SEAFDEC Training Department

SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER

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EXPLANATION OF SLIDES ON TRAINING AT DIESEL ENGINE FACTORY

by
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Preface

This reference book has been compiled from the script of the slide series "Training at Diesel Engines Factory", 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.

April 1991

SHINZO YAMAMOTO

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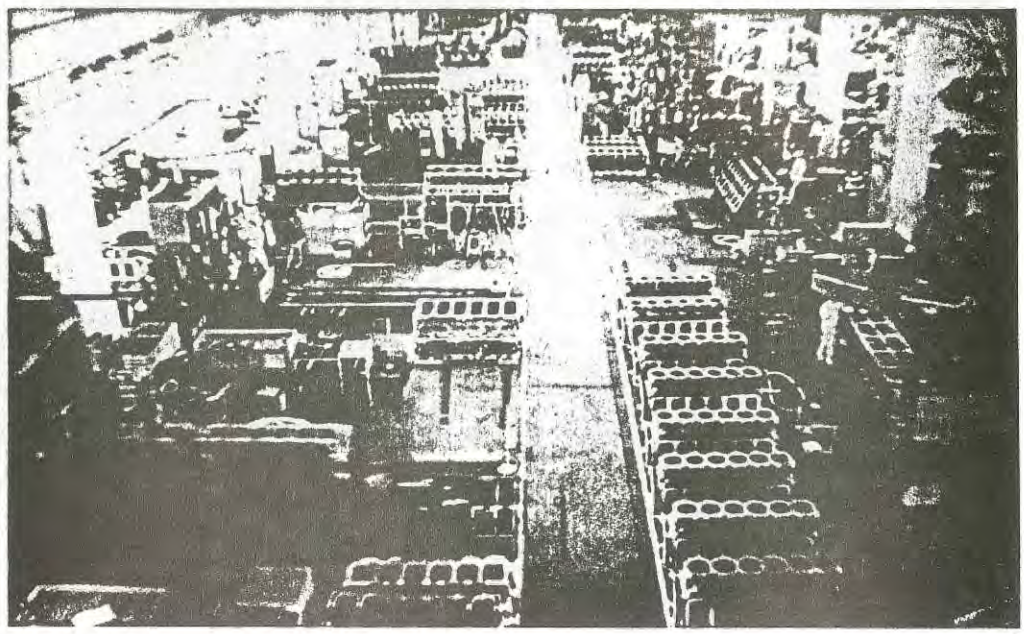


3

1. MANUFACTURING PROCESSES USED FOR MACHINING OF MAIN PARTS OF DIESEL ENGINE

2. ASSEMBLY PROCESSES

3. OPERATION & INSPECTION

4

Training at Diesel Engine Factory
(Explanation of Slides)

By S. Yamamoto
Narration: 1- 90

1.

2. The certificate of the retraining course for marine engine operators and engineers.

   After receiving this certificate, which includes courses in five engineering subjects suggested by the fishing boat engineer's association, it is recommended that the operators and engineers be given further practical training in a leading engine manufacturers workshop for a week or so.

3. The diesel engine machine shops.

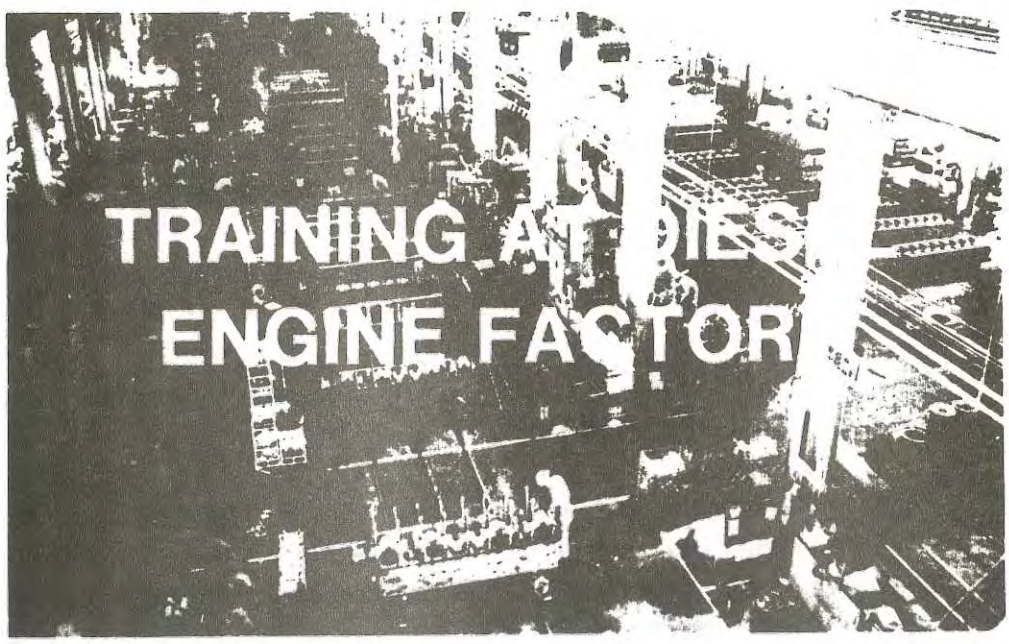
   Both engine operators and engineers will benefit from shop-floor experience where information ranging from basic technology to advanced technical know-how is provided under rigorous and supervised working conditions.

4. The contents of this slide series includes:

   4.1 How the main parts of the engine are produced

   4.2 How an engine is assembled

   4.3 How the assembled engine is tested. (These slides will help you during training to improve your technical knowledge in marine engines).



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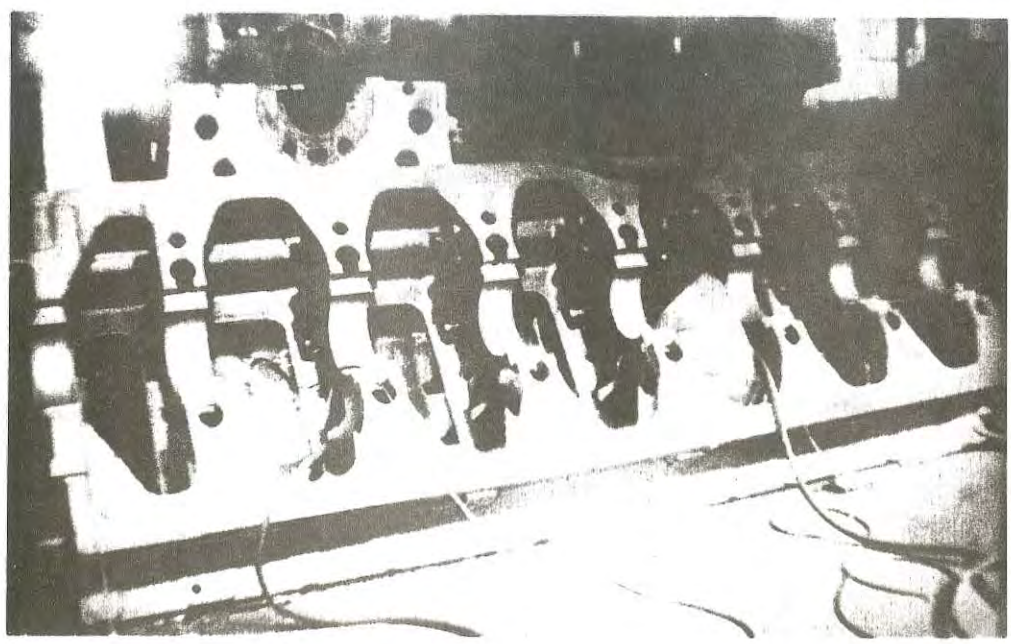

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5. A training session taking place in a diesel engine factory.

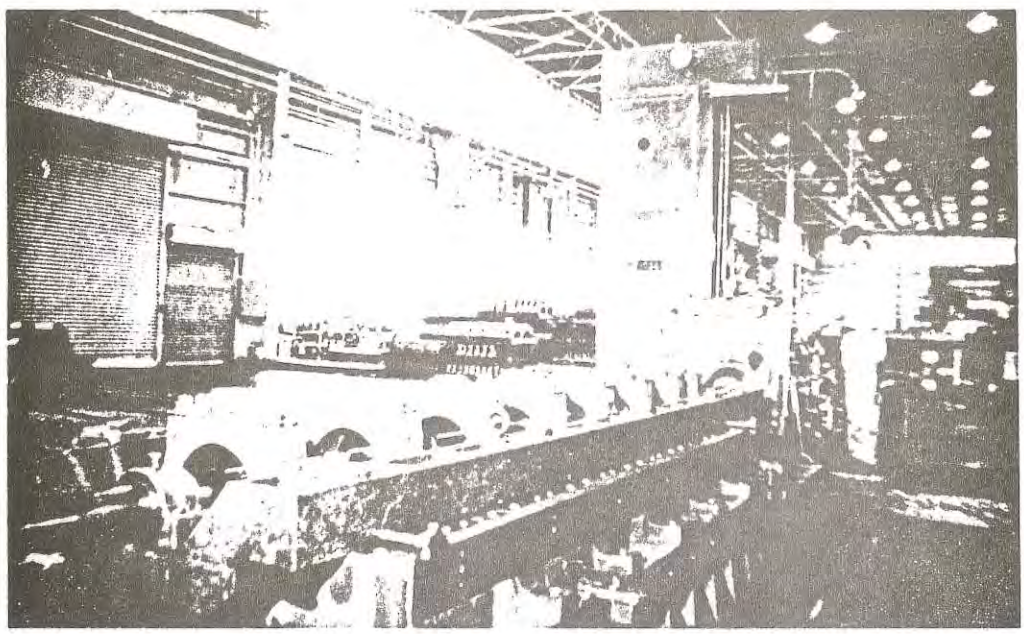
6. The engine bed.

Let us now take a closer look at the engine bed which comprises the main body of a diesel engine.

The engine bed is made of high quality cast iron which is produced by an elaborate casting process.

The casting stages consist of (1) forming a mold with sand, (2) producing molten iron in a cupolla, and (3) pouring the molten iron into the mold.

The cast iron products are then subjected to heat treatment, in order to relieve the strain, in an annealing furnance after first removing the flash or bur metal which has accumulated in the iron during the melting process.



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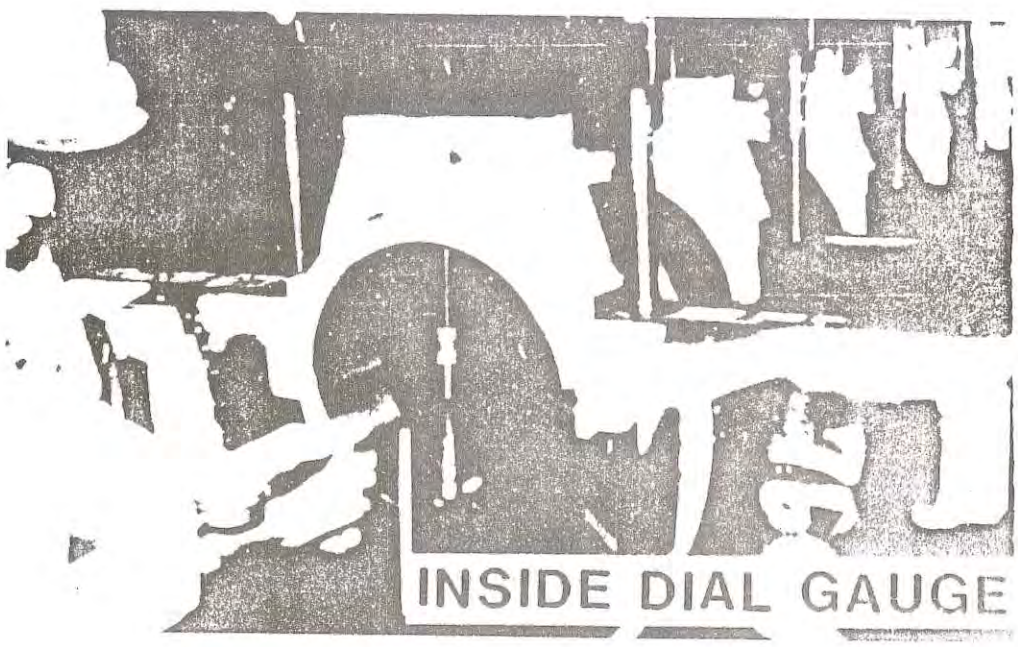

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7. The machining process of the inside diameter of the main bearing of the engine bed.

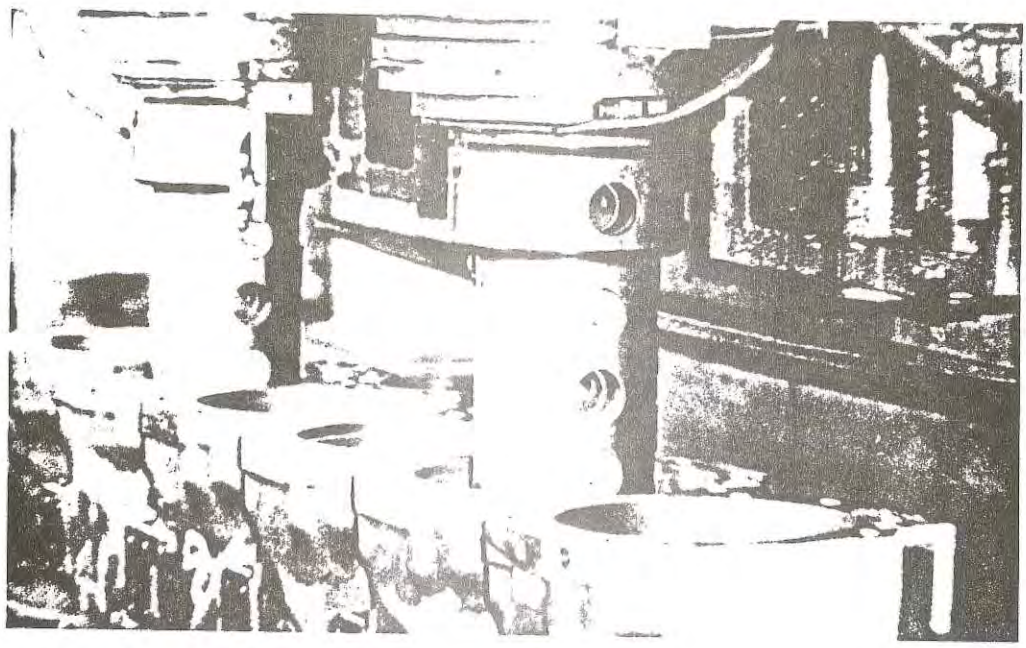
   The main metel housing is precision tooled after which the bearing cap is fixed onto the housing by applying a previously specified tightening torque.

   Each housing is finished in a perfect cylindrical shape, without any run-out of roundness or misalignment between the housings, within a specified degree of tolerance.

8. Measuring the inside diameter of the main bearing housing.

   The inside diameter of the housings are measured by a special limit gauge or inside micrometer before fitting the precision bearing into the bearing housing.

   The main bearing housings are provided with finished bearing-shells and they need no adjustment, therefore the dimensions of the housing should be accurate and precise.



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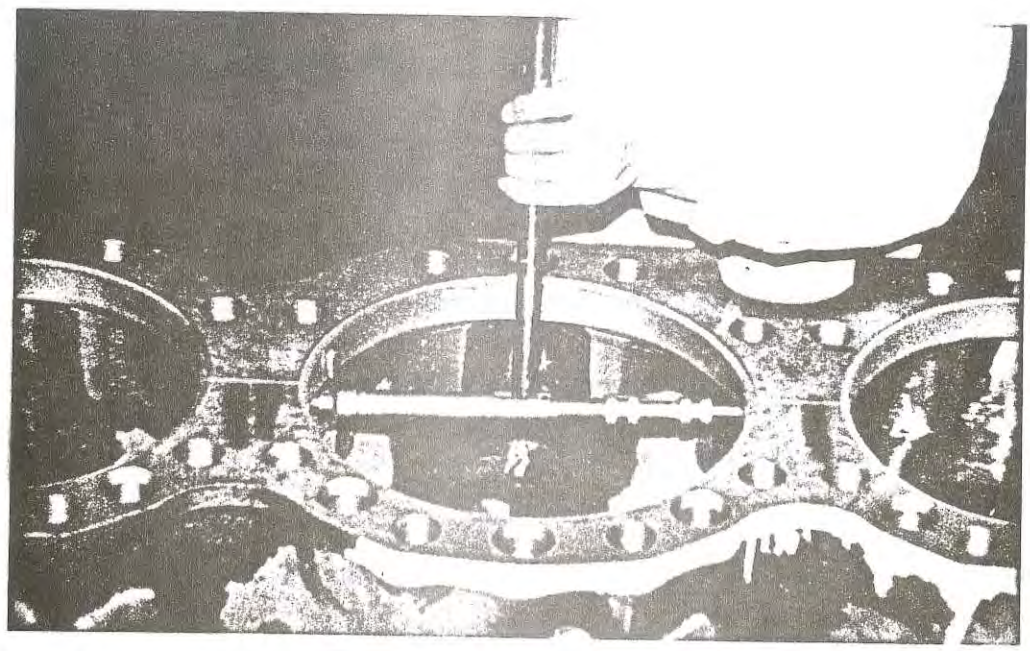
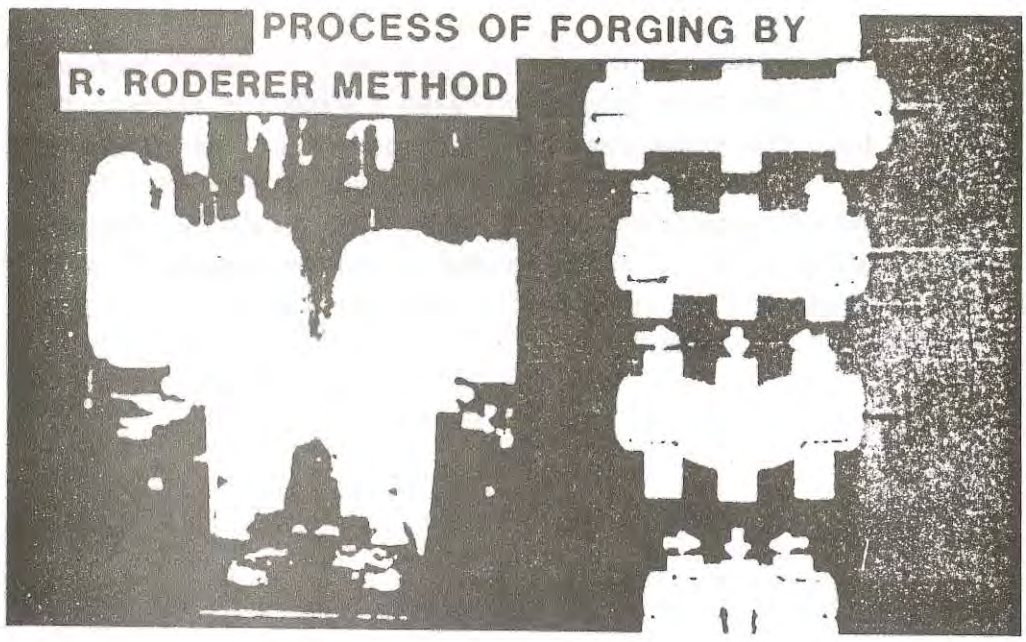


10

9. Boring the cylinder block. The cylinder is sleeve machine tooled. Extreme care should be taken during the process to control both the tolerance and rounding-off of the diameter of the bore. The section where the liner sleeve is fitted plays several important roles such as, enabling smooth reciprocating motion of the piston, and providing a good seal for the cooling water for both protection from wear and corrosion of the liner.

10. Measurement of the flange fitting portion of the cylinder liner.

    The tolerance of the machined portions are carefully measured with a special limit gauge or inside micrometer.



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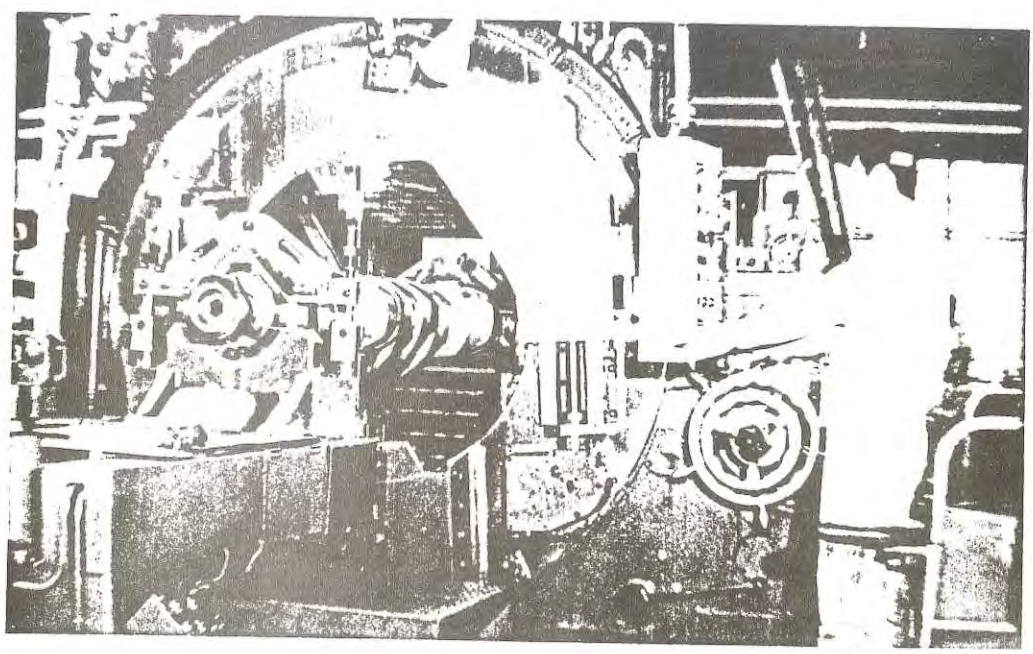

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11. The sequence of the crankshaft forging process.

The crankshaft is one of the most important parts of an engine. The method of production is by forging, such as the RR forging method shown in this picture.

RR forging is performed as follows:

A long steel rod is heated and then pressed into the crank-throw shape.

This process is repeated several times over the length of the steel rod.

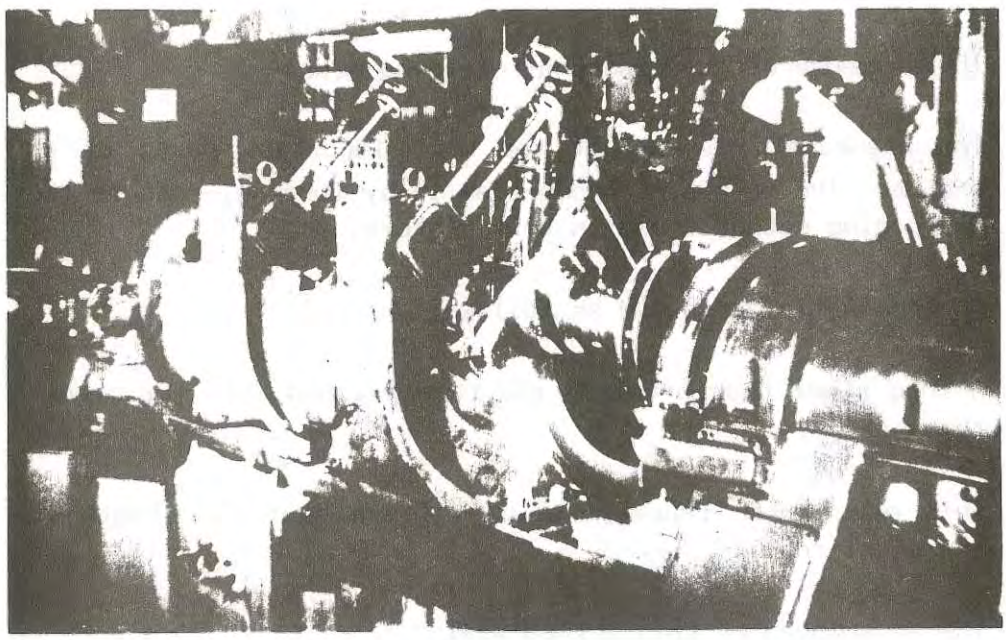
The advantages of this method are:

1) It reduces the amount of cutting tolerance on the shaft.

2) It maintains the molecular flow structure of the steel rod which will increase the strength of the crankshaft.

12. The cutting operation of the crankshaft pin section.

The journal of the crankshaft is turned on a lathe. The crank-pin is machined on a special crank-pin lathe, in which, unlike the other type of lathe, the cutting head is turned around the crank-pin while the crankshaft itself remains stationary.



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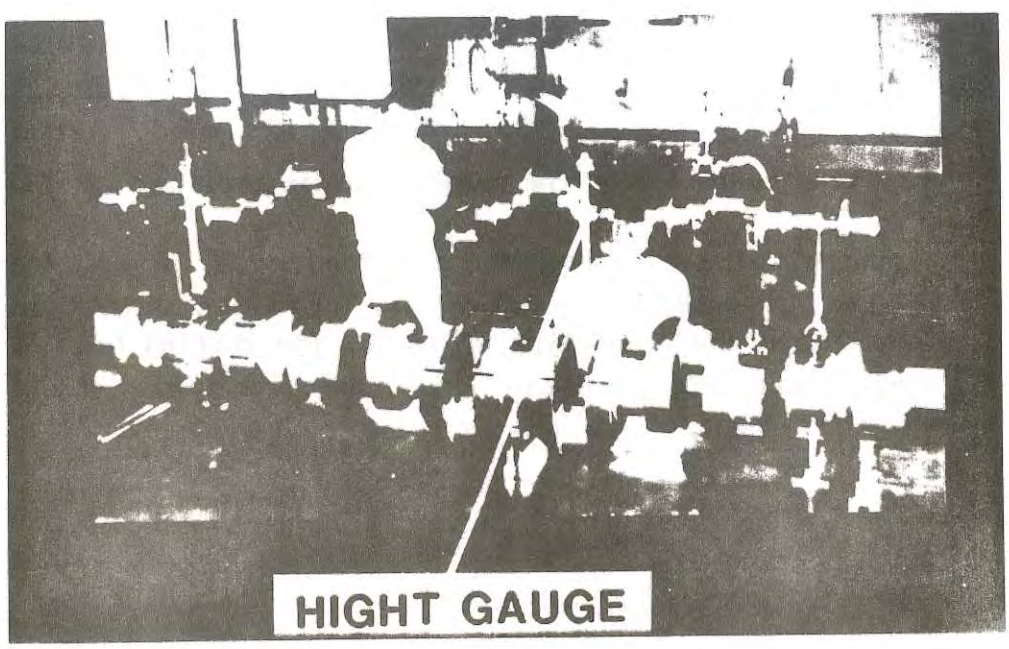

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13. Grinding the crankshaft journal.

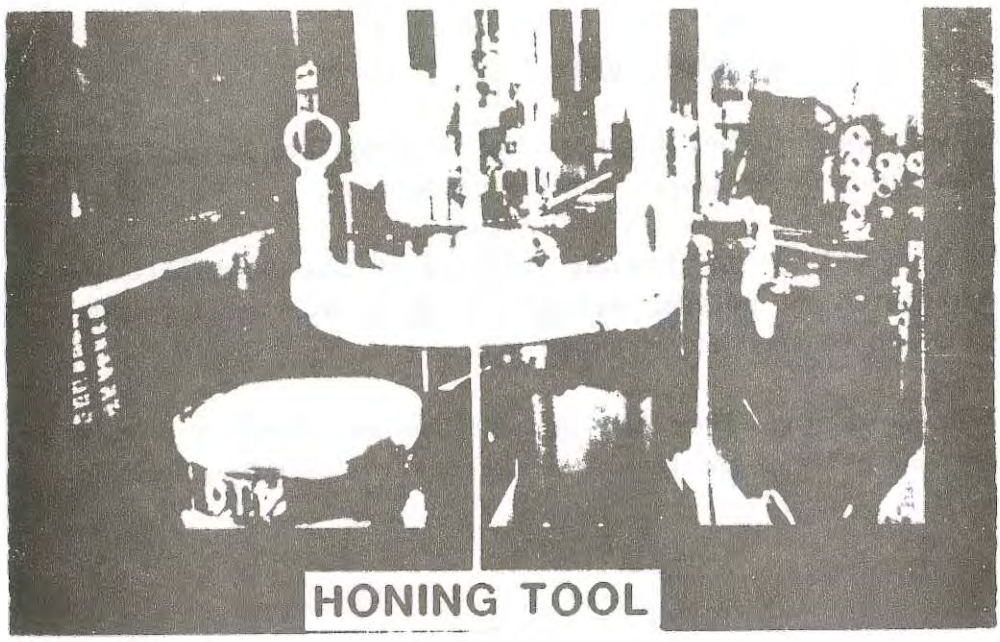
In high speed diesel engines, the bearings are subjected to heavy loads under severe service conditions.

The surfaces of the journal and pins of the crankshaft are impregnated by several milimeters depth of high-frequency hardening to witstand abnormal wear.

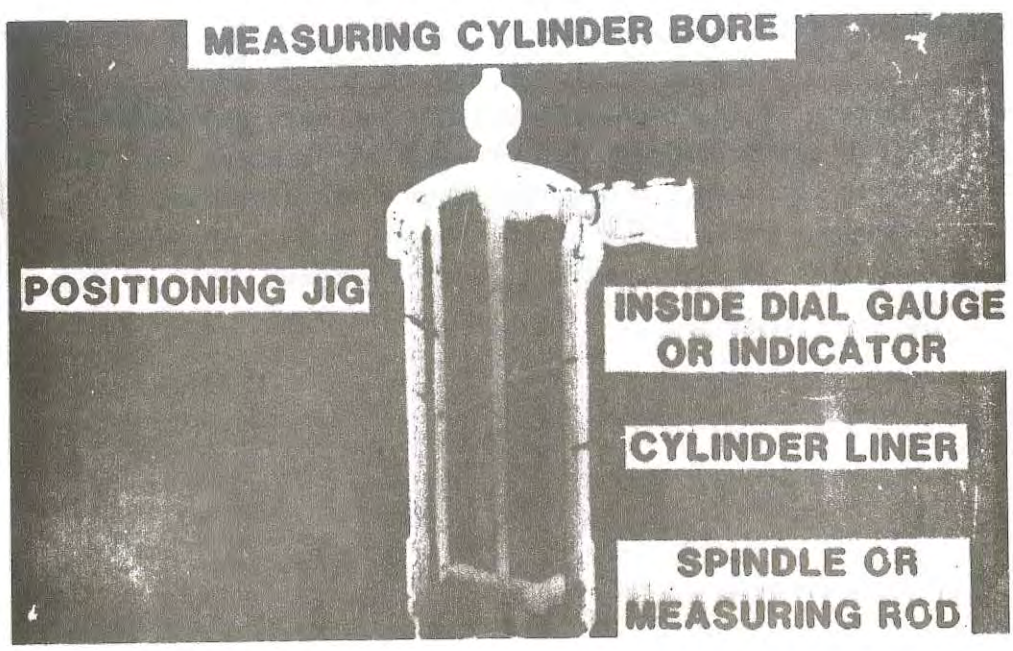
After hardening, they are then ground to obtain a precise size and perfect smoothness on a precision grinding machine.

14. Inspection of the crank-stroke.

The diameters of the crank-pin and the journals are measured at several predetermined points with micrometers and the results are recorded. Other inspections are also conducted, for instance, the run-out of the shaft, degree of parallelism of pin to the journal, angle between throws and strokes.


HONING TOOL

15


MEASURING CYLINDER BORE
POSITIONING JIG
INSIDE DIAL GAUGE OR INDICATOR
CYLINDER LINER
SPINDLE OR MEASURING ROD

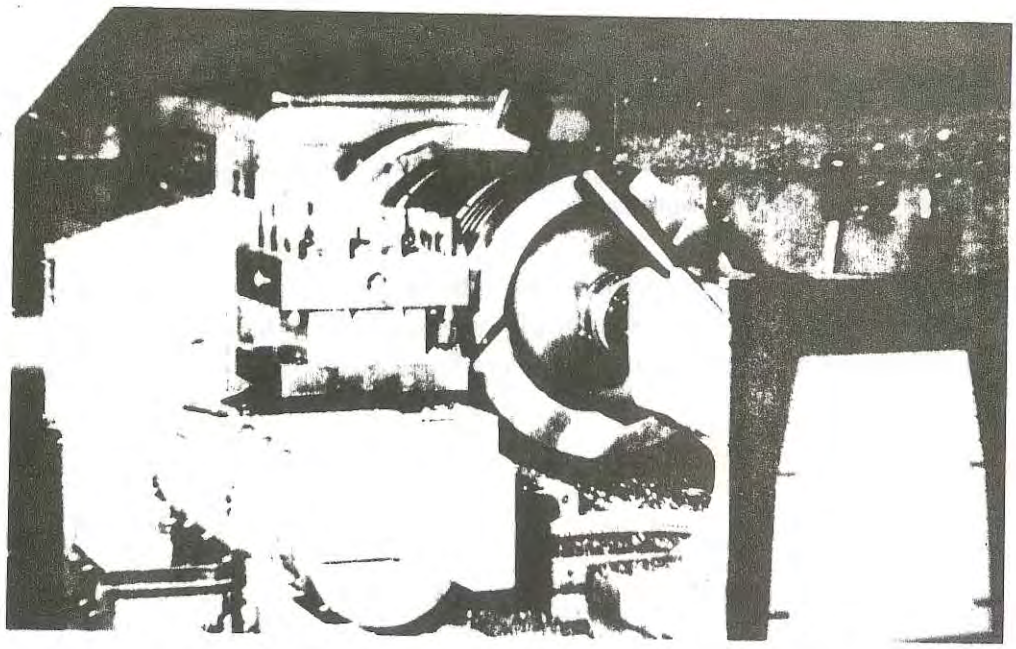
16

15. Honing work the cylinder liner's bore.

The bore of the cylinder liner is honed to a fine finish by a precision honing machine.

The honing tool consists of abrasive stones which are mounted radially. It is slowly reciprocated as it rotates' to produce a fine finish and uniform high accuracy of the bore.

16. To measure the inside diameter of the finished cylinder liner a cylinder gauge or inside micrometer is used. The measurements should be made in two directions; the first, parallel to the crankshaft and the second, at a 90^{o} (degree) angle to the crankshaft at the top, middle and bottom of the cylinder.



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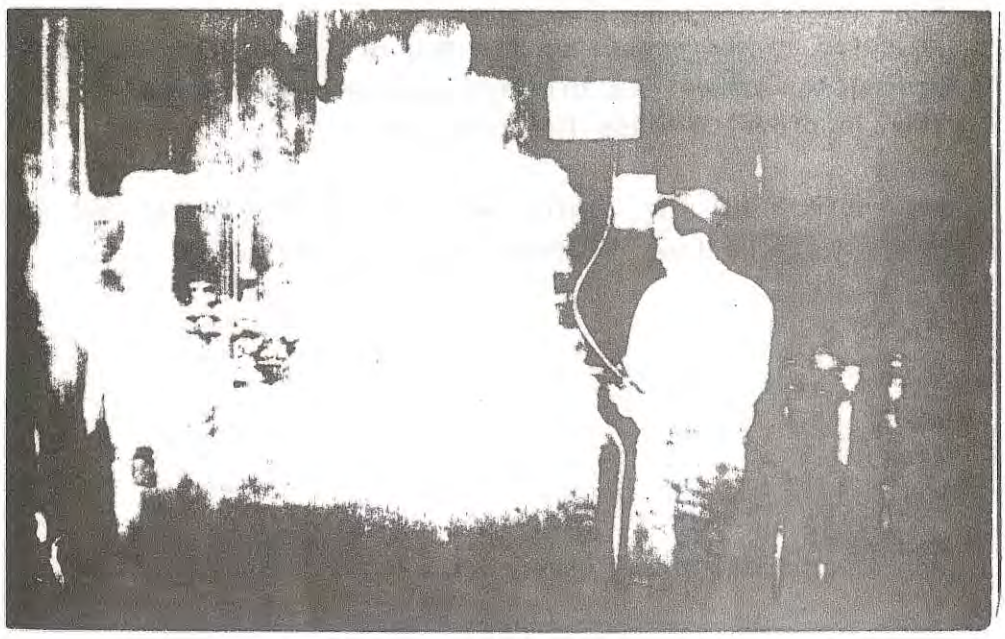
17. The outer circumference of the top of the piston should be tapered to reduce its diameter approaching the end of the crown in order to allow for expansion.

    The surface of the piston must be smooth so as not to generate cracks from residual sharp cutting edges.

18. Measuring the piston's diameter with a micrometer.

    The diameter and piston pin hole of the piston are measured with a micrometer, or limit gauge, to ensure that any variation in size is within the tolerance level.

    In a similar way, the ring grooves are also checked and the size confirmed.



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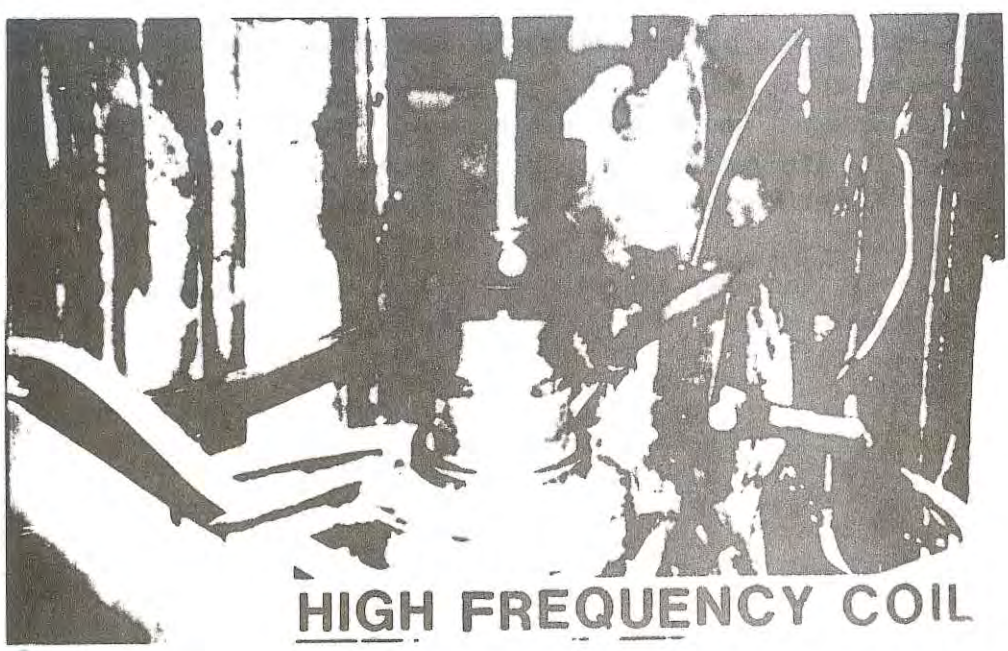

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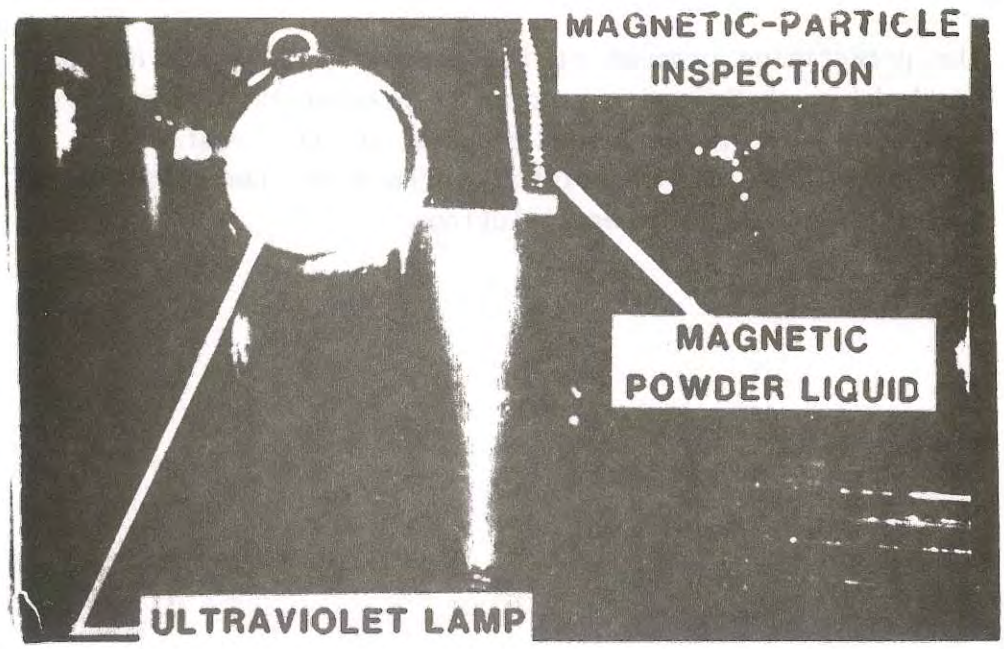
19. The perkerizing process of the pistons. Some pistons are treated by a perkerizing process to prevent its surface from seizing. The perkerizing process is the coating of a phosphate film on the piston surface by immersion in a heated phosphate manganese solution.

20. The hardening process of the piston-pin. There are two methods of hardening the piston-pin; (1) case-hardening; and (2) high frequency induction hardening.

The principle of induction hardening is similar that of a transformer. When a high frequency current flows into the primary heating coil, the secondary current will be induced in the piston-pin. This current, flowing through the material's own resistance, generates heat and raises the temperature of the piston-pin surface to the desired level. The heated pin is quickly immersed in water, and thus rapidly cooled, before being tempered in an electric furnace to give it resilience.


MAGNETIC-PARTICLE
INSPECTION
MAGNETIC
POWDER LIQUID
ULTRAVIOLET LAMP

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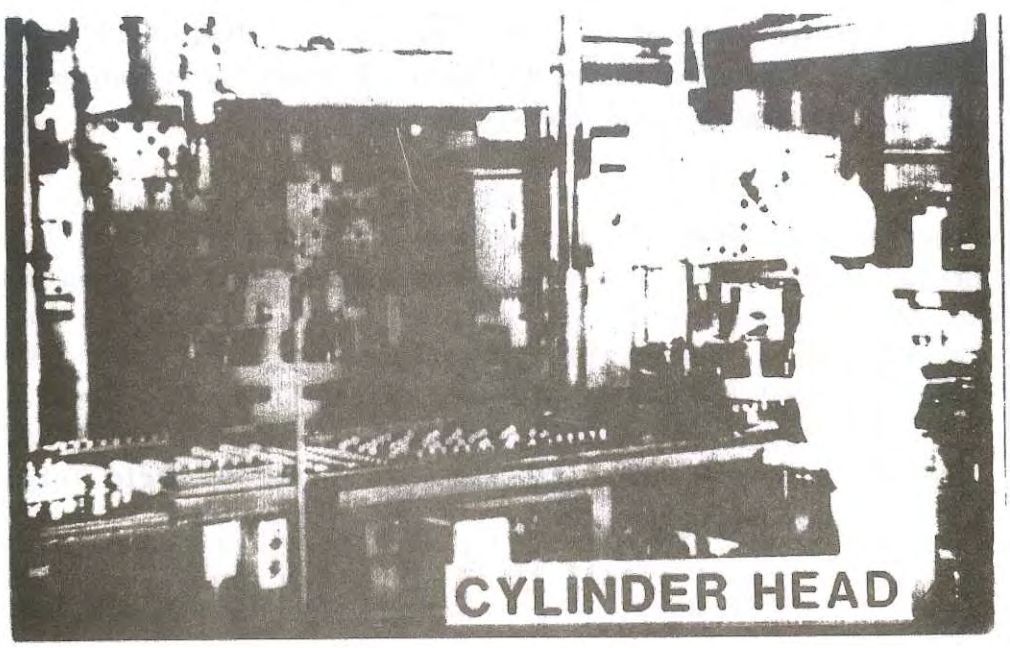

CYLINDER HEAD

22

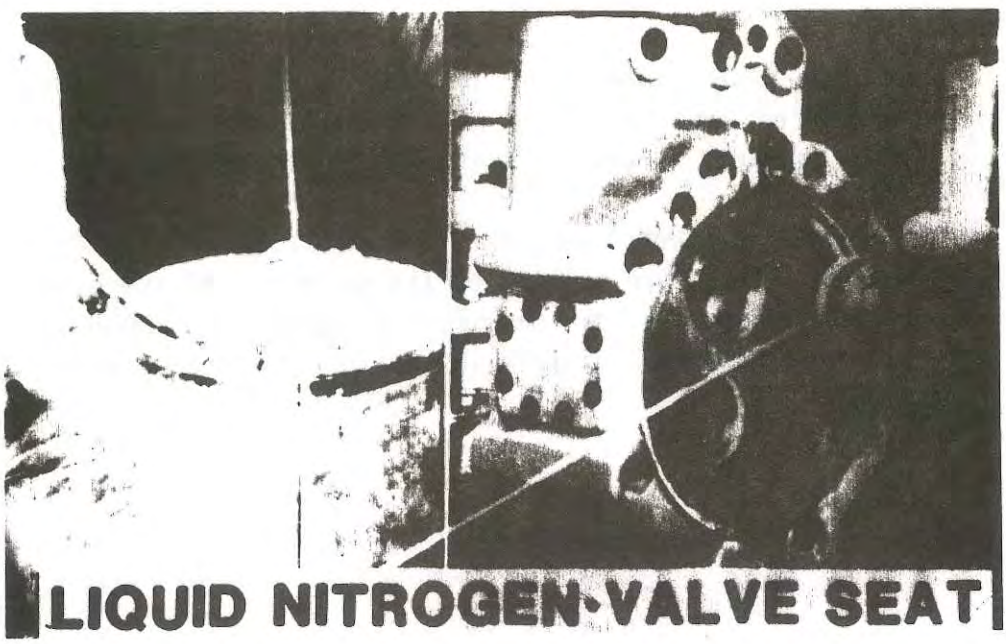
21. Magnetic-particle inspection of the piston-pin. This inspection is carried out to detect any fine cracks which may have appeared during the grinding or cooling process.

    To perform this test, the pin is magnetized and specified magnetised filings are applied to its surface. If there are any defective points, the magnetized particles collect in that portion to give a visible indication of the presence of a crack.

22. Machining the cylinder head.

    The cylinder head is usually made of high grade cast iron. It is a complicated structure and is subject to high pressure and temperatures during the combustion stroke of the engine.

    Therefore, the machining of the cylinder head should be performed so as not to leave any sharp corners and with extreme care to prevent a crack occuring due to undue stress being exerted on any remaining sharp edges while the engine is running.



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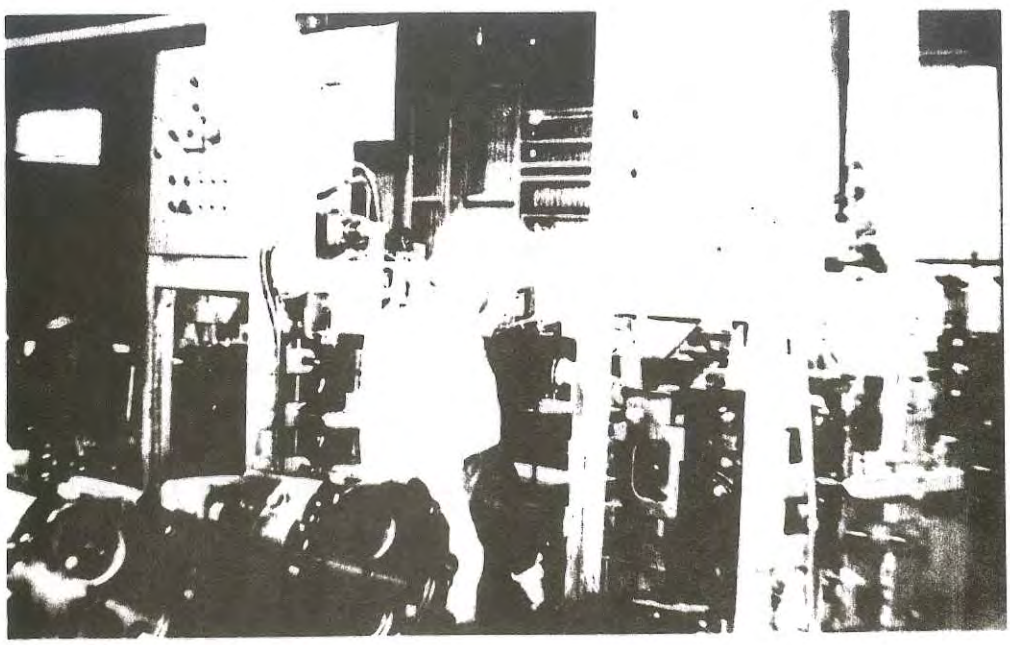

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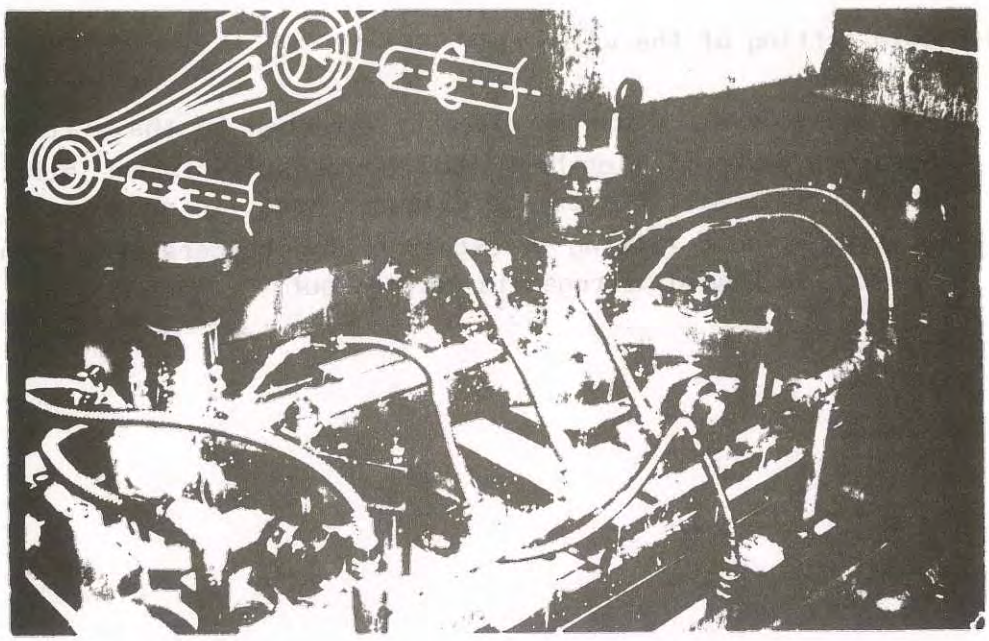
23. Cold fitting of the valve seat.

The valve seat, which is directly attached to the cylinder head, is made of high-heat and abraision resistant alloy. When it is inserted into the cylinder head, in order to fix it firmly, cold fitting at extremely low temperatures using dry-ice or liquid nitrogen is carried out.

24. The hydrostatic proof test of the cylinder head.

The wall of the combustion chamber of the cylinder head is tested by applying much higher hydraulic pressure than that which will be normally generated by combustion.

This test is performed by a high pressure water pump. The results are checked by observing the amount of leakage of the water during a certain period when under pressure. The water jacket portions of the cylinder head are also tested by this method.



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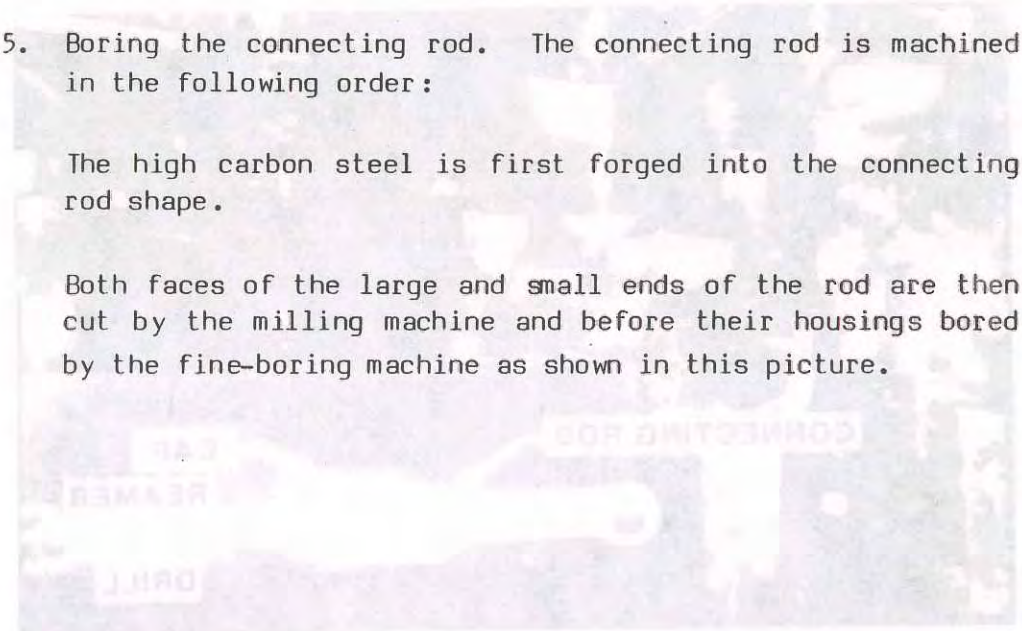
25. Boring the connecting rod. The connecting rod is machined in the following order:

The high carbon steel is first forged into the connecting rod shape.

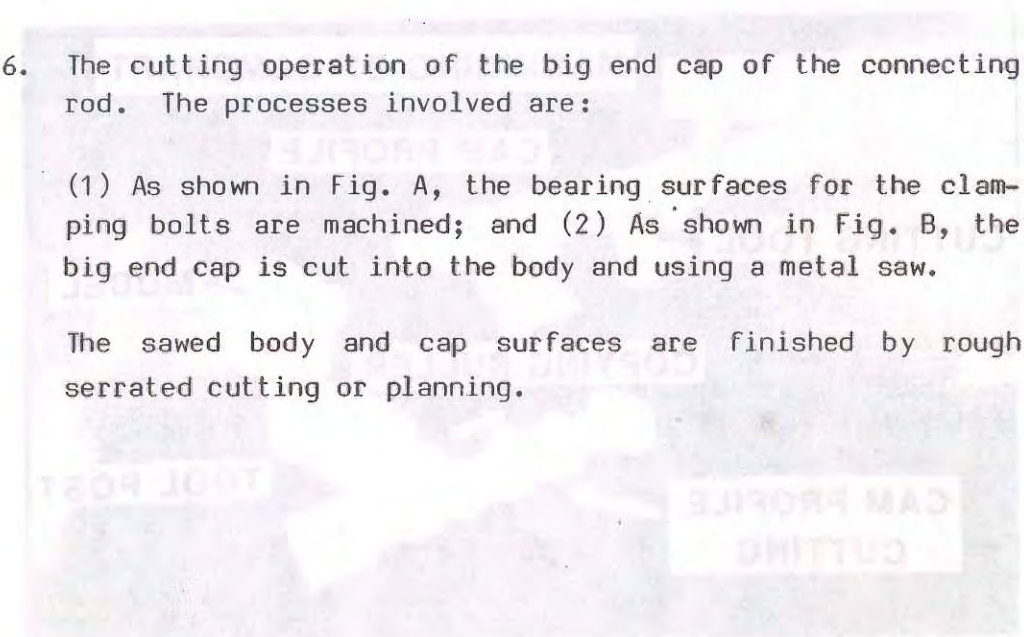
Both faces of the large and small ends of the rod are then cut by the milling machine and before their housings bored by the fine-boring machine as shown in this picture.

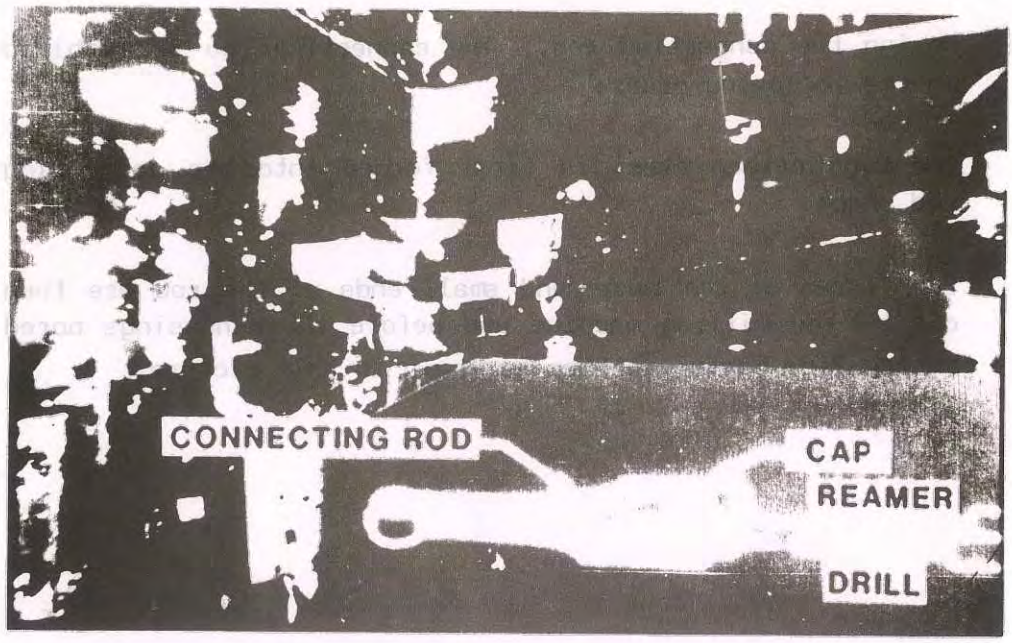


26. The cutting operation of the big end cap of the connecting rod. The processes involved are:

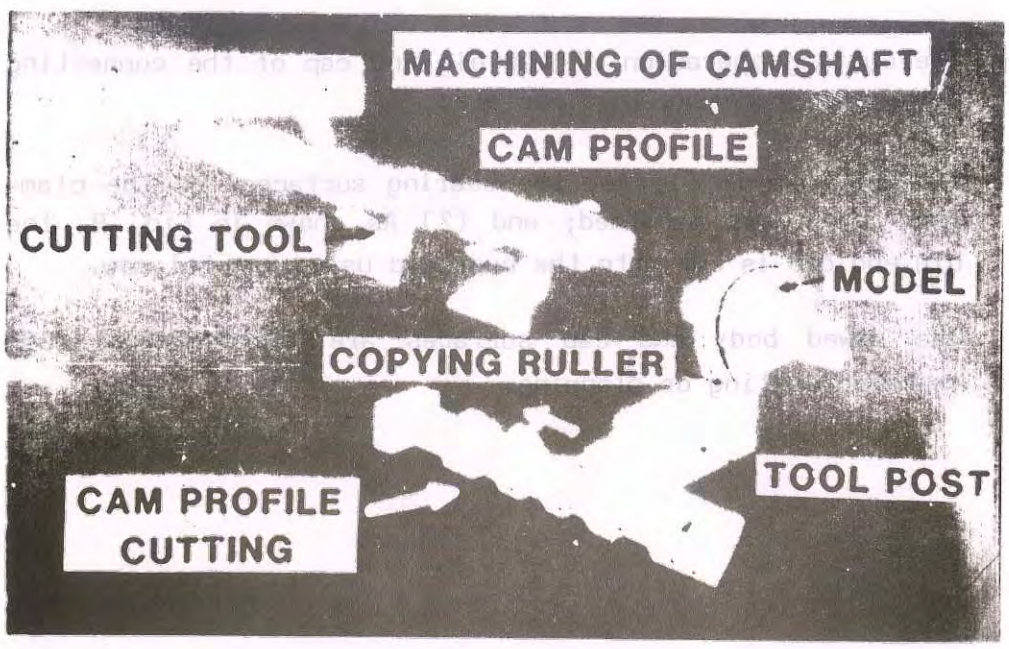
(1) As shown in Fig. A, the bearing surfaces for the clamping bolts are machined; and (2) As shown in Fig. B, the big end cap is cut into the body and using a metal saw.

The sawed body and cap surfaces are finished by rough serrated cutting or planning.




CONNECTING ROD
CAP
REAMER
DRILL

27


MACHINING OF CAMSHAFT
CAM PROFILE
CUTTING TOOL
MODEL
COPYING RULLER
TOOL POST
CAM PROFILE
CUTTING

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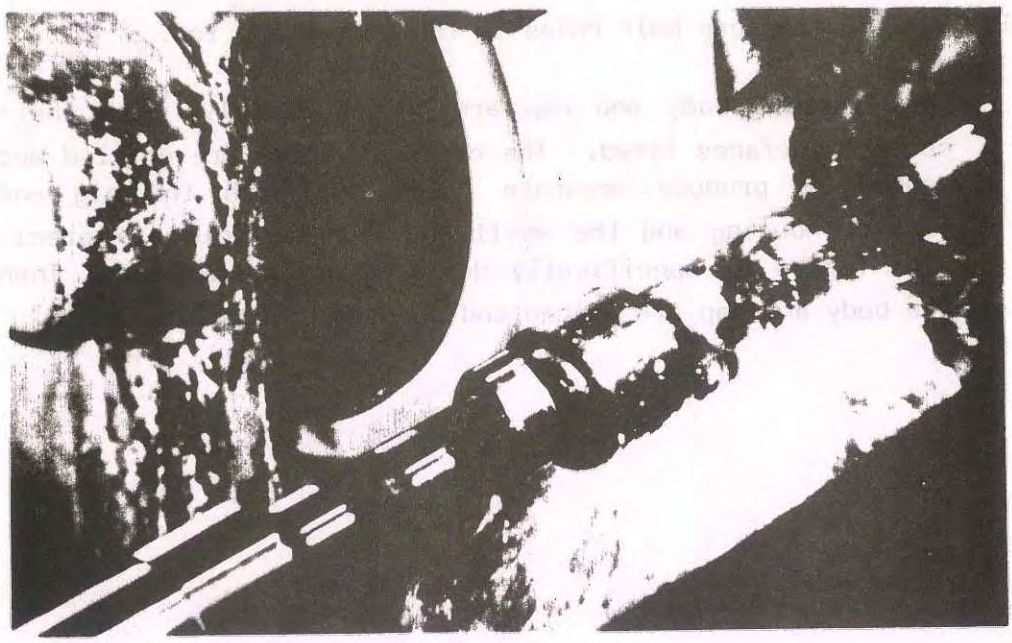
27. Drilling the cap bolt holes in the connecting rod.

The finished body and cap are joined closely, with their contact surfaces fixed. The cap bolt holes are drilled and reamed to produce accurate holes and both the big end journal housing and the small end bearing hole are precision tooled by specifically designed boring machine. Then the body and cap are joined and secured by clamping bolts.

28. Machining of the cam shafts.

There are two kinds of cam shaft: (1) assembly type; and (2) solid body type. After the carbon steel bar is die forged into the cam shaft shape, the cylinderical parts of the bar are roughly cut leaving an allowance for the finishing grinding process.

The cam profile is cut as shown in Fig. B. The grinding allowance is calculated by a special copying lathe whose cutting bite is adjusted according to the model on the template.



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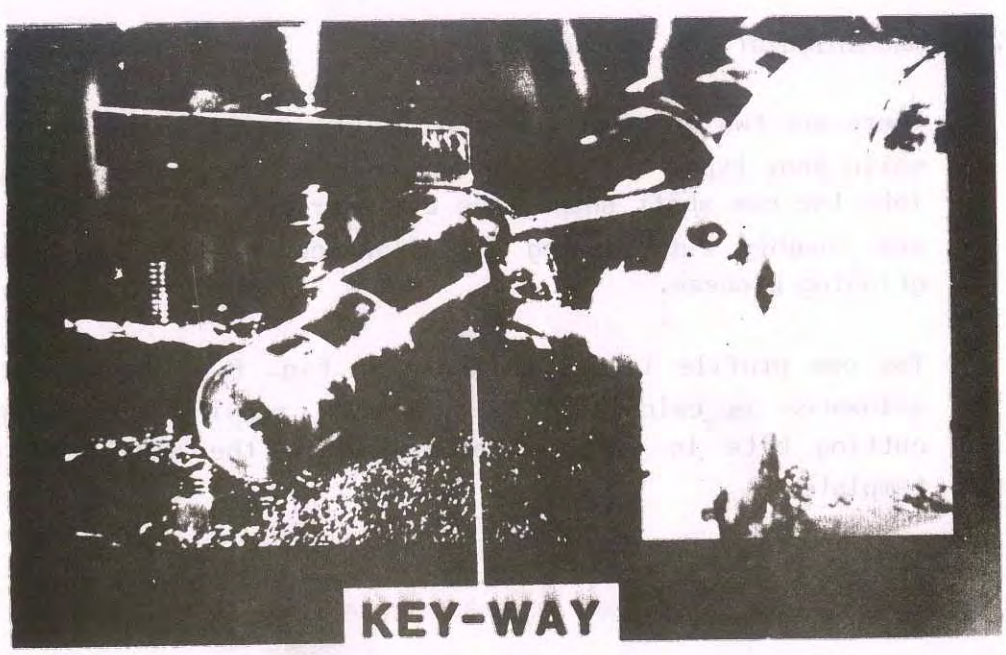

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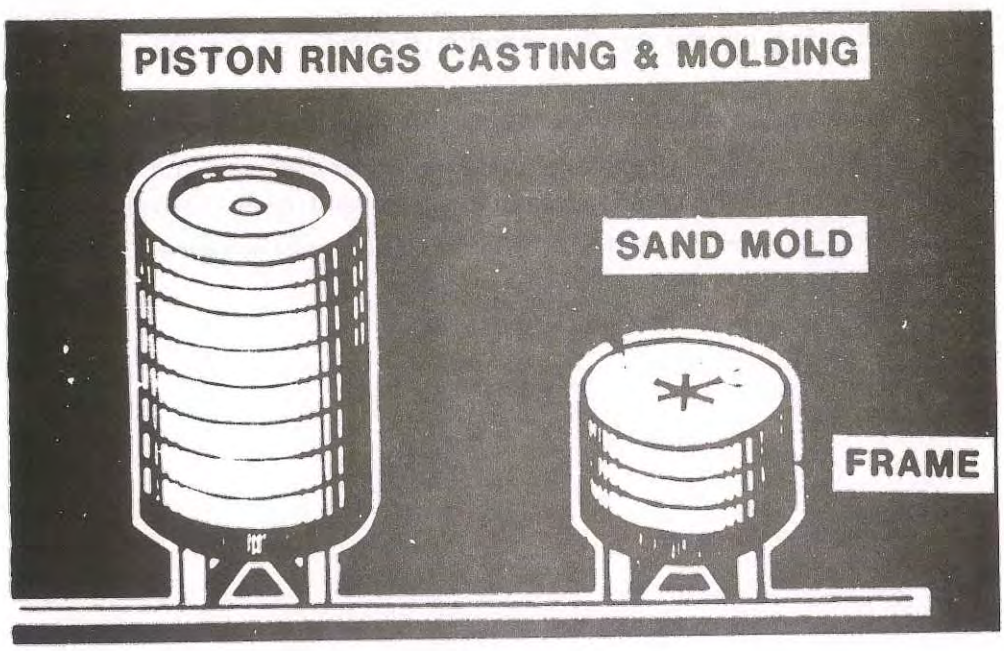
29. The grinding operation for producing the cam profile.

The rough-cut cam shaft is first hardened and then ground by the precision cam grinding machine according to the template pattern. Obtaining an accurate shape and good finish of the cam will directly affect the engine performance and its durability.

30. Key way cutting of the cam shaft.

Among all the machining processes undertaken, such as drilling holes, screw cutting and key way cutting, the key way cutting is the most important process. The position of this key way plays an important role in the alignment of the timing between the crankshaft and the cam shaft.

Therefore, the key way is cut by a special key milling machine, after first accurately calculating the angle in reference to the cam profile.



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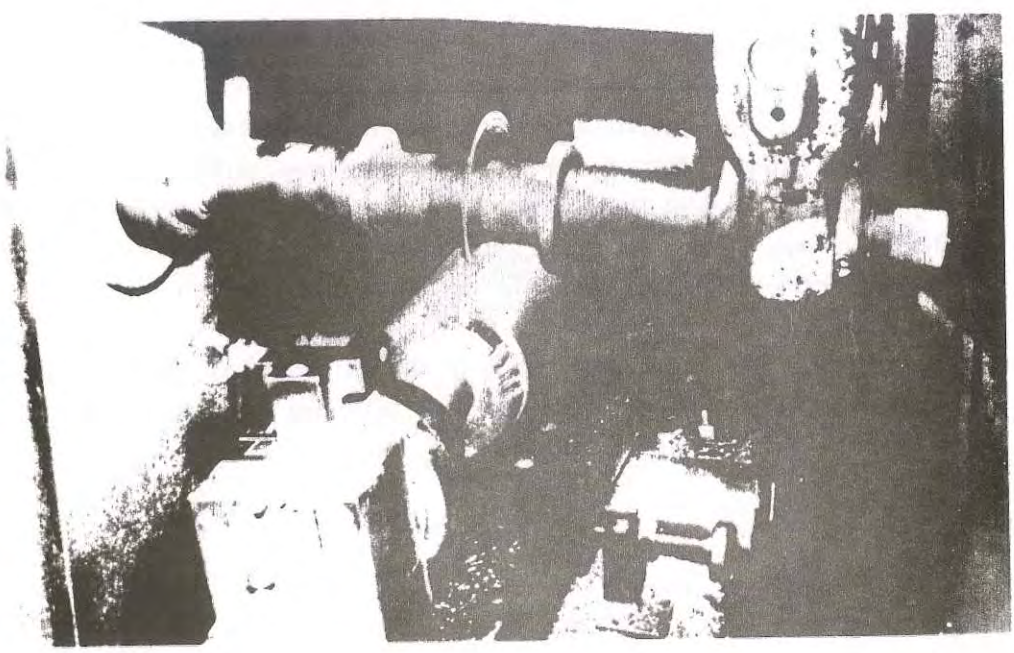

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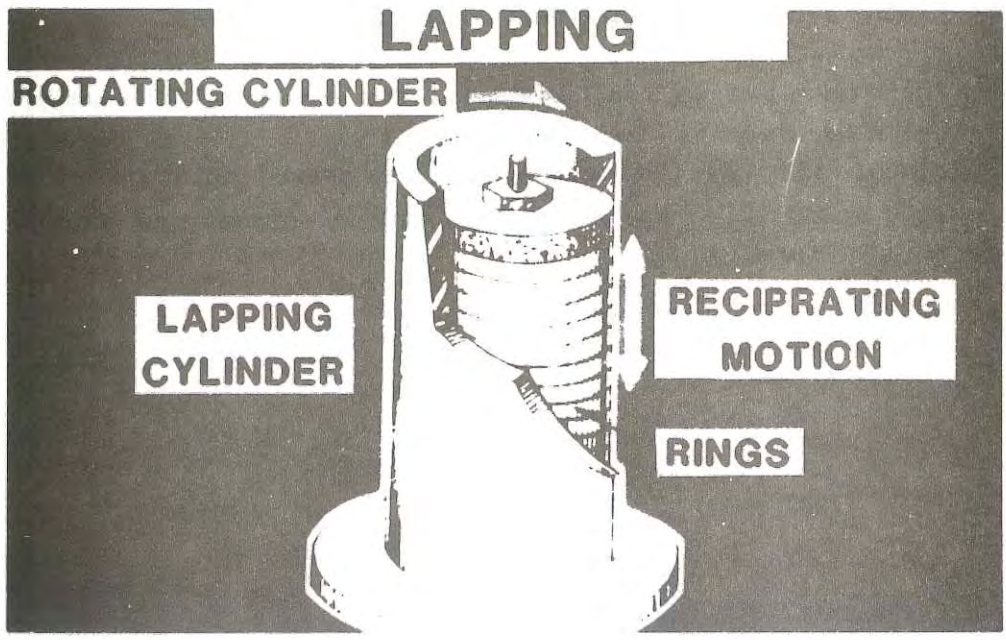
31. Piston rings casting method: individual cast type.

There are two ways of producing the rings: (1) an angular cylinder body is cast and cut it into several separate rings; and (2) the molten iron is poured into individual ring molds which are stacked in several stages, as shown in this picture.

32. The cutting operation of the ring's gap.

After the circumference of the ring has been machined by a precision lathe, the gap on the ring is slit, according to a prior calculation, in order to allow adequate tension to the ring in relationship to the engine's bore. Next, the inner diameter of the ring is finished and this process is also affected by the tension required on the ring.


LAPPING
ROTATING CYLINDER
LAPPING CYLINDER
RECIPRATING MOTION
RINGS

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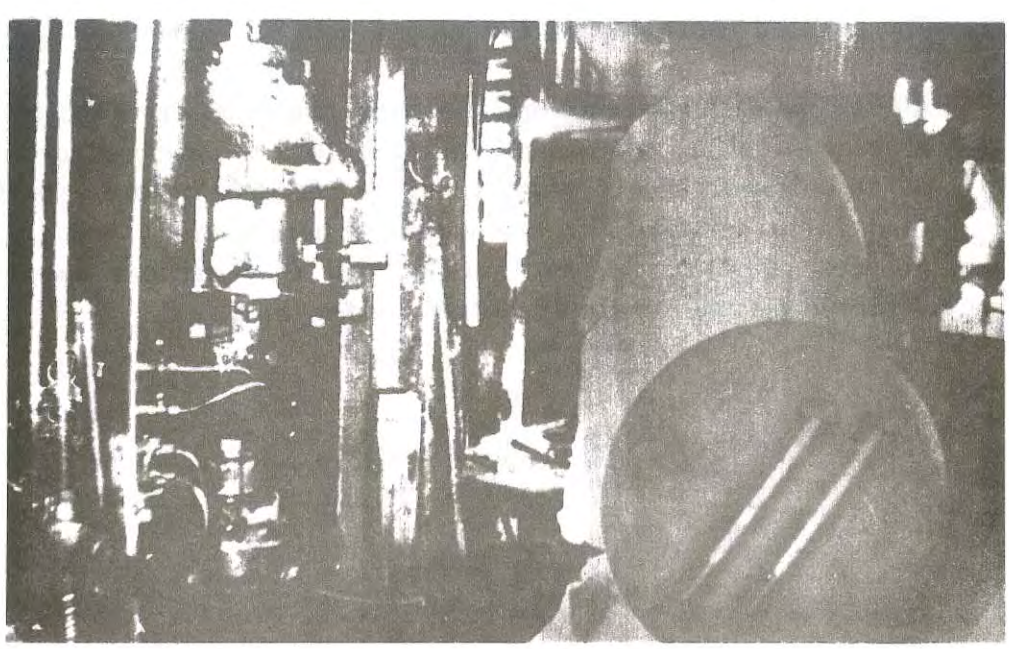

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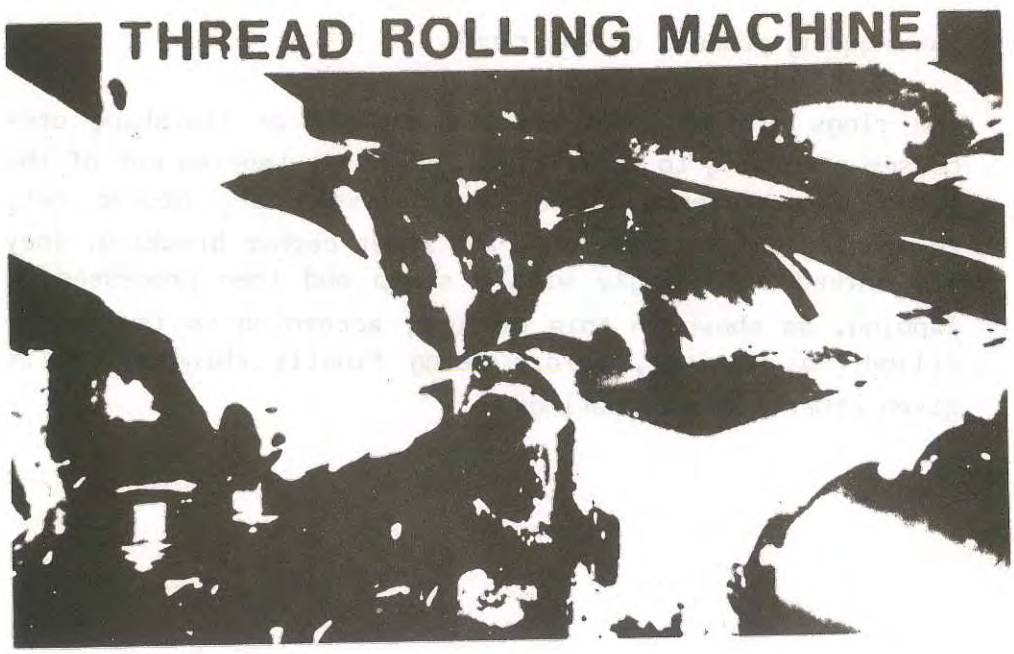
33. The lapping process of the rings.

The rings are machined using a variety of finishing processes according to their types, such as; tapered cut of the outer circumference, under cut, level cut, groove cut, chamfering inner groove cut, and inner corner breaking. They are marked accordingly with a stamp and then processed by lapping, as shown in this picture, according to the engine cylinder's diameter, before being finally chromeplated or given other surface coatings.

34. The production of the connecting rod bolts or cap bolts.

The connecting rod bolts are one of the most important parts of the engine. They are made of the highest grade steel and are cut to specified length and forged into bolt shape. After that they undergo magnaflux inspection, and only the bolts having no cracks or flaws are machined.



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35. Thread rolling the connecting rod bolts.

The outer diameter and the end surface of the working section of the bolt are roughly cut, leaving an allowance for grinding on the copy lathe.

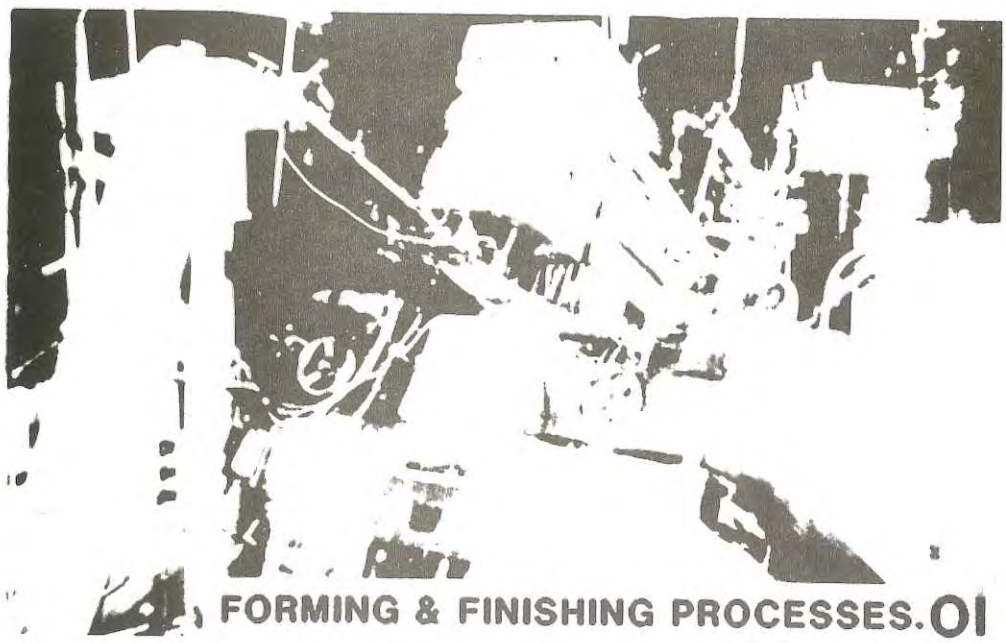
The outer diameter is ground precisely using an external cylindrical grinding machine and finally the bolts are threaded by a rolling machine as shown in this picture.

36. Bearing metal sintering equipment.

There are a variety of bearing metals; white metal, kelmet metal, and aluminum.

In the kelmet bearing, a copper-based alloy, first the steel sheet of the bearing material undergoes correction to its surface flatness in the rewinding machine.

The sheet is then sintered on one side by metal powders such as a copper-lead alloy, or lead bronze alloy, and is again rolled into the desired thickness.



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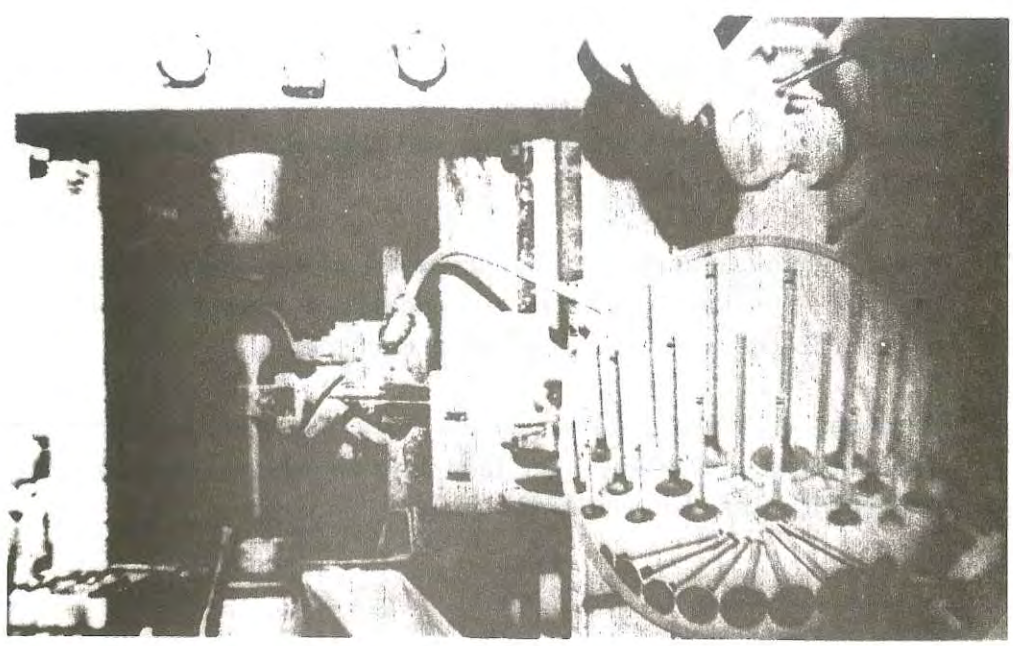

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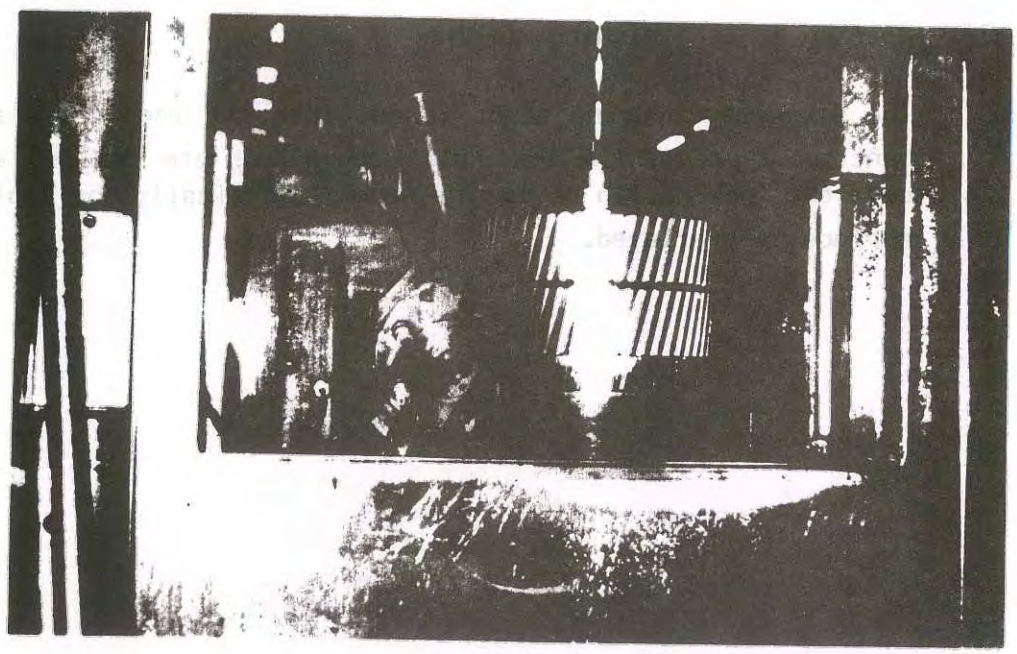
37. Bearing sheet finishing machine.

The processed bearing sheet is cut into the required size, bent on a press, the oil hole and groove are drilled and cut, the locking lip or lug is formed and finally the inside surface is overlayed.

38. The intake and the exhaust valve production.

Standard intake and exhaust valves are made by the following steps.

The bar metal is first cut into specified lengths, upset forged and formed into shape in the forging press. It is then subjected to heat treatment to increase its strength at high temperature and is finished by a various grinding processes into a high precision product.



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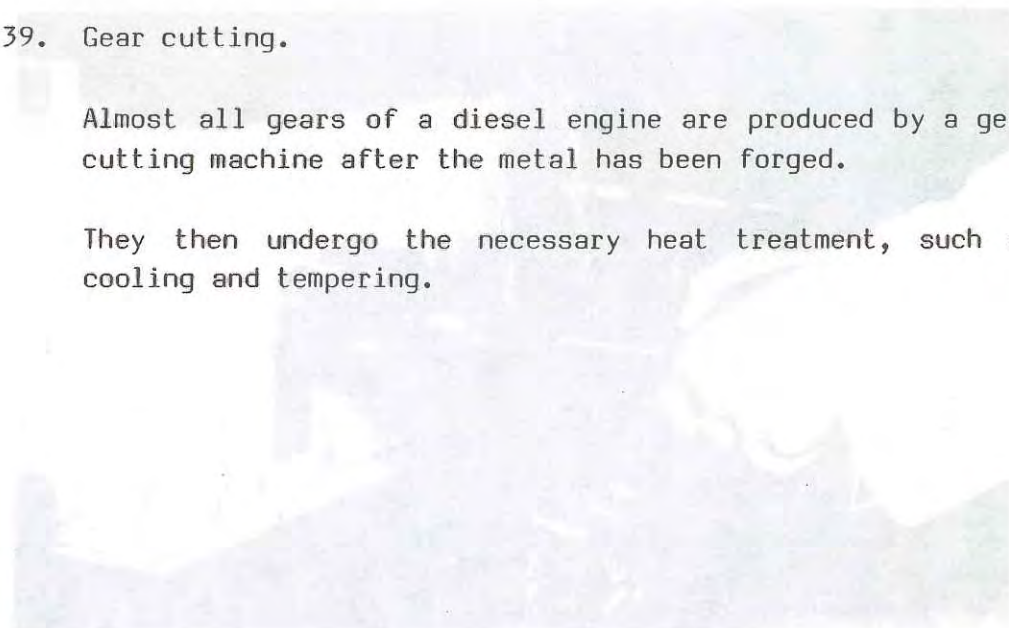
39. Gear cutting.

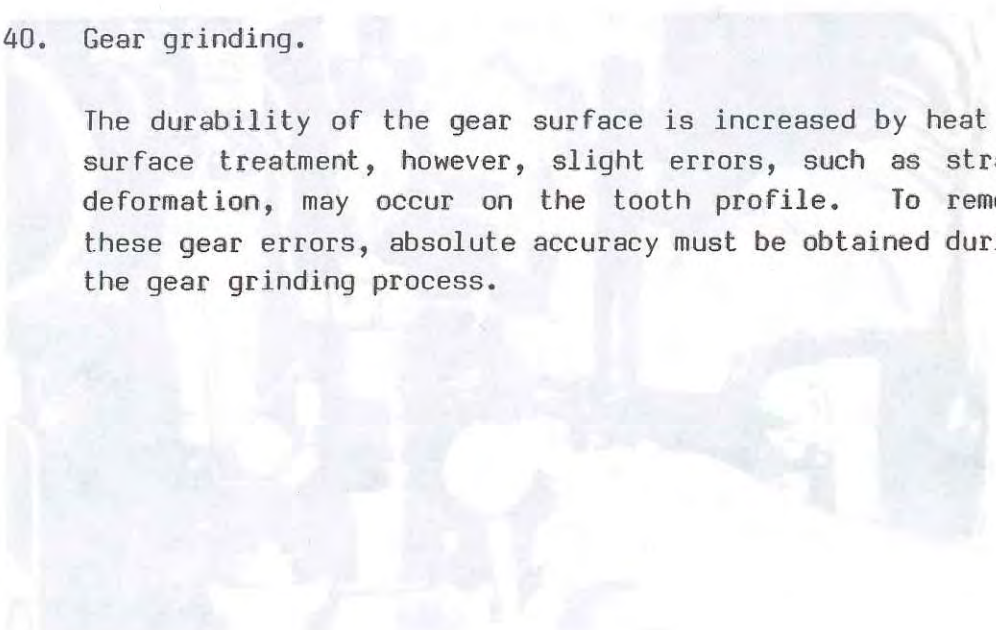
Almost all gears of a diesel engine are produced by a gear cutting machine after the metal has been forged.

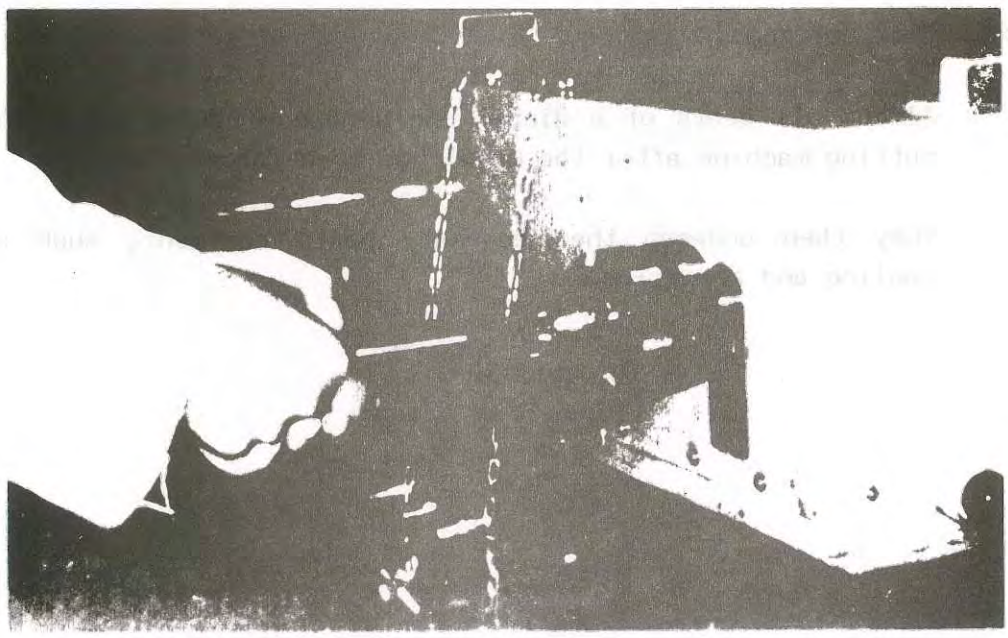
They then undergo the necessary heat treatment, such as cooling and tempering.



40. Gear grinding.

The durability of the gear surface is increased by heat or surface treatment, however, slight errors, such as strain deformation, may occur on the tooth profile. To remedy these gear errors, absolute accuracy must be obtained during the gear grinding process.





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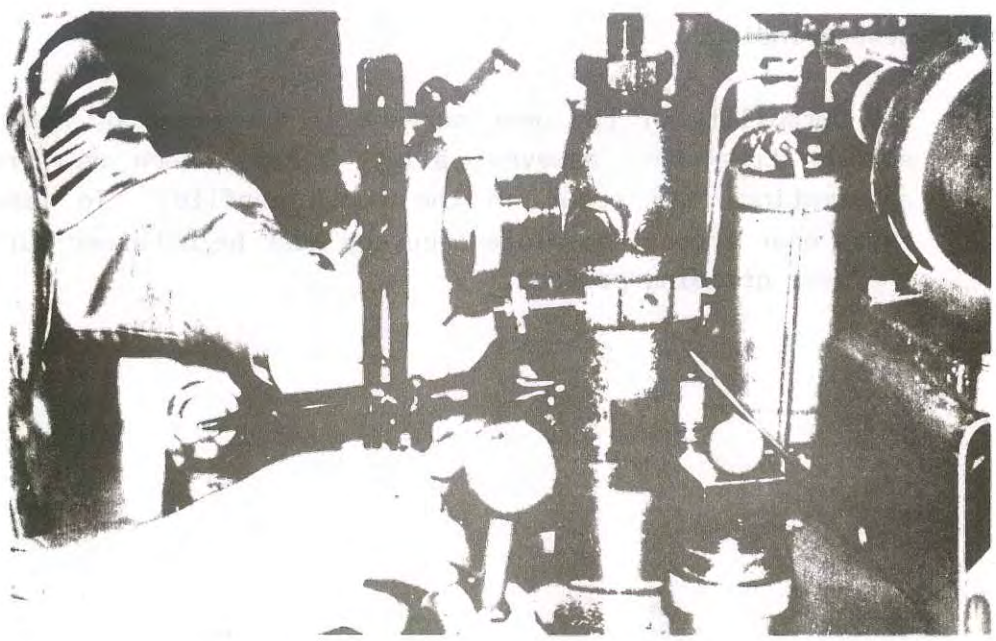


42

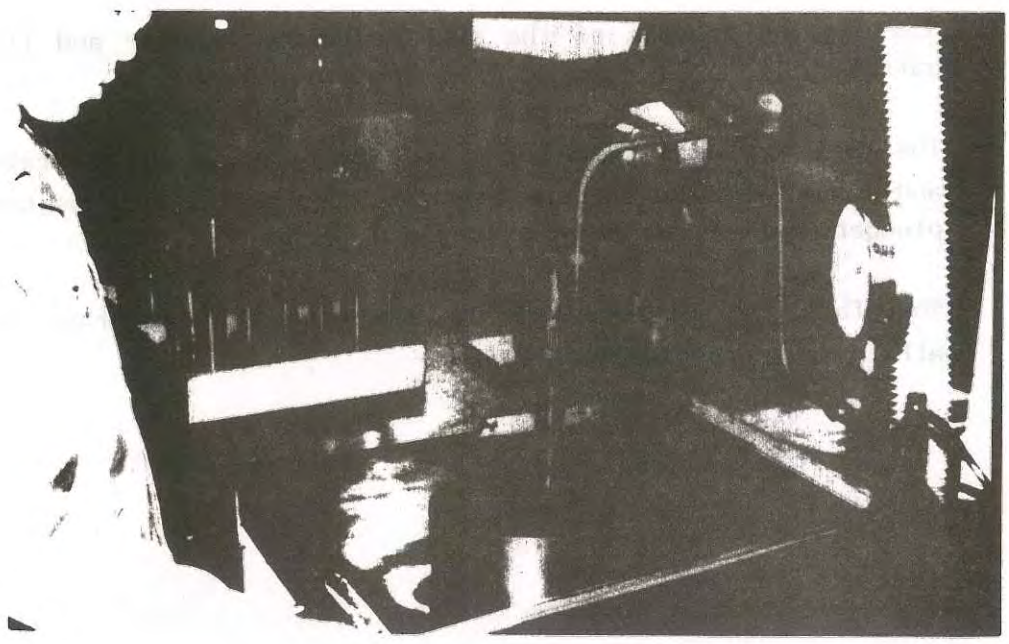
41. The lapping process of the fuel injection plunger and its barrel.

The fuel injection pump requires a smoother, more accurate and longer-wearing surface than its components, such as the plunger, barrel, delivery valve, and its seat.

Therefore, it is necessary to lap each part together to attain an extra precision finish.

42. Incorporating the plunger into an injection pump.

The production of the plunger and barrel must be carried out with extreme care before the injection timing, injection volume, and air tightness are inspected.



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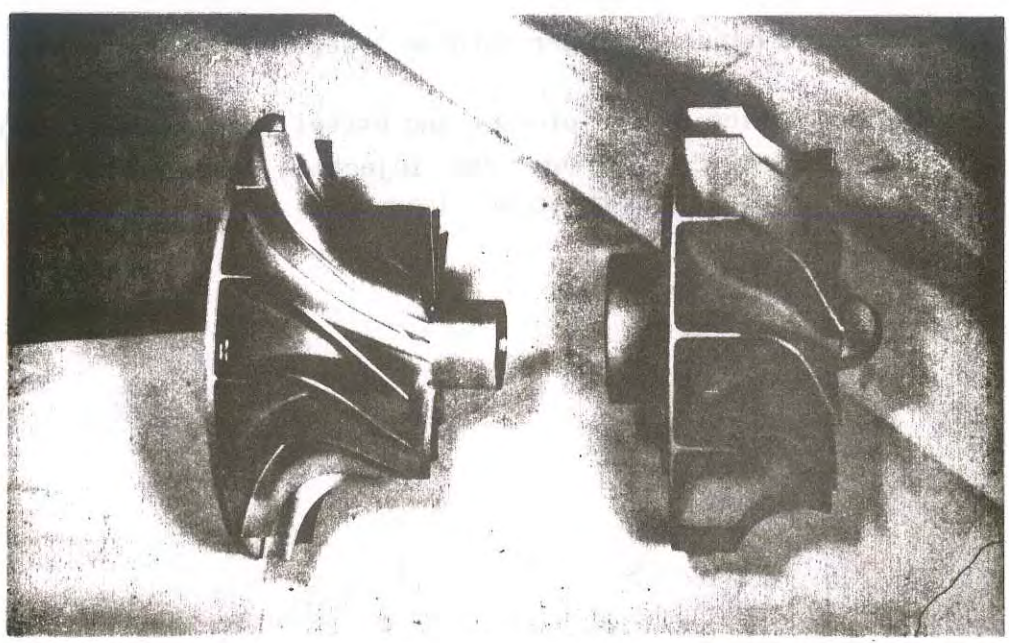
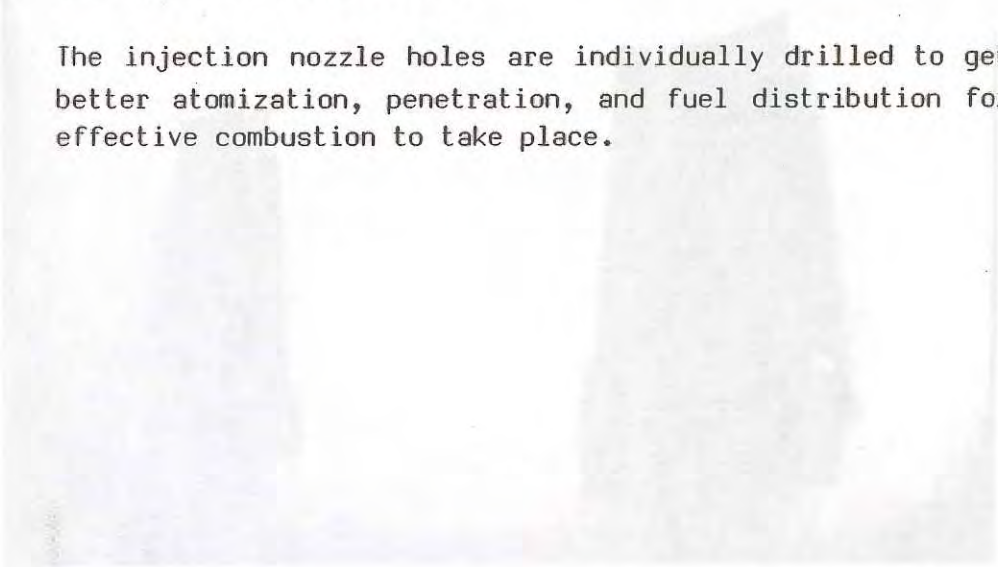


44

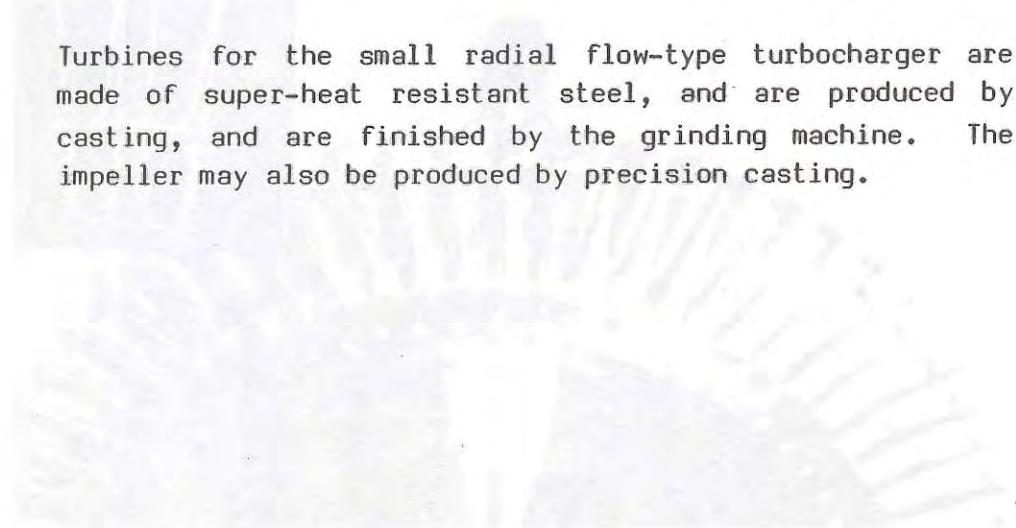
43. The injection nozzle test.

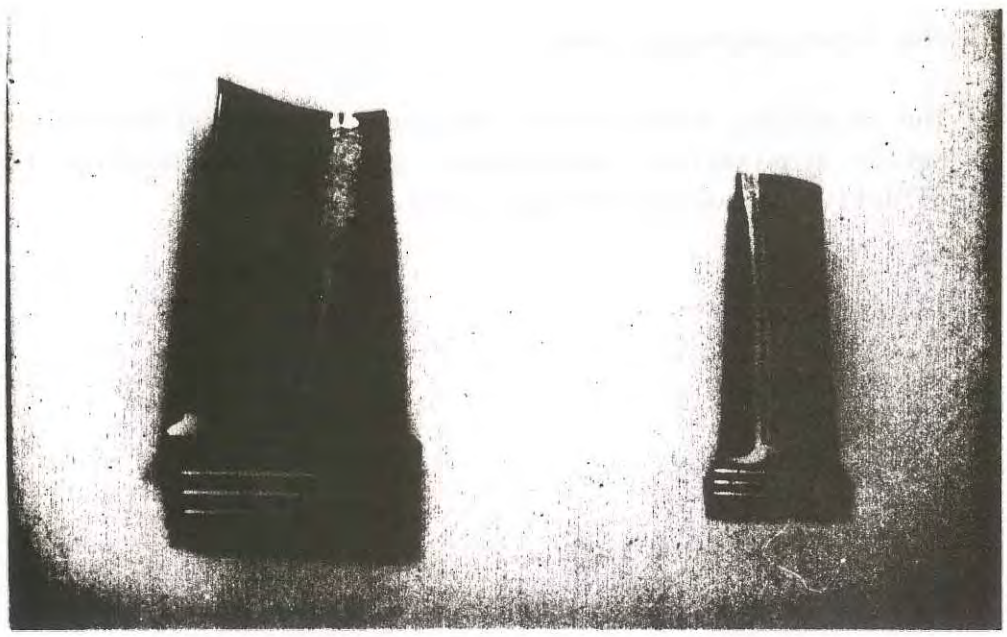
The injection nozzle holes are individually drilled to get better atomization, penetration, and fuel distribution for effective combustion to take place.



44. The impeller and the turbine wheel for the diesel engine turbocharger.

Turbines for the small radial flow-type turbocharger are made of super-heat resistant steel, and are produced by casting, and are finished by the grinding machine. The impeller may also be produced by precision casting.





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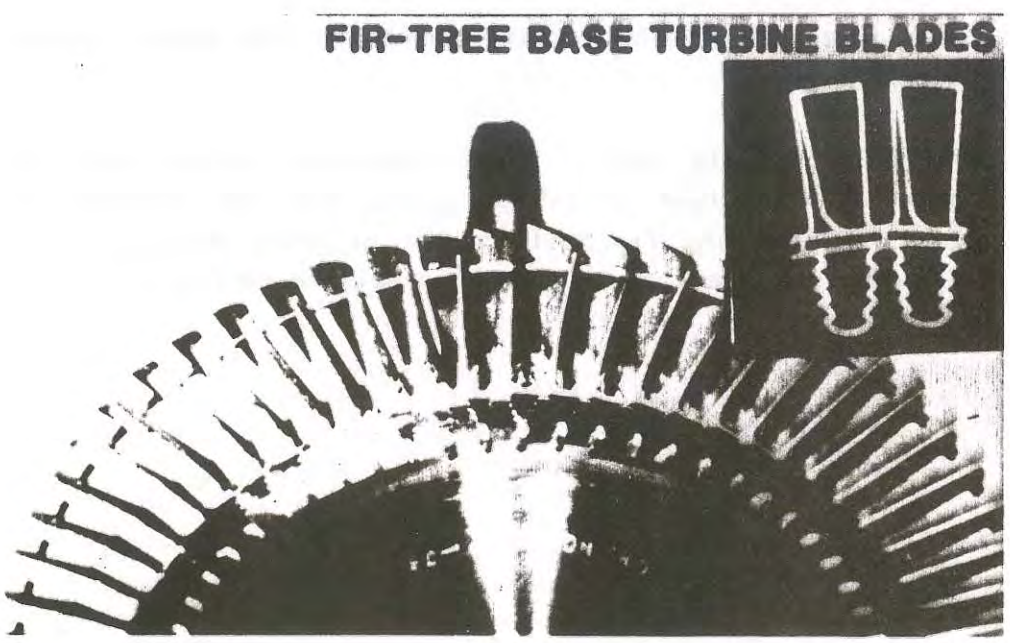


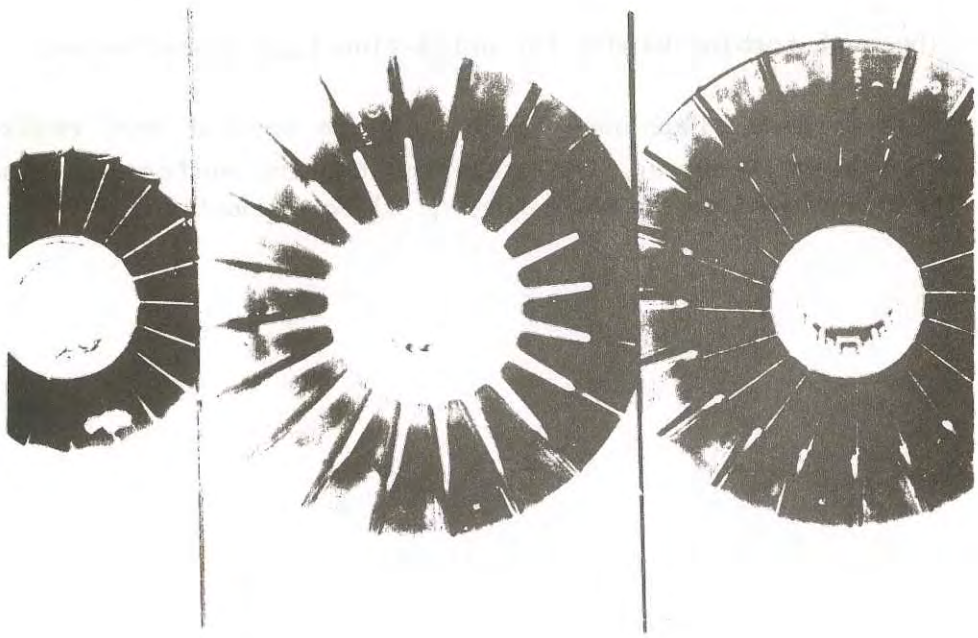
46

45. The cast turbine blades for axial-flow type turbocharger.

This turbine blade used to be cut from special heat resistant steel, however, the precision casting method has also been employed recently in turbine blade production.

46. The assembled turbine blades being incorporated in a turbine wheel.

The turbine blades are generally fixed on the turbine disc using the fir-tree or christmas-tree base-type method. The disc and blades are cut by the broaching machine.



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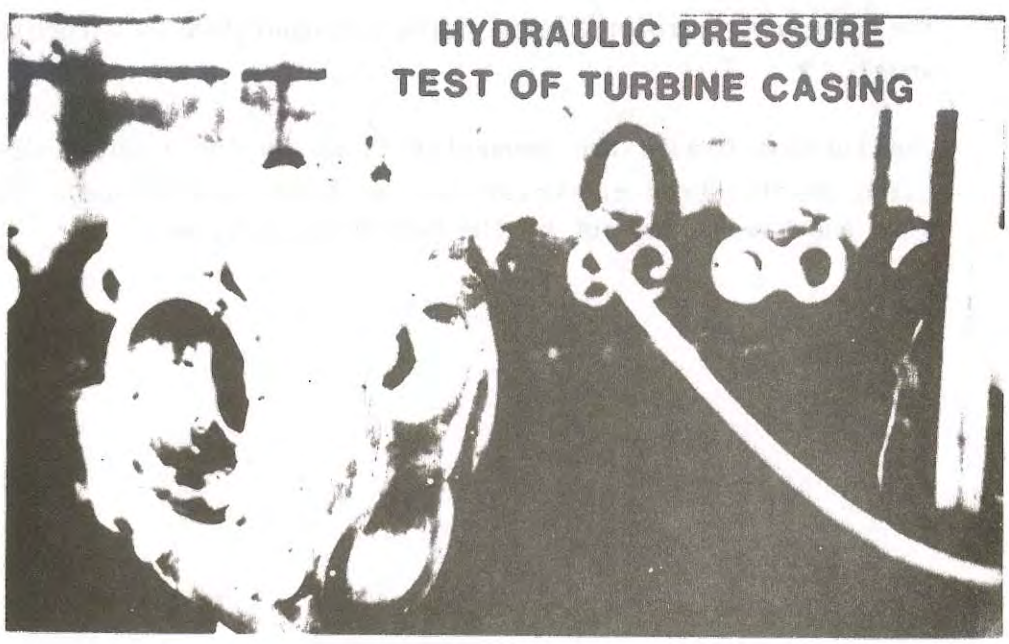


48

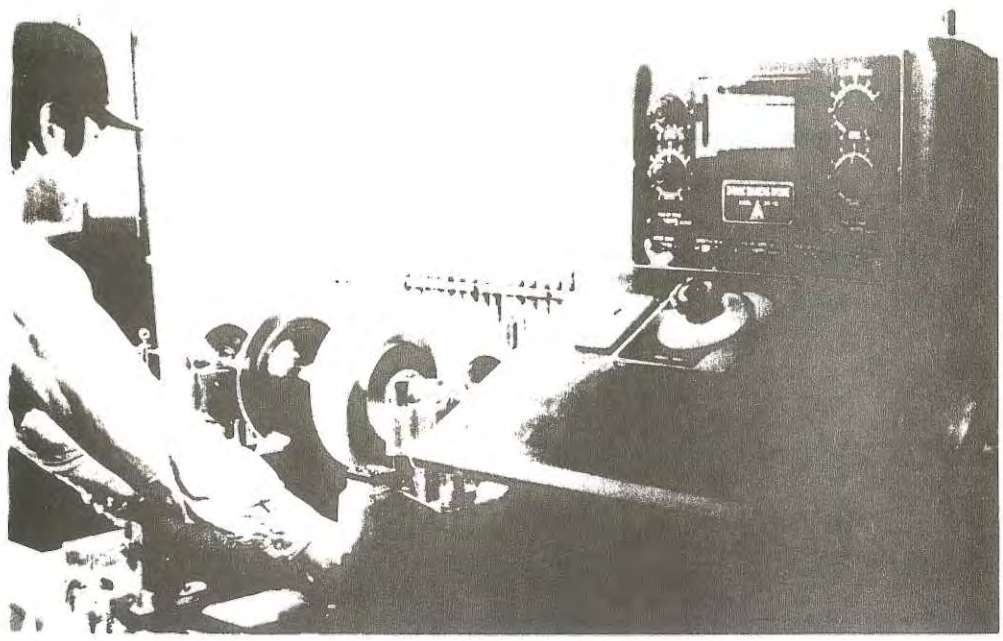
47. The impeller of the blower used for the turbocharger.

The impeller of the blower used to be cut from a solid body or forged aluminum, but now it consists of two separate parts.

The body is cut from aluminum and the inducer is made by precision casting.

48. A turbine casing being tested under hydraulic pressure.

Although the blower casing is made of aluminum cast alloy, the turbine casings for both the radial and axial flow turbocharger are made of heat resistant cast iron. The former is air cooled and the latter is cooled by water being passed through the jacket.



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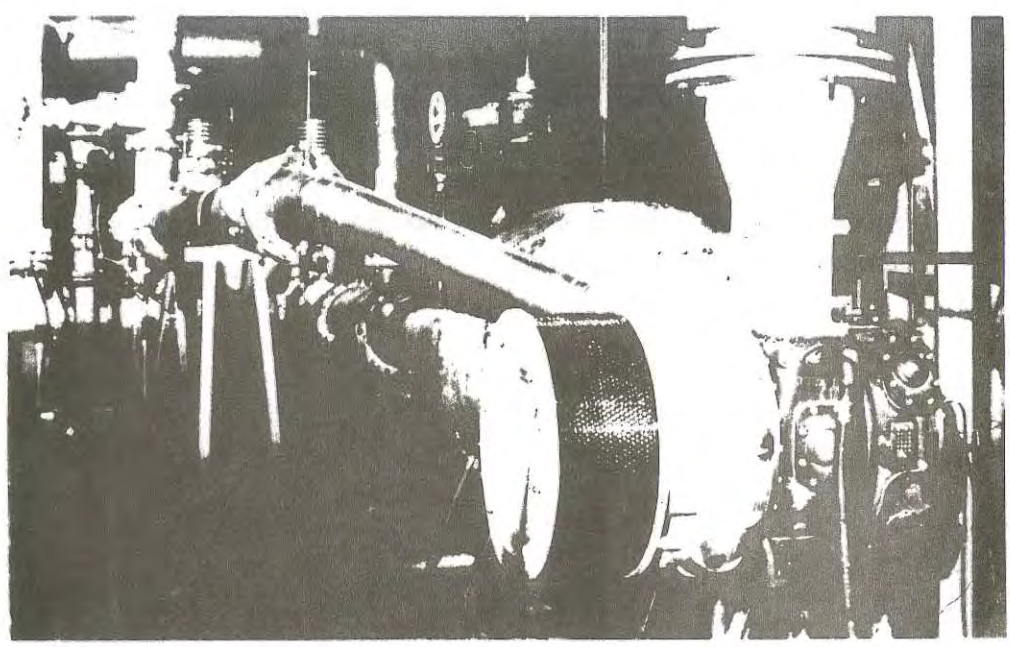


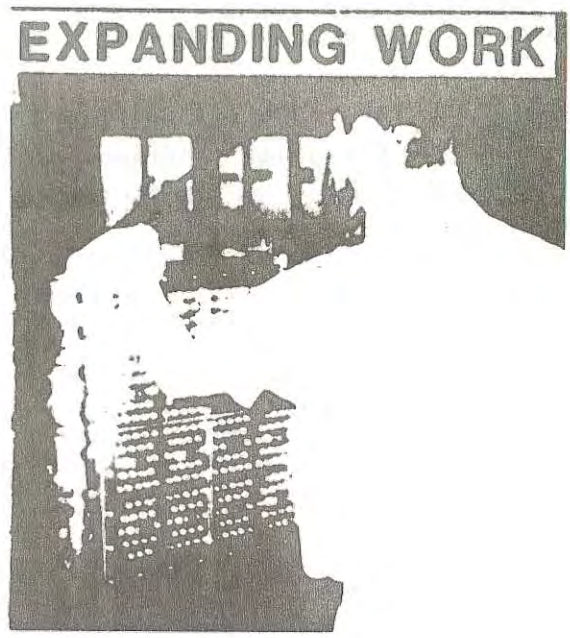
50

49. The dynamic balancing test on a balancing machine.

The rotor shaft itself is first checked for any imbalance. Then the dynamic balance of the assembled unit is measured and adjusted on the balancing machine.

50. Testing the turbocharger unit.

The assembled turbocharger undergoes a performance test under high pressure combustion gas at a measured speed using specifically designed testing equipment.



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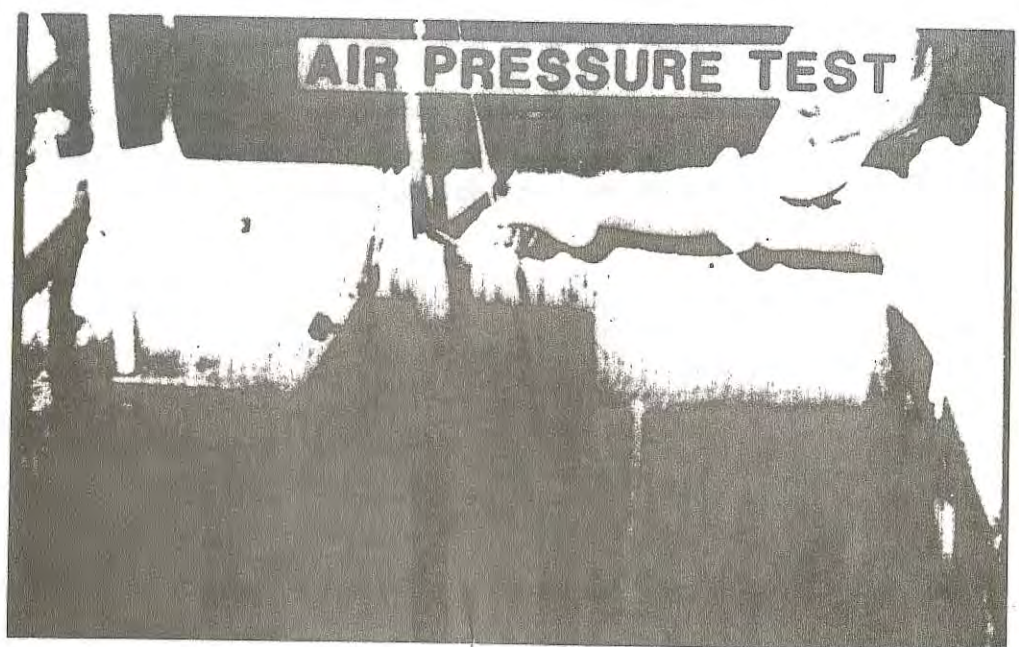


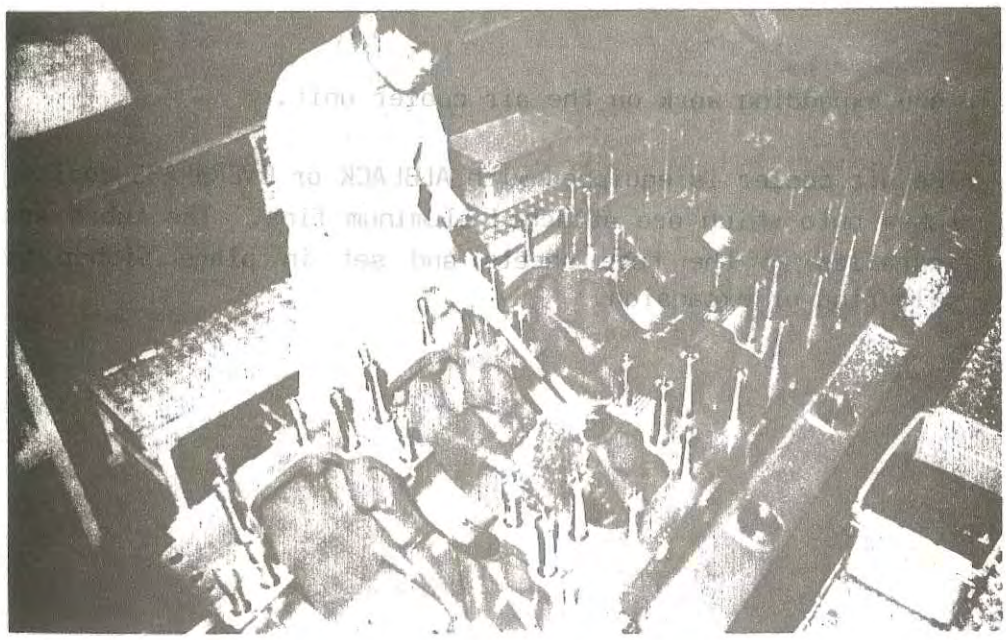
52

51. Tube expanding work on the air cooler unit.

The air cooler is equipped with ALBLACK or EVERBRASS cooling tubes onto which are attached aluminum fins. The tubes are installed in the tube sheets and set in place either by soldering or expansion.

52. The air pressure test for the air cooler assembly unit.

The complete air cooler unit is tested by air pressure. The unit is totally immersed in a water tank to check any leakage on the mounting surfaces of the water cooling tubes and on the body itself.



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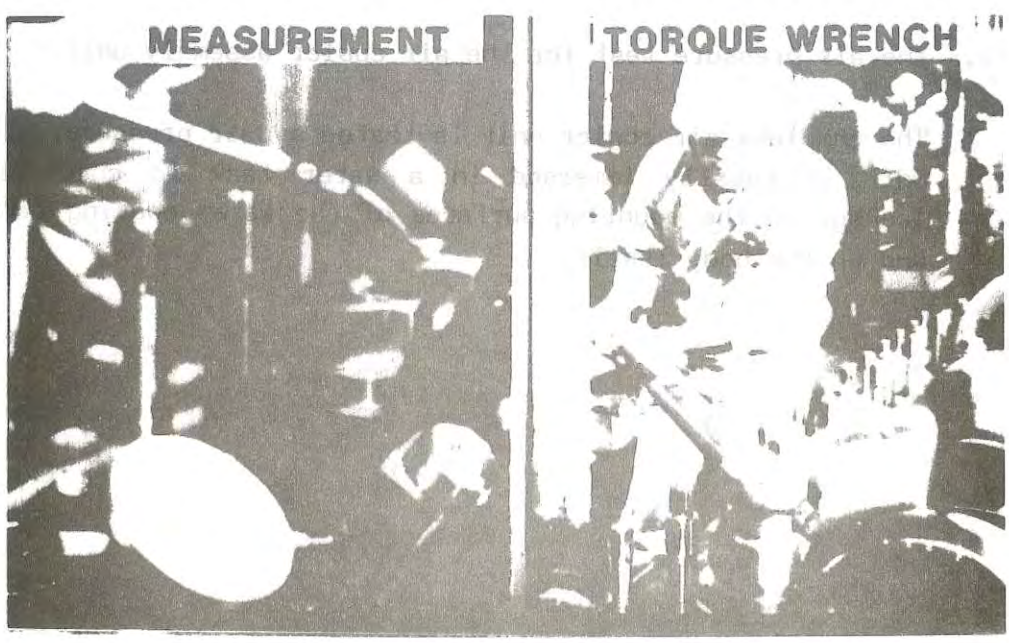


54

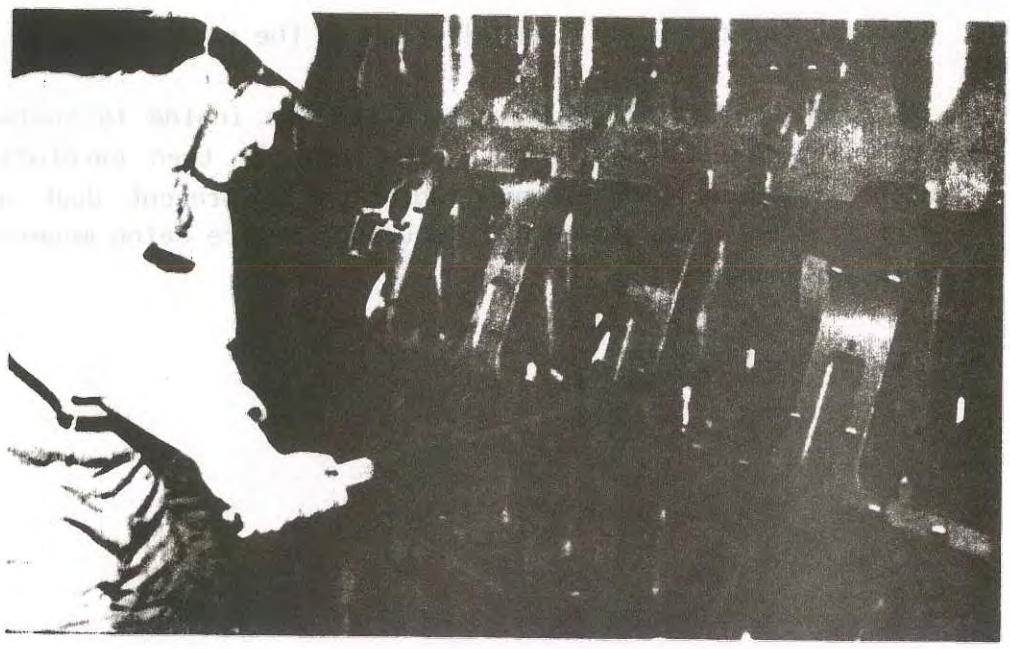
53. Mounting the crankshaft installation on the engine bed.

The machined bed is steam cleaned and the inside is coated with an anti-rusting paint. The unit is then carefully washed again with a cleaning solution to prevent dust or dirt from entering the bearing housing, before being mounted onto the crankshaft.

54. Tightening the main bearing bolts and measuring and adjusting the end-play of the crankshaft.

Adequate tightening of the bearing cap bolts when mounting on the crankshaft is very important, therefore, a torque wrench is used to guarantee a good clamping force.

The clearance, which is parallel to the axial direction, is adjusted by the thickness of base thrust bearing metal and this is checked with a dial gauge as shown in this picture.



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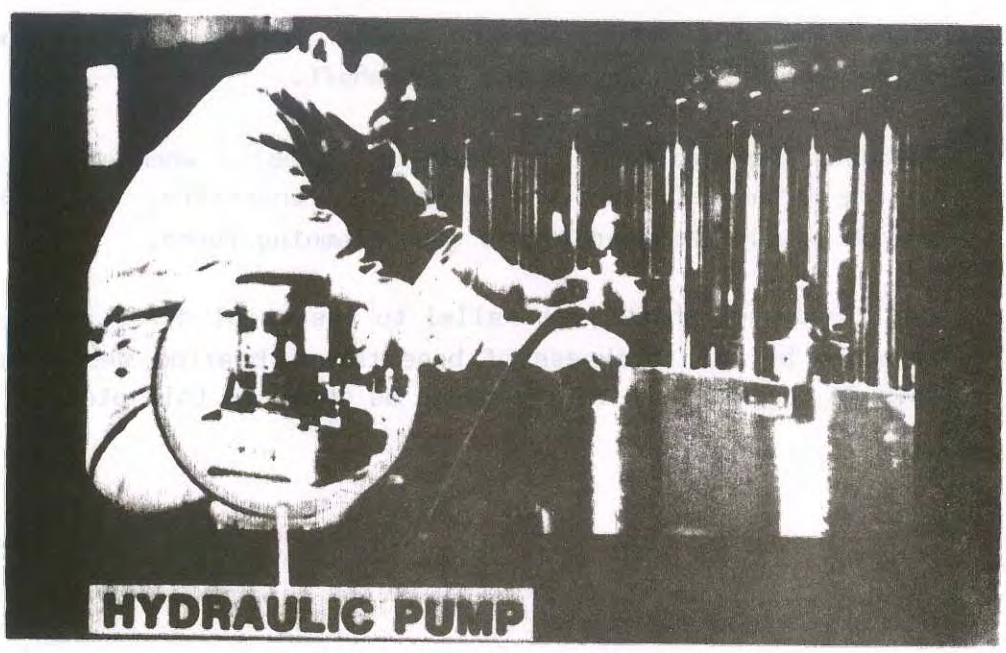


56

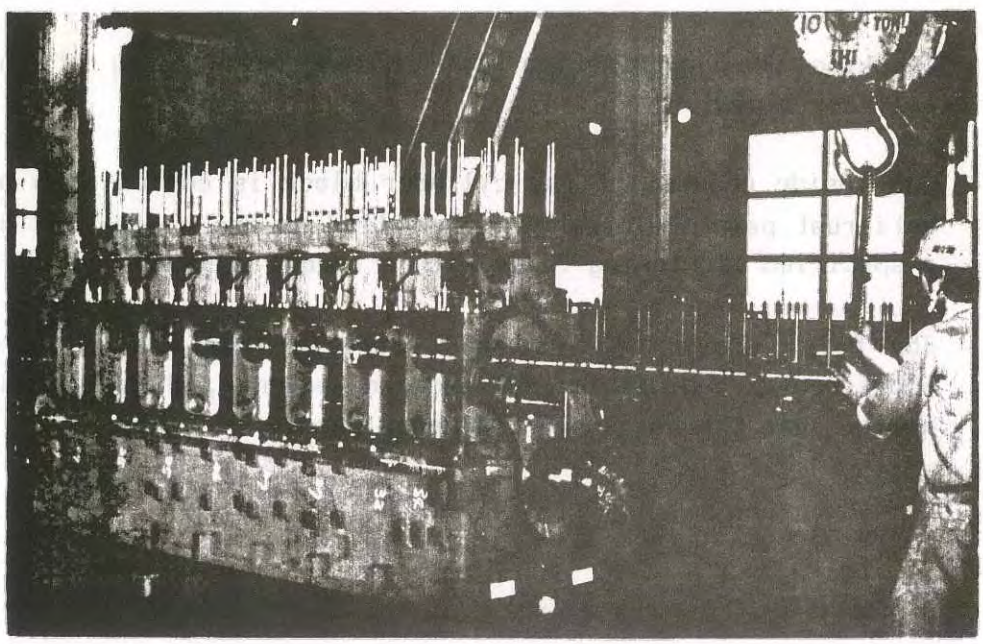
55. Checking the installation and correct positioning of the cylinder block.

The inside chamber of the cylinder block is coated with an anti-rust paint before being installed on the engine bed by a specified tightening force with a torque wrench.

The bolts should be tightened starting from the cylinder block center and working outwards in sequence, while equally making sure the bolts are tightened evenly.

56. Tightening the tie rod bolts. The hydraulic pressure method is as follows:

While the tie-rod bolt is taut and elongated under hydraulic pressure, the screws are turned.



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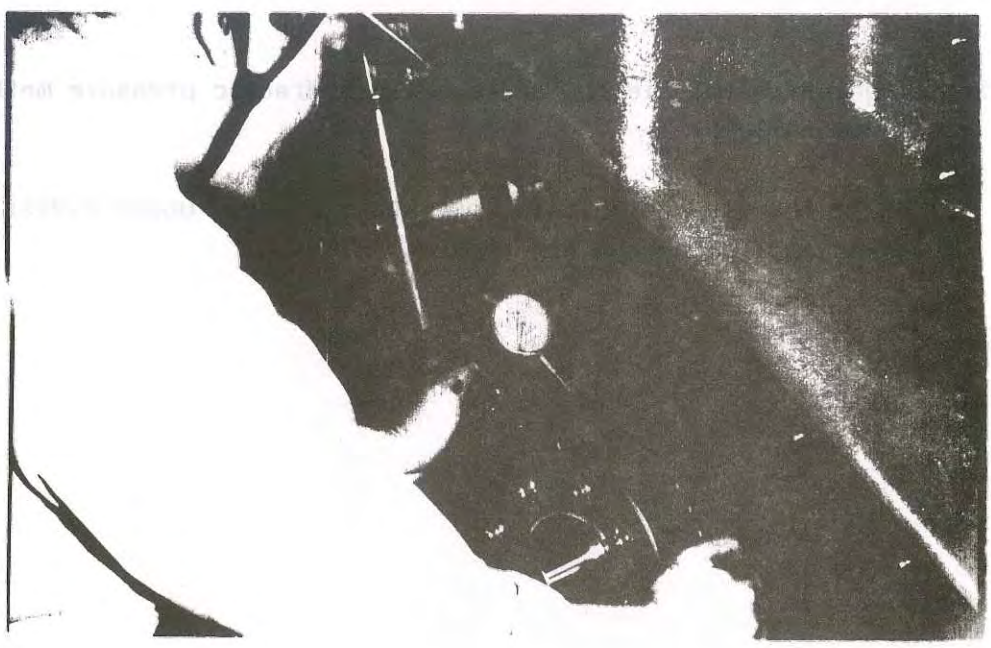
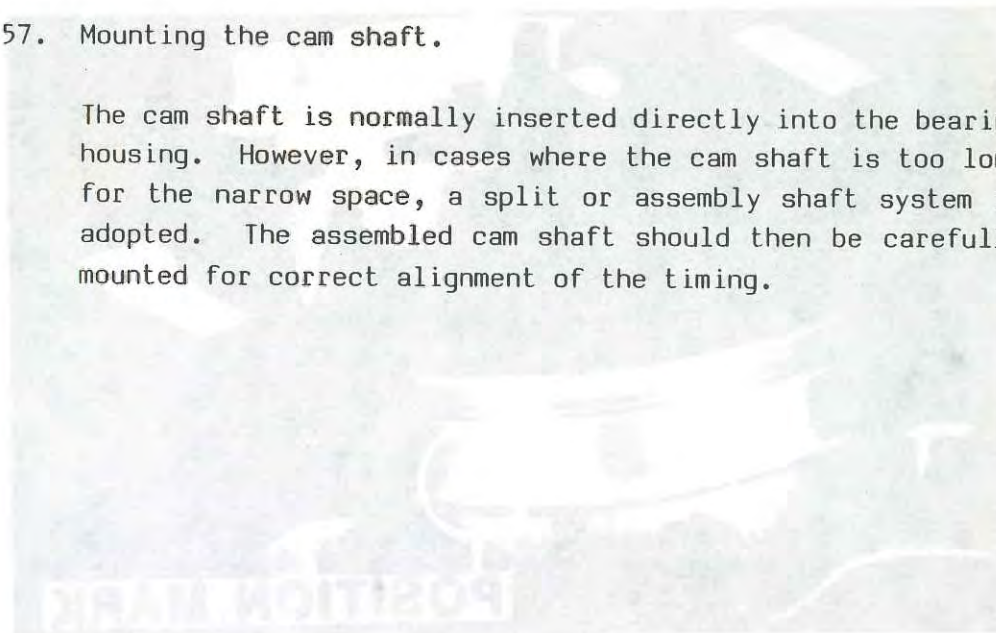


58

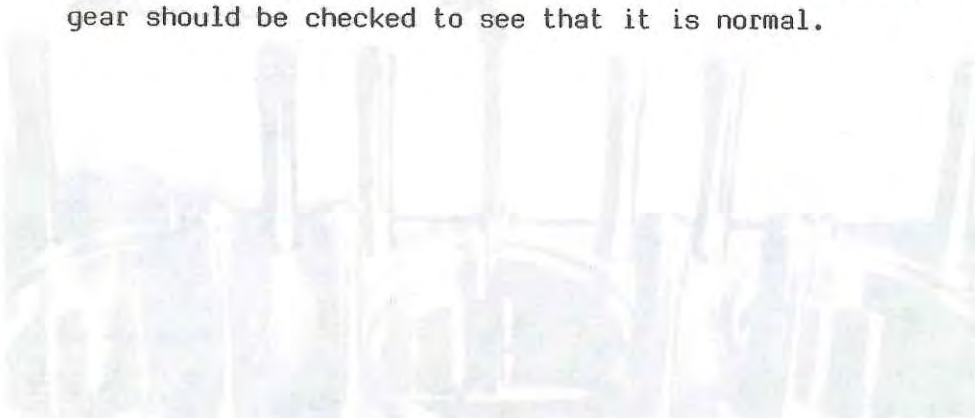
57. Mounting the cam shaft.

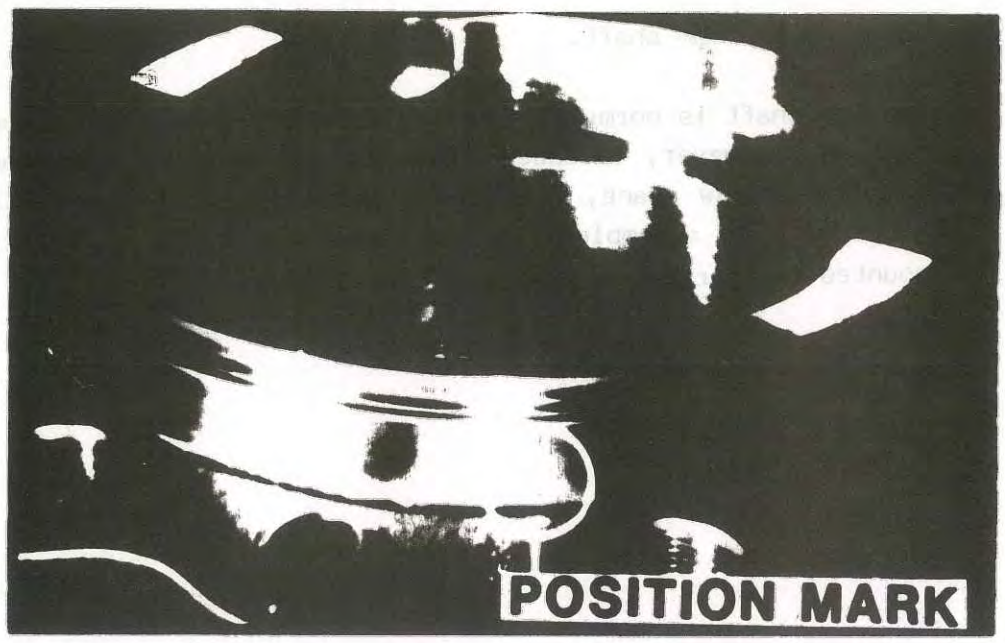
The cam shaft is normally inserted directly into the bearing housing. However, in cases where the cam shaft is too long for the narrow space, a split or assembly shaft system is adopted. The assembled cam shaft should then be carefully mounted for correct alignment of the timing.



58. Mounting the gears in the engine.

When installing the gears, the timing marks for meshing with other gears should be checked and the backlash should be adjusted. Also, the condition of the tooth contact of each gear should be checked to see that it is normal.





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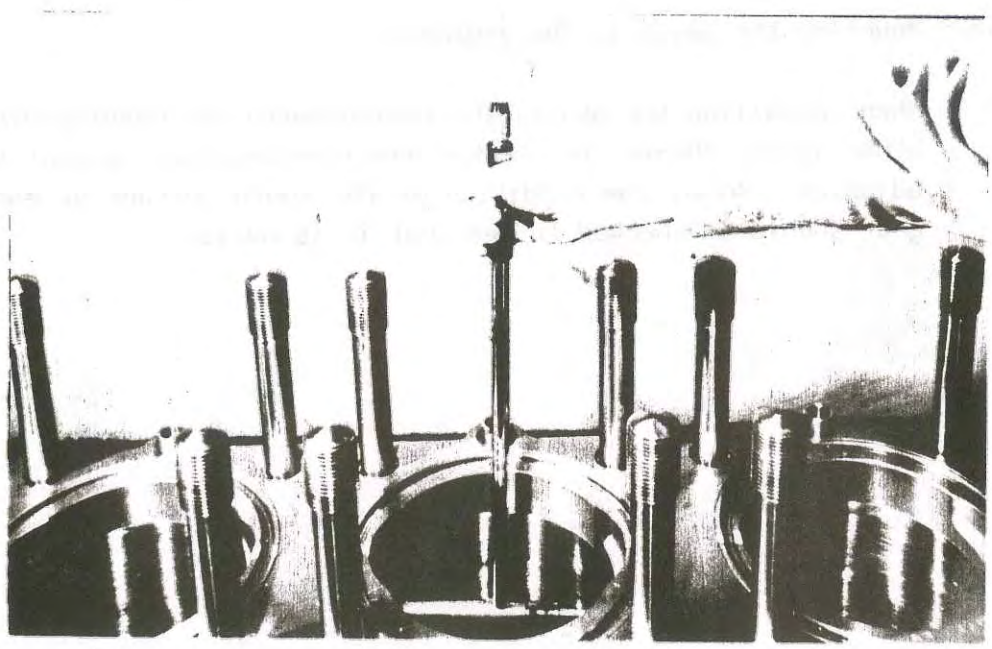


60

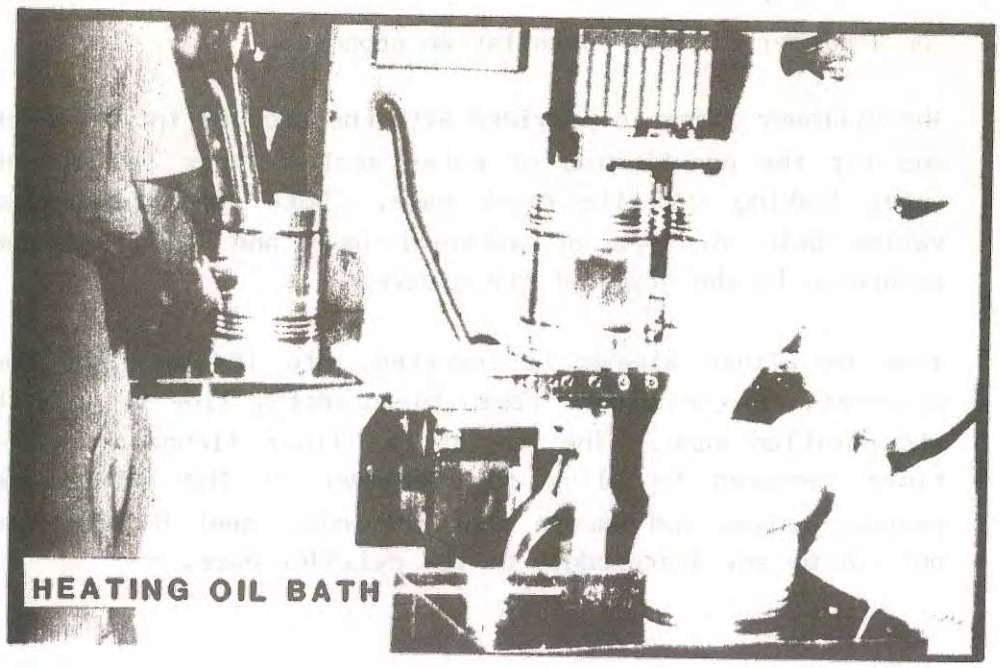
59. The cylinder liner's installation process.

The cylinder liner is provided with the grooves in its lower end for the positioning of water seal O-rings to prevent water leaking into the crank case. Note that the O-ring varies both in type of material used and in its shape according to the style of the grooves.

When the liner sleeve is inserted into the back of the cylinder, care should be taken to correctly line it up with its position mark. The top of the liner flange is sometimes recessed to allow for movement of the intake and exhaust valves and ensure that the water seal O-rings are not cut by any sharp edges on the cylinder bore.

60. Measuring the inside diameter of the liner.

After the liner has been inserted into the cylinder block, the roundness or cylindricality of the liner must be measured. If distortion exists, it may cause scuffing on the liner, excessive consumption of lubricating oil, and excessive generation of blow-by gas.



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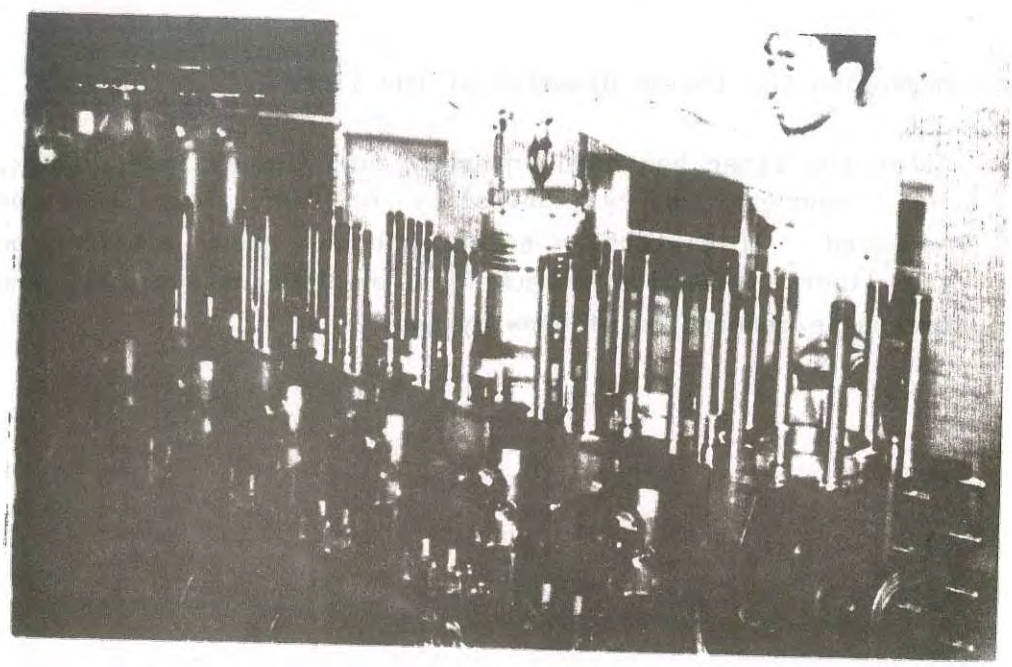


62

61. The assembly of the piston and the connecting rod.

When the aluminum piston is connected to the connecting rod it is first heated to 70°C in order to more easily insert the piston pin into the piston pin hole.

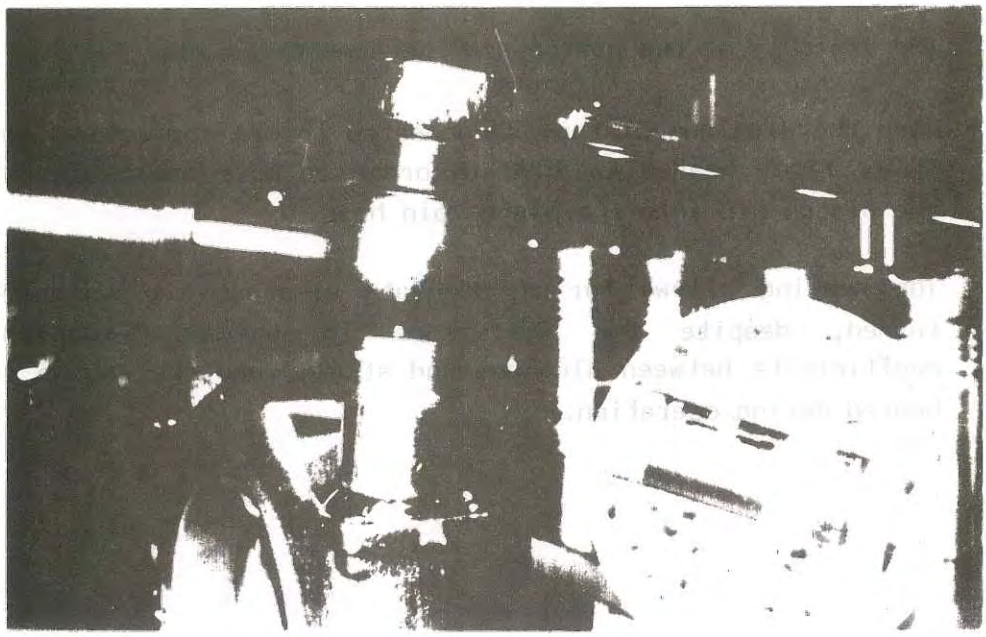
The heating allows for an adequate clearance to be maintained, despite the difference in thermal expansion coefficients between aluminum and steel, when the engine is heated during operation.

62. Installation of the piston into the cylinder.

When the pistons are inserted into liner, the following care must be taken:

1. The piston rings gaps should not be lined up in the same position or space.

2. A piston inserting tool, such as a piston compressor or piston guide, should be used to avoid the ring gap being caught and damaged on the recess of the intake or exhaust valve.



63

64

63. The tightening of the crank pin cap or connecting rod bolt.

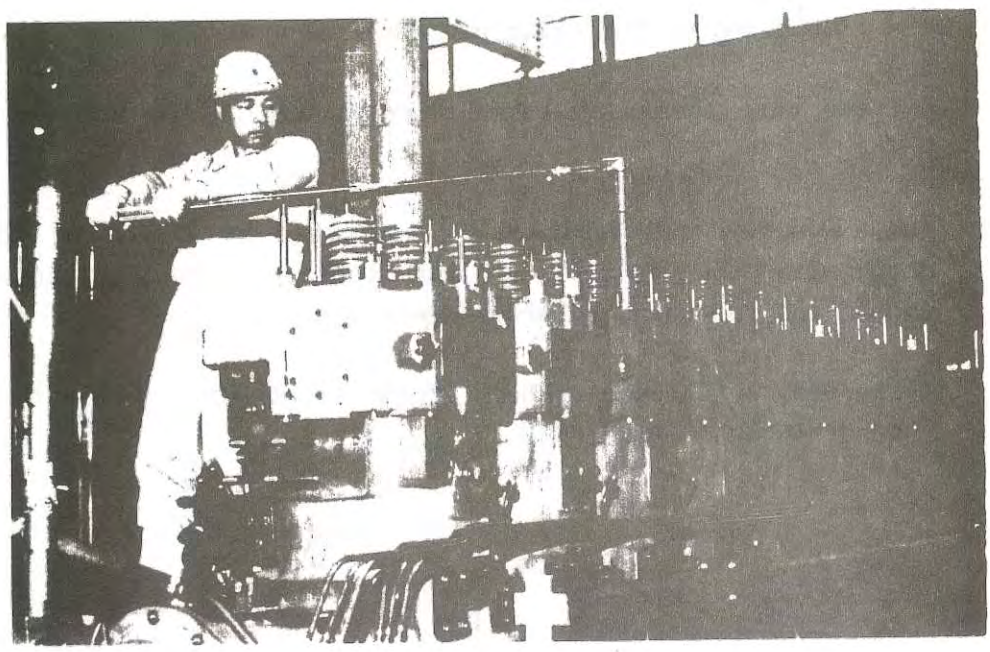
Extreme care should be taken when tightening the crank pin bolt.

The tightened nut position is indicated by lining up the mark with the results of the test on the individual connecting rod using a torque wrench.

Therefore, a thorough recheck of the tightening force with a torque wrench is required.

64. The installation of the valve cage on the cylinder head.

When the valve cage is installed on the cylinder head, an anti-seize compound should be applied to allow for easy dismounting of the cage when it needs to be replaced.



65

66

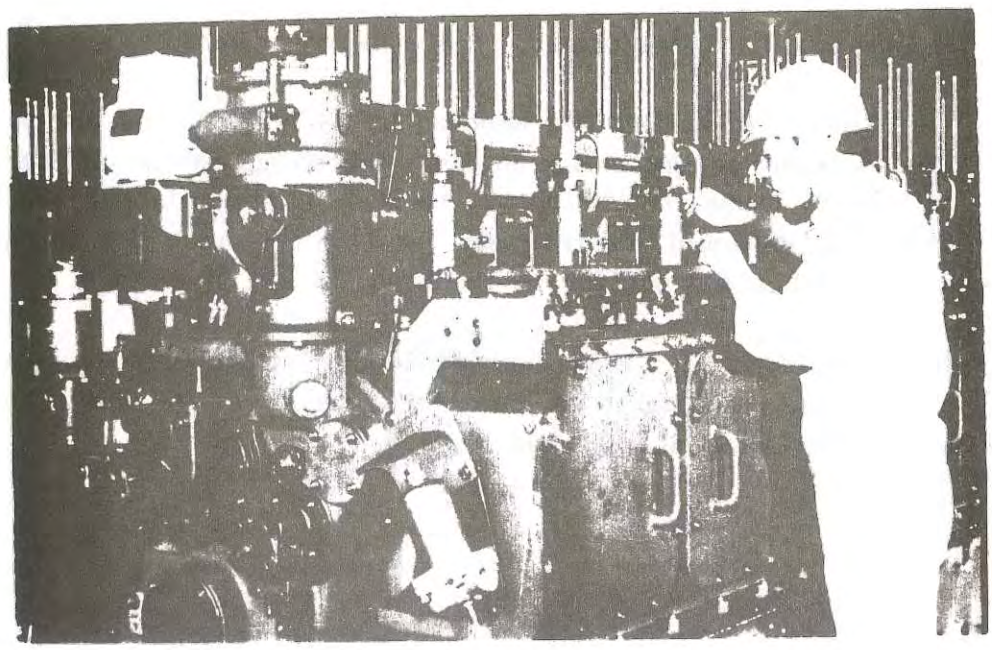
65. Tightening the clamping bolt on the cylinder head.

When the cylinder head is mounted by tightening the bolts, any shortage or uneveness on the tightening torque of the bolts will cause combustion gas to leak or the cylinder head to become deformed and this may result in a crack appearing on the combustion surface of the head.

The tightening by torque wrench should be performed in a criss-cross manner in a specified sequence in order to attain the designated torque level.

66. Mounting the fuel injection pump.

The crankshaft is turned to set the cam in the designated position for injection starter timing. The fuel injection pump should then be installed using the adjusting screw so that mark line on the plunger is aligned with the mark line on the pump body housing.



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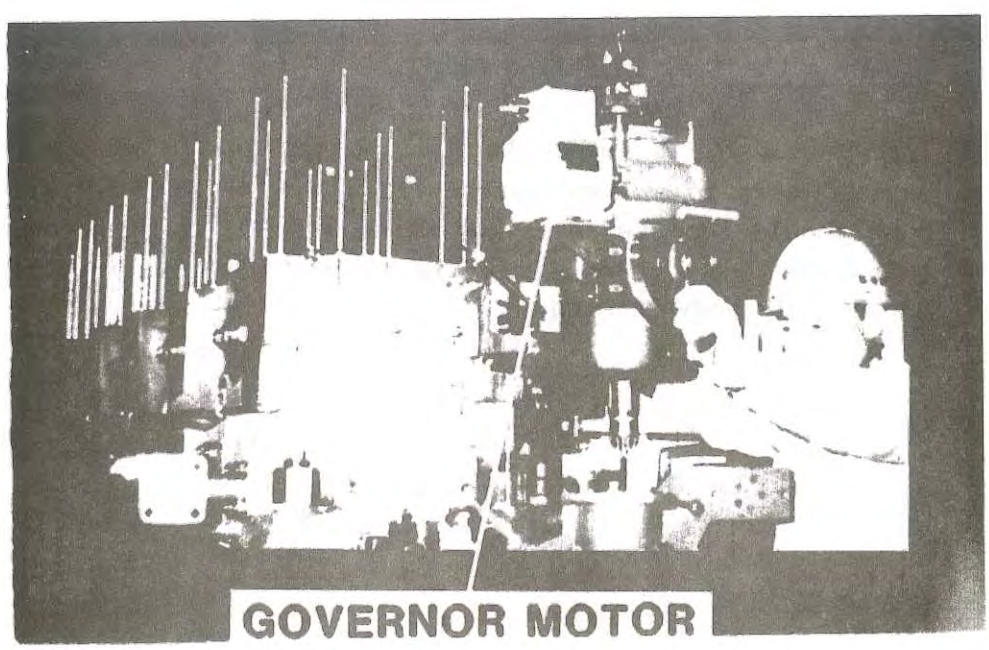


68

67. Adjusting the fuel injection volume control rack.

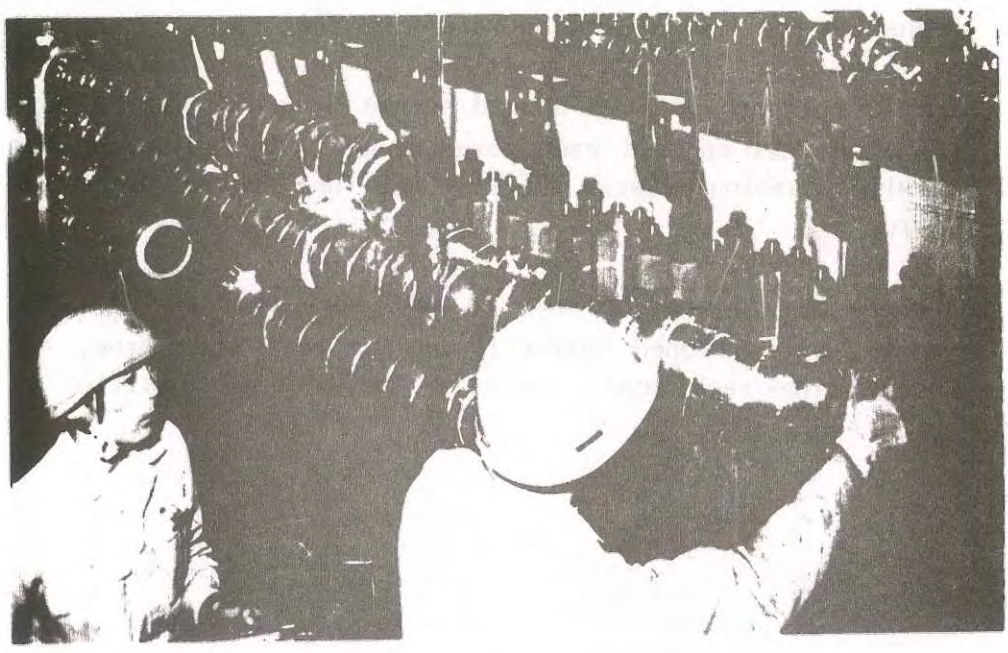
The fuel injection pump should be set in place making sure that the fuel control rack moves smoothly by adjusting the parallel spacing between the rack and fuel control adjusting shaft.

A check should also be make to make sure that the stopping handle is positioned correctly on the fuel stop line, and whether the rack scale comes to the fuel-cut position or not.

68. Mounting of the governor.

When the governor is installed in the engine the setting knock pin should be positioned with extreme caution to ensure correct tooth contact and proper backlash of the driving gear.

When the linking equipment has been mounted, the knock pin, split pin, locking washer, and whirl-stop should be secured.



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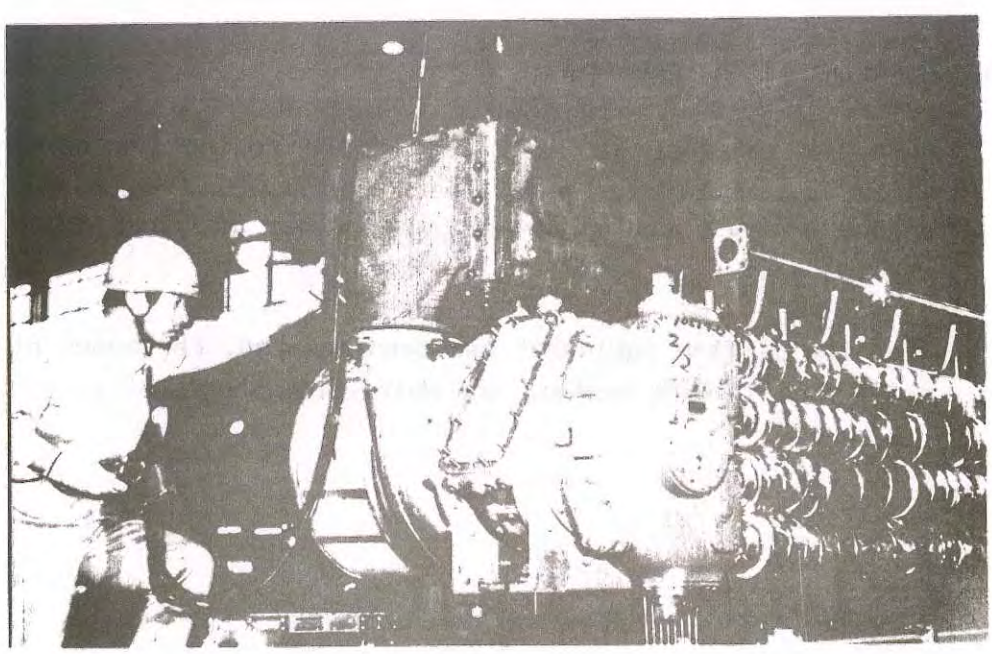


70

69. The installation of the intake and exhaust manifolds.

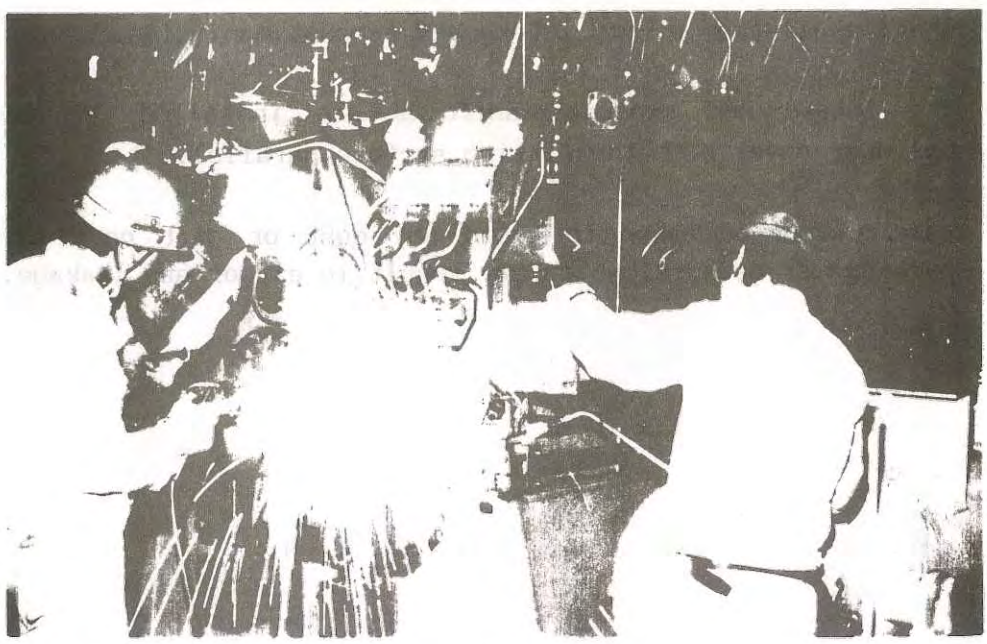
The intake and exhaust manifolds are installed on the cylinder cover with the fitting surface parallel.

Care should be taken to avoid any dust or dirt on their packings or gaskets, which may result in air or gas leakage.

70. The installation of the turbocharger and air cooler.

The turbocharger and air cooler are heavy for their size and they must be carefully handled to avoid applying excessive force during installation, otherwise they may not be able to perform their functions correctly.

All the related connecting parts of these units should be manufactured on site taking into consideration the above points.



71

72

71. Arrangement and installation of the pipes.

The pipe arrangement should be carried out taking into consideration the following items:

(1) they should not obstruct the assembly or possible disassembly of other engine parts.

(2) they should not increase resistance to the fluid flow.

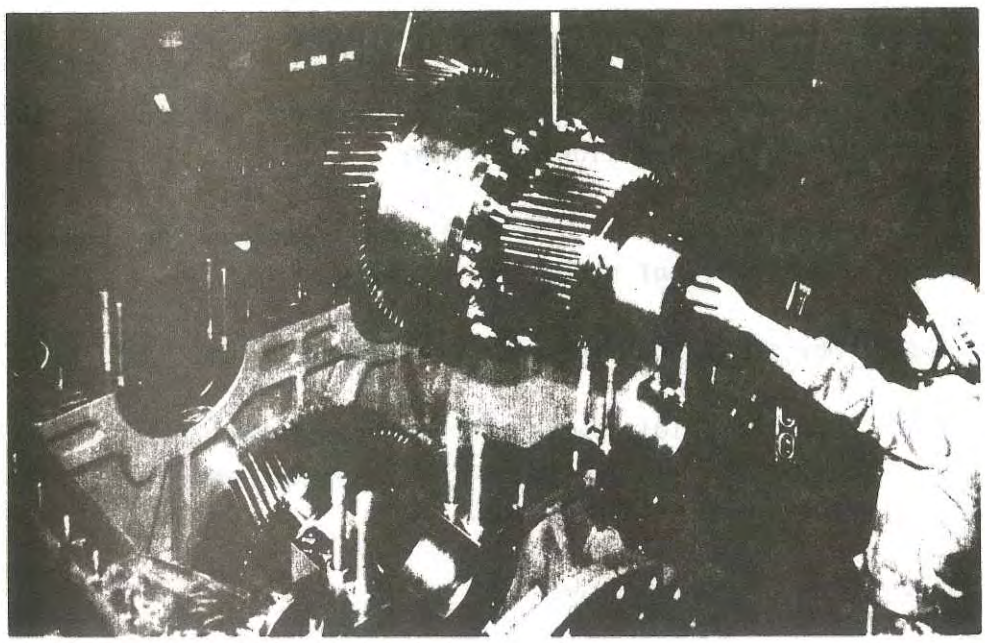
(3) When the welding work has been completed, all the pipes should be washed in acid to remove any inner dirt, scale, and welding slugs.

72. Installation of the friction plate and clutch drum for reversing and reduction gears.

A wet-type multi-friction disc is now incorporated into the clutch.

All the parts, such as the friction plate or discs, should be washed to remove any dirt and foreign matter.

The assembly sequence is: (1) the clutch steel plate is inserted; (2) the lining plate; (3) the steel plate again; and so on until each plate is incorporated into the clutch disc.



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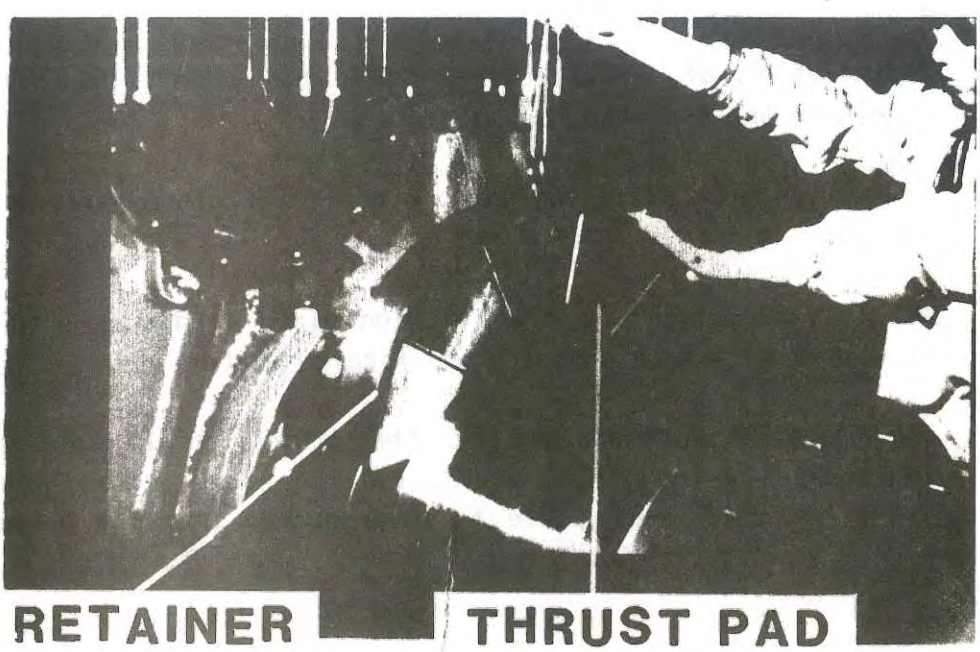


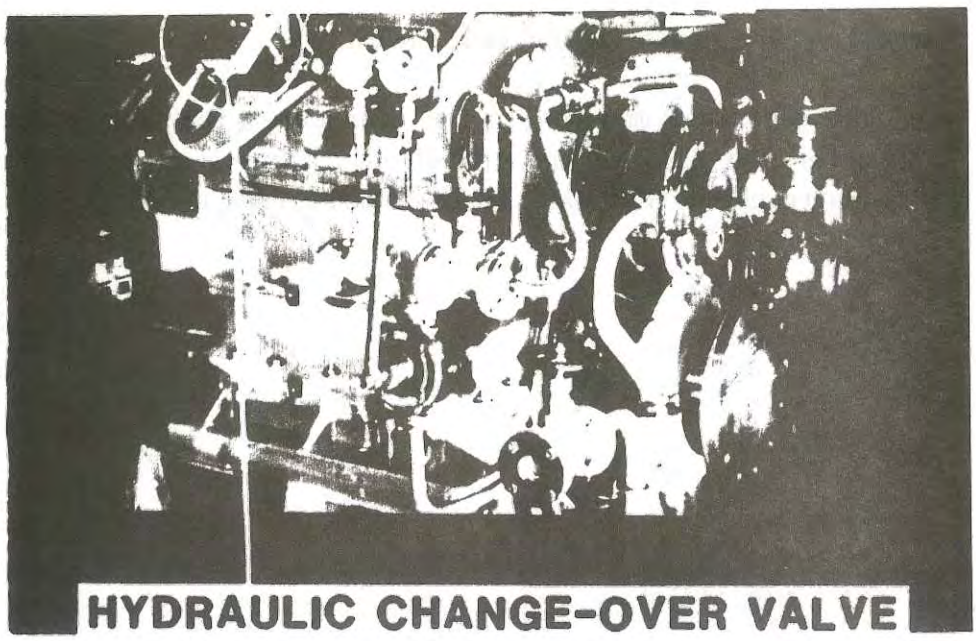
74

73. Assembling the gears to the gear case.

When the gears are mounted in the gear case, the gear shaft should then be cleaned and installed. Extreme care should be taken to check that each tooth contact fits correctly.

74. Assembling the thrust bearing.

The thrust bearing of the pad should be placed in the bearing retainer. The surface of the pad is cast in white metal therefore care should be taken to avoid its deformation or damage when handling.



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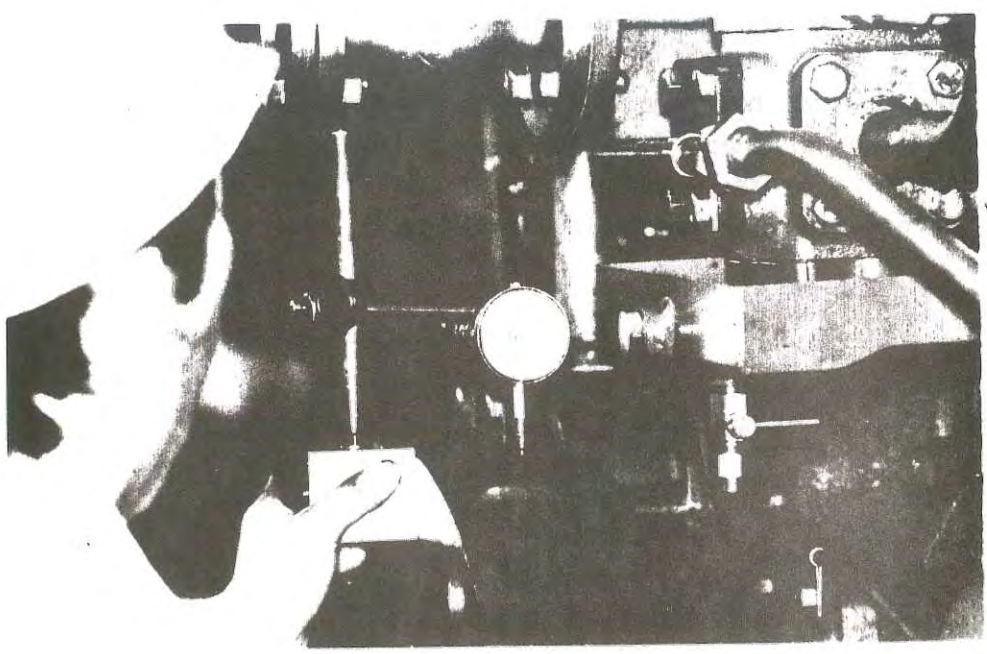


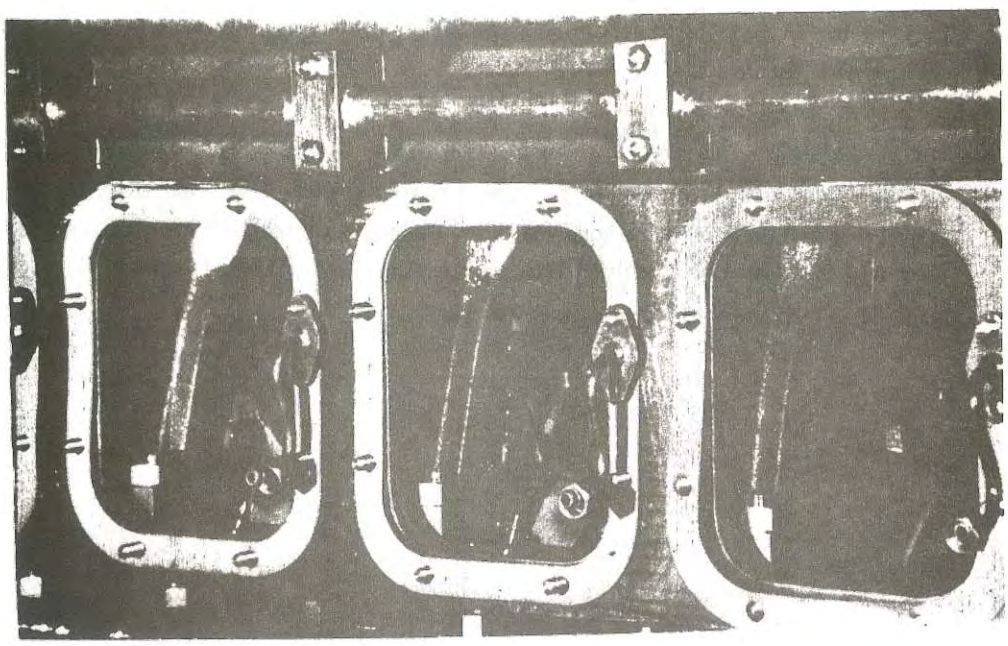
76

75. Mounting the control equipment on the reversing and reduction gear.

The control equipment, such as the hydraulic change-over valve for clutch on-off operation, and the actuator for remote control clutch operation using hydraulic pressure, is installed in the reduction gear case. Finally the piping work is connected to complete the unit.

76. Centering the thrust shaft and dynamometer.

Before the engine is tested in the factory it is installed on the testing-stand bed and the dynamometer and engine thrust shaft are centered. Any deflection of the crank-shaft should be checked during this operation, and adjusted within the specified limit.



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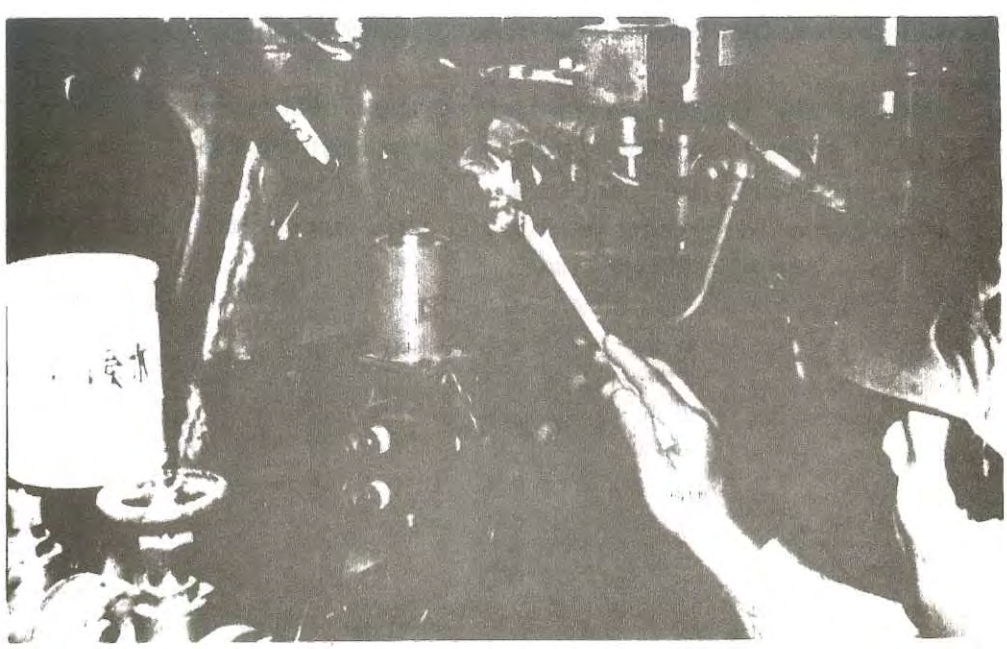


78

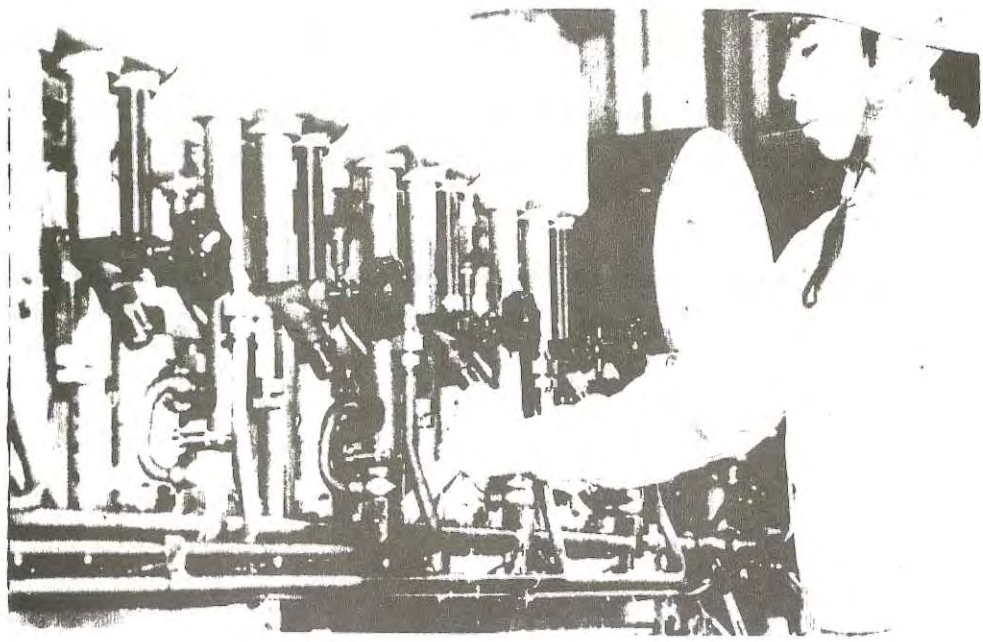
77. Flushing the lubricating oil pipe system.

When the engine installation is completed, preparations for starting are made. First, the lubricating oil system is flushed.

The main pipe lines in the crank case are disconnected and then the flushing oil is passed by tapping the pipes lightly.

78. Air leak inspection.

When the flushing has been completed, air pressure is applied to the water cooling system, lubricating oil pipes, and fuel oil systems to check for any leakage or blockage in the system. The presence of a leak is verified by applying soapy water to the target section.



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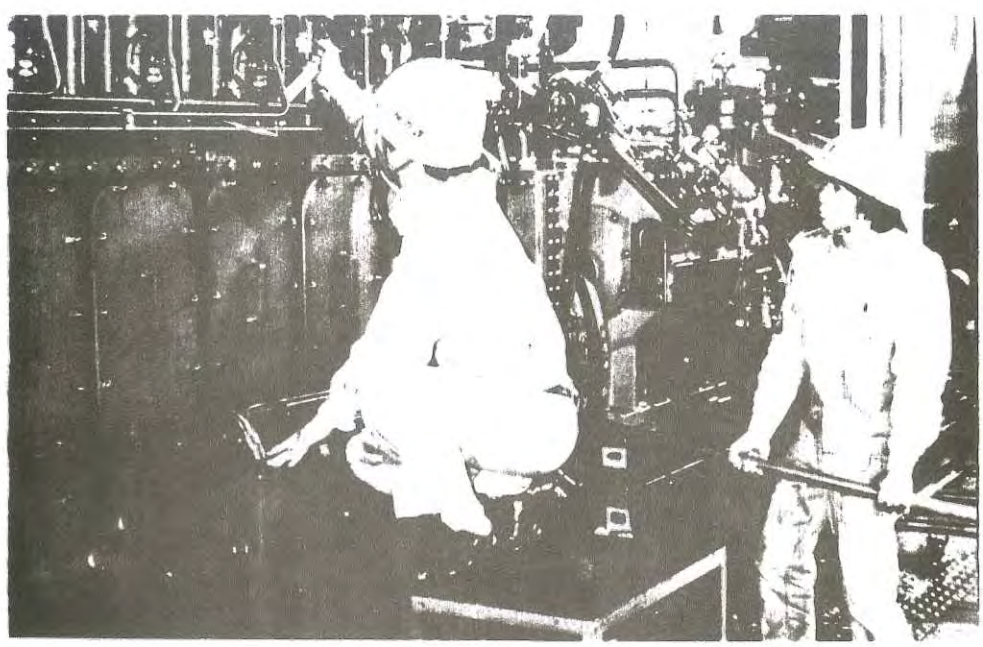

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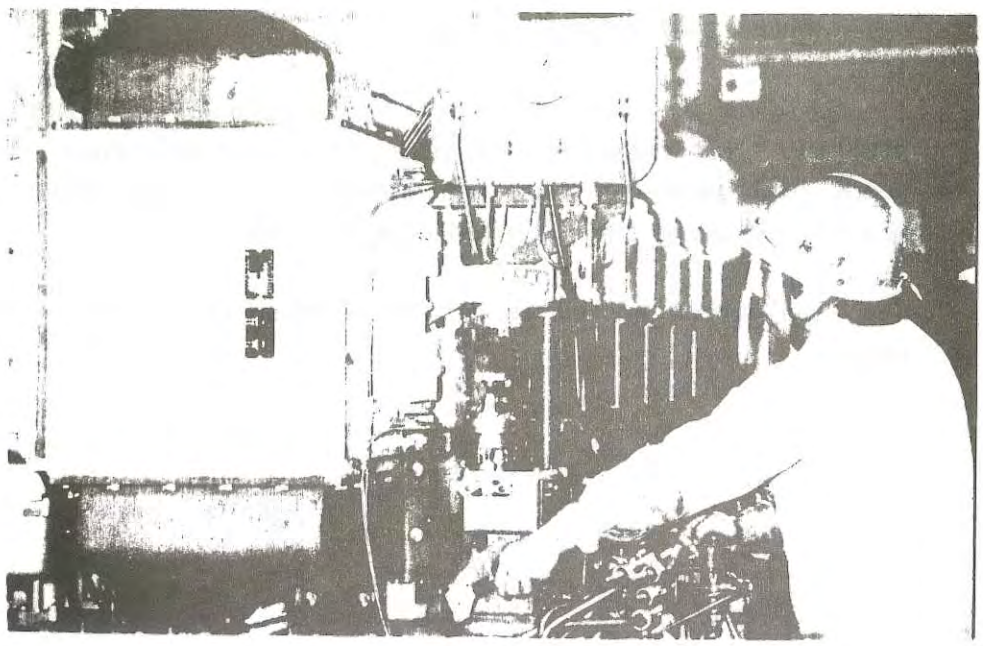
79. Priming the fuel injection pump.

The priming or venting operation should be carried out starting first from the main pipe, to the branch pipes, fuel pump, high pressure pipe and finishing with the injection nozzle, by using the attached priming pump.

The lubrication system is also air-vented using the priming pump.

80. Inspection of the fuel injection timing.

When the engine is assembled, most of the injection cams are set. However, the injection timing should be rechecked to confirm the start of delivery of the fuel by the plunger.



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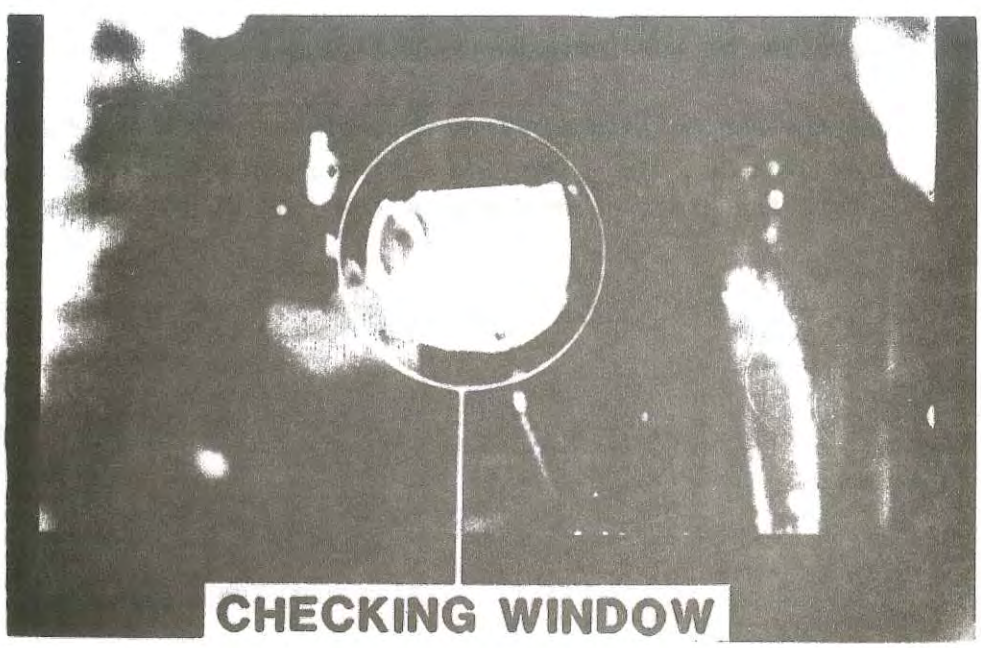

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81. Starting the engine.

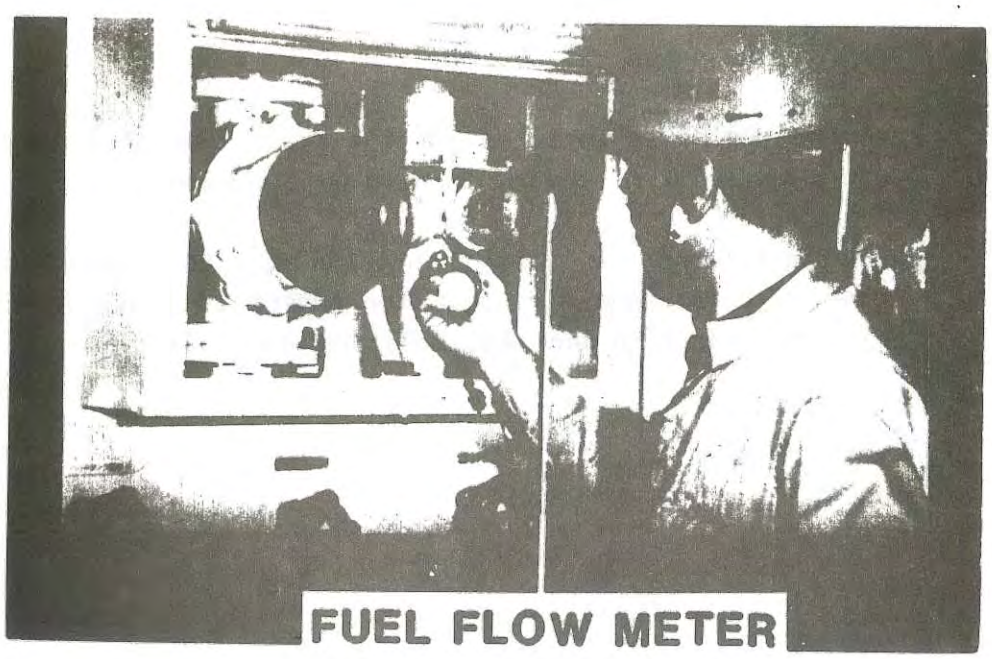
When the engine is operated for the first time, the turbo-charger and exhaust manifold should be disconnected.

After confirming the smooth rotation and running of the engine by compressed air, then the engine is started using fuel and checked for any abnormalities while running.

82. Checking the working parts.

The engine should be run-in by starting under no load conditions and then increasing the load gradually.

When increasing the load, first the speed is increased to the target speed while the former load is maintained. Then the load is applied accordingly. During this process all the working parts should be checked visually.



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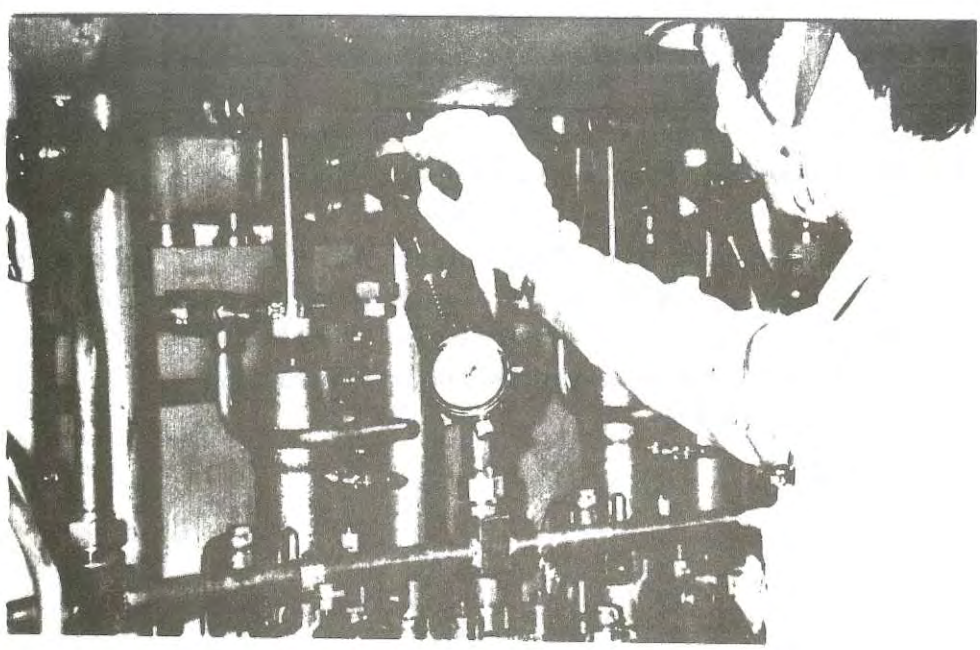

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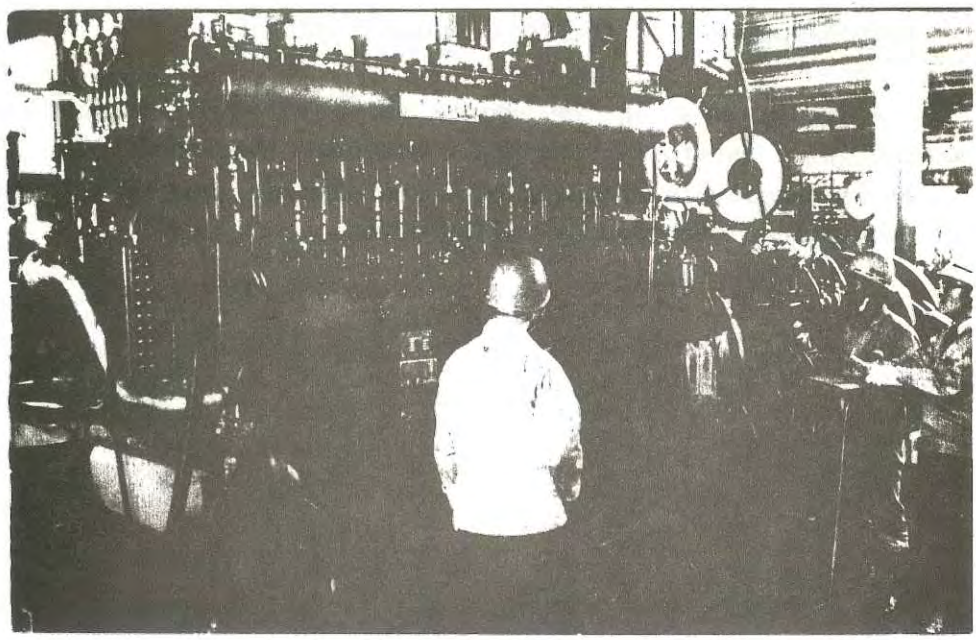
83. The measurement of the fuel consumption rate.

The performance of the engine during the run-in operation should be carefully recorded under each load condition. The smoke density is measured by a smoke meter, and its the fuel consumption measured by a flow meter.

84. Measuring the maximum combustion pressure in the cylinder.

If there is no large difference observed in the maximum pressure between each cylinder during the run-in operation then adjustment is not necessary.

When the run-in operation has been completed, the engine performance records are examined and analyzed and, if necessary, the adjustments are made for a uniform maximum combustion pressure at a standard value by regulating the start of the injection.



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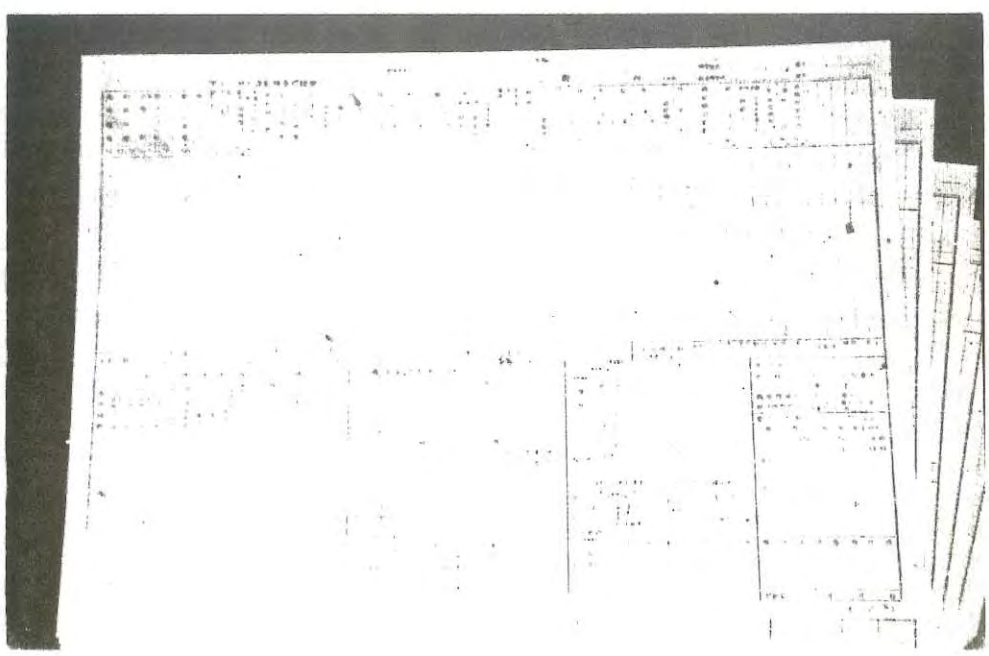

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85. Official inspection being carried out on the testing stand in the factory.

After the in-house test has been completed, official land trials take place in the presence of a government officer.

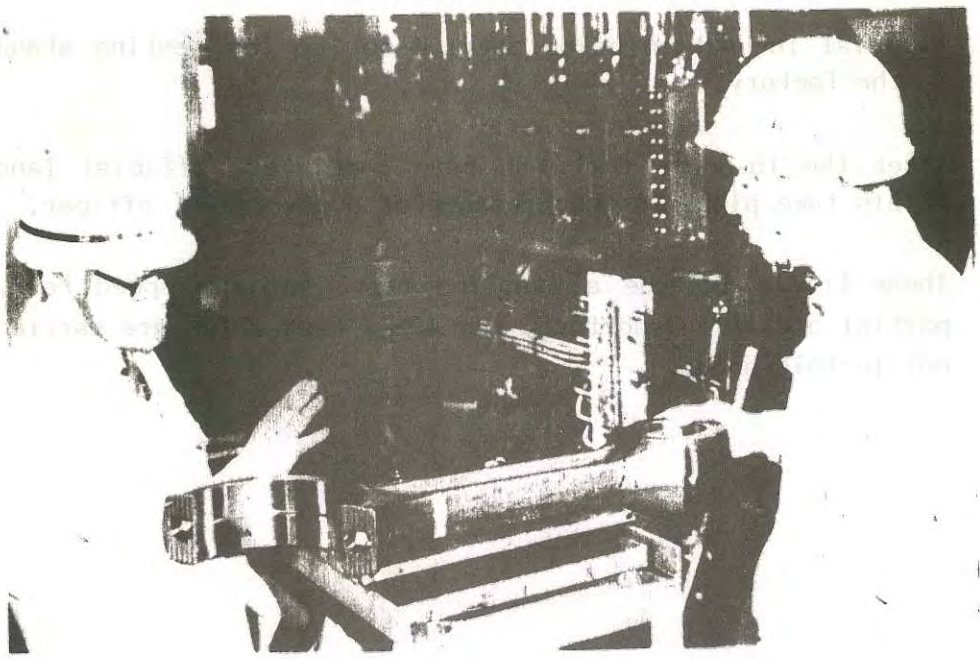
These trials include a starting test, minimum speed test, partial and full load test, and after test which are carried out in this order.

86. The land trial performance data tables.

The engine performance is recorded in the log book after both the loading and engine conditions are stabilized.

These land trial records are registered as official and are considered basic reference data for judging future engine performance and also used as a comparative source of data during the sea trials.

These official records should therefore be carefully preserved.



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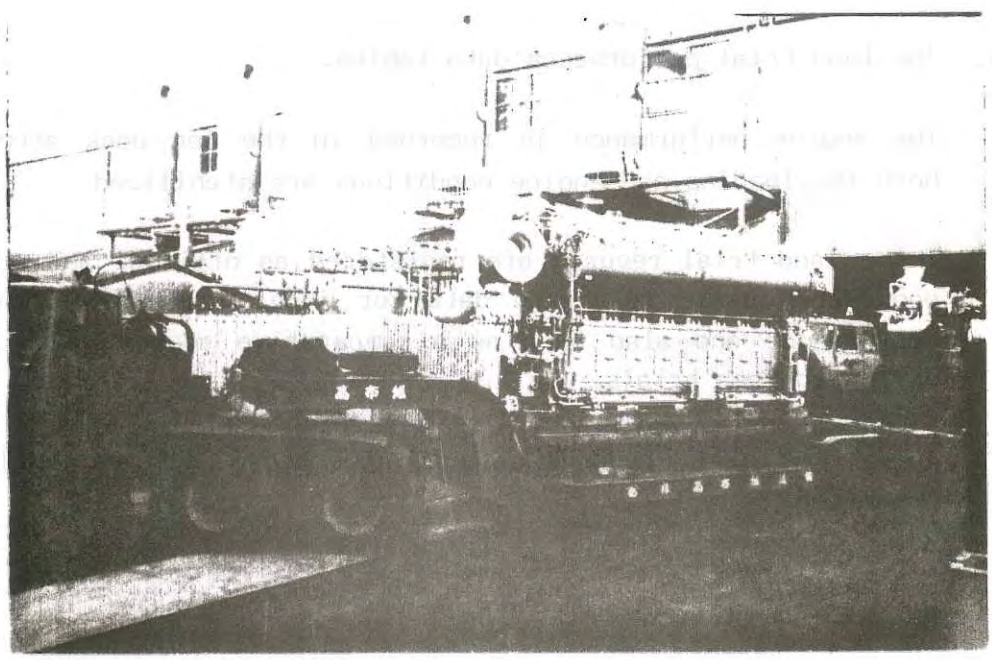

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87. The inspection of the disassembled engine.

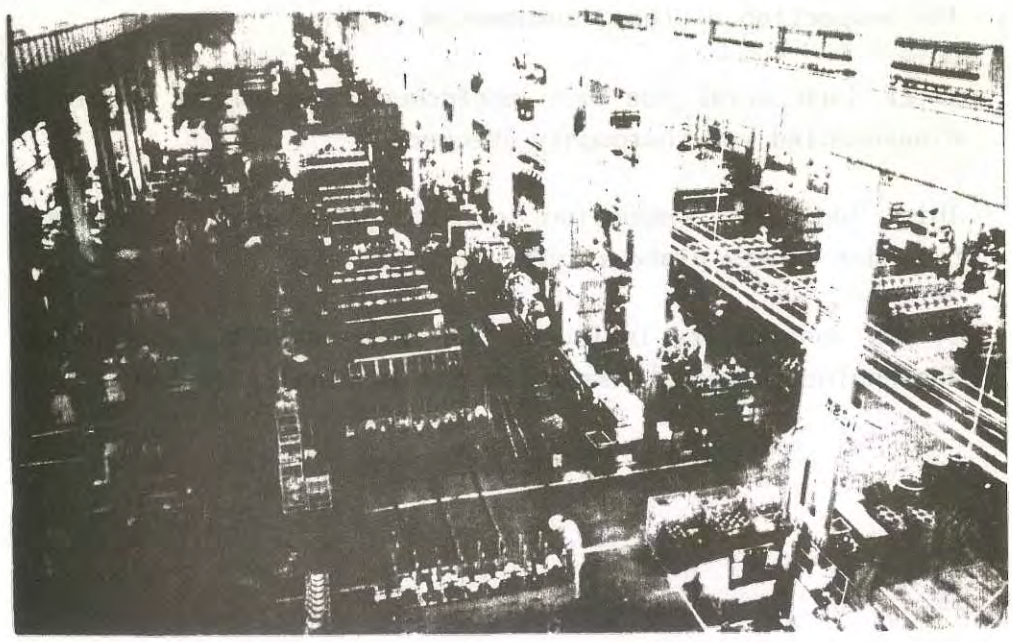
After land trial has been performed, the engine should be disassembled and thoroughly checked.

This includes inspection of the crankshaft, bearings, cylinder liner, pistons, gear contacts etc.

If any abnormality is found, the cause should be corrected. The engine is then reassembled and is finally fitted out.

88. Transportation of the completed engine.

We have now seen the complete construction of an engine, part by part, from the fabrication of the main parts, through assembling, and operational testing.



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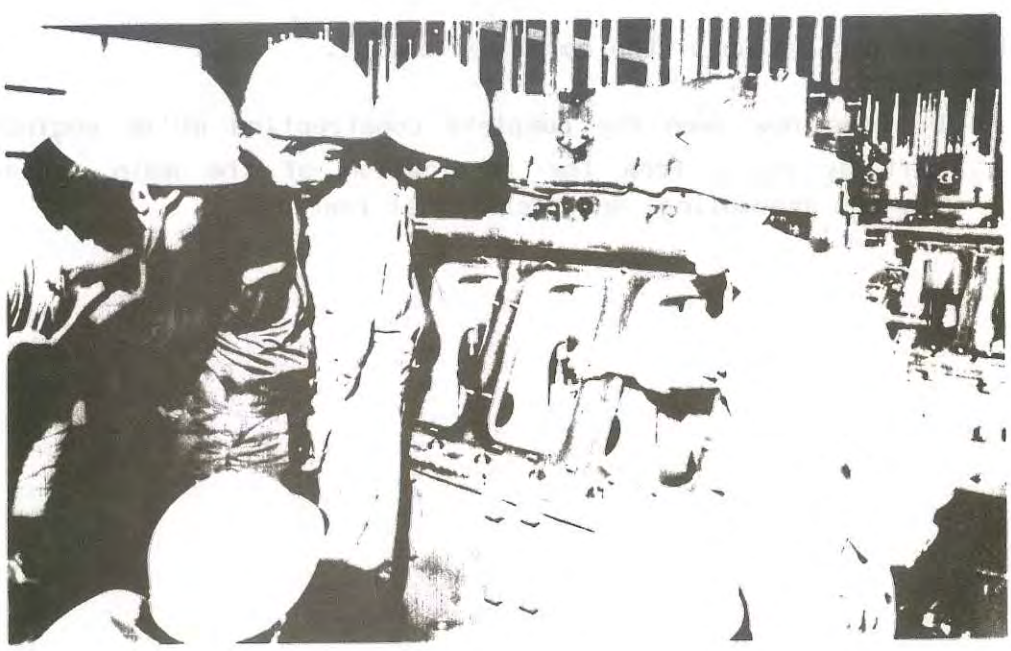

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89. This picture shows the whole assembly line of the engine.

What is your impression on seeing these slides: We hope you have gained much useful information and that it will prove of great benefit to you in your career as a marine engineer.

90. And finally: Students receiving practical training at a factory.

We hope this training will help you progress in your speciality and contribute to your overall skill and experience.

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