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MACHINE TOOL PRODUCTION IN THE US AND USSR

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I. Introduction

In April 1961 Mikhail Suslov, in a speech at the Indian Communist Party Congress, asserted that the USSR was producing more machine tools* than the US.1/ This was apparently the first time that the USSR had publicly recognized what had been evident for some years--that the USSR was far outproducing the US in metalcutting machine tools. Until Suslov's statement Soviet newspapers and trade journals had hammered at the theme that the USSR must overtake the US in production of machine tools, even though, as early as April 1959, Allen Dulles had told a meeting of the Edison Electrical Institute that Soviet production of machine tools was four times that of the US.2/

The USSR has been outstripping the US in volume of production of metalcutting machine tools since about 1954. Soviet production of metalcutting machine tools in 1961 was officially reported to have been 164,000 units.3/ By comparison, the US produced 40,363 units** of an average value of $1,000 or over, the category that is believed to be roughly comparable to the Soviet production figures. In the production

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* In this study, machine tools are classified as metalcutting or metalforming. Metalcutting machine tools are defined as power-driven machines not supported in the hands of an operator when in use, designed to remove metal in the form of chips, turnings, and borings, and include honing machines, lapping machines, grinders, and electro-erosion and ultrasonic machines. Metalforming machine tools are defined as machines, either power-driven or manually operated, but not supported in the hands of an operator when in use, designed to press, forge, emboss, hammer, extrude, blank, spin, shear, or bend metal into shape. Formerly the term "machine tool" usually referred to metalcutting machine tools, and the term "metalworking machinery" both to metalcutting and metalforming. Currently, the term "machine tool" generally includes both metalcutting and metalforming machinery.

** Because of a lack of information on production, data for the US are for shipments.

of metalforming machine tools, the USSR is believed to have surpassed the US in volume of production for the first time in 1961, when Soviet industry produced 30,500 metalforming machine tools compared with an estimated production of 28,900 in the US.[4/]

II. Patterns of Growth

Production of machine tools in the USSR showed a steady and substantial growth during the past decade. Production of metalcutting machine tools more than doubled from 1950-60, increasing at an average annual rate of 8 percent. In terms of value, the rate of growth was much more than 8 percent, for the product mix of 1960 was considerably more complex than that of 1950. The rate of growth of certain categories of machine tools, generally the more technologically advanced, was much more rapid than that of machine tools as a whole, as shown in Table 1 on page 3. While the production of lathes of all types, for example, increased at only 4 percent annually, production of automatic and semi-automatic lathes increased at a rate of 17 percent.

Production of metalforming machine tools, traditionally the lagging sector of the Soviet machine tool industry, increased at an even faster rate than did metalcutting machine tools. Production of metalforming machine tools more than tripled from 1950 to 1960, increasing at an average annual rate of 13 percent.

During this period the Soviet machine tool industry was operating at full capacity and was expanding in order to meet the rapidly increasing needs of the machine building and metalworking industry, which by 1950 had regained the prewar level of production and was on the threshold of an ambitious program of expansion that was to result in an increase in gross output during

Table 1

USSR: Production of Metalcutting Machine Tools, by Category 5/
1950 and 1958-60

Category	Units				Average Annual Rate of Growth 1951-60 (Percent)
	1950	1958	1959	1960	
Total	70,597	138,290	147,574	155,566	8.2
Lathes, total	24,140	34,105	36,795	36,968	4.4
Turret lathes	1,402	2,986	3,474	3,583	9.8
Automatic and semiautomatic lathes	863	3,280	3,512	4,274	17.3
Milling machines	3,857	13,295	14,378	16,138	15.4
Gearmaking machines	1,658	2,427	3,001	3,313	7.2
Boring machines	227	864	1,052	1,314	19.2
Planers	218	480	328	433	7.1
Shapers	2,561	3,430	2,896	2,533	- 0.1
Slotters	104	677	497	733	21.6
Broaching machines	179	515	587	600	12.9
Grinding machines (cylindrical, external, internal, and surface grinders)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tool and cutter grinders	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vertical drilling machines	9,889	30,367	32,228	31,769	12.4
Radial drilling machines	870	3,010	3,518	4,121	16.8
Special, specialized, and unit types	8,623	17,412	19,298	22,138	9.9
Other (such as sharpening, bolt-threading, and nut-tapping tools)	10,857	15,484	15,117	15,867	3.9

the 1950's of about 15 percent annually. As a result of the priority accorded to it, the machine tool industry increased its gross output during 1951-55 at a faster rate than that of any other branch of machine building and metalworking.6/

In the US, production of metalcutting machine tools fluctuated widely during 1951 to 60, increasing sharply during the Korean War, maintaining a steady level from 1954 to 1957, and dropping after 1958 to about the pre-World War II level. Fewer metalcutting machine tools were produced in 1960 than in 1950, but value of output increased about two-thirds during this period, reflecting a doubling in the average cost per machine tool. At the end of the decade the USSR was producing 3.6 times as many metalcutting machine tools as the US, with an estimated value 3.9 times that of the US.

In the US during this period the already mature metal fabricating industries possessed an adequate inventory of machine tools in terms of numbers. Growing at a much slower rate than their younger and smaller Soviet counterparts, the US metal fabricating industries also needed fewer machine tools for expansion. The problem of technical obsolescence of US machine tools was a pressing one, but inability to secure fast tax write-offs of new machine tools may have hampered the replacement of the machine tool inventory that many industry officials felt should have taken place.

Continued growth of Soviet production of metalcutting machine tools is expected for the remainder of the 1960's. Production for the last three years of the Seven Year Plan (1959-65) should continue to increase at about 5 to 6 percent a year as it has for the past three years (1959-61). This rate would be sufficient to ensure fulfillment of the Seven Year Plan goal for the production of 190,000 to 200,000 metalcutting machine tools in 1965.7/ A

statement by an "observer" in Ekonomicheskaya Gazeta of 17 May 1961 that 270,000 metalcutting machine tools would be produced in 1965, later repeated by several other spokesmen for the industry, suggests that the Seven Year Plan goal may have been revised sharply upward. To meet the higher figure, the industry would have to achieve an average annual increase of slightly over 13 percent for the remaining years of the Plan. It is unlikely that such an acceleration of output can be achieved by 1965. Nor do the modest goal for 1962 of 170,000 and the fulfillment of the six months plan for 1962 indicate that the 270,000 unit figure for 1965 is a firm goal. 8/

Peering far into the future, some Soviet industry spokesmen have claimed that by 1980 the USSR will be producing 600,000 metalcutting machine tools annually. This figure probably is a rough projection of the production required to support the planned increase in the output of the metal-fabricating industries, and undoubtedly assumes the continued use of predominantly conventional metalworking processes. It fails to take into account the replacement of conventional metalcutting by metalforming, new processes for removal and shaping of metal, and the greatly increasing use of plastics in place of metal.

No authoritative voice in the US has dared hazard a guess on the shape of the US machine tool industry by the end of the current decade, much less on the situation in 1970. Indeed the prospects for the next two or three years are anything but clear. Chances are that production of metalcutting machine tools will increase in the next few years in terms of value if not in numbers. Numbers become less significant when one considers that the new machine tools being produced have a far greater capacity for metal removal than the tools they replace. Furthermore, in the US, as in the USSR, new methods of removal of metal currently

being developed may replace conventional methods to a significant degree.

III. Problems of Comparison of US and Soviet Production of Machine Tools

Comparison of production of machine tools in the US and the USSR is difficult because of the lack of adequate detail on the product mix of each country. Soviet statistics on the quantity of production are fairly detailed but contain two large omnibus categories. In addition, the value of output has not been reported. Assessment of the US position is complicated by the existence of two sets of figures for the production of machine tools, those of the Bureau of the Census and those of the National Machine Tool Builders Association (NMTBA). The vast difference between the two is apparent from statistics on production of metalcutting machine tools in the US in 1961, which totaled 124,054 units according to the Bureau of the Census and 28,600 units according to the NMTBA.9/

In terms of value of output the two organizations were much closer. Value of output of metalcutting machine tools in 1961 according to the Bureau of the Census was $531 million, according to NMTBA $507 million. A comparison of the statistics on output by these two organizations during the last three years is shown in Table 2.

Table 2

US: Production of Metalcutting Machine Tools
1959-61

Year	Units		Value (Million US$)	
	Census	NMTBA	Census	NMTBA
1959	143,380	33,900	469	413
1960	133,511	34,000	539	508
1961	124,054	28,600	531	507

The magnitude of the difference between the number of units reported by NMTBA and by Census is puzzling. NMTBA allegedly expands its figures on production to include an estimate for the production of non members

of NMTBA. The Bureau of the Census specifically excludes "low-priced types of small size and light construction... designed primarily for the home workshop, laboratory, or service shop." If both organizations use the same definition of machine tools, the figures should be similar. The greater similarity of the value figures suggests that a substantial proportion of the units reported by Census consist of machine tools of low value. This hypothesis is verified by the Bureau of the Census statistics which reveal that of the 124,054 metalcutting machine tools shipped in 1961, 83,691, or 67 percent, were of an average value under $1,000. The average value of these 83,691 machine tools was $217.00. This relationship for selected categories of metalcutting machine tools is shown in the following tabulation:

Product Class Code	Category	Total Number Shipped	Number Shipped with an average value under $1,000	Average value of those shipped with an average value of under $1,000 (US $)
3541	All metalcutting machine tools	124,054	83,691	217
35412	Drilling machines	22,778	20,202	188
35414	Grinding and polishing machines	47,873	37,705	123
35415	Lathes	16,114	6,567	508
35417	All other metalcutting machine tools (except those designed primarily for home workshops, laboratories, garages, etc.)	21,389	15,790	297

The Bureau of the Census classifies these low value machine tools as light industrial types. The very low average value and the large quantities suggest, however, that there is a considerable number of the home workshop

and service shop variety in these statistics.

Whether or not this is the case, Bureau of Census statistics on total numbers produced cannot be used satisfactorily for purposes of comparison with the USSR. Analysis of Soviet catalogs and other literature on machine tools indicates that the Soviet product mix includes few models of the type that would cost under $1,000 in the US, except for a bench drill, of which about 6,000 are produced annually in the USSR, and perhaps 1,500 of the 37,000 lathes produced in the USSR in 1960.

To achieve rough comparability of US and Soviet production in quantitative terms, the Bureau of the Census category of metalcutting machine tools of an average value of $1,000 or over appears to be the best representative of US production of machine tools. Thus in 1961 the US produced about 40,000 metalcutting machine tools. If announced Soviet production is reduced by 8,000 units to adjust for the lathes and bench drills that would cost less than $1,000 in the US, Soviet production in 1961 would be 156,000, or 3.9 times that of the US.

Comparison of US and Soviet production of metalcutting machine tools by category shows a commanding Soviet lead for all categories for which a comparison can be made, except for boring machines. Some important categories such as lathes, milling machines, grinders, and vertical drilling machines cannot be compared because of the presence in the US figures of large numbers of machine tools of low value. This comparison

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of categories is shown in Table 3,/ Although important industrially, the machine tools listed in Table 3 constitute only a small percentage of the total production of metalcutting machine tools in either country.

Table 3

US and USSR: Comparison of Production of Selected Categories of Metalcutting Machine Tools[10/]
1960

Category	Units		Ratio of USSR to US
	US	USSR	
Slotters	51	733	14.4 to 1
Planers	41	433	10.6 to 1
Radial drilling machines	489	4,121	8.4 to 1
Shapers	492	2,533	5.1 to 1
Broaching machines	176	600	3.4 to 1
Gearmaking machines	1,243	3,313	2.7 to 1
Turret lathes	1,599	3,583	2.2 to 1
Automatic and semi-automatic lathes	2,275	4,274	1.9 to 1
Boring machines	1,523	1,314	0.9 to 1

In order to obtain a comparison more meaningful than that of numbers produced, a comparison of production by value has been estimated. The Bureau of the Census provides a value figure for US production, but the Soviet Central Statistical Administration does not provide such a figure for the USSR. It was necessary, therefore, to obtain an average value for each category of metalcutting machine tool produced in the USSR and to multiply the average value by the number of units produced in that category. The year 1960 was selected because it is the last year for which the USSR reported production by category. An article by Prokopovich provided average costs (sebestoimost') in 1956 of most categories of machine tools. Values of the remaining categories were estimated on the basis of an analysis of the types of machine tools contained in these categories. The result is an estimate, shown in Table 4, page 10, of production of metalcutting machine tools in the USSR in 1960 valued at 3.6 billion ~~pre-1961~~ rubles.* A comparison of the prices and technical characteristics of selected Soviet and US models, which was made several years ago, indicated a ruble-dollar ratio of 1.7 rubles/to US $1 for metalcutting machine tools. The use of

* Ruble values in this report are given in old rubles (rubles in use before the Soviet currency reform of 1 January 1961).

Table 4

USSR: Estimated Value of Production of Metalcutting Machine Tools
1960

Category	Production (Units)	Thousand Rubles	
		Average Value per Unit[a]	Total Value
Lathes, total	36,968	12.5	462,100
Turret lathes	3,583	12.5	44,788
Automatic and semiautomatic lathes	4,274	32.0	136,768
Milling machines	16,138	18.1	292,098
Gearmaking machines	3,313	36.0	119,268
Boring	1,314	83.2	109,325
Planers	433	80.0[b]	34,640
Shapers	2,533	14.5	36,728
Slotters	733	15.9	11,655
Broaching machines	600	30.2	18,120
Grinding machines	7,439	21.7	161,426
Tool and cutter grinders	4,343	7.5[b]	32,572
Vertical drilling machines	31,769	5.9	187,437
Radial drilling machines	4,121	27.9	114,976
Special, specialized and unit types	22,138	75.0[b]	1,660,350
Other (such as sharpening, boltthreading, and nut-tapping tools)	15,867	10.0[b]	158,670
TOTAL			3,580,921

a. Unless otherwise indicated, from A. Ye. Prokopovich, "Methods for Determining the Effectiveness of Modernization of the Existing Inventory of Metalcutting Machine Tools" in Ekonomicheskaya effektivnost' kapital'nykh vlozheniyy i novoy tekhniki, Moscow, Sotsekgiz, 1959, p. 329.

b. Estimated.

this ruble-dollar ratio results in a Soviet production for 1960 of US $2,106 million compared with US shipments in that year, as reported by the Bureau of Census, of $539 million. Thus the value of production in the USSR in 1960 was 3.9 times that of the US.

A rough estimate of the ruble value of Soviet production of metal-cutting machine tools can be obtained by another method. A Soviet source states that output of the machine tool industry in 1958 was 1.31 percent of the gross output of machine building and metalworking.11/ Another Soviet source states that metalcutting machine tools comprise 80 percent of the output of the machine tool industry.12/ Khrushchev reported at the XXII Party Congress that the output of machine building and metal-working in 1960 was 340 billion rubles. Thus:

$$340 \times 1.31 \times 0.8 = 3.6 \text{ billion rubles}$$

The striking coincidence of the two estimates should not conceal the defects in the respective methodologies. Concerning the first estimate, it should be noted that average costs were used rather than wholesale prices on which the ruble-dollar ratio was based. Average wholesale prices would have been several percent higher. Another defect was the failure of Prokopovich to provide average values for two categories that together comprised 24 percent of the machine tools produced in 1960, and for which average values were estimated. Another problem is the probability that average values given by Prokopovich would have been somewhat higher in 1960 because of the upgrading of the Soviet product mix after 1956, the year for which the average values were applicable. These defects

in the aggregate probably resulted in an understatement of the Soviet position. The second estimate also has drawbacks, for it is possible that the share of the machine tool industry in the total output of machine building and metalworking changed slightly betweeen 1958 and 1960.

A final opportunity for error occurs in the ruble-dollar ratio used. An unweighted arithmetic average of 1.7 to 1 US dollar is believed to be more valid for the sample studied than the unweighted median average of 1.2 to 1. The ratio selected was based on 1955 US and USSR prices. Although the USSR still used 1955 prices in 1960, except for models introduced since 1955, it is believed that US prices for machine tools increased during this period. A ruble-dollar ratio calculated from 1960 prices, therefore, probably would be more favorable to the USSR.

Comparison of US and Soviet production of metalforming machine tools presents difficulties as perplexing as those encountered in comparisons of metalcutting machine tools but differing slightly in nature. Soviet statistics on metalforming machine tools do not give the breakdown into categories that is given in the statistics on metalcutting machine tools. In the US NMTBA gives no figures for production in terms of units, so that the only unit figures available are given by the Bureau of the Census. As is the case with metalcutting machine tools, the Census figures contain a substantial number of types for which there are few comparable models in the Soviet product mix.

In order to achieve rough comparability of US and Soviet statistics on metalforming machine tools, it is therefore necessary to adjust again the US Bureau of the Census figures. To use the figures for tools of an average value of $1,000 or over, as was done with metalcutting machine tools, probably would understate the US position, for there are believed to be a number of simple models in the Soviet product mix that would cost

under $1,000 in the US. A better method of adjustment would be to eliminate specific categories which are not believed to be included in the Soviet statistics -- manual presses, manual punching and shearing machines, riveting machines, metal container making machines, die casting machines, machines for weaving and other wire fabricating, wire drawing machines and draw benches, spinning lathes,* marking machines, and knurling machines. Elimination of these categories would reduce the 1961 shipments by 16,739 units.

There is some doubt as to whether or not the 10,026 "other bending and forming machines" of an average value under $1,000 in the Census listing would find counterparts in the Soviet product mix. For lack of detailed information on this category, however, it was decided not to eliminate it.

After adjustment of the Census statistics, a figure is obtained for production in the US in 1961 of metalforming machine tools of 28,828 units. Soviet production of these machines in 1961 was reported at 30,500.

The value of the 28,828 units used to represent US production in 1961 was $191 million. The NMTBA reported shipments of only $149 million in 1961.

Quantitative comparisons of US and Soviet production of machine tools, even by value, do not reflect the productive capacity of the machine tools built in the two countries. Comparisons of technical characteristics indicate that US machine tools generally are more complex, more highly automated, and more productive than similar Soviet models.

IV. Product Mix

The product mix of metalcutting machine tools has become increasingly sophisticated in the USSR in recent years. The number of type-sizes in

* Spinning lathes were excluded only because they could not be extracted from the group in which they were lumped.

production increased from 384 in 1950 to 788 in 1955 and to approximately 1,000 in 1960.[13] The Seven Year Plan calls for production of 1,500 type-sizes in 1965, but there was an indication in 1961 that the planned number had been reduced from 1,500 to 1,200 probably as a result of greater emphasis on standardization and the dropping from production of an increased number of obsolete models.[14]

The upgrading of the Soviet product mix also is evidenced by changes in the volume of production of various categories of machine tools. The share of lathes has decreased in the past decade from 34 percent to 24 percent of the total production, and the share of automatic and semi-automatic lathes has increased from 1 percent to 3 percent and "precision" machine tools from 3 percent to 7 percent. Changes in the composition of the Soviet product mix are reflected in Table 1, page 3, which shows production for 1950, and for 1958-60, by category, as reported by the Central Statistical Administration of the USSR.

During the 1950's the Soviet machine tool industry emphasized the production of heavy machine tools. [redacted] lathes for parts 10 feet in diameter and 90 feet long, gear hobbers for gears up to 20 feet in diameter, and vertical boring mills with capacities for parts 80 inches in diameter. Since about 1959 the industry has placed more emphasis on increasing the proportion of small size and precision machines, such as tool room lathes with less than 12-inch swing, high speed drills of less than 1/2-inch diameter capacity, and fine-pitch precision hobbers.

Since 1958 the USSR has built many prototypes of numerically controlled machine tools, including lathes, milling machines, drilling machines, horizontal and vertical boring mills, and jig borers that perform the functions of automatic positioning, tool changing, and two and three dimensional

duplicating. Open-loop and closed-loop control circuits that are actuated by punched cards, punched tape, or magnetic tape are used in these machines. The USSR has not built so many numerically controlled machine tools as has the US. Instead, the USSR has developed a variety of modular numerical control units for use on machine tools. These units currently are being tested under actual production conditions. In addition, the USSR also has developed a number of machine tools with plug board type program controls that are not numerically controlled. The programs are preset by mechanical, hydraulic, and electromagnetic means. It appears that the USSR is delaying mass production of both types, numerical and plug board, until it is decided which is more appropriate for each category.

In the area of electrical discharge methods of metal removal, the USSR has advanced rapidly, having built 95 units in 1958 and 200 in 1959; 400 were planned for 1960.15/

There also has been considerable emphasis on production of automatic lines for the Soviet machine building and metalworking industries and of standardized components and units needed for incorporation into these lines. In the last few years, several new plants have been built and at least three plants have been converted to produce this type of equipment. Soviet production of these lines has been as follows:16/

1959	160
1960	153
1961	160 (est.)
1962	219 (Plan)

The size of these lines also is increasing. In 1959 the most complicated transfer line on which information is available contained only 30 units, whereas 85 power units were used in a single line in 1960, a large number even in the US. The majority of newly built transfer lines in the USSR

are allocated to the motor vehicle industry and most of the remainder to the bearings, agricultural machinery, and tractor industries.

During the entire period of the Seven Year Plan, 1,722 automatic lines are to be built. The majority of these will be transfer lines. Others will be lines composed of general purpose machines integrated with heat treating and inspection equipment when necessary. Transport devices are used in such lines to convey the part through all engineering operations, starting with a rough blank and ending with the finished machined product.

In the area of metalforming machine tools the Soviet product mix is not adequate for the needs of the various industries. The USSR has built more than 400 type-sizes, but many are prototypes and not yet in production. Among the prototypes built in 1960 are high-speed hydraulic presses, rotary swagers, high-speed cold headers, and multistation mechanical presses, all types that are principally used for production of consumer goods. These prototypes resemble Western models and are believed to be of higher quality than the earlier Soviet models.

Most of the metalforming machine tools built in the USSR are general-purpose presses (mostly mechanical), hammers, shears, and bending machines. More sophisticated types, such as those for spin-forming, stretch-wrap-forming and are built, but most of these are just emerging from the prototype stage.

There has been considerable emphasis, however, on building very large metalforming machine tools. The USSR has built an 8,000-ton mechanical press, a 30,000-ton forging press, a 70,000-ton forging press, a 20,000-ton extrusion press, a 100-ton-meter counterblow hammer, and 6-inch horizontal forging machines.

The quality of Soviet machine tools, both metalcutting and metalforming, when compared with Western models, runs the gamut in technology and craftsmanship from obsolete to highly advanced types and from poor to very good in workmanship. Materials are good, and designs are functionally adequate. Almost all Soviet models, however, are underpowered compared with US machine tools of similar size. Soviet industry officials have been realistic in appraising the quality of their own machine tools. Results of a comparison of Soviet and foreign machine tools conducted by the Experimental Scientific Research Institute of Metalcutting Machine Tools (ENIMS) and published in 1960 showed that of 270 widely used models of general purpose Soviet metalcutting machine tools, 20 surpassed, 210 were the same, and 40 were below the level of comparable foreign models. 17/

V. Organization of Production

The Soviet machine tool industry consists of about 170 plants, of which 60 are specialized producers. Fifty of the specialized producers produce metalcutting machine tools and 10 produce metalforming machine tools. In the US in 1958 there were 505 establishments having 10 or more employees engaged in the production of machine tools, 315 producing metalcutting machine tools and 190 producing metalforming machine tools.

As a comparison of the relative size of the industries in the two countries, these statistics are misleading. In the US a relatively few firms dominate production of most of the major categories of machine tools. Three firms are preeminent in the field of gear making machinery; three firms make most of the milling machines, and two firms produce most of the internal grinders. Lathes are an exception, for there are a number of firms competing in this field. In the USSR a somewhat similar specialization occurs. Almost

all of the gear machinery is made in three plants. Most of the milling machines are manufactured at Gor'kiy and Dmitrov. Almost all radial drills are produced at a plant in Odessa. In 1960, 80 percent of the machine tools produced were manufactured in plants which specialized in machine tools.[18/] Although comparable figures are not available for the US, a high degree of specialization is suggested by the fact that in 1958, 89 percent of the shipments of metalcutting machine tools by value were from the machine tool industry, and that metalcutting machine tools represented 85 percent of the total products shipped by this industry.

The specialization of the Soviet machine tool industry, combined with a high degree of standardization of machine tool components and a limited number of models, permits a high rate of production of the more popular models. This is accomplished by the use of conveyor lines for machining parts and for assembling finished machines. The ultimate in these techniques is used at the Krasnyy Proletariy plant in Moscow, the largest Soviet producer of machine tools. This plant produces about 12,000 lathes a year, using conveyor-line methods for machining bases, beds, headstocks, and gears, and also a moving conveyor for assembly.

The Odessa Radial Drill Plant, using similar methods, has been producing more than 2,000 radial drilling machines annually since 1956. Other Soviet producers of engine lathes, milling machines, and upright drilling machines use similar methods but not so extensively as the two plants mentioned above. Soviet officials claim that about 40 percent of Soviet metalcutting machine tools are produced by means of these mass production methods.*

* Many Soviet machine tool plants, including all of the builders of metalforming machinery, employ small batch production methods.

Seymour Melman, Associate Professor of Industrial Engineering at Columbia University, who visited machine tool plants in the USSR and Western Europe in 1959 as a consultant for the European Productivity Agency, OEEC, found that the manufacture of certain 16 inch swing engine lathes in the USSR using mass production methods required 200 man hours. In Western Europe the production of a similar machine tool required 600-800 man hours per machine.[19]

Methods of mass production are not used in the machine tool industry of Western Europe and are used only in a few plants in the US. The main recommendation of Professor Melman in his report to the EPA was that such methods should be introduced rapidly into the machine tool industry of Western Europe. The circumstances which favor such an organization of production in the USSR, however, are not present in the machine tool industries of Western Europe, as was pointed out by a report issued by the British Board of Trade.[20] Nor are they favorable in the machine tool industry of the US. In the market economies of the US and Western Europe, the demand for a single model is not sufficient to justify mass production methods of manufacture. Machine tools are tailored to the customer's requirement to a much greater degree than in the USSR. The trend is increasing in the US and Western Europe toward the production of larger, more complex, and more highly specialized machine tools, which are not compatible with the standard and general purpose designs that would have to be produced under conditions of mass production.

Soviet pride in the mass production methods used in the machine tool industry is matched by displeasure with the high degree of vertical integration of the industry in the USSR. Captive foundries in 1960 satisfied 85 percent of the industry's requirements for castings, and almost all of

the plants produced their own stampings and forgings.[21] In the US in 1958 only 2.9 percent of the metalcutting machine tool plants had their own foundries, 0.2 percent had forging shops, and 2.7 percent carried out stamping, blanking, and forming operations. All specialized machine tool plants in the USSR have tool and die shops. In the US in 1958 only 12 percent of the machine tool plants had such shops.

To increase the efficiency of machine tool production, the USSR plans to establish more centralized foundries and forges. By 1965, centralized foundries are to produce 65 percent of the castings required by the machine tool industry instead of the 15 percent produced by centralized foundries at the beginning of the Seven Year Plan. Centralized forges are to produce from 32 to 35 percent of the required stampings and forgings by 1965.

The great amount of vertical integration in the Soviet industry would normally indicate a less efficient industry than that of the US. A paucity of data on the Soviet machine tool industry prevents an adequate comparison between the two countries. A valiant attempt to do so was made in the USSR by Kuznetsova and Sergeyeva resulting in a conclusion that productivity of labor in the Soviet machine tool industry in 1958 was 53.7 percent that of the US in 1956.[22] Although these two ladies made numerous adjustments to achieve comparability, the comparisons are of doubtful validity. The authors proceed from the premise that US machine tool plants are basically machining and assembly enterprises, an impression conveyed by the statistical reports of the Bureau of the Census. Although this is true for most of the smaller plants, many of the largest producers perform both casting and forming operations. In addition, the authors overextend the US statistics in concluding that "castings, forgings, gears, spindles, turret heads, and other components are purchased from firms outside the industry."

Actually most of the larger US machine tool firms produce their own gears, spindles, and turret heads. By comparing the machining and assembly operations of the two countries, the Soviet writers overstate the efficiency of the Soviet machine tool industry, because in foundry and forging operations, which are eliminated from the comparison, Soviet productivity is lower than in machining and assembly operations. Another basic defect in the Kuznetsova-Sergeeva comparison is the difference in the product mix that has been discussed elsewhere in this paper. The authors made a good start in this regard by eliminating bench lathes and polishing machines from the US production, but they also should have eliminated a number of other types of low value. Had they done so, the results would have been more favorable to the Soviet industry.

Although the data probably do not permit an accurate comparison of labor productivity in the machine tool industries of the US and the USSR, qualified observers generally agree with Soviet economists that productivity in the US industry is higher than in the Soviet counterpart.

VI. Inventories

In inventory of machine tools the US and the USSR are closer than in production. In 1958 the inventory of metalcutting machine tools was 2.2 million units in the US and 1.9 million units in the USSR. 23/ The USSR early in 1962 reported an inventory of 2.3 million units. Although the precise size of the US inventory is unknown, it probably is about the same. The US inventory of metalforming machine tools probably is larger than that of the USSR. The most recent comparable figures, for 1958, showed the US with an inventory of 683,000 units, and the USSR with about 450,000 units.

The Soviet inventory of machine tools is younger on the average than that of the US. A Soviet newspaper claimed in January 1962 that 50 percent of the Soviet metalcutting machine tools were less than 10 years old.24/ In the US only 38 percent of the metalcutting machine tools are less than 10 years old.

The Soviet claim for the age of its inventory implicitly overstates the capability of that inventory. Up through the middle 1950's the USSR was producing a large proportion of obsolescent machine tools, and these tools make up the bulk of the present Soviet inventory. Until recently, only a very small number of machine tools were scrapped each year, probably less than 2 percent of the inventory. At present a large proportion of the Soviet machine tool inventory needs replacement because of physical depreciation and because of the previous technological backwardness of the Soviet machine tool models. Spokesmen for the US machine tool industry have urged strongly that US machine tools be replaced at a more rapid rate, an objective that recent changes in the tax laws are designed to accomplish.

That the US with a production of 89 million tons of crude steel to process in 1961 should be able to get along with an inventory of metal-cutting machine tools of about the same size as the USSR, which produced only 71 million tons of crude steel in 1961, suggests that the US inventory is more productive than that of the USSR, or is utilized more efficiently. Soviet officials are considerably concerned over the low rate of utilization of their machine tools, and several recent articles in the Soviet press have dealt with this matter. A year ago at the XXII Party Congress it

was reported that a sampling by the Central Committee showed that one-sixth of the machinery inventory was idle during the first shift and one-third during the second shift. Down time within shifts for some types of machinery (presumably referring mostly to metalworking machinery) reached 18 percent of total work time. 25/ Another factor of concern to Soviet officials is the high percentage of machine tools used for repair. Forty-two percent of the machine tool inventory is located outside of machine building, much of it in repair enterprises. 26/

VII. Foreign Trade

The USSR is a net importer of machine tools, having imported during 1957-61 machine tools valued at $433 million and exported machine tools valued at $269 million. The US is a net exporter of machine tools, having imported during the same period machine tools valued at $165 million and exported machine tools valued at $793 million.

Soviet imports of machine tools, as shown in Table 5, page 24, have increased considerably from $61 million in 1957 to $111 million in 1961. Soviet exports of machine tools, as shown in Table 6, page 24, however, have not moved consistently upward. Soviet exports of machine tools rose from $52 million in 1957 to $73 million in 1959. In 1961, however, these deliveries had fallen to about $43 million, about 18 percent less than exports in 1957. 27/ US exports of metalcutting machine tools increased 56 percent during the period, and imports increased by 18 percent. 28/

US foreign trade in machine tools is a larger percentage of US domestic production than is the case for the USSR. US exports of metalcutting machines during 1957-61 were equivalent to 18 percent of

Table 5

USSR: Imports of Machine Tools

1957-61

Thousand US $

Year	Metalcutting	Metalforming
1957	32,161	28,749
1958	43,169	34,925
1959	46,089	35,936
1960	62,899	38,174
1961	69,356	41,575
TOTAL	253,674	179,359

TOTAL METALCUTTING AND METALFORMING 433,033

Table 6

USSR: Exports of Machine Tools*

1957-61

Thousand US $

Year	Metalcutting	Metalforming
1957	40,245	11,973
1958	29,068	6,550
1959	59,568	13,703
1960	50,077	15,182
1961	33,354	9,433
TOTAL	212,312	56,841

TOTAL METALCUTTING AND METALFORMING 269,153

* Annual totals include estimates of the value of machine tools exported as part of complete plants.

domestic production, while similar Soviet exports were only 4 percent of Soviet production. US imports of metal-cutting machines during 1957-61 were equivalent to about 5 percent of domestic production while similar Soviet imports also were 4 percent.

The bulk of Soviet imports of machine tools have come from the European Satellites, principally East Germany, Czechoslovakia, and Hungary. During 1960-61, Western European countries, particularly West Germany and Switzerland, became increasingly important as suppliers to the USSR. Imports of metalcutting machine tools have consisted of all types, but precision and single-purpose types predominate. Imports of general-purpose types usually consist of "elephant" sizes. During the last two years, the USSR has attempted unsuccessfully to buy from the US transfer lines for the Soviet automotive industry and internal grinders for the antifriction bearings industry. Internal grinders have been purchased by the USSR from Italy and installed in an automatic line at one of the Soviet bearings plants.

Most Soviet exports of machine tools have gone to other Bloc countries, particularly Communist China. The drop in value of Soviet exports of machine tools from 1959-61 is due in part to the drop in Soviet deliveries to Communist China. Exports to the underdeveloped countries of the Free World have increased in recent years. Cuba, the UAR (Egypt), and India were the principal consumers in 1961. Soviet exports to the industrial West have increased slightly. The precise pattern of Soviet exports of machine tools cannot be determined, because Soviet trade handbooks bury a large part of machine tool exports in a general category labeled "equipment and materials for complete plants." Soviet sources other than trade handbooks have given the quantities of machine tools exported as part

of complete plants for selected years. These deliveries are generally several times those of exports specifically identified as machine tools. For example, in 1960 the USSR exported about 2,100 units of metalcutting machines, specifically identified as machine tools, while 5,000 units were exported as part of "complete plants."

VIII. Research

The USSR for many years has devoted substantial resources to research on machine tools. Soviet research in this field continues unabated in numerous central scientific research institutes, special design bureaus, and the design bureaus of the more important machine tool plants. The Experimental Scientific Research Institute for Machine Tools (ENIIMS), located in Moscow, is the central institute for the industry, with many laboratories for basic research on metal-cutting machine tools. ENIIMS develops and produces prototypes, which are then assigned to other plants for quantity production. This institute has final acceptance authority for all new developments and prototypes of metalcutting machine tools originating in other institutes, plants, and design bureaus.

Basic research on metalforming machine tools and processes is carried out at the Central Scientific Research Institute of Technology and Machine Building (TsNIITMASh) in Moscow. This institute also performs basic research on other equipment and on materials for machine building plants. The emphasis in the metalforming field has been on hydraulics, especially as related to the design of heavy presses. Development of mechanical presses and forging machinery is conducted at the Experimental Scientific Research Institute for Forge and Press Machine Building (ENIIMASh) in Moscow.

The 70,000-ton forging press and the 20,000-ton extrusion press built by the USSR probably were designed by TsNIITMASh, which also has developed a new concept of building large forging presses of more than 30,000 tons, using a large cylinder of prestressed concrete to contain the moving components. The USSR claims that this concept will eliminate the need for building any more large forging presses of conventional all-metal construction. In the US the only presses of more than 30,000 tons that were ever built were two each of 35,000 and 50,000 tons. These presses, of all-metal construction, were built for the Air Force in the mid-1950's. Prewar Germany was the only other country ever to build a forging press as large as 30,000 tons, and this press also was of all-metal construction.

Another function of the central research institutes is to develop standards for modernizing the older machine tools or converting them to automatic cycle. In 1961 most of the research institutes of the machine-tool industry were working on various projects concerning programing controls of machine tools and electrospark and ultrasonic machining.

The USSR is engaged in extensive research on various phases of high energy rate forming (HERF)* and has had considerable success in laboratory applications of this technique. There is no evidence, however, of successful application of HERF to production processes in the USSR.

* The practical application of explosives, gases, electrical energy, or magnetic fields to shape metals by bending, forming, drawing, and extruding.

Considerable research on machine tools also takes place in Western Europe and the US. In some Western European countries this research is partially centralized--in Germany, for example, in the Technische Hochschule in Aachen and in Great Britain, in the Production Engineering Research Association. In the US, however, research on machine tools is neither centralized nor coordinated. Applied research is, of course, carried out by the various machine tool manufacturers. Basic research is done at certain universities and at some private research organizations, the projects of which are financed by individual machine tool firms. Some basis research on metalcutting is done by manufacturers of cutting tools and tool steels. The research of manufacturers and of private research organizations financed by manufacturers is proprietary and not made available throughout the industry.

Much of the basic research in the US on new methods of shaping and removing metal is performed outside the machine tool industry. Most of the early research on high energy rate forming was done in the aircraft industry, either directly or indirectly from funds provided by government defense contracts. Some of the pioneer work on electrical discharge methods of metalworking was done by a steel producer. Electronic firms have invested heavily in research on controls for numerically controled machine tools.

The rapid pace of technological development in metalworking processes means that research is likely to continue at an increasing rate in both the US and USSR.

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