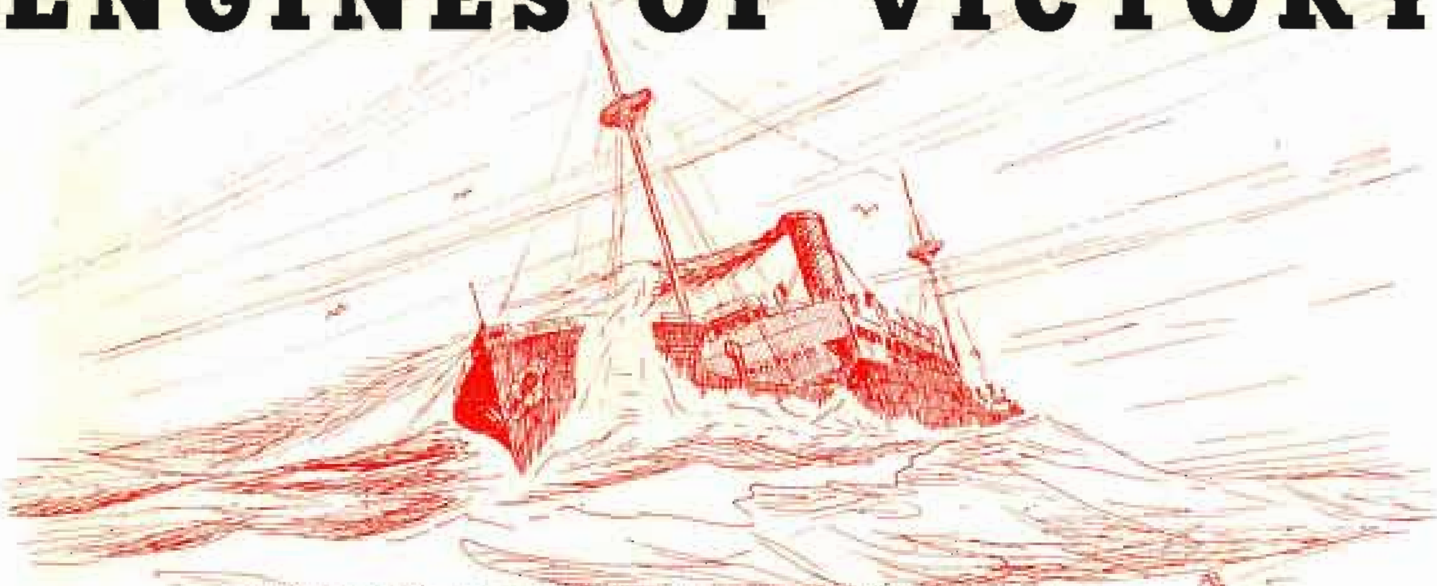
ENGINES OF VICTORY



"I'll stand the middle watch up here—alone wi' God an' these
My engines, after ninety days o' race an' rack an' strain
Through all the seas of all Thy world, slam-bangin' home again.
Slam-bang too much—they knock a wee—the crosshead gibs are loose,
But thirty thousand mile o' sea has gied them fair excuse . . ."

(McAndrew's Hymn) KIPLING, 1893.

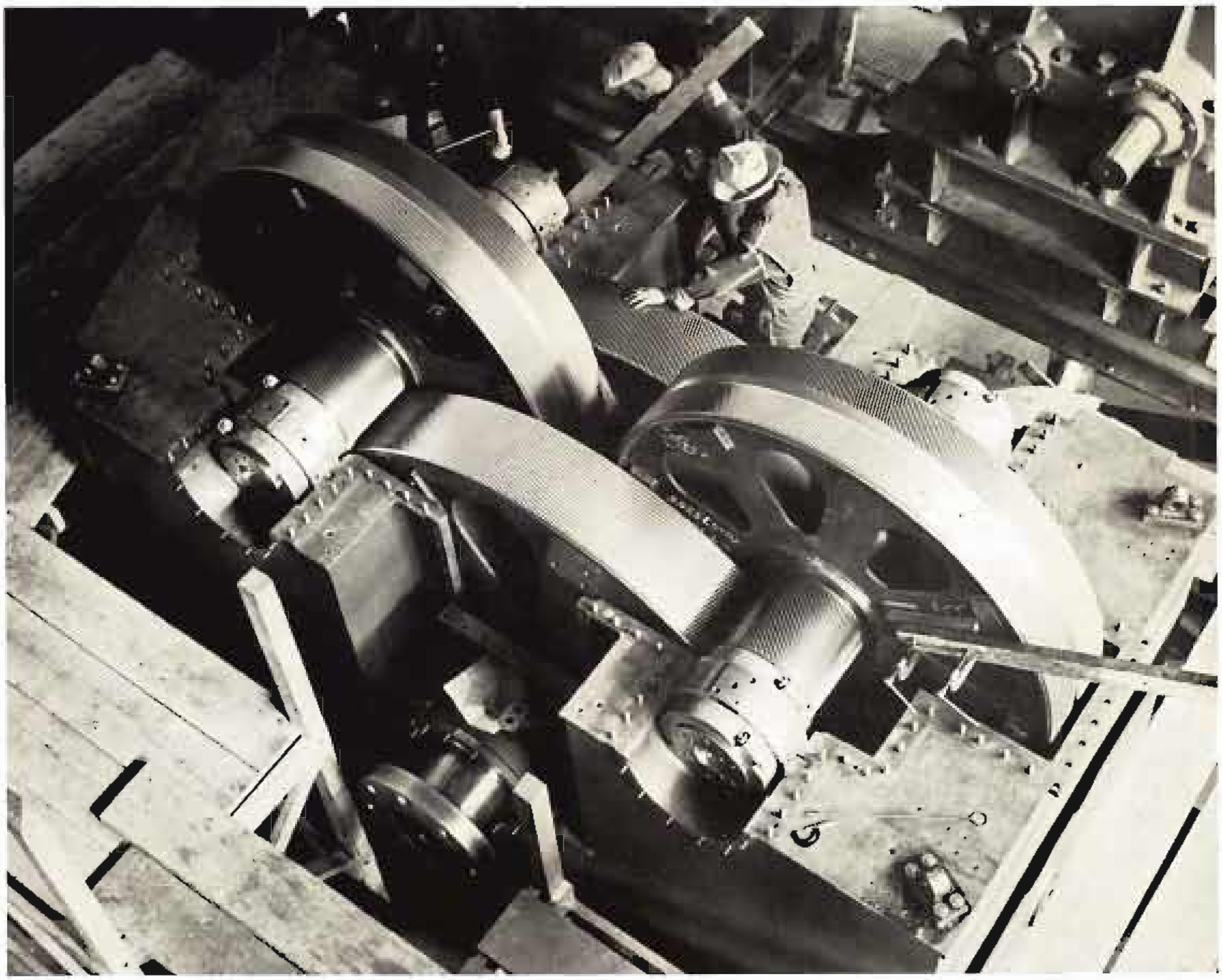
No war every fought on earth has been so far flung as the Second World War. Furthermore, of all its participants, the United States is the farthest from the actual fighting fronts. Add to that the fact that it is a war of machines and the production of more machines, and that in this the United States is the most potent member of the Allied Nations. As Allied success in the war depends directly upon American production so does the whole vast campaign depend directly upon ocean transportation, without which American products and American forces could not be taken to the battle zones.

The conclusion is elementary. The answer was to produce ships faster than they were being lost, and to minimize the loss of shipping by carrying on a concerted drive against the submarine menace. The record of ship production became fantastic as compared with the best records of World War I. They were incredible even from modern prewar standards. The showing of what could be done when the necessity was strong was a showing of miraculous strength of American industrial methods.

As a consequence, as ship after ship moved majestically into the water from coast to coast with increasingly monotonous regularity, the great shipyards were hailed by press, radio and public as the great instruments to Victory, which indeed they are. However, the fanfare and ceremony attendant upon the launching of a ship sometimes overshadows the important elements of the background which made the ship what it is. The advantage, from a publicity standpoint, automatically goes to the producer of the finished article, and in this case the shipyard gets the credit for the whole ship. Thus, if one is to really comprehend what a wonderful job has been done he must not see the ship as a single item, but must look at her fittings, equipment, and her engines, which were made by someone else and had to be furnished to meet a launching schedule which is outside the ken of peacetime industry.

The job which all U. S. industry has done to keep pace with the speed of the war effort is no less remarkable than the work of the shipbuilders who have more or less set the pace. This applies to all industrial operators the country over. *ESCO* is a part of it in its valve and fitting work for Maritime Commission and Navy, and

Charles E. Moore, president of the Joshua Hendy Iron Works, found, in the war demand for marine engines, an opportunity to test his ideas about line production, with the result that his company is now turning out one-third of the engines for the whole Liberty fleet, in addition to other vital power products.



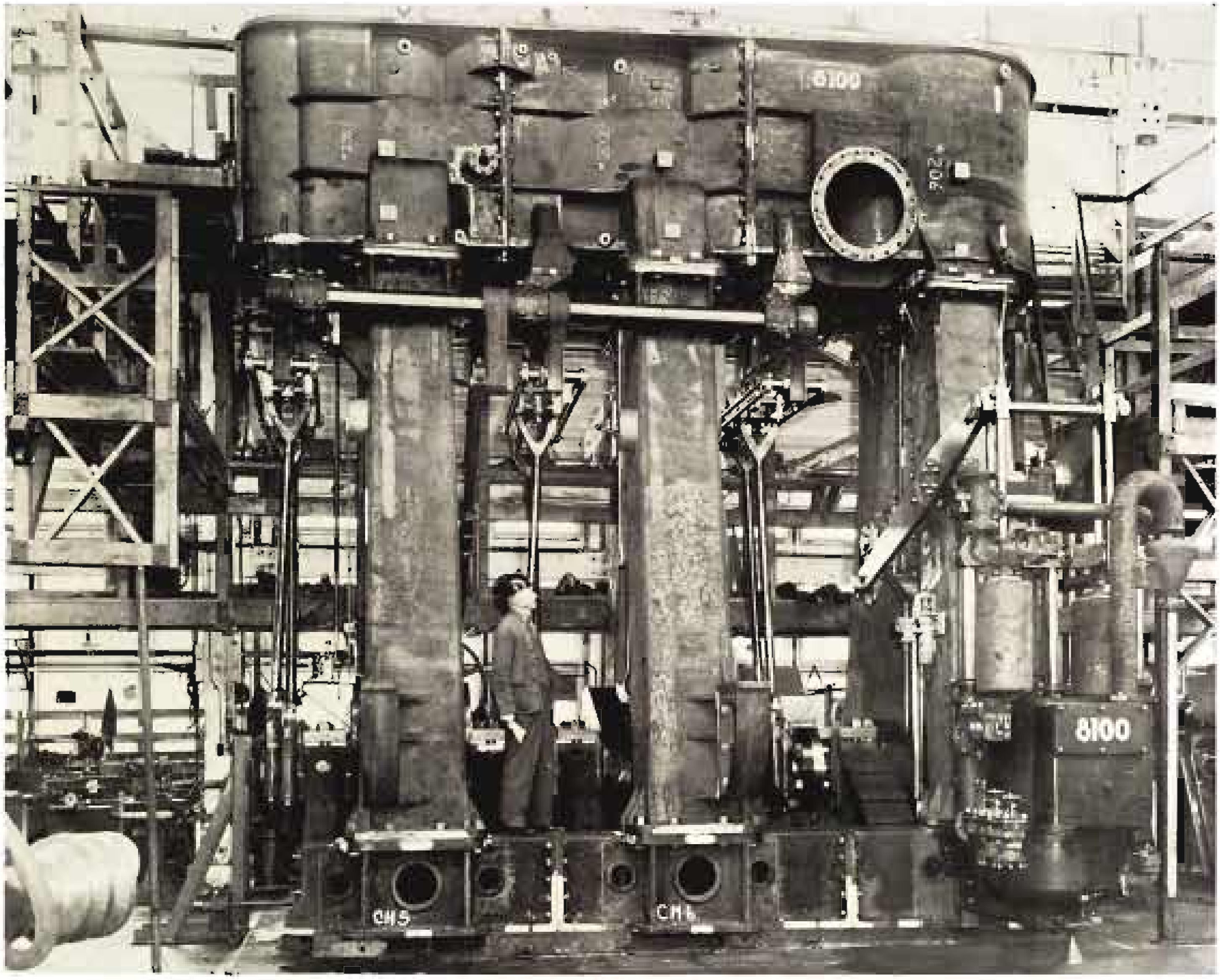
A view of the partial assembly of reduction gears, with the top of the case yet to be placed. The gear box is a part of the complete turbine unit, and in three reductions, brings a spindle speed of 6000 rpm down to 90 for the propeller shaft. Grinding of the bull gear takes 18 days, during which cutting must not stop and temperature must not vary more than two degrees.

there are literally hundreds of related enterprises who have the work of their shops in every ship which goes down the ways.

Two and one-half years ago, on the sunny plain of the Santa Clara Valley in California, a pear orchard blossomed near an old foundry, where for years the Joshua Hendy Iron Works had made a name as producers of mining equipment and other heavy machinery. It was still a year before Pearl Harbor, but the war was spreading even then and far-sighted men like Charles E. Moore anticipated the coming need for American industrial expansion. The Hendy property, which was then employing about 60 men and had been operating for six years under a receivership, was virtually without orders. It looked good to Moore and his associates, and they purchased the plant November 4, 1940. They set themselves up to produce the engines for the Liberty fleet which was coming.

First of all, the planners of the Liberty fleet adopted as standard a type of engine which was dependable, rugged, and which would lend itself to economical quantity production. This was the old triple expansion steam reciprocating engine long outmoded by the turbine. The Liberty fleets were to be equipped with engines which could be built as fast as they were needed, which was plenty fast, and which could be depended upon to come "slam-bangin' home again" no matter what happened. They were designed by Scotch marine engineers like those immortalized by Kipling and Guy Gilpatrick, the McAndrews and Glencannons of all the seven seas.

The Moore associates rebuilt the Hendy plant and began a program of engine building which was destined to make industrial history. The Liberty engines stand 25 feet high, weigh 137 tons and develop 2500 horsepower. They were needed by the hundreds. Production speed on this engine was achieved by the revolutionary process of putting it on a production line, like an automobile. Previously a job that was fitted and machined by hand, the engine was replanned by Hendy engineers so that all parts are now standardized to a point where they can be put together with a minimum of individual fitting. Once as-



Ready for testing is this Joshua Hendy-built triple-expansion reciprocating steam engine, which will power one of the Liberty Fleet. It is 25 feet high, weighs 137 tons, and generates 2500 horsepower. These engines are being turned out by Hendy at rate of one every 22 hours.

sembled and tested they are taken down and loaded on four flatcars for each, to be shipped to their destination on a schedule of *one a day!* Joshua Hendy today is turning out one of these giants every 22 hours, and this firm is supplying motive power for one-third of the Liberty ship fleet.

In the corvette building program, which is part of the answer to the enemy submarine problem, and an important part, too, the production of powerful engines to drive these fast little destroyers was a serious bottleneck which threatened to hold back the speed of delivery of finished ships. Each of these formidable little fighters contains two four-cylinder Vicars type reciprocating steam engines which weigh 70 tons each and develop 2750 horsepower apiece.

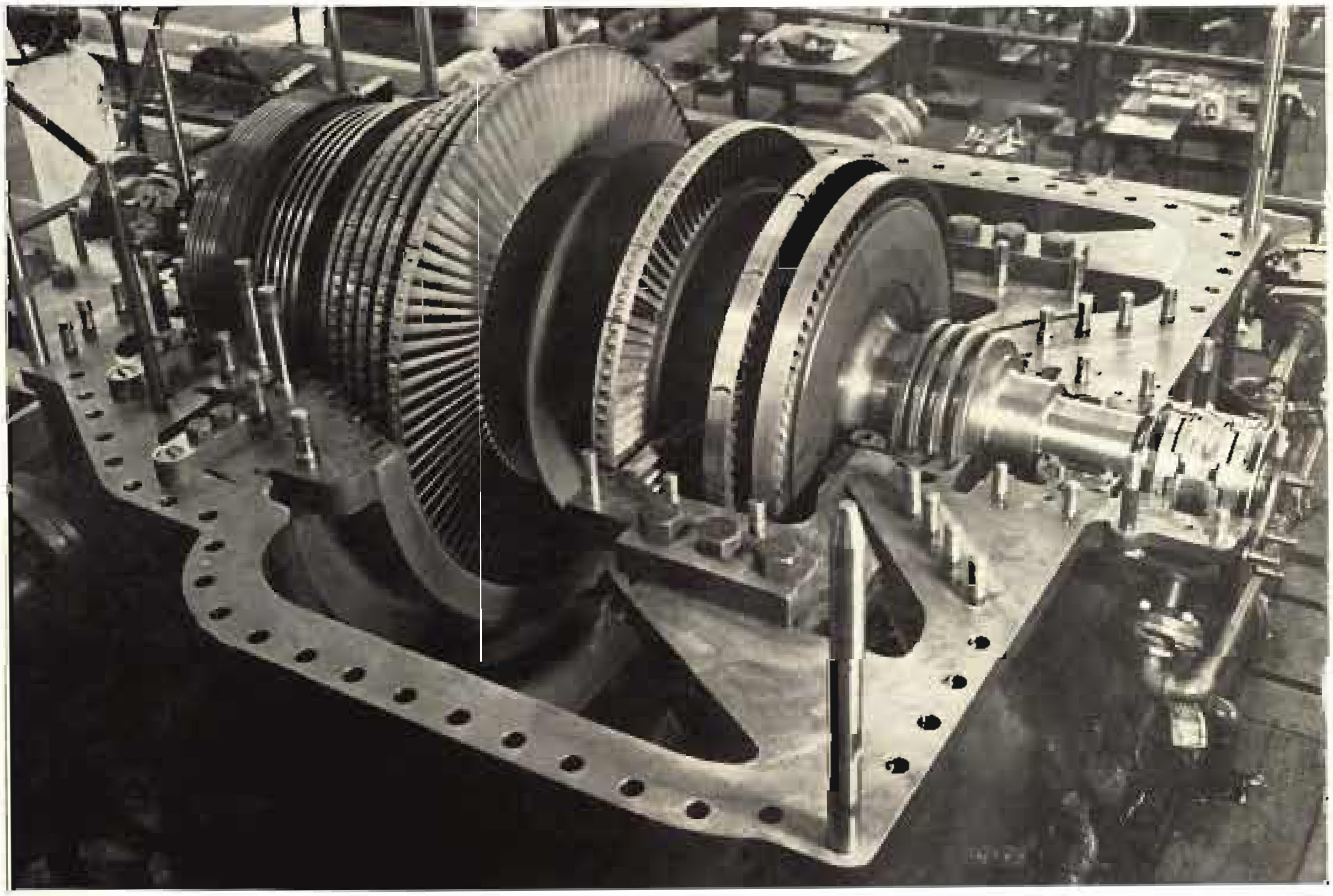
The "Iron Men of Hendy" undertook production of these matched pairs of engines in the same manner they had handled construction of the Liberty ship engine. They put them on a standardized assembly line basis and sent them rolling out. The month of June, 1943, said Secretary of Navy, Frank Knox, (and said also Winston Churchill) was the best month of the war in the record of shipping losses by submarine, in that these losses are unbelievably lower than previous months and a greater toll of enemy submarines sunk has been taken. This means that our anti-submarine-ship construction is taking effect. Engines made possible by enterprising industrialists like the "Iron Men of Hendy" are sweeping the seas.

But the production of reciprocating marine engines wasn't even half of the story. The shipbuilding program gained momentum and engines had to be supplied for more than just corvettes and Liberty ships. A Naval building program has been going forward, too, on the construction of all classes of Naval ships so that today Secretary Knox is able to tell us that the U. S. Navy is built up 60 per cent in tonnage, and 100 per cent in numbers over its strength in 1942!

U. S. Naval ships are the best there are. Into them goes the finest in the way of material and equipment and their engines must be of the latest type, the best built, powerful, fast, efficient. The last word in steam propulsion is the turbine—reduced to simple terms, a series of intricate fans blown by steam at high pressure and tem-

First Hendy turbine ever built was installed in the C-1 ship, Mormactern and functioned perfectly in spite of "remote control" methods of assembly and testing necessitated by the complex job of building and tooling a turbine shop. H. C. Buckingham, turbine engineer, (center), proudly demonstrates the fine machining of an L.P. spindle to Chief Engineer John J. Valentine (left), and First Engineer Curt Schmutch of the Mormactern.

This is one of the "steam windmills" which provides the turbine with its source of power. Pictured is the spindle and blade assembly of the low-pressure turbine which is teamed with a smaller high-pressure job and a reduction-gear case to make up the complete unit for the C-1 Victory ships, capable of 17 knots or better.



Tolerance on the reduction gears of the Hendy turbine is kept at a minimum of .0002, necessitating exacting finishing work, a large part of which is performed by women workers.

perature, at high speeds, which are passed through reducing gears to the propeller shaft.

Turbines are also used on most modern merchant ships with the exception of the EC 2 (Liberty). A few C-1 type ships are powered with Diesels.

With an increased demand for steam turbine power plants a year and a half ago, Hendy's blooming pear orchard gave way to a new modern plant addition with plans for turbine production which caused skeptical snickering among eastern engineers. Hendy had contract to produce 4000-horsepower turbines on a production basis and to turn out the first one within nine months at a time when the pear orchard was still flourishing and they had neither shop, equipment nor previous experience. The skeptics laid bets (1) that Hendy would not make the time limit and (2) that a practical Hendy turbine would *never* be produced. The "can do" spirit with which Hendy had surmounted other obstacles went to work and in December the first complete turbine was assembled, in the *Mormactern*, a C-1 type merchant ship. According to Maritime Commission inspectors, it functioned with perfection.

This 4000-horsepower turbine being produced by Hendy is composed of three main parts: a high pressure and low pressure turbine, and a gear reduction unit which is larger than both of them put together. The first turbine gets the steam at a pressure of 440 lbs. per square inch and a temperature of 740° with a resulting spindle speed of 5995 R.P.M. A given point on the circumference of the blades will travel approximately 10,000 miles in 24 hours of operation. The steam then goes into the second turbine at a 30 lb. pressure, producing a speed there of 4662 R.P.M. The reduction gears, of which the largest is 104 inches in diameter, bring the spindle speeds down to 90 R.P.M. in a double reduction. This is the speed at which the ship's propeller rotates.

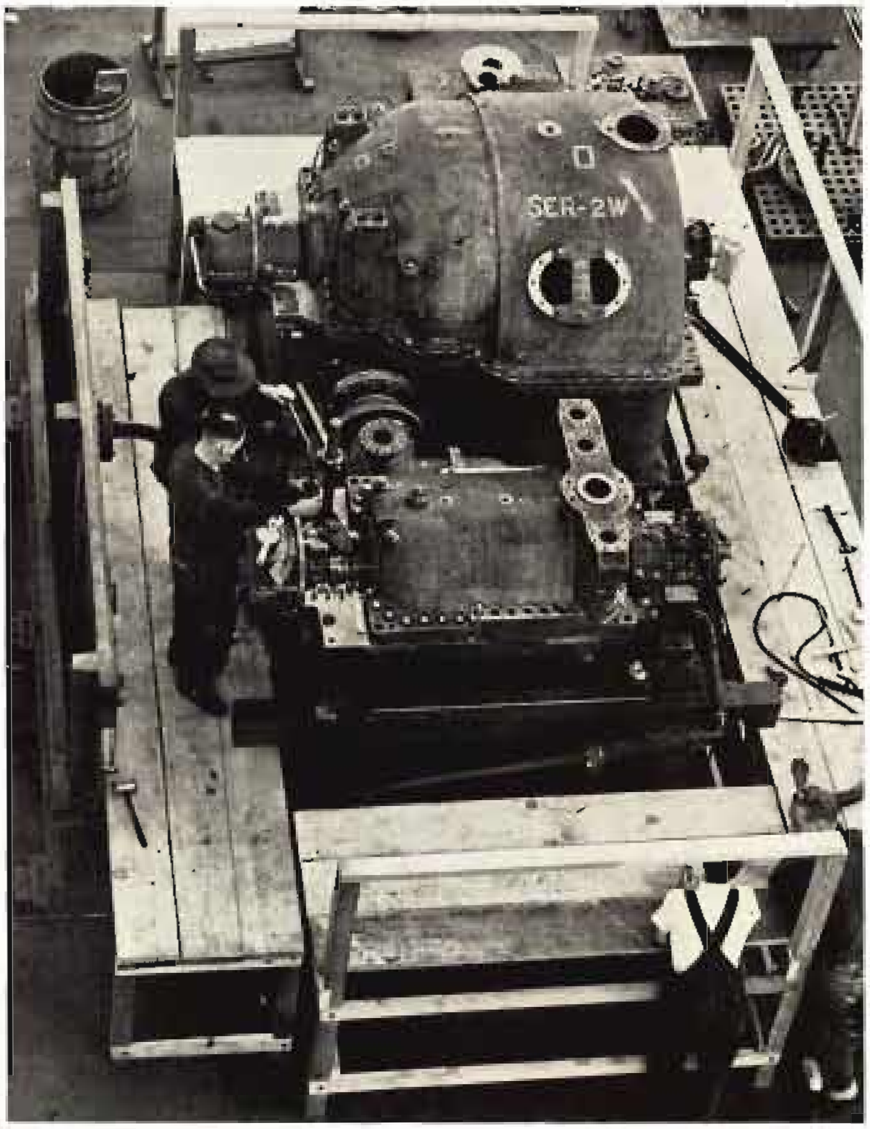
Such high speeds at which the turbines operate demand the highest standards of precision. A minimum tolerance of .0002 is maintained by Hendy engineers for all contact points, and that accuracy is rigorously checked by the Turbine Gauge laboratory, complete with a wide assortment of the finest precision instruments obtainable.

The most remarkable thing about the first turbine job was that at the time of delivery the shop still lacked 60 per cent of the essential tools with which it is now stocked. According to Manuel Aflague, turbine superintendent, "We did what we could on our machines, then used a knife and fork for the rest of the job." Hendy is no longer using a "knife and fork" On the contrary, the plant is completely tooled, and even makes machine tools to make machine tools—notably an improved and time-saving gear-hobbing device.

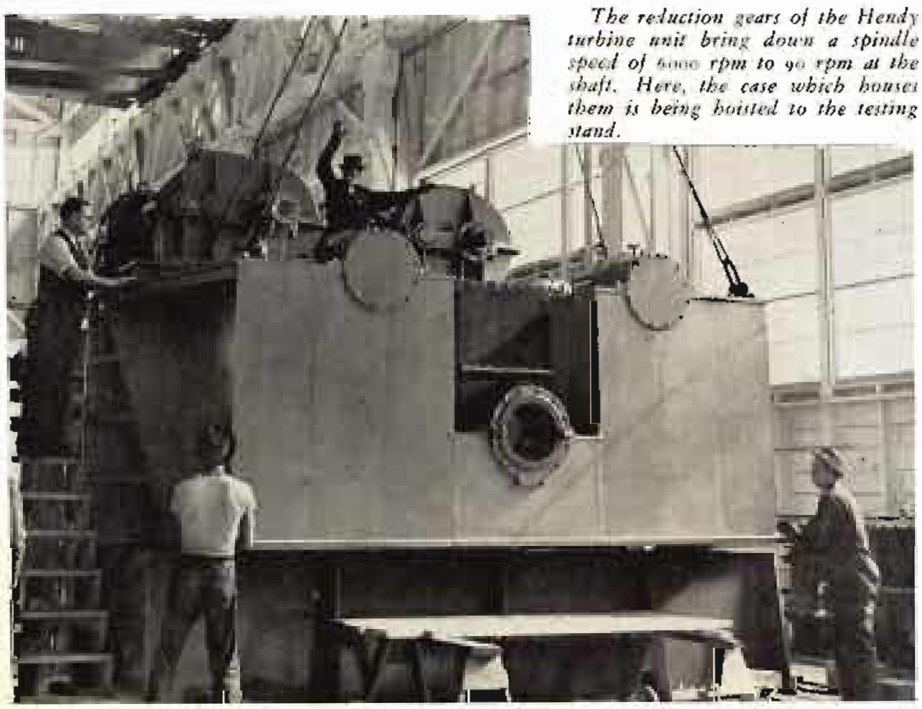
In keeping with the precise craftsmanship necessary must also be the quality of the materials used. Much credit on this score goes to Hendy's suppliers the country over who produce the material for Hendy's intricate handiwork. *ESCO*, for example, supplies such of these things as cast steel parts for some of the Liberty engines, notably reversing gear lever castings.

ESCO also furnishes Carpenter tool steel in large quantities for use in making the tools and dies of the Hendy shops in addition to hundreds of thousands of pounds of stainless steel rolling mill products used in the manufacture of turbines.

Preparations are now under way for starting production on an 8500-horsepower turbine without reducing the out-



A Hendy turbine unit is being assembled. The lower turbine gets steam at 740 degrees temperature and 440 pounds pressure, generating 6000 rpm, then feeding the steam at 30 pounds into the larger, which revolves at 4662 rpm. Total horsepower is 4000. The gear case into which they feed is tested separately, and the two parts are assembled aboard the C-1 ship which they are to power.



The reduction gears of the Hendy turbine unit bring down a spindle speed of 6000 rpm to 90 rpm at the shaft. Here, the case which houses them is being hoisted to the testing stand.

put on the 4000-horsepower engine—in the same way the first turbine contract was accepted and executed without interfering with the program of other products. Hendy is also similarly beginning production of a line of 300KW turbo-generators to serve as auxiliary lighting and power units for maritime vessels, and now undergoing tests are Diesels of a new type.

Adaptability is perhaps the most characteristic quality of the Hendy plant in Sunnyvale, for it is so equipped and organized that it could almost without delay, start manufacturing practically any type of large machinery.

The turbine accomplishment is characteristic of modern Hendy history. Compared with the situation of the Hendy plant in 1940, it today employs 6500 men and its orders run into millions of dollars. The extraordinary record established in the building of many types and kinds of engines at the same time without interference with each other is due in large part to numerous time-saving devices plus the assembly line method, which, for example, enabled the reduction of time on final assembly of Liberty engines from 4800 to 1800 man hours! Instead of following usual shop practice of using flexible standard tools, Hendy utilizes dozens of small machines rigged for their special repetitive operations; set-up plates to save machine time, and innumerable jigs and fixtures for fast accurate production.

Thus, in another brilliant example of American enterprise at work, it is seen how the seemingly impossible is done when the necessity demands it. It is clearly demonstrated how the comparatively easy-going U. S. industrial world snaps from its lumbering peacetime stride into vigorous energetic action in war, accomplishing things under forced draft in a few months which would take years to do at the old peacetime pace.

Today Joshua Hendy builds the only marine turbines ever built west of Milwaukee and the "Iron Men of Hendy" say they're the best ever built anywhere!