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EXPLANATION OF SLIDES ON DIESEL ENGINE OF FISHING BOAT

by

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Preface

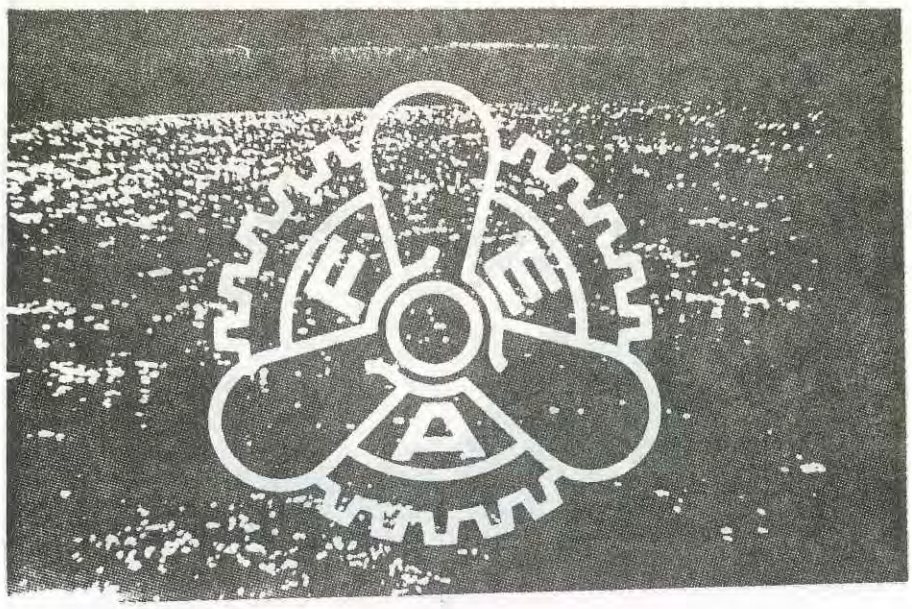
This reference book has been compiled from the script of the slide series "Diesel Engines in Fishing Boats", the text of which was translated into English from a Japanese production issued by the Fishing Boat Engineers Association of Japan.

I hope this script will prove to be a useful reference source for Marine Engineering trainees and students who wish to gain a broader understanding in this field.

I would like to thank Mrs. Hild, who not only edited my translation but also undertook the narration of the script.

February 1991

SHINZO YAMAMOTO



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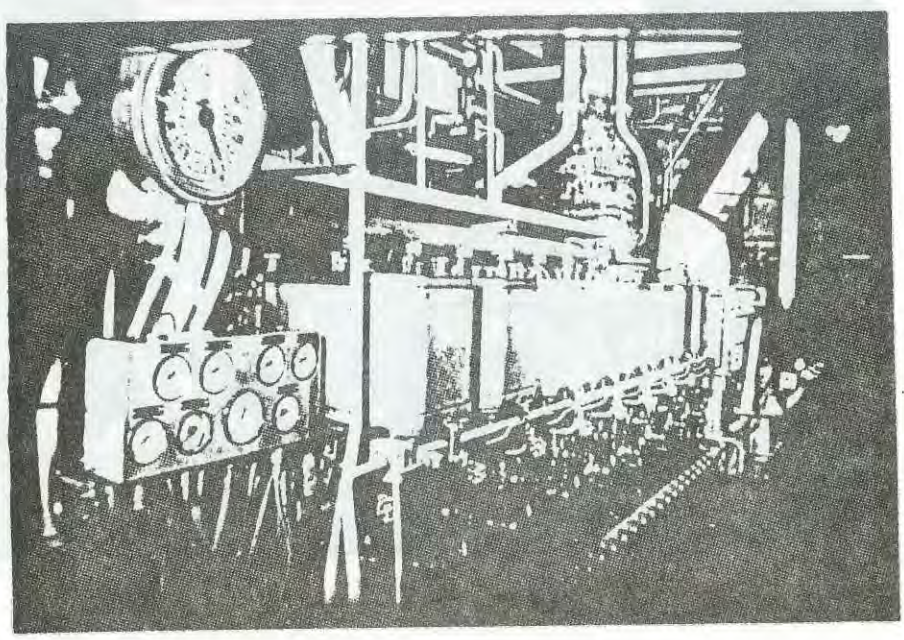

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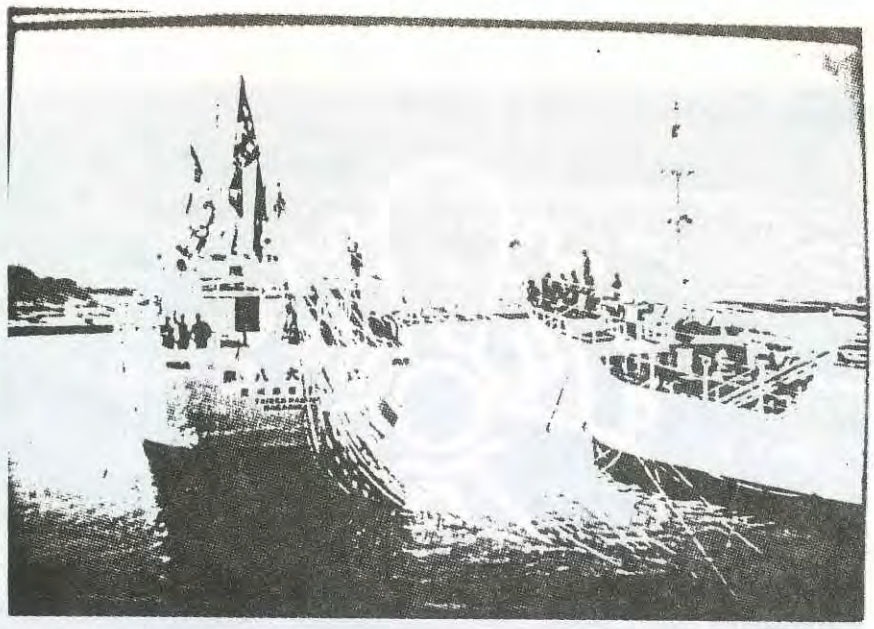

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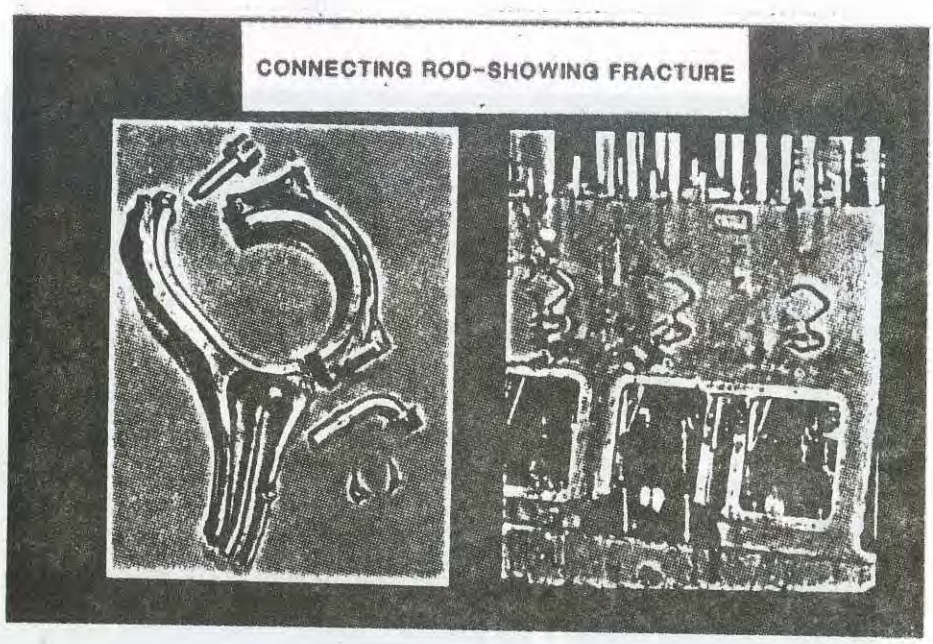

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EXPLANATION OF SLIDES ON DIESEL ENGINE OF FISHING BOAT

By : S. YAMAMOTO

P = Picture

N = Narration

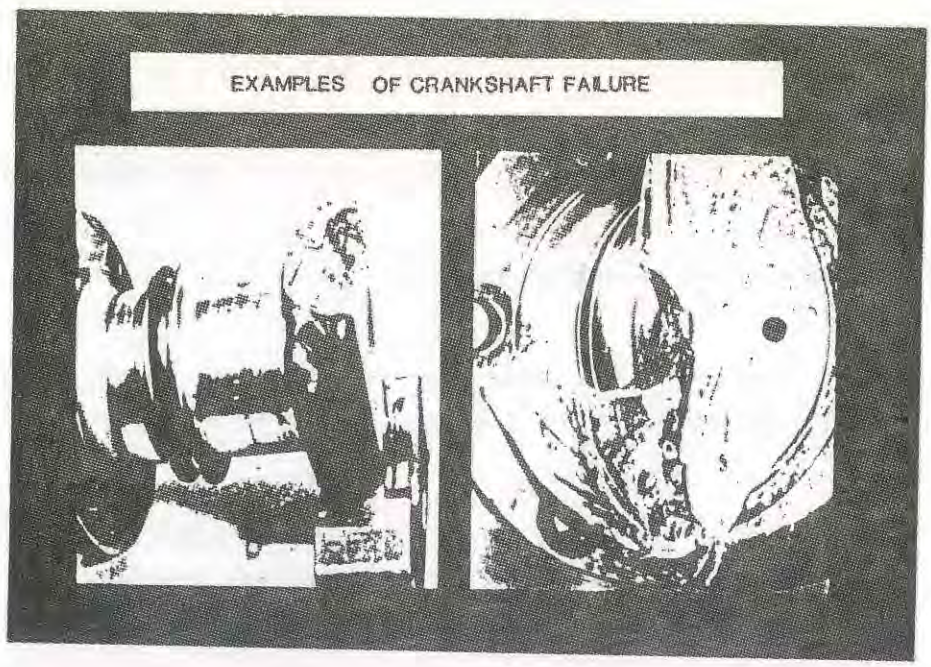
1. The picture shows an engine room.

2. The main engine of the boat can be compared to the human heart; careful maintenance is required in order to keep in good condition.

If the engine is to operate with 100 percent efficiency it is necessary to carry out a regular daily maintenance routine.

3. The following pictures show some examples of serious accidents which arise from the lack of attention or from carelessness on the part of the engine operator. Having a proper understanding of the responsibilities and the operator's dirty is very important.

4. One example is where a fault is found in the torque of the connecting bolt (it can either be too loose or too tight) causing the cylinder block to break; this is known as a "leg-showing" or, "rod-showing" accident.



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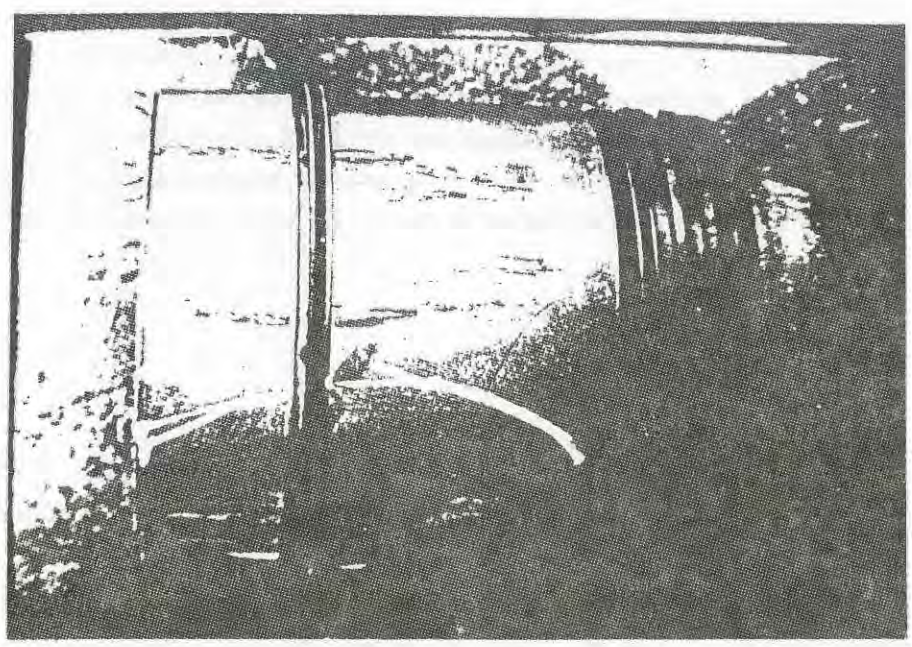

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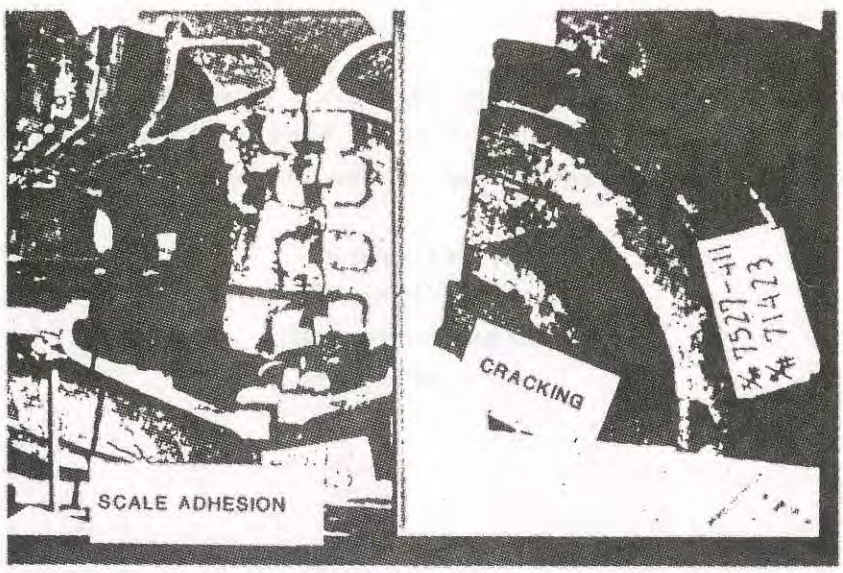
5. Another example is when an incorrect alignment of the crankshaft goes unnoticed; this will cause bending stress and material fatigue and will eventually lead to the crankshaft breaking.

fatique cracks
crank distortion
crank deflection
deflexion

6. This picture shows an example of piston seizure. This may be the result of one of three types of trouble associated with the lubricating oil:

- insufficient feed quantity
- a clogged filter or the presence of
- water or dirt in the lubricating oil



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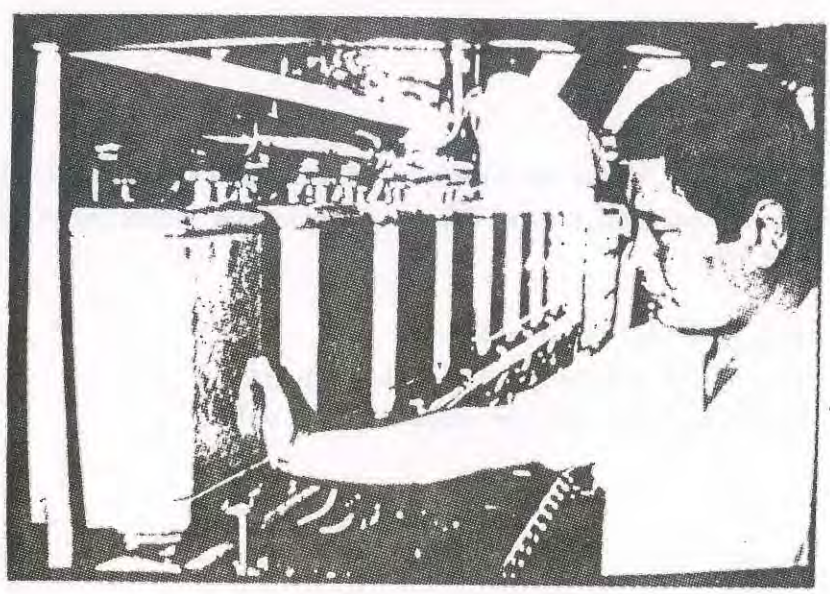

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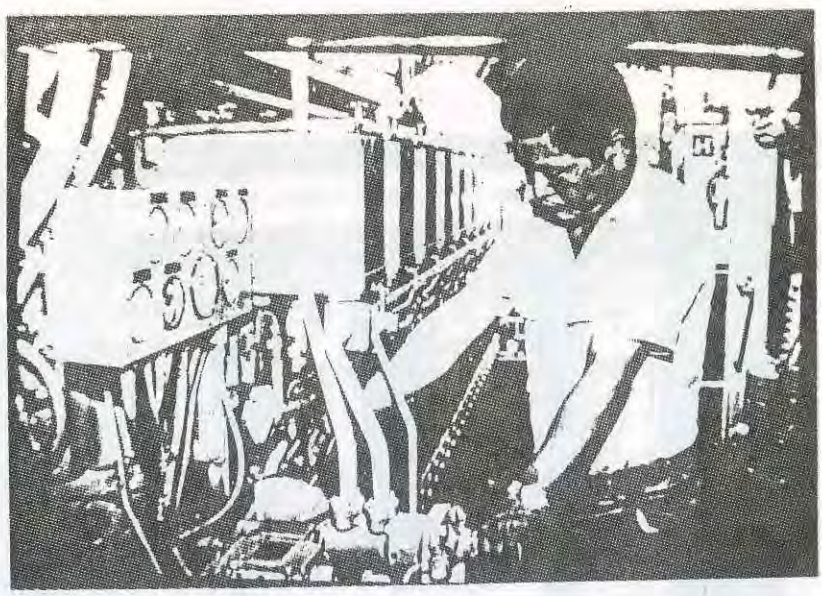

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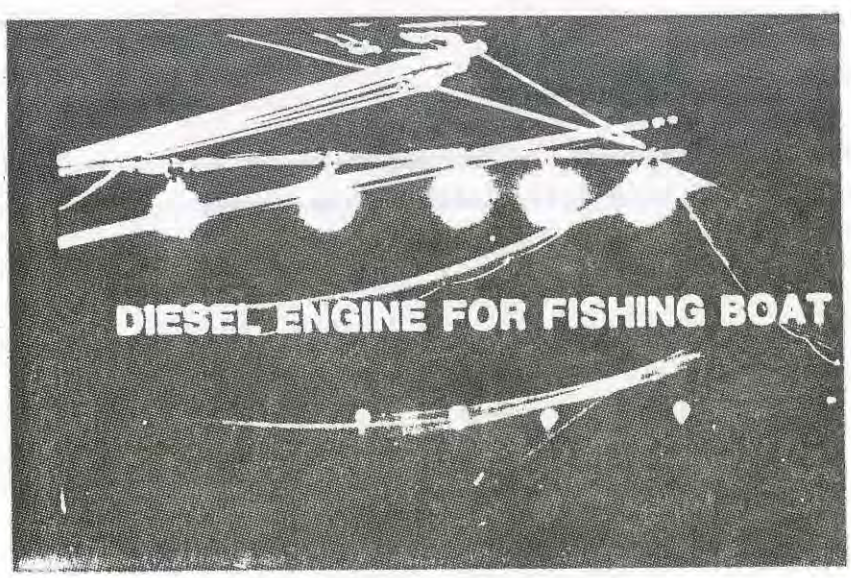

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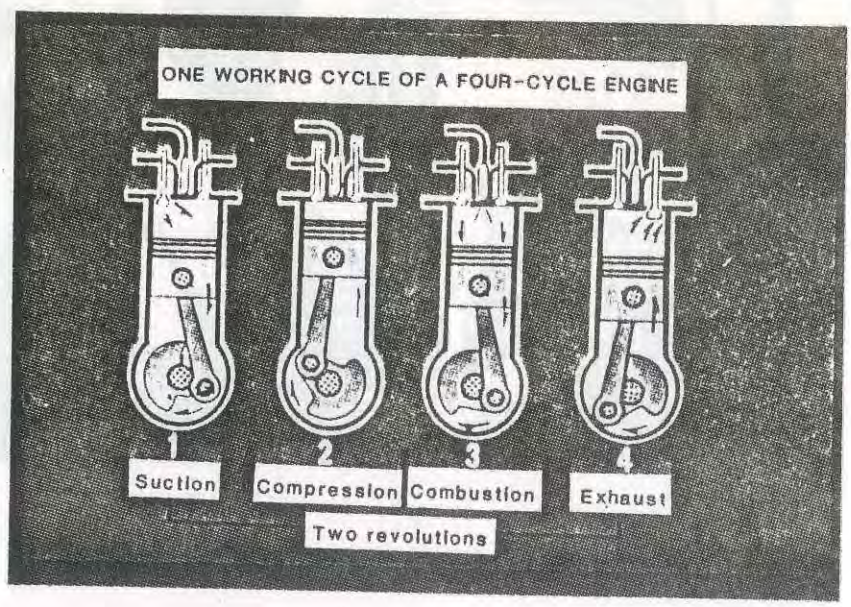


11

7. Scale from sea water;

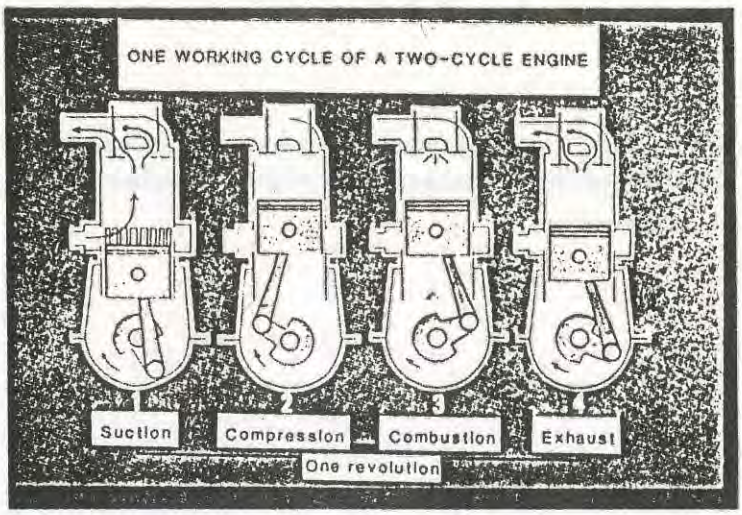
Sea water produces an accumulation of scale on the supercharger casing. This scale inhibits the proper conduction of heat and the supercharger casing cracks.

8. A good engine must well designed, be made of best materials, and during manufacturing process a high standard of quality control must be maintained.

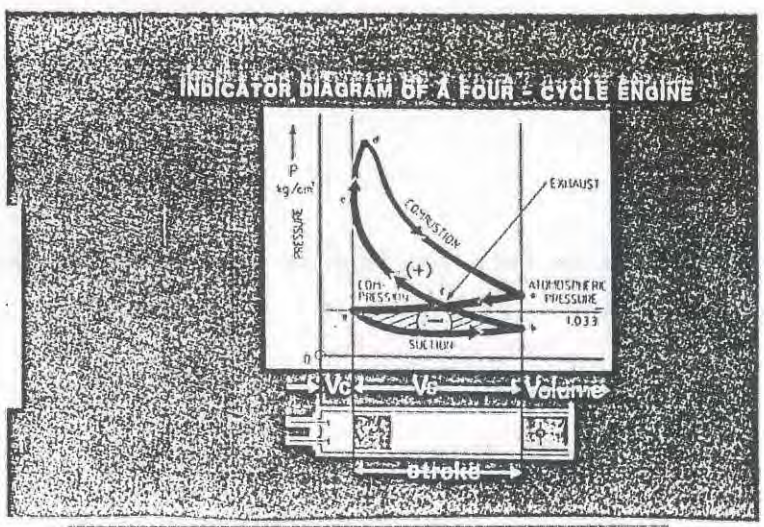
9. It is equally essential that the operator handles and maintains the engine correctly.

10. These slides are to help you improve your technical knowledge and increase your skill.

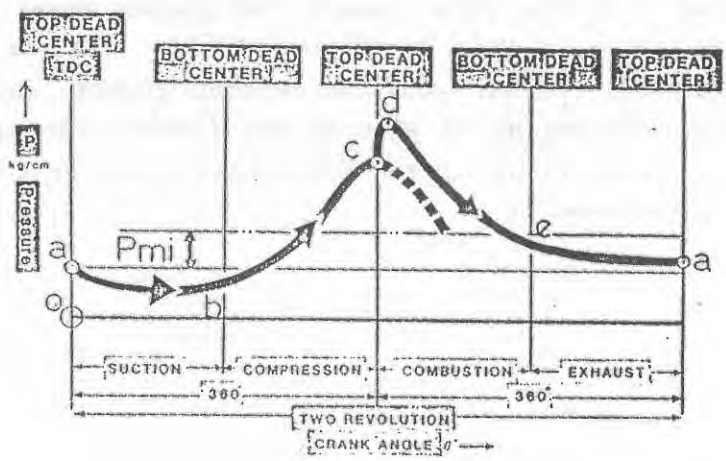
11. This picture shows a typical diesel engine, a 4-stroke (4 cycle) engine. In the first phase, the piston moves down to allow air to be drawn in; this is suction stroke. The piston then moves up to compress the air, the compression stroke; during the combustion stage the engine is working and finally the gases are exhausted. Two revolutions of the crankshaft complete one cycle of this working process.


ONE WORKING CYCLE OF A TWO-CYCLE ENGINE
Suction
Compression
Combustion
Exhaust
One revolution

12


INDICATOR DIAGRAM OF A FOUR - CYCLE ENGINE
P
kg/cm²
PRESSURE
EXHAUST
COMPRESSION
(+)
COM-
PRESSION
ATMOSPHERIC
PRESSURE
1.033
SUCTION
(-)
Vc
Vs
Volume
stroke

13

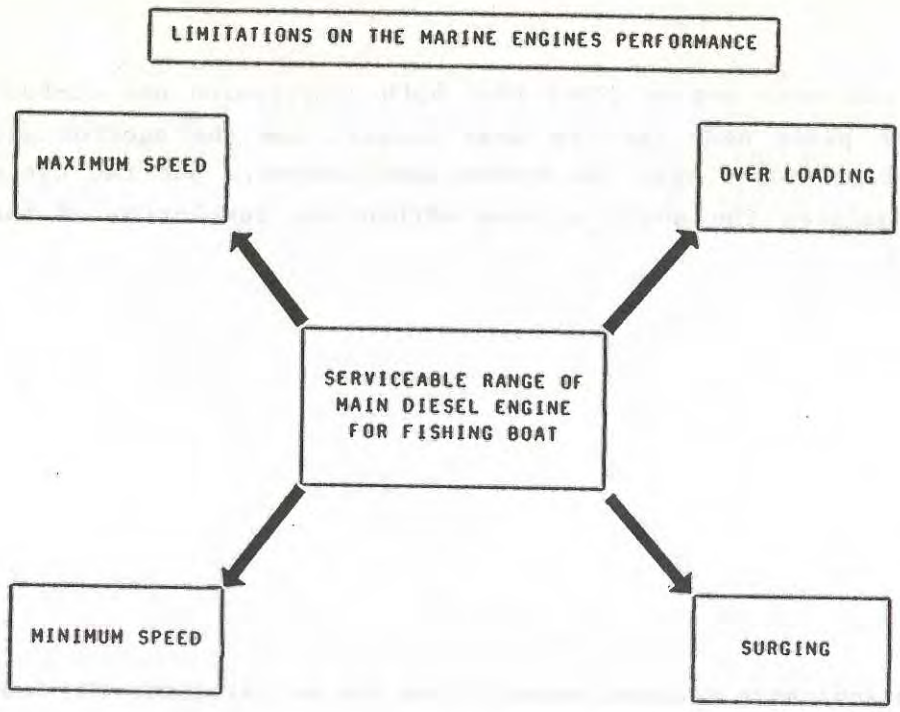

TOP DEAD CENTER
TDC
BOTTOM DEAD CENTER
TOP DEAD CENTER
BOTTOM DEAD CENTER
TOP DEAD CENTER
Pressure
kg/cm
Pmi
a
b
c
d
e
SUCTION
COMPRESSION
COMBUSTION
EXHAUST
360°
360°
TWO REVOLUTION
CRANK ANGLE

14

12. The two-cycle engine shows that both compression and combustion, take place near the top dead center, and the suction and exhaust stages occur near the bottom dead center. The two cycle engine completes the whole process within one revolution of the crankshaft.

13. This indicator diagram demonstrates how we calculate the mean effective pressure. The x-axis shows the stroke of piston and y-axis the pressure in the cylinder.

14. This pressure changes over time as shown in this diagram. The x-axis indicates time (in 1/1,000 seconds) and the change of pressure can be seen in the curve. For high speed small- or medium-sized diesel engines a "maximum combustion pressure" is measured rather than using the standard indicator diagram.



15

NORMINAL HORSE POWER & OUTPUT OF A MARINE ENGINE

NORMINAL DESIGNATION	DEFINITION	RATIO (%)
Continuous Service Rating (CSR)	Economical output for continuous cruising speed	80-95
Maximum Continuous Rating (MCR)	Maximum output for continuous safe cruising. The calculation of strength of the engine parts referrec to as the nominal output of the engine	100
Overload Power (rating)	This output is the capacity of the engine to function beyond the Maximum continuous rating for a specified period of time	105-110

16

15. There are some limitations in the marine engine's performance

1) The maximum speed limit states the number of revolutions permitted and this must not be exceeded.

2) Not exceeding the maximum continuous rating avoids overloading.

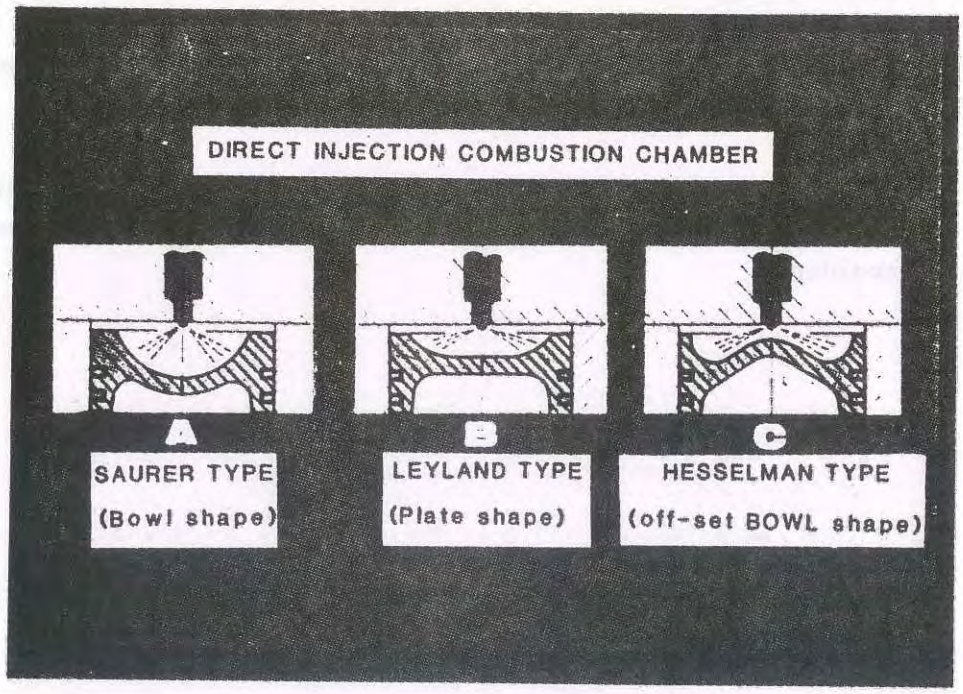
3) Low revolution speed with a high torque applied must be avoided as it causes surging in supercharged engine.

4) Using only 1/4 or 1/3 of the normal speed of engine, that is slow running, over a long period of time should be avoided.

16. This Table shows the relation between output and nominal horse power of the marine engine.

Firstly: it shows the continuous service rating

This indicates the economical output in order to maintain maximum efficiency of operation and maintenance. This rating is applies to normal cruising speeds.


DIRECT INJECTION COMBUSTION CHAMBER
A
SAURER TYPE
(Bowl shape)
B
LEYLAND TYPE
(Plate shape)
C
HESSELMAN TYPE
(off-set BOWL shape)

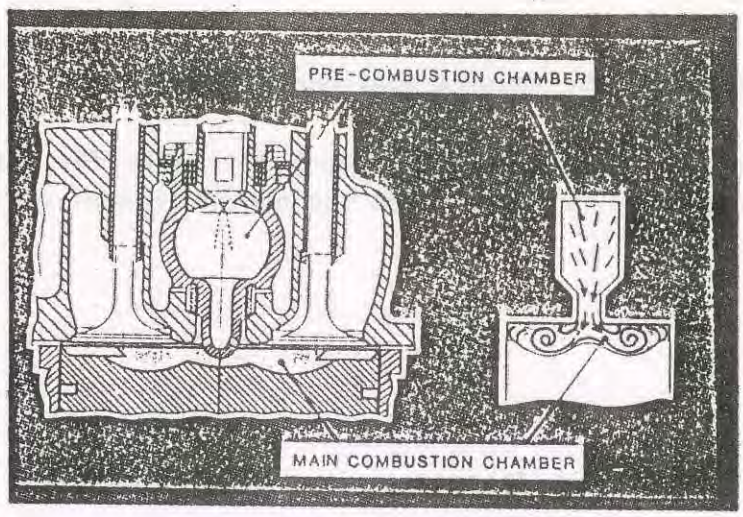
Secondly: the maximum continuous rating

This shows the maximum output advisable for safe cruising. This is usually referred to as the nominal output of the engine.

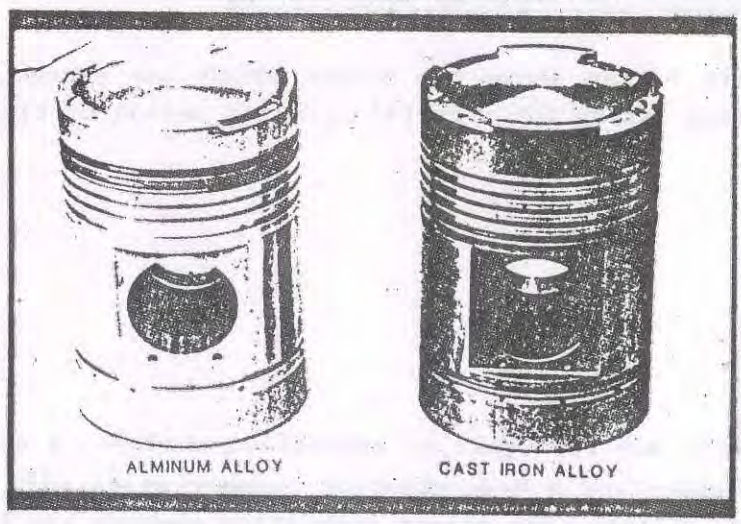
Thirdly: the overload power rating

This rating shows the output which can exceed the maximum continuous rating for a certain limited period of time.

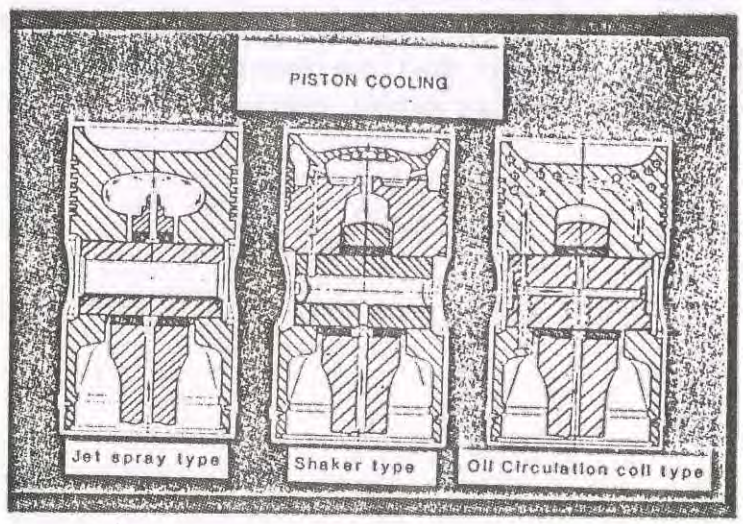
17. There are two types of combustion chamber: a direct combustion chamber and a precombustion chamber which will be shown in the next picture. The direct combustion chamber can be subdivided into 3 types. A, B and C, which are all known as direct injection types. The advantages of this type are; Simple construction, easy starting and economical fuel consumption. Type B, or C especially are widely used for high output engines.


PRE-COMBUSTION CHAMBER
MAIN COMBUSTION CHAMBER

18


ALMINUM ALLOY
CAST IRON ALLOY

19


PISTON COOLING
Jet spray type
Shaker type
Oil Circulation coil type

20

18. This is a precombustion chamber type of engine. In this engine a small proportion of the injected fuel is partially burnt with the bulk being jetted by its pre-combustion pressure to burn completely when mixing with new air in the main combustion chamber. This is commonly called two stage combustion. As combustion takes place in two stages, the combustion pressure is low, making this type of engine quieter.

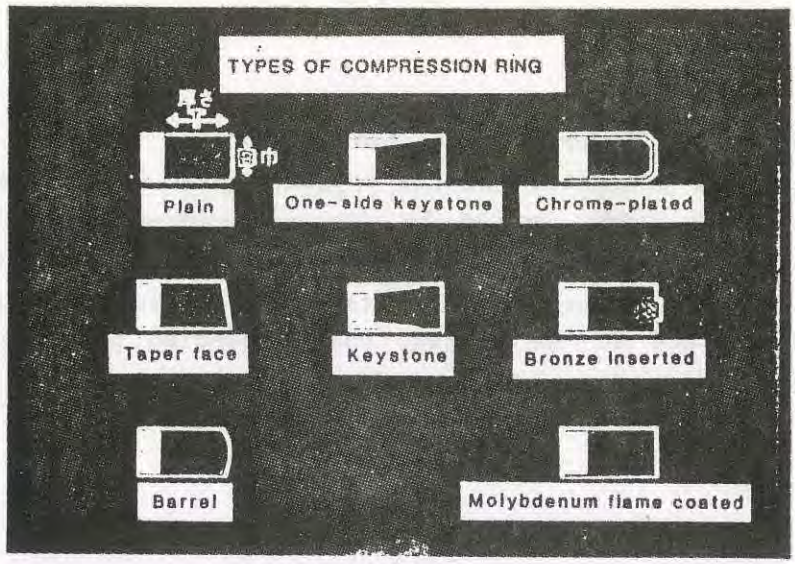
19. This picture shows the main moving parts of an engine. One of the most important parts is the piston; which not only must be able to resist combustion pressure and the heat load but also must be lightweight.

20. All engines must be provided with measures to reduce the thermal load which is generated in a highly turbocharged engine.

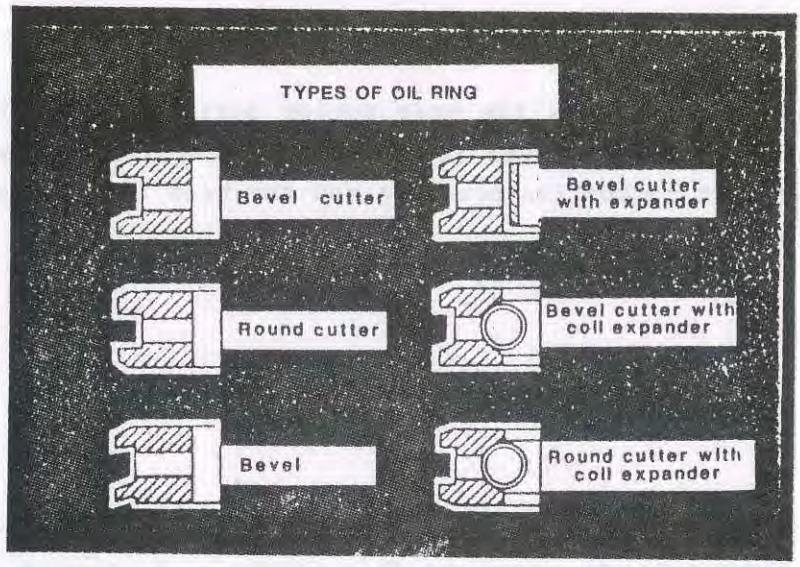
There are three ways to cool the piston:

a) jet cooling
b) shaker type cooling and
c) coil pipe cooling

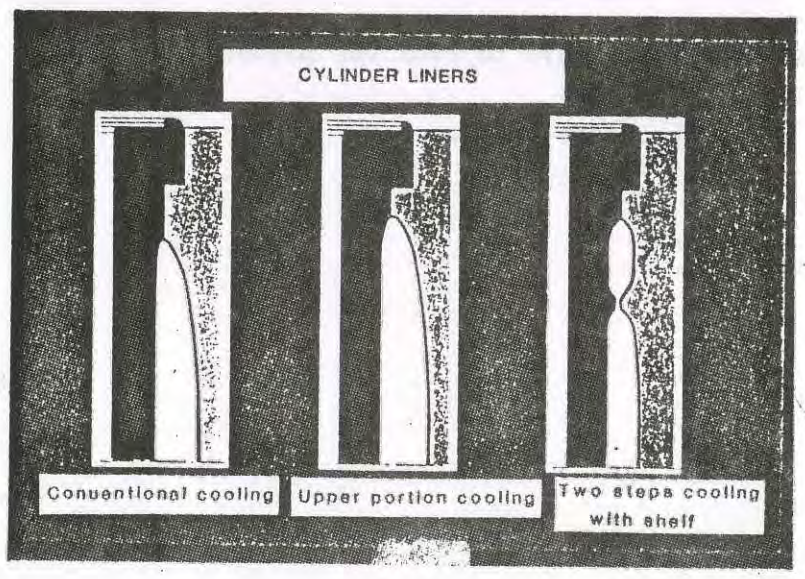
21


TYPES OF COMPRESSION RING
厚さ
巾
Plain
One-side keystone
Chrome-plated
Taper face
Keystone
Bronze inserted
Barrel
Molybdenum flame coated

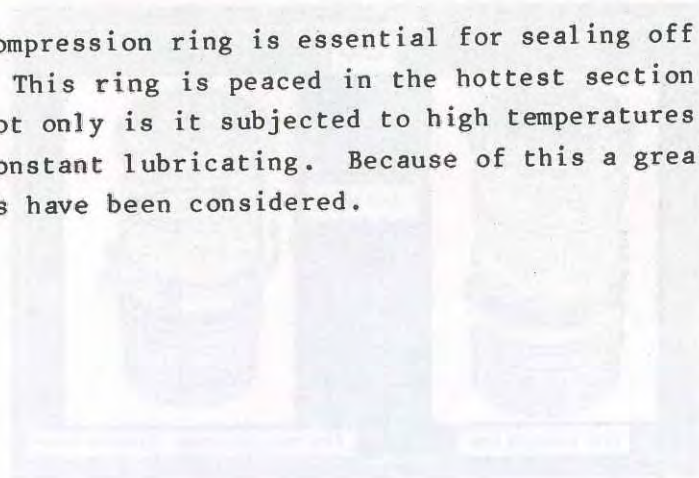
22


TYPES OF OIL RING
Bevel cutter
Bevel cutter with expander
Round cutter
Bevel cutter with coil expander
Bevel
Round cutter with coil expander

23

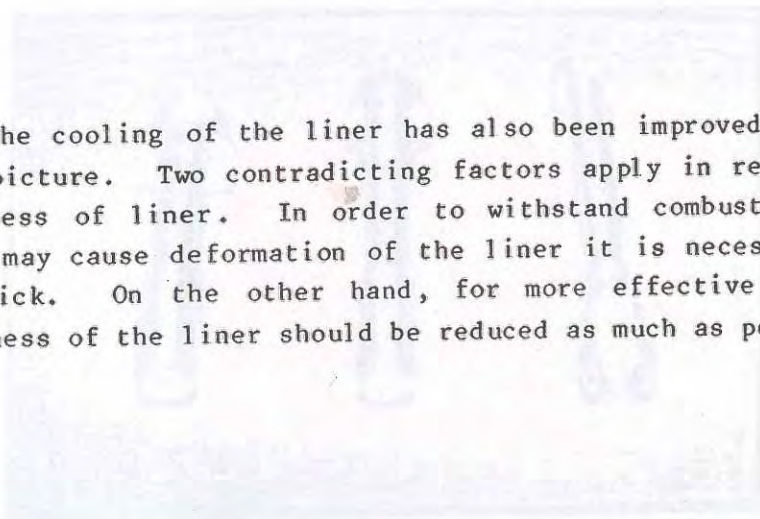

CYLINDER LINERS
Conventional cooling
Upper portion cooling
Two steps cooling with shelf

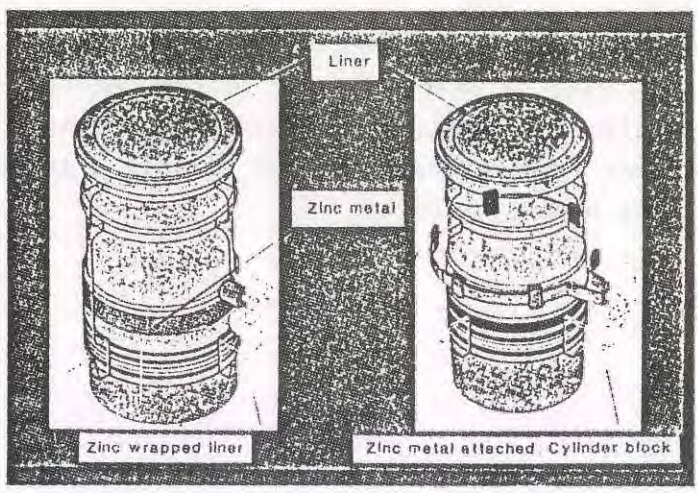
21. The compression ring is essential for sealing off the combustion gas. This ring is peaced in the hottest section of the ring belt and not only is it subjected to high temperatures but it also requires constant lubricating. Because of this a great variety of ring shapes have been considered.



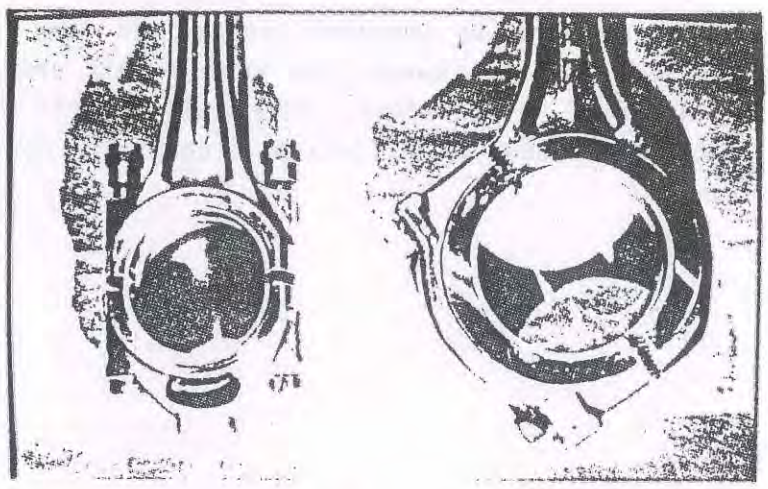
22. This picture shows an improved type of oil ring. As engines are getting increasingly faster, the need to oil cool the piston has also increased. Therefore, many improvements in the ring shapes have been made to efficiently control lubricating oil consumption.

23. The cooling of the liner has also been improved as shown in this picture. Two contradicting factors apply in respect to the thickness of liner. In order to withstand combustion pressure which may cause deformation of the liner it is necessary to make it thick. On the other hand, for more effective cooling the thickness of the liner should be reduced as much as possible.




Liner
Zinc metal
Zinc wrapped liner
Zinc metal attached Cylinder block

24



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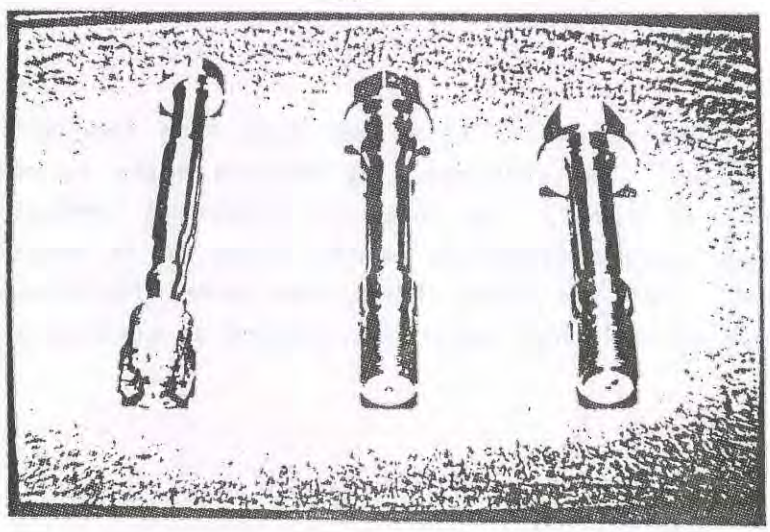


26

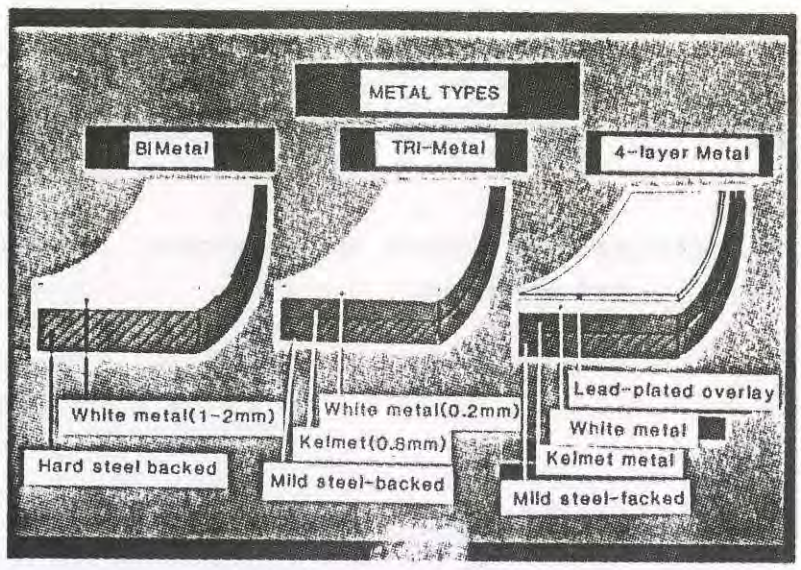
24. The liner should also be protected from corrosion by sea water in cases where a direct cooling system by sea water has been adopted.

In this picture two methods of protection, in which anti-corrosion zinc is used are shown.

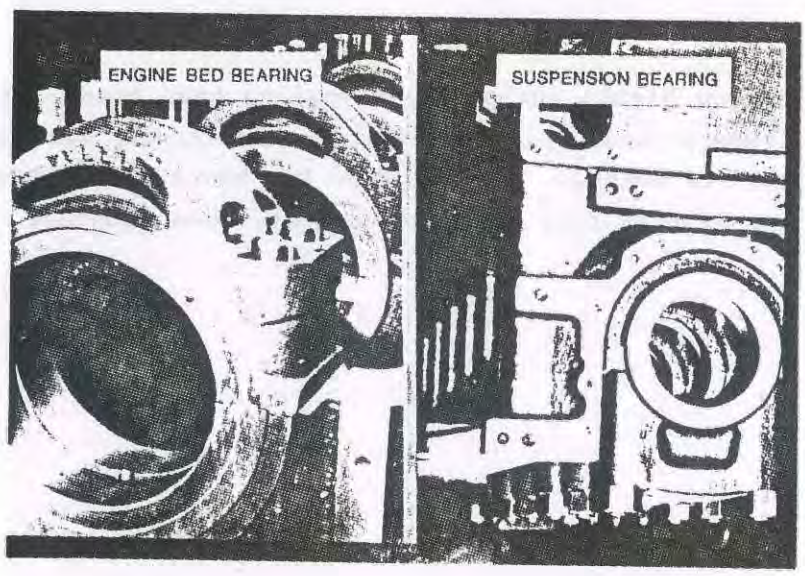
25. The modern highly turbocharged engines have been fitted with a larger diameter crank-pin to resist the increasing stress caused by the increased output. So, in order to remove the piston easily this angular jointed type has most commonly been adopted.

26. All these crank pin bolts have been made of High tension materials. Great care has been taken in the selection of materials and the manufacturing process involved.

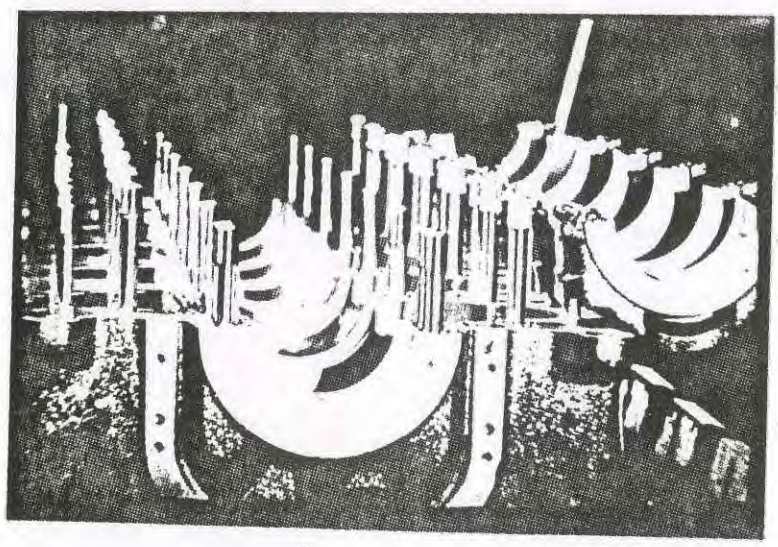
27


METAL TYPES
BiMetal
TRI-Metal
4-layer Metal
White metal(1~2mm)
Hard steel backed
White metal(0.2mm)
Kelmet(0.8mm)
Mild steel-backed
Lead-plated overlay
White metal
Kelmet metal
Mild steel-facked

28


ENGINE BED BEARING
SUSPENSION BEARING

29



27. In each case precision finished metals such as bimetal, trimetal and 4 layer metal have been used.

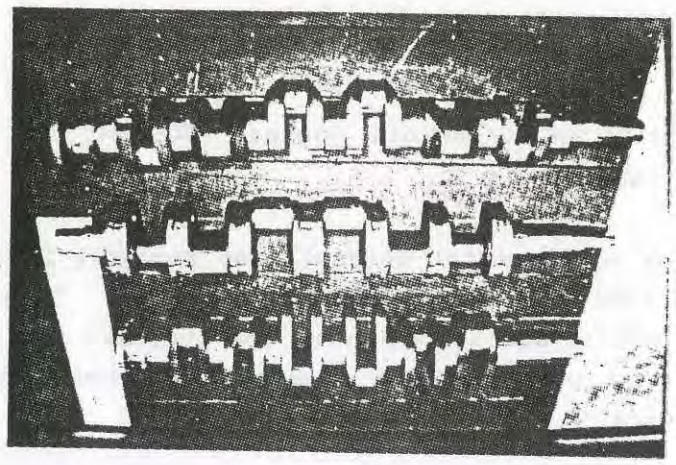
For hardening of crank-pin journal "Kelmet" or aluminium alloy metal is used.

The overlay on the metal bearings has recently been improved by the use of lead tin, or lead-indium plating. This not only provides good initial surface behavior and prevents the embeddability of small dirt particles but also improves the effectiveness of the lubrication.

28. This picture shows the main bearing:

The two kinds of bearing most commonly used are: The bed type and the hunger type. The bed type is fitted in slow or medium-speed engine, and the hunger type in high speed engines in accordance with the advantage.

29. The metals used for making the main bearings are the same as for the crankpin bearing; that is trimetal or the four layer metal. Precision manufacturing has now made it unnecessary to make adjustments during fitting by hand.



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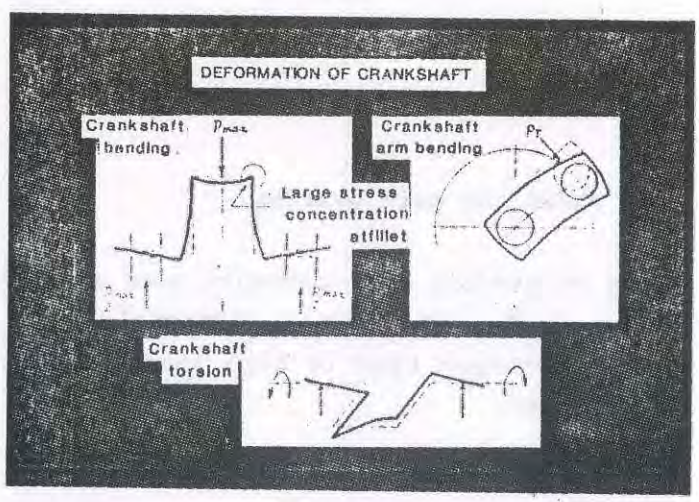
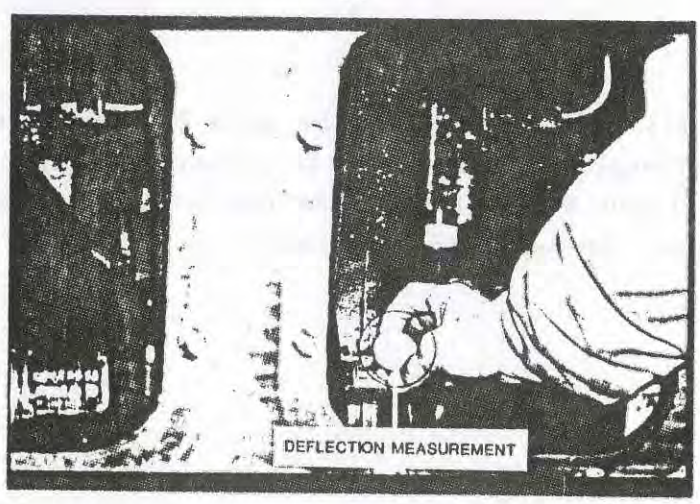
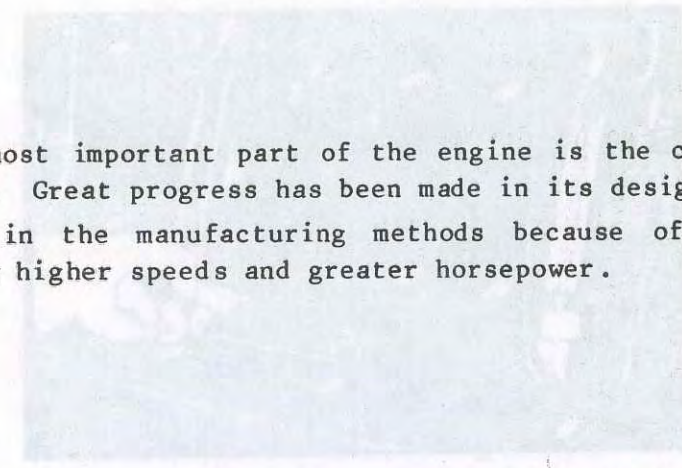

DEFORMATION OF CRANKSHAFT
Crankshaft bending
Large stress concentration at fillet
Crankshaft arm bending
Crankshaft torsion

31

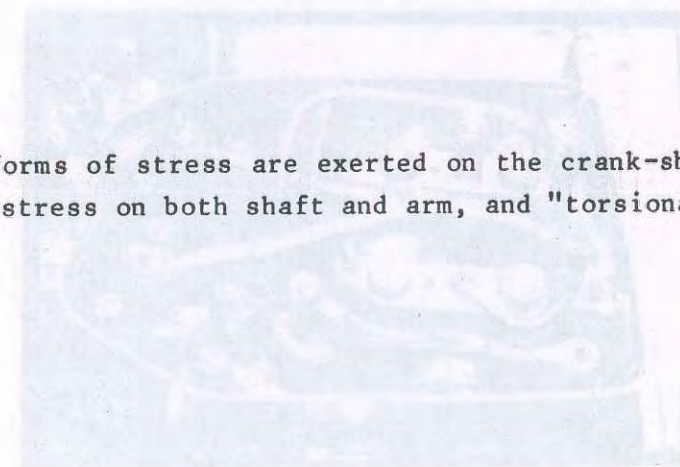

DEFLECTION MEASUREMENT

32

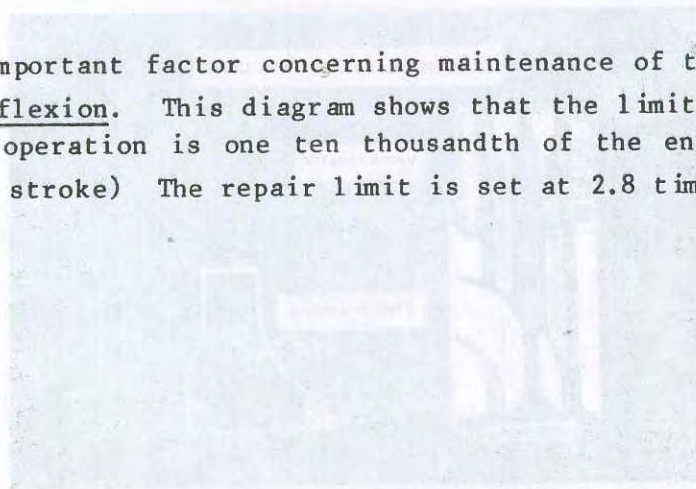
30. The most important part of the engine is the crank-shaft as show here. Great progress has been made in its design, the metals used and in the manufacturing methods because of the demands imposed by higher speeds and greater horsepower.

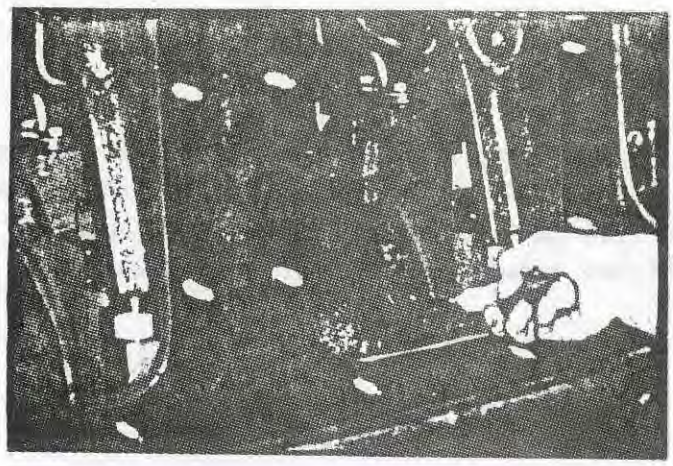


31. Two forms of stress are exerted on the crank-shaft; they are "bending" stress on both shaft and arm, and "torsional" stress.



32. An important factor concerning maintenance of the crankshaft is its deflexion. This diagram shows that the limit of deflexion for safe operation is one ten thousandth of the engines stroke. ($\frac{1}{10,000}$ x stroke) The repair limit is set at 2.8 times its safety limit.





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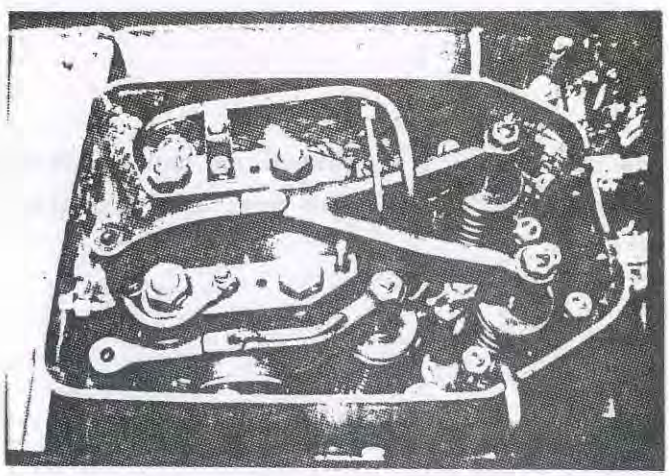

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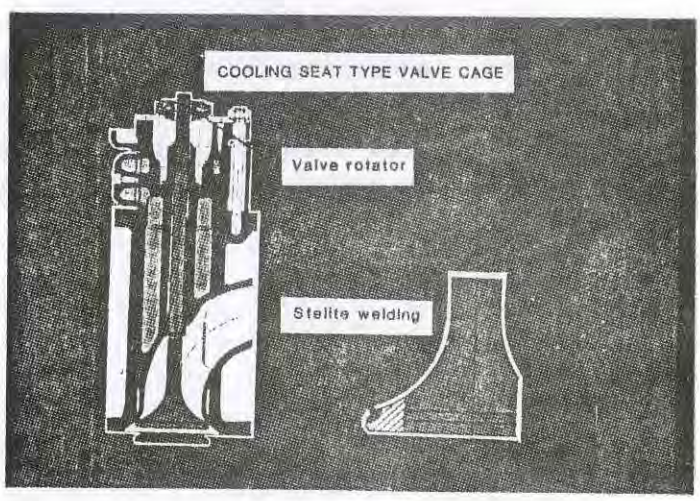

COOLING SEAT TYPE VALVE CAGE
Valve rotator
Stelite welding

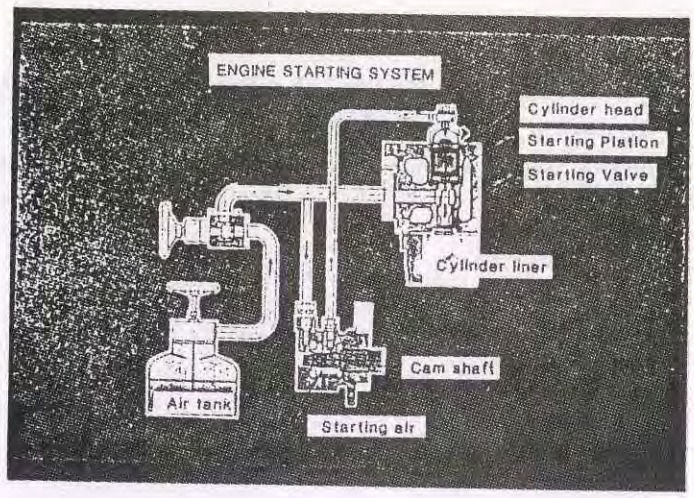
35

33. Here is the sealed crankcase chamber where the crank shaft and other moving parts are contained. The condition of the crank-pin or main bearing inside the case can be observed through this check window.

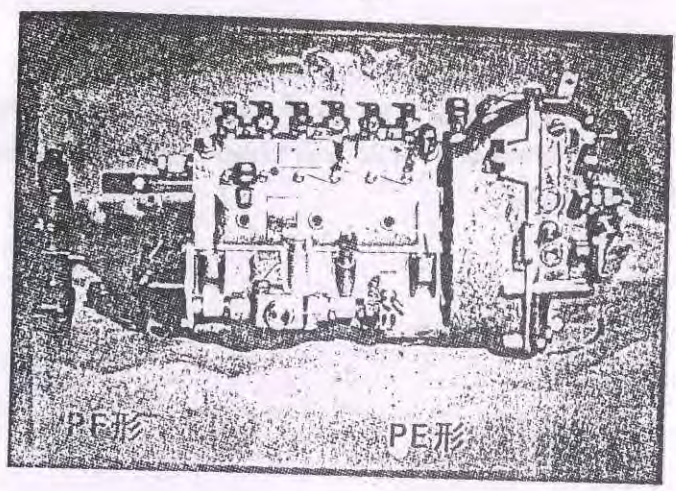
34. Modern highly turbocharged engines have 2 intake valves and 2 exhaust valves to increase the efficiency of both charging and exhausting, and to strengthen the cylinder head, as shown in this four valve cylinder head.

35. In the cylinder head or cover, the exhaust valve operates under extremely hard conditions and is protected from damage by the following:

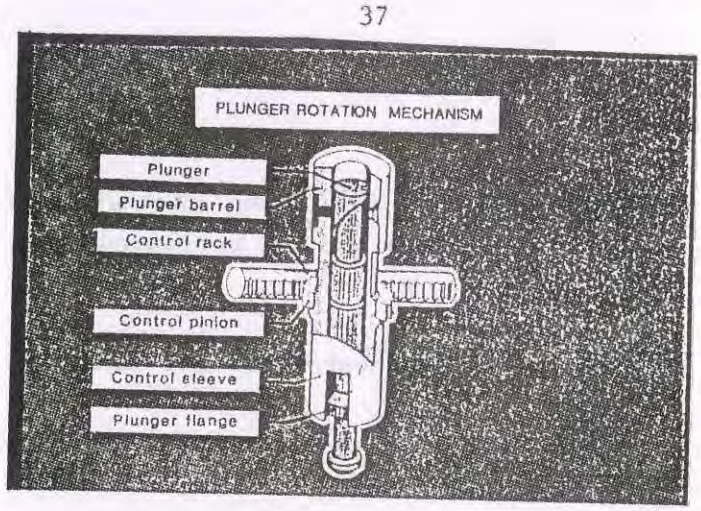
a) by welding a special heat-resistant metal on the valve face
b) by providing a rotating mechanism for the valve and
c) by cooling the valve sheet


ENGINE STARTING SYSTEM
Cylinder head
Starting Piston
Starting Valve
Cylinder liner
Cam shaft
Air tank
Starting air

36



37


PLUNGER ROTATION MECHANISM
Plunger
Plunger barrel
Control rack
Control pinion
Control sleeve
Plunger flange

38

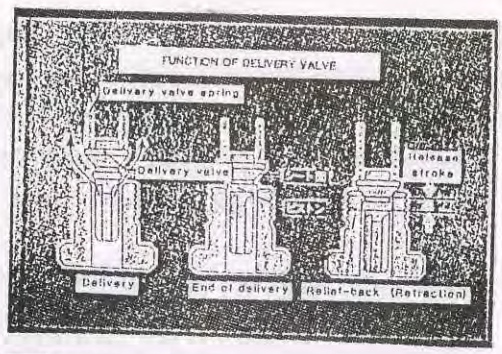
36. There are two engine starting systems; one is air-starting type and the other is an electric starting system. The air-starting type shown here, works by compressed air which operates a starting valve mounted on the cylinder head, via a distributing valve connected by a pipe to a high pressure air tank.

The electric starting system not shown here operates uses a starting motor with a small pinion which drives the flywheel to start the engine.

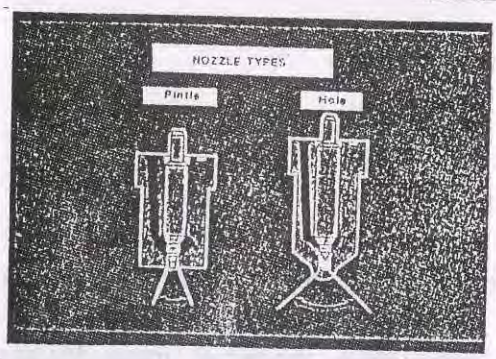
37. This is a Bosh type fuel pump. It can be further sub-classified into a PE or PF type pump. The PE type is generally used in small engines; this integral pump drives all cylinders in one pump stand. For medium-sized engines the PF type fuel pumps are mounted on each cylinder separately.

38. To control the quantity of fuel the injection nozzle is adjusted in both the lead part of plunger and in the discharging hole position. In other words, it is adjusted by changing the effective stroke of the fuel rack movement; which drives the plunger and rotates its motion to change the lead.

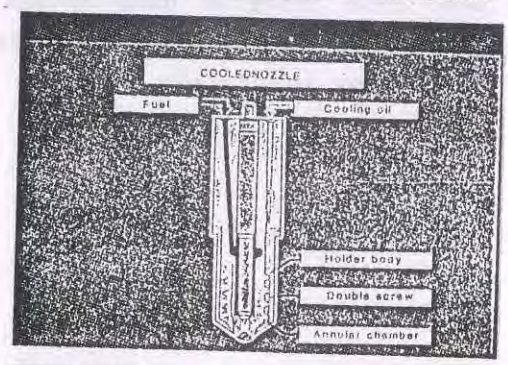
39


FUNCTION OF DELIVERY VALVE
Delivery valve spring
Delivery valve
Release stroke
Delivery
End of delivery
Relief-back (Retraction)

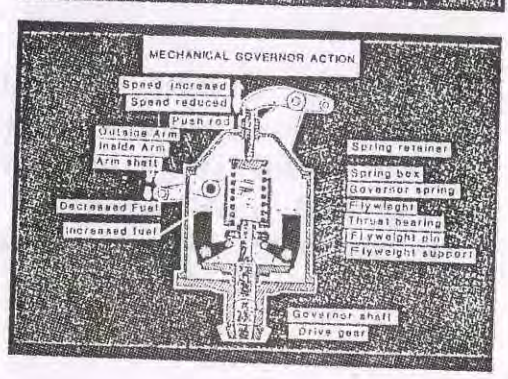
40


NOZZLE TYPES
Pintle
Hole

41


COOLEDNOZZLE
Fuel
Cooling oil
Holder body
Double screw
Annular chamber

42


MECHANICAL GOVERNOR ACTION
Speed increased
Speed reduced
Push rod
Outside Arm
Inside Arm
Arm shaft
Decreased Fuel
Increased fuel
Spring retainer
Spring box
Governor spring
Flyweight
Thrust bearing
Flyweight pin
Flyweight support
Governor shaft
Drive gear

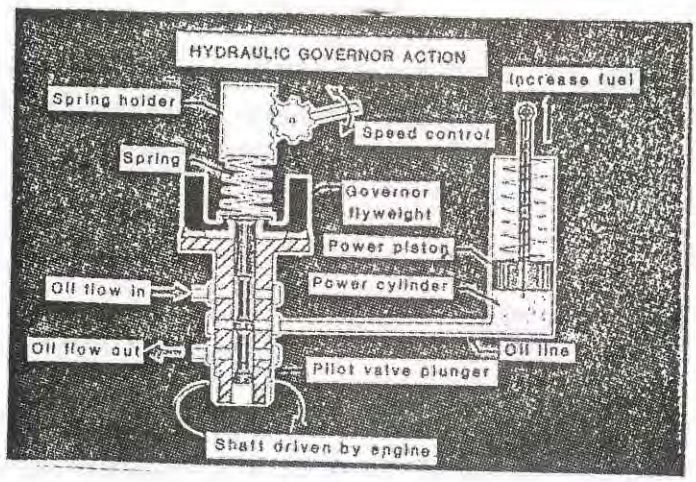
39. The delivery valve of the injection pump contains a suction piston whose function is to release the pressure in the fuel pipe to ensure instant fuel injection without leakage and to stop the fuel spray without a dribble.

40. The two types of injection nozzle are the pintle type which is used in the precombustion chamber engine and the hole type in the direct injection chamber engine.

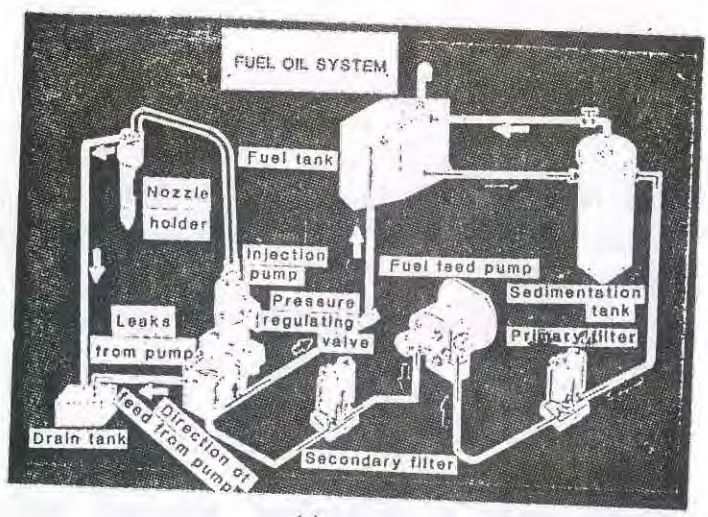
41. The nozzle is cooled to prolong its life and prevent the deposit of carbon flower. Oil or water can both be used as coolants for the nozzle.

42. This picture shows a mechanical governor which works as follows:

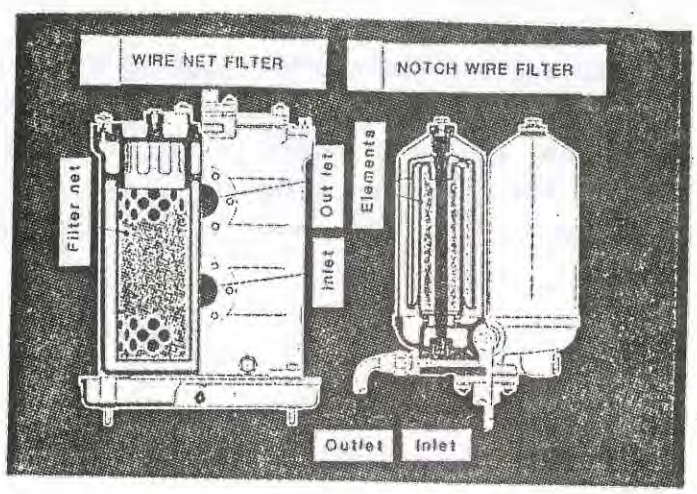
When the centrifugal force of the rotating flyweight reflecting the engine speed is exactly balanced by the force of the spring, the mechanical governor control sleeve assumes a position where it determines the fuel-regulating mechanism setting, allowing the engine speed to remain constant as long as the load does not change.


HYDRAULIC GOVERNOR ACTION
Spring holder
Increase fuel
Speed control
Spring
Governor flyweight
Power piston
Power cylinder
Oil flow in
Oil flow out
Oil line
Pilot valve plunger
Shaft driven by engine

43


FUEL OIL SYSTEM
Fuel tank
Nozzle holder
Injection pump
Fuel feed pump
Sedimentation tank
Pressure regulating valve
Leaks from pump
Primary filter
Drain tank
Direction of lead from pump
Secondary filter

44


WIRE NET FILTER
NOTCH WIRE FILTER
Filter net
Out let
Elements
Inlet
Outlet
Inlet

45

43. And this a hydraulic governor

The hydraulic governor's function is the same as that of the mechanical governor. It also mechanically balances the power of centrifugal force of the flyweight and the spring.

However, it differs from the mechanical governor in that it can generate a relatively large amount of force through the hydraulic servo-mechanism in spite of its small size.

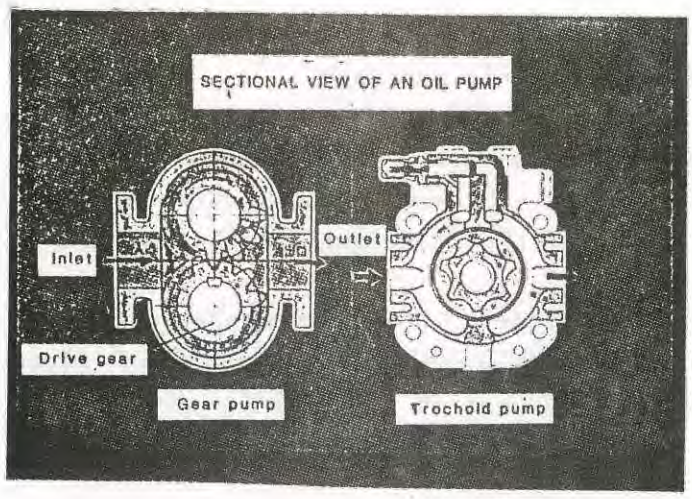
44. This picture shows a fuel system

Two filters are fitted in this system to prevent any dirt, sand, scale, or sludge etc. from getting into the engine.

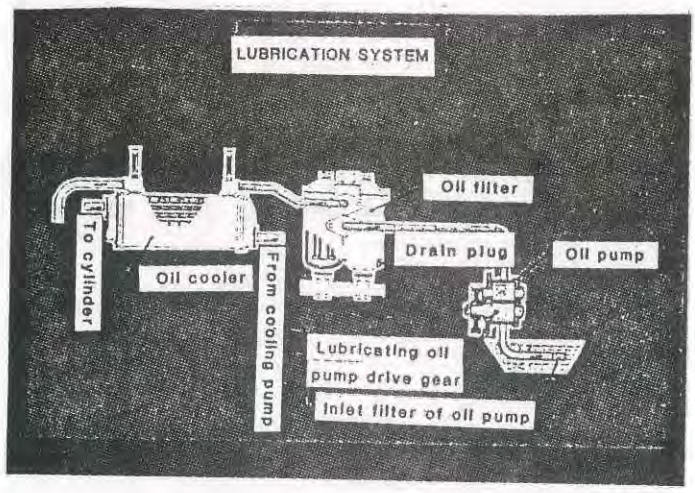
45. Two of the several kinds of filters are shown here:

(a) Wire net
(b) Notch wire. Other filters include
(c) "Auto-Klean" metal-edge filter
(d) Paper filter
(e) Rock wool filter, which are not illustrated.

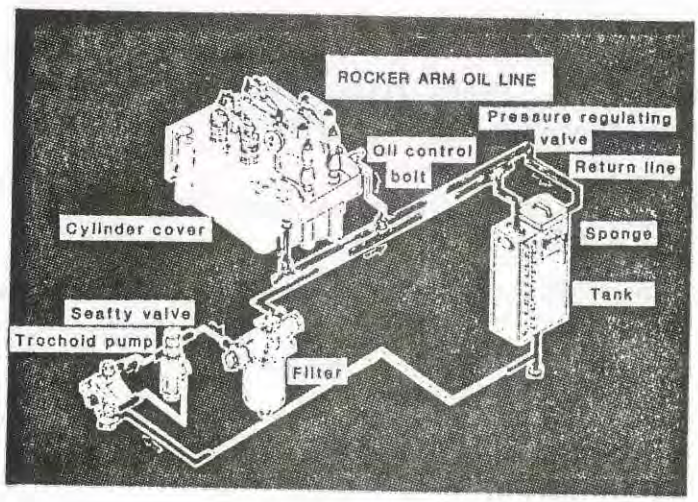
Each of these filters has its own characteristic advantages.


SECTIONAL VIEW OF AN OIL PUMP
Inlet
Outlet
Drive gear
Gear pump
Trochoid pump

46


LUBRICATION SYSTEM
To cylinder
Oil cooler
From cooling pump
Oil filter
Drain plug
Oil pump
Lubricating oil pump drive gear
Inlet filter of oil pump

47


ROCKER ARM OIL LINE
Pressure regulating valve
Oil control bolt
Return line
Cylinder cover
Sponge
Tank
Seafty valve
Trochoid pump
Filter

48

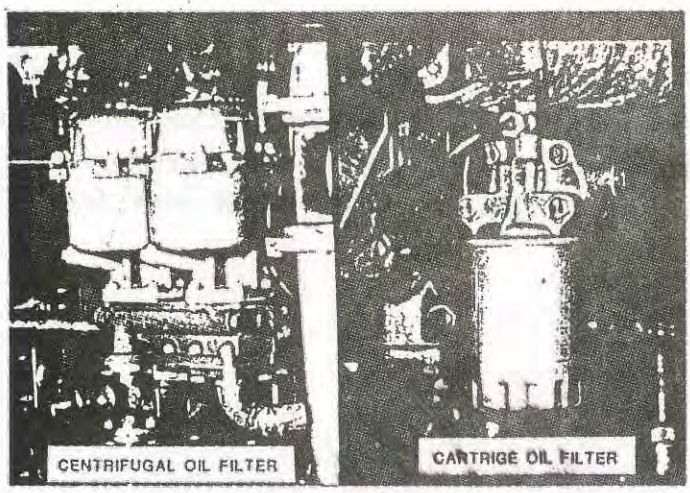
46. One feed pump in this picture is a gear pump the second is an internal-gear pump (a trocoidal-pump) They both force the fuel under pressure into the injection pump, they prevent the temperature from rising excessively and prevent foam from forming in the fuel pipe.

47. This is the wet sump type of lubricating system, where the oil is stored inside the crankcase. A second type of lubricating system, not shown here, is the dry sump type where an external sump tank is filted take the oil drauned from crankcase.

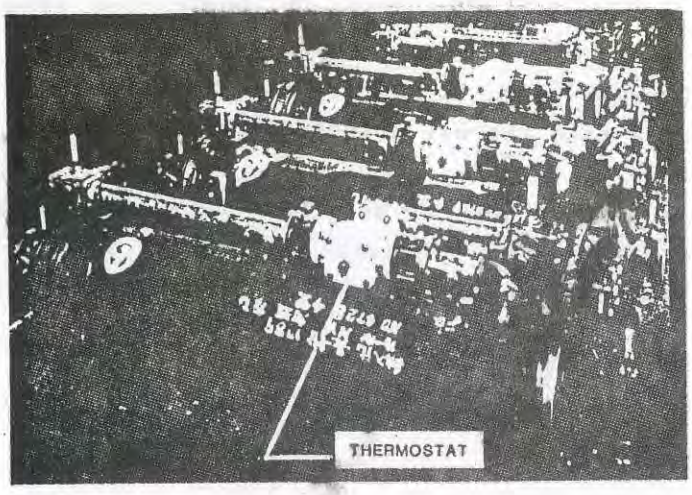
In this picture you can see that the oil is sucked by pump and circulated under pressure between the filter and the oil cooler to reduce the temperature of the oil and lubricate the required parts.

48. In this second type of lubricating system the valve lubricating mechanism is independent from the main system.

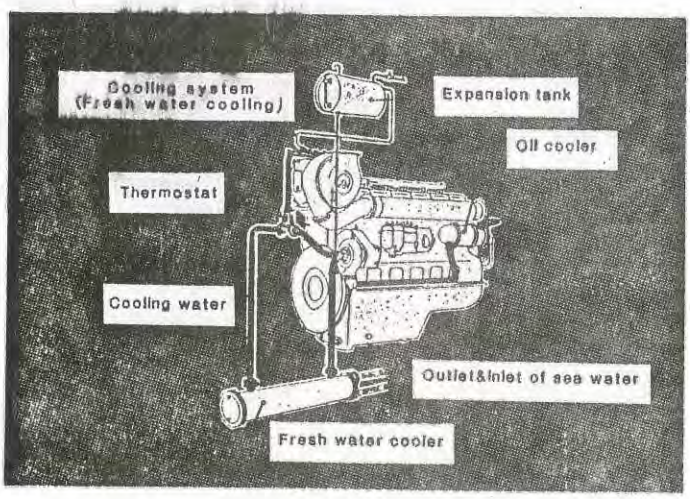
This seperate system avoids the possibility of fuel or cooling water entering the main lubricating system.


CENTRIFUGAL OIL FILTER
CARTRIGE OIL FILTER

49


THERMOSTAT

50


Cooling system
(Fresh water cooling)
Expansion tank
Oil cooler
Thermostat
Cooling water
Outlet&Inlet of sea water
Fresh water cooler

51

49. The lubricating oil filter is very similar to the fuel filter.

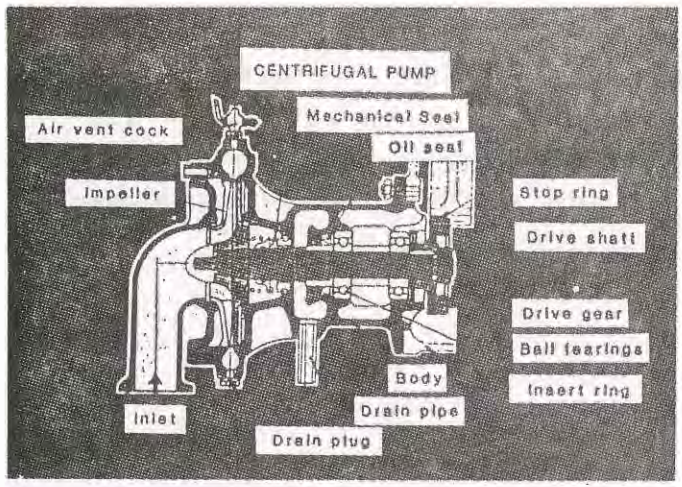
Modern high turbocharged engines must have purifiers placed in the bypass oil pipe system to remove any sludge, dirt and carbon deposits from the lubricating oil.

50. The oil temperature is controlled by this shell-and-tube oil cooler by opening and shutting the by-pass circuit gate.

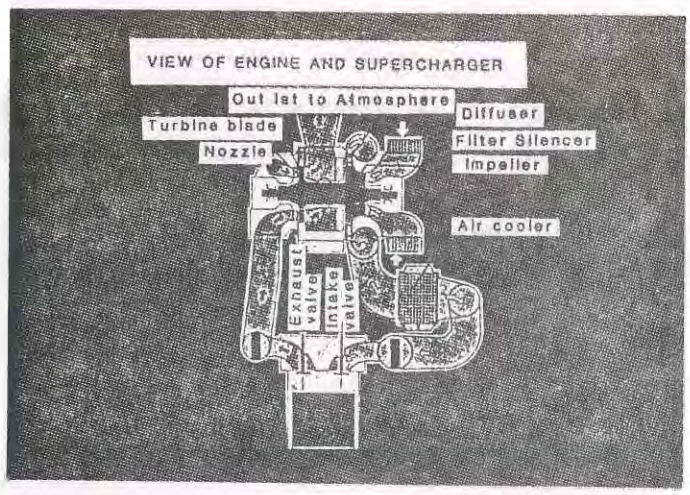
A more recent inmovation is the fitting of a thermostatic control valve to provide automatic temperature control.

51. Two types of cooling systems, are installed in marine engines one is the fresh water system, the second the sea-water system.

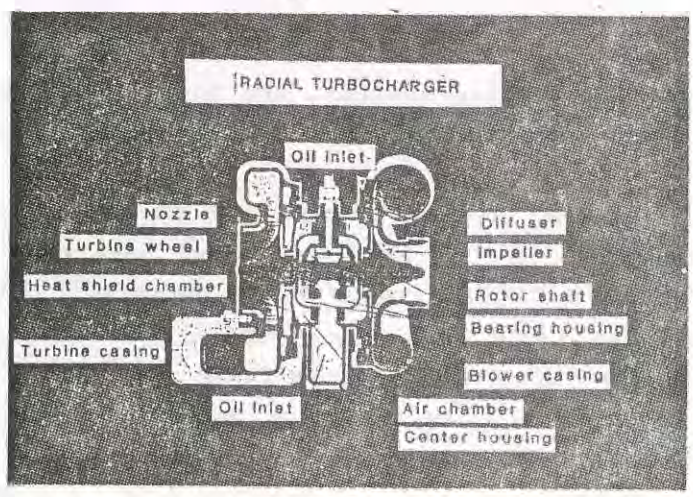
In both systems air or trapped air pockets in cooling water must be avoided. It is therefore very important to keep the temperature of the cooling water at an acceptable level, to avoid wear on cylinder liner and reduce fuel combustion, both of which are greatly affected by the temperature. The cock of water outlet should be adjusted frequently or an automatic thermostatic valve should be filted.


CENTRIFUGAL PUMP
Air vent cock
Mechanical Seal
Oil seal
Impeller
Stop ring
Drive shaft
Drive gear
Ball bearings
Inaert ring
Body
Drain pipe
Inlet
Drain plug

52


VIEW OF ENGINE AND SUPERCHARGER
Out let to Atmosphere
Diffuser
Turbine blade
Filter Silencer
Nozzle
Impeller
Air cooler
Exhaust valve
Intake valve

53


RADIAL TURBOCHARGER
Oil inlet
Nozzle
Turbine wheel
Heat shield chamber
Turbine casing
Oil inlet
Diffuser
Impeller
Rotor shaft
Bearing housing
Blower casing
Air chamber
Center housing

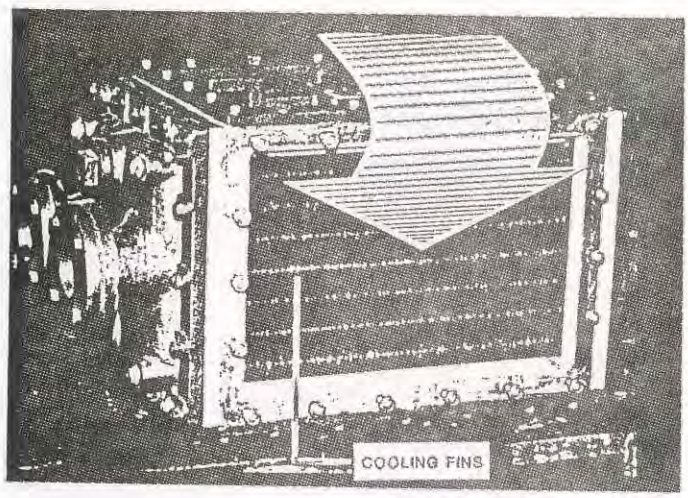
54

52. The centrifugal pump for cooling system, is driven either directly by engine or indirectly by electricity and are known as the "plunger" and the centrifugal type.

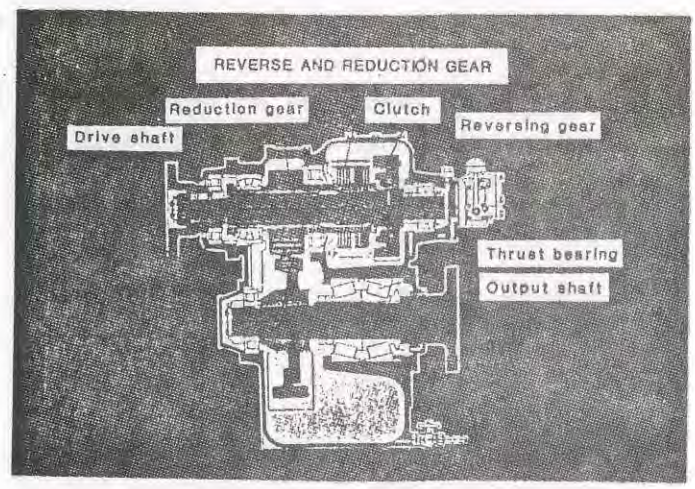
53. The supercharging system is connected to the engine. The supercharger consists of a turbine which is driven by high temperature exhaust gas under high pressure and a centrifugal blower.

The turbine blades are installed on the impeller shaft of the blower which compresses air, and sends it through the intercooler into the intake port of the engine.

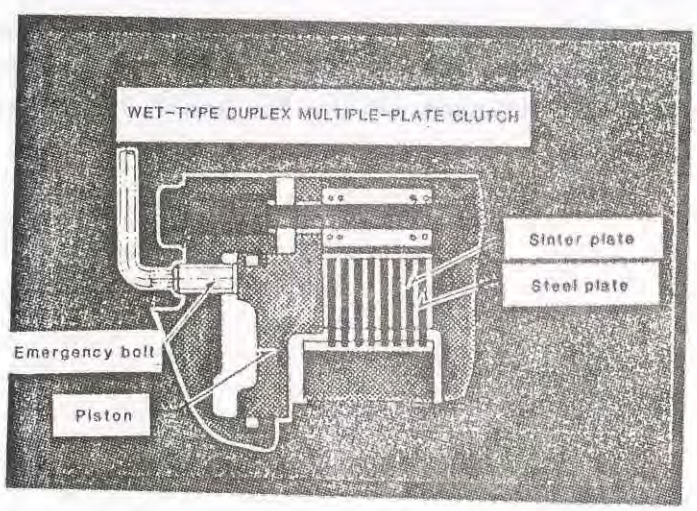
54. Turbochargers are classified according to the type of gas flowing to the turbine blade: the axial, and inward flow or radial types. This picture shows the radial type of turbine. Its mechanism is very simple and it is used mainly for small diesel engines.


COOLING FINS

55

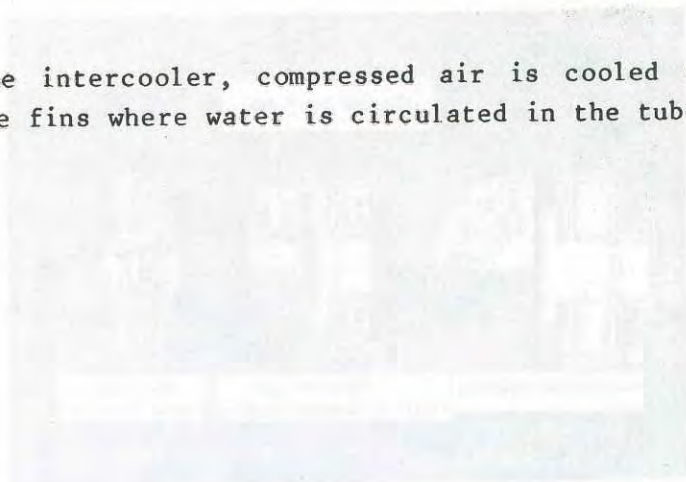

REVERSE AND REDUCTION GEAR
Reduction gear
Clutch
Reversing gear
Drive shaft
Thrust bearing
Output shaft

56


WET-TYPE DUPLEX MULTIPLE-PLATE CLUTCH
Sinter plate
Steel plate
Emergency bolt
Piston

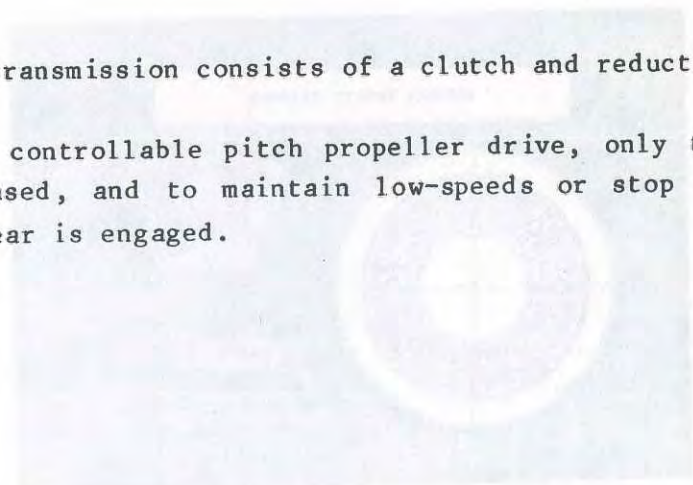
57

55. In the intercooler, compressed air is cooled as it passes through the fins where water is circulated in the tubes.



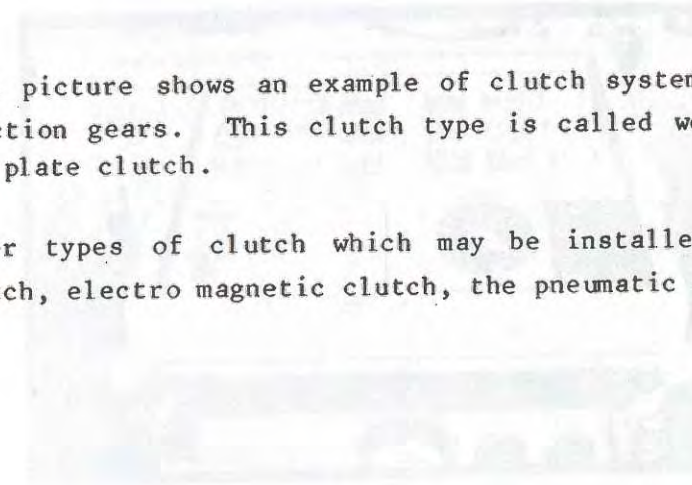
56. The transmission consists of a clutch and reduction gears.

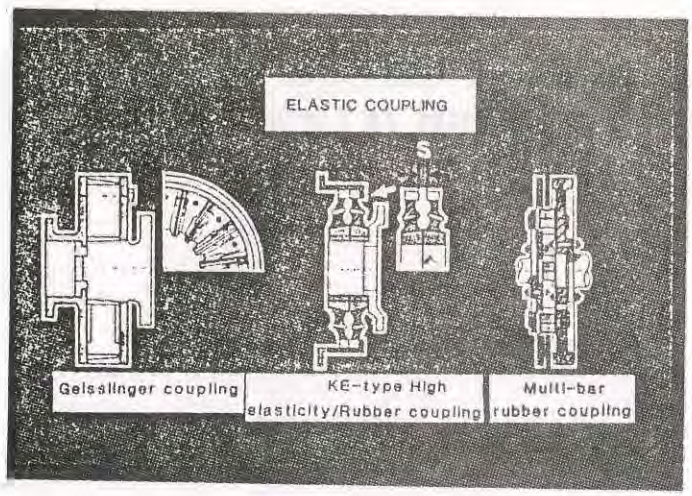
In a controllable pitch propeller drive, only the reduction gear is used, and to maintain low-speeds or stop the boat the reverse gear is engaged.



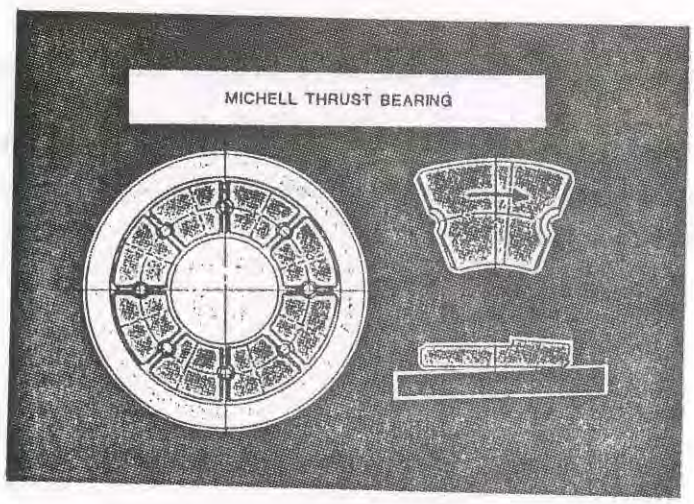
57. This picture shows an example of clutch system with reverse and reduction gears. This clutch type is called wet-type duplex multiple-plate clutch.

Other types of clutch which may be installed include the cone-clutch, electro magnetic clutch, the pneumatic clutch etc.

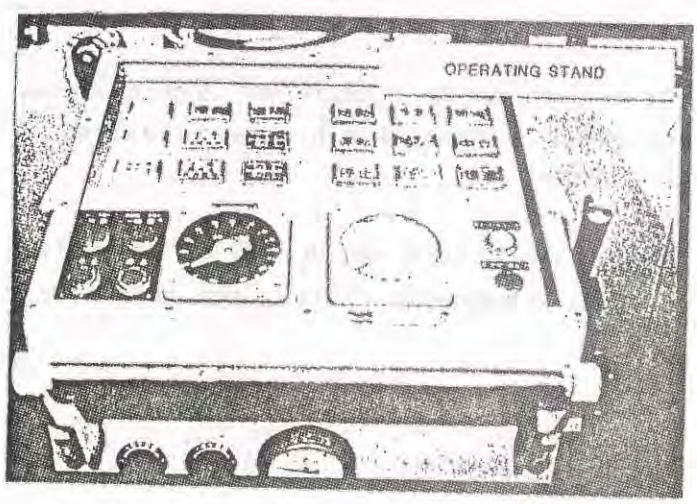



ELASTIC COUPLING
S
Geissinger coupling
KE-type High elasticity/Rubber coupling
Multi-bar rubber coupling

58

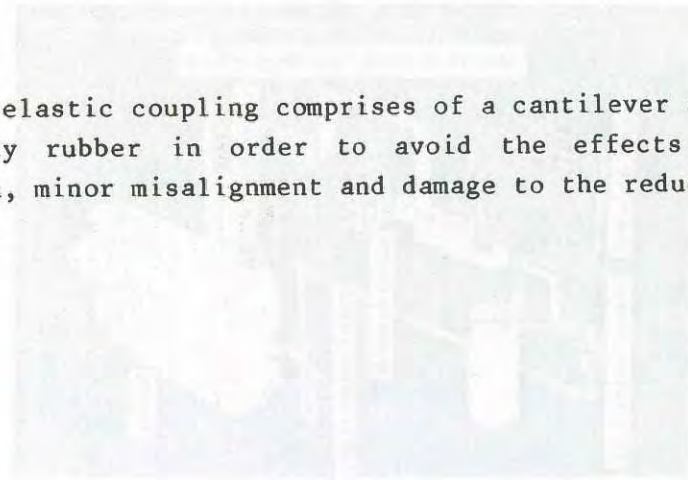

MICHELL THRUST BEARING

59


OPERATING STAND

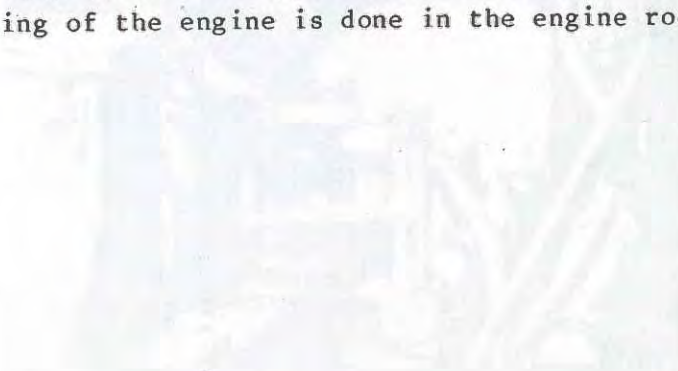
60

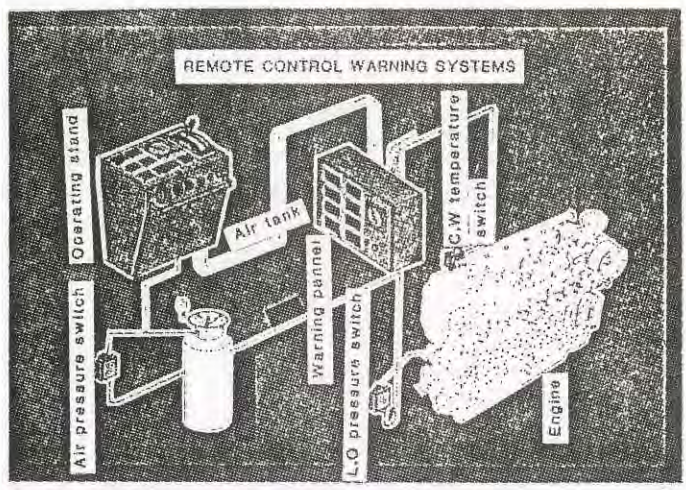
58. The elastic coupling comprises of a cantilever spring or high elasticity rubber in order to avoid the effects of torsional vibration, minor misalignment and damage to the reduction gear.



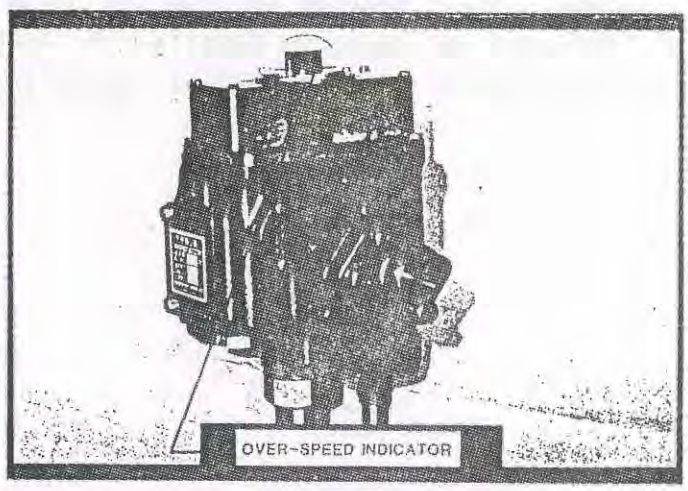
59. This Mitchell thrust bearing is used for large engines. It has a high load-carrying capacity despite its small size. The second rolling bearing is used for smaller horsepowered engines.

60. The remote control system enables commands from the bridge to be carried to the engine room either by wire, hydraulic, pneumatic or electrical means. A typical console is shown here. However, the starting of the engine is done in the engine room.

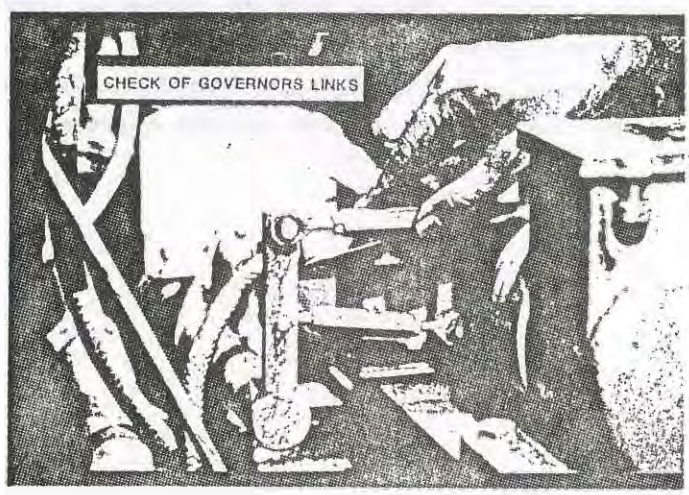



REMOTE CONTROL WARNING SYSTEMS
Operating stand
Air tank
Warning panel
C.W temperature switch
Air pressure switch
L.O pressure switch
Engine

61


OVER-SPEED INDICATOR

62


CHECK OF GOVERNORS LINKS

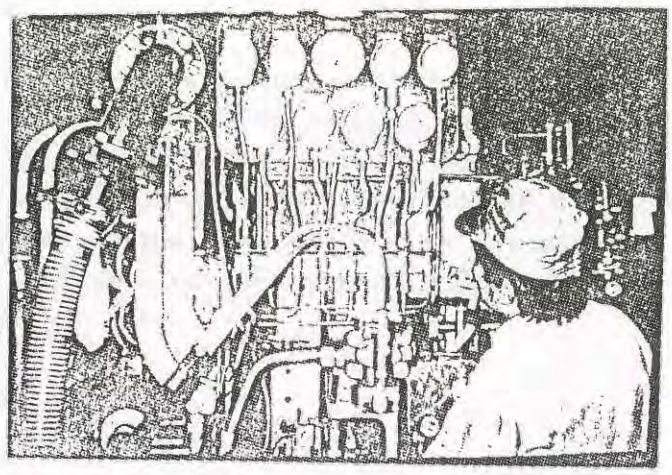
63

61. There are certain regulations governing the alarm or warning system of the remote control system, which should be standardized. Each component of the remote control system should be able to detect problems such as the pressure of the air tank, lubricating oil, or the temperature of the cooling water and be able to trigger an alarm immediately if it ceases to function normally.

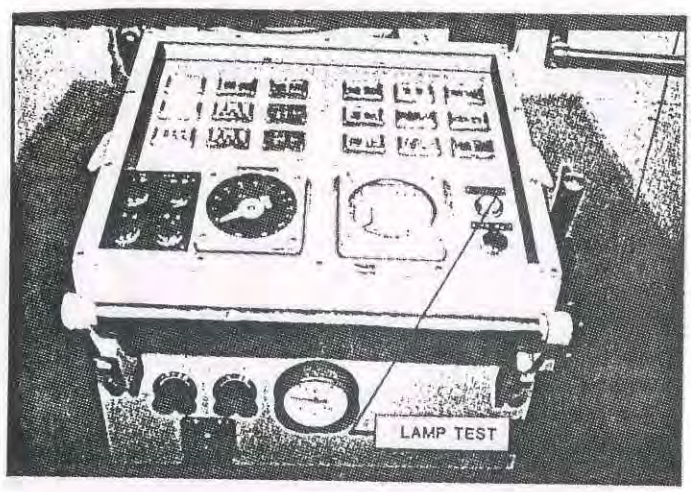
62. The overspeed stop mechanism is activated when the engine revolution exceeds a certain limit. This device cuts the fuel supply to stop the engine.

63. To start the engine. The following preparations are required: First, turn the engine by hand or by the turning bar, drain any water out of air and fuel setting tanks.

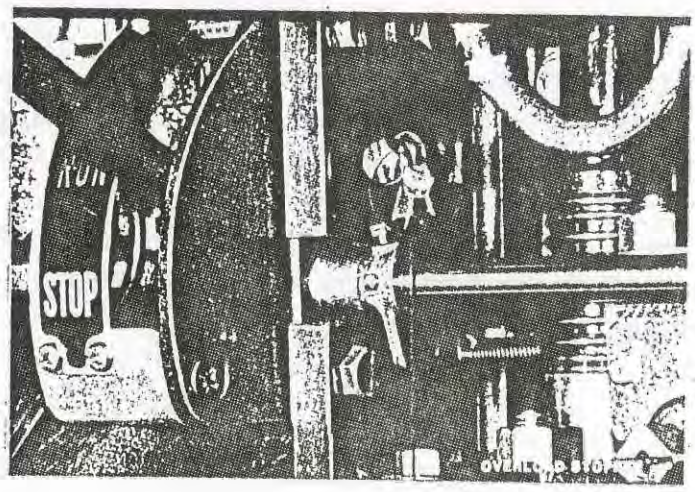
Check the lubricating oil levels and top up where necessary. Finally, check that the governer links move smoothly. This picture shows the check for the governor links.



64



65



66

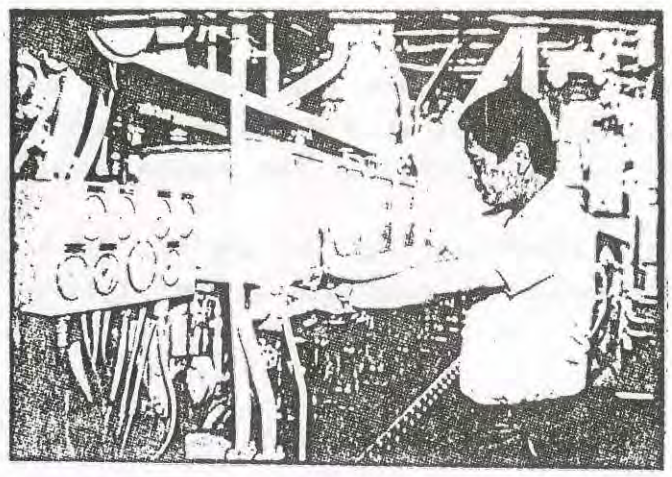
64. The engine should be air run before the actual starting process is performed. This will ensure that there is no abnormal reside in the cylinder and that the engine rotates correctly.

Immediately after starting the engine, check all pressure gages, and the combustion condition of each cylinder, using the testing cock.

65. Remote control console.

Following these engine checks and after ensuring that all is running normally, the manoeuvring system must then be tranferred from the engine room to the bridge. A lamp test should be conducted on the remote control system and the warning switches should be put on.

66. A warming-up period of 5-10 minutes, with no load and at idling speed should be allowed. At the end of this time the load should be gradually introduced according to the revolutions of the engine. Special care should be taken that the overload stopping equipment is in full working order. This particular equipment must never be disconnected.



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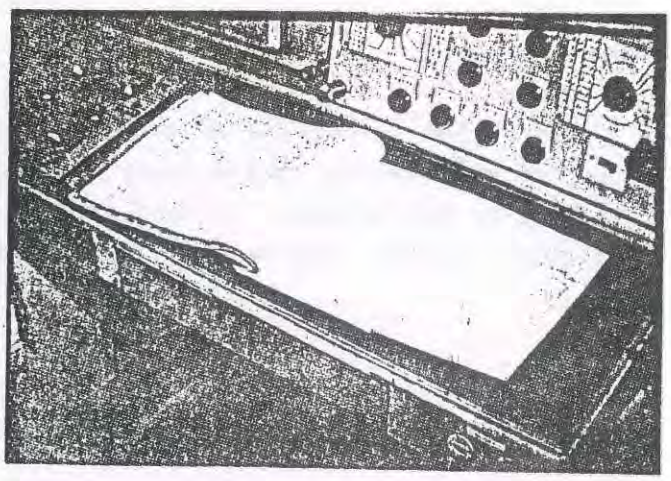

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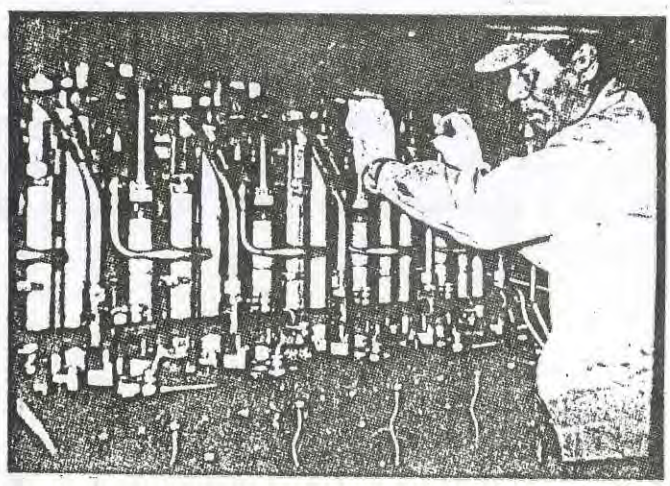


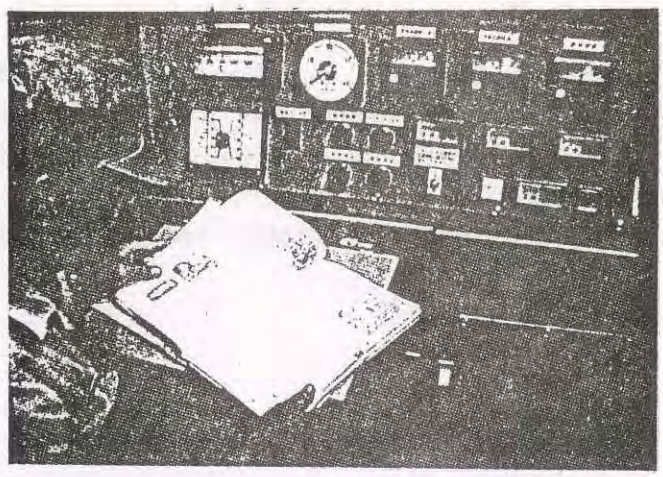
69

67. It is not always possible to rely solely on instruments to detect engine trouble even given the present advanced state of technology. A good engineer must also cultivate the ability to diagnose abnormalities by using his five senses; he should aware of any temperature changes, vibrations, and changes in sounds and smell of the engine.

68. This is a typical log book.

To gain an overall picture of the engine it is necessary to record all the operating data i.e. to keep a log record. If there is no such record, the counter measures taken to correct abnormalities or note their occurence will not be carried out immediately. A daily record must be entered in the log book.

69. When the engine is stopped the residual gas in the cylinder should be exhausted either by turning by hand or by air running.



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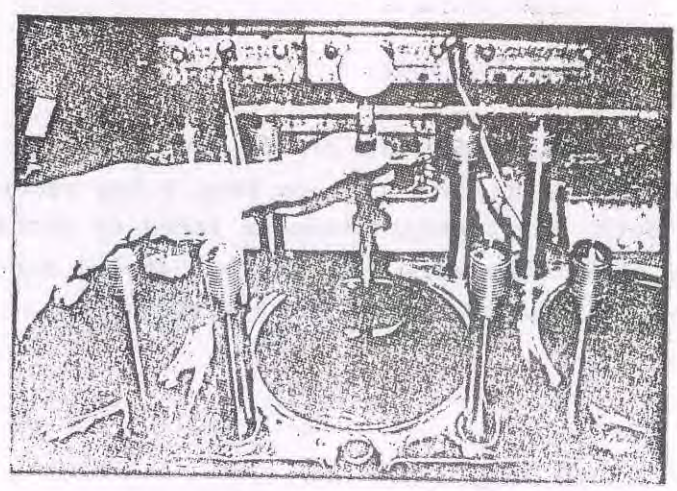

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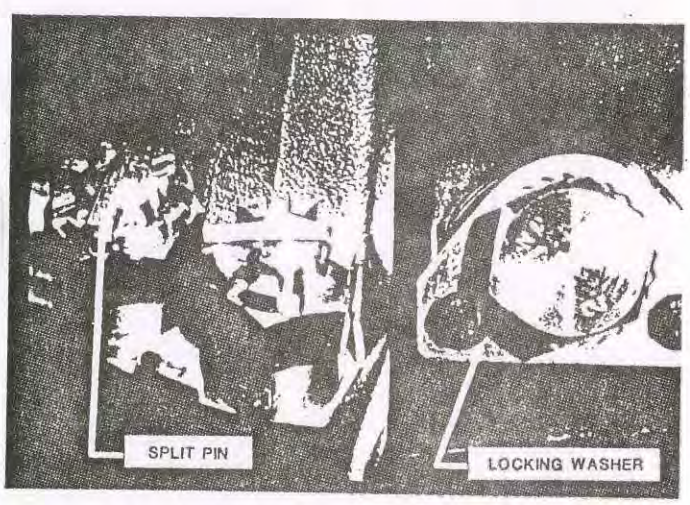


72

70. This picture shows the precautions to be taken during disassembly and assembly, as described in the instruction manual.

It is essential that an engineer understands the construction of the engine and the relationship between its assembled parts.

During disassembly a sign or a mark must be put on each individual part so that they can be reassembled in the correct order.

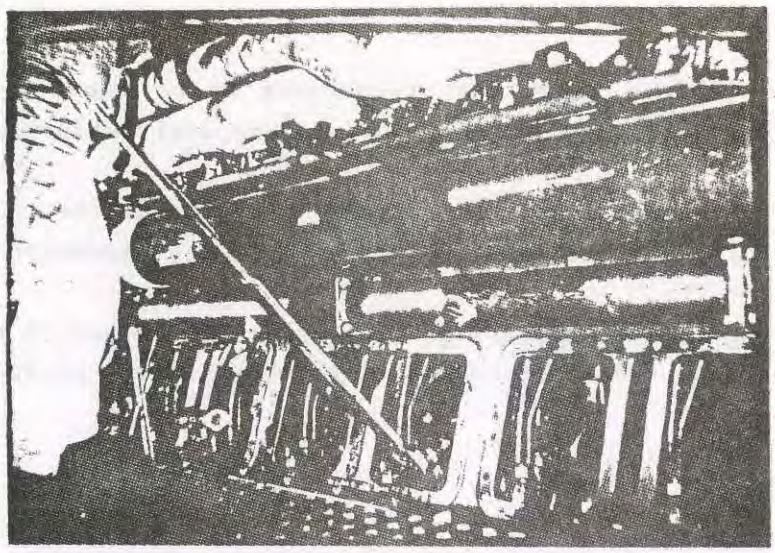
71. During regular maintenance checks measurements should be taken on all the important moving parts, such as the diameter of the liner, as shown in this photo. Should engine trouble be diagnosed the cause should be immediately investigated and rectified, otherwise the same trouble will occur again. If there is any doubt as to the cause of trouble the engine manufacturer should be consulted.

Never throw away a part which has been replaced. It should be shown to an expert who will be able to determine the cause of the problem and thus help with trouble shooting.

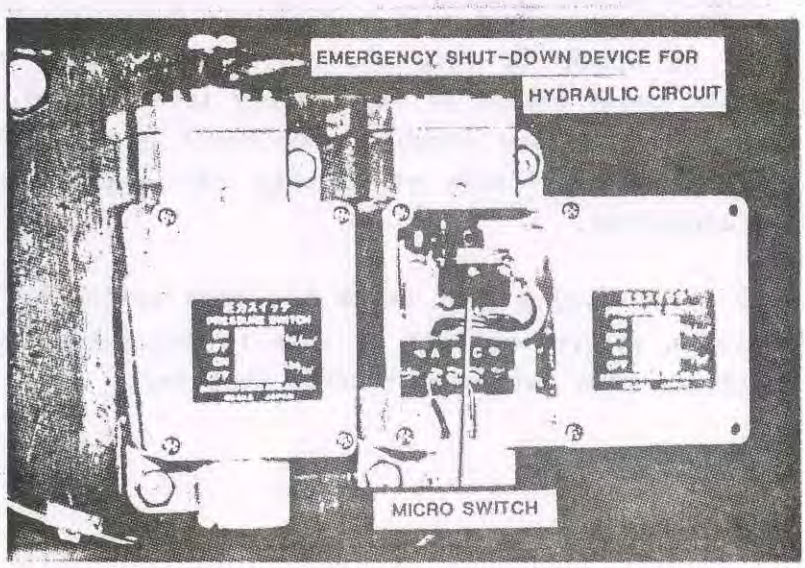
72. Assembly work should be carried out as follows;

Each part should be cleaned and inspected to make sure that it is not damaged. All parts should be lubricated according to specifications. The split pin, which is used for some important nuts, must be correctly positioned. The O-ring, split pin and lock washer should be replaced on each occasion.

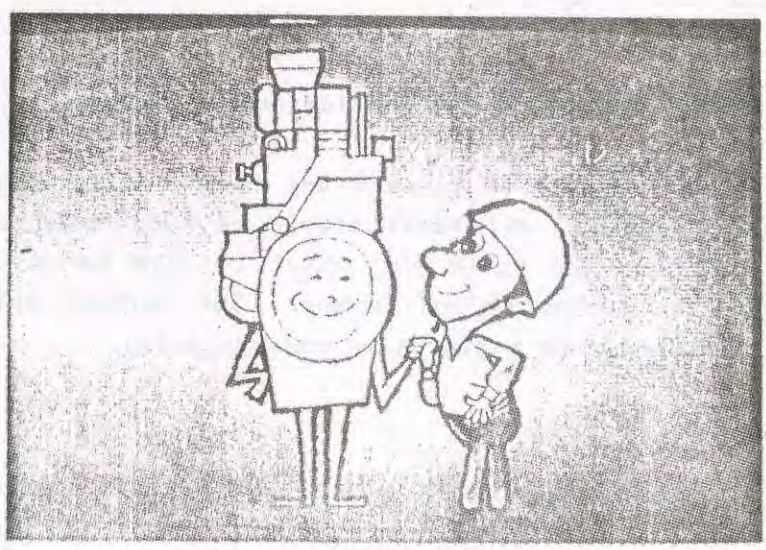
73



74


EMERGENCY SHUT-DOWN DEVICE FOR
HYDRAULIC CIRCUIT
MICRO SWITCH

75



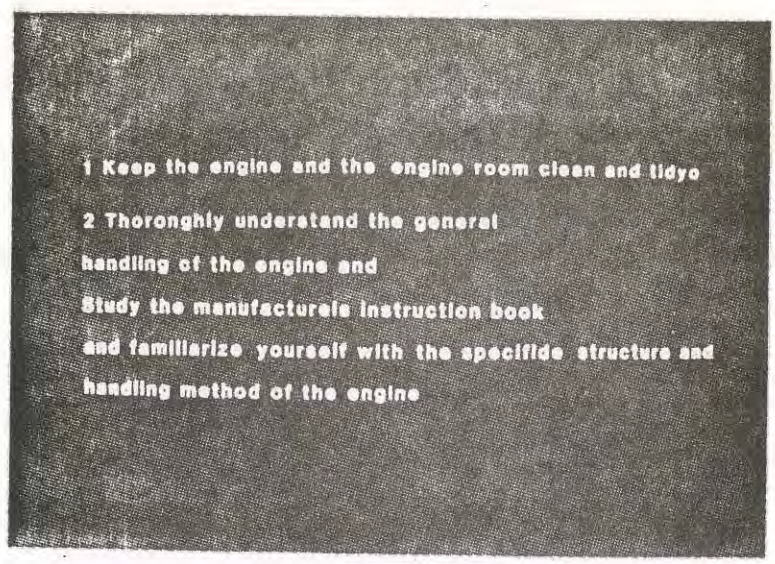
73. The bolts are tightened by torque wrench according to the standards set in the manufacturer's instruction manual.

When assembly is completed a final check should be made, especially on the locking fastener (bolt) and on the correct alignment of the different parts between each other.

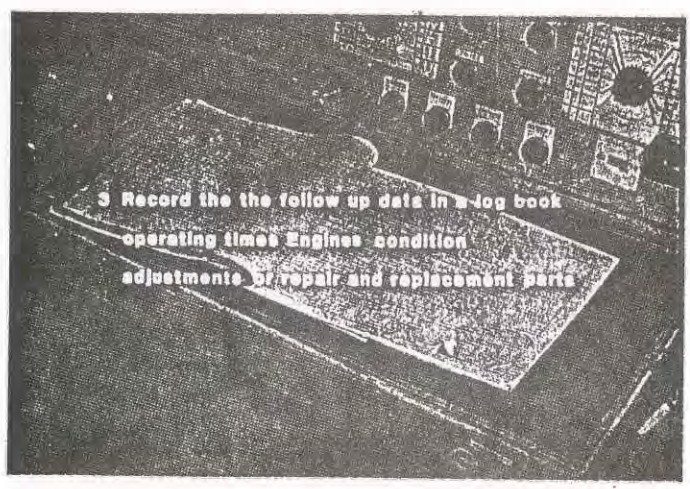
74. The alarm system and the engine emergency stop mechanism should be checked daily.

75. Finally, here are some methods for preventive maintenance.

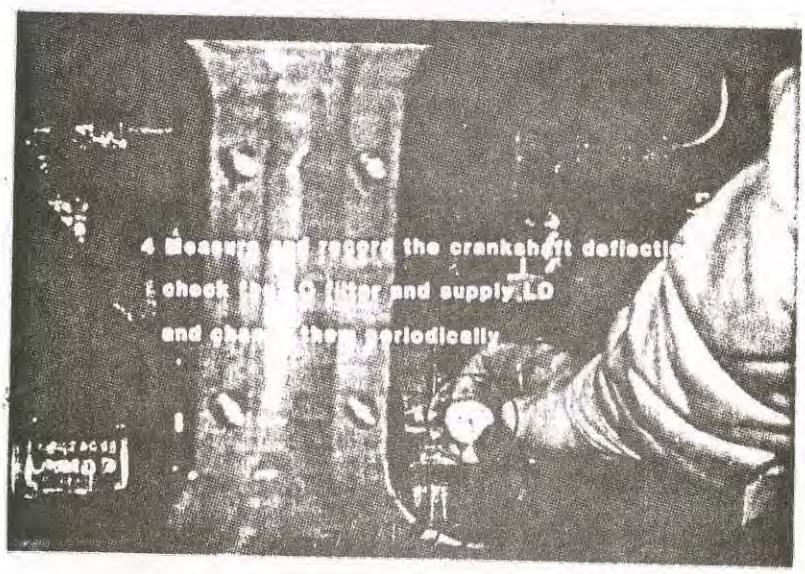
It is better to prevent trouble than to have to replace and repair.


1 Keep the engine and the engine room clean and tidyo
2 Thoronghly understand the general
handling of the engine and
Study the manufacturels instruction book
and familiarize yourself with the specifide structure and
handling method of the engine

76


3 Record the the follow up data in a log book
operating times Engines condition
adjustments or repair and replacement parts

77


4 Measure and record the crankshaft deflecti
check the LO inlet and supply LO
and chec them periodically

78

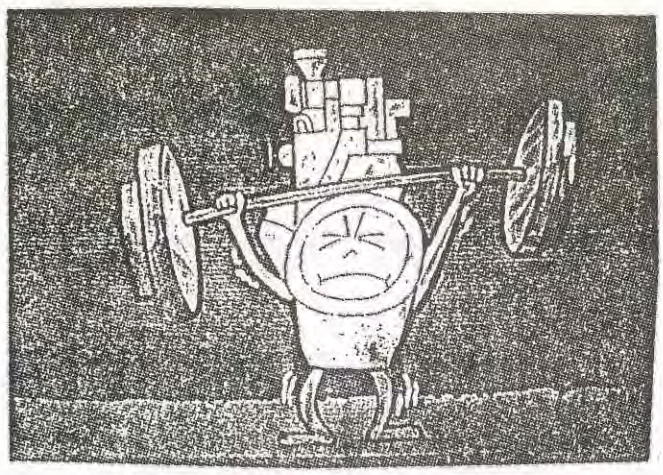
76. The fundamental principles for prevention of troubles are as follows:

1st: To keep engine and engine room clean and in good in order.

2nd: It is necessary to throughly understand the general handling of an engine, as well as to carefully read the manufacturer's instruction manual, and compare the parts described to the actual parts in the engine.

77. 3rd: To make regular entries in the log book of such items as operating time, fuel consumption, and of the parts which have been adjusted or repaired etc. This record will help prevent trouble and assist in future maintenance.

78. 4th: Measure and record the deflexion of the crank-shaft; if the value exceeds the standard, immediate correction is necessary. Periodical checking for change of lubricating oil, filter etc, should be undertaken as advised by the manufacturer.



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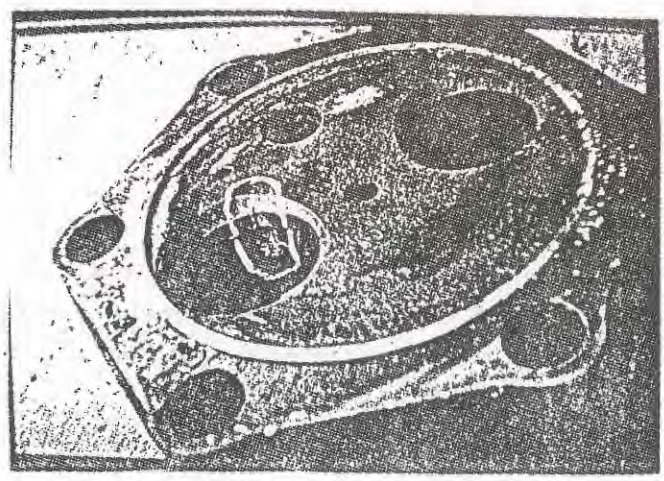

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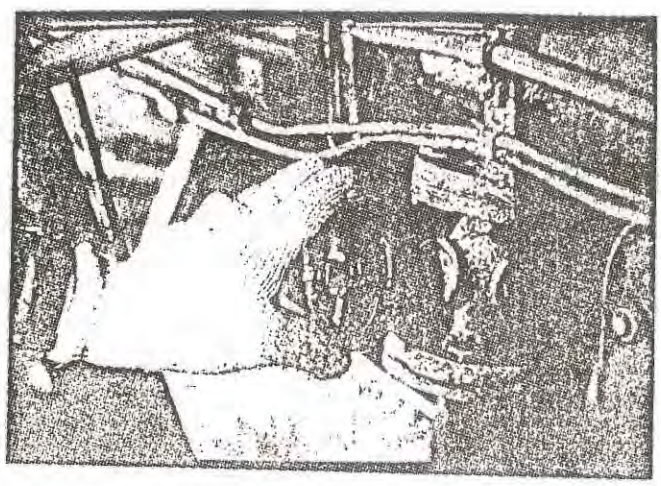


81

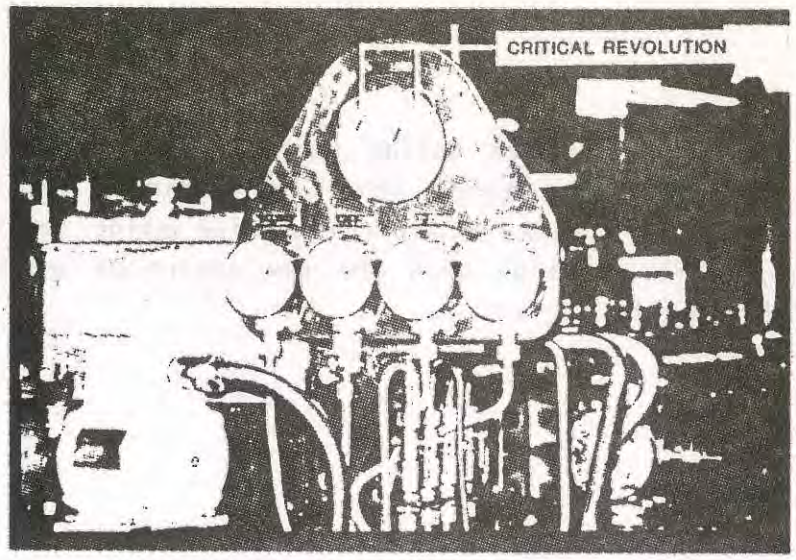
79. To prevent troubles during operation, overloading or rapid change in revolution speed should be avoided, especially when operating a new engine or after replacing major parts, or overhauling, until the time when the new engine or parts have been completely run-in.

80. Constant repetition of alternately overloading and slowing down the revolutions must be avoided as this may lead to increased thermal stress and cause a crack to appear in the cylinder head. The repeated operation of going forward and astern by clutch should be done when the engine revolutions are reduced to the minimum.

81. Measures against freezing.

Cooling water should be thoroughly drained when the engine is not being operated. If the engine is to remain unused over a long period of time, all moving parts should be oiled or greased to protect them from dust.

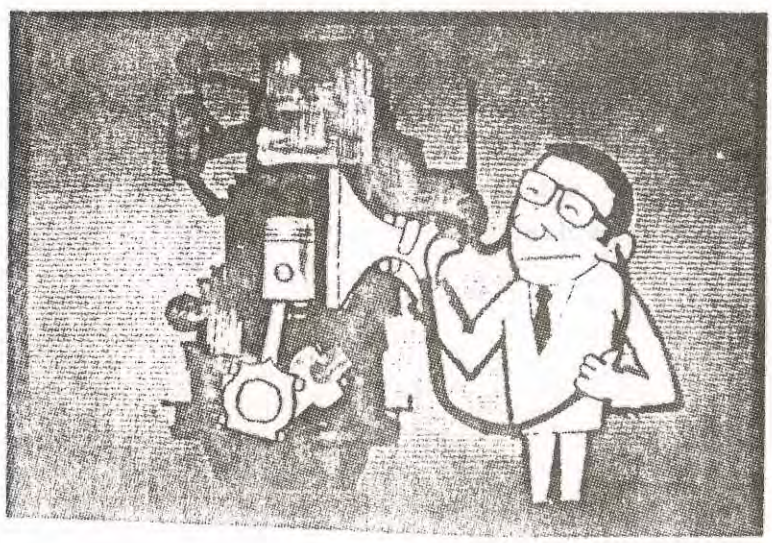
82


CRITICAL REVOLUTION

83


ALWAYS KEEP YOUR HEAD AND QUICKLY DETERMINE THE CAUSE OF THE TROUBLE

84



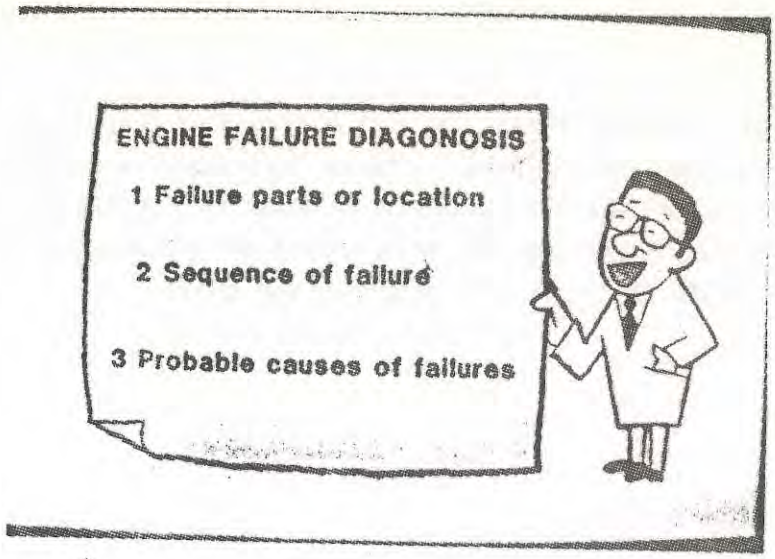
82. The section marked in red on the tachometer shows the critical maximum revolutions. These critical revolutions exist for every engine and are strongly related to the torsional vibration. Continuous operating at this critical revolution may cause the crank shaft to break or damage to the gears.

83. There are many kinds of engine trouble frequently encountered by engine operators, for example, difficulty in starting, fluctuations in the engine speed, sudden drop in revolutions, sudden stopping of the engine etc. In each case, it is important to find the cause immediately and take corrective measures as soon as possible. It is also very important to keep one's presence of mind in any of these situations.

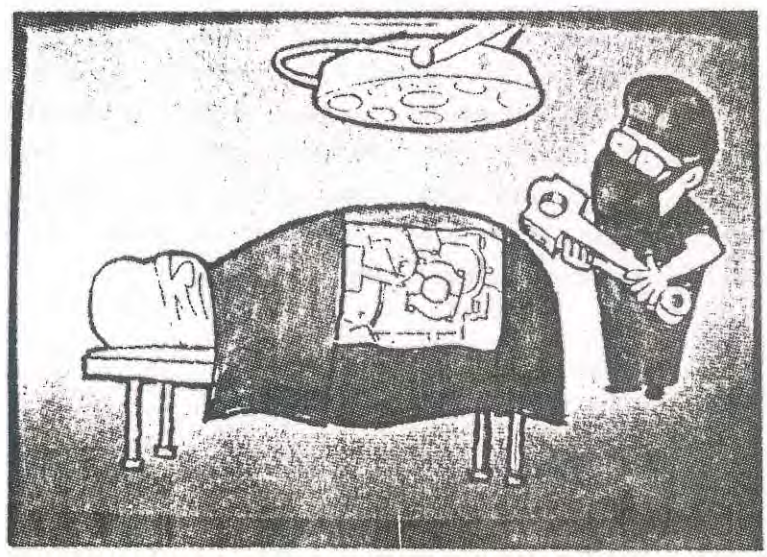
84. How do you find the cause of trouble?

First, try to recollect any trouble you may have had in the past with the same engine.

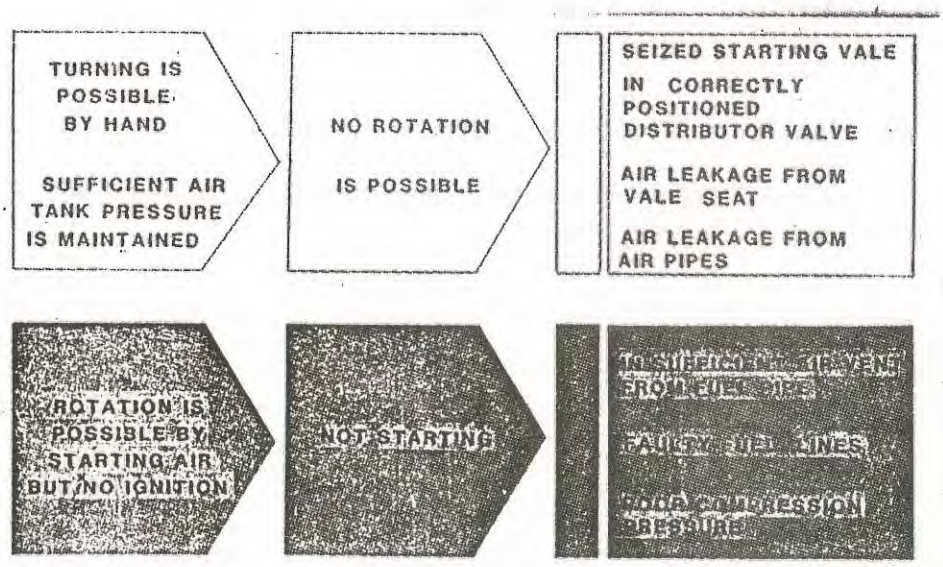
85


ENGINE FAILURE DIAGONOSIS
1 Failure parts or location
2 Sequence of failure
3 Probable causes of failures

86



87


TURNING IS POSSIBLE BY HAND
SUFFICIENT AIR TANK PRESSURE IS MAINTAINED
NO ROTATION IS POSSIBLE
SEIZED STARTING VALE
IN CORRECTLY POSITIONED DISTRIBUTOR VALVE
AIR LEAKAGE FROM VALE SEAT
AIR LEAKAGE FROM AIR PIPES
ROTATION IS POSSIBLE BY STARTING AIR BUT NO IGNITION
NOT STARTING
FAULTY FUEL LINES
POOR COMPRESSION PRESSURE

85. If you are aware of how and when the trouble occured it will not be so difficult to diagnose and locate the affected part.

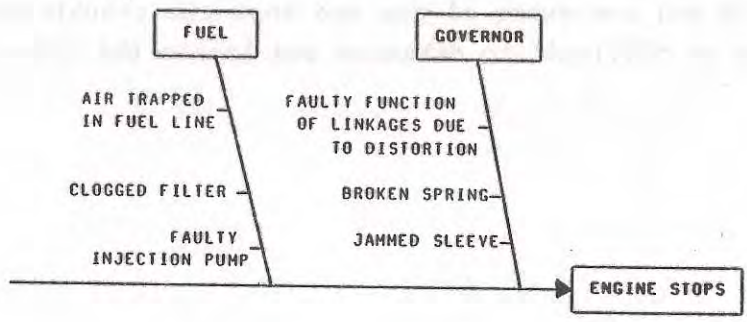
86. When the cause of the trouble has been determined, corrective measures should be taken. The general procedures for trouble shooting are shown in the following examples:

87. 1) The engine will turn by hand but will not start by air running. First, check the starting valve, it may be positioned incorrectly or there is an air leakage from the valve seats.

2) The engine can turn by air running but does not continue running. The cause of this problem may be in the fuel system; if some air remains in the pipeline it will block the flow of fuel, or it may be that the compression pressure is too low.

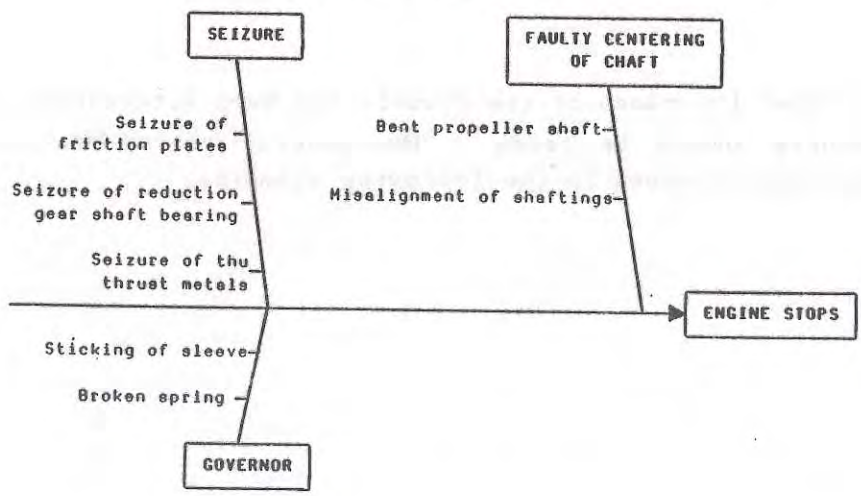
88

WHEN CLUTCH IS NOT ENGAGED

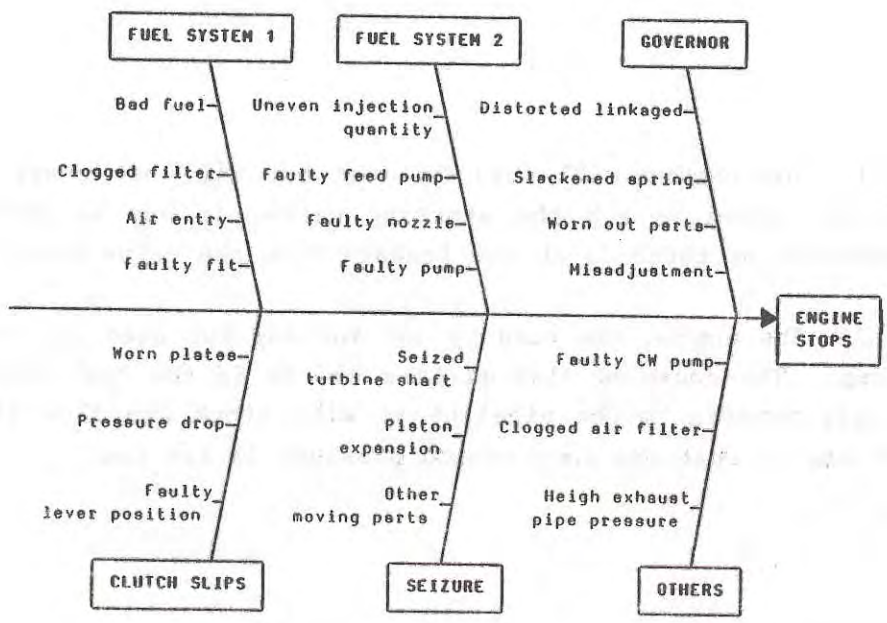


89

WHEN CLUTCH IS ENGAGED



90

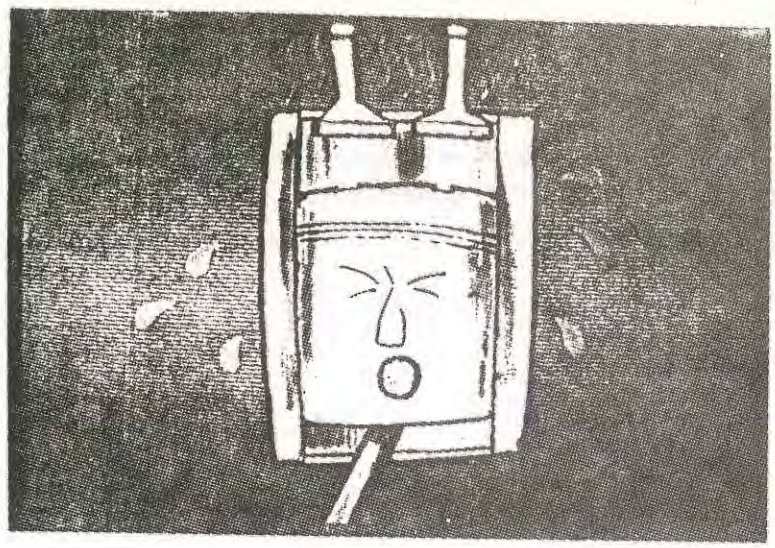


88. 3) When the engine starts but does not continue running, the cause may be found in the governor or the fuel systems, e.g. air in fuel, a clogged filter or malfunctioning injection pump.

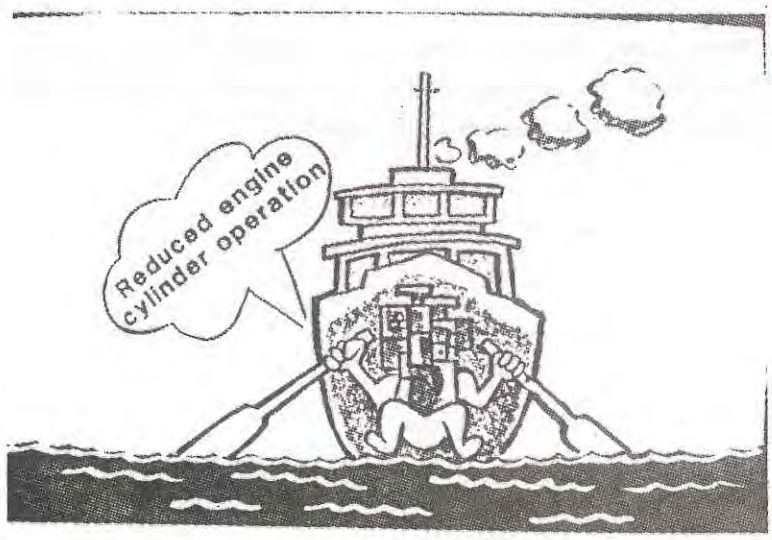
89. 4) When the engine does not connect with the clutch; the cause may be lack of movement in the reduction shaft bearing, or a misalignment of the intermediate shafts.

90. 5) When a sudden drop in revolutions or an unexpected fluctuation of speed is observed the cause may be found in the poor quality of the fuel, a moving part not running freely, a worn-out governor link system etc.

91



92



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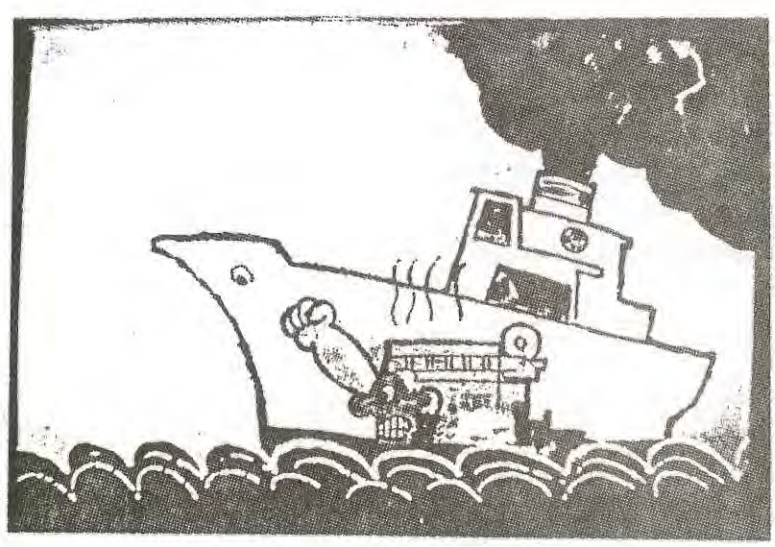
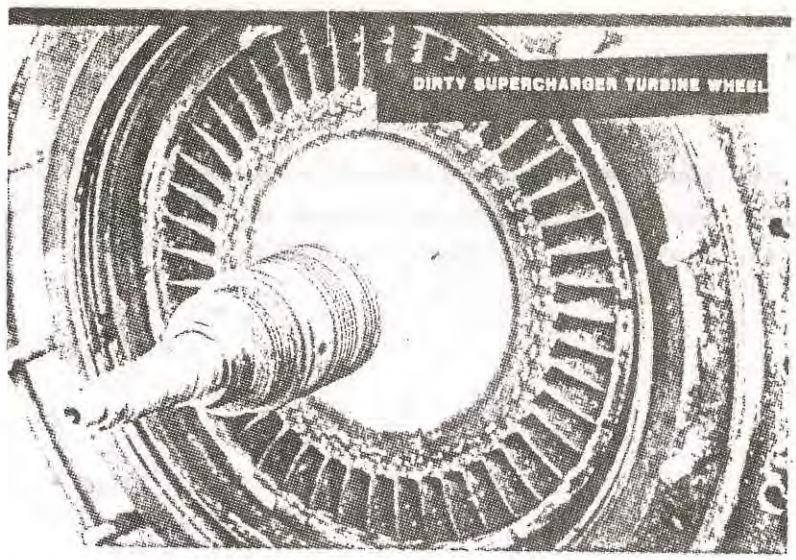


91. 6) When the engine suddenly stops and then cannot be turned by hand, the cause may be a seizure or the moving parts sticking. Both the piston and crank-shaft should be checked.

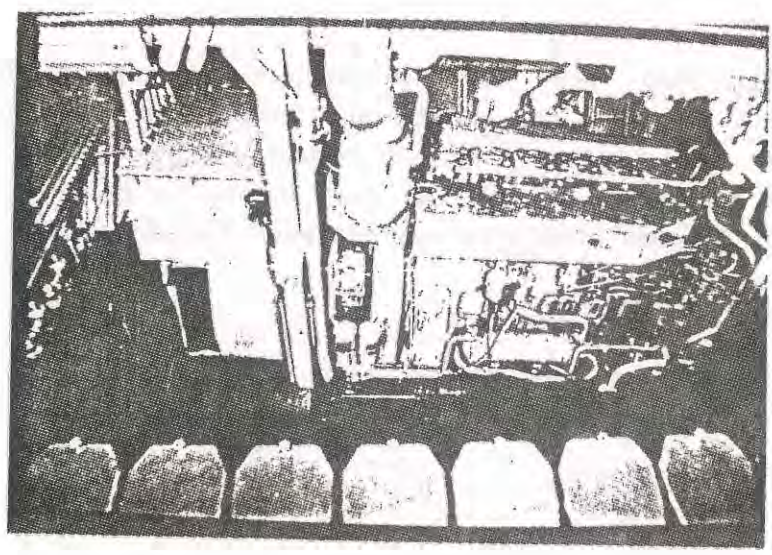
92. 7) When there is a seizure or burning of the piston or crankpin journal, the piston and connecting rod should be dismounted from the cylinder. If possible, first block the oil hole on the crankpin, and cut the fuel supply to this cylinder. Then you may proceed slowly to nearest port for refitting.

93. 8) When the exhaust gas is blackened the buel, the fuel system, and overloading of the engine should be checked.

94



95



96

94. 9) A raised temperature in the exhaust gas shows abnormal operating conditions: and quick action should be taken to repair or adjust as necessary. For example in the fuel system there may be a dirty supercharger or aircooler, or a leakage from intake, or exhaust systems might be the cause of this trouble.

95. Earlier, we have discussed the points where special attention should be paid in connection with assembly and disassembly, of an engine, as well as about preventive maintenance and trouble-shooting. By consulting the check points above and by drawing on the knowledge gained through experience the operator can ensure smooth safe and trouble free operation of his engine

Good luck!!!

(The end)


THE END