INTRODUCTION

This Workshop Manual is composed of three sections.

■ **First section**
Servicing information for the F2000 Kubota front mower.

■ **Second section**
Servicing information for the F2000-II and F2400 Kubota front mowers. Please note, however, that the servicing information for the F2000 which applies also to the F2000-II and F2400 is not repeated in this section.

■ **Third section**
Servicing information for the F2400B Kubota front mowers. Please note, however, that the servicing information for the F2400 which applies also to the F2400B is not repeated in this section.

Please make full use of this workshop manual to service Kubota front mowers and ensure your customers' complete satisfaction

April. '91

TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the mechanism, service and maintenance of KUBOTA Front Mower F2000. It is divided into two parts, "Mechanism" and "Servicing".

■ **Mechanism**

Information on construction and function are included for each section. This part should be understood before proceeding with troubleshooting, disassembling and servicing.

■ **Servicing**

Under the heading "General" comes general precautions, check and maintenance and special tools. For each section, there are troubleshooting, servicing specification lists, checking and adjusting, disassembling and assembling, and servicing which cover procedures, precautions, factory specifications and allowable limits.

All information, illustrations and specifications contained in this manual are based on the latest production information available at the time of publication.

The right is reserved to make changes in all information at any time without notice.

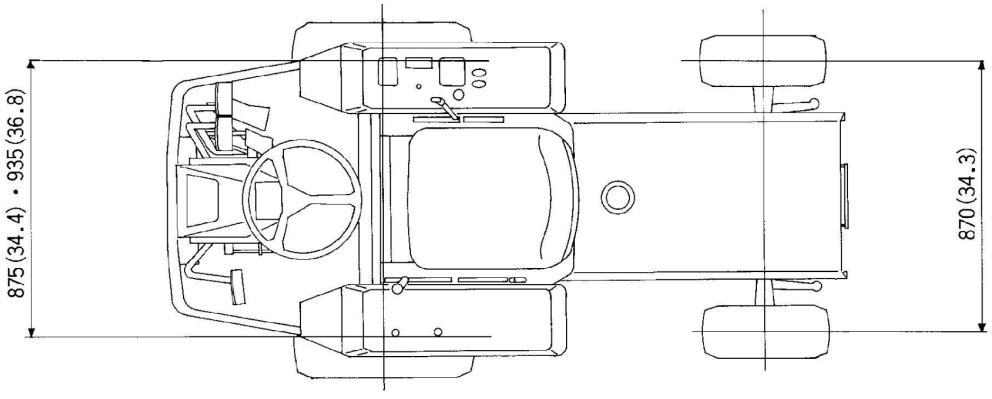
May '87

SPECIFICATIONS

Model			F2000
Maximum P.T.O. power			16.5 HP (12.3 kW)
Engine gross H.P. (SAE)			20 HP (14.9 kW)
Engine	Model		D950-FM
	Type		Vertical, water cooled, 4-cycle diesel
	Number of cylinders		3
	Bore and stroke		75 mm x 70 mm (3.0 in. x 2.8 in.)
	Total displacement		927 cm^3 (56.6 cu.in.)
	Rated revolution		2600 rpm (43.3 r/s)
	Combustion chamber		Spherical Type
	Fuel injection pump		Bosh type K mini pump (NP-PFR3KD50/2 NP4)
	Governor		Centrifugal ball mechanical governor
	Injection nozzle		"Throttle" type (ND-DN12 SD12)
	Injection timing		20° to 22° before top dead center
	Injection order		1–2–3
	Injection pressure		13.73 MPa (140 kgf/cm^2, 1991 psi)
	Compression ratio		22
	Lubricating system		Forced lubrication by trochoidal pump
	Cooling system		Water with pressurized radiator
	Lubricating oil		MIL-L-2104B or MIL-L-2104C, quality better than CC class (API)
	Starting system		Electric starter with battery, glow plug, 12V, 0.8 kW
	AC dynamo		12 V (150 W)
	Battery		12 V (65 Ah)
	Fuel		Diesel fuel No.2-D [No.1 diesel fuel, if temperature is below −10°C (15°F)]
	Weight (Dry)		105 kg (232 lbs)
Capacities	Fuel tank		34 ℓ (9.0 U.S. gals.)
	Engine crankcase		3.1 ℓ (3.3 U.S. qts.)
	Engine coolant		3.7 ℓ (3.9 U.S. qts.)
	Transmission case		12.7 ℓ (13.4 U.S. qts.)
	Rear axle diff. case		1.5 ℓ (1.6 U.S. qts.)
	Rear axle gear case		0.5 ℓ (0.5 U.S. qts.)
Tires	Front		23 x 10.50–12 (4PR) Turf
	Rear		16 x 6.50–8 (4PR) Turf
Traveling speeds	Forward	Low	0 to 7.4 m/h (4.6 mph)
		High	0 to 15.2 m/h (9.5 mph)
	Reverse	Low	0 to 4.4 m/h (2.8 mph)
		High	0 to 9.0 m/h (5.6 mph)
Dimensions	Overall length		2190 mm (86.2 in.)
	Overall width		1140 mm (44.9 in.)
	Overall height		1260 mm (49.6 in.)
	Wheel base		1235 mm (48.6 in.)
	Minimum ground clearance		175 mm (6.9 in.)
	Treads	Front	875 mm (34.4 in.) · 935 mm (36.8 in.)
		Rear	870 mm (34.3 in.)
Weight			625 kg (1380 lbs) w/o mower deck
PTO shaft			Transmission case front
Front PTO			Kubota 10 tooth involute spline, 2 speeds (1130 and 2550 rpm at 2600 engine rpm) (18.9 and 42.5 r/s at 43.3 engine r/s)
Clutch			Dry single
Steering			Power, hydrostatic
Transmission			Main-hydrostatic transmission, High-Low gear shift (2 forward, 2 reverse)
Minimum turning radius m (feet)			LH 0.53 m (1.7 feet) w/o brake
Brake			Internal expanding type, right and left independent with interlocking device
Differential			Bevel gear

DIMENSIONS

mm (in.)



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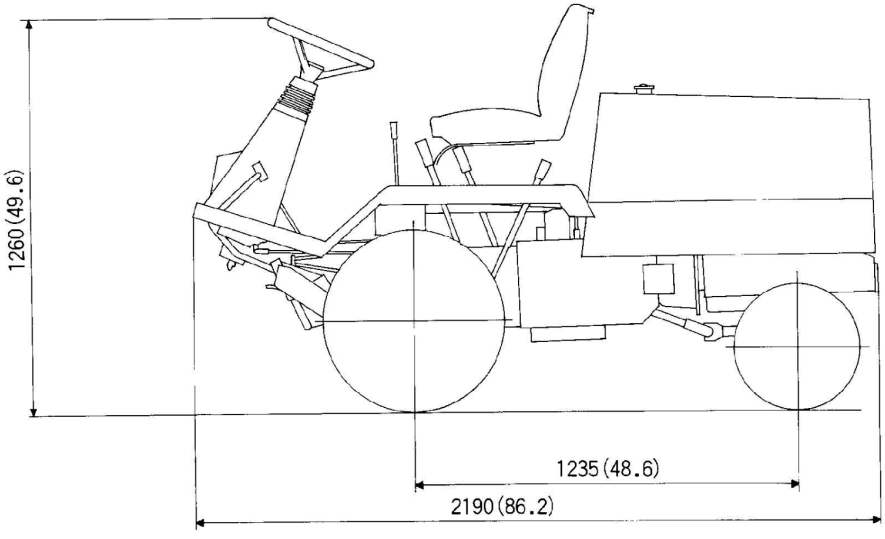

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M MECHANISM

M MECHANISM

CONTENTS

F FEATURES

■ **Vertical, Water-cooled, 3-Cylinder Diesel Engine**
The quiet Kubota water-cooled 3-cylinder diesel engine produces high torque rise, maximum work efficiency, and reduced fuel costs.

■ **Hydrostatic Transmission**
The hydrostatic transmission [HST], with high-low range selection, permits matching the optimum speed to the task at hand.

■ **2 Pedal System Speed Control with Cruise Control**
With the hydrostatic transmission, gear shifting is accomplished by an independent forward and rear 2 pedal system with cruise control.

■ **Hydrostatic Power Steering**
Hydrostatic power steering reduces work fatigue. And the rear wheel steering, by permitting a tighter turning radius, makes cutting around trees much easier.

■ **4WD**
4WD, with its greater tractive power, makes work on slopes or soft ground possible.

■ **Front Wheel Differential Lock**
The front wheel differential lock is superb for assisting the negotiation of slopes and soft or slippery ground.

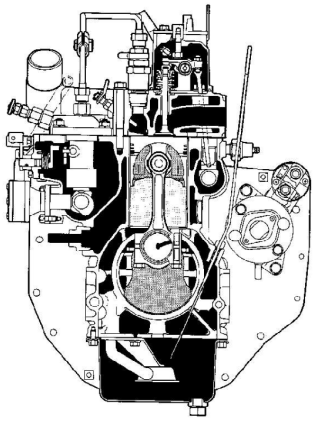
■ **Independent Left and Right Brakes**
Independent left and right brakes enhance trimming performance

■ **Front Off-set Mower**
The front off-set mower ensures easier and closer trimming.

1 ENGINE

[1] FEATURES

The D950-FM is a water-cooled, 4-cycle diesel engine, incorporating KUBOTA's leading-edge technology. By utilizing KUBOTA's unique spherical combustion chamber, the well-known Bosch K type injection pump and a well-balanced design, the engine features greater power, low fuel consumption, reduced vibration and quiet operation.



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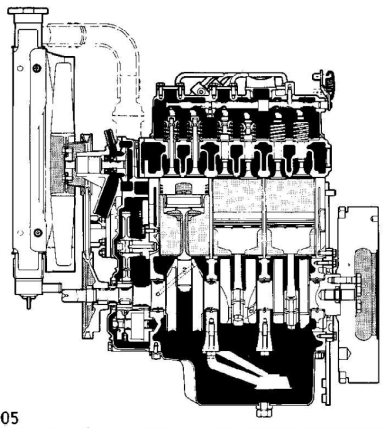

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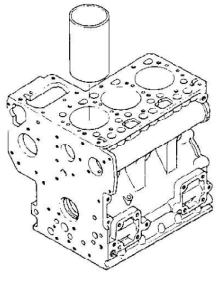
[2] ENGINE BODY

(1) Cylinder Block



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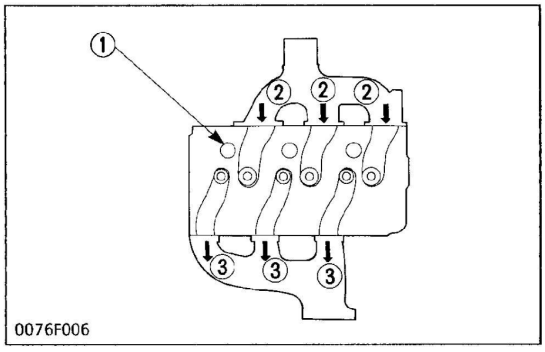
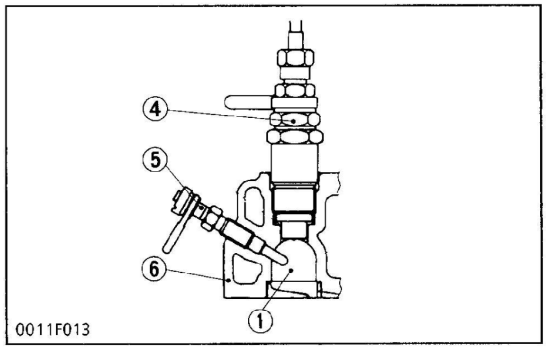
The engine features a highly durable tunnel type cylinder block containing the main bearings. Furthermore, the pressure-fitted dry type cylinder liners allow effective cooling, less distortion, higher wear-resistance qualities and, because each cylinder has its own chamber, noise is minimized.

(2) Cylinder Head



(1) Combustion Chamber
(2) Suction
(3) Exhaust

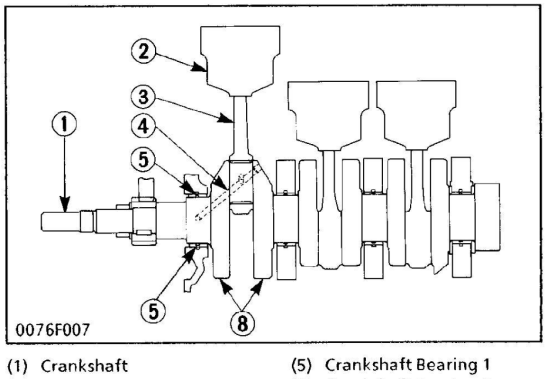


(4) Nozzle Assembly
(5) Glow Plug
(6) Cylinder Head

The cross-flow type inlet/exhaust ports in this engine have their openings at both sides of the cylinder head. Because the overlap between the inlet/exhaust ports is less than that of conventional types having all ports on one side, the drawn in air is prevented from being heated and expanded by the exhaust gases. The cool, high density suction air has a high voluminous efficiency and raises the power of the engine. Furthermore, distortion of the cylinder head by heated exhaust air is reduced because suction ports are arranged alternately. The combustion chamber is of KUBOTA's exclusive spherical combustion chamber type. Suction air is whirled to be mixed effectively with fuel, prompting combustion and reducing fuel consumption.

In the combustion chamber are installed throttle type injection nozzle and rapid heating sheathed type glow plug. This glow plug assures easier than even engine starts even at –15°C (5°F).

(3) Crankshaft



(1) Crankshaft
(2) Piston
(3) Connecting Rod
(4) Oil Passage
(5) Crankshaft Bearing 1
(6) Crankshaft Bearing 2
(7) Side Bearing
(8) Counterweight

The crankshaft (1) is driven by the pistons (2) and connecting rods (3) and converts reciprocating motion into rotary motion. It also drives the oil pump, camshaft and fuel camshaft. Six counterweights (8) are integrated into one unit to minimize bearing wear and lubricating oil temperature rise.

Crankshaft journals, crankpins and oil seal sliding section are induction-hardened to increase wear resistance quality.

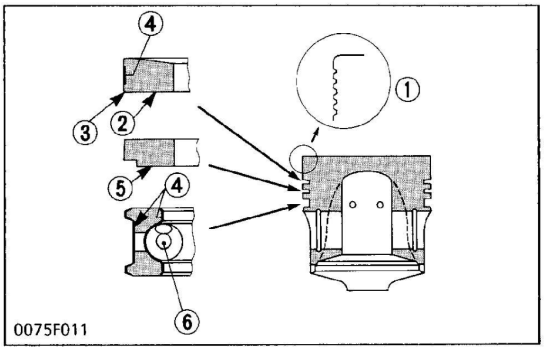
Crankshaft journals are supported by the main bearings.

Crankshaft bearing 1 (5), located at the front end, is a wind type bushing and the three other bearings 2 (6), located behind, are split type bushings.

Side bearings 1, 2 (7) are of split type and are mounted on both sides of the main bearing case 1 at the flywheel side.

Crankshaft bearings and side bearings are plated with a special alloy to increase wear resistance.

(4) Piston and Piston Rings



(1) Rib
(2) Top Ring
(3) Barrel Face
(4) Hard Chrome Plating
(5) Second Ring
(6) Coil Expander Ring

Each piston is machined to an ellipse. This allows for expansion and a perfect fit inside the cylinder bore when the piston becomes hot. The head of the piston is flat. Furthermore, ribs (1) are provided between the piston head and top ring (2) to reduce distortion and to help heat radiation.

The pistons are made of special low thermal expansion aluminum alloy which resist high temperatures.

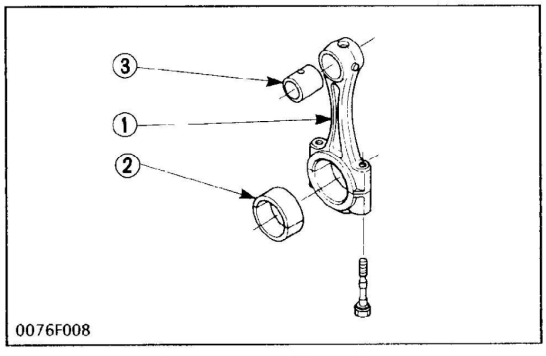
The top ring is of the key stone type which can withstand heavy loads, and the sliding surface to the cylinder wall is shaped into barrel face which is well fitted to the wall and plated with hard chrome.

Second ring (5) is of under-cut type which is effective to prevent oil rising.

Oil ring is effective to scrape oil because it is closely fitted to the cylinder wall by coil expander and the upper and lower ends of its sliding surface are cut diagonally to raise fare pressure to the cylinder walls.

A part of scraped oil is forced into the inside of piston through oil escape holes of rings and piston. The oil ring is plated with hard chrome to increase wear resistance quality.

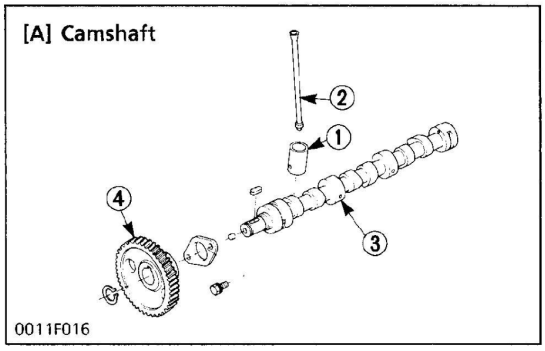
(5) Connecting Rods



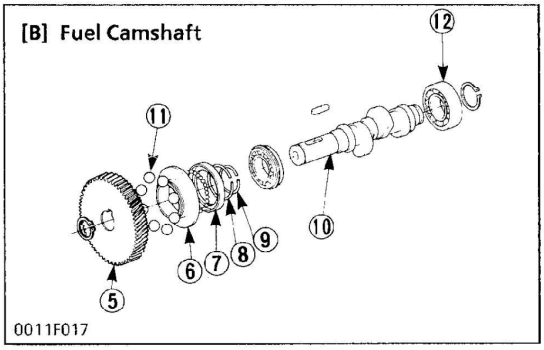
(1) Connecting Rod
(2) Crankpin Bearing
(3) Bushing

Connecting rod (1) is used to connect the piston with the crankshaft. The big end of the connecting rod has crankpin bearings (2) (split type) and the small end has a bushing (Solid type).

(6) Camshaft and Fuel Camshaft



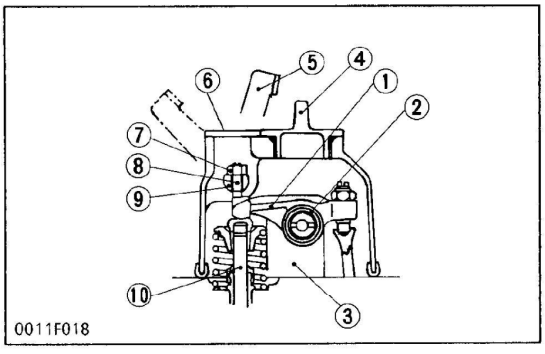
(1) Tappet
(2) Push Rod
(3) Camshaft
(4) Camshaft Gear



(5) Injection Pump Gear
(6) Governor Sleeve
(7) Governor Ball Case
(8) Snap Ring
(9) Snap Ring
(10) Fuel Camshaft
(11) Ball
(12) Ball Bearing

The camshaft (3) is made of special cast iron and the journal and cam sections are chilled to resist wear. The journal sections are force-lubricated. The fuel camshaft controls the reciprocating motion of the injection pump, and is equipped with a ball to control the governor. The fuel camshaft is made of carbon steel and cam sections are quenched and tempered to provide greater wear resistance.

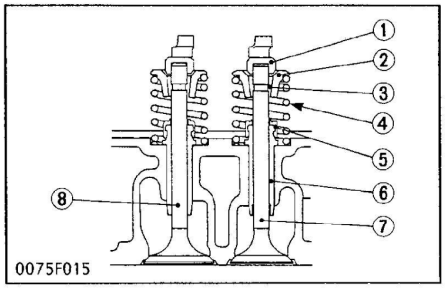
(7) Rocker Arm Assembly



(1) Rocker Arm
(2) Rocker Arm Shaft
(3) Rocker Arm Bracket
(4) Oil Filer Plug
(5) Decompression Lever
(6) Decompression Window Cover
(7) Decompression Nut
(8) Decompression Bolt
(9) Decompression Shaft
(10) Valve

The rocker arm assembly includes the rocker arms (1), rocker arm brackets (3) and rocker arm shaft (2) and converts the reciprocating motion of the push rods to an open/close movement of the inlet and exhaust valves. Valve control timing must be adjusted with screws on the rocker arms. Lubrication oil is pressure fed through the bracket to the rocker arm shaft so that the rocker arm bearings and the entire system are lubricated sufficiently.

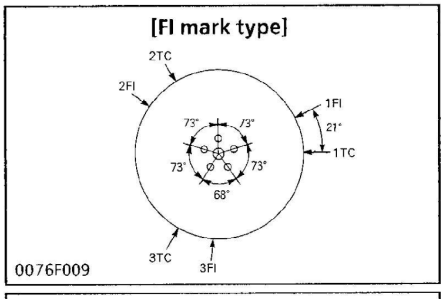
(8) Inlet and Exhaust Valves

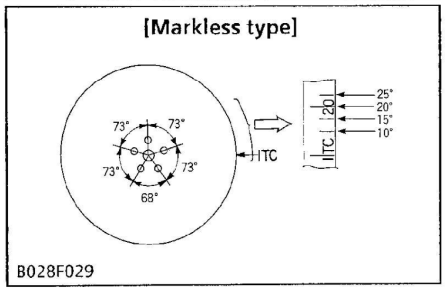


The inlet and exhaust valves (7), (8) and their guides (6) are different from each other. Other parts, such as valve springs (4), valve spring retainers (2), valve spring collets (3), valve stem seals (5), and valve caps (1) are the same for both the inlet and exhaust valves. All contact or sliding parts are quenched and tempered to resist wear.

(1) Valve Cap
(2) Valve Spring Retainer
(3) Valve Spring Collets
(4) Valve Spring
(5) Valve Stem Seal
(6) Valve Guide
(7) Inlet Valve
(8) Exhaust Valve

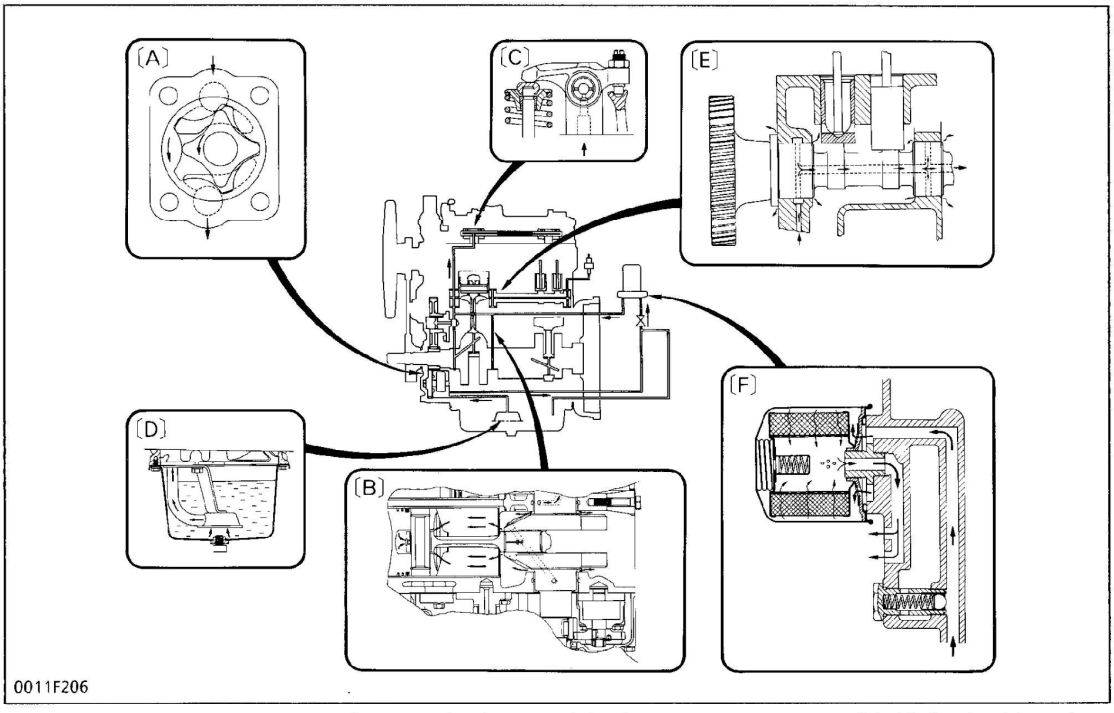
(9) Flywheel





[FI mark type] On the circumference of the flywheel are stamped the fuel injection timing **(FI)** and top dead center **(TC)** marks for each cylinder.
[Markless type] On the circumference of the flywheel are stamped the top dead center **(1TC)** mark for the 1st cylinder and four lines indicating every 0.087 rad. (5°) of crank angle from 0.175 rad. (10°) to 0.436 rad. (25°) before mark **1TC**.

[3] LUBRICATING SYSTEM



[A] Oil Pump
[B] Crankshaft and Piston
[C] Rocker Arm and Rocker Arm Shaft
[D] Oil Strainer
[E] Camshaft
[F] Oil Filter Cartridge and Relief Valve

The lubricating system within this engine consists of an oil strainer, oil pump, relief valve, oil filter cartridge and oil switch.

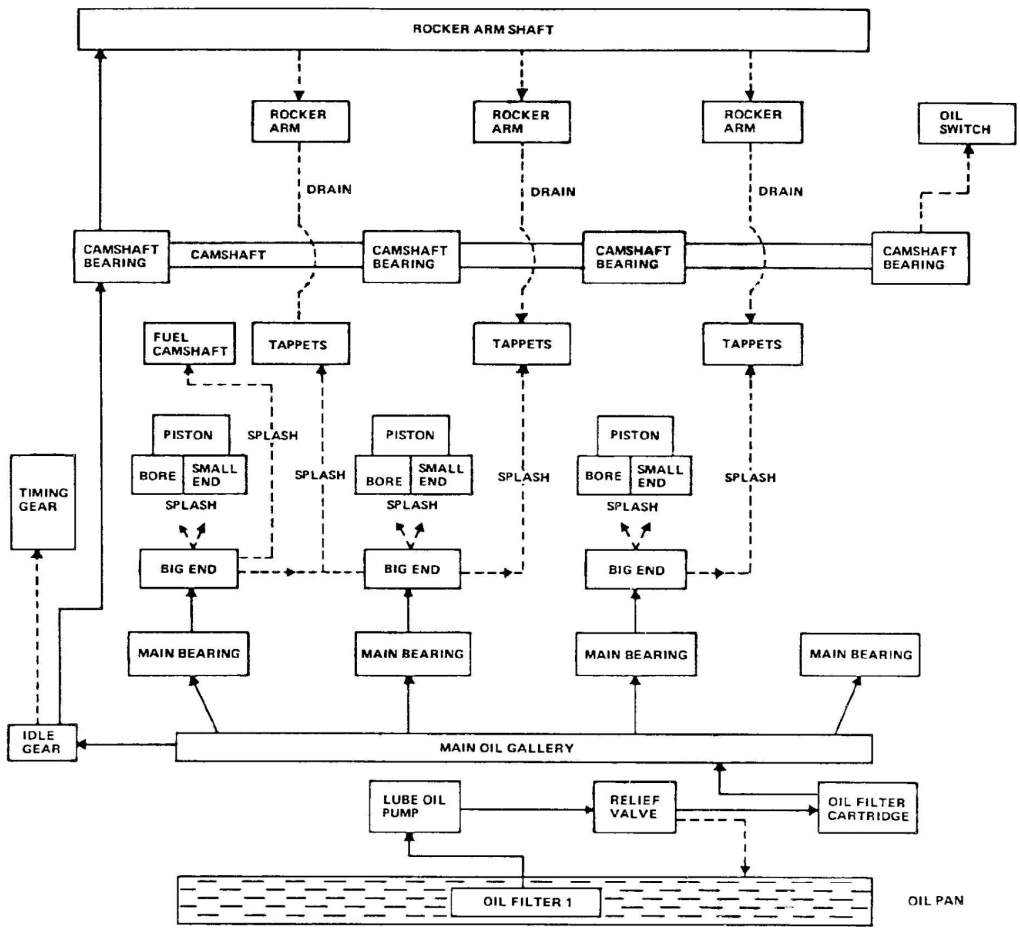
The oil pump draws in lubricating oil from the oil pan through the oil strainer. The oil flows down to the filter cartridge, where it is further filtered.

Then the oil is force-fed to the crankshaft, connecting rods, idle gear, camshaft and rocker arm shaft and lubricates each part.

Some part of oil, splashed by the crankshaft or leaking and dropping from gaps of each part, lubricates these parts: pistons, cylinders, small ends of connecting rods, tappets, push rods, inlet and exhaust valves and timing gears.

■ Engine Oil Flow

[A] Engine Oil Flow



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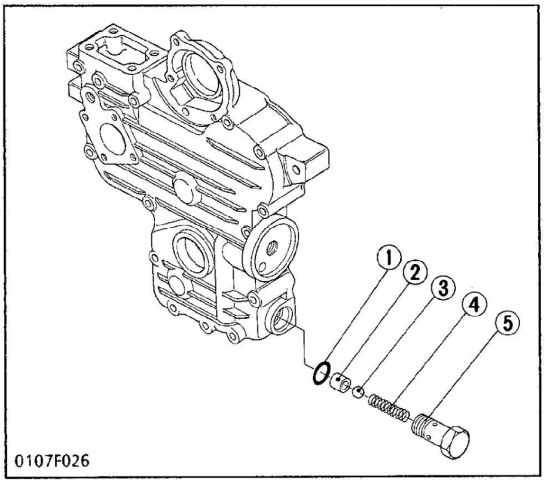
(1) Relief Valve

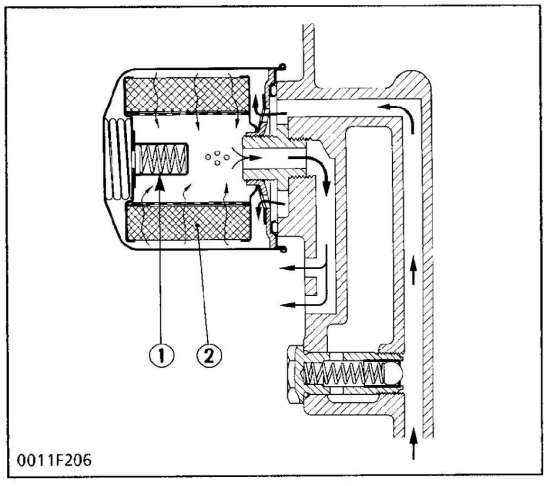


(1) O-ring
(2) Valve Seat
(3) Steel Ball
(4) Spring
(5) Relief Valve Body

The relief valve prevents damage to the lubricating system due to high oil pressure. This relief valve is a ball type direct acting relief valve, and is best suited for low pressures. When oil pressure exceeds the upper limit, the ball (3) is pushed back by the pressure of oil allowing the oil to drain off.

Valve opening pressure at rated speed	167 to 343 kPa 1.7 to 3.5 kgf/cm^2 24 to 49 psi

(2) Oil Filter Cartridge

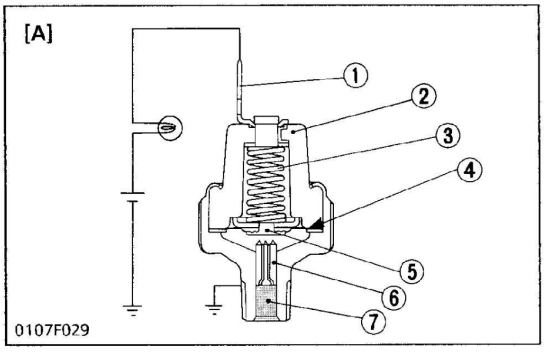


(1) Bypass Valve
(2) Filter Element

Impurities (various metallic chips, and dust, carbon, etc. in the drawn in air) in engine oil can cause components to wear and seize as well as impairing the physical and chemical properties of the oil itself. Impurities contained in force-fed engine oil are absorbed by the filtering medium for removal as they pass through the filter element (2).

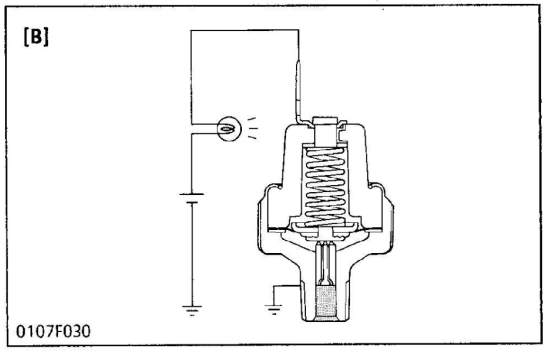
When the filter element is clogged and the oil pressure in the inlet line builds up to 98 kPa (1.0 kgf/cm^2, 14 psi) more than the outlet line, the bypass valve (1) opens and the oil flows from inlet to outlet bypassing the filter element.

(3) Oil Switch



[A] At Proper Oil Pressure
[B] At Oil Pressures of 49 kPa (0.5 kgf/cm², 7 psi) or Less

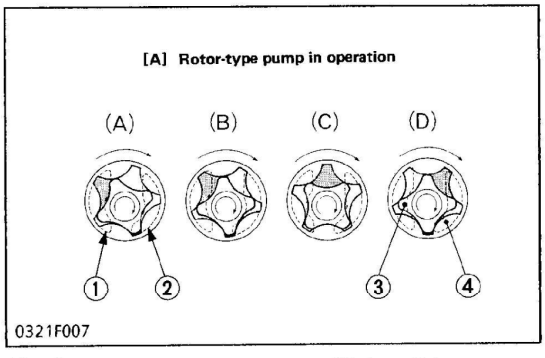
(1) Terminal
(2) Insulator
(3) Spring
(4) Rubber Gasket
(5) Contact Rivet
(6) Contact
(7) Oil Switch Body



The oil switch is mounted on the crankcase, to warn the operator that the lubricating oil pressure is poor.

If the oil pressure falls below 49 kPa (0.5 kgf/cm², 7 psi), the oil warning lamp will light up, warning the operator. In this case, stop the engine immediately and check the cause of pressure drop.

(4) Oil Pump



(1) Inlet
(2) Outlet
(3) Inner Rotor
(4) Outer Rotor

The oil pump in this engine is a trochoid pump.

Inside the pump body, the 4 lobe inner rotor (3) is eccentrically engaged with the 5 lobe outer rotor (4).

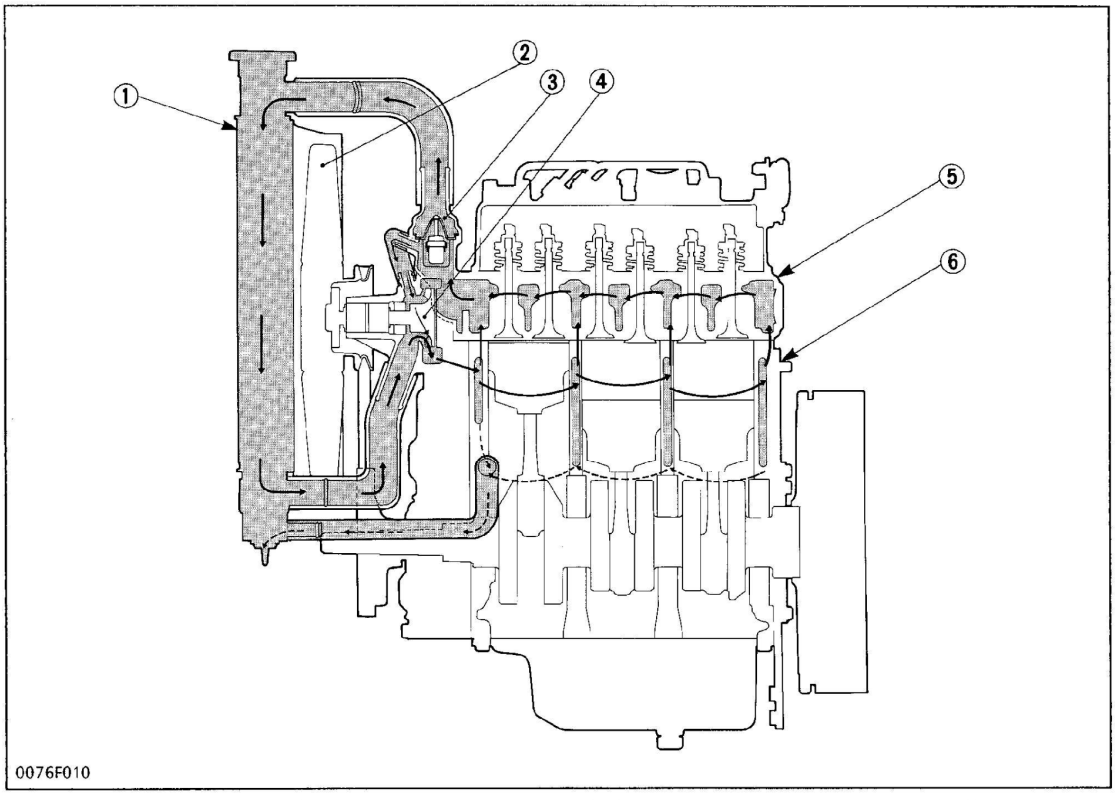
The inner rotor is driven by the crankshaft via gears, which in turn rotate the outer rotor.

When the inner rotor rotates, the outer rotor also rotates in the same direction.

The two rotors have differences in lobe number and center which generates space between lobes as shown in the figure. At position (A), there is little space between lobes in the inlet port. As the rotor rotates towards position (B), the space between the lobes becomes larger, creating a negative pressure which sucks in oil.

Outside the inlet port, as shown in position (C), the space between the lobes becomes gradually smaller, and oil pressure increases. At position (D), oil is discharged from the outlet port.

[4] COOLING SYSTEM



(1) Radiator
(2) Suction Fan
(3) Thermostat
(4) Water Pump
(5) Cylinder Head
(6) Cylinder Block

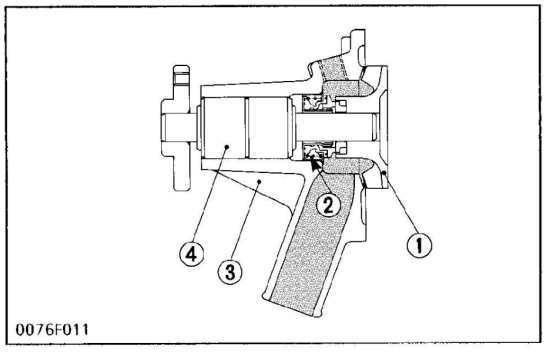
The cooling system consists of a radiator (1), centrifugal water pump (4), suction fan (2) and thermostat (3).

The water is cooled through the radiator core, and the fan set behind the radiator pulls cooling air through the core to improve cooling.

The water pump sucks the cooled water, forces it into the cylinder block and draws out the hot water.

Then the cooling is repeated. Furthermore, to control temperature of water, a thermostat is provided in the system. When the thermostat opens, the water moves directly to radiator, but when it closes, the water moves toward the water pump through the bypass between thermostat and water pump. The opening temperature of thermostat is approx. 82°C (180°F).

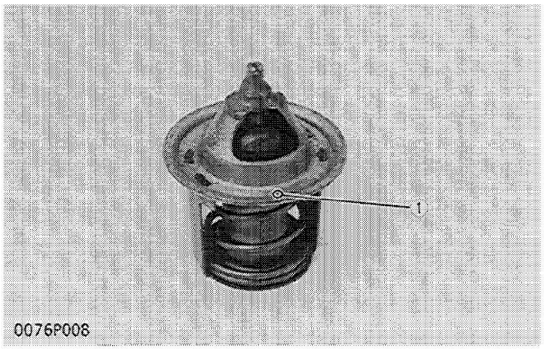
(1) Water Pump



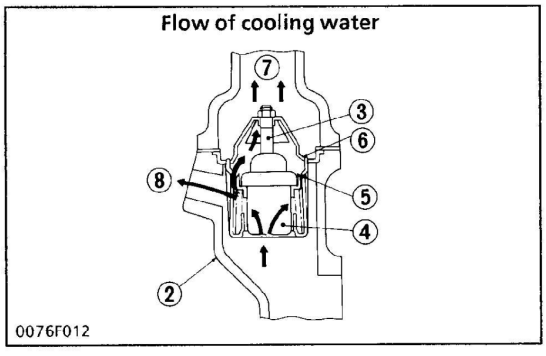
35 ℓ/min. (7.7 Imp.gals./min., 9.2 U.S.gals./min.) of water is forced into the crank case and cylinder head to cool them. The impeller, of backward type, is bent as far as possible from the center, in the opposite direction to rotation. The bearing unit prevents cooling water from entering by a special mechanical seal.

(1) Water Pump Impeller
(2) Mechanical Seal
(3) Water Pump Body
(4) Bearing Unit

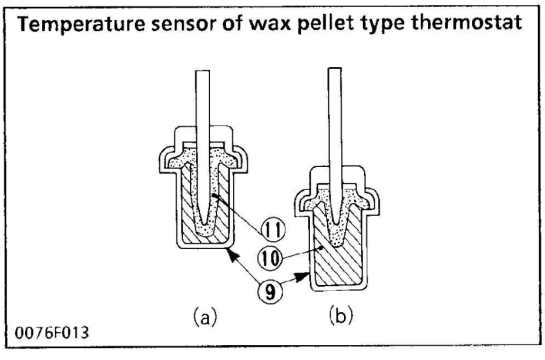
(2) Thermostat



(1) Leak Hole



(2) Water Cover
(3) Spindle
(4) Pellet
(5) Valve
(6) Sheet
(7) To Radiator
(8) To Engine



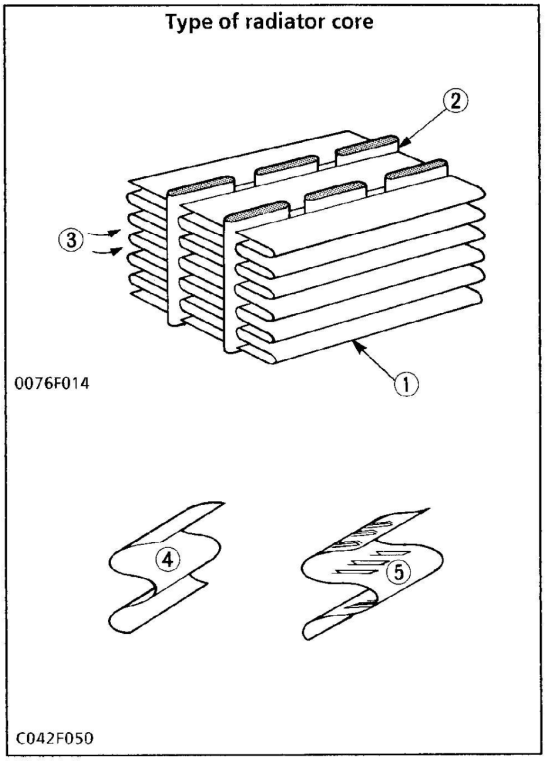
(9) Pellet
(10) Wax (liquid)
(11) Wax (solid)
(a) At low temperature
(b) At high temperature

The thermostat maintains the cooling water at correct temperature. KUBOTA's engine uses wax pellet type thermostat. Wax is enclosed in the pellet. The wax is solid at low temperatures, but turns liquid at high temperatures, expands and opens the valve.

a) At low temperatures (lower than 82°C (180°F)).
As the thermostat is closed, cooling water circulates in the engine through water return pipe without running to the radiator. Air in the water jacket in the engine escapes to the radiator side through leak hole of the thermostat.

b) At high temperatures (higher than 82°C (180°F)).
When the temperature of cooling water exceeds 82°C (180°F), wax in the pellet turns liquid and expands. Because the spindle is fixed, the pellet is lowered, the valve is separated from the sheet, and then cooling water is sent to the radiator.

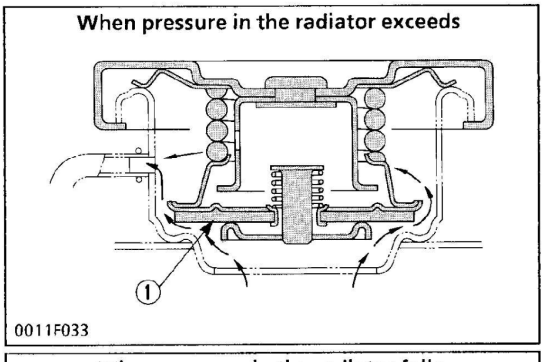
(3) Radiator

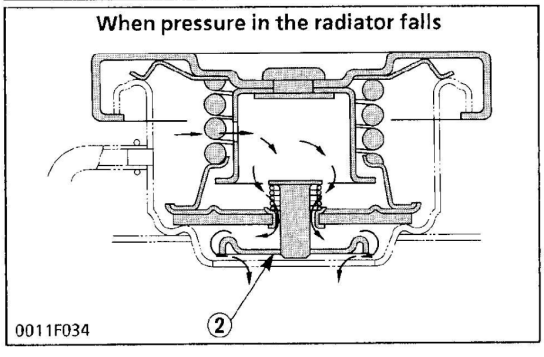


Radiator core consists of water carrying tubes (2) and fins (1) making a right angle with the tubes. Heat of hot water in the tubes is radiated from the tube walls and fins. KUBOTA's engine uses corrugated fin type core which has a light weight and high heat transfer rate. Clogging is minimized by the louverless fins.

(1) Fin
(2) Tube
(3) Cooling air
(4) Louverless Corrugated Fin
(5) Louvered Corrugated Fin

(4) Radiator Cap



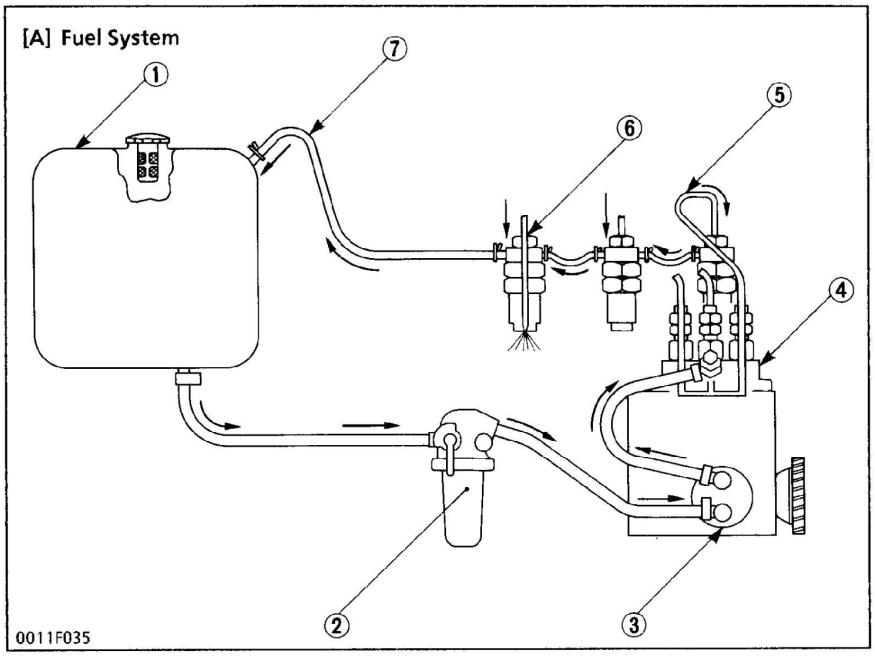


The radiator cap is a pressure type, which opens the pressure valve (1) to reduce internal pressure when internal pressure is increased beyond a certain point due to increase in water temperature. The normal valve actuating pressure of the radiator cap is 88 kPa (0.9 kgf/cm^2, 13 psi).

· When water temperature is reduced (and its volume is reduced) pressure in the radiator becomes negative, and the vacuum valve (2) opens and introduces air into the radiator to prevent distortion of the radiator.

(1) Pressure Valve
(2) Vacuum Valve

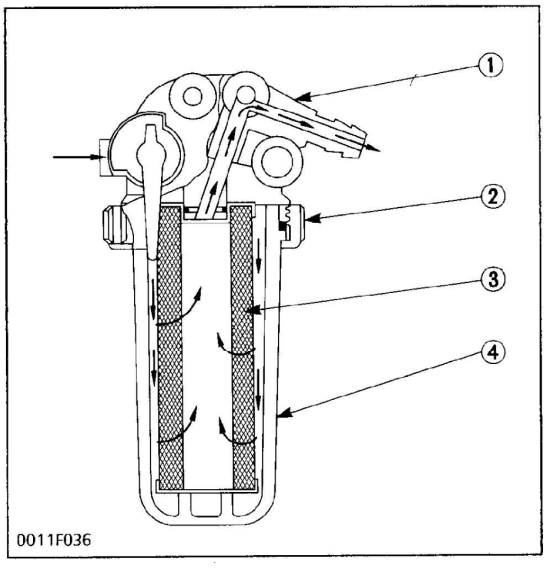
[5] FUEL SYSTEM



(1) Fuel Tank
(2) Fuel Filter
(3) Fuel Pump
(4) Injection Pump
(5) Injection Pipe
(6) Injection Nozzle
(7) Fuel Overflow Pipe

While the engine is running, fuel tank (1) through the fuel filter (2) to the fuel pump (3), which feeds fuel to the injection pump (4). The injection pump then feeds the fuel through the injection pipes (5), to the nozzles (6) which inject fuel to the cylinders for combustion. Any fuel leaking from nozzles is collected in the fuel overflow pipes (7) which drain into the tank.

(1) Fuel Filter

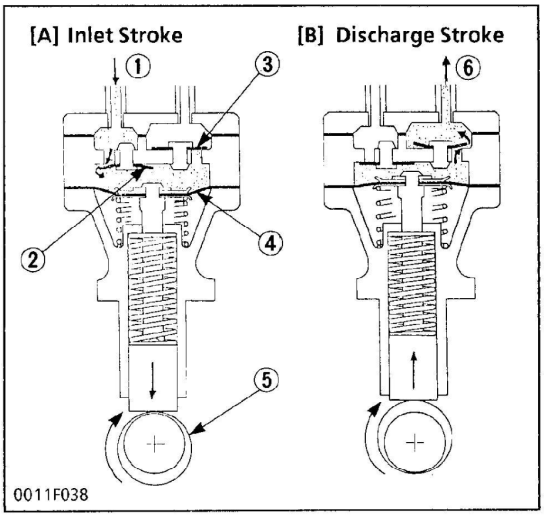


A fuel filter is used to prevent dirty fuel from reaching the injection pump and injection nozzles. The filter element (3) will require occasional replacement to maintain an adequate flow of fuel to the injection pump. The frequency of this service will vary according to the cleanliness of available fuel and the care used in storage.

Fuel pumped by the fuel pump from the fuel tank is filtered by the fuel filter between the tank and pump to eliminate foreign matter and protect injection pump and nozzles. When fuel enters the filter, it passes through the filter element's circumference toward the center for filtering. The maximum filtrated granular size of this element is 48μm (0.048 mm, 0.0019 in.), and general size is from 10 to 20 μm (0.01 to 0.02 mm, 0.0004 to 0.0008 in.).

(1) Cock Body
(2) Retaining Ring
(3) Element
(4) Filter Cup

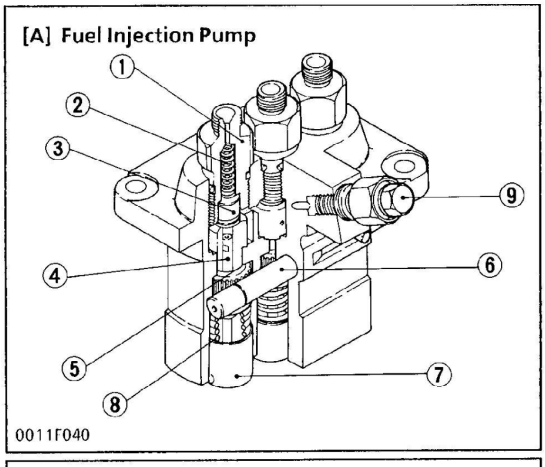
(2) Fuel Pump



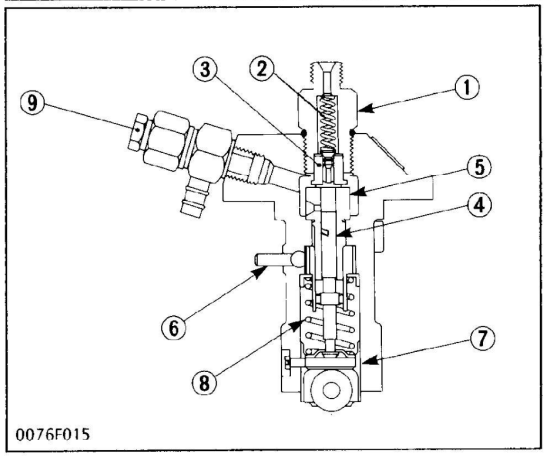
Filtered fuel is forcibly sucked from the tank by the fuel pump and fed under pressure to the injection pump. Inlet and discharge pressures are produced by a vertical movement of the diaphragm which is caused by the special cam (for pump) of the fuel camshaft. Fuel is suctioned on the downward stroke, and discharged on the upward stroke. A system of two valves allows fuel to flow in only one direction.

(1) From Fuel Filter
(2) Inlet Valve
(3) Outlet Valves
(4) Diaphragm
(5) Fuel Camshaft
(6) To Injection Pump

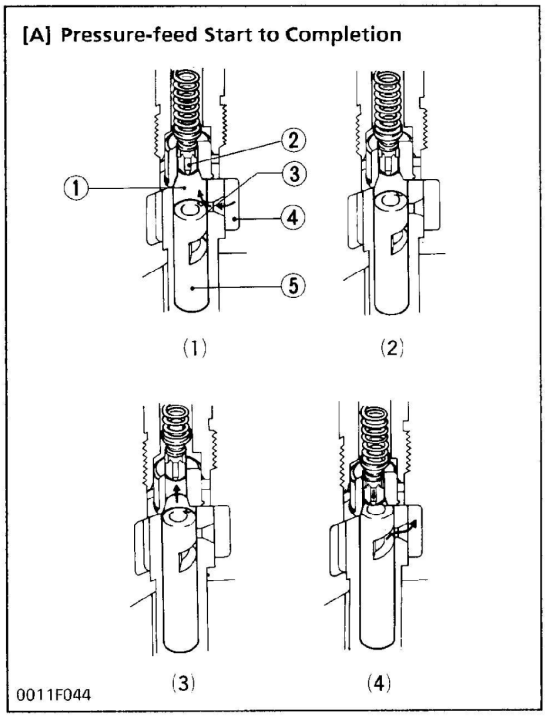
(3) Fuel Injection Pump



The well-known Bosch K type mini pump is provided, it features high injection quality even at low engine speed. The fuel injection pump plunger is reciprocated by the fuel camshaft which is driven by the crankshaft through a system of timing gears. Fuel camshaft rpm is 1/2 of camshaft rpm.



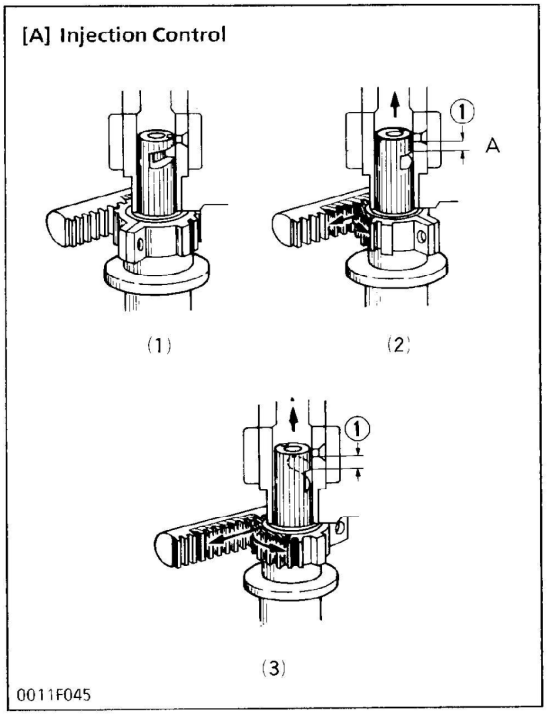
(1) Delivery Valve Holder
(2) Delivery Valve Spring
(3) Delivery Valve
(4) Plunger Pump Element
(5) Cylinder Pump Element
(6) Control Rack
(7) Tappet
(8) Plunger Spring
(9) Air Vent Screw



■ **Fuel Pressure-feed**

1) Bottom dead center of plunger
   At bottom dead center, fuel enters the delivery chamber (1) through the fuel chamber (4) and the feed hole (3). (Fuel chamber is always kept full by the fuel pump.)
2) Pressure-feed start
3) Pressure-feed process
   Plunger (5) is pushed up by camshaft to close the feed hole, and fuel pressurization starts. As the plunger moves up, pressure increases, and delivery valve (2) is opened. Then fuel is pressure-fed through the injection pipe and nozzle into the combustion chamber.
4) Completion of pressure-feed
   When plunger moves further up, the control groove and feed hole meet. Pressurized fuel in the delivery chamber is returned through the plunger's center hole, control groove, and feed hole to the fuel chamber. Then pressure falls and pressure-feed is completed.

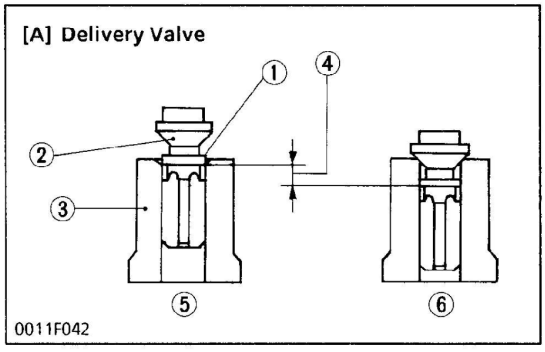
(1) Delivery Chamber
(2) Delivery Valve
(3) Feed Hole
(4) Fuel Chamber
(5) plunger

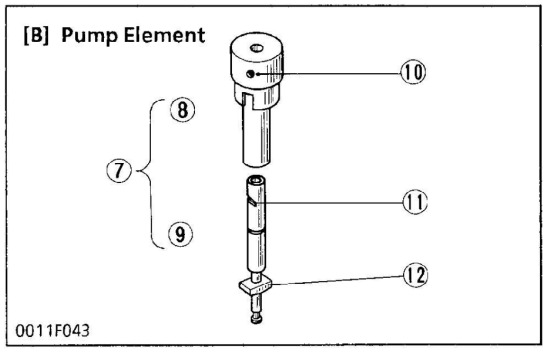


■ **Injection Control**

1) Injection "zero"
   The feed hole meets the control groove before it is closed by the plunger top. Therefore, fuel is not pressurized, and is not injected even if the plunger moves up.
2) Injection "medium"
   When the plunger is rotated a certain amount in the direction of the arrow by the control rack, stroke A is effective until the feed hole meets the control groove and fuel is injected as the stroke amount.
3) Injection "maximum"
   When the plunger is rotated by the control rack to the maximum amount (in the direction of the arrow), effective stroke reached maximum and maximum injection is provided.

(1) Effective Stroke





(1) Relief Valve
(2) Seat
(3) Delivery Valve Seat
(4) Pressure decrease because of Increase in this Volume.
(5) End of Pressure-feed and Start of Sucking Back
(6) End of Sucking Back
(7) Pump Element
(8) Cylinder
(9) Plunger
(10) Feed Hole
(11) Control Groove
(12) Driving Face

■ Delivery Valve

The delivery valve is composed of the valve and the valve seat. It performs two functions:

1) Reverse flow prevention
   If the circuit between the delivery chamber and the nozzle is always closed, a time lag will occur between pressure-feed start of valve element and start of nozzle injection. This, in turn, will prevent injection from stopping properly until after completion of pressue-feed.
   To eliminate this time lag, the valve lowers on completion of pressure-feed and the relief valve contacts the valve seat, and breaks the circuit between the injection pipe and plunger.
2) Fuel dribbling prevention
   After the relief valve contacts delivery valve seat, this valve lowers a little. Since the relief valve breaks the circuit, pressure in the injection pipe is reduced as the valve lowers, preventing fuel dribbling from the nozzle.

■ Pump Element

The pump element is composed of a cylinder and a plunger. Their contact surfaces are precision finished to provide a high injection pressure even at low speeds. The cylindrical surface of the plunger has slanted grooves, which are called control grooves, and a connecting hole for plunger head.

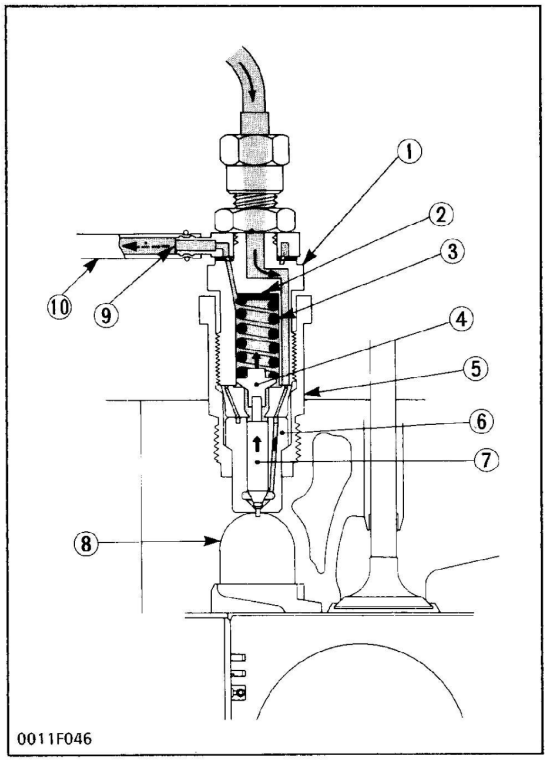
■ Control Rack

This is connected directly to the governor fork in the engine body. It is connected with the plunger by pinion to change injection volume.

■ Tappet

The tappet converts rotating movement of the camshaft into a reciprocating movement to drive plunger. A roller is used where it contacts the cam to reduce friction.

(4) Injection Nozzle

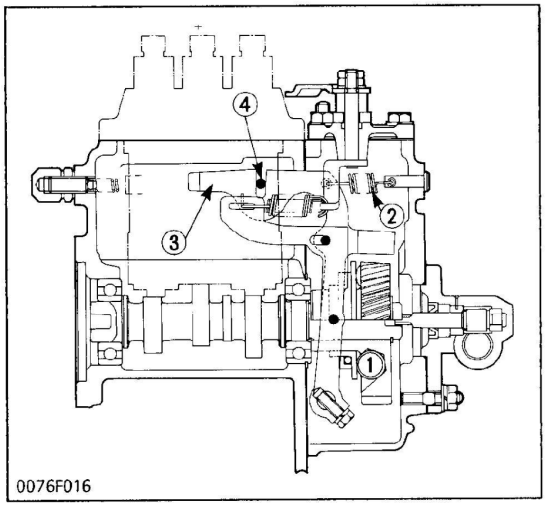


This nozzle is throttle-type. Fuel fed from the pump is pressurized to push the needle valve (7) up and the fuel is then injected. The needle valve is pressed by the nozzle spring (3) through the push rod (4). Fuel overflow is passed from nozzle holder center through the fuel overflow nipple (9) and the fuel overflow pipe (10) to the fuel tank. The injection pressure is provided 13.7 to 14.7 MPa (140 to 150 kgf/cm^2, 1991 to 2133 psi). Injection pressure can be controlled by inserting shims between nozzle holder body (1) and adjusting washers (2). The pressure increases approx. 981 kPa (10 kgf/cm^2, 142 psi) when inserted a 0.1 mm (0.0039 in.) shim. Injection nozzle is also precision finished as is the injection pump, treat it carefully and protect from water and dust.

(1) Nozzle Holder Body
(2) Adjusting Washer
(3) Nozzle Spring
(4) Push Rod
(5) Retaining Nut
(6) Nozzle Body
(7) Needle Valve
(8) Combustion Chamber
(9) Fuel Overflow Nipple
(10) Fuel Overflow Pipe

(5) Governor

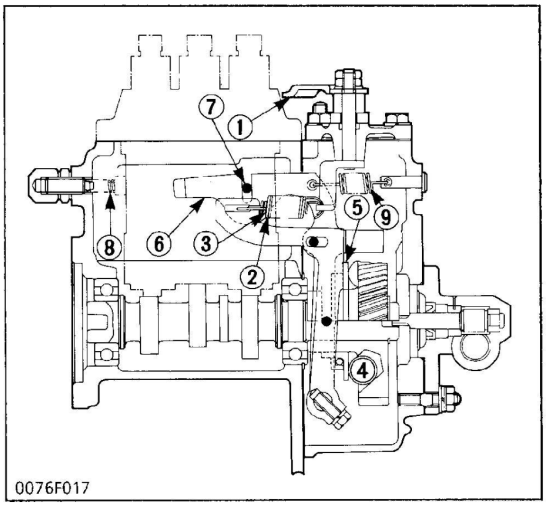
With centrifugal ball weight system, this mechanical governor works in the whole range of speeds. It keeps the engine speed and controls the engine output.



■ At Start

When the engine is started, more fuel is required than in running. At starting, fork lever 1 (3) is pulled rightward by start spring (2) because ball weights (1) have no centrifugal force. Control rack (4) moves to a position for over limit discharging of fuel to assure easy starting.

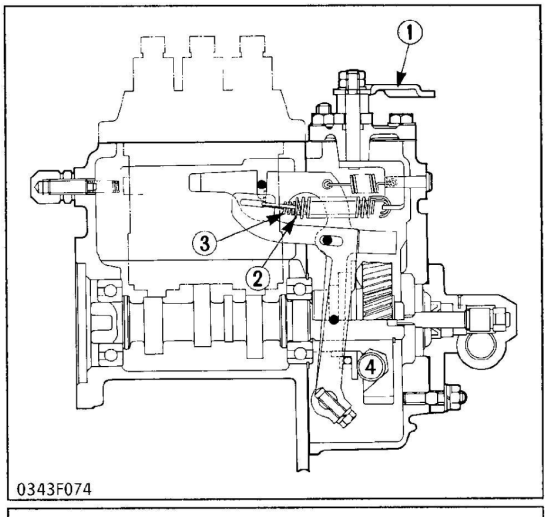
(1) Ball Weights
(2) Start Spring
(3) Fork Lever 1
(4) Control Rack



■ **At Idling**

When speed control lever (1) is set at idling position after the engine is started, high speed governor spring 1 (2) does not work at all and also low speed governor spring 2 (3) does only a little action. Therefore, governor sleeve (5) is pushed leftward by a centrifugal force of ball weights. Fork lever 1 and control rack are moved leftward by the sleeve and then idling limit spring (8) is compressed by control rack. As a result, the control rack is kept at a position where a centrifugal force of ball weights and forces start spring, governor spring 2 and idling limit spring are balanced, providing stable idling.

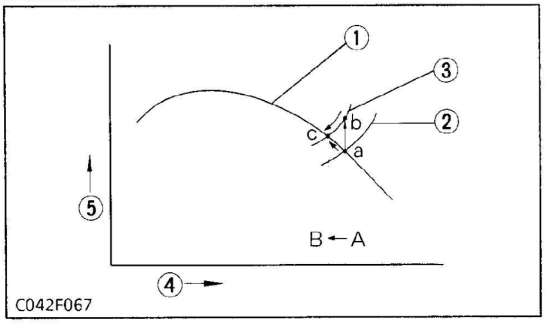
(1) Speed Control Lever
(2) Governor Spring 1
(3) Governor Spring 2
(4) Ball Weight
(5) Governor Sleeve
(6) Fork Lever 1
(7) Control Rack
(8) Idling Limit Spring
(9) Start Spring



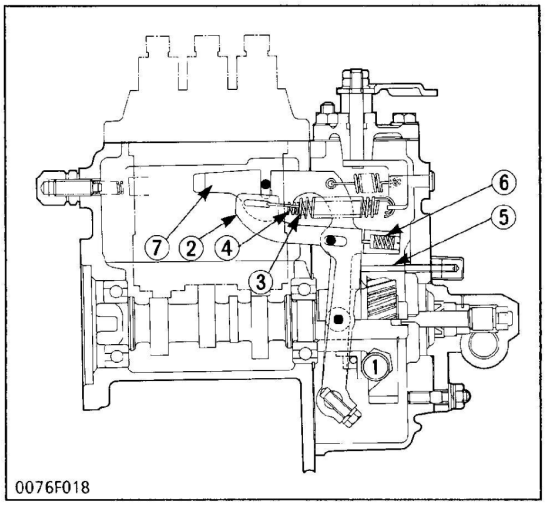
■ **At Middle/High Speed Running**

The engine speed is controlled when the tension of governor springs 1 and 2, which are pulled speed control lever, and the centrifugal force of ball weights are balanced. When the speed is reduced (A→B) with load increased (a→b), the centrifugal force of ball weights becomes smaller than the tension of governor springs 1 and 2. As a result, the control rack is moved rightward and fuel injection amount is increased to produce an engine torque required for the load. (a→c).

(1) Speed Control Lever
(2) Governor Spring 1
(3) Governor Spring 2
(4) Ball Weights



(5) Engine Torque Curve
(6) Small Load Torque Curve
(7) Large Load Torque Curve
(8) Engine R.P.M.
(9) Torque



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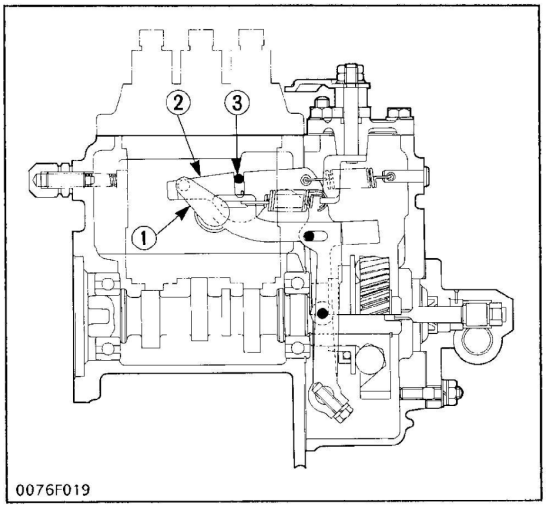
■ At High Speed Running with Overload

When an overload is applied to the engine running at a high speed, the centrifugal force of ball weights become small as the speed is reduced, and fork lever 2 is pulled rightward by governor springs 1 and 2, increasing fuel injection. Fork lever 2 becomes ineffective to increase fuel injection when it is stopped by maximum output limit bolt (5). After that when the force of spring becomes larger than the centrifugal force of ball weights, fork lever 1 moves rightward to increase fuel injection, driving the engine continuously with a high torque.

(1) Ball Weight
(2) Fork Lever
(3) Governor Spring 1
(4) Governor Spring 2
(5) Maximum Output Limit Bolt
(6) Spring
(7) Fork Lever 1



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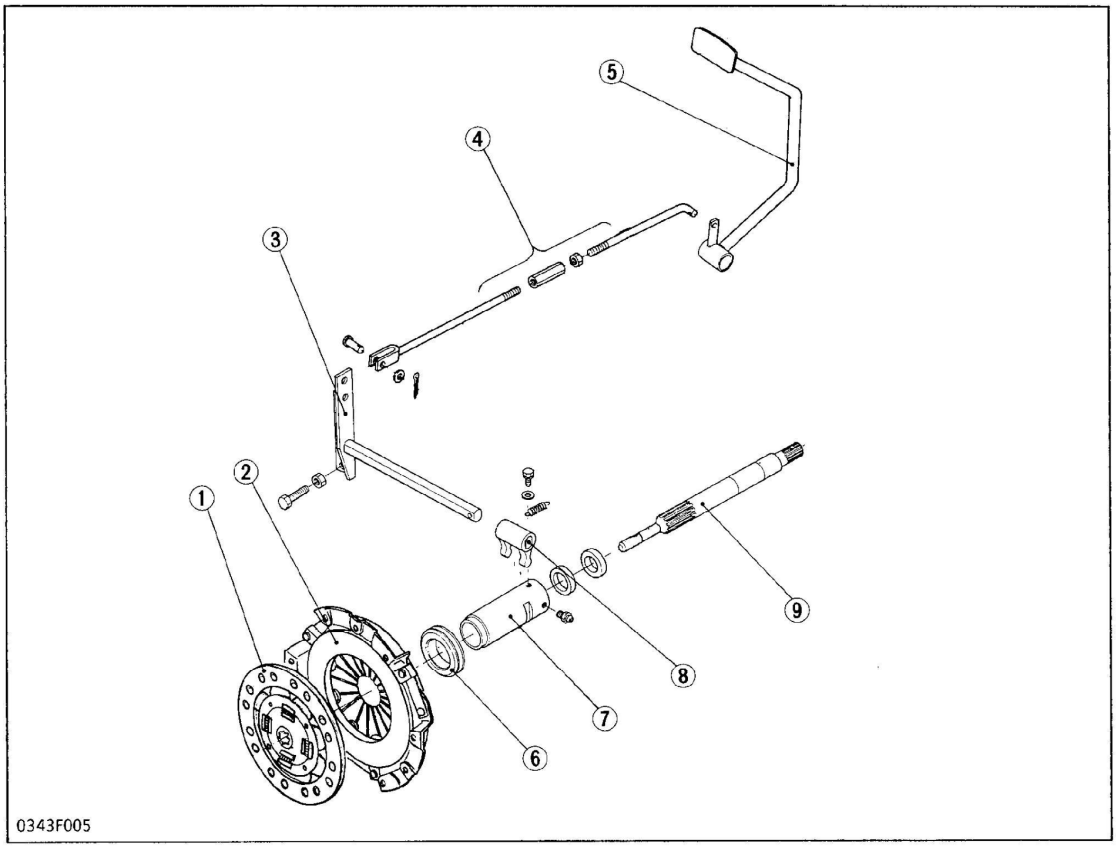
■ To Stop Engine

When stop lever (1) is moved to "STOP" position, fork lever is moved leftward and then control rack is moved to the non-injection position, stopping the engine.

(1) Stop Lever
(2) Fork Lever 1
(3) Control Rack

2 CLUTCH



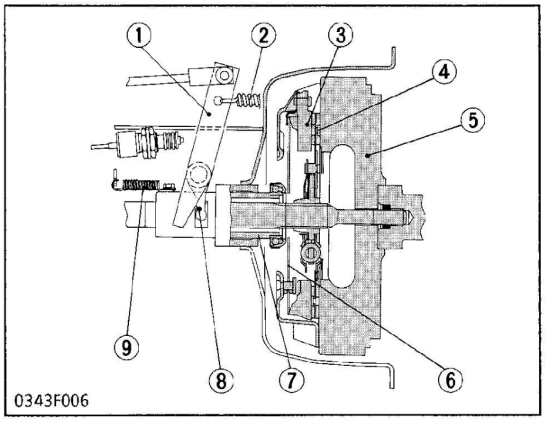
(1) Clutch Disc
(2) Pressure Plate
(3) Clutch Rod
(4) Clutch Rod
(5) Clutch Pedal
(6) Release Bearing
(7) Release Bearing Holder
(8) Clutch Release Fork
(9) Propeller Shaft

The dry, single-disc type clutch is attached to the flywheel.

The clutch disc (1) is splined to the propeller shaft (9), and engages or disengages the power flow from the engine to the transmission.

A torsion spring is incorporated in the clutch disc and acts as a shock absorber to protect the engine and transmission from excessive loads.

■ Engage



(1) Clutch Rod
(2) Spring
(3) Pressure Plate
(4) Clutch Disc
(5) Flywheel
(6) Diaphragm Spring
(7) Release Bearing Holder
(8) Clutch Release Fork
(9) Release Spring

By releasing the clutch pedal, the spring (2) pulls the arm of the clutch rod (1). The clutch release fork (8) then moves the release bearing holder (7) together with the release spring (9). Diaphragm spring (6) is released and presses the pressure plate (3) against the clutch disc (4).

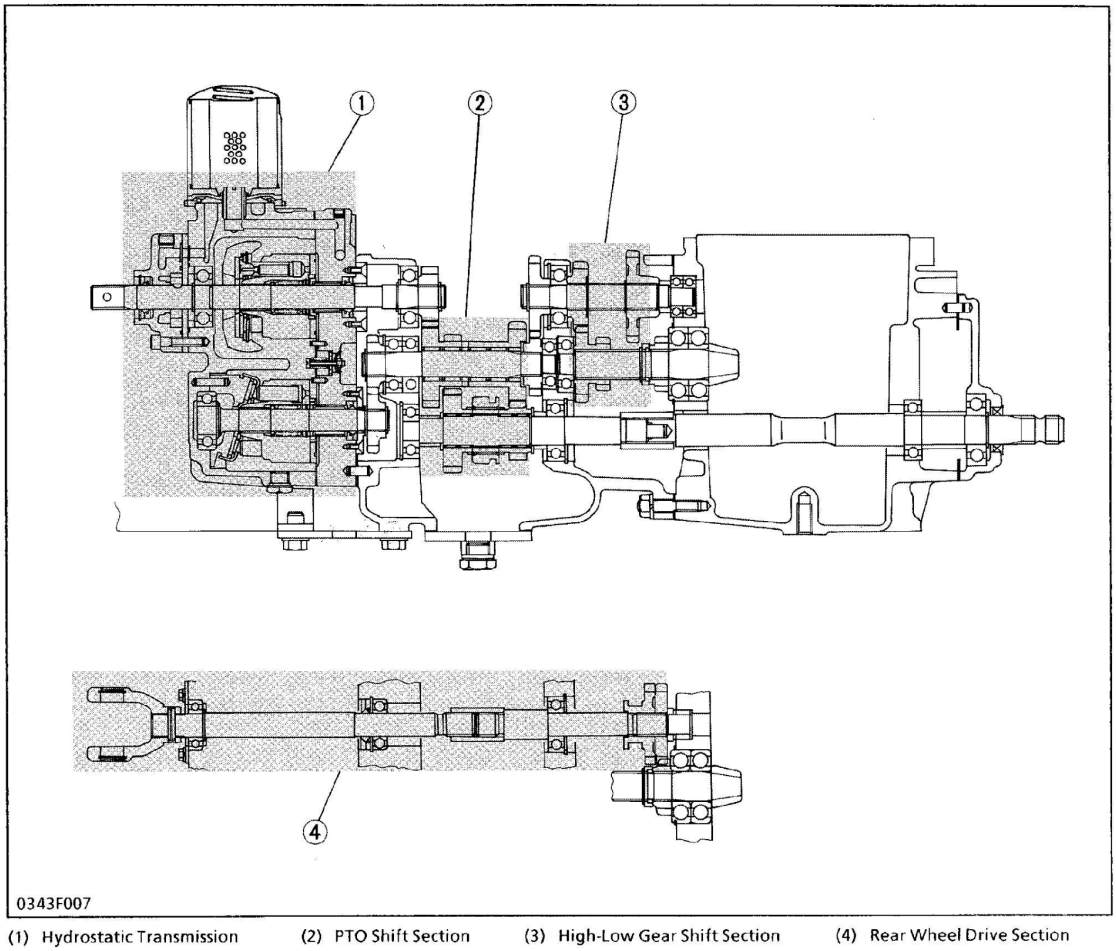
The clutch disc is held between the flywheel (5) and pressure plate, and the friction between them cause the clutch disc to rotate, thereby transmitting power from the engine to the transmission.

■ Disengage

By depressing the clutch pedal, the rod is moved forward to pull the arm of the clutch rod. The clutch release fork moves the release bearing holder which in turn pushes the diaphragm spring.

The pressure plate, which is linked to the diaphragm spring by clips, is pulled away from the flywheel and release the clutch disc which is no longer in contact with the flywheel.

3 TRANSMISSION



(1) Hydrostatic Transmission (2) PTO Shift Section (3) High-Low Gear Shift Section (4) Rear Wheel Drive Section

The transmission consists of HST (Hydrostatic Transmission) and a series of gears shown previously. It offers the most suitable speeds for traveling and operation by combination of them.

And power is transmitted to the front or rear axles and the PTO shafts, which are classified respectively as the traveling system and PTO system.

The traveling system consists of the HST (1) high-low gear shift section (3) and rear wheel drive section (4).

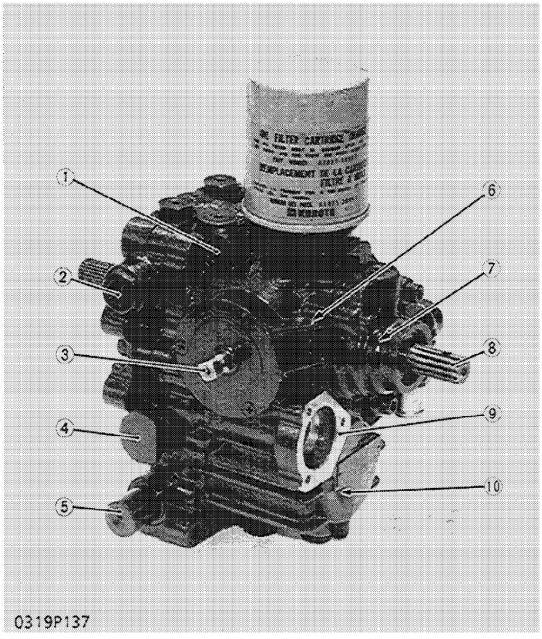
The traveling speeds are selected by the operation of the speed control pedal and the high-low gear shift lever.

■ Traveling Speeds

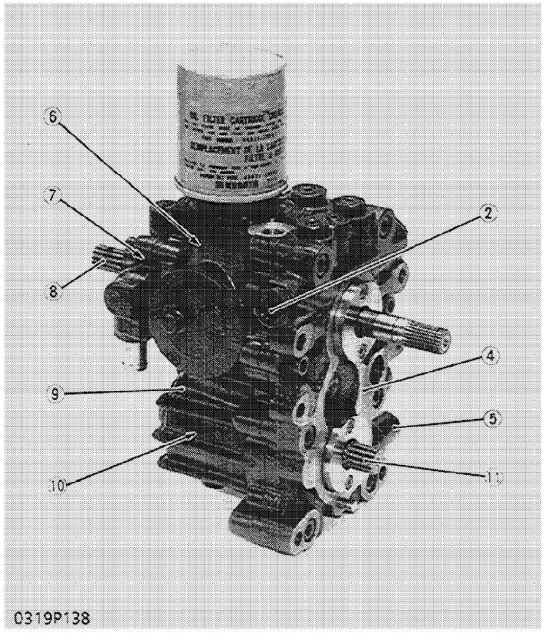
Forward	Low	7.4 km/h (4.6 mph)
	High	15.2 km/h (9.5 mph)
Reverse	Low	4.4 km/h (2.8 mph)
	High	9 km/h (5.6 mph)

[1] HYDROSTATIC TRANSMISSION

(1) Structure



(1) Charge Relief Valve
(2) Neutral Valve
(3) Trunnion Shaft
(4) Port Block
(5) High Pressure Relief Valve
(6) Variable Displacement Piston Pump



(7) Charge Pump
(8) Input Shaft
(9) Case
(10) Fixed Displacement Piston Motor
(11) Output Shaft

Hydrostatic transmission is composed of variable displacement piston pump, fixed displacement piston motor, charge pump and valve system.