SERVICE MANUAL

MODEL
SD22 & SD33
DIESEL ENGINE

NISSAN

NISSAN MOTOR CO., LTD.
TOKYO, JAPAN

SECTION EF

ENGINE FUEL SYSTEM

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CONSTRUCTION AND OPERATION

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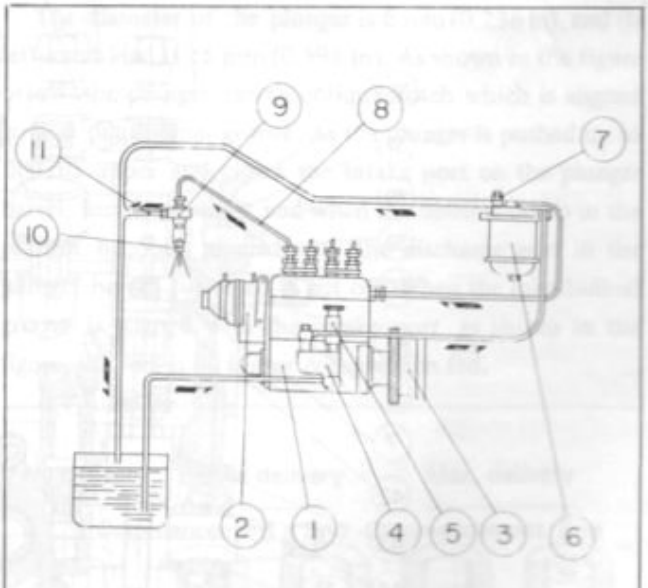
FUEL INJECTION SYSTEM

The fuel injection pump is the most important part of the engine. Through the action of the governor and timer, it serves to properly feed highly pressurized fuel, in the required amount and at the right time to the combustion chamber, depending upon the conditions under which the engine is being operated.

The bosch fuel injection pump is used on both the SD22 and SD33 engines. The fuel feed system is as shown below:

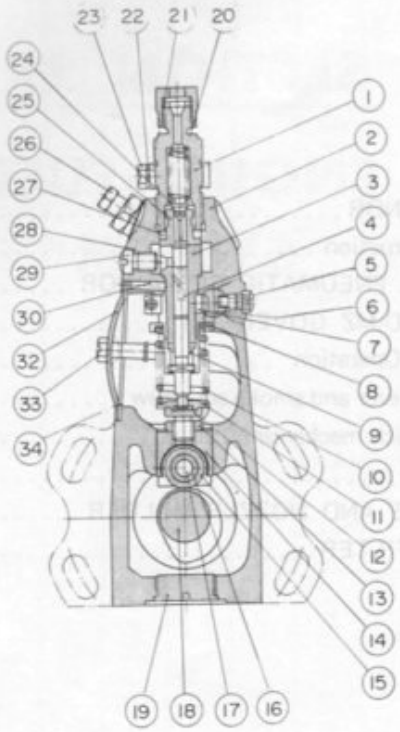
Fuel tank → Feed pump (pumps the fuel from the tank to the fuel filter) → Fuel filter (filters the fuel and adjusts fuel to a constant volume, returning surplus fuel to the fuel tank through the overflow valve on the top of the filter) → Plunger (forces the prescribed amount of fuel into the nozzle) → Delivery valve → Nozzle (injects the fuel under constant injection starting pressure into the cylinder for combustion). The slight amount of fuel accumulating in the fuel injection pump returns through the fuel spill tube, along with the surplus fuel in the fuel filter, to the fuel tank.



1	Fuel injection pump	7	Overflow valve
2	Governor	8	Nozzle pipe
3	Timer	9	Nozzle holder
4	Feed pump	10	Nozzle
5	Priming pump	11	Fuel spill tube
6	Fuel filter		

Fig. EF-1 Fuel injection system

FUEL INJECTION PUMP



1	Delivery valve holder	30	Pin
2	Pump housing	31	Cap
3	Plunger barrel	32	Plate cover
4	Plunger	33	Cover screw
5	Rack guide screw	34	Gasket
6	Control rack	35	Air breather assembly
7	Control pinion	36	Governor housing
8	Upper spring seat	37	Screw plug
9	Control sleeve	38	Spring eye
10	Plunger spring	39	Washer
11	Lower spring seat	40	Set screw
12	Adjusting bolt	41	Control rack
13	Lock nut	42	Control pinion clamp screw
14	Tappet	43	Tappet guide
15	Roller	44	Tapered roller bearing
16	Roller bushing	45	Oil seal
17	Roller pin	46	Adjusting shim
18	Camshaft	47	Distance ring
19	Screw plug	48	Connector bolt
20	Delivery valve spring	49	Nipple
21	Lock plate	50	Check valve (out)
22	Lock washer	51	Check valve spring
23	Bolt	52	Feed pump housing
24	Delivery valve	53	Piston
25	Delivery valve seat	54	Connector bolt
26	Air bleeder screw	55	Priming pump
27	Delivery valve gasket	56	Drain plug
28	Gasket	57	Bearing cover
29	Screw	58	Oil level gauge

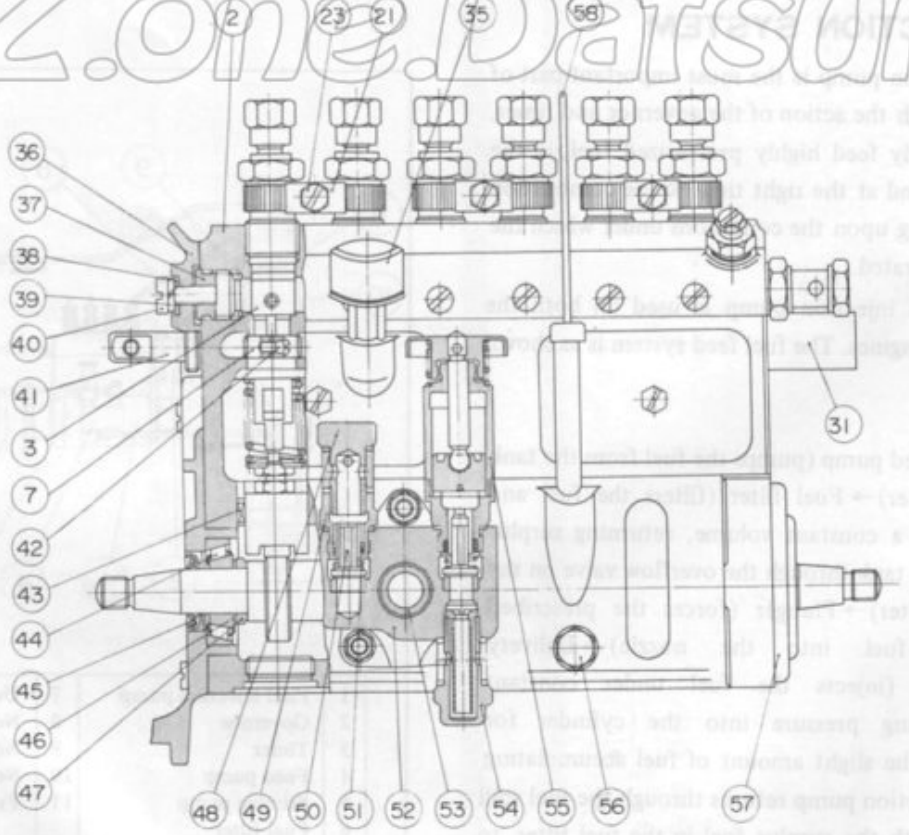


Fig. EF-2 Injection pump for SD33 engine (Injection pump for SD22 engine is identical with the SD33's with to exception of two less plangers)

Construction

The fuel injection pump is equipped with one plunger and one delivery valve for each cylinder.

The plunger is pushed upward by the cam spring force of the plunger spring. It moves vertically within the plunger barrel at a fixed stroke, and fuel is fed as the plunger opens and closes the intake port. The automatic timer, attached (bolted) to the fuel injection pump drive gear, is installed on the drive end of the fuel injection pump housing, with the governor installed on the opposite end and the feed pump installed on the side of the fuel injection pump housing. The camshaft, tappet, plunger, control sleeve, and control rack are contained within the housing.

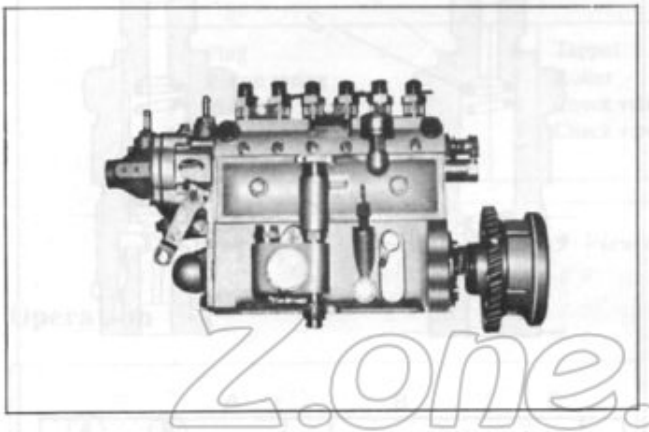


Fig. EF-3 MZ pneumatic governor with injection pump

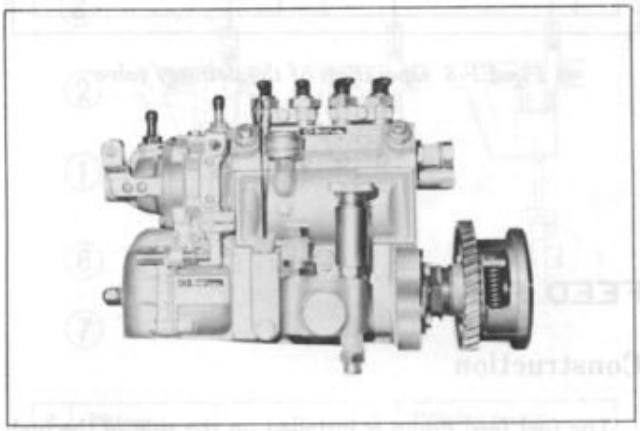


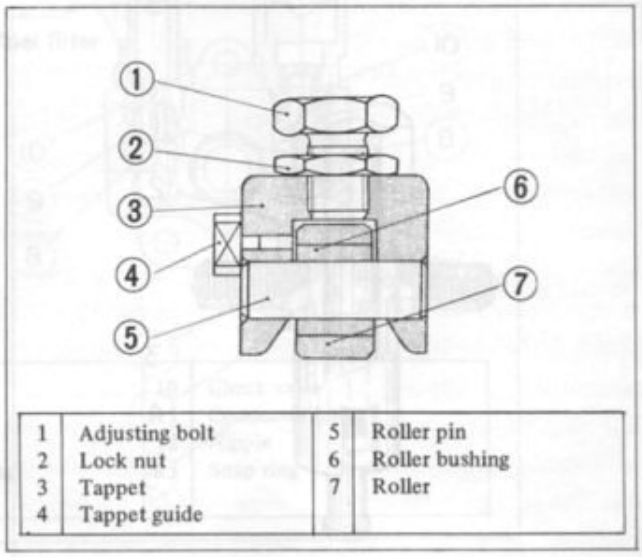
Fig. EF-4 RBD-MZ governor with injection pump

Camshaft

Arc-eccentric (up/down) cams are provided on the camshaft, so as to prevent the tappets from jumping at high-speed operation and to insure proper injection.

Tappets

A roller bushing is provided between the roller pin and the roller. A roller guide is seated in the groove in the injection pump housing to insure that the roller makes proper contact with the cam.



1	Adjusting bolt	5	Roller pin
2	Lock nut	6	Roller bushing
3	Tappet	7	Roller
4	Tappet guide		

Fig. EF-5 Tappet assembly

Plunger

The diameter of the plunger is 6 mm (0.236 in), and its left-hand lead is 15 mm (0.591 in). As shown in the figure below, the plunger has an oblique notch which is aligned with a longitudinal groove. As the plunger is pushed up so that its upper end closes the intake port on the plunger barrel, fuel is expelled, and when the oblique notch in the plunger becomes aligned with the discharge port in the plunger barrel, fuel feed is cut off. When the longitudinal groove is aligned with the intake port as shown in the figure, the fuel is no longer compression fed.

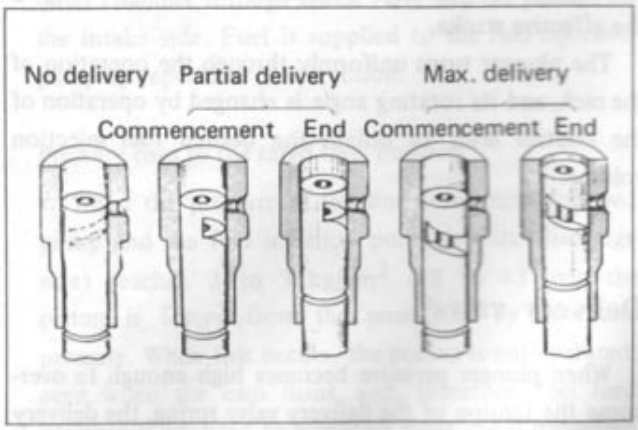
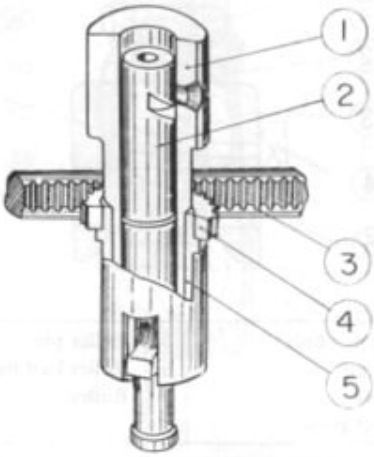


Fig. EF-6 Plunger operation

The volume of fuel injected can be changed by changing the effective stroke of the plunger, by turning the plunger and changing the position of the notch. The figure below shows the injection volume adjusting mechanism.



1	Plunger barrel	4	Control pinion
2	Plunger	5	Control sleeve
3	Control rack		

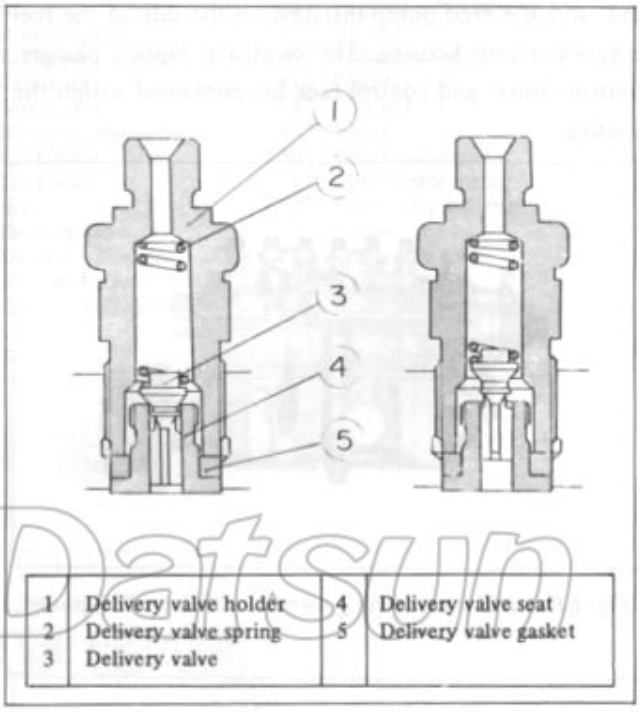
Fig. EF-7 Plunger turning mechanism

In other words, as the control rack is moved to the left or right by operation of the control lever or the governor, the control sleeve engaged with the control rack turns. Since the plunger trunnion shaft fits under the control sleeve, the plunger turns together with the control sleeve. Thus, fuel injection volume can be changed by changing the effective stroke.

The plunger turns uniformly through the operation of the rack, and its rotating angle is changed by operation of the control lever to obtain the desired fuel injection volume.

Delivery valve

When plunger pressure becomes high enough to overcome the tension of the delivery valve spring, the delivery valve is opened and fuel is infused into the nozzle through the nozzle tube. When delivery of the fuel is completed, the delivery valve returns to its seat and is closed by the tension of the delivery valve spring. When this occurs, the fuel in the nozzle tube is withdrawn by the piston on the bottom of the delivery valve seat, thereby momentarily restricting the fuel passing between the delivery valve and the nozzle. Because of the feature, fuel injection from the nozzle is instantaneously and completely cut off to prevent fuel from spurting out after fuel delivery has been completed.



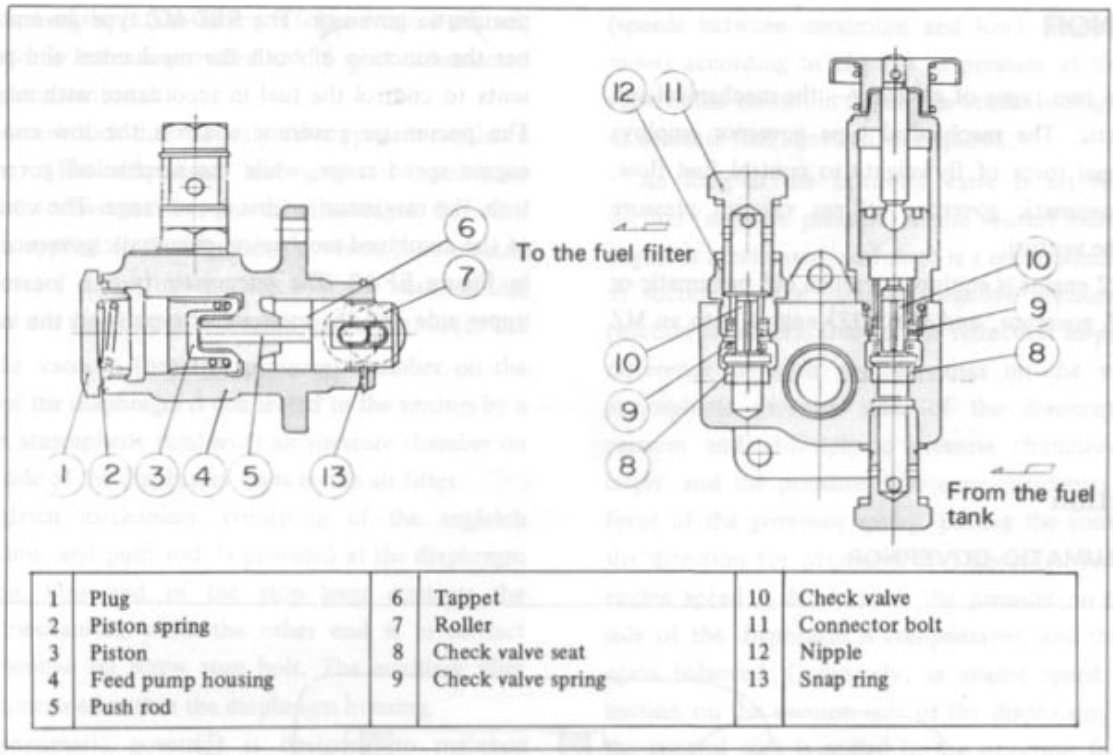
1	Delivery valve holder	4	Delivery valve seat
2	Delivery valve spring	5	Delivery valve gasket
3	Delivery valve		

Fig. EF-8 Operation of the delivery valve

FEED PUMP

Construction

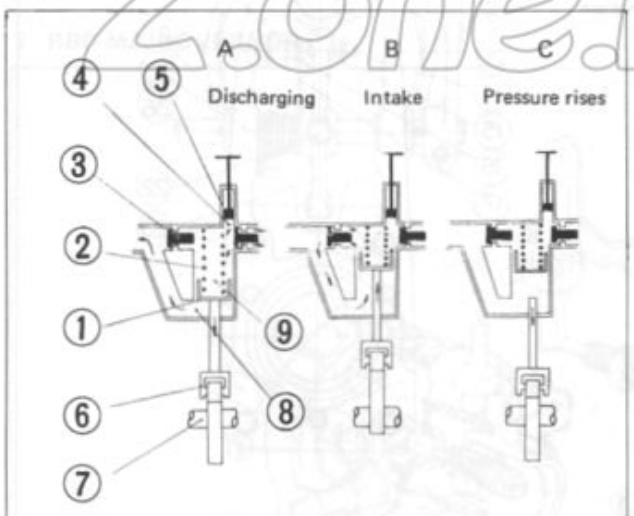
The fuel feed pump is installed on the side of the fuel injection pump and is exclusively driven by the eccentric cam. It is a piston type pump which pumps fuel from the fuel tank to the fuel injection pump through the fuel filter. The fuel feed pump is equipped with a priming pump. By manually operating the priming pump, fuel can be pumped from the fuel tank to the fuel injection pump when the engine is stopped.



1	Plug	6	Tappet	10	Check valve
2	Piston spring	7	Roller	11	Connector bolt
3	Piston	8	Check valve seat	12	Nipple
4	Feed pump housing	9	Check valve spring	13	Snap ring
5	Push rod				

Fig. EF-9 View of the fuel feed pump

Operation



1	Piston	5	Priming pump
2	Piston spring	6	Tappet
3	Check valve (discharge side)	7	Camshaft
4	Check valve (intake side)	8	Outer chamber
		9	Inner chamber

Fig. EF-10 Operation of the fuel feed pump

Discharging position

The piston is depressed by the tension of the piston spring, and the check valve on the discharge side is closed.

Under this condition, the check valve on the intake side is opened, and fuel is drawn into the inner chamber.

The fuel in the outer chamber on the outer side of the piston is simultaneously forced into the fuel injection pump through the oblique passage, the discharge port, and the filter.

Intaking position

The piston is forced up and fuel is taken into the outer chamber through check valve and the passage on the intake side. Fuel is supplied to the fuel injection pump by repetition of this action.

Pressure rises to the rated level position

When the pressure in the line connecting the feed pump and the fuel injection pump (on the discharge side) reaches 2 to 3 kg/cm^2 (28 to 43 psi), the piston is forced from the push rod by hydraulic pressure. When this occurs, the poston is not operated, even when the cam turns, and, therefore, fuel feed pressure is adjusted to a contact value and is prevented from becoming too high.

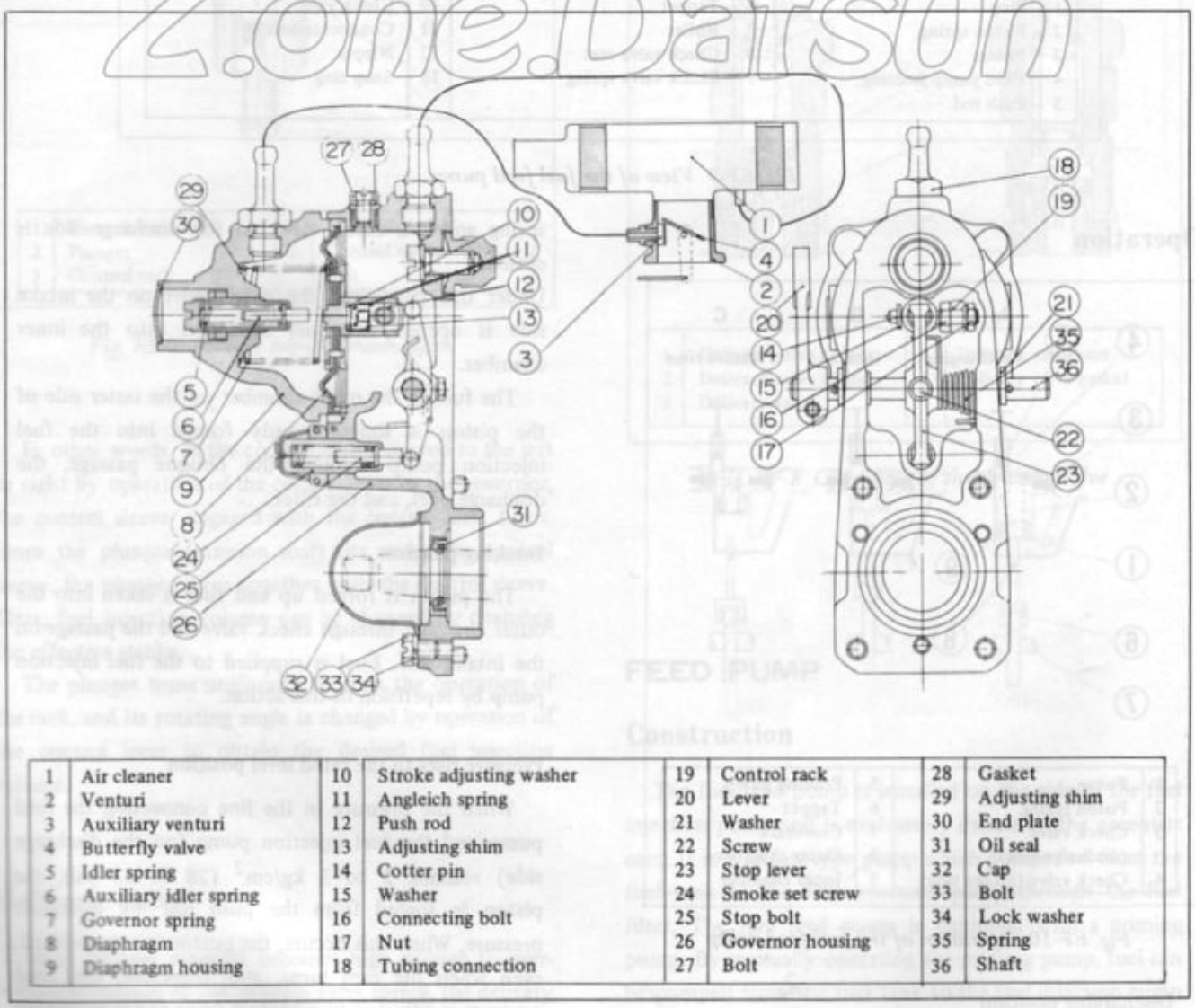
GOVERNOR

There are two types of governor – the mechanical and the pneumatic. The mechanical type governor employs the centrifugal force of flyweights to control fuel flow, and the pneumatic governor utilizes vacuum pressure created in the venturi.

The SD22 engine is equipped with an MZ pneumatic or an RBD-MZ governor, and the SD33 engine with an MZ pneumatic governor. The RBD-MZ type governor combines the function of both the mechanical and pneumatic units to control the fuel in accordance with engine load. The pneumatic governor controls the low and medium engine speed range, while the mechanical governor controls the maximum engine speed range. The construction of the combined mechanical-pneumatic governor is shown in Figure EF-12. The pneumatic type is located on the upper side and the mechanical type is on the lower side.

Construction

1. MZ PNEUMATIC GOVERNOR



1	Air cleaner	10	Stroke adjusting washer	19	Control rack	28	Gasket
2	Venturi	11	Angleich spring	20	Lever	29	Adjusting shim
3	Auxiliary venturi	12	Push rod	21	Washer	30	End plate
4	Butterfly valve	13	Adjusting shim	22	Screw	31	Oil seal
5	Idler spring	14	Cotter pin	23	Stop lever	32	Cap
6	Auxiliary idler spring	15	Washer	24	Smoke set screw	33	Bolt
7	Governor spring	16	Connecting bolt	25	Stop bolt	34	Lock washer
8	Diaphragm	17	Nut	26	Governor housing	35	Spring
9	Diaphragm housing	18	Tubing connection	27	Bolt	36	Shaft

Fig. EF-11 View of the MZ pneumatic governor with venturi

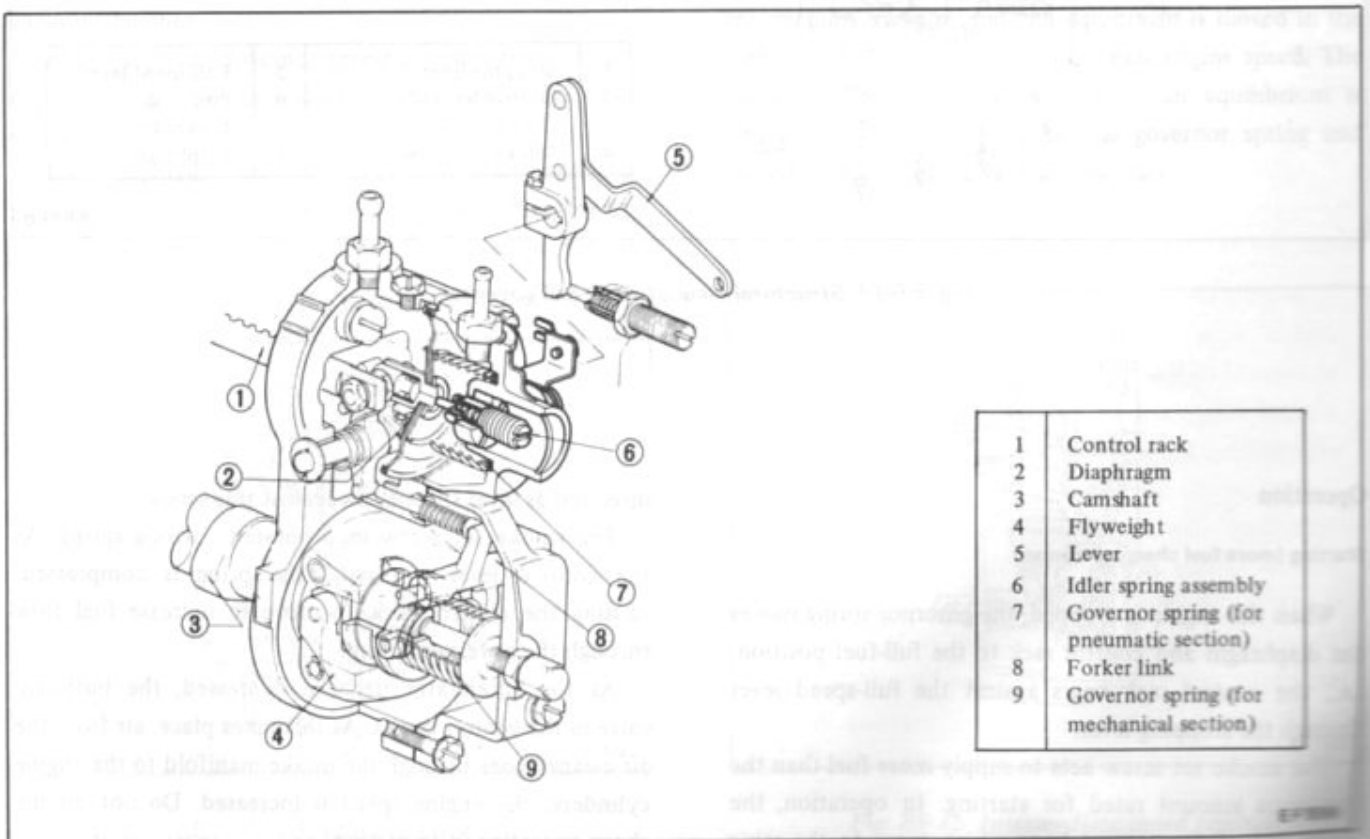
A portion of the intake tubing is formed into a venturi, and a butterfly valve is provided at the most constructed portion of the venturi.
The extent to which this butterfly valve opens is regulated by a lever. The diaphragm and governor housing are separated into two sections by the diaphragm. Constant pressure is applied to this diaphragm, which is connected to the control racks by the force of the main spring, pushing in the direction of increased fuel injection (to the right). The vacuum (negative pressure) chamber on the left side of the diaphragm is connected to the venturi by a tube. The atmospheric (ambient) air pressure chamber on the right side of the diaphragm leads to the air filter.

A angleich mechanism, consisting of the angleich spring, shims, and push rod, is provided at the diaphragm connection. One end of the stop lever contacts the angleich mechanism, while the other end is in contact with the smoke set screw stop bolt. The auxiliary idler spring is contained within the diaphragm housing.

The pneumatic governor is designed to maintain desired speed within a very limited variation, depending upon changes in load and engine speed, not only at low speed and maximum speed, but for all intermediate speeds (speeds between maximum and low). The control rack moves according to changes in pressure at the butterfly valve in the venturi in the engine intake tubing, to increase or decrease fuel injection, as required.

As long as the butterfly valve is set (unchanged), suction (negative pressure) in the venturi increases as the engine is accelerated, and there is a corresponding increase in suction in the vacuum (negative pressure) chamber (suction chamber). Due to this reduction in pressure, the difference between the pressures on the suction and atmospheric pressure sides of the diaphragm (in the vacuum and atmospheric pressure chambers) becomes larger, and the pressure difference overcomes the spring force of the governor spring, pulling the control rack in the direction for decreased fuel injection. As the result, engine speed is decelerated, the pressure on the vacuum side of the diaphragm is compensated, and the system is again balanced. Conversely, as engine speed drops, the suction on the vacuum side of the diaphragm is reduced, the control rack is pulled in the direction for increased fuel injection by the force of the governor spring, and engine speed is accelerated until suction and spring force are again balanced.

2. RBD-MZ GOVERNOR



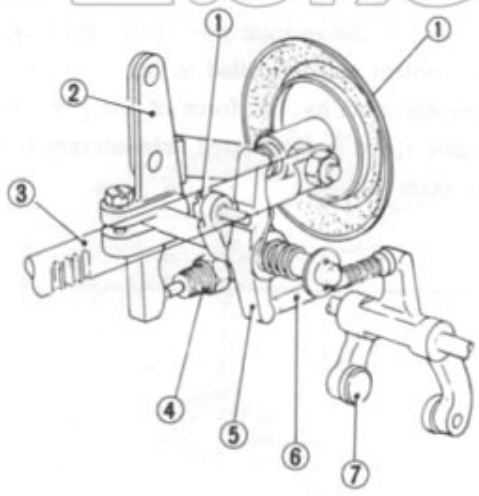
1	Control rack
2	Diaphragm
3	Camshaft
4	Flyweight
5	Lever
6	Idler spring assembly
7	Governor spring (for pneumatic section)
8	Forker link
9	Governor spring (for mechanical section)

Fig. EF-12 RBD-MZ governor

Construction of the RBD-MZ governor is shown diagrammatically in Figure EF-12. The control rack is connected to the rod at the joint secured to the diaphragm with rack connecting bolts. The diaphragm separates the housing into a vacuum and an atmospheric chamber.

The governor spring, built into the vacuum chamber, constantly pushes the control rack toward the "fuel increase" direction through the diaphragm. The idle spring extends from the vacuum chamber through a push rod.

The full-speed lever is located in the atmospheric chamber. The upper part of this lever is attached to the diaphragm rod so that the lever shaft acts as a fulcrum, and the lower part is installed in such a manner that the shaft comes into contact with the push rod which slides in response to the lift of the flyweight. Adjacent to the full-speed lever is a stopping lever which is connected to the full-speed lever through control lever (2) and the lever shaft. The stopping lever pin pushes the upper rear part of the full-speed lever, determining the maximum limit position of the diaphragm. This position is properly adjusted by means of the smoke set screw located at the lower part of the control lever (2). The flyweight is attached to the fuel injection camshaft. The flyweight slider contacts the governor spring (in mechanical section) through the sleeve and spring guide. When the flyweight compresses the governor spring, the guide arm is pushed down. This motion is in turn transmitted to the lower part of the full-speed lever through the forker link.



1	Stopping lever	5	Full-speed lever
2	Control lever (2)	6	Push rod
3	Control rack	7	Forker link
4	Smoke set screw	8	Diaphragm

EF560

Fig. EF-13 Structural view of RBD-MZ governor

Operation

Starting (more fuel charging) control

When the engine is stopped, the governor spring moves the diaphragm and control rack to the full-fuel position; i.e., the control rack bears against the full-speed lever through the stopping lever.

The smoke set screw acts to supply more fuel than the maximum amount rated for starting. In operation, the lower end of the control lever which turns to the same direction as lever shaft bears against this screw.

The smoke set screw incorporates a strong spring. As the control lever is tilted, this spring is compressed, causing the control rack to move to increase fuel flow through the governor spring.

As the accelerator pedal is depressed, the butterfly valve in the venturi opens. As this takes place, air from the air cleaner goes through the intake manifold to the engine cylinders; the engine speed is increased. Do not do the above operation in an attempt to increase its output.

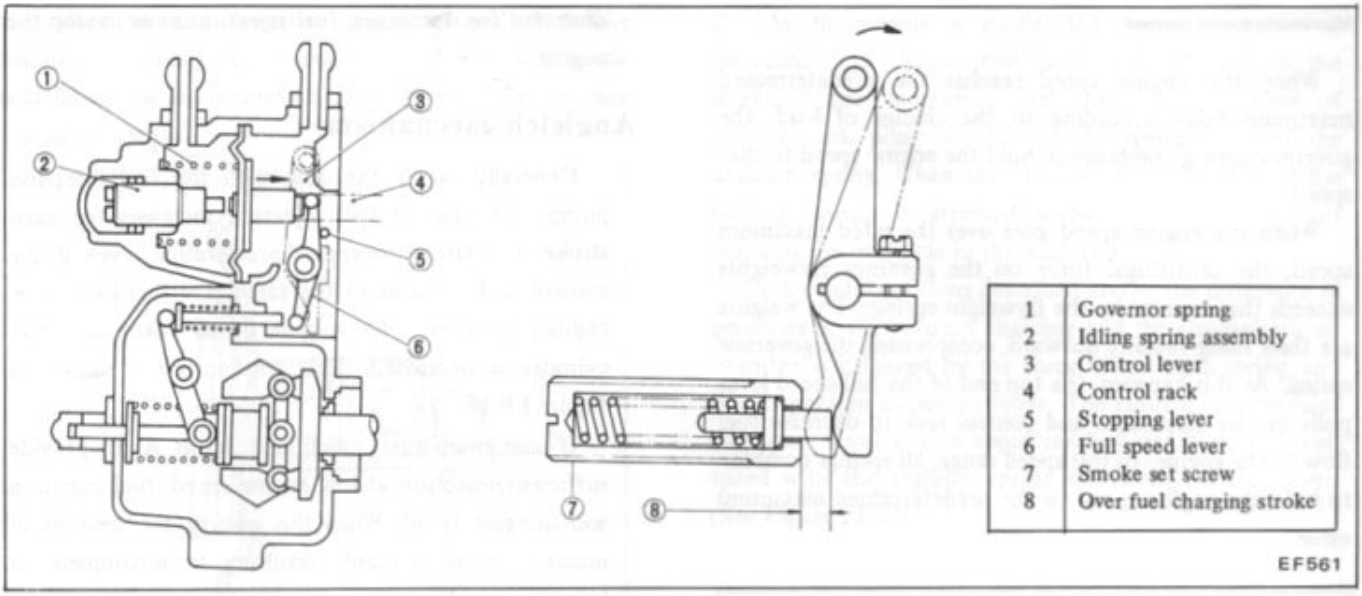


Fig. EF-14 Starting control

Idling control

When the engine starts, the butterfly valve in the venturi will nearly be closed as the accelerator pedal is released. Thus, with the butterfly valve nearly closed, the suction of the cylinders creates a very low pressure in the vacuum chamber.

As a result, the governor spring is compressed, causing the diaphragm to move until it bears against the idling spring.

The diaphragm will be kept stationary when an equilibrium is reached between the force of the governor spring and vacuum pressure in the governor vacuum chamber.

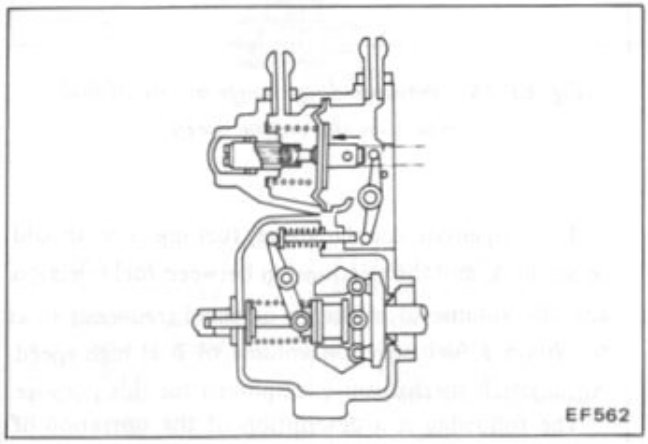


Fig. EF-15 Idling control

Intermediate-speed control

When the accelerator pedal is depressed, the butterfly valve in the venturi is opened and a drop in vacuum pressure in the vacuum chamber takes place.

As this happens, the governor spring tension overcomes the vacuum pressure and the diaphragm is moved in the direction of Fuel Increase; to increase engine speed. The diaphragm is kept stationary when an equilibrium is reached between the force of the governor spring and vacuum pressure in the vacuum chamber.

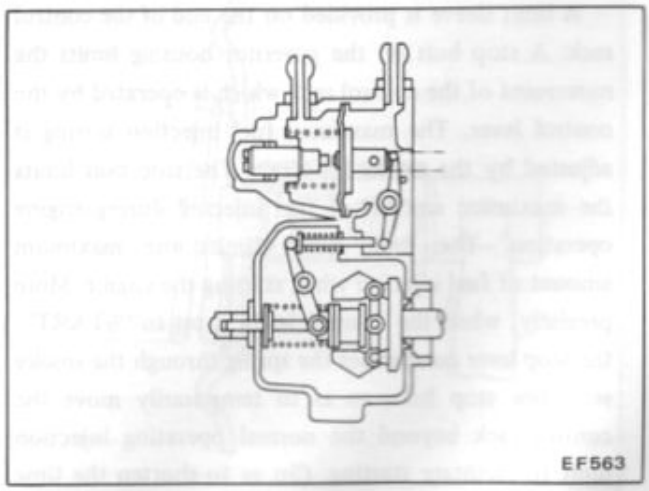


Fig. EF-16 Intermediate-speed control

Maximum-speed control

When the engine speed reaches the predetermined maximum value according to the change of load, the governor spring combines to hold the engine speed to that speed.

When the engine speed goes over the rated maximum speed, the centrifugal force on the governor flyweights exceeds that exerted by the flyweight springs. The weights are then flung radially outward, compressing the governor spring. As this happens, the top end of the full-speed lever pulls on the diaphragm and control rack to decrease fuel flow to the engine. In this speed range, all springs combine to hold the engine speed to the predetermined maximum value.

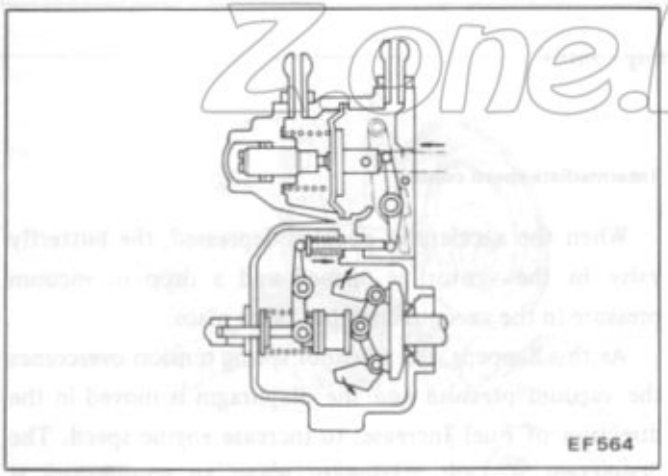


Fig. EF-17 Maximum-speed control

Stop lever and smoke set screw

A limit sleeve is provided on the end of the control rack. A stop bolt on the governor housing limits the movement of the control rack which is operated by the control lever. The maximum fuel injection setting is adjusted by the smoke set screw. The stop bolt limits the maximum amount of fuel injected during engine operation. The limit sleeve limits the maximum amount of fuel injected when starting the engine. More precisely, when the control lever is set to "START", the stop lever compresses the spring through the smoke set screw stop bolt, so as to temporarily move the control rack beyond the normal operating injection limit to facilitate starting. (So as to shorten the time required for starting). When the control lever is set to "STOP", the control rack, conversely, is moved in the direction for decreasing fuel injection so as to stop the engine.

Angleich mechanism

Generally, as is the case with the fuel injection pump, the rate of fuel injection increases for each stroke in relation to engine acceleration, even if the control rack remains in the same position. In 4-cycle engines, however, the volume of air taken into the cylinder is decreased. This relationship is shown in Figure EF-18.

If maximum fuel injection is set at A, to provide sufficient injection at low engine speed, fuel injection will increase to B'. When this occurs, the amount of intaken air is reduced, resulting in incomplete or improper combustion.

Conversely, if maximum fuel injection volume is set at B, for high engine speed, fuel injection will decrease to A' at low speed, with a resultant drop in engine output, and engine power will not be sufficient.

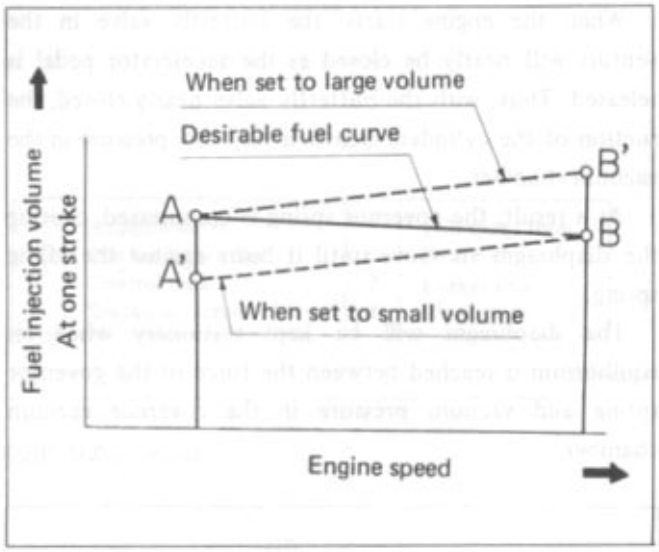


Fig. EF-18 Corresponding change in rate of fuel injection and engine speed

To compensate for the above, fuel injection should be set to A, and the relationship between fuel injection and the volume of intake air adjusted (reduced) so as to obtain a fuel injection volume of B at high speed. An angleich mechanism is employed for this purpose.

The following is a description of the operation of the angleich mechanism with the butterfly valve opening set at a constant value.

1. Since vacuum (negative) pressure applied to the diaphragm housing at low engine speed is very low, the angleich spring is compressed by the governor spring. (See Figure EF-19.)

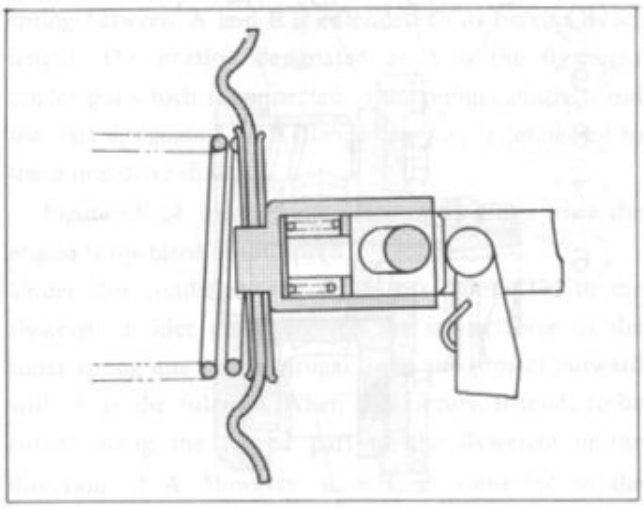
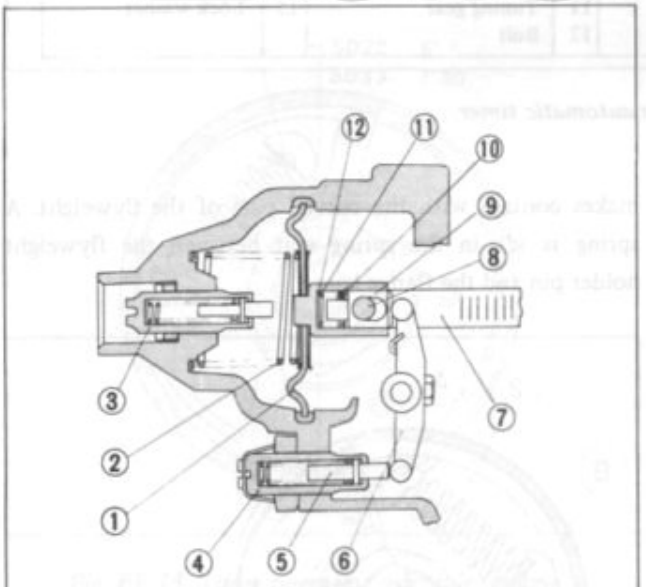


Fig. EF-19 When stroke is zero



1	Diaphragm	7	Control rack
2	Governor spring	8	Connecting bolt
3	Auxiliary idler spring	9	Push rod
4	Smoke set screw	10	Adjusting shim
5	Stop bolt	11	Angleich spring
6	Stop lever	12	Stroke adjusting washer

Fig. EF-20 When stroke is maximum

2. As the engine is accelerated, vacuum pressure is increased, and the control rack is drawn back in the direction for decreasing fuel injection, regardless of control rack position, due to the spring force of the angleich spring. When this occurs, the full stroke of the balance spring is attained when the connecting bolt contacts the oval hole in the push rod.

Under the conditions described above, the difference in pressures in the vacuum chamber and the atmospheric air chamber is balanced by the force of the main spring, and the diaphragm ceases to move. The control rack remains stationary until engine speed reaches maximum full load speed with the angleich spring contacting the stop lever. (See Figure EF-20.)

3. As the engine is further accelerated, this balance is upset and suction (negative pressure) overcomes the spring force of the governor spring. When this occurs, the angleich spring is released from the stop lever and the governor goes into operation to control the engine at high speed. (See Figure EF-21.) The foregoing is a description of the operation of the angleich spring mechanism which operates so as to decrease fuel injection in proportion to decrease in intake air at high speed. At low engine speed, the balance spring moves the control rack in the direction of fuel injection decrease to provide increased torque (torque modulation effect) by maintaining a constant balance between fuel injection and the amount of intake air.

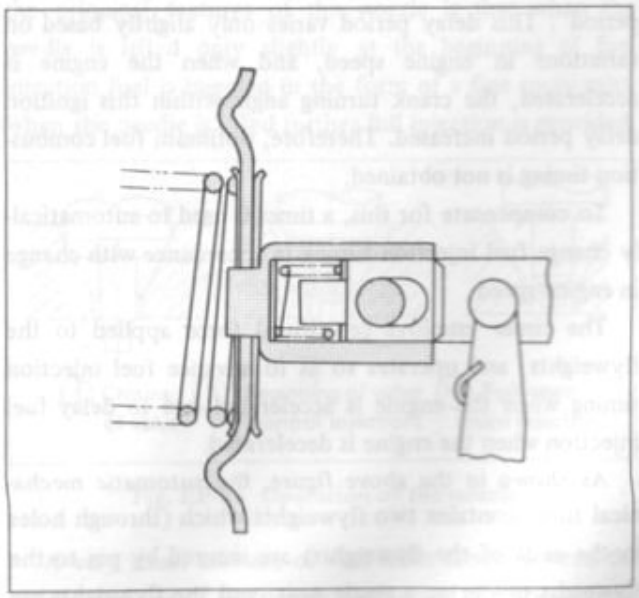
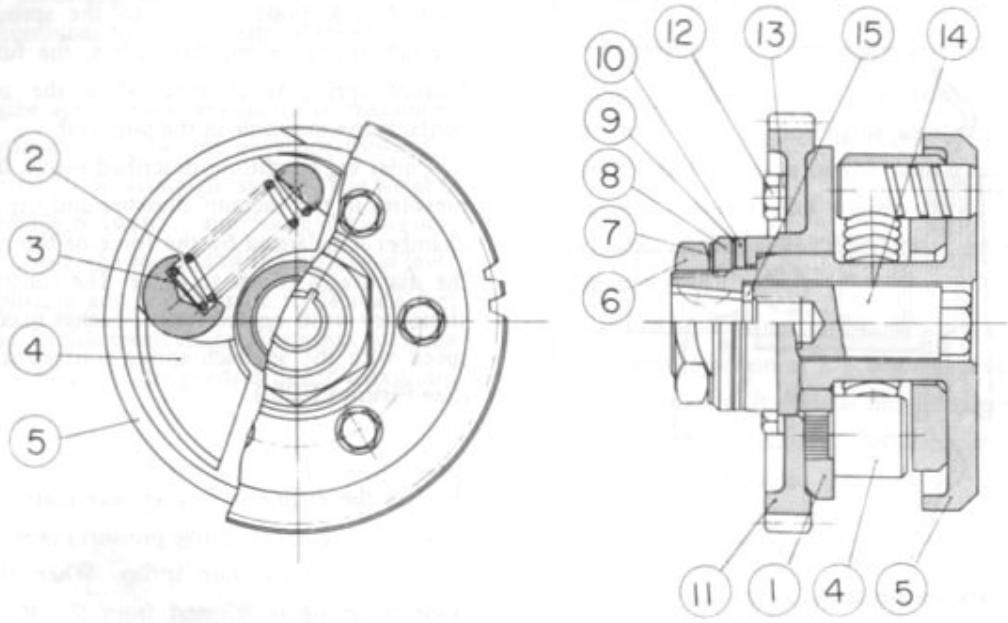


Fig. EF-21 End of the angleich spring operation

TIMER



1	Timer flange	5	Flyweight holder	9	Adjusting shim	13	Lock washer
2	Timer spring	6	Nut	10	Thrust washer	14	Round nut
3	Adjusting shim	7	Lock washer	11	Timing gear	15	Lock washer
4	Flyweight	8	Lock plate	12	Bolt		

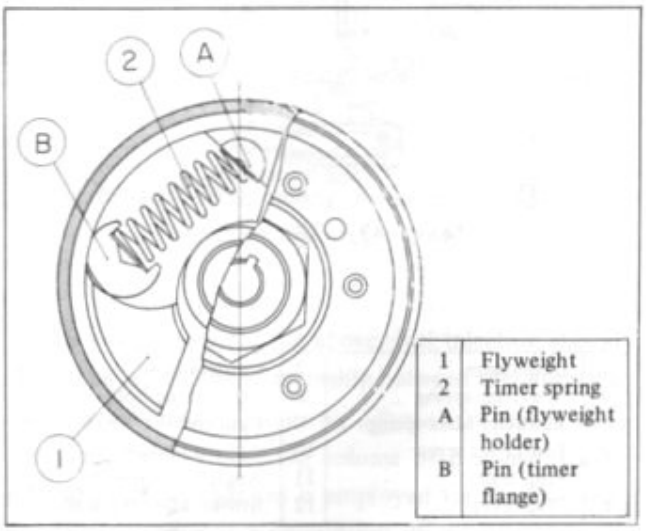
Fig. EF-22 View of the automatic timer

A short period of time is required after the fuel is injected into the combustion chamber before it is ignited. This period of time is referred to as "ignition delay period". This delay period varies only alightly based on variations in engine speed, and when the engine is accelerated, the crank turning angle within this ignition delay period increased. Therefore, optimum fuel combustion timing is not obtained.

To compensate for this, a timer is used to automatically change fuel injection timing in accordance with change in engine speed.

The timer employs centrifugal force applied to the flyweights and operates so as to advance fuel injection timing when the engine is accelerated and to delay fuel injection when the engine is decelerated.

As shown in the above figure, the automatic mechanical timer contains two flyweights which (through holes in the ends of the flyweights) are secured by pin to the flyweight holder as a single unit, and the flyweights are supported on the flyweight holders. The flange base makes contact with the curved part of the flyweight. A spring is set in the spring seat between the flyweight holder pin and the flange base.



1	Flyweight
2	Timer spring
A	Pin (flyweight holder)
B	Pin (timer flange)

Fig. EF-23 Timer operating principle (engine does not operate)

Figure EF-23 shows the timer position when the engine is not in operation. Under this condition, the flyweights are forced inward by the tension of the timer spring due to lack of centrifugal force. In this position, the timing spring between A and B is extended to its maximum set length. The portion designated as A is the flyweight holder pin which is connected to the pump camshaft, and the part designated by B (flange base pin) is connected to the pump drive shaft.

Figure EF-24 shows the position of the timer when the engine is operated at full speed.
Under this condition, the flyweights connected to the flyweight holder pin overcome the spring force of the timer spring due to centrifugal force and project outward with A as the fulcrum. When this occurs, B tends to be forced along the curved part of the flyweight in the direction of A. However, since B is connected to the pump drive shaft, it does not move. Therefore, the flyweight holder pin A moves in the rotating direction, likewise turning the pump camshaft in the rotating direction, advancing fuel injection timing.

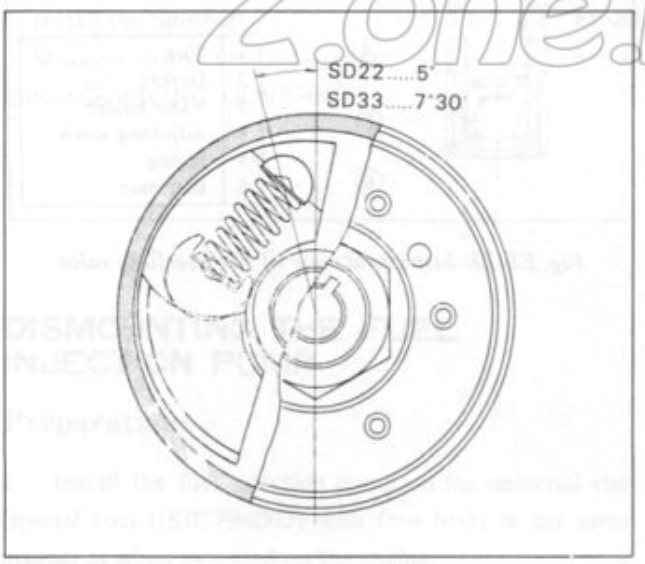
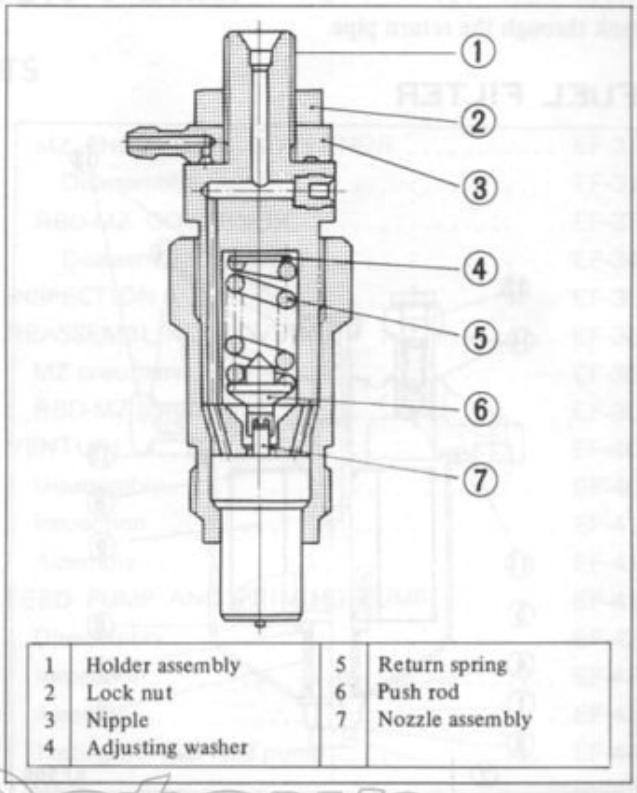


Fig. EF-24 Timer operating principle (engine operates at top speed)

NOZZLE AND NOZZLE HOLDER

The nozzle injects the fuel under high pressure from the injection pump into the whirlpool chamber (swirl chamber).



1	Holder assembly	5	Return spring
2	Lock nut	6	Push rod
3	Nipple	7	Nozzle assembly
4	Adjusting washer		

Fig. EF-25 View of the nozzle and nozzle holder

In the SD engines, a throttle type nozzle with 0° injection angle and a single injection orifice is employed. Nozzle opening pressure is 100 kg/cm^2 (1,422.5 psi). This throttle type nozzle is a pintle nozzle. The end of the needle shaft is slightly smaller than the nozzle orifice. This shaft projects from the orifice in the nozzle body. One of the principal features of this nozzle is that when the needle is lifted only slightly at the beginning of fuel injection fuel is injected in the form of a fine spray mist. When the needle is lifted further full injection is provided.

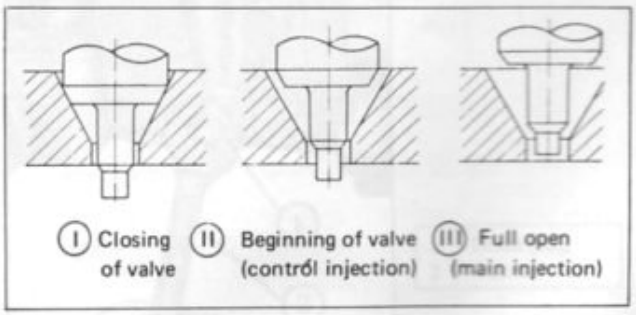
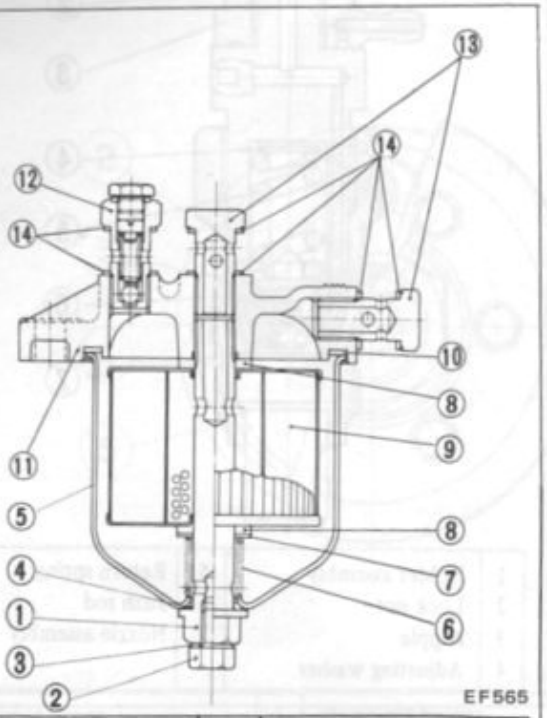


Fig. EF-26 Operation of the nozzle

A very small amount of fuel leaks from between the sliding surfaces of the nozzle needle and the body of the nozzle, lubricating the nozzle. This fuel returns from the

nozzle holder nipple, through the spill tube to the fuel tank through the return pipe.

FUEL FILTER

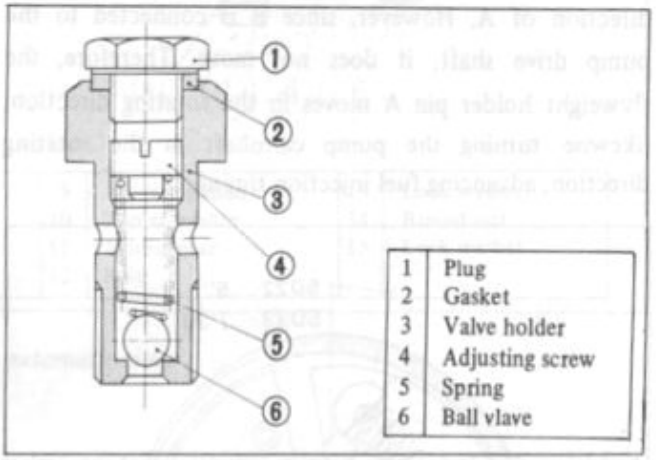


1	Center bolt	8	Element packing
2	Drain plug	9	Paper element assembly
3	Drain plug gasket	10	Body gasket
4	Center bolt gasket	11	Upper cover
5	Body	12	Overflow valve assembly
6	Set spring	13	Connector bolt
7	Retainer.	14	Packing

Fig. EF-27 Structural view of the fuel filter

Since the sliding parts of the fuel injection pump and the nozzle are machined to a high precision, even the slightest amount of dirt, water, or other foreign matter entering the fuel may cause these components to be damaged or worn, resulting in loss of efficiency. To prevent this from occuring, the fuel must be effectively filtered.

A paper type filter is used in the fuel filter assembly. Fuel feed pressure is maintained at a constant level by the overflow valve. This overflow valve serves to bleed air from the fuel system while driving. The fuel discharged from the overflow valve returns to the fuel tank.



1	Plug
2	Gasket
3	Valve holder
4	Adjusting screw
5	Spring
6	Ball vlave

Fig. EF-28 Structural view of the overflow valve

FUEL INJECTION PUMP

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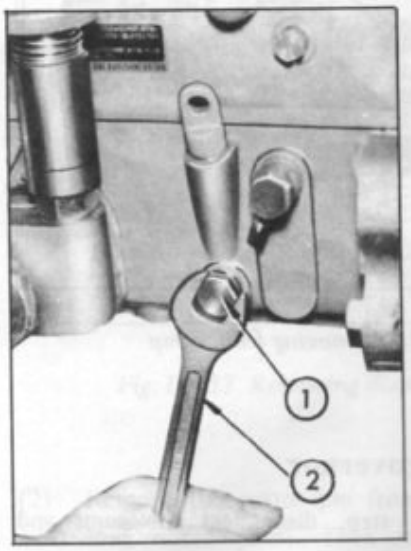
DISMOUNTING THE FUEL INJECTION PUMP

Preparations

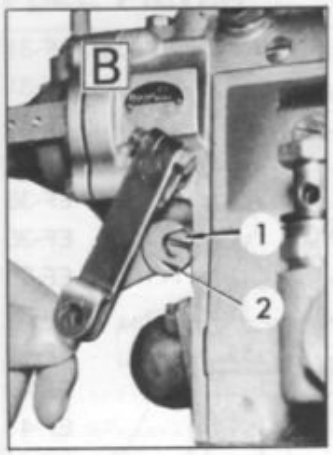
1. Install the fuel injection pump on the universal vise (special tool DK05794002) with four bolts in the same manner as when mounted on the engine.
2. Install the timer in its proper position with round nut through lock washer.



1	Drain plug
2	Wrench

Fig. EF-29 Removing cam and drain plug

3. Remove the drain plug and drain the oil from the cam and governor chambers.



1	Drain plug
2	Wrench

Fig. EF-30 Removing governor chamber drain plug

Removing the feed pump

Remove the nuts and lock washers from the three pump housing studs and then remove the feed pump assembly.

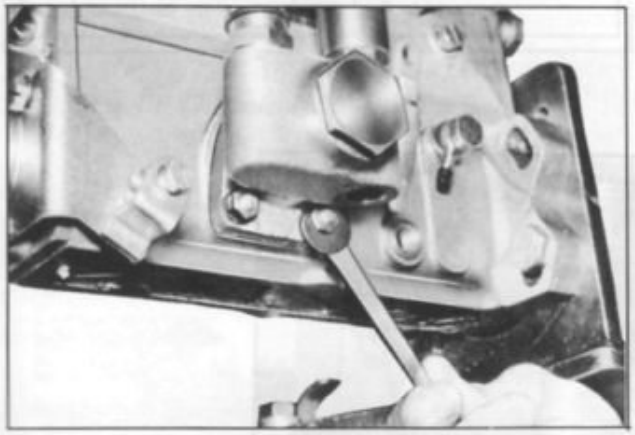


Fig. EF-31 Removing feed pump

Removing the governor

As a preparatory step, disconnect the cams and tappets.

1. Loosen the two cover set screws and remove the plate cover.

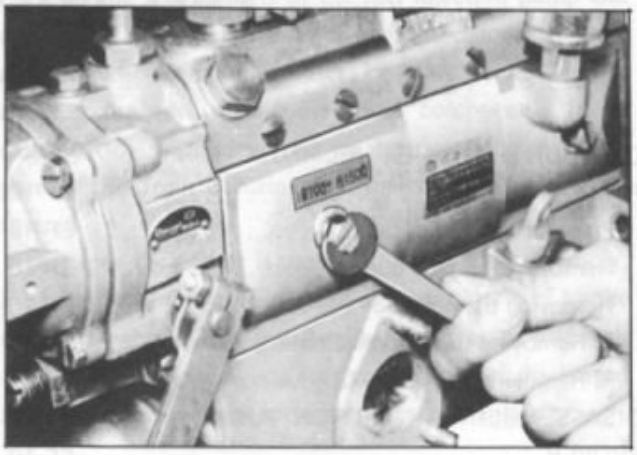
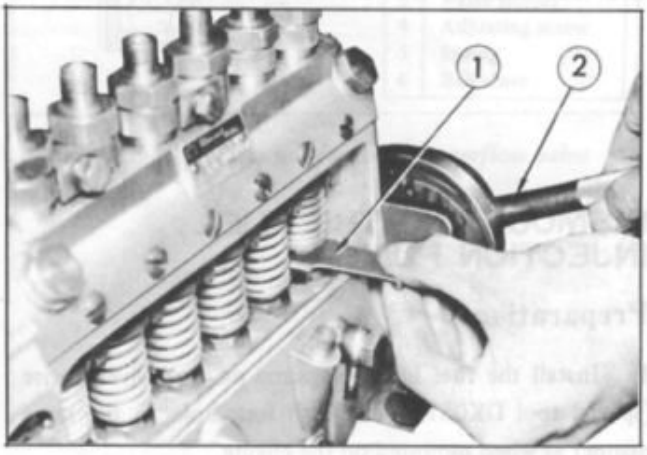


Fig. EF-32 Loosen screws

2. Applying the special wrench (special tool DK57916432) to the timer, turn the camshaft until all tappets (tappet for each cylinder) are raised to TDC (Top Dead Center). Then place the plunger spring holder (special tool DK57931210) between the tappet adjusting bolt and nut for each cylinder.



1	Plunger spring holder
2	Special wrench

Fig. EF-33 Inserting tappet holder

3. Removing the MZ pneumatic governor

(1) Remove the four bolts and then remove the diaphragm housing and governor spring.

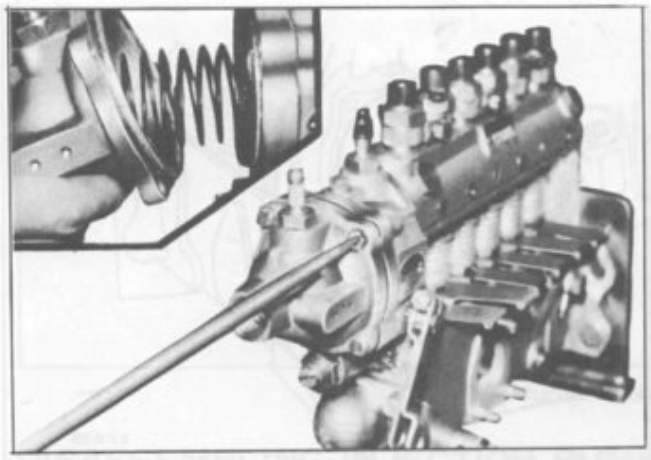
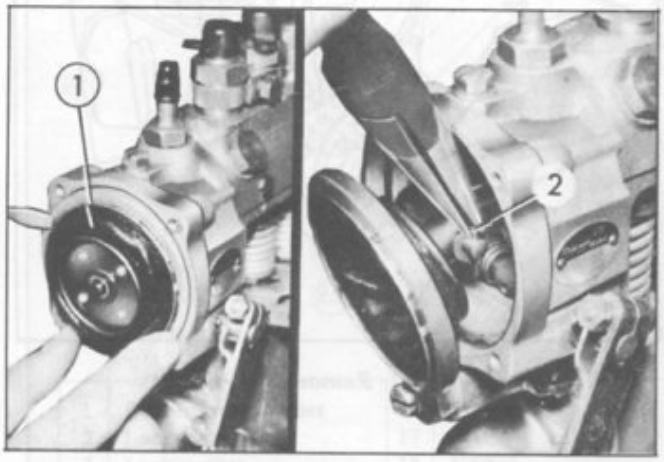


Fig. EF-34 Removing the bolts

(2) Remove the cotter pin from the connecting bolt with long nosed pliers. Then remove the diaphragm assembly from the control rack.

Note: Be careful not to damage the diaphragm.



1	Diaphragm	2	Split pin

Fig. EF-35 Removing diaphragm

(3) Remove the five set screws and then remove the governor housing by applying the blade of a screwdriver in the slit between the governor and pump housings.

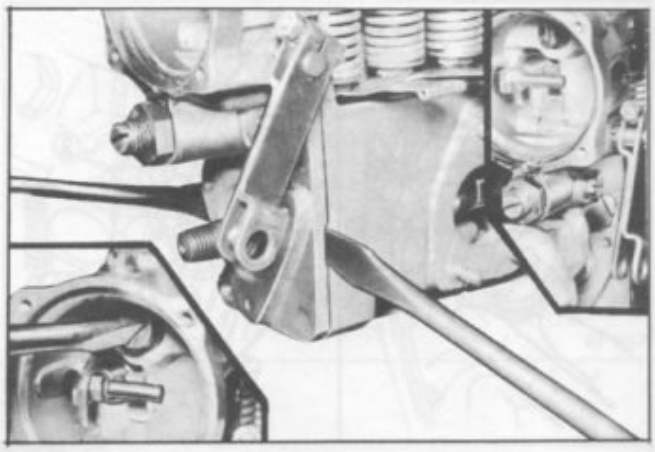


Fig. EF-36 Remove the governor housing

(4) Remove the timer (previously temporarily installed) with the timer extractor (special tool DK57926581).

4. Removing the RBD-MZ governor

(1) Remove four bolts of the pneumatic governor and remove the governor spring in pneumatic section along with the diaphragm housing and the adjusting washers. Be careful not to lose the adjusting washers.

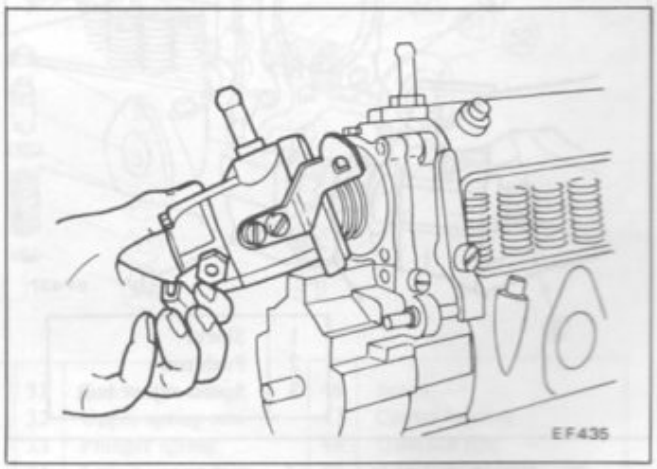


Fig. EF-37 Removing diaphragm housing

(2) Remove the cotter pin from the connecting bolt with long nosed pliers. Then remove the diaphragm assembly from the control rack.

Note: Be careful not to damage the diaphragm.

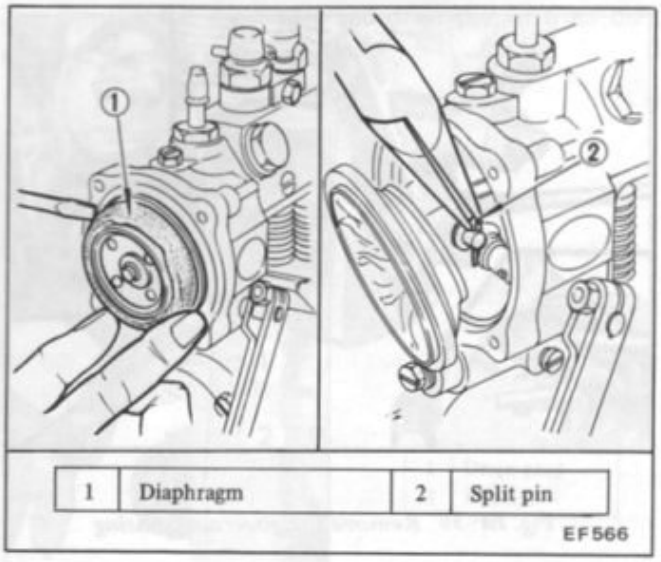


Fig. EF-38 Removing diaphragm

(3) Remove the five bolts securing the mechanical governor cover. To facilitate removal of the cover, tighten up the speed adjust bolt (R.H. thread) to compress the spring. Remove the cover and sleeve.

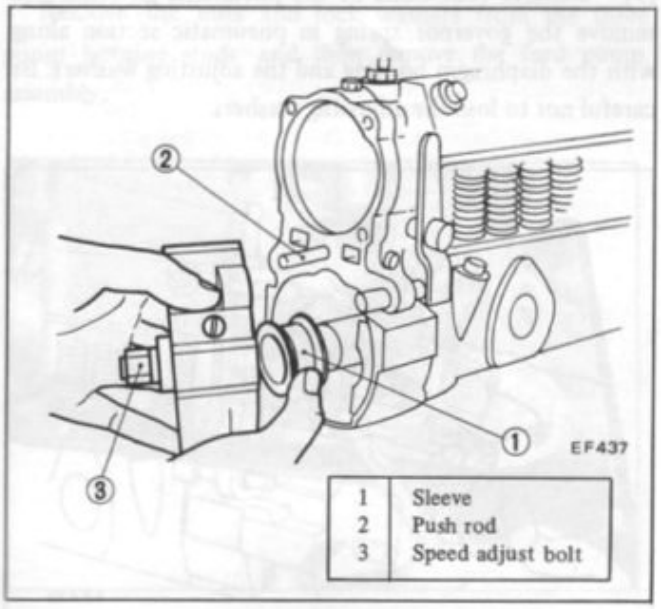


Fig. EF-39 Removing machanical governor cover

(4) Pull out the push rod. (Refer to Figure EF-39.)

Caution:

Be careful not to drop the return spring.

(5) Attach Wrench DK57916432 to the timer and lock securely. Using a special wrench DK57915010, remove the round nut and spring washer.

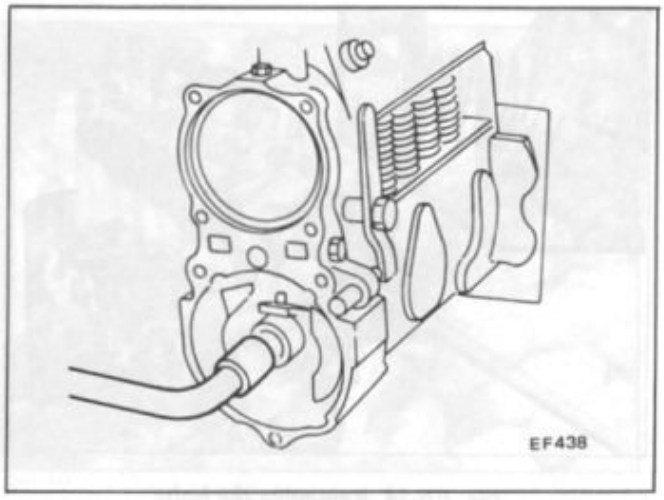


Fig. EF-40 Remvoing round nut

(6) Insert the Extractor DK57926512 into the screw portion of the flyweight holder and pull out the flyweight.

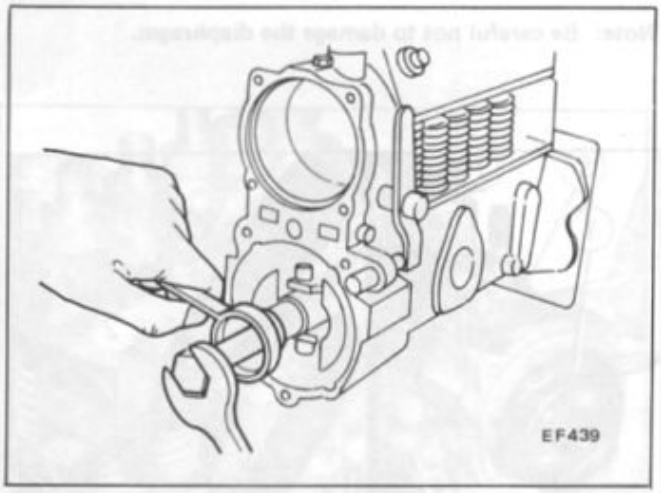


Fig. EF-41 Removing flyweight

(7) Remove the five setting screws and take the governor housing out of the pump housing by tapping it with a wooden mallet. (Refer to Figure EF-42.)

(8) Pull impeller out of camshaft.

(9) Remove the timer with the timer extractor (special tool DK57926581).

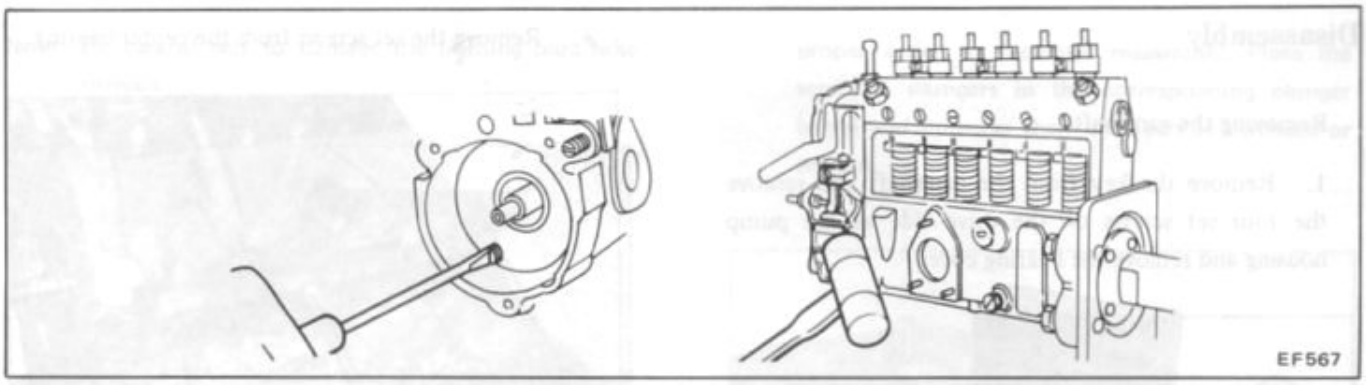
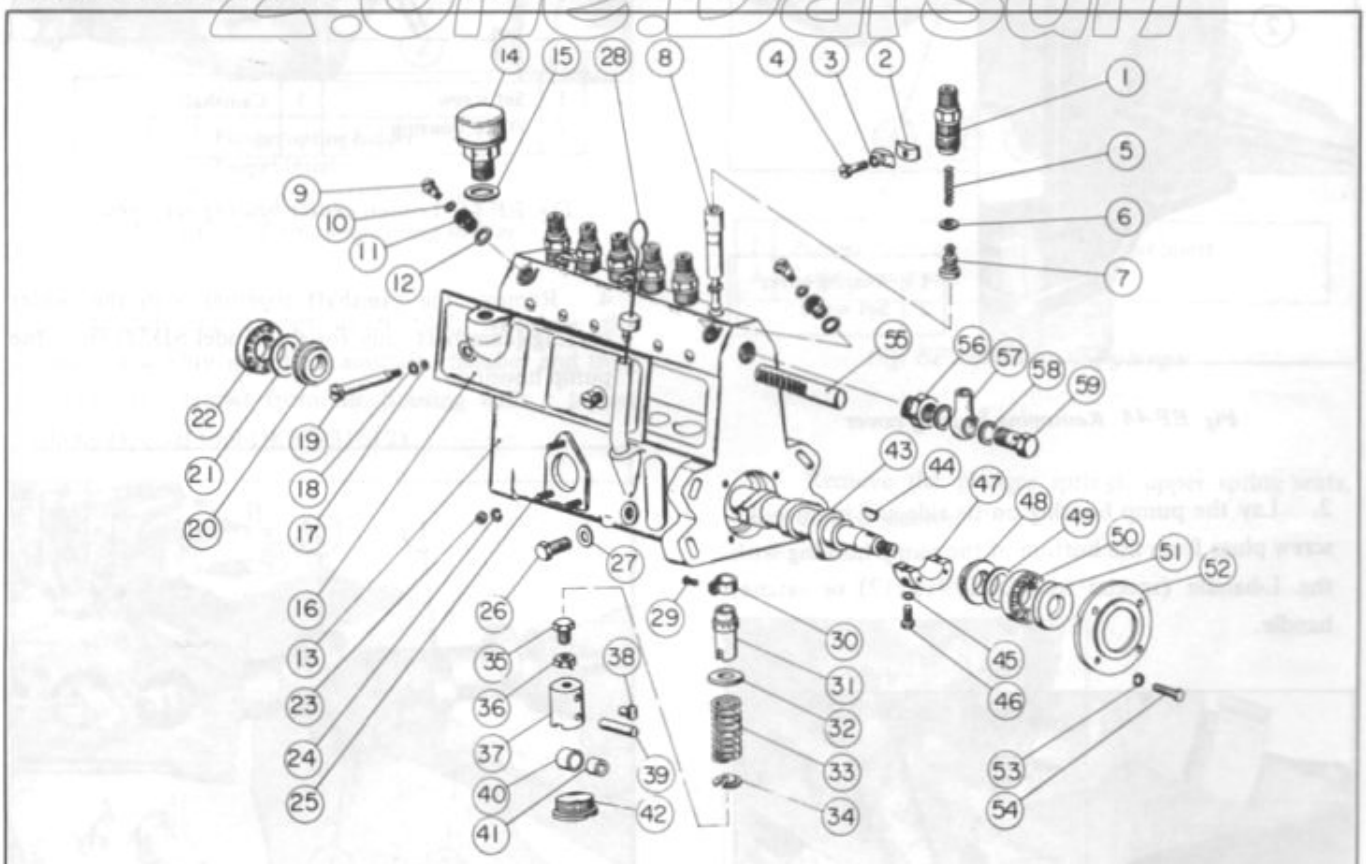


Fig. EF-42 Removing governor housing

DISASSEMBLING INJECTION PUMP PROPER



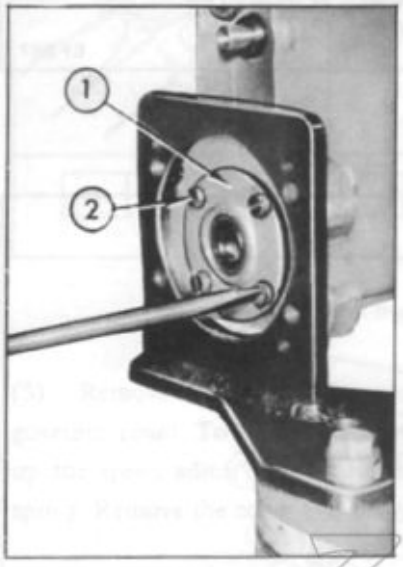
1	Delivery valve holder	16	Plate cover	31	Control sleeve	46	Screw
2	Lock plate	17	O-ring	32	Upper spring seat	47	Center bearing
3	Lock washer	18	Gasket	33	Plunger spring	48	Distance ring
4	Bolt	19	Set screw	34	Lower spring seat	49	Adjusting shim
5	Delivery valve spring	20	Distance ring	35	Adjusting bolt	50	Tapered roller bearing
6	Delivery valve gasket	21	Adjusting shim	36	Lock nut	51	Oil seal
7	Delivery valve assembly	22	Tapered roller bearing	37	Tappet	52	Bearing cover
8	Plunger assembly	23	Nut	38	Tappet guide	53	Lock washer
9	Air bleeder screw	24	Lock washer	39	Roller pin	54	Screw
10	Gasket	25	Stud bolt	40	Roller	55	Control rack
11	Air bleeder plug	26	Screw plug	41	Roller bushing	56	Adapter
12	Gasket	27	Gasket	42	Screw plug	57	Connector ring
13	Pump housing assembly	28	Oil level gauge	43	Camshaft	58	Gasket
14	Air breather assembly	29	Control pinion clamp screw	44	Key	59	Connector bolt
15	Gasket	30	Control pinion clamp	45	Lock washer		

Fig. EF-43 Disassembly drawing of the fuel injection pump proper

Disassembly

Removing the camshaft

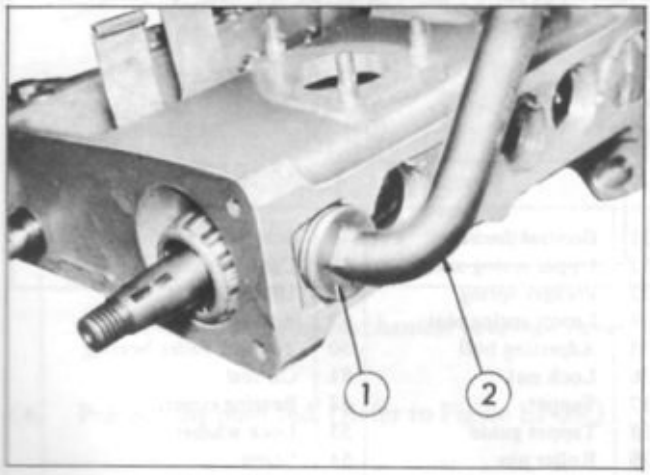
1. Remove the key from the camshaft and remove the four set screws on the drive side of the pump housing and remove the bearing cover.



1	Bearing cover
2	Set screw

Fig. EF-44 Removing bearing cover

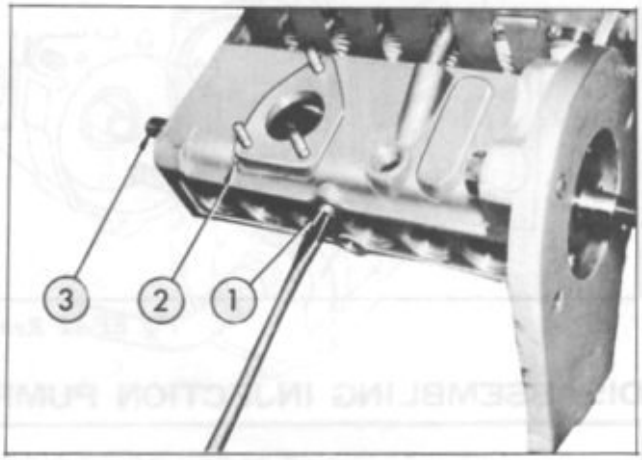
2. Lay the pump housing on its side and remove the screw plugs from the bottom of the pump housing with the L-handle (special tool DK57910112) or ratchet handle.



1	Screw plug	2	L-handle

Fig. EF-45 Removing plug

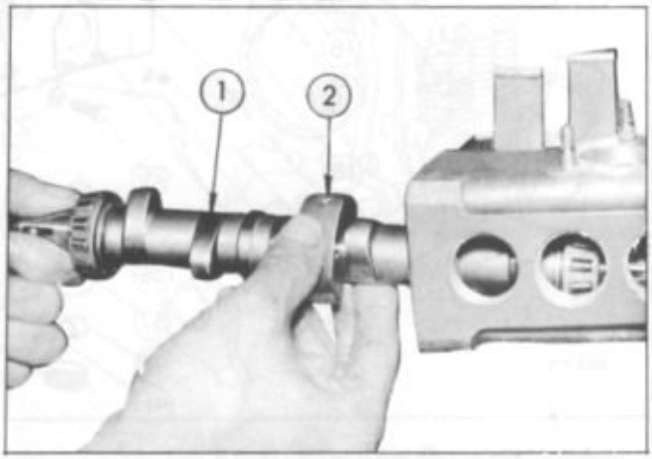
3. Remove the set screws from the center bearing.



1	Set screw	3	Camshaft
2	Pump housing		

Fig. EF-46 Loosen center bearing set screws

4. Remove the camshaft together with the center bearing (camshaft only for the Model SD22) from the pump housing.



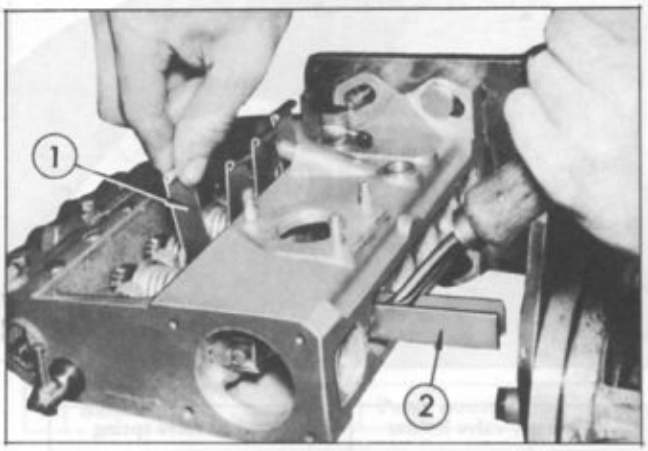
1	Camshaft	2	Center bearing

Fig. EF-47 Removing camshaft

Removing the plungers

1. Engage the tappet assembly with the tappet insert (special tool DK57921012) and remove the tappet holder, removing the tappet from the holder at the same time.

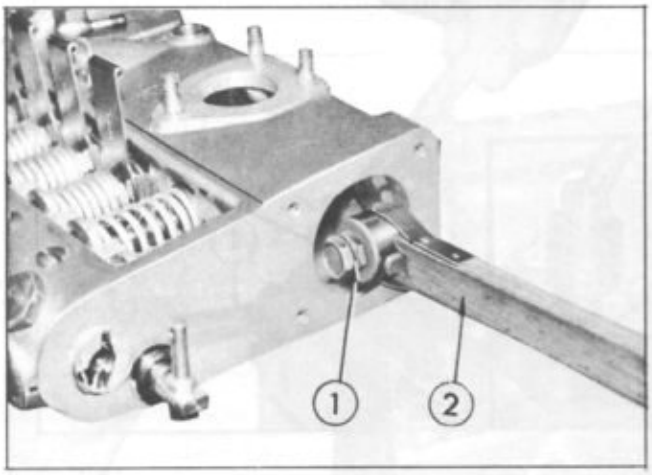
Note: Be careful not to damage the housing plug hole threads.



1	Plunger spring holder
2	Tappet insert

Fig. EF-48 Removing spring holder

2. Loosen the tappet insert tool, withdraw the tappet assembly into the camshaft chamber and then remove the tappet from the housing with a tappet clamp (special tool DK57931612).

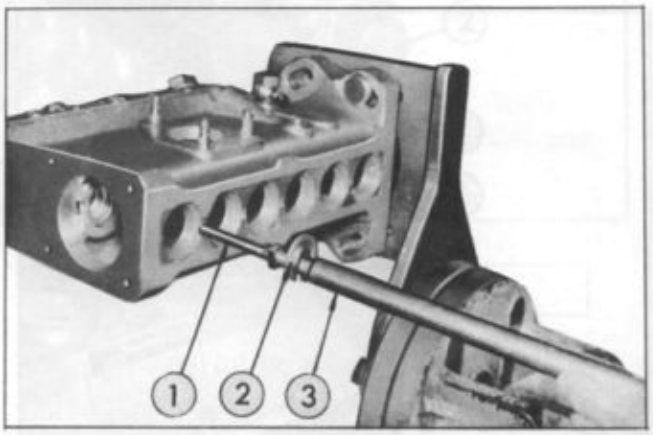


1	Tappet assembly	2	Tappet clamp

Fig. EF-49 Removing tappet

3. After removing the tappets, carefully remove the plungers with the plunger insert (special tool DK57921412) together with the lower spring seat.

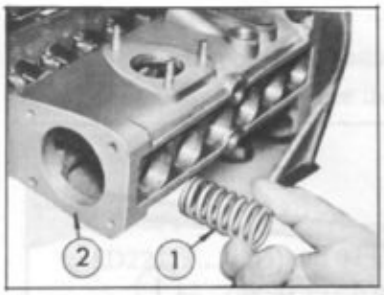
Note: This operation must be carefully performed. Lay out the disassembled parts on a work bench in proper order to facilitate reassemble. Place the servieble plungers in the corresponding plunger barrel and immerse them in a pan of kerosene or solvent.



1	Plunger	3	Plunger insert
2	Lower spring seat		

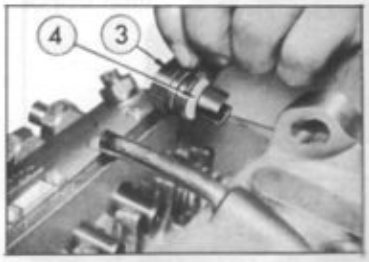
Fig. EF-50 Removing plunger

4. Remove the plunger springs, upper spring seats, and control sleeves.



1	Plunger spring
2	Pump housing

Fig. EF-51 Removig spring

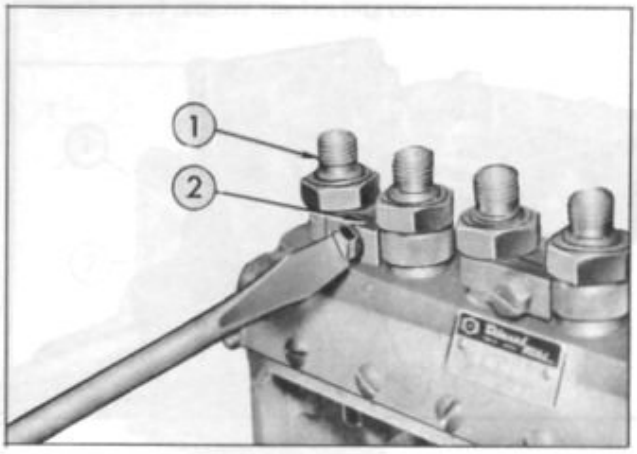


3	Control sleeve
4	Upper spring seat

Fig. EF-52 Removing control sleeve

Removing the delivery valve

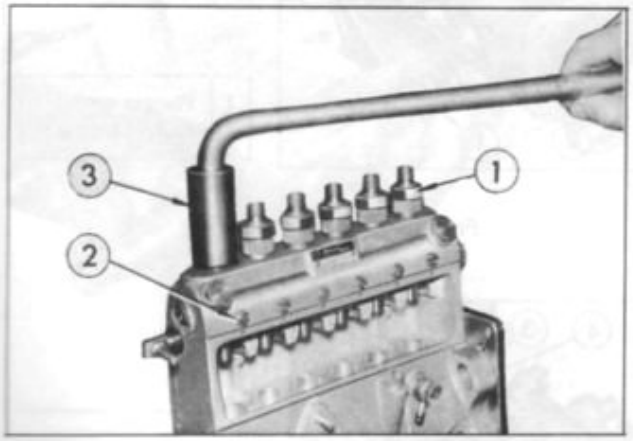
1. Raise the pump housing so that it is upright and remove the lock plate.



1	Delivery valve holder	2	Lock plate

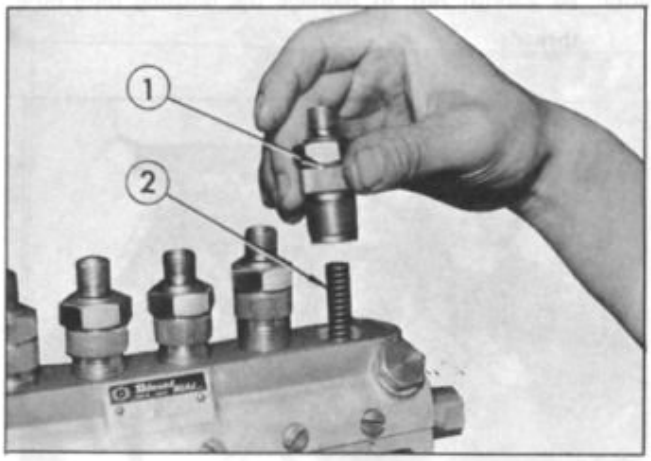
Fig. EF-53 Removing lock plate

2. Loosen the delivery valve holder and remove the delivery valve holder together with the delivery valve spring.



1 2	Delivery valve holder Pump housing	3	Socket wrench (special tool: DK57914050)

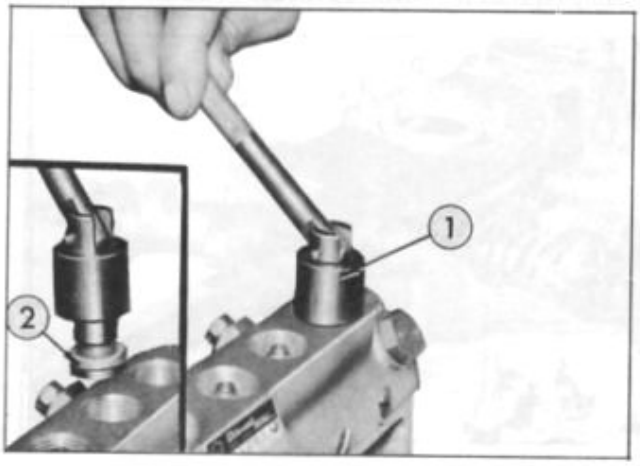
Fig. EF-54 Loosen delivery valve holder



1	Delivery valve holder	2	Delivery valve spring

Fig. EF-55 Removing delivery valve holder

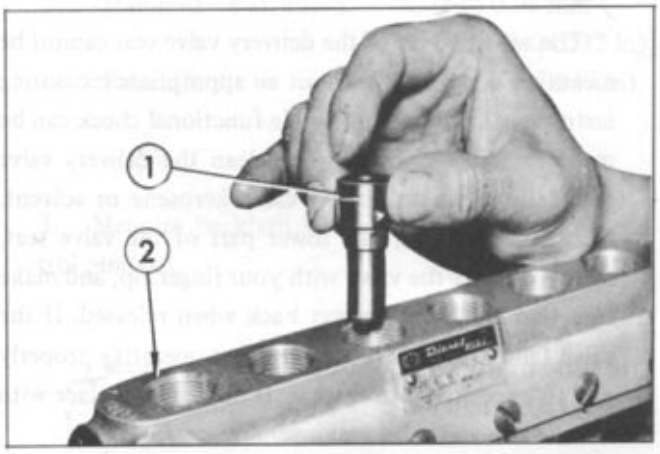
3. Thread in the delivery valve extractor (special tool DK57920032) and remove the delivery valve and gasket.



1	Delivery valve extractor
2	Delivery valve

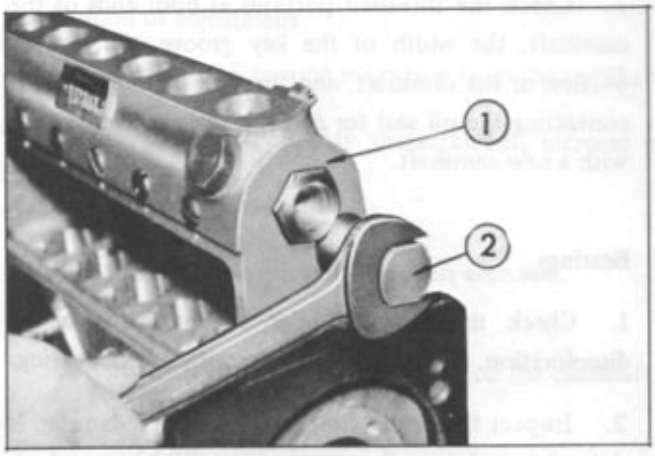
Fig. EF-56 Removing delivery valve

4. Pushing the barrels from below, remove the barrels through the top of the pump housing.



1	Barrel	2	Pump housing

Fig. EF-57 Removing plunger barrel

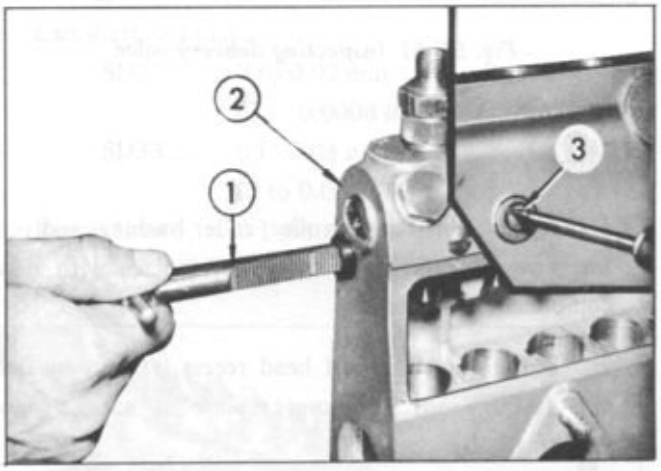


1	Pump housing	2	Cap

Fig. EF-59 Removing cap

Removing the control rack

1. Remove the control rack guide screw on the rear of the pump housing and remove the control rack.



1 2	Control rack Pump housing	3	Control rack guide screw

Fig. EF-58 Removing control rack

2. Remove the cap.

INSTECTION

Pump housing

1. Inspect the pump housing for damage, cracks, etc. If excessively damaged, replace it with a new housing.

2. Check the plunger barrel drum surface for proper contact with the plunger barrel seating hole. Also, check for damage or cracks.
If defective, replace with a new barrel.

3. Measure tappet to housing clearance. If worn beyond the wear limit replace the tappet or housing, as required.

Maintenance standard:
SD22 ..... 0.03 to 0.07 mm (0.0012 to 0.0028 in)
SD33 ..... 0.02 to 0.07 mm (0.0008 to 0.0028 in)
Repair limit: 0.2 mm (0.0079 in)

Camshaft

1. Measure the cam profile for uneven or excessive wear. If excessively or unevenly worn, replace the camshaft with a new one.

2. Check the threaded portions at both ends of the camshaft, the width of the key groove, the tapered portion of the camshaft, and the part of the camshaft contacting the oil seal for damage. If defective, replace with a new camshaft.

Bearings

1. Check the tapered roller bearing for wear of discoloration. If defective, replace with a new bearing.

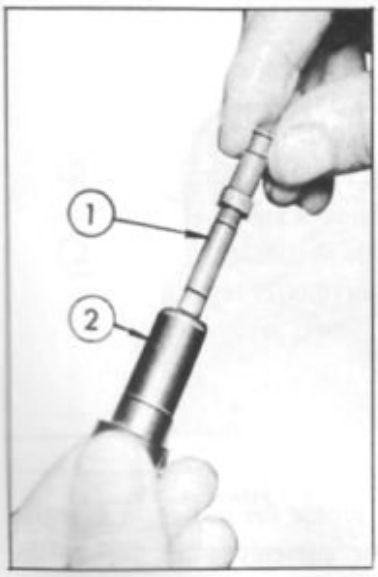
2. Inspect the center bearing for wear or damage. If defective, replace with a new bearing (SD33 engine).

Plunger and plunger barrel

The operation of the plunger should be checked based on the results of fuel injection volume measurement. The following simplified alternate method can be used to check oil-tightness of the plunger barrel. When replacement is required, replace both the plunger and plunger barrel as a set.

1. Thoroughly clean the plunger barrel in clear kerosene or solvent.

2. Turn the plunger barrel upside down and tilt it to approximately 60°. Then, let the plunger slide down through the barrel, making sure that the plunger slides smoothly. Repeat this procedure by turning the plunger to various positions, making sure that the plunger slides smoothly in any of the positions.

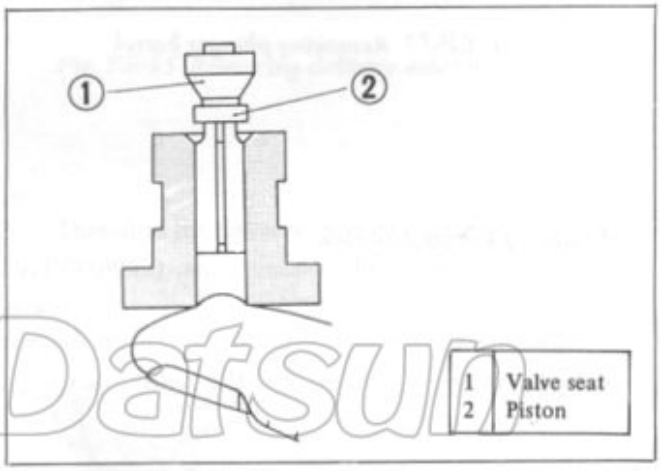


1	Plunger
2	Plunger barrel

Fig. EF-60 Inspecting plunger

Delivery valve

The air-tightness of the delivery valve seat cannot be measured accurately without an appropriate measuring instrument. However, a simple functional check can be made as follows: Thoroughly clean the delivery valve and delivery valve seat in clear kerosene or solvent. Place a finger over the lower part of the valve seat, lightly depress the valve with your finger tip, and make sure that the valve springs back when released. If the valve falls to the valve seat, it is not operating properly due to excessive piston wear. If defective, replace with a new valve and valve seat assembly.



1	Valve seat
2	Piston

Fig. EF-61 Inspecting delivery valve

Tappet

1. Inspect the tappet, roller, roller bushing, and pin for wear or damage. If defective, replace with new components, as required.

2. If the adjusting bolt head recess is worn by 0.2 mm (0.0079 in) or more, replace it with a new adjusting bolt.

Control rack and control sleeve assembly

1. Inspect the control rack for bending and damage. If defective, repair or replace with a new control rack, as required.

2. Measure control sleeve to plunger lug clearance with a thickness gauge. If worn excessively, replace the control sleeve or plunger, as required.

Maintenance standard: 0.02 to 0.08 mm (0.0008 to 0.0032 in)
Repair limit: 0.12 mm (0.0047 in)

3. Measure backlash between control rack and control pinion.

Maintenance standard: 0.15 mm (0.0059 in)
Repair limit: 0.3 mm (0.0118 in)

Spring

Inspect the plunger and delivery valve springs for damage, and measure spring force with a spring tester.

Camshaft

Apply a dial gauge to the governor end of the camshaft and measure camshaft end play by pushing the camshaft from the timer end so as to move the camshaft in the shaft direction.

Camshaft end play:
SD22 ..... 0 to 0.02 mm (0 to 0.0008 in)
SD33 ..... 0 to 0.03 mm (0 to 0.0012 in)
Repair limit: 0.1 mm (0.004 in)

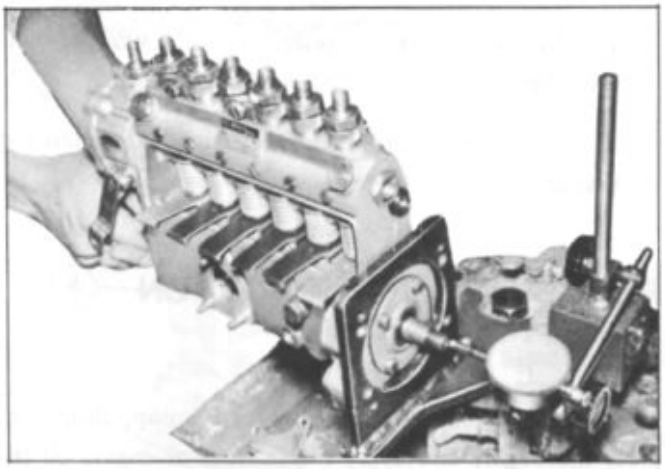


Fig. EF-62 Measuring camshaft end play

Method of adjustment

1. Remove the bearing inner race from the camshaft.
2. Based upon end play measurement, increase or decrease adjusting shims.

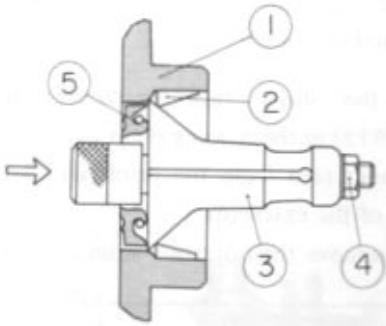
Note: Use the same shim thickness on each end.

3. Re-install the bearing inner race on the camshaft.

REPLACEMENT

Replacing the oil seal and the bearing outer race

1. Remove the bearing outer race from the bearing cover with the outer race extractor (special tool DK57925012). (Refer to Figures EF-63 and EF-64.)



1	Bearing cover	3	Extractor
2	Bearing outer race	4	Nut
		5	Oil seal

Fig. EF-63 Removing bearing outer race

As shown in Figure EF-63, set the tool in position, tighten the nut at the end of the tool, and insert the other end of the tool between the bearing outer race and the oil seal. Then, holding the bearing cover by hand, remove the outer race from its position by tapping the knurl part of the tool with a hammer.

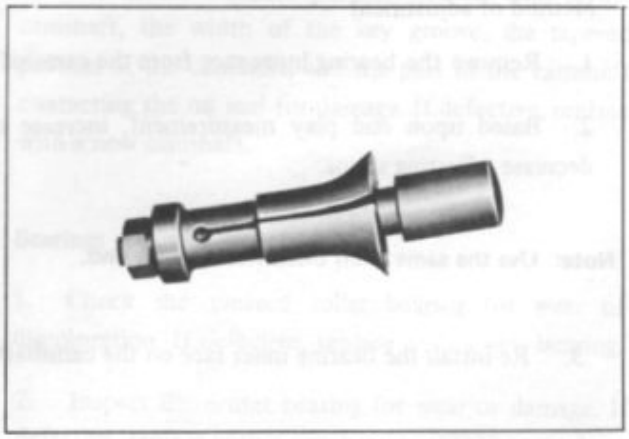


Fig. EF-64 Outer race extractor

2. Remove the oil seal and replace it with a new one. (When installing the oil seal, make sure that it is inserted in the proper direction.)

3. Install the bearing outer race in position with an appropriate tool so that the outer race and the oil seal are in complete contact.

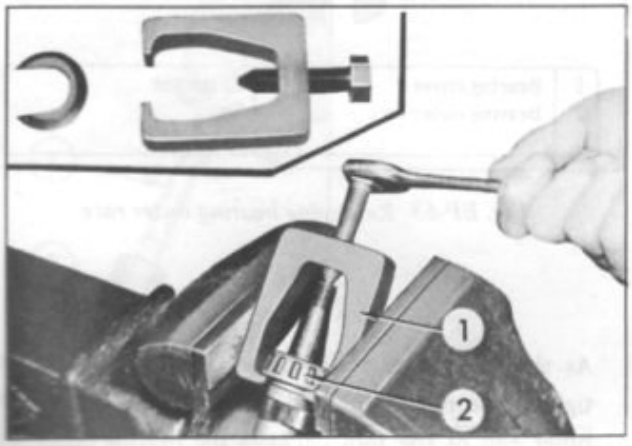
4. Follow the same procedure with respect to parts replacement of governor housing components.

Replacing the camshaft bearing inner race

1. Method of removal

Place the inner race extractor (special tool DK57925412) in the bearing inner race and remove the bearing inner race from the camshaft by threading in the screw of the extractor.

Then, remove the adjusting shim and camshaft ring.



1	Extractor	2	Bearing inner race

Fig. EF-65 Removing bearing inner race

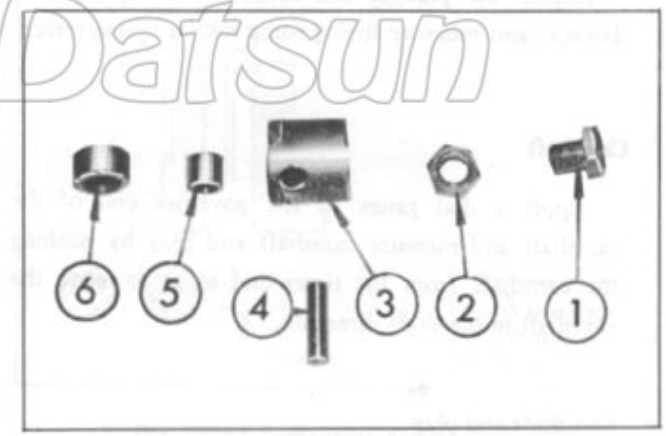
2. Method of installation

Install the adjusting shim and camshaft ring on the camshaft and force the inner race on the camshaft with a press through the inner race insert tool.

3. Measuring and adjusting camshaft end play

Camshaft end play is sometimes changed due to replacement of the bearing, bearing cover, governor housing, or oil seal. Thus, after any of these components have been replaced, measure and adjust camshaft end play after installing the governor housing.

Disassembling the tappet assembly



1	Adjusting bolt	4	Roller pin
2	Adjusting nut	5	Roller bushing
3	Tappet	6	Roller

Fig. EF-66 Components of tappet assembly

1. Remove the tappet guide, the roller pin, and then the roller bushing and roller in that sequence.

2. Loosen the adjusting nut and remove the adjusting bolt and nut from the tappet.

REASSEMBLING INJECTION PUMP PROPER

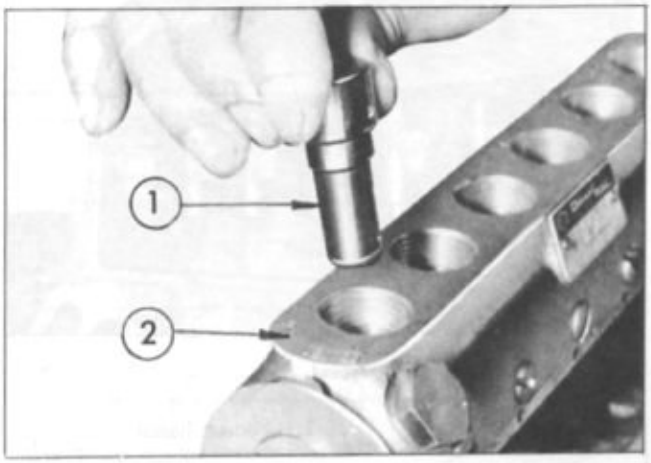
Before assembling the fuel injection pump, clean the parts thoroughly and apply a thin coat of engine oil to rotating and sliding parts.

Plunger and delivery valve

1. Secure the pump housing on the universal vise.

2. Assemble the plunger barrels in their proper positions.

Turn the plunger barrel escape port toward the front of the housing and install the barrel so that the groove of the barrel is properly aligned with the knock pin in the housing.



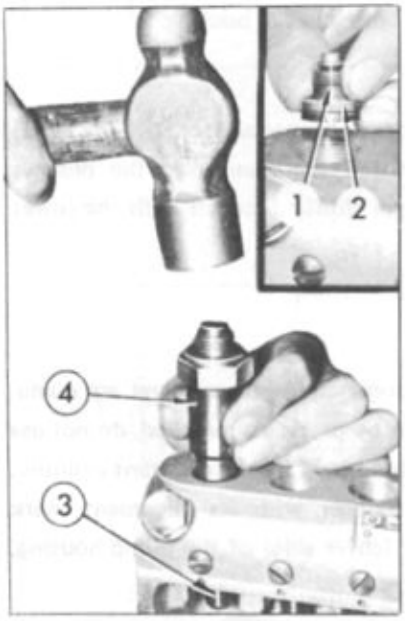
1	Plunger barrel	2	Pump housing

Fig. EF-67 Installing plunger barrel

3. Apply the gasket to the delivery valve.

Note: Apply the gasket with its gasket facing part down.

4. Install the delivery valve, setting it into position by tapping lightly from the top through the extractor (special tool DK57926012).

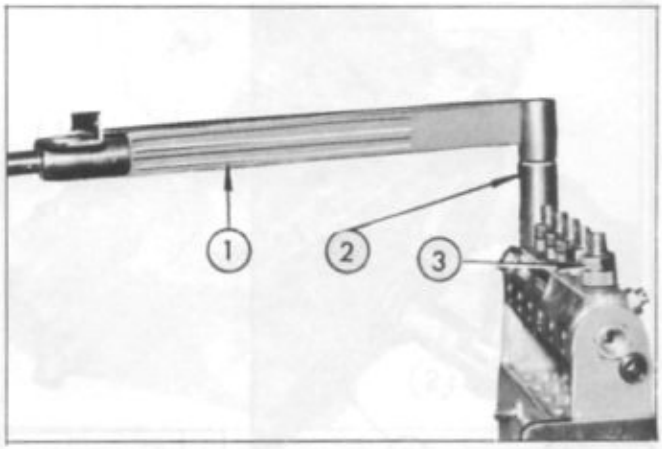


1	Delivery valve assembly
2	Delivery valve gasket
3	Barrel (plunger barrel)
4	Extractor

Fig. EF-68 Installing delivery valve and gasket

5. Apply the delivery valve spring to the delivery valve.

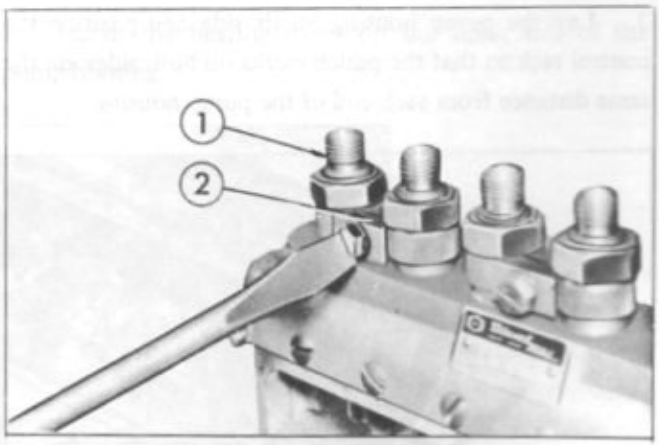
6. Install the delivery valve holder and tighten it with a tightening torque of 3.0 to 3.5 kg-m (21.7 to 25.3 ft-lb) evenly, using a torque wrench.



1 2	Torque wrench Socket wrench	3	Delivery valve holder

Fig. EF-69 Valve holder installation

7. Attach the lock plate and lock the delivery valve holder.



1	Delivery valve holder	2	Lock plate

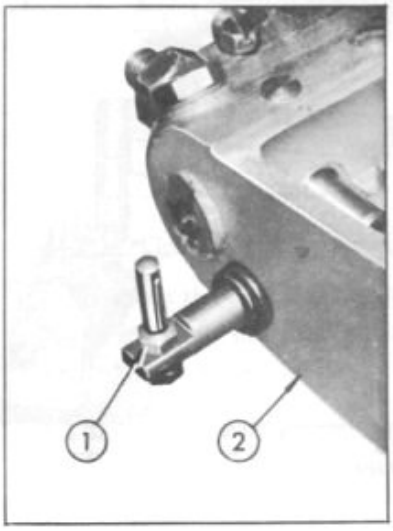
Fig. EF-70 Installing lock plate

Install the control rack

1. Install the control rack in the pump housing so that

the end with the hole is toward the governor.

2. Install the control rack guide screw.



1	Control rack
2	Pump housing

Fig. EF-71 Installing control rack

3. Lay the pump housing on its side and position the control rack so that the punch marks on both sides are the same distance from each end of the pump housing.

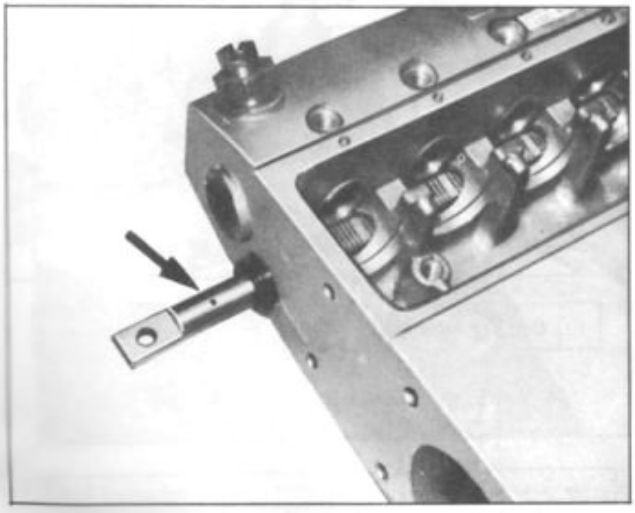
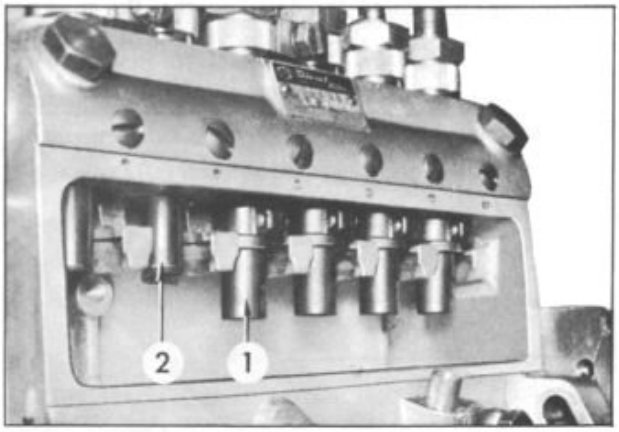


Fig. EF-72 Control rack punch marks

4. Holding the sliding part of the control sleeve combined with the pinion, install the control sleeve in the plunger barrel.



1	Control sleeve	2	Plunger barrel

Fig. EF-73 Installing control sleeve assembly

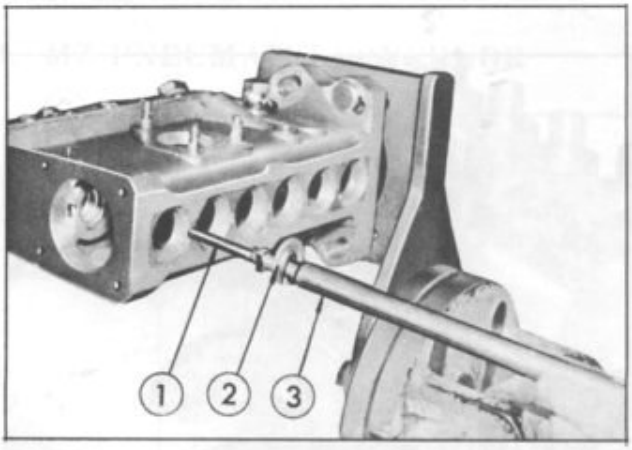
Install the plunger

1. Install the upper spring seat on the control sleeve.

2. Install the plunger spring in the housing.

3. Apply the plunger insert (special tool DK57921412) to the plunger and install the plunger in the plunger barrel. Install the plunger slowly together with the lower spring seat.

Note: a. Since the plunger and plunger barrel are manufactured so as to be precision matched, do not use the plunger with a barrel from a different cylinder.
b. Install the plunger with its alignment mark facing the front (cover side) of the pump housing. (See Figure EF-75.)



1	Plunger	3	Plunger insert
2	Lower spring seat		

Fig. EF-74 Installing plunger

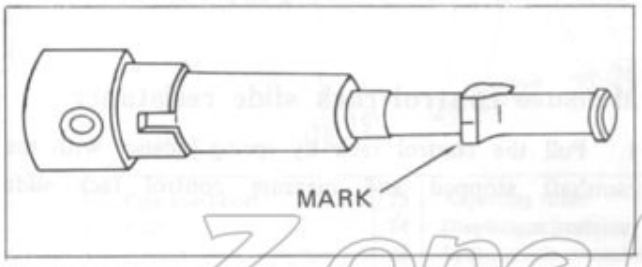


Fig. EF-75 Plunger alignment mark

Install the tappet assembly

1. Using slide calipers, measure and adjust the distance between the outer diameter of the roller and the head of the adjusting bolt so that it is between 34.0 to 34.5 mm (1.339 to 1.358 in).

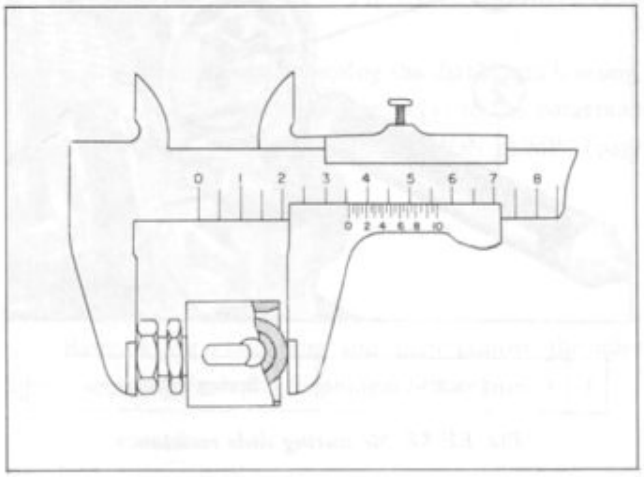
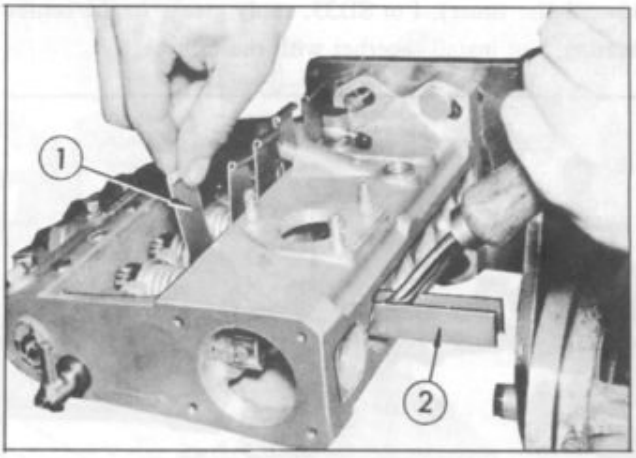


Fig. EF-76 Adjusting tappet height

2. Apply the tappet insert (special tool DK57921012) to the tappet, in the same manner as for disassembly, install the tappet from the bottom of the pump housing, press the tappet into position and place a tappet holder between the adjusting bolt and nut.



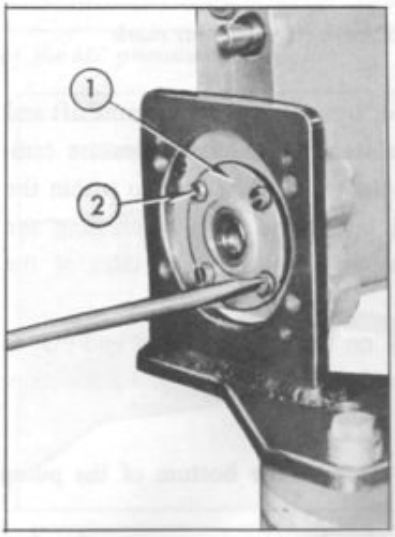
1	Tappet holder	2	Tappet insert

Fig. EF-77 Installing tappet

3. When installing the plunger and tappet in each cylinder, make sure that they are properly positioned so that the rack slides smoothly.

Install the camshaft

1. Install the bearing cover on the timer side of the pump housing.

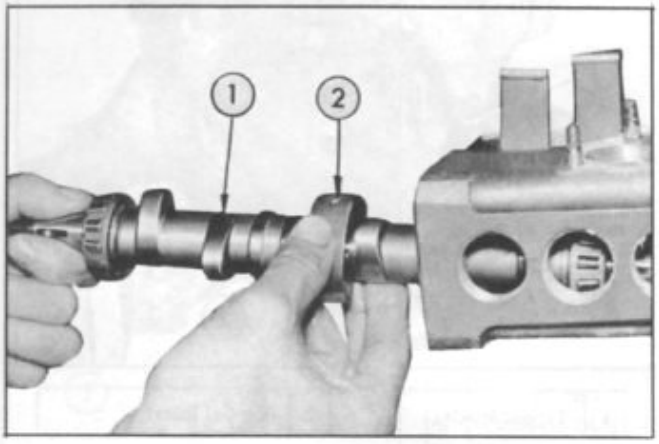


1	Bearing cover
2	Set screw

Fig. EF-78 Installing bearing cover (timer side)

Note: Install the bearing cover set screw with its faced portion toward the rear of the pump housing.

2. Install the camshaft so that its alignment mark is toward the governor (for SD22, so that the mark is toward the timer). For SD33, apply grease to the center bearing, and install togerher with the camshaft.



1	Camshaft	2	Center bearing (SD33)

Fig. EF-79 Installing camshaft

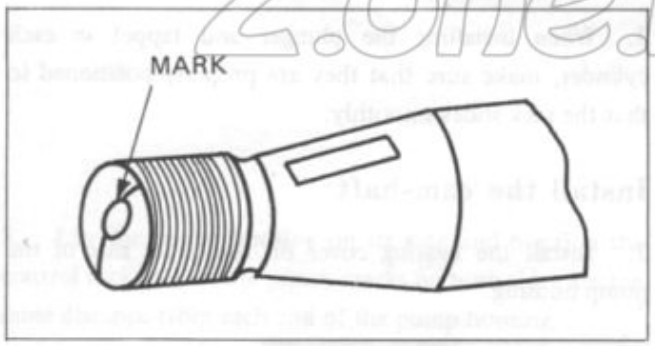


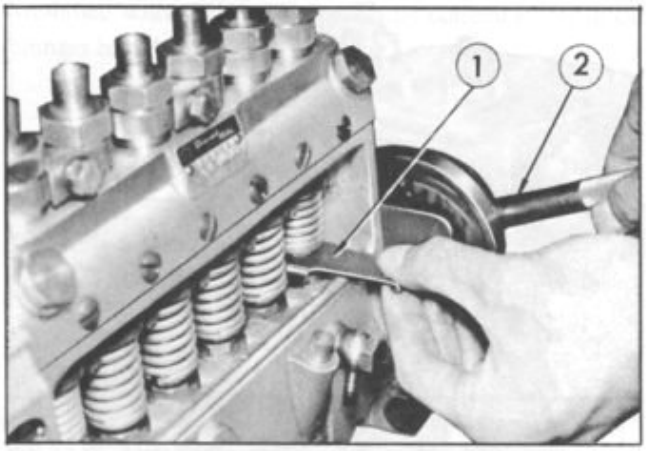
Fig. EF-80 Camshaft alignment mark

3. Install the governor housing and adjust camshaft end play to within the maintenance standard. Measure camshaft end play with a dial gauge and adjust to within the maintenance standard by increasing or decreasing the thickness of the adjusting shims on both sides of the bearing.

Apply shims evenly on both sides so that end play is evenly distributed. For details, refer to page EF-25, Camshaft.

4. Install the screw plug on the bottom of the pump housing.

5. Temporarily install the automatic timer and remove the tappet holders while turning the camshaft.



1	Tappet holder	2	Special wrench

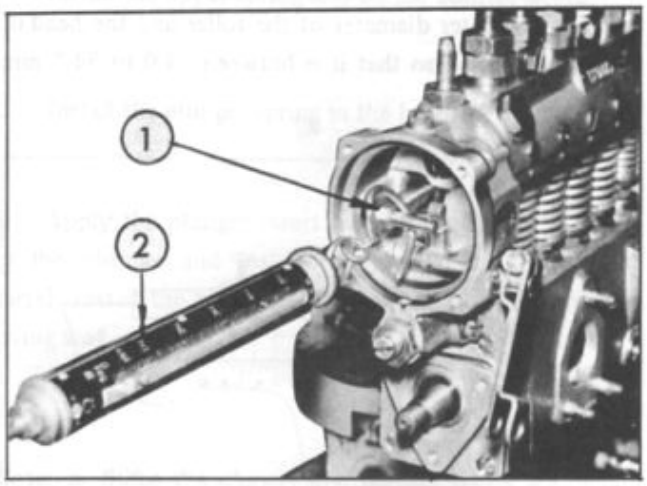
Fig. EF-81 Removing tappet holder

Measure control rack slide resistance

1. Pull the control rack by spring balance with the camshaft stopped and measure control rack slide resistance.

Sliding resistance:

SD22 ..... Less than 150 g (0.331 lb)
SD33 ..... Less than 150 g (0.331 lb)



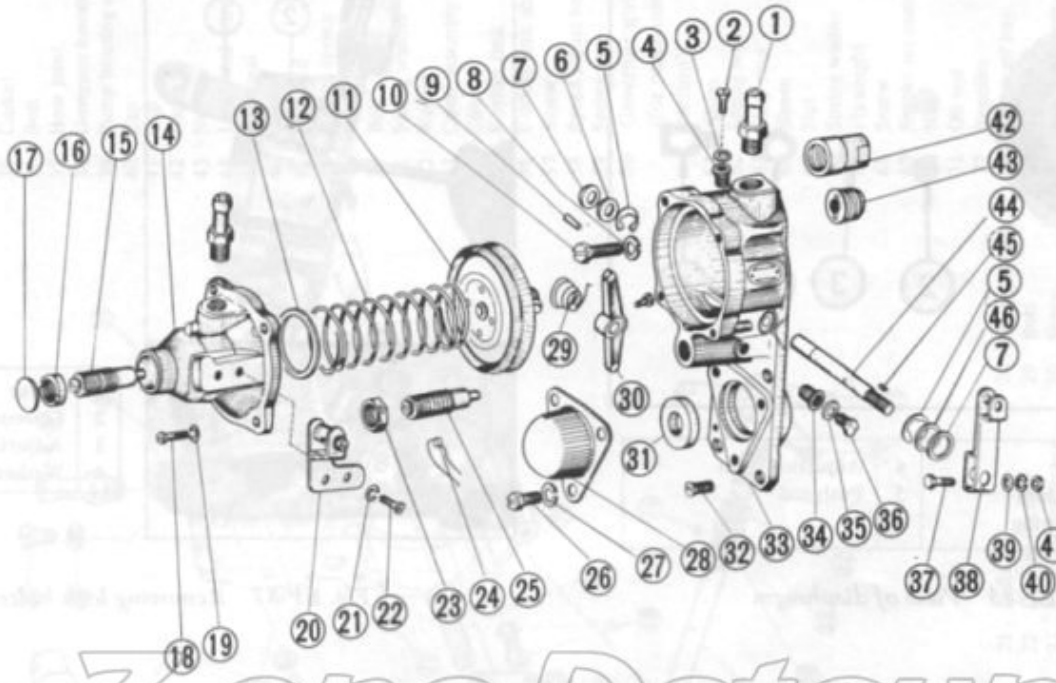
1	Control rack	2	Spring balance

Fig. EF-82 Measuring slide resistance

2. Control rack slide resistance should be less then the prescribed value for all positions of the cam.

DISASSEMBLING GOVERNOR

1. MZ PNEUMATIC GOVERNOR



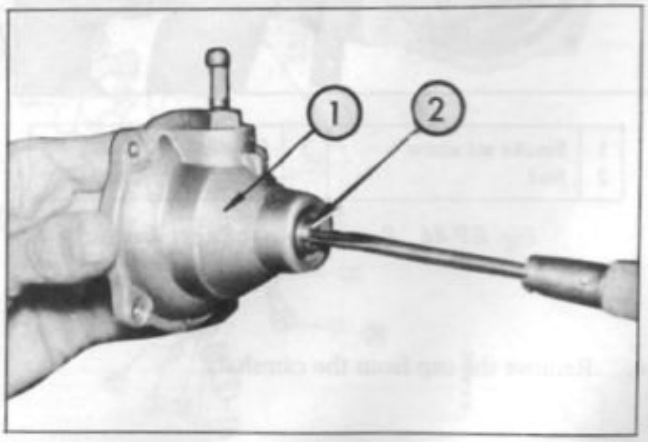
1	Pipe joint bolt	13	Adjusting shim	25	Spring guide assembly	36	Screw
2	Bolt	14	Diaphragm housing	26	Screw	37	Bolt
3	Gasket	15	Spring guide assembly	27	Lock washer	38	Control lever
4	Nippel	16	Round nut	28	Cap	39	Washer
5	Snap ring	17	End plate	29	Return spring	40	Lock washer
6	Adjusting shim	18	Screw	30	Stop lever	41	Nut
7	Washer	19	Lock washer	31	Oil seal	42	Cap
8	Lock washer	20	Clamp assembly	32	Screw	43	Screw plug
9	Guide pin	21	Spring washer	33	Governor housing	44	Shaft
10	Screw	22	Screw	34	Nipple	45	Key
11	Diaphragm	23	Lock nut	35	Gasket	46	O-ring
12	Governor spring	24	Lead seal				

Fig. EF-83 Disassembly drawing of the MZ pneumatic governor

For the procedure of removing the diaphragm housing, diaphragm, and governor housing, refer to the paragraph "DISMOUNTING THE FUEL INJECTION PUMP" (page EF-15).

Disassembly

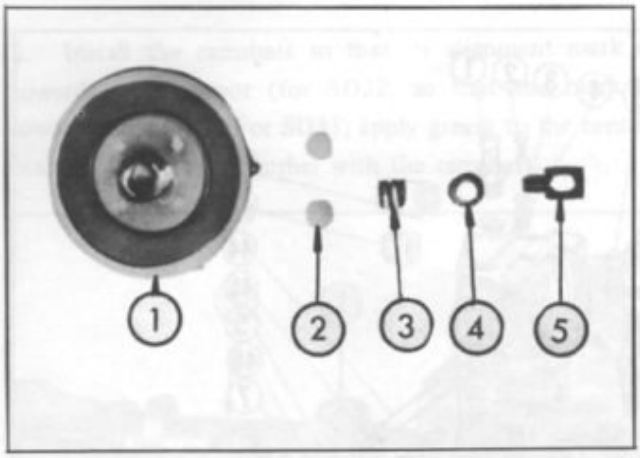
1. Remove the plate plug and then remove the idler spring assembly from the diaphragm housing.



1	Diaphragm housing	2	Spring guide assembly

Fig. EF-84 Removing idler spring

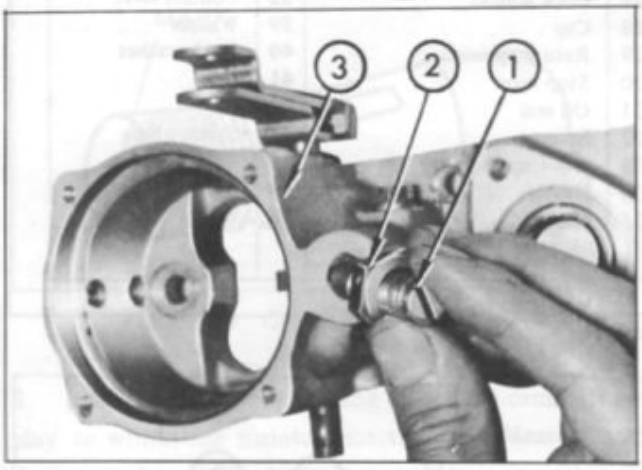
2. Remove the push rod and angleich spring, and adjusting shim from the diaphragm.



1	Diaphragm	4	Adjusting shim
2	Adjusting shim	5	Push rod
3	Angleich spring		

Fig. EF-85 View of diaphragm

3. Remove the smoke set screw.

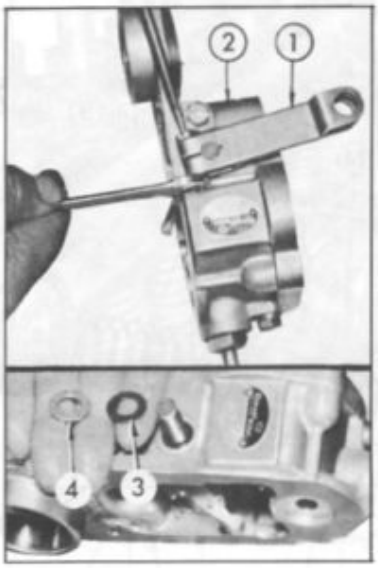


1	Smoke set screw	3	Governor housing
2	Nut		

Fig. EF-86 Removing smoke set screw

4. Remove the cap from the camshaft.

5. Remove the stop lever shaft lock bolts and nuts and then remove the lever, washer, and adjusting shims.

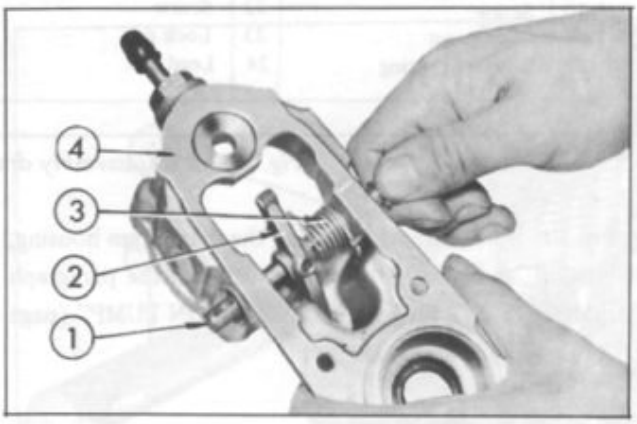


1	Lever
2	Governor housing
3	Adjusting shim
4	Washer

Fig. EF-87 Removing lock bolts

6. Remove the stop lever screw and then remove the cotter pins from both ends of the shaft.

Then, remove the stop lever shaft from the governor housing.



1	Stop lever shaft	3	Return spring
2	Stop lever	4	Governor housing

Fig. EF-88 Removing stop lever shaft

2. RBD-MZ GOVERNOR

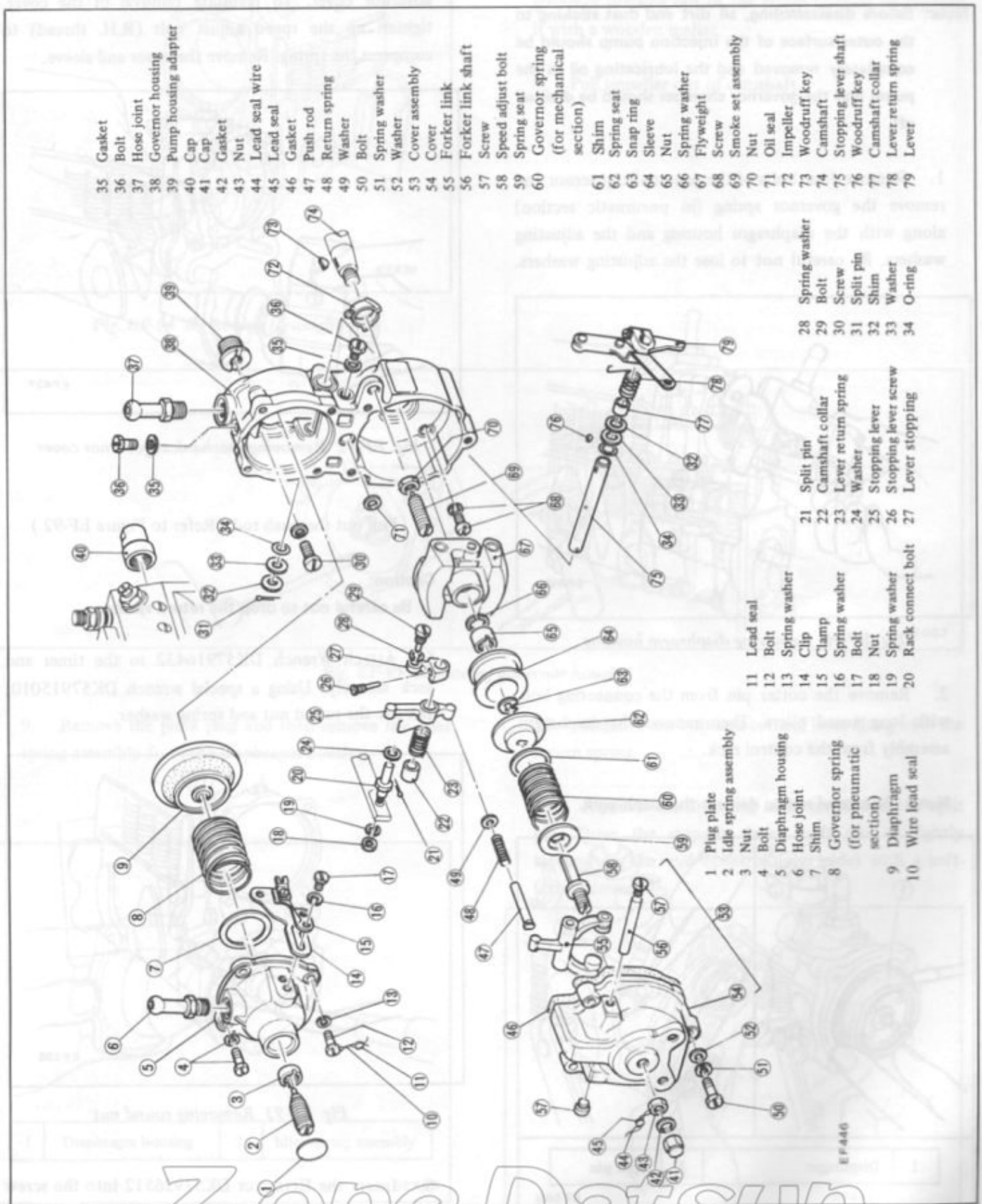


Fig. EF-89 Disassembled RBD-MZ governor

Disassembly

Note: Before disassembling, all dirt and dust sticking to the outer surface of the injection pump should be completely removed and the lubricating oil in the pump and the governor chamber should be drained off.

1. Remove four bolts of the pneumatic governor and remove the governor spring (in pneumatic section) along with the diaphragm housing and the adjusting washers. Be careful not to lose the adjusting washers.

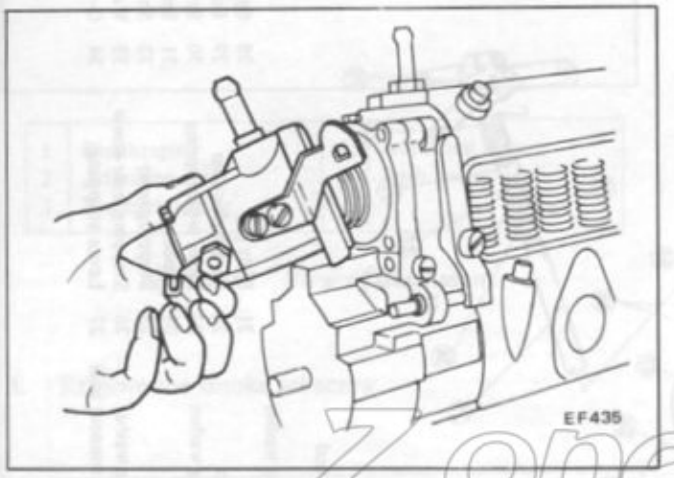
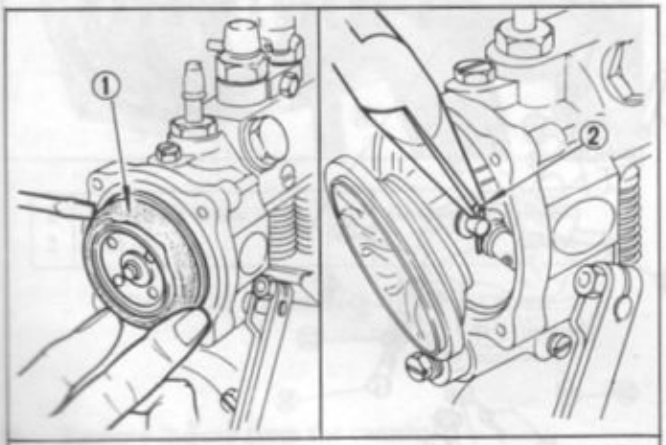


Fig. EF-90 Removing diaphragm housing

2. Remove the cotter pin from the connecting bolt with long nosed pliers. Then remove the diaphragm assembly from the control rack.

Note: Be careful not to damage the diaphragm.



1	Diaphragm	2	Split pin

Fig. EF-91 Removing diaphragm

3. Remove the five bolts securing the mechanical governor cover. To facilitate removal of the cover, tighten up the speed adjust bolt (R.H. thread) to compress the spring. Remove the cover and sleeve.

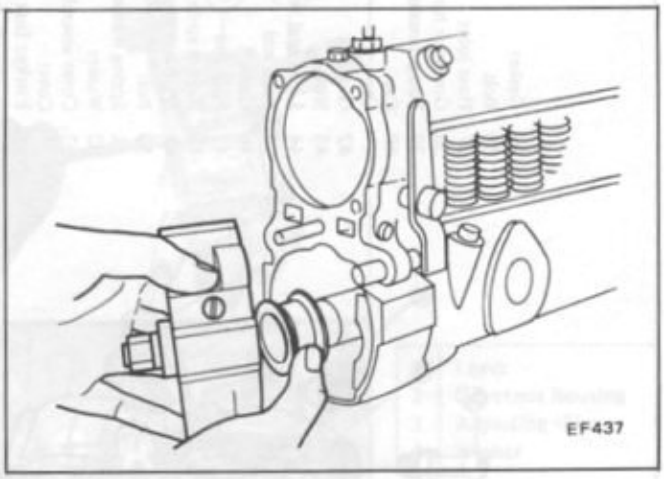


Fig. EF-92 Removing mechanical governor cover

4. Pull out the push rod. (Refer to Figure EF-92.)

Caution:
Be careful not to drop the return spring.

5. Attach Wrench DK57916432 to the timer and lock securely. Using a special wrench DK57915010, remove the round nut and spring washer.

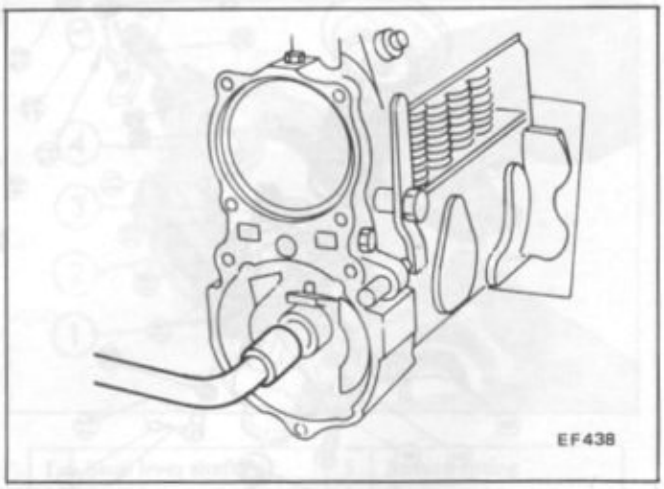


Fig. EF-93 Removing round nut

6. Insert the Extractor DK57926512 into the screw portion of the flyweight holder and pull out the flyweight.

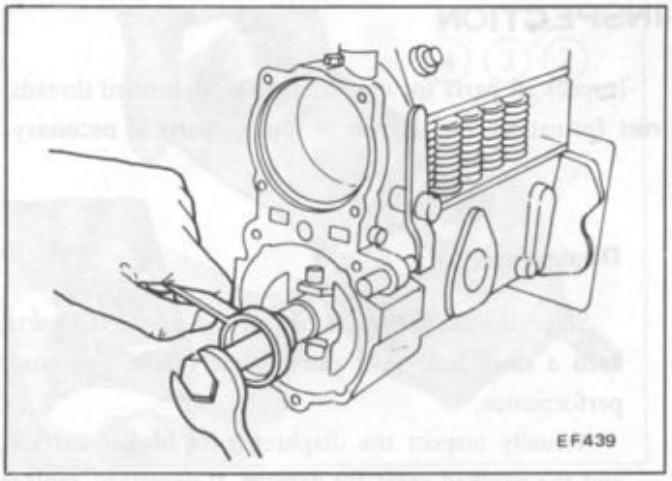


Fig. EF-94 Removing flyweight

7. Remove the five setting screws and take the governor housing out of the pump housing by tapping it with a wooden mallet.

8. Pull impeller out of camshaft.

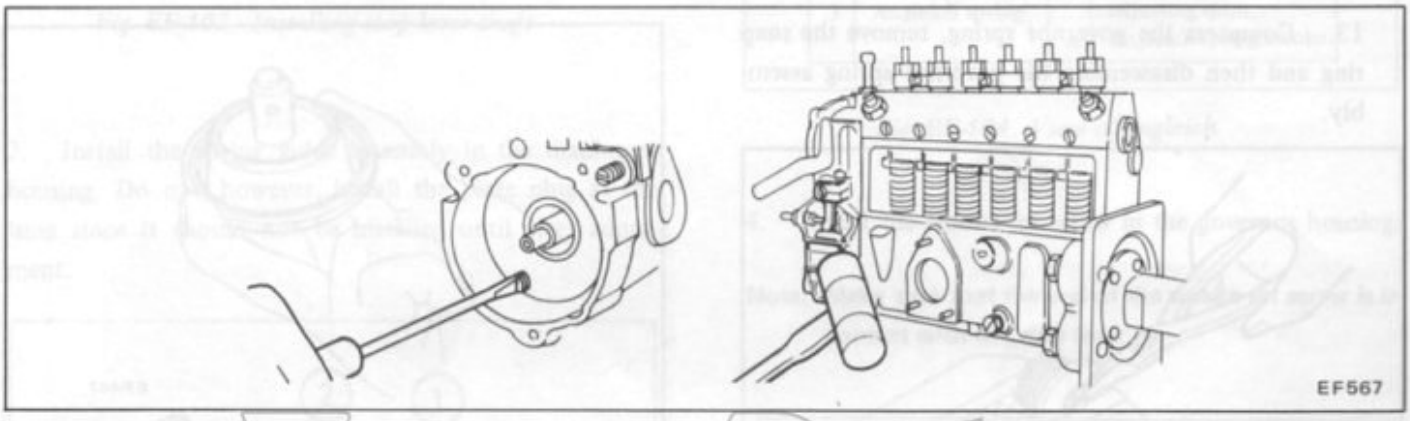


Fig. EF-95 Removing governor housing

9. Remove the plate plug and then remove the idler spring assembly from the diaphragm housing.

10. Remove the bolt and control lever along with the return spring.

11. Remove the stopping lever screw and the split pin. Drive the stopping lever shaft out by lightly tapping on the end (control lever side) with a soft-faced hammer.

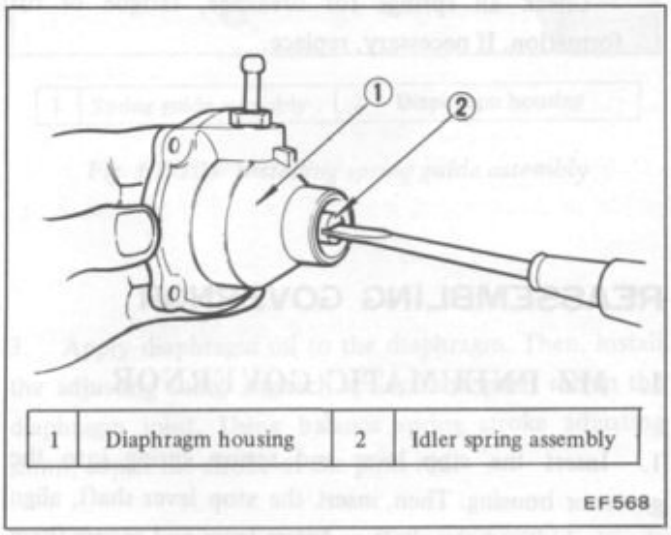


Fig. EF-96 Removing idler spring

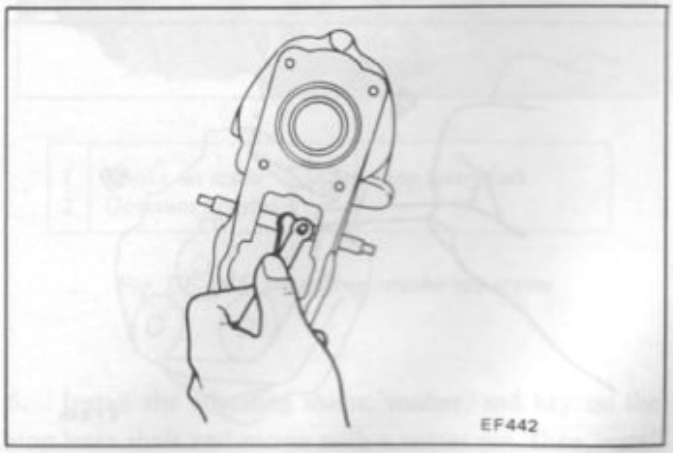


Fig. EF-97 Removing the stopping lever shaft

12. Remove the cap and nut and take out the governor spring assembly (in mechanical section).

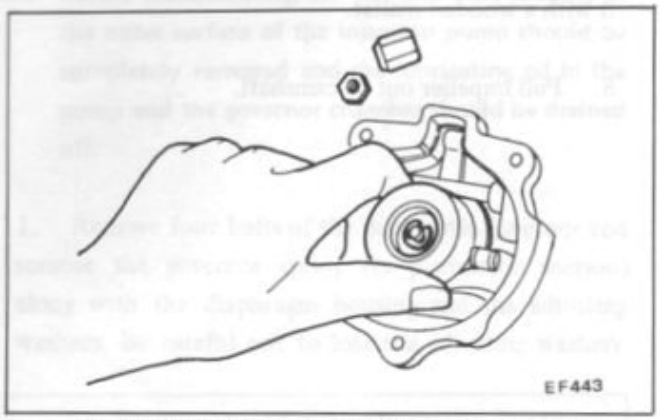


Fig. EF-98 Removing governor spring assembly (in mechanical section)

13. Compress the governor spring, remove the snap ring and then disassemble the governor spring assembly.

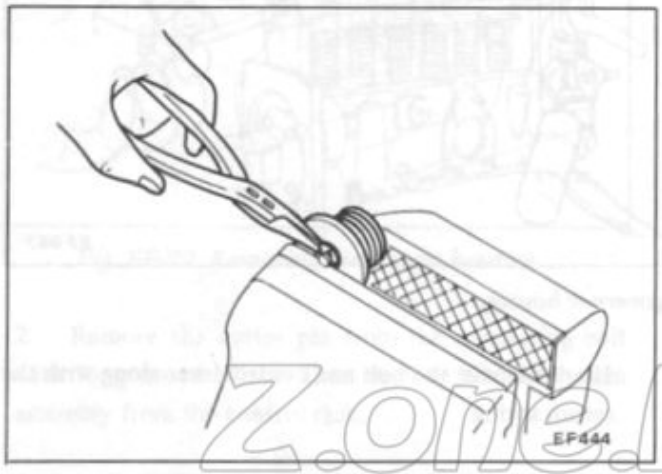


Fig. EF-99 Removing snap ring

14. Remove the screws on both sides, pull out the shaft and take off the guide arm.

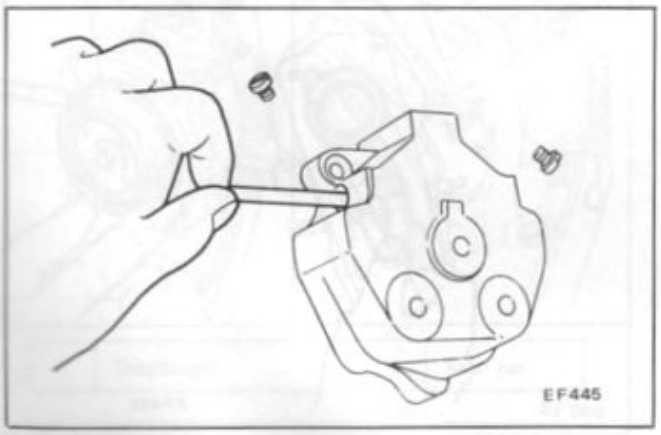


Fig. EF-100 Removing forked link shaft

INSPECTION

Inspect all parts for cracks, damage, deformed threads, rust formation, etc. Repair or replace parts as necessary.

Diaphragm

Since the diaphragm is one of the most vital parts, even a small hole in it can adversely affect governor performance.

Visually inspect the diaphragm for broken surface, and the caulked areas for damage. If necessary, replace the diaphragm as an assembly.

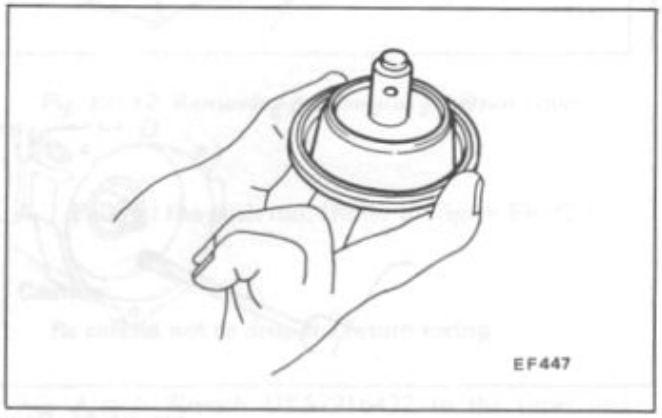


Fig. EF-101 Checking diaphragm

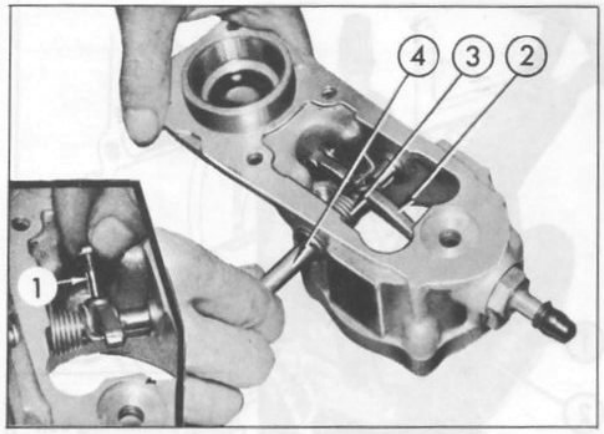
Springs

Check all springs for breakage, fatigue or rust formation. If necessary, replace.

REASSEMBLING GOVERNOR

1. MZ PNEUMATIC GOVERNOR

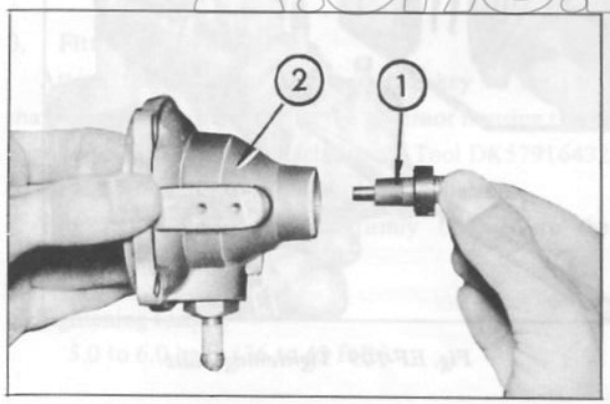
1. Insert the stop lever and return spring into the governor housing. Then, insert the stop lever shaft, align the pin holes in the shaft and stop lever and secure them with the stop lever screw.



1	Screw	3	Return spring
2	Stop lever	4	Stop lever shaft

Fig. EF-102 Installing stop lever shaft

2. Install the spring guide assembly in the diaphragm housing. Do not, however, install the plate plug at this time since it should not be installed until after adjustment.

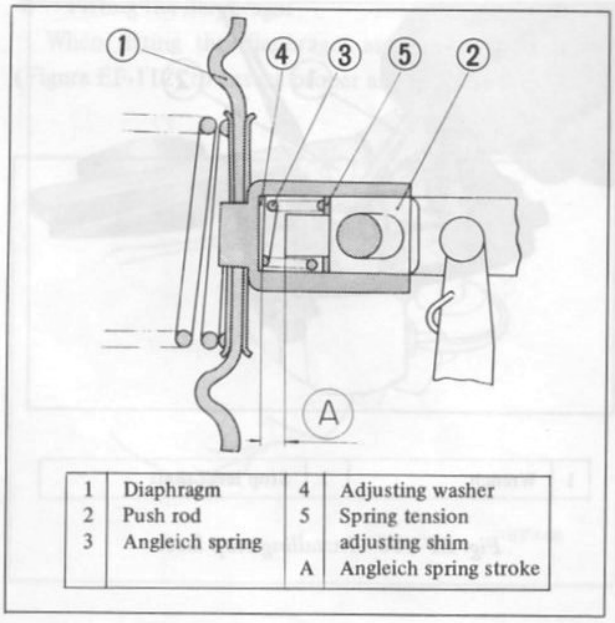


1	Spring guide assembly	2	Diaphragm housing

Fig. EF-103 Installing spring guide assembly

3. Apply diaphragm oil to the diaphragm. Then, install the adjusting shim, angleich spring, and push rod in the diaphragm joint. Using balance spring stroke adjusting shims, adjust the stroke of the push rod.

Standard stroke: SD22 1.0 mm (0.039 in)
SD33 0.6 mm (0.0236 in)

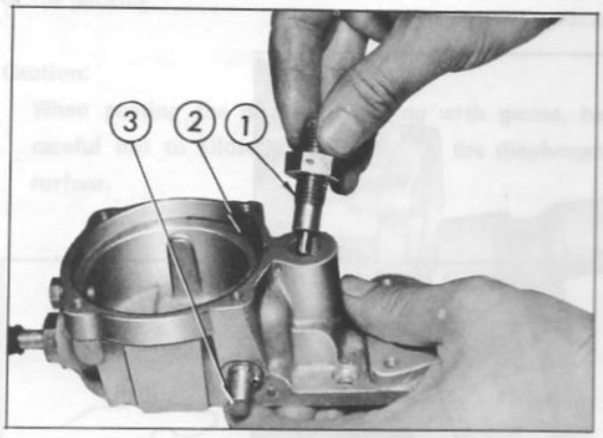


1	Diaphragm	4	Adjusting washer
2	Push rod	5	Spring tension adjusting shim
3	Angleich spring	A	Angleich spring stroke

Fig. EF-104 View of angleich

4. Install the smoke set screw in the governor housing.

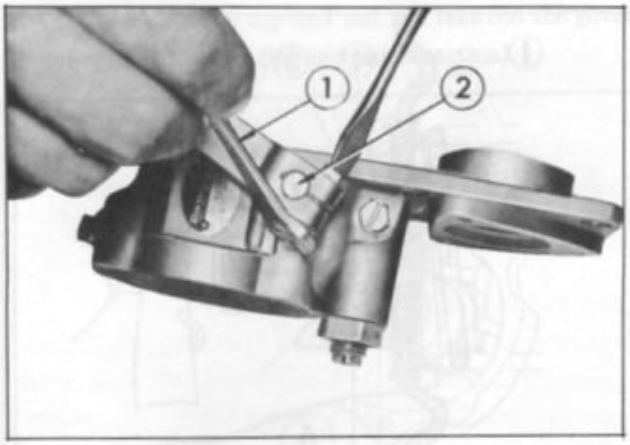
Note: Make sure that the end of the smoke set screw is in contact with the stop lever.



1	Stroke set screw	3	Stop lever shaft
2	Governor housing		

Fig. EF-105 Installing smoke set screw

5. Install the adjusting shims, washer, and key on the stop lever shaft and secure with a cotter pin. Then, install the lever.

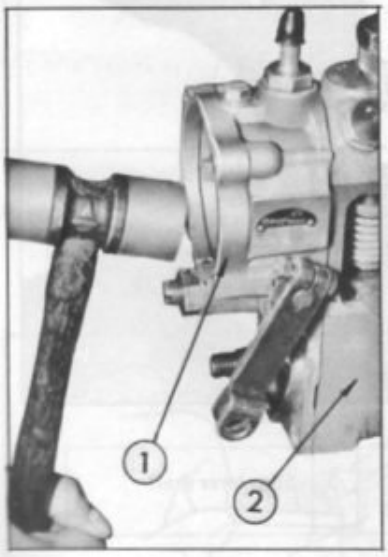


1	Wrench	2	Stop lever shaft

Fig. EF-106 Installing stop lever

6. Install the cap on the camshaft.

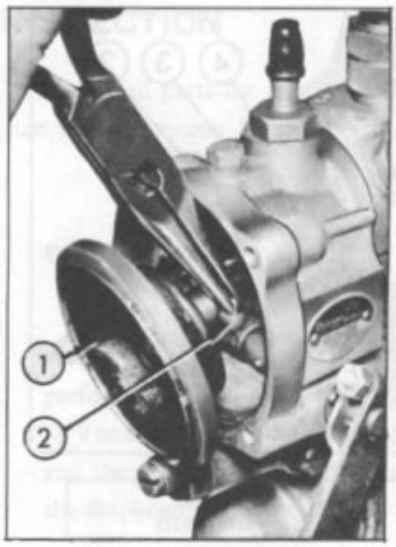
7. Apply non-drying liquid gasket material to the governor housing, position the governor housing on the fuel injection pump assembly, tapping it into position with a plastic mallet, and secure it in position with five set screws.



1	Governor housing
2	Pump housing

Fig. EF-107 Installing governor housing

8. Install the diaphragm and angleich spring on the control rack connecting bolt and lock with a cotter pin. Then, apply grease to the diaphragm ring.



1	Diaphragm
2	Connecting bolt

Fig. EF-108 Installing diaphragm

9. Insert the main spring and then install the diaphragm housing with four bolts.

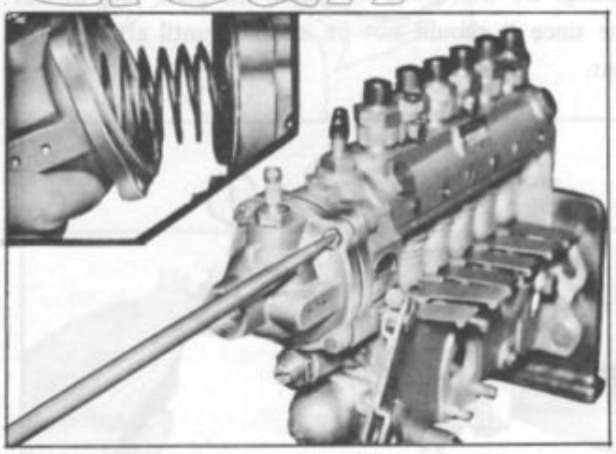


Fig. EF-109 Tightening bolts

2. RBD-MZ GOVERNOR

Assemble the RBD-MZ governor in the reverse sequence of disassembly, paying attention to the following points:

Note: Do not reuse any O-ring or gaskets after removal. Always install new ones.

1. Installing the impeller

After installing the governor housing, install the impeller to the camshaft with the flat blade side toward the governor.

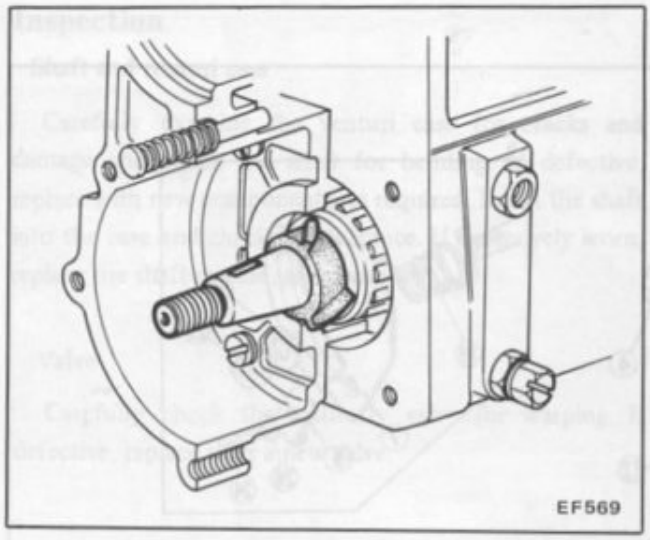


Fig. EF-110 Installing impeller

2. Fitting the governor housing

In assembling, the contact surface between the pump housing and governor housing should be fully coated with non-drying liquid gasket material so as to prevent leakage of lubricating oil.

3. Fitting the flyweight

Attach the flyweight and woodruff key to the camshaft of the pump after fitting the governor housing to the injection pump housing. Attach Special Tool DK57916432 to the timer and lock securely during installation.

The round nut should be firmly fastened to the specified torque.

Tightening torque:

5.0 to 6.0 kg-m (36 to 43 ft-lb)

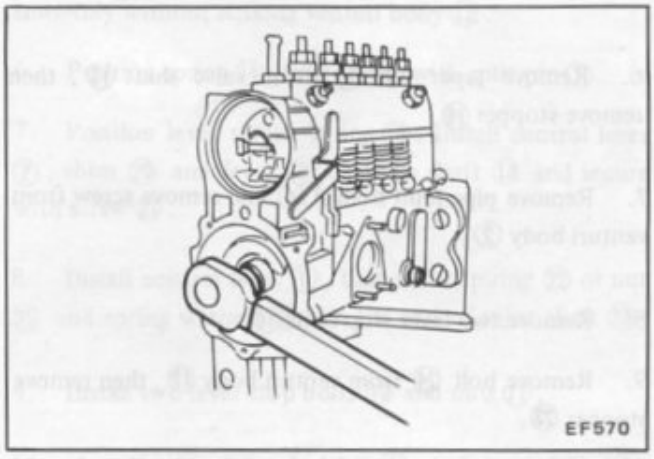


Fig. EF-111 Fitting the flyweight

4. Fitting the diaphragm

When fitting the diaphragm assembly, grease it well (Figure EF-112) to ensure proper air tightness

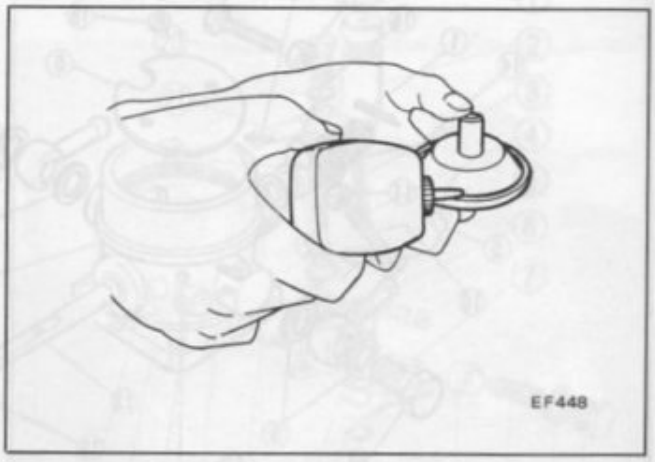


Fig. EF-112 Greasing diaphragm assembly

5. Fitting the governor cover

Always place fresh packing between the housing and the cover of the mechanical governor; lacquer both sides of the packing.

Caution:

When coating the governor housing with grease, be careful not to allow grease to get on the diaphragm surface.

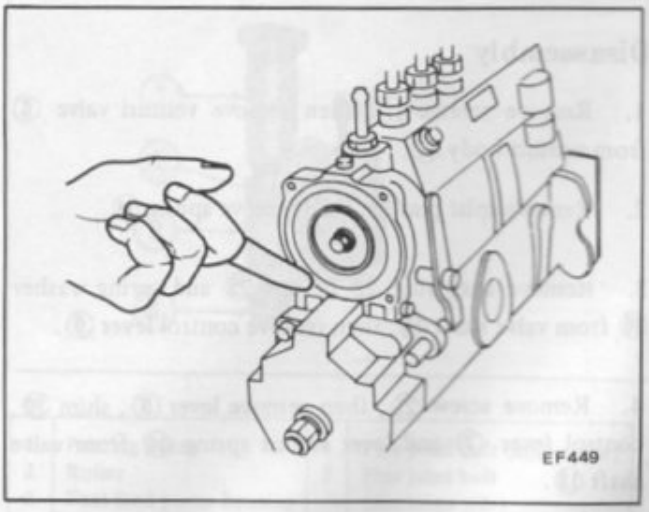
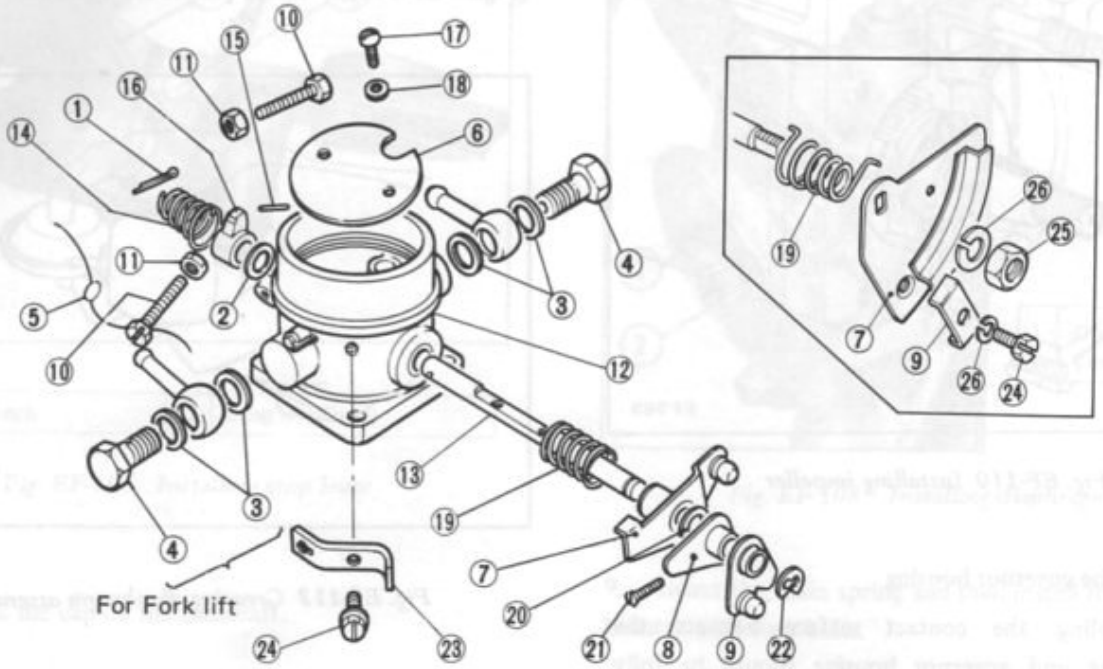


Fig. EF-113 Greasing governor housing

VENTURI



1	Split pin (for model 330)	10	Bolt (Lever stop)	19	Spring (Lever return)
2	Shim	11	Nut	20	Shim
3	Gasket	12	Body (Venturi)	21	Screw
4	Bolt (Pipe joint)	13	Shaft (Valve)	22	Snap ring
5	Hose joint	14	Spring (for model 330)	23	Stopper
6	Valve (Venturi)	15	Taper pin	24	Bolt
7	Control lever	16	Stopper	25	Nut
8	Lever	17	Screw	26	Spring washer
9	Control lever	18	Spring washer		

EF571

Fig. EF-114 Disassembly drawing of the venturi

Disassembly

1. Remove screws ⑰, then remove venturi valve ⑥ from venturi body ⑫.

2. Remove split pin ①, then remove spring ⑭.

3. Remove snap ring ㉒ or nut ㉕ and spring washer ㉖ from valve shaft ⑬, then remove control lever ⑨.

4. Remove screw ㉑, then remove lever ⑧, shim ⑳, control lever ⑦ and lever return spring ⑲ from valve shaft ⑬.

5. Remove valve shaft ⑬ from venturi body ⑫.

6. Remove taper pin ⑮ from valve shaft ⑬, then remove stopper ⑯.

7. Remove pipe joint bolt(s) ④ and remove screw from venturi body ②.

8. Remove two lever stop bolts ⑩.

9. Remove bolt ㉔ from venturi body ⑫, then remove stopper ㉓.

Inspection

Shaft and venturi case

Carefully examine the venturi case for cracks and damage and check the shaft for bending. If defective, replace with new components, as required. Insert the shaft into the case and check for clearance. If excessively worn, replace the shaft or case, as required.

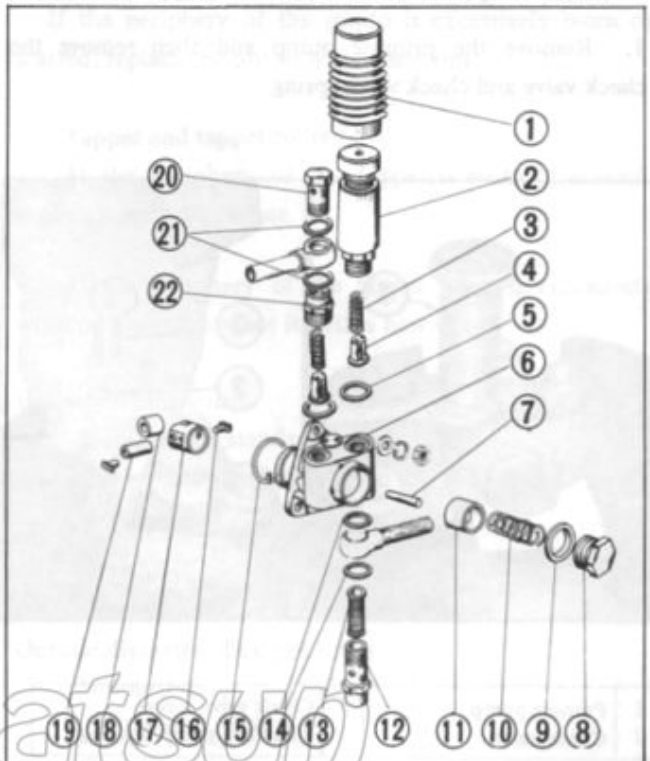
Valve

Carefully check the butterfly valve for warping. If defective, replace with a new valve.

Assembly

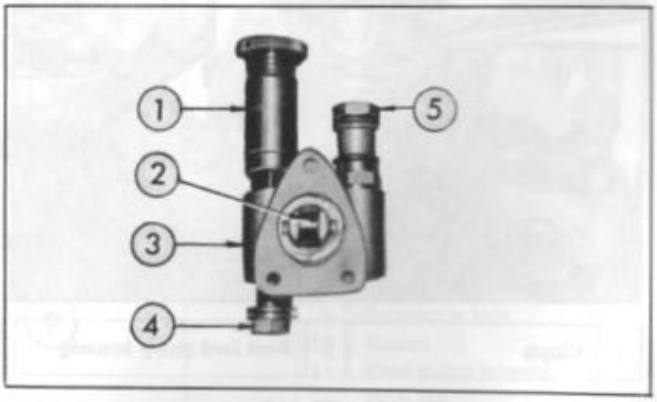
1. Install screw on venturi body ⑫.
2. Install stopper ㉓ on venturi body ⑫ and secure it with bolt ㉔ and washer.
3. Install stopper ⑯ on valve shaft ⑬ and secure with taper pin ⑮.
4. Insert valve shaft ⑬ into venturi body ⑫ through adjusting shim ② and secure venturi valve ⑥ to valve shaft ⑬ with screws ⑰ and spring washer ⑱.
5. Check that venturi valve ⑥ opens and closes smoothly without striking venturi body ⑫.
6. Position spring ⑭, then secure with split pin ①.
7. Position lever return spring ⑲. Install control lever ⑦, shim ⑳ and lever ⑧ on valve shaft ⑬ and secure with screw ㉑.
8. Install control lever ⑨, then set snap ring ㉒ or nut ㉕ and spring washer ㉖ on the end of valve shaft ⑬.
9. Install two lever stop bolts ⑩ and nuts ⑪.
10. Install pipe joint bolt(s) ④ and hose joint ⑤ through gaskets ③.

FEED PUMP AND PRIMING PUMP



1	Priming pump cover	12	Pipe joint bolt
2	Priming pump	13	Gauze filter assembly
3	Check valve spring	14	Nylon packing
4	Check valve	15	Snap ring
5	Washer	16	Spring holder
6	Fuel feed pump housing	17	Tappet
7	Push rod	18	Roller
8	Piston chamber plug	19	Roller pin
9	Washer	20	Pipe joint bolt
10	Piston spring	21	Nylon packing
11	Piston	22	Nipple (plug)

Fig. EF-115 Disassembly drawing of the feed pump

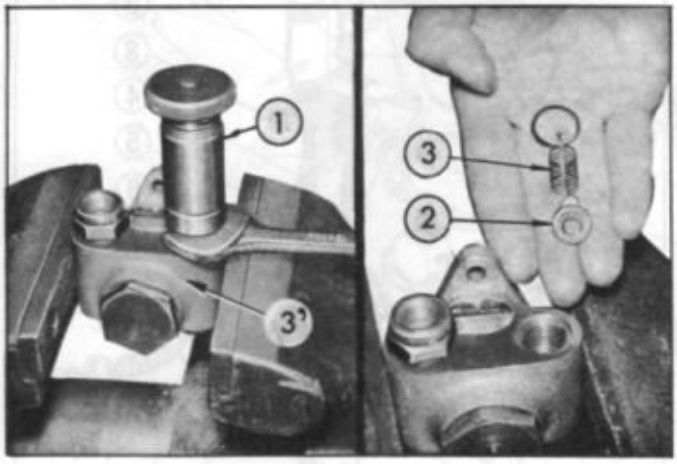


1	Priming pump	4	Pipe joint bolt (intake side)
2	Roller	5	Pipe joint bolt (discharge side)
3	Fuel feed pump housing		

Fig. EF-116 Feed pump

Disassembly

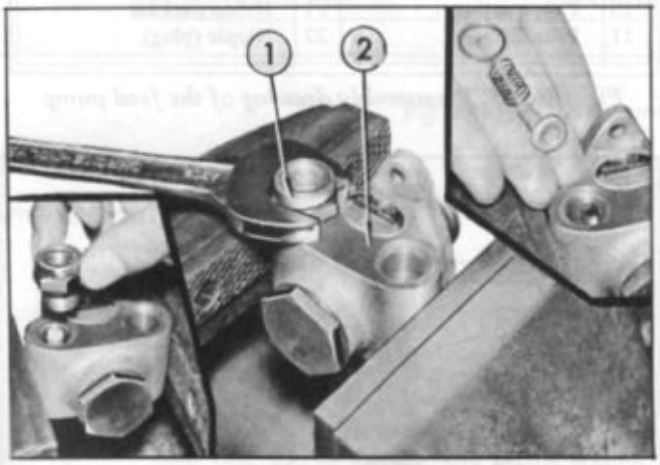
1. Remove the priming pump and then remove the check valve and check valve spring.



1	Priming pump	3	Check valve spring
2	Check valve	3'	Fuel feed pump housing

Fig. EF-117 Removing priming pump

2. Remove the nipple and then remove the check valve and check valve spring.

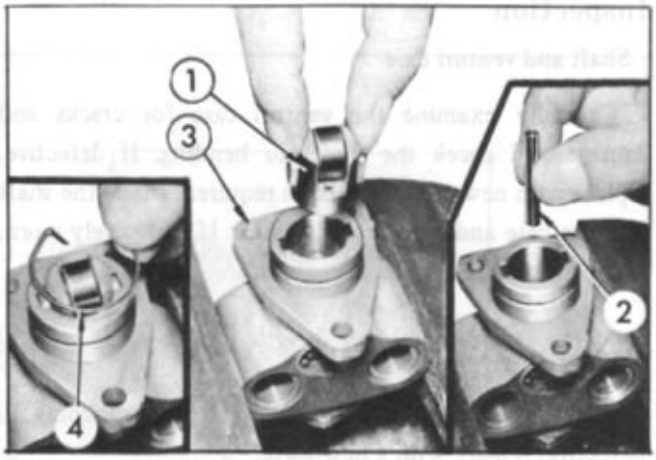


1	Nipple	2	Fuel feed pump housing

Fig. EF-118

3. Remove the snap ring holding the tappet.

4. Remove the tappet and push rod.



1	Tappet assembly	3	Fuel feed pump housing
2	Push rod	4	Snap ring

Fig. EF-119 Removing tappet

5. Remove the plug.

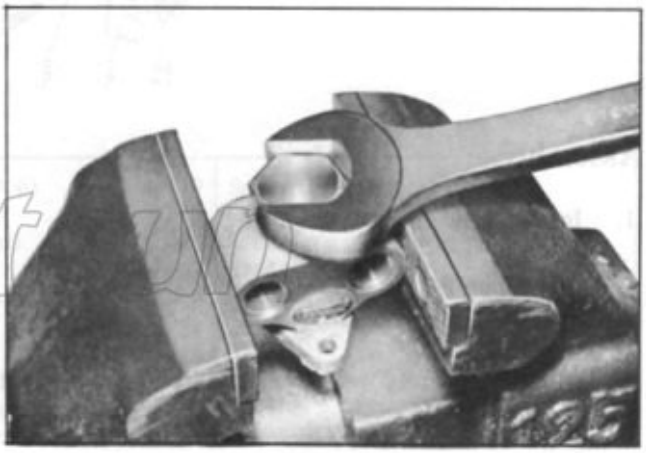
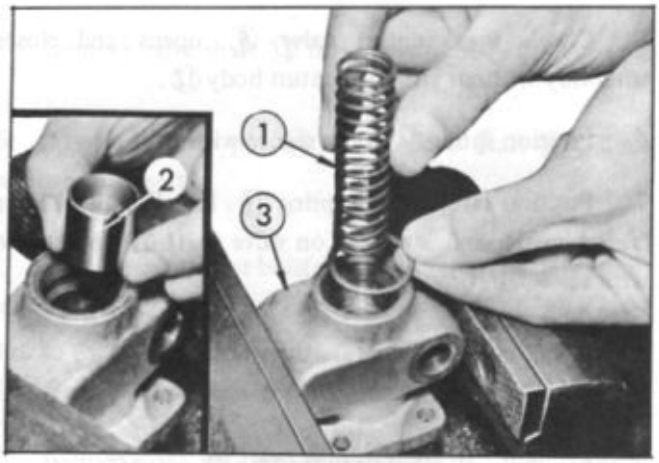


Fig. EF-120 Removing plug

6. Remove the piston and piston spring.



1	Piston spring	3	Fuel feed pump housing
2	Piston		

Fig. EF-121 Removing spring

Inspection

Fuel feed pump housing

1. A steel seat is inserted in the check valve in the fuel feed pump housing. Improper contact of this seat will result in reduce fuel feed capacity. If defective, replace the fuel feed pump housing (with the push rod).

2. If the push rod hole is excessively worn, a portion of the fuel from this area may enter the fuel injection pump camshaft chamber, thinning out and contaminating the lubricating oil. If excessively worn, replace the fuel feed pump housing with a new one.

3. Place the push rod in the feed pump housing and make sure that a slight resistance is felt when pressed with the ball of the thumb.

4. If the push rod hole is excessively worn, but not worn to the extent that replacement of the fuel feed pump housing is required, replace the push rod with an oversized push rod. (Refer to specifications for push rod oversizes). Use a reamer (broach) to correct uneven wear of the push rod hole.

Check valve

If the check valve seat is excessively worn or scarred, replace the check valve with a new one.

Piston

If the periphery of the piston is excessively worn or scarred, replace the piston with a new one.

Tappet and tappet roller

1. If the periphery of the tappet is worn of scarred, replace it with a new one.

2. If the periphery of the tappet roller is excessively worn or scarred, replace it with a new one.

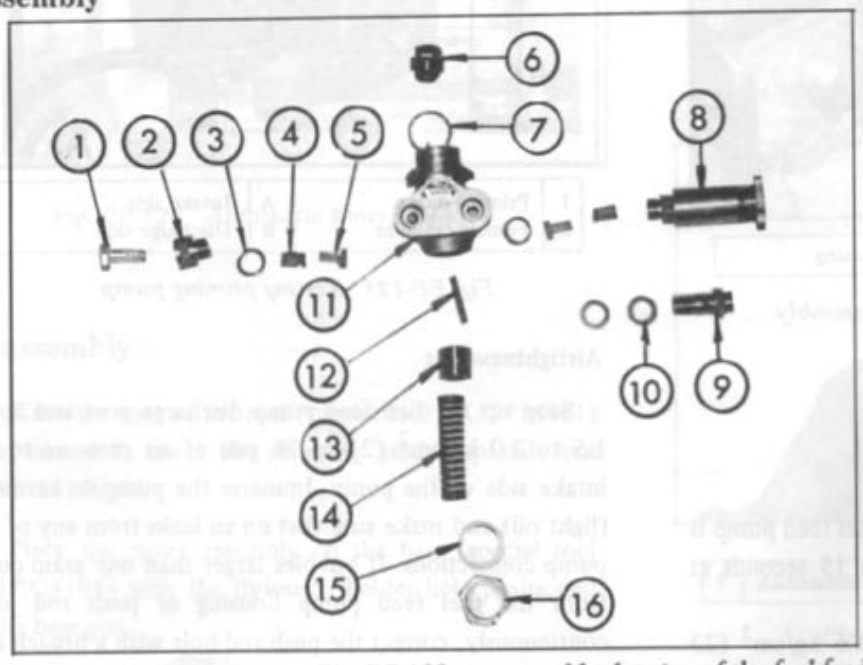
Roller/pin clearance:
Maintenance standard:
0.04 to 0.08 mm (0.0016 to 0.0032 in)
Repair limit:
SD22 ..... 0.3 mm (0.0118 in)
SD33 ..... 0.15 mm (0.0059 in)

Outside diameter of tappet roller:
Nominal size:
15.0 mm (0.0591 in)
Wear limit:
0.4 mm (0.0197 in)

Spring

Examine the spring for damage and check spring tension with a spring tester, or by measuring the free length of the spring. If defective, replace the spring with a new one.

Assembly



1	Pipe joint bolt
2	Nipple
3	Washer
4	Check valve spring
5	Check valve
6	Tappet assembly
7	Snap ring
8	Priming pump
9	Connector bolt
10	Gasket
11	Feed pump housing
12	Push rod
13	Piston
14	Piston spring
15	Gasket
16	Plug

Fig. EF-122 Disassembly drawing of the fuel feed pump

1. Install the tappet in the housing and apply the snap ring to secure the tappet.

2. Insert the push rod.

3. Install the piston and piston spring and secure them with the plug.

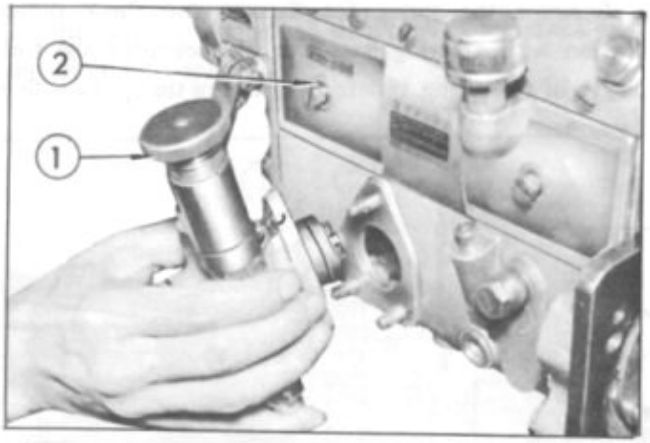
Note: Apply non-drying liquid gasket material to the threads of the plug.

4. Install the check valve, check valve spring and plug through a gasket on the discharge side.

Note: Tighten slowly to insure that the check valve spring remains in the groove.

5. Install the check valve on the intake side with the priming pump in a similar manner.

6. Apply non-drying liquid gasket material to the feed pump housing and install the feed pump housing on the fuel injection pump assembly with three nuts through lock washers.



1	Feed pump assembly	2	Pump housing

Fig. EF-123 Installing feed pump assembly

Testing the fuel feed pump

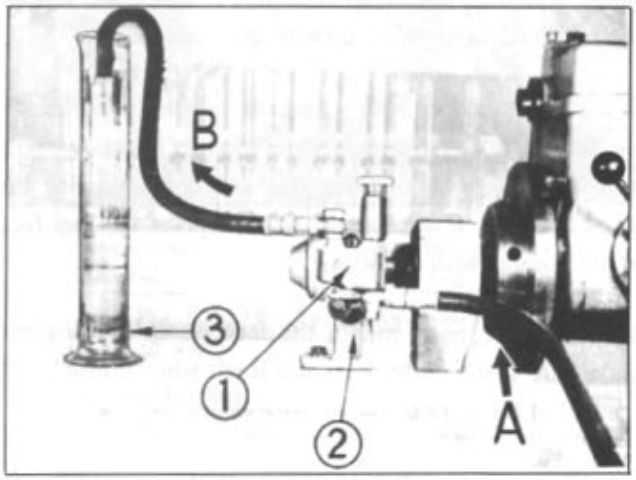
Standard fuel feed volume (feed rate)

The volume of fuel displaced by the fuel feed pump is more than 300 cc (18.3 cu in) for each 15 seconds at 1,000 rpm.

The discharge pressure is more than 1.6 kg/cm^2 (23 psi) per 30 seconds at 600 rpm.

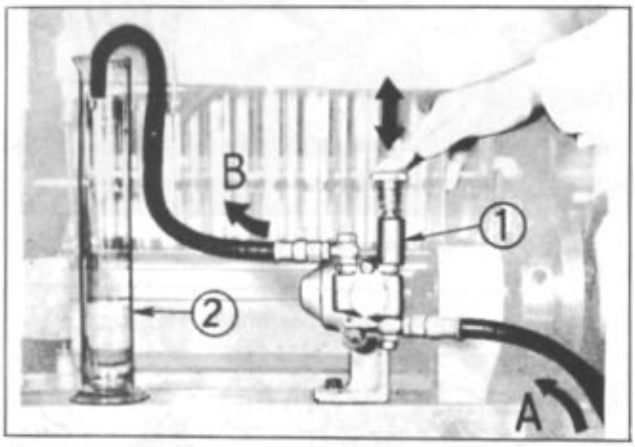
Simplified pump performance test

Connect a pipe to the intake side of the fuel feed pump and operate the piston so as to operate at a speed of 80 rpm (80 strokes per minute) with the oil level [one meter (39.37 in) below the pump], and make sure that the fuel pump starts pumping fuel within one minute.



1	Fuel feed pump	A	Intake side
2	Fuel feed pump drive	B	Discharge side
3	Female cylinder		

Fig. EF-124 Testing oil bleeding volume



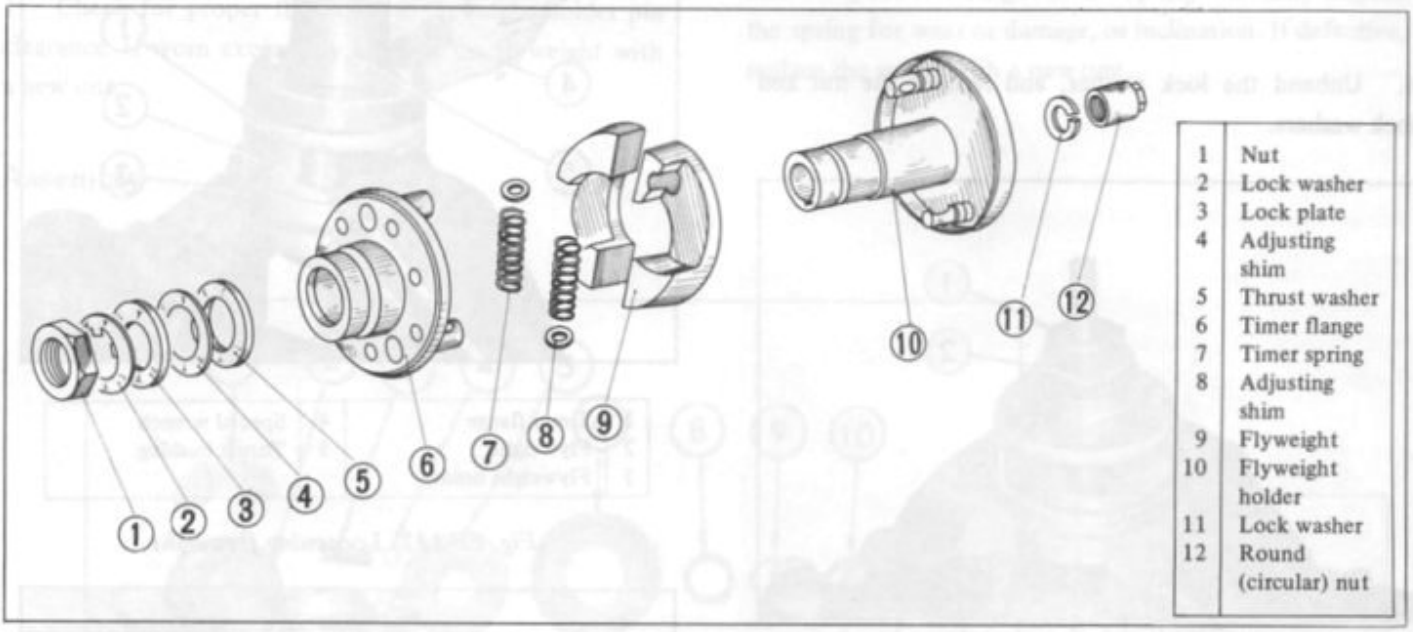
1	Priming pump	A	Intake side
2	Female cylinder	B	Discharge side

Fig. EF-125 Testing priming pump

Airtightness test

Stop up the fuel feed pump discharge port and apply 1.5 to 2.0 kg/cm^2 (21 to 28 psi) of air pressure to the intake side of the pump. Immerse the pump in kerosene (light oil) and make sure that no air leaks from any of the pump connections. If bubbles larger than one grain come from the fuel feed pump housing or push rod joint continuously, correct the push rod hole with a broach and replace the push rod with an oversized push rod.

TIMER

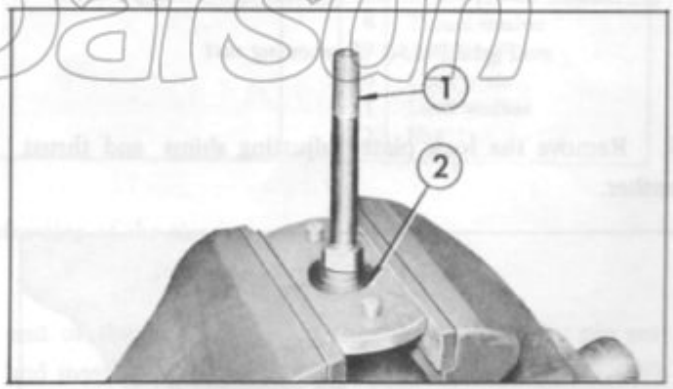


1	Nut
2	Lock washer
3	Lock plate
4	Adjusting shim
5	Thrust washer
6	Timer flange
7	Timer spring
8	Adjusting shim
9	Flyweight
10	Flyweight holder
11	Lock washer
12	Round (circular) nut

Fig. EF-126 Disassembly drawing of the timer

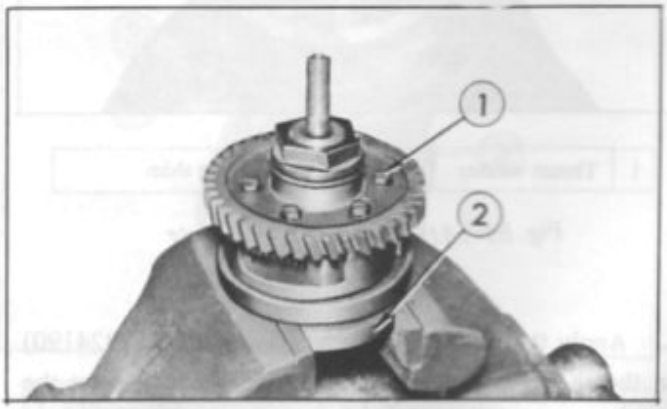
Use the timer disassembly and reassembly tool (special tool set No. DK05790502) for disassembly and assembly of the automatic mechanical timer.

Fig. EF-127 Automatic timer assembly



1	Bushing guide
2	Base

Fig. EF-128 Securing the base of the tool in a vise



1	Automatic timer	2	Base

Fig. EF-129 Setting timer

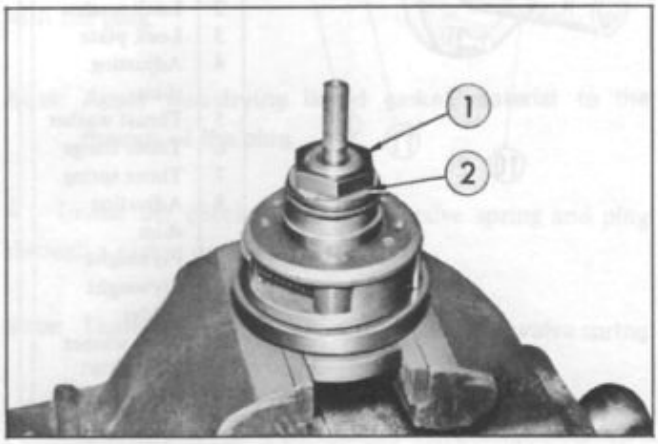
Disassembly

1. Place the base of the tool (special tool DK57924161) in a vise and insert the bushing guide (special tool DK57924170).

2. Place the timer assembly on the base (special tool DK57924161) with the flyweight holder hole positioned on the base pin.

3. Remove six bolts and lock washers and remove the injection pump drive gear.

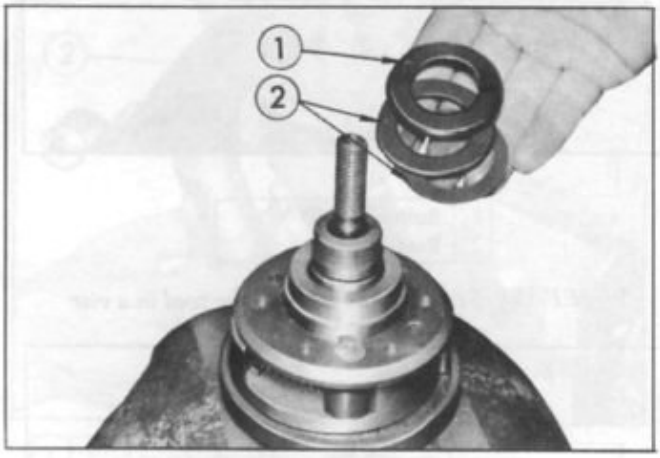
4. Unbend the lock washer, and remove the nut and lock washers.



1	Nut	2	Lock washer

Fig. EF-130 Removing nut

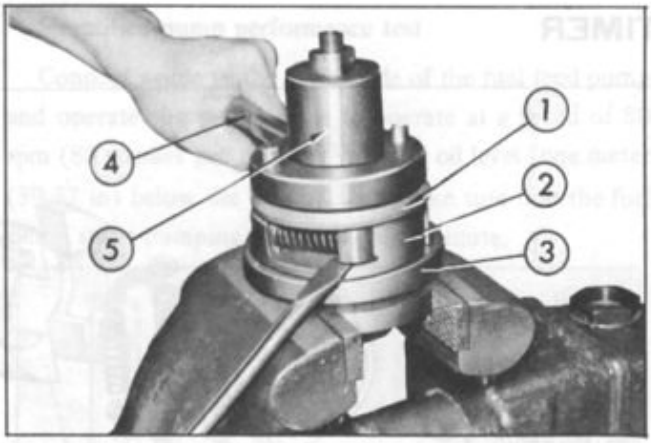
5. Remove the lock plate, adjusting shims and thrust washer.



1	Thrust washer	2	Adjusting shim

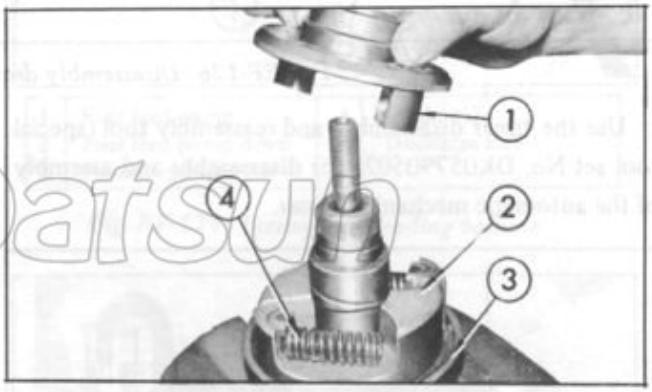
Fig. EF-131 Removing lock plate

6. Apply the thrust bushing (special tool DK57924190) on the threaded portion of the guide bushing, press the spring with the special wrench (special tool DK57916432), loosen the thrust bushing with a lever (by prying), and remove the timer flange.



1	Timer flange	4	Special wrench
2	Flyweight	5	Thrust bushing
3	Flyweight holder		

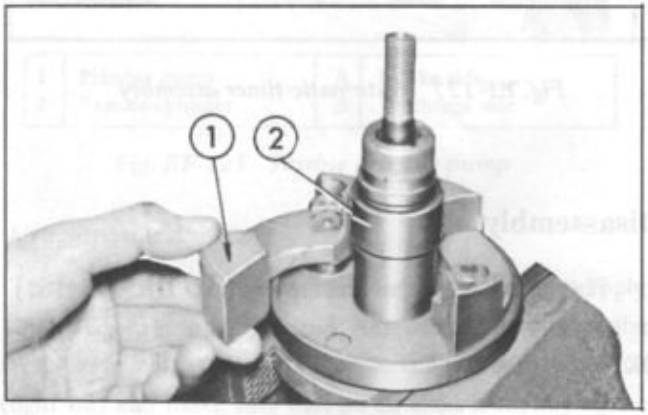
Fig. EF-132 Loosening flyweight



1	Timer flange	3	Flyweight holder
2	Flyweight	4	Timer spring

Fig. EF-133 Removing timer flange

7. Remove the timer spring, adjusting shim and flyweight from the flyweight holder one by one.



1	Flyweight	2	Flyweight holder

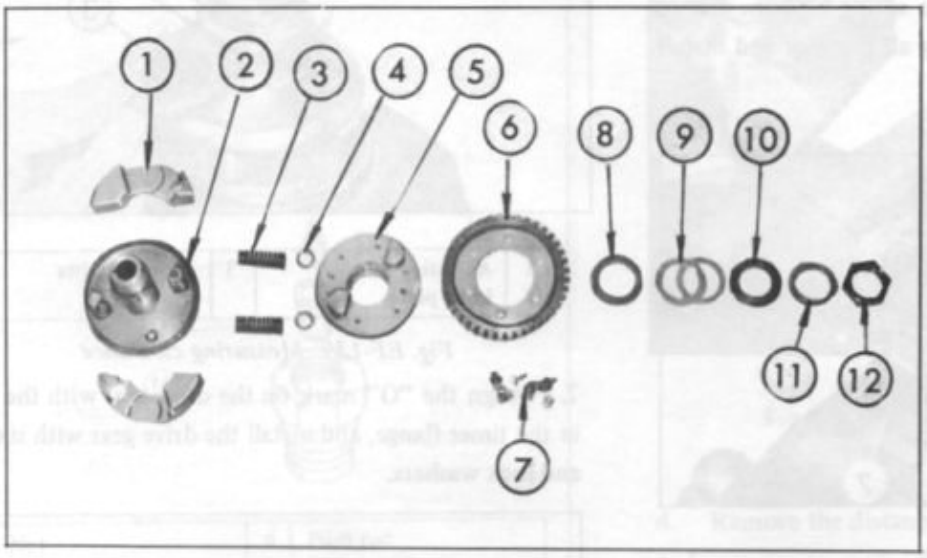
Fig. EF-134 Removing flyweight

Inspection

1. Check for proper flyweight to flyweight holder pin clearance. If worn excessively, replace the flyweight with a new one.

2. Check spring tension with a spring tester and measuring the free length of the spring. Carefully inspect the spring for wear or damage, or inclination. If defective, replace the spring with a new one.

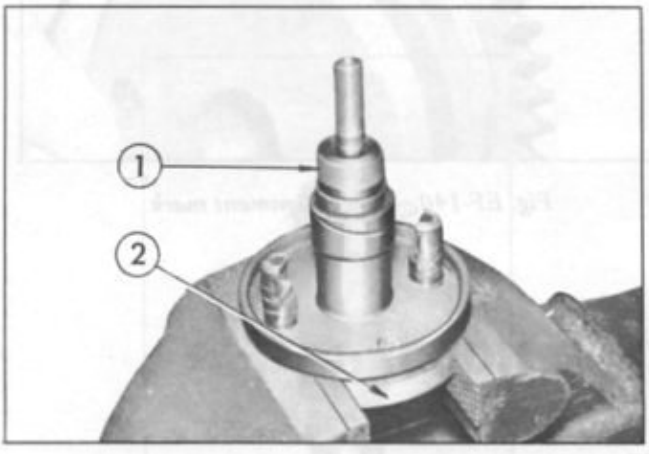
Assembly



1	Flyweight
2	Flyweight holder
3	Timer spring
4	Adjusting shim
5	Timer flange
6	Drive gear
7	Bolt and lock washer
8	Thrust washer
9	Adjusting shim
10	Lock plate
11	Lock washer
12	Nut

Fig. EF-135 Disassembly drawing of the timer

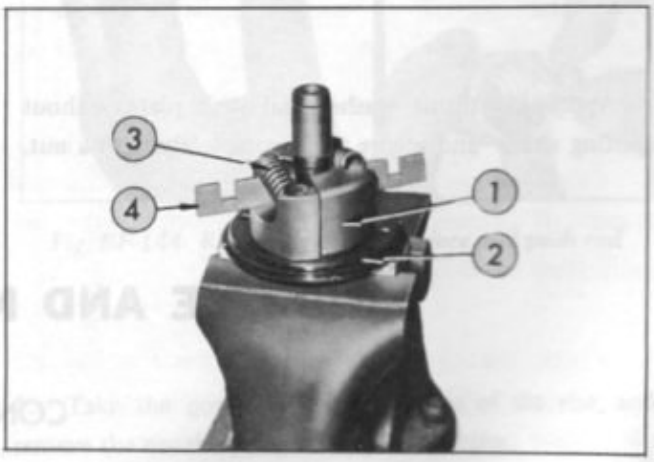
1. Secure the base and guide bushing in a vise, apply the hole in the flyweight on the base pin.



1	Flyweight holder	2	Base

Fig. EF-136 Setting flyweight on the base

2. Apply grease to the flyweight holder pin and the flyweight holder hole and install the flyweight. Place one end of the timer spring in the flyweight holder pin seat and insert the spring support (special tool: DK57932020) under the spring, positioning the spring on the flyweight.



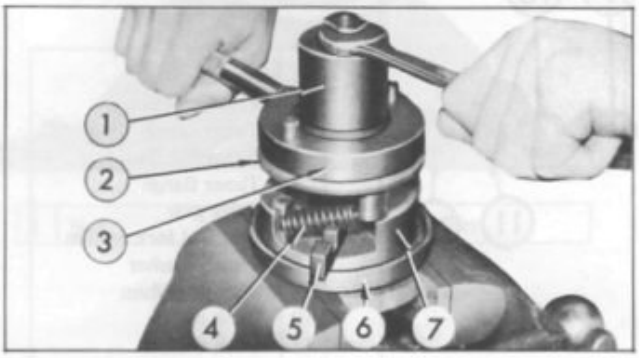
1	Flyweight	3	Timer spring
2	Flyweight holder	4	Spring support

Fig. EF-137 Installing timer spring

3. Align the notch on the timer flange with the key groove in the flyweight holder, apply the special wrench to the flange, and install the thrust bushing on the threaded part of the bushing guide.

4. Turn the special wrench in the direction to compress the spring, thread in the thrust bushing, and remove the spring support.

Then, using a lever, insert the spring into the flange hole, thread in the thrust bushing all the way and install the flange in its proper position.



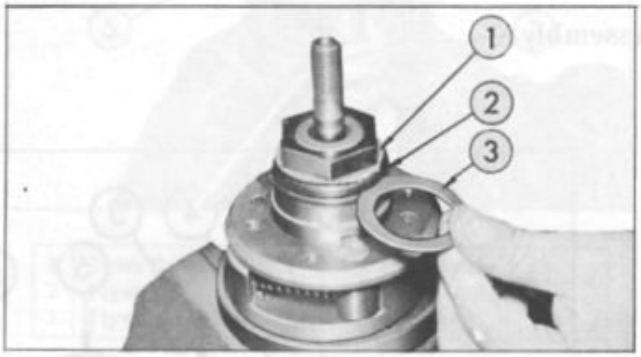
1	Thrust bushing	5	Spring support
2	Timer flange	6	Flyweight holder
2	Special wrench	7	Flyweight
4	Timer spring		

Fig. EF-138 Installing timer flange

Note: Make sure that the spring is fully seated in the holes in the flange and flyweight holder.

5. Apply the thrust washer and lock plate without adjusting shims and secure them completely with a nut.

6. Measure lock plate to thrust washer clearance with a thickness gauge, select adjusting shims of appropriate thickness so that clearance will be adjusted to within 0.02 to 0.1 mm (0.0008 to 0.0039 in), and install the shims between the washers.



1	Adjusting shim	3	Thrust washer
2	Lock plate		

Fig. EF-139 Measuring clearance

7. Align the "O" mark on the drive gear with the notch in the timer flange, and install the drive gear with six bolts and lock washers.

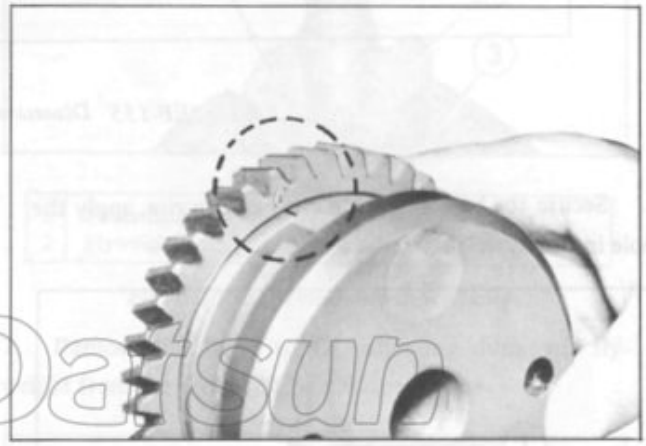


Fig. EF-140 Timer alignment mark

NOZZLE AND NOZZLE HOLDER

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Inspection EF-50
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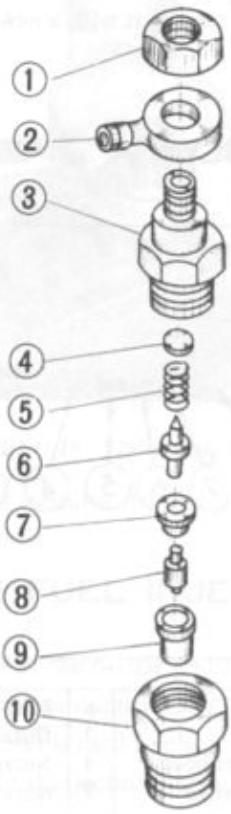


1	Nut	6	Push rod
2	Nipple	7	Distance piece
3	Holder assembly	8	Nozzle assembly
4	Adjusting shim	9	Nozzle assembly
5	Return spring	10	Nozzle nut

Fig. EF-141 Disassembly drawing of the nozzle and nozzle holder

Fig. EF-142 Nozzle and nozzle holder

DISASSEMBLY

1. Secure the nozzle holder body in a vise.
2. Remove the lock nut and then remove the nipple.
3. Remove the nozzle holder body from the nozzle nut.

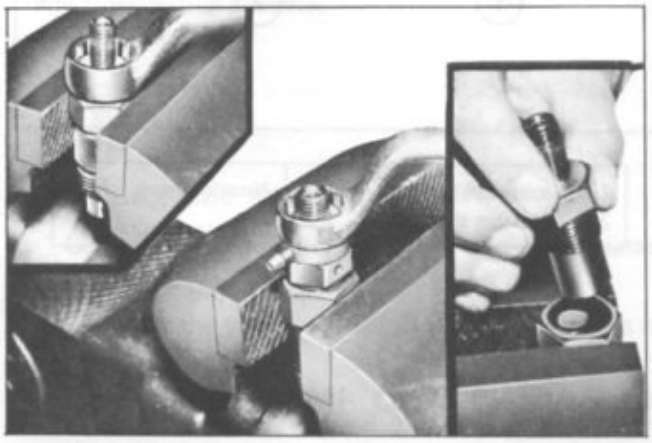


Fig. EF-143 Removing nozzle holder

4. Remove the distance piece and push rod.

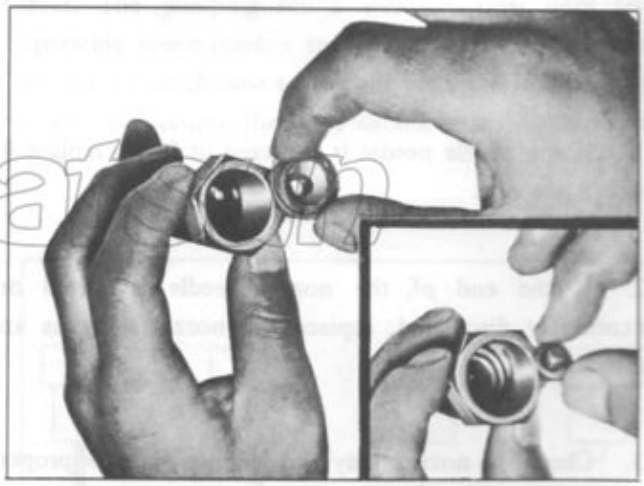
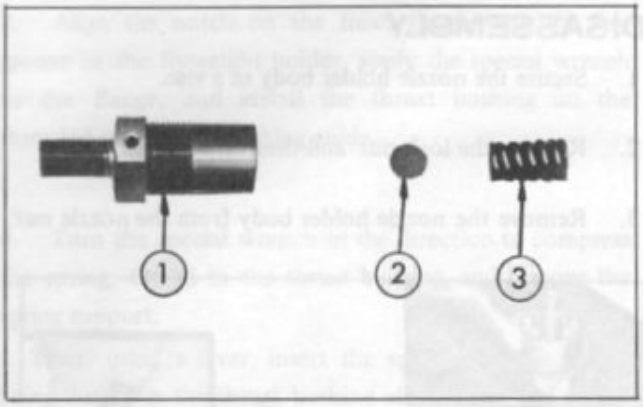


Fig. EF-144 Removing distance piece and push rod

5. Take the nozzle holder body out of the vise, and remove the nozzle spring and adjusting shims.

Note: Remove the adjusting shims with a piece of wire. Be careful not to damage the end of the nozzle holder.



1	Nozzle holder body	3	Nozzle spring
2	Adjusting shim		

Fig. EF-145 Removing adjusting shim

CLEANING AND INSPECTION

Cleaning

Thoroughly clean all disassembled parts with fresh kerosene or solvent.

Inspection

1. If the nozzle needle is damaged or fused, replace it with a new one.

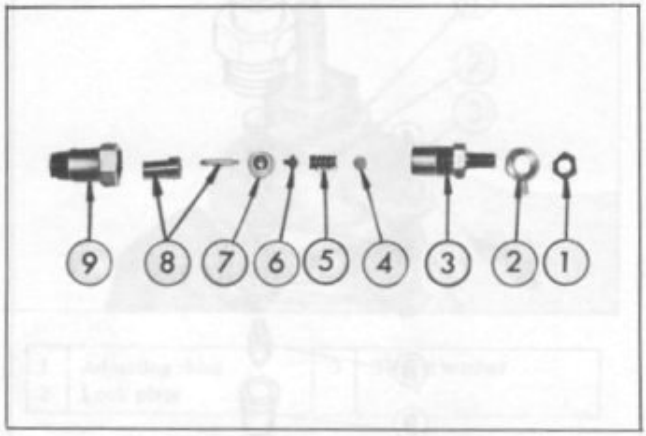
2. If the end of the nozzle needle is seized or excessively discolored, replace the nozzle body as an assembly.

3. Check the nozzle body and distance piece for proper contact. If excessively worn or damaged, replace the nozzle body or distance pieces as required.

4. Check the distance piece and nozzle holder for proper contact. If excessively worn or damaged, replace the distance piece or nozzle holder, as required.

5. Examine the nozzle spring for excessive wear or damage. Check spring force with a spring tester or by measuring the free length of the spring. If excessively worn or damaged, replace it with a new spring.

REASSEMBLY



1	Gasket	6	Push rod
2	Nipple	7	Distance piece
3	Nozzle holder body	8	Nozzle assembly
4	Adjusting washer	9	Nozzle nut
5	Nozzle spring		

Fig. EF-146 Dissembly drawing of the nozzle and nozzle holder

1. Insert the nozzle spring and adjusting shims to the nozzle nut.

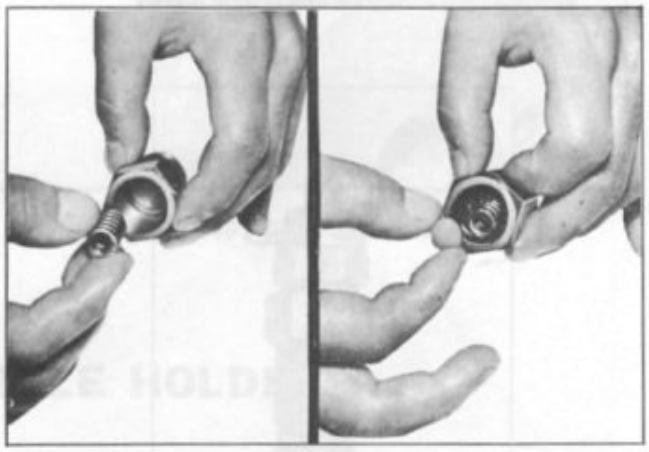


Fig. EF-147 Inserting spring and shims

2. Secure the nozzle nut in a vise and then tighten the nozzle holder assembly.

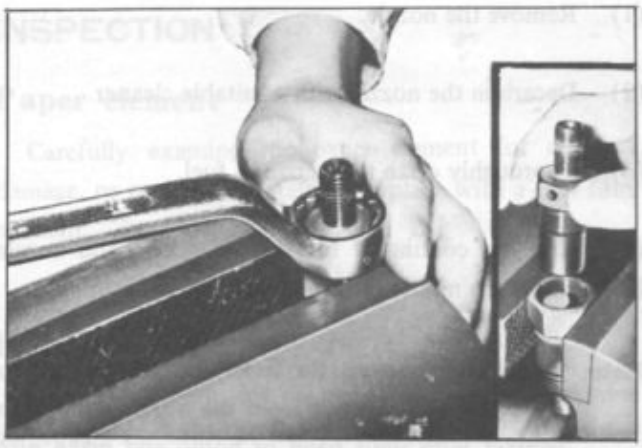


Fig. EF-148 Tightening holder

3. Install the connector to the nozzle holder body through a gasket.

ADJUSTING FUEL INJECTION PRESSURE

Thoroughly clean the nozzle and tester and make sure that there is no dirt or impurities in the kerosens used for the tester. The tester is used to check the spray pattern of the fuel and to adjust injection starting pressure.

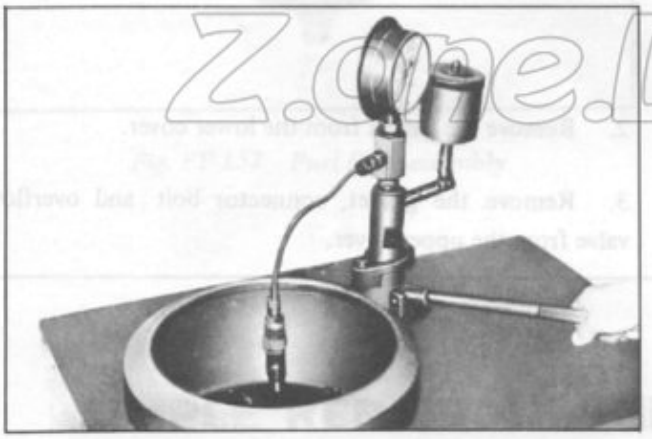


Fig. EF-149 Manual type nozzle tester

Adjusting initial injection pressure

The nozzle injection starting pressure should be equal for all cylinders.

1. Operate the lever of the tester at the rate of one stroke per second and read the pressure at time of injection. The pointer on the well oscillates slightly during fuel injection. Adjust using the center of the oscillating amplitude of the pointer as the fuel injection starting pressure.

2. Based upon the indication of the pressure gauge pointer, increase or decrease the thickness of the nozzle spring adjusting shims until injection starting pressure becomes 100 kg/cm^2 (1,422.3 psi). Increasing the thickness of the adjusting shims increases injection starting pressure, and decreasing shim thickness reduces injection starting pressure.

A shim thickness of 0.05 mm (0.0020 in) corresponds approximately to a difference of 6 kg/cm^2 (85.338 psi) in injection starting pressure.

Checking the spray pattern

Generally, it is better to check the spray pattern without applying a pressure gauge.

However, the pressure gauge can be used if it does not have a cock.

1. To check the spray pattern, operate the tester lever at the rate of one stroke per second and observe the spray issuing forth from the nozzle. The spray must be evenly injected in a thin, symmetrical jet, and should not be thin and vaporized, stepped, branched or uneven.

2. Gradually increase the operating speed of the tester lever. The pumping sound will disappear until lever operating speed reaches approximately 4 to 6 times per second, at which time a fast pumping sound will be heard. When this occures, the spray should be a fine even spray mist.

3. Proper and improper spray patterns

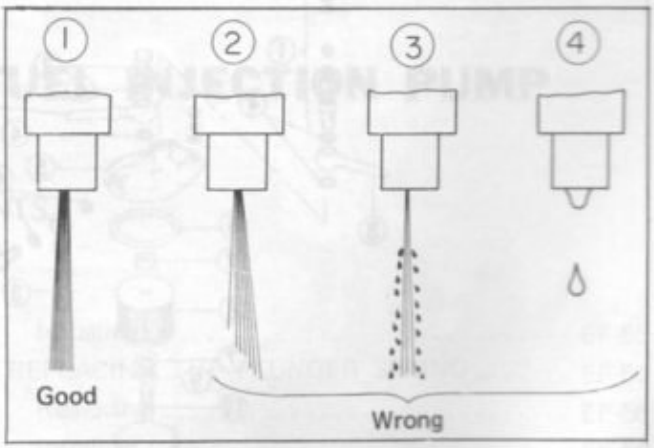


Fig. EF-150 Spray pattern

(1) A proper spray pattern is provided when the spray is injected as a fine mist in a direct projection fo the nozzle centerline.

(2) If the spray is deflected up or down or to one side or is branched, the spray pattern is not satisfactory.

(3) If small droplets of fuel are observed in the spray, or if the spray is stepped, thinly vaporized, or uneven, the spray pattern is not satisfactory.

(4) If drops from on the end of the nozzle, or if fuel drips from the end of the nozzle, the spray pattern is not satisfactory.

4. Inadequate fuel spray pattern or drips from the nozzle end is often due to improper contact of the needle with the seat. If such a failure is experienced, service the injection nozzle as follows:

(1) Remove the nozzle.

(2) Decarbon the nozzle with a suitable cleaner.

(3) Thoroughly clean it in a pan of fuel.

(4) Apply a coating of fuel to the needle and nozzle body, insert the nozzle into the body and lap properly.

Note: When using the nozzle tester, be careful not to leave the fuel sprayed from the nozzle come into contact with your hand or body, and make sure that your eyes are properly protected.

FUEL FILTER AND OVERFLOW VALVE

CONTENTS

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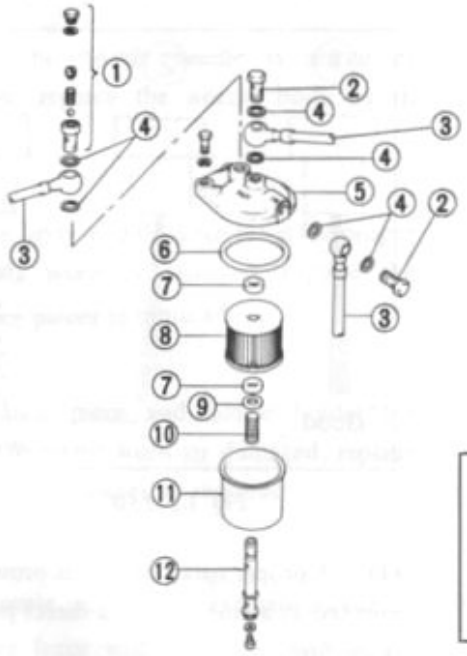
Filter element .. EF-53
Filter body and upper and lower covers .. EF-53
REASSEMBLY .. EF-53
TESTING THE OPENING PRESSURE OF THE OVERFLOW VALVE .. EF-53

DISASSEMBLY

1. Remove the center bolt from the bottom of the fuel filter assembly and remove the filter body, filter element and lower cover together.

2. Remove the gasket from the lower cover.

3. Remove the gasket, connector bolt and overflow valve from the upper cover.



1	Overflow valve	7	Element packing
2	Connector bolt	8	Paper element
3	Fuel line	9	Packing seat
4	Packing	10	Set spring
5	Upper cover	11	Body
6	Body gasket	12	Center bolt

Fig. EF-151 Disassembly drawing of the fuel filter

INSPECTION

Paper element

Carefully examine the paper element for clogging, damage, or peeling. If defective, replace with a new filter element.

Body and upper covers

Inspect the body for cracks or damage and examine the covers for splits or damage. Replace defective components with new ones, if necessary.

Fig. EF-152 Fuel filter assembly

REASSEMBLY

1. Assemble the body, packing, set spring, spring seat, element packing and paper element, on the center bolt.

2. Install the above assembled parts on the upper cover with the body gasket.

Note: Make sure that the body gasket between the body and the upper cover is properly seated and is completely air tight.

TESTING THE OPENING PRESSURE OF THE OVERFLOW VALVE

Attach a pressure gauge to the fuel filter discharge port, and check valve opening pressure by operating the priming pump. If the pressure is not within the range of 1.5 to 1.6 kg/cm^2 (21.33 to 22.76 psi), apply a shim on top of the spring, or replace spring or overflow valve with a new one, as required.

SIMPLE REPAIR OF THE FUEL INJECTION PUMP

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Installing the delivery valve holder EF-54
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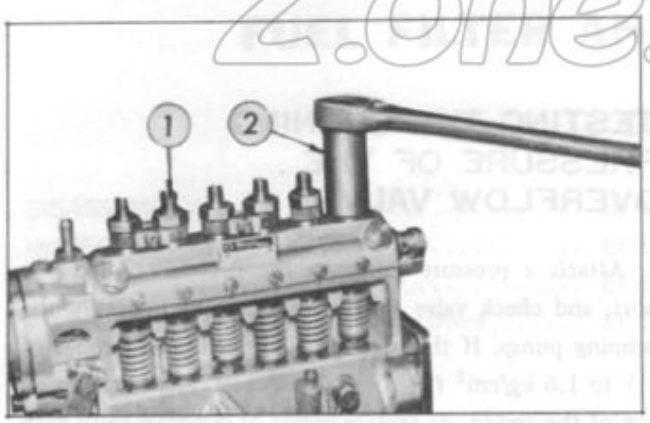
Installing EF-57

REPLACING THE DELIVERY VALVE

Remove the delivery valve holder

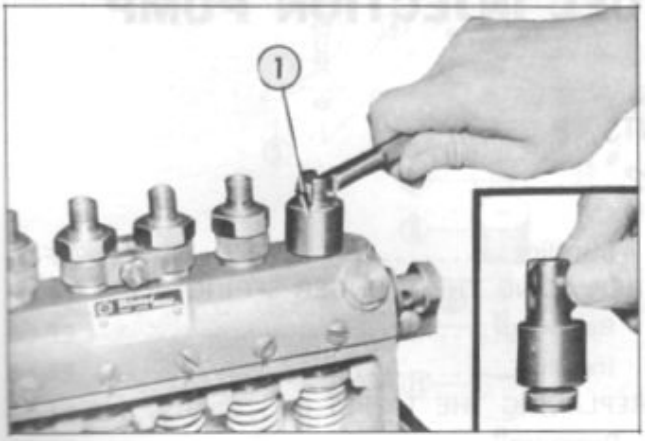
1. Thoroughly clean the area around the nozzle tube and the delivery valve.
2. Remove the nozzle tube.
3. Remove the delivery valve holder lock plate.
4. Remove the delivery valve holder and the delivery valve spring.



1	Delivery valve holder	2	Socket wrench

Fig. EF-153 Removing delivery valve holder

Remove the delivery valve



1	Delivery valve extractor

Fig. EF-154 Removing delivery valve

Thread in the delivery valve extractor (special tool DK57920032) and remove the delivery valve as shown in the Figure EF-154.

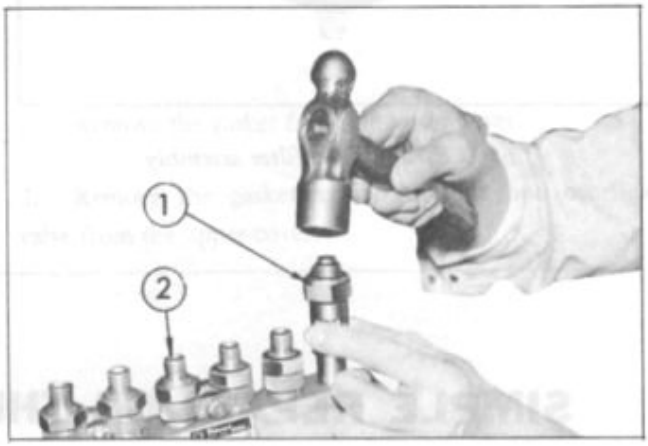
Installing the delivery valve

1. Thoroughly clean the delivery valve.
2. Install the delivery valve in the pump housing.

Note: Make sure that dirt does not enter between the top of the plunger barrel and the delivery valve.

3. Settle the delivery valve gasket, with its larger faced portion down, in its proper position by tapping it lightly with a hammer through the extractor (special tool DK57920032).

Note: Do not reuse any gaskets after removal. Always install new ones.

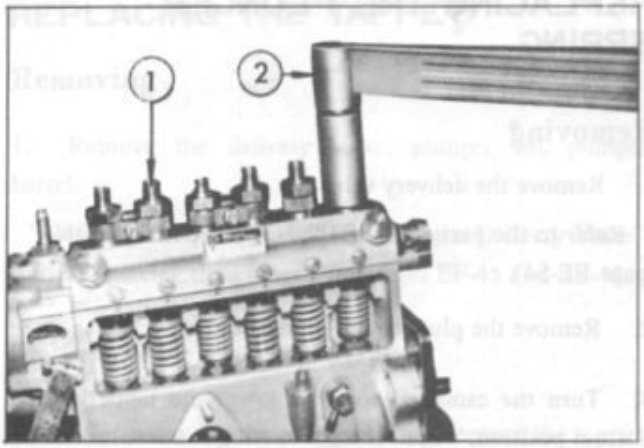


1	Extractor	2	Delivery valve holder

Fig. EF-155 Tapping extractor

Installing the delivery holder

1. Install the delivery valve spring.
2. Tighten the delivery valve holder with a tightening torque of 3.0 to 3.5 kg-m (21.7 to 25.3 ft-lb). The holder should be loosened once and then retightened.



1	Delivery valve holder	2	Torque wrench

Fig. EF-156 Tightening delivery valve holder

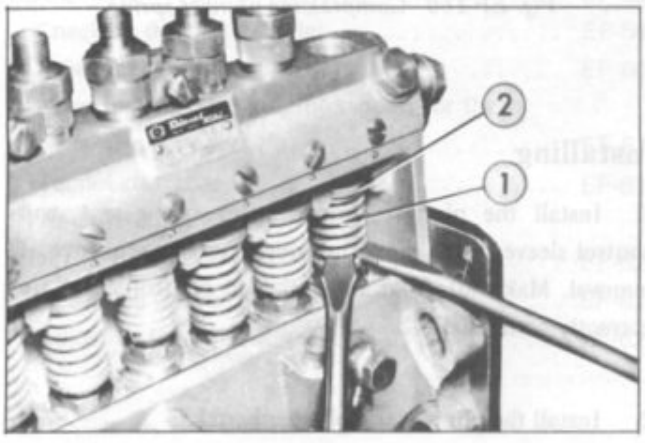
3. Install the lock plate, nozzle tube and nozzle tube clamp.

REPLACING THE PLUNGER

In case of emergency, the plunger can be replaced without removing the fuel injection pump. However, when replacing the plunger, injection timing and fuel injection volume must be readjusted. This method of replacement is described below:

Removing

1. Remove the delivery valve. Refer to the paragraph "Replacing the Delivery Valve" (page EF-54).

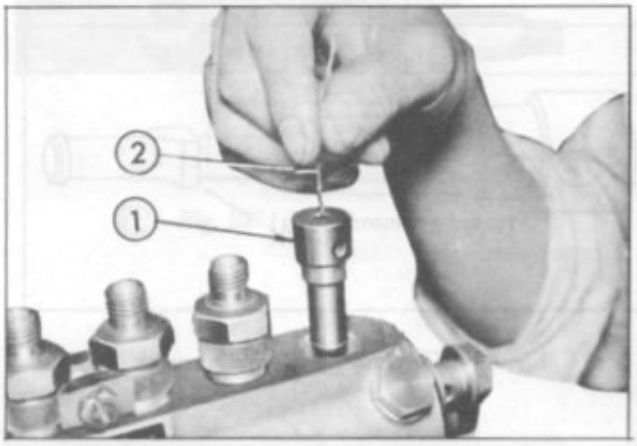


1	Plunger spring	2	Upper spring seat

Fig. EF-157 Pushing plunger spring

2. Push up the plunger spring with two screwdrivers, and remove the lower spring seat from the plunger.

3. Insert a wire having a hooked end through the top of the pump housing and hook the hole on the lead unit of the plunger and pull upward removing the plunger and the plunger barrel.



1	Plunger barrel	2	Wire

Fig. EF-158 Removing plunger and plunger barrel

Installing

1. Immerse a new plunger in fresh kerosene or solvent and rapidly move it back and forth several times to remove the rust-proof oil from the inside of the plunger.

Handling the plunger

(1) Since the plunger has been processed by lapping at the factory, it should be held by the plunger head or by the plunger barrel. Do not hold the plunger by the lapped part.

(2) The plunger should also be cleaned and operated in kerosene to make sure that it is operating properly.

(3) When replacing two or more sets of plungers and plunger barrels, inscribe the cylinder number of the plunger and the corresponding barrel with an electric pen.

2. Slowly insert the plunger and plunger barrel in the fuel injection pump housing with the barrel groove and the notch on the plunger piston pin facing forward.

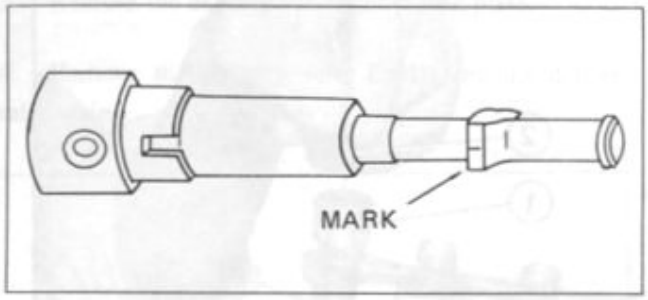


Fig. EF-159 Plunger alignment mark

3. Make sure that the plunger piston pin is properly fit into the groove in the control sleeve.

4. Push up the plunger spring with two screwdrivers and insert the lower spring seat in a manner similar to that for disassembly.

5. Install the delivery.

6. Install the delivery valve holder.

7. Upon completion of assembly, make sure that the control rack moves smoothly.

When replacing the plunger and plunger barrel, check and adjust fuel injection timing and fuel injection volume, using a tester.

REPLACING THE PLUNGER SPRING

Removing

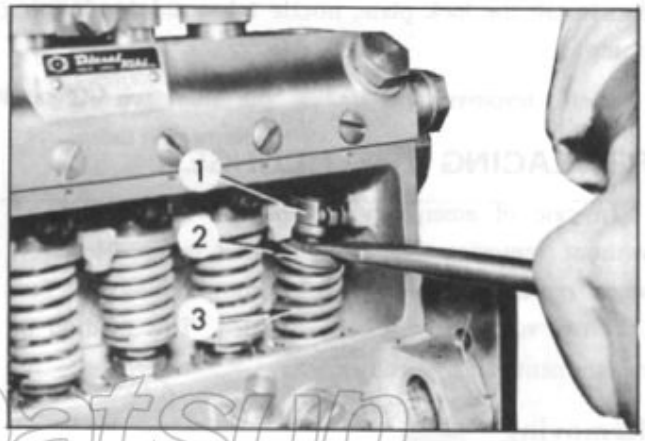
1. Remove the delivery valve.

Refer to the paragraph "Replacing the Delivery Valve" (page FE-54).

2. Remove the plunger and plunger barrel.

3. Turn the camshaft so as to lower the tappet to its bottom position.

4. Compress the spring with a screwdriver, pull the control sleeve, upper spring seat and plunger spring to the front, and remove them from the pump housing.



1	Control sleeve and pinion clamp	3	Plunger spring
2	Upper spring seat		

Fig. EF-160 Compressing plunger spring

Installing

1. Install the plunger spring, upper spring seat, and control sleeve in the pump housing in reverse sequence of removal. Make sure that the rack and control sleeve are correctly combined.

2. Install the plunger and plunger barrel.

3. Install the delivery valve.

REPLACING THE TAPPET

Removing

1. Remove the delivery valve, plunger and plunger barrel.

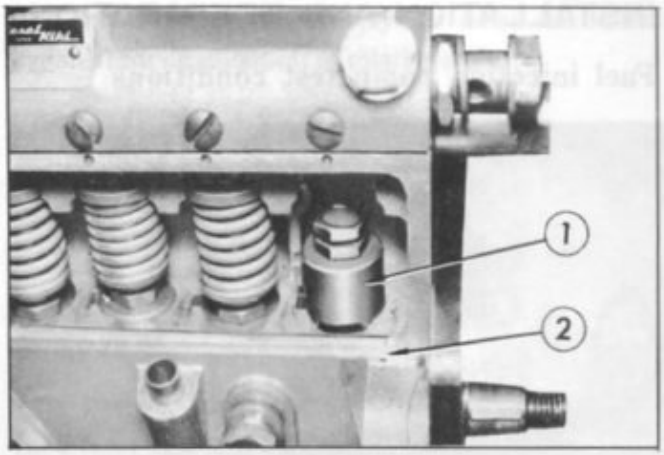
Refer to the paragraph "Replacing the Delivery Valve" and "Replacing the Plunger" on pages EF-45 and EF-46.

2. Remove the plunger spring.

3. After removing the plunger spring, remove the tappet from the pump housing.

Installing

Install in the reverse order of removal.



1	Tappet assembly
2	Pump housing

Fig. EF-161 Removing tappet

ADJUSTING AND TESTING INJECTION PUMP

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- Fuel injection pump test conditions . . EF-58
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TESTING AND ADJUSTING THE TIMER . EF-66

BLEEDING THE FUEL SYSTEM (Engine on vehicle) EF-66

It is necessary to inspect and adjust the fuel injection pump using a pump tester, after it has been disassembled or assembled, when the plunger or plunger spring have been replaced, or when any of the component parts have been replaced.

INSTALLATION AND PREPARATIONS

Fuel injection pump test conditions

Nozzle to be used:	Test nozzle (KV11205000)
Nozzle holder to be used:	Test nozzle holder (KV11205780)
Injection starting pressure:	100 kg/cm^2 (1,422.3 psi)
Noxxle tube:	2 dia (ID) x 6 dia (OD) x 610 mm (L) (0.079 in x 0.236 in x 24.02 in), (KV11257805)
Fuel:	Clean diesel fuel (kerosene)
Rotating direction:	Clockwise (to the right) as observed from the srive side.
Injection sequence:	SD22: 1-3-4-2 SD33: 1-4-2-6-3-5 This sequence is referred to by cylinder numbers 1, 2, 3, etc., beginning on the drive side.

Installing the fuel injection pump on the tester

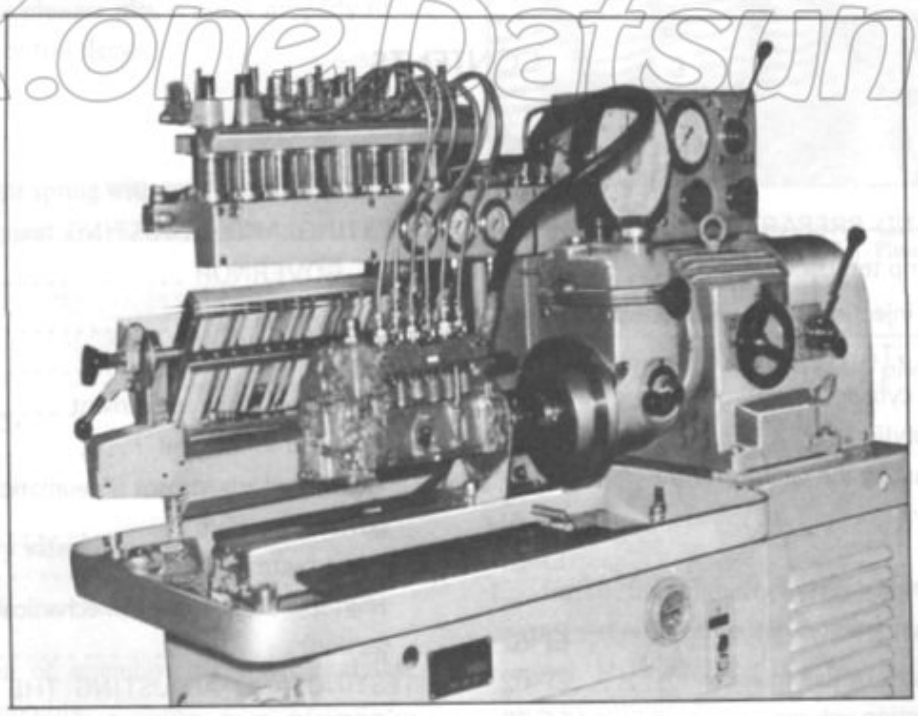


Fig. EF-162 Installing the fuel injection pump on the tester

1. Remove the fuel feed pump and cover plate from the fuel injection pump.

2. Install the fuel injection pump on the bed of the tester with the securing stand.

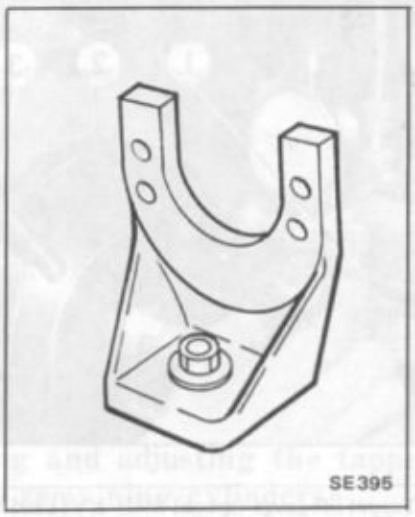
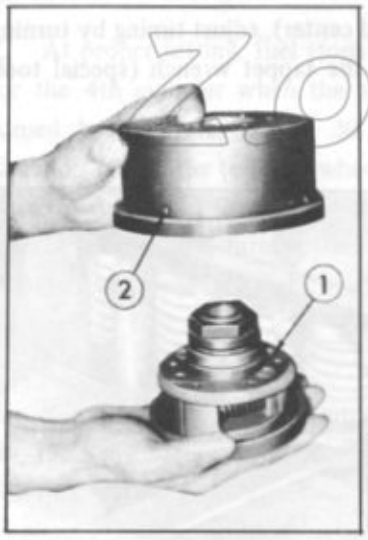


Fig. EF-163 Securing stand

3. Remove the automatic timer drive gear and attach the testing coupling on the pump drive end of the camshaft with a circular nut and lock washer.



1	Timer
2	Coupling (special tool: KV11205784)

Fig. EF-164 Attaching testing coupling

4. Connect the test coupling to the tester drive shaft with the coupling disc.

5. Connect the flexible hose from the tester to the nozzle tube on the pump.

6. Remove the cap and apply the tester dial to the camshaft for measurement of rotating angle.

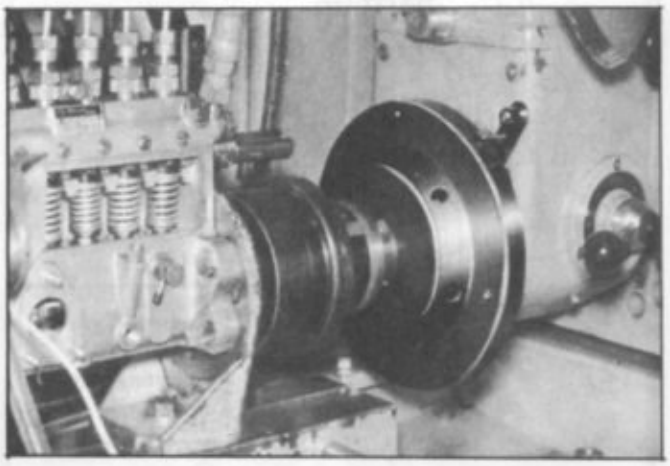


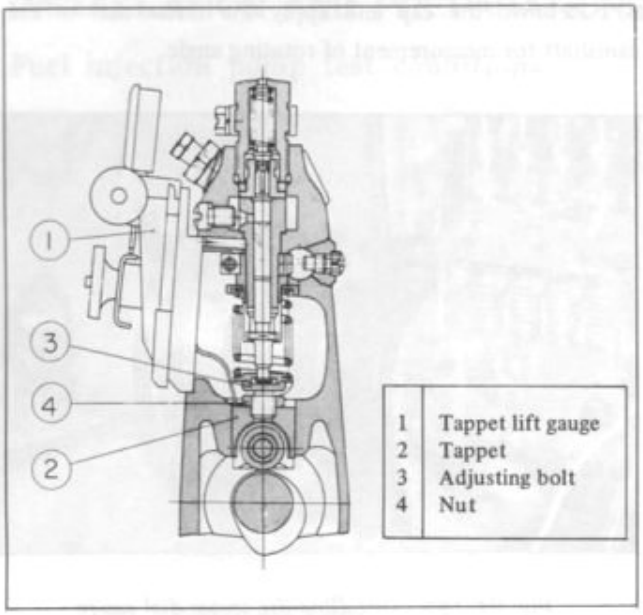
Fig. EF-165 Installing the tester dial gauge

FUEL INJECTION STARTING TIMING

Fuel injection starting time is defined at the instant the plunger barrel fuel intake port is cut off by the top of the plunger. It should be adjusted to a prescribed interval. To determing this timing with a tester, the pump tester is devised so as to feed oil at a pressure of 30 to 35 kg/cm^2 (427 to 498 psi) in through the fuel intake. This pressure is sufficient to overcome the force of the fuel injection pump delivery valve spring and to push up the delivery valve. The injection timing is then measured based upon the fuel discharged from the test nozzle and is adjusted to the proper injection timing. For checking injection timing during general engine assembly, covering adjustment and testing with the fuel injection pump mounted on the engine.

Checking the first cylinder

1. Apply a tappet lift gauge to the tappet of the standard cylinder (1st cylinder from the drive side).



1	Tappet lift gauge
2	Tappet
3	Adjusting bolt
4	Nut

Fig. EF-166 Installing the tappet lift gauge

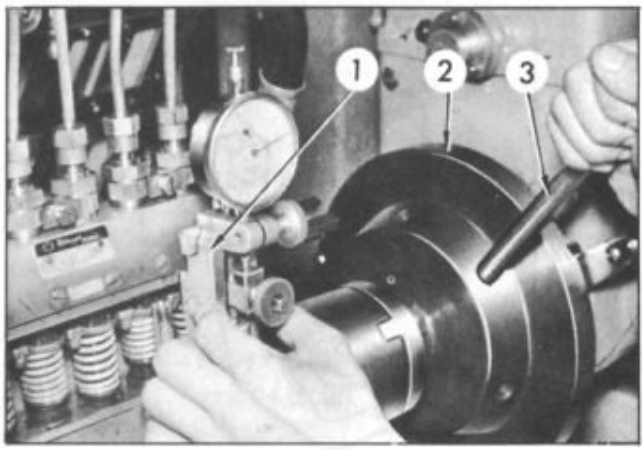
2. Position the tappet so that it is completely lowered, corresponding to bottom dead center (BDC) position of the camshaft, and set the dial gauge to "O" (zero).

3. Loosen the pump bleeder screw and bleed air from the fuel system.

4. For testing, loosen the ball valve of the nozzle holder.

5. Feed fuel into the fuel inlet of the pump, slowly turn the pump tester (camshaft) by hand in the same rotating direction as the engine, and fuel will flow from the test nozzle. As the pump camshaft is turned by hand, the fuel suddenly stops flowing.

This is the exact position for fuel injection starting. Make sure that at this point, the tappet is lifted 2.25 to 2.35 mm (0.0886 to 0.0925 in) from bottom dead center (BDC) position.



1	Tappet lift gauge (special tool: KV11205782)
2	Flyweheel equipped with angle scale
3	Lever

Fig. EF-167 Checking first cylinder injection starting timing

Adjustment (first cylinder)

When the fuel does not stop flowing, even when the tappet is lifted by 2.25 to 2.35 mm (0.0886 to 0.0925 in) from BCD (bottom dead center), adjust timing by turning the adjusting bolt with the tappet wrench (special tool; DK57911010).

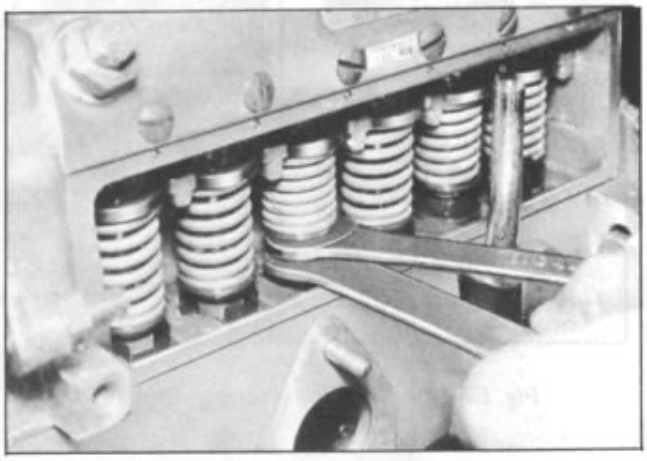


Fig. EF-168 Adjusting the adjusting bolt

1. If the fuel does not stop flowing with the tappet lifted by more than 2.35 mm (0.0925 in), loosen the lock nut, and turn the adjusting bolt to the left (counter-clockwise) to raise the position of the plunger.

2. If the fuel stops before the tappet rises above 2.25 mm (0.0886 in), turn the adjusting bolt to the right (clockwise) to lower the position of the plunger.

3. When adjustment is completed, make sure that the adjusting bolt lock nut is tightly secured. [Tightening torque: 6.0 to 7.0 kg-m (43.6 to 50.6 ft-lb)].

Checking and adjusting the tappets for the remaining cylinders

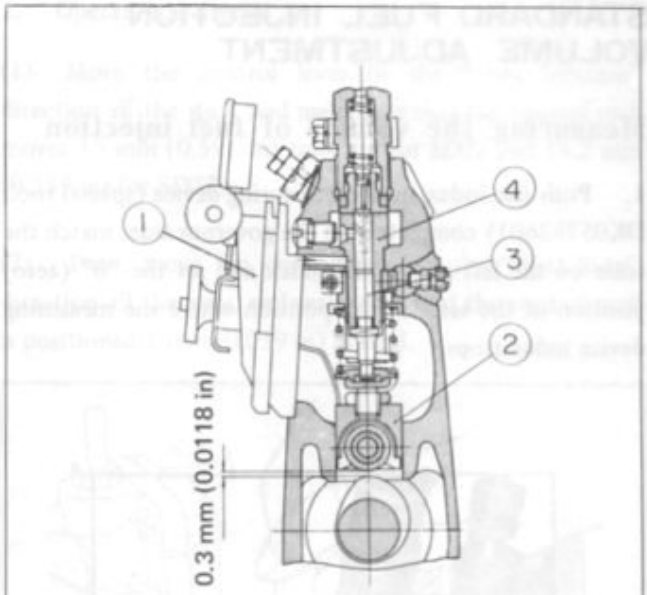
1. After the injection starting timing of the frist (standard) cylinder has been set to the correct cam lift position, position the camshaft at this setting and set the angle scale mark on the tester flywheel at an appropriate position for testing (0° or 180°)

2. At proper setting, fuel stops flowing from the nozzle for the 4th cylinder when the tester flywheel has been turned by the lever 60° ± 30' in the engine rotating direction (when the tester flywheel has been turned 90° ± 30' for the 3rd cylinder for SD22). If timing is not correct, adjust by turning the adjusting bolts in the manner previously described.

3. Subsequently check and adjust each cylinder in order of fuel injection sequence: 1-4-2-6-3-5 (For SD22 1-3-4-2).

Tappet clearance

When the fuel injection starting timing adjustment for each cylinder has been completed, position the cam at top dead center (TDC), check plunger piston pin to plunger barrel clearance, and make sure that the clearance for upward movement of the tappet is 0.3 mm (0.0118 in) or more for each tappet (for each cylinder).



1	Tappet lift gauge	3	Plunger
2	Tappet	4	Plunger barrel

Fig. EF-169 Tappet clearance

1. Set the top camshaft to top dead center (TDC), apply the tappet lift gauge so that it contacts tappet and set the dial gauge scale to "0" (zero).

2. Lift the tappet with a screwdriver and measure tappet top clearance (stroke unitl the plunger contacts the end of the plunger barrel) on the tappet lift gauge.

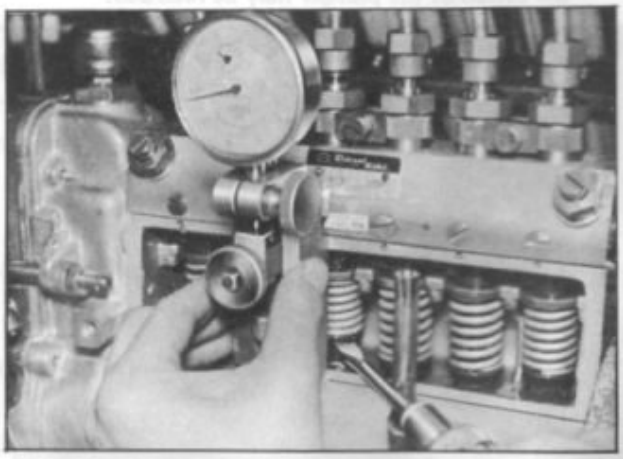


Fig. EF-170 Checking tappet clearance

STANDARD FUEL INJECTION VOLUME ADJUSTMENT

Measuring the volume of fuel injection

1. Push the index of the measuring device (special tool; DK05782601) completely to the governor side, match the scale on the left end of the index and set the "0" (zero) position of the scale at the position where the measuring device index stops.

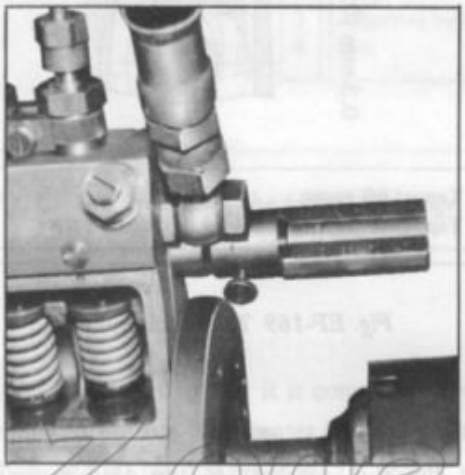


Fig. EF-171 Measuring device

2. Remove the rack guide screw from the rear of the pump housing and apply the lock screw attached to the tester, and secure the control rack in the standard position for adjustment.

Note: Tighten the lock screw by hand. If the lock screw is excessively tightened, the rack may be bent, and the action of the plunger may be retarded.

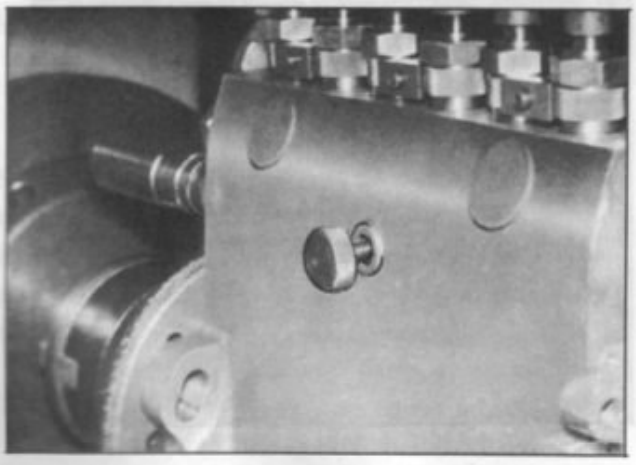


Fig. EF-172 Installing the tester lock screw

3. Operate the tester and drive the pump at rated speed.

4. Set the fuel feed pressure of the pump at 1.5 to 1.6 kg/cm^2 (21.3 to 22.8 psi) and measure injection volume at the rated stroke (1,000 strokes) or the female cylinder.

5. In a like manner, measure injection volume at rated speed and standard rack position and compute the allowable unbalance of fuel injection.

$$\text{Allowable unbalance} = \frac{\left(\begin{array}{l}\text{Max. or min. injection}\\ \text{volume for each plunger}\end{array}\right) - \left(\begin{array}{l}\text{Main injection}\\ \text{volume}\end{array}\right)}{\text{Mean injection volume}} \times 100$$

Adjusting fuel injection volume

If results of measurement and calculations show that mean injection volume and rate of allowable unbalance are not within the prescribed limits, adjust by changing the relative positions of the control pinion and the control sleeve.

1. Loosen the control pinion clamp screw holding the control pinion.

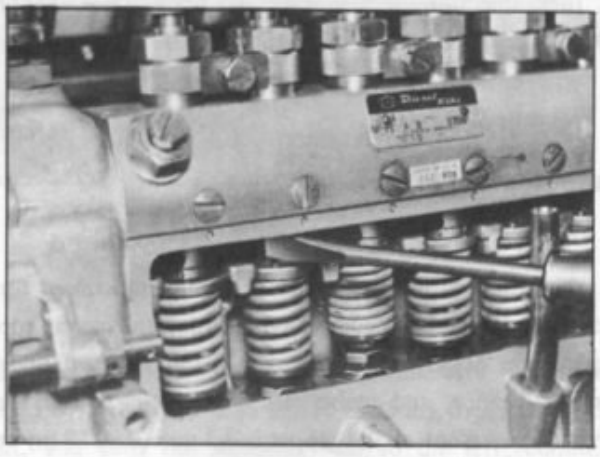


Fig. EF-173 Loosening control pinion clamp screw

2. Place an appropriate size pin into the hole in the control sleeve and adjust by moving the control sleeve along the control rack little by little.

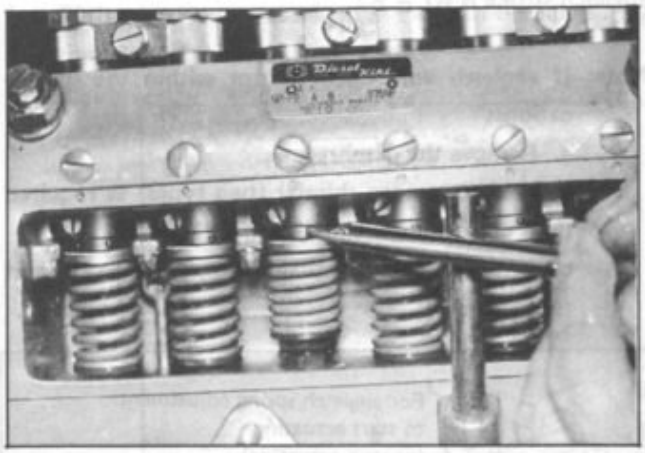


Fig. EF-174 Moving control sleeve

3. After adjustment is completed, tightly secure the pinion set screw.

4. Remove the lock screw from the control rack and reinstall the guide screw.

TESTING AND ADJUSTING THE GOVERNOR

Note: a. Testing and adjusting procedures for the MZ governor and RBD-MZ governor are carried out in the similar manner. For the RBD-MZ governor, high-speed adjustment should additionally be made on the mechanical unit.

b. When making a governor performance test, maintain the pump speed at 500 rpm.

c. Gradually step up negative pressure when adjusting.

Preparation

1. Match the measuring device index to the "O" (zero) point on the scale and set the control rack at its "O" (zero) position.

2. Operational check

(1) Move the control lever in the "Fuel Increase" direction all the way, and make sure that the control rack moves 15 mm (0.591 in) outward for SD22 and 14.2 mm (0.559 in) for SD33.

(2) Then, move the control lever in the "Fuel Stop" direction all the way, and make sure that the control rack is positioned 1 mm (0.039 in) inward.

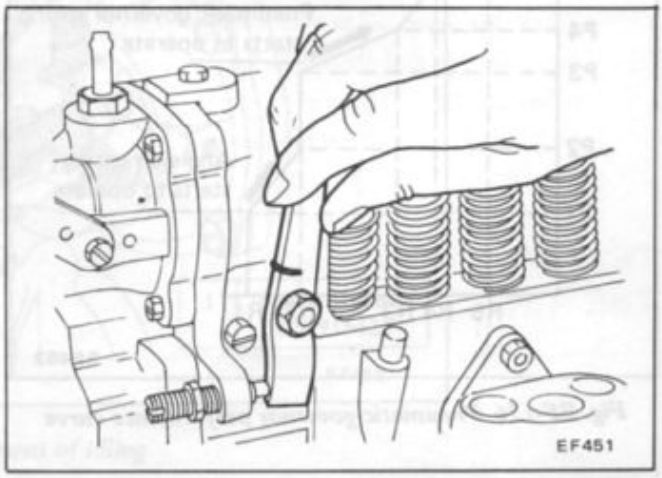


Fig. EF-175 Turning control lever

Note: If the control rack cannot be properly set as outlined in steps (1) and (2) above, replace the push rod with one of proper length.

3. Connect a line (tube) between the vacuum pump of the tester and the governor negative pressure chamber and provide the same negative pressure as under engine operation.

4. Adjust the governor with the fuel injection pump driven at a rate of 500 rpm since control rack movement resistance differs when the injection pump is operated and when it is not operated.

Air-tight test

1. Apply a negative pressure of 500 mmAq (19.7 inAq) to the governor with the rack set at position R1.

2. Stop applying the pressure and measure the time required for pressure to drop from 500 mmAq to 480 mmAq (19.7 inAq to 18.9 inAq).

Note: a. If it takes more than 10 seconds for the pressure to drop, the governor is functioning properly.
b. It is drops in less than 10 seconds, check the diaphragm and replace if necessary.

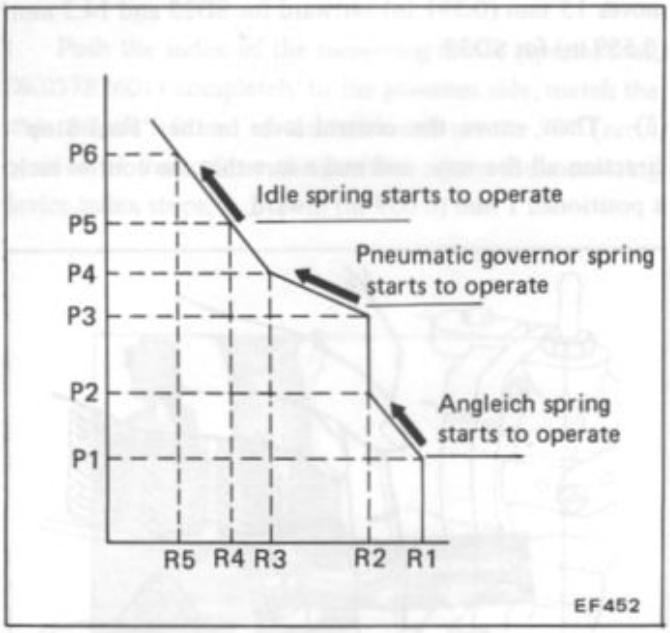


Fig. EF-176 Pneumatic governor performance curve

Smoke set screw adjustment

With no negative pressure applied, adjust the smoke set screw so that the rack is set at position R1.

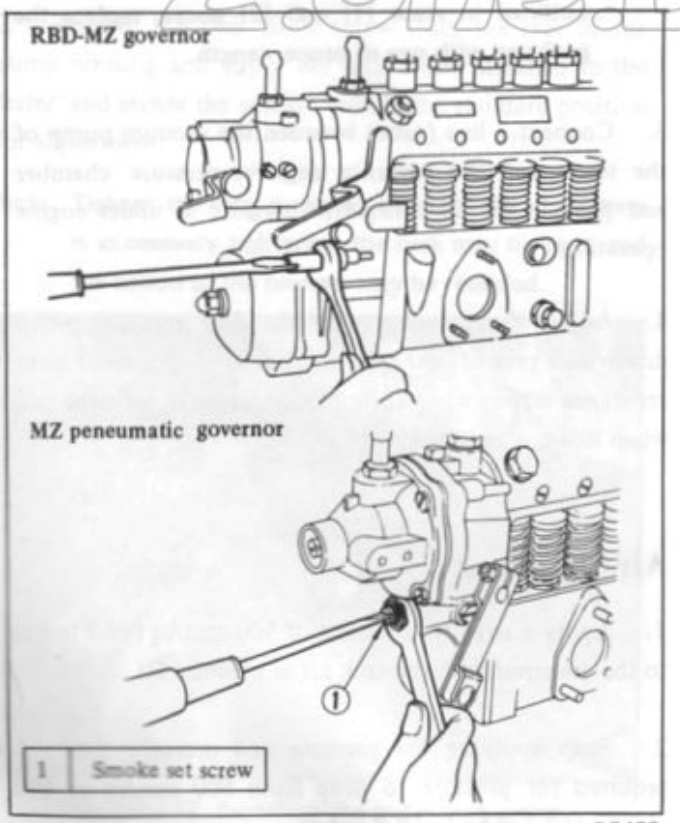


Fig. EF-177 Adjusting smoke set screw

Angleich adjustment

Make sure that the angleich spring starts to actuate at negative pressure P1 and stops at P2. In other words, the angleich stroke is R1 – R2.

Note: If angleich adjustment is not within the specifications:
a. Remove the diaphragm.
b. Add or remove shim(s) (two types) as required until correct angleich adjustment is made.
c. After installing the diaphragm, make an air-tight test again.

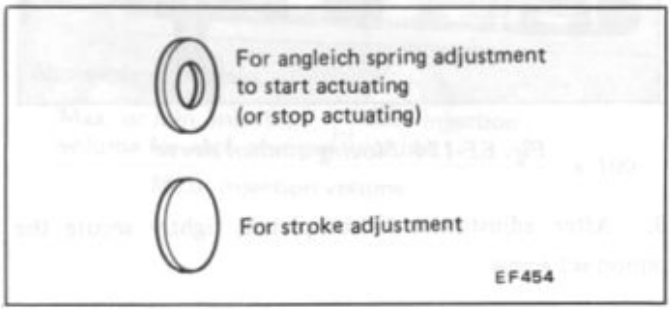


Fig. EF-178 Angleich adjusting shim

High-speed adjustment (Pneumatic governor section)

1. Secure the control lever so that the idle spring does not operate during adjustment.

2. Increase negative pressure. Adjust the governor shim until there is a balanced condition between rack position R2 and negative pressure P3.

3. Gradually increase negative pressure. Make sure that negative pressure is P5 when the rack is moved to position R4.

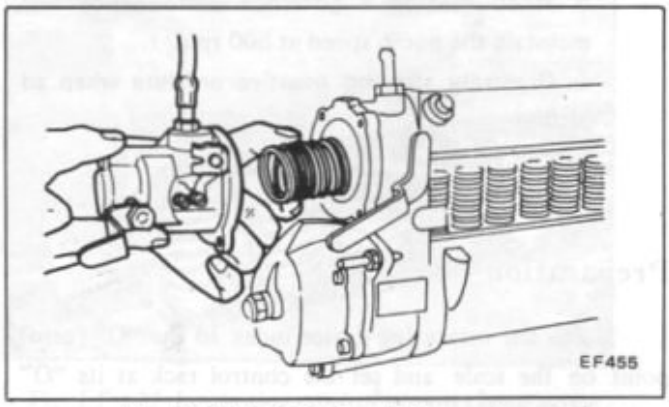


Fig. EF-179 Adjusting high-speed control (Pneumatic governor section)

Idle adjustment

Use a pump tester to make idle adjustment.

1. With negative pressure kept at P4, turn the idle spring screw in until the rack is set at position R3.
2. Tighten the lock nut.
3. Further increase negative pressure. Make sure that negative pressure is P6 when the rack is set at position R5.

Note: If necessary, replace the idle spring as an assembly.

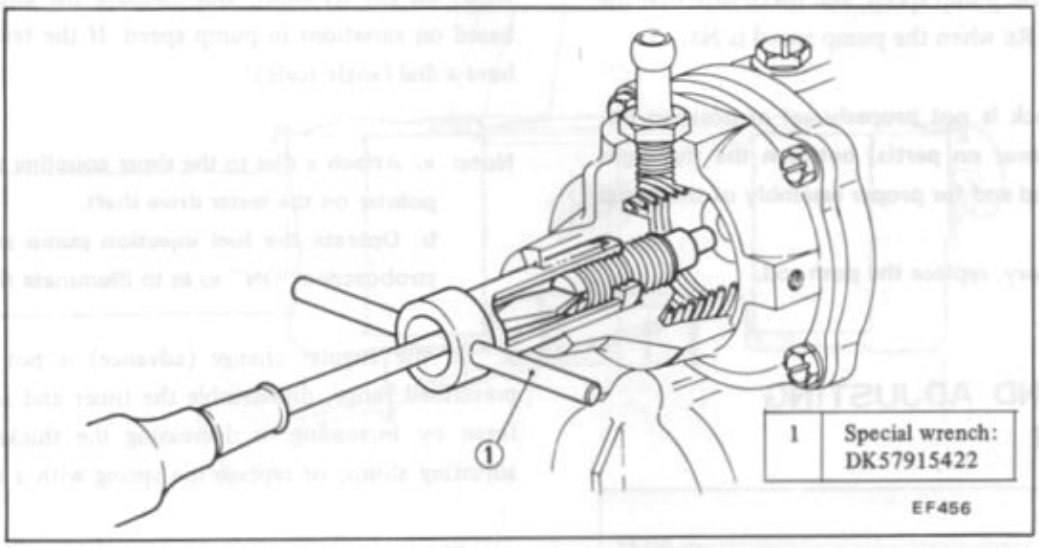


Fig. EF-180 Adjustment of idling

High-speed adjustment (Mechanical governor section): Only RBD-MD governor

1. With negative pressure kept in condition P3, increase pump speed.
2. Adjust the adjusting bolt of the governor spring so that the pump speed is N1 when the rack starts to be pulled from R2.

Note: If the above adjustment cannot be made properly by means of the adjusting bolt, add or remove governor spring shim(s).

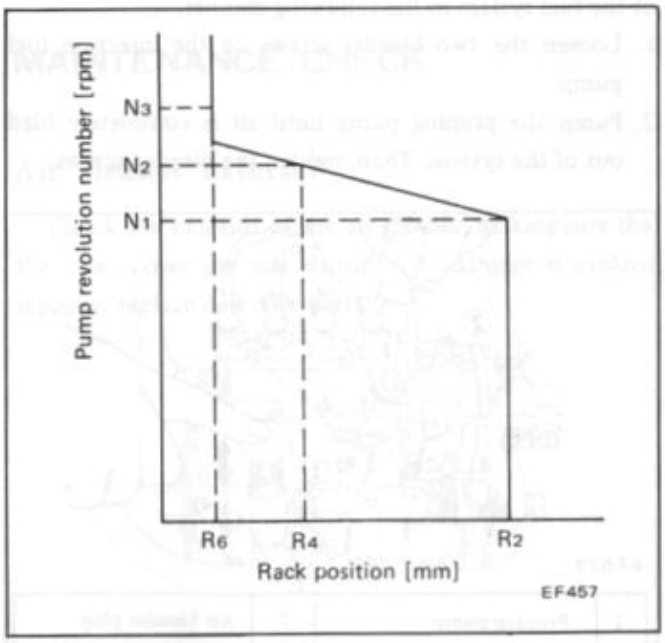


Fig. EF-181 Mechanical governor performance curve

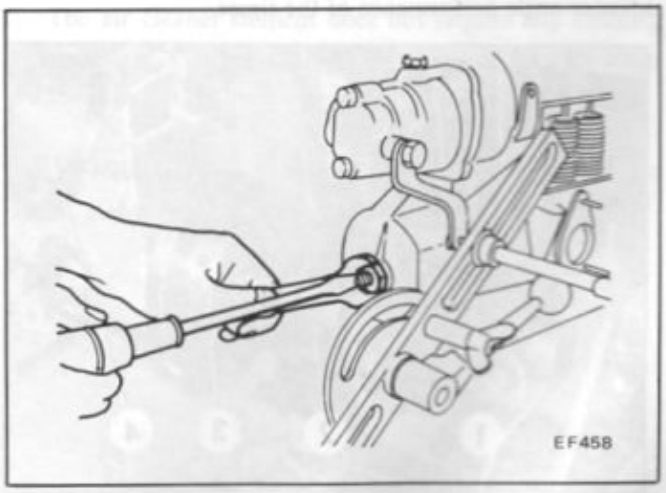


Fig. EF-182 Adjusting high-speed control (Mechanical governor section)

3. Increase pump speed, and make sure that the pump speed is N2 when the rack is set at point R4.

Note: If pump speed is within the specified range, replace the governor spring and readjust.

4. Further increase pump speed, and make sure that the rack is set at point R6 when the pump speed is N3.

Note: a. If the rack is not properly set at position R6, check for wear on part(s) between the flyweight and push rod and for proper assembly of the pump housing.
b. If necessary, replace the push rod.

TESTING AND ADJUSTING THE TIMER

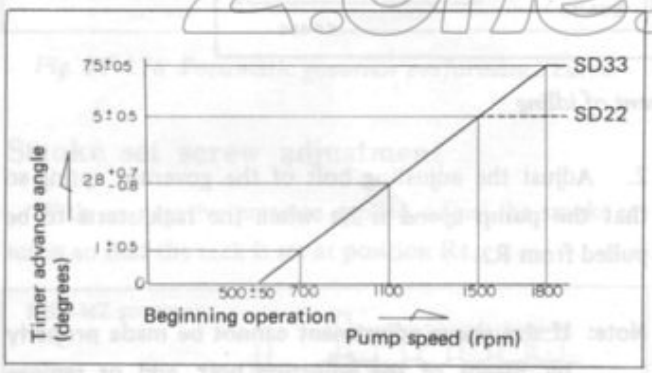
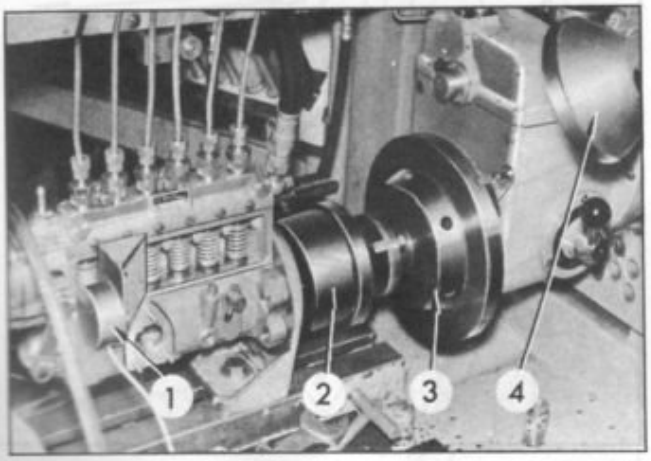


Fig. EF-183 Timer advance angle performance curve

Use a stroboscope on the pump tester to measure the advance angle performance of the timer.



1	Synchronizer attachment	3	Flywheel (angle scale)
2	Coupling (timer)	4	Stroboscope

Fig. EF-184 Measuring advance angle

1. Install the stroboscope, using the cover plate installation bolts, so that the synchronizer lever attachment is applied to the tappet.

2. Operate the fuel injection pump, turn "ON" the switch of the stroboscope illuminating the dial (angle scale) on the flywheel, and measure the angular change based on variations in pump speed. If the tester does not have a dial (angle scale).

Note: a. Attach a dial to the timer coupling and mount a pointer on the tester drive shaft.
b. Operate the fuel injection pump and turn the stroboscope "ON" so as to illuminate the dial.

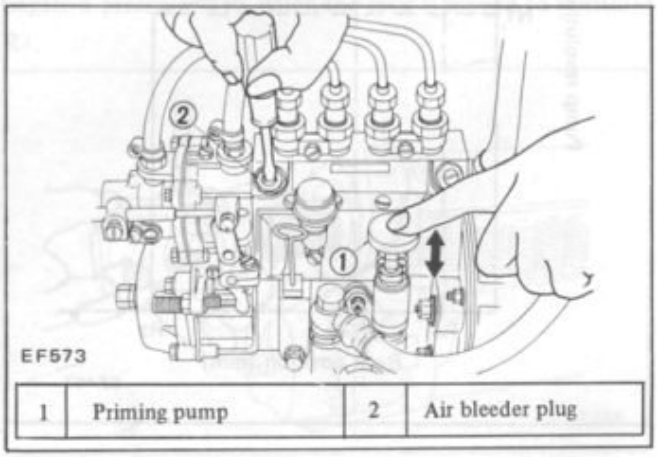
3. If the angular change (advance) is not within the prescribed range, disassemble the timer and adjust spring force by increasing or decreasing the thickness of the adjusting shims, or replace the spring with a new one.

4. Make sure that you switch the stroboscope "OFF" before turning off the pump tester.

BLEEDING THE FUEL SYSTEM (Engine on vehicle)

After the engine has been disassembled for reconditioning or the fuel system repaired, air should be bled out of the fuel system in the following manner.

1. Loosen the two bleeder screws on the injection fuel pump.
2. Pump the priming pump until air is completely bled out of the system. Then, tighten the bleeder screws.

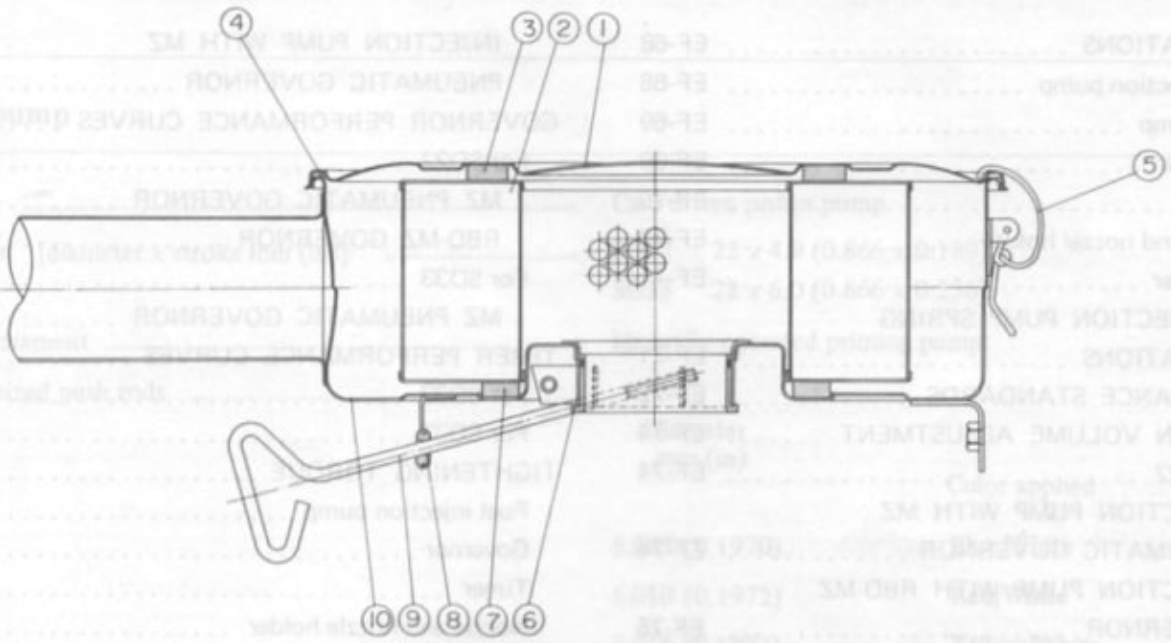


1	Priming pump	2	Air bleeder plug

Fig. EF-185 Bleeding injection pump of air

AIR CLEANER

CONSTRUCTION AND OPERATION



1	Cover assembly	5	Wire clip	9	Bolt
2	Element assembly	6	Rubber ring	10	Body assembly
3	Element packing	7	Element packing		
4	Body packing	8	Rubber ring		

Fig. EF-186 Gross-sectional view of air cleaner

MAINTENANCE CHECK

Air cleaner exterior

Check the exterior of the air cleaner, making sure that the case, cover are not damaged. If damage is evident, repair or replace defective parts.

Air cleaner element

The air cleaner element does not require any cleaning regardless of contamination until it is replaced at every 40,000 km (24,000 miles).

Note: Never treat the element by brushing or air blasting before the time for replacement.

SERVICE DATA AND SPECIFICATIONS

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SPECIFICATIONS

Fuel injection pump

Type			Bosch Type A — SD22, SD33
Injection order (counted from the drive side)			SD22 1-3-4-2 SD33 1-4-2-6-3-5
Rotating direction			To the right, as viewed from the drive side.
Plunger	Diameter	mm (in)	6 (0.234)
	Left lead	mm (in)	15 (0.591)
	Start of injection		Fixed
	End of injection		Variable
Injection timing	Stationary injection start	mm (in)	2.3 ± 0.05 (0.0906 ± 0.0020) before cam bottom dead center. Measurement to be made on No. 1 cylinder on the drive side
Oil capacity (Camshaft chamber)		cc	SD22 80 SD33 180

Camshaft end play adjusting shims thickness mm (in)	0.10 (0.0039), 0.12 (0.0047), 0.14 (0.0055), 0.16 (0.0063), 0.18 (0.0071), 0.30 (0.0118), 0.50 (0.0197)

Feed pump

Type	Cam driven piston pump
Piston [diameter x stroke mm (in)]	SD22 22 x 4.8 (0.866 x 0.189) SD33 22 x 6.0 (0.866 x 0.236)
Attachement	Manually operated priming pump

Oversized push rods

Diameter mm (in)	Color applied
5.005 (0.1970)	Blue/White
5.010 (0.1972)	Red/White
5.015 (0.1974)	Yellow/White
5.020 (0.1976)	Green/White
5.025 (0.1978)	Black/White
5.030 (0.1980)	Brown/White
5.035 (0.1982)	Purple/White
5.045 (0.1986)	Gray/White

Governor

Type	MZ type Q(L)140, Q(L)C240, FD104, FD105, FD106, FD107 RBD-MZ type Q(L)330, Q(L)C240
Oil capacity	3 or 4 drops (Diaphragm oil)
Main spring adjusting shim thickness mm (in)	0.2 (0.0078) 0.5 (0.0197) 1.5 (0.059) 0.3 (0.0118) 1.0 (0.039) 2.0 (0.078)
Angleich stroke adjusting shim thickness mm (in)	0.1 (0.0039) 0.3 (0.0118) 1.0 (0.039) 0.2 (0.0078) 0.5 (0.0197)
Angleich spring adjusting shim thickness mm (in)	0.1 (0.0039) 0.3 (0.0118) 1.0 (0.039) 0.2 (0.0078) 0.5 (0.0197)

Timer

Type	Automatic mechanical timer	SD22 SD33	
Injection timing advancing angle (Engine crank angle give in)	SD22	5° (10°) Starting (20°) BTDC High-speed (30°) BTDC	
	SD33	7.5° (15°) Starting (20°) BTDC High-speed (30°) BTDC	
Timer spring adjusting shim thickness	0.1 (0.0039)	0.3 (0.0118)	0.5 (0.0197)
Timer plate bearing adjusting shim thickness mm (in)	0.1 (0.0039)	0.16 (0.0062)	0.3 (0.0118)
	0.12 (0.0047)	0.18 (0.0070)	0.5 (0.0197)
	0.14 (0.0055)	0.2 (0.0078)	

Nozzle and nozzle holder

Type	Closed, throttle type		
Injection angle	0°		
Injection nozzle orifices [diameter x number mm (in)]	1.0 x 1 (0.039 x 1)		
Initial injection pressure kg/cm² (psi)	100 (1,422)		
Adjusting shim thickness mm (in)	0.05 (0.0020)	0.50 (0.0197)	0.55 (0.0217)
	0.60 (0.0236)	0.65 (0.0256)	0.70 (0.0276)
	0.75 (0.0295)	0.80 (0.0315)	0.85 (0.0335)
	0.90 (0.0354)	0.95 (0.0374)	1.00 (0.0394)
	1.02 (0.0402)	1.04 (0.0409)	1.06 (0.0417)
	1.08 (0.0425)	1.10 (0.0433)	1.12 (0.0441)
	1.14 (0.0449)	1.16 (0.0457)	1.18 (0.0465)
	1.20 (0.0472)	1.22 (0.0480)	1.24 (0.0488)
	1.26 (0.0496)	1.28 (0.0504)	1.30 (0.0512)
	1.32 (0.0520)	1.34 (0.0528)	1.36 (0.0535)
	1.38 (0.0543)	1.40 (0.0551)	1.42 (0.0567)
	1.44 (0.0567)	1.46 (0.0575)	1.48 (0.0583)
	1.50 (0.0591)	1.52 (0.0598)	1.54 (0.0606)
	1.56 (0.0614)	1.58 (0.0622)	1.60 (0.0630)
	1.62 (0.0638)	1.64 (0.0646)	1.66 (0.0654)
	1.68 (0.0661)	1.70 (0.0669)	1.72 (0.0677)
	1.74 (0.0685)	1.76 (0.0693)	1.78 (0.0701)
	1.80 (0.0709)	1.82 (0.0717)	1.84 (0.0724)
	1.86 (0.0732)	1.88 (0.0740)	1.90 (0.0748)
	1.92 (0.0756)	1.94 (0.0764)	1.96 (0.0772)
	1.98 (0.0780)	2.00 (0.0787)	

Fuel filter

Type		Full-flow, paper type filter
Filtering area	m^2 (in^2)	0.092 (142.6)
Overflow valve opening pressure	kg/cm^2 (psi)	1.5 to 1.6 (21.3 to 22.8)

FUEL INJECTION PUMP SPRING SPECIFICATIONS

Item		Nomenclature		Free length mm (in)	Spring constant kg/mm (lb/in)	Remarks
Fuel injection pump		Delivery valve spring		30.1 (1.174)	0.812 (45.47)	
		Plunger spring		45.0 (1.755)	1.66 (92.96)	
Feed pump		Piston spring		68.0 (2.677)	0.174 (9.744)	
		Check valve spring		15.5 (0.604)	0.00945 (0.5292)	
Governor	MZ	Pneumatic governor spring		72.0 (2.83)	0.03 (1.7)	
		Angleich spring		8.5 (0.335)	0.8 (45)	
		Idler spring		30.0 (1.181)	0.15 (8.4)	
	RBD - MZ	Pneumatic governor spring		69.5 (2.736)	0.03 (1.7)	
		Mechanical governor spring		71 (2.795)	0.15 (8.4)	Use 75 mm (2.953 in) [free length] when more than 476 gr (1.05 lb) is applied.
		Angleich spring		8.5 (0.335)	0.8 (45)	
		Idler spring		30.0 (1.181)	0.15 (8.4)	
Timer		Timer spring	SD22	40.5 (1.580)	8.4 (470.4)	
			SD33	40.5 (1.580)	8.0 (448)	
Nozzle		Nozzle spring	SD22	22.0 (0.858)	28.00 (2,568)	
			SD33	22.0 (0.858)	28.25 (2,582)	

MAINTENANCE STANDARDS

Component	Item		Nominal size mm (in)	Maintenance standard mm (in)	Repair limit mm (in)	Wear limit mm (in)	Remarks
Injection pump	Pump housing/ tappet clearance	SD22	—	0.03 to 0.07 (0.0012 to 0.0028)	0.2 (0.0079)	—	
		SD33	—	0.02 to 0.07 (0.0008 to 0.0028)	0.2 (0.0079)	—	
	Tappet adjusting bolt head recess		—	—	—	0.2 (0.0079)	
	Control sleeve/plunger trunnion shaft clearance		—	0.02 to 0.08 (0.0008 to 0.0031)	0.12 (0.0047)	—	
	Camshaft play in the shaft direction	SD22	—	0 to 0.02 (0 to 0.0008)	0.1 (0.0039)	—	
		SD33	—	0 to 0.03 (0 to 0.0012)	0.1 (0.0039)	—	
	Control rack and pinion backlash		—	0.15 (0.0059)	0.3 (0.0118)	—	
	Oil sealing test of delivery valve		—	Primary pressure : 100 kg/cm^2 (1,422 psi) Full of pressure : 5 kg/cm^2 (71.1 psi) Take more than 5 seconds			
	Pressure test of plunger		—	Primary pressure : 100 kg/cm^2 (1,422 psi) After 5 strokes, more than 125 kg/cm^2 (1,778 psi)			
	Control rack slide resistance	When the pump is stopped	—	150 grams or less (0.331 lb)	—	—	At time of initial movement of the control rack
		When pump speed is 1,000 rpm	—	50 grams (0.110 lb) or less	—	—	
	Injection interval deviation by cylinder		—	–0.5° to +0.5°	2°	—	Cam angle
	Injection starting timing		—	2.25 to 2.35 0.089 to 0.093	—	—	Plunger lift from BDC (Bottom Dead Center)
	Tappet clearance		—	0.3 or more (0.012)	—	—	At cam TDC (Top Dead Center)

Governor	Angleich spring stroke	SD22	—	1.0 (0.039)	—	—	Adjust with adjusting shims
		SD33	—	0.6 (0.023)	—	—	
	Rack Stroke	SD22	—	15.0 (0.591)	—	—	
		SD33	—	14.2 (0.559)	—	—	
Feed pump	Roller/pin clearance		—	0.04 to 0.08 (0.0016 to 0.0031)	0.3 (0.012)	—	
	Roller outer diameter		15 (0.591)	—	—	14.9 (0.587)	
Feed pump	Oil feed rate		300 cc or more within 15 seconds at a pump speed of 1,000 rpm.				Feed pump drive: (5781 to 401) Pumping pipe: 8 dia. (0.315) (Inner diameter) x 2,000 mm (78.74 in) (Length) Cam lift: 10 mm (0.3937 in)
	Pumping capacity		Discharge should occur within one minute (60 seconds) with a pump speed of 80 rpm and intake head of 1 meter (39.37 in).				
	Oil feed pressure		The time required to develop an oil feed pressure of 1.6 kg/cm^2 (22 psi) with a feed pump speed of 600 rpm should be within 30 seconds.				
	Pumping capacity (priming pump)		Operate the priming pump at a rate of 60 to 100 strokes per minute and verify that pumping is started within 30 strokes.				
Timer	Advancing angle	SD22	—	5° (10°)	—	—	
		SD33	—	7.5° (15°)	—	—	
	Flyweight holder to flange clearance		—	0.03 to 0.1 ((0.0012 to 0.0039)	—	—	Adjust with adjusting shims
Nozzle	Injection starting pressure		—	100 kg/cm^2 (1,422 psi)	—	—	Adjust with adjusting shims

INJECTION VOLUME ADJUSTMENT

For SD22

I. INJECTION PUMP WITH MZ PNEUMATIC GOVERNOR

1. Models Q (L) C240 and Q (L) 140

Rack position mm (in)	Pump speed rpm	Mean injection volume cc (cu in) at 1,000 strokes	Allowable unbalance %	Remarks
15.0 (0.591)	800	40.4 ± 1 (2.47 ± 0.061)	± 2.5	Nominal rack position
14.0 (0.551)	1,700	38.9 ± 1.6 (2.37 ± 0.098)	± 4.0	
9.0 (0.354)	1,700	11.0 ± 0.8 (0.671 ± 0.049)	± 7.5	
Approx. 10 (0.39)	300	7.5 ± 1.1 (0.458 ± 0.067)	± 15.0	
Maximum injection volume adjustment				
15.0 (0.591)	800	40.4 ± 0.5 (2.47 ± 0.031)	———	Smoke occurs

2. Models FD104 and FD105

Rack position mm (in)	Pump speed rpm	Mean injection volume cc (cu in) at 1,000 strokes	Allowable unbalance %	Remarks
14.6 (0.575)	800	38.0 ± 1.0 (2.32 ± 0.061)	± 2.5	Nominal rack position
13.6 (0.535)	1,700	36.7 ± 1.6 (2.24 ± 0.098)	± 4.0	
9.0 (0.354)	1,700	11.0 ± 0.8 (0.671 ± 0.049)	± 7.5	
Approx. 10 (0.394)	300	7.5 ± 1.1 (0.458 ± 0.067)	± 15.0	
Maximum injection volume adjustment				
14.1 (0.555)	1,000	36.4 ± 0.5 (2.22 ± 0.031)	———	Full load set

II. INJECTION PUMP WITH RBD-MZ GOVERNOR

1. Models Q (L) 330 and Q (L) C 240

Rack position mm (in)	Pump speed rpm	Standard fuel injection cc (cu in) at 1,000 strokes	Allowable unbalance %	Remarks
12.0 (0.472)	800	40.4 ± 1 (2.47 ± 0.061)	± 2.5	Standard
11.0 (0.433)	1,700	38.9 ± 1.6 (2.37 ± 0.098)	± 4	
6.0 (0.236)	1,700	11.0 ± 0.8 (0.671 ± 0.049)	± 7.5	
Approx. 7.0 (0.276)	300	7.5 ± 1.1 (0.458 ± 0.067)	± 15.0	
Maximum injection volume adjustment				
12.0 (0.472)	800	40.4 ± 1 (2.47 ± 0.061)	———	Smoke occurs

For SD33

INJECTION PUMP WITH MZ PNEUMATIC GOVERNOR

1. Models FD106 and FD107

Rack position mm (in)	Pump speed rpm	Mean injection volume cc (cu in) at 1,000 strokes	Allowable unbalance %	Remarks
14.4 (0.567)	800	38.0 ± 1.0 (2.32 ± 0.061)	± 2.5	Nominal rack position
13.8 (0.543)	1,900	40.0 ± 1.6 (2.44 ± 0.098)	± 4.0	
9.0 (0.354)	1,900	12.8 ± 1.0 (0.781 ± 0.061)	± 7.5	
Approx. 10 (0.394)	300	7.5 ± 1.1 (0.458 ± 0.067)	± 15.0	
Maximum injection volume adjustment				
14.1 (0.555)	1,000	36.4 ± 0.5 (2.22 ± 0.031)	———	Full load set

GOVERNOR PERFORMANCE CURVES

For SD22

I. MZ PNEUMATIC GOVERNOR

1. Models QC240 and Q140

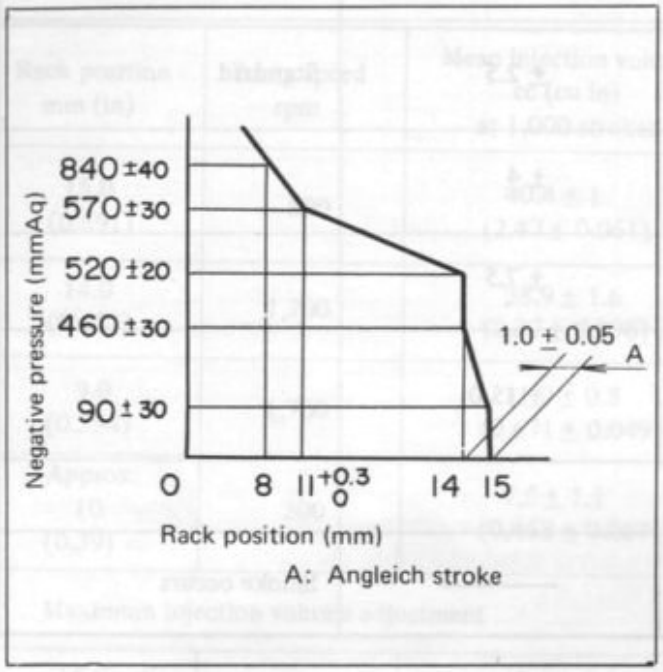

Fig. EF-187 Governor performance curve

2. Models FD104 and FD105

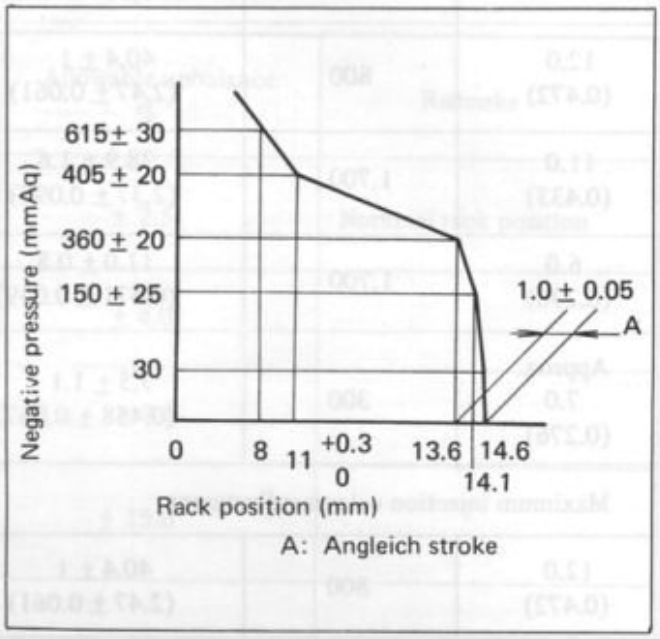

Fig. EF-188 Governor performance curve

II. RBD-MZ GOVERNOR

1. Models Q(L)330 and Q(L)C240

Pneumatic

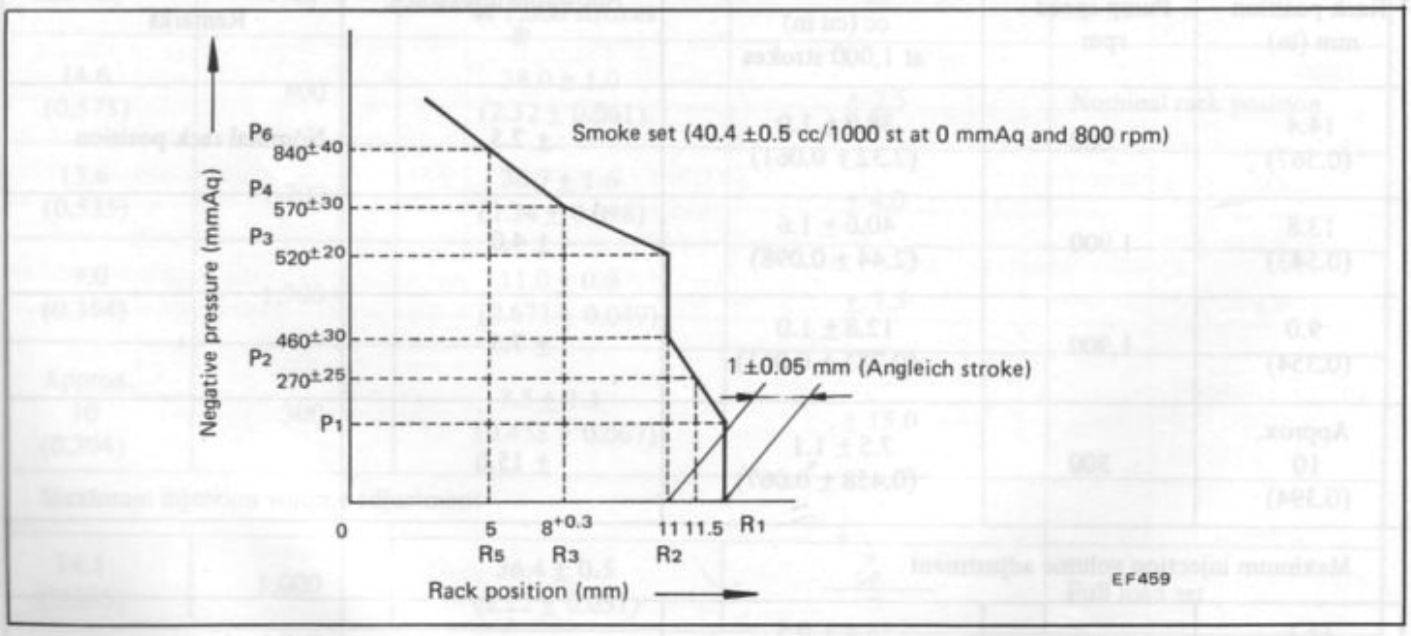

Fig. EF-189 Pneumatic governor performance curve

Mechanical

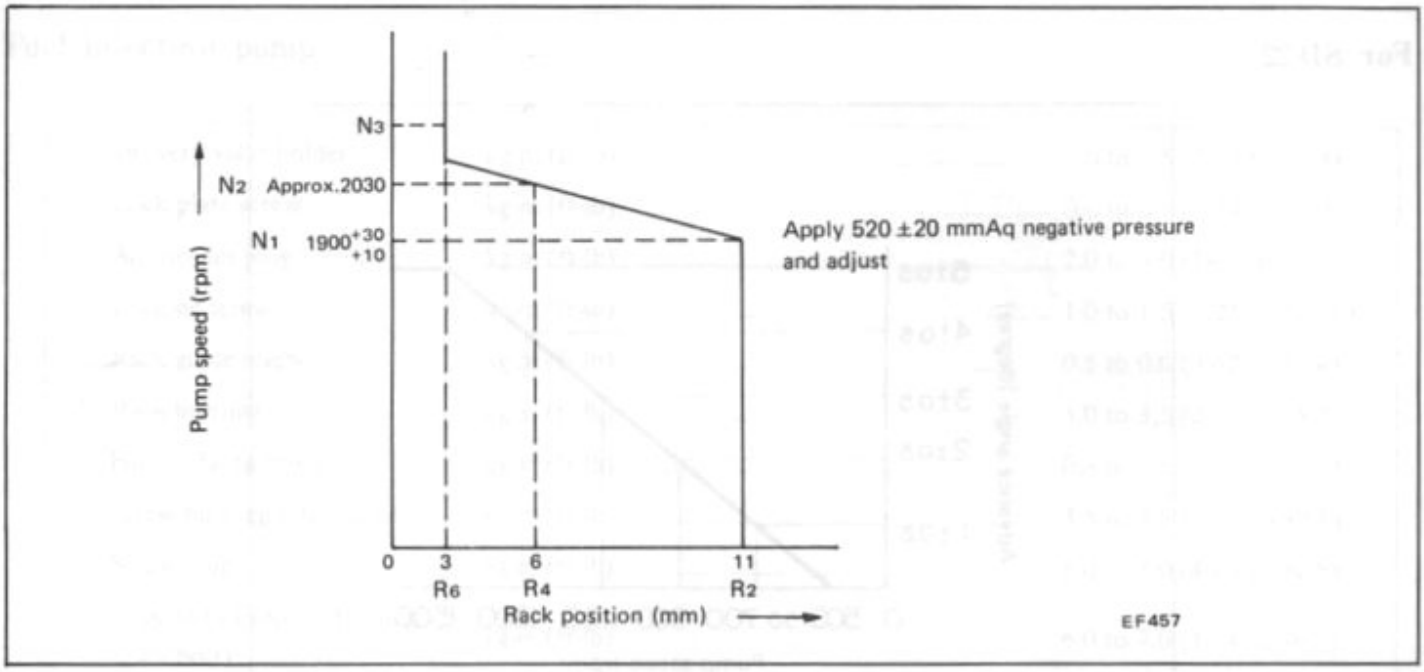

Fig. EF-190 Mechanical governor performance curve

For SD33

MZ PNEUMATIC GOVERNOR

1. Models FD106 and FD107

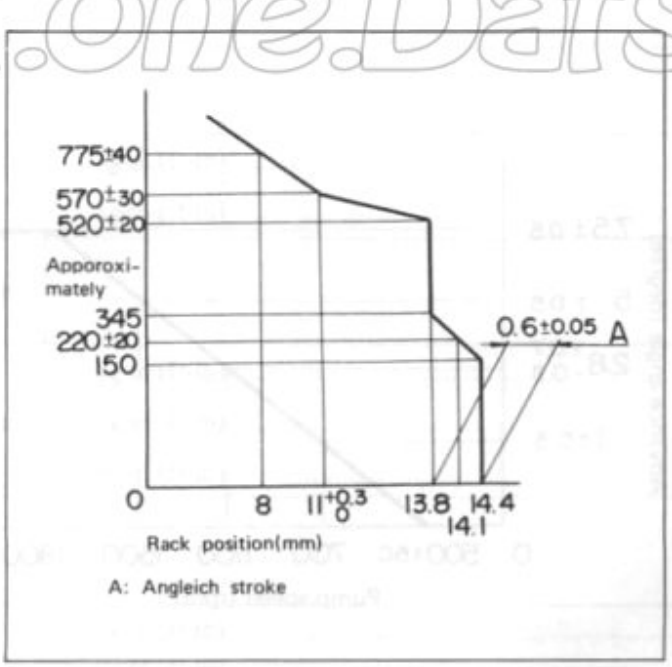

Fig. EF-191 Governor performance curve

TIMER PERFORMANCE CURVES

For SD 22

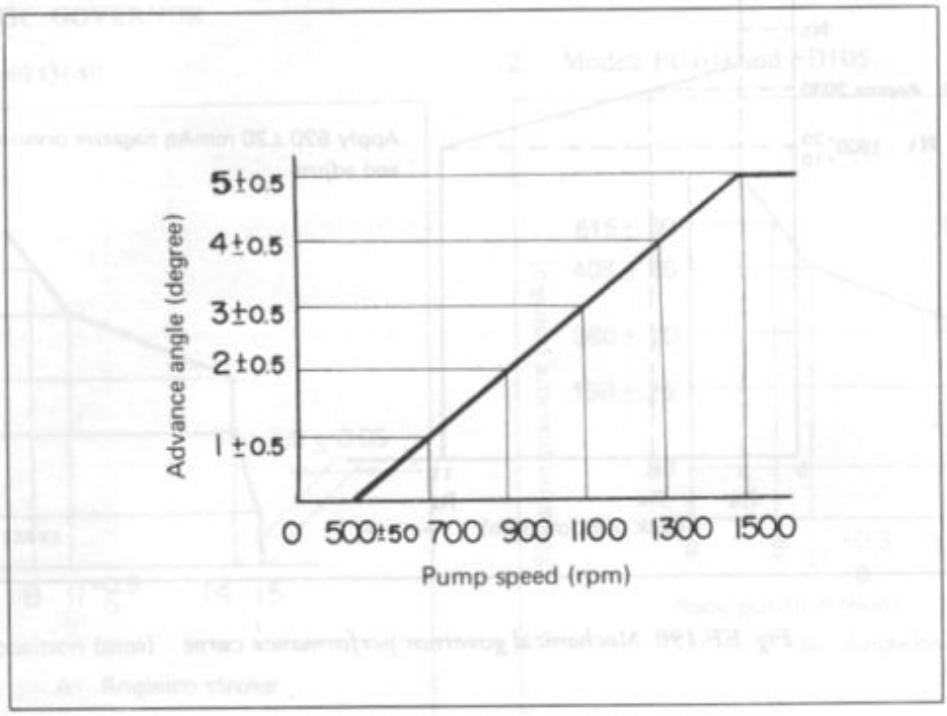

Fig. EF-192 Timer performance curve

For SD 33

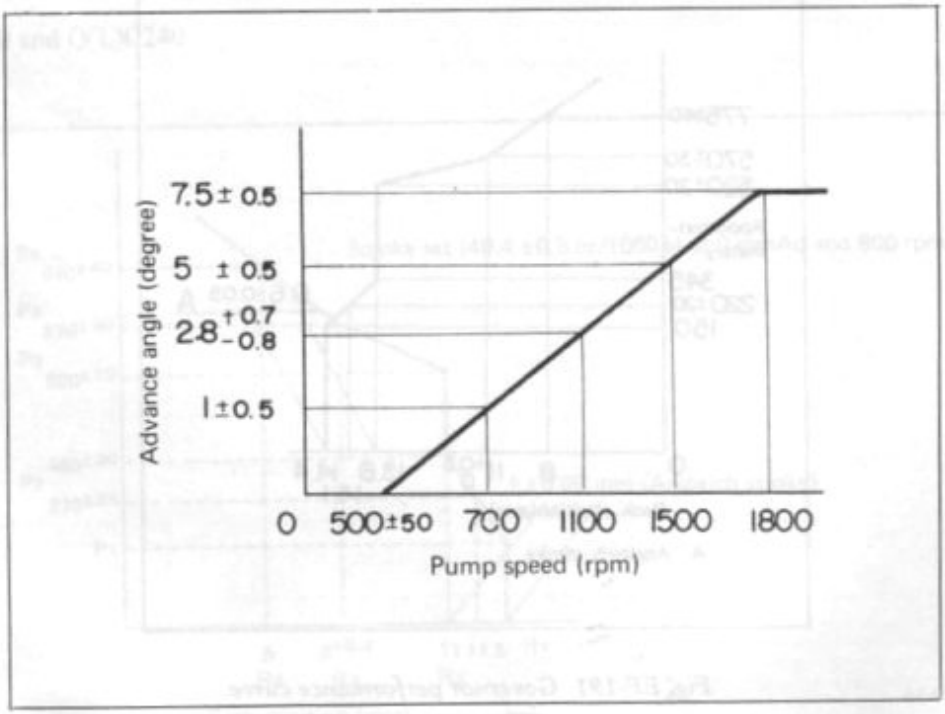

Fig. EF-193 Timer performance curve.

TIGHTENING TORQUE

Fuel injection pump

Delivery valve holder	kg-m (ft-lb)	3.0 to 3.5 (21.7 to 25.3)
Lock plate screw	kg-m (ft-lb)	0.6 to 0.8 (4.34 to 5.79)
Air bleeder plug	kg-m (ft-lb)	2.0 to 3.0 (14.5 to 21.7)
Locking screw	kg-m (ft-lb)	1.0 to 1.5 (7.23 to 10.85)
Rack guide screw	kg-m (ft-lb)	0.5 to 0.6 (3.62 to 4.34)
Rack bushing	kg-m (ft-lb)	3.0 to 3.5 (21.7 to 25.3)
Pinion clamp screw	kg-m (ft-lb)	0.3 to 0.5 (2.17 to 3.62)
Screw bushing (Oil chamber)	kg-m (ft-lb)	3.5 to 4.5 (25.3 to 32.5)
Screw plug	kg-m (ft-lb)	6.0 to 7.0 (43.4 to 50.6)
Lock nut (Tappet adjusting bolt)	kg-m (ft-lb)	6.0 to 7.0 (43.4 to 50.6)
Set screw (Bearing cover)	kg-m (ft-lb)	0.7 to 0.9 (5.04 to 6.50)
Stud bolt (Feed pump)	kg-m (ft-lb)	0.3 to 0.4 (2.17 to 2.89)
Nut (Feed pump)	kg-m (ft-lb)	0.5 to 0.7 (3.62 to 5.04)

Governor

Flyweight round nut	kg-m (ft-lb)	5.0 to 6.0 (36 to 43)

Timer

Round nut	kg-m (ft-lb)	6.0 to 7.0 (43.4 to 50.6)
Lock nut	kg-m (ft-lb)	10 to 18 (72.3 to 130.2)

Nozzle and nozzle holder

Nozzle nut	kg-m (ft-lb)	10.0 to 12.0 (72.3 to 86.8)
Nozzle holder retaining nut	kg-m (ft-lb)	7.0 to 8.0 (50.6 to 57.9)
Overflow nut	kg-m (ft-lb)	4.0 to 5.0 (28.9 to 36.2)

Fuel filter

Filter case center bolt	kg-m (ft-lb)	1.5 to 2.0 (10.85 to 14.5)
Lead line connector bolt	kg-m (ft-lb)	5.5 to 6.5 (39.8 to 47.0)