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THE SOVIET PROGRAM FOR ICBM PRODUCTION: AN INTERPRETATION AND ANALYSIS OF OFFICIAL SOVIET STATEMENTS

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FOREWORD

The growing volume of Soviet statements on the program for production of the ICBM stands in need of collation, interpretation, and analysis. Apart from the question of whether or not the statements are a valid representation of the actual status of the production program, it is important to understand clearly what meaning the statements convey in a Soviet context. The present report is written primarily for the reader who is only slightly acquainted with Soviet production theory and terminology, but it also presents supplementary information for those already familiar with these topics.

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THE SOVIET PROGRAM FOR ICBM PRODUCTION: AN INTERPRETATION AND ANALYSIS OF OFFICIAL SOVIET STATEMENTS*

Summary and Conclusions

Taken as a set of milestones in the history of the Soviet program for ICBM production, the statements by Soviet leaders on the status of ICBM production trace a logical pattern from the creation of the prototype ICBM through its development phase, series production, and, finally, mass production. The statements are internally consistent in the use of production terminology, and, although containing some ambiguities in Russian, the terms describing each phase of industrial production are nevertheless widely used in the USSR and are more strictly defined than comparable US terms.

Although Soviet statements as a group clearly imply a transition from the manufacture of individual prototype ICBM's to production of larger numbers, these statements cannot be translated into an absolute volume of output. The statements imply clearly, however, that a progressively greater number of ICBM's are being made available for operational purposes.

If the statements are valid, the USSR required less than 18 months to make the transition from development to series production after the first successful launching of an ICBM prototype in mid-1957. Moreover, the development function and the series production function probably took place concurrently in separate enterprises. The decision to activate a series producer, which is contingent on the lead time required to organize series production, may have been made as early as the first half of 1957, with actual output of missile hardware from the series plant having begun by early 1959. About 1 year was required to make the transition from series to mass production.

* The estimates and conclusions in this report represent the best judgment of the contributing Offices as of 1 September 1960.

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The implied beginning of series production of the Soviet ICBM by early 1959 does not necessarily signal the initiation of deliveries to operational units, because of a unique feature of missile development -- the necessity to expend relatively large numbers of missiles in the development program. Series production provides a sound solution to the problem of obtaining relatively large numbers of expendable development hardware and should therefore be expected even when further development of the vehicle is anticipated.

A statement by Premier Nikita S. Khrushchev in January 1960 on the "mass production of intercontinental ballistic missiles of various types" contains two new elements that should be given serious attention. First, the statement implies that a standardized item is in continuous production on a large scale relative to the complexity of the vehicle and the difficulty of its manufacture, but it does not necessarily signify unusually large numbers in an absolute sense. Second, the statement that the USSR is producing more than one type of ICBM on a large scale opens to question the degree of difference between ICBM's which, in Soviet thinking, might constitute a distinction between types. At the present time, available evidence tends to support the existence of only one basic type of ICBM in the USSR.

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I. Introduction

Official Soviet statements on the ICBM* have engendered considerable interest in the Soviet concept of production as an aid in understanding the status of the Soviet ICBM program. The principal objective of this report is to examine the significance of the Soviet statements in the light of what is known of Soviet production theory and practice and in the absence of definitive complementary information of ICBM production in the USSR. Section II of the report presents a discussion of the concept of series production as it pertains generally to Soviet manufacturing. In Section III the steps leading from a development program to series production are reviewed, with emphasis on the experience noted in the Soviet aircraft industry. Section IV contains a critical evaluation of the pertinent statements made at various times concerning the Soviet ICBM. Information relevant to the topic of this report but not essential to the discussion is presented in a series of appendixes.

The ICBM itself represents but one important component in an operational weapons system. Clearly, production of the ICBM is not tantamount to production of a weapons system, for many other elements such as ground-based electronics; specialized support and handling equipment; and communications, logistical, and launch site equipment also are required and present independent manufacturing problems in their own right. In order to simplify the presentation of several of the more complex aspects of Soviet terminology and classification, the focus of this report is solely on the Soviet program for ICBM production. It should be understood, however, that the general phenomena described and the Soviet production terms and classifications discussed in this report apply equally and directly to all elements of the ICBM system.

II. Soviet Theory of Production

In the Soviet theory of production, all machine-building production is divided into three basic types: custom production (individual'noye proizvodstvo),** series production, and mass production. These three

* For a recapitulation of significant statements by leading Soviet personalities on the status of the ICBM program of the USSR, see Appendix A.
** For a discussion of this term and certain other Russian terms enclosed in parentheses, which have no counterpart in English or require explanation, see Appendix B.

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types are distinguished by the characteristics of the production processes, the types and the layout of the equipment employed, and the organization of production.* The most important single determinant of the types of production is the repetitiveness with which an end-item is manufactured,** for it is the total number of identical end-items produced in sequence without interruption that determines the feasible level of specialization and the technology to be employed.

As their designations suggest, custom production is the manufacture of one end-item or a very small number of identical end-items without recurrence in production; mass production is the regular, uninterrupted manufacture of a single, standardized end-item usually in large quantities; and series production is the consecutive manufacture of a series (seriya) or batch (partiya) that may or may not recur in production or, alternatively, the consecutive manufacture of one type of machine in batches that recur in production sequentially without interruption. The latter alternative is characteristic of the Soviet aircraft industry and armaments in general and is compatible with the manufacture of missiles. The advantages of this type of production lie in the relatively large volumes of output obtained and in an adaptability to frequent changes in the final product.

The manufacture of most machinery in the USSR is classified as series production, which is further subdivided into small, medium, and large series production. The classification of an end-item under one of these subdivisions is dependent on the following four variables: (1) the volume of production measured by the size of the series or batch, (2) the physical size of the finished product, (3) the complexity of the product measured in terms of the direct labor input (trudoyemkost'), and (4) the frequency with which the product is returned to production in the course of a year. 1/*** Because the ICBM is believed

* For a discussion of Soviet definitions of types and methods of production and a description of the general characteristics of the three types of production, see Appendix C.

** The concept of serial production is appropriate to the manufacture of parts and subassemblies as well as finished commodities. For a brief account of this usage, see Appendix D.

*** For serially numbered source references, see Appendix F.

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to be produced in a continuously recurring series, the last variable does not appear to bear on ICBM production. *

When illustrating series production, Soviet authors normally use only two of the variables to delimit subdivisions -- the volume of output and the size of the end-item. ** In treating specific categories of equipment, only the volume of output and the type of machinery are generally indicated. *** Although a time period for production of a given volume of a specific commodity is designated in some cases, the units of time used are not consistent. Timespans of 1 month or 1 year are employed for this purpose. The possibility of drawing general conclusions appropriate to all Soviet machine building on rates of production from this type of data thus is precluded. In practice, assigning production of a commodity to one of the subdivisions of series production is relative and varies according to the nature of the machine produced. As the variables relating to a given commodity change, the classification of its production also may change. A Soviet authority cites the following illustrative example. 2/ If a small oil engine† of 5 to 10 horsepower (hp) is produced in a batch of 50 units, its production is considered to be medium series. The manufacture of the same number of large oil engines of 500 to 1,000 hp, however, is classified as large series. The reason for this change in classification arises from the significant

* Further elaboration of the fourth variable, frequency of return to production in the course of a year, has not been found in Soviet literature. It is possible that a return to production in the course of a year may have the effect of raising the seriality of a given commodity. If this conclusion is valid, the total annual production of the commodity, together with its physical size and its complexity, would serve as the basis for assigning production of a commodity to one of the serial subdivisions.

** See Table 1, Appendix E, p. 28, below.

*** See Tables 2 and 3, Appendix E, pp. 29 and 30, respectively, below. Table 3 presents quantitative data on annual output and the recommended size of series for specific commodities.

† An oil engine (neftyanoy dvigatel') is an internal combustion engine that uses the vapor from petroleum, either crude or illuminating, instead of gasoline. It is a low compression engine with fuel injection in the operating cylinder and ignition provided by a spark plug. The diesel engine, which is also an internal combustion engine with fuel injection in the operating cylinder, is a self-igniting high-compression engine.

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differences in the size and input of direct labor between the two engines. In the instance of marine diesel engines of 600-hp to 1,000-hp capacity, however, production of a batch of 15 to about 50 units is considered small series production; 50 to 300 units, medium series; and 300 to 400 units, large series. 3/

Although serial terminology has the same usage throughout Soviet industry, there appears to be no consistently established application of the concept among industries. This conclusion is supported by the foregoing examples, in which production of 50 oil engines of 500 to 1,000 hp by one industry is considered large series, whereas production of 50 marine diesels of approximately the same capacity by another industry is small series or, at best, medium series production. Nevertheless, the oil and diesel engines are similar in operating principle and basic design. This apparent inconsistency is explained by the fact that this equipment is nonhomogeneous and that the agency which has the responsibility for classifying equipment in terms of size or weight for the purpose of determining seriality makes its own estimate according to the peculiar characteristics of the equipment. It follows, therefore, that the relative sizes presented in the illustrative tables of seriality for all machine building (see Table 1, Appendix E, p. 28, below) pertain only to homogeneous commodities produced by one plant or group of plants.

Inasmuch as the criteria for applying series production nomenclature are not based on established engineering parameters, they cannot be used as precise analytical tools. As noted above, only two of the four variables are normally used by Soviet authors in illustrating the serial subdivisions: the size of series (volume of output) and the physical size of the end-item. The ranges of volume output within a subdivision frequently are too broad to permit a meaningful estimate of the size of a production program, and the physical size of the end-item is described in the most general terms -- large, medium, and small. In addition, the ranges of output appear to change in the course of time and vary somewhat according to author, and the series ranges of output for specific commodities diverge from those presented in the illustrative tables. Moreover, the absence of a time period to which to attach these ranges precludes the determination of rates of production.

A further complicating feature in the concept of series production is the difficulty of procuring data on the variables, because this information normally would be available only to plant management or possibly

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to statistical and planning bureaus of governmental organizations. Finally the lack of an absolute scale by which to measure the variable determinants impedes interindustry comparisons of series production and comparisons by analogy. The concept of series production thus affords a means of classifying production but by itself fails to provide a means of precisely quantifying output.

III. Transition from Prototype to Series Production

The facilities and organizations engaged in the design and development of new equipment in the USSR vary considerably, ranging from design bureaus attached to producing plants to special development enterprises that are separate and distinct from the producing plants. Machinery of long standing -- for example, turbines, motor vehicles, and diesel engines -- are usually developed by a central design bureau working in close conjunction with the design bureau of the producing plant. Because models of this type of equipment usually do not embody radical changes in design but rather modifications or refinements of a well-established, fundamental design, the central design bureau has very limited production facilities of its own but makes use of those of a manufacturing plant.

Equipment never before produced or so new that accumulated experience is insufficient to predict accurately the operational characteristics of the finished product often are designed and developed in a separate enterprise with its own experimental production facilities. In the past, Soviet fighter aircraft have been in this category. Accumulated evidence indicates that production of Soviet missile development hardware probably also is organized in this manner.

In the instances of Soviet bomber aircraft, such as the Badger (Tu-16), the Bison (M-4), and the Bear (Tu-95), and turboprop transports, such as the Coot (Il-18) and the Cleat (Tu-114), both experimental production and series production were organized in the same facility. One of the primary reasons for this practice of using the same facility, especially in the case of the Bear and the Cleat, appears to be the large size of the aircraft being produced, which necessitates the use of major manufacturing buildings with extensive floorspace and high bay areas. Other important considerations are the expensive production equipment and tooling required to manufacture experimental models of

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modern aircraft with high performance characteristics and the traditional association of certain production facilities with particular Soviet aircraft designers and their design bureaus.

In bringing a new aircraft to series production, the following steps are carried out by the development function whether in the same or a separate facility: (1) preliminary design, (2) manufacture of models, (3) preparation of drawings and patterns necessary for the construction of test aircraft, (4) manufacture of experimental aircraft, (5) testing, (6) preparation of drawings and patterns for series production, and (7) delivery of drawings and specifications to the series enterprise. The series enterprise receives the technical documentation for the new aircraft, carries out the technological tooling for production, organizes the processes for series manufacture, and tests and delivers the finished aircraft. 4/

The above steps also are generally applicable to guided missile production. Two interdependent variables, however, should be considered in furthering an understanding of the nature of the transition from development to series production in guided missile programs.

First, the steps in the transition from development to series production are not necessarily carried out sequentially. The increased rate of technological change since World War II and the obverse of the rate of change -- the acceleration in the rate of obsolescence -- have generated a need to translate technology into hardware for most weapons systems more rapidly than in the past. This need has been further accentuated by the possibility of nuclear and thermonuclear warfare, which, in all real respects, has outmoded previous concepts of industrial mobilization for warfare. The result has been a more pronounced trend in the employment of concurrent or parallel programing techniques for complex weapon systems in which both development and volume production activity proceed simultaneously in two or more facilities. These techniques, which demand a high degree of decision-making centralization in planning and coordination, are well adapted to Soviet military-industrial organization.

In the instance of an earlier Soviet surface-to-air missile, the USSR demonstrated the accomplishment of the development-production transition through a closely integrated and concurrent operation between designers and highly skilled experimental producers. This process was paralleled by the preparation for series production in two plants

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simultaneously. These plants directly employed corrected precision design and development drawings for accomplishing initial tooling and production engineering. Evidence on the development and production of rocket engines for Soviet ballistic missiles provides a similar example of the use of concurrent programing techniques.

Second, the hardware requirements of a guided missile system program are somewhat unique relative to other weapon systems. It is necessary to expend relatively large numbers of missiles in the development program. This requirement, combined with the compressed lead times involved in concurrent programing techniques, has resulted in the adaptation of practices characteristic of quantity production to production that in the past would have been regarded as developmental or prototype in nature. Not only does the adaptation of techniques employed in assembly-line production to the manufacture of development hardware supply the relatively large amounts of test vehicles that are necessary for the program, but it also provides a reduction of lead time in the total program by allowing production engineering to take place concurrently with development of the product.

There are a number of outstanding advantages in the probable Soviet practice of employing an enterprise for missile design and development and a separate enterprise for series production, which has been directly evidenced in the instances of the surface-to-air missiles and ballistic missile rocket engines. Some of these advantages can be immediately noted by comparing the salient general differences in the organization of production between the development producer and the series producer that are listed below.

	Development Enterprise	Series Enterprise
Labor force	Elite; highly skilled; and capable of making parts from drawings, sketches, and technological charts	Mostly semiskilled performing repetitive operations and adapting to tooling changes for new product output
Equipment	General-purpose	General-purpose and special-purpose
Special tools	Few. General-purpose jigs, fixtures, and the like are required.	Special tools

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	Development Enterprise	Series Enterprise
Processes	Varied. Numerous operations are carried out at one machine tool	Greater specialization, consolidated operations alternating in sequence at definite time periods
Interchangeability of parts	Little or no interchangeability. Special fitting often is required.	Interchangeability of parts and components
Programing and production organization	Flexible in accordance with the basic outline of the development program	Assembly line, rigid program within the series
End-product	Unique in accordance with the test program	Virtually identical within a series

The differences are even more striking in practice when the effects on changes in the organization of program resources are considered. For example, the labor force in the development experimental plant must consist of a considerably larger group of skilled workers and technicians than that in the series production plant, where the skilled workers are predominantly found in such places as the tool and die shop rather than in the production machine shops or on the assembly floor. By turning the experimental plant producer into the series producer, there is considerable loss of skilled worker time and disruption of valuable development assets. The USSR does not appear to possess more than one development center for specific types of specialized components of guided missile weapon systems. This one center would tend to make for a rather well-defined separation of development and series production facilities, which is, in fact, indicated by the evidence. It must be realized, however, that the very large facilities such as those existing in the USSR could readily accommodate both development and production resources in different areas of a single complex.

One other consideration relevant to Soviet practice should be mentioned in passing. Soviet aircraft production has been characterized by the use of general-purpose machine tools and equipment requiring relatively more space requirements for assembly and subassembly areas. Current evidence resulting from an analysis of Lunik construction

indicates that similar practice may hold true in the manufacture of ballistic missiles. The result is a heavier missile and greater labor inputs than would have occurred if special-purpose equipment had been used. This relative lack of structural sophistication does not prevent production of a satisfactory weapon.

IV. Evaluation of Soviet Statements on the Soviet Program for ICBM Production

Although official statements by Khrushchev on production of the ICBM may be regarded as a set of milestones intended to convey an image of the status of this important program to the Soviet populace and to the world, the statements, by their very nature, may contain nuances, ambiguities, misrepresentations, and even outright falsifications. In view of the official occasions, such as a Party congress or a session of the Supreme Soviet of the USSR, which served as a backdrop to several of these pronouncements, complete falsification would be improbable, in part because of the possible internal political ramifications of such an action. Official statements of this type in the past generally have been true or have had a firm basis in truth, if properly and accurately interpreted. Nevertheless, the obvious desire on the part of Khrushchev to extract the maximum propaganda effect from the announcement of series production and his subsequent commentary on the status of the program should be recognized, and care should be exercised in interpreting the statements.

The principal statements on the ICBM that signify a transition from one phase to another are recapitulated in Appendix A. The first important statement, which appeared in November 1957, indicated that a workable ICBM prototype had been produced by the development enterprise but was subject to further improvements in design. In November 1958, Khrushchev revealed that production had been "successfully set up" (uspeshno nalazheno).* In January 1959 he spoke of the "creation and production (sozdaniye i proizvodstvo) of the intercontinental missile" and later in that month he stated that "series" production had been "organized" (organizovano). In February he described series production

* In this citation and subsequent citations, the perfective aspect of the Russian verb is used. The perfective aspect denotes the completion of past actions or states or single units of actions or states in the future. A Russian would never err in making use of the perfective aspect.

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as having been "mastered" (osvoyeno). Later, in November 1959, in alluding to these earlier statements, he used the expression "assembly line" (proizvodstvo ... na potok) to characterize ICBM production.

If these statements are a valid description of the Soviet program for ICBM production, they would imply that actual output of missile hardware from a series production facility began in the latter months of 1958 or the early months of 1959. If lead time requirements for facility preparation, production engineering, and tooling and startup were taken into account, a decision to activate a series producer would have been made probably no earlier than the first half of 1957 and no later than the beginning of 1958. That the first Soviet ICBM firing was announced in August 1957 suggests some degree of concurrence in the phasing of the program. By November 1958, at the time of Khrushchev's statement that production of ICBM's had been successfully set up, the USSR had fired a number of additional vehicles, including three earth satellites, from their test range located at Tyura Tam. If the lead time and program requirements from the time of the first firing until November 1958 are considered, the statement probably refers to the beginning of production of the first series at a facility different from the producer of the initial prototype.* The degree of success or failure in vehicle launchings, except in the 1957 period, should have had little immediate effect on the progress of organizing the starting up of the over-all production program, although it could have caused a later slowdown because of the scarcity of some component or part that may have required modification.

In the statement of 12 February 1959, Khrushchev used the word mastered and added the adjective series to describe ICBM production. There can only be speculation as to the distinction, if any, from the November statement. If the firing of the space vehicle in January 1959 (Lunik I) made use of a booster from the new assembly line, the word mastered may have applied to the proved success of the production hardware in a test firing.

* For the purpose of this analysis, it is not necessary that series production of the ICBM take place in a facility separate from the development enterprise, as long as it is understood that the salient features of the organization of production are most probably distinct.

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Whatever the true case, the statements on production signify the beginning of an assembly-line production program with no indication as to the disposition of the plant output. Although the beginning of series production of conventional machinery normally implies scheduled delivery to the final consumer, the same is not necessarily true in a program for ICBM production, because of the organization and unique requirements. In the instance of an ICBM, series production provides an economical and efficient means of organizing output in order to obtain relatively large quantities of hardware while preserving the flexibility demanded by the necessity of making numerous and frequent changes in the product.

A number of the Soviet series produced ICBM's in the 1959 period undoubtedly would have been allocated to development purposes and expended in the test firing program. The case for allocation to operational units, however, presents a complex analytical problem in the face of fragmentary, and what often appears to be contradictory, evidence. Only one Soviet statement reflects an operational capability in early 1959. R. Ya. Malinovskiy, Soviet Minister of Defense, thanked the "toilers ... who have equipped [osnastivshim] the armed forces with ... intercontinental ... missiles" in a speech on 3 February 1959. This statement differs from other relevant statements made before and after this date until June 1960 that indicate in a general way that the USSR or Soviet armed forces "have" or "possess" the ICBM. The use of the verb "equip" (osnastit'), which is used specifically with regard to armaments, implies an operational capability. No statement with a similar implication has been found before the speech by Khrushchev in Bucharest on 21 June 1960, in which he described the activity of the U-2, stating that "only the experimental grounds for launching rockets were photographed, not rocket bases of military and strategic importance." The inference that operational sites exist is clear. The absence of an official statement reaffirming Malinovskiy's statement of February 1959 is not readily explainable.

Khrushchev's statement in January 1960 on ICBM production alluded to the "mass production [massovoye proizvodstvo] of intercontinental ballistic missiles of various types." The use of the term mass production should be interpreted in the context of Soviet production theory and usage. It is mass production only in terms of the relatively large number of ICBM's being produced, taking account of size, complexity, and

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direct labor input required for manufacture. In this context the term does not necessarily mean unusually large quantities in an absolute sense but as it relates to the Soviet application of these variables. Therefore, Khrushchev's statement about mass production cannot be translated directly into a rate of output. The implication that allocations are being made regularly to operational units seems clear. The reference to ICBM's of "different types" might seem to indicate that the USSR has more than one type of vehicle. Whether or not Khrushchev is alluding to a second basic type of ICBM or merely to variations -- such as increased tankage or a different guidance package -- on a basic type of ICBM is open to speculation. This topic, however, is not within the purview of this report. Nevertheless, current evidence fails to support the existence of more than one basic type of ICBM.

In summary, taken as a set of milestones in the history of the Soviet ICBM program, the statements by Soviet leaders on the status of ICBM production trace a logical pattern from the creation of the prototype ICBM through its development phase, series production and, finally, mass production. Although these Soviet statements as a group clearly imply a transition from the manufacture of individual prototypes to production of larger numbers of ICBM's, they cannot be translated into an absolute volume of output. The statements imply clearly, however, that a progressively greater number of ICBM's are being made available for operational purposes.

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APPENDIX A

SELECTED STATEMENTS ON THE STATUS OF SOVIET ICBM PRODUCTION

The principal statements by two of the leading personalities in the USSR on the status of the Soviet ICBM program are presented below in chronological order. In each instance, key words or expressions have been presented in transliterated form in brackets. Each statement is followed by its appropriate citation.

Date	Statement
22 Nov 1957	Khrushchev: "... the Soviet Union was the first to create /sozdal/ the intercontinental missile* ... and this makes it possible for us to improve the fabrication /sozdaniye/ of missiles, to lead the US in this respect, and to accumulate the necessary stock of missiles, if we do not come to terms on disarmament." ("Conversation of N.S. Khrushchev with the Head of the Newspaper Publishing Trust, W.R. Hearst," Pravda, 29 November 1957.)
14 Nov 1958	Khrushchev: "The production of the intercontinental ballistic missile has been successfully set up /nalazheno/." ("Control Figures for the Development of the National Economy of the USSR for 1959-65," Pravda, 14 November 1958.)

* In this excerpt and subsequent excerpts, the Russian word raketa is translated "missile," although strictly translated, it means "rocket" -- that is, the propulsion unit of a missile. In Russian usage raketa is more frequently used than the literal equivalent for "guided missile" (upravlyayemyy snaryad), which is used in the US.

Date	Statement
3 Jan 1959	Khrushchev: "... the socialist government ... which ... occupies first place in the world in the creation [sozdaniye] and production [proizvodstvo] of the intercontinental missile." ("Speech of Comrade N.S. Khrushchev at a Grand Meeting of the Supreme Soviet of the Belorussian SSR," Pravda, 4 January 1959.)
27 Jan 1959	Khrushchev: "Series production of the intercontinental ballistic missile has been successfully organized [organizovano]." ("On the Control Figures for the Development of the National Economy of the USSR for 1959-60," Pravda, 28 January 1959.)
3 Feb 1959	Malinovskiy: "We applaud with joy our scientists, engineers, and technicians, all workers -- the toilers, who have created the Soviet cosmic rocket and who have equipped [osnastivshim] the armed forces with a whole series of military ballistic missiles: Intercontinental; continental of long, medium, and close range; and a whole group of tactical missiles -- and we express our deep gratitude to them." (R. Ya. Malinovskiy, Minister of Defense, "Address at the 13th Session of the Extraordinary 21st Congress of the CPSU," Vneocherednoy XXI s'yezd kommunisticheskoy partii sovetskogo soyuza [Extraordinary 21st Congress of the Communist Party of the Soviet Union], Volume 2, 1959, Moscow, p. 122.)
12 Feb 1959	Khrushchev: "When it was stated in a report of the Party congress that series production of the intercontinental ballistic missile had been mastered [osvoyeno], some western leaders began by inertia to voice doubts, but at once they broke off, declaring that if the Russians had said so, then it surely meant that series production of missiles was organized." ("Speech of Comrade N.S. Khrushchev," Pravda, 13 February 1959.)

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Date	Statement
14 Nov 1959	Khrushchev: "Then, when we put these missiles into production [pustili eti rakety v proizvodstvo], I stated that, in our country, intercontinental missiles were on the assembly line [proizvodstvo mezhkontinental'nykh raket postavleno na potok]." ("The Soviet Press Should Be the Most Mighty Combatant," from an address by Khrushchev to Soviet journalists in the Kremlin, Pravda, 18 November 1959.)
14 Jan 1960	Khrushchev: "We are several years ahead of other countries in the creation and mass production of intercontinental ballistic missiles of various types." ("Disarmament -- Path to the Strengthening of Peace and the Assurance of Friendship Among Peoples," from a report by Comrade N. S. Khrushchev at a session of the Supreme Soviet of the USSR, Pravda, 15 January 1960.)
21 Mar 1960	Khrushchev: "You know, probably, that in some plants we build aircraft, we also make missiles. You probably will not especially enjoy looking at missiles which are made in aircraft plants. But, of course, it is possible to find an aircraft plant which is not building missiles." ("A Meeting of N. S. Khrushchev with Representatives of the Trade Unions of France," from the journalists accompanying the Chairman of the Soviet of Ministers of the USSR, Izvestiya, 2 April 1960.)
21 Jun 1960	Khrushchev: "We know that the spy flights were carried out over regions which have no rocket bases. We know that two or three years ago regions where experimental rocket-launching sites were situated were photographed. Only the experimental grounds for launching rockets were photographed, not the rocket bases of military and strategic importance." ("Text of Speech by Nikita Khrushchev, First Secretary of the CPSU Central Committee, at the Third Rumanian Workers Party Congress, Bucharest, 21 June 1960," Moscow, TASS, Radiotele-type in Russian to Europe, 21 June 1960, 2030 GMT.)

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APPENDIX B

EXPLANATION OF SELECTED SOVIET TERMS OF PRODUCTION

The following Soviet terms of production either have no exact counterpart in English or warrant greater elaboration than that presented in the text.

Term	Discussion
Individual'noye proizvodstvo	Occasionally an author draws a distinction between custom (individual'noye) and unit (yedinichnoye) production (proizvodstvo). 5/ In most respects the two types of production are similar; they differ only in the repetition of production. Custom production refers to the manufacture of one model with no repetition of its manufacture at any future time, whereas unit production provides for the manufacture of the same item at some indeterminate time in the future. Unit production supposedly permits the establishment of more stable technological processes and the opportunity to specialize the operations of some machine tools.
Seriya, partiya	The Russian words "batch" (partiya) and "series" (seriya) are sometimes used interchangeably. There is, however, a distinction between the two terms. Batch refers to the number of parts that are put into production and processed as a group. A series is a batch of finished products, from which is derived the concept of series production -- the uninterrupted, consecutive production of a number of identical commodities. 6/

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Term	Discussion
Trudoyemkost'	In Soviet terminology, trudoyemkost' generally refers to the activity of production workers, which includes the activity of all those whose work contributes directly to a change in the form of a particular product. Trudoyemkost' is roughly equivalent to "direct labor" except that trudoyemkost' excludes all operations not directly attributable to production as defined in the USSR. Thus trudoyemkost' does not include servicing operations -- for example, materials-handling -- or inspection.

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APPENDIX C

SOVIET DEFINITIONS OF TYPES AND METHODS OF PRODUCTION

The terms custom production, series production, and mass production are quite current in Soviet literature and often are used interchangeably to refer to the volume of output or to the organization of production. The following discussion and definitions of types and methods of production are presented in an attempt to clarify Soviet usage and explain possible ambiguities.

Confusion in the usage of production terminology undoubtedly arises from the inherent interrelationship and interdependence between the volume of output and the organization of production by which the manufacture of goods is accomplished. Fundamentally it is the size of the batch (partiya) -- that is, the number of identical parts to be processed consecutively, without interruption -- which determines the nature of the process. The size of the batch, in turn, is a function of the number of identical machines produced, the number of identical parts in the machine, and the number of spare parts required.

Although the terms custom production, series production, and mass production are used in a dual sense in the USSR, the more authoritative sources define the types of production principally on the basis of volume of output. In general, a statement that a commodity is in series production connotes an absolute number of the commodity in production. Where reference is made to the organization of production, the terms custom production methods, series production methods, and mass production methods normally are used.

1. Types of Production Defined According to the Volume of Output

The most concise definitions of the types of production in terms of the volume of output follow 7/:

> Custom production is that production in which products are manufactured in units or in small numbers without regular repetition in the production schedule. Series production is that production in which the

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> regular repetition in the manufacture of a batch or series of identical products takes place. Depending on the size of the series, the frequency with which it returns to production, and the direct labor input (trudoyemkost') in manufacturing the parts, series production is subdivided into small, medium, and large series production. Mass production is that production in which a given product is turned out regularly and in very large numbers.

In US terminology these three types of production probably would be subsumed under the terms scale or scale of production. In at least one instance, the Russian word masshtab (scale) is used synonomously with the word seriynost' (seriality). 8/

The definition of series production according to the quantity produced also is given by the Bol'shaya sovetskaya entsiklopediya (Large Soviet Encyclopedia), 9/ which describes such production as "a type of production in which the repetition in the manufacture of a series of identical products (or batch of identical parts) during some interval of time is provided for in advance." In a recent publication a Soviet author warns that "one must not confuse types and methods of production" and goes on to define types of production in terms of the volume of output and methods in terms of assembly-line and non-assembly-line production. 10/

2. Types of Production Defined According to the Organization of Production

Use of the terms custom production, series production, and mass production to mean the organization or methods employed in the production of commodities is found implicitly or explicitly in both Soviet technical works and dictionaries. A recently published dictionary defines all three terms as "a type of organization of production." 11/ The definitions follow:

> Custom production is a type of organization of production by units or by small, single series. Series production is an organization of production in which products are turned out in batches (series). Mass production is one of the progressive forms of the

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organization of production in specialized enterprises, turning out a single type of production of limited nomenclature.

3. General Characteristics of the Types of Production

The general characteristics of the three types of production are presented below. 12/ In practice, some parts or components may be produced by methods that are atypical of the over-all production technology of the final product. These characteristics hold true whether the three types of production are defined in terms of volume of output or in terms of organization of production.

a. Custom Production

The production processes are flexible in accordance with the diverse nature of the products manufactured and require general-purpose equipment and highly skilled workers capable of carrying out frequent retooling. A large number of diverse operations may be carried out at the same machine tool or work station. Normally there is no assembly-line production involved in individual production, and only the labor-intensive and heavy work is mechanized. Because there is less need for interchangeability of parts, allowances and tolerances for forging, casting, and machining have relatively wide limits. As a result, much custom fitting work is required in the final assembly of the product. Examples of custom production are rolling mills, large hydraulic turbines, heavy presses, and the like.

b. Series Production

Production processes are more rigidly established than in individual production. The equipment is more specialized, and most of the workers need not be highly skilled. Several different operations on a given part are carried out at each work station for a given period of time. Then, after retooling, a new series of parts is processed. Some secondary and auxiliary processes as well as labor-intensive and heavy work are mechanized. Allowances and tolerances in forging, casting, and machining operations are more narrowly specified. Parts produced in series are partly interchangeable. Small series production is exemplified by various types of compressors, diesel engines, machine tools, and the like; medium series production by railroad

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passenger cars, locomobiles, materials-handling equipment, and the like; and large series production by freight cars, heavy tractors, and the like.

c. Mass Production

The processes involved in mass production are inflexible. Equipment is highly specialized, and each work station has a rigidly defined operation. Assembly-line production is found in its more perfected form. The workers may have a minimum of skills, for retooling takes place only at rare intervals. Secondary as well as auxiliary work is mechanized. Allowances and tolerances are narrowly defined, for parts must be entirely interchangeable. Mass production in its most highly developed form becomes automation, and the workers' responsibility lies only in the surveillance of the automatic machinery and in retooling. In this highly developed form, however, the workers must be highly skilled technicians. The classic example of mass production is the automobile. Other examples are cutting tools, ball bearings, fasteners, and the like.

4. Methods of Production

Soviet authors in general recognize two methods of production: assembly-line (potochnyy; literally, flow) and non-assembly-line (nepotochnyy; literally, nonflow). 13/ The former is usually associated with mass production and the latter with custom production. Series production, embracing by far the largest share of total machine-building output, combines elements of both methods.

Assembly-line production is defined as that method of production in which operations connected with the manufacture or assembly of machines are assigned to predetermined equipment or work stations. The equipment and work stations are laid out according to the order of performing the operations, and the part worked or the product assembled is transferred from one operation to the following, immediately after the completion of each operation, as a rule with the aid of special materials-handling installations.

Non-assembly-line production is that method of production in which the manufacture of parts is carried out in batches for each operation. The production equipment is arranged in groups without established links between succeeding operations, and the assembly of the product is carried out at stationary stands. In the preparation and production shops the entire batch is worked at each work station, and the batch as a whole is transferred to the succeeding station.

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APPENDIX D

SERIES PRODUCTION OF PARTS AND SUBASSEMBLIES IN THE USSR

Distinction should be made between series production in the USSR as it pertains to parts and subassemblies and as it pertains to finished commodities. Both concepts are current and have appropriate quantitative indicators. The following is a very brief account of the use of terminology for series production in contexts other than those developed in the textual portion of this report.

The seriality of basic processes (forging, casting, heat treatment, machining, and assembly) employed in the manufacture of parts and subassemblies is used as an engineering technique to establish assembly-line production and to check the efficiency of processes. 14/ It is possible that, through development of an efficiently balanced set of subprocesses, varying orders of seriality may pertain to diverse processes that are used in the manufacture of a single item.

Many individual processes are given quantitative indicators characterizing the physical output according to the seriality of production. An example of such indicators for stamping is provided below in a tabulation of the annual output of stampings. 15/

Thousand Units

	Size of Stamped Parts (in Millimeters)*		
Type of Production	Large (250 to 1,000)	Medium (50 to 250)	Small (Less than 50)
Small series	Less than 10	Less than 50	Less than 100
Medium series	10 to 50	50 to 500	100 to 1,000
Large series	50 to 500	500 to 2,000	1,000 to 10,000
Mass	More than 500	More than 2,000	More than 10,000

* The data are reported as they appear in the Soviet source.

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In addition to processes, basic production shops in the plant are classified according to seriality. Each category is distinguished by such shop parameters as the annual output and the typical weight range of the product as well as the characteristic technology, equipment, and layout of the shop. These data are normally used by plant designers as a basis for the design and construction of new plants.

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APPENDIX E

VOLUME OF PRODUCTION IN THE USSR ACCORDING TO SUBDIVISION OF SERIES PRODUCTION

Soviet technical literature contains examples of series production expressed in terms of volume of output. The following tables contain a summation of such data gleaned from a large body of Soviet technical monographs, textbooks, handbooks, and periodicals. Table 1* is a compilation of several illustrative tables appropriate to Soviet machine building in general. Table 2** is similar to Table 1 but relates the quantitative data to specific commodities. Table 3*** shows the annual volume of output and/or the recommended size of series together with the Soviet-designated type of production for selected commodities produced by the machine-building industry of the USSR.

* Table 1 follows on p. 28.
** Table 2 follows on p. 29.
*** Table 3 follows on p. 30.

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Table 1

Compilation of Illustrative Tables of Series Production for Soviet Machine Building

Quantitative Ranges of Output in Units

	Large Equipment		Medium-size Equipment				Small Equipment	
Type of Production	1954 and 1958 a/ b/ c/	1949 d/	1954 b/	1958 c/	1949 d/	1949 e/	1954 and 1958 b/ c/	1949 d/
Small series	2 to 5 f/	2 to 10	5 to 25	2 to 25	5 to 25	5 to 25	10 to 50	10 to 50
Medium series	5 to 25	10 to 50	25 to 150	25 to 150	25 to 200	25 to 100	50 to 300	50 to 500
Large series	More than 25	More than 50	More than 150	More than 150	More than 200	More than 100	More than 300	More than 500

a. The years given in the headings of this table are the years of publication of the respective sources.
b. 16/
c. 17/
d. 18/. This source classifies the equipment in terms of weight (heavy, medium, and light). The relationship of size to weight is considered sufficiently stable to equate the two terms in this report.
e. 19/
f. The data are reported as they appear in the Soviet source.

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Table 2

Series Production of Selected Categories of Equipment in the USSR

Units

Type of Production	Large Electric Power Generating Equipment [a]	Coal Mining Equipment [b]	Polygraphic Machinery [c]	Metal-cutting Machine Tools [d]	Centrifugal Pumps [e]
Small series	2 to 3	5 to 25	Less than 25	10 to 100	Less than 100
Medium series	3 to 10	25 to 200	25 to 100	100 to 1,000	500 to 2,000
Large series	More than 10	200 to 1,000	More than 100	More than 1,000	More than 3,000

a. 20/. The data pertain to the size of the series; no time period is specified by the source.
b. 21/. Volume of output per month.
c. 22/. The data pertain to the size of the series; no time period is specified by the source.
d. 23/. Volume of output per year.
e. 24/. Volume of output per year. The ranges pertain to the manufacture of small and medium pumps.

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Table 3

Series Production of Selected Commodities in the USSR*

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Agricultural machinery a/			
Combine, RSM-8	Mass	75,000 to 100,000	
Combine, KSK-2.6	Mass	About 100,000	
Engines b/			
Diesel, 1 MCh	Series	2,460	
Diesel, 2 MCh	Series	1,000	
Diesel, 4 MCh	Series	600	
Diesel, 6 MCh	Series	200	
Marine diesels, 600-1,000 hp	Small series	15 to 50	
Marine diesels, 600-1,000 hp	Medium series	50 to 300	
Marine diesels, 600-1,000 hp	Large series	300 to 400	

* Footnotes for Table 3 follow on p. 35.

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Table 3
(Continued)

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Engines b/ (Continued)			
Oil engine, 5-10 hp	Medium series	50	
Oil engine, 500-1,000 hp	Large series	50	
Excavators c/			
EGK-4 (formerly SE-3), 3 - 4 - 5m^3	Large series	220 (annual average)	
E-153, 0.15 m^3	Large series	1,234 (1956)	
E-502, 0.5 m^3	Mass	2,700 (1957)	
Materials-handling equipment d/			
Crane, K-102	Medium series	196 (1956)	

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Table 3

Series Production of Selected Commodities
in the USSR
(Continued)

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Motor vehicles			
Buses, ZIL-127 e/	Mass	100 (1955)	
Buses, ZIL-158 f/	Mass	1,200	
Polygraphic machinery g/			
Linotype machine, N-4	Large series	350	10 to 20
Typecasting machine	Medium series	25	6 to 8
Rotary newspaper press, GA type	Small series	7	2 to 4
Single-roll newspaper rotary press, 2 RK	Medium series	80	5 to 7
Book-periodical rotary press, 2 RK	Small series	10	3 to 4
Flatbed two-cycle press, DPI	Large series	120	5 to 10

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Table 3
(Continued)

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Polygraphic machinery (Continued)			
Small flatbed press, MP	Large series	500	15 to 20
Heavy platen press, TT-1	Medium series or large series	100	5 to 10
Light platen press, TTs	Large series	650	20 to 25
Two-color offsetting press	Small series	12	3 to 4
Hydraulic matrix press, MP-400	Medium series	40	5 to 8
Typecasting automatic, OGA	Small series	10	4 to 5
Vertical photoreproduction apparatus, FV	Medium series	25	5 to 8
Horizontal photoreproduction apparatus, FG-2	Small series	10	3 to 4
Paper cutter, BR-3	Large series	250	10 to 15
Bookbinding press, NSh-2	Medium series	30	5 to 10
Sheet aggregate, BO-2	Small series	10	3 to 4
Cover-detail press, KD-2	Small series	10	3 to 4
Book-assemblying machine, B-2	Small series	10	3 to 4

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Table 3

Series Production of Selected Commodities
in the USSR
(Continued)

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Railroad equipment h/			
Steam locomotive 2-4-2	Small series	5 (1952)	
Steam locomotive 2-4-2	Medium series (1955)	N.A.	
Tractors i/	Mass	More than 5,000	
DT-54	Mass	60,000 to 70,000	
Belarus	Mass	About 60,000	
Turbines			
Steam turbines j/	Large series	More than 10	
VK-25	Medium series	About 50 (1955)	

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Table 3
(Continued)

Commodity	Type of Production	Annual Volume of Output (Unit)	Recommended Size of Series (Unit)
Steam turbines j/ (Continued)			
VK-50-1	Medium series	12	
VK-100	Medium series	10 (1955)	
Hydraulic turbines k/			
Turbines, 50-kw to 200-kw capacity	Medium series	104 (1955)	
Turbines, more than 2,000-kw capacity	Custom or small series	1 to 10	

a. 25/
b. 26/
c. 27/
d. 28/
e. 29/
f. 30/
g. 31/
h. 32/
i. 33/
j. 34/
k. 35/

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