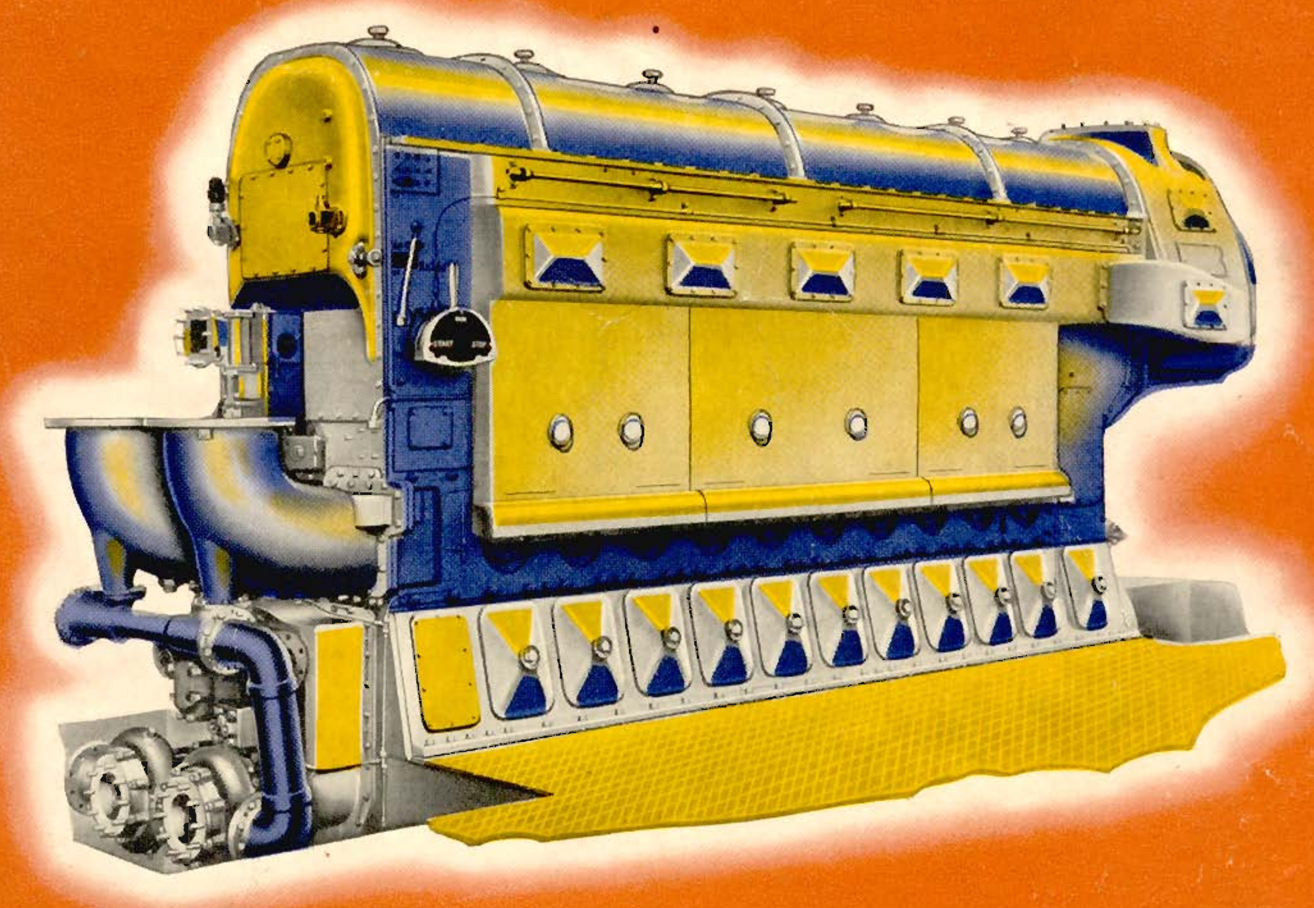
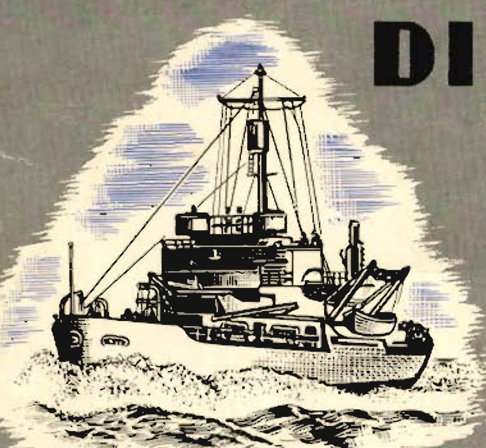
BULLETIN 3800D

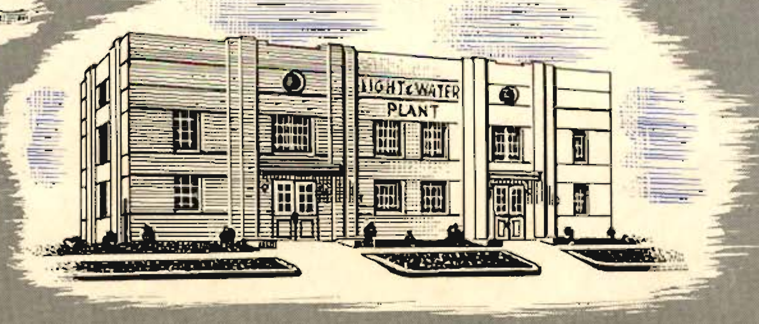


FAIRBANKS-MORSE

OPPOSED PISTON

DIESEL ENGINE





FAIRBANKS-MORSE

Opposed-Piston
DIESEL ENGINES

MARINE—*Day after day, in all weather and at all speeds, "OP" Marine Diesels are setting records for staying power. Call it dependability or endurance, the point is they're built that way.*

STATIONARY — *Operating economy in sustained, heavy-duty service, permitting low rate schedules—that's the performance story of the stationary "OP" Diesel in power plant installations.*

LOCOMOTIVE — *Fairbanks-Morse builds Diesel locomotives for passenger, freight and switcher service. The "OP" Diesel engines powering these locomotives assure high availability on the heaviest assignments.*

The Fairbanks-Morse, Model 38, opposed piston Diesel is the carefully considered answer to the demand for a universal engine. Designed and originally built in the "leisure years" before the war, ample time was allowed to perfect each part. Engines installed years before Pearl Harbor are in successful daily operation.

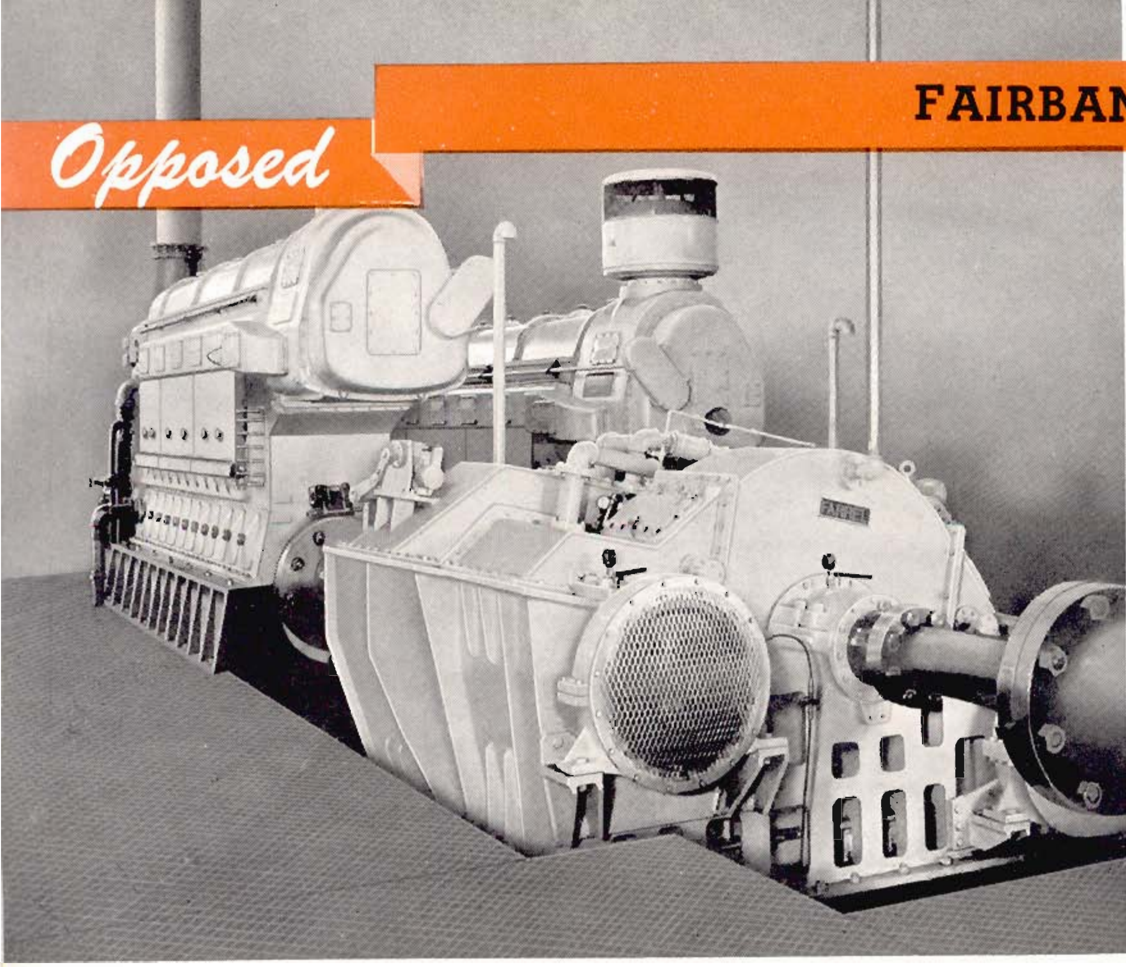
Refined in the crucible of war, this Model 38 established a world-wide reputation as the famous "OP" and even tremendously enlarged manufacturing facilities were severely taxed to meet the demands of the fighting services. Quality was not allowed to suffer, however, but rather was improved.

In the development of this engine no thought has been given to a reduction in cost as a result of increased rotative speed and reduced weight. Rather, first consideration has been given to the more important features of reliability and overall economy. These, when coupled with the lighter weight and smaller cubical contents per horsepower, permit savings in operating costs which may far overshadow any saving in manufacturing costs which might have been accomplished with cheaper materials or less skilled workmanship.

The pages which follow show first, details of construction of this unique and highly successful engine, and second, some of the more interesting manufacturing methods.

FAIRBANKS, MORSE & CO.
MANUFACTURERS • CHICAGO

Opposed



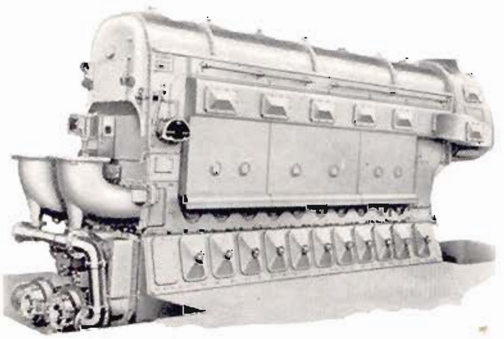
The illustration at the left pictures two ten cylinder opposed-piston Diesel engines (part of a multiple-unit installation) connected to a two-pinion reduction gear on a direct drive. Higher elevation of port engine conforms to hull curvature.

Millions of Horsepower in Service

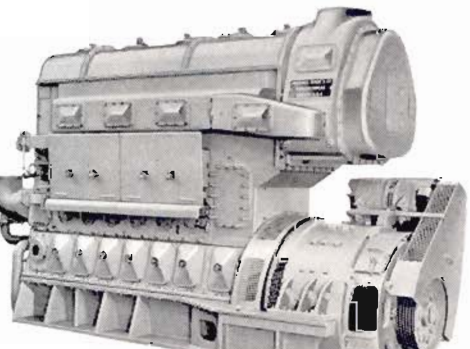
The first Fairbanks-Morse opposed-piston Diesel Engine was designed over ten years ago. Today there are about three million horsepower in active service in marine, stationary and locomotive installations.

What is the "OP" engine? Two pistons in each cylinder, driven apart by a central explosion . . . no cylinder heads . . . no valves . . . a minimum of moving parts . . . less bulk . . . less weight; this is the Fairbanks-Morse opposed-piston Diesel.

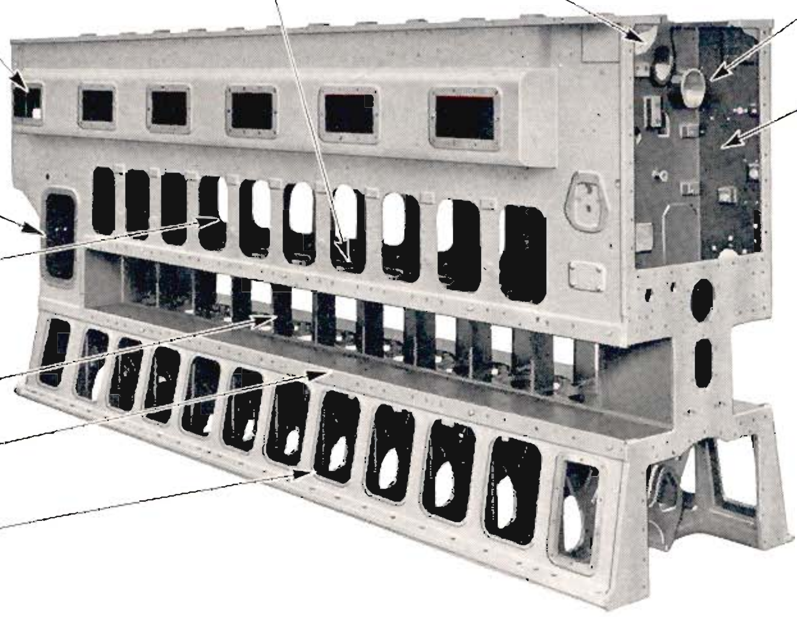
No matter how exacting the service, the "OP" has the staying power to do the job. In every detail, its heavy duty construction provides great power, dependability, and easy, quick serviceability.



10 cylinder, starboard "OP" Marine Diesel.



5 cylinder, "OP" Locomotive Diesel with Generator and belted Exciter.



Cylinder Block

The cylinder block is the main structural part of the engine and is designed to give it the necessary strength and rigidity. Steel plates are welded together into a unit that is compact, strong and light in weight.

Transverse vertical members with horizontal decks form enclosures, bearing housings and fastenings for the operating parts. The horizontal decks are bored to receive the cylinder liners along the center line of the engine. An extension is provided for attaching the scavenging blower to the cylinder block at the vertical drive end. The blocks are identical for right and left hand controlled engines.

The cylinder block contains compartments for the control end, vertical drive assembly, upper and lower crankshafts, air passages, injection nozzles, and exhaust manifold.

The air receiver, vertical drive and control end compartments are provided with covers. The upper crankshaft compartment is closed with a sheet metal top cover having several small inspection covers over the cylinders. These are spring loaded so that any abnormal pressure in the crankcase compartment will be relieved. The oil pan closes the lower crankcase compartment at the bottom, and suitable covers complete the closure at the sides.

The block is sand blasted after welding and magnaflux tests are made as a check of the welding at vital points. It is then stress-relieved to remove the internal strains introduced by welding.

Crankshafts with Vertical Drive Assembly

These are the crankshafts of the Model 38 Diesel engine, and the vertical drive assembly which unifies their power.

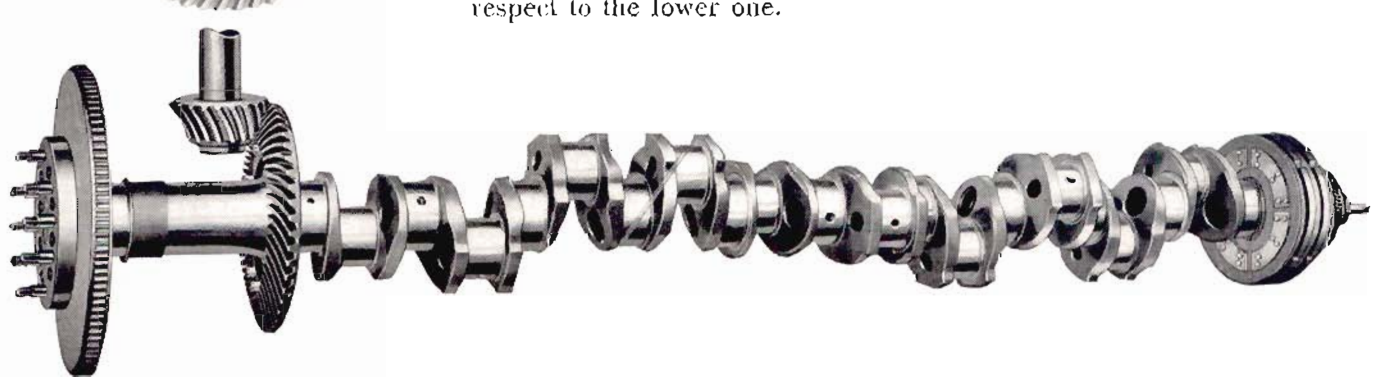
The upper and lower crankshafts are designed to transmit the power produced in the cylinders to the vertical drive gears and crankshaft coupling, respectively. A thrust bearing is provided next to the vertical drive gears and plain main bearings at each transverse vertical member of the cylinder block.

The crankshafts are made of chrome-nickle-molybdenum alloy, with precision machined bearing surfaces for the main and connecting rod bearings to insure a perfect wearing surface. All surfaces not finish machined are thoroughly cleaned and painted with oil-proof paint.

The blower drive gear is secured to the upper crankshaft with a key and retainer plate while at the opposite end is the camshaft driving chain sprocket and starting air distributor camshaft.

The torsional damper is connected to the lower crankshaft at the control end. This is applied to the crankshaft to eliminate critical speeds of torsional vibration. The flexible pump drive gear for driving the governor and all attached pumps is keyed to the torsional damper spider. Power is taken from the engine through a flexible coupling mounted on the lower crankshaft at the blower end.

The vertical shaft connecting the upper and lower crankshafts is made up essentially of only three parts:—the upper and lower pinion shafts and the flexible coupling between them. Each pinion shaft runs in a large roller bearing next to the pinion and is further supported by a substantial thrust bearing. The flexible coupling compensates for expansion and in addition provides torsional flexibility. The vertical shaft also incorporates a provision for properly timing the upper shaft with respect to the lower one.



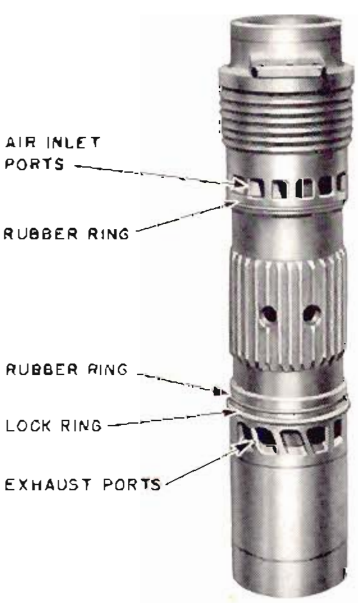
Cylinder Liners

The removable cylinder liners on the Fairbanks-Morse Model 38 Diesel engine are cast from a close-grained iron of great tensile strength.

The cylinders are bolted into the cylinder block in a row along the center line of the engine. The lower end enters the bored hole in the exhaust decks and spacing is such that the pistons and connecting rods are accurately aligned with the throws of the crankshaft.

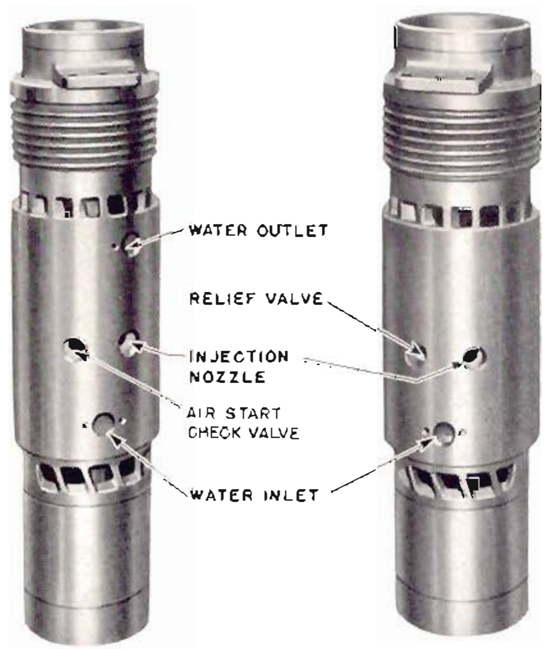
Each cylinder consists of the liner, jacket, rubber rings and lock ring, as illustrated below. The water jacket for the liner is rolled from steel, and welded at the joint. After machining, it is hydraulically pressed onto the liner. The cylinder liner and jacket form a unit enclosing water passages for cooling the combustion space. The rubber rings act as a water seal, and the lock ring prevents any movement of the liner due to expansion from the heat of engine operation. The liner and jacket are always furnished together for replacements.

Circular ribs near the top of the liner are surrounded by the scavenging air and cool this section. Vertical ribs around the combustion space direct the water travel upward absorbing heat from this part of the cylinder. Openings in the liner are provided for the two injection nozzles, an air start check valve, and a cylinder relief valve. Tapped holes for lifting eyebolts are also provided in the lugs used for bolting the liner to the top deck of the cylinder block.



LINER

LINER JACKET



ASSEMBLY, SIDE OPPOSITE CONTROLS

ASSEMBLY, CONTROL SIDE

Connecting Rod, Connecting Rod Bearings And Pistons

There are two pistons, each with its connecting rod, operating in each cylinder. This construction eliminates the need of a cylinder head. The pistons have four basic functions:

(a) To act as movable gas and compression tight closures for the cylinder.

(b) To function as valves to admit scavenging air and permit exhaust of the combustion gases.

(c) To form the combustion space between their recessed heads as they approach inner dead center.

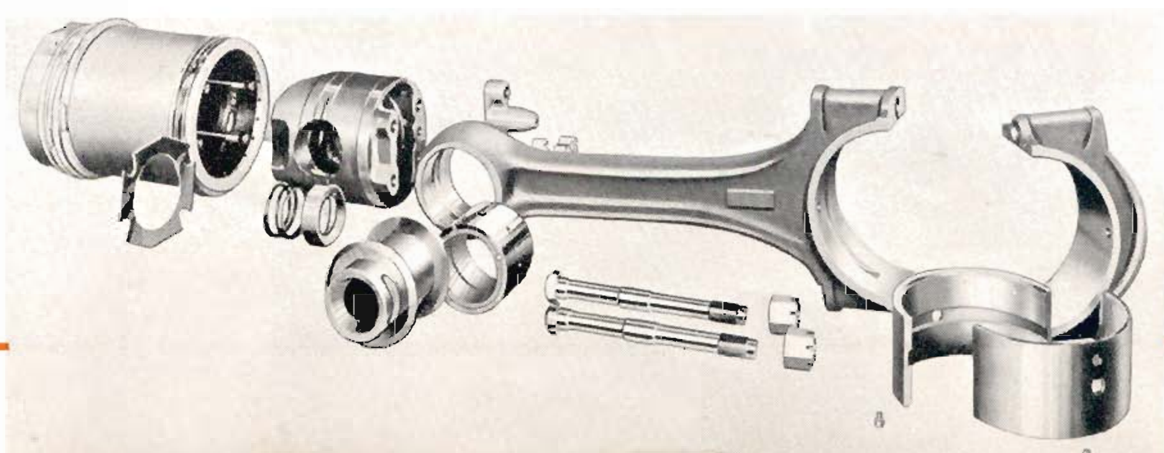
(d) To transmit the power of the expansion forces to the connecting rods and crankshafts.

The design of the upper and lower piston and rod assemblies are similar, the only difference being that the lower connecting rod is approximately four inches longer than the upper one.

The two pistons are identical, with oil cooled heads and a smooth cylindrical outer surface unbroken by any cross-bore for the piston pin. This is accomplished by the use of an inner piston pin bracket into which the piston pin is fitted. This bracket is securely bolted to the piston body and shims are inserted to adjust the clearance between the two pistons. The piston pin bracket also acts as an inner oil jacket wall. The cooling oil outlet pipe fitting is bolted to the piston pin bracket. Cooling oil is discharged from this fitting into the crankcases without any additional piping.

Each piston is fitted with compression rings at the closed end and oil control and oil drain rings at the open end. Both pistons may be simply removed from the lower end of the cylinder and out through the openings at the side of the crankcase.

The drop forged connecting rods and crank-pin caps are precision machined at each end and drilled lengthwise to transmit the piston cooling oil and piston pin lubricant from the crankpin. The piston pin bearing consists of a cast bronze lining pressed into the steel bushing in the connecting rod eye. At the crankpin end of the rod are steel backed bearing shells lined with a special bearing metal and fitted so accurately that no shims are required. These shells are dowelled in place and a circular groove in each furnishes a path for the lubricating oil to travel from the opening in the crankpin to the oil hole in the connecting rod.



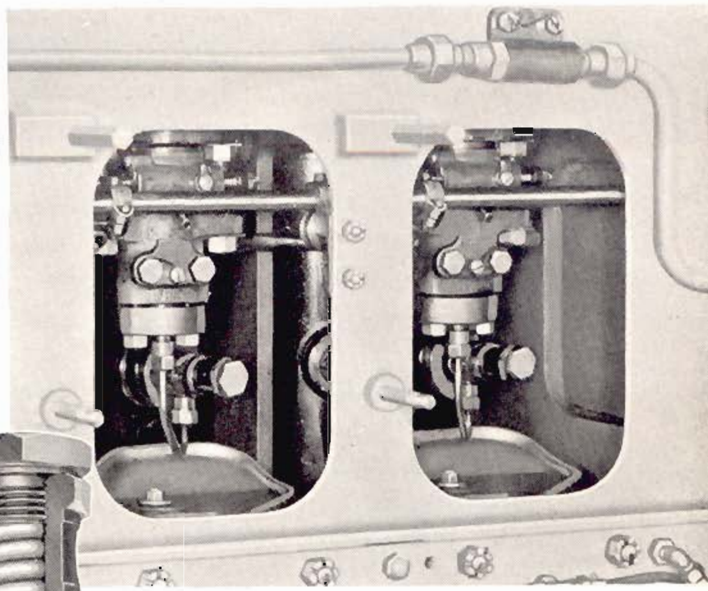
Fuel System

The fuel system of the Model 38 Diesel engine consists of the supply and injection systems. The supply system includes a fuel service tank, standby pump, built-in supply pump on the engine, strainer-filter, gauges and the necessary piping and fittings. The fuel supply pump is driven by gears from the lower crankshaft.

The supply pump draws fuel from the fuel service tank and delivers it through the strainer-filter to the engine inlet. The capacity of this pump is such that more fuel is pumped into the header than is needed by the injection pumps, with the result that a pressure of about 15 pounds is built up and maintained in the header. A regulating valve built into the header controls the pressure, allowing the excess fuel to return to the tank.

The fuel oil header consists of a pipe which is connected to each injection pump. Fuel from the strainer-filter is circulated through the headers by the supply pump. The necessary fuel required enters the injection pumps and the excess returns to the service tank through the return pipe on the outside of the opposite control side of the engine. The capacity of the supply pump is such that a sufficient velocity is obtained in the injection pump headers to insure rapid replacement of fuel as it is used by the individual injection pumps.

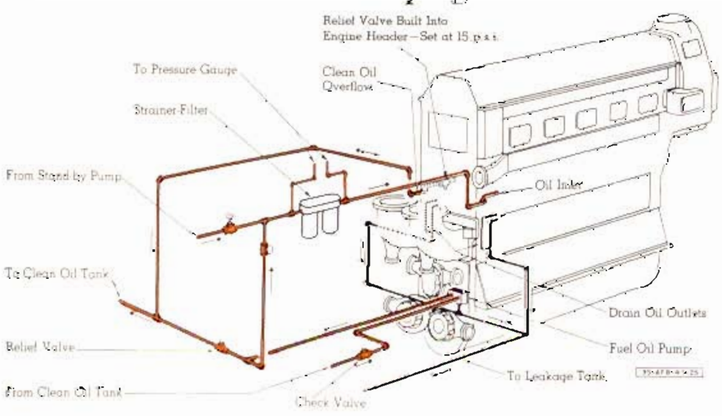
The fuel oil supply pump is of the positive displacement gear type, requiring no other attention than an occasional inspection.



Large openings in the cylinder block make the injection pumps and nozzles readily accessible.

Injection nozzle cutaway view.

Fuel Oil Piping



Fuel Injection

The fuel injection system consists of two injection pumps and two nozzles for each cylinder. These are enclosed in the cylinder block and are located symmetrically with one pump and nozzle on each side of every cylinder.

Injection pumps are mounted vertically directly under the camshafts. They are of the constant stroke, single valve, rotating plunger type. The amount of fuel delivered at each stroke depends on the position of a helix machined on the plunger, relative to the inlet port in the fuel pump barrel. The angular position of the helix is changed by a rack and pinion connected to the Woodward governor at the control end of the engine.

Injection nozzles are of the spring loaded, differential type with a built-in fuel filter of novel design. A nozzle adapter screws into the cylinder wall and carries a flange. The nozzle is then inserted in the adapter and bolted to the adapter flange, making it easily removable for inspection. Each nozzle is connected to its pump by short, equal lengths of high pressure tubing.

Lubricating System

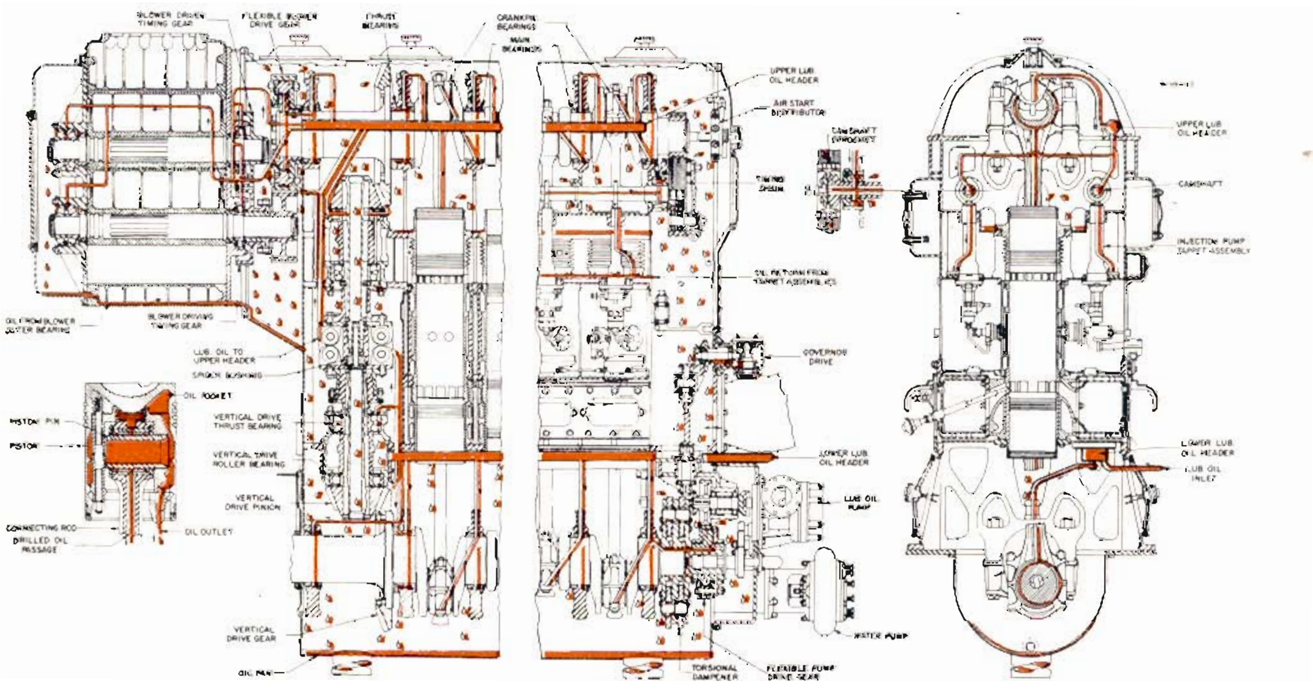
The Model 38 Diesel engine is equipped with a pressure lubrication and piston cooling system which supplies a continuous flow of oil to all surfaces requiring lubrication, and to the pistons for cooling. The system consists of a positive pressure gear pump and two oil headers built into the cylinder block, an oil sump tank, a strainer, cooler, thermometers and the necessary piping and fittings.

The lubricating oil pump is mounted on the control end of the engine and is driven by the lower crankshaft. The pump draws oil from the sump below the engine and forces it successively through the strainer and the coolers.

The drawing shown below illustrates how lubricating oil is circulated through the engine. Entering the lower lubricating oil header from the inlet near the control end, the oil flows through the lower header toward the blower end. There a vertical pipe carries the oil to the upper header.

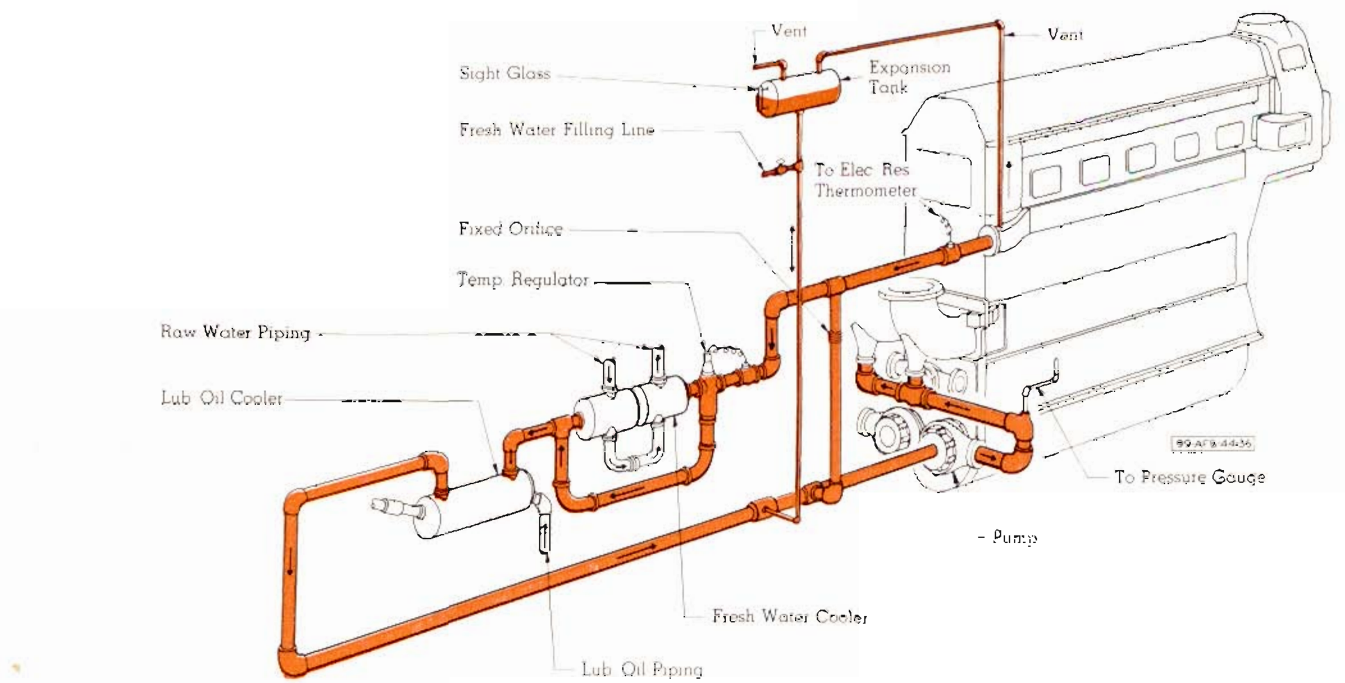
Through supply pipes from both lower and upper headers, oil is forced to each main bearing, then through tubes swedged into the crankshaft, to each crankpin bearing. From there, oil passes through the drilled passage in the connecting rod to the piston pin bearings and to the piston oil cooling jackets.

Throughout the engine the lubricating oil efficiently lubricates all working parts. Then having performed its various functions, the oil not used drips down into the oil pan below the lower crankshaft. From the pan it drains to the sump tank below where it is then ready to repeat the cycle set up by the suction of the lubricating oil pump.



Lubricating Oil Circulation in the Engine

Cooling System



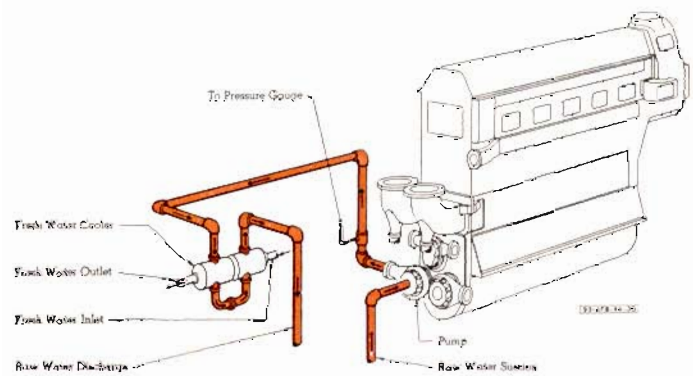
Closed Cooling System

The engine is cooled by circulating fresh water through its water passages. Entering the engine through an inlet in each exhaust nozzle the water moves through passages which surround the exhaust nozzles, and on into the exhaust manifold water passages extending the full length of the engine. The exhaust passages from the cylinder liners and the lower part of the liner are also cooled by the fresh water travel through the exhaust belts.

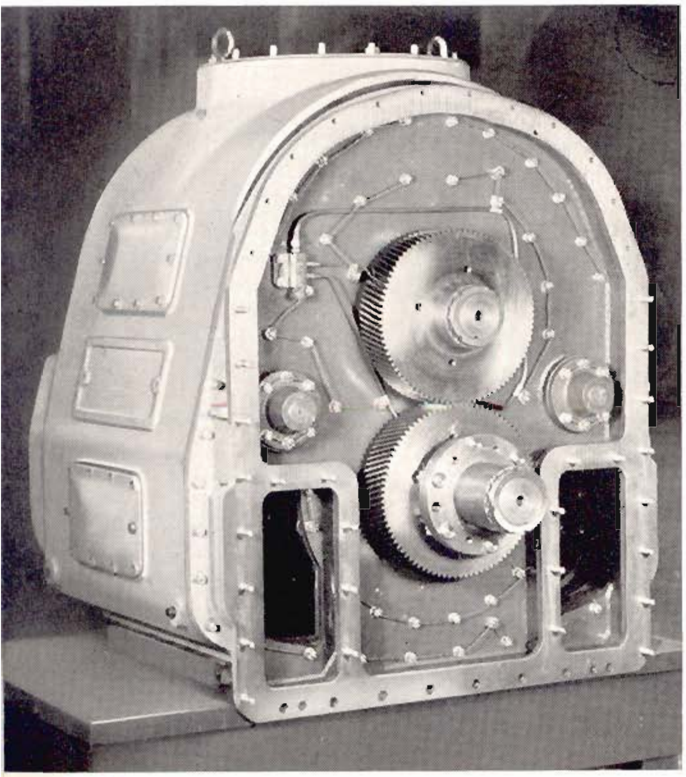
From the exhaust manifold jackets the water passes into the space between the cylinder liner and its jacket, to cool the liner. Water also surrounds the injection nozzle, cylinder relief valve, and air start check valve adapters. to cool these units.

The water cooling system on the Model 38 engine is a closed system, the same water being used repeatedly. Having performed its engine cooling functions, the water leaves the engine and is piped to the fresh water cooler. After leaving the cooler the fresh water is used as the coolant for the lubricating oil cooler, after which it is piped back to the pump suction inlet to repeat its passage through the engine. The fresh water centrifugal pump is driven from the control end of the lower crankshaft.

A second centrifugal pump, similarly located and driven, circulates the raw water through the fresh water cooler.



Raw Water System

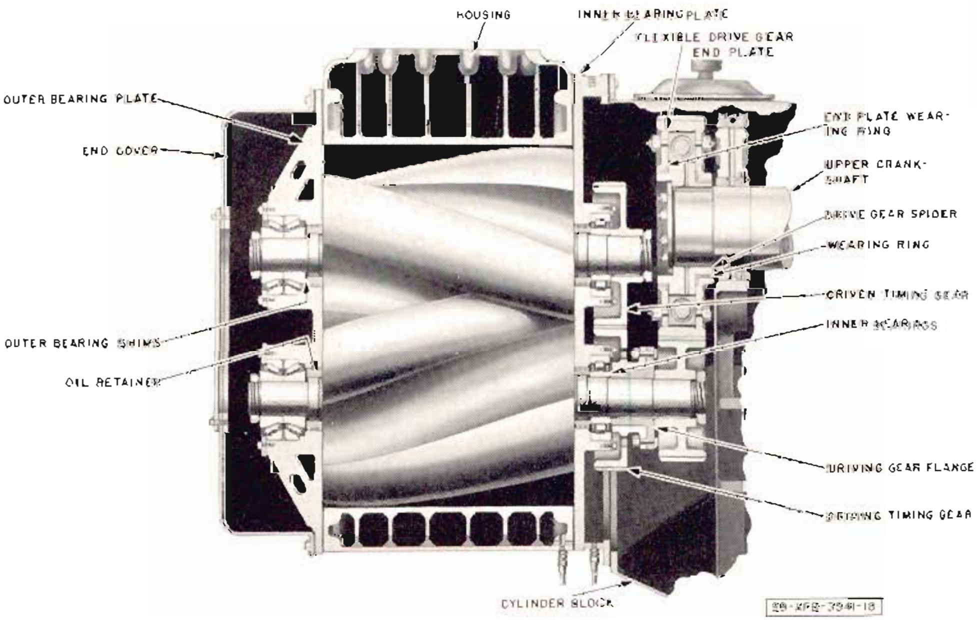


Blower removed from engine showing inner bearing plate, and timing gears on inner ends of impeller shafts.

Scavenging System

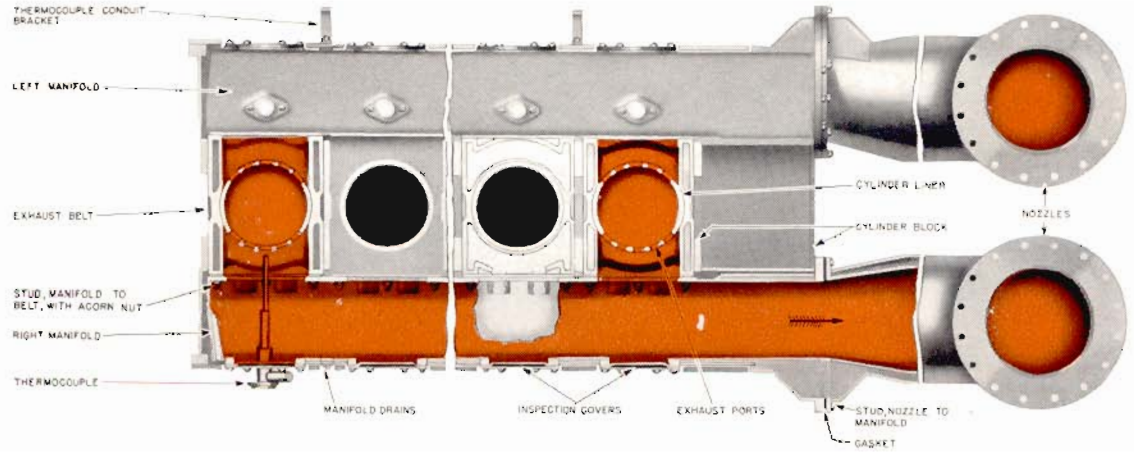
Scavenging air is supplied to the cylinders under a pressure of from 3 to 6 pounds per square inch by a positive displacement type blower. This is a housing containing inlet and outlet passages enclosing two three-lobe spiral impellers. The impellers are interconnected by timing gears driven by a flexible gear drive from the upper crankshaft. These timing gears prevent actual contact of the impellers, but maintain close clearances to give high efficiency.

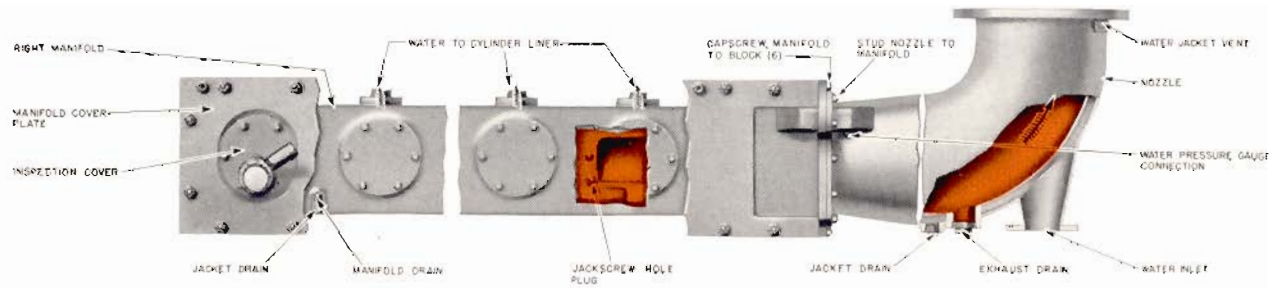
Air is drawn from the atmosphere into the inlet passage of the blower. It is moved by the impeller along the walls of the blower housing and forced through the outlet passages. The scavenging air is conducted to the air receiver compartments extending the entire width of the cylinder block, and completely surrounding the cylinder liners at the air inlet ports. The air enters the cylinders under pressure and sweeps the exhaust gases out through the exhaust ports, producing complete scavenging. Enough scavenging air remains in the cylinders after the pistons close the ports to provide fresh air for the next compression stroke. The scavenging air is discharged from the blower with a uniform velocity due to the design of the impeller lobes.



Cross-section View of Scavenging Air Blower.

Exhaust System



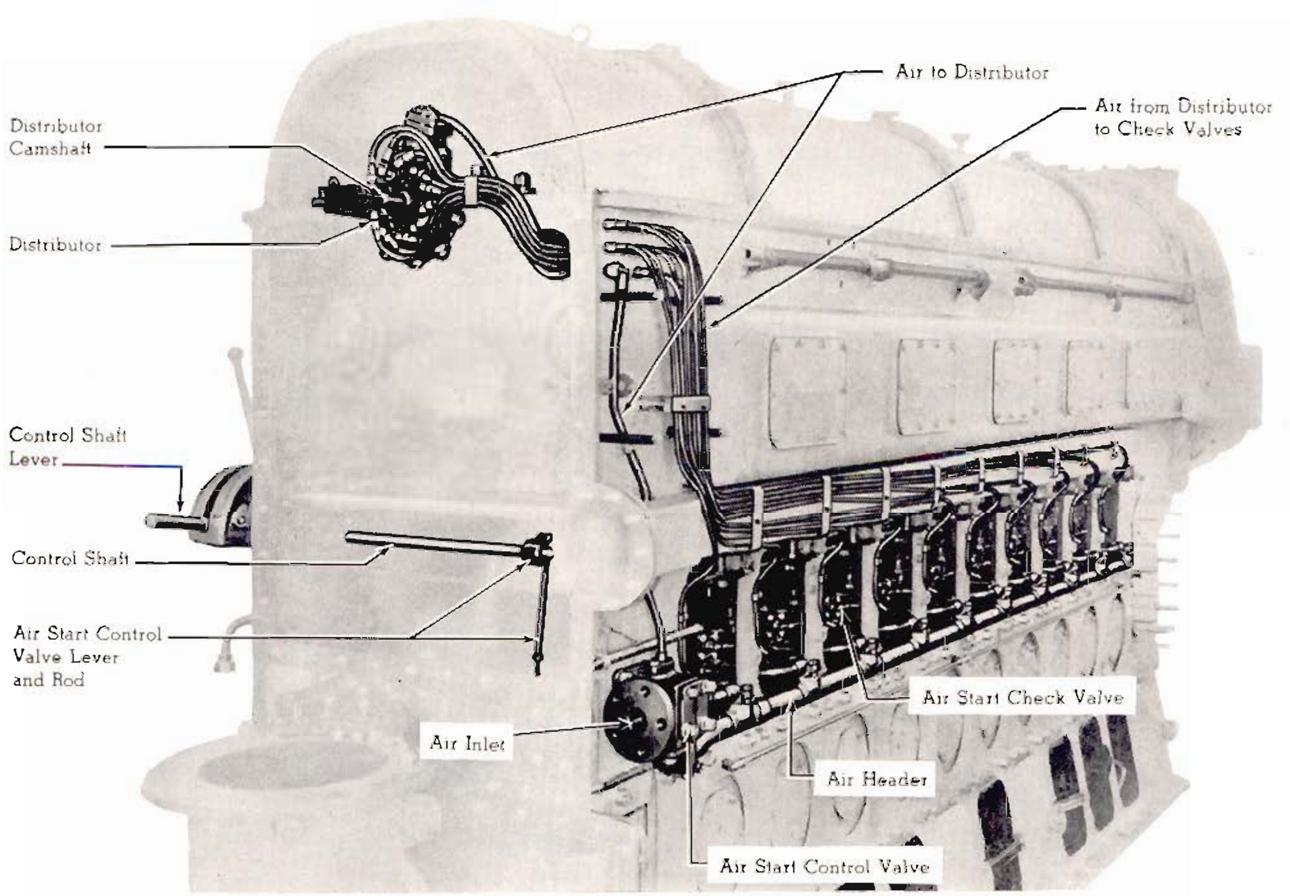


The exhaust system is made up of large, water-jacketed passages built into the engine frame, permitting an unrestricted flow from the cylinders to the exhaust nozzles at the control end of the engine from which they are piped to the atmosphere. The exhaust manifolds are located on each side of the frame and the exhaust ports completely surround the liner. The scavenging air ports are at the top and the exhaust ports at the bottom of the liner thus giving a straight-through, downward passage of the scavenging air.

The scavenging air ports are controlled by the upper piston while the exhaust ports are uncovered by the lower piston. The piston timing is such that the exhaust ports open about 16° before the scavenging air ports which allows most of the exhaust gases to escape before the scavenging air enters.

When the upper ports open at about 40° before bottom dead center of the lower piston, the scavenging air rushes in and forces the remaining exhaust gases out. The lower piston then closes the exhaust ports about 8° before the scavenging air ports are closed, leaving the cylinder filled with fresh air for the compression stroke which immediately follows.

The exhaust manifolds are provided with openings at each cylinder for inspection and servicing purposes. Plain flange covers are furnished for these openings for the opposite control side of the engine. The covers on the control side are equipped with thermocouples from which conductors connect to an indicating pyrometer instrument to indicate the temperature of the exhaust gases leaving the exhaust ports of each cylinder.



Air Starting Mechanism

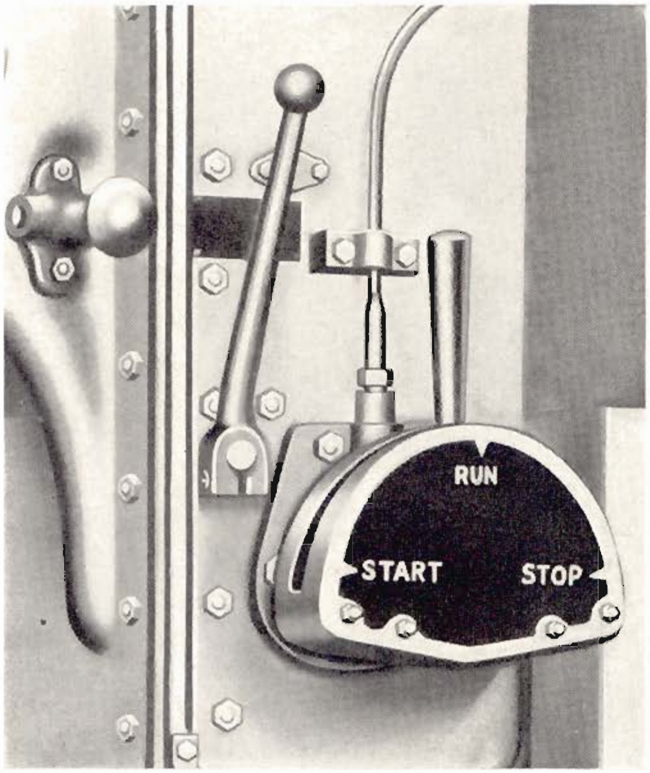
The air starting system consists of the starting air piping and the engine starting mechanism. Air for the starting system is required at 250 p.s.i. or less and is stored in suitable air tanks or receivers. Where space is limited high pressure air flasks may be used with suitable pressure reducing valves.

Engine starting is accomplished by the action of compressed air on the pistons in their proper firing position. Instant turnover is assured by the elimination of dead centers as air is admitted to the cylinder until the engine begins to rotate.

The engine starting mechanism includes the air start control valve, air start distributor, the header, the pilot air tubing and the air start check valves at the individual cylinders.

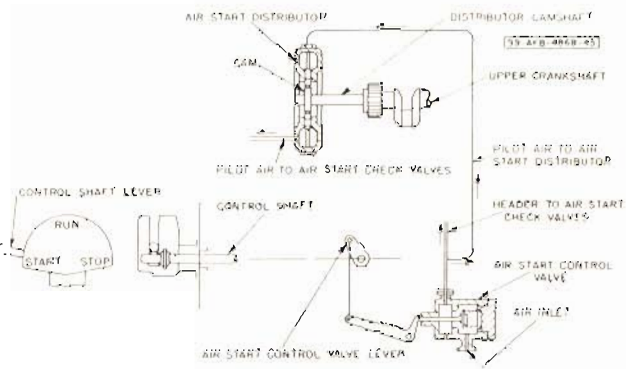
When the control valve is opened, starting air fills the header to each check valve. These are of the balanced pressure type pneumatically opened by air from the distributor valve. This valve is accurately timed by a cam at the control end of the upper crankshaft.

The check valves are inserted in adapters, screwed into the cylinder walls, the same as the injection nozzles. The distributor valves are in contact with the timing cam only while the main control valve is open. At other times, retriever springs hold them out of contact. The system is adequately vented so that starting air pressure is immediately relieved as soon as the engine fires and the lever is moved to the "Run" position.



Control System

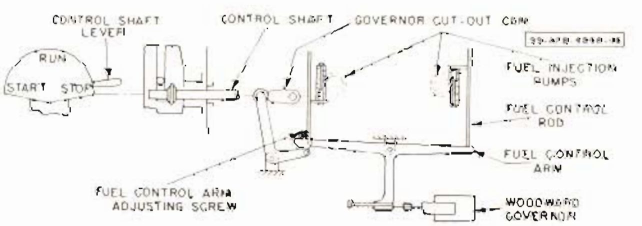
The control mechanism is one of studied simplicity. A single lever controls the "Start," "Stop" and "Run" positions for the stationary units and the maneuvering positions for marine engines. This lever, through its control shaft actuates the Air Starting and Fuel Control mechanisms illustrated in the diagrams below. A second lever resets the emergency overspeed governor, and a conveniently located push button actuates the emergency stop.



Control of Air Starting System

Fuel Control

The fuel control system is illustrated in the diagram below. In the "Stop" position, the governor cut-out cam through its linkage tilts the fuel control arm moving the fuel control rods to the shut-off position of the fuel injection pumps. With the control shaft lever in the "Run" position, the governor cut-out cam through its linkage releases the fuel control arm which immediately regains its normal position under the control of the Woodward governor. The latter automatically regulates the position of the fuel injection pump plungers in accordance with the load.

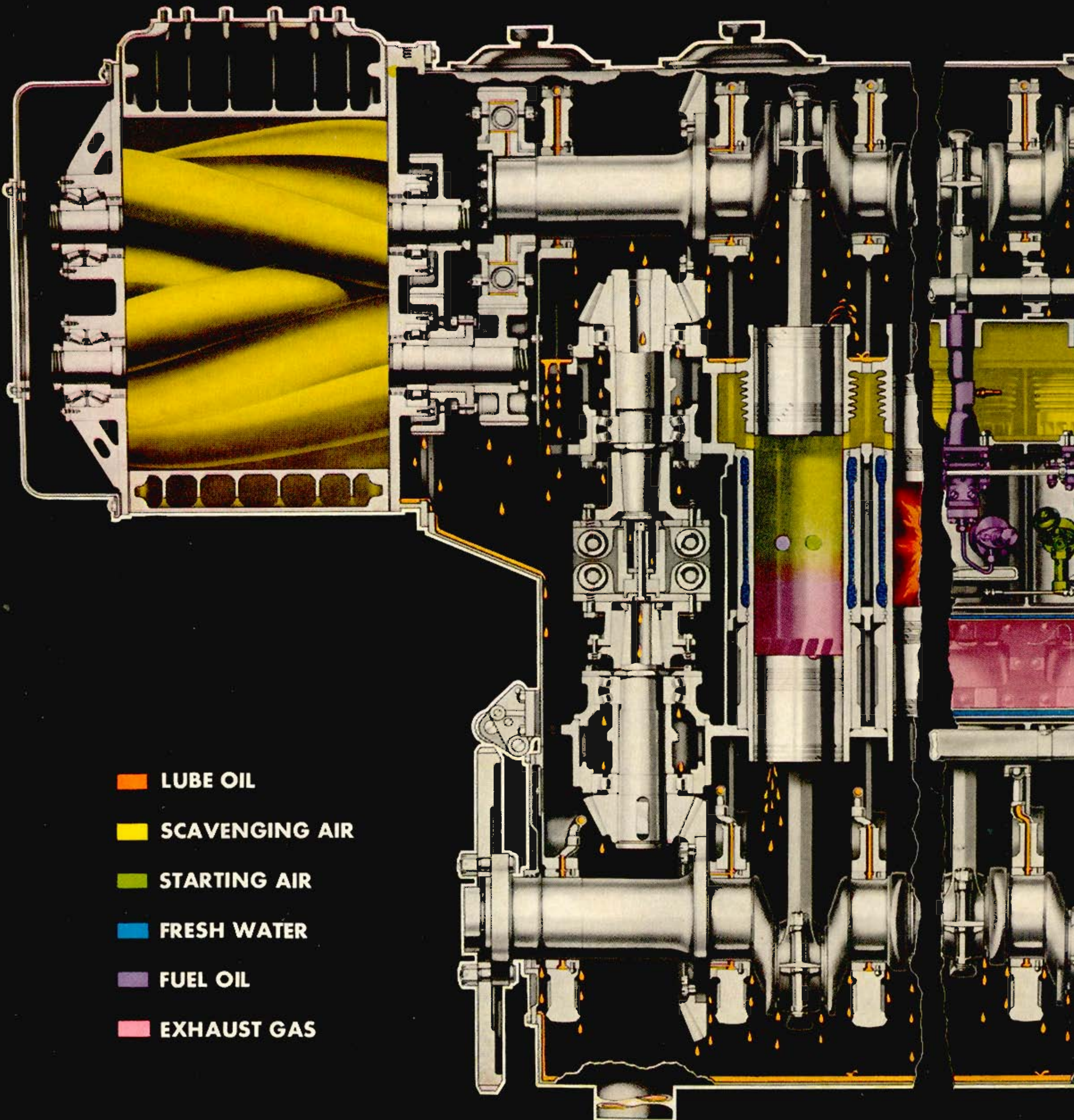


Stopping the Engine with the Control Shaft Lever

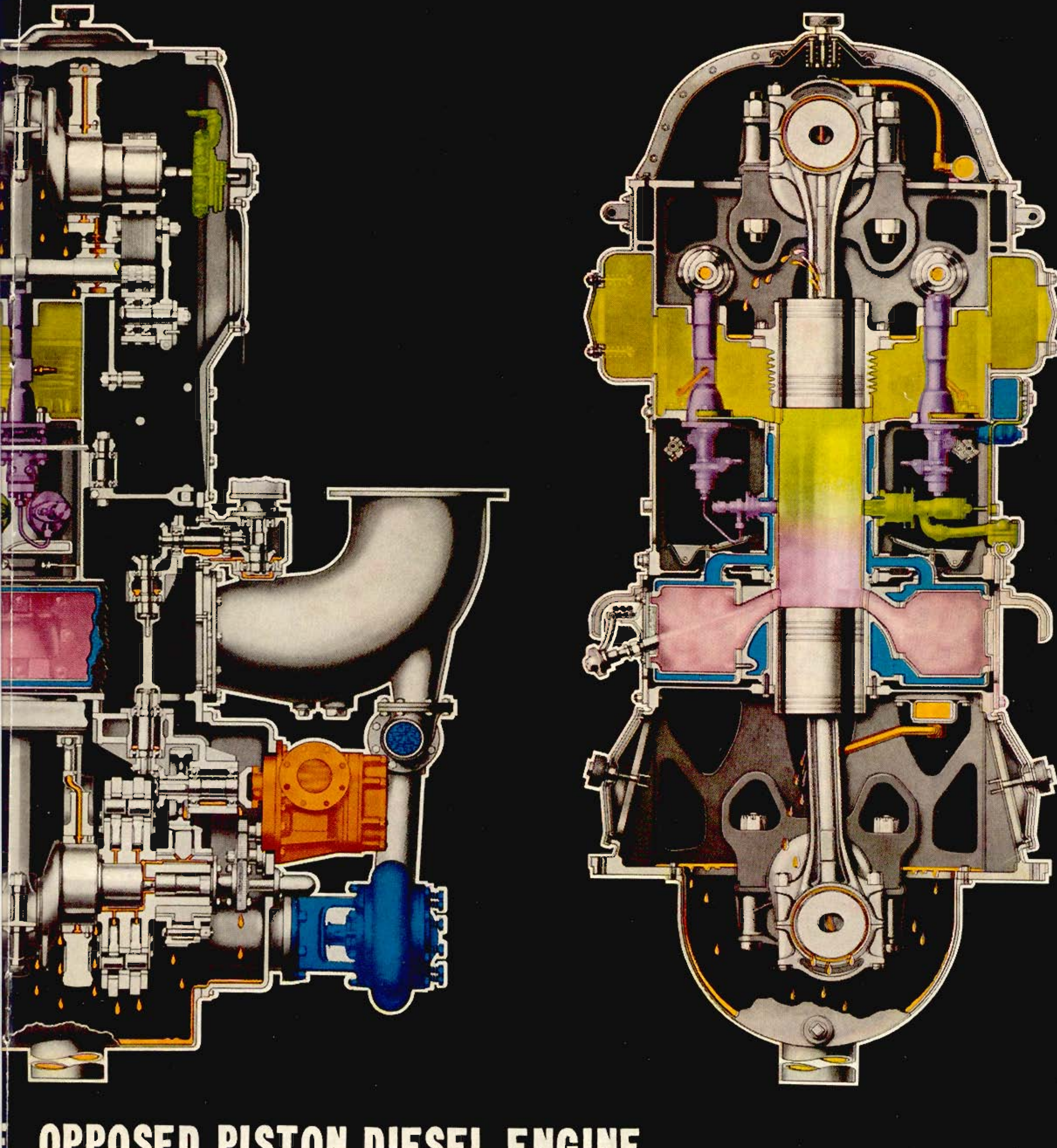
Air Start Control

Quick and reliable starting is equally important in either stationary or marine service. The diagram above illustrates clearly the simplicity of the mechanism employed in this vital detail. Moving the control shaft to the "Start" position opens the main air start control valve. This valve admits starting air from the main storage tanks to the header supplying the individual check valves located on each cylinder. A second line from this same air control valve, leads the pilot air to the distributor driven from the opposite blower end of the upper crankshaft. The distributor accurately times the pilot air and delivers it to the balanced air check valves at the cylinders thus opening them at the correct time regardless of the direction of rotation.

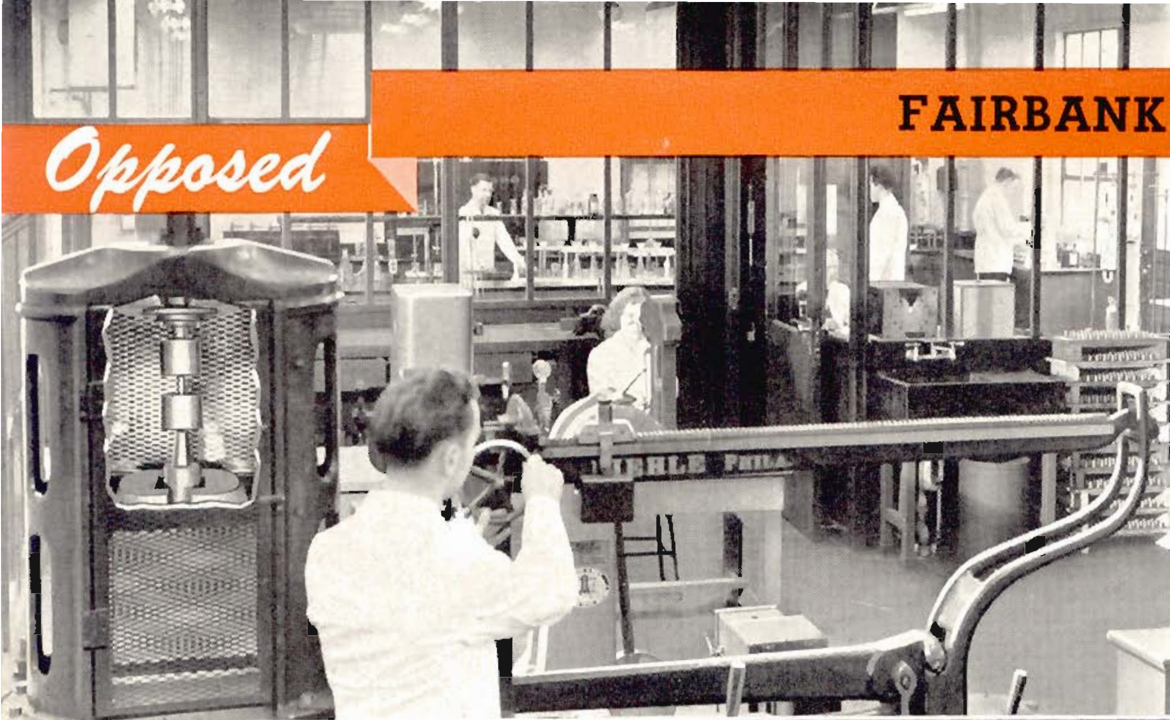
Starting air is shut off and the system automatically vented when the control lever is moved to the "Run" position. The control quadrant shown in the illustration is, of course, for the stationary application. For direct reversing marine service, both ahead and astern positions are provided.



MODEL 38D8⅛ FAIRBANKS-MORSE



OPPOSED PISTON DIESEL ENGINE

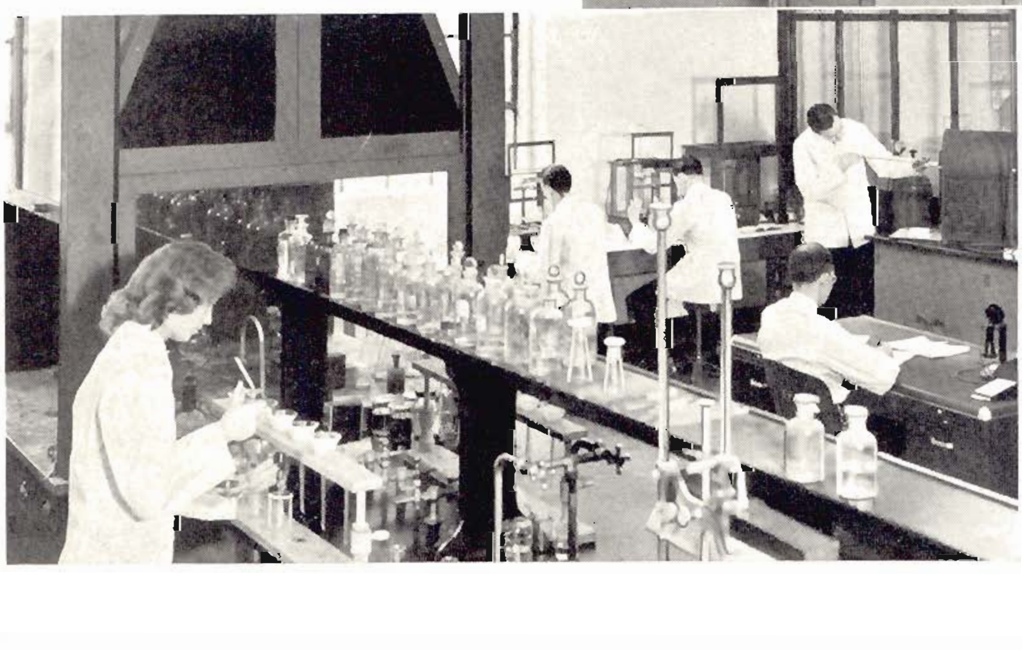


Here is the metallurgical laboratory where materials are pre-tested for required physical properties.

Material Inspection

All materials used in the construction of the Model 38 opposed-piston Diesel engine must measure up to the exacting standards of Fairbanks, Morse & Co. as to chemical and physical characteristics. Close laboratory control is maintained, with trained technicians making complete tests of all materials.

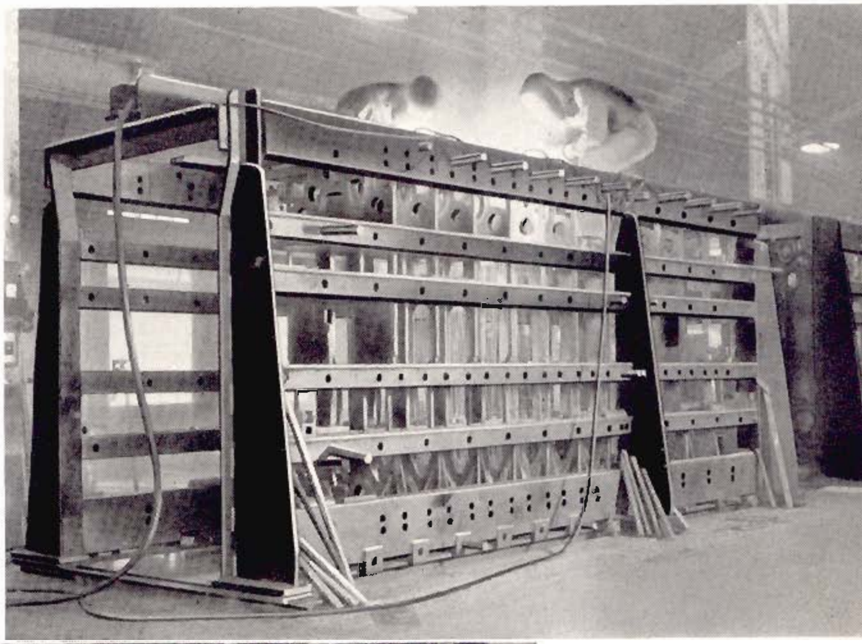
Above is the Spectograph which reveals the percentage of different ingredients in iron.

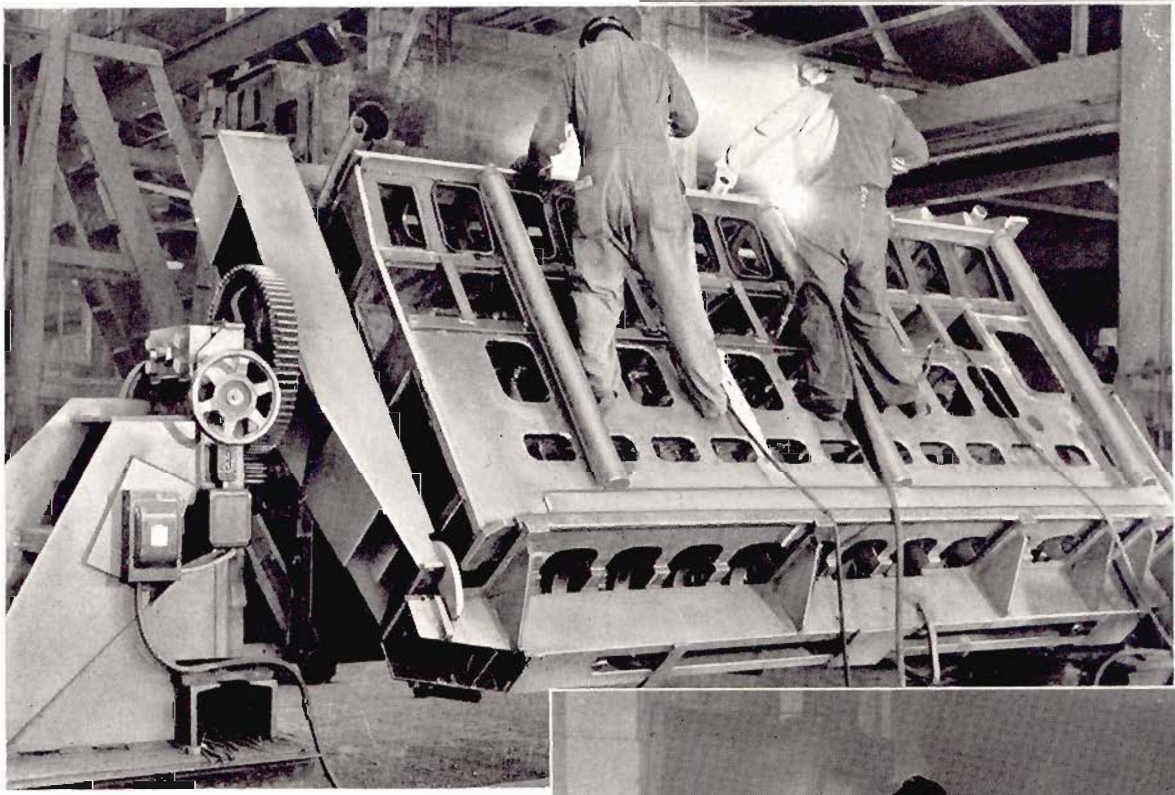


The chemical characteristics of materials are determined in the chemical laboratory shown at the left.

Welding

Modern Diesel engine design employs weldments to a great degree. The cylinder blocks are welded together in fixtures in order to secure the exact location of all parts. The welded cylinder blocks are tested for soundness of the welds, are stress-relieved, and then checked again before being laid out for machining.



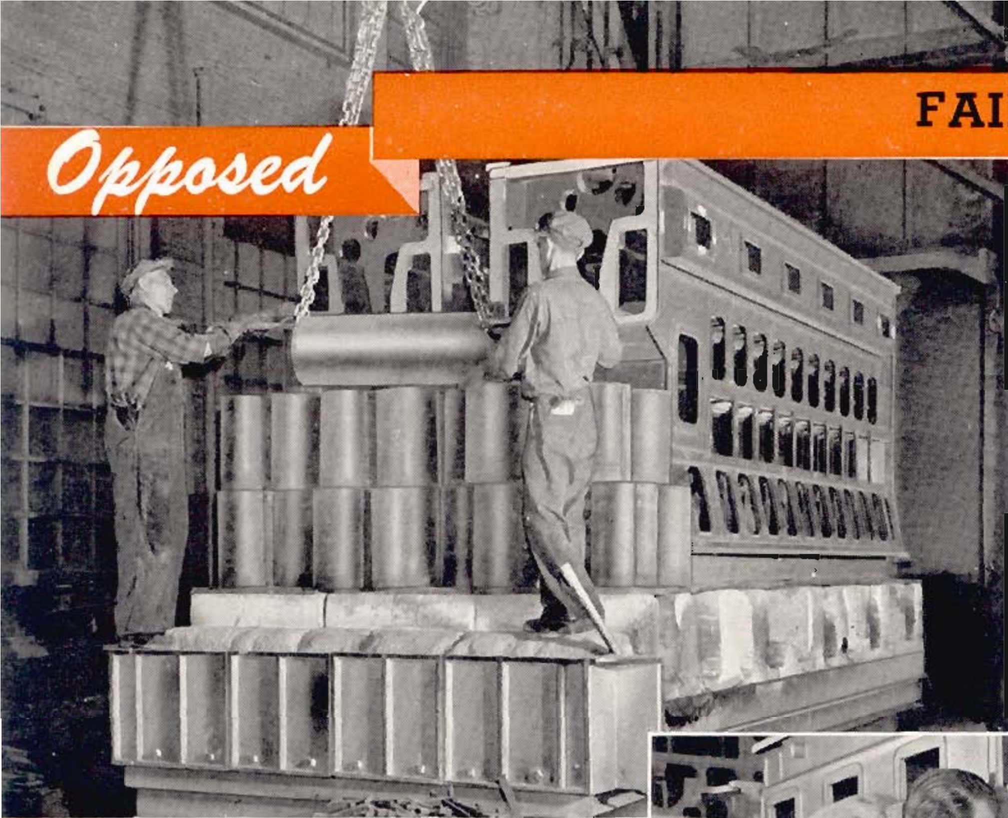


The above illustrations picture three welding operations in the fabrication of the Model 38 Diesel engine cylinder block. Revolving fixtures simplify the work.

Opposed

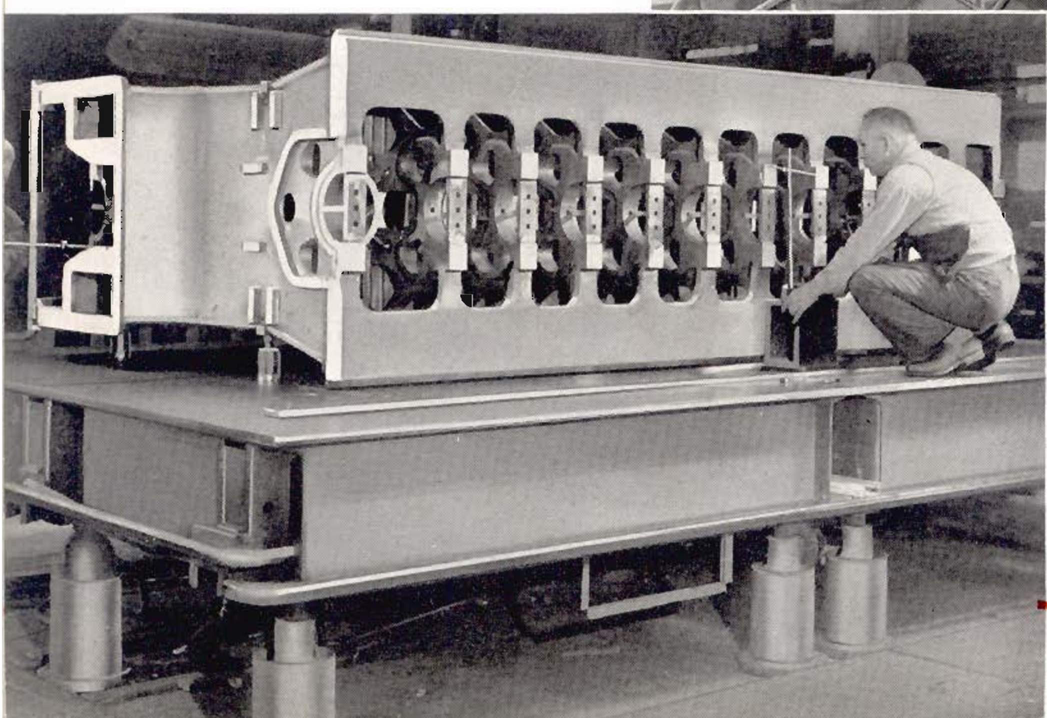
Stress-relieving

The block is sand-blasted after welding and magnaflux tests are made to check the vital points. It is then stress-relieved to remove the internal strains introduced by the welding.



Getting the blocks ready for the specially designed ovens in the all-important stress-relieving operation.

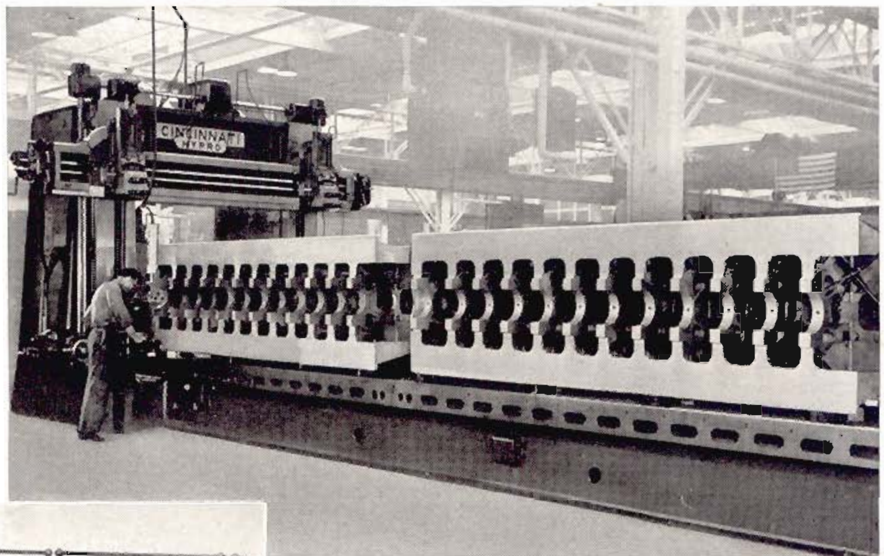
After stress-relieving the block is again magnafluxed to check the soundness of the welds.



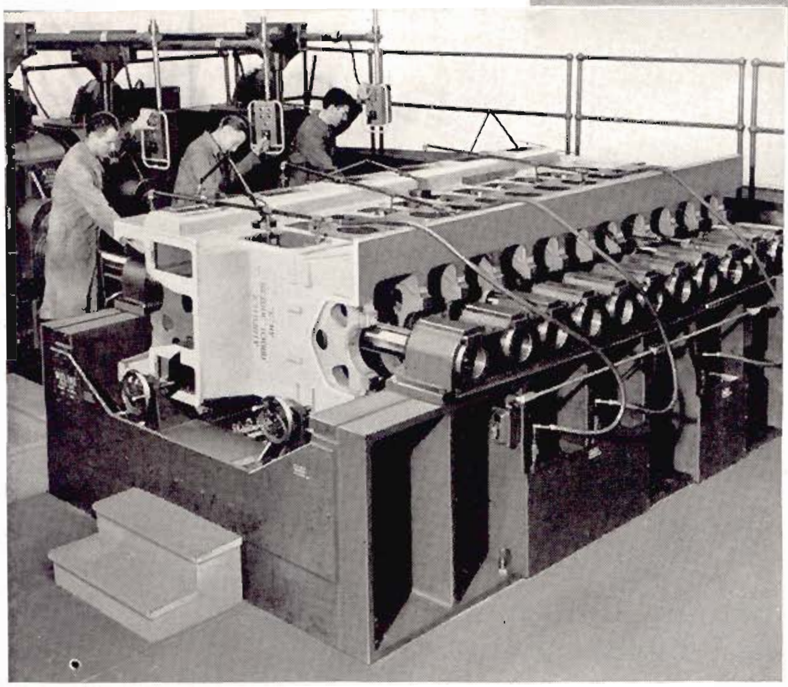
The block undergoes another inspection before being laid out for machining.

Machining

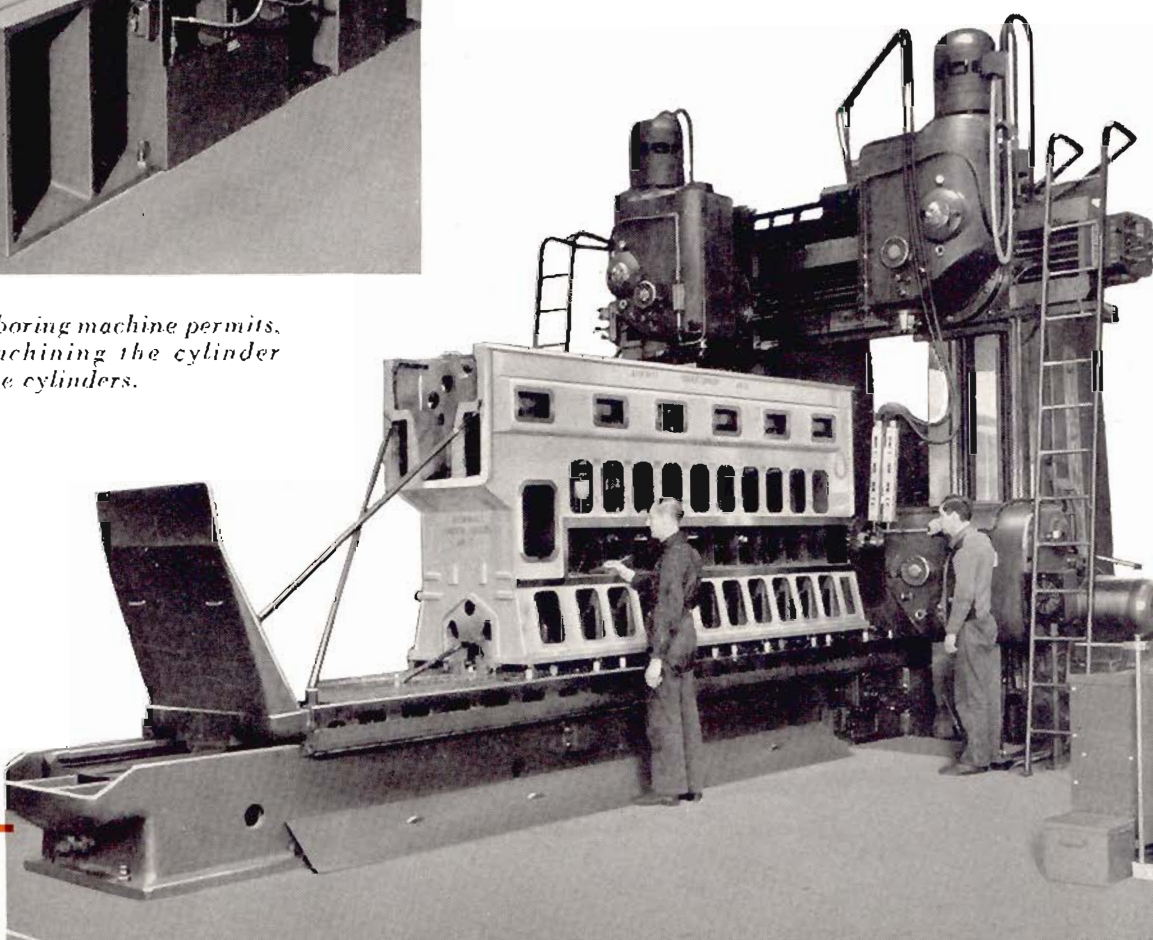
Precision machining of the cylinder blocks is done on hydraulically operated planers. The first operation is the machining of the top and bottom of the block. The planer is large enough to machine two cylinder blocks in one operation.



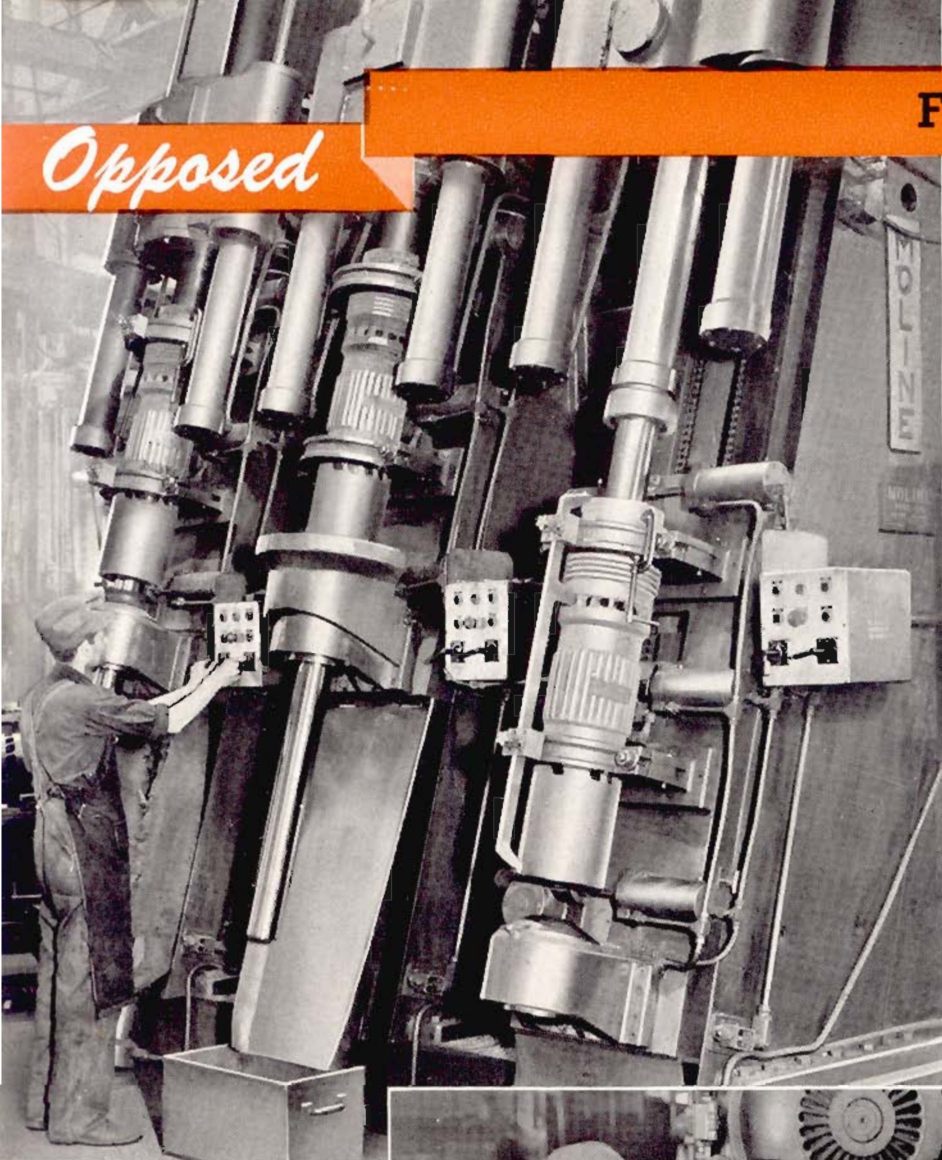
Two blocks are placed end to end in planer, and tops and bottoms of both blocks are machined at the same time.



A multiple spindle boring machine permits, at one setting, machining the cylinder blocks to receive the cylinders.



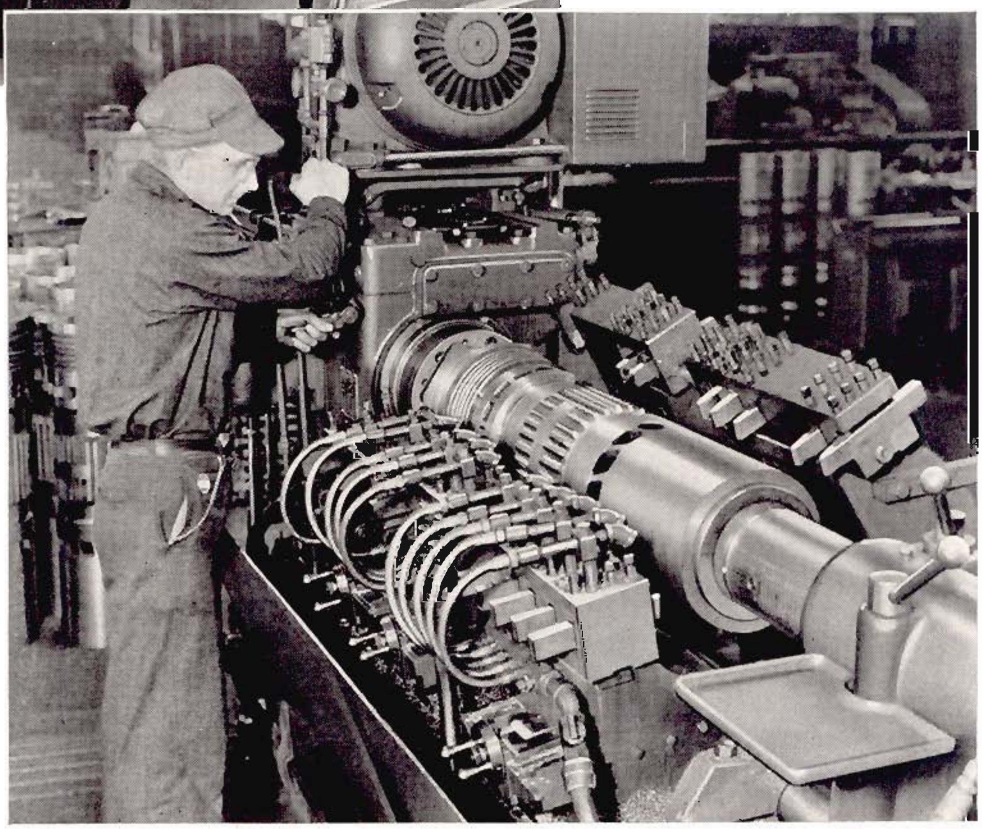
Both sides of the block are machined at the same time in this milling machine.



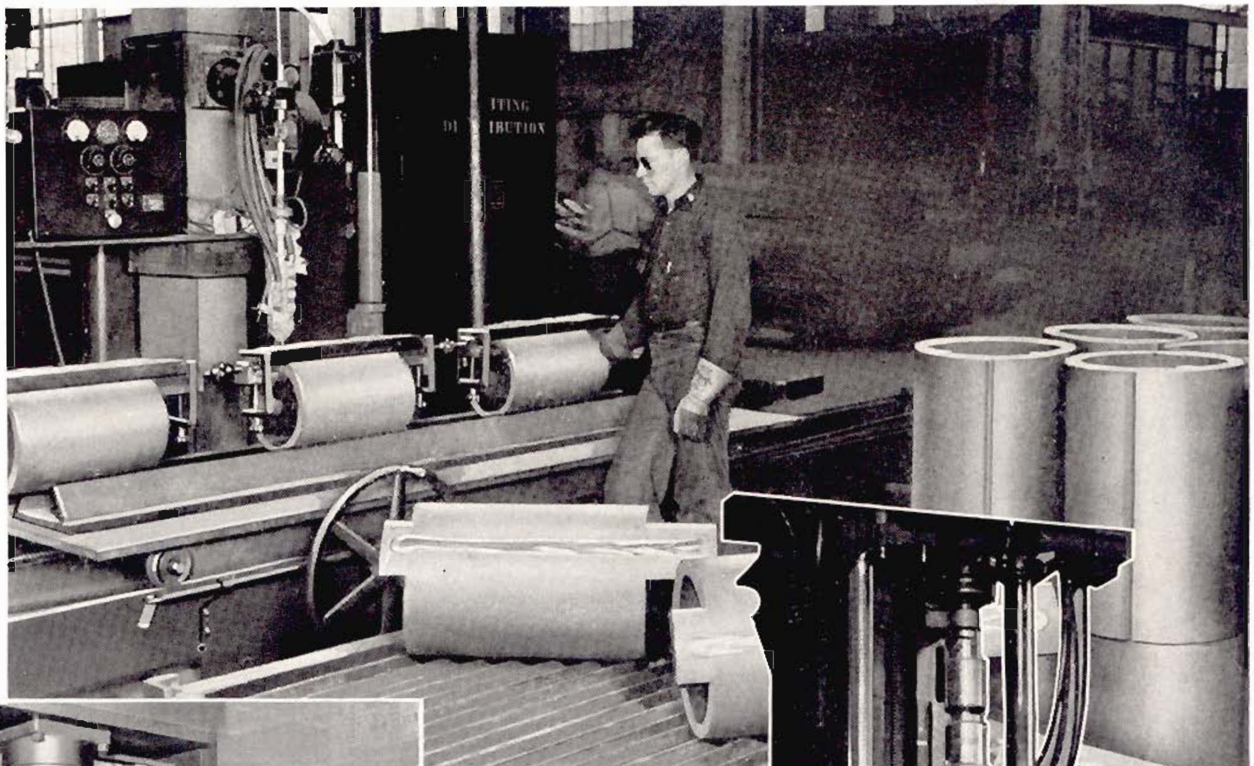
Cylinder Liners

The removable cylinder liners on the Fairbanks-Morse Model 38 Diesel engine are cast of a special close-grained iron of great tensile strength, and are machined and bored to exact dimensions. The machines pictured on these pages work to exceedingly close tolerances, assuring interchangeability and correct piston to cylinder clearances without individual selection.

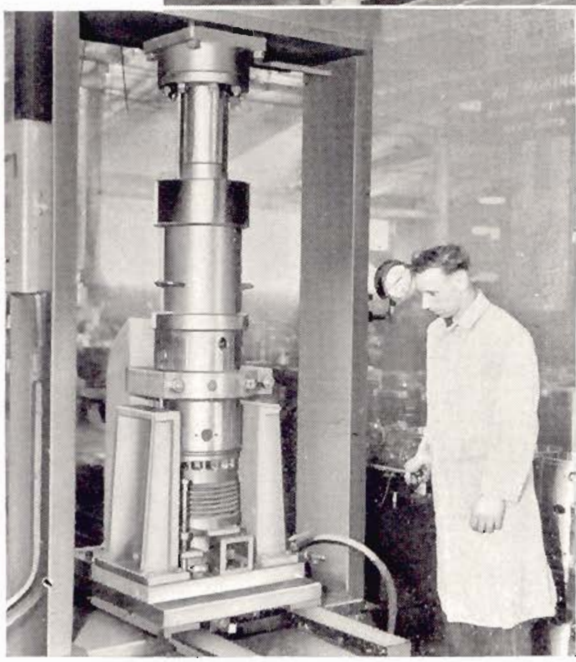
Bores of the liners are machined in a vertical boring machine which has three spindles.



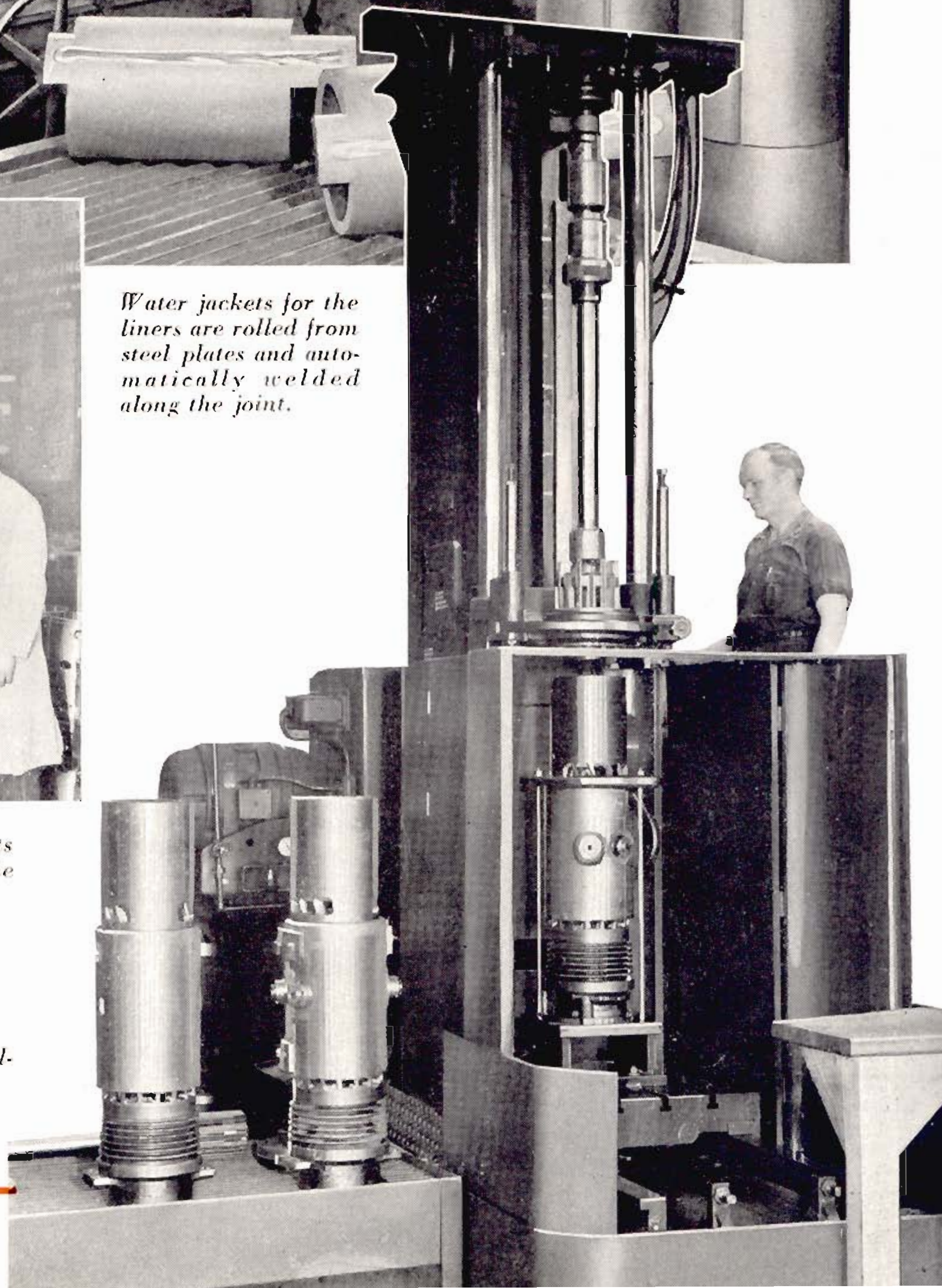
The outsides of the liners are rough-turned and finished in this multiple-tool automatic lathe.



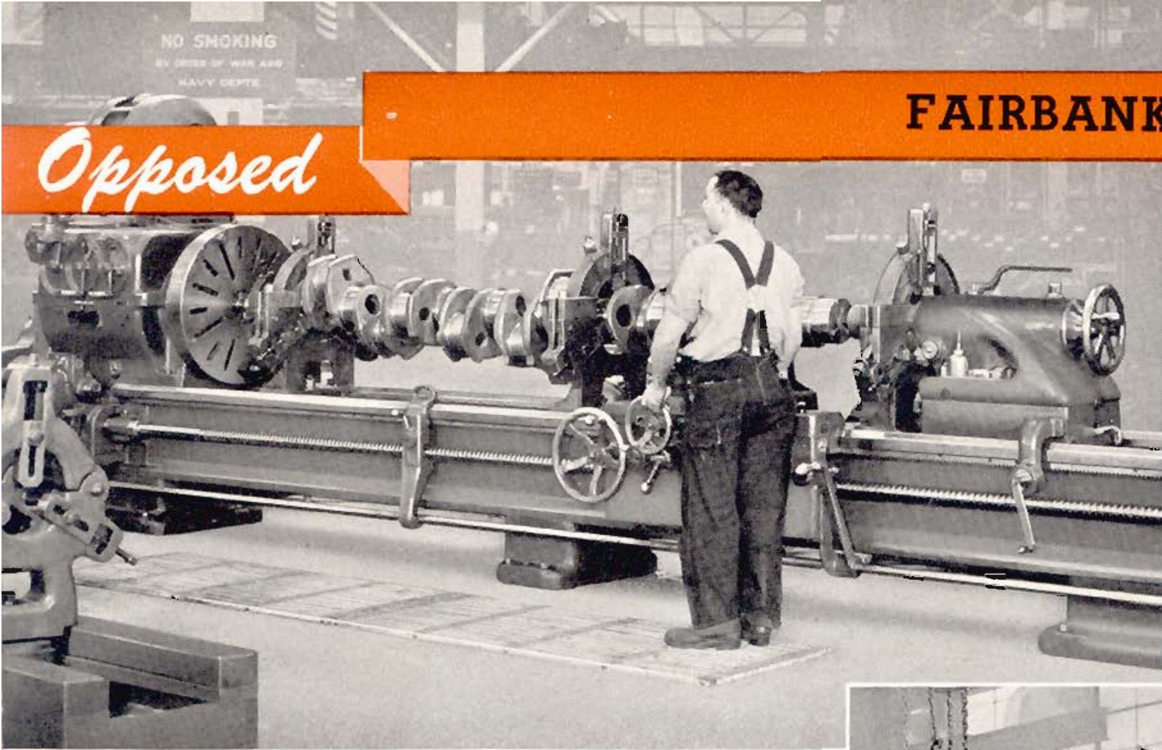
Water jackets for the liners are rolled from steel plates and automatically welded along the joint.



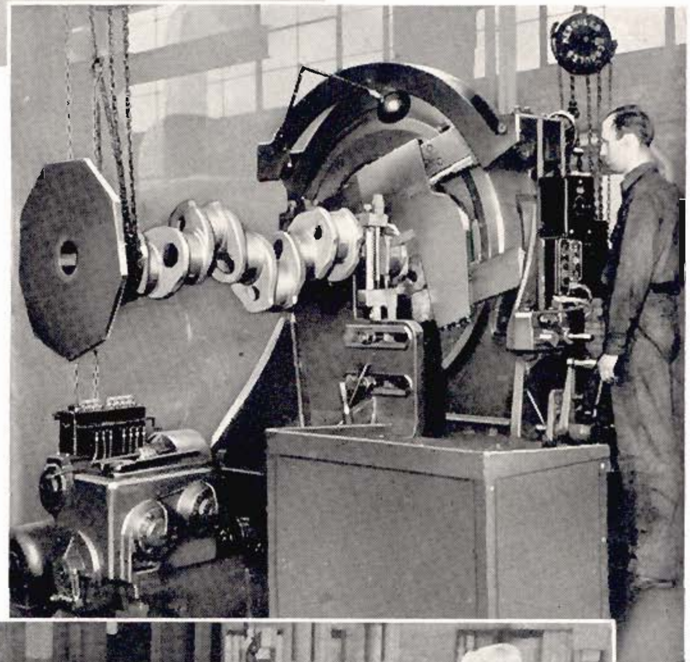
After machining, the water jackets are hydraulically pressed onto the liners.



Precision honing the bore of each cylinder liner to its final dimension.

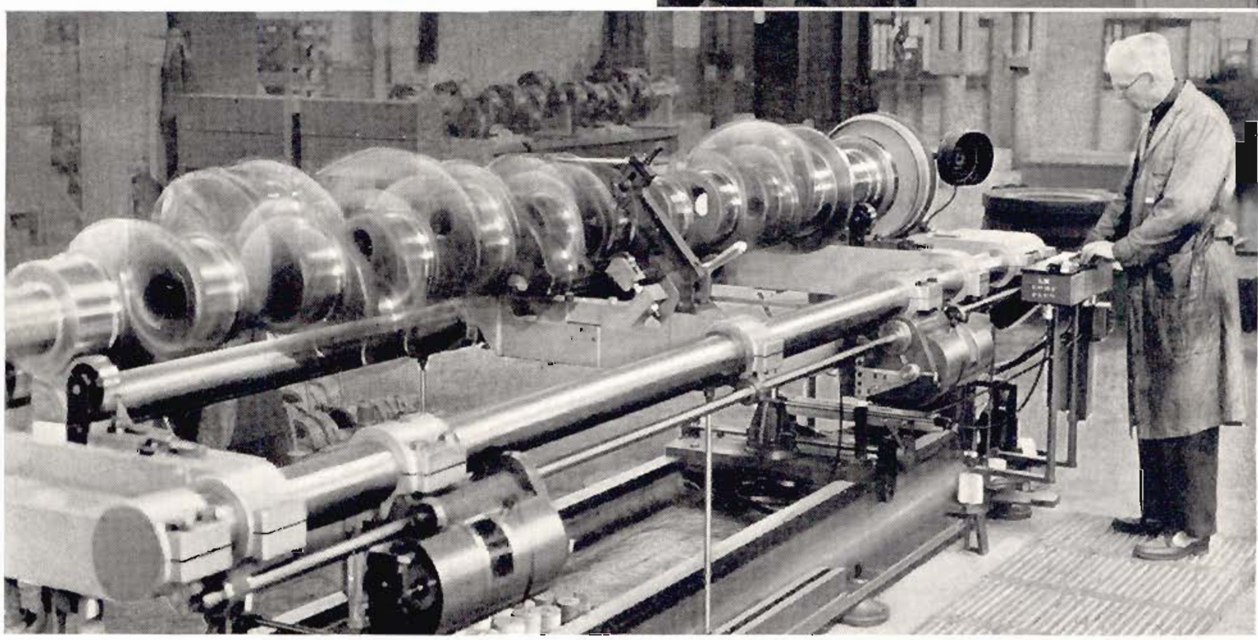


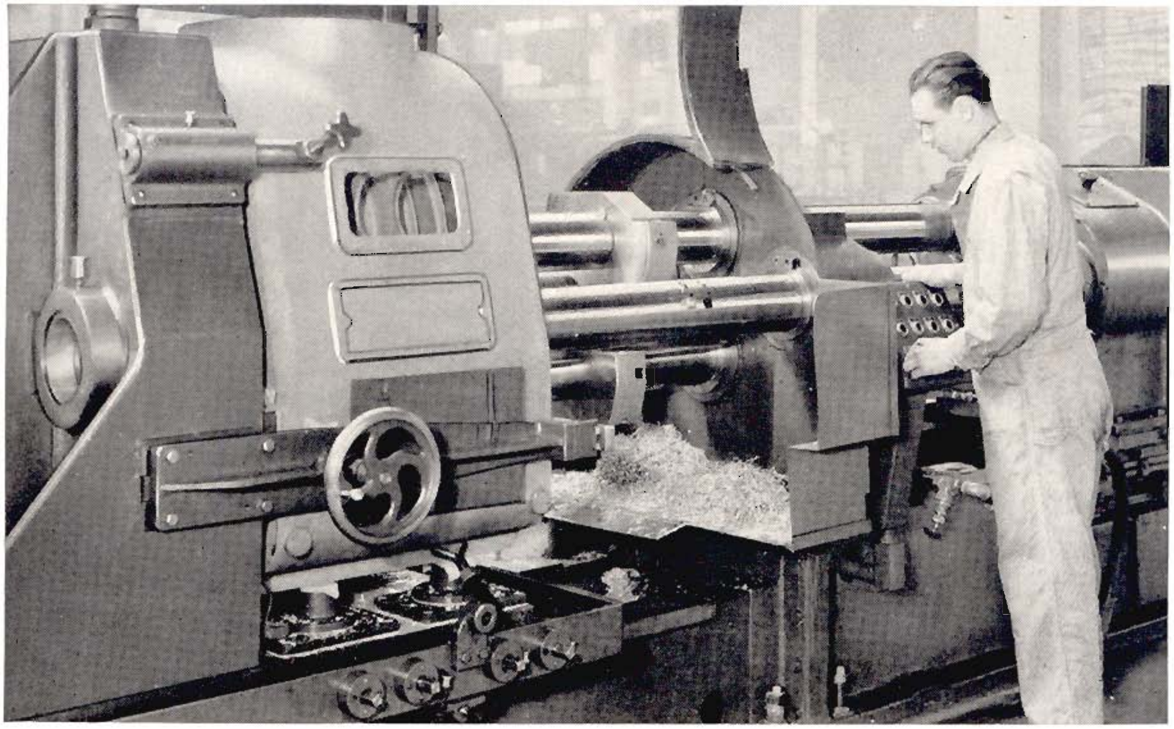
Illustrating a few of the precision operations in the making of the crankshafts.



Crankshafts

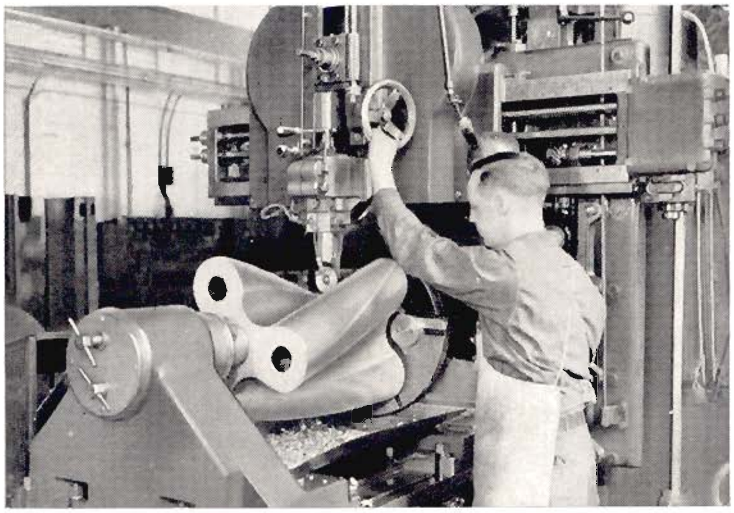
The crankshafts of the Model 38 Diesel engine are cast of special high-grade alloy and are machined and ground on machines built especially for this purpose. The main bearing journals are machined on a lathe, in one setting, to within a few thousandths of an inch of their finished diameter. A final grinding operation then reduces the journals to their exact dimension. Crankpins are finished in a special machine in which the shaft remains stationary. The crankshafts are dynamically balanced within very close limits.



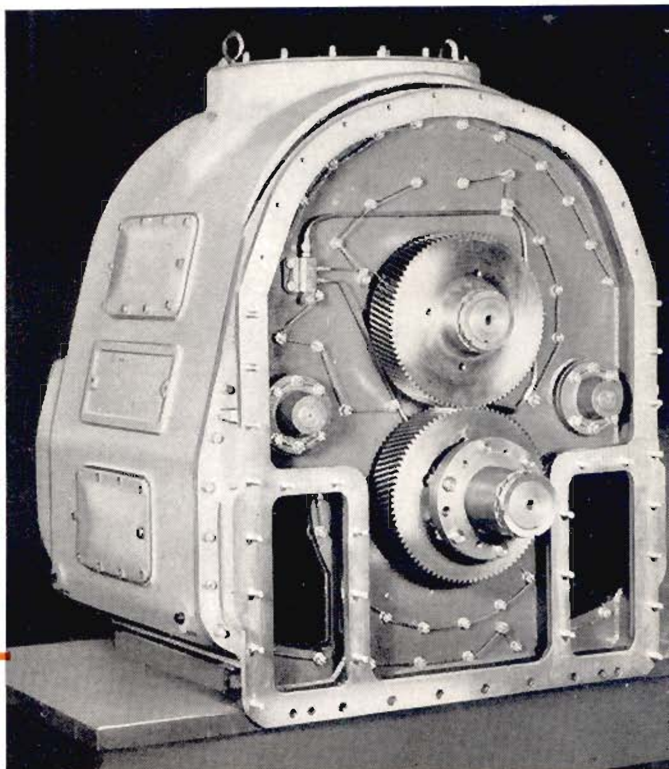


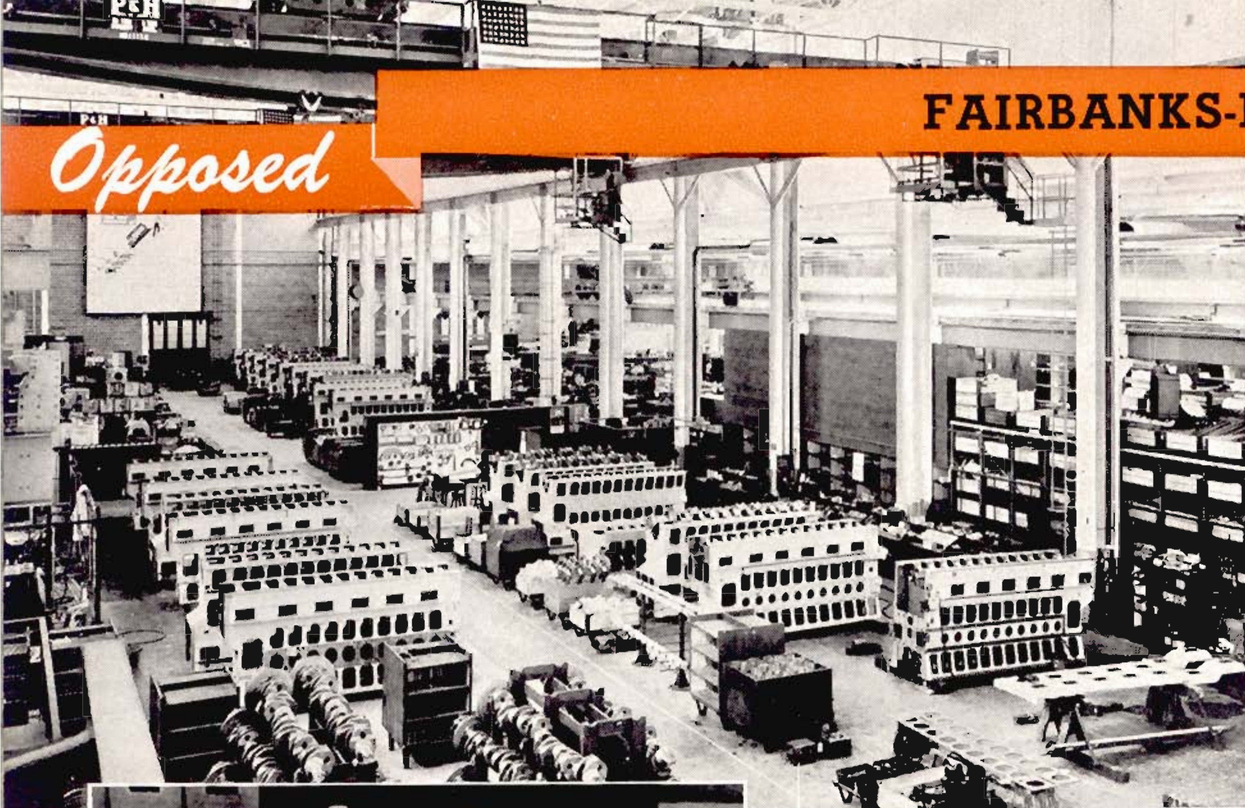
Blower

The blower housing, cast of aluminum, is first machined on both sides, then all four holes are drilled simultaneously in a multiple-spindle boring bar. The impeller for the blower, also made of aluminum, is cast directly around the steel shaft which actuates it. After being dynamically balanced and assembled the blower is rigidly tested on the blower test floor before going on the engine.

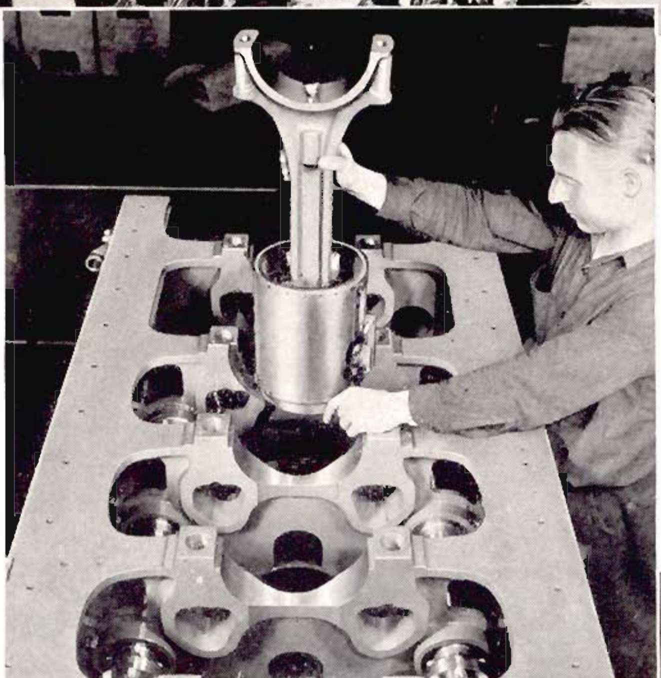


Lobes of the impeller are shaped on a special hydraulically operated machine.



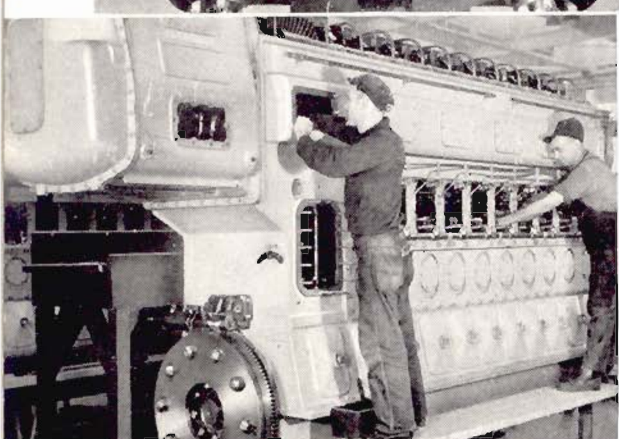


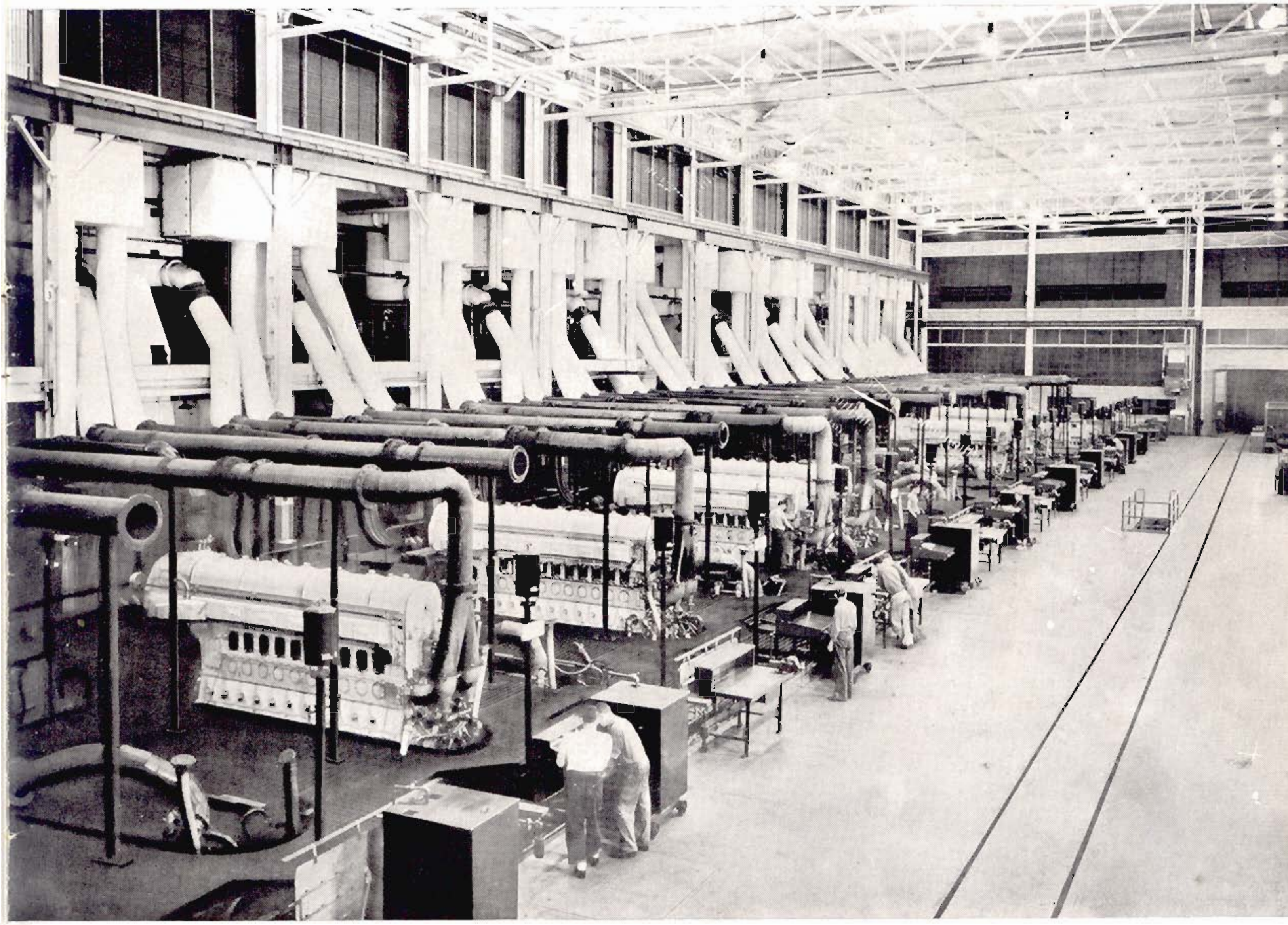
Opposed FAIRBANKS-MORSE MODEL



Assembling

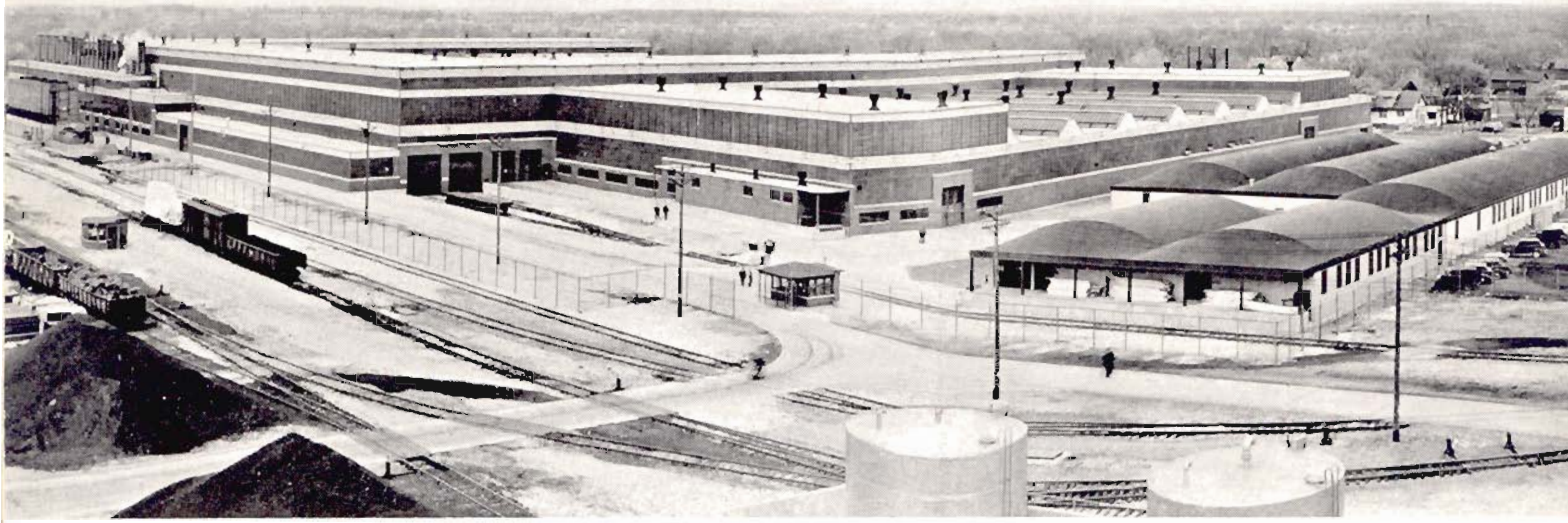
The first assembly operation is putting all of the cylinder liners in the blocks, connecting the two exhaust manifolds, and installing the water header. The block is then given the water test by keeping water in all water spaces under high pressure so that each and every joint can be checked for tightness. When the water test has been completed, assembly of the entire engine then takes place. Crankshafts, pistons, connecting rods, camshafts, and other parts are assembled by specially trained erectors.





The Final Test

From the erecting floor the engines move to the ultramodern test floor where they are "run-in". They are then subjected to rigorous tests for full power at full speed. Here, also, the engine receives its final inspection, the last of the frequent tests of every component part, that take place continuously during the building of this Diesel engine. The floor is laid out to permit normal testing with the engines driving generators, the current from which is used to furnish power to the plant. Provisions are made, however, to test the engine under any conditions desired.



The Home of Fairbanks-Morse Opposed-Piston Diesels

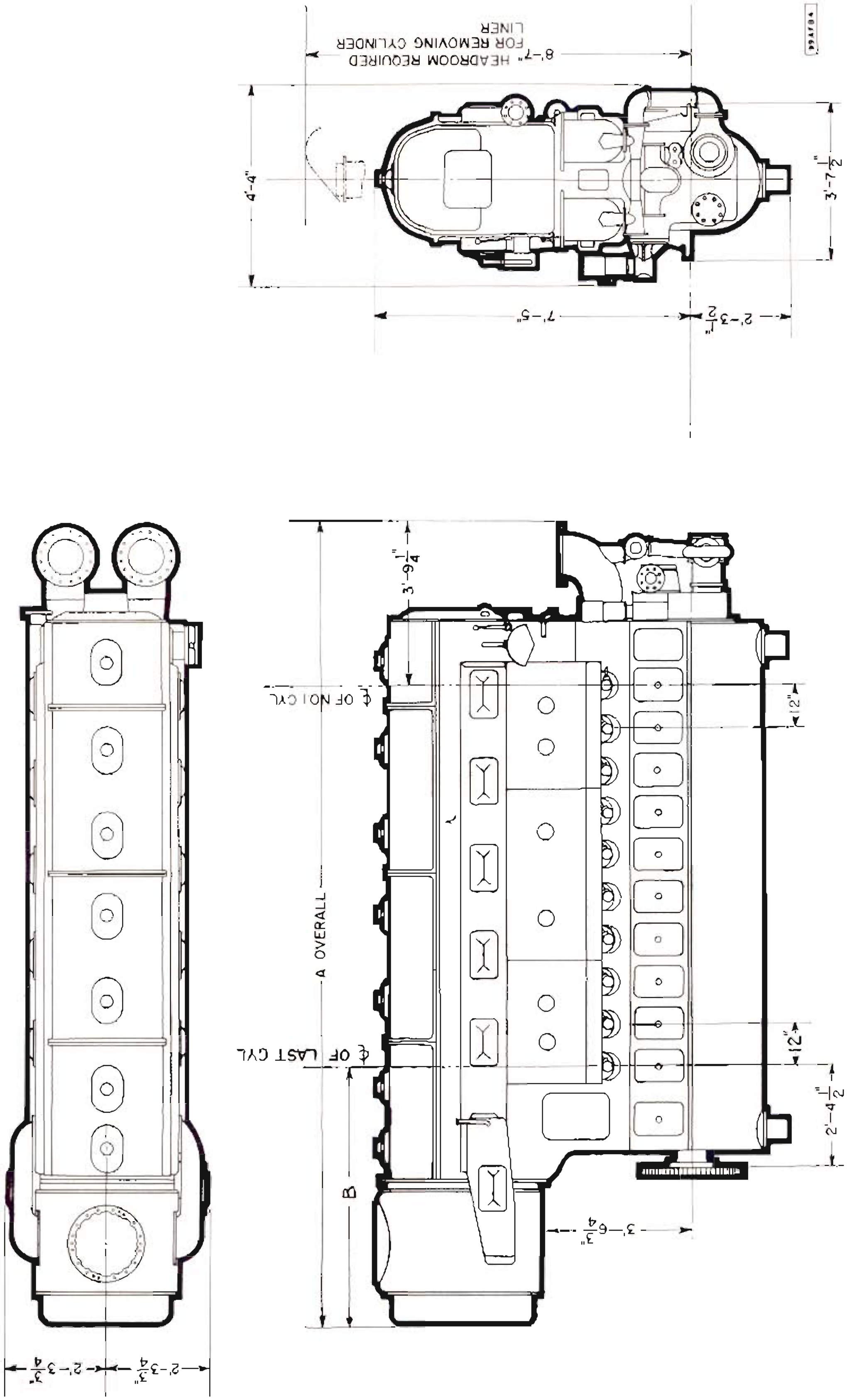
Pictured above is the large modern plant especially designed and built for efficient, streamlined production of the opposed-piston Diesel engines. Here, modern manufacturing methods and facilities plus precision workmanship with the highest grade materials combine to make the "OP" an engine highly dependable in all types of service.

Shown below is an aerial view of the vast Fairbanks-Morse factories at Beloit, Wis. of which the "OP" building is an important part.

Facilities and Service

The Model 38 Opposed-Piston Diesel Engine is built by a company having over forty years experience in the highly specialized field of engine design and construction.

Service facilities are immediately available from the many conveniently located Fairbanks-Morse branches.



Dimensions for Opposed-Piston Engines

No. Cyls.	A	B
5	13' 1-3/16"	5' 3-15/16"
6	14' 1-3/16"	5' 3-15/16"
8	16' 7-3/16"	5' 9-15/16"
9	17' 10-3/16"	6' 0-15/16"
10	18' 10-3/16"	6' 0-15/16"

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All specifications herein are subject to variations in design and construction, except such as would substantially affect installation or matters of performance otherwise expressly guaranteed.

Fairbanks-Morse

Diesels

for

Marine, Stationary and Locomotive Application

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