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ECONOMIC INTELLIGENCE REPORT

PRODUCTION OF MARINE STEAM TURBINES AND GEARS IN THE USSR

CIA/RR 46

8 October 1954

CENTRAL INTELLIGENCE AGENCY

OFFICE OF RESEARCH AND REPORTS

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PRODUCTION OF MARINE STEAM TURBINES AND GEARS IN THE USSR*

Summary

The current Soviet program for building cruisers and destroyers has created an unprecedented demand for marine steam turbines. Soviet factories have met the requirements by diverting some facilities formerly engaged in building turbines for land power installations and by eliminating geared turbine drives in merchant ship construction. Inability to produce all the new turbines needed for both naval construction and the expanding industrial economy has led the USSR to import turbines for stationary uses. In some recent years, Soviet imports of stationary turbines have run as high as 20 percent of requirements.

During the period 1949 to 1955, Soviet production of marine turbines is estimated to average 1,450,000 horsepower annually. This is more than twice US production for the same period. About 67 percent of US production has been for merchant ships. Soviet production has so far been allocated entirely to naval combat ships. The horsepower output of turbines produced for warships in the US during the past 5 years has been less than 17 percent of Soviet production.

There are few plants in the USSR capable of producing large marine geared turbine units. As a result, the industry is highly concentrated with 67 percent of the production in Leningrad, 25 percent in Khar'kov, and 8 percent in Sverdlovsk.

There is little information on Soviet plans for the industry, but there are some indications that planned increases in turbine production through 1955 will permit deliveries of destroyers and larger vessels from Soviet shipyards through late 1956 or early 1957.

* The estimates and conclusions contained in this report represent the best judgment of the responsible analyst as of 1 July 1954.

I. Introduction.

A. Definition.

Marine steam turbines are propulsion engines which convert heat energy into rotary motion. In many cases, diesel, gasoline, or reciprocating steam engines can be used as substitutes, but wherever a large amount of power is needed, as in large, fast merchant ships and major surface warships, there is presently no satisfactory substitute for the marine steam turbine.

The rotary speed at which marine turbines operate most powerfully is much faster than the efficient speed of the propeller which drives the ship. The power of the revolving turbine shafts is, therefore, transmitted to the propeller shaft through a reduction gear which permits the turbine and the propeller to revolve at different speeds.

The production of turbines is a specialized process which requires highly trained technicians, skilled labor, and complex, special-purpose machines. There is no basic difference in the capital equipment or skills needed to manufacture marine turbines and stationary turbines. A factory which produces marine steam turbines can usually produce stationary turbines and frequently produces both types.

Gear production, however, is more specialized. There is no need to reduce the shaft speed for most stationary turbines. Accordingly, the gear industry will usually have a smaller capacity than the turbine industry.

B. Importance.

The ability of a country to manufacture turbines is one measure of its industrial capability. Inadequate production of turbines or gears can limit the growth of the economic or naval strength of a nation. 1/* In turbine production, the limitation may be the priorities granted the industrial, merchant fleet,

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and naval users. In gear manufacture, the limitation may be inadequate production facilities* as well as priority. 2/

Since the end of World War II, all of the marine steam turbine production in the USSR is believed to have been used in warships. The result has been a denial of further expansion in the merchant fleet. About 35 percent of all turbine production, marine and stationary, during 1949-51 was for the navy. 3/ One of the results of this policy was the necessity to import from the European Satellites and from Western countries 20 percent of the turbines needed for stationary uses. 4/

C. History of Soviet Production.

Foreign successes in the use of marine steam turbines in ships influenced the Czarist fleet to try an imported turbine as the main machinery for the naval yacht Lastochka in 1904. 5/ During the years 1905 to 1907, the Baltic Shipyard was expanded and rebuilt, and in the reorganization of the yard shops, construction facilities were provided for Parsons-type turbines. In 1911, the Petrovski Metalworks also began to produce marine turbines, manufacturing the first large native-built main propulsion turbines used in the Russian Navy. These were for the Petropavlovsk class battleships. The total horsepower for each of these ships was 38,000. 6/ In the same building program were the 40,000-horsepower destroyers of the Novik class. Most of the destroyer turbines were imported, but the choice of propulsion is interesting because the destroyers, at the time, were claimed to be the most powerful in the world. 7/

With the advent of the Soviet regime in 1917, production of marine turbines was limited to the Petrograd (Leningrad) area. The neglect of heavy industry which characterized the first 10 years of Soviet rule was especially evident in shipbuilding and allied fields. 8/ By 1928, the annual Soviet turbine production for both marine and stationary use totaled only 35,700 horsepower -- less than was used in one of the old 1911 class battleships. 9/

* In the US in World War II, shortage of reduction gears was a major factor in the decision to build many ships with reciprocating steam engines, diesel, and turboelectric propulsion.

Special attention was given to turbine production during the First Five Year Plan (1928-32). By 1932, steam turbine production, marine and stationary, had risen to 6 times that of 1928. 10/ Following the Czarist pattern, the Soviet authorities turned to the West for designs, adopting Italian and Swiss turbine designs for production in Soviet plants. 11/ During the Second (1933-37) and Third (1938-42) Five Year Plans, new turbine plants were built and older plants modernized and enlarged. This development occurred at a time when new shipyards at Nikolayev and Komsomol'sk were being built and expanded. 12/ Equipment necessary to manufacture turbine reduction gearing was included in shops of the turbine plants, with the result that the USSR today probably has a balance of gear production facilities to turbine facilities better than that of many Western countries. Quantity production of marine turbines began in the mid-thirties and has constituted a significant percentage of turbine production ever since.

II. The Manufacturing Process.

A. Organization.

In the USSR today, most of the plants which produce marine turbines and gears are under the Main Administration of the Boiler Turbine Industry (Glavkotloturboprom) of the Ministry of Heavy Machine Building. Main reduction gears are often produced in the turbine plants. 13/ Marine turbine producers, generally speaking, also produce steam, gas, and water turbines for stationary purposes and may also do some boiler making. There are additional plants under the same main administration which specialize in boiler construction. Thus, for factories producing marine propulsion equipment in the USSR, the basic idea underlying plant organization is the principle of horizontal integration. Plants producing like products have similar ministerial subordination.

With one exception, the turbine producing plants are not subject to the administrative authority of the navy or the shipyards. 14/ Orders from these organizations are funnelled up through channels to the ministerial level, then down through the Main Administration (Kotloturboprom), and then to the plant which eventually makes the propulsion unit. The exception is the turbine shop located in the Zhdanov Shipyard, which is believed to be subordinate to yard management. The shop is adjacent to the turbine shop of the Kirov plant and works closely with it.

The interests of the navy and of the shipyards are protected, however, by the presence of navy and shipyard inspectors, who inspect materials and production procedures in the shops, and who make an acceptance test on the stands before a turbine can be accepted for delivery. 15/

A plant producing a turbine for the navy may also be producing turbines and related products for other ministries, thereby creating problems of priority in supplies, in production scheduling, and especially in interplant cooperation. In theory, accountability to the Main Administration permits specialization of effort, but in many cases it may also add unnecessary administrative delays to factory operations. Thus production at a Khar'kov plant dropped because the Main Administration failed to provide appropriate materials, and because bearings, instead of being delivered directly to the plant, were delivered to the warehouse of the Main Administration, where they lay undelivered for as long as two weeks. 16/

A principal organizational weakness stems from the absence of direct controls and of good plant-to-plant coordination between assemblers and the factories supplying blades, castings, and the like. The lack of 2-way charge sheets and the refusal of other plants to accept responsibility for rejected castings supplied to the plant are reasons cited in the press for long-drawn-out production cycles, plant losses, and underfulfillment of the plan. 17/ Similar complaints found in the pre-World War II newspapers indicate that many of the shortcomings of Soviet industrial administration are chronic. 18/

To avoid administrative delays, many plants appear to have developed a modus operandi which often cuts across some of the established organizational control lines. Direct plant-to-plant negotiations often take place without prior approval of the Main Administration. In such cases, the Main Administration receives notice of transactions actually made, as a de facto formality. 19/

On the whole, the plant retains a great deal of independence in execution of assigned tasks, but it must adhere to ministerial instruction for over-all direction and delivery dates. Any failure to meet deadlines can be the occasion for carping criticisms from the

press,* which will assign responsibility for errors to anyone from the minister down to the shop foreman. 20/

The organizational system tends to fix the responsibility for each phase of production on a specific individual. The Glavk officer, plant director, or shop foreman not only must do his productive work, but presumably must be prepared to defend any departure from established procedures. The hierarchy of control levels inevitably impedes some plant operations. Plant-to-plant contracting without prior approval of the Main Administration is not only permitted but is sometimes encouraged by the Glavk, which will set up for the subordinate plants a credit at the State Bank to finance direct contracting. 21/ Instances of this nature appear to constitute recognition of some of the fundamental organizational weaknesses of strong centralization in Soviet industrial administration. With the reorganization which followed Stalin's death, all of the consuming shipyards and producing plants were brought under the Ministry of Transport and Heavy Machine Building, thereby eliminating several intermediate offices. 22/ The Ministry of Shipbuilding re-emerged as a separate entity on 27 April 1954, 23/ indicating that the original merger was primarily a political move and was not designed for greater economic efficiency.

The organization chart (Fig. 1)** shows the control channels to the producing plants from the various ministries and shipyards concerned with marine turbine production.

* The role of the press in fixing responsibility for failure is seen from the following excerpts. Izvestiya on 8 September 1949 reported that "the foreman of the M7 shop has turned his work area into a stable. Mountains of metal shavings lie between brand new lathes making high-speed work methods impossible. The gap between words and deeds at this plant must be closed." Izvestiya on 3 July 1951 reported "five-month losses were 1,799,000 rubles. The minister's attitude is restricted by formalism. He issued an order (for corrective measures) but failed to demand that all underlings execute all measures of the order."

** Fig. 1 follows p. 6.

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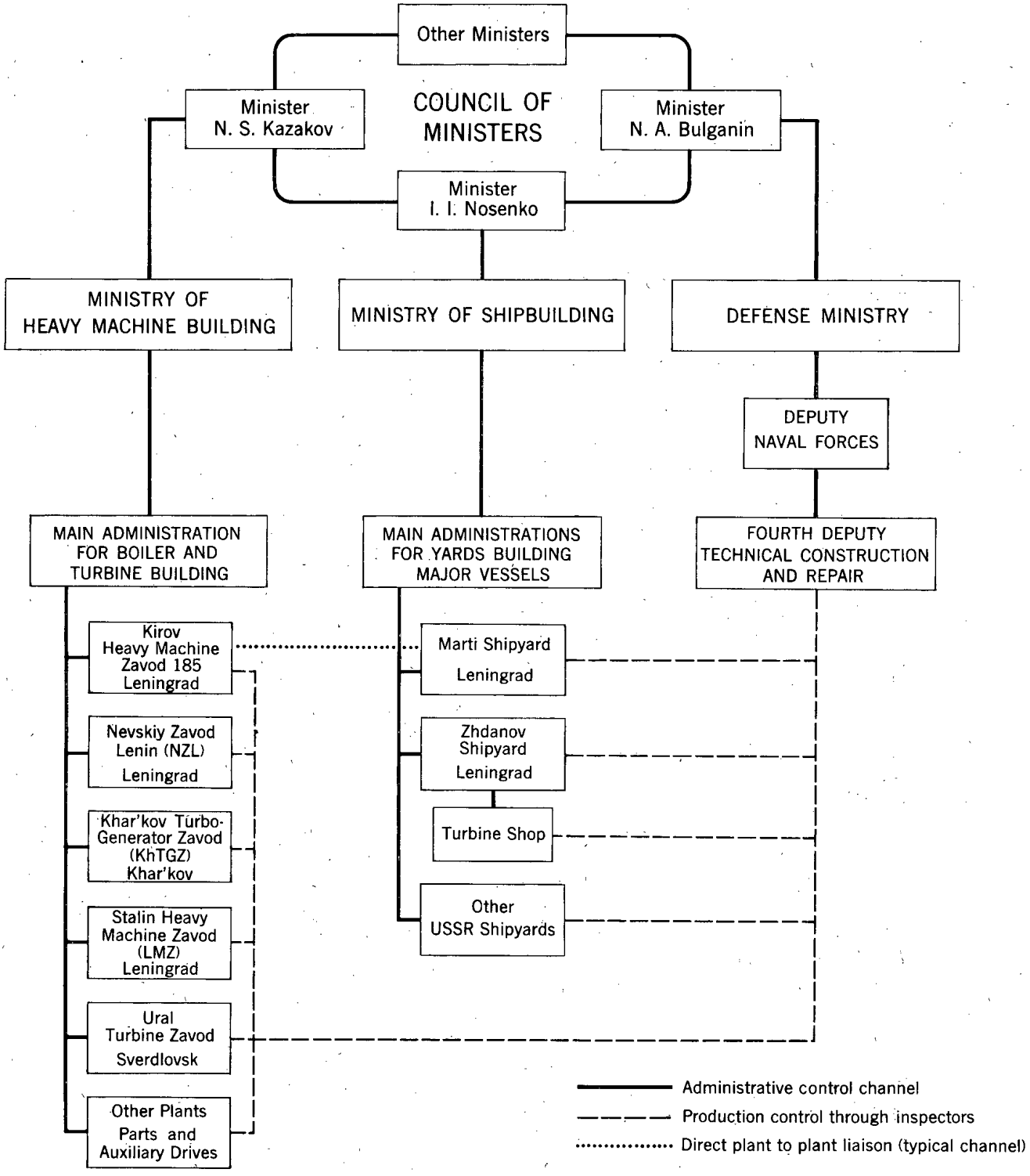
Figure 1

USSR

PROBABLE CONTROL CHANNELS FOR MARINE TURBINE PROCUREMENT AND PRODUCTION

(Selected Plants and Yards)



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B. Location.

1. Concentration.

The production of marine steam turbines is centered in the European part of the USSR. The largest concentration of plants is in Leningrad, where the Leningrad Metal Zavod imeni Stalin (LMZ), the Nevsk Zavod imeni Lenin, the Heavy Machine Plant imeni Kirov, and the Turbine Shop of the adjoining Zhdanov Shipyard, produce about 67 percent of the national output.

Another major plant is located in the Ukraine at Khar'kov. This plant, the Khar'kov Turbogenerator Zavod (KhTGZ), produced 25 percent of the yearly production and is 1 of 3 plants believed to have manufactured gears and turbines for the Sverdlov class cruisers. The second largest turbine plant in the USSR, it has been the leading producer of marine turbines in several recent years. 24/

Two cities, Leningrad and Khar'kov, account for over 90 percent of marine turbine and gear production in the USSR today. To the east at Sverdlovsk is the Ural Turbine Zavod, built just before the outbreak of World War II and designed for the production of smaller turbines. 25/ It may have produced some small turbines of 8,500 horsepower for minelaying vessels in 1940-41. It was expanded during the war, however, with equipment evacuated from Leningrad and Khar'kov, 26/ and production of large marine turbines for destroyers was begun in 1945. 27/ On the Baltic coast, the naval base at Lepaya is known to have done repair work on turbines for several ships, 28/ but it is not a manufacturer of new turbines. The accompanying map, Fig. 2* shows clearly that the concentration of marine gear and turbine producers is in the western part of the USSR.

2. Dispersion.

The Sverdlovsk area, which produced no large marine turbines before the German invasion of the USSR, now accounts for 8 percent of the national production of marine steam turbines. Sverdlovsk is about 1,400 miles east of Leningrad and Khar'kov, but is 4,400 miles west of the Komsomol'sk Shipyard. There is no other evidence of an attempt to disperse the industry to the east, despite the many economic and strategic advantages of having a turbine plant close to the Far East shipbuilding area.

* Fig. 2 follows p. 8.

C. Technology.

The Russians have made no significant advance in either turbine design or the technology of manufacturing. The eclectic methods repeatedly demonstrated in procuring designs, prototypes, and detailed productive techniques from the West are indicative of Soviet reliance on proved processes. 29/

The Orgtyazhmash Institute, part of the central apparatus of the Ministry for Heavy Machine Building, has as one of its main functions the rationalization of production techniques and processes of factories in the Ministry. The Institute works in close cooperation with the Central Boiler and Turbine Institute, which has duties of a research nature. Orgtyazhmash teams assist various plants by suggesting new production equipment and methods. 30/ Among the techniques which Orgtyazhmash has been urging the plants to adopt in recent years are wider application of precision casting and increased uses of modern forge press and stamping machines. 31/

Leningradskaya Pravda, 31 March 1951, pointed out that 25 to 30 percent of the total work involved in building a steam turbine is blade manufacture. The blades are made from billets, with as much as 80 percent of the high cost alloy steel going off into chips. The Orgtyazhmash Institute had made blades by precision casting with negligible loss of chips, but Pravda pointed out that the Leningrad Plant imeni Stalin had done very little toward using the method, with the result that tons of valuable high alloy steel are wasted for every steam turbine built. A similar situation existed at the Lenin plant in Leningrad, where the plant manager, Moykin, and the chief engineer, Kholin, were slow in applying precision casting.*

Five weeks later, Pravda decried the lack of modern forging and stamping equipment in Leningrad and pinpointed the heat treatment shops of the Kirov works and the Stalin works, which process turbine blades, as being equipped only with drop hammers. "The

* The US Navy has found precision casting to be unsatisfactory for turbine blade manufacture. Higher rejection rate and difficulty in achieving required tolerances have characterized recent experiments. Soviet efforts to introduce precision casting are indicative of preoccupation with conservation of alloy steels.

USSR: Marine Geared-turbine Assemblers and Users

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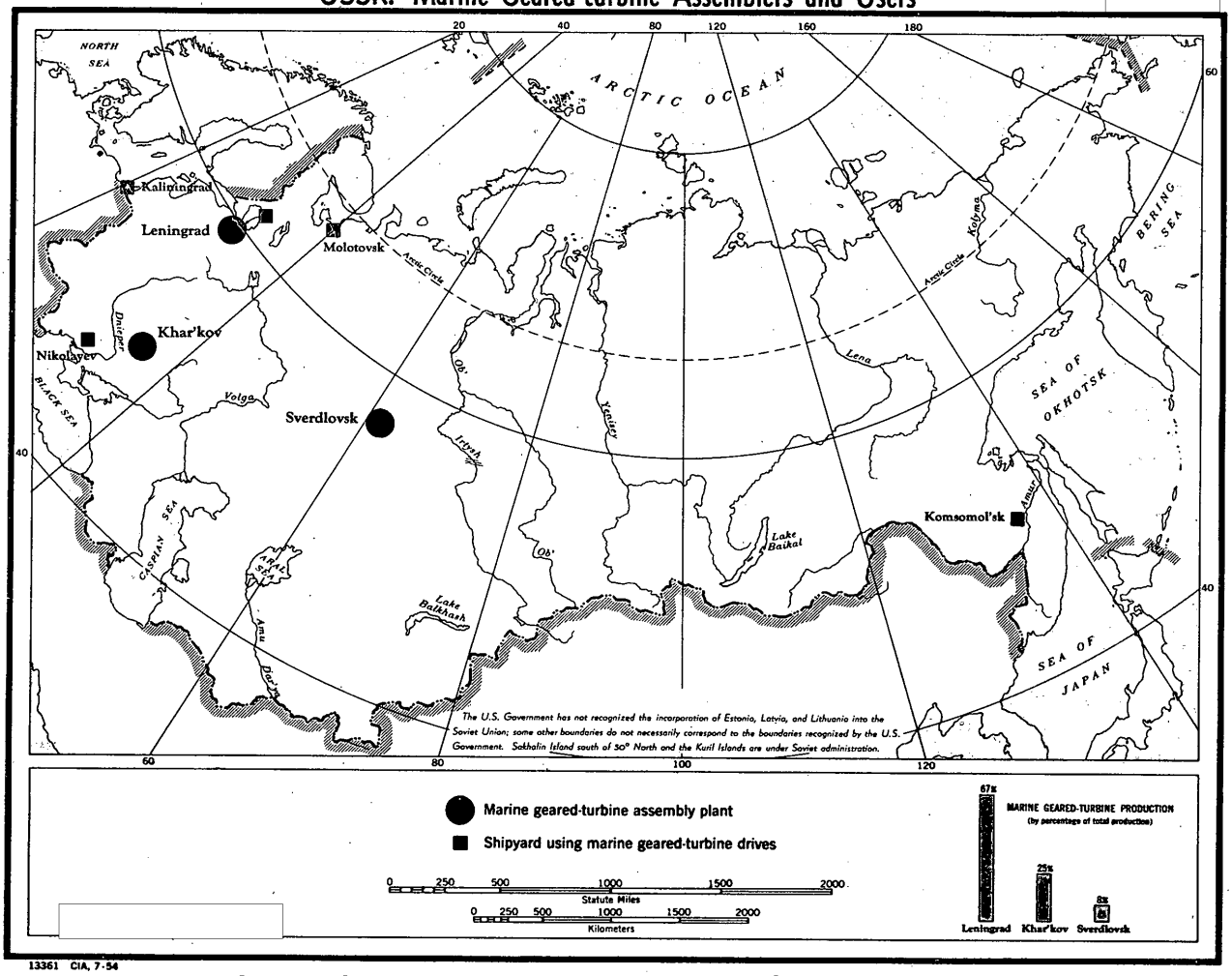

Figure 2

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conservatism and backwardness shown in these and other Leningrad plants in regard to modern casting and stamping machines and methods is intolerable." 32/

The KhTGZ made a contribution to improved turbine production technology when a plant worker named Drokin suggested an improved design on the carriage of a plant machine. His suggestion reduced handling operations and permitted a reduction in machine time from 698 to 166 hours. 33/

It appears that the principal aim of new processes and techniques is the conservation of scarce materials, particularly special steel alloys. A second important consideration is reduction in processing time with the resultant conservation of highly skilled labor and the release of special-purpose production equipment for other work.

The Soviet press plays an important role in prodding the plant managers to accept changes in technology. It does so by giving favorable publicity to persons who have made successful innovations and castigating those who are slow to accept recommended techniques. Press articles on technology are sometimes quite detailed and are an excellent source of intelligence information.

III. Production of Gears and Turbines.

A. Types of Steam Turbines.

Open Soviet literature is quite detailed in its mention of the many different turbines used for stationary purposes. Very few marine turbines are described, however, and no model numbers are given. Most of the marine turbines are produced for the navy, and security measures render the information sparse. Occasionally an interesting reference is made. A 1949 textbook mentions that the largest marine turbine built in the USSR is a 55,000-horsepower unit. 34/ The accompanying diagram shows the turbine to be similar to the unit of the Italian Duca D'Aosta class cruiser, upon which the Kirov class turbine is patterned. Another Soviet text 35/ shows a geared turbine unit which develops 60,000-horsepower. Since a report 36/ mentions production at the Kirov works in Leningrad of a 60,000-horsepower unit for cruisers, it could be concluded that the propulsion unit in the Sverdlov class cruisers is made up of two 60,000-horsepower turbine units. Estimates based on known speed, draft, and dimensions

of the Sverdlovs vary from 55,000 to 75,000 horsepower. Although neither of the sources can be regarded as completely reliable and definitive, the 60,000-horsepower figure will be used in this report.

The horsepower figure used for the Skoryy class destroyers is 70,000, and this figure agrees with official ONI estimates. 37/ The coastal class destroyer type now in production has been estimated by various sources to have 35,000 to 45,000 horsepower. 38/ In this report they are assumed to have 40,000 horsepower. Turbine types are summarized in Table 1.

Table 1

Three Soviet Turbine Types

Ship Type	Horsepower	Range
Sverdlov Class Cruisers (CL)	2 x 60,000	55,000 to 75,000 Horsepower
Fleet Type Destroyers (DD)	2 x 35,000	33,500 to 35,000 Horsepower
Smaller Destroyers (DC)	2 x 20,000	17,500 to 22,500 Horsepower

B. Production of Marine Steam Turbines.

In the immediate postwar period, 1945-46, the Russians began a long-range program of reconstruction and expansion of plants and equipment in an effort to increase production of marine steam turbines over that of prewar years. The Soviet radio pointed out that turbine-driven ships of up to 200,000 horsepower were afloat* and that a great expansion in the ability of the USSR to produce marine turbines was planned for the postwar Five Year Plan. 39/ A short time later, Stalin prizes were awarded to several turbine designers "for the development of the construction and technology of manufacturing engines for combat ships." 40/ Those receiving the prizes included: Leonid Aleksandrovich Shubenko-Shubin, Director of the Central Boiler-Turbine Insitute; Osip Aleksandrovich Pyzh, Vulf Elyevich Berg, Victor Efimovich Solevei, and Vasili Tikhonovich Kholin, engineers in Leningrad plants.

* A reference to US carriers and battleships.

The large number of stationary turbines which had been damaged or destroyed during the war created a large volume of work for the turbine industry at a time when normal operations at the factories were subject to disruption because of recurrent power failures 41/ and plant reconstruction. It is apparent that production of turbines for the navy at the scale planned was not possible for several years. The priorities given to production of stationary units may have contributed to the slow production of naval vessels immediately after the war, but major war damage to many of the important shipyards was probably the chief obstacle to production.

Production in the 1945-47 period consisted of some new turbines for Bird class destroyers, together with completion, repair, and reconditioning of propulsion units for a cruiser and for destroyers of prewar design. Completion of these vessels had been delayed by the war. New turbine construction was concentrated at the Ural Turbine Zavod and the Zhdanov Shipyard, both of which emerged from the war in good condition. Considerable reconstruction of plant facilities went on at the Khar'kov Factory, which had been severely damaged. Plant reconstruction and conversion from other production delayed production at the Stalin, Lenin, and Kirov plants in Leningrad. By 1948-49, however, production was under way in all plants, and the output curve shows a sharp rise from 1949 to 1951. In 1952, a changeover from production of turbines for fleet type destroyers to production of smaller units for coastal type destroyers caused a marked reduction in output for that year. A summary of production is given in Table 2.*

C. Production of Gears for Steam Turbine Drives.

Published Soviet source information on reduction gear production is quite limited, and the press is especially careful to omit references to specific types of gears. However, there have been occasional references in the press and in technical periodicals that indicate that the Khar'kov Turbogenerator Zavod, and the Zhdanov Shipyard in Leningrad produce the gears for their own turbines. 43/ In addition, many prisoner-of-war reports confirm gear production at Khar'kov and also mention gear production in the Stalin, Lenin, and Kirov plants in Leningrad. 44/ From the information in these reports, it appears that gear production is conducted in separate departments in the turbine plants. The evidence indicates that these departments

* Table 2 follows on p. 12.

Table 2

Production of Marine Steam Turbines in the USSR 42/
1949-55

Thousand Horsepower

Plant	Location	Ship Type	1949	1950	1951	1952	1953	1954	1955
Ural Turbine Zavod	Sverdlovsk	DD	105	140	140				
		DC				80	120	120	120
Nevsk Heavy Machinery Zavod imeni Lenin	Leningrad	DD	b/	b/	b/				
		DC				40	80	80	40
Shipyard imeni Zhdanov	Leningrad	DD	140	280	280	280	210	210	280
		DC					40		
Leningrad Metal Zavod imeni Stalin (LMZ)	Leningrad	DD	245	315	490	210	210	280	280
		CL	60	120	180	120	60	60	a/
Heavy Machinery Plant imeni Kirov	Leningrad	DD	210	210	420	210	140	70	210
		DC					40	160	80
		CL	60	120	180	120	60	a/	a/
Khar'kov Turbogenerator Zavod (KhTGZ) imeni Kirov	Khar'kov	DD	350	350	350	140			
		DC				120	160	200	240
		CL	120	120	120	120	60	60	a/
Subtotals		DD	1,050	1,295	1,680	840	560	560	770
		DC				240	440	560	480
		CL	240	360	480	360	180	120 a/	a/
Grand Total			1,290	1,655	2,160	1,440	1,180	1,240 a/	1,250 a/

a. Capacity available.
b. Auxiliary drives only.

are parts of the turbine plants and are administratively subordinate to them. There is no report of production of gears at the Ural Turbine Zavod at Sverdlovsk. It seems likely, however, that this plant assembles its own gears, although other local plants may supply some components.

There are separate factories throughout the USSR which manufacture parts, castings, and forgings for the assembly plants. A few of the larger shipyards have produced gears in the past and may still have some production potential.

The figures in Table 3 include production at final assembly plants producing marine steam turbine drives.

Table 3

Production of Reduction Gears for Marine Steam Drives in the USSR 45/
1949-55

Units

Location	Ship Type	1949	1950	1951	1952	1953	1954	1955
Leningrad Area	DD	17	23	34	20	16	16	22
	DC				2	8	12	8
	CL	2	4	6	4	2	1 a/	a/
Khar'kov Area	DD	10	10	10	4			
	DC				6	8	10	12
	CL	2	2	2	2	1	1	a/
Sverdlovsk Area	DD	3	4	4				
	DC				4	6	6	6
Totals	DD	30	37	48	24	16	16	22
	DC				12	22	28	26
	CL	4	6	8	6	3	2 a/	a/

a. Capacity available.

IV. Input Requirements.

A. Materials.

Carbon steel and alloy steel are the two principal materials used in marine turbine and gear production. 46/ It is believed that Soviet practice conforms to Western standards in this respect. In recent years, the Soviet annual production has contained some 2,000 tons of finished carbon steel, which is a very small fraction of Soviet production. 47/ Alloy steels used in turbines also form a small drain on annual national output. The average of 630 tons of finished alloys contained in 7 years' production has represented a negligible percentage of national output. 48/

The constant concern which the turbine plants have shown in regard to the conservation of alloy steels 49/ may be a result of the necessity to maintain working inventories of the several kinds of alloys used in various parts of the turbines and gears. The machining of some alloys is difficult, even under optimum conditions, and constant care is necessary to avoid excess wastage and depletion of working inventories.

Turbine blades for the high pressure units use a chromium stainless steel which contains about 12 percent chrome and 0.5 percent nickel. 50/ Other blades use more nickel and less chrome. 51/ Forgings used in the rotors contain from 2.5 to 12.5 percent nickel and up to 0.5 percent manganese and/or molybdenum. Requirements for other metals are negligible.

A summary of finished material weights for both turbines and gear production is shown in Table 4.* Figures are based on US practice and are unadjusted for differences in technology and design.

B. Manpower.

Building marine turbines on the scale undertaken in recent years has required from 21 to 37 percent of the total number of employees engaged in turbine construction of all types. Since much of the work deals in very close tolerances, this figure includes a large number of skilled machinists and technicians. 52/

* Table 4 follows on p. 15.

Table 4

Materials Requirements for Marine Turbine and Gear Production in the USSR a/ 53/ 1949-55

Thousand Pounds

	1949	1950	1951	1952	1953	1954	1955
Gross Weight	4,060	5,270	7,340	4,990	4,330	4,850	4,600
Carbon Steel	3,050	3,950	5,500	3,740	3,250	3,640	3,450
Alloy Steel b/	1,010	1,320	1,840	1,250	1,080	1,210	1,150

a. Finished materials are based on US practice.
b. The alloy steel includes the following finished weights of nonferrous metals:

	1949	1950	1951	1952	1953	1954	1955
Nickel	43.6	56.5	78.9	53.6	46.5	52.1	49.5
Chrome	14.2	18.4	25.6	17.4	15.1	16.9	16.1
Manganese	0.1	0.13	0.18	0.12	0.1	0.12	0.11

In any large-scale industrial mobilization, marine turbine production would be somewhat hampered by a shortage of skilled labor, unless it received sufficient priority to draw labor from stationary turbine production.

The yearly requirements in man-years are shown in Table 5.*

C. Power.

In the immediate postwar period, 1946-48, production was repeatedly interrupted at the Khar'kov Turbogenerator Zavod by power shortages and power failures. 54/ The shortages were a direct result of war damage, however, and by 1949, power requirements were being met by repaired and new facilities.

* Table 5 follows on p. 16.

Table 5

Labor Requirements for Marine Turbine and Gear Production
1949-55

Man-Years

Year	Direct Labor	Administrative	Total
1949	5,800	1,900	7,700
1950	7,500	2,500	10,000
1951	10,500	3,200	13,700
1952	6,800	2,200	9,000
1953	5,500	1,800	7,300
1954	6,000	2,000	8,000
1955	5,900	2,000	7,900

The average annual requirement of power for marine turbine production in the period under review is 50 million kilowatt-hours. This compares with average annual power output of 120 billion kilowatt hours. 55/ Marine turbine production has consumed only 0.04 percent of available power.

D. Transportation.

Transportation requirements for delivery of completed geared turbine units to the shipyard are small. The Leningrad area, which produces 67 percent of the turbines, also produces a larger percentage of the vessels which use turbine drives. Several of the Leningrad turbine shops have private rail connections with the shipyards. Deliveries consequently form a negligible requirement on the rolling stock of the country.

There are several haulages involved, however, which are of intelligence interest. Deliveries to the Komsomol'sk Shipyards are estimated to require about 6 million ton-kilometers of rail transportation on the Trans-Siberian Railroad annually. Computed on a weight basis, this is 0.002 percent of the average annual eastbound traffic. 56/ The shipyard at Molotovsk is dependent upon a haulage of 1,275 kilometers on the Leningrad-Vologda Railroad.

Several prisoners-of-war have reported on the extreme care given to packing the turbine parts. 57/ Of special interest are statements that detachments of sailors from the Far East came to Khar'kov to guard the freight cars on which the turbines were shipped over the Trans-Siberian Railroad. This information suggests that the safe handling of freight over this route leaves much to be desired, and that delivery schedules might not be dependable.

E. Summary of Input Requirements.

The average annual input requirements for the industry are shown in Table 6.

Table 6

Average Annual Requirements for Marine Turbine and Gear Production in the USSR
1949-55

Item	Quantity	Percentage of National Output
Carbon Steel (Tons)	2,000	0.009
Alloy Steel (Tons)	630	Negligible
Man-Years	9,100	0.6 a/
Kilowatt-Hours	50,000,000	0.04
Ton-Kilometers, Trans-Siberian Railroad, Eastbound	6,000,000	Negligible

a. Percentage of industrial labor force.

V. Distribution.

Marine geared turbine drives are used in warships and can be used efficiently in merchant vessels of more than 4,000 to 5,000 gross tons. There is no concrete evidence to suggest use of geared turbine drives in any merchant ship built in the USSR since 1945. All the known newly built Soviet merchant ships are diesel-powered. Maximum estimates of production of large merchant vessels in the USSR since World War II could account for no more than 1 percent of the marine turbines produced. For all practical purposes, the Soviet Navy can be considered the only user of marine turbines in the USSR.

The shipyards which install the turbines in cruisers and destroyers are located in Leningrad, Nikolayev, Komsomol'sk, Molotovsk, and Kaliningrad. 58/

Except for a few units installed in imported ships, there are no exports or imports of marine turbines to or from the USSR at the present time.

VI. Intentions, Limitations, and Vulnerabilities.

A. Intentions.

Marine turbines ordinarily take from 18 to 24 months to build. They are delivered to the shipyard 1 to 4 months before the hull is launched, or from 8 to 16 months before the ship is completed. For this reason, information on planned turbine production can indicate shipbuilding intentions as much as a year before the keels are laid and in some cases 2 to 3 years before the ships are delivered.

Reports from released prisoners of war who had worked in the Leningrad and Khar'kov plants from 1947 to 1950 were sufficient to indicate that a large-scale destroyer-cruiser building program could be expected in 1949-52. This program was eventually substantiated by sightings on the building ways.

Current information is largely limited to occasional newspaper and radio releases and to information gleaned from the analysis of plan announcements. These official sources are careful not to give out information of obvious value, but there is an occasional slip. A 1952 newspaper, reporting on metal savings at the KhTGZ, indicated that reduction gear housings, probably for destroyers, were being produced in the spring of that year. This information suggested that destroyer yards, probably at Nikolayev or Komsomol'sk, would continue to build destroyers through 1953.

The 1955 goal set by the Fifth Five Year Plan 59/ is an increase in steam turbine production to 2.3 times the 1950 figure. There is, of course, no clue here as to the proportion allocated to shipbuilding or that going to land power installations. In 1949-50, a high percentage of the total turbine production went into shipbuilding. Since the plan announcement does not indicate a disproportionately large number of new steam power projects for 1955 as compared with 1950, it can be assumed that production of ship turbines and gears will continue

through 1955. This deduction in turn indicates that construction of destroyers or larger vessels will continue, if on an unknown scale, through late 1956 or early 1957.

The plan announcement also provides for the development of shipbuilding and the manufacture of turbines in the Lithuanian Republic. This plan might include creation of new facilities for production of ship turbines for merchant ships.

B. Limitations.

Well developed industrial economies need plants to produce power-generating equipment including turbines. Turbine facilities can easily be converted to production of marine turbines. Gear production, however, is usually limited to the requirements of a normal shipbuilding program, and shortages of gear-production facilities and equipment may consequently limit shipbuilding expansion. During World War II, such shortages led the US to build many merchant vessels and smaller naval vessels (including some destroyer escorts) with diesel, reciprocating steam engines, or turboelectric drives. 60/ This fact has led to speculation in intelligence circles that the Soviet gear production may also limit shipbuilding. 61/

The USSR has only two plants which normally produce the large gear-cutting machinery needed for the production of marine gears. These plants are the "Komsomolets" plant at Yegorevsk and the Kolomna Heavy Machine Tool plant. Expansion of gear production facilities would depend on the ability of these two plants to provide the necessary machine tools. Although Soviet ability to expand gear production may be somewhat limited, the industry is already operating at a high level of production. Soviet gear-manufacturing facilities and turbine facilities are well balanced.

Construction and expansion of turbine plants occurred in 1932-38, at a time when a large-scale building program for the Soviet Navy was under way. 62/ Provision was made for gear production in adequate proportion to turbine production. Postwar reconstruction and expansion of plants also coincided with a large naval construction program, and the proportion was maintained. In the USSR, then, gear production may not limit shipbuilding to the extent that it does in many Western countries.

Turbine production, however, is more limited in capacity. The slow rate of naval shipbuilding from 1946 to 1948 was partially caused by the inability of turbine plants to meet the demands of both postwar factory reconstruction and an accelerated shipbuilding program. In 1949, with reconstruction of plants largely completed, steam turbine output was twice that of 1948. 63/ It was in 1949 that construction of cruisers and destroyers began in earnest. In the years since 1949, naval shipbuilding has required from 19 to 35 percent of estimated total Soviet turbine production. 64/ From 1949 to 1951, the USSR imported 20 percent of its stationary turbine requirements from Satellite and Western countries.

C. Vulnerabilities.

In Soviet marine turbine and gear manufacture there are few areas of weakness which are capable of economic exploitation. The USSR does import turbines, alloy forgings, and other parts for its turbine production, but these are for small stationary units. 65/ Disruption of such shipments would have some annoyance value in creating tighter supply schedules. Production of geared turbines for naval use would undoubtedly receive sufficient priorities for scarce materials so that even total embargo would have little practical value. In any case, much of the importing is done from the European Satellites.

The concentration of marine turbine production facilities does present several areas of extreme vulnerability to direct action. In Leningrad, 38 percent of national production is concentrated at the adjoining buildings of the Kirov Zavod and the Zhdanov Shipyard. A few miles away, the LMZ produces 25 percent of the national production. To the south at Khar'kov, the KhTGZ produces an additional 25 percent of total output. Elimination of these three entities -- the LMZ, the Kirov-Zhdanov Shops, and the KhTGZ -- would destroy 88 percent of the output of marine steam turbines.

The isolation of the Komsomol'sk Shipyard from the turbine producers presents another area of vulnerability. From the nearest turbine plant at Sverdlovsk, the minimum rail haul to the shipyard is 4,500 miles. Komsomol'sk has produced from 15 to 25 percent of destroyer production in some recent years.

APPENDIX A

PLANT STUDIES

1. Khar'kov Turbogenerator Zavod (KhTGZ) imeni Kirov. 66/*

Under construction in 1933, the Khar'kov Turbogenerator Zavod was originally designed for the manufacture of 2 million kilowatts of steam-power generating equipment per year. The factory was built beside the existing Khar'kov Electro-Mechanical Zavod (KHEMZ) and shared with KHEMZ the foundry and other plant facilities.

The KHEMZ-KhTGZ plant compound is about 4.5 miles east-southeast of the Khar'kov railroad station. The plant is situated in a 6-sided enclosure and lies between the Khar'kov-Chuguyev railroad and the Khar'kov-Chuguyev highway. The plant is served by rail, truck, and streetcar. [redacted] 50X1

On completion, the KhTGZ plant became the second largest turbine producer in the USSR, the largest being the Stalin Plant in Leningrad. The KhTGZ became a manufacturer of marine turbines soon after production began. It produced the turbines for a Soviet cruiser and for many of the new destroyers. Large-scale production began in 1936-39, at a time when new and modernized shipyards at Nikolayev in the Ukraine and Komsomol'sk in the Far East were taking an active part in the naval construction program. In 1939 the Khar'kov plant is reported to have become the largest producer of marine steam turbines in the USSR.

During World War II, the plant suffered major damages. Some of the equipment was evacuated, but the fixed installations, including most of the foundry facilities and power equipment, were damaged considerably. Reconstruction began immediately after reoccupation of Khar'kov. By 1946 the plant was able to turn out a few units, which were tested and sent to Leningrad. Rebuilding and expansion of old shops continued through 1948, and by the spring of 1949 the plant had regained much of its prewar capacity. The last recurrent power stoppages are reported for April of 1949. Construction of new foundry and machine shops continued through 1949 and 1950.

* Fig. 3 (diagram of plant) follows p. 22.

During the postwar period, the plant was under the administrative authority of the Ministry of Heavy Machine Building, but many naval officers had technical inspectors' and supervisors' positions. The acceptance tests were conducted by naval personnel.

The main erection and assembly shop of the turbine plant is a 3-story building with a concrete floor. The first floor contains 1 very large milling machine, 20 smaller millers, 20 lathes, a large turret lathe, 10 planers, 5 drill presses, and several other metal-cutting machines. Heavy parts, including shafts, propellers, and large gears, and turbines are machined on the ground floor. The second floor houses about 100 smaller boring and milling machines, lathes, and grinding machines. Smaller parts are produced here. The third floor is equipped with machine tools, and part of it is used as a school for apprenticed girls and boys 12 to 18 years old.

The main building is a restricted area requiring a special pass for admission. Prisoners of war were allowed inside only for special maintenance work.

A great many prisoners report quantity production of small turbines for warships and submarines. Their reports, however, appear to describe large marine pumps, which resemble turbines in many respects. The KhTGZ is therefore believed to be an important producer of pumps for the navy as well as turbines, gears, shafts, and possibly propellers.

From 1946 to 1950, castings for turbines and gear housings arrived in a semifinished condition and were machined in the plant. By 1952, however, castings for reduction gears were being produced, probably indicating that the new foundry was in operation.

Shortages of materials plagued the plant as late as 1950, and the workers apparently were not paid for idle time resulting from lack of materials. The norms required of the workers were high, and a great deal of cheating went on, sometimes with the help of the foremen. One method reported was the stealing of accepted piecework from the storerooms and changing the control stamp. The pieces were then run through the assembly line and credited as new production. In such cases, bonuses for production above the norm would be split between the worker and his supervisor. There was a lively black market in materials of all kinds from 1946 to 1949, and workers were sometimes searched before leaving the plant. One prisoner of war reports that

Khar'kov Turbogenerator (KhTGZ) and Electric Motor (KhEMZ) Plants

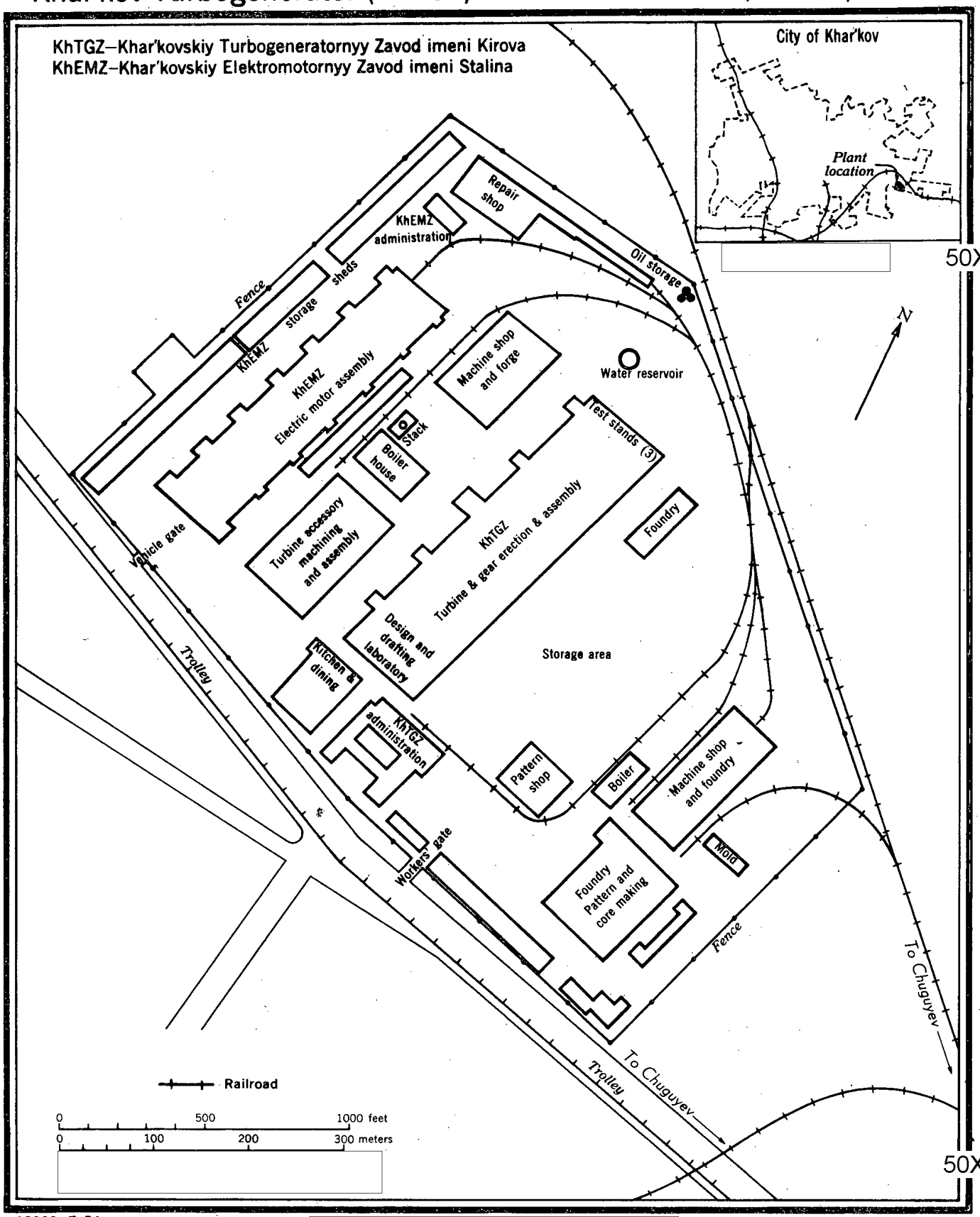

Figure 50X1

specialists earned 800 to 1,000 rubles per month, while general labor was paid 500 to 700 rubles. Morale was especially poor among the least skilled workers, who were paid the same wages as the German prisoners. Morale affected production, and several Germans described the plant philosophy as "quantity before quality." Rejects were high.

The plant works closely with the Kirov and Stalin plants in Leningrad, and there is apparently an interchange among these three plants of semifinished parts as well as technological information. Other suppliers of semifabricated parts are the Uralmash Zavod in Sverdlovsk and the Electrostal factory in Novo Kramotorsk.

A great deal of care is taken in packing the turbine parts for shipping. The flatcars with the loaded parts were covered with canvas. One shipment is reported to have required 14 flatcars. There are indications that the plant supplies turbines to the shipyard at Komsomol'sk, which is the only user of turbines for new ship construction in the Far East. Other reports mention shipments to Nikolayev, Odessa (for transshipping), and Leningrad.

In 1950 and 1951 the plant was the object of several unfavorable press editorials because of failure to meet the plan. A poorly organized supply of semifabricated materials to the plant, long-drawn-out production cycles, and disregard of advanced technology all contributed to plan failures. The Ministry of Heavy Machine Building issued an order to correct deficiencies by establishing a 3-shift schedule for operating special-purpose equipment. The order was ignored, "with the result that thousands of machine tool hours are lost as bottleneck production equipment remains idle at night."

In the same compound as the KhTGZ, the KHEMZ plant also produces marine components which are mistakenly credited by some sources to the KhTGZ. These include switchboards and control panels for submarines, several kinds of electric motors, switch boxes, resistor sets, and generators.

Production of geared turbine units at the KhTGZ is 25 percent of national production.

2. Heavy Machine Zavod imeni Kirov [redacted] 67/ 50X1

The Kirov Heavy Machine Zavod [redacted] was founded in the 1880's 50X1
and was known in Czarist times as the Putilov Works. It was and is one of the largest industrial complexes in the USSR. The plant is situated on the eastern bank of the south fork of the Neva, in the Alekeevka district of Southwest Leningrad. It is about 2 miles southwest of the Leningrad railroad station and occupies an area directly north and northeast of the Zhdanov Shipyard.

At the close of World War I, the plant had complete facilities for shipbuilding. Its furnaces and mills furnished the steel plates and shapes required. Its machine shops manufactured the machinery and many of the components needed at the building ways and outfitting piers. Under Soviet administration the shipyard became a separate entity and is now known as the Zhdanov Shipyard under the administration of the Ministry of Shipbuilding.

The other shops of the Putilov Works became part of the Ministry of Heavy Machine Building. The plant has several departments and produces cranes, winches, and lifting devices, as well as vehicles, plate, castings, and forgings. During World War II, it produced ammunition and parts for tanks.

The main turbine shop is located in the southwest part of the plant area, close to the boundary of the Zhdanov Shipyard. This shop is at least 3 stories high and is reported to be the tallest building in the plant area. It is equipped with 2 overhead traveling cranes of 25-ton capacity each. The building is very close to and parallel to the turbine shop of the Zhdanov Shipyard, across the boundary wall.

Part of the equipment of the turbine shops was evacuated to Chelyabinsk and Sverdlovsk in late 1941. Much of what remained was damaged when the shop was shelled by German artillery, and reconstruction began before the war ended.

From 1945 to 1947, the turbine department was primarily engaged in repairing war damage, replacing old and evacuated machinery, and in building additional facilities. At the end of 1946, the turbine section covered 27,000 square meters, and 1,000 new machines had been installed. In June 1947, the local papers reported that the turbine shop was virtually a new shop.

The turbine department draws on some of the other Kirov shops for various services. Among shops identified as contributing to the first postwar turbine, which was completed as a special project in 1947, were the pattern shop, machine shop, metal-fabrication shop, steel foundry, turbine blade manufacturing department, the new forge, and the old forge. The main machine shop of the plant produced the condensor for the first turbine.

During 1946-47, the turbine shop was also able to produce some turbine parts and do repair work on damaged units. An initial production assignment of eight turbines was given to the plant in 1947. A ground floor section of the turbine shop is partitioned off from the rest of the building, and here the turbine gears are produced. No great advances have been made in technology, but a few improvements were introduced in 1947, including increased use of weldings on cast turbine parts. The turbine blade manufacturing shop may now be in a separate building.

Turbine designers V.E. Berg and V.Y. Solovei worked on plans for the new turbines. Both of these men received Stalin Prizes in 1946 for perfecting the design and technology of production of turbines for combat vessels.

After early 1947, one prisoner of war was allowed to work on improvements in the production methods for reduction gear wheels. [redacted] 50X1
[redacted] in 1947 the plant was working on two different 50X1
types of turbines for cruisers. [redacted] in 50X1
August 1947 the yard was planning to resume serial production of high capacity units for ships.

The Kirov plant also produces steam turbines for large industrial and municipal power plants, but the frequent visits of naval officers during 1948 and 1949 indicated that a large part of the work was for the navy. Under normal conditions, production initiated in late 1947 could be completed 20 to 24 months later. Since these were new designs being produced in a rebuilt factory, with new and semiskilled labor, completion may have been delayed until late 1949 or early 1950. At this time the cruiser-destroyer program was readily discernible in the shipyards.

The Kirov plant is believed to account for about 21 percent of national production of units for the cruiser-destroyer program.

3. Shipyard imeni Zhdanov. 68/*

Also known as the Northern Yard [redacted] the Zhdanov Shipyard is the former Putilov Yard of Czarist times. It became a separate entity in the early thirties, when it was detached from the Kirov Works. It has been administered at various times by the Ministry of Transport Machinery Construction, the Ministry of Transport and Heavy Machine Construction, and the Ministry of Shipbuilding. Since late April of 1954, it has been under the Ministry of Shipbuilding. 50X1

The plant is located along the eastern bank of the south fork of the Neva River and occupies an area south and southwest of the Kirov Zavod in Southwest Leningrad. The turbine shop is situated along the northern boundary wall of the shipyard and stands parallel to the turbine shop of the Kirov Zavod. The two plants account for 38 percent of the annual Soviet production of marine steam turbines and gears. The close proximity of the two shops and their importance to national production make them a prime target of intelligence interest.

In the middle thirties, facilities in the turbine shop were expanded, and by 1936 the yard was able to produce its own reduction gearing as well as turbines up to 25,000 horsepower.

During World War II, some of the equipment was evacuated. The few available reports indicate that the plant has 2 overhead traveling cranes, is well equipped with machine tools of Russian and foreign manufacture, and has 2 test beds for turbines. Several sources indicate that the yard produces all the turbines for its own ships.

Two qualified observers, who worked in the yard from 1934 to 1946 and in 1949-50, indicate that the entire yard had been put into good condition by 1946 and that the turbine and gear shops were especially well equipped. The turbine shop manufactures many turbine and gear parts and makes the complete final assembly and test. It is apparently dependent on shipments of parts from the Kirov Zavod and other plants. Completed units leave the erection and assembly shop and are delivered to the turbine installation shop. About 120 men in the shop prepare the propulsion unit for installation.

Production estimates for the yard are based entirely on launching information and on the assumption that the yard builds all the geared

* Fig. 4 (diagram of plant) follows p. 26.

turbine units required for its own shop but does not deliver propulsion machinery to other shipyards. Production is estimated at 17 percent of the average national output.

4. Leningrad Metal Zavod (LMZ) [redacted] 69/ 50X1

One of the oldest heavy industrial plants in the USSR, the Stalin Zavod, was built as the Petersburg Engineering Works in 1857. It is located in the northern section of the city, on the north bank of the Neva River, approximately 1 mile east-northeast of the Liteynyy Bridge. [redacted] 50X1

The Stalin plant has manufactured a wide variety of products. It is primarily a turbine plant, but has also produced tanks, guns, boilers, hull sections, subway equipment, and refrigeration and refinery plants.

The factory is the leading plant of the Main Administration of the Boiler Turbine Industry and is the largest producer of turbines in the USSR, accounting for about 30 percent of annual output. Production includes gas and hydroturbines, as well as steam turbines for both marine and stationary use. The Stalin plant produces about 25 percent of the national output of marine steam turbines, but there are indications that marine turbine production will constitute a much smaller percentage of total plant output than it did before the war.

The Stalin plant has an excellent steam turbine research and design laboratory. Under the direction of Professor M.I. Grinberg, this laboratory was instrumental in the development of warship propulsion both before and after World War II. Stalin prize-winning designers at the plant include A.G. Antonov, M.N. Bushvyev, V.P. Yegorev, A.S. Zilberman, V.N. Zubkov, A.V. Levin, A.A. Lomakin, and M.Z. Kheyfets. The plant management has long advocated that the plant confine itself to production of turbines only.

5. Zavod imeni Lenin [redacted] Leningrad. 70/ 50X1

The Lenin plant is located on the west bank of the Neva River in Southeast Leningrad. [redacted] 50X1
[redacted] The plant address is 118 Sela Smolensk Prospekt, 50X1
Leningrad.

In the center of the grounds along the eastern boundary is a large L-shaped building where cranes are assembled. Boiler construction may also take place in one wing of this building. In the southeast corner of the grounds is a large open-hearth foundry building which also houses the pattern and core-making shops.

In 1936, two turbine assembly shops were built, designed primarily for production of smaller units. These shops are reported to have built turbines for minesweepers in 1941. The turbine shops produced armaments during World War II and were slow in converting back to turbine production. Until 1949, only a few units were produced. Even today, the turbine shops turn out a great many drives for air blowers used in industrial furnaces, compressors, and pumps. In 1950, it was the only large producer of these items in the USSR.

The plant is equipped with a good turbine research and development laboratory, which does a great deal of work for the Main Administration of the Boiler-Turbine Industry on units to be produced in other plants. The plant is of special intelligence interest, because it is a potential center for experimentation and development of gas-turbine drives for submarines. Naval officers were present in the plant from 1946 to 1949 and are reported by several prisoners of war to have held administrative and supervisory jobs.

The factory does not produce turbines for cruisers. Its geographic location indicate that its units are most likely used in destroyer construction in shipyards in Leningrad, Molotovsk, and/or Kaliningrad. Turbines currently in production are not believed to exceed 20,000 horsepower. They are probably used in small destroyers and for auxiliary propulsion units on larger ships. Postwar production of geared turbine units is estimated at not more than 4 percent of the national output.

6. Ural Turbine Zavod Sverdlovsk (UTZ). 71/

The Ural Turbine Zavod is the only producer of large marine turbines east of Khar'kov. It is located at Sverdlovsk, about a mile and a quarter northeast of the railroad station. The plant was designed in 1936, and was in production before the outbreak of World War II. It is located in the same plant compound as the Ural Turbomotor Zavod [redacted] which makes diesel engines. The plants probably share some loading, storage, and shipping facilities, and foundry space. 50X1

The Ural Turbine Zavod was originally designed to produce turbines of up to 16,800 horsepower. Before 1942 it could not have produced marine turbines for ships larger than minelayers or small coastal type destroyers. During World War II, however, the plant was expanded and equipped with machinery evacuated from the Kirov Works in Leningrad and from the KhTGZ in Khar'kov.

By 1945, the Ural Turbine Zavod had initiated production of marine turbines. In the first quarter of 1946 it completed its first unit, probably for a Bird class destroyer. A second unit was scheduled for completion in the same year. By 1947, high pressure marine steam turbines were in serial production. During the period 1945 to 1947, stationary turbines were also produced, the largest unit being of 33,500 horsepower. Information from 1945 to 1948 indicates that naval officers had administrative or inspectors' positions in the plant.

In 1947 the staff was working on the design of new high pressure units, and the plant was being enlarged.

The plant probably receives many larger forgings and castings from the nearby Uralmash Plant, which is one of the best equipped plants in the USSR for such production. Uralmash is known to have shipped castings and forgings to marine turbine producers in Leningrad and Khar'kov. Present production is believed to represent at least 8 percent of the national output.

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