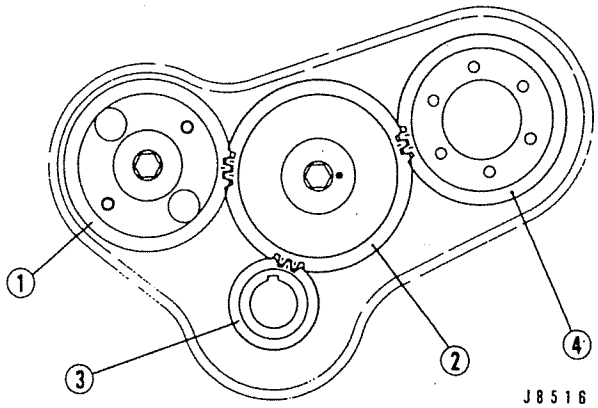
19-Camshaft gear

Removing camshaft gear



NOTE

Be sure to align the matching marks of timing gears before removing gears. The matching marks should also be aligned at the time of assembly.



1-Camshaft gear 3-Crankshaft gear
2-Idler gear 4-Injection pump gear

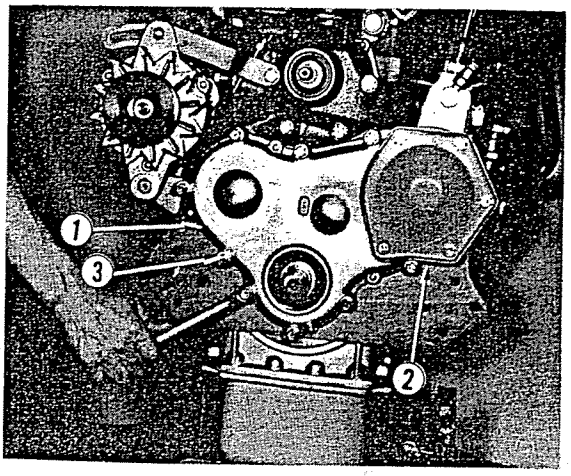
Matching marks

Installation

Install timing gears in the reverse order of removal.

(1) Install injection pump gear and camshaft gear. Align matching marks, install idler gear and secure thrust plate with bolt.

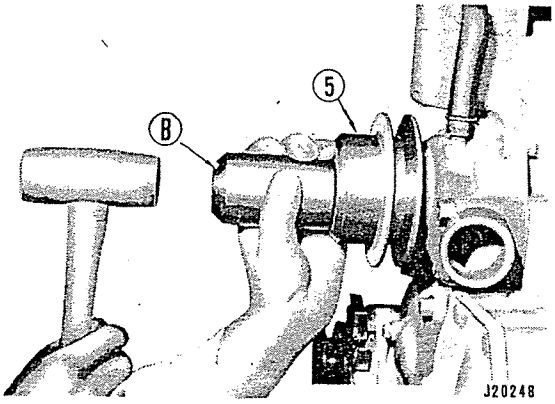
(2) Apply Three Bond No. 2 to timing gear case packing and install gear case (1) to front plate properly. Apply Three Bond No. 2 to injection pump cover packing and install cover (2).



1-Timing gear case 3-Bolt and washer (13 pcs each)
2-Cover

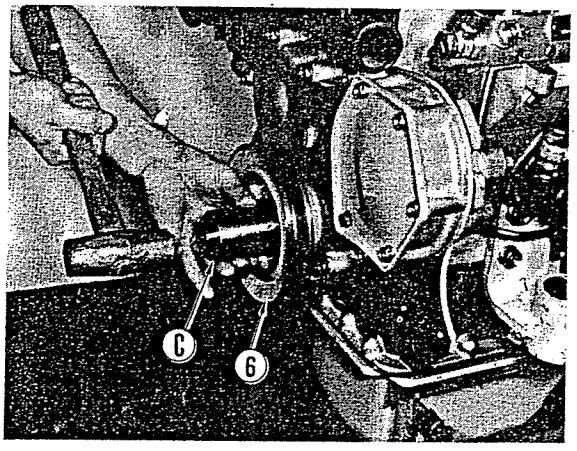
Installing timing gear case

(3) Drive in water pump pulley (5) and crankshaft pulley (6) by using installers (B) and (C), respectively.



5-Water pump pulley B-Installer

Driving in water pump pulley



6-Crankshaft pulley C-Installer

Driving in crankshaft pulley

(4) After pressing in the crankshaft pulley, place washer (7) and tighten nut.

(5) Attach fan belt to the pulley and install fan. Adjust the fan belt tension so that it has a slack of 12 mm (1/2 in.). (See "Fan belt adjustment," MAINTENANCE AND ADJUSTMENT.)

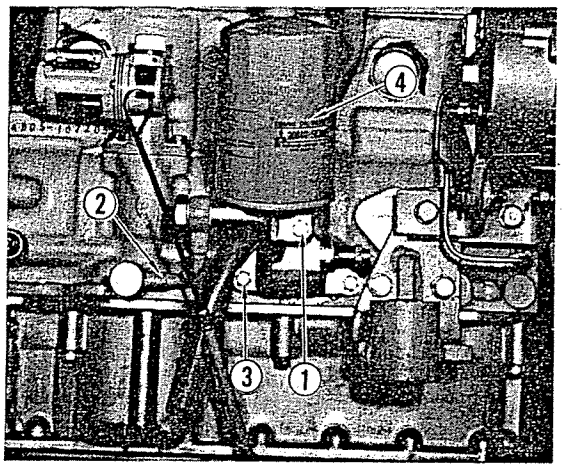
5. Lubrication system

Removal and installation of oil filter

(1) Remove drain plug (1) and drain the filter case.

(2) Disconnect oil pipe (2) from oil fiter and main gallery. Loosen oil filter attaching bolts (3), and remove oil filter assembly (4) from the engine.

(3) To install the oil filter, follow the reverse of removal procedure. Be sure to apply Three Bond No. 5 or the like to the threaded part of oil filter attaching bolts and place a packing between oil filter and crankcase.



1-Drain plug 3-Bolt and washer (5 pcs each)
2-Oil pipe 4-Oil filter assembly

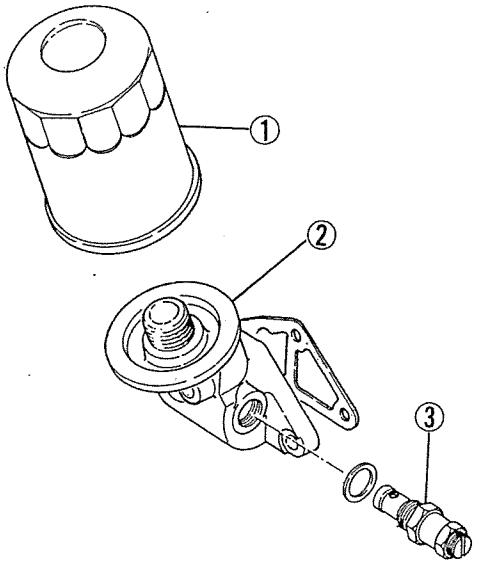
Removing oil filter

Disassembly and assembly of oil filter

(1) Remove element assembly (1) from filter head (2).

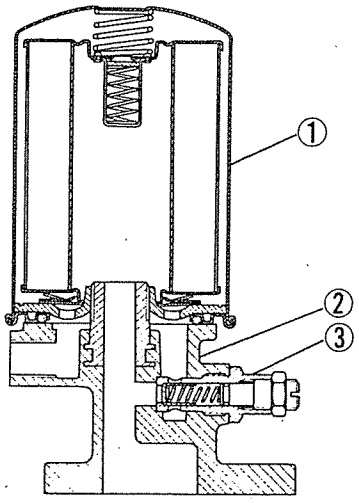
(2) Remove relief valve from filter head.

(3) To assemble, follow the reverse of disassembly procedure.



1-Element assembly 3-Relief valve
2-Filter head

Oil filter — exploded view



1-Element assembly 3-Relief valve
2-Filter head

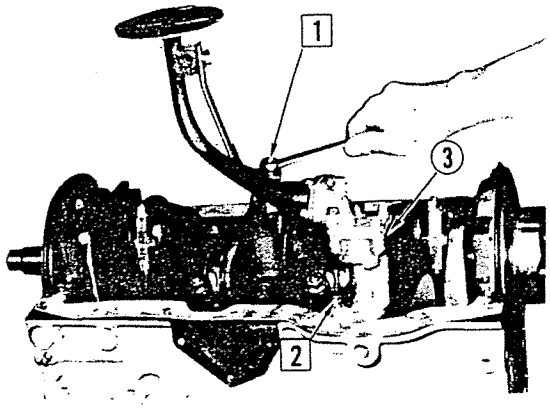
Oil filter — assembled view

Oil pump

(1) Removal

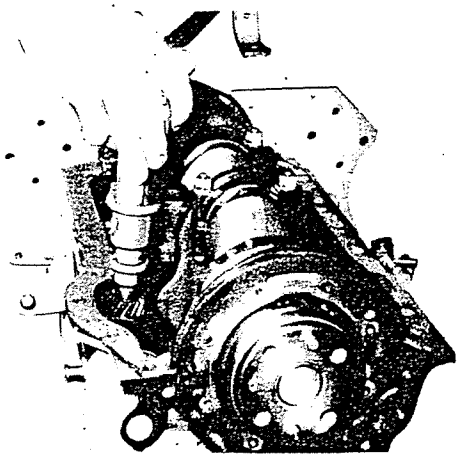
Drain the oil pan and remove the oil pan. Then loosen oil pump stay bolt (1) and oil pump body attaching bolts (2), and remove oil pump assembly (3).

J8524



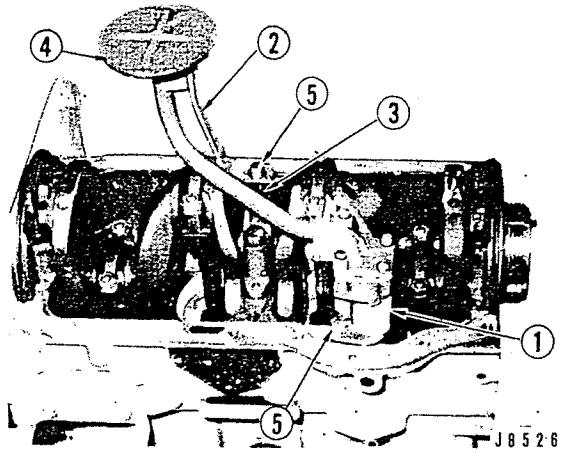
1-Bolt and washer
2-Bolt and washer
3-Oil pump assembly

Removing oil pump



J8525

(2) Installation of oil pump assembly



J8526

1-Oil pump
2-Oil strainer stay
3-Distance piece
4-Oil strainer
5-Bolt and washer (2 pcs. each)

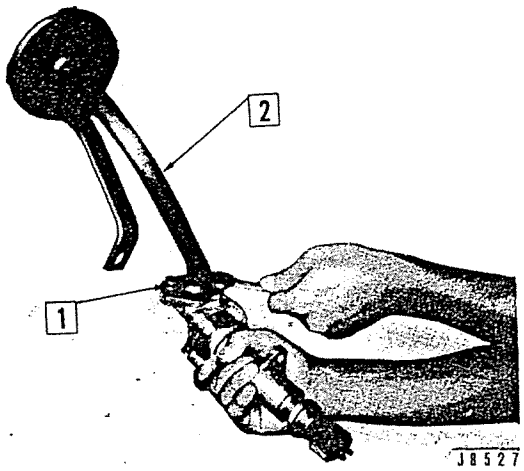
Installing oil pump

(a) Install oil pump (1) in place to the pump installation base in the crankcase, and mesh the pump drive gear with that on camshaft.

(b) Install one end of oil strainer stay (2) to No. 2 bearing cap with distance piece (3) inserted between the two, and the other end to oil strainer (4) with bolts (5).

(3) Disassembly of oil pump

(a) Loosen attaching bolts (1) of oil strainer (2), and separate the strainer from oil pump case.

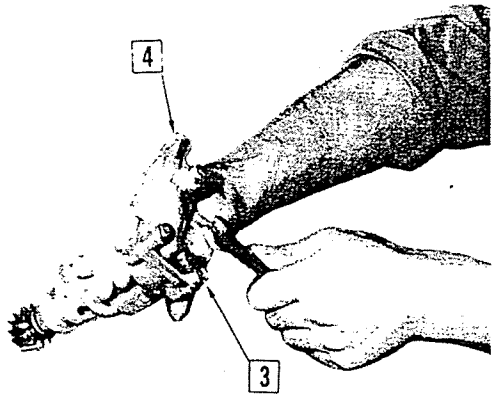


J8527

1-Bolt and washer. (2 pcs. each)
2-Oil strainer

Removing oil strainer

(b) Loosen attaching bolts (3) of oil pump cover (4), and separate the cover from oil pump case.

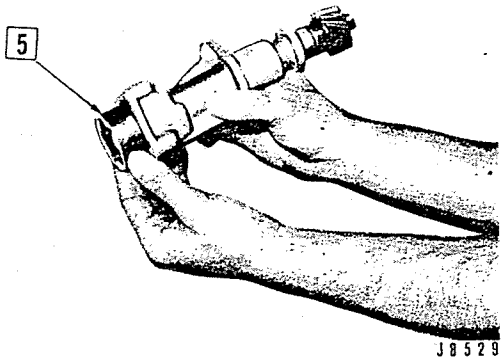


J8528

3-Bolt and washer (4 pcs each)
4-Oil pump cover

Removing oil pump cover

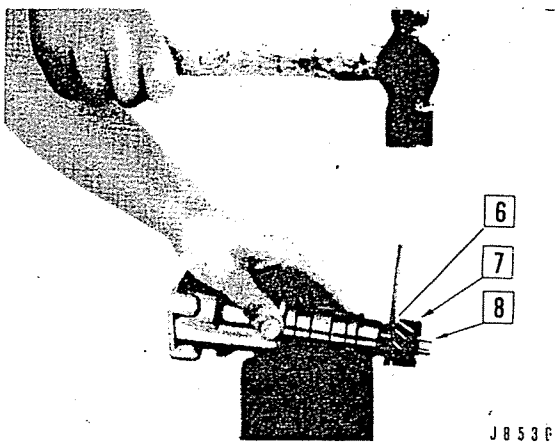
(c) To facilitate removal of outer rotor (5), turn the pump case upside down.



5-Outer rotor

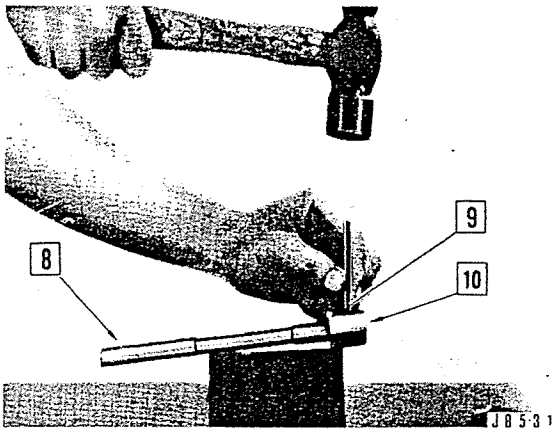
Removing outer rotor

(d) Drive out pump drive gear taper pin (6), and remove drive gear (7) from main shaft (8). Pull out the main shaft from pump case.



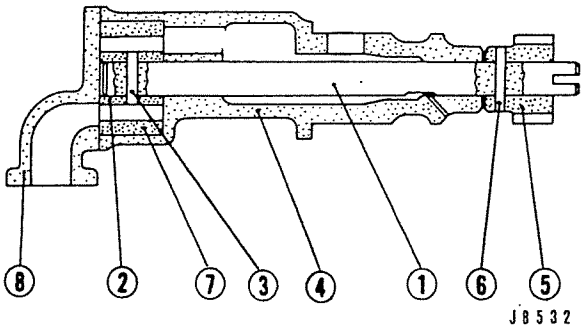
6-Taper pin
7-Drive gear
8-Main shaft

(e) Drive out inner rotor pin (9), and separate inner rotor (10) from main shaft (8).



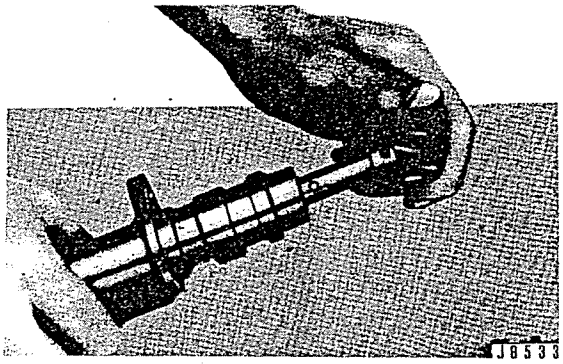
8-Main shaft
9-Inner rotor pin
10-Inner rotor

(4) Assembly



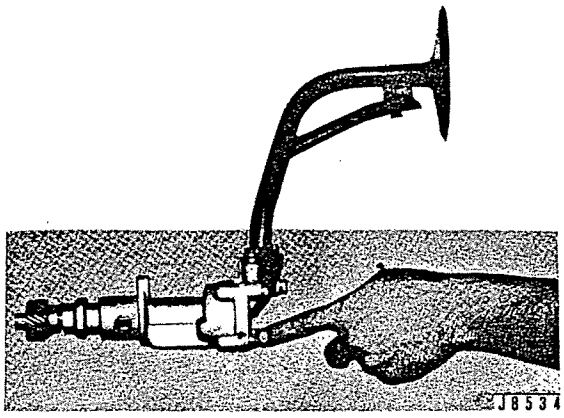
1-Shaft	5-Drive gear
2-Inner rotor	6-Pin
3-Pin	7-Outer rotor
4-Case	8-Cover

Oil pump assembly



Installing drive gear

(a) Install inner rotor to main shaft with a pin and then put them into pump case. Install oil pump drive gear to the shaft.



Matching marks on pump case and cover

NOTES

a) When replacing main shaft and drive gear, dowel pin holes must be drilled in the two at assembly.

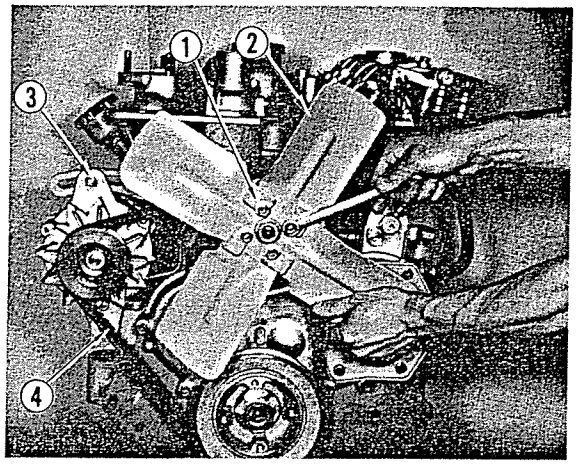
b) Place outer rotor in pump case, and check to see that the matching marks on pump case and pump case cover are aligned properly before tightening pump case attaching bolts. If the marks are not aligned, the pump will not operate properly.

c) Install strainer to pump case, immerse it in oil and rotate drive gear to see if pump draws oil properly.

6. Water pump (including thermostat)

Removal and installation

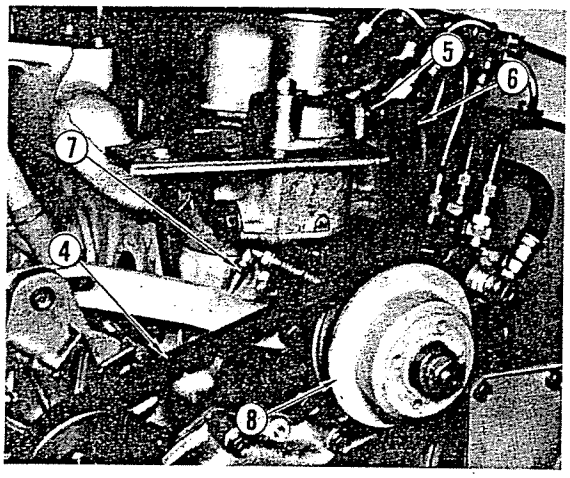
(1) Remove fan (2) by loosening fan attaching bolts (1). Loosen bolt (3) securing fan belt adjusting plate and alternator, and remove fan belt (4).



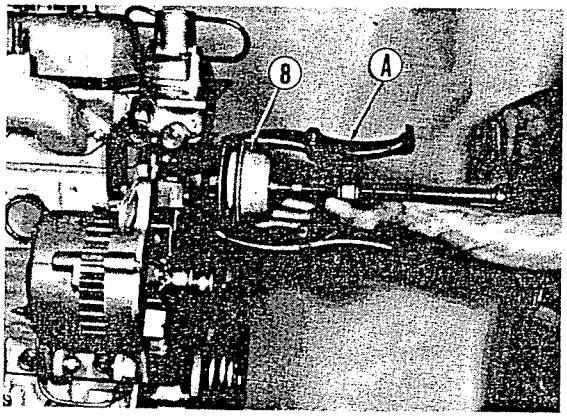
1-Bolt and washer (4 pcs each) 3-Bolt
2-Fan 4-Fan belt

Removing fan

(2) Loosen bypass hose clamp (5) and remove hose (6). Loosen pulley clamping bolts. Attach puller (A) to pulley (8), and turn in the center bolt of the pulley to remove the pulley from water pump shaft.



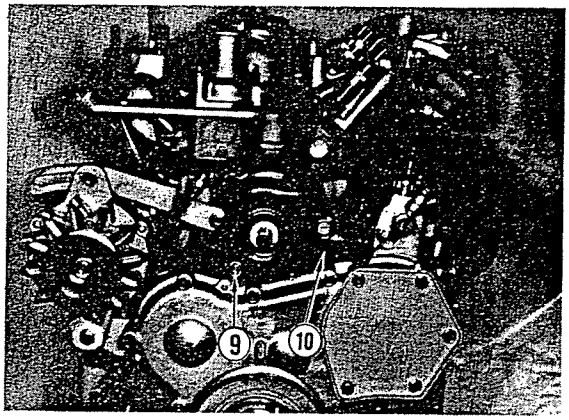
4-Fan belt 7-Pipe
5-Clamp 8-Pulley
6-Bypass hose



8-Pulley A-Puller

Removing pulley

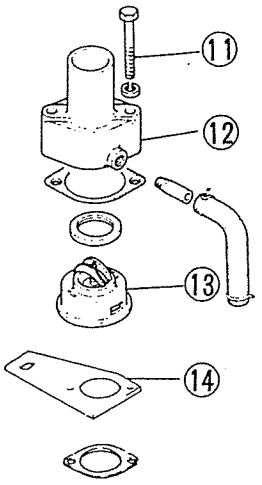
(3) Loosen water pump case attaching bolts (9), and remove water pump assembly (10) from crankcase.



9-Bolt and washer (4 pcs each) 10-Water pump assembly

Removing water pump

(4) Loosen attaching bolts (11) of elbow (12), and remove thermostat (13). (See "Removal of cylinder head.")



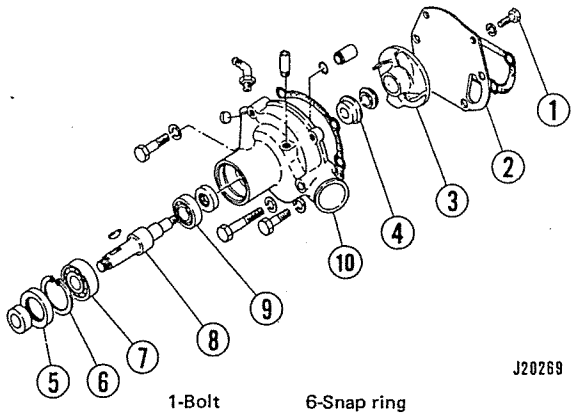
11-Bolt and washer (2 pcs each)
12-Thermostat elbow
13-Thermostat
14-Bracket

(5) Install water pump in the reverse order of removal. After installation, be sure to adjust fan belt tension. (See "Fan belt adjustment," MAINTENANCE AND ADJUSTMENT.)

NOTE

Exercise care not to allow oil or grease to come in contact with fan belt nor to permit entry of dust into crankcase through water inlet port after water pump is removed.

Disassembly

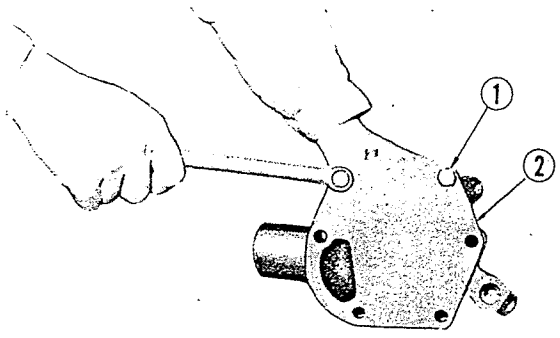


J20269

1-Bolt
2-Cover
3-Impeller
4-Unit seal
5-Oil seal
6-Snap ring
7-Bearing
8-Shaft
9-Bearing
10-Pump case

Water pump — exploded view

(1) Remove pump cover (2) by loosening cover attaching bolts (1).

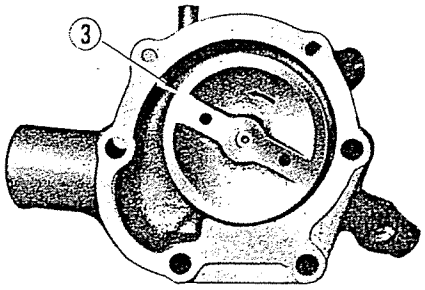


J20270

1-Bolt and washer
2-Cover

Removing pump cover

(2) Support the shaft with a stand, and remove impeller (3).

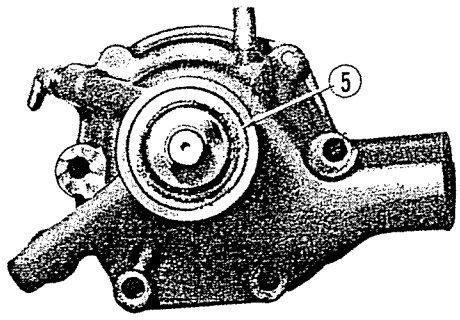


J20271

3-Impeller [Impeller is secured to shaft by LH threads. Turn impeller counterclockwise (in the direction of arrow) for removal.]

Removing impeller

(3) Remove oil seal (5) from case.

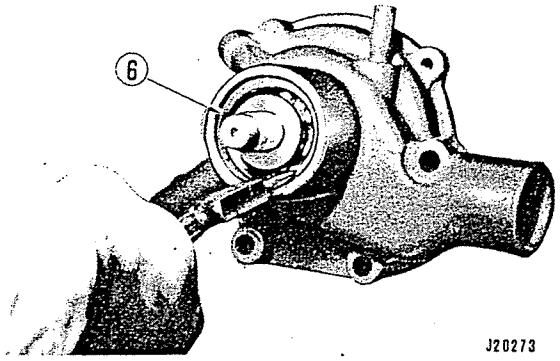


J20272

5-Oil seal

Removing oil seal

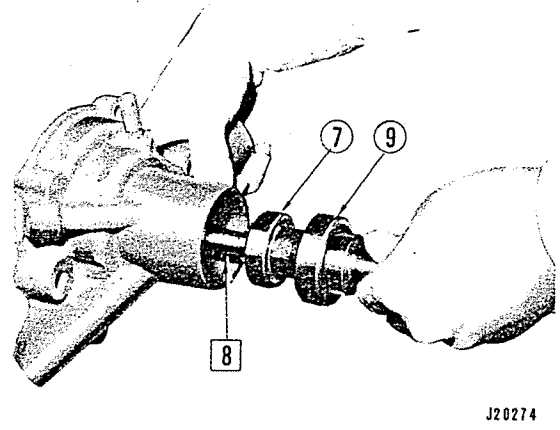
(4) Remove snap ring (6) from water pump shaft.



6-Snap ring

Removing snap ring

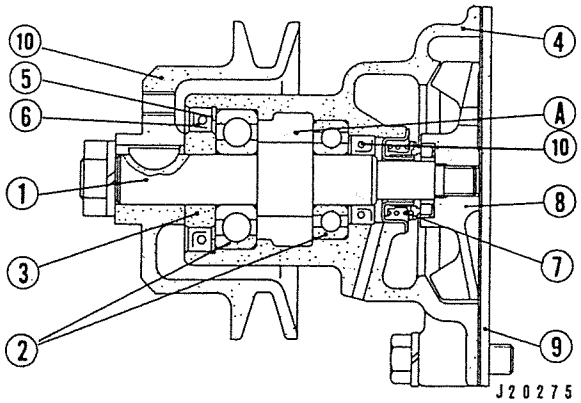
(5) Pull shaft (8) from the pulley side of pump case, and remove bearings (7) and (9) from shaft (8).



7-Bearing 9-Bearing
8-Shaft

Removing shaft

Assembly



1-Pump shaft 5-Snap ring 9-Cover
2-Bearings 6-Oil seal 10-Oil seal
3-Spacer 7-Unit seal A-Lubricating point
4-Pump case 8-Impeller

Water pump assembly

(1) Insert oil seal (10) in pump case (4).

(2) Install bearings (2) and spacer (3) on pump shaft (1), and install the shaft in pump case (4).

(3) Install snap ring (5) in case pulley.

(4) Install unit seal (7) in impeller (8), and secure the impeller to the shaft.

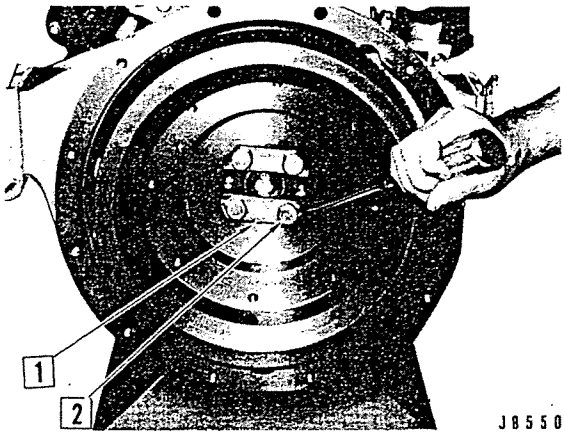
(5) Install cover (9).

(6) Rotate the shaft, and check to see if the impeller rotates smoothly.

7. Flywheel and ring gear

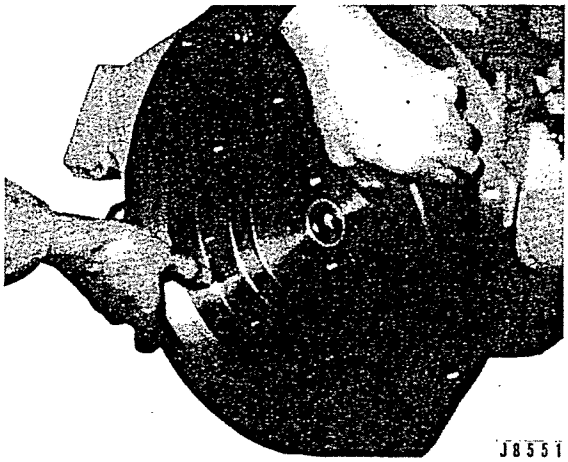
Disassembly

(1) Straighten lock washers (1) of flywheel attaching bolts and remove bolts (2) (after removing power direction clutch).



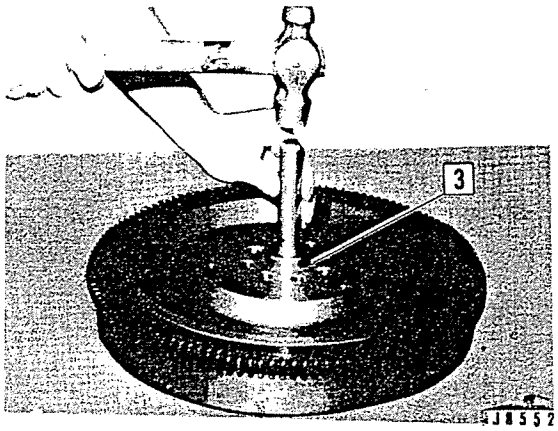
1-Lock washer (2 pcs) 2-Bolts (4 pcs)

(2) Remove flywheel and ring gear as a unit from the engine.



Removing flywheel

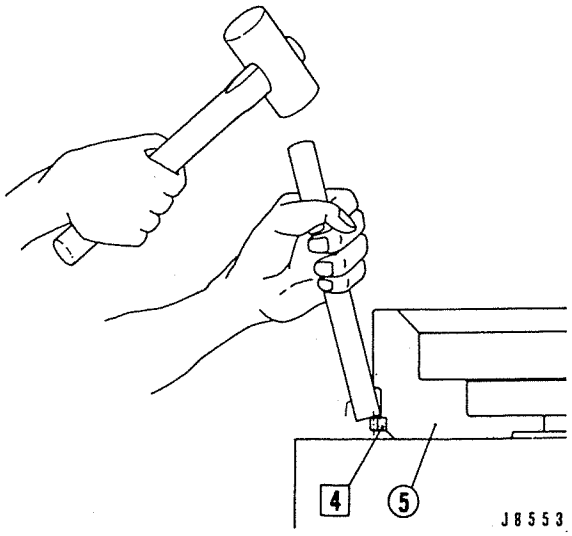
(3) Drive out pilot bushing (3) as shown in Fig. J8552 below.



3-Pilot bushing

Driving out pilot bushing

(4) Place flywheel complete with ring gear in a piston heater and heat it for about 3 minutes at 100°C (212°F). Place the heated flywheel on a surface plate, and lightly tap the periphery of ring gear with a pad or the like to remove the gear.



4-Ring gear 5-Flywheel

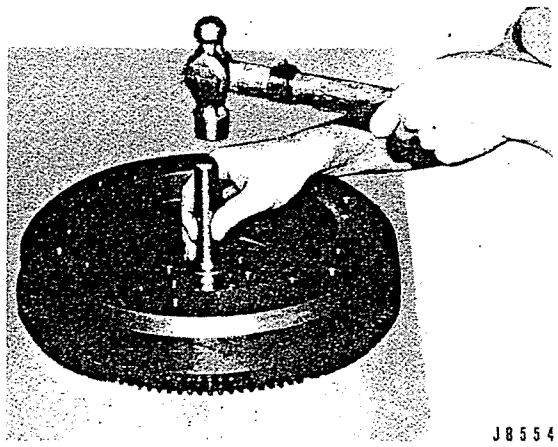
Removing ring gear

Assembly

(1) Thoroughly clean the flywheel surface to which ring gear is installed.

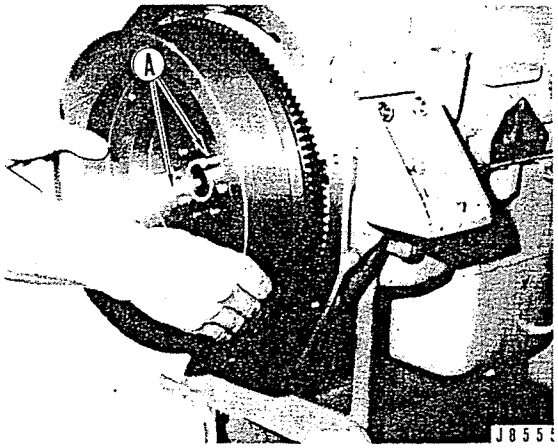
(2) Place ring gear in a piston heater. Heat it for about 3 minutes at 100°C (212°F) and quickly fit the gear to flywheel.

(3) Press clutch pilot bushing into flywheel.



Pressing pilot bushing

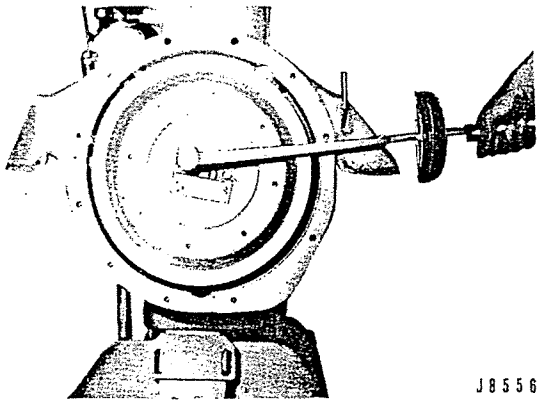
(4) Screw guide bolts (A) in crankshaft, and install flywheel to crankshaft.



A-Guide bolts (2 pcs) (to be removed after flywheel is installed)

Installing flywheel

(5) Uniformly tighten flywheel attaching bolts to a torque of 8.5 kg-m (61.5 ft-lb) and bend lock washers.

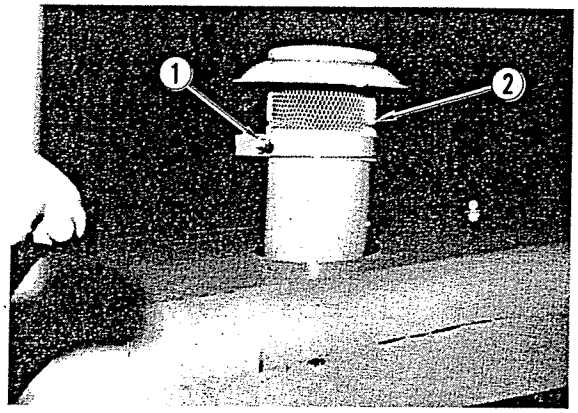


Tightening flywheel attaching bolts

8. Air cleaner

Removal and installation

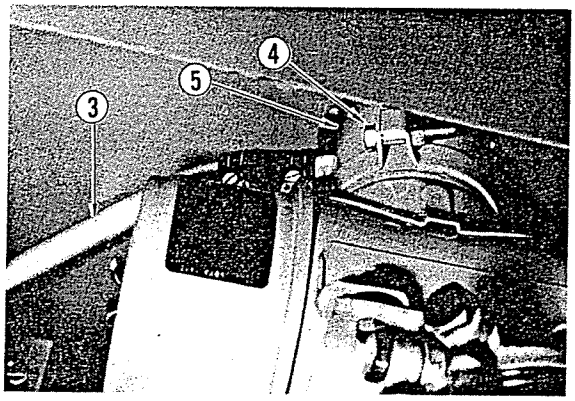
(1) Loosen bolt (1), and remove precleaner hood (2).



1-Bolt 2-Hood

Removing precleaner hood

(2) Disconnect pipe (3), loosen bolt (4) and remove precleaner body (5).

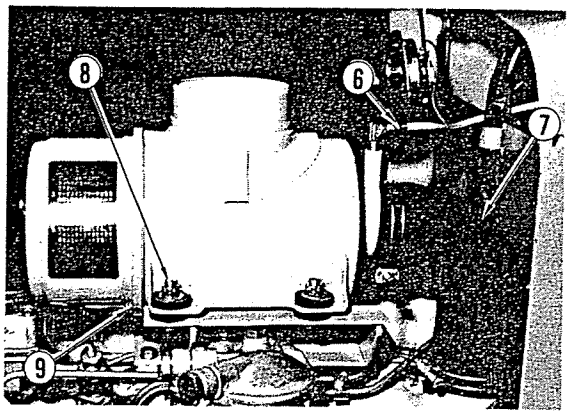


3-Pipe 5-Precleaner body
4-Bolt

Removing precleaner body

(3) Disconnect dust indicator hose (6) and intake manifold rubber hose (7). Loosen bolts (8), and remove air cleaner assembly (9).

(4) To install air cleaner, follow the reverse of removal procedure.



6-Hose 8-Bolt (4 pcs)
7-Rubber hose 9-Air cleaner assembly

Removing air cleaner assembly

9. Fuel filter

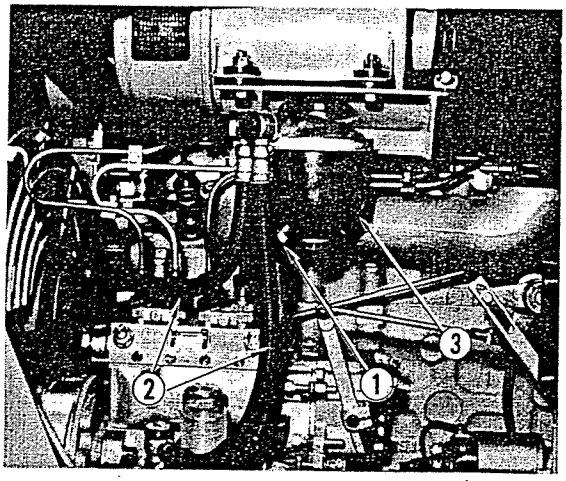
Removal and installation of fuel filter

(1) Close fuel supply valve at the bottom of fuel tank.

(2) Disconnect fuel feed pipes (2) at fuel filter.

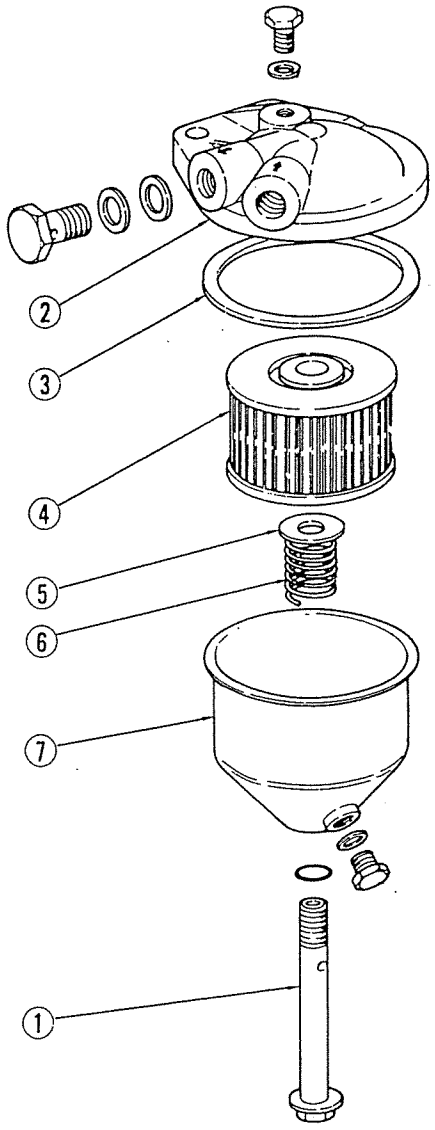
(3) Loosen two attaching bolts and remove fuel filter assembly (3) from the engine.

(4) To install fuel filter, follow the reverse of removal procedure. After installation, bleed air from fuel lines. Then start the engine to check fuel lines for any sign of leakage.



1-Drain plug 3-Fuel filter assembly
2-Fuel feed pipes (2 pcs)

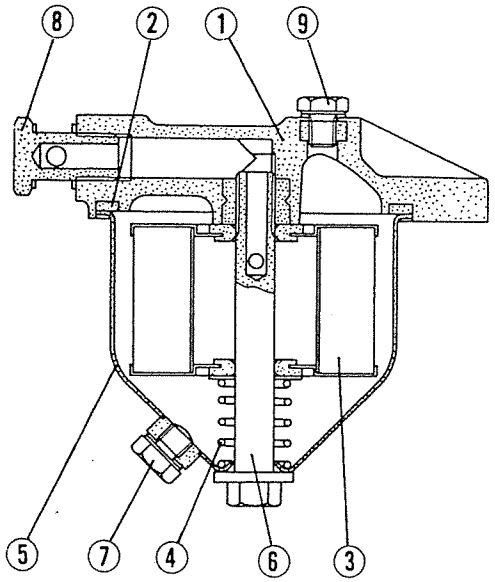
Disassembly and assembly



1-Bolt
2-Filter cover
3-Gasket
4-Element
5-Spring seat
6-Spring
7-Case

(Index numbering shows disassembling sequence.)

Fuel filter — assembled view



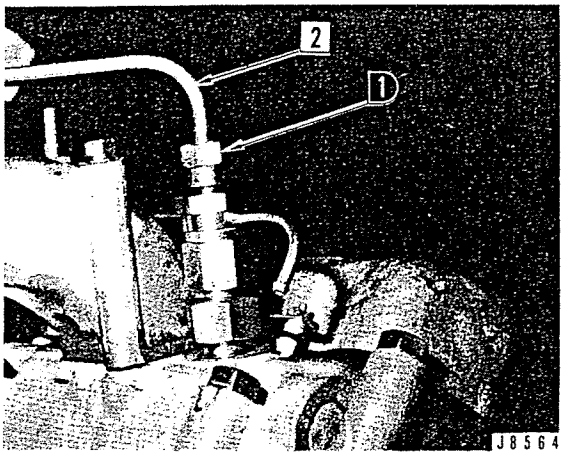
1-Filter cover
2-Gasket
3-Element
4-Spring
5-Case
6-Bolt
7-Drain plug
8-Bolt
9-Air plug

Fuel filter — assembled view

10. Injection nozzles

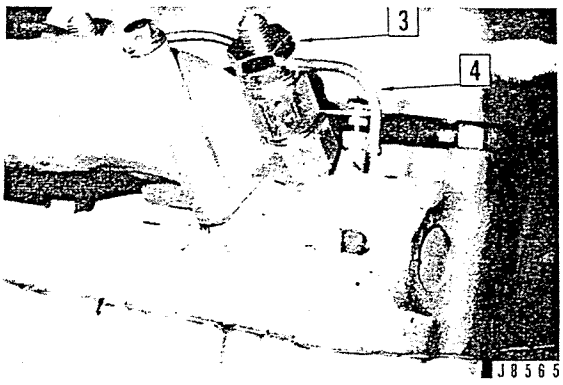
Removal and installation

(1) Remove injection pipe connector (1), and disconnect injection pipe (2).



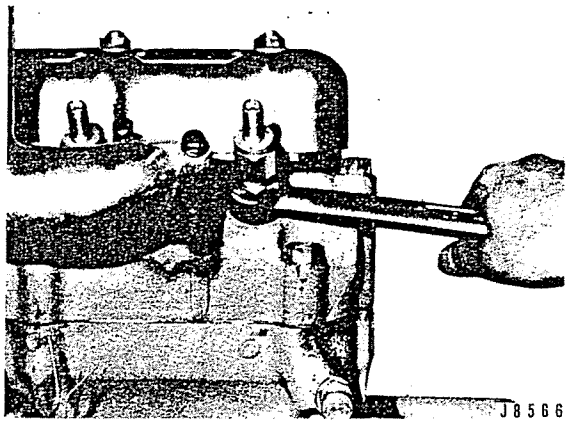
1-Connector (4 pcs) 2-Injection pipe (4 pcs)

(2) Disconnect leak-off pipe (4) connecting nozzles by loosening nut (3).



3-Nut (4 pcs) 4-Leak-off pipe

(3) Using a wrench, remove nozzle from cylinder head as shown. Also remove nozzle packing with a wire or a screwdriver. Replace a defective packing, if any.



Removing injection nozzle

(4) To install injection nozzles, follow the reverse of removal procedure. Tighten nozzle holders to a torque of 5 kg-m (36.2 ft-lb).

NOTE

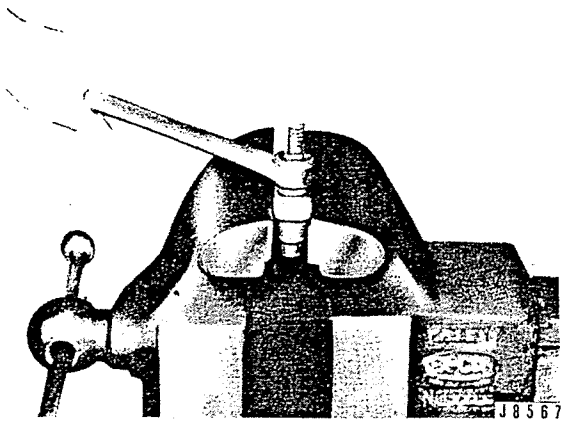
Cover the injection pipe and cylinder head openings to prevent entry of dust or foreign matter after removing the nozzles.

Disassembly of injection nozzles

(1) Before disassembling injection nozzle, check the nozzle for injection beginning pressure and spray pattern, and adjust it if necessary. Carry out oil-tightness test and repair it if necessary.

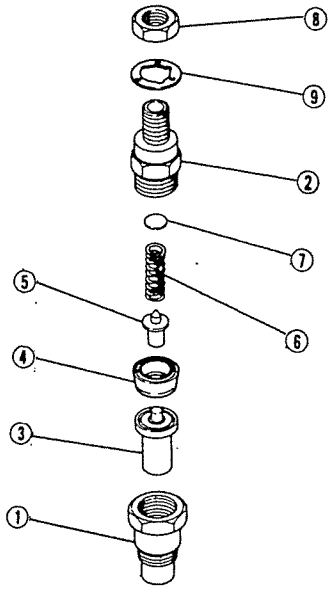
Exercise care not to damage the points of needle valve during disassembly, washing and assembly of nozzle. (For inspection and adjustment, see MAINTENANCE AND ADJUSTMENT.)

(2) Hold retaining nut (1) in a vice, and loosen nozzle holder (2) with a wrench.



Disassembling nozzle holder

(3) Remove nozzle tip (3), distance piece (4), pressure pin (5), spring (6) and washer (7) from nozzle holder.



1-Retaining nut
2-Nozzle holder
3-Nozzle tip
4-Distance piece
5-Pressure pin
6-Spring
7-Washer
8-Nut
9-Gasket

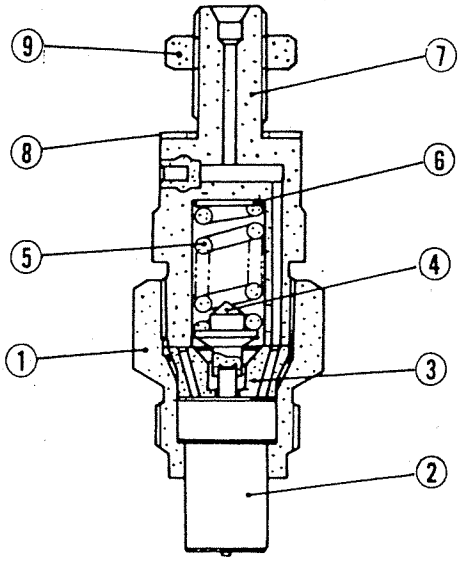
Injection nozzle – exploded view

(4) All the parts disassembled should be washed in clean kerosene and dried with compressed air. Decarbon the nozzle with a wooden scraper and clean it thoroughly in gasoline.

Assembly

Assemble injection nozzle in the reverse order of disassembly. Be sure to assemble nozzle assembly in kerosene.

When using a new needle valve, remove sealer (synthetic resin coating) from the valve and wash it in kerosene to remove rust and corrosion inhibitor sprayed over it by sliding valve in nozzle immersed in kerosene.



1-Retaining nut	4-Pressure pin	7-Nozzle holder
2-Nozzle tip	5-Spring	8-Gasket
3-Distance piece	6-Washer	9-Nut

Injection nozzle — assembled view

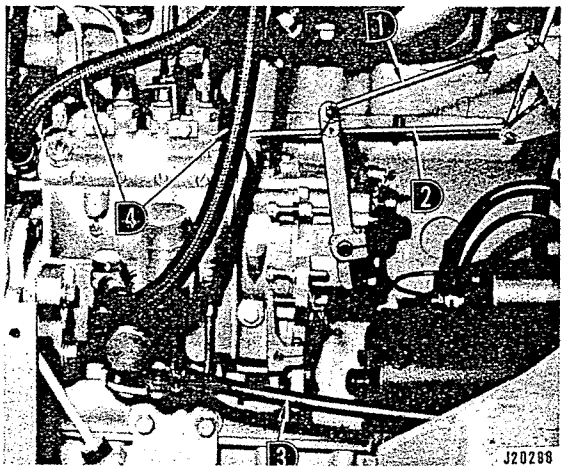
11. Injection pump and governor

NOTE

Injection pump and governor should not be disassembled without valid reason. Disassembly work must be performed by a well-experienced mechanic in clean place with the use of right tools, measuring equipment and testers.

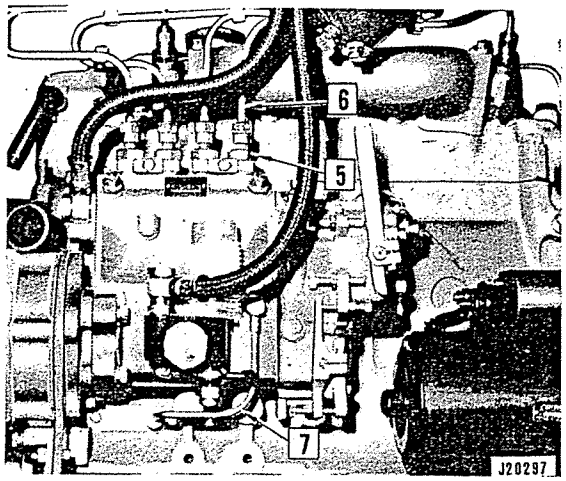
Removal

(1) Disconnect adjusting lever rod (1) and stop lever rod (2). Disconnect fuel pipe (3) from fuel tank and fuel feed pipe (4) from injection pump and fuel filter by loosening joints at pump.



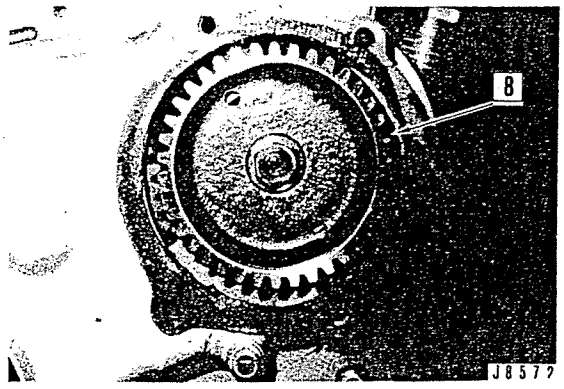
1-Rod 2-Rod 3-Fuel pipe 4-Fuel feed pipe

(2) Remove connector (5) and disconnect injection pipe (6). Disconnect oil pipe (7).



5-Connector 7-Oil pipe
6-Injection pipe (4 pcs)

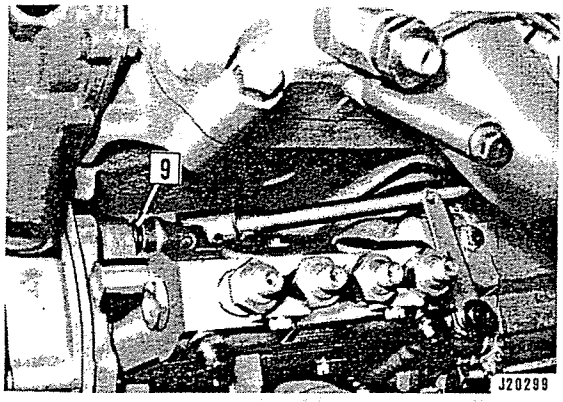
(3) Remove injection pump gear cover. Place No. 1 cylinder to top dead center on compression stroke. Make sure that idler and injection pump gear are properly meshed, and put matching marks on two gears. Then remove injection pump gear (8). (See "Removal of timing gears," DISASSEMBLY AND ASSEMBLY.)



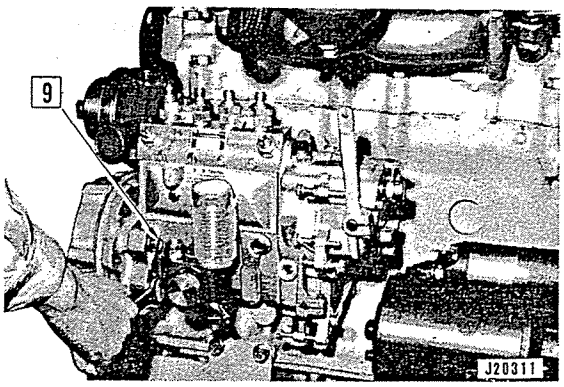
8-Injection pump gear

Removing injection pump gear

(4) Loosen pump attaching bolts (9), and remove injection pump assembly from the engine front plate.



9-Bolt and washer



9-Bolt and washer (4 pcs each)

Removing injection pump

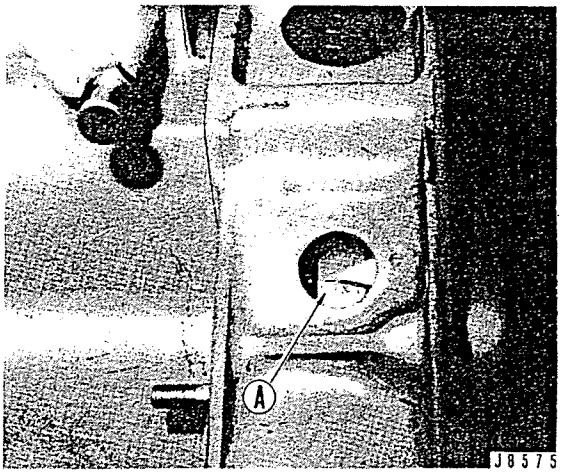
Installation

(1) Temporarily install injection pump to engine front plate flange with bolts, and install injection pump gear and idler in place by aligning the matching marks.

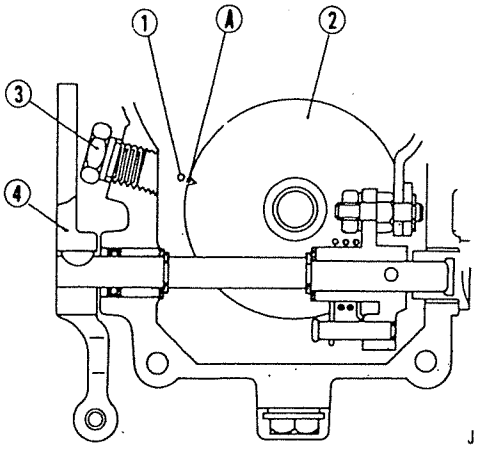
(2) Connect fuel feed pipe and fuel feed pump lubricating oil pipe, and then connect fuel injection pipes No. 2, No. 3 and No. 4. Injection pipe No. 1 is left disconnected at this time.

(3) Slowly turn crankshaft and see if "T" mark on flywheel is aligned with pointer at the time of the beginning of injection of No. 1 plunger. If "T" mark and pointer are not aligned, change the position of injection pump.

(4) The injection timing can be adjusted by turning injection pump. Turning the pump toward the engine will advance the timing: turning it away from the engine will retard the timing. One graduation on the outer periphery of flange corresponds to 6° crank angle.



A-Flywheel timing mark



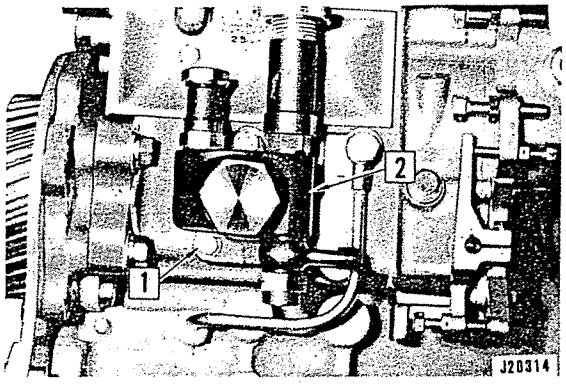
1-Timing pointer pin
2-Camshaft bushing
3-Timing hole plug
4-Stopper
A-Timing mark

Injection pump timing mark

(5) When injection timing is properly adjusted, secure injection pump to engine front plate. Connect injection pipes and bleed air from fuel lines. Run the engine and check to see that injection pump is installed correctly. After the engine has warmed up, check for abnormal noise and color of exhaust gases at low, medium and high engine speeds.

Removal and installation of fuel feed pump

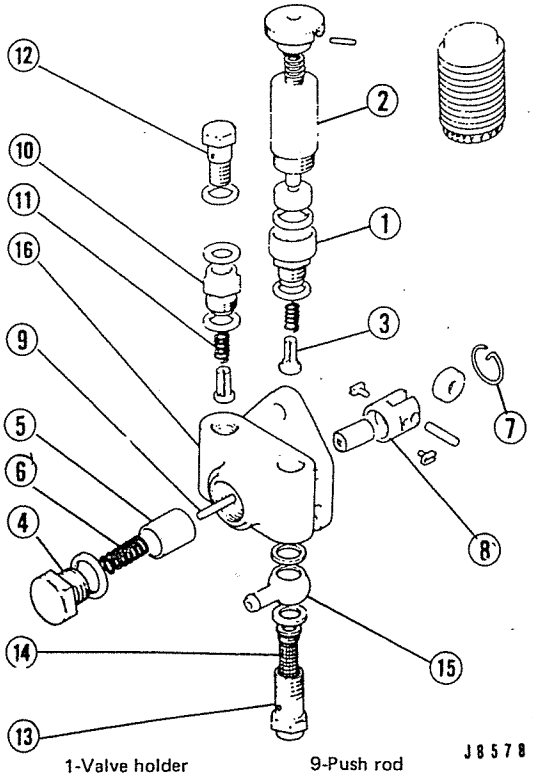
Loosen fuel feed pump attaching nuts (1), and remove feed pump assembly (2) from injection pump.



1-Nut and washer (3 pcs each) 2-Fuel feed pump assembly

Removing fuel feed pump

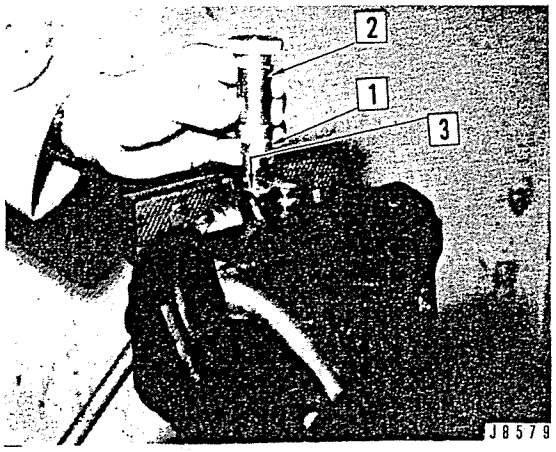
Disassembly and assembly of fuel feed pump



1-Valve holder
2-Priming pump
3-Check valve
4-Piston chamber plug
5-Piston
6-Piston spring
7-Ring
8-Tappet
9-Push rod
10-Valve support
11-Check valve spring
12-Hollow screw
13-Hollow screw
14-Gauze filter
15-Nipple

Fuel feed pump – exploded view

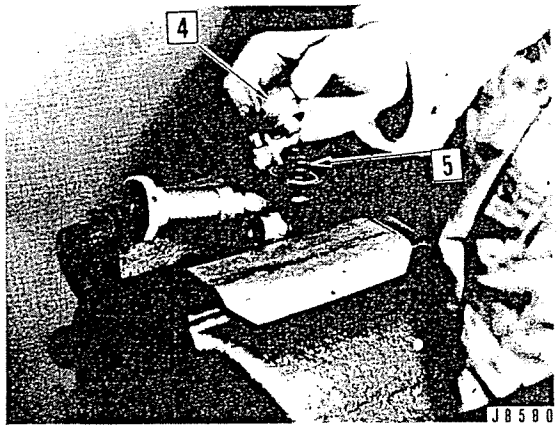
(1) Remove valve holder (1) and priming pump (2) and take out check valve (3). Priming pump cannot be disassembled as cylinder and valve holder are adhered to each other with adhesives.

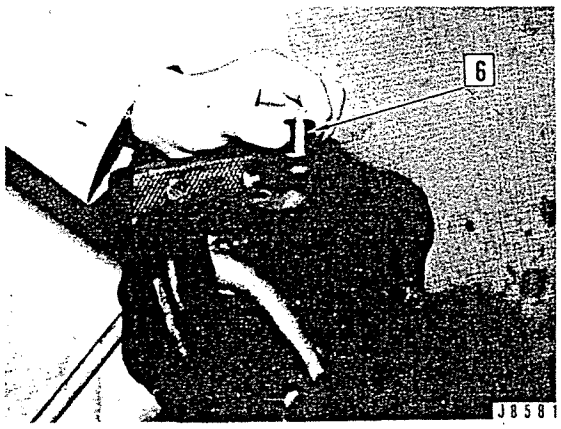


1-Valve holder 3-Check valve
2-Priming pump

Removing priming pump

(2) Loosen piston chamber plug (4), and pull out piston spring (5) and piston (6).

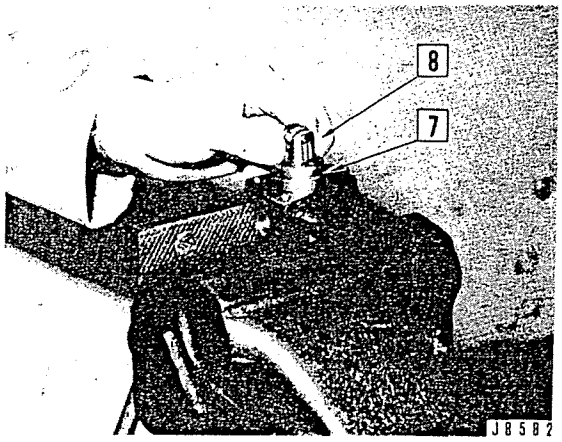




4-Piston chamber plug 5-Piston spring 6-Piston

Removing piston

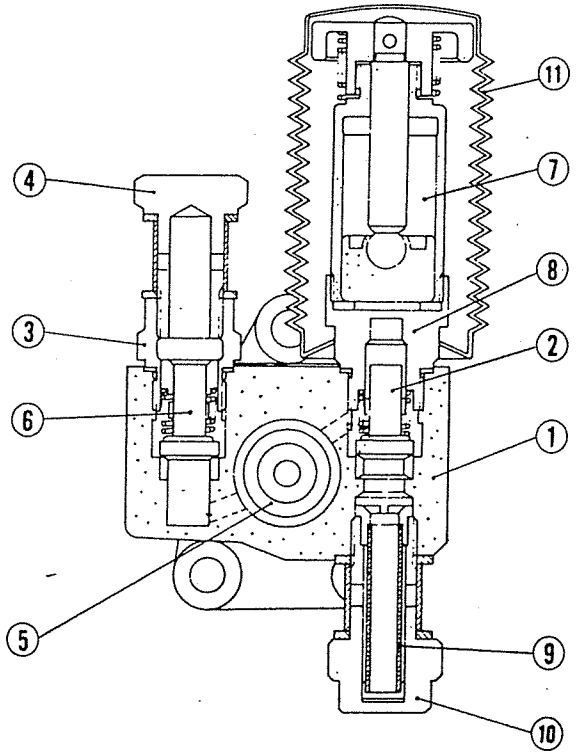
(3) Remove snap ring (7), and take out tappet (8) and push rod.



7-Snap ring 8-Tappet

Removing tappet

(4) Assemble fuel feed pump in the reverse order of disassembly.

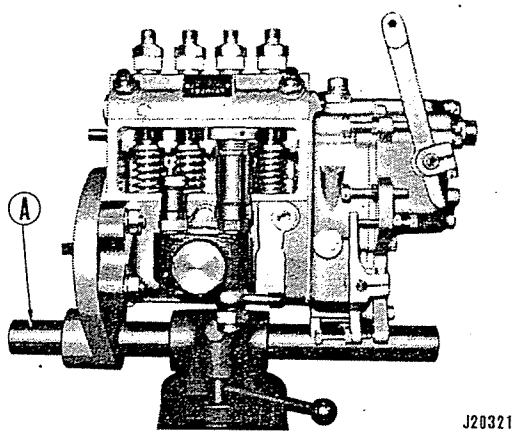


1-Pump housing
2-Check valve
3-Valve support
4-Hollow screw
5-Piston and tappet
6-Check valve
7-Priming pump
8-Valve holder
9-Gauze filter
10-Hollow screw
11-Cover

Fuel feed pump — assembled view

Disassembly of governor

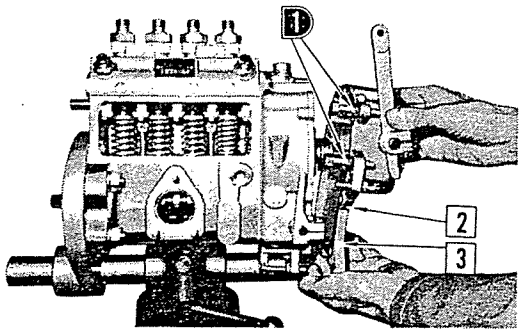
(1) Wash the exterior of injection pump, and install the pump on pump stand (A) as shown below.



A-Pump stand

(2) Turn out stopper bolt (1) to reduce the force of control spring. Loosen cover attaching bolts (2) and remove governor cover (3) by pulling it backward.

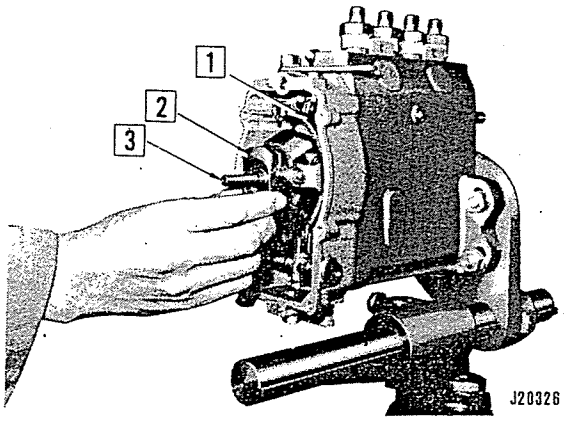
J20322



1-Stopper bolt (2 pcs)
2-Bolt and washer (4 pcs each)
3-Governor cover

Removing governor cover

(3) Pull out spring seat, turn governor sleeve 90° to disconnect it from sliding piece of floating lever (1), and remove governor sleeve (2) from shaft (3).

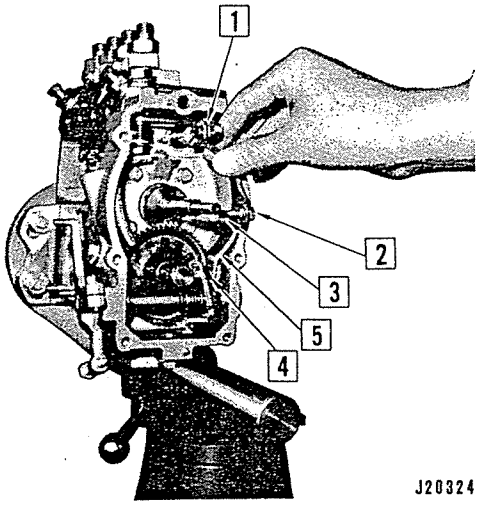


1-Floating lever 3-Governor shaft
2-Governor sleeve

Removing governor sleeve

(4) Remove snap washer (1) from the upper part of floating lever and remove start spring. Straighten lock washer, loosen nut (2) and remove connecting pin (3) from control rack. Exercise care not to drop the bushing.

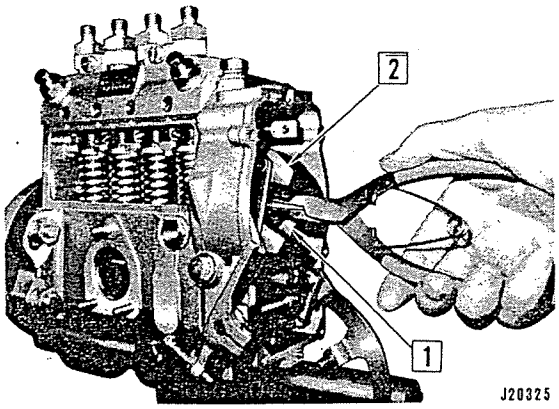
Then remove snap washer (4) from the lower part of floating lever, and remove floating lever (5).



1-Snap washer 4-Snap washer
2-Nut and lock washer 5-Floating lever
3-Connecting pin

Removing floating lever

(5) Remove circlip (1) by using a service tool, and take out governor complete (2).



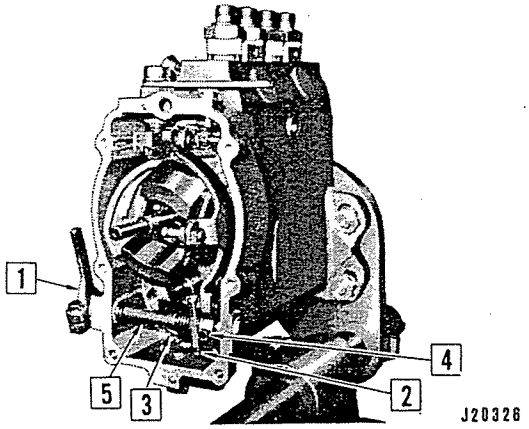
1-Circlip 2-Governor complete

Removing circlip

(6) Remove spring (3) connecting supporting lever (1) to arm (2), and remove stopper bolt (4). Remove snap washer from both ends of control lever shaft (5) and take out the shaft. Bearing bushing must be removed only for replacement. Do not remove the stopper unless shaft replacement is necessary.

NOTE

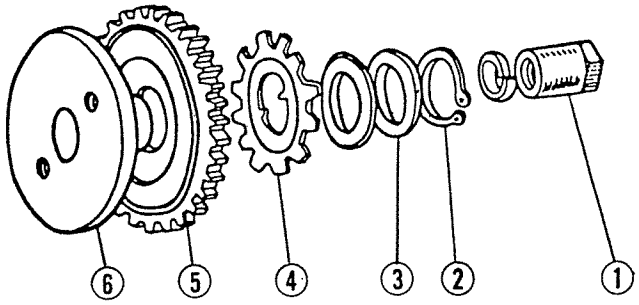
The above job must not be done except when replacing shaft components or when removing gear complete.



1-Supporting lever 4-Stopper bolt
2-Arm 5-Control lever shaft
3-Spring

Removing lever shaft

(7) To disassemble gear complete, loosen camshaft round nut (1), remove gear complete from camshaft, and remove circlip (2), shim plates (3), slip disc (4) and gear (5) in that order.

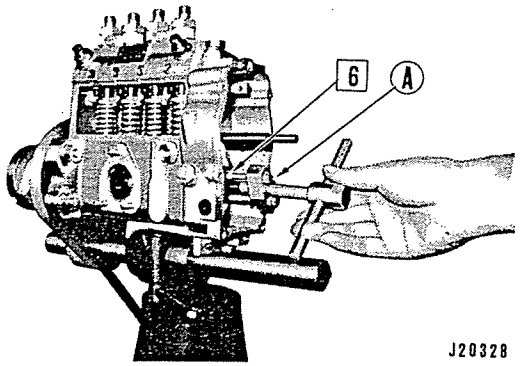


J8590

1-Round nut
2-Circlip
3-Shim plate
4-Slip disc
5-Gear
6-Camshaft bushing

Gear complete — exploded view

Screw two bolts of puller (A) into the threaded holes in camshaft bushing, and pull out camshaft bushing (6) from camshaft to permit removal of governor shaft thrust bearing.

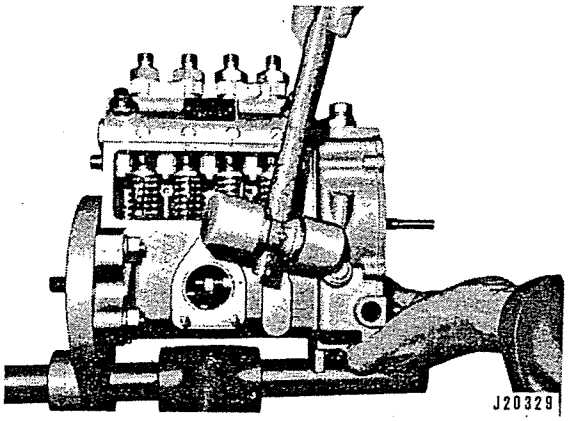


J20328

6-Camshaft bushing
A-Puller

Removing camshaft bushing

(8) To remove governor housing, turn out clamping screws and give light blows to the housing. (See the figure J20329.)



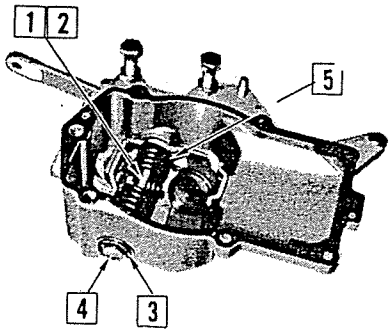
J20329

Removing governor housing

NOTE

Do not remove governor housing unless governor shaft or bearing outer race is damaged.

(9) Loosen nut (1) with an 8 mm (5/16 in.) box wrench, and pull out stop screw (2). Then remove snap washer (3) from the opposite side of adjusting lever, and remove shaft (4) and control spring (5).

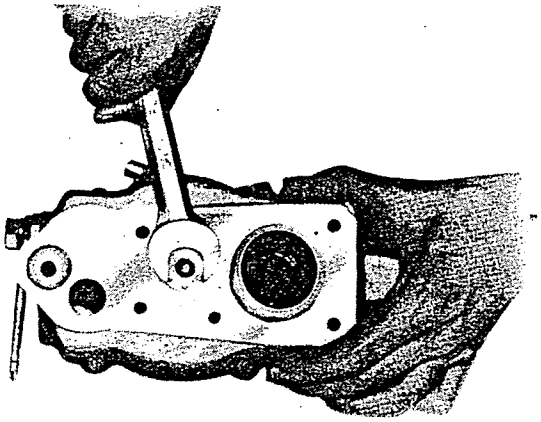


J20331

1-Nut
2-Stop screw
3-Snap washer
4-Shaft
5-Control spring

Removing control spring and control lever

(10) Remove governor shaft by loosening nut on the rear side of governor housing.



J20330

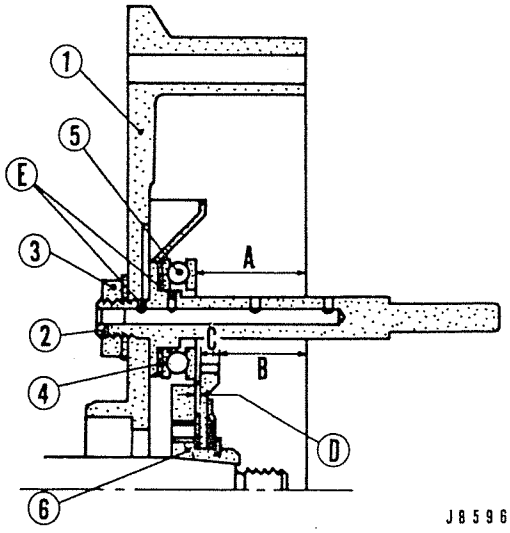
Removing governor shaft

Assembly of governor

To assemble governor, follow the reverse of disassembly procedure, observing the following points:

(1) Be sure to assemble governor shaft so that oil hole in governor shaft faces upward as shown. If this oil hole faces downward, governor complete, thrust bearing and governor sleeve would be lubricated poorly and governor might be damaged.

After governor housing and governor gear are installed to the pump housing, adjust the clearance (D) between thrust bearing (5) and gear (6) to 0.6 ± 0.25 mm (0.024 ± 0.01 in.) with 0.1 mm (0.004 in.) shim plates (4). If this clearance is too large, the rear surface of governor complete (fly-weights) will come in contact with the circlip of gear complete. If the clearance is too small, gear complete will come in contact with thrust bearing. To measure clearance (D), first temporarily install thrust bearing and governor gear complete in place, and then measure the distance (A) between governor housing and thrust bearing and the distance (B) between governor housing and governor gear. The clearance (D) is satisfactory if the value of (A) – (B) is between 5.85 mm (0.230 in.) and 6.36 mm (0.250 in.). This value is the sum of the specified clearance and gear width (C) (5.5 mm or 0.216 in.).

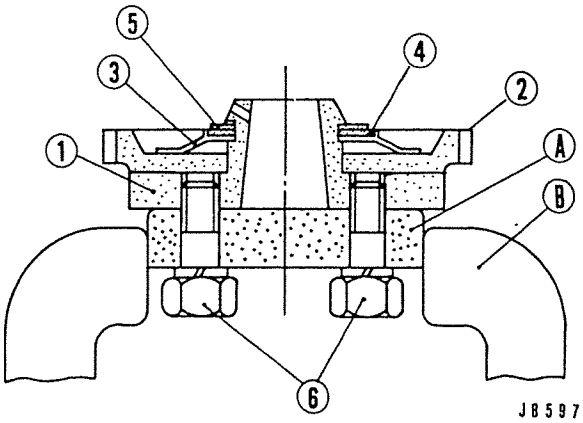


1-Governor housing
2-Governor shaft
3-Lock nut
4-Shim plate
5-Thrust bearing
6-Governor gear complete
A-Governor housing-to-thrust bearing dimension
B-Governor housing-to-governor gear dimension
C-Gear width (5.5 mm or 0.216 in.)
D-Gear-to-bearing clearance (0.6 ± 0.25 mm or 0.024 ± 0.01 in.)
E-Oil hole

Governor shaft assembly

(2) Install governor gear complete as follows:

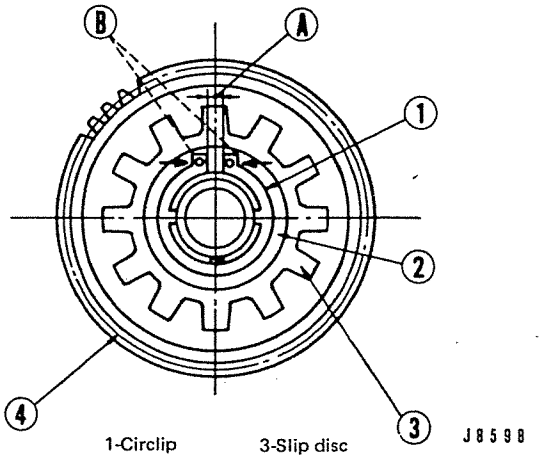
Install camshaft bushing (1) to governor assembly stand with two bolts as shown, insert gear (2) and place slip disc (3) and shim plate (4), securing with circlip (5). Be sure to install circlip with the chamfered side facing inward. Do not reuse circlip. Adjust the slipping torque of governor gear with 0.15 mm (0.006 in.) shim plates.



1-Camshaft bushing
2-Governor gear
3-Slip disc
4-Shim plate
5-Circlip
6-Attaching bolts
A-Assembly stand
B-Vice

Governor gear complete assembly

After inserting circlip, be sure to give light hammer blows to circlip in the direction of arrow with a driver placed on circlip to see if the circlip is properly engaged in the camshaft bushing groove. The clearance (A) is proper if it is less than 2 mm (0.08 in.).



1-Circlip
2-Shim plate
3-Slip disc
4-Governor gear
A-Circlip end clearance (when installed): 2 mm (0.08 in.), max.
B-Push from both sides

Governor gear complete

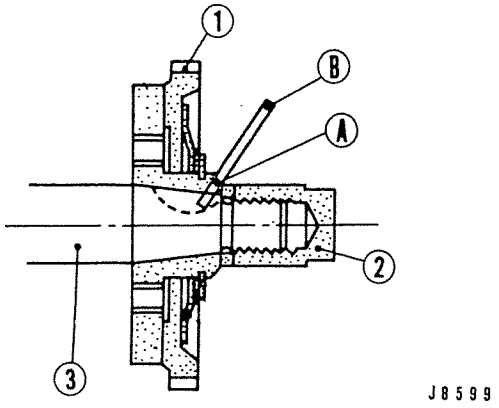
NOTE

If the circlip moves out of the groove, the governor gear will slip to prevent the governor from operating properly, resulting in engine overrunning.

(3) Install governor gear complete to camshaft in the following manner:

Install governor gear complete (1) on governor shaft and insert pin (B) into 3 mm (0.12 in.) dia. hole (A) in camshaft. Tighten round nut (2) to a

torque of 2 to 3 kg-m (14.5 to 21.7 ft-lb) and pull out the pin.

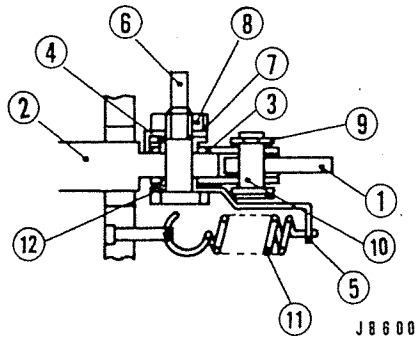


1-Governor gear complete 3-Camshaft
2-Round nut
A-3 mm (0.12 in.) dia. hole
B-Pin (3 mm or 0.12 in.) dia. (To be removed after installation of governor gear complete.)

Installing governor gear

(4) Install floating lever (1) as follows:

Install shackle (3) to control rack (2). Install bushing (4) to both sides of the shackle and install connecting pin (6) together with spring arm (5) and temporarily tighten nut (8) with lock washer (7). Do not bend lock washer at this time.



1-Floating lever	5-Spring arm	9-Snap washer
2-Control rack	6-Connecting pin	10-Shackle pin
3-Shackle	7-Lock washer	11-Start spring
4-Bushing	8-Nut	12-Bushing

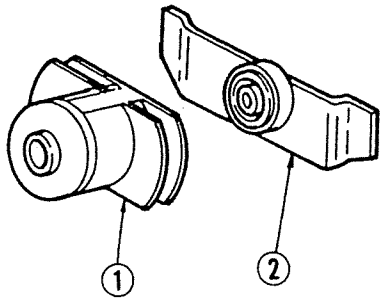
Installing floating lever

NOTES

a) Two bushings installed on both sides of the shackle are different in shape. Install the flanged bushing to the outer side (nut side) of governor to see if the shackle moves smoothly. Then connect the lower part of floating lever with safety lever connecting pin and lock it with snap washer. Connect the upper part of floating lever to shackle. Install shackle pin so that its head comes to the side of spring arm as shown.

b) After making sure the floating lever moves smoothly, tighten the connecting pin nut and then bend lock washer to lock the nut. Do not install start spring at this time; it must be installed after measuring the sliding resistance of control rack.

(5) Install governor sleeve complete (1) and spring seat (2) to governor shaft correctly.



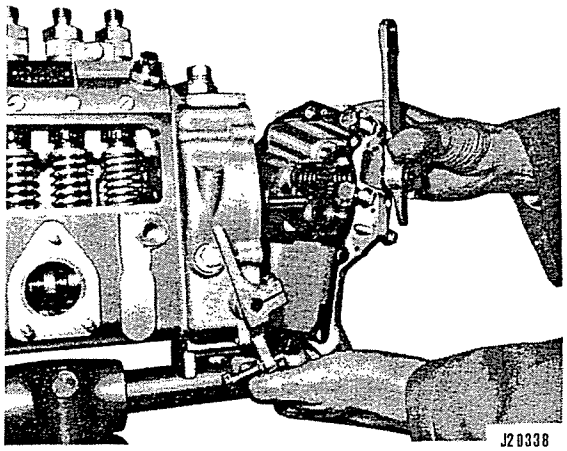
1-Governor sleeve complete 2-Spring seat

Governor sleeve and spring seat

NOTE

If governor sleeve complete and spring seat are installed in wrong direction, they will come in contact with the control spring, resulting in failure of governing function.

(6) To install governor cover, place the flanged parts of governor sleeve and spring seat correctly on the guide part of cover complete. Temporarily tighten governor cover attaching bolts (to be removed when testing on test bench).

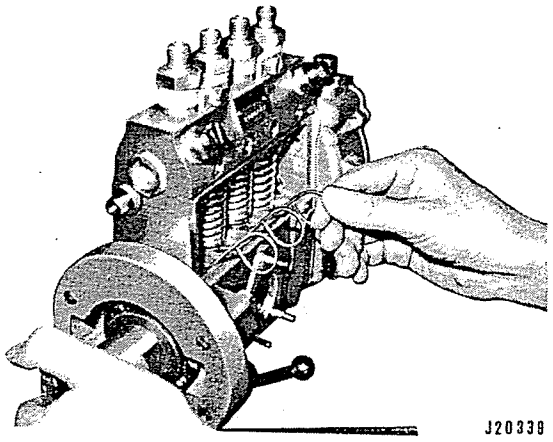


Installing governor cover

Disassembly of injection pump

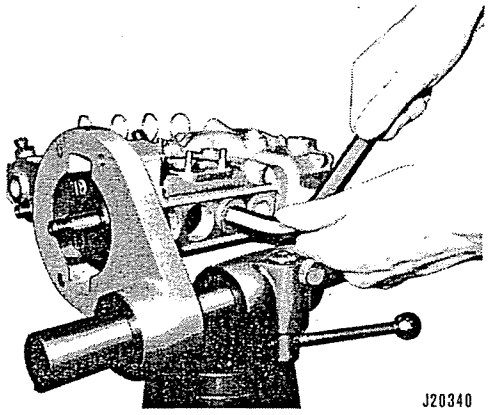
(1) Turn the camshaft and place plunger to top dead

center, and insert tappet insert into tappet hole to make each tappet free of cam.



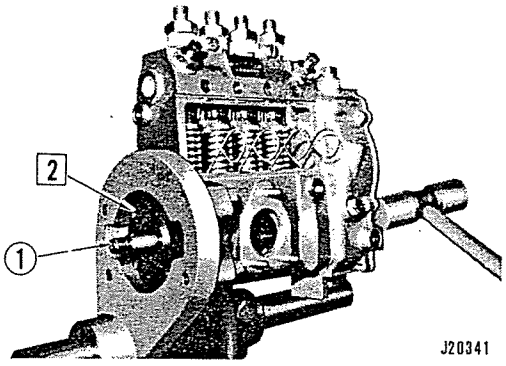
Inserting tappet inserts

(2) Tilt pump body as shown, and remove screw plugs from the bottom of pump.



Removing screw plugs

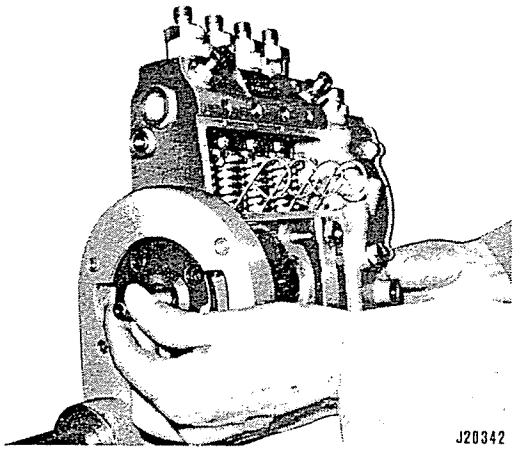
(3) Loosen four bearing cover attaching screws, and lightly tap the threaded part of camshaft on governor side using a plastic hammer to drive out bearing cover (2) slightly; then pull out bearing cover using two screwdrivers.



1-Camshaft 2-Bearing cover

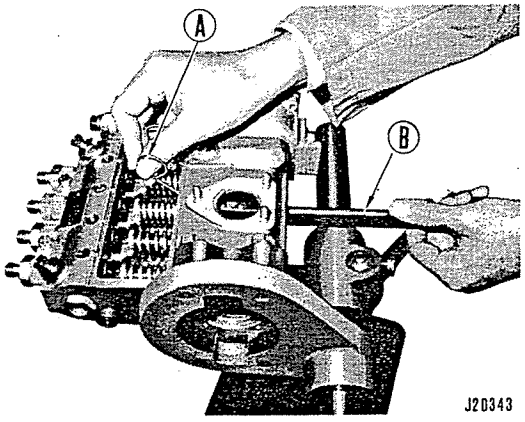
Removing bearing cover

(4) Remove governor gear complete, and pull out camshaft by turning it slowly.



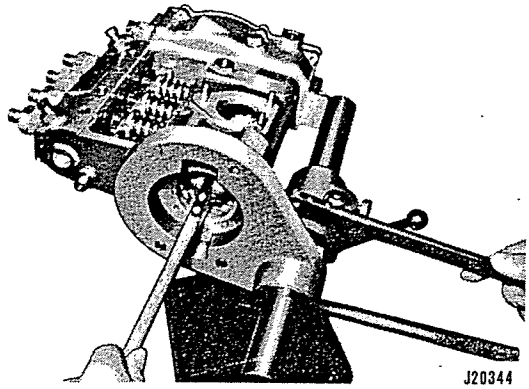
Pulling out camshaft

(5) After pulling out camshaft, remove tappet inserts (A) while pushing tappet with a roller clamp (B). After pulling out tappet inserts, insert a roller clamp through screw plug hole and pull out tappet from the bottom of the pump. Insert a tappet clamp from the drive side and hold tappet, and pull out roller clamp from tappet. Tappet can be pulled out by a tappet clamp.



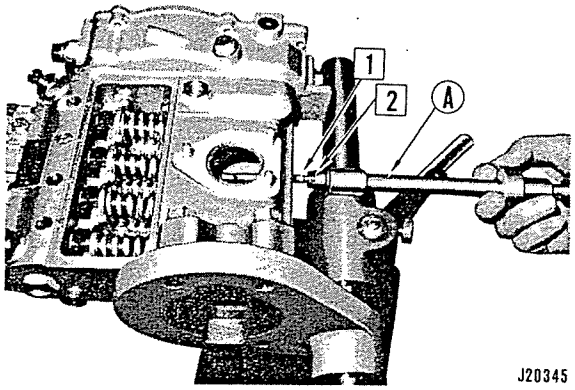
A-Tappet insert B-Roller clamp

Removing tappet



Removing tappet

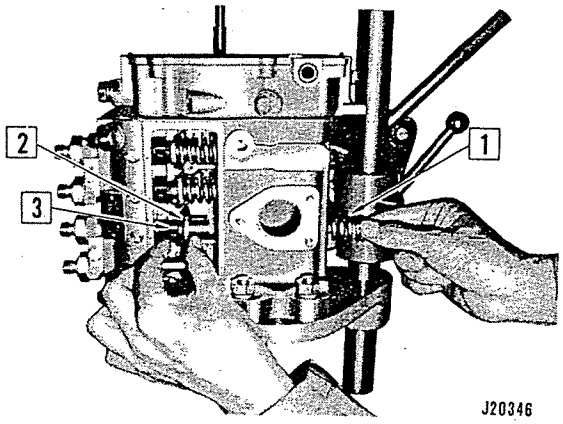
(6) Insert a plunger clamp (A) into lower spring seat (2), and take out plunger (1) together with spring seat.



1-Plunger A-Plunger clamp
2-Lower spring seat

Pulling out plunger

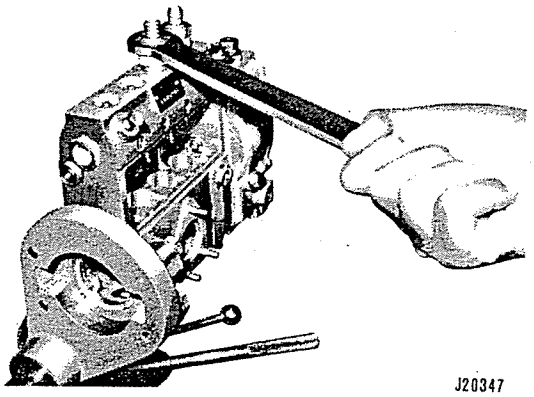
(7) Pull out plunger spring (1) through screw plug hole, and take out control sleeve (3) together with upper spring seat (2).



1-Plunger spring 2-Spring seat 3-Control sleeve

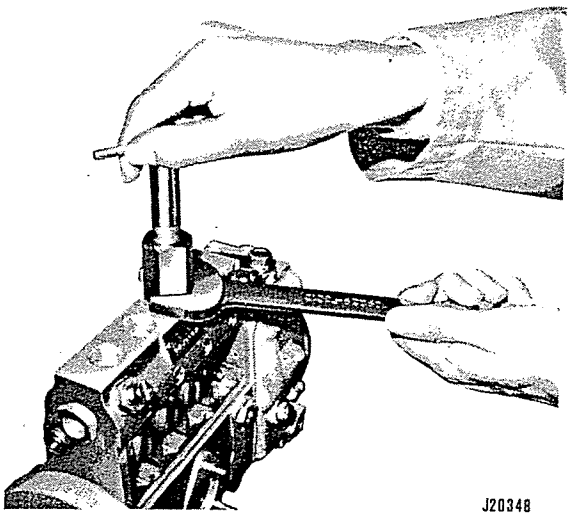
Removing control sleeve

(8) After removing control sleeve, set up the pump and remove delivery valve holder lock plate. Then loosen delivery valve holder with a wrench and remove delivery valve holder together with valve spring.



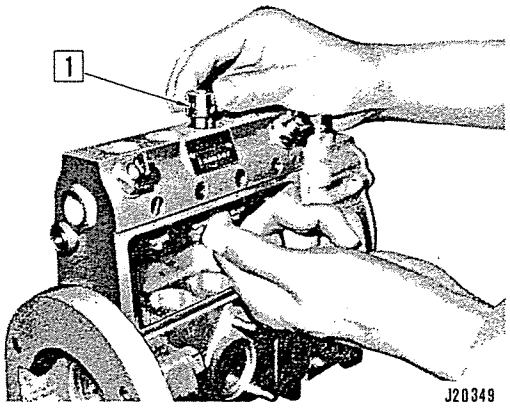
Removing delivery valve holder

(9) Screw a valve extractor into delivery valve and turn the extractor clockwise with a wrench to remove delivery valve. Keep the valve and seat as a pair.



Removing delivery valve

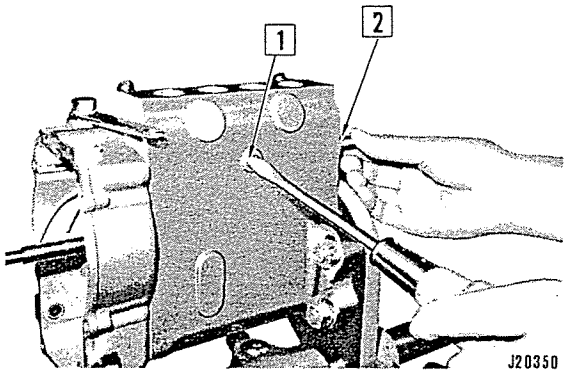
(10) Pull cylinder (1) upward. Keep cylinder and plunger as a pair.



1-Cylinder

Pulling out cylinder

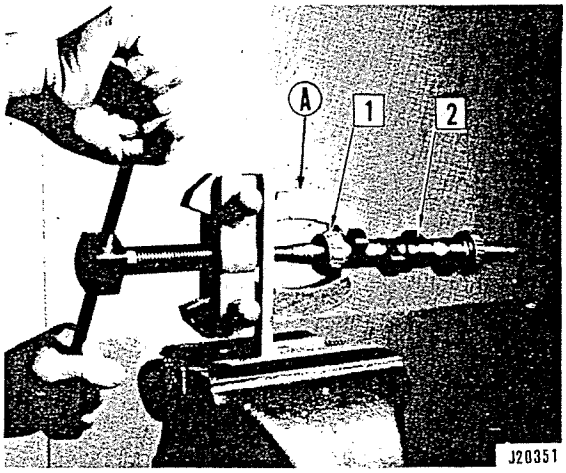
(11) Loosen rack guide screw (1) on the rear side of housing and pull out control rack (2).



1-Rack guide screw 2-Control rack

Pulling out control rack

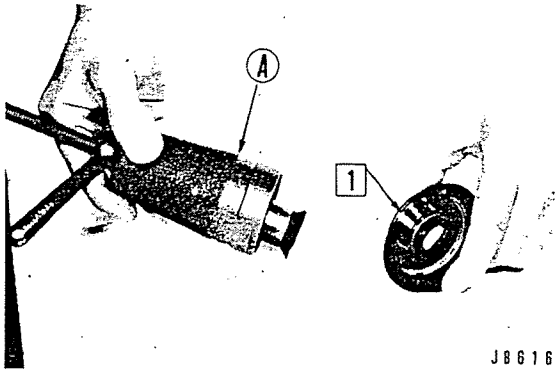
(12) Pull inner race (1) of tapered roller bearing of camshaft (2), using a puller (A).



1-Camshaft bearing inner race 2-Camshaft A-Puller

Pulling out camshaft bearing

(13) Pull out tapered roller bearing outer race (1) as shown by using a service tool (A).



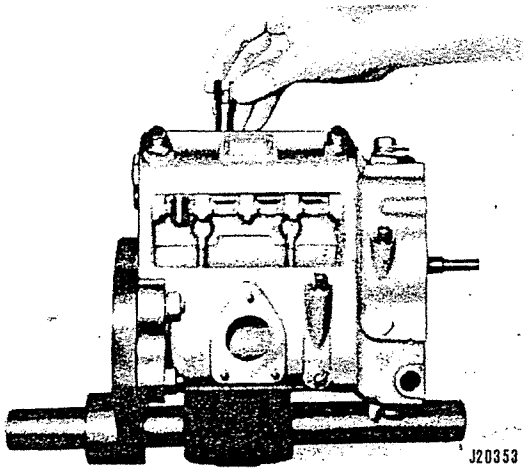
1-Tapered roller bearing (outer race) A-Bearing remover

Pulling out bearing

Assembly of injection pump

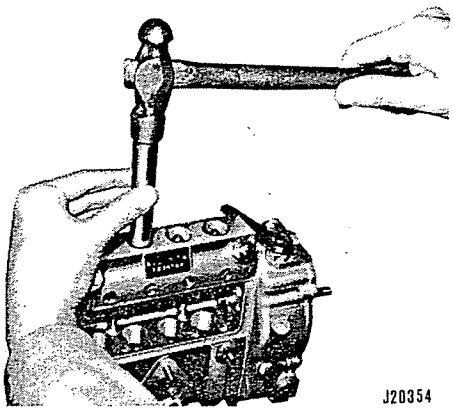
(1) To assemble governor housing, refer to the instructions in "Assembly of governor." Apply special adhesive (Denso Bond) to the surface of governor housing and install it to injection pump body. Be sure to see if "O"ring is inserted properly in pump housing guide.

(2) Properly position pump element, and insert it in pump housing, aligning dowel pin.



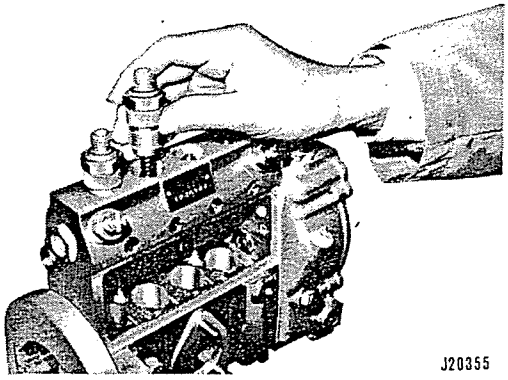
Inserting cylinder

(3) Insert delivery valve and gasket, and uniformly tap the valve until the bottom surface of valve comes in contact with the top end of cylinder, using a service tool. Always use new valve gaskets.



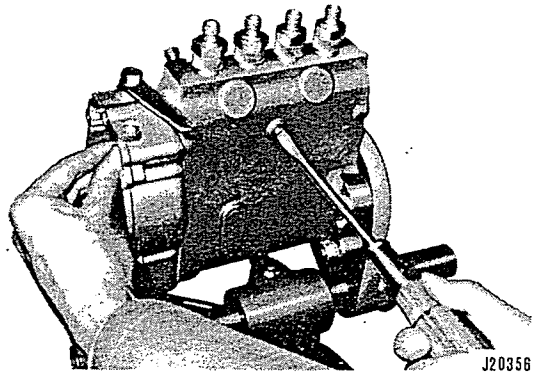
Inserting delivery valve

(4) Place delivery valve spring on valve, and screw in valve holder. Tighten valve holder with a torque wrench while checking the sliding resistance of control rack (after plungers are inserted).



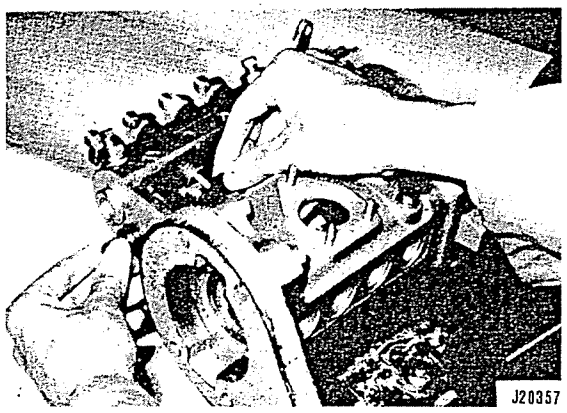
Installing valve holder

(5) Insert control rack, and screw in guide screw. Check to see if the control rack slides smoothly without binding.



Securing control rack

(6) Secure control rack in such a position where it is pulled out about 17 mm (0.67 in.) from the end surface of pump housing, and insert control sleeve into cylinder with pinion slot facing upward. Move control rack to the right and left to assure that pinion rotates equally in both directions.



Inserting control sleeve

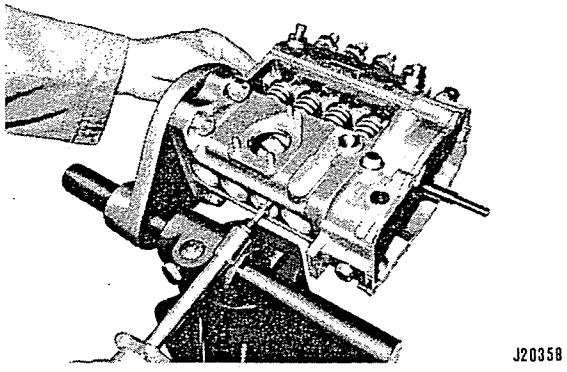
NOTE

The above item must be checked each time control sleeve is installed in each cylinder. If pinion movement is not uniform, the difference in injection quantity among cylinders will be increased, causing faulty governor operation.

(7) Insert upper spring seat and plunger spring into control sleeve. Insert lower spring seat into plunger, and hold it with a plunger clamp as shown. Then insert it into cylinder through screw plug hole.

NOTE

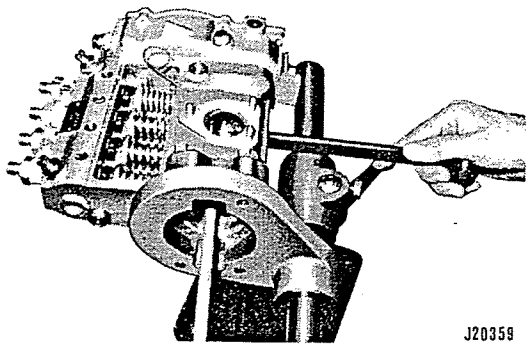
Check to see if the helical recess in plunger faces upward.



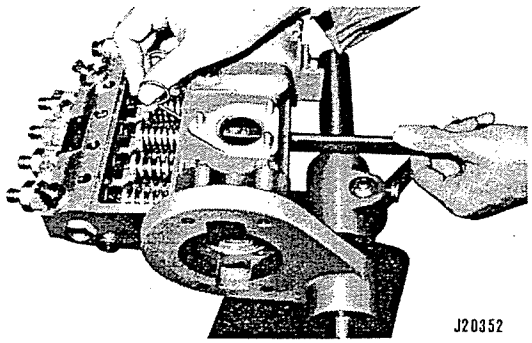
Installing plunger

(8) Hold tappet with a tappet clamp and place it through the camshaft inserting hole.

Insert a roller clamp through screw plug hole, and insert it into tappet roller. Then press tappet as shown, and place insert to hold tappet.

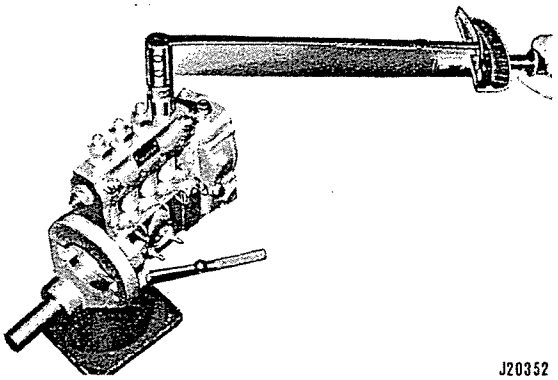


Installing tappet (1)



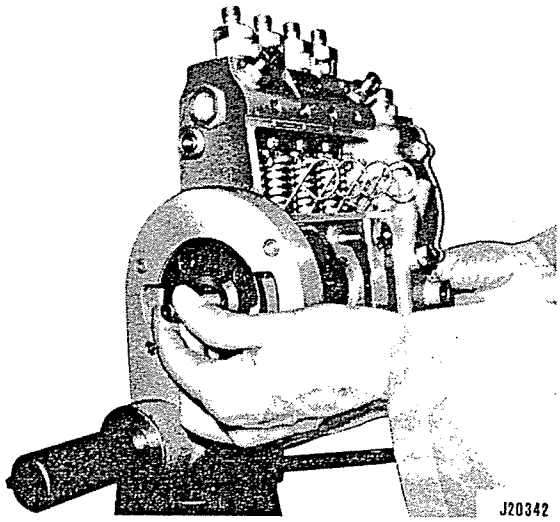
Installing tappet (2)

(9) Tighten valve holder to a torque of 2.5 to 3.5 kg-m (18.1 to 25.3 ft-lb) with a torque wrench. Move control rack to right and left whenever each valve holder is tightened. Measure the sliding resistance of control rack with a spring scale. Check to see if control rack moves smoothly without binding with a sliding resistance of 150 g (5.3 oz) or less, and correct if sliding resistance is excessive.



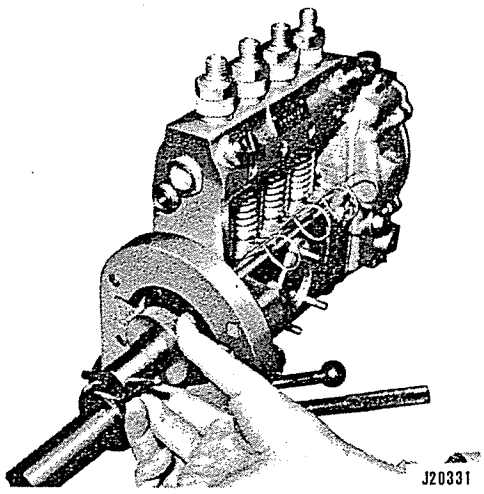
Tightening valve holder

(10) Install camshaft with the notch mark on the end of threaded part of camshaft facing the drive side. Apply Denso Bond (adhesive) to the inside surfaces of pump housing and bearing cover, and install "O"rings. Use new "O"rings.



Installing camshaft

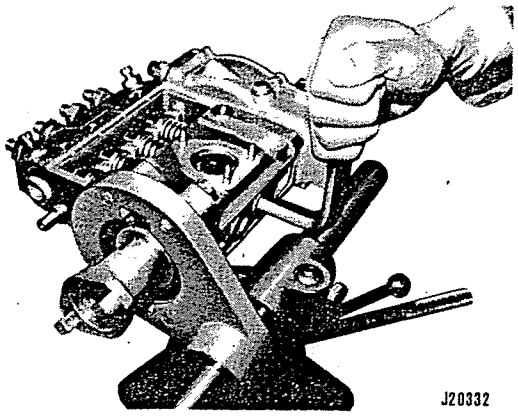
(11) Measure the end play of camshaft. If the end play is out of specification (0.03 to 0.05 mm or 0.0012 to 0.0020 in.), adjust it with shim plates.



Measuring camshaft end play

(12) Pull out tappet inserts while rotating camshaft.

(13) Tilt pump as shown below, and install screw plugs at the bottom.



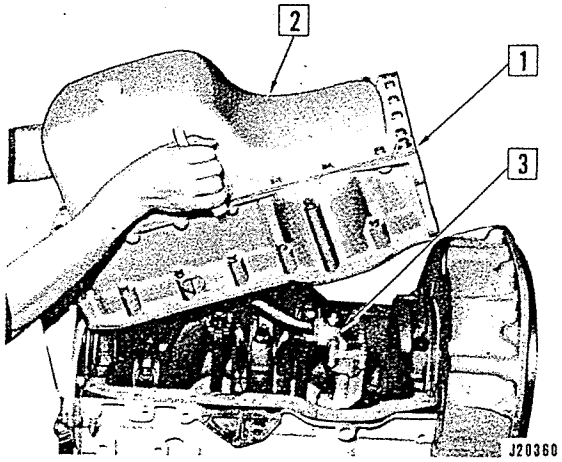
Installing screw plugs

12. Main moving parts

Disassembly

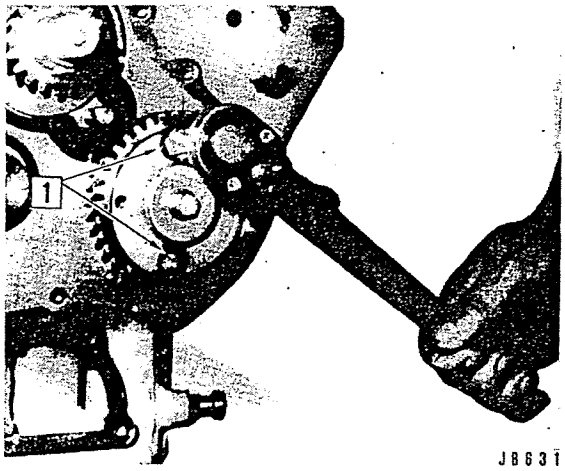
Wash the exterior of the engine and place it on an overhaul stand.

(1) Loosen sixteen oil case attaching bolts with oil pan (2) installed on oil case (1), and remove the oil case and oil pan as a unit from the crankcase. Then remove oil pump (3). (See "Removal of oil pump assembly.")



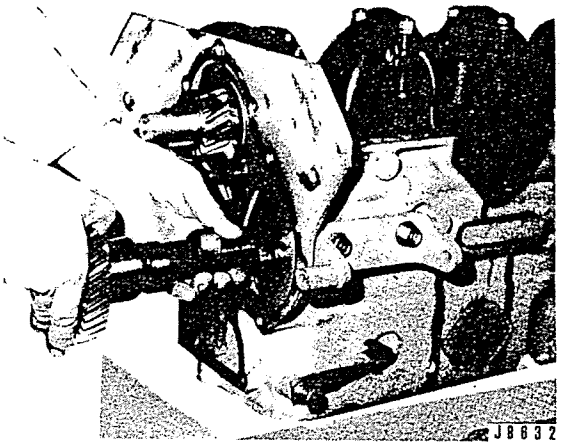
1-Oil case 2-Oil pan 3-Oil pump

(2) Position two tapped holes in camshaft gear in the vertical position, and loosen thrust plate clamping bolts (1).

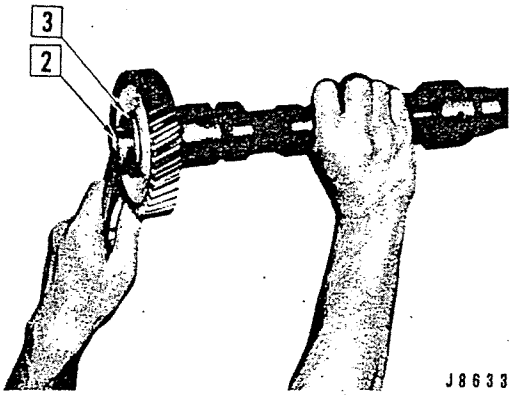


1-Bolts and washers (2 pcs each)

Remove camshaft assembly from crankcase. Remove camshaft bolt (2) and washer (3).

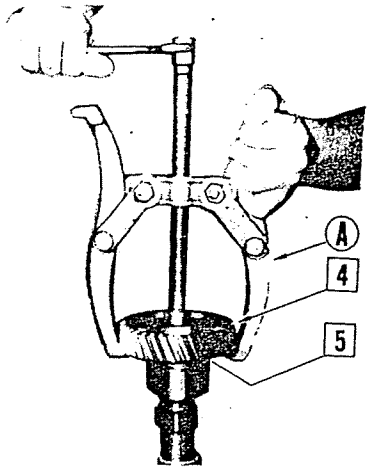


Removing camshaft assembly



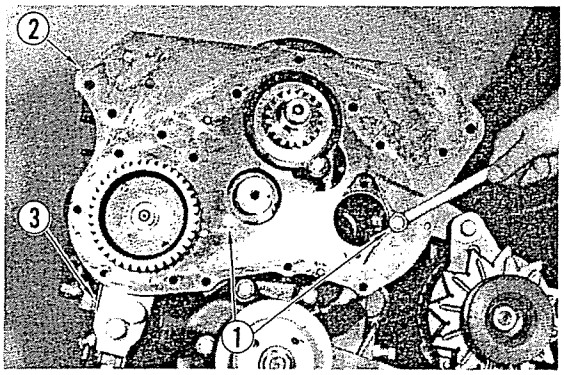
2-Bolt 3-Washer

Remove camshaft gear (4) from camshaft by using a puller (A). This permits thrust plate (5) to be removed.



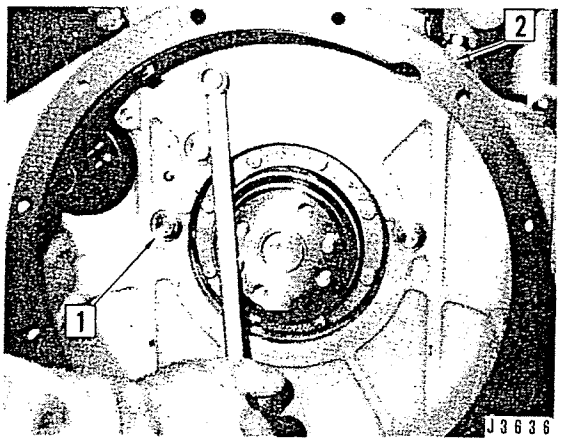
4-Camshaft gear 5-Thrust plate A-Puller

(3) Loosen front plate attaching bolts (1) and remove front plate (2) from crankcase. This permits injection pump assembly (3) to be removed together with front plate.



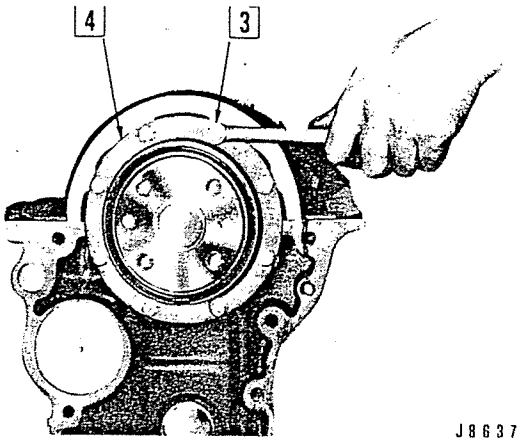
1-Bolts and washers (2 pcs each) 3-Injection pump assembly
2-Front plate

(4) Remove flywheel housing (2) by loosening attaching bolts (1) (after flywheel is removed).



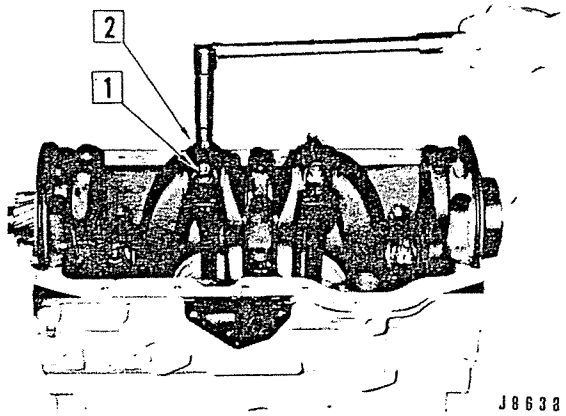
1-Bolt and washer (5 pcs each) 2-Flywheel housing

Loosen oil seal attaching bolts (3) and remove oil seal (4) from crankshaft.



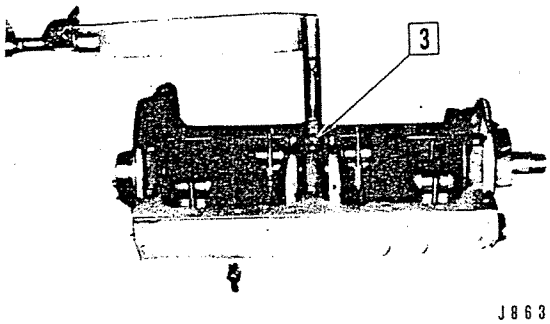
3-Bolt and washer (8 pcs each) 4-Oil seal

(5) Remove connecting rod bearing cap (2) together with connecting rod bearing (lower) by loosening nuts (1).

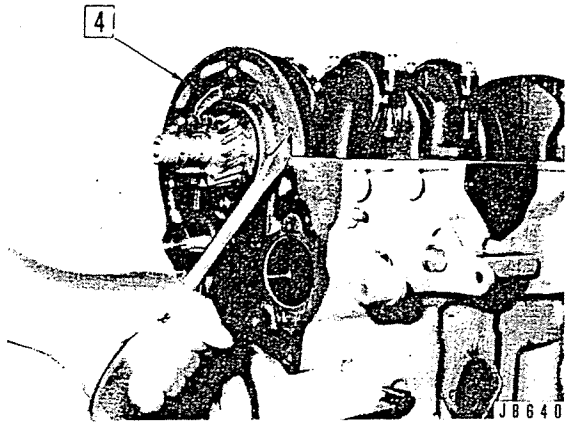


1-Nut (8 pcs) 2-Connecting rod bearing cap

Loosen main bearing cap bolts (3) and remove main bearing caps (front, center and rear) together with bearings (lower) from crankshaft.



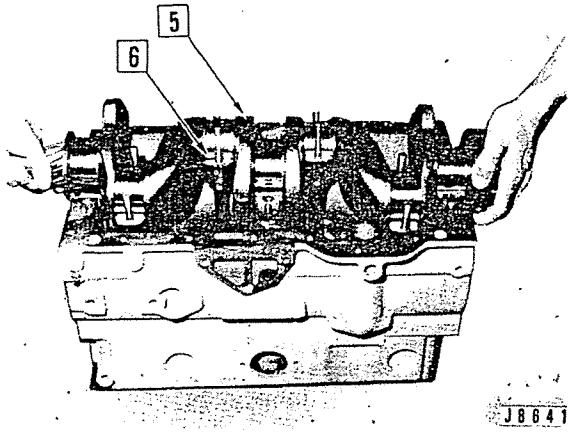
3-Bolt (6 pcs)
Loosening main bearing cap bolts



4-Main bearing cap

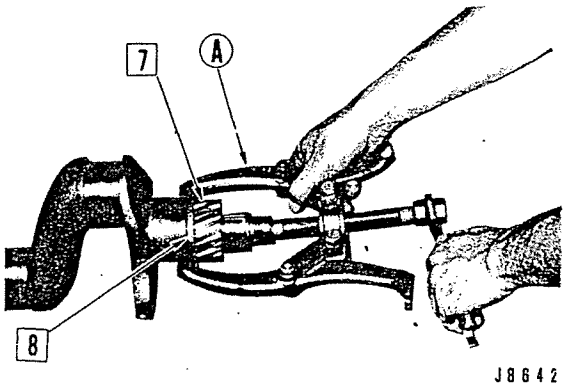
Removing main bearing cap

Remove crankshaft (5) from crankcase. Remove main bearings (upper) (6) and set them aside with main bearings (lower). Remove crankshaft gear (7) from crankshaft by using a puller (A).



5-Crankshaft 6-Main bearing (upper)

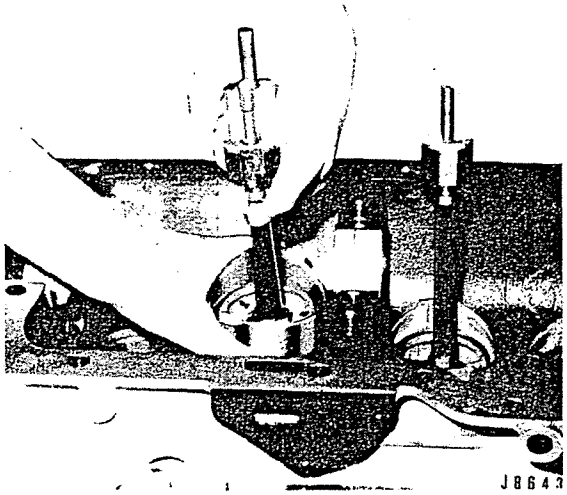
Removing crankshaft



7-Crankshaft gear A-Puller
8-Thrust plate

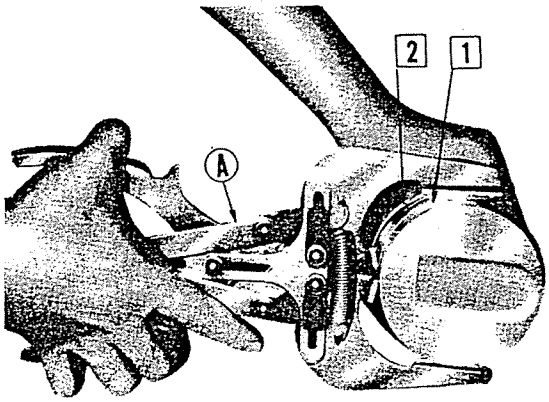
Removing crankshaft gear

(6) Remove piston and connecting rod as a unit from crankcase.



Removing piston

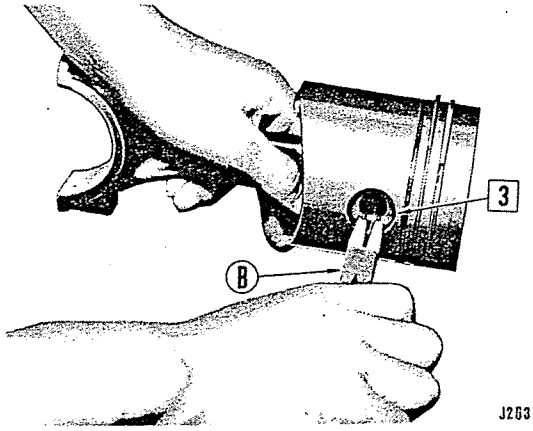
Remove compression rings (1) and oil ring (2) by using a piston ring tool (A). The oil ring spring can be removed by hand.



1-Compression ring A-Piston ring tool
2-Oil ring

Removing piston rings

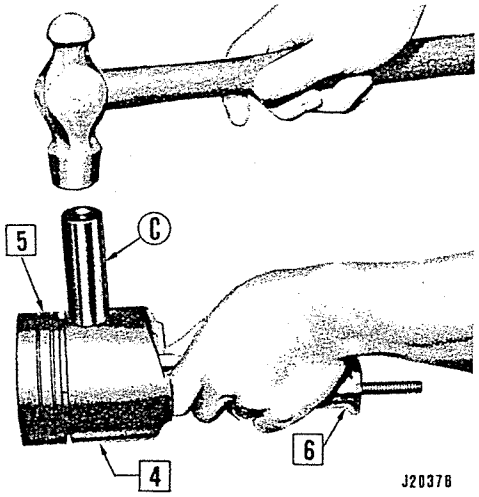
Remove snap rings (3) by using a snap ring tool (B).



3-Snap ring (2 pcs) B-Snap ring tool

Removing snap ring

Remove piston pin (4) and separate piston (5) from connecting rod. If it is difficult to remove the piston pin, heat the piston in a piston heater and tap it lightly by using a piston pin remover (C) to facilitate removal of piston pin. Remove connecting rod bushing and bearing (upper). Wash the parts removed in washing fluid to decarbon them.

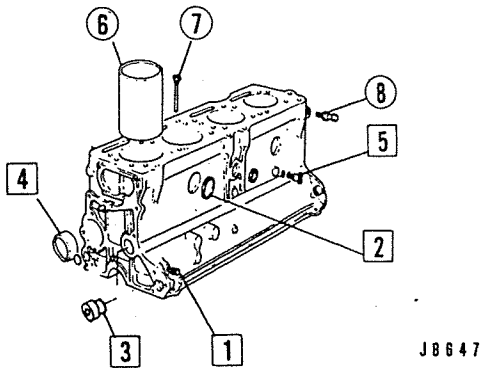


4-Piston pin 6-Connecting rod
5-Piston C-Piston pin remover

Removing piston pin

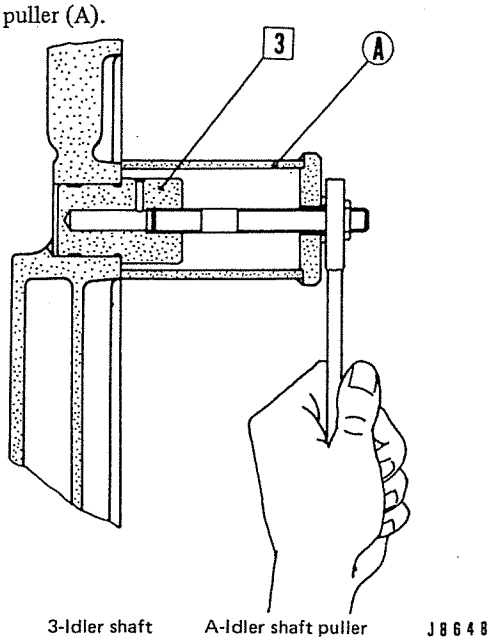
(7) Disassemble crankcase as follows:

Remove tappets from crankcase. If necessary, remove expansion plugs (2) from both sides of crankcase. Discard the plugs removed.



1-Taper plug 5-Drain cock
2-Expansion plug 6-Cylinder liner
3-Idler shaft 7-Oil pipe
4-Camshaft bushing 8-Rear hanger

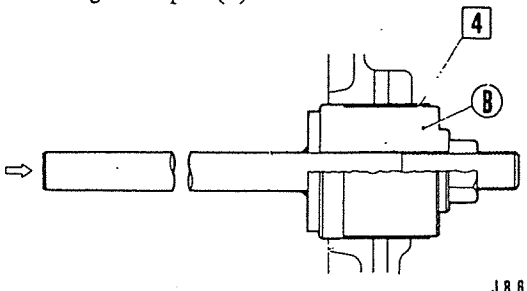
Pull out idler shaft (3) from crankcase by using a puller (A).



3-Idler shaft A-Idler shaft puller

Pulling out idler shaft

Remove expansion plug through camshaft inserting hole, and take out camshaft bushing (4) by using an adapter (B).



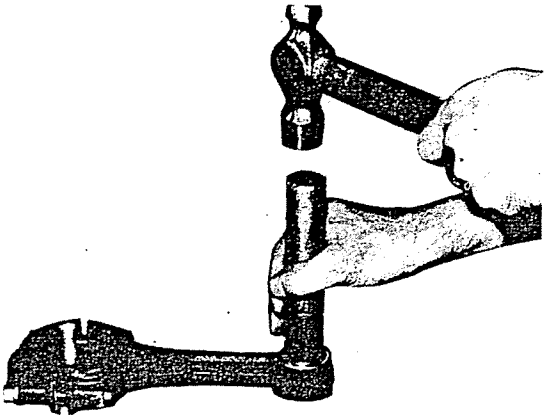
4-Camshaft bushing B-Adapter and rod

Driving out camshaft bushing

Crankcase must be washed in a soda bath or in washing fluid. Wash oil lines with a long-handle brush and dry them with a blast of steam or compressed air.

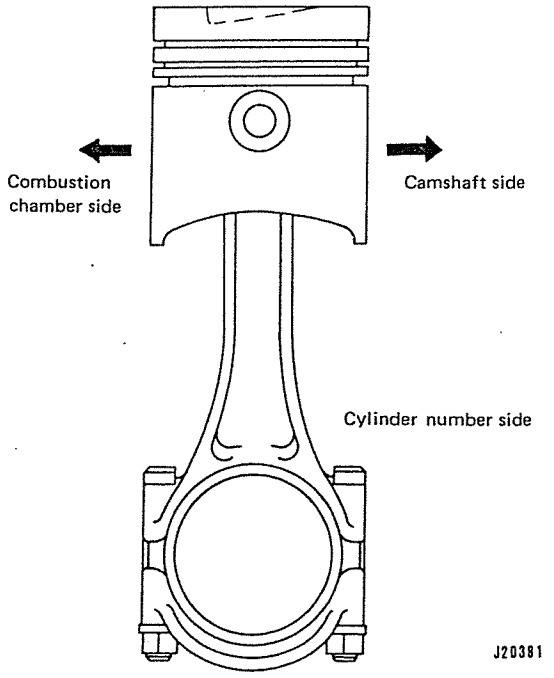
Assembly

(1) Drive in bushing into connecting rod small end. The oil holes in bushing and rod must be aligned.



J8650

Driving in connecting rod bushing

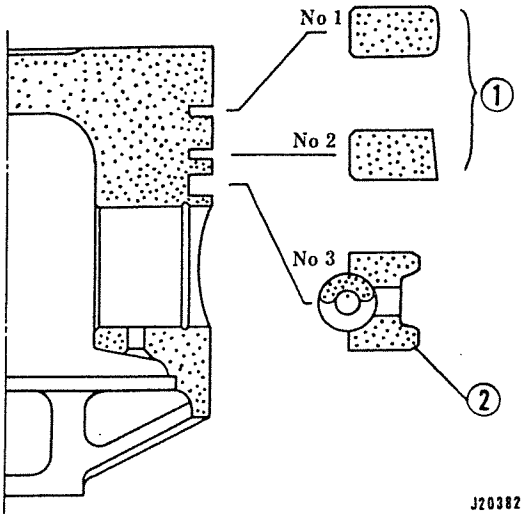


J20381

Piston and connecting rod assembly

Heat piston in a piston heater up to 100°C to 120°C (212°F to 248°F). Place small end of connecting rod into boss of piston, and slowly insert piston pin into piston. Insert snap ring in each end of piston. Install connecting rod to piston so that the marking side of the connecting rod big end comes to the camshaft side.

Install compression rings and oil ring as shown by using a piston ring tool.



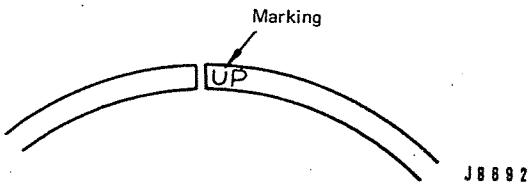
J20382

1-Compression rings 2-Oil ring

Piston rings installed

NOTE

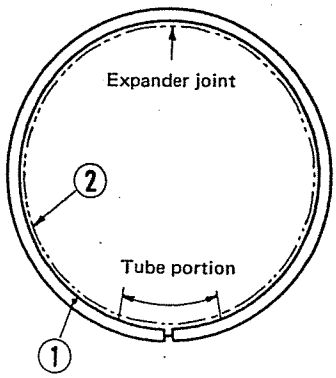
When No.2 piston ring is installed, the marking "UP" on the ring should face upwards.



J8692

Upper side of piston ring

Install No. 3 oil ring (1) and expander (2) as shown below.

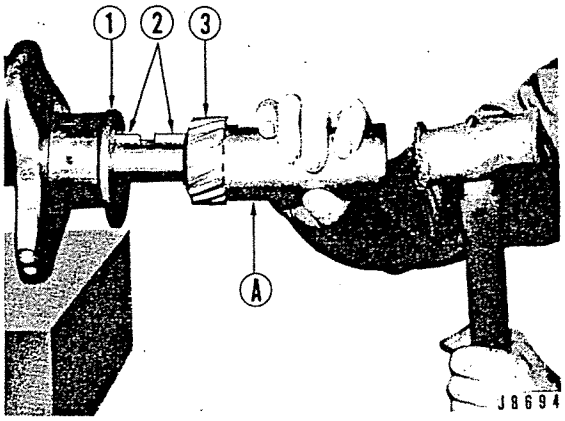


J8693

1-Oil ring . 2-Expander

Oil ring and expander installed

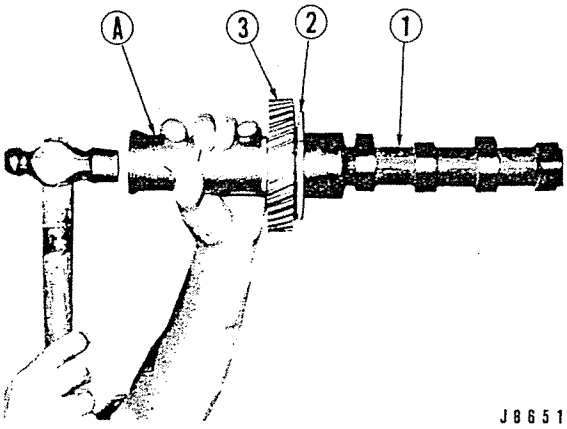
(2) Install thrust plate (1) and two woodruff keys (2) to the crankshaft and drive in crankshaft gear (3) by using an installer (A). Heating the crankshaft gear will facilitate installation.



1-Thrust plate
2-Woodruff keys (2 pcs)
3-Crankshaft gear
A-Installer

Driving in crankshaft gear

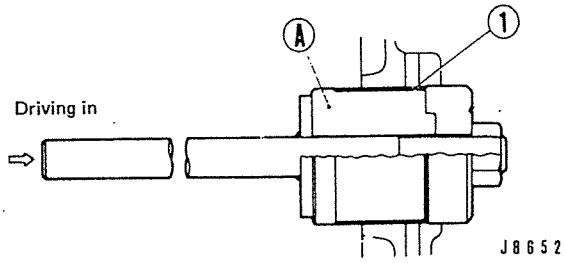
(3) Install thrust plate (2) to camshaft (1). Drive in camshaft gear (3) by using an installer (A) and secure it with bolt and washer.



1-Camshaft
2-Thrust plate
3-Camshaft
A-Installer

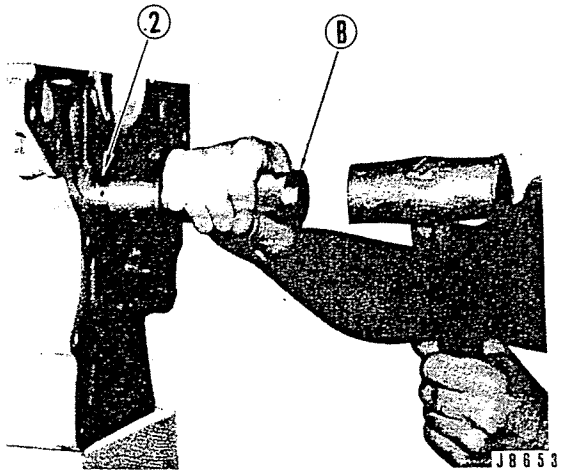
Driving in camshaft gear

(4) Drive three camshaft bushings (1) into camshaft hole in crankcase by using an adapter (A). Drive idler shaft (2) into crankcase by using an installer (B).



1-Camshaft bushing
A-Adapter

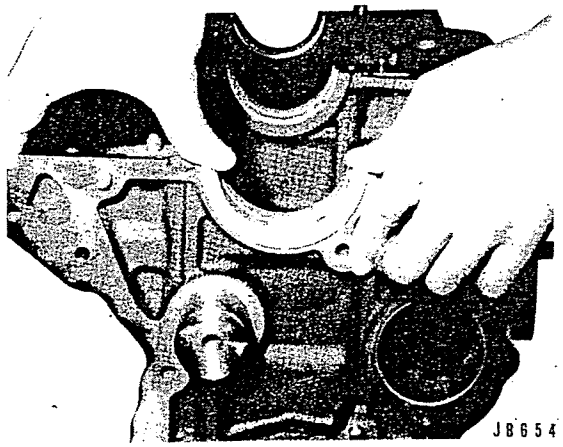
Driving in camshaft bushing



2-Idler shaft
B-Installer

Driving in idler shaft

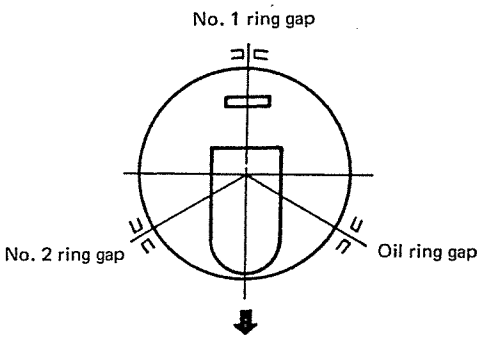
(5) Drive in expansion plugs and insert tappets into holes. Apply a coat of engine oil to crankpins and install main bearings (upper). Securely engage bearings with crankpins.



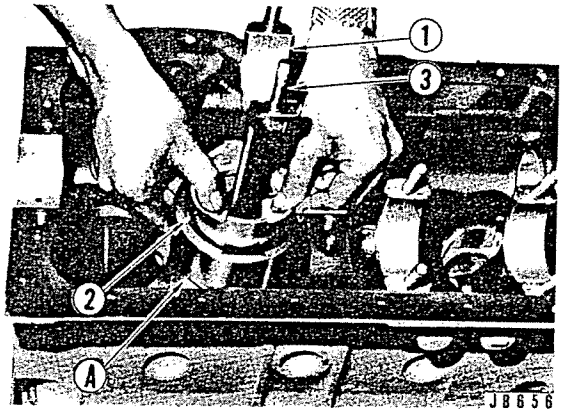
Installing main bearing (upper)

(6) Install connecting rod bearing (upper) (1) to the big end of connecting rod. Apply a coat of engine oil to internal surface of bearing and to periphery

of piston. Position piston rings so that ring gaps are staggered as shown in the figure below, and then insert piston assembly (2) into crankcase. Matching marks on the connecting rod must face the camshaft side. Put cap attaching bolts (3) into rod in advance. Insert piston assembly into crankcase by using a piston guide (A).



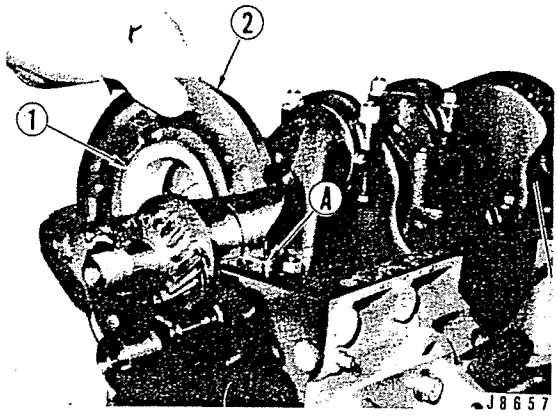
Arrangement of piston ring gaps



1-Connecting rod bearing (upper) 3-Bolt (12 pcs)
2-Piston assembly A-Piston guide

Inserting piston assembly

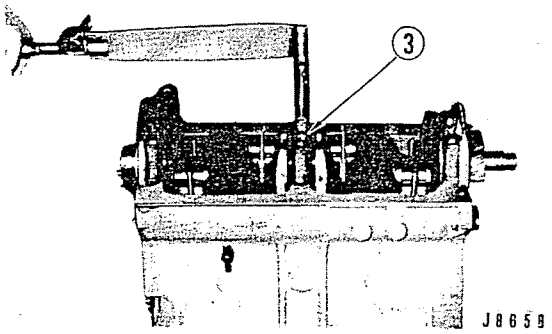
(7) Apply a coat of engine oil to crankshaft journals and crankpins, and install crankshaft in crankcase securely. Attach main bearings (lower) (1) to main bearing caps (2) (front, center and rear) and install the caps in place in alignment with dowel pins (A) of crankcase.



1-Main bearing (lower) A-Dowel pin
2-Main bearing cap

Installing main bearing cap

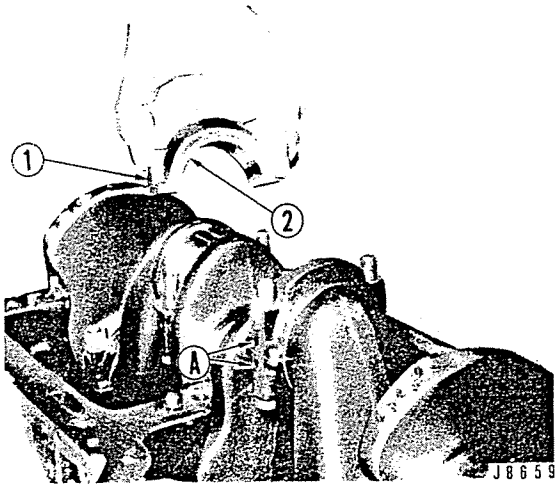
Measure the crankshaft end play with a thickness gauge. Replace No. 1 main bearing if the end play is out of sepcification. Tighten main bearing cap bolts (3) to a torque of 8.5 kg-m (61.5 ft-lb).



3-Bolt (6 pcs)

Tightening main bearing cap bolts

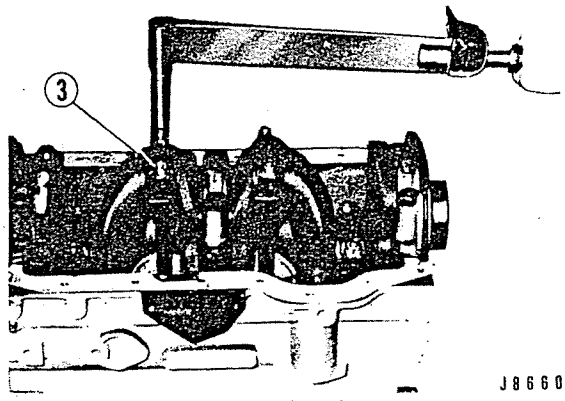
(8) Install connecting rod bearing (lower) (2) to cap (1) and apply a coat of engine oil to internal surface of bearing, and then install the cap with the matching mark on the cap aligned with the mark (A) on the rod.



1-Connecting rod bearing cap (4 pcs)
2-Connecting rod bearing (lower) (4 pcs)
A-Matching marks on rod

Installing connecting rod bearing

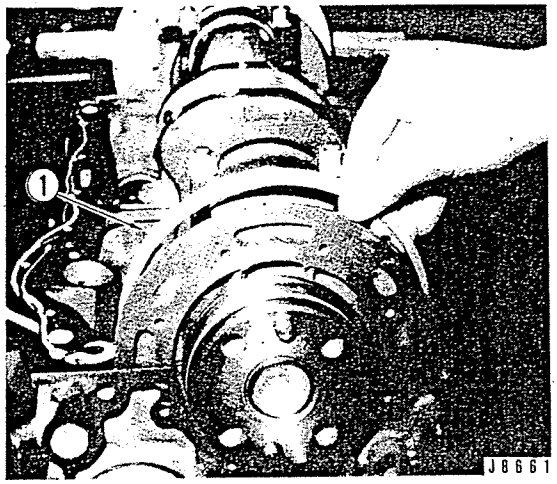
Tighten connecting rod cap nuts to a torque of 5.5 kg-m (39.8 ft-lb).



3-Nut (8 pcs)

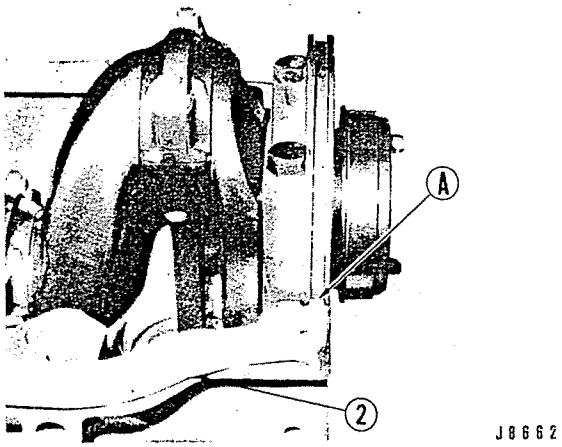
Tightening connecting rod bearing cap

(9) Install retainers (1) to main bearing caps No. 1 and No. 3 with flanges facing the inside. Apply Three Bond No. 2 (sealer) to both sides of oil pan gasket (2) and place it on crankcase. Make sure that the gasket is completely attached in the grooves (A) in the caps.



1-Retainer (2 pcs)

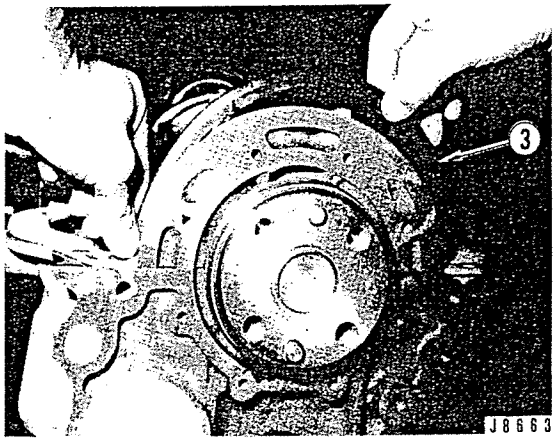
Installing retainer



2-Gasket A-Cap groove

Installing gasket

Apply Atmojet (sealer) to both sides of rubber packing (3) and insert the packing into cap.



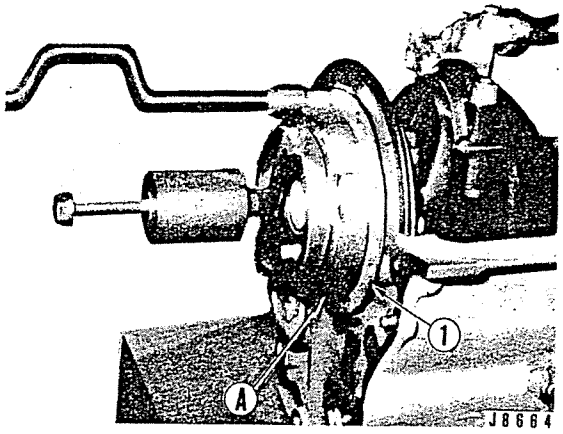
3-Rubber packing (2 pcs)

Installing rubber packing

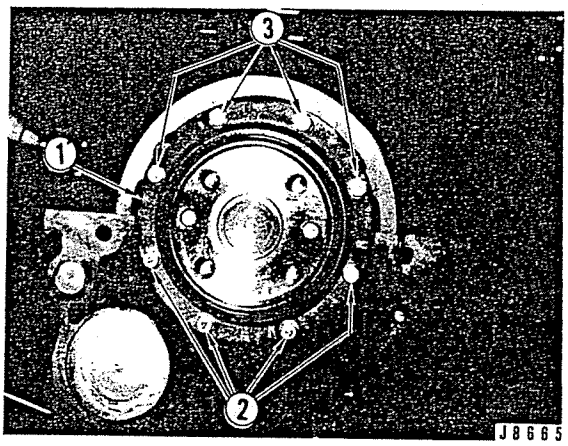
(10) Install sleeve onto the rear end of crankshaft. Apply a coat of engine oil to internal surface of oil seal (1) and secure it with bolts (2) by using an oil seal aligner (A).

NOTE

Be sure to use an aligner when installing oil seal; otherwise the oil seal might not be aligned, resulting in oil leakage.

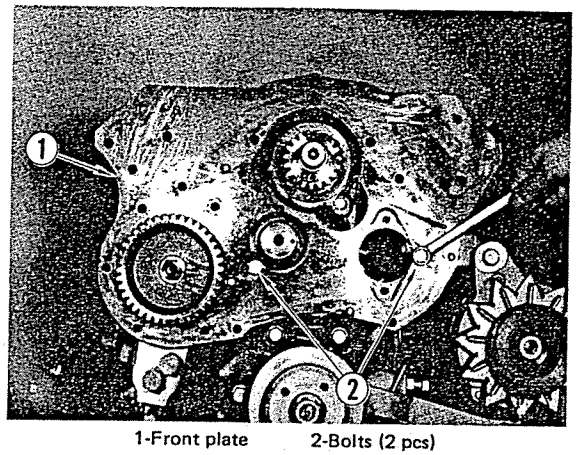


1-Oil seal A-Oil seal aligner
Installing oil seal



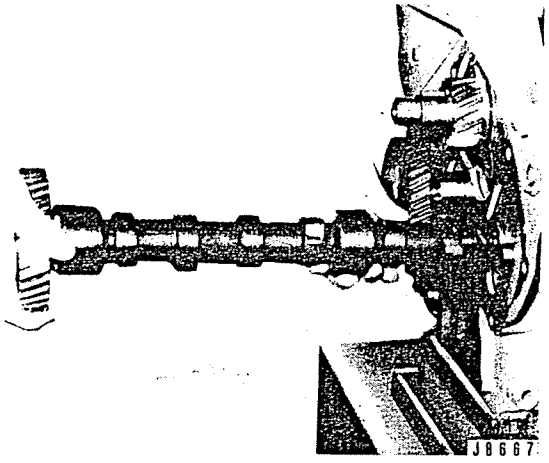
1-Oil seal 3-Bolts (4 pcs) (Use sealer.)
2-Bolts (4 pcs)
Installing oil seal

(11) Apply Three Bond No. 2 to both sides of front plate packing and attach the packing to the front face of crankcase. Secure front plate (1) complete with injection pump with two bolts (2). The tightening torque of the bolts is 2.1 kg-m (15.2 ft-lb).



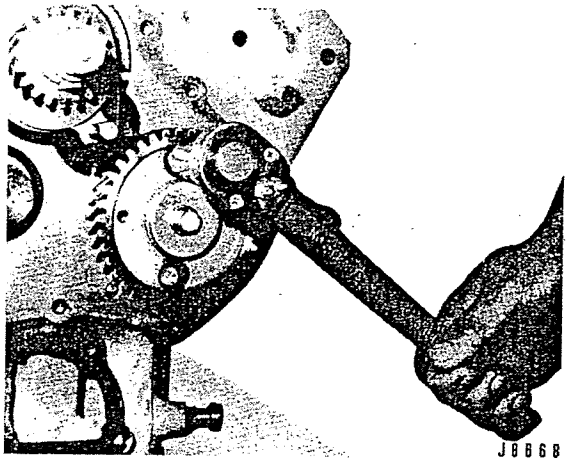
1-Front plate 2-Bolts (2 pcs)
Installing front plate

(12) Slowly insert camshaft into crankcase.



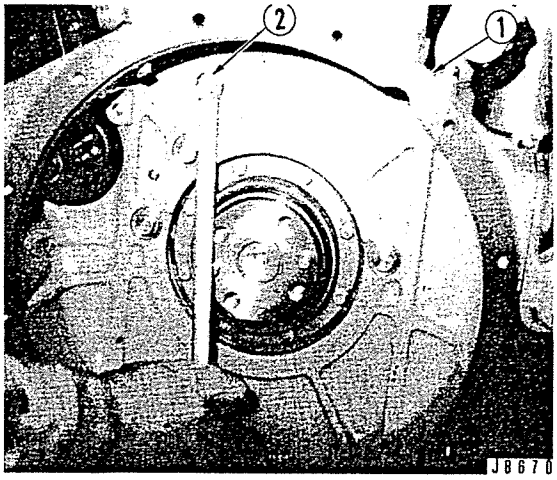
Installing camshaft

Tighten camshaft thrust plate to crankcase through holes in camshaft gear.



Tightening camshaft thrust plate

(13) Tighten flywheel housing (1) to the rear end of crankcase with bolts (2) to a torque of 3.5 kg-m (25.3 ft-lb).



1-Flywheel housing 2-Bolt and washer (5 pcs each)

Installing flywheel housing

(14) Place oil pump in the oil pump attaching hole in the crankcase and secure the pump to the crankcase, making sure that the drive gear and camshaft gear are properly meshed. (See "Installation of oil pump assembly.")

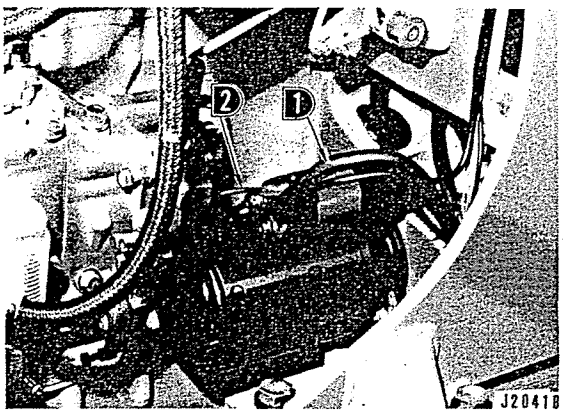
(15) Place the oil pan on the crankcase and secure the pan to crankcase with sixteen bolts.

(16) Install the assemblies removed in disassembly of the engine proper.

13. Starting motor

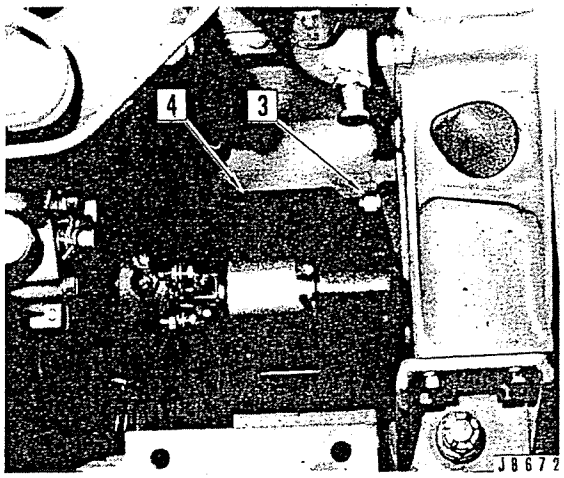
Removal and installation

(1) Disconnect wire lead (1) from starting motor and battery and wire lead (2) from starting motor and starter switch.



1-Wire lead between starting motor and battery
2-Wire lead between starting motor and starter switch (2 pcs)

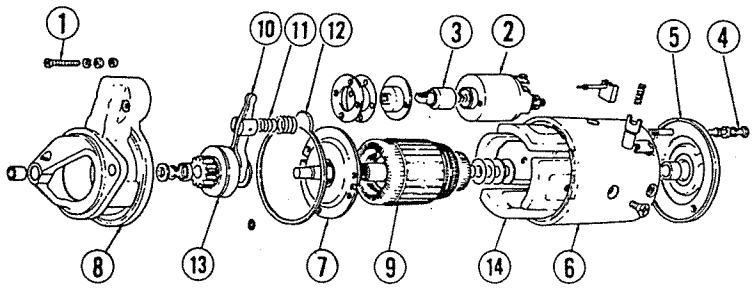
(2) Loosen attaching nuts (3) and remove starting motor assembly (4) from engine.



3-Nut and washer (2 pcs each) 4-Starting motor assembly

(3) Install the starting motor in the reverse order of removal.

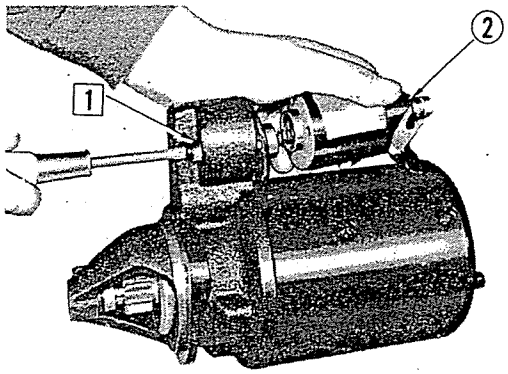
Disassembly and assembly



1-Bolt and washer (2 pcs each)
2-Switch
3-Plunger
4-Bolt and washer (2 pcs each)
5-Rear bracket
6-Yoke
7-Center bracket
8-Front bracket
9-Armature
10-Lever
11-Lever spring
12-Rubber packing
13-Overrunning clutch
14-Pole piece

Starting motor — exploded view

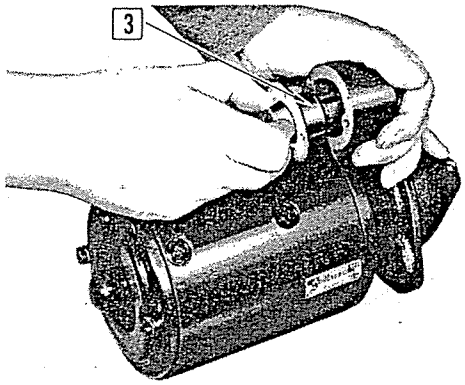
(1) Loosen switch attaching bolts (1) and remove switch (2) from front bracket.



J20451

1-Bolt and washer (2 pcs each) 2-Switch

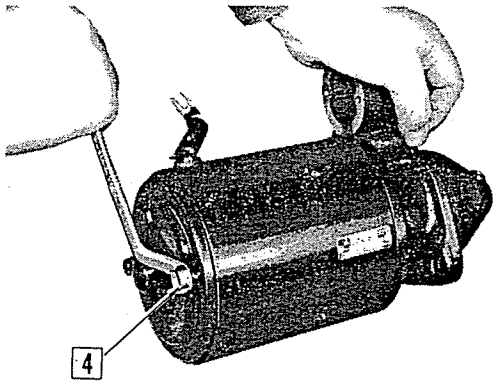
(2) Remove plunger (3) (with rubber cover) from front bracket.



J20452

3-Plunger (with rubber cover)

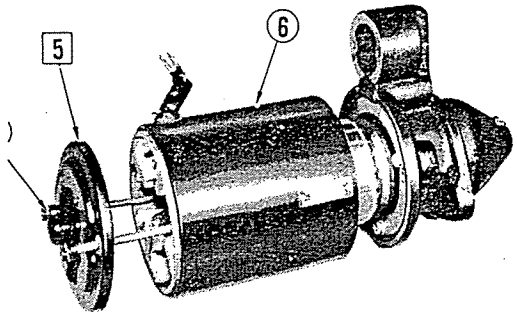
(3) Remove rear bracket attaching bolts (4).



J20453

4-Bolt (2 pcs)

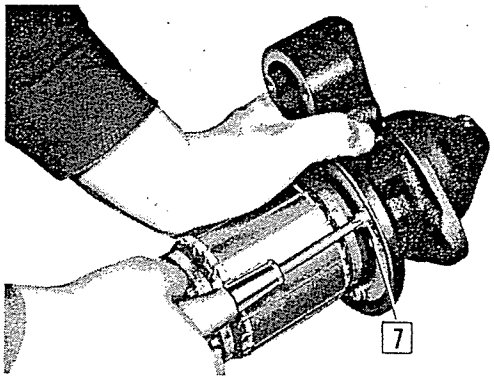
(4) Give light hammer blows to rear bracket (5) to remove yoke (6).



J20454

4-Bolt (2 pcs) 6-Yoke
5-Rear bracket

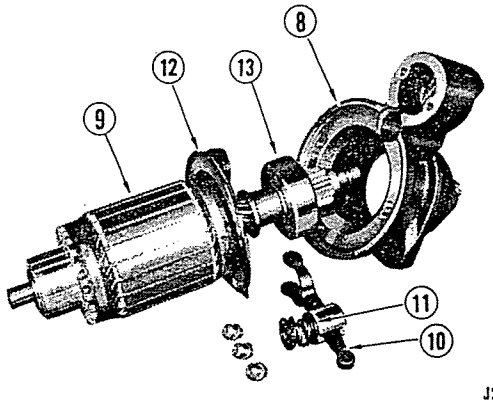
(5) Remove attaching bolts of center bracket (7).



J20455

7-Center bracket

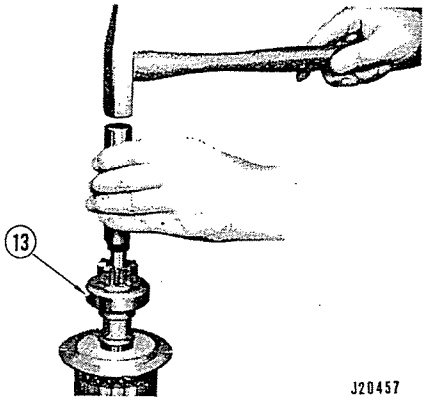
(6) Pull armature (9) out of front bracket (8) and remove lever (10), lever spring (11) and rubber packing (12).



J20456

8-Front bracket 11-Lever spring
9-Armature 12-Rubber packing
10-Lever 13-Overrunning clutch

(7) Remove overrunning clutch (13) from armature.

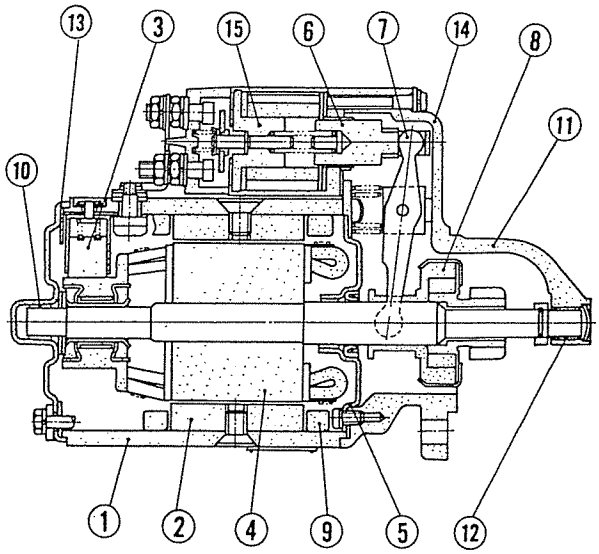


13-Overrunning clutch

NOTE

When removing center bracket, wrap tape around the shaft splines to prevent damage to oil seal.

(8) To assemble the starting motor, follow the reverse of disassembly procedure.

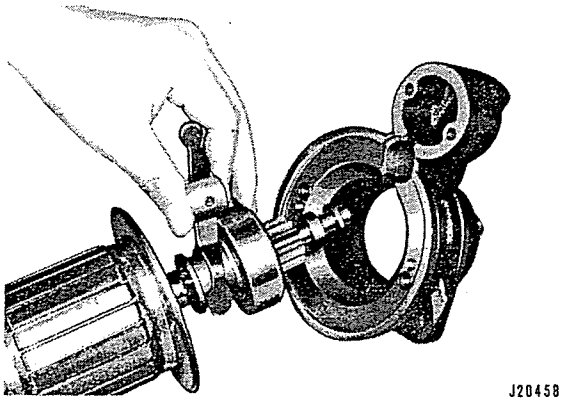


1-Yoke
2-Pole piece
3-Brush
4-Armature
5-Center bracket
6-Plunger
7-Lever
8-Overrunning clutch
9-Field coil
10-Metal
11-Front bracket
12-Metal
13-Rear bracket
14-Bolt
15-Switch

Starting motor assembly

NOTE

When installing lever, be careful to install it correctly.



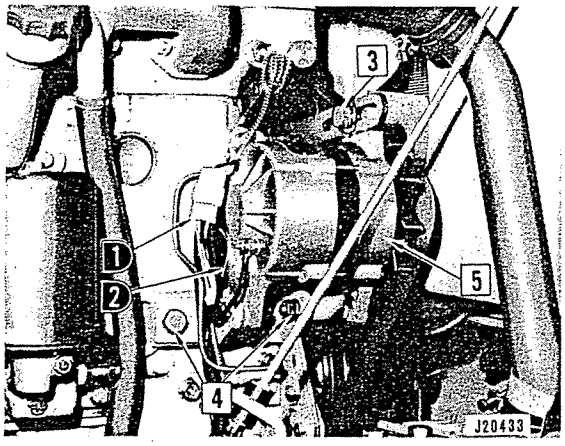
14. Alternator and relay

Removal and installation of alternator

(1) Disconnect wire lead from alternator and relay and disconnect ground harness (2). Loosen adjusting plate bolt (3) and remove fan belt.

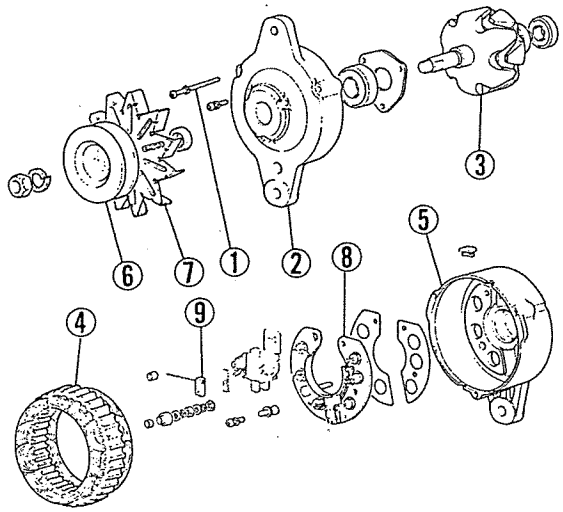
(2) Loosen alternator bracket bolts (4) and remove alternator assembly (5) from engine.

(3) To install the alternator, follow the reverse of removal procedure.



1-Wire lead between alternator and relay
2-Ground
3-Bolt and washer
4-Bolts, nuts and washers (2 pcs each)
5-Alternator assembly

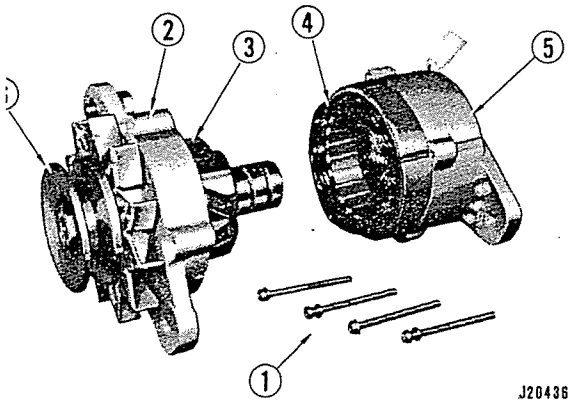
Disassembly and assembly of alternator



1-Bolt (3 pcs)	6-Pulley
2-Front bracket	7-Fan
3-Rotor	8-Diode
4-Stator coil	9-Brush
5-Rear bracket	

Alternator — exploded view

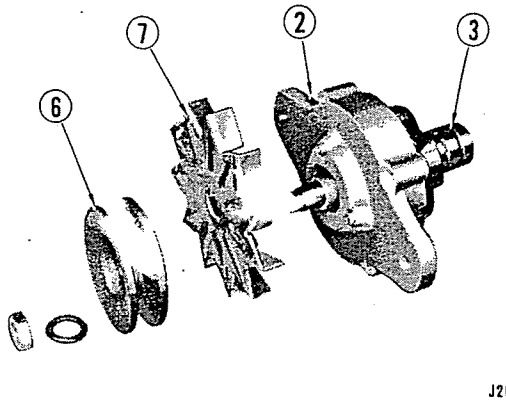
(1) Pulling out through bolts (1) will permit removal of rotor (3) (with front bracket and pulley) and stator coil (4) (with rear bracket).



J20436

1-Bolt (3 pcs)	4-Stator coil
2-Front bracket	5-Rear bracket
3-Rotor	6-Pulley

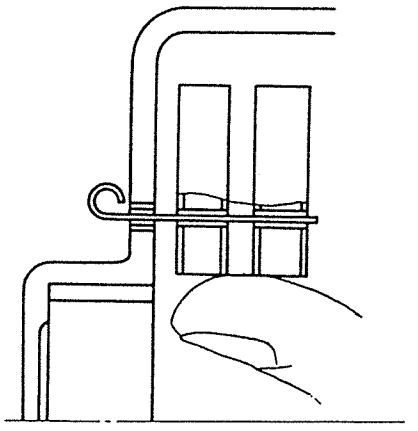
(2) Hold rotor in a vice and remove pulley by loosening pulley clamping nut.



J20437

2-Front bracket	6-Pulley
3-Rotor	7-Fan

(3) Assemble generator in the reverse order of disassembly. Place brush in brush holder and secure it by passing a pin through a small hole vacated by removing screw as shown. After assembly, be sure to pull out the pin.

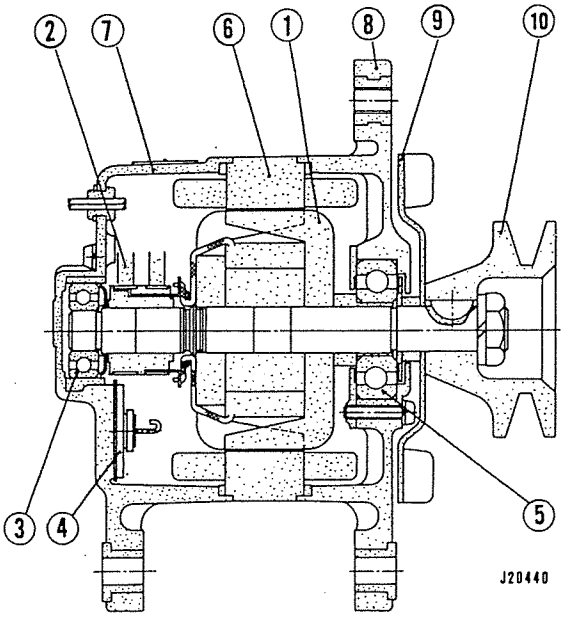


J20439

(4) Apply a coating of sealer to the mating surfaces between the stator and rubber packing and those between the front and rear brackets and rubber packing.

NOTE

Care should be taken to install the rubber packing to the stator properly.

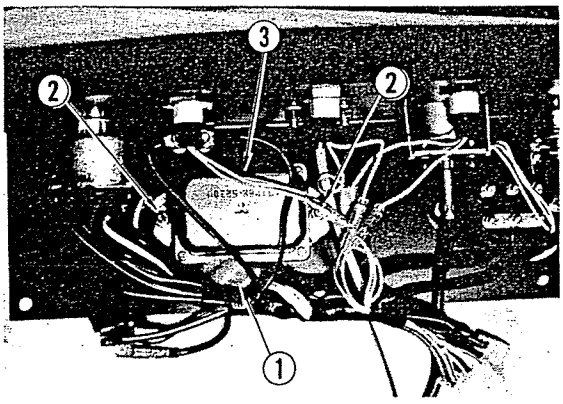


1-Rotor
2-Brush
3-Bearing
4-Diode
5-Bearing
6-Stator coil
7-Rear bracket
8-Front bracket
9-Fan
10-Pulley

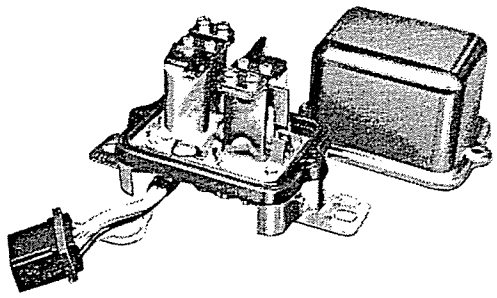
Alternator assembly

Removal and installation of relay

The generator relay is installed on dash board. Disconnect each wire (1), loosen relay attaching screws (2) and remove relay assembly (3). Install the relay in the reverse order of removal.



1-Relay wire
2-Screws (2 pcs)
3-Relay assembly



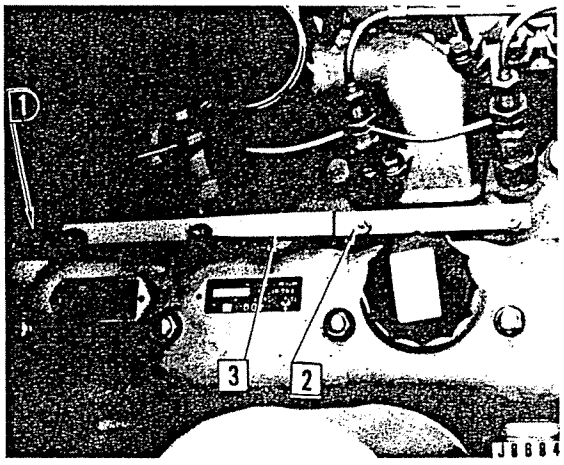
Relay

15. Preheating system

Removal and installation of glow plugs

(1) Before removing glow plugs from engine, be sure to disconnect battery terminals.

(2) Disconnect cable (1) from No. 4 cylinder glow plug. Loosen glow plug connection plate attaching nut (2) and remove connection plate (3).



1-Cable
2-Nut
3-Connection plate

(3) Remove all glow plugs from cylinder head. Take out packings from glow plug installation holes.

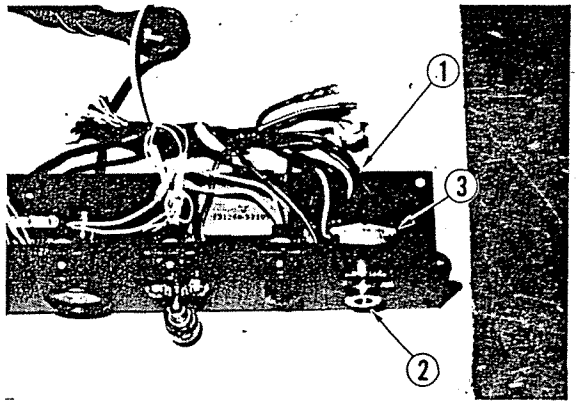
(4) Install glow plugs in the reverse order of removal.

Removal and installation of starter switch

(1) Disconnect starter switch wire from the instrument panel in the cab.

(2) Loosen nut located on starter switch key hole side and remove starter switch.

(3) Install starter switch in the reverse order of removal.

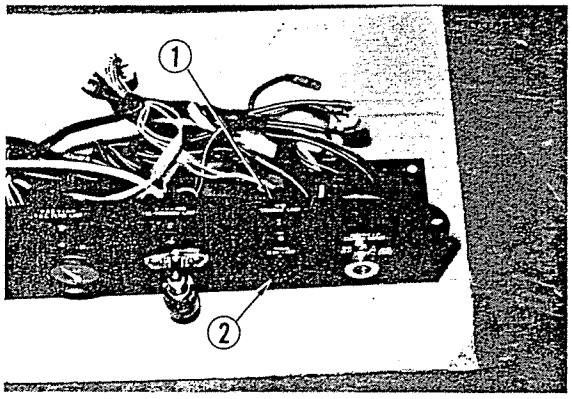


1-Wire lead
2-Nut
3-Starter switch

Removal and installation of glow plug pilot lamp

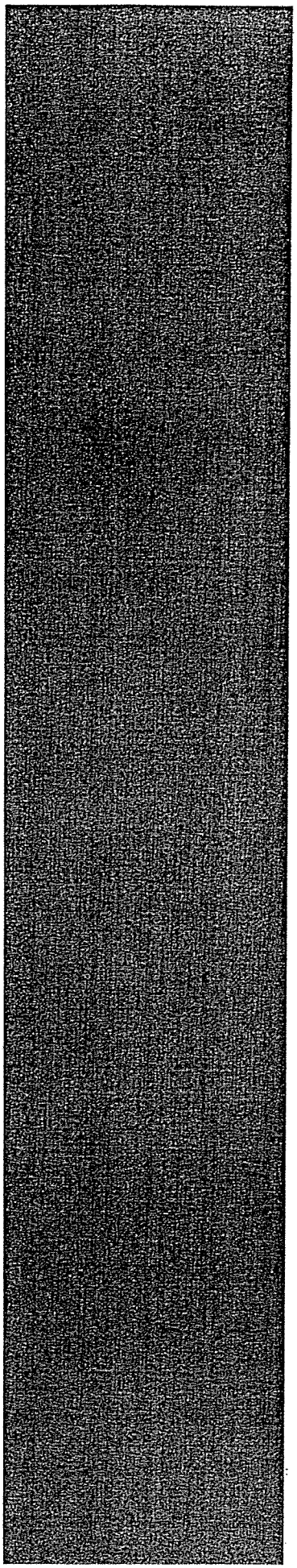
(1) Disconnect pilot lamp nichrome wire (1) from the instrument panel and remove pilot lamp.

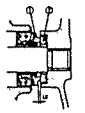
(2) Install glow plug pilot lamp in the reverse order of removal.



1-Wire
2-Glow plug pilot lamp

MAINTENANCE STANDARDS



Timing gear train	Idler	Fit of shaft in bore in crankcase	30 (1.181)	0.09T ~ 0.045T [(0.0035T ~ 0.0018T)]				
	Timing gear, backlash			0.12 ~ 0.24 (0.0047 ~ 0.0094)	0.3 (0.0118)		Replace gear.	
Lubrication system	Oil pump	Fit of main shaft in body	12.6 (0.496)	0.040 ~ 0.121 [(0.0016 ~ 0.0048)]		0.20 [(0.0078)]	Replace pump case.	
		Fit of outer rotor in body	40.5 (1.594)	0.2 ~ 0.275 [(0.0078 ~ 0.0108)]	0.5 [(0.0197)]			
		Depth of case and height of rotor	24 (0.945)	0.04 ~ 0.09 [(0.0016 ~ 0.0035)]	0.15 [(0.0059)]		Reface case cover or case.	
		Trochoid gear tooth clearance		0.013 ~ 0.15 [(0.0005 ~ 0.0059)]		0.25 [(0.0098)]		
	Oil pressure regulating valve		3.0 kg/cm^2 (42.7 psi)	± 0.3 kg/cm^2 (± 4.27 psi)				
Cooling system	Water pump bearings	Fit of outer race in pump casing	47 (1.850)	0.011T ~ 0.025T [(0.0004 ~ 0.0010)]			Replace pump case or pump assembly.	
			40 (1.575)	0.011T ~ 0.027T [(0.0004 ~ 0.0011)]				
		Fit of inner race on pump shaft	20 (0.787)	0.002T ~ 0.021T [(0.00008 ~ 0.00083)]				
			40 (1.575)	−0.001 (−0.00004) −0.017 (−0.00067)				
		Radial play	20 (0.787)	0.010 ~ 0.025 (0.00039 ~ 0.00098)		0.045 (0.00177)	Replace bearing.	Replace bearing when it does not rotate smoothly.
			17 (0.669)	0.010 ~ 0.022 (0.00039 ~ 0.00087)				
	Spacer, I.D.			0.001T ~ 0.019T [(0.00004 ~ 0.00075)]				
	Water pump impeller, vane-to-casing clearance (front and rear sides)		0.5 ~ 1 (0.020 ~ 0.039)				Replace impeller or bearing if vanes are binding.	 1-Floating seat (carbon) 2-Seal ring (ceramic)
	Unit seals	Carbon protrusion	1.5 (0.059)		0			
		Height (free length)	23.4 (0.921)	± 1 (± 0.04)				
	Thermostat	Valve opening temperature	76.5°C(169.7°F)	± 2°C (±35.6°F)				
		Valve lift	9 (90°C) [0.354 (194°F)]					

Unit: mm (in.)

Group	Part or item		Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
Cooling system	Belt, tension		Deflection: 12 (0.472)					
Fuel system	Injection nozzles	Injection pressure	120 kg/cm^2 (1706.4 psi)	$^{+10}_{-0}$ kg/cm^2 ($^{+142}_{-0}$ psi)	110 kg/cm^2 (1564.2 psi)		Adjust by means of shim(s).	Injection pressure varies 10 kg/cm^2 (142.2 psi) per 1 (0.04) of shim thickness.
		Spray angle	40°				Test by means of hand tester, using diesel fuel at, 20°C or 68°F approx. If spray pattern is improper even after nozzle is washed in clean kerosene, replace nozzle tip.	Spray of fuel oil should be uniform and consist of fine droplets.
		Needle valve seat oil-tightness	Seat should not be leaking under a pressure of 100 kg/cm^2 (1422 psi).				Wash needle valve seat or replace nozzle tip.	Replace nozzle tip when needle surface is scratched or scored.
	Fuel feed pump	Fit of tappet roller pin in pin hole	7 (0.276)	$^{0.013\sim0.071}_{(0.0005\sim0.0028)}$		Total play: 0.3 (0.0118), max.		
		Fit of tappet roller on roller pin		$^{0.033\sim0.085}_{(0.0013\sim0.0033)}$				
		Roller OD	15 (0.590)	0 ~ −0.027 (−0.0011)				
		Airtightness	No air should leak through clearance between push rod and housing.		See Assembly Standard.			Close pump discharge port with a plug. Apply an air pressure of 2 kg/cm^2 (28 psi) to the pump, and keep the pump immersed in diesel fuel longer than 1 minutes.
		Number of strokes for pumping (priming pump)		25, max.	30			Operate priming pump handle at a speed of 60 strokes/minute. Check the number of strokes requied for making the pump start dischaging at a head of 1 meter.
		Number of strokes for pumping		40 seconds, max.	50 seconds			Operate injection pump at 150 rpm to check the length of time required for the feed pump to start discharging.

Unit: mm (in.)

Group	Part or item			Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
General	Maximum rpm (no-load)			2800 ± 20				Adjust governor.	
	Minimum rpm (no-load)			650 ~ 700					
	Compression pressure			26 kg/cm^2 (369.7 psi), min. (at 150 ~ 200 rpm)	20 kg/cm^2 (284 psi)				Oil and water temperatures: 20 ~ 30°C (68 ~ 86°F)
	Engine oil pressure			3 ~ 4 kg/cm^2 (43 ~ 57 psi) (at 1500 rpm)	2 kg/cm^2 (28.4 psi)				Oil temperature: 70°C (158°F)
				1.5 kg/cm^2 (21.3 psi) min. (at idle speed)	0.5 kg/cm^2 (7.1 psi)				
	Valve timing	Intake valve	Opens	30° BTDC	± 3°				
			Closes	50° ABDC					
		Exhaust valve	Opens	74° BBDC					
			Closes	30° ATDC					
	Beginning of injection			25° ± 1 (Crank angle)					
Main moving parts	Cylinder liners	I.D.		84 (3.307)	+ 0.035 ~ 0 (+0.0014 ~ 0)	+0.20 (+0.008)	1.20 (0.047)	Hone liner to 0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295) or 1.00 (0.0394) oversize with prescribed tolerance. Oversize pistons and piston rings should be used.	Four liners should be finished to the same oversize. Hone cylinder bore to $87\ ^{-0.010}_{-0.045}$ ($3.425\ ^{-0.0004}_{-0.0018}$) and heat the crankcase. Press liners into crankcase and machine each liner I.D. to assembly standard.
		Out-of-roundness			0.015 (0.0006), max.				
		Taper							
	Pistons, protrusion above crankcase gasketed surface				0.35 ~ 0.75 (0.0138 ~ 0.0295)			Check bearing clearance.	
	Piston rings and ring grooves	No. 1 compression ring		2.5 (0.098)	[0.050 ~ 0.085 (0.0020 ~ 0.0033)]	[0.20 (0.0079)]		Use pistons by replacing piston rings up to service limit. Replace pistons when service limit is reached.	(1) Ring side clearance Measure side clearance with ring kept flush with second land. (2) Replace oil ring together with expander.
		No. 2 compression ring		2.0 (0.079)	[0.025 ~ 0.060 (0.0010 ~ 0.0024)]	[0.15 (0.0059)]			
		Oil ring		4.0 (0.157)					

Unit: mm (in.)

Group	Part or item		Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
Main moving parts	Piston ring gaps	No. 1 compression ring		0.30 ~ 0.50 [(0.0118 ~ 0.0197)]	1.5 [(0.059)]			When oil ring is compressed to 84 (3.307).
		No. 2 compression ring						
		Oil ring						
	Piston pins	Fit in pistons	25 (0.984)	0 ~ 0.016 [(0 ~ 0.0006)]	0.05 [(0.002)]		Use pistons by replacing piston pin, up to repair limit.	
		Fit in connecting rod bushings		0.020 ~ 0.051 [(0.0008 ~ 0.0020)]	0.08 [(0.003)]		Replace pistons or bushings. (Ream if necessary.)	
	Pistons, variance in weight per engine			± 3g (± 0.1 oz)				
	Connecting rods	Variance in weight per engine		± 5g (± 0.17 oz)				
		Fit on crankpin O.D. (big end bearing I.D.) (in two directions at right angles to each other with bearing in place)	58 (2.283)	0.035 ~ 0.100 [(0.0014 ~ 0.0040)]	0.20 [(0.008)]		Use connecting rods by replacing bearings, up to repair limit. Regrind crankpins and use undersize bearings when repair limit is reached.	Cap must be installed with marks on cap and rod on the same size.
		Fit on crankpins (length)	35 (1.378)	0.15 ~ 0.35 [(0.006 ~ 0.014)]	0.50 [(0.020)]		Replace connecting rods.	
		Parallelism between piston pin bushings and crankpin bearings		0.05/100 (0.002/4), max.				
	Crankshaft	Center-to-center dimension between journals and crankpins	47 (1.850)	± 0.05 (± 0.002)				
		Parallelism between crankpins and journals		0.01 (0.0004), max as runout				
		Out-of-roundness of crankpins and journals		Variance in dia.: 0.01 (0.0004), max	0.03 (0.0012)			
		Taper of crankpins and journals						
		Fillet radius	3 (0.12)	± 0.2 (0.008)				
		Variance in crankpin angles		± 20′				

Main moving parts	crank-shaft	Runout (measured with 1st and 4th journals held in "V" blocks			0.02 (0.0008), max	0.05 (0.0020)		Straighten or replace crankshaft.	
	Main bearings	Fit on crankshaft journal (in two directions at right angles to each other with bearing in place)		65 (2.559)	0.03 ~ 0.089 [(0.0012 ~ 0.0035)]	[0.20 (0.008)]	−0.9 (−0.035) (at crankshaft journal O.D.)	Replace bearings up to repair limit. Regrind crankshaft journals and use undersize bearings 0.25 (0.0098), 0.50 (0.0197) or 0.75 (0.0295) when repair limit is reached.	(1) Replace crankcase and bearing caps as an assembly. (2) Install bearing so that shell having oil hole comes to upper side.
		Thrust clearance		3.7 (0.146)	0.1 ~ 0.189 [(0.004 ~ 0.0074)]	[0.30 (0.012)]		Replace thrust bearing.	
	Flywheel, face runout				0.1 (0.004), max				Install dial gauge to flywheel and measure face runout with respect to flywheel housing rear end.
Cylinder head	Crankcase, warpage on gasketed surface				0.05 (0.002), max	0.2 (0.008)		Regrind if warpage is minor.	
	Cylinder head	Warpage of gasketed surface							
		Valve seat angle		45°					
		Valve sinkage		0.8 (0.031)	± 0.2 (± 0.008)	1.3 (0.051)			
		Valve seat width		1.4 (0.055)	± 0.14 (± 0.0055)	1.6 (0.063)			
	Valve guides, protrusion above cylinder head gasketed surface			18 (0.709)	± 0.3 (± 0.012)				
	Cylinder head gasket, as-installed thickness			1.35 (0.053)	± 0.05 (± 0.002)				
Timing gear train	Valves	Fit of valve stem in guide	Intake valve	8 (0.315)	0.055 ~ 0.085 [(0.0022 ~ 0.0033)]	[0.15 (0.0059)]		Replace valve guide when repair limit is reached.	
			Exhaust valve		0.070 ~ 0.100 [(0.0028 ~ 0.0039)]	[0.20 (0.0079)]			
		Margin		1.5 (0.059)			Reface to 1.2 (0.047)		
		Face runout of head			0.03 (0.0012), max (perpendicular to valve face)				

Unit: mm (in.)

Group	Part or item		Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
Timing gear train	Valve springs	Free length	48.85 (1.923)		47.6 (1.874)			
		As-installed length	43 (1.693)		44 (1.732)		Adjust by means of shim(s) when repair limit is reached.	
		Squareness		0.4 (0.016)/25 (0.98), max.				Squareness of each end with respect to center line.
	Valve clearance		0.25 (0.0098) (cold setting)					0.25 clearance may also be obtained by warm setting if intake and exhaust valves are at the same temperature.
	Tappets, fit in crankcase		22 (0.8661)	[0.035 ~ 0.086 (0.0014 ~ 0.0034)]	[0.12 (0.0047)]	+0.10 (+0.004) (at tappet hole dia.)	Replace tappet until repair limit is reached.	
	Valve push rods, bend			0.4 (0.016), max.				
	Rocker arms, fit on rocker arm shaft		18 (0.709)	[0.016 ~ 0.095 (0.0006 ~ 0.0037)]	[0.10 (0.0039)]		Replace bushing until repair limit is reached.	
	Camshaft	Fit of No. 1 journal in bushing	54 (2.126)	[0.040 ~ 0.090 (0.0016 ~ 0.0035)]	[0.15 (0.0059)]		Replace bushing when repair limit is reached. (Ream if necessary.)	
		Fit of No. 2 journal in bushing						
		Fit of No. 3 journal in bushing	53 (2.087)					
		Fit of thrust plate on thrust journal	5 (0.197)	[0.05 ~ 0.112 (0.0019 ~ 0.0044)]	[0.3 (0.0118)]		Replace thrust plate.	
		Cam height — For exhaust valves	45.944 (1.8088)			Cam lift: For exhaust valves 6.84 (0.269) For intake valves 6.18 (0.243)	Replace camshaft.	
		Cam height — For intake valves	46.916 (1.8471)					
		Cam dia. — For exhaust valves	38.600 (1.5197)					
		Cam dia. — For intake valves	40.232 (1.5839)					
		Runout		0.02 (0.0008), max.	0.05 (0.0020)		Straighten or replace.	
	Idler	Fit of bushing on shaft	36 (1.417)	[0.025 ~ 0.075 (0.0010 ~ 0.0030)]	[0.1 (0.0039)]		Replace bushing.	
		Fit of boss on thrust journal	26 (1.024)	[0.05 ~ 0.15 (0.0020 ~ 0.0059)]	[0.35 (0.0138)]		Replace thrust plate.	

Fuel system	Fuel feed pump	Displacement		900 cc (55 cu in.)/min, min.	600 cc (37 cu in.)/min, min.			Check displacement with injection pump operated at 1000 rpm with a discharge pressure of 1.5 kg/cm^2 (21 psi).
	Fuel injection pump	Cam height	32 (1.260)	0 ~ −0.1 (0 ~ −0.0039)		−0.2 (−0.0079)	Replace camshaft.	Check cam surface for condition.
		Axial play of camshaft bearing		0.03 ~ 0.05 [(0.0012 ~ 0.0020)]	0.1 (0.004)		Adjust by means of shim.	
		Fit of tappet pin in tappet (hole)	7 (0.276)	0.013 ~ 0.050 [(0.0005 ~ 0.0020)]				
		Fit of tappet floating bushing on tappet pin		0.033 ~ 0.078 [(0.0013 ~ 0.0031)]		Total play: 0.3 (0.0118), max.	Replace tappet complete.	
		Fit of tappet roller on floating bushing	11 (0.433)	0.050 ~ 0.097 [(0.0020 ~ 0.0038)]				
		Tappet roller OD	17 (0.669)	0 ~ −0.027 (0 ~ −0.0010)		−0.075 (−0.0030)		
		Plunger springs — Free length	49.4 (1.945)	±1 (0.04)		−0.5 (−0.020)		
		Plunger springs — As-installed length	44 (1.732)					
		Backlash between pinion and rack		0.15 (0.0059)		0.25 (0.0098)		
		Rack sliding resistance	150 g (5.3 oz) with pump at standstill 50 g (1.8 oz) with pump running at 1000 rpm					
		Free length of delivery valve spring	32 (1.26)	±0.5 (±0.02)		−1 (−0.04)		
		Lift before beginning of injection	1.95 (0.077)	±0.05 (±0.002)				
		Fuel injection quantity						Mount injection pump on pump tester and allow pump to inject.

Pump speed rpm	Rack position mm	Injection quantity mm^3 (cu in.)/rev. cyl	Variance mm^3 (cu in.)/rev. cyl
2000	8.5 (0.335)	36 ~ 39 (0.0022 ~ 0.0024)	≦3 (0.0002)
1000			≦2 (0.0001)
1000	8.0 (0.315)	32 ~ 35 (0.0020 ~ 0.0021)	
200	6.0 (0.236)	10 ~ 16 (0.0006 ~ 0.0010)	

Unit: mm (in.)

Group		Part or item	Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
Fuel system	Fuel injection pump	Fuel injection quantity	Test conditions Nozzle tip: ND - DN40 SDND32 Injection pipe: 6 x 1.6 x 600 (1/16 x 1/4 x 23-5/8) Injection pressure: 120 kg/cm² (1706.4 psi) Delivery pressure: 2.0 kg/cm² (28.44 psi) Test oil: ASTM Diesel fuel No. 2					
	Governor	Fit of flyweight bushing on shaft	7 (0.2756)	0.019 ~ 0.047 (0.0007 ~ 0.0019)	0.025 (0.0010)		Replace flyweight assembly.	
		Fit ot flyweight bushing on governor shaft	11 (0.433)	0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.10 (0.0039)		Replace bushing.	
		Accelerating gear backlash		0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.20 (0.0079)			
		Slip torque of gear complete		0.4 ~ 0.6 kg-m (2.90 ~ 4.34 ft-lb)			Adjust by means of shim.	
		Fit of governor sleeve on governor shaft		0.006 ~ 0.059 (0.0002 ~ 0.0023)	0.15 (0.0059)			
		Fit of governor sleeve on sliding piece	6 (0.236)	0.03 ~ 0.13 (0.0012 ~ 0.0051)	0.18 (0.0071)			Replace sliding piece.
		Fit of floating lever bottom end(hole)on connecting bolt		0.01 ~ 0.052 (0.0004 ~ 0.0020)	0.08 (0.0031)			Replace floating lever or connecting bolt.
		Fit of floating lever bottom end (hole) on shackle pin						Replace floating lever or shackle pin.
		Fit of shackle on pin						Replace shackle or shackle pin.
		Fit of shackle rack side on bushing	8 (0.315)	0.01 ~ 0.055 (0.0004 ~ 0.00217)				Replace shackle or bushing.
		Fit of control lever shaft in bearing bushing		0.025 ~ 0.07 (0.0010 ~ 0.0028)	0.2 (0.008)			Replace shaft or bushing.
		Fit of adaptor capusle on adaptor	5 (0.197)	0.02 ~ 0.13 (0.0008 ~ 0.0051)	0.18 (0.0071)		Adaptor should slide smoothly in axial direction.	
	Mechanical governor							

Step	Item	Adjusting lever angle	Pump rpm Np. rpm	Control rack position RW. mm	Fuel injection quantity mm³ (cu in.)/rev. cyl
1	High-speed control	4° ± 5°	1150 1400 1300	8.3 ~ 8.7 (0.327 ~ 0.343) 3.3 ~ 3.9 (0.130 ~ 0.154) 5.9 ~ 6.9 (0.232 ~ 0.272)	

Fuel system — Mechanical governor

2	Angleich control	4° ± 5°	350 600 700	9.7 ~ 9.6 (0.382 ~ 0.378) 8.7 ~ 9.3 (0.343 ~ 0.366) 8.4 ~ 9.0 (0.331 ~ 0.354)	
3	Low-speed control	− 16° ± 5°	300 400 100	5.5 ~ 6.1 (0.217 ~ 0.240) 4.1 ~ 5.5 (0.161 ~ 0.217) ≧ 14.8 (0.583)	
4	Requirements	4° ± 5°	600		36.5 ± 1.5 (0.0022 ± 0.00009) (At full-load stopper)
			1150		36.0 ± 1.5 (0.0022 ± 0.00009) (At torque spring)
			1400		6 ± 1 (0.0004 ± 0.00006) (At lever)
5	Stop lever operation	RW shall be not more than 2 mm (0.08 in.) when adjusting lever VH is placed in low-speed control position.			

Electrical system — Starter

No-load operation			Load operation			Magnetic switch operating voltage	
Voltage (V)	Current (A)	Rpm	Voltage (V)	Current (A)	Torque	Switch IN	Switch OFF
23	55, max.	4500, min.	9	710, max.	3.5 kg-m (25 ft-lb), min.	16V, max.	When circuit is opened.

Shaft	Rear	Metal	Rear	Intermediate metal	Commutator O.D. service limit	Brush		
	Front		Front	Bracket shaft		Thickness x Width x Height	Wear	Spring compression, kg (lb)
$14.2\ ^{-0.050}_{-0.077}$ $(0.559\ ^{-0.0020}_{-0.0030})$		$14.2\ ^{+0.027}_{-0.016}$ $(0.559\ ^{+0.0011}_{-0.0006})$		$20.6\ ^{+0.02}_{-0.08}$ $(0.811\ ^{+0.0008}_{-0.0031})$	43.2 (1.701)	6.5 x 1.9 x 1.9 (0.256 x 0.075 x 0.075)	6 (0.236)	2 (4.4) ± 1.5 %
$12.2\ ^{-0.050}_{-0.077}$ $(0.480\ ^{-0.0020}_{-0.0030})$		$12.2\ ^{+0.027}_{-0.016}$ $(0.480\ ^{+0.0011}_{-0.0006})$		$20.3\ ^{0}_{-0.033}$ $(0.799\ ^{0}_{-0.0013})$	42.2 (1.661)			

Electrical system — Alternator

No-load operation (battery connected)			Load operation (battery + resistance load 12.5A connected)		
Terminal voltage(V)	Current (A)	Rpm	Terminal voltage(V)	Current (A)	Rpm
28	0	1100, max.	28	12.5	1900, max.

Ball bearings	Rear	Field resistance 20°C (68°F)
	Front	
#6201		27 (Ω)
#6303		

Unit: mm (in.)

Group	Part or item	Nominal dimension	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remedy	Remarks
Electrical system	Relay						

	Voltage regulator	Lamp relay
Air gap	1.0 ~ 1.4 (0.039 ~ 0.055)	0.9 ~ 1.4 (0.035 ~ 0.055)
Contact point gap		0.7 ~ 1.1 (0.028 ~ 0.043)
Back gap	0.7 ~ 1.5 (0.028 ~ 0.059)	
No-load voltage (V)	28 ~ 31 at 300 rpm (alternator speed)	
Cut-out voltage (V)		7.5 ~ 9.5
Cut-in voltage (V)		5.5, max.

TIGHTENING TORQUE

Unit: kg-m (ft-lb)

Item	Torque	Item	Torque
Cylinder head bolts	12 (86.8)	Idler thrust plate bolt	3.5 (25.3)
Main bearing cap bolts	8.5 (61.5)	Rear oil seal bolts	0.4 (2.9)
Connecting rod cap bolts	5.5 (39.8)	Oil pan bolts	0.7 (5.1)
Flywheel bolts	8.5 (61.5)	Oil case bolts	0.7 (5.1)
Camshaft thrust plate bolts	1.8 (13.0)	Oil pan drain plug	10.0 (72.3)
Front plate bolts	1.0 (7.2)	Nozzle holder retaining nuts	5.0 (36.2)
Timing gear case bolts	1.0 (7.2)	Injection pump delivery valve holders	3.0 (21.7)
Crankshaft pulley nut	40 (289)	Flywheel housing bolts	3.5 (25.3)
Camshaft gear bolt	3.5 (25.3)		

APPLICATION OF SEALERS

Sealing point	Mating part	Sealer	Remarks
Oil pan gasket	Crankcase	THREE BOND No.2	Apply to crankcase bottom surface. Do not use too much sealer or the excess will squeeze out of rear cap bolt holes.
	Front and rear	ATMOJET No. 2	Apply to both sides of cork packing
Main oil gallery plug	Crankcase	HERME SEAL H - 1	Apply to crankcase bore. After installing plug, apply to plug.
Crankcase screw plug	Crankcase		Apply to threaded portion.
Front plate gasket	Front plate	THREE BOND No. 2	Apply when installing temporarily.
	Crankcase		Apply to gasket when installing.
Gear case gasket	Gear case		Apply when installing temporarily.
	Front plate		Apply to gasket when installing.
Oil filler attaching bolts	Crankcase oil filler		Apply to gasket when installing. Do not use too much sealer or the excess will squeeze out of attaching bolt (lower) holes.
Water pump gasket	Plate		Apply when installing temporarily.
	Water pump		Apply to gasket when installing.
Pump plate gasket	Plate		Apply when installing temporarily.
	Crankcase		Apply to around port when installing.
Water bypass hose nipple	Thermostat cover, pump	HERME SEAL H - 1	Apply to threaded portion.
Gear case attaching bolts	Crankcase, gear case		Apply to threaded portion of one upper bolt and two lower bolts.
Manifold studs	Cylinder head		Apply to tapped holes (through holes only)

TROUBLESHOOTING

TROUBLESHOOTING

A good program of troubleshooting–diagnosing and testing–is the key to not only safety for mechanics but economy for the engine. It should consist at least of the following seven basic steps:

1. Know the system

Study the service manual and parts list to know how the system is designed, how it works. Read the latest service bulletins and other technical news. Problems on your engine may be found in this month's bulletin.

2. Ask the operator

You can get the full story from the operator; he will tell you how the engine acted when it began to fail, what was abnormal about it. Ask about how the engine was used. Most failures are usually traced to poor servicing or abuse of the engine.

3. Operate the engine

Operate the engine if it is able to start. While you operate the engine, ask yourself as you asked the operator to have more data for examination. Do not trust what the operator told you; check the engine by yourself.

4. Check the engine

Check the engine for visual defects first. Use your eyes, ears and nose to locate failure. While inspecting, list up all the possible causes. It is your responsibility to check the engine safely.

5. List up the possible causes

Now you can make a list of the possible causes. What signs did you find while inspecting the engine? What is the most likely cause? Any other possibilities?

6. Reach a conclusion

Look over the possible causes you listed and decide which is most likely, which is easiest to verify. Reach you decision on the leading causes and plan to check them first for saving time. Consult your foreman for specific problems.

7. Review your conclusion

As the final step, review your conclusion to see if it is correct before starting repair. Some of the causes on your list can be verified without further examination, but others should be further analyzed.

TROUBLESHOOTING CHART (1)

	Complaint / Possible cause	Engine will not start: Engine turns over but does not start: No exhaust smoke	Engine will not start: Engine turns over but does not start: A little exhaust smoke	Engine will not start: Engine turns over but does not start: Too much exhaust smoke	Engine will not start: Starting motor does not turn over sufficiently to crank engine	Engine will not start: Engine does not turn: Engine can be cranked manually	Engine will not start: Engine does not turn: Engine cannot be cranked manually	Glow plugs do not glow red	Glow plugs glow red too early	Engine lacks power: A little exhaust smoke	Engine lacks power: Too much whitish exhaust smoke	Engine lacks power: Too much black exhaust smoke	Abnormal exhaust smoke: When idling	Abnormal exhaust smoke: When operating: Whitish exhaust smoke	Abnormal exhaust smoke: When operating: Black exhaust smoke	Engine knocks excessively	Engine is noisy	Engine runs rough	Engine hunts: When idling	Engine hunts: When operating
Fuel system	Insufficient fuel supply to injection pump	○	○	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—
	Greater variance of injection quantity	—	—	○	—	—	—	—	—	—	—	○	○	—	○	○	—	○	○	○
	Defective injection pump seals	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Insufficient injection quantity	○	○	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—
	Excessive injection quantity	—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	—
	Improper fuel spray from injection nozzles	—	—	○	—	—	—	—	—	—	—	○	○	—	○	○	—	○	○	○
	Excessive fuel return from injection nozzles	—	○	—	—	—	—	—	—	○	—	—	—	—	—	—	—	○	—	—
	Injection timing too advanced	—	—	○	—	—	—	—	—	—	—	○	—	○	○	—	○	—	—	—
	Injection timing too retarded	—	—	○	—	—	—	—	—	—	○	—	○	—	—	—	—	○	—	—
	Defective auto timer	—	—	—	—	—	—	—	—	—	—	○	○	—	○	○	—	—	—	—
	Defective governor control spring	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Maladjusted governor damper spring	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	○
	Engine speed too low	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	—
	Failure of engine to stop properly	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Poor grade of fuel oil	—	—	○	—	—	—	—	—	—	○	○	○	○	○	—	○	—	—	—
	Fuel viscosity too high	○	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lubrication system	Poor grade of oil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Oil viscosity too high	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Oil viscosity too low	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	—
	Low oil pressure	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Excessive oil leakage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Pumping up of oil	—	—	—	—	—	—	—	—	—	—	—	—	○	—	○	○	—	—	—
	Clogged oil filter	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective oil bypass alarm or lamp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective oil indicator switch or lamp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Air system	Insufficient air	—	—	○	—	—	—	—	—	—	—	○	—	—	—	○	—	—	—	—
	Poor compression	—	—	○	—	—	—	—	—	—	○	○	○	○	○	○	○	—	○	○
	Low pressure at high atomospheric temperature (or altitude)	—	—	—	—	—	—	—	—	—	—	○	—	—	○	—	—	—	—	—

(● For detailed information refer to the separate chart.)

Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speed	Engine operates at high speeds but fails to stop	Engine turns in reverse direction	Excessive fuel consumption	Excessive oil consumption	Oil is diluted by fuel	Water in oil	Excessive blow-by	Defective lubrication system: When engine stops, warning lamp does not come on	Defective lubrication system: Warning lamp comes on at low-speed operation	Defective lubrication system: Warning lamp comes on at high-speed operation	Abnormal water temperature rise: Water temperature too high (Engine overheats)	Abnormal water temperature rise: Water temperature too low	Defective alternator: Indicator lamp does not come on when engine stops	Defective alternator: Indicator lamp comes on at high-speed operation	Remedy
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●
○	○	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●
—	—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	Check and replace if necessary.
—	○	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●
○	○	—	—	—	—	○	—	○	—	—	—	—	—	○	—	—	—	●
—	○	—	—	—	—	○	—	○	—	—	—	—	—	—	—	—	—	●
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace nozzle tips.
○	○	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	●
○	—	○	○	—	—	—	—	—	—	—	—	—	—	○	—	—	—	●
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check and replace spring if necessary. Then adjust governor setting on bench.
—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Adjust.
○	○	—	—	—	○	—	—	—	—	—	—	○	—	—	—	—	—	Adjust idling set bolt. Hold lever in STOP position.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
—	○	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	●
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Use fuel for cold weather.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Use good quality oil.
—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	Use proper viscosity oil.
—	—	—	—	—	—	—	○	—	—	○	—	○	—	—	—	—	—	Use proper viscosity oil.
—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	●
—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	Retighten and replace packing if necessary.
—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	●
—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	Change element and oil.
—	—	—	—	—	—	—	—	—	—	○	○	○	—	—	—	—	—	Check and replace if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check and replace if necessary.
—	○	—	○	—	—	○	—	—	—	—	—	—	—	—	—	—	—	●
—	○	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	●
—	—	—	—	—	—	○	—	—	—	—	—	—	—	○	—	—	—	(Adjust full-load setting of governor.)

	Complaint / Possible cause	Engine will not start: Engine turns over but does not start: No exhaust smoke	Engine will not start: Engine turns over but does not start: A little exhaust smoke	Engine will not start: Engine turns over but does not start: Too much exhaust smoke	Engine will not start: Starting motor does not turn over sufficiently to crank engine.	Engine will not start: Engine does not turn: Engine can be cranked manually	Engine will not start: Engine does not turn: Engine cannot be cranked manually	Glow plugs do not glow red	Glow plugs glow red too early	Engine lacks power: A little exhaust smoke	Engine lacks power: Too much whitish exhaust smoke	Engine lacks power: Too much black exhaust smoke	Abnormal exhaust smoke: When idling	Abnormal exhaust smoke: When operating: Whitish exhaust smoke	Abnormal exhaust smoke: When operating: Black exhaust smoke	Engine knocks excessively	Engine is noisy	Engine runs rough	Engine hunts: When idling	Engine hunts: When operating
Cooling system	Engine is too cold.	—	—	○	○	—	—	—	—	—	—	—	○	—	—	○	—	—	—
	Radiator dissipates heat excessively	—	—	—	—	—	—	—	—	—	○	—	○	○	—	○	—	—	—
	Insufficient coolant	—	—	—	—	—	—	—	—	—	—	○	—	—	○	—	—	—	—
	Failure of radiator to dissipate heat properly	—	—	—	—	—	—	—	—	—	—	○	—	—	○	—	—	—	—
	Water leak through cylinder head gasket	—	—	—	—	—	—	—	—	—	○	—	○	○	—	—	—	○	—
	Cracks in crankcase water jacket	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Electrical system	Defective starter switch	—	—	—	—	○	—	○	—	—	—	—	—	—	—	—	—	—	—
	Defective starter magnetic switch	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective starting motor	—	—	—	○	○	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective starting motor free wheel	—	—	—	○	○	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective flywheel ring gear and pinion	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	—
	Battery voltage drop	—	—	○	○	○	—	○	—	—	—	—	—	—	—	—	—	—	—
	Open circuit in heater plugs or pilot lamp	—	—	○	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—
	Short circuit in heater plugs	—	—	○	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—
	Defective alternator	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Defective alternator relay	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Improper wiring	—	—	○	○	○	—	—	○	—	—	—	—	—	—	—	—	—	—
Main moving parts	Jammed moving parts	—	—	—	○	—	○	—	—	—	—	○	—	—	○	—	○	○	—	—
	Worn cylinders, pistons or piston rings	—	—	○	—	—	—	—	—	—	○	—	○	○	—	○	○	—	—	—
	Sticking piston rings	—	—	○	—	—	—	—	—	—	○	—	○	○	—	○	—	—	—	—
	Excessive main bearing clearance	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—
	Loose connecting rod cap bolts	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—
	Interference between valve and piston	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	○	—	—	—
	Broken valve springs	—	—	○	—	—	—	—	—	—	○	—	○	○	—	—	○	○	○	○
	Excessive valve clearance	—	—	—	—	—	—	—	—	—	—	○	—	—	○	—	○	○	○	○
	Foreign substances in cylinders	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	○	—	—	—
	Excessive gear backlash	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—

(● For detailed information refer to the separate chart.)

Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speed	Engine operates at high speeds but fails to stop	Engine turns in reverse direction	Excessive fuel consumption	Excessive oil consumption	Oil is diluted by fuel	Water in oil	Excessive blow-by	Defective lubrication system: When engine stops, warning lamp does not come on	Defective lubrication system: Warning lamp comes on at low-speed operation	Defective lubrication system: Warning lamp comes on at high-speed operation	Abnormal water temperature rise: Water temperature too high (Engine overheats)	Abnormal water temperature rise: Water temperature too low	Defective alternator: Indicator lamp does not come on when engine stops	Defective alternator: Indicator lamp comes on at high-speed operation	Remedy
—	○	—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	Heat oil pan from bottom side at starting. After starting, warm up engine thoroughly.
—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	○	—	—	●
—	—	—	—	—	—	—	○	—	—	○	—	○	—	○	—	—	—	●
—	—	—	—	—	—	—	○	—	—	○	—	○	—	○	—	—	—	●
—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	Retighten and replace gasket if necessary.
—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	Replace crankcase.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check for connections and repair. Replace if necessary.
—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace motor if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace ring gear. Replace pinion.
—	—	—	—	—	○	—	—	—	—	—	○	—	—	—	—	○	—	Recharge or replace battery. If necessary heat it.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace copper packings and if necessary heater plugs.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	Replace alternator if necessary.
—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	○	○	Adjust or replace.
—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	○	—	Connect wires properly.
—	○	—	○	—	—	○	○	—	—	○	—	—	—	○	—	—	—	●
—	○	—	—	—	—	○	○	○	—	○	—	—	—	—	—	—	—	Repair or replace.
—	○	—	—	—	—	○	○	○	—	○	—	○	○	—	—	—	—	Repair or replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check and replace bearing(s) with undersize one(s) if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Retighten.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Re-time timing gear train or adjust valve sinkage properly.
○	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace.
○	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Adjust valve clearance to 0.25 mm (0.0098 in.).
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace gears or idler bushing.

TROUBLESHOOTING CHART (2)

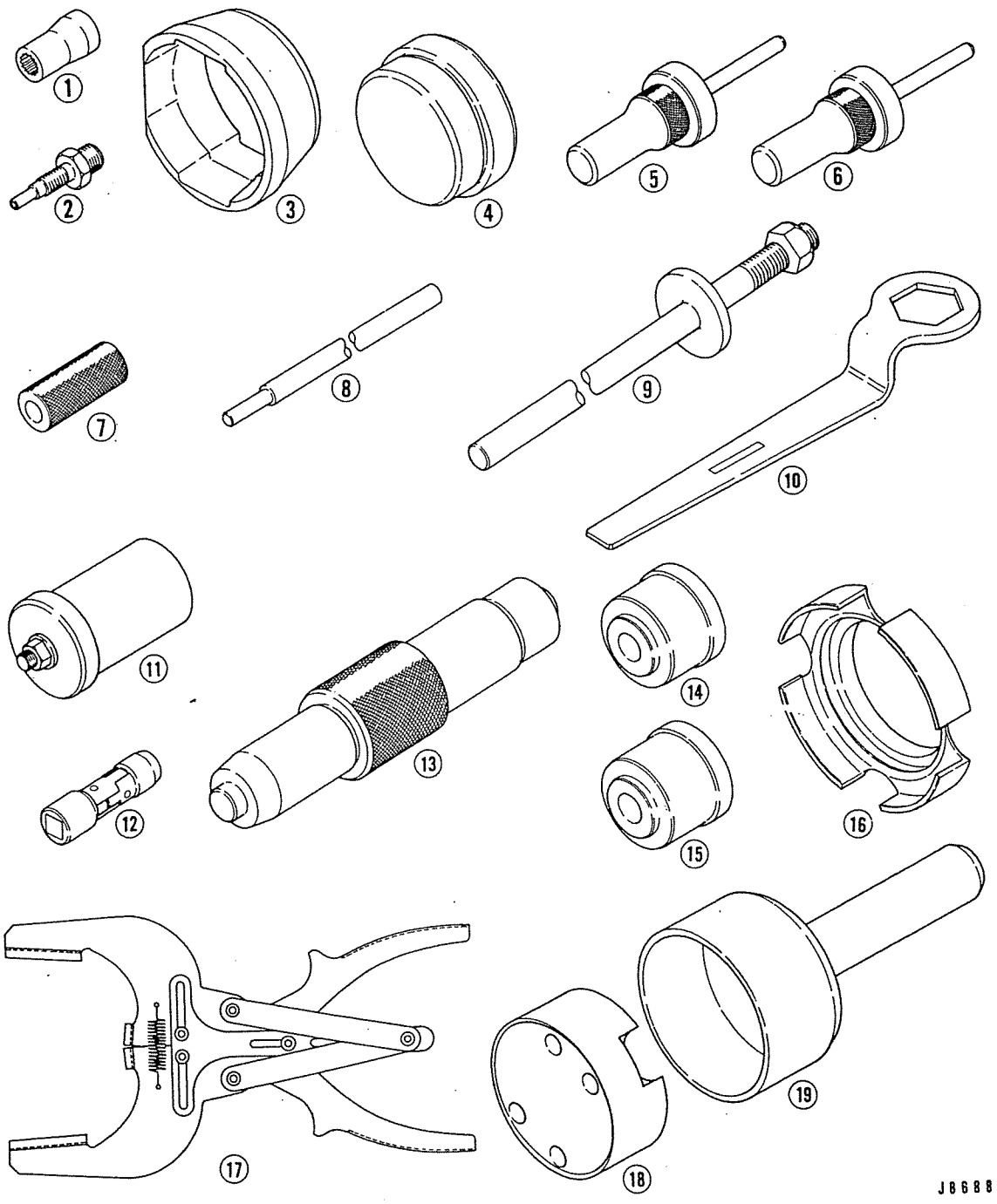
Possible cause		Remedy
Poor fuel supply to fuel injection pump	Closed fuel tank supply cock	Open the cock.
	No fuel in tank	Fill fuel tank.
	Clogged fuel lines	Repair or clean fuel pipes with air.
	Air in fuel system	Retighten connections or replace fuel pipes.
	Clogged fuel feed pump inlet strainer	Remove and clean strainer.
	Defective fuel feed pump	Repair.
	Leaky fuel lines or connections	Retighten connections.
	Clogged fuel filter	Disassemble and clean filter.
	Air in fuel system	Bleed air out of fuel system
Greater variance of injection quantity	Jammed plungers	Replace plungers.
	Jammed tappets	Replace tappets.
	Worn plungers	Replace plungers.
	Worn tappet cams	Replace tappet cams.
	Worn bearings	Replace bearings.
	Worn or broken plunger springs	Replace plunger springs.
	Loose plunger pinions	Reinstall properly by matching marks.
	Defective delivery valves	Replace valves.
	Worn or broken delivery valve springs	Replace valve spring.
Insufficient injection quantity	Governor stop lever link is binding.	Straighten link, placing lever in neutral position.
	Control rack is sticky.	Relubricate or repair.
	Jammed plungers	Replace plungers.
	Jammed tappets	Replace tappets.
	Worn plungers	Replace plungers.
	Worn tappet cams	Replace tappet cams.
	Worn bearings	Replace bearings.
	Loose plunger pinions	Reinstall properly by matching marks.
	Improper full-load setting of governor	Adjust governor setting on bench.
Excessive injection quantity	Stop lever jammed in "increase" position.	Repair lever link, placing lever in neutral position.
	Improper full-load setting of governor	Adjust governor setting on bench.
	Loose plunger pinions	Reinstall properly by matching marks.

Possible cause		Remedy
Improper fuel spray from injection nozzles	Sticking needle valve in one or more nozzles	Repair and replace nozzles if necessary.
	Damaged nozzle tip seats	Repair and replace seats if necessary.
	Worn or broken nozzle springs	Replace nozzle springs.
	Too low an injection pressure	Adjust pressure to 120^{+10}_{0} kg/cm^2 (1706.4^{+142}_{0} psi) on nozzle tester by inserting shim(s).
	Carbon deposited on packings at nozzle tips	Remove carbon.
Injection timing too advanced	Improper installation of fuel injection pump	Re-time properly by tilting injection pump away from engine.
	Incorrect installation of timing gears	Re-time timing gear train.
Injection timing too retarded	Improper installation of fuel injection pump	Re-time properly by tilting injection pump toward engine.
	Incorrect meshing of timing gears	Re-time timing gear train.
	Worn cams, tappets or bearings in fuel injection pump	Replace.
Poor grade of fuel oil		Use good-quality fuel.
	Water in fuel	Use good-quality fuel.
Low oil pressure	Lack of oil in oil pan	Add oil to prescribed level.
	Air in oil strainer	Replace damaged pipes or packings. Retighten loose connections if any.
	Defective oil pump	Repair.
	Clogged fuel lines	Clean.
	Defective oil pressure regulating valve	Repair and replace if necessary
	Clogged oil filter	Change element and oil.
	Leak in lubricating system	Repair.
Pumping up of oil	Excessive oil in oil pan	Drain oil to lower oil level.
	Worn cylinders, pistons or piston rings	Repair and replace parts if necessary
	Sticking piston rings	Repair and replace damaged rings if necessary.
	Worn valve guides	Replace valve guides.
	Prolonged operation under no load	Overhaul engine if oil-laden gases are exhausted.
Insufficient air	Clogged air cleaner (Paper element type)	Clean and replace element if
	Clogged air cleaner (Oil bath type)	Wash interior.
	Clogged intake manifold	Check and clean.

Possible cause		Remedy
Poor compression	Defective valve seats	Repair.
	Sticking valve stems	Repair and replace valve stems if necessary.
	Failure of rocker arms to lift valves	Adjust valve clearance to 0.25 mm (0.0098 in.).
	Worn cylinders, pistons or piston rings	Repair and replace parts if necessary.
	Sticking piston rings	Replace damaged rings.
	Exhaust gases leak through cylinder head gasket	Retighten and replace gasket if necessary.
	Worn or broken valve springs	Replace springs.
	Insufficient torque of starting motor (at starting)	Replace parts.
Insufficient coolant	Insufficient coolant	Add water to prescribed level.
	Overheating	
	Water leaks from unit seal of water pump	Replace seal.
	Crack in crankcase water jacket	Replace crankcase.
	Water leaks from other parts	Check and repair.
Failure of radiator to dissipate heat properly	Air in cooling system	Bleed air by loosening air bleed plug, drain plug, or hose clamp.
	Rust and scale deposited in radiator	Flush.
	Dust and dirt around radiator	Flush.
	Slippage of fan belt	Adjust belt tension.
	Inoperative thermostat (kept closed)	Replace.
Radiator dissipates heat excessively	Extremely low atmospheric temperature	
	Uncovered radiator	Cover radiator.
	Inoperative thermostat (kept open)	Replace.
Jammed moving parts	Sticking cylinders, pistons or piston rings	Repair and replace if necessary.
	Sticking main bearings and crankpin bearings	Repair and replace if necessary.
	Sticking cam bushing and idler bushing	Repair and replace if necessary.

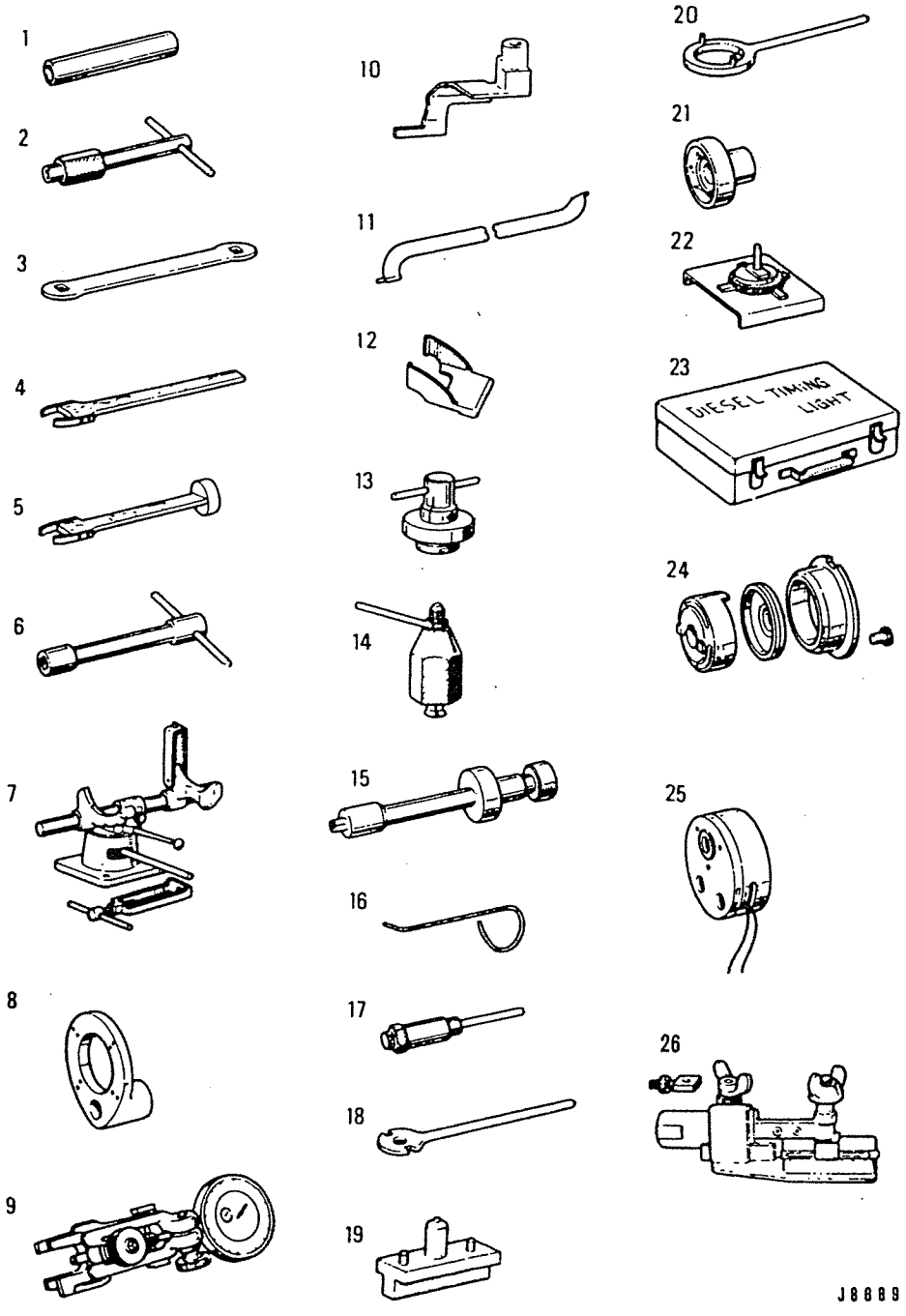
SPECIAL SERVICE TOOLS

ENGINE SERVICE TOOLS

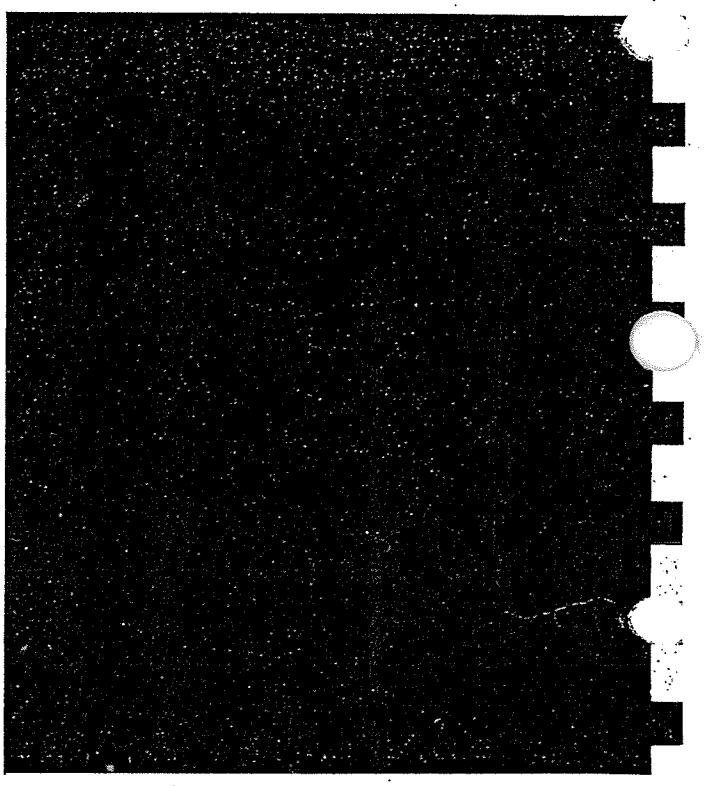


Key no.	Tool no.	Tool name	Qt. carried	Use
1	30691 – 00300	Socket wrench	1	Camshaft thrust plate
2	30691 – 11100	Adapter	1	Compression pressure measurement
3	30691 – 52100	Piston guide	1	Piston installation
4	30691 – 51600	Liner installer	1	Cylinder liner installation
5	31391 – 13010	Intake valve seat insert calking tool	1	Intake valve seat insert installation
6	31391 – 13020	Exhaust valve seat insert calking tool	1	Exhaust valve seat insert installation
7	31391 – 10600	Valve guide installer	1	Valve guide installation
8	31391 – 10500	Valve guide remover	1	Valve guide removal
9	31391 – 12300	Rod	1	Use together with 7 Valve guide installer
10	30691 – 11800	Cranking handle	1	Engine cranking
11	30891 – 02400	Idler shaft puller	1	Idler shaft removal
12	30091 – 01101	Universal extension	1	Injection pump installation
13	30091 – 07300	Idler bushing puller	1	Idler bushing removal and installation
14	30891 – 04500	Adapter	1	Camshaft bushing removal and installation
15	30891 – 04600	Adapter	1	Camshaft bushing removal and installation
16	30691 – 00801	Aligner	1	Rear oil seal alignment
17	31391 – 12900	Piston ring tool	1	Piston ring removal and installation
18	30691 – 13106	Guide	1	Crankshaft sleeve installation
19	30691 – 13200	Installer	1	Use together with 18 Guide

INJECTION PUMP SERVICE TOOLS



Key no.	Tool no.	Tool name	Qt. carried	Use
1	31391 – 15100	Delivery valve gasket adapter	1	Delivery valve gasket installation
2	31391 – 15200	Valve extractor	1	Delivery valve removal
3	31391 – 15300	Eye wrench	1	Valve holder and nozzle holder cap loosening
4	31391 – 15400	Tappet clamp	1	Tappet removal and installation
5	31391 – 15500	Roller clamp	1	Tappet removal and installation
6	31391 – 15700	Socket wrench (10 mm or 3/8 in.)	1	
7	31391 – 15800	Injection pump support	1	Injection pump disassembly and assembly
8	31391 – 15900	Injection pump angle support	1	Pump securing
9	31391 – 16100	Tappet clearance tool	1	Prestroke and tappet clearance measurement
10	31391 – 16200	Tappet clearance adapter	1	High speed tappet clearance measurement
11	31391 – 16300	Tappet clearance bar	1	
12	31391 – 16400	Spring holder	1	Tappet shim adjustment
13	31391 – 16700	Camshaft clearance tool	1	
14	31391 – 16800	Camshaft bearing (outer) puller	1	Tapered roller bearing outer race removal
15	31391 – 16500	Plunger clamp	1	Tappet removal and installation
16	31391 – 16600	Tappet insert	1	Tappet removal and installation
17	31391 – 11800	Timer extractor	1	Timer removal and installation
18	31391 – 17200	Holding wrench	1	Coupling removal and installation
19	31391 – 17300	Timer support	1	As timer bench
20	31391 – 17400	Holding wrench	1	Timer removal and installation
21	31391 – 17500	Lock nut wrench	1	Automatic timer lock nut tightening
22	31391 – 17700	Slip torque measuring device	1	Gear slip torque measurement
23	31391 – 18100	Timing light	1	Advance angle measurement of automatic timer on injection pump test bench
24	31391 – 18200	Timer testing flange	1	
25	31391 – 18300	Timer testing breaker	1	
26	31391 – 17900	Rack position measuring device	1	Rack position measurement
	31391 – 15600	Socket wrench (22 mm or 7/8 in.)	1	Delivery valve holder tightening
	31391 – 16900	Camshaft bearing (inner) puller	1	Tapered roller bearing inner race removal
	31391 – 17100	Coupling and round nut	1	Injection pump driving
	31391 – 17600	Puller	1	Camshaft bushing removal



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