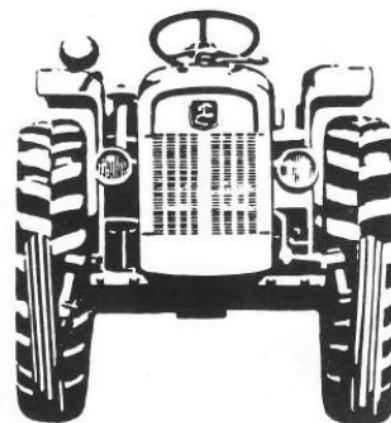


**SATOH  
TRACTOR  
*BEAVER S-370*  
REPAIR  
MANUAL**



**SATOH AGRICULTURAL MACHINE MFG. CO., LTD.**

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## SPECIFICATIONS

<b>Model</b> .....	S-370	S-370D (4 wheel drive)
<b>Body structure</b> .....	Mono cock tyoe	
<b>Tractor dimension</b>		
<b>Overall length</b>		
(End of rear tire) .....	73.82 in. (1875 mm)	75.98 in. (1930 mm)
(End of 3 point linkage) .....	80.90 in. (2055 mm)	83.07 in. (2110 mm)
<b>Overall width (at rear tire)</b> .....	38.00 in. (960 mm)	
<b>Overall height (steering wheel)</b> .....	43.5 in. (1105 mm)	
<b>Wheel base</b> .....	48.23 in. (1225 mm)	49.80 in. (1265 mm)
<b>Ground clearance</b> .....	9.65 in. (245 mm)	9.05 in. (230 mm)
<b>Weight</b> .....	1035.24 lb (470 kg)	1180.62 lb (536 kg)
Front wheel load .....	444.93 lb (202 kg)	557.27 lb (253 kg)
Rear wheel load .....	590.31 lb (268 kg)	623.35 lb (283 kg)
<b>Engine</b>		
<b>Model</b> .....	KE70 (MITSUBISHI)	
<b>Type</b> .....	4 cycle water cooled overhead valve in line diesel engine	
<b>Number of cylinder</b> .....	2	
<b>Combustion chamber type</b> .....	Swirl type with pre-heater	
<b>Cylinder liner</b> .....	Non liner	
<b>Bore and stroke</b> .....	2.87 x 3.15 in. (73 x 80 mm)	
<b>Piston displacement</b> .....	40.8 cu. in. (669 cc)	
<b>Compression ratio</b> .....	20 : 1	
<b>Injection order</b> .....	1 - 2	
<b>Rated rpm</b> .....	2700 rpm	
<b>Max. rpm</b> .....	2900 rpm	
<b>Idling rpm</b>		
<b>Rated HP</b> .....	13 HP/2700 rpm	
<b>Max. bare HP</b> .....	15 HP/2700 rpm	
<b>Compression pressure</b> .....	455 lb/in <sup>2</sup> (32 kg/cm <sup>2</sup> )	
<b>Number of piston ring</b> .....	4 (3 compression ring, 1 oil ring)	
<b>Intake valve (open)</b> .....	B.T.D.C. 18 degree	
(close) .....	A.B.D.C. 46 degree	
<b>Exhaust valve (open)</b> .....	A.B.D.C. 46 degree	
(close) .....	B.T.D.C. 18 degree	
<b>Injection timing</b> .....	B.T.D.C. 25 degree	
<b>Valve clearance (intake)</b> .....	0.0138 in. (0.35 mm) at cold	
(exhaust) .....	0.0138 in. (0.35 mm)	
<b>Fuel consumption</b> .....	0.45 - 0.506 lb/HP/H (205 - 230 g/HP/H)	
<b>Turning direction</b> .....	Clockwise (see from front)	
<b>Weight (air dry)</b> .....	2201 lb (100 kg)	
<b>Cooling system</b>		
<b>Radiator fin</b> .....	Corrugate fin	
<b>Radiator cap ressure</b> .....	9.9 psi (0.7 kg/cm <sup>2</sup> )	
<b>Thermoswitch</b> .....	221 F ~ 232 F (105 c ~ 111 C) ON	
<b>Water pump</b> .....	Centrifugal impeller type	

Feeding capacity . . . . .	9.5 gal. (35.8 l/min.)
Cooling fan diameter . . . . .	11.42 in. (290 mm)
Number of fan blades . . . . .	4 blades
Pulley ration of fan & crank shaft . . . . .	1/1.23
Blade material . . . . .	Plastic
Drive system . . . . .	V type belt

**Fuel equipment**

Fuel . . . . .	Diesel fuel
Injection pump type . . . . .	Bosch M type, plunger type
Model . . . . .	ND-PFR2M55/1 ND068
Diameter of plunger . . . . .	0.216 in. (5.5 mm) right lead
Delevery valve . . . . .	Bosch type 0.196 in. (5 mm)
Injection nozzle type . . . . .	Throttle type
Model . . . . .	ND-DN4SD24
Injection pressure . . . . .	1706-1849 psi (120 — 130 kg/cm <sup>2</sup> )
Fuel filter . . . . .	Paper element cartridge type

**Lubrication system**

Oil pump type . . . . .	Trochoid pump
Feeding capacity . . . . .	0.132 gal (5.0 l/min.)
Oil filter . . . . .	All flow paper element cartridge type
Pressure for relief valve setting . . . . .	42.66 psi (3 kg/cm <sup>2</sup> )

**Air cleaner**

Type . . . . .	Dry paper element cartridge type
----------------	----------------------------------

**Governor**

Type . . . . .	Mechanical all speed control
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**Electrical system**

Generator type . . . . .	Alternator
Model . . . . .	02100-2431
Output volt . . . . .	35AH-12 Volt
	Minus earth
	26.5A up at 2500 rpm

**Starter motor**

Type . . . . .	Magnet type
Model . . . . .	M4T14673
Output volt . . . . .	1.2KW—12V

**Regulator**

Type . . . . .	Tirrill type, 2 element
Model . . . . .	02600-1763
Regulator voltage . . . . .	13.5—14.5V (68 F, 20 C)
Warning lamp light on voltage . . . . .	0.5—3.5V

**Glow plug**

Type . . . . .	Sheathed type
Rated voltage . . . . .	10.5V
Resistance (at room temperature) . . . . .	1—1.2 $\Omega$

**Clutch**

Type . . . . .	Dry single disc plate diaphragm spring type
Clutch disc diameter . . . . .	7.24 in (184mm)
Lining thickness . . . . .	0.307 in. (7.8 mm)

### 1-3 GENERAL DESCRIPTION

Torque capacity .....58.61 ft-lb (8.1 kg-m)

Spring pressure .....429.51 lb (195 kg)

#### Transmission

Number of shift lever .....2

Speed steps .....6-forward, 2-reverse

Speed change method .....Selective sliding gear type

Travelling speed

Tire size 8-16 (AG) at engine speed 2700 rpm

Speed	Lever position	Mile/H	Km/H	M/sec
F-1	L-1	0.59	0.98	0.27
F-2	L-2	0.92	1.48	0.41
F-3	L-3	1.56	2.51	0.70
F-4	H-1	2.66	4.29	1.19
F-5	H-2	4.04	6.50	1.81
F-6	H-3	6.87	11.06	3.07
R-1	L-R	0.78	1.25	0.35
R-2	H-R	3.41	5.48	1.52

Tire size 9.5-16(ES) at engine speed 2700 rpm

F-1	L-1	0.63	1.10	0.28
F-2	L-2	0.96	1.53	0.43
F-3	L-3	1.64	2.61	0.73
F-4	H-1	2.80	4.46	1.24
F-5	H-2	4.24	6.75	1.88
F-6	H-3	7.21	11.48	3.19
R-1	L-R	0.81	1.29	0.36
R-2	H-R	3.57	5.69	1.58

Differential .....Bevel gear type with differential lock

Differential lock .....Foot pedal (Right hand)

#### Final reduction

Final reduction gear .....Spur gear

Reduction ratio .....11/60

Type of rear axle .....1/2 floating type

#### Power take off

Power take off step .....3 steps

Power take off HP .....12.2 HP/540 rpm

Power take off shaft (standard) .....18-spline

(option) .....1-3/8 in. 6-spline SAE standard

PTO speed/2700 engine rpm .....1 : 517 rpm

2 : 762 rpm

3 : 1249 rpm

Standard PTO speed .....540 rpm / 1913 engine rpm

1000 rpm / 2162 engine rpm

PTO speed / 2700 engine rpm .....1 : 537 rpm

(option) .....2 : 791 rpm

3 : 1297 rpm

Standard PTO speed	.540 rpm / 1843 engine rpm 1000 rpm / 2086 engine rpm
Direction of rotation (standard)	Unclickwise viewed from tractor rear
(option)	Clockwise viewed from tractor rear
Max. drawbar pull (2 wheel drive)	772 lb (350 kg)
(4 wheel drive)	1213 lb (550 kg)

**Steering (2 wheel)**

Steering system	Ackerman Jant Method
Axle center	Center pivot type
King pin type	Rumoin
Steering gear box	Worm sector type
Tread adajustment	With set in adverse
Axle center swing angle	.8
King pin angle	.8
Chamber	.2.5
Caster	.3
Toe-in	.0.24 in. (6 mm)
Steering angle (2-wheel)	Inside 55°, outside 42.5°
(4-wheel)	.44° -0° -2°
Gera ratio	.1/15
Steering wheel size	.14.96 in. (380 mm)
Turning radius	
2-wheel (with brake)	.66.93 in. (1700mm)
(without brake)	.78.74 in. (2000mm)
4-wheel (with brake)	.78.74 in. (2000mm)
(without brake)	.98.42 in. (2500mm)

**Brake**

Type	Mechanical internal expanding dry sealed brake
Brake pedal	Foot brake separate
Parking brake and operating	Main brake used with hand
Lining dimension	.4.685 x 1.181 x 0.177 in.
(length x width x thickness)	(119 x 30 x 4.5 mm)
Number of lining	.4
Dram diameter	.4.488 in. (114 mm)
Position	.Diff. pinion shaft

**Front tire (2 wheel)**

Tire size and ply rating	.400-9, 2 ply
Tire pattern	.Fam service rib
Tire pressure	.22.8 lb/in <sup>2</sup> (1.6 kg/cm <sup>2</sup> )
Outside diameter	.17.99 in. (457 mm)
Tire width	.4.49 in. (113 mm)
Loaded radius	.286.3 lb (130 kg)
Type of valve	.TR-13
Rim	.3.00 x 10

**Front tire (4 wheel)**

Tire size and ply rating	.5-12, 2 ply
Tire pattern	.AG

## 1-5 GENERAL DESCRIPTION

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Tire pressure	17.1 lb/in <sup>2</sup> (1.2 kg/cm <sup>2</sup> )
Outside diameter	21.57 in. (548 mm)
Tire width	4.92 in. (125 mm)
Loaded radius	330.4 lb (150 kg)
Type of valve	TR-13
Rim	4-JA x 12

### Front tire (ES tire)

Tire size and ply rating	18 x 700-8
Tire pattern	Pillow Dia
Tire pressure	14.22 lb/in <sup>2</sup> ( kg/cm <sup>2</sup> )
Outside diameter	17.99 in. (457 mm)
Tire width	6.69 in. (170 mm)
Loaded radius	451.5 lb (205 kg)
Type of valve	TR-413
Rim	5,50 x 8

### Rear tire (2 wheel and 4 wheel)

Tire size and ply rating	8 ~ 16
Tire pattern	Farm service
Tire pressure	22.8 lb/in <sup>2</sup> (1.6 kg/cm <sup>2</sup> )
Outside diameter	80.9 in. (783 mm)
Tire width	7.8 in. (197 mm)
Loaded radius	1047.4 lb (475 kg)
Type of valve	TR-15
Rim	W - 6 x 16W

### Rear tire (ES tire)

Tire size and ply rating	9.5 ~ 16
Yitr pattern	Farm Service
Tire pressure	19.91 lb/in <sup>2</sup> (1.4 kg/cm <sup>2</sup> )
Outside diameter	32.3 in. (820 mm)
Tire width	9.5 in. (242 mm)
Loaded radius	1223.8 lb (555 kg)
Type of valve	TR-15
Rim	W - 8 x 16W

### Rear tire (AG high-lug tire)

Tire size and ply rating	8.00 ~ 16
Tire pattern	Farm Service
Tire pressure	22.8 lb/in <sup>2</sup> (1.6 kg/cm <sup>2</sup> )
Outside diameter	32.0 in. (813 mm)
Tire width	7.7 in. (196 mm)
Loaded radius	1047.4 lb (475 kg)
Type of valve	TR-15
Rim	5JA x 16W

### Hydraulic

Control	Lift hold down and flow control external service
Type of cylinder	Single acting cylinder
Diameter of cylinder	2.205 in. (56 mm)
Stroke of piston	2.8 in. (71 mm)



Max. lift power at end of lower link	Category "O" (ASAE) 1273.9 lb (580 kg) Category "O" (JIS) 1.58.4 lb (480 kg)
Pressure for pump relief valve setting	1920 lb/in <sup>2</sup> (135 kg/cm <sup>2</sup> )
Type of hydraulic pump	Pressure loading gear pump
Name and model	KAYABA GP1-15
Output of hydraulic pump	3,84 gal/min (14.2 lit) / 2700 rpm
Control valve type	Spool valve 3-port, 3-position
Oil lock valve	Oil lock valve (adjustable flow control)
Strainer mesh	100 mesh
Hydraulic oil	SAE #80 gear oil (Same as transmission oil)
External service	Accessory

**3 point linkage**

Category	ASAE Category "O" & JIS Category "O"
Lifting capacity ASAE Category "O"	1277.5 lb (580 kg)
JIS Category "O"	1057.3 lb (480 kg)

**Drawbar**

Type	Fix type
Ground clearance	10.63 inch (270 mm)

**Electrical system**

Battery	YUASA Battery
Model	NS-60
Capacity	20HR 45AH
Size	9.3 x 5 x 8.86 in. (236 x 126 x 225 mm)
Weight	28.63 lb (Including electrolyte)
Specific gravity	0.82 gal (3.1 lit)
Terminal ground	Negative earth
Head lamp	12V 25W/25W, 2 pcs
Light switch	
Engine lubrication oil warning lamp	On the instrument panel
Warning lamp lighting pressure	
Lamp color	Red
Water temperature warning lamp	
Location	On the instrument panel
Type	Warning lamp
Lamp color	Red
Safety starter switch	
Model	
Capacity	
Stroke	
Fuse	
Working lamp (option)	
Lamp	
Location	At the rear of right hand fender

**Capacity**

Cooling water	1.10 gal (4.2 lit)
Engine oil	0.79 gal (3.00 lit)
Fuel	3.3 gal (12.5 l)
Transmission oil (2 wheel)	2.25 gal (8.50 lit)
(4 wheel)	2.59 gal (9.8 lit)

## 1-7 GENERAL DESCRIPTION

Front diff. case (4 wheel) .....0.21 gal (0.8 l)

Front gear case .....0.03 gal (0.12 l)

### Rotary tiller (optional)

Model .....2PR-1100S

Type .....Side drive type rotary tiller

Applicable tractor .....Satoh Beaver S-370 and S-370D

Overall length .....46.54 in. (1,182 mm)

Overall width .....48.90 in. (1,242 mm)

Overall height .....31.69 in. (805 mm)

Tilling width .....43.31 in. (1,100 mm)

Tilling depth .....7.09 in. (180 mm)

### Tilling blade

Diameter .....17.72 in. (450 mm)

Weight .....289 lb (131 kg)

Number of blade .....28

Mounting method .....Special 2 point hitch

drive system .....Universal joint spiral bevel gear, chain side drive

Depth control .....Lifting and lowering of rear gauge wheel with a handle

Tilling shaft revolution .....C-1: 153 rpm

C-2: 226 rpm

C-3: 371 rpm

Holder pitch .....1.83 in. (46.38)

Tilling pitch.....

unit: in, (mm)

	C-1	C-2	C-3
F-1	4.13 (105)	2.75 (70)	1.73 (44)
F-2	6.41 (163)	4.25 (108)	2.67 (68)
F-3	10.23 (260)	6.77 (172)	4.25 (108)

### Oil capacity

Gear case oil .....0.85 pint (0.4 liter) SAE #8 ~ 90 gear oil

Chain case oil .....0.65 pint (0.3 liter) SAE #80 ~ 90 gear oil

★ These specifications are subject to change without previous notice.

### Service Schedule Chart

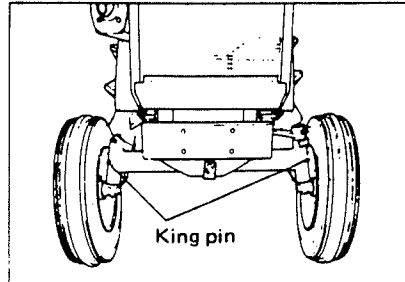
Hours of operation	A service	B service	C service	D service	E service	F service
50	○					
100		○				
200		○	○			
300		○		○		
400		○	○		○	
500		○				
600		○	○	○		
700		○				
800		○	○		○	○

★ After 800 hrs. runing, service should be repeated in the order of B, C, D, E and F.

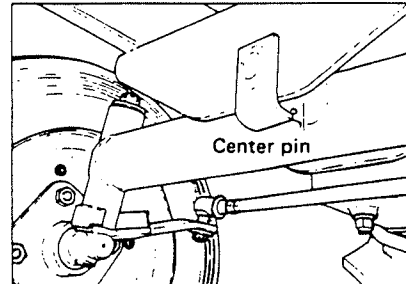
★ "A" service should be given only for a brand new tractor.

# GREASING DIAGRAM

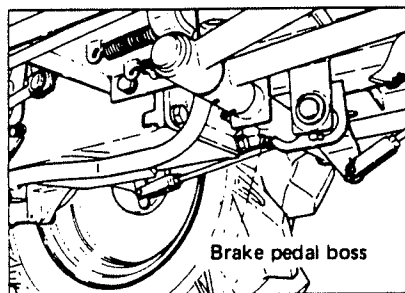
Grease front axle king pin



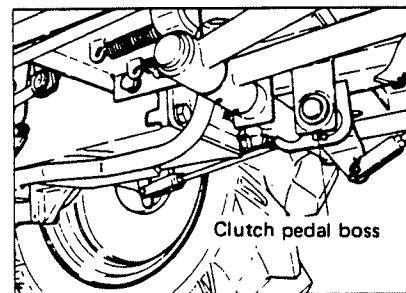
Grease front axle center pin



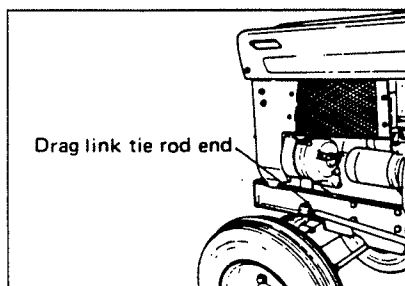
Grease brake pedal boss



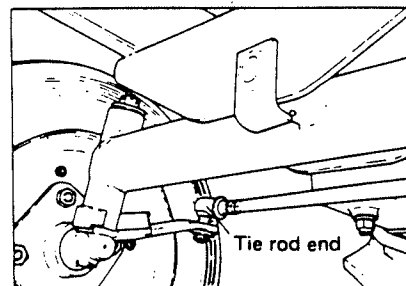
Grease clutch pedal boss



Grease drag link tie rod end

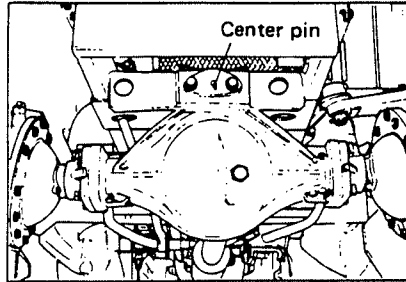


Grease tie rod end

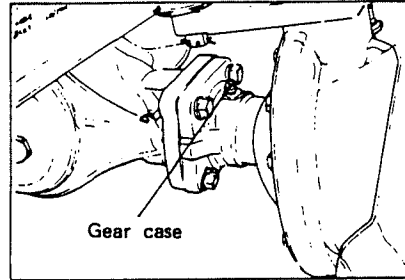


## 4-WHEEL DRIVE

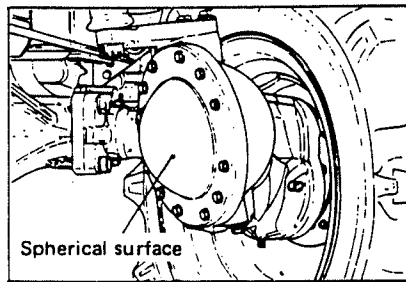
**Grease front axle center pin**



**Grease gear case**



**Grease spherical surface**



## RECOMMENDED LUBRICANTS

Application	Air Temperature	A.P.I. classification	Grade	Mobil	Esso	Shell
Engine	Below 20° F (−7° C)	CC CD	Multigrade SAE 10W	Mobil Delvac 1210	Esso LUBE D-3 10W Esso LUBE HDX 10W Esso LUBE HD 10W	Shell myrinal oil 10W Shell Rimula CT 10W Shell Rotella TX10W-30 Shell Rotella SX 10W
	20° F to 90° F (−7° C to 32° C)					
	Above 90° F (32° C)	CC CD	Multigrade SAE 20W SAE 20 SAE 30	Mobil Delvac 1220 Mobil Delvac 1230	Esso LUBE D-3 30 Esso LUBE HDX 30 Esso LUBE HD 30	Shell myrina 30 Shell Rimula CT 30 Shell Rotella TX 30 Shell Rotella SX 30
Transmission Hydraulic system and Steering gear box	Below 20° F (−7° C)	SAE #80	Multigrade SAE 40	Mobil Delvac 1230	Esso LUBE D-3 40 Esso LUBE HDX 40 Esso LUBE HD 40	Shell Multigrade 20W-40 Shell myrinal il 40 Shell Rimula CT 40 Shell Rotella TX40 Shell Rotella SX 40
	20° F to 90° F (−7° C to 32° C)					
	Above 90° F (32° C)					
				Mobilfluid-423 or Mobil A.T.F. -220	Essolub HDX 10W or Essolub XD3-10W	Dentax 80
Antifreeze				Mobilube C80	Esso Gear Oil GP80	Dentax 90
				Parmagone	Esso Antifreeze	Shell Antifreeze

## 1-11 GENERAL DESCRIPTION

### ANTIFREEZE

When the atmospheric temperature is lower than 32° F (0°C), cooling water should be drained off completely or antifreeze solution should be added to prevent the breakdown of the cylinder block due to the frozen cooling water. Percentage of the antifreeze to be added should be a little higher than specified for the lowest atmospheric temperature in your area.

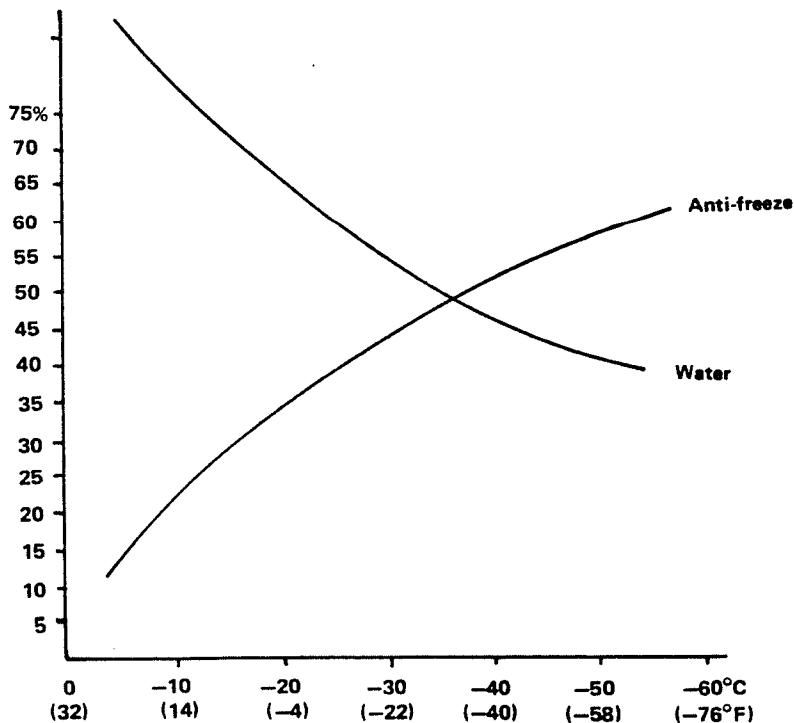
When adding antifreeze solution, the following rules should be observed, otherwise, the cylinder block will rust.

1. This tractor's engine is of a diesel type and its cylinder block is made of cast iron. Therefore antifreeze solution suitable for such a cast engine block must be used.
2. Before adding mixture of antifreeze and water, completely drain cooling water and clean the radiator using a detergent.
3. Water to be added to the antifreeze should be a clean soft water.
4. When the antifreeze is no longer required, drain and wash the cooling system using a detergent and fill it again with clean water. Do not re-use the antifreeze solution after it has been drained from cooling system.

5. Treat antifreeze carefully as it can remove paint from the cylinder block.
6. Any antifreeze solution (antifreeze and water), even if it is a permanent antifreeze, should not be used for more than 2 years.
7. Confirm that there are no leaks from the hose joints or cylinder head gasket.
8. Antifreeze with correct density to suit the climate in your area should be used.
9. When antifreeze is used for a long period in winter, measure the specific gravity frequently.

Temperature, mixing ratio and specific gravity of the antifreeze

Freezing point	Percentage of antifreeze	Specific gravity 68° F (20° C)
20.7° F ( -6.3° C)	15%	1.022
15.3° F ( -9.3° C)	20%	1.029
9.3° F ( -12.6° C)	25%	1.037
2.8° F ( -16.2° C)	30%	1.044
-4.9° F ( -20.5° C)	35%	1.051
-13.0° F ( -25.2° F)	40%	1.058
-23.8° F ( -31.2° C)	45%	1.066
-33.7° F ( -37.6° C)	50%	1.073
-49.0° F ( -45.2° C)	55%	1.078
	60%	1.088



**Liquid Packing "3 Bond No. 4"**

Any gasket is not used for Satoh Stallion but liquid packing. To order the liquid packing, contact the following address or Satoh.

**Mr. Eisuke Watanabe**  
 Three Bond America Bldg.  
 Century City North Bldg.  
 Suite 945, 10100 Anta Monica Blvd.  
 Los Angeles 90068, California  
 Phone No.: 213 (556) 3614  
               213 (879) 9143  
 Telex No.: 67-7615

**BOLTS AND TIGHTENING TORQUES**

Bolt Size	4T		6T		7T		8T	
	ft-lb	kg-m	ft-lb	kg-m	ft-lb	kg-m	ft-lb	kg-m
M-5	1.44~2.53	0.2~0.35	3.25~3.97	0.45~0.55	3.97~4.69	0.55~0.65	4.69~5.42	0.65~0.75
M-6	3.61~5.06	0.5~0.7	5.78~7.22	0.80~1.00	7.22~8.68	1.01~1.2	8.67~10.1	1.2~1.4
M-8	8.67~12.3	1.2~1.7	14.4~18.1	2.0~2.5	18.1~21.7	2.5~3.0	21.7~25.3	3.0~3.5
M-10	15.2~21.7	2.10~3.0	28.9~36.1	4.0~5.0	36.1~43.3	5.0~6.0	43.3~50.6	6.0~7.0
M-12	32.5~39.7	4.5~5.5	50.6~57.8	7.0~8.0	61.4~68.6	8.5~9.5	68.6~79.5	9.5~11.0
M-14	46.9~57.8	6.5~8.0	72.2~86.7	10.0~12.0	86.7~97.5	12.0~13.5	97.5~108.0	13.5~15.0
M-16	65.0~79.5	9.0~11.0	93.9~108.0	13.0~15.0	112.0~126.0	15.5~17.5	130~144	18.0~20.0
M-18	86.7~101.0	12.0~14.0	123~137	17.0~19.0	152~173	21.0~24.0	181~202	25.0~28.0
M-20	108.0~123.0	15.0~17.0	144~159	20.0~22.0	173~202	24.0~28.0	231~260	32.0~36.0

**Note:**

The bolts and nuts to be used on SATOH BEAVER (Model S-370 & S-370D) are classified as 4T, 6T, 7T and 8T for providing best fit in the part on which they are to installed. When installing these fasteners in place, be sure to tighten them to specifications above.

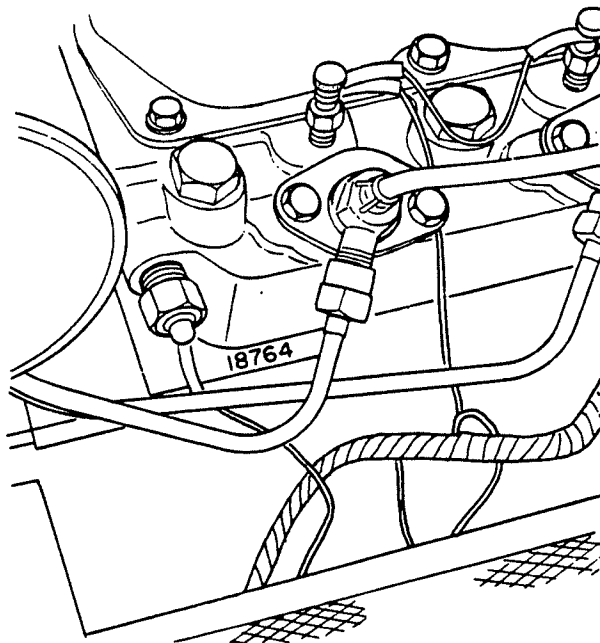
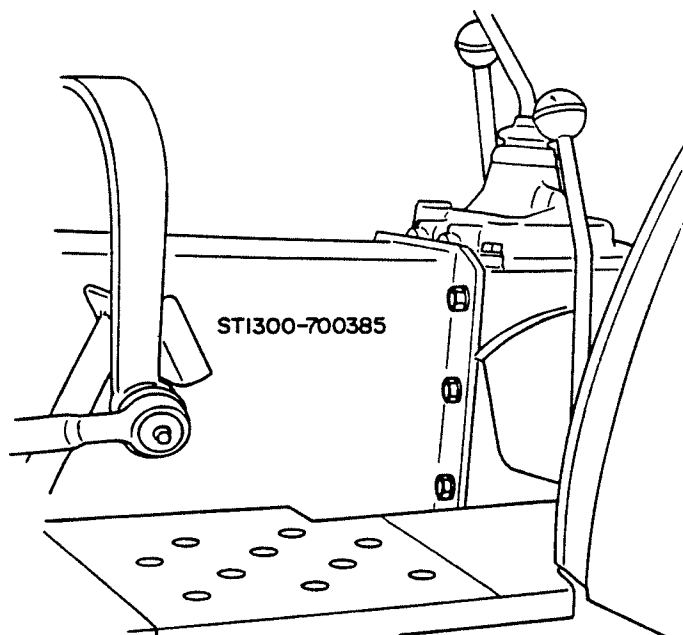
## 1-13 GENERAL DESCRIPTION

### LOCATIONS OF THE TRACTOR AND ENGINE SERIAL NUMBERS

Tractor and engine serial numbers are located at the place respectively shown in below figure. When you file a warranty claim, fill in the the serial numbers in the corresponding column of the warranty claim Application Form, otherwise the claim will not be accepted.

1. Tractor Serial No.

It is located at the left hand side of the clutch housing.

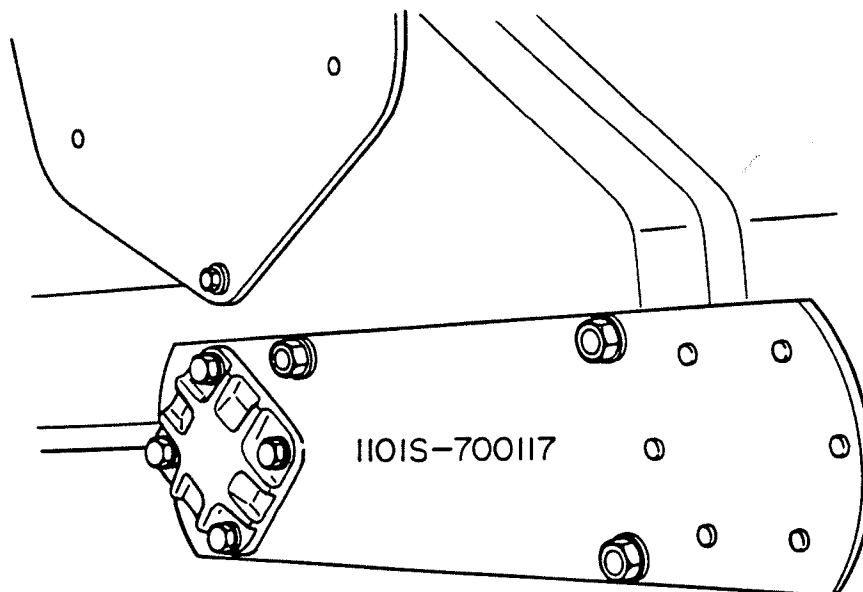


2. Engine Serial No.

It is located at the left hand side of the clutch housing.

3. Rotary tiller Serial No.

It is located at the right hand side of the side plate.





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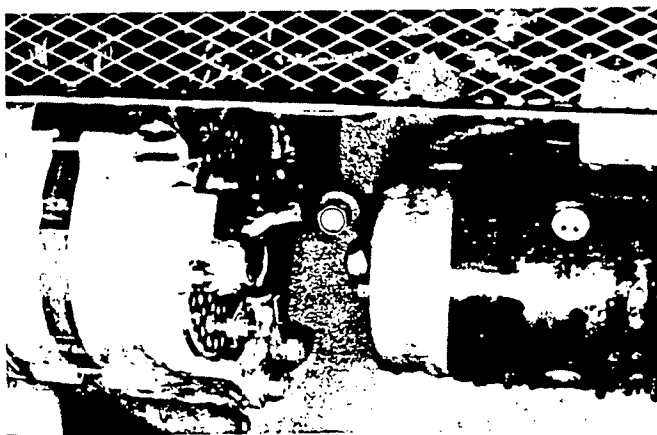
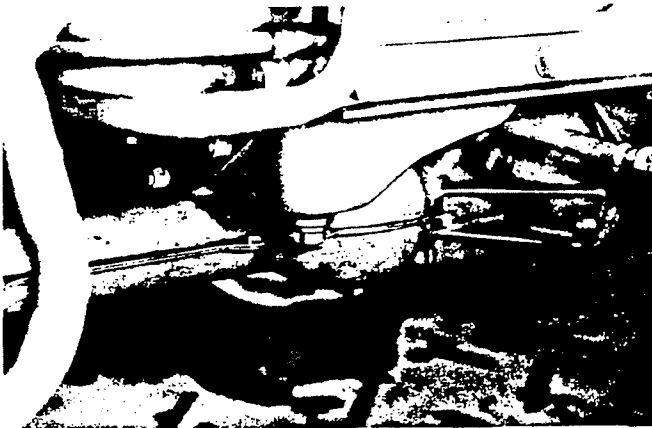
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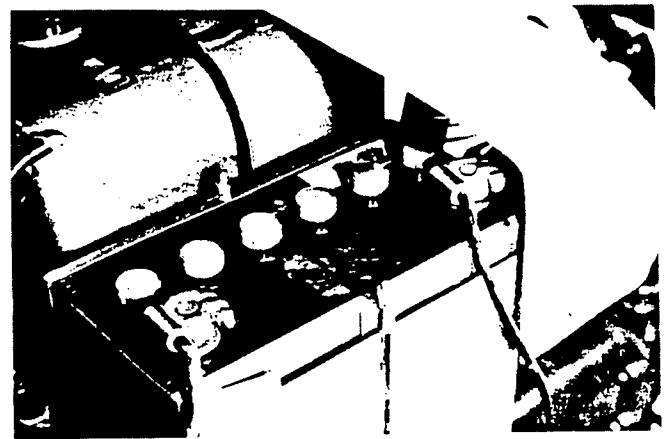
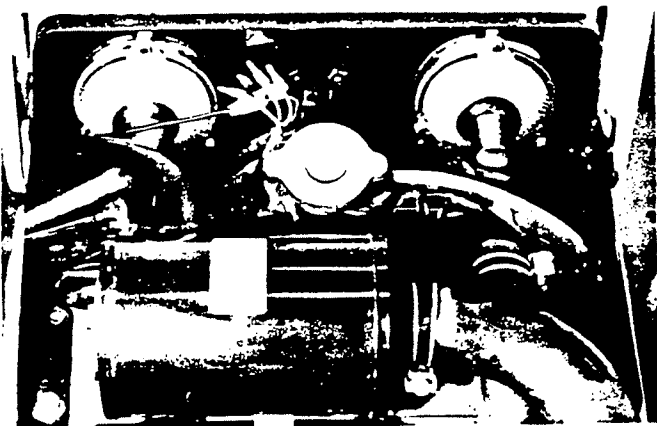
## ■ DISMOUNTING THE ENGINE

When the engine develops troubles and requires disassembly for repair, dismount the engine from the tractor in the following manner:

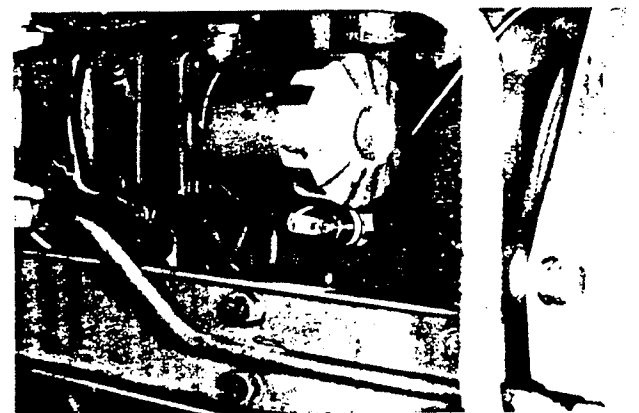
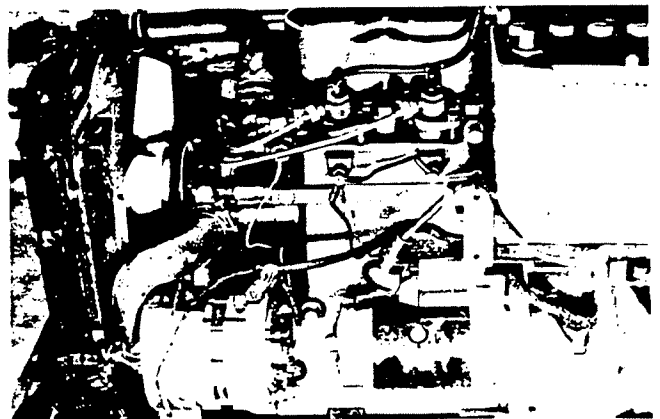
1. Drain engine oil; it can easily be drained off when its temperature remains high. Drain cooling water completely from both the radiator and the cylinder block.



2. Remove the bonnet.

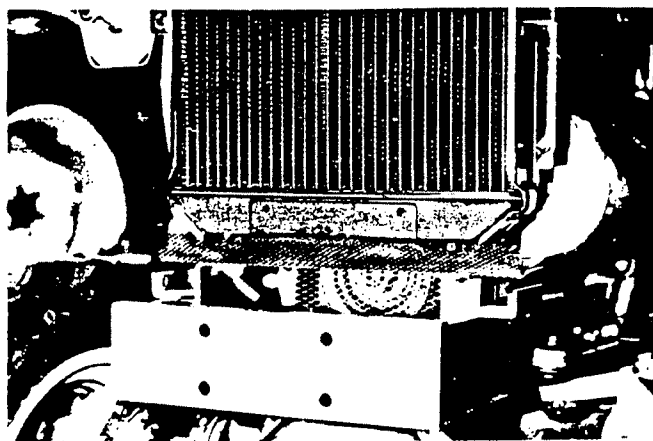
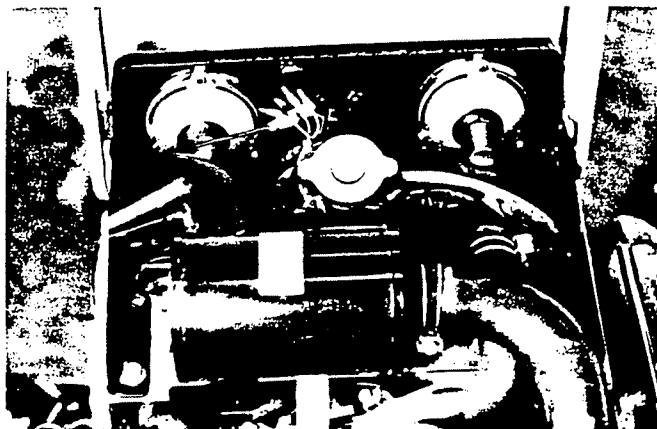


3. Remove the negative and positive battery cables from their respective terminals.
4. Disconnect lead wires from the alternator, oil switch, headlight, water temperature gauge, and starter switch.

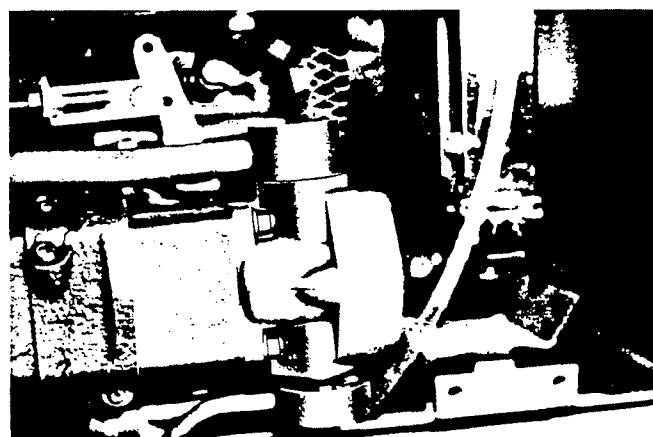
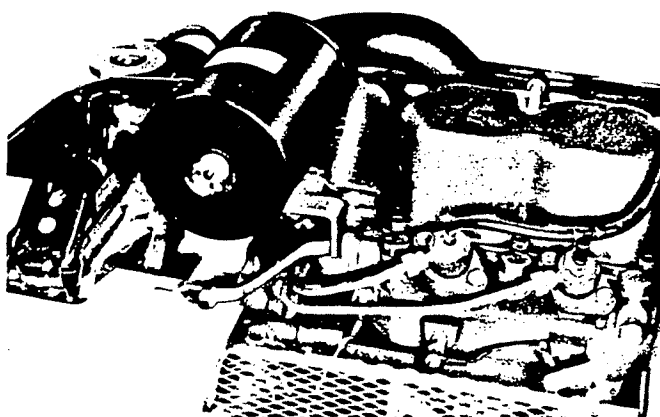


## 2-2 ENGINE SYSTEM

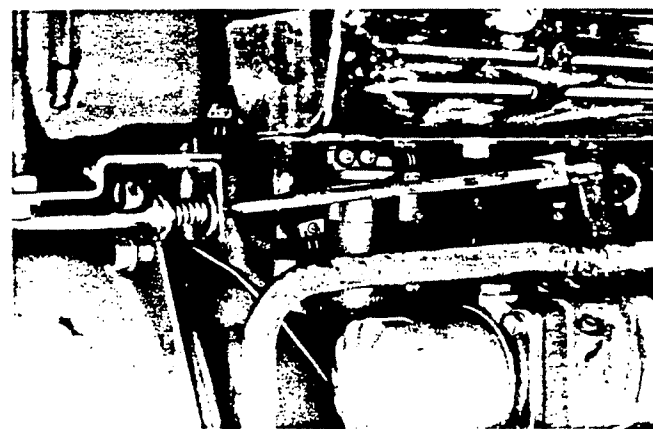
5. Remove the light holder together with both the bonnet cover and air cleaner.



7. Loosen the bolts securing hydraulic intake and exhaust pipes to the pump, and disconnect the pipes being very careful not to lose the "O" rings.

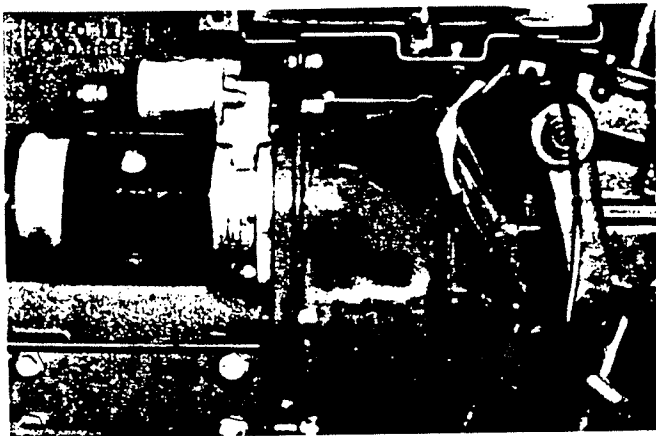
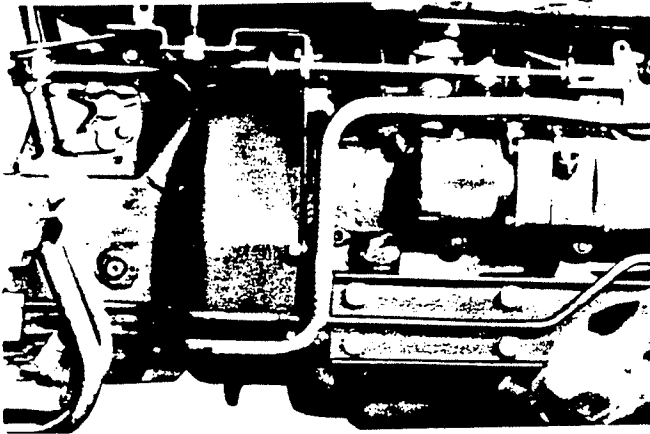


6. Loosen radiator hose clamps and disconnect the hoses. Then, remove the radiator.

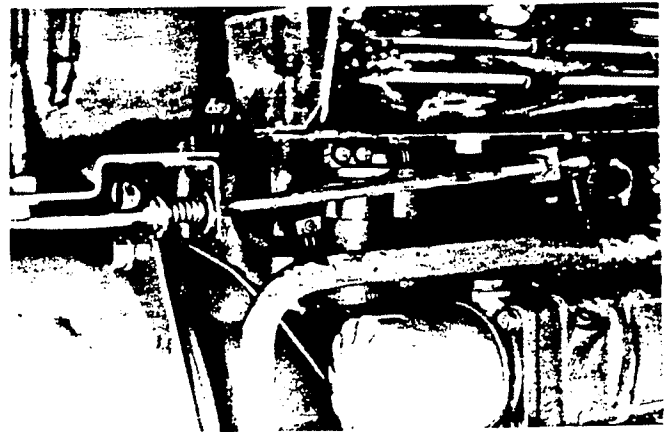
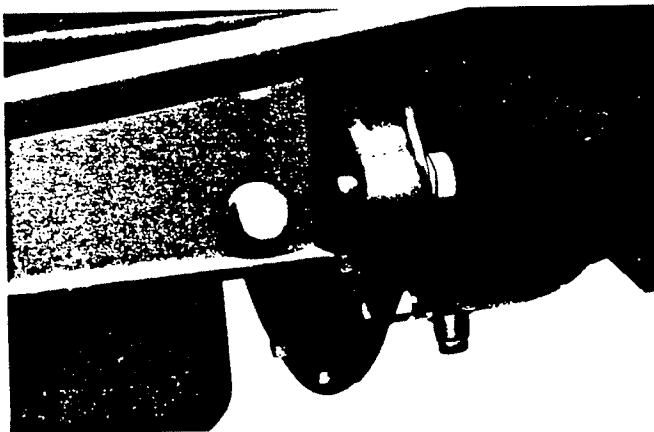


8. Disconnect the throttle lever.
9. Disconnect the drag link from the pitman arm.
10. Place a jack under the clutch housing. Keeping the housing slightly raised, remove the bolts securing the housing to the chassis and

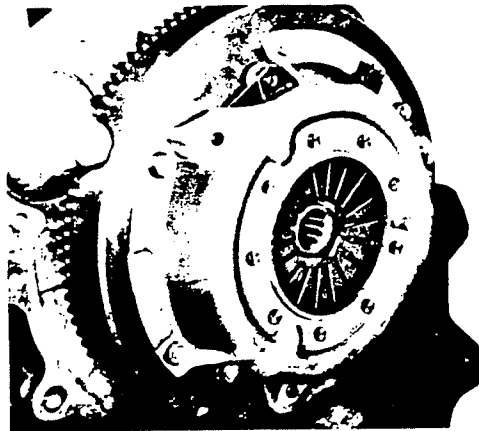
take out the chassis with the front axle installed.



11. Take out the engine rear plate.



12. Disconnect the fuel pipe; install the blind plug in the place of the pipe so that fuel will not flow out. Disconnect the return pipe.



13. Hoisting the engine, remove all clutch housing securing bolts. Gently move the engine backward to place it on the bench.
14. Remove six bolts securing the clutch housing to the transmission case. Take out the clutch housing.

#### ■ MOUNTING THE ENGINE

Mount the engine in the reverse order of dismantling.

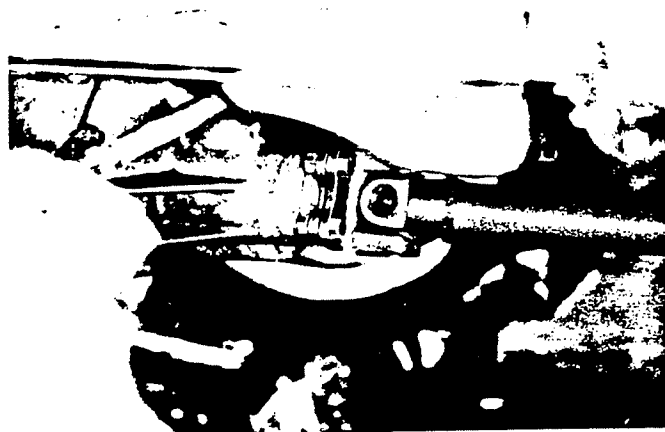
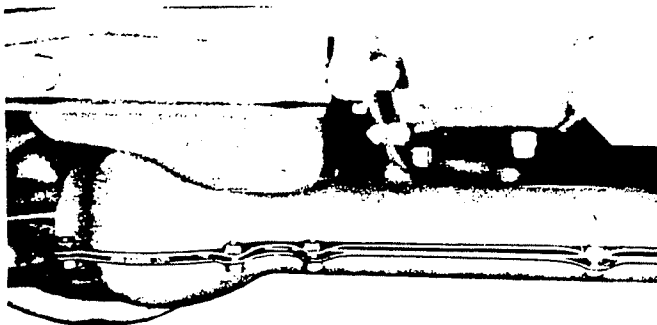
Engine and clutch housing tightening torque:  
32.5 – 39.7 ft-lb (4.5 – 5.5 kg-m)

## 2-4 ENGINE SYSTEM

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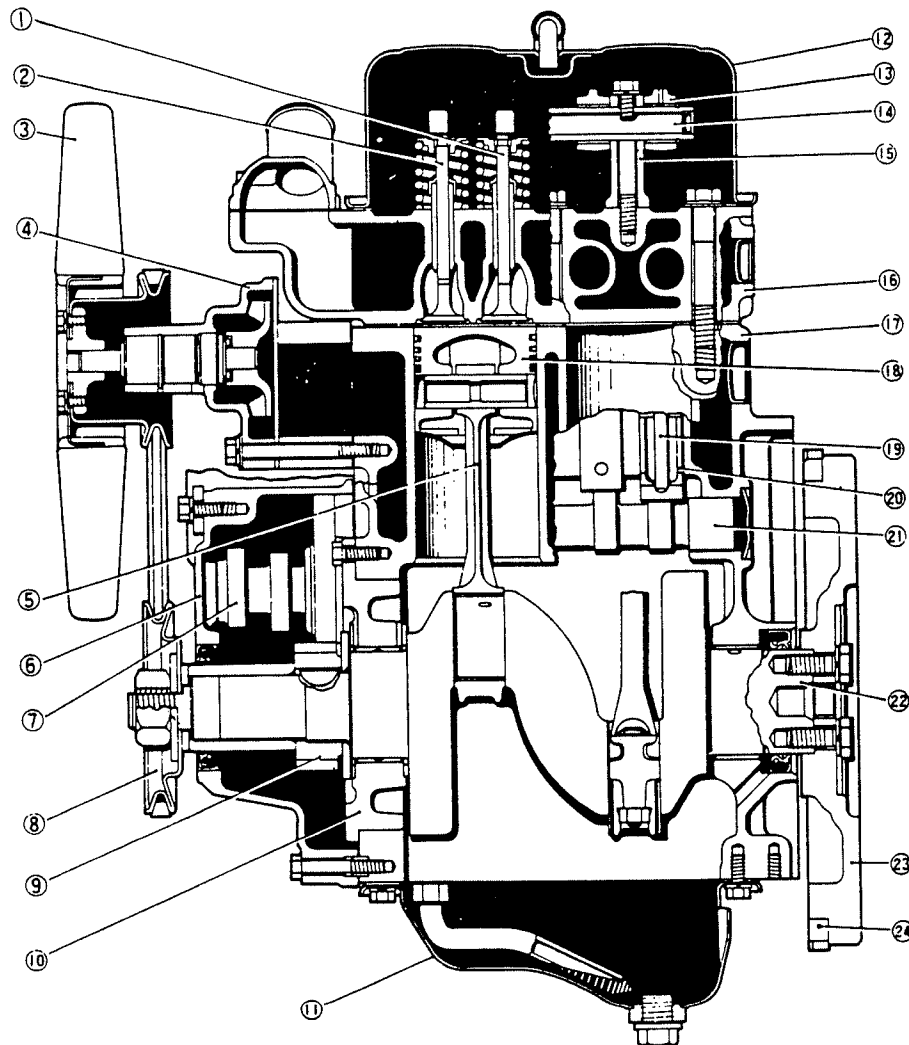
### ■ DISMOUNTING THE ENGINE ON THE 4-WHEEL DRIVE MODEL

1. Remove the universal joint cover.

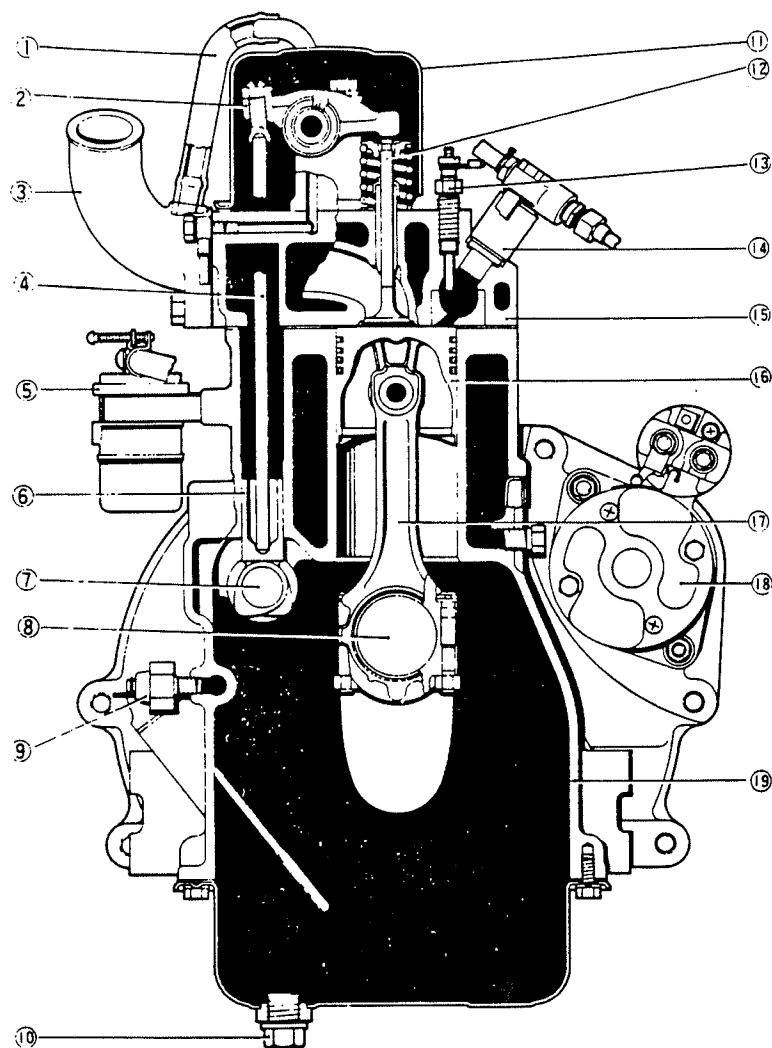


2. Remove the flang ass'y-to-carrier securing bolts and universal joint securing bolts. Then, disconnect the universal joint from the MID. P.T.O.
3. Remove the chassis from the engine with the front axle housing installed on the chassis.

## CROSS SECTION OF ENGINE



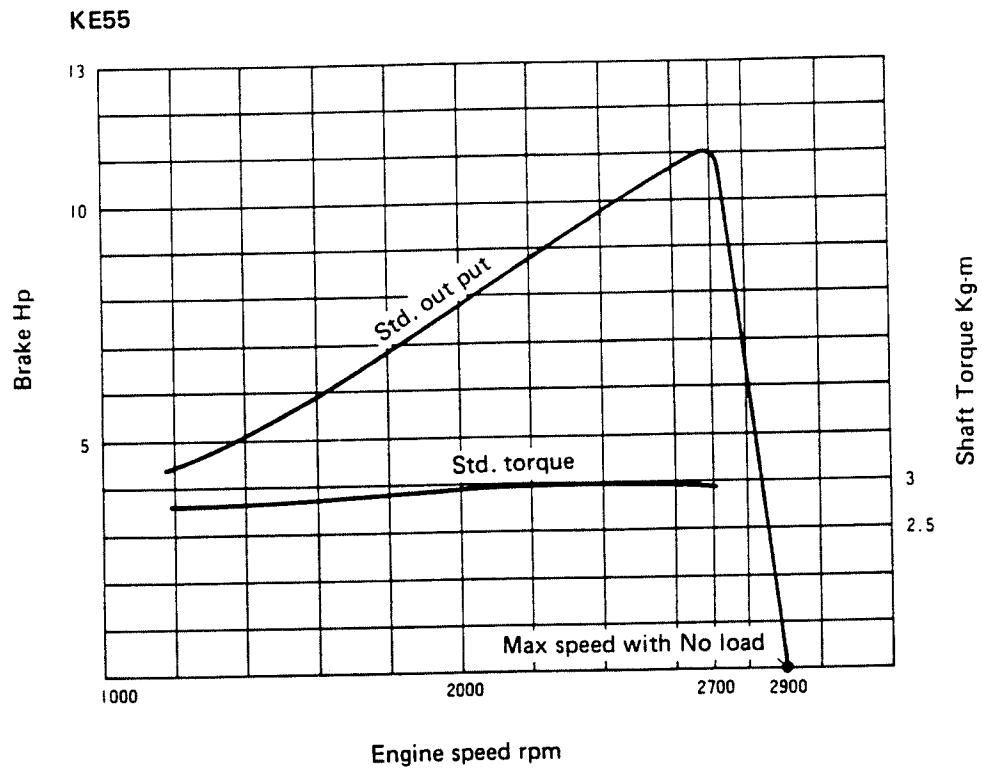
- |                      |                     |                |
|----------------------|---------------------|----------------|
| 1. Intake valve      | 9. Crankshaft gear  | 17. Crankcase  |
| 2. Exhaust valve     | 10. Bearing housing | 18. Piston     |
| 3. Cooling fan       | 11. Oil pan         | 19. Push rod   |
| 4. Water pump        | 12. Rocker cover    | 20. Tappet     |
| 5. Connecting rod    | 13. Rocker arm      | 21. Camshaft   |
| 6. Gear case         | 14. Rocker shaft    | 22. Crankshaft |
| 7. Camshaft          | 15. Rocker stay     | 23. Flywheel   |
| 8. Crankshaft pulley | 16. Cylinder head   | 24. Ring gear  |



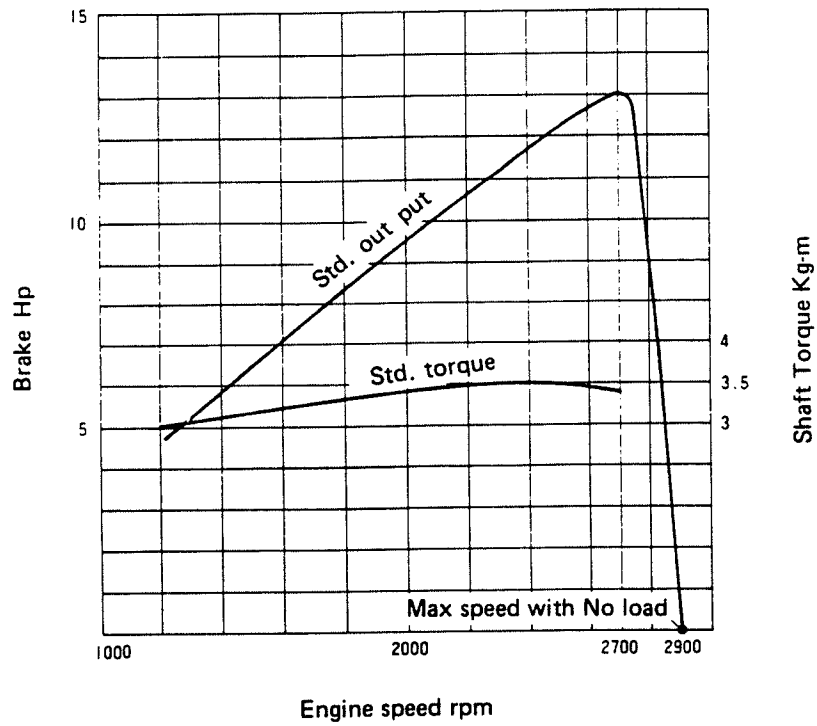
- |                  |                       |                    |
|------------------|-----------------------|--------------------|
| 1. Breather hose | 8. Crankshaft         | 15. Cylinder head  |
| 2. Rocker arm    | 9. Oil pressure gauge | 16. Piston         |
| 3. Inlet-valve   | 10. Drain plug        | 17. Connecting rod |
| 4. Push rod      | 11. Rocker cover      | 18. Starting motor |
| 5. Fuel filter   | 12. Exhaust valve     | 19. Crankcase      |
| 6. Tappet        | 13. Glow plug         |                    |
| 7. Camshaft      | 14. Nozzle            |                    |



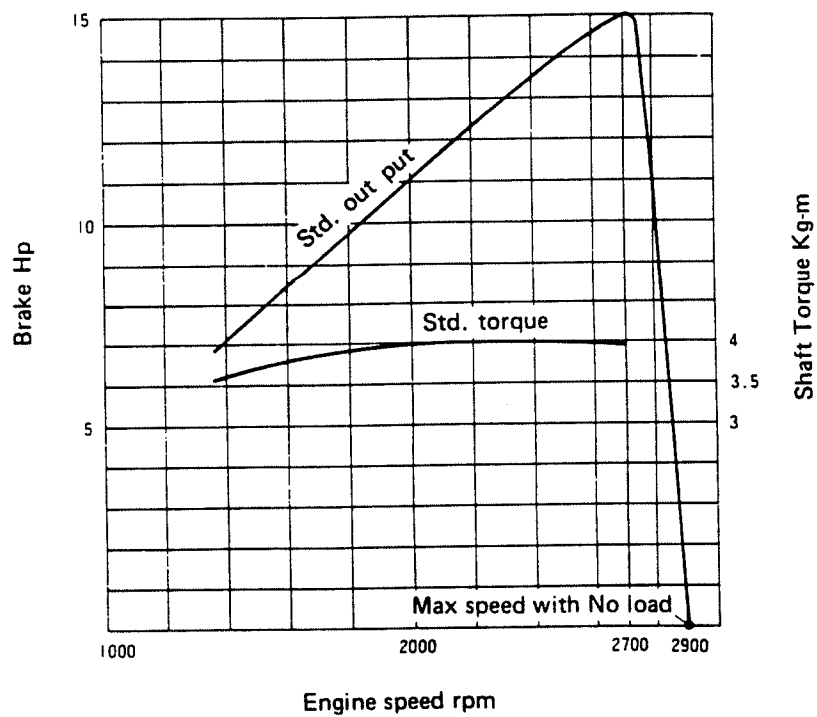
## PERFORMANCE CURVE



KE70



KE75



## SPECIFICATIONS

Model	KE55	KE70	KE75
Engine	4-cycle, water-cooled, overhead valve type diesel engine		
Combustion chamber	Swirl combustion chamber type		
Number of cylinder	2		
Bore x stroke (inch)	2.68 x 2.95 (68 x 75mm)	2.87 x 3.15 (73 x 80mm)	3.07 x 3.15 (78 x 80mm)
Displacement (cu. inch)	33 (544 cc)	40.8 (669 cc)	46.6 (764 cc)
Compression ratio	23	20	
Injection order	1 – 2		
Performance	Refer to “Engine Performance Curve” of each model.		
Dimensions	18.70 x 18.66 x 24.57		
L x W x H (inch)	(475 x 474 x 624mm)		
Dry weight (lb)	198.45 (90 kg)	220.5 (100 kg)	231.53 (105 kg)
Fuel	JIS No. 2 light oil (No. 3 in extremely cold weather)		
Fuel injection pump	Bosch-M type		
Governor	Centrifugal weight type		
Nozzle	Throttle type		
Injection pressure (lb/in <sup>2</sup> )	1706.4 (120 kg/cm <sup>2</sup> )		
Lubrication sytem	Forced feed type		
Oil pump	Trochoid type		
Oil filter	Paper element type		
Lubricant capacity (gal)	Max. 0.53~min.0.29 (2.0 ~ 1.1ℓ)	Max. 0.69~min. 0.42 (2.6 ~ 1.6ℓ)	
Cooling system	Forced circulation, water-cooled type		
Water pump	Centrifugal type		
Coolant capacity (gal)	Approx. 0.55 (2.1ℓ) (for engine proper only)		
Starter motor	Electromagnetic, inertial drive type		
	(12V – 0.9 kW)	(12V – 1.2 kW)	
Generator	Alternator (12-35A)		
Glow plug	Sheathed type		

## PERIODIC INSPECTION

Interval/time Check item	Daily Inspection	After first 30 hrs	Every 100 hrs	Every 200 hrs	Every 400 hrs	Every 800 hrs	Extended storage	Remarks
Slacks, damages, Leaks in parts	○							
Engine oil	○	●	●					
Oil filter		●						
Air Cleaner element			□		●			When placed at dusty location, clean every 50 hrs, replace every 200 hrs
Fuel	○						△	
Fuel tank					□		□	
Injection pump*						○		Adjust amt of fuel injection
Nozzle*				○				
Fuel filter			□		●			
Cooling water	○	●				●	△	Remove after operation except nonfreeze solution
Fan belt tension		○		○				
Meter check incl pilot lamp	○							
Glow plug					○			
Starter, alternator, regulator*					○	Note ○		Note voltage/current adjustment
Retightening of engine parts*		○				○		
Valve clearance*		○			○			
Engine idling*		○	○					
Condition, noises, Vibration of exhaust	○							
Engine compres- sion pressure*						○		

Notes: 1. Symbols ○ ..... Inspection, adjustment, replenishment

□ ..... Cleaning

● ..... Replacement

△ ..... Removal

2. For items marked with \*, consult our service engineer.

## SPECIFICATIONS AND MAINTENANCE STANDARDS

## ■ ENGINE-GENERAL

Item	Specification & Std. value	Repair limit	Service limit
Compression pressure . . . . .	455 lb/in <sup>2</sup> (32 kg/cm <sup>2</sup> ) (at 380 rpm)		Approx. 312.8 lb/in <sup>2</sup> (22kg/cm <sup>2</sup> )
Max. pressure difference between cylinders . . . . .		35.6 lb/in <sup>2</sup> (2.5 kg/cm <sup>2</sup> )	
Fuel injection order . . . . .	1 - 2		
Fuel injection timing . . . . .	.25° BTDC		
Cylinder head			
Distortion of cylinder head lower surface . . . . .	0.00197 inch (0.05mm) or less	0.00394 inch (0.1mm)	
Valve guide ID (both intake & exhaust)			
KE55 . . . . .	0.25984 ~ 0.26043 inch (6.6 ~ 6.615mm)		
KE70, 75 . . . . .	0.31496 ~ 0.31555 inch (8 ~ 8.015mm)		
Valve seat angle (both intake & exhaust) . . . . .	.45°		
Valve seat width (both intake & exhaust) . . . . .	0.03937 ~ 0.05906 inch (1 ~ 1.5mm)	0.07874 inch (2mm)	
Valve sinkage (both intake & exhaust) . . . . .			-0.03937 inch (-1mm)
Valve timing			
Inlet valve opens . . . . .	.18° BTDC		
Inlet valve closes . . . . .	.46° ABDC		
Exhaust valve opens . . . . .	.46° BBDC		
Exhaust valve closes . . . . .	.18° ATDC		
Valve clearance (both intake & exhaust) . . . . .	0.01378 inch <sup>r</sup> (0.35mm) (in cold condition)		
Intake valve			
Head dia x overall length			
KE55 . . . . .	1.10 x 4.19 inch (28 x 106.5mm)		
KE70, 75 . . . . .	1.18 x 4.57 inch (30 x 116mm)		
Stem OD . . . . .			
KE55 . . . . .	0.25846 ~ 0.25906 inch (6.565 ~ 6.580mm)		-0.00394 inch (-0.1mm)
KE70, 75 . . . . .	0.31338 ~ 0.32398 inch (7.96 ~ 7.975mm)		-0.00394 inch (-0.1mm)
Stem-to-guide clearance . . . . .			
KE55 . . . . .	0.00079 ~ 0.00197 inch (0.020 ~ 0.050mm)	0.00394 inch (0.1mm)	
KE70, 75 . . . . .	0.00098 ~ 0.00217 inch (0.025 ~ 0.055mm)	0.00394 inch (0.1mm)	
Seat face angle . . . . .	.45°		
Valve head thickness . . . . .			
KE55 . . . . .	0.03937 inch (1mm)		0.19785 inch (0.5mm)
KE70, 75 . . . . .	0.05906 inch (1.5mm)		0.19685 inch (0.5mm)
Exhaust valve			
Head dia. x overall length			
KE55 . . . . .	1.02 x 4.19 inch (26 x 106.5mm)		
KE70, 75 . . . . .	1.14 x 4.57 inch (29 x 116mm)		
Stem OD . . . . .			
KE55 . . . . .	0.15709 ~ 0.15787 inch (6.530 ~ 6.550mm)		-0.00591 inch (-0.15mm)
KE70, 75 . . . . .	0.3251 ~ 0.3234 inch (7.938 ~ 7.960mm)		-0.00591 inch (-0.15mm)

## 2-12 ENGINE SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
Stem-to-guide clearance	KE55 . . . . . 0.00197 ~ 0.00335 inch (0.050 ~ 0.085mm)	0.00591 inch (0.15mm)	
	KE70, 75 . . . . . 0.00157 ~ 0.00303 inch (0.040 ~ 0.077mm)	0.00591 inch (0.15mm)	
Seat face angle	. . . . . 45°		
Valve head thickness	KE55 . . . . . 0.03937 inch (1mm)		0.01969 inch (0.5mm)
	KE70, 75 . . . . . 0.05906 inch (1.5mm)		0.01969 inch (0.5mm)
Valve spring			
Free length	KE55 . . . . . 1.85 inch (47mm)	1.80 inch (45.6mm)	
	KE70, 75 . . . . . 1.81 inch (45.85mm)	1.75 inch (44.5mm)	
Installed load/installed height	KE55 . . . . . 46.5/1.43 (lb/inch) [21.1/39 (kg/mm)]	39.5/1.54 (lb/inch) [17.9/39 (kg/mm)]	
	KE70, 75 . . . . . 37.5/1.61 lb/inch [17/41 (kg/mm)]	32.0/1.61 lb/inch [14.5/41 (kg/mm)]	
Squareness	. . . . . 1.5°		.3°
Rocker arm			
Rocker arm-to-shaft clearance	. . . . . 0.00126 ~ 0.00417 inch (0.032 ~ 0.106mm)		0.00787 inch (0.2mm)
Crankcase			
Material	. . . . . Iron alloy casting		
Tappet hole bore	KE55 . . . . . 0.91055 ~ 0.90634 inch (23 ~ 23.021mm)		+0.00394 inch (+0.10mm)
	KE70, 75 . . . . . 1.2362 ~ 1.02445 inch (26 ~ 26.021mm)		+0.00394 inch (+0.10mm)
Camshaft hole bore (front)	. . . . . 1.77165 ~ 1.77263 inch (45 ~ 45.025mm)		+0.00591 inch (+0.15mm)
Camshaft hole bore (rear)	. . . . . 1.14173 ~ 1.14256 inch (29 ~ 29.021mm)		+0.00591 inch (+0.15mm)
Cylinder bore	KE55 . . . . . 2.67717 ~ 2.67835 inch (68 ~ 68.03mm)		+0.04724 inch (+1.2mm)
	KE70 . . . . . 2.8740 ~ 2.8752 inch (73 ~ 73.03mm)		+0.0472 inch (+1.2mm)
	KE75 . . . . . 3.0709 ~ 3.0720 inch (78 ~ 78.03mm)		+0.0472 inch (+1.2mm)
Cylinder wear limit	. . . . .	0.00787 inch (0.2mm)	0.0472 inch (1.2mm)
Cylindricity of cylinder bore	. . . . . 0.00039 inch (0.01mm) or less		
Piston			
Type	. . . . . Solid		
Material	. . . . . Aluminum alloy		
OD (skirt end)	KE55 . . . . . 2.6741 ~ 2.6748 inch (67.923 ~ 67.940mm)		
	KE70 . . . . . 2.8707 ~ 2.8715 inch (72.915 ~ 72.935mm)		
	KE75 . . . . . 3.0673 ~ 3.0681 inch (77.910 ~ 77.930mm)		
	KE55 . . . . . 0.00236 ~ 0.00421 inch (0.060 ~ 0.107mm)		

Item	Specification & Std. value	Repair limit	Service limit
Cylinder-to-piston clearance	KE70 . . . . . 0.00256 ~ 0.00453 inch (0.065 ~ 0.115mm)		
	KE75 . . . . . 0.00276 ~ 0.00472 inch (0.070 ~ 0.120mm)		
Oversize. . . . .	0.00984, 0.0197, 0.0295, 0.0394 inch (0.25, 0.50, 0.75, 1.00mm)		
Piston pin			
Installation. . . . .	KE55, 70. . . . . Press fit into con'rod KE75 . . . . . Full floating type		
OD. . . . .	KE55, 70. . . . . 0.74807 ~ 0.74831 inch (19.001 ~ 19.007mm)		
	KE75 . . . . . 0.90551 ~ 0.90516 inch (23.0 ~ 22.991mm)		
Piston pin-to- . . . . .	KE55, 70. . . . . 0.00004 ~ 0.00059 inch (0.001 ~ 0.015mm)		0.00315 inch (0.08mm)
piston clearance	KE75 . . . . . 0.00055 ~ 0.00016 inch [0.014 ~ 0.004T(tight)mm]		0.00315 inch (0.08mm)
Piston pin-to-connecting rod clearance			
	KE55, 70. . . . . 0.00063 ~ 0.00130 inch (0.016T ~ 0.033Tmm)		
Connecting rod-to-bush clearance			
	KE75 . . . . . 0.00098 ~ 0.00173 inch (0.025 ~ 0.044mm)		0.00394 inch (0.1mm)
Press fit load to con'rod . . . . .	KE55, 70. . . . . Within 1102.5 ~ 3307.5 lb (500 ~ 1500 kg)		
Piston ring			
No. of rings			
Compression. . . . .	.3(chrome plating for No. 1 only)		
Oil . . . . .	.1 (chrome plate)		
Ring thickness			
Compression. . . . .	KE70 . . . . . 0.079 inch (2mm) KE55, 75. . . . . 0.098 inch (2.5mm)		
Oil . . . . .	.0157 inch (4mm)		
	KE55, 75. . . . . 0.00787 ~ 0.01575 inch (0.2 ~ 0.4mm)		0.05906 inch (1.5mm)
Ring end clearance. . . . .			
	KE70 . . . . . 0.00591 ~ 0.01378 inch (0.15 ~ 0.35mm)		0.05906 inch (1.5mm)
Side clearance			
No. 1 . . . . .	0.00197 ~ 0.00354 inch (0.050 ~ 0.090mm)		0.001181 inch (0.3mm)
	KE55 . . . . . 0.00118 ~ 0.00295 inch (0.030 ~ 0.075mm)		0.00787 inch (0.2mm)
No. 2 & 3. . . . .			
	KE70, 75. . . . . 0.00138 ~ 0.00295 inch (0.035 ~ 0.075mm)		0.00787 inch (0.2mm)
Oil ring . . . . .	0.00118 ~ 0.00276 inch (0.03 ~ 0.07mm)		0.00787 inch (0.2mm)
Connecting rod			
Type. . . . .	Forged I beam		
Bend, twist . . . . .	0.00118 inch (0.03mm) or less . . . . .	0.00591 inch (0.15mm)	
Big end thrust clearance . . . . .	0.00394 ~ 0.01378 inch (0.1 ~ 0.35mm)	0.01969 inch (0.5mm)	

## 2-14 ENGINE SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
<b>Connecting rod bearing</b>			
Type .....	Special copper alloy w/ back metal		
Oil clearance. ....	0.00173 ~ 0.00327 inch (0.044 ~ 0.083mm)	0.00591 inch (0.15mm)	
KE55, 70. ....			
KE75 .....	0.00138 ~ 0.00378 inch (0.035 ~ 0.096mm)	0.00591 inch (0.15mm)	
Undersize. ....	0.00984, 0.0197, 0.0295 inch (0.25, 0.50, 0.75mm)		
<b>Crankshaft</b>			
Type .....	w/counter complete bal- lance		
End play .....	0.004 ~ 0.014 inch (0.1 ~ 0.35mm)		0.016 inch (0.4mm)
Journal OD .....	2.32 ~ 2.321 inch (58.945 ~ 58.96mm)		-0.0047 inch (-0.12mm)
<b>Journal undersize finish dimensions</b>			
0.0098 U.S. ....	2.310 ~ 2.311 inch (58.695 ~ 58.71mm)		
0.0196 U.S. ....	2.301 ~ 2.302 inch (58.445 ~ 58.46mm)		
0.0295 U.S. ....	2.291 ~ 2.291 inch (58.195 ~ 58.21mm)		
KE55, 70 .....	1.769 ~ 2.203 inch (44.95 ~ 55.965mm)	-0.0047 inch (-0.12mm)	
Pin OD .....	1.888 ~ 1.8883 inch (47.950 ~ 47.965mm)	-0.0047 inch (-0.12mm)	
KE75 .....			
<b>Pin undersize finish dimension</b>			
0.0098 in U.S. ....	1.759 ~ 1.760 inch (44.700 ~ 44.715mm)		
0.0196 in U.S. ....	1.750 ~ 1.7503 inch (44.450 ~ 44.460mm)		
0.0295 in U.S. ....	0.740 ~ 1.7407 inch (44.200 ~ 44.215mm)		
0.0098 in U.S. ....	1.8779 ~ 1.8785 inch (47.700 ~ 47.715mm)		
0.0196 in U.S. ....	1.8681 ~ 1.8687 inch (47.450 ~ 47.465mm)		
0.0295 in U.S. ....	1.8582 ~ 1.8588 inch (47.200 ~ 47.215mm)		
Bend of crankshaft .....	0.00078 inch (0.02mm)	0.00196 inch (0.05mm)	
Cylindricity of journal and pin. ....	0.0002 inch (0.005mm)	0.00196 inch (0.05mm)	
<b>Main bearing</b>			
Type .....	Special copper alloy with back metal		
Main bearing-to-crankshaft clearance. ....	0.0012 ~ 0.0045 inch (0.03 ~ 0.115mm)	0.006 inch (0.15mm)	
Undersize. ....	0.0098, 0.0196, 0.0295 inch (0.25, 0.50, 0.75mm)		
<b>Thrust bearing</b>			
Material. ....	Special aluminum alloy w/back metal		
Thickness. ....	0.0964 ~ 0.0984 inch (2.45 ~ 2.5mm)		-0.006 inch (-0.15mm)



40.76mm

Item	Specification & Std. value	Repair limit	Service limit
<b>Camshaft</b>			
Drive. . . . .	Gear		
Support (front, rear) . . . . .	Crankcase hole		
	1.7687 ~ 1.7696 inch		-0.006 inch
Journal OD (front) . . . . .	(44.925 ~ 44.95mm)		(-0.15mm)
	1.1260 ~ 1.1401 inch		-0.006 inch
Journal OD (rear) . . . . .	(28.939 ~ 28.96mm)		(-0.15mm)
Camshaft-to-crankcase hole clear- ance (front) . . . . .	0.00196 ~ 0.004 inch (0.050 ~ 0.100mm)	0.006 inch (0.15mm)	
Camshaft-to-crankcase hole clear- ance (rear) . . . . .	0.00157 ~ 0.00328 inch (0.040 ~ 0.082mm)	0.006 inch (0.15mm)	
Bend of camshaft . . . . .	0.00078 inch (0.02mm)	0.00196 inch (0.05mm)	
Tappet cam long diameter (intake and exhaust) . . . . .	1.6008 ~ 1.6086 inch (40.66 ~ 40.86mm)		-0.04 inch (-0.10mm)
Fuel injection pump cam long diameter . . . . .	1.9251 ~ 1.9330 inch (48.9 ~ 49.1mm)		-0.04 inch (-1.0mm)
<b>Tappet</b>			
	0.9036 ~ 0.9052 inch		-0.04 inch
KE55 . . . . .	(22.952 ~ 22.993mm)		(-0.10mm)
OD . . . . .	1.0217 ~ 1.0233 inch		-0.04 inch
KE70, 75 . . . . .	(25.952 ~ 25.993mm)		(-0.10mm)
Tappet-to-crankcase clearance . . . . .	0.000275 ~ 0.002716 inch (0.007 ~ 0.069mm)	0.006 inch (0.15mm)	
<b>Pushrod</b>			
Pushrod bend . . . . .			0.0118 inch (0.3mm)

## ■ LUBRICATION SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
<b>Engine oil</b>			
Engine oil capacity . . . . .	KE55 . . . . . 0.53 gal (2.0 ℓ)		
	KE70, 75 . . . . . 0.68 gal (2.6 ℓ)		
Engine oil viscosity . . . . .	SAE 10W-30 or SAE 20, 30		
<b>Oil pump</b>			
Type . . . . .	Trochoid		
Relief valve opening pressure . . . . .	49.7 psi (3.5 kg/cm <sup>2</sup> ) or more		
Outer rotor-to-body clearance . . . . .	0.006 ~ 0.008 inch (0.15 ~ 0.20mm)		0.012 inch (0.30mm)
Outer rotor-to-inner rotor clearance . . . . .	0.002 ~ 0.005 inch (0.05 ~ 0.12mm)		0.010 inch (0.25mm)
Rotor-to-cover clearance . . . . .	0.0012 ~ 0.003 inch (0.03 ~ 0.07mm)		0.010 inch (0.25mm)
<b>Oil pressure switch</b>			
Switch-on oil pressure . . . . .	2.84 ~ 5.68 psi (0.2 ~ 0.4 kg/cm <sup>2</sup> ) or less		

## 2-16 ENGINE SYSTEM

### ■ FUEL SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
Fuel . . . . .	JIS #2 gas oil (JIS #3 gas oil in very cold condition)		
Fuel filter			
Type . . . . .	Filter paper, cartridge type		
Fuel injection pump			
Type . . . . .	Bosch M		
Designation . . . . .	ND-PFR2M		
Plunger . . . . .	0.217 inch (5.5mm), left lead		
Fuel injection timing . . . . .	25° BTDC		
Nozzle			
Type . . . . .	Throttle		
Designation . . . . .	ND-DN4 SD24		
Injection start pressure . . . . .	1706 ~ 1849 psi (120 ~ 130 kg/cm <sup>2</sup> )	1564 psi (110 kg/cm <sup>2</sup> ) or less	
Governor			
Type . . . . .	Centrifugal		
Governor spring . . . . .	Varies according to specification		

### ■ COOLING SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
Cooling fan			
Type . . . . .	Blades made of synthetic resin, unequal pitch suction type		
Belt			
KE55 . . . . .	V-belt, HM standard type, circumferential length: 32.79 inch (833mm)		
Type . . . . . KE70, 75 . . . . .	V-belt, HM standard type, circumferential length: 34.25 inch (870mm)		
Water pump			
Type . . . . .	Centrifugal impeller type		
Thermo-switch			
Switch-on water temperature . . . . .	221 ~ 232°F (105 ~ 111°C) or more		

## ■ ELECTRICAL SYSTEM

Item	Specification & Std. value	Repair limit	Service limit
<b>Starter motor</b>			
Type	Electromagnetic coupling		
Designation	KE55 . . . . . M003T 15772		
	KE70, 75 . . . . . M004T 14673		
Out put, voltage	KE55 . . . . . 0.9kW, 12V		
	KE70, 75 . . . . . 1.2kW, 12V		
Direction of revolution	CW (viewed from pinion side)		
<b>No-load characteristics</b>			
At terminal voltage 11V	Current	KE55 . . . . . 55A or less	
		KE70, 75 . . . . . 62A or less	
	Speed	KE55 . . . . . 6500 rpm or more	
		KE70, 75 . . . . . 4500 rpm or more	
Brush length	0.67 inch (17mm)		0.45 inch (11.5mm)
Pinion gap (pinion-to-stop ring clearance at pinion operating position)	0 ~ 0.08 inch (0 ~ 2mm)		
<b>Alternator</b>			
Type	AC type		
Output voltage	35A, 12V		
Polarity	Negative (—) earth		
Direction of revolution	CW (viewed from pulley side)		
<b>Out put characteristics ( in cold condition)</b>			
Terminal voltage 14V	Current	.26.5A or more	
	Speed	.2500 rpm	
Brush length	0.5 inch (12.5mm)		0.33 inch (8.3mm)
<b>Regulator</b>			
Type	Tirril, 2-element		
Regulated voltage (at 20°C)	13.5 ~ 14.5V		
<b>Pilot lamp relay</b>			
	Extinguishing voltage	4.0 ~ 5.8V	
	Lighting voltage	0.5 ~ 3.5V	
<b>Glow plug</b>			
Type	Sheathed type		
Rated voltage	10.5V		
Resistance (at room temperature)	1 ~ 1.2Ω		
<b>Glow lamp</b>			
Type	Red heat type		
Rated current	20A		
Voltage between terminals (at 20A)	0.9 ~ 1.1V		

## ■ TABLE OF TIGHTENING TORQUES

## DETERMINATION OF ENGINE OVERHAUL TIME

Generally the time to overhaul the engine is determined by symptoms such as decreased engine output, decreased compression pressure and increased fuel/lubricant consumption. However, decreased engine output can result from the damaged nozzle, maladjusted injection pump, etc. not directly relating to the engine fault. Accordingly, it is more appropriate to determine the engine overhaul period based on the compression pressure drop.

Compression pressure drops are caused by a number of factors. Therefore, the cause of trouble must be found with reference to the data obtained by periodic inspections and maintenance.

In case of wear of cylinder liners, piston rings, etc., the following symptoms will be found.

1. Decreased engine output and compression pressure
2. Increased fuel consumption
3. Increased lubricant consumption
4. Hard engine start
5. Louder noises of engine parts

Usually, two or more of the above symptoms accompany. Above 2 and 4 are sometimes caused by excessive fuel injection, improperly timed injection or worn plunger and nozzle. Malfunction of the electrical system such as the battery, alternator, starter and glow plugs greatly affects the engine performance.

Therefore, it is advisable to determine the engine overhaul time based on the compression pressure drop due to wear associated with cylinder liners and pistons together with increased oil consumption, etc.

### ■ MEASUREMENT OF COMPRESSION PRESSURE

Compression pressure is the source of explosive force of diesel engine. Complete combustion can not be obtained unless sufficient compression pressure is achieved even if the engine parts are otherwise normal.

In order to determine apt overhaul time based on the compression pressure drop, it is important to check its level by means of periodic compression pressure measurement. Since compression pressure varies with the engine speed, the engine speed

should be checked concurrently. The engine speed can be checked at the front end of the crankshaft.

### Compression pressure measurement procedures

- a. Remove the glow plug of the cylinder to be checked.
- b. Install the special tool Adapter in the glow plug threaded hole, then connect a pressure gauge to the adapter.
- c. Turn the starter. When the starter has gained a constant speed, read the engine tachometer and pressure gauge.
- d. Measure the compression pressure of remaining cylinders by the same steps as above.

### NOTE:

Be sure that two cylinders are measured. Checking only one and estimating the other are not acceptable.

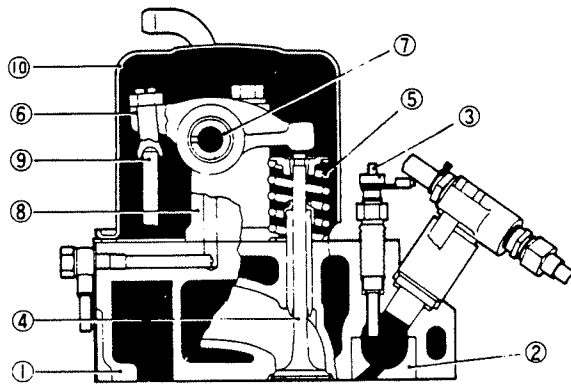
### Judging Engine Conditions from Compression Pressure

- a. In case of a new engine, the compression pressure more or less increases due to break-in of piston rings, valve seats, etc. However, it gradually drops as a result of wear of engine parts.
- b. When the compression pressure has fallen below the repair limit, the engine must be overhauled.

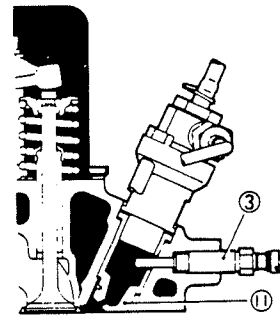
### ■ INCREASED LUBRICANT CONSUMPTION

An overhaul is essential when the lubricant consumption is found to be approx. 150% with the standard taken as 100%.

## ENGINE CONSTRUCTION AND MAINTENANCE



Swirl chamber type

Pre-combustion chamber type  
(Early type of KE70, 75)

Cross Section of Cylinder Head

1. Cylinder head
2. Swirl chamber
3. Glow plug
4. Exhaust valve
5. Valve spring
6. Rocker arm
7. Rocker shaft
8. Rocker stay
9. Pushrod
10. Rocker cover
11. Pre-combustion chamber

## CONSTRUCTION OF CYLINDER HEAD

## ■ CONSTRUCTION

**Cylinder Head**

The cylinder head is made of cast iron and possesses a high rigidity and superb cooling effect. It is the overhead valve type and the intake and exhaust ports are integrally cast. On the left side of the cylinder head are provided the swirl chamber and glow plug to obtain complete combustion and higher starting characteristic.

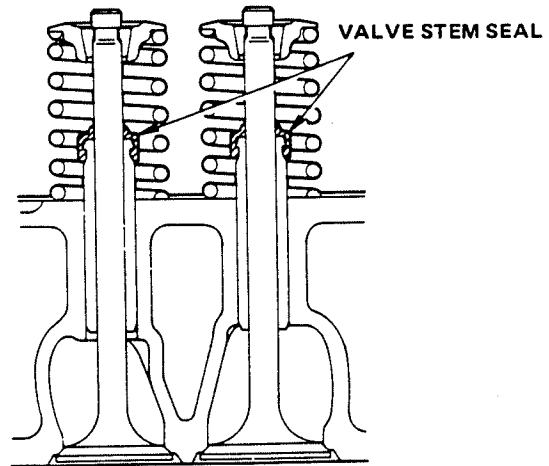
**Cylinder Head Gasket**

The cylinder head gasket is of steelbest as sheet. The cylinder bore portion has a wire ring and is provided with a grommet of stainless steel. (For preventing water leakage or oil leakage, apply sealout to the water passage and, the both sides around the push rod hole).

A patch sheet with adhesives stuck on the outside portion of the pushrod hole on the cylinder head side makes the coating of the sealant at installation unnecessary. The mark "KE70" is cut on the surface of the cylinder head side.

**Valves and valve Springs**

The intake valve has a large head diameter to improve intake efficiency and is of heat resisting steel. The exhaust valve has the head portion on which special heat resisting steel is welded in order to withstand higher temperature. At the top of the valve guide, the valve stem seal is installed to seal the oil.



The valve spring is made of highly rigid valve spring material. The spring, spring retainer and retainer lock are used in common for intake and exhaust.

**Combustion Chamber**

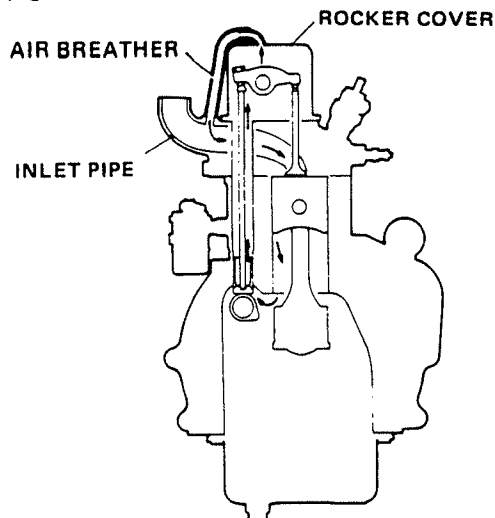
The combustion chamber is the swirl chamber type and is provided with the swirl chamber.

The swirl chamber is of heat resisting steel and is pressed into the cylinder head. The swirl chamber cannot be removed from the cylinder head since both are worked together.

**Rocker Arms and Rocker Shaft**

The rocker arms are made of forged carbon steel and lead bronze bushings are pressed therein.

The rocker shaft is a hollow pipe which provides oil passage. The periphery of the rocker shaft which engages the rocker arms is induction hardened.

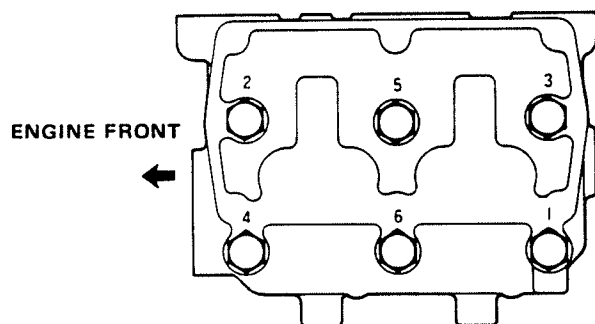
**Blow-by gas Recirculator****Blow-by Gas Recirculator**

The blow-by gas recirculator keeps the blow-by gas in the crankcase from being liberated in air. The blow-by gas in the crankcase is guided into the rocker cover through the pushrod hole from the tappet hole and goes into the inlet pipe via the air breather pipe from the rocker cover and is re-combusted.

### ■ CYLINDER HEAD DISASSEMBLY, ASSEMBLY AND ADJUSTMENT

**Disassembly**

1. Remove the air breather pipe.
2. Remove the inlet pipe and exhaust manifold.
3. Remove the oil pipe from the cylinder head.
4. Remove the alternator brace mounting bolts from the cylinder head.
5. Remove the fuel return pipe.
6. Remove the fuel injection pipe from the nozzle holder.
7. Remove the rocker cover.
8. Remove the cylinder head bolts as shown in the figure below.

**Sequence of Loosening Cylinder Head Bolts**

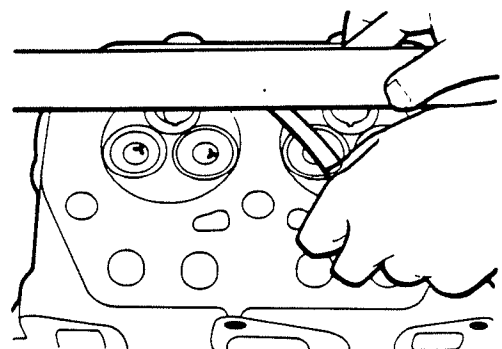
9. Remove the cylinder head assy. Scrape off the gasket stuck on the crankcase completely.
10. Remove the nozzle holder assy.
11. Disconnect the glow plug lead wire, then remove the glow plug.
12. Loosen the rocker stay mounting bolts and remove the rocker shaft assy.
13. Compress the valve spring with the valve lifter and remove the retainer, spring and valve. Keep the valves, etc. for each cylinder so that none is lost.

**Inspection****NOTE:**

1. Check the cylinder head for possible water leaks, damages, etc. before flashing.
2. Before inspection/repair, thoroughly flash each part to remove oil, deposits, carbon, dust, etc.
3. Remove deposits in the oil hole by introducing air and make sure of no clogging.

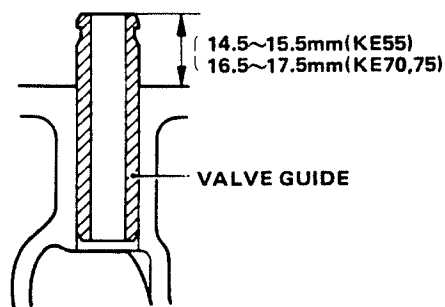
**Cylinder Head**

- a. Before cleaning, check the cylinder head for possible cracks, damages, water leaks, etc.
- b. Check the oil passage for clogging.
- c. Check the bottom of the cylinder head as shown below for possible distortion using a straight edge and thickness gauge.

**Cylinder Bottom Distortion Check****Valve Guide**

- a. Check the valve stem-to-valve guide clearance. In case the service limit is exceeded, replace the valve guide and valve. When the valve is replaced due to worn valve guide, replace the valve guide also which must have been worn.

- b. To replace the valve guide, press the old valve guide allway through the cylinder head from bottom to top using a press. Then press the new valve guide into position from the top of the cylinder head using a press as shown in the figure below. After the above press-in, check for proper valve guide-to-valve stem clearance. If the clearance is smaller than the standard, correct it with the reamer until the standard value is obtained.

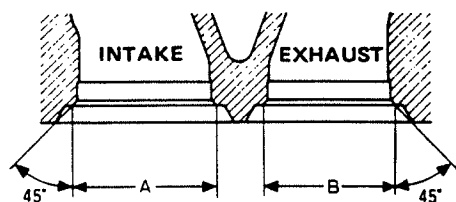


Press-in of Valve Guide

### Valve Seat

- a. Check the valve seat for possible damages, dents, etc. Correct any defect as shown in the figure below. After correction, lap the valve seat face in contact with the valve using the compound.

Tolerance Model	A(mm)	B(mm)
KE55	26.1~26.3	24.1~24.3
KE70, 75	28.9~29.1	26.9~27.1



Correction of Valve Seat

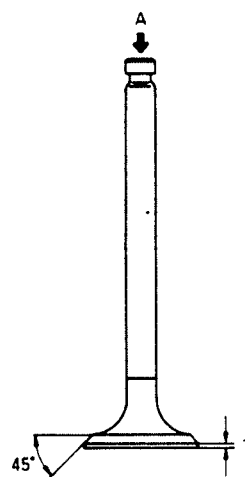
### NOTE:

Before correcting the valve seat, check the valve guide for possible wear, etc. Make correction, if necessary, after replacement of the valve guide.

- b. In case the valve seat sinkage exceeds the service limit, replace the cylinder head. The valve seat sinkage is checked by measuring the length of the valve spring installed.

### Valve

- Check the valve head (seat face) and the stem. In case of excessive wear, damage or deformation, repair or replace.
- Replace the valve having the valve head thickness T beyond the service limit.
- Repair or replace the valve stem with the worn or concaved top end A (contact face with rocker arm).



Valve checking

### Valve Spring

- Check the valve spring for possible cracks and damages.
- Check the free length and load of the spring. Replace excessively deteriorated spring.
- Check the squareness of the spring. Replace excessively tilted spring.

### Rocker Arm and Rocker Shaft

- Replace the rocker arm with excessively worn or damaged face engaging the valve. Check the adjusting screw and replace the one with worn or damaged contact face relative to the push-rod.
- Measure the rocker arm bush ID and rocker shaft OD (the point where the rocker arm is installed). In case of excessive clearance, replace the rocker arm assy.



## ASSEMBLY AND ADJUSTMENT

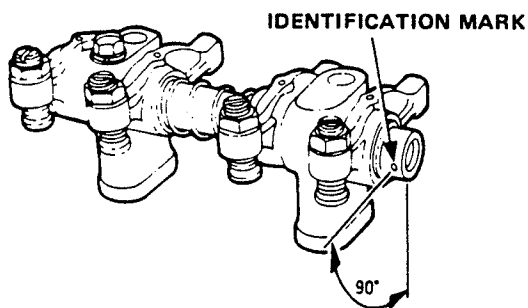
### NOTES:

- 1 Thoroughly clean the parts to be assembled.
- 2 Assemble sliding and moving parts while applying oil.

1. Securely fit the valve stem seal on the valve guide.

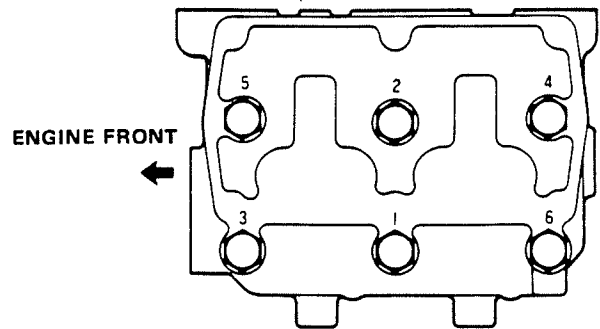
### NOTES:

- The valve stem seal shall not be reused.
2. Apply engine oil over the valve stem and insert it into the valve guide. Then assemble the valve springs and retainers into position, compress the spring with the valve lifter and install the retainer lock.
  3. Assemble the rocker arms, rocker shafts and rocker stays as shown.
- Note the direction of rocker shaft installation. Install the rocker shaft so that the identification mark at the front end of the shaft comes on the left side from front. Apply engine oil to the internal face of the rocker arm bush before installation.



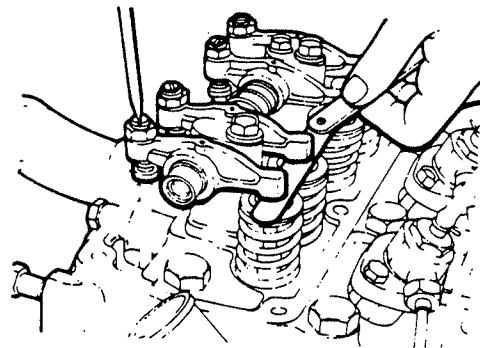
Rocker Arm Shaft Assembly

4. Install the rocker arm shaft assembly on the top of the cylinder head and bolt it into place securely.
5. Install the glow plug. Tighten it by the specified torque.
6. Insert the nozzle holder gasket. Install the nozzle holder assy. Tighten the mounting bolts by the specified torque.
7. Connect the glow plug lead wire.
8. Do not apply sealant over the cylinder head gasket since the sealant is already coated thereon.
9. Tighten the cylinder bolts in the order shown by the specified torque.



Order of Tightening Cylinder Head Bolts

10. Install new gaskets and packings. Apply sealant over the specified locations.
11. Adjustment of Valve Clearance  
Insert the thickness gauge between the valve stem and the rocker arm with each cylinder at TDC on compression stroke and make adjustment by turning the adjusting screw until the specified value is obtained.

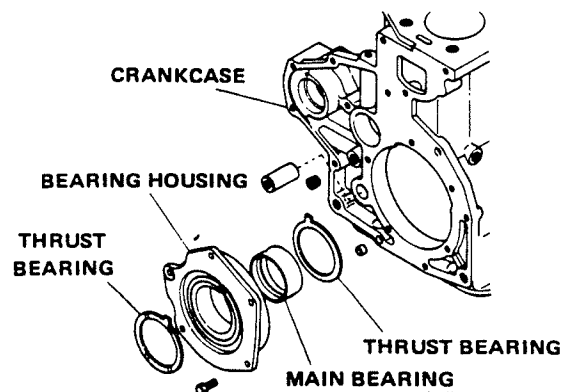


Valve Clearance Adjustment

## ■ CONSTRUCTION OF CRANKCASE

### Crankcase and Cylinder

The crankcase is made of alloyed cast iron and integral with the cylinder. It is the full jacket type.



Crankcase and Bearing

The main bearing is the bush type with the back metal and is made of special copper alloy. It is flush plated. The thrust load of the crankshaft is born by the thrust bearing in the front bearing section.

### Crankshaft

The crankshaft is made of high carbon steel and is precision forged. The pin and journal are induction hardened to enhance wear resisting property. The balancer is of integral construction.

### Flywheel and Ring Gear

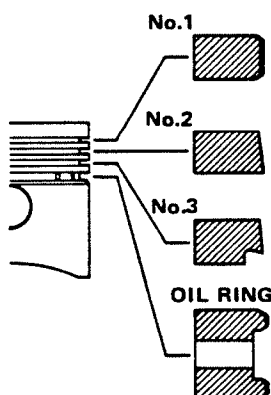
The flywheel is designed to have a high inertial efficiency and the least torque variation. The ring gear is of shrinkage fit to the flywheel and its teeth have induction hardened addenda to increase wear resisting property.

### Piston, piston pin and piston Ring

The piston is of special light aluminum alloy. The piston profile is cylindrical and tapered (smaller upward) so as to assure optimum contact with the cylinder bore.

The piston pin is a hollow, special alloy steel product and completely carburizing annealed. The piston pin is press-fitted into the connecting rod.

Four (4) piston rings, three (3) and one (1) oil ring are used. The No. 1 ring and oil ring have hard chrome plated contact face relative to the cylinder.



Piston Ring

### Connecting Rod

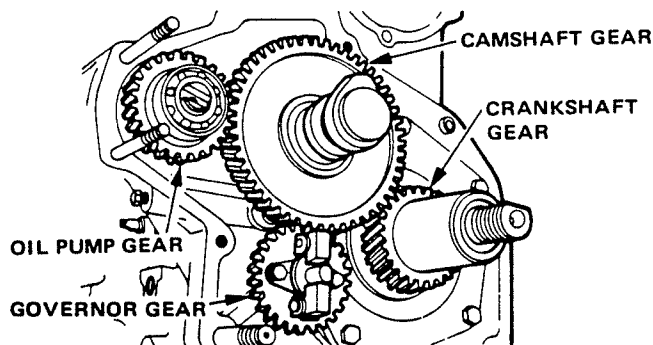
The connecting rod is a forged high carbon steel product with I-section and the large end is of horizontal split construction, thus enhancing the rigidity.

The piston pin is press-fitted to the small end of the rod.

The bearing at the large end is of a special copper alloy with back metal and is flush plate.

### Timing Gears

The timing gears are herical gears. The crankshaft gear drives the camshaft gear. While the camshaft gear drives the governor gear and oil pump gear.



Timing Gear Train

### Camshaft

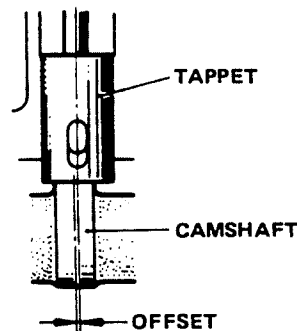
The camshaft is a forged high carbon steel product and is integral with the injection pump cam. The cam face and the journal are induction hardened. The camshaft is supported by the bearings of the crankcase.

The front journal has an oil hole for supplying oil to the cylinder head and rocker arm therethrough intermittently.

The thrust load of the camshaft is born by the crankcase front and the plane provided in the timing gear case.

### Tappet and pushrod

The tappet is cylindrical and the bottom and the pushrod receiving portion have been subjected to



Offsetting of Tappet and Cam

special surface treatment.

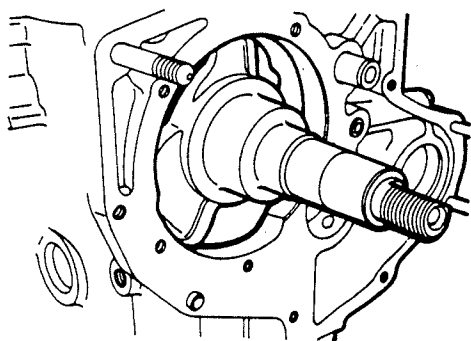
The tappet is designed to rotate in an offset relationship with the cam for the prevention of lopsided wear of the tappet bottom.

The pushrod is made of steel bar and specially hardened at both ends.

## ■ CRANKCASE DISASSEMBLY, ASSEMBLY AND ADJUSTMENT

### DISASSEMBLY

1. Refer to "Cylinder Head" for the removal of items belonging to the cylinder head.
2. Refer to "Fuel System", "Cooling System" and "Electrical System" for the removal of injection pump, water pump and electrical items.
3. Refer to "Lubrication System" for the removal of oil filter and oil pump.
4. Remove the pushrod. Extract the tappet upward from the crankcase.
5. Remove the oil pan and the gasket.
6. Remove the flywheel.
7. Loosen crankshaft pulley nuts and remove the pulley and washer.
8. Remove the timing gear case and gasket.
9. Remove the oil pump gear.
10. After removal of the governor weight assy, remove the snap ring and then governor gear.
11. Remove the camshaft and gears from the crankcase.
12. Remove the sleeve, crankshaft gear, plate and thrust washer.
13. Remove the connecting rod cap and remove the piston and connecting rod from the crankcase. Keep removed caps and bearings separately for each cylinder.
14. Remove the bearing housing from the crankcase.



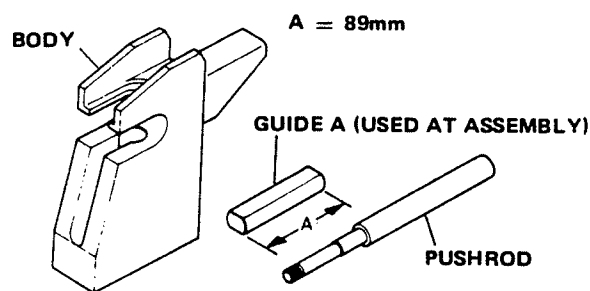
Removing Crankshaft

15. Align the notch of the crankcase hole with the crankshaft counter weight and remove the crankshaft. Care should be taken not to damage the main bearing.

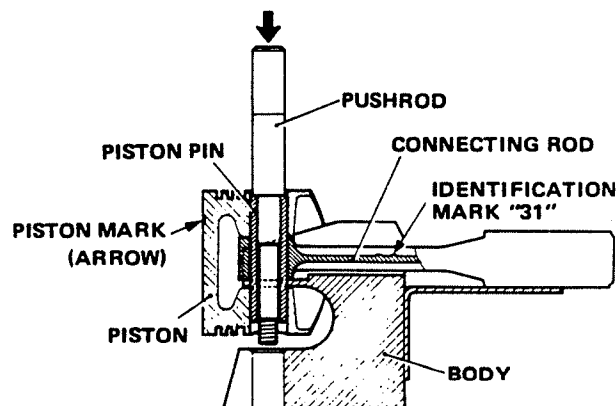
### 16. Disassembly of Piston Pin and Connecting Rod

To disassemble the piston and connecting rod, use special tool piston pin setting tool MD 998130 and follow the procedures below.

- 1) Set the piston and connecting rod assy on the tool body as shown, insert the tool pushrod into the piston pin hole and remove the piston pin by pushing with a press.



Piston Pin Setting Tool



Removing Piston Pin

### NOTES:

1. Always use a press for removing the piston pin. Never tap or strike the piston pin. When a great force is required to remove the piston pin seized, replace it with a new one. Do not apply a load exceeding 3000 kg to the pin setting tool.
2. For the proper setting of the piston and connecting rod on the tool body, make sure the small end of the connecting rod securely rests on the tool body receiving part.

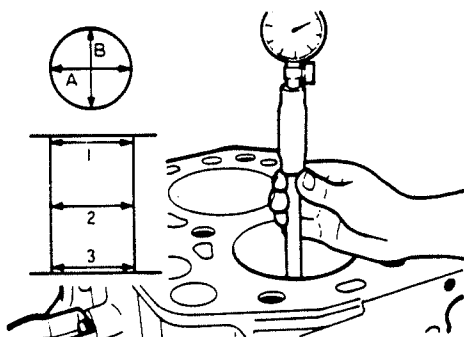
## Checking

### NOTES:

1. Check the crankcase for possible water leaks, damages, etc. before cleaning.
2. Before inspection/repair, clean each part to remove dust, oil, carbon, deposits, etc.
3. Remove the deposits on the oil passage with air under pressure and check for possible clogging.

### Crankcase

- a. Check the crankcase for possible cracks and damages. Replace defective crankshaft.
- b. Check the water jacket for deposits, rust, etc. and correct as required.



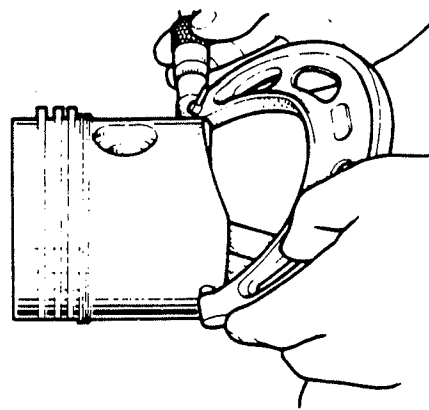
Cylinder Bore Measurement

- c. Measure the cylinder liner ID of A and B at 3 points shown using the cylinder gauge. Correct the liner to oversize or replaces as required.
- d. In case the cylinder liner is still within the repair limit and only the piston ring is to be replaced, check for a ridge at the top of the cylinder liner. If there is a ridge, hone as required.

### Piston, piston pin and piston Ring

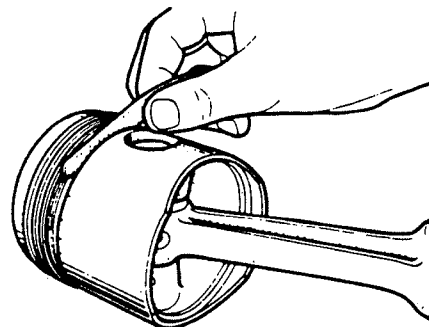
- a. Check the piston for sticking, scores, wear, etc. Replace defective piston.
- b. Measure the piston OD and replace excessively worn piston. If the piston-to-cylinder clearance is greater than normal, rebore and hone the cylinder bore to the oversize or replace the piston.

Measure the piston OD in the direction at right angle and parallel to the piston pin hole (thrust direction) at the bottom of the skirt.



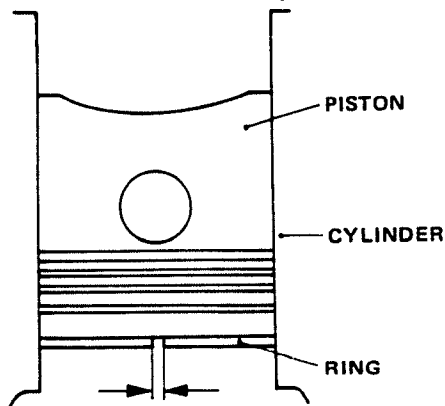
Measuring Piston OD

- c. When using the oversize piston, finish the cylinder bore to oversize. First measure OD of the oversize piston used (diameter in the direction of thrust at the bottom of the piston skirt), then bore the cylinder bore to obtain the cylinder bore-to-piston clearance of the specified value (0.065 – 0.115 mm) and hone the cylinder bore.
- d. Measure the clearance between the piston ring groove and the piston ring (side clearance) and replace the piston ring as required. If the clearance is not corrected after replacement of piston ring, replace the piston.



Measuring Side Clearance

- e. Measure the piston ring gap clearance and replace the piston ring if the gap clearance is excessively great. For measuring the gap clearance, push the ring down to the point of the clearance with the thickness gauge.

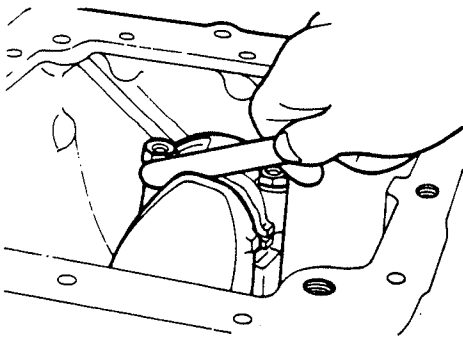


Measuring Gap Clearance

- f. When the clearance between the piston pin and piston or connecting rod small end is excessive, replace piston pin assy or connecting rod assy.

### Connecting Rod

- Measure the bend and distortion of the connecting rod using the connecting rod aligner. If the bend or distortion is excessive, correct or replace the connecting rod.
- Install the connecting rod on the crankshaft. Measure the thrust clearance. If the clearance is excessively great, replace the rod assy.



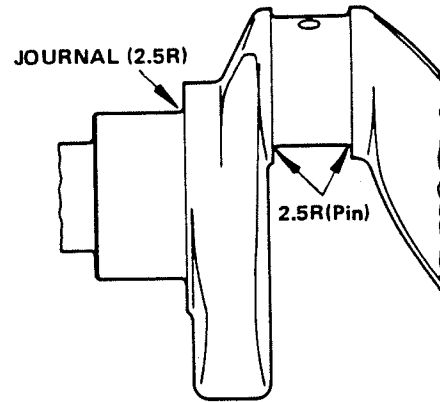
Measuring Thrust Clearance of Connecting Rod

### Crankshaft

- Check the periphery of the journal and pins for damages, sticking, etc. Measure OD. If wear is excessive, correct to an undersize and replace the main bearing and connecting rod bearing with those of the same undersize.

### NOTE:

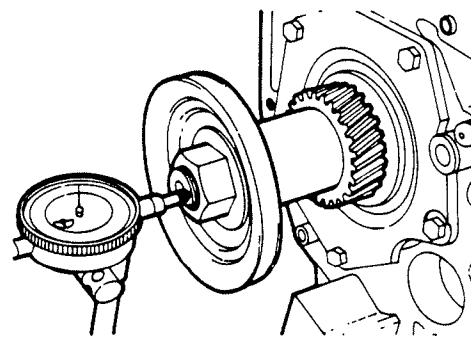
- Grind the crankshaft, if required, only after the bend is corrected. Finish so that the fillets radius become the following dimensions shown.



Fillet Radius

- Measure the end play of the crankshaft. If the end play exceeds the specified value, replace the thrust bearing.

For measuring the end play, install the crankshaft and main bearing housing, then the gear, sleeve and pin, and tighten the nuts. Apply the dial gauge to the tip of the crankshaft.



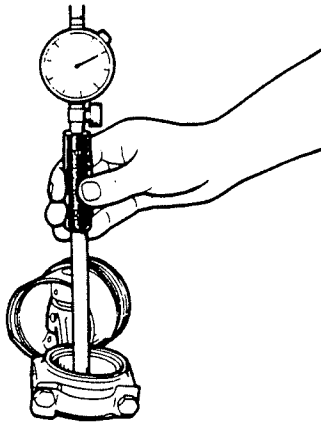
Measuring End play of Crankshaft

### Main Bearing, Connecting Rod Bearing

- Check the bearing surface for peeling, fusion, sticking and dents. Replace the defective parts.
- Measure ID with the main bearing and the connecting rod bearing installed on the crankcase, bearing housing and connecting rod, respectively.

Then measure OD of the crankshaft journal and pin and calculate the oil clearance.

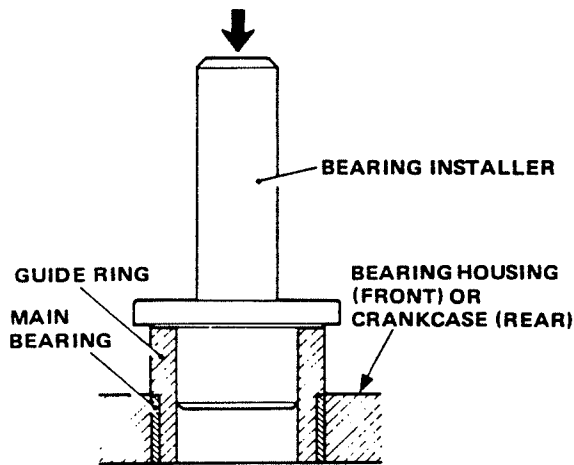
If the oil clearance is excessively great, replace the bearing. If the standard oil clearance is not obtained after bearing replacement, grind the crankshaft to an undersize and install the bearing of the same undersize.



Measuring ID of Connecting Rod Bearing

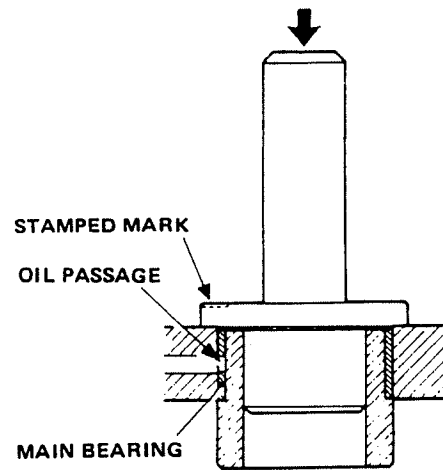
c. Use special tool bearing installer for replacing the main bearing.

- 1) To remove the main bearing, place the installer body on the guide ring as shown. To remove the main bearing from the bearing housing, push it all the way through from the front to the rear. To remove the main bearing at the back of the crankcase remove the oil seal, then push from the back of the crankcase to the case interior.



Removing Main Bearing

- 2) To press-fit the main bearing, assemble the installer body, guide ring and main bearing to be pressed in as shown and press in from the same direction as for removal.



Press fitting of main Bearing

#### NOTE:

1. Install the main bearing by pressing so that the oil passage of the crankcase is aligned with that of the bearing. Set the main bearing so that the oil passage is aligned with the mark provided on the collar of the installer body and press it into position aligning with the oil passage of the crankcase. Once set, do not turn the tool or bearing. Press the main bearing so that its xxxxxx comes above the center of the crankshaft.
2. Before installing the bearing, apply engine oil over the bearing surface. Always use a press. Never strike with a hammer, etc.

#### Timing Gears

- a. Check each gear teeth for dents, wear, damages, etc. Replace defective gears.

#### Camshaft

- a. Measure the clearance between the camshaft journal (front, rear) and the crankcase hole. If the clearance is excessively great, replace the camshaft or crankcase.
- b. If the cam face has a damage or wear of the cam projection exceeds the service limit, replace the camshaft.

#### Oil pump Drive Gear

- a. If wear and damage on the oil pump drive gear and ball bearing are excessive or there are abnormal noises and binding, replace affected parts.

**NOTE:**

1. When pressing the ball bearing into the gear shaft, press the inner race firmly so that no load is applied to the outer race.

**Tappet**

- a. Check the tappet bottom (tappet-to-cam contact face) for cracks, peeling and scores. Replace the tappet if such defect is excessive.

**Pushrod**

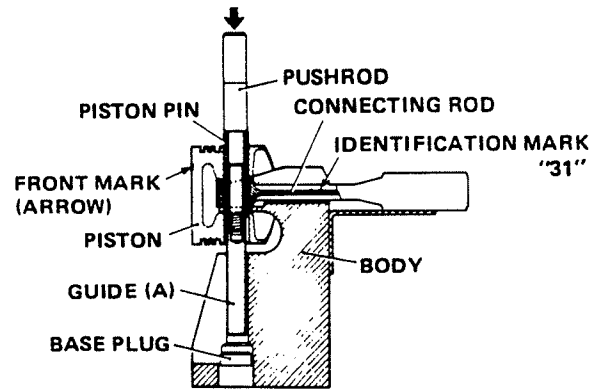
- a. Replace the pushrod if wear at the end is excessive.
- b. Place the pushrod on the stool and measure the bend at the center. If the bend exceeds the standard, correct or replace the pushrod.

**ASSEMBLY AND ADJUSTMENT****NOTES:**

1. Thoroughly clean the parts to be installed. Clean the oil passages, bearings, bearing fitting holes and cylinder interior with great care.
2. Apply engine oil over the sliding parts and moving parts such as cylinder inner walls, bearings, etc. before installation.
3. Do not reuse gaskets, packing, oil seals, etc. Use new ones for replacement.
4. Always apply sealant over the specified parts.
5. Observe instructions on tightening torque and sequence wherever applicable. For other places, follow the practice for tightening general screws.
6. Make sure of proper clearance and end play while assembling.

**1. ASSEMBLING PISTON AND CONNECTING ROD**

- a. For assembling the piston and connecting rod, use the special tool piston pin setting tool MD 998130 and follow the procedure steps below.

**Installing Piston Pin**

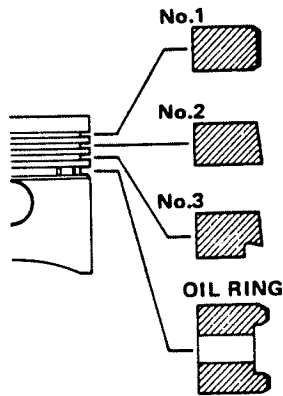
- 1) Insert the piston pin into the pushrod of the tool and fully screw in the guide to the pushrod.
- 2) Insert assembled pushrod, piston pin and guide to the piston pin hole from the guide side. Assemble by passing them through the connecting rod small end hole. Assemble so that the front mark (arrow) at the top of the piston and the identification mark on the connecting rod face the same side. Sufficiently apply engine oil over the piston pin and the connecting rod small end bore.
- 3) Set the assembled piston, connecting rod and tool on the tool body. For the above setting, insert while aligning the notch of the guide and that of the body, then turn the guide 90 deg. At the end of setting, make sure that the connecting rod small end securely rests on the holding part of the body. Also, make sure that the front mark (arrow) at the top of the piston and the identification mark on the connecting rod point upward.
- 4) Install the piston pin using the press. Press-in load at this time will be 500 - 1500 kg. If other than the above, replace the connecting rod or piston pin assy. The piston pin is pressed into place by the guide. At the end of installation, turn the pushrod 90 deg to align notches of the guide and the body and remove the connecting rod assy from the tool body.

### NOTE:

After assembling the piston and connecting rod, make sure that the piston and connecting rod, make sure that the piston pin has been installed evenly with respect to the rod center. Correct if the piston pin is abnormally offset. In such case, check the tool for normalness.

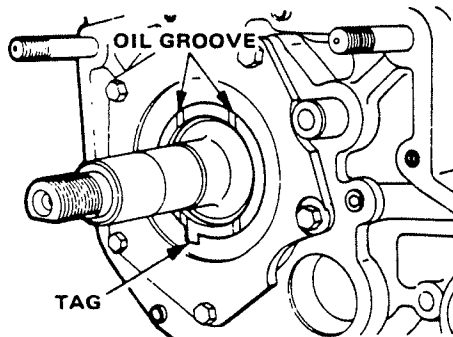
#### b. Assembly of Piston Rings

The piston ring assy is composed of rings of different shape. Install each ring in the correct position and direction as shown. Install the piston rings so that the face on which the maker mark and size mark are stamped comes to the piston top side.



Position of Piston Rings

2. Insert the crankshaft into the crankcase. Apply engine oil over the main bearing and journal. Be careful not to damage the main bearing.
3. Install the bearing housing. When installing, align the tag of the inner thrust bearing and the oil grooves of the bearing housing.

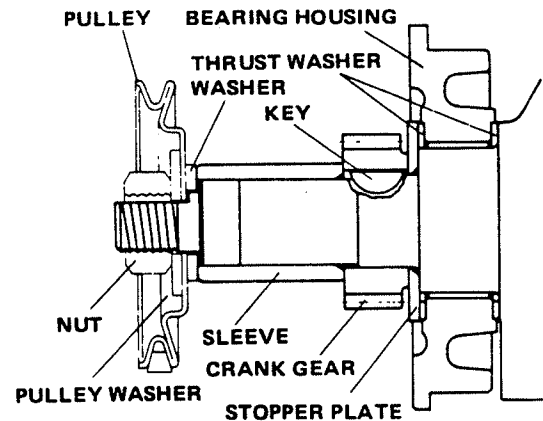


Mounting Thrust Bearing

### NOTE:

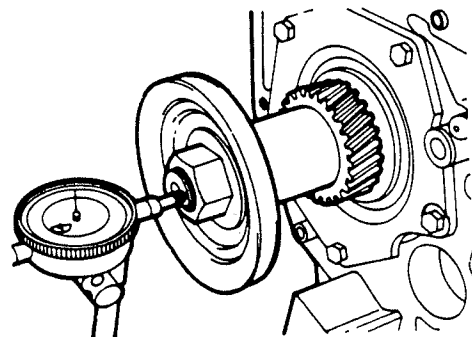
The inner and outer thrust bearings are the same. Measure the thickness before installation and use only those of specified dimension. Thereby the end play of the crankshaft is controlled.

4. Install the outer thrust bearing in alignment with the bearing housing groove, then install the stopper plate, crankshaft gear and distance piece. Install so that the stopper plate has its chamfered side at the rear of the engine, the crankshaft has its ridged side at the rear of the engine and the distance piece of the larger ID goes first.



Assembling Gear and Sleeve

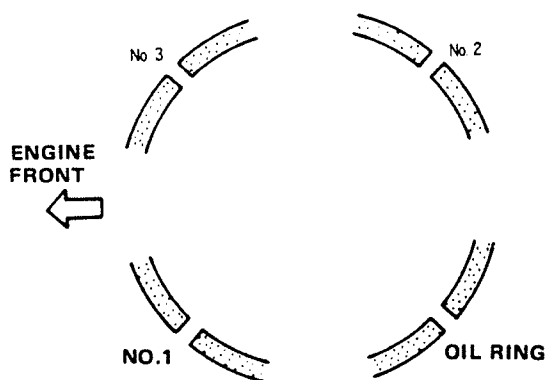
5. Tentatively install the crankshaft pulley and tighten the nut. Then check the crankshaft for the end play. If the end play is far greater than the specified value, recheck the thrust bearing. Make certain that the crankshaft and sleeve piece have been installed securely. After checking the end play, loosen the nut and remove the pulley and washer.



Checking Crankshaft End Play

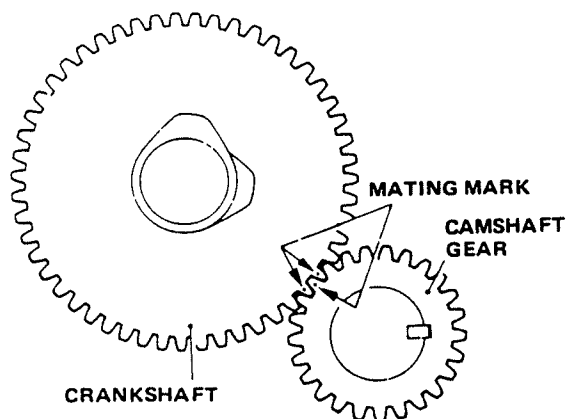


6. Insert the piston and connecting rod assy into the cylinder. Install the connecting rod cap, tighten it by the specified torque. Insert the bolt into the connecting-rod side and tighten the nut from the cap side. When inserting the piston, firmly fasten the piston ring with the ring band and insert so that the front mark on the top of the piston and identification mark on the connecting rod point are directed to the engine front. Also, install so that the ring gap is neither in the direction of thrust nor in the direction of piston pin and the gaps of adjoining rings are spaced as far as possible.



Positions of Piston Ring Gaps

7. Key the camshaft to the cam gear and insert into the crankcase. At this time, align the alignment marks on the crankshaft gear with that on the camshaft gear as shown.

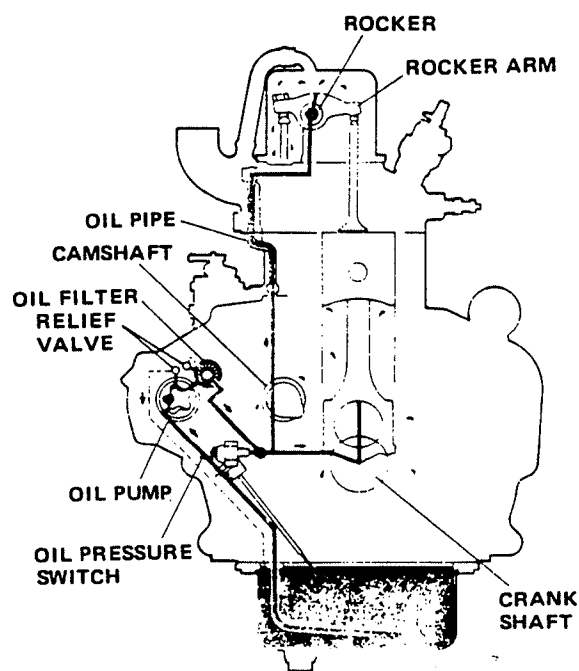


Gear alignment mark

8. Install the governor gear and fit the snap ring into the shaft. Then install the governor weight assy and sliding shaft.
9. Install the oil pump drive gear having the ball bearing.
10. Install the timing gear case (the governor link is installed). Stick the gasket coated with the specified sealant on the gear case.
11. Install the key for pulley on the crankshaft and install the crankshaft pulley. Before fitting the nut, make sure that the crank pulley washer has been installed.
12. Install the flywheel and tighten the bolt by the specified torque.
13. Install the oil pan.
14. Insert the tappet.

## LUBRICATION SYSTEM CONSTRUCTION AND MAINTENANCE

### CONSTRUCTION OF LUBRICATION SYSTEM



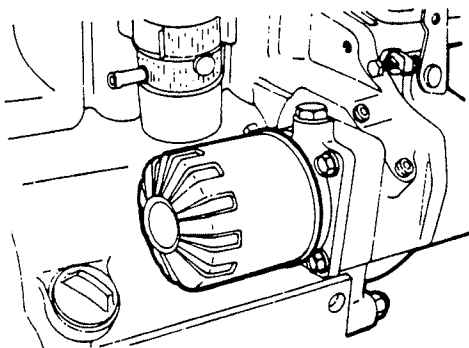
Lubricant Oil Flow

#### Oil Filter

The oil filter is of the cartridge type and has the integral body and element, accordingly, handling is facilitated.

When the element becomes dirty or loaded and the difference between the oil pressure at the front and

the back of the element becomes more than approx. 1 kg/cm<sup>2</sup>, the relief valve incorporated in the element opens and the oil is supplied to each part without passing the element. Therefore, it is important to check or replace the element periodically. Internal cleaning is not required. The element should be replaced after a 100-hour operation.



Oil Filter

### Oil pump

The oil pump is of the trochoid type and is located at the right front part of the crankcase. The oil filler is attached thereon.

The oil pump has the built-in relief valve, which relieves oil into the oil pan when the discharge pressure exceeds 3.5 kg/cm<sup>2</sup> thus preventing the oil pressure from increasing.

### Oil pressure Switch

The oil pressure switch is installed on the right rear side of the crankcase. This switch is actuated to turn on the lamp when the hydraulic pressure of the lubrication system drops to less than 0.2 - 0.4 kg/cm<sup>2</sup> during normal operation. When the lamp has lit, stop operation and perform troubleshooting.

## ■ DISASSEMBLY, ASSEMBLY AND ADJUSTMENT OF LUBRICATION SYSTEM

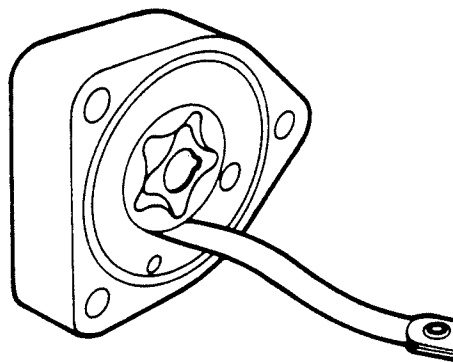
### Oil Filter

- When the removal by hand failed, use commercially available special tool or a V-belt which is to be wound about the filter.
- Thoroughly tighten the oil filter by hand for installation (Ref: tightening torque 1.1-1.3 kg-m). Make sure that the O-ring is firmly seated in the groove, then apply a thin coat of engine oil.
- Start engine and check for oil leaks.

### Oil Pump

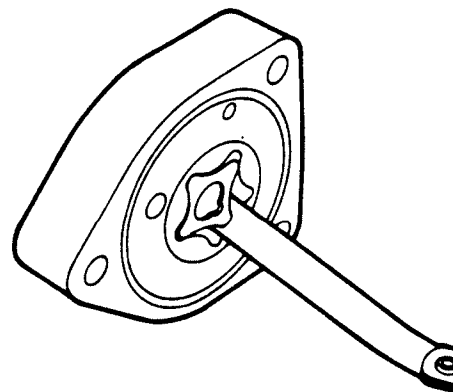
Observe the following precautions for disassembly and assembly.

- Apply engine oil over the moving parts before assembly.
- At the end of assembly, make sure that the pump shaft turns smoothly.
- Measure the clearance between the outer rotor and the body with the thickness gauge. If the clearance is excessively great, replace the rotor assy or body.



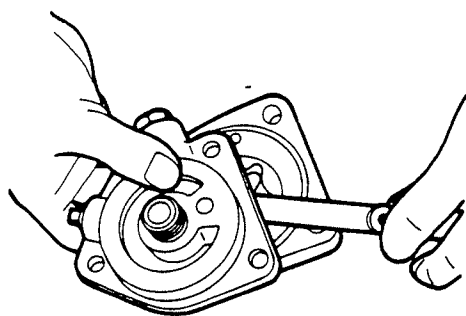
Outer Rotor-to-Body Clearance

- Measure the clearance between the outer rotor and the inner rotor with the thickness gauge. If the clearance is excessively great, replace the rotor assy.



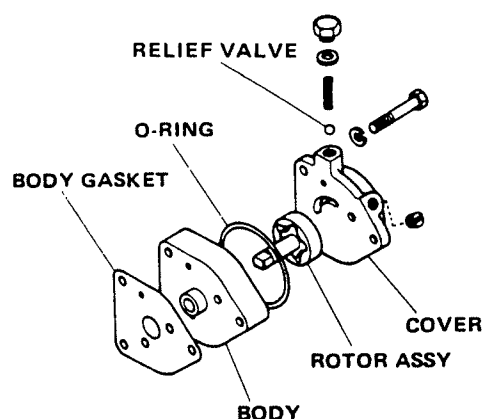
Outer Rotor-to-Inner Rotor Clearance

- Check the clearance between the rotor and the cover after inserting the rotor in the pump body. Attach the straight edge and measure the clearance between the straight edge and the rotor with the thickness gauge. If the clearance is not within the specified limit, replace the rotor assembly or the body.



Rotor-to-Cover Clearance

## f. Assembling Oil Pump

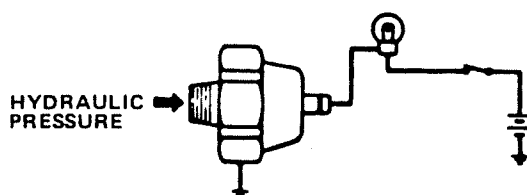


Oil Pump

- 1) Install the rotor assy on the oil pump body.
- 2) Install the oil pump on the crankcase so that the oil pump shaft projection and the gear shaft groove comes into engagement. Replace the gasket with new one.
- 3) Replace the O-ring with new one and install it to the pump body. Install the cover.

## Oil Pressure Switch

- a. Check the oil pressure switch as shown. Replace the oil pressure switch which has failed to meet the standard value.



Checking Oil Pressure Switch

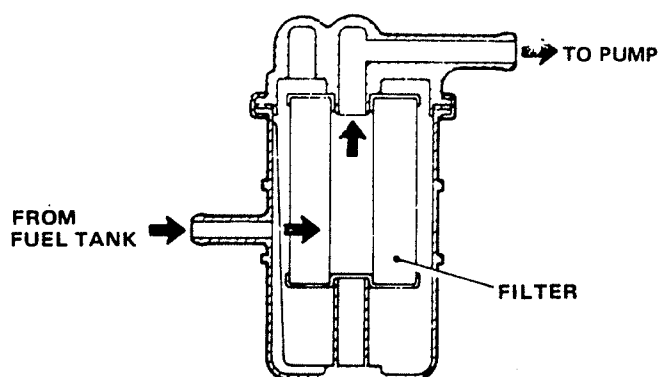
## CONSTRUCTION AND MAINTENANCE OF FUEL SYSTEM

## ■ CONSTRUCTION OF FUEL SYSTEM

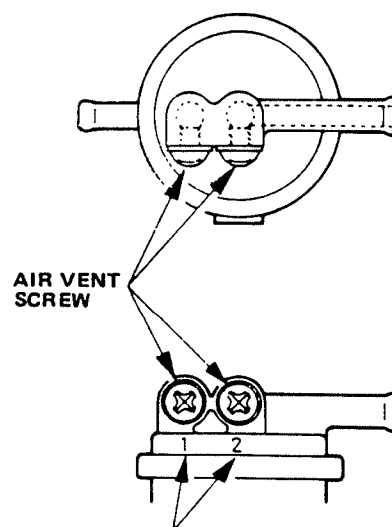
## Fuel Filter

The fuel filter is of the easy-to-use cartridge type and the paper filter element is employed.

At the top of the filter are provided with two air vent screws. These screws are numbered as shown. Air must be vented in that order.



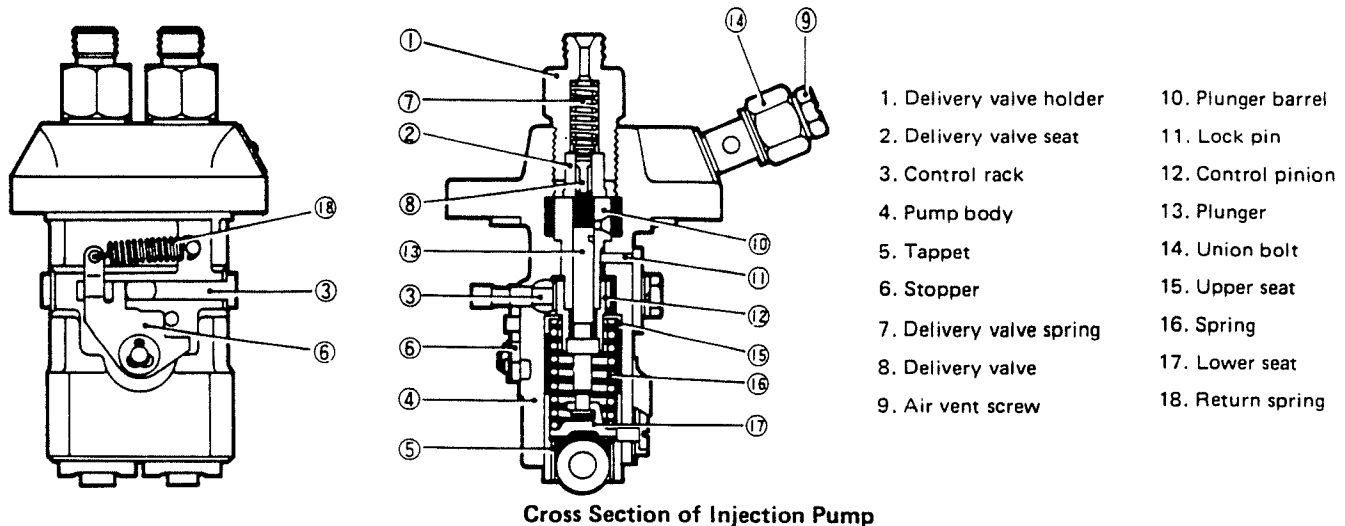
CROSS SECTION



AIR VENT ORDER

Fuel Filter

## Fuel Injection Pump



The fuel injection pump is the 2-cylinder type and comprises a pump element, delivery valves, tappets, a smoke set unit, etc.

The injection pump is installed at the top of the gear case. Fuel is pressure fed by the reciprocation action of the plunger of a given stroke which takes place as the plunger is pushed up by the injection pump cam in the gear case.

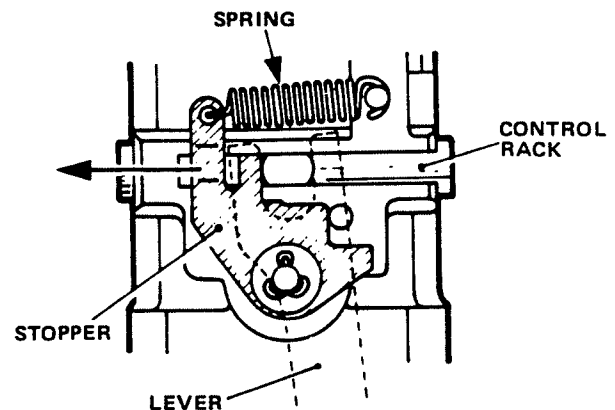
The increase and decrease of injection change the relative position of the plunger lead and plunger barrel. The plunger is turned by the control pinion provided on the outer periphery of the plunger barrel. With this pinion is meshed the collar at the bottom of the plunger and the plunger turns as the pinion does.

The control pinion is turned by the control rack. The control rack is turned through the governor weight, governor sleeve and governor lever which are acted upon by the centrifugal force generated by the engine revolution (camshaft rotation). The clockwise rotation of the rack decreases the amount of injection, while the counterclockwise rotation of the rack increases it.

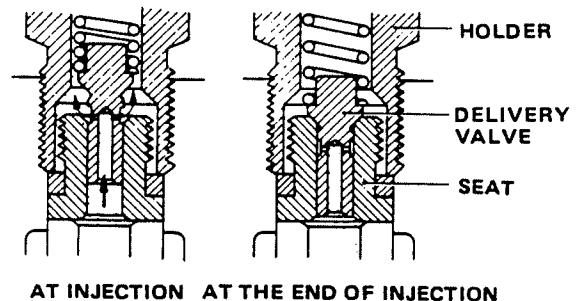
The smoke set unit is provided in this injection pump to limit the maximum amount of injection. The stopper is held in the position shown by the action of the spring and this is the position of the smoke set.

When, starting, the speed control lever is pulled fully in the direction of maximum speed, the control rack overcomes the action of the stopper spring

via the link and moves in the direction shown by an arrow. Thus, overinjection can be obtained.



**Smoke Set Unit**



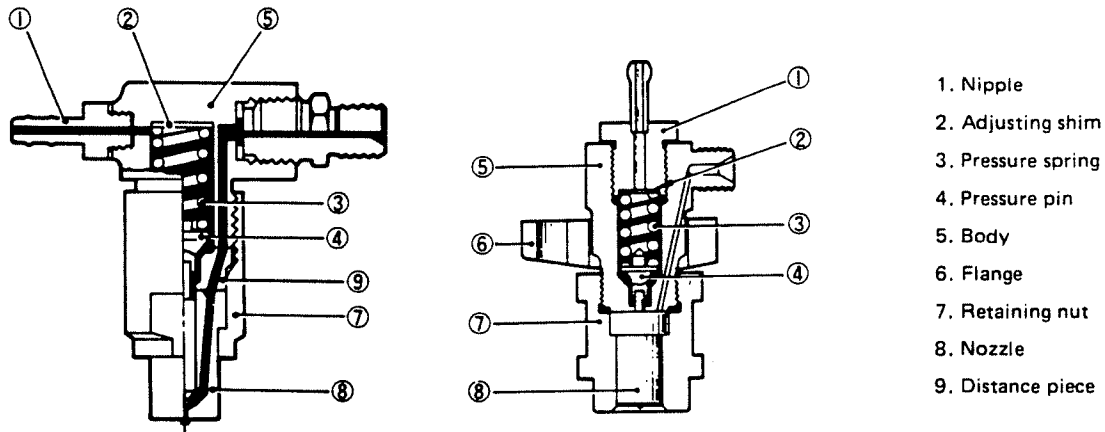
**Delivery Valve Operation**

In addition to feed the fuel to the injection pipe when the fuel pressure is sufficiently built up, the delivery valve has the important function to pre-

vent dribbling of fuel at the end of injection. As the fuel pressure above the plunger drops at the end of injection, the piston of the delivery valve closes the delivery valve seat, however, compressed fuel still remains in the pipe and drips from the

nozzle. The delivery valve piston draws the residual fuel back into the injection pipe while the delivery valve rests on the seat and reduces the pressure in the injection pipe to almost zero.

### Nozzle and Nozzle Holder

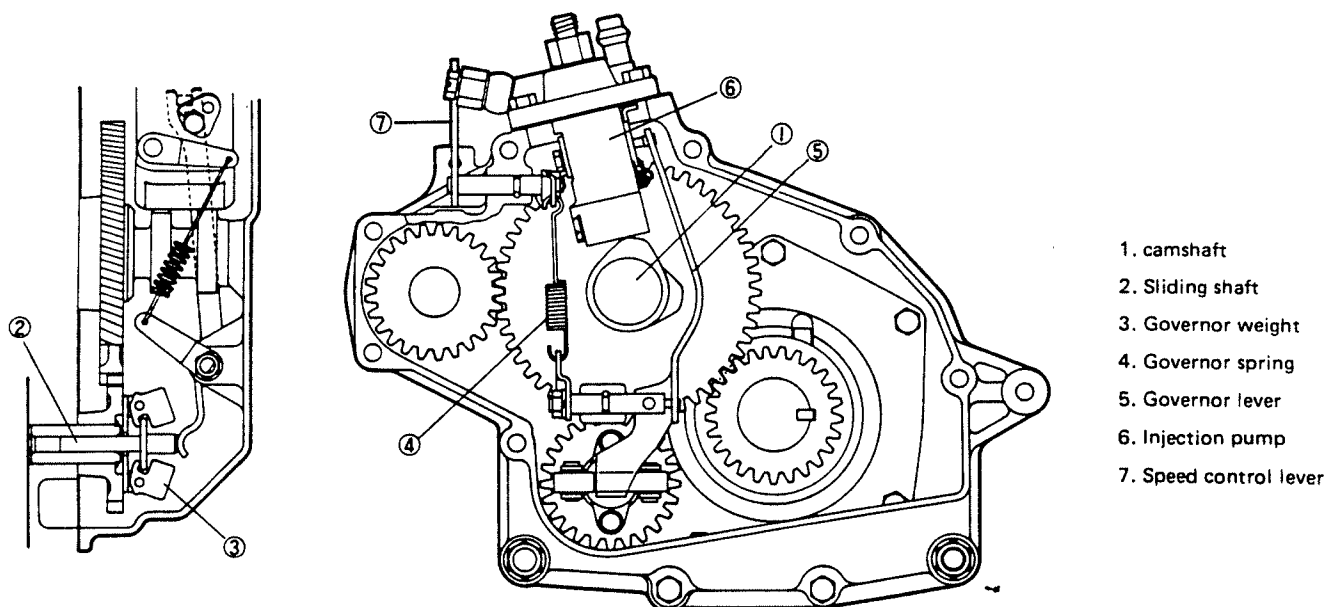


**Cross Section of Nozzle Holder**

The fuel which has been pressure fed from the fuel injection pump is injected into the combustion chamber from the nozzle after passing through the nozzle holder body. The fuel overflowing from the

nozzle is returned to the fuel tank from the nipple at the top via the overflow pipe after passing through the nozzle holder.

### Governor



**Governor**

The governor keeps the engine speed constant by maintaining a balance between the centrifugal force acting upon the governor weight according to the engine speed and the tension of the governor spring. As the engine speed becomes high, the governor weight 3 opens, pushing the sliding shaft 2 forward. Resulting action of the governor lever 5 moves the injection pump control rack in the direction of reducing the amount of injection and concurrently pulls the governor spring 4. At the point where the above tension and the centrifugal force exerting on the governor weight are balanced, the engine is kept at a constant speed.

## ■ FUEL SYSTEM DISASSEMBLY, ASSEMBLY AND ADJUSTMENT

### DISASSEMBLY

#### Nozzle and Nozzle Holder

- a. Remove the injection pipe from the nozzle holder.
- b. Remove the overflow pipe from the nipple at the top of the nozzle holder.
- c. Loosen the nozzle holder mounting bolt and remove the nozzle holder assy. Disassemble the nozzle holder by the following procedure:

Separate the holder body from the retaining nut. To remove the nozzle from the retaining nut, gently tap the nozzle with a piece of wood. Be careful not to damage the nozzle.

#### Governor

- a. Remove the V-belt. (Refer to "Cooling System".)
- b. Remove the crank pulley.
- c. Remove the injection pump. (Refer to "Injection Pump".)
- d. Remove the gear case mounting bolt and remove the gear case assy.
- e. Remove the governor spring.
- f. Remove the governor lever.
- g. Remove the speed control lever.
- h. Remove the governor weight assy and sliding shaft.

### NOTE:

Avoid disassembly and assembly of the injection pump except when these are absolutely necessary. Since pump adjustment requires an accurate pump tester and highly skilled personnel, do not attempt to disassemble or adjust the injection pump where those requirements are not met.

### INSPECTION

#### Fuel Filter

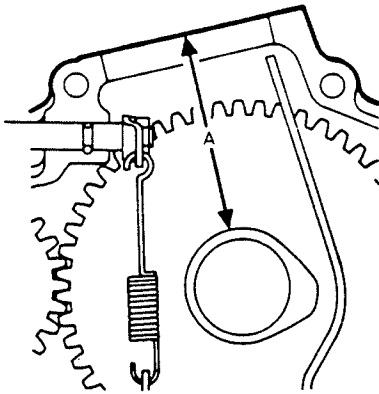
- a. Check the fuel filter for cracks, deformation and damages on the cover and body.
- b. Replace the filter assy after every 400-hour operation. In case of excessive contamination, replace the filter assy even within 400 hour period.

#### Delivery Valve Seat

- a. Delivery valve seat
  - 1) Check the contact face of the delivery seat for normalness. Replace defective delivery valve seat.
  - 2) When the oil pressure of 150 kg/cm<sup>2</sup> is applied after the delivery valve and seat being assembled, oil pressure drop should not occur within 5 seconds. Replace if oil pressure drops to less than 130kg/cm<sup>2</sup>.
- b. Plunger barrel
  - 1) Plunger oil-tight test  
Raise the oil pressure to 300 kg/cm<sup>2</sup> with the oil-tight tester and measure the time required for oil pressure drop from 200 kg/cm<sup>2</sup> to 100 kg/cm<sup>2</sup>. Satisfactory if the time is within 6 seconds. Replace the assy if unsatisfactory.
  - 2) Check the plunger for seizure, damages and rust. Check the motion of the plunger for a smooth sliding after insertion of the plunger into the barrel. If the result is unsatisfactory, replace the plunger. Never reuse.
- c. Control rack and pinion
  - 1) Replace the rack and pinion which have worn or damaged tooth surface.
- d. Tappet  
Check the tappet for the presence of wear and damages on its periphery. Check the tappet roller and shaft for the same purpose. Replace defective parts.

### Injection Pump

- When reinstalling the injection pump assy, install the adjusting shim that has been removed.
- When installing the new injection pump assy, obtain the adjusting shim which can bring the dimension A shown (distance from the base circumference, the injection pump cam and the pump mounting face of the gear case) within 75.95 ~ 76.05 mm and install the pump assy. Fit the projection of the control rack securely into the fork at the tip of the governor lever. Thickness of shims: 0.3, 0.5, 1.0 mm



Dimension Relative to Mounting Injection Pump

- Connect the fuel feed hose. Loosen the injection pump air vent screw and vent air.
- Check the injection timing. Remove the delivery valve holder, remove the delivery valve and spring, then install only the delivery valve holder.

Turn the crankshaft to stop the flow of fuel from the discharge port of the delivery valve holder. The instant when fuel flow stops is the injection timing.

If the injection timing does not satisfy the standard value, adjust by increasing or decreasing the thickness of the adjusting shim (between the pump and gear case).

When the thickness of the shim is changed by 0.1 mm, the injection timing changes by approx. 1 deg. In case the injection timing is to be adjusted outdoors or at a dusty place, perform adjustment with the delivery valve and spring being kept installed so as to prevent missing of parts and dust infiltration. In this case, remove the injection pipe No.1 from the nozzle holder side, fit the socket wrench over

the crank pulley nut and gradually turn the nut. The fuel starts flowing to the tip of the pipe.

The instant when the tip expands is the injection timing. This occurs at approx. 1 deg behind the standard injection timing.

### Nozzle

- Injection start pressure test

- 1) Measure the injection start pressure with the nozzle tester. If the value obtained does not correspond to the standard value, adjust to obtain the standard pressure by increasing or decreasing the thickness of the adjusting shim.

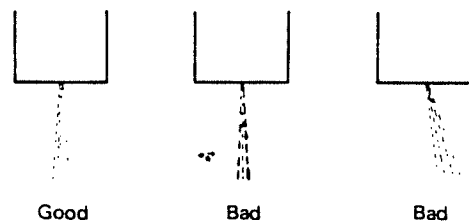
By changing the thickness of the adjusting shim by 0.1 mm, the pressure changes by 10 kg/cm<sup>2</sup>. When the nozzle holder or nozzle has been replaced with new one, the pressure more or less drops at the initial stage. Therefore, it is desirable to adjust after 30 to 50 hours operation.

Do not attempt to adjust unless the pump tester is available. In case of trouble, call the service factory for adjustment where the tester is on hand.

- Injection test

- 1) Chattering test (small amount interrupted injection)

Satisfactory if the fuel is injected interruptedly and positively as the tester lever is slowly operated (approx. 10 strokes/min). The fuel should be injected in the axial direction of the nozzle in a straight line. Unsatisfactory if the direction of injection varies excessively from time to time or the mist goes in several lines. Also unsatisfactory if the particles are large or granular.



Chattering Test

## 2) Dripping

Unsatisfactory if in the above chattering test the fuel is collected at the bottom of the nozzle after injection and falls in drops. Replace the nozzle.



Dribbling

## 3) Manner of injection

The fuel should be injected in fine mists straightly in the axial direction of the nozzle when the tester lever is set to high speed (approx. 200 strokes/min). Bad if the particles are granular.

**Governor**

- Check the governor weight for wear and damage on its pawl. Replace defective governor weight.
- Check the sliding shaft operation. Repair or replace defective part.
- Check the governor lever for wear on the contact face relative to the sliding shaft and the fork to be fit into the control rack. Replace the defective part.
- Check the governor spring for deterioration and breaks. Replace defective part.

**ASSEMBLY AND ADJUSTMENT****NOTES:**

Before assembling, immerse each part in cleaning oil, and wash it. Do not clean with cloth, etc.

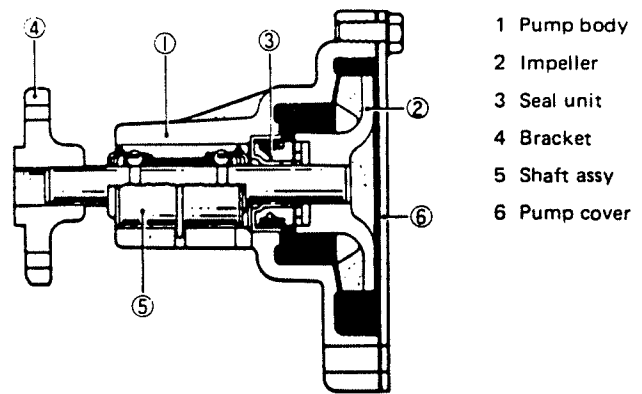
Check the nozzle for dents. Replace in assy if irregularity has been found.

Check the pressure spring for damages.

- Assemble the nozzle and nozzle holder by reversing the steps for disassembly referring to the cross section in 1.12.1. When assembling the nozzle holder body and retaining nut, tighten the nut by the specified torque. Be careful not to leave out the flange when assembling the nozzle holder body and retaining nut. Then install the nozzle holder assy on the

cylinder head and tighten the mounting bolt by the specified torque. Install new nozzle holder gasket.

- Assemble the injection pump and governor in the reverse order to disassembly. After installation, make sure the links of the governor operates effortlessly.

**COOLING SYSTEM CONSTRUCTION AND MAINTENANCE**
**■ CONSTRUCTION OF COOLING SYSTEM**  
**Water Pump**


Cross Section of Water Pump

The water pump is of the centrifugal impeller type and installed on the front-top side of the crankcase. The pump shaft is a double row radial ball bearing and has grease sealed inside. Accordingly, no lubrication is necessary.

**Thermo Switch**

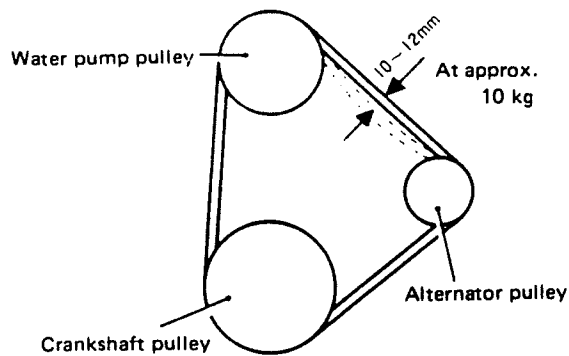
The thermo switch is installed on the left side of the front-most part of the cylinder head. This switch is turned ON to light the lamp for warning when the temperature of cooling water rises above 105 ~ 111°C. In such case, action must be taken to check the level of cooling water and other parts of cooling system.

**■ DISASSEMBLY, ASSEMBLY AND ADJUSTMENT OF COOLING SYSTEM**

- Loosen the alternator support bolt. Then loosen the bolts fastening the alternator and brace and press the alternator to the engine side.
- Remove the belt.
- Loosen the fan mounting bolt and remove the cooling fan and water pump pulley.



4. Check the fan for cracks and damages. Replace defective fan.
5. Check the belt for elongation and cracks due to deterioration. Replace defective belt. Reinstallation will be performed in the reverse order to the removal. Perform adjustment as follows:
6. Adjust by moving the alternator so that when pushed the middle point between the water pump pulley and the crankshaft pulley sags as much as 10 to 12 mm. Then securely tighten the support bolt and brace bolt.



**Belt Tension Adjustment**

## CAUTIONS IN HANDLING ENGINE

- (1) Always use proper engine oil and watch oil pressure during operation.
- (2) Use clean fuel, free from impurities and water content.
- (3) Prevent ingress of air and water into the fuel system.
- (4) In case the starter motor pinion fails to engage with the ring gear at the time of starting, turn on the starter switch again after the starter motor has come to a complete stop.
- (5) Prevent the temperature of cooling water from falling too low.
- (6) Watch for abnormal noise. Diesel engine produces greater noise than gasoline engine.
- (7) Pay attention to the color of exhaust gas.
- (8) Clean or replace the fuel filter and oil filter periodically.
- (9) Renew oil as specified.

## SAFETY PRECAUTIONS

- Never put the engine in operation in improperly ventilated places.
- Do not touch moving parts during operation.
- Do not touch hot parts such as exhaust pipe, and do not place combustible materials there.
- Inspect and adjust parts of the engine only while it is stopped.
- Check and refill engine oil, cooling water and fuel after the engine is brought to a stop.
- In checking the level of and refilling cooling water, remove the radiator cap after the temperature of the water has fallen enough.
- Always use tools of right sizes and full caution during servicing.

## BEFORE PUTTING YOUR ENGINE IN OPERATION

Service life of your engine is dependent upon how your engine is operated and serviced during the initial 30 hours of operation.

Your new engine needs 30 hours of conditioning operation for breaking each moving part in and obtaining a high performance, and perform this conditioning carefully bearing the following points in mind:

## IMPORTANT:

- Idle and warm up your engine at least for 5 minutes.
- Avoid hasty acceleration.
- Use caution not to overload the engine.
- Inspect, maintain and service your engine in accordance with the instructions in this Manual.

## PRE-STARTING PREPARATIONS

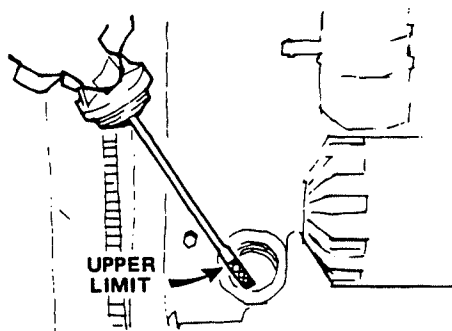
Take steps as shown below in starting your engine for the first time when it has not been used for a long time.

### Refill of engine oil

Refill engine oil up to the upper limit line given on the dip stick attached to the oil inlet cap.

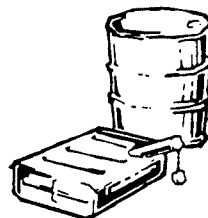
Specified quantity:	Upper limit of oil level
2.6 lit. (upper limit)	— 1.6 lit (lower limit)

For further details of engine oil, refer to instructions appearing on Pages      and



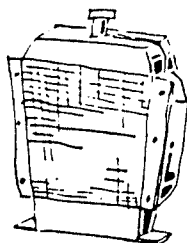
### Fueling

Feed gasoline JIS-No. 2 to the fuel tank. (In cold district, gasoline JIS-No. 3 is recommended to use.) The interior of the fuel tank must be maintained clean.

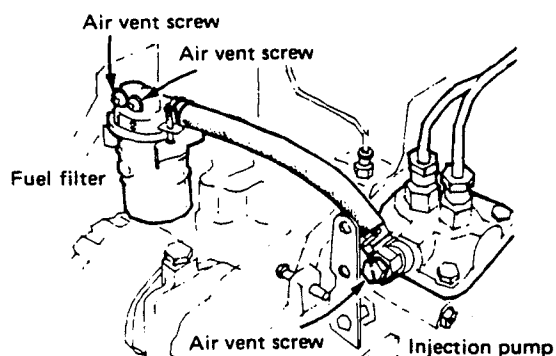


**Filling the radiator with water**

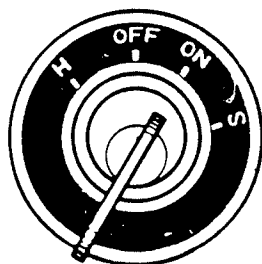
Pour clean water up to the filler port. Add Anti-freeze during cold winter.

**Purging air from the fuel system**

After purging air from the fuel filter through two air vents, purge air also from the fuel injection pump. For procedures of air purge, refer to instructions appearing on Page .

**STARTING PROCEDURES****Turning starter switch on**

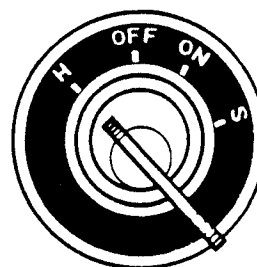
Turn the starter switch on and check that the oil pressure lamp and the charge lamp are lit.



Confirm that the switch is at "on"

**Glow plug preheating**

Turn the lever of the starter switch to "H" position, and preheat until the glow plug indicator turns sufficiently red hot.



"H" for preheating

**IMPORTANT:**

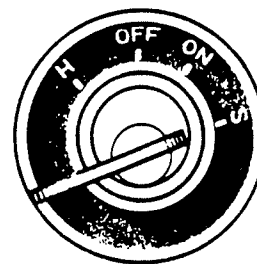
- Proper preheating time is about 20 seconds. Take longer time for preheating if it is cold. Preheating time required is as indicated in the table below. However, preheating should not last in excess of 2 minutes not to shorten the life of the glow plug.

Atmospheric temperature	Preheating time
+5°C or higher	Approx. 20 sec.
+5°C ~ -5°C	Approx. 30 sec.
-5°C or lower	Approx. 60 sec.

- Checkup is necessary by a Mitsubishi service station if the glow plug indicator fails to turn red hot.

**Starting**

The starter motor will run thereby starting the engine as the starter switch is turned to "S" position while the speed control lever is left at the 1/2 position of "full open."



"S" for starting

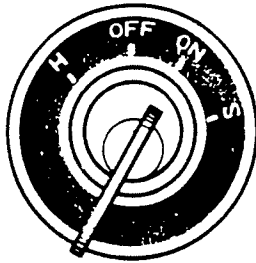
**IMPORTANT:**

Should the engine not start even when the starter switch is left at "S" position for 10 seconds, put

your hand off the starter switch for 30 sec., and then attempt to start the engine again by sufficiently preheating the glow plug. The starter motor should never be left to run for more than 30 seconds.

### Operation

As soon as the engine has started, release the key. The key automatically return to "ON" position, and leave the key at the position during operation. Confirm that following such starting the oil pressure lamp and charge lamp go off.



"ON" for operation

### Warm-up operation

Warm up the engine by turning the speed control lever to "IDLE" position, and initiate the work as the temperature of cooling water rises.

### ■ NORMAL STARTING

Follow the procedures below for routine starting of your engine:

- (1) Check the oil pan for level, and refill if necessary.
- (2) Refill gasoline into the fuel tank.
- (3) Check cooling water level, and refill if necessary.

Note: Check for leaks of water or oil, particularly when signs of such lead are found on the bottom of the machine.

- (4) Start the engine in accordance with the procedures given on the preceding pages.
- (5) Start the work as the temperature of cooling water rises following idling operation.

### ■ STARTING UNDER SUB-ZERO CONDITIONS

The following three adverse conditions concur as the atmospheric temperature drops exceedingly, and the engine must, under such conditions, be started by taking steps described below:

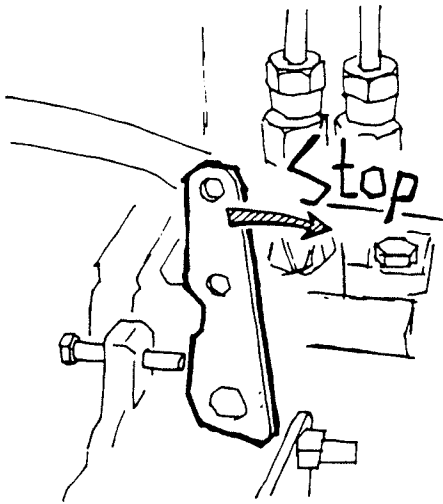
- (1) Lubricating oil becomes viscous
  - Pour hot water into the radiator.
  - Make certain that oil used is adequate for the prevailing atmospheric temperature. Check the oil also for deterioration.
- (2) Voltage across the battery terminals drops
  - Protect the battery against the cold by covering it with proper material.
  - Check that the battery is fully charged.
- (3) The temperature of intake air is low and compression temperature does not rise enough
  - Allow the glow plug to turn red hot sufficiently.

### CAUTIONS DURING OPERATION

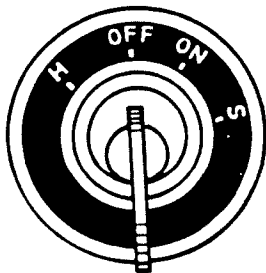
- Never place the key switch at "S" position during operation, or the starter motor can be damaged.
- Confirm the following when the engine is warm:
  - During normal operation  
Confirm that the oil pressure alarm lamp is off.
  - At the time of starting  
Confirm that the lamp is lit.
- Confirm that smoke produced is as follows:
  - While the engine is cold — White smoke
  - When the engine grows warm — Almost smokeless
  - When the engine is overloaded — Some black smoke
- Check for abnormal noise such as knocking, friction and leaking sound, and vibration and blow-back sound.
- Water temperature is to be maintained at an optimum level of 80 to 90°C.
- Check for leaks of fuel and engine oil.
- Knocking sound is heard while the engine is cold, during quick acceleration and idling. Confirm that no knocking sound is heard in other cases.
- Never touch moving and hot parts, and never put the engine in operation in improperly ventilated places.

## STOPPING PROCEDURES

- (1) As the speed control lever is depressed to the full in the direction indicated, fuel supply is shut off and the engine is stopped.  
(Hold the lever until the engine comes to a complete stop, or it may run in the reverse direction.)



- (2) With the engine stopped, push the starter switch key back to "OFF" position. The battery will run out if the key is left at "ON" position. To prevent this, the key must be removed after stopping the engine.



"OFF" for stopping

## REQUIREMENTS FOR PROPER OPERATION

### ■ LUBRICATION SYSTEM

#### Engine oil

For engine lubrication, use diesel engine oil. Diesel engine oils are classified according to the SAE Specifications into grades CA, CB, CC and CD. Anyone of them is usable, but use of CB or higher prepared well-known makers is recommended.

#### Engine oil with right viscosity

Use oil having viscosity best suited to the local atmospheric temperature. Use of an all-season oil SAE10W-30 with minimum viscosity change under different temperatures is suggested.

Atmospheric temperature	Viscosity
20°C or higher	SAE 3 or 10W-30
0°C - 20°C	SAE 20 or 10W-30
0°C or lower	SAE 10W-30

#### Oil pressure

Properness or improperness of oil pressure during operation of the engine is indicated by the oil pressure alarm lamp.

- During normal operation - Oil pressure is normal if the lamp is not lit.
- At the time of starting (cranking) - The lamp must light.

The lamp lights during normal operation in case oil pressure declines below 0.2 - 0.4 kg/cm<sup>2</sup>, and a Mitsubishi-authorized service station should be consulted in such case.

#### Renewal of engine oil

Renew engine oil following the first 30 hours of operation and at intervals of 100 hours thereafter.

To renew engine oil, discharge old oil by removing the drain plug in the bottom of the oil pan after bringing the engine to a stop and while the engine is still warm. Renew the oil filter also.

Completing draining of old oil completely, replace and tighten the drain plug and feed fresh engine oil through the oil inlet port.

Refilling oil, idle the engine for several minutes and stop, and then measure the quantity of oil in the oil pan with the oil gauge.

#### IMPORTANT:

- The engine needs to be positioned horizontal to check oil level. Pull the level gauge out, wipe it with clean rag, and then replace and tighten the cap, and remove the gauge again to check the level.

#### Checkup and refilling of engine oil

Refill into the oil pan same oil as that used before until the level reaches near the upper limit line on the level gauge.

When the engine is cold, check the level about one

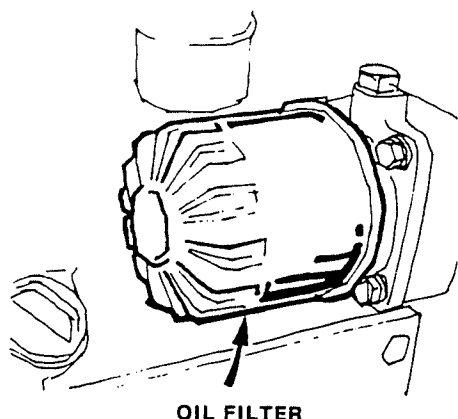
minute after the level gauge has been put into the oil.

### Renewal of oil filter

Renew the oil filter after the initial 30 hours of operation and at intervals of 100 hours thereafter. Being an easy-to-handle cartridge type, the oil filter requires no cleaning inside.

In installing the oil filter, apply engine oil thinly on to O-ring, and then tighten it with hand firmly.

Completing the step, put the engine in operation, and check for oil leak.



## FUEL SYSTEM

### Diesel fuel

Use Diesel fuel No. 2 specified by JIS. (Use Diesel fuel No. JIS-3 in cold districts). Never use kerosene or heavy oil.

Refill fuel in good time. In cold wintertime, in particular, much water vapor is produced when much air is present in the fuel tank. The tank, thus, should be kept full as much as possible.

Follow the instructions given below in feeding fuel to the tank not to allow ingress of impurities.

The fuel tank, furthermore, needs to be deprived of dirt and water.

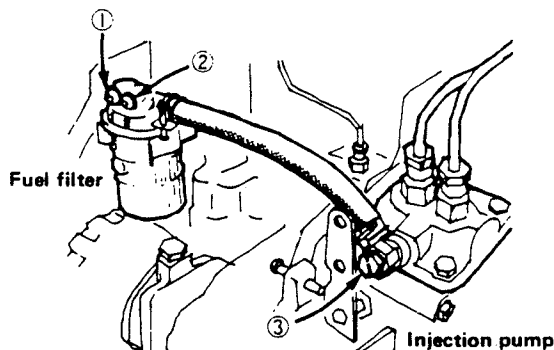
### Filtering of fuel

- Ideal method — Use of a centrifuge for removal of water and impurities. However, this is costly.
- Minimum requirement — Fuel is put into a drum for precipitation of impurities for several days, and only the supernatant is used. In this case, set the drum a little tilted backward, and draw

a necessary quantity of fuel through the tap. This is a convenient way of separating water and dirt from fuel.

### Air purging of the fuel system

Presence of air in the fuel system prevents the diesel engine from starting. It is imperative, for this reason, that the fuel system be inspected and serviced properly so as to check ingress of air.



To purge the fuel system of air, firstly loosen the air vent screw (1) from the fuel filter, and as bubbles cease to come out, tighten the air vent screw. At the same time, purge air by loosening air vent screw (2) and (3) in the fuel filter and the injection pump in that order, and then tighten the screws.

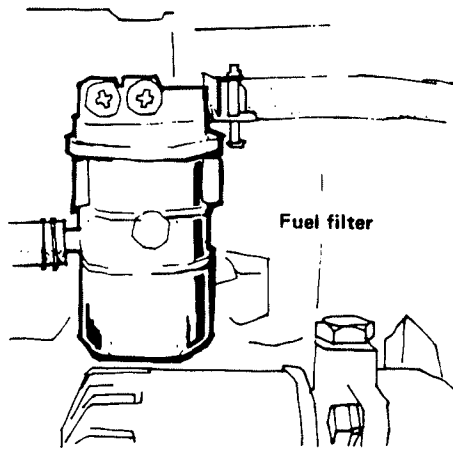
Then, allow the engine to run for several seconds by the starter motor by turning the lever to "full open" position in order to release air out of the plunger, fuel injection pipes and nozzles.

The engine can be started by taking the above steps. In case where the engine can not be started easily, remove two injection nuts on the nozzle side, turn the speed control lever to "full open" position, turn the starter motor, and then tighten the nuts firmly.

### Cleaning and replacing fuel filter

The fuel filter is of an easy-to-handle cartridge type. Collection of dirt and water on the filter leads to difficulty of operation. Remove the filter from the engine every 100 hours of operation, clean outside, remove two air vent screws. Purge water if collected inside, and then rinse the filter in fresh gasoline.

The filter is to be renewed at intervals of 400 hours of operation.



### Fuel injection pump

The fuel injection pump is one of the most important components of the diesel engine and thus it calls for utmost caution in handling. Furthermore, the fuel injection pump has been thoroughly shop-adjusted and should never be readjusted carelessly. Such adjustment, whenever necessary, should be performed at service station as a precision pump tester and skills are required.

Requirements in handling the fuel injection pump:

- Always use fuel which is free from impurities.
- Clean and renew the fuel filter periodically.

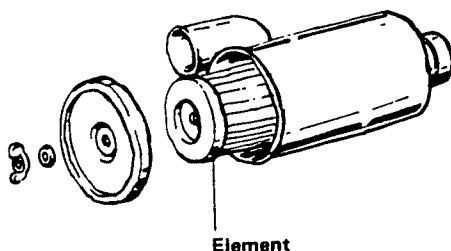
## ■ INTAKE SYSTEM

### Cleaning air cleaner and replacing element

#### a. Cleaning air cleaner

Under normal conditions, clean the element every 100 hours. It needs to be cleaned every 50 hours in case the engine is run in a particularly dusty place.

Remove dirt off the element by blasting air from inside or by giving vibration to the element.



#### b. Replacing element

Under normal conditions, renew the element every 400 hours. It needs, however, to be renewed every year even when within the above-specified period.

It must be renewed every 200 engine is operated in a particularly c

## ■ COOLING SYSTEM

### Cooling water

As cooling water, use soft water with least impurity content such as tap water (potable water) or rainwater, and never use hard water or foul water. Use of hard water or water containing much impurity will lead to collection of fur in the engine and the radiator with resultant decline in cooling effects.

### Antifreeze

In cold districts, care should be taken to prevent cooling water from getting frozen. Cooling water as frozen expands to break the radiator and the crankcase, and it is essential that Antifreeze be added to cooling water in a quantity being proportional to the lowest temperature of the district.

- Antifreeze of poor quality will cause corrosion of the cooling system, and thus always use Antifreeze prepared by a reliable maker, and never use it mixed with Antifreeze of different brand.
- Make sure that the cooling system of the engine is cleaned well before adding Antifreeze.

### NOTES:

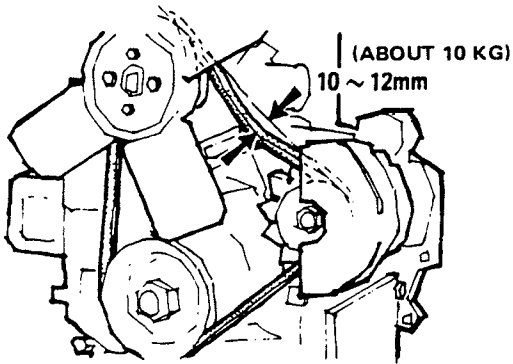
It is advisable that Antifreeze concentration be selected on the basis of a temperature which is about 5°C lower than the actual atmospheric temperature.

While the quantity of cooling water is 2.1 lit. For the engine only, it must be increased appropriately to fill the radiator and pipes.

Make sure that the engine is stopped and cooling water is cool enough before removing the radiator cap. Furthermore, use full caution in releasing cooling water not to get scalded with hot water.

### Fan belt tension

The fan belt is properly tense if it deflects 10 to 12 mm as it is depressed with a finger in the center between the alternator pulley and the water pump pulley. Excessive tension can cause quick wear of the belt and bearings of the water pump and the alternator. Excessive lackness or presence of oil on the belt, on the other hand, can lead to engine overheating and insufficient charging due to slipping belt.

**IMPORTANT:**

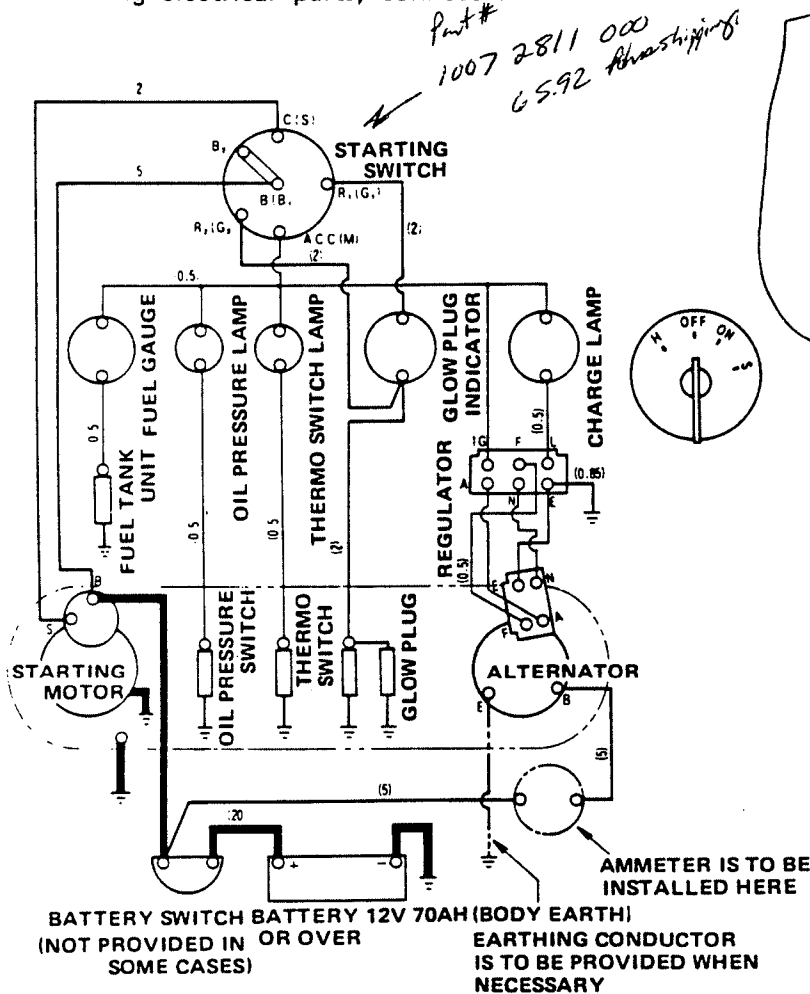
Never attempt to adjust tension of the fan belt while leaving the engine in operation.

## ■ WIRING DIAGRAM

Your engine is of 12V system and its electric circuit is as shown in the diagram below.

For installing electrical parts, connect them cor-

rectly by referring to the diagram and at the same time check for damaged wire sheathing and confirm that grounding is provided properly.



CONNECTION OF STARTING SWITCH

TERMINAL	B	R1	R2	C	ACC
KEY POSITION	B1	G1	G2	S	M
H	○	○			
OFF	○				
ON	○				
S	○		○	○	(○)

( ) IS FOR M ONLY.

**NOTES:**

- (1) Number in the parenthesis denote code (JIS C3406).
- (2) For coupling the engine with an industrial equipment, refer to the wiring diagram provided for such equipment.



## PERIODIC CHECKUP AND ITS PROCEDURES

Check and service your engine at specified intervals to maintain it in its best conditions and permit it to perform as it should. As for those asterisked items of jobs, you are suggested to have them performed by a service station.

### ○ Daily checkup before use

- (1) Checkup of engine oil level and refilling —  
No refill is required if the level is near the upper limit line on the gauge.
- (2) Checkup of cooling water and refilling —  
Refill up to the feed port of the radiator.
- (3) Checkup of fuel —
- (4) Checkup of gauges and meters —  
After getting the engine started, check oil pressure and water temperature, and confirm that the charge pilot lamp is off.
- (5) Checkup for loose parts, damages and leaks —
- (6) Checkup for abnormality with exhaust gas, noise, and vibration.

### ○ Servicing following the initial 30 hours of operation

- (1) Renewal of engine oil —
- (2) Replacing of oil filter —
- (3) Renewal of cooling water —
- (4) \* Adjusting of valve clearance —  
Adjust clearance of both intake and exhaust valves to 0.35mm when the engine is cool.
- (5) Fan belt adjustment —  
The correct adjustment of tension of the fan belt allows 10 to 12mm of deflection when depressed with a finger between the water pump pulley and the alternator pulley.
- (6) \*Tightening of bolts and nuts —
- (7) \*Adjusting of engine idling —

### ○ Servicing at every 100 hours of operation

- (1) Renewal of engine oil —

- (2) Replacing of oil filter —

- (3) Cleaning of fuel filter —

If the filter is dirty, remove the air vent screw and rinse in clean gasoline.

- (4) Cleaning of air cleaner —

Clean inside the body of the cleaner and element.

- (5) Adjusting of engine idling —

### ○ Servicing at every 200 hours of operation

- (1) \*Checkup of nozzles —

Set the injection starting pressure to 120 kg/cm<sup>2</sup>, and eliminate undesirable injection conditions including "after dripping."

- (2) Fan belt adjustment

### ○ Servicing at every 400 hours of operation

- (1) Cleaning of fuel tank —
- (2) Replacing of fuel filter —
- (3) Replacing of air cleaner element —
- (4) \*Adjusting of valve clearance —
- (5) \*Checkup of starter motor, alternator and regulator —

Check the brush and surface of commutator for the degree of wear down. Replace the brush if it has worn out beyond the limits of wear.

- (6) \*Checkup of glow plugs —

Check the glow plugs for blow-out.

### ○ Servicing at every 800 hours of operation

- (1) \*Checkup of compression pressure —

Remove glow plugs (or nozzle holders) and measure one by one using a compression pressure gauge. Perform necessary adjustment if pressure difference is over 2.5 kg/cm<sup>2</sup> or between the cylinders or if the pressure of each cylinder is less than 26 kg/cm<sup>2</sup> (280 rpm).

- (2) \*Fuel injection adjustment —

In case of severe vibration during idling, have it repaired at a service station which is

equipped with a pump tester.

(3) Flushing of cooling system —

(4) \*Checkup of alternator and regulator —

Regulate the voltage and current by use of a circuit tester.

(5) \*Checkup of starter motor pinion, and fly-wheel ring gear —

Rectify the chamfered area that has been severely damaged by use of a file, and replace the part if it is damaged all over.

(6) \*Tightening of bolts and nuts —

## TROUBLESHOOTING

It is essential that any trouble or defect should be detected and rectified as early as possible. Check up and take proper action in accordance with the instructions appearing below. In case a trouble requires techniques beyond your ability, have it repaired at your service station.

Symptom	Possible cause	Remedy
Engine does not start	<ol style="list-style-type: none"> <li>✓ 1. Starting switch is defective</li> <li>✓ 2. Deficient drive torque of the starter motor</li> <li>✓ 3. Improper viscosity of engine oil</li> <li>✓ 4. Engine too cold</li> <li>✓ 5. Seizure of moving parts</li> <li>6. <del>_____</del></li> <li>✓ 7. No fuel in the fuel tank</li> <li>8. Fuel filter clogged</li> </ol>	<ul style="list-style-type: none"> <li>• Correct connections and contacts</li> <li>• The battery is exhausted, trouble with the starter motor, or dirty or loose wiring.</li> <li>• Check the viscosity and renew oil if necessary.</li> <li>• Put hot water into the cooling system.</li> <li>• Rectify.</li> <li>• Purge thoroughly.</li> <li>• Refill.</li> <li>• Clean or renew.</li> </ul>
Engine stalls while in operation	<ol style="list-style-type: none"> <li>1. Fuel tank is empty</li> <li>2. Fuel filter clogged</li> <li>3. Air is present in the fuel system</li> </ol>	<ul style="list-style-type: none"> <li>• Refill.</li> <li>• Clean or renew.</li> <li>• Retighten fuel pipe connections.</li> </ul>
Engine malfunction	<ol style="list-style-type: none"> <li>1. Fuel filter clogged</li> <li>2. Air is present in the fuel system</li> </ol>	<ul style="list-style-type: none"> <li>• Clean or renew.</li> <li>• Retighten fuel pipe connections.</li> </ul>
Improper oil pressure	<ol style="list-style-type: none"> <li>1. Oil short</li> <li>2. Oil leak through connections</li> <li>3. Oil pressure switch defective</li> </ol>	<ul style="list-style-type: none"> <li>• Refill.</li> <li>• Repair.</li> <li>• Replace.</li> </ul>
Engine overheating	<ol style="list-style-type: none"> <li>1. Cooling water short</li> <li>2. Water leak</li> <li>3. Belt loose or smeared with oil</li> <li>4. Radiator defective</li> <li>5. Fan damaged</li> </ol>	<ul style="list-style-type: none"> <li>• Refill.</li> <li>• Repair.</li> <li>• Clean or renew.</li> <li>• Repair or renew.</li> <li>• Renew.</li> </ul>
Battery is undercharged	<ol style="list-style-type: none"> <li>1. Belt tension improper</li> <li>2. Faults with wiring</li> <li>3. Improperness of ammeter (if provided)</li> <li>4. Battery faulty</li> <li>5. Regulator faulty</li> </ol>	<ul style="list-style-type: none"> <li>• Rectify.</li> <li>• Rectify.</li> <li>• Replace.</li> <li>• Replace.</li> <li>• Repair or renew.</li> </ul>

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### GENERAL

The clutch used on the Satoh Beaver (Model S-370 & S-370D) tractor is single plate dry type using a diaphragm that provides not only the spring pressure required to hold the friction disc against the flywheel but also services as the release levers to take up the pressure when the clutch is disengaged.

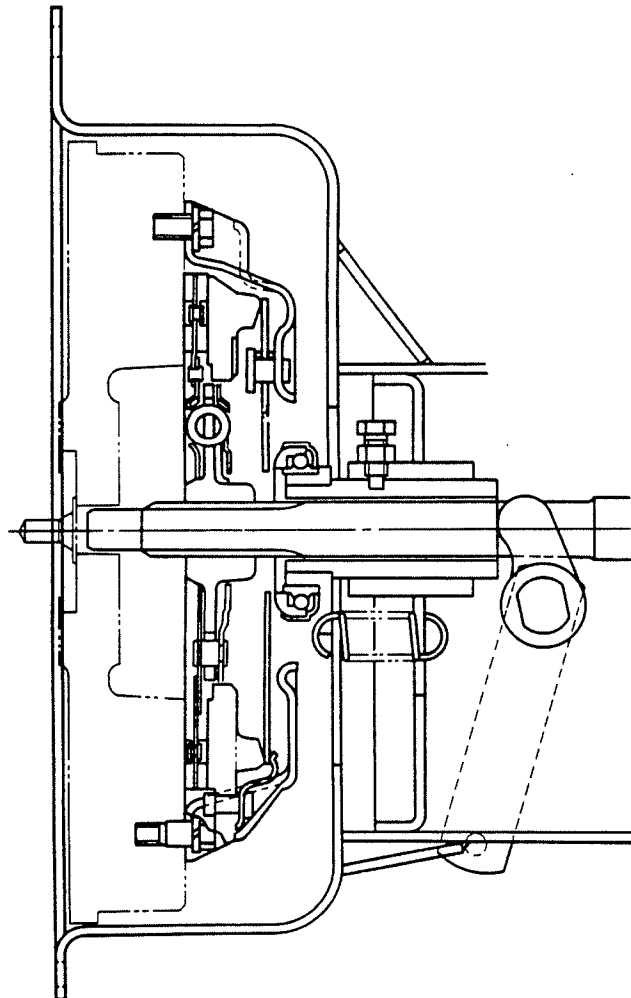
As compared with coil spring type clutches, the device is featuring: —

1. The tapering fingers require by far less pedal effort when taking up the spring pressure when the clutch is disengaged.  
This reduces operator fatigue to a minimum and allows smoother shifting of the transmission gears.
2. The spring pressure increases as the clutch facings wear. In clutches using coil springs and

release levers, the spring pressure decreases as the clutch facings wear from the first time. Longer facing life is a feature of the system.

3. The disc-like construction resists distortion due to centrifugal force at higher speeds.  
The turning effort of the engine is delivered to the transmission without relative movement between the disc and plate when the clutch is engaged.
4. The tapering fingers assure even spring pressure over the entire surface of the pressure plate to hold the clutch disc against the flywheel.  
When the clutch is disengaged, the diaphragm is dished inward to lift the pressure plate away from the friction disc, there being no distortion in the plate.  
The clutch is built with ample margin of capacity to transmit the engine power to the transmission.  
Simple, rugged construction assures long, trouble-free life.

### CONSTRUCTION



### Clutch Release Mechanism

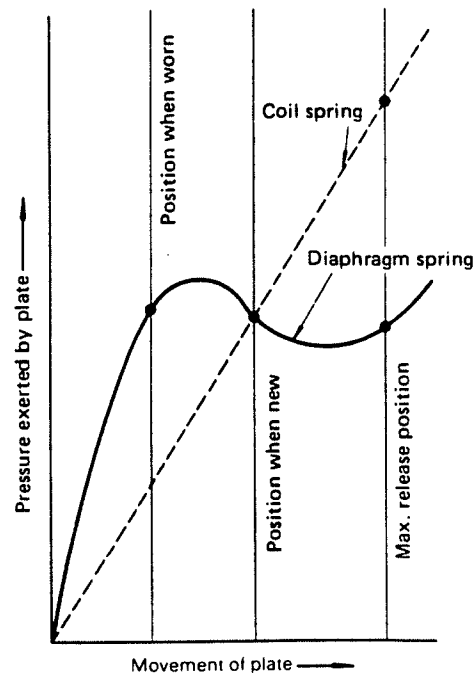
1. The clutch uses a one-piece tapering finger diaphragm that has a series of tapering fingers pointed inward toward the center of the clutch.
2. The ends of the fingers are brought into direct contact with the clutch release bearing.
3. The clutch release bearing is fitted through oilless bushing to the clutch release collar.
4. The entire assembly is pulled lightly toward the ends of the tapering fingers by springs.
5. The spring is also connected to the pressure plate with clips at the outer circumference.
6. The action of the diaphragm spring is somewhat like the flexing action as experienced when we depress the bottom of an oil can.
7. When the clutch release bearing moves in against the ends of the tapering fingers, the diaphragm is forced against the pivot rings (wirings). As this takes place, the diaphragm is dished inward.
8. The clutch cover is bolted to the flywheel with a total of six bolts, two of which are of a reamer type.

### Clutch Cover

1. The clutch cover consists of a clutch cover, a diaphragm spring, a pressure plate and two wirings (pivot rings).
2. The diaphragm spring is connected to the clutch cover with two pivot rings (wirings).

### Tapering-Finger Diaphragm

1. The pressed diaphragm is a solid ring on the outer diameter and has a series of tapering fingers as shown.



Diaphragm spring

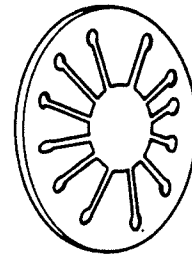


Fig. 2 Diaphragm spring

2. It is made of high quality spring steel and is heat-treated to provide optimum flexing action.
3. The Table above shows a relationship between the diaphragm spring and coil spring clutches regarding the movement of the pressure plate and the resultant pressure.
4. In the diaphragm clutch, the spring pressure increases as the clutch disc wear, in the coil spring clutch, vice versa.
5. The clutch requires less pedal effort at the maximum release position.

### 3-3 CLUTCH SYSTEM

#### Clutch Disc

1. The clutch disc is spline-fitted to the main shaft of the transmission so that it turns together as a unit when the disc is rotated.
2. The disc is normally held against the machined face of the flywheel by means of the pressure plate. It is light yet of sturdy construction.
3. The facings are rivetted through a cushion plate to the clutch plate and transmit the engine power to the splined hub through a total of 6 torsion springs.
4. They are of a special woven type with steel wires to increase friction.
5. The torsion springs absorb torsional vibration of the engine being transmitted through the clutch at starting and driving on rough surface.
6. Radial grooves in the facings prevent excessive rise in temperature during operation and assure longer life of the facings.

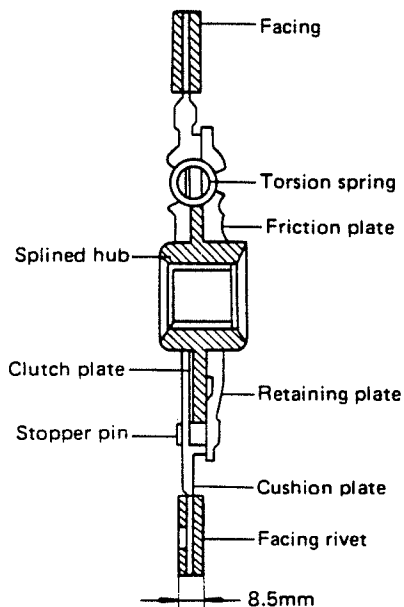


Fig. 3

#### SAFETY SWITCH

To prevent an accident or a runaway of the tractor when starting the engine, a safety starter switch is provided between the starter switch and starter motor. This switch is positioned on the left side of the clutch housing.

When the clutch pedal is completely depressed, the clutch is disengaged so the flow of engine power to

the transmission is interrupted. When the clutch is uncoupled, the safety starter switch is turned on, the starter motor circuit is closed to turn the starter motor.



#### OPERATION

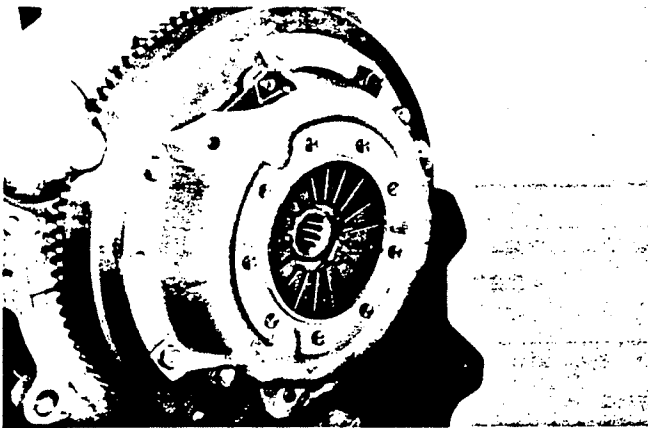
1. When the clutch is in the engaged condition, the spring pressure between the clutch cover and the pressure plate exerted by the diaphragm spring holds the disc tightly against the machined face of the flywheel.
2. The friction between these surfaces causes the disc to rotate with the flywheel and in this manner transmits the engine power to the transmission.
3. The friction disc uses both a cushioning and a dampening device. The power delivered from the engine passes through the clutch facings, cushion plate, clutch plate and stop pins, retaining plate, clutch plate and retaining plate, torsion springs, splined hub and drive shaft to the transmission gears.
4. The cushion plate provides a cushion effect between the facings whereas the torsion springs absorb torsional vibrations of the engine.
5. When the clutch pedal is depressed to uncouple the clutch, the release collar is moved toward the flywheel, causing the diaphragm to dish inward round the inner pivot rings (wirings).
6. This lifts the pressure plate away from the friction disc through a series of the clips. That is, the clutch is disengaged.

## REMOVING THE CLUTCH

To remove the clutch, the engine must be removed first from the clutch housing. For the procedure for engine removal, refer to "1-1. Removing the engine."

After removing the engine from the clutch housing, loosen the six bolts securing the main clutch to the flywheel, and remove the pressure plate assembly and clutch disc from the flywheel. The bolts must be loosened evenly.

When loosening the bolts, care should be taken so that no extremely heavy load is imposed on a bolt.

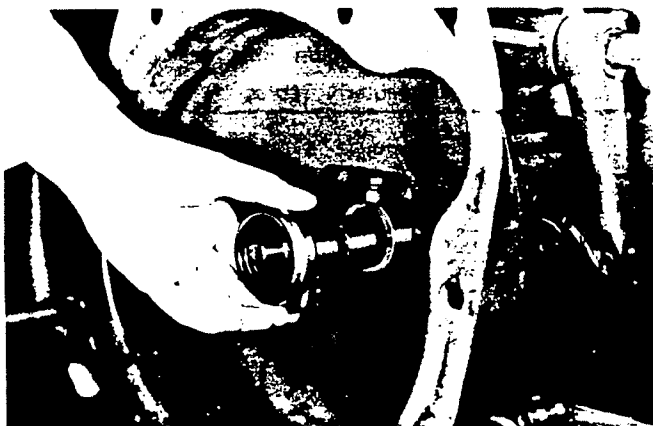


### Note:

The pressure plate assembly is not designed to be disassembled. If the pressure plate is worn more than the specified limit, the entire assembly must be replaced.

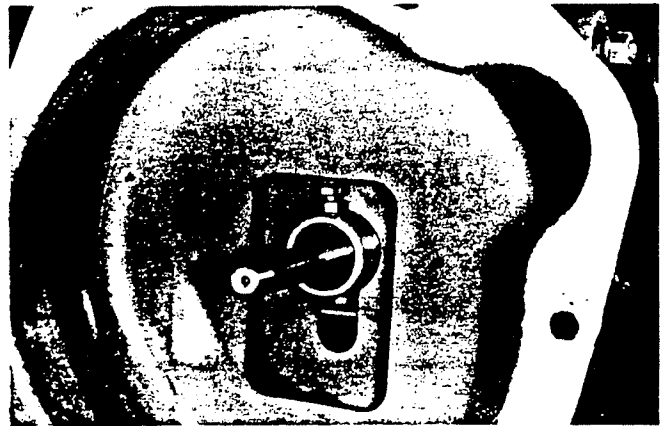
### Removing the Release Bearing

Remove the return spring, and remove the release bearing together with the boss.

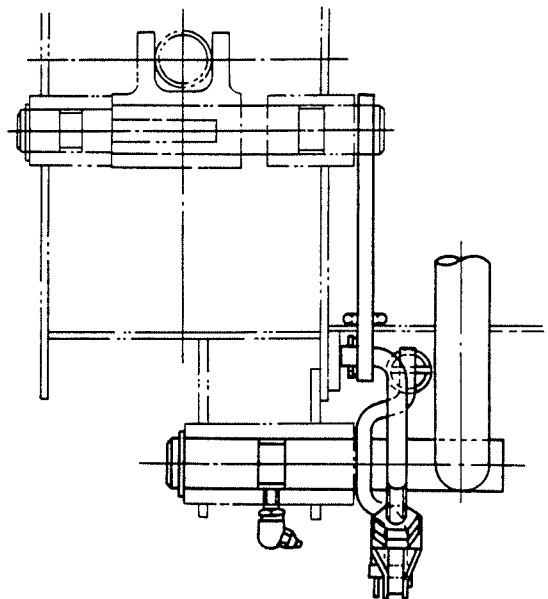


### Notes:

1. Except when either the release bearing or the clutch boss is defective, don't attempt to disassemble them.
2. The clutch housing bolt and lock nut are so adjusted that the release bearing boss operates smoothly. Don't loosen or remove them unnecessarily.

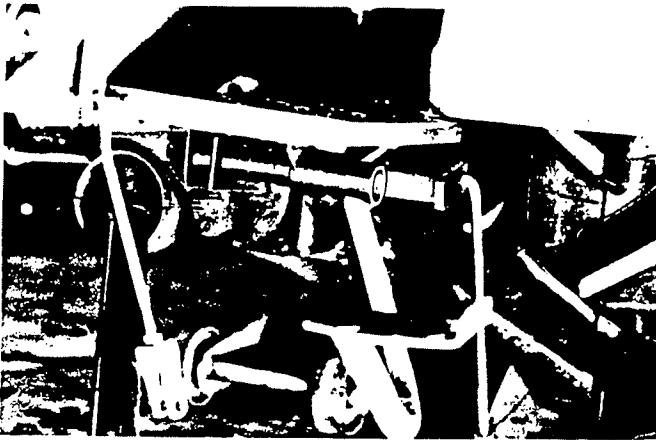


### Disassembling the Clutch Pedal



Disassembly of the clutch release shaft should be carried out after removing the clutch housing from the transmission case.

1. Remove the cotter pin on the clutch pedal side of the rod.
2. Remove the release shaft circlip, and remove the release shaft and fork.



3. Remove the clutch pedal return spring and clutch pedal shaft circlip, and remove the clutch pedal.

Note: \_\_\_\_\_

On the tractors shipped to Southeast Asian countries in the early stage of shipment, part of the clutch pedals are of shaft type.

### INSPECTION, MAINTENANCE, AND WEAR LIMITS

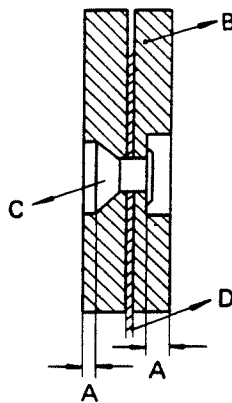
Inspection	Maintenance	Wear Limit
Contact of clutch disc with matching parts, seizure, and cracks	Smooth out if within the wear limit. If exceed wear limit, replace.	If the distance between rivet head and lining is 0.012 in. (0.3 mm) or more, replace.
Oily or greasy clutch disc	Eliminate the cause. If oil or grease is little, wipe it off with cloth damped with gasoline and allow it to dry.	If oil or grease is too much, replace.
Hardened surface of clutch disc	Smooth out hardened surface.	If the distance between rivet top and lining is 0.012 in. (0.3 mm) or more, replace.
Wear on clutch disc	Measure gap between rivet top and lining.	If the distance between rivet top and lining is 0.012 in. (0.3 mm) or more, replace.
Deflection of clutch disc	Rotate the clutch disc, and measure deflection at its outer edge.	If deflects 0.03 in. (1 mm) or more, replace.
Loose rivet		Replace, even if lining thickness is within the allowable limit.
Scratches or burning on pressure plate	Smooth out. Readjust clutch pedal free play properly.	0.0078 in. (0.2 mm) or less
Flatness of pressure plate	If impossible to correct by smoothing out the surface, replace.	0.0078 in. (0.2 mm) or less
Release bearing	Washing is not allowed.	Rotate by hand. If abnormal noise is heard, or it turns irregularly, replace.



## ASSEMBLING AND ADJUSTING THE CLUTCH

### 1. Assembling the Clutch

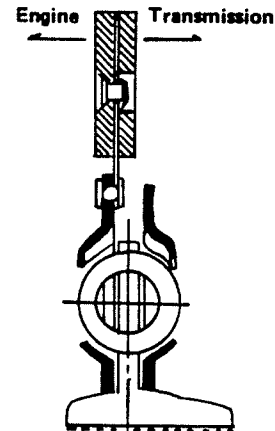
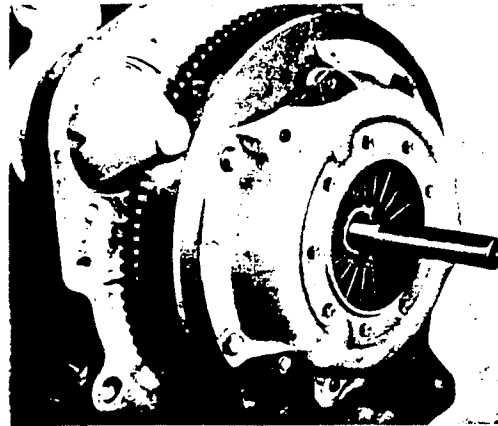
1. Thoroughly wipe off the oil or grease on the flywheel or on the contact surface of the pressure plate assembly with the lining.
2. If the facings are worn down excessively so that the recession of the rivet heads from the facing is 0.0078 in. (0.2 mm), discard the disc and install a new one.
3. When a new disc is to be installed, make sure that the recession is 0.039 – 0.047 in. (1.0 – 1.2mm).



- A: Wear limit 0.0078 in. (0.2 mm)  
 New disc 0.039 in. ~0.047 in. (1.0 ~ 1.2 mm)  
 B: Clutch lining  
 C: Rivet  
 D: Cushion plate

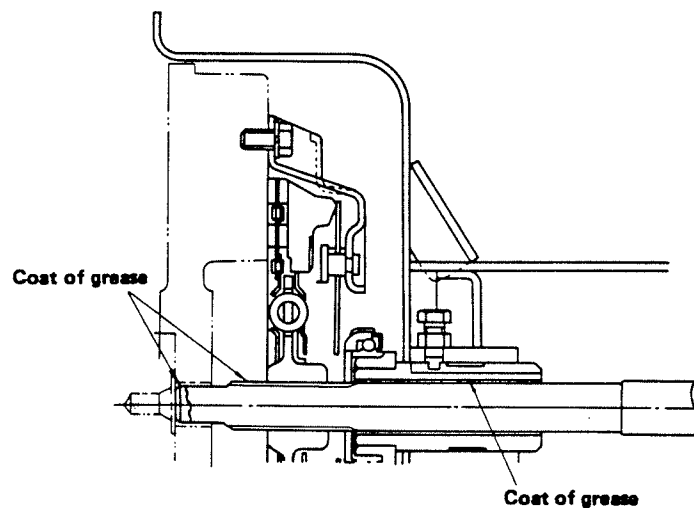
Apply a thin coat of grease to the flywheel pilot bearing.

Place the clutch disc with the longer clutch disc splined boss on the transmission side, and center the clutch disc using the clutch idsc center tool, and install the pressure plate to the flywheel.



While watching the two reamer bolt positions, tighten the six bolts evenly.

Tightening torque: 8.67 – 12.3 ft-lb  
 (1.2 – 1.7 kg-m)

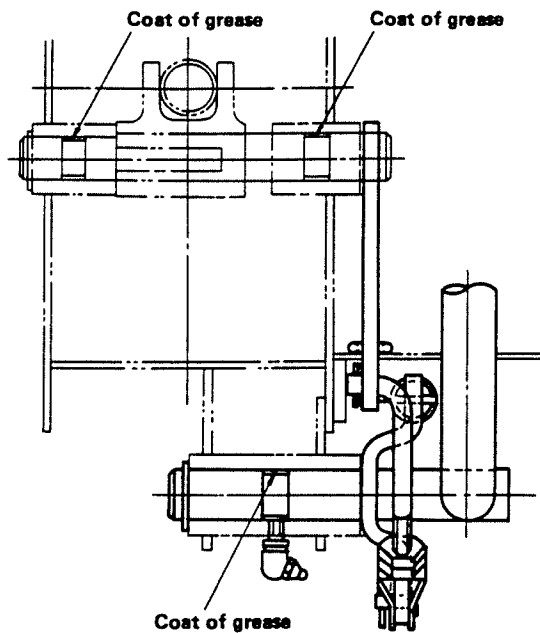


### 3-7 CLUTCH SYSTEM

#### 2. Assembling the Release Bearing

1. When reinstalling the release bearing to the bushing, make sure that the release bearing is directed correctly.
2. Apply grease to the slot in the boss, and align the stopper bolt with the slot, and install.  
When the stopper bolt is removed:  
Slowly screw in the stopper bolts. When the bolt end comes to contact with the slot, back it out 1/3 to 1/2 turn from this position, and lock it with the lock nut.
3. Install the return spring.

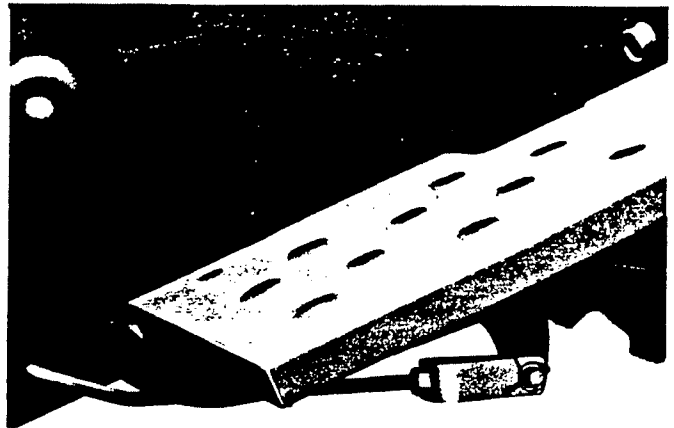
#### 3. Assembling the Clutch Shifter and Clutch Pedal



1. Pack the machined area of release shaft with grease, and install the shift fork.



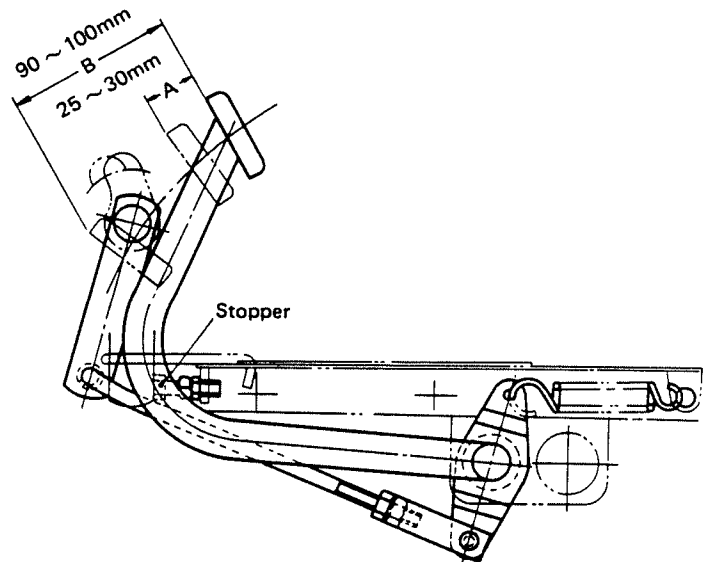
2. Install the circlip to the release shaft.
3. Install the clutch pedal to the clutch housing shaft, and set with the circlip.



4. Install the clutch pedal spring, and set the rod with the pin.

#### 4. Adjusting the Clutch Pedal Free-play

1. The clutch pedal free-play should be adjusted from time to time to compensate for natural wear on the facings. If there is excessive pedal play, even full movement of the pedal to the floor board will not force the clutch release



bearing in against the diaphragm spring. The correct pedal free-play is 0.98 ~ 1.18 in. (25 ~ 30mm)

### Pedal Free Play Adjustment

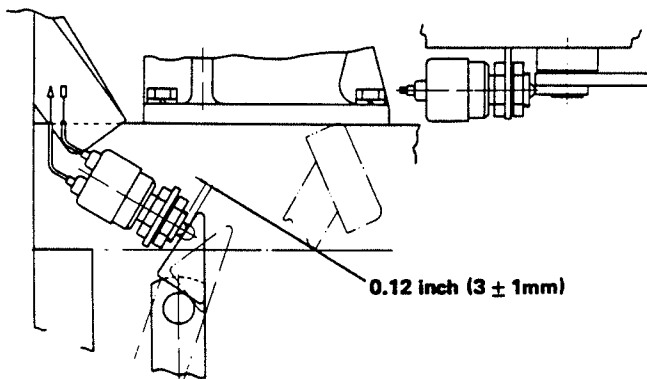
Adjust the rod length so that the free play (A) becomes to be 0.98 – 1.18 in. (25 – 30mm).

### Pedal Effective Stroke Adjustment

Adjust the stopper bolt so that, when the pedal is depressed and the full effective stroke became 3.54 – 3.94 in. (90 – 100mm), the release shaft lever firmly rests on the stopper head, and lock with the lock nut.

After the adjustment is complete, make sure that the power from the engine is interrupted as the pedal is fully depressed and that no abnormal noise is generated in the clutch system.

## 5. Adjusting the Safety Starter Switch



After adjusting the clutch pedal, depress the clutch pedal. When the release shaft arm comes to contact with the stopper bolt, make an adjustment with lock nut C as shown in Fig. to become 0.12 in. (3±1mm), and lock the nub.

## MOUNTING THE ENGINE

Mounting the engine should be carried out in the reverse order to its removal.

## TROUBLESHOOTING

## 6-1. Clutch Slips While Engaged

Slipping of the clutch while it is engaged is very hard on the clutch facings. The relative movement between the clutch disc, pressure plate and flywheel causes heat to develop as well as loss of power developed by the engine. It also increases fuel consumption.

Possible cause	Remedy
Too little a pedal play	Adjust to 0.98 ~ 1.18 in. (25 ~ 30mm)
Oil or grease getting on facings	Replace.
Worn clutch disc	If disc is worn too badly so that rivet head recession from top face of facings is 0.0078 in. (0.2 mm), replace a new one.
Too little a pedal play due to wear on facings	Discard old disc and install a new one when rivet head recession is 0.0078 in. (0.2 mm). Adjust pedal free play to 0.98 ~ 1.18 in. (25 ~ 30mm)
Excessive wobbling of disc	Replace if wobbling exceeds 0.03 in. (1mm).
Corroded disc splines due to neglected lubrication	Remove rust and coat with grease.

## 6-2. Shudder When Starting

Possible cause	Remedy
Hardened disc surface	Grind it with sandpaper or replace.
Exceeding disc shudder	Replace.
Rust in disc spline groove	Correct and apply grease.
Looseped or damaged tension spring	Replace.

## 6-3. Clutch Overheats

Possible cause	Remedy
Burnt release bearing	Replace.
Too little play in release bearing	Adjust

## 7. SPECIFICATIONS

Type	Dry single disc plate diaphragm spring type
Lining material	Wire-reinforced special woven fabric
Dimension of clutch disc (outer x inner x thickness)	7.24 x 5 x 0.307 inch (184 x 127 x 7.8mm)
Static transmission torque	58.61 ft-lb (8.1 kg-m)
Release bearing	Non-lubrication system
Operation	Foot operating system
Clutch disc depressing pressure	429.51 lb (195 kg)
Diaphragm max. operating length	0.27 inch (7mm)
Release lever height	1.22 inch (31mm)

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	91	8		175	28		89	13
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	89	11	0830 0120 400	152	11	1003 2419 001	156	4

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	177	18		56	3~	69561-00021	213	1~4
	182	18		56	9	69561-06001	213	1
68275-60502	170	31		56	12	69561-06101	213	2
	172	5		56	18	69561-06300	213	3
	175	23	69502-00900	55	4	69561-06301	213	3
	177	8		56	4	69561-06701	215	24
	181	31		56	13	69572-16100	152	3
	182	8	69502-01000	55	5	69573-16012	164	11
68401-01412	57	4		56	5	69573-16013	164	12
68401-01700	57	15		56	14	69573-16014	164	13
68401-02101	57	7~9	69504-062C0	188	27	69573-16016	164	10
68401-02112	57	7		192	27	69573-16017	164	14
68446-70200	221	5		195	27	69573-16018	164	14
68453-60524	151	11	69504-17200	202	8, 9	69573-16019	164	14
68453-60525	150	7	69508-06113	59	4	69573-16020	164	14
68453-60526	150	8	69508-06115	59	5	69573-16021	164	14
68453-60527	150	9	69508-06116	59	6	69573-160C1	164	9
68453-60531	151	22~25	69509-16000	68	16			
68453-60532	151	22		69	13			
68453-60544	149	29	69517-06201	69	12			
68453-60545	151	30	69526-01000	80	15			
68453-60546	151	31	69526-01100	80	16			
68453-60547	151	28	69528-06200	130	16			
68453-60550	151	26	69528-06400	130	19			
68453-60553	151	21	69528-07600	130	12			
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68461-020C0	215	9		117	10			
68461-02101	215	10	69541-06400	110	9			
68461-02200	215	12		113	7			
68461-118C0	215	5		117	9			
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69474-80200	154	30	69553-06417	148	20~22			
9501-06300	57	14	69553-06418	148	21			
9501-06400	57	15	69553-06420	148	23~27			
9501-06512	57	4	69553-06421	149	27			
9501-06612	57	8	69553-06422	148	24			
9501-06613	57	9	69553-06423	148	23			
9501-07045	57	16	69553-06424	148	10~12			



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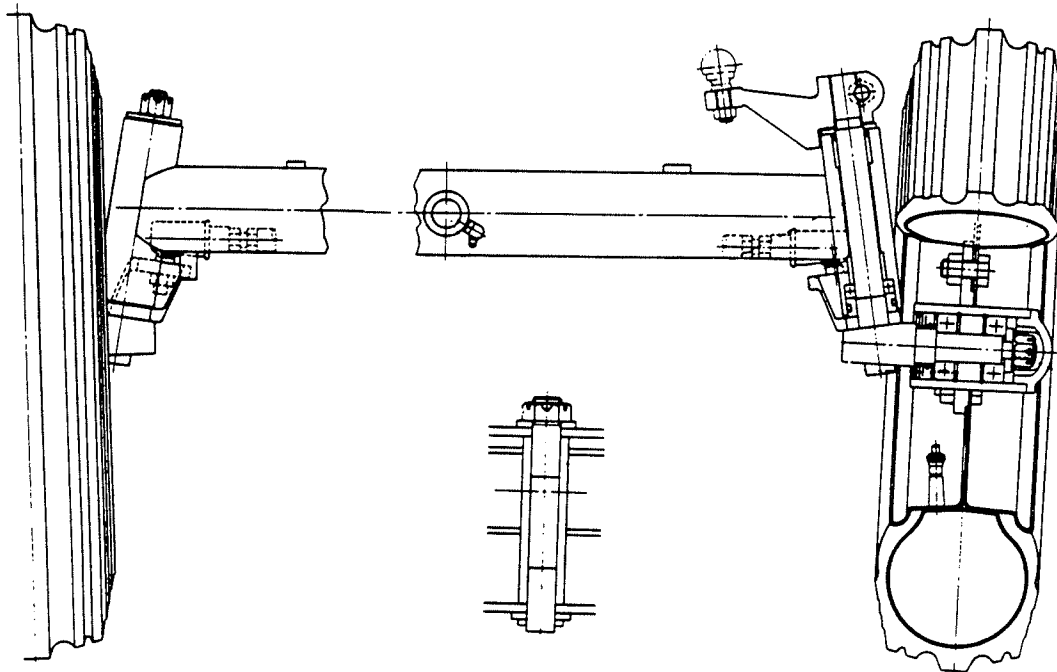
### 2-WHEEL DRIVE

#### GENERAL

The Satoh Beaver (Model S-370 & S-370D) steering system is the type that is most widely used for the farm tractors.

The front axle is a center pivot type and provided with a full swinging angle, permitting full-face contact even with a rough ground. King pin is the Lumoan type which allows greater ground clearance and stable steering.

The steering gear is a worm and sector type which offers simple construction and accurate steering.



#### CONSTRUCTION

The Ackerman Jant steering linkage is employed so that the front wheels can be swung concentrically.

The steering gear has simple construction consisting of a worm and sector gear. The optimum gear ratio permits the most comfortable steering.

The torque applied to the steering wheel is carried to the worm shaft integrated with the worm gear and then to the worm gear integrated with the sector shaft, thus causing the front wheels to turn to right or left.

The pitman arm is connected to the end of the sector shaft, and as the sector shaft turns, the end of the pitman arm moves describing an arc.

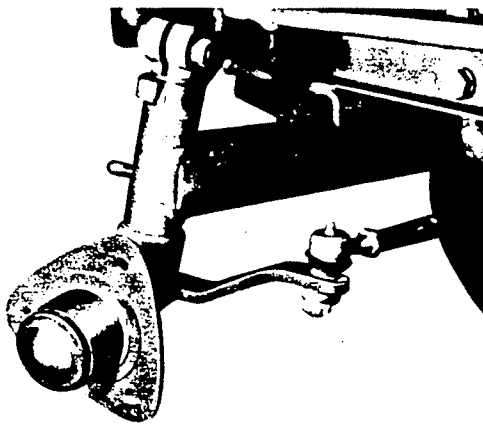
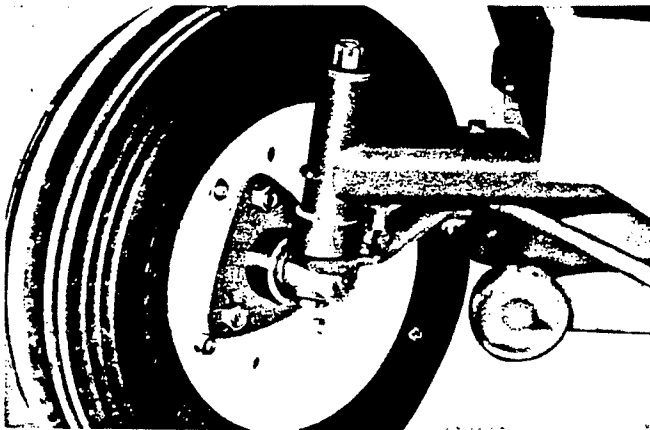
The drag link attached to the end of the pitman arm moves back and forth with the movements of the pitman arm, and the steering lever pivots on the king pin. This causes the front wheels to swing, thus steering the tractor.

The steering system consists of the steering gear box incorporating a worm gear and a sector gear, drag links, steering levers, tie rods, front axle, king pins and front wheels.

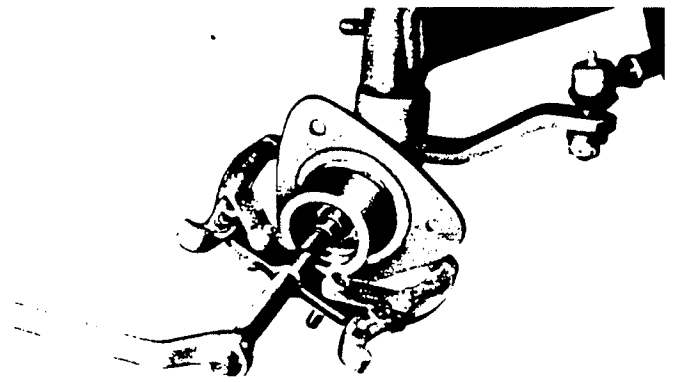
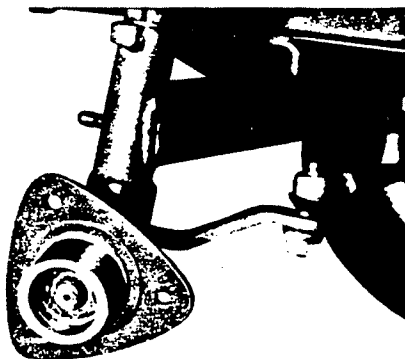
## DISASSEMBLING THE STEERING SYSTEM

### Front Wheel Hub Disassembly

1. Loosen the front wheel mounting bolt lock nuts, and lightly loosen the three front wheel mounting bolts.



2. Jack up the front axle, loosen the front wheel mounting bolts, and remove the front wheels.
3. Remove the front wheel hub cap, straighten the tab of the lock washer, and remove the sleeve nut.



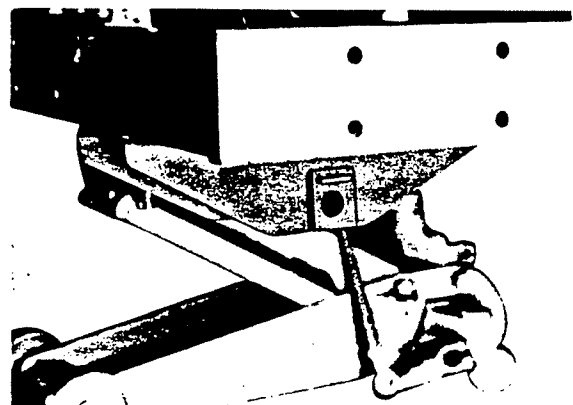
4. Remove the front wheel hub using the gear puller, and remove the oil seal.
5. Remove the ball bearing from the front wheel hub.

### King Pin Disassembly

1. Remove the cotter pin locking the castle nut on each end of the tie rod, loosen the castle nut, and remove the tie rod.
2. Loosen the knuckle arm bolt, and remove the knuckle arm while taking care so that the king pin does not fall.  
Remove the drag link from the knuckle arm, as required.
3. By tapping the top end of the king pin, pull out the king pin.
4. Remove the right hand castle nut, and remove the king pin.  
For the right side king pin, remove the castle nut and the king pin.

### Front Axle Removal

1. Pull out the cotter pin from the center pin nut, and remove the castle nut.



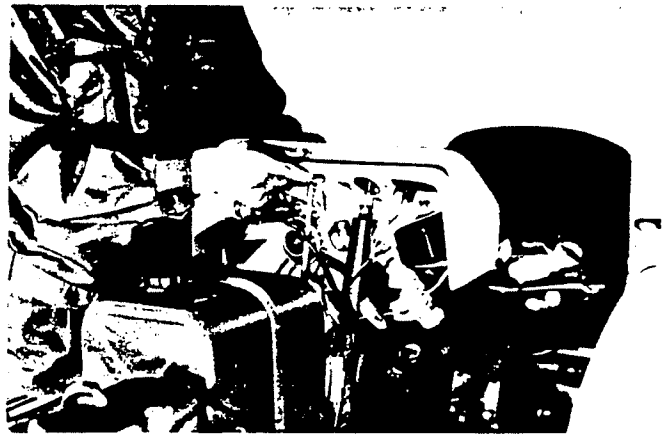
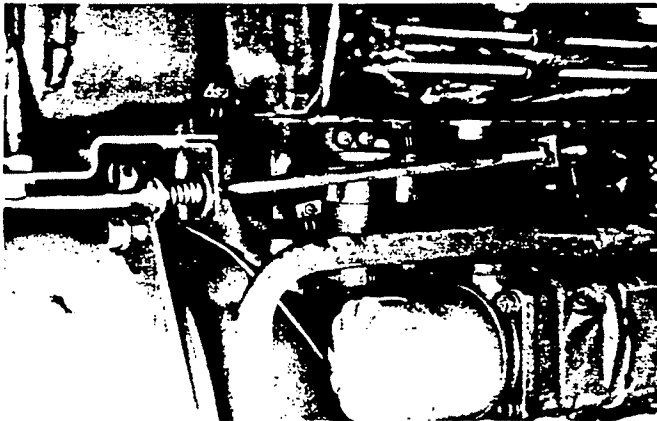
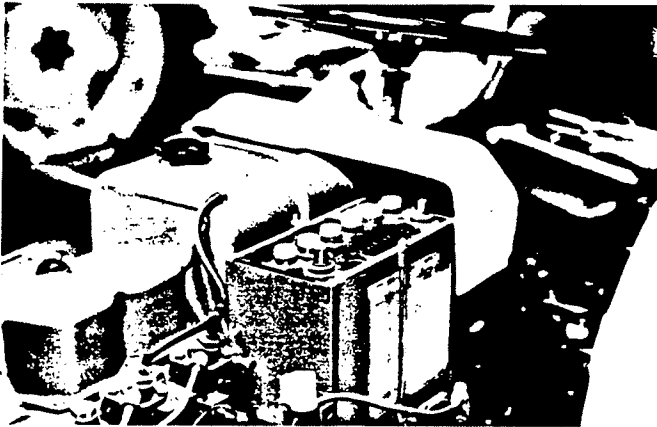
## 4-3 STEERING LINKAGE SYSTEM

2. Support the front axle, pull out the center pin, and remove the front axle.

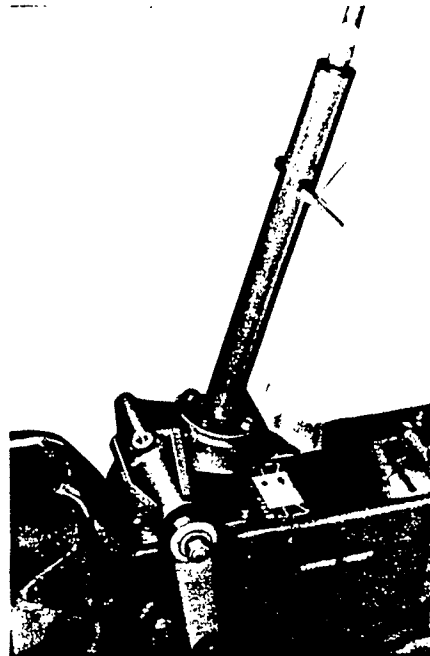
### DISASSEMBLING THE STEERING GEAR BOX

#### Steering Gear Box Removal

1. Release the hook on the right side of the bonnet, and open the bonnet.
2. Remove the battery cables from the terminals, and remove the battery.
3. Disconnect the fuel pipe from the fuel filter, and take the necessary step so that fuel does not leak out. Disconnect the fuel return pipe from the fuel pipe.



4. Remove the fuel tank, and remove the fuel tank base.
5. Loosen the steering gear box bolts, and remove the steering gear box from the clutch housing.



#### Throttle Lever Removal

1. Remove the steering wheel cap, loosen the steering wheel nut, and remove the steering wheel.
2. Disconnect the lead wires at connectors and terminals.
3. Loosen the three bolts securing the instrument panel, and remove the instrument panel.



### Disassembling the Steering Gear Box

1. Remove the steering column from the steering gear box, and remove the worm shaft.

**Note:**

There is a shim for clearance adjustment between the steering gear box and steering column.

Take special care not to lose it.

2. Remove the pitman arm from the sector shaft.
3. Remove the cover from the steering gear box, and remove the sector shaft.

**Note:**

There is a collar, thrust liner, O-ring. Take special care not to lose them.

### INSPECTION

Wash all the disassembled parts with cleaning oil and blow them dry with compressed air. Check for excessive wear or damage.

Replace with new one if defective or excessively worn.

1. Grease nipple and grease passage for clogging
2. Tire setting tap for damage.
3. Smooth rotation of ball bearing

Center Pin outside diameter:

0.866 inch (22mm  $\begin{smallmatrix} -0.065 \\ -0.095 \end{smallmatrix}$ )

Front axle center pin hole diameter:

0.866 inch (22mm  $\begin{smallmatrix} -0 \\ +0.052 \end{smallmatrix}$ )

King Pin outside diameter:

0.98 inch (25mm  $\begin{smallmatrix} -0.020 \\ -0.035 \end{smallmatrix}$ )

King Pin bushing inside diameter:

0.984 inch (25mm  $\begin{smallmatrix} -0.020 \\ -0.035 \end{smallmatrix}$ )

Measure the shaft outside diameter and bushing inside diameter. If measurements exceed the above limits, replacement of parts is necessary.

Install the king pin bushing, and measure the inside diameter. If the measurement is smaller than specified above, correct the diameter using a reamer very carefully.

After this operation, thoroughly clean the metal dust.

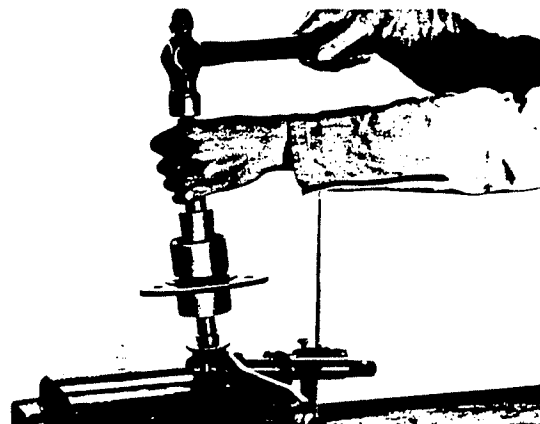
Always use new O-rings and oil seals.

### ASSEMBLY

Apply oil or grease to contact surfaces of moving parts, and assemble them carefully so that they maintain the specified dimensions.

### 1. Assembling the Front Wheel Hub

1. Install the washer to the king pin. Install the grease-coated oil seal.
2. Install two circlips to the front wheel hub, and insert the ball bearing into the hub.
3. Install the front wheel hub to the king pin, pack with Alvania grease, and insert the ball bearing into the hub.



4. Install the lock washer, and tighten the sleeve nut.

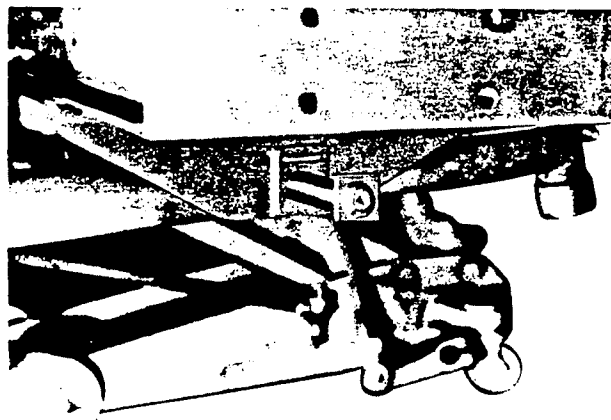
Front wheel hub starting torque:

10.1 – 11.6 ft-lb (0.4 – 0.6 kg.m)

5. After tightening the nut with starting torque, make sure that the front wheel hub rotates smoothly, and lock with the lock washer. Apply a bond to the cap, and install it to the front wheel hub.

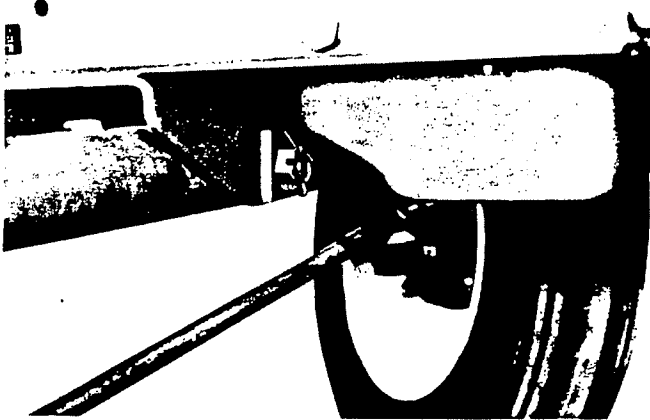
### 2. Assembling the Front Axle

1. Clean the center pin hole in the front axle and holes in the chassis, and install the front axle to the chassis with the longer boss facing forward.



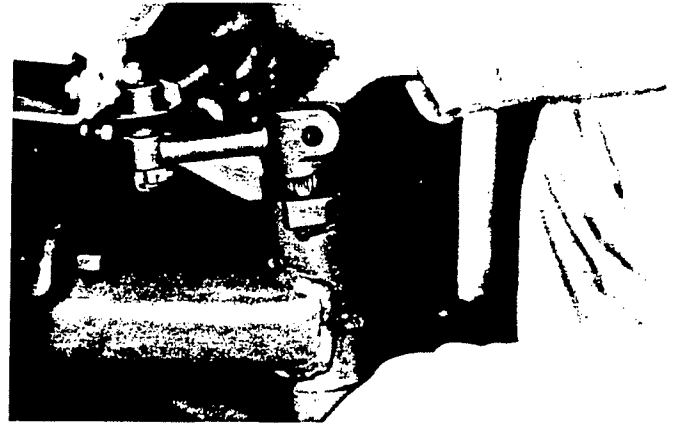
Push the greased center pin to the rear, and tighten the castle nut to specification. Then back it off 1/4 ~ 1/3 turn so that the cotter pin holes can be aligned.

Tightening torque: 108 – 123 ft-lb  
(15.0 – 17kg.m)



2. Lock with the cotter pin.
3. Make sure the front axle swings smoothly without end play.
4. Insert the greased oil seal into the king pin, while taking care so that the king pin does not slip off.
5. not slip off.

Install the washer, and align the knuckle arm bold hole with the cut on the king pin, and tighten the bolt.

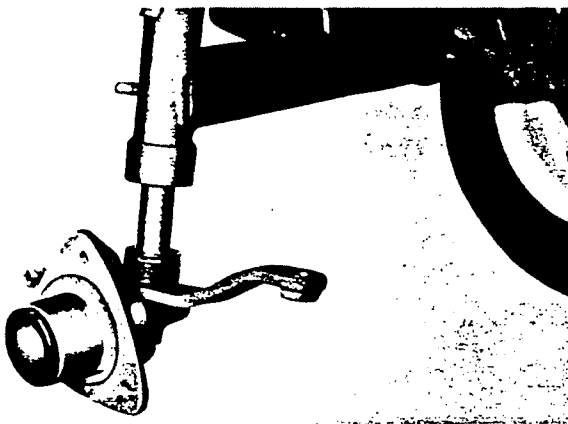


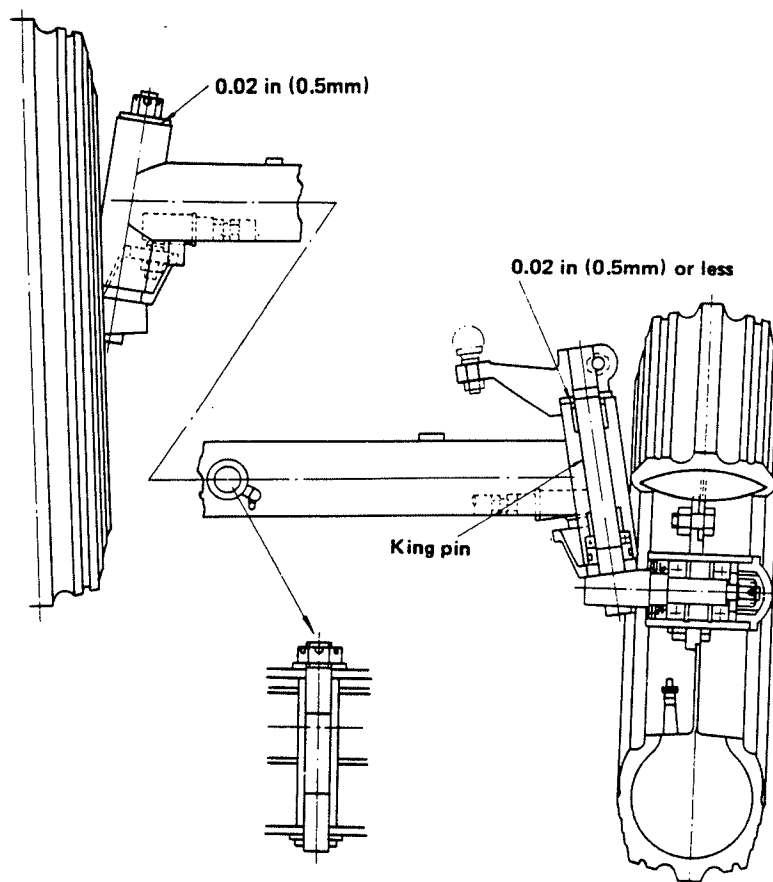
### **3. Assembling the King Pin**

Before installing the front axle to the chassis, insert the bushing into the king pin.

1. Oil the king pin sparingly, and push the bushing into the king pin. Install the grease-coated O-ring.
2. Install the thrust bearing, and apply a liberal amount of grease to it, and install the king pin to the front axle.

Tightening torque: 15.2 – 21.7 ft-lb  
(2.1 – 3.0 kg-m)





5. Make sure the gap between the knuckle arm lower side and the washer is 0.02 inch (0.5mm) or less.
6. Install the washer to the right hand king pin, tighten the castle nut, and lock with the cotter pin.

Tightening torque: 32.5 – 39.7 ft-lb  
(4.5 – 5.5kg.m)

7. Make sure the king pin operates smoothly, and grease it as required.

#### 4. Assembling the Steering Gear Box

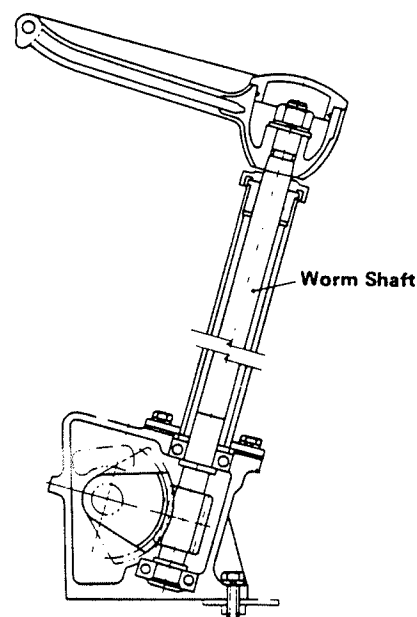
1. Push the two ball bearings into the worm shaft.
2. Install the steering column, and make an adjustment using a shim so that worm shaft end play is 0 – 0.079 inch (0 – 0.2mm).

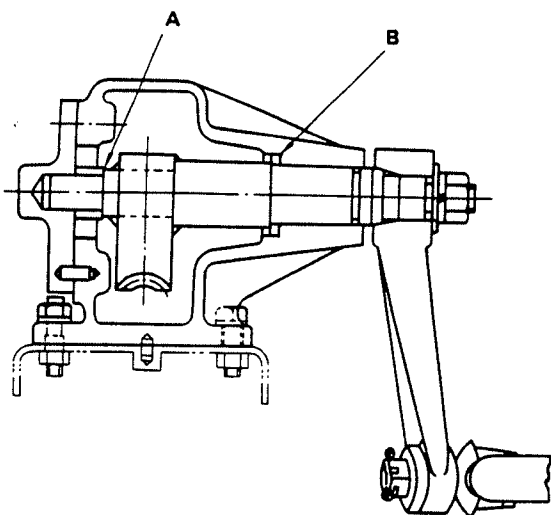
Worm shaft end play: 0 – 0.079 inch  
(0 – 0.2mm)

Adjusting shim

1135-2120-000: 0.0039 inch (0.1mm)

1135-2121-000: 0.0079 inch (0.2mm)





5. Incorporate the sector shaft in the steering gear box, install the collar and cover, and adjust the play of sector shaft end to 0.004 inch (0.1mm) by inserting shims into the A and B portions.

Adjusting shim

- \*1135-2109-000: 0.004 inch (0.1mm)
- 1135-2112-200: 0.004 inch (0.1mm)
- \*1135-2110-000: 0.008 inch (0.2mm)
- 1135-2111-000: 0.008 inch (0.2mm)
- \*1135-2112-100: 0.012 inch (0.3mm)
- 1135-2111-000: 0.016 inch (0.4mm)

The shim marked \* should be used at the B portion.

Select the proper shims for end play of the worm shaft and sector shaft, and proceed as follows:

6. Install the greased O-ring to the sector shaft, install the adjustment shims and collar, and install the cover with the gasket.

Tightening torque: 14.4 – 18.1 ft-lb  
(2.0 – 2.5 kg.m)

7. Place the worm wheel in the case so it faces upward, push the worm shaft (to which the bearing is already installed), and engage the worm wheel with the worm gear.
8. Install the collar, shim, and install the steering column, together with the gasket, in the gear box.

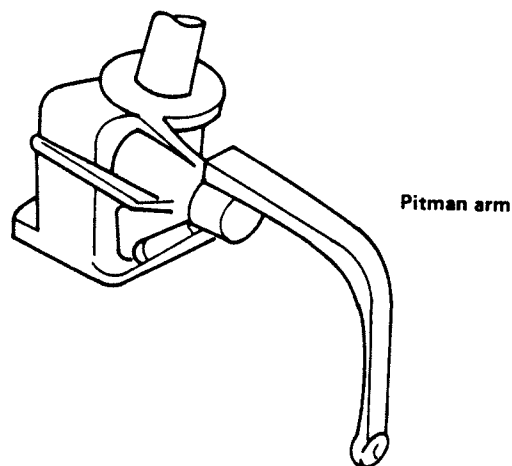
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg.m)

9. Align the punch mark on the sector shaft with the punch mark on the pitman arm, and install the pitman arm.

Tightening torque: 46.9 – 57.8 ft-lb  
(6.5 – 8.0 kg.m)

### Note:

The pitman arm used in some models is shaped as illustrated, but it can be installed in the similar way.



10. Install the steering gear box assembly to the clutch housing, while watching the dowel pin position.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

11. The fuel tank base, fuel tank, battery, instrument panel, steering wheel, etc. should be installed in the reverse order to the removal.

## 4-WHEEL DRIVE

### GENERAL

A 4-wheel drive tractor is capable of easily operating and moving around in places such as marshy land, slippery fields, hilly areas, etc., where an ordinary 2-wheel drive tractor would have difficulty. In the case of a 4-wheel drive tractor, the force applied to the treads of the wheels is more widely distributed than with a 2-wheel drive tractor since all the tires of the tractor work as traction wheels. Consequently the traction of the tractor is considerably increased due to less slippage. The efficiency of the

## 4-9 STEERING LINKAGE SYSTEM

The knuckle unit has two functions: one is to drive the front tires and the other is to steer them. The spherical portion of the king pin case is hard chrome plated to protect the knuckle from being damaged by protecting the seal from damage due

to rust on the spherical portion and muddy water from entering due to a damaged seal, etc.

The steering operation is made easy by reducing the frictional resistance between the spherical portion and seal by this chrome plating.

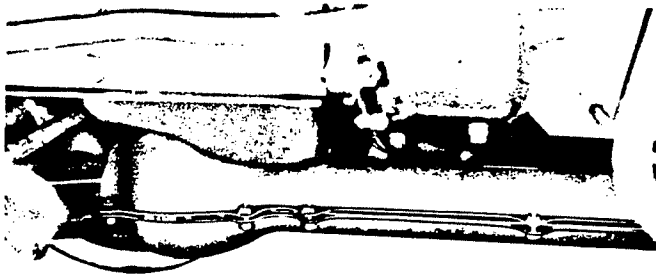
### DISASSEMBLING THE 4-WHEEL DRIVE STEERING SYSTEM

#### Front Axle

1. When disassembling the knuckle assembly only, it is unnecessary to remove the universal joint and differential.
2. This manual describes the general procedure for disassembly and assembly of the 4-wheel drive system. Take the proper disassembling procedure depending on the trouble.

#### Removing the Universal Joint

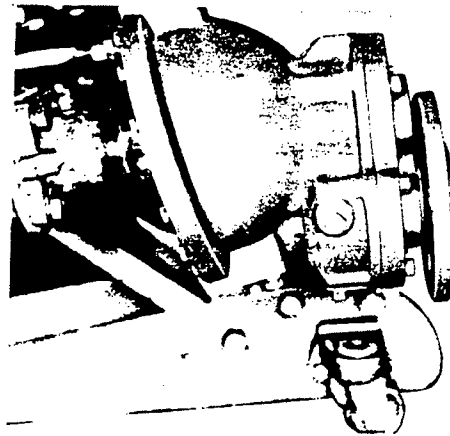
1. Loosen the universal joint cover, tightening bolts, and remove the universal joint cover.



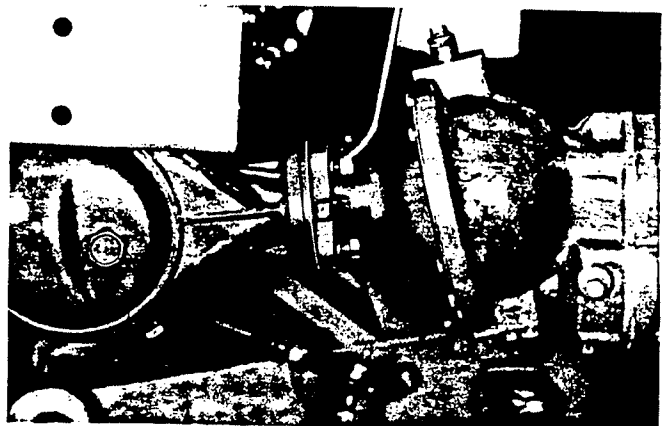
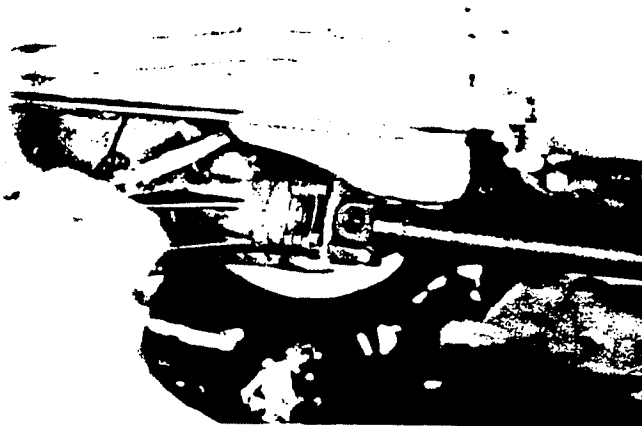
2. Remove the universal joint flange yoke and flange assembly bolt, and remove the universal joint.
3. Remove the cotter pins from the castle nuts on the drag link and tie rod, loosen the castle nut, and remove the drag link and tie rod.

#### Removing the Knuckle Assembly

1. Jack up the front axle, and remove the front wheel.



2. Loosen the bolt securing the axle housing and knuckle assembly, and remove the knuckle assembly.

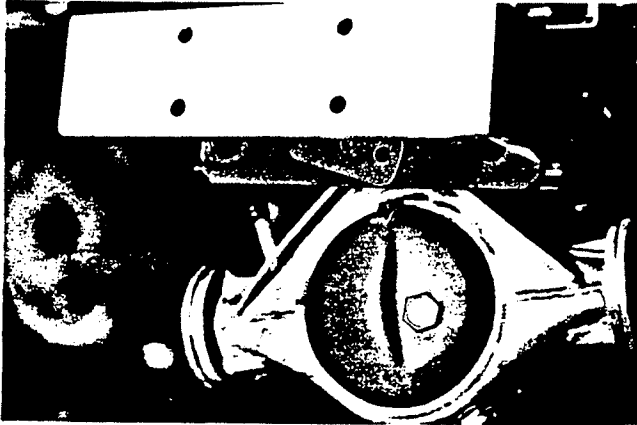


A long shaft is held to the knuckle assembly at one end. When removing the shaft, hold it carefully until it is completely pulled out.

### Removing the Axle Housing

1. Remove the center pin grease nipple, and loosen the two bolts securing the center pin to the chassis.

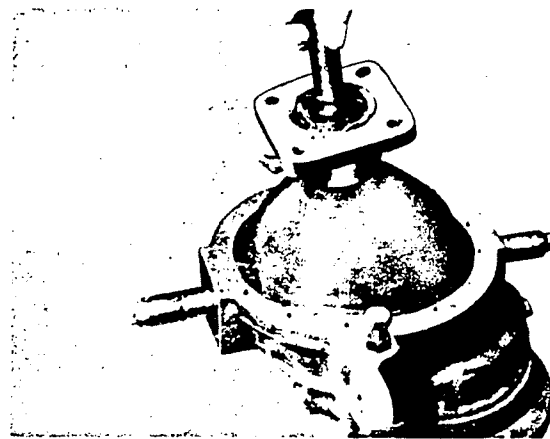
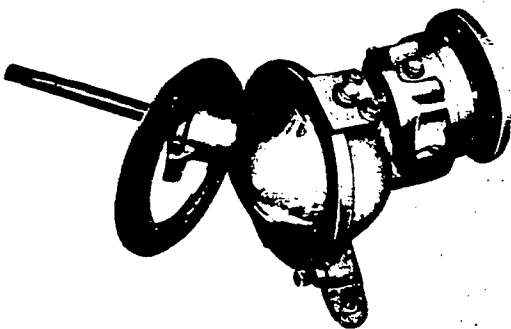
Pull out the center pin, and remove the axle housing from the chassis.



**Note:** There is a shim between the chassis and axle housing.

### Disassembling the Knuckle Assembly

1. Loosen the oil seal retainer plate holding bolt on the spherical part, and remove the oil seal felt and oil seal.



2. Loosen the king pin bolt on both upper and lower parts of the knuckle arm, and remove the key plate.

Insert a screwdriver into the key plate, and pull out the king pin gently, and remove the king pin case and final gear case.

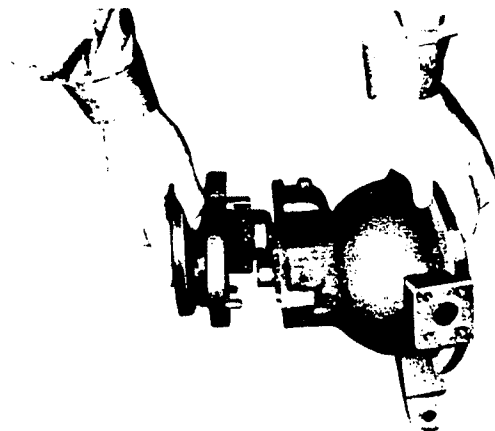
#### **Note:**

There is a shim on the top of the king pin case and in the final gear case.

3. Remove the oil seal from the king pin case (the oil seal can not be reused), and remove the circlip on the king pin case side. Pull out the shaft with the ball bearing installed.
4. Remove the circlip from the shaft, and remove the ball bearing.

### Disassembling the Final Gear Case

1. Loosen the bolt securing the final gear case (B), and remove the final gear case (B) from the final gear case (A).





2. Remove the ball bearing from the final gear case, and remove the circlip. Remove the gear, and by tapping the shaft, remove the yoke assembly from the final gear case.

**Note:** \_\_\_\_\_

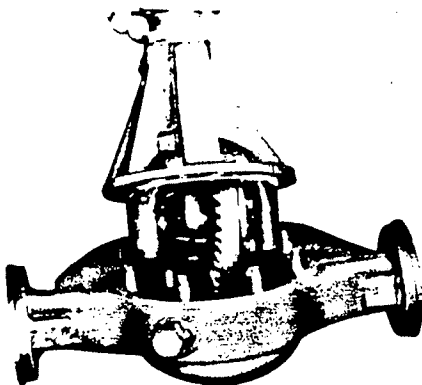
The yoke must be replaced as an assembly.

3. Remove the circlip from the wheel shaft, and by tapping the shaft, remove it from the final gear case (B).  
Remove the ball bearing and oil seal.

### Disassembling the Axle Housing and Differential Gear Assembly

Normally it is unnecessary to disassemble the axle housing and differential gear assembly. In principle, replacement of a single component is impossible. In case that disassembly is required, proceed as follows:

1. Loosen the differential gear assembly mounting nut, and remove the differential gear assembly from the axle housing.



2. Loosen the bearing holder bolt, and remove the differential gear.
3. Remove the ball bearing from the differential case assembly, loosen the ring gear bolt, and remove the ring gear.
4. Pull out the pin locking the center pin, and pull out the center pin, and remove the pinion gear and side gear as well as thrust washer.

### Disassembling the Pinion Gear

1. Loosen the self-lock nut, and pull out the pinion shaft while taking care so that the shim or spacer does not drop.
2. Remove the flange assembly, and remove the oil seal from the flange assembly.

### INSPECTION

1. Check the spherical part of the king pin case for scratches or rust.
2. Check the oil seal retainer plate, and if excessively deformed, replace.
3. Check the oil seal felt, and if deformed or damaged, replace.
4. Check the oil seal, and if deformed or damaged, replace.
5. If the king pin O-ring is damaged, replace.
6. Check the smooth rotation of each bearing, and if not, replace.
7. Check the oil seals, and if any one is damaged, though slightly, replace with a new one.
8. Check shafts, gear and joints for damage or wear, and correct or replace as required.

### ASSEMBLY

1. Always use new O-rings and oil seals.
2. Thoroughly wash all parts, and apply oil or grease to moving parts. Assemble them in the correct manner.
3. Using special tools, measure the pinion shaft cone center and pre-load correctly.

### Assembling the Differential Gear

1. Install the thrust washer and side gear in the differential case, and set the pinion gear and thrust washer with the center pin, and measure the backlash between the side gear and pinion gear.

Backlash: 0.001 – 0.006 inch (0.05 – 0.15mm)

Backlash adjustment should be made by changing the thickness of thrust washer installed, together with the side gear.

Thickness of thrust washer:

0.035 inch (0.9mm)  
 0.04 inch (1.0mm)  
 0.043 inch (1.1mm)  
 0.047 inch (1.2mm)  
 0.051 inch (1.3mm)

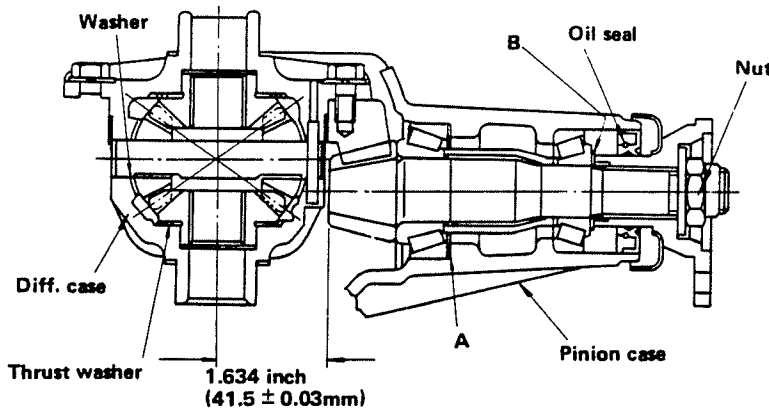
When the backlash is correctly adjusted, lock the center pin with the lock pin, and further

clinch the lock pin with the center punch.

2. Install the ring gear to the differential case, and tighten it with the mounting bolt.

Tightening torque: 21.7 – 28.8 ft-lb  
 (3 – 4kg-m)

3. Install the taper roller bearing collar and taper roller bearing to the pinion shaft, in that order and install the pinion shaft in the pinion gear case. Adjust the cone center to 1.634 inch ( $41.5 \pm 0.03\text{mm}$ ) using a shim or shims of A portion.



Shime thickness: 0.002 inch (0.05mm)  
 0.017 inch (0.07mm)  
 0.004 inch (0.10mm)  
 0.008 inch (0.20mm)  
 0.012 inch (0.30mm)  
 0.02 inch (0.50mm)

After adjusting the cone center to 1.634 inch ( $41.5 \pm 0.03\text{mm}$ ), install the pinion shaft to the pinion shaft case, and install the flange. Tighten the self-lock nut to 72.2 – 86.7 ft-lb (10 – 12 kg-m) and adjust the pinion shaft pre-load to 21.7 – 43.3 ft-lb (3 – 6 kg-m) using the shim of the B portion.

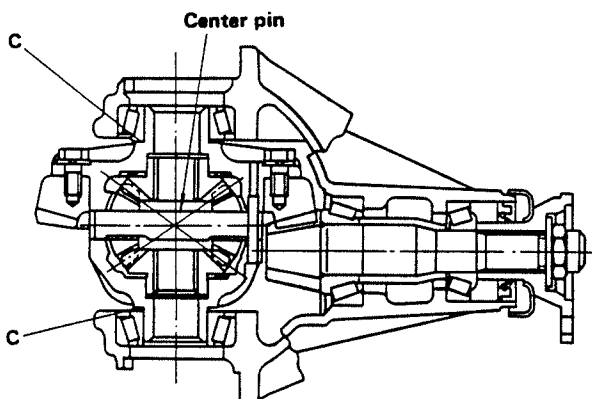
Thickness of shim

0.0669 inch (1.70mm)	0.0740 inch (1.88mm)
0.0681 inch (1.73mm)	0.0752 inch (1.91mm)
0.0693 inch (1.76mm)	0.0764 inch (1.94mm)
0.0705 inch (1.79mm)	0.0776 inch (1.97mm)
0.0717 inch (1.82mm)	0.0787 inch (2.00mm)
0.0728 inch (1.85mm)	

4. Install the differential gear to the pinion case, and adjust the backlash between the ring gear

and pinion gear to 0.004 – 0.006 inch (0.10 – 0.15mm) using the shim of the C portion.

Back lash: 0.004 – 0.006 inch  
 (0.10 – 0.15mm)



Thickness of shim: 0.002 inch (0.05mm)  
 0.0028 inch (0.07mm)  
 0.004 inch (0.10mm)  
 0.012 inch (0.30mm)  
 0.02 inch (0.50mm)



## 4-13 STEERING LINKAGE SYSTEM

Install the bearing metal, and tighten the bolts evenly. Make sure that the differential gear turns smoothly.

Tightening torque: 10.8 – 14.4 ft-lb  
(1.5 – 2 kg-m)

5. Apply a sealing compound to the axle housing, and install the pinion gear case.

Tightening torque: 8.67 – 12.3 ft-lb \_\_\_\_\_  
(1.2 – 1.7 kg-m)

6. Install the axle housing to the chassis, and

adjust the clearance between the chassis and axle housing to  $0 - 0.0077$  inch ( $0 - 0.2$ mm) using a shim, and lock with the center pin.

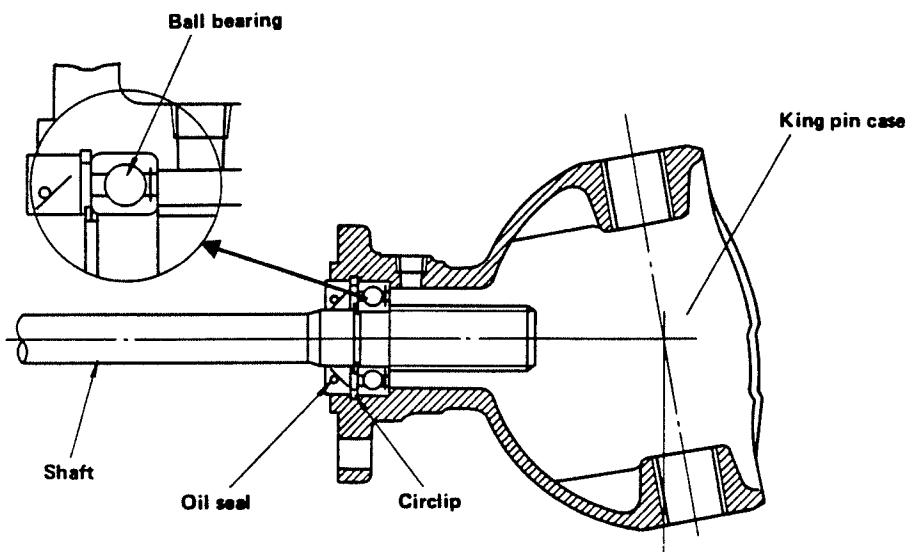
Tightenign torque: 43.3 – 50.6 ft-lb  
(6.0 – 7.0 kg-m)

Install the grease nipple to the center pin.

7. Make sure that the axle housingswings lightly.

### Assembling the Knuckle Assembly

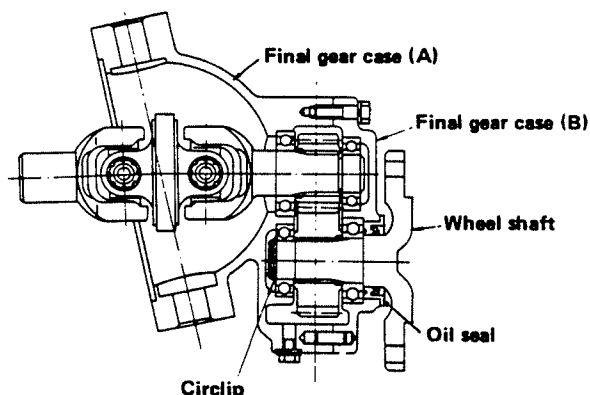
1. Push the ball bearing into the differential shaft so that the sealed surface faces inward, set with the circlip, and install the king pin case.
2. Apply grease to the oil seal, and install the king pin case.

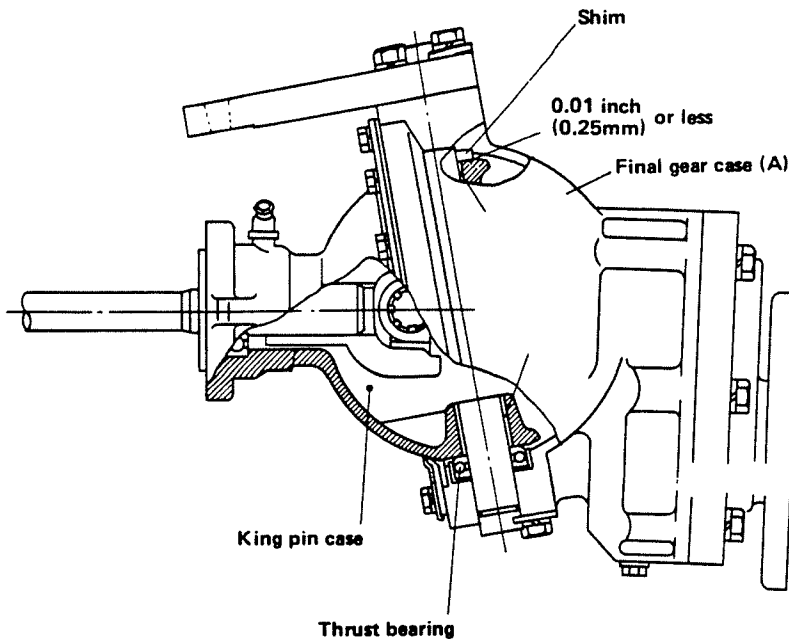


### Assembling the Final Gear Case

1. Install the oil seal to the final gear case (B), and apply grease.
2. Install the wheel axle, and install the ball bearing, gear, and ball bearing, in that order. Set with circlips.

**Note:** The chamfered side must face the oil seal.



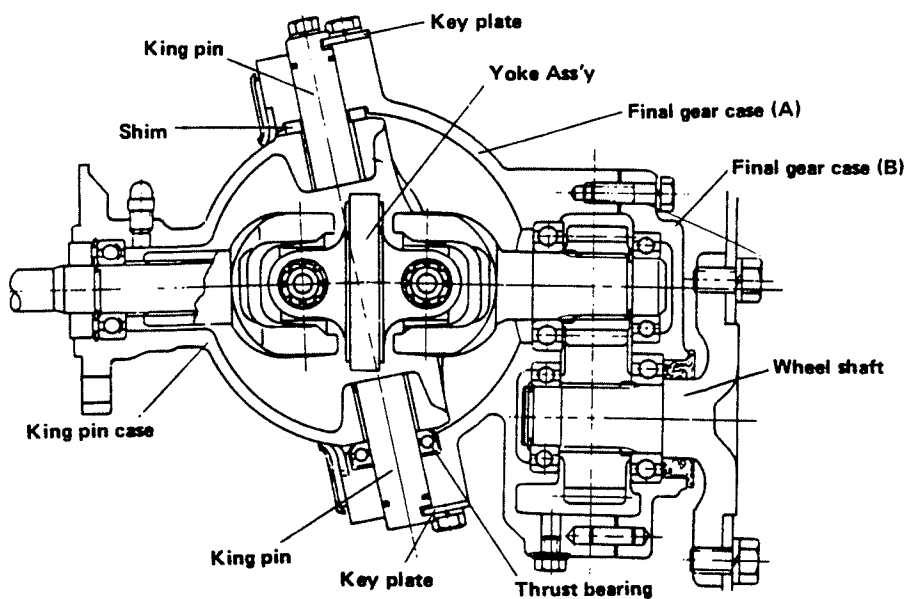


#### Thickness of shim

1119-0682-000:	0.177 inch (4.5mm)
1119-0682-100:	0.187 inch (4.75mm)
1119-0682-200:	0.20 inch (5.0mm)
1119-0682-300:	0.207 inch (5.25mm)
1119-0682-400:	0.217 inch (5.5mm)

3. Install the thrust bearing in the king pin hole on the bottom (inside) of the final gear case (A) paying attention to the direction of the thrust bearing, as illustrated.

4. Adjust the clearance between the final gear case and king pin case to 0.01 inch (0.25mm) or less using a shim.



\*Next, set the king pin case and final gear case with the king pin.

#### 4-15 STEERING LINKAGE SYSTEM

5. Set the yoke assembly to the splined portion of the differential shaft in the king pin case, and pack the yoke with 0.44 lbs (200 g) of grease.
6. Install the greased O-ring to the king pin. Install the shim (selected previously) into the hole on top of the final gear case. Install the king pin case and final gear case (A) while keeping the shim in its position with the king pin. Insert the ends of the yoke into the gear case (A) correctly.
7. Insert the key plate into each king pin, and

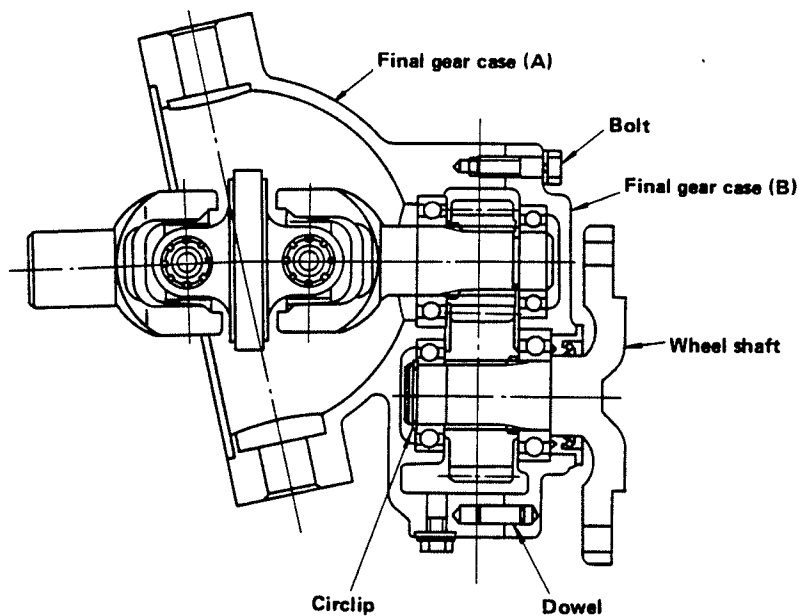
lock with the bolt.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

**Note:**

The king pin on the top of the left side final case is longer than the three other king pins since the steering lever is attached to it.

8. Push the ball bearing into the final gear case so that oil seal is on the inner side, and install the gear with the chamfered side on the inner side, and set with the circlip.



9. Apply a sealing compound to the matching surfaces of the final gear cases (A) and (B), install the gasket, and install the final gear case (B) together with the dowel pin.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

10. Install the oil seal and oil seal felt (which is oiled) to the spherical part, hold them down with the oil seal retainer, and tighten the bolt.

Tightening torque: 3.61 – 5.06 ft-lb  
(0.5 – 0.7 kg-m)

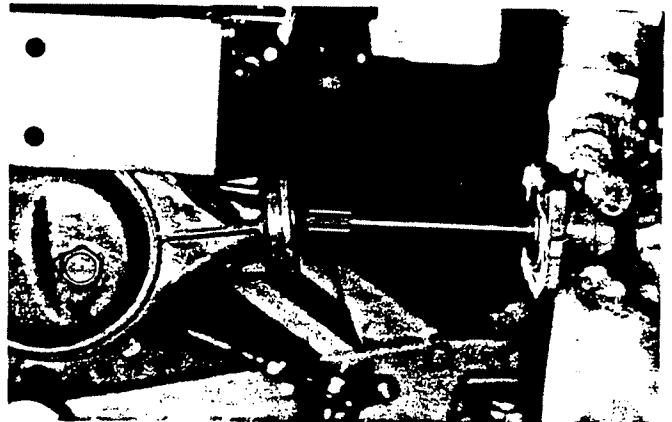
11. Install the steering lever to top of the left side final gear case, and install the key plate, then tighten the bolt.

Tightening torque: 18.1 – 21.7 ft-lb  
(2.5 – 3.0 kg-m)

Make sure that the king pin case lightly moves and also the differential shaft turns lightly.

12. Install both right and left knuckle assemblies to the axle housing assembly.

Tightening torque:



## Front tire (ES tire)

Tire size and ply rating	18 x 700-8
Tire pattern	Pillow Dia
Tire pressure	14.22 lb/in <sup>2</sup> (1.0 kg/cm <sup>2</sup> )
Outside diameter	17.99 in (457mm)
Tire width	6.69 in. (170mm)
Loaded radius	451.5 lb (2-5 kg)
Type of valve	TR-413
Rim	5.50 x 8

## SPECIFICATIONS

## Steering (2-wheel)

Steering system	Ackerman Jant Method
Axle center	Center pivot type
King pin type	Rumoin
Steering gear box	Worm sector type
Tread adjustment	With set in adverse
Axle center swing angle	.8°
King pin angle	.8°
Chamber	.2.5°
Caster	.3°
Toe-in	.0.24 in. (6mm)
Steering angle	
2-wheel	Inside 55°, outside 42.5°
4-wheel	.44° $\begin{smallmatrix} -0^{\circ} \\ -2^{\circ} \end{smallmatrix}$
Gear ratio	.1/15
Steering wheel size	.14.96 in. (380mm)
Turning radius	
2-wheel (with brake)	.66.93 in. (1700mm)
(without brake)	.78.74 in. (2000mm)
4-wheel (with brake)	.78.74 in. (2000mm)
(without brake)	.98.42 in. (2500mm)

## Front tire (2-wheel)

Tire size and ply rating	.400-9, 2 ply
Tire pattern	.Fam service rib
Tire pressure	.22.8 lb/in <sup>2</sup> (1.6 kg/cm <sup>2</sup> )
Outside diameter	.17.99 in. (457mm)
Tire width	.4.49 in. (113mm)
Loaded radius	.286.3 lb (130 kg)
Type of valve	.TR-13
Rim	.3.00 x 10

## Front tire (4-wheel)

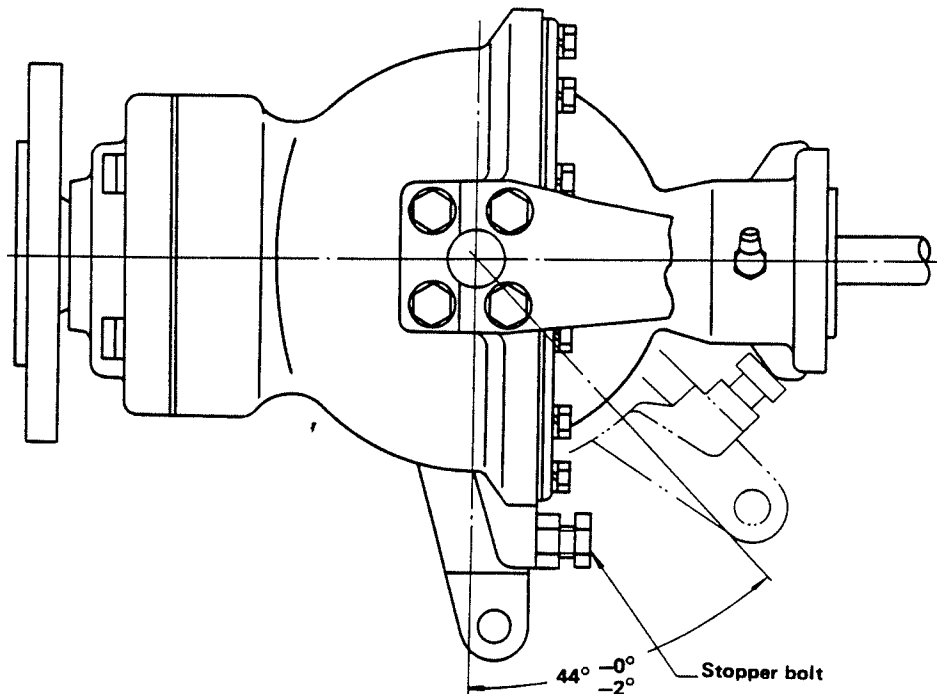
Tire size and ply rating	.5-12, 2 ply
Tire pattern	.AG
Tire pressure	.17.1 lb/in <sup>2</sup> (1.2 kg/cm <sup>2</sup> )
Outside diameter	.21.57 in. (548mm)
Tire width	.4.92 in. (125mm)
Loaded radius	.330.4 lb (150 kg)
Type of valve	.TR-13
Rim	.4-JA x 12

**Installing the Universal Joint**

1. Apply oil to the mid P.T.O. felt on the universal joint assembly, and install it to the P.T.O. shaft, and fully push it downward.
2. Install the front part of the universal joint to the flange assembly of the axle housing.

Tightening torque:

3. Make sure that the universal joint rotates smoothly.
4. Install the universal joint cover. Make sure that the universal joint does not contact with
5. Install the tie rod, and set the castle nut with the cotter pin.
6. Install the drag link.
7. Adjust the toe-in to 0.23 inch ( $6 \pm 2\text{mm}$ ) with the tie rod, and lock the tie rod.
8. Adjust the steering angle of the front wheels to  $44^\circ - \frac{0}{2}^\circ$  by turning the stopper bolts.

**Steering Gear Box**

Disassembly and assembly of the steering gear box.  
Refer to the disassembling procedure of the steering gear box for the 2-wheel drive tractor.

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## GENERAL

The transmission of the Satoh Beaver Model (S-370 & S-370D) Tractor is of the selective sliding gear type, and six-forward and two-reverse speeds can be obtained by the sub-shifting mechanism.

Three P.T.O. speeds of 517rpm, 762rpm and 1249 rpm and the differential gear mechanism with a differential lock unit are compactly mounted in the transmission case.

The gear shifting lever and gear shifting mechanism are built-in at the front side of the transmission case so that proper tractor speeds and power-take-off speeds suitable for various types of work can be obtained.

The differential gear mechanism is mounted at the rear side of the transmission case and a differential lock unit is also provided as standard specifications. The final drive case integrally constructed with a brake unit is mounted on both right and left rear sides of the transmission case.

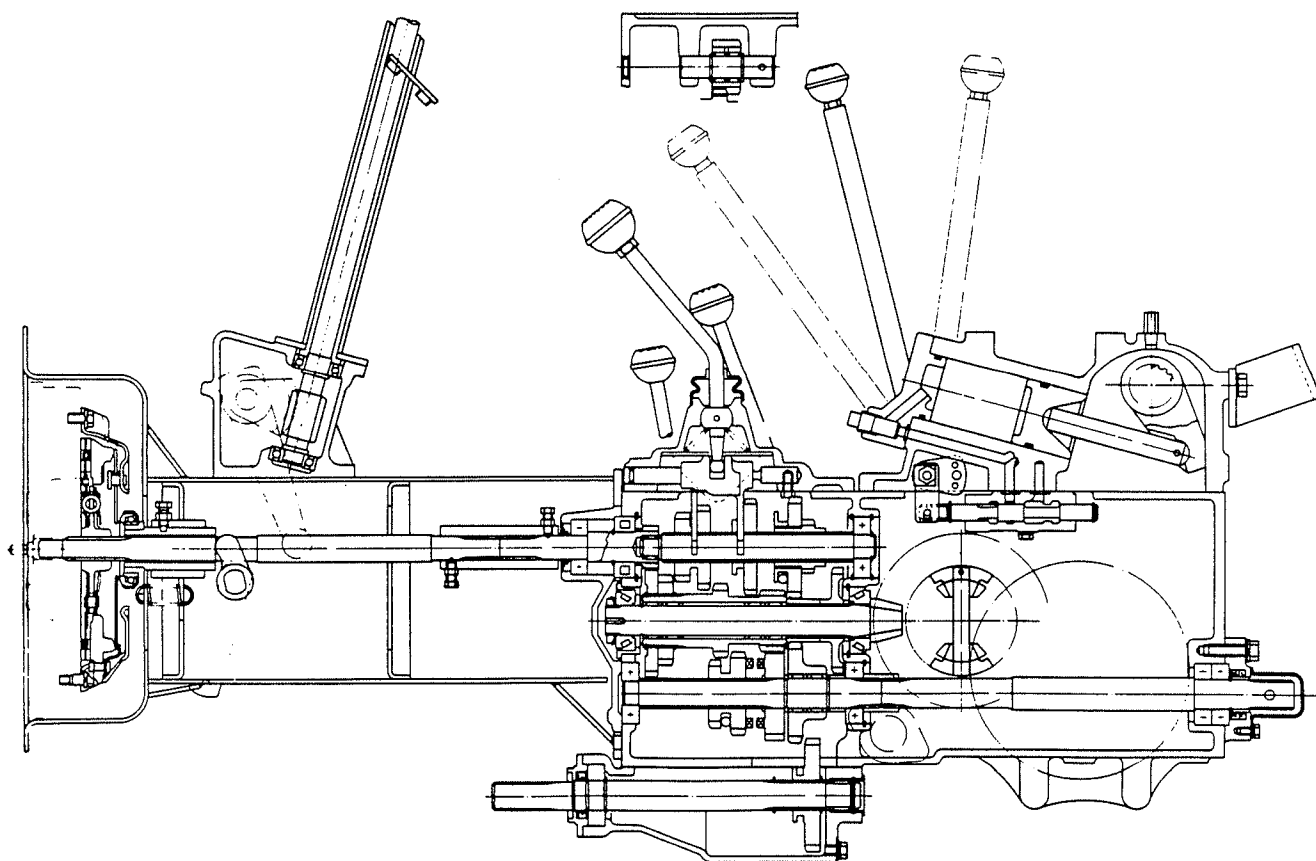
The P.T.O. (power-take-off) shaft is an 18-spline shaft, but it can be converted into SAE 1 3/8 6-spline shaft by installing a P.T.O. adaptor, an optional equipment.

Shifting mechanism and hydraulic system are mounted at the upper portion of the transmission case. SAE#80 oil is a standard oil to be used for both the transmission case and hydraulic system, but it is recommended to change the oil depending on the temperature.

Transmission case is highly strong since it is made of specially selected case iron, and also the case is highly accurate because of its simultaneous machining. The transmission is strong and accurately made so that the power is transmitted positively and for smooth transmission operation. The gears, axles and bearings also have high accuracy to ensure quiet operation.

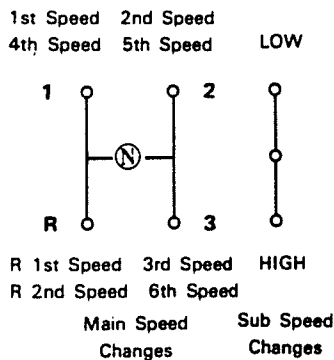
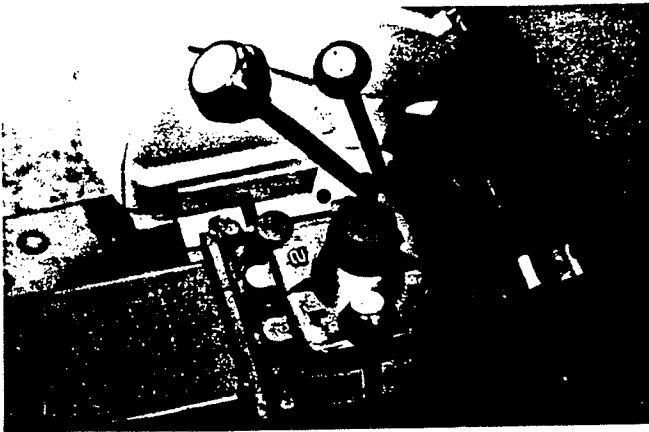
Various kinds of bearings with high strength and long durability are used according to the loads.

## CONSTRUCTION





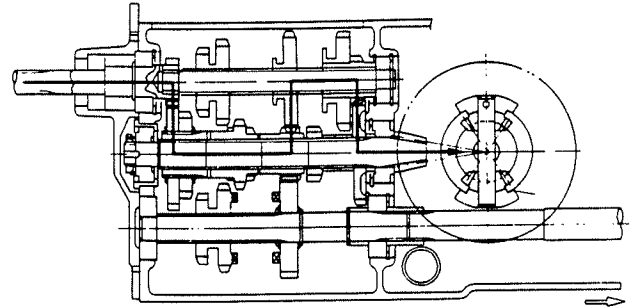
The transmission mechanism is of the selective sliding gear type and is capable of varying the tractor speed by means of 13 gears and 3 shafts, including a reverse shaft.



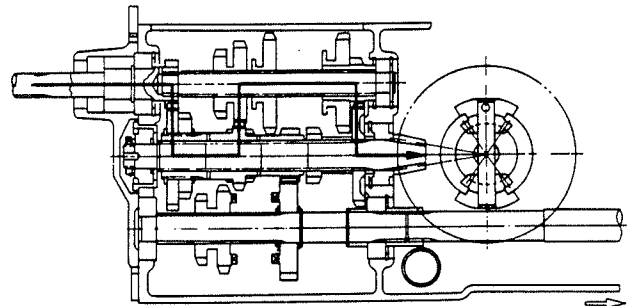
Operating the shifting lever causes the gear on the select shaft to slide and mesh with a gear on the counter shaft due to the action of the shifting mechanism mounted on the upper portion of the transmission case, which allows power from the engine to be through the spiral pinion gear to the ring gear. The power is then transmitted through differential gears to the differential pinion shaft which drives the final drive gear.

### Gear meshing

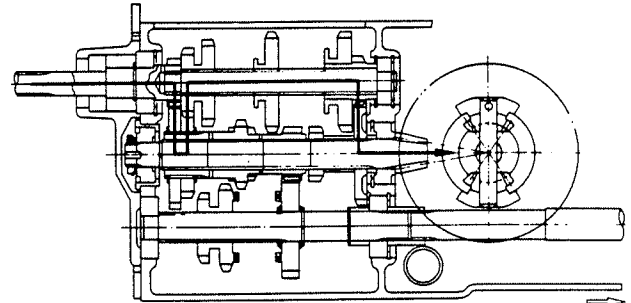
F-1



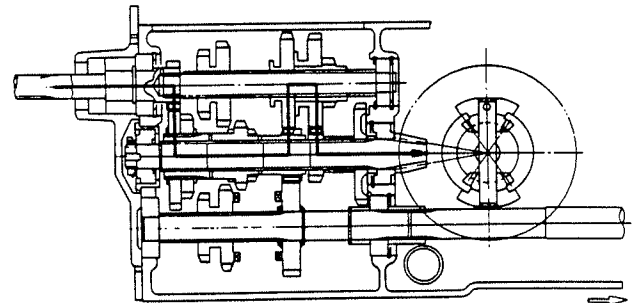
F-2



F-3

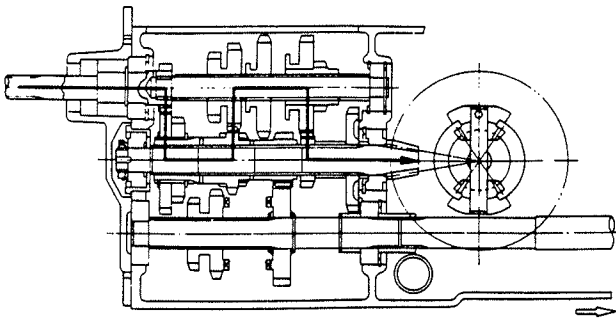


F-4

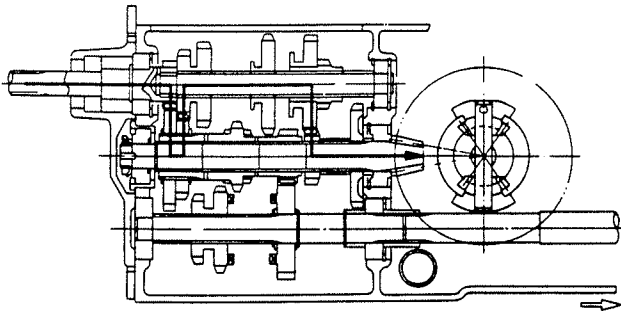


## 5-3 TRANSMISSION SYSTEM

F-5

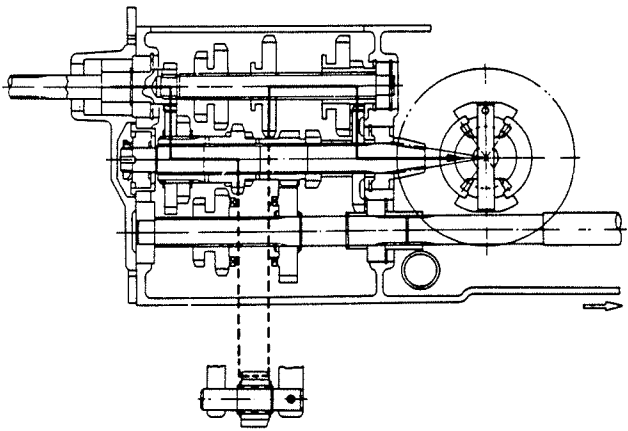


F-6

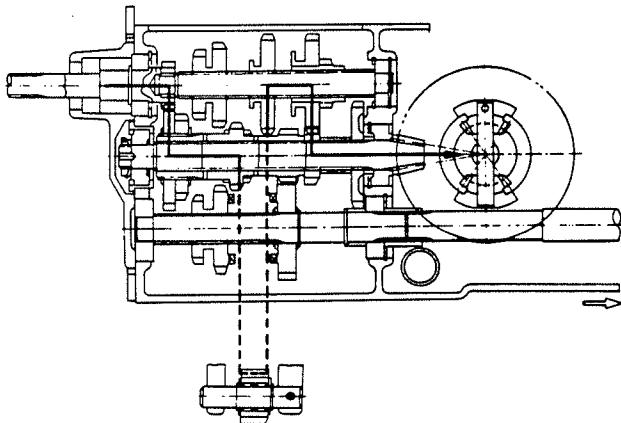


Reverse

R-1



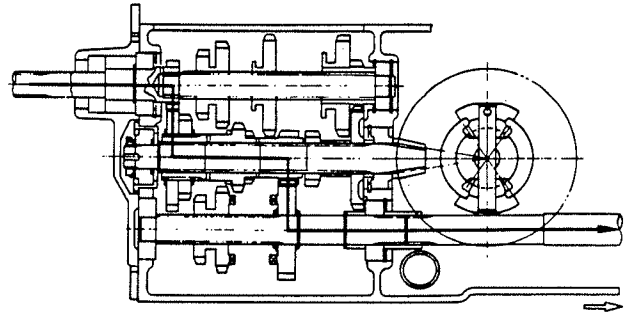
R-2



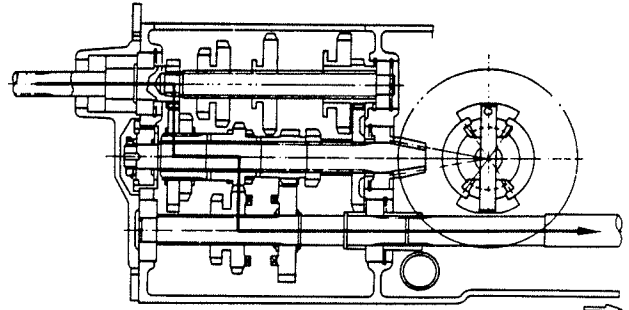
### Power-Take-Off

A power-take-off assembly is installed at the lowermost portion of the transmission case and provides 3 different speeds by means of 3 gears.

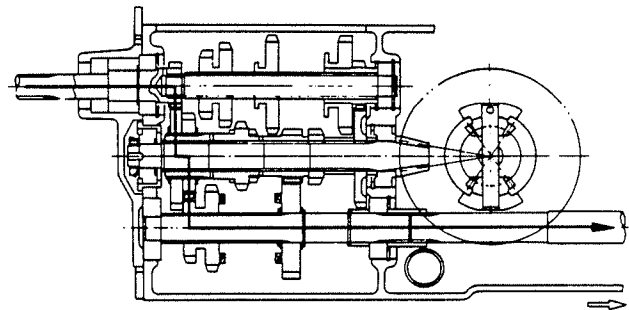
P-1



P-2



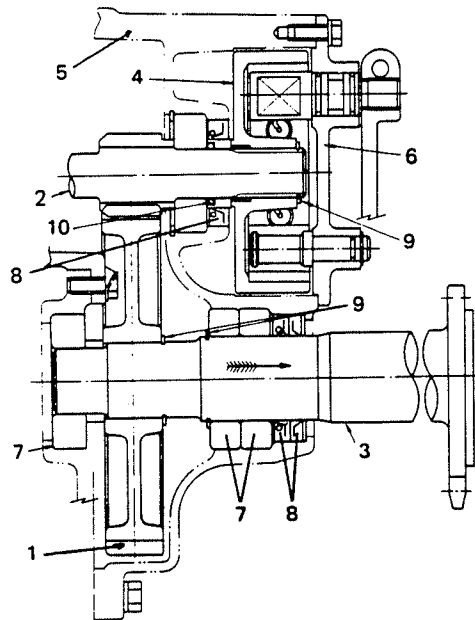
P-3



### Final Drive Case

A differential pinion shaft, final drive gear, final drive shaft and brake mechanism are assembled together in one case as the final drive case, and a

differential lock unit is installed at the right side as standard specifications.



1. Final gear
2. Diff. shaft
3. Final shaft
4. Brake drum
5. Final case
6. Brake cover
7. Ball bearing
8. Oil seal
9. Circlip
10. O ring

Final Drive Case Assembly

### DISASSEMBLING THE TRANSMISSION

#### Note:

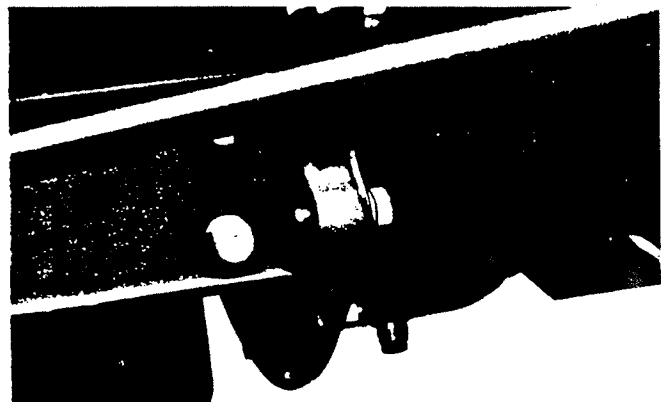
1. It is required to disassemble the transmission case only when the case itself has been damaged. When the gear shaft or bearing in the transmission system is damaged, determine location of trouble for efficient disassembly and speedy repair.
2. Take care during the disassembly operation of the transmission case because it is very heavy and slippery with oil. Use well-arranged clean spacious floor which is hard and flat.
3. The ring gear and the select shaft in the transmission case can be disassembled with the engine mounted.

#### Removing the Transmission Case

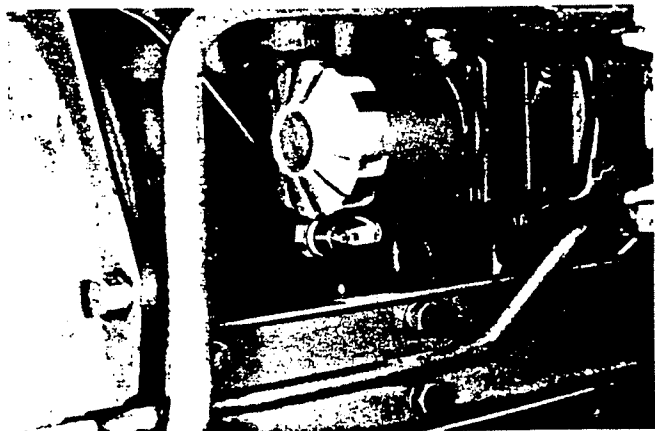
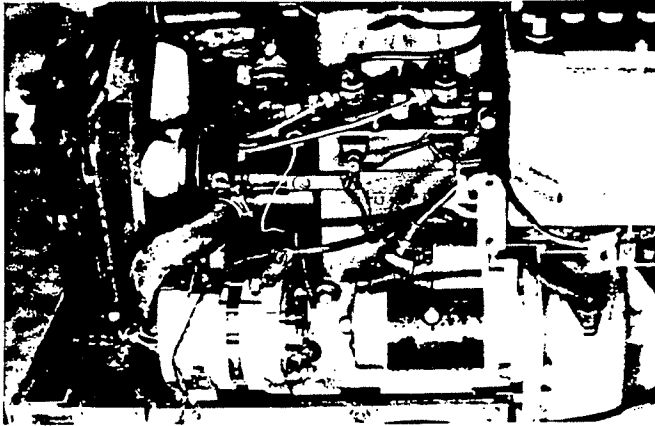
1. Remove the drain plug, and drain off the transmission case oil.



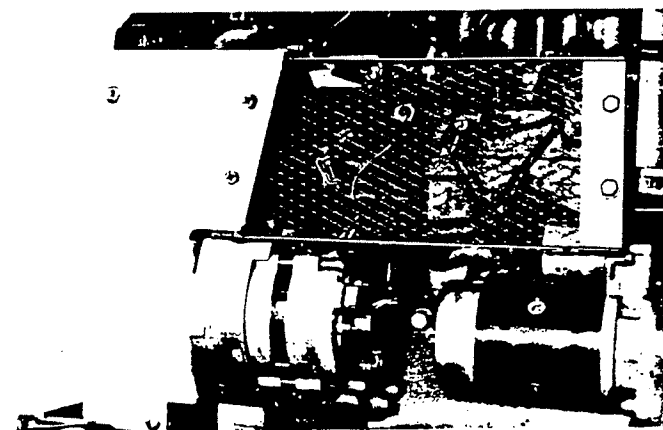
2. Remove the drag link from the pitman arm.
3. Remove the front plate from the clutch housing.



4. Release the bonnet hook, open the bonnet, and disconnect the battery cables from the terminals.
5. Disconnect the wire connectors from the terminals.



6. Remove the safety guard screws.



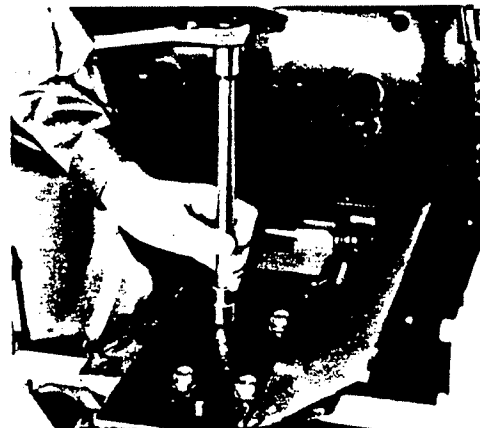
7. Remove the fuel pipe from the fuel strainer, and make it so that fuel does not leak out. Remove the return pipe.

8. Pull out the cotter pin on the engine side, and remove the throttle rod.
9. Remove the bolts securing the suction pipe and delivery pipe from the hydraulic pump. Note that there is an O-ring installed.
10. Hang the engine with a chain block, and place the jack under the clutch housing. Loosen the bolts securing the engine and clutch housing, and demount the engine from the clutch housing by pulling it forward gently.

**Note:**

On the 4-wheel drive tractor, remove the universal joint cover, loosen the universal joint bolt, and separate the engine.

11. Remove the driver's seat together with the tool box.



12. Jack up the rear wheel axle, and remove the rear wheels.
13. Remove the fenders.
14. Remove the brake rods and remove the steps.
15. Shift the jack under the clutch housing to under the transmission case, and separate the clutch housing from the transmission case.
16. Remove the hydraulic pipe, and bring the transmission case onto the work bench with the hydraulic case mounted.
17. Loosen the set bolt on the drive shaft coupling, and remove the main shaft together with the coupling.
18. Loosen the hydraulic case bolt, and remove the hydraulic case.
19. Loosen the main shift cover bolt, and remove the cover.

20. Loosen the final reduction case bolt, and remove the case.

## DISASSEMBLING THE TRANSMISSION CASE

### Disassembling the Drive Shaft

1. Loosen the bearing holder bolt and nut, and remove the bearing holder together with the drive shaft.

Take care so that the needle bearing in the drive shaft does not fall off.

2. By tapping the end of the drive shaft, pull out the drive shaft from the bearing holder. Remove the drive shaft circlip, and remove the ball bearing.

Remove the oil seal and ball bearing from the bearing holder.

#### Note:

On some of the tractor produced in the early stage of production, the bearing holder is secured by a bolt instead of a stud bolt.

### Disassembling the Select Shaft



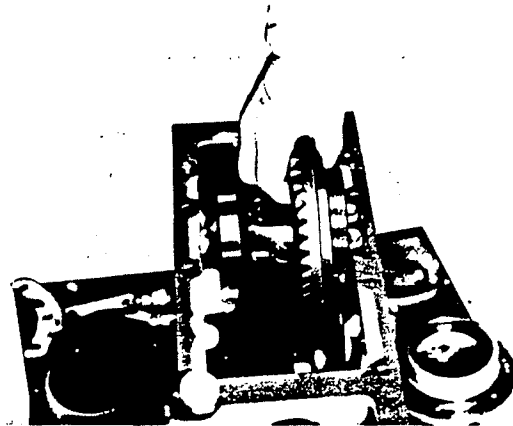
1. Remove the circlip on the rear end of the select shaft, and by tapping the front end of the select shaft, pull it out so that the gear is removed.

Remove the select shaft circlip, and remove the ball bearing.

### Removing the Differential Gear

1. Straighten the stopper washer on the bolt securing the each bearing holder, and loosen the bolt.

Insert a screwdriver into the cut on the bearing holder and pry out the bearing holder or install the bolt to the bearing holder tap, and by tightening it, remove the bearing holder.



#### Note:

When removing the differential gear which is in good condition, be sure to remember its thickness and quantity exactly. Otherwise, you will be confused when reinstalling.

2. Remove the differential gear from the transmission case.

### Disassembling the Counter Shaft

1. Straighten the lock washer, and loosen the sleeve nut, then remove the taper roller bearing.
2. Remove the circlip from the front end of the counter shaft, and remove the gear collar and needle bearing, and thrust washer by gently pulling out the counter shaft.
3. Remove the taper roller bearing from the counter shaft.

### Disassembling the Reverse Shaft

1. Remove the reverse shaft seal cap on the front end of the transmission case.
2. Pull out the reverse shaft lock's spring pin, and pull out the reverse shaft to the front by shifting the circlip, and remove the reverse gear, needle bearing and circlip.

### Disassembly of the P.T.O. Shaft

1. Loosen the bolt for tightening the P.T.O. shaft plate at the rear side of the transmission case, and pull out the P.T.O. shaft backwards.

2. Remove the plate from the P.T.O. shaft, and remove the sleeve.
3. Remove the circlip and then remove the ball bearing from the P.T.O. shaft.
4. Remove the collar from the P.T.O. shaft joint, move the P.T.O. shaft forward, and remove the ball bearing at the front of the P.T.O. shaft by means of a gear puller.
5. Remove the P.T.O. shaft by lifting the rear side of the shaft upward, remove the gear and the circlip.

Note: Although the 4-wheel tractor is equipped with an idler gear, the disassembly of the P.T.O. shaft is the same as for a 2-wheel tractor. Remove the idler gear together with the needle bearing after removing the circlip.

#### Disassembly of the Differential Gears

1. Put reference marks on the differential gear case and differential gears.
2. Remove the ring gear by loosening the bolts after straightening the bent portion of a stopper washer.
3. Remove the pinion gear, side gear and thrust liner.

#### Disassembly of the Final Drive Case

##### Disassembly of the pinion shaft

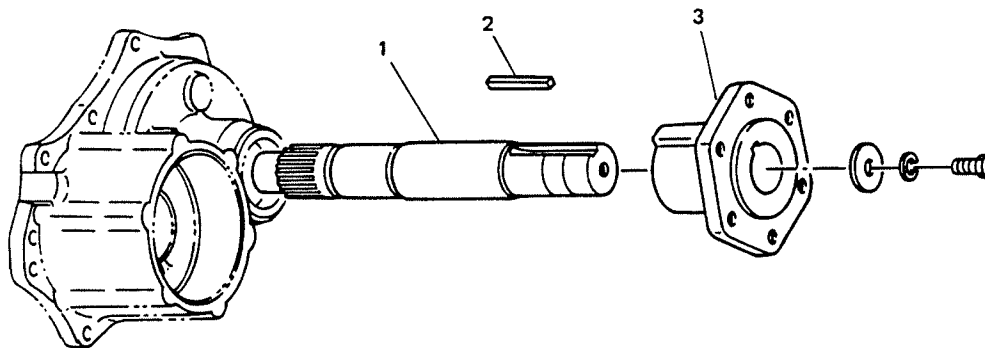
After removing the brake cover and brake drum:

1. Remove the circlip, then remove the pinion shaft while lightly tapping it and remove the oil seal bush together with the ball bearing.
2. The right hand side drive case is equipped with a differential lock shifter. Remove the shifter after loosening the nuts.

#### Disassembly of the Rear Wheel Shaft

1. Remove the ball bearing and the collar final reduction gear.
2. Remove the 2 circlips, and remove the rear wheel shaft from the final gear case while lightly tapping it.

Note: Some early S-370 model tractors are equipped with separate wheel axles and wheel bosses, but the disassembly of such components is the same as above.



1. Final shaft
2. Key
3. Wheel boss

Wheel boss and axle

## ASSEMBLING THE TRANSMISSION CASE

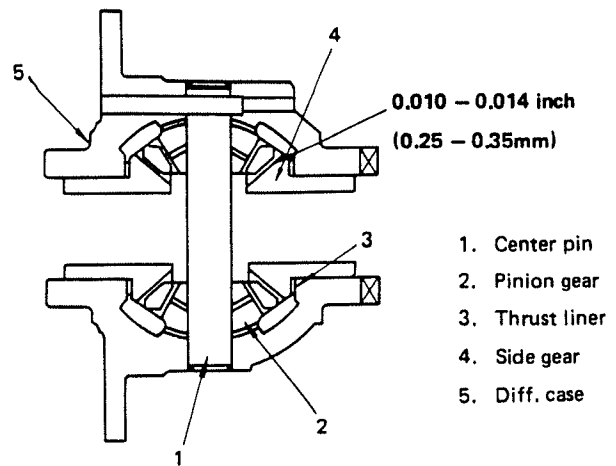
1. The transmission case is the most important part of the tractor. So, take special care when assembling it. Wash all the components before reassembling. Avoid careless mistakes. When assembling, never omit parts and adjust properly. Adjust and assemble in accordance with the specified standards.
2. Prior to assembling rotating parts, sliding parts connecting parts, "O" rings, oil seals, etc., apply lubricant or grease to them.
3. Wash each component, check it for faults and replace if faulty.
4. Pay particular attention to "O" rings, oil seals, tab washers, etc. Gaskets should be replaced with new ones.
5. Be sure to wind seal tape on through screws and bolts.

### The Transmission Case is Assembled in the Following Order:

1. Assemble the differential gears.
2. Measure the cone center of the countershaft.
3. Assemble the P.T.O. shaft.
4. Assemble the countershaft.
5. Assemble the reverse gear.
6. Assemble the select shaft.
7. Assemble the drive shaft.
8. Install the differential gear ass'y.
9. Assemble the final gear case.
10. Install the final drive case.

### Assembly of the Differential Gear

1. Install in the differential gear case the side gear on which an oil-coated thrust liner is mounted, assemble the pinion gear and the thrust liner and set them with a center pin.
2. Adjust the backlash of pinion gear and side gear to be 0.010 – 0.014 inch (0.25 – 0.35mm) by means of a thrust liner.



#### Backlash measurement

Pinion gear and side gear backlash

0.010 – 0.014 inch (0.25 – 0.35mm)

Thickness of the adjusting shim

1135-1408-001 0.047 inch (1.2mm)

1135-1409-001 0.055 inch (1.4mm)

1135-1411-001 0.063 inch (1.6mm)

3. After adjusting the backlash properly, lock the center pin by driving a lock pin into it, install the pinion shaft and make sure that it rotates smoothly.
4. Install the ring gear together with a stopper washer in the differential gear case with their reference marks aligned, and tighten them with bolts.

Tightening torque: 21.7 – 25.3 ft-lb  
(3.0 – 3.5 kg-m)

#### Note:

The protruding portion of stopper washer A should be placed so that it covers the pin locking the center pin to prevent it from pulling out.

5. Install the ball bearing in the differential gear case.

### Measuring the Cone Center of the Countershaft

1. Set a circlip in the center hole of the transmission case where the countershaft is placed, install circlip paying attention to the direction of the outer race of the taper roller bearing.
2. Install the taper roller bearing on the countershaft, paying attention to its direction.
3. Install the countershaft in the transmission case.

Then install a taper roller bearing at its front

## 5-9 TRANSMISSION SYSTEM

side and tighten it with a sleeve nut so as not to leave any end play. Then measure the cone center with a special tool.

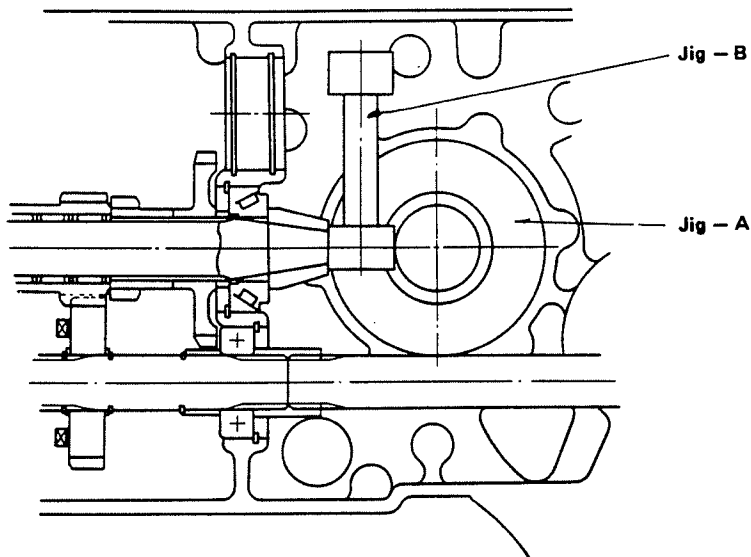
Cone center of the countershaft

3.031±0.002 inch (77±0.05mm)

### How to use the Special Tool

Set jig A for measuring the countershaft at the portion of the transmission case where the differential

gear case and bearing holder are installed, and insert jig B for measuring the countershaft between the top end of the countershaft pinion gear and jig A. Select shims which permit inserting the smaller diameter portion of jig B and which don't permit inserting the larger portion, place these shims between the outer race of the taper roller bearing and the circlip when assembling.



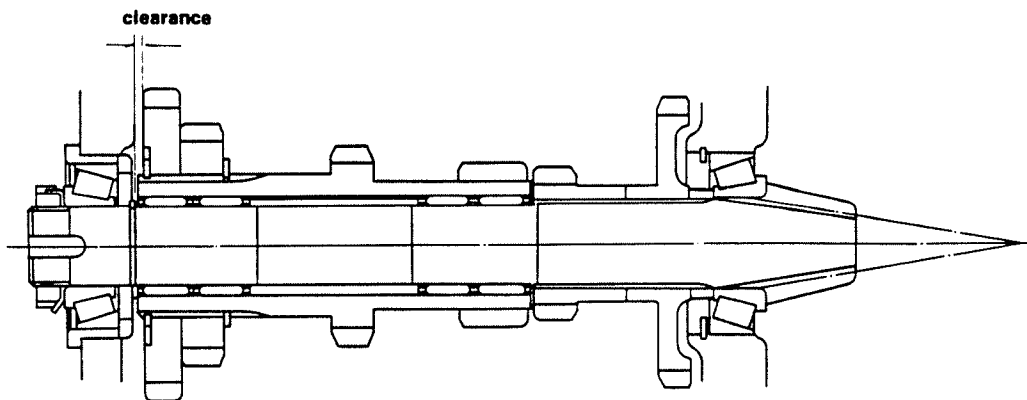
### Thickness of the shim

1135-1315-011: 0.004 inch (0.1mm)

1135-1316-011: 0.008 inch (0.2mm)

1135-1317-011: 0.020 inch (0.5mm)

### Counter Shaft Gear Clearance



Install on the counter shaft on which the taper roller bearing is installed, the collar, gear 34T, gear 17T, liner gear 18-23T, gear 29T, gear 47T, and needle bearing collar liner.

With a circlip inserted, select the shim properly enough to provide a clearance of 0.004 – 0.016 inch (0.1 – 0.4mm) between the circlip and the line;

the shim thus selected should be inserted between the collar and the gear 34T when the counter shaft is installed on the transmission case.

Gear clearance: 0.004 – 0.016 inch (0.1 – 0.4mm)

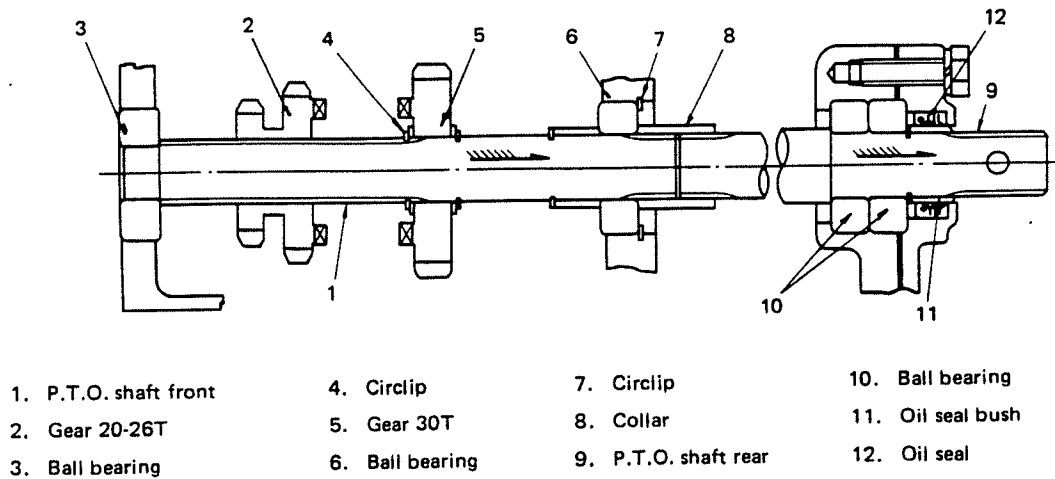
Thickness of shim:

1135-1314-011: 0.008 inch (0.2mm)

1135-1318-000: 0.016 inch 0.4mm

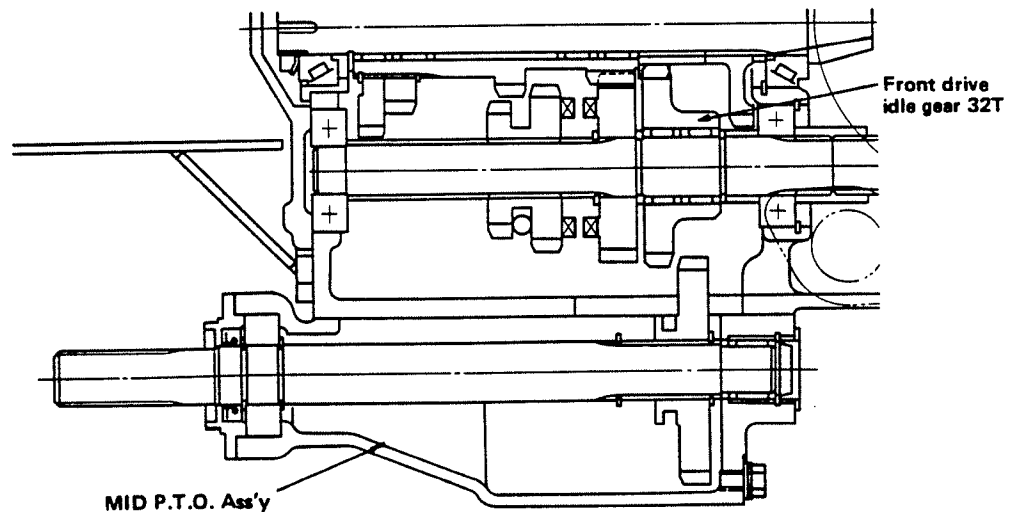


## Assembly of the P.T.O. Shaft



P.T.O. shaft diagram

1. Install the P.T.O. shifter in the transmission case without the "O" ring. Install the grease coated "O" ring on the shifter from outside of the transmission case, and tentatively install the guide plate for the P.T.O. shift.
  2. Install a circlip in the hole of the transmission case where the P.T.O. shaft is placed.
  3. Install a circlip at the rear of the P.T.O. shaft and insert the collar and ball bearing.
  4. Install a circlip, thrust liner, gear 30T, and liner and set them with the circlip, making sure the gear 30T is installed with its clutch facing forward.
  5. Install the gear 20-26T on the P.T.O. shaft. Install them on the transmission in the reverse order of disassembly. Install the P.T.O. shaft on the transmission case by hammering the front side of the shaft.
  6. Install the front side ball bearing.
- Note:** \_\_\_\_\_  
 The disassembling and assembling procedures of a 4-wheel drive model is just the same as that for a 2-wheel drive model although at the rear of the gear 30T, the idle gear 32T, needle bearing thrust liner, which are for the 4-wheel driving, are assembled.



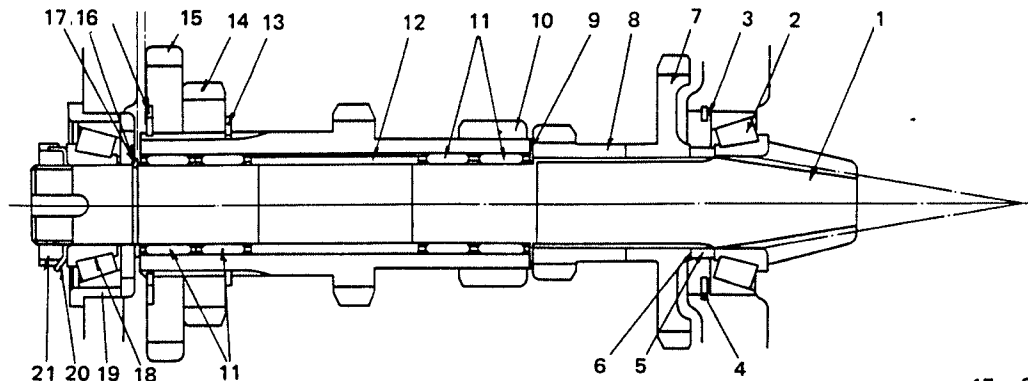
## 5-11 TRANSMISSION SYSTEM

7. Install the two ball bearings on the rear P.T.O. shaft and set them with a circlip. Install the oil seal collar on the P.T.O. shaft with the chamfered side of the collar facing rearward.
8. Install the joint collar on the P.T.O. shaft inside the transmission. Mount the P.T.O.

shaft on the transmission case from the rear side. Install the grease-coated oil seal on the plate and install them together with a gasket on the rear of the transmission case.

Tightening torque: 36.1 – 43.3 ft-lb.  
(5.0 – 6.0 kg-m)

### Assembling the Counter Shaft



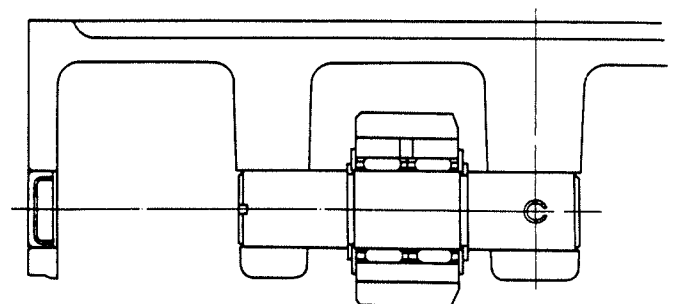
1. Counter shaft	5. Collar	9. Liner	13. Circlip	17. Circlip
2. Taper roller bearing	6. Shim	10. Gear 18-23T	14. Gear 29T	18. Taper roller bearing
3. Shim	7. Gear 34T	11. Needle bearing	15. Gear 47T	19. Holder
4. Circlip	8. Gear	12. Collar	16. Liner	20. Tab washer
				21. Sleeve nut

1. Insert the shim selected in measurement of the cone center between the circular clip and taper roller bearing of the transmission case.
2. Push the countershaft to which the taper roller bearing is installed into the transmission case from the rear side and measure the collar gear clearance. Install shims to provide a clearance of 0.004 – 0.016 inch (0.1 – 0.4mm) then install gear 34T, gear 17T, liner and gear 18-23T with gear 29T and 47T attached in the order listed. Insert a needle roller bearing collar and needle bearing in that order between gear 18-23T and the countershaft and set them with circlips. Attention should be paid to the direction of the gear installation.
3. Insert the taper roller bearing, install a tab washer and tighten them with a sleeve nut. Adjust the countershaft to eliminate end play by lightly tapping both ends and measuring the preload.  
Countershaft preload: 5.78 – 7.22 ft-lb.  
(0.8 – 1.0 kg-m)
4. Lock the sleeve nut with a tab washer after setting the proper preload 5.78 – 7.22 ft-lb (0.8 – 1.0 kg-m).

### Adjustment of the P.T.O. Gear

1. Put stopper spring, grease and the stopper ball on the P.T.O. shift lever, install the P.T.O. shift lever and set it with a spring pin.
2. Align the gear teeth of the countershaft gears 29T, 23T and the P.T.O. gear and fix the guide plate.  
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)
3. Install the knob on the P.T.O. lever and lock it with a lock nut.

### Assembly of the Reverse Shaft

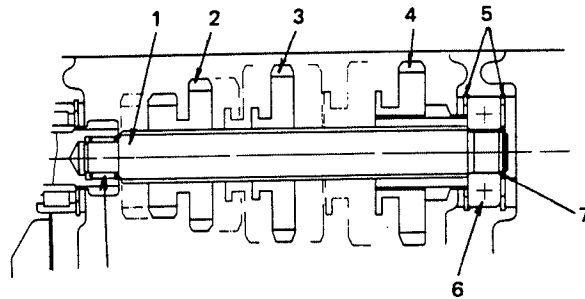


Reverse shaft diagram

1. Insert the reverse shaft through the reverse shaft setting hole at the front side of the transmission case and insert a circlip, thrust liner, reverse gear with needle bearing installed, thrust liner and a circlip in this order, set

- the reverse shaft while moving it slowly, align the spring pin hole and set with a spring pin.
2. Drive the seal cap into the hole in the front of the transmission case. The cap should not protrude from the surface of the transmission case.

### Assembly of the Select Shaft



1. Selector shaft
2. Gear 20-27T
3. Gear 32T
4. Gear 15-35T
5. Circlip
6. Ball bearing
7. Circlip
8. Needle bearing

### Selector shaft diagram

Install the speed shifter in the transmission case. Also install a grease coated "O" ring from outside of the case and then install and tentatively tighten the sub-shift guide plate.

1. Install the ball bearing on the select shaft and set it with a circlip.
2. Set the circlips of the transmission case.
3. Install the select shaft from the rear and set it with its side so that the shifting fork is placed

facing forward together with gears 15T-35T and 32T, install gears 20T-27T with it smaller gear facing forward and set them with circlips.

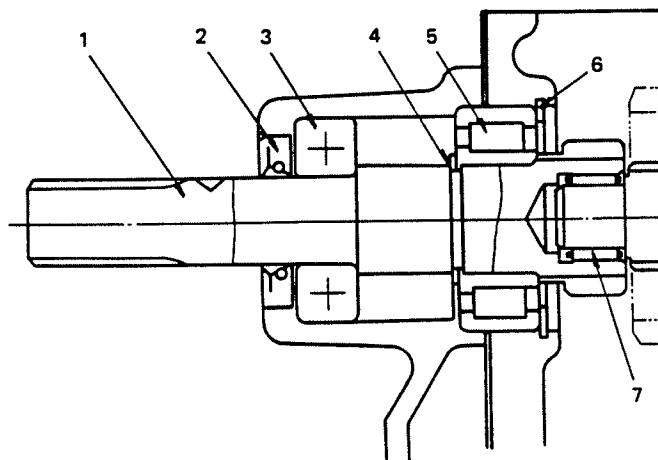
### Note:

Gears should be correctly installed with great care.

If installed backwards it may become hard to change gears or may cause trouble.

### Assembly of the Driveshaft

1. Install the roller bearing on the driveshaft and set it with a circlip. Install the roller bearing as shown in the following diagram.



1. Drive shaft
2. Oil seal
3. Ball bearing
4. Circlip
5. Roller bearing
6. Circlip
7. Needle bearing

## 5-13 TRANSMISSION SYSTEM

2. Install the ball bearing.
3. Install a grease coated oil seal on the bearing holder. Install the driveshaft in the bearing holder.

### Note:

1. If there was a shim between the oil seal and ball bearing when the driveshaft was disassembled. Assemble it as there was.
2. In case the end play of the driveshaft is excessive after all or part of the mechanical parts are replaced, adjust it using shims.
3. Check whether a circlip has been placed in the transmission case. Apply oil to the needle bearing, install it on the select shaft and assemble it in the bearing holder. Install the driveshaft combined with the bearing holder

at the front of the transmission case together with a gasket coated with adhesive.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

4. Make sure that the shaft rotates smoothly.
5. Place the stopper spring, grease and stopper ball on sub-shift lever, install it on the shifter shaft and set it with a spring pin.
6. Align the teeth of gears 17T and 34T of the counter-shaft at their correct positions and fix the guide plate.  
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)
7. Install the knob on the sub-shift lever and lock it with a locknut.

### Assembly of the Differential Gear Unit

1. Install the differential gear with the ball bearing installed placing longer bearing holder on the right and the shorter one on the left and machine the holder notch to that of the transmission case.
2. Temporarily tighten the bearing holders by bolts with the stopper washer.
3. Evenly place shims to provide the same thickness as the backlash adjusting shim for the circular area between the ball bearing holder on the left and the transmission and then tighten them.
4. Select shims to make a thickness so as to have a backlash of 0.010 – 0.014 inch (0.25 – 0.35mm) in the ring gear.

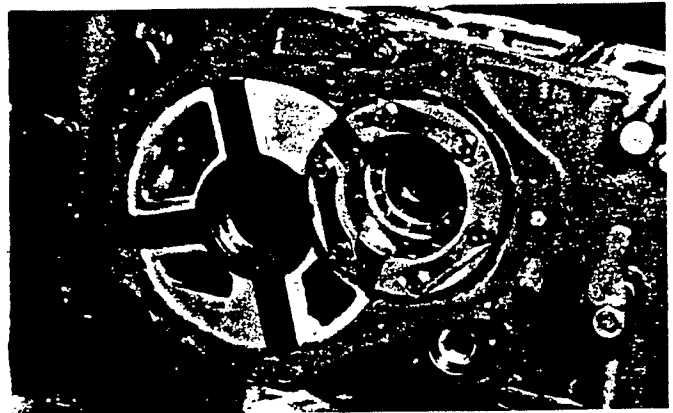
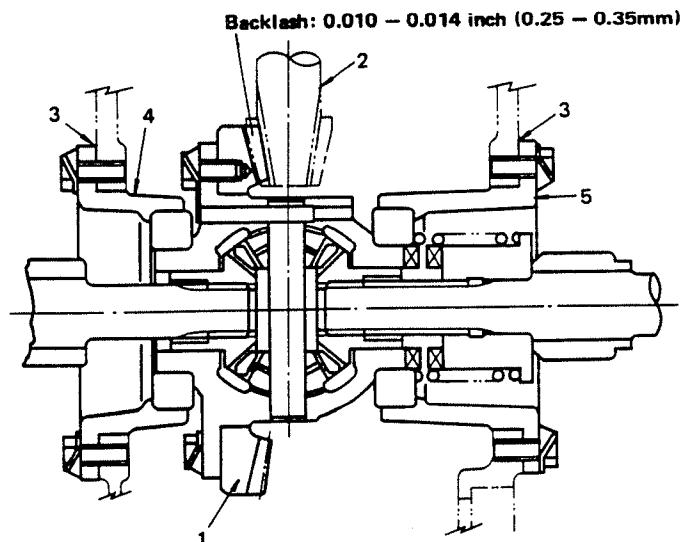


Diagram of the notch portion

Ring gear backlash: 0.010 – 0.014 inch  
(0.25 – 0.35mm)



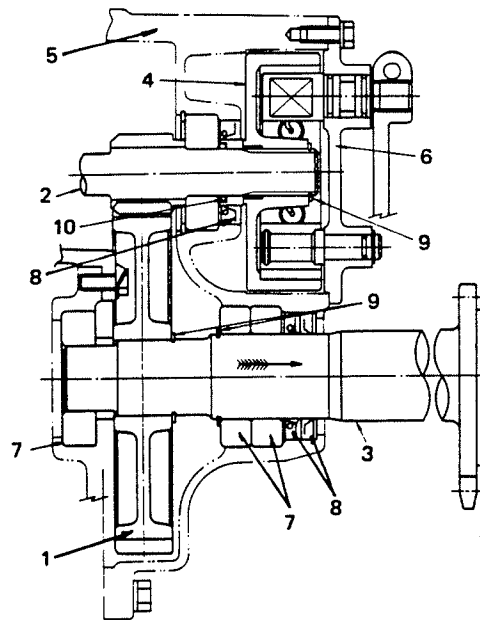
1. Ring gear
2. Countershaft
3. Shim
4. Bearing holder (L.H.)
5. Bearing holder (R.H.)

5. After a normal backlash of 0.01 – 0.014 inch (0.25 – 0.35mm) has been obtained, measure the clearance between the bearing holder on the right and the transmission case. Select shims suitable for the clearance, place them evenly around the circumference and tighten the holder with stopper washers. Confirm that

there is no end play by lightly tapping the differential gear case from both sides. Measure the backlash again to confirm that it is within the specified range, and finally tighten the bolts.

Tightening torque: 14.4 – 18.1 ft-lb  
(2.0 – 2.5 kg-m)

### Final reduction



- 1. Final gear
- 2. Diff. shaft
- 3. Final shaft
- 4. Brake drum
- 5. Final case
- 6. Brake cover
- 7. Ball bearing
- 8. Oil seal
- 9. Circlip
- 10. O ring

1. Push the ball bearing onto the pinion shaft. Apply grease to the "O" ring, install it on the oil seal collar and install the collar so that the "O" ring comes to the ball bearing side.
2. Install the pinion shaft in the final reduction case and set with a circlip.
3. Apply grease to the washers and oil seal and install on the pinion shaft. Install the brake drum, set it with a circlip and then install the brake cover.  
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 2.7 kg-m)
4. Apply grease to the washers and the two oil seals, and install them in the axle mounting portion.
5. Install the rear wheel shaft in the final drive case, push two ball bearings in and set them with circlips. Be sure to tap the inner ring when driving the ball bearing into position.
6. Place circlips to set the final drive gear, and install the reduction gear.
7. Put the collar into place and tighten the ball bearings.

8. Measure the height from the surface where the final drive case is installed on the transmission case to the surface of the ball bearing, and the distance from the said installation plane of the final drive case to the ball bearing housing.

Select shims so that the end play of the rear wheel becomes 0.005 – 0.015 inch (0.12 – 0.4mm) and place them in the ball bearing housing of the transmission case. In measuring dimensions, consider the thickness of the gasket.

9. Apply adhesive to both sides of the gasket. Install the differential lock sleeve, return spring on the pinion shaft at the right side. Install the drive case in the transmission case and tighten with bolts.

Tightening torque: 36.1-43.3 ft-lb  
(5.0-6.0 kg-m)

In the case of 4-wheel drive, a mid P.T.O. is mounted underneath the transmission case. Install the mid P.T.O.

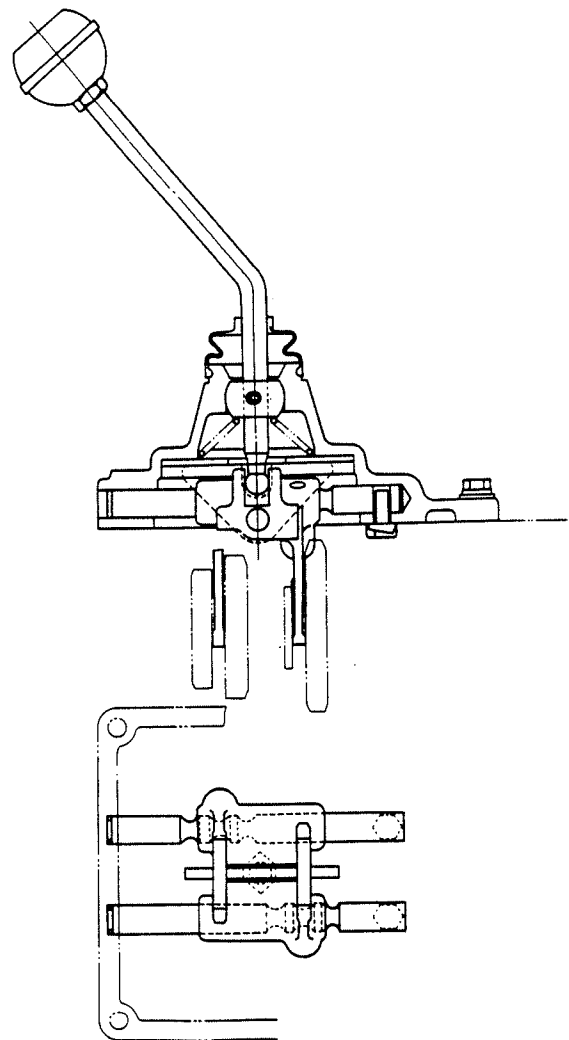
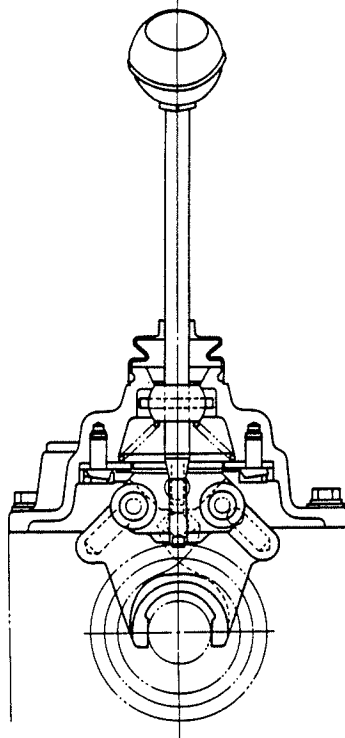
### Disassembly of the Speed Shifter

After removing the speed shifter from the transmission case:

1. Loosen the shift rod set bolt after raising the bent portion of the stopper washer.

2. Pull the shift rod out forward and remove the shift fork, steel ball and stopper spring.
3. Remove the bracket after loosening bracket tightening bolt, and remove the shift lever with its knob removed.

### Assembly of the Speed Shifter



1. Place the shift lever and spring in the speed shift cover, install the bracket together with the stopper washer, tighten them with bolts and lock with stopper washers.

Tightening torque: 14.4 – 18.1 ft-lb  
(2.0 – 2.5 kg-m)

2. Place the stopper spring and steel balls in the two shift forks and set with the jig.
3. The shift rod with the longest "O" ring groove and steel ball groove is for the first speed and reverse; the shorter one is for the second and third speeds. Apply grease to the shift rod for the first speed and reverse and

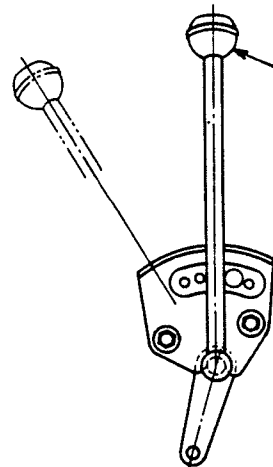
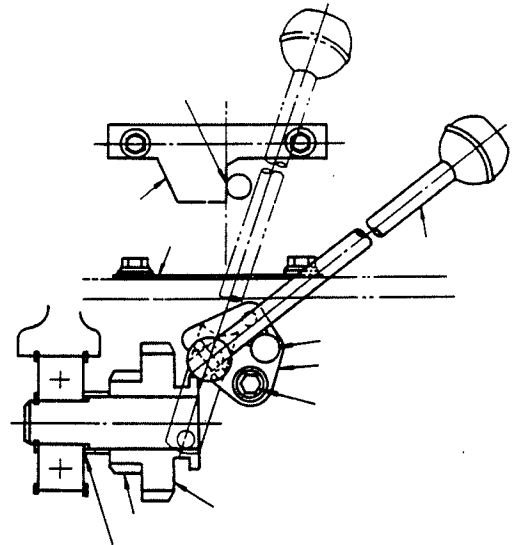
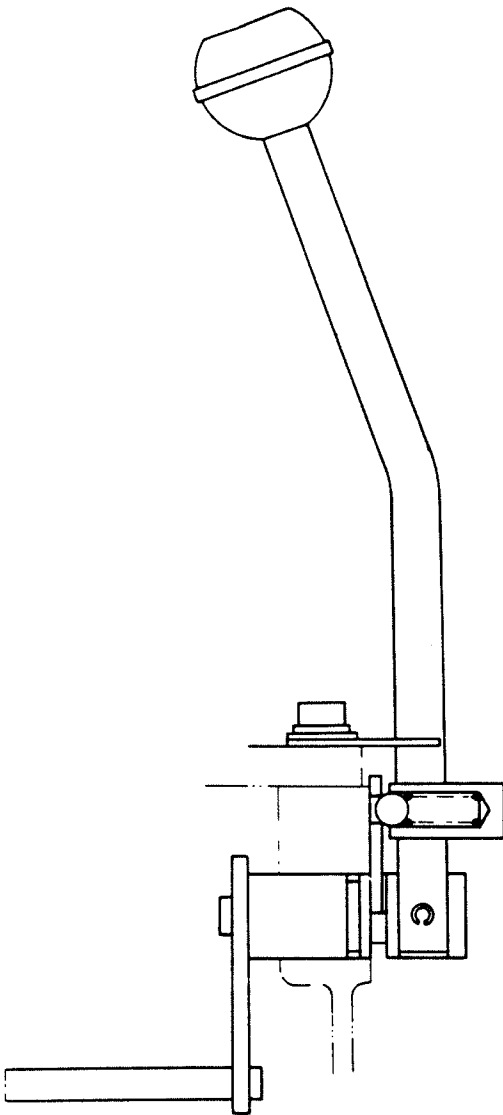
install it with the "O" ring attached so that its shift fork faces the rear; then install the rod for the second and third speeds with a similar "O" ring attached so that its shift fork faces forward. Next, tighten them with stopper bolts which are aligned with the corresponding holes, together with stopper washers.

**Note:** Transmission oil is easily filled before the cover is installed.

4. Apply adhesive to the surface of the transmission case where the cover is to be installed before installing the cover.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

5. The two bolts at the rear right hand side should be tightened at the position where the stopper plate is placed against the auxiliary speed shift lever to prevent it from being overshifted when shifting to a high speed.



Correctly install the hydraulic pressure case, step, brake pedal, fender, tool box and seat, clutch housing and the universal joint of the 4-wheel drive in the reverse order of the disassembly.

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## GENERAL

The brake system for the Satoh Beaver Model S-370 & S-370D tractor is of a mechanical internal expansion type.

When the foot pedal is depressed, a cam rotates, the brake lining is pressed against the inside of the brake drum, thus applied the brakes. Brakes are installed in the final drive cases of right and left.

Two brake pedals are provided to brake right and left wheels independently, which is an essential requirement for an agricultural tractor, so that one wheel can be locked completely and the tractor can make a sharp turn in a confined space or in the corner of field. Both right and left wheels can be braked at the same time by joining the right

and left brake pedals using the connecting plate.

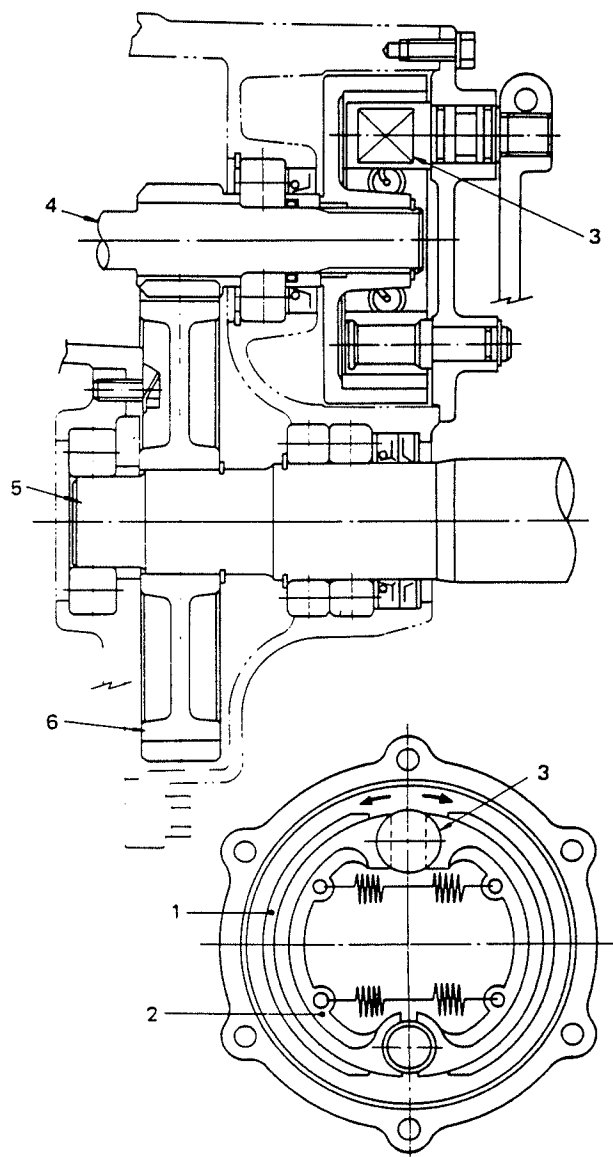
The parking brake is applied by connecting right and left main brake pedals, depressing and locking the main brakes.

The brake drum is installed on the pinion shaft, which rotates at a high speed, to ensure high braking efficiency.

High braking efficiency both in forward and reverse is also provided by the internal expansion type structure where lining is applied to the brake shoe which is pressed against the inside of the brake drum by means of a cam.

The brake system is completely enclosed, which eliminates trouble due to water or dust, even in paddy fields or very dusty places.

## CONSTRUCTION



The brake drum is installed at the end of the pinion shaft mounted on the differential side gear. In the middle of the shaft, a gear is provided to operate the final shaft.

The brake drum is covered with a brake cover attached to the final drive case and completely enclosed in a brake cover in which the brake shoe is incorporated.

Anchor pin, cam shaft and brake shoe with a lining are fitted to the brake cover. Brake cam shaft arm is installed in the outside of the brake cover to rotate the cam. The brake pedal is fitted to the cross shaft mounted on the lower part of the transmission case. Brake cam shaft arm and brake pedal are connected by an adjust rod and the cam is rotated by depressing the pedal via the brake cam shaft arm and pressing the lining against the brake drum, thus applying the brakes thereto.

When the plate of the brake pedals are disconnected, right and left wheels can be braked independently, which can be used selectively depending on the work and field conditions.

Parking brake is applied by connecting right and left brake pedals with a connecting plate and lock the brake pedal with the parking brake lever on the transmission case side.

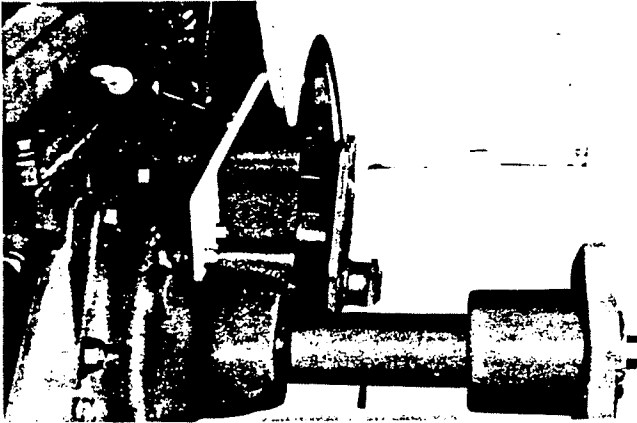
- |   |              |    |                    |
|---|--------------|----|--------------------|
| 1 | Brake shoe   | 4  | Diff. pinion shaft |
| 2 | Brake lining | 5. | Final shaft        |
| 3 | Brake cam    | 6  | Final gear         |

## DISASSEMBLING THE BRAKE

Disassembling of the brake cover and brake drum.

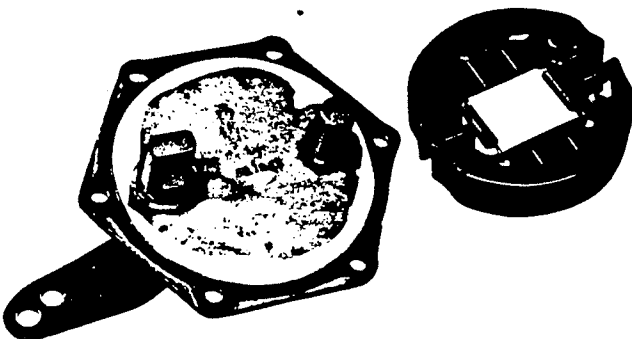
The brake cover can be removed without removing the rear fender and rear tires.

Remove the brake rod from the brake cam arm, loosen the six M8x20 bolts securing the brake cover, and remove the brake cover.



Remove the circlip attached to the differential shaft, and remove the brake drum.

Remove the brake shoe from the brake cover, as required.



## NOTE:

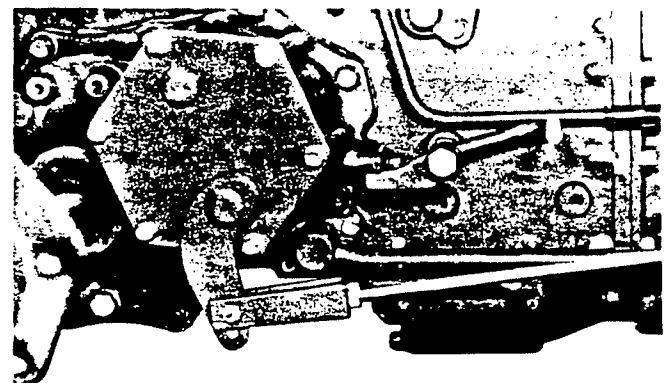
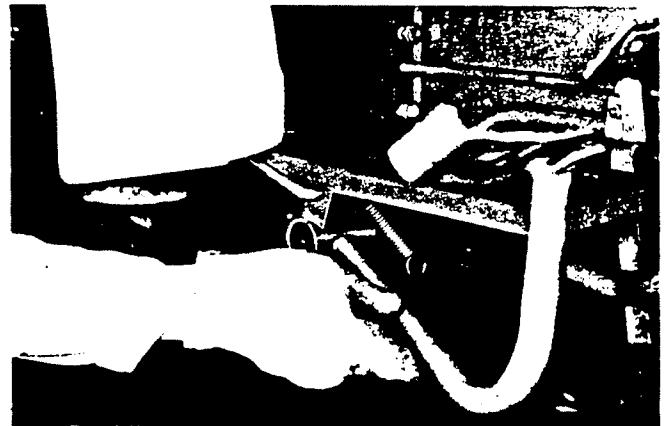
To replace the differential shaft oil seals and ball bearings, first remove the final reduction case from the transmission case. For the procedure, refer to "Disassembling the final reduction case."

Remove the cam arm circlip, and remove the cam arm.



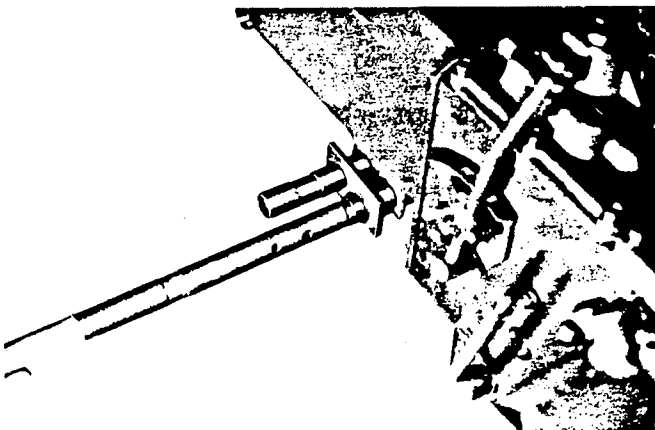
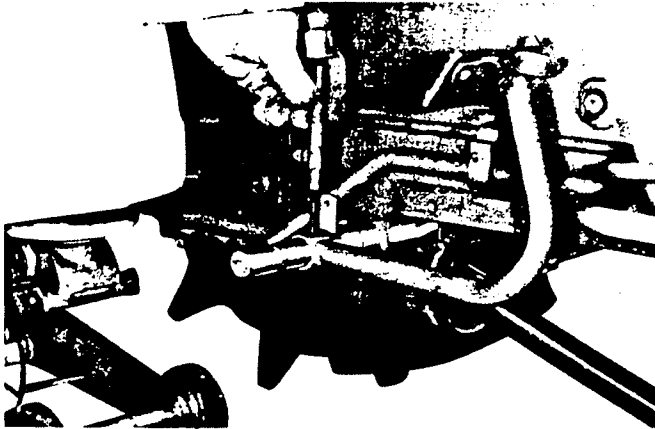
## Disassembling the Brake Pedal

To remove the right side brake pedal, remove the brake rod without removing the step, and remove the return spring. Remove the shaft circlip, and remove the brake pedal.



Loosen the four M10 bolts securing the right side step and the bolts tightening the fender and the step and the remove the step.

Remove the two spring pins, and remove the left side brake pedal.



Remove the left side brake rod, and remove the brake shaft.

### INSPECTION

1. Check the brake cam shaft O-ring, and if scratched, replace.
2. If the brake shoe is excessively worn, replace.
3. Check for oil or grease on the brake shoe.
4. Check the oil seal for oil leakage.
5. Check the brake cam shaft for excessive wear.
6. Check the brake shoe spring for fatigue.
7. Check the brake shaft and brake pedal for rust or streaks.

### ASSEMBLY

#### Brake Drum and Brake Cover

1. Install the greased O-ring to the cam arm, and apply grease to the grease groove. Install the cam arm to the brake cover, and set with the circlip.
2. Hook the spring to the brake lining, and install it to the brake cover.
3. Install the brake drum to the differential shaft, and set with the circlip.
4. Install the gasket to the brake cover, and install it to the final reduction case.

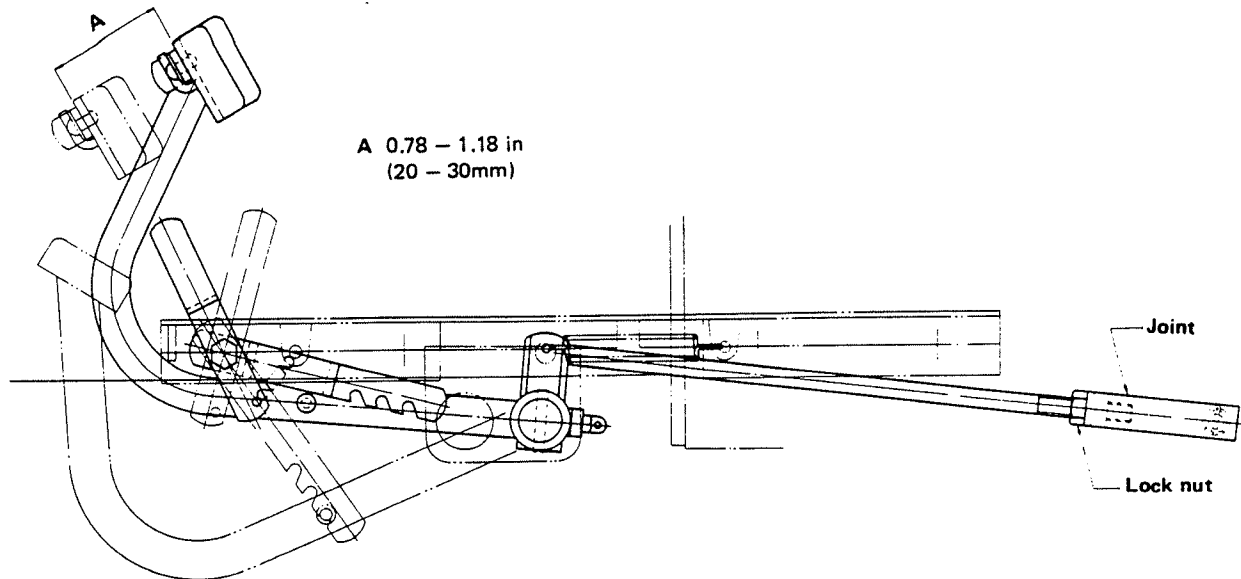
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

#### Brake Pedal

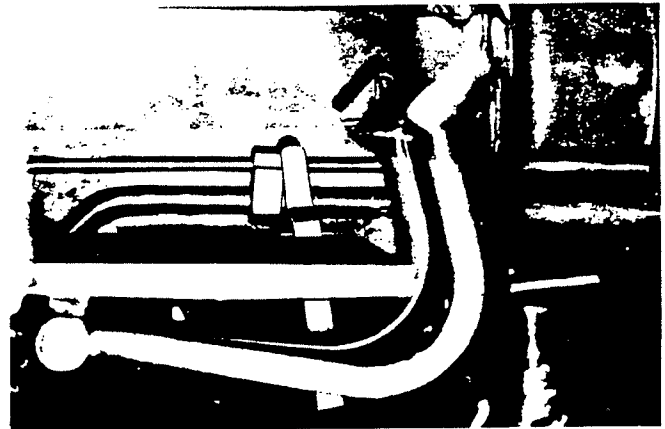
1. Install the circlip to the brake shaft.
2. Grease the brake shaft mounting boss under the clutch housing, and insert the brake shaft into the boss.
3. Push in the left-side brake pedal, and install the spring pin.
4. Push in the right side brake pedal, and install the circlip.
5. Install both right-and left-side brake rods, and set with cotter pins.
6. Install the step, and install the return spring.

Tightening torque: 28.9 – 36.1 ft-lb  
(4.0 – 5.0 kg-m)

## ADJUSTMENT



1. Remove the joint from the brake cam arm, loosen the lock nut, and adjust so that the brake pedal free-play becomes to be 0.78 - 1.18 inches (20 - 30mm).
2. Make sure that both right and left wheels are braked evenly.
3. Make sure that the parking brake operates correctly.



## INSPECTION, MAINTENANCE AND LIMIT OF MODIFICATION

	Inspection	Maintenance	Limit of Modification
1	Wear in brake lining	If wear is within 0.247 in. (3.75mm), use it again.	If it exceeds 0.147 in. (3.75 mm), replace.
2	Uneven brake lining contact	Correct the trouble and grind the surface.	If it is 0.049 in. (1.25 mm) in width after grinded, replace.
3	Oil on brake lining	If a little oil is attached, correct with a sandpaper.	If a lot of oil is attached, replace each lining.
4	Brake drum	If it is flawed, grind it.	If the drum inner diameter exceeds 4.508 in. (114.5 mm), replace.
5	Return spring		If it is loose, replace.
6	Brake pedal play	Use adjusting rod.	0.78 - 1.18 (20 - 30 mm)
7	Parking brake	Supply oil to ensure that lock plate operates properly.	
8	Oil leakage in brake	Find the fault, and replace or tighten the screws.	If oil seal is faulty, replace it.
9	Foreign matter in drum	Checking "O" ring and Packing	If "O" ring and Packing are faulty, replace them.

## TROUBLESHOOTING

## 6-1 Brakes Insufficient

Trouble	Remedy
Small pedal travel	Adjust with the adjusting rod.
Worn lining	Adjust with the adjusting rod or replace.
Uneven lining contact	Grind with sandpaper.
Burnt lining	Replace.
Oil attached due to oil leak	Replace.

## 6-2 Brakes Remain ON

Trouble	Remedy
Little pedal play	Adjust with the adjusting rod
Loose brake spring	Replace.
Loose return spring	Replace.
Cross shaft and holder sticking	Disassemble, correct and supply oil.

## 6-3 Strange Sound Heard

Trouble	Remedy
Foreign matter in drum	Clear away.
Damaged lining	Replace it.
Loose brake housing securing bolt	Retighten.
Damaged return spring	Replace.

## SPECIFICATIONS

Type	Mechanical internal expanding dry sealed brake.
Brake pedal	Foot pedal separate
Parking brake	Hand pedal lock type
Parking	Main brake used
Lining material	Special woven
Lining demensions (length x width x thickness)	4.685 x 1.181 x 0.177 inch (30 x 4 x 4.5mm)
Number of linings	4
Drum diameter	4.488 inch (114mm)
Brake position	Diff pinion shaft
Brake pedal free play	0.78 — 1.18 inch (20 — 30mm)

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## HYDRAULIC SYSTEM

### GENERAL

The Satoh Beaver (Model S-370 & S-370D) hydraulic system is of so simple construction that it can be easily and accurately controlled by operating a single control lever. That is, a single action hydraulic system is employed.

The oil pump is a pressure balance type gear pump and mounted on the timing gear case in the engine. The oil pump is driven by the oil pump drive gear and therefore, while the engine runs, the hydraulic can be used, that is, it is a "live hydraulic" system. The transmission case oil is used as the hydraulic oil after cleaned by the high-performance oil

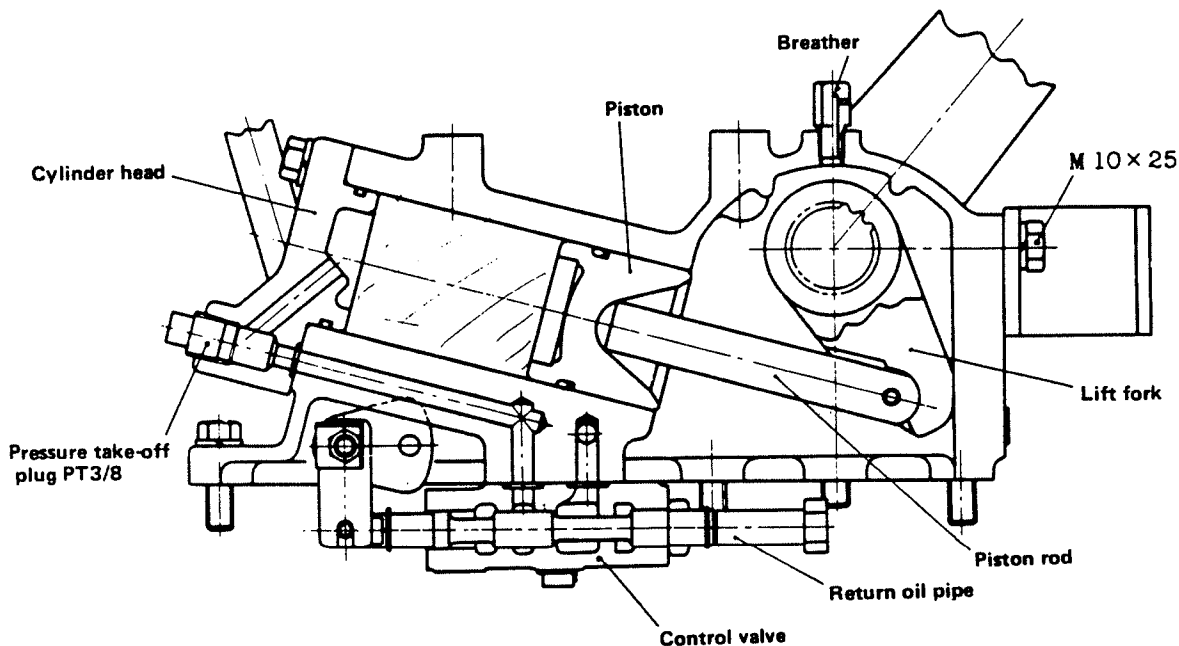
filter. Since the quantity of oil is great, the external service of the hydraulic system can be easily made.

The hydraulic control valve is a precision three-way type and installed in the hydraulic case. To control the lowering speed of the implement, the speed control lever is attached to the right side of the hydraulic case.

The control lever has a special link mechanism so that when the implement is lifted up to a certain height, the spool valve in the control valve unit returns to neutral automatically and the pump is placed under no load.

The hydraulic case can be removed without draining off the hydraulic oil (transmission case oil)

### CONSTRUCTION



The hydraulic oil in the transmission oil is sucked out by the pressure balance type gear pump installed in the engine timing gear case through the oil filter element installed to the end of the suction pipe and is carried to the control valve in the hydraulic case. The oil is further carried through the spool valve, which is opened by operating the

control valve, to the necessary part.

When the control lever is placed in "Lift," the oil flows from the pump to the cylinder, and the piston is pushed downward by the hydraulic pressure. When the piston is pushed downward, the ram arm is pushed by the rod, and thus the end of the ram shaft turn depicting an arc. This causes the



## 7-2 HYDRAULIC SYSTEM

lift arm to move up and down, and thereby the implement is also moved up and down.

When the lift arm rises to a certain height, the rod connected to the control lever by the auto-return arm, which is installed to the ram shaft, is returned to "Neutral." This causes the control valve spool to return to Neutral, and as a result, the pump is placed at non-load operation.

When the control valve is moved forward to "Lower," the spool valve causes the cylinder and tank port to open, and thus the oil in the cylinder

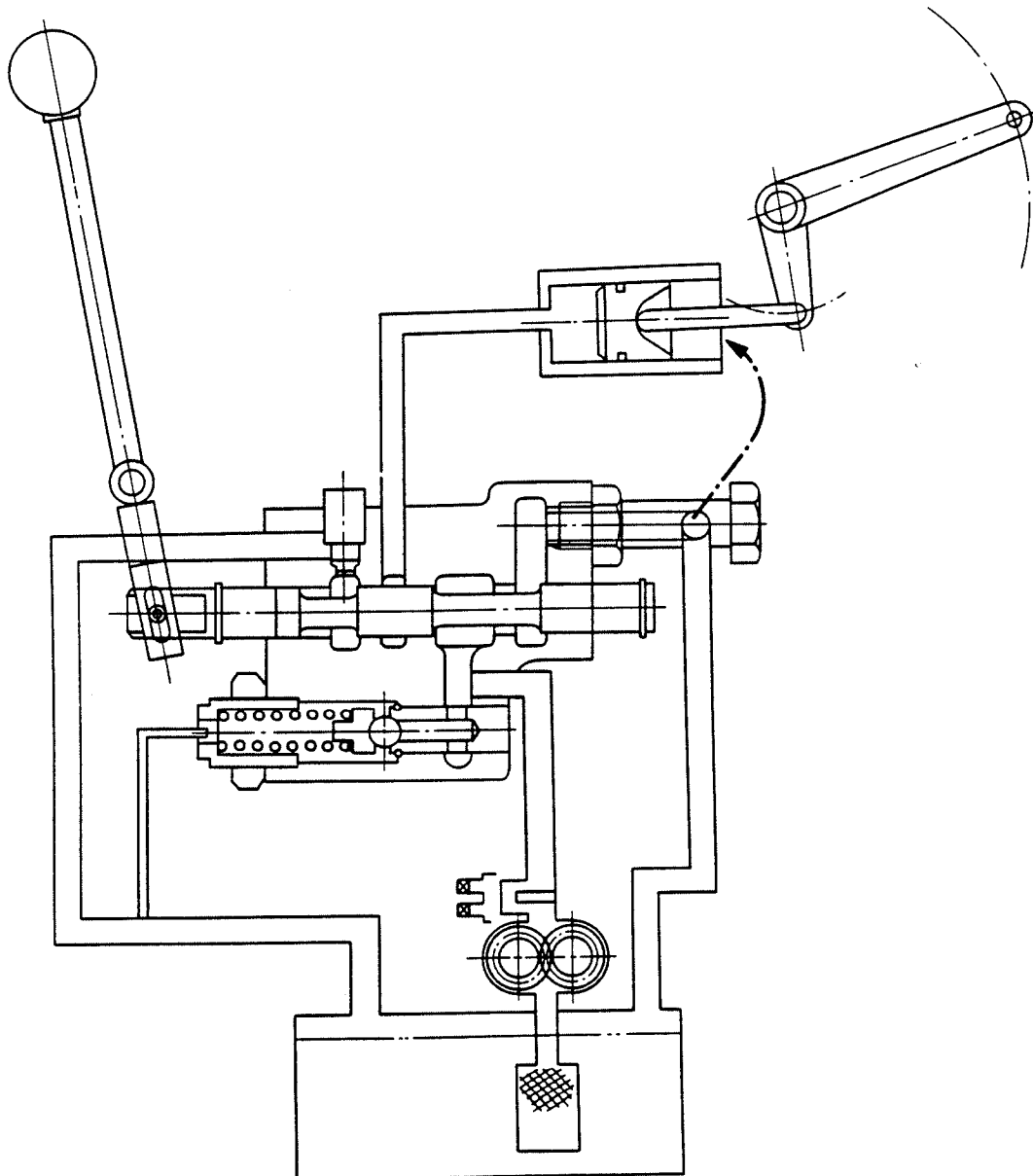
is forced back to the tank by the implement moving downward on its own weight.

There is a flow control valve between the cylinder and tank, and by operating the lever, the oil returning to the tank can be regulated, and thus the lowering speed of the implement can be controlled.

The pressure take-off can be controlled by the control valve attached to the hydraulic case or by the control valve attached to the implement.

### OPERATION

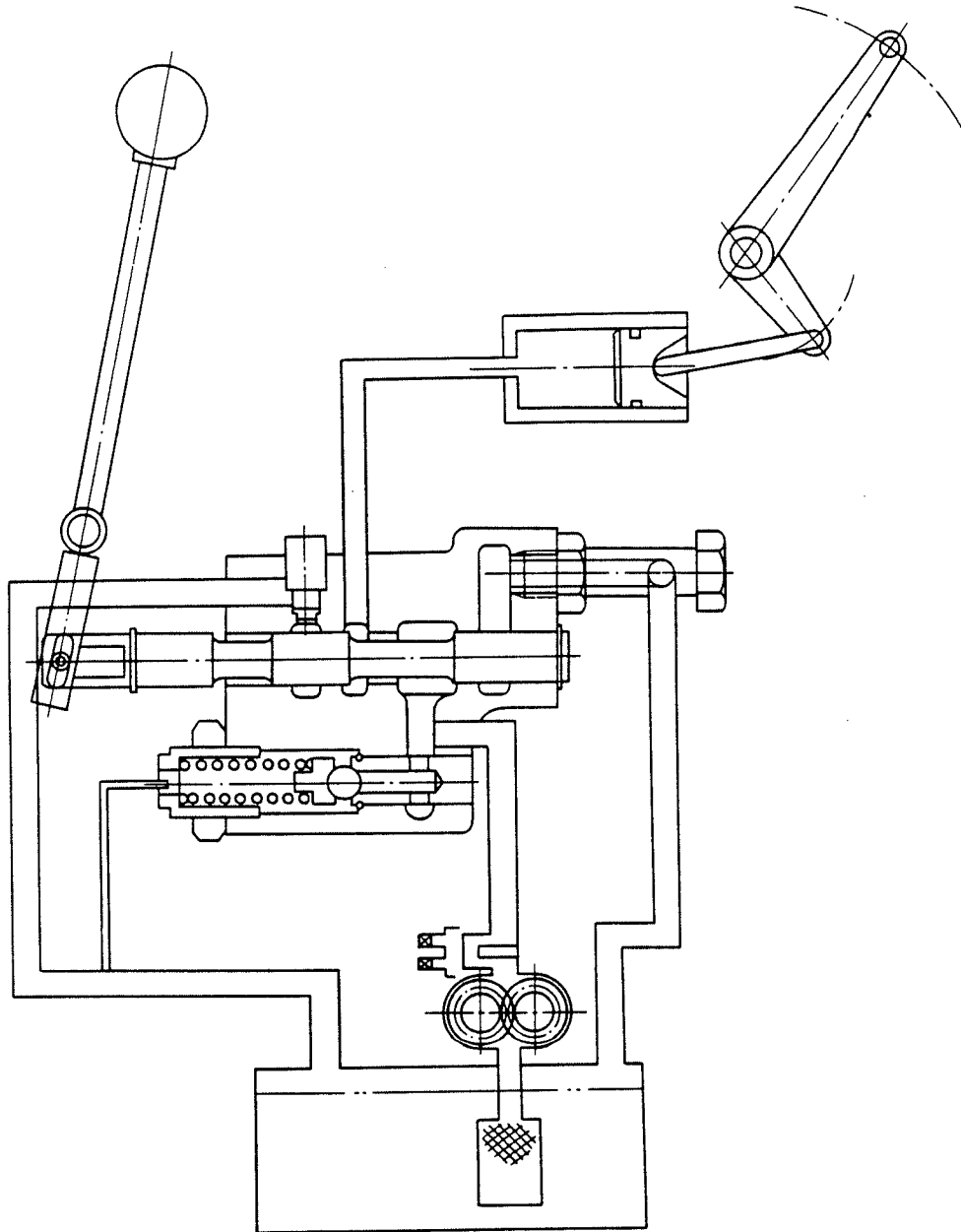
#### Neutral Position



The oil discharged from the pump flows from the port (A) to the control valve, and returns to the tank through the port (C). Part of the returning oil is used to lubricate the connecting rod and ram shaft.

The oil in the ram cylinder can not flow because the port (B) is closed by the spool valve, and thus the implement is kept in its position. The oil flows through the control valve and returns direct to the tank, and the pump is placed under no load.

### Lift Position



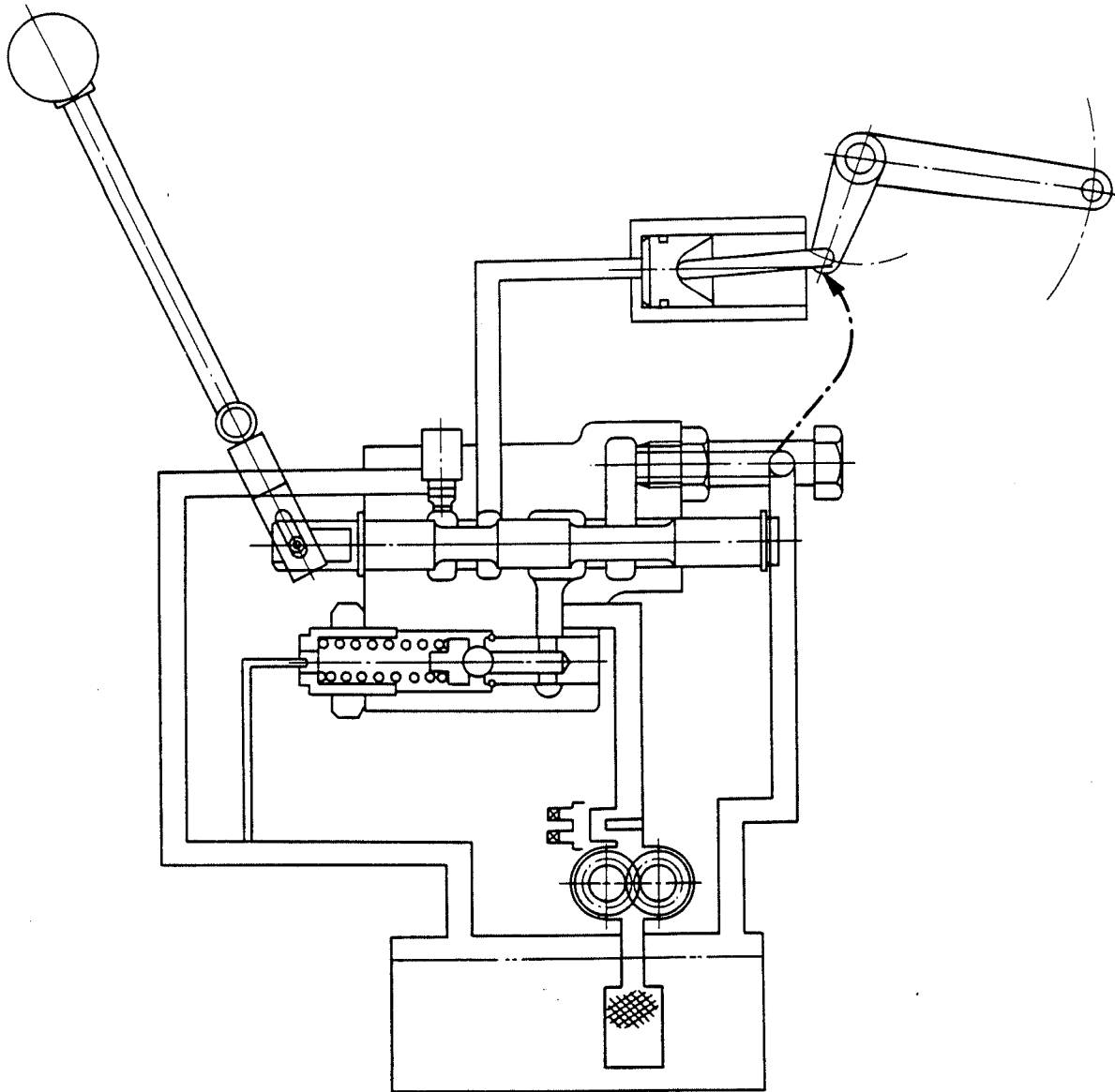
When the control lever is set to "Lift," the spool valve moves forward, and the oil from the pump flows from the port (A) to the control valve. The oil further flows through the port (B) to the cylinder.

The oil flowing into the cylinder pushes the piston downward. This causes the implement to move upward, and when it reaches a certain height, the spool valve is automatically returned to Neutral

by the rod connected to the auto-return arm installed to the ram shaft. As a result, the implement also stops, and the pump is placed under no-load.

If the spool valve does not move to Neutral or the implement is too heavy even when the cylinder is filled with oil, the oil flows through the port (D) and pump safety valve to the tank so that the pump and pipes can be protected against accidents resulting from over-load.

### Down Position

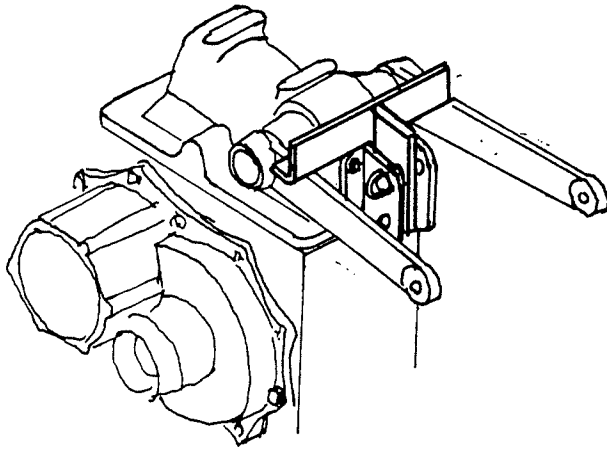
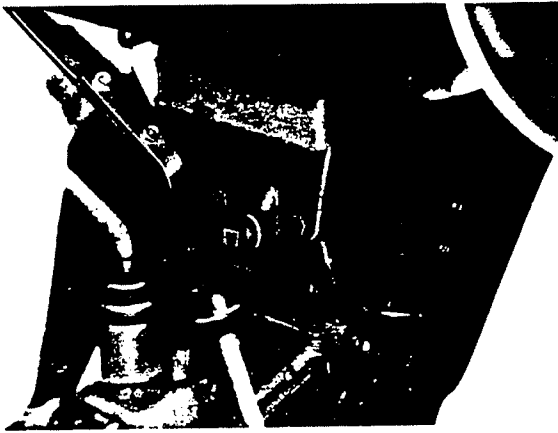


When the control lever is moved forward to "Down," the spool valve moves backward, thus opening the oil passage from the port (B) to the port (E). As a result, the oil in the cylinder is forced back to the tank through the flow control valve by the implement moving downward on its

own weight. That is, the oil discharged from the pump flows from the port (A) to the port (C) as in the case of the control lever being placed in Neutral. The lower speed of the implement can be controlled by operating the flow control valve.

## HYDRAULIC EXTERNAL SERVICE

### When the Tractor's Control Valve is Used:



The control valve attached to the tractor is a single action type, and therefore, the implement mounted on the tractor must also be a single action type. Lock the lift arm to the top link bracket with a T-shaped tie bar.

Connect the hydraulic external service plug to the cylinder to the cylinder plug of the implement mounted on the tractor.

Start the engine, and place the implement in the Lift position. By operating the safety valve, bleed the air completely from the cylinder and pipes. When the hydraulic control lever is placed in "Lift," the implement moves upward, when placed in "Down," the implement moves downward.

### Notes:

The hydraulic control lever will not return to "Neutral" automatically, so the control lever must be returned to Neutral when the attachment reaches a maximum height. If the control lever is left in "Lift," the safety valve starts operation, and the temperature of hydraulic oil rises, thus causing machine trouble. Be sure to move the control lever back to Neutral.

### When the External Hydraulic Adapter is Used:

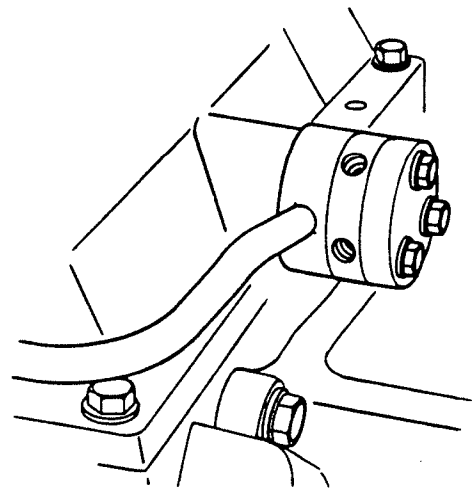
To use the external hydraulic adapter, the implement mounted on the tractor must have a double action control valve.

### Installing the external hydraulic adapter

Loosen the bolt in the area where the delivery pipe is connected to the hydraulic case, and while watching the O-ring position between the cover and pipe, install the external hydraulic adapter and secure with the adapter mounting bolt.

Tightening torque: 18.1 – 21.7 ft-lb  
(2.5 – 3.0 kg-m)

Connect the outlet of external hydraulic adapter, inlet of the control valve attached to the implement mounted on the tractor, outlet of the control valve, and oil return port of the external hydraulic adapter by pipes.





Start the engine, and by operating the control valve of the implement mounted on the tractor, bleed the cylinder and pipes. Then check the pipe joints for oil leakage.

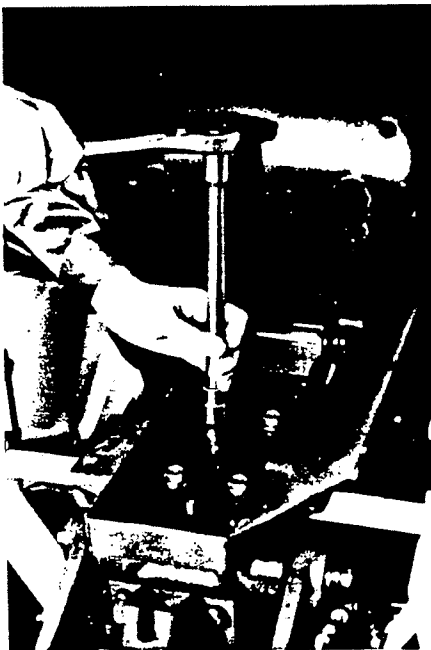
### DISASSEMBLING THE HYDRAULIC SYSTEM

The troubles of the hydraulic system can be classified into the following three groups; the pump, hydraulic case incorporating the piston, control valve, etc., and piping incorporating the oil filter, etc. To make correct repairs, their functions must be fully understood.

#### Disassembling the Hydraulic Case

To remove the hydraulic case, it is unnecessary to drain off the hydraulic oil (transmission case oil).

1. Remove the seat and tool box.



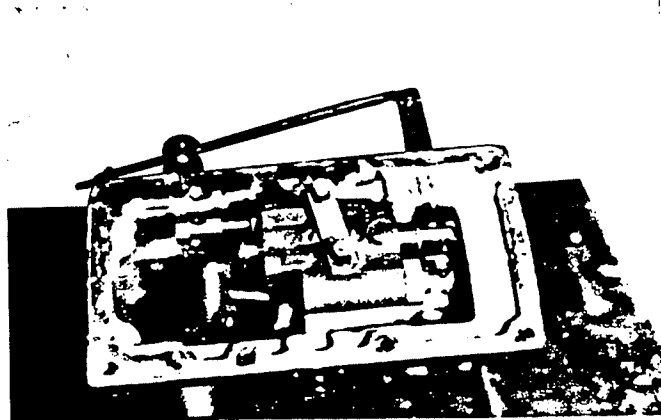
2. Remove the fender bracket.
3. Remove the delivery pipe tightening bolt.
4. Loosen the eight bolts (M10) tightening the hydraulic case assembly to the transmission case, remove the hydraulic case, and place it on the work bench.



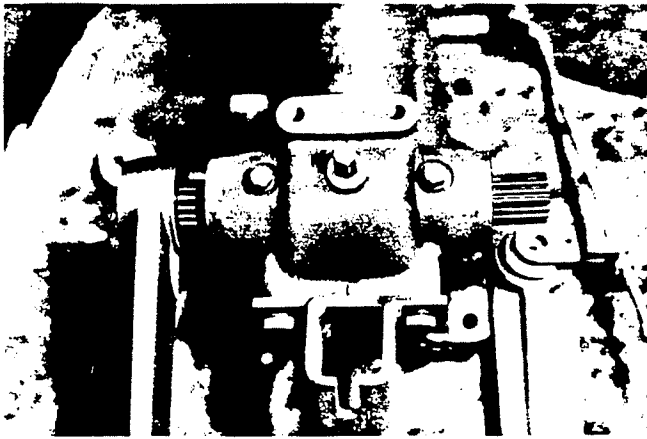
#### Note:

A bond is applied to the contact area of the hydraulic case with its mount. To remove the case, it is advisable to tap the case with a screwdriver.

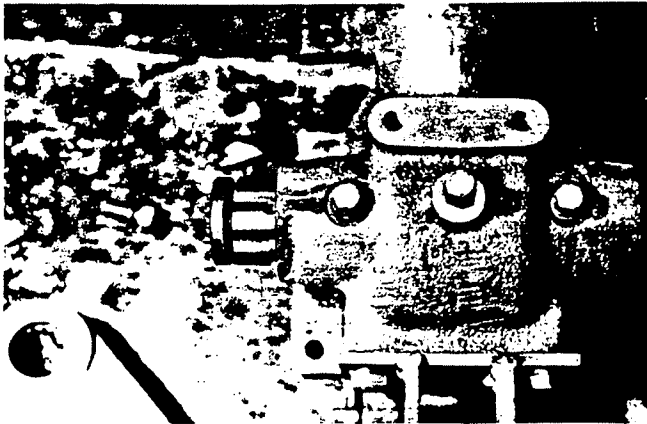
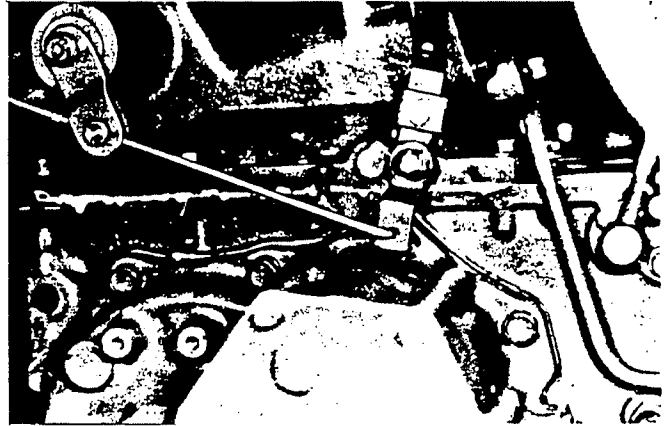
Loosen the control valve mounting bolt lock plate, and loosen the bolt, then remove the control valve. Take care not to damage the O-ring.



Remove the auto-return feedback rod cotter pin from the end of the control lever. Loosen the bolt on the right side of the lift arm, and remove the lift arm bolt, then pull out the left side lift arm.



Pull the piston out of the hydraulic case.  
Loosen the control lever stopper ball holder, and remove the steel ball.



Remove the bushing set bolt, and by tapping the ram shaft from its both sides, remove the bushing and oil seal, then remove the ram shaft.

**Note:**

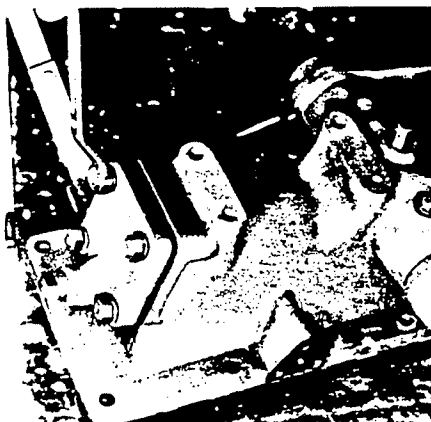
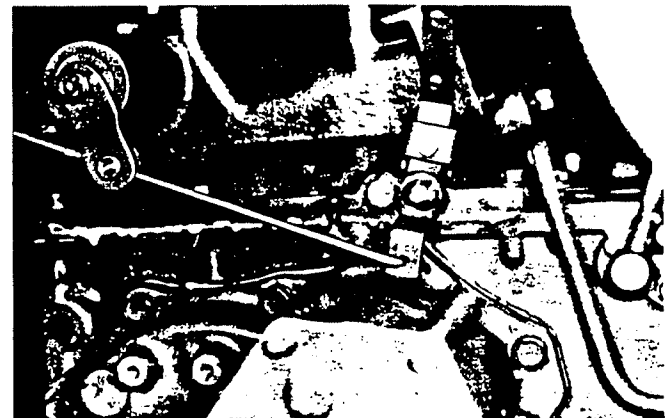
When removing the ram shaft, note the lift fork position.

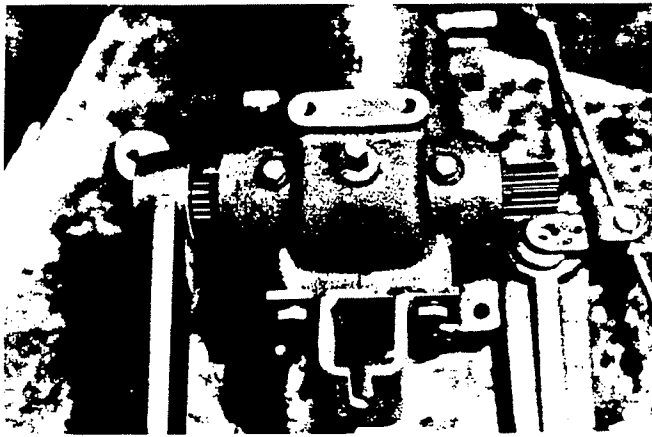
Remove the lift fork and connecting rod.

Loosen the four M10 bolts holding the cylinder head, and remove the cylinder head.



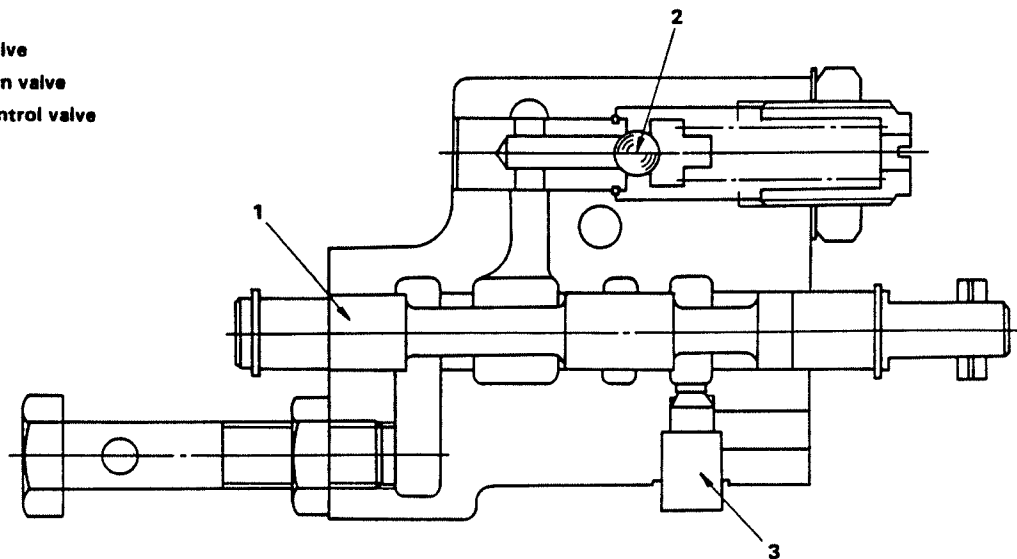
Loosen the arm tightening nut, remove the arm, collar and plate, and pull out the control lever.  
Remove the flow control adjuster.





Remove the breather from the hydraulic case.

- 1. Spool valve
- 2. On return valve
- 3. Flow control valve



Remove the circlip on the opposite side to the spool valve spring pin, and remove the spool valve. Loosen the pump relief valve lock nut, and remove the lock nut.

Loosen the relief adjuster, and remove the spring retainer, spring and ball.

By tapping the valve seat from outside, remove the valve seat.

### INSPECTION

Check the valve seat and steel ball seat surface for scratches.

Check the spool valve and body for scratches.

### DISASSEMBLING THE CONTROL VALVE

Normally it is unnecessary to disassemble the control valve. Only when disassembly is really necessary, it should be disassembled while taking care not to give damage to components. Also take care to keep the valve free from dust and dirt.

#### Important Instructions

1. When replacing the spool valve, be sure to replace it together with its body.
2. Never attempt to disassemble the pump relief valve in a place where the pressure gauge is unavailable.

### ASSEMBLING THE CONTROL VALVE

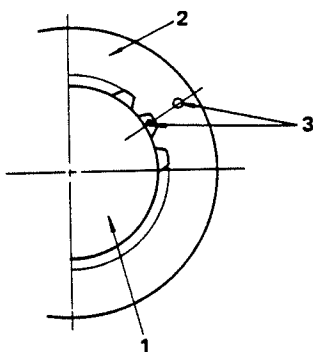
After washing clean each part, apply lubricant, and then assemble the parts in the reverse order of disassembling, take care so the parts are free from dust and dirt.

The set pressure of the pump relief valve is 1,991 psi (140 kg/cm<sup>2</sup>) at full flow.

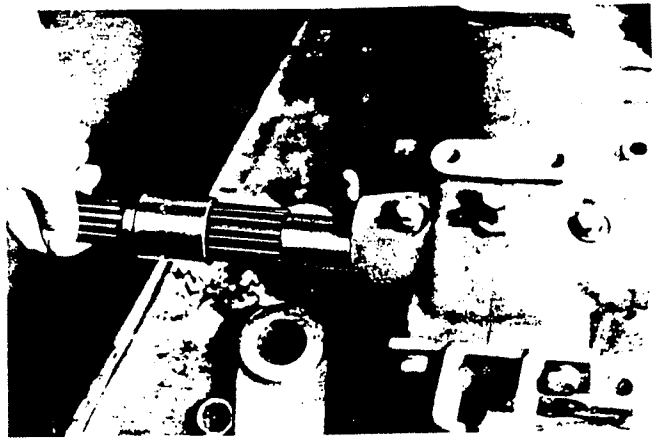
## ASSEMBLING THE HYDRAULIC CASE

1. When assembling the hydraulic system, the following steps must be taken.
  - a. Thoroughly wash all parts with cleaning oil.
  - b. Blow all washed parts with compressed air to dry them off. Do not use cloth to wipe them.
  - c. As for valves and related parts, they should be kept dipped in gear oil SAE #80 after being washed.
  - d. Avoid reusing "O" rings Backup Ring and gaskets. Always use new ones. Before installing "O" rings, coat them with good quality grease.
  - e. Always use new cotter pins.
  - f. Do not put on gloves while assembling operations.
  - g. Before starting assembly, make sure that the place is clean.
  - h. When reusing the used oil after assembly is over, avoid to use the lower part of the oil. Add new oil to make up for the amount of discarded oil (about one-tenth of the total oil amount).
  - i. Do not stretch "O" rings so that they will not permanently deformed.

1. Install the connecting rod to the lift fork, and set with the cotter pin.
2. Place the lift fork in the hydraulic case, and align the punch mark on the ram shaft with the punch mark on the lift fork.



1. Ram shaft
2. Lift arm
3. Punch mark

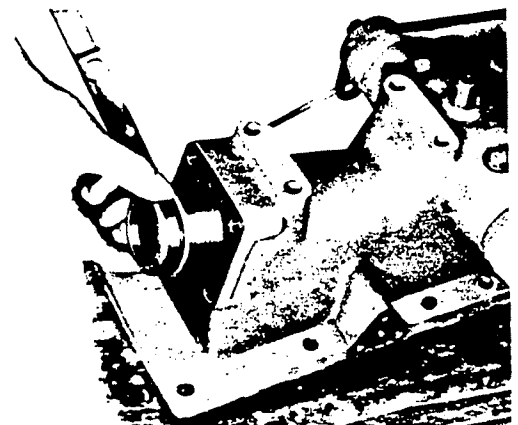
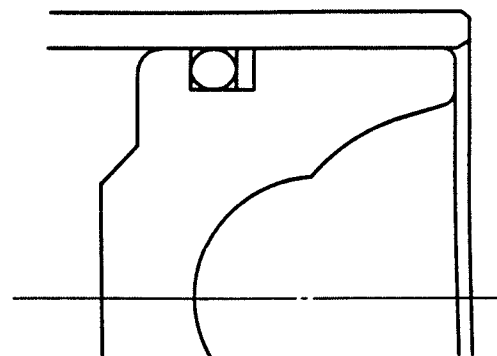


3. Hold the bushing with the chamfered side facing inward, and tap the set bolt into the ram shaft while paying attention to the set bolt position.

Tighten the ram shaft by tightening the set bolt (around which a seal tape is wound) from the top of the case.

Tightening torque: 43.3 – 50.6 ft-lb  
(6.0 – 7.0 kg-m)

4. Grease the oil seal, and tap it in until it contacts the bushing.
5. Install the bake-up ring (fully damped with oil) and O-ring to the piston. Oil the cylinder, and install the piston.

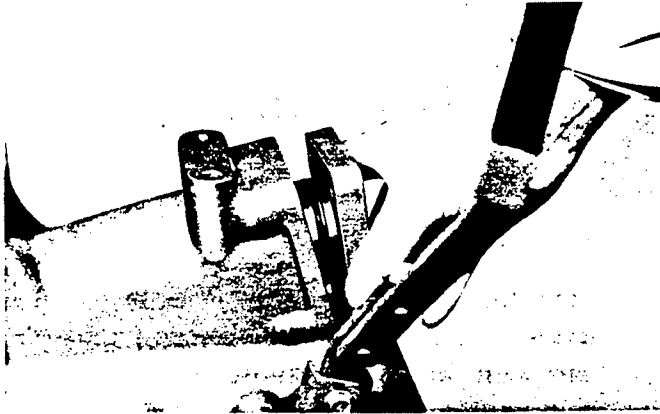




## 7-10 HYDRAULIC SYSTEM

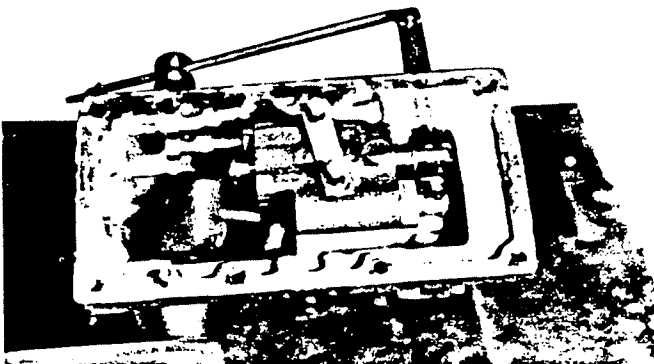
6. Install the larger O-ring (fulled damped with oil) to the cylinder head, and install the smaller O-ring to the cylinder.

Tightening torque: 43.3 – 50.6 ft-lb  
(6 – 7 kg-m)



7. Install the greased O-ring to the control lever shaft, and install it to the case.
8. Install the plate (with the holed side facing rearward), collar and two arms to the control lever shaft, and tighten them with the nut and washer. Then lock the nut with the stopper washer.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

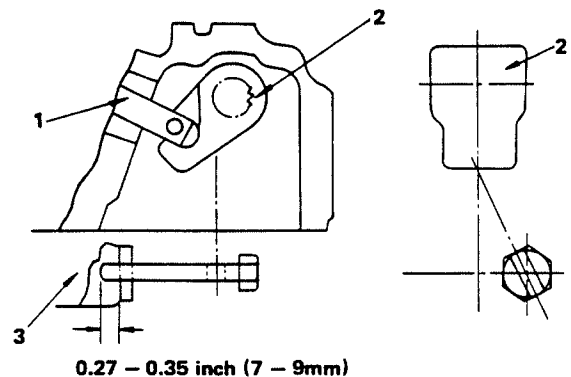


9. Install the O-ring to the control valve, and install it to the hydraulic case. Tighten it with the bolt, and lock with the stopper washer.

Tightening torque: 5.78 – 7.22 ft-lb  
(0.80 – 1.00 kg-m)

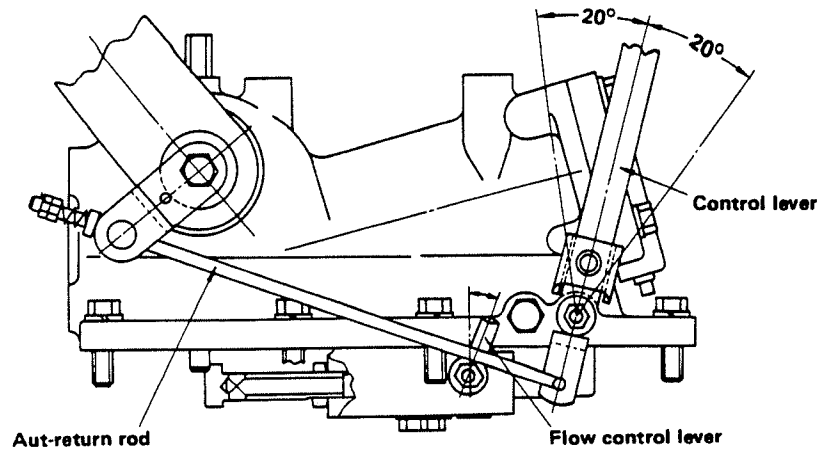
### Note:

1. Make sure that the spring pin on the end of the control valve spool correctly fits in the cut on the arm installed to the control lever.
  2. Make sure that the flow control valve is installed to the control valve.
10. When reinstalling the pipe to the rear of the control valve, tighten it 5 or 6 turns so that the opened end of the pipe faces toward the center of the lift fork, then lock it with the lock nut.



1. Piston rod
2. Lift fork
3. Control valve

11. Apply the "Tight Lock" to the holder, and put the spring in two layers. While taking care so that the steel ball does not drop off, install the holder to the hydraulic case. Make sure that the control lever stops at intervals of the same angle.



12. Matching the mark with the punch mark on the ram shaft, install the right and left arms. Install the auto-return arm to the right return arm, and tighten it with the bolt.  
bolt.

Tightening torque:

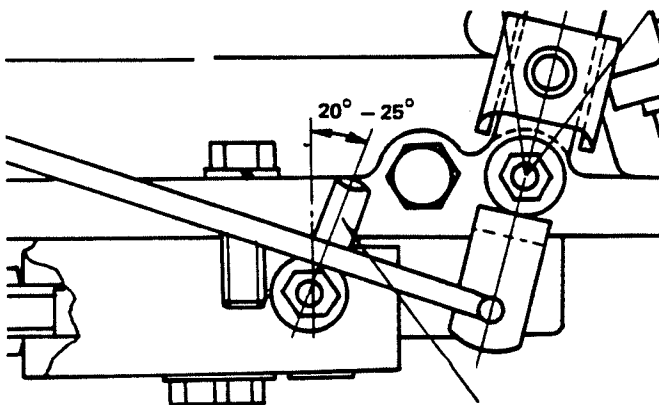
13. Install the auto-return feedback rod to the control lever and auto-return arm, and set them with the cotter pins.

14. Install the breather.

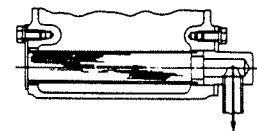
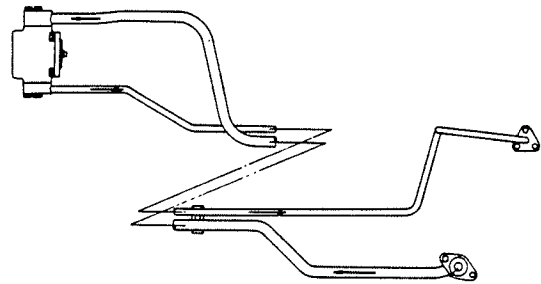
15. Apply a sealing compound to the contact surface of the transmission case with the mating parts, and install the hydraulic case while taking care so that the dowel pin does not fall off. Then tighten it with the bolt.

Tightening torque: 43.3 – 50.6 ft-lb  
(6.0 – 7.0 kg-m)

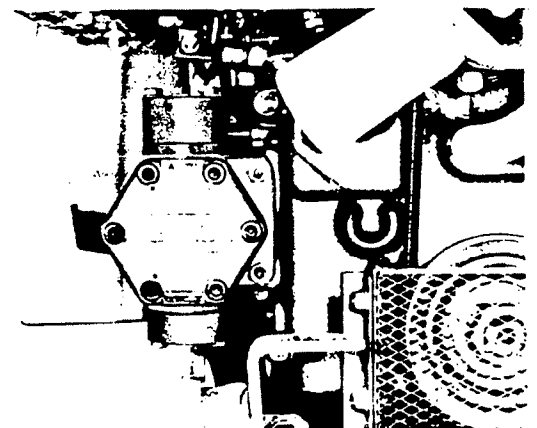
16. Lightly tighten the flow control valve adjuster from the transmission case side, and turn the lever 20° – 25° forward, and secure with the nut.



17. Install the delivery pipe to the hydraulic case.  
Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)



18. Secure the pipe to the pump with the bolts.  
Tightening torque: 5.78 – 7.22 ft-lb  
(0.8 – 1 kg-m)



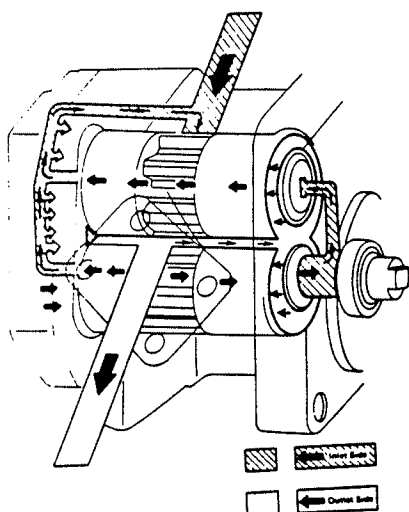
## OIL PUMP

## Oil Pump — Construction

This oil pump (Kayaba-Dowty, GP-1) is of the gear type, employing the pressure loading system. The pressurized oil is forced out to bearing bush's rear side, and the minimum clearance is maintained between the gear teeth and the bush to make lubrication, thereby securing a high volumetric efficiency even at high-pressure-low-speed operation. (The bearing bush serves as a pressure loading component and casing at the same time.) The bearing bush is of movable design, and, as a result, it is able to maintain a proper clearance whether the bush swells due to heat or is worn due to protracted low-temperature operation.

The bearing bush is designed to be lubricated by low pressure oil which is forced fed, independently of the pressurized oil on the outlet side. This prevents the seizing-up of the bearing and the damage of the oil seal.

As far as the oil is clean, 90 percent of the specified volumetric efficiency can be secured for a long period. The pump has been tested for 4,000 hours continuous operation and proven to maintain high-performance.



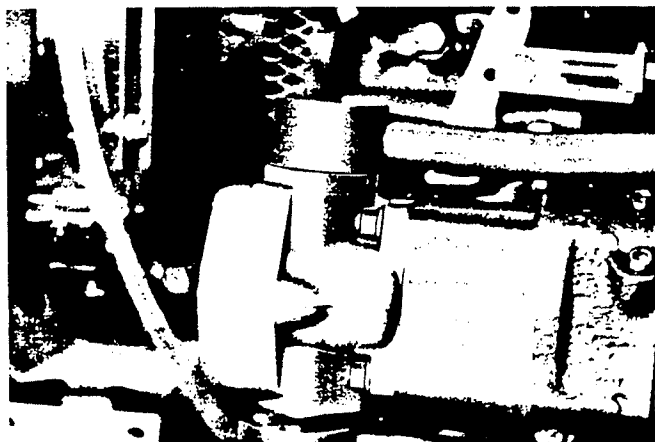
## Note:

1. The pump oil seal is made of synthetic resin, and therefore, mineral oil should be used for lubrication. Use of acid and alkaline oil, kerosene, and high octane vegetable oil is not allowed. Extremely high temperature oil may cause corrosion to the oil seal.
2. The oil should be gear oil SAE 80 or equivalent. For details, refer to the Instruction Book.

## Removing the oil pump

To remove the oil pump the radiator must be removed first. For the procedure for radiator removal, refer to "Engine" in this manual.

1. After removing the radiator, loosen the suction pipe and delivery pipe securing bolts, and remove the pipes from the pump.



2. Remove the pump from the engine timing gear case.

## Oil Pump — Disassembly

## Note:

The oil pump should be disassembled in a clean place, and the tools must be also clean. All disassembled parts are blown with compressed air for drying, after being washed. Do not use rags. Take care not to damage the body and cover, because they are made of light alloys.

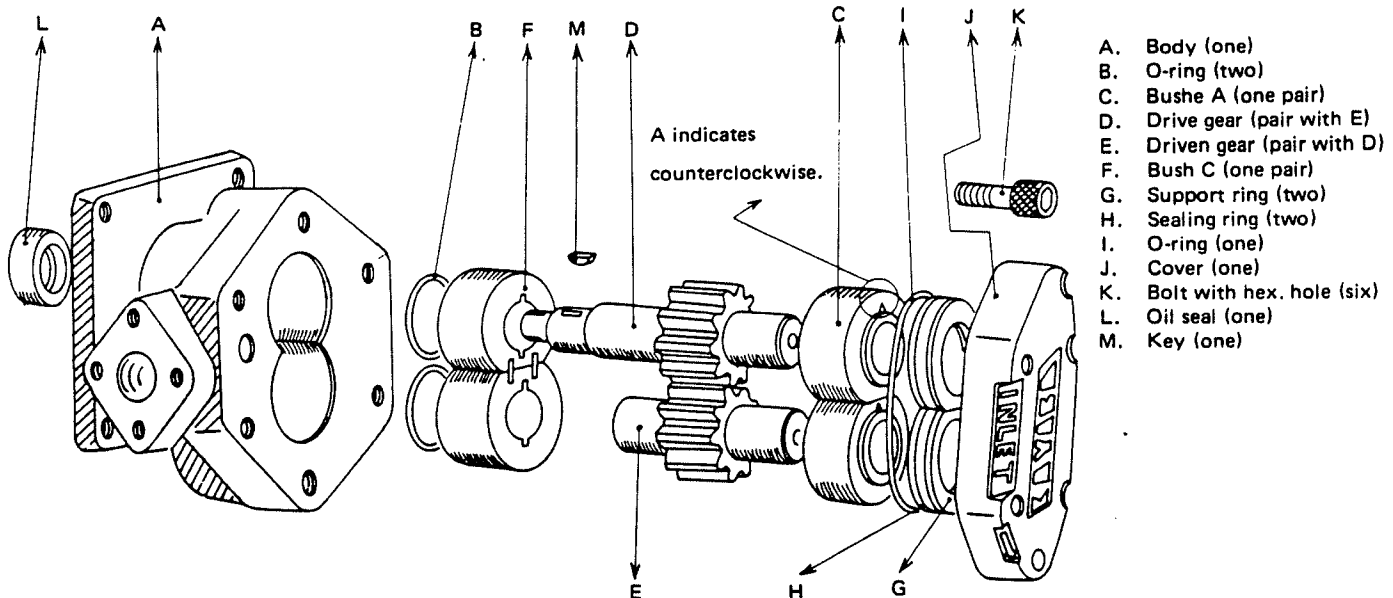
For this disassembly work, refer to Fig. 25.

1. Loosen the bolt (L) with a hexagon hole, and remove the cover (K) and O-ring (1).
2. Remove the seal element consisting of two sealing rings and support rings (H and G).

**Note:**

Both sealing ring (H) and support ring (G) are made into one piece assembly, and therefore, they can not be separated.

3. Push the drive gear (D) into the body (A), and the bush (L) can easily be taken out by finger. Remove the bush (C), and remove the gear (D) and driven gear (E). The bush (F) can be taken out together with the O-ring (B).



The disassembled parts should be arranged in order. As for the shafts and bushes, their positions should be correctly memorized.

When installing bushes, take care not to confuse the bush (C) for bush (F) in relation to their positions.

Each bush has a mark A or B stamped on its end. A bush having the same character should be installed on the cover side. (e.g. A indicates clockwise rotation, and C denotes counterclockwise rotation.) The oil seal (M) should not be removed unless otherwise broken. To pull out the oil seal (M) from the body, take special care not to scratch the housing bore.

**Checking During Disassembling**

Replacement of worn or damaged parts should be done with special care. In order to increase pumping efficiency, the gear rotates with its teeth in slight contact with the pump casing. The contact is evidenced on the low pressure side of the pump. After a long period of use, the oil will become dirty, and bush holes and journal bearings will be worn. As a result, the casing wall begins to show

wear. If the amount of wear exceeds more than 0.001 in. (0.05 mm), the clearance between the gear teeth and the casing wall will be excessive, and oil leakage will increase. This will reduce the performance of the pump. Replacing the bush will not be effective to improve the performance. The use of a worn bush is not recommended except when the pump is operated under low pressure and with special care.

In general, working parts are subject to wear after a long period of use, and there will be not a big difference in wear between them. It is advisable, therefore, that when any component parts show an excessive wear, the pump itself should be replaced, instead of replacing worn parts. It will be more economical.

Each part should be washed with kerosene and blown with compressed air. All removed O-ring should also be replaced. Check the gears and gear shafts for scratches and broken teeth. The contact ratio in a pair of gears in mesh should be even. Measure the shaft diameter with an outside micrometer caliper (special tool No. 25MB). If the measurement shows a smaller value than 0.495 in. (12.598 mm), replace the shaft.

Check the bushes for deformed bore and scratches. If the discoloring of a gear can be considered to be related with a defective bush, check for the relief valve and related oil passages. If the length of a bush is shorter than the value as shown below, it should be replaced. 0.809 in. (20.574 mm)

Any discolored gear should also be replaced. Measure the clearance between the shaft and bush. If the measurement is larger than the following value, the bush should be displaced.

0.006 in. (0.177 mm)

### Note:

If the clearance between the gear and the bush is more than 0.00019 in. (0.005 mm), both parts should be replaced together.

### Oil Pump Assembly Order

Make sure that all parts are clean. If any oil seal (M) has been replaced, it should be replaced. To install the oil seal, use a press. (The seal lip must face inward.)

1. Place the "O" ring (B) on the bush (F), and coat it with good quality of mineral grease. Insert it in the body (A) and push it in further. A pair of bushes must be at right angles to the bore in order to protect them against scratches. Tolerance is allowed for the bush so that it can be smoothly fitted in place without requiring force. If the bush has a scratch on its surface, it will not move smoothly. In this case, pull out the bush and smooth down the raised part with oil stone. Make sure that the surface of the bush is smooth. For this check, use a surface plate. After using oil stone, be sure to wash the bush. Oiling the bore will make it easy to install the bush. Make sure that after installation, the "O" ring is in place.

The "O" ring must be located between the bush and the body's bottom. The pressure balance type is greatly affected by the result of assembly. Make sure that the escape groove in the bush surface is not inclined. Incorrect assembly will not provide the pressure balance effect, and as a result, the bush in the bore will be deformed by pressure.

2. When inserting the drive gear (D) into the body A, take care not to damage the oil seal

with the stepped (machined) part of the gear shaft. To this end, wind a cellophane tape around the machined part or cover it with a specially designed sleeve.

The sleeve should be the same in outside diameter as the shaft (larger part in diameter), and its end is tapered. Install this sleeve firmly around the end of the drive gear (D), and insert it into the body (A).

The oil seal will not be damaged. If a gear which is once used is to be reinstalled, it should be positioned so that the same contact with the other gear in mesh will be exactly the same as before.

3. Fully grease the bushes (C) in pair, and insert them in the body. Place the seal ring (H) on the support ring (G), and set the position on the bush.
4. Place the "O" rings (I) and (J) on the body, and place the cover. Finally tighten the bolt with a hole (L) by using a hexagon wrench (special tool AW-60-6 mm). Tightening torque is 5.77 ft-lb. (0.8 kg-m). Lock the bolt head with center punch, feed a small quantity of oil through the port.
5. Make sure that the assembly is done perfectly by turning the drive gear (D) with an open end wrench (special tool BT-9, 8 x 9). If the gear turns smoothly, the assembly is correct. If too tight, correct it.  
Refer to Fig. 26.

### Installing the Oil Pump

1. Align the pump shaft with the pump drive shaft, and install it to the engine timing gear case.
2. Set the O-ring correctly, and install the suction pipe and delivery pipe to the pump.  
Tightening torque: 5.78 – 7.22 ft-lb  
(0.8 – 1.9 kg-m)
3. Install the radiator.

**Test**

Special care should be taken for test run, particularly when bushes, gears and body have been replaced. Test run should be continued at least for 30 minutes. First make sure that the engine oil, cooling water, transmission oil and other components of the tractor are all perfect. Run the engine with no-load at idling speed, and when oil temperature rises as specified (engine water 180°F or 82°C), increase the engine speed to increase the pump delivery. Operate the control lever for hydraulic control, and give load to the pump.

In particular, while operating the pump, check the temperature of the pump. If the temperature is excessively high (about 178°F or 80°C), reduce the engine speed temporarily, and continue no-load operation until working parts are fully broken in.

**Note:**

The disassembly and reassembly of the pump are relatively easy, but it should not be unnecessarily disassembled because of trouble of the hydraulic system, of which causes are unknown. Avoid perform disassembly for repair in the field, because it is very difficult to prevent dust and dirt from entering in the pump. Parts may also be scratched. Frequent disassembly will result in leaky oil seals.

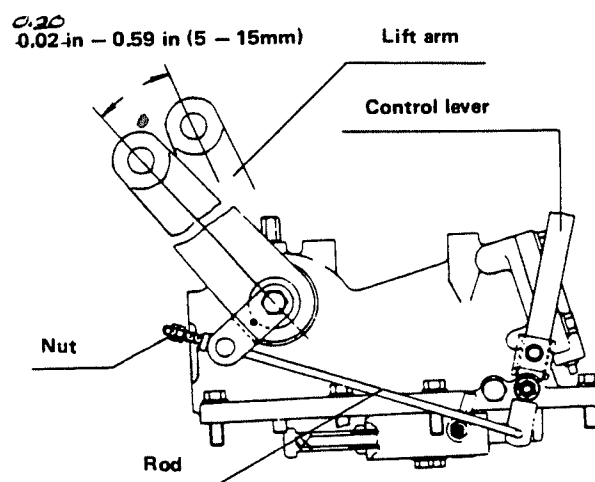
**HYDRAULIC CONTROL**

When an implement is fully lifted, the control lever automatically returns to NEUTRAL position. If the control lever does not return, adjust as follows:

1. Disconnect the lift rod from the lift arm.
2. Set the lift arm to UP position with the control lever. When at the UP position, check and adjust the free-play (A) to be about 0.20 in. – 0.59 in. (5 – 15mm).

Unless the above free-play is obtained, the control lever will not automatically return to NEUTRAL position.

3. If the play is too small or there is no play, shift the adjust nut toward the control lever (in the tightening direction).
4. If the play is too large, shift the adjust nut toward the rod end (loosening direction).



## 7-16 HYDRAULIC SYSTEM

### TROUBLESHOOTING GUIDE

This paragraph describes the troubleshooting procedures on the hydraulic system used on Satoh Model S-370 & S-370D tractor. It lists the various troubles that might be blamed on the hydraulic system together with their possible causes, the checks to be made, and the corrections needed.

#### Implement will not Lift at all when Control Lever is Placed in LIFT

	Probable cause	Remedy
1	Excessive load on end of lower link	Reduceload
2	Oil pump O-ring damaged or oil seal slipped out of position	Replace
3	Broken pump drive shaft	Replace
4	Improper relief pressure setting	Adjust to 1700 lb/in. <sup>2</sup> (120 kg/cm <sup>2</sup> (full-flow))
5	Cracked piping or damaged or weakened O-ring	Replace
6	Control valve joint to control valve spring pin broken	Replace

#### Implement is not Raised Quickly

	Probable cause	Remedy
1	Scratched or leaky relief valve seat	Replace as an assembly
2	Pump not delivering enough oil	Replace
3	Suction strainer clogged	Wash strainer and replace oil
4	Implement too heavy	Reduce weight
5	Broken piping or damaged O-ring	Replace
6	Improper relief pressure setting	Adjust to specification

#### Implement Lowers During Neutral

	Probable cause	Remedy
1	Broken or leaky O-ring	Replace
2	Worn spool valve	Replace spool and body as a matched set
3	Safety valve improperly adjusted	Readjust to 3,980 lb/in <sup>2</sup> (180 kg/cm <sup>2</sup> )

#### Implement will not Lower when Control Lever is Placed in Down

	Probable cause	Remedy
1	Flow control valve kept closed due to loosened lock nut	Readjust and secure with lock nut positively
2	Flow control lever not properly set	Readjust

#### Oil Temperature is Excessively High

	Probable cause	Remedy
1	Oil pump seized	Replace. (Check for presence of foreign particles in oil)
2	Pump not delivering enough oil	Replace
3	Relief valve at fault	Check valve height (highest position) or stopper. Refer to 44.3 for adjustment procedure.
4	Leak relief valve seat due to damage	Replace
5	Automatic kick-out not properly adjusted	Readjust

**Abnormal Noise**

	Probable cause	Remedy
1	Pump seized	Replace
2	Pump not sucking enough oil	Check oil level in tank or clogged suction filter
3	Air leaking into suction pipe or past oil seal	Repair
4	Deteriorated oil	Replace
5	Clogged strainer	Clean

**SPECIFICATIONS****Specification**

1. Control ..... Lift hold down & flow control external service.
- Type of cylinder ..... Single action cylinder
- Diameter of piston ..... 2
- Type of cylinder ..... Single action cylinder
- Diameter of piston ..... 2.205 in. (56 mm)
- Stroke of piston ..... 2.795 in. (71 mm)
- Pressure for relief valve setting ..... 1.706 lb/in. (120kg/cm)
- Maximum lift power lnd end ..... 1,277.5 lb (580 kg)
- Type of hydraulic pump ..... Pressure loading gear pump
- Out put of hydraulic pump ..... 3.84 gal/min (14.2 lit/min)/2700 rpm
- Controle valve type ..... Spool valve 3 port 3 position
- Name and model hydraulic pump ..... KAYABA GP1-15
- Oil lock valve ..... Oil lock valve (adjustable flow control)
- Strainer mesh ..... 100 mesh
- Hydraulic oil ..... S.A.E. #80 geae oil (same as transmission oil)



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## GENERAL

The Satoh Beaver (Model S-370 & S-370D) tractor is equipped with a Yuasa NS-60 battery having a capacity of 12 volts, 45 AH which supplies all the power for the electrical system of the tractor.

This battery supplies power for the starter motor, 2 Sheathed type glow plugs, the water temperature warning switch for sensing over-heating of the engine cooling water and oil pressure warning switch for sensing decrease in the lubricating oil pressure. A charger is also provided for maintaining the voltage of the battery at a constant value.

The instrument panel is equipped with a starter switch for starting the engine; water temperature warning lamp for the engine cooling water; engine oil pressure warning lamp; a unit with a built-in battery charge warning lamp, head light switch,

glow signal lamp for indicating that the glow plug is red hot; horn button; regulator to control the battery charging.

Two 12V-25W/25W headlight lamps are located at the front of bonnet. These can be switched to high and low beam.

A safety starter switch is installed on the clutch housing to prevent accidents such as abrupt motion of the tractor when the engine is started. The circuit between the battery and starter switch can't be closed unless the main clutch is completely disengaged by fully pressing the clutch pedal down. Therefore, the engine can't be started even if the switch is turned to the start position.

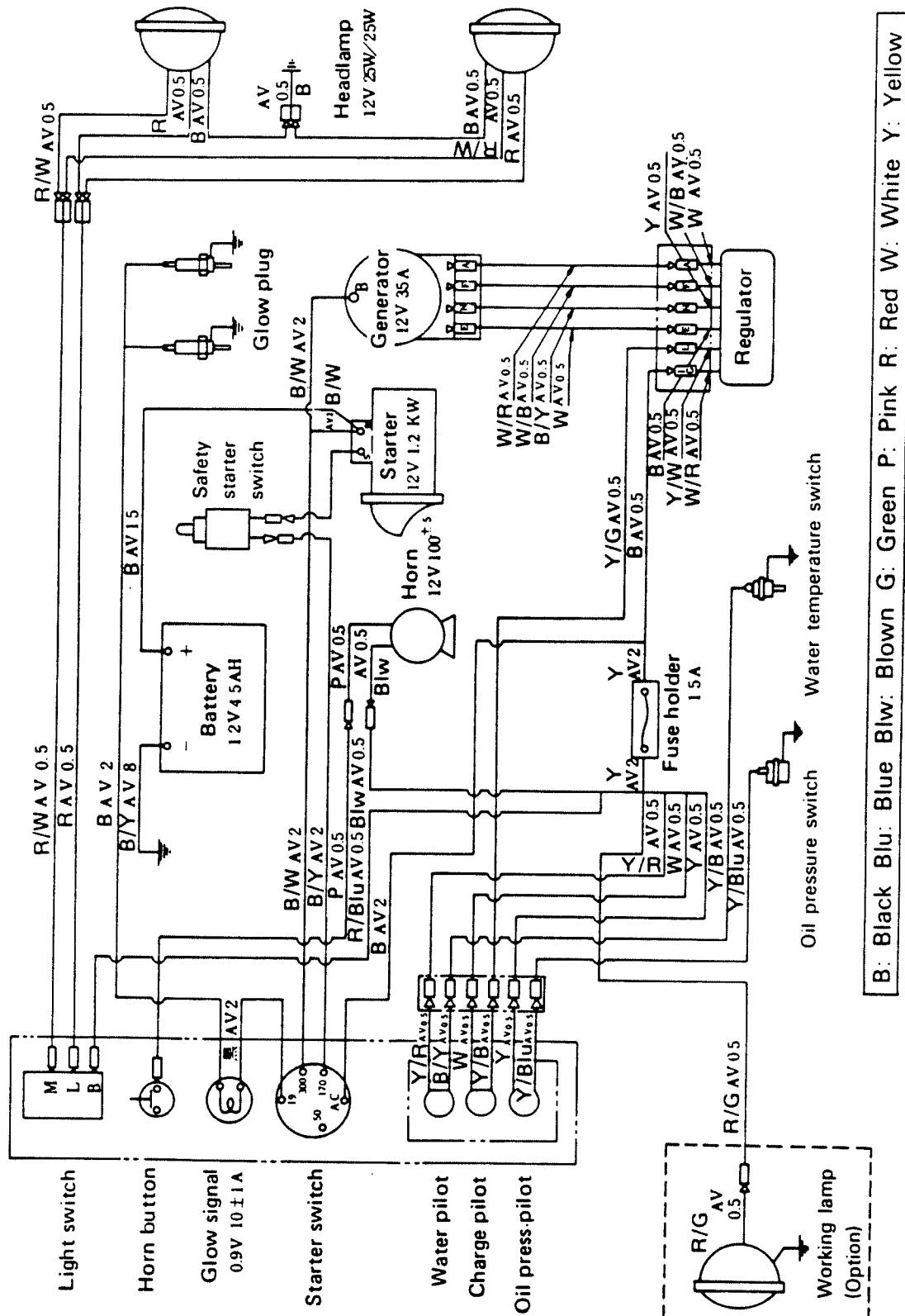
An optional direction indicator unit and working light can also be installed.

## DATA AND SPECIFICATIONS

The electrical units provided on the Satoh Beaver (Model S-370 & S-370 D) and their types are as follows:

- |                                     |                           |             |
|-------------------------------------|---------------------------|-------------|
| 1. Battery                          | Yuasa NS 60 12V-45AH      |             |
| 2. Starter motor                    | M4T                       | 14673       |
| 3. Generator                        |                           | 021000-2431 |
| 4. Water temperature warning switch |                           |             |
| 5. Oil pressure warning switch      |                           |             |
| 6. Glow plug                        |                           |             |
| 7. Glow signal lamp                 |                           |             |
| 8. Regulator                        |                           |             |
| 9. Starter switch                   |                           | Honda Lock  |
| 10. Light switch                    |                           | Honda Lock  |
| 11. Safety starter switch           |                           |             |
| 12. Water temperature warning lamp  |                           |             |
| 13. Oil pressure warning lamp       | Stanley 12V-3.4W          |             |
| 14. Charge warning lamp             |                           |             |
| 15. Headlamp                        | Stanley 12V-25W/25W 2 ea. |             |
| 16. Fuse                            |                           |             |
| 17. Horn                            |                           |             |
| 18. Horn switch                     |                           |             |

## ELECTRICAL WIRING DIAGRAM



## BATTERY

The battery provided with the Satoh Beaver Model S-370 & S-370D tractor is the Yuasa NS60 12V, 45AH, negative ground type.

### Note:

1. The generator for the engine is of the minus ground type. Pay attention to the polarity of the battery when replacing or reinstalling so as not to connect it in reverse.
2. The battery on tractors shipped abroad from Satoh factories are always dry-charged except in special cases. Be sure to perform initial charging immediately after unpacking, before attempting to start the engine.

### Dry Charge

"Dry charge battery" means the directly-usable battery, in which both negative and positive plates are fully charged, plate drying is specially done, so that it may not combine with oxygen in the air when it is stored.

Batteries which are usable only by supplying electrolyte and performing the initial charging are called

"dry charge battery" or "directly-usable battery".

The direct usability of the directly-usable battery very gradually deteriorates due to temperature change while it is manufactured and stored. Accordingly, the direct usability performance within six months after manufacture is about 75% of the nominal capacity.

Therefore, it is important to perform the following initial charging when using the battery.

### Initial Charging

Batteries in store cannot be used even if the electrolyte is supplied, as the negative plate is oxidized by oxygen in the air.

Therefore, to restore the negative plate to the sponge lead, charge a relatively low specified direct current.

This charging is called initial charging.

#### 1. Notes on initial charging

The electrolyte to be filled first should be dilute sulfuric acid specified by the battery manufacturer, of which specific gravity is nearly that with the battery fully charged.

### Relation between temperature and specific gravity of dilute sulfuric acid.

Sulfuric Acid Weight %	32°F (0°C)	41°F (9°C)	50°F (10°C)	59°F (15°C)	68°F (20°C)	77°F (25°C)	86°F (30°C)	95°F (35°C)	104°F (40°C)	113°F (45°C)	Temperature Coefficient
23.0	1.218	1.215	1.212	1.208	1.205	1.202	1.198	1.195	1.191	1.183	0.00067
28.5	1.223	1.220	1.217	1.213	1.210	1.207	1.203	1.200	1.196	1.193	
29.1	1.228	1.225	1.222	1.218	1.215	1.212	1.208	1.205	1.200	1.198	
29.8	1.233	1.230	1.227	1.223	1.220	1.217	1.213	1.210	1.206	1.203	0.00070
30.4	1.238	1.235	1.232	1.228	1.225	1.222	1.218	1.215	1.211	1.208	
31.0	1.244	1.241	1.237	1.234	1.230	1.226	1.223	1.219	1.216	1.212	
31.6	1.249	1.246	1.242	1.239	1.235	1.231	1.228	1.224	1.221	1.217	
32.2	1.254	1.251	1.247	1.244	1.240	1.236	1.232	1.229	1.226	1.222	
32.8	1.259	1.256	1.252	1.249	1.245	1.241	1.238	1.234	1.231	1.227	0.00071
33.4	1.264	1.261	1.257	1.254	1.250	1.246	1.243	1.239	1.236	1.232	
34.0	1.269	1.266	1.262	1.259	1.255	1.251	1.248	1.244	1.240	1.237	
34.6	1.274	1.271	1.267	1.264	1.260	1.256	1.253	1.249	1.254	1.242	
35.2	1.276	1.276	1.272	1.269	1.265	1.261	1.258	1.254	1.250	1.247	
35.8	1.284	1.281	1.277	1.274	1.270	1.266	1.263	1.259	1.255	1.252	0.00072
36.4	1.289	1.286	1.282	1.279	1.275	1.271	1.268	1.264	1.260	1.257	
37.0	1.294	1.291	1.287	1.284	1.280	1.276	1.273	1.269	1.265	1.261	
37.5	1.299	1.296	1.292	1.289	1.285	1.281	1.298	1.274	1.270	1.266	
38.1	1.304	1.801	1.297	1.294	1.290	1.286	1.293	1.279	1.275	1.271	
38.7	1.309	1.305	1.302	1.299	1.295	1.291	1.288	1.286	1.280	1.276	
39.3	1.314	1.311	1.307	1.304	1.300	1.296	1.293	1.289	1.285	1.281	

**Note:**

Temperature constant fixes the standard of specific gravity at 68°F (20°C), and is the mean value in the chart.

When the electrolyte is filled, its temperature usually rises up due to combining heat, so in summer use the low-temperature electrolyte (in case of NS60 Battery 37.0% at 68°F (20°C), 1.280).

2. Charge the battery usually for 72 hours with a stabilized current one-twentieth the battery capacity.

In case the battery is stored for more than one year, it is necessary to charge for a longer period than the above.

If the electrolyte temperature exceeds 113°F (45°C) during charging, decrease the current gradually or stop charging.

The temperature must be below 113°F (45°C) when the charging is completed.

3. Completion of charging can be known by the facts outlined below.
  - a. You have charged for 72 successive hours with a specified stabilized current.
  - b. The terminal voltage has risen over 2.50V per one cell, and is stable for several hours.
  - c. Specific gravity of each cell has risen up to an optimum degree, and is stable for several hours.
  - d. Gas is vigorously generated from each cell.

**Note:**

The generated gas, which is combined gas of oxygen and hydrogen, is very explosive, so keep it from fire.

**Auxiliary Charging**

The charged battery discharges itself by 0.5 ~ 1.0% of its capacity every day even if it is not used, and the higher its electrolyte temperature is, the more the discharge is.

If the battery keeps discharging for a long time, it does not work well even if it is necessary to perform the auxiliary charging once a month for batteries which are not in use, while perform the charging for those which are in use when the specific gravity is 1.260, 68°F (20°C).

**Handling and Inspection**

Handle the Yuasa Yumicron battery in the same

way as for normal batteries.

1. The battery performance depends on your handling. To inspect the battery, do as follows. See whether something is wrong with the battery on its surface.

Remove the plug and see whether the electrolyte is properly filled.

Measure the specific gravity and temperature of each cell with a hydrometer and a thermometer.

Measure the terminal voltage of each cell or whole cells with a voltmeter.

Check the charging of the battery with a battery tester.

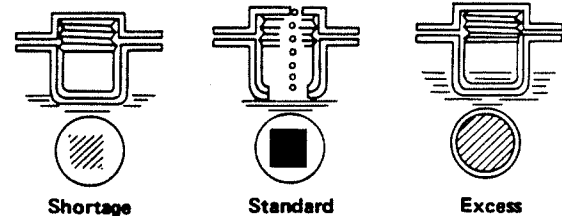
Check the battery on the tractor for connection and tightness.

2. Fluid inspection

If the battery fluid is insufficient, replenish refined water up to the specified height.

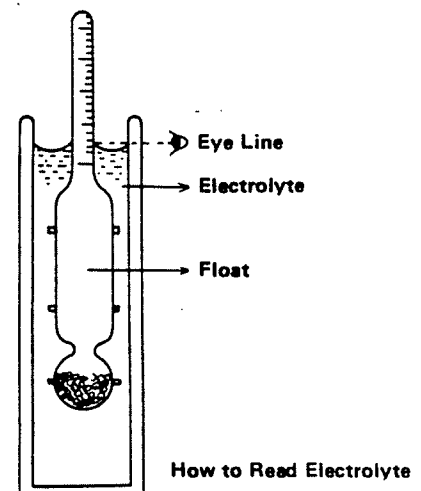
In principle, the fluid should remain about 0.39 – 0.51 in. (10 – 13 mm) above the splash plates.

Inspect it in the following way.



3. Specific gravity measurement

The specific gravity of the electrolyte is in proportion to the discharged quantity, so the battery discharging state can be known by measuring the specific gravity.



## 8-5 ELECTRICAL SYSTEM

- When measuring the specific gravity, set your eyes at the top of the electrolyte which is raised due to surface tension.
- The specific gravity depends on the temperature. If the temperature is high, the specific

gravity is small.

The specific gravity for this battery fixes the standard of 68° F (20° C).

Therefore, it is necessary to know the specific gravity in the case of 68° F (20° C).

### Troubleshooting

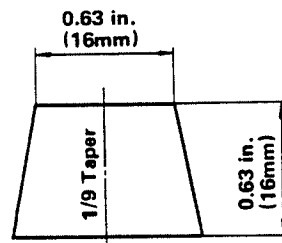
Testing of battery with a hydrometer. If the specific gravity of the electrolyte in the battery has been correctly adjusted after the battery is fully charged, the state of charge of the battery can be estimated by measuring the specific gravity of the electrolyte with a hydrometer.

Specific Gravity of Electrolyte after Temperature Correction (at 20° C)	State of Battery	Correction
1.280 . . . . . 1.270 . . . . .	Specific gravity too high Satisfactory	Adjust specific gravity while recharging battery 1. No further attention is necessary if difference in specific gravity of electrolyte in each cell is 0.015 or less. 2. If difference in specific gravity of electrolyte in each cell of battery is more than 0.015, make a high-rate discharge test. If the test result indicates that the battery is in good condition, adjust specific gravity while recharging battery.
1.240 . . . . .	Fair	1. Recharge battery. 2. If specific gravity of electrolyte in each cell is unequal, make adjustment while recharging the battery. 3. Check regulated voltage and function of voltage regulator.
Below 1.200 . . . . .	Unsatisfactory	1. Follow the steps outlined under specific gravity reading of 1.240 ~ 1.200. 2. Check the generator circuit for short, loose connections and poor contact due to corrosion and give necessary service attention.
When difference in specific gravity of electrolyte in each cell is 0.025 or more	1. Short in cell with lowest specific gravity reading. 2. Electrolyte leaking 3. Level of electrolyte in cell too high or electrolyte diluted with water leading into cell. 4. Self-discharged	1. Recharge battery and check specific gravity of electrolyte twice at one hour interval and if the hydrometer readings are nearly equal. 2. Adjust specific gravity of electrolyte in each cell to 1.255 ~ 1.260 while recharging battery. 3. Make a high-rate discharge test after discharging the battery continuously for 12 hours. 4. If difference in cell voltages is 0.5V or more, the battery should not be used without recharging.

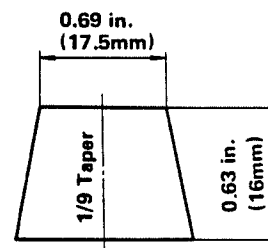
### Data and Specifications of Battery

Model	YUASA NS 60
Capacity	20HR 45AH
Size L x W x H	9.3 x 5 x 8.86 inch (236 x 126 x 225mm)
Weight	28.63 lb(including electrolyte)
Q'ty of electrolyte	0.82 gal (3.1 lit)
Specific gravity of electrolyte	1.280 ± 0.010 at 68° F (20° C)

### Size of terminals



Negative: 1/9 tapered



Positive: 1/9 tapered

## SAFETY STARTER SWITCH

A safety starter switch is installed between the start switch and starter motor to prevent inadvertent accidents such as abrupt motion of the tractor when the engine is started. The switch is installed on the clutch pedal. In this condition the engine can be started by the starter motor when the starter switch is turned to the Start position.

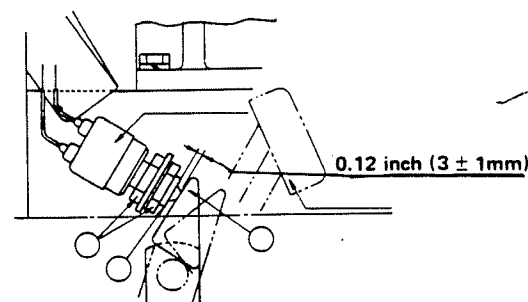


### Removal of the starter switch

The switch can be removed by removing the connector and loosening the locknut. The safety switch itself can't be disassembled.

### Adjustment

After the amount of free movement of the clutch pedal is adjusted, use the locknut to adjust the gap between the top end of the safety switch and that of the release shaft arm to be 0.12 inch ( $3 \pm 1\text{mm}$ ) with the clutch pedal fully depressed.



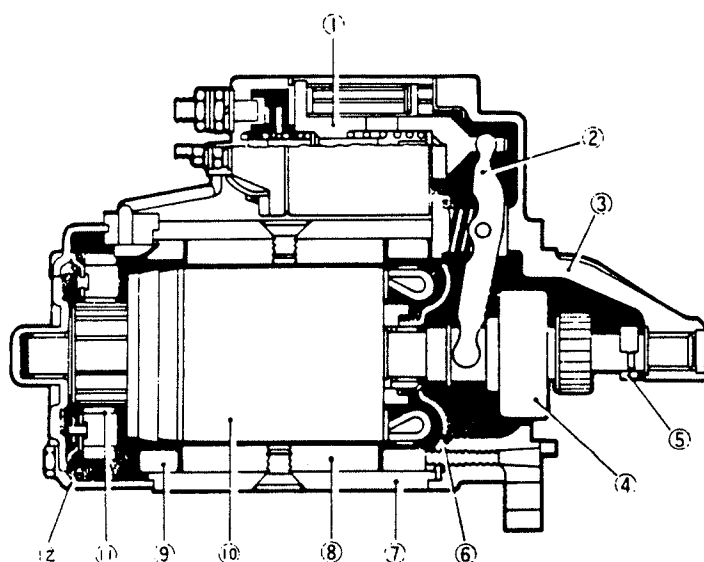
Upon completion of adjustment, confirm that the starter motor does not rotate when the clutch pedal is released.

## STARTING MOTOR

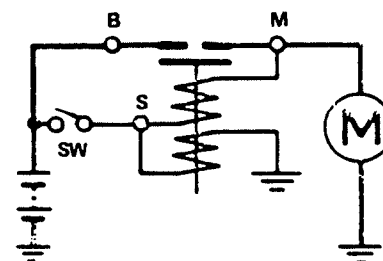
Model . . . . . KE55. . . . . M003 T 15772  
 Model . . . . . KE70, 75. . . M004 T 14673  
 Type . . . . . Electromagnetic coupling  
 Nominal output. . . KE55. . . . . 12V-0.9kW  
 . . . . . KE70, 75. . . 12V-1.2kW

Direction of rotation. . . . . CW (viewed from pinion side)

Yoke diameter. . . . . KE55. . . . . 90  
 . . . . . KE70, 75. . . 100  
 Weight. . . . . KE55. . . . . 6.4 kg  
 . . . . . KE70, 75. . . About 7.5 kg



Cross Section of Starting Motor



1. Magnetic switch
2. shift lever
3. Front bracket
4. Overrunning clutch
5. Stop ring
6. Center bracket
7. Yoke
8. Pole
9. Field coil
10. Armature
11. Brush
12. Rear bracket

The starting motor is an electromagnetiac pinion sliding type DC series motor. It is of the construction for providing a smooth engagement of the pinion and the ring gear by the action of the magnetic switch.

The starting motor is composed largely of the motor section for generating power, the overrunning clutch section for transmitting the turning force and preventing overrunning after engine start and the magnetic switch section for bringing the pinion

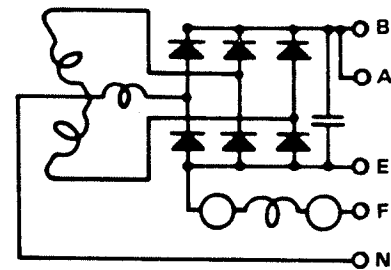
and the ring gear into engagement and supplying the load current to the motor.

The stationary part consists of a yoke, pole piece, field coil, an armature, a brush and rear bracket, while the moving part comprises an armature and overrunning clutch.

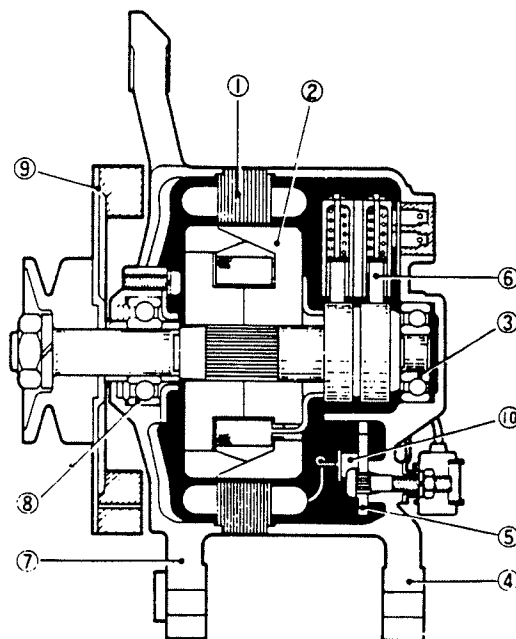
The magnetic switch is composed of an iron core, plunger and contactor coil. The plunger and the clutch are connected via the lever.

### ALTERNATOR

Model .....021000-2431  
 Type .....AC type  
 Nominal output. ....12V-35A  
 Direction of rotation...CW (viewed from pulley side)  
 Weight.....About 3.6 kg



Wiring



- 1 Stator
- 2 Rotor
- 3 Ball bearing
- 4 Rear bracket
- 5 Fin complete
- 6 Brush
- 7 Front bracket
- 8 Ball bearing
- 9 Pulley
- 10 Diode

Cross Section of Alternator

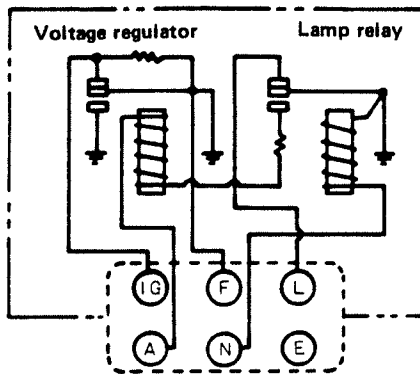
The alternator is a three-phase AC motor equipped with a diode rectifier and is driven by the crankshaft pulley via the V-belt.

The alternator is mainly composed of the moving part and the stationary part. The moving part

comprises a rotor, ball bearing pulley with fan, etc, while the stationary part consists of an armature, a front bracket, rear bracket, fin complete, brush, etc. Diodes ( +3, -3) are secured on the fin complete (heat sink).



## REGULATOR



Wiring Diagram

The regulator is composed of voltage regulator and lamp relay, the wiring thereof are together contained in the connector.

The voltage regulator is for keeping the power generated by the alternator constant regardless of the alternator speed and on/off the current to the field coil as required.

The lamp relay is for extinguishing the pilot lamp by the use of neutral voltage (N terminal voltage) of the alternator.

That is, this lamp is off while the alternator is generating power.

## ELECTRIC SYSTEM DISASSEMBLY, ASSEMBLY AND ADJUSTMENT

### Disassembly

1. Starting Motor
  - a. Disconnect the cable from the battery terminal.
  - b. Disconnect wiring from terminals B and S.
  - c. Remove the mounting bolt and remove the starting motor.
2. Alternator
  - a. Disconnect the cable from the battery terminal.
  - b. Disconnect each wiring on the alternator rear panel.
  - c. Remove the alternator brace bolt and remove the V-belt.
  - d. Loosen the support bolt and remove the alternator.

### Assembly and Adjustment

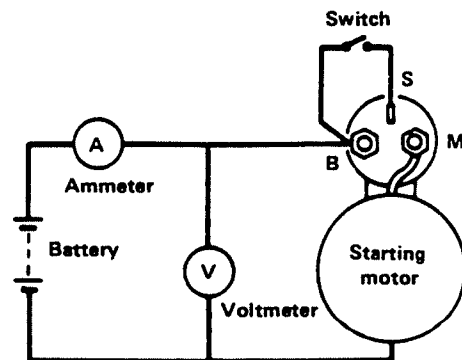
#### 1. Starting Motor

When the engine does not start upon the starter switch ON, do not hastily take it as a starting motor trouble.

The cause of the trouble may be in the starting motor but it is also possible that other switch or some part of engine is in trouble. Therefore, check the starting circuit with the starting motor installed. If no abnormality is found, remove the motor from the engine and test it.

- a. Check items of starting circuit
  - 1) Charge condition of battery
  - 2) Tightening of battery terminal
  - 3) Tightening of Starting motor terminal
  - 4) Wiring (grounding, disconnected wire)
  - 5) Grounding of starting motor
  - 6) Starter switch
- b. No-load test

Connect the starting motor, ammeter, voltmeter and switch as shown. Set the switch ON, then measure the motor speed, voltage and current. If the value obtained does not correspond to the standard value, trouble-shoot according to the table below and correct it.

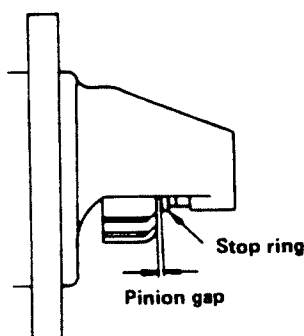


No-load Test Wiring

### Trouble shooting

Sympton	Probable cause
1. Great current & low motor speed . . . . .	Loss of bush oil, bush damage
	Friction of armature & pole piece
	Grounded armature coil & field coil.
	Shorted armature coil.

2. Great current & no turning . . . . .  
Grounded magnetic switch  
Grounded armature coil & field coil.  
Seized bush.
  3. No current, No turning . . . . .  
Discnnected armature coil & fild coil.  
Disconnected pigtail of brush.  
Poor contact of brush & commutator.
  4. Small current & low motor speed . . . . .  
Poorly connected field coil.
  5. Great current & high motor speed. . . . .  
Shorted field coil.
- c. Replace the brush if it is worn beyond the service limit.
  - d. Measure the gap (pinion gap) between the pinion and the stop ring as follows: When the battery is connected between the 3 terminal of the magnetic switch and the starting motor body, the pinion projects and comes to rest. In this condition, gently push the pinion back to the armature side and measure the gap.



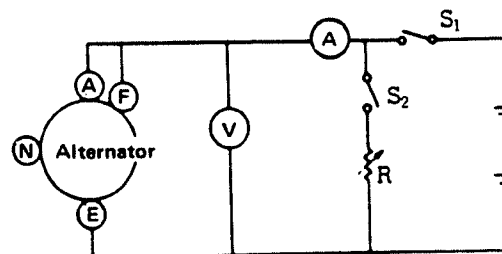
Measuring Pinion Gap

**Note:**

1. Disconnect the connector of M terminal while the pinion gap is measured.
2. Assemble by reversing the steps for disassembly. However, note the following.
3. Thoroughly clean the front bracket flange of the starting motor and the starting motor mounting face of the crankcase. Be sure to remove coating, oil, rust, etc. before installation.

**Alternator**

For the alternator performance test, connect an ammeter, voltmeter, switch, variable resistor, and battery as shown and cause the alternator to be driven by the motor.



Performance Test

- a. No-load test  
Turn the alternator and set the switch S1 ON and the excitation current flows from the battery to the alternator field coil. In this condition, gradually increase the alternator speed until reverse current to the field coil is not present, set the switch S1 OFF, further increase the alternator speed and read rpm when the voltmeter indicates 14V. Satisfactory if the reading is below 1300 rpm.
- b. Output test  
With load resistance (variable resistor) R set at the maximum and in the condition that almost no load current flows, set the switches S1 and S2 ON. Increase the alternator speed while gradually increasing the load current. Satisfactory if the alternator speed is less than 300 rpm at the terminal voltage of 14V and current of 15A.  
Assemble by reversing the steps for disassembly. Note the following.
- c. Wire carefully.
- d. Adjust tension of V-belt.

**Notes on handling:**

1. Do not use a high pressure tester such as megger. Otherwise the diode may be broken.
2. Perform quick charging, if required, with the quick charger or the like with the battery terminal removed.

**Regulator**

- a. Checking no-load adjustment valve

Connect the voltmeter between terminals A and E of the regulator, remove the terminal B during engine idling and increase the alternator speed to 4000 rpm. Satisfactory if the voltage at this time is 14.0 ~ 15.0 V.

Notes on handling:

1. Note that the regulator is sealed.
2. Do not operate the engine with the regulator coupler removed.

**Glow Plug and Glow Lamp**

- a. Satisfactory if the plug tip is red heated when the positive pole of the battery and the negative pole of the battery are connected to the terminal and the body respectively.
- b. Check if it takes a long time to red heat the glow lamp with the engine installed. Either one of two lamps may have blown. The glow lamp should be red heated within approx. 25 seconds.
- c. Check the glow lamp for fused filament.

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## GENERAL

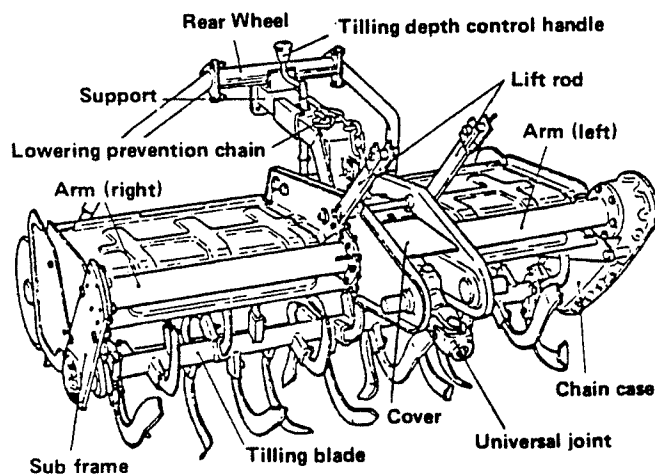
Satoh Rotary Tiller, Model 2PR-1100S, is a chain side drive type rotary tiller designed for Satoh Tractor "Beaver" (Model S-370 & S-370D) on the basis of year's study and latest technology of Satoh. It is a light, compact, high-performance and durable tiller which has been manufactured from well-selected materials, finished precisely, assembled with utmost care and then inspected strictly in the factory provided with the excellent quality control system and the latest engineering equipment. Special method of using a bracket greatly facilitates its mounting and demounting. Mounted on a tractor, the tiller is well-balanced and given enough ground clearance. Tilling width of 43.4 in. (1,100 mm) is obtained with 28 pieces of blades. Tilling shaft rotates at the speed of 153, 226 or

371 rpm at the rated engine revolution according to the speed of P.T.O. shaft of the tractor. By selecting appropriate tilling shaft speed and forward speed of the tractor the most efficient operation is ensured for each field condition.

The blade holder is attached to the tilling shaft at a sweepback angle to provide smooth tilling operation and prevent entangling grass or straw.

The blade with excellent durability has been designed so that it may reverse and crush any type of soil without wasting power. Depth adjustment is made easily from the operator's seat with a handle. Ridger is equipped as option for ridging operation. In paddy fields, the tilling shaft can be replaced with plowing rotor. Thus, the Satoh "Beaver" tractor can fully show its excellent performance in wider areas of operation.

## CONSTRUCTION



Satoh rotary tiller (Model 2PR-1100S) is a light, small size rotary tiller of a chain side drive type. It is mounted on a tractor using a bracket. One person can mount and demount the tiller to the tractor easily. For its installation, insert the shaft fitted to the rotary tiller frame into the U-shaped part of the rotary tiller frame into the U-shaped part of transmission case, fit the sleeve and fix with a pin. The height of the rotary is controlled with the hydraulic system of the tractor by means of the left and right lift rods set to the frame.

Power is transmitted to the rotary tiller gear box through P.T.O. shaft and universal joint of the

tractor and then turned in its direction with the spiral bevel gear incorporated in the gear box.

The tilling shaft is rotated by the chain in the chain case mounted on the left side of the rotary tiller cover, by which the blades mounted on the tilling shaft behave for digging out the ground and reversing to crush the soil and then the rear cover levels the ground.

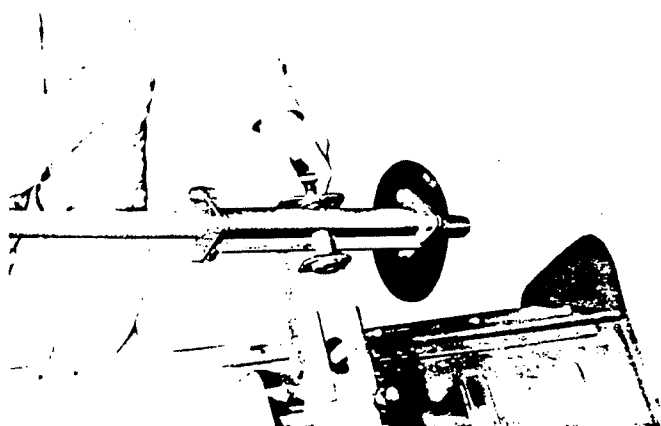
A frame is set to the frame for the center of the rotary tiller and a shaft is fixed installing the tiller to the tractor. A lift rod for lifting and lowering the rotary tiller is fitted to the center of the shaft and a support is fitted to the rear side. The support is provided with a gauge wheel and a handle with a screw to control the tilling depth. Lowering prevention chain for preventing the rotary chain from lowering naturally while traveling, and universal joint cover are provided to ensure safe operation. Each rotating part is completely water-and dust-proof and excellent in durability.

As an optional part, ridger fitting support is set to behind the support. The tilling shaft can be easily detached and replaced with a plowing rotor or other parts in the paddy field.

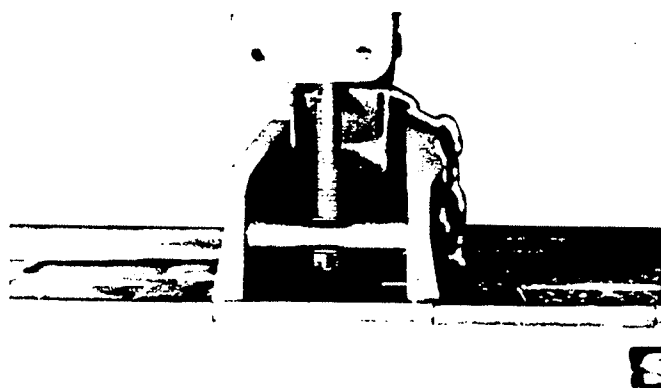
## DISASSEMBLY OF THE ROTARY TILLER

The rotary tiller should be cleaned by washing to remove mud and dirt before disassembling.

1. With the tiller mounted on the tractor, drain the oil from the chain case after removing the drain plug.  
After that, detach the tiller from the tractor.
2. After the tiller is detached from tractor, drain the oil from the gear box after removing the drain plug.
3. Remove the depth wheel gauge after removing the depth gauge wheel set pin.

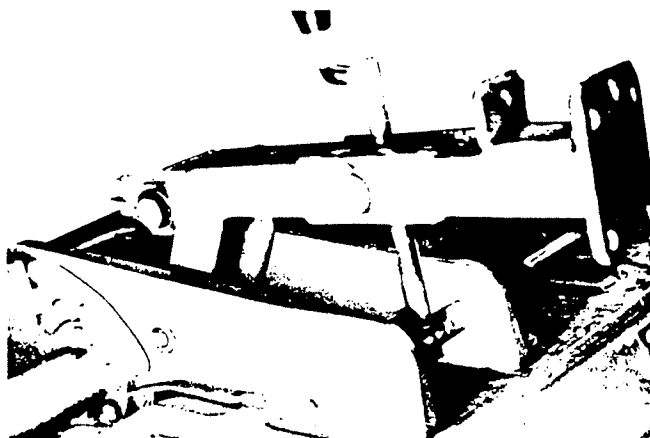


Removing the depth wheel gauge



Removing the castle nut

4. Remove the cotter pin locking the castle nut at the underside of the depth control sled, and then loosen the castle nut.
5. Remove the cotter pin from the shaft at the fulcrum of the support and frame and remove the support.



Removing the support

6. Loosen the bolts for tightening the frame, cover chain case and side plate, and remove the cover.
7. Raise the bent portion of the lock washer of the bolt which holds the frame to the gear box and loosen the bolt. Remove the frame after loosening the bolt holding the cover plate and frame.
8. Remove the rotary shaft by loosening both sides of the mounting portion.
9. Remove the chain case cover and then remove the tension springs. Loosen the circlip setting the sprocket wheel and release the lock of the tab washer. Remove the sleeve nut and then remove the sprocket wheel with its chain.
10. Remove the chain case carefully after loosening the arms (LH) and bolts.
11. Pull out the rotary shaft (L.H.) from the lower portion of the chain case by tapping lightly it; then remove the circlip and ball bearing oil seal.
12. Remove the left arm from the gear box.
13. Remove the pinion bearing case paying attention to the shims between the case and gear box.
14. Remove the rubber cap from the pinion bearing case, raise the bent portion of the tab washer and loosen the sleeve nut. Take out the pinion gear oil seal, bush and taper roller bearing.
15. Release the lock of the driveshaft tab washer and loosen the sleeve nut. Take out the driveshaft from the gear box after removing the bevel gear.
16. Loosen the bolt tightening the right arm and

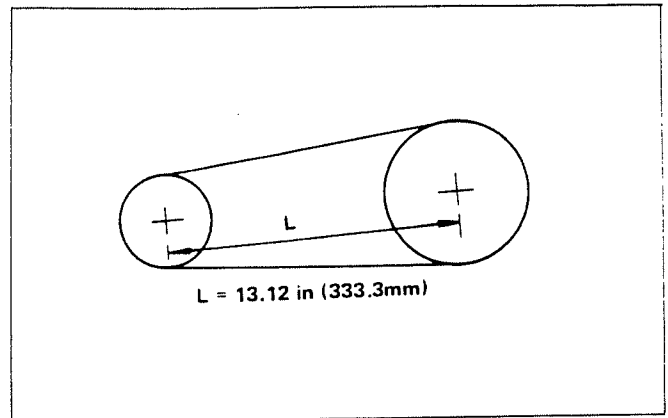
### 9-3 OTHERS

remove the gear box.

17. Remove the cover under the plate and the circlip and pull out the rotary shaft (R.H.).
18. Remove the bearing housing from the plate and remove the ball bearing oil seal.

### INSPECTION

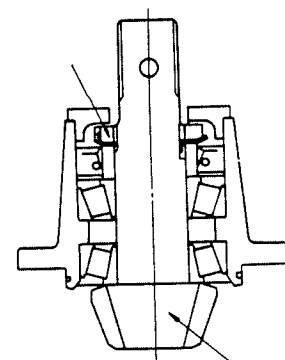
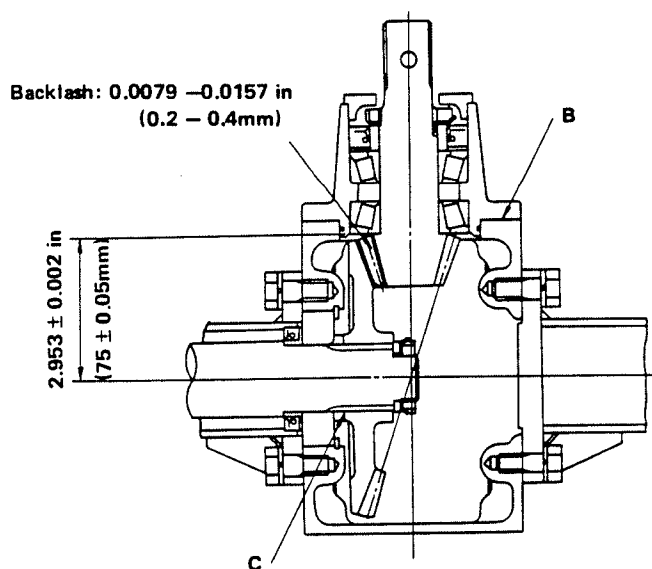
Inspect chains for excessive pitching on the surface of the chain roller. Excessively bent or cracked bushes should be replaced with new ones.



### ASSEMBLY OF THE ROTARY TILLER

1. Parts should be carefully washed with cleaning oil and checked for damage, wear or other defects.  
Repair any defect or replace with new parts, if necessary.
2. In principle, new oil seals, "O" rings, gaskets, circlips and cotter pins should be used.
3. Be sure to check whether the ball bearing rotates smoothly. If any resistance is felt during rotation, replace with a new one.
4. Deteriorated rubber parts should be replaced with new ones.
5. If the rotary shaft is bent or the tine holder is cracked, they should be repaired or replaced with new parts.
6. Grease should be applied to all sliding parts and revolving parts and they should be carefully assembled in accordance with the specified dimensions.

### Assembly of the Gear Box



Preload:  $1.44 - 2.88 \text{ ft-lb}$   
 $(0.2 - 0.4 \text{ kg-m})$

Assembly diagram of the gear box

1. Install the taper roller bearing on the pinion shaft paying attention to the direction.
2. Install the taper roller bearing on the pinion bearing case paying attention to the direction of its outer race.
3. Install the pinion shaft, with the taper roller bearing mounted, in the pinion bearing case and push the bearing into it.
4. Install the oil seal bush and push in a grease-coated oil seal. Tighten the sleeve nut with a tab washer.

Preload: 1.44 – 2.88 ft-lb  
(0.2 – 0.4 kg-m)

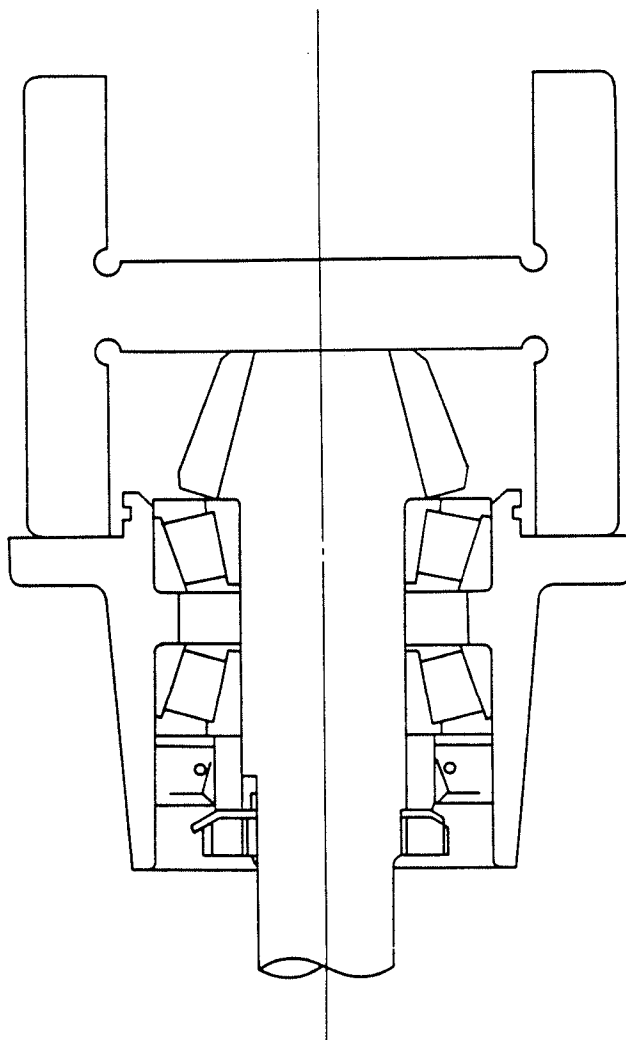
After setting the proper preload, bend the tab washer and lock the sleeve nut.

5. Select shims by using a special tool so that the cone center of pinion shaft becomes  $75 \pm 0.05\text{mm}$ .

Measurement of the cone center

Pinion shaft cone center  $2.953 \pm 0.002\text{ in.}$   
( $75 \pm 0.05\text{mm}$ )

Place a Special tool on the pinion gear, measure the gap between the top end of the tool and the mounting place of the pinion bearing case. Place shims to fit the gap between the gear box and tighten the gear box after adjusting the backlash of the bevel gear.



Thickness of the shim

Part No.1136-3011-000: 0.004 inch (0.1mm)

1136-3012-000: 0.0079 inch (0.2mm)

1136-3013-000: 0.0157 inch (0.4mm)



**Backlash of the Bevel Gear**

1. Set circlips in the gear box.
2. Install the oil seal, bush and oil seal ball bearing on the shaft which in turn is installed in the gear box. Install the left arm in the box.  
Tightening torque: 15.2 – 21.7 ft-lb  
(2.10 – 3.0 kg-m)
3. Apply grease to the oil seal and install under the chain case. Push a ball bearing into it and set it with circlips.
4. Carefully push an oil seal bush onto the rotary shaft (L.H.) and install the shaft, with adhesive applied on its gear box mounting surface, in the chain case.
5. Install the chain case on the left arm by loosely tightening the bolts and push a ball bearing onto the drive shaft. After that, tighten the bolts securely.  
Tightening torque: 43.3 – 50.6 ft-lb  
(6.0 – 7.0 kg-m)
6. Place the collar, bevel gear and washer in sequence on the drive shaft of the gear box and tighten them with a sleeve nut. Together with shims which have been selected so that the cone center is  $2.953 \pm 0.02$  inch ( $7.5 \pm 0.05$  mm), install the pinion bearing case without an "O" ring in the gear box, and adjust the bevel gear so that the backlash is 0.0079 to 0.0157 inch (0.2 – 0.4mm) by placing shims between the collar and bevel gear.

Thickness of the shim:

Part No. 1136-3011-000	0.004 inch	(0.1mm)
1136-3012-000	0.0079 inch	(0.2mm)
1136-3013-000	0.0157 inch	(0.4mm)

7. After proper backlash is obtained, remove the pinion gear case and install a grease-coated "O" ring on the case; then install it again in the gear box with the same thickness and number of shims.  
Tightening torque: 28.9 – 36.1 ft-lb  
(4.0 – 5.0 kg-m)
8. Together with the chain, install the sprocket on the shaft with its boss facing inside and fix it to the respective shaft with circlips and sleeve nuts.
9. Install the chain tension springs and confirm that the chain is properly tensioned. Install

the cover with a gasket.

Tightening torque: 8.67 – 12.3 ft-lb  
(1.2 – 1.7 kg-m)

10. Apply grease to an oil seal and install on the right bearing holder. Place rotary shaft R.H. in the bearing holder, push a ball bearing into it and set them with circlips.
11. Install the bearing holder on the side plate and fill it with grease. Tighten it together with the gasket cover.  
Tightening torque: 15.2 – 21.7 ft-lb  
(2.1 – 3.0 kg-m)
12. Install the R.H. arm in the gear case with its rib placed at a position corresponding to that of the left arm rib and apply adhesive to the gear case mounting surface.  
Tightening torque: 15.2 – 21.7 ft-lb  
(2.10 – 3.0 kg-m)
13. Install the side plate on the R.H. arm.  
Tightening torque: 43.3 – 50.6 ft-lb  
(6.0 – 7.0 kg-m)
14. Install the rotary cover. Use bolts wrapped with sealing tape for the through tap holes in the chain case side. Leave the bolts tentatively tightened.
15. Install the frame on the gear box with the bolts loosely tightened. Tighten each bolt fully with care after the support is installed.
16. Confirm that the pinion shaft to which the rotary pipe is to be installed rotates smoothly by turning it by hand. Fill the gear box with oil and install the gear box cover.  
Tightening torque:  
Cover 8.67 – 12.3 ft-lb (1.2 – 1.7 kg-m)  
Pipe 68.7 – 79.5 ft-lb (9.5 – 11.0 kg-m)
17. Install the castle nut for depth control and confirm that it operates smoothly. Next, install the depth gauge wheel.
18. Mount it on the tractor paying attention to the direction of the universal joint.

**SPECIFICATIONS**

Model . . . . .2PR-1100S

Type . . . . .Side drive type rotary tiller

Applicable Tractor . . . .Satoh Beaver S-370 and  
S-370D

Overall length . . . .46.54 in. (1,182 mm)

Overall width. . . .48.90 in. (1,242 mm)

Overall height . . . .31.69 in. (805 mm)

Tilling width . . . .43.31 in. (1,100 mm)

Tilling depth . . . .7.09 in. (180 mm)

**Tilling Blade**

Diameter . . . . .17.72 in. (450 mm)

Weight . . . . .289 lb (131 kg)

Number of blade . .28

Mounting method

Special 2 point hitch

Drive system . . . . .Universal joint spiral bevel  
gear, chain side driveDepth control . . . .Lifting and lowering of rear  
gauge wheel with a handle**Tilling shaft revolution**

C-1: 153 rpm

C-2: 226 rpm

C-3: 371 rpm

Holder pitch . . . .1.83 in. (46.38)

Tilling pitch

Unit: in. (mm)

	C-1	C-2	C-3
F-1	4.13 (105)	2.75 ( 70)	1.73 ( 44)
F-2	6.41 (163)	4.25 (108)	2.67 ( 68)
F-3	10.23 (260)	6.77 (172)	4.25 (108)

**Oil Capacity**

Gear case oil . . . .0.85 pint (0.4 liter)

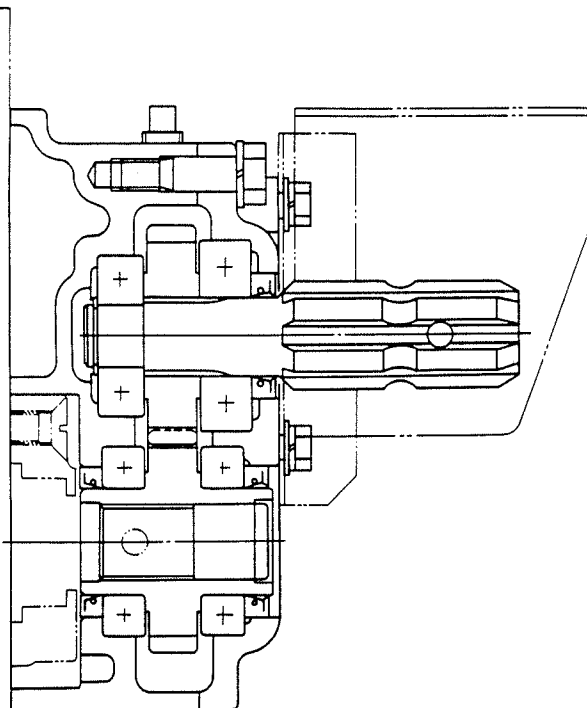
SAE#8 ~ 90 gear oil

Chain case oil . . . .0.65 pint (0.3 liter)

SAE#80 ~ 90 gear oil

★ These specifications are subject to change with-  
out previous notice.

## REAR P.T.O. ADAPTOR



### General and Construction

The Rear P.T.O. adaptor for the Satoh Beaver (Model S-370 & S-370D) can be attached to the rear of the tractor with 6 bolts. The P.T.O. shaft has a SAE 1-3/8 6 spline and provides 3 speeds of 537, 791 and 1297rpm from the engine's rated 2,700rpm by means of the P.T.O. variable speed lever.

### Disassembly of the Rear P.T.O. Adapter

1. Detach the rear P.T.O. adapter after loosening the 6 bolts fixing it to the transmission case.
2. Remove the P.T.O. guard, and divide case A from case B by loosening the 7 bolts.
3. After removing the P.T.O. shaft and circlips, remove the ball bearing, gear, ball bearing, oil seal.
4. Remove P.T.O. drive gear 27, and then remove the oil seal and ball bearing.

### Assembly of the Rear P.T.O. Adapter

Parts should be thoroughly washed and checked for any defect or abnormality; then apply oil or grease to the revolving parts. Assemble the parts with care.

1. Coat the oil seal with grease and install it on the P.T.O. shaft; then install the ball bearing,

gear and ball bearing and set them with circlips.

2. Apply grease to the ball bearing and oil seal and install it on both sides of P.T.O. drive gear 27T.
3. Assemble P.T.O. drive gear 27T with its spline portion facing the transmission case side in case A.
4. Assemble the P.T.O. shaft in case A in the same manner, and connect and tighten together case A and B with bolts after applying adhesive to their joining surface. Use a reamer bolt for the lower left hole and install the cover.

Tightening torque: 36.1 – 43.3 ft-lb  
(5.0 – 6.0 kg-m)

Reamer bolt: 28.9 – 36.1 ft-lb  
(4.0 – 5.0 kg-m)

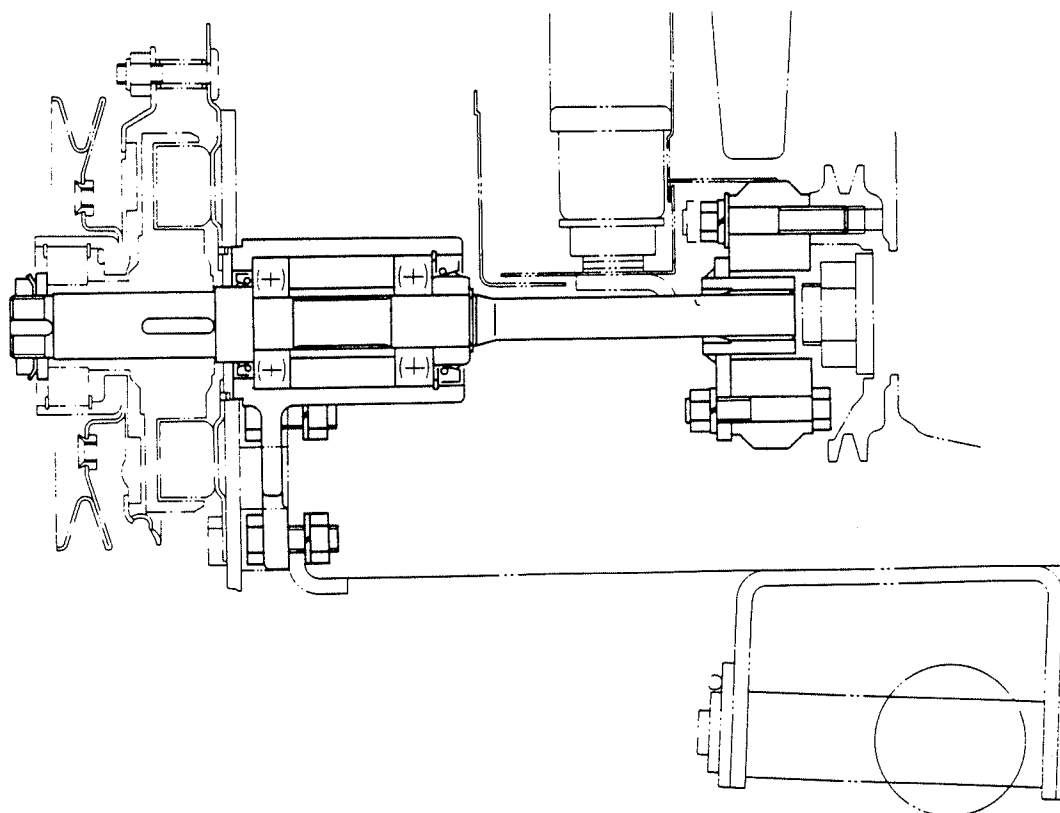
5. Fill the case with oil, install the P.T.O. guard and attach it to the rear of the tractor.

Tightening torque: 32.5 – 39.7 ft-lb  
(4.5 – 5.5 kg-m)

### SPECIFICATIONS:

P.T.O. shaft	SAE 1-3/8
No. of revolutions	
First speed:	537rpm at Engine 2700rpm
Second:	791rpm at Engine 2700rpm
Third:	1,297rpm at Engine 2700rpm

## FRONT P.T.O. KIT

**General and Construction**

This kit is capable of taking power from the engine to the front side of the tractor through a CG rubber coupling installed on the crank pulley of the engine. Since power can be directly obtained from the crankshaft of the engine, it is capable of driving working machines such as mowers, sweepers, snow blowers, etc. as long as the engine is operating.

**Disassembly of the Front P.T.O.**

1. In case the kit is equipped with an electric magnetic clutch, remove the guard and disconnect the connector of the electric cord. Remove the V-belt after loosening the tension pulley. Raise the bent portion of the tab washer at the top of the electric magnetic clutch and loosen the sleeve nut. Then remove the clutch after removing the bolts fixing the base.
2. Remove the front P.T.O. by loosening the bolts fixing the bracket to the chassis.
3. Remove the circlips and pull out the shaft by tapping it forward with a plastic hammer.
4. Remove the oil seal collar, oil seal, and then remove the circlips.
5. Remove the ball bearing collar from the bracket.

**Assembly of the Front P.T.O.**

1. Apply grease to the oil seal and install it in the front of the bracket.
2. Install the ball bearing collar, ball bearing and oil seal collar on the P.T.O. shaft, assemble it on the bracket and set it with circlips.
3. Apply grease to the oil seal and install it on the bracket.
4. Lightly apply grease to the spline portion of the P.T.O. shaft, install it on the flange of the CG coupling, install the bracket on the chassis and tighten them taking care to avoid looseness of the P.T.O. shaft.  
Tightening torque: 36.1 – 43.3 ft-lb  
(5.0 – 6.0 kg-m)
5. Assemble the electric magnetic clutch in the reverse order to the disassembly.