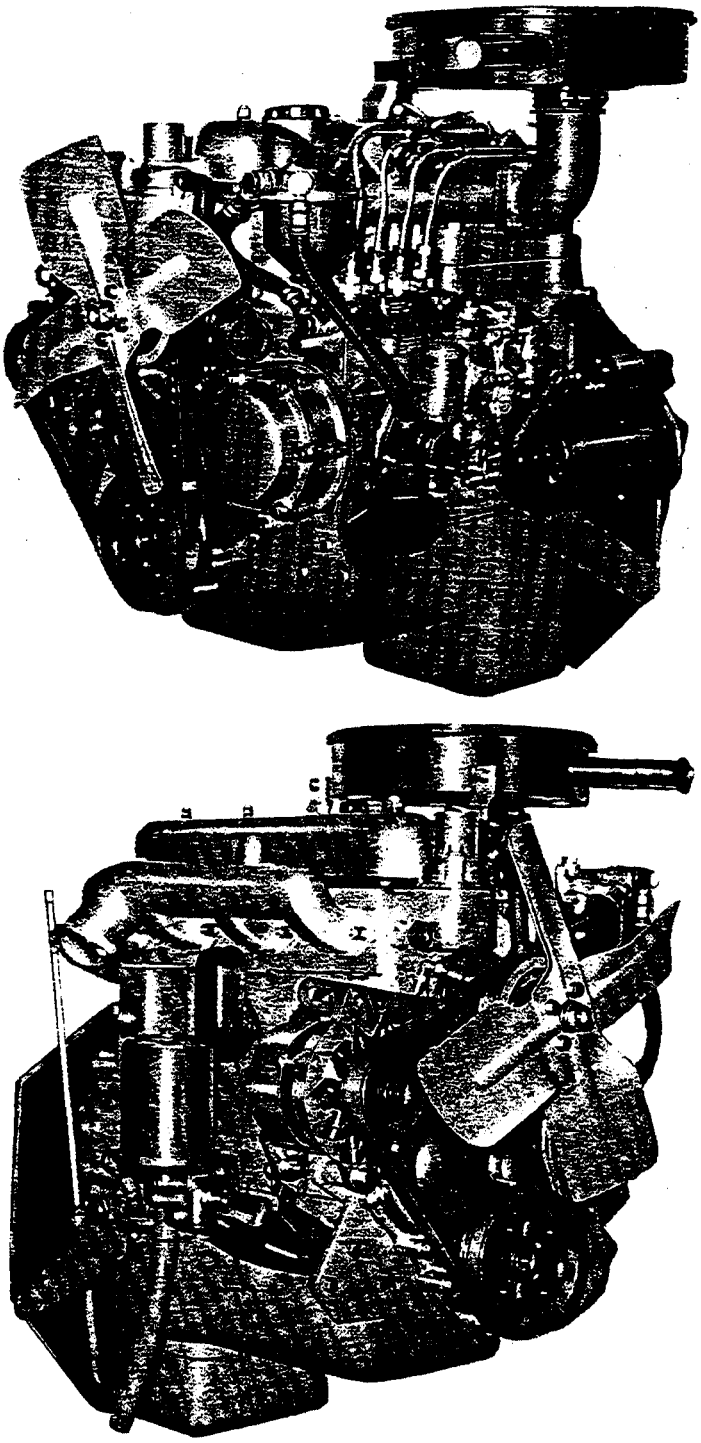
SERVICE MANUAL

三菱ディーゼルエンジン

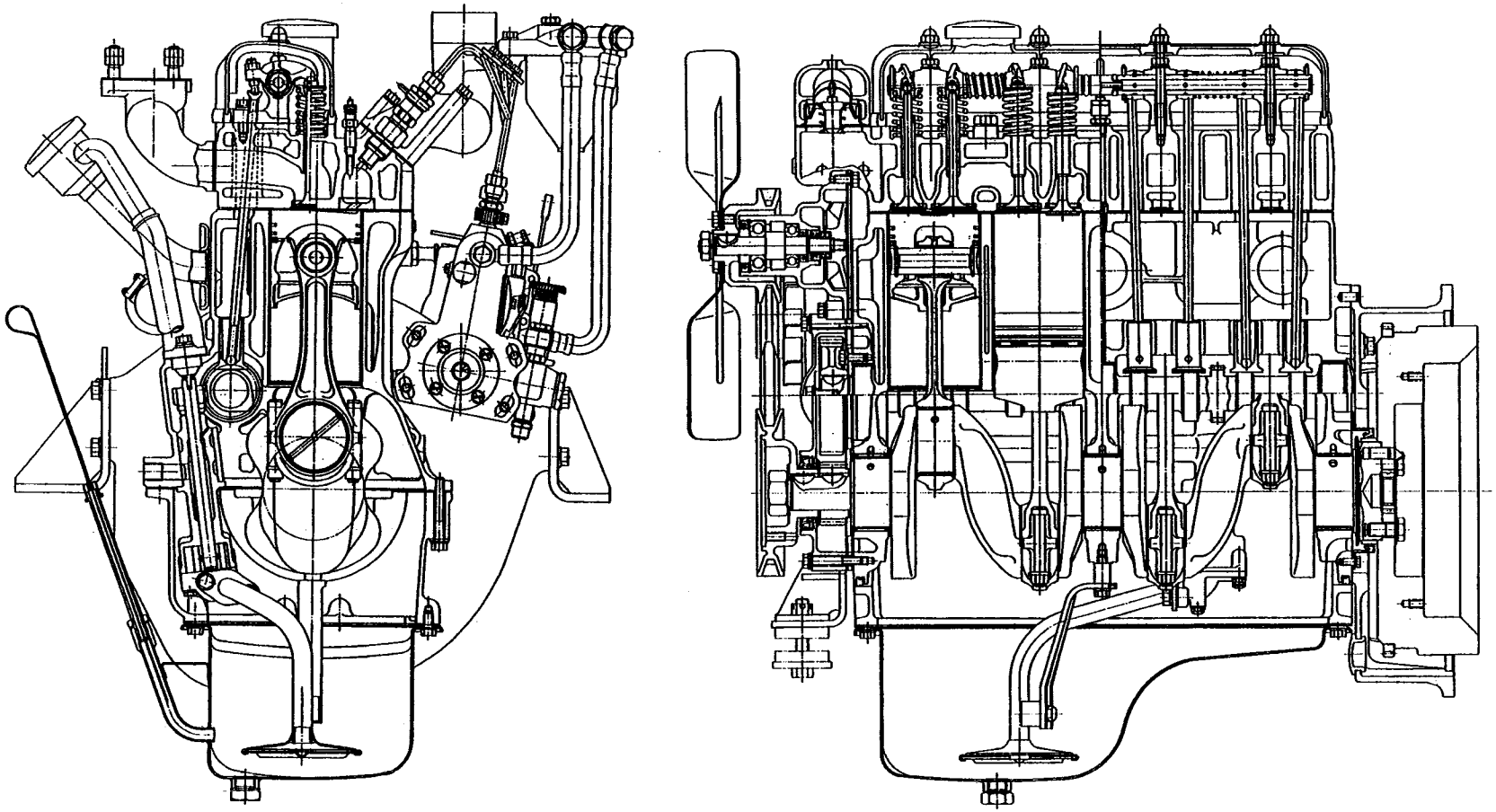
MITSUBISHI DIESEL ENGINE

4DQ50

MITSUBISHI HEAVY INDUSTRIES, LTD.



MITSUBISHI DIESEL ENGINE MODEL 4DQ50W



MITSUBISHI DIESEL ENGINE MODEL 4DQ50C

CONTENTS

PREFACE

1. In every new Model 4DQ50 Engine, fuel injection pump and governor lever bear lead seals that were put after their setting upon final confirmation of its performance through test runs, at our factory. This service manual is intended to cover regular maintenance services. For informations about particular servicing, especially of sealed units and parts such as mentioned above, please contact our service man or your dealer.
2. Engine name plate is found on the up-side of rocker case. Engine Model and No. are given on it.

   They are also stamped on the right side of crankcase. They will serve as important data to know the engine's career and make-up of components.

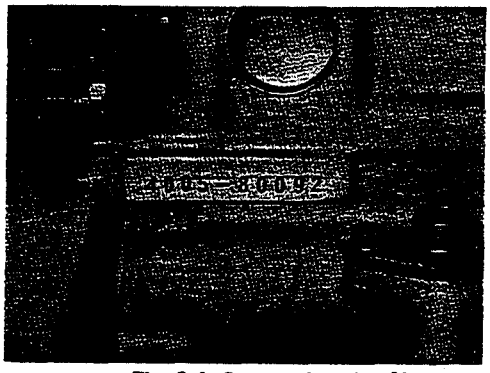


Fig. 0-1 Stamped engine No.

Fig. 0-2 Service meter

3. As for fuel, engine's power source, and lubricating oil to smooth engine operation, please use those are above DM class as shown in caution plate. Their choice has a considerable influence on the engine's service life. Lubrication and other servicing in accordance with the instructions given herein will promise its most satisfactory operation. For regular service intervals are based on the reading of service meter, don't forget to read it every day. At the same time, check the day's fuel and oil consumptions. The data collected thus every day will prove very useful to know later how the engine has been running and is at the time.
4. We hope that, along with this manual, you will make use of the parts catalogue to deepen your knowledge about the handling of your engine.

CHAPTER 1 OPERATION AND HANDLING

1. NEW ENGINE

Prior to putting it in use, check as follows:

1) See if there are any loose bolts or nuts.
2) Lubricate according to Lubrication Table given later.
3) Fill fuel tank with clean fuel and bleed (or prime) fuel system.
4) Fill radiator with clean soft water as a ccolant.

When air temperature is expected to fall below the freezing point, use an antifreeze.

The service life of new engine much depends upon how it is handled in the initial runs. So, lubricate, and check it with particular care (Refer to Lubrication and Service Tables), and before it covers 60Hr, follow the instructions given below, taking care not to overstrain it.

1) After starting, never apply load immediately without warming it up well by idling.
2) Don't run it at high speed.
3) Run under some 70% of load at the maximum.

2. CHECKUP AND PREPARATIONS PRIOR TO STARTING

Prior to starting the day's operations, check as follows with the engine placed as level as possible.

1) **Engine oil level**

Pull out oil level gauge and wipe; then put it in and out again to check oil level. Oil level must be above mid-point between upper "FULL" line and lower one. If near or below the mid-point, refill up to upper line "FULL".

Oil level difference between these two lines corresponds to approx. 1 litre.

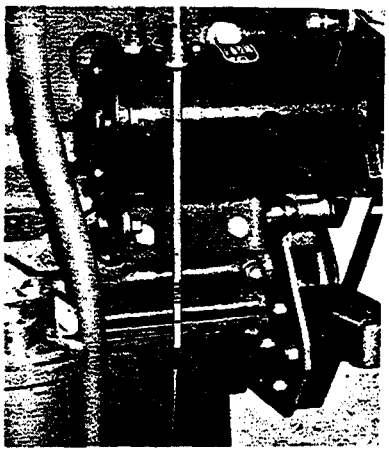


Fig. 1-1 Checking oil level

After refilling, wait for all added oil to run down into oil pan and for oil level to settle, before checking it again.

2) **Cooling water level**

Optimum water level is 20~30mm below the bottom of water inlet for pressure type radiator, and up to overflow pipe for non-pressure type one.

Remarkable decrease of cooling water means leak somewhere, hence the necessity to repair immediately.

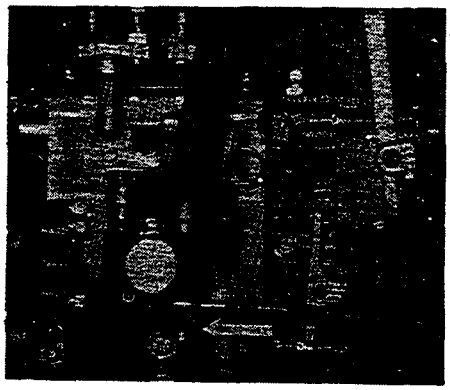
In the case of pressure type radiator, don't screw off its cap just after the engine stopped, lest you should get burnt by outblow of high-temperature steam.

3) Fuel

Check fuel level.

If fuel tank is equipped with fuel feed cock, make sure that it is open. At starting after long leaving idle, or when air seems to be in fuel system, practise bleeding (or priming).

(Refer to "Bleeding".)



(Mechanical governor)

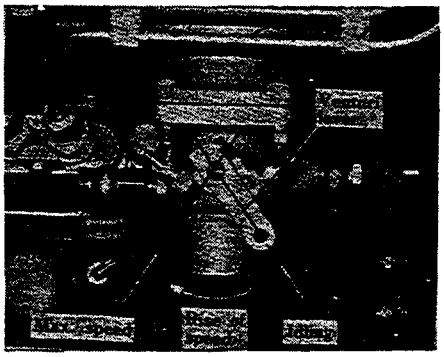


Fig. 1-2 Around Venturi lever

(Pneumatic governor)

Fig. 1-3 Around Stop lever

4) Power source

Make sure that battery switch and battery terminals are on.

Now check as follows and proceed to starting,

1) That the engine is clutched off or free from load.
2) That stop lever is not in "stop" position.
3) That venturi lever is in "full-open" position (for pneumatic governor use)

3. ENGINE STARTING

Model 4DQ50 engine is equipped with either of push button or key type starting switches. In push button type switch, a press on button "H" keeps it on until another press on button "S" makes it pop out automatically.

1) Put key into starting switch.
2) Press button "H" (or turn key counterclockwise) to make glow plugs red hot. Pre-heating time depends upon air and engine temperatures. In any case, pre-heat until glow plug indicator becomes red hot. Usually some 25 seconds pre-heating will make it red hot. If it gets red hot too early or too late, check glow plugs, for that is an evidence of one or more of them breaking.

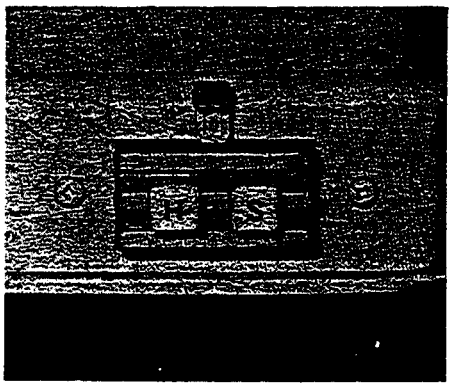
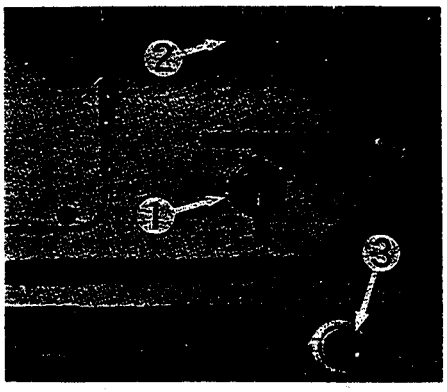


Fig. 1-4 Push button type starting switch



1 Starter switch
2 Glow plug indicator
3 Engine stop button
Fig. 1-5 Key type starting switch

3) Then, press button "S" (or turn key clockwise) to switch on starter. When the engine is very cold, pull stop lever at the same in opposite direction to position "stop", and an increase of injection will make starting easier. In this case, pull it back to "neutral" as soon as first firing.

   Keep starter running until the engine has completely caught to run with a steady rise of speed, but never any longer than 30 seconds at a time.

   If starting has failed, don't switch on starter again before both starter and engine come to a dead stop and starter cools down. While the engine is running, don't try to increase injection nor switch on starter.

Note: According to specifications, Model 4DQ Engine is equipped with a governor that has a built-in automatic device to increase injection. In pneumatic governor use, prior to starting, place stop lever once in position "stop" and pull back to "neutral" to assure a quick increase of injection. Particularly attempt

the same when the engine has stopped by chance.

4) When the engine has perfectly caught, bring back Venturi lever (or control lever) immediately to "idling".

For starting in winter, Refer to "Cold starting".

4 AFTER THE ENGINE'S START

Keep it idling at medium speed for some 5 minutes for warm-up, then start driving or operations. This will prove very effective in protecting moving parts from wear and in other aspects. With the engine idling, check as follows:

1) Anything unusual with oil pressure? (Refer to Par. 3-4, "Oil pressure", Chap. 3, "Regular Servicing".)
2) Does the engine make unusual noise?
3) Is exhaust colour abnormal?
4) Any leak of water, fuel or oil?

5 ENGINE OPERATION

Model 4DQ50 engine is equipped with a pneumatic governor or a mechanical governor for each use. This governor being of the all-speed governing type, variation of engine speed depends upon how far Venturi unit is opened for in which position control lever is. This design is such that, at a certain degree of Venturi unit opening or control lever position engine output is automatically governed with changes of load so as to keep engine speed almost constant.

During operation, leave stop lever in "neutral". (pneumatic governer use)

For details, refer to Par. 4-6, "Governor"

6 DURING OPERATION

After warm-up run, apply load on the engine.

During operation, judge how the engine is going, from the indications of meters, sound, exhaust colour and etc.

1) **Oil pressure** (Refer to Par. 3-4, "Oil pressure".)

Oil pressure gauge, if the engine is equipped with one, must read 3~4kg/cm^2 (2kg/cm^2 at minimum) at usual engine speed and above 0.5kg/cm^2 in idling. If oil pressure alarm lamp attached, watch it every now and then. If it should get alight, check oil system.

2) **Water temperature**

Optimum range is 75°~85°C. Overheating arises from lack of cooling water, loose

fan belts and poor functioning of thermostat. In case the engine gets overcooled, put a suitable cover on radiator.

3) Generator charge

While generator is charging batteries, ammeter pointer indicates (+) scale. At the beginning of charging, it indicates about 10A, then gradually decreases as batteries get charged. So you must not take this aspect for any generator trouble.

Charge pilot lamp, which is attached at option, goes out when the engine has started and generator begins to charge. If a rise of engine speed should not put it off, check and service charging system immediately. If the system left defective, batteries will entirely run down, making engine starting absolutely impossible.

7 STOPPING

After the operations over, let the engine idling for some 5 minutes. Don't bring it to a sudden stop with its parts heated hot.

As letting it idling, pull back stop lever to position "stop", and fuel injection will be cut off and thethe engine come to a stop.

When the engine has come to a dead stop, pull back stop lever to "neutral". Remember that, if the lever released when the engine has not yet stopped, it may run reverse.

Note: Reverse running of the engine

Model 4DQ50 engine may happen, though rarely, to run reverse in the following cases.

1) When, in an attempt to cut off injection by pulling back stop lever, the lever is released, before the engine comes to a dead stop.
2) When starting motor is switched on with batteries not charged enough to power it as required to start the engine.

Reverse running can be readily noticed, as the engine emits then much black smoke through air cleaner, making noise at the same time. But it will rather hard to stop in the usual way, for exhaust pressure will then press governor diaphragm so tight to "full injection" position as not to permit stop lever be easily pulled back.

So take any of the following emergency measures to stop it.

1) Bring accelerator button to "full-open" position and force back stop lever.
2) Increase load to maximum to bring the engine to stop. (Apply brakes, if available.)
3) Shut exhaust pipe by hand or with waste cloth.

Keep in mind that long reverse running will make oil pump run reverse, too, and as the result, metals will get burnt from the stop of oil circulation.

8 HANDLING IN COLD WEATHER

When the air temperature is very low and the engine is cold, engine starting is confronted with such factors as low temperature of intake air which disturbs the rise of compression temperature, an increase of oil viscosity and a drop battery voltage which keeps starter from developing enough power to drive the engine. In addition, cooling water and battery electrolyte may freeze up. For starting and handling in cold weather, follow the special instructions given below.

8-1 Starting in cold weather

Proceed according to the following additional hints so that a single attempt will make success in starting. Repeated use of starter will discharge batteries.

1) Put the engine as free from load as possible. If clutch attached, disengage it, besides shifting transmission gear into neutral.
2) Pre-heat well by electrifying glow plugs for 30~40 seconds, so as to permit ready ignition. If starting has failed, don't switch on starter again without pre-heating.
3) The moment first firing takes place, bring back lever to neutral. Further increase of fuel feed will cool combustion chamber, hence a lag in perfect firing.
4) Even when initial ignition has taken place and been followed by imperfect combustion, keep starter running until the engine perfectly catches to gather speed, so that glow plugs will remain red hot to help perfect firing. Starter has a free wheel, which protects it against any damage even when its pinion is kept in mesh with ring gear in that way. In any case, don't run it any longer than 30 seconds at a time.

8-2 General instructions

1) Unless an antifreeze is mixed in cooling water, drain it off entirely after the operations over, lest it should freeze up to damages cylinder block, cylinder heads, radiator, etc.

   Use of an antifreeze dispenses with the trouble of draining.

   Choose a reliable brand of antifreeze that contains a suitable proportion of anticorrosive, and mix it according to the manufacturer's instructions given on the can, for its proportion usually depends upon the lowest temperature expected. Quantity of cooling water for 4DQ50W is 10 litres and 4DQ50C is 16 litres. (with standard radiator)
2) In winter, use engine oil of lower viscosity. (Refer to Chap. 2, "Engine Oil".)
3) Existence of water in fuel will cause some trouble with fuel system from

freezing of pipes. So bleed (or prime) fuel tank, fuel filter, etc.

4) At low temperature, battery capacity goes down, hence batteries should be covered with a tarpaulin sheet, or be stored in a warm place when not needed. Keep the specific gravity of battery electrolyte above 1.25 so as to prevent it from freezing. (Refer to Par. 6-4, "Batteries" Chap. 3).

5) Warm up the engine well, and never overstrain it.
During operation, watch thermogauge and if it gives any sign of overcooling, put a cover on radiator.

9 HANDLING IN THE HOT SEASON

1) Use engine oil intended for summer. (Refer to Chap. 2, "Engine Oil".)

2) Keep the tension of fan belts properly adjusted so as to allow them a slack of 12mm. (Refer to Par. 5-3 "Tension of fan belt" Chap. 3) Watch thermogauge, too. When cooling water has started boiling from overheat, Don't stop the engine at once, but let it idling for a time, Waiting for water temperature to fall.

3) Check battery electrolyte level every day and if lower than specified, add distilled water.

4) When the engine is to be left idle under high temperature for several days or longer, store batteries in a cool dark place to prevent their self-discharge.

CHAPTER 2 FUEL, OIL AND COOLING WATER

1 FUEL

1) For fuel, use gas oil (with greater cetane number than 45) of a well-known and reliable brand and destined for high-speed Diesel engines.

2) Use of clean fuel is of greatest importance for the fuel system of a Diesel. Dust and water in fuel do damage to precisionmachined injection pump, nozzles, etc. In filling fuel tank, take care not to let in any bit of dust and water. The refilling of fuel tank should be done after the operations are over. At regular intervals, open drain cock on fuel tank to draw off settled water and dirt prior to starting, and wash its interior.

2 ENGINE OIL

2-1 Quality required of engine oil

A high-speed Diesel requires for its lubrication better-quality mineral oil than that intended for ordinary gasoline engines.

It means that such oil satisfies the following requirements.

1) To be stable against heat and oxidation.

   By high heat of cylinders, oil is subject to oxidate and carbonize, and consequential collection of carbon and residues leads to wear and seizure. Therefore, oil needs to contain at least two kinds of additives to improve its stability; an anticorrosive and a detergent that dissolves carbon and sludge in oil and thus washers them away.

   From these view-points, use always H.D. type that contains both, so is very favourable for the service life of pistons, liners, rings and metals, etc.

2) To have high viscosity stability against changes of temperature.

   For easy starting at low temperature, oil is required to be low in viscosity but, after starting, be high enough to assure perfect oil film on high-temperature parts. Practically, however, a single oil cannot opportunity satisfy these requirements, so it follows that an oil whose viscosity is less subject to change should be used.

2-2 Recommendable classes of engine oil

In view of the foregoing requirements, DM class in A.P.I.'s service classification should be chosen.

As for viscosity selection, consult the following table.

Climates	Above 40°C	40° ~ –5°C	–5° ~ –15°C	Below –15°C
Viscosity	SAE #40	SAE #30	SAE #20	SAE #10W

Except in an frigid region, SAE 30 can be applied throughout the year.

2-3 Time to change engine oil

Time to change engine oil is indicated as a general standard in Lubrication Table. It may, however, get dirty and deteriorate very soon and need to be changed much ahead of the given time, under some conditions of use, and be very show to do so under others.

Practically speaking, the user himself should judge whether it can stand further use or must be changed. For this, we recommend a simple test called "spot test", where some drops of used engine oil are put on filter paper to see how far it has deteriorated and got dirty. For details about this test, ask the manufacturer of the oil.

3 DIAPHRAGM OIL (Pneumatic Governor)

Diaphragm oil is a kind of leather oil intended to prevent the aging or deterioration of sheep skin diaphragm placed in pneumatic governor of fuel injection pump, and to keep governor action smooth and sensitive. Use always those brands indicated on Lubrication Table, and never substitute by engine oil (mineral oil).

4 COOLING WATER

4-1 Required quality

Cooling water must be clean and soft. Never use any water that contains salt or is near a mine or a spa, because it will scale hard water jacket and corrode cylinder liners along their outer circumference.

4-2 Handling of cooling system

1) In leaving the engine idle for many hours, especially in cold weather, open all drain cocks to thoroughly drain off cooling water.
2) When the engine has overheated and has been empty of water, never pour cold water in radiator.
3) For the use of an antifreeze, refer to Sect. 8, "Handling in Cold Weather" Chap. 1.

CHAPTER 3 REGULAR SERVICING

To service your engine regularly is the key to enjoy its ever trouble-free and efficient operation and long service.

To say nothing of usual services before and after the work, appropriate measures must be taken if, during operation, any unusual symptons in sound, exhaust colour, smell, etc. should be noticed.

In this chapter are given in detail the necessary instructions for regular checkup and servicing, starting with lubrication, along with the constructional descriptions of engine parts. Standard intervals are based on the reading of service meter. For any checkup and servicing, place the engine as level as possible.

1 LUBRICATION

This section covers the points of lubrication, which is a basic factor of maintenance. It is most desirable to use the classes of oils recommended in the preceeding chapter.

1) Engine oil pan Checkup of oil level:

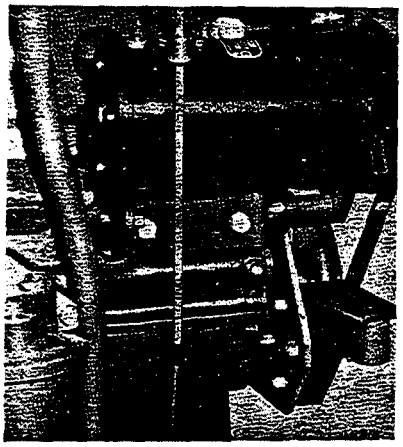
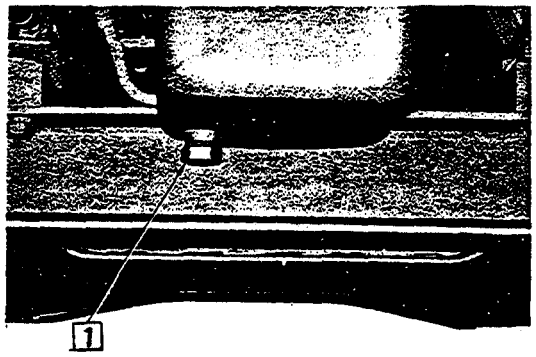


Fig. 3-1 Checking oil level



1 Drain plug

Fig. 3-2 Drain plug on oil pan

Check it every morning or prior to starting.

Checking procedure is described in Sect. 2, "Checkup and Preparations prior to Starting", Chap. 1.

Change of engine oil:

Every 250Hr of run, or when bypass alarm has got alight, change oil. In new engine, change it after initial 60 Hr of run.

For complete change of used oil, drain it off, screwing off drain plug on oil pan while it is still hot, i.e., a little after the engine stopped. At the same time, empty oil

filter and oil cooler (if attached) too, and replace oil filter elements.

When used oil has all drained off, pour in the specified quantity of new oil through oil filler on the side of crankcase or rocker case cover, let the engine run at idling for several minutes, and stop it and check oil level with level gauge.

Note: Standard quantities of oil for 4DQ50W is 4.7 litres.

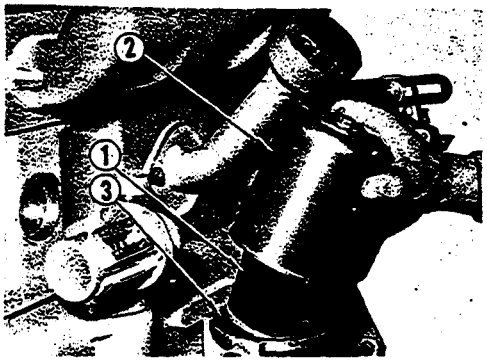
4DQ50C is 6.0 litres.

4DQ50P (without oil cooler) is 6.7 litres.

2) Fuel injection pump cam case

Chockup of Oil level:

Every 120Hr of run, pull oil level gauge (1) out of injection pump cam case and check oil level. If it tells a decrease of oil. Check and repair the leak. Standard oil level is up to the mark line cut on the gauge.



1. Filter element 3. Head
2. Cover

Fig. 3-3 Replacing oil filter element

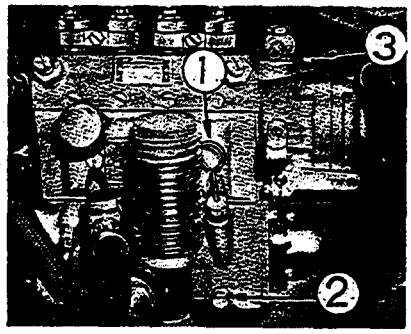


Fig. 3-4a Lubrication of fuel injection pump (pneumatic governor)

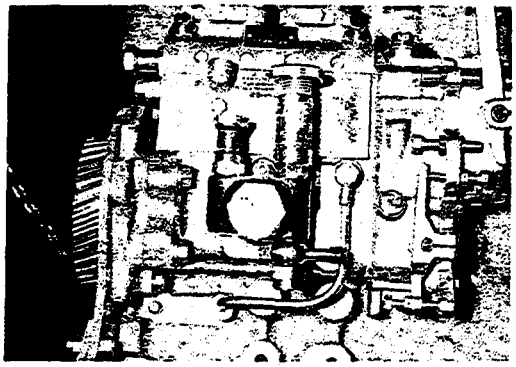


Fig. 3-4b Lubrication of fuel injection pump (mechanical governor)

Change of oil:

Every 250Hr of run, screw off drain plug (2) to drain off oil thinned with fuel, and pour in about 70cc of new engine oil through level gauge hole.

Oil in pump cam case usually get thin with fuel that leaks from around plungers, and consequential rise of its level makes it overflow pipe. Long operation on oil thinned almost equal in viscosity to fuel will do damage to cam surfaces and bearings.

3) Governor (pneumatic)

Every 250Hr of run, apply 3 to 5 drops of diaphragm oil through diaphragm oil hole (3).

Never use engine oil.

4) Governor (mechanical)

In mechanical governor, fuel injection pump and governor is forced lubrication by engine oil, so it need not check up of oil level.

5) Air cleaner (with oil bath type)

Check up of oil level:

Keep to the optimum oil level in the oil bath. Every 60Hr check up of oil level, if necessary refill up to "OIL LEVEL". Lower level oil is not sufficient clean action and higher level oil act bad influence to engine. Standard quantities of oil is 0.85 litres.

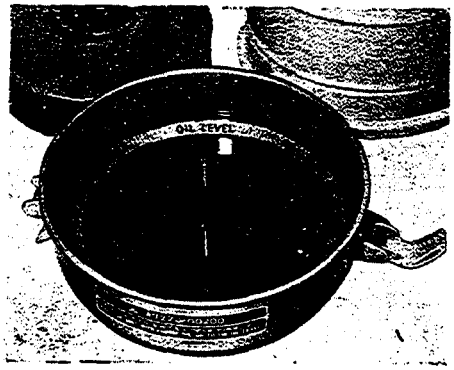


Fig. 3-5 Change of oil in the oil bath type air cleaner

Change of oil:

Every 120Hr, change the oil. But in the very dusty areas, change the oil every day. (5~10Hr)

At the same time clean the oil bath and element.

6) Starter

Every 1,000Hr of run, apply oil to pinion shaft bearing in clutch housing through respective oil holes. (1).

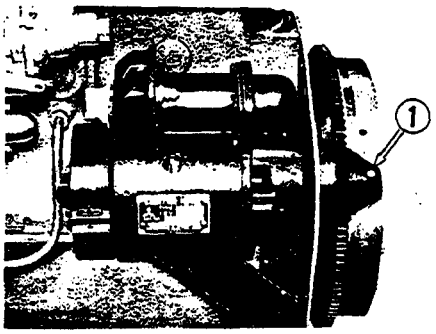


Fig. 3-6 To apply oil to starter

7) Tension pulley

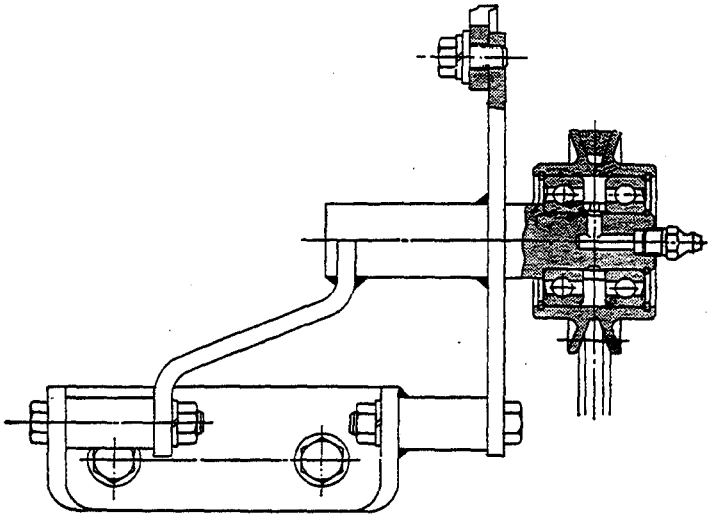


Fig. 3-7 To apply grease to tension pulley

If engine is no need of dynamo, tension pulley is equipped. Tension pulley has a grease nipple (Fig. 3-7), every 250Hr of run apply grease to it.

Lubrication Table for Model 4DQ50 Engine

Items	Description	Lubri-cants	Lub. Intervals						Q'ty	Remarks
			Daily	60Hr	120Hr	250Hr	500Hr	1000Hr		
Engine oil pan	Check oil level	E.0	○							
	Change oil			※		○			Refer Chapt 3	At the same time,empty oil filter and replace filter elements
Injection pump cam case (Pneumatic)	Check oil level	E.0			○					
	Change oil					○			70cc	
Governor (Pneumatic)	Apply oil to diaphragm	D.0			○				3～5 drops	
Air cleaner (With oil bath type)	Check oil level	E.0	□	○						
	Change oil		□		○				0.85ℓ	
Starter	Apply oil to bearing	E.0						○	Several drops	
Tension pulley	Apply oil to bearing	G				○				

Note : 1. Marks

○ : Generally

□ : In very dusty areas

※ : First service for new or overhauled engine

2. Symbols

E.0 : Engine oil

D.0 : Diaphragm oil

3. Mechanical governor is forced lubrication by engine oil

2 AIR SYSTEM

2-1 Air cleaner (oil bath type)

Model 4DQ50 engine is equipped with either of oil bath or filter paper type air cleaner. Oil bath type air cleaner consists of centrifugal type pre-cleaner and oil bath type cleaner.

1) Quantities of oil and change of oil refer to "Lubrication".

2) Pre-cleaner gathers comparative parge dirt.

3) Oil bath gathers comparative small dirt. If the oil is not fluidity by very small dirt, change the oil in spite of the existence of sediment and servicing interval.

4) For washing the oil). At the same time wash the lower element.

5) Be care not to tamper the air cleaner during engine operation.

6) Be care not to leak from connecting pipe. If the dirty air enter the cylinder, it injur the valves and cylinder sleeves, and in the case of pneumatic governor use, it gives bad influence to the governor action.

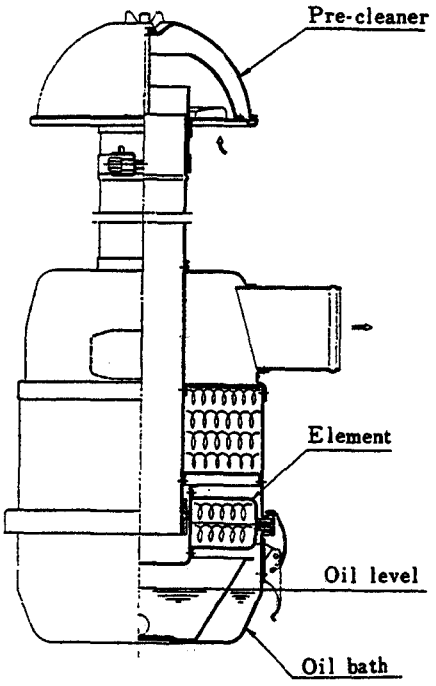


Fig. 3-8 Air cleaner (Oil bath type)

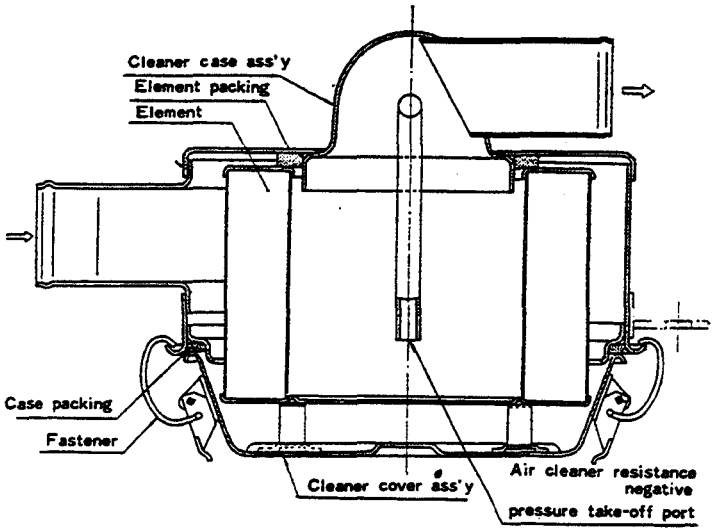
2-2 Air cleaner (Filter paper type)

In filter paper type air cleaner, paper element performs an important part. In handling, be very careful not to rub or scratch its surface. If scratched or damaged even a bit, replace with a new element.

A thin pipe from the case is connected, with a vinyl tuve, to diaphragm air chamber in pneumatic governor. (Refer to Par. 4-6, "Governor".) Keep this tube firmly connected. If off, it will let in dust.

1) Every 250Hr of run, take out element to clean by blowing air from inside. At the same time, clean the interior of case. If compressor not be available tap element clean of dust. Never wet it with water. When the engine used in a very dusty place, do the cleaning at shorter intervals.

2) Every 500Hr of run, replace element with new one.



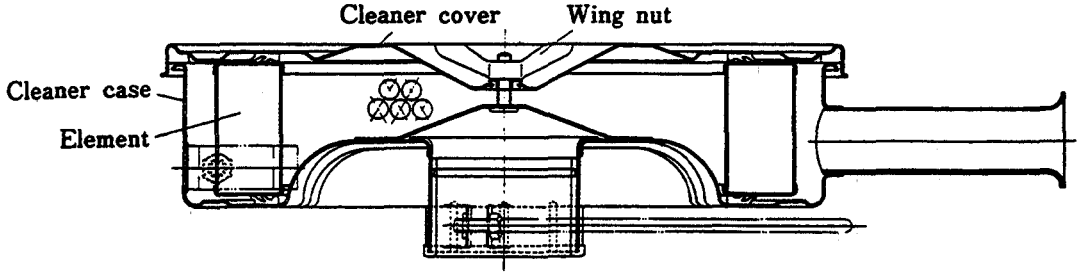


Fig. 3-9 Air cleaner (filter paper type)

2-3 Valve clearances

Both lack and excess of valve clearances affect engine performance. Especially excessive valve clearances will induce much strain on valve mechanism, making the engine subject to serious trouble.

Apart from regular checking required every 250Hr of run, check and adjust them whenever low-speed running of the engine makes any unusual sounds. For new Engine, adjust them when it has run for 60Hr. Proper clearances are, exhaust and inlet valves alike, 0.25mm as measured in cold (or uniformly warm) engine.

Firing order is: 1–3–4–2.

2-4 Compression pressure

1) To see whether or not intake air into cylinders undergoes there sufficient compression with no blow-by to help the firing, measure compression pressure.
2) The results will tell if:
   a) Valve seats are in tight enough contact.
   b) Cylinder liners and piston rings are not worn or sticking hard.
   c) There is any leak of gas ascribable to other cuases.

Regular measurement at intervals of about 500Hr of run will provide reliable data to decide when to overhaul the engine.

3) Prior to measuring it, check and adjust valve clearances so that rockers do not press down valves in compression stroke, and make sure that Venturi butterfly valve is full open.
4) Standard compression pressure is above 20kg/cm^2 at an engine speed of 150~200 r.p.m., and with oil and water temperatures in a range of 20°~30°C. Please have it measured by your dealer or at a service shop.

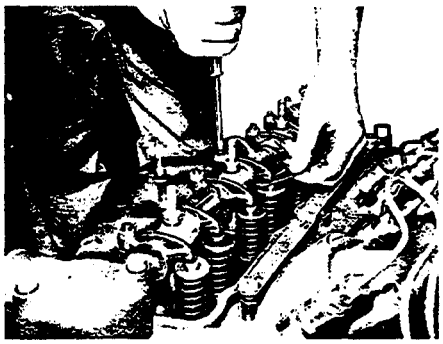


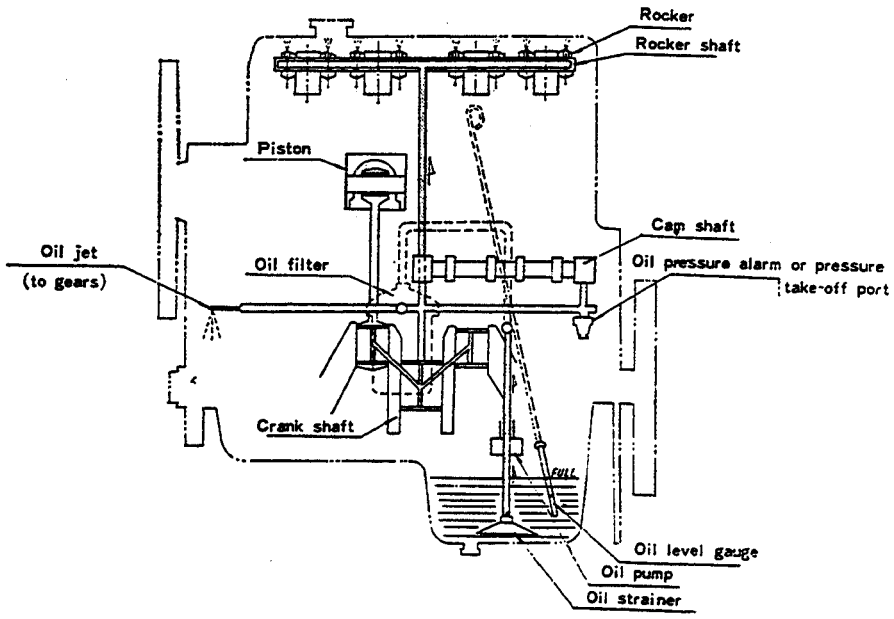
Fig. 3-10 Adjusting valve clearance

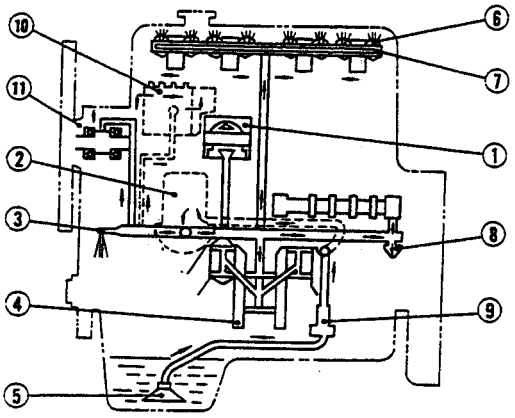
3 OIL SYSTEM

As can be seen in circulation diagram (Fig. 3-11), lubrication system is forced lubrication by a trochoid oil pump. At option, a water-cooled oil cooler is equipped between oil pump and oil filter to keep oil in an optimum temperature range.

3-1 Oil pan

1) For checkup of oil level and change of oil, refer to Sect. 1, "Lubrication".
2) Every 500Hr of run, unfasten oil pan to wash its interior and oil strainer in cleansing oil.





1. **Piston**
2. **Oil Filter**
3. **Oil jet**
4. **Crank Shaft**
5. **Oil Strainer**
6. **Rocker-arm**
7. **Rocker-shaft**
8. **Oil alarm**
9. **Oil pump**
10. **Injection pump**
11. **Water pump**

Fig. 3-11 Oil circulation diagram

3-2 Oil filter

Oil filter is of the filter paper full-flow type.

1) Every 250Hr run, change oil. On the same occasion, unfasten filter case and replace element with new one. If bypass alarm lamp has got alight with the engine hot, replace element as soon as possible, without sticking to the standard intervals.
2) At the same time to replace element, wash the interior of filter case in gas oil (or cleaning oil). In assembling again, don't forget to place spring and spring seat where they were.
3) Carefully examine used element and oil and if many metallic, particularly copper-color settlings found, which is an evidence of bearing metals being abnormally worm, take appropriate measures at once.

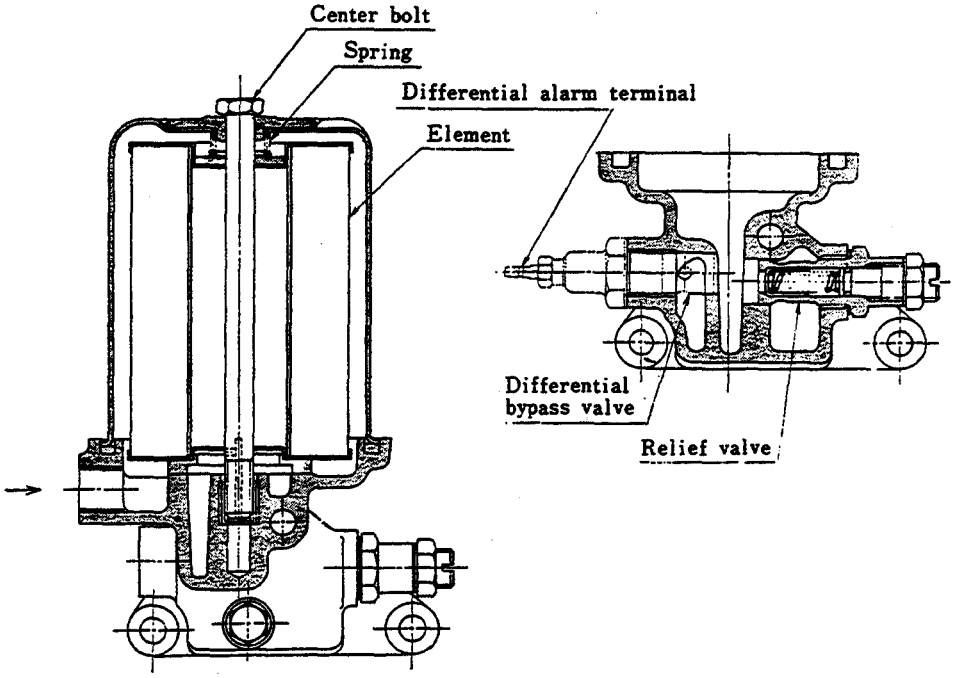


Fig. 3-12 Oil filter

3-3 Differential bypass valve

This valve is set in oil filter cover. The design is such that an oil pressure difference above 1.5kg/cm^2 between inlet and outlet sides of filter element arisen from its being choked with dirt makes it open to bypass unfiltered oil directly into main oil gallery in

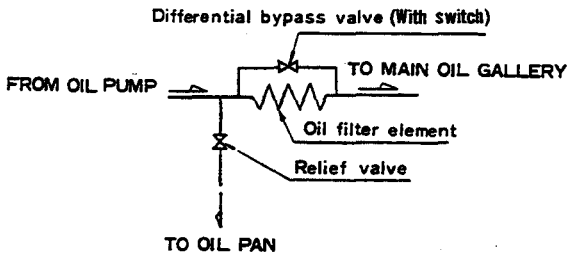


Fig. 3-13 Oil flow diagram

order to prevent any serious trouble, seizure for example, that might be caused by lack of oil. Whenever the valve set to perform so, of which the operator will be signalled by alarm lamp in front of his seat, element must be replaced at the earliest possible opportunity, for lubrication with unfiltered oil will affect moving parts.

The above alarm lamp is set alight, as soon as the valve opens to perform such an emergency bypassing, by contactor that is attached to it for that purpose.

3-4 Oil pressure

Under ordinary weather conditions and at usual engine speed, oil pressure is kept between 3 and 4kg/cm^2 by relief valve on oil filter cover. (The lowest permissible pressure is 2kg/cm^2). Model 4DQ50 engine is provided, at option, with either an oil pressure gauge or an oil pressure alarm switch (which puts alarm lamp alight at a drop below 0.5kg/cm^2).

1) Under the following conditions, oil pressure often goes out of the given range, but will usually become normal as the engine is run.
   a) When the engine has not yet warmed up, i.e., soon after its starting. In this case, oil pressure goes above the standard range, claiming for its good warm-up through low-speed idling.
   b) When, after a warm-up, the engine is let to idle, oil pressure drops low. But this means nothing wrong so far as it remains above 0.5kg/cm^2.
2) Any other drop of oil pressure than incidental to the above case will lead some serious trouble; hence the necessity to check as follows and take necessary measures.
   a) Is oil level high enough? It must be above lower mark line on oil level gauge.
   b) Anything is wrong with oil pressure gauge and its piping?
      Check also alarm switch and lamp, measuring oil pressure with an oil pressure gauge.
   c) Any leak in oil line? Other probable causes are:
   d) Oil pump suction-side piping is inhaling air.
   e) Bearings worn down.

f) Oil pump worn down.

g) Relief valve covered with dirt.

4. FUEL SYSTEM

As can be seen in the above diagram, fuel is, from fuel tank, pumped up by fuel feed pump through piping, by which it is discharged into fuel filter where it is filtered clean; thence is runs into fuel injection pump to be ejected, under control of injection rate according to the load and under high pressure, into combustion chambers via injection pipes and nozzles. For stopping and cold starting, control of injection rate can be done with stop lever but in other cases, should be left to pneumatic governor that works by Venturi negative pressure.

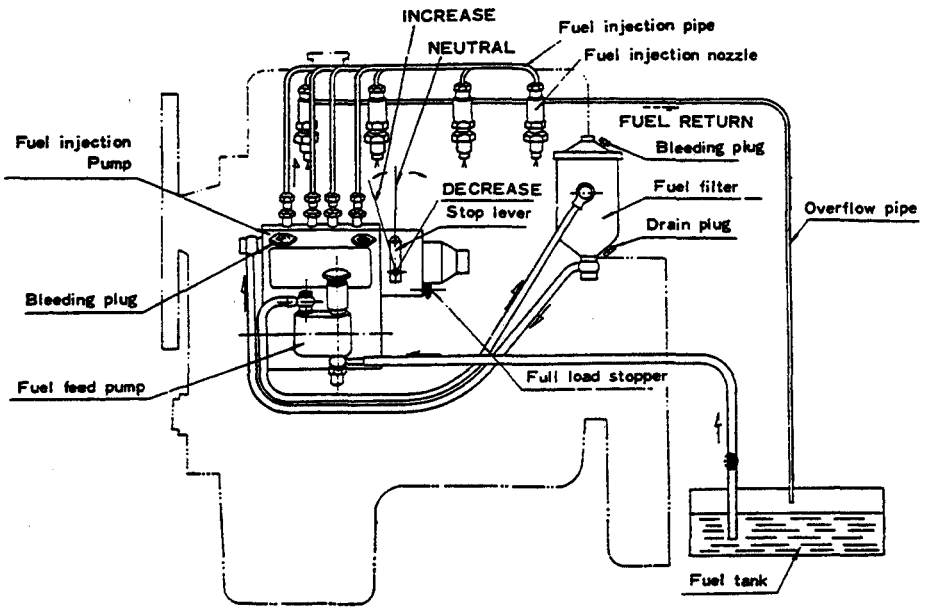


Fig. 3-14 Fuel system diagram

4-1 Fuel filter

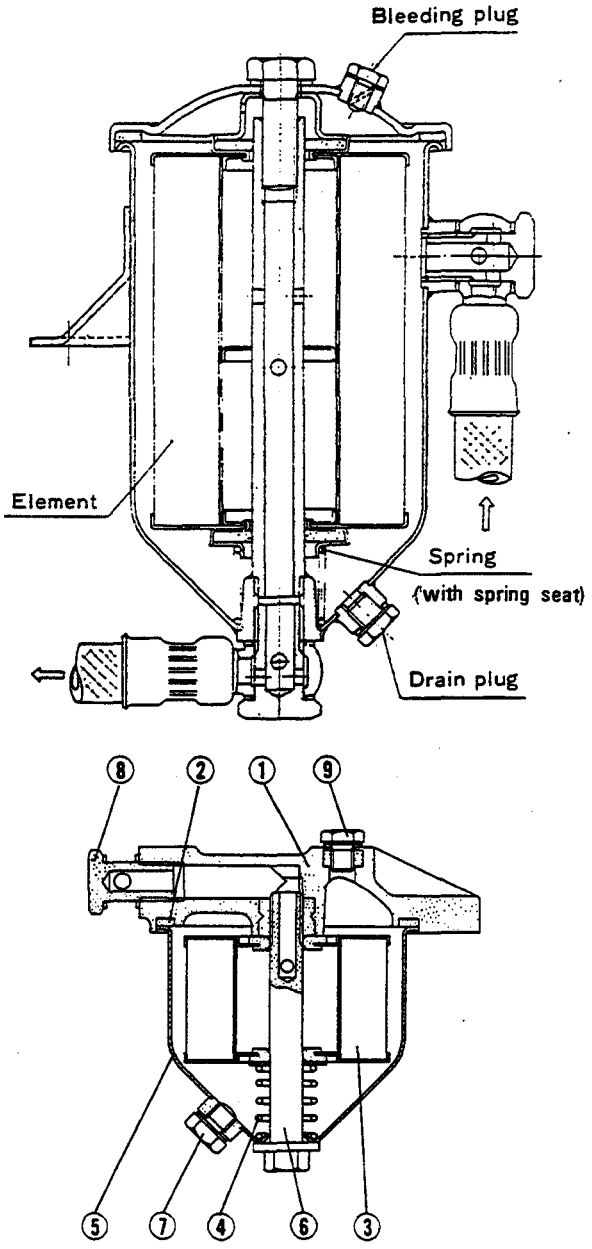
1) Every 120Hr of run, screw off bleeding and drain plugs to drain off dirt and water settled at its bottom; then screw in drain plug and make a bleeding (or priming).

2) Fuel filter element is of paper. When it gets clogged with dirt, fuel feed makes a drop. Replace it with a new element every 1,000Hr of run. To wash it in

cleansing oil will remove dirt on the surface but surely affect the texture of paper, involving a drop of its filtering efficiency. When filter disassmebled for that, wash the interior of filter case clean of dirt. After assembling it with a new element in, make a bleeding (or priming) without fail.

3) Joint on the side of filter case is inlet and that on its bottom is outlet. Be careful not to connect wrong pipes with them. (Refer to "Fuel system diagram".)

4) In inlet joint of fuel feed pump that connect pipe from fuel tank is placed a strainer to filter off large dust particles. Clean it every 120Hr of run. If choked with dirt, fuel feed will go down.



1. **Filter cover**
2. **Gasket**
3. **Element**
4. **Spring**
5. **Filter case**
6. **Bolt**
7. **Drain plug**
8. **Bolt**
9. **Air plug**

Fig. 3-15 Fuel filter

4-2 Bleeding (or priming)

If air should get in fuel system, injection will go wrong, keeping the engine from steady running or making it difficult to start. So, whenever any servicing done with this system, bleed (or prime) it in the following procedure.

1) Loosen bleeding plug on fuel filter and move hand pump on fuel feed pump up and down.

   As fuel filter is fed full with fuel, air bubbles will run out with fuel through bleeding plug. When the outflow of fuel does not contain air bubbles any longer, screw bleeding plug tight.

2) Loosen bleeding plug on the top of injection pump, and move hand pump like-wise up and down to eliminate air out of fuel pump in it.

3) With nozzle-side cap nuts on injection pipes loosened and stop lever in "full-open" position, run run the engine scores of revolutions by starting motor, and all four injection pipes will be bled of air at a time.

   The bleeding must be done, too, when the engine has been left idle for a long time, fuel pipes replaced, or nozzled checked.

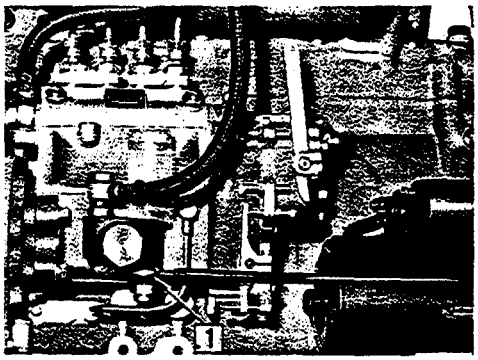


Fig. 3-16 Joint on fuel inlet in fuel feed pump

Fig. 3-17 Bleeding fuel injection pump

4-3 Checkup of nozzles

When something unusual notices with exhaust gas or firing, check nozzles and service accordingly.

Regular checking and servicing of them at intervals of 500Hr of run will keep them always in perfect conditions. For new engine, check them when it has been run for 250Hr. Their checkup and servicing should preferably be entrusted to your dealer or a xervice shop.

1) Nozzles are checked by means of a nozzle tester. Set nozzle on the tester and slowly pressing its hand lever, see how it will eject fuel. It must make

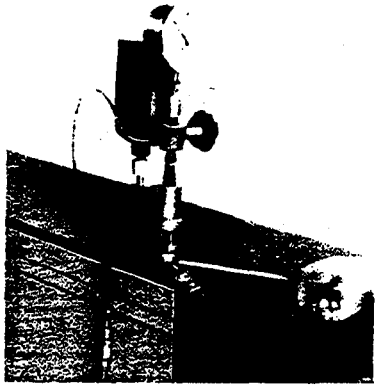


Fig. 3-18 Testing nozzle

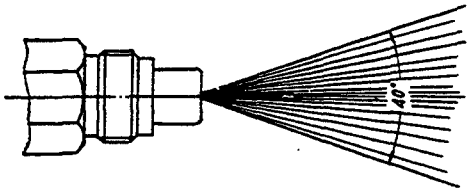


Fig. 3-19 Main injection from nozzle

intermittent injection in fine spray with sharp hisses. Spray must not split at the end, nor go astray, nor dribble.

2) See also at what pressure it will start injection. It must be within a range of 120±5kg/cm^2. Any discrepancy is corrected by changing the total thickness of shims on nozzle spring with nozzle nut off. For the calculation of how much shims must be added or removed, remember that 0.1mm of thickness corresponds to approx. 10kg/cm^2 of injection pressure.

3) Main injection that takes place when hand lever is pressed hard must form a straight cone of about 40° in spray angle that contains no large fuel particles, and must break clean off without leaving any drop of fuel around injection orifice. In handling nozzles, follow the instructions given below.

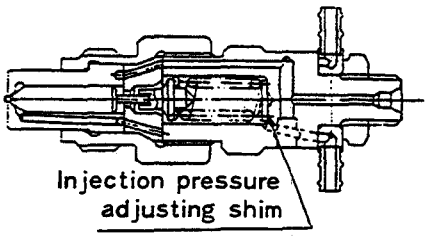


Fig. 3-20 Nozzle spring shim

1) Each time to remove nozzles,clean off dust from around them in advance, lest it should on packings on their tips.
2) In leaving nozzles off, put caps on their inlets to keep off dust.
3) Never change the combination of needle valve and valve seat. This must be remembered particularly in removing nozzle tip from nozzle holder for replacement.
4) If nozzles stained with carbon and sludge, scrape them off with a piece of wood or such-like soft material. Never pick injection orifices with a wire, etc.

5) To service nozzle tips, wash them well in clean cleansing oil, carefully fit valves onto their respective seats in oil and after washing them clean once more, put together in clean gas oil. Never wipe them with waste cloth, etc.

6) Nozzles usually let a little fuel go back. Excessive increase of return fuel is an evidence that they must to replaced with new ones.

7) To install nozzles, clean off carbon from nozzle seat packings, but be careful not to scratch or otherwise damage seats. Any seat notably sunken in the surface must be replaced, for it will spoil air-tightness of cylinder even if clamped down tight. To install, screw nozzles by about 5kgm of clamping torque. To strain them.

4-4 Fuel injection pump

1) For checkup of oil level and change of oil, refer to Sect. 1, "Lubrication". (Mechanical governor is forced lubrication by engine oil, so it need not check up of oil level and change of oil)

2) Being precision-machined and adjusted like nozzles, injection pump will not require any particular adjustment but at the time of over-hauling, it should be thoroughly adjusted by means of a pump tester. If anything unusual noticed with it, have it examined and if necessary, serviced by your dealer or at a service shop. In such a case that, nozzles having nothing wrong at all, combustion does not go well in any of cylinders, check as follows.

a) With the engine running, loosen either cap nut on one injection pipe after another. So you will fined the cylinder from which the symptom comes. Such symptons come from, for example, the following causes.

b) Set screw on pinion is loose. In this case, injection rate is out of perfect control, that is to say, not varying exactly in conformity to control rack travel.

c) Plunger spring is broken.

d) Delivery valve spring is broken. To inspect it, loosen delivery valve spring. Broken spring keeps injection from breaking clean off for poor sucking back of fuel.

Inspect the contact of delivery valve seat, too. If badly worn or otherwise defective, pull it out to replace by means of a special tool intended for that. In putting together again, attach a new gasket to valve so far as possible. In these operations, take every possible measure to keep off dust. Remember that valve holder must be screwed exactly to 3.5kgm of clamping torque with a torque wrench.

3) When injection pump needs to be removed for adjustment or servicing, try to learn how to set it right again, memorizing especially in what relation the match mark on injection pump flange part is to the mark on the flange plate. (Refer to Fig. 3-22) Before it is fixed again, never run the engine lest the injection timing should go wrong. For removing, take the follwoing steps. Loosen clamp bolts that fasten pump flange to engine crankcase with a socket wrench fitted on the end of universal joint. Then, unfasten cover from timing gear case and separate injection pump gear from pump camshaft. To leave the gear in mesh with idler in gear case will make the pump setting much easier don't disjoin autotimer from the gear, for easier operation in installment.
Having removed injection pump, put caps on delivery valve holders to keep off dust.

4-5 Fuel injection timing

In this engine, injection pump starts injection at a fixed time, whatever the injection rate may be. Model 4DQ50 is attached a mechanical autotimer in option, which is coupled with injection pump gear, varies the injection starting time according as the engine speed changes and thus provides always the fittest injection timing. This injection pump is fastened by means of flange so that injection starting time can be varied by changing its setting angle. The pump having been adjusted right to the values and firmly fixed at our factory, the injection starting timing will never to wrong.

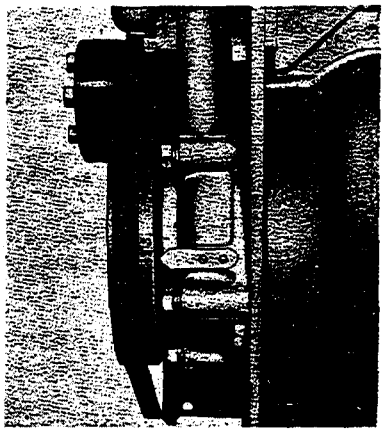


Fig. 3-21 Timing mark on crank shaft pulley

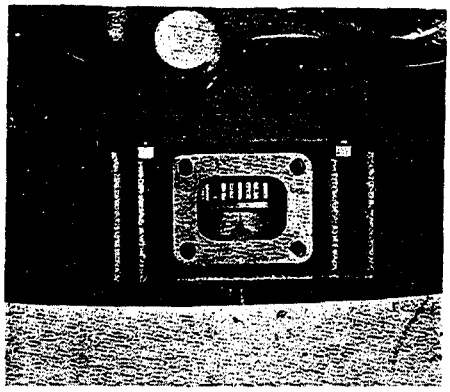


Fig. 3-22 Timing mark on flywheel

In the case that the injection starting angle needs to be newly set for such reasons as replacement of the injection pump with a new unit, do as follows.

Fig. 3-23 Timing mark on injection pump

1) First locate the top dead center of #1 cylinder compression stroke, turning crank shaft. For this, turn crank jaw with a wrench if it permits easy access of hand, or ring gear by a tooth after another with a screw driver, if it does not. Go on turning it until symbol T on crank shaft pulley or symbol 1.4 on flywheel exactly meets the pointer, and #1 cylinder piston will be at top dead center. But assuring this, open rocker case cover and make sure that both #1 cylinder inlet and exhaust valves keep proper clearance.
2) With #1 cylinder piston thus placed at top dead center, read at what crank angle injection will start. For this, take the following steps.
3) Loosen off #1 cylinder injection pipe so that a little fuel remains in the upper part of delivery valve holder. Slowly turn crank shaft in its usual direction (that is, clockwise as viewed from fan), and fuel level will start swelling. Read crank angle at that moment.
4) In case injection timing needs to be set ahead, move injection pump body little by little in the reverse direction that its camshaft revolves (or toward crankcase). Note that graduations on pump flange corresponds each to 6° of crank angle.

4-6 Governor (pneumatic)

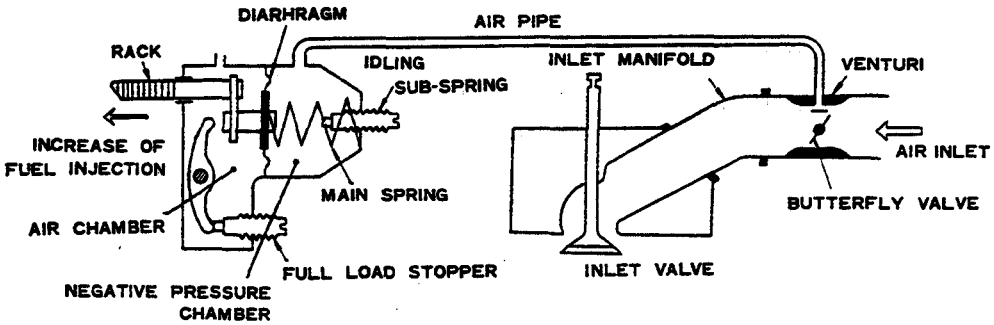


Fig. 3-24 Scheme of pneumatic governor

1) A pneumatic governor, for governing of its speed, consist of diaphragm block in fuel injection pump and of Venturi unit in inlet manifold, which are connected together with an air pipe.

2) Now, following the scheme and diagram of operation principle, we will briefly explain how this governor operates. When intake air passes through Venturi that closes inlet manifold to some extent, its flow velocity rises but at the same time, static pressure at that part (to be taken through pipe that opens to its flow direction at a right angle) falls considerably below the pressure on the area free from the inflow of air (generally, atmospheric pressure) or in short, turns into negative. This negative pressure rises, as can be seen in Fig. 3-25, with the rise of engine speed and consequently of flow velocity of intake air. Through an air pipe, it is conducted into negative pressure chamber in diaphragm block to work on diaphragm. The governing force it produces is calculated:
(Venturi negative pressure)x(Diaphragm area)=(Governing force)

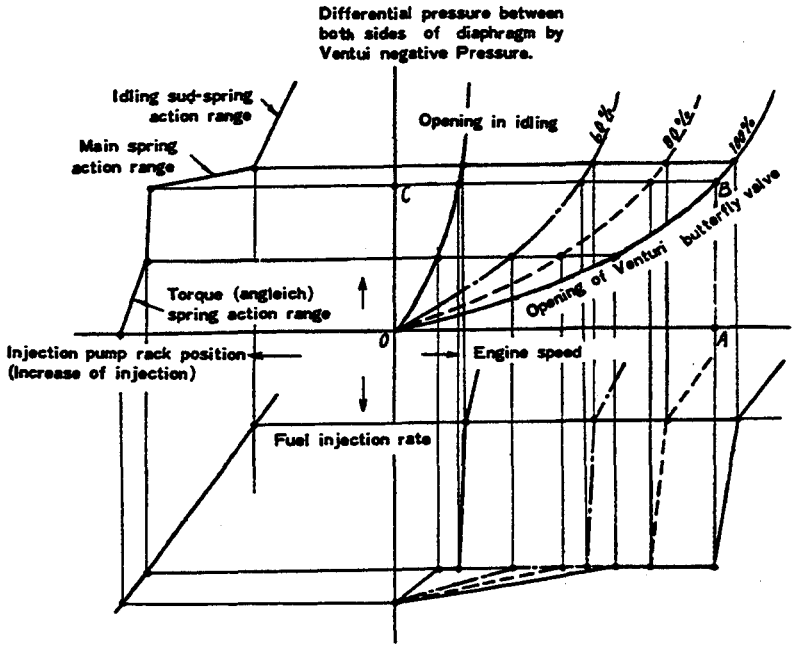


Fig. 3-25 Diagramatized principle of pneumatic governor operation

Now suppose that max. engine speed needs to be governed at A (rlp.m.). While, with Venturi butterfly valve opened 100%, main spring with setting load equivalent to governing force Fc that is produced by negative pressure C at point B on Venturi negative curve (Fig. 3-25) is placed on diaphragm. When the

engine tries to run at a higher speed than A (r.p.m.), a consequential rise of negative pressure provides greater governing force, which compresses main spring against its setting load, thereby pulling back injection pump control rack to reduce injection, and as the result, engine speed is slowed down to A (r.p.m.). When, on the other hand, engine speed is made to fall below A (r.p.m.), a decrease of negative pressure lets main spring press control rack ahead to rise injection rate, whereby it is vised back to A (r.p.m.). Meanwhile, the more Venturi butterfly valve throttles, the quicker rise of negative pressure to engine speed can make engine keep low constant speed, by producing governing force Fc. Governing the engine speed thus in one-to-one proportion to the percentage of Venturi opening, this governor is called an all-speed type. In case heavy load on the engine makes it run at a lower speed than equivent to the Venturi opening (for example, lower than A even at 100% of Venturi opening, in the diagram), control rack is pressed over its whole travel to full load stopper, making it to develop max. torque. If "tough" torque is required of the engine, governor is equipped with a buitin torque spring (angleich spring).

3) This type of governor requires especially perfect air-tightness of air pipe and intake system, for lack of their air-tightness will much affect its performance and cause particularly overrunning.

   Into air chamber for atmospheric pressure in diaphragm block negative pressure is lead from inside paper element of air cleaner through vinyl tube so as to compensate the change of resistance the might arise from its clogging.

4) Being of sheep skin, diaphragm in diaphragm block requires regular lubrication. (Refer to "Lubrication".) When a sudden unusual change noticed in idling, have it checked by your dealer or at a service shop, as it is suspected to be broken from aging.

   Each time to apply oil to diaphragm, loosen red plug on the side of diaphragm block to draw off the excess of diaphragm oil or fuel collected there from pump. If too much fuel found there, make necessary repairs.

5) In any case whatever, don't tamper with the seals on (Fig. 3-26, 3-27)

   Injection pump full load stopper Seal 1

   Diaphragm block cover Seal 2

   'Idling sub-spring Seal 3

   Venturi lever stopper ("full-open" side) Seal 4

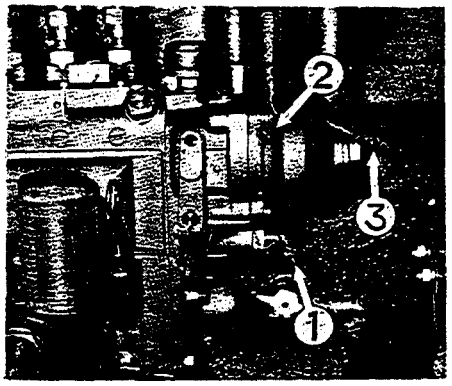


Fig. 3-26 Diaphragm block of governor

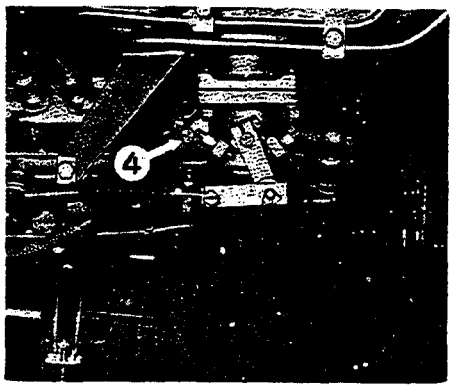


Fig. 3-27 Venturi unit

4-7 Governor (mechanical)

1) Model 4DQ50 Engine is equipped, for governing of its speed, with mechanical governor (centrifugal type) which connected directly with fuel injection pump camshaft.

   This governor is RUV and all-speed type, so it controls not only max-min engine speed but also can control every engine speed by control lever position.

2) As mechanism illustrated Fig. 3-28, two flyweight combined with governor shaft and rotates through the gear which equipped with camshaft, and centrifugal force of weight conducts to the governor sleeve.

   In the governor sleeve, angleich spring is equipped. Centrifugal force of flyweight and control spring force act to this spring, so it works as angleich.

   Control spring is installed to the adjusting lever's shaft and one end of spring put to the spring seat. Control spring force changes by this lever's motion.

   The lower parts of floating lever is combined to supporting lever and this position is determined by full-load stopper.

   Sliding peace, which is equipped in the middle of the floating lever, inserts governor sleeve groove and works with movement of sleeve, and move the control rack which connected with upper parts of the floating lever.

   The arm, which connects floating lever and control rack, is equipped with start spring and one end of spring is connected with governor housing.

   This spring always pull the control rack to the fuel feed "increase" and increase of fuel feed at starting. In the case of torque spring equipped, torque control lever is installed, and upper parts of lever touch to the torque spring adapter,

and lower parts touch to the spring seat and act to reduce the control spring force by torque spring force.

Stop lever, which is installed to the upper parts of governor housing, pull back the control rack to the position "stop".

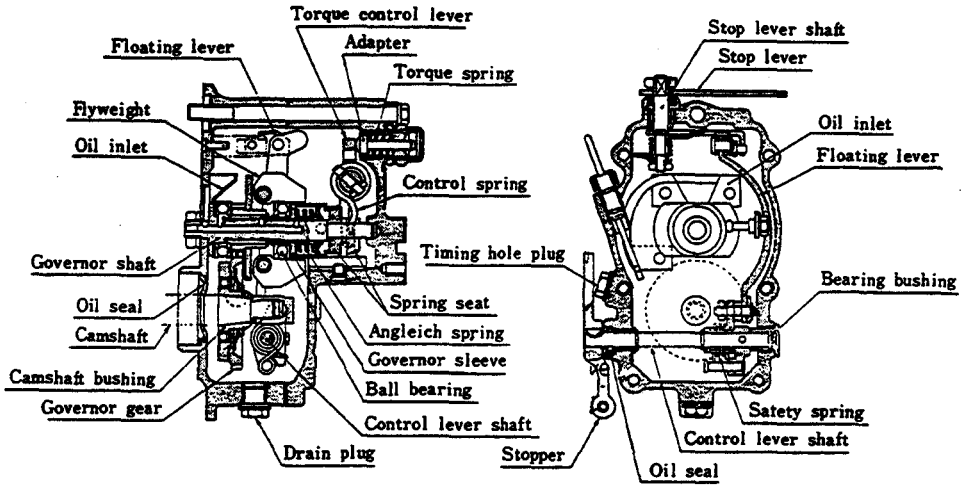


Fig. 3-28 Mechanism of RUV governor

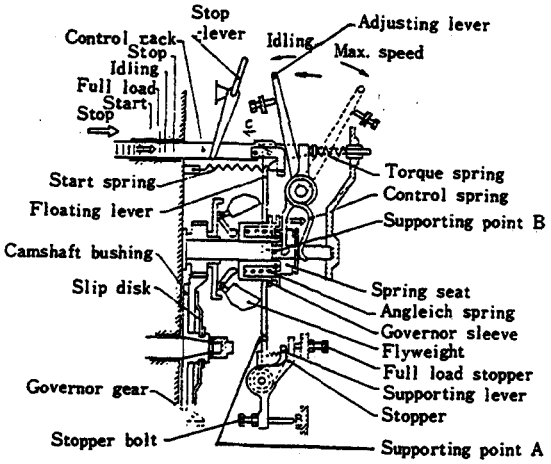


Fig. 3-29 RUV governor, movement of idling

3) Fig. 3-29 shows the situation of idling. Flyweight, though it is lower speed, expand to the outside by centrifugal force, overcome weak spring force and push the governor sleeve to the right hand with spring lever.

Therefore floating lever's supporting point (B), which touch to governor sleeve,

move to the right hand as lower part (A) is supporting point and pullback the control rack to the idling position.

Centrifugal force of flyweight, weak force of control spring and spring force of start spring act each other and keep the smooth idling by this force balance.

As engine speed rise, centrifugal force of flyweight becomes large and push the control spring and floating lever moves to the right hand, and transfer the control rack to the fuel feed "decrease".

As engine speed becomes to fall, it acts the opposite action of above and keep the constant idling by this action and reaction. Fig. 3-30 shows the situation of max. engine speed control.

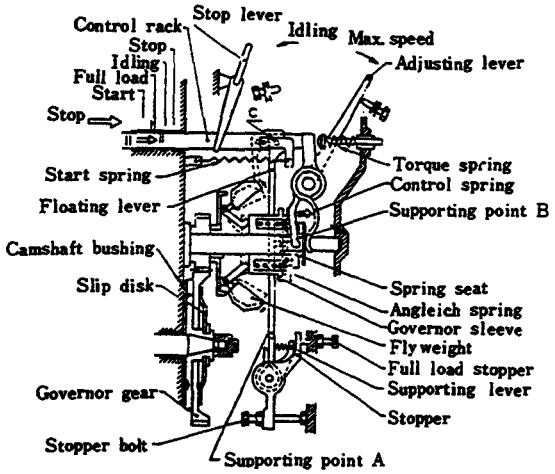


Fig. 3-30 RUV governor, movement of max. engine speed control

When the engine speed rise from regulation speed by the rapid down of load while the engine running, centrifugal force of flyweight overcome the spring force of control spring, and flyweights expand to the outside and move the governor sleeve to the right hand. (as illustrated arrow mark) At this time supporting point (B) of floating lever, which contact to the governor sleeve, move to the right hand as (A) is supporting point.

Therefore it moves control rack to the fuel feed "decrease" and acts not to over the regulation max. speed.

4) In any case whatever, don't tamper with the seals on (Fig. 3-31).

Injection pump full load stopper

Seal 1

Torque spring Seal 2

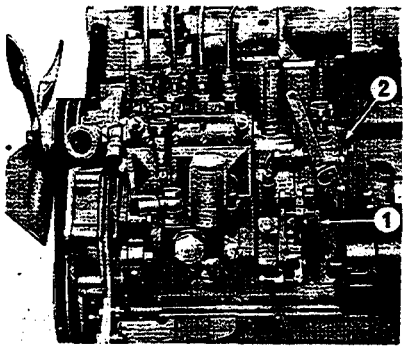


Fig. 3-31 RUV Governor

***GOVERNOR (Model RSV, bosch type)**

(1) STRUCTURE AND OPERATION

Fig. 1 is the open-up view of the sectioned governor and its parts and Fig. 2 shows the disposition of such patts.

In the RSV type Mechanical All-speed Governor, the flyweight-holder and flyweight of the revolving part of the governor are attached to the comshaft of the injection pump.

The two flyweights revolve around the flyweight pin which is inserted in the flyweight holder, and when the flyweights opens themselves outside, the shoulder of the guide-bush is pushed by the roller toward the oxis.

The guide-bush sliding on the cylinderical surface of flyweight-holder may move freely with the flyweight-holder, and the guide-bush is contacted to the shifter by means of bearing. The shifter may be moved only longitudinally toward the axis. The trunnion of the shifter is inserted in the guide-lever which hung by the pin of the governor-cover like a bob and prevents the rotation of the shifter. A pin is attached to the position slightly above the coupling point of guide-lever and shifter with wax.

The floating-lever is attached to either left point or right point of the pin so that the floating-lever may revolve (the left or right point of the pin may be fixed the side of the governor to which the governor pump is attached). The pin attached to the lower end of the floating-lever with wax is inserted in the fork.

The floating-lever contacts with the control-rack of the injection pump on the upper end of the revolving axis through the link which involves the leaf-spring, the link-pin and the split-pin. The start-spring is attached to the other end of the floating lever. This spring is operated at the r.p.m. lower than that of the idling. One of the ends of this spring is

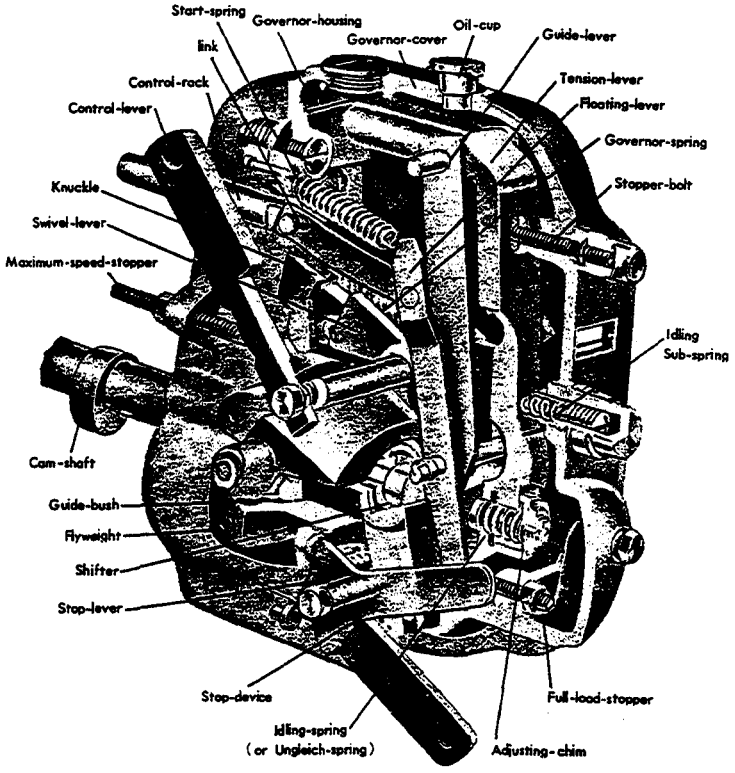


Fig. 1

connected with the eye of the pin which is inserted in the governor-housing. The pin to which the guide-lever is attached like a bob holds also the tension-lever likewise. When the strong governor-spring contacted with the eye of the short rim of tension-lever is strained, the tension-lever is pushed to the shifter and the governor-spring is streched until the centrifugal force yielded by the rotation of engine balances with the spring force. In case when the spring force is stronger than the centrifugal force of the flyweight, the tension-lever will move until its lower end contacts with the adjustable full-load stopper.

The revolving axis of the swivel-lever is inserted in the governor-bush, and the center of the lever is slightly eccentric against the spring-eye of the tension-lever.

The other end of the governor-spring is connected with the knuckle which is attached to the upper end of the boat-shaped swivel-lever. There are two bosses on the side of the boat-shape which will touch with the side of guide-lever when the engine is stopped so as to complete their work. The control-lever of the governor is attached to either side (left or right) of the shaft of the swivel-lever according to the order.

Along with the rotation of the control-lever, the swivel lever will begin to revolve, and

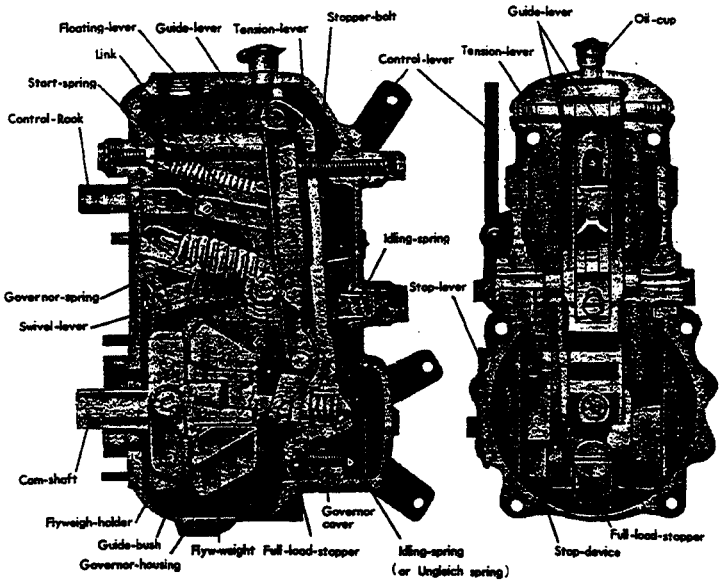


Fig. 2

the length of the arm of moment against the revolving axis will change together with the tension of the governor spring. This is because, as aforesaid, that the revolving center of the swivel-lever and the spring-eye of the tension lever are eccentric each other. The set-load of the governor spring may adjust the adjsuting-screw of the knackel.

The stopper-bolt attached to the back of governor-cover may be adjusted so that it will contact with the knuckle when the control-lever barely reaches its "STOP" position. In the governor equipped with a stop-device, this stopper-bolt may be used as a idling-stopper. The ungleich equipment may be screwed in the tension-lever if necessary.

This is a bush with a pin having the spring load and may be controlled from outside by taking off the closing-cover of the governor-cover, as it is designed.

The ungleich device will amend the full-load jet volume of the injection pump within a specified scope according to the set-load of the spring which is adjusted by the constant of equipped spring, stroke and shim so as to be fit successively for the necessary volume of fuel for engine between the r.p.m. of idling and that of full-load.

The adjustable screw bush is inserted in about the middle of the governor-cover, and the idling-sub-spring which is involved in the bush may be adjusted so that it will affect the control of non-load high-speed rotation as little as possible. However, in case when the ungleich is unnecessary at the full load jetting volume but the firm control is needed at a large stroke of control-rock at a lower r.p.m. of idling, a comparatively weak spring shall be involved in the bush of the ungleich-device. This spring, in case when the engine is an idling

condition, will push back the shifter from the tension-lever which is contacted with the idling-sub-spring. Accordingly, the stroke of the control-rack will become larger automatically.

Whether the pin attached to the lower end of the floating-lever with wax will be inserted in the slot of the supporting-lever on the shaft of the stop-lever or it will be supported so that it will act at the fork part which is pushed into the governor cover, will be fixed as to whether or not the governor has the stop-device. A governor of standard size has no stop-device. But the device will be necessitated when you want to pull back the control-rack of the injection pump with a slight power without regarding the position of control-lever of governor or to use the stopper-bolt as the stopper of the limit of the idling r.p.m.

(2) PRINCIPLE OF OPERATION

The principle of the governor operation is as follows:

When the r.p.m. of engine increases and its centrifugal foece becomes larger than the spring force, the flyweight will spread outside. When the r.p.m. decreases the centrifugal foece will decrease and consequently the controlling power of the governor spring will become stronger so that if folds itself inside again.

The action of the flyweight is transmitted to the control-rack through the guide-bush, shifter and link. And the control-rack, when the r.p.m. of engine increases, will be moved in the stop direction. Then the r.p.m. is limited because the injection pumpsupplies smaller amount of fuel. When the r.p.m. of engine decreases the process will be reversed. This RSV, as an all-spread governor, controls the rotations of all kinds covering from the idling r.p.m. to the maximum r.p.m. outomatically.

If the driver or the operator of the machine will adjust once the control-lever at the necessary engine r.p.m. by operating pedals or handles, then the governor will adjust the r.p.m. automatically.

Now let us explain the special operating conditions by taking up several cases for example. Fig. 3 is the performance curve of these operations.

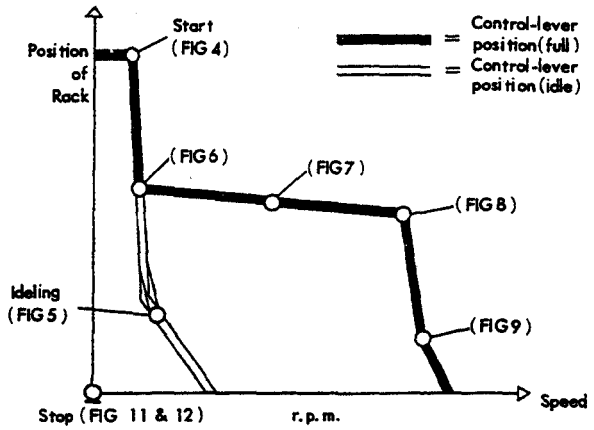


Fig. 3

1. Starting of Engine

When the control-lever of the governor is removed to the starting position (maximum-speed-stopper) by means of the hand-lever or pedals through the link, the bosses of the swivel-lever which move together with the control-lever, will be separated from the guide-lever, and the governor-spring, which is connected with the tension-lever, is stretched. This governor-spring pulls the tension-lever to the place of full-load stopper. Then the shifter and the guide-bush act on the left side and the weak start-spring will move the floating lever so as to transfer the control-rack of the injection pump to the starting point beyond the position of the full-load. Thus the start of engine will be easily yielded.

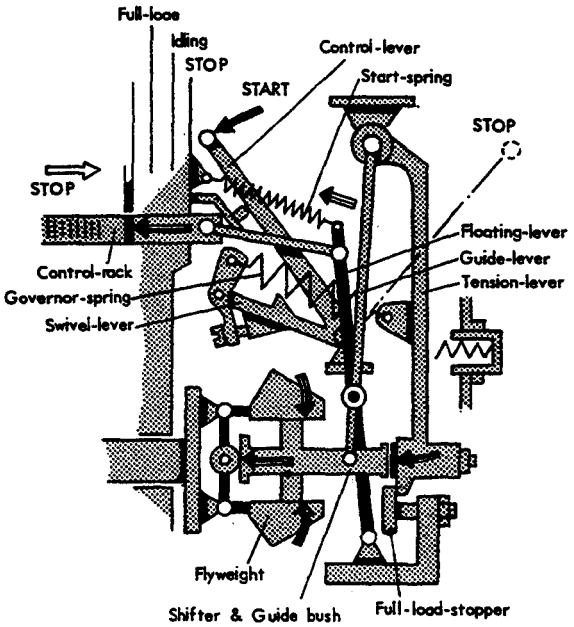


Fig. 4 Start

2. Controlling process at the lowest governing scope of engine.

(Fig. 5)

Once the engine has started, the engine is kept at idling condition by maintaining the control-lever at idling position (2). In this case the idling position of the control-lever (2) is slightly before the original position (0).

Under this condition, the governor begins its self-governing automatically. When the control-lever drawn back from the starting position, the governor-spring is eased so that it reaches barely the vertical position coming about under the revolving center of the tension-lever. Accordingly the force of the governor-spring which acts on the shifter, guide-bush and flyweight through the tension lever becomes very weak, and the flyweight may spread outside even at a low-speed r.p.m.

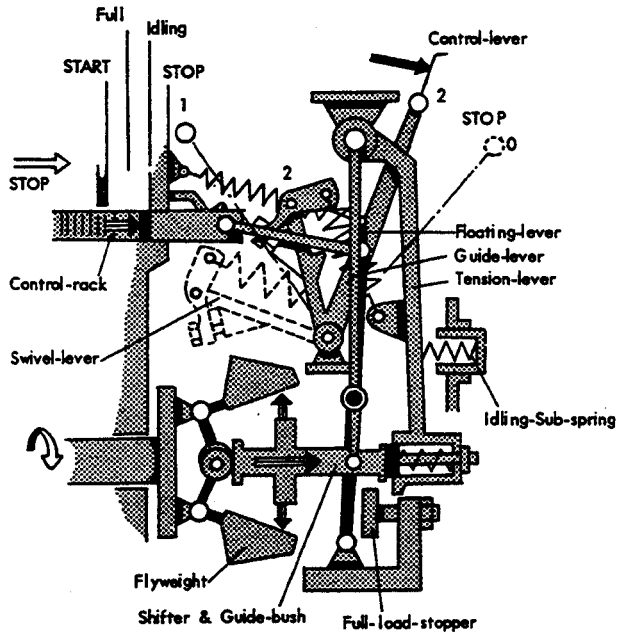


Fig. 5 Idling

The flyweight transfers the guide-bush and the shifter following the direction of the arrow as shown in Fig. 5. The guide-lever connected with the shifter will move with the shifter, and revolve the floating-lever, and the lever will pull the control-rack connected with it to the idling position.

In this case the tension-lever comes in touch with the idling-sub-spring and performes idling smoothly helped by the spring.

When the r.p.m. is lowered, the centrifugal force will be decreased, the spring will be

eased so as to move the shifter and the guide-bush, and the control-rack will be also moved toward the full-load.

In case when the r.p.m. is extremely lowered, the weak start-spring will also begin to act to pull the control-rack swiftly toward the full-load and the specified r.p.m. may be maintained.

3. Controlling process at the highest rotation

(Fig. 6)

In case when the engine at a certain r.p.m. fixed by the control lever is affected by load or remains non-load, the governor, excepting the case of over-load, will maintain the adjustment of rotation within the limit which is fixed by the changing rate. Let it be supposed that a driver moves the control-lever from the idling position to a position where the proper speed will be obtained through the link by working the pedals (Fig. 6); in this case. The tension of the governor spring and the moment arm concerning the revolving center of the tension-lever are increased, the governor-spring pulls back the tension-lever until it comes in touch with the full-load stopper and the tension-lever pushes the shifter and guide-bush to the side of the injection pump by pushing them.

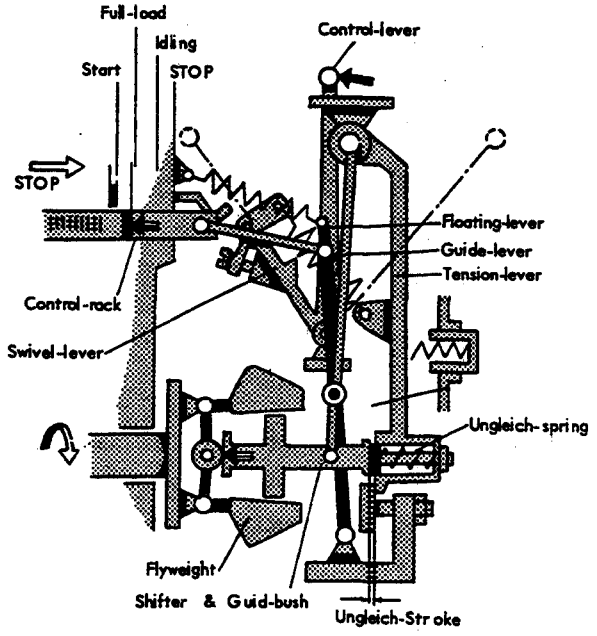


Fig. 6 The starting of the Ungleich at the low r.p.m. full-load

The guide-lever, the floating-lever and the link will push the control-rack to the full-load position by transferring the action to the lever.

To transfer the control-rack to the full-load position, it is enough to move the control-lever slightly from the idling position. Then the ungleich-spring in the tension lever (if the spring is involved in it) becomes effective. The injection pump supplies much fuel to the cylinder of engine and the r.p.m. rises. As soon as the centrifugal force exceeds the tension of the governor-spring, the flyweight will spread itself outside and pulls back the guide-bush, shifter, floating-lever and the control-rack in the direction of "fuel decrease". The r.p.m. of the engine will not rise from this point and it is maintained by the governor under a fixed condition.

When the control-lever is transferred to the position of the highest r.p.m. (Fig. 7), the governor works as shown in the Fig. 6 as aforesaid.

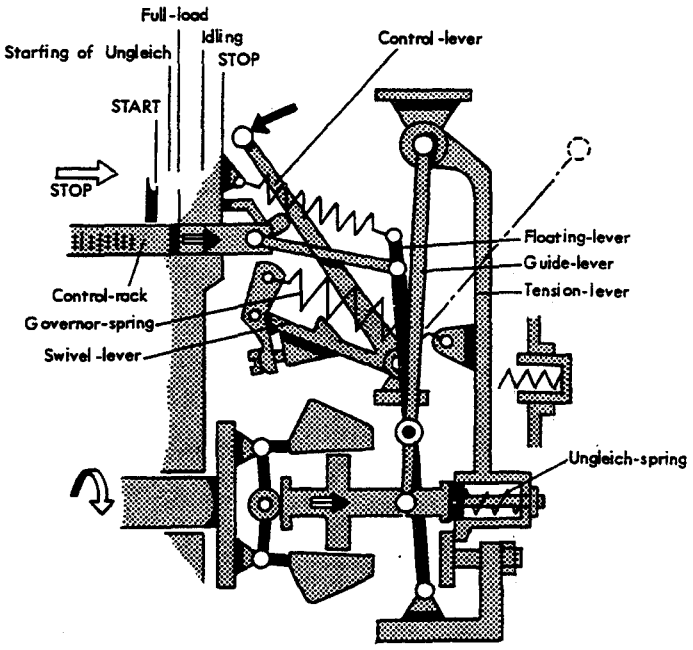


Fig. 7 The highest revolving position of the control-lever

In this case, the swivel-lever of course stretches the governor-spring fully. Accordingly the governor-spring stretches the tension-lever with its large-power to the full-load stopper and transfers the control-rack to the full-load position. The r.p.m. of the engine rises and the control r.p.m. and the centrifugal force also increase.

In this governor in which the ungleich-device is involved, when the tension-lever comes

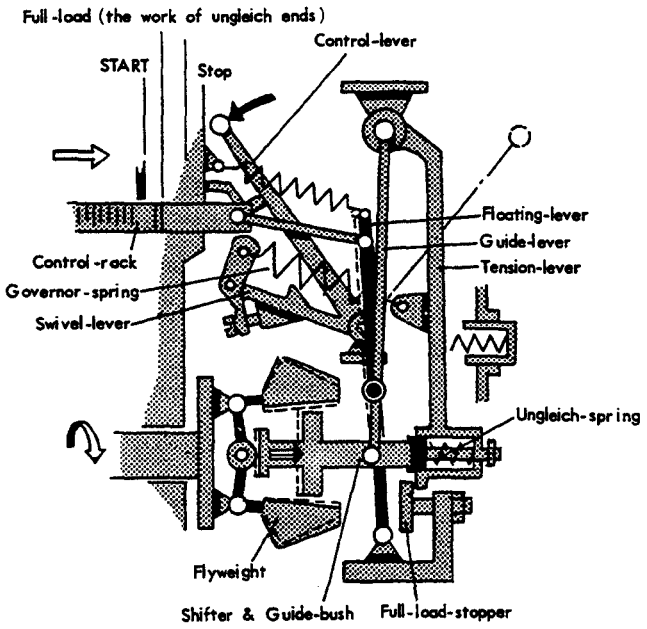


Fig. 8 Starting of the highest r.p.m. control

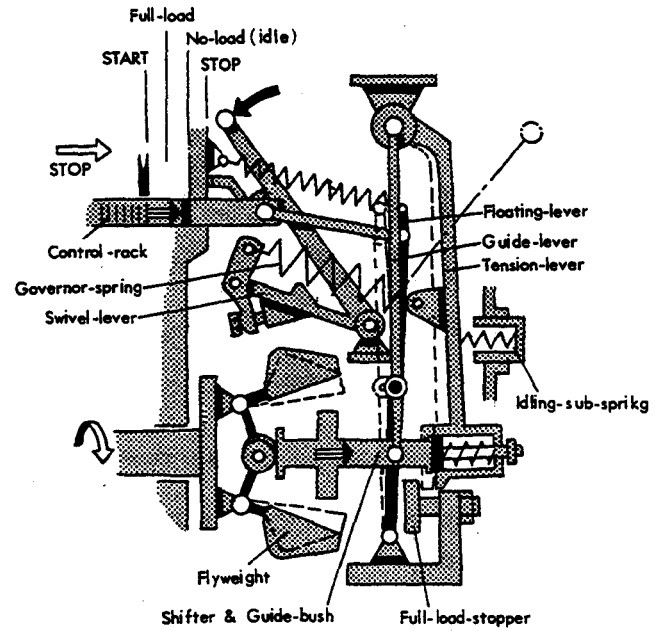


Fig. 9 The case as controlled at the non-load condition

in touch with the full-load stopper, shifter will directly came in touch the tension-lever along with the rise of r.p.m. Accordingly, the ungleich-spring will be pressed under a fixed condition (Fig. 8, Fig. 9).

With the result of such movement as above, the guide-lever and the control-rack move in the "STOP" direction up to the corresponding volume of ungleich and "ungleich" the jet volume. When the machine reaches the full-load and the centrifugal force wins over the tension of the governor-spring, the tension-lever is pushed back. The shifter, the guide-lever and the control-rack move in the direction of "STOP" and obtain a new balance at the place where small jet volume suitable to the load condition of engine may be obtained.

4. Work of Ungleich

The fuel supplying curve is shown in Fig. 10. In this figure the fuel, which will burn smokelessly (smoke-limit) at the regular r.p.m. and at a fixed load is ploted by inspecting the jet condition against engine cylinder per each stroke adopting the r.p.m. as parameter. The

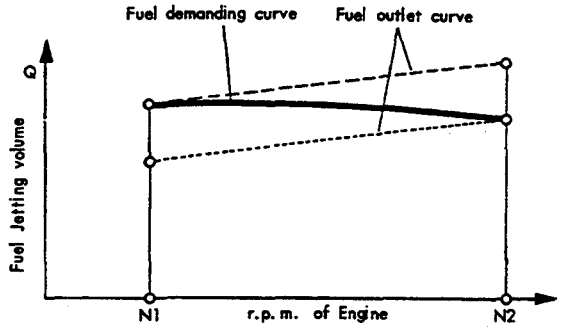


Fig. 10

fuel jetting volume curve in the same figure is shown at the full-load position of the control-rack by adopting the fuel jet volume which is supplied by the injection pump per each stroke as function. This fuel demanding curve shall be made similar to the fuel outlet curve within the limit of possibility. In other words, the fuel necessary for engine shall be injected smokelessly so as to operate engine without hindrance.

Fig. 10 shows the following facts: The demand for engine fuel decreases as the r.p.m. rises (worse condition of air inhalation), on the other hand, the injection pump, when the control rack placed on a fixed condition, injects more fuel as the r.p.m. rises. No engine can burn (consume) this increased fuel without giving out smoke. If the maximum jet volume of the injection pump is adjusted to themaximum r.p.m. of the engine so as to meet the requirement at full-load condition the r.p.m. of the engine is lowered and sufficient output cannot be obtained. In an ordinary case, therefore, the maximum jetting volume of the

injection pump is adjusted as the dotted line shown in the above figure so as to obtain large torque as much as possible at N1 within the low r.p.m. limit.

As aforesaid, without the control given by the ungleich device, if the engine is driven at high-speed r.p.m. N2 full-load, surplus fuel will be outlet with smoke.

The ungleich-spring and the stroke thereof shall be adjusted so that the jet volume will meet the fuel consumption at the full-load condition, in other words, the fuel demanding curve and the outlet curve shall be adjusted so that they may be in conformity with each other at the time of full-load.

5. Stoppage of engine

An engine having a governor without a stop-device will be stopped by transferring control-lever of the governor to "STOP" regardless of the position of the flyweight. Slightly before the control lever reaches "STOP" or before the knuckle come in touch with the topper-bolt the boss of the swivel-lever will push the guide-lever and transfer the control-rack of the injection pump to "STOP" through the guide-lever, the floating-lever and the link (Fig. 11).

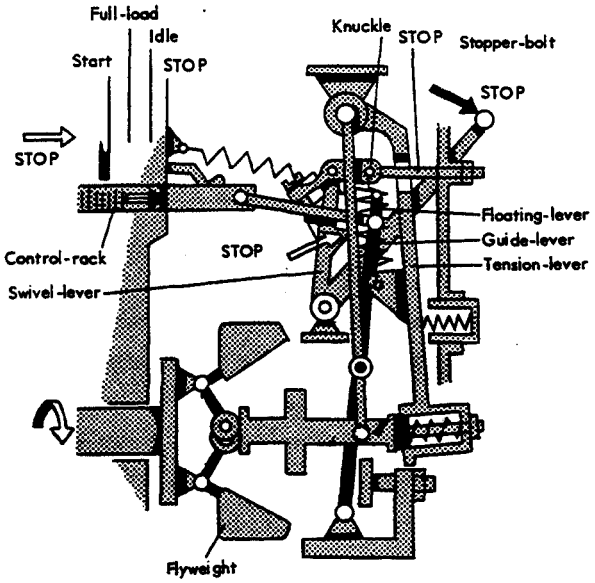


Fig. 11

In a governor with a stop-device, control-lever may be transferred to "STOP" by moving the stop-lever to "STOP" regardless of the positions of the flyweight and other lever mechanisms (Fig. 12).

By means of the two stoppage system the engine will be stopped without jet fuel.

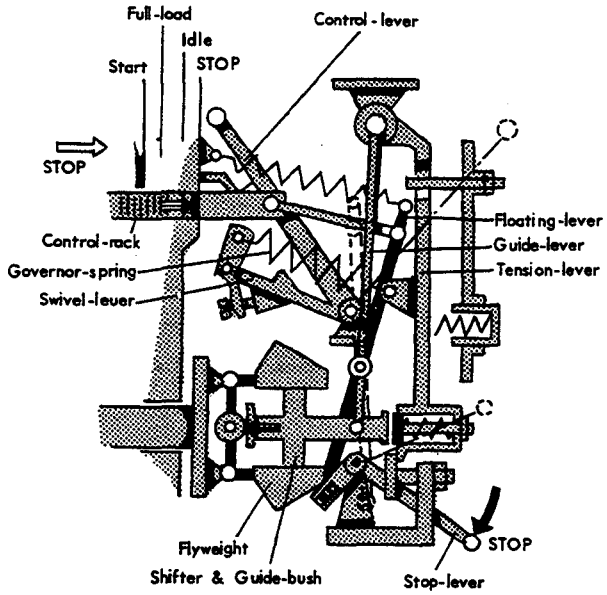


Fig. 12

4-8 Automatic timer

To the front end of injection pump is attached an automatic timer or a device that changes the phase of the pump camshaft with its driving shaft according to fluctuation of the engine speed so as to provide the fittest injection timing. The design is such that automatically puts ahead the injection timing with a rise of the engine speed and regards the injection with its drop.

Fig. 3-32 shows the timer in disassembled condition. Each of two flyweights has a hole by which it is supported on flyweight holder. On it is made a curved surface designed to help it develop the required efficiency. Bearing pins fixed on the holder have one of the seats for timer springs.

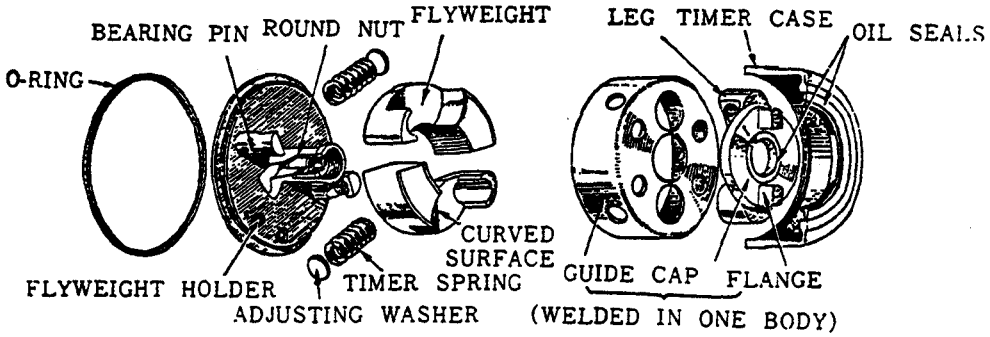
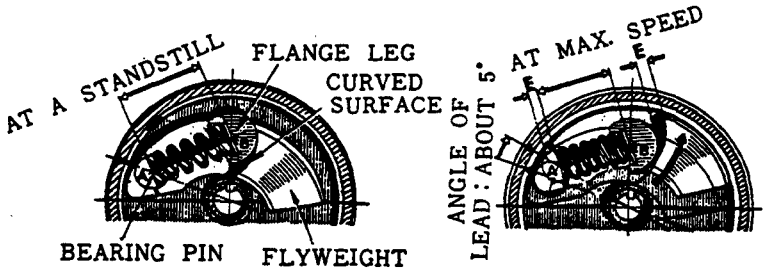


Fig. 3-32 Automatic timer

In appearance the flange looks identical to that of our conventional type hand timer, but has inside two legs that project in the same phase with flange teeth and keep contact with the curves surfaces of the flyweights. In these legs are machined the other seats for timer springs. Each timer spring is held in the said pair of seats, that is, in the bearing pin by one end and in the leg by the other. These major components are housed in timer case, which is screwed to the flyweight holder.

Fig. 3-33 A shows the time at a standstill. Being free from centrifugal force, the flyweights do not lift at all and timer springs are now longest in their setting length.

Fig. 3-33 B illustrates how the timer works at the max. engine speed. Centrifugal force is now making the flyweights lift. In the picture the letter B indicates flange leg, whose phase with the pump driving shaft of the engine is designed to remain constant. So the lift pulls bearing pin A over the distance E, which results in turning the pump camshaft on the driving shaft so as to put ahead the injection timing.



(A) ATA STANDSTILL (B) AT MAX. SPEED

Fig. 3-33 Timer flyweight

The timer for Model 4DQ50 Engine is intended for clockwise revolution and provides a max. angle of lead of 6° as measured on the pump camshaft. At a standstill, it keeps the injection slowest.

The automatic timer was assembled with 150gr. of grease inside and unless leaked by chance, needs not be refilled. When the timer disassembled, change grease for new one.

4-9 Measurement of engine speed

1) A drop of engine speed below the specified level will disturb the engine working up to the given efficiency, while a rise above it will cause the overrunning of the engine itself or of the vehicle it drives. Therefore, both max. and rated speeds must be always as specified.
2) As mentioned before, pneumatic governor governs engine speed in one-to-one proportion to the percentage of Venturi opening, hence permits the engine to

run at max. speed when Venturi opening is 100%. It should be noted that the governing efficiency depends much upon how the air system is, especially whether or not it is perfectly air-tight.

3) Engine speed should be measured under no load in Model 4DQ50 engines intended for motor vehicles and construction machines, non-load max. speed is 5~10% over the rated speed.

4) How to measure engine speed.

In case of hourmeter equipment with engine, pick up the hourmeter and equip a special parts (Fig. 3-34) and measured by tachometer. In this case, tachometer indicates 1/2 engine r.p.m.

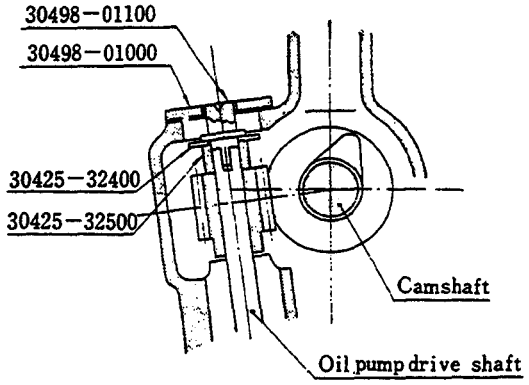


Fig. 3-34

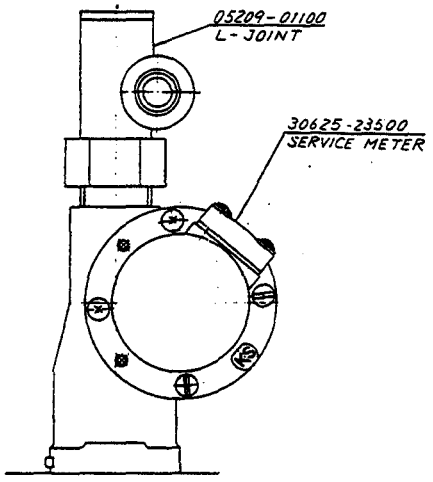


Fig. 3-34'

5 COOLING SYSTEM

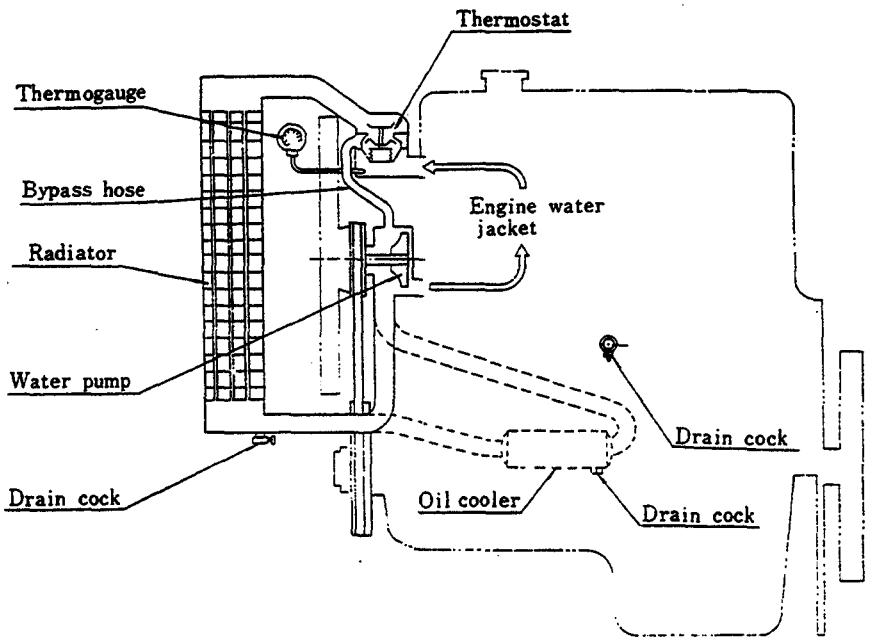


Fig. 3-35 Cooling system diagram

As illustrated in the diagram (Fig. 3-35), cooling water is kept in forced circulation by centrifugal water pump. The system has a thermostat, whose valve remains close at low water temperature, letting cooling water circulate between water pump and engine body via bypass hose, and opens, as water gets hot from absorbing heat from crankcase, cylinder head, etc., to let it run into radiator to be cooled there by air blasts from fan, and at the same time, close bypass hose.

Thermostat case on cylinder head has two bosses: one covering hole to fit in thermostat and the other, water outlet for car heater.

5-1 Cooling water and radiator

1) For checkup of water level, refer to "Checkup and preparations prior to starting".
2) In order to remove scale and dust in radiator and engine water jacket to improve cooling efficiency, open drain cocks to drain, fill radiator with fresh oil through its inlet, and run the engine for some 20 minutes for flushing, at intervals of 500Hr or 12,000km of run, or twice a year (in spring and fall).
   If they have gathered much scale and dust, run the engine for about 30 minutes with caustic soda solution or cleansing liquid in the system and drain it off

then fill the system with fresh water and run the engine again for flushing. Before and after the use of an antifreeze, be sure to flush radiator.

3) For engine that has rather intricate water piping for the equipment with oil cooler or for other reason, open bleeding cocks on cooling system, each time cooling water changed, to make sure that the piping is full in every part. If an overheat noticed even when thermostat is functioning well, bleed (or eliminate air out of) the system.

4) If dust collected on fins, clean them by blowing compressed air or water on them from fan to recover cooling efficiency. Don't try to remove foreign matters with a wire or the like. Such a way of cleaning often makes scratches or cuts in water pipes, hence leading to leakage.

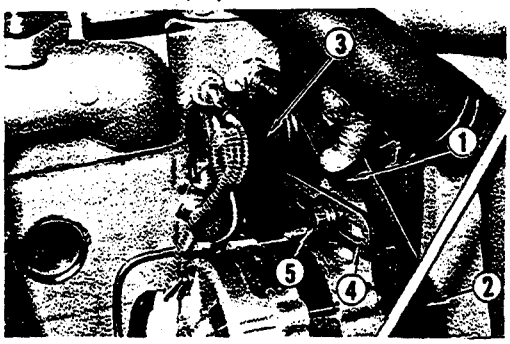
5-2 Thermostat

Poor operation of thermostat will much affect the service life of the engine in the long run. In case the engine overheats even when cooling system is full and fan working well the probable cause is that thermostat has got stuck up and remains close. If, on the contrary, long oreration should not raise water temperature up to the optimum level (75°~85°C), thermostat is suspected to remain open from puncture. In either case, check it and take necessary measures.

Thermostat is designed to start opening at 76°C and fully open at 90°C under atmospheric pressure. Continuous operation on cold water will quicken wear of cylinder liners and rings.

5-3 Tension of fan belt

1) Every 60Hr of run, check the tension of fan belt, Optimum tension is such that a press with a thumb at mid-point between generator pulley and water pump pulley makes it slack about 12mm. Execessive tension quickens wear of belt itself and of water pump and generator bearings, while lack of tension makes it slip and a consequential drop of cooling efficiency will cause an overheat. Continuous slipping does it damage, too.



1. Fan belt 2. Generator pulley 3. Water pump 4. Adjusting plate 5. Lock bolt

Fig. 3-36 Checking the tension of fan belt

2) Inspect fan belt at times to see it is not damaged. Keep it always free from oil,

grease and dirt.

6 ELECTRIC SYSTEM

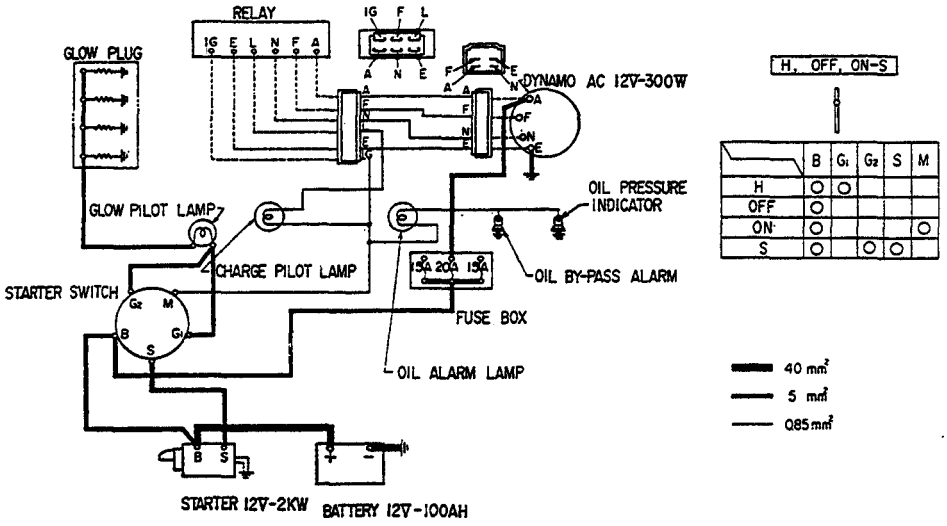


Fig. 3-37 Diagram of electric wiring (in case of AC dynamo)

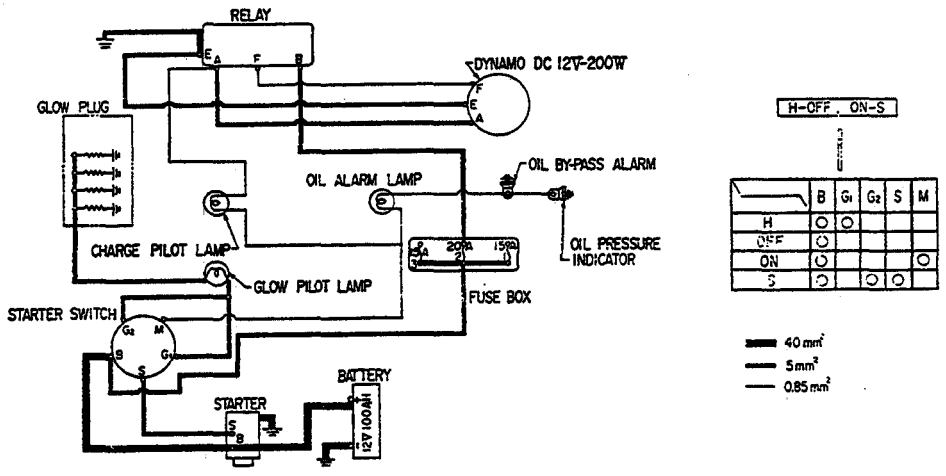


Fig. 3-38 Diagram of electric wiring (in case of DC dynamo)

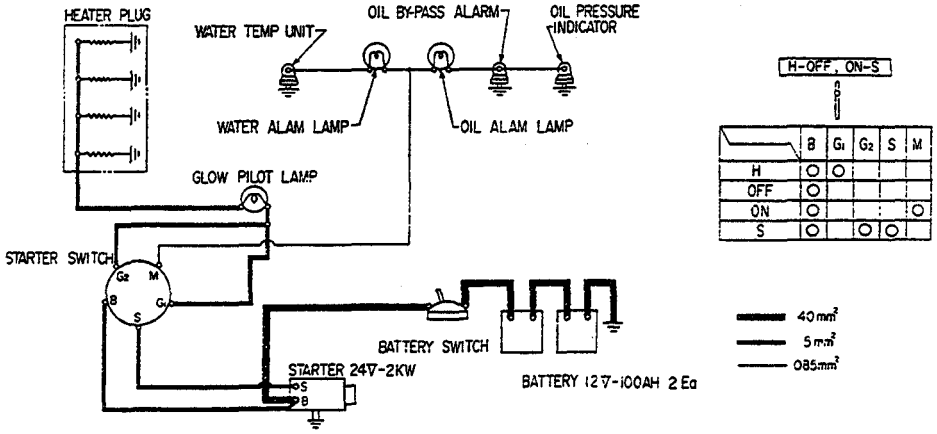


Fig. 3-39 Diagram of electric wiring (24 system)

The wiring diagrams given herein cover only the engine. System is of the so-called negativeearth type and standard specification is 12 volts and wiring diagram shows Fig. 3-37 (in case of A.C. Dynamo) and Fig. 3-38 (in case of D.C. Dynamo). 24 volts (Fig. 3-39) is special specification. In this case, 4DQ50 Engine is equipped with tension pulley in stead of Dynamo. To follow the service hints given herein in addition to those in "lubrication Table" will maintain the electric system trouble-free.

Prior to making any service, be sure to turn off battery switch.

6-1 D.C. Generator

This generator is a D.C shung-wound type, whose main components are field coil, armature and brushes.

1) Check for wrong wiring and loose terminals.
2) Inspect brushes at times: remove carbon particles from around them and make sure that they move smoothly in their holders. If badly affected in contact surface or worn more than 11mm in height, replace with new brushes. Standard intervals to replace them are 500Hr of run. In setting new brushes, polish them with #250 sand paper so

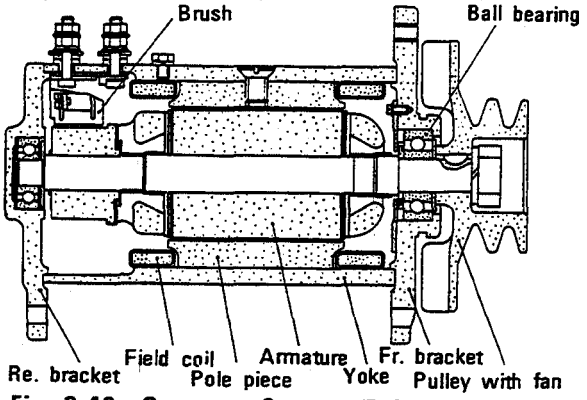


Fig. 3-40 Generator Section (D.C. generator)

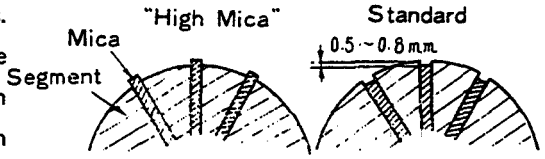


Fig. 3-41 Wear of commutator

that they make uniform contact with commutator over the whole surface.

3) Inspect commutator every 500Hr of run. If affected, polish clean with #400 sand paper and wipe with clean cloth wetted with gasoline. Mica pieces must be 0.6~0.8mm below commutator surface. If out, undercut them accordingly.

6-2 A.C. Generator

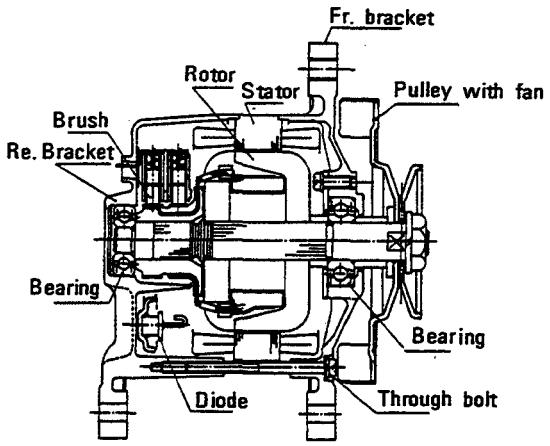


Fig. 3-42 Generator Section (A.C. generator)

This A.C. generator is, differently from a conventional D.C. unit, built so that the armature is installed outside and the field is turned inside as a rotor. It features, among others, an extremely long service life of the brushes and ability to operate at a very high r.p.m., because the arrangement dispenses with commutators and subjects the brushes only to a small current, while its field has very simple make-up as compared with the armature of a D.C. generator and it is free from the need of commutation.

The construction of the A.C. generator is illustrated in Fig.3-42 Revolution of the field generates a three-phse alternating current in the armature, which is rectified by silicon diodes installed in the rear bracket and supplied at D terminal. The field circuit is electrified at F terminal from the battery through field relay and relay, the current running, on one part, from brush to the field coil through slip ring and on the other, to E terminal through the other brush and slip ring. Having silicon diodes, the generator cannot make self-starting as a D.C. unit does by residual magnetism of the field coil, so is excited to start from the battery.

The alternator is designed to limit its own output by itself so that the amature is free from any overcurrent that may burn it up. It is free from an overcurrent, too, because the silicon diodes check any current from the battery when the output voltage of the generator falls below the battery voltage.

To operate the field relay, the alternator has N terminal connected with the neutral point of the armature. A half of D terminal voltage is on this terminal.

Relay

6-2-1. D.C. Generator Relay

This unit performs the functions to regulate voltage generated by generator (constant-voltage regulation) and to prevent reverse current to generator.

1) Make sure that relay terminals A and F are connected with right ones on generator. Wrong connection will cause relay to burn up.
2) Connect earth terminal firmly with frame or with terminal E on generator. Its loose connection will much affect relay performance, causing too much current to run.
3) Relay bears a seal placed on after necessary adjustments. Its checkup and adjustments require precise instruments. If gone wrong, have it serviced at a specialized service shop, without breaking the seal.

6-2-2. A.C. Generator Relay

Relay

The relay is a point-action type that regulates the field current by closing and opening the contact points so as to control the generator output.

6-3 Starter

The starter is a D.C. compound motor of so-called pinion-shift type where pinion is shifted by magnet switch.

It is provided with an overrunning switch so as to prevent it from driving the starter any longer than necessary. But remember that, its function consisting only in starting, it should be switched off as soon as the engine catches.

1) Keep flange fastened tight. Poor grounding will keep starter from running.
2) If starting should be difficult, don't run starter repeatedly but take appropriate measures and after pre-heating well, try again.
3) If a press on button "S" on starting switch has failed to bring pinion in mesh to set the engine running, switch off starter immediately. If it should be kept on with pinion out of mesh or in imperfect mesh, magnet switch might get burnt.
4) With long use, commutator will get blackened or spotted with burns and thus spark harder. So, every 500Hr of run take off brush cover and check its

surface. If roughened, polish it with sand paper #400 or so and wipe clean with dry cloth.

Mica pieces in commutator segments should be undercut 0.5~0.8mm below the sliding surfaces of brushes.

5) A heavy current runs through starter circuit. Check it and if any loose connections detected, fasten tight again.

6-4 Battery

Battery requires good maintenance, as it is the Power Source for engine starting and lamps.

Every 60Hr of run, check and service it as follows. Even when the engine is out of operation, it should be checked once in two weeks or in summer, once a week, because it its self-discharge.

1) Screw off plug and check electrolyte level. Standard level is about 10mm above pole plate.

If specific gravity has increased from evaporation of electrolyte, and distilled water.

If electrolyte spilled out of cells (which does not involve an increase of its specific gravity), add dilute sulphuric acid of 1,280 in specific gravity (at 20°C).

2) To see how much battery is discharged, measure the specific gravity of its electrolyte. The following table shows the relation between the degrees of discharge and hydrometer readings (at 20°C).

Degree of Discharge	Totally discharged	3/4 discharged	1/2 discharged	1/4 discharged	Completely charged
Hydrometer Reading	1,160	1,190	1,220	1,250	1,280~1,300

Specific gravity varies with temperature. For the correction of hydrometer reading, apply the formula given blow.

$S_{20} = S + 0.007\ (t-20)$,

S : Hydrometer reading

S_{20} : Specific gravity at 20°C

t : Electrolyte temperature (°C)

Long use of battery in insufficient charge will do damage to its pole plates, resulting in a remarkable drop of its efficiency. Make it a rule to recharge it before it gets discharged any more than 1/2. In winter, a fall of temperature

involves a sharp drop of its capacity. Remember especially that a decrease of specific gravity in inadequate charge might make electrolyte ready to freeze in a cold area. (Refer to Sect. 8, "Handling in Cold Weather", Chap. 1).

3) Good battery maintenance requires moreover such cares as mentioned below.

a) Keep battery always clean and dry.

b) Connect terminals always firmly.

Corroded parts of terminals can be easily cleaned by washing with solution of sodium bicarbonate. But be careful not to splash it into cells. After polishing terminals well, connect them firmly and give a thin coating of grease. Never try to hammer or hit them off or on.

c) Don't put any metal articles such as pliers and spanners on battery. Such careless doing will short-circuit it with a spark and might cause a serious accident, to say nothing of early break-down of battery, nor bring naked fire near it.

7 RE-SCREWING OF MAIN BOLTS

With initial fatigue of gaskets and packings in newly assembled engine and with its long use, bolts will get loose. To prevent accidents arising therefrom, check main bolts at regular intervals to see if they are working tight enough and if loose, screw again accofdingly. Apart from this, always give attention to those bolts that can be seen from outside. Re-screwing of main bolts must be done according to the given below clamping Torque List with fit torque wrenches, so should be entrusted to your dealer or a service shop.

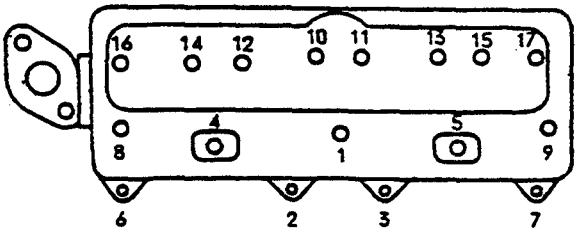
Clamping Torque List for Model 4DQ50 Engine

Bolted Parts	Pitch	Clamping Torque		Remarks
		kgm	ft-lb	
Cylinder head	**12P–1.75**	**12**	**86**	**See Par. 7-1 below.**
Main bearing caps	12P–1.75	8.5	60	
Connecting rod caps	10P–1.5	5.5	38.5	
Flywheel	12P–1.5	8.5	60	
Nozzle holders	24P–2.0	5	35	
Nozzle tip retaining nuts	22P–1.5	7	50	
Delivery valve holders	18P–1.5	3	22	

7-1 Cylinder head clamp bolts

Every 500Hr of run, re-screw head clamp bolts. For this, unfasten rocker case cover, rocker ass'y and intake manifold, and screw them to specified clamping torques following the order indicated in Fig. 3-43.

Remember that it must be placed with apron-shaped parts up. In clamping, screw bolts first a little but uniformly, then tight according to the illustration.



Notes: 1) Numbers show bolt screwing order
2) Clamping torque: 12.0 kg-m (86 lb-ft)

Fig. 3-43 Order to screw bolt on cylinder head

7-2 Main Bearing caps and connecting rod caps

Each time to wash oil pan and strainer, check bolts on main bearing caps and connecting rod caps, and if loose, screw them tight again.

7-3 Others

Keep the following bolts and nuts tight.

Oil pan clamp bolts
Engine mounting bracket nuts
Engine mounting bolts
Exhaust manifold (outlet) nuts

Regular checkup and Service Table for Model 4DQ50 Engine

(Consult "Lubrication Table, too.)

Units & Parts		Description	Checkup & Service Intervals						Remarks
			Daily	60Hr	120Hr	250Hr	500Hr	1000Hr	
Air System	Air cleaner (oil bath type)	Clean pre-cleaner	○						
		Disassemble and clean element	□	○					
	Air cleaner (filter paper type)	Clean case and element		□					
		Replace element					○		
	Valve clearance check and adjust			※		○			0.25mm in cold engine, both for inlet and exhaust valves ◎
	Compression pressure measure						○		◎
Oil System	Oil filter	Replace element			○				At the same time to change oil or when bypass alarm lamp got alight
		Wash inside of case		※	○				
	Oil pan	Wash inside and strainer					○		
Fuel System	Fuel filter	Drain off water and sediment			○				
		Replace element						○	
	Fuel feed pump	Clean inlet joint strainer			○				
	Injection nozzles	Check injection pressure and spray			※	○			120±5kg/cm² ◎
		Remove carbon from nozzle seat packings			※	○			
	Fuel tank	Check fuel level and refill	○						
		Drain off water and sediment			○				
		Wash inside					○		
Cooling System	Radiator	Check water level	○						
		Change water Wash inside				○			Before and after the use of antifreeze
		Clean cooling fins		○					
	Fan belt	Check tension and adjust		○					

Units & Parts		Description	Checkup & Service Intervals						Remarks
			Daily	60Hr	120Hr	250Hr	500Hr	1000Hr	
Electric System	D.C. Generator	Check brushes; replace if necessary					○		◎
		Service commutator					○		
	A.C. Generator	Check brushes and slipring ; replace if necessary						○	
	Starter	Check brushes and commutator					○		◎
		Dismount to check pinion clutch					○		
	Battery	Check electrolyte level and refill		○					Usually once in two weeks, but once a week in summer
		Measure specific gravity of electrolyte		○					
	Main bolts	Screw again		※			○		See "Clamping Torque List" ◎

Notes: ○ : General

□ : In very dusty areas

※ : First servicing for new engine or after overhauling

◎ : Services to be made by your dealer or a service shop

CHAPTER 4 TROUBLE-SHOOTING

When the engine has got out of order or something wrong happened with it, consult the following instructions to take appropriate measures.

In the event of any serious trouble such as arisen in the inside of the engine or with fuel injection pump, ask your dealer or a service shop for necessary repairs. Whenever any trouble noticed, put on record its detailed descriptions and the odometer reading on that day.

In disassembling to research into the cause of trouble and repairs, take necessary measures to keep off dust and arrange removed parts so as not to miss any of them, as well as to permit easy reassembling.

1. TROUBLE SHOOTING CHART

	Complaint / Probable cause	Engine will not start: Engine turns over but does not start. — No exhaust smoke	Engine will not start: Engine turns over but does not start. — A little exhaust smoke	Engine will not start: Engine turns over but does not start. — Too much exhaust smoke	Engine will not start: Starting motor does not turn over sufficiently to crank engine.	Engine will not start: Engine does not turn over — Engine can be cranked manually.	Engine will not start: Engine does not turn over — Engine cannot be cranked manually.	Heater plugs do not glow red.	Heater plugs glow red too early.	Engine lacks power — A little exhaust smoke	Engine lacks power — Too much white exhaust smoke	Engine lacks power — Too much black exhaust smoke	Abnormal exhaust smoke — When idling	Abnormal exhaust smoke — When operating — White exhaust smoke	Abnormal exhaust smoke — When operating — Black exhaust smoke	Engine knocks excessively.	Engine is noisy.	Engine runs irregularly.	Engine hunts — When idling	Engine hunts — When operating.
Fuel system	Improper fuel supply to fuel injection pump	○	○	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–
	Greater variance of injection quantity	–	–	○	–	–	–	–	–	–	–	○	○	–	○	○	–	–	○	○
	Defective fuel injection pump seals	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Insufficient injection quantity	○	○	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–
	Excessive injection quantity	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	–
	Improper fuel spray from injection nozzles	–	–	○	–	–	–	–	–	–	–	○	○	–	○	○	–	–	○	○
	Excessive fuel return from injection nozzles	–	○	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	○	–
	Injection timing too advanced	–	–	○	–	–	–	–	–	–	–	○	–	–	○	○	–	–	–	–
	Injection timing too retarded	–	–	○	–	–	–	–	–	–	○	–	○	○	–	–	–	–	○	–
	Defective automatic timer	–	–	–	–	–	–	–	–	–	–	○	○	–	○	○	–	○	–	–
	Defective governor control spring	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Maladjusted governor damper spring	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	○
	Engine speed too low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–
	Failure of engine to stop properly	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Poor grade of fuel oil	–	–	○	–	–	–	–	–	–	○	○	○	○	○	○	○	–	–	–
	Fuel oil viscosity too high	○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lubricating system	Poor grade of oil	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Oil viscosity too high	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Oil viscosity too low	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–
	low oil pressure	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Excessive oil leak	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Pumping up of oil	–	–	–	–	–	–	–	–	–	–	–	–	○	○	○	○	–	–	–
	Clogged oil filter	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective oil bypass alarm or lamp	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective oil indicator switch or lamp	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

(● For detsiled information refer to the separate table.)

Engine vibrates excessively.	Engine stalls.	Poor response for deceleration.	Engine does not pick up speed.	Engine operates at high speeds but fails to stop.	Engine turns over in reverse direction.	Excessive fuel consumption	Excessive oil consumption	Oil is diluted by fuel.	Water in oil	Blow - by	Defects in lubricating system: When engine stops, warning lamp does not come on	Defects in lubricating system: Worning lamp comes on at low - speed operation.	Defects in lubricating system: Warning lamp comes on at high - speed operation.	Abnormal water temperature: Water temperature too high (Engine overheats)	Abnormal water temperature: Water temperature too low	Defective charging generator: Indicator lamp does not come on when engine stops.	Defective charging generator: Indicator lamp comes on at high - speed operation.	Possible remedy
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●
–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	Check and replace part (s) if necessary
–	○	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●
○	–	–	–	–	–	○	○	○	–	–	–	–	–	○	–	–	–	●
–	○	–	–	–	–	○	○	○	–	–	–	–	–	–	–	–	–	●
○	–	–	–	–	–	○	○	–	–	–	–	–	–	–	–	–	–	Replace nozzle tips
–	○	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	●
–	–	–	○	–	–	–	–	–	–	–	–	–	–	○	–	–	–	●
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Check and replace spring if necessary. Then adjust governor setting on bench
–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Adjust.
○	–	–	–	–	○	–	–	–	–	–	–	○	–	–	–	–	–	Adjust idling set bolt. Hold stop lever in STOP position.
–	○	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	●
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Use fuel for cold weather.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Use good quality oil.
–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	Use proper viscosity oil.
–	–	–	–	–	–	–	○	–	–	○	–	○	–	–	–	–	–	Use proper viscosity oil.
–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	–	●
–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	Retighten and replace packing (s) if necessary.
–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	●
–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	Change element and oil.
–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	Check and replace part (s) if necessary
–	–	–	–	–	–	–	–	–	–	–	○	○	–	–	–	–	– –	Check and replace part (s) if necessary

	Complaint / Probable cause	Engine will not start.						Heater plugs do not glow red.	Heater plugs glow red too early.	Engine lacks power			Abnormal exhaust smoke			Engine knocks excessively.	Engine is noisy.	Engine runs irregularly.	Engine hunts.	
		Engine turns over but does not start.			Starting motor does not turn over sufficiently to crank engine.	Engine does not turn over							When idling	When operating					When idling	When operating
		No exhaust smoke	A little exhaust smoke	Too much exhaust smoke		Engine can be cranked manually	Engine cannot be cranked manually.			A little exhaust smoke	Too much white exhaust smoke	Too much black exhaust smoke		White exhaust smoke	Black exhaust smoke					
Air system	Insufficient air	–	–	○	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–	○
	Poor compression	–	–	○	–	–	–	–	–	–	○	○	–	–	○	–	–	–	–	○
	Low pressure at high atomospheric temperature	–	–	○	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–	○
Cooling system	Engine not sufficiently warm.	–	–	○	○	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–
	Radiator dissipates heat excessively.	–	–	–	–	–	–	–	–	–	○	–	○	–	–	○	–	–	–	–
	Insufficient coolant	–	–	–	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–	–
	Failure of radiator to dissipate heat properly	–	–	–	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–	–
	Water leak in cylinder head gasket	–	–	–	–	–	–	–	–	–	○	–	○	–	–	○	–	○	–	–
	Cranki in crankcase water jacket	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Electrical system	Defective starter switch	–	–	–	–	○	–	○	–	–	–	–	–	–	–	–	–	–	–	–
	Defective starter magnetic switch	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective starting motor	–	–	–	○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective starting motor free wheel	–	–	–	○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective flywheed ring gear and pinion	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Battery voltage drop	–	–	○	○	○	–	○	–	–	–	–	–	–	–	–	–	–	–	–
	Open circuit in heater plugs or pilot lamp	–	–	○	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–
	Short circuit in heater plugs	–	–	○	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–
	Defective charging generator	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Defective generator regulator	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Improper wiring	–	–	○	○	○	–	–	○	–	–	–	–	–	–	–	–	–	–	–
Engine proper	Jammed moving parts	–	–	–	○	–	○	–	–	–	–	–	○	–	○	–	○	○	–	–
	Worn cylinders, pistons or piston rings	–	–	○	–	–	–	–	–	–	○	–	○	–	○	–	○	–	–	–
	Sticking piston rings	–	–	○	–	–	–	–	–	–	○	–	○	–	○	–	–	–	–	–
	Excessive main bearing clearance	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–
	Loose connecting rod cap bolts	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–
	Interference between valve and piston	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–
	Broken valve springs	–	–	○	–	–	–	–	–	–	○	–	○	–	–	–	–	–	○	○
	Excessive valve clearance	–	–	–	–	–	–	–	–	–	–	○	–	–	○	–	○	–	○	○
	Foreign substances in cylinders	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	○	–	–	–
	Excessive gear backlash	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–

(● For detailed information refer to the separate table.)

Engine vibrates excessively.	Engine stalls.	Poor response for deceleration	Engine does not pick up speed.	Engine operates at high speeds but fails to stop.	Engine turns over in reverse direction	Excessive fuel consumption.	Excessive oil consumption.	Oil diluted by fuel.	Water in oil	Blow - by	Defects in lubricating system: When engine stops, warning lamp does not come on.	Defects in lubricating system: Warning lamp comes on at at low - speed operation.	Defects in lubricating system: Warning lamp comes on at high - speed operation.	Abnormal water temperature: Water temperature too high (Engine overheats)	Abnormal water temperature: Water temperature is too low.	Defective charging generator: Indicator lamp does not come on when engine stops.	Defective charging generator: Indicator lamp comes on at high - speed operation.	Possible remedy
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●
–	○	–	○	–	–	○	–	–	–	–	–	–	–	–	–	–	–	●
–	–	–	–	–	–	○	–	–	–	–	–	–	–	○	–	–	–	(Adjust full - load setting of governor.)
–	○	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	Heat oil pan from bottom side at starting. After starting, warm up engine sufficiently.
–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	○	–	–	●
–	–	–	–	–	–	–	○	–	–	○	–	○	–	○	–	–	–	●
–	–	–	–	–	–	–	○	–	–	○	–	○	–	○	–	–	–	●
–	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	Retighten and replace gasket if necessary.
–	–	—	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	Replace crankcase.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Check for connections and repair. If necessary replace part (s).
–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	Repair and replace if necessary.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Repair and replace if necessary.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Repair and replace starting motor if necessary.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Repair or replace ning gear. Replace pinion.
–	–	–	–	–	○	–	–	–	–	–	○	–	–	–	–	○	–	Recharge or replace battery.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	If necessary heat it. Replace part (s).
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Replace copper packing (s) and if necessary heater plugs.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	If necessary replace charging generator.
–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	○	○	Adjust and replace if necessary.
–	–	–	–	–	–	–	–	–	–	–	○	–	–	–	–	○	–	Connect wires properly.
–	○	–	○	–	–	○	○	–	–	○	–	–	–	○	–	–	–	●
–	○	–	–	–	–	○	○	○	–	○	–	–	–	–	–	–	–	Repair and replace if necessary.
–	○	–	–	–	–	○	○	○	–	○	–	○	○	–	–	–	–	Repair and replace if necessary.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Check and replace bearing (s) with undersize one (s) if necessary.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Retighten.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Re-time timing gear train or adjust valve sinkage properly.
○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Replace part (s).
○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Adjust valve clearance to 0.3 mm.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	—	–	–	–	Repair.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Replace geat (s) or idler bushing (s).

2. TROUBLE SHOOTING CHART (APPENDIX)

Probable cause		Possible remedy
Improper fuel supply to fuel injection pump	Closed fuel tank supply cock	Open the cock.
	No fuel in tank	Fill fuel tank.
	Clogged fuel lines	Repair or clean fuel pipes with air.
	Air in fuel system	Retighten attaching parts or replace fuel pipes.
	Clogged fuel feed pump inlet strainer	Remove and clean stainer.
	Defective fuel feed pump	Repair.
	Leak in fuel lines or connections	Retighten connections.
	Clogged fuel filter	Disassemble and clean filter.
	Air in fuel system	Bleed air out of fuel system
Greater variance of injection quantity	Jammed plungers	Replace plungers.
	Jammed tappets	Replace tappets.
	Worn plungers	Replace plungers.
	Worn tappet cams	Replace tappet cams.
	Worn bearings	Replace bearings.
	Worn or broken plunger springs	Replace plunger springs.
	Loose plunger pinions	Reinstall properly by matching stamped marks.
	Defective delivery valves	Replace valves.
	Worn or broken delivery valve springs	Replace valve spring.
Insufficient injection quantity	Governor stop lever link is binding.	Repair link properly, placing lever in neutral position.
	Control rack is sticky.	Relubricate or repair.
	Jammed plungers	Replace plungers.
	Jammed tappets	Replace tappets.
	Worn plungers	Replace plungers.
	Worn tappet cams	Replace tappet cams.
	Worn bearings	Replace bearings.
	Loose plunger pinions	Reinstall properly by matching stamped marks.
	Improper full-load setting of governor	Adjust governor setting on bench.

Probable cause		Possible remedy
Excessive injection quantity	Stop lever jammed in "increase" position. Improper full - load setting of governor Loose plunger pinions	Repair lever link properly, placing lever in neutral position. Adjust governor setting on bench. Reinstall properly by matching stamped marks.
Improper fuel spray from injection nozzles	Sticking needle valve (s) in one or more nozzles Damaged nozzle tip seats Worn or broken nozzle springs Extremely low injection pressure Carbon deposited on packings at nozzle tips	Repair and replace nozzles if necessary. Repair and replace seats if necessary. Replace nozzle springs. Adjust Pressure to $120 \pm 5 kg/cm^2$ (1706.4 ± 71.1 lb/in^2) on nozzle tester by inserting shim (s). Remove carbon.
Injection timing too advanced	Improper installation of fuel Injection pump Incorrect installation of timing gears	Re - time properly by tilting injection pump toward engine. Re - time timing gear train.
Injection timing to retarded	Improper installation of fuel injection pump Incorrect meshing of timing gears Worn cams, tappets or bearings of fuel injection pump	Re - time properly by tilting injection pump outward. Re - time timing gear train. Replace.
Poor grade of fuel oil	Poor grade of fuel oil Water in fuel	Use good quality fuel. Use good quality fuel.
Low oil pressure	Lack of oil in oil pan Air in oil strainer	Add oil to prescribed level. Replace damaged pipes or packings. Retighten loose parts.

Probable cause		Possible remedy
Low oil pressure – cont.	Defective oil pump Clogged fuel lines Defective oil pressure valve Clogged oil filter Leak in lubricating system	Repair. Flush. Repair and replace if necessary Change element and oil. Repair.
Pumping up of oil	Excessive oil in oil pan Worn cylinders, pistons or piston rings Sticking piston rings Worn valve guides Prolonged operation under no load	Drain oil to lower oil level. Repair and replace parts if necessary Repair and replace damaged rings if necessary. Replace valve guides. Overhaul engine if oil-laden gases are exhausted.
Insufficient air	Clogged air cleaner (paper element type) Clogged air cleaner (Oil bath type) Clogged intake manifold	Clean and replace element if necessary. Wash interior. Check and clean.
Poor compression	Defective valve seats Sticking valve stems Failure of rocker arms to lift valves Worn cylinder, pistons or piston rings Sticking piston rings Exhaust gas leak in cylinder head gasket Worn or broken valve springs Insufficient torque of starting motor (at starting)	Repair Repair and replace valve stems if necessary Adjust valve clearance to 0.3 mm (0.012 mm). Repair and replace parts if necessary. Replace damaged rings. Retighten and replace gasket if necessary. Replace parts.

Probable cause		Possible remedy
Insufficient coolant	Insufficient coolant Overheating Water leak in unit seal of water pump Crack in crankcase water jacket Water leak in other parts	Add water to prescribed level. Replace part (s) Replace crankcase. Check and repair.
Failure of radiator to dissipate heat properly	Air in cooling system Rust and scale deposited in radiator Dust and dirt around radiator Slippage of fan belt Inoperative thermostat (kept closed)	Bleed air by loosening air bleed plug, drain plug, or hose clamp. Flush. Flush. Adjust belt tension. Replace.
Radiator dissipates heat excessively	Extremely low atmospheric temperature Uncovered radiator Inoperative thermostat (kept open)	 Cover radiator. Replace part (s).
Jammed moving parts	Sticking cylinders, pistons or piston rings Sticking main bearings and crankpin bearings Sticking cam bushing and idler bushing	Repair and replace part (s) if necessary. Repair and replace part (s) if necessary.

CHAPTER 5 OVERHAULING INSTRUCTIONS

1. GENERAL INSTRUCTIONS

1) At present we cannot say when your Model 4DQ50 Engine should be put to a thorough overhauling, for it presupposes under what conditions the engine will be sued, but can mention as general hints the following cases where an overhauling is required.

a) When, engine parts having been uniformly fatigued (or worn) down from long use, involving a drop of output, it is judged better to overhaul it.

b) When an increase of blow-by out of crankcase has caused a notable drop of engine output.

c) When oil consumption has increased.

d) When, with nothing wrong with oil system, a remarkable drop of oil pressure is noticed, which is judged ascribable to the wear of metals, etc.

e) When water leaks into oil.

f) When such a serious trouble has happened inside the engine that cannot be remedied by usual services or permits the replacement of broken or affected assemblies.

2) In taking apart the main parts such as pistons, connecting rod, valves and metals, arrange then or put numbers on them in an appropriate way to place them later where they were. Remember particularly that caps on connecting rod and main bearings, being machined in pairs with respective bodies, cannot be replaced separately.

3) When the engine overhauled, make every service specified in "Retular Checkup and Service Table".

4) After a thorough overhauling, practice an adequate running-in and performance test on bench, coupling it with a dynamometer, so as to adjust it perfectly for actual operation, for example, on the vehicle.

For fuel injection pump and governor, they must also be tested, when overhauled, individually on a fuel injection pump tester in order to make necessary adjustments. New units supplied in an integral assembly, "injection pump general ass'y", can be readily put in service, as already adjust thoroughly. For informations about the engine bench test and individual adjustment of injection pump and governor, ask your dealer or service shop.

5) Reference to "Parts Catalogue" will greatly help you in knocking down and

reassembling the engine. Remember that special tools are available for those operations. (Refer to Chap. 6, "Tools")

2 CYLINDER HEAD AND VALVES

2-1 Reface of valve seats

Valve seat angle is 45°. After a rough machining with a 45-degree cutter, give perfect fitting. Standard seat width is 1.4mm. Excess in width affects airtightness. If valve seat has become wider, cut the face accordingly with a cutter with an end angle of 120°. Use a cutter of 42φ in outer diam. for inlet valve seats and of 33φ for exhaust ones. Valve depression must be within a range of 0.8±0.2mm. In case valve has sunk more than 1mm, which requires a valve seat insert be fitted in, ask your dealer or a service shop for the service. If valve face scratched or worn, replace with a new seat so far as available. It can, however, be ground until margin becomes 1.2mm.

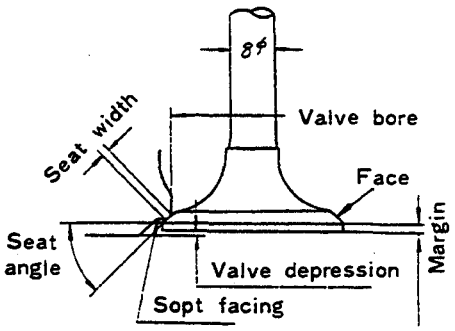


Fig. 5-1 Valve seat

2-2 How to replace valve guides

To remove valve guide, press it down with remover, while to fit in a new guide, use installer so as to set it with the top end 18mm above the surface of cylinder head. (See Fig. 5-2)

2-3 Combustion chamber jet and director

To remove combustion chamber jet, lightly press it out with a long bolt of 10φ, as illustrated on the right.

For new jet, tap them in uniformly until their surfaces get level with that of cylinder head. Setting directions are indicated in Fig. 5-4. Having set them right, calk each at a spot with a punch. To replace directors, hammer new ones so as to place jets midway between inlet and exhaust valves as indicated arrows.

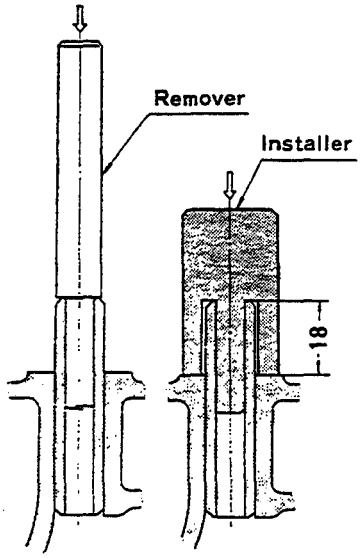


Fig. 5-2 Replacement of valve guide

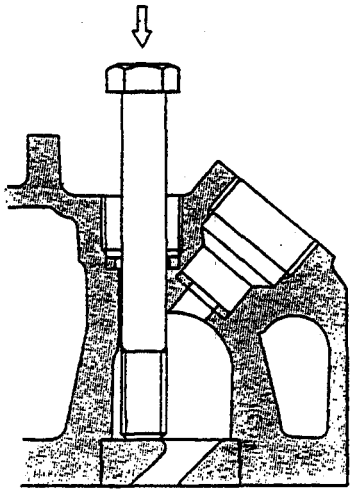


Fig. 5-3 Pressing out combustion chamber

2-4 Rocker shaft brackets

To remove rocker shaft bracket, prior to loosing center bolt 1 , loose short ones 2 , lest bracket should be strained to break.

In bolting it down, screw those bolts in reverse order, that is, first long bolt 1 and then short ones 2 .

In setting brackets, allot enough clearances to permit both left and right rockers to move smoothly.

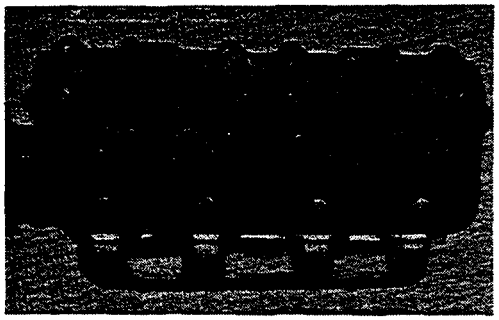


Fig. 5-4 Setting direction of combustion chamber jet and director

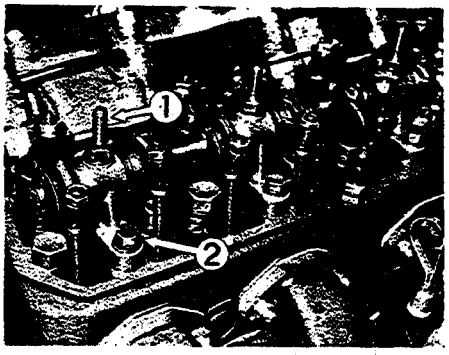


Fig. 5-5 Bolts on rocker shaft bracket

3 PISTONS AND CONNECTING RODS

3-1 How to remove and install piston and connecting rod assy.

In Model 4DQ50 Engine, connecting rod large end has a larger diameter than

cylinder bore, hence piston, as coupled with connecting rod, cannot be pulled out upward (that is, toward cylinder head), but through the bottom of cylinder with crank shaft off.

Fig. 5-6 To install piston

To install piston coupled with connecting rod, press it into cylinder from below, then install crank shaft. To install piston, use the special tools. But don't forget to coat it with oil in advance.

3-2 How to couple piston with connecting rod

Pistons and connecting rods are marked with serial numbers, No. 1, No. 2, No. 3 and No. 4, according to their arrangement as seen from timing tear case.

How to couple together each pair and to set in cylinder crank-case is illustrated on the right.

3-3 How to remove and install piston pins

Fitting of piston pin is such that does not permit it to be pressed in by hand at normal temperature. So, warm up piston in boiling water to expand the inner diam, of piston pin hole, then remove it or install by hand. Never hammer it in cold piston. Arrangement of piston rings on piston is an shwon in Fig. 5-8.

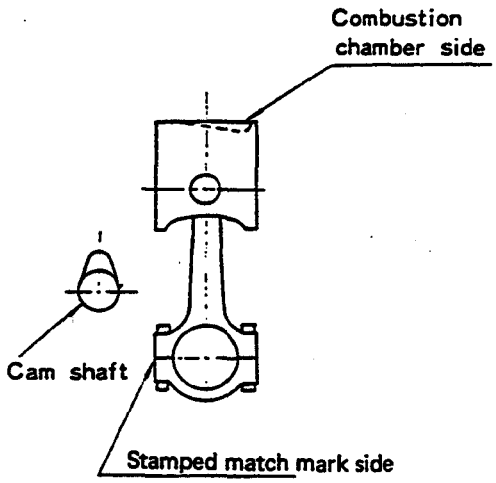
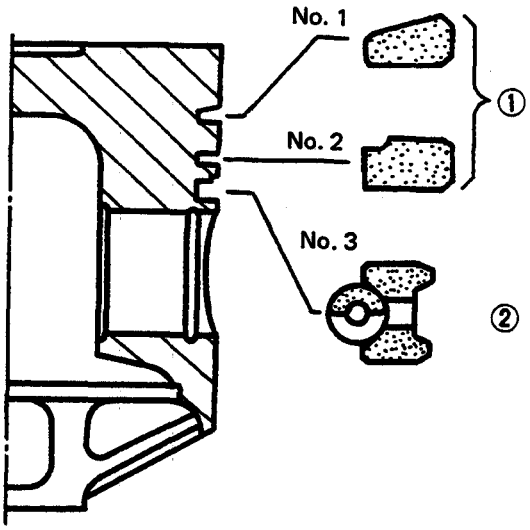


Fig. 5-7 How to couple piston and connecting rod



1. Compression ring 2. Oil ring

Fig. 5-8 Arrangement of piston rings

Top and oil rings are chromium-plated in sliding surfaces, while the other, namely, 2nd. are tapered, install these taper rings with marks "UP" on cut ends up.

To oil ring is attached a spring type expander to provide high and uniform contact pressure. The ends of spring are butted to each other with a short steel wire between them.

Arrangement of piston ring cut ends is indicated in Fig. 5-9.

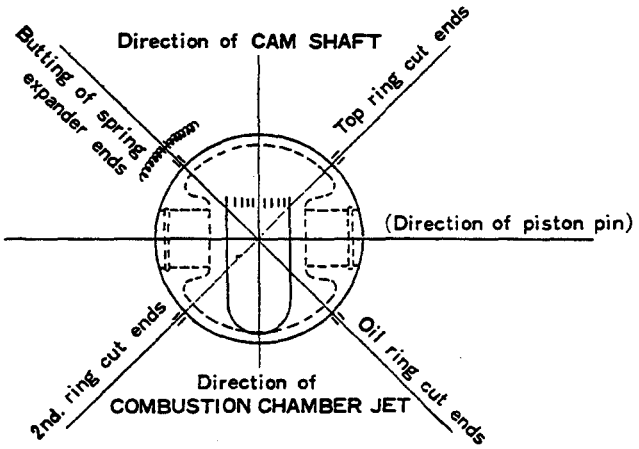


Fig. 5-9 Arrangement of piston ring cut ends

4 CYLINDERS

4-1 Oversize

In Model 4DQ50 Engine, cylinders, being cast in one body with crankcase, have dry liners.

When they have got worn more than 0.2mm in bore or cut deeply in lines, machine them to a suitable oversize. Oversize pistons and piston rings are available in three sizes: +0.25, +0.50 and +0.75.

4-2 Cylinder liners

If oversize parts are not available or when they have got worn over the limit of use (+1.20mm), change cylinder sleeve. For details, ask your dealer or a service shop.

5 BEARING METALS

5-1 General cautions

Handle metals on main bearings and connecting rods always with good care not to scratch or otherwise damage their bearing surfaces. In assembling them, clean bearing surfaces and coat them with oil; then clamp them down, making sure that they are free from any strain.

5-2 How to assemble main bearing metals

Of each pair of main bearing metals, assemble that which has a groove in the middle that is, on crankcase up side, especially the other with thrust bearing on the side of timing gear case. To prevent leak of oil, give a thin coating of liquid packing to their contact surfaces with main bearing cap cases on both ends. For connecting rod bearings, either of the pair can be assembled upon the other.

5-3 Undersizes

To both main bearings and connecting rod bearings, metals must be renewed when their clearances exceeded 0.2mm. When replacement of metals not considered to produce satisfactory results because of crank shaft being unevenly worn or streaked deep, grind it so much as to fit to any of undersize metals which are available in three sizes; –0.25, –0.50 and –0.75.

6 TIMING GEAR

6-1 Timing gear train

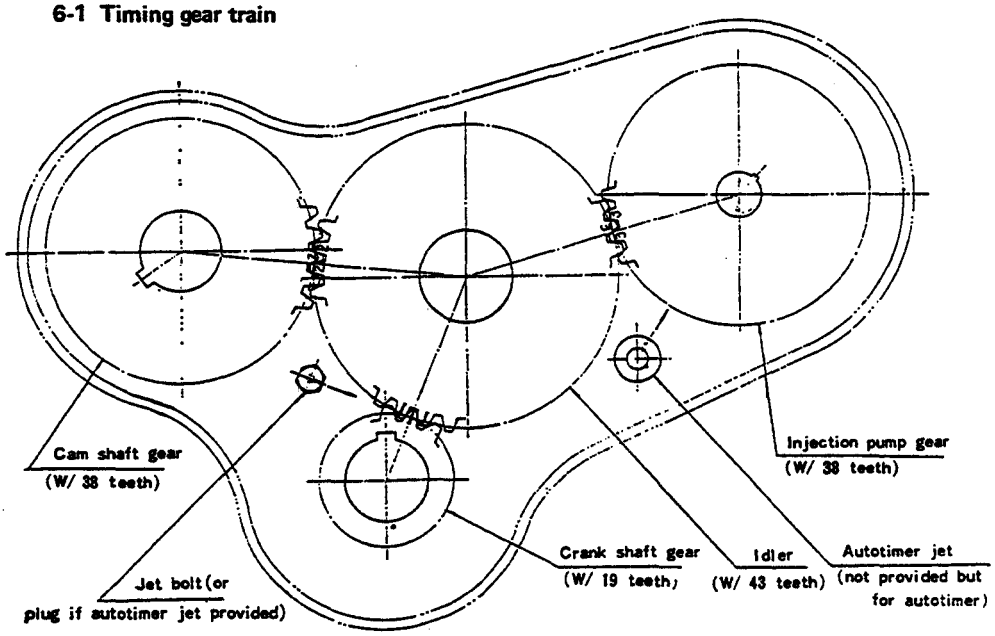


Fig. 5-10 Timing gear train

The view of timing gear train with cover off is shown as (Fig. 5-10). To install gears that were taken apart, bring #1 cylinder piston to top dead center and holding it there, mesh gears one after another with idler, following their numerical meshing marks, as illustrated in Fig. 5-10.

Align autotimer key way with mark line on injection pump gear.

6-2 Valve timing

To install gears according as indicated with numerical meshing marks dispenses with the trouble of checking valve timing. For reference sake, however, valve timing diagram is given in Fig. 5-11. Every cam having a symmetrical profile, checkup of valve timing requires to measure crank angle, at max. cam lift to see if it equal to the angle indicated with broken line in Fig. 5-11. The procedure is detailed as follows.

Take for instance, No. 1 cylinder inlet and exhaust valves. First set valve clearances by means of plane plates with uniform thickness of 3—4mm, and put the thinnest

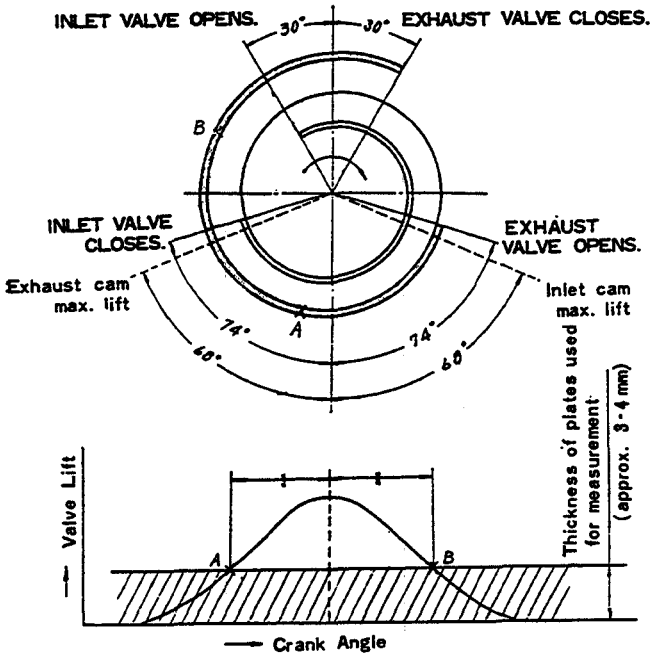


Fig. 5-11 Valve timing

(0.05mm) of thickness gauge blades between valve tops and rockers. Now turn crank shaft slowly until gauge blades are pressed tight, this point crank angle is valve lifts reach point A and B shown as Fig. 5-11. The mid-point between them corresponds to max. cam lift. Compare the results of measurement with the specified crank angles.

7 OIL SEALS

Oil seals on front and rear ends of crank shaft must be centered right. So take care in clamping down timing gear case and rear end oil seal.

The part to install front end oil seal has concentrically-machined periphery. Center the seal so as to fit to it. Meanwhile, for rear end oil seal, center it on basis of its periphery. In either case, a special centering tool is available.

Remember that rear end oil seal must be set with oil leak-off knotch in slinger down.

Prior to installing oil seals, coat their lips with pure engine oil.

8 MOUNTINGS

On motor vehicle, rubber cushions on front mountings form a paralle-logram in free condition as shown in Fig. 5-12, and a rectangle under load. Remember this in setting them. On construction machine, three point support mounting is used. Timing gear side has cushion rubber.

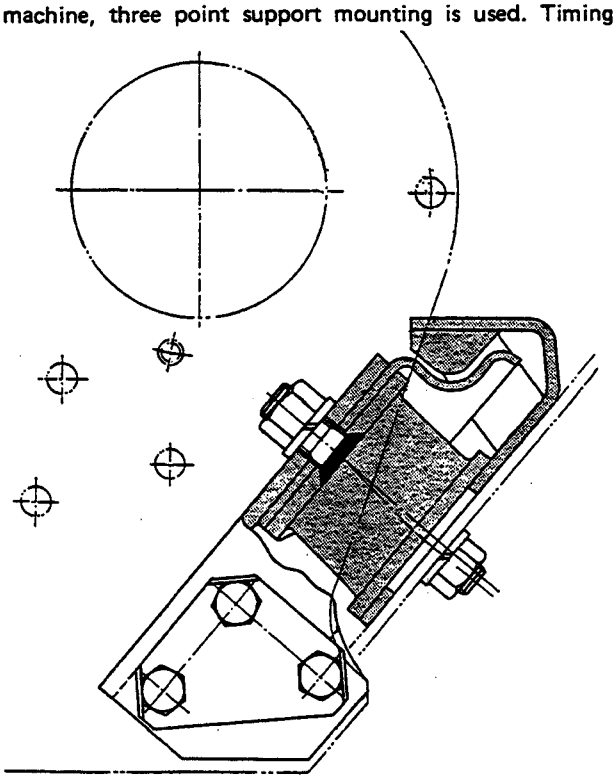


Fig. 5-12 Mounting on motor vehicle (in free condition)

9 OIL PAN INSTALLING

Oil pan of Model 4DQ50 Engine is designed so as to be installed with its center in alignment with those of crankcase and crank shaft. At either end, fasten it tight enough not to leak.

Main bearing caps on both front and rear ends have grooves. Fit retainers in those grooves as illustrated in Fig. 5-13. Then, to their corners, put the ends of side packings (cork plates). and fit semi-circular rubber-packings in the grooves. To apply liquid packing to corner intersections will prove very effective in preventing leakage.

Coat semi-circular rubber packings with oil on the surface so that oil pan edges will slide easily on. Finally screw bolts (4 pieces each in front and rear) uniformly in order not to strain packings.

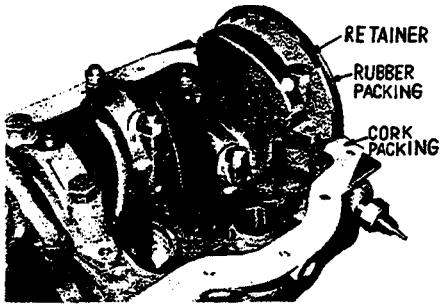


Fig. 5-13 Arrangement of oil pan packings

10 OIL PUMP

In fastening down pump case cover, align its setting mark with that on pump body.

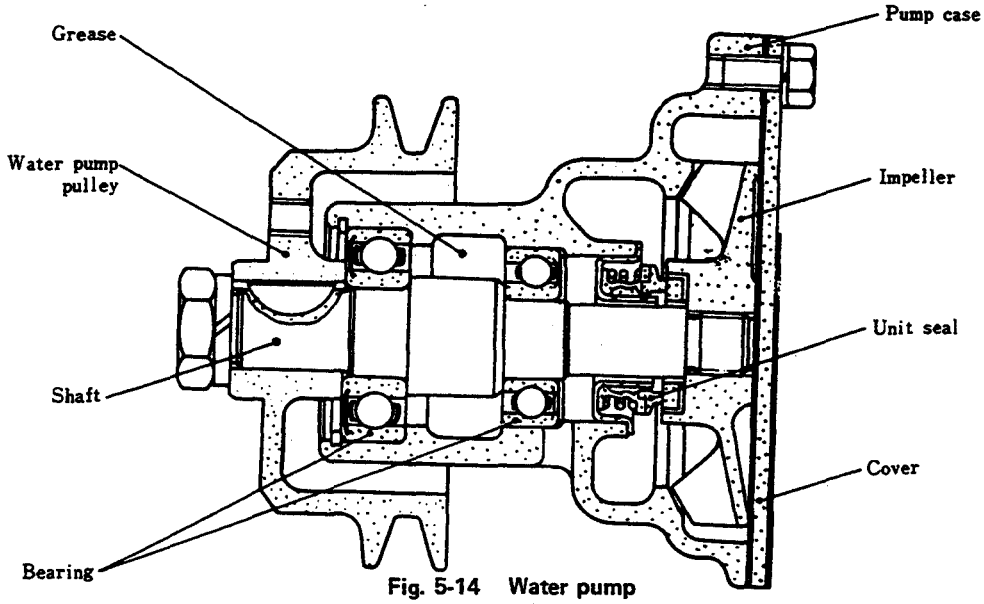


Fig. 5-14 Water pump

11 WATER PUMP

If any play developed on water pump shaft or water leaking, disassemble pump in the following procedure and service as required.

First, remove fan coupling flange with puller and take off snap ring. Then open rear cover and take out inner components. Impeller can be pulled cut with puller.

Check unit seals and if badly worn or affected in floating seat surface or carbon worn off, renew them.

Of new bearings, grease may come out a little, but this means nothing particularly wrong.

12 BOLT SCREWING

1) For screwing of main bolts, the necessary instructions were already given in Sect. 7, "Re-screwing of Main Bolts", Chap. 3. The other bolts should be screwed with reference to the following table.

Nominal Thread		mm	6	8	10	10	12
Pitch		mm	1	1.25	1.25	1.5	1.25
Clamping	Plated	Kg m (ft-lb)	0.9 (6.5)	2.1 (15)	4.3 (31)	4.0 (29)	7.4 (54)
	Not plated	kg m (ft-lb)	0.7 (5.0)	1.4 (10)	3.0 (22)	2.8 (20)	5.2 (38)

2) Prior to screwing the following bolts, coat their threads with oil-proof liquid packing ("atmosit") for prevention of leakage.

- 4 lower clamp bolts on crank shaft rear end oil seal
- 3 lower clamp bolts on timing gear case
- 2 clamp bolts on flange plate to couple injection pump
- 2 fixing bolts on breather

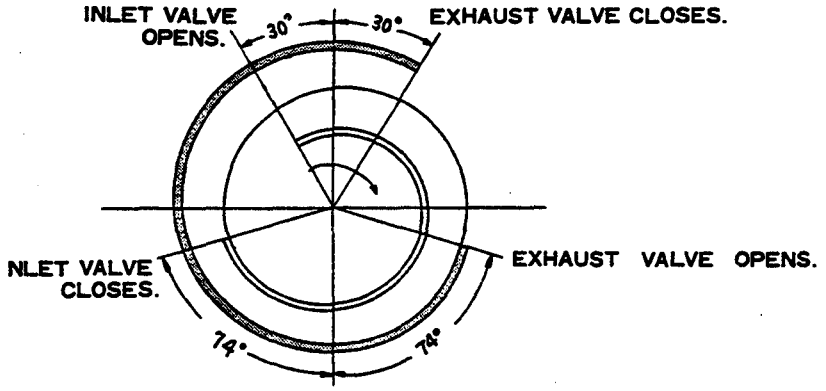
3) Packings (gaskets) and liquid packings to be used are listed below.

Uses	Materials of Packings (Gaskets)	Liquin Packings
Cylinder head	Copper asbestos	"Three Bonds" No. 201
Front plates	Rubber asbestos	" No. 2
Timing gear case	"	" No. 2
Timing cover	"	" No. 2
Oil pan (sides)	Rubber cork	" No. 2
Oil pan (ends)	Rubber	"Atomosit"
Oil filters	Rubber asbestos	"Three Bonds" No. 2

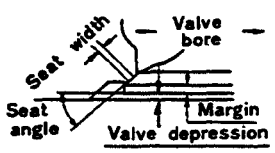
Model 4DG50 Engine

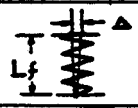
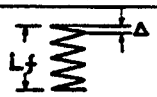
Section	Units	Parts	No.	Checkup Items	Nominal	Setting Standard	Limit of Repair (Clearance)
General			1	Max. speed	5-10% higher than rated speed		Not below rated speed 15% nor above it
			2	Min speed	700~750rpm(Pneumatic Gov.) 650~700rpm(Wechanical Gov.)		Not above 800 r.p.m.
			3	Engine preformance (on bench)			
			4	Compression pressure	Above 20kg/cm² (at 150-200r.p.m.)		Not below 16kg/cm²
			5	Engine oil pressure	3-4kg/cm²(at 1,500 r.p.m. or higher 1.5kg/cm²(in idling		Not below 2.0kg/cm² 0.5kg/cm²
			6	Valve timing	Illustrated on right	±3 (crank angle)	
			7	Injection starting timing	See Right	±1°(crank angle)	
Engine body (1)	Cylinder crankcase	Cylinder bore	8	Bore out of round Taper	84φ - -	+0.035~0 Less than 0.015 Less than 0.015	+0.20
		Top surface	9	Strain		Less than 0.05	0.2
Main moving parts	Pistons		10	Projection of pistons above cylinder crankcase top surface		+0.35~+0.75	
		Periphery	11	Outer diam.	83.46φ	-	-
		Rings and ring grooves	12	Width and standard clearance Top 2nd oil	2 2 4	+0.020~0.040 +0.015~0.035 +0.015~0.035	(0.2) (0.15) (0.15)
		Piston pin bosses and piston pins	13	Inner and outer diams and standard clearans	25φ	0.011T~0	(0.05)
		Weight	14	Weight difference among 4 pistons		±3gr	

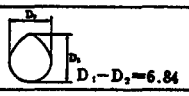
Service Standards

Limit of Use	Remedies	Remarks
	Check Venturi or governor.	
	Ditto above	
		Specified separately.
	Refer to "Trouble-Shooting"	At 20-30℃ of oil and water temperatures.
	Ditto above.	At 70℃ of oil temperature
		
Refer to "Caution Plate" on rocker cover.		
+ 0.95	Hone to +0.25, +0.50 or +0.75 on nominal diam. of 84φ and use oversize pistons and rings. If worn beyond limit of use, change liners.	Hone 4 cylinder to equal oversize. Change of liners is desecribed separately.
	Re-grind to minimum required.	
	Check bearing clearances.	
-	Use oversize pistons according to Col. 8. Oversize: +0.25, +0.50 and +0.75	
0.15 0.10 0.10	Till worn up to limit of use, pistons replacing rings; once limit over, replace pistons.	
Piston pins ; -0.03	Till worn up to limit of repair, replace piston pins; once limit over, replace pistons.	

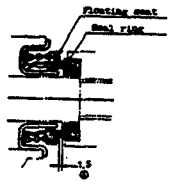
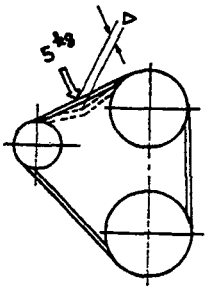
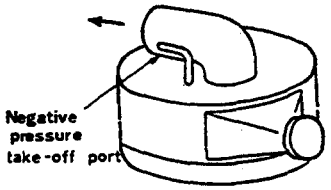
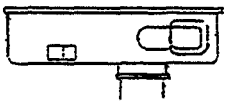
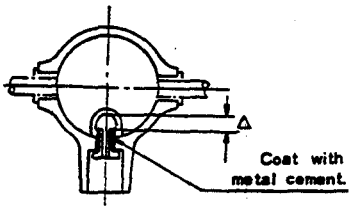
Section	Units	Parts	No.	Checkup Items		Naminal	Setting Standards	Limit of Repair (Clearance)
Main moving parts	Piston rings		15	Cut end clearances (in free)	Top 2nd Oil		Approx. 11 Approx. 11 Approx. 10.5	
			16	Cut end clearances (When fitted within Sample:84φ±0)	Top 2nd Oil		0.3~0.5 0.3~0.5 0.3~0.5	
	Connecting rods	Small-end bushes and piston pins	17	Inner and outer diams. and standard clearances.		25φ	+0.020~+0.051	(0.08)
			18	Parallelness among large. and small end bearings			Less than 0.05/100	
			19	Distance between large- and small-end bearings		168	±0.05	
		Weight	20	Weight difference among rods per unit			±5gr	
	Crank shaft	Pin and rod large-end	21	Inner and outer diams and standard clearance		58φ	+0.035~+0.100	(0.20)
			22	Width		35	+0.15~+0.35	(0.50)
		Journals and main bearings	23	Inner and outer diams. and standard clearances		65φ	+0.030~+0.089	Metals (general) :0.20
			24	End journal width(No.1 Main bearing width)		3.7	0.1~0.189	(0.30)
			25	Runout of center, supported at end journals			Less than 0.02	0.05
	Fly-wheel		26	Axial runout at rear end			Less than 0.1	
Engine body (2)	Cylinder head	Bottom surface	27	Strain			Less than 0.15	0.2
		Valve guides and holes	28	Inner and outer diams. and standard clearance		13φ	-0.035~-0.007	
			29	Fitting depth (Height above head top surface)		18	±0.3	
		Valve seats	30	Valve seat angle		45°		
			31	Valve depression		0.8	±0.2	1.3
			32	Seat width		1.4	±0.14	1.6
	Valves	Stems and guides	33	Inner and outer diams.and standard clearances	Inlet EXhaust	8φ 8φ	+0.055~+0.085 +0.070~+0.095	(0.15) (0.20)
			34	Valve face reface		Margin 1.5	Margin +0.1~0	

Limit of Use	Remedies	Remarks
	1) According to Cols.8 and 11, use oversize rings. Oversizes: +0.25,+0.50 and +0.75	
1.5 1.5 1.5	2) Replance oil rings in sets with expander springs.	If sample not available, measure approximately at top of cylinder.
	Replace piston pin or bush (Ream if necessary.)	
		1) Use bodies and caps in respective pairs. 2) In putting together each body and cap, place marks on same side.
	Till worn up to limit of repair, replace metals: one limit over, use undersizes metals. Undersize: -0.25,-0.50 and -0.75 re-grind Crank shaft pins under-size,-0.25,-0.50,-0.75	
Crank shaft pin: +0.25		
	Re-grind journals. Undersize: -0.25,-0.50 and -0.75 Till worn up to limit of repair replace metals, once limit over, use undersize metals, Undersize: -0.25,-0.50 and -0.75	1) Use crankcases and bearing caps in a set. 2) Place metal with thrust bearing at top. 3) Of each pair of metals, place that which has oil hole upon the other.
	Replace main bearings (with thrust bearing).	
	Repair bend or replace.	
		Measure as set in crankcase.
	Re-grind to minimum required.	
	If over limit of repair, replace valve guides.	Special tools available to press them out and in. Interference: more than 0.007 Equal both inlet and exhaust valves. Can be measured as fitted in.
	Put in seat inserts.	How to fit in inserts is described separately.
	If over limit of repair, widen valve bore.	Use tapered cutter of 30°
Decrease of margin by refacing: up to 1.2		

Section	Units	Parts	No.	Checkup	Naminal	Setting Standards	Limit of Repair (Clearance)
Valve mechanism	Valve springs	Outer	35	Free length Lf	48.85		47.6
			36	Rectangularity 		Less than 0.4mm/25mm	
			37	Parallelness of both ends 		Less than 0.4mm/25mm	
			38	Setting length	43		44
		Inner	35'	Free length	40.8		39.4
			36'	Rectangularity		Less than 0.3mm/17mm	
			37'	Parallelness of both ends		Less than 0.3mm/17mm	
			38'	Setting length	36.5		37.5
	Tappets		39	Valve clearances	0.25 (in cold)		0.15~0.33
		Tappet holes in cylinder crankcase	40	Inner diam.	22φ	+0.021~0	
		Outer periphery	41	Outer diam.	22φ	-0.025~-0.040	(0.12)
	Rockers	Rocker shafts and rocker holes	42	Inner and outer diams. and standard clearances	18φ	+0.016~+0.052	
	Cam shaft	Cam shaft bushes and journals	43	Inner diam (installed) No.1 No.2	54φ	+0.04~+0.09	(0.15)
				No.3	53φ		
		Thrust plates and retainers	44	Width	5	+0.05~+0.112	(0.3)
		Cam profile	45	Longitudinal diam.	45.944	+0.1 -0.3	
			46	Runout of center with end bearings fixed		0.02	0.05
Gear train	Idler	Idler bush and idler shaft	47	Inner and outer diams. and standard clearance	36φ	+0.025~+0.075	(0.1)
		Idler and idler shaft thrust bearing	48	Width	26	+0.05~+0.15	(0.35)
		Fitting of idler shaft of cylinder crankcase	49	Inner diam, shaft outer diam. and standard clearance	30φ	0.090T~0.045T	
	Gears		50	Backlashes		0.12~0.24	
Oil system	Oil pomp	Case	51	Inner diam, rotor outer diam. and standard clearance	40.7	+0.2~+0.275	
			52	Rotor depth and standard clearance	24	+0.04~+0.09	(0.15)
			53	Shaft hole inner diam., shaft outer diam. and standard clearance	12.6φ	+0.100~+0.121	
		Rotor	54	Trocoid tooth tip clearance	-	0.013~0.15	
		Gears	55	Clearance to case top	-	0.5	0.7

Limit of Use	Remedies	Remarks
1.5mm in overall length		
1.0mm in coil diam.		
	If over limit of repair, and shims	
1.5mm in overall length		
1.0mm in coil diam.		
	If over limit of repair, add shims	
	Adjust.	Equal both for inlet and exhaust valves. Can be measured in warm engine if Engine is uniform temperature.
+0.10	If not over limit of repair, replace tappets.	
		In setting, give even play in rocker shaft direction.
	If over limit of repair, replace bushes; ream if necessary.	
	Replace thrust plates.	
$D_1 - D_2 = 6.84$		
	Replace bush.	
	Replace thrust plate.	
	Replace gears.	
	Repair case cover or case surface.	
(0.15)	Replace case.	
1.0	Replace gear ass'y	

Section	Units	Parts	№	Checkup Items	Naminal	Setting Standards	Limit of Repair (Clearance)
Oil system	Relief valve		56	Valve opening pressure	3.0kg/cm²	±0.3kg/cm²	
	Oil filter bypass valve		57	Valve opening pressure	1.5kg/cm²	+0.3 kg/cm² -0	
Oooling system	Water pump	Impeller	58	Gap before blades		0.5~1	
				Gap behind blades		0.5~1	
		Unit seals	59	Hight(in free):H	23.4	±1	
			60	Projection of carbon:A	1.5		
	Thermostat		61	Valve opening temperature Full-opening temperature	76.5 ℃ 90 ℃	±2 ℃ ±2 ℃	
			62	Valve lift	9 mm		
	Fan belt		63	Tension	△= 12mm		△= 20mm
Air system	Air cleaner (filter paper type)		64	Resistance negative pressure	Approx. 50mmAq (at 3,000 r.p.m.)		250mmAq or higher (at 3,000 r.p.m.)
					Approx. 120mmAq (at 3,000 r.p.m.)		250 mmAq (at 3,000 r.p.m.)
	Venturi		65	Axial play of shaft			0.5

Limit of Use	Remedies	Remarks
		Varies 0.24kg/cm²per 1mm of shim thickness.
		Varies 0.15kg/cm² per 1mm of shim thickness.
	If hitting,replace impeller and bearing.	
23.5	Replace unit seal ass'y.	
0		
		at atmospheric pressure
	Shifting generator,adjust with adjusting plate.	 Usually press with a finger tip.
	Clean or replace element.	
		
	Adjust with shims.	

Section	Units	Parts	No.	Checkup Items		Naminal	Setting Standards	Limit of Repair (Clearance)
Fuel system	Injection nozzles		66	Injection starting pressure		120kg/cm²	±5kg/cm²	110kg/cm²
			67	Spray angle (main injection)		40°		
			68	Oil-tightness of needle valve seats		Seats must not leak under 100kg/cm²		
	Injection pump	Piston and hole	69	Inner and outer diams. and standard clearance		22φ	+0.001~+0.021	
		Push rod and hole	70	Inner and outer diams. and standard clearance		5φ	-0.005~-0.015	
		Tappet and hole	71	Inner and outer diams. and standard clearance		20φ	+0.018~+0.056	
		Tappet roller pin and hole	72	Inner and outer diams. and standard clearance		7φ	+0.013~+0.071	
		Roller	73	Inner and outer diams. and standard clearance		7φ	+0.033~+0.085	
		Roller pin	74	Outer diam.		15φ	0~-0.027	
			75	Ait-tightness test		No air leak in any ass'y. Leak from between push rod and housing: less than 50cc/min.		
		Priming pump	76	Suction capacity			Less than 25 strokes	not more than 30 strokes
		Pump body	77	Suction capacity			Shorter than 45 sec.	not more than 50 sec.
			78	Delivery pressure			1.8~2.2kg/cm²	Ditto left.
			79	Delivery rate			More than 900cc/min.	600cc/min.
		Cam shaft	80	Longitudinal diam. of profile		32	0~-0.1	
		Bearings	81	Cam shaft play Axial			0.03~0.05	0.1
		Pump body	82	Tappet hole inner diam., tappet outre diam. and standard clearance		24φ	+0.02~+0.062	
		Tappets	83	Pin hole inner diam., pin outer diam. and standard clearance		7φ	+0.013~+0.050	
			84	Floating bushes and rollers	Floating bush inner diam., pin outer diam. and standard clearance	7φ	+0.033~+0.78	
			85		Roller inner diam., floating bush outer diam. and standard clearance	11φ	+0.050~+0.097	
			86		Roller outer diam.	17φ	0~-0.027	

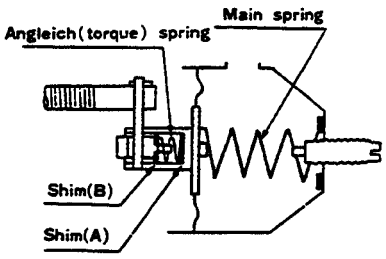
Limit of Use	Remedies	Remarks
	Adjust with shims	Varies 10kg/cm²per 0.1mm of shim thickness.
	Check with hand tester(at approx. 20°C of gas oil temperature).Wash in gas oil. If cleaning not effective, replace nozzle tips.	Must inject in a straight cone of fine spray without dribble and under gradual apolication of pressure,make throttle injection.
	Wash or replace nozzle tips.	If needle bearing scratched, replace nozzle tips.
Judge from discharge pressure test.		
Judge from air-tightness test.		
+0.2		
Overall play: less than 0.3		
-0.075		
Ditto left		With discharge port plugged up, apply 2kg/cm² of air pressure; then put whole pump in gas oil.
		Moving priming pump handle at about 60 strokes per min.,see how many strokes required to start discharging. Suction head: 1.0m
		Running injection pump at 150 r.p.m. see how much time required for feed pump to start discharging.
Ditto left.		Measure at full discharge with injection pump running at 600 r.p.m.
		Measure at 1.5kg/cm²of delivery pressure with injection pump running at 1,000 r.p.m.
		See if roughened in surface.too
-0.2	Replace cam shaft.	
+0.25	Adjust with shims	
Overall play: less than 0.3	Replace tappet complete.	
-0.075		

Section	Units	Parts	No.	Checkup Items	Numerical	Setting Standard	Limit of Repair (Clearance)
Fuel System	Fuel injection pump	Plungers (pump element)	88	Oil-tightness			
			89	Collar width Control sleeve groove with and standard clearance	7 / 7.02	+0.02~ +0.078	
			90	Concavity in spring seats			
		Plunger springs	91	Free length	49	+1~0	
			92	Setting length	44		
		Rack	93	Play of pinion on rack		0.15	
			94	Sliding resistance		At standstill: less than 150gr. At 1,000r.p.m: less than 50gr.	
		Delivery valves	95	Oil-tightness			
			96	Spring free length	32	±0.5	
			97	Injection starting intervals	90°	±30′	
			98	Lift to start injection	1.95	±0.05	(with rack at 21mm position)
			99	Adjustment of injection rates			

Pump Speed (r.p.m)	Rack Position (mm)	Injection Rate mm³/rev.cyl.	Unevenness mm³/rev. cyl
2,000	8.5	36 ~ 39	≦ 3
1,000	8.5	36 ~ 39	≦ 2
1,000	8.0	32 ~ 35	≦ 2
200	6.0	10 ~ 16	≦ 2

Pneumatic governor	Diaphragm chamber	100	Air-tightness	Drop from 500 to 480mmAq: not shorter than 10 sec.
	Spring data	101	

Main spring	Free length	
	Spring constant g/mm	
Angleich (torque) spring	Free length	
	Spring constant g/mm	
	Thickness of shims (A)	
	Thickness of shims (B)	

Limit of Use	Remedies	Remarks
not below 150kg/cm²	Replace plunger ass'y	Use good delivery valve. Put a pressure gauge of 300-400kg/cm², set rack at small injection rate and, running pump at 200 r.p.m., read the gauge. A reading above 150kg/cm² is satisfactory.
+0.15		
0.1		
-0.5		
0.25		
not less than 5 sec.	Replace delivery valve ass'y	Use good plunger. Set pressure at 150kg/cm² and bring control rack to non-injection position (0mm) to see how soon it will drop 10kg/cm². If it takes longer than 5 sec., oil-tightness is satisfactory.
-1		
		Tappet clearance: more than 3.
Conditions) Nozzle tips: ND-DN40SDND32 Injection pipes: 6Ø×1.6Ø×600 Injection pressure: 120 kg/cm² Delivery pressure: 2.0 kg/cm² Test oil: JIS No.2 gas oil		Making it inject into open air on injection pump tester.
		Running injection pump at 600 r.p.m.
		

Section	Units	Parts	No.	Checkup Items	Naminal	Setting Standards	Limit of Repair (Clearance)
Fuel system	Autotimer		103	Timing characteristics		Pump Speed (r.p.m.) / Angles of Lead ($\Delta\alpha^{\circ}$): 500 / 0; 600 / 0~0.75; 750 / 1.5~3.25; 2,000 / 7.75~9.25; 2,200 / 7.75~9.25	
			104	Thrust clearance	0.1~0.3		
Electric system	D.C Generator	Armature	105	Eccentricity(runout)		Less than 0.05	0.20
			106	Axial play		Less than 0.1	
			107	Sawying of pulley		Less than 0.4	
		Commutator	108	Diameter	37Ø		
			109	Eccentricity(runout)		Less than 0.05	0.20
			110	Mica depth		0.5~0.8	0.2
		Brushes	111	Height	17		
			112	Strength of springs	0.5kg	±15%	
			113	Performance: Non-load characteristics — Terminal Voltage 14V, Current 0A, Generator Speed below 2,100 r.p.m.			
				Performance: Load characteristics — Terminal Voltage 14V, Current 14.3A, Generator Speed below 2,600 r.p.m.			
				Performance: Motoring test — Terminal Voltage 12-volt battery, Current 7~8.5A, Generator Speed 1450~1650 r.p.m.			
	Relay	Charge switch relay	114	Point gap		0.4~0.6	
			115	Air gap		0.7~0.8	
			116	Switch-in voltage		13~14V	
			117	Switch-off voltage		above 8.2V	
		Constant voltage relay	118	Air gap		1.05~1.15	
			119	Non-load voltage regulation		14.5~15.5V at 3000 r.p.m. of generator speed	
	A.C Generator	Armature		Eccentricity(runout)		Less than 0.05	0.20
				Axial play		Less than 0.1	
				Sawying of pulley		Less than 0.4	
		Commutator		Diameter	33φ	±0.3	
				Eccentricity(runout)		0.35	
		Brushes		Height	13		
				Sfrength of springs	0.35kg		

Limit of Use	Remedies	Remarks
Error in intermediate angles between 2.5° at 750 r.p.m. and 8.5° at 2,000 r.p.m. must be less than ± 0.75°C.	Conditions) 1) Injection pump: 04290-32700 2) Nozzle opening pressure: 120 kg/cm² 3) Injection rate: 38mm³/rev.cyl.	Check visually as follows: 1) Anything wrong with springs? 2) Weight holder pins not loose?
		30668-30100 (DP200/12Z.R) Relay for joint-use: 30668-26200 (RH200/12D₂)
35Ø		
11.0		5 thick and 20 wide.
		Crank pulley pitch diam.: 120Ø Generator pulley pitch diam.: 71Ø Revolution ratio: 1.69 Charge alarm lamp gets alight below 880 r.p.m. of engine speed
		(Switched on)

Section	Units	Parts	No.	Checkup Items	Naminal	Setting Standards	Limit of Repair (Clearance)
				Performance: Non-load characteristics — Terminal Voltage 14V; Current 0; Generator Speed below 1,050 r.p.m			
				Performance: Load characteristics — Terminal Voltage 14V; Current 25A; Generator Speed below 2,500 r.p.m			
	Relay	Voltage regulator		Point gap		0.3~0.4	
				Air gap		0.8~1.2	
				Back-gap		0.8~1.1	
				Non-load voltage regulation		14.0~15.5V at 4,000r.p.m	
		Ramp relay		Air gap		0.9~1.2	
				Point gap		0.75~1.1	
				Back gap		0.75~1.1	
				Switch-involtage		0.5~3.0	
				Switch-offvoltage		4.2~5.2	
	Starter(12V)	Shaft and brackets		Commutator-side bracket outer diam. inner diam and standard clearance	14.2ϕ	+0.050~ +0.098	(0.2)
				Opposite bracket outer diam, inner diam. and standard clearance	12.2ϕ	+0.030 +0.070	(0.2)
				Pinion outer diam, pinion metal inner diam and standard clearance	14.2ϕ	+0.050 +0.098	(0.2)

Limit of Use	Remedies	Remarks
		30666-23108 M0 1 5B 10072

Section	Units	Parts	№	Checkup Items	Nominal	Setting Standard	Limit of Repair (Clearance)
Electric system	Starter (12V)	Shaft and brackets	125	Middle bracket outer diam, inner diam and standard clearance	22φ 23φ	+0.8~+0.942	
		Commutator	126	Diammeter	43Ø		
			127	Eccentricity (Runout)		less than 0.05	0.3
			128	Mica height		0.5~0.8	0.2
		Brushes	129	Height	16		
			130	Strength of springs	1.0 kg	±15%	
		Pinion	131	Gap between pinion stopper and pinion, when pushed ahead by lever		0.3 ~1.5	
			132	Switch-on voltage with pinion locked		6.5~10V	
			133	Axial gap to ring gear	3	± 1	
			134	Performance			

	Terminal Voltage	Current
Non-load running speed	11.3V	below 80A
Load charactoristics	10 V	200A
Binding torque	6.5V	above 500A

Electric system	Starter 24 V	Shaft and Brackets		Front metal inner diam shaft diam and standard clearance	12.2Ø	+0.030 ~+0.076	(0.2)
				Rear metal inner diam shaft diam and standard clearance	14.2Ø	+0.050 ~+0.098	(0.2)
				Center metal inner diam shaft diam and standard clearance	20.3Ø	+0.220 ~+0.353	(0.5)
		Commutator		Diameter	43Ø		
		Brushes		Height Strength of spring	19 2 kg	±15%	
		Pinion		Gap between pinion stopper and pinion Axial gap to ring gear	3	0.5~2.0 ±1	

Limit of Use	Remedies	Remarks
41 Ø		
10		6.5 thick and 19 wide

Starter Speed	Torque
above 3,000 r.p.m.	
1900 rpm	
0	more than 18 kgm

41 Ø		
13 1.5 ± 15% kg		

Section	Units	Parts	No.	Checkup Items	Nominal	Setting Standard	Limit of Repair (Clearance)
				Performance			

	Terminal Voltage	Current	Starter speed	Torque
Non- load running speed	23 V	below 50 A	above 4000 rpm	
Load characteristics	9 V	below 700 A		more- than 3.1kgm
Switch in voltage	below 16 V			

Limit of Use	Remedies	Remarks

CHAPTER 6 TOOLS

1 COMMON TOOLS

The following tools are supplied for routine servicing.

Ref. No.	Name	Parts No.	Uses
1	Socket wrench (27)	31391-02300	To screw nozzle holders
2	Socket Wrench (12)	31391-12500	To screw glow plugs
3	Handle (12φ x 250)	30091-01900	For above tools (1) & (2)
4	Thickness gauge	03714-63000	To check and adjust valve clearance
5	Cranking handle	30691-11800	To turn crank shaft

Other ordinary tools such as mentioned below will be necessary, too.

Double end wrenches (spanners) (8 ~ 26)

Adjustable wrench (monkey spanner) (10")

Pliers

Screw driver (150)

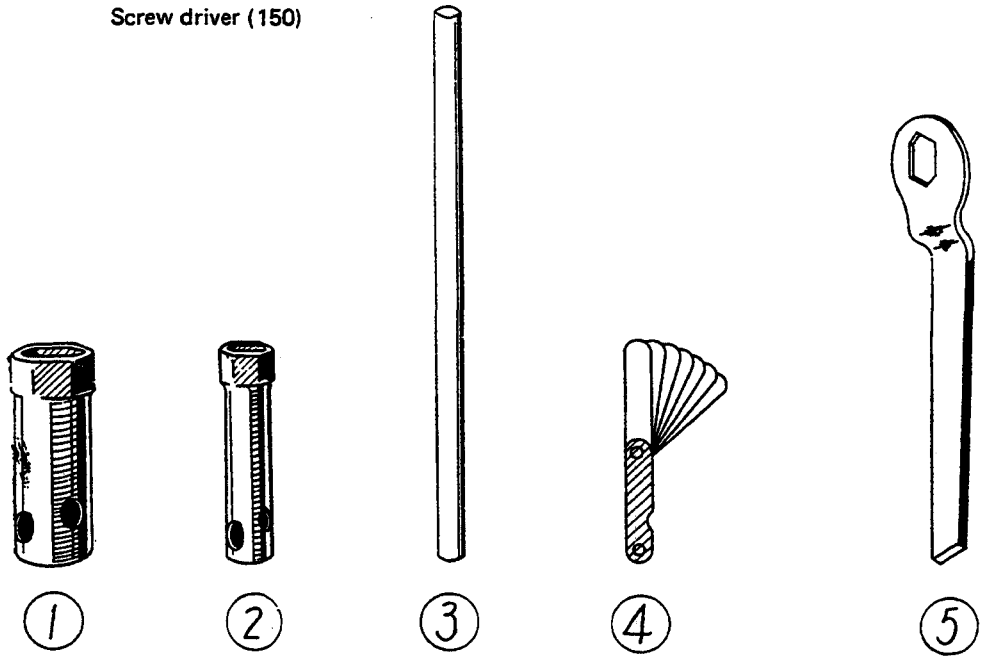


Fig. 6-1 Common Tools

2 SPECIAL TOOLS

For overhauling, the following special tools are available on request.

Key no.	Tool no.	Tool name	Q'ty	Application
1	30691–00300	Socket wrench	1	Camshaft thrust plate attaching bolt removal and installation
2	30691–11109	Adapter	1	Compression pressure measurement
3	30691–52100	Piston guide	1	Piston installation
4	30691–51600	Sleeve installer	1	Cylinder sleeve installation
5	31391–13010	Inlet insert calking tool	1	Inlet insert installation
6	31391–13020	Exhaust insert calking tool	1	Exhaust insert installation
7	31391–13600	Puller	1	Camshaft gear pulley removal
8	31391–10600	Valve guide installer	1	Valve guide installation
9	31391–10500	Valve guide remover	1	Valve guide removal
10	31391–12300	Rod	1	Use together with 8, 31391–10600
11	30691–11800	Cranking handle	1	Engine cranking
12	30891–02400	Idler shaft puller	1	Idler shaft removal
13	30091–01101	Extension universal	1	Injection pump installation
14	30091–07300	Idler bushing puller	1	Idler bushing removal and installation
15	30891–04500	Adapter	1	Camshaft bushing removal and installation
16	30891–04600	Adapter	1	Camshaft bushing removal and installation
17	30691–00801	Aligner	1	Rear oil seal alignment
18	31391–12900		1	Piston ring removal and installation
19	30691–13106	Guide	1	Crankshaft sleeve installation
20	30691–13200	Installer	1	Use together with 19, 30691–13106

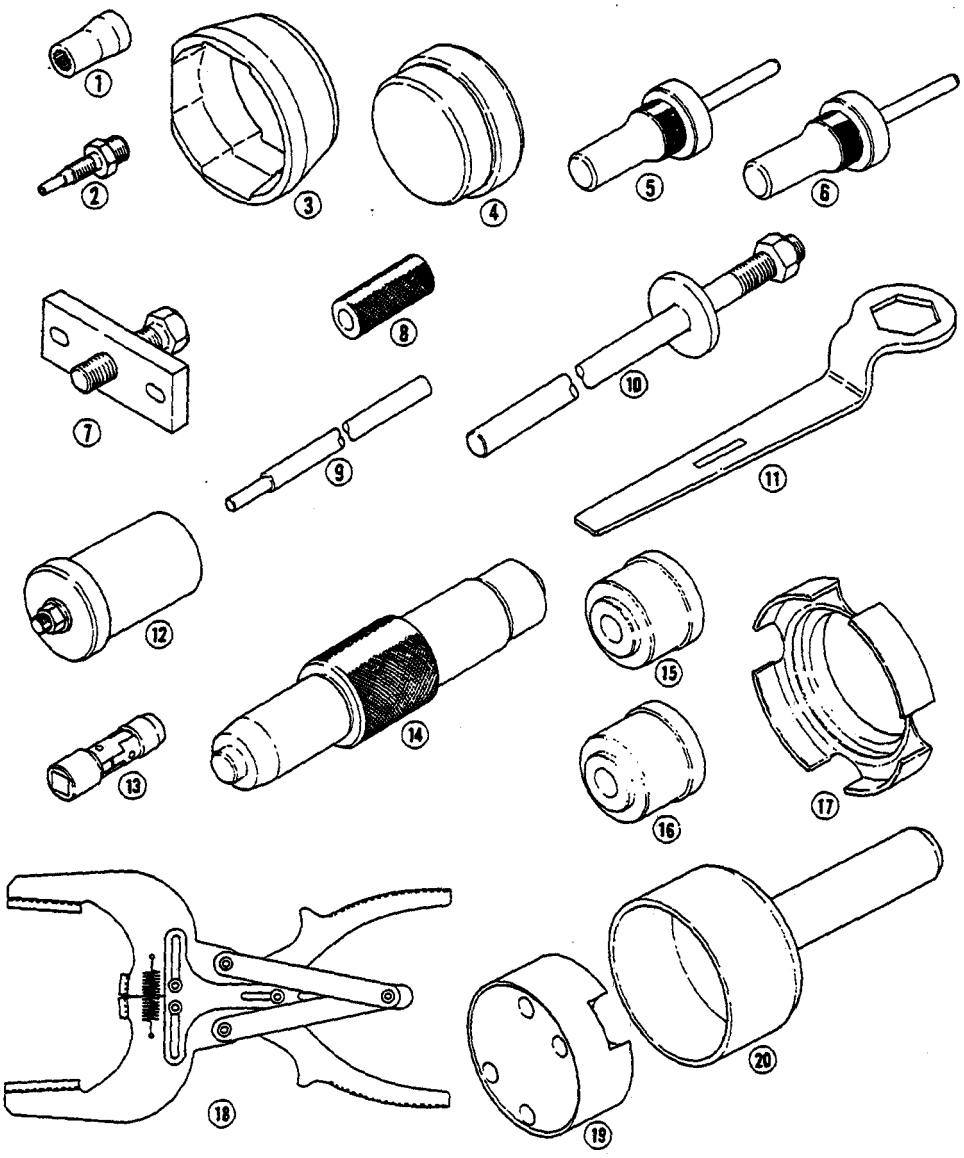


Fig. 6-2 Special tools

CHAPTER 7 MAIN SPECIFICATIONS AND PERFORMANCE

1 MAIN SPECIFICATIONS

Model:	4DQ50
Uses:	For motor vehicles, construction machine, general power etc.
Type:	4-cycle, water-cooled, swirl chamber type Diesel
Cylinder No. — arrangement:	4-in-line
Cylinder bore x stroke:	84mmφ x 94mm
Piston displacement:	2,084cc (127 cu. in.)
Compression ratio:	21 : 1
Firing order:	1-3-4-2
Direction of revolution:	Clockwise (as seen from timing gear case)
Fuel:	Gas oil (with greater cetane number than 45)
Engine oil:	Mineral oil (heavy duty type)
Lubrication system:	Forced-lubrication
Oil pump	Trochoid pump
Oil filter	Full-flow type with filter paper element
Cooling system:	Forced-circulation of cooling water
Water pump	Centrifugal pump
Thermostat	Wax type
Fuel system:	
Fuel injection pump	Bosch type, Model PES4A65B
Fuel injection nozzles	Bosch type, Model DN40SD
Governor	Pneumatic, Bosch type, Model EP/MZ60A Mechanical, Bosch type Model EP/RSV250
Autotimer (option)	Mechanical
Fuel filter	filter paper element
Air cleaner:	Dry type with filter paper element Oil bath type with pre-cleaner
Electric system:	12-volt system (common) 24-volt system (option)
Starter	Pinion shift type, 12V-2.0 kW Pinion shift type, 24V-2.0 kW
Glow plugs:	Sheathed type, 10.5V — 8.3A, 22.5V — 4.8A

Generator:	D.C., 12V – 200W A.C., 12V – 300W
Battery:	12V – 100Ah (12V) 12V–70Ah x 2 (24V)

2 PERFORMANCE OF 4DQ50 DIESEL ENGINE

For electric generator Rated output kW/rpm 50 ∞ 60 ∞	(P)	 14 ⓐ 1,500 17 ⓐ 1,800	 28 ⓐ 3,000
For construction equipment Rated output HP/rpm	(P)	 22.5 ⓐ 1,500	 ~ 45 ⓐ 3,000
For construction equipment Rated output HP/rpm	(C)	 36 ⓐ 2,200	 46 ⓐ 3,000
For Locomotive (Hr rated output HP/rpm	(L)	 54.5 ⓐ 3,600	
For water craft (pleasure boats) Max. output HP/rpm	(B)	 62 ⓐ 3,800	
For outomobiles Max. output HP/rpm	(A)	 66 ⓐ 3,800	

The above performances (exclude automobile and water craft use) are under standard conditions (atmospheric pressure: 760 mmHg, Temperature: 20°C, Humidity 65%), max. output is under condition with 760 mmHg pres., 15°C temp.

Performance tests in relation to the above are being carried out in compliance will JIS specifications.

In relation to applying to generators and general power plants, continuous day and night running operation should be performed within about 90% of the rated output.

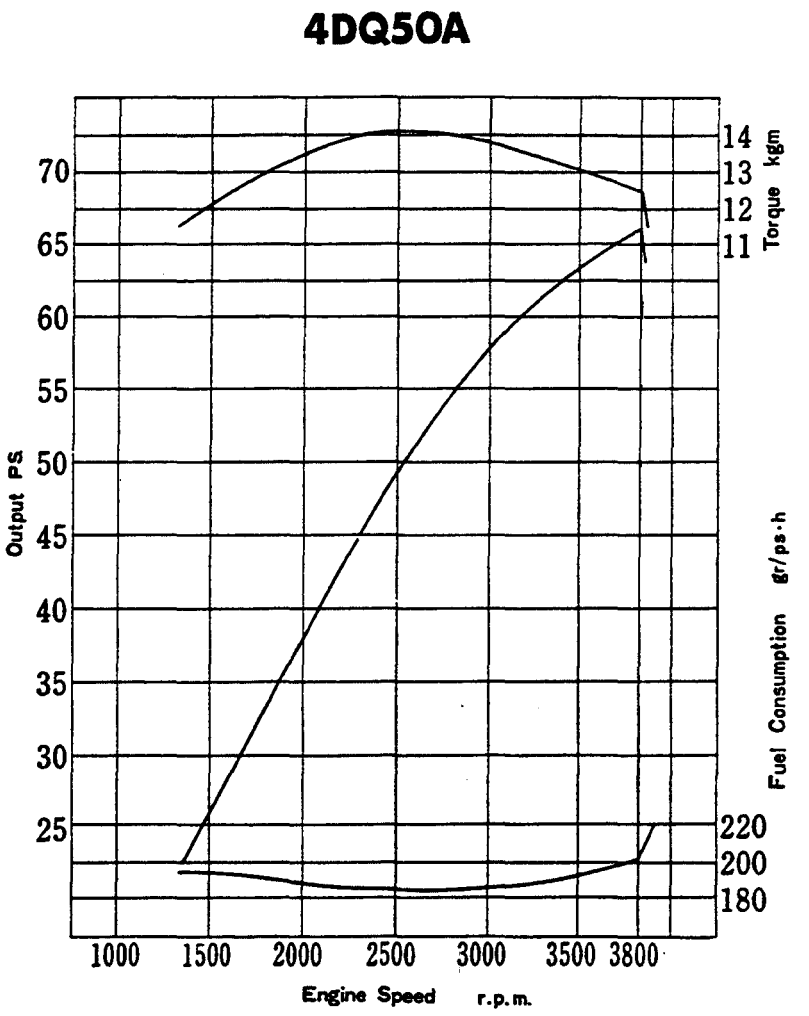
Concerning overload, 10% of the rated output is available for one hour.

Detail of specifications of marine engine is showed an another seat catalogue of Mitsubishi Marine Diesel.

Performance Curves of Model 4 DQ 50 A Engine

(for Motor Vehicles)

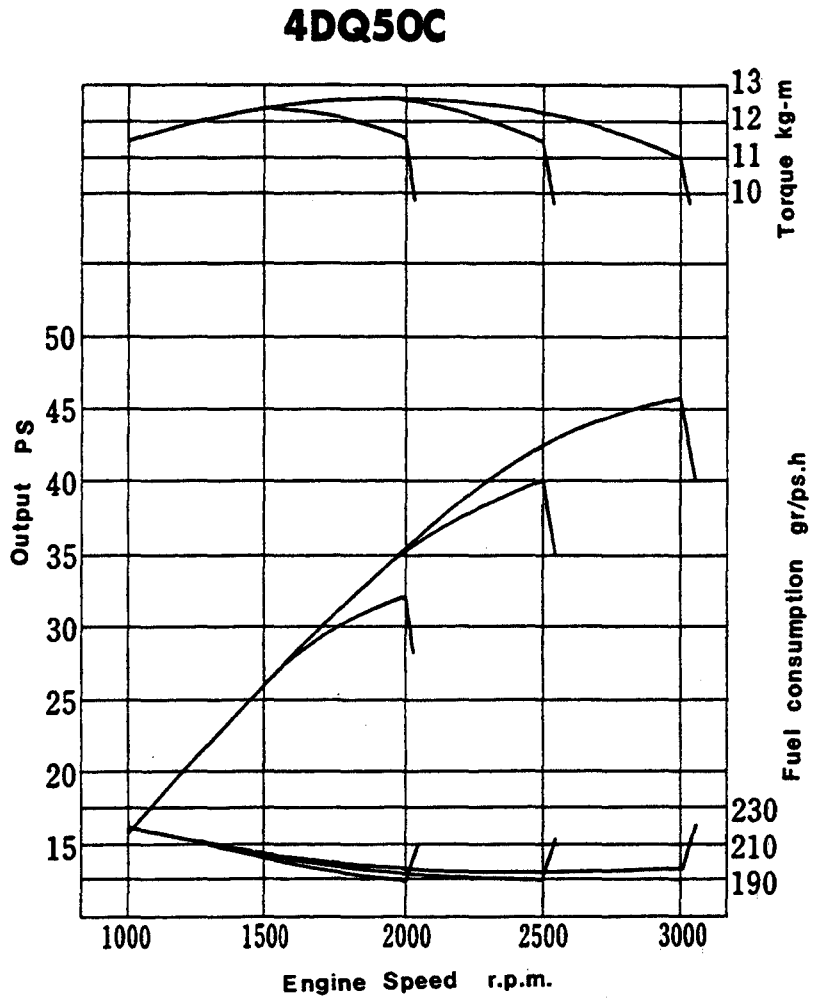
Equipped with fan, air cleaner and generator (not loaded)
Air temperature: 15°C, atmospheric pressure: 760mmHg,
relative humidity: 0%



Performance Curves of Model 4DQ50C Engine

(for Construction Machine)

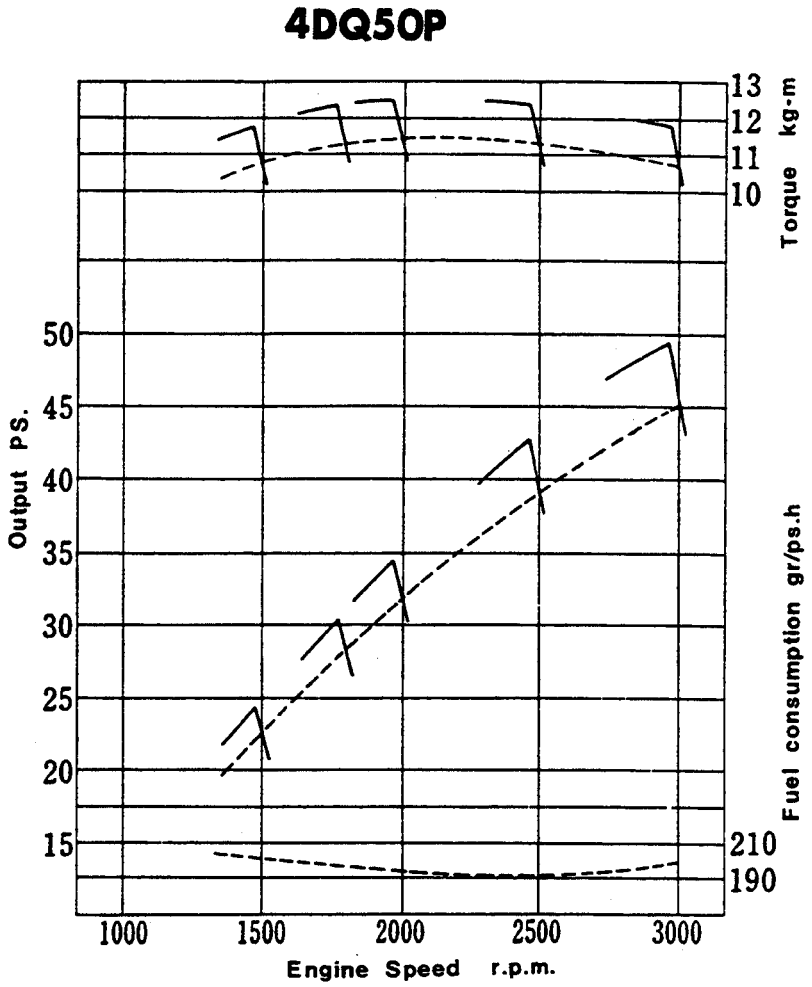
Equipped with fan, air cleaner and generator (not loaded)
Air temperature : 20℃, atmospheric pressure : 760mmHg,
relative humidity :65%



Performance Curves of Model 4DQ50P Engine

(for General Power)

Equipped with fan, air cleaner and generator (not loaded)
Air temperature : 20℃, atmospheric pressure : 760mmHg,
relative humidity :65%



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