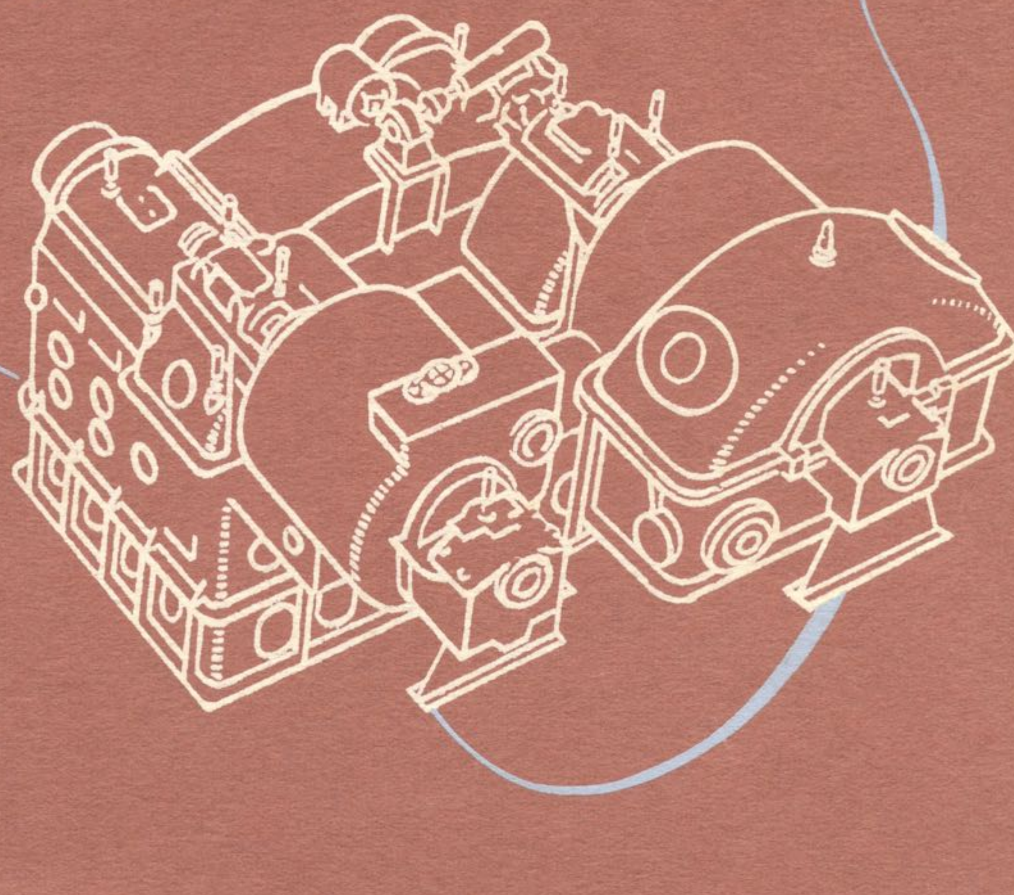
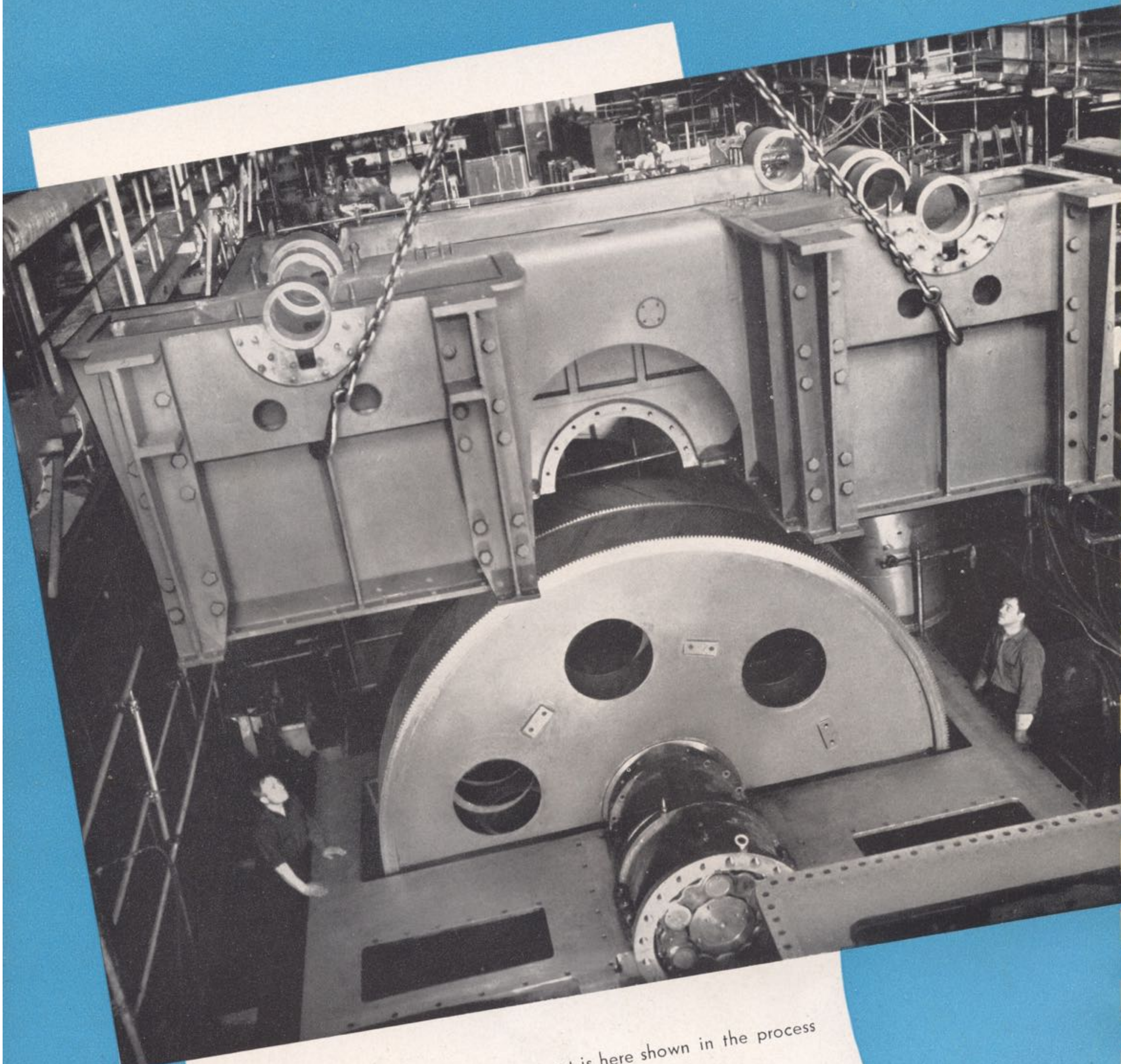
MARINE GEARED-TURBINES

for ship propulsion



ALTHOUGH this booklet describes marine *geared-turbine* propulsion units only, the General Electric Company also manufactures *turbine-electric* and *diesel-electric* propulsion equipment. In addition, General Electric manufactures marine auxiliary and operating equipment, such as switchboards, turbine-generators, cable, motors, controls, searchlights, and other apparatus for ships of all classes.



A G-E double-reduction-gear set is here shown in the process of being assembled for testing.

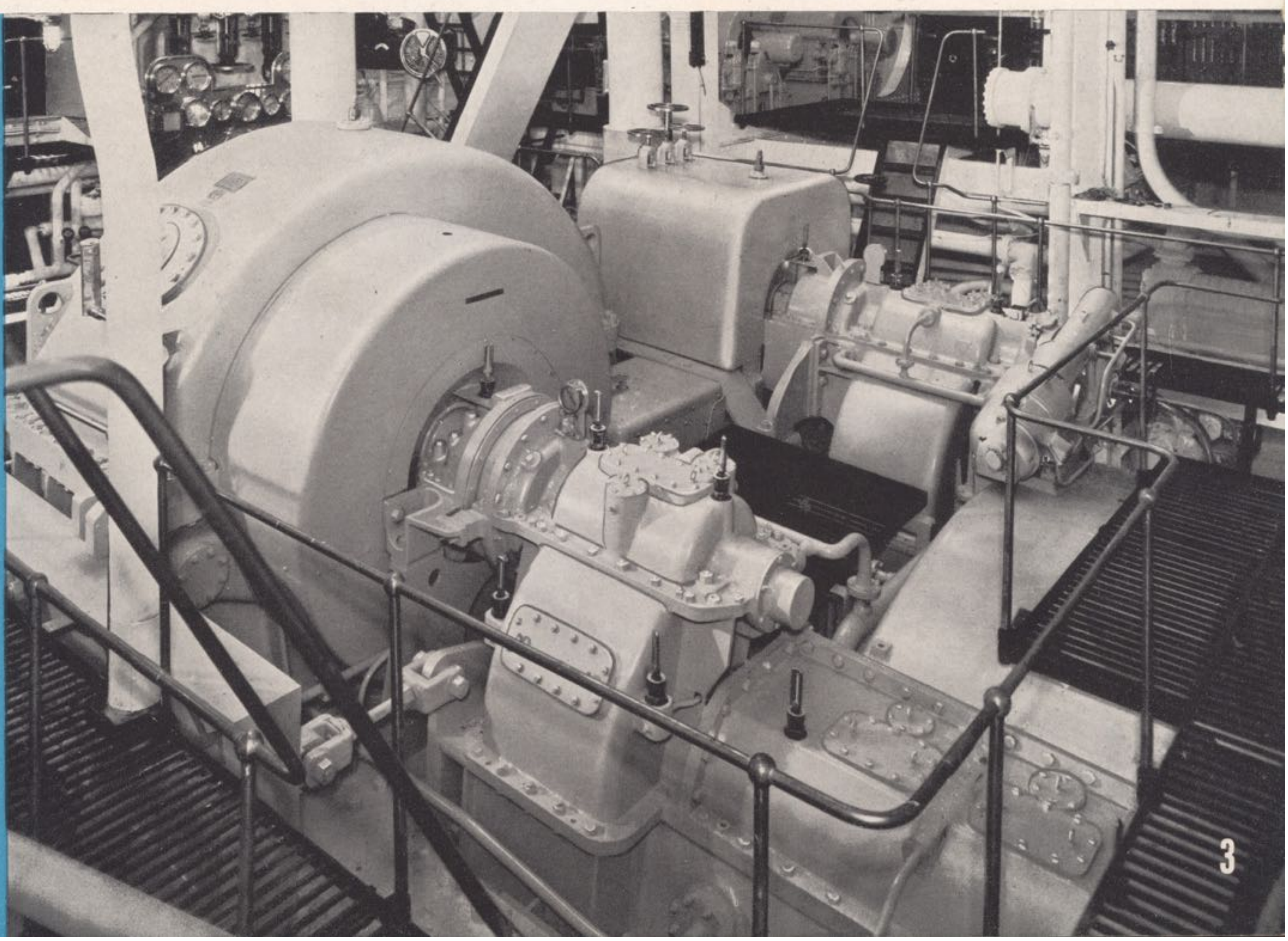
The General Electric geared-turbine unit is simple in design, is compact, thoroughly dependable, and long-lived. Reliability—a prime consideration in any service—is of especial importance in the propulsion of vessels; and G-E turbines and gears are built to the precision of fine clockwork.

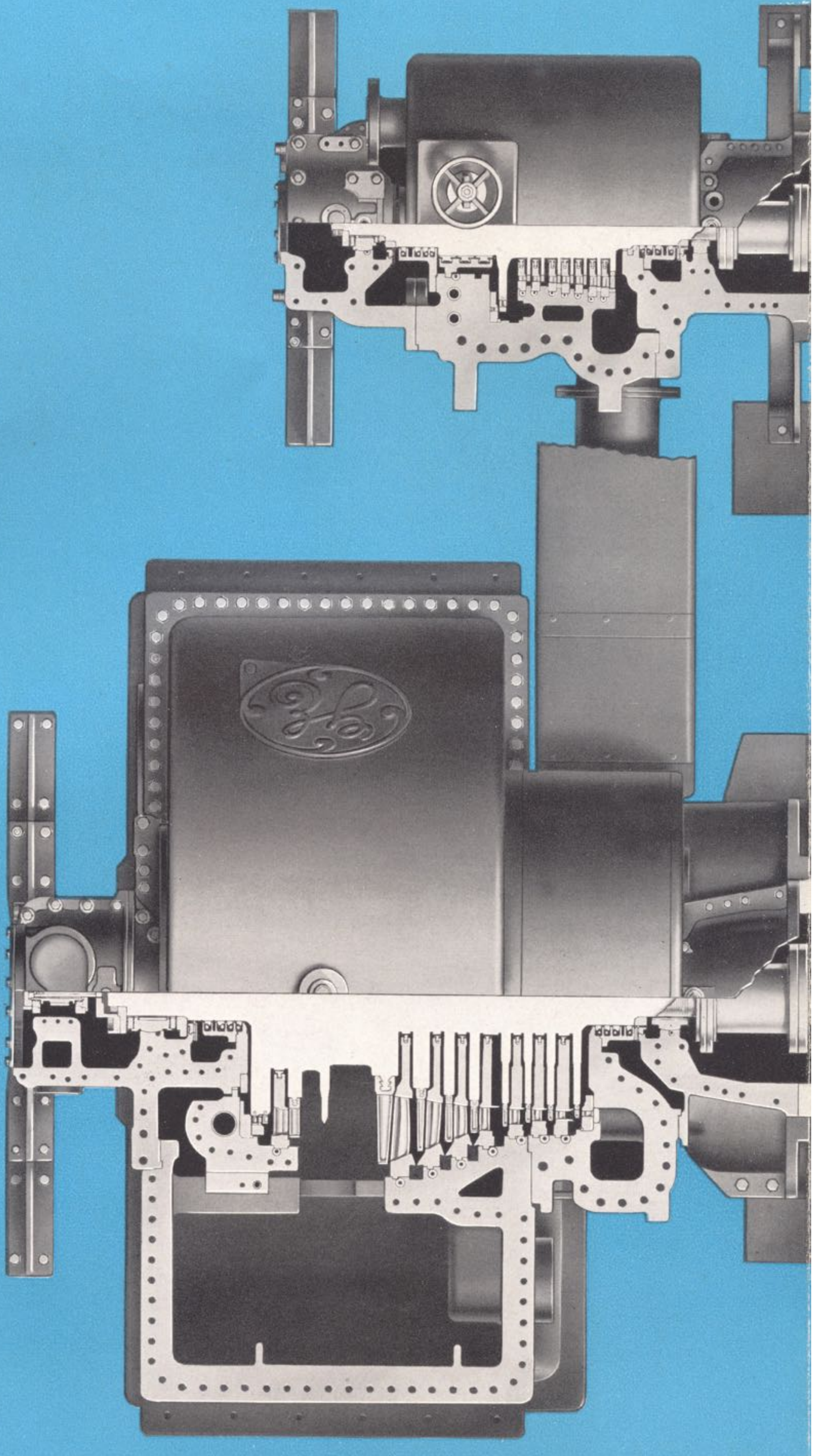
LET'S TAKE A TRIP through the shops in which General Electric marine steam turbines and gears are made.

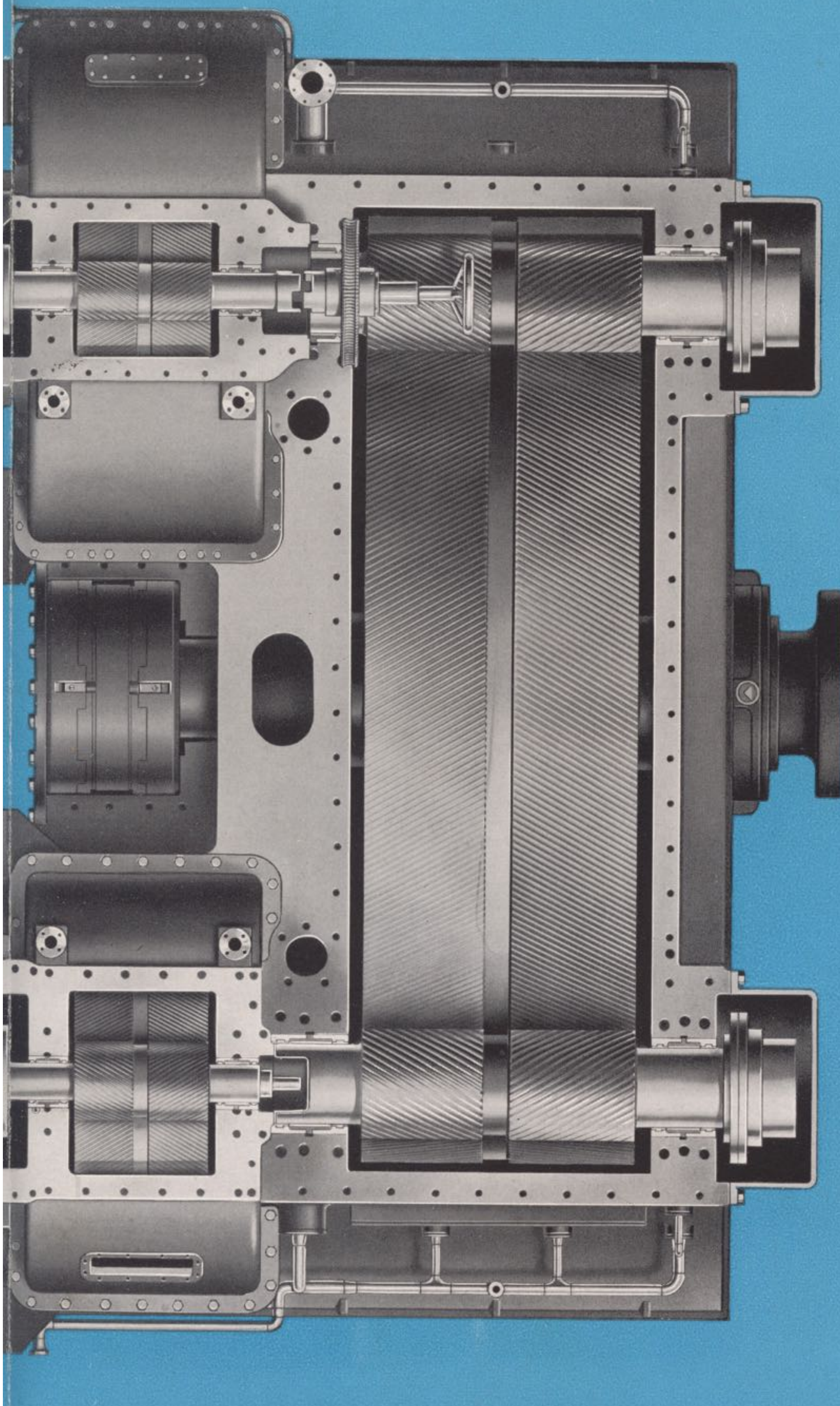
In these few pages you will see pictured some of the manufacturing operations, the modern, accurate machinery, and testing. And, finally, typical installations of G-E geared-turbine units for ship propulsion. The descriptions and illustrations included in this booklet are presented so that you may know more about the excellence of design and other advantages of G-E marine geared-turbines. They show units that are now in service or under construction, not merely engineering proposals. It is not intended that they show the specific designs of the sets.

For more than 30 years General Electric has been manufacturing marine steam turbines, and for more than 25 years has made marine reduction gears. Many propulsion sets of G-E manufacture have made such outstanding performance records that they have established new efficiency standards.

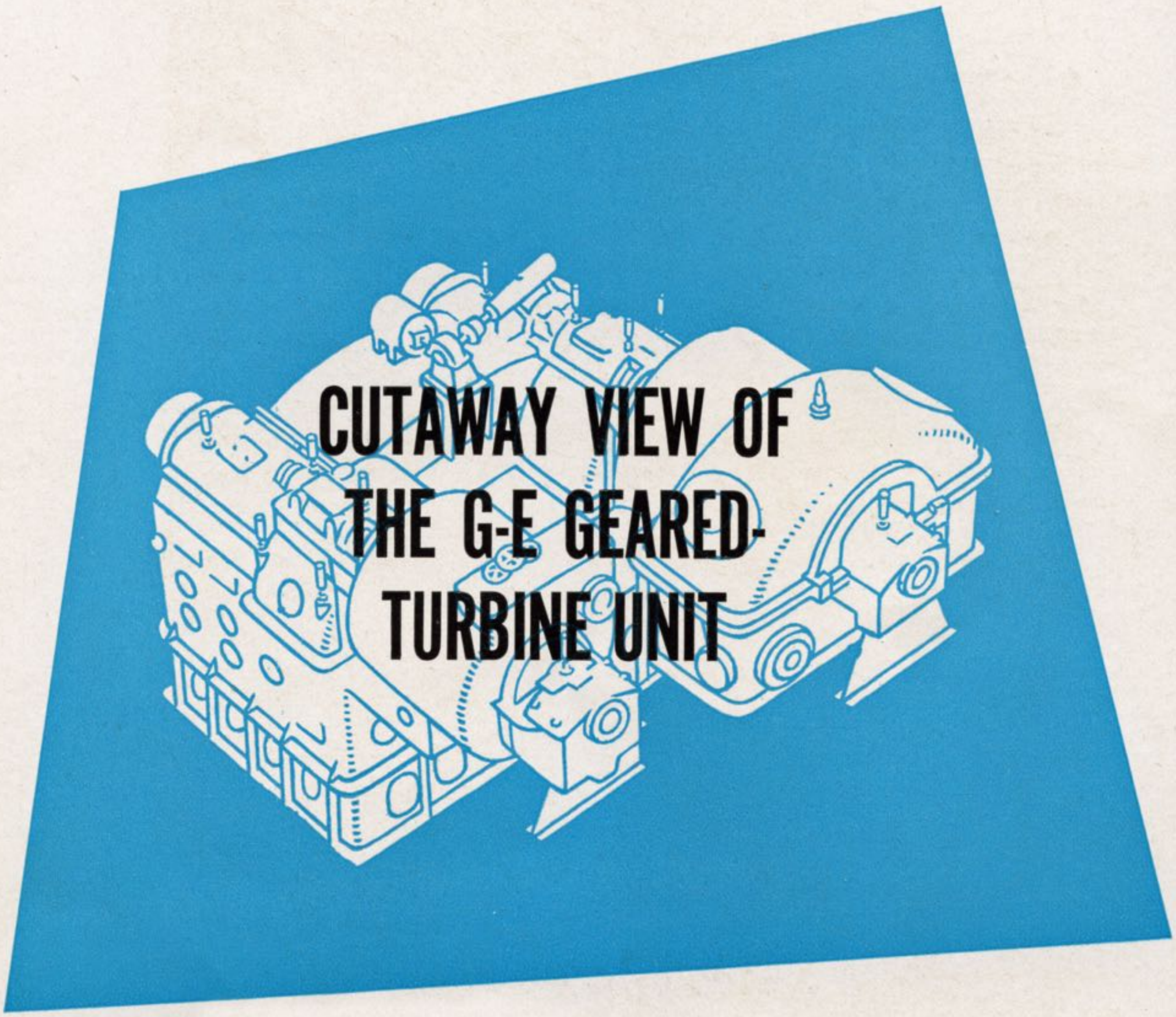
Vast and diversified experience, combined with remarkable manufacturing equipment enables General Electric to continue to produce turbines and gear units that give our merchant marine and naval vessels the greatest reliability and highest over-all economy of operation, together with outstanding performance.







CUTAWAY VIEW OF THE G-E GEARED-TURBINE UNIT



THE GEARED-TURBINE UNIT

THE General Electric geared-turbine propulsion set is a unit of high over-all efficiency and economy. As shown at the left, it consists of a high-pressure turbine (lower) and a low-pressure turbine (upper), both of which are connected to the propeller shaft through a double-reduction gear. When steam flows through two turbines arranged in this manner, the set is known as the cross-compound type. The G-E reduction gear is so arranged that it transmits high-speed turbine power efficiently to the relatively slow-turning propeller. These turbines and reduction gear form a compact, lightweight unit that lends itself well to marine propulsion application.

Steam from the boiler enters the steam chest of the high-pressure turbine. Then it goes through the first-stage nozzles where a large portion of its energy is transformed into velocity and directed at the proper angle against the first-stage buckets of the rotor. This supplies an impelling force to the buckets. In the impulse type of turbine the steam leaves the buckets at the same pressure at which it entered, and goes into the second-stage nozzle, or diaphragm, where the process is repeated for that stage. It continues a similar path through the rest of the turbine and gives up a part of its available heat energy to mechanical energy in each stage.

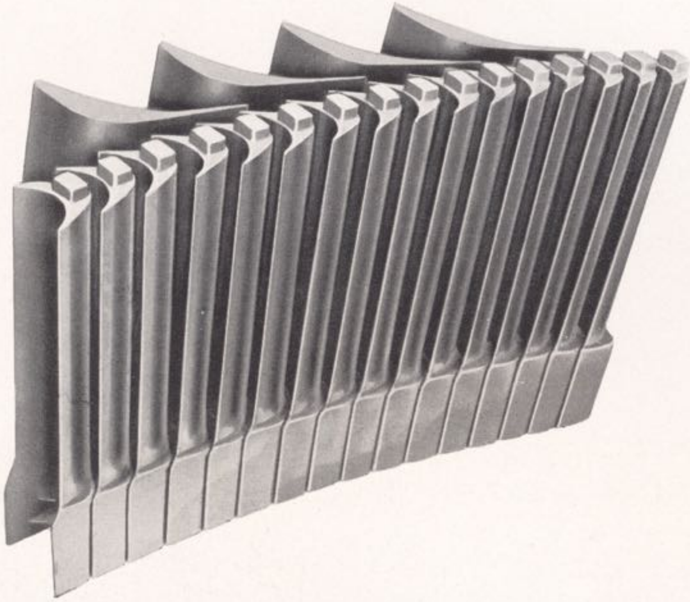
The steam exhaust from the high-pressure turbine is piped through a cross-over connection to the ahead end of the low-pressure turbine where additional energy is derived as it rushes from stage to stage. It exhausts directly into the condenser.

Now that we have a general picture of the plan and purpose of the G-E geared-turbine unit, we'll start our trip into the shops.

First, let's look in the turbine shop...

THE TURBINES

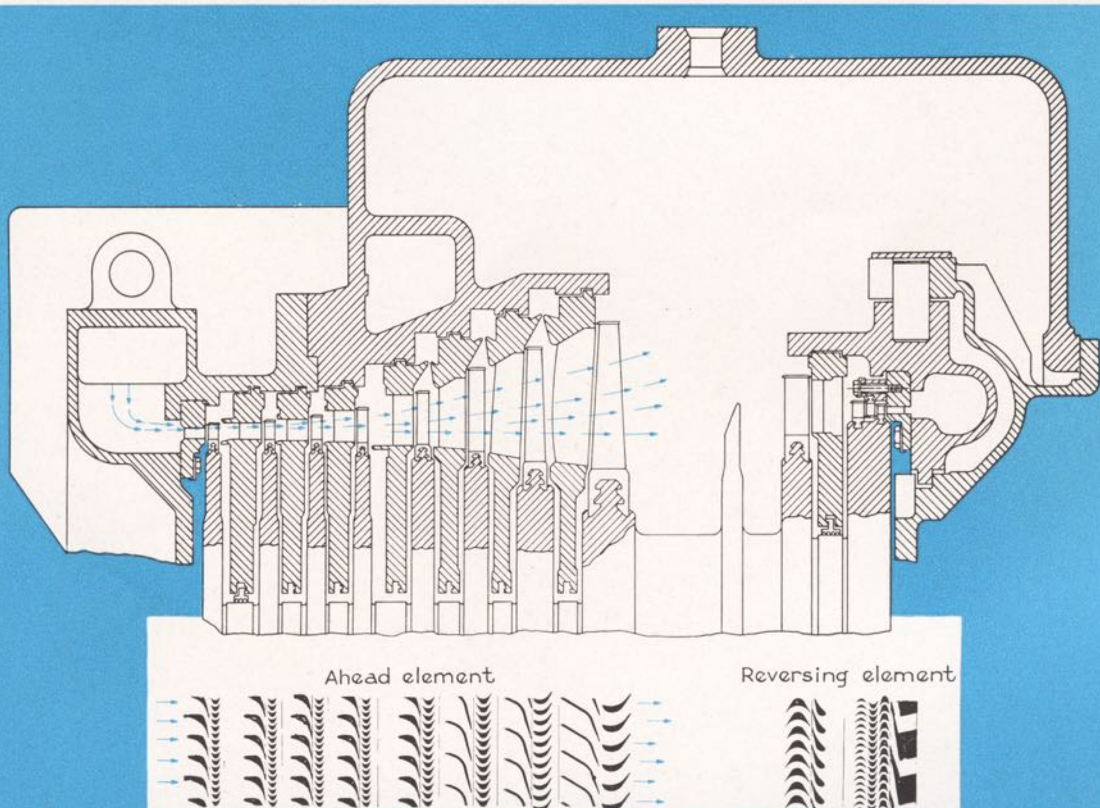
The G-E cross-compound marine turbine set consists of a high-pressure and a low-pressure element, each enclosed in a separate casing and connected by means of a cross-over pipe. Steam can be either admitted or exhausted at the cross-over for emergency operation; thus, propulsion can be continued even with one turbine out of service.



The turbines are of the solid-rotor, impulse type and meet the requirements of the American Bureau of Shipping and the U.S. Coast Guard, Vessels Inspection Section. The impulse turbine has inherently large clearances around the rotating parts and is practically free from end thrust.

The reversing element is included in the low-pressure turbine only. The reversing stages are like the stages which drive the ship ahead, except that when steam is admitted into the reversing element, all rotating parts of the geared-turbine unit are rotated in the opposite direction.

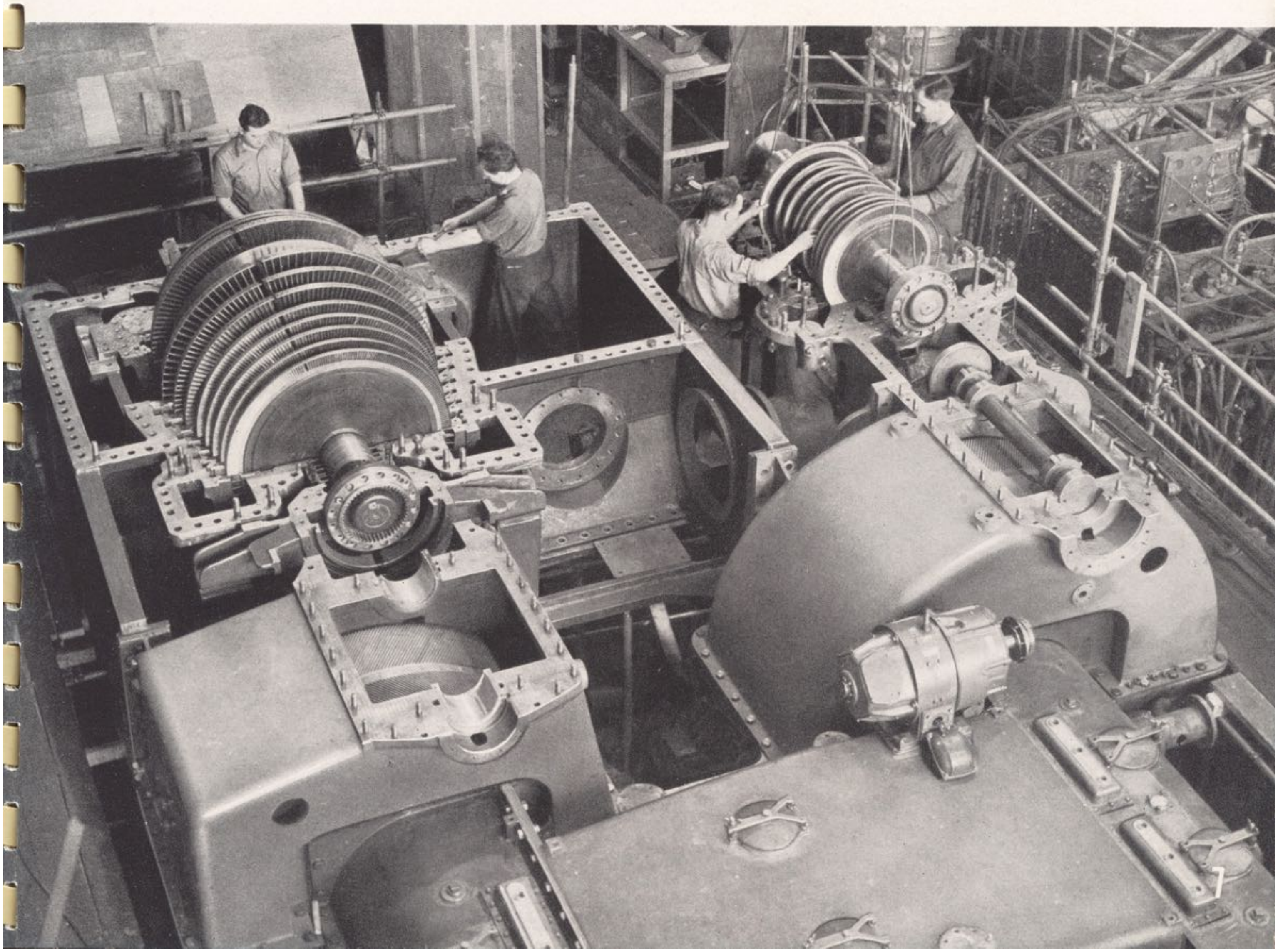
The diagram below illustrates how steam flows through the low-pressure turbine.

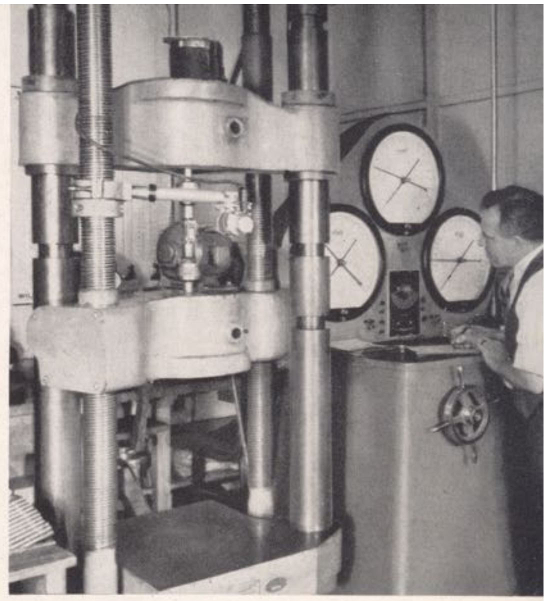


THE ROTOR

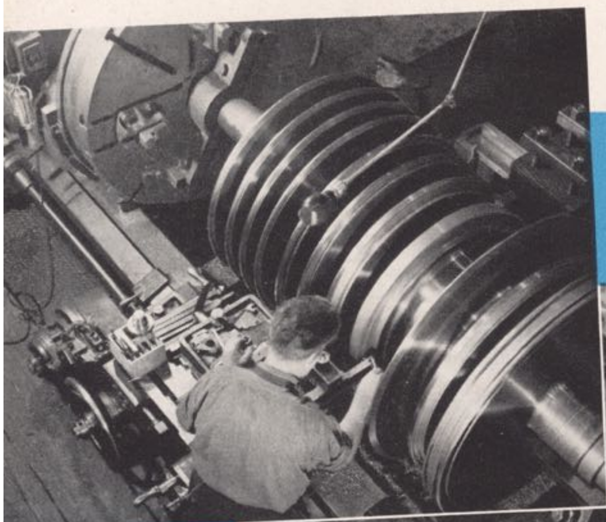
Since the mechanical power of the turbine originates in the rotor, the rotor is one of the most vital parts. It must be of the proper design for a given job. A marine turbine rotor is machined from a special solid-steel forging; the resulting solid rotor—shaft and wheels—is of one piece. A finished solid rotor for the low-pressure turbine of an 8500-horsepower unit may weigh, with its buckets, approximately 12,000 pounds.

Years of experience and many tests have proved what the best materials and forms are, and General Electric research and design engineers have set up standards that are maintained by constant inspection. Chemical samples are taken from every melting, and physical samples are cut from every forging. Our laboratory checks these samples very thoroughly and impartially. In this way we make sure that each forging used meets our rigid requirements.



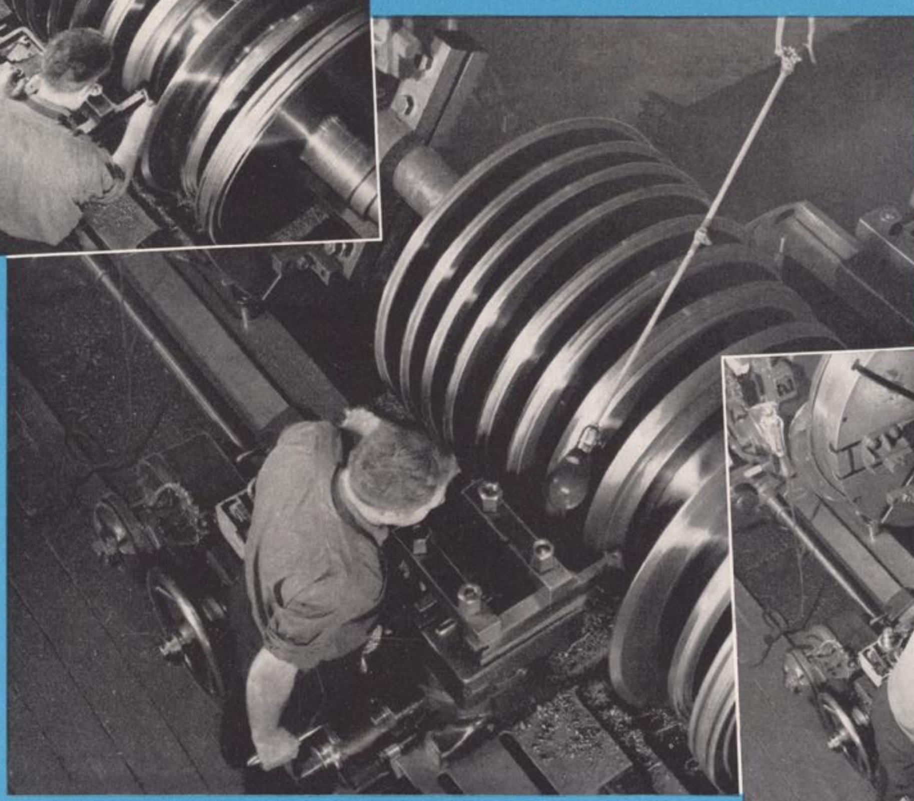


A sample for testing has been cut from the forging shown at left. It will be tested for the proper metallurgical characteristics in one of the machines in a G-E laboratory. The operator at right is checking the tensile strength, yield point, and elongation of an accurately machined sample.

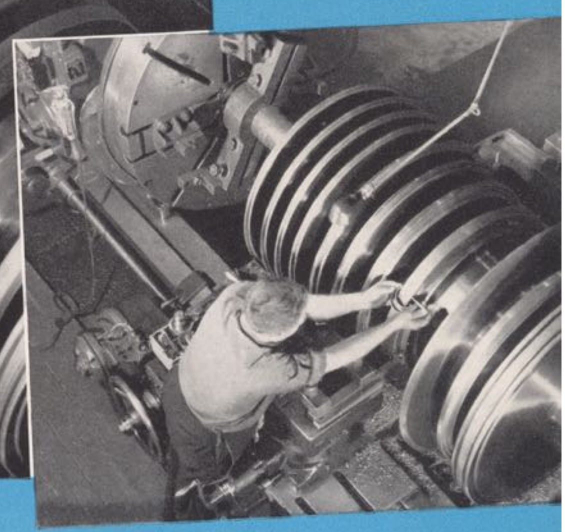


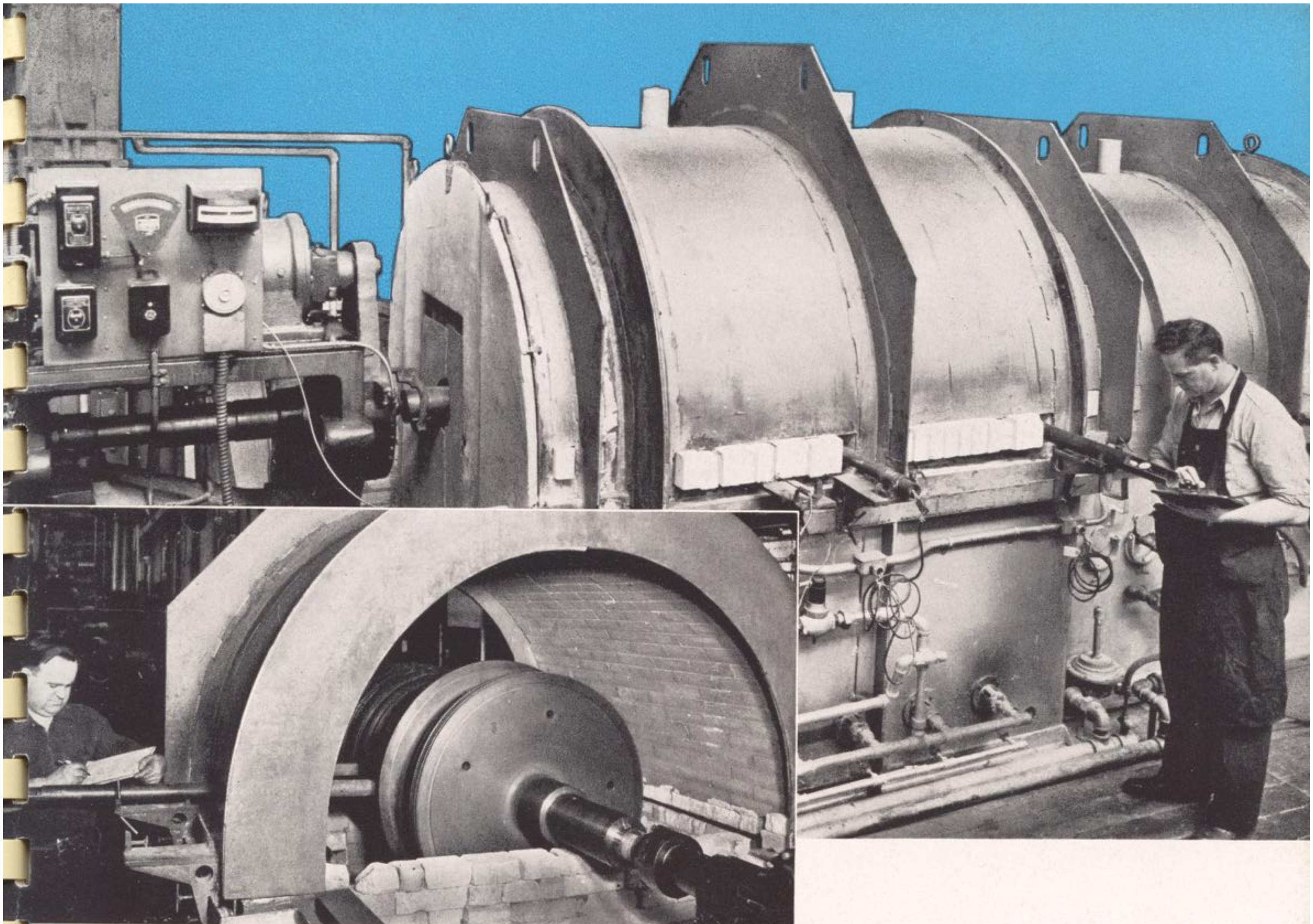
(Left) The operator is setting a tool for machining dovetails on a low-pressure marine turbine rotor.

(Below) The actual cutting operation of machining the dovetails is in progress.



Accuracy of the cut is important, and the operator measures carefully each dovetail.



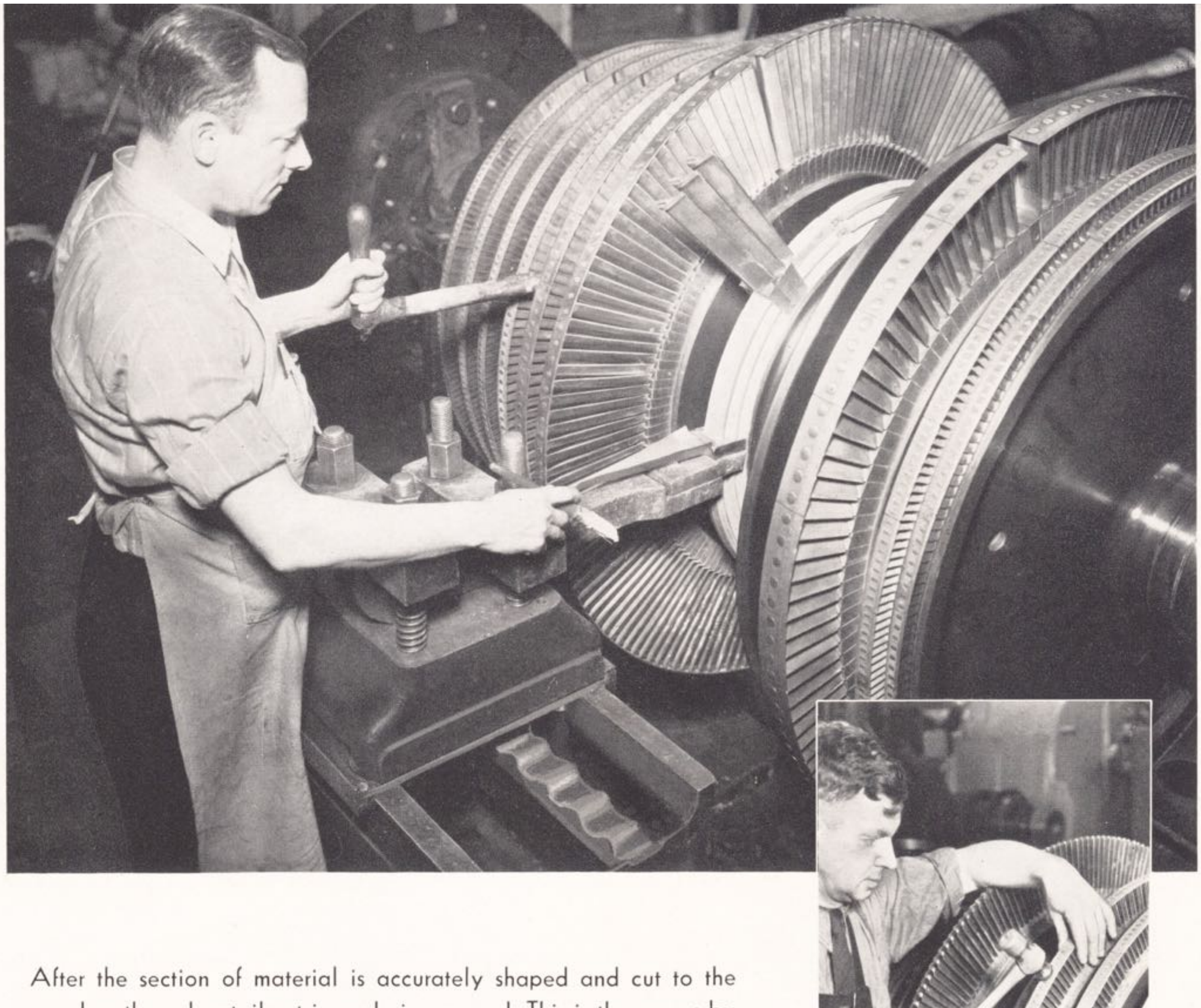


After the rotor is machined on a lathe, it is inspected, and then finished with an accurate dovetail for the securing of the buckets along the outer rim of each wheel. These dovetails provide a firm fastening for the buckets—it is a construction that assures the inherent dependability of this important part.

Of special interest is the heat test, which is applied to every shaft before bucket assembly. In this test each shaft is rotated slowly in an oven that is maintained at a temperature well above the temperature to which it will be subjected during operation. Every shaft is required to run true at both high temperatures (above, right) and low temperatures (above, left) to assure its running true in service.

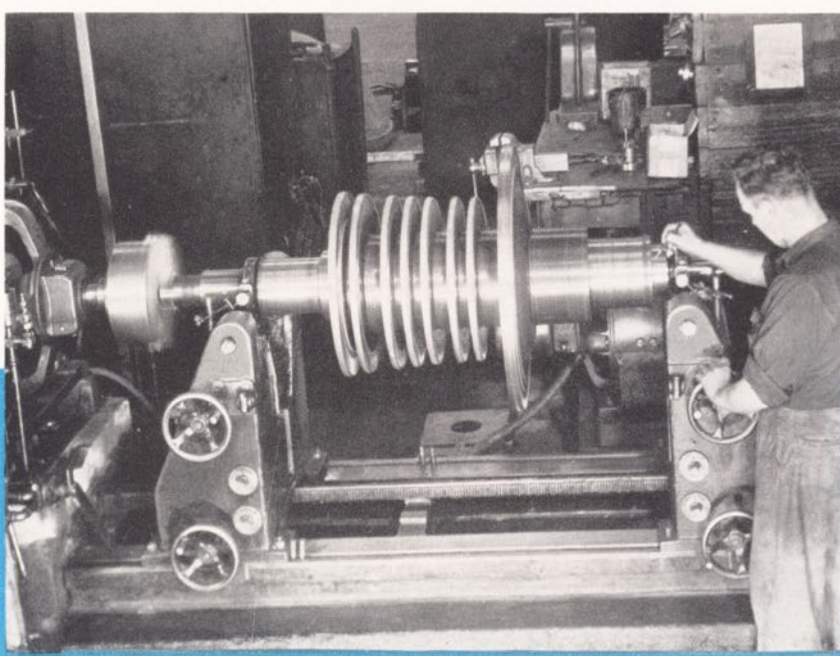
THE BUCKETS

The material from which the buckets are made is selected for its high quality and its resistance to erosion and corrosion. The buckets are accurately shaped sections that are either forged or milled from solid bar stock. Their shape, size, and weight—their strength against centrifugal stresses and bending forces of the steam, and that they have the proper vibrational characteristics—are determining factors in the performance of the turbine. This is why General Electric takes such care in the accuracy of their manufacture.



After the section of material is accurately shaped and cut to the proper length, a dovetail cut is made in one end. This is the means by which buckets are fastened to the rotor wheel. They are then smoothly finished. Inspectors gage and check the dovetail of each turbine bucket. They must be accurate, and the skilled operators take pride in maintaining close tolerances.

Assembly of the buckets on the wheels is accomplished by the use of special bucketing machines, such as the one above.



The rotor is completed by enclosing the steam passages of each wheel by a shroud band, which is hand-riveted to the tips of the buckets. Each complete rotor is then dynamically balanced. Rotor balancing is pictured at the left.

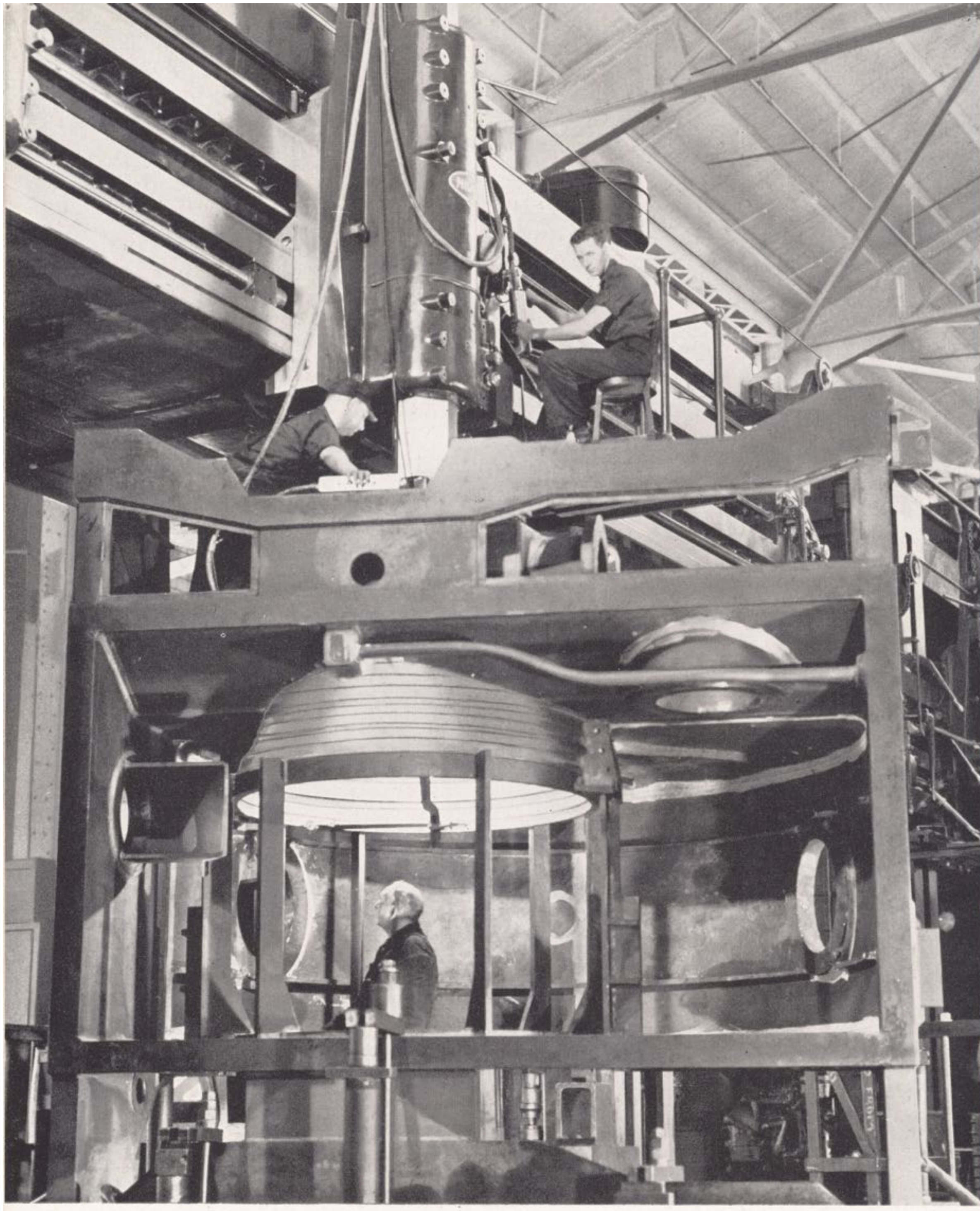
THE CASING

The turbine casings are necessarily strong and rigid to be able to withstand pressures and temperatures that are often high and are subject to wide variation. Materials are carefully selected for the temperatures involved, and the pattern work and foundry practice are highly specialized. Steam chests are cast integrally with the high-pressure section of the turbine casings. The liberal use of webs and fillets adds to the strength and soundness of the castings.

In the photograph above you see the preparation of a casting for the initial machining operation. Castings are cast with generous risers that allow foreign material and air pockets to float above the part intended for the casing. This metal is cut off (as shown above), leaving a solid casting that is free from defects and impurities.

Accurate machining provides steamtight joints for the diaphragms, valve seats, casing flanges, and other parts. The casing is split at the horizontal center plane, and joints are metal-to-metal. Casing joints are maintained steamtight by this metal-to-metal seal, which is secured by means of heavy flanges and flange bolts.

Properly designed supports which hold the casing in rigid alignment allow free expansion and contraction with changes in temperature.



MACHINING THE CASING

This photograph shows a fabricated lower half of a low-pressure turbine casing standing on end in a huge boring mill. One machining operation has already been completed.

The operator (in the foreground), looking into the cone-shaped section into which the diaphragms will be secured later, is observing an indicator that is attached to the vertical ram of the boring mill. It shows when the casing is properly aligned on the table for making an accurate cut on the shaft opening. This cut will be made at the upper end of the casing, as the casing appears here.

This 20-foot boring mill maintains such accuracy in machining that close tolerances are assured.

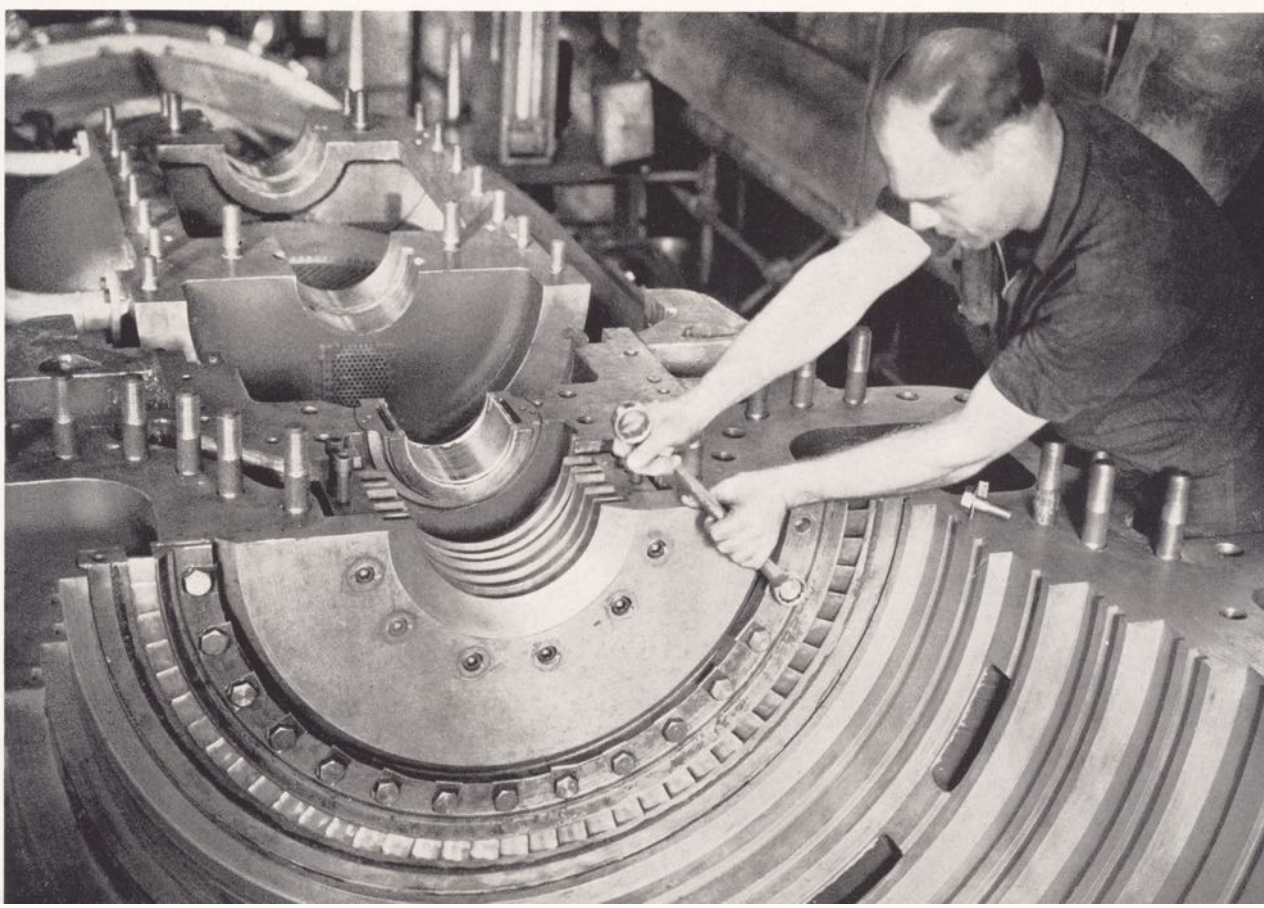
NOZZLES AND DIAPHRAGMS

Here we see the fabrication of a diaphragm. The G-E method of assembly provides accuracy to the steam passages and strength to their supporting structures.

Nozzle partitions, machined to the correct shapes from corrosion-resistant materials, are accurately spaced and are arc-welded to the inner and outer bands. This assembly is welded to an outer ring and an inner web.

In the low-pressure stages, where the volume of steam is large, diaphragms with cast-in nozzle partitions are used. Annealing and machining complete the diaphragm.

Where the shaft passes through the center of each diaphragm, a steam seal is provided by labyrinth packing. Moisture separators are part of the diaphragms of the low-pressure turbine in the stages where condensate may be expected. The first-stage nozzle plate is shown being bolted into the lower half of a low-pressure turbine casing. Individual lock washers are provided for each bolt to assure reliability. Diaphragms (which contain the nozzles for all the stages except the first) are of similar construction except in their manner of support. They are supported at the center line so that expansion will be away from the shaft—thus maintaining the accuracy of packing clearances. Proper axial clearances assure the correct position of the diaphragms in relation to the rotating element.



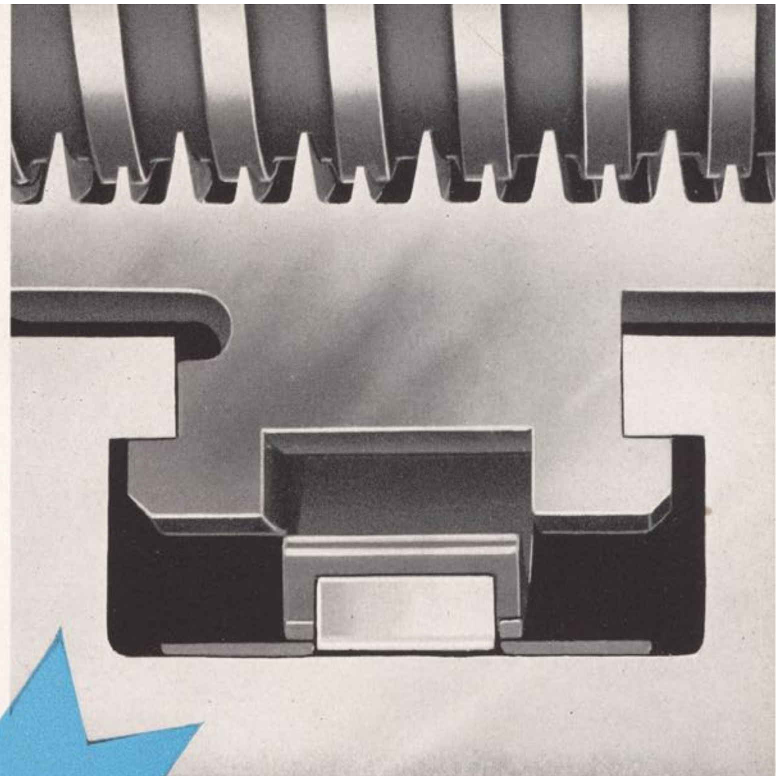
BEARINGS

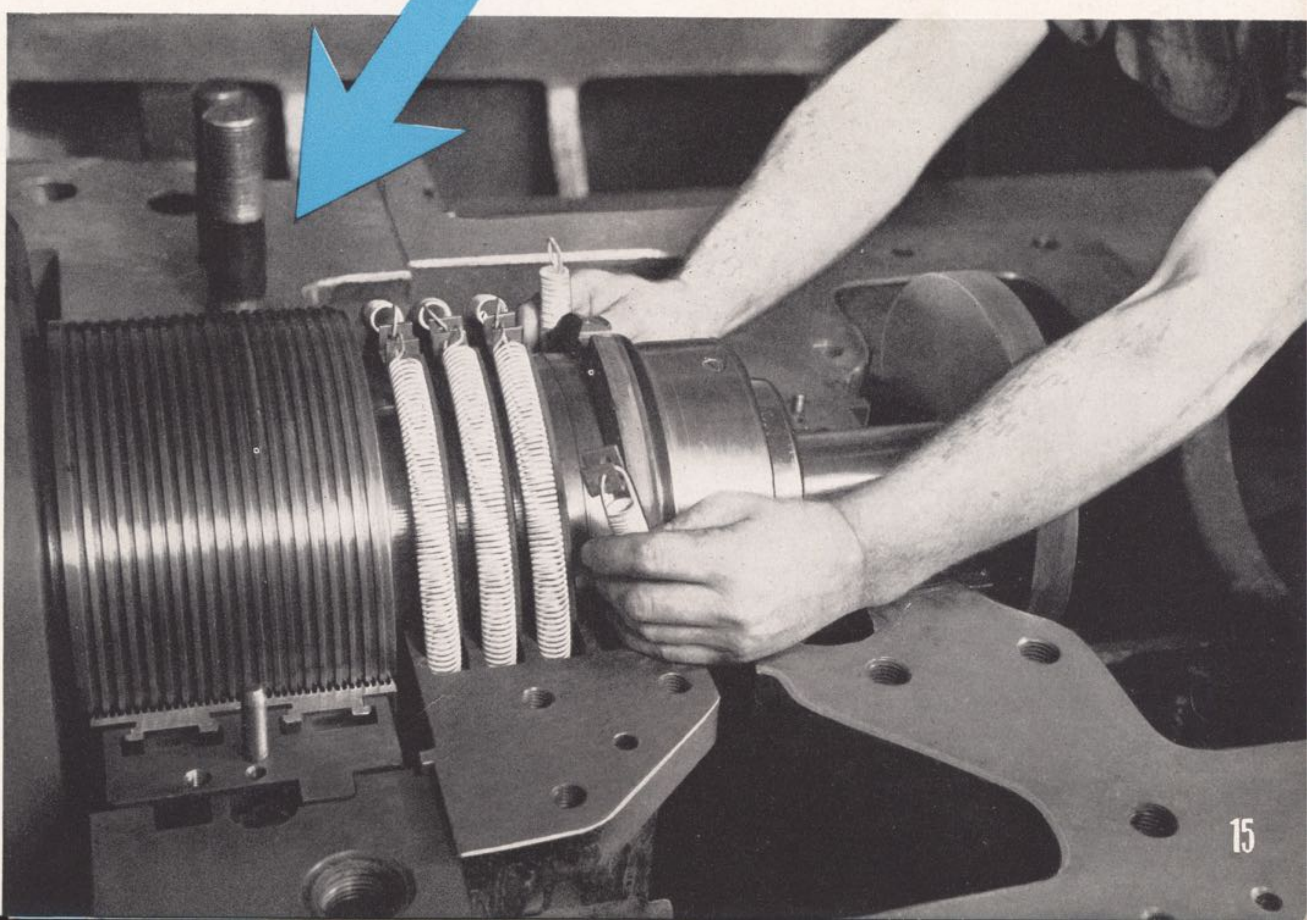
The designs of the main and thrust bearings are based on engineering and research, and actual operating experience. The spherical-seated, self-aligning main bearings are pressure lubricated from the ship's lubrication system. Proper grooving of the babbitt lining assures an oil film, and allows a liberal flow of oil for cooling.

The axial position of the turbine rotor is maintained by means of a simple, yet effective "tapered-land" thrust bearing. The faces of the plates are so tapered that oil is continually trapped and forced between the bearing surfaces. The photograph above shows one half of the high-pressure turbine thrust-bearing plate being installed.

PACKING

Where the shaft passes through the casing, steam-sealed, spring-supported, hi-low-tooth labyrinth and carbon packings minimize steam leakage. Where vacuum conditions exist in the turbines, these packings prevent the entrance of air. Packing rings, whether metallic or carbon, are divided into segments for easy inspection. They provide dependable close-running seals.

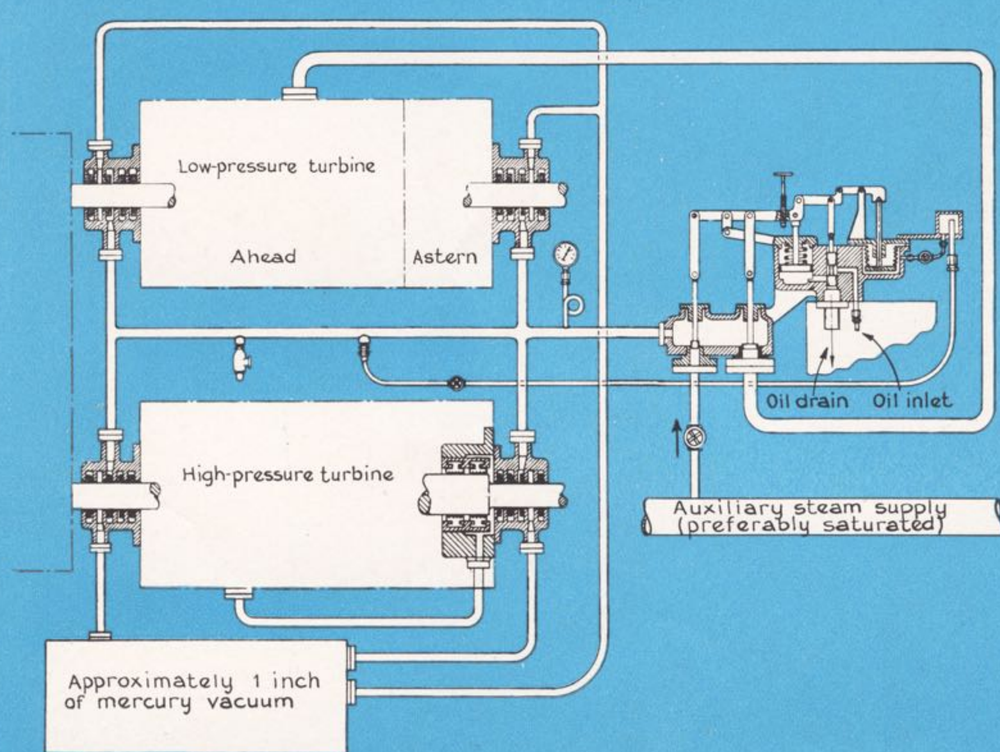




STEAM SEAL REGULATOR

Means must be provided to prevent the escape of steam or the entrance of air wherever a shaft extends through a casing. There are four shaft seals—one on each end of each turbine. The purpose of the steam seal regulator is to maintain, automatically, the proper seal on a shaft (even under changing conditions) by keeping the proper steam pressure on the inner cell of each of the shaft seals. Pressure must be maintained high enough to prevent the leakage of air along the shaft into the turbine casing, and low enough to keep the small amount of nuisance (escaping) steam from getting into the turbine room. Just inside the turbine the pressure may be either above or below atmospheric pressure, according to its location and the load being carried.

It can be seen from the diagram below that a simple, effective seal is maintained by having the steam seal regulator either add the necessary steam or by-pass the excess steam back into a lower stage of the low-pressure turbine in order to maintain a pressure of, say, 2 pounds gage on the inner cells of all the seals. Since the outer cell is connected to a vacuum, the 2-pound steam leaks into this cell from the turbine side, and air leaks toward it from the atmospheric side. Thus, the desired result is achieved—steam does not leak into the room, nor does air get into the steam system.



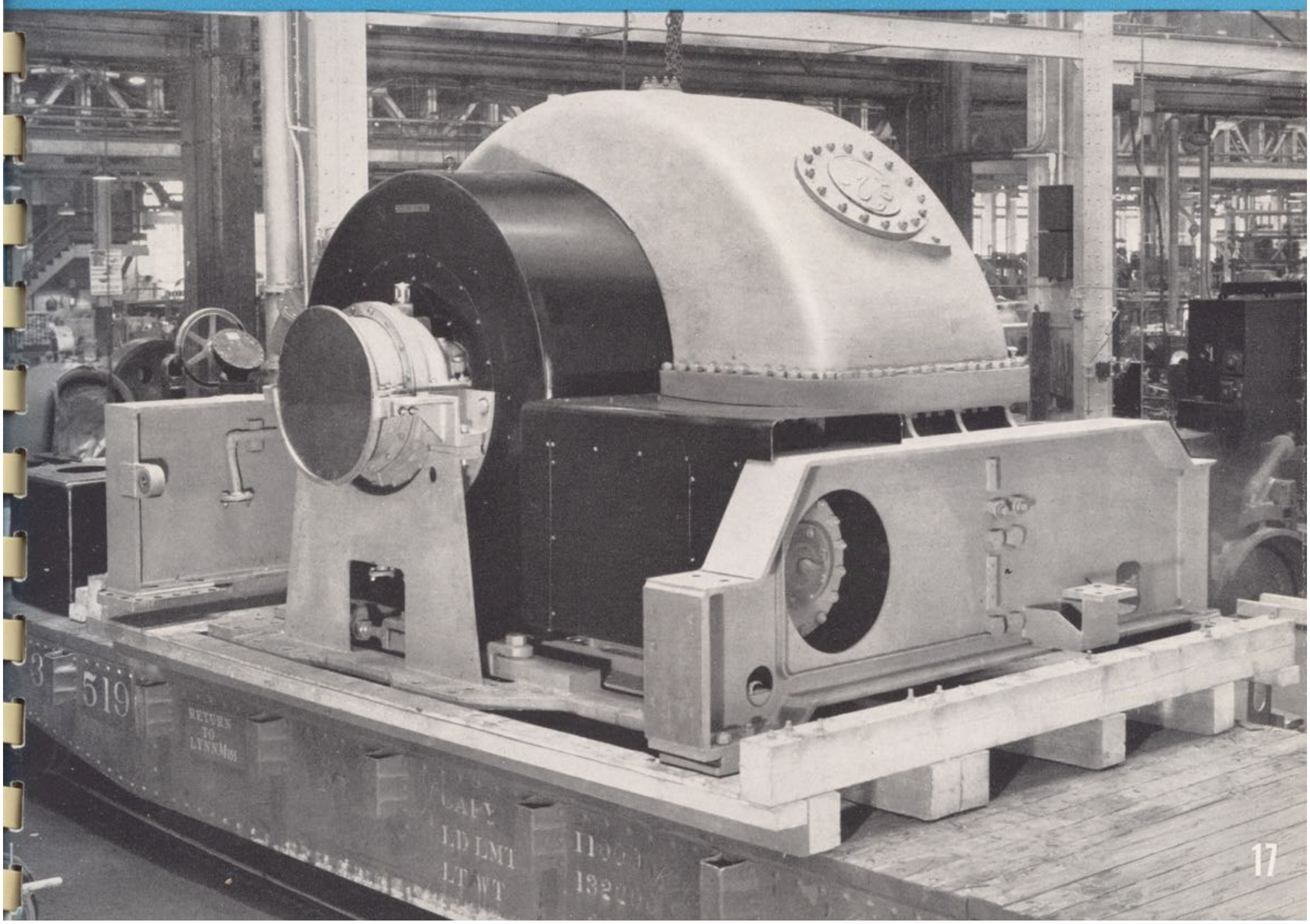
LAGGING

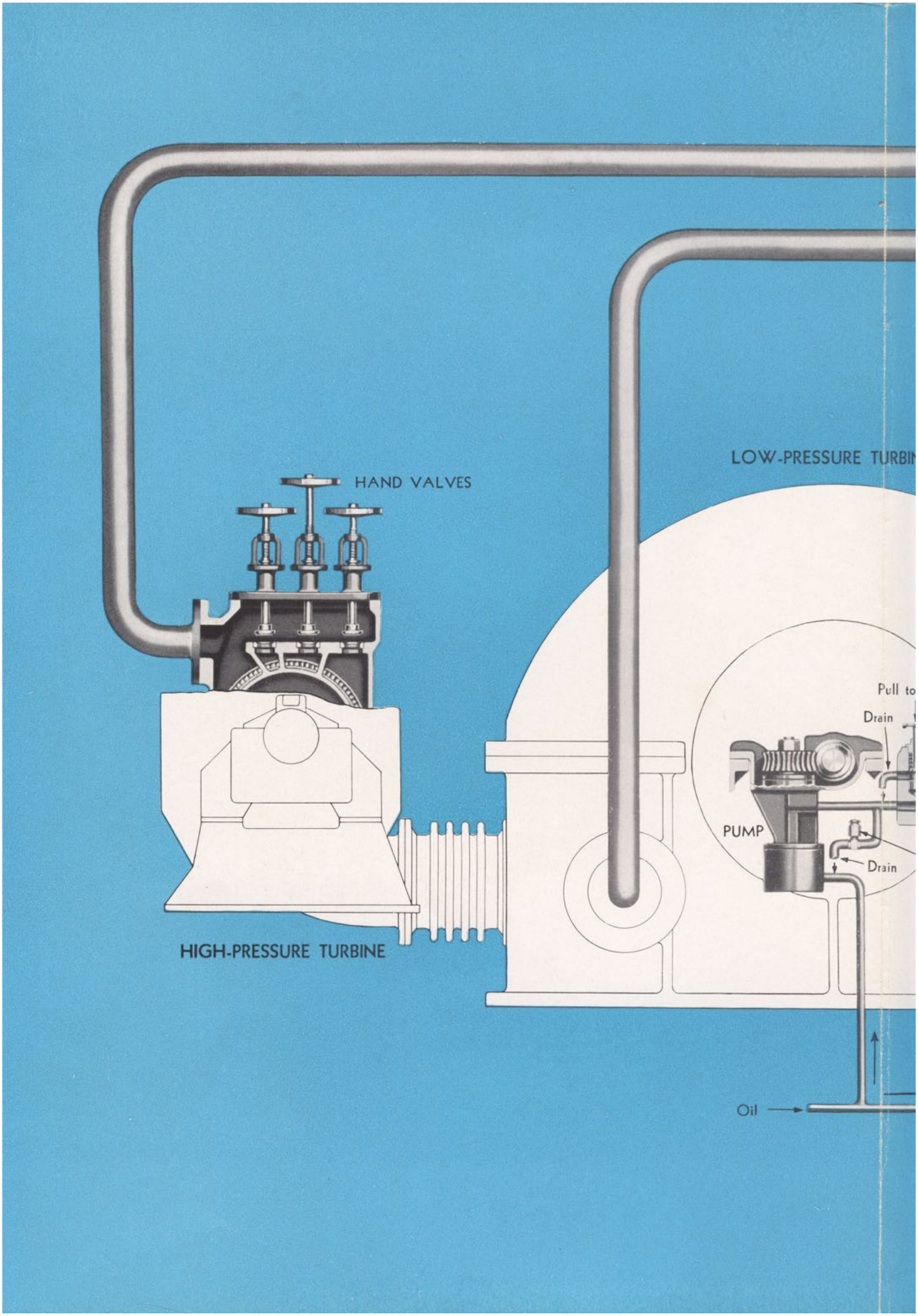
On the railroad car below is a low-pressure turbine with its lagging in place. The lagging is rolled and fabricated from steel plates. It protects the heat-retention insulation of the turbine and contributes to the uniform and attractive appearance of the unit.

It is of heavy, reinforced construction, is durable, and can be handled easily. It can be removed and reassembled without its becoming distorted or suffering damage to its fit. The lagging is shot-blasted before it is finished so that it will match the appearance of the exhaust casing. This surface is especially suited for a tight-bond adherence of the finish to the metal.

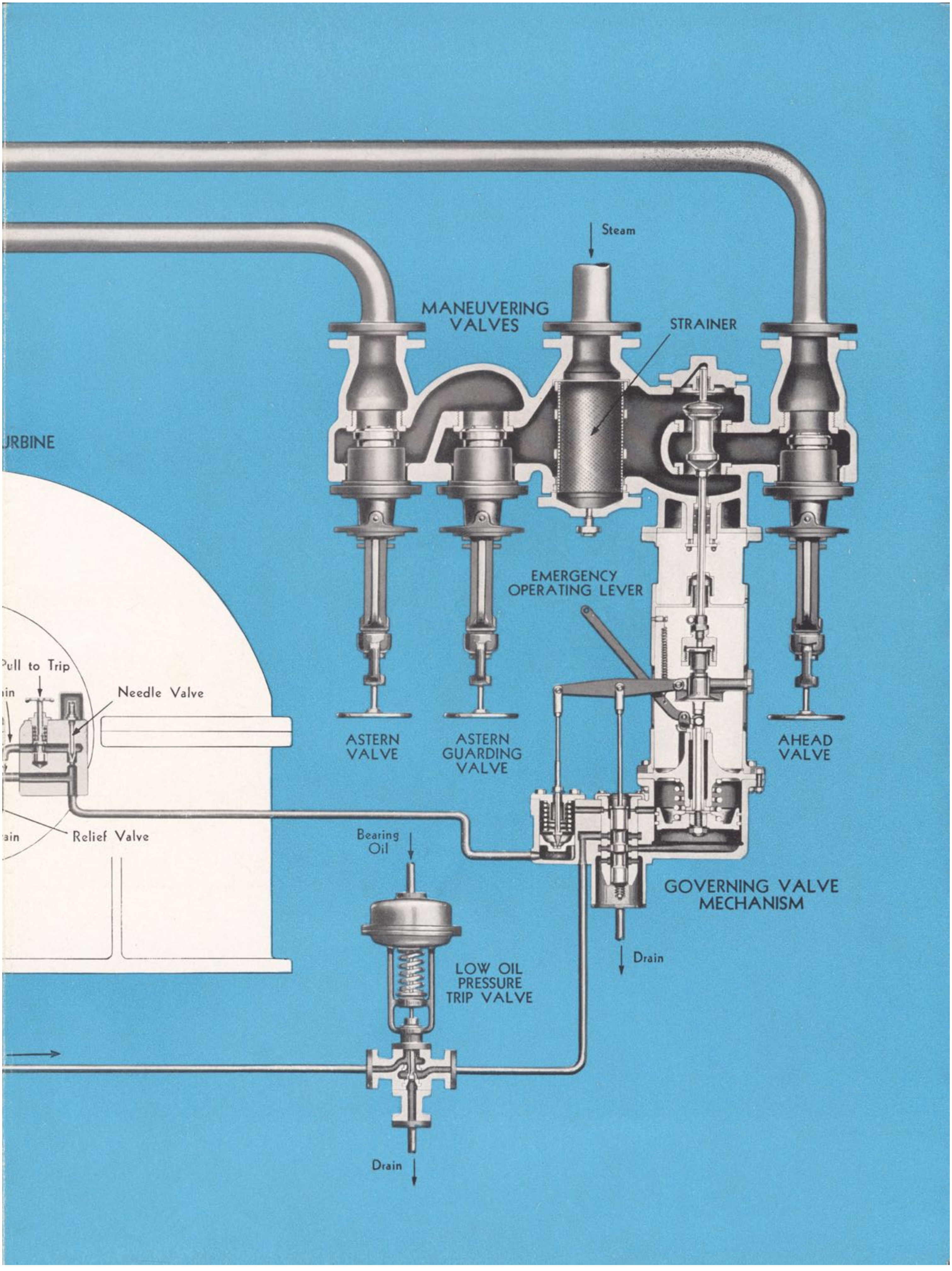
FLEXIBLE SUPPORT

The picture below shows the flexibly-supported high-pressure end of a low-pressure turbine. The flexible support is the vertical steel plate below the high-pressure-end bearing. This construction is rigid to forces transverse to the axis of the shaft, but, with the turbine rigidly supported at the low-pressure end, it allows the unit to expand fore and aft.





HAND VALVES
LOW-PRESSURE TURBIN
Pull to
Drain
PUMP
Drain
HIGH-PRESSURE TURBINE
Oil


Steam
MANEUVERING VALVES
STRAINER
URBINE
EMERGENCY OPERATING LEVER
Pull to Trip
Needle Valve
ASTERN VALVE
ASTERN GUARDING VALVE
AHEAD VALVE
Relief Valve
Bearing Oil
GOVERNING VALVE MECHANISM
Drain
LOW OIL PRESSURE TRIP VALVE
Drain

SCHEMATIC PLAN OF THE OIL-OPERATED GOVERNING SYSTEM

THE GOVERNING SYSTEM

Maneuvering valves are provided for the ahead and astern elements and, in addition, there is a guard valve for the astern element. A small drain between the astern valve and the astern guarding valve removes condensate which might otherwise get into the astern steam element of the low-pressure turbine.

There is a sturdy steam strainer in this same manifold and it has at least two-and-one-half times as much free area as the incoming steam line. The resulting steam velocity through the mesh of the strainer is so low that the chances are fairly remote that foreign material will get into the turbine.

Hand valves are provided at the inlet of the high-pressure turbine. They permit adjustment of the first-stage nozzle area to meet the load condition most efficiently.

The governing system has two chief purposes: (1) to provide an upper limit to the speed of the turbines; (2) to close off the steam automatically if the ship's oil supply which feeds the bearings should run low. The governing system shown at the left is the oil-pump-governor type, which is outstanding for its flexibility of operation. A positive-displacement gear-type pump is on the forward end of the low-pressure turbine shaft. It boosts the pressure of the oil to an amount which is in accordance with a pre-determined setting of the needle by-pass valve. If the speed of the turbines increases above the desired maximum, the oil pump raises the oil pressure sufficiently to close the pre-emergency governor valve. This system works quickly and effectively to prevent overspeeding of the propulsion set.

At the high-temperature end of the set, both oil lines that feed into the governing valve operating mechanism are inside the drain line (not shown). The reason for this is that if a leak should occur in one of the oil lines under pressure, the escaping oil will not be sprayed on a hot steam surface.

If the oil supply to the bearings runs low, the low-pressure trip immediately closes the pre-emergency valve. An emergency operating lever is provided for opening the pre-emergency valve in case the propulsion equipment must operate even though the lubricating oil supply has failed.

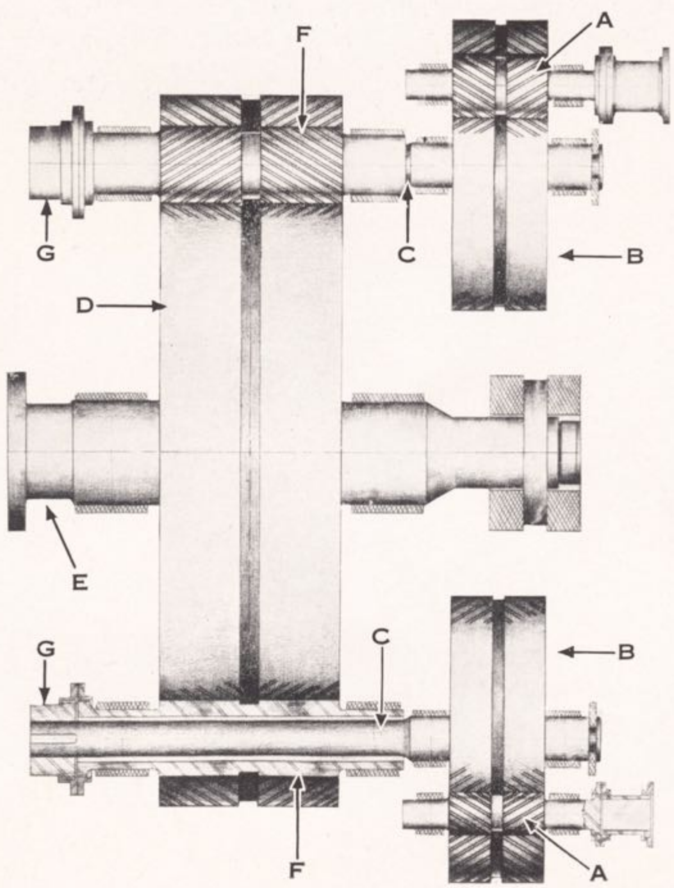
Now let's look in the gear shop...

THE DOUBLE-REDUCTION GEAR

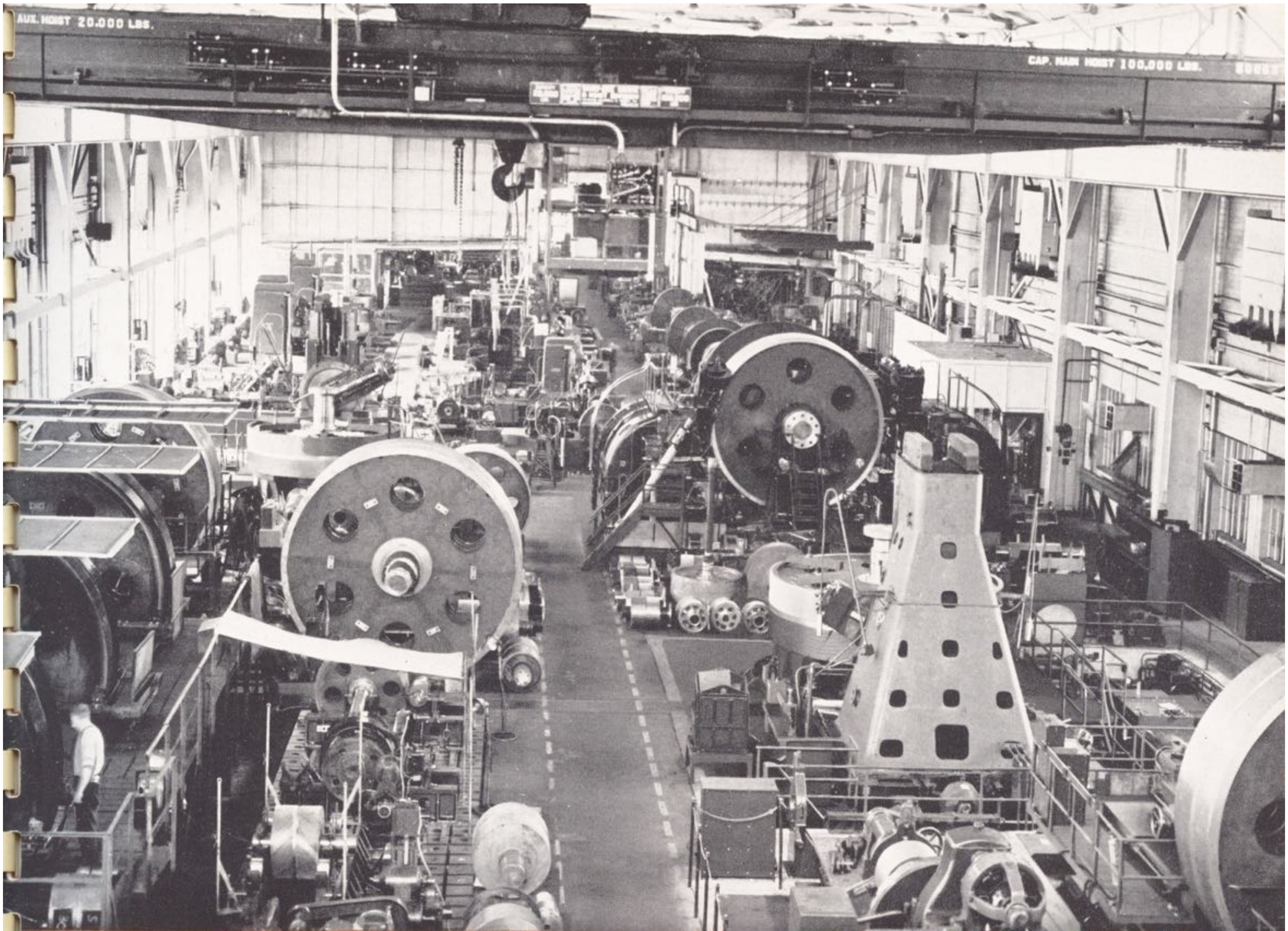
General Electric reduction gears are of the double helical type.

The gear set consists of two high-speed pinions (designated below by the letter A), both driving intermediate gears (B). Each is connected by a quill shaft (C) through flexible couplings to the low-speed pinions (F) which drive the low-speed gear (D). The shaft of the low-speed gear (E) connects directly to the propeller shaft. The quill shaft permits flexibility and compactness, and it allows the intermediate couplings (G) to be placed where they are easily accessible. Each gear and pinion is supported by two bearings.

The high-speed pinions are generally placed directly above and in line with the quill shaft. For illustrating simply the plan of this typical G-E reduction gear set, the pinions are shown slightly off-set. These pinions are solid with their shafts, and are made of forged alloy steel, treated to give it the proper Brinell hardness and physical characteristics.

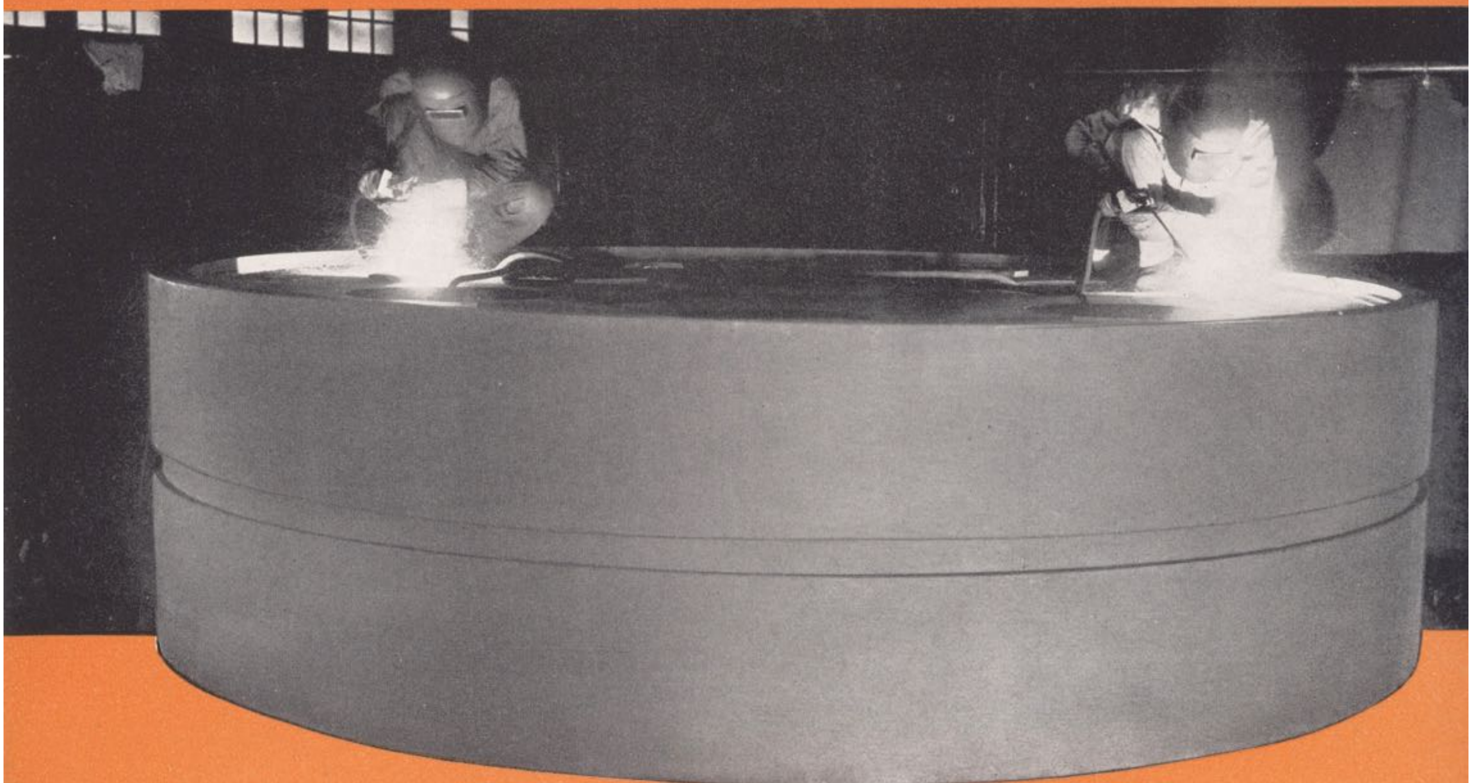


Actual operation of the G-E reduction gear has proved its efficiency, and also its ability to maintain proper tooth contact, which results in long life.



This is one bay of a newly enlarged G-E gear shop. Here, temperature is closely controlled for maintaining accuracy in gear cutting.

On the left you see balancing and contacting machines. Farther along are the hobbing machines cutting both gears and pinions. In the lower right-hand corner is a gap-lathe—big enough to machine 200-inch diameter main propulsion gears. The next machine is one of General Electric's giant hobbers. These hobbers cut teeth on gears up to 200 inches in diameter. In addition to these machines, we have many other facilities for gear cutting.



GEAR WHEELS

The high-speed gear wheels are either of all cast steel, or of the fabricated type, whichever construction is best suited for the purpose for which they are to be used.

The low-speed gear is of the fabricated type, and consists of a cast-steel hub, sheet-steel web, a forged steel tire, and a forged shaft which has an integral coupling. The webs are welded to the tire and hub, and the whole gear wheel is then annealed, to relieve all internal strains. In the above picture, the welding operators are putting the finishing touches to the fabrication of a low-speed gear.

ASSEMBLY WITH SHAFT

After annealing, the assembled wheel is placed in a giant press, and the accurately machined shaft is pressed into and keyed to the hub. The fit of the shaft into the hub is carefully gaged to avoid setting up undue strains during the pressing operation.

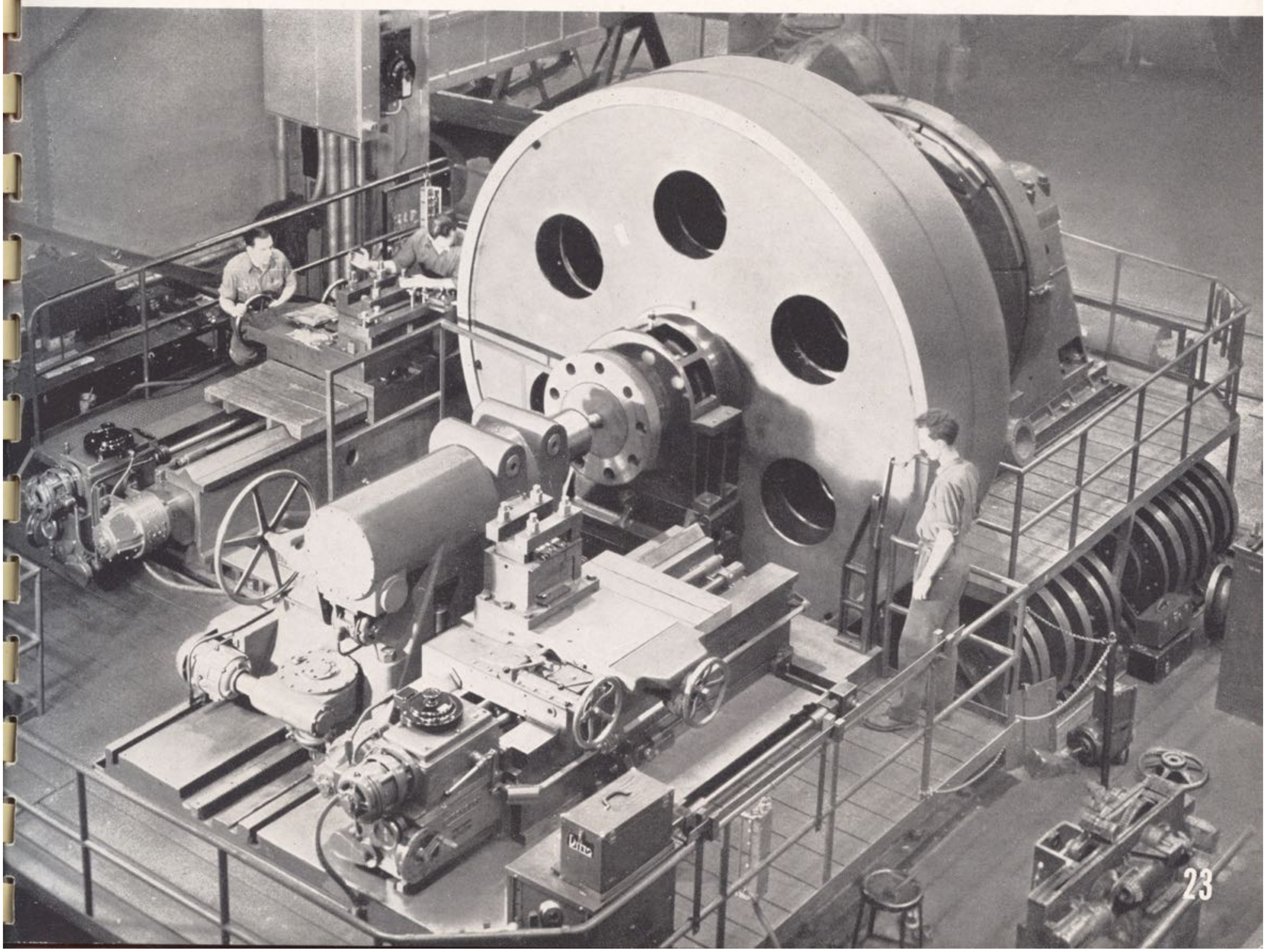
PINIONS

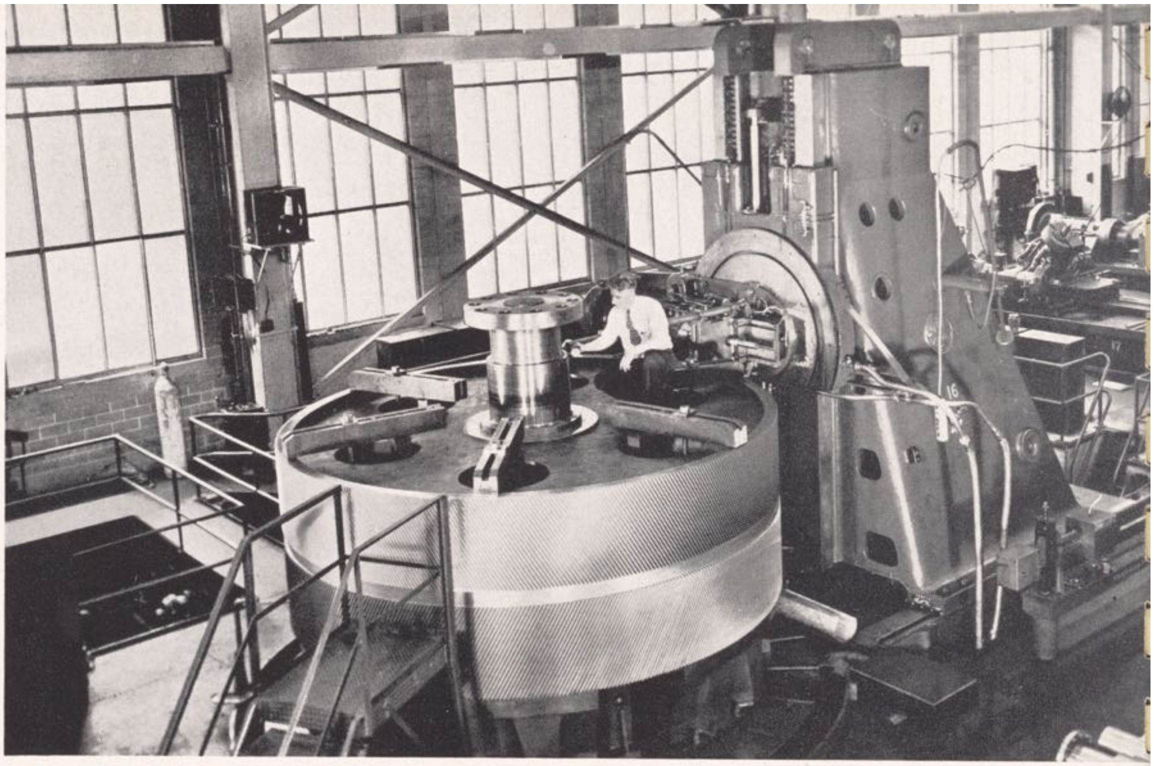
Turbines in merchant ships generally run at speeds from 6000 to 7000 rpm, although some marine turbine speeds in excess of 10,000 rpm are not uncommon. The pinion of a gear set connected to a turbine must also run at that speed and transmit its driving torque through teeth to its companion gear smoothly and quietly. To get an idea of the speed involved, try to visualize 4000 to 7000 tooth contacts having been made in one second when the full-speed rate between the high-speed pinion and the intermediate gear it drives is attained.

ACCURATE MACHINING

Smooth, quiet operation of the gears requires great accuracy in both their design and manufacture. They must be accurate not only when they leave the General Electric Company, but also even after they have given years of service. For example, after fabrication and annealing, entire gear wheels are machined to accurate concentric circles in the 200-inch gap lathe pictured above.

The tooth spacing, or the distance between any two teeth, must not vary more than three-tenths of a mil, which is about one-fourth the thickness of a cigarette paper.





HOBBING THE MAIN GEAR

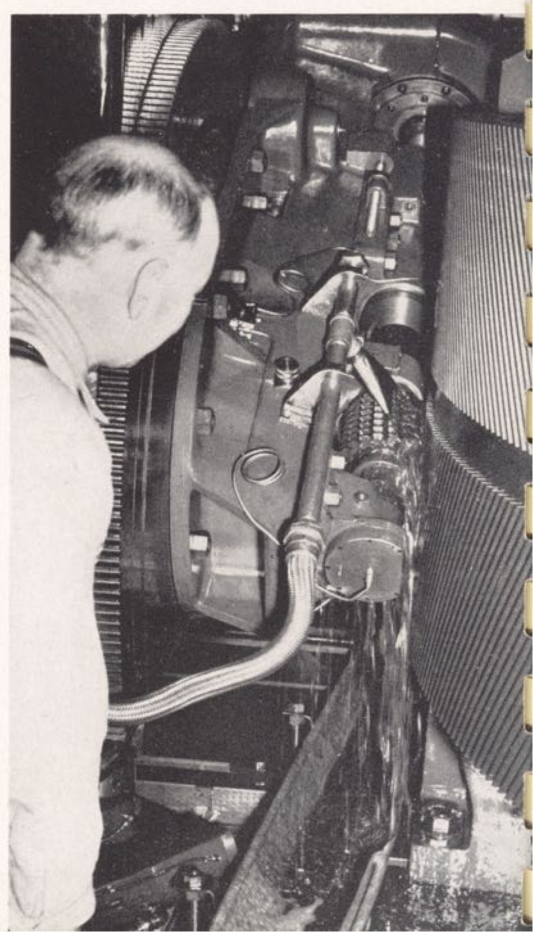
A gear wheel that has been rough-cut is here being set up for the finish cut in a huge reduction-gear hobber. This hobber is one of the few machines of its size in the United States. Designed and built by General Electric, it will hob worm, spur, or helical gears up to 200 inches in diameter, 88-inch face, and having a maximum total weight of 144,000 pounds.

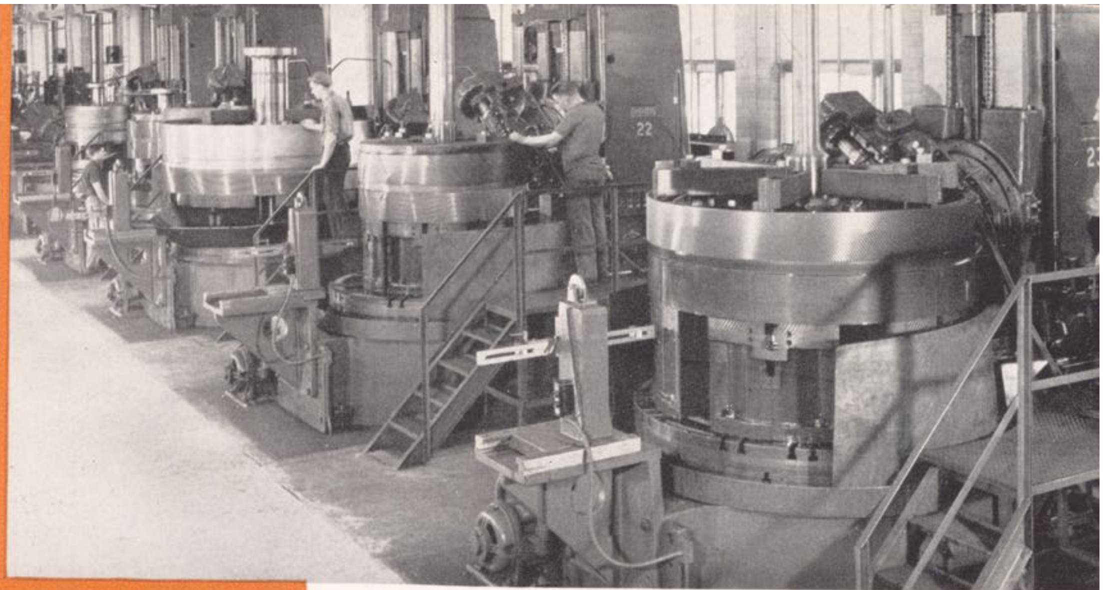
CONSTANT TEMPERATURE IS NECESSARY

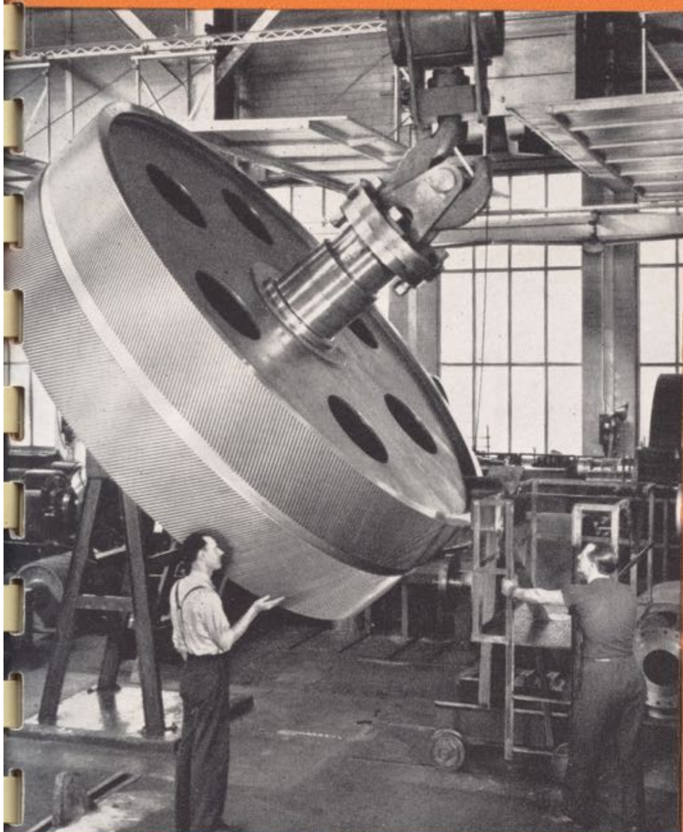
Accurate machining of large parts requires careful temperature control. This machine was designed to operate at room temperature, and it has duplicate systems for supplying both lubricating and cutting oils and oil refrigeration. If one system fails, the other functions immediately to prevent damage to either the machine or the work on it. As a safety feature, all mechanical and electric controls are interlocked; other devices warn the operator of danger.

The machine must be kept in continual operating motion for 72 hours before a finish cut can be started. This allows all working parts to reach a uniform temperature. To rough cut and finish-cut a big gear requires two to three weeks. The hobbing operation must be continuous on each helix. If the machine stops during the finish cut, the teeth may be ruined and a large loss incurred. An auxiliary power source keeps it in motion in the event of main power interruption.

At the right is a close-up of the hobbing operation.



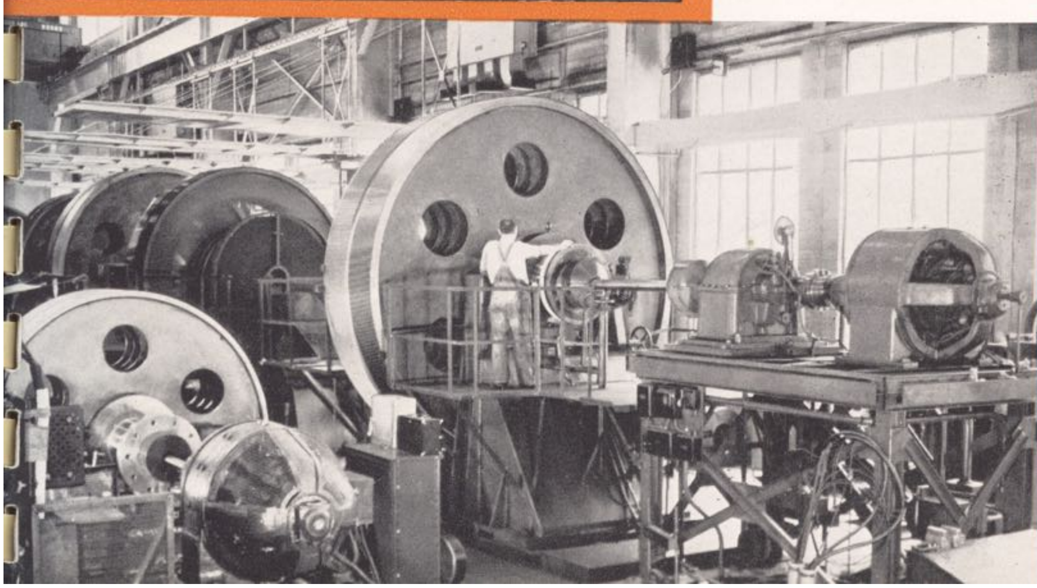




HOBBING INTERMEDIATE GEARS

The top photograph shows a battery of five 96-inch vertical hobbing machines at work. Here you see intermediate gears being cut. These machines are part of our extensive gear cutting facilities.

A great deal of care must be given to gear wheels, both in their manufacture and handling. As we have seen, the various manufacturing operations on the low-speed gear are done with the gear in horizontal and vertical positions. In the course of its manufacture its position is changed several times, for various operations. The gear at the left has just come from the hobbing machine, where the finish cut on its teeth was made, and is being changed to a vertical position. It is now ready for contacting and final inspections—preliminary to its assembly with the rest of the set on a test base.



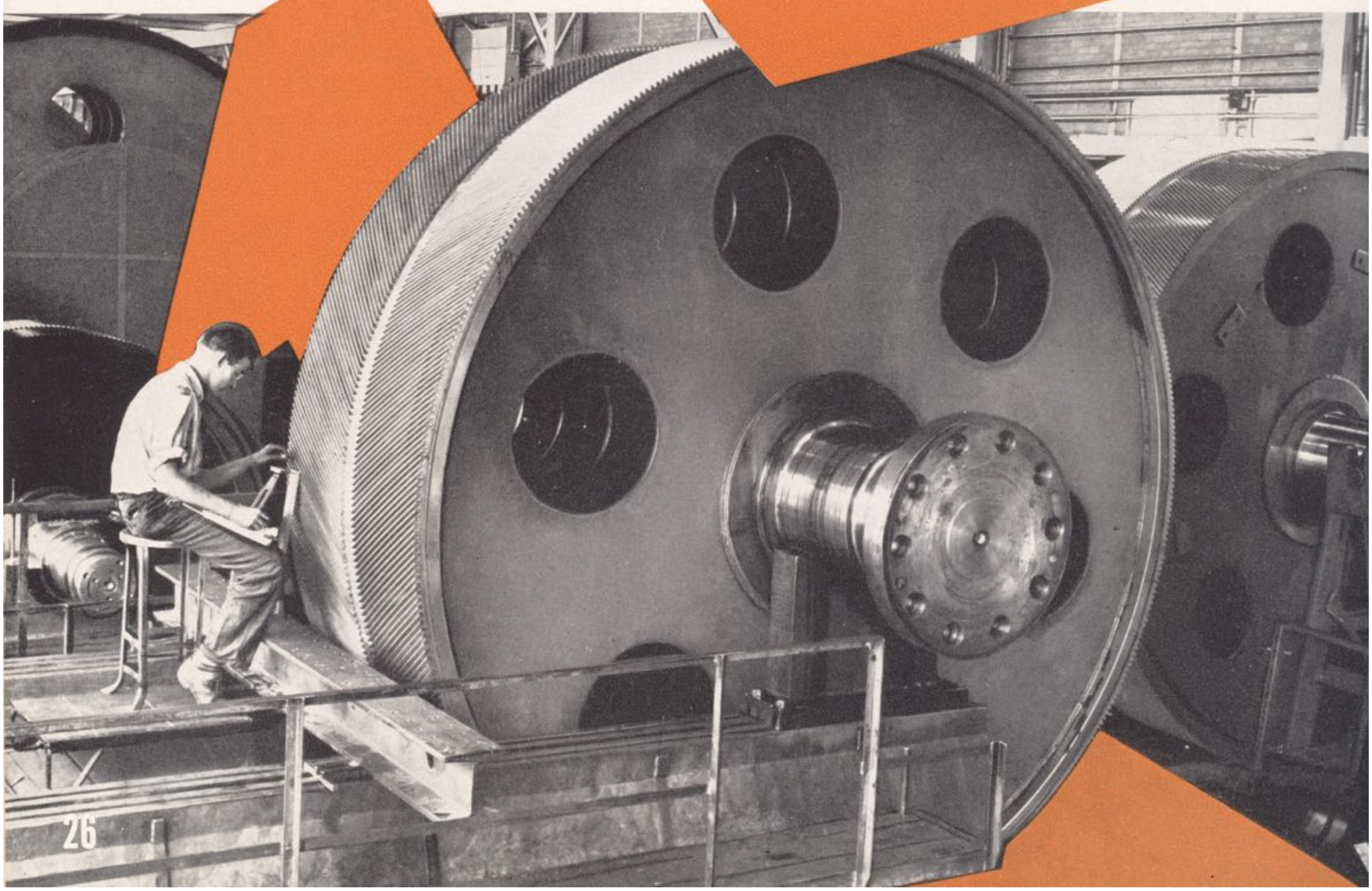
DYNAMIC-BALANCING machines for 100-inch and 200-inch gears

THE PIN CHECK

An extremely high degree of accuracy is maintained in gear cutting, but as a further check the teeth are measured on both helixes by a method known as the *pin check*.

The gear is rotated slowly, and the operator inserts a hardened pin in the space between adjacent teeth. As the gear rotates, the pin bears on the lever and gives a reading on how far the pin dropped in between the teeth. Readings are plotted and analyzed to check tooth spacing and accuracy for smooth operation.

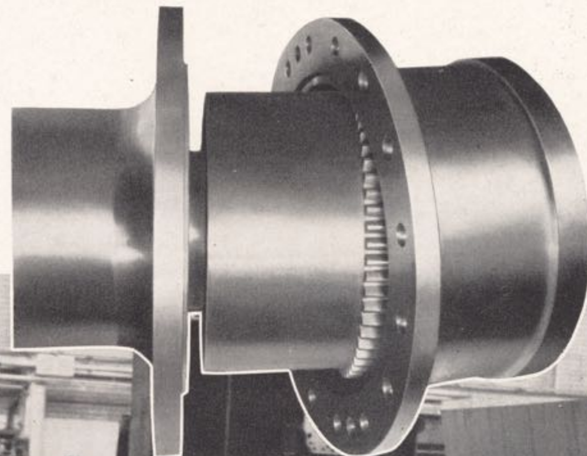
This is the most accurate method that we know for the checking of gear cutting.

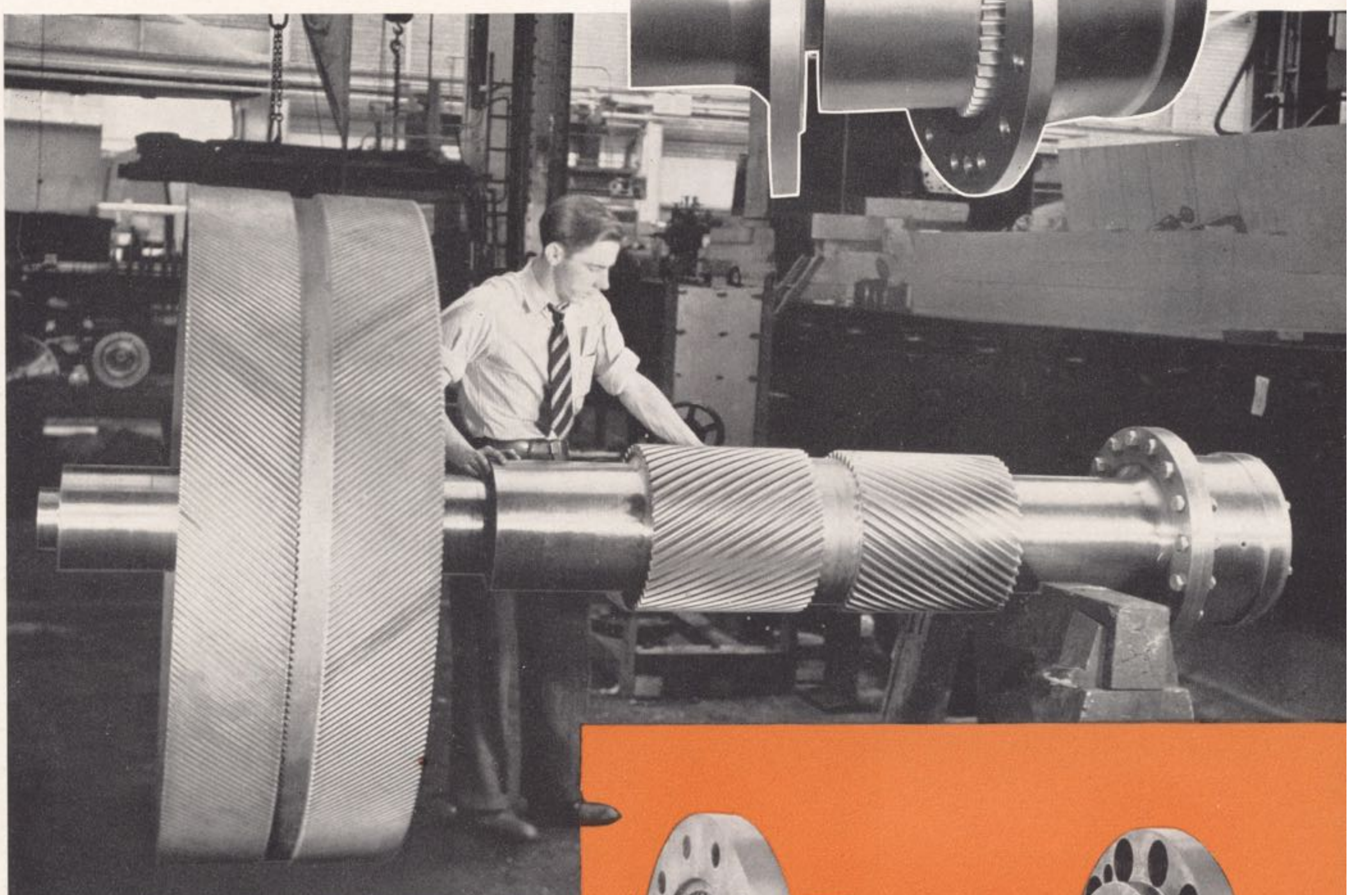


COUPLINGS

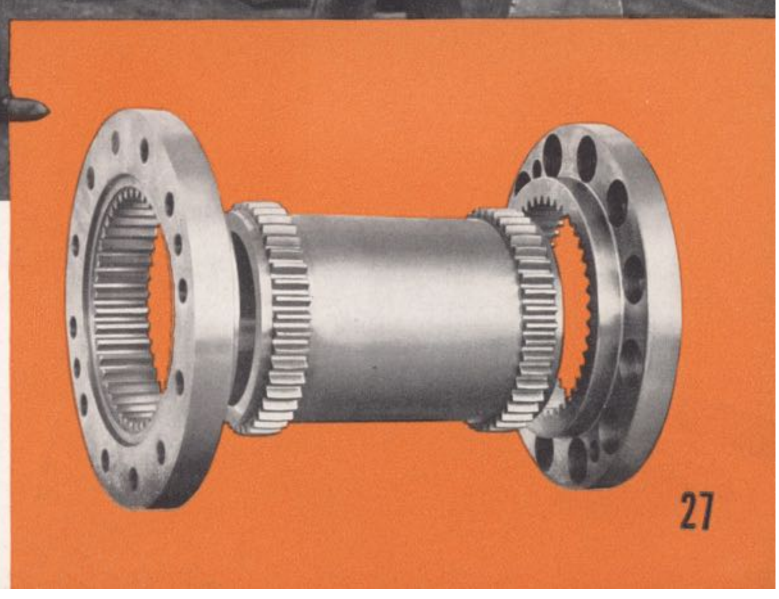
Sturdy gear-type couplings are designed to compensate for offset and angular misalignments which are beyond our control, and which occur in the natural operation of the gears. A flange for the intermediate coupling is machined integrally with the low-speed pinion. It is bolted to an internal tooth flange, the teeth of which engage external teeth in a hub which is pressed on the after end of the quill shaft.

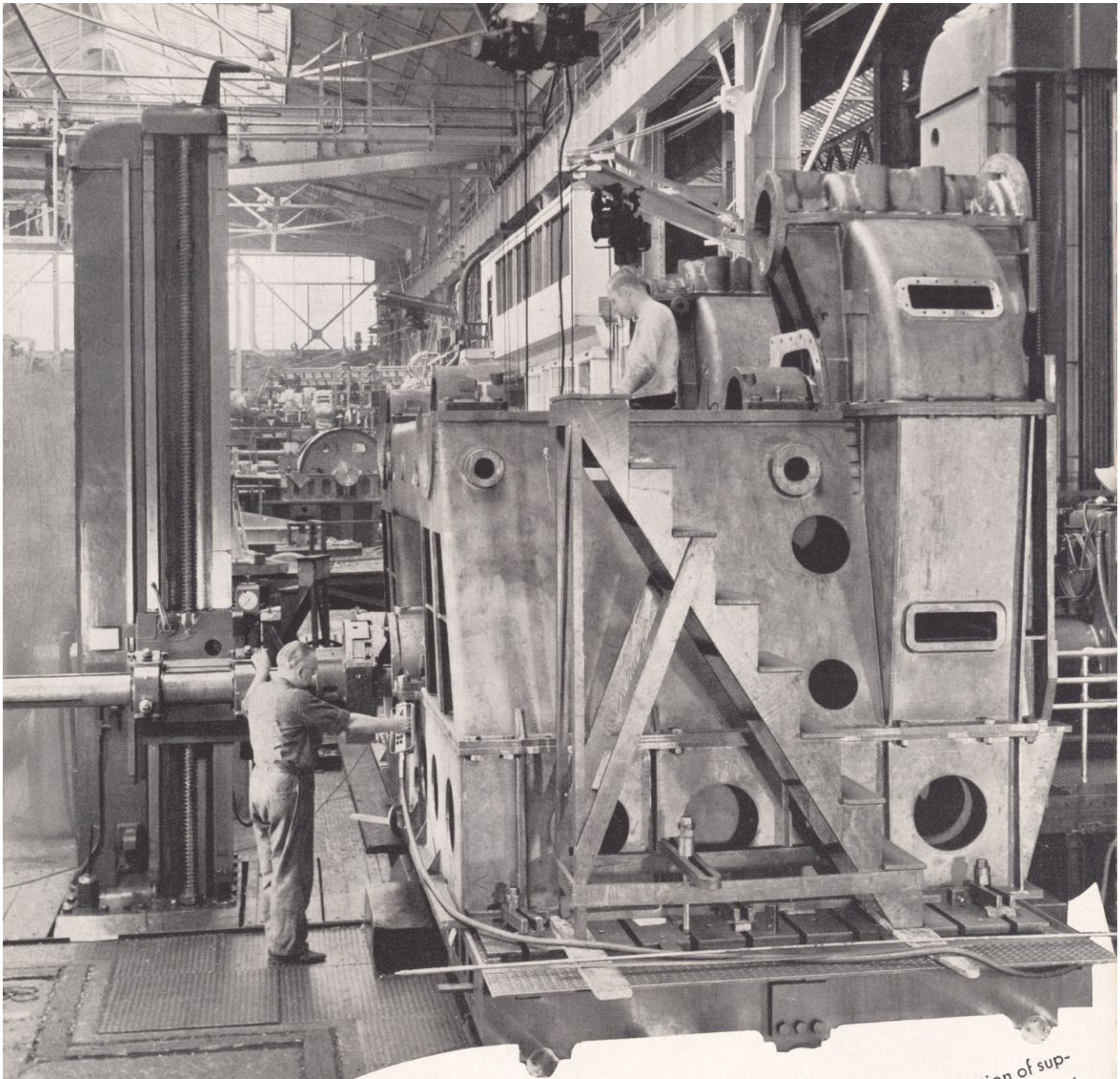
Below is an assembly of the intermediate gear, the quill shaft, the low-speed pinion, and the intermediate coupling. The quill shaft extends through the hollow pinion and is connected to it at the aft end. This flexible quill shaft allows the low-speed pinion to locate itself in its bearings independent of the highspeed gear.





At the right is the flexible, high-speed coupling which connects the turbine to its high-speed pinion. It is so designed that it will take care of both offset and angular misalignments between the turbine and the gear. The entire coupling can be removed without disturbing either the turbine or the gear. Small sleeves permit inspection to be made easily. All couplings are dynamically balanced.





THE GEAR CASING

In recent years, General Electric has made important improvements in the construction of supporting casings, or housings for the gear set. They were formerly made of heavy cast iron or cast steel and weighed 60 tons; now they are made of light but rigid fabricated construction. The comparable new type of casing weighs only 35 tons, and consists of cast steel and steel plate welded together so neatly that it appears to have been cast. It is divided into three main sections. The horizontal divisions are made at the center line of the shafts.

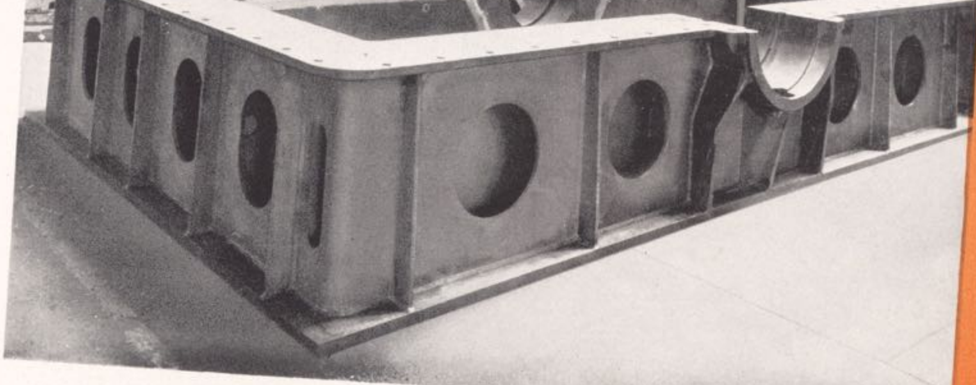
MACHINING THE CASING

The casings are machined in large, horizontal boring mills like the one on opposite page to accuracies of less than the thickness of a cigarette paper.

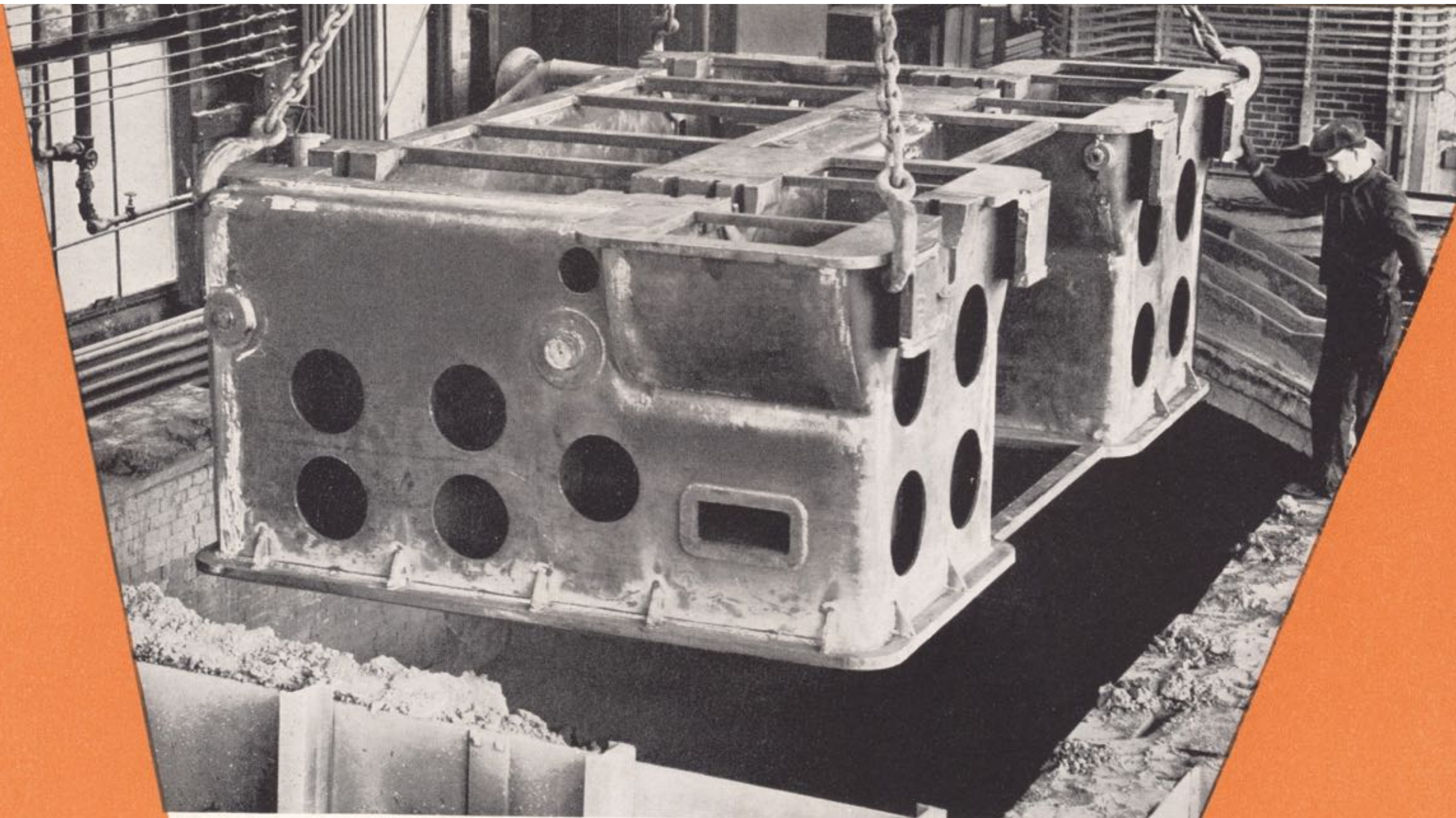
The workmen are facing the aft low-speed bearing seat and cap. This machine is used for accurately boring a casing for the five shafts. The intermediate gear and pinion for example, will have four bearing seats in one line, and the casing is bored from one end so that all will be in a straight line. Essential flat surfaces are milled, or faced, by the same machine before the casing is moved. This is done in order to make sure that these surfaces will be at right angles to the bores and that turbines, oil deflectors, and thrust bearings will be aligned properly. A higher degree of accuracy of alignment is obtained as a result of this procedure than would be if the casing were moved from one machine to another for the various operations. Joints between casing sections are made tight without the use of gaskets by accurate machining and scraping.

FABRICATING THE CASING

Part of the arc welding of casing sections is done with the section supported at an angle on specially designed "A" frames which were built for this specific purpose. By their use, a better-quality weld is obtained because the welder works with the aid of gravity—i.e., downward—and a 100-per-cent fill of the joint is obtained.

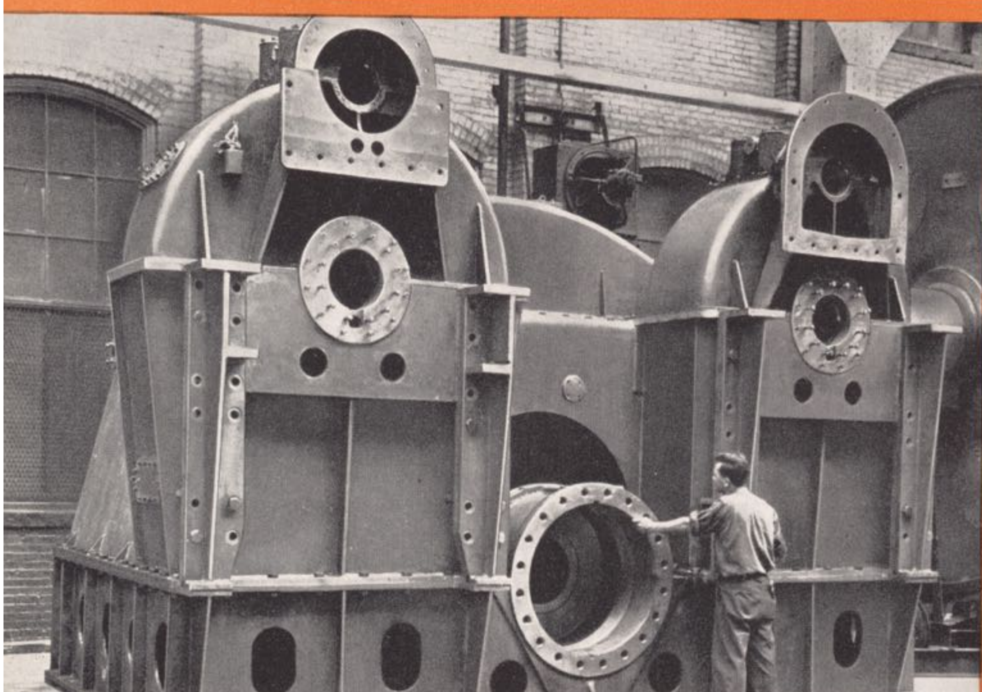


LOWER SECTION of a reduction-gear casing



ANNEALING CASING SECTIONS

Each of the three main sections is fabricated by arc welding, after which it is annealed to relieve the welding strains. After the annealing operation, it is ready to be machined. Thus, rigid support and permanent alignment for the bearings are provided.



THRUST-BEARING HOUSING

The ship's main thrust bearing is arranged on the forward end of the low-speed gear casing in a housing which is integral with the casing.

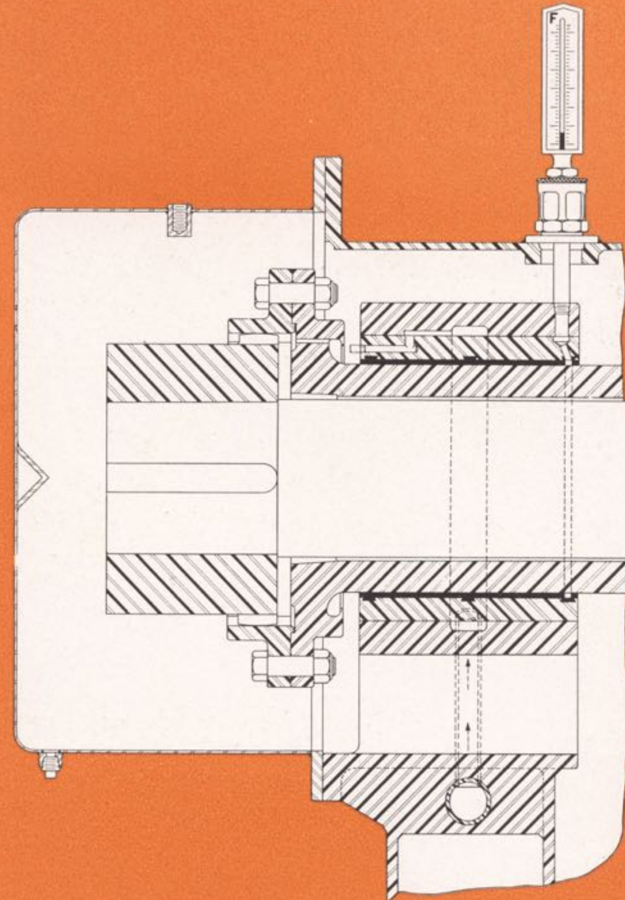
The complete gear casing (shown here) is of compact and rigid construction and is designed to retain the gear-and-pinion bearings in accurate alignment. Removal for inspection or repairs is easy, because of the way in which the casing is divided.

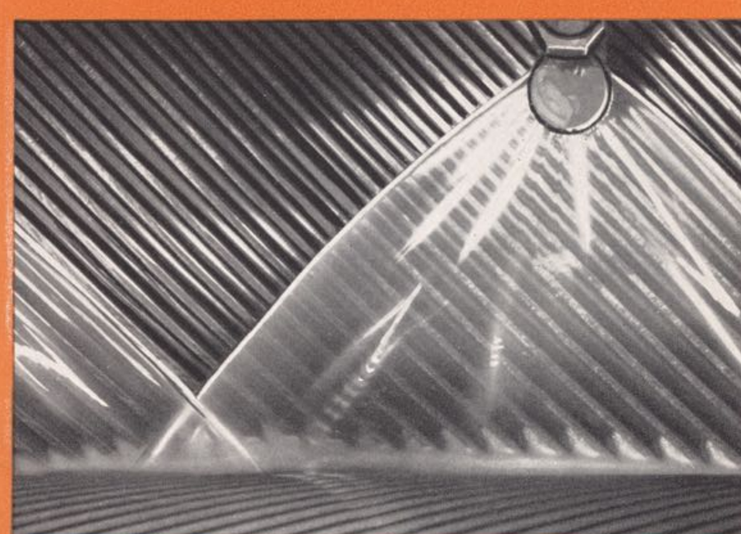
Ample footing is provided for bolting the casing to the ship's structure with heavy bolts.

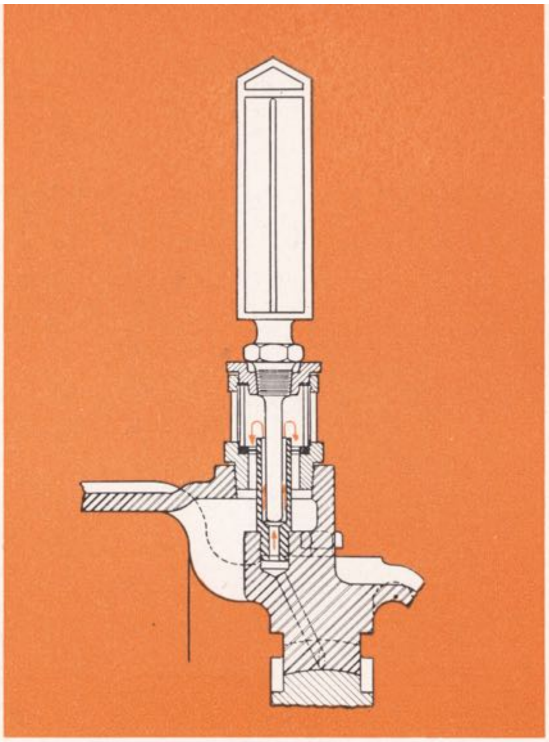
LUBRICATION

No matter how sturdy the design of a gear, or how well it is manufactured, the gear is no better than its lubrication system. An oil film must be kept continuously on the gear teeth, and the bearings must be kept well oiled; otherwise, excessive bearing wear will cause poor tooth contact and noisy operation.

Gear teeth must not run in oil, as this would cause excessive heating from high rotation heat-loss of the teeth in the oil, and the efficiency of the gears would be lowered. It is difficult to keep oil on the high-speed gears because of the centrifugal force. Therefore, oil is put on the gear teeth just before they enter mesh by means of spoon-shaped oil nozzles which direct thin films of oil into the mesh. By the use of this system, only a small amount of oil is required. Each nozzle is protected by an individual screen, and the entire nozzle can easily be removed for inspection or cleaning.







OIL INDICATOR

Oil-flow sight indicators, or bubblers, are assembled on all bearings for indicating the oil flow through the bearings. A thermometer is mounted on each bubbler to indicate the temperature of the oil in the bearing. This diagram indicates the path of the oil through the indicator assembly and shows how the oil is forced around the bulb of the thermometer.

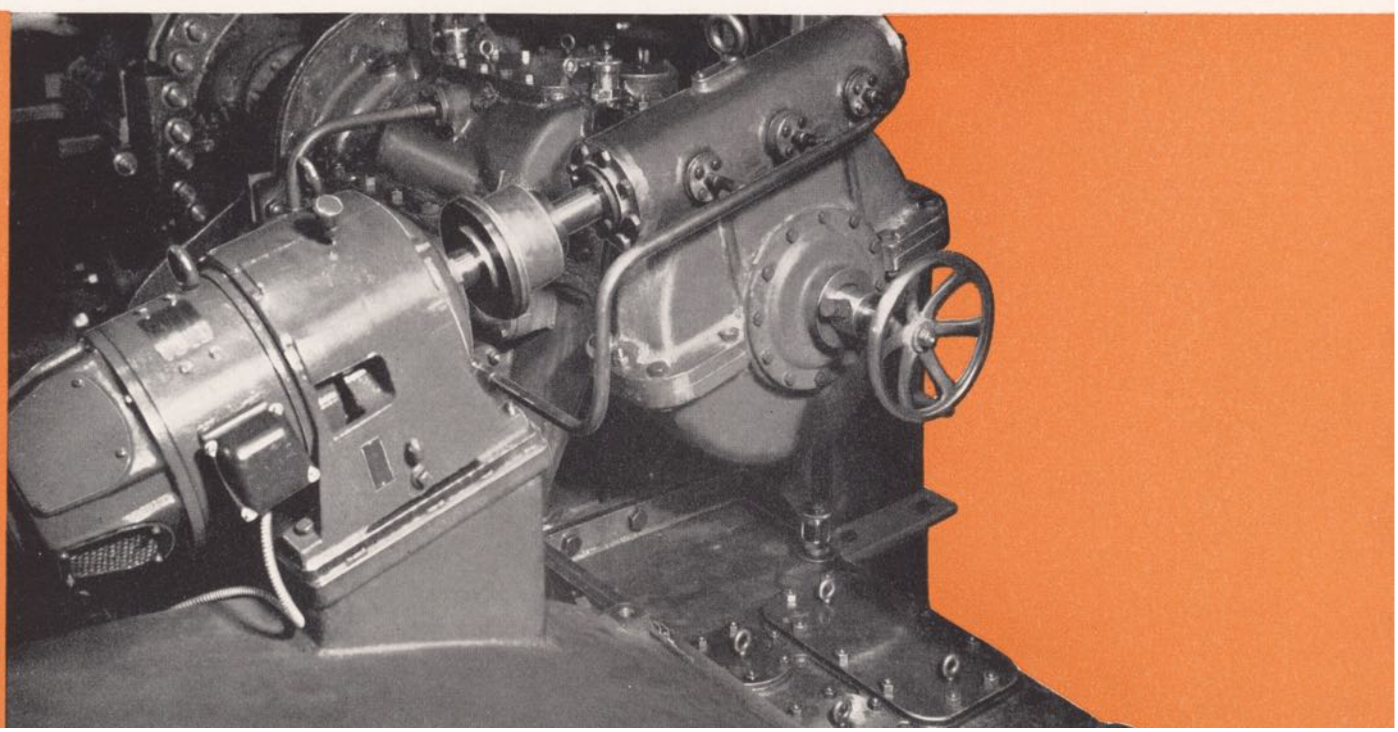
TURNING GEAR

The turning gear, which is motor-operated, has two main purposes; (1) to rotate all the parts slowly while the turbine-gear unit is shut down so that localized cooling of the turbine shafts will be prevented; (2) to rotate the gears slowly so they may be inspected.

It is mounted on the gear casing and its worm drive can be connected through a clutch to one of the high-speed pinions.

The turning gear can be engaged by means of the handwheel, and ample protection is afforded the equipment by means of a safety device. This is a safeguard against the engaging of the turning device when the gears and turbines are rotating.

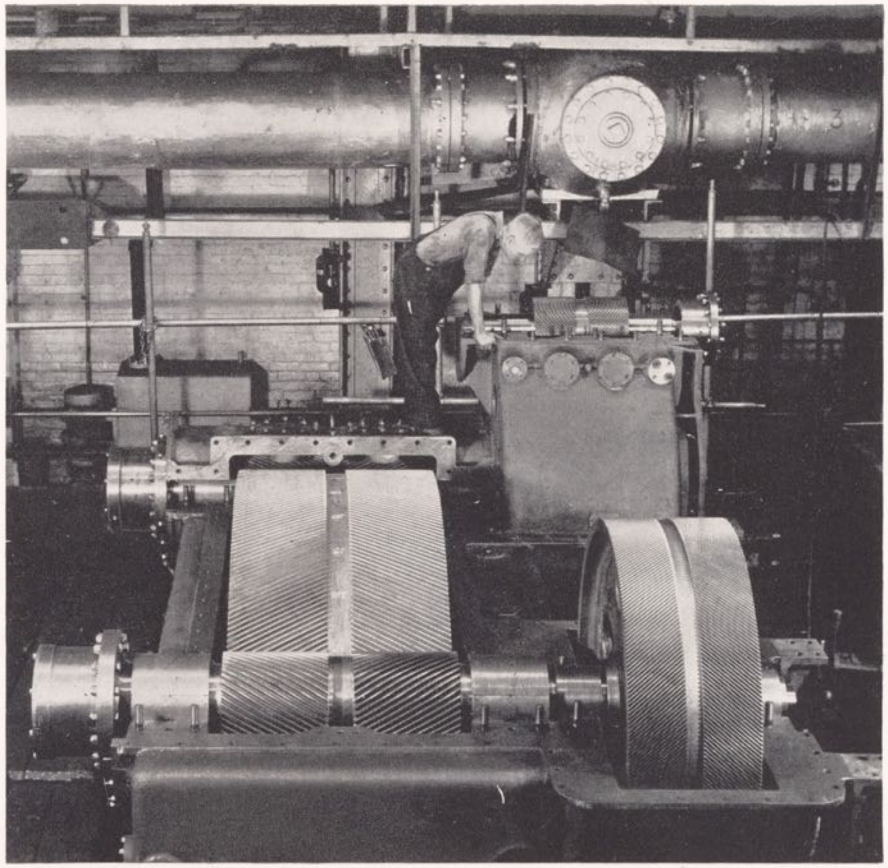
The motor is reversible, and it is provided with a magnetic control panel and a drum controller.



TESTING

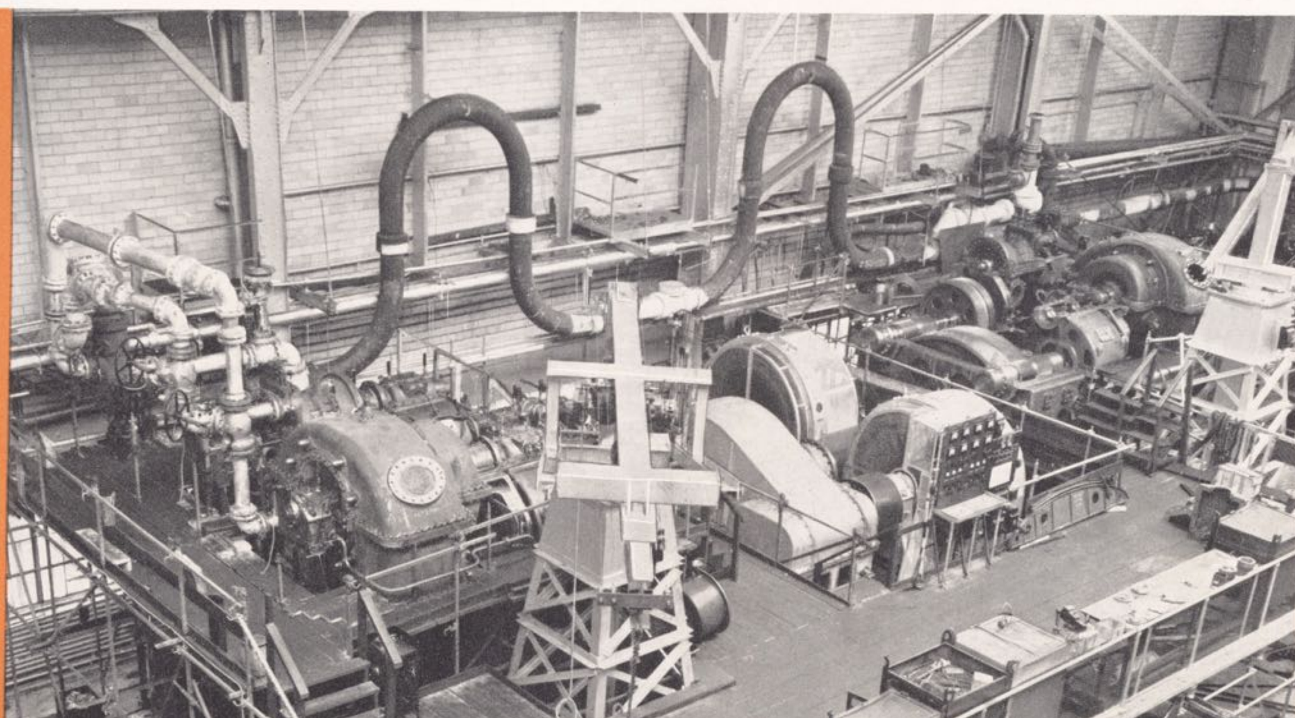
The final stage of gear manufacture is reached on the test floor—the factory "proving ground" for turbines and gears.

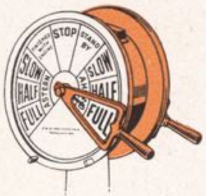
The unit is assembled and run under conditions that are similar to operating conditions aboard ship. The performance of the unit is constantly watched and carefully recorded all through the tests. Irregularities in the operation of the unit are found and corrected while it is "on test." Thus, General Electric has saved many vessel owners thousands of dollars that might have been expended for duplicate trials of ships.



Testing facilities have been added to keep pace with the improved manufacturing equipment. We have several test bases (like the one below) for assembling and testing geared-turbine sets.

The sight of a big double-reduction gear being driven smoothly by its high- and low-pressure turbines at full speed and load is a never-ending source of amazement to visitors.



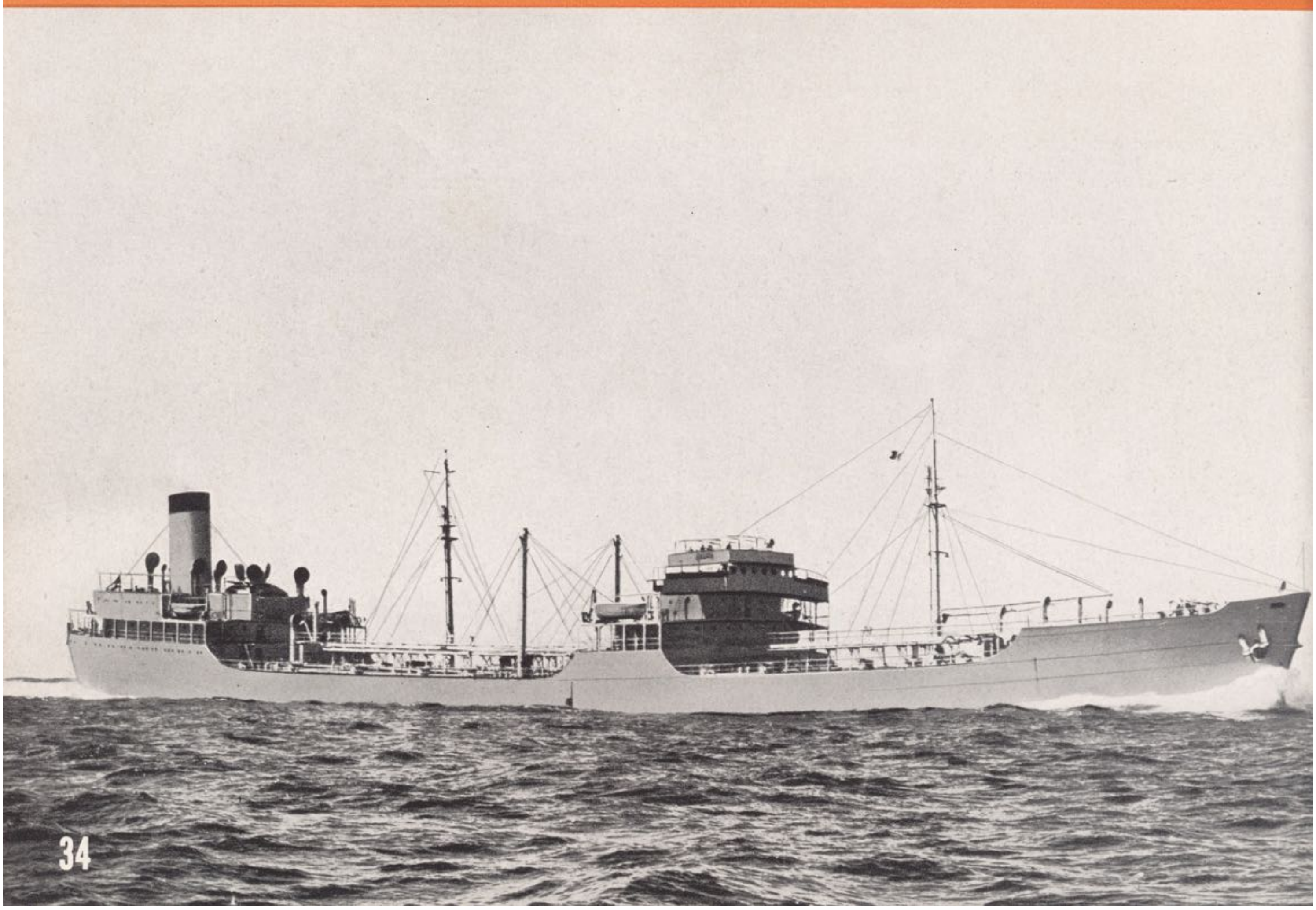


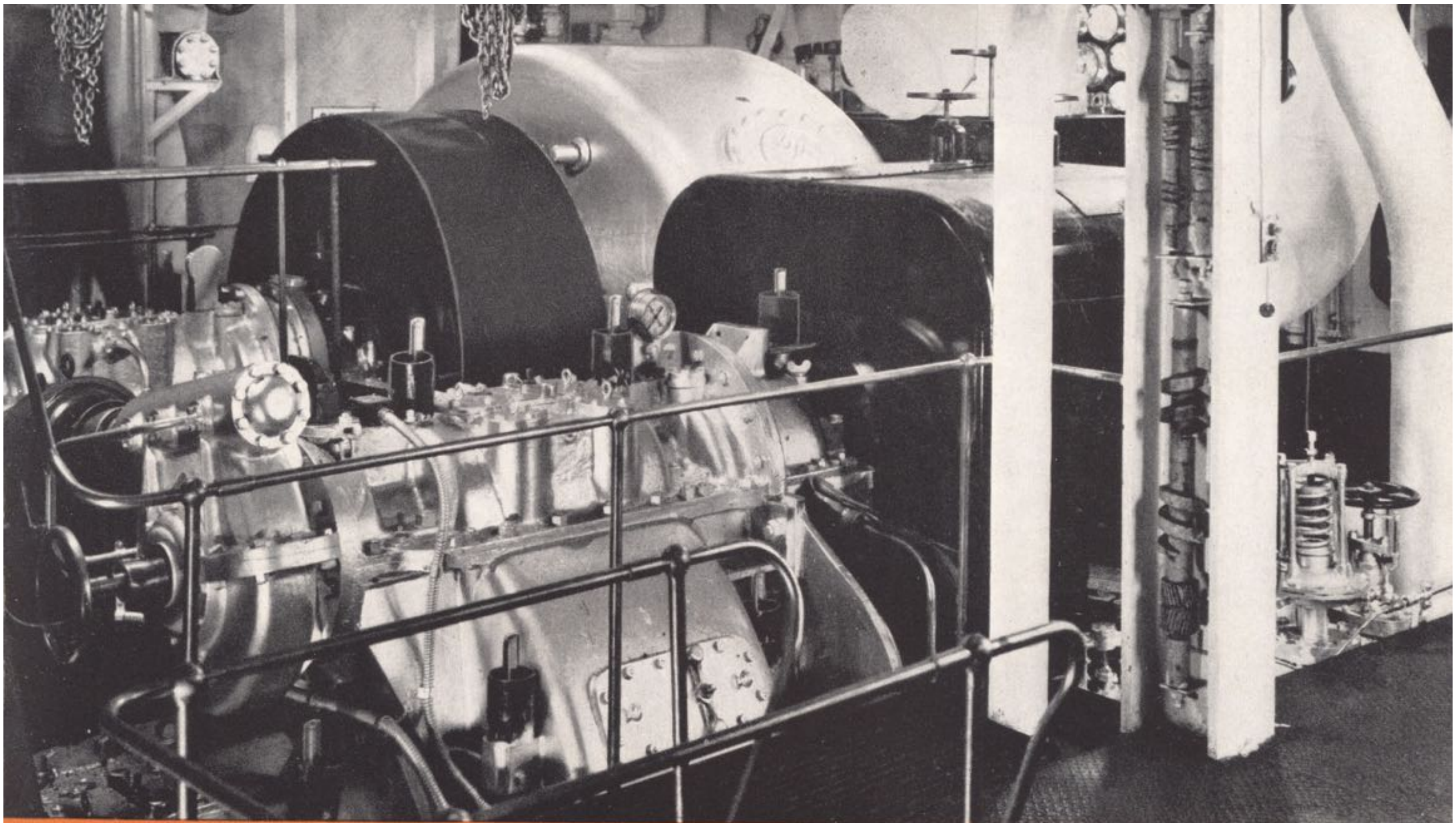
IN ITS many years of marine-turbine and reduction-gear manufacture, General Electric has installed more than 5,000,000 horsepower in turbines and gears for ship propulsion—has equipped more than 400 ships with G-E geared-turbine propulsion units. The propulsion and auxiliary equipment—from stem to stern—of many of the approximately 2500 vessels (both merchant and naval) being completed in the present United States shipbuilding program is of General Electric manufacture.

Our trip through the turbine and gear shops being ended

...let's see some typical installations

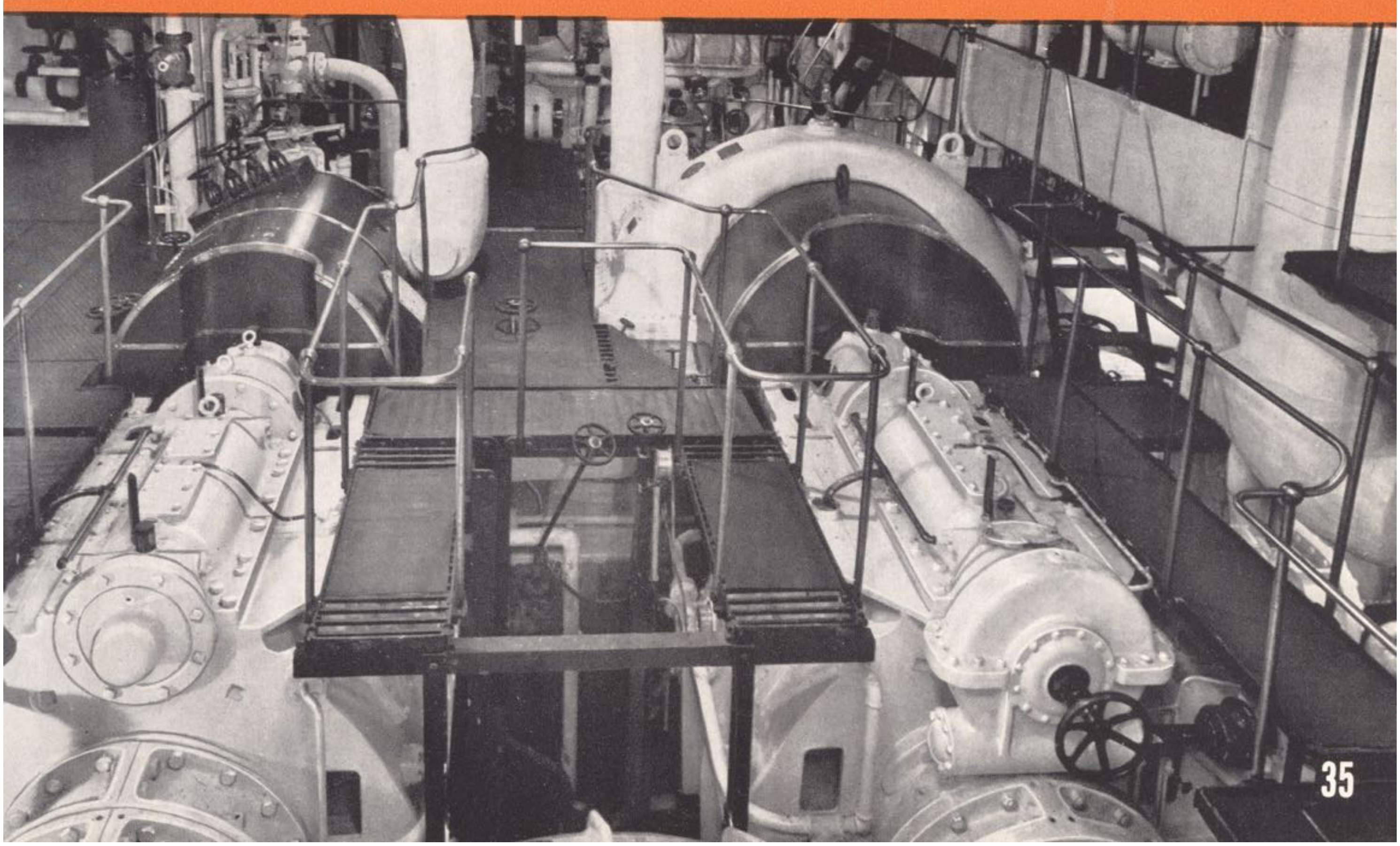
This twin-screw tanker is equipped with two G-E geared-turbine units, and with G-E auxiliaries and switchboards.

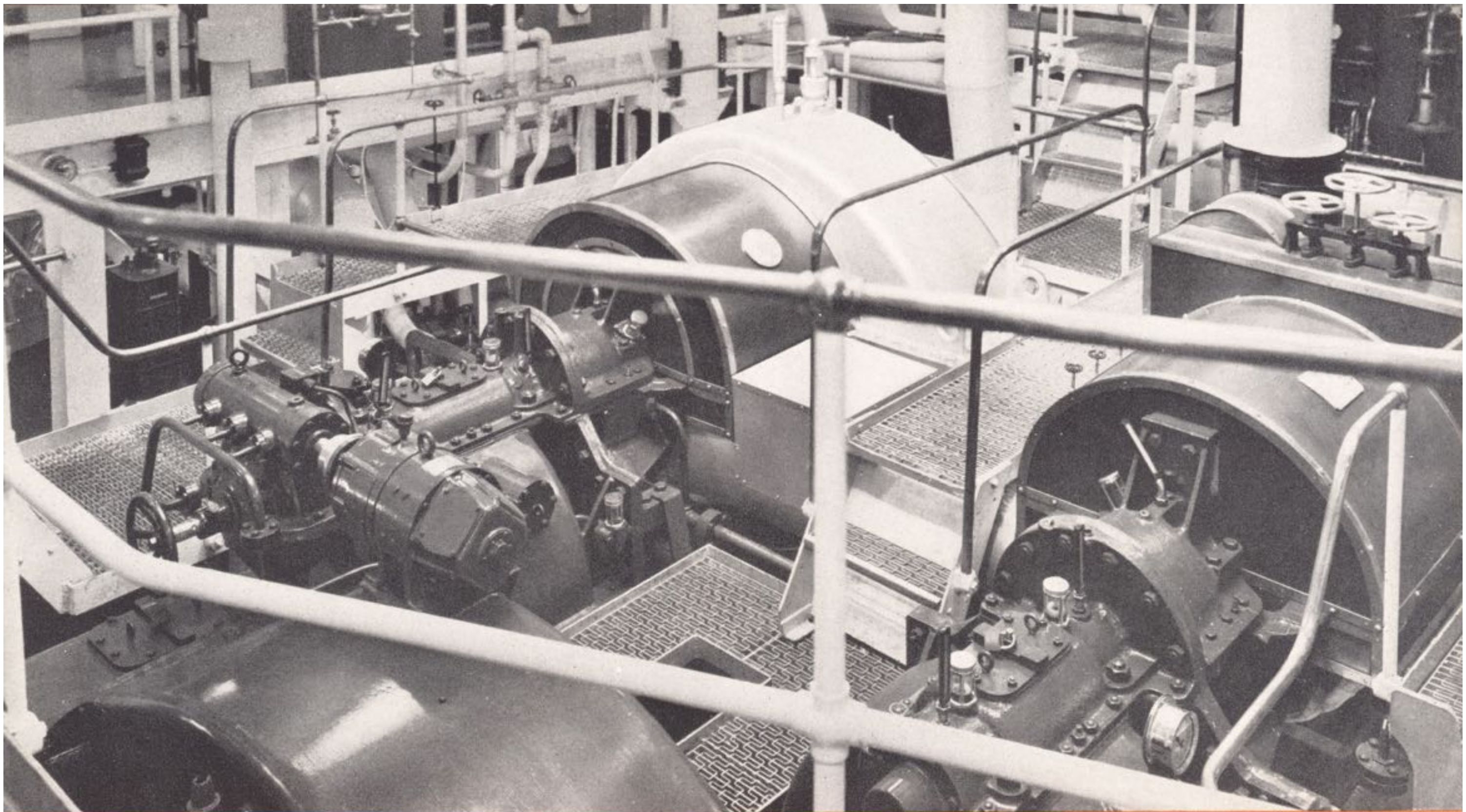




Above: This 7800-hp G-E geared-turbine propulsion unit is in a cargo-passenger vessel serving Central and South America.

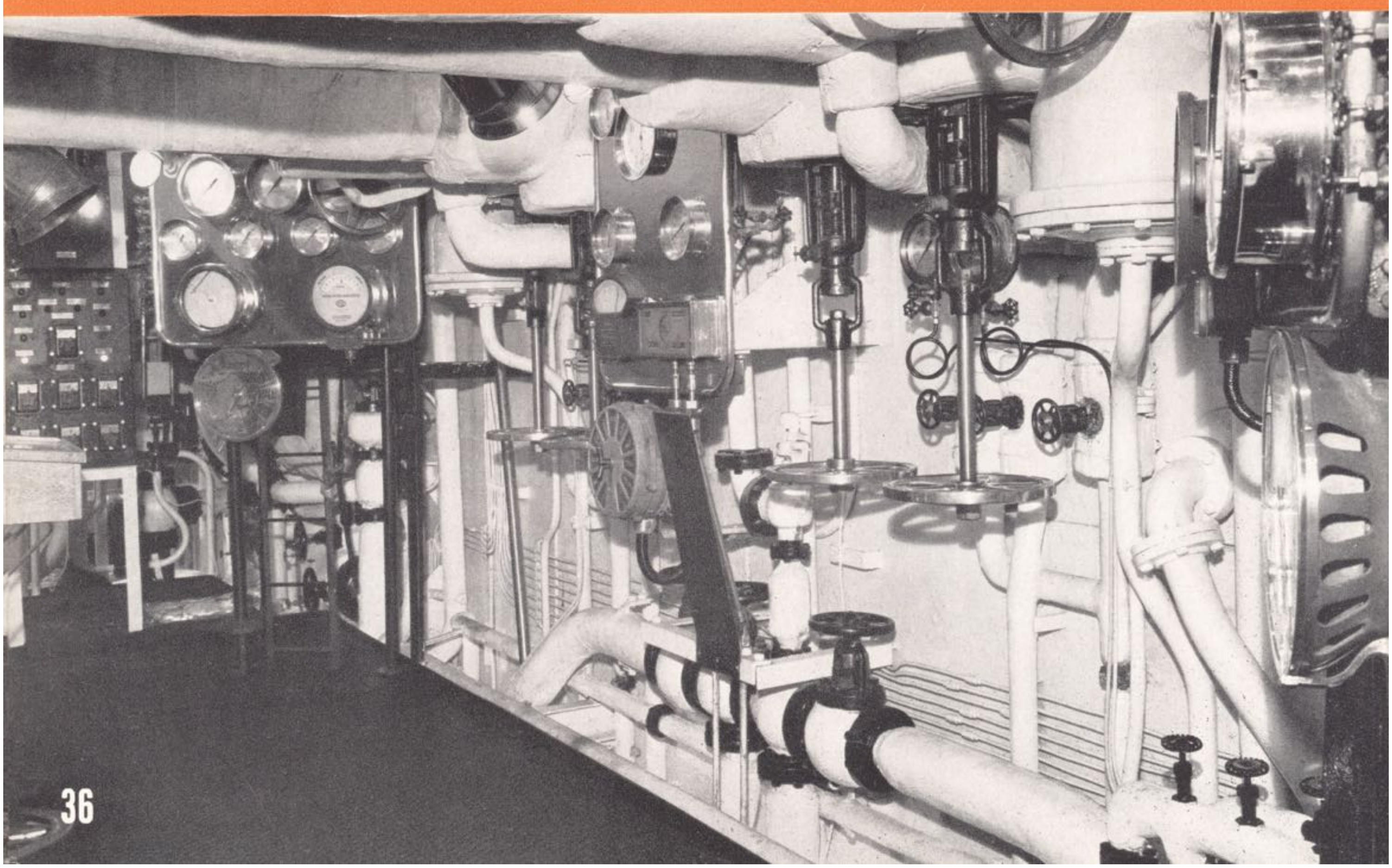
Below: Starboard main propulsion unit, rated 6000 hp at 95 rpm. This G-E equipment is in service on a freighter.

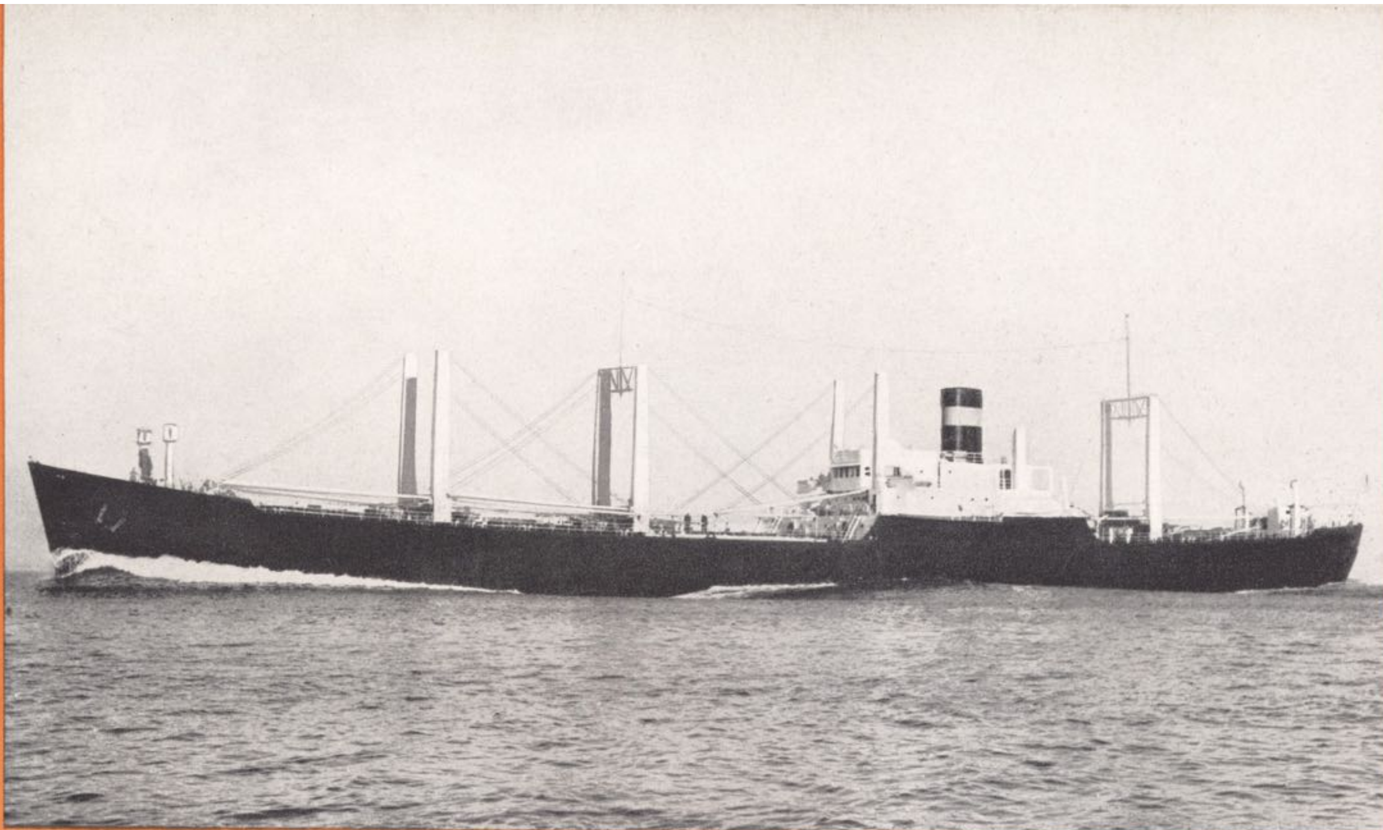




Above: 2000-hp G-E cross-compound marine steam turbines and reduction gear in engine room of a Great Lakes ore carrier.

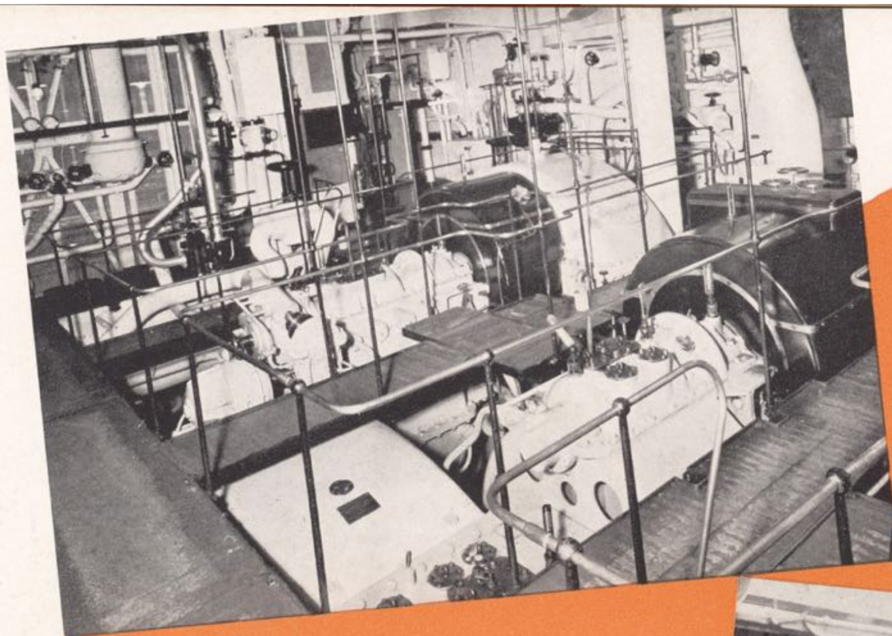
Below: Typical main control station in a merchant ship. Equipment includes maneuvering valves, gage boards, and ship telegraph.



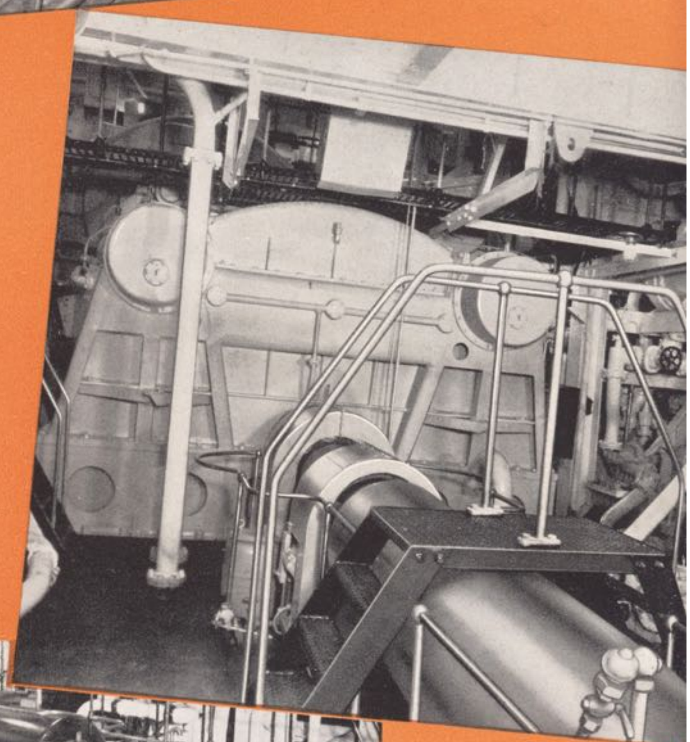


Above: This C-2 vessel is one of a large group—all equipped with G-E geared-turbines—that have established remarkable over-all fuel consumption economies.

Below: This oil tanker, propelled by a G-E turbines-and-gear unit, was put into service last year. Fuel rate for all purposes is exceedingly low.

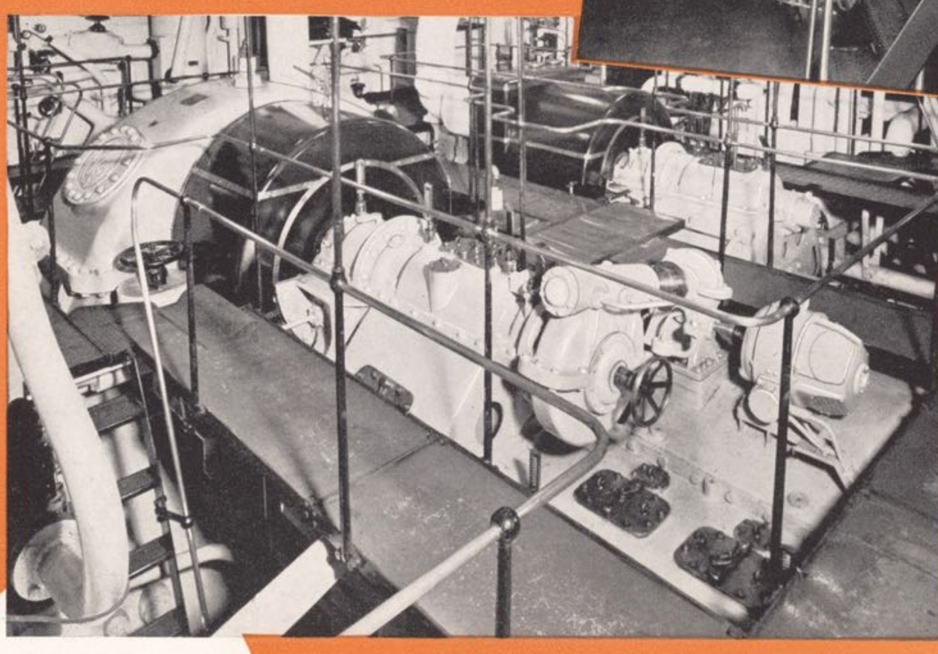


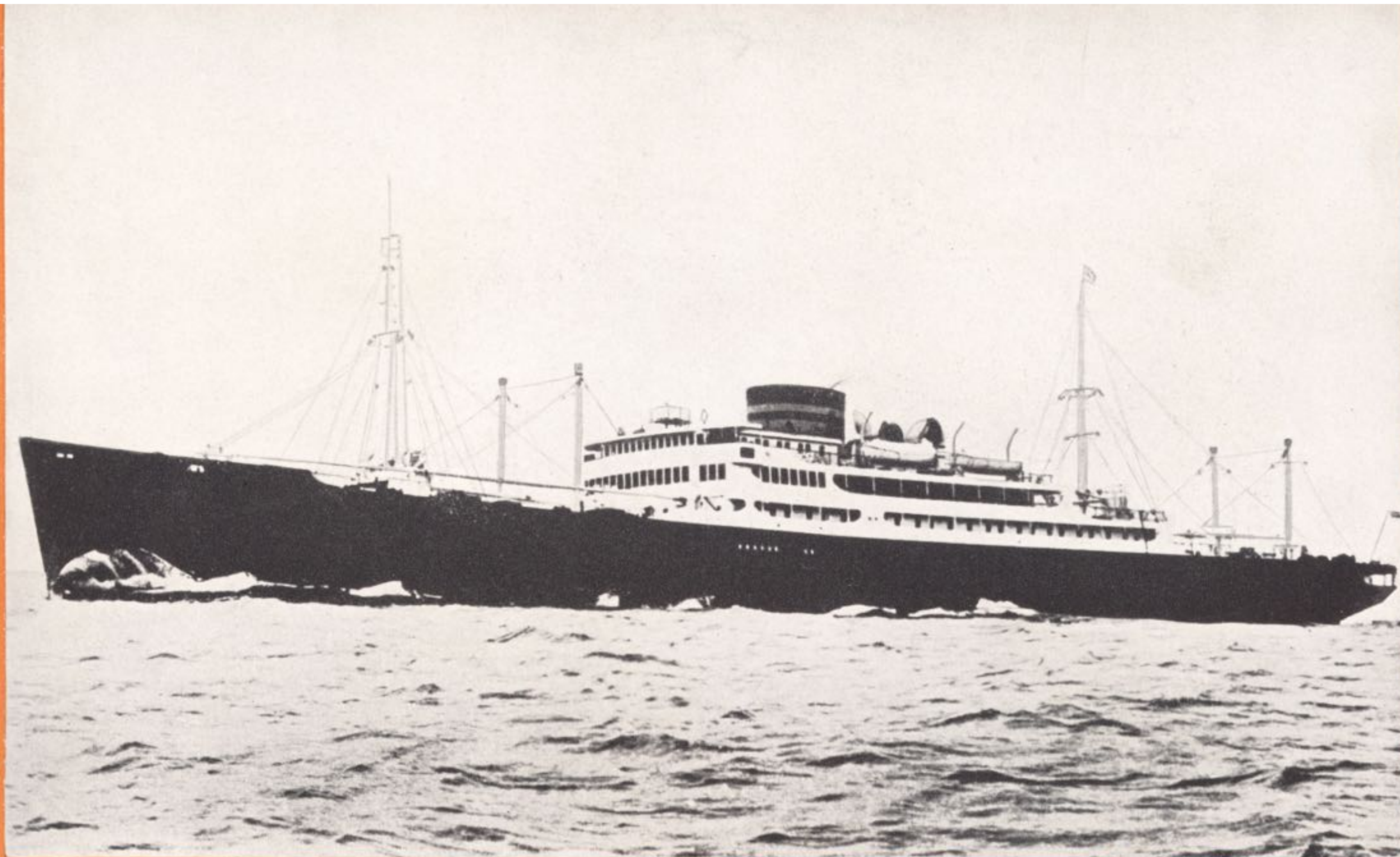
Above: Complete G-E geared-steam-turbine propulsion unit in a new freighter. Photograph is from the starboard side, looking forward.



Right: The freighter in which this G-E geared-turbine unit is installed was built for coastal freight service. The photograph shows the low-speed gear coupled to the propeller shaft.

Below: This G-E geared-turbine unit aboard a C-2 ship is typical of the G-E compact, lightweight design for modern cargo carriers.





Above: This ultra-modern cargo-passenger ship is one of a large fleet equipped with G-E geared-turbines and G-E auxiliaries.

Below: The first all-welded cargo-passenger ship in the world (photographed after launching in 1941) has G-E geared-turbine drive and G-E auxiliaries.

Every piece of General Electric marine apparatus is backed by the largest manufacturer of turbines and high-speed gears. Our resources enable us to give unsurpassed repair service on this equipment. ¶ There are G-E Service Shops and turbine inspectors in the principal ports of the United States. The inspectors have no duties other than the servicing of turbine sets; they can reach any vessel in port quickly. They are specialists—your first choice for any kind of job in their line. ¶ This inspection service is not included in initial contracts, but it is essential for keeping ships in operating condition with little delay. Only a company with the extensive experience and resources of General Electric could put at your disposal such a complete service organization.

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