WSM

WORKSHOP MANUAL
DIESEL ENGINE

MECHANISM

Kubota

KiSC issued 03, 2008 A

TO THE READER

The main purpose of this manual is to train the servicing personnel so that he / she can understand and service Kubota engines with speed.

This manual is also an excellent reference for the trained mechanic who wants to refresh his memory on Kubota engines.

All information and illustrations 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.

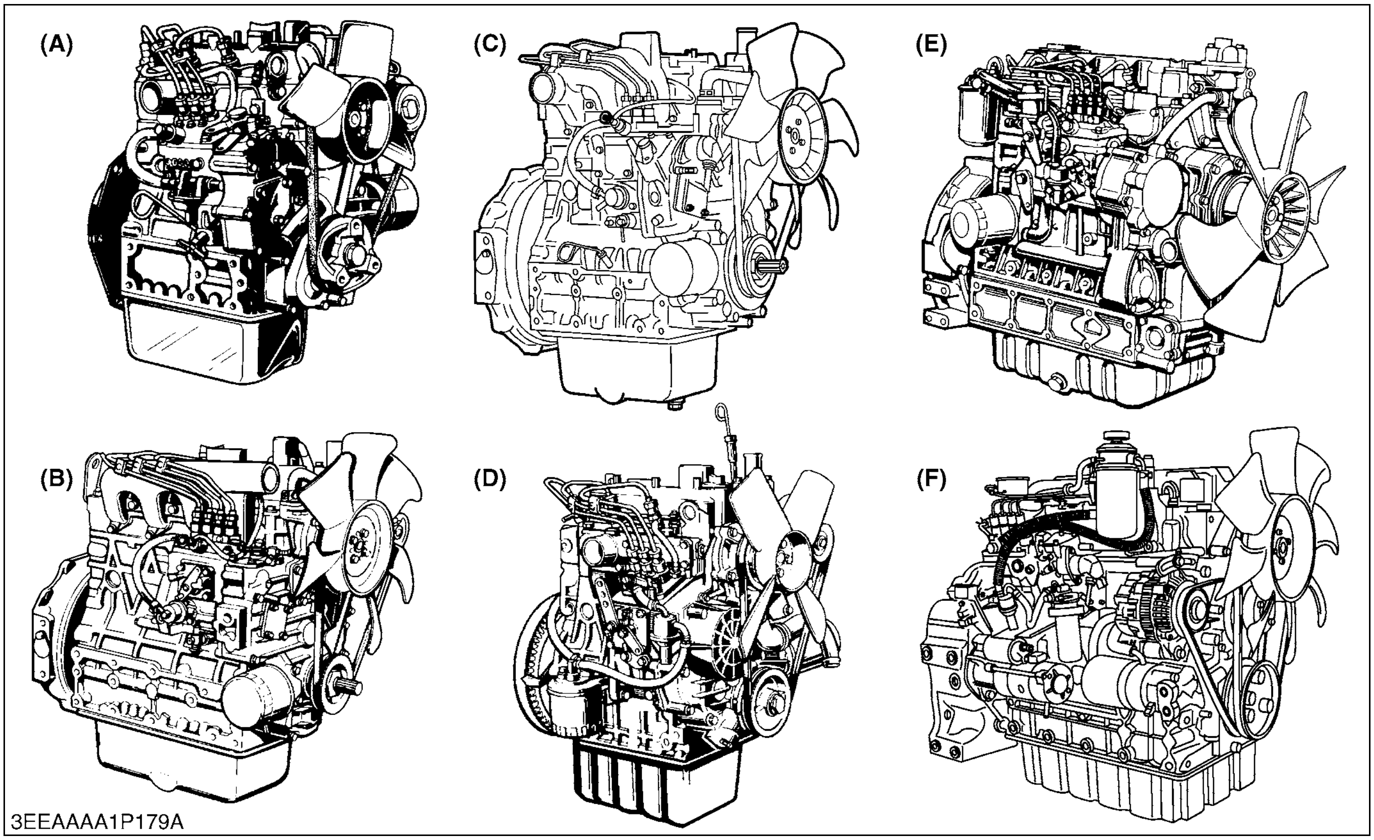
September 2000

MECHANISM

CONTENTS

1. GENERAL

[1] FEATURE



(A) Super Mini Series (SM Series)
(B) 03 Series
(C) 03-M Series
(D) 05 Series
(E) V3 Series
(F) 07 Series

Kubota vertical diesel engines are classified in different series names according to their strokes. They include Super Mini Series (SM Series), 03 Series, 05 Series and so on.

Making a more fuel efficient, clear exhaust engine has always been a top priority for Kubota. Our undying pursuit for clearance emission led to the development of the E Series. This series complies with CARB ULGE* equipments regulations (less than 19 kW) for industrial (off-road) diesel engines.

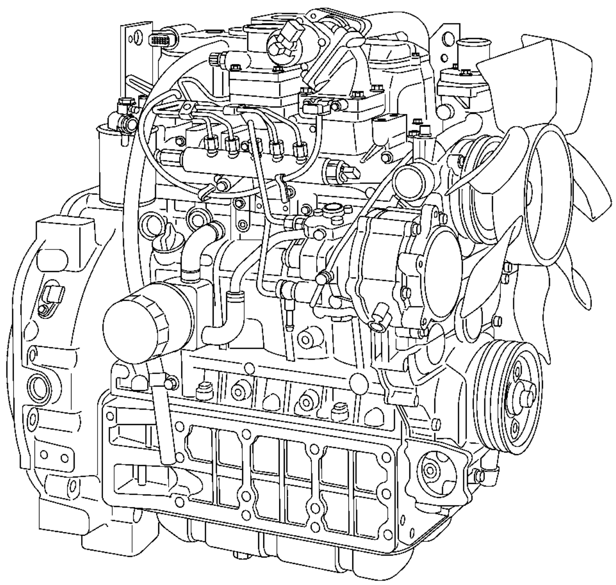
Kubota's D1105-E is the world's 1st ULGE diesel engine under 19 kW to be certified by CARB on Apr. 13, 1993.

Kubota has been providing top-notch engines that meet the emission controls today and tomorrow in North America, Europe, Japan and other local markets.

*U.S.A. :CARB (California Air Resource Board)
ULGE (Utility, Lawn and Garden Equipments)
EPA (Environmental Protection Agency)
EU : Non-road CI Regulation

JAPAN :MLIT (MOT) / MLIT (MOC)
MLIT (Ministry of Land, Infrastracture & Transport)
MOT (Ministry of Transport)
MOC (Ministry of Construction)

(A)



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■ **Common Rail System**

The diesel engines have the feature of low cost and high efficiency. On the other hand, it is said that an amount of the nitrogen oxide (NOx) and particulate matter (PM) contained in their exhaust gas is relatively large, and the emission regulation by the EPA (Environmental Protection Agency) has been gradually strengthened in North America recently. Kubota, which has been positively engaging in the strict emission regulations of the world, has developed the new engine conforming to the regulation of the EPA Tier III that becomes effective since January 2007, by adopting the CRS (Common Rail System) and the EGR (Exhaust Gas Recirculation) in the course of pursuing more clean exhaust gas.

The common rail system uses a type of accumulation chamber called a rail to store pressurized fuel, and injectors that contain electronically controlled solenoid valves to inject the pressurized fuel into the cylinders.

Because the engine ECU (Electronic Control Unit) controls the injection system (including the injection pressure, injection rate, and injection timing), the injection system is independent and thus unaffected by the engine speed or load.

Because the engine ECU can control injection quantity and timing to a high level of precision, even multi-injection (multiple fuel injections in one injection stroke) is possible.

This ensures a stable injection pressure at all times, even in the low engine speed range, and dramatically decreases the amount of black smoke ordinarily emitted by a diesel engine during start-up and acceleration.

As a result, exhaust gas emissions are cleaner and reduced, and higher power output is achieved.

(A) V38DICR-TIE3

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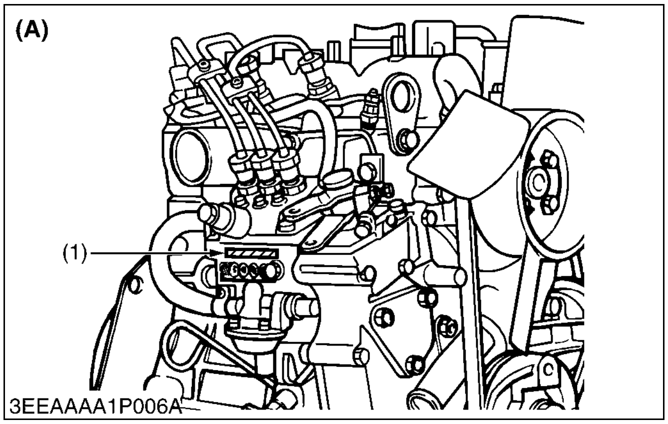
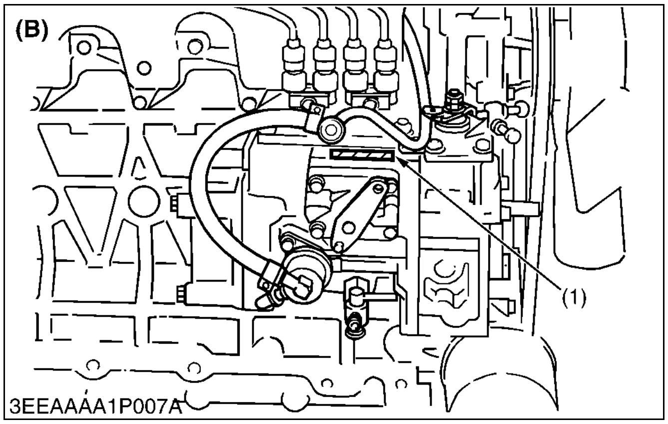
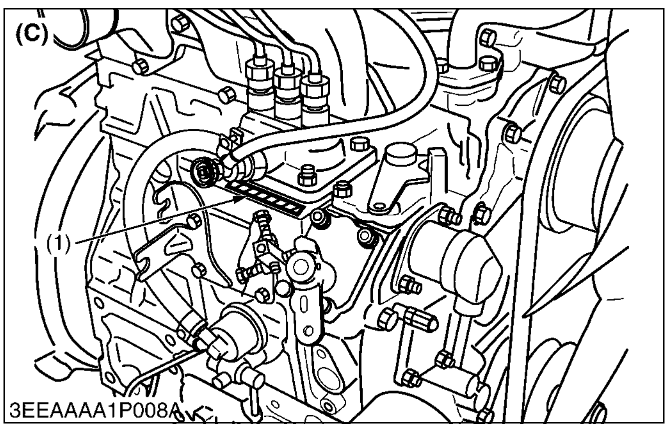
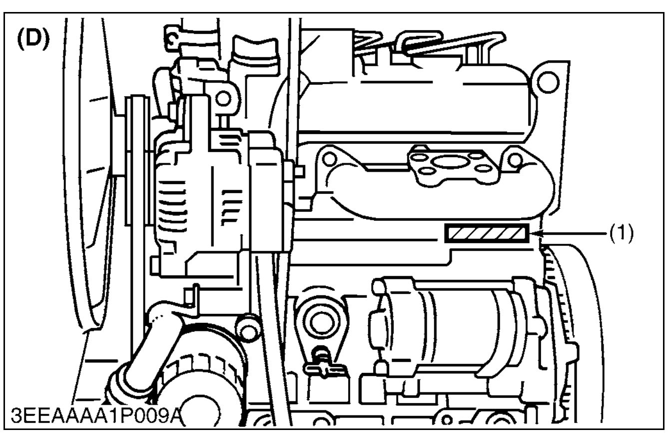
KiSC issued 03, 2008 A

[2] ENGINE MODEL IDENTIFICATION









The alpha numeric model number of each Kubota diesel engine has a definite meaning. Each letter and number provides some technical information about the engine.

The first alpha letter (E, Z, D, V, F, S) used in Kubota model number disignates the number of cylinders in the engine. This method of naming comes from the German numbering system.

Alpha Letter	Number of Cylinders	Alpha Letter	Number of Cylinders
E	1	V	4
Z	2	F	5
D	3	S	6

The numerical portion of the model number denotes the approximate engine cubic entimeter displacement.

■ **Engine Serial Number**

The engine serial number is an identified number for the engine. It is marked after the engine model number.

New serial number has been applied since January, 1998.

It indicates month and year of manufacture as follows.

- **Year of manufacture**

Alphabet or Number	Year	Alphabet or Number	Year
W	1998	F	2015
X	1999	G	2016
Y	2000	H	2017
1	2001	J	2018
2	2002	K	2019
3	2003	L	2020
4	2004	M	2021
5	2005	N	2022
6	2006	P	2023
7	2007	R	2024
8	2008	S	2025
9	2009	T	2026
A	2010	V	2027
B	2011	W	2028
C	2012	X	2029
D	2013	Y	2030
E	2014	1	2031

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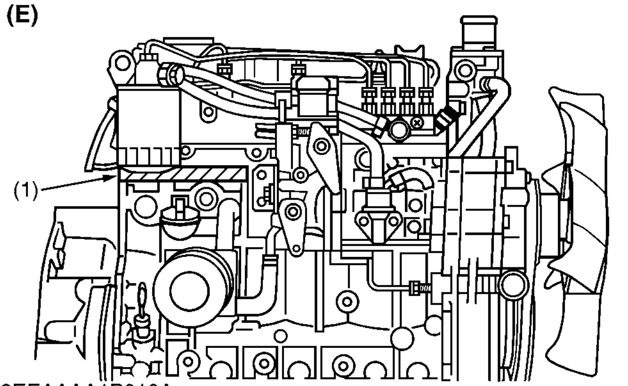
(E)



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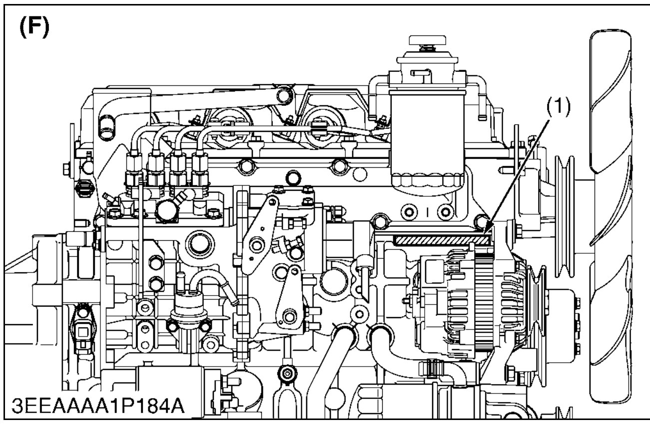
(F)



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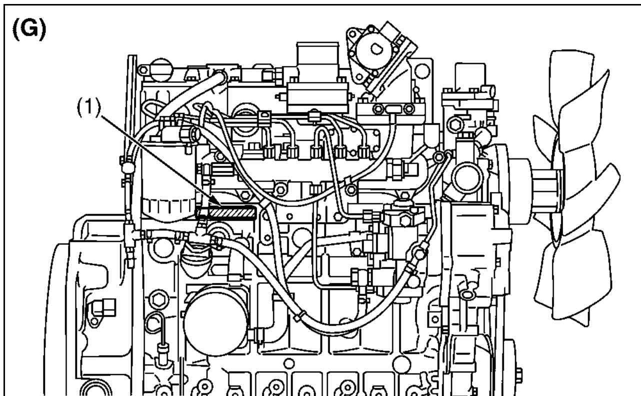
(G)



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- **Month of manufacture**

Month	Engine Lot Number	
January	A0001 ~ A9999	B0001 ~ BZ999
February	C0001 ~ C9999	D0001 ~ DZ999
March	E0001 ~ E9999	F0001 ~ FZ999
April	G0001 ~ G9999	H0001 ~ HZ999
May	J0001 ~ J9999	K0001 ~ KZ999
June	L0001 ~ L9999	M0001 ~ MZ999
July	N0001 ~ N9999	P0001 ~ PZ999
August	Q0001 ~ Q9999	R0001 ~ RZ999
September	S0001 ~ S9999	T0001 ~ TZ999
October	U0001 ~ U9999	V0001 ~ VZ999
November	W0001 ~ W9999	X0001 ~ XZ999
December	Y0001 ~ Y9999	Z0001 ~ ZZ999

* Alphabetical letters "**I**" and "**O**" are not used.

e.g. D902 - 7 B A001
(a) (b)(c) (d)

(1) Engine Model Identification

(a) Engine Model Name : **D902**
(b) Year : **7** indicates **2007**
(c) Month : **A** or **B** indicates **January**
(d) Lot number : (**0001 ~ 9999** or **A001 ~ Z999**)

(A) Super Mini Series
(B) 03 Series
(C) 03-M Series
(D) 05 Series
(E) V3 Series
(F) 07 Series
(G) V38DICR-TIE3

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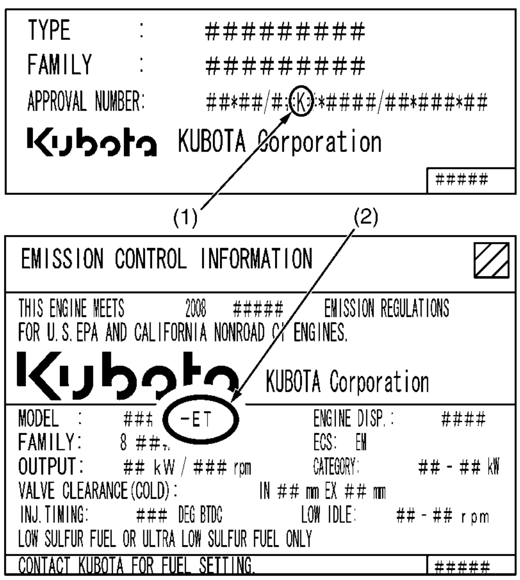
[3] E3B ENGINE

[Example : Engine Model Name D902-**E3B**-XXXX]

The emission controls previously implemented in various countries to prevent air pollution will be stepped up as Non-Road Emission Standards continue to change. The timing or applicable date of the specific Non-Road Emission regulations depends on the engine output classification.

Over the past several years, Kubota has been supplying diesel engines that comply with regulations in the respective countries affected by Non-Road Emission regulations. For Kubota Engines, E3B will be the designation that identifies engine models affected by the next emission phase (See the table below).

When servicing or repairing ###-E3B series engines, use only replacement parts for that specific E3B engine, designated by the appropriate E3B Kubota Parts List and perform all maintenance services listed in the appropriate Kubota Operator's Manual or in the appropriate E3B Kubota Workshop Manual. Use of incorrect replacement parts or replacement parts from other emission level engines (for example: E2B engines), may result in emission levels out of compliance with the original E3B design and EPA or other applicable regulations.Please refer to the emission label located on the engine head cover to identify Output classification and Emission Control Information. E3B engines are identified with "ET" at the end of the Model designation, on the US EPA label. Please note : E3B is not marked on the engine.



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Category (1)	Engine output classification	EU regulation
K	From 19 to less than 37 kW	STAGE IIIA
J	From 37 to less than 75 kW	STAGE IIIA
I	From 75 to less than 130 kW	STAGE IIIA

Category (2)	Engine output classification	EPA regulation
ET	Less than 19kW	Tier 4
	From 19 to less than 56 kW	Interim Tier 4
	From 56 to less than 75 kW	Tier 3
	From 75 to less than 130 kW	Tier 3

(1) EU regulation engine output classification category
(2) "E3B" engines are identified with "ET" at the end of the Model designation, on the US EPA label.
"E3B" designates Tier 3 and some Interim Tier 4 / Tier 4 models, depending on engine output classification.

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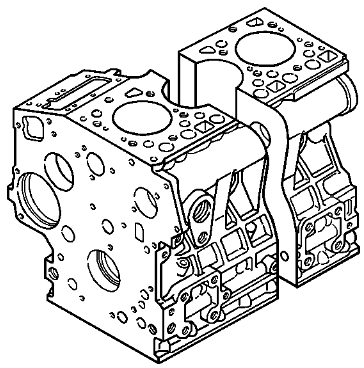
2. ENGINE BODY

[1] CYLINDER BLOCK

(A)



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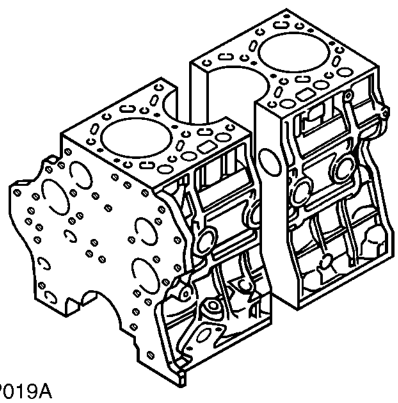
(B)



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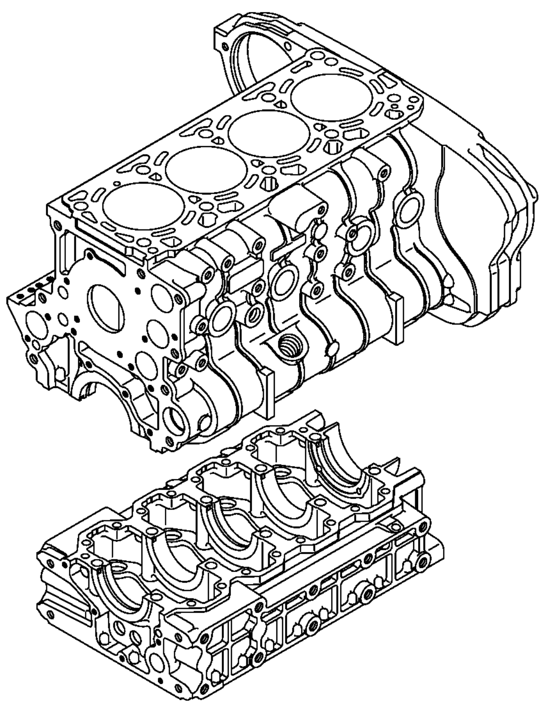
(C)



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The cylinder block is the main housing of engine and supports the other main parts.

The cylinder block is usually of integrated cast iron construction, and includes complete passages for coolant and lubricating oil.

Three kinds (the tunnel type, the hanger type and ladder frame type) are adopted in Kubota engines.

(A) Tunnel Type
(B) Hanger Type
(C) Ladder Frame Type

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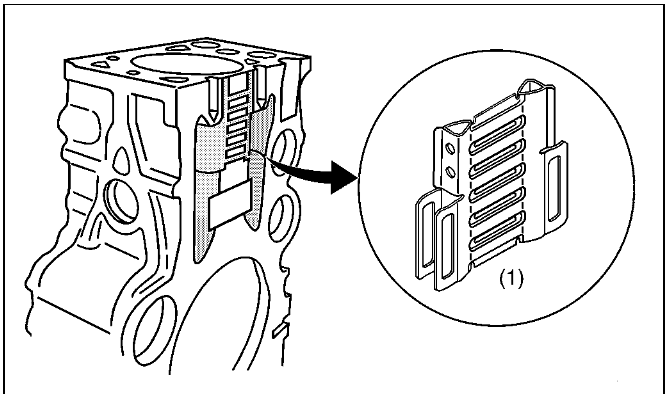
(1) Hollow Core



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On some models, the cylinder block has a hollow core already cast inside the cylinder-to-cylinder water jacket.

In this core, there is a pair of vertical cooling passages (right and left) as well as multiple horizontal cooling channels that interconnect these cooling passages. This design allows smoother cooling water flow through the cylinder block, which cools down a wider range between the cylinders more effectively.

(1) Hollow Core

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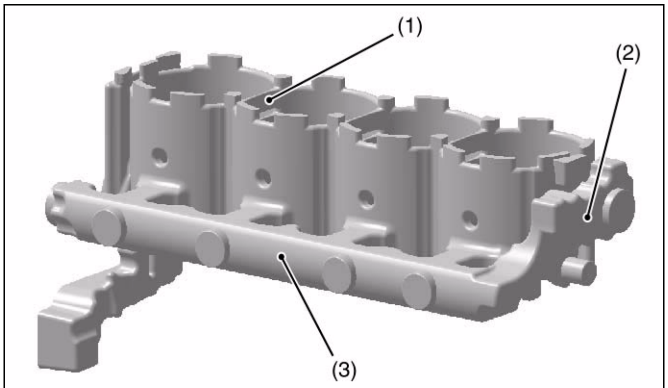
(2) Main Gallery



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The 07 series DI engine employs coolant evenness distribution type cooling jacket inside crankcase 1. The coolant is evenly supplied to each cylinder through the main gallery in the jacket mold core.

(1) Coolant Passage between Cylinder
(2) Jacket Mold Core
(3) Main Gallery

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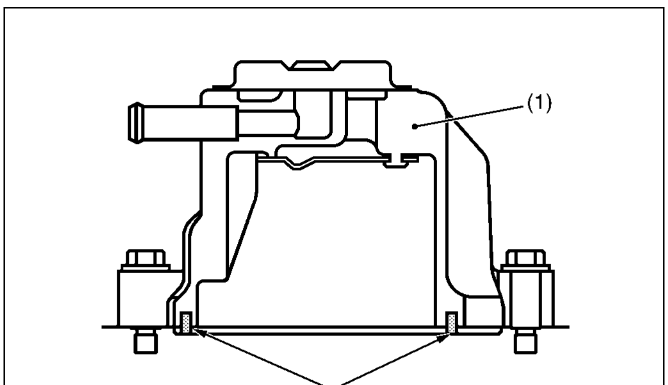
[2] HALF-FLOATING HEAD COVER



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The rubber packing is fitting in to maintain the head cover 0.5 mm (0.02 in.) or so off the cylinder head. This arrangement helps reduce noise coming from the cylinder head.

(1) Cylinder Head Cover
(2) Rubber Packing

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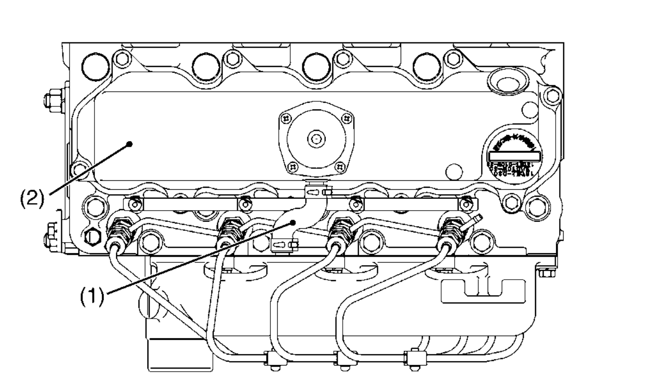
[3] CLOSED BREATHER



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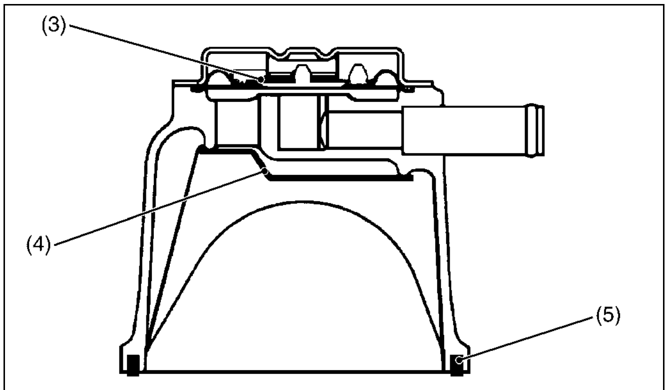

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Closed breather system has been adopted to prevent the release of blow-by gas into the atmosphere.

After its oil content is filtered by oil shield (4), the blow-by gas is fed back to the intake manifold through breather valve (3) to be used for re-combustion.

(1) Breather Tube
(2) Cylinder Head Cover
(3) Breather Valve (PCV)
(4) Oil Shield
(5) Rubber Packing

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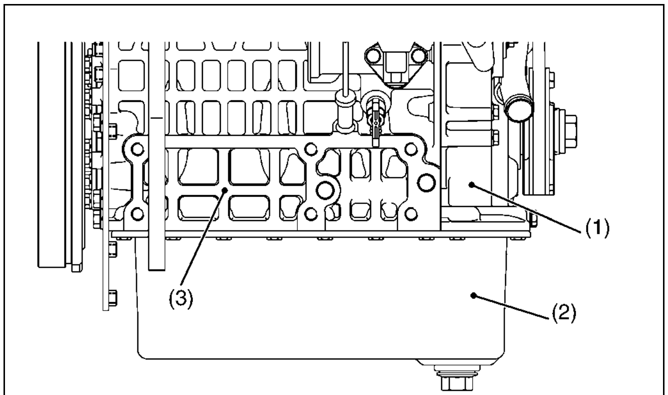
[4] EXTENDED OIL PAN



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Some models of SM series engines have the extended oil pan.

The oil pan is extended under the gear case. Therefore, the height of the engine can be lowered more than so far while securing a necessary amount of oil.

(1) Gear Case
(2) Oil Pan
(3) Cylinder Block

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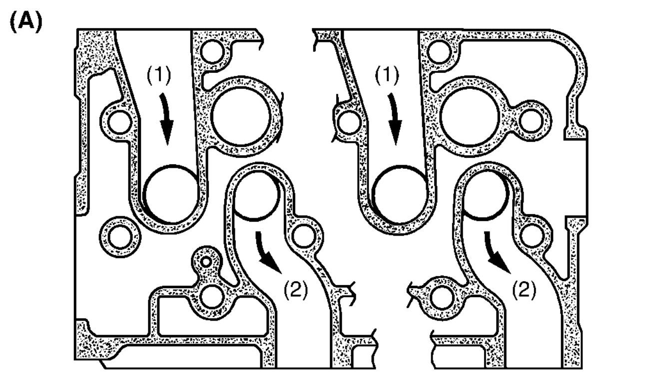
[5] CYLINDER HEAD



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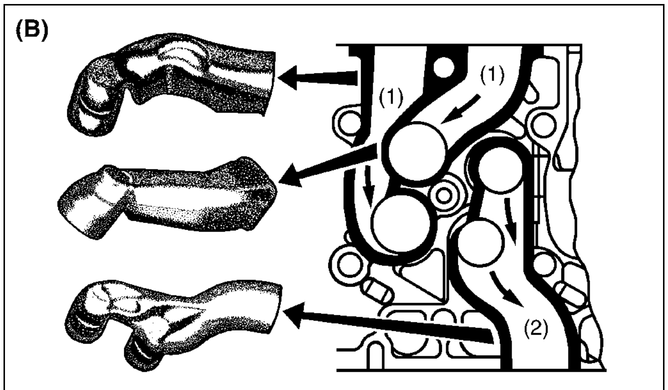

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The cylinder head is made of an alloy of iron and copper or chromium for greater strength and durability. The intake and exhaust passages are cast or bored into the cylinder head.

The cylinder head of two valves or three valves has a single intake / exhaust passage. The cylinder head of four valves, on the other hand, is provided with double intake passage in order to ensure appropriate air suction and give an optimum swirl.

The cross-flow type intake / exhaust passages in Kubota engines have their openings at both sides of the cylinder head. Because overlaps of intake / exhaust passages are smaller than in passages of other types which have openings on one side, the suction air can be protected from being heated and expanded by exhaust gas. The cool, high density suction air has high volume efficiency and raises the power of the engine. Furthermore, distortion of the cylinder head by exhaust gas is reduced because intake passages are arranged alternately.

(1) Intake Passage
(2) Exhaust Passage

(A) Single Intake Passage / Single Exhaust Passage
(B) Double Intake Passages / Single Exhaust Passage

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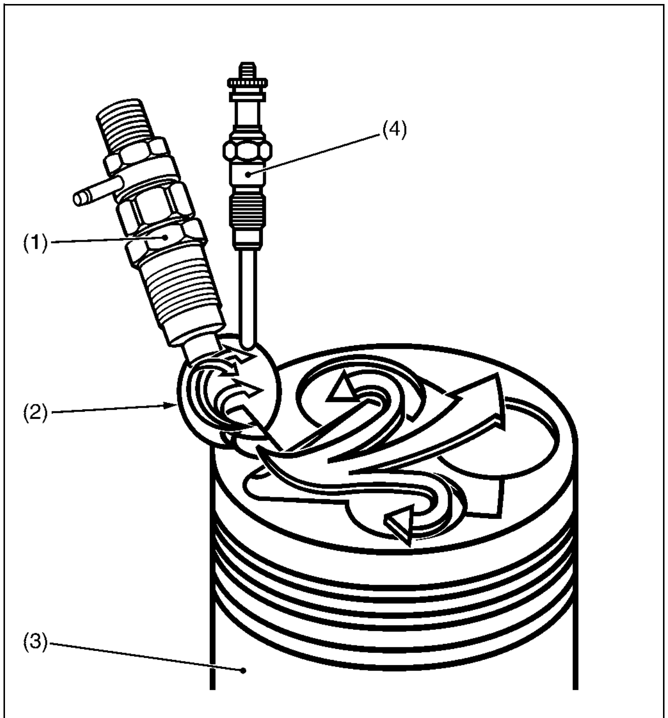
(1) E-TVCS



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The combustion chamber (2) is of Kubota's exclusive E-TVCS 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 (1) and rapid heating sheathed type glow plug (4). This glow plug assures easier than ever engine starts even at –15 °C (5 °F).

(1) Injection Nozzle
(2) Combustion Chamber
(3) Piston
(4) Glow Plug

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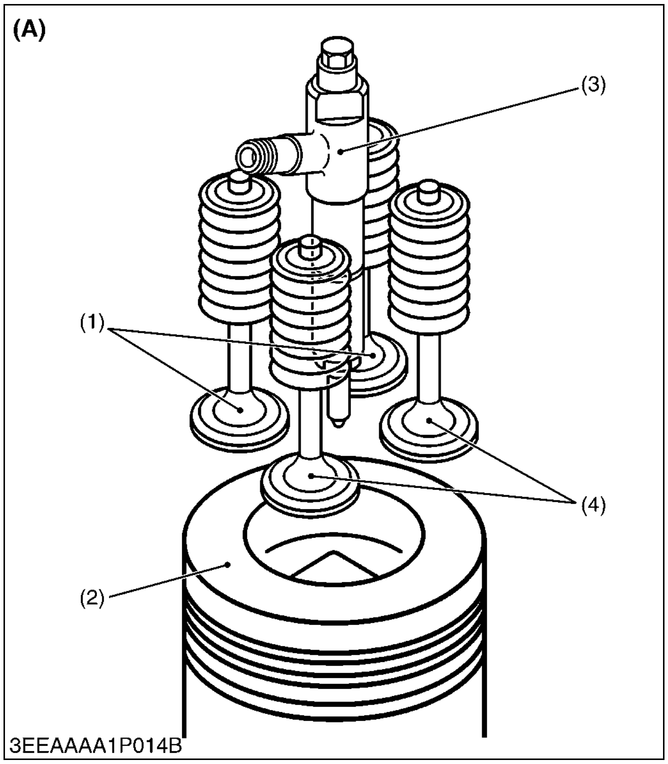
(2) Center Direct Injection System (E-CDIS)



Some models adopt the Center Direct Injection System (E-CDIS), in which the injection nozzle is positioned upright at the center of the cylinder.

This system serves to inject fuel directly at the center of the cylinder. By so doing, injected fuel and suction air can be mixed more uniformly, leading to more stable, higher combustion performance. In other words, cleaner emission, higher power output, lower fuel consumption, lower operating noise and higher start-up performance have been achieved.

(1) Exhaust Valves
(2) Piston
(3) Injection Nozzle
(4) Intake Valves

(A) V3 DI Series, 07 Series
(B) V38DICR-TIE3

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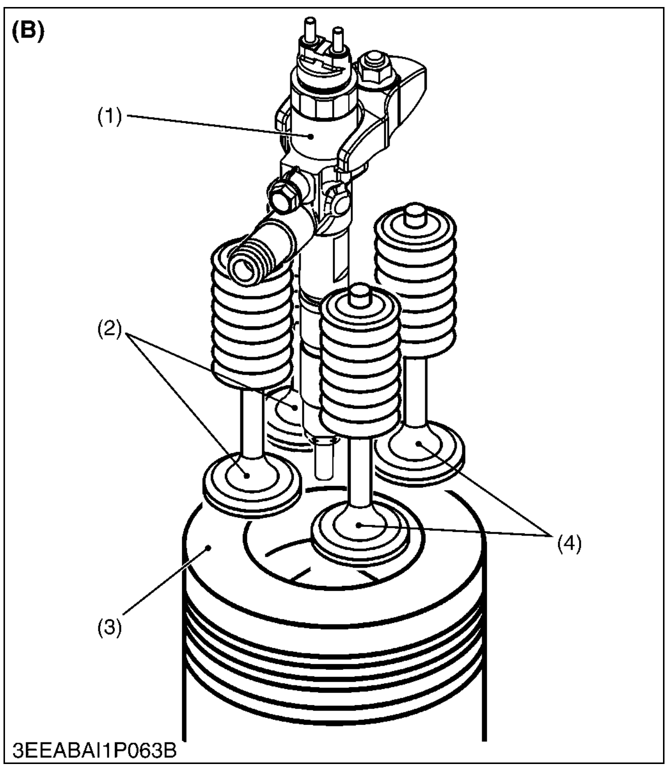

(1) Injector
(2) Exhaust Valve
(3) Piston
(4) Intake Valve

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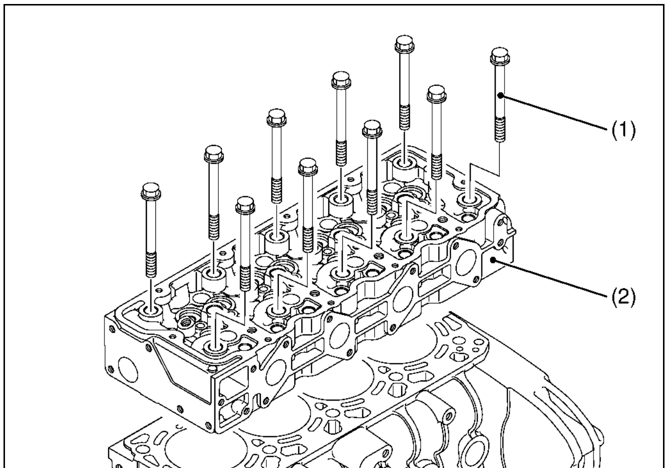
(3) 4 Screws Per Each Cylinder Assembling Structure



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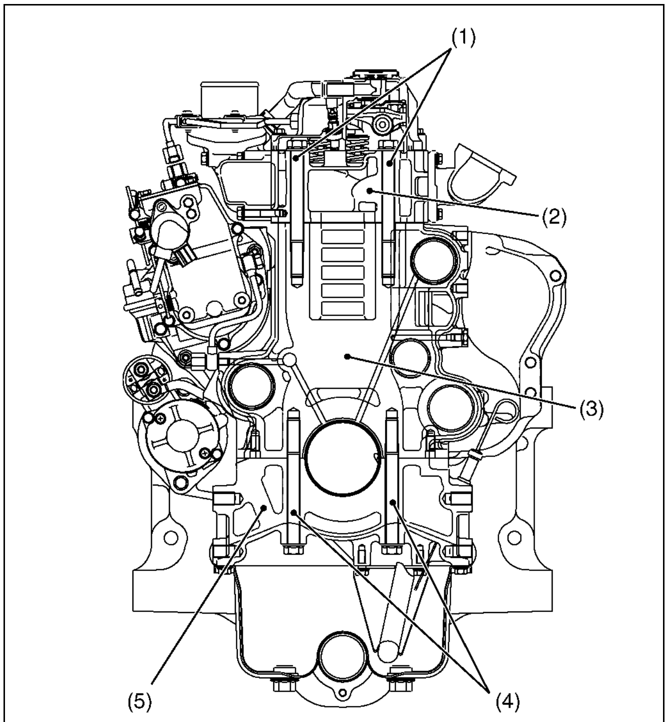

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The 07 series DI engine employs 4 screws per each cylinder assembling structure.

The cylinder head (2) and the crankcase 2 (5) are assembled from the top and bottom to the crankcase 1 (3) with each of 10 screws.

The following objectives are in the 4 screws per each cylinder assembling structure.

1. Reduce the load share rate of combustion pressure on outer block surface wall.
2. Flexibility of cylinder head design.

(1) Cylinder Head Mounting Screw
(2) Cylinder Head
(3) Crankcase 1
(4) Crankcase 2 Mounting Screw
(5) Crankcase 2

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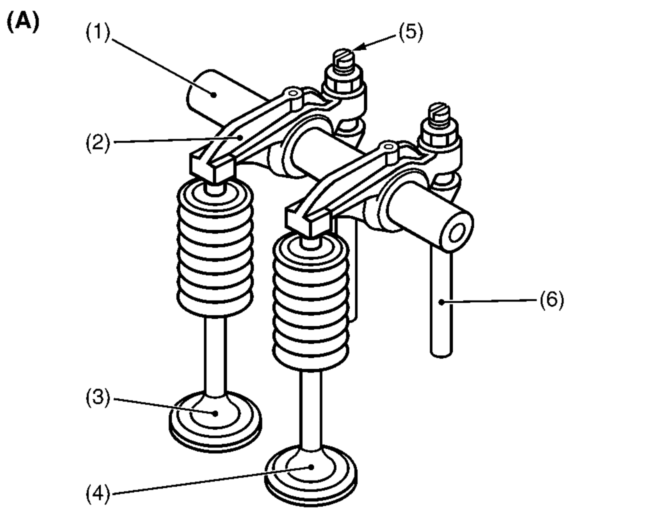
[6] ROCKER ARM



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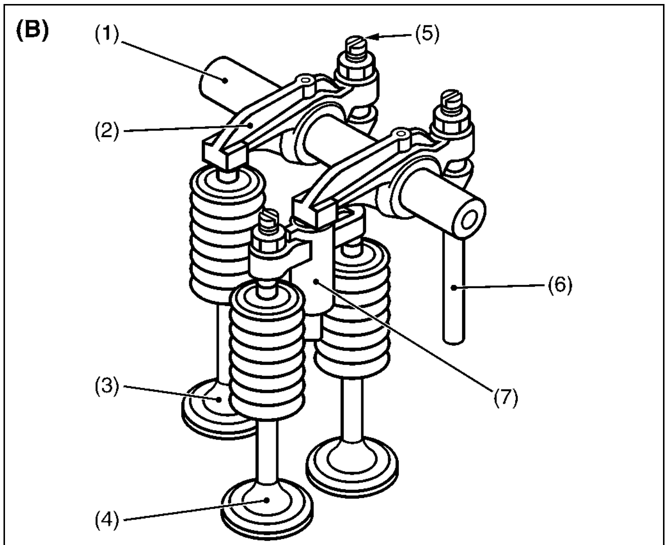

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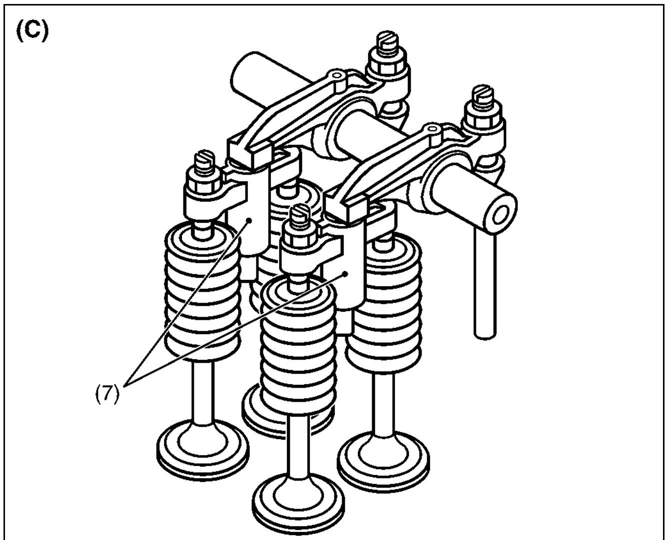

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The rocker arms (2) are mounted on a rocker arm shaft (a single hollow shaft) (1) at the top of the engine.

When the push rods (6) move up, the mating rocker arm is moved down, contacting its valve stem tip and opening the valve.

Some engines with two intake and one exhaust valves (or two intake and two exhaust valves) per cylinder, the rocker arm contacts a bridge arm (7) instead of the valve stem tip. The bridge arm then contacts both intake or both exhaust valves and causes two valves to open simultaneously.

Lubricating oil pressurized through the rocker arm bracket to the rocker arm shaft, which serves as a fulcrum so that the rocker arm and the entire system are lubricated sufficiently.

(1) Rocker Arm Shaft
(2) Rocker Arm
(3) Exhaust Valve
(4) Intake Valve
(5) Adjusting Screw
(6) Push Rod
(7) Bridge Arm

(A) Two Valves
(B) Three Valves
(C) Four Valves

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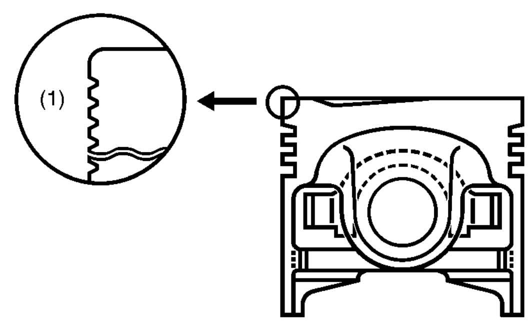
[7] PISTON



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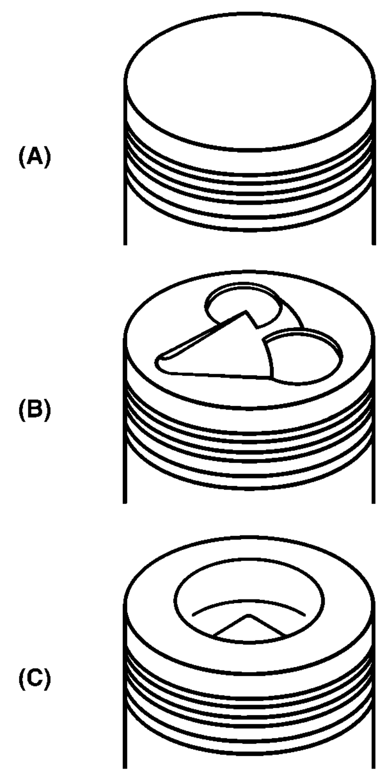

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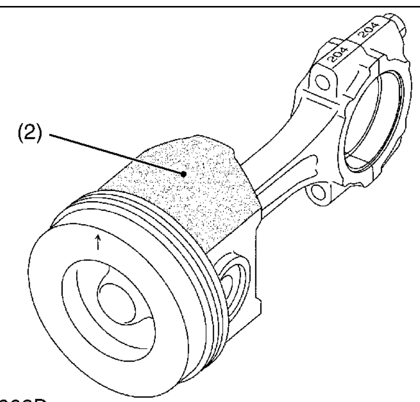

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The reciprocating motion of a piston in the engine cylinder creates the forces for the suction, compression, power and exhaust cycles.

To be strong yet light, pistons are constructed of cast iron or aluminum alloys. Reinforcing ribs are used to keep the piston as light as possible.

The parts of the piston are as shown in left figure.

The piston head shape depends on the engine's combustion chamber. A relatively deep concave head is used for direct injection engines, whereas a flat or slightly concave one is used for engines with sub-combustion chambers.

The ring grooves are cut around the piston to fit the piston rings. They are shaped to the proper rings for good control of oil and blow-by. The lower groove in which the oil ring is inserted has many holes for oil collected by oil ring to flow back to the crankcase.

The piston lands are the areas between the ring grooves which hold and support the piston rings in their grooves. A fine groove called a **"heat dam"** is provided on the top land to protect the top ring from high temperatures.

The skirt of the piston is the outside part below the ring grooves. The piston is kept in alignment by the skirt. Some piston's skirt is coated with **molybdenum disulfide★**, which reduces the piston slap noise and thus the entire operating noise.

★ Molybdenum disulfide (MoS2)

The molybdenum disulfide serves as a solid lubricant, like a Graphite or Teflon. This material helps resist metal wears even with little lube oil.

(1) Heat Dam
(2) Molybdenum Disulfide

(A) Flat Head
(B) Slightly Concave Head
(C) Concave Head

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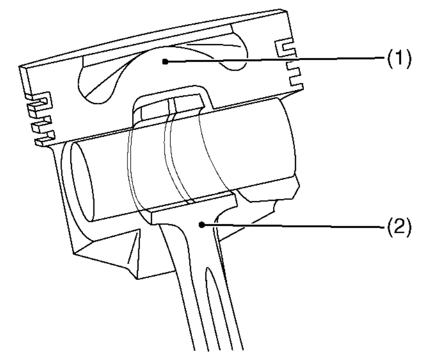

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The piston profile (1) of the V38DICR-TIE3 engine has been optimized in compliance with high pressurization of fuel injection. Moreover, the piston pin portion of the connecting rod (2) has been tapered and the stress concentration has been leveled for the countermeasure of fatigue due to enhancement of high-power. Accordingly, its reliability has been further improved.

(1) Piston Profile
(2) Connecting Rod

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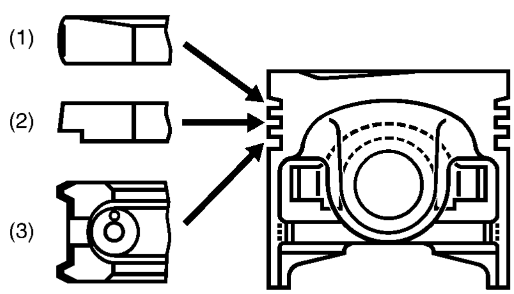
[8] PISTON RING



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Piston rings are classified as compression and oil control rings. Diesel engine has two or three compression rings around the piston head and one oil ring just below them.

The compression rings prevent gases from leaking by the piston during the compression and expansion strokes. They seal by expanding out against the cylinder wall. The rings expand by their own tension and also by combustion pressure behind the rings during the expansion stroke. The compression rings are split for easy assembly on the piston.

The top compression ring (1) is a keystone type ring to get durability against heavy load.

The second compression ring (2) is an undercut ring to prevent shortage of oil.

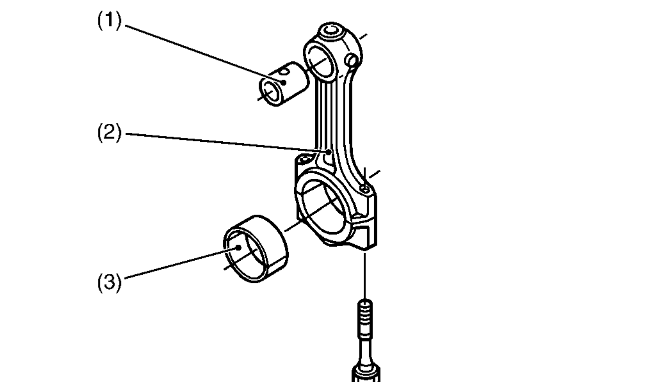
The main job of the oil control ring (3) is to wipe the excess oil from the cylinder walls. This oil is fed through slots in the rings to holes in the piston groove, where it returns to the crankcase. For better oil control, spring expanders are often used under the oil control ring.

The piston rings are usually made of hardened cast iron. To reduce the wear on the ring, they are often plated with chrome on their contact faces, or are coated their contact faces with molybdenum disulfide.

(1) Top Compression Ring
(2) Second Compression Ring
(3) Oil Control Ring

W10138390

[9] CONNECTING ROD



3EEAAAA1P025A

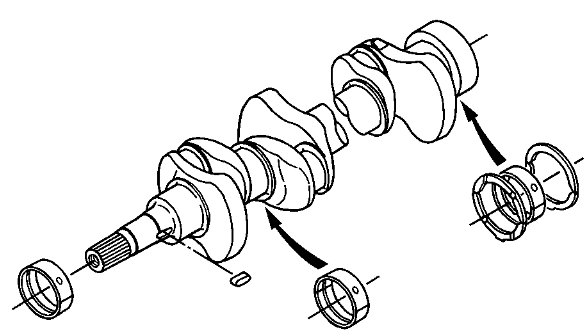
The connecting rod (2) must be light and yet strong enough to transmit the thrust of the piston to crankshaft.

The big end of connecting rod has a crankpin bearing (3) (split type) and the small end has a small end bushing (1) (solid type).

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

W10139350

[10] CRANKSHAFT



3EEAAAA1P021A

The crankshaft converts the up-and-down motion of the pistons into rotary motion. It ties together the reactions of all the pistons into one rotary force that drives the machine.

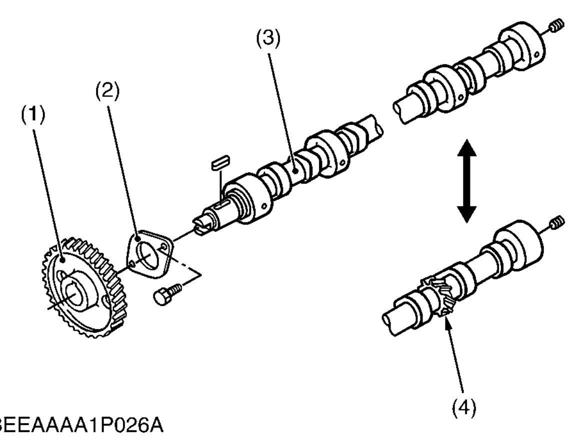
The crankshaft is made of tough special alloy steel, and the journals, pins and oil seal sliding portions are induction hardened to increase the hardness for higher wear resistance.

The front journal is supported by a solid type bearing (tunnel type cylinder block) or by a split type (hanger type cylinder block), and the intermediate journal by a split type, and the rear journal by a split type with thrust bearings.

The crankshaft is provided with an oil gallery, through which engine oil is fed to the crankpin portion, and lubricates it.

W10134720

[11] CAMSHAFT



3EEAAAA1P026A

The camshaft (3) is normally driven by gearing from the crankshaft.

This is made of special cast iron, and the journal and cam sections are chilled to resist wear. One intake and one exhaust cam is provided for each cylinder.

On some models, the camshaft may also drive oil pump using a gear (4).

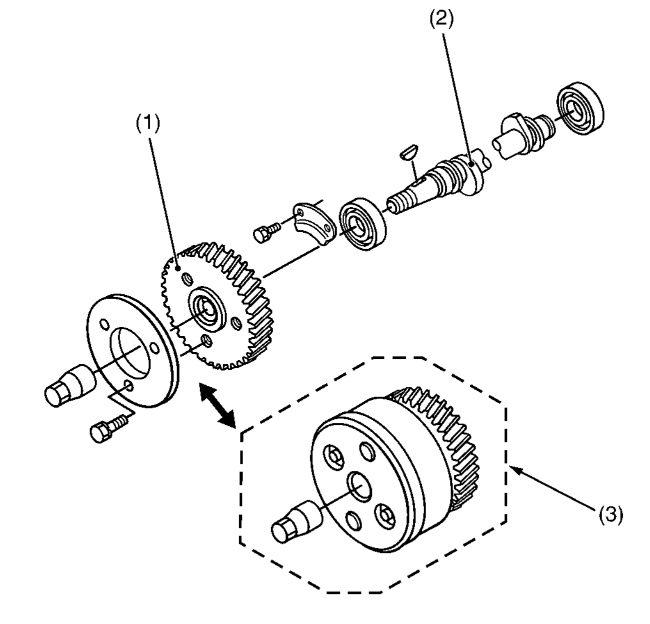
The journal diameters are large to permit removal of the shaft from its bore.

The journal sections are force-lubricated.

(1) Cam Gear
(2) Camshaft Stopper
(3) Camshaft
(4) Gear

W10140700

[12] FUEL CAMSHAFT



3EEAAAA1P027A

The fuel camshaft is driven by gearing from the crankshaft, and controls the reciprocating movement of the injection pump and the mechanical feed pump.

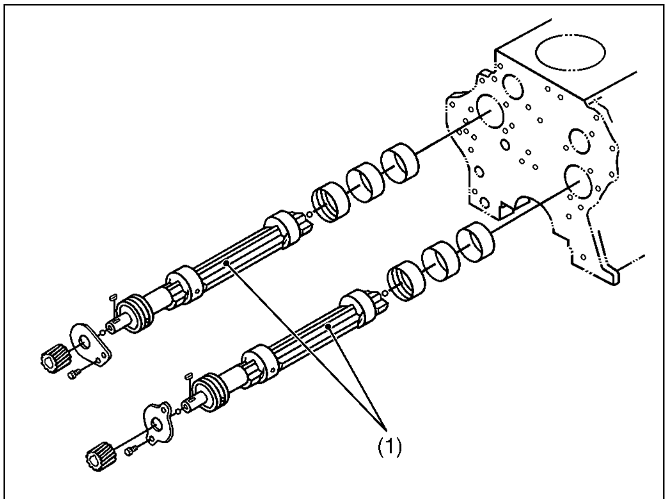
This is made of carbon steel and the cam sections are quenched and tempered to provide greater wear resistance.

On some models, the fuel camshaft is equipped with an automatic advance timer, which is designed to adjust the injection timing according to the engine speed and to obtain the best combustion efficiency.

(1) Injection Pump Gear
(2) Fuel Camshaft
(3) Automatic Advance Timer

W10141730

[13] BALANCER



3EEAAAA1P028A

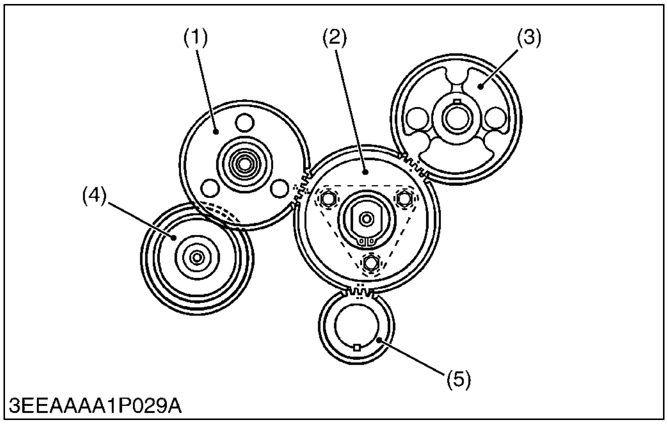
Engines are sure to vibrate by piston's reciprocation. Theoretically, three-cylinder engines are much less prone to cause vibration than four-cylinder ones (second inertia, etc.). However, any engine has many moving parts in addition to its pistons and cannot be completely free from vibration.

To reduce the vibration on high-speed engine, balance weights or balancer shafts are used.

(1) Balancer Shaft

W10142750

[14] TIMING GEARS



The crankshaft is the **"hub"** around which other parts of the engine can be timed and driven. This is done by the meshing of gears as shown in the figure.

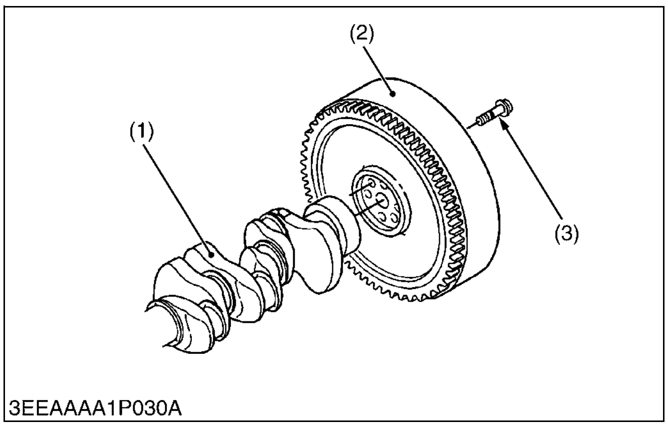
The timing gears transmit torque from the crankshaft to the oil pump and injection pump and, at the same time, correctly control fuel injection to the cylinders and valve timing.

Each gear has a mating mark inscribed on it for correct and easy assembly and is spherical with teeth set obliquely to the axis of rotation to rotate smoothly and reduce noise.

(1) Injection Pump Gear
(2) Idle Gear
(3) Cam Gear
(4) Governor Gear
(5) Crank Gear

W10143480

[15] FLYWHEEL



The flywheel is generally made of heavy cast iron or steel and has gear teeth around its outer rim, which mesh with the drive pinion of starter.

The flywheel (2) mounted on the rear of the crankshaft (1) is a stabilizer for the whole engine.

The flywheel stores the rotating force in the combustion stroke as inertial energy, reduces crankshaft rotating speed fluctuation and maintains the smooth rotating conditions.

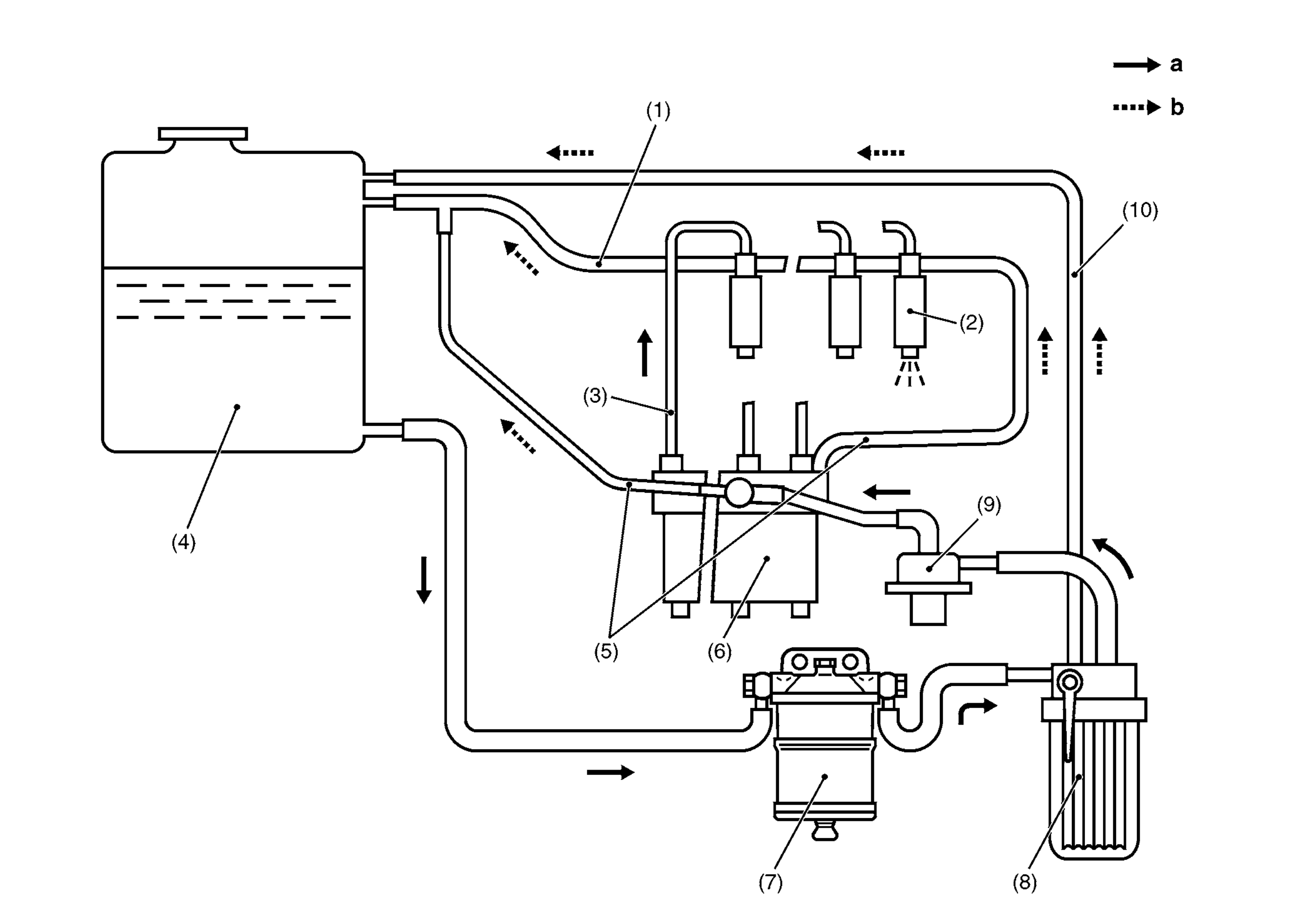
The flywheel periphery is inscribed with the marks showing fuel injection timing angle lines and top dead center mark **TC**.

(1) Crankshaft
(2) Flywheel
(3) Flywheel Screw

W10144750

3. FUEL SYSTEM

[1] GENERAL



(1) Fuel Overflow Pipe
(2) Injection Nozzle
(3) Injection Pipe
(4) Fuel Tank
(5) Injection Pump Air Vent Pipe
(6) Injection Pump
(7) Sedimenter
(8) Fuel Filter
(9) Fuel Feed Pump
(10) Fuel Filter Air Vent Pipe
(a) Injected Fuel Flow
(b) Returned Fuel Flow

The fuel system of Kubota engines is shown in the diagram above.

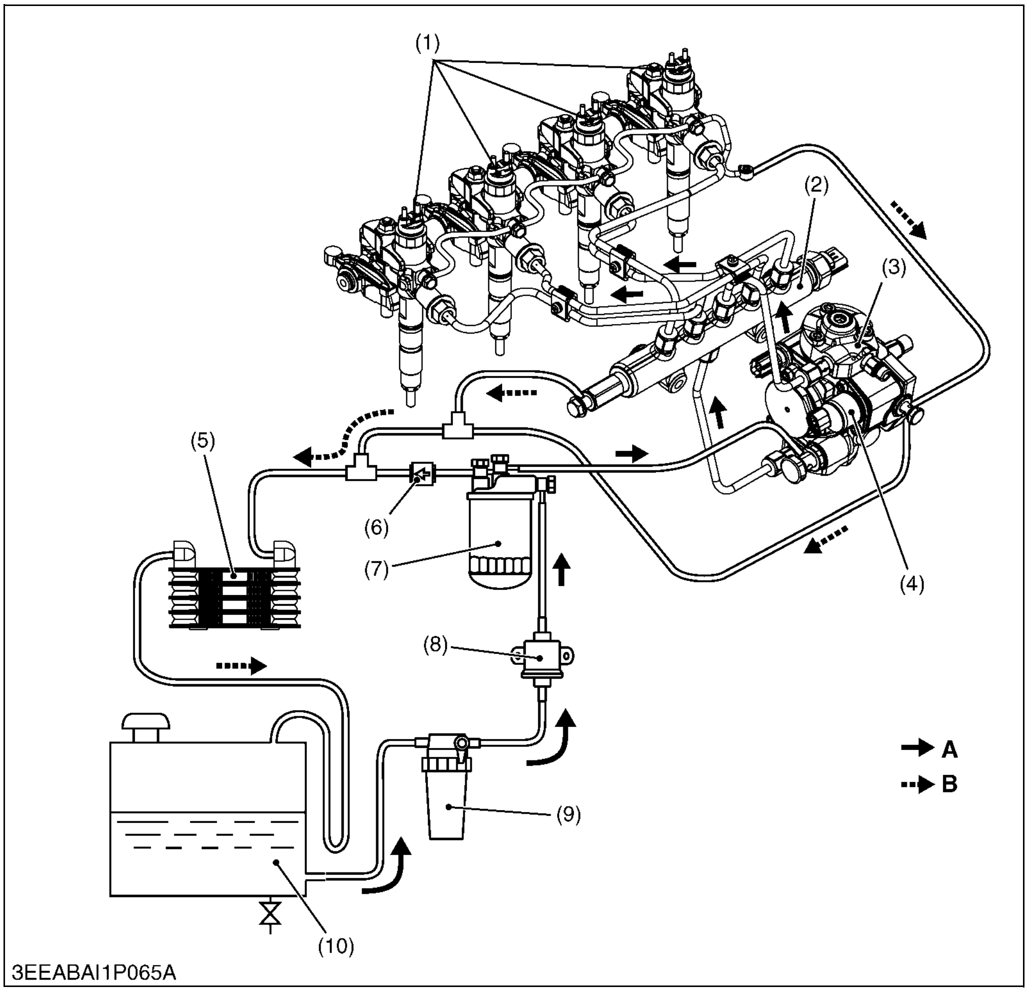
Fuel from the tank flows in the passage as shown by the arrows, and is injected from the nozzle via the fuel injection pump. Overflow fuel returns to the tank.

The system includes filters and other concerns to protect it from entrance of air, water and dust.

While the engine is running, fuel is fed into the injection pump (6) by the fuel feed pump (9) after passing through the sedimenter (7) and fuel filter (8) where any foreign matter is removed. The fuel camshaft actuates the injection pump and force-feeds fuel to the injection nozzle (2) through the injection pipe (3). Fuel is then sprayed through the nozzle into the combustion chamber. The fuel discharged after lubricating and cooling the injection nozzle is returned to the fuel tank (4) automatically through the overflow pipe (1).

W1013101

■ V38DICR-TIE3



(1) Injector
(2) Rail
(3) Supply Pump
(4) SCV (Suction Control Valve)
(5) Fuel Cooler
(6) Check Valve
(7) Fuel Filter
(8) Electromagnetic Fuel Feed Pump
(9) Sedimenter
(10) Fuel Tank

A : Injected Fuel Flow
B : Returned Fuel Flow

W1013924

The fuel system of Kubota common rail system diesel engine is shown in the diagram above.

Fuel from the tank flows in the passage as shown by the arrows, and is injected from the injector (1) via the supply pump (3) and the rail (2). Overflow fuel returns to the tank through the fuel cooler (5).

The system includes filters and other concerns to protect it from entrance of air, water and dust.

While the key switch is at **"ON"** position, fuel is fed into the supply pump (3) by the electromagnetic fuel feed pump (8) after passing through the sedimenter (9) and fuel filter (7) where any foreign matter is removed.

The fuel sent from the electromagnetic fuel feed pump (8) has the required discharge quantity adjusted by the SCV (Suction Control Valve) (4) and enters of the supply pump (3). The fuel pumped by the supply pump (3) is sent by pressure through the delivery valve to the rail (2).

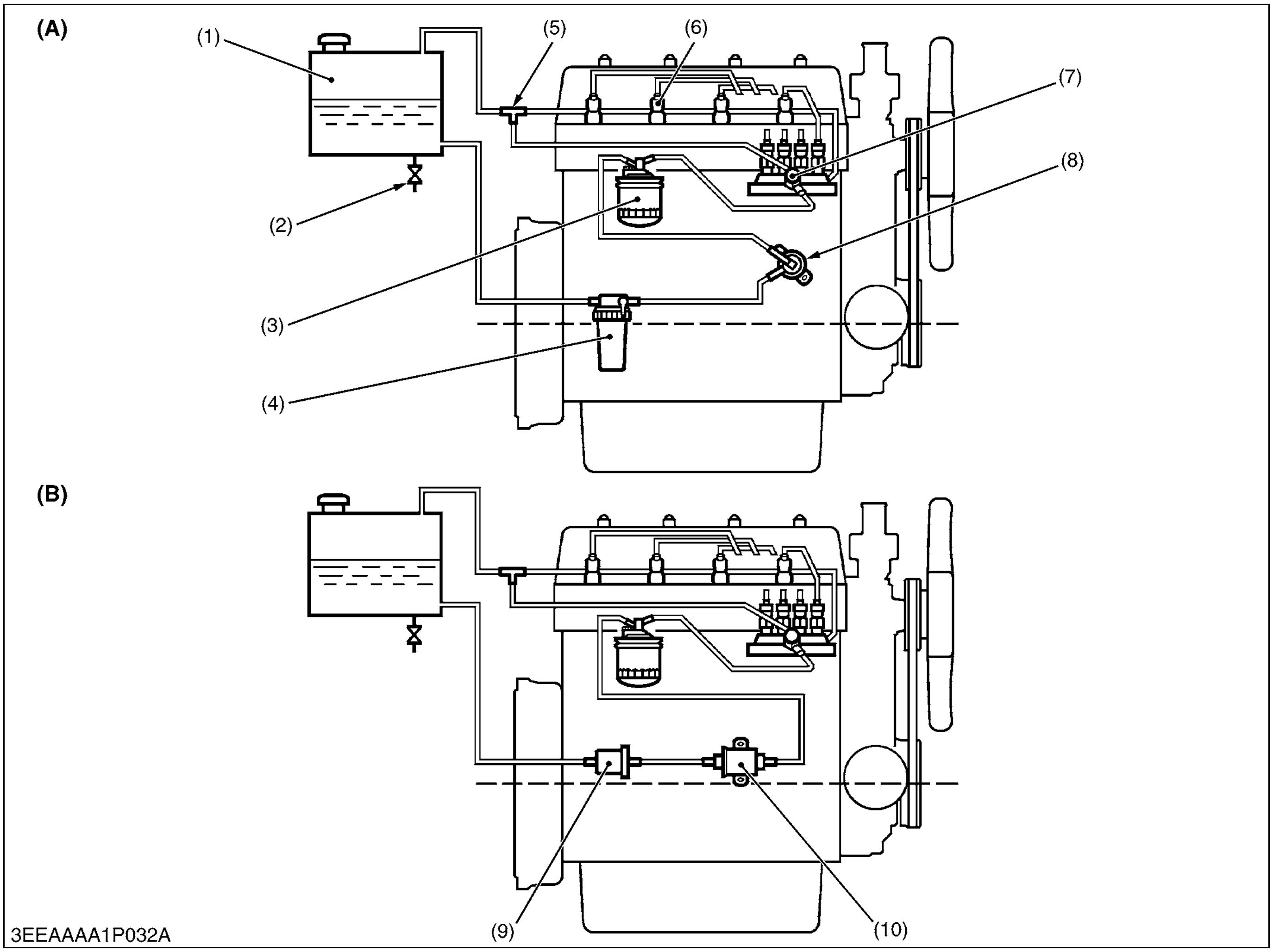
The injector (1) injects the pressurized fuel in the rail into the engine combustion chamber at the optimal injection timing, injection quantity, injection rate, and injection pattern, in accordance with signals from the engine ECU (Electronic Control Unit).

[2] FUEL PIPING

The fuel tank and fuel injection pump, the position of fuel filter and fuel feed pump, and length of piping may make air bleeding difficult, and also may cause air to be entrapped after long-term storage. In many engines, the fuel tank is installed at a lower level than the injection pump or at same level. In this case, if an electromagnetic fuel feed pump is added to smoothen the flow of fuel and to bleed the air included in the fuel system, starting failure, the output decrease and the fluctuation of rotation, all of which occur due to such installation positions, can be prevented.

Kubota recommends the following standard fuel piping.

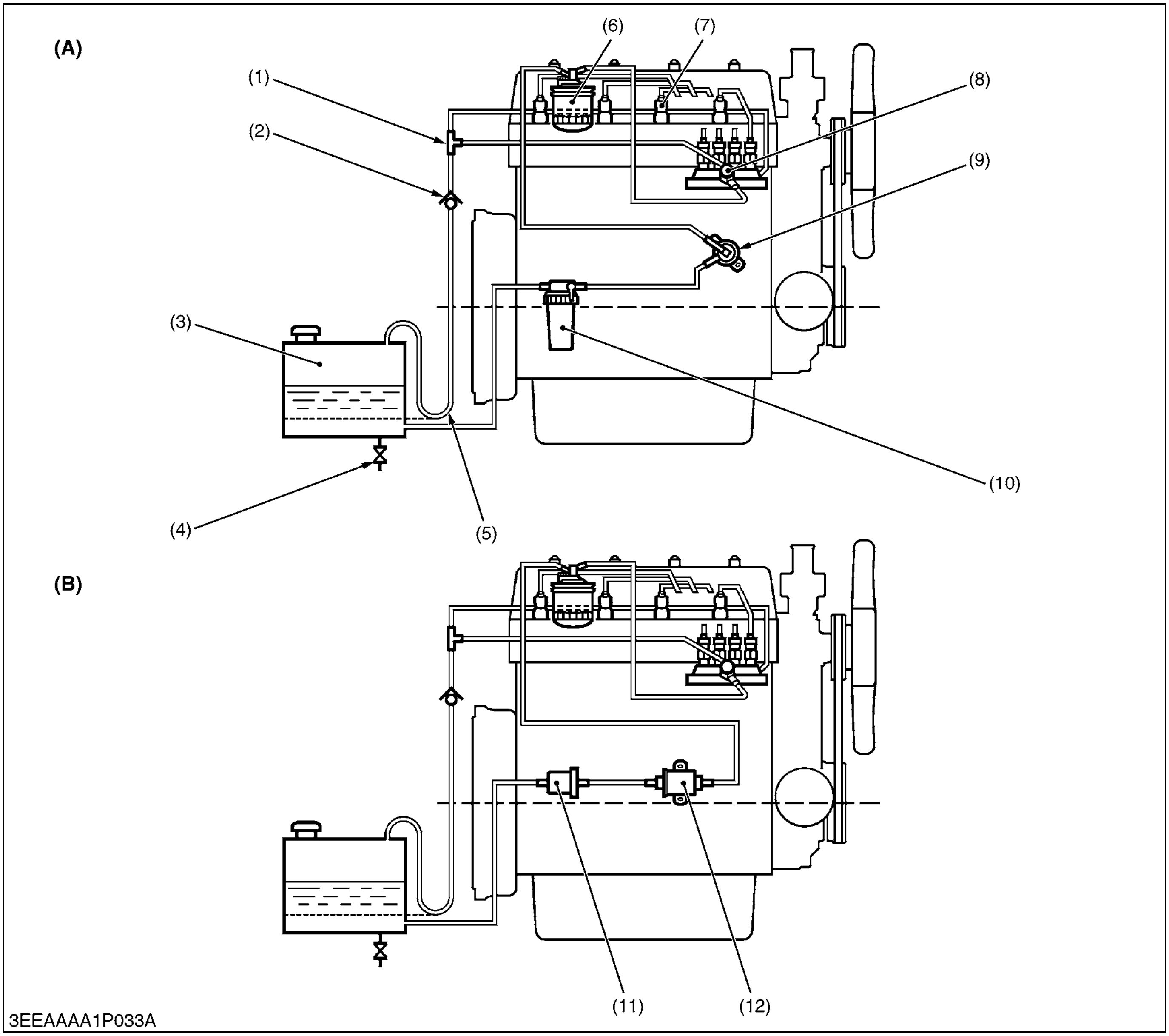
(1) SM and 05 Series (Upper Tank)



(1) Fuel Tank
(2) Drain Cock
(3) Fuel Filter
(4) Sedimenter
(5) T Joint
(6) Injection Nozzle
(7) Injection Pump
(8) Mechanical Fuel Feed Pump
(9) Pre-filter
(10) Electromagnetic Fuel Feed Pump

(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

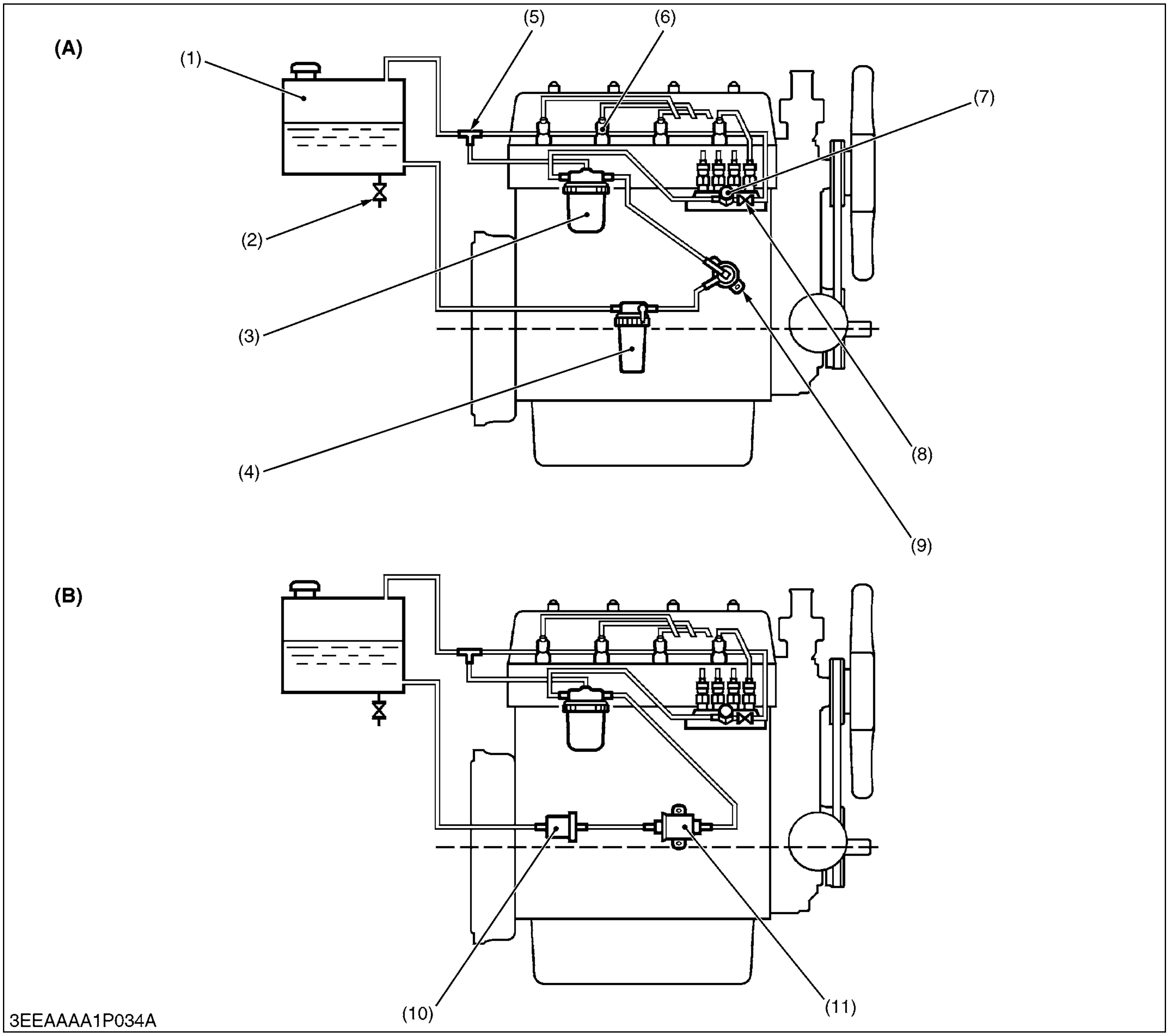
(2) SM and 05 Series (Lower Tank)



(1) T Joint
(2) Check Valve
(3) Fuel Tank
(4) Drain Cock
(5) U Return
(6) Fuel Filter
(7) Injection Nozzle
(8) Injection Pump
(9) Mechanical Fuel Feed Pump
(10) Sedimenter
(11) Pre-filter
(12) Electromagnetic Fuel Feed Pump

(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

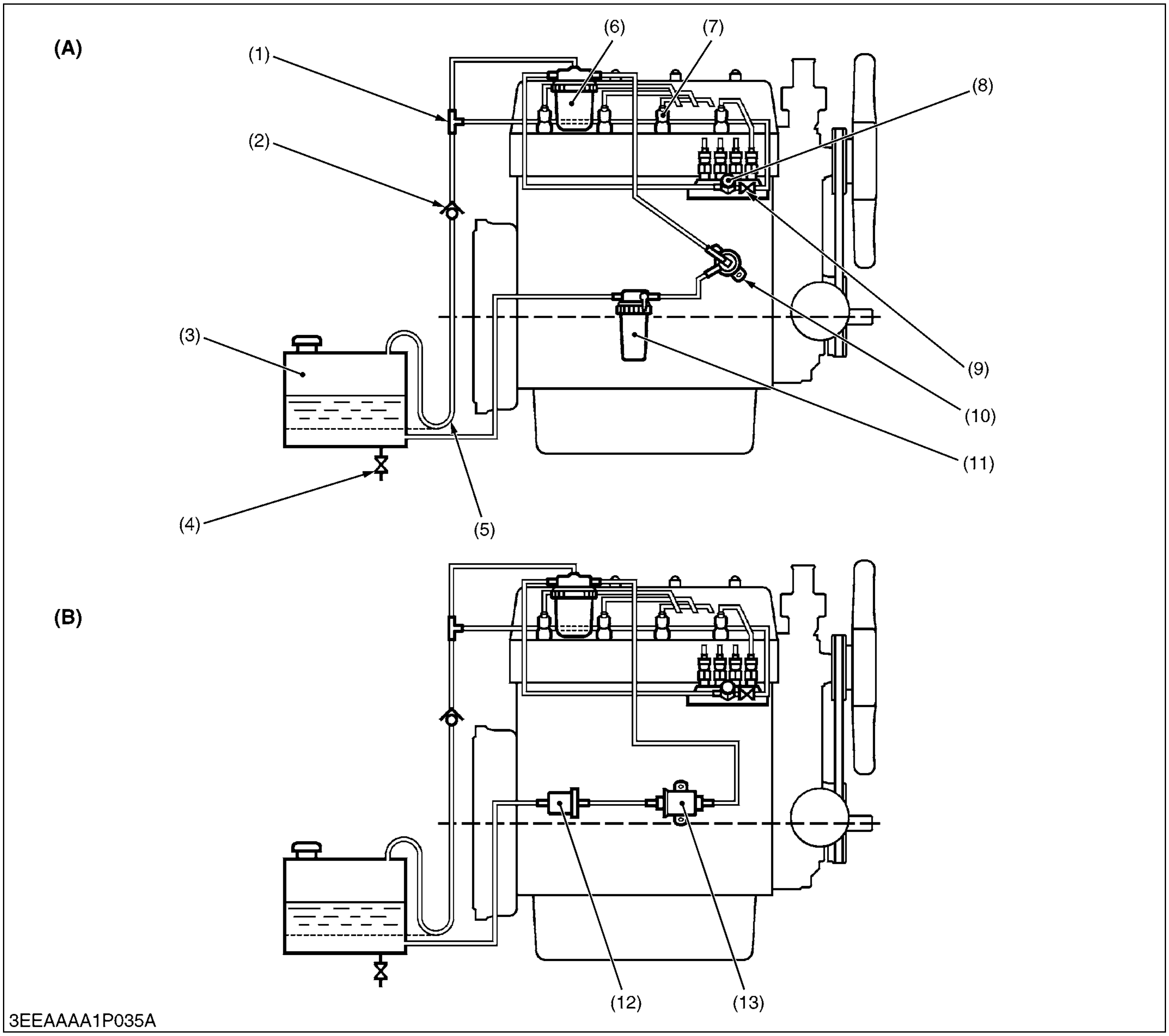
(3) 03 and 03-M Series (Upper Tank)



(1) Fuel Tank
(2) Drain Cock
(3) Fuel Filter
(4) Sedimenter
(5) T Joint
(6) Injection Nozzle
(7) Injection Pump
(8) Air Bleeding Valve
(9) Mechanical Fuel Feed Pump
(10) Pre-filter
(11) Electromagnetic Fuel Feed Pump

(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

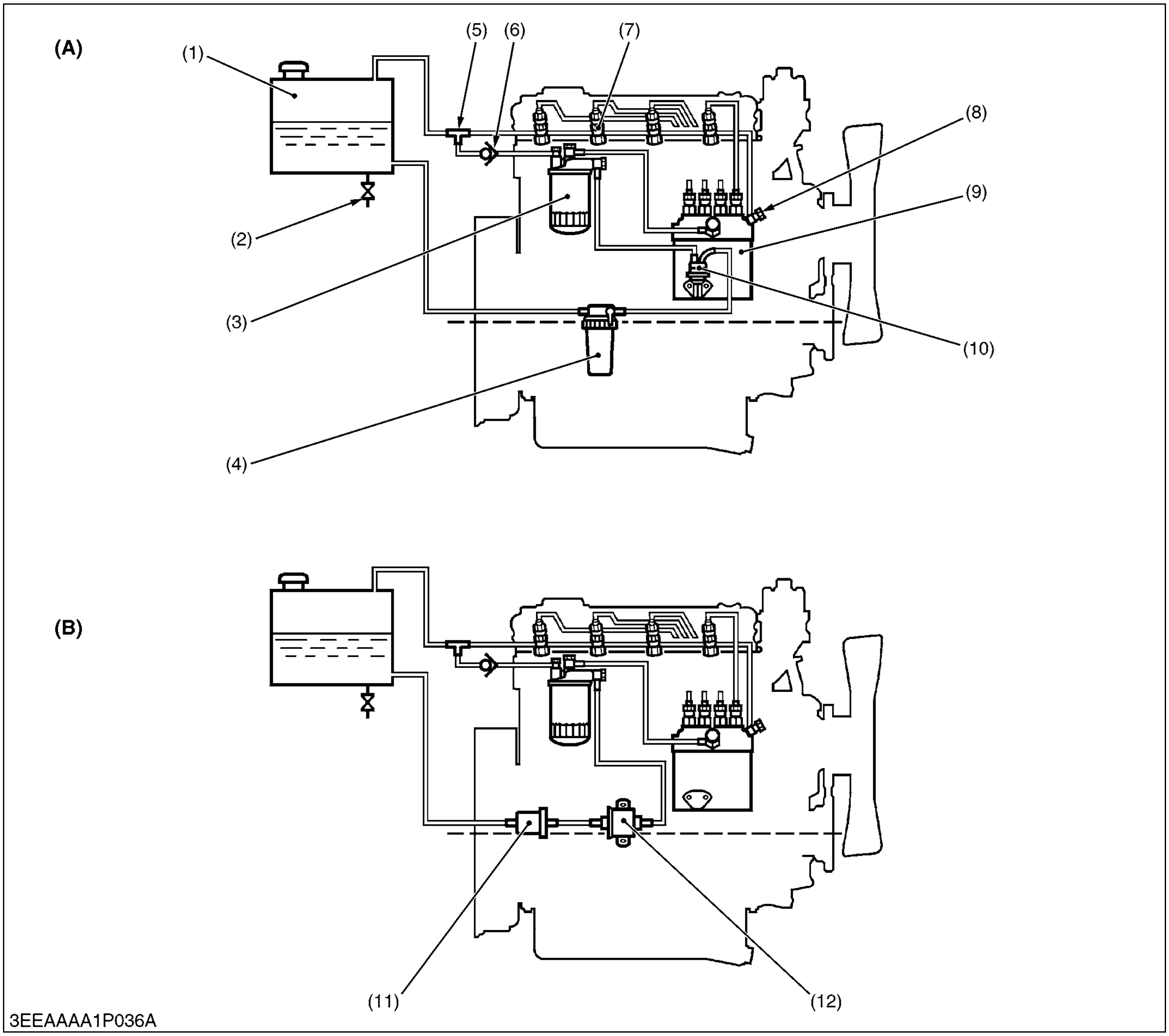
(4) 03 and 03-M Series (Lower Tank)



(1) T Joint
(2) Check Valve
(3) Fuel Tank
(4) Drain Cock
(5) U Return
(6) Fuel Filter
(7) Injection Nozzle
(8) Injection Pump
(9) Air Bleeding Valve
(10) Mechanical Fuel Feed Pump
(11) Sedimenter
(12) Pre-filter
(13) Electromagnetic Fuel Feed Pump

(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

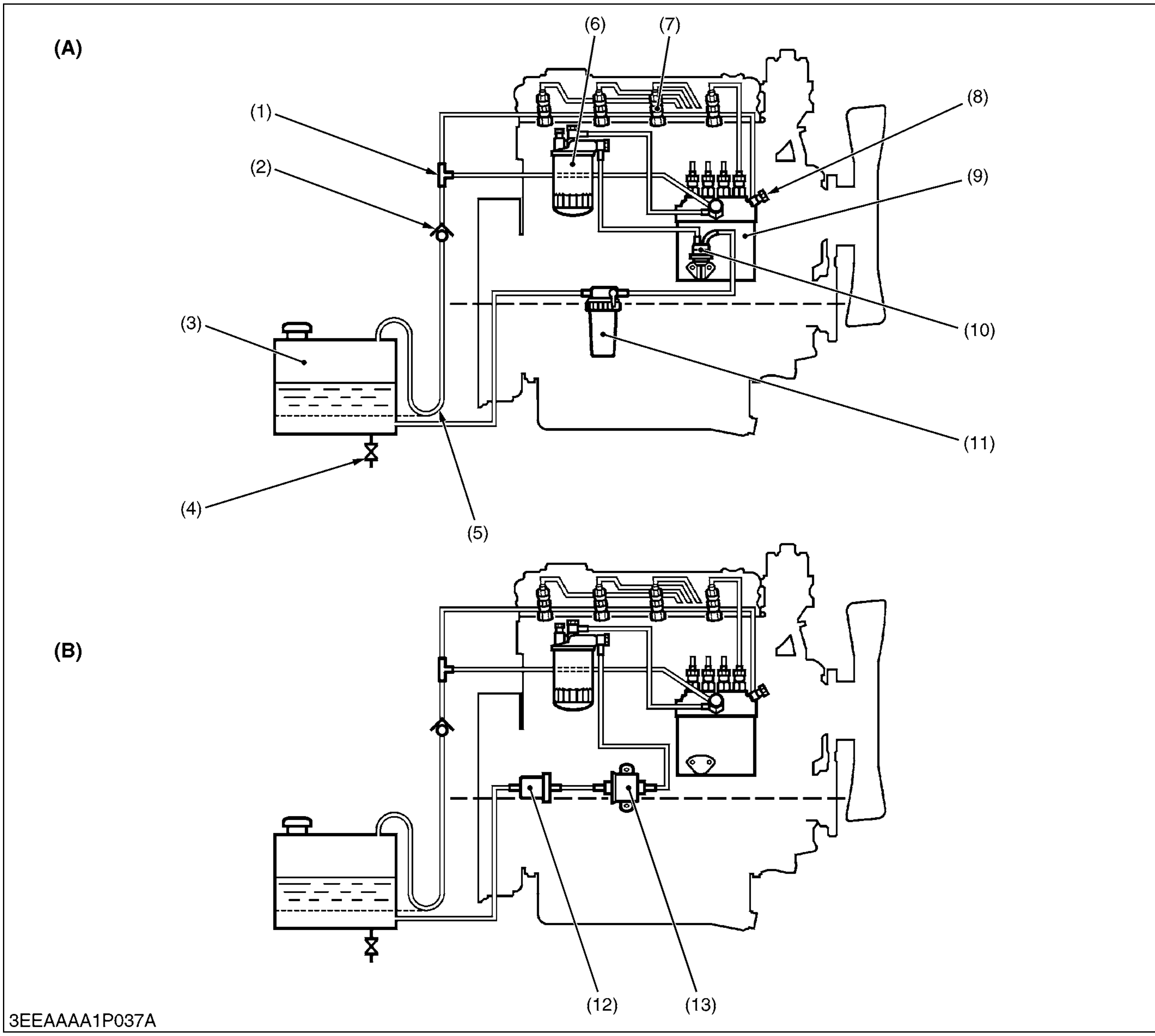
(5) V3 Series (Upper Tank)



(1) Fuel Tank
(2) Drain Cock
(3) Fuel Filter
(4) Sedimenter
(5) T Joint
(6) Check Valve
(7) Injection Nozzle
(8) Air Bleeding Valve
(9) Injection Pump
(10) Mechanical Fuel Feed Pump
(11) Pre-filter
(12) Electromagnetic Fuel Feed Pump

(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

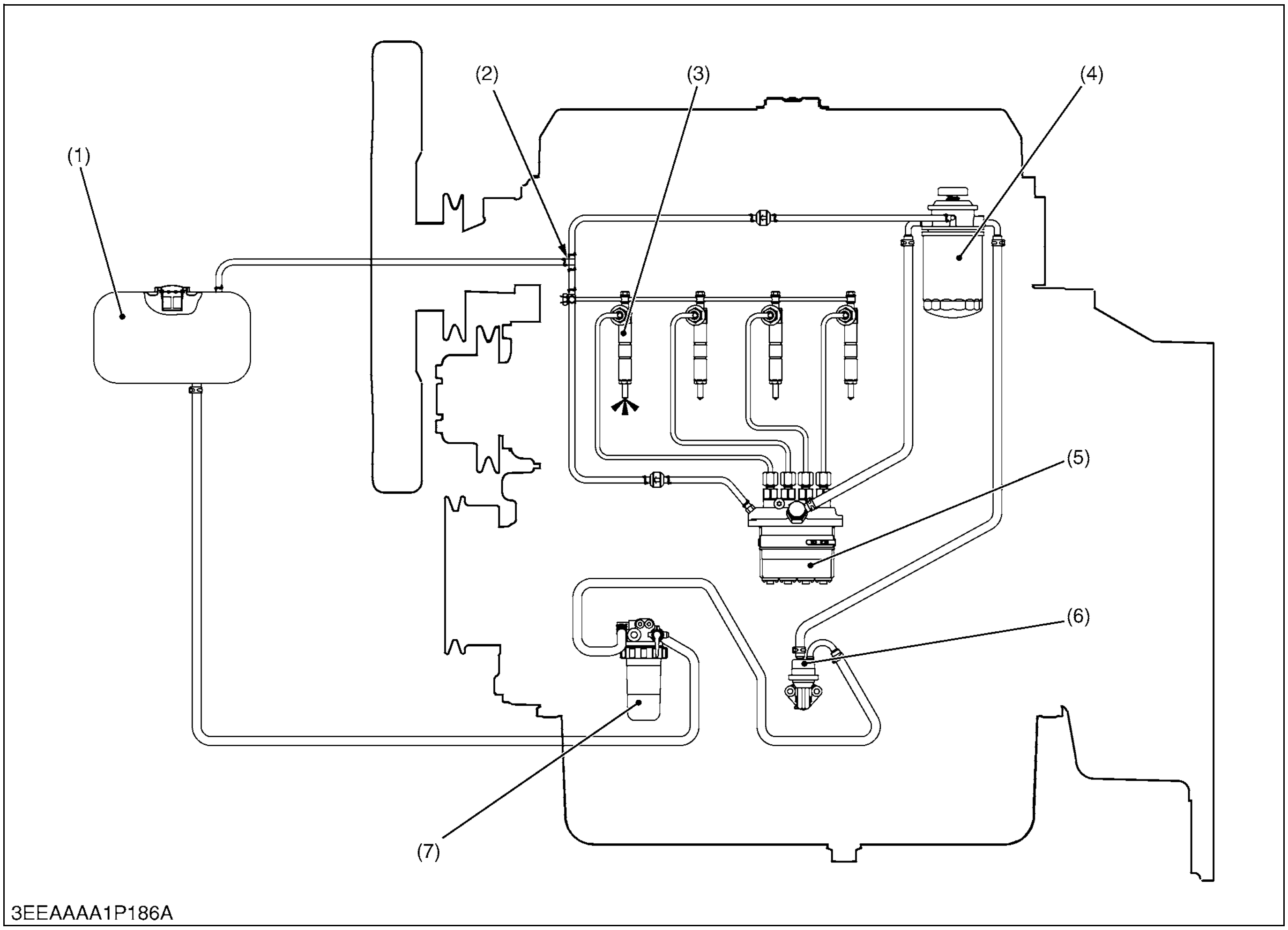
(6) V3 Series (Lower Tank)



(1) T Joint
(2) Check Valve
(3) Fuel Tank
(4) Drain Cock
(5) U Return
(6) Fuel Filter
(7) Injection Nozzle
(8) Air Bleeding Valve
(9) Injection Pump
(10) Mechanical Fuel Feed Pump
(11) Sedimenter
(12) Pre-filter
(13) Electromagnetic Fuel Feed Pump

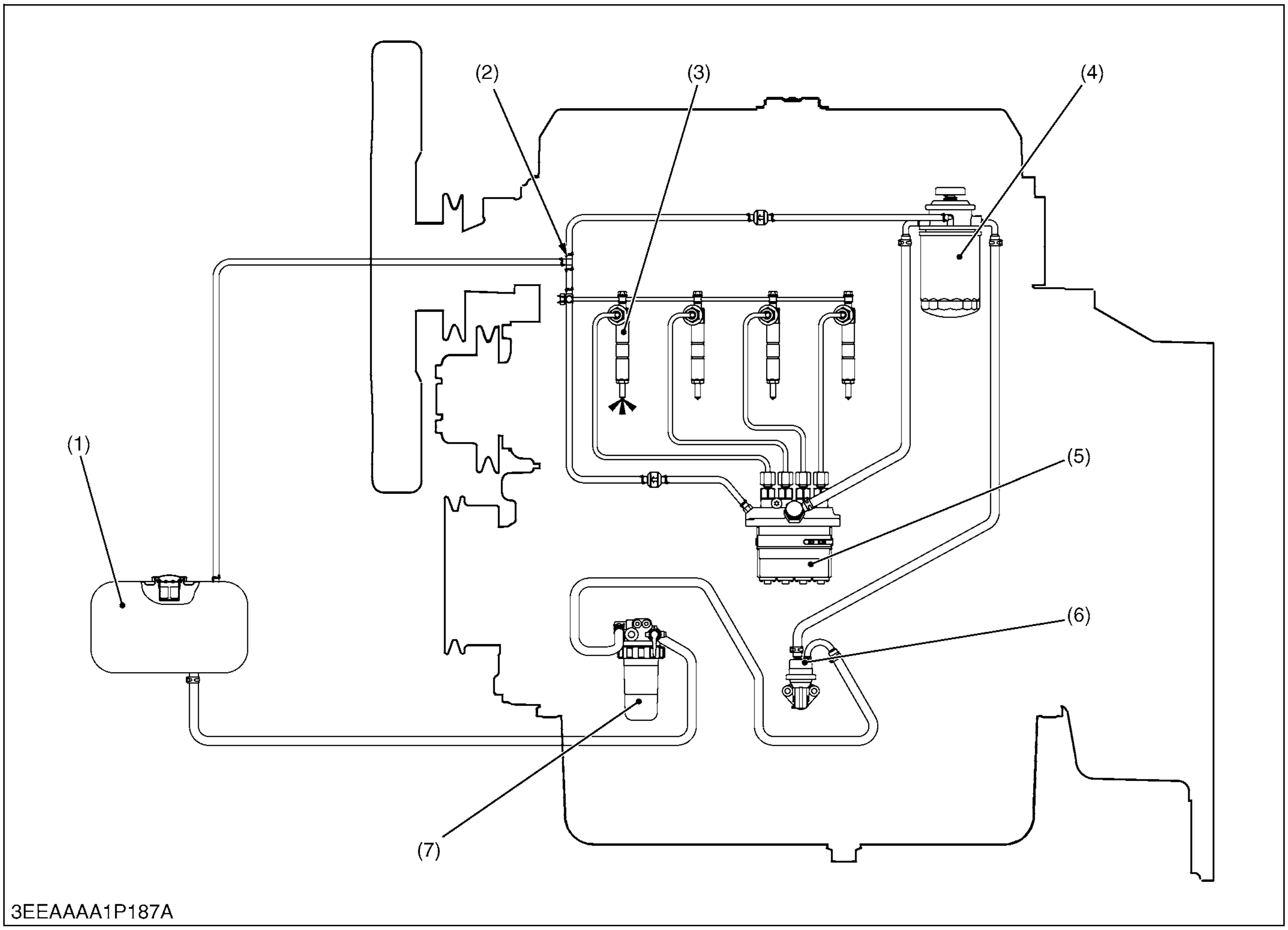
(A) Mechanical Fuel Feed Pump Type
(B) Electromagnetic Fuel Feed Pump Type

(7) 07 Series (Upper Tank)



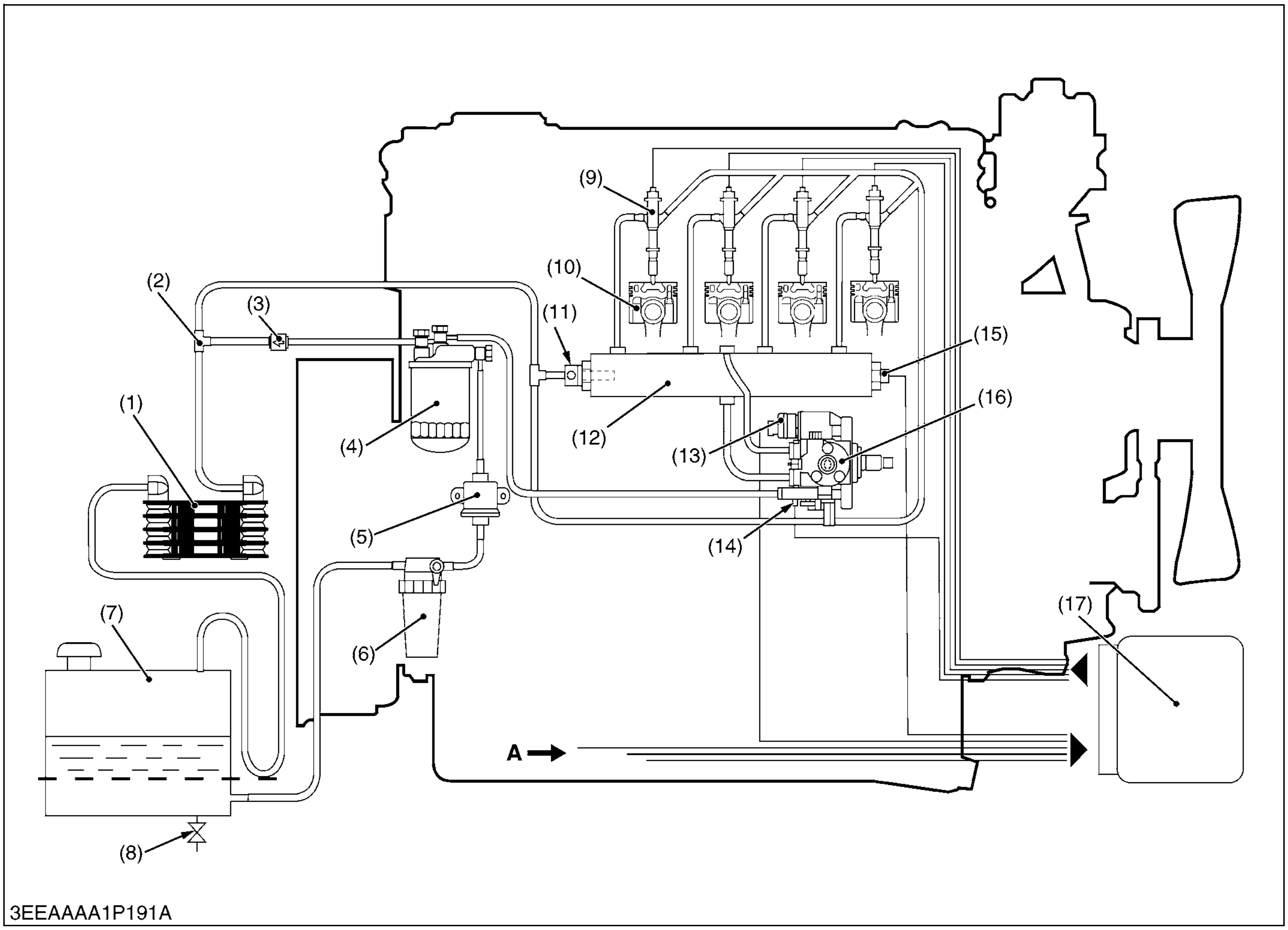
(1) Fuel Tank
(2) T Joint
(3) Injection Nozzle
(4) Fuel Filter
(5) Injection Pump
(6) Fuel Feed Pump
(7) Sedimenter

(8) 07 Series (Lower Tank)



(1) Fuel Tank
(2) T Joint
(3) Injection Nozzle
(4) Fuel Filter
(5) Injection Pump
(6) Fuel Feed Pump
(7) Sedimenter

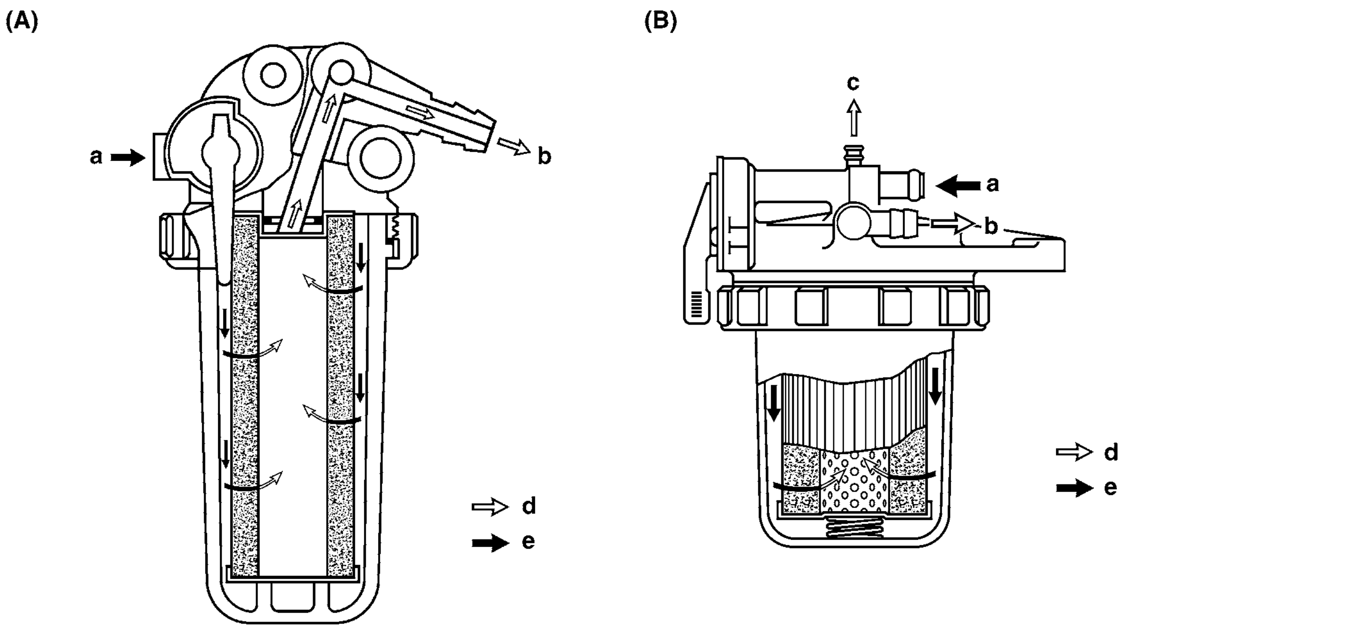
(9) V38DICR-TIE3 (Lower Tank)



(1) Fuel Cooler
(2) T Joint
(3) Check Valve
(4) Fuel Filter
(5) Electromagnetic Fuel Feed Pump
(6) Sedimenter
(7) Fuel Tank
(8) Drain Cock
(9) Injector
(10) Piston
(11) Pressure Limiter
(12) Rail
(13) Fuel Temperature Sensor
(14) SCV (Suction Control Valve)
(15) Rail Pressure Sensor
(16) Supply Pump
(17) Engine ECU (Electronic Control Unit)

A : From Various Sensors

[3] FUEL FILTER



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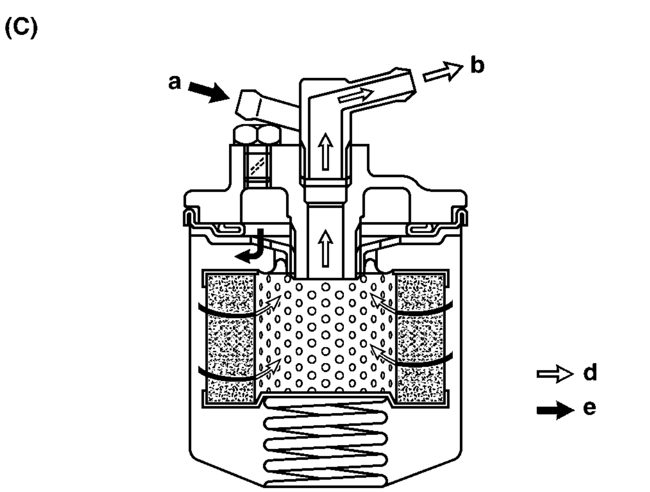

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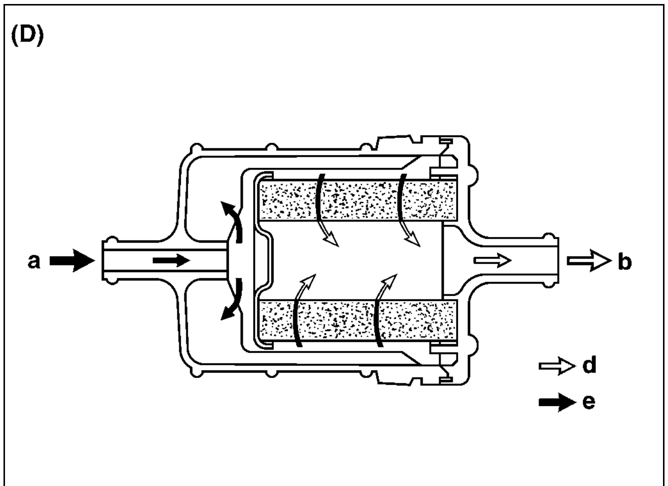


3EEAAAA1P040A

A standard Kubota filter uses a paper cartridge element (filtration diameter less than 15 µm).

Filtration surface areas available in Kubota filter are 250 cm^2 (38.8 sq.in.), 1100 cm^2 (170.5 sq.in.) and 1660 cm^2 (257.3 sq.in.), according to engine model.

Normally, filter elements or cartridges must be changed every 400 hours.

Three types of filters are shown.

Type 1 **(A)** is paper element.

Type 2 **(B)** filter has an automatic venting mechanism that can complete venting in about one minute with the lever the open position.

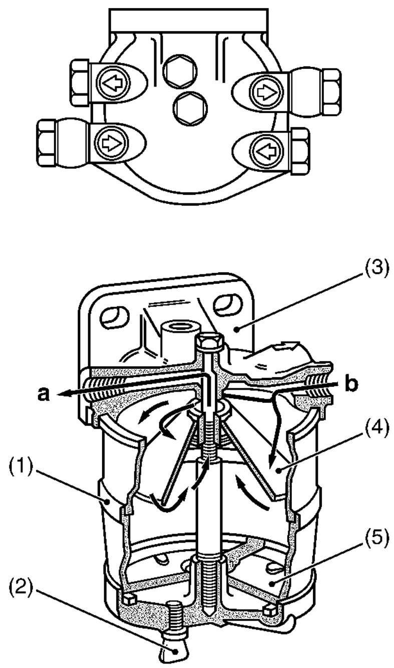
Type 3 **(C)** is cartridge element.

Type 4 **(D)** filter is installed in the fuel line with an electromagnetic fuel feed pump.

(A) Type 1	**a : Fuel In**
(B) Type 2	**b : Fuel Out**
(C) Type 3	**c : Returned Fuel**
(D) Type 4	**d : Filtered Fuel**
	e : Unfiltered Fuel

W10177840

[4] SEDIMENTER



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The sedimenter mainly removes all large droplets of water and solid particles from fuel.

(1) Transparent Bowl
(2) Drain Plug
(3) Sedimenter Head
(4) Conical Diffuser
(5) Sedimenter Chamber

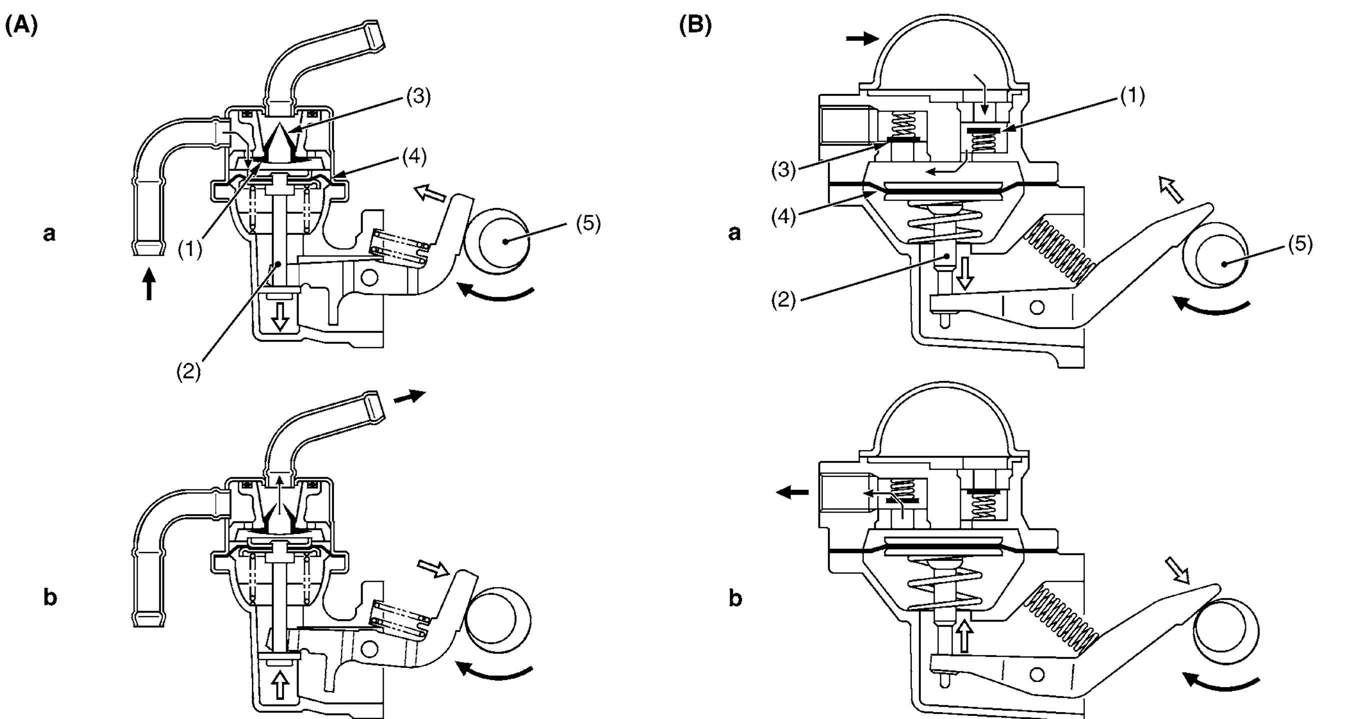
a : Fuel Out
b : Fuel In

W10180120

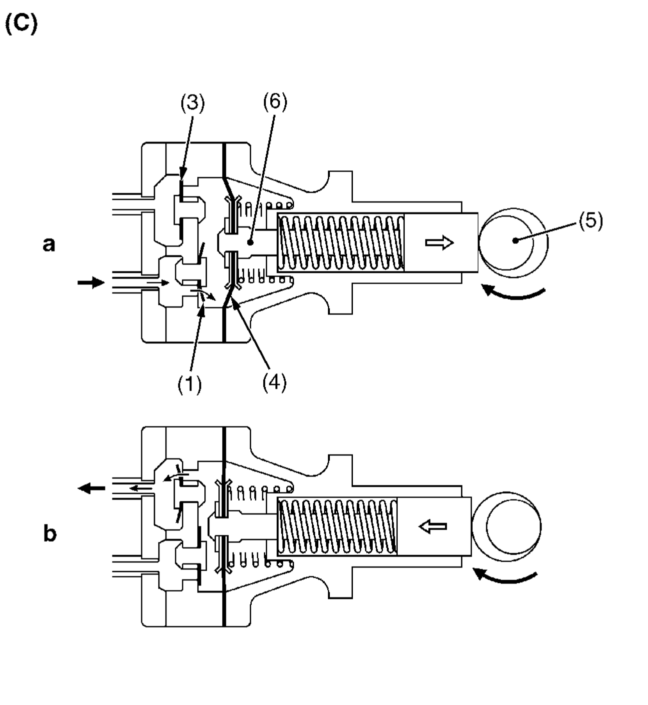
[5] FUEL FEED PUMP

Feed pump comes in two general types.
(1) Mechanical Fuel Feed Pump
(2) Electromagnetic Fuel Feed Pump

(1) Mechanical Fuel Feed Pump



3EEAAAA1P042A



3EEAAAA1P043A

This type of pump uses a diaphragm in which the flexing of the diaphragm attached to the pump body changes the capacity of the pump chamber to create the vacuum necessary for pumping.

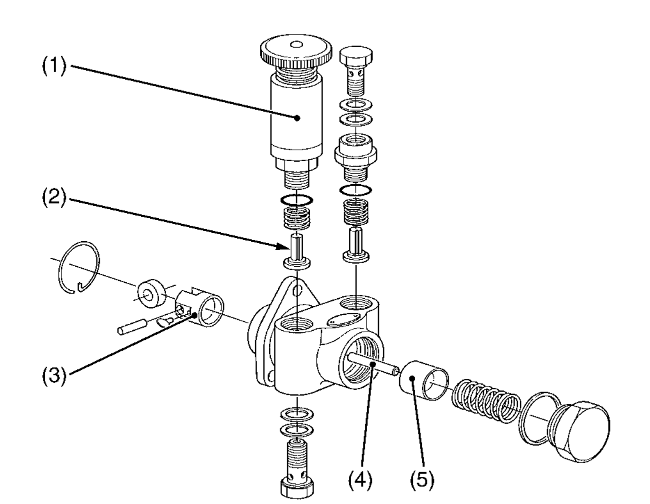
The pump is mounted on the side of the injection pump and driven by an eccentric cam on the camshaft of the injection pump.

(1) Inlet Valve
(2) Pull Rod
(3) Outlet Valve
(4) Diaphragm
(5) Fuel Camshaft
(6) Push Rod

(A) Type 1
(B) Type 2
(C) Type 3

a : Intake Stroke
b : Discharge Stroke

W10185110



1) Fuel Feed Pump with Hand Priming Pump

This type of pump uses a piston.

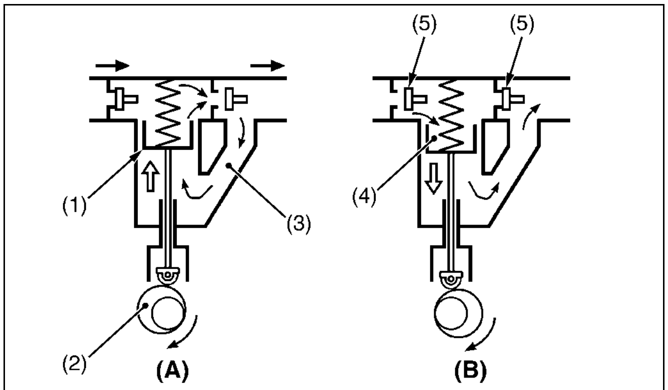
Pressure is applied to fuel by reciprocating movement of the piston (5) which is driven by the tappet (3) of the feed pump via the push rod (4).

The priming pump (1) is provided to the feed pump, which is used to feed fuel manually to the injection pump, and is used for purging air.

The construction of the feed pump is schematically shown in figures and consists of two check valves (2) and a piston (5).

(1) Priming Pump
(2) Check Valve
(3) Tappet
(4) Push Rod
(5) Piston

W10187790



■ Operation

(A) Intermediate Stroke Position

When the cam (2) is at position **(A)**, the piston (1) is rising, the check valve (5) on the fed side opens and fuel in the suction chamber (4) is sent to the pressure chamber (3).

(B) Intake and Discharge Position

When the cam (2) is at position **(B)**, the piston is pressed down by the spring and fuel in the pressure chamber (3) is sent to the injection pump.

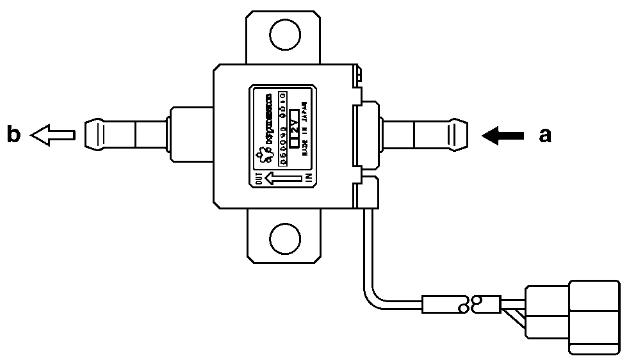
At the same time, the suction check valve (5) opens to take fuel into the suction chamber (4).

The above operation is repeated to suck and feed fuel to the injection pump.

(1) Piston
(2) Cam
(3) Pressure Chamber
(4) Suction Chamber
(5) Check Valve
(A) Intermediate Stroke Position
(B) Intake and Discharge Position

W10933760

(2) Electromagnetic Fuel Feed Pump



3EEAAAA1P046C

An electromagnetic fuel feed pump is used when a fuel tank is positioned below the pump of the engine.

An electromagnetic fuel feed pump uses a transistor that causes the pump to start pumping fuel when the main switch is turned to the **"ON"** position.

Therefore, fuel is supplied to the injection pump regardless of engine speed. This pump is driven by the battery. It can therefore be operated even with the engine being stopped.

a : Fuel In **b : Fuel Out**

W10188690

[6] INJECTION NOZZLE

Injection nozzle of Kubota engines may be classified as.

(1) Throttle nozzle (for IDI*)

(2) Hole nozzle (for DI*)

1) Multiple hole type

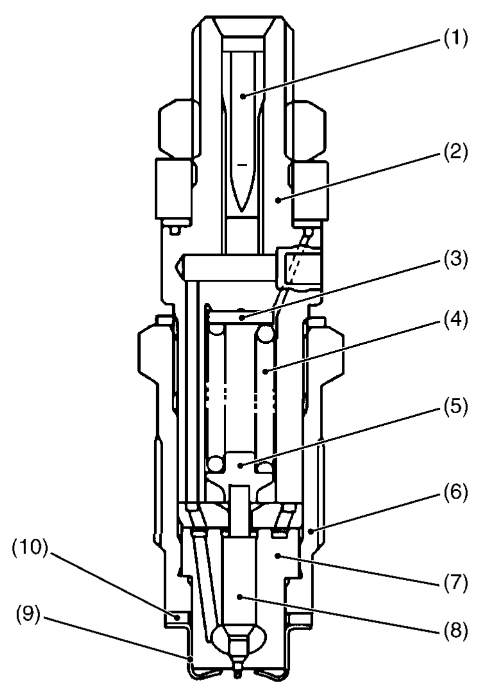
2) Pencil type

3) Two spring type

4) Two stage type

* IDI : In-Direct Injection, DI : Direct Injection

(1) Throttle Nozzle (For IDI)



3EEAAAA1P047A

Uses as E-TVCS system, the small-sized DENSO made OPD mini nozzle is of a flat-cut-provided double throttle type.

This type of nozzle is designed to control the injection quantity when the lift rate is low at start of the injection, and to cut down on the knocking sound caused by excessive fuel injection by giving the needle valve section more taper than before to prevent the rapid increase in the injection quantity when the initial injection turns into the full-force injection.

Also, employed to prevent the injection quantity loss in the throttle section caused by carbon, the flat cut provided at the needle valve section helps the throttle withstand long use and reduce as much knocking sound as when it was new.

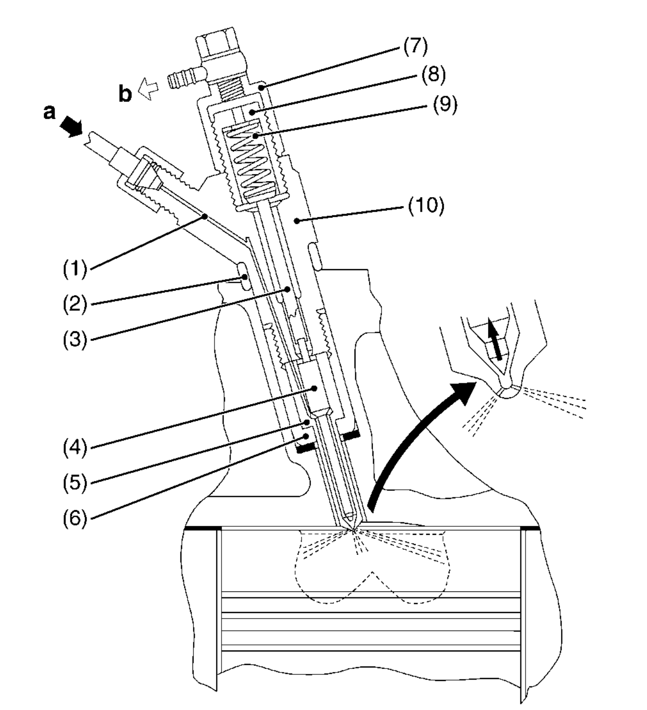
The heat seal is employed to improve the durability and reliability of the nozzle.

(1) Bar Filter
(2) Nozzle Holder Body
(3) Adjusting Washer
(4) Nozzle Spring
(5) Push Rod
(6) Retaining Nut
(7) Nozzle Piece
(8) Needle Valve
(9) Heat Seal
(10) Gasket

W10273510

(2) Hole Nozzle (For DI)

1) Multiple hole type



3EEAAAA1P048A

This hole type injection nozzle has a needle valve (4) which is conical at its end.

This type of nozzle can atomize fuel in three directions and mix it with air to generate air mixture suitable for combustion.

The three injection ports are provided at the tip of the nozzle nut (6) at a given angle centering around the nozzle.

The injection port diameter is 0.35 mm (0.014 in.).

The reason why the injection port diameter is so small is that it betters the injection shut off and lowers the temperature at the injection port to prevent the injection ports from narrowing or clogging due to carbon deposit. The high-pressure fuel fed from the injection pump passes through the passage (1) at the side of the nozzle body and compresses the nozzle spring (9) to push up the needle valve.

The fuel is injected into the combustion chamber from the injection ports at the nozzle nut tip.

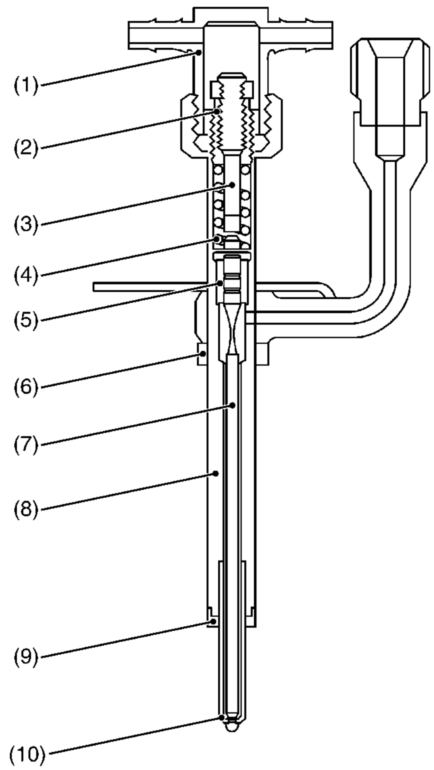
The fuel, after lubricating the needle valve and nozzle body, returns to the fuel tank after passing through the fuel overflow pipe.

(1) Fuel Passage
(2) Seal Ring
(3) Push Rod
(4) Needle Valve
(5) Nozzle Body
(6) Nozzle Nut
(7) Nut
(8) Adjusting Screw
(9) Nozzle Spring
(10) Nozzle Holder

a : From Injection Pump
b : To Fuel Tank

W10275520

2) Pencil type



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The nozzle is a pencil type, which is suitable for the direct injection system.

When the fuel is not delivered from the injection pump, the needle valve (7) is tightly closed against the nozzle tip (10) by the pressure spring (4).

As the injection pump force-feeds the fuel to the injection nozzle through the delivery pipe, the fuel pressure in the closed chamber is increased.

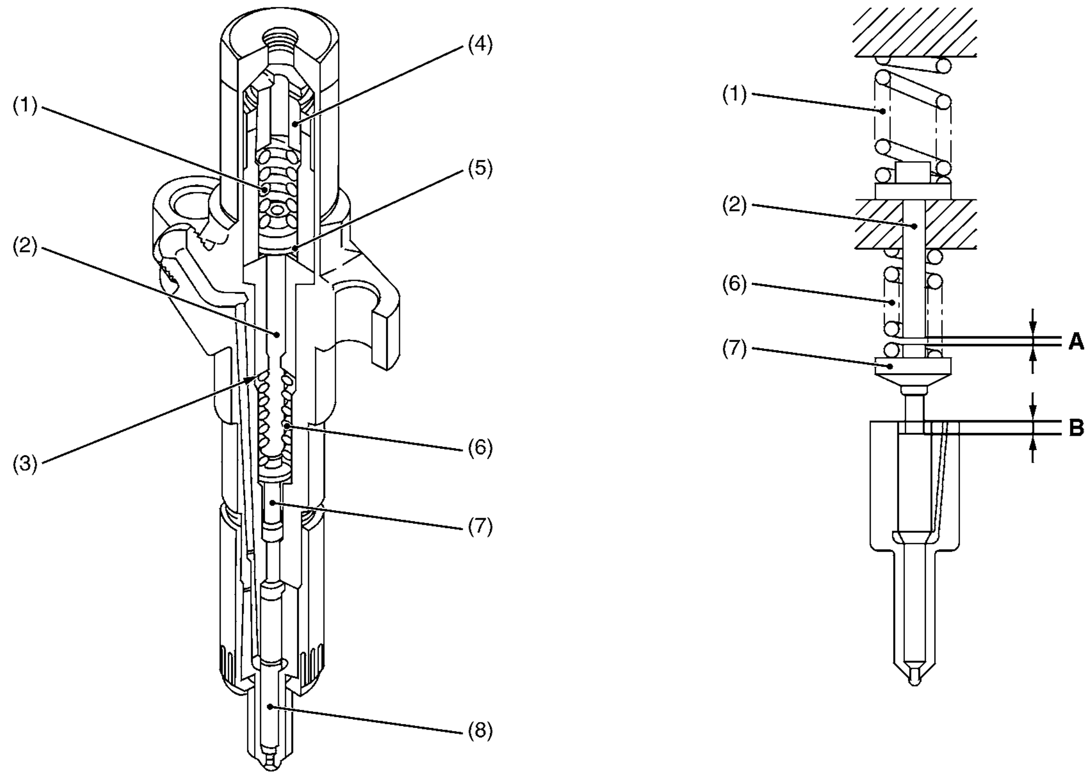
When the fuel pressure rises and overcomes the tension of the pressure spring (4), the valve is pushed up and the fuel is sprayed through four 0.25 mm (0.0098 in.) diameter holes into the cylinder, where the fuel is ignited by the high-temperature and high-pressure air.

The excessive fuel from the injection pump flows through the space between the needle valve (7) and the valve guide (5) to the leak-off cap (1), cooling and lubricating the nozzle.

(1) Leak-off Cap	(6) Dust Seal
(2) Pressure Adjusting Screw	(7) Needle Valve
(3) Lift Adjusting Screw	(8) Valve Body
(4) Pressure Spring	(9) Carbon Stop Seal
(5) Valve Guide	(10) Nozzle Tip

W10276440

3) Two Spring type



(1) No.2 Spring
(2) No.2 Push Rod
(3) Opening Valve Adjusting Shim
(4) Adjusting Screw
(5) Pre Lift Adjusting Shim
(6) No.1 Spring
(7) No.1 Push Rod
(8) Needle Valve
A : Pre Lift
B : Full Lift

To improve stability during low and middle speed operation and reduce the noise level, the two spring type nozzle is adopted for some models.

The construction is shown above.
The nozzle has two nozzle spring and push rods.
Between No.1 and No.2 push rod (7), (2) is a gap (Pre Lift) which is used to injection fuel in two stages.

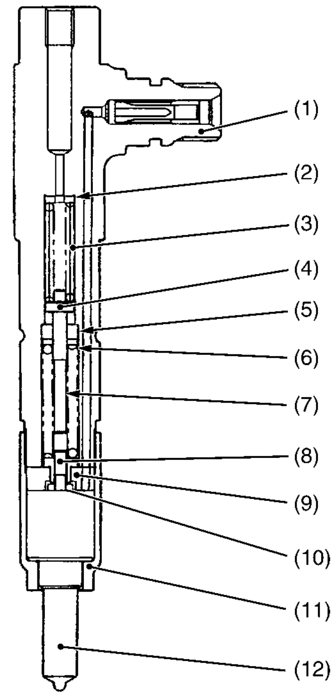
The nozzle operation as below.

1. Then fuel pressure in the nozzle increases to reach the predetermined valve opening pressure, the needle valve rises by the **"Pre Lift (A)"** to start fuel injection (throttle injection).
2. When fuel pressure further increase in the nozzle exceeding the total force of No.1 and No.2 springs (6), (1), the needle valve further rises to reach the **"Full Lift (B)"** position, causing the main injection to occur.

No.1 spring (No.1 opening valve) (6) and pre lift are adjusted by the respective shim while No.2 spring (1) is adjusted by the adjusting screw (4).

W1024201

4) Two stage type



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Exhaust and noise regulations are becoming increasingly strict, particularly in regard to the reduction of NOx (nitrogen oxides) and particulates.

The two-spring nozzle holder has been developed to reduce NOx (nitrogen oxides) and particulates from direct injection diesel engine exhaust.

■ **Features**

The two-spring nozzle holder limits needle valve lift at initial valve opening to throttle the injection quantity. Main injection occurs when the in-line pressure has increased sufficiently to move the needle valve through its full lift.

This gives the following features.

- Improved engine stability at low and intermediate speeds.
- Decreased engine hunting and surge.
- Decreased noise at idling.
- Decreased idling speed because of improved engine stability.
- Stabilized fuel injection characteristics from the injection pump and nozzle system, and easier matching of governor characteristics to engine demand.

(1) Nozzle Holder Body
(2) 1st Stage Injection Pressure Adjusting Shim
(3) First Spring
(4) Pressure Pin
(5) Spring Seat
(6) 2nd Stage Injection Pressure Adjusting Shim
(7) Second Spring
(8) Pre-lift Adjusting Spring Seat
(9) Chip-packing
(10) Max-lift Adjusting Washer
(11) Retaining Nut
(12) Nozzle

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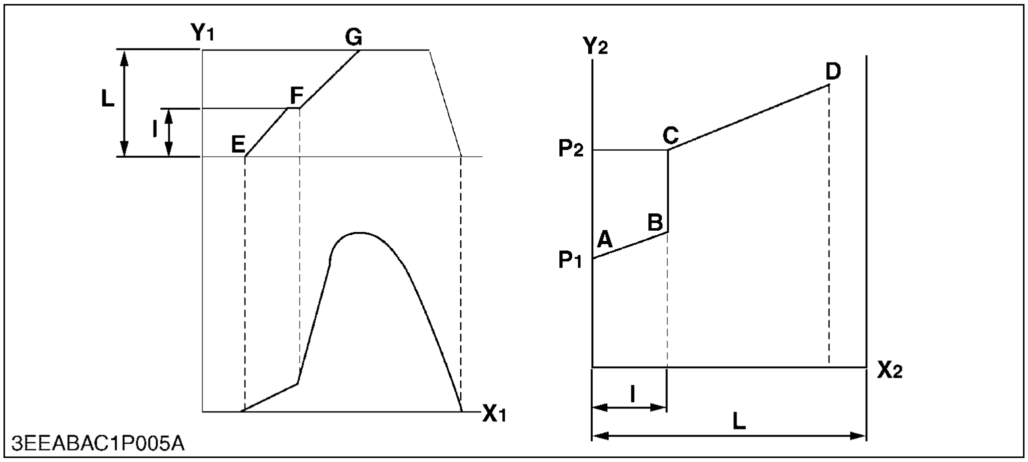

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A-B :First Spring's Set Force
B-C-D :Combined Force of First and Second Springs
P1 :First Opening Pressure
P2 :Second Opening Pressure
L : Full Needle Valve Lift
I : Needle Valve Pre-lift
X1 :Cam Angle (°)
Y1 :Injection Rate (mm3/°)
X2 :Needle Valve Lift (mm)
Y2 :In-line Pressure

W1097222

■ **First opening pressure**

The force of the high pressure fuel delivered by the injection pump acts to push the needle valve up. When this force exceeds the set force of the first spring, the nozzle's needle valve pushes the first pushrod up and the valve opens. (First opening pressure is represented by point **E** in the bottom left hand figure, and point **A** in the above figure.)

■ **Second opening pressure**

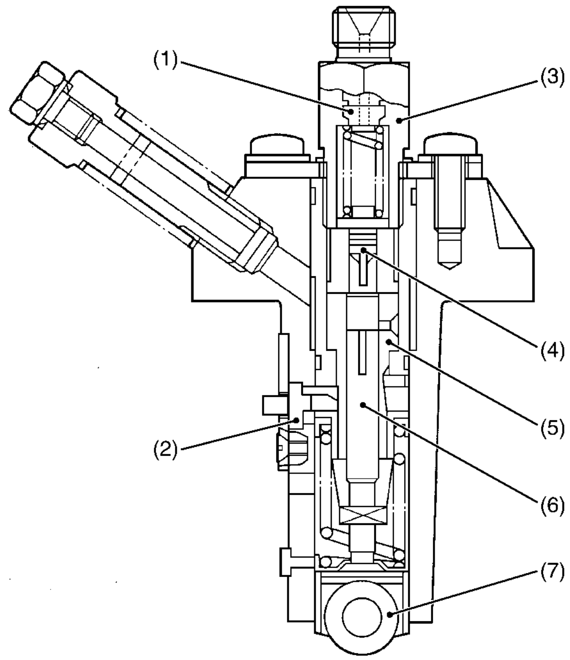
When the first pushrod has been lifted through the pre-lift, it contacts the second pushrod. As the set force of the second spring is acting on the second pushrod, the combined forces of both the first spring and the second spring then act on the needle valve, which will not lift unless these forces are overcome.

When the high pressure fuel (ie, in-line pressure) overcomes the combined forces of the first and second springs, the needle valve is again lifted and main injection can begin. (Second opening pressure is represented by point **F** in the bottom left hand figure and **B-C** in the above figure.)

[7] INJECTION PUMP

Kubota engines used independent pump (SM Series, 05 Series, 03 Series, 03-M Series, V3 Series, 07 Series, F5802) and distribution pump (D3200, V4300).

(1) Independent Pump



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■ SM Series, 05 Series

A Bosch MD type mini pump is used for the injection pump. It is small, lightweight and easy to handle.

The plunger (6) with a left-hand lead reciprocates via the tappet roller (7) by means of the camshaft fuel cam, causing the fuel to be delivered into the injection nozzle.

(1) Dumping Valve
(2) Control Rack
(3) Delivery Valve Holder
(4) Delivery Valve
(5) Cylinder
(6) Plunger
(7) Tappet Roller

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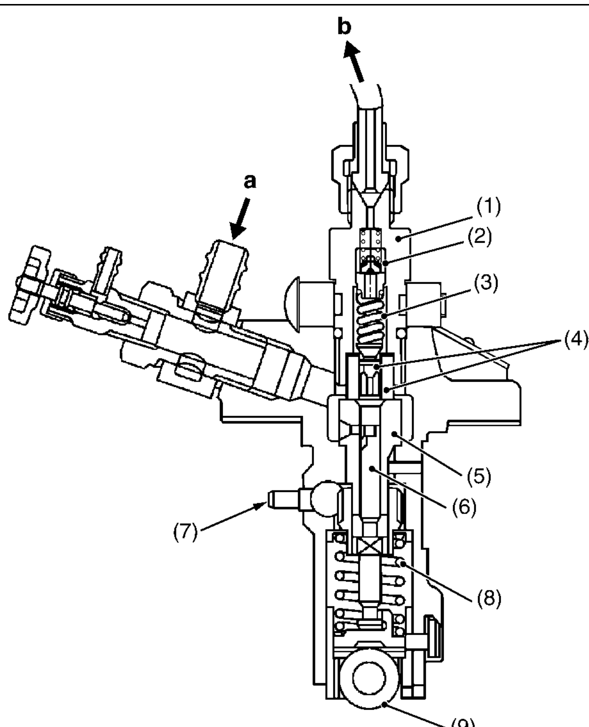

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■ 03 Series, 03-M Series, V3 Series, 07 Series

The injection pumps of these engines are Bosch K type mini injection pump.

It features a compact and lightweight design.

(1) Delivery Valve Holder
(2) Dumping Valve
(3) Delivery Valve Spring
(4) Delivery Valve
(5) Plunger Barrel
(6) Plunger
(7) Control Rack
(8) Plunger Spring
(9) Tappet Roller

a : From Feed Pump
b : To Injection Nozzle

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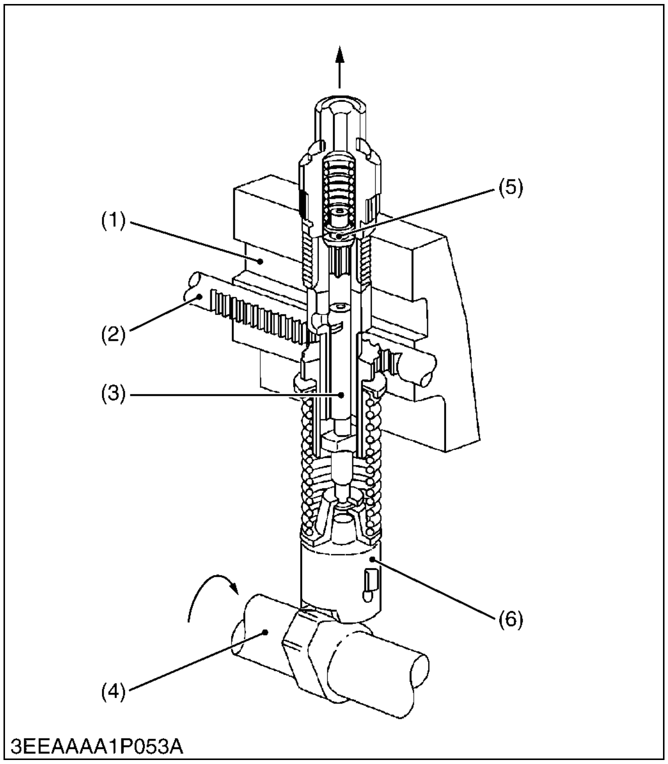

1) Injection pump structure

■ **F5802**

The injection pump of this model is a parallel injection pump of Bosh A type, and is provided with the plungers necessary for the number of the cylinders of an engine.

Injection pump is constructed as shown in the figure and consisted of a plunger (3), tappet roller (6), control rack (2), delivery valve (5), camshaft (4), and other components.

(1) Fuel Chamber
(2) Control Rack
(3) Plunger
(4) Camshaft
(5) Delivery Valve
(6) Tappet Roller

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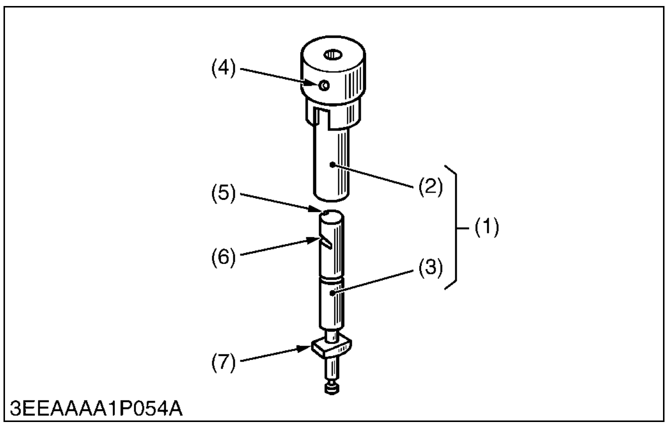

■ **Pump Element**

The pump element (1) is consist of the plunger (3) and cylinder (2).

The sliding surfaces are super-precision machined to maintain injection pressure at engine low speeds. Since the driving face (7) fits in the control sleeve, the plunger (3) is rotated by the movement of the control rack to increase or decrease of fuel delivery.

As described above, the plunger (3) is machined to have the slot (5) and the control groove (6).

(1) Pump Element
(2) Cylinder
(3) Plunger
(4) Feed Hole
(5) Slot
(6) Control Groove
(7) Driving Face

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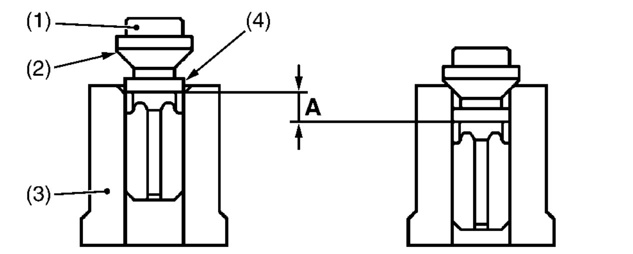

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■ Delivery Valve

The delivery valve consists of the valve (1) and valve seat (3).

The delivery valve performs the following functions.

1. Reverse flow-preventing function

If the fuel flow reverse from the injection nozzle side when the plunger lowers, the time lag between the next delivery start and the nozzle injection start increases.

To avoid this, the delivery chamber to injection pipe interruption by valve (1) prevents this reverse flow, thus keeping fuel always filled in the nozzle and pipe.

2. Suck-back function

After completing the fuel delivery, the valve lowers, and the relief plunger (4) end contacts the valve seat (3). The valve further lowers until its seat surface (2) seats firmly the delivery valve seat. During this time, the amount of fuel corresponding to **"A"** is sucked back from inside the injection pipe, the pressure inside the pipe is reduced, thus leading to an improved injection shut off and preventing after leakage dribbling.

(1) Valve	(3) Valve Seat
(2) Seat Surface	(4) Relief Plunger

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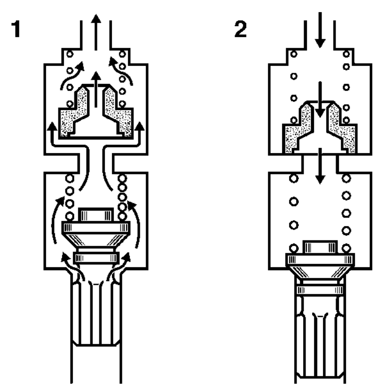

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■ Dumping Valve

1. At fuel injection

Since dumping valve is pushed up to press the spring, fuel is pressure-fed to injection nozzle the same as without dumping valve.

2. At suck-back

At suck-back by delivery valve after fuel injection, fuel returns through dumping valve orifice.

Generally second injection is apt to occur by reflex pressure due to reaction of sudden pressure drop when changing into suck-back by delivery valve from high injection pressure. As a result of preventing this second injection perfectly by dumping valve and dissolving nozzle clogging, durability of injection nozzle is improved.

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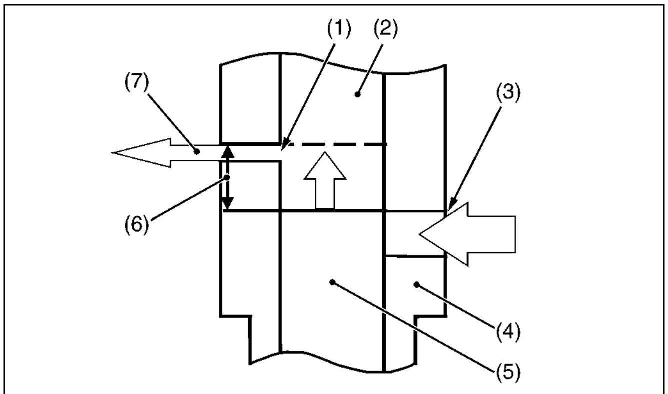

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■ **Injection pump with F.S.P.**

Some models of E2B / E3B engines have the special fuel injection pump.

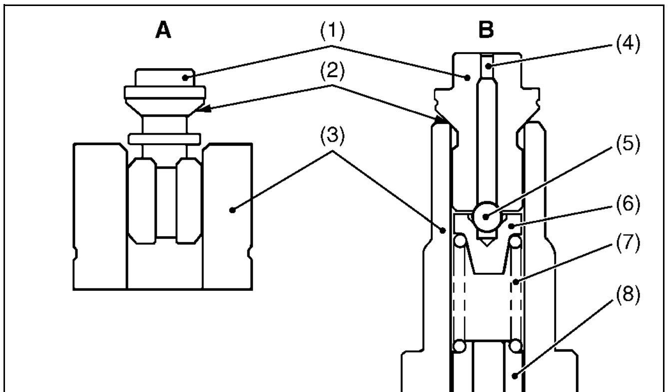
The fuel injection pump with F.S.P. (Fine Spill Port) mechanism is equipped with two functions: speed timer function and injection rate control function.

The former function works like this. As the rpm is low, the injection timing gets delayed. This helps cut down on NOx and operating noise.

The latter function serves to keep down the initial injection rate and keep up the later injection rate, which cuts down on NOx and PM as well.

(1) Fine Spill Port (F.S.P.)
(2) Plunger Chamber
(3) Main Port
(4) Cylinder
(5) Plunger
(6) F.S.P. Stroke
(7) Leaking Fuel at Initial Fuel Pressure-Feed Stage

W10996760



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■ **CPV equipped delivery valve**

The Constant Pressure Valve (CPV) is a mechanism that maintains uniform residual pressure in the hight pressure pipe. It stabilizes overall delivery quantity characteristics and especially delivery quantity characteristics at low speeds.

1. At high fuel pressure

The delivery valve (1) , the steel ball (5) and the snapper valve (6) are moved up together. The delivery valve seat surface (2) opens when the fuel pressure becomes more than the delivery valve set pressure.

2. At after injection

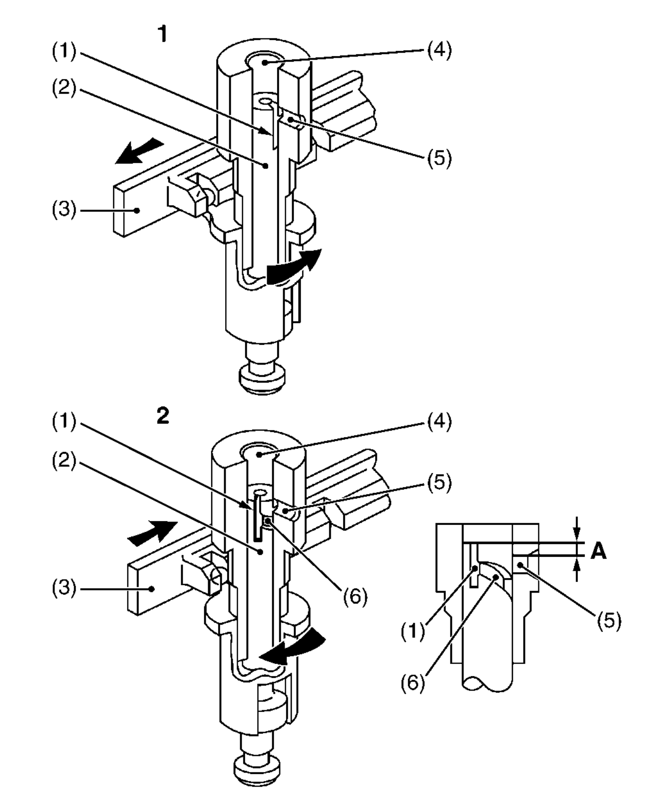
The delivery valve (1) , the steel ball (5) and the snapper valve (6) are moved down and the delivery valve seat surface (2) closes. The steel ball still opens on the way and the fuel returns to the injection pump side. The steel ball (5) closes when the fuel pressure becomes less than the snapper valve set pressure.

(1) Delivery Valve
(2) Seat Surface
(3) Valve Seat
(4) Orifice
(5) Steel Ball
(6) Snapper Valve
(7) Snapper Valve Spring
(8) Snapper Valve Seat

A : Current Delivery Valve
B : CPV Equipped Delivery Valve

W10723160

2)Injection control



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■ SM Series, 05 Series

1. No fuel delivery (Engine stop)

At the engine stop position of the control rack (3), the lengthwise slot (1) on the plunger (2) aligns with the feed hole (5). And the delivery chamber (4) is led to the feed hole during the entire stroke of the plunger. The pressure in the delivery chamber does not build up and no fuel can be forced to the injection nozzle.

2. Fuel delivery

The plunger (2) is rotated (see figure) by the control rack (3). When the plunger is pushed up, the feed hole (5) is closed. The pressure in the delivery chamber (4) builds up and force-feeds the fuel to the injection nozzle until the control groove (6) meets the feed hole (5).

The amount of the fuel corresponds to the distance **"A"**.

(1) Slot	(4) Delivery Chamber
(2) Plunger	(5) Feed Hole
(3) Control Rack	(6) Control Groove

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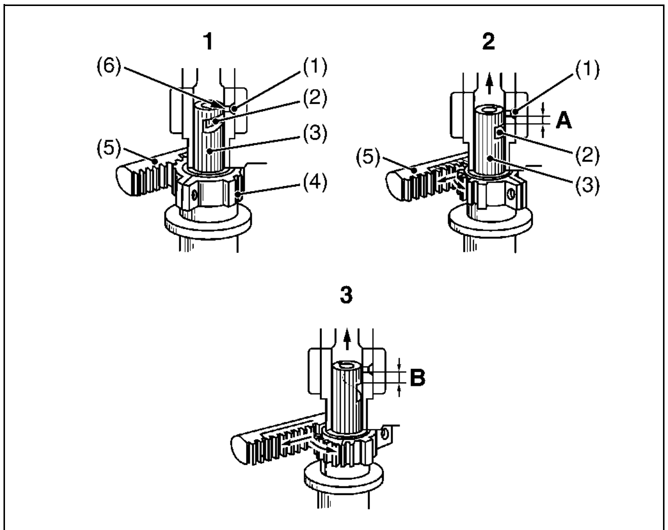

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■ 03 Series, 03-M Series, V3 Series, 07 Series

1. No fuel delivery (Engine stop)

When the control rack (5) is set at the engine stop position, the plunger does not force fuel and no fuel is delivered since the feed hole (1) aligns with the slot (6) in the plunger (3).

2. Partial fuel delivery

When the plunger (3) is rotated by the control rack (5) in the direction of arrow, the fuel is delivered to the injection nozzle.

The amount of fuel corresponds to the effective stroke **"A"** from closing the feed hole (1) by the plunger head to contact of the control groove (2) with the feed hole.

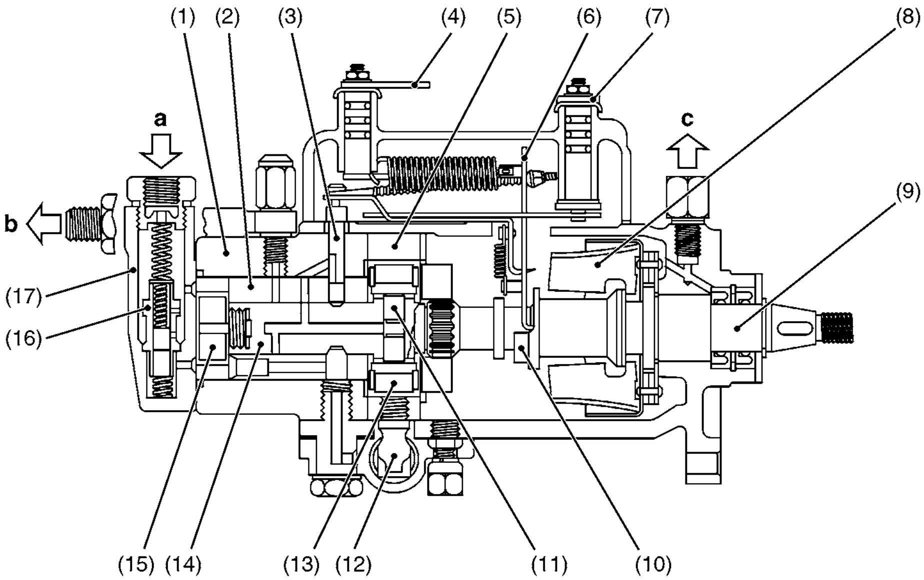
3. Maximum fuel delivery

When the control rack is moved to the extreme end in the direction of the arrow, the effective stroke **"B"** of the plunger is at its maximum.

(1) Feed Hole	(4) Control Sleeve
(2) Control Groove	(5) Control Rack
(3) Plunger	(6) Slot

W10239610

(2) Distribution Pump



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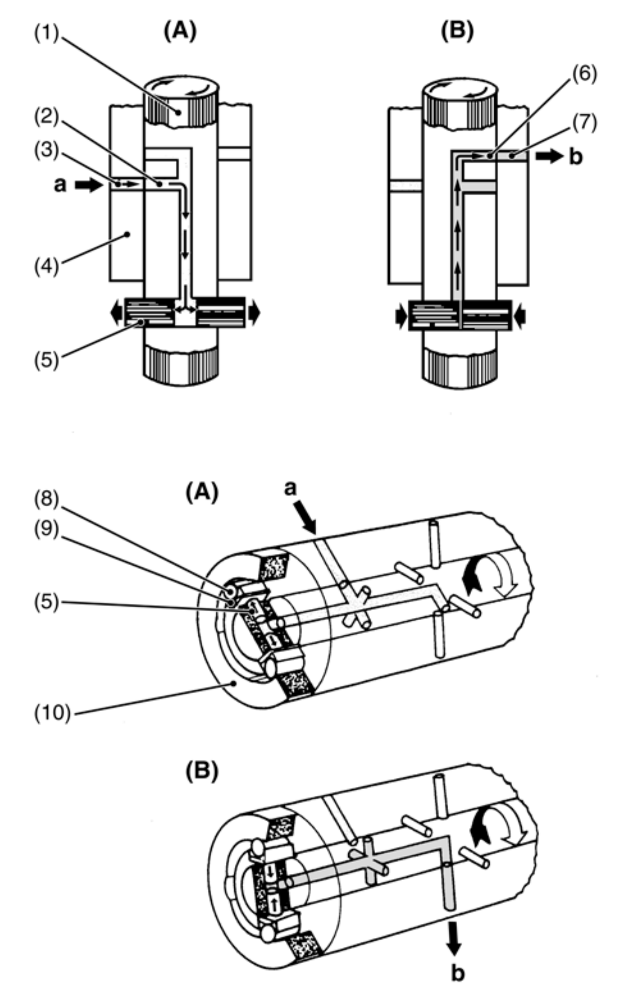
(1) Pump Body
(2) Hydraulic Head
(3) Metering Valve
(4) Throttle Arm
(5) Cam Ring
(6) Control Arm
(7) Shut-off Lever
(8) Governor Weight
(9) Drive Shaft
(10) Thrust Sleeve
(11) Plunger
(12) Automatic Advance
(13) Roller
(14) Rotor
(15) Transfer Pump
(16) Regulating Valve
(17) End Plate

a : Fuel Inlet
b : High Pressure Fuel Outlet (To Injection Nozzles)
c : Excess Fuel (Returning to Filter)

The CAV's DPA distributor type fuel injection pump forms a compact unit.

W1025101



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■ **Working principal**

The basic element of the pump is the rotor (1) which embodies the pumping element and functions as a distributor. The pumping element consists of two opposed plungers (5) which move inwards and outwards inside the rotor (1) and are actuated, through the cam rollers (8) and sliding shoes (9), by the lobes of the stationary cam ring (10) fixed to the pump housing.

During the fuel inlet stroke (Fig. A) in the pumping element, the radial inlet ports (2) in the rotor are coaxial with the metering port (3) drilled in the hydraulic head (4) fixed to the pump housing.

The fuel enters the rotor and fills the cavity between the opposed plungers (5).

During this phase the distributor port (6) is cut off.

During the injection stroke (Fig. B), as the rotor turns, the fuel inlet port (2) is cut off and the distributor port (6) registers with one of the outlet port (7). At the same time the plunger rollers make contact with the cam lobes, the plungers are forced inwards, pressure increases and injection takes place.

(1) Rotor
(2) Inlet Port
(3) Metering Port
(4) Hydraulic Head
(5) Plunger
(6) Distributor Port
(7) Outlet Port
(8) Cam Roller
(9) Sliding Shoe
(10) Cam Ring

(A) Fuel Inlet Stroke
(B) Fuel Injection Stroke
a : IN
B ; OUT

W10249090

[8] GOVERNOR

Injection pump performance is closely related to the engine performance, and in many ways, the function of an injection pump depends on the governor connected to the pump.

A governor performs an important role in saving fuel while allowing the engine run smoothly.

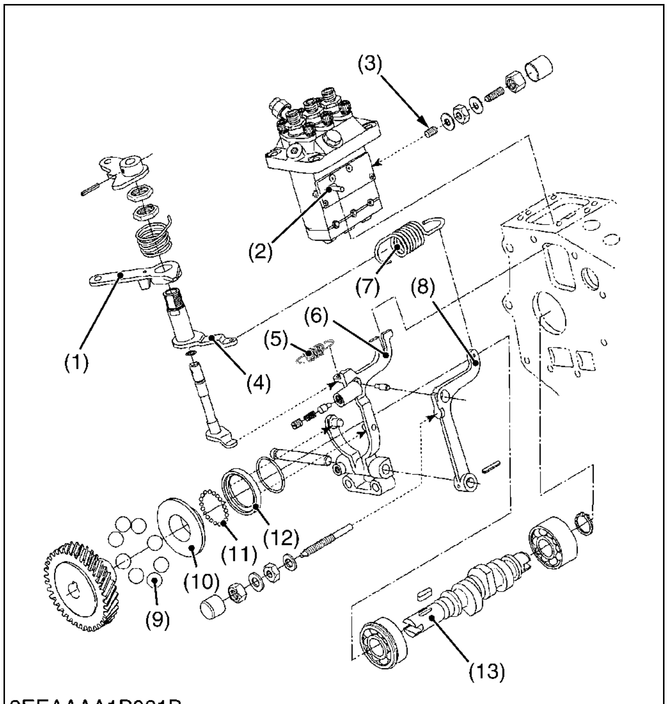
Kubota engine uses two kinds of mechanical governor.

(1) Steel Ball Type (SM Series, 03 Series, 03-M Series)

(2) Weight Type (05 Series, 03 Series BG Type*, V3 Series, F5802, 07 Series)

* BG type is engine for generator specification.

(1) Steel Ball Type



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This mechanism maintains engine speed at a constant level even under fluctuating loads, provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

The fork lever 1 (6) is hold where two forces on it are balanced.

One is the force that fork lever 2 (8) pushes, which is caused by the tension of the governor spring (7) between the governor lever (4) and fork lever 2 (8). Another is the component of the centrifugal force produced by the steel balls (9) which are rotated by the fuel camshaft (13).

(1) Speed Control Lever
(2) Control Rod
(3) Idling Adjust Spring
(4) Governor Lever
(5) Start Spring
(6) Fork Lever 1
(7) Governor Spring
(8) Fork Lever 2
(9) Steel Ball
(10) Governor Sleeve
(11) Steel Ball
(12) Governor Ball Case
(13) Fuel Camshaft

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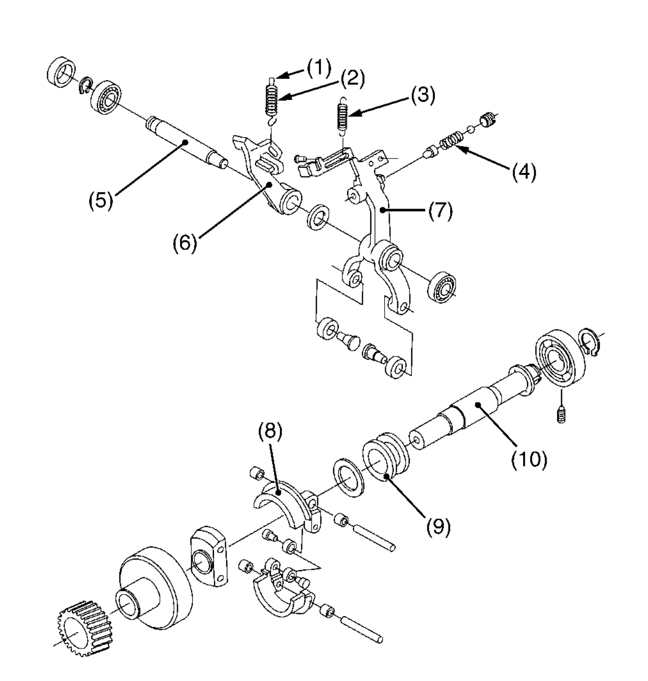
(2) Weight Type



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■ 05 Series

This engine uses a mechanical governor that controls the fuel injection rate at all speed ranges (from idling to maximum speed) by utilizing the balance between the flyweight's centrifugal force and spring tension.

A governor shaft (10) for monitoring engine speed is independent of the injection pump shaft and rotates at twice the speed of conventional types, providing better response to load fluctuation and delivering greater engine output.

(1) Governor Spring 2	(6) Fork Lever 2
(2) Governor Spring 1	(7) Fork Lever 1
(3) Start Spring	(8) Flyweight
(4) Torque Spring	(9) Governor Sleeve
(5) Fork Lever Shaft	(10) Governor Shaft

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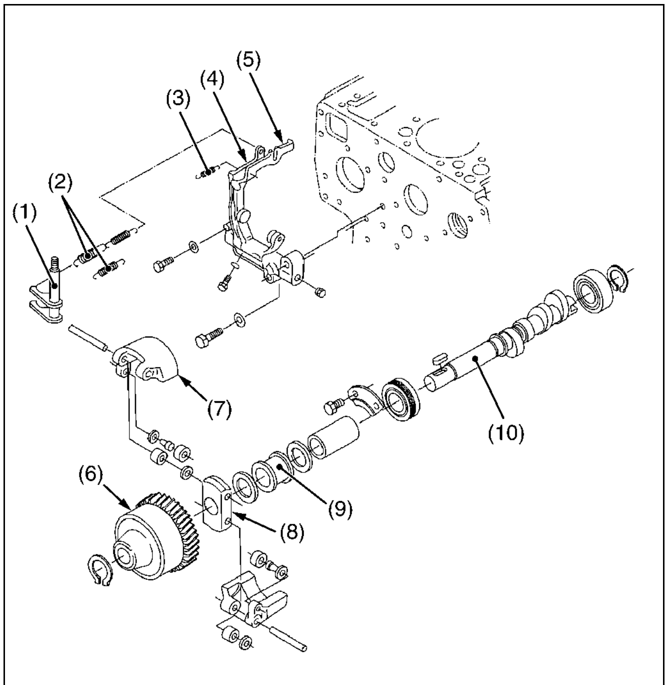

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■ 03 Series BG Type

The governor controls the amount of the fuel to be fed in the entire speed range to prevent the engine from changing its speed according to the load.

The fork lever 1 (5) is held where two forces on it are balanced.

One is the force that fork lever 2 (4) pushes, which is caused by the tension of the governor spring (2) between the governor lever (1) and fork lever 2 (4).

Another is the component of the centrifugal force produced by the flyweight (7) which are rotated by fuel camshaft (10).

(1) Governor Lever	(6) Injection Pump Gear
(2) Governor Spring	(7) Flyweight
(3) Start Spring	(8) Weight Holder
(4) Fork Lever 2	(9) Governor Sleeve
(5) Fork Lever 1	(10) Fuel Camshaft

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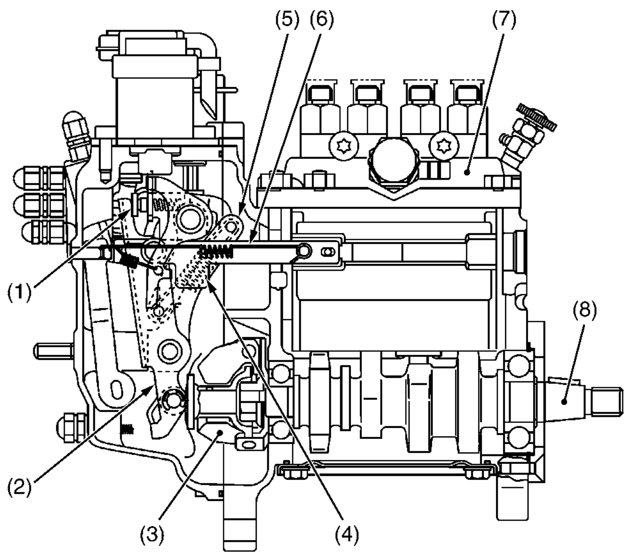

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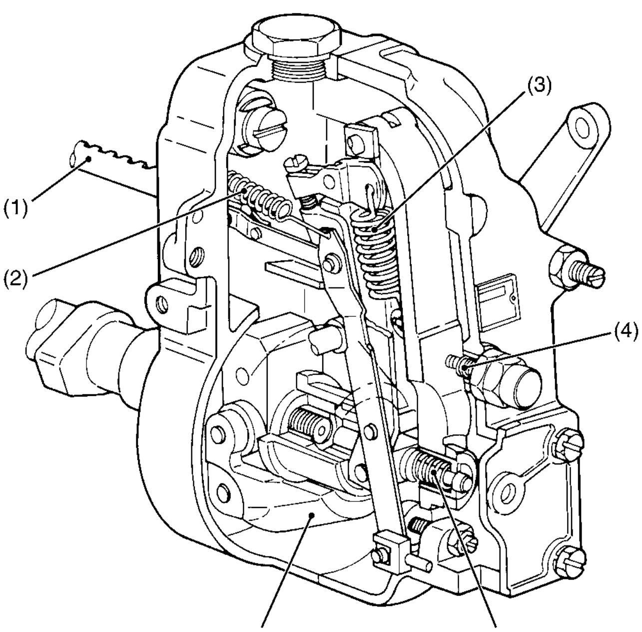
■ V3 Series

It also employs the torque limiting mechanism to control the maximum peak torque so that it complies with the regulations of exhaust gas.

This mechanism maintains engine speed at a constant level even under fluctuating loads, provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

(1) Spring Pin
(2) Fork Lever 1
(3) Flyweight
(4) Governor Spring
(5) Fork Lever 2
(6) Start Spring
(7) Injection Pump
(8) Fuel Camshaft

W10293020



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■ F5802

The mechanical governor is adopted, which uses balance between centrifugal force of the flyweight (6) and spring force.

It is capable of controlling the fuel injection throughout the entire range from idling to maximum engine speed.

The construction of the mechanical governor is shown in the figure and consists of the flyweight (6), four springs (2), (3), (4), (5) and associated linkages.
Function of four spring as follows;

- **Governor spring**
  Controls the fuel injection in the range from medium to high speed.
- **Idle subspring**
  Controls the fuel injection during idling to obtain stable idling.
- **Start spring**
  Pushed out the control rack to the position for ensuring fuel injection necessary to start the engine.
- **Idle spring**
  Compensates fuel injection quantity in proportion of air intake quantity in the range low to medium speed to prevent insufficient output during low revolution and black smoke during high revolution.

(1) Control Rack
(2) Start Spring
(3) Governor Spring
(4) Idle Subspring
(5) Idle Spring
(6) Flyweight

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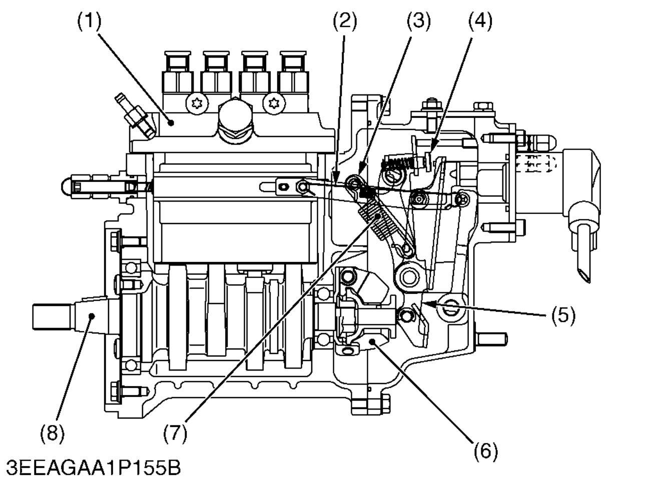

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■ **07 Series**

It also employs the torque limiting mechanism to control the maximum peak torque so that it complies with the regulations of exhaust gas.

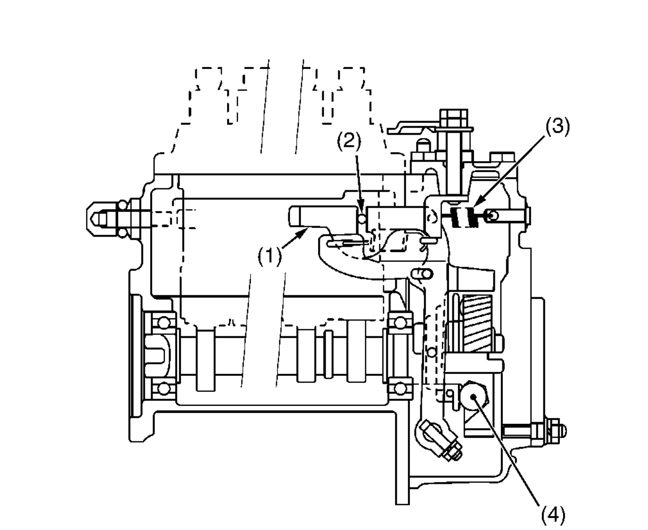
This mechanism maintains engine speed at a constant level even under fluctuating loads, provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

(1) Injection Pump
(2) Start Spring
(3) Fork Lever 2
(4) Spring Pin
(5) Fork Lever 1
(6) Flyweight
(7) Governor Spring
(8) Fuel Camshaft

W10413860

(3) Governor Operation

1) SM series, 03 series



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■ **At Start**

Since the steel ball (4) have no centrifugal force, a fork lever 1 (1) is pulled to the right by the start spring (3).

Accordingly, the control rack (2) moves to the maximum injection position to assure easy starting.

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

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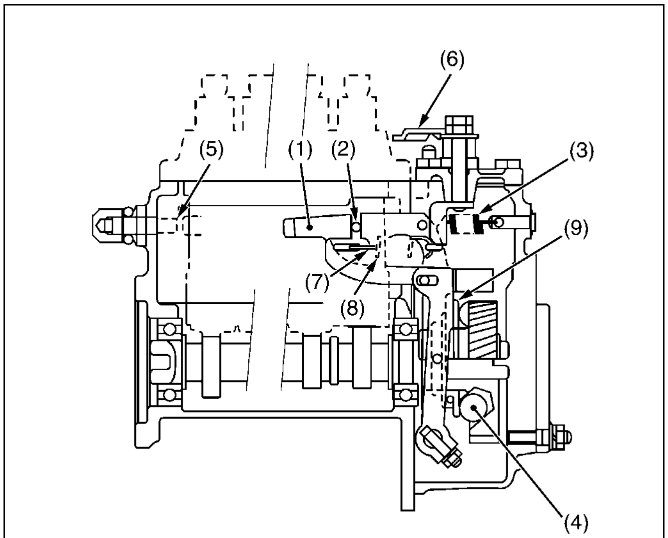

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■ **At Idling**

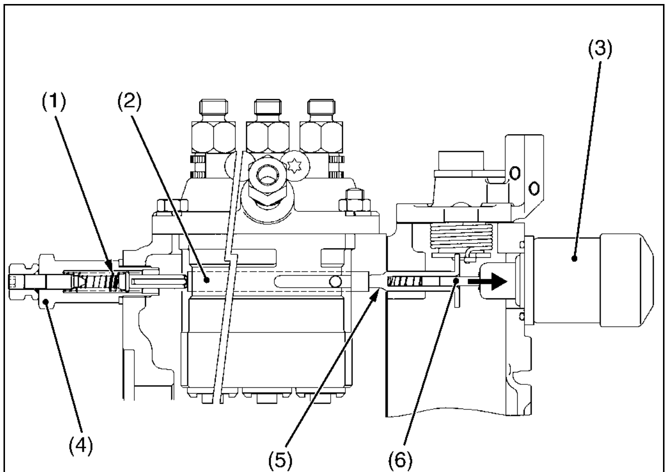
When the speed control lever (6) is set at the idling position after the engine starts, the governor spring 1 (8) does not work at all and the governor spring 2 (7) does only act slightly. The governor sleeve (9) is pushed leftward by a centrifugal force of steel ball (4).

Therefore, the fork lever 1 (1) and control rack (2) are moved to the left by the governor sleeve and then the idle limit spring (5) is compressed by the control rack. As a result, the control rack is kept at a position where a centrifugal force of governor spring 2 (7) and idle limit spring (5) are balanced, providing stable idling.

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

W10298090

2) 03-M series



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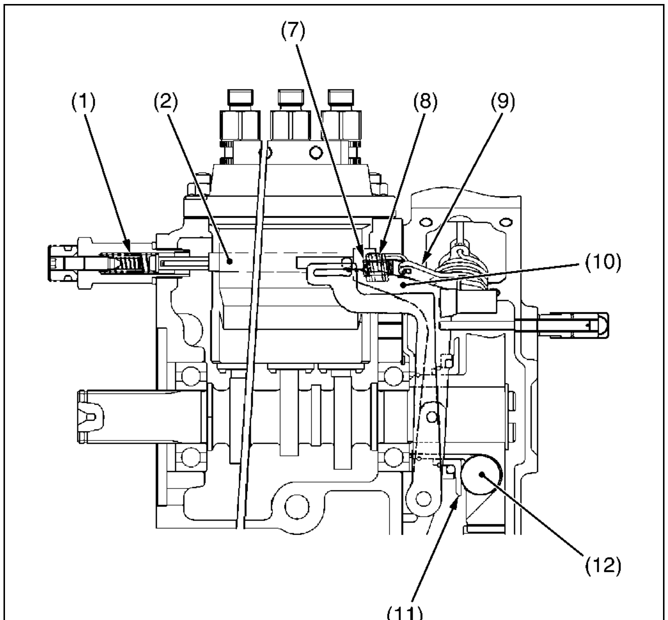
■ **At Start**

Flowing of the battery current into the engine stop solenoid (3), the plunger (6) is actuated to arrow direction.

Since the steel ball have no centrifugal force, the control rack (2) is pushed to the right by the start spring (1). Accordingly, the control rack (2) moves to the maximum injection position to assure easy starting.

(1) Start Spring
(2) Control Rack
(3) Engine Stop Solenoid
(4) Idling Apparatus
(5) Guide
(6) Plunger

W11182370



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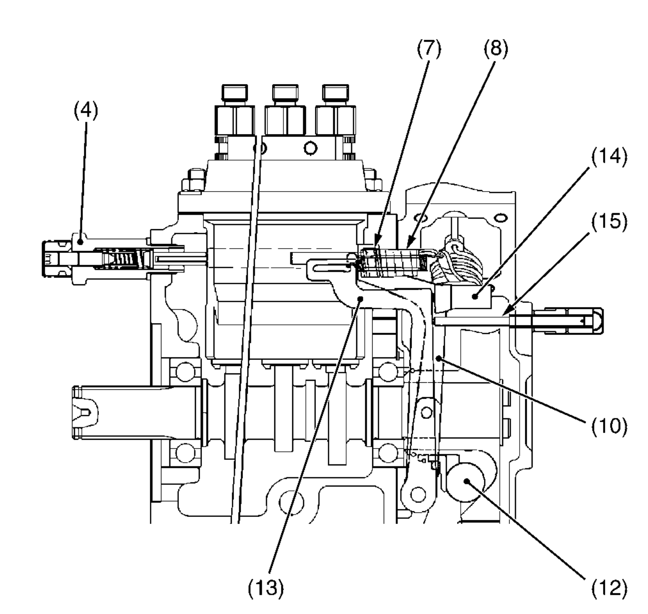
■ **At Idling**

When the speed control lever is set at the idling position after the engine starts, the governor spring 1 (8) does not work at all and the governor spring 2 (7) does only act slightly. The governor sleeve (11) is pushed leftward by a centrifugal force of steel ball (12).

Therefore, the fork lever 1 (10) and control rack (2) are moved to the left by the governor sleeve (11) and then the start spring (1) is compressed by the control rack. As a result, the control rack is kept at a position where a centrifugal force of steel ball and forces of start spring (1), governor spring 2 (7) are balanced, providing stable idling.

(1) Start Spring
(2) Control Rack
(7) Governor Spring 2
(8) Governor Spring 1
(9) Governor Lever
(10) Fork Lever 1
(11) Governor Sleeve
(12) Steel Ball

W1101907



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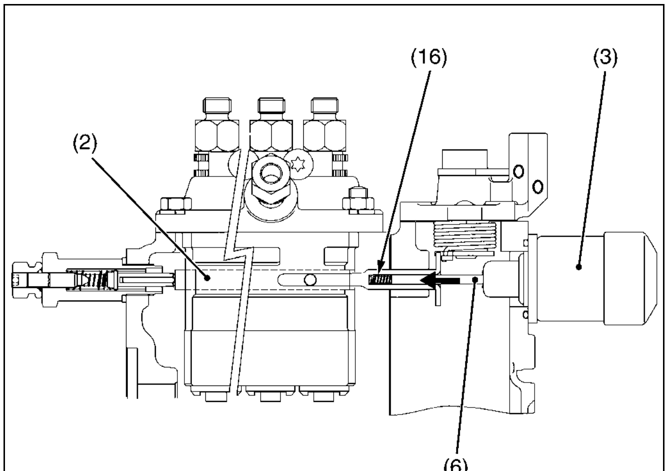
■ **At High Speed Running with Overload**

When an overload is applied to the engine running at a high speed, the centrifugal force of steel ball (12) becomes small as the engine speed is dropped, and fork lever 2 (13) is pulled to the right by the governor springs 1 (8) and 2 (7), increasing fuel injection. Though, fork lever 2 (13) becomes ineffective in increasing fuel injection when it is stopped by the adjusting screw (15).

After that, when the force of torque spring (14) becomes greater than the centrifugal force of the steel ball, fork lever 1 (10) moves rightward to increase fuel injection, causing the engine to run continuously at a high torque.

(4) Idling Apparatus	(12) Steel Ball
(7) Governor Spring 2	(13) Fork Lever 2
(8) Governor Spring 1	(14) Torque Spring
(10) Fork Lever 1	(15) Adjusting Screw

W1103260



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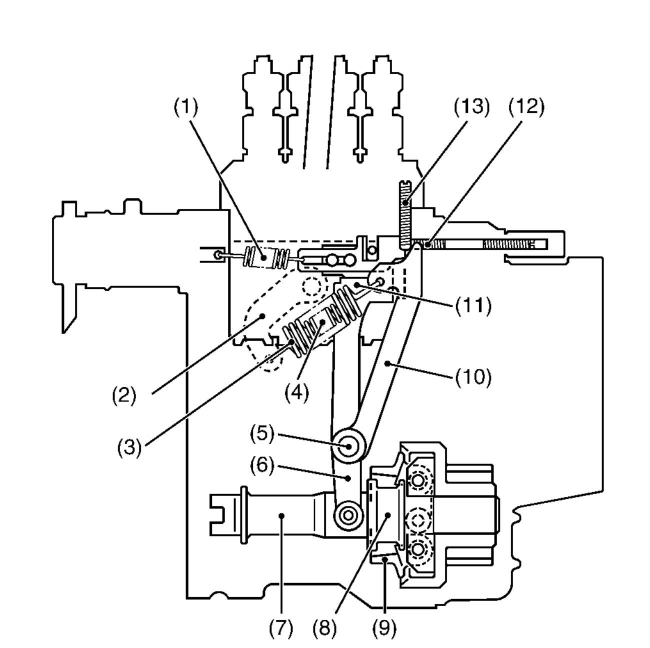
■ **To Stop Engine**

When the battery current stops, the plunger (6) of engine stop solenoid (3) is returned to the original position, the spring (16) to keep the control rack (2) in **"No fuel injection"** position.

(2) Control Rack	(6) Plunger
(3) Engine Stop Solenoid	(16) Spring

W1105151

3) 05 series



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■ **At Start**

As no centrifugal force is applied to flyweight (9), low tension of start spring (1) permits control rack to move to the starting position, supplying the amount of fuel required to start the engine.

■ **At Idling**

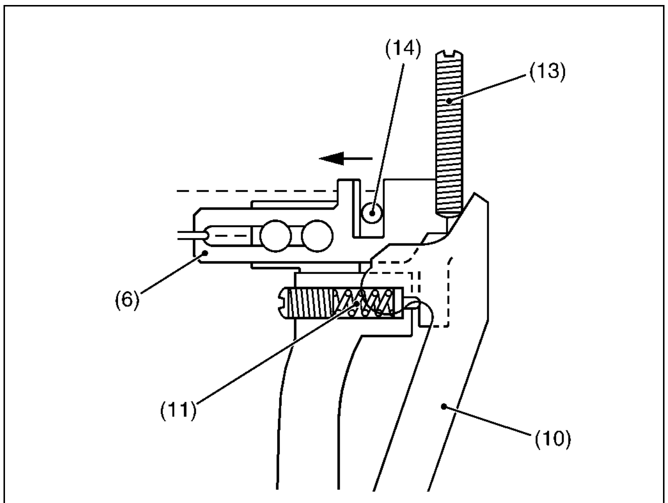
Setting speed control lever (2) to the idling position during engine rotation permits the low tension of governor spring 2 (4), start spring (1) and idle limit spring (12) to balance the centrifugal force of flyweight (9) without activating high tension governor spring 1 (3). In this way, the fuel injection rate can be controlled to ensure stable idling.

■ **At High Speed Running with Overload**

Governor spring 1 (3) and 2 (4) control the fuel injection rate. To maintain the required engine speed, fuel is supplied according to the speed control lever setting and load by balancing the tension of governor springs 1 and 2 with the centrifugal force of flyweight (9). In addition, idle limit spring (12) provided stable engine rotation.

(1) Start Spring
(2) Speed Control Lever
(3) Governor Spring 1
(4) Governor Spring 2
(5) Fork Lever Shaft
(6) Fork Lever 1
(7) Governor Shaft
(8) Governor Sleeve
(9) Flyweight
(10) Fork Lever 2
(11) Torque Spring
(12) Idle Limit Spring
(13) Fuel Limit Adjust Bolt

W10300470



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■ **During Overload**

At load increases, the engine speed decreases, reducing the flyweight's centrifugal force. Governor spring 1 and 2, the therefore, pull fork levers 1 (6) and 2 (10), increasing the fuel injection rate and maintaining engine speed.

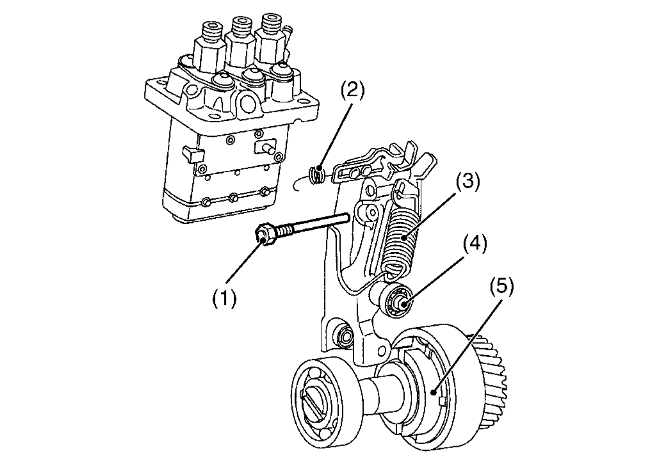
If engine speed decreases due to a further increases in load, fork lever 2 (10) will come in contact with the fuel limit bolt, stopping a further increase in the fuel injection rate.

Torque spring (11) incorporated in fork lever 1 (6) moves the lever in the direction of fuel injection rate increase, thereby boosting torque and providing greater engine output.

(6) Fork Lever 1
(10) Fork Lever 2
(11) Torque Spring
(13) Fuel Limit Adjust Bolt
(14) Control Rack

W10302690

4) 05 series (Max Torque Limiter and Fork Lever Comp Equipment Model)



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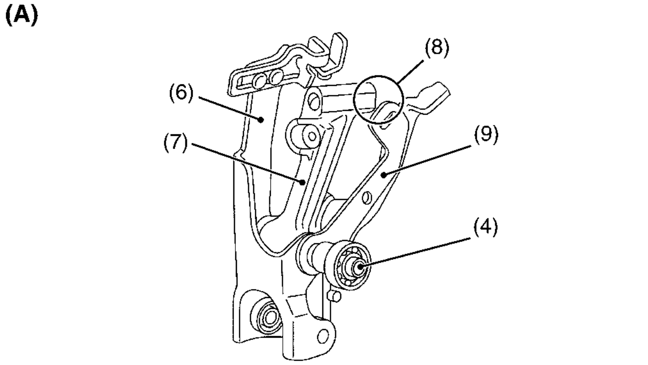
(A)



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The governor system is a mechanical governor that used the flyweight (5).

The flyweight (5) is mounted on the governor shaft that rotates at the same speed as the crankshaft.

Because the feature of this mechanism takes out the engine rotational speed directly as a centrifugal force of weight, the speed control that the change in the engine rotational speed is sensitively transmitted to fork lever Comp (**A**) and accuracy is high is enabled.

The fork lever assembly of this engine is composed of fork lever 1 (6), fork lever 2 (9), and the floating lever (7). A thrust lever is installed in fork lever 1. The governor spring (3) is hooked to fork lever 2 (9).

The floating lever (7) installs the torque pin (8) of the output drop prevention at the overload. The start spring (2) is hooked to a thrust lever, and holds the control rack in the direction of the increase.

Fork lever 2 (9) and the floating lever are installed in fork lever 1 (6) with the fork lever shaft (4). The max torque limiter (1) limits the amount of the fuel exhalation at the overload with the torque pin.

(1) Max Torque Limiter
(2) Start Spring
(3) Governor Spring
(4) Fork Lever Shaft
(5) Flyweight
(6) Fork Lever 1
(7) Floating Lever
(8) Torque Pin
(9) Fork Lever 2

(A) Fork Lever Comp

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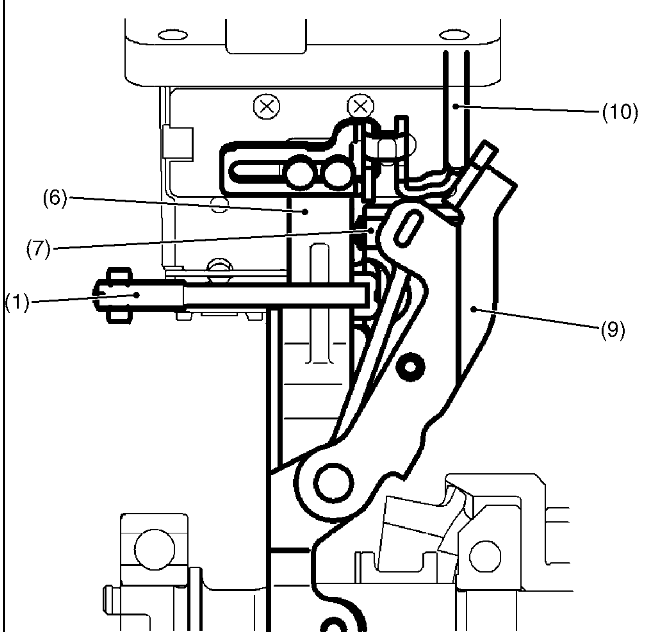

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■ At Rated Operation

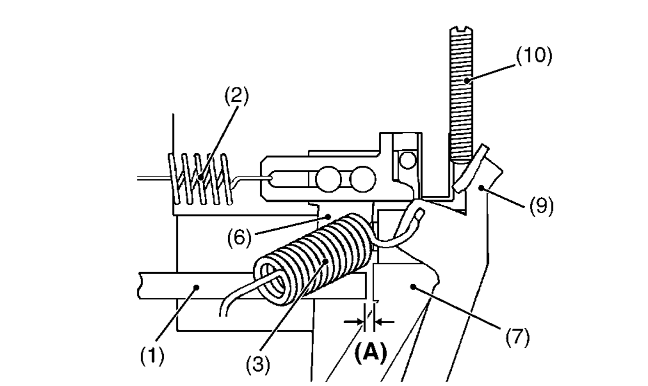
When the engine is running, the fork lever 2 (9) and the floating lever (7) are moving with the fork lever 1 (6) due to the tension of the governor spring (3).

During the time, the torque pin (8) is pressed into the floating lever by centrifugal force of the governor weight.

The fork lever 2 (9) comes in contact with the fuel limitation bolt (10), and the fuel injection pump supplies a fuel necessary for rated operation.

(1) Max Torque Limiter
(6) Fork Lever 1
(7) Floating Lever
(9) Fork Lever 2
(10) Fuel Limitation Bolt

W11082270



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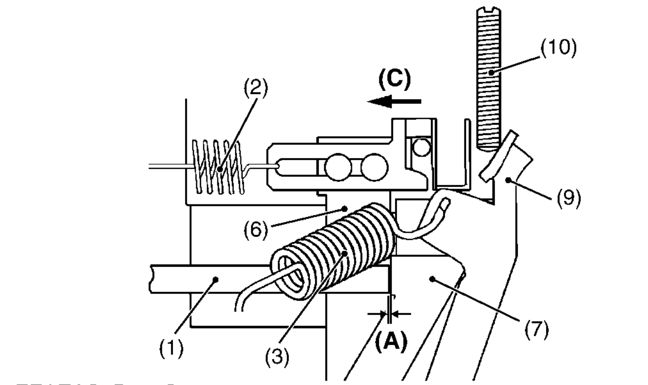

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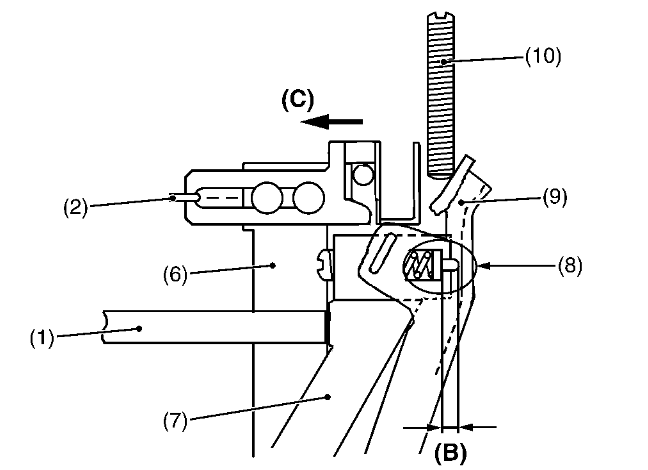

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■ Overloaded Operation

The amount of the movement of the fork lever comp. is limited with the fuel limitation bolt (10) and can not be moved in the direction of the fuel increase.

As overload reduces the centrifugal force of the governor weight, which is pressing the torque pin (8) into the floating lever (7), the torque pin pushes the fork lever 1 (6) in the way to increase the fuel supply with the help of the torque spring tension.

The fuel supply increases **(C)** in relation to the degree of the torque pin motion, thus preventing the engine speed from dropping.

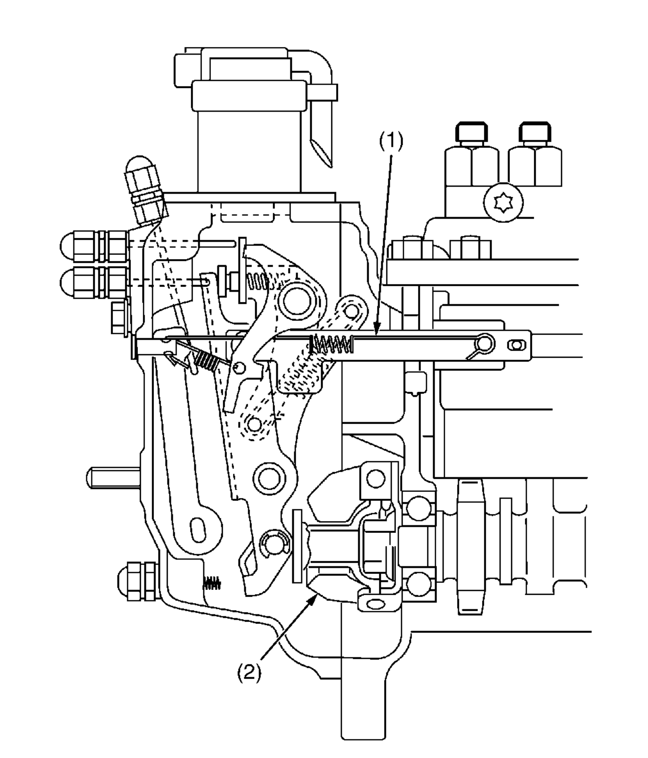
At the time, the maximum torque limiter (1) prevents superfluous fuel supply and suppresses the generation of black smoke.

(1) Max Torque Limiter
(2) Start Spring
(3) Governor Spring
(6) Fork Lever 1
(7) Floating Lever
(8) Torque Pin
(9) Fork Lever 2
(10) Fuel Limitation Bolt

(A) Distance between Max Torque Limiter and Floating Lever
(B) Distance to which Torque Pin (8) Pushes Fork Lever 1 (6) out
(C) Increase of Fuel

W11085170

5) V3 series



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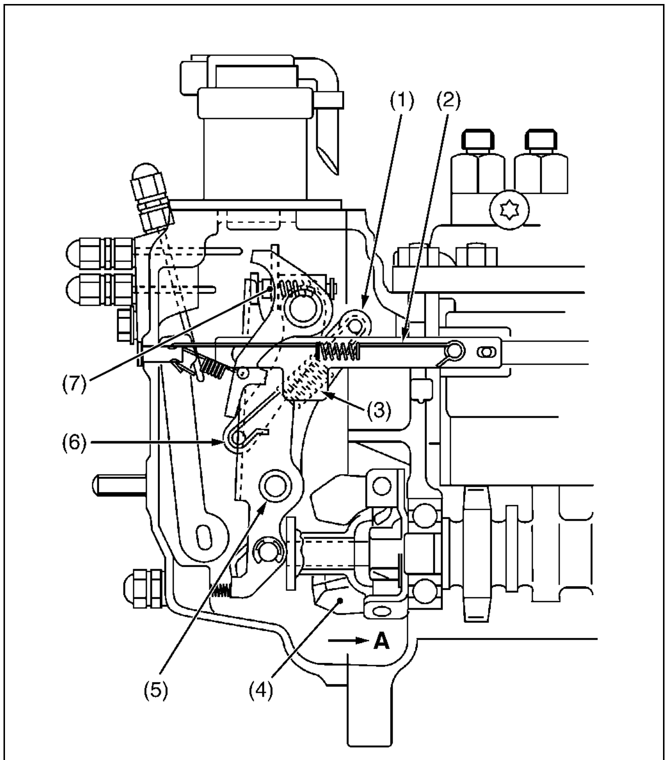
■ **At Start**

The stop solenoid (energized-to-run type) is powered to release the stop lever.

As no centrifugal force is applied to flyweight (2), low tension of start spring (1) permits control rack to move to the starting position, supplying the amount of fuel required to start the engine.

(1) Start Spring
(2) Flyweight

W10305080



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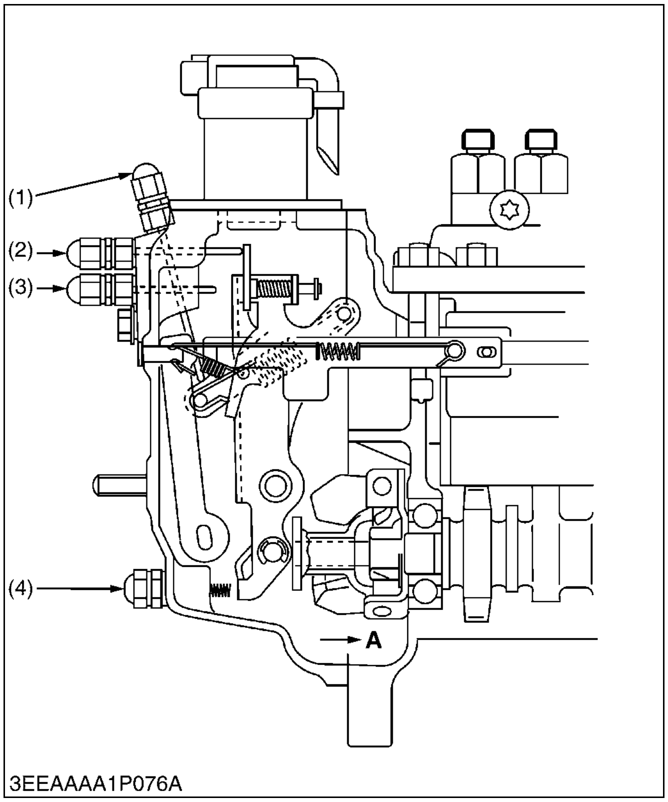
■ **At Idling**

Turn the speed control lever (6) clockwise to idle the engine. It tensions the governor spring (3) to pull the fork lever 2 (1).

When the fork lever 2 (1) is pulled, it moves the torque spring pin (7) and the fork lever 1 (5) in the direction of the arrow **A** to restrain the weight. In combination with the start spring tension, it is balanced with the centrifugal force of flywheel weight to keep idling.

(1) Fork Lever 2
(2) Start Spring
(3) Governor Spring
(4) Flyweight
(5) Fork Lever 1
(6) Speed Control Lever
(7) Spring Pin

W10306920



■ **At Rated Speed with Full Load or Overload**

As the speed control lever is changed from the medium speed to high speed, the governor spring tension increases to compress the torque spring and move the fork lever 1 in the direction of the arrow **A**.

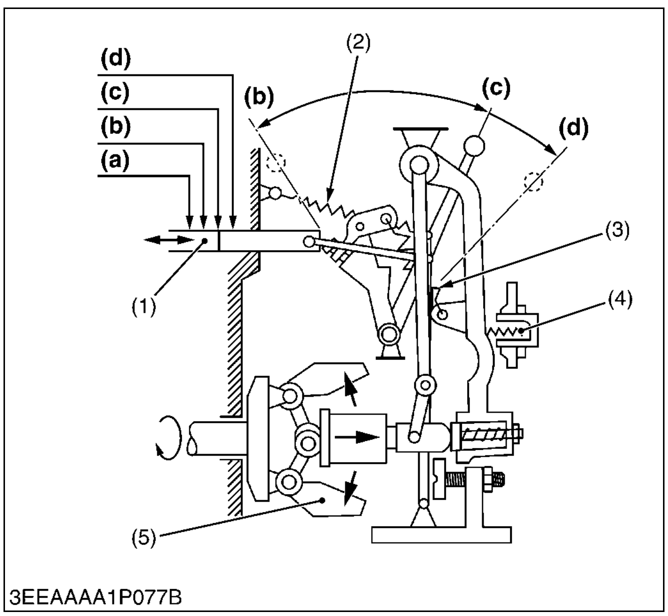
The fork lever 2 moves until it reaches, the output limiting bolt to keep rated rotation and rated output.

When the engine is overloaded, the engine rotating speed decreases and the centrifugal force of flyweight decreases. Then the torque spring moves the fork lever 1 in the direction of arrow **A**. The control rack moves in the direction that increases fuel supply to increase the output. It is balanced with the centrifugal force of the flyweight to produce low speed output (torque output).

(1) No-load Maximum Rotation
(2) Output Limiting Bolt
(3) Torque Limiting Bolt
(4) Idling Adjusting Bolt

W10474450

6) F5802



■ **Starting Engine**

Since no centrifugal force is applied to the flyweight (5), the weak start spring (2) moves the control rack (1) to the start position, causing the quantity of fuel necessary for starting to be injected.

■ **Idling**

When the control lever is set to the idling position, the governor spring (3) does not function. Instead, the idling sub-spring (4) controls the fuel injection quantity to obtain stable idling by balancing with the centrifugal for a of the flyweight (5).

■ **Medium to High Speed**

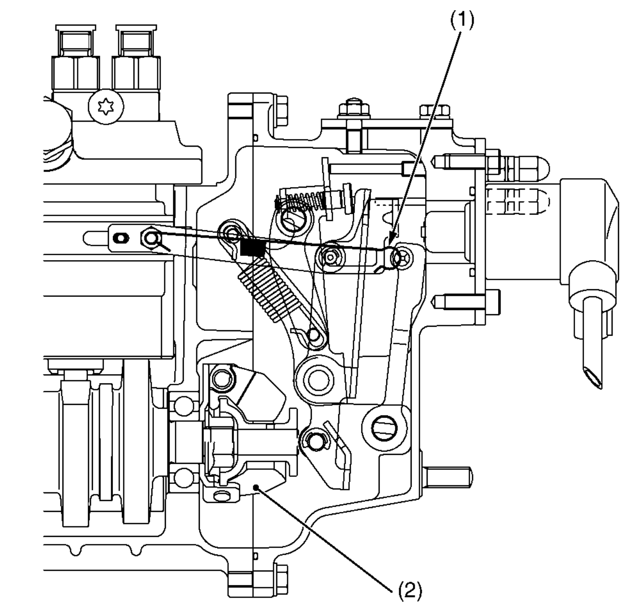
Mainly the governor spring (3) controls the fuel injection. It feeds an appropriate fuel quantity in accordance with the control lever position and load applied by balancing with the centrifugal force of the flyweight (5), thereby maintaining the engine at a desired speed.

(1) Control Rack
(2) Start Spring
(3) Governor Spring
(4) Idling Sub-spring
(5) Flyweight

(a) Start
(b) Full Load
(c) Idling
(d) Stop

W10312840

7) 07 Series



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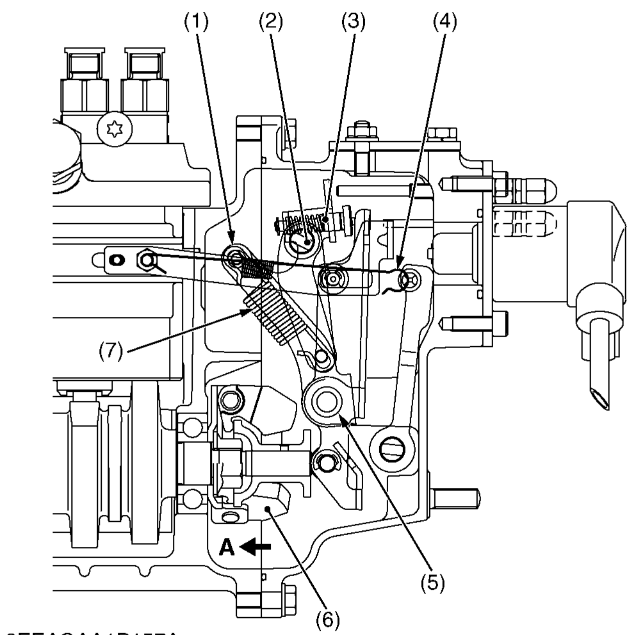
■ **At Start**

The stop solenoid (energized-to-run type) is powered to release the stop lever.

As no centrifugal force is applied to flyweight (2), low tension of start spring (1) permits control rack to move the starting position, supplying the amount of fuel required to start the engine.

(1) Start Spring
(2) Flyweight

W1013967



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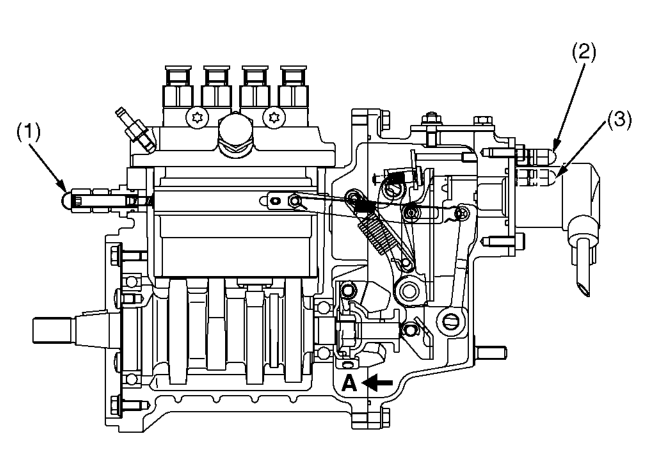
■ **At Idling**

Turn the speed control lever (2) clockwise to idle the engine. It tensions the governor spring (7) to pull the fork lever 2 (1).

When the fork lever 2 is pulled, it moves the torque spring pin (3) and the fork lever 1 (5) in the direction of the arrow **A** to restrain the weight. In combination with the start spring tension, it is balanced with the centrifugal force of flywheel weight to keep idling.

(1) Fork Lever 2
(2) Speed Control Lever
(3) Spring Pin
(4) Start Spring
(5) Fork Lever 1
(6) Flyweight
(7) Governor Spring

W1014034



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■ **At rated speed with full load and overload**

As the speed control lever is changed from the middle speed to high speed, the governor spring tension increases to compress the torque spring and move the fork lever 1 in the direction of the arrow **A**.

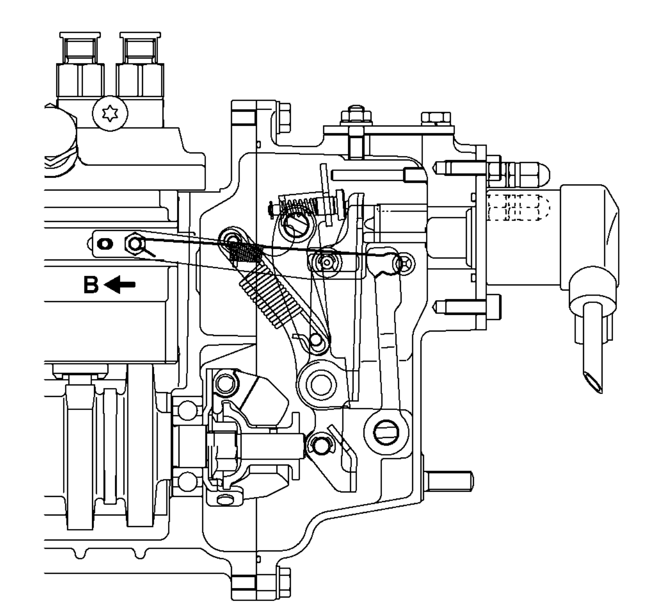
The fork lever 2 moves until it reaches the output limiting bolt to keep rated rotation and rated output.

When the engine is overloaded, the engine rotating speed decreases and the centrifugal force of flywheel weight decreases. Then the torque spring moves the fork lever 1 in the direction of arrow **A**.

The control rack moves in the direction that increases fuel supply to increase the output. It is balanced with the centrifugal force of the flywheel weight to produce low-speed output (torque output).

(1) No-load Maximum Rotation
(2) Output Limiting Bolt
(3) Torque Limiting Bolt

W1014276



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■ **To stop engine**

When the stop solenoid is turned off, the spring tension of the solenoid is released, the rod extrudes and the stop lever moves the control rack in the direction of the arrow **B** which stops the engine.

To stop the engine manually, move the external stop lever to the left.

W1014393

(4) Electronic Governor

1) Feature

■ General

The control unit adopted for a Kubota electronic governor has not only an isochronous control but also the emergency stop function, the failure diagnosis function, and the starter automatic operation secession function.

■ Function

Emergency Stop

1. Over running: When it becomes engine speed exceeding 115 % of rated engine speed.
2. Low Oil pressure: When oil pressure **SW** turns on 1 second or more.
3. High-coolant temperature: When coolant temperature **SW** turn on 1 second or more.
4. Poor charge: Although engine has started, **L** terminal of alternator does not supply 12 V.

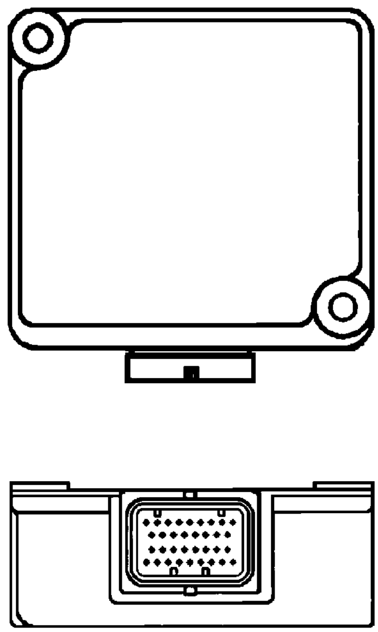
Failure Diagnosis

1. The failure of speed sensor: Even though **L** terminal of alternator supply 12 V after a key is set to **ST** position, the engine speed remain 0.
2. Solenoid and Harness disconnection: When current hardly flows at the time of full duty.
3. Coolant temperature sensor harness disconnection, short-circuit: When sensor data 5 shows below -50 °C (-58 °F) (disconnection) or more than 150 °C (302 °F) (short).
4. Alternator terminal disconnection: When the off does not carry out at the time of ACC-On.
5. Over voltage: When power supply voltage is over 18 V.
6. Sensor power supply short-circuits: When voltage of analog 5 V for potentiometer etc. falls.

Protection Circuit

1. Glow time setting
   When Key **SW** is set to glow position, turn on electricity during time to set up from coolant temperature. (Max. 10 seconds, Min. 3 seconds).
2. Starter Auto reduction Engine Speed setting
   For better start ability at time of low temperature, the function to adjust starter secession engine speed at the time of low temperature is added. The setting engine speed is 1100 min^{-1} (rpm) at below 10 °C (50 °F) however since target engine speed is made into the maximum setting if target engine speed is 1000 min^{-1} (rpm), starter secession engine speed is 1000 min^{-1} (rpm).
   The starter reentry prevention function after engine starting also work at over secession engine speed.

2) Components



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■ **Control Unit**

It processes the speed signal received from the speed sensor and compares it to a reference speed set with Calibration Program. The output of the control unit is a pulse width modulated signal to the actuator.

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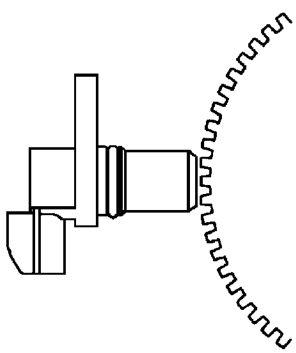

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■ **Speed Sensor**

The speed sensor senses engine speed by converting mechanical motion into electrical signals.

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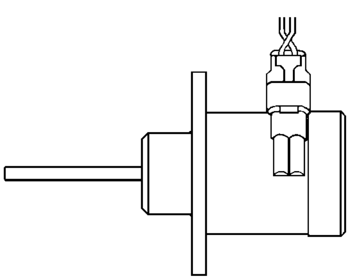

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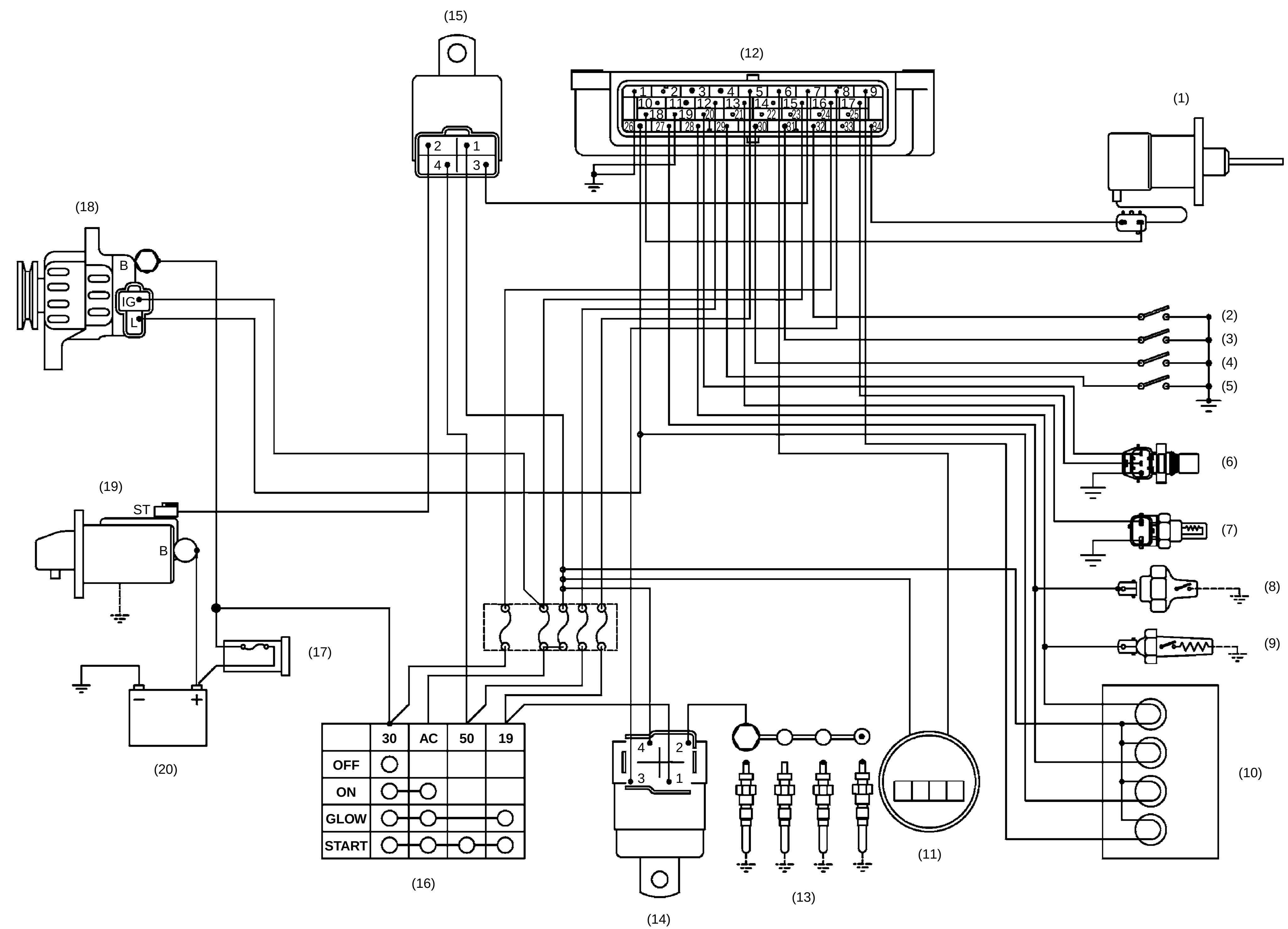
■ **Actuator**

The actuator converts a pulse width modulated signal received from the controller, to an output rod position, proportional to the duty cycle of the pulse width modulated signal.

W11135100

3) Wiring Diagram (03-M Series Standard Spec.)



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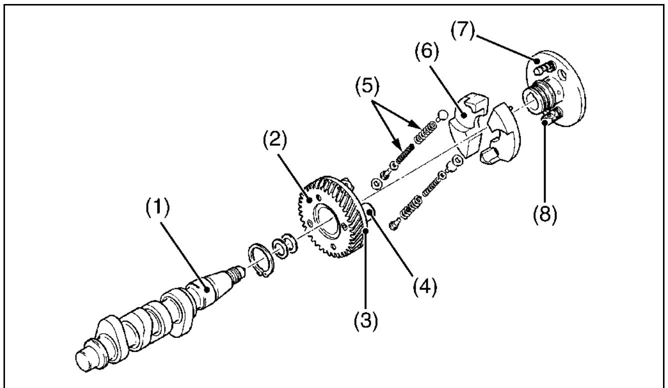
(1) Actuator
(2) Speed Switch
(3) Slow Down Switch
(4) Option
(5) Manual Stop Switch
(6) Speed Sensor
(7) Water Temperature Sensor
(8) Oil Switch
(9) Water Temperature Switch
(10) Pilot Lamp
(11) Hour Meter
(12) Control Unit
(13) Glow Plug
(14) Glow Plug Relay
(15) Start Relay
(16) Key Switch
(17) Slow Blow Fuse
(18) Alternator
(19) Starter
(20) Battery

[9] TIMER

Fuel fed by the injection pump passes through the injection pipe to the injection nozzle. The time required for fuel to flow from the injection pump to the nozzle is almost constant, irrespective of engine speed. The time required for injected fuel to ignite, burn and reach the maximum pressure is also virtually constant, irrespective of engine speed. Therefore, as engine speed increases, injection timing is delayed, and vice verse. If fuel injection timing is fixed, it is impossible to provide optimum injection timing at each engine speed. To solve this problem, an automatic injection advance timer is used to control fuel injection timing automatically. The automatic injection advance timer has 3 types: mechanical type, mechanical timer with cold start advance function type and distribution pump type.

(1) Mechanical Type



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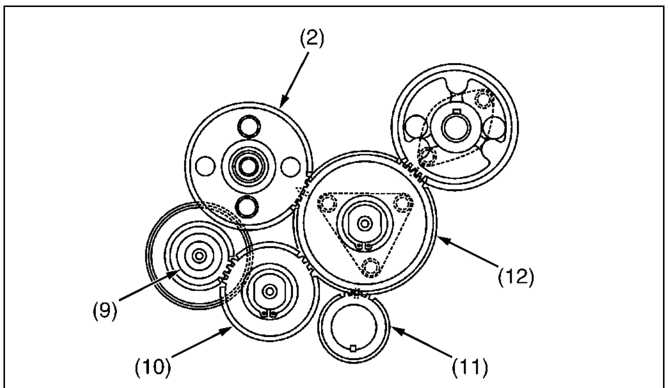

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■ Structure

Mechanical timer utilizes the balance between the flyweight's centrifugal force (generated by engine rotation) and spring tension.

The structure of the timer is as shown in the figure.

Hub bolt (8) is inserted into the hole located on one side of flyweight (6). Hub (7) is secured to fuel camshaft (1) by key and nut. Driving plate (3) is bolted to injection pump gear (2). Driving bolt (4) securing driving plate (3) is in contact with the curved surface of flyweight (6). Timer spring (5) is installed between driving bolt (4) and hub bolt (8).

Therefore, torque is transmitted from the crankshaft to the fuel camshaft via the following route :

Crank gear (11) → Idle gear 1 (12) → Injection pump gear (2) → Driving plate (3) → Driving bolt (4) → Flyweight (6) → Hub bolt (8) → Hub (7) → Fuel camshaft (1).

(1) Fuel Camshaft	(7) Hub
(2) Injection Pump Gear	(8) Hub Bolt
(3) Driving Plate	(9) Governor Gear
(4) Driving Bolt	(10) Idle Gear 2
(5) Timer Spring	(11) Crank Gear
(6) Flyweight	(12) Idle Gear 2

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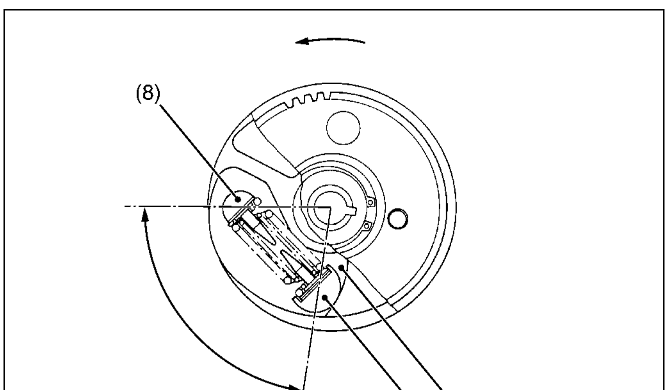

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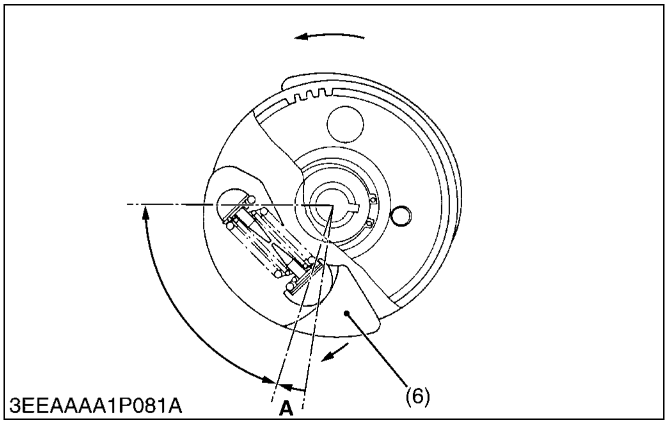
■ During Low-speed Travel

As the centrifugal force applied to flyweight (6) is small, spring force presses the flyweight inward, permitting driving bolt (4) to come in contact with flyweight at the position shown in the figure.

(4) Driving Bolt	(8) Hub Bolt
(6) Flyweight	

W10686600



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■ **During Medium- to High-speed Travel**

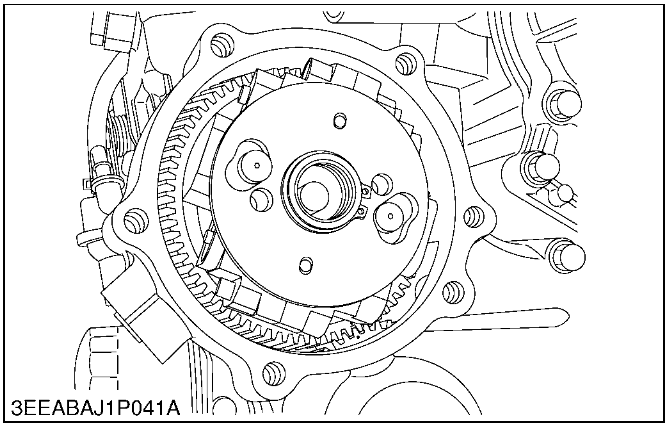
As engine speed increases, the centrifugal force applied to flyweight (6) increases, expanding it around hub bolt in the direction of the arrow, thereby rotating the position (where driving bolt is in contact with flyweight (6)) through angle **A** as shown in the figure.

Therefore, since the fuel camshaft rotates from injection pump gear in the rotational direction through angle **A**, injection timing is advanced.

(6) Flyweight

W10712730

(2) Mechanical Timer with Cold Start Advance Function Type (V3600-E3B, V3800DI-T-E3B)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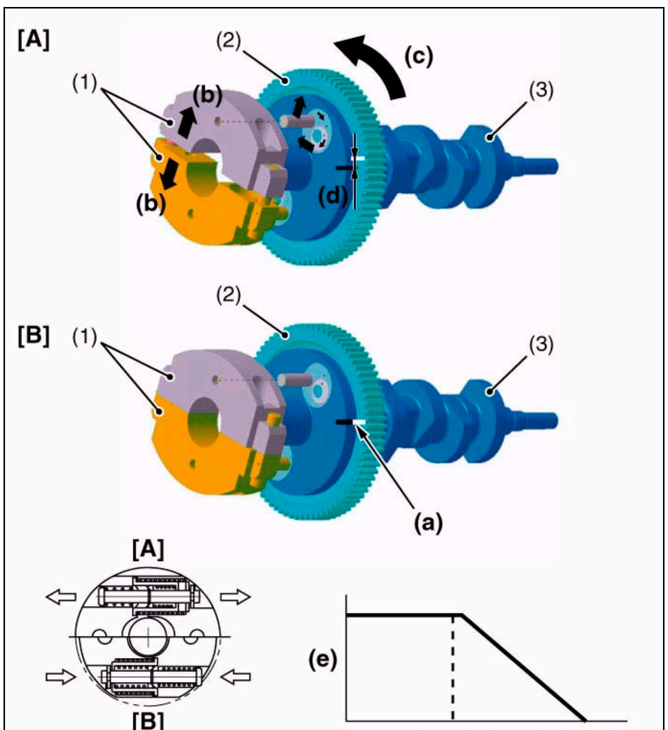
This device makes the fuel injection timing advanced by engine oil temperature and engine rpm in order to improve the engine cold start-ability and reduce the blue white smoke.

W1017432



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■ **Thermal control**

When the engine rpm is low and engine oil temperature is under 30 °C, the fuel injection timing is max. advanced.

When the engine rpm is low and engine oil temperature is higher than 70 °C, the fuel injection timing advance is 0 degree.

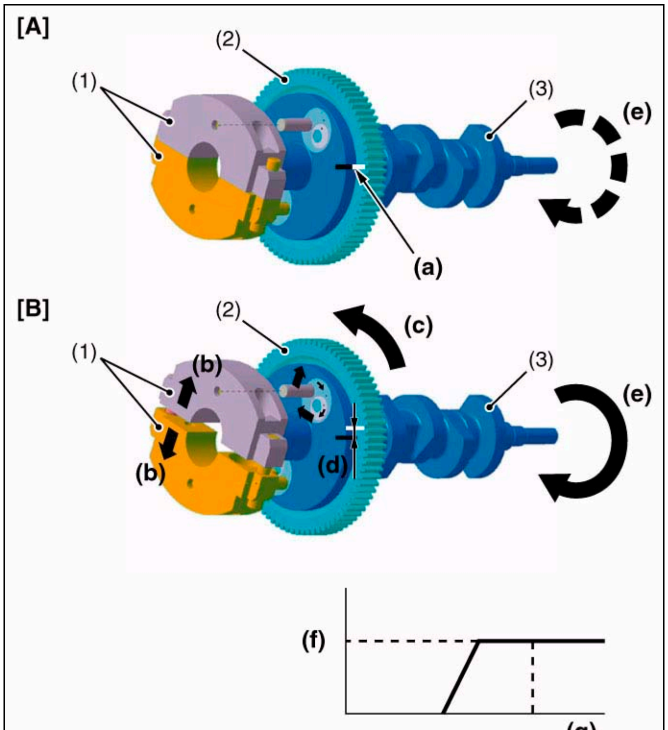
The fuel injection timing advance by engine oil temperature is controlled with shape memory (storage) spring.

(1) Timer Flyweight
(2) Injection Pump Gear
(3) Fuel Camshaft

[A] At Cold
[B] At Hot

(a) No Gap Between Timer and Injection Pump Gear
(b) Spring Force
(c) Advanced Injection Timing
(d) Gap Between Timer and Injection Pump Gear
(e) Advanced Injection Timing (degree)
(f) Engine Oil Temperature

W1017478



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■ Speed control

If the engine rpm is higher than a certain rpm, the fuel injection timing advance by engine oil temperature does not work. At that time, the quantity of advance timing is variably changed by centrifugal force of the timer flyweights which meets engine rpm.

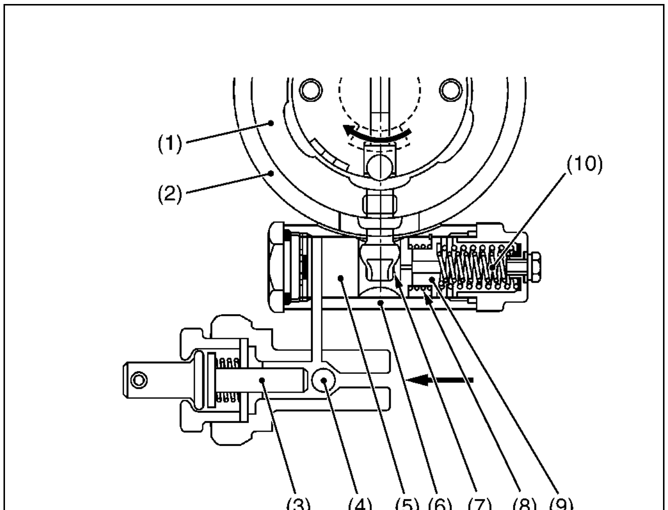
(1) Timer Flyweight
(2) Injection Pump Gear
(3) Fuel Camshaft

[A] At Low rpm
[B] At High rpm

(a) No Gap Between Timer and Injection Pump Gear
(b) Centrifugal Force
(c) Advanced Injection Timing
(d) Gap Between Timer and Injection Pump Gear
(e) Rotation
(f) Advanced Injection Timing (Degree)
(g) Engine rpm

W1017759

(3) Distribution Pump Type



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■ Automatic Advance Device

The automatic advance device is available to control the timing of the pump with respect to engine starting characteristics and loading requirements.

The piston (5) is free to slide in a cylinder machined in the body of the device (6). Movement of this piston is transmitted to the cam ring (1) by the ball-ended cam screw (7), causing the cam ring to rotate within the pump housing (2).

Pressure exerted on the piston by the springs tends to hold the piston (5) and the cam ring (1) in the fully retarded position.

Fuel at transfer pressure acts upon the piston (5) and tends to move the cam ring (1) against the spring pressure.

Transfer pressure increases progressively as the engine speed is raised, and the piston is moved along the cylinder to compress the springs and move the cam ring towards the fully advanced position. When engine speed is decreased, transfer pressure falls, and the piston and cam ring are moved towards the retarded position by spring pressure.

The manual advance canceling device (3) facilitates cold starting by preventing the ball (4) to move off its seating to avoid fuel pressure action upon the plunger, thus maintaining the max retard of injection.

(1) Cam Ring
(2) Pump Housing
(3) Manual Advance Canceling Device
(4) Ball
(5) Piston
(6) Body
(7) Cam Screw
(8) Spring
(9) Spring Plate
(10) Spring

W10482550

[10] FUEL

Fuel is flammable and can be dangerous. You should handle fuel with care.

■ **IMPORTANT**

- **Be sure to use a strainer when filling the fuel tank, or dirt or sand in the fuel may cause trouble in the fuel injection pump.**
- **For fuel, always use diesel fuel. You are required not to use alternative fuel, because its quality is unknown or it may be inferior in quality, and kerosene, which is very low in cetane rating, adversely affects the engine. Diesel fuel differs in grades depending on the temperature.**
- **Be careful not to let the fuel tank become empty, or air can enter the fuel system, necessitating bleeding before next engine start.**

■ **NOTE**

- **Cetane Rating : The minimum recommended Fuel Cetane Rating is 45. A cetane rating greater than 50 is preferred, especially for ambient temperatures below −20 °C (−4 °F) or elevations above 1500 m (5000 ft).**
- **Diesel Fuel Specification Type and Sulfur Content % (ppm) used, must be compliant with all applicable emission regulations for the area in which the engine is operated.**
- **Use of diesel fuel with sulfur content less than 0.10 % (1000 ppm) is strongly recommended.**
- **If high-sulfur fuel (sulfur content 0.50 % (5000 ppm) to 1.0 % (10000 ppm)) is used as a diesel fuel, change the engine oil and oil filter at shorter intervals. (approximately half)**
- **DO NOT USE Fuels that have sulfur content greater than 1.0 % (10000 ppm).**
- **Diesel fuels specified to EN 590 or ASTM D975 are recommended.**
- **No.2-D is a distillate fuel of lower volatility for engines in industrial and heavy mobile service. (SAE J313 JUN87)**
- **Since KUBOTA diesel engines of less than 56 kW (75 hp) utilize EPA Tier 4 and Interim Tier 4 standards, the use of low sulfur fuel or ultra low sulfur fuel is mandatory for these engines, when operated in US EPA regulated areas. Therefore, please use No.2-D S500 or S15 diesel fuel as an alternative to No.2-D, and use No.1-D S500 or S15 diesel fuel as an alternative to No.1-D for ambient temperatures below −10 °C (14 °F).**

1) SAE : Society of Automotive Engineers
2) EN : European Norm
3) ASTM : American Society of Testing and Materials
4) US EPA : United States Environmental Protection Agency
5) No.1-D or No.2-D, S500 : Low Sulfur Diesel (LSD) less than 500 ppm or 0.05 wt.%
No.1-D or No.2-D, S15 : Ultra Low Sulfur Diesel (ULSD) 15 ppm or 0.0015 wt.%

Grade of Diesel Fuel Oil According to ASTM D975

Flash Point, °C (°F)	Water and Sediment, volume %	Carbon Residue on, 10 percent Residuum, %	Ash, weight %	Distillation Temperatures, °C (°F) 90% Point		Viscosity Kinematic cSt or mm^2/s at 40 °C (104 °F)		Viscosity Saybolt, SUS at 37.8 °C (100.0 °F)	
Min	Max	Max	Max	Min	Max	Min	Max	Min	Max
52 (125)	0.05	0.35	0.01	282 (540)	338 (640)	1.9	4.1	32.6	40.1

W1047379

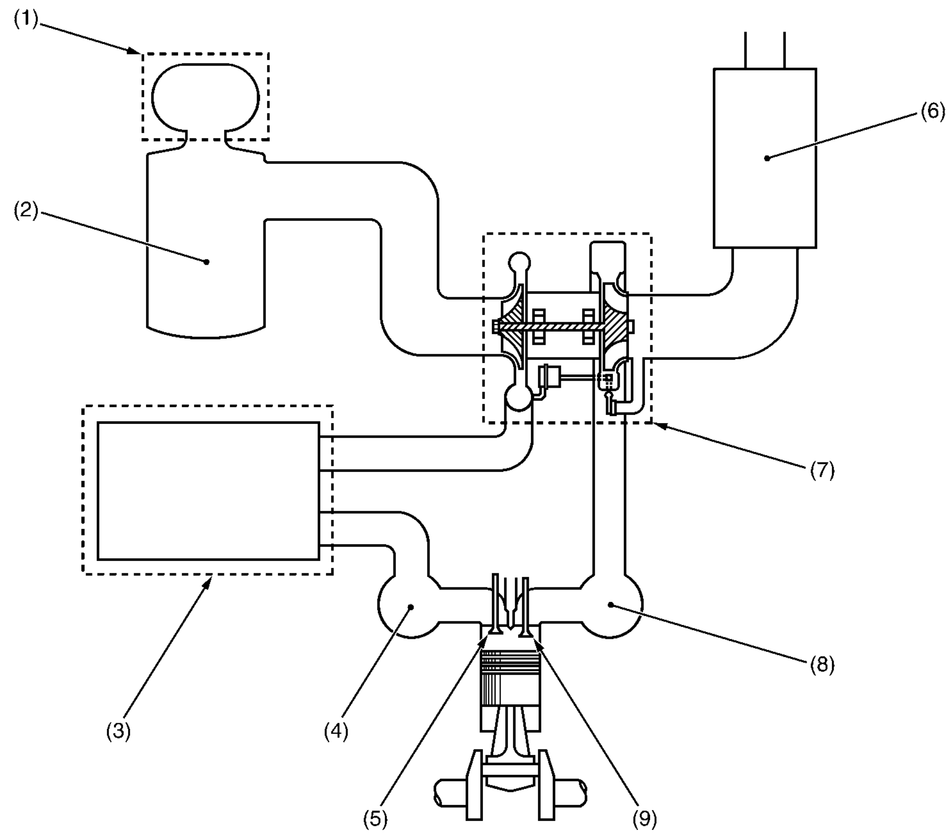
Sulfur, weight %	Copper Strip Corrosion	Cetane Number
Max	Max	Min
0.50	No.3	40

The cetane number is required not less than 45.

W1048333

4. INTAKE AND EXHAUST SYSTEM

[1] GENERAL



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(1) Pre-cleaner
(2) Air Cleaner
(3) Intercooler
(4) Intake Manifold
(5) Intake Valve
(6) Muffler
(7) Turbocharger
(8) Exhaust Manifold
(9) Exhaust Valve

W10346150

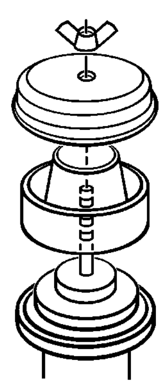
The intake system supplies the engine with the proper quantity of clean air, while the exhaust system collects exhaust gases from the engine and carries them away.

The intake system consists of pre-cleaner (1) (if equipped), air cleaner (2), turbocharger (7) (if equipped), intercooler (3) (if equipped), intake manifold (4), intake air heater (if equipped) and intake valves (5).

The exhaust system consists of exhaust valves (9), exhaust manifold (8), turbocharger (7) (if equipped) and muffler (6).

W1034616

[2] PRE-CLEANER



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The pre-cleaner is usually installed at the end of pipe extended upward into the air from the air cleaner inlet. This places them in an area relatively free of dust.

The pre-cleaner is a simple device which removes larger particle of dirt or other foreign matter from the air before it enters the air cleaner.

This relieves much of the load on the air cleaner and allows longer intervals between servicing.

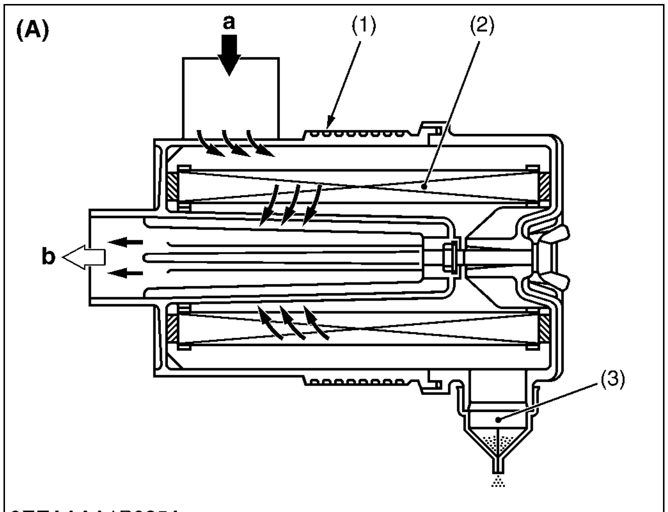
W10349100

[3] AIR CLEANER

Clean air is essential to satisfactory performance and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as chaff, or lawn from the air.

A cleaner must also have a reservoir large enough to hold material taken out of the air so operation over a reasonable period of time is possible before cleaning and servicing is necessary.

(1) Dry Element Type Air Cleaner



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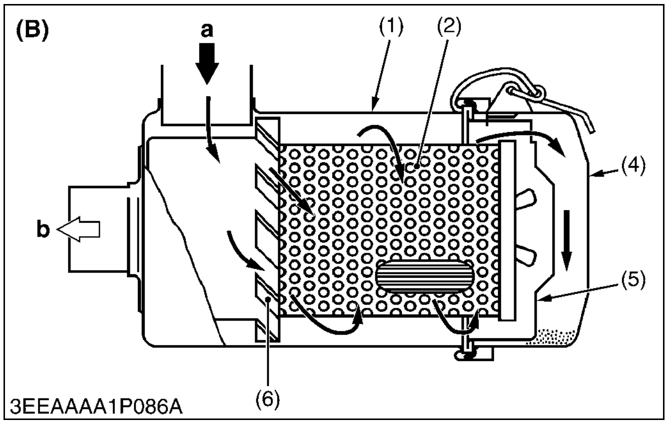

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Two major types of dry element type cleaners are used at present as shown in figure.

Dry element type cleaners are built for two stage cleaning.

This first stage (pre-cleaning) directs the air into the cleaner at high speed so that it sets up centrifugal rotation around the filter element.

Air cleaner with evacuator valve directs the air into the pre-cleaner so it strikes one side of the air guide. This starts the centrifugal action which continues until it reaches the far end of the cleaner housing. At this point, the dirt is collected into an evacuator valve (3) at the bottom of the housing.

Air cleaner with dust cup conducts the air past tilled fins which start the centrifugal action. When the air reaches the end of the cleaner housing, the dirt passes through the holes in the top of the cleaner and enters the dust cup (4).

The partially cleaned air then passes through the air filter element (pleated-paper filter) (2). Filtering is done as the air passes through the paper filter. This is the second stage of cleaning.

Some cleaners have a small safety element built into the unit in case the main element fouls.

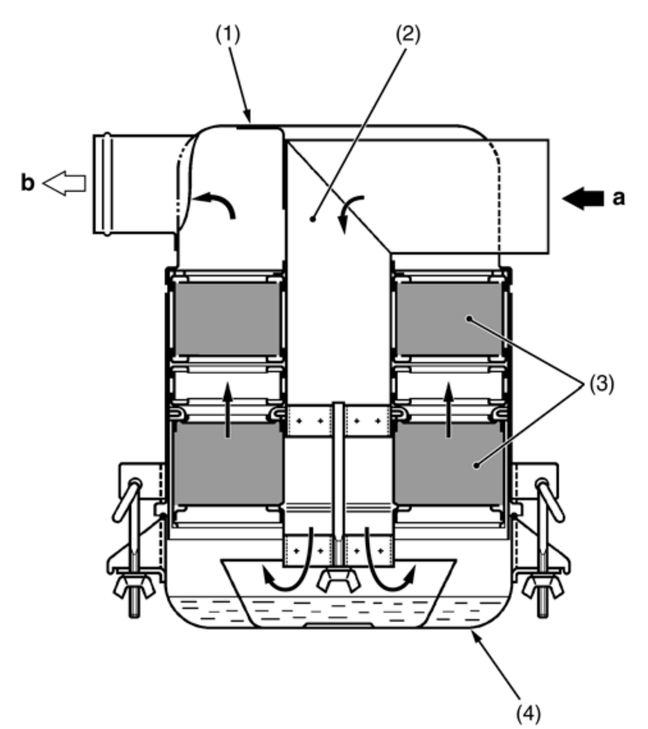
(1) Air Cleaner Housing
(2) Air Filter Element
(3) Evacuator Valve
(4) Dust Cup
(5) Baffle Cover
(6) Fin

(A) Air cleaner with evacuator valve
(B) Air cleaner with dust cup

a : From air inlet or pre-cleaner
b : To engine cylinder or turbocharger

W10350030

(2) Oil Bath Type Air Cleaner



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Oil bath type air cleaner draw air down a center tube (2) where it strikes the surface of oil in a partly filled cup (4). The impact causes a mixture of air and oil spray to be carried up into the element of baffles and steel wool (3). The separating element breaks up the dust-laden air and fine dust particles are trapped by the oil film. The particles are then washed down as the oil later drains back into the cup.

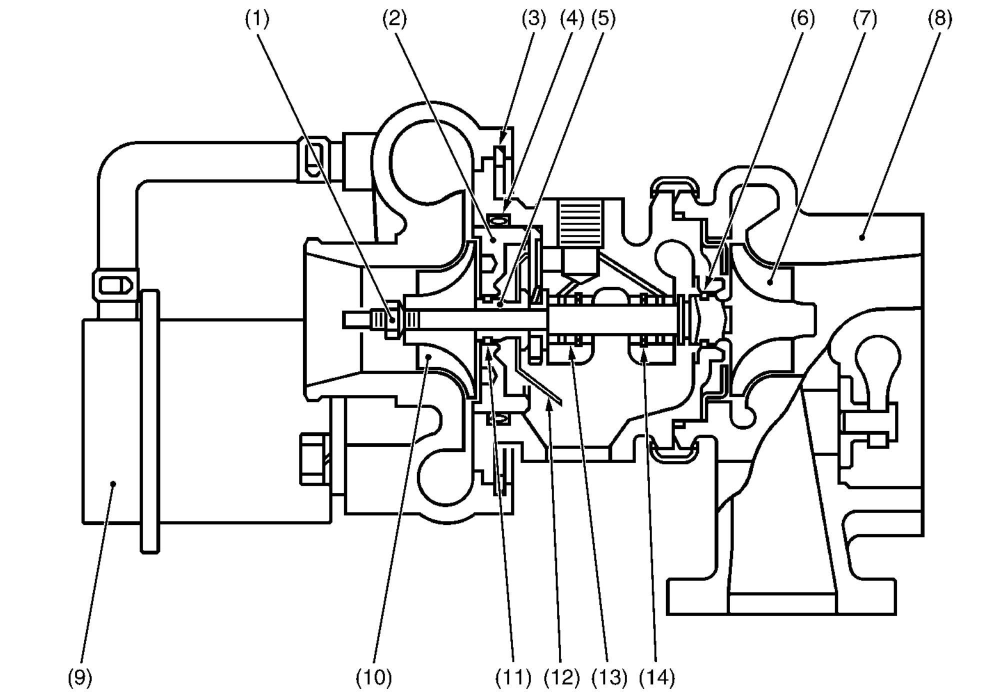
Clean air continues through the element and on to the engine.

(1) Air Cleaner Housing
(2) Center Tube
(3) Steel Wool
(4) Oil Cup

a : From air inlet or pre-cleaner
b : To engine cylinder or turbocharger

W10352520

[4] TURBOCHARGER



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(1) Lock Nut
(2) Thrust Bearing
(3) Snap Ring
(4) O-ring
(5) Thrust Sleeve
(6) Piston Ring
(7) Turbine Wheel
(8) Turbine Housing
(9) Actuator
(10) Compressor Wheel
(11) Piston Ring
(12) Oil Deflector
(13) Bearing
(14) Snap Ring

W10353780

A turbocharger consists basically of a centrifugal compressor mounted on a common shaft with a turbine driven by exhaust gas. The compressor is usually located between the air cleaner and the intake manifold (or intercooler; if equipped), while the turbine is located between the exhaust manifold and the muffler.

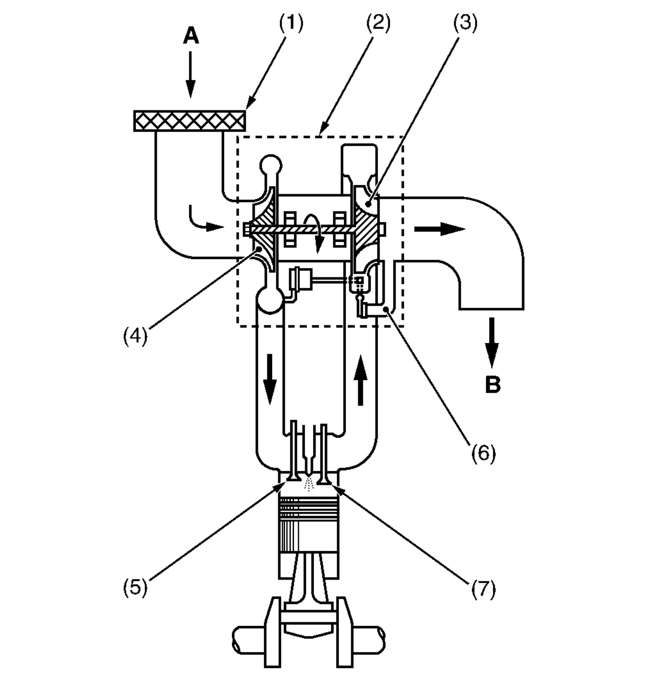
The prime job of the turbocharger is, by compressing the air, to force more air into the engine cylinders. This allows the engine to efficiently burn more fuel, thereby producing more horsepower.

In applications where the boost pressure is relatively low, the turbocharger is capable of reducing the smoke concentration, the concentration in the cylinder, fuel consumption, and deterioration in performance at elevated terrain by increasing the amount of air into the engine cylinders.

In applications where the boost pressure is high, the turbocharger is capable of providing a large increase in engine output by increasing the amount of air into the engine cylinders.

W1035379

(1) Mechanism



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■ **Turbocharger Works**

While the engine is running, exhaust gases pass through the exhaust manifold to rotate the turbine wheel (3) of the turbocharger at high speed.

Rotation of the turbine wheel (3) rotates the compressor wheel (4) at same speed because both wheels (3), (4) are on the same shaft. As the compressor wheel (4) rotates, air is sucked in, compressed, and sent into the engine cylinder.

The higher density of the compressed air per cylinder volume results in increased output compared with non-turbocharged engines of the same displacement.

■ **Advantages**

Turbocharged engines have the following advantages :

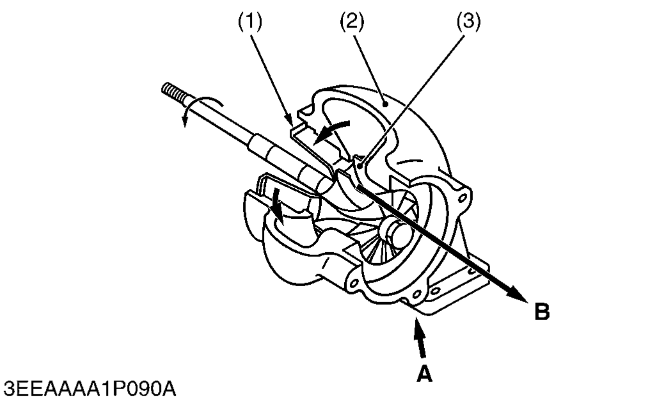
1. Despite the increase in output, there is little increase in friction loss. Therefore, good mechanical efficiency is insured.
2. During overlap (when both the intake and exhaust valves are open), compressed air forces out exhaust gas and fills the cylinder with fresh air. This increases combustion efficiency.
3. Improvements in mechanical and combustion efficiency lead to a lower fuel consumption.

(1) Air Cleaner
(2) Turbocharger
(3) Turbine Wheel
(4) Compressor Wheel
(5) Intake Valve
(6) Waste Gate Valve
(7) Exhaust Valve

A : Air
B : Exhaust Gas

W10356140

(2) Turbine



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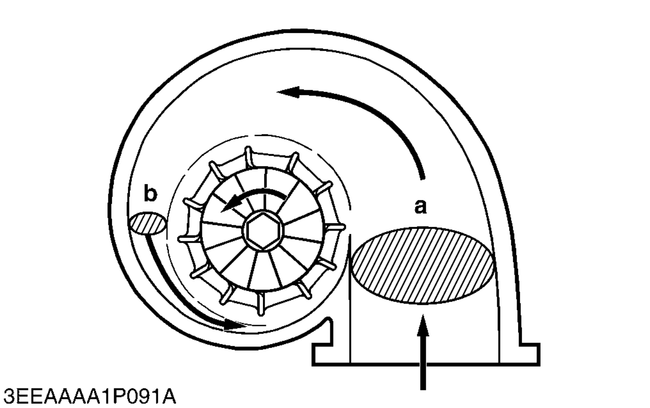

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This is radial flow turbine.

The turbine wheel assembly (3) uniting the turbine wheel and shaft is designed to balance even at high speeds.

The turbine housing (2) has a vortex gas passage. As the passage becomes smaller (from "**a**" to "**b**", the gas flow rate increases so that the turbine is rotated at high speeds.

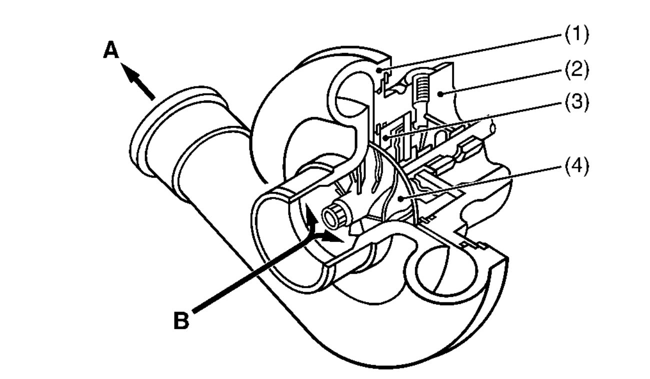
The turbine back plate (1) prevents the bearing housing and bearing (floating metal) inside from being directly exposed to the heat of the exhaust gas on the turbine wheel side.

(1) Turbine Back Plate
(2) Turbine housing
(3) Turbine Wheel Assembly

A : From Cylinder
B : To Exhaust Muffler

W10358740

(3) Compressor



3EEAAAA1P092A

A centrifugal compressor is used.

The compressor consists of a cast compressor wheel (4), bearing housing (2), insert (3) and compressor cover (1).

Air is sucked at high speed by the compressor wheel (4). As it passes through the spiral passage in the housing, its speed is reduced to the proper level and forced into the cylinder.

The compressor wheel (4) is a precision-cast component, which maintains the proper balance even at high speed. Its blades are curved backward to ensure the highest performance.

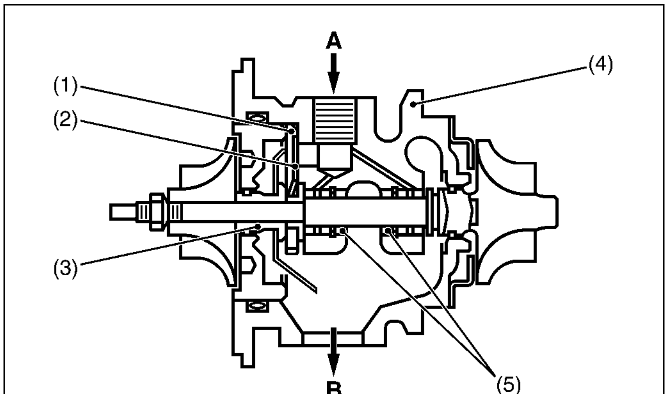
The compressor housing is designed to regulate the flow drawn by the wheel and increase its pressure.

(1) Compressor Cover
(2) Bearing Housing
(3) Insert
(4) Compressor Wheel

A : To Cylinder
B : From Air Cleaner

W10360110

(4) Bearing



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The shaft rotates at a very high speed (tens of thousands of revolutions per minute). To withstand high speeds, the bearings (5) use floating metals. These bearings float on a film oil between the shaft and bearing housing (4) and rotate to reduce the sliding velocity.

The shaft also receives thrust (in the axial direction) on the compressor side from both the turbine and compressor wheels. This load is borne by the thrust bearing (1) fitted between the thrust sleeve (3) and thrust ring (2) which is secured to the shaft and turns together with the shaft.

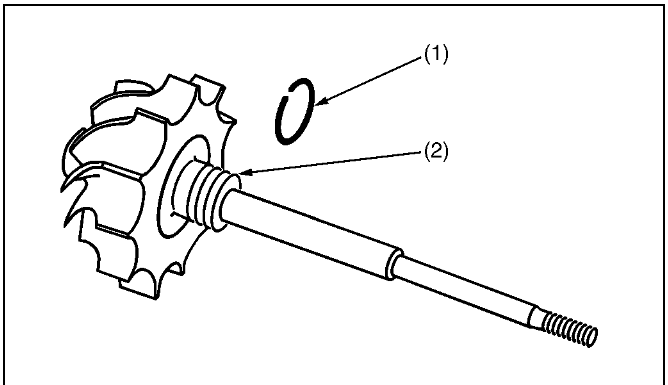
Lubricating oil fed from the engine's oil pump enters the bearing section through the top of the bearing housing (4) and passes through the internal passages, lubricating the bearings (5). After that, it returns to the engine from the bottom of the bearing housing (4).

(1) Thrust Bearing
(2) Thrust Ring
(3) Thrust Sleeve
(4) Bearing Housing
(5) Bearing

A : From Engine Oil Pump
B : To Engine

W10361770

(5) Seals



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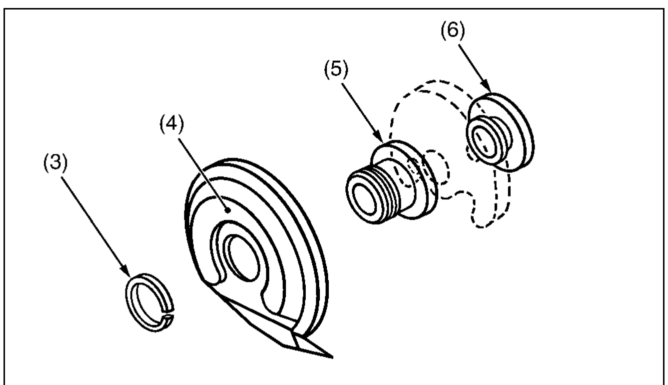

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When lubricating oil leaks on the turbine or compressor wheel side, it will adhere to the wheel or housing. The oil may then be contaminated with dust or carbon. Such contamination will destroy the balance of the rotating shaft and prevent normal operation.

To prevent this problem, lubricating oil is sealed by the following parts:

(On the turbine wheel side)

- A piston ring (1) is placed over the shaft.
- The shaft itself has an oil fling portion (2).

(On the compressor wheel side)

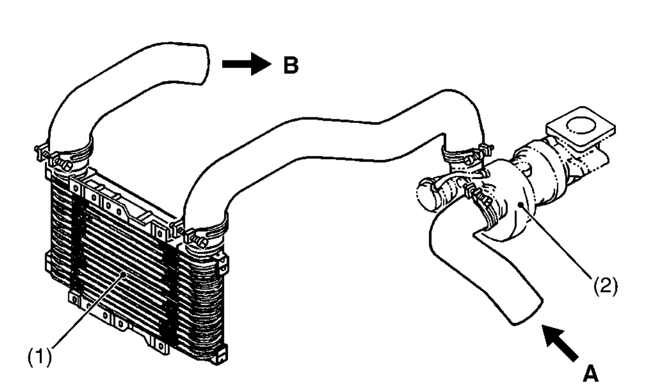
- A piston ring (3) is placed over the thrust sleeve (5).
- The oil deflector (4), which is placed on the thrust sleeve (5), prevents oil from leaking to the piston ring side.

In addition, oil is prevented from leaking to the outside by a seal ring (square rubber ring) placed between the center housing and the back plate.

(1) Piston Ring (Turbine Side)
(2) Oil Fling Portion
(3) Piston Ring (Compressor Side)
(4) Oil Deflector
(5) Thrust Sleeve
(6) Thrust Ring

W10363180

[5] INTERCOOLER



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When the turbocharger (2) compresses the intake air, the air becomes heated (due to compression) and expands. When the heated air expands it becomes less dense. The result is that part of the purpose of the turbocharger is defeated; that is, due to heat expansion, less air is forced into the engine.

To overcome this condition, some turbocharged engines are equipped with an intercooler. This is installed between the turbocharger and the intake manifold.

The intercooler (1) reduces the temperature of the compressed air. This makes the air denser, allowing more to be packed into the combustion chambers.

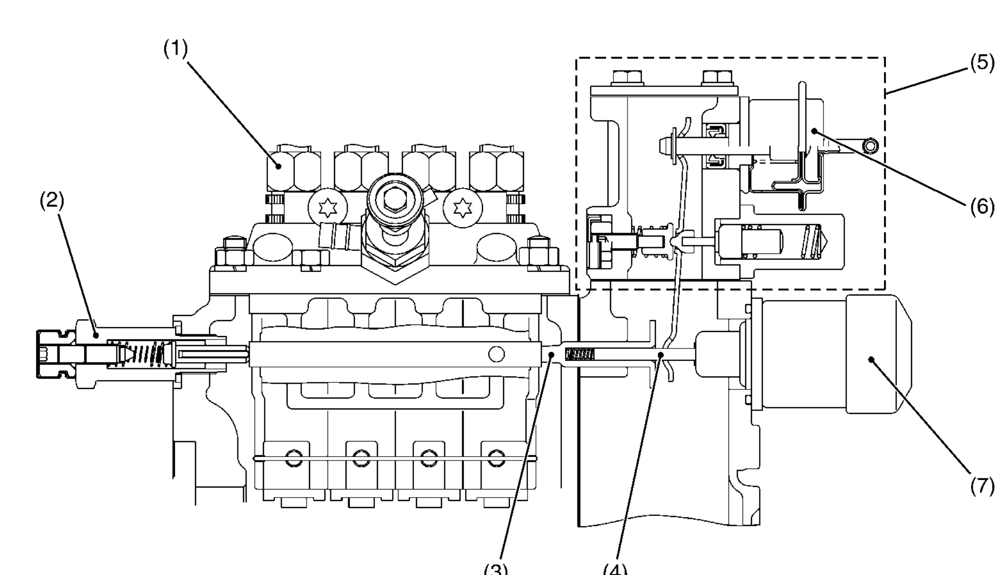
(1) Intercooler
(2) Turbocharger

A : From Air Cleaner
B : To Cylinder

W10369150

[6] BOOST COMPENSATOR

(1) 03-M Series



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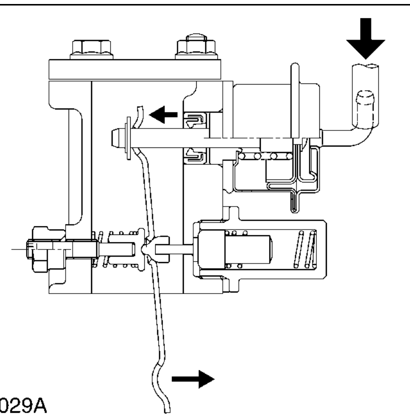
(1) Injection Pump Assembly
(2) Hi-Idling Body
(3) Stop Solenoid Guide
(4) Plunger
(5) Boost Compensator Assembly
(6) Actuator
(7) Stop Solenoid

W11177180



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The higher the boost pressure rises, the more fuel is fed. In this way, the turbocharger proves itself for high-power performance.

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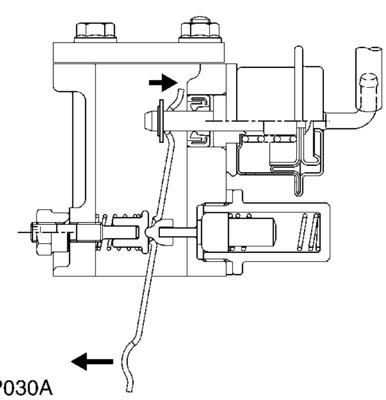

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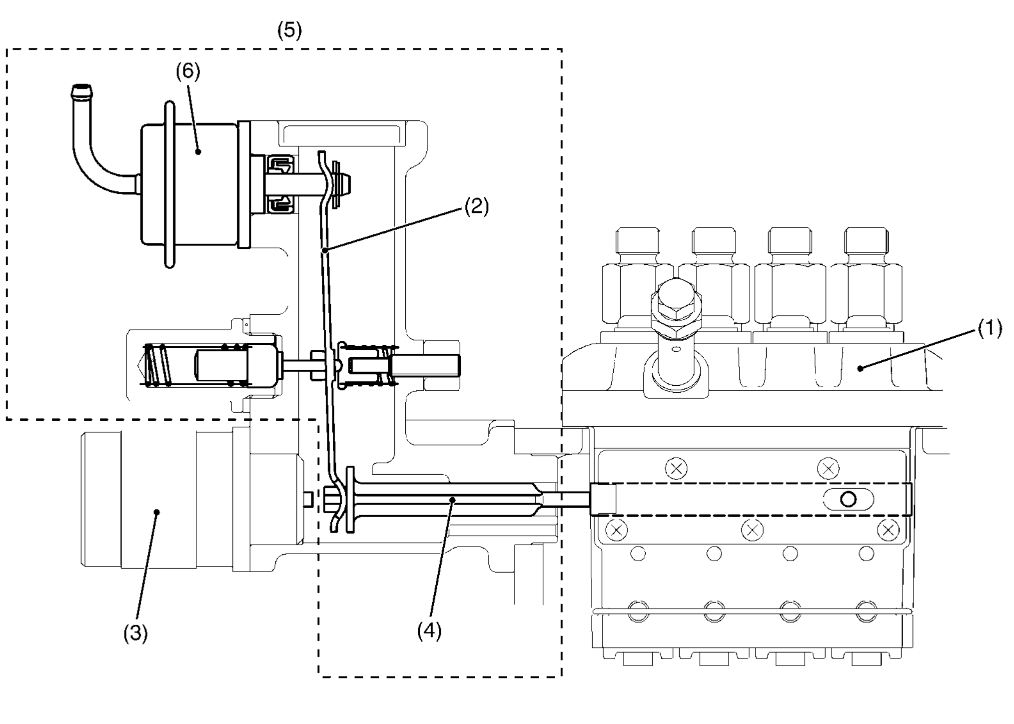
When the boost pressure drops, excess fuel is cut down, allowing much less black emission.

The system is tremendously efficient in cutting down on the emission; under low boost pressures at quick speed-up or start-up, in particular.

W11181010

(2) 05 Series

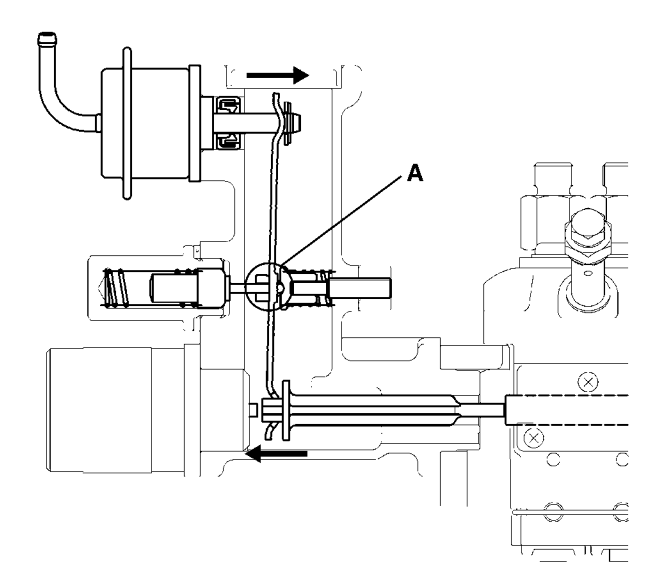


3EEAEAC1P012A

(1) Injection Pump Assembly
(2) Plate
(3) Stop Solenoid
(4) Guide
(5) Boost Compensator Assembly
(6) Actuator

A : Fulcrum

W11190940



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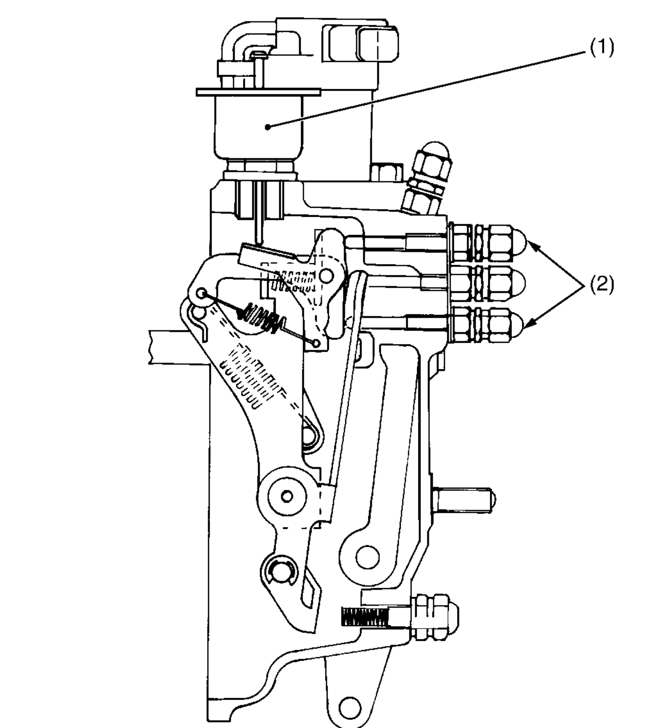
Boost compensator is the device that reduces black smoke during the engine startup and acceleration.

The rod of actuator (6) is pushed out by the rise of boost pressure, and the plate (2) moves in the direction of the fuel increase around the fulcrum **(A)**.

W11202430

(3) V3 Series



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The boost compensator is controlled by the boost pressure of the turbocharger, which reduces transient smoke caused by oversupply of fuel when the engine starts and accelerates.

When the boost pressure is lower than working pressure of the boost actuator (1), it prevents oversupply of fuel to reduce transient smoke.

When the boost pressure is higher than working pressure of the boost actuator (1), it controls the supply of fuel to the equivalent of maximum power / rated speed output.

The boost compensator adjusting screws (2) are set and tamper-proof capped in factory, so never take off the tamper-proof cap and readjust the screws.

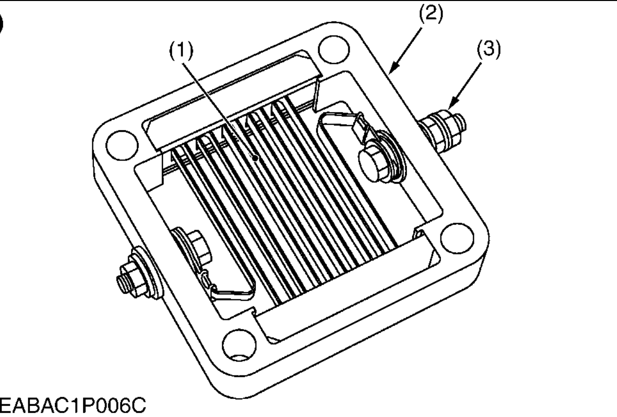
(1) Boost Actuator
(2) Boost Compensator Adjusting Screw

W11203310

[7] INTAKE AIR HEATER

(1) V3 Series

(A)



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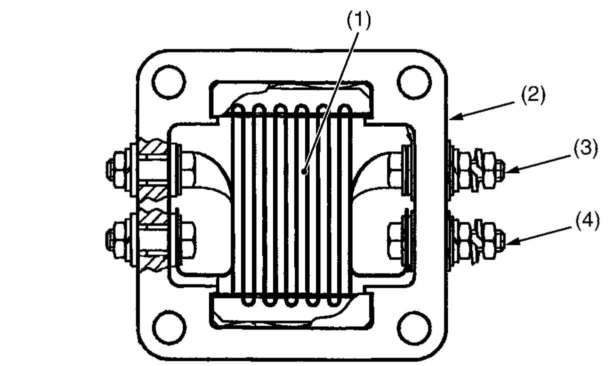
(B)



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The intake air heater is introduced in order to further improve the starting performance and to reduce the white smoke at cold starting.

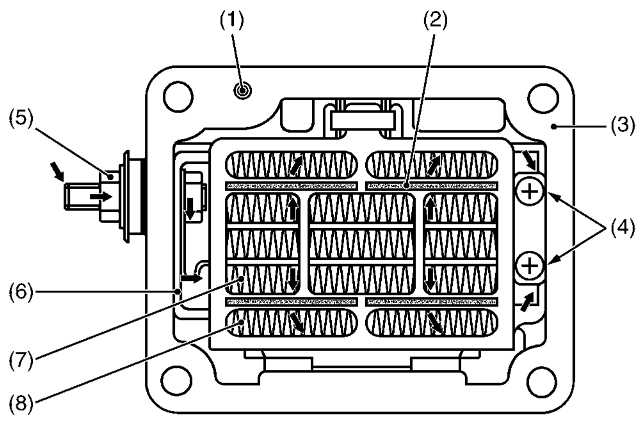
The intake air heater is mounted on the intake manifold. In this new construction, there is no need to arrange any glow plug on the cylinder head. This means that a multi-valve design can be implemented and that the starting performance and serviceability are enhanced.

(1) Heater Element
(2) Intake Air Heater Body
(3) + Terminal 1
(4) + Terminal 2

(A) 1 Heater Element Type
(B) 2 Heater Element Type

W11207900

(2) F5802



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The Positive Temperature Coefficient (PTC) intake air heater is introduced in order to further improve the starting performance in cold regions.

The intake air heater is mounted on the intake manifold, while the conventional glow plug is attached on each cylinder. In this new construction, there is no need to arrange any glow plug on the cylinder head. This means that a multi-valve design can be implemented and that the starting performance and serviceability are enhanced.

The PTC intake air heater features an automatic temperature control function. As the climate gets colder, the heater gives a greater output without little white plume and odor. What's more, this self-control of its own temperature makes the heater protective against overheat and easy to control.

[STRUCTURE]

The 12 V battery's positive terminal is connected with the main terminal as shown below. When the main switch is set the **ON** position, the current starts flowing in this route as indicated with the arrow marks : main terminal → lead bar → inner fin → PTC element → outer fin → housing → battery's negative terminal.

The four PTC elements are heated up to 160 °C (320 °F) or so in order to raise the temperature of air that passes through the air inlet pipe.

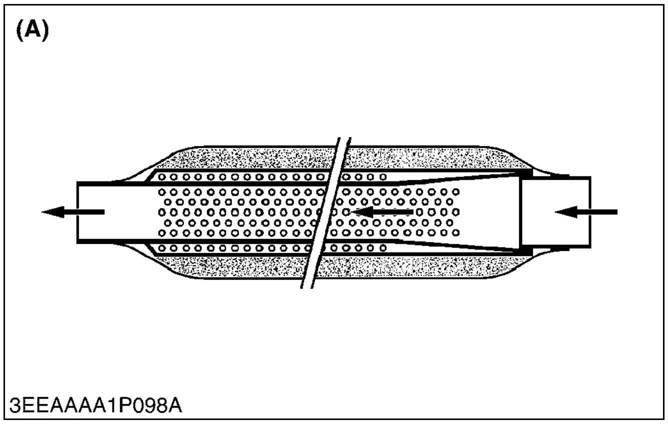
The heater's output varies according to the intake air temperature : usually 800 W at 25 °C (77 °F), 1000 W at 0 °C (32 °F) and 1200 W at –25 °C (–13 °F). (Note that the self-control temperature stays the same level.)

The pre-heating time is also automatically controlled to meet the intake air temperature.

(1) Bolt Ground to the Exhaust Manifold
(2) PTC Element
(3) Housing
(4) Grounded to the Housing
(5) Main Terminal
(6) Lead Bar
(7) Inner Fin
(8) Outer Fin

W10370390

[8] MUFFLER



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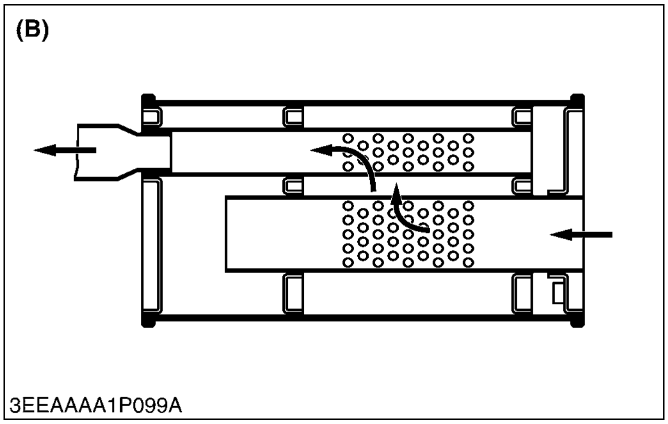

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The mufflers consist of a perforated inner tube enclosed by an outer tube. Some mufflers are chambers using baffle plates to force the exhaust gases to travel before being discharged.

The space between the tubes is sometimes filled with a sound-absorbing and heat-resistant material.

The muffler acts as an expansion chamber, reducing the noise of the exhaust gases.

(A) Straight-through Type **(B) Reverse-flow Type**

W10373700

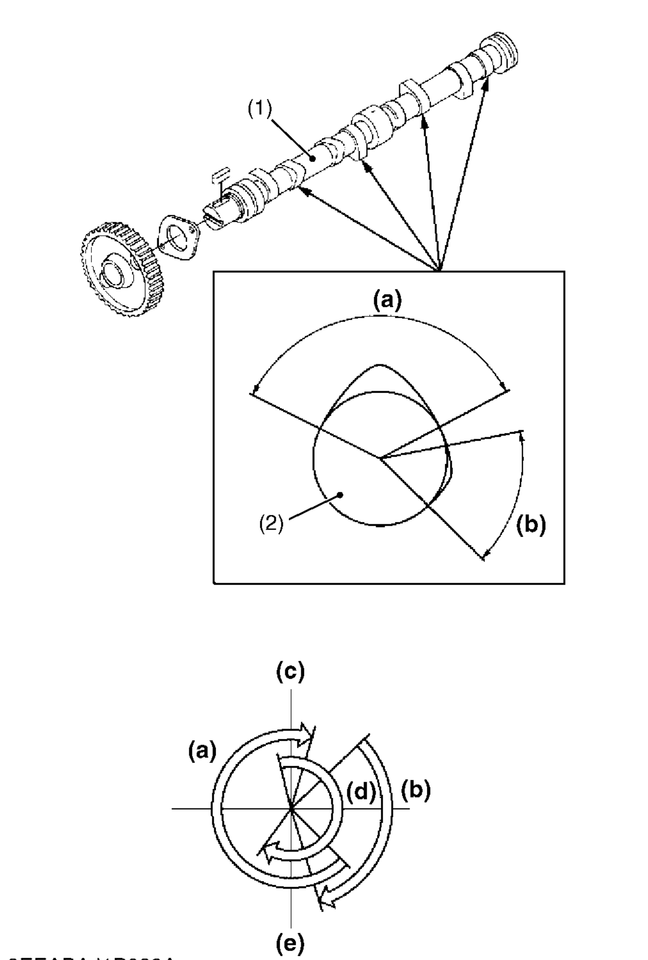
5. EXHAUST GAS RECIRCULATION (EGR) SYSTEM

[1] GENERAL

In order to meet with the strict emission regulations, Kubota has adopted the EGR on the V3-E3B series and 07-E3B series. The nitrogen oxide (NOx) which is a hazardous component in exhaust gas is generated by oxidation of nitrogen in the air, due to rise of the combustion temperature in cylinders. The EGR is a system in which the exhaust gas with lean oxygen is cooled and returned to cylinders again in order to lower the combustion temperature. As a result, NOx can be decreased.

And EGR has 2 types. One is an internal EGR, the other is an external EGR.

[2] INTERNAL EGR (V3600-T-E3B)



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Internal EGR consists of 2 stage exhaust camshaft. At the exhaust stroke, 1st stage exhaust cam opens the exhaust valve, and exhaust gas flows into the exhaust manifold. At the suction stroke, intake valve is open and fresh air flows into the cylinder, and also, 2nd stage exhaust cam opens the exhaust valve, and exhaust gas in the exhaust manifold is sucked back into the cylinder.

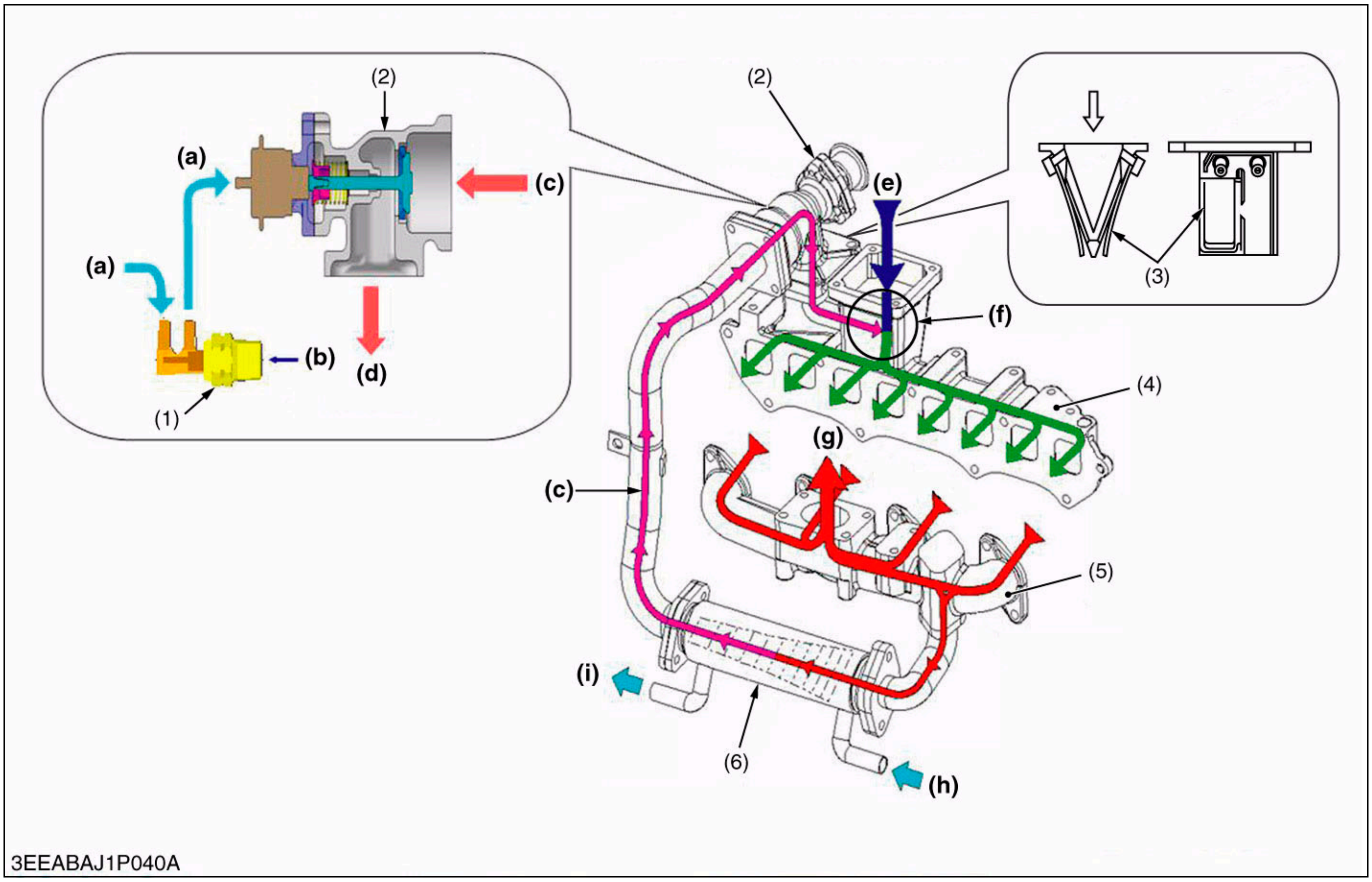
(1) Camshaft
(2) 2 Stage Exhaust Cam

(a) Exhaust Stage
(b) EGR Stage
(c) T.D.C. (Top Dead Center)
(d) Intake Stage
(e) B.D.C. (Bottom Dead Center)

W1174459

[3] EXTERNAL / MECHANICAL EGR

(1) V3800DI-T-E3B



(1) Thermo Valve
(2) Mechanical EGR Valve
(3) Reed Valve
(4) Intake Manifold
(5) Exhaust Manifold
(6) EGR Cooler

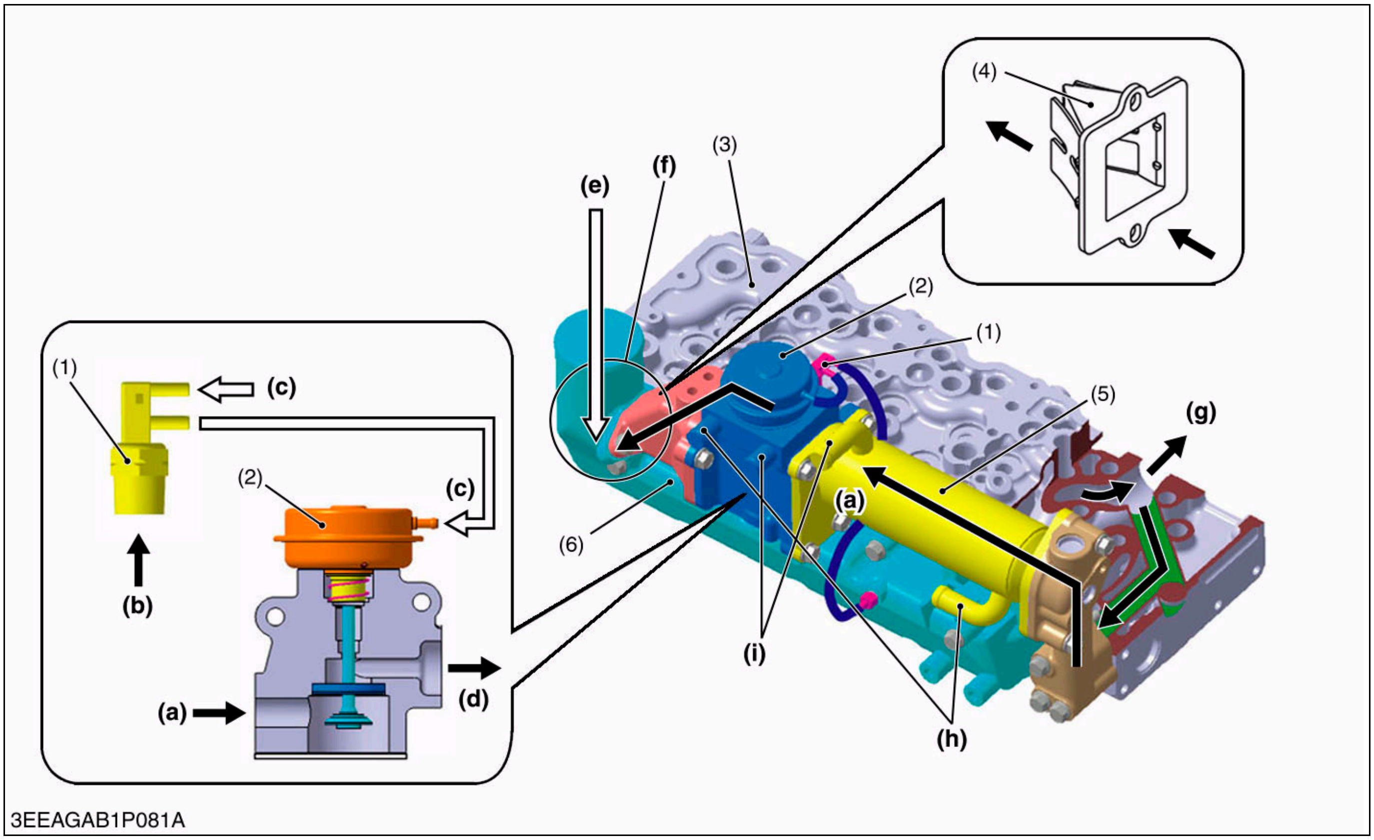
(a) Boost Pressure
(b) Coolant Temperature
(c) Cooled EGR Gas
(d) To The Intake Manifold
(e) Fresh Air
(f) Cooled EGR Gas Merges with Fresh Air
(g) Exhaust Gas
(h) Coolant Inlet
(i) Coolant Outlet

External / Mechanical EGR consists of water cooled EGR cooler, mechanical EGR valve, reed valve and thermo valve.

When the coolant temperature is getting higher, thermo valve is open and the boost pressure of intake manifold gets to reach the diaphragm of mechanical EGR valve.

If the coolant temperature is high, but the boost pressure is low, the EGR valve does not open. If coolant temperature is high, boost pressure is also high, EGR valve is open and cooled EGR gas through the water cooled EGR cooler flows into the intake manifold. And the reed valve between EGR valve and intake manifold prevents the fresh air flowing into EGR system.

(2) V3007-DI-T-E3B / V3307-DI-T-E3B



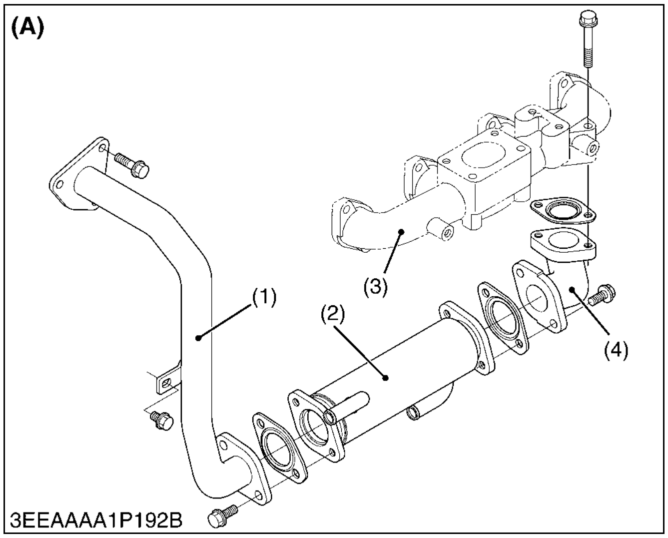
(1) Thermo Valve
(2) Mechanical EGR Valve
(3) Cylinder Head
(4) Reed Valve
(5) EGR Cooler
(6) Intake Manifold
(a) Cooled EGR Gas
(b) Coolant Temperature
(c) Boost Pressure
(d) To The Intake Manifold
(e) Fresh Air
(f) Cooled EGR Gas Merges with Fresh Air
(g) Exhaust Gas
(h) Coolant Inlet
(i) Coolant Outlet

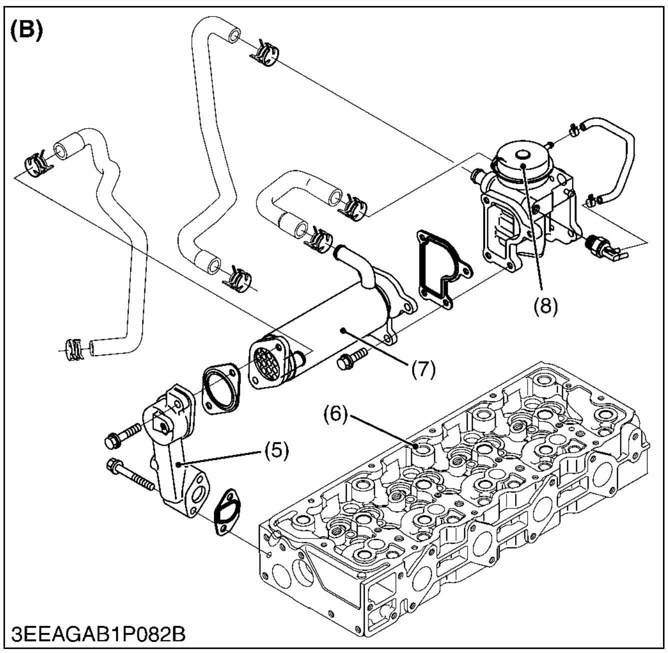
External / Mechanical EGR consists of water cooled EGR cooler (5), mechanical EGR valve (2), reed valve (4) and thermo valve (1).

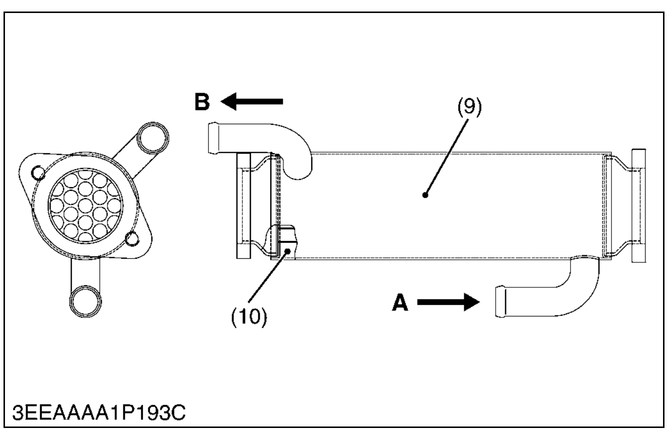
When the coolant temperature **(b)** is getting higher, thermo valve (1) is open and the boost pressure of intake manifold (6) gets to reach the diaphragm of mechanical EGR valve (2).

If the coolant temperature **(b)** is high, but the boost pressure is low, the EGR valve (2) does not open. If coolant temperature **(b)** is high, boost pressure is also high, EGR valve (2) is open and cooled EGR gas **(a)** through the water cooled EGR cooler (5) flows into the intake manifold (6). And the reed valve (4) between EGR valve (2) and intake manifold (6) prevents the fresh air flowing into EGR system.

(3) EGR Cooler







The EGR (Exhaust Gas Recirculation) cooler is used to lower combustion temperature and efficiently cool EGR gas, with the aim of reducing the NOx that is in the exhaust gas of diesel engine.

The EGR cooler is placed between the exhaust manifold and the intake manifold of the engine and returns the cooled exhaust gases to the engine suction side.

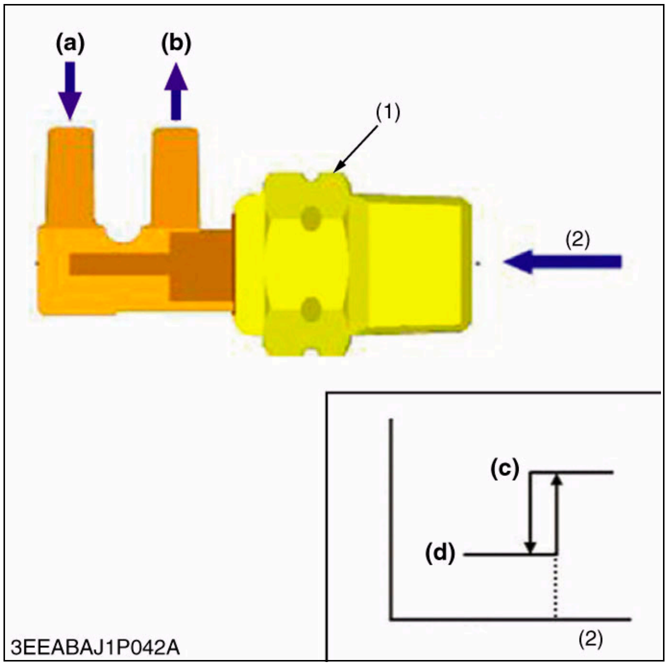
The EGR cooler has resistant to clogging up, compact and efficient tubes internally.

(1) Pipe
(2) EGR Cooler
(3) Exhaust Manifold
(4) Flange
(5) Flange
(6) Cylinder Head
(7) EGR Cooler
(8) Mechanical EGR Valve
(9) EGR Cooler
(10) Tube

(A) V3800DI-T-E3B
(B) V3007-DI-T-E3B / V3307-DI-T-E3B

W1175338

(4) Thermo Valve



Thermo valve controls boost pressure “ON / OFF” for the EGR valve.

If the coolant temperature is low, thermo valve is closed, so that boost pressure does not reach to the EGR valve.

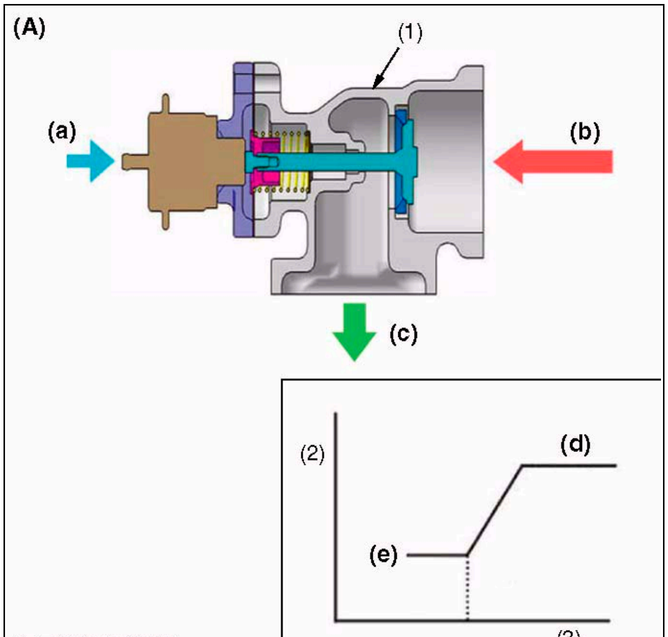
If the coolant temperature is high, thermo valve is open, so that boost pressure reaches to the EGR valve.

(1) Thermo Valve
(2) Coolant Temperature

(a) Boost Pressure From Intake Manifold
(b) Boost Pressure To EGR Valve
(c) Open
(d) Close

W1175753

(5) Mechanical EGR Valve



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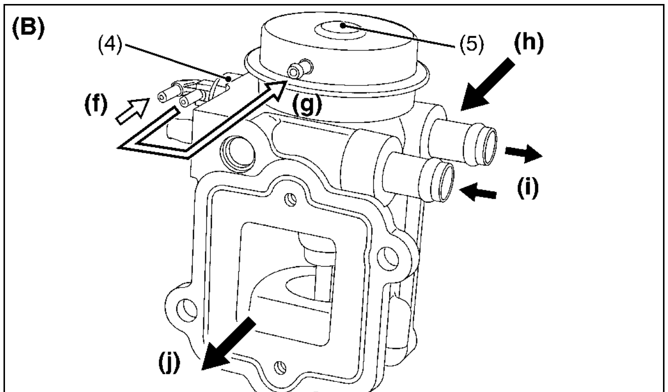

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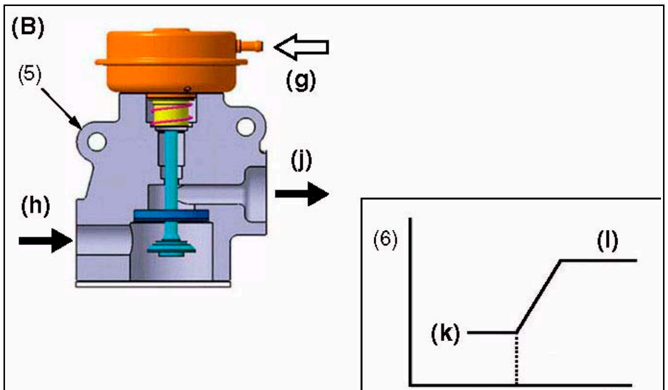

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Mechanical EGR valve controls the flow of cooled EGR gas to the intake manifold.

If the boost pressure is low, EGR valve is closed, so cooled EGR gas does not flow to the intake manifold.

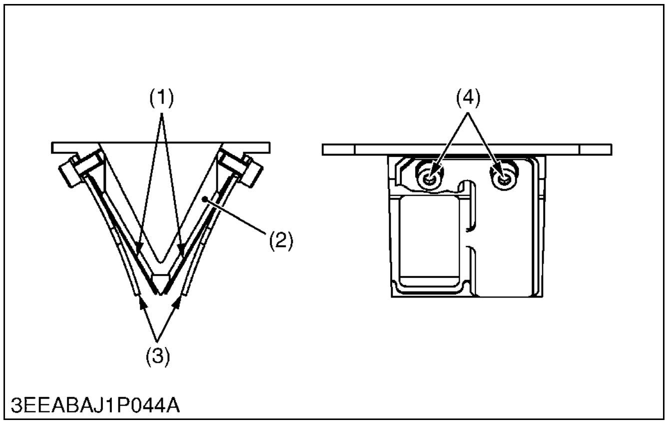
If the boost pressure is getting higher, EGR valve is opening and cooled EGR gas is flowing to the intake manifold.

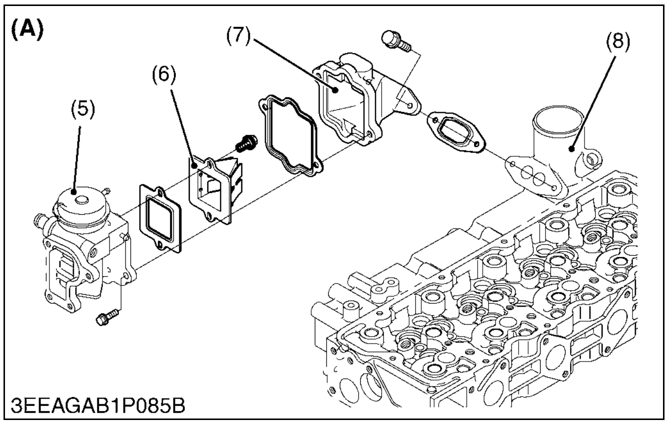
(1) Mechanical EGR Valve
(2) EGR Valve Lift
(3) Boost Pressure
(4) Thermo Valve
(5) Mechanical EGR Valve
(6) EGR Valve Lift
(7) Boost Pressure

(a) Boost Pressure From Intake Manifold
(b) Cooled EGR Gas
(c) Cooled EGR Gas To The Intake Manifold
(d) Open
(e) Close
(f) Boost Pressure from Inlet Manifold
(g) Boost Pressure from Thermo Valve
(h) Cooled EGR Gas
(i) Coolant
(j) Cooled EGR Gas To The Intake Manifold
(k) Close
(l) Open
(A) V3800DI-T-E3B
(B) V3007-DI-T-E3B / V3307-DI-T-E3B

W1176088

(6) Reed Valve





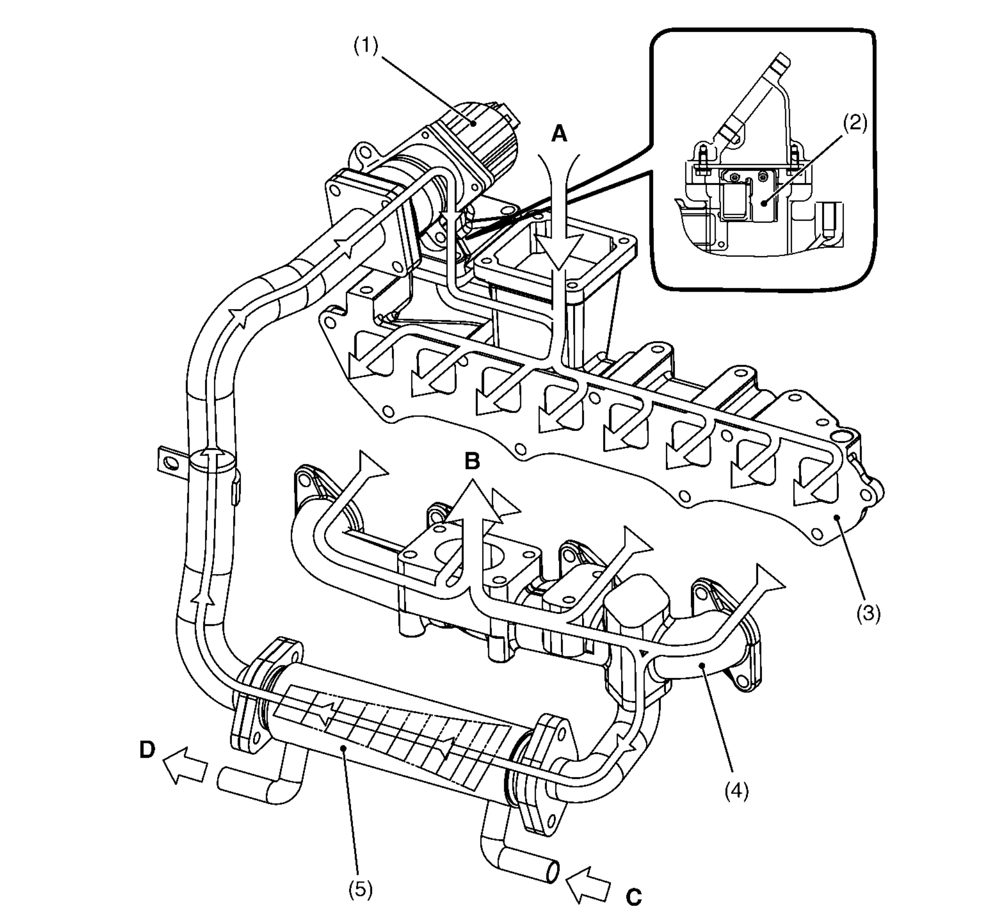
The reed valve is provided at the confluence of exhaust gas after passing the EGR valve, and intake air. It operates by the pressure difference between inside of the crankcase and the atmosphere, and prevents backflow of the mixture of exhaust gas and intake air generated by the piston and valves. It is used as the secondary air introduction device for the countermeasure against exhaust gas of four-cycle engines.

(1) Valve
(2) Case
(3) Stopper
(4) Screw
(5) Mechanical EGR Valve
(6) Reed Valve
(7) Reed Valve Housing
(8) Intake Manifold

(A) V3007-DI-T-E3B / V3307-DI-T-E3B

W1176594

[4] EXTERNAL / ELECTRONIC CONTROLLED EGR (V38DICR-TIE3)



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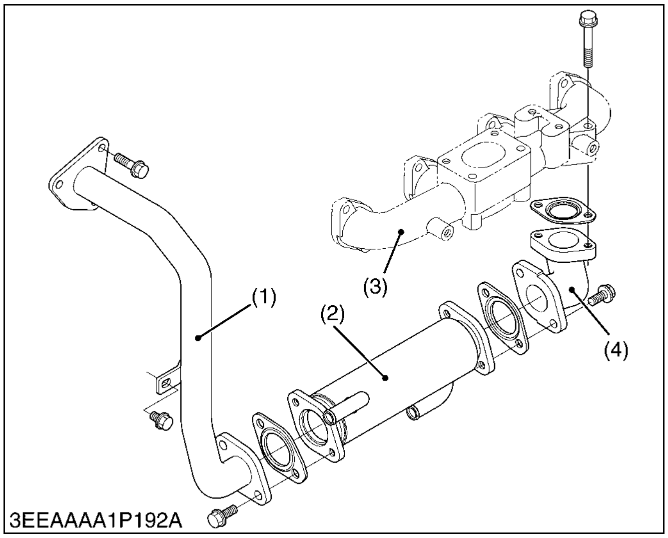
(1) EGR Valve
(2) Reed Valve
(3) Intake Manifold
(4) Exhaust Manifold
(5) EGR Cooler

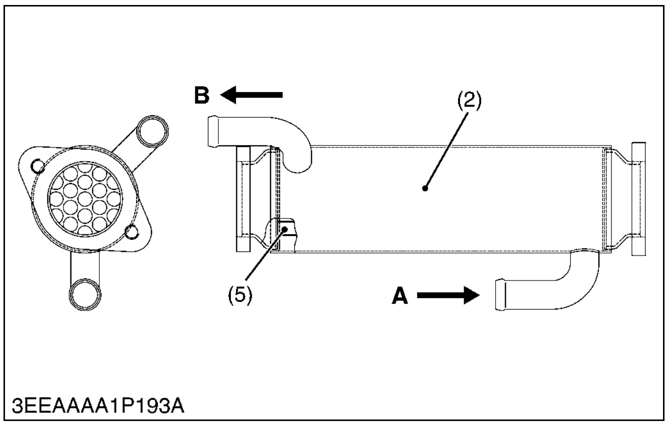
A : Intake Air
B : Exhaust Gas
C : Coolant Inlet Port
D : Coolant Outlet Port

W1020494

In order to meet with the strict emission regulations, Kubota has adopted the EGR on the V38DICR-TIE3. The nitrogen oxide (NOx) which is a hazardous component in exhaust gas is generated by oxidation of nitrogen in the air, due to rise of the combustion temperature in engine combustion chambers. The EGR is a system in which the exhaust gas with lean oxygen is cooled and returned to engine combustion chambers again in order to lower the combustion temperature. As a result, NOx can be decreased.

(1) EGR Cooler





The EGR (Exhaust Gas Recirculation) cooler is used to lower combustion temperature and efficiently cool EGR gas, with the aim of reducing the NOx that is in the exhaust gas of diesel engines.

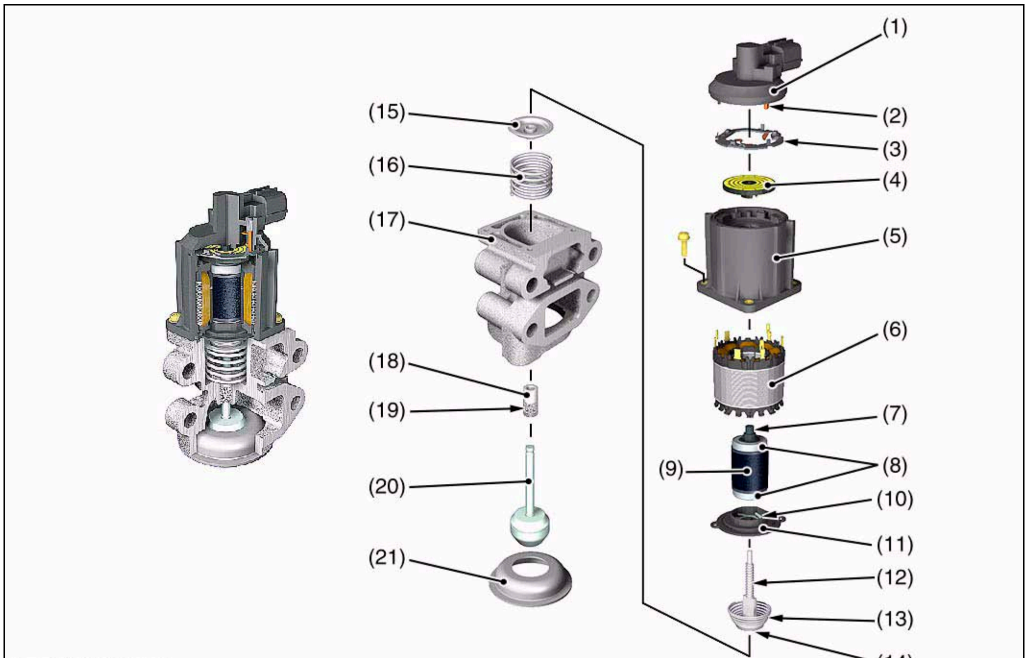
The EGR cooler is placed between the exhaust manifold and the intake manifold of the engine and returns the cooled exhaust gases to the engine suction side.

The EGR cooler has resistant to clogging up, compact and efficient tubes internally.

(1) Pipe
(2) EGR Cooler
(3) Exhaust Manifold
(4) Flange
(5) Tube

A : Coolant Inlet Port
B : Coolant Outlet Port

(2) EGR Valve



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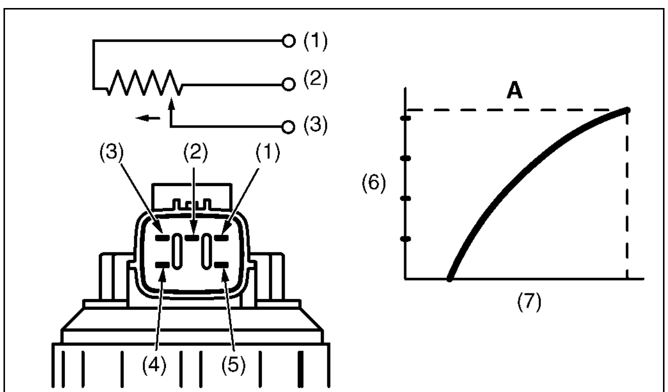
(1) Position Sensor
(2) Brush
(3) Circuit Sensor
(4) Commutator
(5) Motor Exterior
(6) Poki Poki Core
(7) Rotor
(8) Bearing
(9) Magnet
(10) Washer
(11) Boss
(12) Shaft
(13) Assist Spring
(14) Spring Holder
(15) Spring Holder
(16) Spring
(17) Housing
(18) Bush
(19) Filter
(20) Valve Assembly
(21) Valve Sheet

W1020740

The motor incorporated in the EGR valve is a brush type DC motor (magnet rotating type brush motor) having the commutator which determines the power distribution pattern in accordance with rotation of the magnet, and is driven by switching over the conducting pattern of the coil that is arranged at the circumference. By adopting the DC motor, the rapid response and high driving force under the condition of large pressure difference is assured.



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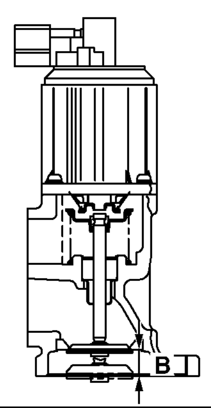

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■ EGR Valve Lift Sensor

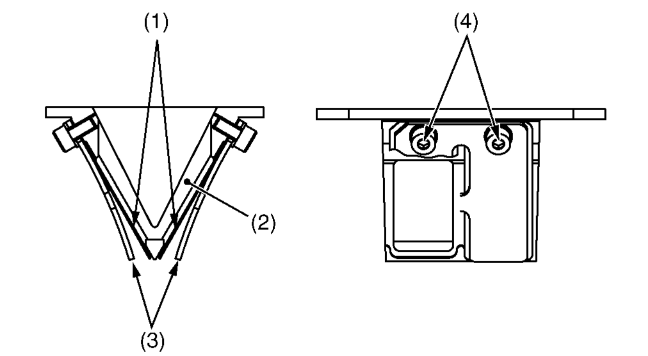
The opening position detecting method of this EGR valve is used for detecting the movement of the motor shaft by means of the contact-type position sensor. The motor shaft engages with the female screw inside the rotating magnet, and it performs amplification of motor torque and conversion to translation motion by means of the screw type speed reduction mechanism.

(1) Terminal Vcc
(2) Terminal GND
(3) Terminal Vout
(4) Terminal EGR DC Motor –
(5) Terminal EGR DC Motor +
(6) Exhaust Gas Flow
(7) Output Voltage

A : Exhaust Gas Flow-Output Voltage Characteristic
B : Stroke (10 mm (0.39 in.))

W1020993

(3) Reed Valve



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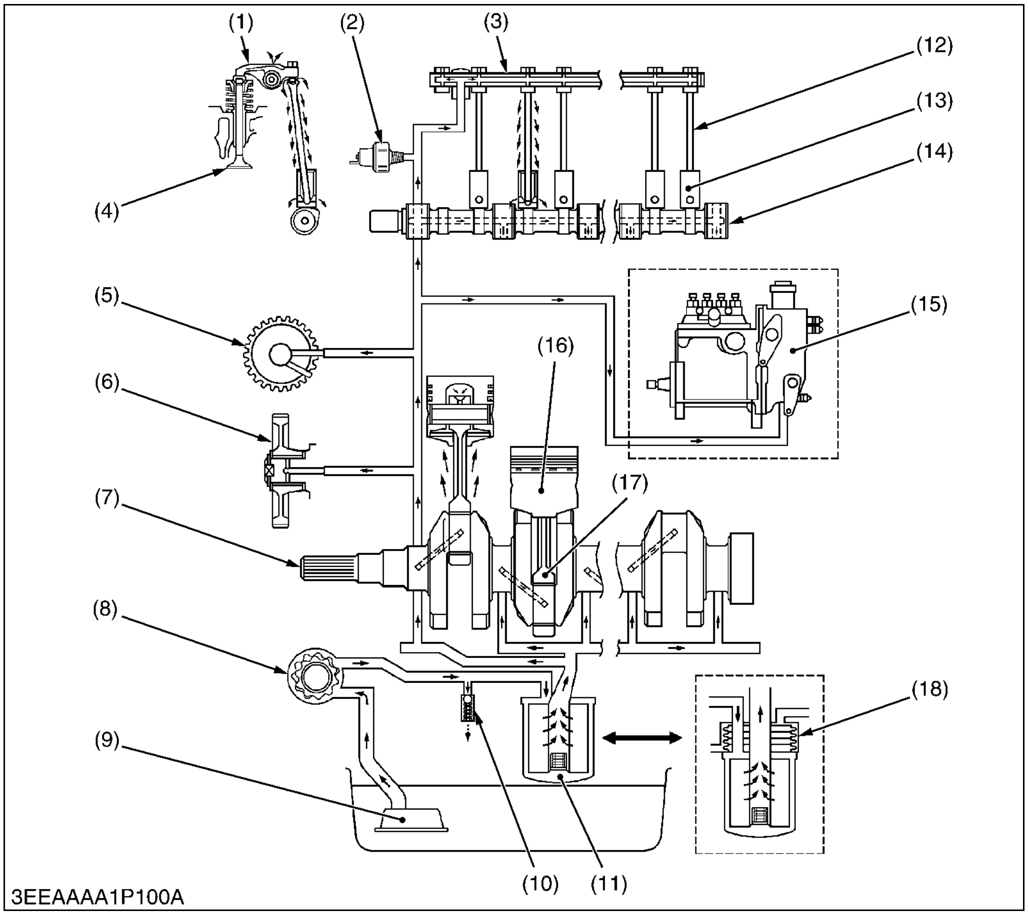
The reed valve is provided at the confluence of exhaust gas after passing the EGR valve, and intake air. It operates by the pressure difference between inside of the crankcase and the atmosphere, and prevents backflow of the mixture of exhaust gas and intake air generated by the piston and valves. It is used as the secondary air introduction device for the countermeasure against exhaust gas of four-cycle engines.

(1) Valve
(2) Case
(3) Stopper
(4) Screw

W1021094

6. LUBRICATING SYSTEM

[1] GENERAL



(1) Rocker Arm
(2) Oil Pressure Switch
(3) Rocker Arm Shaft
(4) Valve
(5) Governor Shaft
(6) Idle Gear
(7) Crankshaft
(8) Oil Pump
(9) Oil Strainer
(10) Relief Valve
(11) Oil Filter Cartridge
(12) Push Rod
(13) Tappet
(14) Camshaft
(15) Fuel Injection Pump Unit
(16) Piston
(17) Connecting Rod
(18) Oil Cooler

W10332800

Engine lubricating system may be classified as:

- Full pressure feed type
- Pressure feed and splash type

Kubota engines have lubricating system of full pressure feed type.

This system consists of an oil strainer (9), oil pump (8), relief valve (10), oil filter cartridge (11), oil cooler (18) (some models) and oil pressure switch (2).

The oil pump sucks lubricating oil from the oil pan through the oil strainer and the oil flows down to the oil filter, cartridge where it is further filtered. Then the oil is forced to crankshaft (7), connecting rods (17), idle gear (6), governor shaft (5), camshaft (14), rocker arm shaft (3) and fuel injection pump unit (15) (some models) to lubricate each part through the oil gallery.

Some part of oil, splashed by the crankshaft or leaking and dropping from gaps of each part, lubricates following parts.

- Pistons
- Cylinder walls
- Small ends of connecting rods
- Tappets
- Push rods
- Intake and exhaust valves
- Timing gears

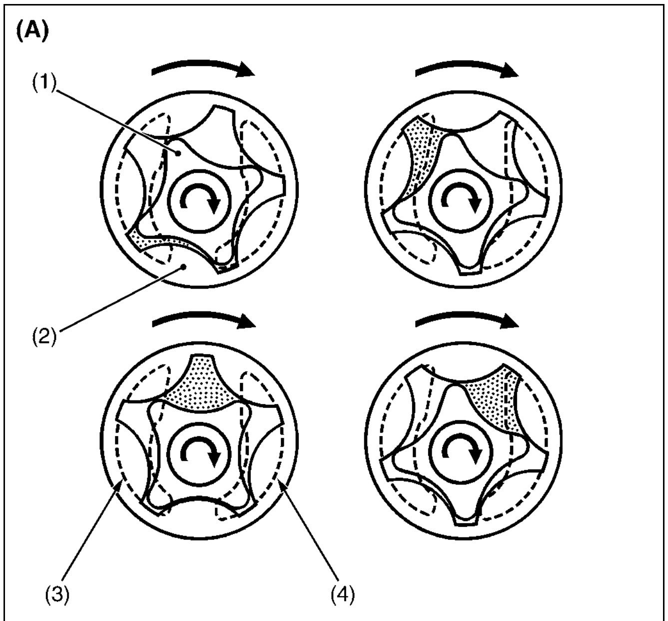
W1033281

[2] OIL PUMP

Kubota engines use rotor pump or gear pump for the engine lubrication.

Normally, the oil pump is mechanically driven by the engine. The rotor pump is driven from the crankshaft, while the gear pump is driven from the camshaft.

(1) Rotor Pump



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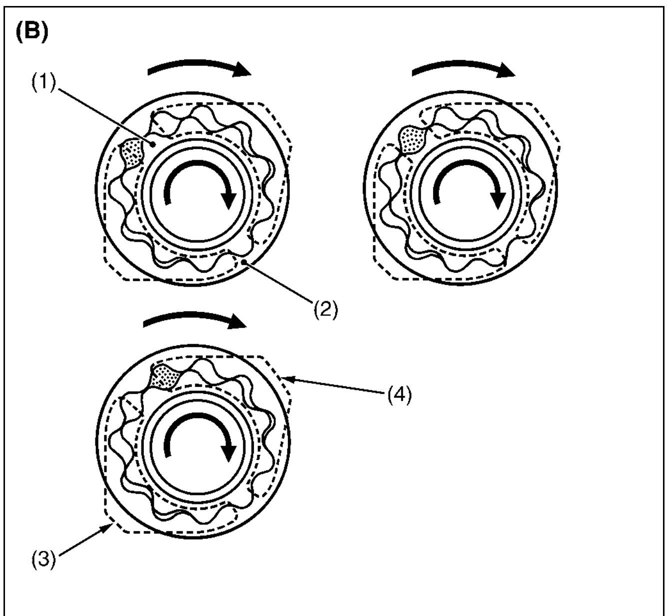

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This oil pump has an inner rotor (1) and an outer rotor (2).

The inner rotor (1), which is driven by crankshaft, rotates the outer rotor (2) in the same direction.

The inner rotor (1) has one less lobe than the outer rotor (2), and they are eccentrically engaged with each other.

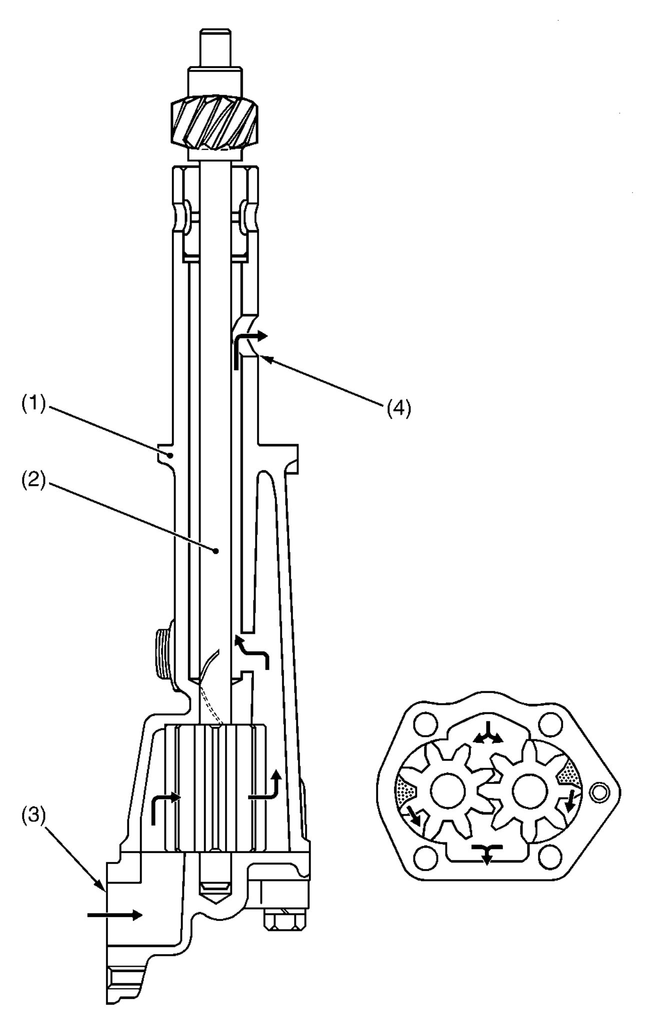
This allows the other lobes to slide over the outer lobes, making a seal to prevent back-up of oil. As the lobes slide up and over the lobes on the outer rotor (2), oil is drawn in. As the lobes fall into the outer rotor's cavities, oil is squeezed out.

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

(A) 4 Lobes Inner Rotor
(B) 10 Lobes Inner Rotor

W10337370

(2) Gear Pump



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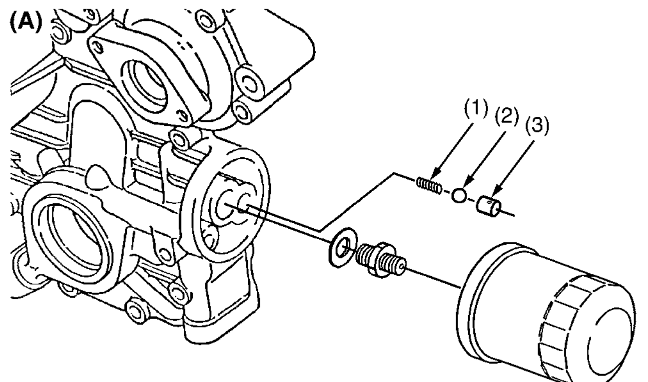
This oil pump has two gears in mesh, closely fitted inside a housing (1). The drive shaft (2) drives one gear, which in turn drives the other gear.

As the gears rotate and come out of mesh, they trap inlet oil between the gear teeth and housing. The trapped oil is carried around to the outlet port (4). As the gears mesh again, they form a seal which prevents oil from backing up to the inlet port (3). The oil is forced out at the outlet port (4) and sent each part through the oil gallery.

(1) Housing
(2) Drive Shaft
(3) Inlet Port
(4) Outlet Port

W10338960

[3] RELIEF VALVE



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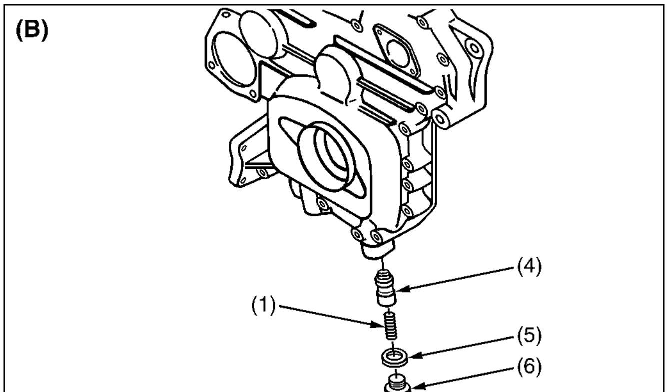

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The relief valve prevents the damage of the lubricating system due to high oil pressure.

Kubota's engine has a ball type direct acting relief valve or a poppet type direct acting relief valve. These valves are best suited for low pressure.

The valve is closed when the spring tension is greater than the oil pressure at the inlet. The spring tension holds the ball (or poppet) securely in position.

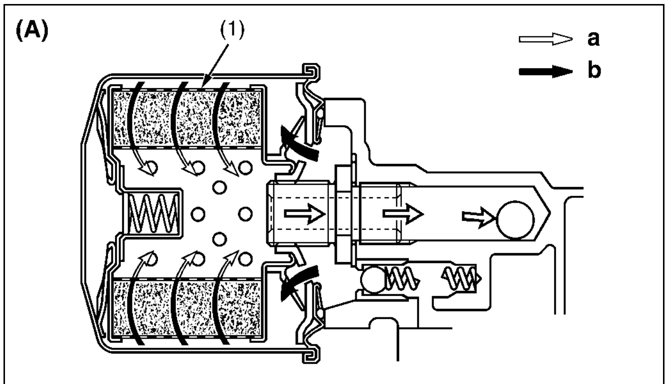
The valve opens when the oil pressure at the inlet exceeds that of the spring. This pushes the ball (or poppet) off the inlet hole and oil flows through the valve.

(1) Spring
(2) Ball
(3) Valve Seat
(4) Poppet
(5) Gasket
(6) Plug

(A) Ball Type Direct Acting Relief Valve
(B) Poppet Type Direct Acting Relief Valve

W10340040

[4] OIL FILTER CARTRIDGE



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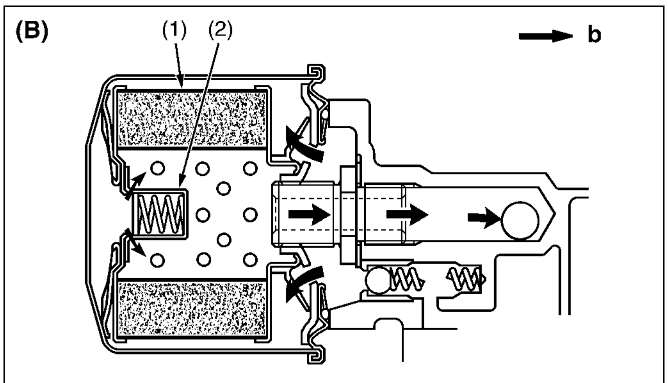

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Kubota engines have filtration system of full flow.

In the full filtration system, there is only one oil flow from the oil pump to the oil filter cartridge. After filtering, the oil goes to the lubricating portion, and is returned to the crankcase.

When the filter cartridge is new, there is very little pressure drop through the filter element (1). However, if the filter gets clogged, the resulting pressure [the oil pressure in inlet line builds up by 98 kPa (1.0 kgf/cm^2, 14 psi) more than the outlet line] will open the bypass valve (2) and allow unfiltered oil to bypass to the lubricating portion.

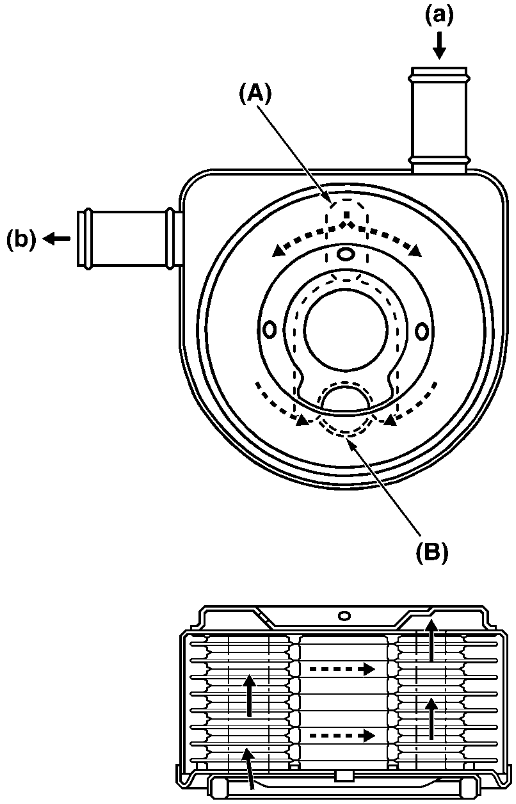
(1) Filter Element
(2) Bypass Valve

(A) Bypass Valve Closed
(B) Bypass Valve Open

a : Filtered Oil
b : Unfiltered Oil

W10341790

[5] OIL COOLER



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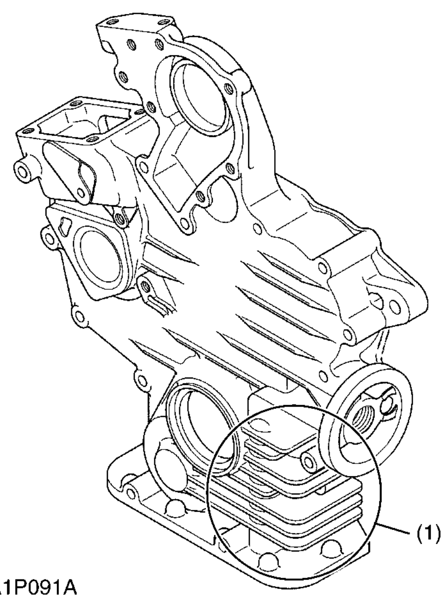
Some models of engines have a water-cooled oil cooler that keeps the oil against overheat and also warms it up just after the engine gets started.

As shown in the figure, the oil flows inside the connected cooler plate, whereas coolant is kept circulating outside the cooler plate, thereby cooling down the oil.

(A) Oil Inlet Port
(B) Oil Outlet Port
(a) Coolant Inlet Port
(b) Coolant Outlet Port

W10344770

[6] COOLING FIN



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Some models of SM series engines have the cooling fin.

The cooling fin is set up around the oil passage in the gear case.

Therefore, the temperature of oil is decreased by the wind generated by the cooling fan.

(1) Cooling Fin

W1122279

[7] ENGINE OIL

■ **IMPORTANT**

- **Do not operate a diesel engine when engine oil is overfilled. This oil can drain through the air intake system, which cause engine disacceleration and oil leaks from breather pipings. It could result in a over-running or oil hammering of engine in case of the engine with suction blow-by gases breathered in.**

■ **NOTE**

- **Refer to the following table for the suitable American Petroleum Institute (API) classification of engine oil according to the engine type (with internal EGR, external EGR or non-EGR) and the Fuel Type Used : (Low Sulfur, Ultra Low Sulfur or High Sulfur Fuels).**

Fuel Type	Engine oil classification (API classification)	
	Engines with non-EGR Engines with internal EGR	Engines with external EGR
High Sulfur Fuel [0.05 % (500 ppm) ≤ Sulfur Content < 0.50 % (5000 ppm)]	**CF** (If the "CF-4, CG-4, CH-4, or CI-4" engine oil is used with a high-sulfur fuel, change the engine oil at shorter intervals. (approximately half))	–
Low Sulfur Fuel [Sulfur Content < 0.05 % (500 ppm)] or Ultra Low Sulfur Fuel [Sulfur Content < 0.0015 % (15 ppm)]	**CF, CF-4, CG-4, CH-4** or **CI-4**	**CF** or **CI-4** (Class CF-4, CG-4 and CH-4 engine oils cannot be used on EGR type engines.)

EGR : Exhaust Gas Re-circulation

- **CJ-4 classification oil is intended for use in engines equipped with DPF (Diesel Particulate Filter) and is Not Recommended for use in Kubota E3 specification engines.**
- **Oil used in the engine should have API classification and Proper SAE Engine Oil Viscosity according to the ambient temperatures where the engine is operated.**
- **With strict emission control regulations now in effect, the CF-4 and CG-4 engine oils have been developed for use with low sulfur fuels, for On-Highway vehicle engines. When a Non-Road engine runs on high sulfur fuel, it is advisable to use a "CF or better" classification engine oil with a high Total Base Number (a minimum TBN of 10 is recommended).**

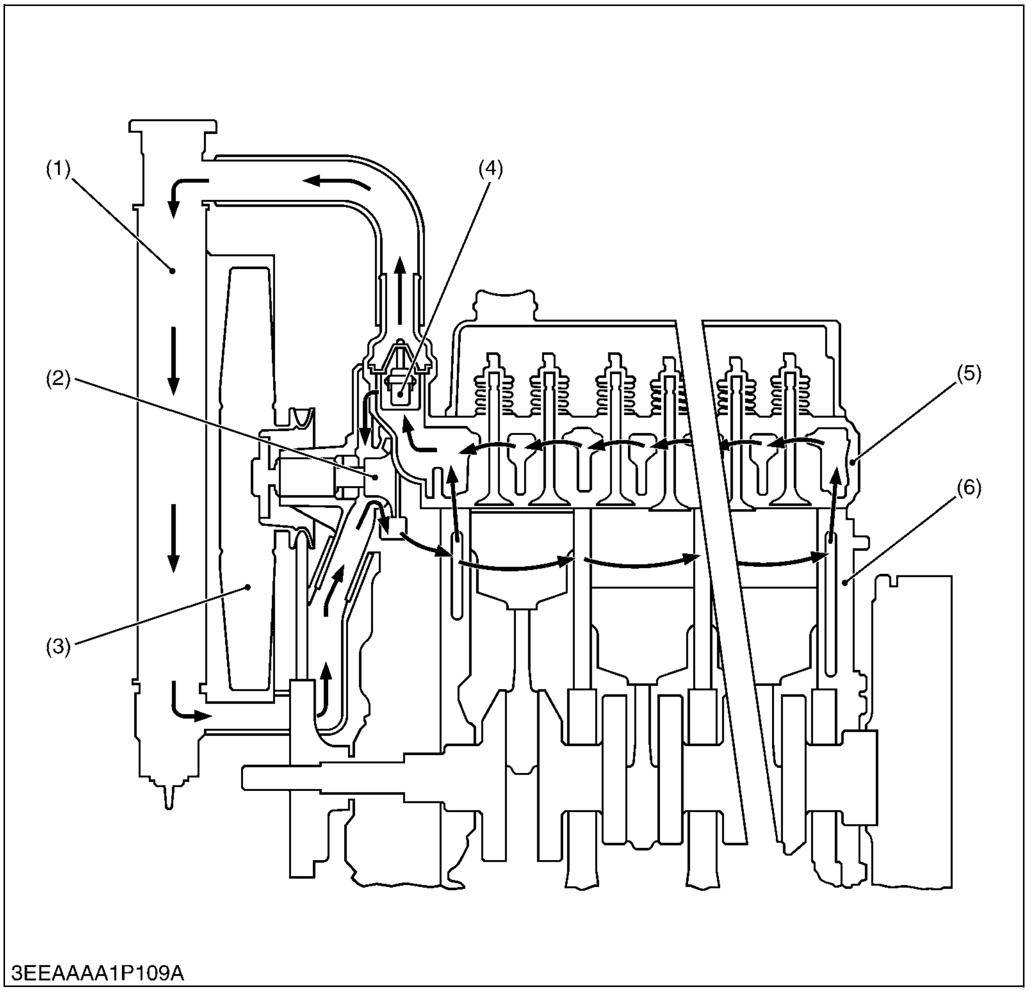
Above 25 °C (77 °F)	SAE30 or SAE10W-30 SAE10W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE20 or SAE10W-30 SAE10W-40
Below 0 °C (32 °F)	SAE10W or SAE10W-30 SAE10W-40

- **Be sure to inspect the engine, locating it on a level place. If placed on gradients accurately, oil quantity may not be measured.**

KiSC issued 03, 2008 A

7. COOLING SYSTEM

[1] GENERAL



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

W10146560

The cooling system cools the engine while it is running to prevent overheating and maintain a proper operating temperature.

Kubota engines are used pressurized forced-circulation type.

This system consists of a radiator (1), water pump (2), cooling fan (3), thermostat (4) and coolant temperature sensor (some models).

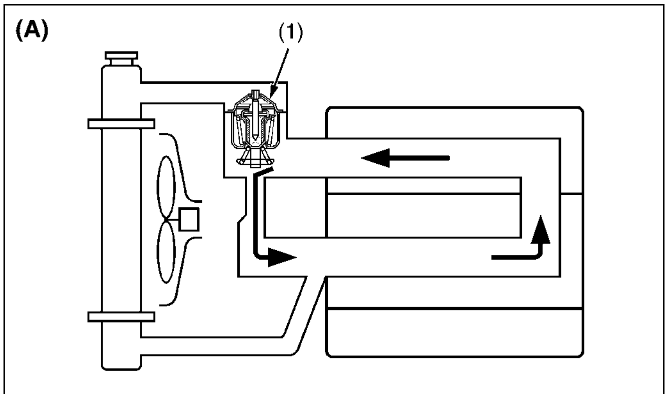
The coolant is cooled through the radiator core, and the fan set behind the radiator pulls cooling air through the core to improve cooling.

When the coolant in the engine is at a low temperature, the thermostat valve is closed so that the coolant is circulated in the engine through the bypass pipe.When the temperature of the coolant becomes the valve opening temperature of thermostat (4), the thermostat (4) opens the valve to return the heated coolant to the radiator (1).

The water pump (2) sucks the cooled coolant, forces it into the cylinder block (6) and draws out the hot coolant.

Some engines employ the bottom bypass system to improve the cooling performance of radiator and the three step valve opening type thermostat to reduce thermal shock radically.

W10146561



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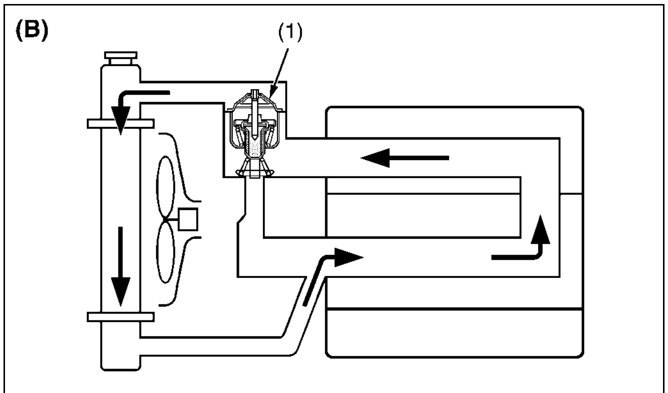

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■ **Bottom Bypass System**

Bottom bypass system is introduced in some models for improving the cooling performance of the radiator.

While the temperature of coolant in the engine is low, the thermostat is held closed and the coolant is allowed to flow through the bypass pipe and to circulate in the engine.

When the temperature exceeds the thermostat valve opening level, the thermostat fully opens itself to prevent the hot coolant from flowing through the bypass into the engine.

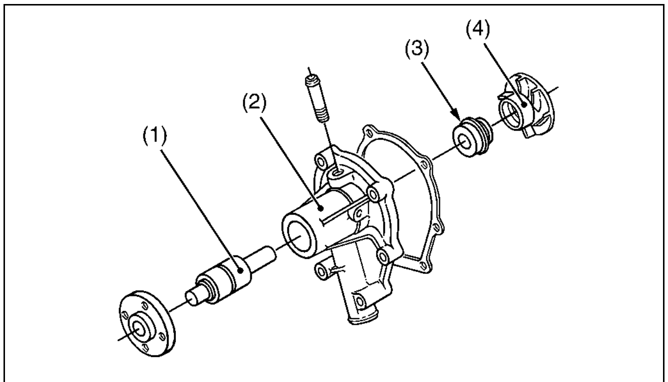
In this way, the radiator can boost its cooling performance.

(1) Thermostat

(A) Thermostat Closed
(B) Thermostat Open

W10943380

[2] WATER PUMP



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The water pump circulates the coolant through the system.

If the pump fails to circulate the coolant, heat is not removed from the engine and overheating damage may occur.

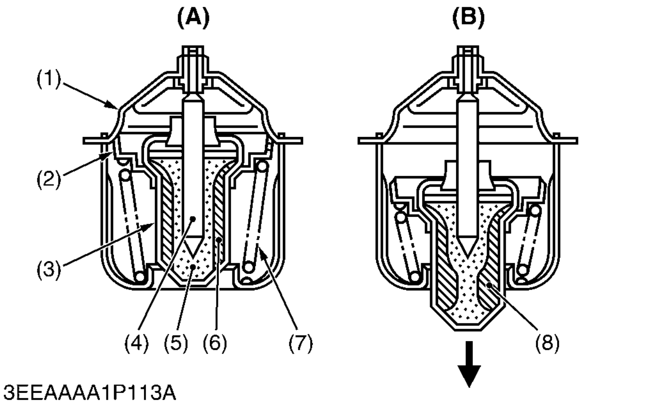
Kubota engines use a centrifugal type, and is driven by the crankshaft via a fan belt. It is composed of a pump body (2), impeller (4), mechanical seal (3) and bearing unit (1).

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

W10148080

[3] THERMOSTAT

(1) In-Line Type Outlet Control



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This thermostat is a heat-operated valve. It controls the flow of coolant to the radiator to maintain the correct operating temperatures.

Kubota engines use a wax element type thermostat. Wax is enclosed in the wax case. The wax is solid at low temperatures, but turns liquid at high temperatures, expands and opens the valve.

(A) Thermostat closed

During warm-up (at low temperature), the thermostat remains closed. The water pump circulates coolant through the engine water jacket only, by way of the bypass.

(B) Thermostat open

When the temperature of coolant exceeds the specified temperature, wax in the case turns liquid and expands. Because the spindle (4) is fixed, the wax case (3) is lowered, the valve (2) is separated from the flange (1), and then coolant is sent to radiator.

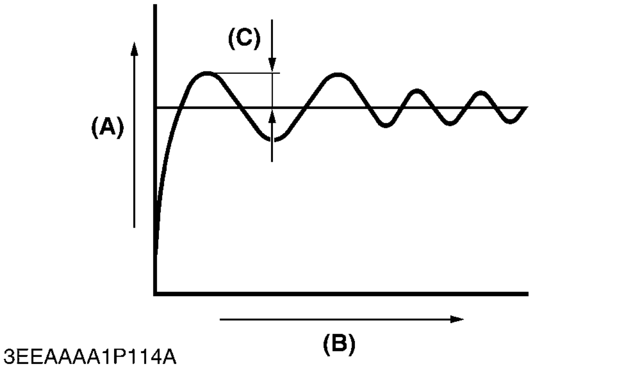
Code Number	Valve Opening Temperature	Valve Full-open Temperature
15317-73011	91.5 to 94.5 °C 196.7 to 202.1 °F	105 °C 221 °F
15321-73014 1A033-73011	80.5 to 83.5 °C 176.9 to 182.3 °F	95 °C 203 °F
15451-73011	77.5 to 80.5 °C 171.5 to 176.9 °F	95 °C 203 °F
15531-73012	80.5 to 83.5 °C 176.9 to 182.3 °F	95 °C 203 °F
19203-73012	69.5 to 72.5 °C 157.1 to 162.5 °F	85 °C 185 °F
19434-73014	69.5 to 72.5 °C 157.1 to 162.5 °F	85 °C 185 °F
1A021-73012	69.5 to 72.5 °C 157.1 to 162.5 °F	85 °C 185 °F
1G253-73011	86.5 to 89.5 °C 187.7 to 193.1 °F	100 °C 212 °F
1G411-73011	80.0 to 84.0 °C 176.0 to 183.2 °F	95 °C 203 °F

(1) Flange
(2) Valve
(3) Wax Case
(4) Spindle
(5) Synthetic Rubber
(6) Wax (Solid)
(7) Spring
(8) Wax (Liquid)

(A) Thermostat Closed
(B) Thermostat Open

W10149240

(2) Flow Control Type



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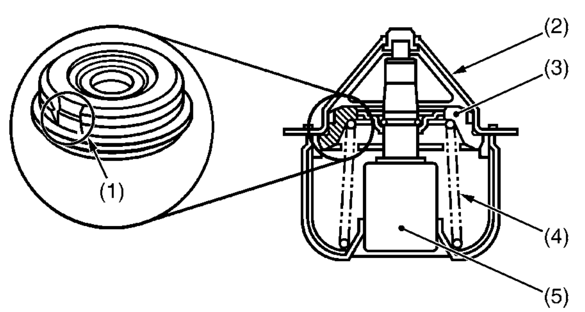

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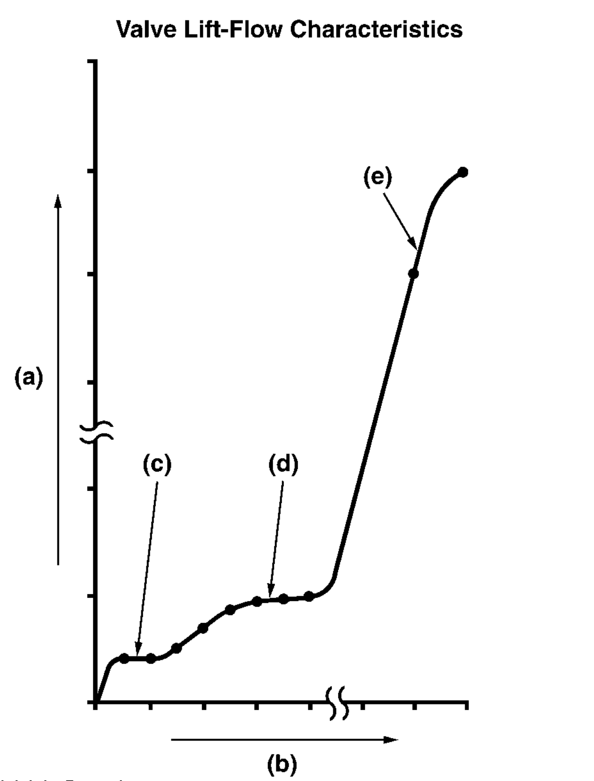

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Traditional outlet type thermostat sometimes open at a considerably high temperature (Overshooting) instead of at the designed temperature. Furthermore, hunting (an effect of dashing coolant) occurs in some cases, since a large amount of coolant is discharged right after the valve opens.

The flow control valve thermostats are equipped with notch in the main valve, through which a small amount of coolant is discharged upon lifting, resulting in reducing fluctuations of coolant temperature at the outlet and inlet of the thermostat, thus diminishing overshooting.

Furthermore, a small amount of coolant circulated in the initial stage of lifting decreases hunting by reducing sudden temperature fluctuations.

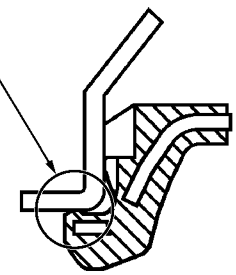
Code Number	Valve Opening Temperature	Valve Full-open Temperature
1C010-73011	74.5 to 78.5 °C 166.1 to 173.3 °F	90 °C 194 °F
1C011-73012	74.5 to 78.5 °C 166.1 to 173.3 °F	90 °C 194 °F

(1) Notch
(2) Flange
(3) Flow Control Valve
(4) Spring
(5) Wax Case

(A) Coolant Temperature (°C, °F)
(B) Time (Min.)
(C) Overshoot

(a) Flow Rate (L / min.)
(b) Valve Lift (mm)
(c) At Short Valve Lift
(d) At Medium Valve Lift
(e) At High Valve Lift

W10157590



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■ **With Valve Closed**

Coolant sealed by No. 1 lip (1).

(1) No. 1 Lip

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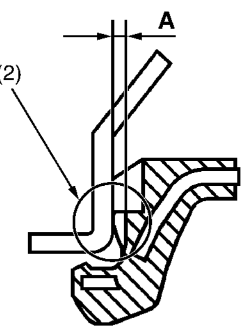

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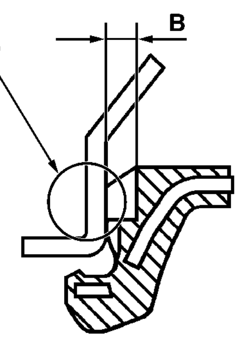
■ **At Short Valve Lift**

Sealing by No. 2 lip (2) : Initial flow-rate determined by the notch's surface area at **A**.

(2) No. 2 Lip

W10170460



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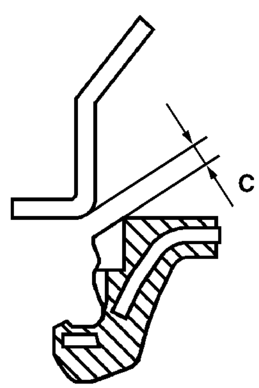
■ **At Medium Valve Lift**

Sealing by No. 3 lip (3) : Halfway flow rate determined by the notch's surface area at **B**.

(3) No. 3 Lip

W10171250



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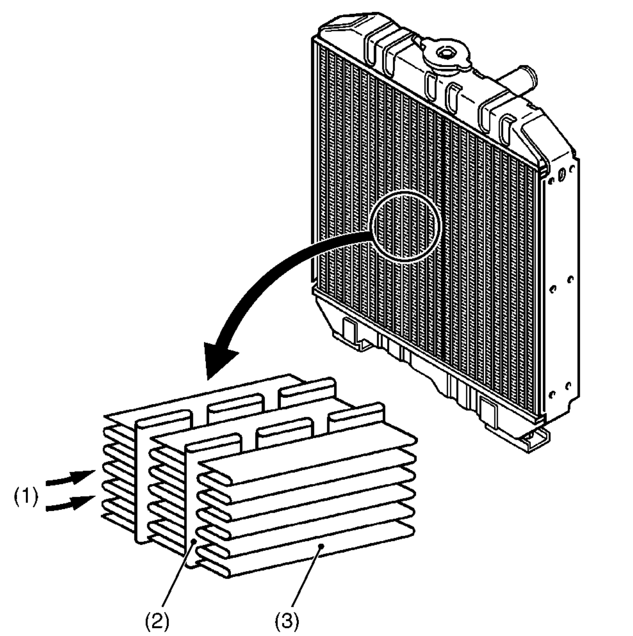
■ **At High Valve Lift**

Flow-rate determined by the valve to flange clearance **C** as with conventional thermostatically-controlled valves.

W10172120

[4] RADIATOR



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The radiator is one of the major components of coolant cooling system. It is here that heat in the coolant is released to the atmosphere.

The radiator core consists of water carrying tubes (2) and fins (3) at a right angle to the tubes.

Kubota engines use corrugated fin type core which has a right weight and high heat transfer rate.

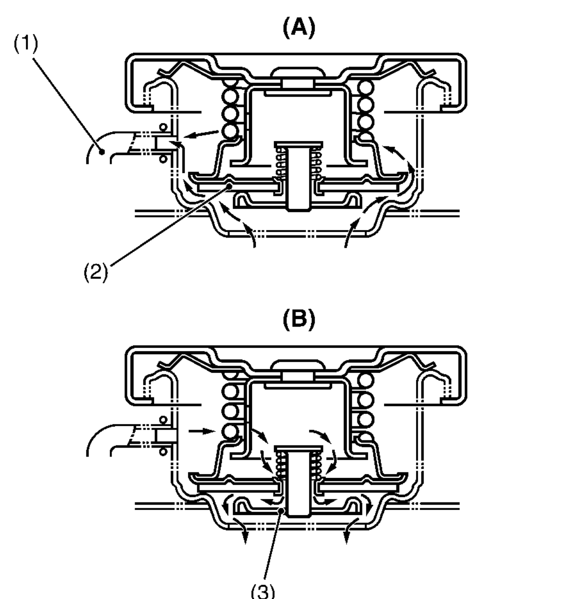
Radiators are usually made of copper or brass.

Recently, however, aluminum-made radiators are introduced for their light weight.

(1) Cooling Air
(2) Tube
(3) Fin

W10172800

[5] RADIATOR CAP



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The pressure system permits operating the engine at a higher temperature without boiling the coolant or losing it by evaporation.

The radiator cap consists of a pressure valve (2), vacuum valve (3), valve springs, gasket, and has two functions.

(A) Pressure valve open

The pressure valve (2) in the cap permits the escape of coolant or steam when the pressure reaches a certain point (88 kPa, 0.90 kgf/cm^2, 13 psi).

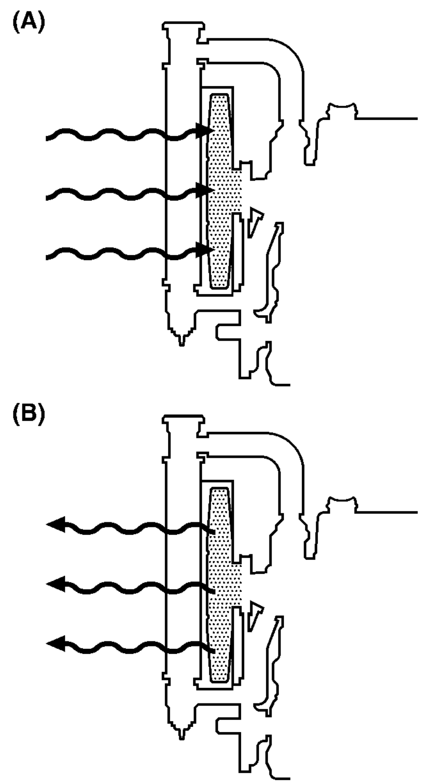
(B) Vacuum valve open

The vacuum valve (3) in the cap opens to prevent a vacuum in the cooling system.

(1) Overflow Tube
(2) Pressure Valve
(3) Vacuum Valve

W10173850

[6] COOLING FAN



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The cooling fan is usually located on the water pump shaft with a fan pulley, and is driven by a V-belt from the engine crankshaft.

The cooling fan is made of steel or synthetic resin, and its blower capacity varies according to the number of blades, twisting angle, outside diameter and rotating speed.

Generally, large diameter cooling fan provides sufficient cooling air at low rotating speed. However, the same cooling effect can be obtained with a smaller diameter fan by providing higher fan speed or fan blades with a steep-blade angle. This allows a more compact installation. Standard cooling fans on Kubota engines have a 240 to 430 mm (9.45 to 16.9 in.) outside diameter.

The fan can be either a suction type or a blower type, depending upon the design of the system.

(A) Suction type fan

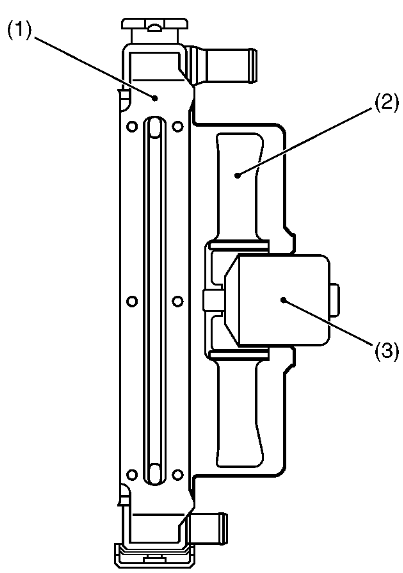
This fan pulls air through the radiator and pushes it over the engine. This design permits the use of a smaller fan and radiator than is required for blower type fan. It is used when machine motion aids air movement through the radiator.

(B) Blower type fan

This fan pulls air across the engine, then pushes it through the radiator. This type is used in slow-moving machine, and on machine where harmful materials might be drawn into the radiator with a suction type fan.

W10175400

(1) Electric Fan



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Use of electric fans on vehicles for radiator cooling has been increasing recently.

These fans turn at a constant speed regardless of engine speed.

However, in cases where cooling air is not enough due to insufficient vehicle velocity, the cooling effect on engine body, oil pan, etc. is sometimes less than that of a direct-driving fan.

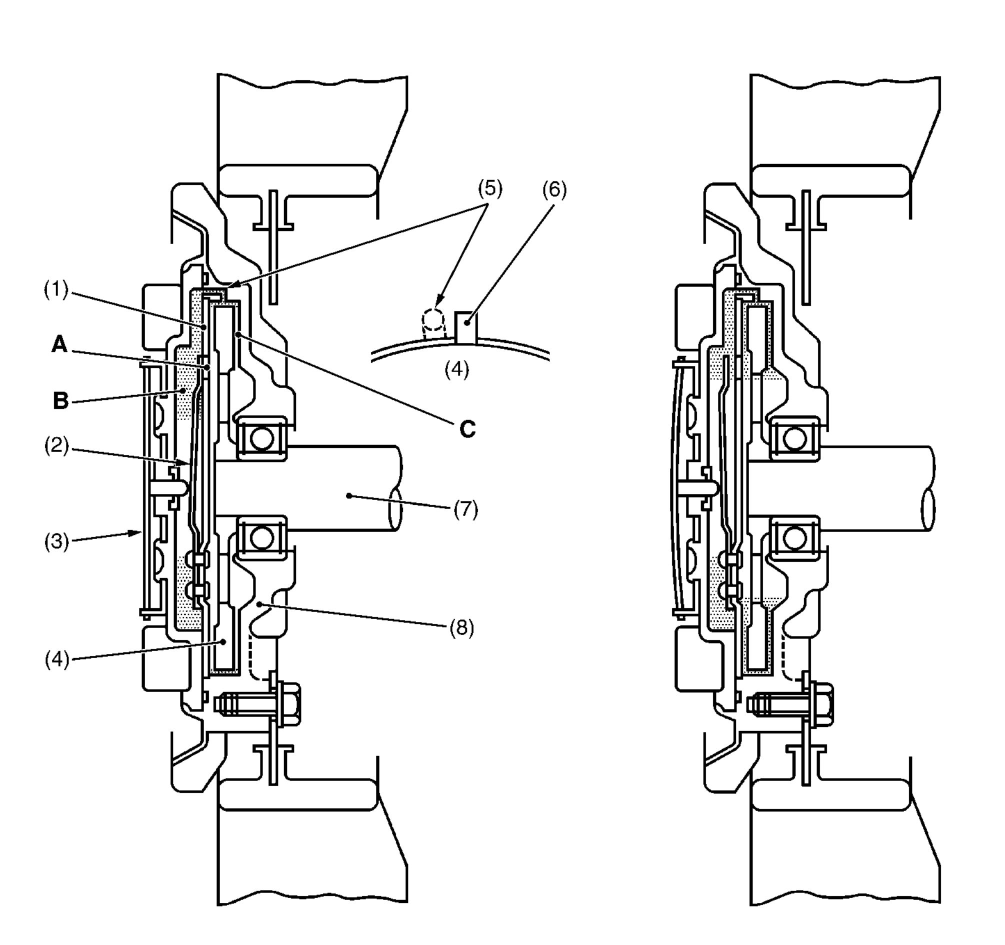
For this reason, cooling capacity and air flow around the engine must be examined and thorough tests conducted after the engine is installed. Also, care must be taken to the capacity of alternator since the DC motor (3) drives the fan (2).

Great care should be taken in the selection of temperature switches and the use of fan relay switches to ensure positive switch relay function.

(1) Radiator
(2) Fan
(3) DC Motor

W11098660

(2) Thermo-modulator Type



(1) Plate
(2) Spring
(3) Bimetal
(4) Drive Disk
(5) Opening
(6) Dam
(7) Shaft
(8) Case

A : Port A
B : Chamber B
C : Chamber C

W1082541

In its basic design, this fan drive is a sort of fluid coupling. Torque is conveyed through silicone oil.

The thermo-modulator type is designed to automatically control the fan speed in response to the temperature of the air that has just flown through the radiator. Here are some advantages.

- Engine's effective output boosted : The fan's power consumption can be minimized. Which means the engine provides greater effective output.
- Shorter warm-up time : When the engine is still cool, the fan is running at very low speed. The coolant temperature may thus be turned up in much shorter time.
- Optimal coolant temperature : The fan speed is controlled with constantly changing travel conditions. In this way, the coolant temperature is kept optimum all the time and the engine's combustion cycle goes on in the best condition.
- Fan noise reduced

When the outside air temperature is low, the bimetal (3) remains straight. The spring (2) is held against the port **A**. With this port now blocked, the oil is scraped out of the chamber **C** by the dam (6) and is fed through the circulating opening (5) into the chamber **B**. This lets most of the oil flow from the chamber **C** into the chamber **B**. In this state, less torque is conveyed, which in turn makes the fan turning little.

When the outside air temperature is high, the bimetal (3) warps itself to release the spring (2) off the plate (1). With the port **A** now open, the oil starts flowing from the chamber **B** into the chamber **C**. Now the chamber **C** gets full with the oil. In this way, more torque is conveyed and the fan runs faster accordingly.

W1013001

[7] COOLANT

Quality of coolant is an important factor.

Cooling is adversely affected by corrosion of engine parts. This can reduce engine output and shorten engine life.

(1) Anti-freeze Coolant

Water freezes at 0 °C (32 °F), and its volume expands approximately 9 %. This expansion force is so great that water loses its fluidity.

When the cooling water freezes in the cooling system, expansion can crack the engine and radiator or lead to other damage. At subzero temperatures or before a long-term storage, let out cooling water completely, or mix fresh, soft water with long-life coolant (hereafter LLC) and fill the radiator and reserve tank with the mixture.

LLC comes in several types. Kubota recommends the use of ethylene glycol base antifreeze coolant of permanent type which is most commonly used.

1. Before employing LLC-mixed cooling water, fill the radiator with fresh, soft water and empty it again.
   Repeat this procedure 2 or 3 times to clean up the inside.
2. Put the LLC in cooling water in the percentage (%) for a target temperature.
   When mixing, stir it up well, and then fill into the radiator.
3. Mixing the LLC
   The procedure for the mixing of water and anti-freeze differs according to the make of the anti-freeze and the ambient temperature.
   Refer to SAE J1034 standard, more specifically also to SAE J814C.

■ IMPORTANT
- **When the anti-freeze is mixed with fresh, soft water, the anti-freeze mixing ratio must be less than 50 %.**

Vol % Anti-freeze	Freezing Point	Boiling Point ☆
40 %	– 24 °C (– 11 °F)	106 °C (223 °F)
50 %	– 37 °C (– 35 °F)	108 °C (226 °F)

☆ At 1.013 x 10^5 Pa (760 mmHg) pressure (Atmospheric)
higher boiling point is obtained by using a radiator pressure cap which permits the development of pressure within the cooling system.

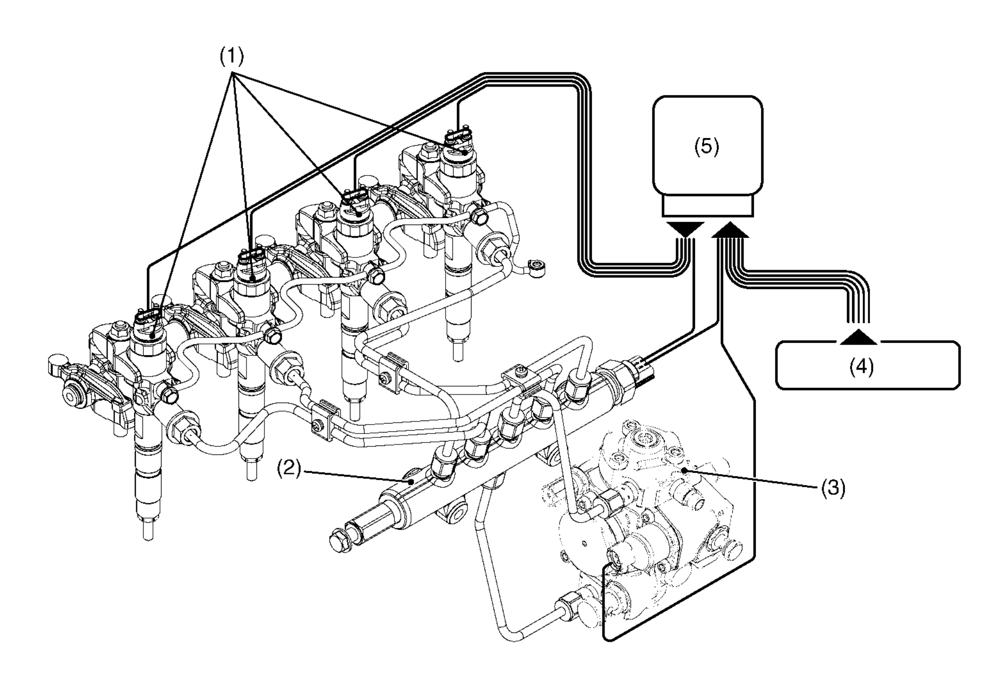
W11283280

4. Adding the LLC
   (1) Add only soft water if the mixture reduces in amount by evaporation.
   (2) If there is a mixture leak, add the LLC of the same manufacturer and type in the same mixture percentage.
   *Never add any LLC of different manufacturer. (Different brands may have different additive components, and the engine may fail to perform as specified.)
5. Kubota's genuine LLC has a service life of 2 years. Be sure to change the coolant every 2 years.

■ NOTE
- **The above data represent industry standards that necessitate a minimum glycol content in the concentrated anti-freeze.**
- **When the coolant level drops due to evaporation, add fresh, soft water only to keep the anti-freeze mixing ratio less than 50 %. In case of leakage, add anti-freeze and fresh, soft water in the specified mixing ratio.**
- **Anti-freeze absorbs moisture. Keep unused anti-freeze in a tightly sealed container.**
- **Do not use radiator cleaning agents when anti-freeze has been added to the coolant.**
  (Anti-freeze contains an anti-corrosive agent, which will react with the radiator cleaning agent forming sludge which will affect the engine parts.)

8. COMMON RAIL SYSTEM (CRS)

[1] GENERAL



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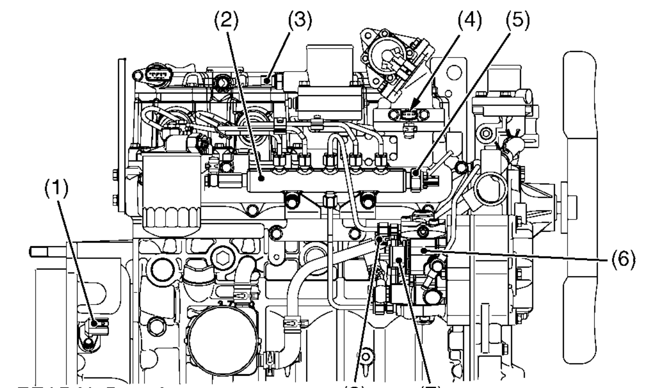
(1) Injector
(2) Rail
(3) Supply Pump
(4) Sensors
(5) Engine ECU

W1014620

The common rail system adopted for the V38DICR-TIE3 is the combustion system which always controls the combustion state in cylinders optimally, by storing ultra high pressure fuel in the rail and performing ultra high pressure injection by the diesel engine. It has excellent combustion efficiency and realizes clean exhaust gas as well as low fuel consumption. It comprises the supply pump, the rail, the injectors, and the sensors that detects its operating state.



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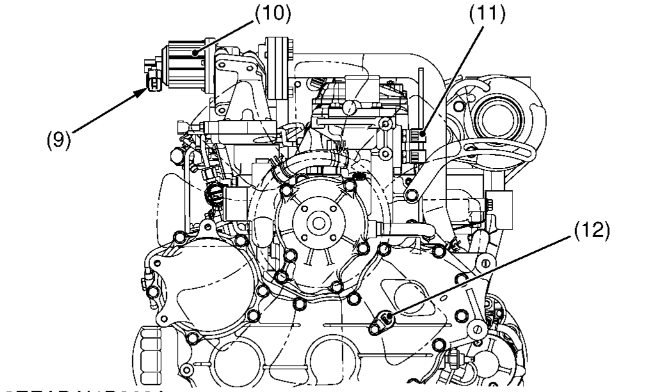

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The common rail control system can be broadly divided into the following three areas : sensors, engine ECU, and actuators.

■ **Sensors**

Sensor detects the condition of the engine and the pump. Refer to “[5] ENGINE CONTROL SYSTEM : (3) Sensors”.

- Crankshaft Position Sensor (1)
- Camshaft Position Sensor (12)
- Accelerator Position Sensor
- Intake Air Temperature Sensor (3)
- Coolant Temperature Sensor (11)
- Fuel Temperature Sensor (8)
- Intake Air Pressure Sensor (4)
- EGR Valve Lift Sensor (9)

■ **Engine ECU (Electronic Control Unit)**

Engine ECU receives signals from the sensors, calculates the proper injection quantity and injection timing for optimal engine operation, and sends the appropriate signals to the actuators. ECU enables the injectors to be actuated at high speeds. Refer to “[5] ENGINE CONTROL SYSTEM : (2) Engine ECU”.

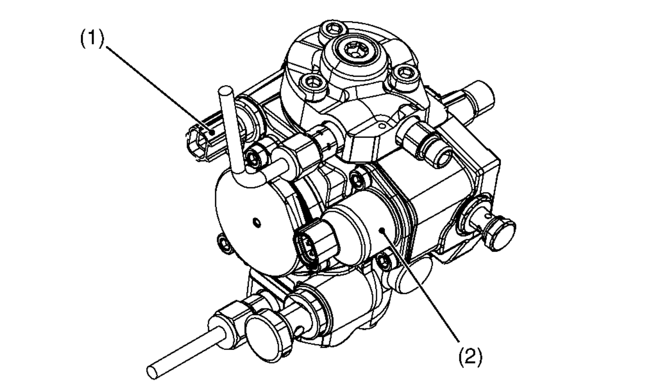
■ **Actuators (Supply pump, Injector, EGR valve)**

Actuators operate to provide optimal injection quantity and injection timing in accordance with the signals received from the engine ECU. Refer to “[2] SUPPLY PUMP”, “[4] INJECTOR” and “5. EGR SYSTEM : [2] EGR VALVE”.

(1) Crankshaft Position Sensor
(2) Rail
(3) Intake Air Temperature Sensor
(4) Intake Air Pressure Sensor
(5) Rail Pressure Sensor
(6) Supply Pump
(7) Suction Control Valve (SCV)
(8) Fuel Temperature Sensor
(9) EGR Valve Lift Sensor
(10) EGR Valve DC Motor
(11) Coolant Temperature Sensor
(12) Camshaft Position Sensor

W1014754

[2] SUPPLY PUMP



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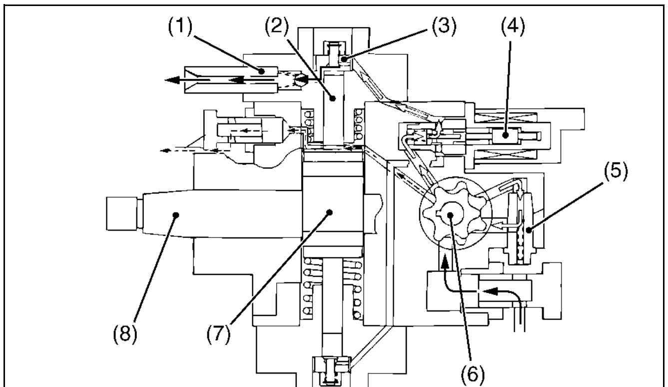
The supply pump is primarily composed of the pump unit (eccentric cam, ring cam, two plungers), the SCV (suction control valve) (2), the fuel temperature sensor and the feed pump (trochoid type), and is actuated at 1/2 the engine crankshaft rotation.

The two compact pump unit plungers are positioned symmetrically above and below on the outside of the ring cam.

The fuel discharge quantity is controlled by the SCV, in order to reduce the actuating load and suppress the rise in fuel temperature. This system adopts the normally open type (the suction valve opens when not energized) SCV.

(1) Fuel Temperature Sensor (2) SCV (Suction Control Valve)

W1015273



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The fuel is suctioned by the feed pump (6) from the fuel tank and sent to the SCV (4). At this time, the regulating valve (5) adjusts the fuel pressure to below a certain level. The fuel sent from the feed pump (6) has the required discharge quantity adjusted by the SCV (4), and enters the pump unit through the suction valve (3). The fuel pumped by the pump unit is pumped through the delivery valve (1) to the rail.

■ Feed Pump

The trochoid type feed pump (6), which is integrated in the supply pump, draws fuel from the fuel tank and feeds it to the two plungers (2) via the fuel filter and the SCV (Suction Control Valve) (4). The drive shaft (8) actuates the outer/inner rotors of the feed pump (6), thus causing the rotors to start rotating. In accordance with the space that increases and decreases with the movement of the outer and inner rotors, the feed pump (6) draws fuel into the suction port and pumps fuel out the discharge port.

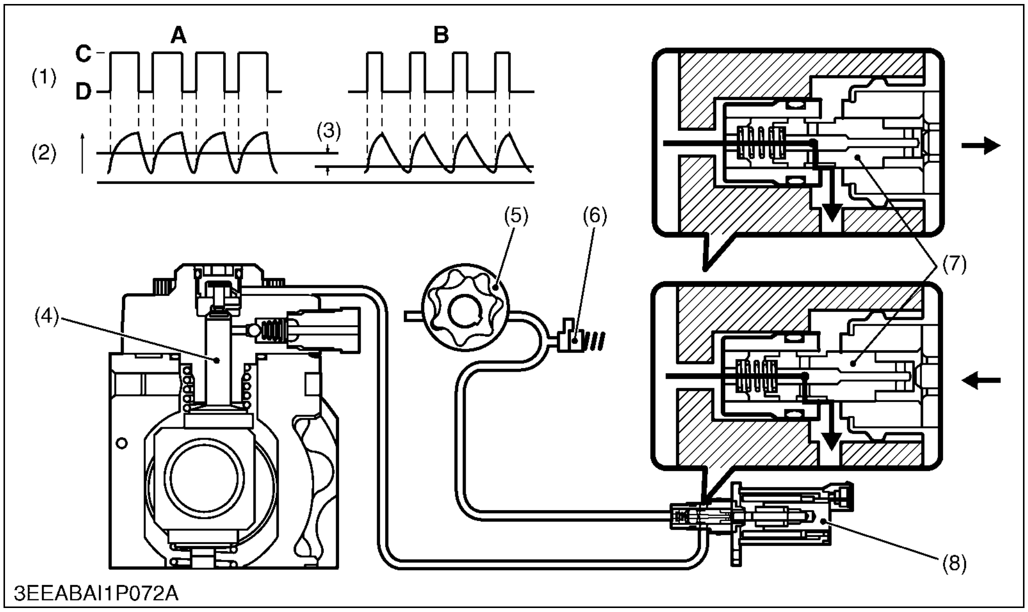
■ Regulating Valve

The regulating valve (5) keeps the fuel feed pressure (discharge pressure) below a certain level. If the pump speed increases and the feed pressure exceeds the preset pressure of the regulating valve (5), the valve opens by overcoming the spring force in order to return the fuel to the suction side.

(1) Delivery Valve
(2) Plunger
(3) Suction Valve
(4) SCV
(5) Regulating Valve
(6) Feed Pump
(7) Ring Cam
(8) Drive Shaft

W1015396

■ SCV (Suction Control Valve)



(1) Actuating Voltage
(2) Current
(3) Average Current Difference
(4) Plunger
(5) Feed Pump
(6) Regulating Valve
(7) Cylinder
(8) SCV

A : Low Suction Quantity
B : High Suction Quantity
C : ON
D : OFF

W1022290

The SCV (8) uses a linear solenoid type electromagnetic valve to control the time for which current is applied from the ECU to the SCV (duty ratio control), and in this way controls the fuel flow quantity supplied to the high-pressure plunger (4). When current flows through the SCV (8), the internal armature moves according to the duty ratio. The fuel flow quantity changes in accordance with the armature operation, and is controlled in accordance with the size of the cylinder fuel passage opening. As a result, the intake fuel quantity is controlled to achieve the target rail pressure and the supply pump actuation load decreases.

1) Normally Open Type

When the solenoid is not energized, the return spring pushes the cylinder (7), completely opening the fuel passage and supplying fuel to the plungers (4). (Full quantity intake and full quantity discharge.)

When the solenoid is energized, the armature presses the cylinder (7), which compresses the return spring and closes the fuel passage.

The solenoid ON/OFF is actuated by duty ratio control. Fuel is supplied in an amount corresponding to the open surface area of the passage, which depends on the duty ratio, and then is discharged by the plungers (4).

2) Duty Ratio Control

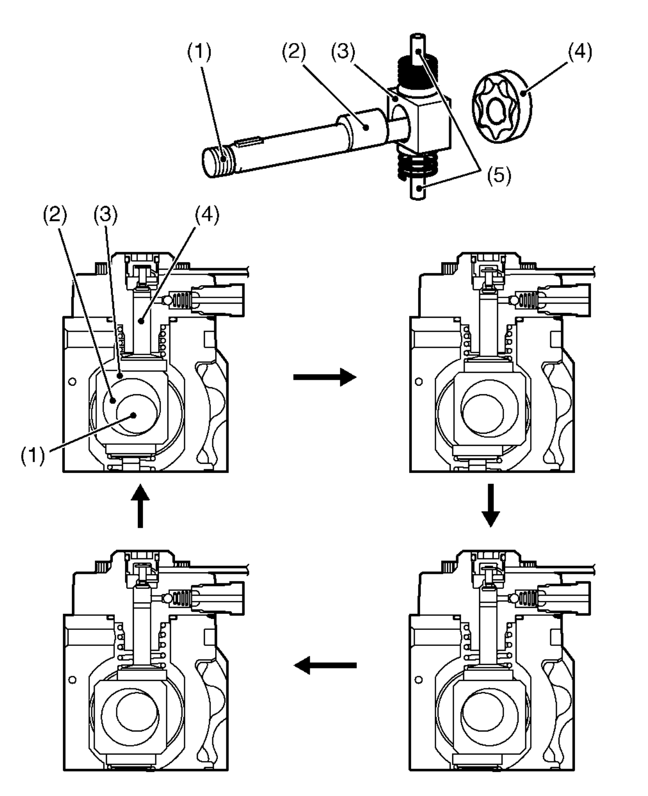
The engine ECU outputs sawtooth wave signals with a constant frequency. The value of the current (2) is the effective (average) value of these signals (3). As the effective value increases, the valve opening decreases, and as the effective value decreases, the valve opening increases.

3) When the SCV Energized Duration (Duty ON Time) is Short

When the SCV energized duration is short, the average current flowing through the solenoid becomes small, the cylinder (7) is returned by the force of the spring, and the valve opening becomes large. As a result, the fuel suction quantity increases.

4) When the SCV Energized Duration (Duty ON Time) is Long

When the SCV energized duration is long, the average current flowing through the solenoid becomes large, the cylinder (7) is pressed out, and the valve opening becomes small. As a result, the fuel suction quantity decreases.



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■ Pump Unit (Eccentric Cam, Ring Cam, Plunger)

The eccentric cam (2) is attached to the drive shaft (1) and the ring cam (3) is installed on the eccentric cam (2). There are two plungers (5) at positions symmetrical above and below the ring cam (3).

Because the rotation of the drive shaft (1) makes the eccentric cam (2) rotate eccentrically, the ring cam (3) follows this and moves up and down, and this moves the two plungers (5) reciprocally. (The ring cam (3) itself does not rotate.)

(1) Drive Shaft
(2) Eccentric Cam
(3) Ring Cam
(4) Feed Pump
(5) Plunger

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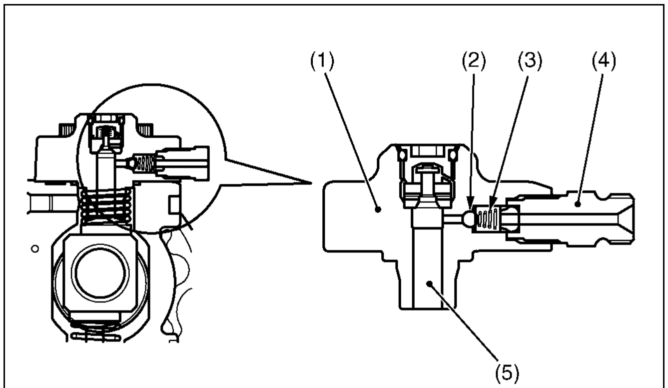

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■ Delivery Valve

The delivery valve has an integrated element (1) and is made up of the check ball (2), spring (3), and holder (4). When the pressure at the plunger (5) exceeds the pressure in the rail, the check ball (2) opens to discharge the fuel.

(1) Element
(2) Check Ball
(3) Spring
(4) Holder
(5) Plunger

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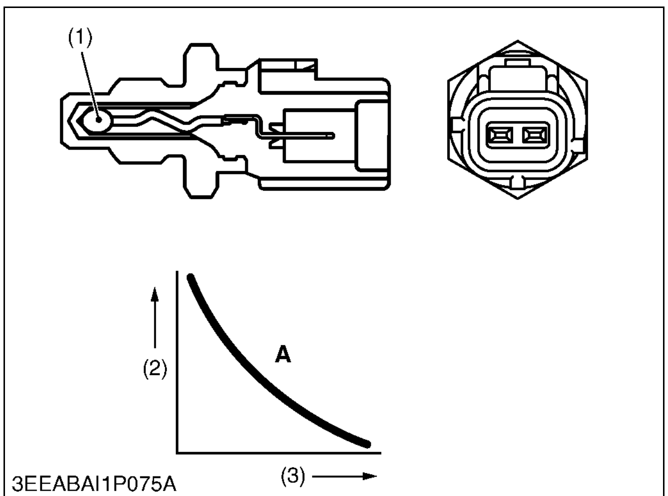

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■ Fuel Temperature Sensor

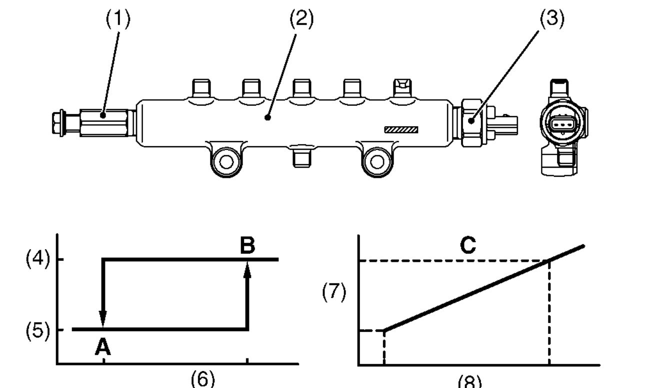
The fuel temperature sensor is installed on the fuel intake side and utilizes the characteristics of a thermistor (1) in which the electric resistance (2) changes with the temperature (3) in order to detect the fuel temperature.

(1) Thermistor
(2) Resistance Value
(3) Temperate

A : Resistance-Temperature Characteristic

W1016490

[3] RAIL



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The function of the rail (2) is to distribute fuel pressurized by the supply pump to each cylinder injector. The component parts are the pressure limiter (1) and the rail pressure sensor (3). The function of the pressure limiter (1) is to open the valve to release fuel pressure if the fuel pressure in the rail becomes abnormally high. The function of the rail pressure sensor (3) is to detect the fuel pressure in the rail.

■ **Pressure Limiter**

The pressure limiter (1) opens to release the fuel pressure if abnormally high pressure is generated (**B**). If fuel pressure within the rail (2) becomes abnormally high, the pressure limiter (1) operates (opens). It resumes operation (closes) after the pressure falls to a certain level (**A**). Fuel released by the pressure limiter (1) returns to the fuel tank.

The operating pressures for the pressure limiter (1) are approximately 200 MPa (2040 kgf/cm^2, 29000 psi) for the valve opening pressure, and approximately 50 MPa (510 kgf/cm^2, 7300 psi) for the valve closing pressure.

■ **Rail Pressure Sensor**

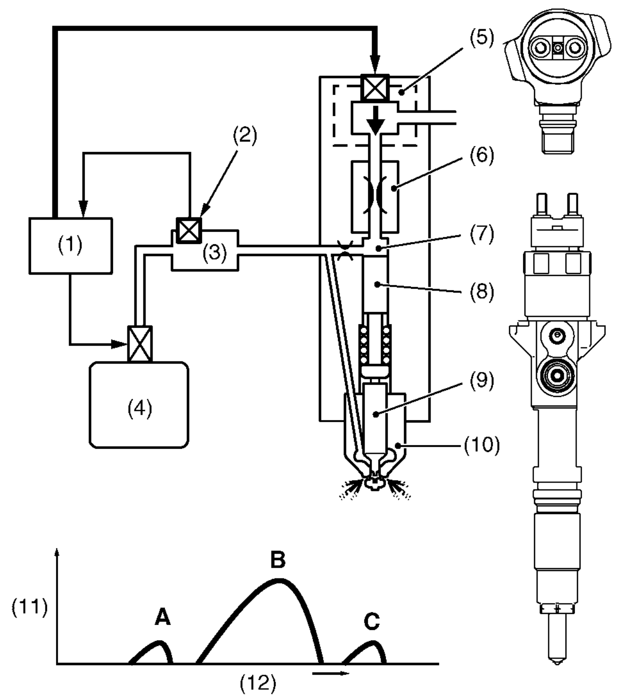
The rail pressure sensor (3) is installed on the rail (2). It detects the fuel pressure in the rail (2) and sends a signal to the engine ECU. This is a semi-conductor sensor that uses the piezo-electric effect of the electrical resistance varying when fuel pressure is applied to a silicon element.

(1) Pressure Limiter
(2) Rail
(3) Rail Pressure Sensor
(4) Valve (Open)
(5) Valve (Close)
(6) Rail Pressure
(7) Output Voltage
(8) Rail Pressure

A : Return Pressure
B : Abnormally High Pressure
C : Output Voltage-Rail Pressure Characteristic

W1016627

[4] INJECTOR



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The injector injects the pressurized fuel in the rail into the engine combustion chamber at the optimal injection timing, injection quantity, injection rate, and injection pattern, in accordance with signals from the engine ECU (Electronic Control Unit) (1).

Injection is controlled using a TWV (Two-Way Valve) (5) and orifice (6). The TWV (5) controls the fuel pressure in the control chamber (7) to control the start and end of injection. The orifice (6) controls the injection rate by restraining the speed at which the nozzle (10) opens.

The command piston (8) opens and closes the valve by transmitting the control chamber pressure to the nozzle needle (9). When the nozzle needle valve is open, the nozzle (10) atomizes the fuel and injects it.

■ **Injector Construction and Features**

The injector consists of a nozzle (10) similar to the conventional “nozzle and nozzle holder”, an orifice (6) that controls the injection rate, the command piston (8), and a TWV (5).

To ensure high pressure, this injector has improved pressure strength, sealing performance and pressure wear resistance. It also has improved high-speed operability, enabling higher-precision injection control and multi-injection.

Multi-injection means that for the purpose of reducing exhaust gas emissions and noise, the main injection is accomplished with one to three injections of fuel without changing the injection quantity.

(1) Engine ECU
(2) Rail Pressure Sensor
(3) Rail
(4) Supply Pump
(5) TWV (Two-Way Valve)
(6) Orifice
(7) Control Chamber
(8) Command Piston
(9) Nozzle Needle
(10) Nozzle
(11) Injection Quantity
(12) Time

A : Pre-Injection
B : Main Injection
C : After Injection

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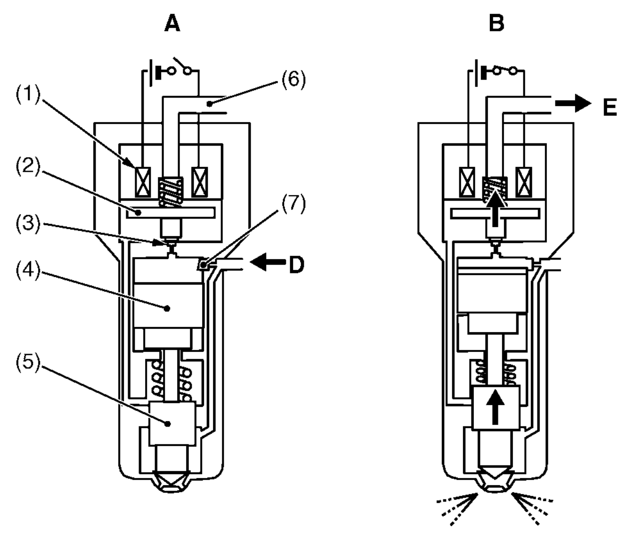
■ Injector Operation



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(1) Solenoid
(2) TWV (Two-Way Valve)
(3) Outlet Orifice
(4) Command Piston
(5) Nozzle
(6) Leak Passage
(7) Inlet Orifice

A : Non Injection
B : Injection
C : End of Injection
D : From Rail
E : To Fuel Tank

W1017602

The injector controls injection through the fuel pressure in the control chamber. The TWV (Two-Way Valve) executes leak control of the fuel in the control chamber to control the fuel pressure within the control chamber. The TWV varies with the injector type.

1) Non-Injection

When the TWV (2) is not energized, the TWV (2) shuts off the leak passage (6) from the control chamber, so the fuel pressure in the control chamber and the fuel pressure applied to the nozzle needle are both the same rail pressure. The nozzle needle thus closes due to the difference between the pressure-bearing surface area of the command piston (4) and the force of the nozzle spring, and fuel is not injected.

For this type, the control chamber outlet orifice (3) is closed directly by the force of the spring.

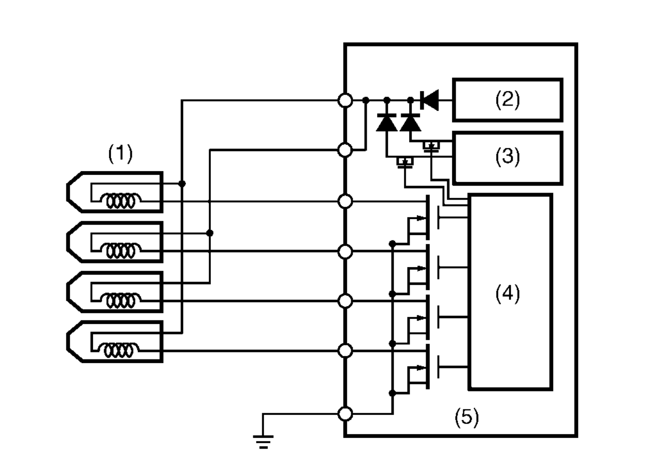
2) Injection

When TWV energization starts, the TWV valve is pulled up, opening the leak passage (6) from the control chamber. When this leak passage (6) opens, the fuel in the control chamber leaks out and the pressure drops.

Because of the control chamber internal pressure drops, the pressure on the nozzle needle overcomes the force pressing down, the nozzle needle is pushed up, and injection starts. When fuel leaks from the control chamber, the flow quantity is restricted by the orifice, so the nozzle (5) opens gradually. The injection rate rises as the nozzle (5) opens. As the current continues to apply to the TWV (2), the nozzle needle eventually reaches the maximum amount of lift, which results in the maximum injection rate. Excess fuel is returned to the fuel tank through the path shown.

3) End of Injection

When TWV energization ends, the valve descends, closing the leak passage (6) from the control chamber. When the leak passage (6) closes, the fuel pressure within the control chamber instantly returns to the rail pressure, the nozzle (5) closes suddenly, and injection stops.



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■ Injector Actuation Circuit

In order to improve injector responsiveness, the actuation voltage has been changed to high voltage, speeding up both solenoid magnetization and the response of the TWV. The charge circuit in the engine ECU (5) raises each battery voltage to approximately 110V, which is supplied to the injector (1) by signal from the engine ECU (5) to actuate the injector (1).

(1) Injector
(2) Constant Amperage Circuit
(3) High Voltage Generation Circuit
(4) Control Circuit
(5) Engine ECU

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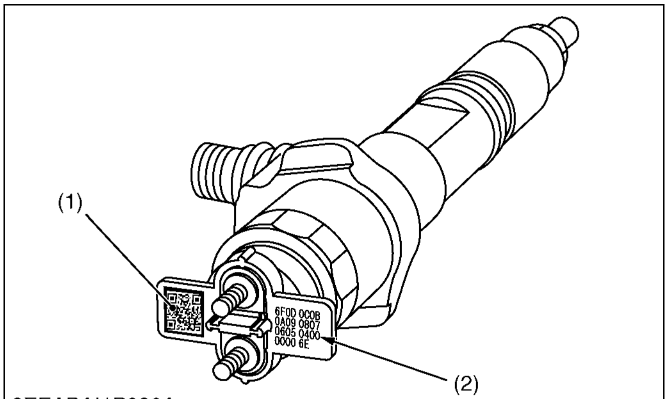

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■ Injector with QR Codes

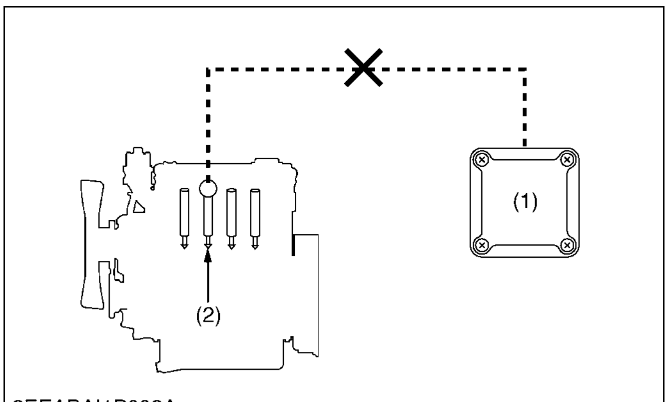
QR (Quick Response) codes have been adopted to enhance correction precision. The QR code (1), which contains the correction data of the injector, is written to the engine ECU. QR codes have resulted in a substantial increase in the number of fuel injection quantity correction points, greatly improving injection quantity precision. In addition to injection quantity correction data, the QR code (1) contains the part number and the product number, which can be read at extremely high speeds.

(1) QR Code
(2) ID Code

W1018198

■ Handling Injectors with QR Codes (Reference)

Injectors with QR codes have the engine ECU recognize and correct the injectors, so when an injector or the engine ECU is replaced, it is necessary to register the injector's ID code in the engine ECU.



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1) Replacing the Injector

Engine ECU (1) cannot recognize the spare injector (2) electrically.

It is necessary to register the ID code of the spare injector (2) that has been replaced in the engine ECU (1).

(1) Engine ECU
(2) Spare Injector

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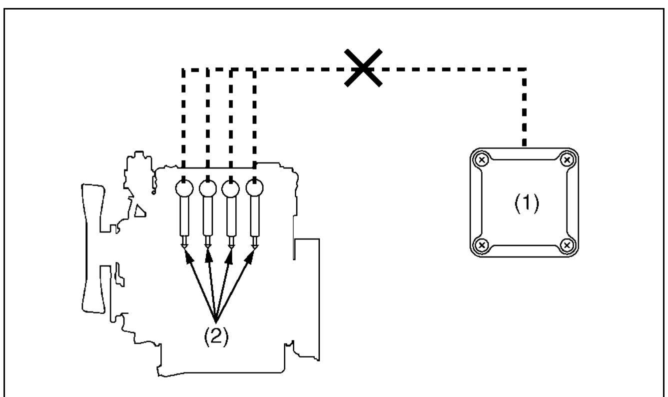

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2) Replacing the Engine ECU

Spare engine ECU (1) cannot recognize the vehicle-side injectors (2) electrically.

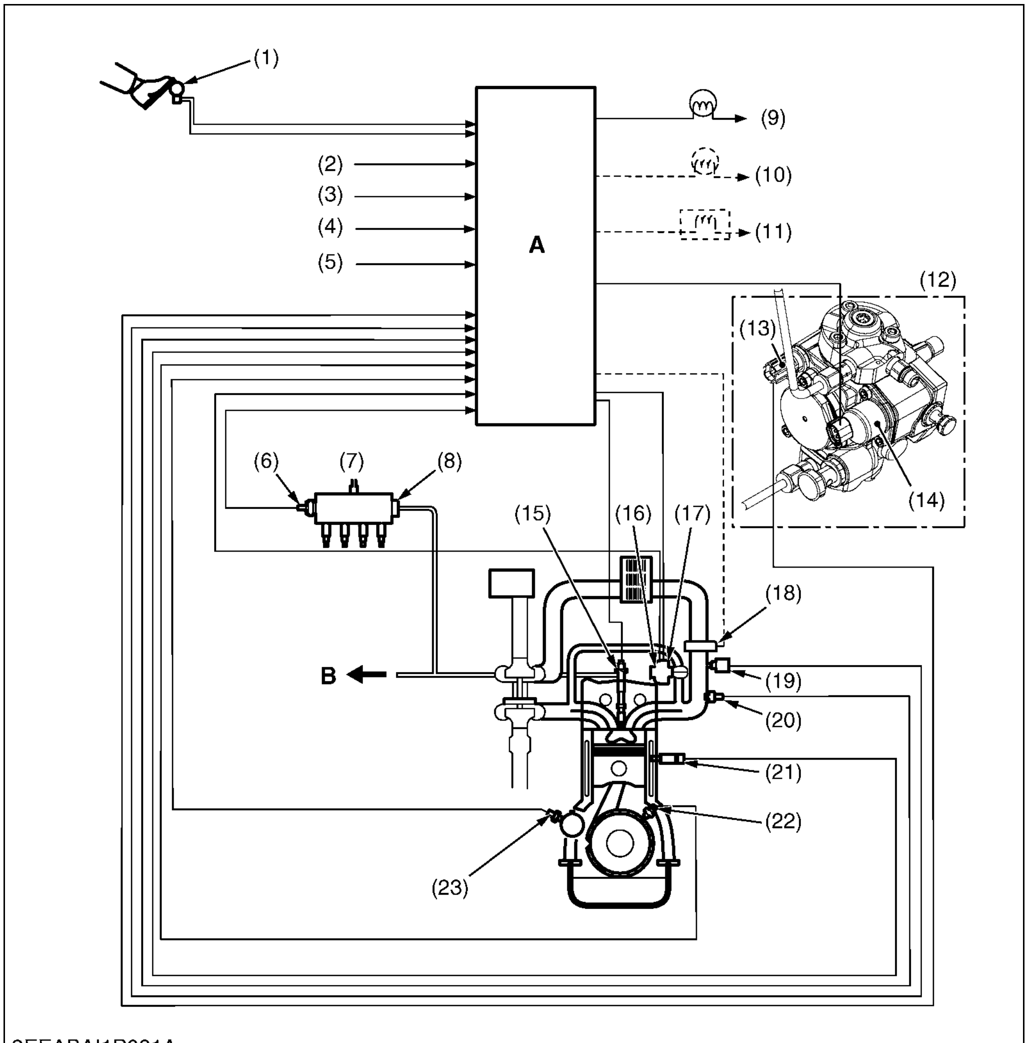
It is necessary to register the ID codes of all the vehicle injectors (2) in the spare engine ECU (1).

(1) Spare Engine ECU
(2) Vehicle-side Injectors

W1023367

[5] ENGINE CONTROL SYSTEM

(1) Engine Control System Diagram



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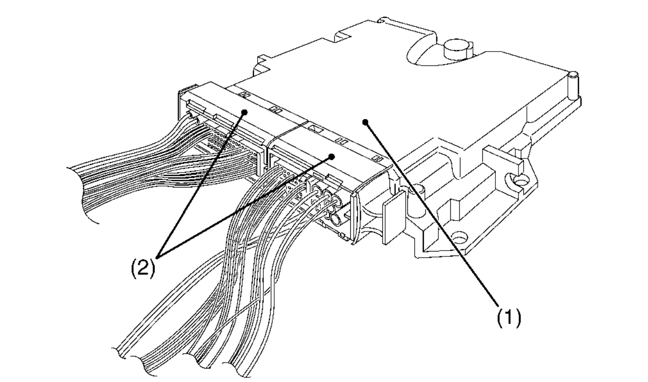
(1) Accelerator Position Sensor
(2) Key Switch ON Signal
(3) Starter Switch Signal
(4) Vehicle Speed Signal
(5) Neutral Switch Signal
(6) Rail Pressure Sensor
(7) Rail
(8) Pressure Limiter
(9) Engine Warning Light
(10) Air Heater Lamp
(11) Air Heater Relay
(12) Supply Pump
(13) Fuel Temperature Sensor
(14) Suction Control Valve
(15) Injector
(16) EGR Valve DC Motor
(17) EGR Valve Lift Sensor
(18) Intake Air Heater
(19) Intake Air Pressure Sensor
(20) Intake Air Temperature Sensor
(21) Coolant Temperature Sensor
(22) Crankshaft Position Sensor (Engine Speed Sensor)
(23) Camshaft Position Sensor (G Sensor)

A : Engine ECU
B : To Fuel Tank

W1018346

(2) Engine ECU (Electronic Control Unit)



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The engine ECU constantly ascertains the status of the engine through signals from the sensors, calculates fuel injection quantities etc. appropriate to the conditions, actuates the actuators, and controls to keep the engine in an optimal state.

The injectors are actuated by the charge circuit in the engine ECU. The charge circuit is provided to enable high-speed actuation of the injectors. The charge circuit has a high-voltage generation device (DC/DC converter) and supplies high voltage to the injectors to actuate the injectors at high speed.

The engine ECU also has a diagnosis function for recording system troubles.

■ **Fuel Injection Control**

This system effects more appropriate control of the fuel injection quantity and injection timing than the mechanical governor or timer used in the conventional injection pump. The engine ECU performs the necessary calculations based on the signals that are received from the sensors located on the engine and the tractor.

Then, the engine ECU controls the timing and duration of the current that is applied to the injectors in order to obtain optimal injection timing and injection quantity.

■ **Various Types of Fuel Injection Control Functions**

1) Fuel Injection Quantity Control

This control replaces the function of the governor in the conventional injection pump. It achieves optimal injection quantity by effecting control in accordance with the engine speed and accelerator opening signals.

2) Fuel Injection Timing Control

This control replaces the function of the timer in the conventional injection pump. It achieves optimal injection timing by effecting control in accordance with the engine speed and the injection quantity.

3) Fuel Injection Rate Control (Pilot Injection Control)

This function controls the ratio of the fuel quantity that is injected from the orifice of the injector within a given unit of time.

4) Fuel Injection Pressure Control

This control uses the rail pressure sensor to measure the fuel pressure, and it feeds this data to the engine ECU in order to control the pump discharge quantity.

(1) Engine ECU (Electronic Control Unit)
(2) ECU Connector

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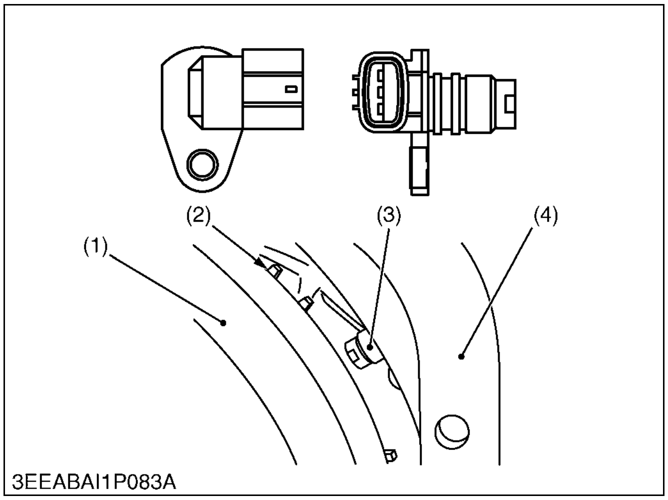
(3) Sensors



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■ Crankshaft Position Sensor (Engine Speed Sensor)

The crankshaft position sensor (3) is installed near the flywheel pulsar gear (2) on the flywheel (1) and detects the crankshaft angle and outputs the engine speed signal.

The sensor unit is a MRE (magnetic resistance element) type. For the MRE type, when the pulsar passes the sensor, the magnetic resistance changes and the voltage passing through the sensor changes. This change in voltage is amplified by the internal IC circuit and output to the engine ECU.

The number of pulses for the pulsar gear is 56.

(1) Flywheel
(2) Flywheel Pulsar Gear
(3) Crankshaft Position Sensor
(4) Flywheel Housing

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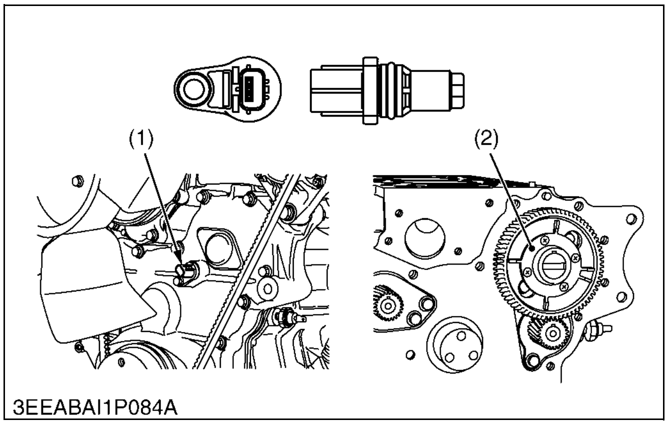

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■ Camshaft Position Sensor (G Sensor)

The camshaft position sensor (1) is installed near the camshaft pulsar gear (2) and identifies the cylinders. Sensor unit construction consists of the MRE type, which is the same as for the crankshaft position sensor.

The number of pulses for the pulsar gear is 5.

(1) Camshaft Position Sensor
(2) Camshaft Pulsar Gear

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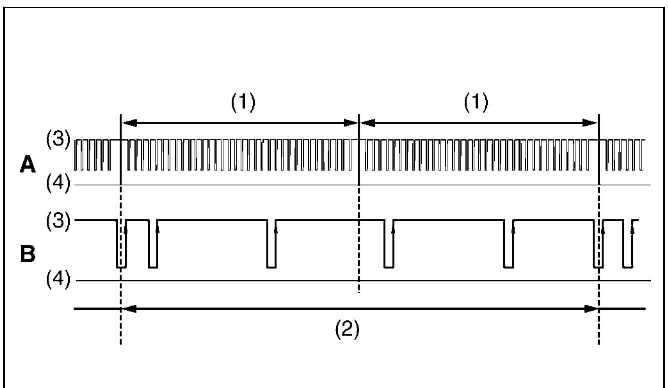

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This figure shows the pulse chart of the crankshaft position sensor output signal and camshaft position sensor output signal.

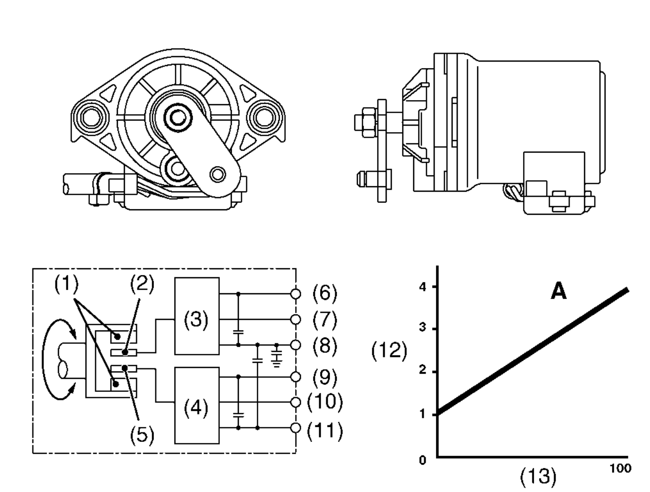
The camshaft pulsar gear rotates once when the crankshaft pulsar gear rotates twice (12.6 rad (720 °) crank angle).

There is a gearless section in the crankshaft pulsar gear. The ECU determines whether it is TDC if the camshaft position sensor signal is detected while the crankshaft position sensor is passing this gearless section.

(1) 56 Pulses (6.28 rad (360 °) crank angle)
(2) 5 Pulses (12.6 rad (720 °) crank angle)
(3) 5 V
(4) 0 V

A : Crankshaft Position Sensor Output Voltage
B : Camshaft Position Sensor Output Voltage

W1019511



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■ Accelerator Position Sensor

The accelerator position sensor detects the opening angle of the accelerator pedal and converts the accelerator opening angle into an electric signal and outputs it to the engine ECU.

This sensor uses a hall element (2) (5) to generate voltage from change in the direction of the magnetic field. A magnet (1) is installed on the shaft that rotates linked with the accelerator pedal, and the rotation of this shaft changes the magnetic field of the hall element (2) (5). The voltage generated by this change in the magnetic field is amplified by an amplifier (3) (4) and input to the engine ECU.

In addition, to provide backup in the event of breakdown, there are two systems and the output voltage is offset.

(1) Magnets (Pair)
(2) Hall Elements 1
(3) Amplifier No. 1
(4) Amplifier No. 2
(5) Hall Elements 2
(6) Vcc 1
(7) Output 1
(8) GND 1
(9) Vcc 2
(10) Output 2
(11) GND 2
(12) Output Voltage
(13) Accelerator Opening (%)

A : Output Voltage - Operating Characteristic

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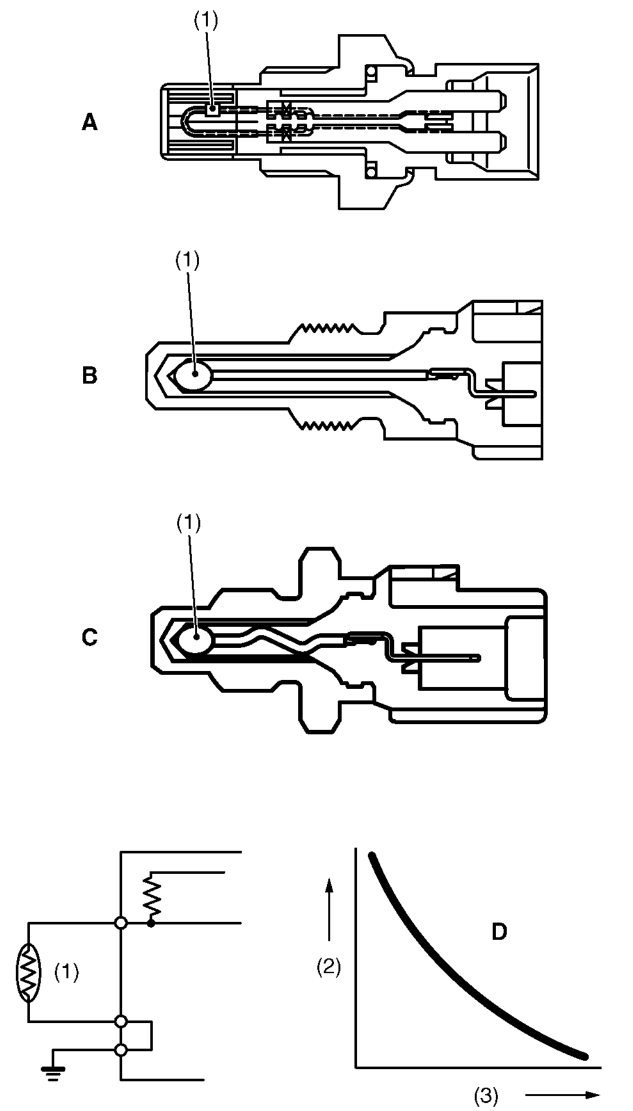

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■ Intake Air Temperature Sensor

The intake air temperature sensor (**A**) detects the temperature of the intake air after it has passed the turbocharger. The sensor portion that detects the temperature contains a thermistor (1). The thermistor (1), which has an electrical resistance that changes with temperature, is used to detect the intake air temperature.

■ Coolant Temperature Sensor

The coolant temperature sensor (**B**) is installed near the thermostat and detects the engine coolant temperature. This sensor is a thermistor (1) type.

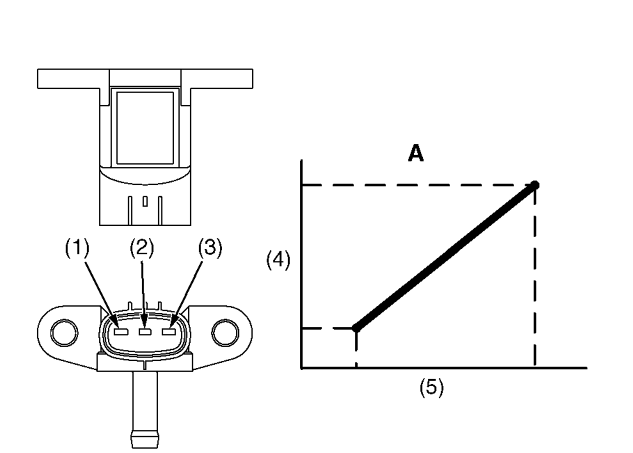
■ Fuel Temperature Sensor

The fuel temperature sensor (**C**) is installed on the fuel intake side of supply pump and utilizes the characteristics of a thermistor (1) in which the electric resistance changes with the temperature in order to detect the fuel temperature.

(1) Thermistor
(2) Resistance Value
(3) Temperature

A : Intake Air Temperature Sensor
B : Coolant Temperature Sensor
C : Fuel Temperature Sensor
D : Resistance - Temperature Characteristic

W1019951



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■ Intake Air Pressure Sensor

This sensor is a semiconductor type sensor. It measures intake air pressure utilizing the piezoelectric effect that when the pressure on the silicon element in the sensor changes, its electrical resistance changes.

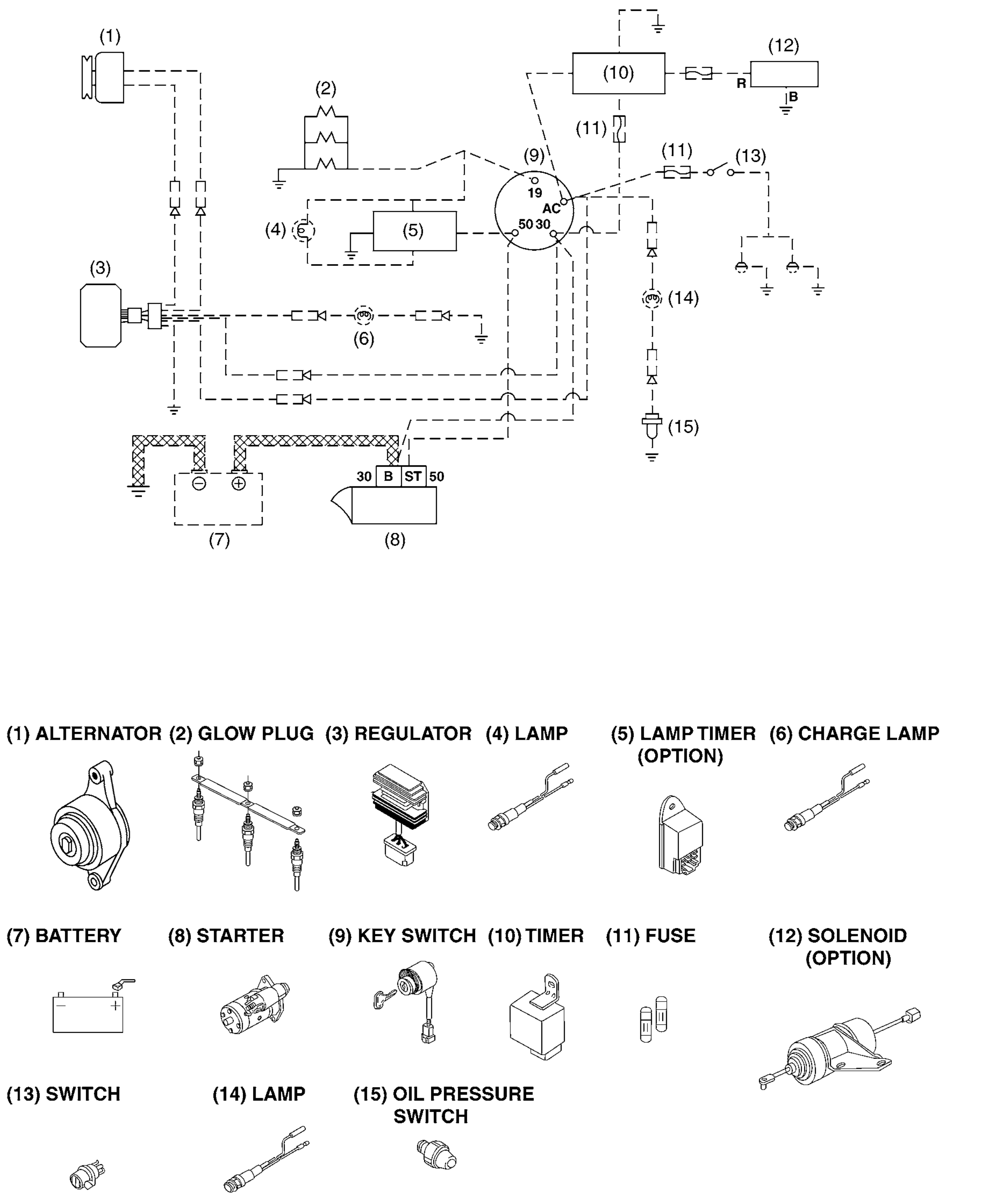
(1) Vcc
(2) Output
(3) GND
(4) Output Voltage
(5) Absolute Pressure

A : Output Voltage - Pressure Characteristic

W1020213

9. ELECTRICAL SYSTEM

[1] GENERAL



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The electrical system of the engine consists of a starting system, a charging system, a battery and electrical equipment.

W1049501

[2] STARTING SYSTEM

The starting system consists of a starter, glow plugs and others. Kubota engines are used three types of starter.

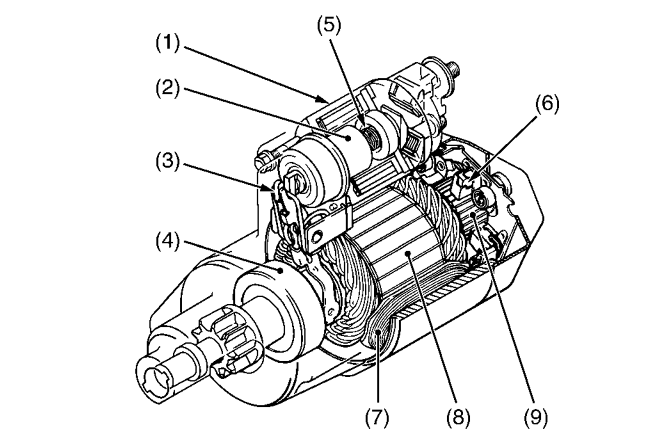
(1) Electromagnetic Drive Type

(2) Reduction Type

1) Gear reduction type

2) Planetary gear reduction type

(1) Electromagnetic Drive Type



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This starter is constructed as shown in the figure.

It is composed of a starting motor and a magnetic switch.

(1) Magnetic Switch
(2) Plunger
(3) Drive Lever
(4) Overrunning Clutch
(5) Return Spring
(6) Brush
(7) Field Coil
(8) Armature
(9) Commutator

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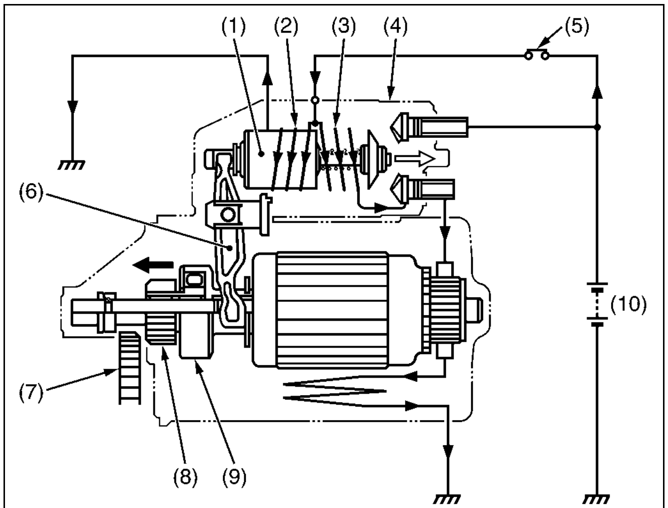
1) Operation of starter



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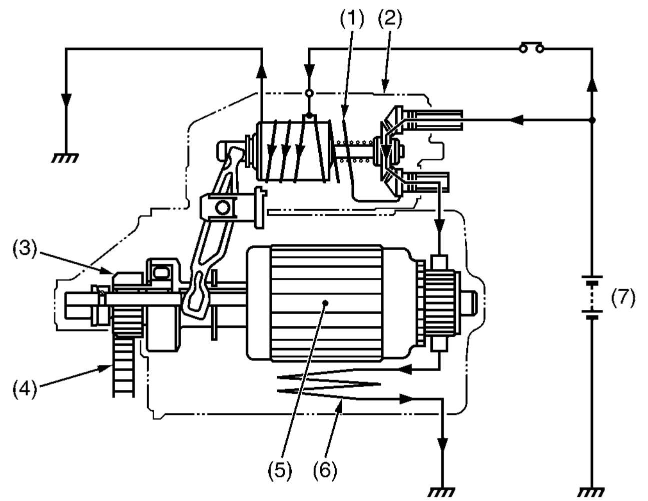
■ **When Main Switch Is Turned to "START" Position**

When main switch (5) is turned to **"START"** position, current from battery (10) flows to holding coil (2) and pull-in coil (3).

The plunger (1) is motivated by magnetism and the pinion gear (8) is pushed towards the ring gear (7) by the drive lever (6).

(1) Plunger
(2) Holding Coil
(3) Pull-in Coil
(4) Magnetic Switch
(5) Main Switch
(6) Drive Lever
(7) Ring Gear
(8) Pinion Gear
(9) Overrunning Clutch
(10) Battery

W10486520



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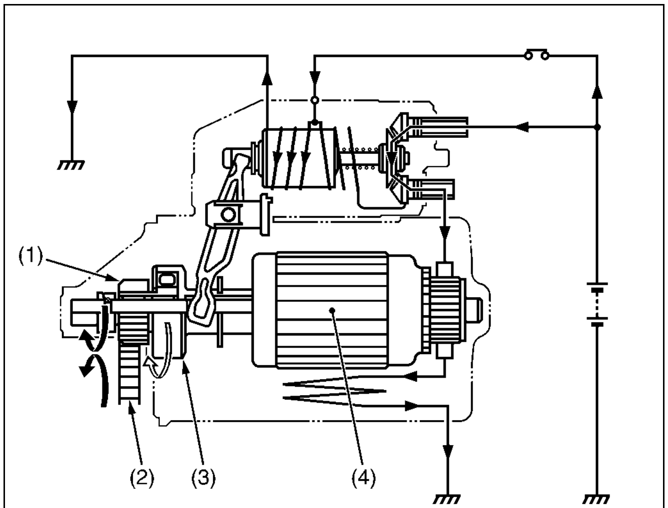
■ When Pinion Gear Meshes with Ring Gear

When the pinion gear (3) comes into mesh with the ring gear (4) on the flywheel and the magnetic switch (2) is closed, a large current flows from the battery (7) directly into the field coil (6) and armature coil, but not through the pull-in coil (1).

This rotates the armature (5) at a high speed, which in turn drives the ring gear (4) through the pinion gear at 200 to 300 min^{-1} (rpm).

(1) Pull-in Coil
(2) Magnetic Switch
(3) Pinion Gear
(4) Ring Gear
(5) Armature
(6) Field Coil
(7) Battery

W10874760



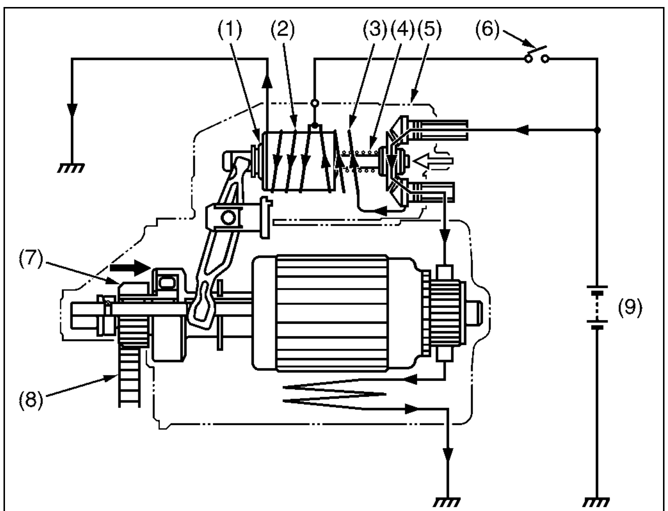
3EEAAAA1P130A

■ When Engine Has Started

When the engine starts and drives the pinion gear (1) with the ring gear (2), the overrunning clutch (3) disengages to prevent the armature (4) from being driven by the engine.

(1) Pinion Gear
(2) Ring Gear
(3) Overrunning Clutch
(4) Armature

W10488790



3EEAAAA1P131A

■ When Main Switch Is Released

When releasing the main switch (6), it returns from **"START"** to **"ON"** position and the starter circuit opens. Then, current flows from the battery (9) to the pull-in coil (3) and the holding coil (2) through the contact plate. Since the magnetic force is generated in each coil in the opposite direction, the magnetic field collapses and the plunger (1) is returned to its former position by a return spring (4).

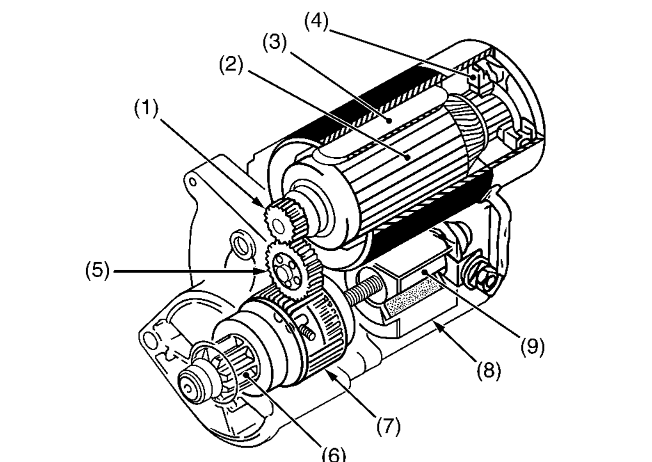
This open the contacts on the contact plate and separates the pinion gear (7) from the ring gear (8), whereupon the pinion gear stops rotating.

(1) Plunger
(2) Holding Coil
(3) Pull-in Coil
(4) Return Spring
(5) Magnetic Switch
(6) Main Switch
(7) Pinion Gear
(8) Ring Gear
(9) Battery

W10877390

(2) Reduction Type

1) Gear reduction type



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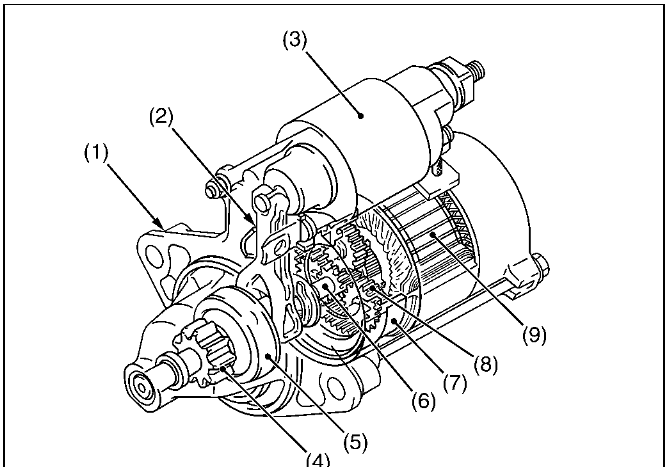
The starter is a reduction type starter with heat-resistant and vibration-resistant features that has a small, high-speed motor, and the revolutions of the armature drive the pinion gear approximately one-third the speed to increase torque.

(1) Drive Gear
(2) Armature
(3) Field Coil
(4) Brush
(5) Idler Gear
(6) Pinion Gear
(7) Overrunning Clutch
(8) Magnetic Switch
(9) Plunger

W10482360

2) Planetary gear reduction type



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This starter is constructed as shown in the figure.

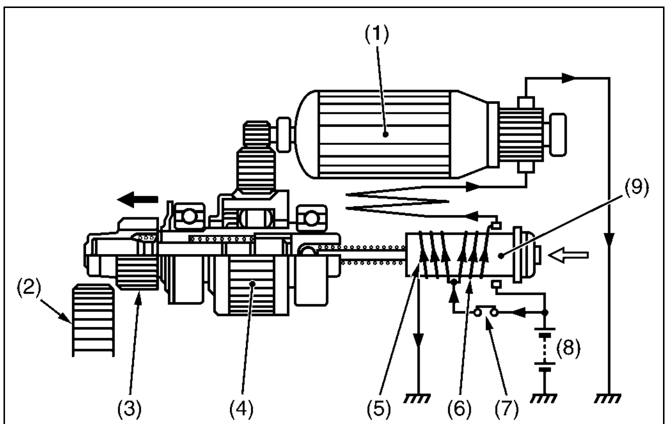
The reduction system is used planetary gears, and the speed of gear shaft (6) is reduced to approximately one-fifth of the armature shaft (9).

The pinion gear (4) is pushed against the ring gear with the overrunning clutch (5) by the drive lever (2). (Refer to **"Electromagnetic Drive Type"** for starter's operation.)

(1) Front Bracket
(2) Drive Lever
(3) Magnetic Switch
(4) Pinion Gear
(5) Overrunning Clutch
(6) Gear Shaft
(7) Internal Gear
(8) Pinion Gear
(9) Armature Shaft

W10484380

3) Operation of starter (Gear reduction type)



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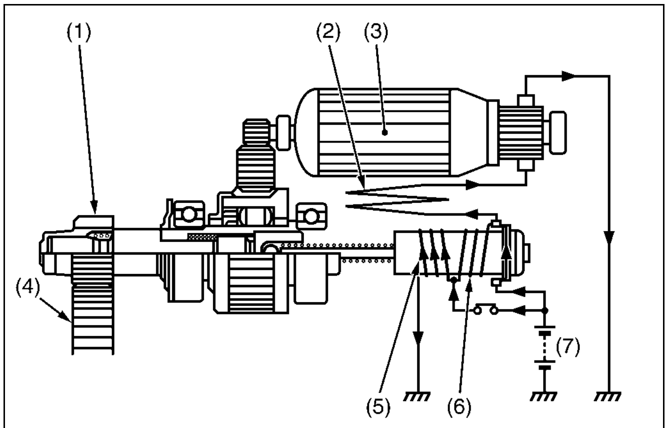
■ **When Main Switch Is Turned to "START" Position**

When main switch (7) is turned to **"START"** position, current from battery (8) flows to holding coil (5) and pull-in coil (6). The plunger (9) is motivated by magnetism and the pinion gear (3) is pushed out.

(1) Armature
(2) Ring Gear
(3) Pinion Gear
(4) Overrunning Clutch
(5) Holding Coil
(6) Pull-in Coil
(7) Main Switch
(8) Battery
(9) Plunger

W10492060



3EEAAAA1P135A

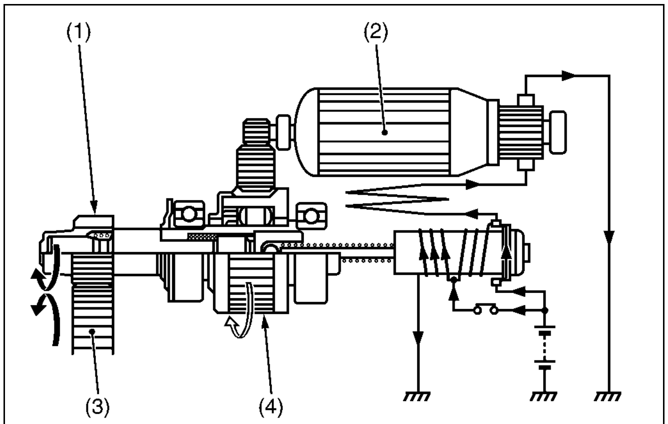
■ **When Pinion Gear Meshes with Ring Gear**

When the pinion gear (1) comes into mesh with the ring gear (4) on the flywheel and the magnetic switch is closed, a large current flows from the battery (7) directly into the field coil (2) and armature coil, but not through the pull-in coil (6).

This rotates the armature (3) at a high speed, which in turn drives the ring gear (4) through the pinion gear (1) at 200 to 300 min^{-1} (rpm).

(1) Pinion Gear
(2) Field Coil
(3) Armature
(4) Ring Gear
(5) Holding Coil
(6) Pull-in Coil
(7) Battery

W10495410



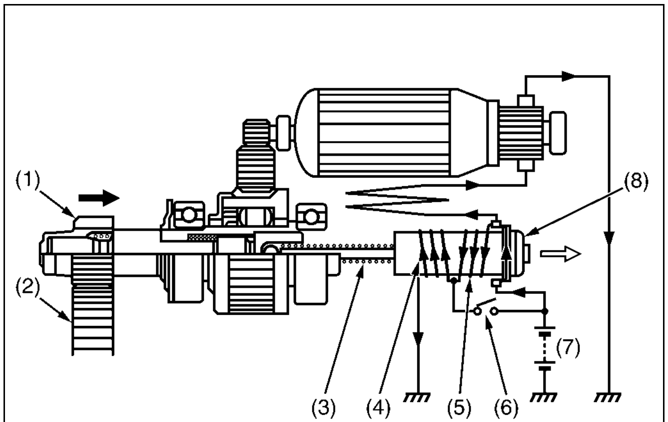
3EEAAAA1P136A

■ **When Engine Has Started**

When the engine starts and drives the pinion gear (1) with the ring gear (3), the overrunning clutch (4) disengages to prevent the armature (2) from being driven by the engine.

(1) Pinion Gear
(2) Armature
(3) Ring Gear
(4) Overrunning Clutch

W10497870



3EEAAAA1P137A

■ **When Main Switch Is Released**

When releasing the main switch (6), it returns from **"START"** to **"ON"** position and the starter circuit opens.

Then, current flows from the battery (7) to the pull-in coil (5) and the holding coil (4) through the contact plate.

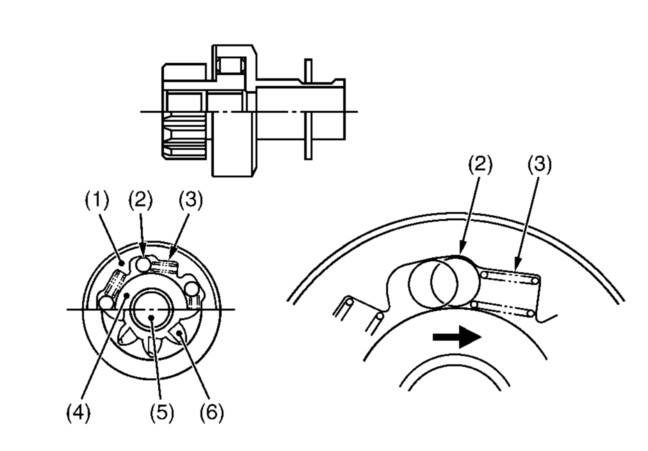
Since the magnetic force is generated in each coil in the opposite direction, the magnetic field collapses and the plunger (8) is returned to its former position by a return spring (3).

This open the contacts on the contact plate and separates the pinion gear (1) from the ring gear (2), whereupon the pinion gear stops rotating.

(1) Pinion Gear
(2) Ring Gear
(3) Return Spring
(4) Holding Coil
(5) Pull-in Coil
(6) Main Switch
(7) Battery
(8) Plunger

W10499010

(3) Overrunning Clutch



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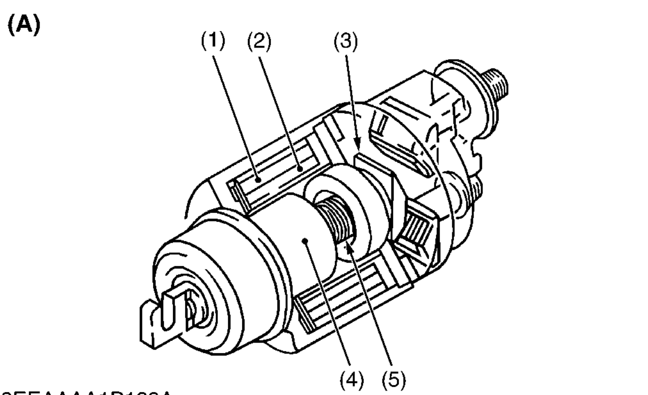
The overrunning clutch is so constructed that the power transmission relationship is automatically severed when the clutch pinion shaft (5) speed exceeds the clutch gear outer (1) speed at increased engine speeds.

Therefore, the armature drives the ring gear and is never driven by the engine.

(1) Clutch Gear Outer
(2) Roller
(3) Roller Spring
(4) Spline Tube Inner
(5) Clutch Pinion Shaft
(6) Pinion Gear

W10509260

(4) Magnetic Switch



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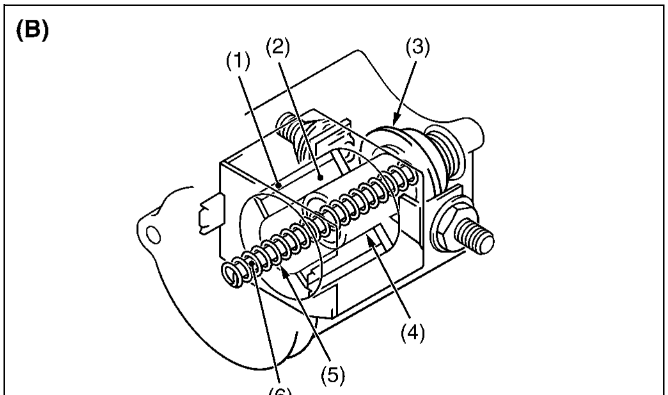


3EEAAAA1P140A

The plunger (4), contact plate (3) and plunger shaft (6) are mode as one unit. When the main switch is turned to **"START"** position, the plunger is drawn in and thus clutch pinion shaft is forced out.

This meshes the pinion gear and ring gear, and causes the contact plate to close the contacts, causing the main current to flow into the armature.

When releasing the main switch, the plunger is returned to its former position by a return spring (5).

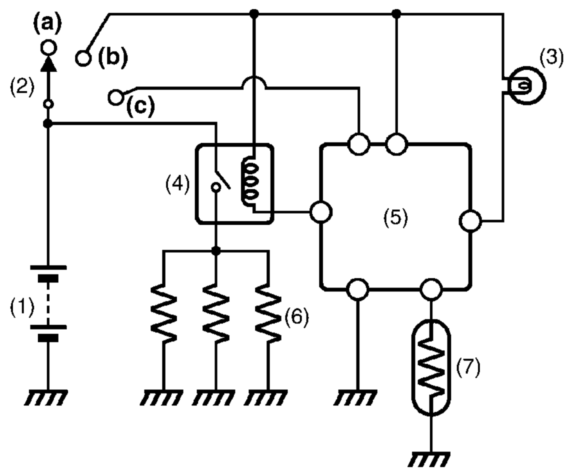
(1) Holding Coil
(2) Pull-in Coil
(3) Contact Plate
(4) Plunger
(5) Return Spring
(6) Plunger Shaft

(A) Electromagnetic Drive Type
(B) Gear Reduction Type

W10510780

[3] GLOW CONTROL SYSTEM

(A)



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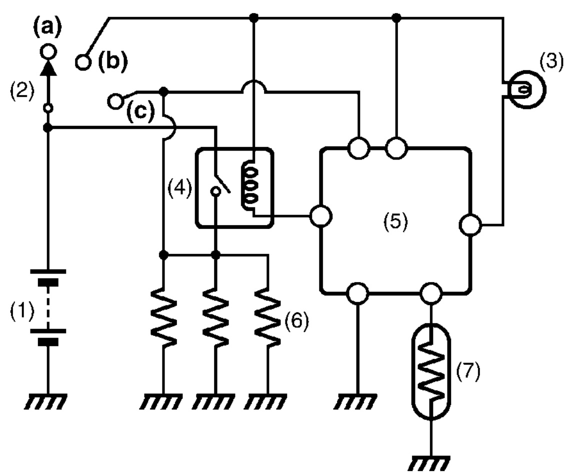
(B)



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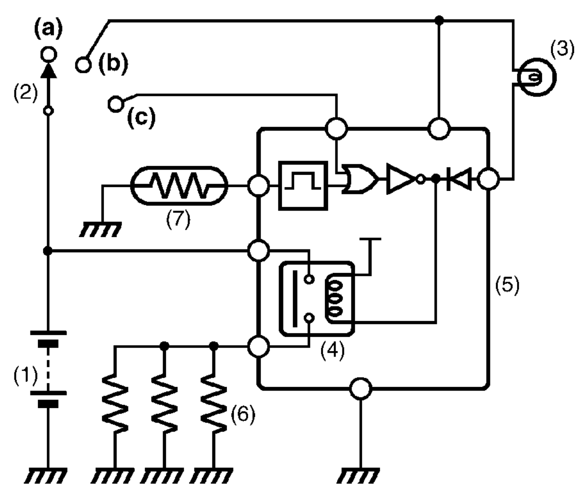
(C)



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The purpose of this system is to control energizing time to the glow plugs (6) by means of coolant temperature of the engine.

This system makes it easy for the operator to start the engine even when it is in cold season, because starting preparation can be completed if it is confirmed that the glow lamp (3) is turned off.

This system consists of main switch, glow lamp, glow relay, glow controller, coolant temperature sensor and glow plug.

■ **Operation Table**

Code Number of Glow Controller	Main Switch	Glow Relay	Glow Lamp	Glow Plug
16415-65661 (12 V)	OFF	OFF	OFF	OFF
	ON	ON	ON	ON
	START	OFF	OFF	ON
17095-65661 (12V)	OFF	OFF	OFF	OFF
	ON	ON	ON	ON
	START	ON	OFF	ON
1K011-65661 (24V)	OFF	OFF	OFF	OFF
	ON	ON	ON	ON
	START	ON	ON	ON
1K533-65661 (12V)	OFF	OFF	OFF	OFF
	ON	ON	ON	ON
	START	ON	ON	ON

(1) Battery
(2) Main Switch
(3) Glow Lamp
(4) Glow Relay
(5) Glow Controller
(6) Glow Plug
(7) Coolant Temperature Sensor

(A) 17095-65661 (12 V)
1K011-65661 (24 V)
(B) 16415-65661 (12 V)
(C) 1K533-65661 (12 V)

(a) "OFF" Position
(b) "ON" Position
(c) "START" Position

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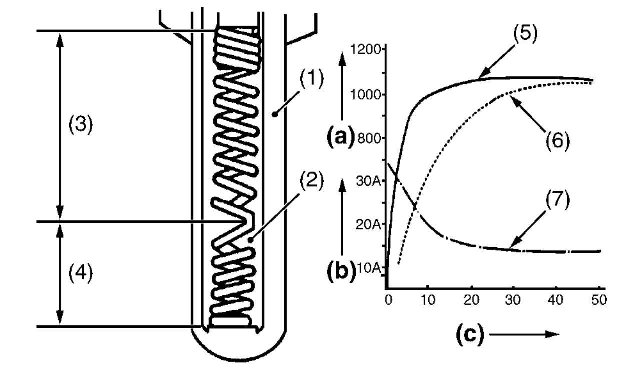

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■ Quick Glow System (QGS)

This plug is a two-material type QGS for quick temperature rises, and has self-controlling function as well as excellent durability.

The heater (4) connected in series to the heater which also functions as the resistor, is incorporated in the sheath tube (1) of the super glow plug.

The resistance of this heater (3) cum resistor is small when the temperature is low, while the resistance becomes large when the temperature rises.

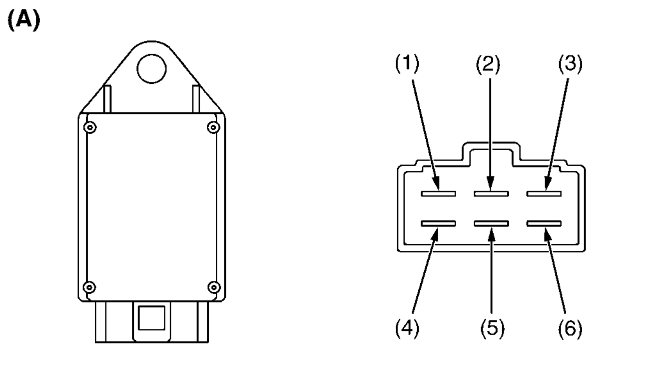
Therefore, because sufficient current is flow to the heater (4) during the initial period of energization, the temperature rise quickly and the resistance grows with the rise quickly and the resistance grows with the rise in the temperature of the resistor, the flowing current is reduced to prevent the heater (4) from being heated.

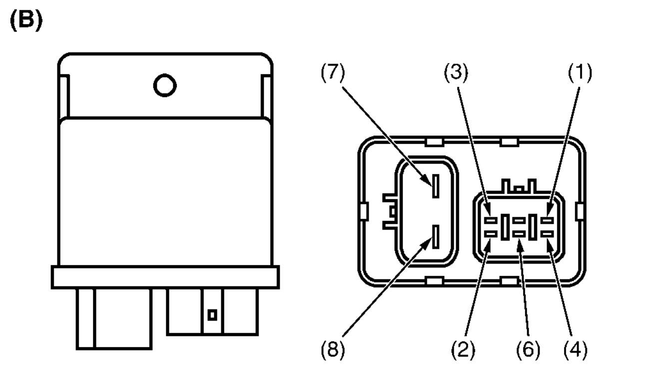
The ignition point is in the area of 2.0 to 3.0 mm (0.079 to 0.11 in.) from the tip of the plug in order to reduce its projection into the combustion chamber.

(1) Sheath Tube
(2) Insulation Powder
(3) Heater also functioning as a Resistor
(4) Heater
(5) Super Glow Plug
(6) Conventional Quick Heating Type Glow Plug
(7) Glow Plug Current

(a) Glow Plug Temperature (°C)
(b) Current (A)
(c) Time (Sec.)

W10364330





■ Glow Controller

When the main switch is turned on, the glow controller detects the coolant temperature by means of the coolant temperature sensor, and controls the energizing time to the glow plugs and glow lamp according to the detected coolant temperature.

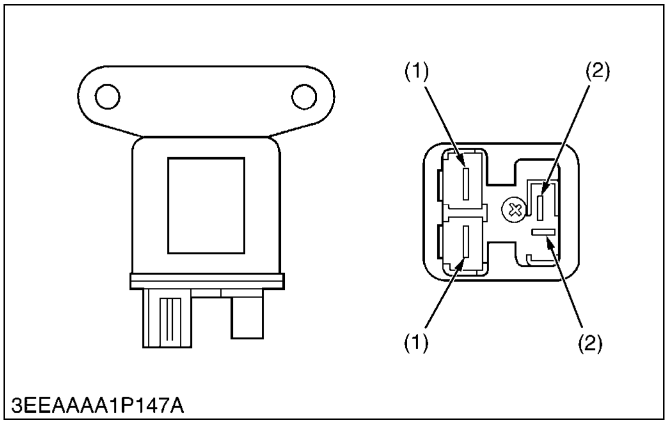
The relation between the coolant temperature and the energizing time is as shown in the table.

Code Number	Coolant Temperature	Energizing Time
16415-65661 (12V)	– 15 °C (5 °F)	5.0 sec.
	– 5 °C (23 °F)	3.8 sec.
	20 °C (68 °F)	1.1 sec.
17095-65661 (12V)	– 15 °C (5 °F)	6.4 sec.
	– 5 °C (23 °F)	5.1 sec.
	20 °C (68 °F)	2.5 sec.
1K011-65661 (24V)	– 15 °C (5 °F)	6.4 sec.
	– 5 °C (23 °F)	5.2 sec.
	20 °C (68 °F)	2.5 sec.
1K533-65661 (12V)	– 15 °C (5 °F)	10.0 sec.
	– 5 °C (23 °F)	7.6 sec.
	20 °C (68 °F)	3.3 sec.

(1) From Main Switch **"ST"** Terminal
(2) From Glow Lamp
(3) From Main Switch **"ON"** Terminal
(4) To Coolant Temperature Sensor
(5) From Glow Relay
(6) To Ground
(7) From Battery Positive Terminal
(8) To Glow Plug

(A) Glow Controller
(B) Glow Controller with Relay

W11123760

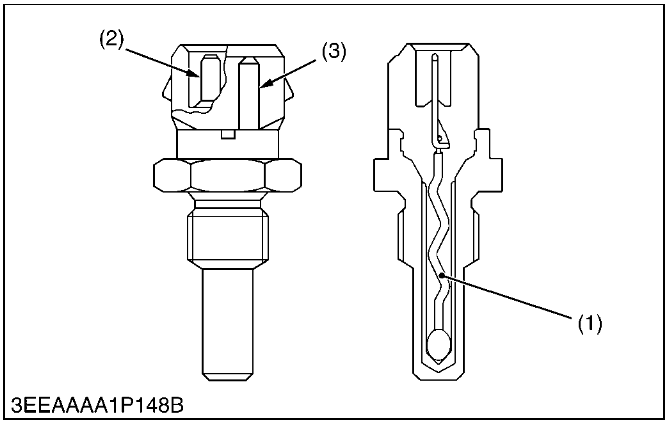


■ Glow Relay

The glow relay is actuated by the signal from the glow controller and supplies the battery power to the glow plug directly.

(1) Contact Point (2) Coil

W10133740



■ Coolant Temperature Sensor (Only use for glow plug)

The coolant temperature sensor for glow plug is installed to near the thermostat.

When the coolant temperature is increased, the electrical resistance will become small, and when the coolant temperature is decreased, it will become large.

Characteristics of Thermistor		
Temperature	Resistance (Terminal 1 - Terminal 2)	
	15668-83041	16415-83041
–30 °C (–22 °F)	28.6 kΩ	28.6 kΩ
–20 °C (–4 °F)	16.2 kΩ	16.2 kΩ
–10 °C (14 °F)	9.56 kΩ	9.56 kΩ
0 °C (32 °F)	5.88 kΩ	5.88 kΩ
20 °C (68 °F)	2.45 kΩ	2.45 kΩ
40 °C (104 °F)	1.14 kΩ	1.14 kΩ
60 °C (140 °F)	0.58 kΩ	0.58 kΩ
80 °C (176 °F)	0.32 kΩ	0.32 kΩ
100 °C (212 °F)	0.19 kΩ	0.19 kΩ
120 °C (248 °F)	0.12 kΩ	0.12 kΩ

(1) Thermistor
(2) Terminal 1
(3) Terminal 2

W11132620

[4] STARTER AUTO REDUCTION UNIT

(1) General

The starter auto reduction unit (7) is designed to start the machine equipped with engine more reliably. This unit has the following function by integrating an alternator (1) that puts out rpm-proportional pulses.

1. Fail-Safe Functions

a) Preventing the starter pinion from getting in mesh while the engine is running.
With the engine running, pulses from the alternator terminal **P** are constantly detected. Even if key switch (2) is wrongly operated or the wiring gets short-circuited, the starter (5) can stay off, the starter (5) and flywheel ring gear are effectively protected.

b) Starter auto reduction at a start of the engine.
When the engine has got started and the alternator (1) has reached the specified rpm, the electrical current to the starter (5) is automatically cut off, even if the key switch (2) is at the **START** position.

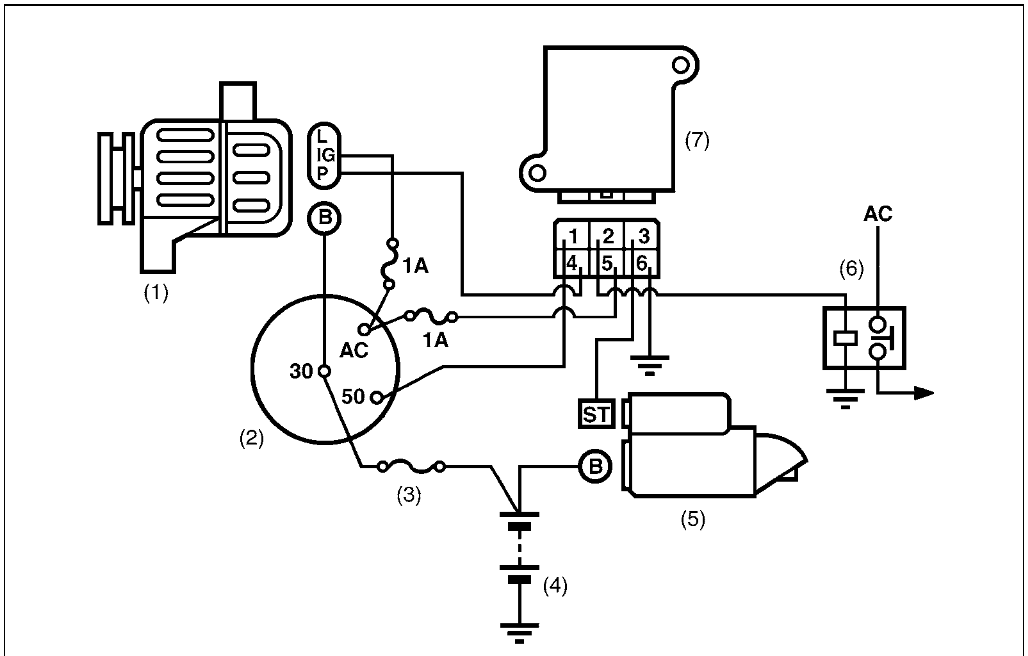
c) Safety mechanism in case of engine stall.
If the engine stalls with the key switch (2) at **AC** or **START** position, the key must be set once to **OFF** position for added safety. The starter (5) is thus kept from turning on unexpectedly.

2. Other Features and Functions

a) Simplified wiring with built-in power relay.
The unit is internally provided with a power relay to get simpler wiring than ever before. If the key switch terminal **AC**, ground cable or any other parts is wrongly connected, the starter (5) stays off. This helps identify wrong wiring more easily.

b) With the output terminal for confirming engine start (Relay drive possible).
The unit has an external output terminal in order to confirm an engine start. An external relay (6) may also be connected to this terminal. (Output current : below 200 mA)

(2) Basic Circuit



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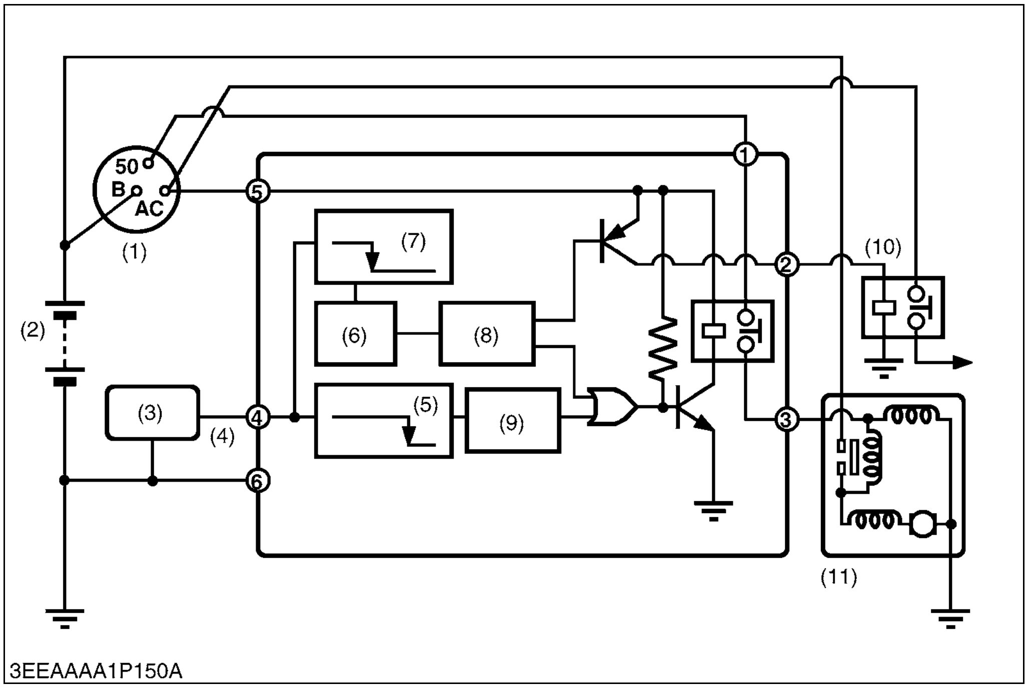
(1) Alternator
(2) Key Switch
(3) Slow Blow Fuse
(4) Battery
(5) Starter
(6) External Relay
(7) Starter Auto Reduction Unit

W10141600

(3) Component



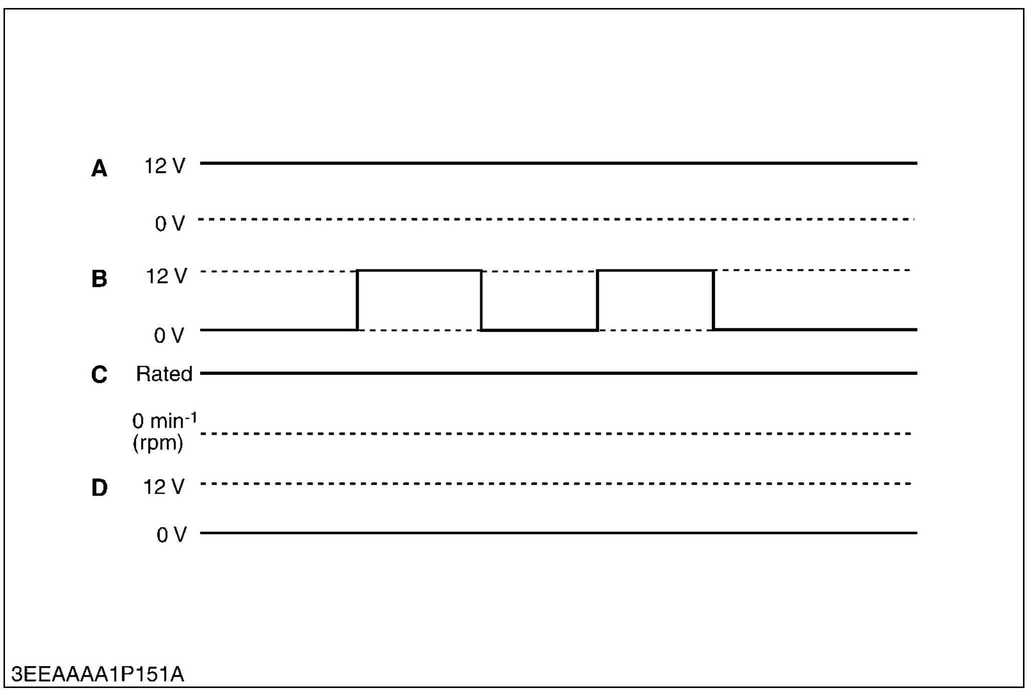
(1) Key Switch
(2) Battery
(3) Alternator
(4) **P** terminal
(5) Detection High rpm (N2)
(6) Delay Curcuit
(7) Detection Low rpm (N1)
(8) Self Holding Circuit
(9) Self Holding Circuit
(10) External Relay
(11) Starter

W10142900

(4) Function

(A) Starter Auto Reduction

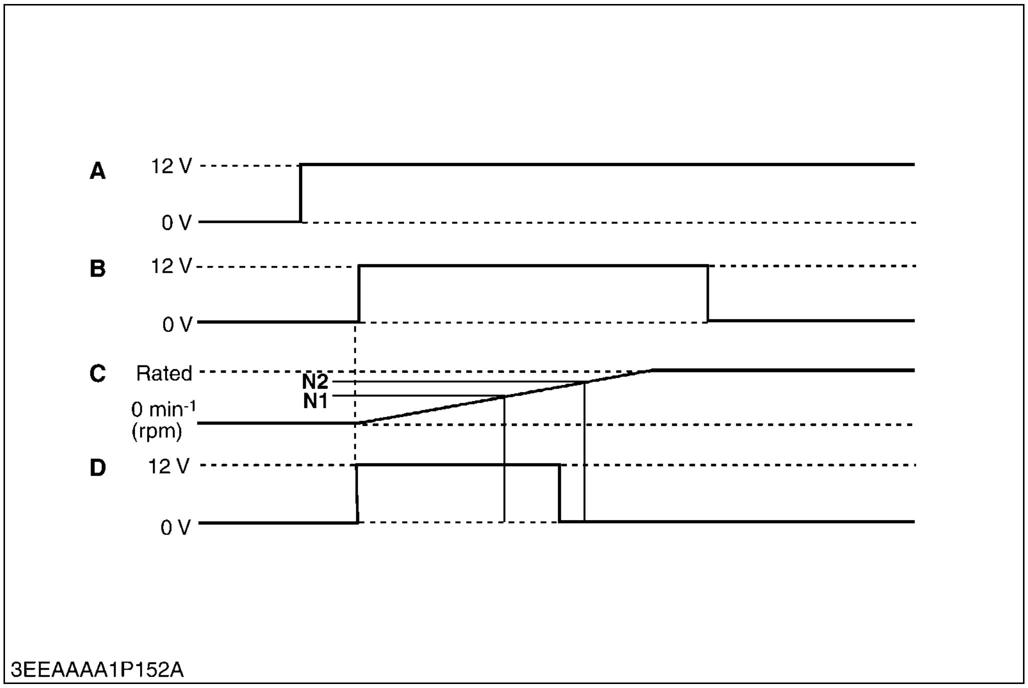
a) While Engine is Running



A : Key Switch AC Terminal (Voltage)
B : Key Switch 50 Terminal (Voltage)
C : Alternator Revolution (min^{-1} (rpm))
D : Starter ST Terminal (Voltage)

W10148070

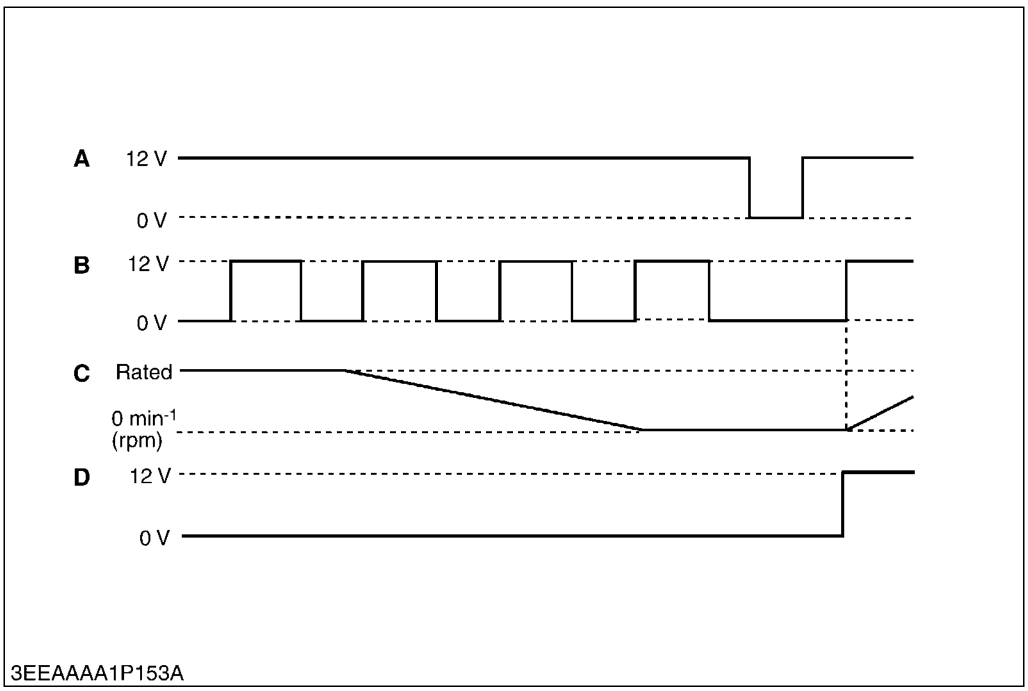
b) When Engine Starts Normally



A : Key Switch AC Terminal (Voltage)
B : Key Switch 50 Terminal (Voltage)
C : Alternator Revolution (min^{-1} (rpm))
D : Starter ST Terminal (Voltage)
N1 :Detection Low rpm (min^{-1} (rpm))
N2 :Detection High rpm (min^{-1} (rpm))

W10149650

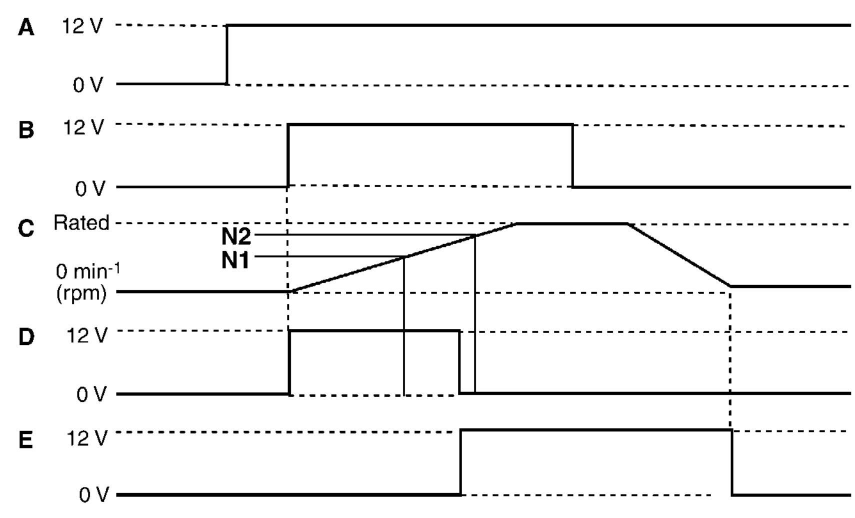
c) When Engine Stalls



A : Key Switch AC Terminal (Voltage)
B : Key Switch 50 Terminal (Voltage)
C : Alternator Revolution (min^{-1} (rpm))
D : Starter ST Terminal (Voltage)

W10150760

d) Output Terminal for Confirming Engine Start



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A : Key Switch AC Terminal (Voltage)
B : Key Switch 50 Terminal (Voltage)
C : Alternator Revolution (min^{-1} (rpm))
D : Starter ST Terminal (Voltage)
E : Output for Confirming Engine Start (Voltage)
N1 :Detection Low rpm (min^{-1} (rpm))
N2 :Detection High rpm (min^{-1} (rpm))

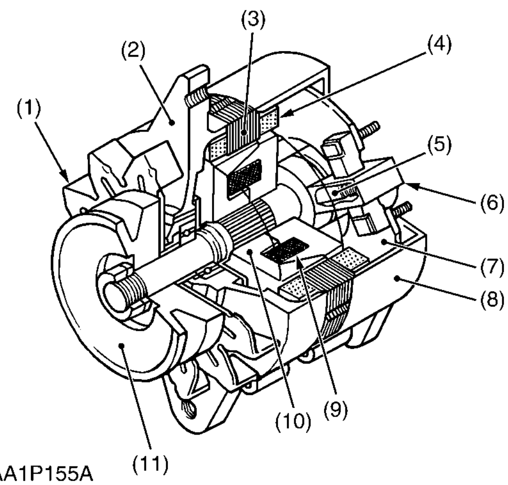
W10152120

[5] CHARGING SYSTEM

The charging system consists of a charging unit, a regulator and others. Kubota engines are used three types of charging unit.

(1) Alternator
(2) Alternator with IC Regulator
(3) AC Dynamo

(1) Alternator



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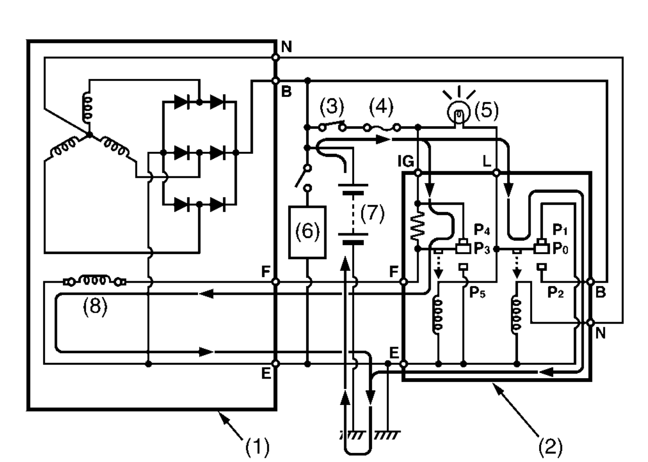
The alternator generates 3-phase current at a fixed coil by the rotation of a rotor, which is then emitted as full-wave rectified current by a diode. The alternator can generate power at all speeds from low to high.

(1) Fan
(2) Drive End Frame
(3) Stator Core
(4) Stator Coil
(5) Brush
(6) Brush Holder
(7) Rectifier
(8) Rear End Frame
(9) Rotor Coil
(10) Rotor
(11) Pulley

W10514030

1) Operation of charging system



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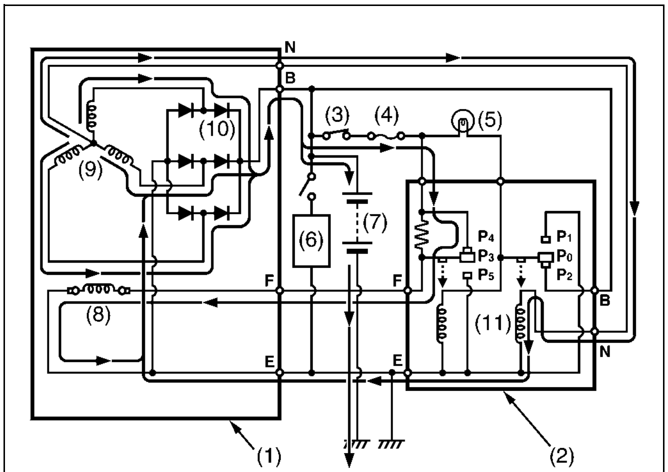
■ When Main Switch Is Turned to “ON” Position

When the main switch (3) is turned to the **“ON”** position, the battery voltage causes two flows of the current. As one of the flows, the current passes from the terminal **“IG”** of the regulator (2) through the contacts **“P_4”** and **“P_3”** and flows into the alternator's rotor coil (8) from the terminal **“F”** thus magnetizing the rotor core. Then, it flows to the ground through the terminal **E**. The other flows from the charge lamp (5) to the ground through the contacts **“P_0”** and **“P_1”** and lights the charge lamp (5).

(1) Alternator
(2) Regulator
(3) Main Switch
(4) Fuse
(5) Charge Lamp
(6) Load
(7) Battery
(8) Rotor Coil

W10522350



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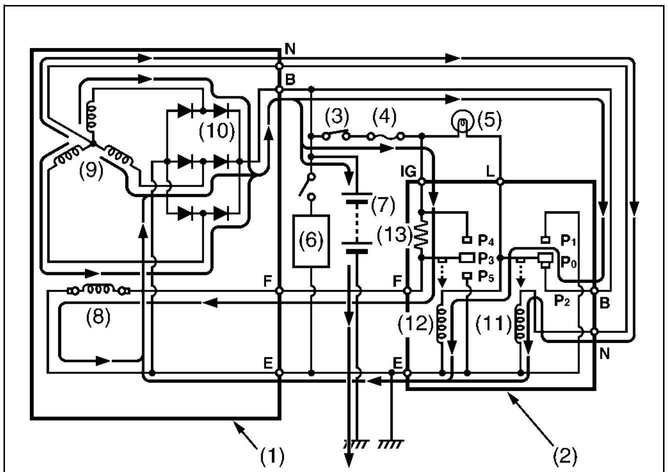
■ When Engine Starts

When the engine is running, three-phase current is generated at stator coil (9) and this is rectified by diode (10). In this situation, if the voltage is higher than the battery voltage, charging is done from terminal **“B”**.

Simultaneously, the **“N”** terminal voltage is applied to pressure coil (11) and when the operating voltage is reached, contact **“P_0”** is drown to **“P_2”** side and charge lamp (5) gone out.

(1) Alternator
(2) Regulator
(3) Main Switch
(4) Fuse
(5) Charge Lamp
(6) Load
(7) Battery
(8) Rotor Coil
(9) Stator Coil
(10) Diode (Rectifier)
(11) Pressure Coil

W10524000



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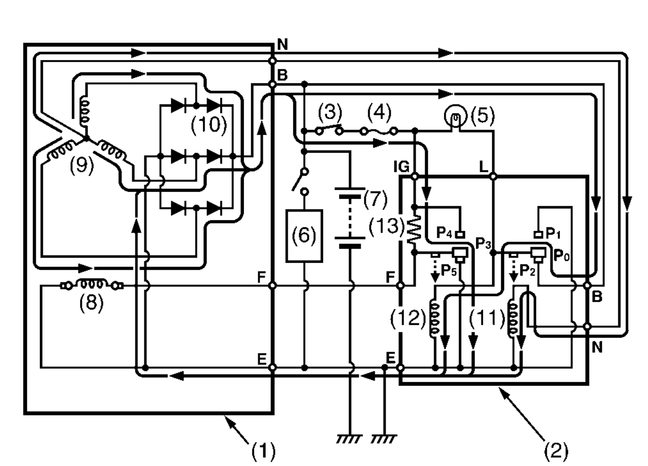
■ When Battery Voltage Rises

When the alternator speed increases and the voltage at the terminal **“B”** rises, the voltage coil (12) is excited, and contact **“P_3”** is attracted toward the **P_5** side and held midway between them. In this case, the rotor coil (8) and control resistance (13) are series-connected, so that the current flowing into the rotor coil is reduced. Thus, the rotor's magnetic force is reduced and the generated voltage drops.

When the battery voltage drops, it causes the voltage coil current to decrease and the magnetic force of the voltage coil becomes small, and closes contacts **"P_3"** and **“P_4”** again, thus increasing the magnetic force of the rotor coil to raise the generated voltage. The operation above is repeated to maintain the generated voltage at a constant level.

(1) Alternator
(2) Regulator
(3) Main Switch
(4) Fuse
(5) Charge Lamp
(6) Load
(7) Battery
(8) Rotor Coil
(9) Stator Coil
(10) Diode (Rectifier)
(11) Pressure Coil
(12) Voltage Coil
(13) Control Resistance

W10528690



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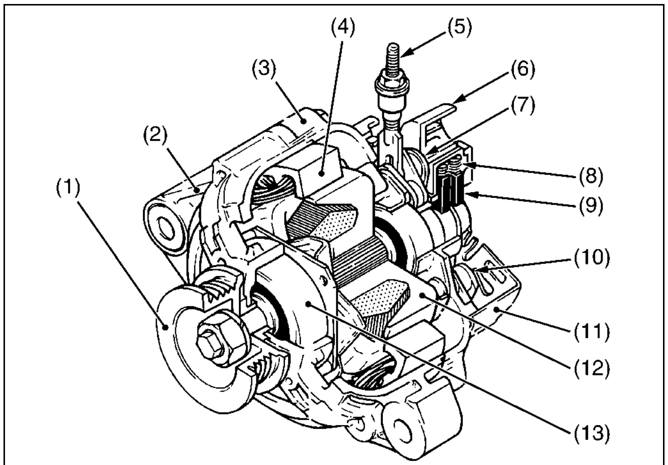
■ Prevention of Overcharging

As the battery approaches full charge, the attraction force of voltage coil (12) increase, contact **"P3"** connects with **"P5"** and current is directly earthen by passing through control resistance (13), consequently, current flowing to rotor coil (8) decrease further and stable voltage is maintained.

(1) Alternator
(2) Regulator
(3) Main Switch
(4) Fuse
(5) Charge Lamp
(6) Load
(7) Battery
(8) Rotor Coil
(9) Stator Coil
(10) Diode (Rectifier)
(11) Pressure Coil
(12) Voltage Coil
(13) Control Resistance

W10527580

(2) Alternator with IC Regulator



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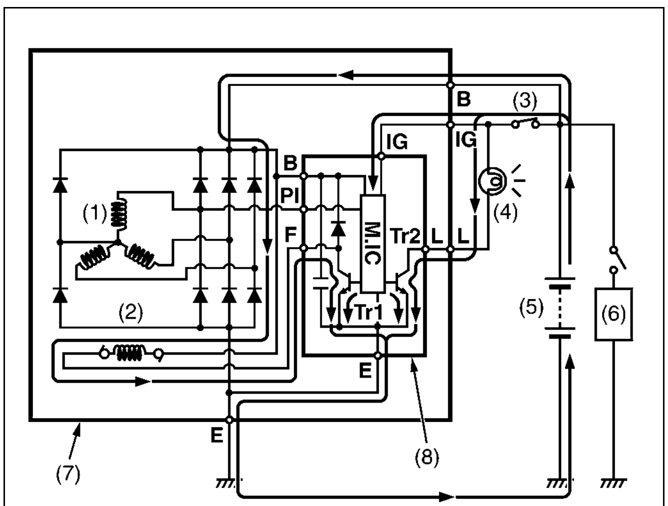
A compact alternator with an IC regulator is used, having the following characteristics :

- Cooling performance and safety have been improved by combining the cooling fan with the rotor and incorporating the fan / rotor unit inside the alternator.
- IC regulator is fitted inside the alternator.
- The rectifier, IC regulator and similar components are easy to remove, making it easier to service the alternator.

(1) Pulley
(2) Drive End Frame
(3) Rear End Frame
(4) Stator
(5) Terminal
(6) Connector
(7) IC Regulator
(8) Spring
(9) Brush
(10) Rectifier
(11) Rear End Cover
(12) Rotor
(13) Bearing

W10516970

1) Operation of charging system



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■ When Main Switch Is Turned to "ON" Position

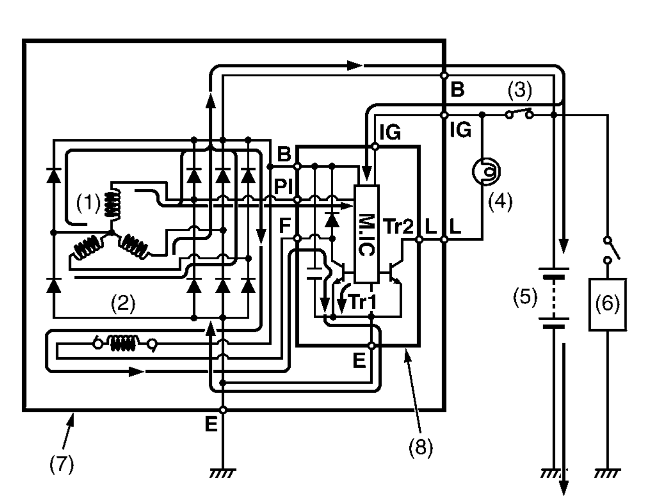
As the battery voltage is added to the terminal **IG**, **M.IC** circuit detects it and makes current pour to the **Tr1**. It results to pour the initial exciting current to the rotor coil (2). (In this case, **M.IC** circuit makes current pour on and off the **Tr1** in pulse and limits the battery discharging current to small value (Approx. 0.17 A) when the main switch (3) is turned on.)

As the alternator (7) is not rotated, it doesn't generate. Therefore the voltage of terminal **PI** is zero volt. **M.IC** circuit detects it and makes current pour to the **Tr2**. It results light on the charge lamp (4).

(1) Stator Coil
(2) Rotor Coil
(3) Main Switch
(4) Charge Lamp
(5) Battery
(6) Load
(7) Alternator
(8) IC Regulator

M.IC : Monolithic IC
Tr1 : Transistor
Tr2 : Transistor

W10537420



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■ When Engine Starts

When the engine starts and the alternator (7) rotates, **M.IC** circuit makes current pour continuously to the **Tr1** instead of the uncontinuous (in pulse) current. Therefore a sufficient exciting current flows and a generated voltage rises rapidly. As a result, the current to the **Tr2** is shut and lights off the charge lamp (4).

When terminal **B** voltage rises over the battery voltage, a charged current flows to the battery (5).

When the terminal **B** voltage further rises over the regulated voltage (14.2 to 14.8 V : 25 °C, 77 °F), **M.IC** circuit shuts the current to the **Tr1**. Therefore the current to the rotor coil is shut, resulting to decrease the terminal **B** voltage.

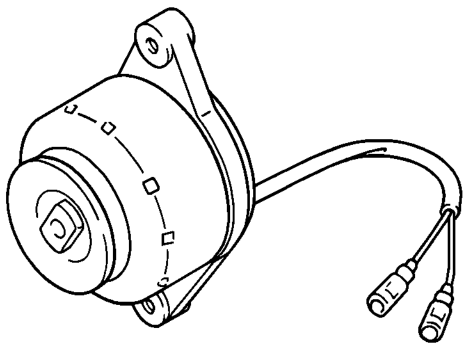
When the terminal **B** voltage lowers below the regulated voltage, the **Tr1** turns on again and makes current pour to the rotor coil.

(1) Stator Coil
(2) Rotor Coil
(3) Main Switch
(4) Charge Lamp
(5) Battery
(6) Load
(7) Alternator
(8) IC Regulator

M.IC : Monolithic IC
Tr1 : Transistor
Tr2 : Transistor

W10540860

(3) AC Dynamo



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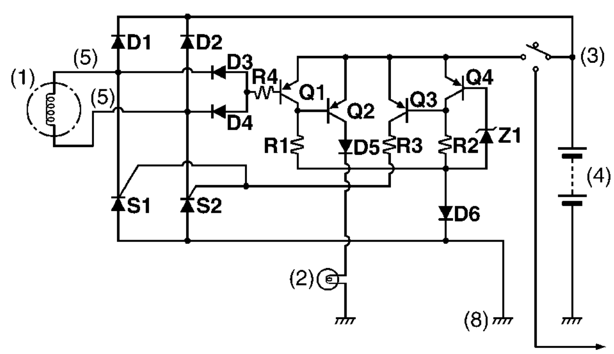
This dynamo is 8-8 pole rotating magnet type generator. It is simple in construction, consisting of a stator and rotor. The rotor is made up of eight permanent magnet pole pieces assembled on a shaft and rotates on the center of the stator around which eight electromagnetic coils are provided for. This dynamo produces higher voltage in slow speed rotation, and charges electric current to the battery during engine idling.

W10541980

1) Operation of charging system



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The charging mechanism is described in four sections:

1. When main switch is ON
2. At starting
3. In charging
4. Overcharge protection

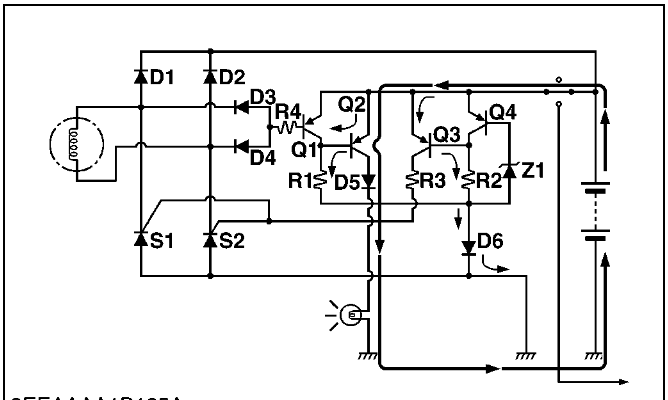
(1) GEN : Magnet type AC generator
(2) LAMP : Charge indication lamp (not included in the basic engine)
(3) Main SW : Main switch (not included in the basic engine)
(4) BATT : Battery (not included in the basic engine)
(5) Blue : GEN connecting terminal
(6) Red : BATT + connecting terminal
(7) Yellow : BATT voltage test terminal
(8) Black : BAT – connecting terminal
(9) Green : LAMP connecting terminal

S1, S2 : Output control / rectification thyristor (SCR)
D1, D2 : Output rectifying diode
D3, D4 : GEN generation detecting diode
D5, D6 : Protection diode for wrong connecting of BATT

Z1 : BATT terminal voltage setting diode
Q1 : GEN generation detecting transistor
Q2 : LAMP on / off transistor
Q3 : Gate current control transistor
Q4 : BATT voltage detecting transistor

W10546940

KiSC issued 03, 2008 A



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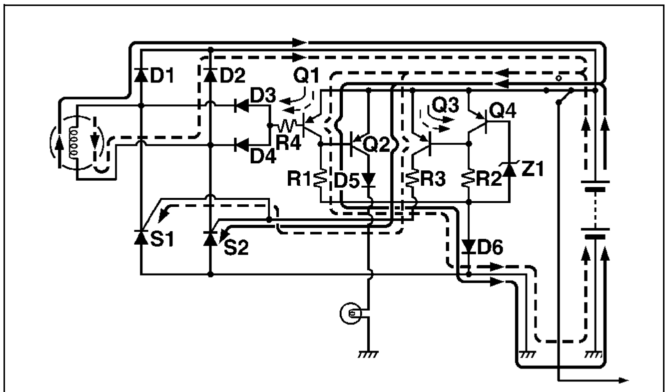
■ When main switch is "ON"

When the engine is at standstill with main switch set at position 1, the circuit functions to light LAMP, as shown in Fig, with main switch at position 1, current flows to base of Q2 through the route of BATT → emitter / base of Q2 → R1 → D6 → BATT and collector of Q2 is then turned on.

As a result, current also flows to LAMP though the route of BATT → Emitter / Collector of Q2 → D5 → LAMP → BATT lighting LAMP to indicate that charging is not carried out.

At this time, though current flows to base of Q3 through the route of BATT → emitter / base of Q3 → R2 → D6 → BATT, collector of Q3 has no current because GEN is stationary.

W10556030



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■ At starting

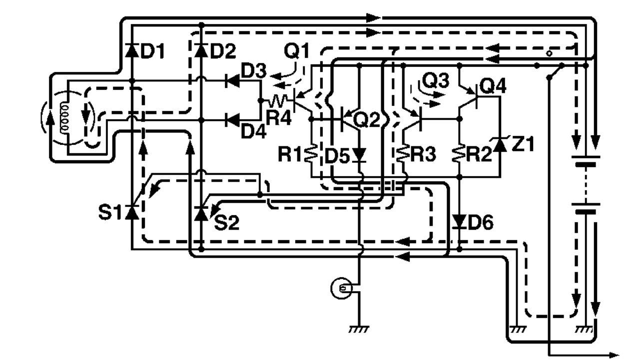
When main switch is turned to position 2, coil of starter relay is energized and starter starts engine.

GEN also starts generation for charging and LAMP is turned off.

In detail, with GEN starting, current flows to base of Q1 through the route of → D1 → emitter / base of Q1 → R4 → D4 → GEN, or GEN -- → D2 -- → emitter / base of Q1 -- → R4 -- → D3 -- → GEN, and therefore current also flows through Q1, shortcircuiting emitter and base of Q2.

As a result, base current of Q2 is interrupted, Q2 is turned off and accordingly current to LAMP is also interrupted.

W10557580



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■ **In charging**

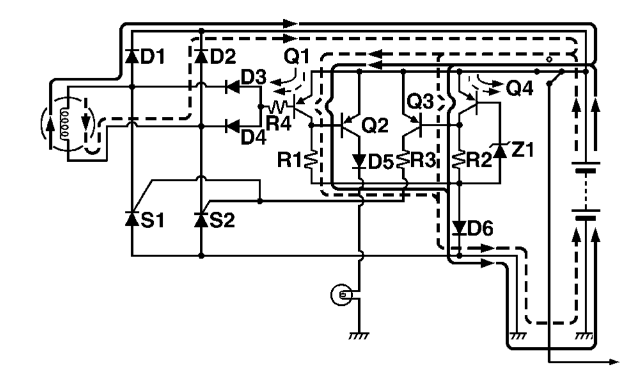
Because BATT terminal voltage just after engine start is lower than setting value (14 to 15V), or lower than zener lever of Z1, current is not supplied to base of Q4 and Q4 is off, as shown in figure. Q3 is on is on with base current which flows through the route of BATT --→ emitter / base of Q3 --→ R2 --→ D6 --→ BATT, and gate current is supplied to S1 or S2 through the route of GEN → D1 → emitter / collector of Q3 → R3 → gate / cathode of S2 → GEN, or GEN -- → D2 -- → emitter / collector of Q3 -- → R3 -- → gate / cathode of S1 -- → GEN.

When engine speed is increased so that GEN generation voltage becomes higher than BATT terminal voltage S1 or S2 is turned on and, as shown in figure, charge current is supplied to BATT through the route of GEN → D1 → BATT → anode / cathode of S2 → GEN, or GEN -- → D2 -- → BATT -- → anode / cathode of S1 -- → GEN.

After S1 or S2 is turned on, collector current of Q1 and base current of Q3 are supplied by GEN, not BATT.

When main switch is returned to position 1 after engine is started, BATT is changed, if BATT terminal voltage is lower than the setting value, or zener level of Z1.

W10559260



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■ **Overcharge protection**

When BATT terminal voltage is higher than the setting value or zener level of Z1, BATT is not charged by the function of circuit as shown in figure.

That is, Q4 is on with base current which flows through the route of BATT --→ emitter / base of Q4 -- → Z1 --→ D6 --→ BATT, shortcircuiting emitter and base of Q3.

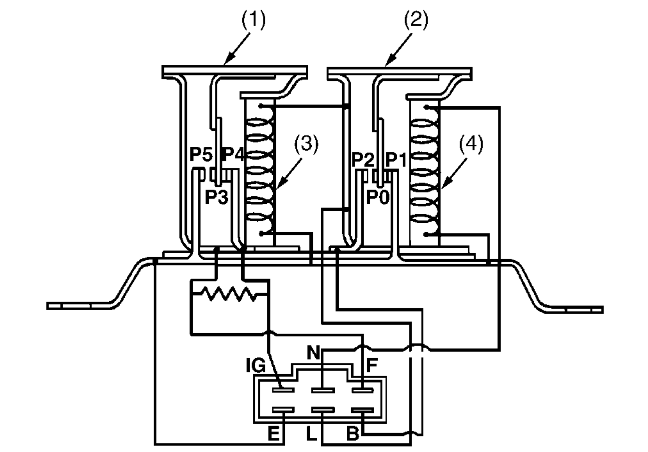
Therefore, Q3 is off with no base current and gate current is not supplied to S1 and S2.

Consequently S1 and S2 are off and BATT is not charged.

W10280370

(4) Regulator

1) Voltage regulator (Contact point type)



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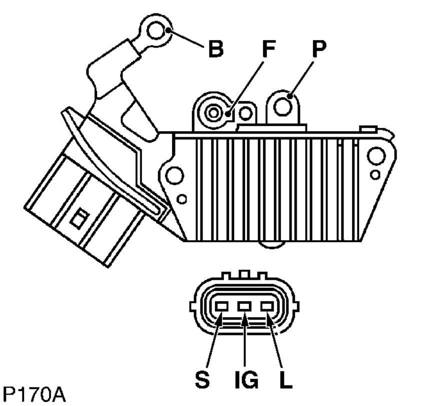
The generated voltage in alternator varies with engine speeds. And the alternator tends to increase its output. Then, the generating voltage is limited by the regulator.

This 2-element, 2-contact regulator consists of a voltage regulator (1) and a voltage relay (2), which have two sets of contact points. The features of this regulator are its stable voltage regulation function over an extremely wide alternator speed range, and its extended contact point life.

(1) Voltage Regulator
(2) Voltage Relay (Charge Lamp Relay)
(3) Voltage Coil
(4) Pressure Coil

W10519680

2) IC regulator



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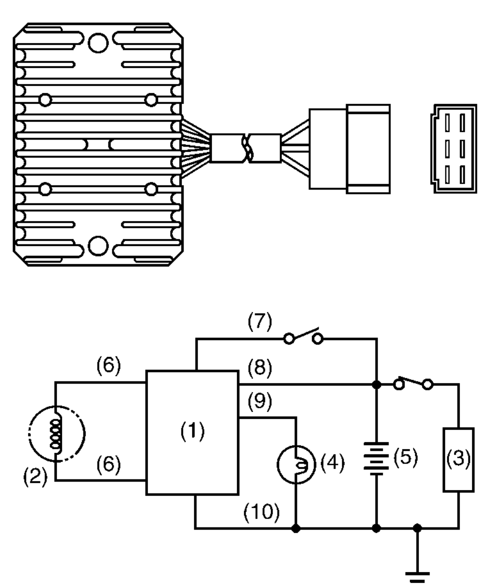
An IC regulator uses solid state transistors, chips or other semiconductor elements instead of the relays in a conventional regulator.

Stable characteristics are achieved by cutting off the field current.

B : B Terminal
F : F Terminal
P : P Terminal
S : S Terminal
IG : IG Terminal
L : L Terminal

W10521010

3) Regulator for AC dynamo



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The regulator performs rectification and voltage regulation. The regulator converts AC into DC which flows through the power consuming circuits and the battery, and also charges the battery.

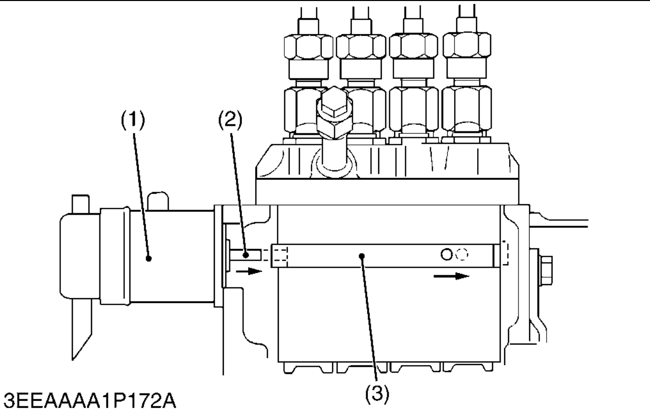
If however, the battery voltage exceeds a certain level, the DC current is cut off from the charging circuit to prevent overcharging.

(1) Regulator
(2) Dynamo
(3) Load
(4) Charge Lamp
(5) Battery
(6) Blue Lead
(7) Yellow Lead
(8) Red Lead
(9) Green Lead
(10) Black Lead

W10543920

[6] ELECTRICAL EQUIPMENT

(1) Stop Solenoid



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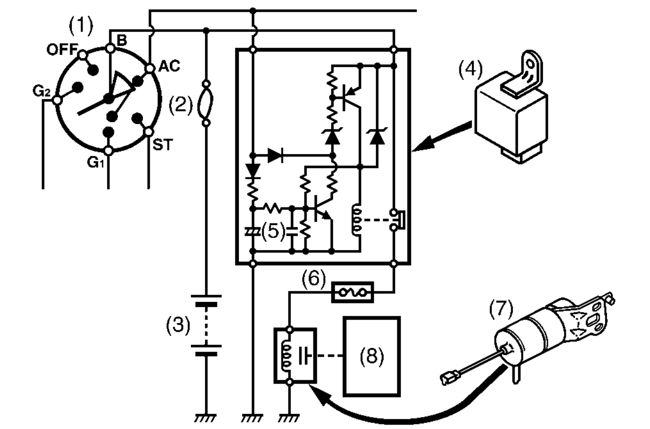
Flowing of the battery current into the stop solenoid (1), the plunger (2) move to left side so that the movement of control rack becomes free, when the battery current stops, the plunger (2) is returned to the original position by the spring to keep the control rack (3) in **"No fuel injection"** position.

(1) Stop Solenoid
(2) Plunger
(3) Control Rack

W10246760



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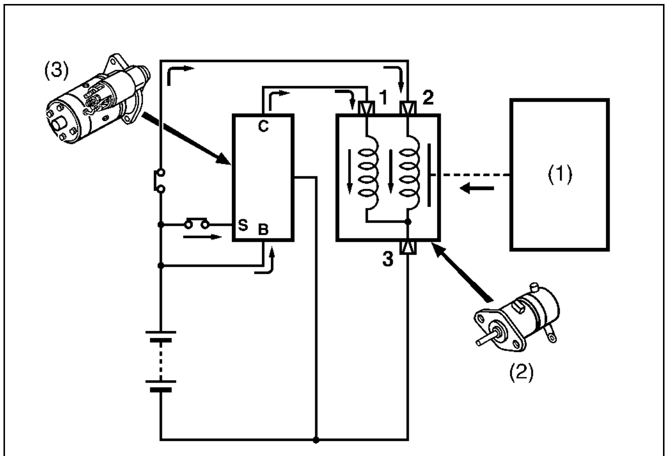
■ **Energized-to-stop Type**

The timer relay capacitor stores a certain quantity of electricity while the engine is running. Just when the main switch (1) has turned off to stop the engine, this capacitor starts discharging the current for about 10 seconds. During this discharging period only, the current flows in this route from battery (3), main switch (1), timer relay (4), stop solenoid (7) to grounding circuit. Ten second later, the timer circuit is shut off to keep the battery (3) against an over discharge.

(1) Main Switch
(2) Fusible Link
(3) Battery
(4) Timer Relay
(5) Condenser
(6) Fuse
(7) Stop Solenoid
(8) Injection Pump

W10247100



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■ **Energized-to-run Type**

Set the main switch to the **"START"** position, and the current starts flowing from the main switch **AC** terminal to the holding coil, which is excited. When the starter's main contact closes itself, the current goes from the starter's **C** terminal to the pull-in coil, which is excited.

In this way, the plunger spring is overwhelmed and then the plunger is drowning in.

Set the main switch to the **"ON"** position, and the engine starts.

When there is no current flowing from the starter's **C** terminal, the pull-in coil is not excited any longer.

But the plunger must be kept drawn in. To do this the holding coil is still excited by the current flowing from the **AC** terminal.

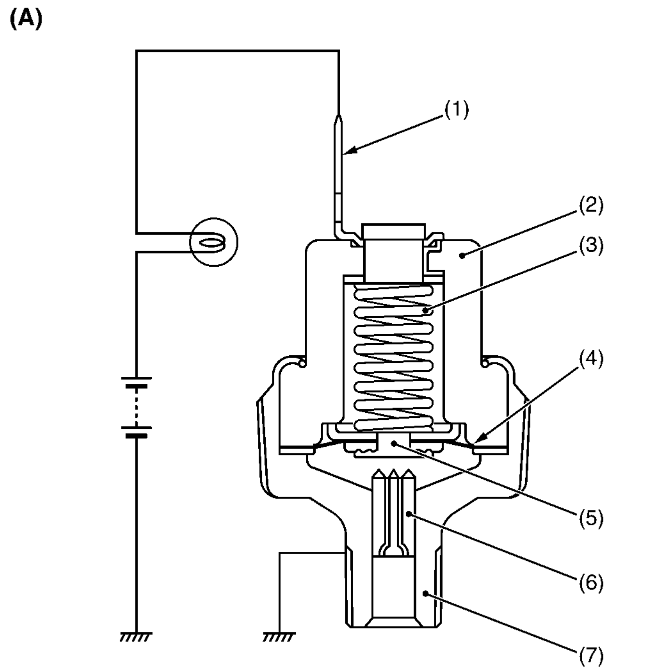
Set the main switch to the **"OFF"** position and current flowing into the holding coil is shut off. Now the plunger pops out by its spring force.

Thus injection pump rack is pushed in, thereby setting the fuel injection to zero and stopping the engine.

(1) Injection Pump
(2) Stop Solenoid
(3) Starter

W10250420

(2) Oil Pressure Switch



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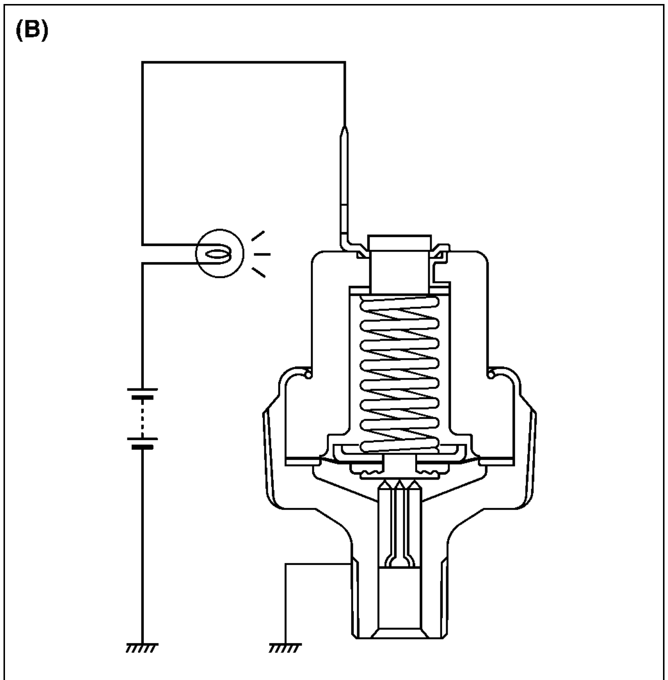

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The oil pressure switch is mounted on the cylinder block and is led to the lubricating oil passage.

When the oil pressure falls below the specified value, the oil pressure-warning lamp lights.

(A) At the proper oil pressure

When the engine is started and as the proper oil pressure builds, the diaphragm (4) is pushed up. This separates the contact rivet (5) and breaks the circuit, causing the lamp to go out.

(B) At lower oil pressure, 49 kPa (0.50 kgf/cm^2, 7.1 psi) or less

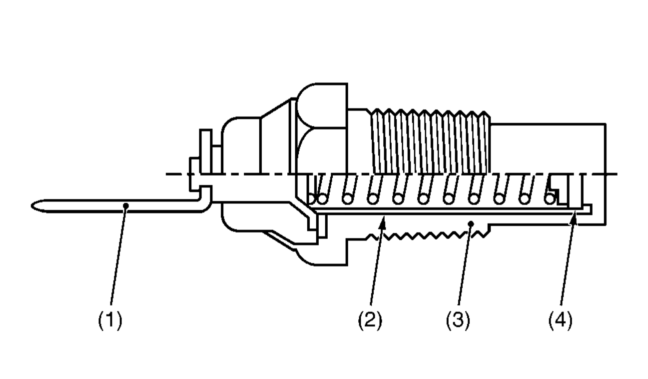
If the oil pressure drops, the resulting deflection of the diaphragm (4) will close the contact rivet (5) and again complete the circuit. The lighted lamp warns that the pressure of the lubricating system has dropped below the pressure setting.

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

(A) At Proper Oil Pressure
(B) At Lower Oil Pressure

W10252170

(3) Coolant Temperature Sensor



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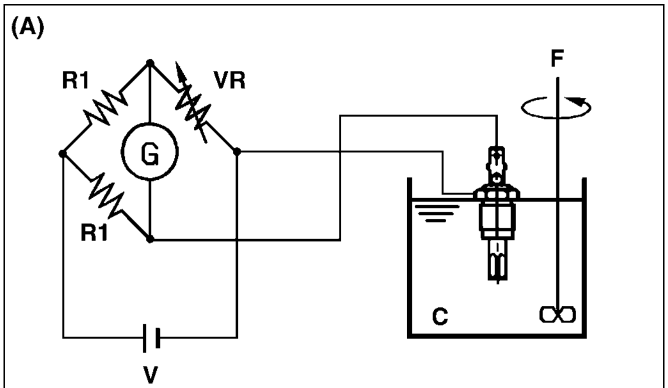

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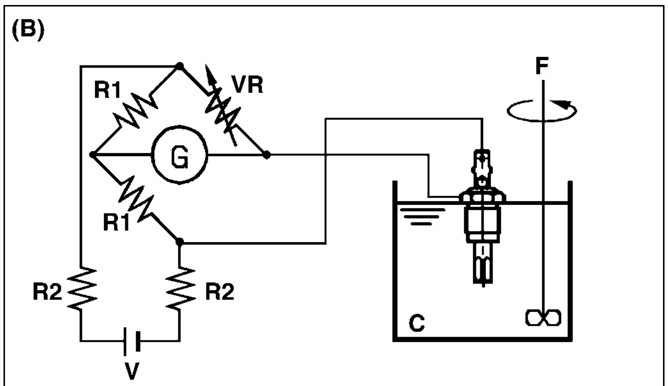

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The coolant temperature sensor is installed to the cylinder head of engine, and its tip is in touch with the coolant. It contains a thermistor (4) whose electrical resistance decreases as the temperature increases.

Current varies with changes in the coolant temperature, and the increases or decreases in the current move the pointer of gauge.

Characteristics of Thermistor			
Code Number	**Temperature**	**Resistance of VR**	**Condition**
15193-83041 1K411-83041	50 °C (122 °F)	80.0 Ω	a
	80 °C (176 °F)	29.5 Ω	
	100 °C (212 °F)	16.5 Ω	
	120 °C (248 °F)	10.0 Ω	
17154-83041	60 °C (140 °F)	80.0 Ω	a
	80 °C (176 °F)	40.6 Ω	
	100 °C (212 °F)	22.2 Ω	
	125 °C (257 °F)	11.3 Ω	
31351-32831 38240-32831	50 °C (122 °F)	153.9 Ω	b
	80 °C (176 °F)	51.9 Ω	
	100 °C (212 °F)	27.4 Ω	
	120 °C (248 °F)	16.1 Ω	
32330-32831	35 °C (95 °F)	670 Ω	c
	80 °C (176 °F)	118 Ω	
	105 °C (221 °F)	54.5 Ω	
	115 °C (239 °F)	42.5 Ω	
35820-75251	50 °C (122 °F)	153.9 Ω	b
	80 °C (176 °F)	51.9 Ω	
	115 °C (239 °F)	18.5 Ω	
	120 °C (248 °F)	16.1 Ω	

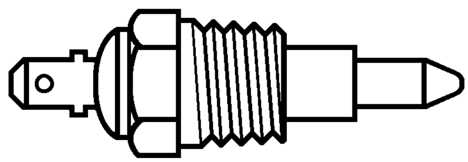
Condition	Circuit	Setting Value
a	**(A)**	R1 : 44.955 to 45.045 Ω V : DC 7.9 to 8.1 V G : 0 μA
b	**(A)**	R1 : 54.945 to 55.055 Ω V : DC 6.9 to 7.1 V G : 0 μA
c	**(B)**	R1 : 169.29 to 172.71 Ω R2 : 142.56 to 145.44 Ω V : DC 25.9 to 26.1 V G : 0 μA

(1) Terminal
(2) Insulator
(3) Body
(4) Thermistor

C : Coolant or Silicon Oil
G : Galvanometer
VR: Variable Resistor
F : Flow Velocity (0.14 to 0.15 m/s)

W10549050

(4) Coolant Temperature Switch



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The coolant temperature switch is installed to the cylinder head of engine, and its tip is in touch with the coolant.

The warning lamp lights when the coolant temperature goes up more tnan the specified value.

When the coolant temperature falls below the specified value, the warning lamp is turned off.

Characteristics of Coolant Temperature Switch

Code Number	Type	Operation Temperature	
		Lamp "ON"	Lamp "OFF"
15181-83042	Normally open	105 °C (221 °F)	98 °C (208 °F)
15436-83041 15543-83041 16222-83041 17538-83041	Normally open	115 °C (239 °F)	108 °C (226 °F)
15661-83041	Normally closed	113 °C (235 °F)	106 °C (223 °F)
16851-83041	Normally open	123 °C (253 °F)	116 °C (241 °F)
19026-83041 19704-83041	Normally closed	110 °C (230 °F)	103 °C (217 °F)
19031-83041	Normally open	97 °C (207 °F)	90 °C (194 °F)
19498-83041	Normally open	110 °C (230 °F)	104 °C (219 °F)

W11236190

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