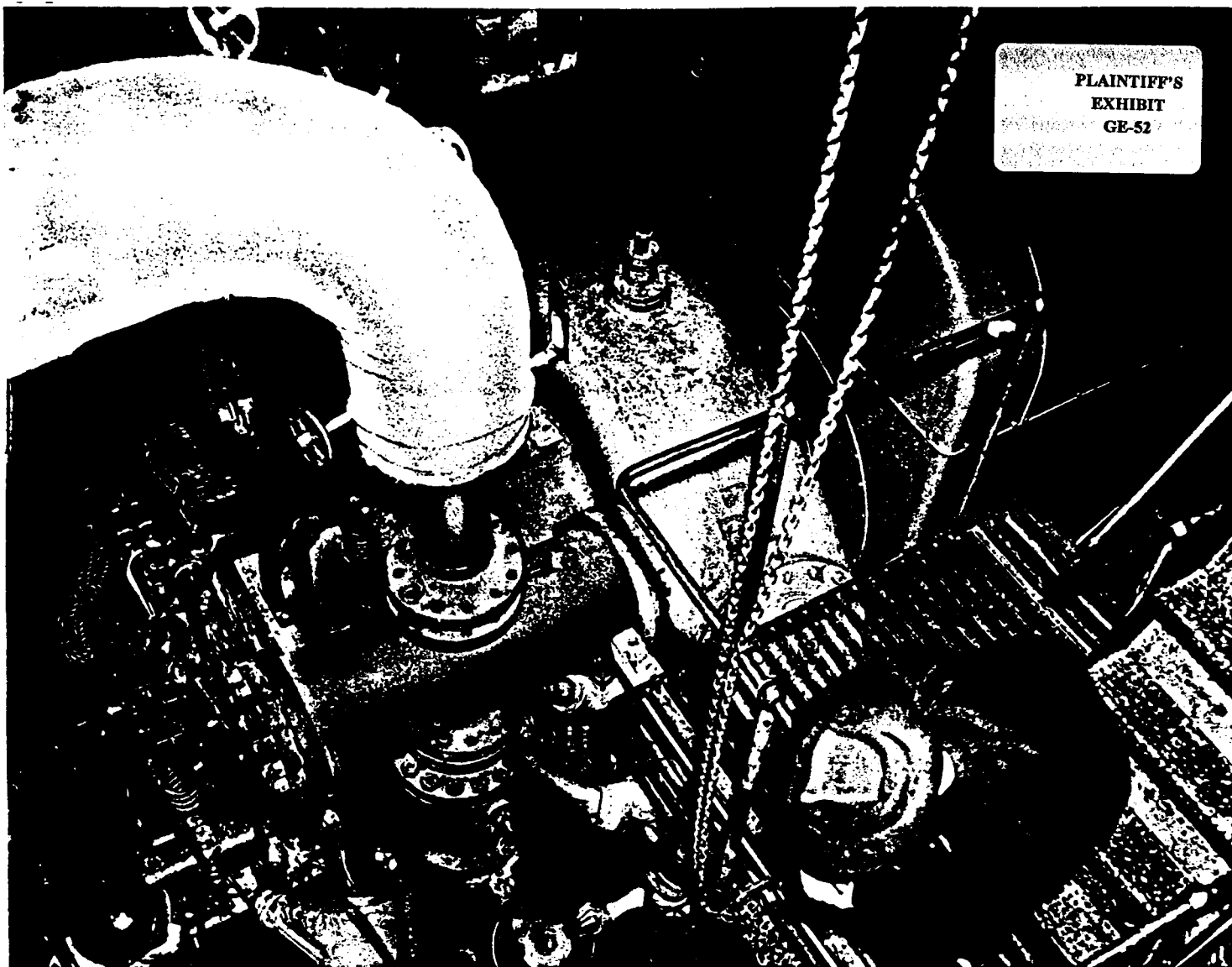


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PLAINTIFF'S
EXHIBIT
GE-52

Skilful UPKEEP OF
PROPULSION TURBINES

GENERAL  ELECTRIC



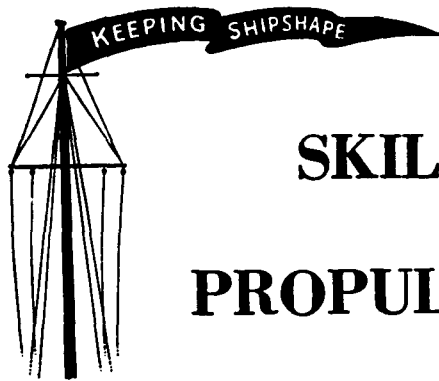
Harold J. Chase

EIGHTEEN years' experience in designing and installing turbines for marine and central station use is the record of Harold J. Chase of the Federal and Marine Department of the General Electric Company. Mr. Chase was born in Woodbury, New Jersey, but he received his education in Portland, Maine.

It was in Portland that he developed a seagoing urge which he satisfied, after graduating from high school, with some real blue-water sailing. The high point of his sea experience was the turn he served as quartermaster on a freighter going to the English Channel and North Sea ports.

In July, 1924, immediately after graduating from the University of Maine with a degree of B. S. in Mechanical Engineering, he joined the Test Course of the General Electric Company and went to work on turbines.

His broad knowledge of propulsion turbines, gained from first-hand field experience, makes him well qualified to write on their maintenance.



SKILFUL UPKEEP OF PROPULSION TURBINES



By Harold J. Chase

THE first requirement presented to the operator of a turbine is to keep the machine ready to meet a load schedule. This involves maintenance, and the best way to assure good turbine maintenance is to set up a system for regular inspection. This should establish a routine to be followed to indicate when and what corrections and repairs are made, and schedule corrections that need to be made. Of course, the character of the load schedule dictates the details of routine maintenance. With today's stepped-up shipping schedules keeping propulsion turbines humming there are many things to do during normal operation as well as during the out-of-service periods, that will contribute to smooth, trouble free service, and maintain high quality performance.

To extract the last bit of power from each pound of steam, turbines of all kinds depend on the accurate guiding of the steam flow. Essentially, this demands that the steam be confined to the smooth paths of the nozzles and buckets which have been carefully

designed by the turbine builder, and that waste flow along the shaft be cut down by well-designed and close-fitting packings.

One of the worst enemies of good turbine performance is distortion of the parts. This can result in all manner of trouble, from the loss of efficiency due to increased clearance, up to conditions where full power operation cannot be obtained because of permanent damage. Such distortion may come from misalignment, uneven heating of parts, or wear on some parts.

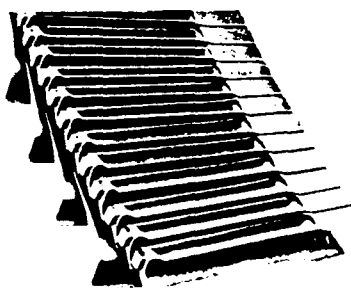
In some cases, misalignment may be due to connections to the turbine. For example, while foundations are ordinarily adequate, the uneven movement of supporting columns may cause trouble. Escaping steam from a joint or connection, loosening of heat lagging from a pipe near a beam, or emergency operation under reduced vacuum, may cause change in position of the turbine base. Such things, however, are ordinarily easy to find and correct.

Uneven heating of parts in the turbine itself is sometimes more difficult to deal with. The natural flow of heat in a turbine shut down after some hours running causes the rotor and casing to distort. Such distortion is most pronounced in the first hours after shutdown. To avoid this difficulty, many turbines are equipped with turning gears. This equipment consists of a small motor with large gear reduction, which is connected to the turbine to keep it turning slowly dur-

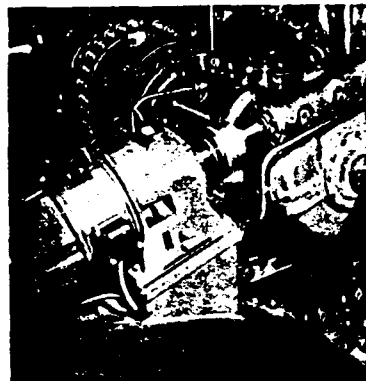
ing cooling down and warming up periods. Regular and consistent use of the turning gear will mean easier starting of the turbine; prevent packing rubbing; and result in better preservation of the close shaft clearances necessary to good economy. For turbines that are not fitted with motor-driven turning gears, it usually is possible to contrive some connection to the shaft to rotate it about half a turn every ten or fifteen minutes. Such a substitute is effective in keeping the shaft straight.

Uneven heating of the turbine due to steam escaping into the machine by way of a leaking valve in an extraction or drain line is a common source of trouble. Such flow of vapor into a turbine during shutdown may also cause corrosion.

Valve leakage can often be detected by noting if the pipe connections remain unduly warm when the turbine



Nozzles and buckets similar to these guide the steam smoothly



A typical motor-driven turning gear for a turbine-gear propulsion unit

is shut down. Operating the air pump daily during shutdown also helps dry out the machine.

Wear, as affecting distortion, is not usually very important and also is much less likely to occur in average turbines. Such things as wear on flexible couplings is brought under control by attention to lubrication. The same is true of bearings. It is usually possible to inspect such parts often enough to detect undue wear and make corrections.

Another operating problem that can have serious effects on the turbine is carryover in the steam. While modern boiler operation is ordinarily entirely satisfactory from this standpoint, it sometimes happens that the situation gets out of hand. Carryover into the turbine in the form of boiler compound, for example, can cause trouble by sticking the valves and can reduce the output of the turbine by its effect on the blades. This is a result of reduction of area of the nozzles, which is revealed by increasing turbine stage pressures, particularly in the high pressure end.

One short and general precept which applies to the whole problem of upkeep is to prevent repairs by keeping things clean. This applies, of course, to strainers, since oil, water, and steam strainers should be inspected frequently to insure that they are clean. Such points as governor levers and joints and valve sliding parts obviously must be kept clean, and should

be greased or oiled as directed by the manufacturer's instructions. The interior of casings sometimes can be inspected through inspection covers. When regular inspections are made, oil sludge and corrosion can be caught and the cause found before serious

ent installations vary, it is impossible to set up a schedule that will meet the maintenance requirements of every installation perfectly. For example, cross-compound turbines on a reduction gear equipment present a different set of requirements than a single casing turbine used with electric propulsion.

However, the general form shown here cross-indexes the points common to all types of turbines which should be included in the schedule for a daily check while under way. Normally, if the engine room watch takes records of the usual steam gage readings and also the normal lubrication oil pressures and temperatures, they will show if any particular change is taking place in turbine performance. However, these records cannot tell the whole story. The most thorough practice is for some engineer other than the watch to make the regular inspection according to a daily schedule sheet which can be signed and used as a record of the examination and the needed and executed repairs.

Here is a list of some of the important things to be considered in making the regular inspection:

1. General Cleanliness

Note particularly any leakage of steam, oil, or water. This should include also looking for any pipe covering becoming oil- or water-soaked.

2. Smoothness of Operation

Any unusual vibration or noise should be investigated and the cause



Governor and control-valve linkage as installed on turbine-electric propulsion unit

trouble results. Items such as oil or water seepages and drips should be repaired promptly, for although the loss or leak may not appear important at its source, such drips, especially of oil, may seep into pipe covering, or electrical apparatus, thus causing a fire hazard.

Because the requirements of differ-

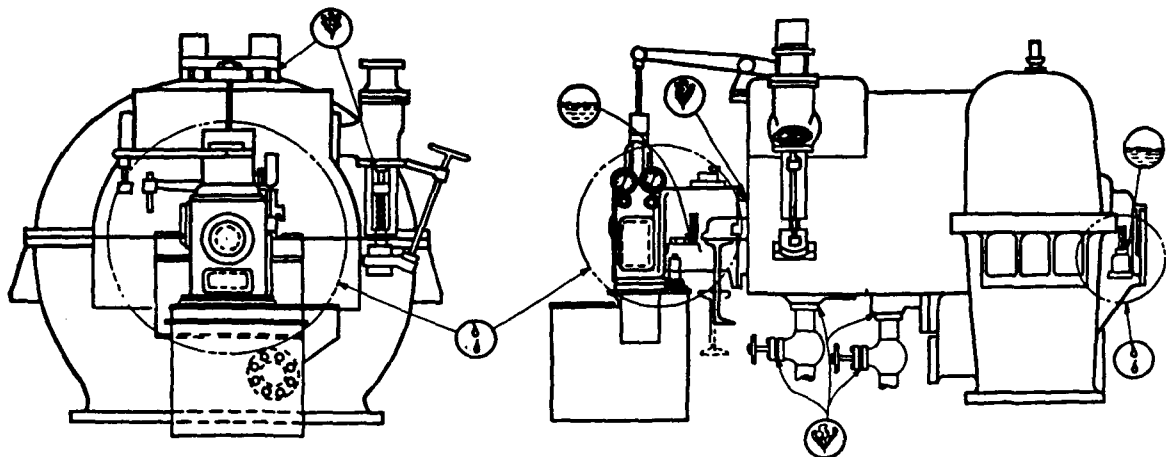


Diagram for use with "Daily Maintenance Chart" on next page

DAILY MAINTENANCE CHART

	CHECK	LOOK FOR			Test Operation
		 Oil Leak	 Steam Leak	 Oil Levels and Foaming	
1.	Main Turbine For'd End Aft End Rotor Position	✓ ✓	✓ ✓	✓ ✓	✓
2.	Trip Valve		✓		✓
3.	Control Valve		✓		✓
4.	Extraction Valves		✓		✓
5.	Oil Pumps (Stand-by)	✓	✓	✓	✓
6.	Oil Alarms				✓
7.	Oil Strainers	✓			✓
8.	Steam Seal System		✓		
9.	Thermometer and Gage Connections	✓	✓		✓

found. It may be a perfectly normal consequence of changing draft of the ship or the result of sea conditions.

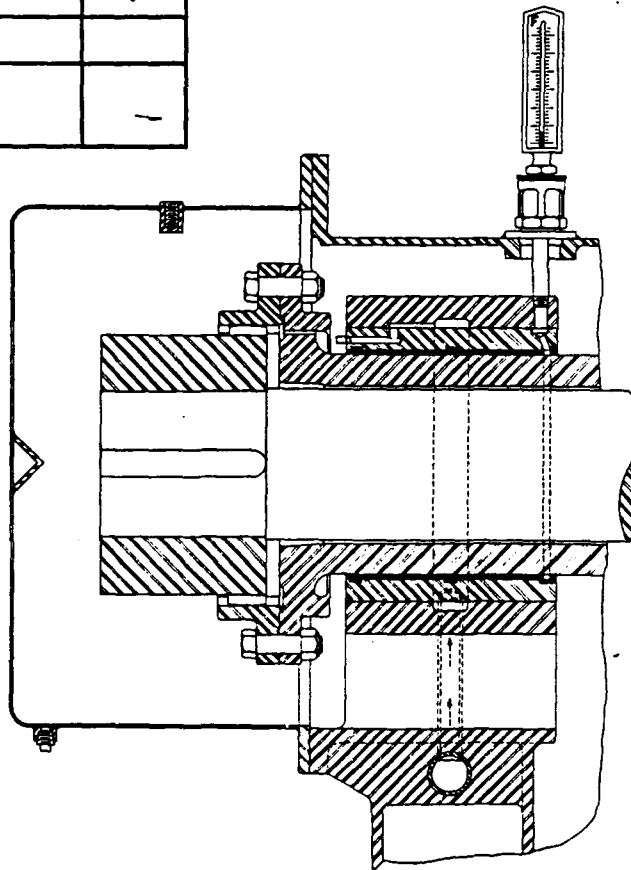
3. Gages, Meters, and Thermometers

Indicating instruments should be checked to be sure that they are in service as intended. Make sure that their sockets or bosses in casings or pipes are well secured, and that there is no vibration either of the gage needles or of the connecting piping.

4. Lubricating Oil Systems

An examination of the lubricating oil systems should include particular attention to any foaming or sludging or variation in normal oil levels in the system. It is sometimes helpful to draw off a small sample of oil from the sump tank to see if any sludge or water has settled there.

Section of bearing assembly, showing arrangement of thermometer and bubbler for observing condition of lubricating oil



5. Throttle Trip Valve

The throttle trip valve should be clean, particularly the stem and the guides to insure that it is free to act. Ordinarily it is possible to close this a few turns momentarily by means of its hand wheel to be sure that the valve stem moves freely.

6. Main Control Valves and Governor Parts

These should be kept cleaned and oiled and the moving parts examined for wear, binding, or lost motion.

7. Automatic Standbys

Where automatic standby equipment is used, a check should be made of the automatic features to insure that the equipment will come into service when required. For example, if an automatic standby lubricating oil pump is used, a test should be made to see that the pump starts and begins to deliver oil in response to its proper signal.

8. Alarm Signals

In addition to automatic standby equipment, there are often alarm signals to indicate such things as low lubricating oil pressure. The operation of this alarm system and similar ones should also be tested.

9. Strainers

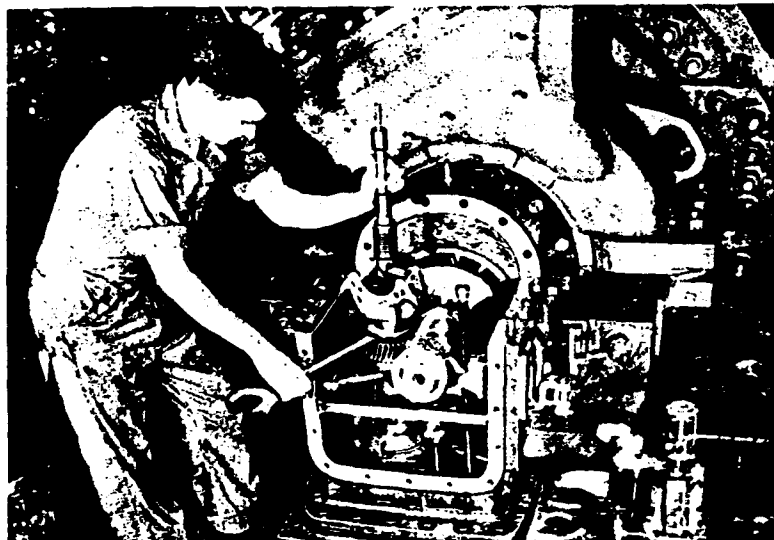
For continuous duty service such as lubricating oil systems, strainers are usually fitted in pairs such that one can be removed and cleaned while the other is in service. Certain cooling water lines sometimes have similar strainers. The regular watch should have a routine for cleaning all strainers to be sure that a clean strainer is always ready for service.

10. Steam Sealing System

During long voyages, the steam sealing system may not be called on to change its action for long periods. This may result in setting of the valves or wear at some particular point on the valve stem. Automatically controlled sealing systems should be checked to make sure that the valves move freely through the full range.

Major Inspections

Once a year the turbine should be completely dismantled for a thorough examination. Services of the shipyard maintenance crew and the turbine manufacturer's engineers are customarily called upon for these major inspections, and the extent of the maintenance necessary then will be in pro-



Governor and bearing housing of a propulsion turbine open for complete examination

portion to how well the daily job has been done.

As part of the major inspection, all valves admitting steam to the turbine should be tested to be sure that they close tightly. Main control and throttle valves, as well as drain valves and extraction valves can be sources of trouble if they do not seat properly.

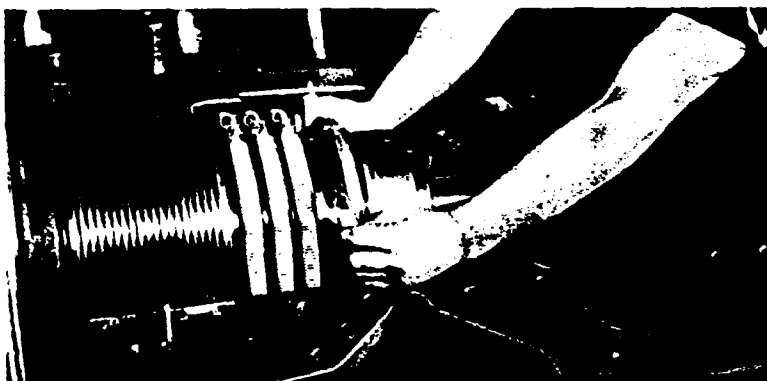
While the turbine is open, a complete clearance check should be made. This should include axial as well as radial clearances, especially around the shaft packings. At the same time, relative readings on the rotor position indicator and, if possible, the clearance inspection opening should be examined

to be certain that these external clearance indicating points are giving a true picture of the interior clearances.

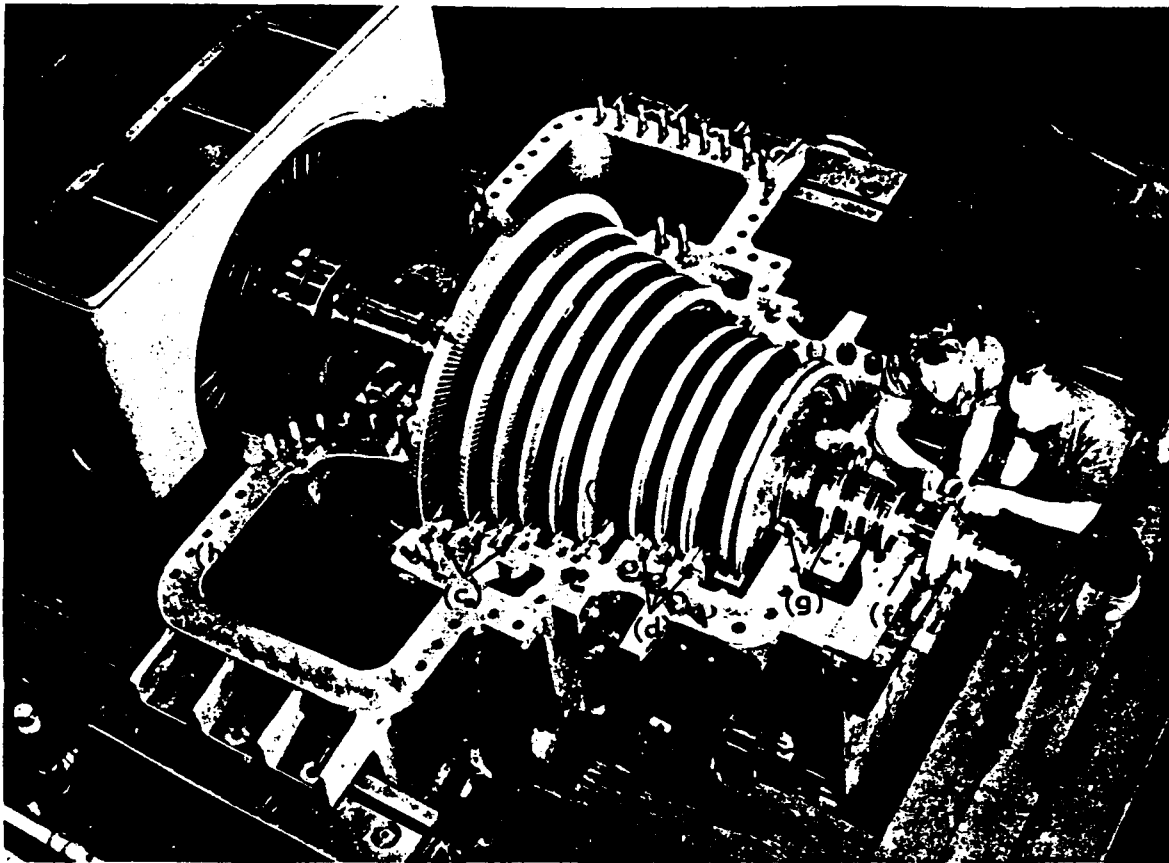
All blading should be examined very carefully for signs of deposits and also for water cutting. Deposits probably will be localized in the high-pressure end of the machine, where corrosion due to impurities in the steam may also be found. Water cutting, of course, is present only in the lower stages of modern high-temperature machines and here the water drainage systems from each stage should be checked.

The interior of the exhaust casing and the condenser tubes, if close to the last wheel, should be examined to see if water thrown off the last stage is impinging on them. On a geared unit, the astern element should be checked for signs of steam leakage past the astern valves.

All interior joints of the turbine, such as those of the stage diaphragms, should be examined for signs of leakage. Leakage may also occur through the packing rings, especially through high-pressure packing rings. Where packings depend on springs for fit, the springs should be checked to be sure that they are still strong enough to hold the packings in place.



Shaft-packing and carbon rings are part of the steam-sealing system



SOME OF THE IMPORTANT POINTS TO BE CHECKED DURING A MAJOR OVERHAUL OF A PROPULSION TURBINE

(a) High-pressure buckets

Scale may be found here. If it is, it can sometimes be removed by washing with water. Some scale must be scraped off mechanically—with emery paper or, if available, fly-ash.

(b) Low-pressure Buckets

Water cutting may have occurred here particularly at the entrance edges near the bucket tips. If they are deeply eroded, it may be necessary to install new buckets. Amount of the erosion which can be measured by using a straight edge and a feeler gage, should be recorded for comparison at the next inspection if the buckets are not replaced.

(c) Water Drainage Orifices

If the low-pressure blades have sustained severe water cutting, these ori-

fices will probably be found to be plugged so they do not drain properly. The orifices should be cleaned out thoroughly to prevent water from backing up and causing further cutting of the buckets.

(d) Diaphragm Joints

Leakage across these joints may be taking place. Flow marks will be evident if it is. Such leakage usually means that the diaphragm is not properly seated, or that a new joint key is needed.

(e) Rotor Clearance

This should be measured and checked against the manufacturer's original tolerance. If necessary, clearance of the rotor is adjusted by means of shims locating the thrust bearing.

(f) Bearing Clearances

If the clearance of the bearings is greater than the manufacturer's tolerance, the bearings should be rebabbitted or spares should be installed.

(g) Packing Rings

Excess leakage may be taking place if the packing clearance is considerably greater than the manufacturer's tolerance. In this case it will be necessary to refit the packing or install new packing to restore the original clearance.

(h) Casing Interior and Condenser Tubes

If erosion is found here, it may be necessary to install baffle plates to protect the eroded parts, which sometimes can be metallized to restore as well as protect their surface.

The following are the
 names of the members of the
 Board of Directors of the
 United States National Bank of
 Commerce, Inc., for the year
 ending December 31, 1934.
 The names of the members of the
 Board of Directors of the
 United States National Bank of
 Commerce, Inc., for the year
 ending December 31, 1934,
 are as follows:



GENERAL ELECTRIC
SCHENECTADY, N. Y.

CONFIDENTIAL

GENERAL ELECTRIC

SUBJECT PROPULSION TURBINES AND GEARS

LOCATION

REFERENCE

August, 1940

To Marine Equipment Salesmen:

Begun four years ago, the greatest boom in shipbuilding since the first World War is continuing now at a still faster pace.

Our orders for turbines and gears during the first six months of 1940 totalled more than 800,000 horsepower for 26 Navy and merchant vessels, including a superbattleship, light cruisers, destroyers, and a mine layer. Equipments ordered for merchant ships represent an increase of 144 per cent over orders for the first half of 1939.

This bulletin reveals the important part we are taking in this program and shows some of the new manufacturing methods and equipment we are using to meet the situation.

D.W. Niven
MANAGER, Federal and
Marine Department

D.W. Niven

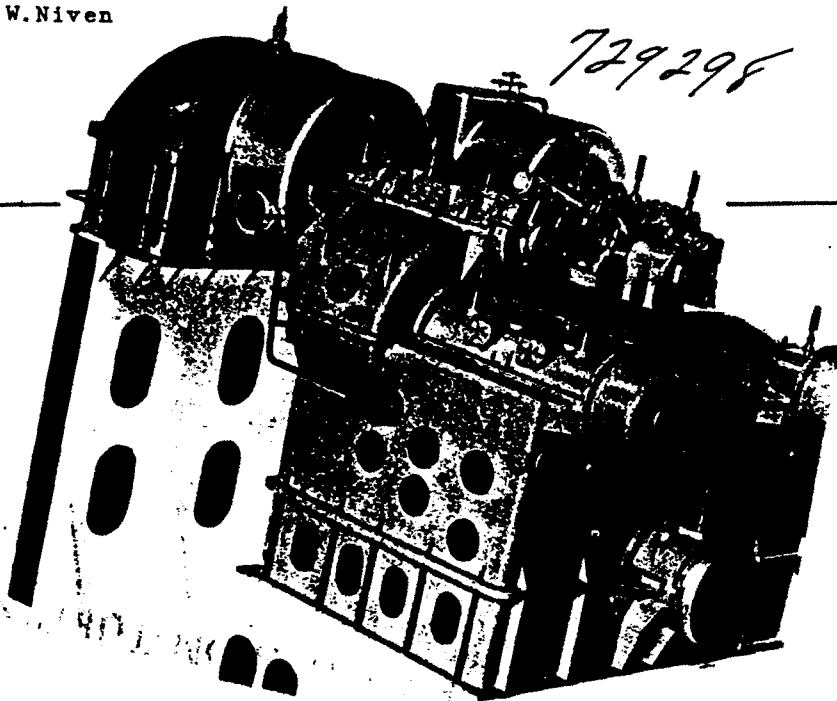


Fig. 1 - Model of typical G-E cross-compound geared turbine for merchant ships.

GEP-17

PROPULSION TURBINES AND GEARS

STEAM PROPULSION EQUIPMENT consists of high-speed, efficient turbines, generally of the cross-compound type, and double-reduction gears. The ahead turbine has a high-pressure and a low-pressure unit in series. The astern turbine has only a few stages, is located in the low-pressure casing, and develops from 30 to 40 per cent as much power as the ahead turbine.

Gear reduction may be as high as 70 to 1. On merchant vessels, mostly tankers and cargo ships, the gears are conservatively rated as the ships operate continuously at full power. Gears on naval vessels are more liberally rated because weight reduction is more important and they seldom operate at full power.

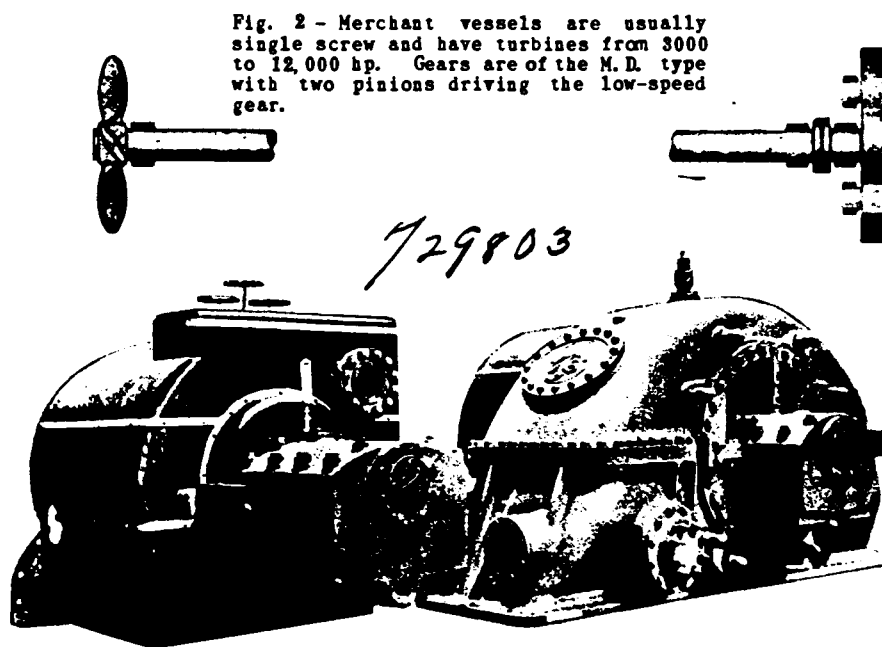


Fig. 2 - Merchant vessels are usually single screw and have turbines from 3000 to 12,000 hp. Gears are of the M.D. type with two pinions driving the low-speed gear.

P. TURBINE

H.P. TURBINE

Fig. 3 - Cross-compound turbine generally used with double-reduction gears (not shown) for merchant ships.

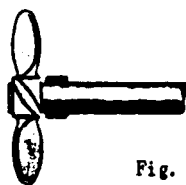


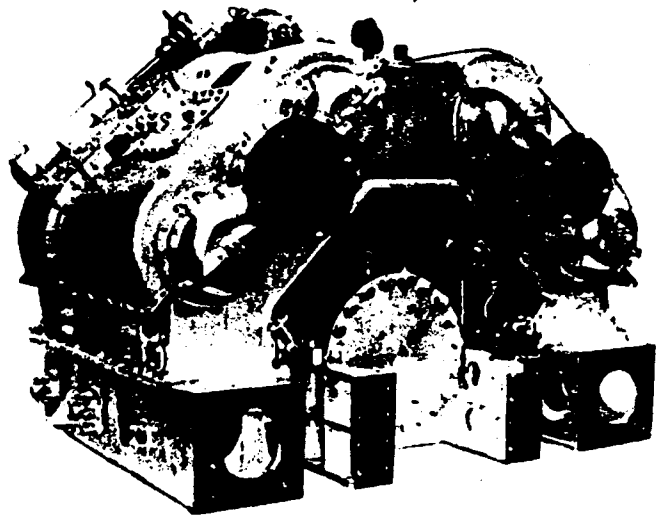
Fig. 4 - Destroyers are twin screw, cruisers and battleships have four screws. Each screw is driven by turbines above 25,000 hp and has MDT type gears with four pinions driving the low-speed gear.

L.P. TURBINE

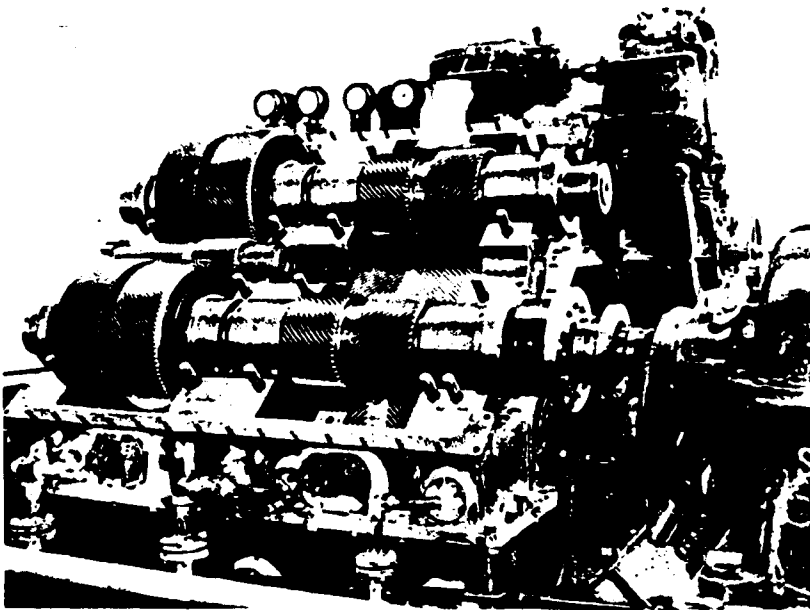
H.P. TURBINE

PROPULSION TURBINES AND GEARS

Fig. 5 (right) - G-E double reduction gears Type MDT-33-A for naval vessels and Fig. 6 (below) - with cover removed.



167 861



TURBINES for naval vessels are usually built at Schenectady; turbines for merchant ships and all reduction gears are built at West Lynn.

Because of the business upswing and an increase in the number of fabricated parts, additions to the fabricating shop at Lynn and installation of more annealing ovens was necessary.

726 221



Fig. 7 - Arc-welding the low-speed gear for a Gulf Refining Co. tanker. This is typical of fabricating done at West Lynn, as is...

PROPULSION TURBINES AND GEARS

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Fig. 8 - ...this center section of a double-reduction gear casing — being lowered into an annealing furnace after welding.

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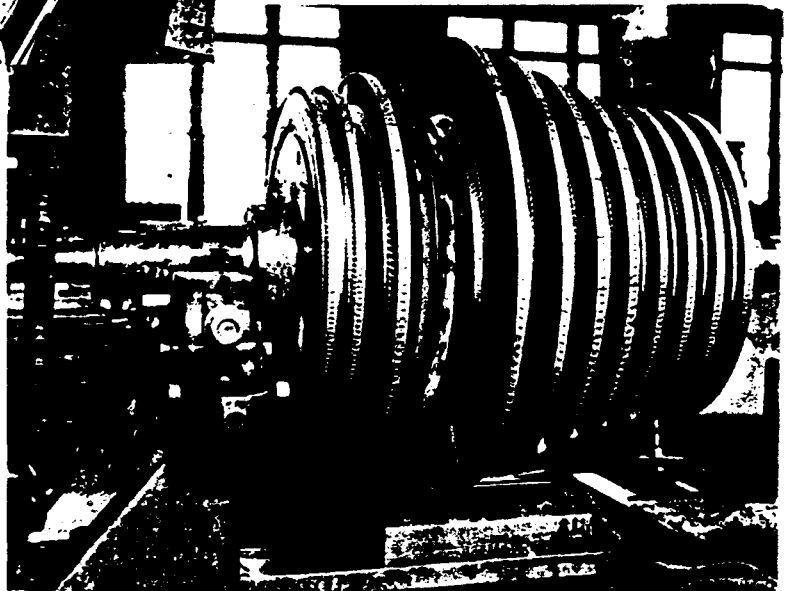


Fig. 9 - Propulsion turbines now have solid rotors -- wheels integral with the shaft -- like this low-pressure rotor for a cross-compound turbine. Lathes have been added to turn these large forgings.

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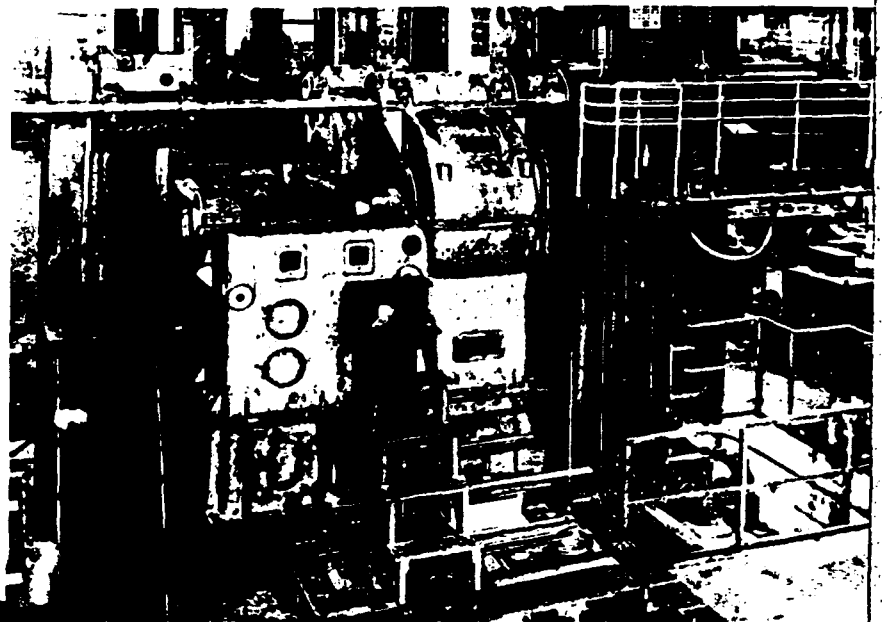


Fig. 10 - Machining a low-speed gear on a 20-ft vertical boring mill at Lynn. This giant and a 14-ft unit have been installed for boring low-speed gear hubs and for turning gear webs and tires.

PROPULSION TURBINES AND GEARS

729469

Fig. 11 - Two large horizontal boring mills have been installed for accurately machining gear casings with their numerous bearings.



729774



Fig. 12 - Quality and accuracy, for quiet operation, are built into G-E gears in this modern temperature-controlled building which houses such equipment as...

730274



Fig. 13 - ...this new 200-in. hobber (and another now under construction) as well as the 165-in. hobber, 200-in. gap lathe, and...

PROPULSION TURBINES AND GEARS

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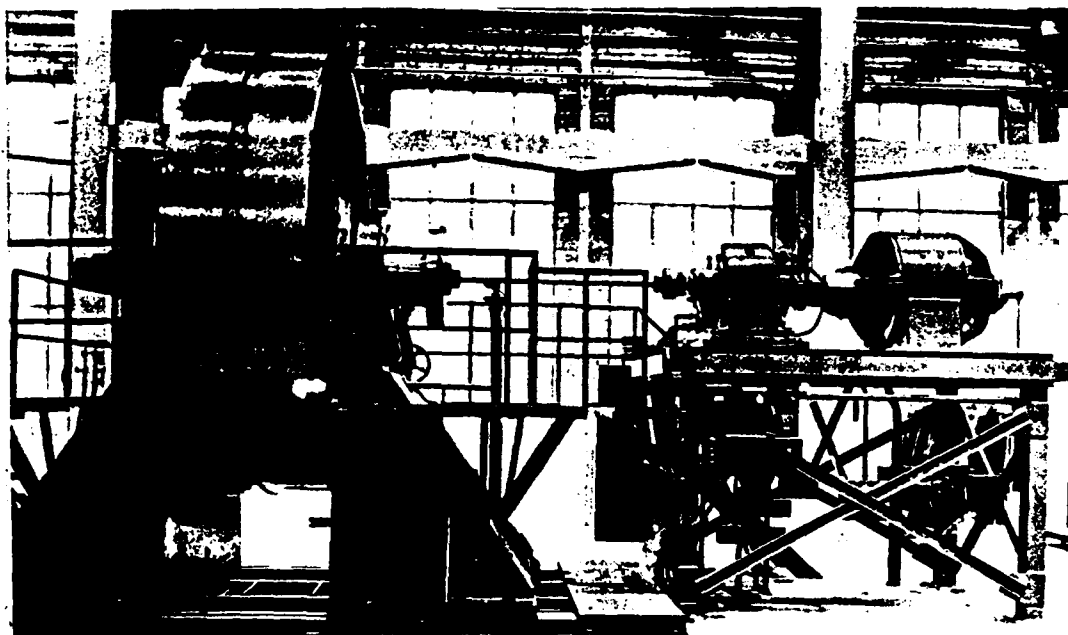


Fig. 14 - ...this dynamic balancing machine for large gears, and contact stands for improving the tooth contact.

THE 200-in. HOBBERs were built by General Electric because no manufacturer of gear-cutting equipment would meet our rigid requirements except at an exorbitant price. The excellent gears that have been cut on the new hobber justify the decision to build our own equipment.

729775



Fig. 15 - Gears and pinions in various stages of manufacture at Lynn.

PROPULSION TURBINES AND GEARS

729526

TESTING FACILITIES have been added to keep pace with the improved manufacturing equipment. New boilers installed recently will enable us to operate turbines under contract steam conditions.

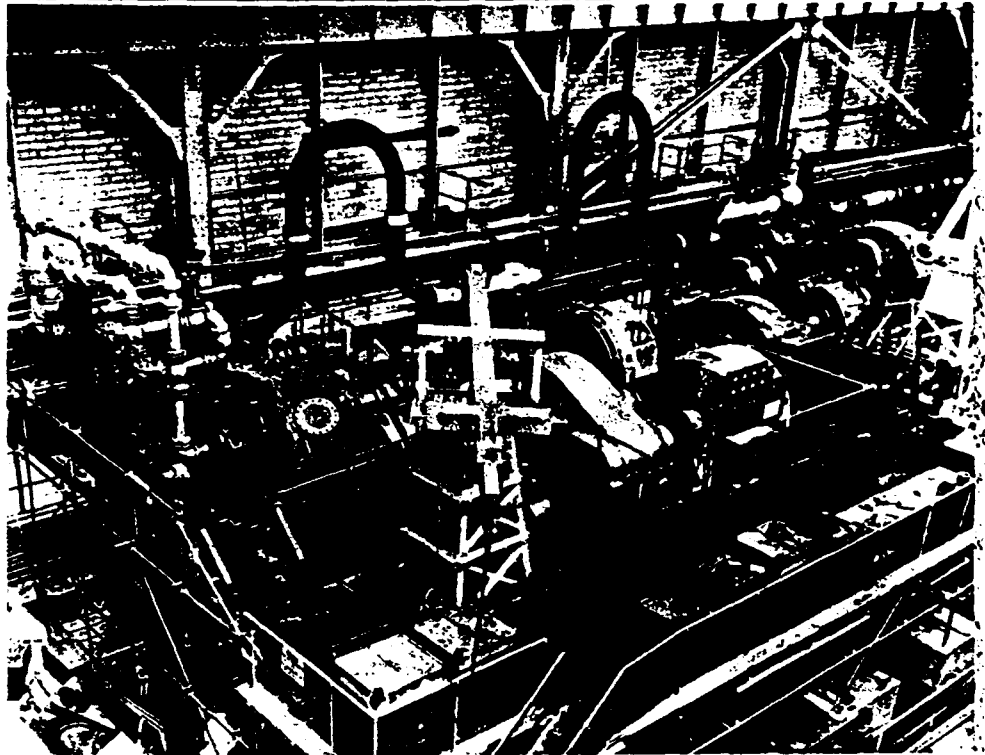
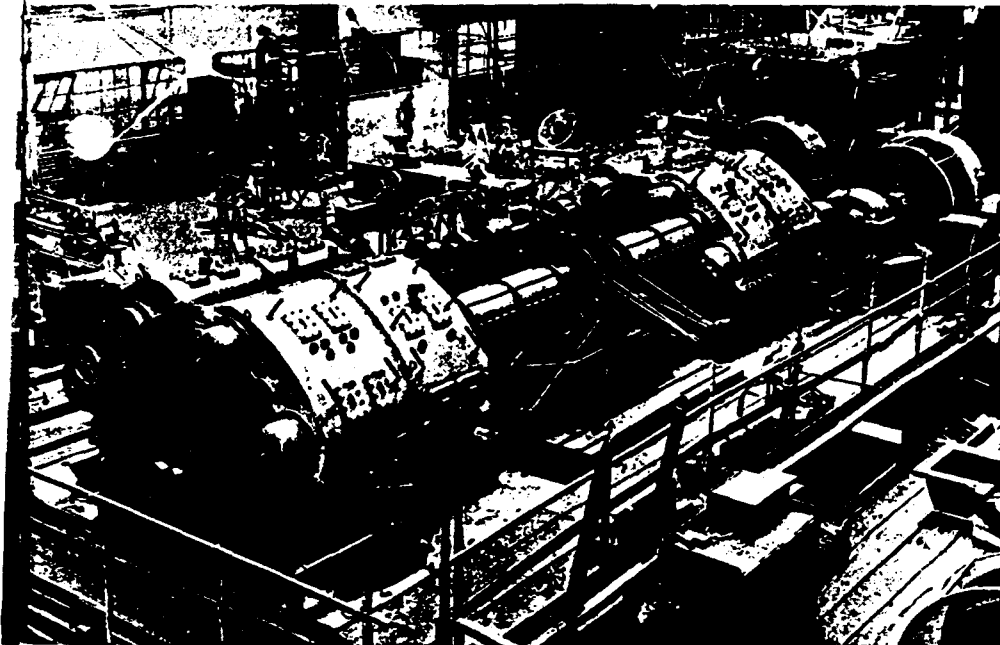


Fig. 16 - Four stands like these are available for assembling and testing turbine-gear sets — usually for merchant ships. The sets can be loaded up to about 8000 hp with the generators provided.

Reduction gears for naval combat ships, and other gears not assembled with their turbines, are tested "back to back" by special torquing devices to obtain full-load tooth pressures.

729816

Fig. 17 - For testing gears in pairs two stands are now available and a third is being erected.



In 25 years we furnished propulsion turbine-gear sets for 402 ships totalling more than 2,500,000 hp; turbines only for 23 ships with more than 1,100,000 hp, and gears for 41 ships with 900,000 hp. This experience combined with the remarkable equipment described herein will enable us to keep right on producing turbine-gear sets that set new standards for the entire industry.