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TRANSLATION

(ORGANIZATION AND PLANNING OF AN AIRCRAFT CONSTRUCTION ENTERPRISE)

(ORGANIZATSIYA I PLANIROVANIYE SAMOLETOSTROITEL'NOGO PREDPRIYATIYA)

By V. I. Tikhomirov

STATE PUBLISHING HOUSE FOR THE DEFENSE INDUSTRY
Pages 1-611

1957

PREPARED BY
TECHNICAL DOCUMENTS LIAISON OFFICE
MCLTD
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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V.I.Tikhomirov

ORGANIZATION AND PLANNING OF AN AIRCRAFT CONSTRUCTION ENTERPRISE

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This book discusses the principal questions of organization and planning of an aircraft construction enterprise: the forms and methods of the organization of production, the productive and organizational structure of the enterprise, the administration of the enterprise, the organization, standardization and payment of labor, the technical preparation and servicing of production, and the internal planning in the plant.

This book also includes a number of standards, so that it may be used as a handbook in practical work.

Reviewers:

Assistant Professors R.M.Tarasevich and A.A.Lapshin, and Engineer V.F.Novatskiy

Editor: L.A.Gil'berg

This book is an attempt at a systematic exposition of the subjects of organization and planning of an aircraft construction enterprise.

The book has been written for the engineering and technical staff of the aviation industry, and may also be useful to students of higher institutes of aviation.

The book discusses the principal questions in the organization and planning of an aircraft construction enterprise: forms and methods of organization of production; productive and organizational structure of the enterprise; administration of the enterprise; organization; standardization and payment of labor; technical preparation and servicing of production; and internal plant planning. As far as possible, I have attempted, in discussing these questions, to give full consideration to the advanced experience of USSR and foreign aircraft construction plants.

Several standards have also been included in the book, which permits its use as a handbook in practical work.

I consider it my duty to express my gratitude to Professors A.N.Ter-Markaryan and N.A.Orlov, to Engineer V.I.Zaytsev and to the reviewers, Assistant Professors A.A.Lapshin and R.M.Tarasevich and Engineer V.F.Novatskiy for their valuable comments made in looking through and reviewing the manuscript.

I also express my thanks to all persons who have helped me, by their advice, to work out individual chapters of the book.

Since this is the first work on this subject item, it is naturally not exempt from faults. I shall accept with thanks all comments and suggestions directed toward improvement of this book.

The Author

INTRODUCTION

The subject of this branch of study is the organization and planning of the production-economic and financial activity of a socialist aircraft construction enterprise.

Other special courses of study do not cover the enterprises as a whole, but merely investigate some definite portion (aspect) of production: some, only the methods of designing machines, others, the materials of which they are manufactured, still others, the processes of their manufacture, etc.

In the course of study "Organization and Planning of an Industrial Enterprise", the action of the economic laws of socialism is investigated under the conditions of a specific enterprise, and, in accordance with the demands of these laws, the principles and methods of the planned organization of production are developed. The Socialist State industrial enterprise is considered as the fundamental element of socialist industry, as the unit productive-economic organism.

The Congress of the Communist Party USSR has pointed out the importance of teaching the engineering and technical personnel the methods of organizing and planning the sound and profitable productive and economic activity of the socialist enterprise. The resolution of that Congress reads as follows:

"It is necessary that young engineers and agronomists, after graduation from the educational institutions, shall have sufficient knowledge with respect to the specific economy and organization of production" (Bibl.1).

This book will consider the problems, organization, and system of administra-

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tion of the Socialist State industrial enterprise; it will describe the forms of specialization of the aircraft construction industry and the advanced methods of organization of its technical preparation and servicing; the methods of labor organization, standardization, and wage payment; the procedure for the preparation of the technological, industrial, and financial plan of the enterprise, the calculation and analysis of the economic indices of its profitable operation; the methods of operational planning of the industrial process in time, assuring a rhythmic course of production and uniform delivery of the finished product, in accordance with a predetermined schedule.

The economic indices are the measure of the rationality of the systems of organization of production and labor to be recommended, since "always and in all things there must be calculation as to what is more advantageous and what is less advantageous, what will yield a greater economic effect and what will yield a lesser economic effect" (Bibl.2). For this reason, economic questions are discussed in this course in inseparable combination with all of its divisions.

In this book, the exposition of the material is limited to a description of the systems and methods of organizing and planning the industrial activity of the enterprise, as its primary activity. The questions of organization and planning of the nonindustrial activity of the enterprise will be merely listed in this textbook, in order to avoid overloading it.

Production is social everywhere and under all conditions. It never remains static for a long period at a single point, but is always in a state of flux and development. The changes and development of production always begin by modification and improvement of the implements of production. The technical aspect of social production is studied directly by the natural sciences, while its economic aspect is studied by the economic sciences. The study course "Organization and Planning of an Aircraft Construction Enterprise" is a part of the system of economic sciences and is related, on the one hand, to the courses of political economy of socialism and of

industrial economics and, on the other hand, to the technological subjects: study of materials, machine design, machine-building technology, and safety measures. In this course, the economics of the enterprise is studied in intimate connection with the development of the technology of production, since "the economist must always look forward, toward technological progress, otherwise he will immediately slide backward" (Bibl.3).

In the organization of production, objective and subjective aspects must be distinguished.

The objective aspect resides in the inseparability of the organization of production from the method of production, organization reflecting the economic essence of that method and characterizing its internal structure and coordination of its processes.

The objective aspect of the organization of production is conditioned by the economic laws of a given society; it cannot be arbitrary and unfounded; human beings are unable to modify or eliminate its essential nature and basic characteristics to conform to their own views. For instance, it is impossible to provide constant planned expansion of a capitalist enterprise, since the economic law of competition and anarchy of production governs capitalist society. On the other hand, the existence of social property in the implements and means of production, and the operation, in the socialist society, of the law of planned, proportional development of the national economy makes the planned development of socialist enterprise an objective necessity. Such functions of socialist production as administration, standardization, planning, wage payment, accounting, etc. are an objective necessity, without which the socialist enterprise cannot function.

The specific systems, methods, and forms of organization of production, on the other hand, constitute the subjective aspect of the organization of production, which may either encourage the expansion of production or retard it. For instance, the use of progressive standards of output and corresponding forms of wage payment stimulates the growth of labor productivity. On the other hand, the use of statistical standards based on past experiences, and of obsolescent forms of wage payment, encourage lack of personal responsibility, wage equalization, and high labor mobility.

Methods and forms of organization of production are effective where they correspond to the objective side of production and encourage its expansion. For instance, the use of the production-line method in processing technologically uniform parts, in the assembly of typical units, etc, leads to better utilization of equipment and considerably increases the labor productivity. On the other hand, the use of the production-line method in a department handling parts of different natures and with operations of different duration, may adversely affect the utilization of equipment and lower the productivity of labor.

The more the systems, methods, and forms of organization and planning of production correspond to the demands of the economic laws of socialism, the stronger will be their influence on production.

In the socialist method of production, enterprises are not considered separately but as links in a single chain, of a branch of industry, of an economic region, or of the entire industry of our country. The problems and plan of an industrial branch or of an economic region determine the problems and plan of each enterprise that forms a part of it, while the organization and planning and production in industry provide an organic relationship between the enterprises and coordinate their work. In turn, the successful and timely fulfillment of the State Plan by each enterprise has a favorable effect on the fulfillment of the plan of socialist industry as a whole.

All sides of the operation of a socialist enterprise are considered in the context of their interrelations, their interwoven causal relationships, their mutual development.

The history of socialist development is the history of the development of the

methods and production, which have superseded each other throughout the course of the centuries. To each method of social production there correspond its own forms and methods of organization, which have developed and changed with the development of production.

The invention of machines, which has led to the conversion of handicraft and manual production into machine production, and to the development of large-scale industry, has marked a turning point in the means of production, and in the organization of production.

In the manual method of production, the subdivision of the productive process depended on the specialization and qualification of the workmen, i.e., on a subjective factor, which excluded the possibility of the scientific division of the labor process, but in the machine method of production, the subjective principle in the division of labor is eliminated. In the machine system, the productive process is dissociated into its component elements in accordance with the laws of science, regardless of the individual qualities of the workmen. To the machine system, the workman is a pre-existing material condition of production.

The rise of large-scale industry was accompanied by an immense concentration of capital, by the centralization of production in the hands of the capitalist, by an enlargement of the scale of production and of the number of workmen employed at an enterprise, as well as by the spatial expansion of the enterprise and the perfection of its technology. Under these conditions, the methods of organization and administration of the enterprise assumed great significance; the capitalist was concerned with their improvement, in order to intensify the exploitation of the workmen. This explains the increased interest in questions of the organization of production, and the appearance, during the first quarter of the Twentieth Century, of various theories of the profitable organization of production.

The Taylor system, followed by that of Ford, enjoyed the widest vogue in capitalist enterprises. The American engineer Taylor worked out a functional s STAT of

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production management and new methods of intensifying the working day. Taylor recommended an analysis of the labor process, its division into its elementary steps, the elimination of the superfluous elements from such steps, and the selection of the most productive, the indoctrination of the physically strongest workmen in the rapid execution of these steps, and the establishment of a standard daily production rate based on their output.

Taylor developed a piecework-progressive-penalty wage system, which, in connection with high daily output quotas, sharply intensified labor, and assured a high rate of profit to the capitalists. V.I.Lenin unmasked the slave driving, exploiting essence of the Taylor system in a series of articles (Bibl.4), stating, however, that the Taylor system did contain some scientific and progressive elements, which should be applied to socialist production. "...The Taylor system, like all the progressive elements of capitalism, combines the brutality of bourgeois exploitation with a number of extremely rich scientific achievements in the analysis of mechanical motions in labor, the elimination of unnecessary and unskillful motions, the working out of the most correct working procedures, the introduction of the best systems of accounting and control, etc." (Bibl.5).

A further development of Taylorism in the organization of capitalist production was the Ford system. In the Ford automobile plants, wide use was made of interchangeability and standardization of the elements of design, of the mechanization of production, the rationalization and simplification of labor motions, and created lines in continuous operation, conveyors and transporters, directing all these measures to speeding up the rate of the production by sharply increasing the workmans' expenditure of muscular and nervous energy, at the expense of premature exhaustion of his strength.

Fordism leads to the sharp intensification of labor, owing to the use of continuous-acting machinery and conveyors, compelling work at high speed.

Such systems are widely used in capitalist industry today, where the intensifi-

cation of labor is continuously increasing. The state apparatus of capitalist countries, which is completely in the hands of the monopolists, introduces anti-labor legislation, like the Taft-Hartley law, which legalizes slavelike conditions of labor and the suppression of organized resistance to capital. This is vividly confined by the class, bourgeois, character of the capitalist rationalization of production.

The existence of private property in the implements and means of production, the operation of the law of competition and the anarchy of capitalist production, all make the process of production unstable and dependent on the rise and fall of the market conditions.

Lenin said: "Capital organizes and systematizes labor in the factory for the further oppression of the workman and to increase its own profits. But chaos remains and increases in all social production, leading to crises, when the accumulated riches find no purchasers, while millions of workmen perish and starve, not finding work" (Bibl.6).

The bourgeois "science" of rationalization of production and of the administration of a capitalist enterprise sets forth the forms and methods of exploitation of the workmen, which assure the capitalist maximum profit, propagandize and extol the capitalist method of production, while concealing its true aims and means from the workmen.

The scientific discipline, dealing with the organization and planning of socialist production follows different objectives. This discipline, in accordance with the demands of the economic laws of socialism, and of the economic policy of the Communist Party and the Soviet State, is concerned with the questions of strengthening and development, in every possible way, of the socialist enterprise, with the questions of the steady increase of output, of improving its quality and lowering its production cost. For these purposes, it studies and systematizes the accomplishments of science, technology, and the advanced experience of the STATa-

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tors of industry, and helps to improve the methods of production and the socialist forms of labor organization.

The social ownership of the means of production, and the planned conduct of the national economy, have created all conditions for the organization of the productive-economic activity of each socialist state enterprise, based on strictly scientific principles, which are characterized, on the one hand, by scientific principles and methods of organization of production, financial, and economic activity, which are common to all enterprises, and, on the other hand, the consideration of the specific features of each branch of industry, due to the forms and scales of the product produced by them, and of the technology of its manufacture.

The branch of science dealing with the organization and planning of the enterprise will help the managers of production steadily to improve the organization and economics of the enterprise, and will help the workmen to enhance labor productivity; and this branch of science is, in turn, enriched by the advanced experience of the best production workers.

PART ONE

BASIC PRINCIPLES OF ORGANIZATION AND MANAGEMENT OF AN AIRCRAFT-CONSTRUCTION ENTERPRISE

CHAPTER I

THE STATE AIRCRAFT-CONSTRUCTION ENTERPRISE AND THE FUNDAMENTAL PRINCIPLES OF ITS ORGANIZATION

Section 1. Definition and Characteristics of the Enterprise

The Socialist State industrial enterprise, as stated by Lenin, is an enterprise of consistently socialist type in which the production means, the building site of the enterprise, and the enterprise as a whole, belong to the Socialist State (Bibl.7).

The Socialist State industrial enterprise is the property of the people and is organized and conducted by the State for maximum satisfaction of the material and cultural needs of society.

The State regulates, plans and controls the productive, economic, and financial activity of the enterprise and issues a State assignment for it to produce an industrial product. The assortment, quantity, quality, and production cost of the production process is established, for the enterprise, by the plan of development of socialist industry.

The fulfillment of the State assignment in all its technical-economic indices, on the basis of continuous technical progress, of the growth of labor productivity, and of the fuller utilization of the internal reserves of production, is the basic task of the enterprise.

The State industrial enterprise is the basic productive-economic unit STAT o-

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cialist industry, which, according to plan, carries on production, markets the industrial product, and is characterized by productive-technical, organizational-administrative and financial-economic unity.

In production-technology, an enterprise consists of a system of operating machines, selected, with respect to number and power, in proportion to the type and scale of production.

The technological productive unity of the enterprise is characterized by the completeness of the productive process, causing the raw materials and work in progress, during their conversion into the finished article, to pass through a number of interrelated production stages. According to the forms of division of labor and to the specialization of the production stages adopted, sections, departments, shops, and technical services are established at the enterprise, and are interrelated by the general plan of the enterprise and by its productive structure.

With respect to organization and administration, an enterprise is characterized by the existence of a collective of workers and a system of management of the industrial activity of that collective. The enterprise possesses the rights of a legal person, and within the limits prescribed by its regulations, possesses administrative and economic independence. The managers of the enterprise are responsible to the State for the results of their management. The State organizes the work of the collective of the enterprise in accordance with the principles and methods inherent in the socialist method of production.

With respect to financial and economic affairs, the enterprise is an independent productive-economic organism in the industrial system, which performs its activity in the manufacture and realization of its product in a profitable manner, on the basis of unsubsidized self-support*.

*Translator's note: Khozraschet, i.e., having all the attributes of a State-owned corporation or "authority", as distinguished from a governmental department. The term will hereafter be, quite conventionally, rendered "unsubsidized" or "nonbudget".

To attain high economic indices in the fulfillment of the plan, the state endows the enterprise with a certain economic autonomy in the field of production and in the field of circulation.

The activity of the enterprise is subdivided into industrial and nonindustrial.

The industrial activity is composed of the processes of production, reproduction, and distribution and is directed toward the fulfillment, by the enterprise, of the State assignment for the output of finished products. The sphere of production includes technical preparation of production for the manufacture of the product, the production process proper, and the technological servicing of production. The activity in the sphere of reproduction is composed of the organized selection and training of cadres, of the organized work to improve their qualifications, as well as of the processes of renewal and expansion of the production means. The economic activity in the sphere of circulation includes the material and technical supply of production and the processes of marketing the finished product.

The workers of the enterprise, employed in the branches of industrial activity, belong to the industrial group.

The expenditures of the enterprise for industrial activity are included in the production cost of the finished product of the enterprise.

The nonindustrial activity of an enterprise is directed toward the fuller satisfaction of the material and cultural needs of its workers. The nonindustrial activity of an enterprise includes the construction, operation and maintenance of housing, restaurants, baths, nurseries, kindergartens, clubs, boy-scout camps, rest homes, etc, and also the conduct of various subordinate industries: lumber procurement, stone and sand quarrying, etc. The relative extent of the nonindustrial activity of an enterprise depends on the results of its industrial activity. The more profitable that activity, the larger will be the funds available to the enterprise for improving the personal and cultural services to its workers.

The workers of an enterprise in the branches of nonindustrial activity STATng

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to the nonindustrial group. The expenses of an enterprise for nonindustrial activity are not included in the production cost of the finished product of an enterprise, and are charged to net income, or to special appropriations.

Section 2. Basic Principles of the Organization and Planning of the Socialist Industrial Enterprise

The organization and planning of a Socialist State industrial enterprise are based on the following fundamental principles:

1) Planned work of the enterprise to fulfill the State assignment;

2) Technological progress of production and maximum utilization of technology;

3) Socialist competition and utilization of advanced experience;

4) Enhancement of the qualification of the cadres and payment for their labor in accordance with its quantity and quality;

5) Observance of a regime of economy and strengthening of unsubsidized operation.

The planned work of a Socialist State industrial enterprise is due to the demands of the economic law of planned-proportional development of the national economy, and is directed toward the fulfillment of the State assignment by the collective of the enterprise with respect to all economic indices. The State assignment to the enterprise is a component part of a single plan of development of the national economy. Success in the fulfillment of the plan of socialistic industry depends on the timely and optimum fulfillment of the plan by each individual enterprise. The enterprise is therefore the fundamental unit in the management of industry, and the State assignment is law to it.

On the basis of the State assignment, the enterprise draws up its own plan of technological, industrial, and financial operation, the tech-ind-financial plan, which contains a schedule of the specific technological, organizational, and financial measures which will assure the fulfillment of the assigned tasks.

The work on the fulfillment of the tech-ind-financial plan must be accomplished,

in accordance with the plan, by all units of the enterprise. The planned nature of the activity of the departments of the plant management and its auxiliary services is expressed in the timely and careful material and technological preparation of the shops, and in the assurance of their uninterrupted operation. The planned nature of the shop operations means the rhythmic operation and output of finished product in accordance with a predetermined production schedule.

The planned nature of the development of socialist production provides immense advantages in the operation of the enterprises: it permits the organization of production on the basis of specialization and cooperation, the application of the achievements of science, technology, and advanced experience, the more complete utilization of material and labor reserves.

The technological progress of the Socialist State industrial enterprise is due to the demands of the fundamental economic law of socialism of the uninterrupted expansion and improvement of production on the basis of the highest level of technology. The application of the highest technology, electrification, combined mechanization, and automation of the productive processes, permits the replacement of manual labor by machine work, assures the continuous operation and speed of the production processes, and high rates of growth of labor productivity. The technological progress of a machine-building enterprise means the production of more economic and improved machines for the national economy, the provision of the most modern equipment for industry, the use of advanced methods of technology and organization of production.

The technological progress of a socialist enterprise is accomplished in accordance with plan, and finds its reflection in the interrelated plans of technological expansion of production and of organizational-technological measures. The plan of technological development reflect the State assignment for the incorporation in production of the latest accomplishment of science, technology, and advanced experience. The plan of organizational-technological measures contains suggestions

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and inventions by the workers of the enterprise, directed toward the more complete utilization of the internal reserves of production. The realization of these measures encourages the improvement and more complete utilization of the existing equipment, and helps to fulfill the technological and economic indices established by the State assignment.

The development of socialist competition and the wide utilization of advanced experience is the fundamental method of organization of production in the socialist enterprise, a method reflecting the active and creative participation of the workers in the improvement and expansion of production. Socialist competition reflects the new socialist productive relationships between the workers of the industry of the enterprise: the relation of comradely collaboration and of socialist mutual aid. These relations are due to the existence of public ownership of the production means, to the liberation of the laborers from exploitation, and to the distribution of the products produced by society in the interest of the laborers themselves. The laborers are directly and vitally concerned with the development and improvement of their production, since the rise in the material and cultural level of their lives depends on it. The primary element in socialist competition is the wide dissemination of advanced experience, the comradely aid given by the skilled workers to the less advanced workers, in order to obtain a common rise. The active participation of the workers of an enterprise in the expansion of production is expressed in their conscious compliance with strict labor discipline, in the development of criticism and self-criticism, in an economical attitude toward socialist property, in the struggle for the enhancement of labor productivity.

The improvement in the qualifications of the personnel and the payment for their labor in accordance with its quantity and quality is conditioned by the demands of the law of steady growth of labor productivity and the law of distribution according to work. In the socialist enterprise, the decisive force is the personnel, its technical qualifications and political awareness. The steady rise in the quali-

fications of the personnel ensures the development of a new technology and a more complete utilization of the existing technology, accelerates the growth of labor productivity, and eliminates rejects and scrap. The increase in the level of qualification and culture of the workers, together with the planned increase of their number, is a characteristic feature of the socialist training of cadres. An extensive system of general educational and technological groups and schools is organized at the plants, and branches of technicums and higher educational institutions are organized, allowing the Soviet workman to become a highly qualified specialist at his job. Payment in accordance with the law of distribution according to work guarantees equal pay for equal work, relates the personal interest of the workers to their social interest and provides them with a material incentive in the improvement of their qualifications, in the better utilization of technology, and in the growth of labor productivity.

The higher the qualification of the workman and the higher his output, the higher will be his earnings. The State increases the real wages of the laborers and improves their living conditions and cultural services to them, thereby complying with an important economic axiom, namely that an increase in the productivity of labor must precede a rise in wages.

Observance of the regime of economy and strengthening of unsubsidized operation is due to the nature of socialist production, whose growth is accomplished on the basis of the resources themselves and of the inner sources of accumulation. For this reason, the constant reduction of the expenditure of living and materialized labor per unit product is an objective necessity.

The essence of the regime of economy resides in the thrifty attitude toward socialist property, in a wise and conscientious expenditure of labor, material and financial resources, in preventing losses and unproductive spending in the fullest utilization of the internal reserves of production. The regime of economy is carried out at all socialist enterprises, and unsubsidized operation is its primary method.

Unsubsidized operation is the method of planned conduct of the economy of socialist enterprises, which demands comparability of the expenditures with the results of production expressed in terms of money, the replacement of the expenditures by an enterprise out of its own revenue, and assurance of the profitability of production.

Profitability (income-production) of an enterprise means that the funds received by the enterprise from the sale of its product must meet the production costs and provide a net income above that production cost. Profitability characterizes the economic effectiveness of the operation of an enterprise.

Unsubsidized operation creates a material incentive of the collective in the fulfillment of the State assignment with respect to all indices, and develops the initiative of the workers.

Section 3. Purpose of an Aircraft-Construction Enterprise, and the Specific Features of its Production

Since imperialism does exist, the economic foundation for the occurrence of wars also persists. The imperialist countries spend immense sums on armament, and pay maximum attention to the expansion of the air forces and the aviation industry, seeing in the aircraft the most powerful means of attack and of transporting atomic and hydrogen weapons. The appropriations by the United States for war items amounted in 1956 to almost half the Federal budget. The number of aircraft in the United States Air Force was to have reached 40,000 by 1957. In 1955 the USAF had 954,000 men, i.e., 50% of the personnel of the Army and Navy. The aviation industry of the United States, which rapidly expanded in 1941 - 1945, not only failed to reduce its activity but actually continued to expand. The aviation industry of the United States passed from 135^{th} to second place among the branches of industry with respect to number of workmen employed, from 1935 to 1955. In 1955 it employed 805,900 men, of whom 559,500 were production workers. The aircraft manufacturers of the United States produced 14,400 in 1954. The orders for aircraft production increase from year to year. In 1955, the aircraft companies had military orders amounting to 22.5 billion dollars. The air forces and aviation industry are expanding at an intensified pace in other capitalist countries as well.

In order not to be taken by surprise under these conditions, the Soviet Union is compelled to have a sufficiently powerful defense, and its material base, a defense industry.

The defense industry differs from the other branches of the national economy in the different scales of production in peace and war, by the peacetime use of its reserve capacity for the production of civilian goods, by the forms of specialization of the enterprises, by their extensive cooperation with enterprises of nondefense branches, and by a number of other features affecting the organization and planning of production.

An aircraft construction enterprise producing both civil and military aircraft, possess certain features of a defense enterprise.

The purpose of an aircraft construction enterprise is to produce aircraft for the needs of the national economy and for the national defense. The aircraft is a complex product with very many parts. A modern heavy aircraft has over 100,000 parts (without the standardized parts), over 2 million standardized parts, and as much as 60 km of wiring. For comparison, we recall that a four-ton truck has about 3500 parts of various descriptions, and a combine little more than 9000 parts.

The complexity of the aircraft and its numerous parts, its large dimensions and size (the heaviest modern aircraft weigh 160 - 190 tons) necessarily lead, under conditions of series production, to high expenditures of material and labor and to high production cost for aircraft.

Thus the labor required to build a series model of a heavy American bomber, B-52, with an output of 12 - 13 aircraft a month, amounts to 142,000 man-hours, and the cost of such an aircraft is 8,700,000 dollars.

The wide range of materials, semifinished products, and finished articles that go into an aircraft, as well as the immense variety of the technological processes of aircraft manufacture, have led to the establishment of large series-production enterprises with a wide variety of equipment, productive shops, various technical services, and a large staff of workmen, engineers, technologists, and employees of the most varied skills.

Some idea as to the magnitude of aircraft construction enterprises can be obtained from the following Table, which has been compiled from the data of American firms:

Name of Company	Product Manufactured	Floor Area of Plant, in m^2		Number of Workers at Plant		Value of Annual Production of Company, in Dollars
		Maximum	Minimum	Maximum	Minimum	
Douglas	Aircraft and Guided Missiles	372,000	232,000	25,443	10,520	867,000,000
Boeing	Aircraft	743,000	376,000	36,251	28,803	771,511,226
Lockheed	Aircraft and Guided Missiles	579,000	34,500	25,971	1,248	524,189,000
North American	Aircraft, Guided Missiles, and Electronic Equipment	372,000	31,600	26,990	2,235	816,676,329

The frequent changes in the object of production and the continuous introduction of design improvements in the aircraft are due to the rapid technical progress of aviation technology. The frequent modifications of aircraft and the replacement of one design by another are responsible for the production of aircraft in series. Statistics indicate that the average period of series production of a civil aircraft is 4 to 5 years, while that of a military aircraft is substantially shorter.

The frequent change of aircraft designs and the constant introduction of numerous design modifications demand the organization of large design offices and development enterprises, capable in a short time of building new aircraft and their modifications. For the series production of new aircraft, within a short time, it is necessary to have series-aircraft construction enterprises with a large tool base and highly qualified personnel. The frequent changes in aircraft design require a system of production organization to ensure smooth operation of the development and series enterprises, and make it possible to change over a series-production line to the production of a new aircraft within a short time, without stopping production.

<u>Different Scales of Aircraft Production in Peace and Wartime</u>. Since aircraft construction plants are designed to produce both civil and military aircraft, the number of aircraft produced by them depends to a considerable extent on the international situation, on the increase or decrease in the threat of war. When international tension slackens and armaments are curtailed, the program of defense production in socialist enterprises decreases steadily. On the other hand, when the international situation deteriorates, the program of defense production may expand. Consequently, the program of defense manufacture may vary sharply, upward or downward, from year to year, or even during the course of a single year. Defense production on a large scale leads to a rapid depletion of the material resources of a country and slows down the rate of development of the other branches of the national economy. For this reason, the program of defense production in peacetime never reaches its immense wartime levels.

All this creates reserve capacity at the aircraft construction plants, which is used in peacetime mainly for the production of a widely varying line of civilian goods. Moreover, the existence of reserve capacity also allows new aircraft to be put into production more often.

The extensive cooperation of the aircraft construction enterprises with enterprises of other branches of industry is due, first, to the fact that the aircraft reflects the latest achievements of science and technology in various fields of

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knowledge and is the result of the work of enterprises of many branches of industry, and second, to the necessity of utilizing the reserve capacity of aircraft enterprises in peacetime to increase the output of civilian goods, while, in wartime, the capacity of nondefense enterprises must be utilized to increase the output of aircraft.

The cooperation of the aviation industry is most fruitful with the mass branches of civilian machine-building, such as agricultural-machine building, automobile manufacture, and electrical engineering industry. The utilization of the experience of these branches in the organization of mass production encourages the enhancement of the technical level of aircraft production.

The high mobility and flexibility of the aircraft construction industry is expressed in its constant readiness to contract its civilian production and in a short period to expand its large-series or mass production of defense items.

The high mobility and flexibility of aircraft production permits aircraft production in small series, guarantees maintenance of production technology and organization at a high level, and envisages the stockpiling of materials and tools as well as the development of plans for change-over of a plant to the output of aircraft in large-scale series. The mobility and flexibility of production must be periodically verified.

Influence of Strategic Factors on the Geographic Location of Aircraft Construction Enterprises and on their Specialization. In selecting the site for an aircraft plant, one must consider not only such factors, generally recognized for all machine-building plants, as proximity to sources of raw material and fuel, proximity to consumers, correct specialization, multiple development of the economy of economic regions, specialization and cooperation of production, and regional transport facilities, but strategic factors as well. The most important of these latter are the distance of the plant from the frontiers, its location with a view to minimum vulnerability to aerial attack, duplication of plants producing identical

products and their corresponding decentralization, specialization and cooperation of defense enterprises in view of the utilization in wartime of enterprises of other branches of industry.

Section 4. The Charter and Economic Independence of an Enterprise

All aircraft manufacturers of the USSR are State enterprises and are established by decree of the Council of Ministers USSR.

The development of aircraft enterprises is under the direct jurisdiction of the Ministry of Aviation Industry USSR. Series-production enterprises are under the jurisdiction of the Councils of National Economy of the economic regions.

The State prescribes the rates of expansion of production at the enterprises, the forms and level of specialization and cooperation, the assignment for production with a designation of its products list, quantity, planned price list and periods of production; it provides the enterprise with the funds necessary to execute the State assignment and the capital construction; it organizes the training and planned assignment of graduate specialists and qualified workmen among the enterprises; it advances the enterprise funds for materials, semifinished products, fuel and power, and organizes the marketing of its finished products; it distributes the profits of the enterprise and systematically inspects all of its activities.

The State manages the enterprise directly through a director.

In its activity the enterprise is guided by its charter, which defines the position and integration of the enterprise, its fixed capital and other funds prescribed by law, management of the enterprise and powers of the director, as well as the accountability of the enterprise to the State. According to its charter, an aircraft construction enterprise is an independent economic organization, functioning on the principles of unsubsidized fiscal autonomy. The charter is presented to an agency of the Ministry of Finances for entry in the State register. From the day of State registration, the enterprise acquires the rights of a juristic person

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and can carry on its activity on the basis of unsubsidized fiscal autonomy.

An unsubsidized enterprise is organized for the profitable production and marketing of a finished (commercial) product and is given its own funds by the State in the form of its investment capital or fund. The capital fund includes the entire balance-sheet value of the fixed capital assets, and the minimum working capital necessary for the plant. By the aid of these resources, the unsubsidized State enterprise organizes its activity.

The lower the actual cost of production, by comparison with the planned cost, and the more machines are produced, the greater will be the profit, the more productive the enterprise, and the smaller the funds required to organize its operations.

The activity of an unsubsidized State enterprise is placed by the State under financial control, conducted by economic organizations, by financial agencies, and by the banking system. Within the enterprise, ruble control is accomplished by accounting and comparison, in financial form, of the expenditures and results of production. The financial condition of an unsubsidized State organization depends on its fulfillment of the plan in volume and in the quality of the production, on its cost and on the rate of capital turnover. If the productive activity of the enterprise is deteriorating, i.e., if it does not fulfill the plan, lowers the quality of production, overexpends the wage fund, accumulates excessive inventories of materials, semifinished or finished products, the inflow of funds will slacken, and financial stringency will result. On the other hand, fulfillment and overfulfillment of the plan and rapid marketing of the product, produces free working capital and improves the financial condition of the enterprise. The dependence of the financial position of an enterprise on the results of its work forces it to search constantly for internal reserves and to put them to work.

An unsubsidized enterprise has its clearing account at the local office of the State Bank, into which all proceeds of the marketing of the product are paid. From

this same account, the enterprise draws funds for payment of all its economic expenditures. The enterprise must conduct its affairs in such a way that the payment of funds into its clearing account will exceed the expenditures and that prompt payment of indebtness remains possible.

An unsubsidized enterprise has a credit at the State Bank for the introduction of new equipment into the production line, and also has a short-term credit to cover the expenditures connected with the building up of seasonal and other temporary inventories above the prescribed levels.

An unsubsidized enterprise has the right to enter the competitive field independently and to contract with suppliers and consumers for the acquisition of raw materials, other materials, fuel and power, and for the sale of its finished product.

Business contracts regulate the economic interrelations between enterprises. The observance of contract discipline is one of the principal demands of the system of unsubsidized fiscal autonomy. The system of contracts strengthens the responsibility of the enterprises for the fulfillment of the plans and for timely delivery of their products, and establishes material responsibility for breach of contract.

An unsubsidized enterprise has a complete system of accounting with a balance sheet showing profits and losses.

The State increases the incentive for an unsubsidized enterprise to fulfill the plan, by expanding the economic independence of the enterprise and making part of its profits available to supplement the working capital, capital investments, and the funds of the enterprise. The resources making up the funds of the enterprise are expended as agreed by the members of the collective, to improve their cultural services and living conditions, and to expand production.

The application of the principles of unsubsidized fiscal autonomy to enterprises and their profitable operation increases the income of the State. In socialist industry, the unsubsidized enterprise is the prevailing form.

Unsubsidized fiscal autonomy is more completely in force at series-aircraft construction plants, but is greatly limited at development enterprises. The difference in the economic independence of the production and development aircraft construction enterprises is due to their different roles in the economy, to the different sources of their financing, and to the different order of utilization of the funds made available by the State.

The State-budgeted development enterprise has a number of peculiarities and is limited in its economic autonomy. A development enterprise has a schematic plan. Each independent project is assigned in the schematic plan as a special item. The expenditures of funds by items is reflected in detail in the production estimate, which is the financial expression of the schematic plan. The State finances the work of the development enterprise, on the estimate of production, out of State-budget funds. The State budget is the basic source of financing of the development aviation enterprise. Besides its State budget work, a development enterprise also does independent nonbudget work. The latter includes the manufacture of machines in small series and contract work performed with the object of a fuller utilization of capacity. With respect to these types of work, a development enterprise has the rights of a nonbudget fiscally autonomous enterprise.

The dual nature of the sources of financing of the development enterprise forces it to account separately for the State-budget funds and the funds received from work on commercial contracts, and, accordingly, it must maintain two accounts at the State Bank, one a budget account, the other an ordinary clearing account.

A development enterprise has the right to make contracts for the acquisition of raw materials, other materials, fuel, power, semifinished goods within the limits of the funds assigned to it, and within its other limits, but it does not have the right to sell the products manufactured with State-budget funds.

A development enterprise has the right to make contracts for the acceptance of work from other enterprises and for the delivery to them of work connected with the

fulfillment of its schematic plan and paid for out of the State-budget account. For instance, a development aircraft plant, in designing a new aircraft model, subcontracts the work of designing and manufacturing installations for equipment, to another development enterprise specializing in this field. In such cases, the work is paid for by agreement between the parties, or the funds assigned in the State budget to the prime development aircraft building enterprise for this part of the work may be transferred by it to the other subcontracting enterprise that actually does the work.

A development enterprise, being organized to build prototypes of new machines, is not concerned with their industrial production and, consequently, has no commercial production, profits, nor enterprise assets. It may accumulate the proceeds of nonbudget work and savings on budget funds which, at the end of the fiscal year, are paid over to the State income.

Section 5. Assets of the Enterprise

To realize industrial activity, the State assigns fixed and working assets to an aircraft enterprise. Such assets taken together, constitute the statutory capital. The difference between fixed assets and working assets is due to their purpose and to the order of circulation in the process of socialist production.

The fixed assets of an enterprise is subdivided into industrial-productive and nonindustrial assets.

The industrial-productive assets include: production buildings and structures, power plants, operating machines and apparatus, power-transmission facilities, transportation facilities, productive housekeeping inventories, tools and devices costing not less than 500 rubles each and having a service life of over one year. The industrial-productive assets are designed for the direct manufacture of the product or for servicing the processes of its manufacture.

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The structures of fixed productive assets of an aircraft building plant is a-

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bout as follows:

	in %
Buildings, structures, and power-transmission facilities	64 - 69
Power and production equipment	24 - 38
Transportation facilities	3 - 5
Inventory and tools	4 - 6

The fixed assets of aircraft building enterprises do not include forms of special technological equipment (machine tools, jigs, attachments, etc.) whose use is limited only to the production of a given machine. The cost of such equipment is included in the floating assets of the enterprise.

The fixed industrial-productive assets, preserving their physical form, participate in many of the manufacturing cycles for producing the product. As they wear out (amortization) the fixed assets gradually transfer their value, in portions, to the product of labor.

The industrial-productive assets of a socialist enterprise are continually being expanded and qualitatively improved. By raising the productivity of labor, the workers of an enterprise improve the utilization of the fixed assets, increase the output, and diminish the need of the enterprise for equipment and manufacturing plant area.

The nonindustrial fixed assets do not directly participate in the process of manufacturing the commercial product, and are designed to serve the living and cultural needs of the workers of the enterprise. This form of capital includes housing, children's institutions, and other items appearing on the balance sheet of the plant. The Socialist State, manifesting constant concern for the improvement of the material conditions of life of the laborers and for benefits to their cultural and living conditions, increases the nonindustrial fixed assets of an enterprise from year to year.

The working capital is necessary to an enterprise for the acquisition of materials, for payment of wages to workmen and employees, and for paying other expenses due to the processes of manufacturing and marketing the output. The working capital of an enterprise is subdivided into owned and borrowed. The owned working capital, in an enterprise, to the extent of its minimum needs comprises the allocation of such sums by the State and drawings from the revenues of the enterprise. The borrowed working capital consists of short-term credits from the State Bank.

The working capital is subdivided into working productive assets and floating assets.

The working productive assets are in the sphere of production. The productive working assets include: production inventories of fuel, primary and auxiliary materials, purchased finished goods and semifinished products, packing materials, spare parts for current maintenance of equipment and buildings, inventory and depletable tools of small value, work in progress, and prepaid charges. These assets are completely used up during the production process; they participate only in a single working period, and their value is completely transferred to the product.

The floating assets are in the sphere of circulation. They consist of finished goods shipped to purchasers, for which payment has not yet been received, funds in transit, and funds in the clearing account of the enterprise at the State Bank.

The working assets which, at times, are in the sphere of circulation and, at other times, in the sphere of production, are in continuous circulation: cash - - material - semifinished products - finished goods - cash, i.e., they are successively transformed into productive, commercial, and cash equivalents. The acceleration of the turnover of the working assets is of great economic importance, since it reduces the need of the enterprise for further working capital.

Section 6. Basic Indices of Industrial Activity of an Enterprise

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The most important economic indices by which the planning is done and the re-

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sults of the industrial activity of an enterprise are determined, are as follows: volume and quality of industrial production, productivity of labor, and labor-cost of article, rhythm of production, utilization of fixed and floating assets, cost of production, and profitability of production.

The volume of industrial production is determined by the gross product turned out by an enterprise in a calendar year. The gross production is composed of commercial (finished) products and of the change in the balance of goods in processing (unfinished products).

The annual output, i.e., the product completely assembled and accepted by the purchaser, is the most important quantitative index of the work of an enterprise. The commercial production is measured in physical and value indices. The physical indices characterize the assortment, assembly, and quantity of products. The value indices characterize the kind, the planned production cost, and the wholesale value of the products. The volume of output according to planned production cost shows the expenditures which have been approved for the enterprise for the production of the finished product, while the valuation of the output according to the established wholesale prices determines the sum of the funds which the enterprise is to receive from the marketing of the finished product.

The work in process is composed of inventories of blanks, parts, units, assemblies, and articles not completely assembled or tested, which must be on hand in the shops of the enterprise in order to ensure a continuous flow of the processes in all stages of manufacture.

The qualitative indices of the work of an enterprise cover the resources of living and materialized labor.

The utilization of the resources of living labor is characterized primarily by labor productivity. "The productivity of labor, in the last analysis, is the most important factor, the principal factor for the victory of the new social order", wrote V.I.Lenin (Bibl.8). The steady increase in labor productivity is the economic

law of socialism.

The growth of labor productivity at the enterprise is reflected in the steady growth of output by each worker in unit time, in the systematic lowering of the labor cost of finished articles, in the increase of their output, and the improvement in their quality. The increase in the output of each individual worker and the increase in the number of workers directly occupied in the production of material values is of great importance for the growth of productivity of social labor.

The level of technology of production, the degree of its utilization, the qualification of the cadres and the dissemination of advanced experience finds its reflection in the level of labor productivity attained.

The utilization of the resources of materialized labor is characterized by the following indices:

With respect to fixed assets, by the gross output per 1000 rubles of fixed assets, per machine, and per square meter of productive area. The higher these indices, the better the organization of the utilization of the fixed assets with respect to productive capacity, plant area, and time.

With respect to working assets, by the standard consumption of working capital per unit of output, by the rate of turnover of the working capital, and by the standard of its reserves. The standards of consumption and reserve of materials, power, fuel, and tools are calculated according to progressive norms. To lower them, economy in the consumption of materials and a more improved technology are necessary. An enterprise accelerates the turnover of its working capital by shortening the length of the industrial (economic) cycle.

The duration of the industrial (economic) cycle (C_{ec}) is measured in days and is composed of the duration of the procurement and productive cycles and the marketing cycle.

The procurement cycle (C_{pr}) is the time necessary for the acquisition of materials, semifinished goods and other material values necessary for production. This cycle characterizes the average time spent from the time of settlement for the material values to be acquired to the instant they are placed in production. The more rationally the suppliers and form of transportation are selected, the more exactly the size of the shipments and the periods of their delivery are calculated, the shorter will be the procurement cycle and the smaller can be the working capital in this stage of the work of the enterprise.

The production cycle (C_p) is the time from placing the article into production to its delivery as finished product. This cycle characterizes the time spent by the capital in the sphere of production. The higher the level of technology and organization of production and the higher the productivity of labor, the shorter will be the cycle for the manufacture of the machine and the smaller can be capital the enterprise will need to fulfill the program.

The marketing cycle (C_m) is the time from the acceptance of the finished product to the receipt of funds for the product delivered. The more rapidly the finished product is marketed, the less will be the working capital needed by the enterprise in this stage.

The marketing cycle and the procurement cycle, taken together, characterize the time spent by the capital in the sphere of circulation (C_c).

The rhythmic operation of an enterprise is characterized by the uniform or uniformly increasing output of finished products in accordance with a predetermined schedule. In its resolutions, the Communist Party has repeatedly emphasized the immense significance of uniform rhythmic operation of all production units, which eliminates the congestion of production in some branches and stoppage in others, which eliminates overtime work, reduces rejects, encourages the uniform loading of equipment and the growth of labor productivity.

The production cost of the finished product is the generalized qualitative index of the entire work of an enterprise. The production cost of the product reflect the results of all the productive, procurement, and marketing activity of the enterprise. On a countrywide scale, the lowering of the production cost is the basic source of the growth of internal growth within industry and of improvement in the living standard and the cultural level of the workers of a socialist society.

Production cost is composed of funds expended for the acquisition and delivery of materials, semifinished products, and finished articles entering into the product, for the payment of production wages to the prime workers and for the overhead due to maintenance of the administrative apparatus, for the service of buildings and machinery, the administrative and housekeeping expenses, and for other expenditures. These expenditures are expressed in the form of money, and are related to the unit of finished product.

The production cost shows how economically and rationally the material, capital, and financial resources have been spent, and how effectively the capital has been utilized. Steady and systematic lowering of the production cost is a law of development of the socialist enterprise.

The socialist enterprise has all prerequisites for the attainment of advanced economic indices. Our enterprises are provided with improved equipment, have qualified cadres of workmen and engineering-technical workers, and dispose of greater material resources than anywhere else; they make extensive use of the experience of innovators of production and of the latest accomplishments of science and technology. In spite of this, some enterprises do not fulfill the plan and operate at a loss. This is explained primarily by the low level of organization of the productive process and by the poor management of the productive and economic activity of the enterprise. Only a continuous improvement of the organization of production and labor can fully ensure proper utilization of the new technological system.

The 20th Congress of the Communist Party USSR, in its directives on the Sixth Five-Year Plan, has set great tasks for machine-building in the increase of output, the growth of labor productivity, and the reduction of production cost.

All branches of the machine-building industry dispose of immense internal reserves. To discover and economically utilize these reserves means to guarantee not only the fulfillment but even the overfulfillment of the assignments of the Sixth Five-Year Plan. The Congress called the special attention of the Party organizations and economic managers to the necessity for unconditional fulfillment of the State assignments by each enterprise with respect to all indices.

CHAPTER II

PRODUCTIVE PROCESS AND TYPES OF PRODUCTION

Section 1. Definition and Essential Nature of the Productive Process

The productive process is the foundation of industrial activity of an aircraft construction enterprise, and consists of the aggregate of interrelated processes of labor and natural processes, as the result of which the raw materials and semifinished products are converted into the finished article, the aircraft.

The technological process, which determines the expenditures of labor for the manufacture of the article, i.e., its labor cost in man-hours, is the fundamental part of the productive process.

The technological process consists of the aggregate of mechanical, physical and chemical processes or operations, as a result of which the forms of the parts and units of the article are changed (fabricating and processing operations), as their properties and appearance are transformed (heat treatment and anticorrosion treatment), the parts and units are combined into sections, assemblies and the finished product (assembly-welding, assembly-riveting and assembly-installation operations), and the conformity of the product with the drawing and the tactical-technical specifications is verified (inspection and testing operations). It must be emphasized that all inspection operations are an inseparable part of the technological process.

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The technological process also includes the auxiliary mechanized or manual work

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performed in lifting and transportation of the materials, blanks, parts, units, sections, assemblies, and finished articles, from one work station to the next.

The productive process of a socialist enterprise is conducted according to plan, on a scientific basis, using the advanced experience and accomplishments of USSR and foreign technology. The productive process is always in a state of improvement and development. The machines turned out by an enterprise are modified or replaced by new ones, the technology of their manufacture is improved, the qualifications of the cadres are raised, and the organization of their labor is enhanced.

The productive process of an experimental aircraft construction enterprise is developed in the following sequence: investigation for, and designing of, a new and improved aircraft design; technological and material preparation of a development enterprise to manufacture the new aircraft; manufacture, testing, and ultimate refinement of the prototype aircraft; delivery of the drawings and specifications to the series-aircraft construction enterprise.

The productive process of a series-aircraft manufacturer develops in the following sequence: receipt of the technical documentation for a new aircraft from the development enterprise, technological and material-technical tooling-up for its production, organization of the processes of series manufacture of the new aircraft design, testing and delivery to the purchaser.

There are several versions of the organization of the work involved in the manufacture of an aircraft.

If the aircraft has already been introduced by another enterprise, then that enterprise turns over the finished parts, units, and assemblies to the enterprise that is also placing this aircraft into production. In this case, the work is developed at the same time in the fabricating, processing, and assembly shops, and the operations of putting the aircraft of the new design into production proceed on a broad front.

If the aircraft is being introduced for the first time, then the fabricating

and mechanical shops start up the operation, and from them the parts pass to the various stages of aircraft assembly. In the stage of assembly of units from parts, the panels, beams, spars, bulkheads, and other units are assembled. In the stage of assembly of major assemblies, the units are combined into sections, and the sections into assemblies: wings, fuselage, wing center section, empennage, etc. In the stage of final assembly, the assemblies are combined into the aircraft, the various installations and instruments are installed in it, after which the final stage begins, in which the aircraft is transferred to the airfield shop where it is tested on the ground and in the air. After the tests, the aircraft (if not transported "in flight") is sent to the shipping department for packing and shipment to the consumer. The manufacture of the aircraft is completed with this process.

The organization of the productive process must ensure high labor productivity and constant increase in output with the existing equipment and productive area. This is accomplished on the basis of the following principles of the conduct of production: constant improvement in the design of the articles being produced and assurance of their high technological level; development of specialization and subcontracting in production, in conjunction with rational concentration; combined and coordinated mechanization and automation; improved rhythm of the productive process and planned operation of the enterprise according to graph or schedule; assurance of a short productive cycle for the finished article.

Section 2. Technological Level of Aircraft Design and its Significance for Increasing the Economy of Production

By improving the tactical-technical, technological, and operational characteristics of an aircraft, the designer lays the foundation for the economic conduct of series production.

The better the tactical-technical operational characteristics of the aircraft, the more stable and prolonged will be its series production. The better t[redacted]chnological characteristics of the aircraft and the more consistent its design ele-

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ments, the more rapid will be the process of putting the new aircraft into series production and the lower will be its production cost.

When the aircraft design is subject to frequent modification during production, the following technological characteristics of the aircraft will be of decisive importance for lowering of its production cost and shortening the introductory period: degree of refinement of the experimental prototype; level of standardization, normalization, and unification of the parts, units, and assemblies of the aircraft and the consistence of its design elements; relative proportion of the blanks fabricated by methods of high productivity, precision casting, stamping, and rolling; prevalence of small detail in the design and prevalence of integral, monolithic elements among its units; interchangeability to the extent to which assemblies and panels are employed in the design.

The degree of refinement of the prototype is of decisive importance for the cost of production during the period of putting a new aircraft into series production and for the uninterrupted and rhythmic output of aircraft. Modifications introduced into the aircraft design during series production involve great additional expenditures of materials, labor, and funds. Design modifications introduced suddenly and in considerable number into an aircraft disturb the start-output schedule of new aircraft, introduce an irregular rhythm into the operation of the shops, and disturb the course of production.

The aircraft must be developed and refined in the greatest possible detail before being put into series production.

Standardization, normalization, and unification of parts, units, and assemblies of the aircraft reduce the variety of materials, forms, and dimensions, and thus shortens the list of parts and units of the aircraft. Standardized and normalized parts and units are interchangeable, are stable in production, and do not vary with the changes in aircraft design. This facilitates the mechanization and automation of the manufacture of normalized parts and units. Unification permits

the combination of geometrically similar parts and units into uniform groups and permits the use, for each uniform group, of the most productive equipment, of typical technology, unified technological equipment, and a rational form of organizing the productive process. The unification of parts and units makes it possible to manufacture them under conditions of experimental batch production i.e., by the methods of series production, or to order these parts and units ready-made from series plants. Under the conditions of series production, normalized and unified design elements may be manufactured by mass-production methods, setting up specialized production lines for them, or setting up specialized departments to produce standard, normalized, and unified parts. Standardization, normalization, and unification of parts, units, and assemblies reduces the amount of tooling, allows broader normalization and repeated use of the same dies, jigs and fixtures in the production of a new machine. The standardization, normalization, and unification of parts and units considerably shortens the period of putting a new aircraft into production and reduces the expenditure for the tooling-up of the production line, raises the efficiency of the operation of the equipment, and encourages the growth of labor productivity (Table 1).

Aircraft construction comprises considerable possibilities for further standardization, normalization, and unification of the elements of aircraft design. It is highly necessary to create single normalized and unified parts for all designs of aircraft, to normalize the fittings, tanks, seats, control units, and many other items. For each group of parts and units of identical purpose, technological similarity of shapes, dimensions, and tolerances should be established. For instance, the unification of the pitch and diameter of the openings on profiles allows the automation of the process of punching openings. Every effort must be made to secure such shapes of the parts and units for which the most productive equipment and advanced technological methods can be utilized.

Increasing the number of blanks that can be prepared by mass-product STAT ethods - precision casting, stamping, and rolling - increases the utilization factor of materials and is an important method of reducing the labor cost of machine work.

Table 1

Economic Advantages of Tooling Normalization

(from Data of the NIAT)

Indices / Forms of Tooling	% of Normalized Elements in Tooling		Reduction of Expenditure on Tooling Fabrication in % of Cost	Reduction in %		Savings	
	By Number of Parts	By Number of Types and Dimensions		Volume of Production Work	Tooling Cycle for Main Production	Metal, in Tons	Funds, in Thousand Rubles
Dies for cold stamping	75	60	30				
Machine-tool attachments	75	65	20				
Assembly tooling	70	45	35				
Other tooling	--	--	20				
In all tooling for main shops				35	30		
On replacement of each 1000 pieces of special machine-tool attachments by universal with replaceable parts						19	700

The higher the quality of such blanks and the larger their number, the higher the level of aircraft construction production.

The number of parts in a design is reduced by using integral units, sections, and assemblies, fabricated by methods of casting, forging, stamping, and profile

rolling (Fig.1). The large number of parts in an aircraft is an obstacle to mechanization and to the more economic organization of aircraft construction enterprises. The larger the number of parts in an aircraft, the larger will be the amount of de-

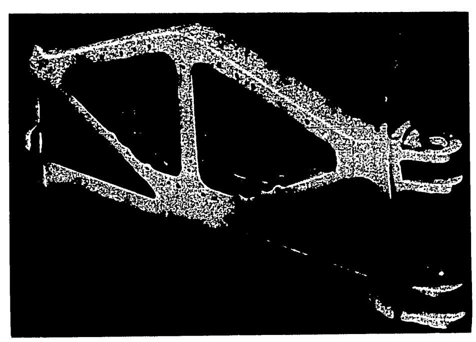

Fig.1 - An Integral Aircraft Unit

sign and technological work and the more varied the necessary tooling, the larger the number of technological combinations, and consequently the more handwork, the more complex the standardization, planning and accounting.

As a result of the large number of aircraft parts, the assembly labor cost amounts to 50% of the total labor cost of the aircraft. The use of monoblocks (integral ribs, bulkheads, spars, panels, wing halves) offers numerous advantages. The rigidity and stability of the structure is increased, the number of parts is reduced many times, and accordingly the amount of work in manufacturing the aircraft and its special tooling as well as the structural weight are reduced. Table 2 gives data on the economic advantages of integral design over multipart design.

The wide use of integral parts, sections, and assemblies in aircraft STAT n

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Table 2

A. Economic Effectiveness of the Use of Integral Stamped and Cast Units Instead of Riveted Units at USSR Aircraft Building Plants

Name of Assembly	Method of Manufacture	Assembled Assemblies			Airframe			
		Weight in kg	Consumption of Nonferrous Metal, in kg	Number of Rivets	Weight in kg	Designations of Parts	Number of Parts	Number of Dies
Landing-Gear Slots	Riveted	10.580	14.305	1604	3.420	18	42	30
	Integral Stamped	9.730	12.805	988	2.430	2	4	4
Landing-Gear Flaps	Riveted	10.726	13.966	1822	5.490	16	82	60
	Integral Stamped	9.156	13.480	938	5.004	8	7	7

Name of Assembly	Method of Manufacture	Designations of Parts	Number of Operations on Parts	Number of Attachments	Standard Time for Manufacture, in Hours	Number of Shops Participating in Manufacture	Period of Fabrication in Months
Front Flap	Riveted	30	180	33	18	7	3
	Chill Cast	5	6	4	3	1	3

B. Economic Effectiveness of Use of Integral Units at Certain British and American Aircraft Building Plants

Name of Assembly	Dimensions of Assembly	Method of Manufacture	Metal Used for Blank	Net Weight of Unit	Number		Cost		Cost Per kg of Structural Weight	Saving
					Parts	Standard Items (Rivets, Bolts, etc.)	Materials, in Pounds Sterling	Labor, in Pounds Sterling		
Box Spar	-	Riveted		96	504	10073	120	2721	29.6 Sterling	
	-	Monoblock		72	302	2854	225	1485	23.8 Sterling	1131 Sterling
Wing Panel	= 9.75 m H = 1.22 m	Riveted	1500	127	1500	5000			$13 - 15	1/2 to 1/6 the Cost of Riveted Wing Panel
		Monoblock	1353	127	1				$2.5 - 6	

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leads to a reorganization of aircraft enterprises. Above all, there is a sharp reduction in the amount of assembly work, it is unnecessary to set up jigs with numerous lodgments for clamping the parts, since the monoblock design of the casting or forging is in itself sufficiently rigid. The quality and precision of the units is increased. Figure 2 shows a front landing-gear strut, with shock-absorber cylinder

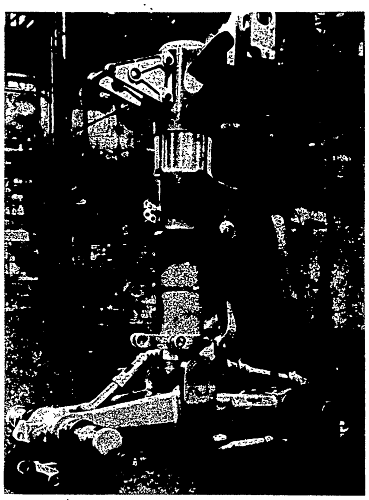

Fig.2 - Front Landing-Gear Strut

produced by casting a magnesium-zirconium alloy. The weight of such a casting is 220 kg, while the net weight of the part made from this casting is 200 kg, i.e., owing to the high accuracy of casting, the losses in machining are very small. High-productivity casting equipment and rolling mills are used to fabricate panels of the desired shapes and sizes, stamping presses of up to 100,000 tons power (Fig.3),

powerful machine tools with electronic automatic devices and other forms of high-productive equipment.

The interchangeability of parts of aircraft in series production sharply decreases the labor cost of assembly and, in the operating organizations, simplifies maintenance and replacement of aircraft units. Interchangeability raises the technical production level and forces strict observance of technological discipline. The

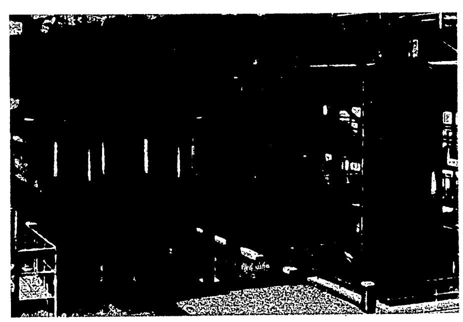

Fig.3 - General View of 35,000-Ton Press for Stamping Integral Panels and other Units

interchangeable design elements may be assigned to an independent specialized production unit.

The division of the aircraft into assemblies, and of the assemblies into sections, technological joints, and panels, opens wide opportunities for handling of riveting-assembly and fitting-assembly work on a wide front in specialized shops and enterprises, which lowers the labor cost of this work and shortens the assembly and subassembly cycle of the aircraft. The use of panelled skin in the design shortens the cycle of the assembly of the sections and assemblies in the assembly jigs, and allows assembly, drilling, and riveting of the panels to be performed on gang tools and presses by means of group riveting, installation of the instruments and wiring on the panels, tending to reduce sub assembly to the connection of separate block panels.

Section 3. Division and Specialization of Labor Processes

Engels said: "The basic form of all production that has existed up to now is the division of labor, on the one hand, within society, and on the other hand, within each individual productive enterprise" (Bibl.9).

The division of labor engenders specialization of production. The interplant and intraplant specialization of, and cooperation in, production favors the use of high-productivity equipment and of advanced technology, leads to the automation of production, and increases the productive capacity of an enterprise.

As a result of the specialization of labor and specialization of production, labor productivity is improved and the production cost of industrial production is lowered.

The 20th Congress of the Communist Party, in its directives on the Sixth Five-Year Plan of Development of the National Economy of the USSR, pointed out the importance of extending specialization and cooperation in industry, with the organization of assembly-line production at specialized enterprises. The Congress noted that specialization is an extremely important means for the further acceleration of the rate of growth of the productivity of social labor, for shortening the delays of production, and for improving the quality of the product.

The basic forms of specialization of industrial production are as follows:

1) Object specialization, i.e., specialization of production in the manufacture of a definite item;

2) Part specialization, i.e., specialization of production for the manufacture of individual units and parts of the item;

3) Stage, or technological, specialization, i.e., specialization of production to handle uniform technological processes, for example, casting, forging.

The interplant specialization of aircraft construction enterprises is arranged

a)	b)	c)	d) e)	f)	g)	h)	i)	j)	k)	l)	m)	n)	o)	p)	q)	r)	s)	t)
Consolidated	4-Engine Liberator-Bomb.	B-24	X	≡	X	X	X	X	X	X	X	X	X	≡	≡	X	X	≡
Boeing	4-Engine Flying Fortr.Bom	B-17	≡	≡	≡	X	X	X	X	X	X	X	≡	X	X	X	X	≡
Boeing	4-Eng.Flying Superf.Bomber	B-29	X	X	X	X	X	X	X	X	X	X	≡	X	X	X	X	X
Douglas	Twin-Engine Bomber	A-20	≡	≡	X	X	X	X	X	X	X	X	≡	X	X	X	≡	≡
North-Americ.	Twin-Engine Bomber	B-25	≡	≡	X	X	≡	X	X	X	X	X	≡	≡	≡	≡	≡	X
Republic	Fighter	Thund. Bolt	≡	≡	X	≡	≡	X	X	X	X	X	≡	≡	≡	≡	≡	X
Bell	Fighter	Aero-cobra	X	≡	X	≡	\	X	X	X	X	X	X	≡	X	X	X	X
General Motors	Torpedo Carr.	Aveng.	X	X	X	≡	≡	X	X	X	X	X	X	≡	≡	≡	≡	X

Legend: Assemblies Received from Subcontractors

Assemblies Manufactured by Aircraft-Construction Plant

Fig.4 - System of Specialization and Cooperation of American Aircraft Construction Enterprises in the Period 1941 - 1945

a) Name of company; b) Aircraft type; c) Aircraft model; d) Objects of specialization and cooperation; e) Part of fuselage; f) Wing center section; g) Wing cantilevers; h) Ailerons and trim tabs; i) Flaps and slots; j) Stabilizer; k) Tail fin; l) Rudder; m) Elevator; n) Landing gear and its units; o) Cockpits; p) Engine nacelles; q) Canopies; r) Bomb bays; s) Machine-gun turrets; t) Fuel tanks

by classes and types of aircraft, which reduces the list of items produced by the enterprise; by the individual components of the aircraft-assemblies, instruments, and installations - which reduces the volume of work and the list of items produced at the shops of the enterprise; by types of parts and blanks, which reduces the list of products and the volume of work in the processing and fabricating shops; by forms of tooling, which reduces the volume of work and the list of products in the shops of the auxiliary production line.

The specialization of aircraft construction enterprises by aircraft classes should provide for the manufacture of aircraft of a single class and of a single designer by a given plant. In this case, the work of the OKB and of the series-production enterprise is most effective, and the tooling-up periods for series production are shortened.

At the present time, all aircraft instruments and engines, and the most complex aircraft installations, are produced at specialized enterprises, but such specialization is no longer adequate. The exceedingly great labor cost of manufacturing the airframe makes it necessary to organize its production on the basis of highly detailed specialization and extensive subcontracting. Today it is possible and necessary to entrust specialized plants with the production of the fittings, hydraulic units, landing gears, seats, tanks, nonmetal parts, spare parts, navigation instruments, and those groups of unified parts and units which are stable in production and interchangeable.

The increase in the number of aircraft parts produced by casting and stamping, and the transition to integral units, demand the establishment of specialized casting and forging-stamping shops and plants. This will allow a sharp increase in the casting and forging-stamping production in aircraft building.

Figure 4 shows the system of cooperation between a number of American aircraft manufacturers. In 1944, in the United States, at a total output of 94,600 aircraft, the average amount of work on an aircraft at the aircraft plants of prime contractors amounted to 35 - 40%, while the remaining 60 - 65% of the work was subcontracted to other plants. A study of the experience of the German aircraft building in-

dustry during the 1939 - 1944 period indicates that this industry also was organized on the basis of high specialization and wide cooperation (Fig.5).

With an annual output of 40,000 aircraft, 32 - 35% of the work on the aircraft

Legend: Assemblies Received from Subcontractors

Assemblies Manufactured by Aircraft Construction Plant

Fig.5 - System of Specialization and Cooperation of German Aircraft Construction Enterprises in 1939 - 1944

a) Company; b) Model; c) Objects of specialization and cooperation; d) Wings; e) Fuselage and its parts; f) Empennage; g) Landing gear; h) Controls; i) Gasoline tanks; j) Canopies; k) Mechanical parts

was done by the prime contractors and 65 - 68% at other plants under the subcontracting system.

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In the postwar years, the share of subcontractors in the production cost of

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prototype and series aircraft remained high. Thus, for instance, the cost of a prototype aircraft produced by Convair includes 37% expended by the Company itself, 45% expended by the companies designing and supplying the systems, and 18% by the suppliers of materials, standard equipment, and other items.

According to data of the Boeing Airplane Co., an American aircraft manufacturer, its own expenditures amount to 36.8% of the cost of a series-produced B-52 aircraft; 38.7% of that cost is expended by companies making contract deliveries of assemblies and equipment for the aircraft; 8.5% of the cost of the aircraft consists of materials, and 16% of purchased finished items.

The experience of specialization of enterprises in the manufacturer of sections and assemblies of the airframe must be more fully utilized since, with the immense and ever increasing list of parts, units, instruments, and assemblies, an aircraft construction enterprise grows to immense size and, under the conditions of series production, becomes difficult to manage.

In the aviation industry it is important to have enterprises specialized in making standardized production tooling and spare parts for the equipment. The centralized manufacture of standardized tooling and specialized machine tools reduces their cost and shortens the tooling-up period of series production for a new aircraft. The 20th Congress of the Communist Party has pointed out that the establishment of specialized enterprises does not necessarily require the construction of new plants. It is preferable to establish specialized production lines primarily on the basis of existing plants, and in some cases, even of individual shops. To fulfill the resolutions of the 20th Congress of the Communist Party it is necessary to specialize the plants of series enterprises for the fabrication of blanks, parts, and units of a smaller production list, with the corresponding increase in the plan for their output. Specialization and cooperation of tool shops, which produce a definite tooling list for all aircraft construction plants, have given good results. An analogous specialization should be introduced with respect to shops making cast-

ings, stampings, standard fittings, mountings, and other aircraft units and assemblies. The lack of such specialization leads to absurdities. For instance, a production line, excellently organized and tooled, and making very complicated and labor-consuming parts, namely spar beams (Fig.6) was compelled to curtail its work

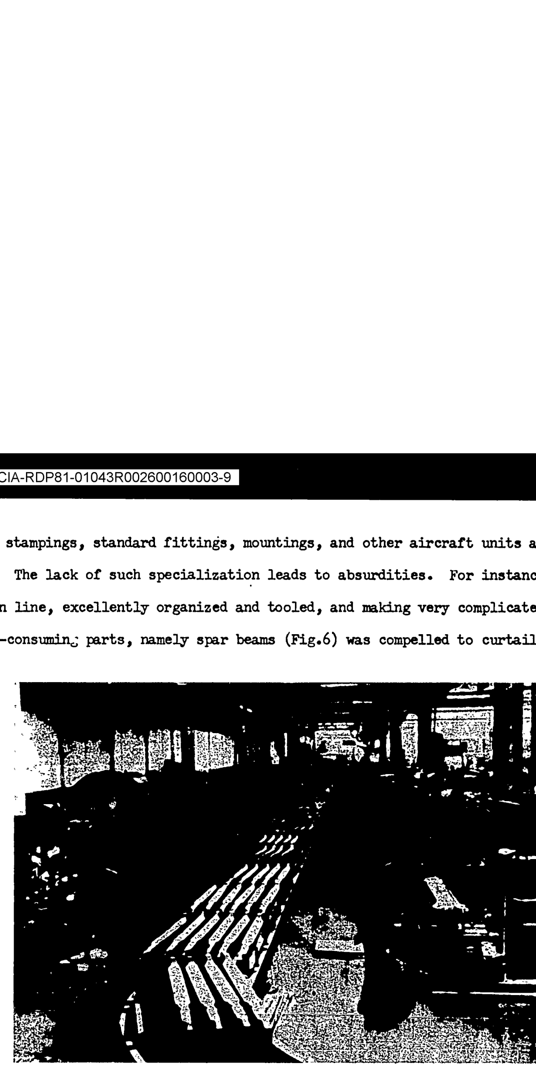

Fig.6 - Conveyor Line for Machining Spar Beams

owing to a sharp cutback in the program. At the same time, the very same beams were being produced at other plants by less productive methods (Fig.7). The utilization of a high-productivity production line to serve several plants at the same time ensures a sharp reduction in the labor cost of machine work and improves the quality of the machining.

The specialization of production is inseparately connected with its cooperation.

Cooperation consists of a productive connection between a number of enterprises which, together, manufacture some definite complicated product or item. STAT

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Cooperation differs from the usual relations of supplying the objects of supply. The objects of supply relations are raw materials, fuel, and starting materials. The object of cooperation of the aircraft building enterprise are semifinished products and component finished articles.

The specialization of aircraft construction enterprises and interplant coopera-

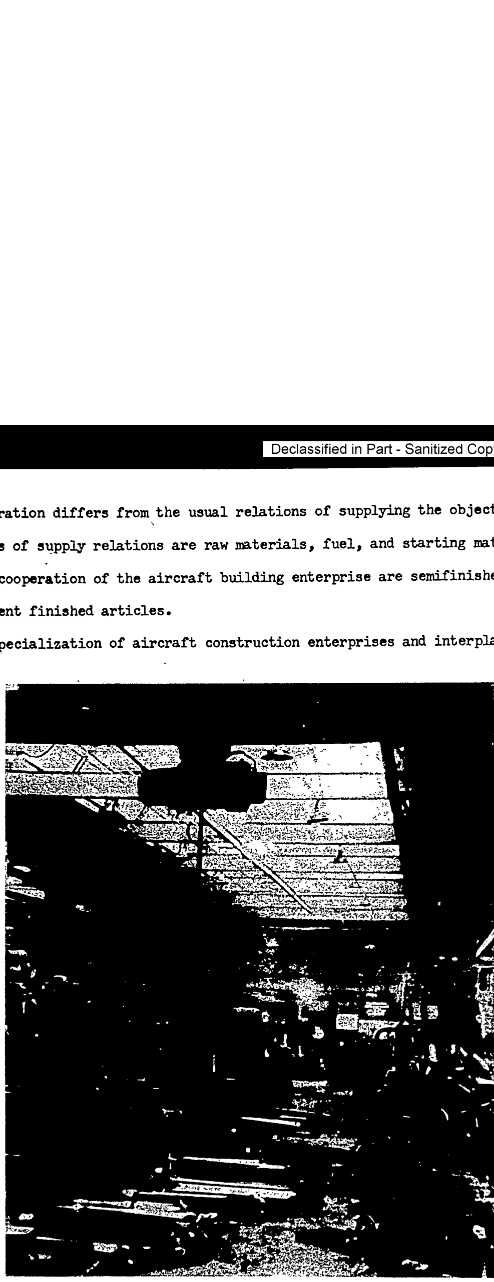

Fig.7 - Series Section for Machining Spar Beams

tion is organized, for some forms of production, on the basis of interconnection, where one plant serves several enterprises of one city, for others, on a regional

basis, where one plant serves enterprises of one economic region, and finally for still others, on an interregional scale, where one plant serves the enterprises of several economic regions with some form of product. Interplant specialization and interplant cooperation is effective if a high technological level of production exists and if contract discipline is observed between the enterprises.

The February Plenum of the Central Committee, Communist Party USSR (1957) has pointed out the importance of the development of specialization and cooperation, in every possible way, among the economic regions of the country. The development of specialization and cooperation inside a single economic region, in conjunction with the reorganization of industrial management, allows a fuller and more effective utilization of local raw material resources and of the productive capacity of each enterprise, liquidates cross hauling and minimizes long hauls, introduces order into material and technological supply, and lowers the costs of transportation and procurement.

The specialization of an aircraft construction enterprise is a process of developing, on the one hand, technological uniformity of the aircraft being produced by means of unification, and on the other hand, of assigning airframe blanks, units, and parts for manufacture at specialized enterprises. The indices of the level of specialization and cooperation of an aircraft construction enterprise are as follows: 1) share of purchased semifinished products and finished components in the production cost of the aircraft; 2) share of the labor cost for airframe blanks, parts, units, and assemblies received from specialized plants in the total labor cost for the airframe; 3) reduction of the labor time and production cost of the articles produced in specialized production; 4) length of the production cycle for the manufacture of an aircraft.

The internal plant specialization of an aircraft construction enterprise leads to a more rational utilization of social labor and to a greater degree of mechanization of that labor. The specialization of labor within an enterprise is developed.

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in three main trends.

The first trend is the division of the industrial part of the enterprise into basic, auxiliary, and service production, based on the specialization of production by types of product and processes performed.

The main production is specialized for the manufacture of the commercial product which goes to satisfy the needs of the national economy. This production is the basic and dominant part of the enterprise. The main production may be complete, if it comprises all stages of the process of manufacturing the product (fabrication, processing, assembly, and testing), or partial, if one or more of these stages are absent. For instance, an enterprise specialized for the production of standard parts has two stages, a fabricating stage and a machining stage, while an enterprise performing only assembly of the article, has only a single stage, that of assembly. Aircraft construction enterprises are mostly organized to handle the complete cycle of aircraft manufacture, and therefore their main production has all these stages.

The auxiliary production is specialized to make products used by the main production. The auxiliary production includes the generation of all forms of power, the manufacture of templates, tools, attachments, dies and patterns; tool grinding and rebuilding; maintenance and repair of equipment, industrial buildings, and structures; reconditioning and regenerating molding sand, oils, and abrasives. The auxiliary production helps to tool up the main production for the manufacture of aircraft of new designs, and raises the productive capacity of the main production by modernizing its equipment and supplying improved tooling.

The service production turns out no product, but specializes in uninterrupted performance of service to the main and auxiliary production. For instance, the material stockrooms do not themselves produce materials, but merely receive, store, sort, list, and issue them to the shops. The transportation department handles the delivery of these materials to the plant. Its staff creates no material values, but merely delivers loads to their destination. The timeliness of the delivery of ma-

terials, blanks, tools, and fuel to the enterprise, and the existence of the necessary reserve stock, ensures the continuous operation of all units of the enterprise.

The coordination of the primary, auxiliary, and service productions finds its reflection in the proportionality between their respective capacities. The work of the auxiliary and service lines is subordinate to the tasks of the main production.

The second trend is specialization within each production, into main, auxiliary, and service work. The division of labor within each form of production is necessary for the specialization of the departments, services, categories of workmen, for the mechanization of their labor, and for their better organization. Wherever machines are used, such division of labor secures uninterrupted operation of the machine during a given shift. For instance, in order to ensure continuous operation of a machine, the operator must be released from auxiliary and service duties, by assigning such duties to auxiliary and service workmen.

The third trend is the further specialization and division of the integral process of labor, within each form of work, into its component partial processes, namely main, auxiliary, and service operations.

Each working process in manufacturing an article consists of a cycle of operations. The operation is the ultimate element of the productive process. A typical example of the division of the integral process of labor into component processes is the division of the machining of a part into operations. The degree of resolution of a technological process into operations is determined by the production scale, by the implements of labor employed, and by the degree of division and specialization of labor. The larger the number of articles turned out and the larger the volume of work, the more will the labor process be subdivided into operations. The division of the integral work into component processes is a progressive phenomenon and encourages the mechanization of the labor processes and their better organization. The labor of the specialized workman is more productive than the labor of a multiple-skill workman. The subdivision of the technological process into i STAT i-

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ual operations encourages the use of more improved implements and forms of labor organization, and helps to improve the quality of the article.

The development of production at aircraft construction enterprises proceeds along the path of ever increasing subdivision of the processes of labor into elementary operations for their mechanization and better organization; in turn, mechanization of the individual operations and shift of the production to a higher level, lead to concentration of the individual operations and their combined performance on more advanced machines. The semi-automatic or automatic execution of operations of the same or different types can be combined: For instance, rough-grinding, finish-grinding, countersinking, reaming, and thread-cutting, which were formerly performed on different single-spindle machine tools, are now combined in a single machine tool. An automatic riveter now performs operations that formerly were separate manipulations: drilling, countersinking, punching holes for flush heads and rivets. The combination or concentration of operations leads to a shortening of the time consumed, since the operations no longer are performed consecutively but usually simultaneously, without additional use of auxiliary, manual, and machine-manual time. The concentration of operations simplifies intradepartmental planning and eliminates the loss of time between operations, when the parts are stored near the machine tools, waiting their turn for machining. The concentration of operations on one machine results in ganging of a series of machines, which automatically execute the complete cycle of operations on a part.

Section 4. Rhythm of the Productive Process

The differentiated system of producer machines constitutes the natural foundation of the organization of machine production. The system of machines gives place to the individual independent machine in the case where the objects of labor pass through a consecutive series of interrelated component processes, performed by a chain of producer machines, different and yet mutually supplementary. In the system

of machines, each component machine delivers the raw material to another machine, following it in direct sequence; since all of the machines operate simultaneously, the product is continuously at various stages of its formation, and constantly passes from one phase of production to another. In order for some component producer machines to deliver work continuously to other component machines, a definite correlation of their numbers, dimensions, and speed is necessary (Bibl.10).

These regularities: proportionality of number, size, and speed of the producer machines, timewise coordination of the partial processes, and continuity of their execution by the producer machines, determine, as a whole, the rhythm of the productive process. The rhythm of the productive process is the technical law of operation of a differentiated system or gang of machines. Rhythm is often confused with the methods of organizing the productive process. Rhythm is not the method of organizing the productive process, but an objective property of that process. The economic advantage of a rhythmic process lies primarily in the uninterrupted and uniform work of both operator and machine, excluding speed-up or stoppage, and guaranteeing uniform output of the finished product by a given enterprise.

Let us consider the principal properties of the rhythmic productive process.

The proportionality of the production sectors is expressed in the observance, between its phases, shops, and departments, of a correct relationship between number, capacity, and speed of the producer machines, number and qualifications of the operators, and floor space. Consistent observance of the correct proportions encourages a better distribution of the producer machines among the phases of production and their fuller utilization. On the other hand, disregard of the correct proportions leads, in production, to overloading of some departments and work shortage in others. Both disturb the normal course of the productive process, causing inadequate utilization of productive capacity and dead time of the producer machines and workmen. In order to prevent disproportions in production, proportionality must constantly be maintained between the main, auxiliary, and service productions, as

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well as within each of them, between the shops, departments, services, and work stations, never allowing one part to lag behind the other in the technology of development, in the level of production organization, or in the qualifications of the personnel.

In order to calculate the proportionality of the sectors of the productive process, it is necessary to have quantitative and qualitative criteria of its component processes and of their properties. The method by means of which proportion is established is called technological standardization. Progressive standards more accurately reflect the proportionality of the sectors of production and completely disclose its reserves.

The timewise coordination of the component processes is based on the fact that each component operation constitutes a component part of the entire process and is directly connected with other operations. Violation of this interrelation disrupts the productive process and disturbs the normal course of production. In order more fully to reflect the proportionality of the sectors of production and to establish the conditions for continuous performance of the component processes, the operations of the productive process and the component machines performing them must be interrelated in time and space.

The timewise coordination of component processes is expressed as follows:

First, in equalizing the time base of the operations of the technological process. The more the durations of the individual operations differ, the less suitable will be the conditions for continuity of the productive process;

Second, in establishing a sequence of start and output of the object of labor in production, such that the object of labor passes through all phases of production according to a graph.

The method ensuring the timewise coordinated performance of partial processes is the operational-calendar planning and the dispatcher system of production.

"The consecutive arrangement of the individual stages of the process in time was transformed into their spatial arrangement, in sequence", wrote Marx (Bibl.11). Consequently, the method of performing operations in time predetermines the form of the arrangement of the working machines in space, i.e., the productive structure of the department, shop, and enterprise. There must be complete correspondence between the method of performing the partial processes in time and the order of the arrangement of the working machines in the department. The more advanced the method of performing the component processes in time, and the greater the degree to which the order in the location of the producer machines in the department corresponds to this method, the more continuously will the productive process operate.

The continuity and speed of the component processes depend on the level of the technology employed, on the attained degree of proportionality of the producer machines, and on the timewise coordination of the individual processes. The gang producer machine, consisting of a differentiated system of various individual producer machines and of groups of such machines, is more advanced, the more continuous the process performed by it, i.e., the fewer the breaks in the passage of raw material from the first phase of the process to the last phase. In a well-developed enterprise, the principle of uninterrupted linkage of the individual processes and of their maximum acceleration is the general rule. In order to maintain this principle, a number of measures are taken:

1. A combined mechanization of the main and auxiliary work is accomplished.

2. The machines and equipment are erected in accordance with the flow of the technological process, in order to shorten the path traveled by the workpieces in production.

3. Efficient supply and servicing of the work stations is organized, providing materials, tools, and maintenance, thus ensuring timely and uninterrupted performance of work at each work station.

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4. The productive process is planned in time on the basis of the series-

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parallel and parallel methods of performing the processes of production, thus shortening the cycle of manufacture of the article.

All these methods of the productive process are manifested to different degrees in different types of production. The rhythm of the process is less sharply manifested in individual production and is more fully manifested in mass production. Rhythm, being an objective property of the machine process, is not, however, manifested of its own accord, but only when conditions necessary for its appearance have been created.

These conditions include primarily: proper technological quality of the aircraft design; existence of stand-by and emergency equipment at all stages of production; uninterrupted supply and timely technical servicing of the work stations; and correct planning of production.

For a socialist enterprise, which is characterized by the planned development of production, the criterion for the rhythm of the production process is the annual output in accordance with a predetermined graph and attainment of the assigned economic indices.

Section 5. Planned Work of an Enterprise According to the Graph

The primary task of a socialist enterprise is to fulfill the State assignments with the optimum economic indices. For successful performance of this task, the plan must most fully reflect the demand of the law of planned proportional expansion of the national economy, must observe the rhythm of the productive process, and must provide for concrete and operative management of the enterprise.

The essence of the planned work of an enterprise consists in fulfilling the annual, quarterly, and monthly plans, not as an overall satisfaction but as a uniform fulfillment of the plans in accordance with a graph worked out in advance for the output of finished product; this means fulfilling the plan not merely as an overall for the entire enterprise, but daily, in each shop, for each crew, for each

machine tool and in each shift, fulfilling the plan not only with respect to its quantitative indices, but necessarily also with respect to its qualitative indices, setwise, assortment-wise, observing the established standards, and according to the established plan for production cost.

Work by graphs is based on an exact calculation of all possibilities of the enterprise and on their fullest possible utilization.

The organization of work by graphs allows an enterprise:

1) More exact maintenance of proper proportion between the volume of material and labor expenditures and the volume of the output;

2) More uniform utilization of the fixed and working assets throughout the plan period;

3) More uniform and more complete loading of the work stations and preparation, in good time and in every way, of each work station for work of the following shift;

4) Timewise coordinating of performance of the component processes on each part or on each batch of parts, and establishing at each work station an alternation of work volumes or of regularly repeated operations which will ensure shift-by-shift performance of the plans at each work station and the uniform output of finished product by the enterprise.

Conducting the production on the basis of graphs induces the managers to proceed to a timely, thoughtful, and more efficient organization of the work of each unit of production, improvement of labor discipline and of the responsibility of each worker for timely and high-quality performance of the work scheduled by the plan, promotion of smooth work of all units of production, increase in labor activity, fuller utilization of equipment, and liquidation of losses of all kinds. Work by means of graphs raises the level of production.

Section 6. Combined Mechanization and Automation of Productive Processes STAT

Combined mechanization and automation of productive processes is the major

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trend in the technological policy of a Socialist State.

Combined mechanization of the productive process and of each work station is expressed in the combination of mechanization of the primary work with mechanization of the auxiliary processes, control of the quality of the work, insertion into and removal of the workpiece from the machine tool, transfer of the workpiece to the next work station or department, collection of the chips and other waste. The combined mechanization of productive processes represents the transition threshold to their automation, enhances the total economic effect of the production, facilitates the operator's work, and increases his productivity.

A machine is more productive, the greater the extent to which it replaces human operators and the more continuously and faster the productive process is realized by it. Automatic machines are the most highly developed machines and ensure continuity of the productive process. Automation is the highest form of organization of the productive process and is characterized by the fact that: ... "the producer machine performs all motions necessary to process the raw material, without the intervention of an operator who only exerts control"...(Bibl.12).

Under the conditions of the socialist economic system, the automation of production creates conditions for the limitless growth of production and of labor productivity, and modifies the conditions and character of labor. With the automation of production, unskilled heavy physical labor disappears. Manual labor is replaced by machine work. The universal operator is replaced by the highly skilled machine setter, the electrician, the group leader of the productive process. The character of labor is modified. The essential difference between physical and mental labor disappears. The technical basis of communism will be the automatic system of machines.

Section 7. The Production Cycle and its Components

One of the most important criteria for the quality of the organization of the

productive process in time, at the enterprise, is the duration of the production cycle for the manufacture of the finished article.

The production cycle is the period of manufacture of an article, measured by the time from placing the raw materials and semifinished goods into production to their conversion into the finished article.

This period consists of the technological time, consumed directly in the processing, assembly, and testing; the inspection time, spent on verifying the quality of the machine and its parts and units; the transportation time, spent in movement of blanks, parts, units, and assemblies from one stage of production to the next; and, finally, the time for natural processes (drying, aging, etc.) and the dead time.

The dead time is composed of breaks caused by:

a) The necessity of delivering blanks and parts to the work station a certain time in advance of the beginning of the corresponding operation, in order to avoid idle time of the operator;

b) The coincidence of the periods of performance of different operations at a single work station, so that the work items must wait for the work station to become free;

c) Incomplete utilization of calendar time and operator time - breaks between shifts, lunch breaks, incomplete coverage of all time by the shifts at some sections and work stations, and stoppages due to poor organization of labor.

The duration of the production cycle of manufacture is affected by the speed of the production process, depending on the level of technical and organizational development of the enterprise. The shorter the production cycle, the more rapid will be the turnover of the working assets of the enterprise, and the smaller will be the amount of such assets required. For instance, 100,000 rubles are spent on manufacturing an aircraft. If a plant turns out one aircraft a day, if its production cycle is 180 days, and if the coefficient of increase in expenditures is 0.6, then

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the enterprise would have to have a volume of work in progress equal to 100,000 × × 1 × 180 × 0.6 = 10.8 million rubles. However, if the cycle is shortened to 60 days, the enterprise would need an inventory of work in progress amounting to only 3.6 million rubles, i.e., only a third as much.

The production cycle is longest if the operations are performed in succession. In this case, the cycle equals the sum of the time spent in performing the technological, control, and transport work and in various breaks, i.e.,: $CY = t_{tech} + t_{cont} + t_{tran} + t_{break}$.

To shorten the production cycle, it is necessary to reduce the time spent on each element of the productive process.

The technological time, or time of direct manufacture of an article (the technological cycle), is shortened by using more advanced machinery and by increasing the labor productivity. To cut the time spent in natural processes, the latter are replaced by processes performed by a producer machine in a shorter time.

The inspection time is cut by mechanization and automation of the inspection work, by better organization of the inspector's work, and by coordinating the inspection operations with performance of the main work.

The time of transporting the article is shortened by arranging the main shops and their equipment according to the course of the technological process of manufacturing the article, as well by mechanizing the transport work, and by timewise coordination of performance of the main work with the movement of the article (work on the conveyor). The time of breaks between operations is shortened by careful preparation of the equipment for the work, by timely commencement of work at all work stations, by exact matching of the times of beginning and finishing the processing of a given batch of parts on various equipment.

In series and mass production, the form of timewise organization of the production process exerts an immense influence on shortening of the length of the production cycle.

Section 8. Forms of Organization of the Production Process in Time

The operations on work items may be performed in sequence, sequence-parallel, and parallel. The cycle will be longest if the sequence method of performing component processes is used, and shortest with the parallel method. The larger the number of articles produced, the wider application is made of the sequence-parallel and parallel methods in all stages of production.

The parallel and sequence-parallel performance of steps and operations of a producer machine shortens the normal time per piece. On universal and certain types of special machine tools, the part is machined by a single tool which successively perform various steps in the operation. Such machines are uneconomical and are being replaced more and more by others in which the process of machining is performed in parallel or in sequence-parallel by several tools on one or on several parts. An example of a machine tool operating by the sequence-parallel method is a multicutter lathe in which a single set of tools simultaneously performs the sum of several steps and another set of tools the sum of other steps on one or several parts that are being simultaneously machined. The same is true of the gang automatic machine in which each spindle performs a definite operation; on such a machine tool, with one approach of the tool to the parts, all operations are simultaneously performed, each of which is performed only on a single part. All operations are performed in parallel by aggregate gang tools, which are placed in operation in an automatic or flow line.

The sequence, sequence-parallel, or parallel performance of operations on a batch of parts has a substantial influence on the length of the cycle of its processing.

The sequence performance of work consists in performing each successive operation only at the conclusion of the processing of each batch of parts in the preceding operations (Fig.8).

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The production cycle of a batch of parts under the sequence method of performing the work, is calculated from the formula

$$C_{seq.} = \frac{1}{T_k S}\left(n \sum_{1}^{m} \frac{T_p}{N_{w.st.}} + mt_{del.} + mt_{nat.}\right),$$

where T_k is the calendar time of one shift in minutes;

S is the number of shifts per day;

n is number of parts in batch;

m is the number of process steps;

T_p is the piece time of operation;

$N_{w.st}$ is the number of work stations occupied in operation;

t_{del} is the delay time spent of batches of parts between operations, in minutes, including time spent in sending them to the intermediate operations in the heat-treatment shop and in the coating shop;

t_{nat} is the time for natural processes, in min.

Note: In the formulas for calculating the production cycle (cf.pp.64, 66, and 68) in work involving resetting of equipment, T_p is replaced by T_{pc} (standard piece-calculated time).

The sequence method of performing operations on a batch of parts is used in individual and series production.

The sequence-parallel performance of work on a batch of parts consists in transferring the parts from one operation to the next, without waiting until the processing of the entire batch has been finished in the preceding operation (Fig.9). The sequence-parallel method is used with large batches of parts to be processed and with long operations. The transfer may be piece-by-piece or in portions of the batch, which are called transfer batches. The size of the transfer batches is determined by the load capacity of the transport facilities, by the capacity of the containers, and by other factors.

If the preceding operation takes longer than the following operation, then the processing of the last transfer batch in the following operation does not begin before the entire batch of parts has been completely processed in the preceding operation (Fig.10).

With the sequence-parallel method, the length of the cycle is shortened because

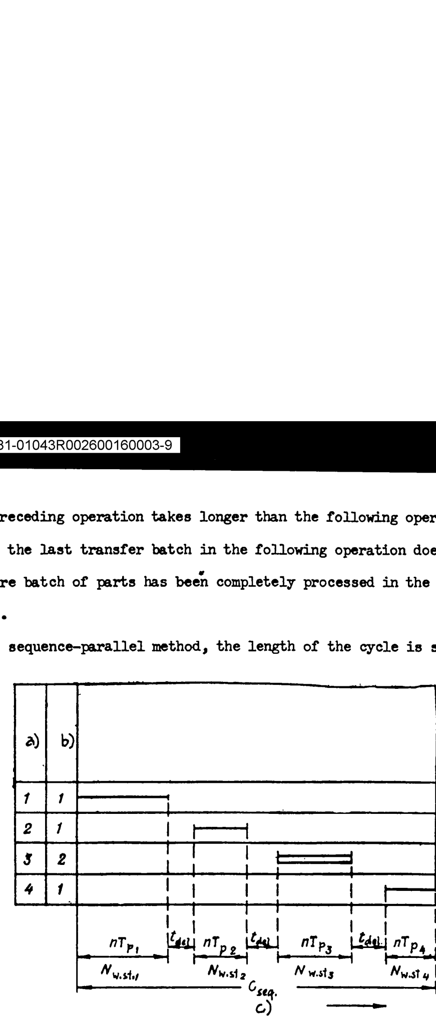


Fig.8 - Graph of Sequence Performance of Operations on a Batch of Parts

n - Number of parts in batch; T_p - Piece time of operation; $N_{w.st}$ - Number of work stations occupied in operation; t_{del} - delay time of batch of parts between operations

a) Operation number; b) Number of work places; c) Calendar time

of partial coincidence of the time of performance of adjacent operations. The number of parallel matchings of operations is always less by unity than the total number of operations in the process. The processing cycle of a batch of parts with the sequence-parallel method ($C_{seq-par}$) is calculated by the formula

$$C_{seq\text{-}par} = n\sum_{1}^{m}\frac{T_p}{N_{w.st}T_k S} - \sum_{1}^{m-1}(n-p)\frac{T_p}{N_{w.st}T_k S}\text{ short} + \frac{mt_{del.}}{T_k S} + \frac{mt_{nat.}}{T_k S},$$

where p is the size of the transport (transfer) batch;

$\frac{T_p}{N_{w.st}T_k S}$ short. is the duration of the shortest operation of each two adjacent operations.

<u>Example</u>. Required, to determine the duration of the manufacture of a batch of

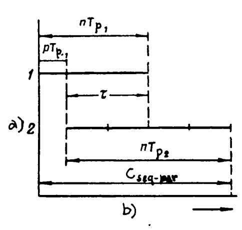


Fig.9 - Graph of Sequence-Parallel Performance of Operations on a Batch of Parts

n - Number of parts in batch;

T_p - Piece time of operation;

p - Number of parts in transfer batch; τ - Elapsed time

a) Operation; b) Calendar time

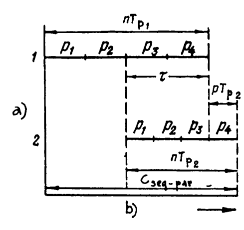


Fig.10 - Graph of Sequence-Parallel Performance of Operation on a Batch of Parts in Cases where the Preceding Operation takes Longer than the Following Operation

n - Number of parts in batch; T_p - Piece time of operation; p - Number of parts in transfer batch; τ - Elapsed time

a) Operation; b) Calendar time

parts: front landing-gear struts - if the size of the batch is 10 pieces, and the system of work is two shifts with an 8-hour working day. The time of the interoperation delay (t_{del}) = 480 min (1 shift).

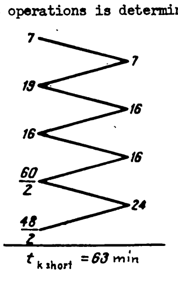
1. On sequence performance of work on the batch of parts, the length of the cycle is equal to:

Operation No.	Type of Operation (as Examples, Only the First Five Operations are Taken)	Standard Time in Min.	Number of Parallel Work Stations at which Operation is Performed
1	Center on two sides	7	1
2	Face and dress at top, to diameter 116 mm	19	1
3	Trim second face and dress at top, to diameter 116 mm	16	1
4	Drill opening diameter 50 mm and turn to 80 mm	60	2
5	Drill second opening to diameter 50 mm and turn to diameter 80 mm, face bottom	48	2

$$C_{seq} = 10\frac{\left(7+19+16+\frac{60}{2}+\frac{48}{2}\right)}{480\cdot 2} + \frac{480}{480\cdot 2} = 1{,}5\text{ days}$$

2. In the sequence-parallel method of performing work on a batch of parts, the cycle is calculated as follows:

a) The sum of the durations of the short operations is determined by selecting the shortest of each two adjacent operations.



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b) A transfer batch of 5 pieces is taken and the cycle is determined

$$C_{seq.par.}=10\,\frac{\left(7+19+16+\frac{60}{2}+\frac{48}{2}\right)}{480\cdot 2}-\frac{(10-5)\cdot 63}{480\cdot 2}+\frac{480}{480\cdot 2}=1{,}17 \text{ days}$$

The smaller the transfer batch, the shorter the cycle.

Parallel performance of operations on a batch of parts is characterized by the simultaneous performance of all operations on different machine tools and by the transfer of the parts from one work station to the next in pieces or batches, immediately after completion of their processing in the preceding operation. The productive cycle C_{batch}, when the operations are performed on a batch of parts, is calculated by the formula

$$C_{batch}=(n-p)\,\frac{T_p}{N_{w.st.}T_kS}\,\text{main}\;+\sum_{1} p\,\frac{T_p}{N_{w.st.}T_kS}+\frac{mt_{del}}{T_kS},$$

where $\frac{T_p}{N_{w.st}T_kS}$ main, is the time of the longest operation.

This method of performing operations on a batch of parts is used in single flow lines with unsynchronized operations.

Organization of Production Departments Working in Parallel. Each shop is divided into specialized departments. The departments operate either in sequence, where the products of one department are transferred to the following department in a definite batch, or in sequence-parallel, where two adjoining departments deliver parts or units to each other immediately after the completion of their processing or assembly, or else in parallel, where the departments are not technologically integrated and operate simultaneously. An example of such departments working in parallel is the assembly department for panels, ribs, and spars, which deliver the completed assembly of the part directly to the wing assembly line in the jig. The sequence-parallel and parallel organization of the work of productive departments shortens the shop cycle of work.

Organization of shops working in parallel is used in many stages of the production of aircraft construction enterprises. In this case, the greater the work time consumed by a stage of the production line, the larger will be the number of specialized shops into which this stage is divided. For instance, the preparatory

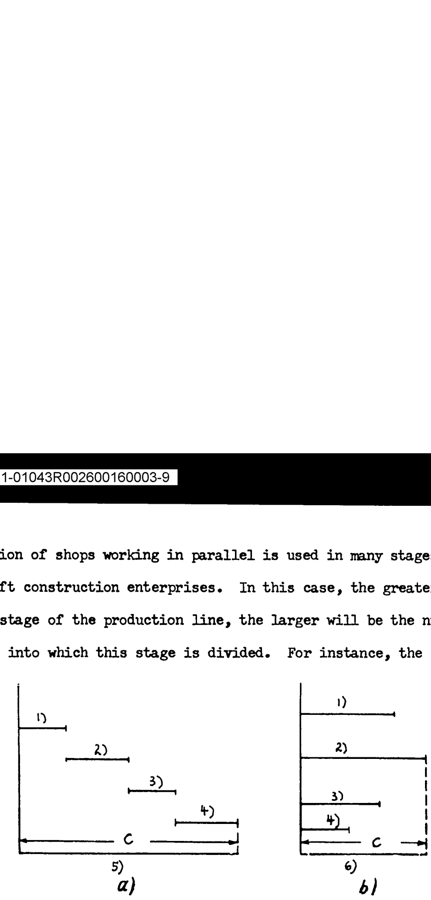

Fig.11 - Shortening of Assembly Cycle for Aircraft by Parallel Organization of the Subassembly

1) Wing; 2) Fuselage; 3) Wing center section; 4) Empennage; 5) Sequence operation; 6) Parallel operation

stage includes the shops during the casting, forging, layout of profiles, layout of nonferrous sheet metal, etc. Since, within each stage, the shops operate in parallel, the cycle of each stage is considerably shortened. This is graphically seen in the example of organization of the subassembly shops (Fig.11). It will be seen from the graph that the total time for all the subassemblies is determined, not by the sum of individual subassembly times, but by the longest subassembly.

The economic significance of the shortening of the production cycle is greater, the greater the labor cost and the monetary outlay for the aircraft (Fig.12). Consequently, the production process must be uniformly accelerated, i.e., the more work time is spent on the article and the closer it is to the final stage of production, the more extensively should the parallel method of performing the operations be used. For this reason, especially wide use is made in aircraft building of the parallel method of performing work in the subassembly work and in the final assembly of the aircraft itself.

Section 9. Types of Production of Machine-Building Enterprises

The concept of "type of production" relates not to the entire production line,

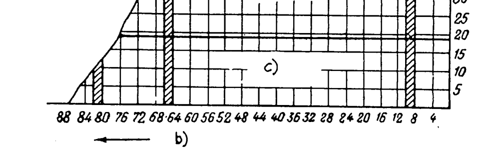

Fig.12 - Diagram of the Increase of Work Expenditure at Various Stages of Aircraft Manufacturing

a) Growth of work expenditure at various stages of the cycle; b) Production cycle of aircraft, in days; c) Fabrication work; d) Machining work; e) Fitting and welding work; f) Heat treatment and coating; g) Part, unit, and subassembly; h) Final assembly; i) Airfield tests; j) Labor cost of aircraft in %

but primarily to the production of complicated products or piece goods. The articles produced by machine-building enterprises are complex products of labor.

Machine-building enterprises are divided according to production type into enterprises with unit (individual), series, and mass production. The criteria characterizing the type of production are the number and labor cost of the articles produced, the level of the technology employed, and the degree of specialization of production. Only a consideration of all these factors permits an accurate determination of the type of a machine-building enterprise.

If an enterprise produces several articles, then the type of enterprise is characterized by that form of product which is dominant with respect to the production scale. For instance, the Moscow Automobile Plant imeni I.A.Likhachev works on mass production of trucks and series production of autobuses and light automobiles. But since the production of trucks is the predominant item, this automobile plant is regarded as a mass-production enterprise.

The simultaneous manufacture by an enterprise of products of different labor cost and unit output, leads to the possibility of various methods of organizing the production process being used in the assembly line. These methods differ in the degree of their refinement. While the product produced on a mass scale will make use of high-productivity special machine tools and assembly-line forms of organization of the production process, less highly productive equipment (including universal equipment), will be used for an article produced in small numbers, while flow lines are organized only for machining parts of particularly high labor cost or which are needed in large numbers. The smaller the production list of parts produced by an enterprise and the larger the output of those parts, the smaller will be the number of parts and operations assigned to each work station and the higher will be the degree of specialization and mechanization.

From this, the conclusion may be drawn that the type of production characterizes the enterprise as a whole, while the production method characterizes only a part of the enterprise, a department or shop.

To each type of enterprise corresponds its own form of organization of the production process, which will be the most economical for the given type. The form of organization of the production process is inseparable from its content, it reflects the peculiarities of a given type of production, the level of the technology, the degree of division of labor, and the production scales, i.e., the entire economic structure of production.

An enterprise with individual production is characterized by the initial form of specialization of production, by the predominance of universal equipment, and by the unit output of nonrecurrent articles of various kinds. The enterprises with unit production includes experimental, development, and, to some extent, also maintenance enterprises.

In order to adapt a unit production to the manufacture of articles of different kinds, the plant is tooled primarily with universal equipment, installed in the shops in uniform groups. In unit production, the number of part-operations is many times greater than the number of work stations available. The manufacture of various different articles does not ensure constancy in the assignment of parts to the work stations. During a shift, an operator may work on various different parts, performing on each part all the single-type operations that are possible on a universal machine tool. Such diversified work demands highly qualified operators. These are universal operators, who know how to set up machine tools and to machine parts on them, guided only by a drawing, sketch, or by the flow chart. In order to make it more convenient to do various types of work on the same machine tool, the work station is equipped with universal tooling in the unit type of production.

The piece-by-piece machining of various different parts during the course of a single shift results in large loss of working time, required to familiarize the worker with the drawing and the technique of the machining, to reset the machine tool and to change the cutting tool. These losses are still further increased by the large share of auxiliary procedures in the standard time.

In unit production, the parts are placed into machining piece by piece, and the

standard parts in small batches. The operations on each part are performed in sequence. On transfer from one department to the next, the part does not go to the machine at once but waits its turn for machining. This waiting time is longer, the more parts are assigned for machining on a single machine tool.

All these peculiarities of individual production result in higher labor cost of such articles, a longer production cycle, and a higher production cost, than in series production.

A development aircraft plant, with respect to the number of aircraft produced, is a unit production with certain special features.

The purpose of the development enterprises is to design and manufacture aircraft of new designs, and to modernize machines already in series production. The development enterprises are specialized for the designing and production of a definite type of aviation equipment: some produce aircraft, others aviation engines, still others-instruments, and so on. Each of these fields of work is exceptionally broad, so that the further specialization of development enterprises is by classes of aircraft, instruments and installations. One development enterprise is specialized for heavy aircraft, another for medium, and still another for light aircraft. Such a specialization improves the quality of new designs and shortens the periods of their creation, and has strategic and economic advantages. The product of a development aircraft enterprise is intended to be put subsequently into production in a series plant, so that a development plant must develop the aircraft with particular care in its design and technology. This helps the series enterprise to set up the production of a new machine in short order. The development enterprise is based on certain definite series aircraft enterprises, and is something like their initial, territorially segregated stage. There is therefore an intimate relation between the development and series enterprise in getting a new machine ready for series production. In scale of production, a development enterprise is considerably smaller than a series enterprise.

An enterprise with a series production is characterized by higher specialization and by a larger scale of production and manufacture of single-type articles in series. A series is characterized by uniform design of the machines and of the number of machines going into it. An enterprise may put out series of various types of machines, which do not recur in production. On the other hand, an enterprise may also put out a single form of machine whose series periodically recurs in production. Such enterprises include aircraft manufacturers. Depending on the number of machines in a series, small-series, medium-series, and large-series production are arbitrarily distinguished.

An enterprise with series production differs from an enterprise with unit production in the more intense division of the processes of labor, in the specialization, mechanization, and more effective organization of the production process.

A distinctive feature of series production is the simultaneous existence, at various stages of production, of various forms of organization. For instance, the predominant form of production organization in assembly shops are single-product and multiproduct assembly lines; in the processing shops, object-group departments; in the intermediate (finishing) and fabricating shops, technological departments with group arrangement of equipment. In multiproduct production in the fabricating and machining shops it is more economical to work on large batches of parts and to repeat their start-up and output less frequently. On the other hand, in the subassembly shops, it is more economical to work with small batches, to receive them from the machining shops everyday, and in sets for each assembly jig. Under these conditions, when the optimum sizes of the batches for the various shops are inconsistent, an extremely important problem of production planning is to find the most economical size of the batch of parts and the most economical form of its movement in production, ensuring smooth operation of all stages of series production. This smoothness is characterized by the regularity of recurrence of the very same processes at the work stations, i.e., by the rhythm of series production. The larger

the batches with which a series production works, the more widely is the manufacture of the article differentiated into operations, the narrower the specialization of the work stations, and the higher the mechanization of the labor processes.

In series production, the average category of the operators is usually above

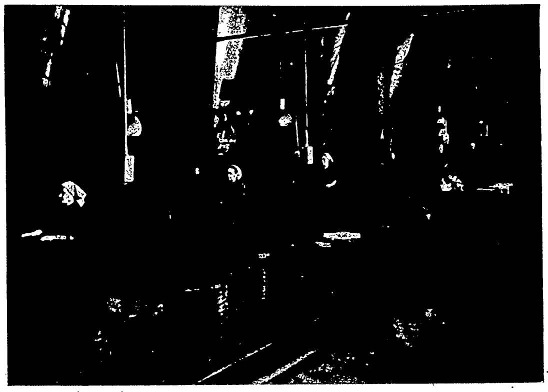

Fig.13 - Endless Belt Conveyor in Casting Shop (Molding Line)

the fourth. This qualification is sufficient for performing several operations at the work station and for resetting the machine tool. The recurrence of uniform work at each work station allows the use of standard times.

The planning of production in a series production plant consists in establishing for each shop an assignment covering the start-up and output of an aircraft series, so calculated that the preceding stage production is in advance of the following stage.

In large-lot production in departments with object-group arrangement of equipment, the sequence-parallel method of performing operations predominates, and in the

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flow areas, the parallel method is more frequent, without sending a batch of parts to the stockrooms between operations.

In small-lot production, the sequence method of performing operations on a batch of parts is primarily used. After each operation, these parts are delivered for storage to the stockroom, to await the next processing on the following machine tool. This considerably lengthens the production cycle of the article.

Series production is not at a uniform level of organization of the production process. Small-lot production has the characteristics of unit production: the assignment of a large number of parts and operations to a single work station, the predominance of universal equipment, the arrangement of the equipment according to uniform technological groups, the prolonged delay of parts between operations, etc. On the other hand, large-lot production gravitates toward mass production. This is expressed in the specialization of the work stations and in the use of special equipment, in the establishment of flows to process labor-consuming parts and units, in conveyorizing the subassembly and final assembly work, and in the development of transportation between shops and within the shops. For this reason, the labor time, the production cycle, and the production cost of an article in series production differ sharply.

Series aircraft construction enterprises are designed to put out aircraft in series and are specialized for the production of aircraft of a definite class and type. Some enterprises are specialized to produce high-tonnage aircraft, passenger and cargo aircraft, long-range bombers; others to produce medium-weight aircraft, hospital and postal aircraft, attack airplanes, light bombers; still others are specialized to produce light aircraft: fighters, reconnaissance aircraft, aircraft for agricultural work; still others to produce helicopters.

Such a specialization of enterprises permits the most expedient choice of the layout of the industrial buildings, the most rational layout of the shops and their work stations, and, most important of all, a more profitable conduct of production.

The number of aircraft in a series depends on the class and labor cost of the aircraft, the size of the production schedule and the stage of development of the production. The more complicated and labor-consuming the production of a given airplane, the fewer units will be in a series. The larger the production schedule, the more units will be in a series. As production develops, the number of aircraft in a series increases. The first series has the smallest number of aircraft. From that series, the technology and design of the series aircraft are developed.

The frequent changes in the items of production and the design improvements introduced in the aircraft during its manufacture, do not exclude large-series production, but merely demand a strict sequence in the introduction of modifications, a higher degree of technological culture in the organization of the production, and the existence of a large-scale auxiliary production, which is able to prepare the main production in a short time, in order to produce a new aircraft prototype.

An extremely important feature of series production enterprises is the availability of highly qualified cadres of engineering and technical workers and of operators who are experienced in the conduct of series production under the conditions of frequent change in the production items and of frequent introduction of design improvements in the aircraft being manufactured.

A mass-production enterprise is characterized by the pronounced specialization in the production of a single-type product in large numbers, the large-scale use of equipment specialized for a definite operation, the high subdivision of labor processes and the high degree of their mechanization, the continuity of the productive processes and the parallel method of their performance, the short production cycle, the high labor productivity and low production cost of the finished article.

A number of books and texts advance the proposition that one of the important criteria of mass production is the invariability of the design in production. We cannot agree with this proposition. For a mass-production machine-buildirSTATerprise, the necessity exists for a stable schedule of parts of articles produced, but not for their unvaried design. A stable product list is necessary for an effective specialization of enterprises and for a rational utilization of their fixed and working assets. As for the design of the article, it must be improved constantly and must be periodically revised during production.

In socialist machine building, mass production is organized to produce the machines needed by the national economy in large numbers, tractors, automobiles, agricultural implements, railroad cars, etc.

In mass production, involving the continuous output of a single type of product, the mutual coordination of the partial processes in time and space is expressed most precisely and consistently at all stages of production. The mutual coordination of the partial processes is expressed in the rhythm of output of the finished articles and, in accordance with that rhythm, by the rhythm of production of the units, parts, and their blanks. The rhythm of output of finished products is the principle of organization in accordance with which the technologists break down the processes of machining the parts and of the assembly of units into partial processes with a duration equal to, or a multiple of, the rhythm of the output of the finished article from the main conveyor. In accordance with the rhythm of manufacture of a unit or part, the term for the performance of the partial process by each producer is established.

In mass production, specialized for the output of a large volume of products of the same type, production lines with automation of the operations of processing and with conveyorized fitting-assembly work are widely used. In mass production specialized to a wider product list, the shops have, besides automatic production lines and continuous conveyors, multiproduct production lines and chain arrangement of the equipment in multipart sections as well.

In mass production, all forms of casting work, beginning with the operation of core drying, molding, pouring, and ending with the flask knockout, are mechanized and handled on conveyors (Fig.13). In the forging shops, automatic forging machines

are used, the stamping is done on closed, multiarm presses with electrical or gas preheating of the blanks, and the blanks are punched to the final dimensions of the part. Intricate parts are stamped on production lines. In the machine shops, high-productivity gang automatic and semiautomatic equipment predominates. The single-

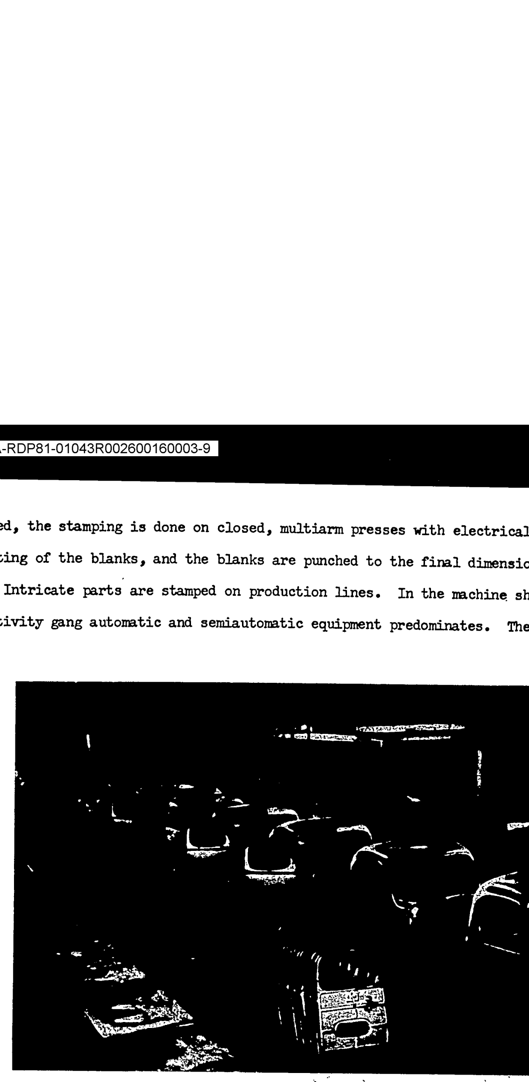

Fig.14 - Assembly and Welding Line for Truck Cabs

tool equipment has given way to multitool equipment: multicutter, multidrill, multireamer and multimilling batch and continuous equipment. The intermediate operations, painting, drying, heat treatment, are mechanized and are included in the processing and assembly lines.

In mass production, in the stamping and machine shops, the parts are not merely manufactured, but are also assembled into units and assemblies. In the automobile industry, the body, cab, engine, gearbox, and other shops are organized alSTAThis principle (Fig.14).

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Fig.15 - Delivery of Finished Cabs and Body Walls by an Endless Overhead Trolley Conveyor to the Automobile Final Assembly Shops

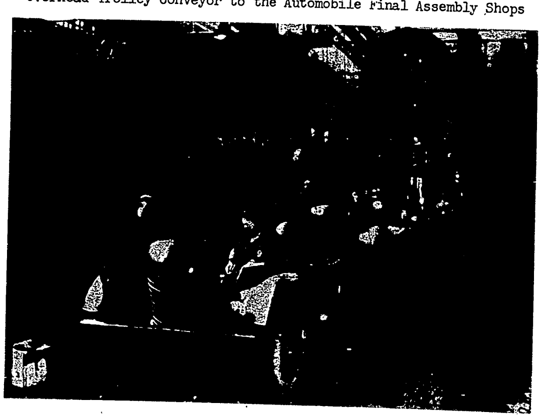

Fig.16 - Main Assembly Conveyor for Trucks at the Moscow Automobile Plant imeni I.A.Likhachev

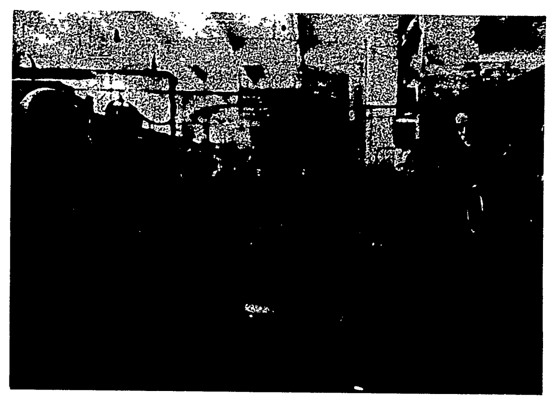

Fig.17 - Transfer of Parts from Machine Tool to Machine Tool on an Inclined Conveyor

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Fig.18 - Transfer of Parts by Means of a Roller Conveyor

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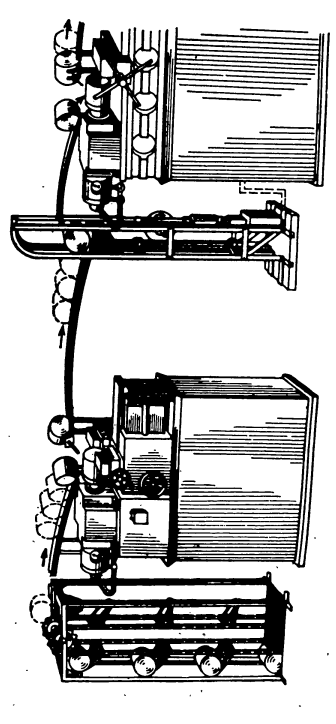

Fig.19 - System of Automatic Transfer of Parts from Machine Tool to Machine Tool

The stockrooms and shops are connected by continuous overhead trolley conveyors and by various floor truck and electric transportation facilities. At the automobile plant imeni I.A.Likhachev, for instance, the frames, wheels, bodies, cabs, and engines are delivered by an overhead continuous trolley conveyor, from various shops on the assembly conveyor, to the places where these assemblies are installed on the automobile (Fig.15). The final assembly of the article is performed on an endless belt conveyor. The frame is placed on the conveyor at the beginning, while the finished automobile leaves the conveyor at the end (Fig.16).

In mass production, the rhythm in the output of the article may be timed in seconds (for instance, in the production of electric bulbs) or in minutes (in the assembly of automobiles). When the length of the operation is timed in minutes, and sometimes even in seconds, it is particularly important that the operators correctly perform the operational steps, that the organization and planning of the work station is convenient for work and does not require nonrational motions. To reduce auxiliary time, pushbutton and automatic control of the machine is introduced, comprising high-speed magnetic, hydraulic, and pneumatic clamping attachments, devices automatically controlling the size of the surface being processed. The hoisting and lowering of heavy parts is performed by workmen by means of electric hoists, parts are transferred from machine tool to machine tool on roller conveyors, inclined conveyors, or mechanical conveyors (Figs.17, 18, and 19).

Mass production uses standards based on a study of rational operating methods, and for each operation an instructive operational chart is worked out. The production instruction of the operator is given great attention. The improvement in the qualifications of the operator in mass production proceeds along the line of improving his general technological knowledge, his mastery of the setting of the machine tools, of the related operations, and of transition to multimachine tending.

In mass production, parallel performance of operations without returSTATparts, units, and assemblies to the stockroom predominates, thus ensuring a short produc-

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tion cycle and a rapid turnover of the working capital. The start-up and output are planned for each part, and are directed toward securing a rhythmic course of production. In order to prevent interruption in the production lines, spares of blanks, parts, and units, the so-called emergency spares, are established in mass production.

The principles of mass production are used by aircraft enterprises in large-lot output.

CHAPTER III

CONVEYOR PRODUCTION SYSTEM AND ITS APPLICATION TO AN AIRCRAFT CONSTRUCTION ENTERPRISE

Section 1. Definition and Classification of Lines

Conveyor production system or line method is the name given to a form of organization of the productive process in which the processing and assembly of the article are subdivided into operations of period equal to, or a multiple of, the output period of the article, in which the work stations are located along the route of the manufacturing process, in which specialization and periodicity in the performance of the operation or operations assigned to each work station are applied, and in which synchronism, continuity, and parallel performance predominate in all operations, thus securing a rhythmic output of the product.

The introduction of line methods of production does not always mean a thorough division of the production process into a number of operations, performed by different operators. Such a subdivision is made in the initial period of industrial development, when manual work and a low degree of mechanization prevail. When production develops on a basis of higher technology, however, there is concentration and combination of high-productivity equipment of processes that were formerly disjointed.

Line production is characterized by a high level of mechanization of the main and auxiliary work, by the use of high-productivity special and combined equipment,

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by the maintenance of communications between the work stations, sections, shops and stockrooms through special transportation facilities. Mass production and interchangeability of the product are the most favorable conditions for the use of the line method. There are several versions of line production, each characterizing a definite level of technological development and organizational stage of line production. This permits a differentiation of one form of the line from another by means of such basic criteria as synchronization of operations, continuity and speed of their performance, level of combined mechanization of the main and auxiliary work.

According to the level of mechanization of processes, lines are classified into automatic and nonautomatic.

Depending on the degree of continuity of the processes, there may be two forms of lines; continuous, characterized by complete synchronization of operations, and discontinuous, characterized by partial synchronization of operations.

Depending on the number of parts or units assigned to a production line, the lines are divided into single-product lines and multiple-product or group lines. If a single item is processed on a production line, such a line will be a single-product line. If the processing of several parts or the assembly of several units is assigned to a production line, such a line will be a group line.

According to the number of parts fed from operation to operation, the lines are subdivided again into such where parts are fed from one work station to the next piece-by-piece, and lines where the parts are fed from one work station to the next in batches. The batch transfer of parts is rational with short operation lines and in cases where it is more economical to transfer the parts in a measuring or counting container, when they are simultaneously processed in a multigang attachment and must be transferred in sets, and, finally, where special features of the technological processes demand this, for instance, when parts are charged in batches into a furnace or into a bath.

Depending on the form of motion of the item being processed or assembled,

single-product lines are again subdivided into lines in which the article is shifted among work stations by means of a production line, and those in which the article remains stationary on stationary stands while the operators pass from one stand to the next at intervals of time equal to the scheduled pace.

The use of the line method allows an increase in labor productivity, an increase in output, reduction in spoilage, economy of productive area, shortening of the production cycle of the finished article, and reduction of its production cost.

The line method permits a considerable reduction of the labor time consumed in aircraft manufacture. This is graphically evidenced by the experience of the large American aircraft manufacturer, Boeing. When this company manufactured the first hundred B-29 aircraft, it used 157,000 man-hours on each aircraft, but when it changed over to the line method, it used only 57,000 man-hours per aircraft and was afterward able to reduce this figure still further to 30,000 man-hours.

During the years of World War II, the extensive use of line methods at Soviet aircraft plants reduced the labor time for the manufacture of the Yak-9 fighter to 2450 man-hours, and of the attack plane Il-2 to 6896 man-hours.

Section 2. Calculation of the Pace of the Production Line, and Synchronization of Operation

In order to reduce the duration of the operations of the technological process to a value equal to, or a multiple of, the pace (rhythm) of output of the article, one must first calculate the average pace of production of the article and bring the paces of the feed lines into correspondence with it.

If the output of N articles by the enterprise is intended during the Plan period T_{pl}, then the average planned pace of production of such an article will be

$$r_{min} = \frac{T_{pl}}{N}.$$

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If the Plan period includes the entire production cycle of an article C or a

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portion of it C_{po}*, then the average pace will be, respectively:

$$r_{man} = \frac{T_{pl} - C}{N - 1} \quad \text{or} \quad r_{man} = \frac{T_{pl} - C_{po}}{N - n},$$

where n is the number of articles in the batch.

The pace is established separately for each form of article. The overall pace of the assembly line of the article and the paces of the feed production lines are calculated in accordance with the average pace.

The time interval between the periodically recurrent output of two identical articles from the final assembly line is called the overall pace. The overall pace is calculated from the formula

$$r_{ov} = \frac{T_{an}\left(1 - \frac{k_1}{100}\right)}{N_{an}},$$

where r_{ov} is the overall pace in hours or minutes;

T_{an} is the annual working time in hours or minutes;

N_{an} is the number of articles produced per year;

k_1 is the time for routine repair of the conveyor, in percent.

For instance, if an aircraft construction enterprise is assigned the program of producing 4700 aircraft a year, working two shifts, with a uniform output, the overall pace of aircraft assembly will be

$$r_{ov} = \frac{[(365 - 52 - 6) \cdot S \cdot 8 - 228]\left(1 - \frac{2}{100}\right)}{4700} \cong 1 \text{ hour},$$

where (365 - 52 - 6) is the calendar annual labor fund in days (52 days are Sundays and 6 holidays);

* This occurs when a new article is first put into production.

S is the number of shifts per day, in this particular case 2;

8 is the number of hours in a shift;

228 is the number of hours by which the time fund is reduced due to shortening of the working day before holidays and Sundays.

The paces of feed lines which provide the final assembly line with parts or assemblies may be equal to the overall pace or several times smaller than it, depending on the number of assemblies, units, or parts going into a single article.

The pace for a parts-processing line is usually established with allowance for the need for spare parts and the necessity of replenishing the emergency spares. The formula for calculating the pace of a part processing line has the following form:

$$r_{part} = \frac{T_{an}\left(1 - \frac{k_1}{100}\right)}{N_{part}\left(1 + \frac{k_2 + k_3}{100}\right)},$$

where k_1 is the time loss on routine repair of equipment, in percent (usually 3-5%, depending on the complexity of the equipment and the number of shifts it is being used);

k_2 is the number of parts going into spare parts, in percent of N_{an};

k_3 is the number of parts to replenish the emergency spares, in percent of N_{an};

N_{part} is the number of parts going into the annual output program ($N_{part} = N_{an} \times n_{part}$ for one machine).

The pace of a production line is calculated, allowing for the features of the processes. For instance, in casting shops one must on certain production lines take the core drying time into consideration, on others, the time of pouring and solidification of the metal; in welding shops, the time required for heating the metal through and for welding large units; in heat-treatment shops, the time taken for heating up the metal in the furnace; in galvanizing shops, the electrolysis time; in painting and varnish coating shops, the drying time.

The operation times in a production line may be equal to the overall pace, to multiples of it, or to fractions of it. The following is an example of the distribution of time among 12 operations in a production line with a 15-minute pace.

Operations	1	2	3	4	5	6	7	8	9	10	11	12
Time in min	15	15	6	9	14	13	15	14.5	15	13	30	15

The time of operations 1, 2, 7, 9, and 12 coincides with the pace of the line. Operations 3 and 4 are handled by a single operator. The time of operation 11 is double the line pace and therefore there must be two work stations in parallel to handle it. The time of the remaining operations approximates the line pace.

The synchronization of the operations, i.e., the equalization of the duration of the operation times to correspond to the calculated pace, is accomplished in various ways: by mechanizing the operations, by improving the technology, by differentiating or combining operations, and by better labor organization. Automatic lines in processing shops and conveyor lines in assembly shops operate on the basis of complete synchronization of operations. With partial synchronization, the time of the individual operations is shorter than the line pace, which leads to dead time of the equipment and to layup of the parts between operations.

The number of work stations in the line for each operation (w.st) is determined by the formula:

$$\text{w.st.} = \frac{T_p}{r},$$

where T_p is the standard time per piece in the operation;

r is the line pace.

The coefficient η of loading of a work station in the production line is determined by the formula

$$\eta = \frac{P_{calc}}{P_{adopt}},$$

where P_{calc} is the calculated number of work stations;

P_{adopt} is the adopted (established) number of work stations.

The pace of a production line must be periodically shortened, as the technology in the line is improved and the operators rapidly master the operational methods. The shorter the pace, the faster the tempo of work.

Section 3. Automatic Production Lines

The automatic line is the highest, most economical form of production line, and consists of continuous-action machines.

Automatic production combines the principle of continuous performance of processes and the principle of automatic performance of processes. The principle of automation distinguishes automatic production from line production. It is the speed of the automatic performance of processes and the degree to which the processes of manufacturing an article are covered by automation that characterize the level of automatic production and distinguish its more developed stage from its less developed stage. According to the stage of development, automatic production lines are divided into lines covering: partially or completely, uniform work on a part; completely, all work on a part; and overall, the entire manufacture of the article. An example of partial automation of uniform work in the manufacture of a part is given by two automatic sections placed in a production line turning out automobile-engine blocks. These sections perform the operations of boring, countersinking, and reaming, and operate at the same pace for all the production lines (Fig.20). The following indices will give some idea on the economic effect of such automatic sections. On the first section, 32 operators out of 36 were released, i.e., labor productivity was increased eightfold. On the second section, 56 operators out of 59

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were released, i.e., labor productivity was increased more than thirteen-fold.

An example of automation of all the work is an automatic piston plant in which all processes, beginning with the operations of casting and ending with the operations of suspending and balancing the pistons, are automated and performed by a sys-

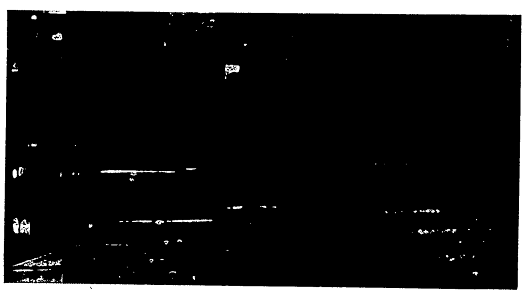

Fig.20 - Automatic Section of Production Line for Engine Blocks

tem of interlocking automatic continuous-acting machines. This plant has only a fifth as many workers as a nonautomatic piston plant, yet their productivity is 8 - 9 times as great. The production cost of the piston has been cut to a third.

The following five basic trends have been noted in the development of automation in the machine-building industry.

The first trend has been the establishment of automatic lines based on the use of existing equipment, by providing it with additional devices automating the machine-manual and manual operations. Such an automatic line for processing hubs, established at the Stalingrad Tractor Plant in 1940 by the inventor I.P.Inochkin, increased labor productivity 12 times and the output of product from the equipment by 95%. The line for processing rollers, established at the First State Bearing Plant by the inventor A.I.Volkov (1941), increased labor productivity fivefold and

doubled the output of product from the equipment.

The second trend is the establishment of automatic lines with individual machines specialized to perform a single operation on a certain part. Such equipment is used in highly developed mass production.

The productivity of special equipment of such production lines is immense. For example, a 207-gang five-position machine tool replaces 276 single-spindle universal tools, cutting the expenditure of time for processing a part by a factor of hundreds, increasing labor productivity 280-fold, and making it possible to save much production space.

A disadvantage of this form of automatic line is the high cost of designing and

Fig.21 - Wing Assembly Line Equipped with Pulsating Belts and Suspended Jigs

producing the special equipment, and the fact that such an automatic line exists only until the production item is changed. Replace one part or unit, and STAT entire line ceases to exist.

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The third trend is the establishment of automatic lines of multiple machines, specialized to perform one or several operations on a single part. Multiple equipment, consisting of a gang of standardized parts and units, is more economical than individual equipment.

The fourth trend is the creation of multiple machines specialized to perform one or several uniform operations on a group of typical parts entering into a single design-technological group. Such automatic lines will presumably become popular in serial aircraft production.

The fifth trend is the creation of special machine-tool combines, including multiple machines, which completely perform all uniform operations on a part. The machine-combine has a number of advantages over producer machines built into an automatic line. At the same or higher productivity, it replaces a group of machines, occupies less floor space, and allows shortening the production cycle of the part. The machine-combine does not demand complex transport facilities between machines, and operates reliably. For this reason, the process of concentration of different or similar operations on a part in a single machine-combine is acquiring increasing favor in machine-building at mass-production plants.

Up to now the design of automatic equipment has proceeded along the line of constructing automatic lines for producing certain articles. The transition to other articles meant, in fact, the construction of a new line. The modern development of machine-building demands a rapid change-over of automatic production from one kind of finished article to another, the development of highly flexible control systems. The development of electronics and the construction of computers now permits the design of machines that will control the technological processes in machine-building.

Section 4. Single-Product Continuous Production Lines

The continuous production line is a higher form of organization of production

than the discontinuous production line. A distinctive feature of the continuous line is the complete synchronization of operations on division of the line into operations, and the complete synchronization of the sum of operations on their distribution among the assembly jigs of the line.

A continuous line is realized with forced movement of the article being processed or assembled. Forced motion is achieved by the use of appropriate transport facilities, which may be either of the continuous-action or the discontinuous-pulsating action type.

Continuous forced motion consists in the simultaneous assembly and transport of the assembled object. Thus the assembly of automobiles, tractors, and other mass-produced machines takes place on the conveyor. In this form of assembly, the conveyor line is arbitrarily divided into working zones of equal length, i.e., into zones of equal distances between the centers of two articles on the conveyor.

The number of work zones w.z is determined by the formula

$$w.z = \frac{T_{aw}}{r_c n_{op}},$$

where $T_{a.w}$ is the labor cost of assembly work on the conveyor, in hours;

r_c is the pace of assembly of an article on the conveyor, in hours or min;

n_{op} is the average number of operators working in one zone of the belt.

The length of a work zone equals the distance traveled by the article during the time taken by a crew or single operator to do the work assigned to that zone. The length of a work zone is defined by the formula

$$l = v \cdot r_c,$$

where l is the length of the work zone of the belt, expressed in m;

v is the belt speed, in m/min;

r is the pace of flow of assembly of the article, in min.

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The belt speed, in continuous motion, is

$$v=\frac{l}{r_c}.$$

The traveling speed of the belt is so established as to make it possible to perform the assembly operations without lowering their quality.

The length of the belt is defined by the product of the belt speed and its pace and by the number of work zones plus 2 to 3 m at the ends of the belt for the approach to it:

$$L=r_c\cdot v\cdot \text{w.z}+(2.\ 2).$$

On an endless belt, the cycle of assembly of the article is equal to the number of work zones multiplied by the overall pace of assembly of the article:

$$C_c=\text{w.z}\cdot r_c.$$

The area S occupied by the belt is equal to

$$S=(H+2\text{Ap})\cdot L,$$

where H is the width of the belt, in meters;

Ap is the width of the approach on the sides of the belt, in m;

L is the belt length, in m.

Example. Required, to calculate a production line for continuous assembly on a belt with an output of 240 units per shift. The belt is equipped with dollies 2.5 m long, with the distance between the dollies being 0.4 m, the belt width 1.5 m, and the width of the approaches 2.5 m each; the standard time (actual) for assembly of one article is 64 min; the loss of working time for rest by the operators is 2%; one operator works in each zone of the belt.

Solution.

1. Determine the rate of assembly of the article on the belt:

$$r_c=\frac{T_{см}\cdot\left(1-\frac{k}{100}\right)}{N_{yw}}=\frac{480\,(1-0,02)}{240}=1,96\ min.$$

2. Find the rate of motion of the belt:

$$v=\frac{l}{r_c}=\frac{2,5+0,4}{1,96}=1,48\ m/min$$

3. Determine the number of work zones on the belt:

$$\text{w.z.}=\frac{64}{1,96\cdot 1}=32,\ 7\ (\text{let us take}\ \ 33).$$

4. The length of the belt is

$$L=r_c\cdot v\cdot \text{wz}=1,48\cdot 1,96\cdot 33=95,7\ m.$$

5. The area occupied by the belt is

$$S=1,5+(2,5+2)\cdot 95,7=622,05\ m^2.$$

6. The assembly cycle for the unit is

$$C_y=33\cdot 1,96=64,68\ min$$

Pulsating forced motion differs from continuous motion in that the processes of assembly of the article and its displacement alternate periodically. The article is assembled with the belt stopped, and as soon as the process of assembly is completed, the belt travels the length of one work zone. A pulsating line is used where the performance of the operations and their control is possible only when the object being assembled is at rest.

The pace of a pulsating line is

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$$r_{puls}=r_c+t_{trav},$$

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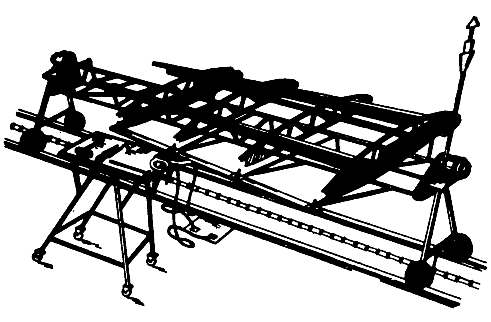

Fig.22 - Jig-Dolly of Floor Belt on Wing Assembly Line

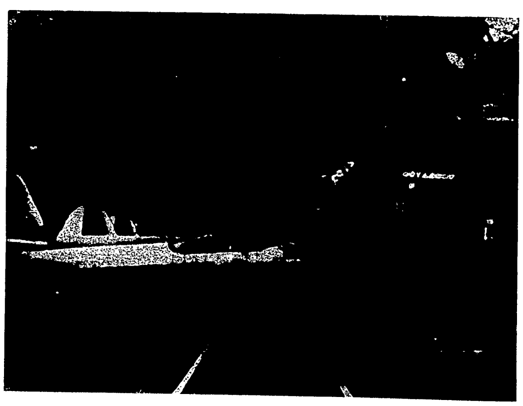

Fig.23 - Transverse Arrangement of Fuselages on Assembly Belt, Shortening the Length of the Belt

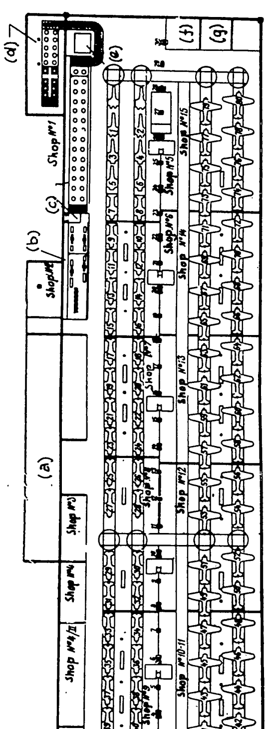

Fig.24 - Diagram of Aircraft Final Assembly Belt

a - Aircraft assembly line before hanging the wings; b - Assembly line for aircraft with wings

(a) Stockroom of shop; (b) Propeller preparation section; (c) Control desk No.1; (d) Section for removal of propeller and engine from storage No.1; (e) Radiator installation; (f) Garage for intrashop transportation; (g) Vestibule where $r_{puls.}$ is the pace of the pulsating line;

r_c is the working pace of assembly on the belt;

t_{trav} is the time taken for the belt to travel the length of one work zone.

Example. Determine the working pace and calculate the length of stay of an

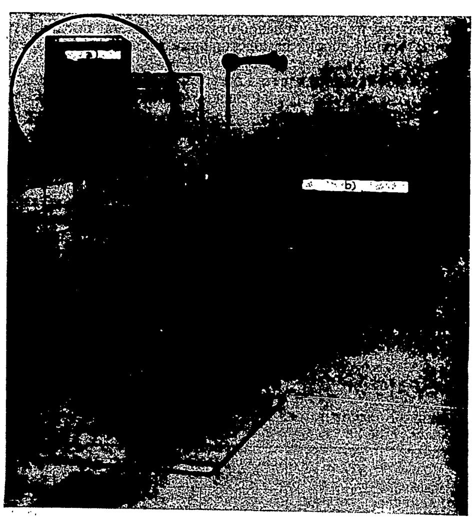

Fig.25 - Diagram of Final Aircraft Assembly Line Equipped with Automatic Control of Belt from Dispatcher's Desk

a) In rhythm; b) Remaining

assembly on a pulsating belt with the following data: 40 assemblies are produced in a shift; the number of work stations on the belt is 20; loss of working time 2%; distance between work stations is 1.6 m; the rate of motion of the belt is 2 m/min.

Solution.

1. The pace of the pulsating line is

$$r_{puls}=\frac{T_{CM}\cdot\left(1-\frac{k}{100}\right)}{N_{unit}}=\frac{480\,(1-0{,}02)}{40}=\sim 12\text{ min}.$$

2. The time taken by the belt to travel one work zone is

$$t_{trav}=\frac{l}{v}=\frac{1{,}6}{2}=0{,}8\text{ min}.$$

3. The working pace of assembly of the article on the belt is

$$r_c=r_{puls}-t_{trav}=12-0{,}8=11{,}2\text{ min}.$$

4. The assembly cycle on the pulsating belt is

$$C_c=r_{puls}\cdot wz=12\times 20=240\text{ min}.=4\text{ hrs}.$$

Lines with pulsating belts have found wide application in subassembly shops and in shops of preliminary and final aircraft assembly. In the subassembly shops the line assembly of spars, ribs, and other units is performed, together with the assembly, welding and protection of the fuel tanks, and the jig assembly, and in particular, the non-jig assembly of assemblies. At some enterprises, the line assembly of flat assemblies is performed in movable jigs with an overhead conveyor (Fig.21), in others, in mobile jigs with a floor belt (Fig.22). In both types of enterprises, various other operations, including finishing of the joint openings and trimming of the skin are performed without removing the assembly from the jig.

The design of a pulsating line is such that the area is effectively utilized and the length of the conveyor trolley is minimized (Fig.23).

For this purpose, two sublines are established in the final aircraft STATbly shop, one during installation on the aircraft before hanging the wings, the second

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for installation on the aircraft after fitting the wings to the fuselage (Fig.24).

During World War II, the final assembly of assemblies and aircraft at a number of aircraft construction enterprises was handled by automatic-acting pulsating belts. The belts were electrified, controlled from a single dispatcher's desk and were equipped with sound and light signals, warning the operators that the belt was about to move again (Fig.25). The performance of assignments on the belt lines was indicated automatically on the switchboards of the dispatcher's desk.

Section 5. Features of Organization and Calculation of Single-Product Discontinuous Lines

A discontinuous line is characterized by partial synchronization of operations and is used in aircraft building in the machine shops, in processing the high-labor-cost parts, for instance, beams and clamping bolts; in the fitting and welding shops, for the assembly and welding of high-labor-cost units (canopy, controls, frame); in the subassembly shops, for assembling the assemblies in stationary (fixed) jigs; in the work shops handling the electric, radio, and special equipment of the shops of preliminary and final aircraft assembly; in the stationary assembly of aircraft.

A continuous production line with a single operator at each work station and with piecewise transfer of parts is organized and calculated in the following order: selection of part (all unit) assuring by its labor cost, with an assigned program, the loading of the work stations of the line; calculating the rate of flow and, in accordance with that rate, the subdivision of the processes of processing or assembly into operations; the partial synchronization of operations to eliminate sharp discrepancies in their duration; designing the tooling, jigs, and fixtures for the combined mechanization of the work in each operation; final designing of the line, setting up of the equipment and instructing of the operators.

The following is an example of the calculation of the pace of such a line, of the required number of work stations and their loading coefficients.

Assume that 32 parts are to be produced per shift.

The operational times of the part are indicated in Table 3.

Find the pace of the line:

$$r = \frac{T_{см}}{N_{part}} = \frac{480}{32} = 15 \text{ min} .$$

The further calculation of the line will be seen from Table 3.

Table 3

a)	b)	c)	d)	e) f)	e) g)	h)	i) f)	i) g)	j)
1	Turret lathe	14,4	15	0,96	1	0,96	0,96	1	0,96
2	Lathe	28,6	15	1,9	2	0,95	1,9	2	0,95
3	Milling	7,2	15	0,48	1	0,48	0,48 }	1	0,98
4	Milling (profiling)	7,5	15	0,5	1	0,5	0,5 }		
5	Grinding	15	15	1	1	1	1	1	1
	Total:			4,84	6	0,81	4,84	5	0,97

a) Operation No.; b) Type of operation; c) Length of operation, in min; d) Rate of flow; e) Quantity of equipment; f) Calculated; g) Adopted; h) Coefficient of loading of equipment; i) Number of operators; j) Coefficient of loading of operators

The discontinuous production line with the crew form of work at each work station is used in the assembly of compartments, assemblies, and of the entire aircraft (Fig.26). The organization of the line is conducted in the following sequence: calculation of the pace, layout of the operations by assembly jigs, calculation of the required number of jigs, setting up regulations for the work of the crew members at each assembly jig, designing the line, and instruction of the operators.

The pace of the line is found by dividing the shift time by the compartments, assemblies, or aircraft to be produced in a shift. For instance, two sets of wings are to be assembled per shift. This means that the rate of output of a set of wings

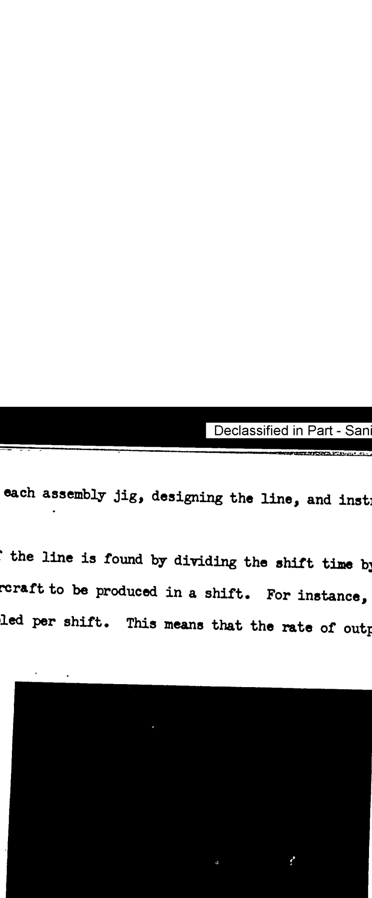
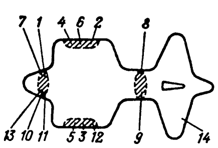


Fig.26 - Discontinuous Fuselage Assembly Line with Crew Form of Labor Organization at Each Assembly Jig

is 4 hours (8 : 2 = 4). The rate of four hours merely established the period of output of the wings by the line, but does not indicate the labor cost per work station. Depending on the cycle, the technologist must distribute the entire labor cost of the work of wing assembly over the assembly jigs in such a way that the maximum number of operators can be assigned to each jig. Taking this requirement into consideration, the technologist will lay out the operations in installations (assembly assignments), and will assign these to the work stations (jigs). For example, four workers may be assigned to the first jig, and three to the second. Consequently, the volume of work of 4 × 4 = 16 hours may be assigned to the first jig, and 4 × 3 = 12 hours to the second. In this way, the technologist distributes all the wing assembly work from jig to jig, including the operations of inspection. If



a)	b)	c)	d)	e)	f)	g) 1st h	2nd h	3rd h	4th h
1	Install silk filter	5	2	Fitter-assembler	1				
2	Test fuel line for tightness	5	4	"	2				
3	Lay drainage line of fuel system in fuselage and wing center section	5	6,1	"	3				
4	Install fuel tanks with settling tank	5	11,8	"	3				
5	Connect drainage line and feed line with fuel tanks	4	3,7	"	2				
6	Test zone 1 for tightness	4	4,3	"	2				
7	Connect electric wiring to knife-blade switch	4,5	4,4	Electrician	2				
8	Lay and attach electric wiring in baggage compartment	4,5	3,5	"	2				
9	Continue electric wiring to lavatory compartment	4	4	"	1				
10	Connect electric wiring to switchboard	4,5	9,6	"	3				
11	Connect electric wiring to instrument board	4,5	2,4	"	3				
12	Lay electric wiring in wing center section	4,5	7,9	"	2				
13	Make electric installation for landing gear	4,5	8,1	"	2				
14	Install stabilizer heating equipment	4,5,6	11,8	Fitter-assembler	3				

Fig.27 - Graph of Organization of Labor on Stand, Showing Distribution of Operations among Operators

a) Operation No.; b) Type of operation; c) Labor category; d) Standard time; e) Operator's specialty; f) Number of operators; g) Graph

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the volume of inspection work is large, then special stands will be provided for it along the line. The inspection time at a stand is fitted into the cycle of the assembly line.

The number of assembly stands required is calculated by the formula adopted for calculating the working zones:

$$w.z = \frac{T_{aw}}{r_c n_{op}}.$$

The technologist draws up a chart for each stand for the rational organization of labor there. It indicates the distribution of the operations between the operators at the stand, together with the sequence and order of performing the operations (Fig.27).

Section 6. Features of Organization and Calculation of Multiproduct (Group) Production Lines

Production lines on which several parts are processed simultaneously or alternately, or several units are so assembled, are called multiproduct or group lines.

The fact that an aircraft contains a large number of typical (uniform) groups of parts and units offers extensive opportunities for the use of certain forms of group lines in the fabricating, processing and assembly shops of an aircraft building enterprise. We present a description of some of the most widely used and economic forms of group lines.

One of the forms is characterized by the specialization of the line to process parts with the same flow chart, without repeatedly setting up the equipment. Such production lines, without resetting of equipment, are established in the tooling, mechanical, fitting-welding, and subassembly shops. In the tooling shops they are set up for making drills, reams, or gages of various diameters.

In the machine shops, a multiproduct nonreset production line is assigned as many unified parts as can be simultaneously machined on each machine. The experience of automobile plants shows the economic advantages of the multiproduct nonreset lines over the ordinary object-group departments. Such a line allows work with mixed batches and holds the emergency spares to a minimum.

To avoid excessive time losses, each work station of a multiproduct line is equipped with all attachments necessary for the simultaneous or consecutive machining of all parts assigned to the line (Fig.28).

All the attachments are permanently installed on the machine and are removed

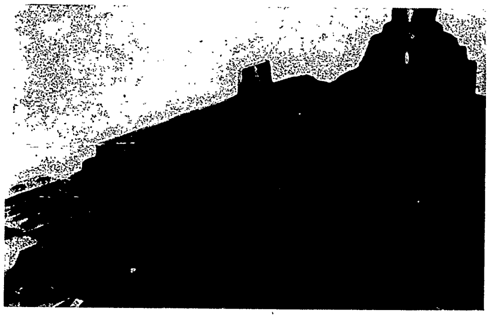

Fig.28 - Machining of a Group of Parts on a Vertical Milling Machine in a Multiproduct Production Line

only for inspection and maintenance. Such production lines will probably find wide application in aircraft-engine building and in aircraft building, for instance, in machining unified parts of high labor cost: clamping bolts, cylinders, fittings, brackets. The future development of multiproduct nonreset production lines will probably proceed along the line of using standardized quick-clamping, multiple attachments, making it possible to shorten the auxiliary time considerably.

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In organizing multiproduct nonreset production lines in fitting and assembly

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shops, only the fitting and assembly operations were at first included in the production lines, but later on the operations of clamping, adjustment, welding and inspection were also added. For the organization of group production lines, the welded units are classified into typical groups, and each group is assigned to a definite line. The simplest form of a group line in the fitting-welding shops is

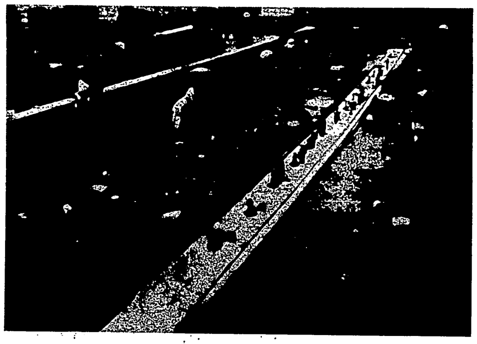

Fig.29 - Group Assembly Line for Units, Equipped with a Belt Conveyor

the discontinuous production line, equipped with specialized work stations, along which an endless belt conveyor is installed for the transfer of units from one work station to the next (Fig.29). In such a production line each work place is specialized to perform one operation on all the units assigned to the line. Since the operational time in such a production line varies, the pace is established according to the longest operation.

In the case where the work stations are specialized to process some of the items of the units handled by the line, it is expedient to use a conveyor with a

distributing device, to relieve the operator of the necessity of watching the belt and removing his own items from it at the right time (Fig.30).

A more complex and productive form of the group production line in fitter-welding shops is represented by production lines in which, instead of a belt, a conveyor in the form of dollies under forced displacement or a plate conveyor with

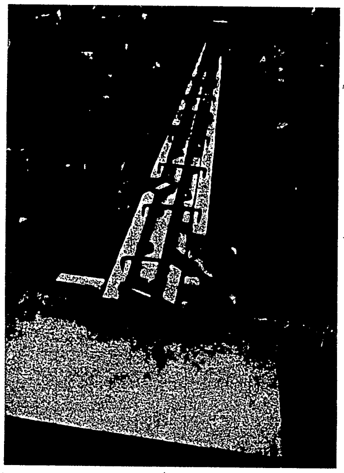

Fig.30 - Production Line with Distributing Belt

single or multiple jigs screwed into it for the assembly and clamping of the units is used. The number of attachments is determined by the number of parts assigned to the line. The first operation in such a line is assembling the parts into sets for the units. With this form of group production line, a forced pace is established, with intermittent or continuous motion of the conveyor (Fig.31).

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The use of group production lines in the fabrication of welded units and in the assembly of ribs, panels, bulkheads, and spars ensures the delivery of the units in sets at every shift to the next assembly stage.

The features of calculating the pace of a group line in the fitting and welding shop will be seen from the following example.

Example. Determine the number of work stations in an assembly line on which units 1 and 2 are assembled in sets during the period of a cycle under the following initial data: units proceed to the machine piece-by-piece, the output is 53 sets a day, the work is in two shifts, and the loss for breaks is k = 3%.

Solution. Determine the rate of output of the set of units during a shift:

$$r=\frac{T_{\text{см}}\cdot S\cdot\left(1-\frac{k}{100}\right)}{N_{yw}}=\frac{480\cdot 2\cdot 0{,}97}{53}=17{,}57\ min.$$

Starting from this rate, we group the assembly operation per units so that the length of work at each work station will be 17.5 min (Table 4).

Table 4

Sequence of Technological Processes

On Unit 1			On Unit 2		
Oper-ation No.	Type of Operation	Standard Time, in Min.	Oper-ation No.	Type of Operation	Standard Time, in Min.
1	Stamp ball bearing	2	1	Stamp ball bearing	4
2	Stamp bushings for ball bearing	2	2	Stamp bushings for ball bearing	5
3	Remove cores	2	3	Remove cores	2.5
4	Place handle on control bolts	1	4	Place pedal tube on control bolts	4.5
5	Check and fit	9	5	Check and fit	3
6	Assemble control stick with cables	10	6	Assemble control stick with cables	7.5

Grouping of Assembly Operations

Work Station No.	Operations on Unit 1	Operations on Unit 2	Total Time on Units, in min
1	1, 2 and 3	1, 2 and 3	17.5
2	4 and 5	4 and 5	17.5
3	6	6	17.5

Thus the assembly is conducted at three uniformly loaded work stations.

Another form of group production line, which does require machine resetting, is used mainly in machine shops, when the labor time of a single part does not pro-

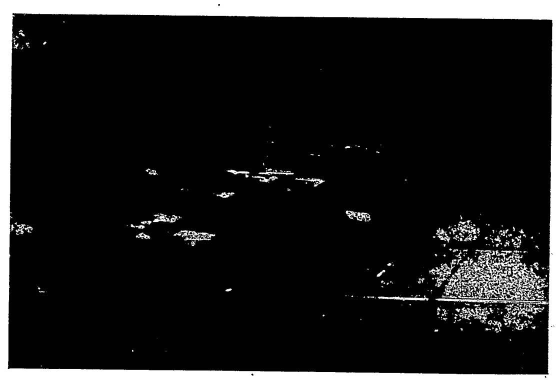

Fig.31 - Group Assembly and Welding Line for Units, Provided with a Pulsating Belt

vide adequate load for the equipment of the line. In that case, several par[redacted]v-ing the same flow sheet and demanding equipment of the same type, and which, taken together, provide a high load for the equipment, are assigned to the line.

Starting from the labor cost of the batch, the corresponding number of days in each month is assigned to each part for its machining, from month to month, and during this period the production line handles only a batch of these parts. In order to change over from the processing of a part of one designation to processing a part of a different designation, the machines of the production line must be changed over and set up again. The change-over of the machines and the starting of the part may take place simultaneously at all work stations of the line if a backlog of emergency spares is in existence; if there is no such backlog, then the machines of the lines are changed over in sequence, as the batches of parts pass through the operations of the line. In such a line the parts may pass from machine to machine in individual pieces or may be transported in batches.

The features of the calculation of the pace and the procedure for start-up of parts in such a line will be seen from the following example.

Example. Required, to determine the pace and the number of work stations, and to construct the flow chart of a batch of parts in a variable line. Two parts, a bushing and a ring, are assigned to the line. The bushing is taken one by one at each machine, and the rings, two by two. The program is to process 64 sets a day. There are two shifts, with an 8-hour working day. Table 5 shows the flow sheet of the manufacture of these parts.

Table 5

Operation No.	Flow Sheet of Part "Bushing"	Length of Operation, in Min	Flow Sheet of Part "Ring"	Length of Operation, in Min
1	Turret lathe	10	Turret lathe	2.5
2	Lathe	15	-	-
3	Milling machine	7	Milling machine	4
4	Drilling machine	6	Drilling machine	4.5
5	Fitting bench	12	-	-

Let us solve this example in two versions: working with monthly batches and working with three-shift batches.

The solution of the first version consists in determining the number of days in the month during which the line will be occupied in processing the parts "bushing" and the number of days during which the line will be occupied in processing the parts "ring". This is determined by the ratio of the labor cost for the parts. The labor time of a bushing is twice that of a set of rings. For this reason, we may consider roughly that of the 26 working days of the month, 17 working days should be assigned to the part "bushing" and 9 working days to the part "ring".

The solution of the second version is performed in the following sequence:

1) Find the rate of output of one set of parts:

$$r=\frac{T_{cm}\cdot S}{N_{set.part}}=\frac{480\cdot 3}{\frac{64}{2}\cdot 3}=15\ min.$$

2) Determine the required amount of equipment on the production line by adding the labor time of the corresponding operation on the bushing and ring (Table 6).

Table 6

a)	b)	c)	d)		g)
			e)	f)	
Turret lathe	10+(2,5×2)=15	15	1	1	1
Lathe	15		1	1	1
Milling	7+(4×2)=15		1	1	1
Drilling	6+(4,5×2)=15		1	1	1
Fitting	12		0,8	1	0,8
	Total for Line		4,8	5	0,96

a) Type of operation; b) Length of operation on bushing and ring, in min; c) Pace of line, in min; d) Number of machines; e) Calculated; f) Adopted; g) Coefficient of machine loading

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3) **Determine the number of parts in a batch:**

$$N_{\text{batch bushings}}=\frac{64}{2}\cdot 3\cdot 1=96 \text{ pieces}$$

$$N_{\text{batch rings}}=\frac{64}{2}\cdot 3\cdot 2=192 \text{ pieces}$$

4) Determine the time taken to process a batch of parts by operations:

	Bushing	Ring
Turret Lathe	$\frac{96\times10}{60}=16$ hrs	$\frac{192\times2,5}{60}=8$ hrs.
Lathe	$\frac{96\times15}{60}=24$ hrs	—
Milling	$\frac{96\times7}{60}=11,2$ hrs.	$\frac{192\times4}{60}=12,8$ hrs.
Drilling	$\frac{96\times6}{60}=9,6$ hrs.	$\frac{192\times4,5}{60}=14,4$ hrs.
Fitting	$\frac{96\times12}{60}=19,2$ hrs.	—

On the basis of the duration of work so obtained, we construct a graph of the machine loading by shift and establish the periods of starting the batch by operations (Fig.32).

Still another form used for the group production line has as its major feature not flow operation, but merely a rhythmic operation and is characterized by the selection and assignment to the production line of typical parts with various operations of varying length on the part. It may even involve several operations on some parts. In this line, the operations on the parts assigned to the line are not synchronous. One condition is important and compulsory for this form of rhythmic operation, namely that the total duration of the operations on the entire set of parts on a machine shall be equal to, or be a multiple of, the pace of output of the parts, or shall approximate it (Table 7).

The sequence of starting the batches of parts is so selected as to minimize the loss of time in resetting the equipment, on change-over from processing one part to processing another. With this object, the parts are first classified. The parts assigned to a multiproduct line are placed in one technological subgroup and have the same flow sheet. If there are not enough of such parts to load the work stations, then a few similar subgroups of parts are also assigned to the line. In this

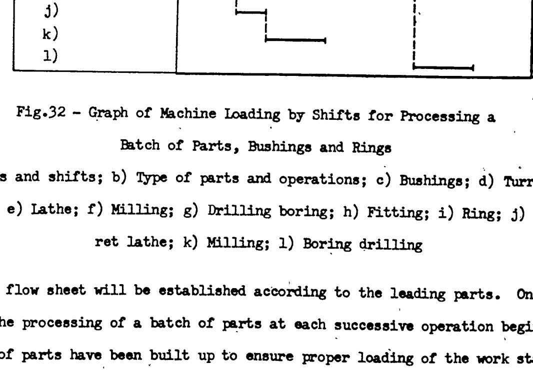

Fig.32 – Graph of Machine Loading by Shifts for Processing a Batch of Parts, Bushings and Rings

a) Days and shifts; b) Type of parts and operations; c) Bushings; d) Turret lathe; e) Lathe; f) Milling; g) Drilling boring; h) Fitting; i) Ring; j) Turret lathe; k) Milling; l) Boring drilling

case, the flow sheet will be established according to the leading parts. On such a line, the processing of a batch of parts at each successive operation begins after reserves of parts have been built up to ensure proper loading of the work station. The times of setting up of the machines and the processing of the batches of one and the same parts for various operations, are successively staggered from shift to shift. The size of a batch of parts is so selected that it is not necessary to reset the machine more often than once or twice in every shift. The technique of calculating such a line will be seen from the following example.

Example. In a machine shop the parts A, B and C are assigned to a production

Table 7

a) \ b)	c)	d)	e)	f)	g)
	h)				
1	6	5	3	6	4
2	4	3	7	5	5
3	5	4	2	5	4
4	3	5	4	7	10
5	5	6	6	—	—
i)	23	23	22	23	23

a) Part,No.; b) Operation; c) Turning; d) Milling; e) Drilling; f) Grinding; g) Fitting; h) Duration of operation, in min; i) Total

line for machining in sequence. The production schedule for these parts is 800 sets a month with 25 working days in the month, two-shift operation (8-hour working day) and a 20% overfulfillment of the standards by the operators. The time loss for equipment maintenance amounts to 3% of the working time. The operational times by parts, taking account of the set-up and clean-up times on a batch, are as follows:

a)	b)							h)	i)	j)	k)
	c) No.1	d) No.2	e) No.3	d) No.4	c) No.5	f) No.6	g) No.7				
A	10	10	4	8	10	8	12	62	2	124	55
B	9	9	8	9	8	9	9	61	1	61	27
C	6	6	6	5	6	6	5	40	1	40	18

a) Part; b) Name of operation and duration, in min; c) Turning; d) Milling; e) Drilling; f) Grinding; g) Fitting; h) Time for machining 1 part, in min; i) Number of parts in 1 sec; j) Time for machining 1 set, in min; k) Share of labor time of part in labor time of set, in %

Solution. Find the number of sets of parts that must be produced in a shift:

$$N_{set} = \frac{800}{25\times 2} = 16.$$

Then find whether it is expedient to use the rhythmic starting and output of parts. Let us select from all series the most protracted and the most often repeated operation. In our example, this will be operation No.1.

The actual labor time for 16 sets of parts in this operation, taking the overfulfillment of the operational standard by the operators into account, will be

$$t_{tot} = \frac{(10\times 2+9+6)\cdot 16}{1,2} = 466 \text{ min}.$$

The time of the machine doing operation No.1 on three parts during the course of the shift will be

$$480\times(1-0,03) = 466 \text{ min}.$$

This indicates that the machine will be loaded by $\frac{466}{466}\times 100 = 100\%$ during the course of the shift. Consequently, a change-over to rhythmic operation is expedient.

Let us further assign the recurrence cycle of the output as 0.5 month and determine the time taken to process each batch of parts, out of the total two-week machine time of the production line.

$$T_A = 12,5\times 2\times 0,55 = 13,75 \text{ shifts};$$

$$T_B = 12,5\times 2\times 0,27 = 6,75 \text{ shifts};$$

$$T_C = 12,5\times 2\times 0,18 = 4,5 \text{ shifts}.$$

Determine the calculated rate of flow for each part separately.

For part A $r = \frac{13,75\times 8\times 60\times 0,97}{400\times 2} = \frac{6240}{800} = 7,8 \text{ min}.$ STAT

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For part B $r = \frac{6,75 \times 8 \times 60 \times 0,97}{400 \times 1} = \frac{3120}{400} = 7,8$ min.

For part C $r = \frac{4,5 \times 8 \times 60 \times 0,97}{400 \times 1} = \frac{2160}{400} = 5,3$ min.

Section 7. The Most Important Conditions for the Normal Operation of a Production Line

The selected form of a production line must most fully correspond to the conditions, needs, and features of a given production.

In series production, the line must first of all be tied in with the system of operation of the shop, with the methods of planning, and the order of starting the batches. The change-over to a production line ensuring rhythmic output of the product must necessarily be accompanied by an increase in labor productivity and an increase in the efficiency of the equipment.

Being the highest form of production organization, the production line also demands a higher level of technical training. In a production line, each work station is related to the adjoining ones by the pace of product output. Interruptions at one work station are immediately reflected at the following work stations. In order to prevent interruptions in the operation of a line, a system of preventive measures is used. The operator receives his shift assignment and instructions from the foreman on the day before the shift; before start of the shift the machine is tested by the maintenance worker and is set up by the machine setter, the work station is supplied with blanks before the beginning of the shift, and the first part turned out is checked by the mechanic or machine setter. During the shift, it is mandatory to change the cutting tool at prescribed intervals of time. The parts produced are periodically subjected to 100% or spot inspection. When signs of spoilage are noticed, the inspector immediately notifies the operator. To ensure uninterrupted operation of the production line during the period between deliveries

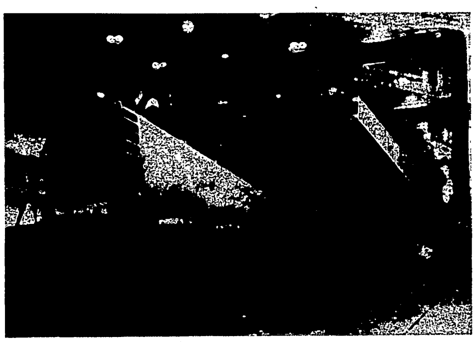

Fig.33 - Installation for Hoisting of Wing Section

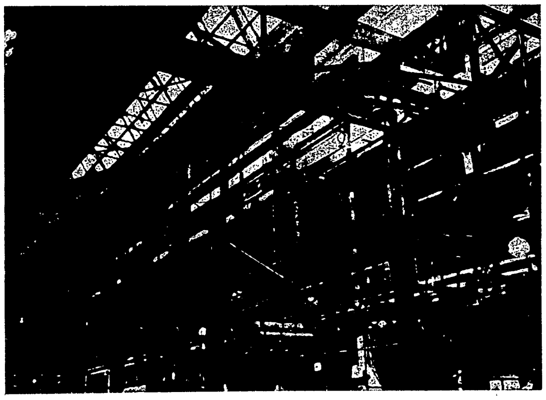

Fig.34 - Continuous Overhead Trolley Conveyor for Delivering Engine to Place of Installation in Automobile

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of batches of parts, a reserve of blanks is built up at the beginning of the production line. This will be the interdepartmental or intershop emergency reserve. To ensure simultaneous beginning of operation at all work stations of a line, there is a reserve of parts, known as the technological reserve, at each work station. To

Fig.35 - Continuous-Action Conveyor; Initial Operation, Installation, and Mounting of Automobile Plane

eliminate excessive dependence of one work station on another and adjacent work station, a turnover reserve is established between them. To eliminate the influence of delays due to inadequate indoctrination on the line, as well as during the period of stoppage of the machine for routine maintenance, an insurance reserve is established*. Line production is based on strictest observance of technological and labor discipline.

* The methods for calculating reserves are given in the Chapter "Operational Planning of Production".

Section 8. Purpose and Forms of Transport Facilities Used on Production Lines

The series arrangement of work stations and an invariable route to be followed by the parts to be processed or the article being assembled create favorable conditions for the use of various transport facilities on production lines, to relieve the operators from lifting heavy articles and from delivering them to the next work station. Transport facilities are divided into inter-operation (local) and line.

Inter-operation transport serves only two adjacent work stations. Such facilities include slides, chutes, roller conveyors, and various mechanical transfer devices.

General line conveyor facilities are represented by a single transport system for the entire line.

The general line facilities include assembly conveyors and roller conveyors used in casting and machine shops; trackless trolleys, used in subassembly shops; monorails, used in fabricating and subassembly shops for hoisting and transporting a compartment or assembly from one jig to the next (Fig.33); chain, band, plate, and other conveyors and conveyors of the floor and overhead type (Fig.34). Transport belts and conveyors may be either of continuous or intermittent action. Overhead conveyors are convenient for assembly and riveting flat assemblies: empennage, wings, and wing center sections; they take less space than floor conveyors.

A transport belt serves only as a means of delivering a part being processed or an article being assembled. A conveyor is not only a transport facility but is also a place of doing work at a mechanically regulated rate of motion of the article being assembled (Fig.35).

* * *

Such advanced forms of labor organization as multitool servicing, through crews for high skill and crews for high labor productivity, have found widest application

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on production lines. The production line does not eliminate the use of individual piece work and of advanced methods of work, but encourages their development.

Collective, mutually coordinated work, is particularly important in the production line.

In aircraft construction enterprises the production line was first employed in the final assembly of the aircraft and in its subassembly operations. Since then, the creative inquiry of Soviet engineers and aircraft builders has been more and more expanded in the field of development of line methods.

During World War II the use of the production line method was especially prevalent. Casting and machining of large parts and welding of large units, as well as the fabrication of tanks, were transferred to production lines.

The principles are used by multiproduct (group) production lines in machine shops and fitting-welding shops, which under the production conditions for multi-product and multi-unit articles, such as the aircraft, were of great economic importance.

In the subassembly and in final assembly of aircraft, the transition from discontinuous production lines to continuous-pulsating production lines began, accompanied by widespread conveyorization of the assembly work.

The use of the production-line method in the Soviet aircraft industry has led to profound technological and organizational changes. More highly developed technological designs of engines and aircraft were introduced, more productive instruments of labor, processing methods and inspection began to be used, together with widespread mechanization of hoisting and transportation work. The design of the productive process was improved and the level of service to the work stations was enhanced. Overall, the production line method has raised aircraft production to a higher level.

The task of further improvement of the line methods of production now faces the workers of the aviation industry.

CHAPTER IV

THE PRODUCTIVE STRUCTURE OF THE AIRCRAFT CONSTRUCTION ENTERPRISE

Section 1. Definition of Productive Structure and its Main Elements

The aircraft construction enterprise, for conduct of the production process has available a group of industrial building and structures, machines, machine tools, transport facilities, and other facilities. The order of arrangement of the technological facilities in space is determined by the sequence of the arrangement of the individual stages of the process in time.

In assembly-line production, the shops and work stations are arranged in sequence, in accordance with the course of the technological process, ensuring continuity in the performance of the technological, transport, and inspection operations. In series-aircraft production operation, this cannot be fully realized, but even in this case one must still strive to straighten and shorten the path of manufacture of the aircraft, and to realize the principle of smooth flow in production.

By the productive structure of an aircraft construction enterprise we mean the forms of specialization and cooperation of its productive elements, their composition, and the forms of their organization. The productive structure determines the position in space of the shops, departments, and equipment, which affects the linear flow and continuity of the process; it also determines the number of shops and their departments as well as the form of organization of the shops and departments STAT

The productive structure is affected by such factors as the kind of machine

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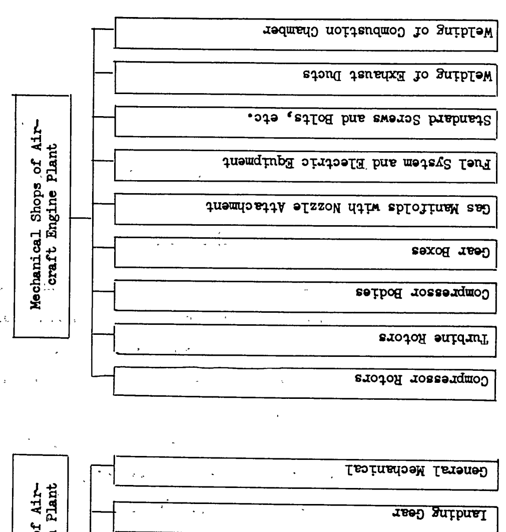

Fig.36 - Comparative Diagram of the Mechanical Shops of Aircraft Construction and Aircraft-Engine Enterprises

manufactured and the technology of its production, the volume of output, and the degree of specialization of the enterprise.

The type of machine being manufactured determines the cross section and composition of the shops of the enterprise, a point which will become obvious, for instance, when comparing the machine shops of an aircraft construction enterprise with those of an aircraft-engine plant (Fig.36). The higher the degree of unification and design integration of the machines, the more stable will be the composition of the shops and departments.

The influence of the production scale is manifested in the fact that, the broader the list of parts and assemblies of the aircraft and the greater the expenditure of social labor, the more shops an enterprise will have. The larger the number of machines put out by a plant, the fewer will be the operations assigned to each work station and the more specialized will the shops and their departments become. Specialization and cooperation lead to a curtailment of the operation schedule and production stages, to a simplification of the productive structure of the enterprise.

The directives of the 20th Congress of the Communist Party on the Sixth Five-Year Plan of Development of the National Economy have forbidden the construction of small casting and forging shops at machine-building plants in regions where specialized casting and forging-stamping plants and shops exist or are under construction. The establishment of high-capacity casting and forging-stamping shops at some aircraft construction plants, to serve a group of plants, will permit the liquidation of the miniature casting and forging-stamping shops at a number of aircraft plants. The directives of the Congress specified the organization of specialized plants for the production of standardized, normalized, and unified parts and units and of specialized plants and shops for fabricating small mass parts of rubber, plastics, or wood. This will lead to a further simplification of the productive structure of aircraft construction plants.

The principal units in the productive structure of an enterprise are shop-department-section-work station.

Section 2. Purpose of Shops and Forms of their Organization

The shop is the primary unit in the management of the enterprise. Depending on its purpose, i.e., on the form of the product being manufactured and the character of the processes performed, shops are subdivided into main, auxiliary, service, and subsidiary. Shops may have a technological, object, and mixed specialization.

In technological specialization, the performance of uniform operations, for instance, casting, forging, machining, heat-treating, are concentrated in the shop.

With object specialization, various operations are concentrated in a shop, thus ensuring complete processing and assembly of a list of uniform parts assigned to the shop (as, standard parts shop), of uniform units (as, fitting shop) or of processing and subassembly (as, landing-gear shop). With object specialization, processes of various stages are combined in a single shop.

Object specialization is widely used in mass-flow and large-lot series production and has a number of economic advantages over technological specialization. It simplifies planning and intershop communications, shortens the cycles of fabrication of parts and units, increases the responsibility of the shop for the quality, not only of the processing of the parts, but also of their assembly into units or assemblies. The mixed form of specialization is characteristic of aircraft construction enterprises. In the assembly shops, uniform operations are concentrated, while at the same time the shop is also specialized for assembly of a given assembly. For instance, shops may be specialized for the assembly of fuselages and wings.

A productive shop consists of production departments and sections, auxiliary work shops, and services.

A section (work shop or bay) is headed by a senior foreman and is the basic unit in the management of the shop.

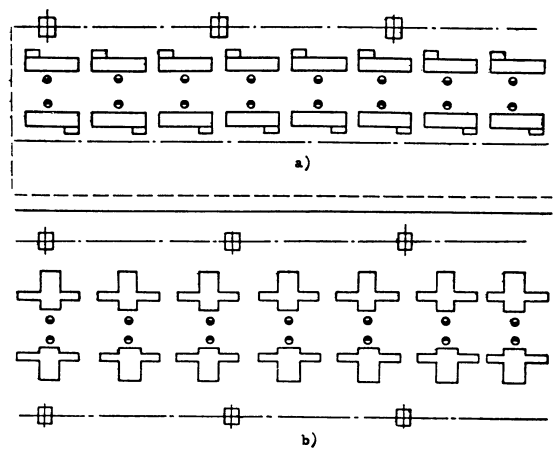

Fig.37 - Diagram of a Department with Process Layout of Work Stations in the Sections

a) Lathe section; b) Universal milling machine section

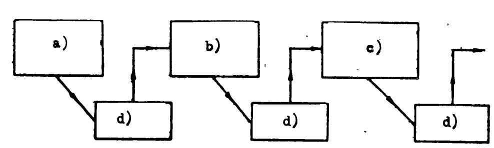

Fig.38 - Diagram of Movement of Parts between Operations with the Process Layout of Work Stations in the Departments

a) Lathe department; b) Milling machine department; c) Grinding machine department; d) Department stockroom

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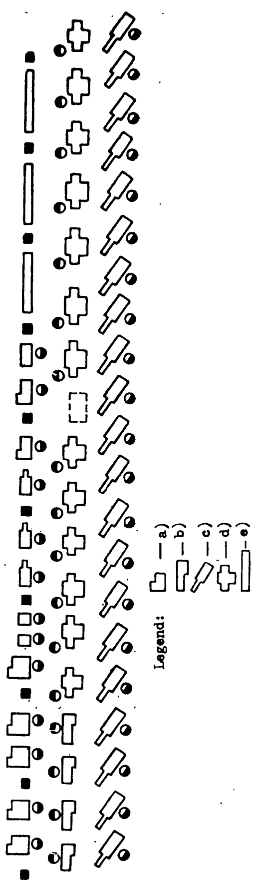

Fig.39 - Diagram of Department (or Section) with Product-Process Layout of Equipment

a) Legend; b) Grinding machine; c) Lathe; d) Turret lathe; e) Milling machine; f) Three-place bench

A department consists of several sections, each headed by a shift foreman. Each senior foreman usually has not less than four shift foremen under him, and each shift foreman 20-25 or more production operators. The more highly specialized a section and the higher the qualifications of the foreman and operators, the more operators it will have.

The entire volume of the work of a shop is determined by the departments and their sections, taking account of the fullest utilization of equipment and productive area, the provision of a short route for the parts, and a short cycle for their manufacture.

Depending on the form of specialization and organization of the production process, the productive structure of the departments and their sections is based on differing layout of the work stations.

A department (or section) with process layout of work stations combines work stations of the same type, specialized to perform technologically

uniform operations on parts of different kinds. If for instance, in a machine shop, the lathes are grouped in one department, the milling machines in another, and only grinding machines in a third, then these will be departments (or sections) with a process layout of work stations (Fig.37). In such a department, a part is not completely processed, meaning it is not finished. To perform operations of a different kind, the part is transferred to a different department, for instance, from the bending-press department to the finishing shop, from the lathe department to the milling department. Parts are transferred from one process department to another through the intermediate stockroom (Fig.38). This prolongs the cycle, complicates the planning, results in the introduction of 100% operation inspection, and gives rise to other substantial disadvantages. The process layout of equipment is the most uneconomical of all and is used under the conditions of development and small-lot production, i.e., in cases where the number of part-operations is many times greater than the number of work stations. The only advantage of the process layout is the absence of replanning of the equipment when the production item is changed.

A department with a product layout of work stations combines work stations which provide for completeness of the cycle of processing parts or assembling units. This almost completely eliminates the operational dependence of one department on another (only for such operations as heat treatment, pickling and coating must a part be transferred from one department to another department or shop, and even then, not invariably). The rational principle of organization of closed departments within the shop must not, however, be carried to the stage when they become economically inefficient. For instance, parts entering into various units or assemblies, but having the same flow sheet, should be processed in the same department and in the same shop. Product departments are subdivided into product-process, product-chain, and product-line.

A department with a product-process layout of the work stations combines work stations of various types, specialized to perform various operations on various

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parts, with all the necessary equipment for completeness of the processing of such parts available in the section, arranged in uniform groups (Fig.39). A part passes through uniform operations on one machine and, for performance of another form of work, is then transferred to another machine in the same department. The processing

Fig.40 - Diagram of Motion of Parts between Operations, with the Chain Layout of Equipment. The arrow under the symbol of the machine indicates that the given subgroup of parts is being processed on that machine.

a) Operation No.; b) Flow sheet of parts; c) Of leading group; d) Of other parts; e) Subgroup No.1; f) Subgroup No.2; g) Subgroup No.3

of parts is done in batches and mainly by the sequence method. The product-process layout, which eliminates the disadvantages of the process department, at the same time still preserves its advantage under the conditions of series production, namely the fact that when the production item is changed the equipment need not be regrouped.

In a department with chain arrangement of the work stations, the equipment is arranged in accordance with the course of the technological process of the leading parts. By leading parts we mean either parts with the greatest labor cost or unified parts. Individual parts, with a processing sequence not coinciding with the processing sequence of the leading parts, may move backward, but the main group of

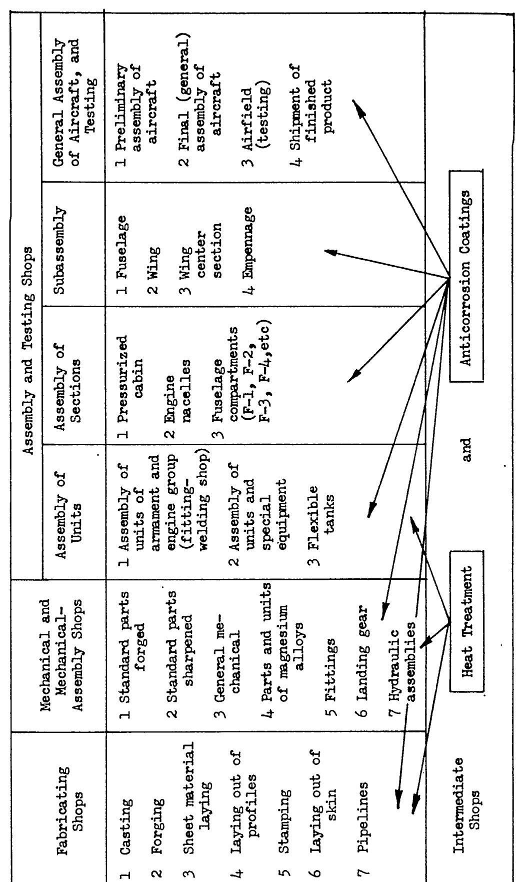

Fig.41 - Classification of Shops of the Main Production

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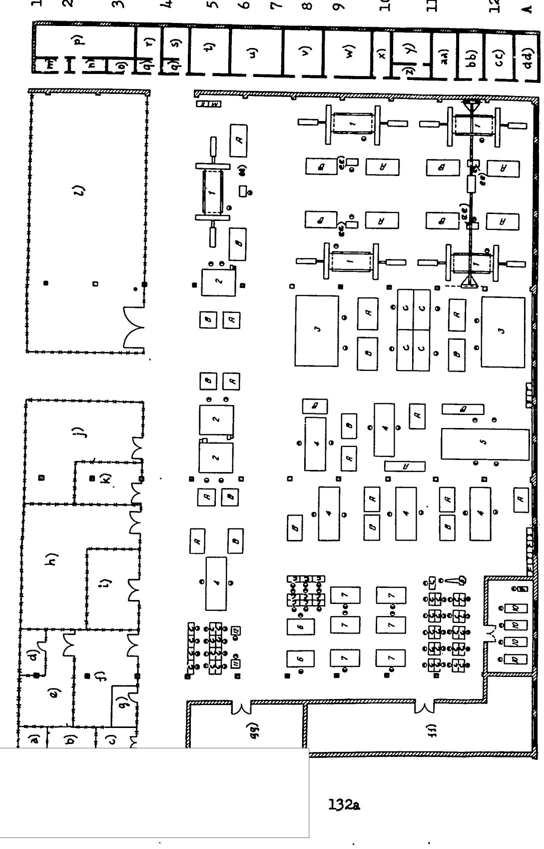
parts in the section is transferred from machine to machine in the order of arrangement of the equipment. A department with such a sequence layout of equipment is customarily called a direct-flow section (Fig.40). In a direct-flow section, the operational times of processing the parts are not equal, and therefore the parts lay over between operations. The parts are processed, and transferred in batches from one machine to the next. When the processing of a batch of parts is completed, the machine is changed over to processing parts of a different batch. The operations on a small batch of parts are serial, but on a large batch they are sequence-parallel. The parts do not go to the intermediate stockroom of the section but remain at the work stations between operations.

A line department is characterized by the arrangement of the work stations according to the course of the process on one or several parts whose operational times are equal to the pace of output by the section, a multiple of it, or close to it. Line departments are organized either in the form of individual line sections, specialized to process one or several parts, or in the form of a single through production line. The latter is the case at aircraft construction plants on subassembly lines and on the final assembly line of the aircraft. Such a unitary production line cannot be split into individually located departments, and yet it cannot be managed by a single foreman. In that case, the production line is arbitrarily divided into sections, with a shift foreman at the head of each.

Each form of department has its own inherent method of organizing the production process. For instance, for a process department, the method of organization of the production process inherent in piece production is used, for a product-process department the method inherent in series production, and for a line department, the method inherent in large-lot and mass production. Each department or section consists of the sum of its work stations.

The work station is the basic unit of the productive structure of the enterprise. Depending on the degree of division of labor, one or several operations are



1 - Drawing press; 2 - Bending installation; 3 - Milling machine; 4 - Profile bending machine; 5 - Drop hammer; 6 - Drop hammer; 7 - Roller shears; 8 - Roller shears; 9 - Fitting machine; 10 - Piercing machine; 11 - Vertical milling machine; 12 - Band saw. A - Rack for parts;

Fig.42 - Planning of Fabricating-Stamping Shop Organized on Process Principle

B - Rack for workpieces; C - Bench; F - Foreman's position; I - Inspector's position. a) Housekeeping material store; b) Lubricant store; c) Scrap store; d) Spare parts store; e) Machinist's group; f) PRIN; g) IRK; h) Die store; i) Pattern store; j) Workpiece store; k) SGD; l) Billet store; m) Women's dressing room; n) Men's dressing room; o) Timekeeper; p) Locker room; q) Lavatory; r) Men's washroom; s) Women's washroom; t) Lunchroom; u) Re corner clubroom; v) Room for social organizations; w) PDB; x) Deputy shop superintendent of production; y) Secretary; z) Shop superintendent; aa) Technological bureau; bb) BTZ and Economic bureau; cc) Shop inspection office; dd) Accounting office; ee) Control desk; ff) Plaster pattern shop; gg) Pickling dept.

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assigned to a given work station. The subdivision of the technological process into operations, which are performed at separate work stations, establishes the interdependence of the work stations. This dependence in space is determined by the layout of the work stations, and in time by the periodicity of the performance of operations at the work station. The more continuous the process, the more sharply will the interrelation of the work station be pronounced. For example, in production lines, the work stations of adjoining operations are arranged in sequence and are as close as possible to each other, while in time they are connected by the same rhythm of work. In piece production, the connection between the work stations is not manifested in so sharp a form, so that the stations are arranged in groups of equipment of the same type.

To ensure uninterrupted operation of the productive departments in a shop, auxiliary workshops and services are organized.

The auxiliary workshops of a shop include the workshop for routine preventive maintenance and current maintenance of fixtures, attachments and tools, for fabricating simple tools and auxiliary tools (gaskets, keys, washers, bushings).

Another auxiliary workshop is the workshop of the shop mechanic, which is designed to handle the preventive inspection and routine preventive maintenance of the shop equipment.

The tool-grinding work shop is organized in large shops, or serves a group of shops.

Such workshops relieve the auxiliary shops from small orders and emergency repairs. The equipment in the auxiliary workshops is arranged in a process layout.

The auxiliary services of a shop supply the work stations with technical documentation, materials, blanks, tools, attachments, and anything the operator may need during the shift. The blueprint files (VYCh) receives the drawings for the article from the central files, delivers the drawings and flow sheets to the foreman and operators, stores them and accounts for them. The starting materials and blanks

stockroom (MASK), receives, stores, accounts for, and issues the materials and blanks to the work stations, collects and sorts the scrap and waste. The interoperation parts reserve stockroom (PROSK) receives, stores, and accounts for the interoperation reserves of parts, and transfers the parts and units finished in process from one department or section to another or to the finished products stockroom of the shop. The finished products stockroom (SGP) receives the finished parts or units from the departments, makes them up into sets, accounts for them, and issues them to the consumer shops. The auxiliary materials store receives these materials, stores them, accounts for them, and issues them to the departments, workshops and shop services. The tool distributing stockroom (IRK) receives, stores, accounts for, makes up sets of, and issues to the work stations, the cutting and measuring tools and attachments. The materials handling crew delivers, transports, and ships the shop loads. The cleaning service cleans the shop and makes sure that the room is kept in order.

The excessive subdivision of an enterprise into shops and, within these shops, into departments and sections, leads to an increase in the payroll for engineering-technical workers, employees, and auxiliary workmen. At present, with the increasing qualification requirement for workers of enterprises, the productive structure should be simplified by consolidation of shops, sections, workshops, and stores. The experience of progressive plants, where the shop auxiliary workshops and certain services have been replaced by plant-wide services, serving groups of similar shops, is becoming more widely disseminated. For example, one workshop is organized for maintenance of equipment, one workshop for maintenance of attachments and other tooling, tool rebuilding, etc. Figure 41 gives a classification of the main production shops of an aircraft construction enterprise, and Table 8 lists the normal complement of productive and auxiliary workmen, engineering-technical workers, and employees for these shops.

Section 3. Classification of Fabricating Shops and their Productive Structu STAT

In the fabricating stage of aircraft construction, the blanks are prepared by the methods of casting, free forging and hot stamping, cold drawing, shaping, punching, drop-hammer stamping, bending, drawing and grinding. The fabrication stage is distinguished by the large list of blanks, numbering many thousand items, depending on the class of aircraft; for their fabrication, specialized fabricating shops are organized in the enterprise. The level of technology and organization of the fabricating shops largely determines the technical level of the subsequent stages of production.

The use of mass-production equipment in the fabricating shops, the expansion of the list of parts produced, which are fabricated in their final dimensions, and of the lists of blanks fabricated with minimum tolerances, release the machine shops from grinding work and the assembly shops from gaging and fitting parts in situ. The concentration of fabricating operations at special shops, owing to the high degree of mechanization, leads to a reduction in the labor cost of the fabrication work and to a saving of scarce and expensive materials. According to the data of a number of enterprises, mechanized sheet material work permits a saving of 5 - 6% of duralumin, 4 - 5% of Plexiglas, and as much as 5% of fabric in an aircraft.

The fabricating shops are organized primarily in accordance with the method of fabricating the blanks and are subdivided into casting, forging, laying and preparing, stamping and piping. With an increased output of machines, the fabricating shops are specialized in accordance with the kind of materials of which the blanks are fabricated. For instance, the sheet-metal and blanking shop is subdivided into the ferrous sheet-metal working shop and the nonferrous sheet-metal working shop.

With a large list of blanks, sheet-metal shops are specialized according to the kind of blanks, and nonferrous sheet-metal work, profile work and skin workshops are organized.

The productive structure of the fabrication shops may be organized according to the technological criterion (Fig.42) or according to the product criterion.

When a shop is organized according to the technological criterion, uniform

Table 8

Approximate Standards for the Number of Engineering-Technical Workers, Employees and Auxiliary Workmen for Shops of Aircraft Construction Enterprises*

Shops	Category of Workers	Shops with Following Numbers of Productive Workmen											
		75	100	150	200	250	300	350	400	450	500	600	800
		in % of Total Number of Productive Workmen of Shop											
Forging and Casting	Engineering and Technical Workers	29,4 / 25,4	28 / 25	25,3 / 22,6	24 / 21	22,7 / 19,6							
	Employees	1,3	3 / 2	2	1,5	1,2							
	Auxiliary Workmen	56 / 53,5	54 / 52	52,5 / 50	51,5 / 49	48 / 45,7							
Fabricating and Sheet Material Work	Engineering and Technical Workers		27 / 26	25,4 / 23,3	23,5 / 22,5	22,4 / 21,6	21,3 / 20,4	20,3 / 20,2	20 / 20	19,3 / 19,5	18,8 / 19,2		
	Employees		3	2	2	1,6	1,6	1,4	1,3 / 1,2	1,1	1		
	Auxiliary Workmen		56 / 55	52 / 50,5	48,5 / 48	43,5 / 43,1	40,6 / 40	39,8 / 39,8	39,5 / 39,5	39,4 / 39,4	39 / 38,6		
Stamping	Engineering and Technical Workers		24 / 22	22 / 20	20,5 / 18,5	19,2 / 17,6	18,5 / 17,3	18 / 17,4	17,7 / 17,2	17,5 / 16,7			
	Employees		3 / 2	2	2	1,6	1,6	1,4	1,3	1,3			
	Auxiliary Workmen		60 / 60	54	50	44	41,6	40,7	39,6	39,7			

Shops	Category of Workers	75	100	150	200	250	300	350	400	450	500	600	800
General Machine Shop Work	Engineering and Technical Workers		27	24	22	20,4	20	19,1	18	17,3	16,8	15,8	
	Employees		2	2	2	1,6	1,7	1,4	1,5	1,3	1,2	1	
	Auxiliary Workmen		62/60	56,8/54	52/53	50,5	48/44	46/41	44,5/40	43/39,9	41,8/39,6	39,4/—	
Mechanical Assembly (Landing Gear and Hydraulic System)	Engineering and Technical Workers		24	22,7/22	21,5/19,5	20,8/18,4	20,3/18	20,3/17,4	19,7/17	19,5/16,2	19,4/15,7	15,1	
	Employees		2	2	2	1,6	1,7	1,4	1,5	1,3	1,2	0,8	
	Auxiliary Workmen		59	52,7/56,8	50/52	48/50,5	46,5/48	44/46	42,8/44,5	41,5	40,7/41,8	39,4	
Heat-Treatment	Engineering and Technical Workers	26,7/21,3	25,6/20	24/19,3									
	Employees	1,4	1	0,7									
	Auxiliary Workmen	66,9/69,2	64/62	60/56									
Coatings	Engineering and Technical Workers	20	19/18	18/16,6	17/15,5	16/14,4	15,3/14,3	15,2/14	15/13,7				
	Employees	1,3	1	0,7	0,5	0,4	0,3	0,3	0,5				
	Auxiliary Workmen	46/46,6	45/46	42,7/42	42/39	39,2/38,3	38,6/38	38/37,2	36,8/36				

(Continued)

Shops	Category of Workers	Shops with Following Numbers of Productive Workmen											
		75	100	150	200	250	300	350	400	450	500	600	800
		in % of Total Number of Productive Workmen of Shop											
Fitting-Welding, Coppersmithing and Plumbing	Engineering and Technical Workers		29/28	24,7/22	22/20	20,4/18	19,3/17,4	18,9/16,9	18,5/16,5	18/16,4	17,8/16,4		
	Employees		2/2	2	2	2/1,6	1,7/1,6	1,4	1,3	1,1	1		
	Auxiliary Workmen		39	38/38,7	37,5/38	37,7/36,4	36/35	35,7/34,8	35,7/34,6	35,2/34,2	35/32,6		
Subassembly	Engineering and Technical Workers			23,3/18,7	20/16,5	18,8/15,2	17,7/14,3	17,1/13,7	16,2/13,7	15,5/13,4	15,2/13,4	14,8/13,1	12,8/11,4
	Employees			2	1,5	1,2	1/1,3	0,9/1,1	0,8/1	0,7/0,9	0,8/1	0,8/1	0,8/0,8
	Auxiliary Workmen			26,7/25,4	26,5/25,3	26/23,6	25,6/22,6	25,5/22,3	25/22,3	24,5/22,2	24,1/22	23,6/21,8	21,9/21,4
Final Assembly of Aircraft	Engineering and Technical Workers			26/22,6	25/21		23/19,5		21/18,5		20/17,5	19,9/16,9	18/16,1
	Employees			2/1,3	1,5		1		1		1	1	1
	Auxiliary Workmen			31,3/29,7	30,5/29		30,4/28,6		28,7/27,2		28,6/27	28,3/26,8	27,2/25,8

* These standards were developed by the NIAT. The figures in the numerator denote the standards for plants producing medium and heavy aircraft, and the figures in the denominator denote the standards for plants producing light aircraft. In practice, some plants have payrolls smaller than these standards, which indicates the presence of large margins.

equipment and uniform technological operations are concentrated in each department. For example, in a fabricating and stamping shop, the following departments are organized: cutting, milling, punching, shaping, heat-treatment, and finishing operations. Such a structure complicates the management of the shop and lengthens the route of each batch as well as the cycle of processing. With technological specialization of the departments, a shop is compelled to plan and take account of the starting and transfer of batches of blanks from department to department for each operation. For instance, with an 8000 blank list on the average, for 3 - 4 operations on each blank, and under the conditions even of three-months batches, the shop is forced to keep 8000 part-operations under observation in each department every month.

The operational specialization of departments makes it necessary to assign operators in separate details for each operation, and 100% operational inspection must be introduced for the acceptance of work and for its accounting. This gives rise to an immense amount of accounting documentation and makes it necessary to employ an excessive number of inspectors.

When a shop is based on the product criterion, equal amounts of work are assigned to each department in the form of a set of typical groups of blanks to be processed in the department from beginning to end (Table 9). This considerably decreases the dependence of one section on another. For instance, the liquidation of the finishing section alone will shorten by almost half the route of each part and at the same time will increase the responsibility of the product departments for completeness and quality of the parts fabricated by them. The arrangement of the equipment in each department, according to the course of the typical technological process, makes it possible to transfer batches of blanks from operation to operation by the shortest route and without going to the intermediate stockroom. The assignment of typical groups by departments increases the load on their equipment. It is no longer necessary to make out individual operator charts.

Instead of operational inspection, inspection and acceptance of batches of

Table 9

Classification of Blanks by Typical Processes and Departments

Oper-ation No.	Nos. of Departments and Typical Processes / Name of Operation	First Department				Second Department			Third Department					
		Typical Processes and Number of Parts in Process												
		I 1100	II 180	III 170	IV 1125	V 2000	VI 235	VII 325	VIII 20	IX 130	X 155	XI 95	XII 45	XIII 230
1	Cut Bands	1*	1	1	1				1		1	1	1	1
2	Stamp Part No.	2	4	4	6	3	7	6	4	4	7		4	8
3	Drill		2		4		5	4		3	4	4	5	6
4	Remove lugs		3	3	3and5	2	4and6	3and5	3	2and6	3and6	3and5	3	4and7
5	Stamp contour			2	2						2	2		
6	Mill contour					1	1	1						2
7	Layout and trim lug						2							3
8	Saw off place of lugs						3							
9	Stamp openings							2						
10	Layout and cut off part								2	1				
11	Stamp groove									5			2	
12	Crimp										5			
13	Stamp													
14	Paste contour with paper											6		
15	Round out corners											7		5

* The figures denote the sequence of operations

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blanks after the last operation is introduced. The shop does not plan operations on parts for the foreman, but plans the starting and output of technological sets in series. The detailed distribution of the starts among the work stations is handled by the foreman himself.

The productive structure of the departments of fabricating and stamping shops is largely determined by the available equipment. For example, the availability of hydraulic presses makes it possible to organize a department for molding hard-rubber parts; the existence of drawing and extrusion presses allows a skin department to be organized. The number of departments in the shop depends on the production scale, the qualifications of the staff and the variety of the list of blanks produced. The larger the scale and the more extensive the list of items produced, the more departments the shop must have. The higher the qualifications of the foreman and operators, the more work stations a department may have. It is necessary to bring one department as close as possible to the other during the course of the technological process, bearing in mind the prospective development of the technology. For instance, taken together with the drop hammers, powerful hydraulic presses should be available since they should gradually replace the drop hammers.

Section 4. <u>Classification of Processing Shops and their Productive Structure</u>

The processing shops may be classified according to their methods of manufacturing the parts and according to the degree of objectization of the production process.

According to the methods of making the parts, the processing shops are subdivided into shops for:

1) Processing the parts by cutting, which include all machine shops;

2) Welding parts into units and assemblies, which include fitting-welding shops.

According to the degree of objectization of the productive process, processing

shops are subdivided into shops for:

1) Processing parts only;

2) Processing parts and assembling them into units;

3) Processing parts and assembling them into units and assemblies.

The shops processing only parts include shops for plastic, general mechanical,

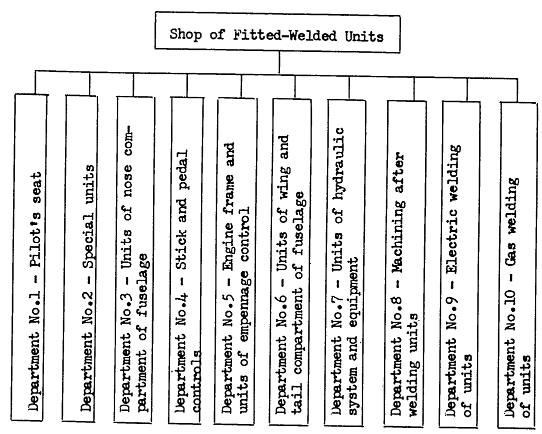

Fig.43 - Diagram of Design Specialization of Departments in Fitting-Welding Shops

and standard parts. Shops manufacturing the parts and assembling them into units include shops for electronic units, fittings, armament units and equipment, and fitting-welding shops. The shops manufacturing the parts and assembling them into assemblies include the landing-gear shop. This shop has mechanical, assembly, and testing departments. It is more economical to subcontract the manufacture of standard parts of some units, and of landing gear to specialized enterprises.

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Owing to the use of more productive equipment and of flow-mass methods of production, a specialized enterprise uses 10 - 14 times less labor than a series-aircraft plant in the manufacture of standard parts, 2 - 3 times less in manufacturing fittings, and half as much in manufacturing a landing gear.

There are two forms of specialization of departments (or sections) in process-

Table 10

First Department		Second Department		Third Department		Fourth Department	
First Line	Second Line	First Line	Second Line	First Line	Second Line	First Line	Second Line
Name of Groups of Typical Parts Assigned to Production Line							
Bushings, plugs	Special bolts	Bodies	Bodies	Pistons, valves, clamps	Rings, flanges, sleeves	Assembly of units	Testing of units
Stub pipes	Special nuts, nipples						

ing shops: design and design-technological. In design specialization, each productive department receives the parts or units going into one or several design groups. As an example, we give above such a specialization of the department of a fitting and welding shop of one aircraft construction enterprise (Fig.43).

With such a specialization of the departments, for each lathe operator, fitter or welder, a definite list of units is assigned, and he is specialized to process them.

Design specialization facilitates inspection in the shop for timely introduction of the current modifications into the unit and simplifies the planning and management of the departments. At the same time, such specialization is uneconomical if the design group contains parts and units of various forms, since this leads to poor utilization of equipment, to excessive all-round occupation of the operators,

retard the use of high-productivity tooling and advanced forms of production organization.

In design-technological specialization, each department is assigned one or several groups of unified parts or units entering into various design groups. As an illustration, we give above such a specialization of the departments of a fittings shop of an aircraft construction enterprise. The parts list of this shop consists of 710 items, comprising 13 typical groups (Table 10).

The shop has mechanical and assembly-testing departments. The specialization of the mechanical compartments to process typical groups has permitted more complete utilization of the equipment and its arrangement by the chain method.

The design-technological specialization of departments may assume the most varied forms. For instance, in the shop for standard parts it is economical for each department to specialize in processing one or several technologically uniform groups of standard parts with a complete cycle of manufacture inside the department. For this purpose, the department must be equipped not only with automatic machines, but also with machine tools for the finishing or cleaning operations, the thread cutting, the cutting of slots, the removal of lugs. Such specialization of the department increases the responsibility of the operators and foreman for the quality of processing of the standard parts, sharply reduces the finishing work, simplifies planning and shortens the cycle of manufacture of the parts. The establishment of independent product-process or line sections in the fitting-welding shops is recommended for manufacturing the assemblies and units of the highest labor cost, including canopy, frame, pedal and stick controls, and process production lines for the processing of small units. For this purpose, the parts list must first be classified into groups of unified units (brackets, braces), etc. The design-technological specialization of departments and sections is more economical than the design specialization.

Section 5. Classification of Finishing Shops and their Productive Structure

The finishing shops, or, as they are also called, intermediate shops, in an enterprise includes heat-treating, electroplating, and painting and varnishing shops.

In the heat-treatment shop, all forms of heat-treatment of the parts and units are performed. The equipment in the shop is arranged by groups according to the

Fig.44 - Use of Conveyors in Coating Shops

course of the technological process. Under the conditions of large-lot production, the heat-treatment and sandblasting work is decentralized by processing shops, and specialized departments are established, or the heat-treatment is included in production lines, such as high-frequency installations.

The painting and varnishing shop consists of technological departments, located territorially around the shops they serve. For instance, the assembly painting departments are located close to the assembly shops. The parts varnishing and painting sections use conveyors with continuous feed of the parts (Fig.44). The operations of coating and drying the assemblies are fitted into the rhythm of the flow of the assembly of these units and are performed in a special department of the assembly shop, connected by a feeder belt with the line of final assembly. In the electroplating shops, equipment with automatic charging of the parts into the bath and automatic removal from the bath is used.

Section 6. Classification of Assembly and Testing Shops and their Productive Structure

Assembly shops are classified according to the kind of work and the stages of assembly.

According to the kind of work, assembly shops are subdivided into riveting-assembly and fitting-assembly. The riveting-assembly shops include the shops for wing, fuselage, empennage assembly, and others. The fitting-assembly shops include the shops for subassembly and final assembly of the aircraft. The testing shops include the airfield shop.

According to stages of assembly, assembly shops are subdivided into unit, compartment, subassembly, and aircraft assembly shops. Under the conditions of small-lot production, all the riveting-assembly and fitting work on an assembly are concentrated in the subassembly shop. In such a shop are organized product-process or line departments (or sections) specialized in the assembly of a group of related units - spars, ribs, panels, on the assembly of compartments of an assembly, F-1, F-2, F-3 (Figs.45 - 46). The general subassembly is subdivided into two independent sections, into a line of subassembly in an assembly jig and into a line of fitting subassembly outside an assembly jig (Figs.47 and 48). In order to shorten the cycle of the final aircraft assembly shop, the assemblies must be delivered to the shop with the maximum number of installations already prepared, and must be completely prepared for attachment to other assemblies.

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Fig.45 - Assembly of Fuselage Compartments in Stationary Assembly Jigs

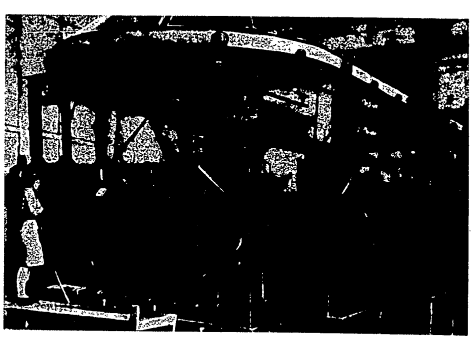

Fig.46 - Assembly of Fuselage Compartment in Moving Assembly Jigs

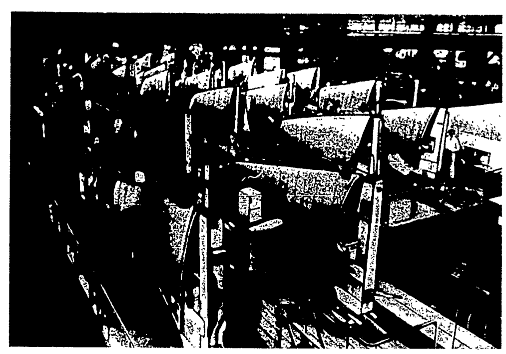

Fig.47 - Assembly Line of Wing in Assembly Jigs

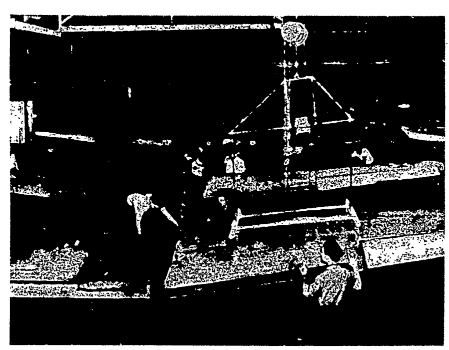

Fig.48 - Assembly Line and Installation of Wing Outside of Assembly Jig

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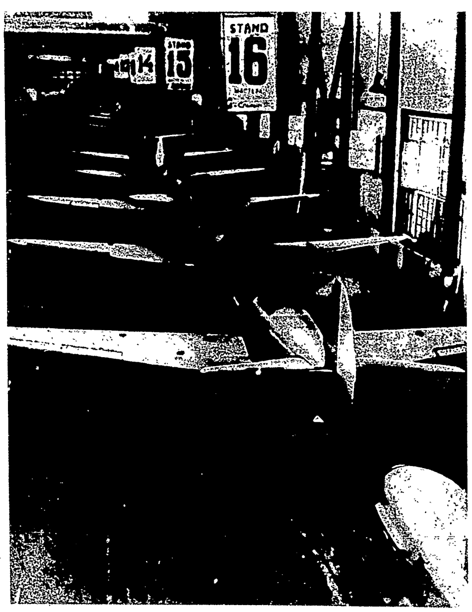

Fig.49 - Assembly Line of Aircraft with Ground Movement of Aircraft by Conveyor

In large-lot production the assembly of similar units is removed from the assembly shops and is concentrated in specialized shops (for spars, for panels). The assembly of each large compartment is assigned to an independent shop, for instance,

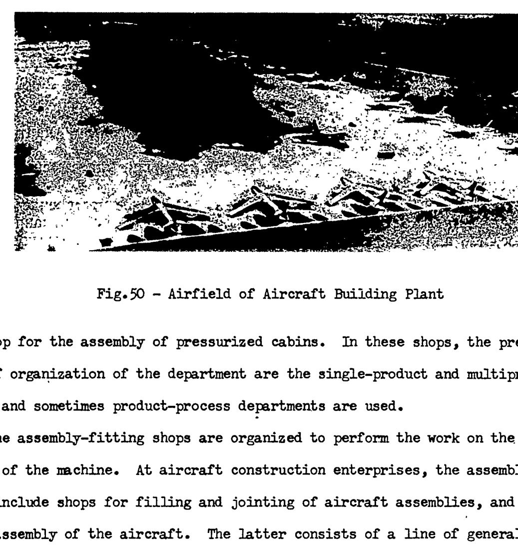

Fig.50 - Airfield of Aircraft Building Plant

the shop for the assembly of pressurized cabins. In these shops, the predominant form of organization of the department are the single-product and multiproduct lines, and sometimes product-process departments are used.

The assembly-fitting shops are organized to perform the work on the final assembly of the machine. At aircraft construction enterprises, the assembly-fitting shops include shops for filling and jointing of aircraft assemblies, and for the final assembly of the aircraft. The latter consists of a line of general assembly of the aircraft and various workshops in which such preparatory work is done as removal from storage of engines and their preparation for installation in the aircraft, untwisting of electric cords, preparation for installation of the electric, radio, and special equipment, such as, instrument boards, control desks, central switchboards, junction boxes. These workshops deliver to the main assembly conveyor, equipment or assembly that has been prepared as thoroughly as possible for installation.

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The final aircraft assembly line is organized in the form of intermittent flow, using a belt (Fig.49).

The testing shop is designed to test the quality of the aircraft. The aircraft tests are subdivided into ground and flight tests, and are carried out by the airfield shop and the flight-testing station (LIS) there. The work of the airfield shop (Fig.50) is performed by the production line method under the conditions of large-lot production.

A special shop, the shipping department, is designed for packing the aircraft, making up sets of single and group spare parts, and for shipment of the packed aircraft to the consumer.

Section 7. Classification of the Auxiliary Shops and their Productive Structure

The classification of auxiliary shops is based on the differences in the forms of the product and on the differences in the work performed for the main shops. The auxiliary shops are subdivided into four groups.

The first group of shops includes the electric power, compressed air, and gas-generator stations, and the thermal power shop. The principal task of these shops is the uninterrupted production of power, gas, and compressed air at the minimum expense per unit of product produced.

The second group includes the following shops: lofting and template, pattern, tool, die, machine and fitting-welding attachments and tooling, large assembly jigs and equipment, and experimental shops. These shops prepare the tooling and other appurtenances for the main and auxiliary shops.

The third group of auxiliary shops is occupied with the rebuilding of the implements of production, their modernization, and the fabrication of spare parts for them. They include the machine repair and electrical repair shops.

The fourth group of auxiliary shops handles maintenance of the buildings and industrial structures of the enterprise. It includes the repair and building shops.

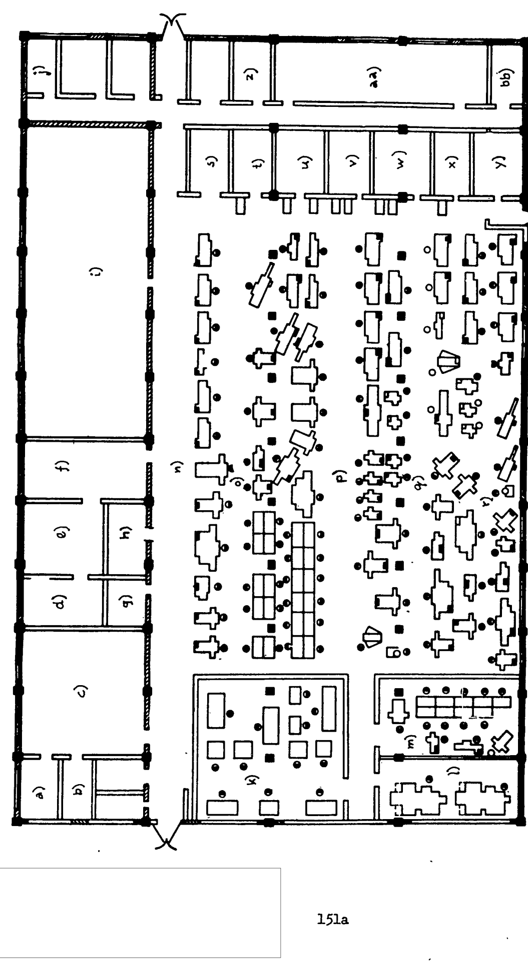

Fig.51 - Planning of Machine Shop

a) Spare parts store; b) Shop machinist; c) Shop machinist's department; d) Measurement laboratory; e) Metal store; f) Shop inspection office; g) Fabricating department; h) IRK; i) Heat treating department; j) Shower; k) Group of tool grinding machines; l) Group of coordinate boring; m) Pattern department; n) Department of threading and measuring tools; o) Department of cutting tools; p) Attachment department; q) Jig department; r) Department of forcing tools; s) Shipping department; t) PROSK, Department No.5; u) PROSK, Department No.3; v) PROSK, Department No.2; w) PROSK, Department No.1; x) PROSK, Department No.4; y) Store for auxiliary and inflammable materials; z) Timekeeper; aa) Locker room; bb) First-aid station

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The auxiliary shops are organized on the product principle, with a closed production cycle. In these shops, the productive sections are organized by the process or product-process criteria, according to the production scale. For instance, the tool shop, along with the product departments cutting-fitting and measuring tools, contains also technological departments with process layout of equipment, for instance, fabricating, heat-treatment, polishing, grinding (Fig.51). The production of tools required in large numbers (cutters, screw dies, gages, drills) is organized in multiproduct chain or production lines.

During the years of World War II, a multiproduct flow line for fabricating screw dies was set up. On such a line, consisting of 17 work stations, 14 types and dimensions of round screw dies with a thread of 3 - 14 mm in diameter were fabricated. The dies were delivered by a roller conveyor in transport batches in a calibrating container. The time of passage of a batch to the operations of the production line was reduced from 96 to 32 hours. The monthly output of screw dies was increased by 75%, using half the number of operators.

In the maintenance shop, the technological structure of departments prevails. Ordinarily disassembly-washing, machine, and installation-assembly departments are organized there. The repair of the most massive mechanisms and units of the equipment may be organized on a production line. For instance, at one aircraft construction enterprise the change-over of the electric motor repair work to a line basis increased the output from 1.25 to 4.8 motors a day.

The auxiliary shops have the same auxiliary workshops and services as the main shops.

Section 8. Classification of Plant-Wide Services and Service Shops

The plant-wide services, serving the industrial activity of the enterprise are classified into several groups.

The first group supplies the shops of the enterprise with materials, semifinished goods, finished articles, standard tools, and reclaims the scrap of the main and auxiliary production. They include the general plant stockrooms of fuel, ferrous metals, nonferrous metals, textiles, stockrooms for blanks, parts, finished articles, tools, abrasives, and the salvage department.

The second group handles the transportation of freight to the plant and shop stockrooms and ships the finished product and scrap from the plant. It includes the railroad and materials-handling shops. At some enterprises, the management of all forms of transport is concentrated in a single transport shop.

The third group of services makes tests of materials, semifinished goods, and finished articles arriving at the shop and verifies the measuring instruments. This group includes the following laboratories: chemical, technological, mechanical testing and measuring instruments, etc.

The fourth group includes the machine accounting station, which handles the mechanized processing of the mass primary documents of production and the plan and accounting documentation.

The fifth group is composed of the services handling the protection of the socialist property of the enterprise.

Section 9. Technical Rating Sheet and General Plan of the Enterprise

The productive-technical rating sheet of an enterprise contains all the basic indices of the enterprise, namely: composition of the fixed assets by forms, expressed in physical and financial terms; productive structure of the enterprise and capacity of its shops; cooperation of the enterprise; composition of the cadres of the enterprise and their wage fund; composition of the production of the enterprise by forms and volume. A general plan of the enterprise and a schedule of its equipment is annexed to the rating sheet. The data of the rating sheet are brought up to date every fiscal year.

All shops and services of the enterprise are covered by the general plan, which defines the dimensions and mutual position of the buildings and structures, the passages and breaks, the railroads and roads, the underground and overhead networks that link all of these into an integral whole for the effective functioning of the enterprise.

The mutual location of buildings and structures and of the shops and attached service units, is determined by the production process and is regulated by legislation, rules, and standards.

The utilization of the plant area is maximized by the construction of buildings and structures between which minimum clearance meeting the fire protection and health regulations are left. The shops and services are laid out in the most compact way, and the small ones are located in a single building.

The territorial combination of shops depends on the type of production.

In piece and small-lot production, the hot fabricating shops are located in a separate building, while the remaining main shops are placed in another, or main building, with a third building housing only the auxiliary shops. The stores and service areas are placed near the shops.

In large-lot and mass production, similar main shops and their auxiliary shops and services are located in the same buildings. The block division of shops into groups, casting, forging, cold-pressing, machining-assembling and assembling, and their location by zones, has found wide favor. With such a grouping of shops, the casting group includes the casting and pattern shops and the stores for the charge, fuel, pattern materials, and castings. The shop fabricating the lead and zinc dies is located next to the drop-hammer shop. The mechanical group includes the blank stockroom, the sheet-metal working, machine and machine-assembly shops as well as the heat-treating, tool and machine-maintenance shops. At an aircraft construction enterprise, the assembly group includes the subassembly and final assembly shops. The location of the main shops follows the sequence of the flow of the aircraft manufacture, which shortens the length of the production lines and of the transport

routes between the shops, facilitates the mechanization of the transportation of materials and articles, reduces the length of the power lines and other communications, improves the management of production and the housekeeping services for the workmen.

The system of the production process and the movement of materials and work in process influences the location of the shops and services in the enterprise.

In all such systems, it is necessary to provide for the flow of materials and work in process to be as short as possible, without cross motion and without reverse motion. The railroads and roads on the site of the enterprise and inside its shops are laid out to correspond to the direction of flow of the goods. The routes of personnel movement (human flow) on the plant site and inside its buildings should be short, should not be combined with the transport routes, and should, as far as possible, not intersect the flow of goods at the most heavily loaded areas.

A number of rules must be observed in the territorial location of shops and services.

The location of hot metal-processing shops in the same building as shops using highly inflammable materials is not recommended. Casting shops and fitting-welding shops are not located together with shops of cold-working for assembly, since this has an adverse effect on the health conditions; forging shops with heavy hammers are not placed together with machine shops since this has an adverse effect on the quality of operation of the mechanical equipment.

Buildings and structures are located with consideration of the direction of the prevailing winds, in order to protect most of the shops from smoke, gases, and dust, as well as with consideration of the orientation with respect to sunlight, in order to avoid excessive heating by the sun, and to make maximum use of the natural conditions for lighting and ventilation of the shops.

For instance, the TETs, the TsES, the hot treating shops, the shops with fire hazard and smoke are so located that the gas and sparks cannot be carried by the

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wind to other shops or populated points. Railroad sidings are provided for shops using large amounts of fuel, metal and other materials. There should be ample space for unloading yards and for location of the stockroom buildings. This group of shops is the initial group and is located close to the entrance of the railroad lines to the site of the enterprise. The processing shops are located close to the fabricating shop in order to receive blanks from them by the shortest path.

The assembly shops are located between the processing shops and the testing shop. The shipping department and the finished product stockrooms are located close to the exit of the railroad siding and roads from the plant. The auxiliary shops are located at the center of the main shops served by them. The general plant administrative, social, cultural and housekeeping, educational and other services are located at the main entrance, forming a group in the square in front of the plant.

In the location of buildings and structures, such factors as the relief of the land, the geological and hydrological conditions, the proximity of railroad and water routes, and of populated points, as well as the opportunities for further expansion of the enterprise, are all taken into account. Two very widely used economic indices have been established to determine the effectiveness of the location of the buildings and structures: the plot coverage factor and the coefficient of utilization of the plant area.

The plot coverage factor indicates the ratio of the total area occupied by buildings and roofed structures to the total area of the enterprise, and usually amounts to 0.22 - 0.35.

The coefficient of utilization of the plant area represents the ratio of the area occupied by buildings, roofed and open structures, including railroads and highways, to the total area of the enterprise, and usually amounts to 0.4 - 0.7.

The productive structure of a socialist enterprise is established on scientific principles and is always being improved.

In the Soviet Union, State enterprises are planned by State planning institutes

for the industrial branches, which are charged with the multidisciplinary development of all questions related to the planning of industrial enterprises.

In order to introduce a single progressive system of planning enterprises, the Soviet government has fixed by law the composition and volume of the planning assignment, of the technical plan and working drawings of an industrial enterprise to be constructed and reconstructed, and has approved, for each branch of industry, compulsory standards for construction, fire protection, and industrial hygiene, as well as economic indices. These standards combine the economic utilization of the productive areas and equipment of an enterprise with the provision of healthy and safe conditions for their workers to do highly productive work. The 20th Congress of the Communist Party USSR, with the object of a more effective utilization of the material resources and funds directed into capital construction, has obligated the Party and economic agencies not to allow the dissipation of capital investments on numerous construction projects and objects, and to improve planning and liquidate waste in designing, which leads to the squandering and dissipation of State funds.

In working out construction projects for new enterprises and for the reconstruction of existing enterprises, the latest accomplishments of science and technology must be taken into account, as well as the highest economic indices attained at progressive USSR and foreign enterprises. It is also necessary to shorten the planning time and to make wide use of standardized construction plans.

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CHAPTER V

MANAGEMENT OF THE AIRCRAFT CONSTRUCTION ENTERPRISE

Section 1. Purpose and Functions of Management

The function of the management of a production agency is based on the social character of labor: "Every directly social or joint labor performed on relatively large dimensions, needs management to a greater or lesser degree, establishing harmony between the individual works and performing the general functions arising from the movement of the entire productive organism in distinction to the movements of its independent organs" (Bibl.13).

The tasks of the management of a socialist production agency are the organization of the work of the staff of the enterprise to perform a State assignment in the interest of all socialist society.

The social form of property in the implements and means of production, that exists in the socialist society, gives rise to the most advanced State form of management of the process of social labor.

The socialist form of management encourages the enlistment of workers of the enterprise in an active struggle for the expansion of production and utilization of its reserves, helps to nurture a communist attitude toward labor among the workers, strengthen the labor-planning-technological and financial discipline at the enterprise, and ensure the integrity of State property.

The management of an enterprise is called upon to guarantee, within the frame-

work of the enterprise, the realization of the political line of the Communist Party, as embodied in the national economic plans, by means of rational organization of production and high rates of expansion of production; by means of rapid growth of labor productivity based on the development of the creative initiative of workers, wide introduction into production of the advanced experience of innovators, and accomplishments of domestic and foreign science and technology; by systematic reduction in the cost of the administrative apparatus; by a more perfect organization of its work; by eliminating arbitrary conduct and bureaucracy; by reducing nonproductive expenses.

As a result of correct management of an enterprise, its capacity should grow in due proportion, the quality of production should rise and its quantity increase, the cost of production should be systematically reduced and the material values of the enterprise should be protected from spoilage, destruction, and theft.

The system of work and the qualifications of the administrative apparatus, which guides all aspects of the industrial and economic activity of the enterprise, depend to a large extent on the level of technical and economic development of the enterprise, and on the profitability of production. For this reason, the Communist Party and the Soviet government are constantly paying exceptional attention to improving the functioning of the administrative production apparatus.

The forms of management of socialist enterprises have passed through various stages of development and improvement, beginning with the workers' control over production (Decree dated 14 November 1917 of the All-Russian Central Executive Committee) and ending with the modern productive-territorial system of management. They must be continuously improved in the future as well.

The Party has developed the system of management of socialist production based on the experience of the build-up of socialism. It has boldly disclosed the faults that have appeared in management and has pointed out methods of managing soc[redacted]t enterprises that meet the new tasks of economic construction. The 17th Congress of the All-Union Communist Party condemned the excesses that were permitted in enterprises in the form of so-called functionalism in labor organization and in production management.

Functionalism in labor was expressed in an artificial division of the integral labor of workmen of the leading trades into separate functions, performed by several poorly qualified workmen-functioneers. This led to the loss of qualified cadres to industry and to lack of personal responsibility in work. Functionalism did not encourage the improvement in the qualifications of the cadres and, consequently, interfered with the use of the new technology.

Functionalism in management was expressed by the management, by the productive units, and the heads of numerous functional departments: technological, planning, dispatcher, and others, in which most employees were concentrated. The head of a shop was dependent on the decision of these functional units, which had no direct responsibility for the fulfillment of the program by the shops. Functionalism in management gave rise to large payrolls, to lack of personal responsibility in management and of any responsibility in work, diminished the role of the director, of the shop superintendent, and of the foreman in management, and replaced concrete leadership by correspondence.

The 17^{th} Congress of the Communist Party adopted a resolution for the liquidation of the functional system of constructing the administrative apparatus of all Soviet economic agencies and their reconstruction according to productive and productive-territorial criteria. The administration of production was no longer concentrated in functional organs but in the hands of the managers of the basic productive units - the director, the shop superintendent, the foreman - who managed their own areas on the basis of individual responsibility and were completely responsible for the condition of the work. The functional offices of the shop were completely subordinated to the shop superintendent, and the functional divisions of the enterprise to the director, and they were deprived of the right to issue

orders directly to the managers of the productive units.

The 17^{th} All-Union conference of the Communist Party paid special attention to further improvement of the management of production. It imposed the following obligations on Party and economic organizations:

To strengthen one-man management and labor discipline, to liquidate completely absenteeism and spoilage in work;

To liquidate planlessness and irregular work, to organize the uniform output of production according to a predetermined schedule;

To strengthen the technical management of production and to enhance the role of the foreman as the direct organizer of production;

To introduce the strictest technological discipline in production and ensure the output of a balanced and high-grade product;

To provide for the accurate accounting and correct utilization of all assets of the enterprise, for the economical expenditures of these assets, and the systematic reduction of production costs.

During World War II, the system of management of socialist enterprise successfully met all tests.

In the postwar period, the Socialist State advanced toward the realization of a magnificent program of further development of socialist production. Under the new conditions, new problems also arose in the field of management of socialist production.

The rapid growth of technology and the rise in the qualification of the cadres of socialist industry created immense opportunities for accelerating the expansion of the socialist economy. To utilize these possibilities more fully, more highly qualified and operative work of the administrative apparatus is necessary. The staff should be small, highly qualified, businesslike and flexible, and should work smoothly, well, and operatively. The administrative apparatus should establish STAT an organization of production under which the operator will have no loss of working

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time or spoilage in his work, which will allow a higher level of labor productivity and profitability of production to be attained.

The Plenum of the Central Committee Communist Party USSR, in September 1953, uncovered a number of serious shortcomings in the work of the administrative apparatus. It stated that the major shortcoming in the administration of production was the official-bureaucratic style of management, in which the administrative apparatus spends most of its time, not in improving production and in organizational work among the workmen, but in composing and filling out numerous technical, planning, statistical, and other papers, in holding meetings and conferences, thus losing its initiative and failing to notice shortcomings.

The plantwide departments and services are often not directly responsible for providing the main shops with materials, for failure to fulfill the daily shift assignments, thus reducing their role to the issuance of assignments, dispositions, and questionaires to the shops and to receiving summaries and reports from them.

The swollen administrative apparatus, the large number of management workers, at a small number of productive workers, is due to the functional fractionation of the apparatus, to the copying by small enterprises of the structure of large enterprises, and to the desire of plantwide departments to have their own branch in every shop.

The elimination of the official-bureaucratic style in the work of the administrative apparatus is the most important task of the production leaders and of the Party organizations at the enterprises.

Let us consider some opportunities for further simplification of the structure of management and for reducing the administrative apparatus.

1. Simplification and minimizing of plans, reports, accounts, primary documentation, and all types of correspondence. There are great opportunities for such contraction, as confirmed by the experience of advanced enterprises. For example, at a single aircraft construction plant, the individual orders to workmen and shift

assignments were replaced by cumulative orders. This measure alone yielded the following results in this plant:

	Number of Documents per Month, in Thousands			
	Work Assignments		Punch Cards	
	Formerly	Now	Formerly	Now
Main production shops	350.3	46.2	673.4	140.2
Auxiliary Production shops	86.7	34.5	122.1	70.9
Total for plant	437	80.7	795.5	211.1

These data show that the number of work orders for the entire plant was cut by a factor of 5.5 and by a factor of 8 for the main production shops. Simultaneously with a reduction in number, documentation was also simplified.

2. Consolidation of small productive departments and shops into larger ones.

In this direction there are great reserves available at aircraft constructing enterprises. It will be sufficient to state that the number of workmen in the main shops of advanced plants is 2 - 3 times as great as in the less progressive enterprises. Some shops with as many as 1000 workmen are going over to the shopless structure. In this case, the functions of the shop administrative apparatus are handled by the departments of the plant management. The senior foremen report directly to the chief engineer or director of the plant.

The experience of the transition of enterprises to the integration system also deserves to be more widely disseminated. In this system, a single administrative apparatus is set up, with some services and auxiliary workshops for a group of similar shops located in a single building.

The economic significance of these measures is great. The elimination of the intermediate shop yields an annual economy of about 500,000 rubles in the wage fund for the engineering-technical workers and employees, and for the released portion of the auxiliary workmen.

3. Elimination of the multiunit system and of the excessive functionality of the administrative agencies. The consolidation of related departments allows the elimination of unnecessary units in the apparatus, improves its operational nature and enhances responsibility. For this purpose, plantwide departments and the plant offices must be objectivized to the maximum, so as to concentrate related functions in a single department or office and, on this basis, to consolidate certain departments, reducing their staff accordingly. For instance, at medium and small enterprises, it is entirely rational to consolidate the department of the chief technologist with the department of the chief metallurgist.

It is expedient to abolish certain departments, and transfer their functions to the department of the corresponding shop. For instance, the functions of the materials-handling department could be given to the materials-handling shop, the functions of the aircraft operating and maintenance department to the aircraft maintenance shop. A number of services in the shops could be made common for a group of similar shops, and these services could be subordinated directly to a plantwide department.

The reduction of the administrative apparatus does not mean an elimination of engineering-technical work, whose role is becomming more important with the growth of mechanization and automation. What we are talking of is the elimination of excessive payrolls in the administrative apparatus, the reduction of office work in every way, and the correct utilization of engineering and technical cadres directly on creative productive work.

4. Raising of the standards of service to the productive units by the auxiliary workmen, by the junior service personnel and employees, and the transfer of some of these workers to productive work. Every effort must be made to increase the number of workers at an enterprise, who directly produce the product, and to reduce the number of service workers and employees.

5. Unification of the system of production organization and standardization of technological, planning and accounting documentation at enterprises, with the adaptation of this documentation to mechanized handling.

The reorganization of the management of the industry and construction on the territorial basis, based on economic regions, makes the management of production more concrete and operative, eliminates departmental barriers, improves specialization and cooperation in production, permits wide masses of workers to be drawn into the management of production, and still more widely to develop local initiative. The reorganization of the management of industry and construction demands a further strengthening of the economic independence of enterprises and the expansion of the rights of plant directors, shop superintendents, and department foremen, with a simultaneous increase of their responsibility for the results of economic and productive activity.

Section 2. Selection of Personnel and Checking of Performance – the Major Elements in Organizational Work

Organizational work plays a vital role in production management. The major element in organizational work is the selection of personnel and the checking of performance. The correct choice of cadres is based on a study of the political and technological characteristics of each worker, the knowledge of the post at which his capabilities can thus be developed, the understanding of how to evaluate the cadres and to nurture them with care, to bring them up in the bold advance of youth.

By steadily raising the political level and business skills of the production chiefs, the Communist Party brings up its business men in the spirit of a rational conduct of production.

The most important feature of the socialist style in the management of an enterprise, shop, or section is the solution of all economic questions in accordance with the interests of the State and the directives of the Party. The production chief should organize his staff for the solution of the problems posed by the State Plan, ensure unity and solidarity of the collective, manifest constant concern for the cultural and technical growth of the cadres, for their correct utilization in production, and for the improvement of the material welfare and living standard of the workers of the enterprise.

Operative and concrete leadership of production is effected on the basis of a constant liason with the masses and, in consideration of their experience, on the basis of a thorough mastery of the essence of the affairs, on the basis of knowledge of concrete conditions and personalities, on the basis of a thrifty attitude toward social property.

The production chiefs must have perfect knowledge of the task entrusted to them, must be thoroughly familiar with modern accomplishments of science and technology, must thoroughly study the technology and economics of the enterprises, must know their daily needs and demands, and manage production concretely. All this obligates Soviet businessmen to be exacting toward themselves and their subordinates, to listen attentively to the voice of the masses, to support actively their creative undertakings,to master skillfully the technical knowledge, to expand their economic horizon, to improve the methods of managing production, to study constantly the experience of socialist construction, to generalize it and to use it creatively in the management of the collective.

The management of a socialist enterprise, based on mutual confidence and businesslike comradely relations between its workers, is concerned with instilling the workers with the spirit of performance in great and small things and with demanding a compulsory verification of the performance of decisions adopted. To verify performance means to organize personnel for a specific task, to ensure actual fulfillment of the directives of the Party and government. A well-organized verification of performance prevents blunders and faulty work, allows specific measures to be rapidly taken to correct mistakes that may have been made and to further improve the

work.

The verification of performance should be not episodic but systematic. The verification of performance must not concern secondary workers but the managers themselves. The performance of an assignment must be verified not only from the reports, but primarily from the actual results of work, and at the actual place of work.

The verification of performance must be objective and exigent. The masses should be enlisted in the verification of performance, particularly the workers who are directly concerned with the results of correct and timely solution of a given problem. The verification of performance should be immediately followed by the performance of everything omitted previously.

Section 3. <u>Principles of Production Management</u>

The management of an enterprise is based on socialist principles and methods of administration: the unity of political and economic leadership, one-man responsibility, active participation of the masses in management, conduct of production on the basis of the most recent accomplishments of science, technology, and advanced experience, planning, and a regime of economy.

The unity of political and economic leadership, as the most important principle of socialist business, starts from the fact that all of the economic activity of the enterprise is determined by the task set by the Communist Party and the Soviet State. Politics can therefore not be separated from economics. Economic progress in an enterprise depends not only on technology and economics, but also on the progress of Party-organizational and Party-political work.

One-man management is the method of managing a State socialist enterprise, based on the subordination of the masses to the single will of the leader of the labor process, and combined with the broad creative initiative of the masses in the process of production.

One-man management consists in the appointment of a manager of the enterprise by the State, and his endowment with full powers for the fulfillment of the State Plan, and the devolution of single and personal responsibility on him for the condition of the entire productive, economic, and financial activity of the enterprise. The principle of one-man management envisages the immediate, precise, and creative performance of the dispositions of the higher administrator by the workers under his jurisdiction.

The strict observance of one-man management in all units of production does not permit diffusion and indefiniteness of responsibility and does not permit irresponsibility in work.

The principle of one-man management in a socialist enterprise encourages the attainment of high labor productivity, the maintenance of order in the enterprise, and strict and rigorous suppression of absentees, idlers, self-seekers, loafers, and work spoilers, as well as effective utilization of the national resources in production.

One-man management is effective when based on the managers' profound knowledge of the technology, organization, economics, and finances of the enterprise and is effected in all units of production from the director down to the foreman and crew boss; other prerequisites are that the higher leader does not substitute for the leader below him, does not issue orders over his head, takes his opinion into consideration, and through him accomplishes his guidance of the lower unit; that the leader does not cover up the mistakes of his workers and does not display either liberalism or hollow administration; that the leader boldly blazes the paths toward advanced and progressive doing.

One-man management envisages a close relation between the manager and the Party and other social organizations, the leader knowing how to listen to the voice of the masses, to teach the masses, and himself being taught by them.

Democratic centralism and active participation of the masses in production

management most fully reflect the characteristic features of management of a socialist enterprise.

"Democratic centralism in the leadership of the national economy results from the nature of large-scale socialist production, from the character of the socialist economy and a planned economy, from the nature of the Soviet system, which raises millions of laborers to conscious historical creativeness, to the management of State and economic construction" (Bibl.14).

The realization of the principle of democratic centralism in the management of an enterprise means the combination of the unconditional fulfillment by all enterprises, shops, and productive sections of the State Plan assignments, with every possible expansion of the rights, responsibilities, and creative initiative of the workers of the enterprise. The Party and government have adopted a number of measures to eliminate excessive centralization in the management of industry and to strengthen the democratic principles of production management. This has been reflected in the reorganization of industrial management according to a territorial criterion, in the elimination of trivial trusteeship of plants, in the expansion of the rights of enterprise directors, in allowing the plant collective the right to work out their technological-industrial-financial plan by themselves, in the extension of the rights of the plant Party and trade-union organizations, in an enlargement of the role of workmen's meetings and production conferences in production management. All this permits the laborers to decide the fate of their enterprise, to determine all aspects of its activity in the interest of their own State and of their own people. The active participation of the masses in production management is organically linked with the principle of one-man management and stems from the directive of V.I.Lenin, according to whom: "Discussion is common but responsibility is individual" (Bibl.15).

The consideration of the experience of the masses and their active paration in the development of production allows the manager of a productive unit to find a more correct answer to a question, to check the results and accuracy of performance. The active assistance of the collective to the management expands the progress of the enterprise. The participation of the masses in production management helps the State to effect control, from the bottom up, of the course of management and on the state of affairs in the enterprise.

The conduct of production on the basis of the latest accomplishments of science, technology, and advanced experience is one of the regularities of socialist production.

In the struggle for further technical progress, science plays an ever increasing role; by its discoveries it helps the Soviet people more fully to discover and better to utilize its production reserves. Some businessmen poorly utilize the accomplishments of science, are little concerned with the technical level of a similar producer in other countries, and forget that technology cannot stand still, that without its continuous improvement development of production is unthinkable. In his report to the July Plenum of the Central Committee Communist Party USSR (1955), N.A.Bulganin, President of the Council of Ministers USSR, noted that "entirely incorrect views with respect to the study of foreign experience have developed in a certain percentage of our workers. These workers consider that the study of foreign experience is useless to them. Indeed, such persons, by resounding phrases, merely cover their own ignorance".

Making use of advanced experience of other USSR enterprises plays a great role in the development of production. Such accomplishments should be rapidly studied and introduced by every enterprise. It is clear that the transition to a new technology and to progressive technological processes involves trouble in the reorganization of production. But this trouble is compensated by a sharp increase in labor productivity, and by such a rise in production as would be impossible with the old technique and the obsolete technology.

The principle of planning and the observance of the economy regime in the man-

agement of an enterprise is reflected in the organization of the work of all units according to a plan for fulfillment of the State assignment.

To lead means to anticipate. To anticipate, in management, means first of all the correct planning of production. To plan correctly means to plan so as to ensure a continuous growth of production and a steady rise in labor productivity, based on the latest accomplishments of science, technology, and advanced experience, and the utilization of internal reserves.

To plan correctly means, in drawing a plan and in planned management, not merely to stay at the level of the results already attained, but to rise to more progressive standards and economic indices; it means, in working out and fulfilling a plan, to start from the interests of the State as a whole rather than from narrow departmental or local interests, and to ensure fulfillment of the plan in all of its indices.

Planned management must ensure organization of the rhythmic operation of the enterprise and output according to the established graph, must not allow disproportions between individual units of the enterprise, must guarantee technical and economic unity and operative productive planning.

Correct planning and management must envisage a material incentive of the workers in improving the work of the enterprise.

Correct planning must envisage a careful, zealous utilization of social labor, the strictest regime of economy in the expenditure of materials and financial resources, and in the introduction of unsubsidized operation in all units of the enterprise.

Section 4. The Role and Rights of Party and Trade-Union Organizations in the Management of the Enterprise

The tasks confronting industry cannot be successfully performed without a further rise in the political and work activity of the working class and the e[redacted]ering-technical intelligentsia. The political organizational work of Party organiza-

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tional work of Party organizations with the masses has always been, and still remains, the foundation of all our victories in economic build-up.

The plant Party organization is the organizing and guiding force in the enterprise.

The constitution of the Communist Party USSR, adopted by the 19th Party Congress, has allocated the following duties to the plant Party organization in the field of management and development of socialist production:

1) Propaganda and organizational work with the masses, in order to realize the Party summons and resolutions;

2) Mobilization of the masses for fulfillment of the production plan, strengthening of labor discipline, and development of socialist competition;

3) Fight against laxity and thriftless conduct of affairs in enterprises, and daily care for the improvement of the cultural and living standards of the workmen and employees;

4) Development of criticism and self-criticism and inculcation of the communist spirit of an irreconcilable attitude toward shortcomings.

The most important task of the Party organization is the striving for technical progress in production, for strictest economy, and for perfection of the administrative apparatus.

The success of the Party organization depends on its skill in combining economic work with Party-political work.

The constitution of the Communist Party USSR gives the Party organization at a plant the right to inspect the activity of the administration of the enterprise. The principle of bolshevist leadership of economic guidance to economic agencies consists in systematically assisting the agencies, strengthening them, and guiding the economy not outside these agencies, but through them.

The trade-union organizations play an important role in the development of socialist production. The trade unions, being a mass organization of the workers,

do great work in the communist training of workmen, engineers, and employees and in developing socialist competition among them, directing their efforts toward the fulfillment of the economic and political tasks which confront our State.

The participation of the trade unions in the management of socialist production is clearly manifested in the collective agreement concluded by the trade unions with the administration of the enterprise.

The December plenum of the Central Committee Communist Party USSR (1956) has emphasized the necessity for enlarging the role of the trade unions in working out and fulfilling the technical-industrial-financial plan of the enterprises, in solving the problems of standardization and organization of labor, wages, in improving safety measures at the enterprises, and especially in the solution of questions connected with housing construction and improving the material and living conditions of the workmen and employees.

As pointed out by V.I.Lenin, the trade unions should be a "school of management, an economic school, a school of communism" (Bibl.16).

Important means of increasing the creative activity of workmen, engineering-technical workers, and of employees are the production conferences, meetings of economic activists, and mass meetings at which workmen and employees discuss the problems of the enterprise and their obligations, examine the work of the administration, and note mistakes or shortcomings in the work.

Section 5. Structure of the Plant Administrative Apparatus and its Functions

For the management of the productive-economic activity of an enterprise a special apparatus is established, which is organizationally so constructed that it covers all functions of production management. According to the number of primary workmen occupied in production, enterprises are divided into three categories. Enterprises having a large complement of workmen also have a more branched structure of administration.

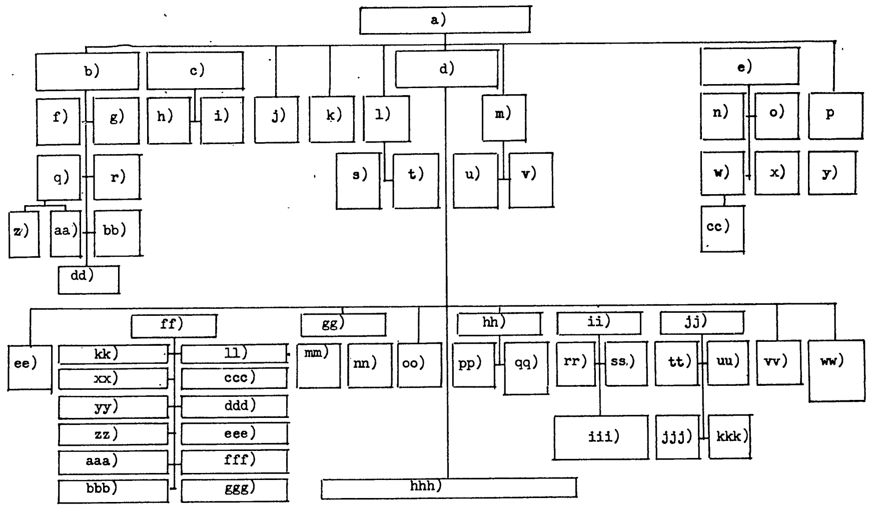

Fig.52 - Diagram of Vertical Integration of Administrative Apparatus at a Large Aircraft Construction Enterprise

(For legend, see next page)

Fig.52 - (Legend)

a) Plant director; b) Assistant director for materials and finances; c) Assistant director for social and living conditions; d) Chief engineer; e) Assistant director for personnel and plant security; f) Department of material and technical supply; g) Department of allied production and subcontracting; h) Housing and community department; i) Social and welfare institutions; j) Department of planned production; k) Department of labor and wages; l) Chief accountant's office; m) Inspection department; n) Personnel department; o) Plant commandant; p) Department of plant construction and reconstruction; q) Administrative economic department; r) Financial-marketing department (with legal group); s) Machine accounting station; t) Shop bookkeeping departments for wages; u) Central testing laboratory; v) Bureau of shop inspection; w) Personnel training bureau; x) VVO, with central timekeeping office; y) Maintenance and construction shop; z) Print shop; aa) Office shop; bb) Transportation shop; cc) Training workshop; dd) Salvage base; ee) Series design department; ff) Chief technologist; gg) Chief metallurgist; hh) Production superintendent; ii) Chief machinist; jj) Power superintendent; kk) Technological department; ll) Cold-stamping department; mm) Department of chief metallurgist; nn) Central plant laboratory; oo) Aircraft equipment laboratory; pp) Dispatcher's department; qq) Shop for sets of spare parts and miscellanies; rr) Department of chief machinist; ss) Machine maintenance department; tt) Department of power superintendent; uu) Heat and power shop; vv) Bureau of technical safety; ww) Bureau of rationalization, inventions, and technical information; xx) Tool department; yy) Lofting and template department (with fabrication of wooden tooling elements); zz) Central technical files; aaa) Technological laboratory; bbb) Interchange group (only for plant management); ccc) Die, chill, and mold department; ddd) Machining department; eee) Tool and tooling shop; fff) Department of riveting assembly work; ggg) Assembly tooling shop; hhh) Main production shops; iii) Shop for special machine tools, unstandardized equipment, hoisting and materials-handling equipment; jjj) Compressed air and gas shop; kkk) Electrical shop

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Figure 52 shows the vertical integration of the administrative apparatus of a large aircraft construction enterprise.

In this system of management, the engineering-technical personnel composes 21.8% of the total number of all workmen, and the administrative personnel 10.7%. Of the administrative personnel, 48% are engaged in plant management, 44% in shop management, and 8% in nonindustrial activities of the enterprise. The field of simplifying the administrative apparatus, eliminating its excessive elements, and further curtailing the payrolls at aircraft construction plants, contains large unutilized reserves.

The enterprises are headed by a director who is the leader of the entire productive, economic, and financial activity of the enterprise and bears sole responsibility for fulfillment of the Plan, for condition of the equipment, economy and finances of the enterprise. He is the representative of the Soviet State, and is endowed by it with plenary powers to utilize the resources of the enterprise in accordance with the State Plan. The director of a development enterprise is appointed and removed by the Minister of Aviation Industry, and the director of a series plant by the Council of National Economy of the economic district.

To enhance the responsibility of enterprise directors for fulfillment of the State Plans and for improvement of the equipment, organization, and economy of the plant, the Council of Ministers USSR, by decrees dated 15 August 1955, has substantially expanded the rights of enterprise directors.

The director has the following rights in the field of planning: approving the technological-industrial-financial plan and modifying it within the limits of the quarterly plan of production, except for the output of mass production; accepting orders from organizations and enterprises (without prejudice to the fulfillment of the State assignment with respect to commercial production); of modifying the technological processes of series and development production, if such modifications do not result in deterioration of the product quality and do not increase its produc-

tion cost; establishing prices for products and charges for services for which there are no official prices or service charges.

In the field of roster, wages and financing, the director has the right to approve and modify the structure and rosters of shops and departments of the plant management within the limits of the plan established for the enterprise of labor and number of engineering-technical workers and employees, to establish and modify (in accordance with labor legislation), the remuneration of workers of the plant administration and shops within the limits of the compensation approved for their respective positions, provided he does not overdraw the average wage funds with respect to payroll distribution by categories.

In the field of marketing material values, the director has the right to sell to other enterprises, from the resources of his own enterprise, materials and minor equipment in sets for contract production of products needed by the enterprise, and to liquidate surplus materials, equipment and other material values which the marketing agencies have refused to redistribute or market.

The rights of directors have also been significantly expanded in the field of capital construction of enterprises, and of acquisition of special equipment.

The shop superintendents and superintendents of certain departments are directly subordinate to the director. The director manages the other units of the plant through his deputies. Let us consider the function of the departments under the direct jurisdiction of the director.

The planned-production department (PPO) handles questions of economic and calender planning of the entire activity of the enterprise. In this department the tech-ind-fin plan of the enterprise is worked out, and productive assignments are prepared for the shops - plans for the following month, and accounting and control of the fulfillment of the monthly and annual plans are carried out.

The department of labor wage organization handles the organization, standardization, pay-scale formulation, and payment of wages and administration of STATage

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fund. One of the tasks of this department is to study and disseminate advanced methods of labor.

This department does not exist at medium and small plants, but its functions are distributed between departments of the chief technologist and the plant-production department.

The office of the chief plant accountant handles the accounting for the fixed and working assets of the enterprise in terms of physical quantities and money values. The chief accountant exercises State control over the expenditure of the material and financial resources of the enterprise in accordance with their designation by the tech-ind-fin plan. The accountant's office daily reflects in the bookkeeping documents all operations involving a change in the fixed and working assets of the enterprise and indicates the results of its productive and economic activity for the month, quarter, and year.

The inspection department (OTK) controls the quality and completeness of the product put out by the enterprise. The chief of quality control is appointed and removed by the immediately superior economic agency on nomination of the plant director. The chief inspector has the duty of notifying the director whenever products of unsatisfactory quality are offered for sale and, if the director approves his disposition on the shipment of such a run, to execute that disposition, at the same time accordingly advising the chief of the administration to which the enterprise is subordinate.

The assistant director for personnel hiring handles the organized selection of personnel, their training and assigning to the various shops in accordance with the plan and the requisitions of the shops and departments, the recording of the movement of the existing personnel, and the formalization of the discharge of workers from the enterprise. The right of hiring and discharging workmen is vested in the shop superintendent, and of engineering-technical workers, in the director of the enterprise. The assistant personnel director exercises supervision over the employment office, the department of in-service training, of watchman protection, and the timekeeping department. In small and medium plants, he also manages housing and other community services.

The chief engineer is the first deputy of the director and enforces the technical policy at the enterprise; he handles all productive and technological questions, the most important of which are assurance of technical progress of the enterprise, timely preparation for the production of new and modified machines, economic utilization of capacity, steady growth in the qualifications of the personnel and the productivity of their labor. To the chief engineer are subordinated all management staff members handling the technical preparation of production and the manufacture of the main product, more specifically: chief technologist, chief metallurgist, chief machinist, superintendent of power, and superintendent of production.

The chief technologist manages the work on the basis of directors' and workmens' graphs of the tooling-up of the shops of the main production for the output of new aircraft prototypes, for the development of technological processes, for designing, fabricating and standardizing tooling; in addition, he manages the shops which make the tools, and controls the observance of technological discipline in production.

The chief metallurgist performs the same functions as the chief technologist, but in the field of casting, forging, and heat treatment. In small enterprises, the metallurgical department is subordinate to the chief technologist.

The chief machinist directs the maintenance work of the plant and handles the acquisition, installation, inventory, preparation of rating sheets and operative-technical records for the equipment, supervision of condition of the equipment and of its correct operation in all shops, of major repairs of equipment and its modernization, of introduction and improvement of the system of handling and maintenance of the equipment. The department of the chief machinist and the maintenance machine shop are subordinate to the chief machinist.

The superintendent of power directs the power system of the plant and handles the acquisition, installation, inventory, preparation of rating sheets, accounting, operation, and maintenance of power equipment, controls the condition of the power installations in all shops of the plant. The superintendent of power works out, for the shops and services of the plant, standards and limits of power consumption, incentive systems for a high efficiency of the power installations, for the saving of fuel and power, directs the work on rationalization and invention in the field of improving and developing the power system of the plant. All power shops and power stations of the plant are under the superintendent of power. In small and medium enterprises, there is no superintendent of power, and the entire power system of the plant is under the chief machinist.

The production superintendent directs the work of the main shops in the fulfillment of the production program. The superintendent of production has a dispatcher department attached to his office. This department is headed by the chief dispatcher, who regulates, controls and accounts for the fulfillment of the operative monthly plans by the main shops. The dispositions of the superintendent of production on questions of starting and output of product are binding on the superintendents of the main shops. The superintendent of production must relieve the chief engineer, to the greatest extent possible, of his current work in directing the fulfillment of the program, so as to give the chief engineer an opportunity to occupy himself more with questions of the technical progress of production and the introduction of new technology and equipment.

The series-design department, the department of major construction, current maintenance and reconstruction, and the safety bureau, are also directly subordinate to the chief engineer.

The series-design department (SKO) handles the designing and technological refinement of the aircraft with respect to the conditions of series production. The primary functions of the SKO are as follows: revision of the experimental drawings

into series production drawings; providing the production with production drawings; drafting specifications of parts and units that go into the aircraft; conversion of the schematic diagrams of assembly into production illustrations; where necessary, providing the additional detail in the drawings; detailed fitting of the assemblies and units on the loft floor on the basis of the general fitting of the contours of the assemblies performed by the OKB; finishing and refining the series drawings on the basis of the results of manufacture of the head series of aircraft by the plant; consideration of the suggestions made by departments, shops and workers of the plant with respect to design improvement; reflecting technological improvements of design in the drawings; formalization of the drawing modifications received from the OKB; organizing the drafting system and supervising the drafting work of the enterprise. All changes in the drawing of the aircraft are made by the series-design department with the authorization of the chief designer. To perform the above work within the SKO, teams, specialized in the various assemblies of the aircraft, are used. The systematic liason between the series plant and the development plant is effected through the series-design department.

The department of major construction and reconstruction handles all questions of major construction, major and routine repairs and maintenance of the buildings and structures of the enterprise.

The industrial safety bureau works out the measures for labor protection and safety measures and supervises compliance in the shops. The plant labor-union organization inspects the plan and the work of the plant safety department and assists it in its work through a system of trade-union agencies and safety delegates.

The assistant director for material and financial questions has the following departments subordinate to him:

<u>The department of material and technical supply</u> (OMTS) negotiates contracts with suppliers for delivery of materials, handles the storage of materials, manages their accounting and issue to the shops and services of the enterprise. The general

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plant material stockrooms are subordinate to the supply department.

The department of cooperation and allied production (OSPK) performs the same functions as the department of material and technical supply, but is concerned not with materials, but with purchased semifinished products, castings, forgings, and finished articles. At small plants, the functions of the department of cooperation and allied production are performed by the department of material and technical supply.

The transport shop handles the delivery of goods to the enterprise and the shipment of finished products and waste materials.

The financial and marketing department works out the financial plan of the enterprise and of its realization, the sale of the finished product, the cash settlements with debtors and creditors of the enterprise, the receipt of funds, and the payment of wages to the workers of the enterprise.

Only large plants have an assistant director for social affairs and living facilities. He handles the housing and community department and the social and welfare organizations.

Section 6. Structure and Functions of the Shop Administrative Apparatus

The shop administrative apparatus is organized in accordance with the functions performed by the shop and the number of workmen employed in it (Fig.53).

The shop superintendent performs the administrative, technical, and economic management of the work of the shop on the basis of one-man authority. The principal elements in his work are: organization of the shop staff in fulfilling the production program, more complete utilization of the internal reserves of the shop, and improvement in its technology. The shop management (various functional bureaus) is subordinate to the shop superintendent, except for the bureau of shop control which is directly subordinate to the chief inspector of the plant. The dispositions of the shop superintendent are binding on all workers under his authority, and must be

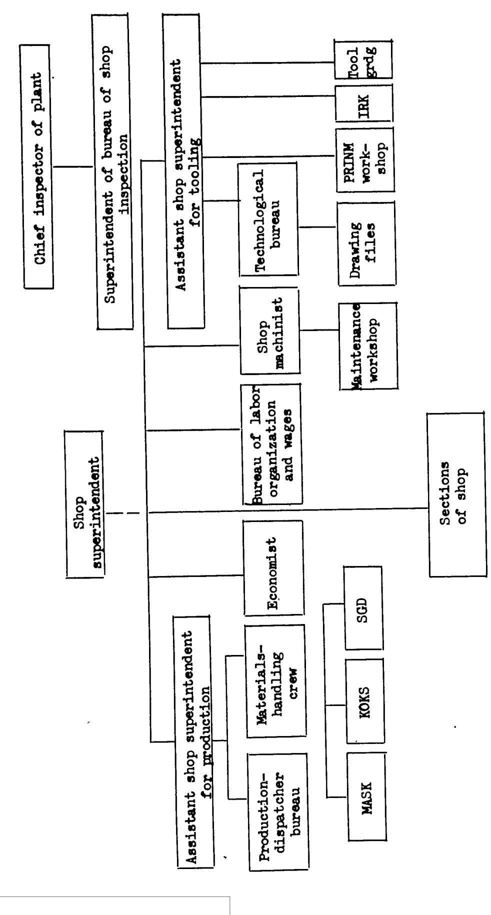

Fig.53 - Diagram of Vertical Integration of Management of a Large Shop

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immediately and precisely executed. The shop superintendent personally bears responsibility for the condition of all the shop work and for the integrity of its material values.

The shop superintendent must realize the qualified management by his foreman, strengthen their one-man authority, and assist them in the introduction of progressive measures.

Let us consider the functions of the most important bureaus of the shop management.

The bureau of technological processes (BTP) works out the technological processes, introduces them into production, and exercises control over the observation of technological discipline in the shop.

The bureau of labor organization and wages (BOTZ) handles the questions of standardization, pay schedules, and payment of wages.

The shop economist handles questions of the unsubsidized operation system, controls the fulfillment by the plant of the established economic indices, issues the monthly plant assignments to the departments of the shop, and keeps their records.

The production-dispatcher bureau (PDB) draws calendar graphs of starts and output of product by days and shifts of the month for the departments and sections of the shop, verifies the fulfillment of the daily shift assignments of the sections in material and tools, calculates and controls the fulfillment of the program and the existence of work in process. The production-dispatcher bureau is concerned with the procurement of materials and semifinished products for the shop, with their issue to the sections, and with the delivery of the finished product to the consumer shops. The material stockrooms (MASK), the set-making stockrooms (KOKS), the finished-parts stockrooms (SGD) and the materials-handling crew, are under the production-dispatcher bureau.

The tooling technologist handles the organization of the shop tooling. The managers of the tool distributing stores and the tooling repair foreman are under

his jurisdiction.

The shop machinist handles the maintenance of the shop equipment, directs the maintenance workmen of the shop and the workshop on the maintenance of equipment. At some plants the shop machinists are replaced by groups serving several shops.

The accounting office handles the accounts for the material values and the wage settlements with the workmen and employees. This office is organized to serve several shops and is directly subordinate to the chief accountant of the plant.

The principal element in the work of all units of the shop management is to secure high quality of the product and fulfillment of the shift-day assignments by each productive section, the steady reduction of material and labor costs per unit of shop production.

Section 7. Organizational Structure of the Department (or Workshop)

The department is the basic productive unit of the shop and is headed by a senior foreman who is directly subordinate to the shop superintendent. The senior foreman has under him several shift foremen who head the production sections of the department. The shift foreman in turn has under him the preparing worker, who prepares the work stations for the shift with materials, blanks, and tools in accordance with the shift-day assignment. A stockroom (PROSK) is organized to store the work in process in the section. For the decentralized assignment of the work squads to the section, an expediter is employed. In large sections there is a special planner-dispatcher and a foreman-distributor, who handle the preparation of the shift-day assignments to the sections and the supply of the work stations with materials, blanks, and tools. The existence of this apparatus available to the senior foreman allows him to concentrate his attention on the direct guidance of the shift foremen and workmen and releases him from functions that do not properly belong to his work scope (office work, assignment of squads, receipt of materials and tools).

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"The foreman", as comrade Ordzhonikidze puts it, "is the central figure in pro-

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duction". The success of the collective depends on how the foreman has given out the production rules, how he maintains labor discipline, how he ensures uninterrupted work of the operators, how he heads the socialist competition for advanced methods of work. Taking account of the leading role of the foreman in production, the Central Committee Communist Party and the Council of Ministers USSR have issued a number of decrees on enlarging the scope of the foreman in production and on his transformation into a fully empowered leader of the productive section. These decrees have raised the status of the foreman in production and have invested him with extensive powers. The foreman has the right to participate in working out the technology, establishing the standards and evaluations for the work of the section (or department) and to give his own conclusion on it, to establish the wage-scale category of the operator and to make him do a sample job to define the category of labor to which he is to be assigned. The foreman disposes of the wage fund and of the funds of the section.

The foreman accepts and releases the workman in the section, with subsequent approval of the shop superintendent.

The duties of the foreman in the section consist in organizing the fulfillment of the program on the whole and by the graph, in the proper arrangement, assignment, training, and instruction of the workmen, in introducing advanced methods of work and their adoption by all workmen of the section, in creating conditions for uninterrupted work and the systematic growth of labor productivity, and in maintaining labor discipline. The foreman must secure the correct wages for the workmen, skillful handling of equipment, observance of technological discipline, and systematic improvement of production quality; he is obligated to check on observance of safety rules, and order and cleanliness in the section.

The foreman should be the technical leader of the section and should participate actively in working out organizational and technical measures. The aim for technical progress of the productive section should be one of his principal tasks.

The foreman should utilize the experience of advanced foremen and should improve the work in his section on the basis of the introduction of self-supporting section management.

The decree of the Council of Ministers USSR dated 20 September 1955 extended the rights of the foremen and considerably increased their wages, which gave the foremen a still greater incentive to increase their qualifications and a greater interest in the attainment of higher labor productivity by the workmen of their section.

The correct organization of the shift (its preparation, conduct, and transfer) is of great importance in the work of the foreman.

<u>The preparation for the shift</u> consists in supplying each work station with everything necessary for work. A careful preparation of the shift lightens the working day of the foreman and allows him to concentrate most of his attention on the productive instruction of the workman and on the fulfillment of the program. On the day before the shift, the foreman ascertains, through the preparation worker, the provision of the shift-day assignment with materials and blanks, and through the machine setters, the availability of tools and attachments, transmits this information to the senior foreman, and concerns himself with the timely procurement of any lacking items.

The foreman keeps the workman informed of the forthcoming work.

Before beginning of the shift, the preparer delivers the blanks to the work stations. The foreman or inspector accepts the first processed parts from the machine setter and thereby verifies the accuracy of the machine setup. By the beginning of the shift, all the machines must be completely set up and ready for work and provided with all necessary complements.

<u>The conduct of the shift</u>, under the leadership of the foreman consists in providing each workman with the conditions for overfulfillment of the shift assignment, in conducting the productive indoctrination of the workmen, and in ensuring the un-

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interrupted servicing of the work stations.

The foreman visits the work stations and verifies the performance of the shift assignment, instructs the workmen, and inspects the quality of their work. The foreman makes certain that order is maintained at the work stations, as well as cleanliness in the section, ascertaining that the preparer has supplied the work stations, taking account of the possibility of overfulfilling the standard by its workmen.

In transfer of the shift, the foreman must not allow disorder of the machines toward the end of the shift, and must teach each operator to hand over his equipment in perfect condition. The foremen, on transfer and acceptance of the shift, visit the work stations and verify how they are cleaned, whether the equipment has been lubricated and set up for the following shift, ascertain who among the workers has attained a high output during the past shift and by what method, and organizes the transfer of this advanced experience to the workers of the next shift.

In some cases, a crew boss is appointed from among the workmen. This is done where highly qualified leadership of a group of less skilled workmen is needed. For instance, a group of young fitters is headed by an experienced fitter boss, who performs the complicated operations and helps to increase the qualifications of the young fitters, by letting them benefit from his knowledge and experience.

A boss is appointed if the labor process cannot be performed by a single workman and has to be done by a group (crew) of workmen. For instance, in welding, in assembling a large assembly or machine, the boss performs the work requiring the greatest skill and is responsible to the foreman for the time and quality of the work of the crew as a whole. The crew boss selects the members of the crew and distributes the work between the workmen, making sure that labor discipline is observed by the crew members, verifying the amount and quality of the work performed by each workman in the crew, and (the main point), instructing the crew members.

Section 8. Organization, Planning, and Control of the Functions of the Management Apparatus

The activities of plant management, auxiliary services, and plant bureaus should be as close as possible to the main production and should be directed toward improvement of the technology and organization of production as well as toward constantly rendering active assistance to the shops in the fulfillment of their shift-day assignments.

The plantwide departments and services must give the shop superintendent and the foreman, to each in his own domain, complete economic independence within the limits of the established assets and the other limits, and must free them from trivial supervision.

Such a system brings the plantwide services close to the main production, and relieves the shops of functions that do not properly belong to their scope.

The work of the management must be based on active, daily, and operative leadership of the main production. The management workers are obligated not merely to issue assignments to the shops and sections, but also to create all prerequisites for their fulfillment. For instance, the labor organization department should not only issue an assignment for the reduction of labor costs, but is at the same time obligated, through the departments of personnel training and the chief technologist, to help the shops in raising the qualifications of their personnel, in mechanizing the processes of production and in disseminating advanced experience. The dispatcher departments should not only check the delivery of the product by the shops, but should also verify the timeliness of start-up of the processing of the batches of parts in each shop. The technologists and designers of the department of the chief technologists and of the shops should improve the technological processes and attain maximum mechanization of the work.

In order to increase the responsibility of the management for the quality of the operative servicing of the shops of the main production, monthly economic in-

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dices for the work of the departments and services are established. The economic indices established for each department and service must be so as to stimulate the work of the management, departments, and services toward improving production as well as toward discovery and utilization of the reserves.

For instance, the dispatcher department should be responsible not only for the rhythmic performance of the program by the enterprise, but also for the monthly shortening of the productive cycle and the freeing of the working capital invested in the work in process of the main shops. Such an index is entirely realistic. Another example: Indices such as the monthly reduction in the standard consumption of material and labor per article might be established for the departments of the chief technologist and the chief metallurgist.

The planning of the work of the departments, services, and shop management begins with the establishment of the economic indices for each department.

The production planning department lays out the corresponding economic indices for the quarter or for the month for each department and service, coordinating these indices with the indices of the quarterly and monthly plans of the main and auxiliary shops.

The production planning department and the director of the enterprise exercise systematic control over the fulfillment of the monthly plans. In the control, main attention is given to the degree to which the measure in question has improved the work of the main shops.

Section 9. Mechanization of Administrative Functions

An important means of improving the labor productivity of the administrative workers is the mechanization of their work. The modern means for mechanization of administrative work vary widely. Their classification by purpose and by types of operation performed is given in Table 11, compiled by Engineer P.G.Popov.

The machines and installations used for the mechanization of office work in-

Table 11

Use of the Means of Mechanizing Administrative Functions and Special Devices in the Departments of Plant Administration

Units of Administration	Mathematical Machines	Punch-Card Machines	Computers	Billing Machines	Product-List Machines	Punch-Card Sorters	Adding Machines	Accounting Tabulators	Electroplanometers	Drafting Machines	Photocopying and Blueprint Machines	Comptometers	Duplicating Machines and Devices	Machines and Devices for Printing Documents	High-speed Radiotelegraph Apparatus
Director's office															
Production Planning Department		X	X	X			X	X	X			X	X		
Series-Designing Department	X	X	X	X			X			X	X	X	X		
Chief Technologist's Department							X	X		X	X		X		
Tool Department			X				X			X		X	X		
Departments of Chief Machinist and Superintendent of Power							X			X			X		
Production-Dispatcher Department			X				X		X				X		
Personnel Training Department							X						X		
Main Construction Department			X				X			X		X	X		
Inspection Department		X						X					X		
Central Accounting Office		X	X	X	X	X	X	X					X		
Labor and Wages Department		X	X				X	X					X		
Personnel Department							X	X					X		
Department of Material and Technical Supply and Department of Allied Production and Subcontracting		X	X				X	X				X	X		
Financial and Marketing Department		X	X	X			X	X				X	X		
Administrative-Economic Department														X	X
Plant Security															
Productive Shops										X		X			
Machine Accounting Station (Shop)		X	X			X									

Teletype	Automatic and Manual Telephones	Dispatcher Switchboard w. Amplif. Capacity 40-70Stat.	Simple Disp. Switchb. without Amplifier	Director's Switchboard w. Pushbutton and Key System (w. and without Amplifier)	Telephone with Siren for Outside Posts	Alarm Switchboard and Protective Sign. Equ. Beam Syst.	Signal System on Operation and Stoppage of Equipment	Paging System	Indicators, Registers, and Time Signals	Mechanized Drafting Instrument	Director and Dispatcher Switchboard	Control and Distributing Equipment	Recording Counters for Production Processes	Card-File Equipment	Letter-File Equipment	Supply Cabinets and Shelves	Computational Tables, Nomograms, and Graphs
				X							X						
														X		X	X
										X				X		X	X
										X				X		X	X
										X				X		X	X
X	X												X	X			X
		X	X				X	X			X	X	X	X		X	X
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			X				X					X	X				X
														X			X

clude electric typewriters, which make it possible to get a large number of copies; dictating machines for the mechanical recording of oral orders and business conversations; billing machines and addressographs for the mechanical filling out of blanks and schedules, addressing envelopes, etc; teletypes for simultaneous wire transmission of typewritten text to several points; facsimile transmission; mechanical, pneumatic, and electrical means of dispatching documents to the departments and shops of the plant.

The machines and devices used in the operative production management include directors' and dispatchers' telephones and switchboards, selective telephone communication and automatic telephone stations; paging equipment; combined devices for communication and signalling, automatic product computers, equipment-loading computers.

For bookkeeping and statistical accounting and Plan computations, electrical comptometers and computers are used, which process the primary documentation according to indices relevent to production and which handle calculation of the payrolls.

For mechanization of the work of draftsmen and copying, reproducing and duplicating devices as well as photostats, and other machines are used.

Mathematical, punch-card and computing machines are used for weight, strength, aerodynamic and other calculations; hydraulic and electric integrators, high-speed electronic analog computers, etc., are also used for this purpose.

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PART TWO

ORGANIZATION, STANDARDIZATION, AND PAYMENT OF LABOR AT AN AIRCRAFT CONSTRUCTION ENTERPRISE

Labor is the purposeful activity of a human being to create useful values and is the primary factor in production. Labor is characterized by its productivity. Labor productivity is measured by the quantity of product turned out by a worker in unit time, or by the quantity of working time consumed per unit of production.

The basic elements determining labor productivity are as follows: length of the working day, or the extensive value of labor; quantity of labor expended during a given time (hour, shift), or the intensive value of labor; productive power of labor, or the capacity of one and the same quantity of labor during a given period of time to yield a greater or smaller quantity of product, depending on the degree of development of the production conditions (Bibl.17).

Karl Marx said: "The more strongly the productive force of labor increases, the more can the working day be cut, and the shorter the working day, the more strongly can the intensity of labor increase. From the social point of view, the productivity of labor also increases with its saving. Labor saving includes not only the saving in the production means, but also the elimination of all forms of useless labor" (Bibl.18).

The expenditure of socially necessary time on the production of a unit product is the index of the productivity of social labor.

The index of the productivity of individual labor of workmen at an enterprise is the average output of product per workman per unit time.

By reducing the labor consumption per unit of product, the Socialist Society is able to produce a larger quantity of product for each worker and, consequently, more fully to satisfy their increasing demands.

A considerable rise in the productivity of labor at socialist enterprises is the decisive factor for fulfillment of the assignments on the growth of production and the further enhancement of the well-being of the people. The attainment of high labor productivity and the expansion of the productive capacities are the main paths for the solution by the Soviet Union of the fundamental economic problem, to overtake and surpass the most highly developed capitalist countries in per capita production.

The advantages of the socialist system, the successful realization of the Leninist plan of industrialization of the country, have permitted the Soviet Union to increase labor productivity in industry in 1956 to a level 8 times as high as in 1913. Such high rates of growth of labor productivity are unknown to even a single capitalist country. At present, the Soviet Union has already overtaken the leading capitalist countries of Europe in labor productivity, but still lags substantially behind the United States.

The task today is to overcome this lag as rapidly as possible. An important stage in the solution of this problem is the implementation of the directives of the 20th Congress of the Communist Party USSR on the growth of labor productivity in the sixth Five-Year Plan, by not less than 50%. This must be accomplished primarily by the growth of the technological equipment of labor and by the introduction of advanced equipment and technology, by expanding in every possible way the combined mechanization and automation of the production processes, by the modernization of equipment, by the wide development of specialization of enterprises, and by the introduction of line methods of production on this basis, by the radical improvement of labor organization and the liquidation of losses and labor time, by enhancing the qualifications of the personnel and giving them a material incentive for the growth of labor productivity.

The increase in the technical equipment of labor and the growth in the qualifications of the personnel, both of which are being realized at socialist enter-

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prises, will allow us to attain a rise in labor productivity and a simultaneous transition to the seven-hour working day, without lowering the pay.

The immense significance of the growth of labor productivity for the development of socialist production is clear from the fact that in the sixth Five-Year Plan, 80% of the increment of industrial production will be obtained on account of the growth of labor productivity. The enhancement of labor productivity by only one percent throughout the entire national economy of the USSR would be equivalent to a reduction of the needs for labor force by more than 165,000 men. An increase in labor productivity by 1% at an aircraft construction plant would mean an increase in output by several million rubles.

For the successful fulfillment and overfulfillment of the assignments on the growth of labor productivity, together with the introduction of advanced equipment and technology, the rational organization of labor, and its rational standardization and payment is of great importance.

CHAPTER VI

LABOR ORGANIZATION AT THE AIRCRAFT CONSTRUCTION ENTERPRISE

Speaking of the fundamental problem of creating a social order higher than capitalism, Lenin pointed out that it consists in the enhancement of labor productivity, and in this connection (and for this purpose), its higher organization (see Bibl.19).

By a rational labor organization within the enterprise, we mean the planned and productive utilization of the working time of every worker. The rational organization of labor envisages mechanization of the labor process, organized selection and induction of personnel into production, enhancement of their cultural and technical level, correct division and cooperation of labor, high labor discipline, good organization of the work station and of service to it, standardization of the expenditures of working time, and payment of labor in accordance with its quantity and quality, development of socialist competition, and extensive utilization of the advanced experience of labor. The saving of labor time, with a high production quality, is a criterion for the perfection of technology and of the organization of production. Marx wrote that "…. the saving of time, just like the planned distribution of working time among the various branches of production, remains the first economic law on the basis of collective production" (Bibl.20).

Section 1. Mechanization of Labor Processes

The introduction of machine technology into production is the foundati mechanization. The machine is the most powerful means of increasing labor productivity and of decreasing the share of working time in the product of labor. For this reason, mechanization of the labor processes at a socialist enterprise is the basic and decisive force that ensures high rates of expansion of production and a powerful rise in labor productivity, and improves the labor conditions.

An index of the level of mechanization of production is the ratio of the amount of work performed by the aid of machines to the total labor cost of the article.

The mechanization of labor processes passes through a number of stages in its development. In partial mechanization, only individual elements of the fundamental operation are mechanized, and a substantial share of manual labor is still retained. Combined mechanization means the replacement of manual labor in the primary operation and in the auxiliary and subsidiary work, so that only the functions of controlling the mechanisms of the equipment remain for the workman. In partial mechanization, some of the functions of the workman and the control of the mechanisms of the equipment are performed automatically, and, finally, in complete mechanization, the processing of the object of labor and the control of the equipment are performed entirely by automatic means, with the workman only checking the mechanisms of the machine for proper functioning and, if necessary, changing its adjustment or replacing the processing tool.

At aircraft enterprises, certain progress has been made in the field of mechanization and automation of production. Wise use is made of machine molding in casting shops, of various presses in stamping shops, of automatic and semiautomatic machine tools in the machine shops, of semiautomatic welding machines in the fitting and welding shops, of machine tools for gang drilling, of group riveting presses and grinding machines in the assembly shops.

The share of hand work in the fabricating, processing, and assembly shops, however, is still great (Table 12).

The high proportion of hand work which, at some plants, reaches 70% makes

mechanization of the labor processes the central task of every aircraft construction enterprise.

An important task posed by the 20[th] Congress of the Communist Party USSR, is the increase in output and the enhancement of labor productivity by a more complete

Table 12

Level of Mechanization of Individual Forms of Work in Aircraft Construction

a)	b) c)	b) d)	b) e)	f) g)	f) h)
1. Casting	0,4	0,5	1,3	25	45—50
2. Forging	0,8	0,5	0,6	25	30—35
3. Blanking and Stamping	13,2–16	17	18,3	25	45—50
4. Machining	17,2—20	14,6	20	40—50	75—85
5. Fitting-Welding	0,8—5	0,8	0,8—1,3	25—30	45—60
6. Drilling-Riveting	5			30*	50—75
7. Major Assembly	30,7	55,5	40	1,5*	2—3
8. Final Assembly	7,2—5,8			1	2
9. Airfield	3,2—5	4	4,1—4,6	—	—
10. Other	11,5	7,1	14,4	10	25—35
Total	100	100		25—30	40—60

* Taking account of hand pneumatic tools, considerably higher.

a) Form of work; b) Share of labor time of given form of work in % of total labor time for aircraft; c) Light aircraft; d) Medium aircraft; e) Heavy aircraft; f) Mechanized work, %; g) Existing; h) Possible in the near future

utilization of the existing equipment. The planned coefficient of equipment loading is satisfactory at aircraft construction enterprises, but the coefficient of actual equipment utilization with respect to useful working time is still lSTAT This is explained by the high share of auxiliary and machine-manual time in the piece-

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work operation standards. For instance, for stamping parts, high productivity presses are used, but the feed of the band to the press, the removal and counting of the blanks are still done by hand. The finishing of various parts is also done manually. The mechanization of the auxiliary operations in machining is inadequate. As a result, the share of machine time in the piecework standard is very low, and at some plants amounts to 10% for work on eccentric and piston presses, to 8% on drop hammers, to 12% on hydraulic presses, and to 14 - 18% on metal-cutting machine tools. Thus, the problem of aircraft construction enterprises is to improve the utilization of the machine equipment and to increase labor productivity by means of combined mechanization of machine-manual and auxiliary work in each production section.

Another extremely important problem posed by the 20th Congress for industry is the automation of the mass operations of production. In aircraft construction, automation should cover such mass operations as sheet layout and stamping, turning, drilling, and milling operations, welding, and riveting. This will sharply reduce the labor cost of the article and will open the way to multiple machine tending.

Such are the basic trends in the field of mechanization at aircraft construction enterprises.

Section 2. Organized Selection of Personnel, Induction into Production, and Enhancement of Qualifications

The continuous growth of socialist industry demands its replenishment with new cadres. This replenishment is secured by an enterprise from the State reserves and by organized selection of personnel.

The State labor reserves are trained as qualified workers for the enterprises through an extensive system of trade schools, in-service training and technical schools, under planned procedure.

The organized selection of personnel assumes that the enterprise has a plan of recruiting and training personnel by quarters, by specialties, and by sources of

recruiting; it assumes the conduct of organized work to fulfill the plan, the creation at the plants of suitable living and cultural conditions for the newly enlisted workmen, the organized induction of personnel into production, and the correct utilization of young workmen according to their skill.

Industrial statistics show that the greatest number of cases of injury, spoilage of product, and damage to equipment and tools occurs with new workers. To avoid these unfavorable incidents and to ensure a more rapid growth of the labor productivity among young workmen, it is necessary that every unskilled workman, before being allowed to do independent work, be trained in the first unit of the in-service training system. The training in the first unit lasts from 4 to 6 months and includes theoretical preparation and production training. It allows training of workmen of the second and third categories.

The systematic enhancement of the productive qualifications and cultural level of the personnel is the law of development of socialist production. Without it, the continuous growth of labor productivity, the expansion and improvement of production, and any technical progress, would all be impossible. The transition to general secondary education, the transformation of the high school into a polytechnic school, and the wide scope of secondary and higher technical education in the USSR, all these allow the enterprises to replenish their personnel with workers of a high general education and technical training level.

The special training of personnel by the system of in-service technical training (Table 13) at each enterprise, is also of great importance.

The enhancement of qualifications helps the workman to master perfectly the new equipment and advanced labor methods. The workman must know his equipment well, must be familiar with its tooling and setting up, and must know how to read blueprints fluently; the workman at assembly shops must be very familiar with the specifications for the units, assemblies, and installations of an aircraft. It is desirable to teach the workers of the main shops a second tool specialty. This will allow the enterprise to use them effectively during the period of tooling up for the production of a new article and will sharply curtail this period. The influence of

Table 13

Kind of Training	Purpose	Form of Training	Period of Training
Second stage of plant training	Increasing the qualifications of workmen to category 4 - 5	Theoretical instruction, group; practical training, individual and crew	Up to 6 months
Third stage of plant training	Increasing qualifications of workmen to category 6 - 7	Theoretical instruction, group; practical training, individual	Up to 10 months
Technical school for foremen	Preparation and increasing the qualifications of foremen and crew chiefs	Theoretical and practical training, form, group	Up to 2 years
Schools for exchange of advanced experience	Dissemination of experience of advanced workers	Individual, crew and group	-
Special purpose courses	Teaching workmen, foremen, chiefs of offices, department and shop superintendents individual questions of equipment, technology, organization and economics of production	Mainly theoretical instruction, form, group	-

personnel qualifications on the growth of labor productivity may be illustrated by the following examples: At some aircraft construction plants, training the operators to set up their own machines has increased the output by 20 - 25% and has increased the monthly earnings of the operators by 160 - 220 rubles. When experienced turners were put on the turret lathe at one aircraft construction plant, they in-

creased the output of parts from these turret lathes by 70% over that attained by less highly qualified operators, who knew only the turret lathe. The experience of advanced French and Swedish machine-building shops is of interest. Here each machinist knows how to operate various machine tools. Owing to these high qualifications, such an operator works without spoilage, and he does not need a detailed process chart, but guides himself merely by the machining plans.

Section 3. Division and Cooperation of Labor

At the socialist enterprise, the division of labor is effected with the object of increasing its productivity, and is expressed in the division of labor by types and stages of production, by specialties, and by qualifications of the workmen.

The division of labor by forms of production (main, auxiliary, and service production) gives rise to the classification of workmen into primary, auxiliary, and service, as well as allows concentration of each type of work in the special shops and services, and mechanization of the work in these.

The division of labor by forms of the technological processes gives rise to the specialties of workmen and to specialized shops within each form of production. The expansion of machine equipment modifies the composition and structure of the shops, leads to the dying out of the technological processes and specialties connected primarily with manual labor and to the formation of new specialties due to the application of the new technique. Under the conditions of the social method of production, the introduction of machine equipment does not lead to the dropping of workmen of the obsolescent specialties from production, which is characteristic for capitalism, but produces instead a new and more perfect assignment of personnel to production and leads to the enhancement of their qualifications and skill.

The division of labor into operations of the technological process of manufacturing the production item permits the manual labor to be defined and mechanized; allows distribution of the operations among the work stations as far as possible,

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so that the times for their execution are equal or a multiple of the pace of output of the article; allows assignment of operations to definite work stations so as to increase the responsibility of the operator for the condition of the equipment, and for the quality and quantity of his work, i.e., to destroy the impersonality and lack of personal responsibility in labor; to specialize the workmen in performing uniform operations so that labor productivity will increase more rapidly.

The division of labor according to qualifications for the work means that work of a definite degree of intricacy and accuracy is assigned to workmen with the corresponding qualifications. This encourages the growth of labor productivity and the improvement of product quality and tends to increase the material incentive of the workmen in the improvement of their qualifications.

The division of labor in socialist production does not mean attaching a workman permanently to specific operations. The workman is given all prerequisites for growth of his qualifications.

The division and specialization of labor under the conditions of interrelated production processes gives rise to a cooperation of labor, under which "many persons participate, in a planned and joint manner, in one and the same process of labor, or in different but interrelated processes of labor" (Bibl.21).

The cooperation of workmen performing the technological process of manufacturing the object of labor expresses the interrelation of the partial processes of labor. The deeper the process of division of labor, the more specialized will the work stations become, and the more sharply and distinctly will the cooperation of the producer machines stand out and, on this basis, the cooperation of the partial labor processes as well. For instance, under the condition of a development enterprise, the workman performs all operations of the given type of work on universal equipment. Here the productive relation between one turner and the turner operating at the adjacent work station is not particularly clear, and is disclosed only at the time of assembly, when parts processed by different turners must arrive at

one and the same time. In line production, however, where each work station in the line is specialized, the workmen are bound by the same rhythm of work.

One of the forms of labor cooperation between workmen is the production crew. Several forms of workmen's crews are characteristic for aircraft construction enterprises.

Crews of one form are organized by joining several workmen of the same or different trades for joint labor, with a common object or common means of labor. Examples of this type of crews are assembler crews or crews in forging and stamping shops. In such a crew, the correct distribution of work between its members and the efficient coordination of its operations are of decisive importance. Crews of a different kind are organized when it is necessary to observe time sequence in work and personal responsibility for a definite portion of the crew assignment. Examples of this form of crew are the equipment maintenance crews, the traveling crews of machine setters or inspectors.

There are also crews that are organized on the principle of servicing a part of a productive section. For instance, a section is divided into two crews, the first performing the control assembly and drilling and the second the riveting of the spars. In this case, it is not only important to efficiently determine and coordinate the work of each crew member, but also to correlate the work of the crews with respect to time.

Section 4. Indoctrination of Labor Discipline in Production

The highly mechanized socialist production, guided by a plan and operating in the interest of all of society, demands a high labor discipline of each of its members. Violation of discipline introduces disorganization into the work of the collective of the enterprise and disturbs the planned course of production. For this reason, the observance of strictest discipline during working time is an objective necessity of socialist production.

The following are the most important features of socialist labor discipline in production:

A conscientious attitude of each member of the collective of the enterprise toward his work, which is expressed in complete and productive utilization of the working time and equalization on advanced examples of production work, at a high level of labor productivity.

Observance of the rules of internal order, of technological discipline and one-man responsibility during the entire working time, i.e., the exact, rapid and creative implementation of the dispositions of his leader.

An economical attitude toward the socialist property entrusted to the worker by the state. This is expressed in the correct operation of the equipment and in the economical use of power, tools, and materials.

These qualities should be inculcated in every workman by the administration and the social organizations of the enterprise, making use of political education and propaganda, individual talks, production conferences, the press, criticism and self-criticism, and other forms of social education and administrative influence.

The administration and the trade union organizations should study the causes of violation of discipline and eliminate them.

Section 5. Organization and Servicing of the Work Station

The term work station, in production, means a part of the production area, with the equipment and related tooling located on it, which is used by the workmen to perform the labor process.

The organization of the work station is directed toward the creation of maximum convenience, allowing the labor process to be performed with the minimum expenditure of working time. This is achieved by rational tooling and correct planning of the work station, and by maintenance of order and cleanliness at the work station.

The rational tooling of the work station consists in providing for combined mechanization of the work. For instance, to reduce the time of inserting and attaching parts in a machine tool, and also for the removal of the part from the ma-

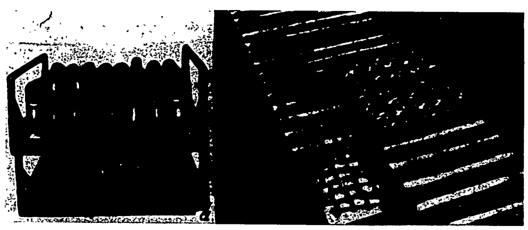

Fig.54 - Counting and Measuring Boxes

chine tool, quick-release clamps, signal and gang-tool attachments are used; to shorten the time for resetting the equipment, rapidly removable attachments are used, attachments with removable clamping parts and adjustable control dies; for feeding strips and profiles into a press, and for automatic loading of machines, automatic feeders and bunkers are used. Preference is given to equipment with push-button control; to shorten the time spent on measuring parts, single-measure gages or gages with electrical, pneumatic, or hydraulic indicators built into the equipment are used, including types which are automatically set to attain a predetermined accuracy of machining; for lifting heavy dies and attachments, inserting them in the press and removing them from the press, electric hoists or electric cars with a platform hoist are used; for delivery of a part or article to the next work station, various intermachine (local) and all-line transfer materials-handling devices are used.

For safety and convenience, the work stations are equipped with shield and protective devices, counting and measuring boxes (Fig.54), floor gratings; a small

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drum for holding oil cans, attachments, and tools; individual lighting; signals for summoning the service personnel; and handling devices for chip removal. The standardization of the main and auxiliary tooling of the work stations considerably reduces the cost of fabricating such tooling.

The planning of the work station (Fig.55) should encourage the economy of movement in work, take account of the convenient access to the machine in maintenance and repair, and the possibility of installation of materials-handling facilities; in planning one must bear in mind the necessity of economical use of space. In multi-machine tending, the equipment is so arranged that the path of the operator from machine to machine will be the shortest possible; in line work, the equipment is laid out in a chain following the cost of the technological process; the machines for processing long-rod materials are laid out at a mutual angle.

The maintenance of order and cleanliness at the work station is of considerable importance. Order in the arrangement of the parts and tools at the work station is determined by the fol-

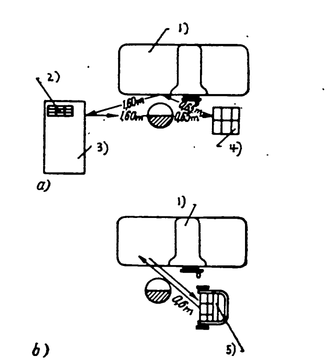
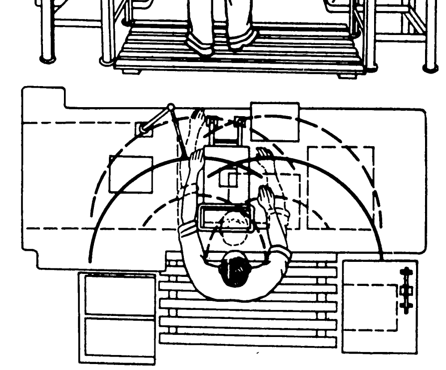


Fig.55 - Planning of the Work Station for a Turner

a - Incorrect; b - Correct

The path of motion of the machinist with the blank to the machine and with the finished part from the machine to the table of the dolly was 390 m per shift at an incorrect layout of the part, and was only 120 m at a correct layout of the part, i.e., it was shortened by 270 m

1) Lathe; 2) Parts; 3) Table; 4) Container with blanks; 5) Measuring dolly with parts and blanks



Legend:

- - - Zone accessible to hand on motion of the wrist

——— Zone accessible to hand outstretched sideways

— — Also with a small forward inclination of the body

Fig.56 - Zones of Location of Implements at the Work Station

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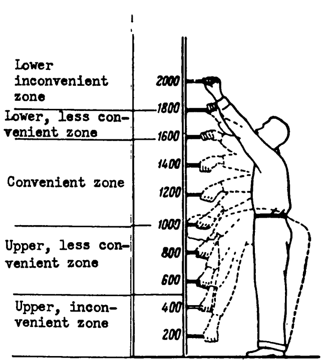
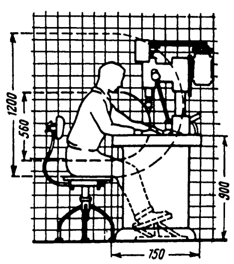


Fig.57 - Zones of Location of Work Stations with Respect to Height and Equipment Items in the Vertical Plane



Legend:

- - - Zone accessible to outstretched hand on motion in the vertical plane

——— Zone accessible to hand on motion of wrist in the vertical plane

Fig.58 - Correct Position of Operator's Body in Work on Bench Machines

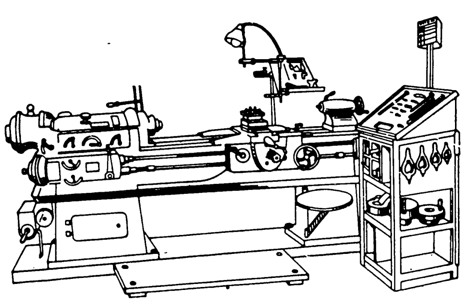


Fig.59 - Work Station of Turner in Piece Production

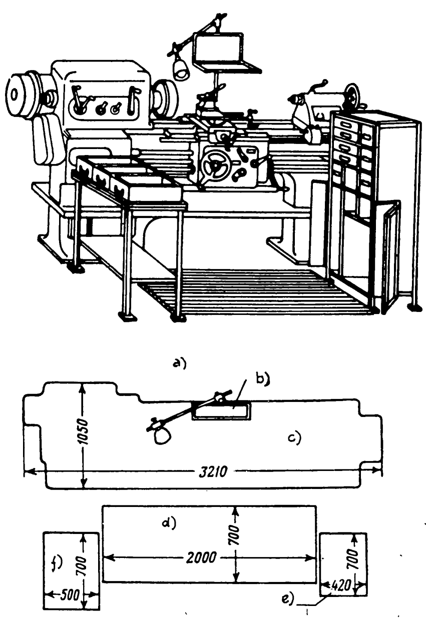


Fig.60 - Work Station of Turner in Series Production

a) Plan; b) Drawer for drawings and gage; c) Machine; d) Floor grating; e) Tool closet; f) Rack lowing elementary propositions: Everything must have its permanent place, all implements used frequently should be placed nearer, everything handled with the right hand should lie to the right, and everything handled with the left hand should lie

Fig.61 - Work Station of Crew on a Hydraulic Press

to the left. It is most convenient when the needed items are in a zone from which the operator can take them without bending, stretching, or turning his body (see Figs.56, 57, and 58). Maintenance of order at the work station helps the worker to develop rapid and automatic motions. Order and cleanliness are important elements in the organization of labor, discipline, and work without spoilage.

Simple and complex work stations are distinguished. At a simple work station the operator works on a single machine; at a complex work station one operator works at several machines (multiple-machine tender) or several operators work on one complex machine, press, or assembly stand.

A simple work station in piece production (Fig.59) is adapted for the performance of various operations, and therefore its equipment and tooling are universal. In this case, in organizing the work stations, provision is made for storage at that place of a list of tooling, materials, and blanks such that the workman does

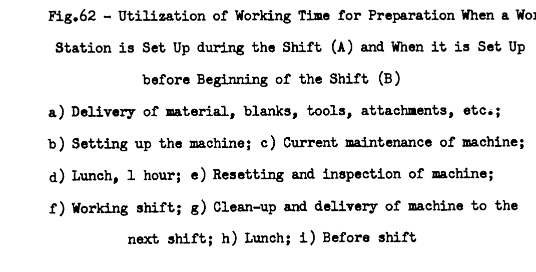


Fig.62 - Utilization of Working Time for Preparation When a Work Station is Set Up during the Shift (A) and When it is Set Up before Beginning of the Shift (B)

a) Delivery of material, blanks, tools, attachments, etc.;
b) Setting up the machine; c) Current maintenance of machine;
d) Lunch, 1 hour; e) Resetting and inspection of machine;
f) Working shift; g) Clean-up and delivery of machine to the next shift; h) Lunch; i) Before shift

not have to leave his station to go to the stockroom during his shift. A simple work station in series production (Fig.60) is equipped to perform definite operations; the corresponding tooling is supplied. A simple work station in mass production is prepared and tooled to perform one or two operations, so that its original tooling is reduced to the minimum and as far as possible built into the machine itself.

Complex work stations are widely used in stamping shops and especially in assembly shops. The hydraulic press is a typical example of a complex work station in the stamping shop. In advanced enterprises, a permanent crew is attached to a hydraulic press; the duties are so distributed among the members of this crew as to ensure uninterrupted operation of the press. The work station is equipped with containers, benches, racks with form-blocks and blanks (Fig.61).

An example of a complex work station in major assembly shops is the work station of the crew at an assembly stand. The work station is provided with an assembly jig, stepladders, portable tools, and hoses. In the major assembly of large components, places are assigned in each assembly zone for holding the sections, units, and parts to be attached in this zone. The workmen have portable boxes for tools and cartridge-holder containers for the rivets. A monorail carrier with a hoist is installed above the assembly jig, and is used for placing the section in the jig, for removing the assembly from the jig, and for its transfer to the following stage of assembly.

Organization of the Servicing at a Work Station. The problem of the most effective utilization of working time during production largely reduces to the problem of separating the service and auxiliary work from the main work, and of mechanizing the former. The machine must operate continuously, but this is possible only in the case where the operator is occupied solely with the main work; before beginning the shift, the equipment must be checked by the maintenance workers, and, if necessary, must be repaired; the preparer and stockroom clerks must make timely delivery of the materials, blanks, and tools to the work station; and the foreman must thoroughly instruct the operator on the work to be done, the day before the shift. Figure 62 shows the degree of utilization of working time with different systems of servicing. The work practice of production innovators shows that, when the preparation of the work stations is organized and if they are serviced without interruption during the shift, the output is far higher, owing to the elimination of idle time between shifts.

Section 6. Organization of Socialist Competition

Socialist competition is a regularity of development of socialist production; it expresses the new, communist attitude of people toward work, develops the feeling of comradely mutual aid, and helps to draw the laggards up to the level of the advanced workers.

With further development of the equipment and with the rising cultural and technical level of the workmen, socialist competition covers an ever widening area of the productive-economic activity of a socialist enterprise and assures an ever greater saving of living and materialized labor.

Socialist competition does not tolerate formalism, red tape, or replacement of living organizational work with people by the compilation of schedules and reports and by working out forms of accounting for the competitors.

The active forms of organization of competition at enterprises, and those involving the widest mass participation, are individual and crew competitions, whose basic indices should be overfulfillment of the output standard and improvement in the quality of the article.

In the course of socialist competition, numerous cadres of innovators and advanced workers of production have been formed and have shown examples of proper utilization of the new equipment and of good labor organization.

The dissemination of advanced experience is the prime desideratum in competition. Advanced methods of work must become the common property of all enterprises and workmen of the given trade.

The most practical forms of dissemination of advanced experience are the hand-down experience of individuals and crews within a shift, the exchange of working experience between shifts, and the mass instruction of workmen in advanced methods of work.

The individual or crew hand-down of experience consists in the advance STAT k-man demonstrating his method of work directly at his own work station to one or

Shop No.10	Name of Operator	Assignment for Day in Stand.Hrs.	Assignment for Month in Std.Hrs.	Socialist Obligations of Oper.,%	% Fulfilment of Assignm.a.Quality	1	2	3	4	5	6	Actual Fulfilment for Month	Causes of lag (Removable poster hung up daily and entered in Daily Record Book of Section)
Shift Foreman Comrade Petin, N.P.	Shift Foremen Comrades Kazakov, S.M. and Fadeyev, A.S.	Machine Setters Comr.______	Daily Performance of Fulfilment of Shift Assignment in ______ (Name of Month) with Estimate of Quality of Output (by Days)										
	Ivanov, P.S.	8	200	110	%	100	107	115	122	128	133		1 Oct. - Comrade did not master the working methods of a shift member
					Qual.								
II	Petrov, N.V.	8	200	115	%	120	130	101	131	130	135		3 Oct.- Comrade Petrov idle for 2 hours due to repair of machine tool (Machinist Vasil)
					Qual.								
I	Sidorov, A.K.	9	225	120	%	115	122	124	130	138	140		
					Qual.								
II	Korelev, M.N.	9	225	130	%	120	140	144	141	142	80		6 Oct-Comrade Korolev idle 3 hrs due to lack of material (Preparer Isayev)
					Qual.								
I	Zimin, A.S.	10	250	110	%	200	220	240	280	300	310		
					Qual.								
II	Gulyayev, I.A.	10	250	120	%	280	302	301	307	180	300		5 Oct-Drop of production due to poorly worked out process (Technologist Mirkin)
					Qual.								

Legend: -Suitable Product -Rejects

Fig.63 - Record Chart for Fulfilment of Assignments by Shift Workers

several workmen who perform analogous operations. Each workman individually repeats the methods of the advanced worker, and then suggests possible improvements. The conduct of this work is directed by the foremen and technologists. The individual or crew type of passing-on of experience must primarily cover the workmen who do not meet the output standards, showing them every cooperation in the improvement of their qualifications and in the mastery of the advanced methods of work. In this case the cadre workmen, who have built up an extensive production experience, play an important role.

At many aircraft plants, advanced experience is exchanged between workmen of different shifts. The shift foremen play a vital role here, organizing the competition and exchange of experience between the workers on adjoining shifts, eliminating the factors that interfere with the attainment of high output by the workers, and helping to uncover and utilize new reserves. Figure 63 is a record of the performance of shift assignments used in organizing a competition between shifts.

The following forms of socialist competition are highly important for the introduction of advanced work: organization of combined crews of workmen, foremen, technologists and designers for solving the current and prospective production problems; strengthening the creative collaboration between the engineering-technical workers and the production leaders; development of the movement of inventors and rationalizers.

The mass instruction of workmen in advanced experience is encouraged in the method developed by Engineer F.Ya.Kovalev, which has found wide application in machine-building, including the aircraft industry. This method, based on the study and generalization of the experience of advanced workers, is composed of the following stages:

1. Selection of objects, i.e., of operations and methods that are most widespread and contribute the greatest share to the labor cost of the article.
2. Selection of advanced workmen, who perform these operations most pro-

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Shop No.10	Shift Foreman Comrade Petin,N.P.			Shift Foremen Comrades Kazakov,S.M. and Fadeyev,A.S.							Machine Setters Comr.____		
	Name of Operator	Assignment for Day in Stand.Hrs.	Assignment for Month in Std.Hrs.	Socialist Obligations of Oper.,%	% Fulfilment of Assignm.a.Quality	Daily Performance of Fulfilment of Shift Assignment in ____ (Name of Month) with Estimate of Quality of Output (by Days) 1	2	3	4	5	6	(etc.)	Actual Fulfilment for Month	Causes of lag (Removable poster hung up daily and entered in Daily Record Book of Section)
I	Ivanov,P.S.	8	200	110	%	100	107	115	122	128	133			1 Oct. - Comrade did not master the working methods of a shift member
					Qual.									
II	Petrov,N.V.	8	200	115	%	120	130	101	131	130	135			3 Oct.- Comrade Petrov idle for 2 hours due to repair of machine tool (Machinist Vasil)
					Qual.									
I	Sidorov,A.K.	9	225	120	%	115	122	124	130	138	140			
					Qual.									
II	Korelev,M.N.	9	225	130	%	120	140	144	141	142	80			6 Oct-Comrade Korolev idle 3 hrs due to lack of material (Preparer Isayev)
					Qual.									
I	Zimin,A.S.	10	250	110	%	200	220	240	280	300	310			
					Qual.									
II	Gulyayev,I.A.	10	250	120	%	280	302	301	307	180	300			5 Oct-Drop of production due to poorly worked out process (Technologist Mirkin)
					Qual.									

Legend: ▥-Suitable Product ▤-Rejects

Fig.63 - Record Chart for Fulfilment of Assignments by Shift Workers

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1. Selection of objects, i.e., of operations and methods that are most widespread and contribute the greatest share to the labor cost of the article.
2. Selection of advanced workmen, who perform these operations most pro-

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ductively and whose work should be studied

3. Study, by observation, time-study, or preparation of descriptions, of the basic features of the work of each advanced workman.
4. Selection of the optimum methods, and on their basis, design of the most rational labor processes.
5. Compilation of description charts of the rational performance of operations.
6. Development and introduction of organizational-technical measures ensuring the tooling and organization of the work station in accordance with the process so developed.
7. Mass instruction of the workmen in the new methods of work.

Experience shows that Engineer Kovalev's method should primarily be applied to the operations of greatest labor cost and bulk. At aircraft construction enterprises, these will be the stamping, milling, welding, and riveting-assembly work.

For a socialist competition to become a mass competition and to penetrate into all production units, one must pass from the accomplishments of the individual leaders of production to the mastery of their methods by the whole collectives of sections, shops, and enterprises.

It is also important to organize the exchange of advanced experience between plants and to send engineering-technical workers and workmen to advanced plants for a thorough study of their favorable work experience.

The shop superintendents, foremen and crew bosses are the direct organizers and leaders of competition at an enterprise. The organization of socialist competition and the widespread dissemination of advanced experience of work are extremely important tasks for the administration and leaders of party, communist youth, and trade union organizations of the enterprise. The technical library plays an important role in the dissemination of advanced experience.

Section 7. <u>Calculation of the Cycle of Simultaneous Work of an Operator on Several Machines (Multiple Machine Tending)</u>

With the development of combined mechanization and automation of the labor processes, great possibilities are offered for the application of multiple-machine tending. This form of work is widely used in performing operations with a prolonged machine time. Multiple-machine work is characterized by the duration and structure of the cycle, i.e., by the period of time during which the process of work regularly recurs at each group of machines. Figure 64 is a graph of a cycle of multiple-machine work, from which the following conclusions may be drawn:

The simplest form of multiple-machine work is the performance of one and the same operation by one operator on several machines. In this case, the duration of the cycle is

$$C = T_M + T_H$$

The number of machines at which an operator can simultaneously work is calculated from the formula

$$n \leqslant \frac{T_M + t_H}{t_H + t_{ov} + t_{obs} + t_{tr}}.$$

In these formulas, T_M is the duration of the machine-automatic elements of the operation;

t_H is the duration of the hand and machine-hand elements of the operation that do not overlap with the machine-automatic time on a given machine;

t_{ov} is the duration of hand and hand-machine elements of operation, overlapping with the machine-automatic time on a given machine;

t_{obs} is the duration of observation on work of the machine after turning on the automatic feed;

t_{tr} is the duration of transition from machine to machine.

The use of multiple-machine work is particularly complicated in multistep operations, demanding repeated return of the operator to the machine in processing one and the same part.

When operations of different structure and duration are performed on several

Fig.64 - Graph of Cycle of Multiple-Machine Work

machines, the length of the cycle of the multiple-machine tender is determined by the longest operation.

If the worker is performing operations of different types on several machines, then multiple-machine operation is associated with the practice of several specialties.

Section 8. Collective Contract

A collective contract is concluded between the plant administration and the factory-plant committee of the trade union, and contains the obligations of both parties.

In capitalist enterprises, a collective contract is a means for the workers of the given enterprise to protect their rights won from the factory owner. Here the interests of the two sides are antagonistic.

In a socialist enterprise, both sides belong to the same class, their interests

are the same and are directed toward the improvement of all aspects of the activity of the enterprise. Here the collective contract represents a bilateral agreement and consists of the following subdivisions: obligations of the administration and plant committee in fulfillment and overfulfillment of the State production plan in all indices; wages and output standards; personnel training at the enterprise and improvement of their qualifications; State and labor discipline; housing and living conditions; labor supply and cafeteria facilities; labor protection and cultural services.

Each of these divisions contains definite obligations, and specifies concrete measures. The collective contract is drawn for one year and is first discussed at general meetings of the collective.

It is necessary, in discussing a draft collective contract, to listen attentively to all comments of the workmen and employees, to ensure extensive discussion of all amendments and additions to the draft, and to use the work, on realization of the measures prescribed by the collective contract, as the foundation of labor union work in the enterprise.

Section 9. Discussion of Labor Disputes and Prime Functions of the Commission on Labor Disputes

The Soviet labor legislation prescribes three procedures for settlement of labor disputes: conciliation, administrative, and legal.

Conciliation procedure means the discussion of labor disputes in a committee for labor disputes (KTS) of the enterprise, or its shop (conciliation). If agreement is not reached in the KTS, the case may be submitted to a court.

Administrative procedure means the discussion of labor disputes by officials of superior agencies (superior with respect to the enterprise or institution at which the labor dispute originated).

Legal procedure means the consideration of labor disputes by the people's court and by the judicial body of appellate jurisdiction.

The KTS is organized at enterprises, and also at shops, having shop labor union committees. The KTS is a parity agency consisting of two parties represented by equal numbers of delegates and having equal rights: the workmen's delegation, appointed by the shop or plant committee, and the administration delegation, appointed by the shop superintendent or the enterprise director, as the case may be. The chairman and secretary of individual sessions of the KTS are appointed alternately by the parties. The positions of chairman and secretary of a session may not both be held by representatives of the same party (side). In accordance with the regulations on plant and shop commissions on labor disputes, disputes on the following questions are subject to obligatory review: transfer to other work and maintenance of earnings in connection with that transfer; payment of a crew for unfinished piecework or for preparation for its performance, stoppage, underfulfillment of standards, rejected work, overtime work, performance by one worker of the work of a workman of different qualifications; discharge for unfitness and for failure to perform duties; deductions from wages for damage caused to the enterprise; satisfaction of the daily material wants of workers (failure to perform obligations under the collective or labor contract), and others.

The following subjects are excluded from the competence of the KTS: cases on discharge and reinstatement of persons exercising the right of hiring and firing; changes in the position and personal salaries and base-pay rates; establishment or change of the tables of organization; disputes connected with the provision of housing space and satisfaction of the material wants of the workers, if the case is not connected with obligations under the collective contract; cases pending in court; cases on disciplinary fines, imposed for infraction of the rules of internal order. The KTS is obligated to consider labor disputes within a five-day period.

CHAPTER VII

ORGANIZATION OF THE TECHNICAL STANDARDIZATION OF LABOR AT THE AIRCRAFT CONSTRUCTION ENTERPRISE

A technically justified standardization is an exact and objective method of determining the measure of labor. The basic task of the technical standardization at an enterprise is to establish the consumption of labor time necessary for the production of unit product or for performing a definite volume of work.

In production, technical standards are necessary in order to determine the labor consumption for production of the product, to calculate the requirements of the enterprise for workmen, equipment and area, to eliminate lack of personal responsibility for labor standards and wages. Without advanced technical standards it is impossible to conduct a planned economy, to maintain proportionality of its parts and to organize labor correctly at the enterprise. Technical standards encourage the development and improvement of the technique of production, and draw the lagging workmen up to the level of the advanced ones. The technically justified standardization of labor forms a link between technology and economics of production, and the social and personal interests of its workers, and is an extremely important factor in improving the technique and organization of production.

An important task today is the replacement of the experience-statistical time standards by technically justified time standards and earning standards, which most fully reflect the accomplishments of science and technology and the advanced experience of the innovators of production.

One of the fundamental tasks of the managers of enterprises is to create the technical and organizational conditions for all workmen to ensure fulfillment and overfulfillment of technically justified standards.

Section 1. Technical Standard Time and Standard Output

The time in which a worker should perform the work assigned to him is called the standard time. Consequently the standard time is a measure of labor productivity. Such a standard time is calculated, with allowance for mechanization of labor of the operator; increase in his technical and cultural level; correct structure of the labor process; efficient organization of the work station and of its servicing. A progressive standard is established in accordance with the concrete conditions of each enterprise and occupies a position intermediate between the record output of the advanced workmen of the enterprise and the average output of the remaining workers who meet the standard.

A technically justified standard time is established on the basis of the operation.

An operation is the part of the technological process which is performed by a single workman or a group of workmen at a single work station and covers all the successive actions of the workman on a part or a group of parts until change-over to work on the next part or group of parts. An operation is characterized by constant labor process, object of labor, and equipment.

For a rational performance of operations and for measurement of the duration of their elements, in technical standardization, operations are broken down into the following elements:

Processing operations into steps, passes, groups of elements, elements, and working motions;

Assembly, installation-adjustment, shaping and similar operations, into elements and working motions.

A step is a part of an operation during which one and the same surface is processed with one and the same tool, at constant operating condition of the equipment. In hand work, a step is characterized by the constancy of the treated surface or of the tool.

A pass is that part of a step during which a layer of metal is removed. A pass consists of a group of elements, in which only a single basic (technological) machine or mechanized element enters, together with several related auxiliary elements related to it and ensuring its performance.

The performance of an operation by a workman is composed of various purposeful working motions which, for convenience of standardization, are combined into an element, and these elements are in turn combined into a group of elements.

A working motion is the simplest fundamental element of the labor process and represents a single action of the workman (for instance "extend hand", "take workpiece", "transport workpiece to chuck").

An operation element is a group of working motions correlated by a single purpose. Elements may be primary and auxiliary. The technological purpose of a given operation is attained by means of primary (technological) operation elements. For instance "grind", "countersink". Auxiliary elements ensure the performance of the primary elements. For instance, "insert blank in chuck", "set cutter", "remove cutter".

A group of operation elements is a group of elements combined into a group according to a technological criterion. For instance, "remove machined part and insert a new blank". The technological group is characterized by the strict sequence of performance of the elements, in accordance with the technology of processing or assembly.

The degree of breakdown of an operation into its component elements depends on the type of production. In formulating the technological process in mass production, an operation is broken down into elements and motions. In series production, only the mass operations are broken down into elements, while the remaining operations are broken down into groups of elements. In a development enterprise, a consolidated standardization is used, by groups of elements or by the operation as a whole. Naturally, the precision and justification of the technical standards in

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these types of production varies.

The working time, meaning the established duration of a working shift, is divided into time for work and time for breaks.

The time for work includes the setting-up and clean-out time; the operative time and the time of servicing the work station. The operative time in turn is composed of primary and auxiliary time. The time for breaks in work includes the breaks for which the operator is responsible and breaks for which he is not responsible. The latter includes the time for his natural needs and, in some cases, for rest.

Differentiation is made between standard piece time, standard piece-calculated time, and standard batch time.

The standard piece time T_p defines the duration of the time to perform an operation on one piece or unit and is composed of the expenditure of primary time T_o, auxiliary time T_a, service time T_{serv}, and the time of breaks for rest and natural needs T_{rest}:

$$T_p = T_o + T_a + T_{serv} + T_{rest}$$

The primary (technological) time is the time during which the change in the processed or assembled article, prescribed by the process chart, takes place. The primary time may be: a) machine time, if the changes in the article prescribed by the process chart are accomplished by a machine without participation of the workman; b) machine-hand time, if the change in the article is accomplished by a mechanism with direct participation of the operator, for instance, work on machines with hand feed, drilling with pneumatic and electric drills; c) hand time, if the change in the article is produced by the operator manually, without participation of a mechanism. The primary time in each form of work (casting, forging, machining, fitting, welding, assembling) is calculated with consideration of the specific features of the process of the given form of work.

Auxiliary time is time spent by the operator in performing auxiliary operation elements which recur with each article processed or in a definite sequence, after a

certain number of such articles. The auxiliary operation elements include the following: pick up part, insert part, attach part, start machine, bring tool to part and remove it from part, stop machine, measure part, release part, remove and dispose of part, switch speed or feed of machine, readjust tool. The auxiliary time may be hand, machine-hand, and machine. In designing the technological process it is important to minimize the time spent on auxiliary operation elements, and to mechanize such elements.

Time of servicing the work station is the time spent by the operator in caring for the work station, maintaining it in order and keeping it clean. This time is divided into the time of technical servicing spent on replacing a dulled tool, adjusting the tool, fine resetting of the equipment during the process of work, lubricating and cleaning the equipment; time of organizational maintenance, spent on distributing and cleaning the tools at the beginning and end of the shift, on inspecting and testing the equipment, and on sweeping up the chips.

The time for natural needs is allowed in all cases of work, and time for rest in all cases except in work with a long machine time, which may be used for rest.

The time standard per batch of parts T_{batch} is established in processing parts or units in batches, and includes the piece time per part T_p, the number of parts n, and the setup and cleanout time $T_{s.c}$. The batch standard time is calculated by the formula

$$T_{batch} = (T_p \times n) + T_{s.c}$$

The setup and cleanout time covers the preparation of the operator and his work station for machining a batch of parts. It includes the time spent by the operator in familiarizing himself with the assignment and technical documentation, in receiving instructions from the shift foreman, in preparing the work station and in setting up the equipment, and in removing the tools and attachments after completion of the assignment. This time is characteristic for the production sections at

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which more than one shift is worked at a work station, which is usually the case when parts are processed in batches. The setup and cleanout time does not depend on the size of the batch being processed, and is usually calculated in percent of the operative time.

The calculated standard piece time $T_{p.c}$ is the standard time for one part or unit, taking account of the setup and cleanout time. This standard time is determined by the formula

$$T_{p.c} = T_p + \frac{T_{s.c}}{n}$$

where $\frac{T_{s.c}}{n}$ is the setup-cleanout time related to a single part.

Not one of these forms of standard time includes the overlapping time, i.e., the time of the elements performed either during the machine time or parallel, i.e., simultaneously, with other operation elements. In the latter case, the standard time will include only one, the longest, element, of the overlapping elements.

The standard output defines the amount of work in unit time and is a quantity inversely proportional to the standard time. The standard output is usually established for a shift, and is calculated for the operations without setup and cleanout time by the formula $N_{out} = \frac{T_{sh}}{T_p}$ and for operations with setup and cleanout time by the formula

$$N_{out} = \frac{T_{sh}}{T_{p.c}}$$

The relation between the standard time and the standard output is expressed by the formula

$$y = \frac{100x}{100 - x}$$

where y is the increase of the standard output in percent;

x is the decrease of the standard time in percent.

Example. The existing standard piece time for a part is 20 min. By how many percent must the standard output be increased in order to increase the labor productivity by 20%? Let us solve this problem as follows:

1. On increasing the labor productivity by 20%, the new standard time will be

$$20 - (20 \times 0.2) = 16 \text{ min}$$

2. With the new time standard, the output of the operator per shift will be 480 : 16 = 30 parts.

3. By comparison with the previous standard output per shift (480 : 20 = = 24 pieces), the new standard output with the new standard time is greater by 30 - 24 = 6 pieces or by $\frac{6}{24}$ 100 = 25%.

Solving this example by means of the above formula we obtain the same result:

$$y = \frac{100 \times 20}{100 - 20} = 25\%$$

The quality of the standard output largely depends on the specialization of production and the method of standardization.

Peculiarities of the calculation of the standard piece time for fitting work. Fitting work includes cutting, chipping, filing, scraping, thread-cutting, chamfering and removal of lugs. For these types of fitting work, the time standards are calculated by standard Tables.

The standard Table of primary technological time for fitting work is worked out in two stages. The first stage is the classification of the separate forms of work and of the factors affecting the time they take. The second stage is finding the relationship between the change in the value of a factor and the change in the time taken by the work. For instance, the filing time for one square centimeter of material, with the same shape of the processed surface and the same material, depends on the width of the surface, the depth of the filing, and the fineness [redacted] the filing. These relations are found analytically; for instance, the relation between

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the time T and the width of filing W at constant depth is expressed by the formula

$$T=\frac{C}{W^{x}},$$

where C is the depth of filing, in mm;

x is a factor depending on the conditions of the work.

This relation is established for each specific type of surface and form of materials and is expressed by a straight line, when plotted in logarithmic coordinates.

The working out of standard Tables of duration of the auxiliary operation elements of fitting work is based on the determination of the typical operation elements (pick up part, clamp it in the vise, pick up production tool, remove production tool, release part, pick up gage, verify surface processed, remove gage, remove part) and the establishment of the duration of these operation elements in accordance with the influence of various factors.

As a result of the fact that fitting operations are brief and are done mainly by hand, the standard times for fitting work in series production are found from standard Tables, calculating the standard times not by operation elements but by groups of operation elements, and by combining the group of auxiliary operation elements with the primary process operation elements. In percent of this operative time, the time for servicing the work station, for rest, and for natural needs is established.

Features of Computing Standard Piecework Time for Drilling and Riveting Work. The process of joining individual metal parts and units of aircraft by rivets includes drilling the rivet holes, countersinking or punching the holes for the rivet head, inserting the rivet in the hole, clamping the riveted material, and riveting.

The primary time in drilling is determined from the formula

$$T_o=\frac{\delta+k_1D}{nsk_2k_3},$$

where δ is the thickness of the drilled layer of material, in mm;

k_1 is a factor characterizing the material; it is taken as 0.31 for duralumin and steel with an ultimate strength of less than 125 kg/mm^2, and 0.18 for steel of greater ultimate strength;

D is the diameter of the drill, in mm;

n is the idling rpm of the drill;

s is the feed per revolution of the drill, in mm;

k_2 is a factor allowing for a decrease in drill rpm during drilling (equal to 0.8);

k_3 is a factor allowing for decrease of feed rate at various ratios between the drill diameter and the depth of drilling, owing to inadequate removal of the drillings and the need for removing the drill during the time of work (usually equal to 1 to 0.7).

The auxiliary time connected with drilling each hole includes the time for performing a number of operation elements: positioning the drill at the point of drilling, removing the drill from the hole, and moving the part or drill by the rivet pitch. On the basis of the data on the primary and auxiliary times, Tables are compiled showing the standard operative time for drilling (cf., for instance, Table 14).

The primary time for riveting is determined in accordance with the diameter and material of the rivets by the formula:

$$T_o=\frac{A_d}{A_{d.imp}n}k$$

where A_d is the work of deformation necessary for clenching the rivet head, in kg-m;

$A_{d.imp}$ is the work of deformation of one hammer impact, in kg-m;

n is the number of hammer blows, in min;

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Table 14

Standard Tables of Operative Time in Drilling Duralumin with D-2

Pneumatic Drill with Guide Holes

Work Procedure	1. Set Drill in Hole 2. Drill 3. Remove Drill from Hole 4. Shift Drill by Pitch up to 50 mm

No.	Position of Operator	Depth of Hole, in mm	Drill Diameter in mm								
			2,1	2,5–2,7	3,1	3,6	4,1	5,2	6,2	7,2	8,2
			Time for 1 Hole, in mm								
1	Free	1	0,026	0,025	0,025	0,025	0,026	0,033	0,040	0,049	0,064
2		2	0,029	0,028	0,028	0,028	0,029	0,038	0,047	0,058	0,077
3		3	0,033	0,031	0,030	0,030	0,032	0,043	0,054	0,067	0,089
4		4	0,039	0,034	0,033	0,033	0,035	0,048	0,061	0,077	0,102
5		5	0,042	0,039	0,036	0,035	0,037	0,053	0,067	0,086	0,114
6		6	0,050	0,042	0,040	0,038	0,040	0,058	0,075	0,095	0,127
7		7	0,054	0,049	0,043	0,042	0,043	0,063	0,081	0,104	0,139
8		8	0,061	0,052	0,050	0,045	0,049	0,068	0,088	0,113	0,152
9		9	0,067	0,056	0,052	0,048	0,051	0,073	0,095	0,122	0,164
10		10	0,074	0,063	0,056	0,055	0,055	0,084	0,111	0,145	0,177
11		12	—	—	0,061	0,057	0,066	0,095	0,130	0,166	0,202
12		14	—	—	—	—	0,072	0,117	0,152	0,210	0,230
13		16	—	—	—	—	0,084	0,130	0,174	0,223	0,278
14		18	—	—	—	—	0,091	0,142	0,190	0,245	0,305
15		20	—	—	—	—	0,114	0,164	0,207	0,265	0,334
16	Crowded	1	0,033	0,032	0,031	0,031	0,033	0,041	0,050	0,061	0,080
17		2	0,036	0,035	0,035	0,035	0,036	0,048	0,059	0,073	0,096
18		3	0,041	0,039	0,038	0,038	0,040	0,054	0,068	0,084	0,111
19		4	0,049	0,043	0,041	0,041	0,044	0,060	0,076	0,096	0,128
20		5	0,053	0,049	0,045	0,044	0,047	0,066	0,084	0,108	0,143
21		6	0,063	0,053	0,050	0,048	0,050	0,073	0,094	0,119	0,159
22		7	0,068	0,061	0,054	0,053	0,054	0,079	0,101	0,130	0,174
23		8	0,076	0,065	0,063	0,056	0,061	0,085	0,110	0,141	0,190
24		9	0,084	0,070	0,065	0,060	0,064	0,091	0,119	0,153	0,205
25		10	0,093	0,079	0,070	0,069	0,069	0,105	0,139	0,181	0,221
26		12	—	—	0,076	0,071	0,083	0,119	0,163	0,208	0,252
27		14	—	—	—	—	0,090	0,146	0,190	0,263	0,287
28		16	—	—	—	—	0,105	0,163	0,218	0,279	0,348
29		18	—	—	—	—	0,114	0,178	0,238	0,306	0,381
30		20	—	—	—	—	0,143	0,205	0,250	0,332	0,418

Note. In drilling on layout, 0.01 min must be added for each hole to the time indicated in the Table.

Table 15

Standard Table of Operative Time for Straight-Row Riveting with

Elastic Rivet Bucker

Method of Riveting – Straight
Shape of Swage Head – Spherical
Shape of Clenching Head – Flat

Procedure of Work	1. Insert Rivet in Hole 2. Set Bucker on Rivet 3. Place Rivet Set on Rivet Shank 4. Tighten 5. Change Rivet Set 6. Position Rivet Gun on Rivet Shank 7. Rivet 8. Change Clamp 9. Shift Rivet Gun by Pitch of Up to 50 mm

№	Type of Bucker	Position of Riveter	Positioning of Tool	Rivet Material	Group of Rivet Guns								
					I	II	III		IV		V		
					2KM UM1 M1	4KM 5KM	M3		7KM		8KM		
					Diameter of Rivets, in mm								
					2–2,6–3	3,5–4	5	6	7	8	9	9,5	10
					Time for 1 Rivet, in min.								
1			Free	D18	0,063	0,065	0,069	0,076	0,090	0,109	0,129	0,140	0,153
2				D16	0,065	0,068	0,073	0,083	0,100	0,124	0,149	0,161	0,174
3				Steel 15	0,065	0,070	0,080	0,099	0,121	—	—	—	—

4	Elastic	Free	fr.Top	D18	0,073	0,075	0,079	0,086	0,100	0,119	0,139	0,150	0,163
5				D16	0,075	0,078	0,083	0,093	0,110	0,134	0,159	0,171	0,184
6				Steel 15	0,075	0,080	0,090	0,109	0,131	—	—	—	—
7			fr. Bottom	D18	0,113	0,115	0,119	0,126	0,140	0,159	0,179	0,190	0,203
8				D16	0,115	0,118	0,123	0,133	0,150	0,174	0,199	0,211	0,224
9				Steel 15	0,115	0,120	0,130	0,149	0,171	—	—	—	—
10		Cramped	fr.Side	D18	0,083	0,085	0,089	0,096	0,110	0,129	0,149	0,150	0,173
11				D16	0,085	0,088	0,093	0,103	0,120	0,144	0,169	0,181	0,194
12				Steel 15	0,085	0,090	0,100	0,119	0,141	—	—	—	—
13			fr.Top	D18	0,093	0,095	0,099	0,106	0,120	0,139	0,159	0,170	0,183
14				D16	0,095	0,098	0,103	0,113	0,130	0,154	0,179	0,191	0,204
15				Steel 15	0,095	0,100	0,110	0,129	0,151	—	—	—	—
16			fr. Bottom	D18	0,148	0,150	0,154	0,161	0,175	0,194	0,214	0,225	0,238
17				D16	0,150	0,153	0,158	0,168	0,185	0,209	0,234	0,246	0,259
18				Steel 15	0,150	0,155	0,165	0,184	0,206	—	—	—	—

Table 16

Time for Servicing Work Station, Rest, and Natural Needs

a)	b)	c)					
		d)				e)	
		f)		g)			
		h)		h)		h)	
		i)	j)	i)	j)	i)	j)
	I. Servicing Work Station						
1.	Preparation of Rivet Gun and Air Line for Work	3,0	0,70	3,0	0,70	1,0	0,22
2.	Setting Tool, Adjusting and Setting up Press and Suspensions	—	—	—	—	3,0	0,67
3.	Familiarization with Work and Receipt of Instructions during the Working Day. Procurement of Tool in Exchange of Dull One	2,0	0,46	2,0	0,47	2,0	0,45
4.	Delivery of Work	5,0	1,14	5,0	1,17	3,0	0,67
5.	Preparation of and Cleaning out Work Station	3,0	0,70	3,0	0,70	3,0	0,67
	Total	13,0	3,0	13,0	3,04	12	2,68
	II. Breaks for Rest and Natural Needs	30,0	7,0	38,0	8,92	20,0	4,4
	Total Time for Servicing Work Station, Rest, and Natural Needs	43,0	10,0	51,0	~12	32,0	~7

a) No.; b) Type of elements of time expenditure; c) Kind of work; d) Drilling and riveting with rivet gun; e) Riveting and punching holes with squeezed riveters; f) On tables and benches; g) Assembly jigs; h) Time; i) In min; j) In percent of operative time

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k is a factor characterizing the type of support.

By means of this formula, Tables of the primary time for riveting with riveting guns are compiled.

The auxiliary time in riveting with hand riveting guns depends mainly on the method and form of riveting, and is also tabulated. The auxiliary time in riveting with squeeze riveters depends on the method of setting the rivet, the method of holding the part or unit, and its dimensions.

In standardizing the drilling and riveting of units, the operative time is obtained by multiplying the operative time for drilling one hole or riveting one rivet by the number of rivets in the part or unit, adding to the product so obtained the time for all auxiliary operation elements connected with the part or unit as a whole, i.e.,

For drilling: $T_{op} = t_{op.hole} \times n + T_a$;

For riveting: $T_{op} = t_{op.riv} \times n + T_a$

Table 15 gives an example of a standard Table of operative times for riveting.

The standard piece time for drilling and riveting is calculated by the formula

$$T_p = T_{op} \left(1 + \frac{k}{100} \right)$$

where k is the sum of the time for servicing the work station, rest, and natural needs, in percent of the operative time (taken from Table 16).

Section 2. Methods of Establishing Standard Time

Two methods are used to establish the standard time: total and analytical-computational.

The total method of standardization consists in establishing the standard time for the operation as a whole by the experience-statistical method, on the basis of the personal experience of the standardizer or by comparing the work being standardized with similar work done earlier in the unit. In this method there is no measurement, analysis nor calculation of the duration of the elements of time making up the operation. The time standards established from statistical data are usually too high, since they start from the level of the old technique and include all the losses that formerly existed in the production.

Experience-statistical standards lead to the application of exaggerated tariff categories for the work performed, to the piling up, over the base-pay rates, of every type of invented bonus payments and correction factors, holding back the growth of labor productivity. Such standards push production backward and do not encourage the utilization of its reserves.

The use of experience-statistical standards and of the total method of standardization was condemned by the Central Committee of the Party even before the December Plenum of 1935. The 19th Party Congress pointed out the necessity of rapid transition of enterprises to technically justified standards of time and output.

In series-aircraft production the experience-statistical standards should be replaced by technically justified standards, established by the analytical-computational method.

This same method is applicable to aviation development work in establishing technically justified standards for typical operations or for unified parts. In calculating the standard times for unified parts, the standardizer first selects a typical representative of this group, establishes the time standard for it, and then compares each part with a typical representative and, in accordance with the value of the deviations, corrects the standard.

The analytical computational method is a method of calculating the standard time according to technical standard Tables, allowing for a rational organization of labor and the work station. The prodedure in the work of establishing standard times by the analytical computational method is as follows: analysis of the structure of the operation by breaking it down into its component elements; study of the productive possibilities and establishment of the optimum operating conditions for the equipment; designing the most rational execution of the operation; establishing the time standards from its component elements.

The standard piece time is calculated by the analytical-computational method, using the formula:

$$T_p = T_{op} \left(1 + \frac{k_1 + k_2 + k_3}{100} \right)$$

where k_1 is the ratio of the time for the technical servicing of the work station to the operative time, in percent (most often taken in percent of the primary time);

k_2 is the ratio of the time for the organizational maintenance of the work station to the operative time, in percent;

k_3 is the ratio of the time for rest and natural needs to the operative time, in percent.

Consider the technique of calculating the individual elements of the standard piece time.

The primary time in work on all metal-cutting machines is calculated by the formula

$$T_o = \frac{L}{s} i = \frac{l + l_1 + l_2 + l_3}{s_0 n} \cdot \frac{h}{t},$$

where L is the path traveled by the tool or workpiece in the direction of the feed, in mm or m (depending on the kinematics of the machine);

s is the feed rate per minute, of the tool or workpiece, expressed in mm or m;

i is the number of passes of the tool or workpiece for removal of the machining allowance;

l is the dimension of the machined surface of the workpiece in direction of the feed, in mm;

l_1 is the size of cut of the tool in mm, depending on the parameter of the enclosed cutting part of the tool, the dimensions of the surface being machined, and the individual elements of the cutting conditions;

l_2 is the overrun of the tool or workpiece in direction of the feed; this quantity is not taken into account if the machining is done against a stop;

l_3 is the additional length to obtain test shavings; for machines already set up, l_3 does not enter into the standard;

n is the rpm in rotary motion, $n = \frac{v \cdot 1000}{\pi \cdot d}$, or number of double strokes with reciprocating motion, $n = \frac{v_{d.s} \cdot 1000}{2L}$, in min;

d is the diameter of the workpiece surface being machined, in mm;

s_o is the feed of the tool or workpiece per revolution or double stroke, in mm;

h is the machining allowance;

t is the depth of cut for a given pass.

The values of s and n obtained by calculation are compared with the corresponding values in the rating sheet of the machine tool, and the values nearest the calculated value are taken from it.

The basic components of this formula in the analytical-computational method are taken from the drawing of the part, from the process chart, from the machine rating sheet, and from the standard Tables of the NIAT or the enterprise for the given form of work (Bibl.22).

The auxiliary time is calculated as follows: First, all the operation elements are found for the operation and are divided into non-overlapping and overlapping. The non-overlapping operation elements are reduced to groups of elements, and for each such group the standard time is taken from the corresponding standard time Tables for auxiliary work.

The time of organizational maintenance, the time for rest, natural needs and the setup-cleanup time are taken from the corresponding standard Tables.

In mass and series production, the standard time for the mass operations derived by the analytical-computational method, is refined experimentally at the technological plant laboratory or at the shop.

In this case the equipment, attachment, and tools are studied from the viewpoint of economy of the cutting conditions used and possibility of reducing the auxiliary and machine-hand time; the labor process, from the viewpoint of correct construction of the labor operation elements and elimination of superfluous elements; the work station, from the viewpoint of its suitability for convenient, safe, and high-productivity work. On the basis of an analysis of the existing labor conditions, the standard times are drafted with the object of utilizing the hidden reserves and establishing a progressive standard time for the operation.

The systems of machining obtained by calculation and the cutting forces generated under these conditions are compared with the capabilities of the equipment, and are then verified experimentally at the cutting laboratory or at the shop. If the calculated cutting conditions are confined by the experience of the advanced workers, they are not experimentally verified. The time of servicing and rest is established from a photographic recording of the working day (shift-time study).

The standard time, refined experimentally, is better founded and more rational, since it is based on the optimum conditions of labor organization, labor mechanization, and organization of the work station.

Section 3. Methods of Studying the Consumption of Man-Hours by Observation

In the practice of the technical standardization of hand work and of the individual operation elements, two methods of studying the consumption of man-hours by observation are widely used; these are the photographic time study and the stopwatch time study. The methods may be used separately or jointly. Each of these methods helps to uncover and utilize the reserves of labor productivity.

The photographic time study is a method of studying, by observation and measurement, all expenditures of working time, without exception, during a shift or during some parts of a shift. The study is performed to ascertain the nonproductive expenditures of working time and to work out organization-technical measures to eliminate such losses; to determine the number of workmen necessary for servicing the units and machines; and, in the crew form of work, to establish the number of workmen and the division of work between them; to establish the standard time tables for the performance of the setup-cleanout and servicing work and for the regulation breaks; to study and disseminate the experience of advanced workmen.

To obtain a photographic record of the working day, first of all the object is selected and prepared for observation; this is followed by observation, work-up, and analysis of the results, after which measures to improve the utilization of working time are developed.

The selection of the object and its preparation for observation depend on the purposes of the study. If the study has the object of defining the causes for nonfulfillment of the standard by workmen, a workman who does not meet the standard is selected. If the study has the object of ascertaining the loss of working time during a shift, then sections or work stations at which the greatest such losses have been recorded are selected. In this case, neither the workman nor his work station are prepared, since the photographic study should reflect the pattern of the usual work shift with all of its favorable and unfavorable sides. If, however, the photographic study is being made to investigate the experience, the establishment of standard time tables, the organization of labor within the crew, or at the initiative of the workman himself, then the corresponding preparation of the workman and his work station are undertaken.

The preparation for observation has the object of familiarizing the time-study man with the condition of the technique and organization of production at the work station where the photographic study will be made. On the basis of this briefing, the observer fills out the face side (the title part) of the shift time study.

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Table 17

Plant No. / Shop No. / Work Shop	Chart of Individual Photography of Working Day	Observer	Shcherban'

Observation Sheet No.	Date	Shift	Beginning of Observation	End of Observation	Duration of Observation
1	28 October 1955	1	0700 h	1605 h 20 sec	8 hr 5 min 20 sec

Workman						Equipment		
Observation Sheet No.	Name	Time Card Number	Category	Specialty	Experience	Type of Equipment	Inventory No.	Technical Condition
1	Baukhina	1517	4	Riveter	6 years	Fitter's vise SD-8 pneumatic drill TsIT rivet gun	256 143 12510	Excellent

Work									Tools and Equipment
Observation Sheet No.	Type of Operation (Work)	Type and Number of Article	Category of Work	Number of Parts in Order	Establ. Standard in min	Output: Suitable	Output: Rejects	% Fulfilmt. of Standard	Designation Number, Characteristic
1	Detail assembly of bulkhead No.8	Bulkhead No.2530	4	20	12	20	–	100	
	Detail assembly of bulkhead No.9	Bulkhead No.82722	4	20	12	20	–	100	

Organization and Servicing of Work Station

ystem of Layout of Equipment, Tools, Workpieces, Finished Parts.......... Typical, Normal for Bench Assembly

aterials Handling Facilities... Unnecessary

rocedure for Receipt and Delivery of Work................................ Issued and Accepted by Foreman

rocedure for Supply of Tools, Attachments, Material and Workpieces....... Receipt and Delivery of Tools and Attachments are the Duty of the Assembler-Riveter Himself; the Workpieces are Delivered by a Specially Assigned Helper

rocedure for Setting-Up and Fine Setting-Up of Equipment and for ool Grinding.. None

Procedure for Servicing Equipment with Minor Repairs and Lubrication...... By Assembler-Riveter Himself

Summary of Observations and Analysis of Time Balance

Category of Working Time	Type of Time Expenditure	Index	Duration in min. When Observed: 1	2	3	4	Total	Average Time	In % of Observation	Standard Time	Excess Time
Setup and cleanout time	Familiarization with work and work drawing	PZ-1									
	Setup of equipment	PZ-2									
	Installation and removal of tool	PZ-3									
	Installation and removal of attachment	PZ-4	0.33				0.33	0.33	0.07		
	Receipt and delivery of tool and attachments	PZ-5	14.83				14.83	14.83	3.05		
		PZ-6					–	–	–		
		PZ-7									
	Total		15.16				15.16	15.16	3.12	7.20	7.96

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(cont'd)

Category of Working Time	Type of Time Expenditure	Index	1	2	3	4	Total	Average Time	In % of Observation	Standard Time	Excess Time
Primary time	Machine Time (observation on untended running)	OS-1	-				-	-	-	-	-
	Machine-Hand work	OS-2	215.5				215.5	215.5	44.20	-	-
	Hand Work	OS-3	195.0				195.0	195.0	40.38		
	Total	T_0	410.5				410.5	410.5	84.58		
Auxiliary Time	Install and Remove Parts	VS-1 VS-2 VS-3	- - -				-	-	-		
	Total	T_a									
	Including Overlapping Machine time	Pk_1									
	Total time of operative work	T_{op}	410.5				410.5	410.5	84.58	456.0	
Time of servicing work station	Disassemble and Collect Tools, and Test Equipment	00-1	-				-	-	-		
	Grease and Lubricate Eq.	00-2	-				-	-	-		
	Clean Equipment	00-3	-				-	-	-		
	Prepare and Clean Workstation	00-4 00-5	15.09 -				15.09 -	15.09 -	3.12 -		
	Total time of organizational servicing of work station	T_{org}	26.09				26.09	26.09	5.38		
	Exchange of dulled tool	TO-1	2.25				2.25	2.25	0.46		
	Fine setting-up of equipment	TO-2	-				-	-	-		

Summary of Observations and Analysis of Time Balance

Category of Working Time	Type of Time Expenditure	Index	Duration in Min. When Observed				Total	Average Time	In % of Observation	Standard Time	Excess Time
			1	2	3	4					
Time of servicing work station	Sweeping up scrap	T TO-3 TO-4	- -				- -	- -	- -		
	Total time of technical servicing of work station	T_{tech}	2.25				2.25	2.25	0.46		
	Total time of servicing work station	T_{serv}	28.34				28.34	28.34	5.84	7.2	21.14
	Including overlapping machine time	Pk_2	-				-	-	-		
	Rest and natural needs	T_{rest}	13.0				13.0	13.0	2.78	9.6	3.4
	Total time of productive work and rest		467				467	467	96.32	480	
Time of unproductive work	Going for tools and attachments	NR-1	-	-	-	-	-	-	-	-	-
	Going for material and workpieces	NR-2	-	-	-	-	-	-	-	-	-
	Going to foreman	NR-3	-	-	-	-	-	-	-	-	-
	Going to inspector	NR-4	-	-	-	-	-	-	-	-	-
	Correction of spoiled work	NR-5	8.0	-	-	-	8.0	8.0	1.65	-	-

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Category of Working Time	Type of Time Expenditure	Index	1	2	3	4	Total	Average Time	In % of Observation	Standard Time	Excess Time
	Minor repairs, made by operator himself	NR-6	–	–	–	–	–	–	–	–	–
	Tool grinding (centralized)	NR-7	–	–	–	–	–	–	–	–	–
	Work not covered by assignment	NR-8	–	–	–	–	–	–	–	–	–
		NR-9	–	–	–	–	–	–	–	–	–
		NR-10	–	–	–	–	–	–	–	–	–
		NR-11	–	–	–	–	–	–	–	–	–
	Total	NR	8.0	–	–	–	8.0	8.0	1.65	–	–
Time of breaks not due to operator	Free time during unattended running of equip.	TP-1	–	–	–	–	–	–	–	–	–
	Waiting for work	PO-1	–	–	–	–	–	–	–	–	–
	Waiting for tools and attachments	PO-2	–	–	–	–	–	–	–	–	–
	Waiting for material and workpieces	PO-3	5.33	–	–	–	5.33	5.33	1.1	–	–
	Waiting for instruction	PO-4	–	–	–	–	–	–	–	–	–
	Waiting for inspector	PO-5	–	–	–	–	–	–	–	–	–
	Waiting for setting up of equipment	PO-6	–	–	–	–	–	–	–	–	–
	Waiting for minor repair of equipment	PO-7	–	–	–	–	–	–	–	–	–
	Waiting for materials handling service	PO-8	–	–	–	–	–	–	–	–	–
	Stoppage due to lack of power	PO-9	–	–	–	–	–	–	–	–	–
	Service conversation	PO-10	3.0	–	–	–	3.0	3.0	0.62	–	–
		PO-11	–	–	–	–	–	–	–	–	–
		PO-12	–	–	–	–	–	–	–	–	–
		PO-13	–	–	–	–	–	–	–	–	–
	Total	PO	8.33	–	–	–	8.33	8.33	1.72	–	–

Summary of Observations and Analysis of Time Balance

Category of Working Time	Type of Time Expenditure	Index	Duration in Min. When Observed				Total	Average Time	In % of Observation	Standard Time	Excess Time
			1	2	3	4					
Time of breaks due to operator	Late start and premature ending of work	PR-1	2.0	–	–	–	2.0	2.0	0.41	–	–
	Strolls from work station and incidental conversations	PR-2	–	–	–	–	–	–	–	–	–
		PR-3	–	–	–	–	–	–	–	–	–
		PR-4	–	–	–	–	–	–	–	–	–
		PR-5	–	–	–	–	–	–	–	–	–
		PR-6	–	–	–	–	–	–	–	–	–
	Total	PR	2.0	–	–	–	2.0	2.0	0.41	–	–
	Total time of breaks	P	10.33	–	–	–	10.33	10.33	2.03	–	–
	Duration of time of observation	T_{obs}	485	–	–	–	–	–	100	–	–

Percent of operative time: $K_1 = \frac{T_{op.}}{T_{obs}} \cdot 100 = \frac{410}{485} \cdot 100 = 85\%$

Utilization of working time

Percent of losses and unproductive work not due to workman: $K_2 = \frac{NR+PO}{T_{obs}} \cdot 100 = \frac{8+8,33}{485} \cdot 100 = 3,3\%$

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Percent of losses due to workman	$K_2 = \frac{T_{rest\,j} - T_{rest\,n} + PR}{T_{obs}} \cdot 100 = \frac{13,0 - 9,5 + 2,0}{485} \cdot 100 = 1,1\%$
Possible increase in labor productivity	
Total	$K_{pr} = \frac{T_{op.n} - T_{op.j}}{T_{op.j}} \cdot 100 = \frac{456 - 410}{410} \cdot 100 = 11,2\%$
By organizational-technical measures	$K = \frac{(T_{s.cl.j} - T_{s.cl.n}) + (T_{serv.j} - T_{serv.n}) + NR + PO}{T} \cdot 100 = \frac{7,96 + 21,14 + 8 + 8,33}{410} \cdot 100 = \frac{45 \cdot 100}{410} = 10,9\%$

Measures for improving utilization of time

Index	Substance of Measure	Time of Performance	To Be Performed by	Expected Effectiveness
PZ-5	1. Form necessary stock of drills and rivets at work station, eliminating time lost in going for them	15/11/1955	PRB	Increase of productivity by 11%
NR-5	2. Improve quality of rivets and drills; intensify inspection on their quality	10/11/1955	BTsK	
00-3 and	3. Provide for timely delivery of workpieces at work station and for collection of finished product by helpers	10/11/1955	PRB	
00-4	4. Instruct workman on layout of all objects at work station	1/11/1955	Foreman	

Date	Submitted by	Checked by

Table 18

Plant No.		Observation Sheet of Individual Photographic Study of Work Day
Shop No.		
Work Shop		

Date	Beginning of Observations	End of Observation	Duration of Observation	Observer
28 Oct. 1955	0700 h	1605 h 20 sec	8 hr 5 min. 20 sec	Shcherban'

Workman				Equipment		Work		
Name	Time Card No.	Specialty	Category	Name and Type	Inventory No.	Article, Part	Operation	Category of Work
Baukhina	1517	Riveter	4	Fitter's vise	256	Bulkhead No.3	Detail assembly	4
				Pneumatic drill	143	Bulkhead No.9	The same	4
				Rivet gun	12510			

No.	What was observed	Elapsed Time	Duration	Overlaps with Element No.	Output	Index
	Beginning of observations	0700				
1	Removing tool from box on bench	1'30"	1'30"			00-1
2	Laying out cover plates, bolt boxes, and rivets from box, on bench	03'40"	2'10"			00-1

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3	Inserting and attaching elastic support in vise	4'	20"			PZ-4
4	Attaching pneumatic tool to hose and connecting it to compressed air system	5'	1'			OO-1
5	Assembly of 10 side boxes of bulkhead No.8 outside of attachment (attaching cover plates to bolt boxes, drilling and riveting)	16'	11'			OS-2
6	Transport of assembled boxes to rack	16'30"	30"			OO-4
7	Assembly of 10 side boxes of bulkhead No.8 outside of jig	27'	10'30"			OS-2
8	Transport of assembled boxes to rack	27'30"	30"			OO-4
9	Joining profiles with assembled 20 boxes outside of jig	30'	2'30"			OS-2
10	Assembling of boxes in jigs	8 h 2'	32'			OS-3
11	Change rivet stamp in riveting gun	3' 30"	1'30"			TO-1
12	Assemble boxes in jig	10'	6'30"			OS-3
13	Select angles	12'	2'			OO-4
14	Assemble boxes in jig	48'	36'			OS-3
15	Correct defects due to unsatisfactory quality of rivets	51'	3'			NR-5
16	Transport tool and parts to bench	53'20"	2'20"			OO-4

17	Drill and rivet on assembled boxes	58'	4'40"			OS-2
18	Absence for personal needs	9 h 3'	5'			T rest
19	Drill and rivet on assembled boxes	10 h 6'	63'			OS-2
20	Going for rivets (and so on until end of shift)	10'	4'			PZ-5

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The observation usually begins and ends with the shift. The observation is timed by stopwatch, since an accuracy of reading of not less than 0.5 min is necessary in the photographic study.

All time expenditures throughout the work shift, without exception, are measured and recorded on the observation log. The expenditures of time are entered in chronological order by elapsed time and in accordance with the established classification of time expenditures.

As an example, we give in Table 17 a filled-out sheet of an individual shift time study, and in Table 18, the observation sheet for this chart.

The work-up and analysis of the data begins with the calculation of the duration of the time expenditures and with their indexing. After this, expenditures with the same index are grouped to determine their total and average duration, and are entered in a schedule from which the data, totalled for each index, are transferred to the summary of observations and analysis of the actual balance of working time. In the summary of observations all the expenditures of working time are divided into two parts. The first contains the time of productive work and rest, while the second contains the time of unproductive work and breaks.

Within the first division, the indexes are grouped according to the principal parts of the calculated standard time: setup and cleanout time, primary and auxiliary time and time for servicing, rest, and natural needs. For each type of time, the sum of the actually expended time and the sum of the time assigned by the standard are shown.

Within the second division, the indices and time are grouped according to types of loss: time of unproductive work, time of breaks not due to workman, and time of breaks due to workman.

The analysis of the data of the photographic study consists in identifying the unproductive losses of working time according to their forms, causes, and share in the total time of the shift, and in setting up a balance of possible improvement in

the utilization of working time, increasing the relative share of operating time and, within the operative time itself, by decreasing the relative share of auxiliary time (Table 19).

Table 19

Analysis of Balance of Working Time

Category of Time	Balance of Working Time			
	Actual		Planned	
	in min.	in % of Time of Shift	in min.	in % of Time of Shift
Setup-cleanout work	32	6.7	30	6.2
Operative time	336	70	406	84.6
Servicing work station	40	8.3	28	5.9
Breaks for rest and natural needs	16	3.3	16	3.3
Unproductive work	20	7.3 (Unproductive work and Stoppages combined)	-	-
Stoppages for causes not due to workman	15		-	-
Losses due to workman	21	4.4	-	-
Total	480	100	480	100

From the data of the analysis of the shift time study, the working organizational technical measures are worked out to improve labor productivity. For instance, if an analysis shows that the workman uses much time in procuring the tools, the work of the tool room must be improved. For each form of unproductive or low-productive utilization of working time the labor organization bureau of the shop indicates the concrete measures to be adopted and the deadlines by which th[illegible] must be done. The administration, Party, and labor unions systematically verify the

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Table 20

Plant		Chart of Individual Stopwatch Study of Machine Work	Date	Shift	Beginning of Stop-watch Study	End of Stopwatch Study	Length of Stopwatch Study
Shop			Observer				
Bay	Section						

I. Article		IV. Machine		VII. Workman
Designation		Designation		Name
Drawing No.	Part	Plant		Time Card No.
Material		Model	Inventory No.	Specialty
Mechanical properties		Principal dimension		Experience in specialty
Weight in kg		Power in kw		Experience in this work
II. Work		Type of starting device		Number of machines tended
Designation		Method of turning off feed		Category of workman
Number by work order	Category of work	Method of changing rpm		Production characteristic
Part on which observation started		Number of supports		Average fulfillment of standard for 3 months
Form of wages		Type of tool holder		Performance of standard during time of observation
Time standard				

III. Sketch of Process	V. Tool and Attachment		
(Place for sketch of part being machined)	No.	Designation	Dimensions
	1		
	2		

VI. Organization of Work Station

A. Service	B. Planning	
Work distribution procedure	Place for plan of work station	
Material supply procedure		
Procedure for supplying and grinding tools		
Instruction		
Materials handling facilities		
Production background	VIII. Inspection	
Additional information	Date	Checked by

Table 21

Observation Sheet of Individual Stopwatch Study Chart

No.	Type of Operation Elements	Reference Points		Obs. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Average Duration	Coefficient of Stability F	Coefficient of Stability N	Standard in Force	Factors of Duration in Observation
1	Take parts, transport and set on mandrel	Contact between part and mandrel	T	0,10	1,51	2,87	4,28	5,67	6,93	8,52	10,01	12,06	13,44	15,14	16,46	17,82	19,19	20,48	1,61	0,12	1,55	1,7	0,06	Weight of workpiece 500 gm; Distance of transport 0.8 m
			P	0,10	0,11	0,12	0,11	0,14	0,09	0,14	0,11	excl	0,11	0,13	0,10	0,09	0,13	0,13						
2	Take washer, place nut on mandrel and tighten	Hand leaves nut	T	0,35	1,78	3,10	4,50	5,90	7,35	8,75	10,35	12,33	13,92	15,37	16,71	18,07	19,42	20,75	3,23	0,25	1,22	1,7	0,24	Screw-down distance of nut, 10 mm
			P	0,25	0,27	0,23	0,24	0,23	excl.	0,23	0,28	0,27		0,23	0,25	0,25	0,23	0,27						
3	Start rotation	Rotation of spindle begins	T	0,37	1,80	3,12	4,51	5,92	7,37	8,77	10,37	12,35	13,93	15,39	16,73	18,09	19,44	20,77	0,26	0,02	1,00	2,0	0,02	Friction lever
			P	0,02	0,02	0,02	excl.	0,02	0,02	0,02	0,02	0,02		0,02	0,02	0,02	0,02	0,02						
4	Position cutter and turn on feed	Contact between cutter and part	T	0,42	1,84	3,17	4,55	5,95	7,41	8,82	10,41	12,40	13,96	15,41	16,78	18,13	19,49	20,81	0,60	0,04	1,66	2,0	0,05	Turning length, 60 mm 477 rpm
			P	0,05	0,04	0,05	0,04	0,03	0,04	0,05	0,04	0,05	0,03	0,02	0,05	0,04	0,05	0,04						
5	Turn	End of turnings	T	0,87	2,26	3,61	5,00	6,39	7,83	9,27	10,86	12,82	14,40	15,86	17,22	18,58	19,91	21,25	5,58	0,44	1,07	1,1	0,42	Feed 0.31 mm One pass (t = 3 mm)
			P	0,45	0,42	0,44	0,45	0,44	0,42	0,45	0,45	0,42	0,44	0,45	0,44	0,45	0,42	0,44						
6	Turn off feed and remove cutter	Rotation of support lever ends	T	0,94	2,32	3,66	5,06	6,46	7,87	9,32	10,91	12,89	14,52	15,93	17,28	18,63	19,95	21,30	0,78	0,06	1,75	2,0	0,05	
			P	0,07	0,06	0,05	0,06	0,07	0,04	0,05	0,04	0,07		0;07	0,06	0,05	0,04	0,05						
7	Turn off rotation and shift support	Removal of hand from support lever	T	1,07	2,44	3,82	5,19	6,56	7,99	9,44	11,05	13,00	14,63	16,04	17,40	18,75	20,08	21,41	1,69	0,12	1,27	1,7	0,06	Distance of longitudinal displacement up to 100 mm
			P	0,13	0,12	excl.	0,13	0,10	0,12	0,12	0,14	0,11	0,13	0,11	0,12	0,12	0,13	0,11						
8	Screw out nut and remove washer	Separation of ring from mandrel	T	1,35	2,71	4,08	5,47	6,78	8,27	9,89	11,51	13,27	14,87	16,32	17,66	19,02	20,30	21,69	3,39	0,26	1,30	1,7	0,20	Unscrewing distance 10 mm
			P	0,28	0,27	0,26	0,28	0,22	0,28	excl.	excl.	0,27	0,22	0,28	0,26	0,27	0,22	0,28						
9	Remove part and put in place	Removal of hand from part	T	1,40	2,75	4,15	5,53	6,84	8,38	9,96	11,57	13,33	15,01	16,36	17,73	19,06	20,35	21,75	0,73	0,06	1,75	2,0	0,04	Weight of part 400 gm Distance of removal 0.8 m
			P	0,05	0,04	0,07	0,06	excl.	0,07	0,06	0,06	excl.	0,04	0,04	0,07	0,04	0,05	0,06						
																		Total		1,37			1,14	

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realization of these measures.

A photographic study of the work day may be either of the individual or crew type. It may be instigated either on the initiative of the administration or of the workman.

Stopwatch time study is a method of observing and measuring the consumption of operative time on an operation or on its individual elements, that recur with each unit of product manufactured. Table 20 gives the form for the stopwatch study card.

A stopwatch study is conducted to work out and correct the standard time tables for machine-hand, hand, and auxiliary work; to study, summarize, and disseminate the experience of production innovators; to establish the time standards for hand work; and to verify and refine the time standards established in large-batch and mass-production operations. In accordance with the problem involved, a stopwatch study may cover the entire work process for a given operation, or only individual operation elements or groups of elements.

The conduct of a stopwatch study is made up of the following stages of work: selection of the object of study, preparation for observation, observation, work-up and analysis of the stopwatch study data.

A stopwatch study is usually run at the work stations of experienced advanced workmen. This is done in view of the fact that stopwatch study data are utilized for improving the organization of labor and for the establishment of standards.

Before starting a stopwatch study, the standardizer or stopwatch-study man discusses with the advanced workman the plan of dividing the operation into operational elements or groups of elements and the sequence of their performance, allowing for maximum possible overlapping of operational elements. The division of operation into elements is accomplished by the determination of "fixed or reference points", which indicate the end of one element and the beginning of the following element and which are used in making the measurement. The standardizer (stopwatch-study man) then prepares the stopwatch-study chart by filling out the title sheet.

At the same time he prepares the work station. When everything has been carefully prepared, he proceeds to the stopwatch study, i.e., the observation and measurement of the time consumed, sometimes making several preliminary measurements to convince himself that the reference points have been properly selected.

The observation and measurement of the time expenditure is made for each reference point by means of a single- or two-hand stopwatch. The entries are made in the observation sheet of the stopwatch-study chart according to elapsed time. An example of an observation sheet is given in Table 21. During the course of the observation the coincident, i.e., the overlapping, operational elements, must be noted. The number and measurements depends on the duration of the operation and the required degree of accuracy of the indices expected. About the following number of observations may be recommended in a continuous stopwatch study:

Length of Operation in Minutes	Number of Observations (not less than)
Up to 2	40
From 2 to 10	20
From 10 to 20	10
From 20 to 40	5

The work-up of the stopwatch-study data begins with calculating the duration of the operational elements or their combination in each study series. Measurements showing sharp deviations from the duration of the remaining measurements are not used in the calculation, and the causes for such measurements are indicated in a special Table (see below).

If the erroneous measurements in the series were over 15 - 20%, then such a stopwatch-study series is considered incorrect and the study is repeated. The time of all correct measurements in the series is added and the sum is divided by the number of correct measurements, giving the average duration of the given group of

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operational elements or of the individual element. The sum of the arithmetic mean durations of the operational elements yields the average consumption of operative

Stoppages, Delays, and Deviation from Normal Conditions

Observation No. Element No.	Cause	T	P P	Remarks
3/7	Operator's fault	-	0.16	Held spindle, preventing its rotation
4/3	Error in reading	-	0.01	
6/2	Shavings got into nut	-	0.42	
5/9	Tight removal	-	0.11	
7/8	Incorrectly screwed in	-	0.45	
8/8	Same	-	0.46	
9/1	Tight placing on mandrel	-	0.49	
10/2	Shavings got into nut	-	0.48	
10/6	Operator delayed	-	0.12	Distracted 10/6
10/9	Tight removal from mandrel	-	0.14	
11/4	Error in reading	-	0.02	

time. The overlapping elements are not included in the standard time.

Besides the method of determining the time consumption by elapsed time, the method of measuring the time consumption by individual readings is also widely used in practice. It consists in starting the stopwatch at the instant a given operational element begins, and stopping the stopwatch at the time it ends, reading off the time and entering it in the stopwatch-study chart, then returning the hand to its original position. At the time of starting the next element, the stopwatch is again started, etc. In this way the length of each measured operational element is determined during the process of stopwatch study itself, by being directly read off

the stopwatch.

The analysis of the stopwatch-study data consists in determining the operations most productively performed, the possibility of having them coincide, the factors affecting the duration of the elements, and in working out measures allowing a reduction in the duration of the operational elements.

Section 4. Organization of Work for Establishment and Review of Standards

For calculation of the standard time, the technologist delivers the process chart to the standards man. The standards man calculates the standard time and enters it in the process chart, then enters the standard time in the standards journal and returns the chart to the technologist.

In view of the continuous growth of technology, the improvement of organization of production, and the increase in the cultural-technical level of the workman, the standards should be systematically reviewed.

The enterprise director has the right, with the agreement of the plant committee of the labor union, to replace obsolete standards by new ones for the entire year, as technical and technical-organizational, or economic measures ensuring the growth of labor productivity are introduced into production. Starting from the assignments for enhancement of labor productivity, raising of the average pay, and lowering of the production cost, the managers of the enterprises must work out calendar plans for replacing the obsolete norms of output by new, technically well-founded standards.

When standards are reviewed, the piece rates are also varied. In no case must the review of standards be reduced to a mechanical reduction of the existing time standards. The review of standards must be based on the discovery and utilization of internal reserves, on combined mechanization and better organization of labor at each work station.

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Limits of reduction of the labor cost of an article for each quarter or month

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may be set for shops. If a proposal for the improvement of production technique or labor organization has come directly from an operator, the old standard is left in force for him for a period of six months, but the new standard is introduced for all other workmen doing similar work.

Besides permanent standards, tentative standards are used in production. The latter are established for a period of not more than 3 months when a new article is put into production, when new and not thoroughly mastered forms of equipment and methods of processing are used, or when tooling prescribed by the series process is unavailable. The technologist and the standards man may replace the tentative standards by permanent standards before the end of the 3-month period.

The development of progressive standard Tables for labor is of great importance for the introduction of technically justified standards and gives assurance of the unity of standard times for similar work. Standard Tables accelerate the calculation of the standard time. In aircraft building, standard time tables are compiled for almost all types of piecework on the aircraft.

Today, when many casual workers and some of the permanent workmen are on a time-bonus and bonus system basis, it is important to have standards for time work and base-pay work, in order to establish the payrolls of the enterprise in the most justified manner on the basis of these standard Tables. In the aviation industry, methodical work is being done on technical standardization by the Council on Technical Standardization and the Laboratory of Technical Standardization of the NIAT. At the leading enterprises, basic standard Table and research bureaus have been organized to work on the drafting of time standard Tables for the entire industrial branch. In aircraft building it has long since become necessary to establish single typical processes and standardized tooling and, on this basis, to establish single standard time Tables for analogous mass operations, for the manufacture of standardized and unified parts, units, and assemblies. This will reduce the number of standards used in series production.

CHAPTER VIII

ORGANIZATION OF WAGES IN THE AIRCRAFT CONSTRUCTION ENTERPRISE

Wages under socialism represent that part of the social product, expressed in monetary form, which is intended for the personal consumption by the workman or employee in accordance with the quantity and quality of his work.

Wages in the USSR are a means of control over the measure of labor and the measure of consumption. This control is exercised by the State by means of a conscious utilization of the law of values. A relationship is established between the quantity and quality of the work performed by the worker to produce a definite product and the quantity and quality of material goods and services, which the worker acquires for his wages. A correct organization of the wage system presupposes accuracy and comparability of the measure of labor and the measure of consumption.

As the national income and the productivity of social labor increase, the Soviet State unswervingly increases the monetary and real wages of the worker and employees.

Section 1. Regulation of Wages and the Tariff or Wage-Scale System

In the regulation of wages, the Soviet State is guided by the demands of the economic law of distribution according to work. In a given enterprise, this finds its expression in the payment of labor and in the establishment of the amount paid in accordance with labor productivity, qualifications, conditions of performance,

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responsibility, and social importance of that labor.

In the interests of constant increase of the national income, of the realization of expanded socialist reproduction and the assurance of stable, planned increase in real wages, it is necessary that the growth of labor productivity always precedes an increase in wages.

Thus the directives of the 20th Congress of the Communist Party USSR prescribe a further increase in the real wages of workers and employees during the sixth Five-Year Plan by about 30%, with an average increase in labor productivity of not less than 50% and a growth of the national income by about 60%.

In establishing the wages of workmen, wage scales, base-pay rates, and manuals of wage scales and qualifications are used.

A wage scale includes the categories of qualification of work and their corresponding factors. The wage scale determines the relations between the pay rates for the various categories of labor, according to the conditions of labor, the methods by which it is performed, and its complexity.

Various wage scales are applied for the workmen of the hot and cold shops, depending on the working conditions. Work that is difficult or performed under adverse conditions, is paid more highly.

Work directly affecting the quantity and quality of the output taken into account is paid at a higher rate than work whose results are measured merely by the amount of time spent. According to the method of performing the work, various wage scales are in effect for piece workers and for time workers. Within each wage scale the complexity of the labor, i.e., its qualification, is determined by the work categories. Qualified labor, being labor of higher grade and producing greater value in unit time, is paid higher than labor of lower skill.

The variety in the current wage scales applicable at enterprises constitutes a serious shortcoming. As an example, Table 22 gives the wage scale of one machine-building enterprise.

At the end of 1956, at a number of enterprises, a new unified wage scale was introduced as an experiment. It provided for the following increase in the scale factor by work categories:

Categories	1	2	3	4	5	6	7	8
Factor	1	1.15	1.32	1.52	1.77	2.06	2.4	2.8

The category of work indicates the complexity of the work and the need of qualification of the workman to perform it. The qualification of a workman is characterized by the following criteria: amount of knowledge and productive know-how necessary to perform the work of the given category; complexity of the process and equipment; precision or degree of perfection of the work being performed; degree of responsibility for the work or for the integrity of the equipment; degree of independence of work. At aircraft enterprises, all workmen and all the work performed by them are divided into eight categories. Each category has its own corresponding scale factor, which determines the ratio between the wages of workmen of different categories and qualifications. This ratio permits avoiding a general equalization of wages and stimulates the growth of the qualifications of workmen. The first category provides for work needing no qualification whatever for its performance. The demands on the qualifications of the workman thereafter increase constantly from category to category. The eighth category is for the most complex work and defines the highest skill. The scale factor for the first category is unity. The scale factors increase with the category.

The category is assigned to a newly employed workman by the foreman or, with his participation, by the rating commission of the OPK, based on an accepted sample of work and the results of two weeks work.

The wage scale determine the amount of the wages of a workman of a given category for unit working time, one hour. STAT

The wage scale is obtained by multiplying the category of work by the scale

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Table 22

Wage Scale of Workman Introduced on 16 September 1946*

a)	b)	c) d) 8 hrs	c) d) 7 hrs	c) d) 6 hrs	c) e)	c) d) 8 hrs	c) d) 7 hrs	c) d) 6 hrs	c) e)	f)	f) d) 8 hrs	f) d) 7 hrs	f) d) 6 hrs	f) e)
1	1,0	1.34,1	1.53,3	1.78,8	268.20	1.46,1	1.67	1.94,8	292.20	1,0	1.25,3	1.43,2	1.67,1	250.60
2	1,12	1.50,1	1.71,5	2.00,1	300.20	1.64,5	1.88	2.19,3	329.00	1,11	1.39,5	1.59,4	1.86	279.00
3	1,27	1.70,1	1.94,4	2.26,8	340.20	1.87,5	2.14,3	2.50	375.00	1,26	1.57,3	1.79,8	2.09,7	314.60
4	1,45	1.94,1	2.21,8	2.58,8	388.20	2.10,2	2.40,18	2.80,3	420.40	1,43	1.78,7	2.04,2	2.38,3	357.40
5	1,62	2.17,2	2.48,2	2.89,6	434.40	2.42,4	2.77	3.23,2	484.80	1,59	1.98,7	2.27,1	2.64,9	397.40
6	1,86	2.49,2	2.84,8	3.32,3	498.40	2.79,2	3.19,1	3.72,3	558.40	1,81	2.27,2	2.59,7	3.02,9	454.40
7	2,16	2.89,2	3.30,5	3.85,6	578.40	3.20,3	3.66,1	4.27,1	640.60	2,1	2.62,8	3.00,3	3.50,4	525.60
8	2,48	3.32,3	3.79,8	4.43,1	664.60	3.70,6	4.23,5	4.94,1	741.20	2,4	3.00,6	3.43,5	4.00,8	601.20

*The wage scale given in this Table is obsolete and does not correspond to the actual earnings of workmen today.

a) Category; b) Factor; c) Piece workers; d) Hourly rates in rubles and kopeks for a work shift lasting, respectively; e) Monthly rate for 25 working days; f) Time workers

factor of that category.

The following are the wage rates of the first category for the newly introduced experimental wage scale:

Category of Workman	For Cold Work	For Hot Work	For Heavy Work	For Work under Particularly Difficult Conditions
Piece workers	1 r. 78 k.	2 r. 10 k.	2 r. 10 k.	2 r. 40 k.
Time workers	1 r. 62 k.	1 r. 78 k.	1 r. 78 k.	2 r. 10 k.

The experimental wage scale and the new wage rates, in combination with technically justified time standards and output standards, have lifted the share of the base pay to 75 – 80% of the earnings of a workman and have eliminated the lag of the base pay behind the increasing actual earnings of workmen.

The directives of the 20th Congress of the Communist Party on the development of the national economy in the sixth Five-Year Plan state the following:

"For the purpose of the most rapid elimination of shortcomings in the organization of labor and wages and the intensification of personal material incentive of the workers in the results of their labor:

Assure the widespread introduction into production of technically justified output standards corresponding to the present level of technology and organization of industry;

Increase the share of the base pay in the earnings of workmen and establish the correct relations in the level of the base pay with respect to the individual industrial branches and trades, taking account of the qualifications of workmen and the establishment of wage differentials in favor of workmen occupied in heavy work and in hot shops;

Introduce order in the wages of individual categories of engineering-technical personnel and employees; liquidate the multiplicity of systems and the discSTATcies in the conditions of wages of the engineering-technical workers and employees;

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Enhance the role of bonus pay in the stimulation of introduction of new technique, of the role of labor productivity, and of the reduction of production cost" (Bibl.23).

The manual of wage scales and qualifications is the basic authority for the assignment of work and workmen to a definite category, and is compiled for each branch of industry. It contains, in a systematized order for each trade, specialty and category, the respective qualification characteristics.

The qualification characteristic, for each specialty and category, determines the content of the work, the level of knowledge and know-how, necessary to perform the work, and contains examples of work typical for each category. It assumes the workman's obligatory knowledge of the rules and means of safety procedure and of the forms of spoilage, their causes, and the methods of eliminating them.

The manual of wage scales and qualifications is used as a guide in establishing the category of a newly employed workman and in transferring a workman from one category to another.

The introduction of a new technique is accompanied by the appearance of new trades and specialties and by the merging of trades. The corresponding revisions must therefore be made periodically in the manuals of wage scales and qualifications.

A substantial shortcoming of the existing manuals of wage scales and qualifications is, in the first place, the low demands on the workers with respect to their knowledge of a new technique and, secondly, the excessively narrow specialization of the workmen.

Wage scales and base rates are approved by the Council of Ministers USSR on recommendation by the trade unions and economic agencies. Manuals of wage scales and qualifications are also worked out with the participation of the trade unions.

Section 2. Forms and Systems of Wages

Two forms of wages are used in socialist industry: piecework and time. Both

forms in turn include several different systems.

The wage system used in aviation enterprises is based on the principle of material incentive to good workers.

The piecework form of payment stimulates the growth of labor productivity and makes it possible for each workman to increase his earnings. It encourages the workman to raise his cultural and technical level and qualifications, favors the development of his creative initiative and interests him materially in the more complete utilization of the equipment and working time.

The piecework form should be used in production wherever the time standard and output standard can be established. Technically justified standards are the foundation of a piecework-wage system. Several systems of piecework wages are used.

Direct Unlimited Individual Piecework Wages. In this system of piecework payment, each unit of article is paid for at the same rate, and the amount of wages of the piece worker depends on the amount of output, the category and the hourly base pay. The system is called direct since it increases the earnings of the workman in direct proportion to the amount of output. It is called unlimited because there are no limits, in the USSR, to the amount of the piecework earnings of a workman. This system of wages is called individual because in it the work of a single workman is the object of standardization and payment.

The output standard per shift is defined by the formula:

$$N_{out} = \frac{T_{sh}}{T_{pw.calc}},$$

where T_{sh} is the time of a shift in minutes;

$T_{pw.calc}$ is the piecework-calculated standard time per unit of finished article, in minutes.

The rate per unit of work (one operation, one article) is calculated by the formula

$$p = \frac{H_{pw} k}{60} T_{pw},$$

where p is the rate in kopeks;

H_{pw} is the hourly base pay of a first-category piece worker, in kopeks;

k is the rate factor of the work category according to the wage scale.

Piecework rates are calculated by category of work, not by category of the workman who is to perform the standardized work.

In practical work, Tables are usually compiled to establish the rates and earnings, and these Tables serve as the guide in wage payment.

To increase the material incentive of the workman in multiple machine tending, a scale with progressive supplements must be used for workers who by their own initiative have agreed to tend a larger number of machines than provided by the standard.

Direct unlimited crew piecework wages are used where the combined work of several workers, operating as a crew, must be used because of production conditions, and where the individual output standard of each crew member cannot be taken into account. The standard time and the standard outputs are established for the crew as a whole.

The piecework rate of a crew is determined by the category of the work covered by the work order to the crew and by the standard time established for such work. The earnings of the crew are distributed between its members in accordance with their qualifications (categories) and the time worked by each of them. A substantial shortcoming of the crew form of wage payment is the fact that the individual output of each worker of the crew is not taken into account. The technical standardization of crew work determines the duration of the standardized productive operation as well as the standard number and qualifications of the crew members. On the basis of these data, the crew rate per unit work is calculated by the following

formula:

$$p = T_{pw.calc} H_{pw} \sum_{k_1}^{k_n} P,$$

where H_{pw} is the hourly piecework rate for a worker of the first category;

k is the scale factor of the different category per workman, required with a normal makeup of the crew;

P is the number of workmen of the respective categories.

The calculation of the distribution of the total earnings of a crew between its members will be clear from the following example.

Example. A crew was instructed to assemble 80 units. For this work, the technical time standard of assembling a unit was established at 2 hours, the assembly cycle at 30 minutes, the standard composition of the crew $\frac{2 \times 60}{30} = 4$ workmen, including one of category 6 (hourly base pay 2 rubles 79 kopeks), one of category 5 (hourly base pay 2 rubles 42 kopeks) and two of category 4 (hourly base pay 2 rubles 10 kopeks).

The crew rate for each unit is:

$p = \frac{30}{60}(279 \times 1 + 242 \times 1 + 210 \times 2) = 471$ kopeks. The total wage fund is 80×4 rubles 71 kopeks = 376 rubles 80 kopeks. The workmen of the crew perform this assignment by working, not 160 hrs (80×2) as provided by the standard but 136 hrs, i.e., they overfulfill the standard by 17%. The category of each crew member, the number of hours worked by him, and the corresponding earnings will be clear from the Table given below.

The piecework-progressive system of payment stimulates the growth of labor productivity and is introduced into work on start-up of a new technique, new forms of articles produced, and new processes. In the piecework-progressive system of wages, the work performed, within the limits of a technically justified standard, is paid according to the normal piecework rate, while the output above the standard is

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paid for at an increased rate which rises proportionally or progressively. In payment for work performed according to the experience-statistical standards, the output attained by a qualified workman of the corresponding category is considered the standard output. The enterprise pays the progressive rates on the basis of savings

a)	b)	c)	d)	e)		g)
				in %	f)	
Ivanov	6	40	111—68	17	18—70	130—38
Petrov	5	32	76—57	17	12—83	89—40
Sergeyev	4	40	84—08	17	14—08	98—16
Antonov	4	24	50—45	17	8—41	58—86
		136	322—78	17	54—02	376—80

a) Name of workman; b) Category; c) Number of hours worked; d) Wages according to tariff for time worked, in rubles and kopeks; e) Payment for time saved; f) in rubles and kopeks; g) Actual pay in rubles and kopeks

produced by the growth of labor productivity, as a result of the application of the progressive wage system. The settlement with workmen, put on a piecework-progressive wage basis, is made according to the results of their work for the month. In this case, the time actually worked includes the reported time, figured by the time-card, with the addition of overtime work. The time-card time does not include the whole-shift delays due to no fault of the workman, the whole-shift work of piece workers on time payment, excused time for nursing and infant care for the period established by law, lost working time due to routine preventive maintenance of the equipment, and to cleaning and lubrication of the equipment.

In the piecework-premium system of wages*, the workman receives payment for his

*(For footnote, see next page)

output by the piecework rate and a bonus for performing the shift assignment or for meeting other economic indexes, provided he meets the monthly standard output. This system encourages the performance of the output standard and the saving in material, tools, power, and other tangible values.

On introduction of the piecework-progressive and piecework premium forms of wage payment, the economic effect of these measures must first be carefully calculated so as not to overexpend the wage fund.

The time-wage payment provides for the payment to a worker of the base pay for the time worked by him. In order to give the workmen an interest in the results of their work, the time pay is supplemented by bonuses established for fulfillment of the shift assignment and for attaining better work indices.

At present, those members of the auxiliary and primary labor force for whom the piecework form of wages was artificially employed, and also in cases where the piecework system lowers the quality of the work, are now being transferred to the time-bonus system. The maintenance workers assigned for the day, machine setters, workmen in heat-treatment shops, coating shops and others, are transferred to the time-bonus system. When there are technically justified standards and correctly established shift assignments, it is expedient to transfer a considerably larger number of primary and auxiliary workmen to the time-bonus system. This would increase the rhythmic nature of the process and save documentation.

System of Position Rates. The pay of engineering-technical workers, employees, and certain groups of workmen is regulated by the category of the enterprise and by the position rates. Among the workmen, the inspectors, distributors, stockroom clerks, material and tool assigners, laboratory workers, and certain others have been given position rates.

*The extent of, and procedure for, the payment of bonuses for the primary and auxiliary workers, employees and engineering-technical workers of aircraft construction plants is governed by special regulations.

The number of engineering-technical workers and employees of an enterprise is regulated by the Organization Chart, indicating the positions of each organizational unit of the shop and enterprise, the number of workers in each position, and the salary established for them.

The director does not have the right to exceed the limits of the Organization Chart and of the wage fund established for the enterprise.

The salaries of the engineering-technical workers of the Development Design Office and research institutes is 25% higher than the salary of the corresponding workers of series plants. The salaries for the positions have a minimum and maximum and are established in accordance with the knowledge, experience, and responsibility of the worker. Shop and department superintendents, in setting the salaries of the engineering-technical workers and employees, cannot go beyond the limits of the average salary established for a given group of workers.

Bonuses are paid to the management personnel, engineering-technical workers, and employees of enterprises on the basis of the regulations on bonus payments approved by the Council of Ministers USSR.

The personnel of the plant administrations are paid bonuses for the introduction of new technology, and for fulfillment and overfulfillment by the enterprise of the monthly plan on commercial production, provided that the plan for growth of production, for reduction of production cost, for output of the assigned list of principal articles, and for subcontract deliveries is also fulfilled.

The personnel of the primary and auxiliary shops are paid bonuses for the introduction of new technology and for fulfillment of the assignments on production volume, production list, and reduction of production cost.

The amounts of the bonus for the introduction of a new technique depends on the economic effectiveness of this technique.

The amounts of the bonuses to the director, chief engineer, assistant director, and chief accountant are approved by the head of the administration to which the

enterprise is subordinated. The bonuses to the other personnel are approved by the plant director. The payment of bonuses to workers may be limited or annulled by the director or shop superintendent for negligence in work, for instance, for failure to maintain a rhythmic output of product.

A fault of the existing system of bonuses to the engineering-technical workers is the slight material interest they provide in the rapid rate of growth of labor productivity, in the complete utilization of the existing productive capacity of the shops, and in the reduction of the shop production costs.

Section 3. Bonus Payments to the Collectives of Enterprises and the Enterprise Fund

The collectives of enterprises are paid bonuses for the best indices attained in the All-Union socialist competition. Three categories of monetary bonuses have been established. These are awarded quarterly. Such bonuses are paid to an enterprise for over-plan profits and are distributed as follows: 30 - 40% of the total amount of the bonus is spent on cultural and welfare measures, while the remaining 70 - 60% is used to pay bonuses to workmen, engineering-technical workers, and employees. Not less than half of the individual bonus fund is expended on bonuses to workmen.

The enterprise fund is established to encourage the profitable operation of the collective of the enterprise. Into this fund are paid 2% of the Plan profit and 30% of the excess Plan profit, provided the enterprise fulfills the Plan in output, product list, and production cost. Of this fund, the director has the right to spend 50% on expansion of production, construction, and housing maintenance, as well as on excess Plan capital investments, and the remaining 50% on the award of benefits and individual bonuses. The estimate for the utilization of the fund is agreed on between the director of the enterprise and the plant committee of the labor union.

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Section 4. Documents for Wages and Procedure for their Formalization

The documents on which the wage settlements with workmen and employees are formalized are as follows: for piece workers, the work order, the flow sheet-invoice, the shift report of the inspector on the product accepted, the dead-time and overtime sheets and the time card; for time workers, engineering-technical workers, etc., the time card showing the days and hours worked during the month.

The foreman giving out work to the piece worker is obligated at the same time to issue for it a formalized work order or a document replacing it, from which the workman learns the conditions of the work, i.e., the title of the work, its category, and quantity, the standard time, and the rates per piece and per entire job.

The acceptor (inspector), in accepting the product from the workman, checks the existence of a work order for it, or of a document replacing the work order. On the work order, the acceptor notes the amount of product delivered and the number of products accepted. The amount of product missing by comparison with that indicated on the work order is charged by the inspector to the workman's account. The work order and the stub for it are verified by signature and stamp of the inspector and are then turned over to the foreman. The foreman, after verifying the work order, gives the workman the stub of the work order for calculation of his pay, and delivers the original work order (or the original document replacing it) to the production-dispatcher bureau of the shop, to which the receipt and issue of the work orders are accounted for in series.

The copying of the work orders is concentrated in the production-dispatcher's bureau of the shop. The order-clerk of the bureau, on the basis of the standards and rates in the summary schedule or in the flow charts, copies out the work orders in series with respect to all the operations shown on it. The work orders so filled out are verified by the superintendent of the production-dispatcher bureau and are posted to the personal account or account card of the foreman. The foreman receipts

for the receipt of the work orders from the bureau and for their return. The production-dispatcher bureau forwards the work orders, formalized and accepted from the foreman, to the shop accounting office, which in turn forwards them to the machine-accounting station. The correctness of the work orders so filled in, and of the standards and rates shown in them, is checked by the bureau of labor organization of the shop. The timely issuance of the work orders to the workman, and the daily return of the formalized work orders, ensures timely accounting for the output and uniform loading of the machine-accounting station of the enterprise.

Section 5. Some Rules of Wage Payment

Periodic Payment of Wages. Permanent workers of the plant are paid wages twice a month on the exact dates fixed by the collective contract.

Persons paid under the salary system receive their wages in equal parts. Workmen under the piecework system of payment receive an advance on account of wages for the first half of the months worked in the amount of 50% of the base pay, and in the second payment the entire amount earned during the past month, after deduction of the advance already received. Payment for time work and individual work is made immediately after it is performed. Wages are paid during nonworking time.

The State wage tax is withheld from the pay of workmen, engineering-technical workers and employees, and amounts may also be withheld for advances made, garnisheeing, to recover losses suffered by the enterprise, compensation for value of property issued and not returned (including spoiled articles and materials). The total withholdings cannot exceed 50% of the wages (except for alimony).

Payment for Dead Time. During dead time, due to the fault of the workman, no wages are paid. The workman must immediately advise the administration of the beginning of dead time, or of causes that may result in stoppage. The administration is obligated to eliminate the causes resulting in stoppage, and if they are unavoidable, it must shift the worker to other work.

If the workman has not been responsible for the stoppage, or in the case of impossibility of shifting the workman to other work, the wages during the stoppage are paid in the amount of 50% of the base pay of a time worker. While new articles are being put into production, stoppages not the fault of the workman are paid during the first three months, to the extent of the full base pay of a time worker of the corresponding category.

When qualified workmen (of category 5 or over) are transferred to piecework of a lower category on account of a stoppage, payment is made according to the previous average earnings, provided the standard is met in the new work.

Payment for Overtime. Work performed by workmen or employees, on the direct disposition or with the knowledge of the administration, after completion or before beginning of the normal working day established for the enterprise, is considered overtime work. Overtime work performed by workers without the agreement and knowledge of the administration is not subject to payment.

Overtime work should be used only under urgent and extraordinary circumstances.

Overtime work by time workers is paid for on the basis of time and a half for the first two hours of overtime, and on the basis of double time for the following hours.

Overtime by piece workers is paid for at the normal piecework rate, with a supplement of 50% of the hourly base pay for time workers of the corresponding categories for the first two hours of overtime and of the full base rate of such time workers for all additional hours.

A worker with an unstandardized working day does not receive supplementary pay for overtime work. He is given additional leave for a period not more than 12 days to compensate him for the extra load in the overtime.

For work on the weekly rest day, a worker must be given a different day off. Substitution of monetary compensation or an increase of regular leave in compensation for the weekly day off is forbidden.

Payment for Spoiled Work. No payment is made for work spoiled through the fault of the workman, if the work is a complete loss. In the case of partial spoilage, the workman is paid at a reduced rate established by the administration, but not more than half the base pay of the worker in question for time work. Work spoiled through no fault of the worker is paid for at the rate of 2/3 of the base pay of a time worker of the corresponding category if the product is a complete loss. If the spoilage occurred as a result of poor quality of the material being processed, detected after not less than one working day was spent on the processing or assembly of the part, the work done will be paid for at the normal piecework rate. The worker is obligated to advise the administration immediately of all cases where he finds that the product produced by him is spoiled. If, however, he has not advised the administration of this or has continued the work in violation of an order to stop it, then the subsequent spoiled work is not paid for at all, and a deduction is made for the spoiled material. During the period of running-in a new product (for a maximum of three months) spoiled work will be paid for at the base rate for a time worker of the corresponding category.

Responsibility for Property. Workmen and employees are partially responsible to the enterprise for damage caused by them (to the extent of not more than 2/3 of their base pay or salary), if the damage was caused by carelessness in work or by violation of the instructions and specifications. The worker has the right to complain to the KTS about such withholding or about its amount.

Workers and employees bear complete material responsibility to the enterprise for damage caused by them if the criteria of acts punishable by the criminal code are present in the actions of the worker, if there is a special contract providing for full material responsibility, or if there are special laws establishing increased material responsibility for a given category of workers. In these cases, the question of damage is decided by the court.

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Payment on Average Earnings. Persons temporarily released from primary pro-

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duction work to perform State and social obligations, are paid for the time of performance of these obligations and for the travel time according to their average earnings, including in such average earnings all forms of regularly received additional compensation, and excluding all forms of one-time compensation.

When 12 or more days are paid for, the average earnings are calculated from the wages for the last three calendar months; when less than 12 such days are paid for, the average earnings are calculated according to the data for the last calendar month.

Vacation Pay. Every workman and employee of a socialist enterprise receives a regular vacation of 12 working days after each 11 months of continuous work. Minors (age up to 16 years) receive a regular vacation of 24 days. Persons working under adverse or dangerous conditions receive additional vacations of 6, 12, and 18 days. Payment for the vacation time is made on the basis of the average earnings, which includes the base pay, the regularly received additional compensation, and such irregularly paid sums as additional payments for night and overtime work, supplements for long service, payment for stoppage, payment for the time of performance of State and social obligations, and benefits for temporary disability. The remaining forms of compensation are not taken into consideration in calculating the average earnings. The average daily earnings are determined by dividing the average monthly earnings by 25.5 days. The average earnings in vacation pay are calculated from the data of the wages for the 12 months preceding the vacation.

Pay for Substituting in a Different Position. The difference in salaries on replacement of temporarily absent workers during the period of leave, illness, or other duty assignments is made only when the replacement lasts more than 12 days, and provided the person serving as substitute is not the deputy or assistant of the absent person. The substitute service must be formalized by an order before beginning of the actual replacement.

Pay for Instruction of Workmen. For individual and crew instruction of new

workmen, qualified workmen and instructors receive up to 70 rubles a month for each pupil with individual instruction, and up to 15 rubles for crew instruction. On completion of the training of each pupil during the established time, the workman who has trained him receives a bonus of 50 rubles.

Supplementary Pay on Deviation from Normal Work Conditions. In cases where the work differs from the established normal specifications and therefore demands additional working time, special supplementary pay forms are made out for payment of this time, indicating the reasons for the departure from the established standards and those responsible, for whose account the additional payment must be made. On deviation from normal conditions, the time lost by workmen is paid to him according to the base pay for a time worker. The accounting and analysis of supplementary payment is important for the elimination of abnormalities in the operation of the shop.

Supplementary Pay for Crew Work. Workmen doing primary work and at the same time supervising a group or crew consisting of not less than two persons are paid at a rate one category above the base pay received for the primary work.

Supplementary Pay for Long Service. With the object of attaching the cadres to the enterprise and to encourage their long-range work, the State has established for the industrial group of aircraft-plant workers, a material compensation for long service with satisfactory work. Payment to workmen for long service begins after 30 years of satisfactory service at the enterprise, and to engineering and technical workers and employees after five years of satisfactory service, and is made annually at the end of the year.

With increasing period of satisfactory and continuous work at a single enterprise, the amount of the compensation for long service is increased.

Control over correct calculation of wages is vested in the shop committee of the labor union and control over correct utilization of the labor funds, in the local office of the State Bank USSR and its superior agency or enterprise. STAT

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PART THREE

TECHNICAL PROGRESS AND ORGANIZATION OF THE TECHNICAL PREPARATION OF PRODUCTION AT THE AIRCRAFT CONSTRUCTION ENTERPRISE

Technical progress is a regularity in the development of socialist enterprise. The primary trends of the technical progress of socialist machine-building enterprises are the creation and production of machines of improved design and the combined mechanization, automation, electrification, and chemization of the production processes.

There is an immense difference in the application of a new technique at socialist and capitalist enterprises.

In socialist production, the machine lightens the work while in capitalist production it increases the intensity of labor. In socialist production, the use of machines marks a victory of man over the forces of nature, while in capitalist production, it means the enslavement of man by the forces of nature. In socialist production, man's use of machines increases the wealth of the producer, while in capitalist production it impoverishes him. In bourgeois society the machine serves as a tool of exploitation and is introduced into production only when it increases the profits of the capitalists. The technological progress of a capitalist enterprise is therefore directed against the workmen, leads to a reduction in their wages, to an elimination of workmen from production, and to the growth of unemployment. V.I.Lenin said: "Progress in technology and science in the capitalist society means progress in the art of exacting sweat" (Bibl.24).

The socialist production is based on higher technology and on the work of workers free from exploitation. At a socialist enterprise, the introduction of the new technique favors the growth of labor productivity and the increase in production, releases great masses of workmen from heavy and tedious work, accelerates the en-

hancement of their cultural-technical level and their material well-being. For this reason, machines are used in socialist production in all cases where they save social labor. The socialist system of economy opens up boundless and extensive vistas for application of the new technology.

In the aircraft industry, technical progress proceeds at a particularly rapid pace. Aircraft are continuously being improved, together with the means and methods of their manufacture.

Under these conditions, to ensure the output of high-grade aircraft in numbers satisfying the needs of the national economy and of the national defense, it is necessary to have specialized enterprises endowed with great and highly differentiated technological and design bureaus and tool shops ensuring a high level of tooling and flexibility of the primary production, in order to make rapid change-overs from the production of an aircraft of one design to the production of a different aircraft; it is also necessary to have qualified cadres with experience of work under the conditions of frequent modification and change of the object of production.

The intense increase in the complexity of the designs of modern aircraft, on the one hand, and the lag in the technology of aircraft building behind the pace of development of aircraft designing, on the other hand, have led to high labor cost and high production cost of aircraft. The most important problem of agencies for the technical preparation and tooling up of aircraft construction enterprises is to attain high rates of technical progress, to reduce the present labor cost of aircraft manufacture by a factor of several times.

One of the primary tasks of the development enterprise is to create aircraft whose designs most fully meet the demands of progressive technology and the advanced forms of organization of series production.

At a series enterprise as wide as possible an application of new technology and new methods of production organization is of high importance, to allow the de-

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signer in designing aircraft to orient himself toward more highly developed implements of production and to ensure the rapid growth of labor productivity.

The economic effectiveness of technical progress is more fully manifested when complete interrelation is attained between the designing of aircraft and the technology and organization of production.

The primary paths of technical progress, ensuring effective growth of labor productivity, increase in output and improvement of its quality, have been pointed out by the 20th Congress of the Communist Party USSR.

It is necessary to reduce the relative consumption of metal by improving the designs of machines, to expand the use of alloy and low-alloy steels, of light alloys and plastics, of economical rolled profiles, precision castings, and stampings.

Measures should be taken on a large scale, to increase the technical level of production on the basis of further development of electrification, combined mechanization and automation, introduction of the latest high-productivity equipment and advanced technology, wide replacement of obsolete equipment, serious improvement in utilization of the existing equipment and mechanisms, and lowering of the labor cost to the level of the best achievements of industry in the USSR and abroad.

CHAPTER IX

ORGANIZATION OF PREPARATION OF DEVELOPMENT PRODUCTION

Section 1. Principal Stages of the Process of Aircraft Designing

A development aircraft enterprise is intended for the creation, in short periods and with minimum expense, of aircraft of the latest designs with high technical- tactical, operating, and technological characteristics.

Continuous improvement and development of these characteristics in aircraft design is the primary task of a development enterprise. The designer, by proper selection of materials, shapes, and sizes of parts and units, by their standardization and unification, by designs with whole assemblies and panels, and by improving the other charactersitics of the aircraft,lays the basis for profitable series production.

The main criteria of the high technological value of a given design are the materials cost, labor cost, and total production cost of the aircraft. Each new aircraft design will be at a higher technological level if the consumption of materials, labor, and funds per kg of basic weight are lower than in the preceding design of an aircraft of one and the same class.

The work of a development enterprise consists in designing new aircraft for modification of aircraft already in series production, in tooling up and preparing the primary shops of the development enterprise to produce new or modified aircraft; in the manufacture, testing and refinement of the aircraft prototype; and STAT transfer of its technical documentation to the series enterprise.

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The Technical Assignment. The work on the planning of an aircraft design begins with the study of the technical assignment or specifications worked out by the purchaser or by the development design office (OKB). The specifications give the tactical-technical, operating, and productive specifications for the aircraft. They relate to the purpose of the aircraft, tasks and conditions of its operation, load-carrying capacity, type and power of the engine, performance data, interchangeability, and other indices. The technical assignment indicates the tactical-technical requirements that must first be met. For instance, the document may state that the designer's attention is to be centered primarily on attainment of maximum speed and rate of climb of the aircraft or, on the other hand, that the requirements with respect to the range and load-carrying capacity of the aircraft must be met first. The specifications for the aircraft is issued to the general plans team together with the instructions by the chief designer on the schematic of the aircraft design and on its initial data. The work on the designing of the aircraft begins with the preliminary layout drawing.

The preliminary layout drawing contains, in first approximation, all calculations, determines the shapes, dimensions, and schematic of the aircraft, and indicates the degree of fulfillment of the assigned tactical-technical requirements.

The general plans team is the leading unit in making up the preliminary layout drawing, and its initial data are used as basis by the computing teams and the lofting and mockup shops.

At the beginning of making the preliminary layout drawing, the primary dimensions of the aircraft, its weight, wing area, and planform are determined. If these initial data are indicated in the specifications, it will become necessary, within the assigned limits, to define the optimum version of the aircraft design. For this purpose, the general plans team or the technical information group makes a selection among aircraft of the same type, studies and works up statistical data on whose basis the characteristics of aircraft of analogous class and type are compiled. These

characteristics are taken into account by the OKB teams in calculating the aircraft version to be designed. The search for the optimum version of the aircraft most fully meeting the technical assignment is conducted simultaneously and jointly by the leading workers of the designing group, the weight group, and the aerodynamic team. Of the aircraft versions set up by them, the best is selected.

The search for the optimum version begins with the planning of the aircraft layout and the drafting of the final layout drawings and the general plan drawings of the aircraft.

The final layout drawing is made by the design group of the general-plans team for the aircraft and its individual assemblies: wings, fuselage, engine nacelles, and landing gear and is an internal document of the development design office at the stage of the preliminary layout.

The final layout drawing of the fuselage determines its internal arrangement, dimensions and shape and gives the teams the initial data for drawing the general view of the aircraft, for working out the theoretical and match drawings, and for making the preliminary calculations of weights and strengths. The layout drawing of the fuselage shows the locations of all of its components and accessories: crew, equipment, and various installations (Fig.65).

The general view drawing of the aircraft gives an idea of the external form and general data on the dimensions of the aircraft. To make the shape selected for the aircraft clearer and more graphic, the designing team makes up a drawing from which the model shop builds a tactical model. The general-view drawing of the aircraft is needed by the purchaser and other interested organizations for familiarization, and by the aerodynamic and strength teams as well as by the weight group for preliminary calculations.

The optimum version of the aircraft selected by the chief designer is subjected to preliminary dynamic, weight, and strength refinements and calculations.

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The aerodynamic team, starting from the tactical-technical specifications of

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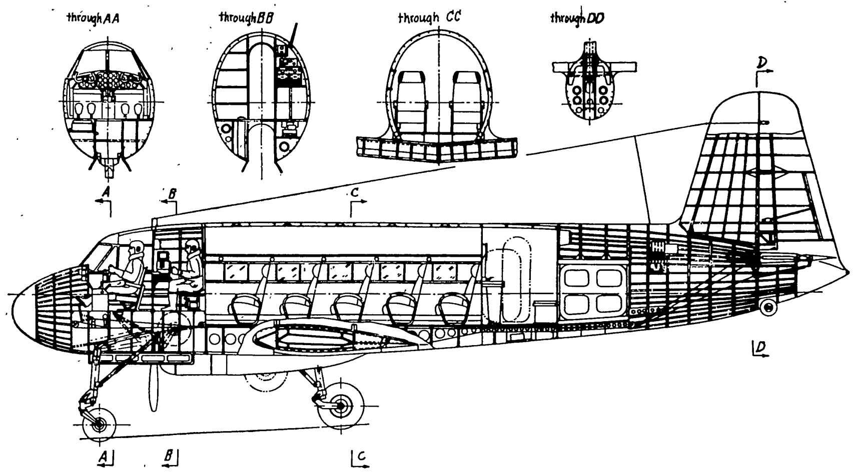

Fig.65 - Layout Drawing of Fuselage

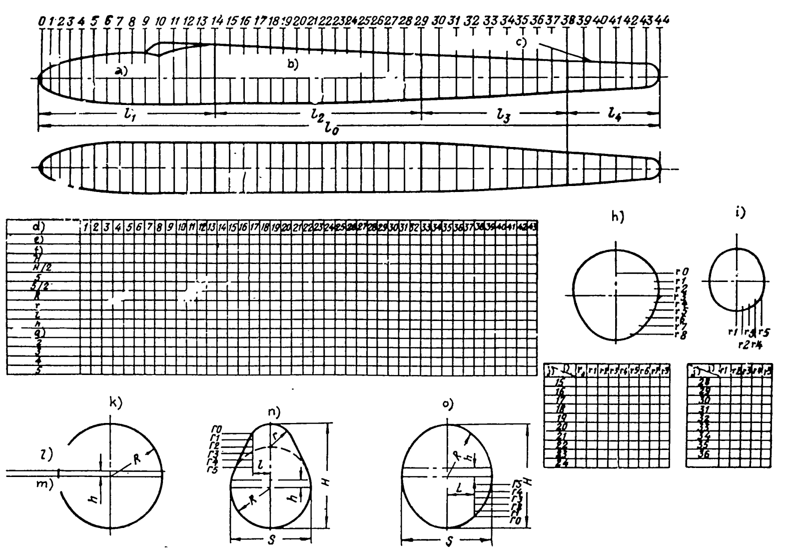

Fig.66 - Theoretical Drawing of Fuselage

a) Canopy; b) Bracing of wing center section; c) Monocoque part; d) Bulkhead No.; e) Distance between bulkheads; f) Distance from tip; g) Horizontal; h) Lateral reduction in area of bulkheads No.15 - 24; i) Bottom reduction in area of bulkheads No.28 - 36; j) Horizontal bulkhead No.; k) Bulkhead Nos.1 - 9; 14 - 24; 37 - 45; l) Structural horizontal; m) Axis of symmetry; n) Bulkhead No.11 - 13; o) Bulkhead No.25 - 36

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the purchaser, which indicate speed, altitude, range, and flying weight of the aircraft, refine in first approximation its dimensions and the wing profile, the aerodynamic forces acting on the aircraft, and its stability.

The weight group of the general-view team, after receiving the dimensions of the aircraft from the aerodynamic team and knowing the specified flying weight of the aircraft from the technical assignment, determines in first approximation the weight of the aircraft being designed and its centering. From the weight estimate of the aircraft parts the group roughly determines the weight of all assemblies, their parts and units.

The strength team, starting from the stresses and forces that will arise with the specified forms of the aircraft during its operation, makes a preliminary strength calculation and determines the value and direction of the main forces acting on the assemblies of the aircraft; these data are communicated to the design teams.

As a result of these preliminary studies the general view of the aircraft is refined, allowing the design group of the general-view team to proceed to make the theoretical drawings and the matching group of the same team to make the preliminary tie-in drawings.

<u>The theoretical drawing</u> is drawn for each assembly and determines its external shape (contour) and the location of the longitudinal and lateral assemblies on it (Fig.66). The theoretical drawing is the reference-standard form of the assembly and is necessary to build up the loftings and to make more precise aerodynamic and strength calculations. Theoretical tables, making it possible to construct, on the loft floor, the contours of the assembly at full scale, are appended to the theoretical drawing.

<u>The preliminary tie-in drawings</u> are made on the basis of the layout and theoretical drawings for all assemblies and complex units of the aircraft and give their general view, not showing minor details. The tie-in drawing defines the position of

the parts and equipment inside the assembly, and their dimensions.

For instance, if a tie-in drawing of the place of installation of an instrument is given, then the drawing will show the place of location of the instrument and the arrangement of its wiring. When several different installations are located in a single zone, the matching group refines their mutual position and coordinates the proposals made by the various teams.

In small development-design offices, the design teams themselves work out and produce the theoretical and tie-in drawings. The general-view team works out only the layout drawing and the general-view drawing of the aircraft.

The general view of the aircraft and the theoretical drawings are approved by the chief designer, and the general-view team then delivers the theoretical, basic layout and tie-in drawings to the calculating and design teams, in the lofting-template shop and the mockup and model shop.

On the basis of the theoretical drawings and tables, the lofting and template shop develops the theoretical loftings. The theoretical lofting refines the external contours of an assembly, the position of its axial lines and of the axes of the principal units. These refinements are transferred to the theoretical drawing and to the lofting floor. Templates of the external contour of the assembly in question are taken from the theoretical lofting.

On the basis of the scheme selected and of the theoretical drawings, the aerodynamic team draws up a second aerodynamic calculation of the aircraft. These theoretical calculations are refined experimentally, for which purpose a special design team makes drawings for models of the aircraft, and the mockup shop builds models of several forms to various scales from these drawings. Depending on their purpose, the models are wind-tunnel, mechanized, dynamically similar, or tactical. The aerodynamic team, in accordance with the program worked out by it, makes wind-tunnel tests of the model at the development design office or at the Central Aerodynamic and Hydrodynamic Institute, and on the basis of the results of the wind-t tests, provides the design teams, before they begin the production design, with precise data of the forms of the assemblies and the aerodynamic forces acting on them.

The modifications in the aircraft contours, required after the model tests, are entered in the theoretical loftings and in the drawings, sometimes making their radical revision necessary.

The weight group, on the basis of the preliminary layout drawing, statistical data, aerodynamic and strength characteristics, and tables of the weight ratios of the aircraft parts, finds the design weights of the assemblies at specified strength, and on this basis computes the centering, determines the weight of the aircraft, its equipment and assemblies, and gives the design teams weight limits for the parts of the assemblies. The aircraft weight affects the tactical and technical characteristics of the aircraft and the fuel consumption. Many aircraft calculations depend on the aircraft weight. For this reason, the weight limits of the aircraft are law for the design team. Every design team must strive to reduce the weight of the aircraft part it is designing, and in no case whatever exceed the established limit.

The strength team, on the basis of the scheme selected and of the aerodynamic and weight characteristics, calculates the principal stresses with the object of determining the points of their application, their magnitudes, directions, distributions, and actions on the aircraft structure (its assemblies and individual units) for various design cases: in flight, on landing, etc. The strength team transmits its calculation and considerations to the design teams. These considerations are the starting point for the detail calculations of the assemblies being designed and of their units and parts. These calculations are then checked by the strength team and are used to make a complete stress analysis of the entire aircraft. It must be mentioned that definite strength standards correspond to each class of aircraft.

The equipment team refines the mounting and location of the equipment on the tie-in drawings and the aircraft mockup, and lists the equipment to be installed.

The technological team, in collaboration with the design teams, prepares the specifications for each assembly.

The materials and semifinished products to be used are refined and unified according to a schedule of types and sizes. The materials to be used are at the same time redetermined.

The scheme of division of the aircraft into assemblies, sections, panels, and technological units is drawn up to ensure the mechanization and optimum organization of the riveting assembly and fitting assembly work in series production. The principle of assembly, whether from skin toward framework or in reverse order, is laid down. The specifications for accuracy of the contours of the surfaces, for the protective coatings, etc., are drawn up.

The assemblies and other structural elements for which design sequence is to be followed, on the basis of what aircraft, are indicated next.

A pre-schedule of parts, units, lines, and joints of the aircraft to be standardized, normalized, and unified is drawn up, indicating the standards and design forms of the part and units to be used in the production design of the aircraft.

The integral units and panels are noted, as well as the blanks of the parts to be fabricated by casting, stamping, or rolling methods. Measures to secure interchangeability of the structural elements of the aircraft are given. The technological processes and equipment that must be used to fabricate the new aircraft design are ascertained. This information is necessary for the design and experimental work in the creation of the prototype aircraft.

The specifications for each assembly and for the aircraft as a whole are delivered by the technological team to the chief designer. After approval by the chief designer, the specifications are as binding for each team of the development design office as the weight, aerodynamics, strength, and layout conditions.

On the basis of all the original materials, the groups of formalizati STAT

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technical description of the aircraft, which belong to the general plan team, prepare a detailed description of the aircraft and formalize the preliminary layout design. The preliminary layout design includes the following basic documents: 1) general view of the aircraft in three projections; 2) layout drawings; 3) tactical model; 4) outline, control, equipment, and load distribution diagrams; 5) aerodynamic characteristics of the aircraft, with calculations; 6) principal data on strength and flying weights of aircraft for various loading versions; 7) calculation of the center of gravity of the aircraft with respect to the mean aerodynamic wing chord for various loading versions; 8) schedule of emergency rescue facilities; 9) outline diagrams; 10) description of the tactical-technical characteristics of the aircraft with an illustration of its design features in numerous tables and diagrams; 11) technological characterization of the aircraft, indicating the possibilities of manufacturing the new design in series production; 12) economic justification of the design with an estimate of the expenses; and 13) an explanatory note justifying each modification of the specifications.

The preliminary layout drawing, formalized by the signature of the chief designer, with the corrected tactical-technical specifications annexed (if they differ from those prescribed by the purchaser) is submitted for review by a special mockup commission.

The Aircraft Mockup. Simultaneously with the working out of the preliminary layout drawing, the general plan team proceeds, in collaboration with the equipment teams and other teams, brought in as necessary, to work out the drawings for the aircraft mockup. From these drawings, the mockup shop constructs a wooden mockup which represents the prototype of the new aircraft or only of its cockpit, in full scale. Instead of the engines, instruments and installations, the mockup is provided with metal or wooden models which are copies of the actual instruments (down to the very paint and inscriptions). The models are made up from the drawings of the development design office and the suppliers of instruments or equipment. The

body of the mockup must have a sufficient reserve strength to ensure safety of the work of its construction and utilization. The mockup has a dual purpose: first, to give the purchaser a complete idea as to the external shape, size, and internal arrangement of the aircraft being designed and to indicate the degree to which it provides convenient placement of the crew, their safety, unobstructed view, control and loading of the aircraft, and its care under operating conditions; second, during the period of planning and construction of the operating prototype aircraft, to serve as an objective and graphic aid to the designers and workers of the development plant.

The mockup is submitted to the mockup commission, which has the right not only to express their comments on the mockup, but on the ground of its examination, to prescribe additional specifications for the design of the aircraft.

The mockup is considered to have been definitively accepted and approved only after agreement has been reached between the mockup commission and the chief designer. The acceptance of the mockup is formalized by the commission in a formal instrument.

The production design is worked out on the basis of the materials of the preliminary layout drawing and mockup, and constitutes their further development and refinement. Each team working on the production drawings receives the following documents signed by the chief designer, from the general plan team: 1) assignment for the production drawing of an assembly or equipment; 2) precise theoretical drawing of the assembly and principal tie-in drawings for it; 3) reference documentation from the computation teams; 4) schedule of specifications for design; 5) methodological instructions on the fulfillment of the specifications submitted at the beginning of the assignment; 6) graph of delivery of the assembly drawings, with units and parts in the sequence prescribed by the plan entitled: "delivery of drawings for production".

On the basis of these initial data, the design team proceeds to work out the

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precise tie-in and assembly drawings for an assembly, and for the units and parts comprising it.

The final tie-in drawing of the technical design of the assembly is worked out by the design team on the basis of the preliminary tie-in drawing. The drawing is the detailing and refinement of the preliminary tie-in drawing, and does not appear subsequently as an independent technical document.

Let us consider the process of preparation of the final tie-in drawing from the following example: The general plan team delivers to the control team a preliminary tie-in drawing, showing the route traversed by the control system. The control team, guided by this drawing, by the aircraft mockup, and by the schematic diagram of the control system, then proceeds to work out the final tie-in drawings, accurately specifying the route of the control system for each assembly, and stating the elements of which it consists. For example, in the tie-in drawing of the control system with respect to the fuselage, the control team shows the displacements of the rods, cables, brackets, rockets, and levers, notes where and how the control system must be attached, calculates and indicates the stresses arising at the points of attachment of the control system; after this, it will deliver the final tie-in drawings for coordination to the fuselage team, and will then itself proceed to the preparation of the production (installation) drawings for layout of the control system and the production drawings for the units and parts of the control-system installation. The fuselage team refines its own tie-in drawing from the final tie-in drawings sent to it by the control-system team.

The coordinated work of the control-system team and the other equipment teams, in collaboration with the airframe teams, assures the timely matching of the drawings and excludes errors and additional work. Differences of opinions that arise in the coordination of the final tie-in drawings are decided by the liaison group of the general plan team or by the supervising aircraft designer. In this case, preference will be given to the drawing which most satisfies the demands of rational

location, minimum weight at maximum strength, and the demands for high engineering quality of design. There is also another system of coordinating the final tie-in drawings. In this system, the control system team, the equipment team, and other teams do not coordinate their final drawings with the framework teams, but the inaccuracies detected in the drawings are ascertained by the matching group of the general plan team, and the final tie-in drawings are there examined and approved. In this case, the immediate supervision and mutual coordination of the final tie-in drawings is assumed by the matching group.

The assembly drawing of an assembly is worked out by the airframe team on the basis of the theoretical and final tie-in drawings, delivered to it by the teams. The assembly is designed to provide a guarantee of specified strength, minimum weight, and specifications for series production. The assembly drawing of an assembly shows the layout in detail and with accuracy. When an assembly drawing is prepared, the airframe crew indicates which are stressed members and which are unstressed members, gives their construction, defines the thickness, width, and length of the skin, shows the places of jointing of the sheets horizontally and vertically, gives the precise position of the hatches, doors, and cut-outs for windows, and makes all of the strength calculations for the parts and units, starting from the forces acting on them. All dimensions are shown on the assembly drawing or the section entering into it. The dimensions taken from the loft floor are usually surrounded by a square marking.

The assembly drawing is delivered for checking to the lofting section. Here, from the dimensions taken from the theoretical lofting, the tie-in (design) loftings are laid out for the assembly in question. On the tie-in lofting, the equipment team finally refines the layout of the equipment, while the airframe team refines the assembly drawing. The refinement of the assembly drawing is performed by the geometric coordination of individual structural elements. **Adjustments of the tie-in lofting plans are countersigned in the lofting shop. At the same time, the lofting**

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department prepares copies of the detail drawings which are then executed, not by pattern but by template taken off the lofting.

On the basis of the assembly drawing, the airframe team makes the production drawings for the units and parts entering into the assembly, except those which, according to the lofting method, are fabricated directly from the templates. In preparing the production drawing of the unit or part, allowance is made for the engineering requirements of series production. The drawing contains all the technical information required in production for fabricating the part or unit from the drawing. The most important units are checked not only by the theoretical drawings but are also fabricated in full scale, weighed, and subjected to static tests. For a more complete realization of the specifications assigned for each unit, the designers, in the production designing of the parts, units, and assemblies of the aircraft must confer with the technologists about the correctness of the choice of the kind and size of material, original blanks, satisfactory technology of the shapes indicated for the parts and units, and convenience of their layout into independent blocks. Thus, because of the inadequate familiarity of designers with the technology of deep drawing of sheet-metal parts, with electric heating of the blanks, such parts are little used in aircraft building. Yet this new method is of great economic advantage, cutting the consumption of metal 2 - 4 fold and the labor 5 - 6 fold.

The drawings, finished in design, and with all requisite approvals, are delivered by the design team (in sets for the unit) to the inspection team. With the drawings, the team delivers a schedule and a routing slip, indicating what sets of units must be fabricated by the development plant and the order to which this is to be charged.

During preparation of the production drawing of the aircraft, the technological team refines and details the specifications for the various assemblies of the aircraft, in consultation with the staff of the chief technologist managing the series

plant, and daily give assistance to the designers of the development design office, in order to attain the best technological form of the parts, units, and assemblies.

Control of Design and Technological Characteristics of the Aircraft. In view of the rapid technical progress in aircraft building and the resultant brevity of the period of series production in each modification of the aircraft, its design and technological refinement is of primary importance for series production. The series plant will master the new design more rapidly, the fewer design modifications it has and the higher the degree of its technological quality. For instance, series plants which were given a light aircraft, well worked out technically and in design, to put into production were able to organize the technological preparation on the basis of extensive specialization and subcontracting in the field of designing and fabricating the tools. As a result of the high technological perfection of the machine and good organization of the work, the plants were able to change over to the production of the new modification, without stopping production and without slowing down the rate of output of the aircraft (Fig.67). The good design and technological characteristics of the aircraft of a number of Soviet designers makes them exceptionally stable in series production; and the introduction of these aircraft by series enterprises takes a relatively short time. However, there have also been cases when certain designers have turned over aircraft for series production that were inadequately worked out in design and technology. Such aircraft, in series production, required an immense number of design and technological modifications and demanded complex and extensive original tooling. All this greatly complicated the production, lengthened the periods of the mastery of series production of the new aircraft, and disturbed the uniform flow of production. Table 23, compiled from data of a certain plant that put an aircraft into production, in whose design over 20,000 modifications were made in the course of a year, indicates how irregularly the output of aircraft proceeded.

The complication of the shape and the unjustified increase in the accuracy class and finish of the parts and units leads to extensive metal losses in chips, to an increase in the time necessary for machining and assembly, and to higher cate-

Table 23

a)	b)				c)			
	d)							
	1st	2nd	3rd	in %	1st	2nd	3rd	in %
Overfulfilled	0	1	8	25	0	0	6	16,6
Fulfilled	0	1	1	6	0	0	0	0
Underfulfilled	12	10	3	69	12	12	6	83,4

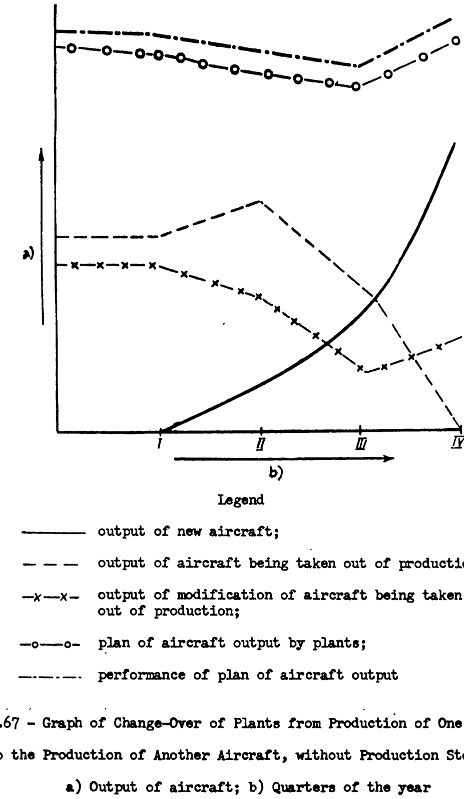
a) Characteristic of performance of ten-day assignments; b) Assembly of aircraft; c) Delivery of finished aircraft; d) Number of ten-day periods

gories for the work. The inadequately typified and standardized forms of the parts and units leads to an increase in the number of dies, jigs, and other tooling and makes the period of their utilization too brief. This is why the designer at the development design office must consider the design and technological finish of each part and unit of the aircraft his very first concern.

The good features or faults of a design find their reflection in the production drawings. An incorrect drawing leads to spoilage in production. For this reason, control of the drawings is of great economic importance, since it protects production from the fabrication of products according to untrue and economically nonrational drawings. Each production drawing, before going into production, is subjected to a comprehensive control, calculation, and standardization, both technological and general.

The calculation control consists in checking the production drawing for conformity with the assigned strength, weight, aerodynamic, and other requirements. For instance, the general-plan team checks the tie-in of the wing with the wing center

section or the fuselage; the aerodynamic team checks and confirms conformity with



Legend

———— output of new aircraft;

— — — output of aircraft being taken out of production;

—x—x— output of modification of aircraft being taken out of production;

—o—o— plan of aircraft output by plants;

—·—·— performance of plan of aircraft output

Fig.67 - Graph of Change-Over of Plants from Production of One Aircraft to the Production of Another Aircraft, without Production Stoppage

a) Output of aircraft; b) Quarters of the year

the specifications for the external shape of an assembly; the strength team checks conformity of the structural strength with the assigned strength; the weight group makes sure that the weight limits have not been exceeded.

The weight control is not limited to the theoretical calculation of the weight of the aircraft parts. Each part or unit fabricated, and each assembled major component as well as the aircraft as a whole, are weighed. The actual weight of the aircraft and its assemblies is compared with the calculated weights.

The normalization control of a drawing is carried out by the normalization and standardization group and consists in checking the correctness of the application of the State standard, the ministerial and plant standards, and in establishing the possibility of replacing the original parts shown in the drawing by standard and unified parts.

The technological control of the drawing is performed by the technological group and consists in verifying the economic soundness of the material selected, the shapes and dimensions of the parts, units, and assemblies of the aircraft and their conformity with the requirements of large-lot production. Large-lot production demands that the design of an aircraft is adapted to manufacture under conditions where the labor is divided into operations allowing the use of the production-line method; that the design consists of interchangeable parts, units, and assemblies with extensive use of open profiles and panels; that standardized and unified parts, units, and assemblies are widely used in the design (this allows the organization of multiproduct lines); that the blanks, parts, and units are amenable to processing by high-production methods, for instance by stamping and casting followed by machining of only the mating surfaces, of large-dimension stamping, rolling, automatic welding, and group squeeze riveting. It is very important to have the engineers of the prime series plant participate in the technological control of the production drawings.

The general control of the drawings is handled by the control team, and consists in checking the accuracy of representation of the object, its dimensions, the

tolerances and their mutual coordination, the justification for the accuracy class, fit and finish selected, the correctness of the formalization and editing of the drawing, and of adequate information content for the high-grade manufacture of the object.

The control team, after verifying and correcting the drawings and the accompanying documentation, delivers them in complete sets for the unit or assembly to the central technical files of the development design office.

The process for the manufacture of the prototype aircraft is designed by the office of the chief technologist, as the drawings for it arrive from the development design office. The procedure and order of the delivery of drawings from the development design office to the development plant is determined by the chief engineer or the chief technologist of the development plant. To accelerate the work on the building of the prototype, the technologists prepare specifications, technical conditions, and drawings for the semifinished articles ordered from outside, as early as during the stage of making the production drawing. In addition, the delivery of the theoretical and preliminary drawings to the development plant is practiced. From such drawings, the technologists, with a certain head start, perform the preparatory work, the standardization and listing of the materials required, the assignment of the drawings to the shops, the issue of orders for tooling, dies and jigs, as soon as the production drawings are ready and only the checking and refinement remain to be done. For instance, from the drawing of the preliminary layout of the skin of an assembly, a master plaster pattern is first fabricated and on it the printing and fitting of the skin is done until the production drawing of the skin is ready.

Directive and working manufacturing process charts are used in development production.

The directive process chart is drawn up by the organization of the chief technologist for assembly of the aircraft, its assemblies, and systems, for the fabrica-

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tion of the most complex parts, and for new processes.

On the basis of the drawings of the articles and of the directive process chart, the technological offices of the primary shops draw up a working process chart, formalizing it, as a rule, into summary (route) flow sheets for the part or unit. In working out flow sheets, the technologists establish the requirements for the necessary special tools, equipment and jigs, without which the new aircraft cannot be produced. In development production, standardized assembly jigs, attachments, and tools are used.

The design of special tooling and attachments is handled by the design offices, under the chief technologist of the development enterprise. The designing of the patterns, flasks, chills, and molds for casting is handled by the department of the chief metallurgist or the office of preparation for production of the casting shop. The drawings for special tooling are approved by the chief technologist or the chief metallurgist and are delivered to the tool department for incorporation in the program of the auxiliary shops, or to be ordered from other enterprises. In development production, the work on tooling design is simplified. For instance, in designing assembly tooling, the theoretical drawing of the assembly or unit is used as a drawing of the tool, by entering on the theoretical drawing the additional points for fixing the outline of the external contour and the points of attachment.

The chief technologist establishes the sequence of a design and the amount of special and other tooling to be fabricated, and draws up a calendar graph of the setwise delivery of the drawings to the tool shops, assuring their uniform loading. The tool shops and attachment shops deliver the tooling in sets, first to the fabricating shops, then to the processing and intermediate shops, and finally to the assembly shops, assuring their operations according to the graph.

Building and Service Testing of the Production Prototype Aircraft. The primary shops, as they receive the production drawings, templates, and tooling, proceed to build the prototype aircraft. During the process of manufacturing and testing the

production model, the production drawings are given their final touches. Several samples of the model are built. First the initial flight aircraft is built, with a second one for static tests. The latter consists only of the airframe, without the internal fittings. After the static tests have been run, corrections are made to the first flight machine. The flight machine is subjected to the service flight tests on the decision of the TsAGI. The tests are made by the development shop in accordance with the program worked out by it and approved by the ministry. The purchaser may also participate in these tests. By agreement with the purchaser, the enterprise may combine certain tests (for instance, for endurance and flying range) with the State tests.

After the plant tests and the corresponding final modifications, the aircraft, together with its ground equipment, is turned over for the State tests, which constitute the certification of the submission of the aircraft for final delivery.

The State tests of the aircraft are made by a commission under a special program and have the purpose of establishing the aircraft's compliance with the assigned specifications. The State tests are made on one aircraft or on several. When the State tests are run, any deviations from the assigned specifications, together with the purchaser's suggestions for improvement of the aircraft design, are entered in the protocol by the commission. If the aircraft, on the whole, meets the specifications, the committee issues a decision that the aircraft can be put into series production. At the same time, the commission, in agreement with the chief designer, establishes the order and dates of introducing the supplementary modifications of the test protocol in the aircraft design.

Simultaneously with the delivery of the flight prototype of the aircraft for the State tests, the development plant builds a third sample of the production model which serves as the standard for series production. All improvements and additions requested by the purchaser on the basis of the results of plant and State tests of the first model are introduced into the third sample. These improvements, addi-

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tions, and refinements are reflected in the drawings and other technical documentation of the development design office.

For each modification, the development design office makes out a drawing modification sheet (LICh) which is sent, together with the drawing, to the prime series plant.

To have these modifications interfere as little as possible with the uniform work of the series plant, after the State tests, the development design office must agree with the prime series plant on the forthcoming modifications and the dates of their introduction.

The production drawing in final form comprises the following basic documents: installation, assembly, and detail drawings; refined specifications for materials, semifinished and finished articles; aerodynamic strength, weight, and other calculations on the aircraft and its assemblies; data on the centering and the weight log of the aircraft; description of the aircraft, specifications, and test reports; drawings of the ground equipment, and production manufacturing and operating instructions. All these documents are delivered by the development plant to the prime series plant. It also turns over: the theoretical loftings with tables and a set of the control-contour templates, of the reference standard and master pattern system; the technological characterization of the aircraft; the specifications and drawings for the special tooling for the newly introduced processes; the specifications for primary and auxiliary materials, castings, forgings and stampings, for parts of plastics, rubber and newly introduced materials, with a separate list of the parts first used in the given aircraft.

Further Improvement of the Aircraft Design. After delivery of the drawings for a new machine to the series enterprise, the development design office (OKB) continues its work on further improvement of the design. In realizing the technological control of the development drawings by the series enterprise, a large number of various comments on the improvement of the technological properties of the new

design are entered. These comments reach the OKB accompanied by the conclusion of the series-design department of the series enterprise. In accordance with the comments received, the OKB authorizes the introduction of modifications in the series drawings and advises the series-design department accordingly. The number of technological refinements may be sharply reduced by improving the quality of the drawings control at the OKB and analyzing them with the participation of technologists from the series enterprise. In the process of building the type series, various design errors show up and are also considered by the series-design department, which sends a list of them to the OKB, together with its conclusion, to secure permission for making changes in the drawings.

When the aircraft reach the operating organizations, suggestions on the improvement of the design are submitted by the flight personnel, during the course of operation. These suggestions are considered by the OKB, and, if accepted, the appropriate changes are made in the drawings, and the series enterprise is notified.

Besides current improvements, the OKB also works on the basic revision of the design, resulting in a new modification of a given aircraft. The modification improves the quality of the aircraft and at the same time lengthens its life in series production.

Section 2. Organization of the Experimental Work

The production prototype, during the process of its design, construction, and improvement, is subjected to various experimental investigations. Anything put out by the designer, initially in the form of calculations, diagrams or drawings, is subsequently checked on models, mockups, and production prototypes. For instance, all theoretical calculations on the search for optimum aircraft shapes are checked and refined on models by the aerodynamic team. To determine the maximum loads and establish the strength characteristics of the assemblies and of the aircraft, the strength team verifies its calculations by static and dynamic tests of the aircraft

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and its parts. The design work in connection with the internal layout of the aircraft and the convenience of location of all necessary elements in it, is tested on a mockup. The installation diagrams for the electrical, radio, navigation and other forms of aircraft equipment are checked in the laboratories. The most important installations are first refined on special full-scale test stands before installation on the aircraft. The assembled aircraft is given ground and flight tests. Consequently, the process of designing an aircraft is inseparable from research and experimental work. For this reason, the development enterprise stages its experimental work in two directions. The first is the development of the prospective problems with the participation of the competent research institutes. The second direction is the working out of questions arising during the designing and refinement of the new aircraft. Such questions are decided, in most cases, by the development design office itself.

Depending on its purpose, the experimental work may be classified into work in connection with checking the aerodynamic shape of the airframe, the strength under static and dynamic loads, the resources of the power plant, the properties of new materials and technological methods of processing and assembly, the quality of the work on the equipment installations and assemblies prior to their installation on the aircraft, with the staging of ground and flight tests of the aircraft.

The experimental base of the development design office is represented by the shops of the development enterprise, the laboratories, the special installations, and the LIIDB (flight test and refinement base).

The development and series enterprises build samples of the aircraft units and assemblies for the development design office, which are then subjected to various tests.

The laboratories are intended for performing a definite type of experimental and control work, and are subdivided into computation, materials, technological, equipment, and power plant.

The computation laboratories investigate questions connected with the aerodynamic, strength, and weight characteristics of the aircraft. For this purpose, the following laboratories are organized within the development design office: aerodynamic, hydraulic, static tests of models and prototypes of aircraft units, assemblies and airframe, vibration tests of assemblies, and others.

The materials-testing laboratories investigate the chemical composition and mechanical properties of materials, and are grouped into chemical, metallographic, and mechanical laboratories. The organization of the development design office also has laboratories specialized in investigating the properties of plastics and electrical and radio materials.

At some development design offices, all these laboratories are combined into a single general materials-testing laboratory.

The technological laboratory searches for methods of processing new materials and new methods of processing and assembly due to the design structure of the aircraft.

The laboratories for electrical, radio and navigation equipment, and similar laboratories, investigate the proper hookup of the systems, their properties, and the trouble-free operation of the equipment.

The power-plant laboratory has the function of refining and checking the entire system of control of the aircraft power plants.

The full-scale test stand is a basic installation equipped with all necessary mechanisms and measurement instrumentation. Full-scale test stands are established to test the assemblies of the horizontal and vertical tail surfaces and other assemblies under various operating conditions on the aircraft, to refine and finish off the mechanism of control and special installations, to ascertain the reserve characteristics of the landing-gear system, the hydraulic system, and the power plants. The utilization of full-scale test stands shortens the time for finishing the production prototype and allows the installation of only completely refined as-

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semblies.

A flying laboratory is an aircraft which is equipped, as the aircraft being designed, with new assemblies, installations, or instruments which can be checked only under actual aircraft operating conditions. These assemblies and installations include the aircraft controls, the engine, the crew rescue facilities, and the mechanisms for improving the take-off and landing characteristics of the aircraft. The preliminary finishing development and testing of these assemblies eliminates possible hazards in the testing of the prototype aircraft and reveals the characteristics of the equipment being checked.

The functions of each laboratory may, in general, be formulated as follows: development of the technique of testing in accordance with the assigned program; designing, and sometimes also building, the attachments and instruments necessary for testing, and their installation on the full-scale test stand; conducting of analyses and tests in accordance with the program; work-up of the results of analyses or tests; and formulation of corresponding conclusions. These conclusions are needed by the design team in designing; by the development production, in installing the equipment or power plant; and by the technical control and flight-experimental units, in ground and air tests of the aircraft. The operation plans of the laboratories are prepared on the basis of the schematic plan of the development design office, and of the requests of the teams and development production unit. For the performance of work on the project, the laboratory receives a program of the forthcoming tests from the team. The diagram (Fig.68) shows the interrelations of the teams, laboratories, and shops in the performance of experimental work on a project, as an example.

Section 3. Specialization of the Development Design Office and Advanced Methods of Work by the Designers

Let us consider some of the advanced methods of organization of development production, which encourage the performance in short periods of work on the designing and building of the aircraft.

Specialization of the development design offices proceeds along the lines of research, planning, and productive work.

The research institutes and laboratories conduct theoretical studies, special tests and search for new materials for the OKB.

Specialized development design offices, assignment by the prime OKB, prepare designs of instruments, installations, and assemblies for it.

The enterprises supply the development plant with materials, finished blanks, parts, units, and assemblies. The more narrow the specialization of the OKB, the broader will be the front of simultaneous work and the shorter the cycle of designing and constructing of the prototype aircraft.

The specialization of the teams and laboratories within the OKB leads to a sharp division of the work, its mechanization and better organization, thus improving the labor productivity of the OKB workers. Specialization of the teams allows design work to be conducted in parallel and parallel-sequence methods, thus shortening the cycle of designing and building the production prototype. Specialization of the teams should be accompanied by a distinct delimitation of functions between the teams.

In each team, there should be exactly defined documents prepared by it during the stages of research and production drawings, a technique of working out each document, a procedure, and periods for its coordination with other teams and for its delivery to other units of the OKB.

The cyclic operation and uniformity in the load on the OKB and the development plant ensures effective utilization of their capacity and eliminates stoppages in the work. It is necessary in planning the experimental work to maintain proportionality in the load on the units of the OKB and its plant, and to maintain uniform loads or uniformly increasing loads, in all units by months of the planning year.

The more widely the OKB realizes standardization, unification, and design se-

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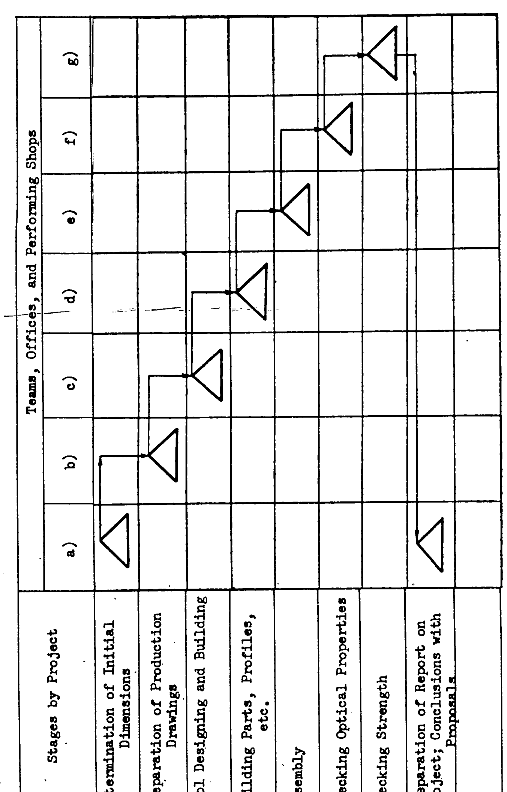

Fig.68 - Diagram Showing Interrelation in the Work of Teams and Laboratories of the Development Design Office in Designing One of the Assemblies

a) Matching and layout team; b) Fuselage team; c) Design department for tool designing; d) Fabricating-stamping shop; e) Assembly shop; f) Special installations laboratory; g) Static testing laboratory

quence of the aircraft being designed, the larger will be the number of parts, units, sections, and assemblies that need no longer be designed and built at the development plant, but which can instead be taken ready-made from the prime series plant.

The planning of the rooms of the OKB and its equipment must correspond to the technological sequence of the design in process. The units serving the primary teams come close to them. The room of the development design office should be light, clean, isolated from noise and equipped with belt conveyors, a pneumatic and electric tube post, permitting rapid transmission of drawings and important papers. Calculations that are tedious or recur often are performed by the machine-computer station.

The work place of the designer is equipped in accordance with the features of the work of the team. The work places of designers and computers are provided with drafting tables, computing machines, and other appliances favoring more productive work.

The planning of the work place of the designer and the layout of all its necessary elements should be convenient for work.

The servicing and preparation of the work place of a designer for work consists in the timely delivery of all required materials to the work place. To save the designer time, it is of prime importance to provide him with various reference material and manuals as well as with catalogs of drawings of parts and units. In the advanced practice of Soviet research institutes and development design offices, calculation methods have been worked out that allow the designers and computers to make use of highly developed techniques, conversion tables, handbooks, instructions and typical diagrams, sparing the designer preliminary searches for material and time-consuming computation.

The designer planning his work first submits his requisition for literature, reference, and other handbook material, and also sends his materials for calculation, checking and control to the service units, the machine-computer station, the bureau of technical information, the technical library, the technical files, etc.

In each new machine, the designers should increase the percentage of standardized and unified parts, units, and sections and should introduce compulsory limitations on the shape, dimensions, and weight of the parts. Parts or units having the same function should be formalized in the same design forms. To save metal, a designer should establish the upper limit of metal consumption for the various types of parts, and should make wide use of modern calculation methods, allowing a reduction in structural weight, organize the exchange of experience between related enterprises, and stage critical analyses of the designs of machines, with the participation of technologists and designers of the series plants.

To increase the labor productivity of the designers, it is necessary to improve their qualifications, to organize their work correctly, to equip their rooms and work places rationally, to mechanize the computational work, to use progressive wage standards and bonus wage payments, and widely to introduce advanced methods of work.

Section 4. Structure of the Experimental Aircraft Construction Enterprise and Functions of its Primary Units

The planning and designing work on an aircraft is measured in hundreds of thousands of hours for machines of small tonnage, and in millions of hours for machines of large tonnage. For this reason, a development design office (OKB) designing heavy aircraft has a greater amount of work and has more highly specialized design teams and other units than a development design office, designing light aircraft. The structure of an OKB depends on whether it is attached to a series plant or is part of the organization of a development plant. At a series plant, the OKB has its own development shop and complete independence in conducting and financing the development work. The security and administrative-economic servicing of such an OKB is handled by the series enterprise services. In practice, independent development enterprises are more widely used. The structure of one of such enter-

prises is shown in Fig.69.

The organization of a development enterprise usually contains a development-design office (OKB), a development production unit, and a flight-test and elaboration base. The structure of a development enterprise is laid out so as to allow the chief designer to devote most of his time to the creative leadership of the design work. The chief designer therefore has assistants, each of whom manages a certain definite part of the work.

The chief designer heads the OKB and is at the same time the responsible director of the experimental plant. He manages both on the principle of one-man management. The new aircraft designs are created by the staff of the development plant under the direct supervision of the chief designer.

The first assistant of the chief designer manages the routine work of the OKB.

The assistants of the chief designer for aircraft types are appointed by the chief designer for the operative leadership of the work on experimental aircraft, when the OKB is simultaneously designing several aircraft. Each of these assistants decides the questions of designing, running experiments and all the research work connected with the aircraft he is handling. He is responsible for the coordination and interrelation of the work of all the teams working on the machine, and for the control of the performance of the work according to the graph. His dispositions are binding on every team and unit of the OKB. He signs the drawings and documentation for a new aircraft, decides questions relating to the construction, testing, and elaboration of the aircraft, and handles the delivery of the aircraft and the technical documentation for series production.

The assistant of the chief designer for series plants, acting through the managing designers under his supervision, exercises control over the building of aircraft by series plants in accordance with the drawings and specifications, periodically checks the tests of the series aircraft, and decides all questions connected with the refinement and replacement of drawings for the series aircraft.

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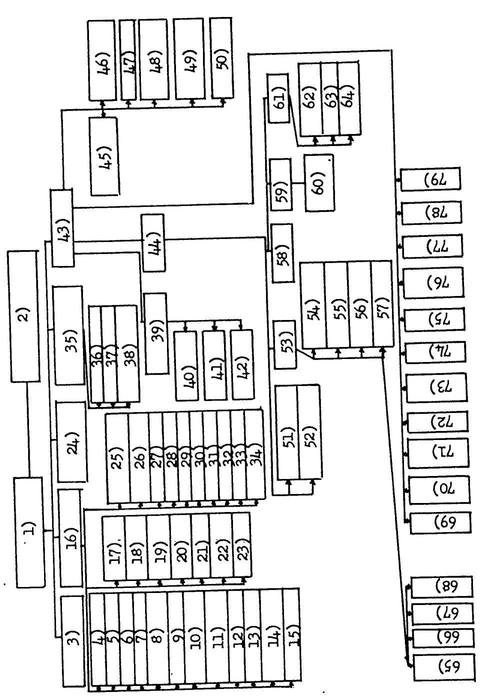

Fig.69 – Structure of One of the Development Aircraft Building Enterprises
(for Legend see next page)

Re Fig.69 – 1) Chief designer – responsible manager of plant; 2) Chief inspector; 3) Flight testing and refinement base; 4) Wing team; 5) Fuselage team; 6) Wing center section team; 7) Empennage team; 8) Power plant team; 9) Landing gear team; 10) Navigation equipment team; 11) Electrical and radio equipment team; 12) Pressurization team; 13) Hydraulic system team; 14) Special equipment team; 15) Controls team; 16) 1st assistant chief designer; 17) General plan and matching team; 18) Aerodynamics team; 19) Vibration team; 20) Strength team; 21) Laboratories; 22) Loft-templet shop; 23) Mockup shop; 24) Assistant chief designers for aircraft types; 25) Administrative and general management group; 26) Planning-dispatcher office; 27) Standards team; 28) Control team; 29) Technical description team; 30) Information office; 31) Library; 32) Files; 33) Blueprinting shop; 34) Technological team; 35) Assistant chief designer for series; 36) Modification team; 37) Leading designer; 38) Aircraft operations department; 39) Assistant director for personnel; 40) Department of hire and discharge; 41) Plant protection; 42) Personnel training department; 43) Director of development plant; 44) Chief engineer; 45) Department of material and technical supply; 46) Department of planning and labor; 47) Accounting department; 48) Capital construction department; 49) Department of administrative and general plant management; 50) Housing department; 51) Office of rationalization and invention; 52) Plant safety office; 53) Chief technologist; 54) Technological department; 55) Attachments department; 56) Tool department; 57) Central tool store; 58) Production superintendent; 59) Chief metallurgist; 60) General plant laboratory; 61) Chief machinist; 62) Maintenance machine shop; 63) Electrical shop; 64) Heat and power shop; 65) Technological laboratory; 66) Pattern shop; 67) Attachment shop; 68) Tool shop; 69) Assembly shop; 70) Fitting welding shop; 71) Carpenter shop; 72) Machine shop; 73) Fabricating and coppersmith shop; 74) Landing gear and hydraulic system shop; 75) Equipment shop; 76) Nonmetallic coating shop; 77) Heat treatment shop; 78) Casting shop; 79) Forging shop

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A development design office, planning light aircraft is usually divided into teams, and the teams into groups. A development design office planning medium and heavy aircraft is divided into departments, teams, and groups. A department comprises teams of the same kind. For instance, the department of computing teams includes the aerodynamic and strength teams.

Each team is specialized to perform definite work: computing, designing, installation, etc. and consists of specialized groups.

Let us consider the functions of the most important teams of the development design office.

The general-plan and matching team is the creative center where the forms of new aircraft designs are conceived and the most important documents on the preliminary layout drawing are prepared. The team consists of the following groups: group of prospective designing, which lays out the schematic diagrams of the future aircraft; group of current design, which works on the current preliminary drawings, and works out the layout and theoretical drawing; matching group, which works out the tie-in and mockup drawings, and handles the coordination of the assemblies and equipment of the aircraft; weight group, which makes the preliminary and working weight calculation and centering; mockup shop, which builds the models and mockups; editing group, which artistically edits, formulizes, and makes up the layout drawings, general drawings, diagrams, and charts; and the photographic laboratory, which participates in making up the preliminary layout drawing.

The aerodynamic team handles the aerodynamic calculations to determine the speeds, stability, and contours, draws up the program of wind-tunnel tests of models of the aircraft, issues the assignments for model building, and carries out tests of models or participates in their conduct.

The strength team makes the preliminary and working strength calculations for the entire aircraft, makes up the program for the static and other tests of the aircraft, and works out the strength standards.

The airframe teams, for the wing, wing center section, fuselage, empennage and others, draft the tie-in drawings, make strength calculations for the individual parts and units, issue production drawings of the assemblies, their units and parts, and draw up preliminary requisitions for materials, semifinished and finished articles by assemblies.

The power-plant teams work out the drawings of the engine installations, the fuel system, and the drawings of the test stands.

The equipment teams (air navigation, electrical, radio, and other) make up the schematic diagrams, the tie-in and production drawings of the location and installation of the corresponding equipment of the aircraft.

The control team takes the working drawings from the design teams for checking purposes, verifies them and then turns them over to the technical files department.

The technological team prepares the specifications for the aircraft; consults the designers of the teams; makes up the summary requisitions for the materials, semifinished and finished articles; handles the technological control over the aircraft drawings; stages experimental work in collaboration with research institutes and other development design offices on the search for indoctrination in, and introduction into design of, new materials and processes; drafts the manufacturing rules for new processes; ascertains the necessity of creating new processes and equipment; prepares data characterizing the technological level of the design; calculates the applicability and unification of materials and semifinished articles; and supplies technological information to the design teams.

The standardization team effects the standardization control of drawings, makes sure that the ministerial and plant standards are applied in the new design of the aircraft, works out and introduces new standards and makes up catalogs of standards, occupies itself with the unification of parts and units of the aircraft, and supplies the design teams and the development production unit with handbook material.

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The technical description team draws the technical description of the new air-

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craft design, which is used in series production and in the organizations operating the machine, systematizes the material on earlier designs, sets up a description of the prototype aircraft, and prepares for the designers folders of the most improved and widely used design of assemblies, units, and parts.

The technical files department receives, registers, numbers, stores, records, issues and replaces drawings. The files department prepares for the delivery of the drawings and technical documentation for a new machine to the series plant. The files department has a blueprint shop under its control.

The laboratories of the development design office perform various experimental and checking work. The laboratories may be under the jurisdiction of the superintendent of the experimental department himself, or may be directly subordinate to the individual teams; for instance, the static testing laboratory is under the superintendent of the strength team; the technological laboratory, under the chief technologist; the metallographic laboratory and the testing laboratory for nonmetal materials, under the chief metallurgist.

The lofting and template shop builds loftings and templates; the mockup shop builds models and constructs mockups of the aircraft.

The aircraft operating department gives the chief designer informational material on the results of the operation of the aircraft, studies complaints received from purchasers, and devises methods of eliminating the defects.

The assistant chief designer for the development plant performs the functions of the director of the plant, thereby relieving the chief designer of all current administrative-financial and production activity. The chief designer decides only the most important questions and gives the basic instructions to assure a more effective and rapid construction of the experimental aircraft. It is important to note that, although the development design office is the primary and leading unit of the development production unit, the juristic person is not this office but the plant itself, through which the Ministry of Aviation Industry finances and controls

the work of the development design office and of the development production. A number of departments of the plant, administrative-economic, plant production, supply, labor organization and wages, finances, accounting department, commander's office, etc., service not only the plant but also the development design office.

The chief engineer of the development plant manages all technical work of the plant and is responsible for its technical progress as well as for the quality and periods of construction of the aircraft prototypes.

The chief technologist of the development plant and (at the same time) of the development design office is responsible for the technological preparation of production and manages the work of design and improvement of the technological processes and tooling, of the fabrication of tools and their introduction into production, and also controls the observance of technological discipline in the development production.

The chief metallurgist handles the questions of application and testing of materials, manages the development of the processes of casting, cold-working, hot-stamping, heat-treatment, welding, coating, and thermal insulation and also maintains liaison with the scientific institutes on these technological processes.

The following work is done at the flight-testing and elaboration base (LIIDB): assembly of the aircraft, if it was delivered to the base in disassembled form; preparation of the aircraft for ground and flight tests; plant tests of the aircraft and (by agreement with the State commission) also part of the State tests. Minor improvements in the aircraft design, the need for which is disclosed by the tests, are also handled at the flight-test base.

Section 5. Operative-Calendar Planning and Dispatching of the Design Work

In aircraft building, for every project envisaging the designing and construction of an experimental aircraft, a directive graph is drawn up.

The directive graph determines the sequence, volume, dates, and personnel as-

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signed for the main stages of the work on the designing and construction of the experimental aircraft (Fig.70). On the basis of the directive graph, the Central Administration of the Ministry controls and finances the work of the development enterprise.

The directive graph is prepared by the planning and dispatcher bureau of the development design office, in collaboration with the managers of the teams and the development plant, on instructions by the chief designer. The graph is signed by the chief designer and is submitted to the Ministry for approval.

For a well-founded preparation of the directive graphs, the development design office must dispose of the following plan norms:

1. Norms on the structural designing of the machine, its assemblies, and units. The starting point for the norms on the structural designing of the machine is the number of drawings of standard format and the standard time for the designing and for the detailing and copying of the drawings.

2. Norms on the designing of the process, on the designing of tools, jigs and fixtures, and their fabrication. The basic elements for these norms are provided by the typical representatives of the tools, jigs, and fixtures by forms of work.

3. Norms for productive work, broken down into forms and categories of work, by equipment, and by shops. The starting basis of the norms for productive work are the technically justified standard times.

4. Norms of the length of the cycles of the preliminary and production designing, of the designing and building of tools, jigs, and fixtures, and for the construction and testing of the aircraft.

5. The norm graphs of the overlapping of work by project, and a detailed list by stages and assemblies.

The directive graph classifies all the work on the new aircraft into theoretical, experimental, productive, and miscellaneous. The theoretical work includes preparation of the preliminary layout drawing and the construction of the mockup.

The experimental work includes the construction of models, the building of various prototypes, the staging of experiments and tests. The productive work includes the designing and construction of the aircraft, and its preparation for the first flight. The miscellaneous work includes the over-plan work on reworking of the drawings, correction of the design after the tests, and dispatch of designers to the plant at its request. Since such work proceeds throughout the entire design period, and cannot be predicted in advance, time for it is reserved on the graph.

In the preparation of a directive graph, an approximate estimate is first made by the chain method in the opposite order to the course of the production process. For this purpose, first the date of delivery of the aircraft for its first flight is laid out on the graph, followed by the cycle of preparation of the aircraft for its tests at the flight-testing and development base, by the cycle of final assembly of the aircraft, and finally by the cycle of assembly of the most labor-consuming major component, namely the fuselage or wings; parallel to this, the cycles of construction and designing of the other assemblies and equipment are laid off on the graph, starting from the spacing of the release of the drawings and the established times of construction of the assemblies as indicated by the development plant. If all these stages fit into the period assigned for the creation of the aircraft, a precise calculation of the work is then made for all stages, in order of precedence of their performance according to the graph. If the performance of the planned stages of the work does not fit into the period set aside for this purpose, then the cycles of the stages are reviewed, and methods for better coordination of the stages are sought. The calculation of the labor cost of the work on the project is established in the development production by three methods: statistical, conversion factors, and consolidated standard tables.

<u>The statistical method</u> is based on the use of the report data of the development design office for aircraft previously produced. The aircraft closest to that being designed is taken as the base. The average actual time consumptions for the

Designation of Stages of Work	Kind of Work	Number of Planned Units (Drawings, Manufacturing Process Charts, Attachments, etc.	Stand. Time per Planned Unit	Labor Cost of This Kind of Work in Stand. Hours	Labor Cost of This Kind of Work in Percent of Total Labor Cost of Aircraft	Work to be Done By	Date of Work: Begin	Date of Work: End	Jan–Dec (Half of Month: 1st, 2nd)
Theoretical and Experimental Work									
Sketch Design					2.5	Gen.Plans Team; Aerodyn. and Weight Teams			
Mockup					2.5	Gen.Plans Team; Mock-up Shop			
Experimental Work					4				
Designing and Prod. Work by Aircr. Components									
Fuselage	Designing constr.				8	Fuselage Team; Devel.Plant			
Wing	Designing constr.				8	Wing Team; Develop.Plant			
Empennage	Designing constr.				4 - 5	Empennage Team Develop.Plant			
Landing gear	Designing constr.				3	Landg.Gear T. Develop.Plant			
Controls	Designing constr.				6 - 7	Control Teams; Develop.Plant			
Power Plant and fuel supply	Designing constr.				11 - 13	Power Plant T. Develop.Plant			
Power, Navigat-ion and Altit. Equipment	Designing constr.				16 - 18	Equipment T. Develop.Plant			
Special equipment	Designing constr.				18 - 20	Special Equ.T. Develop.Plant			
Final Assemb.a. Fittg.of Aircr.	Designing constr.				9 - 10	Airframe Teams Develop.Plant			
Prep.of Aircr. f.Plant Tests					6	Airframe Teams; Dev.Plant LIIDB			
Miscellaneous work	Designing constr.				2	Teams; Develop.Plant			

Total: a) Theoretical and experimental work 9%; b) Designing work 22%; c) Production work 69%

Fig.70 - Directive Graph of Work on Designing, Constructing and Testing and New Aircraft

designing and manufacture of the aircraft, as found by the statistical method, are freed of the unproductive losses of working time fixed in the reports. The remaining labor cost is corrected in accordance with the average percentage of overfulfillment of the time standard that has been attained. Thus the corrected standard time for the earlier aircraft is established. The design under study is next compared with the earlier design in complexity and in the number of parts proposed. A correction factor is applied for these differences. A disadvantage of the statistical method is the fact that it conceals the production losses.

The method of conversion factors differs from the statistical method in that the original measure taken is the basic aircraft while all the other aircraft, with respect to this basic machine, are calculated by means of a conversion factor established for each.

The method of consolidated standards is based on the development of progressive standards for the drafting, technological, and production work on each assembly of the aircraft, distributing its labor cost by forms of work and units of the assembly. As an example of such a standard we give the percentage breakdown of design work for the external part of the wing of a British aircraft:

		%
1.	Tie-in drawings	5 - 10
2.	Detailed calculations	5
3.	Experimental work inside the team	2 - 3
4.	Production drawings	88 - 72
	This last item includes:	
	Front spar	15
	Rear spar	12
	(etc.)	

By using this Table, it can (for example) be established that, if the release of the production drawings for the front and rear spars in January is prescribed by the graph for the wing team, then the delivery production of the wing team in January will be 27%.

The distribution of work between the development design office and the development plant, and their productive units, is accomplished by the production planning department on the basis of the standards and, where no such standards exist, on the basis of experience and statistical data. Statistics show that for each hour of design work spent by the development design office, the development plant spends an average of 2.5 - 3 hrs. Starting from such a ratio between the elements of the work, the time necessary for designing the aircraft and the time required for its construction are established.

The planned labor cost of the designing work is distributed between the teams of the development design office and the shops of the development plant on the basis of the standards of the ratio between the capacities of the teams and shops.

As an example of the distribution of the labor cost of work in the designing and construction of an aircraft between the teams of the development design office and the shops of the development plant, we give a Table (below), compiled from the data of one development enterprise.

The distribution of the volume of planning work within the OKB can also be based on the ratio of the workers of various specialties in the OKB.

The following is the approximate percentage ratio of workers by specialties, in a British design office.

	%
Designers	56.90
Lofting engineers	6.88
Stress analysts	11.58
Weight estimators	3.38
Aerodynamicists	4.75
Technologists	7.42

Department of Technical Documentation:

Writers	2.15	5.24
Artists	3.09	
Trainees		3.85
		100

The planned labor cost of work for the fabrication of tooling, dies, jigs, and

Team of Development Design Office	Work Performed by the Team in % of All Work of Designing the Aircraft	Shop of Development Plant	Work Performed by the Shop in % of All Work on the Construction of the Prototype Aircraft
General plans	9	Casting-forging	7
Aerodynamics	5	Fabricating and stamping	17
Strength	5	Machining	18
Wing	13	Fitting-welding	10
Wing center section	11	Woodworking	5.5
Propeller and engine	9	Assembly	26
Fuselage	12	Upholstery and painting	3.5
Empennage	7	Mockup	3
Landing gear	6	Lofting and template	3
Equipment	6	Tools	3
Special Equipment	9	Dies, Jigs, and fixtures	3
Controls	8	Heat treatment	1
Total	100	Total	100

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fixtures and for the construction of prototypes of the aircraft is likewise distrib-

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uted between the primary and auxiliary shops of the development plant according to consolidated norms.

As will be seen from Fig.70, the work of a development enterprise in the creation of a new aircraft is divided into stages.

The calculation of the cycle of the stage C_s is done by the formula*

$$C_s = \frac{T_{des} - T_{out}}{P_{mean} D_w \left(1+\frac{K_1+K_2}{100}\right)},$$

where T_{des} is the design labor cost of the work per stage, in standard man-hours;

T_{out} is the labor cost of the work subcontracted outside the plant;

P_{mean} is the average daily number of workers in the given stage;

D_w is the length of the working day in hours;

K_1 is the factor of overfulfillment of the existing norm;

K_2 is the planned factor of growth of labor productivity.

The more widely the parallel and sequence-parallel performance of work on the stages is organized, the shorter will be the cycle of creation of the new aircraft. The end point of the cycle is the deadline for delivery of the aircraft for the first flight.

The graph of work completion on a theme shows the cumulative total of work performed in percent, and in standard man-hours. The work performed includes only the finished production of the development design office, i.e., the drawings turned over to production and the work done on construction of the aircraft. From this graph, the Central Administration of the Ministry and the development design office conduct the recording and control of the deadlines and the volume of work actually performed (Fig.71).

The directive graph and the graph of work completion on the project are a di-

* The result is obtained in working days. To reduce this to the calendar period, a correction factor must be applied to the numerator.

rective for the workers of the development plant, and must be fulfilled without qualification or quibbling, and also serve as the original documents from which the teams of the development design office and the development plant set up the working plan graphs.

Working-plan graphs on the project are prepared by the team, department, laboratory, and shop. To prepare a working graph, the chief of the team receives from the planning-dispatcher office of the development design office the original data: a consolidated schedule of the work to be done and its standard labor cost, the

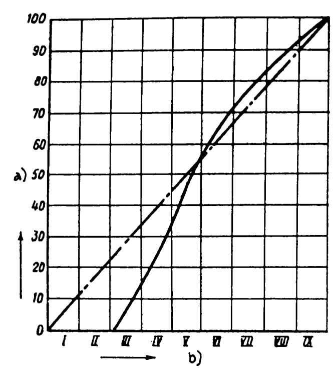

Fig.71 - Graph of Growth of Completion of Work on Project

The dash-dot line is the plan. The solid line is the fulfillment of the plan

a) % Completion; b) Months

dates of beginning and end of the work of the team on the project, the sequence of release of the production drawings to the development plant, and the percentage growth of the completion of work.

For setting up the graph, the chief of the team prepares a schedule of work on the project.

The schedule contains a list of all work of the team on the assembly (or equipment) and of all the production drawings to be released to the development plant. In this schedule, the chief of the team indicates the persons doing the work for each position and the time of his completion of the work. The schedule is checked by the technological and production-dispatcher departments for correct indication of the priorities and release dates of the drawings for the assembly in question. On the basis of this schedule, a team graph is prepared, showing, in accordance with the directive graph, the times of performance of the work enumerated in the schedules and the persons to perform the work in each position (Fig.72). If the team is connected with another unit during the work, then the graph will indicate the times of the receipt of documents from this unit, or of delivery of documents to it.

The working graph of the team is elaborated by the plan-dispatcher office and is approved by the superintendent of the OKB.

The monthly plans of the departments, teams, and shops contain a schedule of the work to be performed in the planned month, taking account of the socialist obligations assumed by the collective. On the basis of the monthly plans, an individual assignment is prepared for each designer.

The summary plan-graph is prepared by the plan-dispatcher office in case the schematic plan of the OKB has not one project but several. The summary graph is required for coordinating the times of performance of the projects, for assigning the necessary number of workers to each project, for uniform loading and complete utilization of the capacity of the units of the OKB and the development plant. The summary graph is prepared for the year and is elaborated by quarters and months.

To prevent the development production from having breaks in work, the process of designing and constructing experimental aircraft must be continuous and must be conducted simultaneously for several objects.

The dispatching of the design work has the aim of ensuring uninterrupted performance of work at all units of the OKB in accordance with the directive and operative plan-graphs. To decide this question, the dispatcher service performs daily observations, accounting, and control of the performance of work by each unit and, in accordance with the operative plan, organizes the uninterrupted servicing of the units of the OKB.

The accounting and control of the work performed is handled by the dispatcher service for each project, with respect to dates and volume, to parts lists, to completeness of sets and degree of technical completion of the project, and is accomplished by the aid of graphs or accounting-control charts.

Accounting-control charts are kept for each unit in ascending consecutive order of part numbers. The form of the record-control card is shown in Table 24. The card gives the plans and actual dates of the delivery in sets of drawings, process plans, and tooling for the unit. The record is kept daily on the basis of the basic delivery documentation, the accompanying service schedules, invoices, and work orders.

The record of technical completion of the project is kept on the basis of the technical report of the departments and shops. The technical reports on the projects are used in developing consolidated standard times, since the reports contain the total data on the number of drawings, flow charts, and special tooling prepared.

Section 6. Organizational Forms of Liaison between OKB and Series Enterprise

The organizational forms of liaison between the OKB and the series plant has a considerable influence on the period of introduction of a new aircraft in series. There are two forms of liaison between the OKB and the series plant.

In one form of liaison, the OKB has its own development plant which builds the prototype, delivers it for the plant and State tests, and then elaborates the prototype. In this form of liaison, the OKB is based on a definite prime series plant.

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The prime series plant maintains direct liaison with the OKB, revises the devel-

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Graph of Work of Wing Crew*

No.	Name of Work	Labor on Work in % of Total Labor on Wing Designing	Planned Labor Cost in Standard Man-Hours	January 1st	January 2nd	February 1st	February 2nd	March 1st	March 2nd	April 1st	April 2nd	May 1st	May 2nd
I	Tie-in drawings	5	1000										
II	Detailed calculations	5	1000										
III	Experimental work within team	3	600										
IV	Production drawings:												
	1. Front spar	13	2600										
	2. Rear spar	10.5	2100										
	3. Fittings for connection of front spar to central part	5.5	1100										
	4. Fittings for connection of rear spar to central part	5.5	1100										

	5. Ribs No.1 (root)	6.1	1220										
	6. Ribs No.2, 3 and 4	3.5	700										
	7. Ribs No.5	4.5	900										
	8. Ribs No.6	4	800										
	9. Nose rib	2.7	540										
	10. Tail rib	1.75	350										
	11. Stringers	7	1400										
	12. Ailerons	10.4	2080										
	13. Nose skin	5.5	1100										
	14. Tail skin	4.3	860										
	15. Tip fairing of wing	2.75	550										
	Total	100	20,000										

*Payroll of team is 20 designers. Monthly working time of one designer is 200 hours.

Fig.72 - Graph of Work of OKB Team

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Table 24

Record and Control Card for Part No. . . . . .

Number of Part Entering into Unit	Name of Part Entering into Unit	Number		Frequency of Part in Article	Design Preparation					Technological Preparation			Material and Tooling Preparation											Manufacture		
		Planned	Actual		Mock-Ups	Working Drawings	Technological Control of Drawings	Standardization Control of Drawings	Reproduction of Drawings	Sketches of Blanks	Flow Sheet	Reproduction of Technological Documentation	Model		Special Tools			Attachments, Jigs, Fixtures			Delivery of Semi-Manufactured Materials from Outside of Plant	Output of Blanks	Number	Shop No.	Date	Delivery to Store
													Designing	Fabrication	Designation or No.	Designing	Fabrication	Designation or No.	Designing	Fabrication						

opment drawings into series drawings, and supplies them to the secondary plants. With this form of liaison, the chief designer knows in advance the capabilities of the series enterprise, and the workers of the series plant receive advance information on the new aircraft.

A great disadvantage of this form of liaison between the OKB and the series plant is the great length of the cycle from designing of the aircraft to tooling up of the series production with the new equipment for producing the aircraft.

To eliminate this fault, the tooling up of the development and prime series enterprises must be planned according to a single graph, requiring a transition to parallel and sequence-parallel organization of the technological work of the OKB and of the prime series enterprise; the necessary new tooling must already be determined at the stage of designing the new aircraft.

The other form of liaison between OKB and series plant is used in the case where the OKB has no development plant of its own. The construction of the prototype aircraft and the production of the type series of aircraft is accomplished by the series plant. This form of liaison is necessary primarily for OKB that design large aircraft which a development plant is unable to construct in a short period. The advantage of this form of liaison is the fact that the OKB is brought closer to the series plant, and the drawings of the prototype aircraft are worked out better.

In the United States, a new form of organization of the development production is used in the construction of heavy and superheavy aircraft. In this form, the experimental design office is located at the prime series plant which builds the prototype and the type series of aircraft. The development design office has a special development shop to do its current production work. This system of organization of the development production is explained by the Americans by the fact that the testing and elaboration of modern heavy jet aircraft has become so complicated that it is now impossible to do this work on one or two sample prototypes without involving an extended delay in putting the prototype into series production. For

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this reason, American aircraft manufacturers do not build a single prototype but a series of 10 - 30 aircraft, on which the tests and elaboration of the new design are carried out in parallel. The Americans consider that the additional expense for building the experimental series is made up by the design, and technological elaboration of the new aircraft in shorter times, and by the rapid development of its series production on a large scale.

CHAPTER X

ORGANIZATION OF THE TECHNOLOGICAL PREPARATION FOR PRODUCTION

Section 1. Purpose and Tasks

The technological preparation of an aircraft construction enterprise must envisage the use of new technology and advanced methods of organization of production ensuring the output of aircraft of new design in a short period, at high rates and with the maximum economy of action and materialized labor.

Because of the frequent replacement of the articles in a series aviation enterprise, the following stages periodically recur there: preparation for production of an aircraft of new design; mastery of the processes of manufacturing a new aircraft by the production line; series production of the new aircraft and mastery of its modifications.

The primary task of the technological service in the stage of preparation for production is to prepare the primary production to manufacture the new aircraft in a short time and with a minimum of losses. This problem is solved by application of the technological advantages of the new design of the aircraft; by planned utilization of the capacities of the auxiliary and primary shops; cooperation and specialization of prime contractor and subcontractor in the designing and manufacture of the tooling for the new aircraft; by temporary utilization of the personnel and equipment of the primary shops for work on the tooling-up. For instanSTAThe workmen of the fabricating shops are used for building templates, mandrels, and the workmen of the machine shops and fitting-welding shops for building dies, jigs, fixtures, and tools. The extent of the material losses and, mainly, of the stoppages of equipment and workmen of the primary shops will differ, depending on how the old aircraft is taken out of production and the new aircraft put into it. These losses are particularly great if the machine is suddenly removed from series production, without using up the existing production spares. On the other hand, these losses are minimized if the enterprise is informed in proper time on the type of the new aircraft and the dates of putting it into production, and if the start of the production of the new aircraft and the continuation of the output of the old are coordinated in time, so that the closer the new aircraft is to the initial stage of production, the more the old aircraft is displaced from production. Such an organization of the change-over to the production of a new aircraft allows the primary production to go on without stoppage and makes it possible to use up the existing parts for the old aircraft.

In the stage of mastery of the manufacturing processes of the new aircraft, the primary task of the technological service is to minimize the period of mastery of

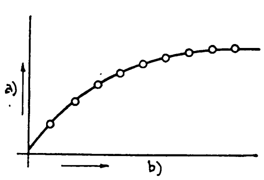

Fig.73 - Graph of Output of Aircraft with the Flattening Curve of Growth of Output

a) Number of aircraft; b) Period of output

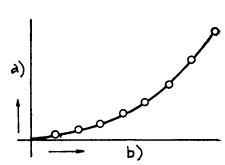

Fig.74 - Graph of Output of Aircraft at Uniformly Increasing Rate of Output

a) Number of aircraft; b) Period of output

the new aircraft by the primary production and to speed up the output of aircraft at high rates. This is more economically effected when, by the beginning of the production of a new aircraft, high-grade tooling has been fabricated and carefully verified on the first, or type series of aircraft, when completeness of set and prescribed priority are observed in the fabrication of the series tooling, and, finally, when the head program of aircraft output is most rationally distributed among the months. It is uneconomic when the primary production is at first assigned high rates of growth and output, and then the growth of the program slows down and finally stops at some level (Fig.73). This leads to irregular intensified production in the first month of output and to slowing down the production at the moment when the shops have mastered the production and picked up speed.

It is desirable to distribute the program so as to assure the planned increase of the rate of output of aircraft throughout the entire year (Fig.74).

At the stage of full development of the series output of the new aircraft, the principal task of the technological service is to encourage the growth of the rate of output of aircraft and the uninterrupted growth of labor productivity. The engineering staff and the auxiliary shops must foresee the development of the primary production and be ahead of it with the tooling, assuring the growth of the capacity of the primary shops and the reduction of the labor cost of the article.

At the stage of reorganization of the series production for the output of a modified aircraft, the primary task of the technological preparation is to change over the primary production to the manufacture of aircraft with the new modification, without reducing the rate of output. This is accomplished by timely notification of the series enterprise as to its preparation for the output of a prototype in the new modification, the release of checked drawings of the new modification to production, and its planned introduction in series. If the modifications relate to one assembly, for example the landing gear, the work of all the remaining shops proceeds normally at the level of the rates already attained. The task of the tech-

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nological system consists in pulling up the landing-gear shop to this level in a short time. For this purpose, the capacity of the auxiliary shop is switched over to the production of new tooling for the landing-gear shop, the workmen of this shop receive thorough production instruction on the new operations, and the progressive wage system is used to perform the higher shift assignments. If the modifications cover many assemblies, and the process is modified in a number of shops, the engineering staff determines the changes introduced by the new modifications in the parts and units, and prepares a schedule of the new tooling and of the priorities of its fabrication. In this period, the capacity of the auxiliary shops and tooling work shops of the primary shops is shifted over to tooling up the operations due to the modifications in the machine.

Section 2. Stages in the Process Design

Three stages are distinguished in the designing of series aviation technology: the initial stage, during which the original guiding technical documentation and the graph of the preparation of production for the output of the new aircraft is worked out; the intermediate stage, during which the tentative processes are developed, together with the tooling prescribed for them; the concluding stage, during which the permanent series processes are developed together with the tooling necessary for the complete tooling up of the series production.

The original directive technological documentation, which is termed the directive technology at the enterprises, determines the technical level and the order of designing the tentative and series technology, and introduces purposefulness, coordination and planning into the work of the agencies preparing production.

The tentative technology has its reason in the impossibility of simultaneous fabrication, by one enterprise, of the numerous and varied tooling prescribed by the permanent version of the series technology. Therefore, the series enterprise builds the type series and the first few series of the aircraft by a tentative technology

with tooling of the first round.

The tentative version of the technological process is formalized in the documents of series technology with the title "tentative", indicating the period it is to be in effect.

The series technology is planned by taking account of the complete tooling up of the shops of the primary production, and provides for the application of advanced technology and labor organization in it.

The entire volume of the work on the design of the series technology is distributed between the central office of the chief technologist and chief metallurgist and the technological staff of the primary shops.

The central technological staff is charged with working out the directive technology, all intershop questions on the tentative and final versions of the series technology, the methodical leadership of the work of the technological staff of the shops, and the control of the quality of their work.

The staff of the technological bureau of the primary shops is charged with developing the tentative and permanent versions of the technological process on the production list of parts, units and assemblies assigned to the various shops.

In working out the temporary and series technology, the product list and amount of tooling must correspond to the number of aircraft to be produced. It is economically disadvantageous to fabricate tooling for a small-lot production in the same quantities as for a large-lot production. This lengthens the periods of tooling up and excessively increases the production cost of the aircraft.

To reduce the amount of tooling at the advanced plants, special attachments are replaced by universal rapid-acting standardized attachments; the pressure, cutting, and assembly tools are standardized; and the units (for instance, stringers) are directly produced in the tabular dimensions without using the templates of the contours; the jig assembly is used directly on the templates of contour cont[redacted] etc.

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Section 3. Composition of the Directive Technology and Procedure for Its Development by the Staff of the Chief Technologist and of the Chief Metallurgist

The directive technology contains the fundamental technological, organizational, and economic propositions, by which all units of the enterprise participating in the preparation for production must be guided. The directive technology determines the order of the control and formalization of the series drawings; the periods and sequence of their release to production; the fundamental propositions on the designing and the order of the tooling up of the processes for various forms of work; the measures ensuring the interchangeability of the aircraft parts, the mutual tie-in, for these purposes, between the assembly and fabrication tooling; the technological schemes of assembly of the aircraft, its aggregates, sections and master units; the specifications for the designing of assembly jigs; the classification of the parts and units of an aircraft into standardized, unified and original, indicating the rational tooling and advanced forms of production organization for each group; the specifications for the delivery of parts, units and assemblies from shop to shop; the type of shops, their number, and the list of products produced by them; the flow sheets of the parts and units and the forms of their grouping into plan groups.

The work on the preparation of the directive technology takes place in the following sequence: After receiving the order to put a new aircraft into production, indicating the dates of production of the type series and the program for the current year, the chief engineer of the prime enterprise instructs the chief technologist to prepare a thorough directive graph of the preparation for production and sets forth the principal propositions by which all units of the enterprise must be guided. On the basis of the instructions by the chief engineer, the work is carried on over a wide front, and from the very beginning the chief technologist and the chief metallurgist give that work the properties of plan and organization.

Not only the staff of the chief technologist and chief metallurgist are used in working out the directive technology, but also the heads and senior technologist of the technological bureaus of the primary shops, together with workers of the OKB, NIAT, and the secondary series plants. Such collaboration accelerates the preparation for production and allows a more rational solution of the questions.

The development of the directive technology begins with the study of the OKB drawings for the new machine, their technological control and formalization into series drawings.

Formalization of the Series Drawings. The OKB delivers the drawings for the new aircraft to the series-design department (SKO) of the prime series plant. This department continues the designing and technological elaboration of the prototype with respect to the series production of the secondary plants. The work of the SKO on a new aircraft begins with the acceptance of the technological documentation from the OKB, its recording, and the establishment of a definite procedure for its storage and utilization. The sequence of formalization of the OKB drawings into series drawings, and the dates of their release to the departments and shops is established by the chief technologist of the prime series plant. Before release of the drawings to production, the series design department runs design and technological checks on the OKB drawings. For this purpose, the SKO blueprints the OKB drawings and issues them to the teams of its own department for checking the correctness of the dimensions indicated in the drawing and the presence on the drawings of all data necessary for manufacturing the aircraft in series; to the departments of the chief technologist and chief metallurgist to establish conformity of the drawings with the demands of large-lot production and to determine whether the industrial-branch and plant standard parts are being completely used; and to the lofting and template shop for laying out the loftings, coordinating them, and preparing master contour templates (ShKK) from the loftings.

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All comments made in checking the drawing are entered in the draft of the

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drawing refinement sheet (LUCh). These sheets are delivered in sets for each unit or group by each department to the SKO. The designers, when making the geometric check of the OKB drawing, look over the refinement sheet with the comments of the technologist, metallurgist, lofting man, and standardizer, and if they are in agreement with these comments they receive permission by the chief designer to introduce the changes in the series drawing, formalize the series drawing and have it O.K.'d at the OKB. Differences of opinion arising between designer, technologist, and standardizer are decided by the chief technologist and the assistant chief designer for the series. The series drawings, in addition to the O.K.'s by the OKB and SKO, must also have the signatures of the chief technologist or chief metallurgist. Without such signatures, a series drawing is not valid. The series drawings, bearing all O.K.'s, are released by the SKO teams, in complete sets by units and assemblies, to the technical file room of the SKO for registration, reproduction, storage and transmission to the technical file rooms of the departments of the chief technologist and chief metallurgist, the superintendent of production and of the primary shops.

The fundamental directive propositions are formulated for each type of technological work and contain individual formulations for the technologist and tool designers, which determine:

Methods of processing (assembling) and inspection to be used for the given form of work, and the means for their mechanization;

Differences between the tentative and permanent versions of the series technology, sequence and order of the tool fabrication;

Coordination of the technology of various stages and the matching (jointing) of their tooling, for instance, matching of the fabricating and assembly tooling;

Forms of the rhythmic flow of work to be used in assembling the article and its major components and in processing the unified and most labor-consuming

units and parts;

Instructions, standards and standard time schedules to be used as guide for the technologists in the designing work. For instance, in designing such mass and uniform processes as welding, heat-treatment, or riveting, the instructions, standards, and typical processes developed by the VIAM, NIAT, or by the enterprise itself are indicated; for setting up the standard pay rates for the various types of work and for calculating the operating time standards, the relevant manuals and standard time tables are indicated; for designing the tooling, the standard parts and albums of typical tooling, the limitations on the applicability of tooling and other reference material are indicated.

To ensure interchangeability of major aircraft components between plants, basic regulations on interplant interchangeability are formulated; a list of the major aircraft components to which such interchangeability applies is compiled; the basic templates determining the interplant coordination of major aircraft components are listed; schemes of coordinating the assembly tooling with the master tooling are worked out; and schedules of the masters and control masters for the assembly tooling, and of the other means of control, are issued, indicating the distribution of their designing and fabrication between the cooperating prime and secondary enterprises.

The major-assembly process charts determine the sequence of entry of the units, sections and compartments into the assembly and show the principal stages into which the major assembly is divided. On the basis of the process chart of the major assembly, the process offices of the assembly shops develop the working technology, and the bureau of technological planning of the chief technologist establishes the primary technological sets. To supplement the assembly process charts, the division of assembly-riveting and assembly-fitting work of the chief technologist, in STAT ab-oration with the technologists of the assembly shops, prepare the specifications for

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the designing of the assembly tooling, introducing unity and standardization in their forms, and (on all of the most important installations) instructions showing how the installation is correctly to be performed.

The classification of blanks, parts, and units into standardized, unified (typical) and individual, is necessary as the initial basis for the designing of typical processes and typical tooling. This classification is based on the grouping of parts and units by similarity of their design-technological criteria. Such criteria, for the parts of the processing shops, are the material, shape, and dimensions of the part (or unit), the accuracy class, the main operations and their sequence, the equipment and its tooling. In other shops, these criteria may be replaced or supplemented by other criteria which are important for these shops. For instance, for welding shops, the type and conditions of welding are important; for heat-treatment shops, the thickness of the parts and the duration and temperature of heating.

The classification of blanks, parts, and units is of great economic significance. It permits specializing the productive departments and sections to process unified parts of units; avoiding discrepancies in the method of processing, in the designing of tools and in the time standards for similar work; arrangement of the equipment according to the course of the typical process; increasing the specialization and mechanization of the labor processes and more complete utilization of the equipment.

The specifications for deliveries from shop to shop of parts, units and assemblies determine the form and accuracy yielding maximum economy, from the plant-wide point of view, in delivering the blanks to the machining and assembly shops; the degree of completion and the set of installations with which it is most economic to supply the assemblies to the final aircraft assembly shops (bearing in mind the necessity of shortening the cycle). The specifications contain the fundamental regulations applying to all blanks.

The type and number of the shops, and the list of their commercial (or delivered) production, are established, starting out from a number of general and special criteria. The general criteria are the forms of work and the labor cost.

The labor cost of work is the main measure determining the economic expedience of organizing an independent shop. For instance, under the conditions of small-lot production there may be a single general machine shop. Under the conditions of large-lot production, however, a number of specialized machine shops are organized, for the landing gear, hydraulic assemblies, etc.

The special criteria are specific for each stage of production. For the fabricating shops, the special criteria are the kind of material and the dimensions of the blank. For assembly shops, the special criterion is the breakdown of the aircraft into assemblies, compartments and panels.

To determine the type of shop and its schedule of work, it must also be remembered that the specialization of the shop is to encourage the improved utilization of the existing shop equipment and the use of new technology; that the assignment of parts and units to the shops must provide for a straight-line flow of work between shops; that each preceding stage of production must relieve the succeeding stage to the maximum extent. Thus, the airfield shop is relieved from work that can be more economically done at the final assembly shop. The final assembly shop receives assemblies completely prepared for jointing. An exception from this rule is constituted by cases where earlier installation of the instrument or assembly means a considerable increase in the consumption of working capital. For instance, the process chart of assembly allows the installation of the engine either in the fuselage or in the wing shops. This would free the aircraft assembly line from the labor-consuming work of installing the engine. However, economically this would not be rational, since it would lead to a considerable increase in the reserve stock of expensive engines.

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The technological characterization of the shop shows the technological processes

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performed in the shop, the composition of the commercial production of the shop, and its distribution among the consumer shops are shown; together with a short characterization of the production departments and sections of the shop, the intermediate operations (heat treatment, painting work), and the places where they are performed; and the services rendered by the given shop to other shops. On the basis of the technological characterization of the shops, the staff of the chief technologist establishes the flow sheets of the parts and units, while the primary shops elaborate the productive structure of the departments.

The flow sheet (shop distribution schedule) establishes the primary shops through which each part is to pass in succession, in order to enter the unit and major component. For this purpose, definite design groups of the aircraft, parts and units are assigned to each technologist at the bureau of technological planning, and he must schedule the shops for them; for each unit he draws a technological planning chart* (cf. Table 25).

This chart determines the list of parts entering into each unit, their flow through the shops in accordance with the manufacturing process, and the method of collecting the parts into sets for the unit.

Blueprints of the technological planning charts of the bureau of technological planning are delivered to the file-room of the series designing department (SKO) which assembles the drawings into sets and issues them, together with the technological planning chart, to the shops and departments of the plant.

The methods of preparing the technological planning charts are by design units (KK) and by process sets (TK).

The method of preparing the charts by design units (KK) is in complete agreement with the method of breakdown of the aircraft into units that has been adopted

*At some enterprises, the technological planning charts are replaced, in order to simplify the work, by a stamp on the drawing indicating the flow sheet of the parts shown in the drawing.

Table 25

For Unit No.02 - 10

Plant No.			Technological Planning Chart											Group No.02				Unit No. 02 - 05		
Unit No.	Fabricating Shop	3	Consumer Shop	12	Designation of Process Set									Consisting of ...... Sheets				Sheet No.		
Parts No.				Figure						Nos. of Leading Units	Quantity			Fabricating Shops						
Unit	Component	Elementary	Designation	Article	Assembly	Unit	Subunit	Part	Nos. of Component Units		To Article	To Single Set	To Group Set	No.16	No.24	No.20	No.	No.	No.	No.
5804-0			Navigator's window								2									
	Standard part		1304c5-14								20		1-3							
			1400c5								20		1-3							
		Washer	234A1-5-10								18			1-3						

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	5804-0-1	Assembly	Framework of window								2			1-3						

Prepared by Superintendent, BTP ....

Technological Planning Chart Routed to:	Reason for Modification	Brief Description of Modification	Series	Date	Signature (Stamp)	Copy Forwarded to Shop
Departments of cold stamping, machining, and assembly-riveting	Technical schedule SKO No.1725, of 7 August	1. Number of 234A1-5-10 washers changed from 20 to 18	2	8 August		No.24

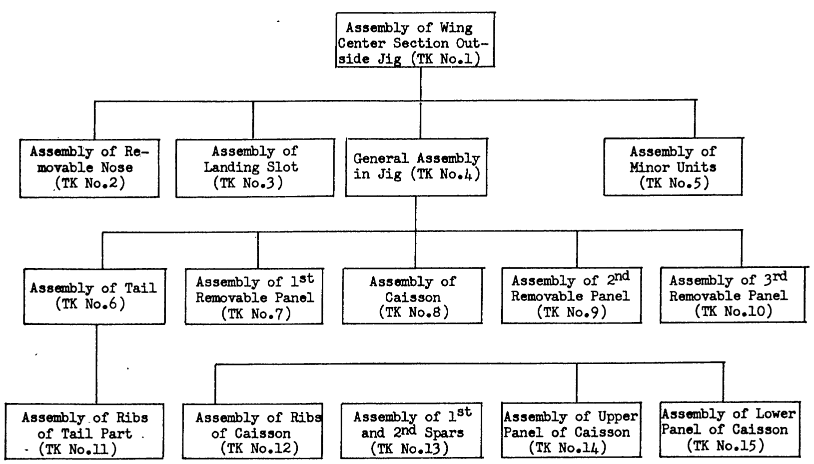

Fig.75 - Diagram of Breakdown of Assembly of Wing Center Section into Leading Process Sets (TK)

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by the chief designer. With this method, there may be as many technological planning charts for each design group of the aircraft as there are units in the group. If there are only a few parts in the design units, then a general technological planning chart is made up for such units. This designing method is simple, but is inferior in that it does not assure the supply of parts and units in complete sets for the aircraft assembly.

<u>In preparing charts</u> by process sets (TK), the parts and units are combined into process groups, ensuring complete delivery of parts and units for one of the following stages of assembly; final aircraft assembly; preliminary aircraft assembly; major assembly outside the jig; major jig assembly; and unit assembly.

The process sets in their purpose and content are subdivided into leading and component.

<u>The leading process sets</u> are prepared within each assembly shop by subdividing the final aircraft assembly or the major assembly into individual technologically complete stages of assembly. For instance, from the schematic diagram given in Fig.75 for the assembly of the wing center section of the twin-engine aircraft Il-12, it will be seen that the assembly of this major component is divided into 15 technologically complete stages, each of which constitutes a leading process set. Starting out from the sequence of assembly stages, the leading process sets will be assigned to various lead groups. For instance, the process sets Nos.11, 12, 13, 14, and 15 will be assigned to one lead group because they are assembled in one stage of assembly; process sets Nos.6, 7, 8, 9, and 10 will be assigned to a different lead group since they are assembled at another, and later, stage of assembly. The number of leading process sets within each lead group depends on the amount of assembly work. For instance, for light aircraft, all the assembly work on the vertical fin goes into one leading process set, all the assembly work on the stabilizer goes into another leading process set. The larger assemblies of the same aircraft, for instance the wing and the fuselage, have more

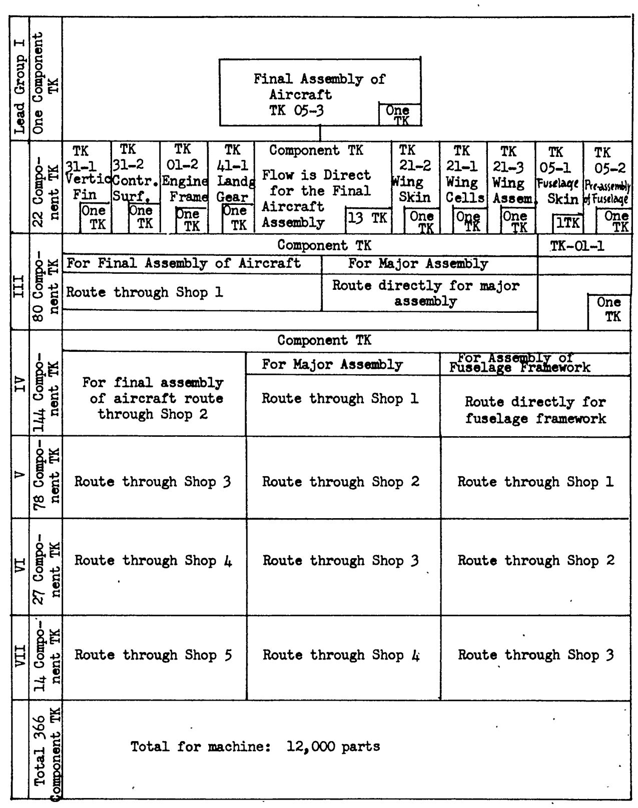


Fig.76 - Diagram of Breakdown of Aircraft into Lead Groups and Leading and Component Process Sets

assembly stages and more steps within the stages, and consequently also a larger number of leading process sets (Fig.76).

A component process set consists of a set of parts produced by a fabricating or processing shop and entering into a single leading process set. To establish the number of component process sets within each fabricating or processing shop, all the parts manufactured by the shop are grouped into sets, each of which enters only into one leading process set.

In the fabricating and processing shops, the component process set is the basic planning and accounting unit of the setwise delivery of commercial production.

The directive technology must encourage the enhancement of the technical level of production in every way.

It is binding for the shops and should be sufficient to work out the detailed (working) technological documentation in the shops. For the methodical guidance and control over the course and quality of the planning of the series processes by the shops, the chief technologists and metallurgists assign, from their departments, a managing technologist to each shop or group of similar shops.

Section 4. Composition of Series Technology and Procedure for its Development by the Technological Bureau of the Shop

On the basis of the directive technology, and in complete conformity with it, the technological bureau of the primary shop will design, at first the tentative process and then the series process, in the following sequence:

Assignment of parts to the departments (or sections) of the shop and establishment of the flow within the shop;

Designing and economic justification for the processes of parts manufacture and quality control;

Selection of equipment and synchronization of operations;

Preparation of wage scale for work and establishment of technically justified standard times for it;

Development of specifications for the blanks and parts delivered by other shops;

Listing of the requisitions for tooling with specifications annexed to the requisition;

Calculation of progressive standards of consumption of materials and tooling;

Preparation of specifications for materials, semifinished articles and tooling;

Planning of work stations of workshop (or section), and of shop;

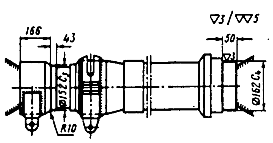
Elaboration of process chart and elaboration of tooling.

The parts and units are assigned by departments (or sections), starting out from the forms of specialization of production.

The departments and their units may be specialized to process parts for delivery to one consumer shop; to process parts entering into one and the same design units; to process parts to be delivered to the assembly line in matched or assembled form; to process parts that are the same with respect to materials or dimensions; to process uniform groups of parts. The assignment of parts to each section should ensure the fullest utilization of the equipment with respect to capacity and to time of useful work. The specialization of the departments to process uniform groups of parts or to assemble unified units simplifies the flow within the shop and reduces to a minimum the transfer of parts to stores or other sections. To eliminate lack of personal responsibility in the work, the detailed operations inside the department are assigned to specific work stations.

The designing of the process of manufacturing the parts, and of quality control, includes: selection of the part; selection of the methods of processing or assembly; breakdown of the manufacturing process into operations and steps; selection of equipment, tooling, and tools; establishment of the conditions of their use; preparation of pay scales for the work; calculation of standard time per operation; establishment of the method of quality control of the product. (The methods and

Table 26



Plant No.	Operational	
Article No.	Number of Parts in Article	
	2	
Type and Model of Machine		
Attachment		
Content of		
LATHE WORK: Turn		

Step No.	Content of Step	Tool and Number: Cutting	Auxiliary	Measuring	Computational: Diameter or Width	
1	Insert and remove					
2	Turn under stay to diameter $152C_3$ at L = 43, maintaining dimension of phase 166 with R10	Through cutter 51610 301-II			154	
3	Turn base band diameter $162C_4$ to l = 50 from second phase	Through cutter 51610 301-II			163	
4	Measurements			Beam Compasses, Micrometer		
Drawn by	Standardized by	Checked by		Chief of Technological Bureau		

Machining Chart		Shop No.	Sheet No.
		Work Shop No.	Number of Sheets
Designation of Parts	Drawing No.	Operation No.	
Cylinder		9	
Lathe 1D63		Welding	
	Cooled		
Conical Centers	Material: S30KhGSA	σ_b = 125 kg/mm^2	
Operation	Category 5	Standard per Piece	Standard per Establishment
Base Bands Diameter $152C_3$ and $162C_4$	Standard Output per Hour	Rate	Date

Data: Length of Machining	Length of Working Stroke	Number of Passages	From Dimension to Dimension	Working Conditions: Number of Revolutions	Feed per Revolution	Cutting Speed	Cut Depth	Time: Primary	Auxiliary
									3.0
43	48	2	154-152	150	0.21	60.5	0.5	3.05	1.6
50	55	1	163-162	150	0.21	64	0.5	1.75	1.5
									2.0
								4.8	8.1
					Total per piece			12.9	
					Extra time	in % 5.1		in min. 0.66	
					Total per piece			13.56	

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means of quality control are adopted by the technologist in agreement with the shop inspection department.) All of this is subordinated by the technologist to the main problem, namely that of ensuring good quality of production, a high level of labor productivity, and an economical utilization of materials.

In order to fulfill this task, the technologist, in accordance with the drawing and the specifications for the article, gives the method and means of its manufacture and control, and designs the process, allowing for the utilization of advanced experience, combined mechanization of the primary and auxiliary work and the rational organization of the work stations. In order to have the workmen learn the new process in due time and assimilate advanced experience, the technologist informs the OPK, through the bureau of labor organization and the shop superintendent, of the operations and new methods of work in which the workman must be instructed.

The procedure for the formalization of the process chart depends on the form of the work and the kind of part (or unit).

A summary process chart is prepared for their original details, and (in the case of complicated operations) operation charts are set up.

A summary process chart is prepared for a part, a unit, or an assembly. The chart shows all operations, processing, assembly, inspection, and preservation, in the order in which they are performed. The intermediate operations, heat treatment, sand blasting, coating, are merely named in the chart, since they are covered by the technologists of the intermediate shops in their own process charts.

The operational process chart (cf. Table 26) is a supplement to the summary chart and is prepared in series production only for complicated operations. In the operation chart, the operations are broken down into steps, and the sequence of these steps is indicated.

A typical process chart is made out for each group of unified parts. A schedule is annexed to the typical chart, listing the parts entering into the typical process and the standard time for each part.

In working out the typical processes, the technologist does not need to repeat in its entirety the content of the process for each process chart; it is sufficient merely to refer to the typical process or to the corresponding production instructions.

The order of performing the operation shown, as indicated in the process chart, is compulsory, and any deviation from it is a violation of technological discipline.

Choice of Equipment and Synchronization of Operations. In selecting the equipment and establishing the duration of the operations, the technologist must start from the fact that the more improved the equipment and its tooling, the more rapidly and continuously will the labor process be performed, and the less time it will take.

For one machine to deliver work to another machine continuously, it is necessary to establish a definite ratio between the number of different machines, taking account of the speed of their operation. In breaking down the process of machining and assembly into operations, it is necessary to provide that the operation times are equal to, or multiples of, the base of coordinated, rhythmic and continuous operation.

The establishment of the technically justified standard time for the operation is not the business, in aircraft building, of the technologists but of the standards man. For the calculation and standardization of the standard time per operation, the technologist submits the process chart for the part (or unit) to the standards man, who enters the standard in the process chart, initials the chart and returns it to the technologist. This procedure for establishing the standard times is incorrect in our opinion, since it in fact deprives the technologist of his responsibility for the standard time, which is the fundamental economic criterion of the rationality of a process.

Under the existing system of organization of the work of the technologist and standards man, most of their working time is not spent on creative work, i.e., on improving the processes and standards, but on the formalization of numerous items of

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documentation. Every effort should be made to reduce the number of operation charts, to cut down excessive detail in the process descriptions, and in every way to diminish the amount of technological documentation, taking account of the increasing qualifications of the personnel.

The formalized process chart is approved by the chief technologist of the plant. All inspection steps and all inspection means shown on the process charts are approved by the chief plant inspector.

The intershop specifications for blanks, units and assemblies are drawn by the technologist in cases where the necessary data are not clear from the drawing. For instance, in order to secure a rational blank, it is necessary to indicate the method of its fabrication, the basis for its attachment to the machine, and the machining tolerance. The intershop specifications are technically and economically substantiated and, after approval by the chief technologist or chief metallurgist, are forwarded to the corresponding shop fabricating the blank (or part or unit).

Orders for designing of tooling are drawn by the shop technologist by selecting from the process chart the tools and attachments indicated in it, subdividing them into special and standard. For a standard tool, a schedule of the tools required is prepared and delivered to the tool department, for it to order and acquire the tool from outside the plant. An order is made out for special tooling, with annexed specifications. Such specifications must fit the tools as designed.

Computing the Standards of Tool and Material Consumption. The consumption standards for a tool on the machining of each part are established by the technologist on the basis of progressive standard Tables of the duration and resistance of the tool. The record of the tooling prescribed by the process chart for each part is kept in two tool charts for the part. In the first chart the technologist enters only special tools and tooling, and in the second only standards.

The technologist has the duty of standardizing the consumption of primary and auxiliary materials whose use is prescribed by the aircraft manufacturing process.

The basic data for establishing the material consumption standards are the drawings, the process chart, the tolerance standards for processing, and the net weight of the part (unit or assembly). The standard material consumption is established for each blank, part, unit, and assembly and, in painting, winding, and impregnation, for each operation. The material consumption standard is established by technical computational or experimental methods.

A standard established by the computational technical method is based on the use of advanced technology in production and on the experience of workmen in saving materials and should be accompanied by a system of organizational and technical measures assuring the performance of the progressive standard introduced.

An experimental standard is established on the basis of experiments staged in the laboratory or shop and is used in calculating the consumption of materials for which no standard Tables exist.

The quality of the established standards is determined by the coefficient of utilization of materials, i.e., by the ratio of the weight of the part to the standard material consumption for its manufacture. The technologist is obligated to select methods ensuring minimum waste of materials.

The standards do not include the recoverable wastes, used a second time, nor allowances for tolerance or for rejects. These allowances are calculated separately by special standards and are taken into account by the planning department and the supply department of the plant in making the calculations and drawing the supply plans. The material standardization office of the chief technologist draws up summary, consolidated standards of the consumption of materials for an article. The summary standards are approved by the agency to which the enterprise is subordinated.

Drawing of Requisitions. Requisitions are schedules enumerating the material values required by a plant or shop. Requisitions are necessary for the summary accounting, for the preparation of consolidated standards, and for the timely distri-

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bution of orders. The most important requisitions are as follows.

Shop and summary requisitions for materials, drawn separately for primary and auxiliary materials necessary to establish the annual and quarterly plans of material-technical supply and to calculate the production cost per unit of output.

Shop and summary requisitions for forgings, castings, and stampings are required by the chief metallurgist to refine the list of blanks, and by the department of subcontracting work for assignment of the orders to the corresponding plants and to procure material resources.

Shop and summary requisitions for standard parts, tools, and other finished articles are needed by the department of subcontracting work for tools acquired outside the plant; by the tool department; and for purchased equipment, by the power superintendent and the chief machinist.

The technological bureau of the shop transmits the shop requisitions to the corresponding departments of the enterprise through the department of the chief technologist.

The planning of the work stations of a department (or section) is so laid out by the shop technologist as best to associate all elements of the productive process and to locate the equipment according to the flow of the process. In this case, provision should be made for most complete utilization of the equipment,and areas of the shop, short routes of parts, multimachine tending in the processing sections, and a wide front of operations on the assembly lines.

The elaboration of the manufacturing process and the refinement of the tooling constitute the concluding stage of the technologist's work in introducing the series technology into production. The working out of the processes and the refinement of the tooling is performed during the manufacture of the aircraft of the head series, as the tooling arrives at the shops. To assure the planned introduction of the process, the shop, in accordance with the plan of putting the parts and units of the new machine into production, prepares a graph of the setwise delivery of the new

tooling, which is approved by the chief technologist. The chief technologist assigns designers and technologists who, together with the foremen, instruct the workmen in the shops, organize the introduction of the new processes, and eliminate any deviations from the planned process that may arise. The elaborated process and the refined tooling are released to the foreman of the main shop.

Section 5. Methods of Calculating the Economic Effectiveness of the Manufacturing Process

Technique cannot be dissociated from economics, since economics is the basic criterion of the perfection of technique. The technologist must understand what Marx said: "If we consider machines exclusively as a means of cheapening the product, then the boundary of their use is defined at the point where the labor it costs to produce them must be less than the labor which is replaced by their application" (Bibl.25).

Comparing various versions of the manufacturing process, the technologist gives preference to one that ensure the best product quality, the least expenditure of time on the performance of the operation, and the greatest reduction in production cost.

In order to determine what method is more economical, given the same qualitative indices, a comparative calculation must be made. There are several methods of making such a calculation.

The method of evaluating production cost by machine-hours consists in establishing certain factors for each type of equipment, indicating the factor by which the expenses per hour of operating that machine exceed, or are smaller than, the production cost of an hour of work of the machine taken as the base. With the method of evaluating production cost by machine-hours, the overhead should not be added to the productive wages indiscriminately but bearing in mind the expenditures due to the operation of various types of equipment.

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The method of calculating by comparing the processing or assembly times is applied to fitting, gas-welding, assembly, and certain other work, mostly manual work. This method is also used in utilizing equipment of the same cost and tooling, and in all cases where a more expensive standardized tooling, which can be used over again, is used in the more productive operation.

The method of computation by comparing the cost of the tooling is applied to operations with equal setup-cleanout times, or in cases where this factor is not taken into account. In this method, the recoverability of the expenditures due to tooling up the new process is bound. For this purpose, the number of parts at which it is economically expedient to use the new tooling is determined. The following formula is used for this determination:

$$D = \frac{C_{base}}{a(1 + HP_{shop}) \cdot (H_{old}T_p - H_{old\ 1}\ T_{p\ 1})}$$

where C_{base} is the cost of tooling for a newly introduced operation;

a is the period of amortization of the tooling, in years;

HP_{shop} is the factor of shop overhead;

H_{old} is the base pay per hour with the old tooling;

T_p is the standard time for the operation with the old tooling;

$H_{old\ 1}$ is the base pay per hour with the new tooling;

$T_{old\ 1}$ is the standard time for the operation with the new tooling.

Example. It is planned to use a new lathe attachment costing 1000 rubles. Its amortization period is two years. The standard time, on introducing this attachment is shortened from 0.25 to 0.05 hr, and the work is transferred from category 5 to category 4. The overhead of the shop is 120%. The base pay of category 5 is 2 rubles 12 kopecks, and of category 4, 1 ruble 94 kopecks. Determine the annual program of parts production under which it is expedient to use this attachment.

$$D = \frac{1000}{2(1+1,2)(2,12\times0,25-1,94\times0,05)} = 524 \text{ parts}$$

If the plant program amounts to 600 aircraft a year, and each aircraft requires two parts, then the cost of introducing the attachment will be recovered in

$$T = \frac{524\times2\times12}{600\times2} \approx 10,5 \text{ months}$$

The method of computation by comparing the total cost of processing is applied to work where the setup-cleanout time represents a large proportion. A comparison of the versions of the technological processes is made on the basis of the formula of the critical batch of parts:

$$n_{crit} = \frac{C_{s.c}T_{s.c} - C'_{s.c}T'_{s.c}}{t' \cdot C_{proc} - tC_{proc}}$$

where $C_{s.c}$ is the cost in kopecks of 1 min of setup-cleanout time by the more improved process;

$T_{s.c}$ is the setup-cleanout time in minutes, by the more improved process;

t is the time of processing (or assembly), less $T_{s.c}$, by the more improved process;

C_{proc} is the cost of 1 minute of processing in kopecks, by the more improved process;

$C'_{s.c}$, $T'_{s.c}$, t', C'_{proc} are, respectively, the symbols relating to the less improved process.

Example. Required, to determine whether it is more economical to machine 200 parts on an automatic tool or on a lathe, if the setup of the automatic tool takes 180 min at a cost of 6 kopecks per minute of setup, while the machining of the parts on the automatic tool takes 0.5 min at a processing cost of 12 kopecks per minute. The setting up of the lathe takes 20 min at a setup cost of 4.5 kopecks per minute, while machining on the lathe takes 2 min at a machining cost of 10 kopecks per minute.

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Using these data, we obtain the critical size of the batch of output:

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$$n_{crit.} = \frac{6\times180 - 4,5\times20}{2\times10 - 0,5\times12} = 71 \text{ pieces},$$

i.e., the use of the automatic tool is advantageous for a batch larger than 71 parts, so that the assigned batch of 200 parts would be more rationally machined on the automatic tool.

Section 6. Main Trends of Organization of Preparation for Production in the Fabricating Shops

To ensure economical consumption of materials and to increase the labor productivity, the organization of the preparation for production in the fabricating shops should proceed in the following main directions:

1. Transition from work by individual processes to work by typical processes. A correct classification of blanks by unified groups and the typifying of the manufacturing processes encourages reduction of the list of tooling, while its unification increases the utilization of the equipment and reduces the waste of metal.

Savings of metal is achieved in the casting shops by reducing the recoverable and nonrecoverable waste, by using precision casting and stamping; in the forging shops, by a rational selection of the volume of the forging, by minimizing the loss of metal in fins, dross, and process allowances, by stamping in closed presses and punching machines; sheet-metal fabrication and laying shops by the rational laying out of sheet, rods and profiles. For instance, group cutting of blanks from sheet yields a saving of 5 - 6% of metal.

2. Use of more improved equipment which would eliminate the finishing handwork after the operations of shaping, drawing, bending, and cutting, and would minimize the waste of metal, while increasing the accuracy and interchangeability of the parts. For these purposes, powerful hydraulic presses at elevated pressure should be widely used, together with gang drawing and extrusion presses, jig drilling ma-

chines for holes, automatic machine tools with a servo system for gang profiling, and other high-production equipment, which sharply reduces the labor cost and minimizes the finishing work.

For instance, no-finish shaping is 3 - 4 times as productive as ordinary shaping, the replacement of drop hammers by hydraulic processes saves time in the operation of deep drawing by a factor of 2.5 - 3.

In forging shops, the replacement of free forging by precision stamping extends the blanks production list for machine shops and cuts the consumption of metal and working time. Already in producing a batch of as few as 100 pieces it is expedient to fabricate precision dies. The replacement of steam drop hammers in the forging shop by stamping presses, the introduction of high-speed electric and gas workpiece heating, allows combination of the heating and stamping processes into a single working cycle. The use of automatic forging machines leads to a multiple increase in labor productivity and yields blanks with minimum allowances.

3. Combined mechanization and automation of such processes as the removal of lugs, the shipping and bending of parts, the drilling of holes in sheet and profiles. For instance, the provision of presses with automatic attachments for feeding strips and blanks to the press, and for knocking out the parts from the female die, results in a 4 - 5 fold increase in the production volume of the press and allows a single operator to tend several presses. The replacement of hole drilling on rectilinear profiles by their punching, with automatic feed of the profile to the press, yields a 6-fold increase in labor productivity. The combination of punching and burnishing holes on the same press eliminates the operation of fin removal and improves the quality of the holes. Such combined mechanization eliminates the hand auxiliary steps and lightens the labor conditions.

4. Extension of the list of blanks for parts fabricated by more productive methods (precision casting and stamping, profile rolling). Today castings, forgings, and stampings amount to 15 - 20% of the parts list of machine shops (withouSTATnt-

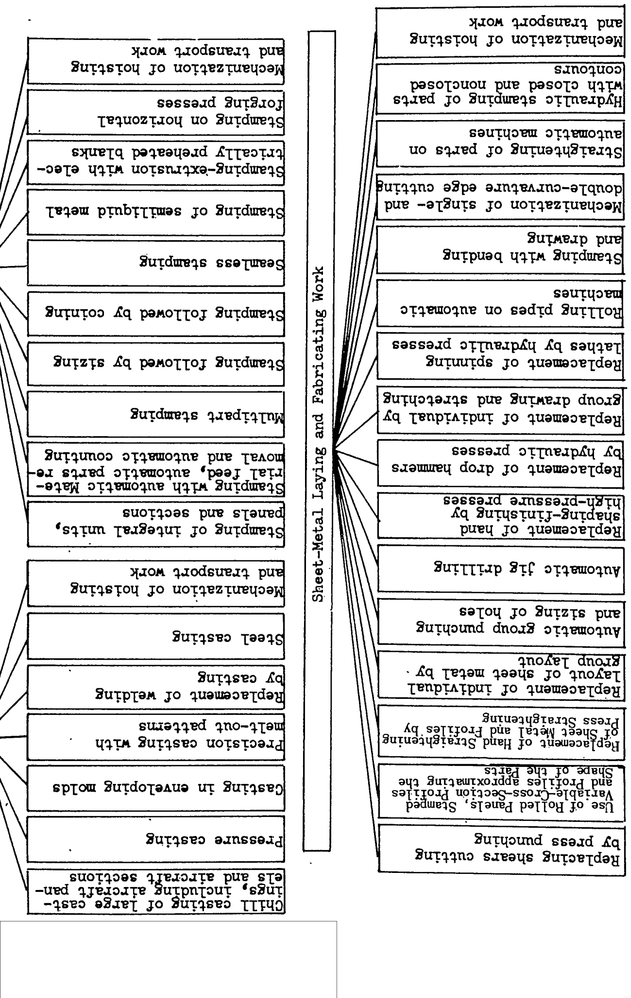

Fig.77 - Principal Trends in Mechanization of Casting, Forging-Stamping and Sheet-Metal Layout and Fabricating Work

ing the standardized items). The lag in the methods of fabricating blanks leads to 72 - 78% of the metal going into shavings in the machine shops, and in processing each ton of metal by cutting, an average of over 1000 machine hours is used, which is equivalent to 10,000 rubles. The use of precision methods of casting, hot-stamping, and burnishing allows the production of numerous parts in their final dimensions without any machining at all. Particularly wide prospects are opened by the possibility of using, on aircraft, panels and sections produced by stamping, casting, or rolling.

Figure 77 shows the main trends of the technical progress in the fabricating shops of an aircraft construction enterprise.

5. Replacement of the process type form of specialization of productive sections by the product type of specialization, with chain arrangement of the work stations according to the flow of the typical process. The existing layout of equipment in uniform groups in fabricating shops and the specialization of foremen in performing uniform operations on an immense list of blanks of different kinds is uneconomical, since it leads to frequent resetting of the process, to a low level of utilization of the equipment, and retards the application of new techniques. The specialization of sections to process unified groups of blanks increases by 20 - 25% the coefficient of utilization of the equipment, ensures unidirectional flow in the movement of batches of workpieces, cuts the processing cycle of batches of workpieces to half or a third its former length, and establishes unity between the technological methods and the forms of organization of the productive process.

6. Establishment at leading aircraft construction enterprises of specialized casting and forging-stamping shops, which supply a group of plants with uniform blanks.

Under the conditions of series production, the establishment of specialized shops allows the most effective solution of the problem posed by the 20th Congress of the Communist Party, namely that of substantially expanding the mechanization and ing the standardized items). The lag in the methods of fabricating blanks leads to 72 - 78% of the metal going into shavings in the machine shops, and in processing each ton of metal by cutting, an average of over 1000 machine hours is used, which is equivalent to 10,000 rubles. The use of precision methods of casting, hot-stamping, and burnishing allows the production of numerous parts in their final dimensions without any machining at all. Particularly wide prospects are opened by the possibility of using, on aircraft, panels and sections produced by stamping, casting, or rolling.

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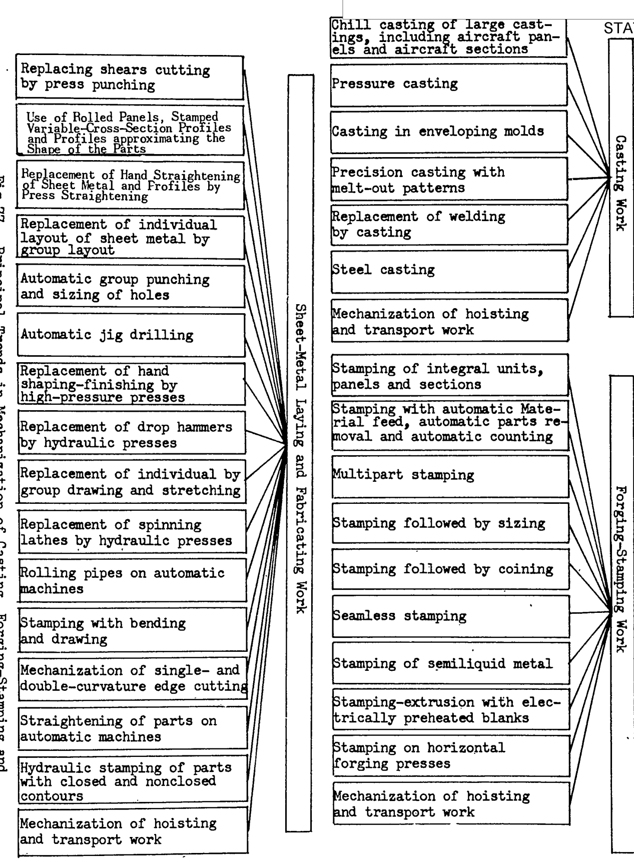

Fig.77 - Principal Trends in Mechanization of Casting, Forging-Stamping and Sheet-Metal Layout and Fabricating Work

automation of the productive processes, primarily in casting and forging-stamping production.

Section 7. Principal Trends in the Organization of the Technological Preparation of Production in the Processing Shops

In manufacturing a jet aircraft, the labor cost of the work in the processing shops is distributed as follows: machining amounts to 22 - 30%, fitting and welding to 2 - 3%, heat treatment to 3%, and coating work to about 1%. By comparison with piston aircraft, the machining work has been particularly sharply increased in jet aircraft, its labor cost has almost doubled. Such an increase in the amount of machine work disturbs the established proportionality in equipment and areas. In order to prevent this drawback, labor productivity must be sharply increased, and the labor cost of machining must be reduced. For this purpose, it is necessary to increase the list of workpieces produced to minimum tolerances, to introduce a widespread combined mechanization of the work that will increase the yield of the equipment in unit time, and to specialize the machining sections to process uniform parts.

The basic feature of such specialization of the productive sections is the classification of the machined parts into technologically uniform groups, which encourages the most economical utilization of the existing equipment.

The classification of parts and units in the processing shops proceeds by three main forms: standardized, unified, and individual. Within the first two of these forms, the parts and units are subdivided into classes and, within these classes, again into typical groups; for each group, a unit technological process is set up and typical tooling is worked out.

Classification allows the reduction of the immense parts list (some thousands of items) that must be machined, to 16 - 20 classes, having 80 - 90 typical groups, and, accordingly, permits the specialization of sections to handle them (Table 27). In fitting-welding shops, classification allows us to reduce units of several hun-

dred titles to several tens of typical groups, for whose machining the establishment of chain and multiproduct production lines is advantageous. In the heat-treatment shop, the classification of parts and units is based on the brand of material, the sequence of heat-treatment operations and thermal states, the configuration, the average weight and thickness of the parts. The typifying of thermal states permits a sharp reduction in the number of resettings of the heat-treatment ovens.

The specialization of departments (or sections) to handle parts of different shape but belonging to the same design group, leads to the assignment of 25 - 30 and more detail operations of different types to one work station, to the provision of the machine tool with attachments of various types, and to frequent resetting of the machines. To avoid this, product specialization of sections must be combined, accompanied by concentration of the processing and, if necessary, even of the assembly and testing, of all parts relating to one or several unified groups with similar flow sheets. For instance, landing-gear cylinders are machined in the landing-gear shop, while cylinders for hydraulic mechanisms and the hydraulic booster are manufactured in other shops. Concentration of the machining of all cylinders in the landing-gear shop, in a specialized section of that shop, would permit the layout of its equipment by the chain method and make it possible to increase the load of the machines, to tool them with typical high-production and rapid-change attachments and tooling, to cut the machine-setting time, to reduce spoilage of work, to diminish labor cost, and to shorten the cycle of cylinder manufacture. The specialization of sections to process unified groups of parts will not increase the total number of parts and will only slightly complicate intershop cooperation.

Computations made at a certain aircraft plant show that such an organization of a section for the manufacture of fittings allows the processing of fittings of 472 items (1440 parts in all) to be combined into 30 typical processes, and the labor cost to be cut from 8978 standard hours to 1497.

The utilization of the internal reserves of the processing shops proceeds main-

Table 27

Distribution of Light Aircraft Parts Requiring Machining According to Technologically Uniform Classes*

Class No.	Type of Parts in One Class	Labor Cost for Machining Parts in % of Total Cost of Labor for Machining
1	Cylinders, piston rods, rollers, shafts, sleeves	7 - 9
2	Bushings, pistons, flanges, covers	7 - 8
3	Rings, disks, boxes, washers	1.7 - 1.9
4	Eyebolts and lug bushings	2.5 - 3.5
5	Rockers, levers	6.5 - 8
6	Brackets	11 - 12
7	Bands, T-sections	8 - 8.5
8	Joints, fittings	4 - 4.5
9	Universal joints, stirrups	3 - 3.2
10	Fittings - stub pipes, angles, T-unions, crosses	5.5 - 6.5
11	Gear wheels	1 - 1.2
12	Loops, gaskets, strips	3 - 4
13	Bolts, screws	4 - 4.5
14	Rollers, pins	2.2 - 2.9
15	Nuts	2.3 - 2.6
16	Thrust bearings, blocks	2.3 - 3
17	Springs	1 - 1.1
18	Original (individual) parts	18 - 22

*Table compiled by Engineer M.Z.Gindel'man.

ly along the line of increasing the service life of the equipment and of its more intense utilization. With the existing methods of utilizing the machine tool inventory, the time of useful work of machine tools is sometimes only 25 - 30% (Fig.78). To increase this time, stoppage of the machine tool inventory must be

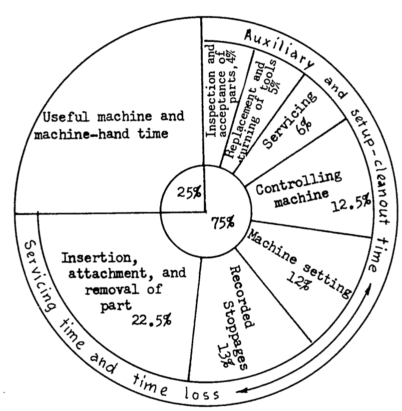

Fig.78 - Distribution of Time During a Shift by Kind of Expenditure in the Machine Shops of a Series Plant

eliminated, the auxiliary work must be mechanized, and the equipment must be more intensively utilized. The intensification of lathe work tends toward the use of automatic and semiautomatic equipment, the introduction of gang processing and the use of rapid-action attachments. The intensification of milling work proceeds by the introduction of processing by gangs of milling cutters (Fig.79), by the use of milling-profiling machines with hydraulic and electric servo systems, and by the

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Fig.79 – Processing of Typical Parts by a Gang of Milling Cutters

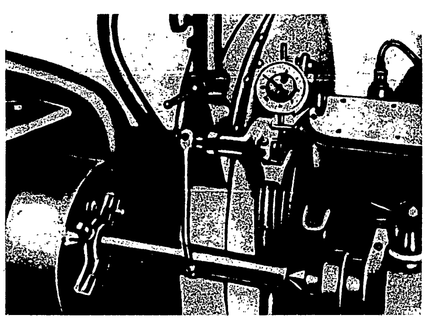

Fig.80 – Device for Automatic Control of Shaft Diameter

in Polishing

Fig.81 – Use of Multiple Head in Operation of Reaming Openings

in "Spider" Unit of Aircraft

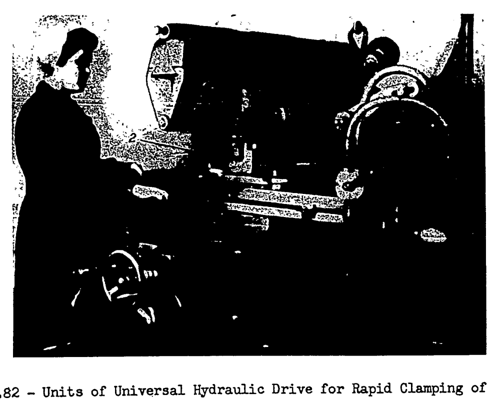

Fig.82 – Units of Universal Hydraulic Drive for Rapid Clamping of Part

1 – Power part of hydraulic drive; 2 – Attachment for clamping part

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use of rapid-action attachments. The development of gang processing and the use of rapid-clamping fixtures leads to an intensification of the drilling work. The introduction of high-speed polishing and automatic dimensional control of parts is of great importance (Fig.80). The use of more durable tools and the change-over of

Fig.83 - Multipoint Semiautomatic Welding of Parts of Automobile Cab

equipment to power and high-speed cutting reduces the machine time per operation by a factor of 3 - 4. The introduction of high-speed multiple machines, specialized to perform type operations and equipped with rapid-action clamping attachments, plays an important role (Fig.81).

To cut the time of installing and removing the attachment from the machine, the clamping part of the attachment must be made independent of the power part, the pneumatic or hydraulic drive (Fig.82).

In fitting-welding shops, the intensification of the processes should proceed along the line of automation of the welding work (Fig.83).

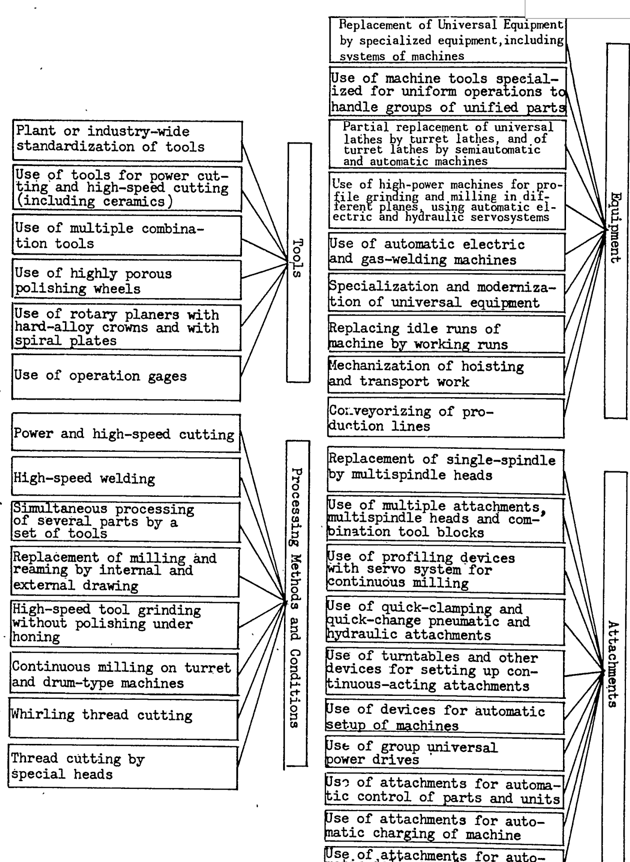

Fig.84 - Principal Trends in the Mechanization of Work in Machine Shops and Fitting-Welding Shops

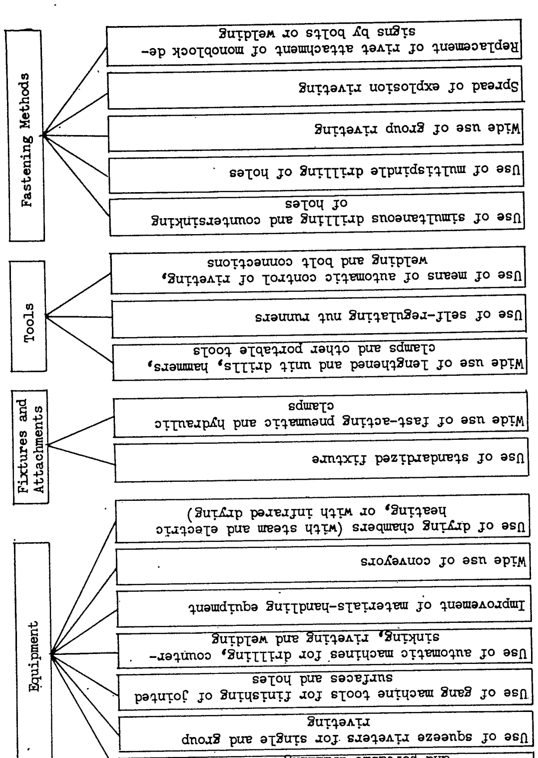

Fig.85 - Basic Directive of Mechanization of Assembly-Riveting and Assembly-Mounting Work

In the heat-treatment shop and the coating shop, increase in labor productivity and improvement in utilization of equipment are attained by introducing more uniform systems of adjusting the equipment, by typifying the processing conditions, by correctly planning the load of the ovens and baths, by more completely utilizing the volume of the baths and furnace soles, by mechanizing the charging of parts into, and the removal of parts from, the baths and ovens, by automation of the thermal conditions of heat-treatment ovens and their equipment with automatic control and regulation instrumentation.

Figure 84 shows the main trends in the mechanization of work in machine shops and fitting-welding shops.

Section 8. Main Trends in the Organization of the Technological Preparation of Production in Assembly Shops

The economic significance of the assembly stage in aircraft building is characterized by the fact that over 50% of the total labor cost for the manufacture of an aircraft is spent on its assembly and testing. The cost of purchased finished articles installed in the aircraft in the major assembly and main assembly shops is as much as 30% of the total production cost of the aircraft, without the engine. Consequently, the reduction of the labor cost on the assembly work and the shortening of the cycles of major assembly and final aircraft assembly are extremely important economic problems for the technological preparation of production in all stages of aircraft assembly. This reduction is achieved by the use of integral panels; by jig drilling and group riveting; by replacing riveting by welding; by breaking down assemblies into sections and panels; by the improved interchangeability of parts, units and assemblies; by minimizing the work done in jigs; by dividing the processes of assembly into separate assignments equal to, or multiples of, the over-all aircraft assembly rate; by maximum mechanization and conveyorizing of the assembly-riveting work (Fig.85). STAT

Mechanization of the assembly-riveting work envisages the use both of portable

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tools and of stationary and movable equipment.

Portable tools (drills, pneumatic riveters) should be used primarily for work at places inaccessible for stationary equipment (Fig.86), or in case where the use of a portable tool saves time in doing auxiliary work (Fig.87).

The development of paneling and the use in aircraft design of open profiles with uniform pitch and the same holes allows the replacement of the pneumatic drill and the pneumatic hammer by more productive portable and stationary equipment (Figs.88 and 89).

Stationary equipment (single-spindle and gang drilling machines, single and

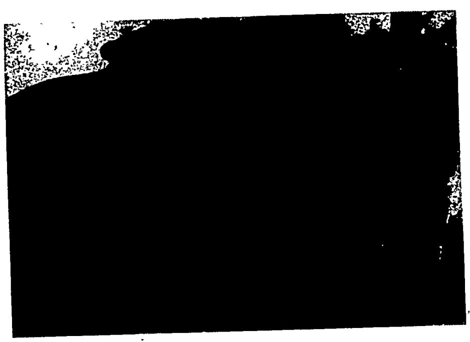

Fig.86 – Riveting with Pneumatic Riveter in Places Inaccessible for Stationary Riveting Equipment

group-acting squeeze riveters with automatic deposit of various caps on the rivet), should be widely used in the assembly and riveting of panels, ribs, spars and other open units. Stationary equipment is included directly in the assembly lines for units, compartments, and assemblies.

In aircraft construction, riveting has recently been displaced more and more by welding. According to American data, welded constructions in 1945 amounted to 15 – 25% of the aircraft, and in 1954 already to 40 – 60%. According to the same

data, the labor cost of a riveted stabilizer is
one, 3 hours. Welding is half as expensive as r
crease in labor productivity (Bibl.26).

In welding shops, the mechanization of inst

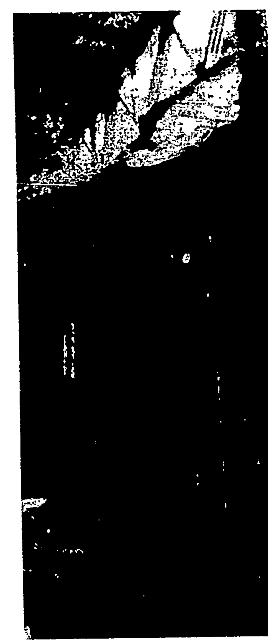

Fig.87 – Portable Pneumatic Drill

use of pneumatic wrenches with automatic regula
anization of auxiliary work envisages the tooli
matic clamps (Fig.90), the use of interoperatio
conveyors and transporters of discontinuous an
anisms (Fig.91), electric cars and automobile

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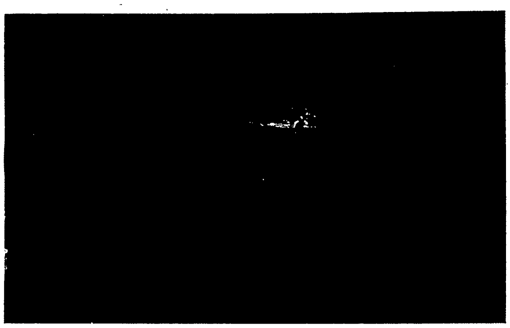

Fig.88 - Portable Pneumatic Squeeze Riveter for Riveting Spars

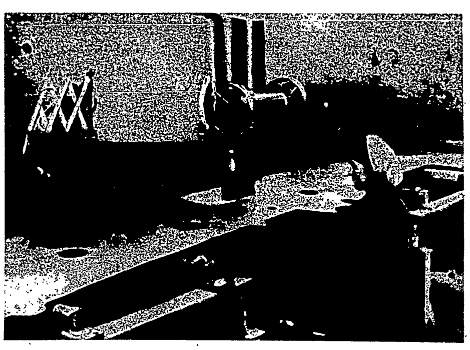

Fig.89 - Group Riveting of Panel on KP-501A Squeeze Riveter

The combined mechanization of welding should be associated with rational forms of organization of assembly work. In aircraft building, several primary forms of

Fig.90 - Assembly Jig Equipped with Pneumatic Clamps

organizing the assembly of units, compartments, assemblies and the entire aircraft are used.

One of these forms (used in the assembly of units: ribs, bulkheads, spars,

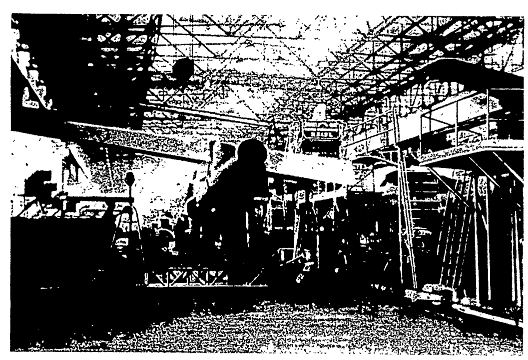

Fig.91 - Hoisting Crane with Beam for Transporting Aircraft

panels, etc.) is characterized by the fact that the maximum possible number of subassemblies are removed from the final aircraft assembly line and the major assembly lines to the unit assembly lines. This reduces the volume of work performed in the jigs and shortens its cycle, creates the most convenient conditions for the assembly of the units, and permits maximum mechanization of the work. These advantages are particularly evident in the paneling of the major assemblies. The assembly of panels is carried on with assembly and guide hose. The hose are built on machines with multispindle heads and the riveting is done on gang squeeze riveters. On the panels, the units, wiring etc. are mounted, which shortens the amount of the subsequent jig work. As a result of such organization of work, the assembly of the assemblies is reduced to the jointing of the blocks of the panels.

Another form of assembly is distinguished by the fact that all the jig work in the assembly of a compartment (section) or assembly is done by a single crew in a universal stationary jig. The universal jig with numerous cutters and fixers complicates the work of the assembly riveters. The absence of a thorough subdivision of labor and its mechanization makes this form of assembly economically disadvantageous. The universal form of assembly is ordinarily used in development production, and less often in series work.

The line form assembly is characterized by the division of labor, by the stand specialization of the workman, by the existence of rhythm in their work, and by the mechanization of the transport operations.

The line assembly of an aircraft, its assemblies and compartments, is organized either by the method of moving crews, with the assembly object stationary, or by the method of stationary crews, with the object to be assembled moving in pulsating motion.

Line assembly by the method of moving crews is used in the assembly of heavy aircraft, for which the pulsating or discontinuous displacement would involve the installation of expensive and complex transport facilities, or in cases where, in

accordance with the production process, the assembly of the object must be done in massive (rigid) stationary jigs (Fig.92). In both cases, the assembly of the aircraft, assemblies, or compartments is performed by several crews replacing each other in succession, and each of which is specialized in performing a single assignment.

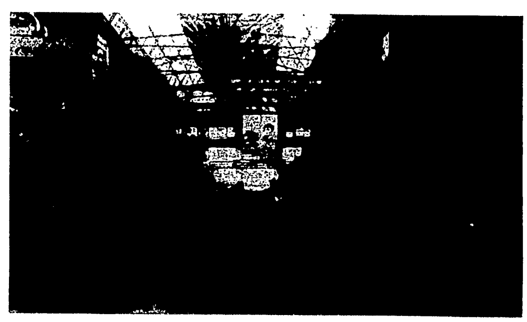

Fig.92 - Stationary Jigs Used in Wing Assembly

The assignment is performed by the crews during the time of the line pace, at the expiration of which the crews successively move from one jig to the next in the case of jig assembly, and from one object being assembled to the next in the case of nonjig assembly.

The jigs are laid out in sequence according to the flow of the assembly process and in such a manner that maximum use can be made of the overhead transportation means for removing the compartment from the jig and transferring it to the major assembly jig, and from there to the section of the extra-jig work on the assembly.

Line assembly by the method of stationary crews with pulsating travel of the object being assembled may take various forms. The most widespread of these are the assembly of the object in portable universal jigs and the assembly of the object

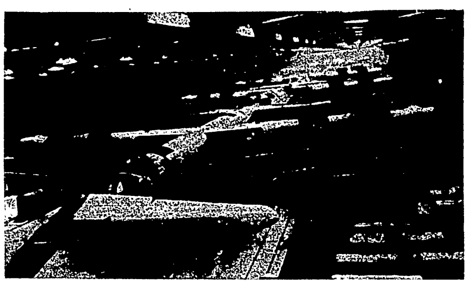

Fig.93 - Final Aircraft Assembly Shop

Fig.94 - Section for Nonjig Assembly of Fuselage Compartments

without any jigs at all.

The assembly of the object in portable universal jigs is used to assemble major components without technological joints, and for the assembly of high-labor-cost compartments. Each major component, or assembly, is assembled from beginning to end in a single universal jig. The jigs are attached either to an overhead conveyor or to a floor dolly. With the pace of the assembly line, all jigs are simultaneously moved to one assembly zone. Definite operations and a few specialized workmen are assigned to each assembly zone. The conveyor, which successively shifts the assembly from one stand to the next, allows the crews at all stands to perform parallel assembly and inspection work on the assembly. This form of line was widely used during World War II in assembling fighter aircraft, combat aircraft, and medium bombers.

Assembly of the aircraft and its major components without the use of jigs is most advantageous economically. The preliminary and final aircraft assembly is organized in this way (Fig.93), the nonjig assembly of compartments and major components is handled in this way (Fig.94). On such assembly lines pulsating conveyors or hoisting bridge chains are used to transport the object being assembled to the next assembly stand.

The efforts of designers and technologists should be directed toward finding ways that would allow the assembly of aircraft and major components without the use of jigs.

This may be accomplished by using integral panels and sections of extreme rigidity in aircraft designs, as well as by using a rigid jig-assembled framework in the design of the major aircraft components. The subsequent assembly of the major components is then handled without the use of jigs, owing to the existence of a rigid framework.

The choice of a certain form of assembly depends largely on the number STAT aircraft to be assembled during a shift, on the dimensions of the aircraft, and on its design. With the increasing dimensions of heavy aircraft, the difference in the principles of organization of the assembly of heavy and light aircraft becomes more pronounced. Whereas the assembly of light aircraft is being more thoroughly organized as the patterns change over to integral units and panels on the basis of assembly-line production, approaching the methods of automobile assembly, the assembly of heavy aircraft will be handled by stationary assembly line, similar to the line assembly of a large house, with moving cranes delivering the finished assemblies, sections, and blocks to the aircraft-assembly front.

To ensure proper rhythm of the assembly stage in the performance of work and in the output of aircraft according to graph, the line for an assembly must be associated with a forced rhythm in the work and intershop as well as intrashop reserves must be maintained at the established level. To save space and shorten the productive cycle, the work at each assembly stand is organized over a broad front, using the entire area of the working zone of the assembly for parallel work. The larger the dimensions of the assembly or aircraft, the more workmen must work on it at the same time.

At each assembly stand, the technologist plots an assembly assignment chart indicating the operations to be performed at the stand; a graph of work organization at the stand, indicating the distribution of operations between the workmen and the sequence of work performed by them within the limits of the cycle; a set-assembly chart, enumerating the parts, units, or finished articles to be supplied to the stand; a tooling chart enumerating the tools and attachments to be delivered to the stand. The existence of the set and tool charts brings order into the work of the material stores and tool cribs of the shop, and allows them, in good time and in complete sets, to prepare everything necessary for each assembly stand.

Section 9. Organization of Work in the Building of Tools, Attachments, and Auxiliary Tooling

The order and specifications for the required tooling are delivered by the

technological bureau of the primary shop to the managing technologist of the department of the chief technologist, for verification. From the managing technologist the order is forwarded to the superintendent of the department, for approval and for fixing the deadline of designing and fabricating the tooling. The order and specifications then go to the planning-dispatcher group of the department of the chief technologist for registration of the order and entry in the plan of the designing group and of the shop which fabricates the tooling.

The initial data for designing the tooling are the drawings of the workpiece, parts, or unit, the specifications, the albums of drawings of standardized and typical tooling, the limitations on the tooling to be used, the technical reference literature, and the plan date of release of the drawing for check and editing. The latter is determined by the monthly operative plan of the design department. The designer, in designing the typical tooling, selects their finished drawings, entering thereon only the dimensions referring to the given design. In designing special tooling, the designer works out a general plan drawing and a rating sheet.

The general plan drawing of the tooling is coordinated by the designer with the technologist, after which the drawing is sent to the detail draftsman, from him to the copy-draftsman, and then to the controller for standardizing and general check-up.

The checked set of drawings for the tooling then goes to the technical files department, where it is recorded, reproduced, and, together with the rating sheet for the tooling, released to the shop which fabricates the tooling. The movement of the order from one unit to another is controlled by the bureau of production planning at the chief technologist.

Forms of Organization of the Work. The work on the designing of tooling may be organized in sequence, sequence-parallel, or parallel with the development of the manufacturing processes.

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In the sequence method, the designer for the tool or attachment proceeds to

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design the tooling on the basis of the order and of the specifications annexed to it. By the time the order is issued for designing of the tooling, the manufacturing process must have been developed, finalized, and approved.

<u>In the sequence-parallel method</u>, the technologist, before finalizing of the manufacturing process, sets up the plan for processing the parts and specifies the necessary tooling, subdividing its fabrication into first and second stages. One copy of the order remains at the technologist's office, a second is given to the attachments designer, a third to the auxiliary tool designer, and a fourth to the designer for cutting and measuring tools, thus allowing them to do the designing simultaneously. In this method, determination of the development of the process conditions is somewhat in advance of the preparation of the drawings for the tooling,

<u>In the parallel method</u>, designers are assigned to the technologist for joint work. The technologist and the designers first look over the parts drawings and, after studying them, discuss the plans formulated by the technologist for processing, equipment, attachments, and tools for each group of parts. While the technologist is finalizing the manufacturing process, the designer prepares the tool drawings. For elementary tooling, the designer finalized the drawing in its terminal form. For complex tooling, he first makes a sketch, refines it in cooperation with the technologist, and then finalizes the drawing. The joint work of the technologist and designer minimizes the cycle of tool designing.

During the manufacture of the aircraft, many parts and units are improved. It is therefore necessary to use attachments in which only individual elements (mainly attachment elements) are modified in case of a change in the dimensions or shape of the part. The principle of design sequence is most completely expressed in the bodies of dies, where the replacement of a plate die involves only insignificant expenditures of funds and results in no changes in the body itself. The same principle is used in machining attachments and in assembly jigs. This principle should be widely used in other forms of tooling as well.

The existence of a large number of standard and unified parts in the aircraft creates the conditions for the extensive use of standard tools and attachments, which considerably reduces the expenditures for the technological preparation of production and also accelerates it.

For instance, today standard parts of the tooling amount to 70 - 75%, standard types and dimensions of the tooling are 50 - 65%, and the cost of fabricating this standardized tooling is 20 - 35% below the cost of fabricating nonstandardized tooling.

Section 10. <u>Technological Discipline and Procedure for Modifying the Technological Documentation in Force</u>

At a given enterprise, technological discipline means precise observance of the process conditions for manufacturing the aircraft at all work stations and in all stages of production.

Series technology is the law of production. There must be no discrepancies between the manufacturing process that is formalized by documents and the process actually carried out at the work places. The observance of the established manufacturing process by all units of production eliminates spoilage and creates the conditions for the uninterrupted progress of the productive process.

The July 1955 Plenum of the Central Committee Communist Party USSR demanded an increase in the responsibility of the chief engineers, the superintendents of the inspection departments and the shop superintendents, for exact observance of technological discipline.

<u>Procedure for Introducing Modifications in Aircraft Drawings</u>. Only the chief designer has the right, at aircraft construction plants, to issue new drawings and make changes in the existing drawings in force.

The original release of drawings of the aircraft or its assemblies to production is authorized only on drawing-release sheets. A single release sheet STAT cover

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the release of a whole group or subgroup of drawings. The numbering of the release sheets is handled by the series-design department (SKO). The experimental work for checking the parts, units, and assemblies before they are put into series production is handled from sketches, and finalized by service notes.

The basis for modification of the installation drawing may be the instructions by the chief designer and the demands of the series plant in connection with the refinement or modification of the drawing, the replacement of a component finished article, the demands of purchasers and subcontracting plants, the suggestions of rationalizers, or the data of plant and State tests.

Reasons for the necessary modification of series-production drawings may be: decision by the chief designer; necessity of eliminating defects disclosed during operation; demands by the purchaser, approved by the agency to which the enterprise is subordinate; expiration of the validity date of the technical documentation; or suggestions by the efficiency experts, adopted by the chief designer and agreed on with the purchaser.

The finalizing of the introduction of modifications or refinements in the drawings is done by the series-design department in two documents, the modification sheet and the drawing-refinement sheet.

The drawing-refinement sheet (LUCh) temporarily allows continuation of production from the drawings, without making the specified changes, but taking account of the refinements in the LUCh.

The drawing-modification sheet (LICh) is intended for entry of the modifications in the drawings, enumerating the modifications in the sheet which accompanies the reissued drawings; for the full account of all modifications and corrections in the drawings; and for invalidation of the sketches and drawing-refinement sheets.

The drawing-modification sheet shows the series with which the modification is to be introduced into production and the manner of handling the reserve of parts existing in the plant. On the basis of the drawing-modification sheet, the old

drawing is canceled and is so stamped from a certain series on, and a new drawing is released, which is stamped to indicate the series from which the drawing is introduced and the document on which such introduction is based.

Changes in the theoretical loftings are authorized only on the basis of a document from the chief designer, while changes in the design loftings may be made on the basis of a document from the series design bureau. Changes resulting in the cancelation of templates or their preparation, are finalized by the template bureau. Changes involving additional work on the templates are finalized by the technologists of the lofting groups. In order to detect any mismatch of the templates, the technologists of the shop agree on a technological signal for discovered template mismatch; if a spoiled template is found in the shop, a notice of rejection is made out and delivered, together with the technological signal, to the lofting and template shop. Modifications or additional working and refinement of the templates are made only by the lofting-template shop. The changes made in loftings are indicated in the identification sheet.

Changes in the process planning chart are entered by the bureau of technological planning of the chief technologist's bureau, on the basis of the drawing modification sheet. The chart indicates the reasons for the changes and the number of the series from which the change is introduced. The new chart is then released for reproduction, and the copies are forwarded to all offices, with simultaneous recall of the replaced charts.

Changes in the technological process are made in cases where the drawings are modified, the manufacturing process is improved, the type of equipment is changed, and errors in the technological process are corrected. The modifications in the flow sheet are entered by the engineering bureau of the shop on the basis of a process-change sheet, approved by the chief technologist. From this sheet, the shop technologist proceeds to work out a new process or to correct the pres STAT process. The changes in the flow sheet during the period of the tentative process are approved by the chief engineer of the enterprise. In the series process, the changes are made with the authorization by the chief engineer and, in some cases, by the agency to which the enterprise is subordinate.

Changes in the manufacturing process on proposal by the technologist or on suggestion by a rationalizer, are made only after they have been checked and have yielded favorable results. Changes in the manufacturing process are entered by the technological files department in the modifications chart and are registered in a special daybook.

Changes in the chart of standard consumption of raw materials are entered by the shop technologist, on the basis of a notice from the bureau of material standards of the department of the chief technologist. This notice is issued on the basis of modification sheets made out by the designing or technological department.

Changes made in the chart of normal material consumption for a part are simultaneously noted by the technologist in the flow sheet and in the materials requisition. The chief technologist receives the authorization of the technical department of the administration to which the enterprise is subordinate for the modification of the material consumption standard, for its replacement and for the introduction of new materials.

Persons allowing a violation of the technological process and an arbitrary introduction of changes in the manufacturing process of series production are held responsible. The inspector, foreman, and technologist are responsible for the daily checkup on proper conduct of the manufacturing process. In addition to the daily control, the chief technologists periodically make a spot check at the work stations for conformity of the actual manufacturing process with the approved process.

Section 11. Organization of Standardization Work

The use of the State All-Union Standards (GOST) is compulsory for all branches

of the national economy. The planned conduct of the economy creates all prerequisites for the widespread use, in production, of standardization and normalization of parts and components of an article, as well as of the methods and means for its fabrication. Normalization means standardization carried out on the scale of an industrial branch or enterprise. Normalization allows the production of the output with smaller expenditure. Under the conditions of frequent change in the object of production, the economic significance of normalization increases, since normalized tooling is not changed on replacement of the machines.

Normal standards are divided into industrial branch and plant normal standards. An industrial branch normal standard is established for objects not covered by the All-Union standard, and a plant normal standard for objects not covered by the industrial branch normal standards.

It is very important to establish unified normal standards for all aircraft and all finished articles entering into these aircraft. This is the basis of normalization of series tooling in all aircraft construction plants.

Plant normalization is the original link in the general system of standardization. The objects of plant normalization are: basic article, processes and means of its manufacture, technical documentation, and system of organization of the production. The more thoroughly the basic article is normalized, the greater will be the opportunities for normalizing the process, equipment, and tooling.

Unification means the classification of blanks, parts or units into groups having uniform design forms and a uniform method of fabrication. Unification of aircraft details should develop along the line of assigning single shapes and dimensions to parts composing a single uniform group.

Work on normalization and unification is a component part of the work plan of the bureau of standardization and normalization, the series-design department, and the department of the chief technologist.

The economic effectiveness of the introduction of standards and norms is established by adding the savings in materials, wages, and overhead.

Section 12. Introduction of New Techniques and Advanced Experience into Production

Definite advances have been made in the matter of technical progress in the aviation industry. But science and technology do not stand still, they develop and move forward, and what was new and advanced today will already become obsolete and unrealistic tomorrow.

To utilize more fully the advantages of the socialist economy and to surpass the accomplishments of foreign science and technology, constant improvement of socialist production on the basis of a planned introduction of the accomplishments of science, technology, and advanced domestic and foreign experience is a prerequisite.

The work of the technological staff for introduction of new techniques and progressive skills into production is organized along the following lines: replacement of obsolete equipment by new and more productive equipment; combined mechanization and automation of the processes of the main and auxiliary production; standardization and normalization of the tooling; dissemination of the advanced methods developed by production innovators.

In order to decide toward what new equipment the aircraft construction enterprises must be oriented, the composition of the parts and units of the aircraft and their design sequence must be carefully studied.

On the basis of such study, parts that do not change on transition from the production of one aircraft to the production of the next one must be defined. It is suggested to use operationally high-productive equipment to fabricate such parts.

It is also necessary to determine the stable groups of unified details and for each such group to create specialized equipment. The distinctive feature of such equipment will be its adaptability to the performance of one or several operations on all parts in a single group.

High-production equipment of this kind has been created by our machine-building

industry for machining ship propellers, for unifying the parts of Diesel locomotives, etc. Such machines are very necessary for aircraft building enterprises as well. Their use will encourage a wider unification of aircraft parts.

Finally, for the original parts, which vary with each new machine, it is necessary to use the fastest and most mechanized general-purpose equipment, provided with rapid-action normalized attachments.

The introduction of new techniques must be performed systematically and must cover many fields, encompassing at each productive section all of its main and auxiliary processes. The technologist and designers should use the data of technical standardization for the introduction of measures on combined mechanization, to find the operations for which the proportion of hand, machine-hand, and auxiliary work is high.

For a successful, rapid, and economically effective introduction of the accomplishments of science, technology, and advanced experience into production, a well-equipped technological laboratory and an experimental shop must be organized at the enterprise, and technical information and a seminar of advanced work experience must be made available.

The technological laboratory and the experimental workshop (or shop) attached to the chief technologist are intended for the introduction of methods created by other institutes and plants; for finding and refining new and more improved technological methods and systems of processing; for planning and manufacturing improved equipment and tooling; for designing, fabricating, and testing means of combined mechanization and automation of the productive processes. In the experimental workshop (or shop) the rationalizers and inventors are given the opportunity of building models of their machines and attachments, and of testing suggestions and inventions. With the growth of the technological progress of production and the rising technical level of the personnel, the role of the technological laboratory and the experimental workshop (or shop) will increase constantly.

The function of the technical information service is rapid and regular dissemination of information to all specialists in the plant as to the present state of technology at progressive plants in the USSR and other countries. The technical information service includes the translation of papers from foreign technical journals and books, technical bulletins of other enterprises, catalogs of novelties, etc.

The exchange of advanced experience between plants includes periodical visits by workers of the plant to the enterprises where a novel method has been put into use; visits of skilled workers of other plants to the home plant to share their advanced experience; organization of special exhibits and technical conferences; and dispatch of personnel to other plants for study of their technology and production organization.

Section 13. Operative Planning and Dispatcherizing of Technological Work

Planning the technological preparation of production includes work on the technological control of the drawings of the primary article and of its assignment to the various shops; loft work; planning and standardization of the technological processes; designing and fabrication of the tooling and special equipment; reorganization of shops to produce the new aircraft; introduction and improvement of series technology.

The planning of technological preparation is based on parallel and sequence-parallel organization of work at all stages, observing priority, completeness and successive order in the fabrication of tooling. At aircraft construction plants, the minimum original unit of planning is the design unit or technological set.

Order of Priority in Fabrication of Tooling. In the first stage, the tooling prescribed by the tentative process is produced, without which it would be impossible to put out the type series and subsequent series of aircraft, for instance, the tooling for newly introduced processes and equipment. In the second stage, the

Table 28

Proportion of Labor Cost of Individual Forms of Tooling in Percent of Total Labor Cost of Tooling

Form of Tooling	Classes of Aircraft and Priority of Tooling Fabrication											
	Light Aircraft			Medium Aircraft			Heavy Aircraft			Superheavy Aircraft		
	Stage 1	Stage 1 and 2	Aircraft in Regular Series Production	Stage 1	Stage 1 and 2	Aircraft in Regular Series Production	Stage 1	Stage 1 and 2	Aircraft in Regular Series Production	Stage 1	Stage 1 and 2	Aircraft in Regular Series Production
1. Templates	6	4	3	11	8	7	11	6	5,1	10,8	9,8	9
2. Casting	1,6	1	1	1	1	1,1	2	2,3	3,1	2	3	4,1
3. Forging	3	2,8	3	7	5	4,2	5	4	4,1	2	3	3,1
4. Stamping and fabricating	20,7	22	23	18	18,3	17,8	15	15	15,2	14,8	16	15,2
Including tool dies	9,8	12	12,5	15	14	14	6	6	7	2	4,23	5
5. Machining	15,2	16,2	17	12	14	16	17	17	17,8	13,2	13,1	14
6. Special tools	8	10	13	5	7	8,2	4	7	8,1	9,5	11,8	12
7. Assembly	27	31	31	31,5	33,5	34	24,1	25,2	24	36	33,5	30
Including jigs and stands	14,2	15	14	26	28,2	29	13,9	16	13,8	24	23	21
8. Welding	1,5	1,5	1,5	1	1	1	0,7	0,7	0,7	1,3	1,3	1,3
9. Total by aircraft class	32	67	100	30	65	100	29	64	100	28	63	100

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equipment and its tooling for the series production are produced. For instance, in the assembling of control surfaces, the first stage of tooling will include one or several general assembly jigs, and a template and master template to check the jig.

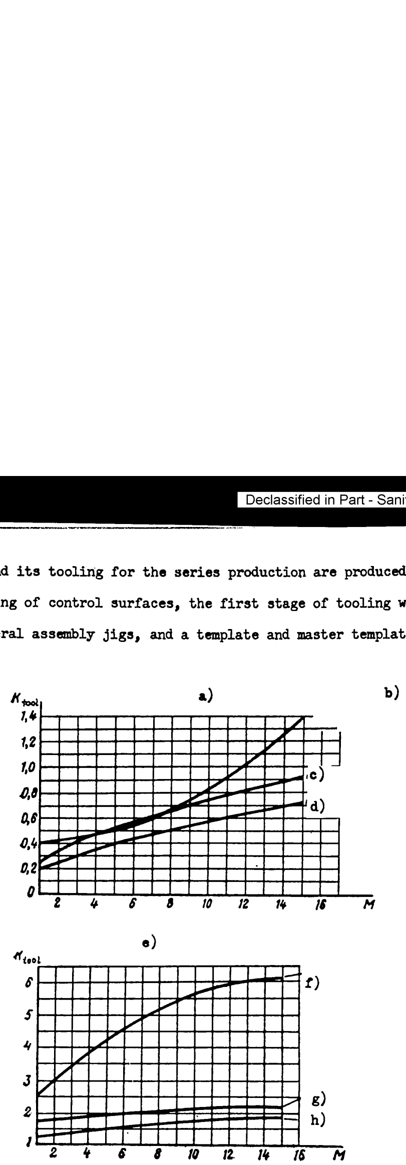


Fig.95 - Relation Between Coefficient of Tooling Supply K_{tool} and the Daily Number of Aircraft Produced, M

a) Tooling for machining; b) Machine attachments; c) Cutting tools; d) Measuring tools; e) Tools for assembly and welding work; f) Control and assembly jigs; g) Assembly jigs for units; h) Assembly jigs for major components

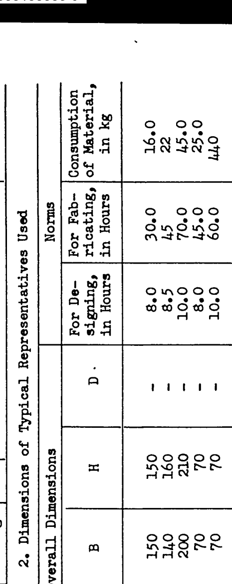
During this period, work on the assembly of the control surface has not yet been broken down into assembly assignments; this breakdown is performed as the output of

Table 29

Norm Chart for Typical Representatives of Tooling (Example)

Norm Chart	Dimensions	Type of Tooling	No.11	Dies for Cold-Stamping	Chart Number
Bending Die	Pieces	Group of Tooling	No.2	Bending, Drawing, and Extrusion Dies	

1. Typical Example



2. Dimensions of Typical Representatives Used

Overall Dimensions				Norms		
L	B	H	D	For Designing, in Hours	For Fabricating, in Hours	Consumption of Material, in kg
150	150	150	-	8.0	30.0	16.0
200	140	160	-	8.5	45	22
310	200	210	-	10.0	70.0	45.0
420	70	70	-	8.0	45.0	25.0
612	70	70	-	10.0	60.0	440

3. Labor Time Standards for Designing Typical Representative of Dimensions 200 × 140 × 160

Labor Time Standards by Forms of Work, in hrs					Labor in % of Total Amount of Design Work		
Designing Work	Detail Drafting	Copying Work	Control Work	Total Standard Time	Detail Drafting	Copying Work	Control Work
4.5	-	3.0	1.0	8.5	-	66.5	22.2

4. Labor Standards for Fabrication of Typical Representative 200 × 140 × 160 in Dimensions

Unit of Measurement	Standards for Technological Preparation				Total Labor for Fabrication, in hrs	Standard Labor Times by Forms of Processing, in hrs															
						Machine Work									Hand and Other Work						
	For Working Out Technical Documentation	For Designing Second-Order Tool	Total	For Fabricating Second-Order Tool		Fabricating	Turning	Shaving	Milling	Polishing	Grinding	Finishing	Other Machine Work	Total Machine Work	Forging	Welding	Fitting	Fitting-Pattern	Carpentry	Other	Total Hand and Other Work
Hrs.	1.5	-	1.5	-	45.0	1.5	4.0	8.5	3.0	1.0	-	-	1.0	19.0	3.0	-	23.0	-	-	-	26.0
%	100%	-	100%	-	100%	3.3	8.9	18.9	6.7	2.2	-	-	2.2	42.2	6.7	-	51	-	-	-	57.8

5. Standard Consumption of Materials per Unit of Typical Representative 200 × 140 × 160 in Dimension

Groups of Material		Machine Steel		
Mark		45	45	20
Profile		Forging	Round steel	Strip
Rough weight, in kg	22.0	21.0	0.6	0.4
Proportion, in %	100%	95.5	2.7	1.8

Date	Prepared by	Date	Checked by	

Table 30

Coefficient of Tooling for Principal Forms of Special Tooling*

Kind of Tooling	Class of Aircraft	Tooling Coefficients for Various Stages of Introduction of Aircraft			Kind of Tooling	Class of Aircraft	Tooling Coefficients for Various Stages of Introduction of Aircraft		
		Stage 1	Stage 1 and 2	Aircraft Completely in Series Production			Stage 1	Stage 1 and 2	Aircraft Completely in Series Production
Forging	Light Medium Heavy Superheavy	0,70 0,40 0,35 0,30	1,20 0,65 0,60 0,55	2,00 1,20 1,10 1	Templates	Light Medium Heavy Superheavy	2,00 1,30 1,00 0,70	3,00 1,70 1,40 0,90	3,30 2,20 1,90 1,40
Casting	Light Medium Heavy Superheavy	0,90 0,70 0,65 0,60	1,70 1,30 1,20 1	2,80 2,50 2,30 1,80	Cold dies	Light Medium Heavy Superheavy	0,55 0,26 1,18 0,09	1,00 0,50 0,35 0,17	1,90 0,90 0,60 0,30
Machining	Light Medium Heavy Superheavy	1,20 0,90 0,70 0,40	2,20 0,70 1,30 0,70	4,00 3,00 2,50 1,20	Assembly jigs	Light Medium Heavy Superheavy	0,90 0,08 0,32 0,08	1,70 1,40 0,60 0,15	3,30 2,70 1,20 0,30
Special tools	Light Medium Heavy Superheavy	1,25 0,90 0,60 0,50	2,50 1,80 1,10 1,00	5,00 3,50 2,20 2,00	Welding	Light Medium Heavy Superheavy	0,35 0,23 0,18 0,07	0,60 0,45 0,35 0,13	1,10 0,80 0,60 0,25

*Table compiled by Engineers A.M.Vladimirov and A.A.Doldabanov.

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control surfaces increases. By that time, the tooling of the second stage should have been produced in the form of jigs for the assembly of the tip, center, and leading parts of the control surface, and of their jig templates. For the tooling of the second stage, the tools permitting a sharp reduction in spoilage and labor-consuming work is first fabricated.

The complete set of tooling means the delivery to the shop by a definite date, of all the tools needed for the operation, part, or process set of parts of the tentative or series process. If, therefore, for one and the same part, the cutting tool must be fabricated in a week, the gage in two weeks, and the attachments in three weeks, then it is obvious that the operative plan must specify different starting dates for this tooling.

The sequence of tool fabrication is established by the chief technologist, starting from the cycles of manufacture of the assemblies and the order of priority of their delivery to the final assembly shops. For instance, if compartment F-2 is the most labor-consuming in the fuselage, then an earlier fabrication of the tooling for its assembly must be scheduled than for the assembly of compartment F-1. In the assembly of F-2, the first to be delivered are the framework units, for which the tooling for its fabrication and assembly will be planned earlier than for the remaining units of F-2. Such a sequence of tool fabrication is observed down to the parts entering into each process set.

For the planning of work on the technological preparation of production and for drawing the directive graph, planned standard Tables are necessary. For the relative proportion of labor cost of fabricating the various types of tooling in the total labor cost of tool production, the standard Tables of typical representatives of tooling, and factors of tooling supply, are used as the principal norms.

The relative proportion of labor cost of individual forms of tooling in percent of total labor cost of tooling is given in Table 28.

The norm of a typical representative indicates the labor and material consump-

tion standards for a definite type of single-type tooling (cf. Table 29).

The coefficient of tooling supply indicates the amount of tooling for a single part, unit, or assembly. Such coefficients are established for each group of tooling, allowing for the different daily output of aircraft (Fig.95).

The tooling coefficient for the main forms of special tooling for aircraft of various classes is calculated for each form of tooling by the formula

$$K_o = \frac{M}{N}$$

where M is the amount of tooling of the given form, in pieces or sets;

N is the number of designations of original parts fabricated by means of the tooling of the given type.

Table 30 gives approximate tooling factors in the production of special tooling.

The directive graph of the technological preparation of production indicates the stages and dates of the preparation of the primary production, allowing for the output of the first (type) series of machines.

The directive graph is prepared by the bureau of production planning (BPPP), with the participation of all departments and shops, of the chief technologist, chief metallurgist, chief machinist, and power superintendent.

The directive graph is plotted on the basis of the development drawings of the aircraft, the process of its assembly and the classification of its parts and units, the planned norms, the deadline for production of the type series of aircraft and the preliminary (orientation) data of the departments and shops on the schedule and volume of work to be done on the new aircraft, and the dates of their performance. These original data from the departments and shops are delivered to the bureau of production planning of the chief technologist, where the materials are corrected, coordinated, and reduced to a through (directive) graph of the technologiSTATreparation for production (Fig.96).

No.	Type of Work	Performed by	Unit of Measurement	Quantity	Labor, Time in 1000 Stand. Hrs.	Calendar Period (in months and decades)
	Preparation of working drawings of article	SKO	Piece			
	Preparation of lofts	Lofting and template shop	Piece			
3	Development of manufact. processes	Chief technologist	Piece			
4	Preparation of drawings for tooling					
	a) Forging and casting	Chief metallurgist	Piece			
	b) Fabricating-stamping	Cold stamping dept.	Piece			
	c) Machine attachments and jigs	Machining dept.	Piece			
	d) Normal and special tools	Tool department	Piece			
	e) Assembly and welding jigs	Riveting and assembling dept.	Piece			
	f) Master tooling (Mockups, master mockups, etc.)	Same	Piece			
	g) Means of transport mechanization	Mechanization dept.	Piece			

o.	Type of Work	Performed by	Unit of Measurement	Quantity	Labor, Time in 1000 Stand. Hrs.	Calendar Period (in months and decades)
5	Preparation of templates of tooling	Lofting and template shop				
6	Fabrication of tooling					
	a) Forging and casting	Dept. of chief metallurgist	Set			
	b) Fabricating and stamping	Cold stamping dept.	Set			
	c) Machine attachments and jigs	Machine-work dept.	Set			
	d) Normal and special tools	Tool dept.	Piece			
	e) Assembly and welding jigs	Dept. of riveting and assembly work	Piece			
	f) Master tooling	Same	Piece			
	g) Means of mechanization and transport	Mechanization dept.	Piece			
	h) Other tooling		Piece			
7	Fabrication of templates of first priority	Lofting and template shop	Piece			

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No.	Type of Work	Performed by	Unit of Measurement	Quantity	Labor, Time in 1000 Stand.-Hrs.	Calendar Period (in months and decades)
8	Reconstruction of shops	Capital construction dept.	%			
9	Installation of equipment	Chief machinist	Piece			
10	Fabrication of assemblies	Main-production shops	Set			
	a) Wing center section	Same	Set			
	b) Fuselage	Same	Set			
	c) Landing gear	Same	Set			
	d) Wing	Same	Set			
	e) Empennage	Same	Set			
	f) Canopies and engine nacelles	Same	Set			
11	Aircraft assembly	Same	Set			
12	Tests and delivery of aircraft	Same	Set			

Fig.96 - Directive Graph of Technological Preparation of the Enterprise for Series Production of Aircraft

In the preparation of the graph, the date fixed for the output of the type series of the aircraft is taken as the starting point. For instance, let the deadline for the delivery of the first machine to the airfield be 1 November. The cycle of the final aircraft assembly shop is 30 days. In that case, the aircraft assembly must begin on 1 October. By this time, the fuselage must have been delivered to the first stand in the final assembly shop. If the fuselage assembly cycle is also 30 days, then the beginning of its assembly will be 1 September. Knowing the labor cost of the work of fabricating the tooling for the fuselage, and the number of workmen that can be assigned by the tool building shop to fabricate the tooling of the fuselage shop, calculation will show that, with this number of workmen, the tooling for the fuselage can be ready, let us say, within two months. Consequently, the work of fabricating the tooling for the fuselage must begin not later than 1 July. This type of consolidated calculation is performed for all assemblies. The directive graph is based on calculations of the throughput capacity of the auxiliary shops, and is reinforced by the plan of organizational-technical measures. The graph envisages the performance of all work on preparation of production by the parallel and sequence-parallel methods.

The directive graph of the technological preparation of production is signed by the chief engineer and the director of the series enterprise and, after approval, becomes binding on the workers of the enterprise.

The working plan-graph of a department or service is a detailed and refined version of the directive graph. It contains schedules of the tooling, calculations of the throughput capacities of the shops of production preparation, working graphs of the production preparation with respect to each assembly, and a plan of organizational technical measures ensuring fulfillment of the working plan.

The tooling schedule includes for each assembly a list of the tooling, its quantity, the deadlines and order of priority of its fabrication, and its STAT cost in standard-hours.

The calculation of the throughput of the shops whose duty is the preparation for production must confirm the possibility of performing the forthcoming volume of work in the periods indicated by the directive graph.

The working graph of production preparation indicates, starting from the deadlines of the directive graph, a schedule and the dates for the performance of the work on designing of the processes and tooling, production of the tools and introduction into the main shops.

On the basis of the graphic plan approved by the chief engineer, the technological and design departments and auxiliary shops draw up their monthly operative plans.

The monthly plan of a department (or shop) is an expanded schedule of the work to be done in the planned month, allowing for the socialist obligations accepted and the plan-fulfillment results of the past month, and also including the extracurricular work resulting from process changes and spoilage in work.

On the basis of the monthly plan of the department, the managers of the technological bureaus and design groups issue individual monthly plans to the assigned personnel, allowing for the volume of work to be done by the given worker, his qualifications, and the productivity of his work.

Operative records and dispatching are necessary for checking on the course of the combined tooling-up for the units and assemblies of the aircraft. The operative record is based on the parts-tooling charts and of the graphs prepared for each unit of the aircraft. This graph indicates the parts of the units, and the tooling necessary for its fabrication. The basis for inclusion of a given item of tooling in the graph is an order for that item. The tool-building shops report daily on the delivery of finished products, supplying the bureau of production planning of the chief technologist with summary reports on the tooling delivered by the main shop, indicating the numbers of the delivery invoices. The data from the reports are transferred daily to the product-list graphs of the tooling of the technological

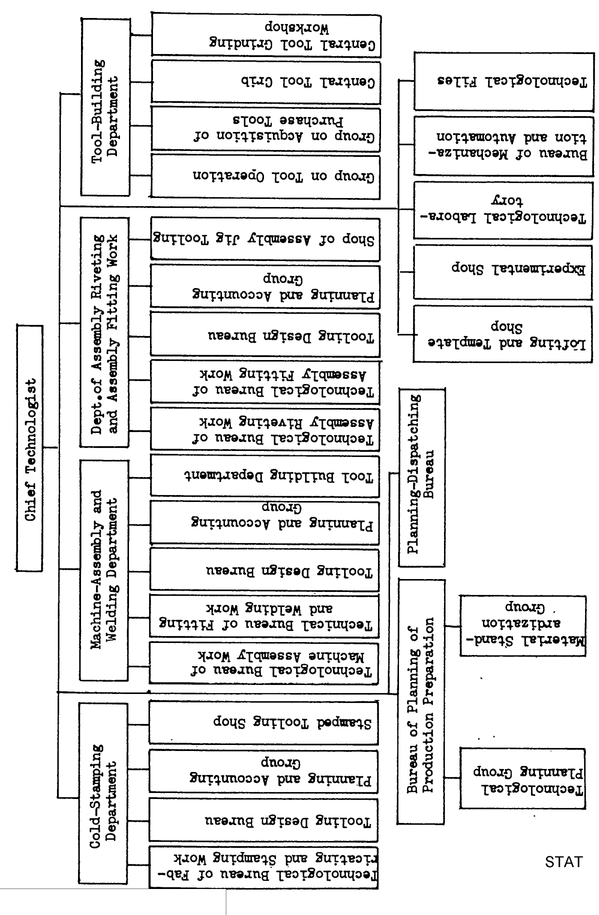

Fig.97 - Vertical Integration Flow Sheet of Chief Technologist's Staff

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units. These graphs will permit making a daily record of the orders arriving and filled and of the completeness of the sets of tooling for producing each unit of the aircraft.

The dispatcherizing of the technological work by methods of organization does not differ in principle from the dispatcherizing of the work in the primary producing shops. The dispatcher currently controls the course of the work on the basis of the monthly plan of preparing for production, and of the graphs for the various units.

Section 14. Organizational Structure and Functions of the Chief Technologist's Office

The chief technologist plays the leading role in the technological preparation for production and handles this work in close contact with the chief metallurgist, the power superintendent, the chief machinist, and the chief inspector. The chief technologist is responsible for the technological preparation for production; gives the shops the directives to be followed in working out the manufacturing processes and in using new techniques; coordinates the amount, deadlines, set completeness and priorities of the tooling for the processes; decides the question of the distribution of work between the shops that will ensure identity of the processes, tooling, and standards for analogous work.

Depending on the scale of the enterprise, the technological office has various organizational structures. Figure 97 gives the structure of the chief technologist's office of a typical aircraft construction enterprise.

In enterprises that produce light aircraft and do less work on the technological preparation of production, the chief technologist's office has fewer units which are under the direct supervision of the chief technologist. For instance, all the technological groups are combined into a technological department. All the designing groups are combined into the department of tooling design.

At aircraft construction plants, producing medium and heavy aircraft where the

amount of work involved in the technological preparation for production is very great, this work is done in three large combined departments: cold-stamping (OKhSH), machining, assembling and welding work (OMO), assembly riveting and assembly-fitting work (OSKMR).

Each department is organized on the closed principle and combines the technological and designing offices and shops fabricating the tooling. Such a structure of the organization operates mainly to relieve the chief technologist of some of his workload and, at the same time, concentrates all the work on planning the manufacturing process and tooling, its fabrication and introduction into production, in the hands of the departmental superintendent.

The superintendent of each department is in charge, with respect to methods, of the technological bureaus of the corresponding primary shops. The chief of the department is responsible for the quality and timeliness of the technological tooling of these shops, controls the condition of technological discipline there, and establishes a schedule of the tooling fabricated by the tool shops and tool-maintenance workshop of the main shop. In connection with the great importance of a centralized decision on questions of interchangeability of aircraft assemblies, the questions of intrashop and intershop interchangeability of aircraft are handled at aircraft construction enterprises by the bureau of interchangeability and the interchangeability laboratory, while the designing of master and assembly-jig tooling is handled by the design bureau. Both bureaus and laboratories of interchangeability are integrated in the department of assembly riveting and assembly fitting work.

Let us consider the functions of the bureaus and departments directly subordinate to the chief technologist.

The bureau of production planning (BPPP) has the function of operative planning, recording, and controlling the work on the technical preparation of production, performed by the departments and shops of the chief technologists. This bureau

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contains two groups: the technological planning group which makes up the directive graph, establishes the type and product list of the work of each shop, defines the priority of fabrication of tooling, and prepares the technological planning charts; and the group of material standardization which sets up limits on the applicability of materials and general and plantwide requisitions of materials, and keeps a log by shops of the material consumption standards.

The planning and dispatcher bureau prepares the monthly assignments for the departments of the chief technologist,and conducts the check-up, recording, and control on their fulfillment.

The tool department plans the acquisition and production of the standardized and special cutting, measuring, fitting, and auxiliary tools required by the enterprise; secures the supply of the enterprise with all forms of purchased tools; calculates and regulates the inventory of tools at the enterprise; organizes technical supervision of the operation of standardized and specialized tools; establishes shop limits for them and controls the fulfillment of these limits; and organizes the centralized grinding and rebuilding of tools. The chief of the tool department has direct authority over the staff of the tool department, the central tool crib, the central or interdepartmental tool-grinding workshops, the abrasive and tool-rebuilding workshops.

The planning, fabrication, and supply of the shops with special tooling (dies, chills, jigs) is the duty of the departments of cold-stamping, machining-assembly and welding work, assembly-riveting, and assembly-fitting work.

The experimental shop and the technological laboratory of the chief technologist work on the development and introduction into production of improved methods of processing and assembly, testing of new methods of tool and tooling fabrication, testing and introduction of high-speed and power cutting systems, and organizing of the technical propaganda for introduction of progressive technology and the advanced experience of production innovators.

The bureau of mechanization and automation works on the mechanization of labor-consuming and heavy work, develops the automation of mass operations, directs the mechanization and automation of inspection processes, and occupies itself with the introduction of intershop and intrashop mechanized transport.

The principal functions of the chief metallurgist are analogous to the functions of the chief technologist and extend to the casting-forging and heat-treating shops, the metal-coating shop and the nonmetallic-coating shop.

In addition to the questions of the technological preparation of series production, the staff of the chief technologist, or a special department of reconstruction, works on questions of the reconstruction of production and of designing the shops in connection with the expansion of the production scale or of radical improvement in technique.

The work in the departments of the chief technologist and chief metallurgist are organized on the basis of division of labor and specialization of the workers. This increases the productivity of their labor.

Section 15. Prime and Secondary Enterprises and the Forms of Their Cooperation

In organizing the production of aircraft of a single model at several enterprises, the most advanced of these enterprises is designated as the prime enterprise while the remaining ones are secondary, i.e., enterprises which perform the technological preparation for production according to the technical documentation and instructions of the prime enterprise.

There are two basic forms of interrelation and organization of the joint work of prime and secondary enterprises.

In one of these forms, the prime enterprise completely performs the technological preparation of its own production and, in addition, provides the secondary enterprises with sets of the series drawings and technical documentation of the article; sets of duplicate theoretical and design loftings, of the master templates

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for the contours, and of the templates fabricated from the master parts; a set of technological documentation and drawings for the tooling, and a set of master tooling, securing interchangeability of the articles between individual plants. Besides this, the prime enterprise is charged with the finalizing and delivery to the secondary enterprises of all changes in the drawings and technological documentation, as well as with instruction and transfer of experience on technical questions of manufacturing the new aircraft. The changes made in the series drawings and the technical documentation of the article, regardless of the point of origin of these changes, are finalized only at the prime enterprise.

The secondary enterprise produces a single-type product from the technological documentation of the prime enterprise, allowing for the features and programs of its own enterprise. The shops of production preparation at the secondary enterprise prepare templates (except for the templates of the basic cross sections and the master template of contour control), part of the master tooling, and all of the remaining tooling.

In this form of interrelation of the prime and secondary enterprise, the prime enterprise is overloaded, a superfluous volume of work is artificially produced there, while the initiative of the secondary enterprise is fettered and its capacities often incompletely utilized. Such an uneconomic form of connection between the prime and secondary enterprise prevents full utilization of all advantages of specialization and cooperation of production.

In the other form of interrelation in question, the total volume of work on the technological preparation of production is distributed between the cooperating prime and secondary enterprises, taking account of the economic utilization of capacities and of the advanced experience of each enterprise. The work of the cooperating enterprises is broken down into two stages.

During the first stage, the directive technology is worked out. For this purpose, a combined team of technologists and designers of all cooperating enterprises

and representatives of the development design bureau is organized at the prime enterprise. The guiding nucleus of the team is formed by the chief technologist of the cooperating enterprises and the senior representative of the development design office, who jointly plan and approve the initial formulations for each document of the flow sheet. In addition, the combined team plots a summary graph of the technological preparation and tooling for each enterprise, starting from the assigned deadlines; establishes the form of specialization of each enterprise in the designing and fabrication of definite forms of tooling, taking account of the personnel and capacity of the auxiliary shops of the cooperating enterprises; plans, for each type of work, the products list and the quantity of tooling to be produced, the specifications of its fabrication and the enterprise that is to produce this tooling. Each cooperating enterprise is to produce, for the parts list assigned to it, the dies, jigs, attachments, tools, and parts for the first series of aircraft for all the remaining enterprises, in accordance with the unified specifications of the crew and on the basis of the deadline indicated in the graph.

The work of the combined team ends with the development of the materials of the directive technology. Then the second stage begins, which constitutes the planning of the working technology. This work is done independently by each enterprise, guided by the data of the directive technology and the unitary graph of production tooling. At this stage, the prime enterprise coordinates the work of the enterprises and exercises operative control of their fulfillment of the graph.

This form of specialization and cooperation is highly effective. As shown by experience, this allows a change-over from the production of one aircraft to the production of another, without lowering the output rates, and permits a considerable reduction in the labor cost and a noticeable shortening of the cycle of complete mastery of the production of the new aircraft. Cooperation and specialization of the enterprises allows complete tool-up of the fabricating and processing shops by the beginning of putting a new aircraft into production. It is also expedient to

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specialize the enterprises, one for the manufacture of aircraft instruments, another for the manufacture of ground equipment, etc., for all of the cooperating enterprises.

This form of specialization and cooperation allows the organization of a single system of technological preparation of production at all enterprises, and permits a fuller dissemination of advanced experience of each enterprise to all the others.

CHAPTER XI

ORGANIZATION OF THE DRAFTING AND LOFTING-TEMPLATE SYSTEM

The basic technical documents for the aircraft are the drawings, loftings, and templates, the specifications for the aircraft and its parts, the schedules of standard parts, the list of drawings by groups, and the list of schedules for the aircraft as a whole, the general technical specifications (TU), the productive instructions and process charts, the specifications of materials and the technical description of the aircraft. To provide for order in the reproduction of the technical documentation and in the fabrication of templates, for proper storage, utilization, and replacement of this technical documentation at enterprises, a central technical file (for drawings), and a lofting-template shop are organized at the enterprises.

Organization of the Technical Documentation File

A central technical file (TsTA), with branches in the shops and several departments, is organized within the development design office of a development enterprise or the series design department of a series enterprise. The central technical file department is charged with the following functions:

1) Receipt, registration, storage, issue, and recording of the movement of drawings and other technical documents;

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2) Providing the secondary enterprises, shops, departments, and other sub-

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scribers with the necessary number of copies of drawings and other technical documents;

3) Withdrawal of canceled drawings and other technical documents and replacement of worn documents;

4) Supervision of the organization of correct storage, recording, and issue of drawings at the file departments of shops and departments.

All original drawings for the basic article, and the copies serving as originals, must be stored at the central technical files.

The equipment of the room and the procedure for maintenance of the technical files, the rights and duties of the file clerks, the procedure for acceptance and issuance of documents, the rules and periods for their storage are defined by special instructions.

Section 1. Categories of Drawings and Their Classification

The drawings of articles for the main production are divided into three principal categories:

1) Design drawings (theoretical, matching, and layout). These give the overall view of the article and its parts. These drawings provide a general idea as to the structure, operating principle, and dimensions of the article being designed and contain the necessary data for preparation of the working drawings.

2) Mockup drawings. These drawings contain the data necessary for the manufacture of mockups of the article, its parts, and equipment.

3) Production drawings. These contain all data necessary for the manufacture of the basic article. Production drawings are subdivided into drawings of the development production, drawings of the type series, drawings of series production, and repair drawings.

According to the purpose and character of utilization, drawings are divided into:

1) Originals, which are drawings made with pencil or india ink on any material and serving for the preparation of duplicate original drawings;

2) Duplicate originals, consisting of the principal drawing of the part, unit, assembly, or article, with all signatures and finalized on a material such that copies can be made by blueprinting, photostating, or other methods;

3) Duplicates, which are copies of the duplicate originals, made on transparent material (in exchange for worn drawings);

4) Copies, which are blueprints or photostats of the duplicate original drawings.

The technical documents for an article of a development or series enterprise must be in complete sets. The composition of a set of technical documents is prescribed by Standard MAP-AN 1237.

Section 2. Finalizing, Recording, and Issuing of Duplicate Originals and Copies of Drawings

Finalizing, Recording, and Issuing of Duplicate Originals. The central technical files accept and store only finalized documentation. On receipt of duplicate originals for storage at the central technical files, the completeness of the documentation set is checked, as well as the presence of all notations; the signatures are verified, and the suitability of the duplicate originals for production of clear copies is checked. The accepted duplicate original drawings are registered, in complete sets for a unit, in the inventory log; an inventory number is assigned to each drawing, a record card is started for it, the number of copies to be made from the tracing paper is established, and the number of the order is entered on the tracing. Drawings for an aircraft are compiled into design groups at the central technical files room. A schedule of drawings of the parts and units in the group is made up for each group. The duplicate originals of the drawings and other technical documents are issued only for reproduction, entry of changes, and re-issue. DuplSTAT originals for making copies are issued on requisition by the central technical files

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room, while duplicates for entry of changes are issued on requisition and schedule of the department that originally issued the drawing. The central technical files of the development enterprise delivers the development drawings for the aircraft going into series production to the central technical drawings files of the series-design department of the series enterprise, where the drawings are stored according to the same design groups as at the development design office.

Duplication, Storage, and Recording of Copies. The overlay of the drawing, with the order number noted on it, is delivered by the central technical files to the blueprint room for making copies (blueprints). On the copies, the central technical files enter the number of the set and stamp the purpose of the copy ("replacement of worn-out copy", "reference", "standard", "not recorded").

The central technical files store the file copies, control copies, and library copies of the drawings and other technical documents.

The file copy fixes the state of the design at the time of its approval. No changes are made in the file copy, and this copy is not released from the files.

The control copy serves to verify the drawings, and all changes are entered in it at the same time they are entered in the duplicate original.

The library copy of the drawing is issued from the files for a definite period for service use and must be returned without fail to the files at the end of that period.

The copies are stored in the files in the form of individual drawings and documents and in the form of albums, made up into sets by articles or according to some other principle.

The copies are recorded in the drawing-record card file.

The control copies are issued from the central technical file rooms on written disposition of the chief of the department that originally issued the technical document, and only for entry of changes or for corrections.

The library copies are issued against requisition signed by the borrower. A

record card is kept for each drawing to record the library copies. When the borrower returns the library copy, a note of its return is made on the card, and the requisition is returned or destroyed.

Section 3. Receipt, Recording, Finalizing, and Issuing of Copies of Drawings in the Files of Shops and Departments

A technical drawing file (VTCh) is organized in each shop. The technical files of the shop have the functions of receiving, storing, recording, issuing, and recalling drawings. Drawings reach the shop through its technical files.

The issue of copies from the central technical files to the shop files is made on the basis of a distribution list. The numbers of the requester shops are taken from the shop distribution list of the department of the chief technologist. A schedule of the remaining permanent requesters and the number of blueprints to be issued to them is established on a list approved by the chief engineer. Copies are issued from the central technical files to an authorized person, the file clerk of the shop or department. The copies of the drawing bear the number of the shop or department to which they are issued.

On receipt of copies from the central technical files, the file clerk checks their numbers, quantity, and quality, and also inspects the copies for presence of the number of the shop or department to which they are issued. The copies received are registered by the file clerk in the shop inventory log of drawings. Each copy is given a number which is entered on the back of the copy. For each number of the drawing (but not of the copy), a record card showing the movement of the drawings is made out. Besides drawings, the technical files of the shop also receive the drawing-modification sheets and the drawing-refinement sheets from the central technical files.

The issue of drawings and other technical documents to the work stations is carried out by the shop files after the chief of the technological bureau has famil-

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iarized himself with this documentation. Technical documentation may be issued from the file room on personal account, on requisitions, or on stubs.

Personal accounts of a library system of utilizing drawings are kept for designers, technologists, standards men, dispatchers, and other technical personnel who continually make use of drawings. A personal account is opened on the authorization of the superintendent of the shop or department.

In the system of issuing drawings on work orders (or work cards) the planner of

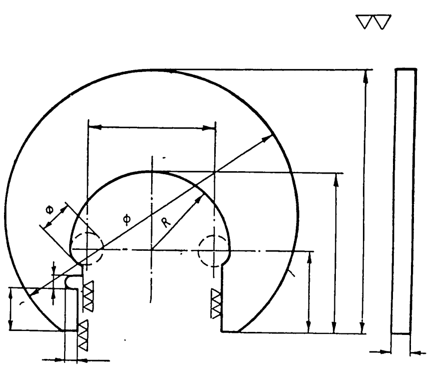

Fig.98 - Blank Drawing for Standardized and Typical Tooling

the shop, on the basis of a work order, writes out a request for the drawing from the technical files of the shop. The request and work order are delivered by the planner to the technical file room of the shop to select the copies of the drawing. The clerk of the technical files of the shop, on selecting the copies, notes the issue of the drawings to the workman in the card index, records the numbers of the selected drawings in the requisition, and enters on the work order "with drawings". The work order with the drawings from the shop technical files is issued to the

planner against his receipt on the requisition, which is kept in the file room. On return of the drawings to the files, the work order and requisition are stamped "drawings returned". Without this note, the work order is not accepted for payment.

If the drawings are issued against stubs, then a board is kept in the technical file room of the shop, provided with hooks for the stubs and numbers. The numbers are based on the number of workers. For each number, several stubs are prepared, usually from two to five. A list of workers who have received stubs entitling them to the drawings is drawn up in the shop. For each drawing or set of specifications issued, one stub is hung on its number on the board. When the drawing is returned, the stub is returned to the workman.

<u>Organization Features of the Technical Files at the Department of the Chief Technologist</u>. Drawings of articles and technological documentation are kept in the technical files of the department of the chief technologist. The file clerks of the department of the chief technologist have the duty to register, record, reproduce, and issue technological documentation to the shops and to certain departments.

The process chart or flow sheet, finalized by the shops on tracing paper, is delivered to the technological file room. Here, for each shop, a special book for registration of the flow sheets is kept. On registration of the flow sheet, the number of the drawing of that part or unit for which it was made up is assigned to it. The tracing of the flow sheet is then delivered by the file room to the blueprint shop for reproduction. After return of the tracing and its copies from the blueprint shops to the file room of the department of the chief technologist, a record card is made out for the flow sheet, indicating the movement of each copy of the blueprint. The number of the blueprint indicates to whom it may be issued. The printed blueprints of the flow sheets are forwarded by the file room according to purpose, against receipt on the record card, while the tracings are retained in the file room. The record cards are arranged in the card index of the file room by divisions: drawings of primary article, flow sheets, drawings of tooling, and of

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tools.

Section 4. Methods of Reproducing Technical Documentation

Technical documentation may be reproduced by the methods of blueprinting, photography, photostating, pencil tracing on parchment, followed by reproduction on diazo tracing paper, printing, and utilization of prepared blank drawings.

Photography and photostating have the advantage over other methods of copying of being free from the errors possible in tracings, and of accelerating the process of making copies. Photostating likewise preserves the scale of the original.

To finalize a drawing for unified parts and tools, the use of blank drawings is recommended, in which the graphic part, the text and the stamp in the corner, are first made by a typographic or hectographic method (Fig.98). The blank dimensions in the blank drawing are entered by the designer when he designs the tooling.

For standard parts, albums of ready-made drawings should be used.

ORGANIZATION OF THE LOFT-TEMPLATE SHOP

Section 5. Purpose, Composition, and Functions of the Shop

In aircraft building, the drafting organization is supplemented by a loft-template organization which is of extreme importance in ensuring interchangeability of aircraft elements and to minimize the matching and fitting work. The loft-template organization is handled by the loft-template shop whose primary task is the loft-fitting of the aircraft and the supply of templates, form-blocks, sand molds, and other loft-template tooling to the shops. In a loft-template shop, the tracing of the theoretical and design lofts of the assemblies and units of the aircraft is done; templates are prepared which are supplied to the productive shops; theoretical and design loftings, master and standard templates are stored; standards of the surfaces and complex blocks are traced; changes are made in the loftings, templates,

and reference surfaces.

To do this work, the following departments are organized in the shop: lofting, template, and central template stockroom.

The lofting department consists of lofting groups, groups of matching and control of changes, technical documentation files, and a stockroom for design loftings. The lofting groups are specialized by assemblies of the aircraft, and consists of the designer-lofters and fitters and layout man and do the following work:

1) Trace the theoretical and design loftings and lay out the master contour templates, the surface plaster blocks and standards, enter the required changes, and keep the theoretical and design loftings;

2) Refine and agree with the template office on the number and list of templates, make out and standardize the assignments for their production, issue instructions on changes in the templates, perform the final acceptance of sets of templates in the fitting workshop after their acceptance by the BTsK;

3) Consult the shops and discuss their claims in connection with the utilization of lofting-template tooling.

Each group handles all questions connected with the tracing of the loft for a definite assembly.

The template department consists of a template-making bureau, manufacturing, and fitting workshops for the fabrication of templates, and a photographic workshop.

The template bureau determines the list and number of templates and follows up the modification and replacement of templates.

The production workshop performs the rational layout of the blank templates and the control prints; adjusts (corrects) the templates; does the welding, coppersmithing, and painting of the template for all departments of the shop.

The fitting workshops specialize in the fabrication of templates for definite assemblies.

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The photographic workshop does the work of preparing the blank templates, the

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blueprinting of the prints from the design loftings for the production of templates and for the definitive finalizing of the photoprints. If there is an offset machine, the photographic workshop uses it for printing the lofting layouts with the design layouts for the manufacture of the templates.

At some plants, the template department includes a sand mold and a wooden fixture workshop. At other plants this workshop is an independent department.

The central template store is subordinate to the production-dispatcher bureau of the shop and includes a group for storage and recording of the templates, consisting of stockroom clerks and set makers assigned to specific assemblies of the aircraft, and a shipping department, consisting of a dispatcher and helpers at his disposition, to deliver the templates assigned to the consumer shops.

The group of storage and record accepts the templates from the departments of the lofting-template shop and issues templates for their use, arranges and stores the basic and master templates and the master parts, makes up sets of the working and jig templates and delivers them to the shop shipping department, and records the presence and movements of the templates.

The shipping department of the template shop sends the finished templates to all shops of the enterprise and receives from them standard reference parts and templates to be modified or cancelled.

Section 6. Fabrication of Loftings and Templates

A schedule of the lofts for the aircraft is planned by the loft department, in agreement with the series-design department and the department of the chief technologist. Based on the directive graph, the productive-dispatcher bureau of the lofting-template shop prepares a graph for priority and deadlines of the laying out of the loftings for the aircraft assemblies.

For tracing of each lofting, the chief of the lofting department makes out a rating plate. The rating sheet, at the same time, represents a technical document

and a record, indicating the characteristics and sketch of the lofting, together with the names of the draftsmen, the staff members tracing the lofting, and the inspector accepting it. Any mismatch and errors in the drawings found on the tracing of the lofting are entered in the coordination log and are settled with the series-design department and the development design office, where a change sheet is made out for each change, to be used as basis for making later changes in the lofting. After the lofting has been traced and approved, its rating sheet is delivered to the shop inspection bureau for storage, while the face card of the rating plate is delivered to the technologist for entering the performance of the work by the operators and their pay.

The theoretical loftings are kept in the loft department, while the design loftings are kept in the stockroom department. Loftings made of "Vinyprose" are stored in a horizontal position, while those made of metal are stored in a vertical position. For each lofting, the stockroom department makes out a record card entering on it the place of storage of the lofting.

Further refinement of the loftings and templates is unavoidable during the production of a new aircraft. The jointing (mutual matching) of the loftings and templates, as well as their verification, is handled by the group concerned with these matches and is performed by the most experienced designers and lofters. All mismatches found in production are registered in a special mismatch log, stating the measures adopted.

In order to determine the number of templates to be prepared, the technologist in each consumer shop sets up a schedule of templates for each design unit.

The template schedule contains a list of all templates necessary for producing the design unit of the article, as well as the specifications for the preparation of the templates.

The specifications contain data as to the requirements made on the templates by the manufacturing process, as to the number of guide holes for fixing the position of the parts during their manufacture, as to the number of tool holes for attaching the workpieces to the dies.

The technologists of the department of assembly-riveting work enter the guide-hole data in the specifications, giving the holes by which the part or unit is fixed in the assembly jig, as well as data on the assembly holes for attaching the parts in the assembly without a jig, and on the guide holes used for drilling rivet holes in the parts.

To indicate the order of the arrangement of all holes on a template, a set of blueprints of the design drawings of the aircraft is annexed to the template schedule. On this so-called unrecorded set of blueprints of the assembly and detail drawings, the technologist indicates the position of the holes in colored pencil.

The template schedule, in two copies, with the annexed diagram of the position of the holes is delivered to the lofting-template shop. Here the schedule is entered in the registration log of template schedules, and the technologist and designer then check the production list of the ordered templates and register them on record cards for template tooling of the part. On the basis of the template schedule, the technologist of the lofting-template shop works out the process of manufacturing the templates and finalizes it in the shape of an assignment for the fabrication of a set of templates for the design part. At the same time, the technologist makes out a requisition for procurement and return of the templates necessary for the jointing and matching of the templates being prepared. In cases where additional work must be done on the loftings to execute the order for the templates, the technologist gives the instructions to do that work to the chief of the lofting group. After completion of the lofting work, the technologist delivers all documentation on production of the templates to the production-dispatcher bureau. At the dispatcher bureau, the deadlines are determined and the operators for the assignment are indicated, after which the documentation is turned over to the planner-recorder who registers the assignment in the record for the assignments put into

process, and enters it in the plan graph. In accordance with the assignment, the work-order clerk makes out the work orders for the workman and the requisitions for materials. The assignment, work orders, and requisitions for materials are delivered by the work-order clerk to the preparer of the workshop, against his signing the record log for work issued. Simultaneously with the issue to the production group of the documentation for the production of the templates, the number and date of issue of the assignment for making the templates are noted in the template schedule against each item. This indicates which templates are in process and which have already been made.

The foreman of the section, on the basis of the plan-graph of work, makes up an assignment for each shift indicating which template must be produced by what workman in a given shift. On the basis of the shift assignment and the work orders, the preparer of the section receives the material from the stockroom and issues it to the production group which cuts out the blanks for the templates to the dimensions indicated by the technologist in the assignment. The set of workpieces accepted by the inspector of the shop inspection bureau is delivered by the preparer of the fabricating workshop, against receipt on the shift assignment, to the preparer of the photographic workshop. The latter, on the basis of the shift assignment, receives the necessary design loftings from the stockroom and, after making prints of them, returns the lofting to the store.

The preparer of the fitting workshop, after receiving a set of workpieces from the stockrooms, their photoprints, and the templates necessary for matching and jointing, reports to the foreman that the set is ready. The set is then entered by the planner in the shift assignment of the workshop, indicating the fitter that is to do the work and the templates he is to fabricate.

The templates are accepted by the inspector only in a set for the unit. Final acceptance of the set of templates is done by the leader of the team of the lofting group. A rating sheet is finalized for the complicated templates. The newly produced and accepted templates, together with the templates taken for matching, are delivered by the preparer of the fitting workshop to the template stockroom where the set-man of the stockrooms receipts for them on the shift assignment of the workshop. After this, the finalized workmen's charts and shift assignment are delivered to the planner-recorder for noting their fabrication in the template schedule and for noting the fulfillment of the assignment in the record log of assignments. The sheet, with the shift assignment and work order is then delivered by the planner to the accounting office for payment.

Section 7. Organization of the Work of the Template Stockroom

The templates accepted from the preparer of the fitter workshop are entered by the set-man of the store in the template inventory book kept for each assembly.

For each template arriving in the template stockroom, a record card is kept.

Table 31

Category No.	Type of Category	Approximate Dimensions, in mm	Method of Storage
1	Small template	Up to 300 × 150	Racks with boxes for templates
2	Medium templates	Up to 1500 × 500	Racks with hooks for templates
3	Long templates	Up to 3000 × 700	Racks with horizontal shelves for 3 - 5 templates
4	Large templates	Over 3000 × 700	Special racks
5	Round templates	1000 × 1000 or more	Special racks

All the templates are sorted by the stockroom into those remaining at the stockroom (master and basic) and those to be delivered to the consumer shops (working and jig).

The master and basic templates are grouped by design groups, overall dimen-

sions, and place of storage. The number indicating the place of storage is punched on the template and indicated in the record card. The master and basic templates are stored in the stockroom by assemblies and, within the limits of the group of templates for each assembly, by overall dimensions. The methods of storing templates are typified (cf.Table 31).

The working and the jig templates are delivered by the set-man of the template stockroom, together with the record cards, to the shipping department of the lofting-template shop, where the templates are laid out in sets on distributing tables assigned to their respective consumer shops. From these tables, the messengers of the store carry the templates to the consumer shop, having finalized the delivery of the templates by bills of lading or by receipt of the shop representative on the record cards of the templates. The workers of the shop also have the duty to recall from the shops any template that has been cancelled or is subject to modification. The canceled and modified templates are stored on the shelves of the stockroom.

At each consumer shop, a template stockroom is set up, in which organization of the template storage is similar to that described above.

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CHAPTER XII

ORGANIZATION OF QUALITY CONTROL

Section 1. Purpose, Task, and Objects of the Control

The trouble-free operation of an aircraft and its long service life depend on the quality of its manufacture. For this reason, the State obligates each enterprise to produce only a product of excellent quality. In aviation, the safety of flight depends on the quality of manufacture, and therefore special attention is paid at aviation enterprises to product quality.

The quality of manufacture of aircraft means its complete conformity to the drawings and specifications.

Side by side with the attempt to improve product quality, it is particularly important to completely eliminate spoiled work or scrap.

To prevent the output of products of poor quality, an inspection service is organized at an aviation enterprise, charged with the following tasks:

Making sure that only finished products in complete sets and in strict conformity with the drawings, standards, and specifications are shipped out by the enterprise;

Development and introduction of preventive inspection, to prevent the spoiled work and scrap at all stages of manufacture of the product;

Control over checking of the manufacturing process during production, and verification of the product quality.

The objects of inspection at an aviation enterprise are the materials, semi-

finished products, and finished articles delivered to the enterprise and stored there, the facilities by which the product is manufactured and by which its quality is checked, the manufacturing processes, and the finished product of the enterprise.

The materials, semifinished and component finished articles are inspected to prevent products in unsatisfactory condition from entering the enterprise. Conformity of a batch of materials, semifinished, and finished components with the technical characterization indicated in the invoice is verified.

The equipment, its tooling, and its means of control are checked by the inspection team to prevent spoilage of the product due to poor condition of the implements of production. For this purpose the inspection workers periodically check the conformity of the equipment, tooling and means of inspection with their accuracy characteristics indicated in their identification sheets.

The product of the enterprise is checked at all stages of its manufacture, so as to detect, in good time, any possible spoilage, to prevent the delivery of spoiled parts to the next operations, and to determine the quantity and quality of the product manufactured by its workmen.

Section 2. Forms and Methods of Inspection

Depending on the stage of the process of manufacture of the part, unit or assembly, inspections are divided into preliminary, operational, and final.

Preliminary, or preventive, inspection is directed toward elimination of the causes resulting in spoilage and is used to check the materials and semifinished components arriving at the enterprise, as well as to check the condition of the equipment and the quality of its adjustment.

Operational or intermediate inspection is performed by an inspector for operations of higher accuracy; for operations at which a high surface finish is obtained; for operations after which the parts are delivered to a different section or STAT different shop; for operations whose quality cannot be subsequently checked. Workmen who have gained good rating, due to the excellent quality of their work, receive an individual inspection stamp and the right of independent inspection of these operations.

The inspection of all secondary operations and the responsibility for their quality is the duty of the workmen themselves and of the foremen.

Final inspection has the duty of checking the quality of a part, unit, assembly, or of the aircraft. Final inspection is handled only by the inspection department.

Depending on the number of objects being checked, inspection may be either random or complete.

In random inspection or spot checks, only part of the product is checked. Such inspection is used in cases where the equipment itself guarantees uniformity of the products fabricated (stamping on presses, machining on automatic machine tools), in operations where spoilage is accidental, and in operations after which the product, during later operations, will be subjected to complete or 100% inspection. The number of parts checked and the period of the sampling are prescribed by the inspection department.

A spot-check inspection, according to its form, may be either systematic or nonsystematic. In the former case it is applied at definite time intervals or after a definite number of parts have been processed. In the latter case, the inspector will appear suddenly. In spot-check inspection, the inspector removes the processed part from the machine. If it proves to be within the limits of the specified dimensions, then the inspector takes, at his discretion, one or several other parts from among those processed. If all the parts prove to be within the tolerance limits, then the whole lot of parts is accepted, stamped by the inspector, and removed from the work station. If, however, a part machined in the presence of the inspector proves to be faulty, then the entire lot of parts processed during the period between two inspections is checked by the inspector, and may be rejected.

Complete or 100% inspection is usually combined with the final inspection, and is characterized by checking 100% of the product. At aircraft plants all parts, units, sections, and assemblies that have been completely processed are subjected to 100% inspection.

Stationary inspection is characterized by a fixed inspection point, to which the object to be inspected is routed. Such inspection is used on production lines in checking a large number of identical objects, which may be more conveniently checked at a special inspection point; on the acceptance of parts whose processing has been completed before delivery to the store or to a different section; and on checking of parts requiring special equipment or a special room.

In mobile inspection, one inspector serves a group of work stations. As shown by the experience of skilled inspectors, mobile inspection of each work station according to a graph and a definite route, for instance a circular route, assures timely transfer of parts from one work station to the next.

Inspection control is applied by the chief inspector to check the quality of the work of the shop inspectors and extends to any form of product accepted by an inspector.

There are a number of inspection methods: visual, geometric, analytical, structural, strength, and others.

Visual inspection is intended to reveal obvious external damage and other defects of the object checked by external inspection with the naked eye or by the aid of a magnifying glass. This method is subjective, is indisputable only in the case of obvious defects, and usually precedes the application of other and more complex inspection methods.

Geometric inspection is used to check the accuracy of the shapes and dimensions of objects within the limits of the assigned tolerances, and is accomplished by means of universal or special gages and of various instruments.

Analytical inspection is used to investigate the chemical composition of materials or semifinished components and is performed by the plant laboratory, using chemical analysis methods.

Structural inspection is used to check the structure and reveal external defects of materials, blanks, and parts and is performed with the aid of photographs of microsections.

X-ray inspection is used to examine the part or unit by X-ray to reveal foreign inclusions and other defects.

Magnetic inspection is used to disclose cracks in the part or unit and is performed by the aid of the magnaflux method.

Strength inspection is intended to disclose the mechanical properties of materials, and is performed on the Brinell hardness tester, the Shore sceleroscope, the Rockwell hardness tester, etc.

Radioactive tracer inspection is used to check complex production processes run at high speeds, temperatures, and pressures, for quality control in cases where the earlier methods have proved to be ineffective or disadvantageous.

Section 3. Statistical Method of Quality Control

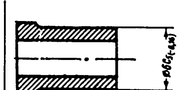
One of the forms of sampling control is the statistical method of control, which makes it possible to verify the quality of parts, to prevent the appearance of spoilage or scrap, and to ensure stability of the manufacturing process. This method of control is advantageous in mass production. In aircraft construction, it is used in machining parts on automatic machine tools, in heat treatment, in coating and riveting operations. The work on introduction of the statistical method of control is usually performed in two stages.

In the first stage, the condition of the equipment is analyzed to establish its operating accuracy.

In the second stage, the routine control of the quality of the processing of the parts is accomplished by the method of statistical control.

Table 32

Card of Measurements of Parts of a Test Lot

hop No.6	Section	No.4	Foreman	A.I.Fedorov	Sketch of Part
Type of Part	Machine	Single-Spindle Automatic Machine	Machine Setter	K.S.Sergeyev	
Bushing	Type Index	Inventory No. 426	Productivity per hour, in Pieces	120	
Part No.	N-6844	46	Type of Operation		

Group No. \ No. of Part in Group	1	2	3	4	5	6	7	8	9	10	R. of Groups	Inspector's Remarks
	Dimensions of Parts in mm											
1	5,906	5,906	5,909	5,907	5,906	5,908	5,900	5,898	5,906	5,909	0,011	
2	913	913	903	909	903	906	900	901	915	913	0,015	
3	913	908	912	910	911	916	914	915	916	918	0,010	
4	916	916	919	917	917	917	915	917	916	917	0,004	
5	916	917	910	914	922	922	919	920	918	916	0,012	
6	915	914	916	917	921	920	918	917	919	918	0,007	
7	918	916	918	919	918	919	919	919	915	918	0,004	
8	917	918	916	918	917	918	918	920	916	918	0,004	
9	917	918	920	919	913	914	916	916	919	914	0,007	
10	918	922	917	916	918	916	918	916	916	912	0,010	
11	912	916	913	914	912	914	914	912	916	911	0,005	

ials or semifinished components and is performed by the plant laboratory, using chemical analysis methods.

Structural inspection is used to check the structure and reveal external defects of materials, blanks, and parts and is performed with the aid of photographs of microsections.

X-ray inspection is used to examine the part or unit by X-ray to reveal foreign inclusions and other defects.

Magnetic inspection is used to disclose cracks in the part or unit and is performed by the aid of the magnaflux method.

Strength inspection is intended to disclose the mechanical properties of materials, and is performed on the Brinell hardness tester, the Shore sceleroscope, the Rockwell hardness tester, etc.

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In the first stage, the condition of the equipment is analyzed to establish its operating accuracy.

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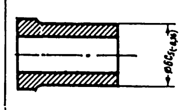
Table 32

Card of Measurements of Parts of a Test Lot

hop No.6	Section	No.4	Foreman	A.I.Fedorov	Sketch of Part
Type of Part	Machine	Single-Spindle Automatic Machine	Machine Setter	K.S.Sergeyev	
Bushing	Type Index	Inventory No. 426	Productivity per hour, in Pieces	120	
Part No.	N-6844	46	Type of Operation		

No. of Part in Group / Group No.	Dimensions of Parts in mm											Inspector's Remarks
	1	2	3	4	5	6	7	8	9	10	R. of Groups	
1	5,906	5,906	5,909	5,907	5,906	5,908	5,900	5,898	5,906	5,909	0,011	
2	913	913	903	909	903	906	900	901	915	913	0,015	
3	913	908	912	910	911	916	914	915	916	918	0,010	
4	916	916	919	917	917	917	915	917	916	917	0,004	
5	916	917	910	914	922	922	919	920	918	916	0,012	
6	915	914	916	917	921	920	918	917	919	918	0,007	
7	918	916	918	919	918	919	919	919	915	918	0,004	
8	917	918	916	918	917	918	918	920	916	918	0,004	
9	917	918	920	919	913	914	916	916	919	914	0,007	
10	918	922	917	916	918	916	918	916	916	912	0,010	
11	912	916	913	914	912	914	914	912	916	911	0,005	

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To perform statistical control, machine tools and tooling in good condition and already checked, must be selected. This is necessary to eliminate the influence, on the results of the statistical control, of factors due to the incomplete preparation of the work station for normal operating conditions. The accuracy of the machine is determined by its accuracy characteristic or operating accuracy.

To establish an accuracy characteristic of a machine, a sample lot of parts machined between two successive setups of the machine is taken. The size of the batch is usually 100 - 200 parts. At the time the parts are removed from the machine, or after the entire batch has been machined, each part is measured with respect to the necessary parameters, and the results of the measurements are entered on a special card.

Table 33

a)	b)	c)	a)	b)	c)	a)	b)	c)	a)	b)	c)
1	5,898	1	7	5,908	2	13	5,914	8	19	5,920	4
2	5,900	2	8	5,909	3	14	5,915	5	20	5,921	1
3	5,901	1	9	5,910	2	15	5,916	19	21	5,922	3
4	5,903	2	10	5,911	2	16	5,917	12			
5	5,906	5	11	5,912	5	17	5,918	17			
6	5,907	1	12	5,913	6	18	5,919	9			

a) Group No.; b) Dimensions of part, x_i; c) Number of parts of the same dimension (frequency) n_i

Table 32 gives a specimen of such a card. The results of 110 measurements of the outside diameter of a part "bushing" are entered.

The results of measurements are arranged in ascending order (Table 33).

According to the group attribute of identical dimensions x_i, the test lot is

divided into 21 groups. The number of parts with the same dimension in each group is called the absolute frequency, and is denoted by n_i.

An accuracy diagram (Fig.99) is drawn on the basis of these data.

From the accuracy diagram, one determines the center of distribution of the dimensions of the part, the range of variation of the test lot, the degree of variation of the dimensions, the coefficient of displacement of the setup, and the coefficient of quality of the process. These data, taken together, are what constitutes the accuracy characteristic of the equipment.

The center of scattering (or the center of grouping, as it is somestimes called) of the dimensions of the parts in the test lot, $\bar{x}$, is found from the formula for the arithmetic mean:

$$\bar{x}=\frac{n_1x_1+n_2x_2+\ .\ .\ .+n_cx_c}{n_1+n_2+\ .\ .\ .+n_c} \quad \text{or} \quad \bar{x}=\frac{\sum_{i=1}^{c} n_i x_i}{n},$$

where n is the number of parts in the test lot;

Σn_i is the sum of frequencies equal to the number of parts in the test lot;

c is the number of groups of parts in the test lot.

In our example, c = 21 and Σn_i = 110. Let us determine the center of scattering (grouping) of the dimensions of the parts of the test lot:

$$\bar{x}=\frac{1\times5,898+2\times5,900+1\times5,901+2\times5,903+5\times5,906+1\times5,907}{1+2+1+2+5+1}+$$
$$+\frac{2\times5,908+3\times5,909+2\times5,910+2\times5,911+5\times5,912+6\times5,913}{2+3+2+2+5+6}+$$
$$+\frac{8\times5,914+5\times5,915+19\times5,916+12\times5,917+17\times5,918}{8+5+19+12+17+9}+$$
$$+\frac{9\times5,919+4\times5,920+1\times5,921+3\times5,922}{4+1+3}=\frac{605,604}{110}=5,915.$$

The range of variation of the test lot R is determined by the formula:

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$$R=x_{max}-x_{min},$$

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where x_{max} is the maximum value of the part dimension in the test lot;

x_{min} is the minimum value of the part dimension in the test lot.

For our example, R = 5.922 - 5.898 = 0.024 mm.

The degree of scattering σ of the dimensions of the batch of parts about the center of scattering is found from the formula for the mean-square deviation:

$$\sigma = \sqrt{\frac{n_1(x_1-\bar{x})^2 + n_2(x_2-\bar{x})^2 + \ldots + n_c(x_c-\bar{x})^2}{n_1+n_2+\ldots+n_c}} = \sqrt{\frac{\sum_1^c n_i(x_i-\bar{x})^2}{n}}.$$

In our case, $\sigma = \sqrt{\frac{0.002704}{110}} = 0.0048$.

The smaller the value of σ, the more compactly will the individual values of x_i be distributed about the center of scattering $\bar{x}$, and the more closely will the curve connecting the individual values of x_i on the accuracy diagram approach the curve of normal distribution.

The curve of normal distribution (Fig.100) is symmetric with respect to the scattering center $\bar{x}$, i.e., the values of x_i which are equidistant from $\bar{x}$ on the side of increase or decrease, are of equal frequency. In this case, the range of variation is taken as equal to six times the mean-square deviation, i.e., R = $= x_{max} - x_{min} = 6\sigma$. Such a distribution expresses the law of normal distribution, according to which the area bounded by the curve of normal distribution and the abscissa includes 100% of all cases of the investigated dimensions of the lot of parts. The area from $-\sigma$ to $+\sigma$, called the two-sigma zone, covers 68.27% of all cases of measurement; the area from -2σ to $+2\sigma$ covers 95.45% of all cases, and the area from -3σ to $+3\sigma$ covers 99.73% of all cases of measurements and is called the six-sigma zone.

To obtain the accuracy characteristic of a given process, the first values determined are the ratio of the magnitude of the tolerance field δ to the investigated dimension of the part, the six-sigma zone 6σ (characterizing the scattering

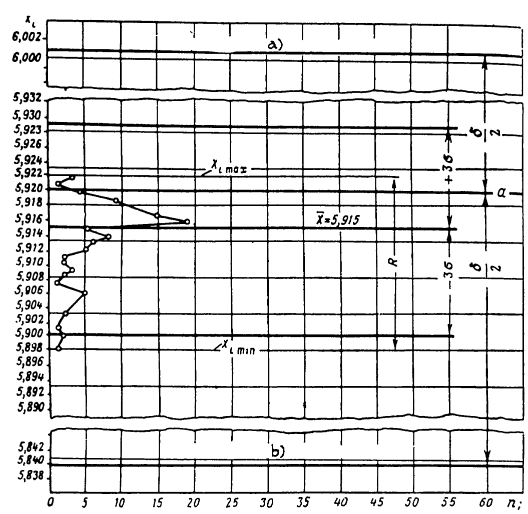

Fig.99 - Accuracy Diagram Prepared from the Data of Table 32

a) Upper limit of tolerance (VDP); b) Lower limit of tolerance (NDP)

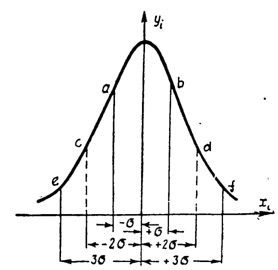

Fig.100 - Curve Expressing the Law of Normal Distribution of Numbers

of the dimensions of the parts under the law of normal distribution), and the range of variation R of the test lot. According to the relations between these three quantities, all processes may be divided into six groups:

1) $R>6\sigma>\delta$;	4) $6\sigma>\delta>R$;
2) $6\sigma>R>\delta$;	5) $\delta>R>6\sigma$;
3) $R>\delta>6\sigma$;	6) $\delta>6\sigma>R$.

The first three groups characterize the existence of defective parts, since $R>\delta$. In these cases, the processes should be carefully examined, and the causes for the violation of the tolerance limits determined and removed. The last three groups indicate the absence of spoilage. The least stable process is the fourth, which must be carefully observed. The fifth and sixth processes may be considered good, stable processes. In our example δ (equal to 0.16 mm) $> 6\sigma$ (equal to 0.0288 mm) $>$ R (equal to 0.024 mm), which indicates the stability of the process.

The coefficient of displacement l of the setup of the process characterizes the accuracy of the setup and is calculated according to the formula

$$l=\frac{\bar{x}-a}{\delta}\cdot 100,$$

where δ is the magnitude of the tolerance field;

a is the center of the tolerance field, and is equal to the half-sum of the upper and lower tolerance limits:

$$a=\frac{VDP\cdot NDP}{2}.$$

In our example,

$$a=\frac{6+5,84}{2}=5,920 \text{ mm}.$$

Thus l, in our example, will be

$$l=\frac{5,915-5,920}{0,16}\cdot 100=-3,1\%.$$

The setup of the machine is usually considered satisfactory if $l \leqslant 15\%$ of the distance from the center a of the tolerance field to the upper and lower limits.

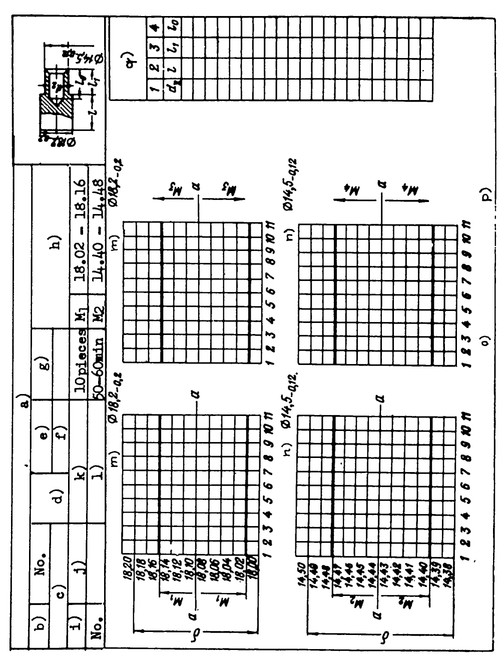

Fig.101 - Statistical Control Card

a) Statistical control card; b) Shop; c) Equipment; d) Part; e) Designation; f) Number; g) Endpiece; h) Position of control boundaries; i) Type; j) Automatic machine; k) Range of selection; l) Sampling period; m) Dimension controlled $\varnothing 18.2_{-0.2}$; n) Dimensions tested with gage; o) Date; p) Inspector; q) Dimension, verification, calibration

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The coefficient of process quality, without considering the machine setup, is defined by the ratio

$$K=\frac{\delta}{R}.$$

The coefficient of process quality without considering the machine setup K, must be more than 1.4 for stable processes. If $K < 1$, it means that the process is poor and will result in spoilage. If K is within the range from 1.0 to 1.4, then the process is unstable and needs constant watching; the process must be so refined that K becomes $\geqslant 1.4$.

In our example

$$K=\frac{0,16}{0,024}=6,66.$$

After establishing the accuracy characteristic of the equipment and after putting the equipment in good condition, the statistical control is started.

This stage begins by filling out the statistical control card (Fig.101). The card consists of the title requisite and the control diagrams. The number of control diagrams is determined by the number of parameters of the part that are to be examined by the method of statistical control.

On the diagram the following are entered: center of tolerance field a; upper and lower limits of tolerance δ of part shown in drawing; upper and lower control boundaries M, beyond which the arithmetic mean of the sample must not extend if the process is proceeding normally and there are no signs of disturbance. The control tolerance of the part is smaller than its technical tolerance.

The technical tolerance is taken from the drawing, while the control boundaries (limits) are unknown and must be calculated. Various methods may be used for this calculation. One of the simplest methods consists in determining the arithmetic mean of samples of a group of parts $\bar{\bar{x}}$ and the value of the mean range of variation of samples of the same group $\bar{R}$. It is sufficient to have 15 - 20 samples, each consisting of 20 parts, for the calculation.

The arithmetic mean of all samples is found from the formula

$$\bar{\bar{x}}=\frac{\bar{x}_1+\bar{x}_2+\ .\ .\ .\ +\bar{x}_m}{m}=\frac{1}{m}\sum_{i=1}^{m}\bar{x}_i,$$

where $\bar{\bar{x}}$ is the arithmetic mean of a group of samples;

$\bar{x}_i$ is the arithmetic mean of a sample;

m is the number of samples in the group.

The value of the mean variance of the group of samples is found from the formula

$$\bar{R}=\frac{R_1+R_2+\ .\ .\ .\ +R_m}{m}=\frac{1}{m}\sum_{i=1}^{m}R_i.$$

The boundaries of the control limits are defined by the formula

$$\bar{\bar{x}}\pm A\bar{R}_b,$$

where A is a coefficient depending on the size of the sample, i.e., on n.

The quantity equal to $\bar{\bar{x}} + A\bar{R}_b$ is to be considered the upper control limit, and the quantity equal to $\bar{\bar{x}} - A\bar{R}_b$ the lower control limit of the dimension of the part. The calculated limits (boundaries) are entered on the control diagram. The statistical control card so prepared is given to the inspector or is hung up on the machine; at this time the current statistical control of the parts machined on this machine begins. At definite time intervals, the inspector takes several parts, called a sample, from the entire lot of processed parts, and inspects them. If the machine turns out not more than 100 parts per hour, samples are taken at intervals of about an hour. At the beginning of the introduction of the process samples should be taken more often, and as the data accumulate, the time interval may be lengthened. It is recommended that samples are not taken at equal intervals, but first at 50-minute intervals, then at 55-minute intervals, then at 65-minute intervals, and so on.

After the cutting tool is changed, or the equipment reset, the inspector must check the dimensions of 20 parts. If the parts do not go beyond the boundaries of the field of tolerance, and $\bar{x}$ does not extend outside the control limits, then STAT

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process can be considered adjusted, and further observation on it is done by the usual sampling method. If individual points have fallen outside the limits of the field of tolerance, or if $\bar{x}$ has gone beyond the control limits, the equipment must be set up again.

The following sequence in the introduction of statistical methods of control is recommended: selection of production sections for introduction of statistical controls; selection of the method of statistical control and development of the technical documentation for the method selected; instruction of the operator or inspector in the method of statistical control; checking and adjustment of the manufacturing process at the production section selected; introduction of statistical control and systematic analysis of the data obtained; improvement of the manufacturing process on the basis of a work-up of the data of statistical control.

Section 4. Planning the Control Processes

The planning of the quality control processes is the duty of the technologist, and is conducted by him in the following sequence: selection of indices to be controlled, selection of the means of control, selection of the form and method of control, determination of the qualifications of the inspector. The indices to be controlled are established by the technologist on the basis of the drawing or of the specifications. The means of control are so selected by the technologist as to guarantee the necessary accuracy of testing, high wear resistance of the measuring instrument, and minimum expenditure of time in the inspection. Mechanization and automation of control is highly important. The main trend in the automation of control is the use of measuring instruments built into the control system of the equipment.

The technologist indicates the means and methods of control in the flow sheet, after listing the operations to be controlled. The flow sheet does not indicate the technique of performing the control operation. There are typical instructions and

control cards for this purpose. Typical control instructions are made up for mass operations: welding, soldering, riveting, testing of uniform mating surfaces (inner and outer screw thread, meshing gear teeth). Instructions are also made up for the acceptance of installation work on a major assembly line or on a final aircraft assembly line, for running various weight, vibration, and other tests of instruments, assemblies, or complete aircraft; and for determining the procedure for the delivery

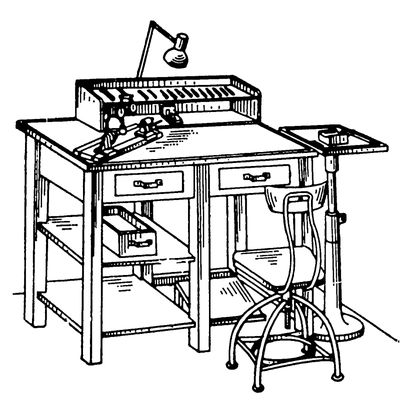

Fig.102 - Work Station of Inspector

and acceptance of an assembly or a complete aircraft. The control card indicates the means, the order, and the technique of the control.

Section 5. Organization of the Work and Work Station of the Inspector

The correct organization of the work and work station of an inspector saves working time and makes the inspection operation more accurate.

The organization of the work of inspectors consists in correctly locating them

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in the production area, in defining their rights and duties and in instructing them. The technical control workers are posted at departments and sections of the shop in accordance with the course of the manufacturing process in such a way as not to interfere with its pace, and they check objects and operations whose inspection is prescribed by the manufacturing process. The inspector has the duty, during the course of the shift, to carry out systematic observation of the quality of the product at each work station, to give timely warning to the operator and foreman as to appearance of spoiled work or signs of imminent appearance, and to observe strictly the established requirements in accepting the product. The inspector has the right to remove from the work station any part found defective and to stop the job, if violations of the prescribed manufacturing processes are being committed; he then must immediately notify the section forman in all such cases.

The inspector must be familiar with the drawings and with the manufacturing processes he is checking, as well as the quality attributes of the controlled product, the conditions under which the part (or unit) being inspected is to operate, its place in the structure, and the specifications it must meet, the forms and sources of spoilage in the operations inspected, the means of control and the technique of using them, the methods and procedure of performing the control operations, and his own rights and duties.

The work stations of the controllers must be provided with the necessary means of control and with the technical documentation, albums of drawings and process charts, specifications, and instructions for performing the inspection work. The equipment and layout of the work station (Fig.102) must be such that the inspector is able to do his work in a convenient position and in the shortest possible time.

The work stations of the inspectors are laid out according to the course of the manufacturing process, while the points of final acceptance of the product are organized as the final operation of a production line. From there the parts accepted and stamped by the inspector are delivered to the next section or to the finished-

product stockroom. For the conduct of inspecting operations demanding an isolated room, special chambers or cubicles are arranged and equipped with test instrumentation and stands. The room of an inspection station must be dry and have a constant temperature of 20°C, and be well lighted and properly equipped. Local illumination is used. Shades and lamps of adjustable height are provided.

Section 6. <u>Procedure for Acceptance and Formalization of Products by the Inspector</u>

The administration of a shop or stockroom is not authorized to deliver a product to the next stage of production unless it passes inspection.

<u>The Concept of Good Product and Rejects</u>. A product is called good if it corresponds to the drawing or specifications. Products not meeting the standard, drawing, or specification are called rejects. Rejects are divided into reworks and scrap. Reworks are products whose reclamation is possible and economically expedient and which can then be re-used for their primary purpose without adversely affecting the quality.

<u>Acceptance of a Product</u>. The products submitted for inspection must be cleaned of shavings and oil, and must be prepared for inspection. The formalized routing documentation is submitted to the inspector together with the products: the work order, the flow sheet, or the shift assignments. The inspector first checks the quantity of the products submitted for inspection. If the quantity of product does not agree with the quantity indicated in the routing documentation, the inspector enters the missing quantity of product in the document submitted. He then proceeds to check and evaluate the quality of the parts, guiding himself strictly by the instructions. After establishing conformity of the part with the drawing, the inspector stamps the part with his stamp. The stamp must be placed exactly at the place indicated by the instructions of the inspection department.

When possible reworks are found in a batch, the inspector returns the rejected parts to the operator or foreman, and after correction of the defects, he makes out

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the documentation for the entire batch. When he finds total spoilage, the inspector notes the number of accepted and rejected parts in the routing document, and at the same time indicates, by a code notation on the work order or notice of rejection, the causes of the spoilage and the person responsible, to whose account the spoilage is to be charged. The inspector makes a mark with red paint on the rejected part or unit, stamps it with the stamp "Brak" [reject] and affixes his number. He then removes the rejected product from the production area and turns it over for storage to the shop salvage crib, from which the rejected parts are delivered, under invoice, to the salvage crib of the plant. The inspector makes out a rejection notice for all spoilage found. The first copy of the notice is delivered with the work card to the shop accounting department, for it to withhold the value of the rejected parts from the wages of the guilty party; the second copy goes to the planning office, as document for the issue of material or blanks in place of the rejects; the third copy is kept in the shop inspection office. If the responsible worker refuses to sign the notice of rejection, it is signed by the inspector and foreman if the operator is at fault; by the inspector and shop superintendent, if a worker of the administrative-technical personnel is at fault; by the inspector of the consumer shop and the inspector of the supplier shop if the supplier shop is at fault (including cases where the shop that has fabricated the tooling is at fault). The inspector is obligated to suppress any attempt to attribute the spoilage to objective causes.

The inspector bears material and administrative responsibility for passing spoiled products in delivery of products from one operation to another, or from one shop to another.

The inspection staff of a shop is administratively subordinate to the chief inspector (of the plant), but is carried on the timekeeping records of the shop, and must observe the rules of internal organization of the shop. The shop administration does not have the right to interfere with the work of the inspection staff nor with

its evaluation of the product quality. The shop administration may indicate the sequence in which an inspector is to accept production, and the inspector must follow these instructions if they do not affect the quality of the acceptance work. In case of disagreement with the inspector's evaluation of product quality, the shop administration may appeal to the head of the shop inspection office, or to the chief inspector.

Section 7. <u>Classification, Record, and Analysis of Spoilage</u>

Spoilage is divided into outside and plant. Spoilage due to the supplier plant or the organization transporting freight is considered as outside rejects and is charged to their account.

Plant or in-house spoilage is classified by part-operations and by place of occurrence, shop, section, work station.

Spoilage is then classified according to cause and responsible party. A single system of coding spoilage is used for each enterprise. Table 34 shows one of such systems.

The procedure for recording spoilage is fixed by the "Typical Instructions on Recording Spoilage in Production at Enterprises of the Aviation Industry".

The record of spoilage permits judging the quality of the manufacturing process and of the implements of production, as well as the qualifications of the personnel, and permits the foci of work spoilage to be determined.

By studying the monthly spoilage reports, which directly disclose the foci of spoilage, the inspectors, on the basis of an analysis of these data, work out organizational-technical measures, in collaboration with the shop technologists and foremen, to improve production quality and eliminate the causes of spoilage.

Section 8. <u>Organization of Instrument Control System</u>

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A correct organization of the instrument control system ensures unity of meas-

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Table 34

Responsible for Spoilage	Code	Cause of Spoilage
Operators	1	Careless attitude toward their work
Shop administration	2	Incorrect instruction of operator
	3	Incorrect conduct of manufacturing process
	4	Equipment out of order
	5	Failure of material or workpiece to correspond to drawing
	6	Spoilage in setting up machine
	7	Organizational shortcomings of shop
	8	Spoilage in mastery of process or product
	9	Incorrectly designed working process
	10	Spoilage during testing
Suppliers	11	Concealed flaws of material or semifinished goods
Inspection department	12	Incorrect control of preceding operations
	13	Incorrect inspection of tools or attachments
Department of chief technologist	14	Incorrectly constructed directive technology
	15	Incorrect design or errors in tool drawings
Series designing department	16	Untimely alteration of designs or cancellation of drawings
	17	Errors in drawings or untimely alteration of drawings
Heat treatment shop	18	Concealed flaws in heat treatment
Casting shop	19	Concealed flaws in casting
Forging shop	20	Concealed flaws of rough forging

ure in all measurements made at the enterprise, by means of correct storage, utilization and restoration of the measuring instruments. At each enterprise, its central testing laboratory develops a verification system, indicating the set of reference standard measures of the enterprise, establishes a system of compulsory verification of the measuring instruments, and a procedure for the successive transfer of dimensions from the primary measures and instruments to the article. On the basis of this system, a calendar graph for verifying the means of measurement is set up. The basic set (assortment) of standard measures is kept at the central testing laboratory of the enterprise.

The measuring instruments delivered to the enterprise are verified in the central testing laboratory and are delivered to the reference standard group for recording and preparation of comparison certificates.

The measuring instruments delivered to an enterprise enter the central tool crib where, after acceptance, as to number, they undergo a qualitative verification at the inspection and verification point. From the central tool crib the measuring instruments issued to a shop are sent to the inspection and verification point at the tool distributing stockroom of the shop for verification and formalization of the identification sheets. A rating sheet, or identification sheet, is made out for all forms of measuring instruments except the simplest types.

Section 9. Features of Inspection in the Fabricating Shops

In the forging-stamping and fabricating-stamping shops the task of the inspection workers is to check correspondence of the brand of material with the drawing, to check the quality of the die and the setup of the press, and to verify the dimensions and qualities of the rough forgings.

The quality of the die is verified by comparing the dimensions of the rough-forging, obtained from the die, with the drawing.

The quality of the setup of the press is verified by the machine setter or the operator from the first parts stamped after setting up the press.

Each batch of rough-forgings is subjected to a final inspection. Rough-forgings made by cold-stamping are mainly checked by the methods of visual and geometric inspection. Rough-forgings, prepared by free-forging and hot-stamping, are checked by the methods of visual, geometric, and structural inspection and by the other methods indicated in the process sheets.

Casting Shop. The representatives of the inspection service at the casting shop check the equipment, materials, composition of the charges, conditions under which the heats are run, and quality of the castings.

A new set of patterns is checked with a test casting.

The molding sands are tested by the laboratory of the casting shop for moisture, gas-permeability, strength, grain-size, and clay content.

Cores are tested for composition, temperature conditions, drying time, strength, dimensions, and type.

Molds are checked for cleanliness, accuracy of assembly, and contact of the parting planes. A special instrument is used to check density of the tamping.

The accuracy of the instrument readings is also verified (thermocouples, pyrometers).

Correct storage of the materials by grades and brands is checked. The composition of the charge is tested by chemical analysis, and the results of the analysis are entered in the charge journal.

The metal being melted is inspected by chemical analysis of each heat, for which purpose a sample is taken or individual specimens are poured and sent by the inspector to the express laboratory.

The final inspection of a casting consists in external examination and verification of the dimensions of the casting, weighing it, X-ray examination, and mechanical testing if prescribed by the specifications. The location of rework defects in a casting is encircled by a colored pencil and the casting is sent for welding up,

and then for a second inspection.

Section 10. Features of Inspection in the Processing Shops

In the machine shops, the equipment is periodically checked by the shop machinist and the representative of the inspection group of the department of the chief machinist, while the attachments, dies and tools are checked by the inspector of the acceptance inspection station of the tool-distributing stockroom of the shop (after each return of a tool or an attachment by the operator to the stockroom). For checking the setup of the equipment, the machine setter or operator submits the first part processed to the inspector. After manufacture, the part is subjected to final inspection. Assembled units or major components are subjected to the tests prescribed by the process chart and by the inspection department instructions.

In the fitting-welding shop, the parts fitted and assembled into a unit are checked for accurate attachment, for compliance with the angles, radii, and mutual position of the parts in the attachment. After the operation of clamping, the unit is checked for absence of cracks, burn-throughs, melt-throughs, correct position of the clamps, and size and uniformity of the clearances. The units that have been welded are checked by external examination with a magnifying glass to detect visible cracks and to check the quality of the welded seam. The dimensions and angles of the unit are checked by means of templates and master jigs, and absence of concealed defects is verified by X-ray; the magnaflux method is used in checking for large cracks, while absence of small, hairline cracks and crazings is verified by means of fluorescent examination; metallographic examination is used to determine the structural state of the seam and detect the presence of slag inclusions in certain specimens; individual units are tested for density under pressure by the aid of special machines.

In the heat-treatment shop, the preparation of parts for heat treatment, the process conditions, and quality of the heat treatment of the parts are checked.

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The preparation of parts for heat treatment is checked by verifying the existence of the routing documentation and the stamps of the inspection department on the parts; and by determining the extent to which dirt and shavings, oil films, coatings, and paint have been cleaned off the parts.

The heat-treatment process conditions are checked by verifying the proper temperature conditions of heating, holding, and cooling of the part, and by verifying the condition of the instruments, thermocouples, pyrometers, and thermostats.

The external defects of heat-treated parts are detected by external inspection. The mechanical properties are checked by testing the parts on Brinell, Rockwell, Vickers, and other hardness testers.

Cracks are found by the methods of magnetic defectoscopy or by the method of fluorescent inspection. A lot of particularly critical parts is examined by X-rays and by metallographic testing of specimens.

In the galvanizing shop, the production quality control is carried out by inspecting the parts under the coating, by verifying the condition of the equipment and instruments, and by verifying the quality of the coating of parts or units.

An inspection of the parts before the coating is applied is made to disclose external defects of the parts, lugs, rust, or scale, and to check whether the parts have been well degreased and washed, and whether they have been correctly hung.

The quality of the coating of parts is tested by external inspection and by comparing the parts with a reference standard, by checking the adhesion of the coating to the metal base, and by checking the thickness of the coating, measured by an electromagnetic instrument or by the drop method.

In the varnish-paint shop, the inspectors check, by means of instruments, the humidity, temperature, and purity of the air in the room. The preparation of surfaces for painting is checked to find whether they have been scavenged with compressed air, degreased, and wiped dry.

The varnish and paint materials are analyzed at the laboratory before issue to

the work stations. The appearance of the painted articles and the film strength of the paint are verified. The thickness of the paint layer is checked by an indicator depth gage, after which the surface of the control point is recoated with paint.

Section 11. Features of the Organization of Inspection at the Assembly Shops

In the major assembly shops the assembly tooling, air pressure in the system, condition of the tools, and quality of the rivets are checked. The quality of the assembly and riveting of the units, sections and assemblies is checked, and the weight of the assemblies is periodically verified.

The quality of the rivets is checked by the inspectors: their diameter, length, coaxiality of head and shank, and conformity of the rivet material with the specifications.

In the assembly operations, the inspectors check the quality of the drilled and countersunk rivet holes, the rivet pitch, and the straightness of the rivet rows, as well as the quality of the riveting (absence of cracks and cuts around the rivet, absence of buckling of the material, quality of clenching the rivet shank). Besides checking the quality of the riveting work, the inspector also checks the connection and fastening of the units, laying and attachment of the cables, piping, and equipment for proper layout. The shop workers have no right to cover surfaces of an assembly whose quality has not been checked by the inspector. For instance, it is not permitted to set the jointing shear bolts before the quality of the reaming of the hole surface beneath the bolts has been inspected.

In order to increase the responsibility of the operators, crew bosses, and foremen for the quality of rigging of the assembly, a system of rating plates for each assembly and for the aircraft as a whole has been adopted in aircraft construction. The planning and dispatching office of the shop issues a rating plate to the foreman simultaneously with issuing the work order for rigging of the assembly. The assembly assignments are indicated in the rating plate in accordance with the

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process chart. On performance of the assembly assignment, the foreman enters the surnames of the workman performing the assignment and their crew boss on the rating plate. The crew boss, inspector, and foreman sign the rating plate. The assembled assembly, together with the rating plate, is submitted by the foreman for final inspection. The procedure for the acceptance of the assembly is prescribed by the rules of the inspection department. On examination of the assembly, the inspector fills out a schedule of defects in which he notes the defects found. The foreman is obligated to eliminate all the faults noted in the defect schedule, and must resubmit the assembly for acceptance to the supervising foreman. The accepted assembly is submitted by the shop inspection department to the purchaser's representative. After the purchaser's representative has accepted the assembly and has signed the rating plate, the component, together with the documentation, is delivered to the final aircraft assembly shop.

At the final aircraft assembly shop the preliminary, operational, and final inspections are made.

The preliminary inspection consists in having all assemblies, units, and finished articles entering the final assembly shop examined by an inspector to detect any external damage and the condition of lubrication, presence of the inspector stamps of the manufacturing shop and the accompanying documentation: rating plate, certificate, log, and test document.

The operational inspection consists in having the inspectors at each assembly stand check the quality of the installation and fitting performed.

The final inspection of the aircraft is made at the last stand of the assembly line, or at a special platform. The aircraft, prepared for delivery to the airfield shop, is submitted by the senior production foreman of the final installations and fittings for delivery to the senior supervising foreman of the shop. At the same time, all accompanying technical documentation is submitted. The senior supervising foreman, on examination of the aircraft, enters the defects found in a defect schedule. After the shop has eliminated the defects, the shop inspection office executes the acceptance of the aircraft and submits it to the purchaser. When the aircraft has been accepted by the purchaser, the necessary documents are executed, the aircraft is weighed, covered with canvas covers, and delivered to the airfield for flight tests.

Section 12. Features of the Organization of the Inspection at the Airfield Shops

The inspection at the airfield shop is handled by the workers of the flight-testing station (LIS).

The aircraft arriving from the final assembly shop is examined by the machinist of the airfield shop and by the supervising foreman of the flight-testing station to discover any external defects and to check the aircraft for completeness and for the presence of the canvas covers. The defects found are eliminated by the final assembly shops. All documentation for the aircraft are delivered with it: the logs of the engine and of the assemblies, together with the certificates of the instruments and the rating plates.

The airfield shop, in accordance with the process chart and the instructions, performs in sequence all the operations connected with ground and flight tests of the aircraft. As soon as the aircraft has passed the ground tests, the airfield shop begins to prepare it for flight. The supervising flight engineer of the flight-testing station makes a preflight inspection of the aircraft in the sequence prescribed in the instructions: checks the condition of the power-plant system, the quantity of fuel and oil carried, the tire pressure, the locking of the wheel attachments, and the extension of the landing gear shock strut. Any defects found are eliminated, and the aircraft is then released for the flight tests. The technician of the instrument laboratory of the flight-testing station installs the control instruments used for the flight tests. The assignment, in accordance with the type and program of the tests, is entered in the flight log for the test pilot, and the aircraft is then tested. The test pilot enters his remarks in the flight log. The supervising foreman and flight engineer make a postflight inspection of the aircraft. All defects found are entered in the defect schedule. An airfield shop crew eliminates all defects under the control of the supervising foreman. If no second flight is required, the aircraft is then submitted to the purchaser. The purchaser's representative inspects the aircraft, which is then subjected to retests, performed this time by the purchaser's pilots. If the aircraft is accepted by the purchaser and is delivered to him by air, the airfield shop prepares the aircract for flight. The aircraft crew receives the documentation for the aircraft. If the aircraft is shipped other than by air, it is delivered to the shipping department for disassembly and packing. These operations are also checked by inspectors.

Section 13. Organization of Interchangeability Control for Major Aircraft Assemblies at the Prime and Secondary Plants

To ensure identity, within the limits of the established tolerances, of the aircraft and assemblies manufactured by the prime and secondary plants, a unified system of master tooling is established at the prime plant, and all secondary plants are guided by it.

The list of the assemblies, units, and places of articulation in the article, with respect to which interplant interchangeability must be maintained, is prescribed by the prime plant.

The prime plant fabricates, and delivers to the secondary plants, the following forms of master tooling: templates of the basic sections, master-contour templates, mockups of the joints on the interchangeable assemblies, master plates at the mating joints of the assemblies, and molds of the mockup surfaces.

The secondary plants, on the basis of the master tooling received from the prime plant, fabricate all of their working sets, using their own personnel.

To fabricate the tooling not connected with guarantee of interplant interchangeability, and also for reference and current matching, the secondary plants

themselves prepare loftings from the theoretical drawings and the basic templates of the master plant.

To check maintenance of the interchangeability of the aircraft assemblies, a number of special measures are taken. The master tooling fabricated for the secondary plants is checked at least twice a year against the master tooling of the prime plant.

All assemblies, units, and hinge joints of the aircraft subject to interchangeability control are inspected at least twice a year at the prime and secondary plants by a special commission. Interchangeable assemblies and units are also dispatched by the prime plant to all secondary plants to verify their conformity with the assemblies and units produced by the secondary plants. On the other hand, each secondary plant sends one set of its assemblies to the prime plant, which verifies their interchangeability with its own assemblies. This work is done in the presence of representatives of the secondary plant and of the purchaser.

The purchaser, the prime and secondary plants all control the quality of interplant interchangeability directly on the aircraft produced. For this purpose, the accepted aircraft of the prime and secondary plants are delivered to the airfield of the prime plant. Here assemblies are removed from an aircraft of each plant and their interchangeability with the assemblies on other machines is verified.

The control of interplant interchangeability is performed on graphs prepared by the prime plant. For all forms of verification of interchangeability, the superior organizations are informed of the test results.

Section 14. Structure and Functions of the Chief Inspector's Office

Let us consider the functions of the most important units of the office of the inspection department.

The technical office of the inspection department develops and introdu STAT into production advanced methods of inspection, manages the inspection stamping system,

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records and analyzes the rejects, works out, together with the shop inspection office and the shop administration, measures for improving the quality of production, controls the execution of these measures, and prepares reports on production quality.

The central testing laboratory develops a testing system, tests and certifies all the subordinate sets of final measures and instruments, handles the adjustment, maintenance and certification of the optico-mechanical instruments, checks their condition, and consults with the shops on questions of measuring technique.

The office of acceptance of materials, semifinished goods and finished articles conducts the quality control for products delivered to the plant by suppliers, the sampling for the laboratories, draws formal claims, and participates in working out the specifications for the delivery of products to the plant.

The superintendent of the shop inspection office (BTsK) directs the work of the shop inspectors and is responsible for the quality and set-completeness of the shop production, for the timeliness and correctness of its acceptance, for the conditions of the inspection tools, and for the quality of the inspectors' work.

In the departments of the shop, the quality control work is directed by the senior supervising foreman and, in the production sections, by the supervising foreman who has under him the inspectors and the reject-men.

Under the existing system of inspection, the functions of verifying the quality of production at all stages of manufacture are performed primarily by special inspectors. This reduces the responsibility of the workers who directly manufacture the product: operator, foreman, and shop superintendent, and compels the enterprise to employ a large number of persons occupied only with inspection. In order to improve the quality of production and reduce the inspection staff, the list of operations inspected by workers of the shop inspection department should be reduced, the responsibility of the operators, foremen, and shop superintendents for the quality of the articles manufactured increased, and a system of material incentive for spoilage-free work and good production quality should be widely introduced.

PART FOUR

ORGANIZATION OF TECHNICAL SERVICING OF THE PRIMARY PRODUCTION AT AN AIRCRAFT CONSTRUCTION ENTERPRISE

Under the conditions of the rapid technical progress of socialist production and the use of an ever increasing amount of high-productivity equipment, the assurance of its uninterrupted utilization acquires primary economic importance. The 20th Congress of the Communist Party USSR has called attention of the Party and economic organizations to the importance of a more complete utilization of the existing equipment.

The continuity and profitable operation of the primary production depends largely on the level of organization of the auxiliary production and of the services to the primary producing shops. The more uninterruptedly the work stations are supplied during the course of the shift, the higher the rhythm of the work of the primary shops, the smaller will be the backlog of parts necessary to fulfill the production program. The lower the cost of the tooling and maintenance of equipment, the lower the prices for the services rendered by the auxiliary shops and services, the

Table 35

At End of Shift	In Preparatory (Night) Shift	Before Beginning of Shift	During Shift
1. Selecting and making out of the technical documentation for the next shift	1. Lubrication and maintenance of the machine	1. Delivery of materials, tools and attachments to the work station	1. Delivery of materials or work-pieces to the work station
2. Familiarization of the operator with the work in the forthcoming shift	2. Setup and re-setup of machine, if these operations are done by the machine setter	2. Re-setup and testing machine, submitting the first parts processed to the foreman or inspector	2. Changing tool and delivery of new tool

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At End of Shift	In Preparatory (Night) Shift	Before Beginning of Shift	During Shift
3. Putting machine in order and lubricating it and delivery of unused material to stockroom (by primary production operator)			3. Instruction of operator by foreman
4. Organized transfer of shifts by foreman			4. Checking and acceptance of finished product
			5. Re-setup of machine during breaks for meals and between shifts

the lower will be the plant and shop overhead per unit of finished product and the lower its shop and plant production cost.

The practice of work of advanced enterprises in various branches of machine building shows that wherever combined mechanization of labor at each work station has been realized and wherever the work station is prepared in advance and supplied with everything necessary for the forthcoming shift, high labor productivity is attained, idle time is reduced to zero, and the production sections operate rhythmically.

Under such a preventive system, the servicing of the work station takes approximately the form shown in Table 35.

The influence of the organized transfer of shifts by foremen on the improvement of the equipment utilization coefficients and on the growth of labor productivity may be seen from the example of the operation of the coating shop of a certain aircraft construction enterprise. In this shop, the organized transfer of shifts and the timely preparation of the work stations for work in the anodizing section yielded the following results:

Previous Organization of Work in Anodizing Section	New Organization of Work in Anodizing Section
In the operating shift, 1 - 1.5 hrs before the end of the working day, the preparation of parts for anodizing (rubbing and mounting) was discontinued. The parts were so charged into the anodizing baths that their removal from the baths would be completed before the beginning of the coming shift. When beginning the shift, at the start of work, the workman spent 1 - 1.5 hrs in preparing the parts for anodizing, which led to idle time of the baths. The idle time of the baths amounted to 12 - 20% of the total shift time.	The working shift turns over the charged anodizing bath and parts prepared for anodizing to the incoming shift. The new shift does not lose time at the beginning of the shift in preparing the parts for anodizing. This measure eliminates idle baths in each shift and increases the output of parts by 12 - 15%, increases labor productivity by 7 - 10%, and puts new output standards into effect.

It is essential to make every possible attempt to reduce the production cost of the auxiliary production and of the servicing work of the plantwide services, and systematically to raise the level of technology and organization of production in all auxiliary shops and services.

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CHAPTER XIII

ORGANIZATION OF THE TOOL ECONOMY

The primary task of the tool economy or system is the uninterrupted supply of the primary production shops with high-grade tools, their economical production, acquisition, storage, and repair.

The tool economy of an enterprise consists of:

1) The tool department, which directs the work of planning and organizing the tool economy;
2) The shops specialized in fabricating a definite kind of tools;
3) The central plant tool crib and the shop tool cribs, which handle the storage and recording of the tools and also supply tools to the shops and their work stations;
4) The tool grinding and tool rebuilding workshops.

The functions of the tool system include the classification, indexing, and plantwide or industrywide standardization and norming of tools; the establishment of progressive standards for their use; the planning and organization of the acquisition, fabrication storage, and issue of tools; the organization of their maintenance and rebuilding.

Section 1. Classification, Indexing, and Industrywide or Plantwide Standardization of Tools

The classification, indexing, and industrywide or plantwide standardization of tools is the foundation for the rational organization of the tool system.

The classification of tools allows their production record and issue to be conducted in an orderly manner. Under classification, all tools are subdivided according to the character of their use, into standardized and special; according to their

	a) Digital
Class- Cutting tool	11133 / 1-16×25
Subclass - Cutter	
Group - Turning	b) Literal
Subgroup - Undercutting	RRTPO / 1-16×25
Form-bent Left	
Material - RF-1	c) Mixed
Dimensions - 16 × 25	R1133 / 1-16×25

Fig.103 - Tool Indexing

purpose, into machining, assembly, measuring and auxiliary; according to their method of use, into hand and machine; according to periods of use, into tools of temporary and permanent use; and according to source of supply, into purchased and

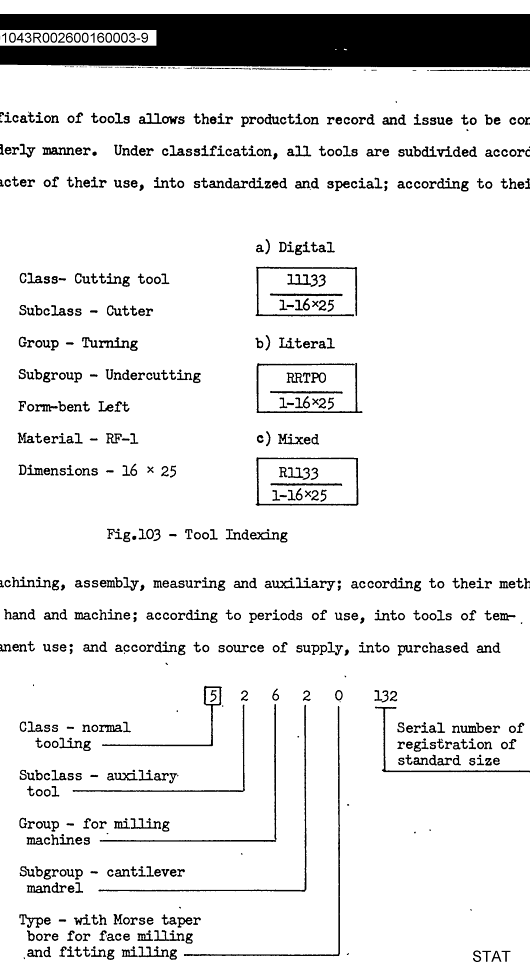

Fig.104 - Digital Coding of Standardized Tooling

fabricated at the plant.

Classification makes it possible to assign to each form of tool an index giving its exhaustive characterization.

There are three systems of indexing tools: by digits, by letters, and mixed (Fig.103).

According to the NIAT AN-886 classification, constructed on the basis of the decimal system, an industrywide or plantwide standardized technological tool is placed in class 5, and a special tool in class 6. Figure 104 gives an example of the digital coding of a standardized piece of tooling according to this classification. For special tooling, the class digit is changed from the digit 5 to the digit 6.

The normalization of tools allows a reduction in the variety of types and dimensions of tooling without affecting its quality, while reducing the expense of fabrication, increasing the coefficient of repeated utilization of the tooling, increasing the number of parts machined by a single standard size tool, and assigning the fabrication of the standardized tool to specialized tool plants.

A classifier-price list of tools is necessary for the organization of the tool system on the basis of independent unsubsidized operation, and is drawn up by the tooling department of the plant (INO) for the entire list of tooling.

Section 2. Standardization and Planning of the Tool Requirements of the Plant

To determine the plant's tool requirements, the necessary tool list must be determined, the standards of use must be established, and the annual consumption must be calculated.

The tool list is determined by various methods, depending on the type of production.

In piece and small-lot production, the tool list is established by a statistical method or on the basis of the typical tooling of work stations. At each work station (press, machine tool, welding machine, or bench), a chart is made up indicating the list of the typical tools in it.

We present an example of such a chart.

Chart of Typical Tooling for Horizontal Milling Machine

(Dimensions of Table up to 300 × 1200 mm)

Tool	Characteristics (by Dimensions in mm)	Percentage of Annual Fund of Machine Time of Machine Tool Spent in Working with the Tool in Question %
Cylindrical cutters	Ø 40 - 60	12.0
	Ø 60 - 100	10.0
	Ø100 - 130	8.0
Disk cutters	Ø 60 - 110	7.5
etc.	Ø110 - 150	7.0

In large-lot and mass production, the list of tools required is determined for each part. For this purpose, a tooling chart is prepared for each part, indicating what tool is necessary for fabricating the part.

The tool consumption standards are established for a standardized tool (pressure, cutting, abrasive, measuring, fitting-installing, and auxiliary) as well as for special tools used in large quantities. The tool consumption standards are established by three methods, statistical, relative use, and technical calculation for each part or unit.

The method of establishing standards on the basis of statistical data is approximate, since it is based on the production data of a past period. It can be used only as an exception, in piece and development production.

The tool consumption standards are established by the method of relative use in small-lot production. Under this method, all the equipment necessary to handle the

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output program is classified into uniform groups, and the annual or monthly fund of machine time of operation of the machine tool is determined for each group (Table 36).

Table 36

Equipment Group	Number of Hours per Program for Given Type of Equipment (Annual Fund)	Coefficient of Machine Time in Operation of Equipment	Number of Hours of Machine Operation	Form of Tool	Type of Tool	Mean Rated Dimensions of Tool	Coefficient of Participation of given Instrument in Machine Time of Machine Tool	Number of Hours of Operation of Tool	Life of Tool until Completely Worn , in Hours	Tool Consumption Standard, per Year, in Pieces
Large Lathes	100,000	0.6	60,000	Cutters	Grinding	20×20×100	0.2	12000	100	120

Table 36 gives a calculation of the annual tool consumption standard, based on the formula

$$N_{c.t} = \frac{F_m K}{t_{wear}}$$

where $N_{c.t}$ is the standard consumption of the given form of tool per year, in pieces;

F_m is the annual fund of machine time for the machine tools (in hours), on which the given type of tool is used;

K is the coefficient of participation of the given tool in the machine time of the machine tools;

t_{wear} is the time of operation of the tool until completely worn, in hours.

The standard consumption of a measuring tool is calculated either on the basis of its coefficient of relative use or by a consolidated calculation according to the

formula:

$$N'_{meas} = n \cdot A \cdot K,$$

where N'_{meas} is the mean annual standard consumption of the measuring tool of a given designation, in pieces;

n is the number of machines, on which a measuring tool of the given kind is used, that are necessary for the fulfillment of the program;

A is the annual consumption of measuring tools per machine tool (taken from Tables);

K is a coefficient allowing for accuracy class and type of production. The value of the coefficients is given in Table 37.

Table 37

Type of Production	Accuracy Class		
	II	III	IV
Small-lot	1.25	1	0.75
Large-lot	2.25	2	1.5

The method of calculating the tool consumption standard for each part is used in large-lot and mass production. The technical tool consumption standard is established for 100 and for 1000 machines, calculated for each part separately or for a group of similar parts, and is expressed in the "chart of calculation, per part, of the standard tool consumption" drawn up by the shop technologist.

In each chart, the machine time for machining 100 parts is calculated by the formula

$$t_{м} = 100 \frac{L}{s} i,$$

where L is the calculated length of machining in the direction of feed, in mm;

s is the length of feed, respectively, in mm;

i is the number of passes for removal of the machining allowance.

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The time of operation of a cutting tool until completely worn is calculated by

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the formula

$$t_{wear}=\left(\frac{q}{h}+1\right)t_{serv},$$

where q is the size of the working part of the tool that can be ground, in mm;

h is the size of the layer of metal removed during one regrinding, in mm;

t_{serv} is the service life of tool between regrindings, in hours.

The service life of the tool is established experimentally, taking account of the experience of skilled operators. The resultant data are entered in the Table of service of each kind of tool.

The technical standard consumption of a cutting tool per 100 parts is calculated by the formula

$$N'_{c.t.}=\frac{t_{M}}{t_{wear}}.$$

The technical standard consumption of a measuring tool is calculated by the formula

$$N_{meas.}=\frac{Q}{q},$$

where Q is the number of measurements necessary (taken from the process charts);

q is the number of allowable measurements up to complete depreciation of the measuring tool.

The tooling department makes up an applicability chart for each kind of tool in which all the parts machined by the given kind of tool are entered, together with the standard consumption of that tool on 100 or 1000 machine tools, at first for each shop separately, and then for the plant as a whole. The data from the applicability charts are transferred by the tool department to a tool record chart, which is opened for each standard size of tool (Table 38). The record cards are grouped into card files of normal and special tools and are broken down into groups and, within the groups, again by numbers (indices). On the basis of the account-card data, limits are placed on the tools consumed by the shops.

Calculation of annual tool consumption by the plant is conducted separately for each kind of tool, on the basis of the program and its standard consumption. The

calculation is made according to the formula

$$U_{ann.}=\frac{N_{ann}N'_{c.t.}}{100},$$

where U_{ann} is the annual plant requirements for the given type of tool;

N_{tool} is the annual program of output of article by the plant, taking account of the spare sets;

$N'_{c.t}$ is the standard consumption of a given tool per 100 articles.

Table 38

IRK of Shop No. ____	Tool Record Card	Operating Fund	
Rack No. ________	No. __________	Standard ______	Order Point ______
Compartment No. ____	Designation ____	Standard Consumption per Article__________	
	Dimensions ____		

Date	From Whom Received or to Whom Issued	Incoming	Consumed	Balance	Remarks

The special tooling - templates, molds, assembly, welding and machine-tool attachments - are not calculated by service hours but by their service lives and by the number of work stations at which they are simultaneously used. Thus the required number of assembly jigs N_{jig} is determined on the basis of the cycle of assembly of the major component in the jig C_{jig}; the number of major components produced daily N_a; the time of jig work F; and the coefficient of absence of the jig for planned maintenance K. For instance, at $C_{jig} = 48$, $N_a = 2$, $F = 16$, and $K = 0.04$, the number of jigs will be equal to

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$$N_{jig} = \frac{c_{jig} \cdot N_a \left(1+\frac{K}{100}\right)}{F} = \frac{48 \cdot 2\left(1+\frac{4}{100}\right)}{16} \cong 6 \text{ pieces.}$$

Section 3. Calculation and Standardization of Tool Stocks

To assure the uninterrupted supply of the work stations with tools, a certain stock of tools must be established. The size of the stock depends on the surface life of the tool and its wear during the course of the year. The first form includes tooling whose obsolescence is more rapid than its physical depreciation, i.e., its service life is longer than the period of production of the aircraft of the given modification. Such tooling includes assembly jigs, special attachments, dies, and chills. No stockpiling of such tools is done; instead, duplicates of particularly important or widely used items are produced.

The second type of tooling includes all standardized tools, as well as special tools frequently repeated and needed in large numbers. The reserve stock of this form of tools is made up of the operational, interim, and emergency stocks.

The operational inventory includes tools in the turnover of the shop and intended for guaranteeing uninterrupted supply of the work stations. The inventory includes tools at the work station, in the distributing tool crib of the shop, and in the tool-grinding workshop.

The operational inventory of cutting tools is calculated from the formula:

$$U_{c.o.} = U_m(K_1 + K_2) + O \cdot a \cdot K_{op},$$

where $U_{c.o}$ is the operational inventory of cutting tools of one standard size, in pieces;

U_m is the average monthly standard consumption of this tool;

K_1 is a coefficient of reserve inventory of the tool in the distributing tool crib, which is taken as 0.5 - 1;

K_2 is a coefficient of reserve supply of tool in the tool-grinding workshop,

taken as 0.5 - 2 (depending on the number of regrindings, the length of the cycle of regrinding, and the number of tools);

O is the number of operations in which the given tool is used (taken from the chart of applicability of this tool);

a is the number of tools of the given standard size at one work station (taken as equal to 2);

K_{op} is a coefficient taking account of the number of operations on which the given tool is used and the number of detail-operations per work station (taken from Table 39).

Table 39

Magnitude of Coefficient K_{op} for a Cutting Tool

Number of Part-Operations at Work Place	Number of Operations in which the Given Tool is used													
	3	4	5	6	7	8	9	10	12	15	20	30	40	50
30	0,7	0,5	0,5	0,33	0,3	0,25	0,22	0,2	0,18	0,16	0,14	0,12	0,11	0,1
20	0,72	0,6	0,55	0,5	0,45	0,4	0,33	0,3	0,27	0,24	0,21	0,19	0,17	0,15

The calculation of the operational inventory of a measuring, fitting-installation, or auxiliary tool is calculated by the formula

$$U_{c.o.} = U_m K_1 + \frac{p}{b} K_3,$$

where U_m is the average monthly tool consumption standard of one standard size, in pieces;

p is the number of work stations and inspection points at which the given tool is used;

b is the number of work stations served by one tool (taken from the applicability charts of the tool);

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K_3 is a coefficient taking account of the number of tools of a given standard

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size, simultaneously used at a work station (established from the process charts).

The interim (current) inventory of a tool is stored at the central tool crib and is intended for the uninterrupted supply of the shops with the tool during the time between the periodic deliveries of batches of this tool. The interim inventory is constantly changing (being consumed), so that two limits of the interim inventory are established for each kind of tool, the maximum, above which the inventory must not rise for economic reasons, and the minimum, equal to the emergency level, below

Fig.105 - Graph of Movement of Inventories of a Tool in the Tool Crib

Q_{max} is the maximum inventory; Q_{min} is the minimum inventory; $Q_{m.o}$ is the inventory at moment of order; T_i is the period of addition; T_m is the period from maximum inventory to moment of order; T_r is the entire period of consumption of batch of tool; T_p is the order period

a) Order point

which the inventory must not fall (Fig.105). A new batch of tools is ordered by the central tool crib when the inventory of the given tool at the crib reaches the level called the "order point". The "order point" is selected in accordance with the time

and interval of the delivery and the time of shipment, so that a lot ordered is delivered not later than the time when the inventory reaches its minimum.

The interim maximum inventory is calculated by the formula

$$U_p = U_m \cdot T_{del},$$

where U_p is the inventory in pieces, of the given kind or of the standard size tool;

U_m is the average monthly tool consumption standard, in pieces;

T_{del} is the interval between deliveries or cycle of fabrication of a new lot of tools (taken as unity, with a monthly delivery cycle).

The emergency stock is set up in the central tool crib and is intended to provide uninterrupted supply of the shops with the tool in case of unforeseen delay in the fabrication or arrival of the regular lots of the tool, or in the case of an unforeseen increase in its consumption.

Under normal conditions, the amount of the emergency stock remains constant and is calculated by the formula

$$U_{e.m.} = U_{a.d.} T'_p,$$

where $U_{a.d}$ is the average daily tool consumption standard;

T'_p is the period of restoration of the tool inventory, in days. This is equal to:

a) For tools received from outside the plant:

$$T'_p = t_1 + t_2 + t_3 \quad \text{(in days)},$$

where t_1 is the time of preparation and shipment of a tool lot;

t_2 is the time of transportation of a tool lot;

t_3 is the time of acceptance, processing and preparation of the tool at the central tool crib;

b) For tools fabricated at the plant, the cycle of fabrication of a minimum batch of these tools applies.

The total inventory of each standard size of a given tool at the plant STAT be

$$U_o = U_e + U_p + U_{em}.$$

Example. Required, to calculate the plant inventory of counterbores, 10 mm in diameter. To solve this problem, we take the applicability chart of the given counterbore (Table 40), which shows the part-operation and the shops at which these counterbores are used, and the average monthly consumption of these counterbores for each part-operation.

Table 40

a)					b)				
c)	d)	e)	f)	g)	c)	d)	e)	f)	g)
1	1	0550—4	1	2	6	10	0840—7	1	2
2	1	0555—3	1	2	7	10	0842—3	0,5	1
3	1	0650—5	2	4	8	10	0844—2	0,5	1
4	5	0975—2	0,5	1	9	10	0846—8	1	2
5	5	0976—3	0,5	1	10	10	0854—4	2	4

a) Code No.; b) Applicability card for counterbore 10 mm in diameter; c) No.; d) Shop; e) Part-operation No.; f) Standard consumption per 100 machines; g) Average monthly consumption

It will be seen from the card that the monthly consumption of counterbores, in shop No.1, is 8 pieces; in shop No.5, 2 pieces; and in shop No.10, 10 pieces; or 20 pieces in all. Let us calculate the operational inventory of the counterbores:

$$U_{c.o.} = U_m(K_1+K_2) + O\cdot a\cdot K_{op} = 20\,(0,5+1) + 10\cdot 2\cdot 0,3 = 30+6 = 36 \text{ pieces}$$

Let us further calculate the interim inventory of counterbores, with a cycle of a delivery of a lot of them once every two months:

$$U_p = U_m \cdot T_p = 20\cdot 2 = 40 \text{ pieces}$$

The emergency reserve of counterbores at T'_{ts} = 10 days, and 25 working days in a month, will be:

$$U_{em} = U_{a.d.}\, T'_p = \frac{20\cdot 10}{25} = 8 \text{ counterbores}$$

The total inventory of these counterbores at the plant will be

$$U_{tot} = U_{c.o.} + U_p + U_{em} = 36+40+8 = 84 \text{ pieces}$$

Section 4. Planning the Acquisition and Fabrication of Tools and Limiting Their Consumption

At the same time as the annual requirements of the enterprise for tools are being calculated, or after such calculations, the tools are divided into those fabricated by the enterprise and those purchased from outside. The prices for purchased tools are taken from the catalog-price list, and for the tools fabricated at the enterprise, from plant calculations.

It is the duty of the outside-order office of the tool department to plan the deliveries of tools from outside. At this office, the data on the consumption and turnover stocks of purchased tools are summarized in a general chart of tools by types, determining the total amount necessary for purchasing the tools, and a schedule of the standardized tools required by the plant is drawn up. This schedule-application also includes the special tools which the plant is not in a position to fabricate itself, as well as the forgings and other types of tool blanks, the standardized elements of assembly jigs, attachments, and other tooling which the tool department must acquire by deliveries from other plants or through the office of the Aviatekhmashsnab (Aviation Technology Machine Supply).

In accordance with the funds allotted for acquisition of tools, the outside-order office of the tooling department works to realize the plan, placing its orders by plants and supply bases, and making the corresponding contracts with them.

Planning Tool Fabrication. The planning group of the tool department, or the department of machine-assembly and welding work (depending on the structure of the

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plant), is charged with the preparation of the annual and quarterly plans for the production of tools to be fabricated by the tool shop. The plan for each group of tools adds up the total number of normal labor hours necessary for its fabrication, while the amount of money necessary for this purpose is established from the classification-price manual. The data so obtained are compared with the capacity of the tool shop and with the funds appropriated for the fabrication of tools. On the basis of the annual and quarterly plans, an estimate of the expenditures of the tool shop is drawn, together with the plan of the organizational and technical measures ensuring fulfillment of the program assigned to the shop.

Starting out from the quarterly plan and the backlog of current orders, a refined assignment for tool fabrication is issued for each month to the tool shop, indicating the standard size of the tools and the deadlines for their fabrication by ten-day periods. In turn, the production and dispatching office of the tool shop details the monthly assignment program by shop departments. In the program, a definite percentage of the productive capacity (not over 10%) is reserved to fill urgent orders for tools. The verified calculation of the throughput capacity of the departments allows a final correction of the products-list portion of the program.

Preparatory work is done for each order at the tool shop: The production and dispatching office provides the order for materials and blanks, the technologists prepare a flow sheet, and the designers design the second order tooling, i.e., the tools and attachments necessary to fabricate the tool orders. As soon as the material has been received and the second-order tooling has been fabricated or made up into sets, the production and dispatching office of the tool shop issues the order for the fabrication of tools to the foreman.

The fulfillment of the program by the tool shop is figured by two indices: by labor cost in normal labor hours and by product list, in number of orders filled. The basis for the examination of the work performed are the invoices on delivery of the tools to the primary producing shops.

<u>Limiting the Output of Tools</u>. The tooling shop, starting from the program and the tool consumption standards, establishes a limit for each shop and each tool item, for its consumption by value and by physical units; this encourages the observance of discipline and economy in tool consumption. The shop, in turn, sets up limits for its departments and workshops. The value of the limit is indicated in the tool record card and in the tool ration book.

Technical supervision over the operational use of tools is exercised by the inspectors of the tool department. Each inspector is assigned to definite shops, where he checks the worn tools before their delivery to the sorting base, and initials the tool write-off schedules. The duties of the inspector also include finding the causes of systematic breakage of tools or their excessive wear, and checking the observance of the rules for the issue, acceptance, operation and storage of tools.

Section 5. <u>Purpose and Organization of the Work of the Central Tool Crib</u>

The central tool crib is intended for storage of inventories of standardized tools and of such special tools whose stocks are stored by the above described "maximum-minimum" system. The other special tools are received by the distributing tool cribs of the primary producing shops directly from the tool shop, without passing through the central tool crib.

The central tool crib has several isolated departments, for testing abrasives, for storage of the master tools and cutting tools, and for sorting and accepting tools. The premises of the central tool crib are equipped with universal and specialized racks designed for tool storage (Fig.106).

<u>Acceptance of Tools</u>. Tools arrive at the central tool crib with an accompanying document, an invoice or routing sheet. A tool arriving at the central crib is unpacked and sent to the scrub room, after which it is checked quantitatively and qualitatively. Tools fabricated by the tool shop of the plant are not checked at

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the crib.

For the accepted quantity of suitable tools, the stockroom clerk and inspector of the inspection department sign an invoice, one copy of which is delivered to the tool department, a second to the material accounting office, while a third is issued to the shop that has delivered the tools.

<u>Storage of Tools</u>. The location of tools in the central tool crib is effected by

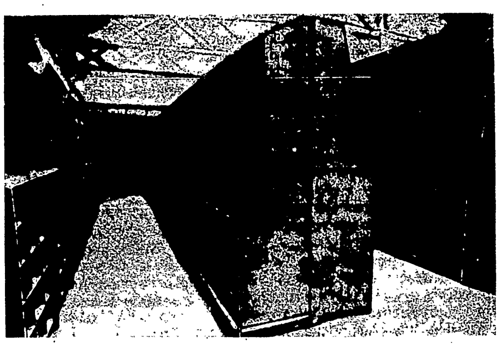

Fig.106 - General View of Central Tool Crib

a system convenient for acceptance and issue. The tools and attachments accepted are arranged in groups, and within the groups in the following sequence:

a) Standardized cutting tools are stored by brands of material and by list numbers in order of increasing dimensions;

b) Measuring tools (caliper gages and smooth gages) are stored by classes of accuracy and of fit, threaded gages by classes of accuracy, diameters, pitch, and type of thread;

c) Special tools are stored separately from normalized tools and are arranged

by designations and drawing numbers;

d) Abrasives are stored in a separate department, equipped with racks on which polishing wheels are arranged in the order of the listed sets;

e) Attachments are usually stored in a separate stockroom and are arranged by detail-operations.

In each compartment of a given rack, tools of the same standard size are stored. In this case the inventory corresponding to the "order point" is separated from the total quantity stored in the compartment; all the racks and compartments are numbered. This makes an exact determination of the place of storage of a tool possible.

Tools are stored in accordance with the instructions for the prolonged storage of materials, semifinished goods, and certain articles at plants. For correct storage of tools, the premises of the central tool crib must completely meet all the requirements stated in the instructions. Exemplary cleanliness must be maintained in the premises of the crib, and both temperature (20°C) and atmospheric humidity must be held constant. The storage of tools together with various chemicals (acids, alkalies) is forbidden. Tools damaged by corrosion must not be placed in storage.

After being placed in storage, tools are given anticorrosive treatment and preservation treatment, under the procedure and at the intervals prescribed by the instructions.

The tools in the central crib are recorded in a card file. A separate tool record card is kept for each standard size of tool. The record is kept by the method of the current balance, i.e., after each operation of acceptance or issue of a tool, the income, outgo, and balance are noted on the card. The stocks of tools at the central crib are periodically inventoried.

Tools are issued from the crib to the shop on account of a limit opened against shop requisition-invoices, or on limit cards, signed by the head of the tool crib of the shop or by the tool technician of the shop.

The regulation of tool inventories of the central tool crib is conducted on the

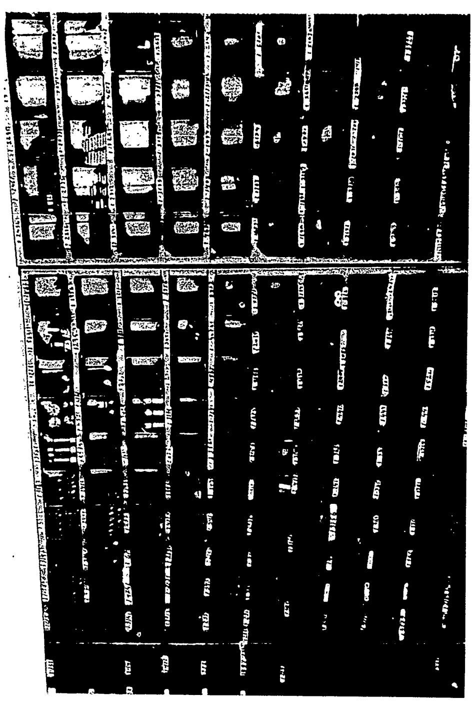

Fig.107 - Rack for Storage of Tools at a Distributing Tool Crib

basis of the data of the account cards and the information provided by the crib.

Section 6. Organization of the Tool System of the Shop

In the shop, the tool office or the tool technician handles the tool supply. The shop stockrooms for tools and attachments and the workshop for attachment maintenance are subordinate to them.

The distributing tool cribs provide an uninterrupted supply of the work stations with tools and attachments. The area of the crib is determined on the basis of 0.15 - 0.25 m^2 for each productive operator served by the given crib.

In the crib, each group of tools is located on a special rack in the same order as in the central tool crib. Each compartment of the rack is designated by the code number of the tools placed in it (Fig.107). During prolonged storage, cutting tools are periodically given anticorrosion treatment.

The record for tools and attachments at a tool distributing crib is kept by the card system. A record card is kept for each standard size of tool. The record cards of standardized tools are stored by types of tool, and those for special tools by the drawings of the parts.

Tools are issued from the stockroom to the operator for permanent or temporary use. Tools or attachments issued to an operator on the service note of the foreman for permanent use, are entered on the operator's personal card and in his tool book. The tool book is retained by the operator himself, while the personal card with his signature is kept at the distributing tool crib.

Tools are issued for temporary use under the double-check system. Under this system, there are two kinds of checks in circulation in the shop, checks with the payroll number of the workman and checks with the code number of the tool. The former are issued to the operator against signature on the personal card. The latter are kept in the rack compartments together with the tool. On receipt of a tool, the check with the payroll number of the operator is hung on a hook in the same com-

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partment of the rack from which the tool was taken, while the check with the code number of the tool received, taken from the compartment, is hung on the payroll number of the workman on a board set up in the tool crib. The payroll board of the tool-distributing crib will show what tools have been charged to each operator, and the payroll-number checks in the compartments of the rack will indicate what operators have the given tools in their possession.

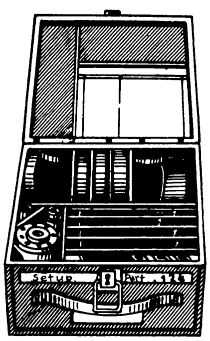

Fig.108 - Box with Set of Tools for Setting up a Machine Tool to Process a Definite Part

Some methods of issuing tools do not make the operator lose time in getting the tool from the tool crib, in person.

For example, on the basis of the shift-day assignment of the foreman, the distributing tool crib may make up sets of tools and deliver them directly to the work station. In exchange for the tools delivered, the messenger takes his tool checks from the operator. When the operator delivers the tools to the incoming shift, he receives the corresponding check from the man on that shift.

A set of tools may be issued by the tool crib to the machine setter. In this case, a complete set in a box (Fig.108) is kept in the compartment of the rack for frequently requested setups. This minimizes the time spent in selecting, issuing, and receiving the tools.

Inexpensive and frequently requested tools, such as drills in major assembly shops, are issued by the tool crib to the foreman, who himself issues the tools to the workman in exchange for worn or dulled tools.

Tools and attachments used only briefly are returned by the operators after

completion of the shift, or after the work has been done, to the distributing tool crib. The inspector of the distributing tool crib and the foreman of the section draw up a formal statement covering a worn or broken tool, indicating the causes of the breakage and the person responsible for it. In the assembly shops of aircraft construction enterprises, all tools are turned in daily by the operators and are stored in the personal tool box of the operator. When tools and attachments are

Fig.109 - Inspection of Tools Turned in by Operators to the Distributing Tool Crib

turned in to the crib, their condition is checked by an inspector who sorts them into good-order tools, into tools for repair at the shop itself (minor repairs), and into tools needing repair at the tool shop (major repair) (Fig.109).

On production lines and at work stations with a permanent list of operations, the system of compulsory replacement of tools is recommended. Under this system, the issuing clerk of the crib, according to a graph, visits the work station and, under an obligatory procedure, replaces the tools of the operators piece by STAT, regardless of whether they are completely or partly dulled. This is the most expedient form of tool utilization, since as much as 40% of the total number of breakage and cases of premature wear are due to work with dull tools.

The write-off and surrender of worn and broken tools are formalized by an official statement. The distributing tool crib delivers such tools to the sorting stockroom of the tool department: the suitable ones for rebuilding, according to number, and the junk as scrap, by weight.

Section 7. Organization of the Repair and Maintenance of Attachments, and the Rebuilding and Grinding of Tools

The current maintenance of all tooling and the major repair of simple attachments are handled by the tool maintenance workshops of the primary producing shops. The major overhaul and the periodic inspection of complex tooling (assembly jigs, bodies for dies) is performed by the corresponding shops of the chief technologist. For example, all assembly jigs in all assembly shops are systematically inspected by workers of the shop inspection office of the large-assembly tooling shop. The large-assembly tooling shop prepares a special graph for the timely conduct of current inspections and repairs of assembly jigs. The periods for conducting inspections and doing maintenance work on the tools are entered in the graph on the basis of the rating plates filled out for each assembly jig.

The shop inspection offices of the large-assembly tooling shop and of the primary producing shop, using the attachment, supervise the adherence to these periods. The actual dates of inspection and maintenance and their results are entered on the rating plates. An analogous control system is extended to all other machine and welding attachments. To shorten the period of tool maintenance, all necessary preparatory work is done before the beginning of the maintenance operation itself.

The rebuilding of tools allows their repeated use, which is of great economic importance (Fig.110). The standards for the delivery of tools by shops for rebuilding must be established at each plant. The following are the principal methods of rebuilding a tool: 1) transforming the worn tool into one of different size and

type by reforging, regrinding, or repolishing; 2) restoring the tool by recutting it (sawteeth); 3) restoring the tool by welding any holes or cracks, welding the rims and segments, deposition by special electrodes; 4) restoration of an abrasive tool by regrinding, pressing, cutting out; 5) restoring a tool by electrochemical methods, for instance, by chromium-plating.

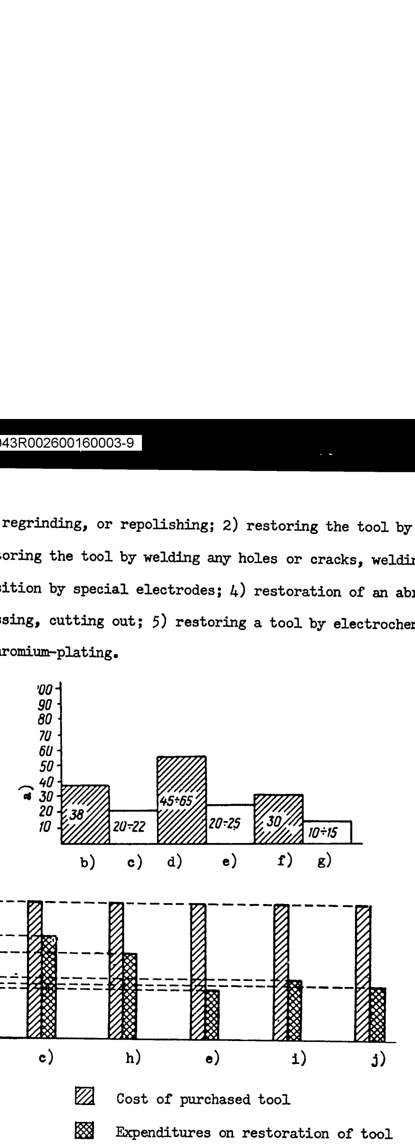

Fig.110 - Economics Effectiveness of Re-Use of Tools

a) Average % of restoration; b) Drills; c) Cutters; d) Centers; e) Milling cutters; f) Reamers; g) Broaches; h) Tools for processing holes; i) Threading tools; j) Other cutting tools

Under the system of centralized grinding of cutting tools, the grinding is done strictly according to the drawing and a process chart; machine finishing of a blade cutting tool is compulsory, and the grinding operators and inspectors are pro-

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vided with means of checking the tool geometry. All this ensures high grinding quality.

The forms of organization of the centralized tool grinding vary widely. At development plants, a tool grinding workshop is organized at the tool shop. At series aircraft plants, the system of group tool-grinding workshops is in wide use. This permits operative servicing of the primary producing shops and productive utilization of the grinding equipment. The tool-grinding workshop includes productive departments for regrinding the tools, a distributing station (exchange crib), and an inspection station for checking and accepting the reground tools.

The distributing tool crib of the primary producing shop delivers a lot of dulled tools to the exchange crib of the tool grinding workshop and receives in exchange the same lot of ground tools. For this purpose, an exchange stock of tools is kept at the crib.

Section 8. Advanced Experience of Automobile and Tractor Plants in the Organization of the Tool System

At automobile and tractor plants the tool system is centralized, and the tool department is charged with all responsibility for providing the shops with tools. The superintendent of the tool department directs the production of tools, their storage, restoration and regrinding. All the distributing tool crib and regrinding workshops of the shop are subordinate to the tool operation shop which is a part of the plant tool department.

For each shop, the plant tool department establishes and makes up sets for the permanent turnover stock of tools.

The interrelations between the central tool crib and the distributing tool cribs are simplified. The crib exchanges worn tools for the shop crib, piece by piece, without invoices, on presentation of a statement of complete depreciation. If a tool is lost or broken, the statement indicates the person responsible and the number of the defect notice. The central crib issues the shop crib a new tool in complete

correspondence with the schedule and the number of those delivered for scrap according to the written statement.

At the distributing tool cribs, worn, broken and lost tools are not written off, but no new ones are received in exchange, since this exchange is conducted piece for piece, and the number of tools established by the turnover stock remains unchanged.

Invoices are made out only when the operating turnover stock of tools in the stockrooms changes. All this simplifies the records and reports.

Table 41

Type of Shop	Name of Tools Fabricated by Shop
Lofting-template	Theoretical and design lofts, lofting templates, baskets or gage templates (three-dimensional templates)
Nonmetallic tooling	Mockups, plaster molds, form blocks, sand molds, wooden router templates and wooden dies
Tooling for cold and hot stamping and casting	Dies, compression molds, pressure chucks, rolls for rolling, mandrels, metal form blocks, forging dies, cutting coining, forging tools, chills, compression molds for casting
Tools	Cutting, forcing, threading, fitting-installation, riveting, edging and special tools; machine-tool attachments; welding attachments.
Large-assembly tooling	Assembly jigs, assembly and master attachments, master patterns, mockups
Mechanization facilities	Test stands, equipment for conveyor production lines, material-handling mechanisms, airfield equipment, dollies, straps

Tools for a machine tool are issued to an operator for permanent use by the tool distributing cribs on set cards. The operator exchanges dulled and worn tools at the crib for good-order tools, piece for piece, without any formality. T STAT -livery by an operator of a broken tool, or the loss of a tool, is formalized by a

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written statement.

Such a system of organization of the tool system results in a reduction of tool consumption and in uniform distribution of its reserves, and permits cutting the number of stockroom clerks and accountants employed.

Section 9. Productive Base for the Fabrication of Tooling

At an aircraft construction enterprise, various shops, specialized in the fabrication of definite forms of tooling, are organized for the fabrication of numerous and varied types of tools. The number of these shops and the amount of work done by them varies with the class of machine produced and the program of its production. Table 41 gives an approximate list of the shops under the jurisdiction of the chief technologist.

The advanced plants cut down the number of auxiliary shops by combining them. This considerably reduces the administrative expense.

At aircraft construction enterprises, in addition to the auxiliary shops, each primary producing shop or group of uniform shops has a workshop for fabricating and maintaining the tooling. The existence of such a workshop makes the work of the shop more operative and relieves the auxiliary shops from having to fabricate simple attachments.

Each tooling shop is an independent productive unit, which carries on its activity on an independent, unsubsidized basis.

The structure and composition of the tool shop depends on its scale. At small enterprises, the tool shop fabricates all forms of cutting tools, machine-tool and welding attachments. In such a shop, the producing departments are organized according to groups: machine-tool, gage, fitting-assembly, heat treatment, galvanizing, and welding. At the large plants, the producing departments of the tool shops are specialized to fabricate tools of uniform design (Fig.111).

The tool shops also include workshops - abrasive, tool grinding, tool repair,

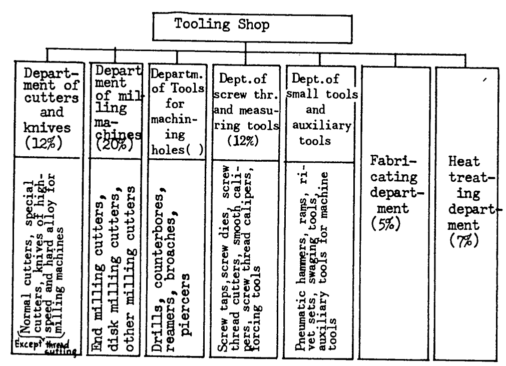

Fig.111 - Productive Structure of a Large Tool Shop (The Proportion of Work Done by the Given Department in the Total Labor Time of the Shop is Indicated in Parentheses)

Total Number of Pieces of Metal Working Equipment in the Plant	Equipment (in % of Total Metal Working Equipment of Plant) for the Shops	
	Tool Shop	Machine-Tool Attachment Shop
500—1000	13—14	14—15
1001—2000	12—13	12—13
2001—3000	11—12	10—11
over 3000	11	10

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and tool restoration.

The abrasive workshop does truing, balancing, and chemical treatment of abrasive wheels, sizing the holes, reworking the shapes and dimensions of the wheels, calking, and diamond burring. The purposes of the remaining workshops have already been discussed.

The relation given in the Table below should hold between the total amount of metal cutting equipment at a plant, the equipment of the tooling shop and that of the machine-tool attachment shop.

By major types of machine tools, the principal equipment of the tool shops is distributed as follows (in % of all metal-working equipment of the tool shops):

Turret Lathes	3
Lathes	28
Gear-cutting lathes	3
Precision jig boring	2
Milling	15
Shaving and slotting	6
Drilling	5
Grinding	15
Screw grinding	2
Tool grinding	15
Finishing	6
Total	100%

The auxiliary equipment, straightening, cutoff and other machines, comprise to 15 - 20% of the principal equipment.

Section 10. Plan of Organizational and Technical Measures and Principal Methods of Saving Tools

The expenses for the fabrication of tooling at aircraft construction plants

amount to over one ruble for each ruble of pay for the production workers. In order to reduce the expenditures on the fabrication of tooling, improve its quality and economically utilize the tooling in production, the tool department establishes and implements a plan of organizational-technical measures. This plan reflects the primary paths of tool economy and reduction of tool production cost find reflection.

Standardization and Typification of Tooling. The work on standardization and typification of tooling develops along three directions: 1) limiters of tooling are used, orienting the technologist and designer to the use of tooling that is economically effective for the given production; 2) use of completely standardized technological tooling, which does not change with the object of production, is expanded; 3) tooling is created in which the basic body elements are standardized and the replaceable elements, holding the part being processed and fixing its position, remain unstandardized.

Improving the Quality of the Tooling. For a cutting tool, this means improving the geometry and lengthening the service between regrindings; for attachments it means providing speed, accuracy, and rigid attachment of one or several parts.

The establishment at tool shops of departments specialized for mass and large-lot production of tools and attachments to supply a group of plants. This increases the load on the equipment, allows using the production line form of organization, and considerably reduces the expenditures of labor.

The mechanization and efficient organization of the labor of the workmen in the auxiliary shops ensures the growth of labor productivity of the auxiliary workmen and lowers the expenditures of labor for the fabrication of tooling.

The use of the experience of advanced workmen in saving tools in each productive operation is very important. The use of advanced economic standards (standard of service between grindings, standard of tool consumption, standard of tool restoration, technically justified standard times for all typical operations) plays an important role.

Section 11. Calculation of Expenditures for the Acquisition and Fabrication of Tools. Economic Indices of the Operation of the Tooling System

The tool department, or the department of machining, assembling, and welding work (according to the subordination of the shop which fabricates the tooling) is charged with the work of preparing the expenditure estimate. Table 42 shows, in a general form, such an estimate for a tool shop as a typical representative of this group of shops.

Table 42

Estimate of Expenditures of Tool Shop

Indices	Total	Including:		
		Special		Normalized Tools
		Tools	Attachments	
1. Output at planned-accounting prices (by price schedule) in thousand rubles	10,000	5000	3000	2000
2. Planned production cost of output in thousand rubles	9400	4750	2700	1950
This includes:				
a) Materials	1880	950	540	390
b) Wages of production workers	3760	1900	1080	780
c) Shop expense	3760	1900	1080	780
3. Production cost in percent of planned-settlement prices	94%	95%	90%	97.5%
4. Percent of reduction of production cost by comparison with planned-settlement prices	6%	5%	10%	2.5%

The estimate presented in Table 42 has been prepared in consolidated indices and reflects the volume of expenditures of the shop on the output planned for it. The calculations are made for each form of tooling separately and are then grouped

into expenditures for special and standardized tooling. From this estimate, the sum of the expenditures for special tooling is separated into a special estimate of expenditures, while the sum of the expenditures for the standardized tools is carried to the overhead expense of the shops consuming the standardized tools.

The planning of the production costs of the tool shop consists in establishing a definite relation between the course of the tooling and the course of its production according to planned-computation prices (rates). The difference between the cost of production according to the planned-computation prices and according to the plan production cost of the tools is the aggregate of the tool shop. The enterprise is obligated to effect a systematic reduction of the production costs of the auxiliary shops.

The output of finished products for a sum of 1000 rubles according to planned-computation prices is usually taken as the consolidated calculation unit.

The principal indices characterizing the quality of work of the tool system are as follows: fulfillment of the plan with respect to acquisition, fabrication, restoration, and consumption of tools; percent of losses of working time in the primary producing shops owing to lack of tools, and the sum of extra payments to workmen as a result of the low quality of tools; planned prices for tooling and production cost of its fabrication; amount of standardized tools in percent of the total amount; relative and absolute values of the expenditures on tooling per machine tool; amount of the turnover stock of tooling in rubles; percentage of technically justified standards employed in the tool shops.

The improvement in the economic indices of the work of the tool system is encouraged by its organization on the basis of independent unsubsidized operations.

The organization in the economic regions of specialized plants producing standardized tools and attachments will play an important role in the reduction of the expense of fabricating tools.

CHAPTER XIV

ORGANIZATION OF THE POWER AND MAINTENANCE SYSTEM

Organization of the Power System

The power system of a plant includes the electric and thermal power stations; the high-voltage substations feeding the plant with electric power from the regional State power station or system; the steam-power shop, generating steam and hot water for process and heating purposes; the gas-generating station, producing acetylene and other gases for process purposes, mainly, for welding; the oxygen station, producing oxygen for process purposes (welding, supply of installations); the compressor station, producing compressed air for scavenging, riveting, cleaning-finishing and other forms of work; the water pumping station, delivering water to the shops and services of the plant; the telephone exchange; the shop for repairing the electric equipment; and the storage facilities for fuel and electric materials.

The workers of the power system must provide for uninterrupted supply of the production line with electric power, steam, gas, compressed air, and water; heat industrial structures of the plant and the housing facilities; maintain the power equipment and communications in a condition of constant readiness for operation; improve the technique and organization of the power system; manage the power system, observing a regime of economy in the consumption of fuel and power of all forms; carefully prepare all power units for operation under autumn and winter conditions, when the load on the power equipment is particularly great.

Section 1. Standardization of the Production and Consumption of Power

The planned and economical management of the power system demands the establishment of progressive standards of production and consumption of all forms of power.

The department of the power superintendent works out standards for the consumption of electric power, fuel, steam, air, gas, water, and auxiliary materials per unit of product.

A technically justified standard is established on the assumptions that the equipment is in good operating condition, that repairs are made in a timely manner according to the aprroved graph, that the work is done by qualified workmen in accordance with the conditions prescribed by advanced technology and experience, that the yield of the equipment is the maximum for the given concrete conditions, that the quality of the fuel or other starting material meets the State standards and the approved specifications, and that the power losses in the shop and plantwide nets correspond to the approved standards.

Standards of power consumption are established for each shop and each service of the plant in the following units of measurement: electric power, in kilowatt hours (kw-hr); steam, in tons of regular steam (640 megacalories per ton); compressed air, in normal cubic meters (Nm^3); oxygen, fuel gases, and unheated water, in cubic meters (m^3); hot water, in megacalories (megcal).

Natural fuel is converted to conventional fuel by using the calorie equivalents approved by the Gosplan USSR. The heating value of a unit of conventional fuel is 7000 kcal.

The calorie equivalent is determined by dividing the heat value of one kilogram of natural fuel by the heating value of one kilogram of conventional fuel. For instance, one kilogram of coke yields 6510 kcal. Consequently, its calorie equivalent will be 6510 : 7000 = 0.93.

The units of production for which the standards of power consumption ar[redacted] tablished are as follows: ton of sound casting, forging or stamping, in casting

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and forging shops; ton of sound heat-treated product, in heat-treatment shops; machine-set of parts, in sheet-metal shaping, stamping, and machine shops; part or unit, in welding shops; square meter of area coated, in coating shops; unit, assembly, or aircraft, in major and final assembly shops.

In the shops for power generation, the following are the units of production on which the standard is based: 1000 kw-hr of power generated, for electric power stations; 1000 Nm^3 of compressed air produced, for compressor stations; 1 ton of normal steam or 1 mgcal of heat, for boiler stations; 1000 m^3 of water pumped, for pumping stations; 1 ton of standard carbide, for carbide stations; 1 m^3 of oxygen gas, for oxygen installations; 1000 Nm^3 of dry gas of standard heat value, for gas-generator installations.

The standards for the consumption of electric and thermal energy for the manufacture of each type of production can be calculated by two methods.

One of these methods is used in mass production and consists in establishing a standard of consumption for each form of energy per part, according to the types of processing: stamping, machining, welding.

The second method is used in multipart series production, and particularly in aircraft building, and consists in establishing the standard consumption for each form of energy per machine-set of parts of the article.

The technique of computing the standards of consumption of fuel, power, gas, and compressed air by these methods is discussed in detail in a publication: "Standardization and Economy of Power and Fuel at Enterprises of the Aircraft Industry" (Oborongiz, 1951).

The standards of power consumption should consistently decrease, in view of the use of new techniques, more complete utilization of existing techniques, and strict observance of a regime of economy in power consumption.

In establishing a standard consumption of fuel or power for a shop or service for the forthcoming month, a limit is at the same time fixed within the limits of

this standard. The limitation of fuel and power consumption is a necessary condition ensuring conformity with the established standards.

Section 2. Planning the Consumption and Production of Power

The consumption of power is separately planned for each form of power, and is directed toward a determination of the actual power requirements of the enterprise, toward observance of a regime of economy in power consumption, and toward reduction of its production cost.

The starting materials for planning the consumption of power are the standards of power consumption by forms of product, the production program for the planned period, and the trend of power demand during the course of the year.

The plan provides for the consumption of power for primary producing and auxiliary needs, and allows for the losses in the shop and plant mains.

The consumption of power for primary requirements, i.e., for operation of the equipment used in processing the primary article, is a variable quantity which depends on the assigned program and on the standards of power consumption. The consumption of power for primary requirements during the planned period may be calculated by two methods: approximate, by equipment operating time; and exact, by standards of power consumption per article produced.

The consumption of power for auxiliary requirements (operation of materials handling devices and equipment of the auxiliary workshops of the shops, as well as lighting and ventilation) is a quantity that is conventionally taken as constant and as not directly dependent on the shop program. The consumption of power for auxiliary purposes is calculated from the number of sources of constant power consumption, time of operation (utilization) of these sources during the planned period, and standards for power consumption per unit time. The conventionally constant power consumption also includes the power losses in the mains, which are calculated according to approved standards.

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In the consolidated calculation of the consumption of electric power for the primary requirements, the equipment is first classified by motor power and by operating time; then the amount of electric power required to fulfill the program is determined by the formula

$$A_{var} = \frac{N_{est} \cdot F_{act} \cdot K_1 \cdot K_2}{K_3 \cdot K_4},$$

where N_{est} is the established power of the primary equipment of the shop (the sum of the powers of the motors of the equipment), in kw;

F_{act} is the actual annual operating time of equipment, in hours;

K_1 is the coefficient of loading of the machine-tool equipment (0.8 - 0.96);

K_2 is the coefficient of simultaneity of operation of the equipment (0.6 - 0.7);

K_3 is a coefficient allowing for power losses in the mains (0.96);

K_4 is the efficiency of the motors (0.85 - 0.9).

In an exact calculation of the consumption of electric power for the primary requirements, the consumption of power per article and the program of production of articles during the planned period are taken as basis.

The consumption of electric power by a shop on the basis of its standard power consumption per article and the program of production of articles is calculated from the formula

$$A_{var} = A_a \cdot N,$$

where A_a is the total standard consumption of electric power for the shop per ton of sound castings, forgings, or for a machine-set of parts;

N is the program of the planned period, expressed in tons or in machine-sets of parts (allowing for the spare parts).

The total consumption of power for the shop and plan period is calculated from the formula

$$A_{shop} = A_{const} + A_{var}$$

where A_{const} is the standard consumption of power for the plan period based on the conventionally constant power consumption of the shop;

A_{var} is the consumption of power in the plan period depending on the quantity of product processed.

The calculation results are entered in a summary schedule of the electric power consumption for the shop. Table 43 is an example of such a schedule.

The computations by shops and services are verified and corrected by the power superintendent's department, and are summarized by it in the general plan of consumption of electric power for the plant.

A balance of electric power is necessary for the final verification of the input and consumption of electric power.

The summary balance is prepared by the department of the superintendent of power. The input part of the balance shows the sources from which electricity is received (the plant's own stations or receipt from the regional mains), while the consumption part of the balance shows the distribution of this electric power by consumers, i.e., by shops or services, during the plan period (year, quarter, or month) taking account of the power losses in the transmission lines and the distributing mains and the varying duration of daylight.

The balances of input and consumption of other forms of power are also drawn up separately for each form of power, i.e., for fuel, compressed air, and gas.

Section 3. Plan of Organizational-Technical Measures and Principal Ways of Saving Fuel and Power

The plan for organizational-technical measures must represent the measures scheduled for improving the profitability of the power system by combined mechanization of the work, by increase in the coefficient of utilization of the existing equipment, by extensive utilization of the experience of production innovators and of advanced enterprises, by better organization of production and labor, by observing a regime of economy in the consumption of fuel and power of all forms. The plan

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prescribes the principal ways of economizing fuel and power.

Table 43

Determination of Expenditure of Electric Power for Shop No. _____ for Year 195 ___

No.	Items of Power Consumption	Constant Component A_{const} in Thousand kw-hr	Variable Component A_a in kw-hr	Output of Product in Physical Units	Consumption of Electric Power on Variable Component A_aN in Thousand kw-hr	Total Consumption of Electric Power per Year A_{shop} in Thousand kw-hr
	I. Article A					
1	Machining	-	0.5	10,000	5	5
2	Heat treatment, etc	-	3.7	10,000	37	37
	Total for Article A	-	4.2	10,000	42	42
	II. Auxiliary Work for Shop					
1	Lighting	3	-	-	-	3
2	Ventilation	3	-	-	-	3
3	Materials handling	1	-	-	-	1
	Total for Auxiliary work	7	-	-	-	7
	III. Losses in shop nets					
1	Losses in nets	4	-	-	-	4
2	Transformer losses	3	-	-	-	3
	Total losses	7	-	-	-	7
	Total for shops	14	-	-	42	56

The reduction of electric power losses in the mains, in the lighting fixtures,

and in the use of the equipment is very important.

To avoid electric power losses in the mains, these must be systematically inspected and checked, no damaged insulation must be allowed, and the load must be uniformly distributed among the lines.

The correct choice of the type and wattage of the bulbs and voltage for lighting will prevent power losses in the lighting fixtures; lights must not be left on during nonworking time.

In the stamping, machine, and other shops, the following factors are of great importance for economy of electric power: coordination of the power of the electric motors and the power of the process and machines on which they are installed; avoidance of idling of the equipment; proper maintenance of the equipment (particularly timely lubrication, which reduces the power loss in overcoming friction); transition to high-speed methods of processing, and reduction of the contribution of auxiliary and service time to the standard time per piece; correct distribution of the parts for processing on the corresponding equipment.

For economy of fuel, important factors are: rational organization of the fuel dumps; control of the quality of each incoming lot of fuel; and verification of its conformity with the State standard. Proper trimming of the coal in the bunker, and storing by grades, will prevent the coal from weathering and spontaneous combustion. The establishment of standards and limits of fuel consumption encourages its economical use.

The change-over of boilers to mechanized stoking and the correct conduct of the process of burning the fuel are highly important. Boiler installations should be equipped with measuring devices to record the fuel consumption and the heat evolved. It is necessary to maintain the installations, the heat insulation, and the fittings of the thermal network in first-class condition, including regular removal of scale from the inside heating surfaces of the boilers and of soot and deposits fSTAThe boiler tubes. Use of water economizers in boiler installations, increased recycling

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of condensate to the boilers, and utilization of the heat of the flue gases and water for the needs of the plant, likewise help to economize fuel. To avoid excess consumption of fuel, the furnaces must not run idle; the parts must not become overheated; the molding sand, clay, and cores in casting shops must not be overdried; the bulk of the conveyors, baskets, and furnace soles in the heat-treatment shops must be reduced; injection burners and short-flame nozzles of the vortex low-pressure type must be used for burning gas; the oven charges must be increased and maximum utilization of their useful area must be achieved. These and many other measures will ensure a 35 - 40% economy of fuel oil and will increase the efficiency of ovens and furnaces.

Maintenance of the equipment, network, and hoses in first-class condition will allow a reduction in compressed-air losses in the compressors, in the compressed-air network, and in the pneumatic tools. A saving of compressed air is likewise accomplished by cutting down its use for scavenging parts, by replacing cylindrical tips with self-closing tips with conical nozzles; by using limiter disks on sandblasting machines and pebble mills; and by supplying pneumatic hammers, furnace tuyeres, and sandblasting machines with compressed air heated by the waste gas of the furnace itself.

To economize calcium carbide, acetylene, and oxygen in gas welding and metal cutting, the carbide should be protected from air, acetylene loss should be eliminated by maintaining the welding equipment in top-notch condition, making absolutely certain that the charging boxes are clean and dry, that the carbide is put into the boxes in strict accordance with the standard, that water is added at the proper time to fill the body of the gas-holder, and that the generator cocks are in good condition and well lubricated. The regenerated water drained from the generator into the sludge pits and remaining there not more than a day should be used for dissolving the acetylene. Carbide dust and fines should also be used by adding them (10 - 15%) to lump carbide for the preparation of acetylene (each kilogram of fines will yield

90 - 200 liters of acetylene). The use of economizers, which automatically shut off the supply of gas on completion of welding, will also have a certain favorable effect.

Section 4. Calculation of the Expenditures on the Power System, and the Principal Economic Indices of Its Operation

The departments of the chief machinist and of the power superintendent have the duty of preparing estimates of expenses and computation sheets for the shop production cost of electric power, steam, gas, and water.

Let us consider, as a typical example, the technique of planning the production cost of electric power.

At enterprises which have their own electric power station, the estimate of expense for the production of electric power includes all forms of expenditure for the maintenance of the station, i.e., the cost of fuel, materials, and lubricating oils; the deductions for depreciation; the base pay and additional wages for the workmen; the transport expense and the shop overhead.

At enterprises that receive electric power from the State regional stations, the plant production cost per kw-hr of power is computed by an estimate, in the form given in Table 44.

We obtain the production cost of one kilowatt-hour of electric power by dividing the total cost of production of electric power by the number of kilowatt-hours of electric power delivered to the consumers.

The cost estimate is drawn by the service under whose supervision the shop is. The cost per individual item of the estimate are calculated as follows:

The cost of electric power received from the city or regional GES (State electric system), is determined from the price for power at the enterprise feeders. The amount of power used during the plan period is taken from the balance of power consumption.

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The expenditure for oil, cleaning and other materials is determined from their

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Table 44

Estimate of Expenditure for Generation of Electric Power or for Payment for Power Received from the State Regional Electric Mains

Elements of Cost	Expenditures: Total for Quarter: Per kw-hr, in Rubles	Total for Quarter: For all el.power received, in 1000 rubels	(Month): Per kw-hr, in Rubles	(Month): For all el.power received, in 1000 rubels	(Month): Per kw-hr, in Rubles	(Month): For all el.power received, in 1000 rubels	(Month): Per kw-hr, in Rubles	(Month): For all el.power received, in 1000 rubels
Electric power from State Regional Mains								
Base pay to production workers								
Additional wages to workmen								
Wage supplements								
Materials								
Services to shops								
Overhead of shop								
Total expense								

	Total for Quarter	For ____ (Month)	For ____ (Month)	For ____ (Month)
Delivery of electric power to consumers (thousand kw-hr)				
Production cost of electric power per kw-hr				

consumption standards per unit of equipment, allowing for the number of shift operated.

The technique for calculating the wages and the shop overhead is analogous for all shops and is set forth in detail in our Chapter "Plan for Labor and Wages".

The principal economic indices of operation of the power system are the fulfillment of the plan for production of power of all forms; the production cost per unit of each form of energy; the value of $\cos\varphi$, indicating the portion of power which goes to perform useful work; the idle time of the equipment of the primary producing shops as a result of interruptions in the power supply; the coefficients of utilization of fuel and other raw materials for the generation of electric power, gas, and steam.

<u>Organization of the Repair and Maintenance System</u>

Soviet aircraft plants are equipped with first-class machines and machine tools, which constitute an important part of the fixed assets of the plant and represent the material basis for the growth of labor productivity. It is important that this modern equipment is maintained in good condition. This goal is served by the system of plant-preventive maintenance (PPR), which is the identical in form of organization of the maintenance system, for all aircraft construction enterprises.

The maintenance system of an enterprise includes the power-maintenance and machine-maintenance shops, the lubricant and emulsion system, the equipment stockrooms, and the spare parts.

At plants for which the post of power superintendent has been established, the maintenance of all electric equipment of the enterprise is handled by the power superintendent's department and by the power-maintenance shop, which is directly subordinate to the power superintendent. The maintenance of all other equipment is handled by the service of the chief machinist of the plant.

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The workers of the maintenance service have the duty of performing the following

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work: classification of equipment and preparation of the necessary rating plates; layout of the processes of maintenance operations and of requisite tooling; planning and conducting inter-maintenance servicing and repairs of the equipment; modernization of the equipment, organization, standardization, and payment of the maintenance workmen on the basis of independent, unsubsidized operation and advanced methods of labor; development and introduction of advanced economic standards in the maintenance system.

Section 5. Classification of Equipment and Provision of the Requisite Rating Plates

Organization of the maintenance system begins with classification of the equipment and provision of rating plates.

In classification of the equipment, a machine tool is assigned a definite index (code).

The code, or inventory number, of a machine tool consists of three parts: one, defining the type of equipment according to the classification of the Central Statistical Administration; another, defining the group of equipment according to the same classification system; a third, indicating the serial number of the equipment of each type.

According to types, the equipment is divided into nine groups: 1) metal-cutting, 2) forging-stamping; 3) woodworking; 4) power; 5) materials-handling; 6) pumping-compressor; 7) casting; 8) welding; 9) miscellaneous. Each type of equipment is composed of groups; for instance, metal-cutting equipment includes such groups as: 01, lathes; 02, turret lathes, etc. To designate the serial number of the equipment, three or four of the last digits are given in the code. For instance, a lathe with the serial No.999 will have the code 1.01.999.

The system of rating plates or sheets covers all equipment of the plant. A rating plate is prepared in the department of the chief machinist for each unit of the equipment, describing the kinematics of the equipment, its operating conditions,

and the allowable loads. Such a rating plate for the equipment is necessary for the machinist in placing the machine tool in a definite group of complexity of maintenance, in establishing the rules of caring for the equipment, and for its maintenance; for the technologist in selecting equipment and defining the planned conditions of processing; for the time-study man in calculating the standard times for operations; for the electrician in selecting or replacing an electric motor and in repairing the other electric parts of the machine tool. Any change in the kinematics or other characteristics of a machine tool must be reflected in its rating plate.

Section 6. System of Planned-Preventive Maintenance

System of planned-preventive maintenance (PPR) is the name given to the aggregate of preventive technical and organizational measures pertaining to the care and supervision of equipment, and to its servicing and maintenance, performed by a plan drawn up in advance, having the purpose of ensuring uninterrupted operation of this equipment.

The system of planned preventive maintenance makes the shop superintendent responsible for the operation and condition of the shop equipment, the foreman for the equipment of the department, the operator for the machine tool entrusted to him, the shop machinist for the quality of maintenance of the equipment, and for the timely and complete performance of all measures prescribed by the system of planned-preventive maintenance.

The system of planned-preventive maintenance of technological equipment is composed of inter-maintenance servicing and periodic maintenance operations.

Inter-maintenance preventive servicing includes checking the equipment, condition, obeying of rules for operating the equipment, timely adjustment of the mechanisms, and elimination of minor irregularities.

The operator of a machine tool participates in the inter-maintenance servicing; he inspects and checks the equipment before beginning his work, observes the operating conditions of the equipment as prescribed by the process chart and obeys the rules for handling the machine tool, checks the normal condition of the equipment, especially the control mechanisms, the guards and the lubricating mechanism, eliminates minor irregularities found, and, at the end of each shift, puts in order, cleans, and lubricates the working surfaces of the equipment, and keeps the work station in a clean and orderly condition. The condition of the equipment, the length of the period of inter-maintenance work and the amount of repairs, all depend on the quality of the care given by the operator to the equipment.

The attendant workers assigned by the repair service check the operator as to adherence to the rules for operating the equipment. They adjust the equipment and, on instruction by the production foreman, eliminate irregularities. The inter-maintenance servicing is performed at the production section of the shop by an attendant mechanic, oiler, saddler, and electrician. As a rule, operation of the equipment is not interrupted for this purpose; lunch breaks, re-setups of the equipment, etc., are utilized.

The periodic maintenance operations include flushing of the equipment, change of oil in the crankcase systems, checking the equipment for accuracy, inspection of the equipment, and, finally, routine overhaul (minor, intermediate, and major).

The periodic maintenance operations are performed by the maintenance mechanics according to a graph of the planned-preventive maintenance.

The system of planned-preventive maintenance does not provide for out-of-plan repairs, due to accident or unsatisfactory operation of the equipment, nor does it include the major overhaul for modernization and reconstruction of equipment, which are handled under special assignments.

Units operating under conditions conducive to accumulation of dirt, are flushed; for instance, a machine tool processing cast iron or abrasives, and casting equipment. Such flushing is done in non-working time, and removal of the equipment from service for this purpose is not allowed.

The oil is changed according to a special graph covering all equipment with centralized and crankcase lubrication systems. This graph is coordinated with the annual plan of equipment maintenance, so that the inspection and planned repairs can be performed at the same time as the change of oil.

The accuracy of precision machine tools and equipment and their conformity with the State standards and the specifications is checked by an inspector of the inspection department, with the assistance of a maintenance mechanic during the time of maintenance, and between the planned maintenance operations, mainly in nonworking time.

Equipment is inspected between routine maintenance, according to a graph, by the attendant mechanics. During an inspection, worn parts are replaced and minor repairs are performed if the equipment cannot be operated without them, until the next scheduled maintenance date. An inspection is made, as a rule, in nonworking time.

The flushing or scavenging of equipment and the verification of accuracy may be performed as independent maintenance operations, or may be included in the regular periodic maintenance.

Minor overhaul is a form of planned maintenance of minimum extent in which, by replacement or restoration of a small number of worn parts (whose service life is not longer than the period between repairs) and by regulation of the mechanisms, normal operation of the unit until the next regular planned maintenance is secured. Minor maintenance operations, for the most part, do not involve idle time for the equipment.

Intermediate overhaul is that form of planned maintenance in which, by replacement and restoration of worn parts and correction of the coordinates, the unit is restored to the accuracy, power, and productivity prescribed by the State standards or by the specifications (for special and specialized equipment), for the period until the next regular scheduled intermediate or major overhaul.

Major overhaul is a form of planned maintenance of maximum extent, which has the purpose of restoring the unit to its original condition. It includes complete disassembly, flushing, and reassembly of a unit, repair and replacement of parts whose service life equals a complete maintenance cycle, scraping of the guides, regulation and testing of the unit for accuracy, etc. Major overhaul is performed, if possible, without removing the machine from its foundation.

Table 45

No.	Maintenance Operations	Fitting Work	Machine Work	Other Work	Total
		in Hrs			
1	Flushing, performed as a separate operation	0.75	-	-	0.75
2	Checking for accuracy, performed as a separate operation	0.4	-	-	0.4
3	Inspection before major overhaul	2	0.5	-	2.5
4	Inspection	1	0.5	-	1.5
5	Periodic minor overhaul, including accuracy checks	5	4	1	10
6	Periodic intermediate overhaul	18	10	2	30
7	Periodic major overhaul	30	20	4	54

It is more economic for a plant to perform the scheduled major overhaul of the equipment in conjunction with its modernization or modification.

Repairs done outside of the plan, due to failure of the equipment, are included in emergency repairs. The expenditures for this type of repair are a loss to the plant and are collected from the responsible party.

Metal-cutting machine tools are modernized to give them new characteristics, for instance to increase the speed or power, to replace the hand control by automatic control, or to increase the resistance to wear of the working surfaces of the

machine.

Section 7. Basic Standards for Planning the Maintenance of Metal-Working Equipment

The labor cost of maintenance operation depends on the form of maintenance and the complexity of the maintenance of the unit, which is determined by its design, technological features, and dimensions.

The labor cost of maintenance work, the standards of consumption of the main lubricating and abrasive materials, and the standard time required for maintenance operations, are established per maintenance unit, denoted by r. Table 45 gives the standard times for one maintenance unit.

The degree of complexity of the maintenance of a unit, depending on its design and maintenance features, and denoted by R, is evaluated by category of complexity of maintenance.

The category of complexity of maintenance indicates the expected number of nominal units of maintenance work required for the maintenance of the given machine tool.

To evaluate the maintenance features of a given piece of equipment, the reference unit is the screw-cutting lathe ID62 with center height of 200 mm and center distance of 1000 mm. Class 10 maintenance complexity has been assigned to this standard reference unit of equipment - 10 R.

The labor cost of the major overhaul of a unit of class 1 of maintenance complexity (1R) equals one maintenance unit r.

For scheduling the dates of performing maintenance work, standard Tables have been established for the duration of the inter-inspection and inter-maintenance periods, and of the maintenance cycle (Table 46).

The inter-inspection period t_0 is the period of operation of the equipment between two regular periodic inspections, or between a regular planned maintenance and an inspection. The duration of the period between inspections is established in

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hours the equipment has operated and is calculated by the formula

$$t_o = \frac{T}{x_p + y_p + z_p + 1},$$

where T is the duration of maintenance cycle, in machine hours operated;

x_p is the number of intermediate maintenances in the cycle;

y_p is the number of minor maintenances in the cycle;

Z_p is the number of inspections in the cycle.

Table 46 (Bibl.27)

Features of Machines	Coefficients Taking Account of				Duration of: Cycle T		Period between Maintenances, t		Period between Inspections, t_o	
	Character of Production β_n	Material Processed β_M	Dust and Gas in Shop β_y	Peculiarities of Operation of Heavy Machine Tools β_T	In Hours Operated	In Years	In Hours Operated	In Months	In Hours Operated	In Months
A. For Single-Shift Operation										
Normal	1.0	1.0	1.0	1.0	26,000	11.5	2900	15.5	1450	7.5
Precision	1.0	0.8	0.8	1.0	16,700	7.5	1850	9.5	900	4.5

The inter-maintenance period t is the period of operation of the equipment between two regular planned maintenances. The duration of the inter-maintenance period is established in hours operated by the equipment and is calculated by the formula

$$t = \frac{T}{x_p + y_p + 1}.$$

The maintenance cycle of equipment is the period between two major overhauls of that equipment. The maintenance cycle is measured in machine-hours operated, and

Table 47

Structure of Maintenance Cycles for Process Equipment

Designation of Equipment	Maintenance Operations in a Cycle: Sequence of Maintenance Operations	Number of Maintenance Operations in Cycle: Intermediate x_p	Minor y_p	Inspections z_p
Metal-cutting machine tools weighing up to 10 tons	$K-O-M_1-O-M_2-O-C_1-O-M_3-O-M_4-O-C_2-O-M_5-O-M_6-O-K$	2	6	9
Woodworking machine tools	$K-O-O-M_1-O-O-M_2-O-O-C_1-O-O-M_3-O-O-M_4-O-O-C_2-O-O-M_5-O-O-M_6-O-O-K$	2	6	18
Forging machines, forging and stamping automatics, hammers, friction presses	$K-O\ O-M_1-O-O-C_1-O-O-M_2-O-O-C_2-O-O-M_3-O-O-K$	2	3	12
Mechanical presses, swaging presses, shears and hydraulic presses	$K-O-O-O-M_1-O-O-O-M_2-O-O-O-C_1-O-O-O-M_3-C-O-C-M_4-O-O-O-C_2-O-O-O-M_5-O-O-O-M_6-O-O-O-K$	2	6	27
Molding-sand preparing and cleaning equipment, knockout screens, molding and core machines	$K-O-O-M_1-O-O-C_1-O-O-M_2-O-O-C_2-O-O-M_3-O-O-K$	2	3	12
Casting molding conveyors, machines for pressure-casting, centrifugal casting machines and belt conveyors	$K-O-O-O-M_1-O-O-O-M_2-O-O-O-C_1-O-O-O-M_3-O-O-O-M_4-O-O-O-C_2-O-O-O-M_5-O-O-O-M_6-O-O-O-K$	2	6	27

Designation of Equipment	Maintenance Operations in a Cycle			
	Sequence of Maintenance Operations	Number of Maintenance Operations in a Cycle		
		Intermediate x_p	Minor y_p	Inspections z_p
Materials-handling equipment (cranes, monorail dollies, and electric hoists)	$K-O-O-O-O-M_1-O-O-O-O-M_2-O-O-O-O-C_1-O-O-O$ $O-M_3-O-O-O-O-M_4-O-O-O-O-C_2-O-O-O-O-M_5-O-O-O$ $O-M_6-O-O-O-O-K$	2	6	36
All forms of equipment of first, second, and third complexity class of maintenance	$C-O-O-M_1-O-O-M_2-O-O-M_3-O-O-M_4-O-O-M_5-O$ $O-M_6-O-O-M_7-O-O-M_8-O-O-C$	1	8	18

Symbols used

K = Capital repair;
C = Intermediate maintenance;
M = Minor maintenance;
O = Inspection

Table 48*

Standards of Inter-Maintenance Servicing of Equipment per Operator per Shift

Designation of Equipment	Standards in Maintenance Units for the Following Categories of Workmen			
	Machinists	Filters on Equipment Servicing Duty	Oilers	Saddlers
Metal-cutting machine tools	1500	500	1000	200
Automatic and semi-automatic machine tools	1500	400	800	200
Casting	700	150	500	150
Forging	800	200	500	150
Pressing	1200	300	600	200
Woodworking	1200	300	900	150
Materials handling	300	200	—	—

* In line production and mass production, the standards of daily servicing may be reduced by 15%.

depends on the type of equipment. All equipment is divided into eight groups. For each group of equipment its own maintenance cycle is established (Table 47).

The standards of daily servicing of equipment in maintenance units per operator per shift are necessary for calculating the numbers of machinists, mechanics, oilers, and saddlers performing the inter-maintenance servicing (Table 48).

The standard dead times of equipment for planned maintenance are calculated per nominal maintenance unit, and depend on the complexity class of maintenance of the equipment. The standards (in working days) for planned dead time of equipment for each unit of maintenance complexity, when the maintenance crew works in a single shift, are given in Table 49.

On the basis of these standards, the volume of maintenance work and the required number of maintenance workmen are determined, and the annual plan of equipment maintenance is prepared.

Table 49

Duration of Idle Time of Equipment during Maintenance

Forms of Inspection and Maintenance	Standard Idle Time Per Maintenance Unit, in Working Days
Minor overhaul	0.25
Intermediate overhaul	0.6
Major overhaul	1.0
Major overhaul of equipment in complexity class below 5	1.25
Total	1.85 - 2.10

The procedure for reinbursement of the cost for current maintenance differs from that for major overhauls. The cost of current maintenance is written off in the same year in which it was incurred, being charged to overhead which is included as STAT element of production cost of the current year, while the cost for major overhauls is charged to the account of depreciation.

Section 8. Features of the System of Planned Preventive Maintenance of the Electric Part of the Equipment

No idle time of the equipment for minor and intermediate overhaul of the electric part is planned, since this maintenance is done on the rest days and during intershift breaks.

Table 50

Designation of Equipment and Operating Conditions	Maintenance Period in Months		
	Minor Overhaul	Intermediate Overhaul	Major Overhaul
AC and DC electric motors operating in clean and dry premises	6	12	120
AC and DC electric motors operating in metal-cold-working shops			
Open and protected operation	4	8	120
Closed operation	6	12	120
AC and DC electric motors operating on machine tools processing cast iron and on polishing machines			
Open and protected operation		4	120
Closed operation	2	6	96
Electromagnetic plates	1.5	-	144
Electric part of cranes and hoists in machine shops	3	8	60
Electric welding equipment for arc welding	-	6	24
Electric panel boxes, switchboards and control boards	2	8	120
Lighting fixtures	6	12	-

The major overhaul cycle of the electric part of the equipment, as a rule, is shorter than that of the mechanical part. The maintenance of the electric part of

the equipment is performed at the same time as that of the mechanical part. For this reason, dead machine time for major overhaul of the electric equipment is likewise not planned. However, restoration of the electric circuits after major overhaul as well as testing the circuits for proper operation delays the release of the equipment from major overhaul. For this reason, additional dead time of the equipment for reconditioning of its electric part is allowed to the extent of 50% of the standard time for intermediate overhaul of the electric part of the equipment.

The periods of maintenance of the electric equipment are established for each form of maintenance, based on the ability of the equipment to operate normally during the period between repairs.

The maintenance periods recommended below are calculated for two-shift operation of the equipment.

If the number of shifts is different, these periods are determined by multiplying the periods shown in Table 50 by the corresponding factor, 0.6 for three shifts, or 1.4 for one shift.

The duration of the inter-maintenance periods for three-shift and single-shift operation, so calculated, should be rounded out to 0.5 month, and the duration of the cycles to 0.5 year.

The extent of major overhaul of the electric part of a unit of maintenance complexity class 1 is established per maintenance unit, rj.

The following are the standard times, in hours, for one maintenance unit, by forms of maintenance and types of work:

Form of Maintenance	Electric-Fitting Work	Machine Tool Work	Other Work	Total
Minor	1	0.2	-	1.2
Intermediate	5	1	1	7
Major	12	2	2	16

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Section 9. Organization of the Lubricating System

The service life of equipment and the quality of its operation depend largely on the quality and period of lubrication.

A correct organization of the lubricating system necessitates a rational selection of the lubricants, establishment of the standard consumption for each model of equipment (preparation of lubrication charts), correct storage and laboratory quality control of the newly received lubricants, utilization of drained oil, and other measures. The lubricating system is organized in accordance with the make-up of the plant equipment and the conditions of its use.

To establish the assortment and consumption standards for the lubricants, as well as to calculate the annual requirements of the enterprise for such materials, the equipment is classified by forms and types demanding lubrication of one and the same composition.

The selection of lubricant materials for each type of equipment is accomplished by the methods of the power and thermal tests of lubricants, and by the method of calculation.

The method of power tests of lubricants consists in the determination of the minimum consumption of motive power for the starting moment and inertia starting of a machine when different oils are used under the same operating conditions. The better the lubricant, the less will be the consumption of power for starting.

The method of thermal tests is based on measuring the operating temperature on a test surface of a mechanism lubricated with various lubricants; the best lubricant results in the lowest temperature.

The computation method reduces to a determination of the viscosity of the oil and its oxidation resistance. As a rule, lubricant materials are selected on the basis of All-Union State standards.

To improve the properties of lubricant materials, various additives are used.

The following methods are used in lubricating pieces of equipment: manual lubrication (for open and non-vital parts); drip and wick oilers, feeding oil automatically to the wearing surfaces; lubrication by grease guns, pressure-feeding the lubricant; lubrication by spraying the working parts of the machine tool. The most economical method is the circulating lubrication system in which the oil is fed by a pump through oil lines to the points of friction, then passes through a filter and cooler, and is recycled to the oil tank.

The points and conditions of lubrication of a mechanism are determined from a lubrication chart prepared for each model of equipment of a given type.

The lubrication chart contains a list of lubricants, the methods and conditions of lubrication, and the standard consumption of lubricants adopted for the given model of equipment.

The lubricant consumption in the operation and maintenance of equipment comprises the consumption for lubricating the mechanisms and units of the machine tool, the consumption for filling the container systems, and the consumption for covering the mechanisms and lubricating the equipment delivered for maintenance.

The standard consumption of oil corresponds to the minimum quantity of oil consumed, at which minimum power consumption and lowest operating temperature of the wearing surfaces of the mechanism are obtained.

Section 10. Planning, Dispatching, and Recording of Maintenance Work

Calculating the Labor Cost of Maintenance Work. To determine the amount of maintenance work, the chief machinist's department prepares a summary schedule of the plant equipment, showing all equipment by type, groups of maintenance complexity, and number of shifts operated (used for two or three shifts). On multiplying the total number of units of maintenance complexity of all equipment by the standard time in hours of one unit of complexity, we obtain the total labor cost of the maintenance work and the labor cost of each form of inter-maintenance servicing, flushing, accuracy check, inspection, and maintenance.

These original data allow the department of the chief machinist to prepare an annual plan of maintenance work and to calculate the amount of equipment and number of maintenance workmen that are necessary to fulfill it.

The amount of equipment necessary to equip the maintenance bases of the plant is calculated by dividing the labor cost of the maintenance work by the annual available working time per unit of equipment. For each group of equipment required, this can be calculated from the formula

$$N_c = \frac{T_p}{S \cdot F_{m.t.}},$$

where N_c is the number of machine tools;

T_p is the annual labor cost of repair work in hours;

S is the number of shifts the equipment is operated;

$F_{m.t}$ is the annual operating time of machine tool per shift, which is equal to

$$[(365-52-6) \cdot 8] \times \left(1 + \frac{K_1 - K_2}{100}\right);$$

K_1 is the plant coefficient of labor productivity increase of the machinist-maintenance men;

K_2 is the coefficient of idle time of equipment in connection with planned maintenance.

The complement of attendant personnel including mechanics, oilers, and saddlers, needed for inter-maintenance servicing, is calculated by the time standard given in Table 48.

The number of servicemen necessary to perform the maintenance operations is calculated on the basis of the total labor cost of the maintenance work and of the planned working time of a single workman (Table 51).

In calculating the proposed number of attendant and maintenance personnel, account must be taken of the average coefficient of actual overfulfillment of the standards by this personnel and the planned coefficient of growth of labor productivity.

The complement of other maintenance workers including welders, painters, pipe-

fitters, riggers, furnace setters, is kept at a number not exceeding the total number of maintenance fitters and machinists necessary for maintenance operations of all forms.

Table 51

Forms of Maintenance and Maintenance Operations	Fitting Work		Machining Work		Total	
	Number of Man-Hours, According to Plan	Number of Fitters	Number of Man-Hours, According to Plan	Number of Machinists	Number of Man-Hours, According to Plan	Number of Workmen
Minor and intermediate maintenance, inspections, flushing and checking	109,523	38	20,514	7	130,037	45
Major overhaul	28,800	10	16,200	6	45,000	16
Fitting work not provided in the plan (10-15% of all forms of planned maintenance)	13,832	5	-	-	13,832	5
Machining work on spare parts (40-60% of time for machining work on all forms of maintenance)	-	-	18,350	6	18,350	6
Total	152,155	53	55,064	19	207,219	72

The operative planning of maintenance work consists in preparing the annual and monthly plans of maintenance of equipment for each shop and service. The duration of inter-maintenance periods and cycles is established from the number of machine-hours actually operated by each unit of equipment.

The annual operative-calendar graph of performance of the maintenance operations (the form of this graph is shown in Table 52) is made up by the department of the chief machinist for each shop separately. This graph takes account of the date of last maintenance of the equipment and, for newly installed equipment, STAT date

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Table 52

Annual Operative-Calendar Graph of Equipment Maintenance

No.	Designation of Equipment	Type (Model)	Group of Complexity of Maintenance	Category of Equipment	Inter-Maintenance Period, in hrs	Shift Factor	Last Maintenance Operation		Kinds of Maintenance Operations, Labor Cost and Idle Time, in Planned Standards												Total for Year		
							Kind	Date	January	February	March	April	May	June	July	August	September	October	November	December	Fitting Work in Man-Hours	Machine Work, in hrs	Idle Time, in Days

Table 53

Plant No. ____
Department of Chief Machinist

Monthly Plan of Periodic Maintenance, Inspections, Accuarcy Checks and Flushings of Equipment For ____ 195_

Shop No. ____

No.	Type of Unit	Manufacturer Plant or Company	Model (Type)	Inventory No.	Complexity Class of Maintenance	Kind of Maintenance Operation	Labor Cost				Idle Time, in Days		Actual Dates		Nos. of Delivery Statements
							Fitting Work in Man-Hours		Machine Work in Hours						
							Planned	Actual	Planned	Actual	Planned	Actual	Maintenance Operation	Completion of Maintenance Operation	

of initial operation. In the graph, the dates for the maintenance operations are corrected to bring about their regular distribution over the months of the year.

The monthly plan of equipment maintenance (Table 53) is prepared by the office of planned-preventive maintenance of the department of the chief machinist, with the participation of the shop machinist. The monthly plan includes: work required by the annual graph, in the given month; work carried forward from the preceding month; work on the socialist obligations of the workman; and extracurricular work to an extent of 10 - 15% of the monthly plan. The monthly plan is agreed on with the shop superintendent. In accordance with the monthly plan, the shop machinist issues the monthly assignments to the maintenance crews, taking account of the socialist obligations of the crew and the productivity of the labor of its members.

The dispatching of maintenance work consists in accomplishing a control, according to the monthly plan, of the timeliness of the performance of the designing, engineering and material preparation for forthcoming maintenance, for timely transfer of the machine tool to maintenance, and for performance of maintenance according to plan.

The basis for noting the performance of maintenance in the plan is the statement of acceptance of a machine tool from maintenance.

Section 11. Organization of the Labor of Maintenance Workmen

At aircraft plants, the assigned attendants who handle the inter-maintenance servicing of equipment belong to a maintenance crew. The equipment of one or several departments of a shop is assigned to each crew. A definite number of machines is assigned to each workman of a crew for responsible observation and daily lubrication. During the current inter-maintenance servicing, the crew assigns mechanics for attendant duty from among its members. The assigned mechanic, during the time not needed for performance of the duties of his assignment, performs maintenance work on assignment by the crew boss. The crew does all kinds of maintenance, and is respon-

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sible for the condition of the equipment. The off-day and the mealtime breaks of the crew are staggered from the off-day and mealtime breaks of the shop, making it possible to use these periods for maintenance work.

The work on cleaning, flushing, lubricating, stitching, and replacing of belts, and on checking the equipment, is specified by the technical orders. The performance of this work in time is governed by graphs, indicating the days on which the preventive maintenance and repair of the machine tool is to be done. This allows the shop machinist, the foreman, and the production workmen to determine what work must be done on the equipment during the shift by the assigned maintenance workers. Maintenance is conducted in parallel-sequence by the individual units of the machine tools.

The unit and assemblies that are to be repaired are, as far as possible, replaced by spares. The crew operates on abroad front. Each workman of the crew performs maintenance of a definite unit of the machine and is responsible for the quality of its maintenance.

Maintenance is begun only when the crew is completely prepared.

After testing, the crew boss delivers the repaired equipment to the inspector or controller of the chief machinist's department, who in turn delivers it to the senior foreman of the shop, on a written statement.

Section 12. Maintenance Base of the Enterprise

To handle the maintenance of the factory buildings and structures, a maintenance-construction shop is organized at the enterprise under the administration of major construction; for maintenance of the power equipment at the enterprise an electric maintenance shop is organized; for maintenance of all other equipment, a maintenance machine shop, under the chief machinist is established, in the shops, machine maintenance workshops under the shop machinists are organized.

The functions of the maintenance machine shop include modernization, major

overhaul, and installation of equipment according to the plan of the chief machinist's department; fabrication of nonstandard equipment, replacement and spare parts;

Table 54

Character of Production	Complexity Class of Maintenance of Plant Equipment (Average)	Number of Physical Units of Equipment at Plant								
		200	400	600	800	1000	1500	2000	2500	3000
		Metal-Cutting Equipment of Maintenance Machine Shop and Maintenance Machine Bases, in % of Number of Pieces of Equipment Installed at the Plant								
Assembly-line	5 - 7	-	6.4	5.9	5.5	5.0	4.4	3.8	3.3	3.0
	8 - 10	-	7.9	7.2	6.7	6.2	5.3	4.7	4.2	3.9
Series	5 - 7	6.0	5.3	4.9	4.5	4.1	3.6	3.2	2.7	-
	8 - 10	7.5	6.7	6.1	5.6	5.1	4.4	4.0	3.6	-

Table 55

Type of Machine	In % of Total Equipment of Shop	Type of Machine	In % of Total Equipment of Shop
Lathe and turret lathes	50 - 40	Milling	7 - 9
Vertical end boring and turning mills	2 - 3	Shaving	7 - 8
Boring	3 - 4	Grooving	2 - 3
Vertical Drilling	7 - 8	Grinding	10 - 12
Radial Drilling	2 - 3	Threading	6 - 7
		Other (Special)	4 - 3

repairing parts or units of equipment that cannot be repaired by the workshop of the shop machinist. The precision work, for instance, of fabricating end supports and mandrels for profile grinding is done for the maintenance machine shop by the tool shop.

The quantity of equipment of the maintenance machine shop depends STAT number of pieces of equipment in the plant. The ratio of the equipment of the maintenance

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machine shop to the entire equipment of the plant, as adopted at aircraft construction enterprises is shown in Table 54.

Table 55 gives the average percentage of the various types of machine-tool equipment in the maintenance machine shops of aircraft construction plants.

In addition to the basic equipment enumerated in the Table, there are also centering, jig saws, tool-grinding machines, and disk saws.

The area necessary for a machine tool is calculated from the average standard of 12 - 18 m^2 per machine. The area necessary for the fitting section is taken as 40% of the area occupied by the machine (6 - 8 m^2 per fitter).

An area equal to 25% of the area of the fitting and assembly section is set aside for disassembly and flushing of the equipment. For the spare-parts stockroom, an area of 0.01 - 0.03 m^2 per maintenance unit is allotted. The layout of the departments of the maintenance shop follows the process and product process plans.

The workshop of the shop machinist and the maintenance crews under him handle the inter-maintenance servicing, inspections, flushings, and accuracy checks of equipment, perform the minor and intermediate overhaul, fabricate simple replacement parts and, under the instructions of the chief machinist, perform the part of work of major overhaul of equipment that can be done by the means available in the maintenance workshop of the shop. The equipment of the maintenance workshop constitutes 4 - 3.5% of the equipment of the shop itself.

Section 13. Principal Methods of Increasing the Effectiveness of the Maintenance System and of Improving the Economic Indices of Its Work

The cost of equipment amounts to 24 - 38% of the total fixed assets of an aircraft construction plant. The expense of maintenance and repair of the equipment constitutes a considerable part of the production cost of the product and, together with the depreciation deductions, amounts to 11 - 12% of the shop expenditure at machine-building plants. Annually, 11 - 12% of the process equipment is subjected

to major overhaul, 20 - 25% to intermediate overhaul, and 90 - 100% to minor overhaul. To decrease the idle time of equipment and the cost of maintenance work, the effectiveness of the work of the maintenance system must be increased.

The principal ways of increasing the effectiveness of the work of the maintenance system is to improve the technology and organization of maintenance work; to increase the productivity of labor of the maintenance men; to economize auxiliary materials, spare parts, and replacement parts; to lengthen the inter-maintenance periods of trouble-free operation of the equipment; to organize the maintenance system on the basis of independent unsubsidized work and observance of a regime of economy; to establish, in the economic regions, shops and plants specialized in fabricating spare parts and units for machine tools and in handling the major overhaul of machine tools.

The improvement in the technology of maintenance work is developing along the line of typifying the maintenance operations and standardizing the machine-tool equipment, along the lines of combined mechanization of maintenance work and wide application of methods of rebuilding and restoring technology, along the lines of standardization and unification of replacement and spare parts of the equipment.

It is of great importance to use methods of unit and sequence-unit maintenance, replacing the repaired units by spare units, to do all the preparatory work before the beginning of the maintenance operation, and to organize the maintenance operations on a wide front, to train the operators in repairing certain units of the equipment themselves, to establish a normal and constant stock of replacement and spare parts of the equipment at the plant itself. Utilization of ready-made parts and units in the repair of equipment considerably shortens the maintenance cycle.

Economy of auxiliary materials, spare parts, and replacement parts is achieved by the repeated use of parts removed, after restoring or rebuilding them to the next repair size, and the regeneration of used oil and abrasive materials. The preventive inspection of equipment allows detection of worn surfaces of parts, at a stage when

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rebuilding is still possible.

The quality of work of the maintenance system is determined by the following economic indices: percent of idle time of equipment, consumption of auxiliary materials per unit of equipment, labor cost and production cost of each form of maintenance and repair.

CHAPTER XV

ORGANIZATION OF THE MATERIAL-TECHNICAL SUPPLY AND TRANSPORT SYSTEM

Organization of the Material-Technical Supply

The material-technical supply of industrial enterprises is the process of the planned supply of the enterprises with raw materials, other materials, subcontracted semifinished goods, and component finished articles.

The planned and regular supply of the enterprise with materials, semifinished goods, and component finished articles plays a vital role in ensuring an uninterrupted flow of the productive process in the shops of the plant, and permits organization of rhythmic output. The establishment of economically desirable stockpiles of materials in the stockrooms releases working capital. The rational layout of materials and the observance of a regime of economy in their use reduces the production cost.

In large enterprises, with a large list of incoming deliveries, a department of material-technical supply (OMTS) is established which manages the supply of the production line with primary and auxiliary materials, and a department of subcontracting production and cooperation (OSPK) which handles the supply of the production line with semifinished goods and finished articles. Each of these departments has a network of specialized stockrooms, equipped in accordance with the conditions for storing and transporting the goods. For utilization of production scrap, shops or workshops for salvage of waste products and regeneration are established.

The primary task of the service of material-technical supply is the uninterrupted fulfillment of the plan of material-technical supply in all of its indices and the efficient organization of the stockroom work, securing preservation of the materials in good order and the timely and complete supply of the shops and services of the plant with such material.

The duties of the service of material-technical supplies includes the following:

1) Classification and indexing of materials and semifinished goods;
2) Planning the requirements of the plant for materials, semifinished goods and finished articles, and standardization of the store inventories;
3) Placing orders, execution and carrying out contracts for delivery, and arranging for timely transportation of materials to the plant;
4) Limiting the volume of materials, semifinished goods and finished articles delivered to the shops and services, and exercising control over their consumption;
5) Organizing the work of the material stockrooms.

Section 1. Classification and Indexing of Materials

The list of materials and semifinished goods used at aircraft enterprises, includes thousands of items, therefore, their classification and indexing is a first-priority measure in organizing the material-technical supply.

All materials used by the enterprise are divided, according to their relation to primary production, into primary and auxiliary.

Primary materials include metal in the form of sheet, profiles, rods, tubes and wire, textiles, plastics, wood, rubber, asbestos, and other materials from which the finished (commodity) product of the enterprise is manufactured. The auxiliary materials include those which are used in production for processing and housekeeping purposes and, as Karl Marx puts it, "do not enter materially into the product itself".

Auxiliary materials used for process purposes include:

a) The materials from which the tooling is fabricated; oils and sands used to fabricate cores; sand for casting boxes;

b) Materials which participate in the manufacturing process; gas for welding, compressed air for riveting, etc.;

c) Materials for maintenance, lubrication and cooling of equipment.

The auxiliary materials that go for routine plant operation include fuel for heating, water for housekeeping needs, etc.

Besides the primary materials, semifinished goods and component finished articles are used in the manufacture of aircraft.

Semifinished goods are products in the form of castings, forgings, and stampings delivered by other enterprises as subcontractors.

The list of component finished articles is very extensive - standard parts of metal, plastics, rubber, and other materials; various instruments, installations and assemblies (wheels, propellers, engines).

In the classification of materials, the attributes "primary" and "auxiliary" are not taken into consideration, since one and the same material (for instance, piping or wires) according to its purpose and use, may be either primary or auxiliary. In the classification of materials, their kind, type, dimensions, and other distinctive features are taken into account. On the basis of these features, all materials and semifinished goods required by the plant are divided into groups, subgroups, and types, down to the standard size, and each subdivision is then designated (coded) by the corresponding index.

The index contains an exhaustive characterization of each type-dimension of the material and makes it impossible to confuse different materials. For instance, under the decimal system, the index 1.514.101 will denote: the first digit (1) the division, in this case ferrous metals; the second digit (5), a group of this division (steel, structural, sheet); the third digit (1), a subgroup of this group STAT (heavy gauge, carbon steel); the fourth digit (4), the type of material (high-

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grade); the last three digits (1) the brand and gauge of steel.

Section 2. Material Stockpiling and Its Realization

According to the method of their distribution, materials are divided into stockpiled, centralized planned, decentralized planned, and self-procured.

Stockpiled products include any material of vital importance to the national economy, whose distribution plans are set up by the Gosplan USSR. The overwhelming majority of the materials going into aircraft manufacture are stockpiled products.

Centralized planned products include the materials whose distribution plan is prepared and approved directly by the Council of National Economy of the economic region producing them.

Decentralized planned products include materials mainly produced by local industry and cooperative organizations (lime, brick). The distribution of such products is handled by the District Executive Committee or other local planning authorities.

Self-procured products include materials and fuel whose extraction and production is organized by the enterprise itself on the forest domains, peat bogs, and quarries assigned to it.

The Council of National Economy advises the plant of the stocks assigned to it for the year and quarters, indicating the supplier plants and the supply bases. The department of material-technical supply collates the stocks assigned with the requisitions. The stock notice is then delivered for registration and record to the planning group, from where it goes to the procurement group for drafting a detailed requisition and for realizing the assigned stock. The procurement groups of the department of material-technical supply, through the administration of supply and marketing of the Council of National Economy or directly, send orders to the supplier plants indicating the specifications, quantities, and dates of delivery of the materials.

The supplier plant prepares a draft contract and requisition for the materials, and sends it to the purchasing plant for signature.

The contract is the basis of work on the procurement of materials, and obligates both parties, at the proper time and in the proper manner, to perform the conditions of delivery and settlement, and to bear material responsibility for any violations. A detailed schedule of the product items, indicating the specifications and ship ment dates, is annexed to the contract. The delivery dates for the materials are established for each item of material, semifinished goods or finished articles, taking into account the economically expedient size of the shipment, the limits of working capital, the use of transportation, the conditions of production of the materials by the supplier enterprises, and the transit standards.

In the process of procurement work, the supply departments prepare and realize the quarterly plans of procurement and the monthly plans of shipment of materials.

The quarterly plan of procurement permits determining conformity of the amount of stocks alloted with the amount of material to be procured under the production-start program. It also permits detailing the contract provisions as to schedules for type of material, quantities, and time of delivery, allowing for the build-up, to normal level, of the plant inventory of individual kinds and type-dimensions of materials. The department of material-technical supply submits its quarterly plan of procurement to the administration of supply and marketing of the Council of National Economy in good time, before the beginning of the quarter.

The monthly operative plan of delivery to the plant of materials, semifinished goods and finished articles is prepared by the procurement groups of the department of material-technical supply and the department of subcontracting and cooperation, on the basis of the quarterly plan. To ensure completeness of assortment and uninterrupted supply of materials to the production line, the advanced enterprises coordinate their operative-calendar graphs of deliveries to the plant with the supplier plants.

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On the basis of the monthly plan of incoming shipments, the procurement groups, the planning and dispatching office of the department of material-technical supply, and the department of subcontractors and cooperation establish an operative control over the arrival of goods according to graph.

Section 3. <u>Standardization and Calculation of Stockroom Inventories</u>

To maintain an uninterrupted flow of production, the normal inventory must be calculated. The planned (directive) standards for material inventories determine, by individual groups of materials, the average amount of the inventories to be held at the stores of the enterprise during the planned period.

The standard of working assets for each type of material values is determined in physical units and by value, is composed of the sum of:

1) Average value of the current supply at the stockrooms of the department of supply $S_{T\ mean}$ (this supply is intended for daily consumption for the production needs);

2) Amount of emergency reserves at the stockrooms of the supply department S_{em} (this reserve is to prevent interruption of production as a result of all possible unforeseen disturbances of supply);

3) Amount of the supplies en route from the suppliers, S_{route}.

The current supply of materials is constantly being consumed by production and is regularly replenished by the regular deliveries of materials. The amount of the current supply varies from the maximum, at the instant of arrival of a regular lot of materials, to the minimum, immediately before the arrival of a new lot of materials (Fig.112). For this reason, the working capital for the formation of the current supplies of materials is not disbursed by the enterprise on the basis of the maximum amount of the supply but on the basis of its average amount. The average amount of the current supplies is determined by the length of the period of time (in days) between two regular deliveries T_d; the length of the period of time (in

days) between two successive issues T_i; the average requirements of material values $M_{a.d}$, and the length of the necessary lead (in days) of the delivery with respect to the next issue of a lot of production T_{lead}, i.e.,

$$S_{t.mean} = \left(\frac{T_d - T_i}{2} + T_{lead}\right) M_{a.d.}$$

Under the conditions of steady production and at uniform consumption of material over the course of the entire planned period, the value of the average daily consumption is determined by dividing the total amount of material to be consumed according to plan (production estimate) for the entire planned period, by the number of days in this period. To simplify the calculations, the number of days in the planned year is taken as 360 and in the planned month as 30.

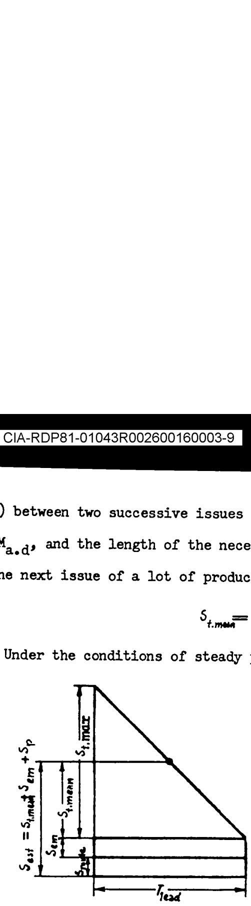

Fig.112 - Graph of Calculation of Material Supplies

With increasing volume of production, the value of the average daily consumption is determined from the last month of the planned period.

The emergency reserve is calculated, taking account of the deviations from the average frequency of deliveries, owing to delays in shipment and transportation of goods; of deviations in the assortment of the deliveries from the monthly work orders; over-plan consumption as a result of unforeseen disturbances of the normal flow of production (design modifications) and other events disturbing the rhythm of deliveries.

The supply built up for each of these reasons must be expressed in days and may be approximately calculated by the formula

$$S_{em} = T' \cdot M_{a.d!}$$

where S_{em} is the emergency reserve or supply of the material, in tons; STAT

T' is the period of replenishment of the supply of materials in days, includ-

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ing the time for preparation and shipment of the material, its transportation, and its preparation for issue.

The supply of materials in transit is calculated taking account of the time of transportation of the material from the supplier to its arrival at the store, and the time for payment of the account and the receipt of the credit from the State Bank. The transit time of the goods from the place of shipment to the entrance point of the railroad siding is determined by the standards indicated in the rules and regulations of the Railroad Transportation Code.

Example of Computing the Stockroom Supplies. Program of output, 1000 articles per year. Consumption of sheet duralumin according to standard, 6000 kg per article. Conditions of delivery, 2 - 3 times a month; conditions of use, once every two days. Consequently, T_i = 2 days, while the average period of delivery T_d must be a multiple of the period of issue, within the limits of the delivery conditions, i.e., on the average every (10 + 15) : 2 = 12.5 days. For convenience of calculation let us assume 12 days. In this case, the possible deviation in the time of delivery will be 15 days - 12 days = 3 days.

To prepare a batch of materials for issue to the shops (acceptance, unpacking, and marking) takes 3 days.

Then the amount of the current supply, under the conditions assumed, must assure the needs of the plant for materials over the course of

$$S_{t.mean}=\frac{T_d-T_i}{2}+T_{lead}=\frac{12-2}{2}+3=8 \text{ working days}$$

The size of the emergency reserve is taken as equal to the possible deviation in the delivery periods and cannot be greater than the interval between two successive deliveries. In this example, the emergency reserve is taken as minimum:

$$S_{em} = 15 - 12 = 3 \text{ days (i.e., a three-day reserve)}$$

The time spent by a material batch in transit is established from the contract

with the supplier; on the average it is 17 days.

According to the rules of the State Bank, the time for payment of an account is composed of

transit time of draft from supplier	2 days
period for acceptance of draft	3 days
delay of payment on draft	7 days
Total	12 days

Consequently, the supply of material in transit should be such as to ensure the operation of the enterprise during the period

$$S_{route} = 17 - 12 = 5 \text{ days}$$

Then the total amount of the supplies of sheet duralumin will be sufficient for the work of the enterprise during the period:

$$S_{tot} = S_{T\ mean} + S_{em} + S_{route} = 8 + 3 + 5 = 16 \text{ days}$$

Let us calculate the amount of stock of duralumin in physical units, according to the program

$$M_{pr} = 6000 \text{ kg} \cdot 1000 \text{ articles} = 6 \text{ million kg} = 6000 \text{ tons}$$

The average daily consumption of duralumin will amount to

$$M_{a.d}=\frac{6000}{360}=16{,}7\ m.$$

The necessary standard stock of duralumin in physical units is equal to

$$S_{tot} = 16 \text{ days} \cdot 16.7 \text{ tons} = 267.2 \text{ tons}$$

Section 4. Limiting the Issue of Materials to Production, and Organization of the Control over Its Use

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The limitation of the release of materials, purchased semifinished goods and

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component finished articles, does not allow the formation of excessive and incomplete inventories at the stockrooms. The limits of issue of materials to production are established by the department of material-technical supply on the basis of progressive norms of material consumption and of the program of production starts, taking account of the supplies of materials unconsumed by the shops and services, at the beginning of the planned month.

The limits are established for permanent, series, single, and outside-plan orders separately, for each kind of material.

For permanent orders, the limits are established for the month. For a series order, the limit is established over the period of validity of the order. For single orders, the limit is issued separately for each order. The limits are calculated either for each part or unit, or consolidated, according to the number of planned articles.

On the basis of inventory schedules and the data of the planning department, on the finally approved monthly programs of the shops, the supply agencies reduce or increase the original limits of issue of materials.

The issue of materials pursuant to a limit is handled on limit cards or on a set schedule of the shop. The individual limit cards are made out for a period of one month in two copies for each kind (grade, mark, profile, and size) of material. One copy of the card file is kept at the stockroom, and the other copy of the card file is forwarded to the responsible person at the shop. The limit cards and schedules are recorded in a roster. Materials may be issued outside the plan in the case of additional issues to rework rejected parts, to replace material by type, kind and marks, or to cover overconsumption.

At the end of the month, the stockrooms and shops reconcile the limit cards and, after mutual verification, deliver them to the materials accounting office.

The record and control over the consumption of material in production is handled by the lot method, or by the method of monthly inventories.

With the former method, each lot is checked to establish the causes and persons guilty of deviations at each work station. This method of control covers high-priority and high-cost materials and to everyday materials including nonferrous metals, organic glass, fabrics, leather, etc.

The second method of control consists in comparing the actual consumption of material with the consumption calculated by the standards for the entire month. With this method, the balance of materials not consumed by the shop at the beginning of the following month is inventoried monthly at each shop. The balance of unconsumed materials is transferred by the accounting office from the production account to the account of material in stock.

Section 5. Forms of Stockrooms and Their Equipment

Forms of Storage Facilities (Bibl.28). An aircraft construction plant has a wide network of various universal and specialized stockrooms which may be divided into material stockrooms (raw materials, primary and auxiliary materials, purchased articles), fuel dumps, (coal, charcoal, peat, cylinders filled with gases, calcium carbide), warehouses for semifinished goods produced by the plant, stockrooms for equipment and tools, warehouses for finished product, and dumps for scrap and salvage.

Depending on the properties of the materials or articles, they may be stored in the open, under cover, in closed unheated or heated rooms.

The following forms of open storage facilities exist:

a) An open area with a 1 - 1.5% pitch toward the water collection; such an area is generally used for storage of cast iron, metal scrap, rails, beams, large profiles, cast-iron and steel pipe of large diameter, heavy steel plates;

b) A scaffolding, consisting of a flooring of boards or timber or bar
which lumber, pipes, heavy articles, and materials in containers are

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placed;

c) A bunker, i.e., an enclosure of 0.5 - 1.5 m height made of boards, timber, or other materials for piling heaps of peat, coal, sand, and other bulk materials;

d) A bin, i.e., a storage area surrounded on all sides or on three sides by fixed or removable walls 1.0 - 2.5 m, or more, high and intended for free-flowing or heapable goods, metal scrap, molding sand and other materials not affected by weathering;

e) A bulkhead up to 2 m high, set up along an unloading area for dumping free-flowing materials, sand, coal, etc., and allowing an increase in the height of the pile;

f) A stockade, a railroad track or truck road for facilitating the unloading operations and for receiving large-volume piles of unloaded free-flowing materials.

Sheds consist of a roof supported by posts and may have a floor at ground level or at a height of 0.9 - 1.1 m. Sheds are used for storing materials needing protection only from rain.

Covered storage facilities (Fig.113) are set up at ground level or with a raised floor. They may be single-or multistory, unheated or heated.

Covered unheated storage places are used for storage of housekeeping equipment, high-grade steels, metal articles, medium and small water-gas fittings, small ceramics, spare equipment, and fire-fighting apparatus.

Covered heated storage places are used for storing materials requiring a constant even temperature, for instance, electric materials, tools, nonferrous metals, precious metals, finished goods, valuable equipment, or special work clothes.

A basement or darkened room is used for storing leather, rubber, chemicals, paints and oils and similar materials.

Cellar and basement stores erected as separate buildings, are generally used

for storing inflammable substances.

Ramps and Chutes. Alongside covered stores, loading and unloading areas (ramps) of 1.5 - 2 m width are usually built on the two longitudinal sides, protected by a sheet-metal overhang. In stores with a raised floor, slides (chutes) with a grade of 0.07 - 0.09 (4 - 5°) are built for bringing hand trucks to the platform.

a)

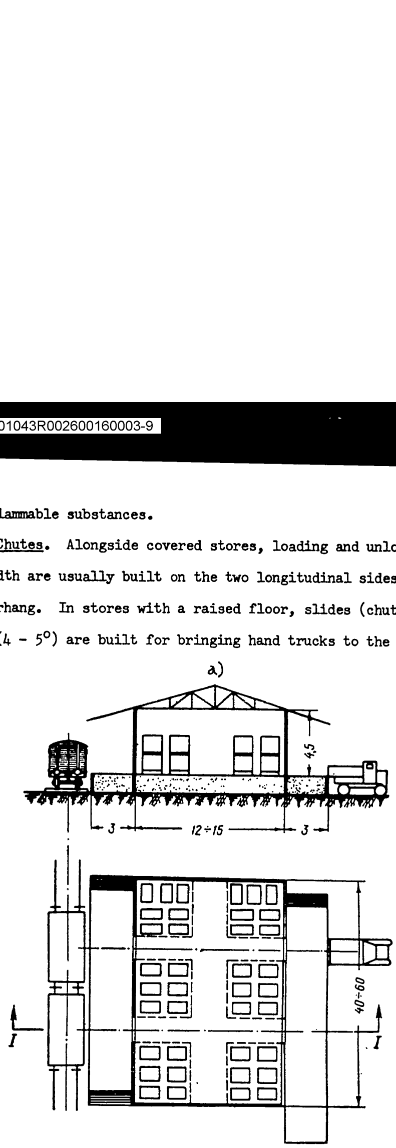

Fig.113 - Roofed Shed for Finished Product.

a) Section through I-I

Passages and Aisles. Each storage facility should have transverse through-passages of the width of the doors, spaced at 20 - 30 m. Inside, along the length of the store and according to its width, several aisles 2.5 - 3 m wide are provided, designed for movement in both directions. The width of the aisles between the racks, bins, and piles is 0.6 - 0.9 m and, if flat hand carts are used, 1.1 - 1.2 m.

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The choice of the type of storage facility, its location, its inside equipment, and layout, depend on the kind of materials and the conditions of their storage. In selecting a location for a store, the direction of the flow of goods on the plant grounds is taken into account and efforts are made to erect the storage facility close to the shops that are working with the materials kept in the store; in addition the fire hazard of the store for the production area is taken into account.

The area of a store comprises the following components:

$$F_{st} = F_{r.s.} + F_{iss} + F_{load} + F_{p.a.} + F_s + F_r + F_{pr},$$

where F_{st} is the total area of the store;

$F_{r.s}$ is the receiving and sorting area;

F_{iss} is the issue area for materials prepared for issue to the consumer shops;

F_{load} is the loading area for storage of the supply;

$F_{p.a}$ is the area for passages and aisles in the store and for moving the loads by materials-handling mechanisms;

F_s is the area for service personnel rooms;

F_r is the reserve area for expansion of store;

F_{pr} is the area of procurement department.

In calculating the area of a warehouse, the sum of the maximum current and emergency supplies of materials is used as computation basis.

The receiving and sorting area has zones for unloading, unpacking, temporary storage and processing of incoming shipments.

The goods area is designed for maximum supply of each kind and size of material. The calculation is made by the methods of loading, volume measurements, or theoretical stacking.

In the method of loading, the size of the useful area is calculated by dividing the weight standard of the supply by the allowable floor load in tons/m^2, using the formula

$$F_{load} = \frac{Q}{qh\lambda},$$

where Q is the quantity of materials to be stored;

q is the average design load, i.e., specific weight of material in storage, in tons/m^3;

h is the assumed height of pile;

λ is the coefficient of utilization of the area, equal for pile storage to 0.65, and for storage in racks to 0.3 - 0.4.

In the method of volume measurements, the size of the necessary area is established according to the standard weight of the supply, the specific weight and the bulk factor of the cubage of the storage places. This method is applicable to materials stored without containers, for piece articles, and for free-flowing and lump materials.

In the method of theoretical stacking, the articles or materials are theoretically stacked in racks or piles; on this basis, first the required number of racks and piles is determined and then the required useful area.

The required number of racks in a store is calculated by the formula

$$C_r = \frac{Comp_1}{Comp_2}$$

where C_r is the number of racks;

$Comp_1$ is the required number of compartments (a compartment for each kind and size);

$Comp_2$ is the number of compartments in one rack.

The number of bunkers or compartments for each type-dimension of material is calculated by the formula

$$Comp_1 = \frac{S_{max}}{E}$$

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where S_{max} is the maximum stock of materials of a given type-dimension to be stored;

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E is the capacity of one compartment of the rack, or of one bunker.

The total goods area will be equal to the sum of the areas occupied by all forms of racks, bunkers, and materials stored in piles.

The area for the aisles to the racks and piles and for the cross passages is established as a result of an exact planning of the storage facility. The size of the area for the office and personnel rooms depends on the number of workers in the warehouse (the standard is 4.5 m^2 per worker). The reserve area for expansion of the storage facility is taken as 15 - 20% of the goods area.

Equipment of the Warehouse. For mechanization of the loading and unloading work, warehouses are equipped with bridge cranes, jibs, monorails and telphers, and conveyors (Fig.114), autocars and electric cars, automatic hoists and elevators, if the store has several floors.

To mechanize the loading and unloading from railroad sidings and trucking facilities, the communication routes are placed in the zone of operation of the crane. The work of washing, drying, lubricating, and marking sheets is mechanized at the warehouses, together with the work of transporting and dumping the materials in piles, bins, and racks, of loading materials into a car or machine; in the shops, the delivery of material to the work station is also mechanized. If the warehouse also performs the operations of sheet-metal layout, these operations are likewise mechanized.

The warehouse is equipped with racks, cribs, and other facilities for storing materials. This is very important for the preservation of the stored materials, the convenience of their piling and the more complete utilization of the area and cubage of the warehouse premises.

The design and dimensions of the racks must correspond to the kind and shape of the material stored. According to purpose, racks are universal (shelf-compartment, box, and rack-closet) and special (for metals and tools). The racks are made of metal or wood (moisture content not over 18%) or are of mixed construction. The

height of universal racks runs up to 2.5 m, and in high rooms, where ladders or stands are used, 3 - 3.5 m. It is expedient to build composite racks in separate sections.

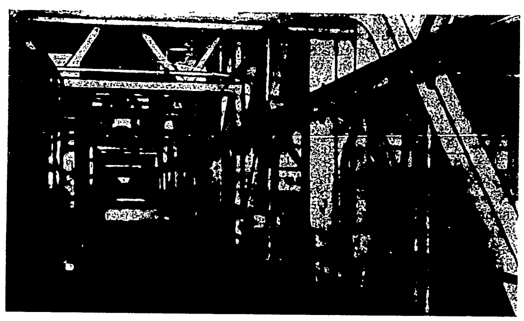

Fig.114 - Conveyor Equipment of Warehouse

Sheet material is stored on wooden bracket-shelf racks, and on support stands (Fig.115). Sheets, if their weight is over 10 tons, are stored in piles 1.5 m high.

For storage of steel rods and tubes (with a supply of over 3 tons), braces and racks with vertical posts are used, which are convenient for mechanized piling (Fig.116). Steel rods and pipes, if the stock does not exceed 3 tons, are stored in bracket racks, and wire in shelf-compartment racks.

The lighting of a warehouse may be natural or artificial. Natural lighting is defined by the coefficient of natural illumination. Artificial lighting of stores is measured in lux per m^2.

Fire Safety. A warehouse must be equipped with fire-fighting apparatus. On the outside, alongside of the warehouse, hydrants connected with the water sy STAT are installed. Inside the warehouse, internal fire cocks are provided. Liquid and

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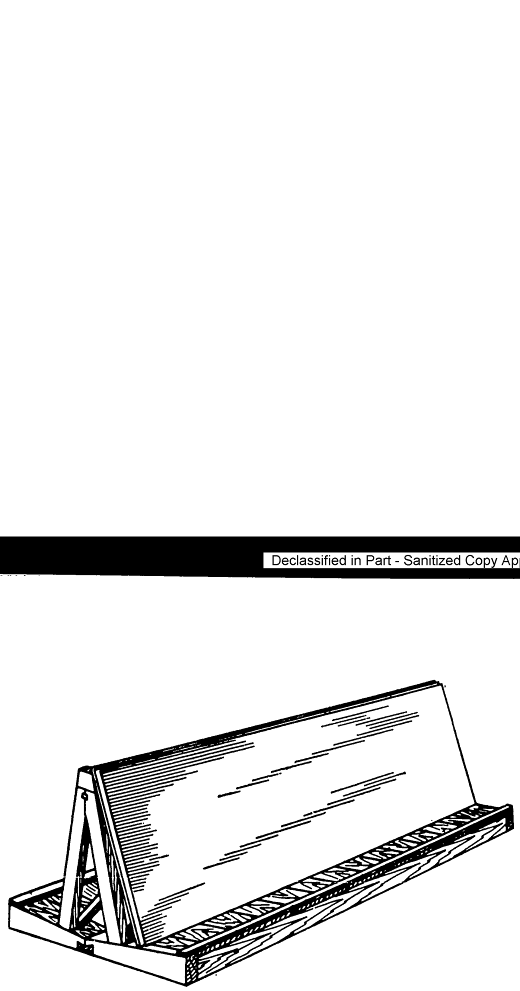

Fig.115 - Racks for Storage of Sheet Material

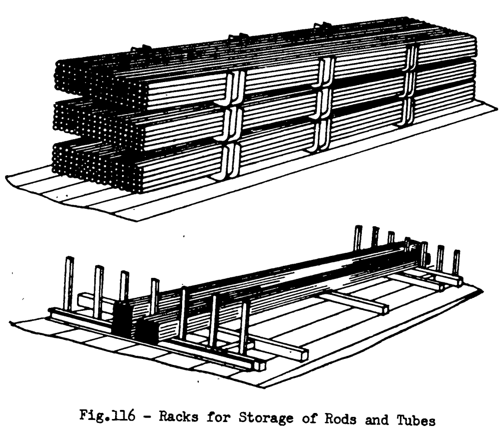

Fig.116 - Racks for Storage of Rods and Tubes

carbon dioxide fire extinguishers are provided in the warehouse. Special locations are also reserved for other forms of fire-fighting equipment, sand boxes and shovels. To communicate with the plant fire-fighting force, electric fire alarms must be installed in the warehouse. On the premises of the warehouse, strict fire-protection rules are enforced, and systematic control over proper functioning of the fire-fighting equipment is practiced. All warehouse workers must participate in compulsory fire drills.

Section 6. Warehouse Operation and Procedure for Their Performance

The principal operations of a store are as follows: inspection and acceptance of materials arriving at the store, preparation of materials for storage, and assignment of their location, storage of materials, inspection and anticorrosive treatment of materials, preparation of materials for issue to the shops, issue of materials from the store, and recording of arrival and consumption of materials.

Inspection and Acceptance. All materials, semifinished goods and component finished articles that arrive at the plant from outside are subject to checking, and cannot be accepted nor issued to the shops without authorization by the inspection service. Inspection is necessary to establish the conformity of the quality and quantity of the materials delivered to the store with the quality and quantity indicated in the accompanying documents. If the materials or finished articles shipped by the supplier do not correspond to the conditions of the contract, the plant has the right to refuse to pay the draft. In that case, the department of material-technical supply is obligated to accept such incoming goods for bailment until receipt of additional instructions from the supplier.

In case of poor condition or damage to the tare of the goods received and also in case of a shortage of the shipment indicated in the railroad receipt, a commercial statement is drawn for presentation of a claim to the railroad or the supplier. STAT

Before unpacking, certain materials such as nonferrous metals are held in an

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auxiliary room until they assume the ambient temperature of the main room. The packing of the supplier plant is then removed from the incoming material which latter is laid out by marks and sizes and prepared for examination and inspection. On inspection, an external examination and a check of the geometric dimensions are made, and samples are taken and analyzed. The conditioning of the materials is checked by the laboratory to the extent prescribed by the standards or specifications in force for the given kind of material.

Every arrival of material is formalized by a statement of acceptance, which reflects the results of the acceptance, the quantity, weight, and results of the tests and analysis. An accepted lot of products is marked and stamped by the inspector in accordance with the instructions of the inspection department. A statement of claim is prepared for a product that does not meet the specifications.

Preparation for Storage. Metals showing no traces of corrosion are accepted for storage in the stockroom. Before sending the material to the place of storage, it is prepared for storage. For instance, sheets of duraluminum are wiped dry, marked, and pasted over with paper on one side.

The storage of materials must ensure preservation of their quality and quantity. The conditions of storage of the materials and semifinished goods going into the manufacture of aircraft are determined by the instructions. All forms of nonferrous metals, as well as fittings, are stored in heated buildings. To protect them from rust, the threads of bolts, nuts, wood screws, end caps, fittings, sleeves, elbows, tees, nipples, and branch pipes are greased with technical vaseline or other lubricants.

One important factor for determining the normal conditions of storage is the protection of metals from the effect of moisture. Many materials must be stored at a definite temperature and atmospheric humidity. The means for reducing the humidity are regulation of temperature, ventilation, and airing the storage rooms. The relative humidity of the air is determined from the difference of the readings of the

Assman psychrometer. The condition of the air in the storage room is checked twice a day. Metals in storage are periodically inspected.

The records of the materials in a stockroom are kept on the basis of the incoming and outgoing documents, the data of which are entered in a record card kept for each type-size of material. The method of current entries, after each arrival or issue of material, yields its balance. To verify and define the entries in the record cards, periodic inventories are taken of the materials in the stockroom, supplemented by surprise spot checks.

Materials are issued from the stockroom of the supply department on material requisitions or limit cards. Before issuance, the stockroom prepares the material for productive use, for instance, the charge materials are ground and screened; rod and sheet metal is laid out or cut; free-flowing material is packed in parcels, liquid material is poured into a container. The representative of the shop, on submitting his copy of the limit card, receives the necessary material. The stockroom clerk weighs and figures the issued material in the presence of the shop representative. The issue of the material is finalized by signatures of the issuer and receiver, on an issue document.

The issue of material from the stockroom of the shop to the work stations takes place against the work orders or flow sheets, made out by the production and dispatching office of the shop. Materials are usually issued from the stockroom in an amount not exceeding the shift consumption. If the material issued has not been completely consumed by the end of a shift, it must be returned to the stockroom for storage, and this return is noted by the clerk on the work order or flow sheet.

Section 7. Plan of Organizational-Technical Measures and Primary Methods of Economizing Materials and Reducing the Warehouse Expense

The plan of organizational-technical measures prescribes measures for improving the work of the agencies of material-technical supply. The plan includes organizational-technical measures for reducing the transportation and procurement expense (improvement of the roster of suppliers and the regions of procurement, intensified control over the correct calculation of the railroad tariff, increasing the sizes of incoming shipments, reducing the standard times for storage of material at warehouses outside the plant, reducing the unloading and transportation expense), by reducing the warehouse expense (mechanization and better organization of the storage operations), reduction of administrative expense (mechanization and orderly organization of the work of the staff, release of superfluous workers from the departments and stores).

Measures for economy of materials are very important.

The reduction in the standard consumption of material per article is reached by reducing the weight of the aircraft, by selecting and typifying materials and profiles, by creating the simplest geometric shapes for the various parts and units, by using such means and methods of fabricating blanks and machining parts which allow the most complete utilization of the surface of sheet or the length of a rod or tube, and lead to minimum machining waste of the metal. In each shop and service, measures are envisaged for a more rational layout and forming of sheet materials, for a complete collection of scrap, for salvage and regeneration of auxiliary materials.

The elimination of spoilage is of great significance for the economy.

The development of the movement of the leaders of production for the economy of materials in each operation yields immense additional reserves for the economy of materials.

Reduction of the work in process in the shops is accomplished by shortening the productive cycle and by a differentiated calculation of the material inventories. In this respect, the experience of certain advanced enterprises is instructive. They establish standard material inventories based on the length of the manufacturing cycle of each group of parts. For instance, with the indices shown in Table 56, if the length of the cycle for the most labor-consuming group of parts were used as guide, the shop would require 150 × 60 = 9000 kg of material to maintain its work in

process. If the length of the cycle of each group of parts is taken into account, however, the shop will require only 7950 kg of material. In this case, the average length of the cycle is 7950 : 150 = 53 days, while the coefficient of introduction of material into production is 53 : 60 = 0.93.

Table 56

Part No.	Consumption of Material Per Day Per Group, in kg	Length of Manufacturing Cycle of Parts, in Days	Total Consumption of Material in kg
1	100	60	6000
2	30	45	1350
3	20	30	600
Total	150	-	7950

The lowering of the standards for warehouse inventories of materials includes measures for the release of frozen assets, for the shortening of the time of processing and delivery of goods to the shop stockrooms, and for reduction in the standards for the current and emergency inventories.

Section 8. Estimate of Plant Warehouse Expenses and Economic Indices of the Operation of the Supply System

The plant stockroom expense includes the expenses for storage and processing of goods stored in the general plant stores. These expenses enter into the general plant overhead, and a special estimate of them is made, including all expense of the storeroom system during the planned period. By dividing these expenses by the number of tons of goods handled by the warehouses (or by an individual stockroom) for the same period, the total expense per ton of goods handled is obtained. The total expense per ton of goods handled $C_{g.h}$ is calculated according to the formula STAT

$$C_{g.h.} = T_{ip} + M_{aux} + S_s + HP_c,$$

where T_{ip} is the intraplant transport expense for transporting the goods from the plant warehouse to the shop stockroom, per ton;

M_{aux} is the cost of auxiliary materials, assumed according to the standard for processing of a ton of goods;

S_s are the wages, with all supplements, of the staff of supply and the stores per ton of goods;

HP_c is the remaining overhead expense of supply, according to the same classification as for the other auxiliary services.

The effectiveness of the work of the agencies of material-technical supply is determined by the following economic indices:

1) Fulfillment of the operative plan of shipment of materials to the plant with respect to dates, quantity, tonnage and assortment;
2) Complete assortment of the inventories of materials and maintenance of the inventories at the established level;
3) Amount of idle time of the primary producing shops owing to delayed supply or incomplete assortment of the supply;
4) Amount of transportation expense for delivery of the material;
5) Amount of working capital assigned to the department of material-technical supply and to the department of subcontractors and cooperation;
6) Plant cost of processing a ton of materials at the warehouses;
7) Detection and liquidation of frozen assets;
8) Salvage of plant waste.

To improve these indices, the work of the agencies of material-technical supply must be organized on the basis of independent unsubsidized operation.

ORGANIZATION OF THE TRANSPORT SYSTEM

Section 9. Purpose and Function of the Transport System

Transport is divided according to its purpose into outside, intershop, and intrashop.

Outside transport is used to deliver fuel, primary and auxiliary materials, semifinished goods, and component finished articles to the enterprise and to ship from the enterprise the finished product, salvage, and other freight. These shipments are serviced by the shops of railroad, truck, and other forms of transport.

Intershop transport is used to deliver material, semifinished goods and finished articles from the general plant warehouses to the shops, and from one shop to another. These shipments are served by the shop of intershop shipments.

Intrashop transport is used to deliver tools, materials and semifinished goods from the shop stockrooms to the work stations. Intrashop transport is handled by the shop where it is used.

The transport work is most effective with maximum mechanization of the loading and unloading work.

The principal task of the transport system is uninterrupted fulfillment of the plan of shipment, with complete utilization of the transporation means and minimum cost of the transport operations.

At aircraft construction enterprises, the use of materials-handling facilities is developing in the following principal directions:

1. Equipment of warehouses, machine tools, and assembly stands with materials-handling mechanisms. Conveyors, monorails, truck loaders, pilers are used at the warehouses (Figs.117 and 118). In the fabricating shops, electric cars with lift platforms are used to transport the dies, and electric hoists are used to set up the dies in the presses. In the machine shops, the machine tools for processing heavy

Fig.117 - Automobile Loader

Fig.118 - Piler

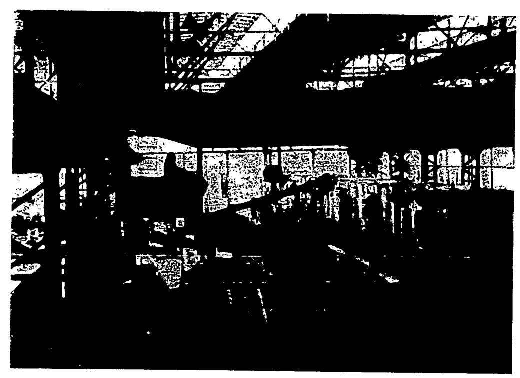

Fig.119 - Beam Crane for Hoisting and Transporting Panels

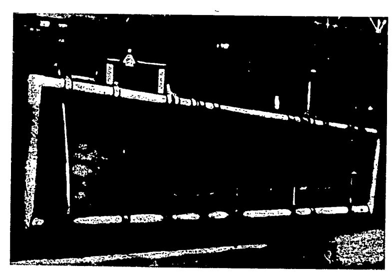

Fig.120 - Pulsating Conveyor on Assembly Line of Leading Section of Wing

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parts are equipped with electric hoisting mechanisms. In the major assembly shops, electric mechanisms and monorails are used to place and remove a section or major component from the assembly jig and to transfer a section or major component to the next work station (Fig.119). In the final assembly shop, electric hoisting mechanisms are used to hang the wings, engines, and other major components on the aircraft.

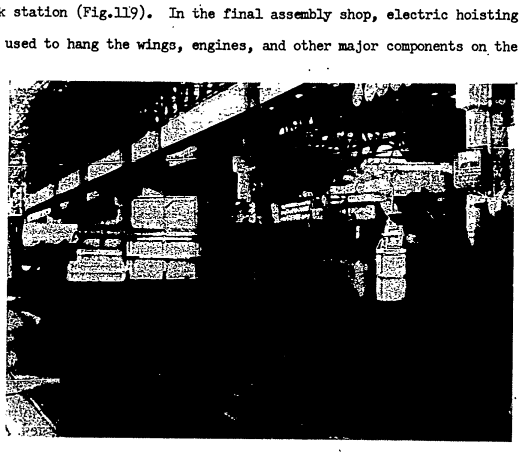

Fig.121 - Electric Cars Serving Intershop Shipments

2. Development of intrashop transport, conveyors and belts, used on production lines (Fig.120); electric cars, used for delivering parts and units from the stockrooms to the work station; endless and discontinuous overhead conveyors, used on permanent flow lines of frequently transported loads, for instance, in transporting the engine from the removal-from-storage line to the engine installation stand on the line of final aircraft assembly.

3. Development of intrashop transport - conveyors, tractors, electric cars (Fig.121). Continuous or pulsating action conveyors directly connect the storage or operating sections of some shops. Tractors are used to transport assemblies to the

final assembly shop, and the aircraft to the airfield.

The mechanization of lifting and transport work considerably lightens the work of the workmen and reduces several-fold the labor cost of moving loads.

Section 10. Classification of Loads and Transport Facilities

The loads to be transported are divided into the following groups: uncrated piece goods; piece-container goods, transported in containers and crates, such as engines, assemblies, equipment, bricks; long goods: profiles, tubes, rods, lumber; bulk materials: coke, coal, sand, slag, soil; liquid materials: crude oil, gasoline, kerosene, fuel oil; other materials such as food products.

Each form of load has its own characteristic features of loading, transportation and unloading. The transport facilities must correspond to these features. For a more complete utilization of tonnage and for shortening the time in the transportation of goods, the transport facilities are specialized as much as possible and are assigned to definite routes and forms of load.

Railroad transport occupies an important place in the outside shipments of the plant, and if there are sidings at the plant site, this will ensure the delivery of railroad cars with freight directly to the place of storage or consumption. The principal transport facilities on plant railroad sidings are locomotives (tender and tank), electric locomotives, Diesel engines, and various types of freight cars, box cars, platform cars, gondolas, hoppers, dump cars, and tank cars. The economic characterization of railroad transport facilities is given in the special literature (Bibl.29).

Automotive transport is the most flexible form of internal plant transport and ensures rapid delivery of the goods.

Plants use trucks of conventional type, specialized trucks, trailers, autocars, and electric cars. Autocars and electric cars are widely used for intershop and intrashop transport. Autoloaders are intended for loading and unloading freight cars, for piling goods at the warehouses, and for transporting piece goods. At aircraft plants. autoloaders are also used in the stamping shops for transporting and lifting heavy dies.

Continuous-action conveyors, overhead, floor, belt, plate, chain, dolly, and other types, inside a building are usually open, with a wire net protection for the catwalks. Between buildings, the conveyors are usually of the enclosed type, laid in a tunnel or tube, to protect the loads being moved from the effect of rain and snow.

Simple transport facilities, dollies, chutes and rollers, are widely and used directly in the production sections.

Section 11. Materials-Handling Installations and Calculation of Their Throughput

Materials-handling installations free the workmen from heavy and sometimes dangerous work, and also save time.

The choice of a materials-handling installation depends on the kind and characteristics of the loads being moved (shape and weight), the type of required productivity of the installation (load-lifting capacity and speed); the directions and lengths of the routes for the loads; the method of piling a load; the local conditions (for instance, type and design of the building, temperature, dust and humidity of the premises).

In productive shops, the materials-handling installations are connected with the manufacturing process. For example, the displacement of a conveyor and of the cranes in the casting, forging, and other shops is correlated with the labor process.

The best materials-handling systems are those that ensure a high degree of mechanization, labor safety, and minimum cost of moving a unit load.

The materials-handling systems are under the control of the superintendent of the shop in which they are permanently installed and used. The responsibility for good order of the materials-handling installations is vested in an inspector of the

department of the chief machinist.

Materials-handling systems may differ widely in their purpose and tonnage. Cranes, electric hoists, trolleys, monorails, conveyors, winches, elevators, jacks, and other installations are widely used.

To shorten the time of loading and unloading, it is important to have the same type of transport and materials-handling equipment in both warehouses and shops.

The throughput capacity of a materials-handling system is determined by its load-lifting capacity and by the number of cycles it can perform during a shift, and is calculated by the formula

$$P_r = \frac{Q \cdot T \cdot \alpha_1 \cdot \alpha_2}{t_1 + t_2 + 2\left(\frac{h_1 + h_2}{v_1} + \frac{l_1}{v_2} + \frac{l_2}{v_3}\right)},$$

where P_r is the productivity of the materials-handling system, for instance, of a beam crane, in tons per shift;

Q is the load-lifting capacity of this system, in tons;

T is the time of operation of the materials-handling system per shift, expressed in minutes;

α_1 is the coefficient of utilization of the installation with respect to time (usually equal to 0.8);

α_2 is the coefficient of utilization with respect to load lifting capacity (usually taken as 0.7);

t_1 is the time of gripping (seizure of load), in minutes;

t_2 is the time of unhooking (release of load);

h_1 is the height of hoisting, in m;

h_2 is the height of lowering, in m;

v_1 is the speed of lifting and lowering the load;

l_1 is the length of the path of displacement of the crane;

v_2 is the average speed of motion of the crane;

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l_2 is the length of path of displacement of the telpher;

v_3 is the speed of motion of the telpher.

Section 12. Organization of Transport Routes and Calculation of Required Number of Transport Facilities

The movement of a load may take place along routes covered only once or along routes established in advance and systematically repeated. Routes may be organized in shuttle and ring systems.

Under the shuttle system of the routing, the transport devices complete trips between two points. The shuttle trips may be one-way or two-way. A one-way shuttle system is ineconomic, since it includes a return trip empty. With the two-way shuttle system, the loads are transported in both directions (for instance, in carrying parts between the machining and heat-treating shops).

With the ring system of routing, the transport facilities make a trip along a closed curve, serving a number of points on their path. The ring system of routing may have an increasing, uniform, or decreasing flow of goods. The ring system of routing is more complex to organize, but to make up for that, it allows a most effective use of the transport facilities.

To calculate the required number of transport devices, the transport shop, on the basis of requisitions made by the departments and shops of the plant, determines the list and quantity of the loads to be carried during the planned year. The transport shop prepares a schedule of the arrival of loads at the plant and the transport of loads from the plant, a schedule of the automobile transport assigned to various series services of the plant or to their current servicing, and a plan of load turnover for each type of transport.

The routes of movement of loads are established by classifying the loads by bases and enterprises going in one direction. Then, for each address of one direction, the category and amount of the freight to be carried is determined.

On intershop shipments, the direction of flow and the routes are determined by the sequence of the technological process of manufacturing the article.

The movement of freight must be carefully prepared and organized. For this purpose, it is important to select the most convenient route and the most suitable form of transport corresponding to the route and the tonnage of the load, as well as the corresponding facilities for loading and unloading it.

Table 57

Arrival of Loads			Departure of Loads		
Designation	Quantity in Tons	Origin	Designation	Quantity in Tons	Destination
Sheet steel	2285	From TsMS (Central Material Warehouse)	Workpieces	1400	Shop No.1
Nonferrous sheet metal	523	Same	Workpieces	705	Shop No.2
Tools	53	From tool shop	Sheet-material scrap	756	Salvage shop
Parts for repair	32	From OGM (chief machinist's department) warehouse	Waste of auxiliary material	320	Regeneration station
Auxiliary materials	362	From TsMS	Worn parts of equipment	32	Sorting base of OGM
Total Arrivals	3255		Total Departures	3255	

The run in ton-kilometers is calculated separately for each route. The data for the calculation are taken from the schedules of routes. By adding the data obtained for all the routes, it becomes possible to calculate the total number of ton-

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kilometers of a run of the transport devices in outside movements.

For intrashop movements, the calculation of the number of loads to be moved is based on the balance of goods turnover made up for each shop and service. As an example, Table 57 shows the annual balance of goods turnover for the sheet-metal stamping shop.

A calculation of the required number of transport facilities is made for each route of movement and for each form of machine. The operational and inventory machine pool are distinguished in the calculations.

The operational pool is the number of transport devices in daily operation. The inventory pool is the operational pool plus the number of machines in routine maintenance (4 - 6%) and in reserve (5 - 10%).

The number of devices in the operational pool is calculated from the formula

$$N_{o.p.} = \frac{Q \cdot L}{vqFK_1K_2(1 - K_3 - K_4)},$$

where Q is the quantity of load to be moved along the route, in tons;

L is the length of the route at both ends, in km;

v is the average speed of the device, in km/hr;

q is the rated load-carrying capacity of the transport device, in tons;

F is the annual working time of the transport device, in hrs;

K_1 is the coefficient of utilization of the transport devices with respect to the load-carrying capacity (usually 0.6 - 0.9);

K_2 is a coefficient depending on the system of organization of load movement (in a two-way shuttle system, $K_2 = 2$; in a one-way system, $K_2 = 1$; in the ring system, $K_2 = 1.65 + 1.85$);

K_3 is the coefficient of time loss for unforeseen delays and stoppages en route (usually 0.1 - 0.15);

K_4 is the coefficient of time loss in loading and unloading work (usually 0.1).

The calculation of the required number of drivers is based on a number of machines and working shifts, taking account of the planned percentage of time loss of the driver on vacation. The number of drivers on the payroll must be larger than those appearing daily for work, by the equivalent of these losses. The calculation of the required number of workmen accompanying the trucks is calculated according to standard Tables.

Section 13. Operative Planning and Dispatcherization of Transport

The operative planning of the transport system prescribes the preparation of monthly and shift-day plans of materials movement and the correlated loading and unloading work.

The monthly plan-graph of shipments is drawn by the planning and dispatching office of the transport shop on the basis of the quarterly plan and the applications of the services and shops of the plant, which are delivered to the office 6 - 10 days before the beginning of the planned month.

The amount of load to be moved during the month is compared with the throughput of the existing transport facilities, and the number of shifts of their use as well as the routes and number of machines assigned to the various routes are refined. For permanent routes, the establishment of a monthly plan for intershop material movement consists in the construction of a standard plan or in its refinement.

The shift-day assignment is prepared by the dispatcher of the transport shop on the basis of the monthly plan of movements and the applications for movement of loads received up to that point from the departments and shops of the plant. No applications are filed for continually recurring work and routes. On continually recurring routes, the movement is handled by transport facilities and permanent drivers whose work is organized by a graph.

The dispatcher, detailing the incoming applications (their date and order), establishes the volume of the forthcoming movements, verifies the possibility of their performance with the presently available number of transport facilities,

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drafts a shift-day assignemnt indicating the distribution of machines among the routes and sections of work, and makes out route sheets for the drivers. The route sheet shows the driver, route, load, tonnage, time of departure, and time of return. In establishing the route of the shift and the time of performance of the work, the dispatcher takes account of the qualifications and experience of the driver, the characteristics, overall dimensions, and weight of the load, the distance of the transportation and the condition of the road, the operating conditions of the addressee and shipper, and other factors.

The control and record of the work on the shift-day assignment is handled by the dispatcher on the basis of the route sheets, on which the consignee or shipper are obligated to indicate the time of arrival and departure of the machine and the quality of the load delivered. The dispatcher notes the performance of the shift-daily assignment in a special daybook.

The regular and high-grade technical intermaintenance servicing and the timely performance of the planned-preventive maintenance are of great importance for efficient operation of the transport.

Section 14. Principal Economic Indices of Transport Work and Methods for Reducing the Expense of Transport Systems

The principal economic work indices of the transport system are the performance of the plan of moving loads with respect to tonnage, assortment, periods, and cost of transportation. By relating all the expenses connected with operation, maintenance, and repair of the transport facilities to the criterion of a ton of load moved, the cost of moving one ton, one ton-kilometer, or the cost of moving one ton by a distance of one kilometer are obtained.

At enterprises, planned prices are established for the use of transport facilities per hour of operation or for the completion of trips over a definite route. The planned annual reduction of the prices shows the extent to which the technology and organization of transport is improving.

The coefficient of utilization of the facilities with respect to time represents the ratio of the time of utilization of the transport facilities to the calendar time.

The coefficient of utilization of the facilities with respect to load-carrying capacity represents the ratio of the weight of the load moved to the rated load-carrying capacity (as shown on the rating plate) of the transport device, during the time of its useful work.

The coefficient of technical readiness of the pool represents the ratio of the number of machines completely ready for operation and for departure on a run to the number of machines carried in the inventory pool of the plant.

The coefficient of consumption of fuel, rubber, lubricants, and abrasive materials represents the ratio of the actual consumption of fuel for other materials to their standard consumption, established for 100 km of run.

The most important work indices of the transport system are reflected in the plan prepared annually by the transport shop of the enterprise.

To reduce the expense of the transport system, it is necessary to organize the transport work on the basis of independent, unsubsidized operation and on the extensive use of advanced working methods of dispatchers, truck drivers, and maintenance crews.

The organization of citywide transportation systems to handle the out-of-plant shipments for all enterprises of the city, yields a great economic advantage.

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PART FIVE

INTRAPLANT PLANNING

The socialist national economy can be run properly only on the basis of the demands of the economic law of planned proportional development of the national economy, which is the regulator of production in the socialist economy.

The planned, proportional development of the national economy makes it possible for the economic life of the USSR to be guided by the State national economic plan along the paths of continuous increase in social wealth, of constant rise in the living standard and cultural level of life of the laborer, of the strengthening of the independence of the USSR, and the intensification of its defensive power.

Thanks to the action of the economic law of planned proportional development, our national economy has been freed from economic crises. It has thus become possible to plan the social production, ensuring its uninterrupted development at scheduled proportional high rates, on the base of the highest technology, and with a constant growth in the production of manufacturing means.

The effect of this law leads to an economic organization of the work of each enterprise and a complete utilization of its material and human resources, ensures a high form of stable and constant profitability of the socialist enterprise, limiting the degree of influence of the law of material value on production.

The planning of the national economy and of the individual enterprise yields positive results only in the case where it correctly reflects the demands of the law of planned, proportional development of the national economy.

In accordance with the fundamental object of socialist production, the planning of the industrial activity of an enterprise is directed toward increasing the output, raising its quality, and constantly reducing its production cost. The planning

of the socialist enterprise must specify the continuous growth and improvement of production on the basis of the highest technology.

In accordance with the demands of the law of constant growth in labor productivity, the planning of the work of an enterprise is directed toward the creation, for each workman, of the technical and organizational conditions necessary for attaining a high output during the shift, for uninterrupted utilization of the equipment, and maximum yield of product.

In accordance with the requirements of the law of distribution according to labor, the planning is directed toward reinstatement of personal responsibility in the organization of labor and its payment, toward widespread use, in the shops, of advanced methods of work and progressive technical standards of time and output.

In accordance with the demands of law of material value, the planning of the work of an enterprise is directed toward stable profitability of production.

Intraplant planning, in its content and the methods of its realization, is subdivided into technical-economic and operative-productive.

Technical-economic planning consists in developing progressive technical-economic standards; in preparing the technical-industrial-financial plan and in coordinating its indices with the low levels of the productive units; as well as in organizing the record and control over the fulfillment of the planned assignment by each unit.

Operative-productive planning is the direct extension of technical-economic planning and consists in organizing uniform work by graph at each work station, section, and shop and in their executing the production program in each shift.

For a planned development of production at high rates and for a more economic utilization of the productive capacities and facilities of a socialist enterprise, it is necessary to have, together with the annual plan, a prospective plan of operation of the enterprise.

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CHAPTER XVI

TECHNICAL-PRODUCTIVE AND FINANCIAL PLAN OF THE ENTERPRISE

Section 1. Definition of the Technical-Industrial-Financial Plan, and Its Structure

A State enterprise has a technical-productive and a financial plan, which is prepared on the basis of the State plan assignments and represents the summary plan of the productive-technical and economic-financial activity of the enterprise.

The technical-industrial-financial plan is directed toward ensurance of technical progress of the enterprise and a more complete utilization of its material-labor and financial resources to fulfill the State assignment as to output of production, improvement of its quality, and reduction of its production cost.

The object of the preparation of the technical-industrial-financial plan is to find, with the active aid of the collective of the enterprise, ways and means of more economical fulfillment and overfulfillment of the State-planned assignment.

The technical-industrial-financial plan of an enterprise consists of the following mutually coordinated parts:

1) A plan of production, establishing, in physical and monetary terms, the productive program of the enterprise and the degree of utilization of the fixed assets;

2) A plan of technical development and organizational improvement of production;

3) A plan of supply of the enterprise with materials, purchased semifinished goods and component finished articles;

4) A labor plan establishing the growth of labor productivity, the labor cost of the production program, the composition and number of the workers of the enterprise, and their wage fund;

5) A plan of production cost of the product, showing the expenditures of production on the fulfillment of the program, and giving a calculation of the production cost of the finished product;

6) A financial plan, determining the volume of funds necessary for the enterprise to conduct its industrial and nonindustrial activity, the sources from which these funds will be covered, and the profitability of the enterprise.

The plan of capital construction is prepared by the enterprise separately from the plan of the primary production.

The indices of each division of the industrial-financial plan are justified by computation Tables and estimates, and are formulated on the basis of standards by the balance method. The balance method allows the requirements and the internal resources of the enterprise to be coordinated, thus ensuring fulfillment of the State assignment. For example, the program established by the enterprise must correspond to its productive capacity, and the consumption of materials must correspond to their arrival. What is taken into consideration is not the reached level of development of the enterprise, but a higher level, taking account of the development of technique, the increase of qualification and labor productivity of the personnel.

The work on the planning of production must not be reduced to the mere preparation of the plan, The preparation of the plan is the beginning of planning, while the genuine planned direction is developed in the course of the realization of the plan, of its refinement and improvement on the basis of mass experience. In the struggle for the fulfillment of the plan at the enterprise, socialist competition develops, disclosing new reserves for the accelerated rise of the national economy. The active participation of the masses in the fulfillment of the plan leads to an

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improvement in the quantitative and qualitative indices of the plan.

Section 2. Technical-Industrial-Financial Plan and Independent, Unsubsidized Cost Accounting

Independent, unsubsidized cost accounting is the fundamental method of the planned direction of a socialist enterprise, and is based on a combination of the centralized direction of socialist enterprises on the part of the government, with the economic-operative independence of each enterprise. The economic-operative independence of the enterprise is expressed in the fact that it receives, at its disposition, State means of production and has the opportunity of manifesting a broad initiative for their most rational utilization in the interest of fulfillment and overfulfillment of the plan.

The application of independent unsubsidized cost accounting makes it possible to provide material incentive to the workers of the enterprise for the fulfillment and overfulfillment of the industrial-financial plan. The system of material incentive must provide for the predominance of the interest of the socialist State and must encourage primarily the fulfillment of the principal, decisive indices of the plan. Such decisive indices, for all shops, are the fulfillment of the plan in output and list of products, the growth of labor productivity, work without spoilage, and lowering of the expenses of production per unit of output.

Unsubsidized independent cost accounting must penetrate to all units of the enterprise and encourage more complete discovery and utilization of the internal reserves. For each unit, under independent unsubsidized accounting, concrete economic indices of operation and progressive standards must be established, together with a system of recording work and the condition of bonus payment. It must be borne in mind that the introduction of independent unsubsidized operation should not be accompanied by complication of the record and report system. The economic independence of the shop differs from the economic independence of the enterprise. The shop is not a juristic person and does not possess the rights of one. The shop does

not acquire and does not sell its product and, consequently, does not enter the sphere of circulation. It does not have its own working capital and does not have a complete system of accounting with an independent balance sheet. For this reason, independent unsubsidized cost accounting is applied in the shops and production sections in a limited form only. The system should encourage the manufacture of a larger quantity of product of better quality and with smaller expenditure of labor and material values.

At present, independent unsubsizides operation in the shop is directed primarily toward stimulating the growth of labor productivity (by the application of unlimited individual or crew piecework systems and bonus payments for systematic fulfillment of the shift assignments during the course of the month).

However, together with the encouragement of the growth of labor productivity, other factors must also be stimulated to effect a lowering of the production costs in a shop, for instance saving of materials and reduction of overhead. For this purpose, the structure of the shop expense must be carefully studied.

Table 58 shows the structure of the shop production cost of certain shops.

This Table indicates that the cost of the primary production materials is the major expense item in the production cost of the fabricating shops. Consequently, the index of saving of materials is particularly important for independent unsubsidized operation in the fabricating shops.

The value of the materials, tools, and power occupy the largest place in the structure of the production cost of the stamping and machining shops. The specific indices of independent unsubsidized operation for these shops will be the savings of materials, tools, and electric power.

In the heat-treatment and fitting-assembly shops, the relative proportion of the expenditures on electric power and auxiliary materials is great. The economy indices of electric power and auxiliary material are of similar importance for this group of shops.

The production in which a large amount of labor and material expense has already been invested, is concentrated in the assembly shops. For this reason, the most

Table 58

Elements of Production Cost of Shop
(Total Production Cost, 100%)

Type of Shop	Materials	Semifinished Goods	Wages of Production Workers	Progressive Bonus	Shop Overhead	Percentage Contribution of Shop Production to Total Plant Production Cost
	In %					
Fabricating shops	72,6	0,9	6,9	1,2	18,4	36,7
This includes:						
Forging	55,4	—	6,4	1,1	37,1	2,1
Casting	54,6	—	13,3	2	30,1	1,1
Profiling	80,3	—	6,3	1,2	12,2	8,9
Sheet-metal layout and fabrication	92	—	1,7	0,3	6	13,5
Machine shops and machine-assembly shops	28,9	27,6	13,6	2,4	27,5	23,2
Fitting-welding and fitting-assembly shops	35,8	—	20,6	3,9	39,7	4,1
Intermediate shops (heat treatment and coatings)	25,6*	—	9,2	1,8	63,4	3,1
Riveting major assembly shops	20,7**	0,8	32,6	7,6	38,3	19,5
Final aircraft assembly shop	36,4**	2,6	24,1	6,7	30,2	6,2
Stitching shop	80,6	—	7,7	1,4	10,3	7,2
Other work (insulation, etc.)	47,7	6,9	14,8	3	27,6	—
Total	—	—	—	—	—	100

* Materials for anodizing and heat treatment.
** Purchased finished component articles are not distributed by shops in this Table, but are directly charged to plant production cost.

important specific index of independent unsubsidized operation for the assembly and

test shops is the shift-by-shift rhythmic output of product and the shortening of the assembly cycle.

The funds for bonus payments for obtaining good indices of independent unsubsidized work in the shop are taken from the amounts received from the over-plan reduction of production costs.

The system of independent unsubsidized operation of a socialistic enterprise must provide material incentive for the workmen and engineering-technical personnel in the output of more productive and economical aircraft, in the continual introduction of the latest technique and advanced experience into production, in the fullest utilization of the existing equipment and working time, in the development of interplant and intraplant specialization and cooperation, and in constant lowering of the production cost.

Section 3. Progressive Planned Standards and Procedure of Preparing the Technical-Industrial-Financial Plan

The socialist plans may play a mobilizing role in the case where the planning agencies are oriented toward new and advanced processes, when the plan is not based on arithmetic average standards but on progressive standards. For this reason, the indices of the technical-industrial-financial plan are calculated on the basis of technically justified time standards and average progressive standards of machine utilization and consumption of material values. Progressive standard Tables are worked out on the basis of utilizing the achievements of technology, the experience of advanced plants and of advanced production workers.

The standards on whose basis the expenditures of labor are standardized include the processing conditions and standard times, and the standards of equipment servicing.

The standards characterizing the utilization of equipment and productive area include the standards and coefficients of loading of equipment, the standard production of finished product per unit of equipment and per square meter of production area, and the standards of area for machines and equipment.

The standards on whose basis the consumption of material values are standardized include the average progressive standards of consumption of primary and auxiliary materials, fuel, power, and tooling per unit of finished product and per unit of equipment.

The standards on whose basis the requirement of the enterprise for working capital is determined include the standards for the stocks of fuel, materials, semifinished goods, and component finished articles in the warehouses, the standards of work in process at the shops, and the standards of duration of the manufacturing cycles for the finished product.

Progressive standards encourage utilizing the internal reserves of the enterprise and raising its lagging production sections to the level of the advanced sections. As the technique develops and the organization of production is improved, the standards in force are replaced by new and more advanced ones.

The State plan sets the assignment for the enterprise with respect to all of the most important economic indices of its operation: output of finished product and output of gross product in assortment, physical units, and value units; growth of labor productivity, of the number of workers, and their wage fund; cost of production; production cost of the principal forms of the product; and reduction of the production cost of comparable products. In accordance with the basic indices of the State assignment for the enterprise, the limits of consumption of materials, labor, and funds are established.

The limits for materials determine the material stocks alloted to the enterprise to fulfill the production program and to establish the necessary inventories of materials.

The limits with respect to labor determine the number of workers of the enterprise and the allotted wage fund (based on the planned growth of labor productivity and the average wage).

The limits of monetary resources for the enterprise establish the working assets of the enterprise, which are sufficient for fulfillment of the plant assignment with the planned reduction of production cost.

In accordance with the State plan assignment, and on the basis of an analysis of the productive-economic activity of the enterprise, the preparation of the technical-industrial-financial plan is approached. The technical-industrial-financial plan is the internal planning document of the enterprise. The development of the technical-industrial-financial plan begins with the establishment, by the director of the enterprise, on the basis of the State assignment and of the materials prepared by the planning-production department, of the order and dates for the preparation of the individual divisions of the technical-industrial-financial plan. The director sets up a production program for each shop, and an assignment for the introduction of new technique, for the improvement of product quality, for increasing labor productivity and the use of fixed assets, for reducing the production cost, together with a list of the most important economic and organizational measures to ensure attainment of the plan indices. The technical-industrial-financial plan is prepared under a centralized procedure by the planning-production department of the plant. The departments, shops, and services submit the necessary starting data – standards, estimates, calculations – to the planning department for calculating the indices of the technical-industrial-financial plan.

The shops take a direct and active part in working out the plan of economic and organizational measures and the estimates of shop expense for the expense items depending on the work of the shop.

The calculations and estimates used in preparing the technical-industrial-financial plan must be based on advanced standards and the advanced experience of production innovators. The statistical and accounting data in the preparation of the technical-industrial and financial plan are used primarily for control of the calculations. The department or service that has worked out standards is responsible

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for their correctness.

A properly prepared technical-industrial-financial plan must start out in all calculations from the established manufacturing process, from the most complete utilization of internal reserves, and must be supported by a plan of organizational and economic measures.

In the preparation of the technical-industrial-financial plan, the planning-production department of the enterprise coordinates all the divisions and indices of the plan. The draft of the technical-industrial-financial plan is discussed at a production-technical conference between the director and the leading workers of the plant, shops, and departments, together with representatives of the public organizations.

The technical-industrial-financial plan is approved by the director of the enterprise and is submitted at the prescribed date to the superior economic agencies for their information.

The government has enlarged the rights of the director of the enterprise, allowing him to modify the production plan within the limits of the quarter and to take orders from outside the plant for a more complete utilization of its equipment.

The record, control, and analysis of the results of fulfillment of the technical-industrial-financial plan are conducted on the basis of the data of the operative, statistical, and accounting records and allow the timely detection of disproportions that may arise and their timely elimination, as well as the discovery of new reserves and the development of measures directed toward the improvement of the work.

CHAPTER XVII

PLAN OF PRODUCTION (PRODUCTION PROGRAM)

Section 1. Purpose of the Plan and Classification of Product

The production plan must disclose, in physical and value units and in labor cost, the productive program of the enterprise, including the amount of its work under productive cooperation. The plan must show the degree of utilization of equipment and production areas for the given productive program and must establish the total production volume. It is prepared in the form shown in Table 59.

The production program must be prepared taking account of the interplant and intraplant specialization and cooperation.

In laying out the production program of an aircraft construction enterprise, the assignment for reduction of the labor cost of the aircraft is used as a guide, from which it follows that the program of increased output of aircraft is directly dependent on the stage of development of the series aircraft production occupied by the enterprise at the moment. The rate of reduction of the labor cost of an aircraft is particularly great during the initial period of aircraft production, and then gradually declines. In accordance with the rate of reduction of the labor cost of aircraft, the program for output of aircraft must increase.

We distinguish a production program with respect to start-up, to manufacture, and to output.

The program of start-up is directly connected with the plan of material-technical supply and reflects the extent of consumption of materials, semifinished

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goods, and finished components in production.

The manufacturing program reflects the value of the expenditures of production for the gross product.

The output program reflects the value of the expenditures for the finished product.

The starting data for calculating the production program are the plan indices, assigned to the enterprise, and the standards of labor cost of the articles, their manufacturing cycles, and the productive capacity and throughput capacity of the shops.

In the production program, the production of an enterprise is classified as gross production, commodity production, and work in process.

Gross production is the term applied to the total production of an enterprise. According to its degree of completion, gross production is subdivided into commodity (finished) production and work in process.

The commodity production of an enterprise is the product manufactured in accordance with the specifications or established standards, completely assembled including the necessary assemblies, instruments, and spare parts, as accepted by the inspection services and the purchaser's representatives and intended for realization outside the enterprise. The commodity production also includes such work and services of a productive nature as are rendered to others outside the enterprise.

The commodity production of an aircraft enterprise includes: 1) series products and products planned on one-time orders; 2) spare parts for series products, if their cost is not included in the wholesale price of the article; 3) semifinished goods produced by the enterprise, forgings, castings, stampings, manufactured for outside accounts; 4) civilian products and articles of mass consumption manufactured from the primary materials or from the production waste; 5) services for major overhaul and capital construction, except work on the repair and construction of buildings and structures; 6) electric power, steam, and other forms of power produced by

the enterprise and sold by the enterprise to outside interests; 7) production of the instruction and auxiliary shops, manufactured for outside account; 8) tares, if they are not included in the wholesale price of the product.

The commodity production of an enterprise does not include: 1) services of the plant transportation system for shipments to points outside the plant; 2) designing, planning and research work; 3) services and work on capital construction and major repair of buildings and structures; 4) work on installation and disassembly of equipment; except for cases where the cost of the installation work is not included in the wholesale price of equipment manufactured by the enterprise and is handled by the personnel of the given enterprise; 5) power, water, steam, and gas obtained from outside; 6) waste and rejects sold for salvage; 7) nonindustrial production of subsidiary producing units. The cost of this work, which does not enter into the gross production, is absorbed in the general estimate of production.

The finished product of an enterprise must not be confused with the finished product of the shops. The finished product of a shop is the product prescribed by the plan, accepted by the shop inspection office, and delivered by the shop to the finished product store of the enterprise or to another shop. For the enterprise itself, the finished product will be that part of the product of the shop which is realized by a plant outside the enterprise, and falls into one of the forms of commodity production of the enterprise enumerated above. All the other production of a shop is work in process, as far as the enterprise is concerned.

Work in process is the incompletely manufactured product designed to assure the uninterrupted rhythmic flow of production, in all stages of production from the first operation to the finalization of the delivery of the finished product. Work in process includes:

1) Blanks, parts, units, and assemblies produced by the plant, and located at work stations, inspection stations, shop stockrooms and laboraSTATs;
2) Products in assembly, being tested, or in process of completed but not

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Table 59
Production Plan (Production Program) (continued next p.)

Designation of Production	In Physical Units						In Wholesale Prices of July 1955						In Current Prices						In Labor Cost	
	Unit of Measurement	For Year	By Quarters				Unit of Measurement	For Year	By Quarters				Unit of Measurement	For Year	By Quarters				Time Standard Per Unit of Product in Standard Hours	Time Required to Fulfill Program, in Thousands of Standard Hours
			I	II	III	IV			I	II	III	IV			I	II	III	IV		
Commodity (finished) production:																				
A. Defense																				
Product A																				
Product B, etc.																				
B. Civilian																				
....																				
C. Articles of Mass Consumption	Thousand rubles																			
D. Other production	Same																			
1) Services to own capital construction and capital repair;																				
2) Services to development production, etc.																				
Total commodity production	Same																			
Change in balance of work in process	Same																			
This includes, for principal products:																				
....																				
Fabrication of special tooling	Same																			
Amortization of special tooling	Same																			
Total gross production	Same																			
Utilization of metal-cutting and forging-stamping equipment (in % of calendar time)																				
Output of gross production per square meter of productive area	Same																			
Output of gross production per 1000 rubles of fixed assets	Same																			

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yet finalized delivery under established plant procedure;

3) Change in balances of tools and attachments produced by enterprise and located at auxiliary shops, during the same period.

Work in process does not include materials, semifinished goods, and finished articles not produced by the enterprise itself and located in the shop stores.

Section 2. Production Criteria

The production of an enterprise is measured in physical, labor, monetary, and arbitrary units.

Physical criteria are pieces, for expressing the number of products, assemblies, or parts; units of weight, tons or kilograms, for measuring material; sets, for measuring products sold in sets.

The labor expense criteria are the man-hour, machine-hour, standard-hour. In the productive plan, the labor cost of an article is calculated in standard-hours and in man-hours.

The monetary criterion is the ruble.

The gross production is valued in stable prices; for the sixth Five-Year Plan, these are the prices introduced on 1 July 1955. The stable price for the period of a current Five-Year Plan is necessary for comparing the indices of operation of an enterprise for different years.

Commodity production is valued in current price-list wholesale prices approved by the government, or according to temporary contract prices; in a case where there are no such prices (for a newly introduced product), arbitrary wholesale prices are adopted in the plan.

The services for major overhaul and capital construction are valued according to the estimate prices, which are coordinated, for the calculation, with the wholesale prices. The basis for the charging of services as finished product is the percentage statement for the volume of work performed, signed by the purchaser of

the services.

The work in process may be expressed in standard-hours or in nominal sets, and is always rated in rubles.

The nominal sets $N_{n.s}$ are determined as the quotient obtained by dividing the total volume of work in process, expressed in standard-hours, by the standard labor cost of one finished product, likewise expressed in standard-hours:

$$N_{n.s} = \frac{H}{T_{meas}}$$

The money value of work in process is taken according to the plant production cost and according to wholesale prices.

The balance of work in process is rated by individual shops only for the expense of the shop itself; but the total value, for the enterprise, is included in the value of the intershop manufacturing reserve stocks.

Section 3. Computation of Labor Cost of Unit Product

The expenditure of labor on a product may be calculated by consolidation, or in detail.

The method of the consolidated labor cost computation for the manufacture of an aircraft is used in the planning and reconstruction of aircraft construction enterprises, for the economic justification at the stages of sketch and working design of the technological characteristics of the aircraft, for preparing the directive graph of preparation of production for the start of a new aircraft in series production, for the economic planning of series production, and for the preparation of prospective plans for its development.

The consolidated computation method consists in establishing the labor cost of manufacturing an aircraft, depending either on the number of aircraft produced or on the daily production, taking account of the weight characteristics of the aircraft.

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The former method was developed by the American researcher Wright, who established the fact that, for each doubling of aircraft output, the labor cost of manufacture for aircraft is reduced by 20%. This relation was expressed by Wright in the formula

$$y = b \cdot x^m$$

where y is the labor cost of the aircraft being determined, in man-hours;

b is the labor cost of the first aircraft, in man-hours;

x is the serial number of aircraft whose labor cost is to be determined;

m is a negative exponent.

Using this formula, Wright constructed what is called the 80% graph of reduction of labor cost per aircraft (Fig.122a).

Wright's formula and graph do not express the effect of the technique employed and the rate of production on the lowering of the labor cost. In practice, however, for the production, let us say, of one aircraft a day, certain technical means and methods or organization of production are used, while for the production of 10 aircraft a day other and more productive techniques and methods are used.

The Soviet engineer S.I.Yel'kov developed a second method of consolidated determination of the labor cost of the aircraft T, as a function of the daily production of aircraft N_c (cf. Fig.122b). This relation is expressed by the formula

$$T = b' \cdot N_c{}^m,$$

where b' is a constant corresponding to the labor cost of manufacturing one aircraft a day;

m is a negative exponent which varies for aircraft of different classes, and decreases with increasing daily output.

It has been established that, with increasing overall dimensions of the aircraft, the area of the surfaces processed increases to a lesser extent than the weight of the aircraft. For this reason, the labor cost per kilogram of weight will

be considerably higher in a light aircraft than in a heavy one. Starting from this proposition, S.I.Yel'kov expressed the relation between the growth of labor cost of the aircraft and its weight characteristic by the formula

$$T = T_1 \sqrt[3]{C^2},$$

where T is the labor cost of the aircraft being determined in man-hours, for the given daily output;

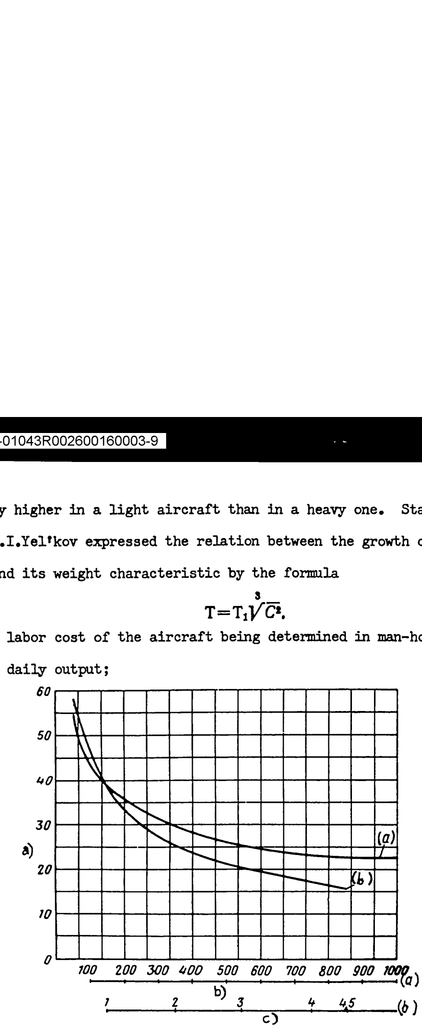

Fig.122 - Influence of the Number of Aircraft Manufactured (a) and the Daily Output of Aircraft (b) on the Reduction of the Labor Cost of Manufacture of the Aircraft

a) Labor cost in arbitrary units; b) Number of aircraft produced; c) Daily output of aircraft

T_1 is the labor cost of an aircraft of earlier or comparable design, in man-hours;

C is the ratio of the empty weight of the various aircraft being compared:

$$C^2 = \left(\frac{q}{q_1}\right)^2;$$

q is the weight of the aircraft whose labor cost is being determined, without taking account of the weight of the components not manufactured by STAT aircraft-construction plant itself;

q_1 is the weight of an aircraft of preceding or comparable design, without taking account of the weight of the components not manufactured by the aircraft construction plant itself.

The method of detailed calculation of the labor cost of an aircraft is based on the standardization of the work.

Under this method, the labor cost of the product is determined as the sum of the time for the standardized work and the time for the time-basis work:

$$T = (t_{stand} + t_{time})$$

The standardized operations t_{stand} are prescribed by the series or tentative process charts and are calculated in standard-hours. As a series process is established, the tentative standards are replaced by the standards of the series process.

The time-basis operations t_{time} are calculated in man hours and are performed by straight-time workers. Such work includes the work on testing the product, on flushing and polishing the parts, etc., which are calculated according to the standard time of servicing equipment.

Section 4. Calculation of the Production Program

In the production program, the production is classified as commodity production, as the change in the balance of work in process and in the balance of special tooling, and as gross production.

Commodity (finished) production in the program is divided into defense, civilian, mass-consumption, and miscellaneous.

Finished production is estimated separately by labor cost for each form of such production, by multiplying the amount of production indicated in the annual program $N_{ob.\ ann}$ by the standard labor cost of one manufactured object T, and is expressed in hours:

$$T_{ann\ pro} = N_{ob.\ ann} \cdot T$$

The calculation of the finished product by value $C_{f.p}$ is performed separately for each form, by multiplying the amount of production $N_{o.\ ann}$ indicated in the annual program by the wholesale price WP of one product:

$$C_{f.p.} = N_{ob.ann} \cdot WP.$$

The volume of productive services is expressed in standard-hours and in rubles, and is divided into services to the enterprise's own capital construction and major overhaul and into services to others, for instance, to a development production organization. The volume of the productive services is determined by an estimate or contract. The labor cost and the value of the services are calculated in the same way as for the finished product.

The computation of work in process is the most complex part of the calculation of the production program. In calculating the amount of work in process, account is taken, in the first place, of articles whose manufacture has not been finished, which have been carried forward from the past year into the present year, and ensure the program of output of commodity production in the first month of the planned year; in the second place, account is taken of the work in process of the planned year. By far the largest part of this work in process will go into the commodity production of the planned year. The other and smaller part, whose amount depends on the length of the aircraft manufacturing cycle, will be carried forward into the work in process in the year following the planned year.

For instance, with a five-month aircraft manufacturing cycle, the program of aircraft output from January to May in the year following the planned year will depend on the extent to which the starting of work in process was correctly calculated and actually accomplished from August to December in the plan year. In order correctly to calculate the work in process, one must know the length of the aircraft manufacturing cycle, know for how many months, or years, the plant will continue to manufacture aircraft of this same design, and must also know what the prospec[STAT]r their series production are in the plan year and the year following it.

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Work in process is calculated according to the standard, according to the degree of completion, and according to the value for each type of production.

To determine the amount of work in process by the standard, one must know the length of the manufacturing cycle of the product. The length of the production cycle is determined, in the fabricating and processing shops, from the cycle of the parts and units with the longest manufacturing period; in the assembly-riveting shops, from the cycle of the major component with the longest period of assembly; and in the final assembly shop, from the aircraft assembly cycle. The cycle of aircraft manufacture is considered to be the period from the time the starting materials and blanks are first put into production to the day of acceptance of the finished aircraft by the purchaser. The amount of work in process according to the standard H equals the length of the productive cycle of manufacturing the product in days Cy, multiplied by the daily average output of product in the planned period N_c, i.e.,

$$H = Cy \cdot N_c.$$

In order to determine the amount of work in process by its degree of completion, we must know the amount of work in process, its present condition, and its present stages of production. To determine work in progress by degree of completion, the coefficient of product completion is used. The coefficient of completion K_c represents the ratio of the labor cost of the production whose manufacture has not been completed to its total labor cost.

The Table below gives examples of calculating the coefficient of completion of work in process by parts and by shops.

The volume of work in process for the product as a whole may be expressed in nominal aircraft, and is calculated by the formula $H_c = Cy \cdot N_c \cdot K_c$.

Example. In a given work in process, there are 160 products for which the manufacturing has not been completed and whose labor cost, according to the inventory data or to the accounting record, amounts to 16,000 hours, the standard time

[redacted]

per product being 200 hrs. Then,

$$K_c = \frac{16\,000}{160 \times 200} = 0{,}5.$$

To determine the amount of work in process by value, we must know the amount of expense for the product incurred at each stage of production. To determine the work in process by value, the cost-growth factor is used. Work in process by value is determined according the formula

$$H_c = Cy \cdot N_c \cdot C_{pl} \cdot K_{pl}$$

Calculation of Coefficient of Completion of Work in Process

By Part					By Shop				
Operation No.	Production Reserve for Part on 1 December 1956: Number of Parts in Operation	Labor Cost in Standard Hours: In Operation	Labor Cost in Standard Hours: Cumulative Total: Per Part	Labor Cost in Standard Hours: Cumulative Total: For all Parts in the Manufacturing Reserve Stock	Part No.	Number of Parts in Manufacturing Reserve Stock	Labor Cost of Parts, in Standard-Hours	Coefficient of Completion of Manufacturing Reserve, by Parts	Labor Cost of Manufacturing Reserve in Standard-Hours, Taking Account of $K_{c.p}$
1	60	0,1	0,1	6	1	150	90	0,5	45
2	50	0,2	0,3	15	2	200	65	0,54	35,1
3	40	0,3	0,6	24	3	300	75	0,6	45
Total	150	0,6	—	45	Total	—	230	—	125,1

$$K_{c.p.} = \frac{45}{150 \cdot 0{,}6} = 0{,}5 \qquad K_{c.s.} = \frac{125{,}1}{230} = 0{,}54$$

where C_{pl} is the planned plant production cost of one product in rubles;

K_{pl} is the weighted average cost-growth factor.

Example. With an annual output program of 1000 aircraft, the mean daily output is 1000 : 307 = 3.23 aircraft. The length of the production cycle of the product is found to be four months, or 26 × 4 = 104 days. With 20 aircraft in STATries and the total cost of 1500 thousand rubles charged to the series, the production

[redacted]

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cost per aircraft is 1500 thousand rubles: 20 × 75 thousand rubles. Taking account of the planned percentage of reduction of the production cost (say 15%), we obtain the planned production cost of one aircraft as 75 · (1 - 0.15) = 63.75 thousand rubles. With a weighted average cost-growth factor of 0.8, the amount of working capital the enterprise will require to finance the balance of work in progress will be

$$H = N_c \cdot Cy \cdot C_{pl} \cdot K_{pl} = 3.23 \times 104 \times 63.75 + 0.8 = 17{,}131.92 \text{ thousand rubles}$$

In preparing the technical-industrial-financial plan, the following two methods of calculating the volume-production cost-growth factor and the volume of work in process are used:

1. The first (simplified) method is recommended for enterprises with a large product list and a short production cycle. Under this method, the volume-production cost-growth factor for work in process by production cost is calculated from the formula

$$K_{pl} = C_m + \left(\frac{1 - C_m}{2}\right),$$

where C_m is the proportion of the value of the primary materials to the production cost of the product for the plan period;

$\frac{1 - C_m}{2}$ is half the remaining expense for the principal items of the estimated cost of the finished product (production wages, shop and plant expense).

Under this method of computing the cost-growth factor for a product, we start from the procedure under which the materials, semifinished goods and finished articles are charged to production cost to the full extent of their consumption and value, immediately on their transfer to work in process, while the labor expenditures in production increase during the course of the month in equal parts, i.e., by 4% a day.

Example. The plant production cost of the product is 15,000 rubles, which includes: cost of the primary materials 4500 rubles; production wages 3000 rubles;

shop expense 5000 rubles; and plant expense 2000 rubles. Then,

1) $C_m = 4500 : 15\,000 = 0{,}3;$

2) $K_{pl} = 0{,}3 + \left(\frac{1 - 0{,}3}{2}\right) = 0{,}65.$

2. The second method is recommended for enterprises producing articles with a long production cycle. Under this method, the cost-growth factor is established by dividing the weighted average cycle or measure of the time that each form of expense remains in the work in process, by the length of the full cycle of production of the product. For instance, if the production cycle of the product is 45 days, and the weighted average cycle of stay of the primary materials in the work in process is 33.83 days, then the cost-growth factor for the primary materials will be 33.83 : 45 = 0.75. Table 60 shows the technique of calculating the cost-growth factor by forms of expense.

The volume of work in process is calculated in nominal sets, by production cost, and in wholesale prices for a finished product. Table 61 shows this computation method. The method of calculating in nominal machine-sets or, as it is sometimes called, in nominal reduced machines, is the principal method in aircraft building. This method is based on the labor cost of the work done, expressed in standard-hours. The production cost of nominal machine-sets by each form of expense is obtained on multiplying the number of nominal machine-sets by the standard for that form of expense. The change in the volume of work in process, expressed in planned production cost, by elements of expense, is established by subtracting from the production cost of nominal sets at the end of the quarter the production cost of the same nominal sets at the beginning of the same quarter.

The volume of working process is calculated separately for each form of primary product.

If such calculations involve a large amount of work, the change in the volume of work in the process is determined for the entire output as a whole, start STAT from the production cost of the work in process for the entire output of the plant

Table 60

Example of Calculation of Cost-Growth Factor

Designation of Shop	Production Cycle in Days	Relative Proportion of Cost Per Machine Set								Weighted Average Cycle of Stay of Expense in Work in Process					
		For Raw Material and Primary Material		For Semi-finished Goods		For Finished Articles		For Production Wages (by Labor Cost)		By Raw Material and Primary Material (col. 2 × col.4)	By Semi-manufactured Goods (col. 2 × col.6)	By Finished Articles (col.2 × col.8)	By Production Wages (On Labor Cost)		
		Of Grand Total	Cumulative Coefficient	Of Grand Total	Cumulative Coefficient	Of Grand Total	Cumulative Coefficient	Of Grand Total	Cumulative Coefficient				By Total Value (col.2 × col.10)	Coefficient of Completion in Shop	Taking Account of Coefficient of Completion in Shop
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Casting	4	0,67	0,67	—	—	—	—	0,07	0,07	2,68	—	—	0,28	0,7	0,20
Machining	35	0,07	0,74	0,82	0,82	0,20	0,20	0,65	0,72	25,90	28,58	7,00	25,20	0,67	16,18
Assembling	5	0,11	0,85	0,03	0,85	0,64	0,84	0,17	0,89	4,25	4,25	4,20	4,45	0,90	4,00
Testing	1	0,15	1,00	0,15	1,00	0,16	1,00	0,11	1,00	1,00	1,00	1,00	1,00	0,98	0,98
Total for Plant	45	1,00	—	1,00	—	1,00	—	1,00	—	33,83	33,83	12,20			21,36
Weighted Average Cost-Growth Factor	—	—	—	—	—	—	—	—	—	$\frac{33,83}{45}=0,75$	$\frac{33,83}{45}=0,75$	$\frac{12,2}{45}=0,27$	—	$\frac{21,36}{45}=0,47$	

at the beginning and at the end of the planned period and from a conversion factor characterizing the ratio of the value of the finished product in comparable wholesale prices to the production cost of the same product turned out during the preceding quarter.

The cost of the work in process at the beginning of the planned period is established on the basis of the accounting data, taking into consideration the results of the inventory and the expected fulfillment of the plan. The production cost of the work in process at the end of the planned period is determined by calculation, for each type of primary production. The correct calculation of the volume of work in process helps to distribute it uniformly over all stages of production.

The gross production is equal in volume to the finished production plus the algebraic change in the balance of work in process and of special tooling. To establish the volume of gross production B, manufactured by the enterprise during the report period, the output volume of finished product F during this period must be added to the balance of work in process H_2, and the balance of special tooling CO_2 at the end of the report period; then, the balance of work in process H_1 and special tooling CO_1 at the beginning of the report period must be subtracted from it:

$$B=F+(H_2-H_1)+(CO_2-CO_1).$$

For instance, the volume of finished production for the year is planned by an enterprise, at wholesale prices, in the sum of 100 million rubles. The work in process at the beginning of the year was 40 million rubles, and the special tooling amounted to 30 million rubles. At the end of the plan year, the work in process is established in the amount of 50 million rubles and the special tooling in the amount of 40 million rubles. In this case, the planned gross production of the enterprise will be

$$B=100+50-40+40-30=120 \text{ million rubles}$$

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The gross production may be less than the finished production if the enterprise,

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because of the removal of an object from production, has put out a finished product by using existing work in process.

Section 5. The Subcontracting Plan

The labor cost of the production program depends to a considerable extent on the amount of subcontracting. The more extensively subcontracting is used, the more specialized will be the production and the smaller will be the list of work to be performed. In order to express properly in the production plan the labor cost of the production program, the work prescribed by the plan for subcontracting must be taken into account. In preparing this plan one is guided, on the one hand, by the State plan assignment and by the backlog of orders for work for other enterprises and, on the other hand, by the schedules of the department of the chief technologist and chief metallurgist indicating the parts and finished components for outside procurement. In addition to these schedules, the department of the chief metallurgist also prepares a balance of castings and forgings. The balance shows the requirements of the enterprise for castings and forgings which may be fabricated by the enterprise itself, and the items-list, number and weight of the workpieces to be procured from other enterprises. All orders entering into the subcontracting plan are calculated according to quantity, cost and dates of performance.

Section 6. Calculation of the Productive Capacity of an Enterprise

By productive capacity of an enterprise we mean its maximum capacity of producing finished products with the use of progressive techniques and technology, advanced methods of organization of production and labor, complete and efficient utilization of the equipment, productive areas, materials and working time.

The productive capacity of an enterprise depends not only on its technical equipment, but also, to an enormous extent, on the creative activity of the collective, on the skill of the workers in utilizing the technique, in improving the technology, and in making use of the latest achievements of science and advanced experience.

The value of the productive capacity is expressed in units of finished product. The calendar period for which the value of the productive capacity is established is the year. The maximum possible volume of production that can be produced by an enterprise during the course of the plan year is calculated on the basis of:

1) The product list and the quantitative relation of the forms of production whose output is prescribed by the technical-industrial-financial plan;

2) The number of units of installed equipment, taking account of the equipment to be introduced and removed; in this case, all equipment of the enterprise is considered as installed, regardless of its condition, whether operating, in repair, awaiting installation, or temporarily disassembled;

3) The total time of utilization of the equipment and areas at the maximum number of shifts and the maximum allowable load on the equipment, taking account of the time losses for planned maintenance and for setup of the equipment;

4) The labor cost of the production to be put out, calculated according to progressive standards and allowing for the planned growth of labor productivity factor;

5) The proportionality in the productive capacity of the production facilities and maintenance of their uniform loading.

The productive capacity of an enterprise is established on the basis of the maximum throughput capacity of the leading shops. In aircraft construction, the leading shops are the stamping, machine, and assembly shops. On change-over to welded aircraft structures, the welding shops will also be included among the leading shops.

In calculating the productive capacity, the basis must be the directives of the 19th Congress of the Communist Party USSR, which condemned the practice of determining the productive capacity of enterprises by equating it to the production "bottlenecks", and also condemned the use of excessively low standards of equipment product-

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Table 61 - Calculation Sample of the Volume of Work in Process, in Nominal Machine-Sets, by Production Cost and Wholesale Prices According to 1957 Plan

Designation and Code of Article	Plan of output, in machine-sets: Period of output	Plan of output, in machine-sets: Quantity	Length of productive process, in days	Expected and Planned Volume of: According to status on	In machine-sets, by numbers	Cost-growth factors: For raw materials and primary materials	Cost-growth factors: For semifinished goods	Cost-growth factors: For finished components	Cost-growth factors: For production wages	Number of nominal machine-sets: For raw materials and primary materials	Number of nominal machine-sets: For semifinished goods	Number of nominal machine-sets: For finished components	Number of nominal machine-sets: For production wages	In production, Per unit, in: For raw materials and primary materials	In production, Per unit, in: For semifinished goods	In production, Per unit, in: For finished components	In production, Per unit, in: For production wages
Product A	1st qu. 1957	180	50	1 Jan. 1957	100	0.75	0.75	0.27	0.47	75	75	27	47	250	50	220	125
	2nd qu.1957	240	45	1 Apr. 1957	120	0.75	0.75	0.27	0.47	90	90	32	56	225	45	200	115

(continued below)

Work in Process cost, rubles: In shop expense	In plant expense	For the number of nominal machines, in thousand rubles: For raw materials and primary materials	For semifinished goods	For finished components	For production wages	In shop expense	In plant expense	Total	Periods of 1957	Change in Volume of Work in Process (+, -), in thousand Rubles, In planned production cost: For raw materials and primary materials	For semifinished goods	For finished components	For production wages	In shop expense	In plant expense	Total	At wholesale prices on 1 July 1955: Number of nominal machine-sets	Wholesale price per unit	Total
250	125	18.75	3.75	5.94	5.87	11.75	5.88	51.94	I Q	+1.5	+0.3	+0.46	+0.57	+1.13	+0.565	+4.525	9	1.2	10.8
230	115	20.25	4.05	6.4	6.44	12.88	6.44	56.46	II Q										

ivity in calculating the productive capacity, as well as the establishment of standards of labor cost of products without taking account of advanced technology and of more improved methods of labor organization.

The productive capacity of a socialist enterprise is always being increased, owing to the steady growth of equipment, the improved organization of production, and the increased qualifications of the personnel.

An important factor in increasing the productive capacity is the growth of extensive and intensive utilization of equipment and productive areas.

Extensiveness of utilization of equipment is expressed by the time of its operation. To increase the extensiveness of utilization of equipment, its idle time must be reduced, and its uninterrupted utilization must be assured during the course of the shift, if possible without having to be set up again from shift to shift. This is accomplished by high-grade technical servicing of the work stations, by high-grade maintenance and care for the equipment, by increasing labor discipline, and by correct planning of production.

Intensive utilization of the equipment is expressed by the amount of its yield or product in unit time. In order to increase the yield of equipment in unit time, maximum mechanization of the process and modernization of the equipment is necessary, together with improvement in its tooling, in the methods of manufacturing the product, and in the method of operative-calendar planning of production.

Intensive utilization of areas is accomplished by rational location of the equipment, by reducing unnecessary passages and stores, by straightening the flow of production, by using overhead conveyors, by mechanizing and conveyorizing the assembly work, and by organizing the work on a wide front.

Intensive utilization of equipment and areas promotes improvement in the qualifications of the personnel and wide use of advanced experience, elimination of spoilage, and use of progressive output standards.

The productive capacity of an enterprise must not be confused with its productive program and its output standard. The former defines the maximum possible output of products by an enterprise under the conditions of high-efficiency organization. The latter indicates the planned assignment for the enterprise with respect to the output of finished product. The ratio between the amount of product indicated in the program and the amount of product that could be manufactured by the enterprise shows the degree of utilization of its productive capacity. Every effort must be made to have the program provide for the fullest possible utilization of productive capacities.

The output standard shows the amount of product that can be taken from the equipment by the operator at the given level of technique, organization of production and labor.

To find the degree of utilization of the production capacity of an enterprise under a given program, the utilization of equipment and productive area is calculated.

<u>Calculation of Utilization of Equipment</u>. To perform this calculation, the program of production of the gross product with its labor cost must be broken down by kinds of work, data on the products list, and amount of existing equipment, broken down into kinds, capacities and sizes, the progressive standards of output of product per unit of equipment and productive area, and the coefficients of utilization of the equipment, of overfulfillment of the existing standards by forms of work and equipment, and also the planned growth of labor productivity factor.

The required quantity of equipment is calculated on the basis of its maximum throughput. This reduces down to finding whether it is possible to manufacture the amount of gross product prescribed by the production program on the existing equipment.

To answer this question, a balance must be set up for each form of work and the form of equipment corresponding to it, in which the labor cost of the program for gross production in standard-hours T_b is equal to the actual annual fund of equip-

ment operating time F_{act}, allowing for the average coefficient of overfulfillment of the standard $K_{o.s}$ by the operators for the given type of work, and also allowing for the growth factor of productivity of labor $K_{p.l}$ in the plan year. Nominal and actual equipment operating times are distinguished. The actual operating time is shorter than the nominal time by the time of the planned maintenance of the equipment.

The amount of equipment N_{eq} necessary to fulfill the program is determined by the formula

$$N_{eq.}=\frac{T_b}{F_{act}\left(1+\frac{K_{o.s.}+K_{p.l.}}{100}\right)}.$$

The annual actual fund of operating time of the unit of equipment F_{act} is taken as equal to

$$F_{act}=D\cdot S\cdot H\left(1-\frac{K_i}{100}\right),$$

where D is the number of working days per year;

S is the number of working shifts per day;

H is the number of working hours per shift, taking account of the shortened work day on days before rest days and before holidays;

K_i is the coefficient of idle time of the equipment for planned maintenance (from 2 to 5%).

The utilization of equipment is estimated separately for each shop and for each of its production sections. The differentiated calculation by production sections allows a more complete utilization of the equipment, detection of bottle necks and redistribution of the work in cases where some sections are overloaded and others underloaded.

The technique of calculating the throughput of equipment depends on the form of organization of the production section.

On production lines, the pace of output of the production line is first established, and, in accordance with the duration of the operations of the line, the coefficient of utilization of the equipment, and the required amount of equipment, are determined for each operation.

Table 62

Calculation of Throughput of Equipment of Machine Shop for Quarter (in Machine-Hours)

No.	Indices	Unit of Measurement	Number of Finished Articles (According to Plan)	Lathes: Standard Time per Unit of Product	Lathes: Machine-Hours Required for Program	Turret Lathes: Standard Time per Unit of Product	Turret Lathes: Machine-Hours Required for Program
1	Products						
	A	Piece	150	170	25 500	45	6 750
	B	Piece	350	150	52 500	30	10 500
	C	Piece	100	50	5 000	20	2 000
2	Other production	1000 rubles	500	60	3 000	30	1 500
3	Change of balance of work in process	Same	+20	36	720	25	500
4	Machine-hours needed according to plan of output	Machine-hours	—	—	86 720	—	21 250
5	Planned fulfillment of standards	%	—	—	125	—	125
6	Machine-hours needed according to plan of output, taking account of overfulfillment of standards in planned year	Machine-hours	—	—	69 400	—	17 000
7	Fund of operating time per machine under conditions assumed	Machine-hours	—	—	1 248	—	1 248
8	Number of machines in group	Pieces	—	—	60	—	15
9	Fund of operating time of group under conditions assumed	Machine-hours	—	—	76 880	—	18 720
10	Losses during maintenance adopted in calculation:						
	a) in percent		—	—	5	—	8
	b) in hours		—	—	3 840	—	1 498
11	Working fund of time	Machine-hours	—	—	73 040	—	17 222
12	Coefficient of equipment loading	-	—	—	0,95	—	0,99
13	Shortage of machine-hours	-	—	—	—	—	—
14	Excess of machine-hours	-	—	—	3 640	—	222

On non-line production sections, the technique of calculation depends on the uniformity of the parts assigned to the section.

If one or several uniform groups of typical parts are assigned to the section, then the calculation of the productive capacity of the section is made according to typical representatives.

If parts of different kinds are assigned to the production section, then the productive capacity of the section is estimated by adding the labor cost of the parts according to types of work or to types of equipment. Further, for each group of equipment of the same type, its throughput is calculated. An example of the calculation of throughput of the equipment of a machine shop is given in Table 62. The load must be so planned as to utilize, completely and uniformly, each type of equipment.

The required productive area is calculated on the basis of the maximum possible yield of product per square meter of productive area.

The area of the shop is divided into productive and auxiliary areas.

Productive area is the area directly occupied by the work stations of the productive sections of the shop. For each type of equipment, there is a standard of productive area.

Auxiliary area is an area occupied by auxiliary workshops, stockrooms, office and personnel rooms, aisles, and corridors. The dimensions of the auxiliary area are calculated from the standards, or are taken at a definite percentage of the productive area. An attempt must be made to increase the productive area at the expense of the auxiliary area and to plan most rationally the arrangement of the work stations in the productive area.

The size of the area of the processing shops is determined by the formula

$$F_s = F_{pr} + F_{aux} = N_{w.s.} f_{w.s.} \left(1+\frac{K}{100}\right),$$

where F_s is the total area of the shop, in m^2; STAT

F_p is the productive area, in m^2;

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F_{aux} is the auxiliary area, in m2;

$N_{w.s}$ is the number of work stations in the shop;

$f_{w.s}$ is the average area per work station, in m^2;

K is the ratio of the auxiliary area of the shop to the productive area, expressed in %.

The size of the area in the assembly shops F_{as} is determined by the formula

$$F_{as} = \frac{A}{D \cdot S \cdot H\left(1 - \frac{K_l}{100}\right)} + F_{aux}$$

where A is the number of articles, multiplied by the area necessary for the assembly of the finished product and multiplied by the duration of the assembly of this finished product;

D is the number of working days in the planned period;

S is the number of shifts in the working day;

H is the duration of the shift, in hours;

K_1 is the coefficient of time loss for planned maintenance of both area and equipment (usually 2 - 3%).

In order to determine the coefficient of utilization of the area of an assembly shop, the assigned program must be compared with the throughput capacity of the shop with respect to areas, expressing them in one and the same units of measurement.

For this purpose the Table below is prepared (Table 63).

From this Table, the following equation can be derived:

$$N_{ob} f \cdot Cy = F_{as} D \cdot S \cdot H\left(1 - \frac{K_l}{100}\right).$$

The results of calculating the throughput capacity of the equipment and the productive areas are reflected in the balance of utilization of the productive capacity of the enterprise, which is established with a breakdown by shops, forms of work, and equipment. The balance helps to detect the bottlenecks of the enterprise and eliminate them.

Section 7. Distribution of Output by Months and Procedure for Initiating Orders for Its Manufacture

The production list, quantity, and periods of output of the finished product, indicated in the production program, must completely correspond to the State assignment.

Table 63

Program of Shop in m^2-Hours					Area of Shop in m^2-Hours				
Designation of Finished Product	Program of Production of Finished Product per Year, in Pieces	Area Necessary for Assembly of One Finished Product, (f) in m^2	Length of Cycle for Assembly of Finished Product, in Hrs	Total Number of m^2-hrs Necessary to Fulfill Program	Productive Area of Shop in m^2	Number of Working Days in Planned Period, one Year	Number of Shifts in Working Day	Length of Shift in Hrs	Total Number of m^2-Hours in Shop during Plan Period
	1000	25	400	10,000,000	2050	307	2	8	~10,000,000

On distributing the output of finished product over the months of the year, the quarterly assignments and the dates of filling the individual orders, are used as guides, as well as the time necessary for the technological preparation for production. The distribution of the output of finished product by quarters and months is reflected in the calendar plan.

At an aircraft construction enterprise, the planning and production department and the central accounting office prepare an individual outside order for the shops for each form commodity production. This order indicates the deadline for the performance of the work and the limit of funds that may be expended by the shop to fill the order.

The costs of fabricating the tooling, maintenance of equipment and other internal work are finalized by internal orders.

The order constitutes the basis, for the shop or service, of the performance of the work and of the expenses connected with filling the order. The orders are issued to the shops by type of finished products and by series of their output.

Section 8. Gross Turnover and Internal Plant Turnover

The article, before becoming a finished product, passes through various shops during the process of its manufacture; for each of these shops, it is at first work in process and then only becomes finished production. Consequently, the article will be taken into account, and valued as gross production of a shop, as many times as there are shops through which it passes. For example, a forging valued at 50 rubles passes through three shops, the forging, machining, and assembly shops. It is therefore reflected in the composition of the gross production of the forging, machining, and assembly shops. In this way, the value of the forging will enter three times into the gross turnover and will amount to the sum of $50 \times 3 = 150$ rubles while it will figure only once in the gross production of the enterprise, as the sum of 50 rubles. In this case, the sum of the gross turnover has exceeded the sum of the gross production by $150 - 50 = 100$ rubles. This difference constitutes the internal plant turnover. Starting from these differences, the following definition of gross turnover and internal plant turnover may be given:

The gross turnover of an enterprise is the amount of total production of all shops of the enterprise. The fewer the shops through which an article passes, the smaller will be the gross turnover.

The internal plant turnover is the difference between the amount of gross turnover and the amount of gross production. The internal plant turnover indicates the value of the products of the individual shops, and the number of times this value is repeated in the gross turnover of the enterprise. An attempt must be made at reducing the discrepancy between the amount of gross turnover and the amount of gross production.

Section 9. Establishment of the Production Program at the Shops of the Enterprise

The production program of the primary producing shops are established by the planning and production department of the plant for each quarter and month on the basis of the summary calendar plan of output of production, taking into consideration the data on the actual fulfillment of the program during the past month (or quarter).

The production program of a shop is prepared taking account of the specialization of the shop to perform certain work, so as to make maximum use of the qualifications of the personnel, the equipment and the area of the shop, and to shorten the manufacturing cycle of the product.

Starting from the State assignment, the program of output is first established for the product testing shop, then for the assembly shops, then for the processing shops, and finally for the fabricating shops. The program of each shop is coordinated with the program of the other shops adjoining it and prescribes the dates of output of finished product and the necessary lead. Table 64 gives an example of the calculation of the program of a machine shop.

For the shops of the auxiliary production, the program established is such as to ensure the uninterrupted operation of the shops of the primary production, and the necessary lead in the yield of tooling or equipment by them. The program of a shop of the auxiliary production prescribes: 1) establishment and maintenance at the assigned level, in the primary producing shops, of stocks of tools; 2) establishment of a planned reserve of productive capacity (5 - 10%) to fill urgent orders, for instance due to modification in the tooling drawings; 3) fabrication of tools for the shops of the auxiliary production and for the servicing systems.

Section 10. Record and Analysis of the Utilization of Fixed Assets and of the Fulfillment of the Production Program

The utilization of fixed assets is determined from the data of the statistical, operative, and accounting record.

Table 64

Program of Machine Shop

Designation of Finished Product	Wholesale Price of Machine-Set in Rubles	Requirement: To Ensure Output of Assembly Shop, in Machine-Sets	Requirement: To Deliver the Spare Parts for Making up Sets of Finished Products, in Reduced Machine-Sets	Stock of Finished Parts at the Central Store, At Beginning of Year: Standard Inventory in Days	Stock of Finished Parts at the Central Store, At Beginning of Year: Average Daily Output in First Quarter of 1957, in Machine-Sets	Stock of Finished Parts at the Central Store, At Beginning of Year: Standard Stock, in Machine-Sets	Stock of Finished Parts at the Central Store, At end of Year: Standard Inventory, in Days	Stock of Finished Parts at the Central Store, At end of Year: Average Daily Output in Fourth Quarter of 1957, in Machine-Sets	Stock of Finished Parts at the Central Store, At end of Year: Standard Stock in Machine-Sets	Assignment to Shops for Delivery of Finished Parts to Store: In Machine-Sets	Assignment to Shops for Delivery of Finished Parts to Store: In Wholesale Prices in Thousand Rubles (Commodity Production)	Reserve Stocks in Production, At Beginning of Year: Production Cycle, in Days	Reserve Stocks in Production, At Beginning of Year: Production Reserve in Machine-Sets	Reserve Stocks in Production, At End of Year: Production Cycle, in Days	Reserve Stocks in Production, At End of Year: Production Reserve in Machine-Sets	Change in Work in Process (+ Increase, - Decrease): In Machine-Sets	Change in Work in Process (+ Increase, - Decrease): In Wholesale Prices, in Thousand Rubles	Coefficient of Completion	Program for Starts, in Machine-Sets	Amount of Gross Production at Wholesale Prices, in Thousand Rubles
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
						6 × 5*			9 × 8	3+4+ +10-7	2 × 11		6 × 13		9×15	16-14	2×17× ×19		11+17	12+18

* I.e., the data of col.6 multiplied by the data of col.5. Similarly in the other columns

The record of idle time of the equipment for maintenance is kept on the basis of the graphs of planned preventive maintenance and of the reports of the shop machinists.

The record of work in progress is kept from the work orders or route sheets, verified by the shop inspection office. The data of this record are refined by inventories taken monthly or quarterly in the shops. The record of finished production is kept on the invoices of delivery of finished production or on the statements of acceptance of the production signed by the purchaser.

The utilization of equipment (Table 65) and of the productive capacities is analyzed to detect unutilized reserves according to the following basic indices:

1. The output of gross production (in wholesale prices as of July 1,1955) per 1000 rubles of fixed assets, per machine, and per square meter of productive area. These indices are calculated by dividing the sum of the gross production in wholesale prices by the value of the fixed assets, by the number of units of equipment, and by the productive area of the enterprise. Such indices permit establishing the degree to which the technical-industrial-financial plan has provided for the growth of utilization of the existing productive capacity, and permit the comparison and evaluation of the work of enterprises, shops and sections producing analogous, or even different, products.

2. The amount of the fixed assets per workman. This index is calculated by dividing the amount of fixed assets by the payroll number of the workman.

3. The average percentage of equipment loading by types of equipment: forging-stamping, machine-tool, etc.

The analysis of the fulfillment of the production program is made by quantity, quality, completeness of sets, assortment and rhythmic character of output, and with respect to the fulfillment of the subcontracting plan.

The analysis of the plan for output of finished products begins with a comparison of the technical-industrial-financial plan with the amount of finished production

Table 65

Analysis of Utilization of Equipment with Respect to Time for .... Month, 195 .....,

in the Machine Shop

Designation of Uniform Groups of Equipment	Number of Units of Equipment, in Pieces: Installed for Report Quarter	Number of Units of Equipment, in Pieces: Actually Operating	Output of Prod. in 1000 rub.: Plan	Output of Prod. in 1000 rub.: Actual	Fulfillment of Plan of Output of Production in %	Shift Factor: Plan	Shift Factor: Actual	Calendar Fund of Time, in Hrs	Regime Fund of Time, in Hrs: Plan	Regime Fund of Time, in Hrs: Actual
1	2	3	4	5	6	7	8	9	10	11
1.Lathes (a)With Height of Centers up to 200mm, etc.	10	10	-	-	-	2	2	7200	4060	4160

Designation of Uniform Groups of Equipment	Idle Time due to Planned Maintenance, in hrs	Planned Fund of Time, in Hrs	Actually Operated, in Hrs	Percent of Utilization of Time Fund: Calendar	Percent of Utilization of Time Fund: Regime	Percent of Utilization of Time Fund: Planned	Idle Time in Hrs: Total	Idle Time in Hrs, This Figure Includes: Repair Outside of Plan	Lack of Electric Power	Lack of Materials	Lack of Work
1	12	13	14	15	16	17	18	19	20	21	22
1.Lathes (a)With Height of Centers up to 200mm, etc.	208	3952	3822	53.2	91.6	96.7	130	22	30	70	8

Designation of Uniform Groups of Equipment	Operating Time of Equipment lost in Spoilage, in hrs	Operating Time of equipment lost in connection with Deviations from established manufacturing process, in hrs	Time lost on Spoilage and in Connection with Deviations from Manufacturing Process, in hrs	Time actually Operated, after Deducting Time Lost on Spoilage and in Deviations from Manufacturing Process	Time Losses on Idle Time, Spoilage, and in Connection with Deviations from the Manufacturing Process	Output of Product per Mach.-Hr in Rubels: Plan (Col.4/col.13)	Output of Product per Mach.-Hr in Rubels: Actual (col. 5/col. 26)	Reserves of Output of Production (in Rubles) (Col. 29 × col. 27)
1	23	24	25	26	27	28	29	30
1.Lathes (a)With Height of Centers up to 200mm, etc.	20	80	100	3722	230	25.3	27.9	5440

actually produced. To know the manner in which the fulfillment of the plan has proceeded during the course of the year, the output of finished product is analyzed by months. Only the finished product and productive services are taken into account. The fulfillment of the plan with respect to output of finished product is also analyzed from the point of view of its influence on the production cost of the product and on the financial condition of the enterprise.

The work in process is analyzed in volume as compared with the established standards, and the uniformity of its distribution among the stages of production is also determined. The following versions may exist here:

Form of Production	Versions of Fulfillment of Progress: First	Second	Third	Fourth	Fifth	Sixth	Seventh
Commodity	Overfulfillment	Overfulfillment	Fulfillment	Fulfillment	Overfulfillment	Underfulfillment	Underfulfillment
Gross	Overfulfillment	Fulfillment	Overfulfillment	Fulfillment	Underfulfillment	Overfulfillment	Underfulfillment

The first four versions indicate the normal flow of production. It must be remembered in this connection that, in peacetime, a considerable overfulfillment of the plan of gross defense production by an aircraft construction plant is uneconomic because the defense product may suddenly be taken out of production, and, in that case, the excess work in process will go to the loss of the State. In addition, the overfulfillment of the plan for defense production, if it proceeds on account of the additional consumption of funds from the State budget, disturbs the distribution of funds established by that budget among the branches of the national economy. An aircraft building enterprise is allowed to overfulfill the plan of productio STAT gross product only on account of its own economy and reduction of the expenditures

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per unit of production.

The fifth version of fulfillment of the program shows that the enterprise (or shop) has fulfilled the program of output of the finished product by decreasing the work in process to a level below the established standard. This might have happened, in particular, owing to the fact that the enterprise did not start up production in the initial stages of the process due to lack of materials or due to the aircraft being taken out of production. The sixth version shows underfulfillment of the program of finished production, with a great accumulation of work in process. This might occur, above all, either owing to the low quality of the work in process, or owing to its uneven distribution among the stages of production. The seventh version indicates general backwardness of the plant, and the existence of serious maladjustments in its operation.

Table 66

Designation of Finished Products	Number of Units According to Plan	Actually Produced	Constant Price of Product, in Rubles	Cost of Entire Number of Products, in Thousand Rubles		This Includes Actually Produced, in Thousand Rubles		
				Planned	Actual	Within Limits of Plan	Over Plan	Not Covered by Plan
Product A	1000	1400	500	500	700	500	200	—
Product B	1200	900	600	720	540	540	—	—
Product C	2000	1800	1000	2000	1800	1800	—	—
Product D	Not in Plan	500	800	—	400	—	—	400
Total	—	—	—	3220	3440	2840	200	400
In %				100	106	87,4	6,2	12,4

The analysis of the fulfillment of the plan with respect to production quality consists in finding the volume and value of the rejects and the causes of their occurrence. The defects with which the assemblies and finished products are presented to the inspectors are studied, and attention is paid to the increase or decrease in the number of defects, and to the rapidity with which rejections are eliminated. The quality of the production of an enterprise is largely characterized by the number of claims from purchasers, a study of which helps to discover the flaws in the quality of production.

An analysis of the fulfillment of the plan with respect to assortment (products list) allows judging the degree to which the plan has been fulfilled for each form of finished production. It is important in this case to identify the finished products not covered by the plan (Table 66).

In the example presented in the Table, the enterprise has fulfilled the plan with respect to value by 106%. The total volume of output, however, includes 12.4% for the product D, which is not prescribed by the plan. Consequently, the enterprise has violated the assortment of production, and has not fulfilled the plan.

The analysis of the fulfillment of the plan with respect to rhythmic output of products consists in determining the deviations, by days or ten-day periods of the month, of the actual output from the established graph.

In the record by days, only those days in which the program was not fulfilled are noted. For instance, in normal output, the enterprise is obligated to fulfill the monthly program to the extent of 4% every day. During the course of the month, the enterprise violated the established daily output on 8 days. The rhythm of fulfillment of the program by this enterprise is $(25 - 8) \times 4 = 68\%$. The rhythmic output of product by ten-day periods is expressed by the amount of production delivered in each ten-day period and by the percent of fulfillment of the monthly plan of output of finished products, by ten-day periods of the month.

An analysis of the plan with respect to subcontracting makes it possible to establish the degree to which the enterprise has observed the set-completeness of filling orders and the shipment times of the product to the purchaser. STAT

CHAPTER XVIII

THE PLAN OF TECHNICAL DEVELOPMENT OF THE ENTERPRISE

The plan of technical development of an enterprise includes the plan of preparation of production for the output of new products, the plan of introduction of new technique, and the plan of organizational-technical measures.

Section 1. Plan of Production Preparation for the Output of New Products

The plan of production preparation for the output of new products determines the volume of the work and the funds needed by the enterprise to prepare production for the output of new products in series.

The new products include items that the given enterprise has not previously produced or products already in production whose design has been fundamentally modified, thus causing a considerable volume of work at the enterprise in preparing production for the series output of the modified product.

The plan of production preparation consists of a calendar graph of preparation, estimates of the expense for the introduction of the production of a new product, and estimates of the depreciation charges on special tools and attachments, and of the cost of establishment of stocks of such tooling.

The estimate of the expense of introducing the production of new products prescribes the one-time expenditures of the enterprise for the following work*, enumerated in the plan-graph of technological preparation of production for the

* This also includes the pay of the workers doing this work.

output of a new product: preparation of working drawings of the product; design of the series manufacturing process; design of the special tooling and of the process of its fabrication; development and finalizing of the specifications, standards and estimates for the product; testing of the materials, semifinished goods, and tools for the manufacture of the new product; acquisition or manufacture of the product used for testing or as a prototype; replanning, rearrangement, and setup of the equipment, except for the work on capital construction; training and retraining of the personnel in connection with the production of new products; correction of the technical documentation before change-over to series (or mass) output of the new product; payment of outside organizations for technical assistance; difference between the actual and planned production cost of the first development sample of the product or the first lot of products manufactured during development of the new production; manufacture of experimental models of special tools and special attachments; upkeep of the workshops and shops during the period of organization of production, as well as miscellaneous expenses connected with the development of the manufacture of new products.

The estimate is prepared on the basis of standards, separately for each newly developed article.

The expense computed from the estimate are charged by the enterprise to the production cost of the newly developed product. In this case, the expense is charged to production cost of series production, allowing for the size of the order, the necessity of proportional allocation of the expense to the output of each year, and the prospects of recurrence of the product in the orders of future years. Usually the period of complete amortization of the expenses must not exceed two years from the time of change-over of the production to the series output of the new product. The estimate indicates the extent of the amortization charges against each unit of product, and against the entire output of the plan year, and the balan[redacted] unamortized expense carried forward that existed at the beginning of the plan year

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and which will be carried forward to the year following the plan year. The procedure for its calculation is similar to the calculation given below for the amortization of the expense for special tooling. On individual orders, the expense for the development of a new production is charged directly to the order.

In the case where the manufacture of the experimental models of the product is paid for by the purchaser, their value is included in the commodity and gross output of the plant according to the contract-settlement price.

The estimate of depreciation charges on special-purpose tools and attachments provides for expenditure for the manufacture of the special tooling necessary only for the production of a given product, for restoration of the special tooling because of wear, and for the establishment and maintenance of stocks of special tooling at the central and shop tool cribs. The estimate of depreciation charges on tools and attachments is calculated in accordance with the consolidated standard established per kilogram of empty weight of the aircraft, since at the time the estimate is prepared, no manufacturing process covering the new aircraft is yet in existence.

The expense is estimated as follows. Starting from the empty weight of the aircraft and the priority of the tooling for its series production, the labor cost of building the tooling per kilogram of empty weight of the aircraft is found from the graph prepared by NIAT (Fig.123). This labor cost, for example, will amount for an aircraft of medium class weighing 50 tons, to 55 standard-hours per kilogram and for the entire empty weight, in small-lot production, to 50,000 × 55 = 2,750,000 standard-hours. Knowing the average cost of one standard-hour and multiplying it by 2,750,000, the sum of the expense necessary for tooling up the work stations with tools and attachments is obtained.

The sum provided by the plant estimate of depreciation charges on the special-purpose tools and attachments is distributed between the auxiliary and primary producing shops, manufacturing the special tooling.

The plan estimate of the cost of a set of special tooling is determined on the

basis of the approved manufacturing process and schedule for special tooling for each product. The cost of the special tooling is amortized monthly over a period of two years, in accordance with the estimate, approved for each type of product, for each year of depreciation.

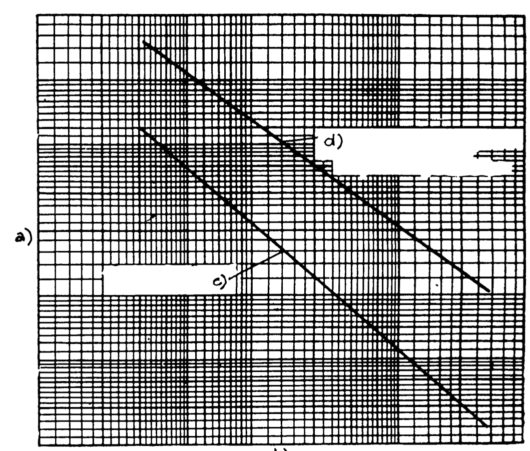

Fig.123 - Approximate Labor Cost for Manufacturing the Tooling Per One Kilogram of Empty Weight of the Aircraft

a) Labor cost of building tooling per kg of empty weight of aircraft, in standard hours; b) Empty weight of aircraft, in tons; c) For small-lot manufacture; d) For manufacturing with completely developed series production

The following procedure has been adopted for calculating the estimate rate.

The first case is in question when the expense for special tooling relates to an aircraft newly placed in production. For example, the preparation of production

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for a new aircraft began 1 June and ended 31 December 1956. During these months, 10,000,000 rubles were spent on building the tooling. The output of aircraft scheduled for 1957 is 40 aircraft and for 1958, 60 aircraft. The cost of building and supplementing the special tooling in 1957 will amount to 20,000,000 rubles, and in 1958 to another 20,000,000 rubles. Thus the planned expenditures on building special tooling amount to 50,000,000 rubles. From this amount, the cost of the tooling that can be used for future products, and the scrap value of unused tooling, is deducted. This amounts to about 10% of the total amount of the expenditures. The amount of the expense to be amortized and charged to the production cost of the commodity output will be 50,000,000 - 5,000,000 = 45,000,000 rubles. This amount must be amortized over the output of 100 aircraft in two years. In this case, the rate of amortization charged to the production cost of one aircraft will be 45,000,000 : 100 = = 450,000 rubles.

The second case is when the expense for the special tooling is written off on the aircraft in series production only one year. In this case, the balance of the special expenses carried over to the plan year is taken into account; let us assume that it is 10 million rubles, while the plan expense for building tooling during the current year is 20 million rubles. Then the total amount of the special expense to be written off will be 30 million rubles. From this amount we exclude 10%, which is recoverable through the value of the scrap and the tooling that can be re-used. Then the expense to be amortized during the plan year will be 30,000,000 - - 3,000,000 = 27,000,000 rubles. With a planned output of 100 aircraft a year, the special expense will enter into the production cost of the aircraft to the extent of 27,000,000 : 100 = 270,000 rubles. If the enterprise does not fulfill the plan of output of new production or if the product is taken out of production prematurely, the unamortized portion of the expense will be a loss to the enterprise.

To reduce the estimate rate, one must improve the quality and productivity of the tooling, plan the list and amount of tooling in strict conformity with the scale

of aircraft production, release funds for tooling to the enterprises in conformity with the planned percentage of its standardization and carry-over of design.

Section 2. Plan for Introduction of New Technique

In socialist production, the introduction of new techniques and technical progress proceeds in a planned manner. The planning is done by the enterprise for each year. The plan of introduction of new techniques is prepared by the department of the chief technologist, with active participation of all technical services.

The plan of introduction of new technique consists of the following divisions: division of standardization and normalization, which contains measures for the introduction into production of All-Union, industrial branch and plant standards and for the normalization of the process tooling and master tooling; division of preparation of production, which contains measures for improving the shops of the auxiliary production; division of automation and mechanization, which contains measures for the combined mechanization of the productive processes, and above all of the heavy and hazardous work, for automation of the most labor-consuming and mass work; division of application of new means and improved methods of technology for each form of work (fabricating, machining, etc.).

Each division contains a concrete list of criteria, indicating the purpose of the criterion, where it will be applied, the number of workmen to be covered by it, and the economic advantage expected.

Many of the measures included in this plan, before introduction into production, demand preliminary investigations, experimental verification, and refinement. For this reason, the measures in the plan are divided into current and prospective. Current work is done on the measures to be introduced into production in the plan year. Such work includes experimental verification of new methods and forms of tooling, development of conditions of cutting with new materials, development and testing of improved methods, replacement of one type of cooling or lubrication by another and

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more economical type. The future projects include research on the development of new technological means and processes, and on the development of substitute materials of full value.

The expense for the new technique is financed from several sources:

1) From the funds released by the State Bank for introduction of the new technique;
2) From the capital outlay covered by the estimate of the enterprise;
3) From the funds released for the building of special tooling;
4) From the transfers proposed by the enterprise for the conduct of research and experimental work;
5) For bonus payments to workers of the enterprise for the development and introduction of new techniques into production, special funds are provided which are not taken from the wage fund, but are set aside additionally to the extent of 0.3% of the planned production cost of the product.

The plan of introduction of new techniques (measures that have passed through research and experimental verification) enters as a component part of the plan of organizational-technical measures of the plant.

Section 3. Plan of Organizational-Technical Measures

The plan of organizational-technical measures combines all the technical-organizational and financial measures planned, which are to ensure the fulfillment and overfulfillment of the economic indices of the technical-industrial-financial plan. This makes the preparation of the organizational-technical plan and its realization particularly important.

The organizational-technical plan includes:

1) Measures to be introduced into production, as a result of the research work of the laboratories and departments;
2) Measures provided by the plan of introduction of new techniques;

3) Measures of the shops, departments and services for improving production and introducing advanced methods of production and labor;
4) Inventive and rationalizing suggestions by the workers of the enterprise;
5) Suggestions envisaged by the decisions of the production conferences, to examine the income and expense statement, and resulting from a technical-economic analysis of the operation of the enterprise.

The plan includes measures favorably affecting the profitable operation of production in the plan and subsequent periods.

All the work on the preparation and realization of the organizational-technical plan is subordinate to the introduction and development of new techniques, to the improvement of the organization of production and the widespread application of advanced methods of labor, with the object of reducing the production cost.

Procedure for Working out the Plan. The more workers of the enterprise take part in working out the plan of organizational-technical measures and the more concrete suggestions are received from them for improving the operation of the enterprise, the more thoroughly and the more comprehensively will it be possible to discover the reserves of production. The preparation of the plan of organizational-technical measures is directed by the chief engineer or, at his designation, by the chief technologist; the planning and production department prepares the initial indices. The chief engineer determines the problems to be solved by each shop, service, and department with respect to lowering the standards of consumption of raw materials, working materials, fuel, and electric power, the use of progressive standards and the reduction of the labor costs of the products, the better utilization of equipment and areas, the cutting of overhead; next, he establishes for each shop, service, and department the control assignments for the economy of funds and the lowering of the labor cost, work spoilage, and overhead and other expense per unit of product put out.

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Starting from these instructions, the services and departments prepare the

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draft plan of organizational-technical measures by shops.

For example, the departments of the chief technologist and chief metallurgist, in their organizational-technical plans, cover measures for improving the methods and equipment of the process technology; the department of labor and wages, cover measures for the introduction of advanced methods of work, for rationalization of labor and introduction of progressive technical time standards; the production department covers measures for the organization of rhythmic operation, the shortening of the cycle, and the increase in the equipment load; the department of financing and marketing covers measures for speeding up the turnover of working capital, for shortening the cycle of realization of production, and for putting the finances of the enterprise on a sound basis. In this case, the effectiveness of each measure is indicated. All these plans are summarized by the chief technologist, together with the other functional departments, into a draft of the plantwide plan of organizational-technical measures, and this draft plan is then forwarded to the shops for refinement, discussion, and extension. In the shops, the draft plan is put into more concrete form and is supplemented by their own suggestions. For a better discussion of the plan, the technological and other offices of the shop usually prepare a schedule of themes on concrete questions that should be decided by inventors and rationalizers. The administration of the shop, with the active assistance of the Party, Labor-union and communist youth organizations, using all means of mass propaganda and agitation, bring the indices and measures of the plan home to each foreman, workman, and employee, who actively discuss the plan and supplement it with their own suggestions. The shop administration is obligated to provide the workmen with constant technical consultation. After discussion of the plan, the specified measures are assigned to definite persons for execution, the deadlines for each measure are set, and the savings from the realization of the plan measures are refined in physical units and monetary units. In this way, the organizational and technical plan of the shop, whose form is shown in Table 67, is

Table 67

Plan of Organizational-Technical Measures of Shop for 1957

Serial Number of Measure	Contents in Brief	By Whom Proposed	Persons to Execute It	Date of Introduction into Production	Object on which measure will be performed: Code of Product	Object on which measure will be performed: No. of Unit or Part	Number	Computation Index	Planned Reduction of Expense according to Program, from Time of Introduction of Measures to End of 1957: On Basic Materials: Designation	On Basic Materials: Unit of Measurement	On Basic Materials: Unit Price	On Basic Materials: Per Unit: Number	On Basic Materials: Per Unit: Sum	On Basic Materials: Per Program: Number	On Basic Materials: Per Program: Sum	On Labor Cost and Productive Wages: Per Unit: Standard Hours	On Labor Cost and Productive Wages: Per Unit: Sum	On Labor Cost and Productive Wages: Per Program: Standard Hours	On Labor Cost and Productive Wages: Per Program: Sum	On Other Items of Calculation: Designation of Expense	On Other Items of Calculation: Shop Expense: Per Unit	On Other Items of Calculation: Shop Expense: Per Program	On Other Items of Calculation: General plant expense: Per Unit	On Other Items of Calculation: General plant expense: Per Program	On Other Items of Calculation: etc.: Per Unit	On Other Items of Calculation: etc.: Per Program	Total: Per Unit	Total: Per Program	On Program for 1957: Number of Products	On Program for 1957: Nominal Annual Saving	Expenditures on Performance of Measures: Source of Financing	Expenditures on Performance of Measures: Total Expense	Expenditures on Performance of Measures: This Includes Expenses Charged to Production Costs of the Plan Period	Savings, Less Expense of Carrying out Measures	Period of Recovery of Expenses
								Before Introduction																											
								After Introduction																											
								Savings																											

Table 68

Summary Plan of Organizational-Technical Measures

Designation of Measures	Planned Reduction of Expense from Time of Introduction of Measure to End of Year					Expenses of Conducting Measures	Savings Less Expense In Thousand Rubles
	In Raw Material and Other Materials, In Thousand Rubles	In Labor Cost and Production Wages	In Shop Expense, In Thousand Rubles	In Other Expense, In Thousand Rubles	Total Planned Savings In Thousand Rubles	Charged to Production Cost of Planned Period, in Thousand Rubles	
I. Measures pertaining to a definite article							
Total for product A							
Total for product B							
Total under Division I							
II. Measures of plantwide character							
Total under Division II							
Total for Plant							

established. The plan, refined and augmented in the shop, is transmitted to the planning department which, in collaboration with other departments, verifies the conformity of the shop plan with the control figures, refines the effectiveness of the proposed service, coordinates the deadlines and the personnel that is to carry out the measures to be performed by several shops jointly. The master plan of the enterprise is then prepared, together with the total estimate of the expense of carrying it out, indicating the expected effectiveness. Table 68 shows the form of the master plan.

The measures indicated in the plan are distributed by the planning and production department among the quarters and months to each subdivision; the additions reflecting the new elements yielded by advanced practice and science are introduced monthly into the plan.

In the shop plan, the measures are classified into those improving the design of the product, the manufacturing process and means of its manufacture, organization of production, labor conditions, and safety practice.

In the master plan, the measures are classified into measures pertaining to a definite product and measures of plantwide character.

According to effectiveness, the measures are divided into three groups. The first group includes measures whose effectiveness is established by direct calculation and which are expressed in a definite money-saving per part, per machine tool, per hour of work, or per any other unit of measurement. For instance, the saving of material per part may be expressed by the weight of the material saved and then converted into monetary terms.

The second group includes measures whose effectiveness cannot be directly calculated. For example, measures for improving the illumination of the work stations and for providing enclosures of hazard zones. The effectiveness of such measures is manifested only indirectly in the shop, in the form of improved labor product STAT and fewer accidents.

The third group includes measures whose economic effectiveness is manifested only at the consumers. For instance, increasing the mechanical strength of a tool may cause an increased expense to the enterprise manufacturing this tool. But the same measure, at the enterprises consuming this tool, will lead to an improved quality of processing and to an increase in labor productivity.

The procedure for calculating the effectiveness of measures has been established by the "Instructions for Compensations for Inventions, Technical Improvements and Rationalizing Measures".

The calculation of the effectiveness of the introduction of economic and organizational measures begins with establishing the area of the economic indices in which the measure will operate directly or indirectly, in order to obtain: reduction of cost of raw material and basic material, reduction of labor cost and productive wages, reduction of shop expense and overhead. These changes in the indices are expressed in quantitative units. The monetary saving obtained by the measure is next calculated. For this purpose, the expense caused by the implementation of the measure is subtracted from the gross monetary saving obtained by introduction of the measure.

The monetary savings due to a given measure are classified into actual saving, i.e., to the end of the year, nominal annual saving, and amount saved per order.

The saving to the end of the year is obtained for the period from the beginning of the industrial application of the measure to the end of its utilization during the plan year.

Example. After 1 September in shop No.4, the workman Ivanov used a new method of shaping duralumin sheet for ribs, increasing the coefficient of utilization of the materials from 75% to 90%. The monthly consumption of material for this group of parts is 1 ton. The cost of 1 ton is 15,000 rubles. The actual saving in material per month is $\frac{1\ (90-75)}{100} \times 15{,}000 = 2250$ rubles. The gross economy to the end of the year, i.e., from 1 September to 31 December amounts to 2250 × 4 =

= 9000 rubles. The cost of putting this suggestion into practice was 2000 rubles. In that case, the saving to the end of the year due to the realization of the suggestion is 9000 - 2000 = 7000 rubles.

The nominal annual saving is calculated as the net saving obtained from the operation of the measure during 12 months from the day of its introduction. If the volume of production of the following year is not known when the saving from the introduction of the measure is estimated, then it is figured according to the products manufactured at the end of the current year (fourth quarter). For instance, the nominal annual saving from the above suggestion of the workman Ivanov is (2250 × 12) - 2000 = 25,000 rubles.

The saving on the order is calculated if the measure proposed pertains to a one-time order.

In evaluating the economic advantage of a certain measure, the index of its recovery period is used. This represents the ratio of the total expense for introducing the measure to the sum of the nominal annual saving, and characterizes the length of the period during which the expense of realizing the measure will be recovered. For instance, if the cost of realizing a measure is 2000 rubles, and the nominal annual saving is 4000 rubles, then the period of recovery of the measure is $\frac{2000}{4000} = 0.5$ year.

The effectiveness of a measure is calculated taking into account all economic indices which are affected, directly or indirectly, by the measure being realized. For instance, a change-over to a more productive method of processing leads not only to an increase in labor productivity, but also simplifies the work (category) and allows a saving in material and a reduction of waste material. If the realization of the proposal yields a reduction in expense for one shop and causes an increase in expense for another, then the saving is calculated as the difference between the saving in one shop and the increase in expense in the other.

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The annual saving for suggestions pertaining to the production as a whole is

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calculated by comparing the annual estimate of expense for production with the annual estimate prepared while taking account of the utilization of the proposals.

The annual saving on suggestions permitting an elimination or reduction of spoilage is estimated by comparing the cost of the rejected articles before and after application of the suggestion (for comparison, the data on the losses due to spoilage for the last six months before introduction of the measure are taken).

If the suggestion adopted modifies the standards and rates, the enterprise is obligated, from the beginning of the application of the suggestion, to introduce new standards and rates, extending them to all operations and to all workmen effected by the given proposal. For the author of the proposal, the previous standards and rates are maintained in effect for six months from the date of their application. The difference between the old and new rates are paid to the author on extra-pay sheets.

Financing Procedure for the Cost of Introducing Organizational-Technical Measures. The costs of introducing technical-economic and organizational measures are divided into capital and current.

Capital expense goes to the creation of new fixed assets of the enterprise, for instance, the acquisition of new installations, equipment, and transport facilities; the reconstruction of existing fixed assets, for instance the revamping of buildings, or the modernization of equipment. Since capital expense increases the value of the fixed assets of the enterprise on its balance sheet, these expenses are included in the plan of capital work, and their financing is handled in accordance with the approved schedule of objects of capital investment for the given enterprise.

Current expense includes expenses connected with the introduction of proposals that do not result in changes in the value of the fixed assets. The cost of implementing such measures is taken from the funds released for overhead.

The enterprise as a whole and its shops prepare an estimate of the cost of

introduction of the proposed measures into production.

If the current expense of realizing a measure is less than the saving received from it to the end of the plan year, then such expenses are completely charged to the production cost of the plan year.

If the current expense for the conduct of a measure is greater than the saving to be obtained by the end from the calendar year, then such current expenses are not completely written off at one time, nor are they completely charged directly to production costs, but are amortized in portions during the period of recovery of the costs of the measure, which must not be over two years. In this case, only that part of the expense relating to the plan year is excluded from the total saving to the end of the year.

The operative record and control over the introduction of measures in production is directed toward achievement of the economic advantage envisaged by the plan. The record is made by the aid of planning-control cards which are kept for each measure. Such a card shows the plan and actual periods of performance of the work on the preparation for introduction of the measure into production, for each realized organizational-technical measure. The course of fulfillment of the plan of technical economic and organizational measures is periodically discussed by the director or chief engineers and the representatives of the public organizations of the enterprise.

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CHAPTER XIX

PLAN OF MATERIAL-TECHNICAL SUPPLY

The planning of the requirements of the enterprise for materials, semifinished goods, and finished component articles consists in the preparation of a plan of material-technical supply and a subcontracting plan.

The plan of material-technical supply determines for the year and by quarters, the quantity and cost of the primary and auxiliary materials, semifinished goods, finished components, fuel and purchased tools required by the enterprise for fulfilling the program and creating the necessary stockpile ensuring timely and complete set supply of the shops.

The plan must correctly reflect the requirements of the enterprise for the necessary materials and must take full account of their balances at the central and shop warehouses. The calculation of the plan indices is conducted according to progressive standards, which take account of the advanced experience and organizational-technical measures for shortening the production cycle and for rational utilization of the materials. The most important sources of more complete utilization of materials are the elimination of spoilage, the use of rational shaping of sheet material, of precision casting, stamping and other improved methods of processing, and of salvage of waste material.

Section 1. Starting Materials and Procedure for Preparation of the Plan

The starting data for the preparation of the plan are as follows:

1) Schedule of the purchased materials, semifinished goods and finished components;
2) Program of starts and output of product in the plan year;
3) Consumption standards for the primary and auxiliary material and fuel;
4) Standards for the waste of materials per finished product, taking account of possible salvage;
5) Standards for the carry-over stocks at the beginning and end of the plan year;
6) Plan-applications of the services for auxiliary materials, fuel, etc.;
7) Price lists for all materials, semifinished goods and finished articles, with indication of their prices;
8) Balances of materials at the warehouses and in the shops at the beginning of the plan period.

Guided by the plan of starts and output of products by quarters of the year, and by the above-enumerated starting materials, the functional departments calculate the requirements of the enterprise for materials. For instance, the department for material-technical supply calculates the requirement of the enterprise for the year and by quarters for the primary and auxiliary materials going for the needs of the primary production; the department of the chief machinist for metals, lubricants, abrasives and other auxiliary materials necessary for the maintenance and operation of the equipment; the department of the chief technologist for the materials necessary for the building and maintenance of special tooling.

All applications for materials are made to the department of material technical supply; those for semifinished goods and finished articles, to the department of subcontracting and cooperation; and those for equipment, to the department of capital construction.

Section 2. Planning the Requirements of the Plant for Materials

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The requirements of an enterprise for primary materials is calculated in the

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consolidated products list by the formula

$$M_{eq} = M_{pr} + M_{s.p.} + M_{w.p.} + M_{aux} + M_{mean\,s} - M_{ex}$$

where M_{pr} is the material required for the annual program of output of the principal products;

$M_{s.p}$ is the material required for spare parts for the principal products;

$M_{w.p}$ is the material required for the growth of the work in process, based on the program of production starts;

M_{aux} is the material required for the auxiliary and servicing production (calculated on the basis of the standard consumption and the applications of of the shops and services);

$M_{mean\,s}$ is the standard of mean stores of material in the stockroom, according to plan at the end of a planned period;

M_{ex} is the expected balance at the warehouse and in transit at the beginning of the plan period.

The material required for the annual program of output of the principal products is calculated from the formula

$$M_{pr} = N_{ob} \times M_{ob},$$

where N_{ob} is the annual program of output of the objects, in pieces;

M_{ob} is the standard of material per object.

The requirements for materials for the manufacture of spare parts is determined on the basis of the production program and the standards of spare parts for single and group sets

$$M_{s.p.} = N_{ob} \times M'_{s.p.},$$

where $M'_{s.p}$ is the standard consumption of materials for manufacturing a set of spare parts for a single product.

The quantity of materials required for the growth of the work in process $M_{w.p}$ is determined by multiplying the number of product objects prescribed by the program

of starts M_{ob}, by the standard consumption of materials per object M_{ob}, and by the coefficient of introduction of materials into production $K_{i.m}$.

$$M_{w.p.} = N_{ob} \times M_{ob} \times K_{i.m}.$$

The standard mean stock of materials in the warehouses $M_{mean\,s}$ is calculated from the formula

$$M_{mean\,s} = S_{em} + \frac{M_{max} - M_{min}}{2},$$

where S_{em} is the emergency reserve whose value depends on the size of the delivered batches, on the distance of the supplier from the plant, and on other factors;

$\frac{M_{max} - M_{min}}{2}$ is the average stock of material at the warehouse brought forward, equal to half the difference between the standards of maximum and minimum stocks.

The materials in the expected balance at the stores and in transit are calculated from the formula

$$M_{ex} = M_{act} + M_{p.a.} - M_{c}$$

where M_{act} is the actual material at the warehouse of the enterprise and in the shop stockrooms on 1 October of the report year;

$M_{p.a}$ are the planned arrivals from 1 October to the beginning of the plan year (data from the delivery contracts);

M_{c} is the assumed consumption of metal during this same period of time.

The requirements of the enterprise for auxiliary materials is determined in accordance with the approved standards of their consumption. The quantity of auxiliary materials for process purposes is calculated on the basis of the standard consumption per aircraft and the number of aircraft to be given inspection and acceptance tests during the course of the year. The technological standard does not include the fuel and lubricant issued to the crew of the purchaser for fuelling the aircraft. This consumption is finalized according to contract with the pur-

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chaser, and a special stock is allotted for these requirements. The fuel and lubricant consumed in experimental tests are likewise issued from special stocks.

The requirement for auxiliary materials for operating and housekeeping needs is calculated from the established consumption standards. For instance, the requirement of the enterprise for lubricating oils is found in accordance with the amount of equipment, the forms of lubrication, and the standards of oil consumption per unit of equipment. The quantity of materials required for production of the tooling is calculated in accordance with the amount of tooling and the standards of material consumption for the manufacture of a typical representative of the tool.

The results of the calculation for requirements of the enterprise for primary and auxiliary materials are summarized by the department of material-technical supply into a yearly plan. This plan is prepared by the balance method. First, the requirement by the plant for material for the starts program and the necessary carry-over stock for this purpose are determined, after which the sources for meeting these requirements are indicated, taking account of the existing resources of materials at the enterprise.

The requirements of the enterprise for semifinished goods and component (setmaking) finished articles are found by analogy with the calculation of the requirements for primary materials. Thanks to its thorough specialization and broad subcontracting, an aircraft enterprise receives numerous blanks, parts, and finished components from outside and, in turn, performs productive assignments for other enterprises. All these items are reflected in the subcontracting plan. On the basis of the subcontracting plan, the department of material-technical supply or the department of subcontracting places orders with other enterprises and executes contracts with them.

Plan for Collection of Scrap and Metal Waste for Reprocessing and Re-Use. The enterprise prepares a plan of collection and delivery of scrap and waste and details the assignments for delivery of scrap or waste down to each shop. The assignment

Table 69

Designation of [H]eating Unit	Throughput Capacity, in Tons	Total Charge of Liquid Metal, in Tons	Quantity of Forgings and Hot Stampings on Program	Number of Parts on Program	Required Number in Planned Period: Hours of Operation	Required Number in Planned Period: Shifts	Yield of Sound Castings: %	Yield of Sound Castings: Tons	Standard Consumption of Nominal Fuel, in kg: Per Ton of Sound Castings	Standard Consumption of Nominal Fuel, in kg: Per Shift	Form of Natural Fuel used	Coefficient of Heating Power of Fuel used as Related to Nominal Fuel (Calorie Equivalent)	Standard Consumption of Natural Fuel: In kg Per Ton of Sound Castings	Standard Consumption of Natural Fuel: Per Shift, in kg	Consumption of Natural Fuel on Program, in Tons	Price per Ton of Natural Fuel, in Rubles	Amount, in Thousand Rubles
Casting Shop																	
Cupola Furnace	4 to. per h	3000	-	-	750	-	65	1950	220	-	Coke	0.93	236	-	460	90	41.4
Heating Furnace	1 to. p.shift	-	500 to.	-	-	500	-	-	-	60	Fuel Oil	1.4	-	43	21.5	180	3.87

Table 70

Designation of Buildings to be Heated	Volume of Building by Outside Measure in m^3	Number of Heating Days in Year	Standard Daily Consumption of Nominal Fuel in kg for Heating 1000 m^3 of Building by 1°C	Design Temperature in Building in °C	Average Outside Temperature in °C	Requirements in Nominal Fuel, in Tons	Form of Natural Fuel used	Coefficient of Heating Power of Fuel used	Consumption of Natural Fuel in Year, in Tons	Price per Ton, in Rubles	Amount in Rubles
Object No.4	30,000	180	1,1	15	-8	136.6	Moscow Basin Coal	0.415	320	60	19,200

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for the casting shops is established on the basis of the furnace-charge balance, and for the processing shops on the basis of the material balance. The balance shows the difference between the gross and net weights for each form of material, taking account of the irrecoverable losses. This difference is the weight of waste, which the shop is obligated to collect and deliver. The shops are categorically forbidden to mix the wastes of different metals. The standards of waste for each form of material per aircraft are calculated by the bureau of material standards of the department of the chief technologist. In establishing the planned production cost of a machine-set, the value of the waste is excluded from the value of the materials. The collection of scrap and waste in the enterprise is handled by the salvage shop or workshop.

Section 3. Planning of the Plant Fuel Requirements

Fuel is consumed for process purposes and for heating the buildings.

In determining the requirements of the enterprise for process fuel, the estimate is based on the amount of equipment, the time of operation on the assigned program, and the standard of consumption of nominal fuel per unit of operating time or per ton of materials processed.

Table 69 gives an example of such a calculation for hot shops.

Table 70 is an example of the calculation of the requirements of the enterprise for fuel for heating the buildings.

The results obtained in calculating the fuel consumption by the shops and services are combined into a summary plan of enterprise fuel requirements by forms of fuel. The requirement for electric power is reflected in the balance of electric power prepared by the superintendent of power.

CHAPTER XX

PLAN FOR LABOR AND WAGES

The plan for labor and wages determines the growth of labor productivity, the requirements of the enterprise for workers and their wage fund, the measures ensuring increased qualification of the personnel and safe conditions of labor. The plan for labor and wages must be directed toward fulfillment and overfulfillment of the State assignment for growth of labor productivity, and for the effective utilization of labor time and the wage fund.

Table 71

Designation of Indices	Units of Measurement	For 195...	For Quarter I	II	III	IV
I. Industrial Activity						
Production of growth product per payroll workman in wholesale prices of 1 July 1955	Thousand Rubles					
Performance of standards by piece workers of the primary production	%					
Labor cost of manufacture of all products and separately by all forms of products	Standard hrs					
Coverage of work by technically justified standards	%					

Designation of Indices	Units of Measure-ment	For 195...	For Quarter I	II	III	IV
Number of industrial productive personnel, total and by categories	Men					
Average monthly wage separately for each category of workers	Rubles					
Wage fund, general, and separately for each category of workers	Rubles					
From the total wage fund, compensation for long service, total, and by categories of workers	Rubles					
Administrative and management personnel:						
a) Number (total and separately by shops)	Men					
b) Wage fund (total and separately by shops)	Rubles					
Wage fund for nonpayroll personnel	Rubles					
II. Nonindustrial activity						
(by systems and organizations)						
Total						

The starting materials for the preparation of the plan are the production programs, the data on the fulfillment of the labor plan in the period preceding the plan period, the standards of labor cost, the plan of organizational and technical measures, the State assignment for the growth of labor productivity, and the labor limits.

Table 71 gives the principal indices of the labor and wage plan.

Section 1. Planning of Labor Productivity

The planning of labor productivity consists in the establishment of the plan output of product per average payroll workman, the growth of labor productivity in the plan period by comparison with the preceding period, and the maintenance of the correct ratio of the growth of labor productivity to the growth of wages. In this case, account is taken of the rate of technical progress in production of the current stage of development of the series production of the aircraft construction enterprise, and the number of aircraft being produced by it.

The planned output of product per workman for the plant is determined as the quotient of the division of the volume of gross production planned for manufacture during a definite period by the mean payroll number of workmen for the same period.

The average index of growth of labor productivity for the enterprise as a whole is defined by the formula:

$$K_{l.p.} = \frac{O_p - O_r}{O_r} \cdot 100\%,$$

where O_p is the output of gross production per average payroll workman during the plan period;

O_r is the same in the report period preceding the planned period.

As an example, we give below a calculation of the growth of labor productivity for a plant.

$$K_{l.p.} = \frac{15\,909 - 13\,333}{13\,333} \cdot 100 = 19{,}3\%.$$

The index of the growth of labor productivity is a controlling factor in the labor plan. This index is calculated on the basis of a careful analysis of the reserves for the growth of labor productivity.

The planning of the growth of labor productivity and the search for reserves of reducing the labor cost per finished article, are given special attention because they are the primary factors in the reduction of production cost.

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The growth of labor productivity leads to a higher output per unit of labor invested, which increases the volume of products put out by the enterprise, and reduces its expense per unit of finished product.

Designation of Shop	Report Period			Plan Period		
	Output of Production in Thousand Rubles	Number of Workmen	Output per Workman, in Rubles	Output of Production, in Thousand Rubles	Number of Workmen	Output per Workman, in Rubles
Shop No.1	1000.0	50	20,000	3000.0	120	25,000
Shop No.2	5000.0	400	12,500	7500.0	540	13,900
For plant as a whole	6000.0	450	13,333	10,500.0	660	15,909

The growth of labor productivity decreases the consumption of productive wages and the amount of shop and plant overhead per unit of finished product.

The growth of labor productivity means increasing the yield of product per unit of working time from each unit of equipment and from each square meter of productive area. This increases the efficiency of the productive assets and at the same time reduces the cost of amortization and servicing of equipment and productive area per unit of finished product.

Labor productivity, labor cost of the finished product, and its production cost, do not vary in the same degree. This difference must be taken into account in planning the growth of labor productivity, the reduction of labor cost and the production cost of the finished product.

To compare data for different periods of time, the gross production is valued at the very same wholesale prices. If the prices vary, the production of the report

period is converted into the prices of the production of the plan period.

The plan department gives each shop the assignment for the growth of labor productivity, and periodically compares the growth of the average earnings with the growth of the average output per workman, maintaining the assigned ratio between the planned growth of labor productivity and the wage level.

Section 2. Classification of Workers of the Enterprise

The workers of the enterprise are divided into industrial and nonindustrial groups.

The industrial group includes all workers of the enterprise employed in industrial activity. This group is divided into production personnel and administration and management personnel. It includes workmen, engineering-technical workers, employees, junior service personnel, trainees, fire fighters, and watchmen.

The nonindustrial group includes workers employed in serving the physical and cultural needs of the enterprise collective.

The workmen are classified according to plant and shop.

According to plant, workmen are divided into productive and auxiliary. The workmen who perform the technological operations of manufacturing the primary products of the enterprise are called productive workers. All other workmen belong to the category of auxiliary workmen.

According to shop, workmen are likewise divided into productive and auxiliary. The productive workmen include those in the main and auxiliary shops performing operations in the direct manufacture of the product of their shop. The remaining workmen of the shop, tool grinders, stockroom clerks, inspectors, reject-men, machine setters, preparers, distributors, belong to the category of auxiliary workmen.

The ratio of the number of productive and auxiliary workmen is governed by special standard Tables.

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Section 3. Calculating the Number of Workers of an Enterprise

To calculate the number of productive workmen, one must know the labor cost of the program of primary production, the useful available working time of the workman, the manner in which the workmen meet the standard in force, and the assignment for the growth of labor productivity in the planned period.

The labor cost of the program of primary production is composed of the labor consumption for the production of the gross product B computed in standard-hours for all articles of the plan period, and is calculated by the formula

$$B = \sum_{1}^{n} N_{ob} T \pm (H),$$

where N_{ob} is the number of finished objects of one type according to program, allowing for spare parts;

T is the labor cost per object in standard hours, including spare parts;

H is the change in the balance of work in process, in standard-hours;

n is the number of types of objects, according to the program.

The labor cost for an article is calculated in standard-hours, while the enterprise's requirements for workmen is calculated according to the labor cost, expressed in man-hours. To pass from the former to the latter, the labor cost of the articles, expressed in standard hours, must be divided by the planned coefficients of fulfillment of the standard. The calculation of the number of workmen required, without taking account of their overfulfillment of the current standards, would lead to an excessive number of workmen at the enterprise.

Workmen's Time Fund. In planning the workmen's time we distinguish the total calendar time fund F_c, equal to the total number of calendar days in the year; the nominal (regime) working time F_n, representing the number of working days per year; the schedule time F_{sch}, representing the working time after deduction of the whole-day absences and work stoppages; the planned useful labor time F_p, representing the schedule working time after deducting the time of the stoppages between shifts. The

Table 72

Balance of Working Time Per Payroll Workman for 195 ....

No.	Indexes	Report: Number of Days	Report: In % of Working Time	Plan for Year: Number of Days	Plan for Year: In % of Working Time
1	Number of calendar days in year, F_c	365	-	365	-
2	Number of off and holiday nonworking days	58	-	58	-
3	Number of working days; nominal working time, F_n	307	100.0	307	100.0
4	Whole-day absences from work:				
	a) Due to illness	8.5	2.77	4.0	1.31
	This includes injuries and occupational diseases	1.5	0.49	-	-
	b) Leave for family reasons	3.0	0.97	3.0	0.97
	c) Regular leave	14.4	4.7	18.5	6.03
	d) Performance of social and state obligations	2.5	0.81	2.5	0.81
	e) Other valid reasons	3.0	0.97	2.0	0.65
	Total whole-day absences	31.4	10.22	30.0	9.77
5	Scheduled number of days of work per workman on the average, F_{sch}	275.6	89.8	277.0	90.23

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No.	Indexes	Report		Plan for Year	
		Number of Days	In % of Working Time	Number of Days	In % of Working Time
6	Losses of working time during shifts:				
	a) Shortened working day on days before off-days and holidays	14	4.6	14	4.6
	b) Breaks for nursing infant	7	2.3	9	3
	c) Losses due to poor organization of production	47	15.3	-	-
	Total losses during shifts	68	22.2	23	7.6
7	Planned useful fund of working time in days, F_p	207.6	67.6	254	82.7
8	Average number of hours of work in day, with respect to schedule fund of time	6.03	-	7.33	-
9	Utilization of maximum possible number of hours of work per workman	-	75.3	-	91.7

useful fund of time of the workmen is:

$$F_p = DH(1 - K_1 - K_2 - K_3) - 112,$$

where D is the number of working days per year; (365 days - 52 Sundays - 6 holidays= = 307 days);

H is the number of working hours per shift;

K_1 is the percent of time loss from whole-day absenteeism;

K_2 is the percent of time loss on stoppage between shifts;

K_3 is the percent of time loss on excused hours to minors, nursing mothers,

and hazardous production conditions;

112 is the number of hours by which the useful time fund is reduced owing to termination of the working day at 1400 h on the 56 days before holidays and off-days.

To determine the useful time fund of the workmen in the plan year, a balance of workmen's time is prepared from standard Tables and statistical data. In preparing the balance, the possibilities of increasing the useful fund of workmen's time are disclosed. Table 72 gives an example of such a balance.

Calculation of the Number of Productive Workmen. We differentiate the payroll complement and the schedule complement of workmen. The payroll complement indicates the number of workers, taken from the time records of the enterprise. The schedule complement shows the number of workmen of the enterprise appearing for work every shift.

The payroll complement of productive piece workers P_c, may be calculated on a consolidated basis by the formula

$$P_c = \frac{B}{F_P\left(1 + \frac{K_4}{100}\right)},$$

where B is the gross production planned for the year, expressed in standard-hours;

F_p is the planned useful fund of working time;

K_4 is the planned coefficient of overfulfillment of standards.

Table 73 gives an example of a consolidated computation for the requirements of an enterprise for productive workmen.

The results of the consolidated computation are refined by shops and by occupations of the productive workmen.

To calculate the number of productive piece workers by articles and by occupations, two Tables are prepared on the scale of the enterprise, and for each shop. The first Table shows the distribution of the labor cost of gross production by articles and by categories of work (Table 74).

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Table 73

Designation of Finished Product	Total Standard Time in Hours Per Finished Product (Average Plan)	Number of Finished Products by Plan	Required Number of Standard-Hours by Production Plan
Product No.1	9.25	1200	11,100
Product No.2 (etc.)	12	1000	12,000
Total for Commodity Production	-		600,000
To increase Balances of Work in process	-	-	34,000
Total			634,000
Coefficient of fulfillment of current standards attained			1.15
Planned coefficient of fulfillment of current standards			1.39
Planned number of working hours taking account of planned coefficient of fulfillment of standards			456,000
Planned useful working time per workman by time balance (time in hours)			2032
Required (plan) number of productive piece workers			224

The second shows the distribution of productive workmen by occupations and categories (Table 75).

The number of productive workers employed on time work is determined from a computation of the number of work stations served by these workmen.

The number of auxiliary workmen employed on standardized work is calculated in

the same way as the number of primary production workers. The number of auxiliary workmen employed on time work is calculated from the standard Tables and is established according to the schedule of employment and positions.

Table 74

List of Finished Products	Category of Work					
	Third Category		Fourth Category		Fifth Category	
	Number of Standard Hours					
	Per Unit of Finished Product	For Entire Program	Per Unit of Finished Product	For Entire Program	Per Unit of Finished Product	For Entire Program
Product A	-	-	1	60,000	-	-
Product B	2	2000	1	60,000	2	2000
Total		2000		120,000		2000

Table 75

Occupation	Category	Number of Standard Hours in Program	Plan Coefficient of Fulfillment of Standards	Number of Standard Hours Taking Account of Overfulfillment of Standards	Planned Working Time Per Workman, in Hours	Required Number of Workmen (Rounded Off)
Turners	3	20,000	1.2	16,000	2032	8
Turners (etc.)	4	20,000	1.1	18,000	2032	9
Grinders (etc.)	4	100,000	1.25	80,000	2032	40

Table 76 gives an example for calculating the number of auxiliary wo STAT.

To reduce the number of auxiliary workmen, the plan prescribes measures for the mechanization and better organization of labor, the consolidation of production sections, and the increase of the servicing standards.

Table 76

Type of Occupation	Category of Work	Designation of Work Station Served by Unit	Number of Units Served	Standard of Service	Number of Shifts Work	Required Number of Workmen	Planned Absence from Work in % of Total Working Time	Workmen Required by Plan, Allowing for Absences
Crane Operators	5	Traveling Crane, Load Carrying Capacity 5 Tons	2	1	2	4	9.77	5
	4	Same	2	1	2	4	9.77	5
Machine Setters	6	Metal-Working Machine Tools	150	15	2	20	9.77	25
Total	-		-	-	-	-	-	35

The results of the estimates of the number of primary production workmen and auxiliary workmen for the entire enterprise are summarized in a general Table.

The number of engineering-technical workers, employees and junior service personnel is determined by the standards and the schedule of employment and positions, as a function of the structure of the enterprise administration and on the number of primary production workmen. It is of importance to steadily reduce the administrative staff by improving the qualifications of its members, mechanizing the labor, merging of related occupations, reducing the correspondence and summaries,

and eliminating the excessive number of levels in the administration.

The number of trainees is established by the personnel training plant.

The enterprise plans only the total number of workers, including workmen, without dividing them into primary production workers and auxiliary workers. The wage fund is planned accordingly. Within the limits of its fund, the enterprise itself regulates the ratio of the primary production workers to the auxiliary workers, and the ratio of the engineering and technical personnel to employees and junior service personnel, reflecting their numbers and their wage funds in the technical-industrial-financial plan.

Section 4. Calculation of the Primary Wage Fund

The wage fund for the production workmen is calculated on the basis of the data on the labor cost of the program, the average pay-scale category of the work, and the corresponding hourly base pay, taking account of the planned relation between the growth of labor productivity and the growth of wages.

The approximate proportion of wages for various forms of work in the total wage fund for aircraft manufacture is as follows:

Forms of Work	Wages in % of Total Wage Fund
Assembly and installation	43
Fabricating and stamping	17
Mechanical and machine-assembling ...	20.5
Fitting-welding	6.5
Coating	5.6
Hot-working	1.4
Other work	6
Total	100

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The principal wages of the productive workmen at aircraft building plants in-

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clude the base pay, extra pay under the progressive-bonus system, and bonuses.

The wages according to the pay scale are estimated by products, separately for standardized (piece) work and unstandardized (time) work.

The wage fund according to the pay scale of productive piece workers is determined on the basis of the program of manufacturing starts and the pay-scale rates per article. The pay-scale rate per article on the whole, for the entire plant, is determined by adding the pay-scale rates for manufacturing the machine-sets of parts, for a given article at the shops of the plant.

The wage fund according to the pay scale for the productive time workers is determined on the basis of the program of productive starts and the pay by the tariff per article. The wage according to the pay scale per article, is determined on the basis of the labor time of the time work per article and the mean hourly pay rate of time workmen.

The wage fund, according to the pay scale, of the productive piece workers W_o may also be determined in consolidated form:

a) Per article, as the product of the labor cost of the article, expressed in standard hours by the average hourly base pay;

b) For the annual program, as the product of the labor cost of the gross production of the primary producing unit, expressed in hours B, by the average hourly base pay H_c:

$$W_o = B \cdot H_c$$

The average category p_c of work and the average category of the workmen are found by the weighted average method, taking account either of the amount of work in each category, or of the number of workmen P. In the latter case, the average category of the workmen is found by the formula:

$$p_c = \frac{(P_2 \cdot p_2) + (P_3 \cdot p_3) + \ldots + (P_n p_n)}{\sum P}.$$

Example. According to plan, 1000 workmen are to be placed on unstandardized time work. This includes 100 workers of category 2, 200 workmen of category 3, 300 workmen of category 4, 200 workmen of category 5, and 200 workmen of category 6. The average category of the workmen will be

$$p_c = \frac{(100 \cdot 2) + (200 \cdot 3) + (300 \cdot 4) + (200 \cdot 5) + (200 \cdot 6)}{100 + 200 + 300 + 200 + 200} = 4{,}2.$$

If the average category of the workmen so obtained is not a whole number, then the corresponding hourly base pay is found by the method of interpolation, starting from the hourly base pay rates of two adjoining categories.

Assume that the base pay of a time worker of category 4 is 169 kopecks and that of category 5 is 192 kopecks. Then the hourly base pay of the category in our example is determined as follows:

192—169=23 kop.
23 · 0,2=4,6 kop.
169+4,6=173,6 kop.

The basic wage fund of the auxiliary piece workers is estimated by the same method as for the production workers. The basic wage fund for the auxiliary workers employed in service work and not paid by the piece is calculated by the formula

$$S_{aux} = P_{aux} \cdot F_{sch} \cdot H_c,$$

where P_{aux} is the number of auxiliary workmen in the planned period;

F_{sch} is the scheduled working time in hours;

H_c is the average hourly base pay rate.

The calculation of the basic wage fund of the engineering-technical workers, employees, junior service personnel, and trainees is based on the Table of organization established for the enterprise, and the approved pay rates. The salaries have a minimum limit and a maximum limit. In planning the pay, the average amounts of the salaries for each occupation and category of worker are used as basis.

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The calculation of the basic wage fund for non-payroll personnel covers the

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payment for work that cannot be performed by the regular payroll workers, for instance, payments to lecturers. The non-payroll fund is governed by a special estimate and calculation.

The calculation of the wage fund for the nonindustrial group is finalized in a special estimate in which the average wage for each organization and system and its total fund are indicated. The calculation is based on indices characterizing the amount of work for each nonindustrial system or organization, for instance, in the case of kindergartens, on the number of children to be accommodated.

The calculations on the wage funds are completed by establishing the average monthly wage by each category of workers.

Section 5. Structure of the Total Wage Fund of an Enterprise

The total wage fund includes all sums of money paid to workers and trainees of an enterprise, whether or not they belong to its payroll (establishment) complement. This fund also includes the amounts paid to workers loaned by the enterprise under special contract to other organizations.

The wage fund does not include one-time bonuses paid to workers out of the enterprise fund or from another fund prescribed by law; bonuses for high indices in a socialist competition; bonuses and compensation for inventions, technical improvements and rationalization of production; traveling expenses and per diem allowances for duties outside the plant; scholarships for students paid by the enterprise; grants for social insurance and pensions to working pensioners, paid from the social insurance fund; cost of special work clothes, protective devices, and antidotes issued by the plant.

The total wage fund is divided into basic and additional.

The basic fund comprises the wages to each category of workers of the industrial group for time actually worked and includes: wages according to wage scale, bonuses (except bonuses from the enterprise fund and bonuses for rationalizing suggestions), extra pay for night work, for bossing a crew, and for instructing trainees in production.

The additional wage fund includes extra pay for time not worked on production: payment for regular and special leave of absences, payment to minors for excused hours, extra payment to nursing mothers for excused time to nurse infants, payments for the time spent in meeting State and public obligations, and long-service allowances.

The additional pay items included in the basic and additional wage funds for production workers are calculated directly for the entire volume of production. The estimate is made by shops.

A total of 7.3% of the total wage fund is paid by the enterprise to the State social insurance fund. From this fund, allotments are made for payment of benefits to the workers of the enterprise during sickness, for payment of pensions to superannuated workers, and for health resort and sanatorium treatment.

The total wage fund of the industrial group, together with the payments to the social insurance fund, is included in the estimate of production and is charged to production cost. In calculating production cost, the total wage fund is divided into two parts.

The first part includes the wages of productive workers paid according to the wage scale, and the extra payments by the progressive bonus system, as well as the bonuses. This part of the wages enters directly into the production cost and forms an independent item.

The second part of the total wage fund, together with the payments for social insurance, enters the production cost by way of the shop and plant overhead.

The total wage fund of the nonindustrial group and the payments into this fund do not enter the production budget and are not charged to the production cost of the enterprise.

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Section 6. Planning of the Recruiting, Training, and Improvement of the Qualifications of Personnel. Planning the Expenditures on Safety Measures and Work Protection

In accordance with the program and personnel requirements of the enterprise, a plan of recruiting and training personnel and of raising their qualifications is developed. The plan of personnel recruiting indicates the number of workers needed by occupations and shops of the enterprise, and by quarters.

The plan of training and raising the qualifications of personnel specifies the system of in-service training and the number of workers to be trained by it. In preparing this plan, the use of the new technique and the planned growth of labor productivity are taken into account.

Considerable sums are allotted to each enterprise for measures on safety, work protection, and industrial hygiene. These measures are carried in a separate division of the labor plan, which is worked out, with the active participation of workers of the enterprise and of medical personnel, by the department of industrial safety together with a committee of the trade union, and is a mandatory annex to the collective contract.

Section 7. Record and Analysis of the Fulfillment of the Labor Plan

The record and analysis of the fulfillment of the labor plan must ensure timely control over the fulfillment of the indices on growth of labor productivity, on the correctness of the wage fund expenditure, and on maintenance of the established relation between the growth of labor productivity and the growth of wages.

The following economic indices of the labor plan are subject to record and analysis:

1. The average payroll number of its category of workers of the enterprise, showing the percentage ratio of the auxiliary workmen to the production workmen, and of the engineering-technical workers and employees to the total number of all workmen.

2. The manufacturing output, in comparable wholesale prices, per payroll workman. This index is calculated by dividing the cost of the total product indicated in the program by the average payroll number of workmen during the plan period. This index may be supplemented by the calculation of the manufacturing output per production workmen and per enterprise worker. The latter shows the degree to which the output of the production workmen is reduced, owing to the presence of a large number of auxiliary and service workmen and of administrative and management personnel.

The different wholesale prices for one and the same aircraft at different plants has the result that the output per workman in rubles is not always an objective index of the growth of labor productivity. For this reason, the output in nominal aircraft or articles per workman, or per enterprise worker, is a more objective index.

3. The fulfillment of the standards by primary production piece workers. This index is calculated by dividing the volume of gross production turned out by the primary production unit, in standard hours, by the fund of time of the primary piece workers who actually worked during the same period, in standard-hours.

4. The percentage of workmen covered by calculated technical standards. This index is found by dividing the labor cost of the work, calculated according to the technical standards, by the total labor cost of the gross production in standard-hours. In their reports on fulfillment of the plan, the shops indicate the distribution of the piece workers by degree of fulfillment of the standards.

5. The power supply, in kilowatt-hours per workman.

This index is calculated by dividing the electric power generated for consumption by the average payroll number of workmen.

6. The shift factor. This index is calculated by dividing the planned or worked number of man-days in all shifts by the planned or worked number of man-days in the greatest shift, respectively.

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For instance, the following number of man-days is planned in the respective

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shifts:

First shift	10,000
Second shift	9000
Third shift	8000
Total	27,000

Then the shift factor will be $\frac{27,000}{10,000} = 2.7$.

7. The labor cost of the principal finished product in standard-hours.

8. The average monthly wage of the primary and auxiliary workmen, engineering-technical workers, and employees.

From these indexes the enterprise performs the control and analysis of the labor plan.

The analysis of the plan on labor and wages determines the actual level of labor productivity attained, the correctness of the utilization of labor power and the wage funds in accordance with the indices established by the technical-industrial-financial plan.

The analysis of labor productivity is performed either by comparing the planned and actual output per average payroll workman, or by comparing the planned working time with the actual working time on the production of the gross product.

Under the first method, the volume of the gross production and the amount of the labor expense of the report period is compared with that of the preceding period in comparable units (for a typical example, see Tables 77 and 78). By comparing the indices of these two Tables, the output is found in time units or in rubles per average payroll workmen (Table 79) per year, per day, and per hour.

Upon this comparison, the production output per workman is corrected to take account of the changes in the level of subcontracting, the structure of production, and other factors.

The index of labor productivity with respect to output per average payroll

Table 77

	Growth Production Actually Manufactured in 1955, in Rubles	Plan of Production of Gross Production in 1956, in Rubles	Gross Production Actually Manufactured in 1956, in Rubles	Gross Production Manufactured in 1956, in Percent	
				Of Past Year	Of Plan
Total Gross Production	100,000	120,000	130,000	130	108.3

Table 78

Index	Actual for 1955	For 1956			
		According to Plan	Actual		
			In Absolute Numbers	In Percent	
				Of Preceding Year	Of Plan
Average payroll complement of workmen	3100	3200	3150	101.6	98.4
Total number of man-days worked by all workers per year (in thousands of man-days)	900	910	915	101.6	100.9
Total number of man-hours worked by all workers per year (in thousands of man-hours)	7000	7280	7180	102.5	98.6

workman is a synthetic index reflecting the influence of all factors.

The index of labor productivity with respect to output per man-hour characterizes the quality of the work, i.e., the intensive and productive power of the work,

Table 79

Index	Actual for 1955	For 1956			
		According to Plan	Actual		
			In Absolute Numbers	In Percent	
				Of Preceding Year	Of Plan
1. Output per average payroll workman per year, in rubles (in prices of 1 July 1955)	27,062	35,065	37,234	137.8	106.1
2. Number of days worked per workman in year	267	295	295	104.0	101.1
3. Output per man-day in rubles	94.3	119	125	132.5	105.0
4. Number of man-hours worked in day, per workman	8.5	10	9.8	115.3	98.0
5. Output per man-hour in rubles, at prices of 1 July 1955	11.09	11.90	12.75	115.1	107.1

the know-how, the density of the working time, the growth of the equipment, and the mechanization of labor. It does not, however, reflect the length of the working time, i.e., the extensive value of the labor. To establish the degree to which the extensive factors, i.e., the change in number of working days per year and in the length of the working day, have affected the increase of output, the total labor

productivity must be divided by the value of its intensive productivity.

The analysis of the fulfillment of the technical time standards is performed by product, shops, and workmen's occupation. In this case, the analysis discloses the quality of the standards, their effect on the lowering of the labor cost of the product, and on the growth of labor productivity.

The analysis of the composition and number of workers of the enterprise is conducted separately for the industrial and nonindustrial groups and indicates the movement of the labor force, establishes the causes for the mobility of labor, verifies the fulfillment by the enterprise of the plan for recruiting and training personnel, and for improving their qualifications.

The mobility of labor is characterized by the number of workmen engaged and discharged during a definite period of time.

The mobility of the composition of workmen by qualifications is characterized by the change in the weighted average payroll category.

The analysis of the balance of utilization of working time is made to find the whole-day and intrashift losses of working time and to work out measures to eliminate them. For the analysis of stoppages during a shift, a detailed micromotion study of the entire working day of individual workmen, sections, and shops must be periodically made.

The analysis of the expenditure of the wage fund is made by parts of the total fund of each category of workers. The saving or overexpenditure of the wage fund is established by comparing the fund actually expended with the planned fund (with a correction for the fulfillment of the plan of gross production).

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CHAPTER XXI

PLAN OF PRODUCTION COST OF OUTPUT

Section 1. The Law of Value and the Production Cost of Output

The law of value is not a regulator of socialist production, and its action on that production is limited by the social property in the means of production, by the law of planned proportional development of the national economy, by the annual and Five-Year Plans, and by the economic policy of the Party and State.

A certain influence exerted by the law of value on the production is due to the fact that the consumer products necessary for covering the consumption of labor power in the process of production are produced domestically and are realized as commodities subject to the action of the law of value. No material incentive for labor can be provided, and no determination of the profit or loss of an enterprise can be made, without taking account of the action of the law of value. The influence of this law on production gives their topical character to such problems as independent unsubsidized operation, production cost and price, profitability and income. Although the derivation of income is not the prime purpose nor the motive force of socialist production, accumulation of funds is still necessary to socialist society. They serve as a source of expanded socialist reproduction. Consequently, also socialist enterprises must be run on a profit basis. The influence of the law of value on production increases the profitability of an enterprise. For this reason our enterprises, during the first phase of communism, cannot manage without taking the law of value into consideration. The influence of the law of value on aircraft production

is manifested in the payment of labor according to its quantity and quality, in independent unsubsidized operation, and in the systematic lowering of the production cost of output. The more profitable the enterprises of the defense industry are, the smaller will be the expenditures of human, material, and financial resources by the State for solving the problem of defense, and the more funds the State will be able to shift to other branches of industry for the direct satisfaction of the material and cultural needs of the workers of the socialist society. Profitable operation of the defense enterprises is therefore of enormous significance for the development of our production.

The socialist national economy is distinguished by the highest form of profitability, by the constant profitability of the entire socialist production as a whole. But this does not eliminate the necessity for profitable operation of individual enterprises. On the contrary, the smaller the expenditure of labor, material, and financial resources with which an enterprise fulfills its State assignment, the more successfully will it solve the general State problems. The amount of the labor, material, and financial resources expended by the enterprise per unit of manufactured product finds its reflection in its production cost.

Production cost expresses in terms of money all the expenditures of the enterprise on the production and realization of the output.

The production cost of the output, like a mirror, reflects the degree of utilization of the existing technique and the level of that technique, the growth of labor productivity attained and the organization of that labor, the effectiveness of the utilization of the fixed assets and the rational consumption of the material and financial resources, as well as the degree of reduction of overhead. The lower the production cost of the output, the higher will be the level of the productive-economic activity of the enterprise.

The 19th Congress of the Party condemned the anti-State practice of planning the production cost of the output, in which certain economic leaders limited by their narrow departmentalized interests and to the detriment of the State interests, artificially build up "reserves" in their plans for the production cost of their output, by raising their standards of consumption of raw material and other materials, and, without justification, thus increase the planned labor cost of the finished product.

The plan for the production cost of the output determines the expenditures of production for the gross and finished product, the production cost of newly developed production items, and the reduction in the production cost of comparable products.

The basic task of planning production cost consists in a determination and utilization of the reserves for increasing labor productivity, and in effecting savings in the material resources and in all other expenses connected with the production and realization of the output.

The basic data for the preparation of the plan of the production cost of output include: the level of production cost attained by the enterprise during the preceding period; the assignment for lowering of the production cost of comparable output; the plan of organizational-technical measures; the progressive standards of consumption of materials and labor per unit of production, and the standards for overhead; and various estimates for individual forms of expense.

Section 2. Calculation of the Production Cost of Commodity Production and Formulation of Prices

Calculation is a method of establishing the production cost per unit of output. Calculation must be based on advanced standards of utilization of equipment, labor consumption, consumption of materials, fuel, and power, and observance of the strictest regime of economy in the expenditures for the management and servicing of production.

Plan calculation and report calculation are differentiated.

A plan calculation reflects an assignment on the production cost of the finished product. Aircraft are calculated including the value of a single set of spare

parts, airborne instruments, and ground equipment. The expense connected with the introduction of modifications or design changes in aircraft is not separately shown in the record and is charged to the production cost of the article under the general procedure, by the corresponding items of expense in the calculation. Plan calculations should prescribe a steady decrease of expense per unit of industrial production.

A report calculation determines the actual production cost of output on the basis of a record of the expenses by items, allows verifying the fulfillment of the plan assignments on production cost and the detection of deviations from the plan that have occurred in individual production sectors.

In the plan and report calculations, the current wholesale price (without the turnover tax) for the given form of production is used, and, in cases where the enterprise pays the turnover tax, the current rate of turnover tax is also indicated. Plan calculations are prepared for the year, and are broken down by quarters. The quarterly distribution reflects the dynamics of production and its expenditures during the course of the plan year. Report calculations of actual production cost of output are prepared for each series monthly.

The calculation is performed by the enterprise for each type of finished production and determines its shop, plant, and total production cost.

The shop production cost of output may be detailed for all cost items, or only for those whose magnitude depends on the work of the shop. Calculations taking account of the cost of semifinished goods are used in shops only for that form of production that leaves the shop as the commodity product of the plant. In such a calculation, the shop production cost of a machine-shop part made from a rough forging of the forging shop, will include the expenditures of the forging shop on the fabrication of rough forging RF, and the expenditures of the machine shop on basic wages W_o and on the shop overhead O_s:

$$_s = SF + W_o + O_s$$

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In shops of aircraft construction enterprises, the shop production cost of output includes only the expenditures by the shop itself but does not include the cost of semifinished goods received from supplier shops. In this case, the shop production cost of output is calculated by the formula

$$C_s = W_o + O_s$$

At aircraft construction enterprises, in shops with a large product list of parts processed, the planning of the production cost consists merely in the preparation of estimates of production expense based on the expenses depending on the shop. In order to determine the production cost per machine-set by shops, the shop expense (for the year or for the quarter) must be divided by the number of machine-sets produced during that same period.

The plant production cost of a unit of finished product includes the expense of the enterprise connected with the production of the aircraft and the single set of spare parts, board instruments, and ground equipment, and is determined by the formula:

$$C_p = M_o + SF + PF + P_o + CO + SE + W_o + O_s + O_p$$

where M_o is the value of primary materials by wholesale (price-list) prices, less the value of the realizable salvage;

SF is the value of purchased semifinished goods;

PF is the value of purchased finished components;

P_o is the expense for development of production of new forms of products;

CO are depreciation charges for special-purpose tooling;

SE is a special expense;

W_o is the basic wage fund of production workmen of the primary producing shops, together with the bonuses and progressive extra pay;

O_s is the overhead of the primary producing shops, in percent of the basic

wage fund of the production workmen per article, without taking account of the bonuses and progressive extra pay;

O_p is the plant overhead, in percent of the same fund as in the calculation of O_s.

Fig.124 - Variation in Production Cost of a Passenger Aircraft and in the Expense Items of this Production Cost, with the Number of Aircraft Produced

1 - Production cost; 2 - Labor cost; 3 - Wages; 4 - Cost of materials; 5 - Cost of purchased semifinished goods and finished components; 6 - Shop overhead; 7 - Plant overhead

a) Production cost, in %; b) Serial number of aircraft

As will be clear from Fig.124, the production cost of the aircraft, and the expense items composing it, are variable quantities both absolutely and relatively. They decrease with increasing daily output of aircraft, with increasing mechanization of production, and with the improving organization of production and of labor processes. For this reason, the respective contributions of the various forms of expense to the production cost of aircraft of different classes are comparable only in cases where the scales and rates of production are rouglyy the same. STAT

The total (commercial) production cost of the finished product consists of the plant production cost C_p and the expense of realizing the product or, as it is called at the enterprises, the extra-production expense EP.

The extra-production expense is taken, on the average, as 0.75% of the plant production cost, and includes the expense of the enterprise:

a) For delivering the products at the railroad siding or wharf, including the cost of transferring to the railroad car; b) for payment of the railroad freight charges or marine freight charges in cases where the prices for the product are quoted f.o.b. destination (ship or wharf); c) for research and experimental work and work on standardization of the objects; d) for marketing the finished product, including discounts to the marketing organizations; e) for training of personnel.

As a rule, the railroad freight charges for shipment of the finished product to the station of destination are paid for the account of the purchaser.

The total production cost of the finished production C_{tot} is equal to:

$$C_{tot} = C_p + EP$$

The production cost per unit of output for the planned period is calculated as the weighted average obtained by dividing the total cost by the number of products prescribed by the production plan during the planned period.

The valuation of the finished product at total production cost shows the funds being expended by the enterprise on the manufacture and realization of the finished products.

The wholesale price of the enterprise P_o for a finished industrial product is equal to the total production cost of the output C_{tot} plus the net income of the enterprise I_{tot}, planned in aircraft building to the amount of 3% of the total production cost:

$$P_o = C_{tot} + I_{tot}$$

The wholesale price guarantees reimbursement to the enterprise for its planned expenses and realization of a net income. The rating of the finished production by the wholesale catalog prices established for it shows the amount of the funds received by the enterprise for its production.

The wholesale price is established in such a way as to guarantee a profit of 3 - 7% of the planned production cost. The profit on production marketed outside the branch of industry in question is established at 2 - 3% of the planned production cost.

The net income (profit) of the enterprise is defined as the difference between the wholesale prices (without the turnover tax) and the total production cost of the production marketed.

The normal rate of profit of the enterprise P_m is the percentage ratio of the net income of the enterprise to the total production cost of the production marketed.

$$P_n = \frac{I_{tot}}{C_{tot}} \cdot 100\%.$$

The actual rate of profit of an industrial enterprise is determined on the basis of the balance-sheet data, taking account of the nonmarketable items of income, loss, and damage. To increase the profit rate of production, the volume of production realized must be increased, or the total production cost of the output must be reduced.

The wholesale price of the industry P_{oi} includes the wholesale price of the enterprise, the surcharge of the marketing organization, and that part of the centralized net income of the State that is represented by the turnover tax. The prices for the output of branches of industry producing the means of production do not, as rule, include the turnover tax.

The reduction of wholesale prices strengthens independent unsubsidized operation, intensifies the regime of economy, and creates a material basis for the reduction of retail prices. STAT

A settlement price is established by the enterprise director for products and

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services for which there are no State prices or tariffs. This price is fixed by agreement with the purchaser, but the profit in this case must not exceed 5% of the production cost of the article.

Section 3. Classification of Production Expenses and Computation Method

The production expenses for the manufacture of the finished product are classified according to the methods of charging them to production cost, according to the places where they are incurred, according to the volume of output, and by other criteria.

According to the method of charging them to production cost, expenses are divided into direct and indirect.

Direct expenses are standardized per unit of finished product. Each form of direct expense constitutes a separate, independent item in the structure of the production cost of finished production. Direct expense includes the following:

1. Under the item "raw materials and primary materials", the value of primary materials and finished articles used generally in industry (fittings, hardware, ball bearings). The consumption standards of primary materials for aircraft include: primary materials going directly into the manufacture of the aircraft; primary materials going into the single set of spare parts, board instruments and ground equipment furnished with the aircraft; the primary materials in foundry and heat-treatment shops going into technically unavoidable spoilage, up to the established percentage.

2. Under the item "purchased semifinished goods", the cost of semifinished goods acquired under the production subcontracting procedure, such as forgings, stampings, castings, etc.; this item also includes payments for services rendered by other enterprises in the partial processing or finishing of the semifinished goods.

3. Under the item "purchased components", the cost of finished components acquired under the production subcontracting procedure: instruments, assemblies, control and testing equipment, etc. Articles whose cost is not included in the wholesale price of the aircraft and which are paid separately by the purchaser (for instance, the engine) are not included in the item "purchased components".

The value of industrial raw materials, materials, purchased semifinished goods, and finished components is composed of the invoice value (according to the supplier's bills) and the transportation-procurement costs, less the value of salvage realized. The transportation-procurement costs include: a) the surcharges paid to the supply (marketing) organizations; b) the freight charges with all additional charges; c) the charges for unloading and delivering of raw materials and other materials to the warehouses of the enterprise, except the wages of permanent warehouse employees; d) the cost of maintaining special procurement offices, stockrooms and agencies, organized at the point of procurement; e) the cost of detailing personnel to points outside the plant for materials procurement; f) the amounts lost by reason of shortages of materials and raw materials occurring in transit, within the limits of expected losses. All these expenses are charged to a special account "Transportation-procurement expense", and from it, to the extent of a definite percentage (5 - 6%), to the cost of primary materials, semifinished goods, and finished components, charged monthly to the production cost of gross output. For instance, 60 tons of DT-16 sheet, valued at 10,000 rubles a ton, are released to the production of series aircraft. Then, with a 6% standard of transportation-procurement expense, 36,000 rubles of these expenses are added to the total amount of 600,000 rubles charged to production for material. The cost of maintaining the supply department and the plant stockrooms is charged to plant overhead.

4. Under the item "development expense for manufacture of new forms of product", the expense for designing a new product and developing the technological process of its manufacture.

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5. Under the item "depreciation of special-purpose tooling", the amortization

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of the cost of special tools designed for series or mass production of definite products or used to fill one-time orders.

6. Under the item "special expense", the cost of running all aircraft tests and of maintaining the OER.

7. Under the item "primary production wages of production workmen", the wages of production workmen paid for work done directly on the manufacture of the primary product. This includes the wage fund according to the wage scale of production workmen, whether on piece rates or time rates, plus the bonuses and extra pay in accordance with the progressive bonus system. The other extra payments and wage supplements are charged to shop overhead. The planned amount of expense on this item is determined on the basis of the approved manufacturing process, the standard times and pay rates for a given product, allowing for the plan assignments for the reduction of labor cost.

8. Under the item "crating and packing", the costs of fabricating the crates and packing the finished product, if these expenses have not been included in the plant production cost. At aircraft construction plants, this item includes the value of the crating and the expense of packing single and group sets of spare parts furnished with the aircraft, as well as spare parts furnished separately.

The amount of direct expense per unit of finished production of the enterprise is calculated from the approved standards and is taken from the corresponding divisions and estimates of the technical-industrial-financial plan.

Indirect expenses cannot be directly estimated per unit of production, and are therefore charged to the production cost of finished production, in proportion to the primary wages of the production workmen of the primary production.

By place of origin, the indirect expenses are divided into shop and plant. The shop and plant indirect overhead is charged to the production cost of the output of finished production to the production cost of the balance of work in process, and to the production cost of services and work for customers.

Shop overhead comprises expenses incurred by the shop for management and for servicing the productive process.

The shop overhead of each shop is charged only to the forms of production put out by the given shop. The list of account-items of overhead is so prepared that the expense for each item can be separately recorded.

These expenses are reflected in the estimate of shop overhead, which breaks them down by cost elements and shows their total amount. Table 80 is an example of such an estimate.

Shop overhead is still high and amounts to 100% or more of the primary wages of the production workers of the shop. The shop overhead is divided into the expense for maintenance and operation of equipment, general shop expense, and shop expense of nonproductive character.

The overhead for maintenance and operation of equipment includes seven items.

Item 1 covers materials (fuel, power), wages of workmen and payment of services for maintenance of equipment, and of other work stations. This item includes:

a. Expense of establishing production lines and closed production sections and for other similar work of noncapital character.

b. Cost of acquiring lubricants, polishing and other materials, minor units and parts replaced, which are necessary for maintaining the productive equipment in operating condition (furnaces, cupolas, presses, machine tools). These materials and parts are used according to the established standards.

c. Basic and extra wages (includ..ng bonuses and payments for social insurance) of oilers, harness makers; furnace builders, mechanics, electricians, machine setters and other workmen employed in servicing and routine checking of equipment condition, if these workmen are not production workers.

c. Expense for electric power to run the motors, steam for the hammers and other equipment, compressed air for the pneumatic tools, boiler make-up water, and other forms of power used for production purposes. The consumption of power of all

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Table 80

Designation of Items	Material	Wages	Wage Supplements	Other Cash Expense	Services to Other Shops	Total
	in Rubles					
Expense for fuel and power for process purposes	—	—	—	—	12695,66 441151,0	453846,66
Expense for power for motors	209274,83	184735,79	13300,98	—	—	407311,60
Maintenance of machines, equipment, and tools	56828,17	265056,77	19084,09	—	427861,00	768830,03
Routine maintenance of machines, equipment, and tools carried in fixed assets account	8149,79	76024,11	5473,74	611230,0	—	700877,64
Depreciation, maintenance, and current repairs of low-cost and perishable tools and attachments	—	—	—	751812,9	—	751812,9
Depreciation of machines, equipment, and tools	281944,80	—	—	—	—	281944,80
Auxiliary materials for process purposes	—	1222215,31	87999,50	—	—	1310214,81
Pay of shop personnel, including supplements	—	—	—	79599,69	—	79599,69
Expense of labor protection and safety measures	2642,50	49300,39	3549,63	-	83690,10	139182,64
Maintenance of buildings, structures and inventory	—	—	—	59407,10	-	59407,1
Depreciation of buildings, structures, and inventory	—	—	—	—	62712,53	62712,53
Current repairs of buildings and inventory	—	—	—	13875,0	—	13875,0
Expenses for rationalization and invention	—	53309,26	3838,27	550,0	18658,24	76355,77
Transport expense	—	153010,67	11016,77	—	—	164027,44
Wages to auxiliary workmen, including supplements	—	1197935,37	306797,44	—	—	1504732,81
Extra wages to production workmen, including supplements	—	—		122525,59	—	122525,59
Other expense						
Total	558840,09	3201587,67	451060,42	1639000,28	1046768,53	6897257,01

forms depends on the equipment operating time, which in turn depends on the quantity of product turned out by the shop. The consumption of electric power can be calculated from the standards of electric power consumption per finished article or, on a larger-scale basis, from the equipment operating time during the planned period, by the formula

$$N_{e.p.} = \frac{N_{inst}\ {}_{0}SK_1K_2}{K_3 \cdot K_4},$$

where N_{inst} is the installed power of equipment in kilowatts (total power is taken from the schedule of all equipment of the shop);

F_0 is the actual annual equipment time fund in hours for single-shift operation;

S is the number of shifts a day;

K_1 is the load factor of the equipment (usually 0.8 - 0.96);

K_2 is the coefficient of simultaneity of operation of the equipment (usually 0.6 - 0.7);

K_3 is a coefficient allowing for line losses (taken from the rating plate of the equipment and usually equal to 0.96);

K_4 is the efficiency of the electric motor (usually 0.85 - 0.9).

To determine the cost in rubles, the consumption of electric power in kilowatt-hour must be multiplied by the cost of one kilowatt-hour.

Item 2 covers routine maintenance of productive equipment, transport facilities and tools (costing 500 rubles or more and carried on the capital assets account of the enterprise).

This item includes:

a. Cost of materials, semifinished goods, and spare parts used by the shop for current maintenance.

b. Basic and additional wages (with bonuses and social insurance payments) of maintenance workmen of the shop. STAT

c. Payment for work done and services rendered, on current maintenance, for

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the shop by the maintenance, tool and other shops of the plant, or by outside organizations.

The cost of the materials required for the maintenance is taken not to exceed 20% of the wage fund indicated under b.

The services of the machine-maintenance shop in producing replacement and spare parts are planned in accordance with the plan of current maintenance of equipment and are taken in the amount of 5 - 7% of the cost of the equipment.

The costs of repairing the transport facilities are taken in the amount of 2% of the cost of such transport means.

Item 3 covers maintenance and expense for operation of the transport facilities. This item includes:

a. Expense of delivery of materials, fuel and semifinished goods to the shop.

b. Expense of delivery of materials, parts, and tools to the work stations and of their pickup from the work stations.

c. Expense on the maintenance of the transport facilities of the shop, including the total wage fund for the drivers, crane operators, and auxiliary workers.

d. Payment for power, fuel, materials, and spare parts for transport requirements.

The wages of the transport workers, with the wage supplements, are taken from the schedule of their wages.

The cost of services of the transport shop is taken from the plan calculation of the production cost of transportation and, in planning, is taken as 35% of the wages of the transport workers.

Item 4 covers depreciation of production equipment, tools, measuring instruments, and transport facilities carried on the fixed assets account (costing 500 rubles and over and intended for use during a period of not less than one year). No depreciation of special tools is included in this item.

The fixed assets include the value of all equipment of the primary and auxil-

iary workshops of the shop, except that of special tooling.

The amount of attachments and tools carried on the fixed assets account should be such that their value amounts to 10% of the value of the productive equipment.

Depreciation transfers are made in accordance with the established standards, based on original cost of the fixed assets (Table 81).

Table 81

Forms of Fixed Assets	Standards of Depreciation in %, for Operation on		
	One Shift	Two Shifts	Three Shifts
Power equipment	7.5	8.5	9.8
Operating machines, apparatus, power-transmission equipment	9.6	10.9	12.5
Tools and attachments	11.2	14.0	16.8

No depreciation transfers are made with respect to facilities held in stock (at the warehouse) or in temporary storage.

Item 5 covers the reimbursement for low-cost and rapidly deteriorating tools and the expense of their restoration. This item includes the following expenses:

a. Writing off the value of general-purpose low cost and depreciable tools and attachments (i.e., implements to be used less than one year and costing up to 500 rubles). The write-off of these expenses may be made up to 50% of the original value at delivery of the tools and attachments from the store to production. The remaining 50% of their value is written off on the basis of full depreciation statements or of the inventory data.

b. Basic and supplementary wages and social security deductions for workmen of the shop in question, employed in tool grinding, maintenance, and restoration of the general-purpose low-cost tools.

c. Cost of materials consumed on maintenance and restoration of low-cost

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general-purpose tools and attachments. The cost of these materials is taken not to exceed 10% of the wage fund indicated in paragraph b.

d. Value of services to other shops in grinding, maintenance, and restoration of general-purpose low-cost tools.

Item 6 covers the additional wages and deductions for social security of production workers; the additional wages also includes long-service bonuses.

Item 7 covers other shop expenses, calculated according to the standards.

The shop overhead includes expenses under the following items.

Item 8 covers the total wage fund of the shop personnel of engineering-technical workers, office and bookkeeping clerks, and junior service personnel, with the transfers for their social security. The wage fund is taken from the labor plan. This same item also includes the wage fund (with the transfers for social security) of these auxiliary workmen not included in the above seven items of shop overhead.

Item 9 covers the expense for maintenance of buildings, structures, and inventory of the shop, including the shop laboratories, stockrooms, and the area and approach ways served by the shop. This item also includes the expense of heating, lighting, and water supply of the buildings and rooms of the shop, the wages of janitors with all supplements, the expense connected with the depreciation and maintenance of the low-cost and depreciable tools and housekeeping supplies.

The cost of lighting is compiled on the basis of the floor space F of the shop in square meters, the relative power of the lighting fixtures $W_{r.p}$ in watts/m^2, the time of operation of the lighting fixtures D_p in hours, and the cost of one kilowatt-hour of electric power for lighting C_{kw-hr}:

$$C_{light} = \frac{FW_{r.p}D_p}{1000} \times C_{kw-hr}$$

The standard consumption of electric power for lighting is usually established at 15 watt-hr per square meter of shop area, plus 5% for day lighting.

The cost of heating the buildings is calculated by the formula

$$C_{heat} = \frac{VN_qD_o}{\beta} \times Cst$$

where V is the volume of buildings heated, in m^3;

N_q is the standard consumption of heat per cubic meter of building per hour, in kcal;

D_o is the length of heating season, in hours;

β is the heat value of 1 kg of steam, in kcal;

Cst is the cost of 1 ton of steam, in rubles.

For other forms of heating (not by steam), the heat value and the cost of power per unit are different.

The cost of water supply and sewerage is determined from the standard consumption of water per workman for housekeeping and personal needs - 25 liters per shift (in hot shops, 30 liters), for the showers 50 liters, for the cafeteria 10 liters, for the settlement 40 liters, For unforeseen needs, 10% of the total consumption.

The costs of building and housekeeping inventory maintenance and cleaning include the total wage fund of the janitors, with all supplements to this fund and the cost of the materials for cleaning purposes (rags, chalk, brushes, pails). In consolidated estimates, the cost of these materials is taken as 3 - 5% of the amount of the janitors' wage fund.

Item 10 covers the expense of routine maintenance of the buildings, structures, and housekeeping inventory. These expenses are determined by the estimate prepared by the maintenance-construction shop and consist of the cost of materials for routine maintenance; the base and additional pay (including the deductions for social security payments) of the workmen doing the routine maintenance; the cost of the work and services of other shops and systems on routine maintenance of buildings, structures, and housekeeping inventory of the shop.

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In consolidated estimates, the cost of routine maintenance of stone, concrete,

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and reinforced-concrete buildings is usually taken as 1 - 1.5% of their overall cost, and for frame buildings as 2 - 3%. The cost of routine maintenance of the housekeeping inventory is taken as 10% of the cost of the inventory.

Item 11 covers the depreciation charges on the shop buildings and structures, housekeeping, and productive inventories. The housekeeping and productive inventories are carried on fixed assets account in cases where their value is not less than 500 rubles, or their service life is longer than one year. The depreciation of the shop buildings is taken at 2.6% of their sound balance-sheet value, and the depreciation of the shop inventory at 15% of that value.

Item 12 covers the cost of testing, research and development, as well as the cost of rationalization and invention, including the wages for the workmen of the shop laboratories, the fees for expert testimony, advice, and consultation, the purchase cost of chemicals, reagents, etc., the royalties paid to patentees, and the bonuses for rationalizing suggestions.

At the operating enterprise, the expense of maintaining the shop laboratories is determined by the standards and estimate of laboratory maintenance, while the cost of introducing rationalizing suggestions and inventions is determined by the plan of technical-economic and organizational measures.

In consolidated estimates, the expense of rationalization is taken at 50 rubles per year per rationalizer, the number of rationalizers being taken as 50% of the number of shop workmen.

Item 13 covers the cost of labor protection. This cost is composed of the current expense for safety measures, the expense for ventilation, for production hygiene and sanitary living facilities, for the acquisition of work clothes, protective devices, special soaps, and special foods. The sum of these expenses, under the conditions of the operating enterprise, are taken from the plans of technical economic and organizational measures of the shops, while for sanitation and hygiene they are taken in accordance with the standards and with the number of workmen of

the corresponding occupations.

In consolidated estimates, the sum of the expenses under this item is taken as 2% of the base pay of the production workmen, plus 0.3% of the value of the equipment.

Item 14 covers the depreciation of the value of low-cost and perishable housekeeping inventory. The calculation is made by analogy to that of the expenses covered by item 5.

Item 15 covers miscellaneous general plant costs, including the cost of qualification tests of workmen, of the acquisition of drugs for the shop dispensary, etc. In consolidated estimates, the sum of the expenses under this item are taken as not to exceed 4% of the productive wages of the primary workmen.

All the above-mentioned overhead items for the shop are summarized in the estimate of the total shop overhead. The estimates for all shops of the primary production are combined into a summary estimate of shop expenses of the enterprise. The expenses of the auxiliary shops are not included in the summary estimate for the plant and are transferred to the cost of production by way of the cost of services rendered by the auxiliary shops to the primary producing shops.

The overhead of a nonproductive character is not planned for the shop and is not included in the estimate of its overhead. As these expenses are incurred, they are charged to the item "nonproductive shop overhead" and are included in the report as losses increasing the actual cost of production of the shop output. These expenses include payment for idle time due to the fault of the shop, expenses connected with spoilage and shortages of material values, losses due to unutilized production backlogs of parts and units of the primary product, and of unutilized tooling of obsolete design (unless paid for by the purchaser).

A typical example of the distribution of shop overhead by elements of expense is presented below:

and reinforced-concrete buildings is usually taken as 1 - 1.5% of their overall cost, and for frame buildings as 2 - 3%. The cost of routine maintenance of the housekeeping inventory is taken as 10% of the cost of the inventory.

Item 11 covers the depreciation charges on the shop buildings and structures, housekeeping, and productive inventories. The housekeeping and productive inventories are carried on fixed assets account in cases where their value is not less than 500 rubles, or their service life is longer than one year. The depreciation of the shop buildings is taken at 2.6% of their sound balance-sheet value, and the depreciation of the shop inventory at 15% of that value.

Item 12 covers the cost of testing, research and development, as well as the cost of rationalization and invention, including the wages for the workmen of the shop laboratories, the fees for expert testimony, advice, and consultation, the purchase cost of chemicals, reagents, etc., the royalties paid to patentees, and the bonuses for rationalizing suggestions.

At the operating enterprise, the expense of maintaining the shop laboratories is determined by the standards and estimate of laboratory maintenance, while the cost of introducing rationalizing suggestions and inventions is determined by the plan of technical-economic and organizational measures.

In consolidated estimates, the expense of rationalization is taken at 50 rubles per year per rationalizer, the number of rationalizers being taken as 50% of the number of shop workmen.

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the corresponding occupations.

In consolidated estimates, the sum of the expenses under this item is taken as 2% of the base pay of the production workmen, plus 0.3% of the value of the equipment.

Item 14 covers the depreciation of the value of low-cost and perishable housekeeping inventory. The calculation is made by analogy to that of the expenses covered by item 5.

Item 15 covers miscellaneous general plant costs, including the cost of qualification tests of workmen, of the acquisition of drugs for the shop dispensary, etc. In consolidated estimates, the sum of the expenses under this item are taken as not to exceed 4% of the productive wages of the primary workmen.

All the above-mentioned overhead items for the shop are summarized in the estimate of the total shop overhead. The estimates for all shops of the primary production are combined into a summary estimate of shop expenses of the enterprise. The expenses of the auxiliary shops are not included in the summary estimate for the plant and are transferred to the cost of production by way of the cost of services rendered by the auxiliary shops to the primary producing shops.

The overhead of a nonproductive character is not planned for the shop and is not included in the estimate of its overhead. As these expenses are incurred, they are charged to the item "nonproductive shop overhead" and are included in the report as losses increasing the actual cost of production of the shop output. These expenses include payment for idle time due to the fault of the shop, expenses connected with spoilage and shortages of material values, losses due to unutilized production backlogs of parts and units of the primary product, and of unutilized tooling of obsolete design (unless paid for by the purchaser).

A typical example of the distribution of shop overhead by elements of expense is presented below:

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	In %
Auxiliary materials	8
Fuel	1.13
Electric power	8.6
Wages	51
Supplement to wages for social security payments	8.36
Depreciation	10.9
Other cash expenses	2.1
Services of auxiliary shops ...	2.46
Services of service shops	7.45
	100

It should be noted, in conclusion, that the existing classification of shop overhead is unwieldy; a smaller number of items could be established, thereby simplifying the planning and record of shop expense.

Plant overhead comprises the expenses of the enterprise for maintaining the plant administration and plant services.

The plant overhead constitutes a large share of production cost, reaching 50% or more of the base pay of production workmen. The plant overhead is subdivided into administrative and management, general housekeeping, taxes and deductions, and plantwide expense of a nonproductive character.

The administrative and management cost includes wages for the personnel of the plant administration and supplements to those wages; expense of detailing personnel outside the plant and their traveling allowances; expense for trips and maintenance of light transportation; office expense and postal and telegraph charges; expense for maintenance of administrative-management buildings and inventory, and for their depreciation; other administrative and management expense (lighting, heating, water supply, current repairs).

The general housekeeping cost includes the expenses for rent, maintenance, upkeep and current maintenance of buildings and inventory of a general productive character, for instance plant stockrooms and plant laboratories; for the upkeep of fire protection and military protection, including wages; for payment of basic and additional wages (and of the transfers for social security) to, or for, workmen serving the general plant buildings (except the offices of the plant administration); cost of labor protection, production practice, organized recruitment of labor power, and training of personnel; expense for inventions and technical improvements (not included in the shop estimates); bonuses for saving of electric power and fuel, and other general plant expense.

Fees and deductions include taxes, fees, and other obligatory expenses and deductions. The amount of these expenses is planned in accordance with established standards.

The expenses for each of these divisions of general plant overhead are calculated on the basis of standards and limits.

The general plant cost of a nonproductive character includes demurrage charges, surcharges for "cos φ ", other penalties, fines, shortages of materials at plant stores, losses from spoilage and damage to materials due to improperly organized work; these are not included in the estimate and appear only in the report on the general plant overhead which is a loss to the enterprise.

The general plant overhead is distributed between the primary and auxiliary shops in proportion to their basic productive wages or, less often, in proportion to the shop production cost.

The general plant overhead includes:

a) Cost of primary production, turning out finished products and semifinished manufactured goods, including mass consumption goods produced from plant wastes;

b) Cost of that part of the auxiliary production done outside the plant, as well as cost of capital construction, major overhauls, housing and communal services, and the cultural and living needs of the enterprise.

The general plant overhead for work and services of capital repair is alloted, for construction, to the extent of 45% of the wages (according to the wage scale) of the workmen employed in major overhaul work, and for installation and fitting work, to the extent of 40% of those wages.

The general plant overhead is reflected in the estimate of expenses for servicing and management of production.

The following is an example of the distribution of general plant overhead by elements of expense:

	In %
Materials	2.5
Fuel	0.22
Electric power	1.28
Wages	47.5
Supplements to wages for social security payments	3.6
Depreciation	6.5
Other cash expense	22.8
Services of auxiliary shops	5.5
Services of service shops	10.1
	100

According to the increase of production output, expenditures are divided into proportional (variable) and nominal-constant.

Proportional (variable) expenditures are those that increase with increasing output, and include all direct expenses. Of indirect expenses, they include only those that increase with increasing output or with increasing operating hours of the equipment. For instance, consumption of fuel, power, tools, and emulsions for process purposes.

Nominal-constant expenditures include those that remain constant in the shop,

regardless of the amount of product turned out. The nominal-constant expenditures include the wages for engineering-technical workers, employees, auxiliary workmen, expenses for general lighting and heating, management, and other expenses. The compilation in Table 82 shows that, when the shop overfulfills the program, the nominal-constant expenditures are a source of savings, while they are a source of loss when the shop does not fulfill the program.

Table 82

Percent of Fulfillment of Program	Basic Wage Fund, in Thousand Rubles	Shop Overhead Expenses (100%)					
		Assumed Per Plan		Actually Expended		Results of Influence of Nominal-Constant Expenses	
		Variable (50%)	Nominal-Constant (50%)	Variable (50%)	Nominal-Constant (50%)	Saving	Overexpenditure
100	100	50,000	50,000	50,000	50,000	-	-
150	150	75,000	75,000	75,000	50,000	25,000	-
50	50	25,000	25,000	25,000	50,000	-	25,000

Section 4. Procedure for Charging the Expenditures of the Auxiliary Shops and Servicing System to the Cost of Production of the Finished Product

The expenditures of the auxiliary shops and servicing systems are charged in part to the manufacturing cost of their product realized outside the plant, in part to the overhead of the primary producing shops, and in part to general plant overhead.

To determine the amount of expense for an auxiliary shop or a service, one must prepare an estimate of the overhead, an estimate of the expense, and a schedule of their distribution.

The estimate of overhead of an auxiliary shop is analogous, in items contained and in the technique of estimation, to the estimate of overhead of the primary pro-

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ducing shops. At some enterprises the estimate of overhead is prepared only by the auxiliary shops and services putting out varied products or rendering varied services,

Table 83

Schedule of Expenses and Distribution of Production of Shops among Consumers

(in Thousand Rubles)

Elements of Expense	Auxiliary Shops		Primary Producing Shops			Total for Plant
	Maintenance	Heat and Power	Fabricating	Processing	Assembly	
Primary materials	297	355	11 830	592	280	13 354
Auxiliary materials	41	98	793	396	1 183	2 511
Fuel from outside	18	26	36	806	136	1 022
Electric power from outside	1	1	1	26	17	46
Wages	556	748	2 396	5 085	4 178	12 963
Depreciation	42	55	177	368	313	955
Amortization						
Other cash outlay	64	109	146	107	80	506
Services of plant shops	32	76	192	257	128	685
Semifinished goods produced	—	178	545	722	998	2 443
by plant	—	—	—	12 725	13 762	26 487
Shop production cost	1051	1646	16 116	21 084	21 075	60 972
General plant expense	73	491	1 380	1 516	826	4 286
Total	1124	2137	17 496	22 600	21 901	65 258
Distribution of production by consumers:						
To heat and power shop						
To fabricating shop	190	—	—	—	—	190
To processing shop	214	466	—	—	—	680
To assembly shop	279	576	13 801	—	—	14 656
To outside	441	802	—	16 450	—	17 693
To increase balance of	—	293	3 695	—	21 901	25 889
work in process	—	—	—	6 150	—	6 150
Total	1124	2137	17 496	22 600	21 901	65 258

and an estimate is made for each such form. The other shops, in which only one form of service is rendered or only one product is turned out, for example, the boiler or

gas generation shops, are limited merely to an estimate of expenses and an estimate of the unit of production with respect to the primary expense elements alone.

The schedule of expense distribution shows the shops and services among which the production to be performed or the services planned are to be distributed, and the amount allotted to each.

Table 83 is an illustration of such a schedule.

The estimate of the shop expense and the schedule of its distribution is prepared by the balance method which determines, on the one hand, the volume of production to be put out by the shop or service during the planned year and, on the other hand, the shops and services which are to receive this production, and the respective amounts allotted to each. The system of distribution of the expense of the auxiliary production among the shops of the primary production is complex.

Many workers of aircraft enterprises suggest charging the expenses of the auxiliary production directly to the plant production cost of the commodity production, which would considerably simplify the recording of production.

Section 5. <u>General Plant Estimate of Production Cost</u>

The general plant estimate of production cost shows, in money form, the expenditures of the enterprise during the entire planned period for the production and realization of all forms of production, and determines its total production cost. The estimate is prepared in two versions, by elements of cost and by kinds of production, which mutually supplement each other and reflect the two methods of planning production cost. The agreement of the sums obtained in both versions indicates the correctness of their preparation.

The estimate of production by cost elements is prepared to determine all the expenses connected with the industrial-economic activity of the plant, and to coordinate the plan on production cost with the other divisions of the technical-industrial-financial plan. The preparation of the estimate of expense is therefore

Table 84

Estimate of Production by Elements of Costs

No.	Cost Item	Unit of Measurement	For Year	By Quarters			
				I	II	III	IV
1	Cost of production of major products	Thousand rubles					
2	Proportional share of comparable production	%					
3	Comparable commodity production at production cost of past year	Thousand rubles					
4	Comparable commodity production at planned production cost of planned year	Thousand rubles					
5	Reduction in cost of production of comparable production of planned year	%					
6	Saving due to reduction of cost of production of comparable production	Thousand rubles					
7	Expense of production:						
	Raw materials and materials, less salvage	Thousand rubles					
	This includes articles, semifinished goods and services of subcontracting enterprises	Thousand rubles					
	Auxiliary materials	Thousand rubles					
	Total materials cost	Thousand rubles					
	Expenses on components, units and complete sets whose value is not included in gross production						
	Fuel from outside sources	Thousand rubles					
	Power from outside sources	Thousand rubles					
	Depreciation of fixed assets	Thousand rubles					
	Basic and additional wages (including long-service supplements)	Thousand rubles					
	Wages for non-payroll personnel	Thousand rubles					
	Transfers for social security	Thousand rubles					
	Other cash expense	Thousand rubles					
	Total of all production cost	Thousand rubles					
8	Expenses for services and work not entering into gross production	Thousand rubles					
9	Expenses for work on development of manufacture of new products	Thousand rubles					
10	Amortization of expense of development of manufacture of new products	Thousand rubles					
11	Reserve for payments of long-service supplements (by quarters)	Thousand rubles					
	Total of all expenses on gross production	Thousand rubles					
12	Change in balances of work in process	Thousand rubles					
13	Change in balances of special tooling	Thousand rubles					

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No.	Cost Item	Unit of Measurement	For Year	By Quarters			
				I	II	III	IV
	Plant production cost of commodity (finished) production	Thousand rubles					
14	Nonproduction cost	Thousand rubles					
15	Total production cost of all commodity (finished) production	Thousand rubles					
16	Value of commodity (finished) production, at current wholesale prices	Thousand rubles					
17	Profit (net income)	Thousand rubles					
18	Loss	Thousand rubles					
19	Gross production, at plan prices	Thousand rubles					
20	Work in process, at plan prices	Thousand rubles					

based on the summation of the data estimated in the various divisions of the technical-industrial-financial plan, and on the classification of expenses according to the corresponding budget items. This classification of expense is the same for all branches of industry. In this way, unity of indices of the plan on production costs is attained throughout the entire industry, despite the fact that different methods of estimating the production cost of finished articles are in use in the various branches of industry. The estimate of production cost elements determines all the expenses of the enterprise in the planned year necessary for fulfillment of the annual program of production of the gross output, and for the services not entering into the composition of the gross output, without distributing these expenses among the forms of finished production (Table 84).

The estimate of production cost, prepared by the method based on kinds of production, permits establishing the production cost of the individual forms of the finished products and of all the comparable commodity production, to prepare the assignments for the reduction of the production cost of comparable commodity production, and to use these estimates in determining the stockpiles and the wholesale prices. The estimate of production cost by forms of commodity and gross production is based on the consolidated estimate of all expense by combined elements, on the distribution of these expenses by forms of commodity production, and on the changes in the balances of their work in process (Table 85). Before preparing this estimate, we must have a plan estimate of the production cost of each form of finished production.

The expenses in this estimate are entered from the corresponding divisions of the technical-industrial-financial plan. The cost of the raw stock, the purchased semifinished goods, and the finished components is estimated from the manufacturing start-ups, after deducting the value of the salvage. The cost of the auxiliary materials is taken for all needs of shop and plantwide purpose. The transportation and procurement expense is determined after deduction of the value of the services of the plant transportation system.

The value of fuel or power is determined, allowing for the consumption for all productive purposes, after deducting the value of the fuel and power delivered to outside parties.

The total depreciation of the fixed assets is determined on the basis of the average annual value of all operating fixed productive assets of the enterprise and the standard deductions for depreciation as established by the State. The amount of depreciation of the fixed assets is taken from the estimates of depreciation deductions.

The estimate of depreciation transfers characterizes the amount of depreciation of the fixed assets of the enterprise. A depreciation fund exists at the enterprise

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Table 85

Estimate of Production by Forms of Commodity Production and of Gross Production

No.	Designation of Forms of Production	Periods Compared	Output of Production in 1957 (Production cost according to Items of Estimate per Unit of Production in Rubles)						
			Raw Materials and Regular Materials	This Includes Semifinished Goods and Finished Components	Basic Wages of Production Workmen	Long-Service Payments	Shop Overhead	Plant Overhead	Development Expense on New Products
1	Comparable production:								
	A	1956							
	A	1957							
	B	1956							
	B	1957							
	Total for comparable production								
2	1) Noncomparable production:								
	C (etc.)	1957							
3	2) Services to capital construction	1957							
	Total for noncomparable production								
4	Total for commodity (finished) production								
5	Change in volume of work in process								
6	Change in balances of special tooling								
7	Gross production								

Continuation of previous page

						Under Program in Rubles		Current Wholesale Prices in Rubles		Profit or Loss, in Rubles		By Quarters (1st Quarter, etc.)			
Special Expense	Losses from Spoilage	Packing	Plant Production Cost	Nonproductive Expense	Planned Total Production Cost	Number of Units	For Planned Total Production Cost	Per Unit	On Program	Profit (Net Income)	Loss	Number of Units	Cost, in Rubles: Per Unit	Cost, in Rubles: Under Program	At Current Wholesale Prices

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to provide reimbursement for depreciation of the fixed assets. This fund is formed by including, in the production cost of each unit of production, a definite part of the value of the fixed assets corresponding to their depreciation. To estimate the depreciation fund, one must know the value of the fixed assets at the beginning of the plan year, the average annual value of the assets retired during the plan year, and the rate of depreciation allowance.

The value of the fixed assets at the beginning of the plan year is established on the basis of the balance sheet. The mean value throughout the year of the fixed

Table 86

Period	Fixed Assets Put Into Operation in Thousand Rubles	Fixed Assets Retired, in Thousand Rubles	Growth of Fixed Assets, in Thousand Rubles	Number of Months of Operation	Total Amount of Growth of Fixed Assets (col.4 × × col.5), in Thousand Rubles
1	2	3	4	5	6
January	550	50	500	11	5500
February	620	20	600	10	6000
March	420	20	400	9	3600
....	....	....	....	....	....
November	920	20	900	1	900
December	610	10	600	-	-
Total	7750	250	7500	11	38,500

assets to be put into operation during the course of the plan year is estimated in accordance with the plan of capital construction and the dates when the fixed assets are to be put into operation. The average value throughout the year of the fixed assets scheduled for retirement is established in accordance with the intended dates of retirement. For machine-building plants, the average rate of annual depreciation

transfers is established at 5.5% of the original cost of the capital assets.

Table 86 is a typical example of an estimate of depreciation transfers.

In the example, the average growth of the capital assets during the year in the plan period is determined as the sum of

$$38,500,000 : 11 = 3,500,000 \text{ rubles}$$

The value of the fixed assets in force at the beginning of the year is added to this sum.

The enterprise makes monthly transfers for depreciation as follows:

1) To the State Bank, to the extent of about 45% to be used for the capital repair of equipment and buildings of the enterprise, according to estimate;

2) To the Industrial Bank, to the extent of about 55% for financing capital construction.

Other extremely important documents used in preparing the production estimate include the estimate of special expense and the plan of reducing the production cost of comparable production.

The estimate of special expense covers the expenditures for running all aircraft tests, including the engine tests by the acceptance test commission, the special tests of assemblies and instruments if not provided by the manufacturing process of the object; the expense for payment of the fees of expertises and consultations related directly to the manufacture of the given articles; the cost of the technological documentation (technical descriptions and rules for operation of the finished product); the cost of the fuel and lubricants, and the cost of fueling the aircraft on delivery to the purchaser by air; and for enterprises manufacturing products for which a warranty period has been established, the cost of maintaining the personnel of the operational-maintenance departments of the enterprise. The write-off for special expenses is so laid out as to provide for uniform writeoff during the course of a year, starting from the program of output of the finished product in the plan

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year.

The plan of reducing the production cost of comparable finished production shows the reduction in the production cost of comparable finished production by forms as well as the cost elements on whose account the reduction of production cost is planned. Comparable finished production includes the production manufactured in the plan period, and also that in the period preceding the plan period (this period is called the report or base period). The comparability of the finished product is not considered impaired, provided its purpose, type, and power remain unchanged. A change in the manufacturing process will not impair the comparability. Production turned out during the report period only in prototype form or in small lot production, is considered incomparable. Products with a long manufacturing cycle, to be turned out under the conditions of piece production, are considered comparable if they were put out in single pieces during the year preceding the plan year.

The schedule of comparable production is approved on establishing the plan and cost of production.

The plans, estimates and reports on the cost of production of industrial output do not include: expenses connected with the servicing of the accommodations for the plant workers (housing system, baths); losses from natural disaster; expenses for the upkeep of cultural institutions and for the execution of cultural measures; losses on canceled orders, to be written off under the established procedure; other losses and damage during the report year and in earlier years; expense of construction and installation work and of capital repair of buildings and structures; expenses incurred on account of special funds; losses from spoilage, except for such losses in the foundry and heat-treating shops.

Shortages of commodity material values discovered in taking inventories, if their value cannot be recovered from the responsible party, debits on account of shortages, embezzlement and theft of commodity material values on which a court has refused to enforce collection, and losses from spoilage during the production of

previous years but only discovered in the report year, are to be included in the production expense and in the production cost of the product in the given report period, regardless of the time of their occurrence.

Section 6. Technique of Calculating the Wholesale Price of an Aircraft

The productive process of the enterprise is continuous. It does not begin on 2 January and does not end on 31 December. For this reason, in preparing the technical-industrial-financial plan, the influence of the preceding year on the results of the economic activity in the plan year is taken into account, and the indices of the plan year are estimated, allowing for its influence on the year following the plan year. In preparing the technical-industrial-financial plan of an aircraft construction enterprise, the influence of the productive program, which rapidly changes during the course of the year, on the quarterly plan indices, are also taken into account. In aircraft construction, the wholesale prices for defense production are established by agreement with the purchaser. This circumstance, in conjunction with the frequent replacement of aircraft in series production, imparts certain specific features to the technique of estimating the wholesale price for an aircraft. Let us consider the typical example of establishing the wholesale price for an aircraft with an annual production program of 100 aircraft.

Draft Estimate of Wholesale Price for an Aircraft Produced by Plant No. ... for 1956*(see end of Table)

I. Material Cost

a. Material Cost per Aircraft

	In Thousand Rubles
1. Cost of primary materials according to approved standards	125
Transportation-procurement expense (6% of cost of materials)	7.5

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Cost of raw stock including transportation and procurement expense	132.5
Value of waste (3.6% of value of materials without transportation and procurement expense)	4.5
Value of materials with transportation and procurement expense, after deduction of waste	128
Value of materials allowing for influence of manufacturing stock carried forward	130
2. Value of semifinished goods	25
Transportation and procurement expense (6% of cost of semifinished goods)	1.5
Cost of semifinished goods, with transportation and procurement expense	26.5
3. Cost of finished purchased components (per specifications, in agreement with the purchaser)	175
Transportation and procurement expense (2% of cost of finished components)	3.5
Cost of finished purchased components, allowing for transportation and procurement expense	178.5

b. Material Cost over Entire Program

	Manufacturing Reserve Carried Forward to 1 Jan 1956	Plan for 1956	Total Commodity Production for 1956
Number of aircraft, in units	20	80	100
Value of materials per unit, in thousand rubles	138	128	130
Value of materials for commodity production, in thousand rubles	2760	10,240	13,000

* The figures given are arbitrary, in order to show the technique of calculation.

<u>Correction.</u> Actual transportation and procurement expense for 1955, for

materials and semifinished goods, amounted to: 1.6% of their value

for finished articles 1.55% of their value

The program of start-up of commodity production is composed of 80 aircraft to be manufactured in 1956, and of 20 aircraft carried over from the previous year. In estimating the material cost, it is important to establish the value of the manufacturing reserve of materials, purchased semifinished goods and purchased finished components carried over from the previous year to the planned year, and its influence on the wholesale price of the aircraft.

The cost of the manufacturing reserves of materials, purchased semifinished goods, and purchased finished components carried over is taken from the accounting data. If there are no such data, then the volume and value of the manufacturing reserve carried over are determined provisionally. In establishing the wholesale price per finished article it is usual at the same time to rate the purchased finished components which, at the beginning of the plan year, are in stock in production, in warehouses, and in transit, at the prices which these articles will command during the plan year. If, however, no such appraisal has been made, then the influence of the value of the carried-over manufacturing reserve on the wholesale price of the aircraft must be determined. In our example, only the balance of the stocks of material carried over affected the wholesale price of the aircraft, increasing it by 2000 rubles. The relative proportion of the material cost and the transportation and procurement expense in the plan year is compared with the relative proportion of the same expenses in the preceding (report) year.

II. Production Wages

The production wage fund is calculated for the entire volume of work in process for the plan year; for work in process carried over from the preceding year to the plan year; and for work in process manufactured in the plan year and entering into the output of commodity production of the same year.

1. Expenses of labor and wages for work in process in the plan year 1956. In our example, the number of nominal aircraft to be manufactured increases every quar-

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ter, and their labor cost per unit decreases. By far the largest part of the wages for work in process enters the cost of commodity production of 1956, and only a small part goes to the manufacturing reserve carried forward to 1957.

Index	Unit of Measurement	1956 (Average for the Year)	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Labor cost	Thousands of standard hours	30.0	40	30	28	26
Hourly wage rate, per wage scale	Rubles and kopecks	2.20	2.20	2.20	2.20	2.20
Premium-progressive wage payment	%	20	20	20	20	20
Hourly wage rate, counting premium-progressive payment	Rubles and kopecks	2.64	2.64	2.64	2.64	2.64
Category of work		4.8	4.8	4.8	4.8	4.8
Wages per scale (including bonuses and premium-progressive payment) per aircraft	Thousand rubles	79.2	105.6	79.2	74.0	68.6
Time work	Thousand standard hours	1.0	1.0	1.0	1.0	1.0
Hourly rate for time work	Rubles and kopecks	2.0	2.0	2.0	2.0	2.0
Bonus for time work	%	35.0	35.0	35.0	35.0	35.0
Hourly rate for time work, counting bonuses	Rubles and kopecks	2.70	2.70	2.70	2.70	2.70
Wage for time work per aircraft	Thousand rubles	2.7	2.7	2.7	2.7	2.7
Total production wages per aircraft	Thousand rubles	81.9	108.3	81.9	76.7	71.3
Number of nominal aircraft	Units	110	20	25	30	35
Productive wages for program	Thousand rubles	9009	2166	2047.5	2301	2495.5

2. Labor cost and wages for work in process carried over from 1955 to 1956.

Item	Number of Nominal Aircraft in Process	Labor Cost of Work in Process, in Thousand Standard-Hours				Total Wages for Work in Process, in Thousand Rubles	
		Per Nominal Aircraft		For Total Number of Aircraft		Per Nominal Aircraft	For Total Number of Aircraft
		Piece Work	Time Work	Piece Work	Time Work		
Balance on 1 January 1956, in thousand rubles	13	45.0	1.0	585	13	119.7	1556.1

The labor cost and wages for work in process brought forward are established from the data of the annual report of the enterprise for the previous year, or provisionally. These data are necessary for establishing the prices of the commodity production, which includes the work in process from the previous year.

3. The labor cost and the wages for work in process manufactured in 1956 and entering into the commodity production of that same year.

Quarter of Plan Year	Number of Nominal Aircraft	Labor Cost, in Thousand Standard-Hours				Total Wages, in Thousand Rubles	
		Per Nominal Aircraft		For Total Number of Aircraft		Per Nominal Aircraft	For Total Number of Aircraft (Rounded off)
		Piece Work	Time Work	Piece Work	Time Work		
I	20	40	1	800	20	108,3	2166
II	25	30	1	750	25	81,9	2047
III	27	28	1	756	28	76,7	2071
IV	15	26	1	390	15	71,3	1069
Total for 1956	87	31	1	2696	88	84,5	7353

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Consequently, out of the total number of 110 nominal aircraft manufactured in 1956, only 87 nominal aircraft go into the commodity production of that same year, while the other 23 are carried forward to 1957 to provide the commodity output during the first months of the year.

To determine the total labor cost and production wages for the commodity output of aircraft during the plan year, the labor cost and productive wage fund for 13 nominal aircraft brought forward from 1955 must be added to the labor cost and wages for 87 nominal aircraft in 1956. It is this sum that will furnish the labor cost and wages for the 1956 commodity production of 100 aircraft.

4. Labor cost and wages for the commodity production of aircraft in 1956.

Index		Work in Process Brought Forward to 1 Jan 1956	1956 Expenses Ensuring Commodity Output	Total	Per Aircraft
Number of nominal aircraft		13	87	100	-
Time standard per aircraft	Piece work, in thousand standard hours	45	31		32.8
	Time work, in thousand standard hours	1	1		1
Total		46	32		33.8
Wages in thousand rubles, per aircraft		119.7	84.5		89.09
Piece work for total number of aircraft, in thousand standard hours		585	2696	3281	-
Time work for total number of aircraft, in thousand standard hours		13	88	101	-
Total		598	2784	3382	-
Wages, in thousand rubles		1556.1	7353	8909.1	-

III. Shop and Plant Overhead

1. The estimate of shop and plant overhead begins with the application of the reference data to the value of these expenses in the report year.

Reference Data	Overhead, in Thousand Rubles	
	Shop	Plant
1. Actual expense in 1955, less nonproductive expense	27,000	12,000
This amount includes:		
First quarter	6900	3100
Second quarter	6400	2900
Third quarter	6300	2800
Fourth quarter	7400	3200

The reference data are then applied to the volume and growth of gross production of the plan year, by comparison with the report year. Such data are necessary since many overhead items increase with the output of gross production, for instance, the overhead expenses connected with operation of the equipment.

2. Next we compare the volume of gross production in wholesale prices:

for 1955, 100,000 rubles;

for 1956, 125,000 rubles;

growth in %, 25.

3. The overhead for the plan year is estimated in detail for each item, allowing for the factors favoring the reduction of overhead and affecting their variation with respect to the previous year. The results of the estimates are tabulated.

Overhead Adopted	Shop	Plant
	In Thousand Rubles	
For work in process brought forward to 1 Jan 1956		
a) For 13 nominal aircraft	3269	1560
b) For 1 aircraft	~ 252	120
For 87 nominal aircraft manufactured in 1956 and entering the commodity output of the same year	14,706	7353

Shop and Plant Overhead for Commodity Production of 1956

Item	Work in Process Brought Forward to 1 Jan 1956	1956 Expense Ensuring Commodity Output	Total	Per Aircraft
Number of nominal aircraft	13	87	100	
Amount of production wages, in thousand rubles	1556.1	7353	8909.1	
Amount of shop expense, in thousand rubles	3269	14,706	17,975	~179.8
Shop expense, in % of production wages	210	200	201.2	
Amount of plant expense, in Thousand rubles	1560	7353	8913	89.1
Plant expense, in % of production wages	100.3	~100	100.1	

In order correctly to establish the percentage of overhead allotted to each form of finished product, the total amount of overhead is distributed by forms of finished product:

1) For the production, for which the amount of overhead has been established by superior agencies;

2) For the production, for which the amount of overhead has been established from the data of certain shops and services of the enterprise;

3) For production, in which not all the services of the aircraft construction enterprise participate.

The production, for which the overhead expense is estimated in an amount established by the State, includes services for major overhaul on construction and installation.

The production, for which the extent of the overhead is estimated from the data of the shops, includes that of special tooling, crating, and packing. For instance, the overhead applicable to special equipment is taken from the data of the fabricating shop, while the overhead for crating and packing is taken from the data of the shipping department. In these cases, the extent of the overhead should not be taken higher or lower than that existing in these shops, since this would lead to an overestimation or underestimation of the cost of the special tooling or crating.

The production not served by all the services of the aircraft construction plant includes civilian production and articles of mass consumption. It also includes the services that do not enter into the gross production nor into the commodity production, such as the maintenance of the series-design department, and by far the greatest part of the staff of the technological department as well as the overhead of the shops not related to the production of civilian products and products of mass consumption. The full apportionment of the shop and plant overhead of the aircraft construction plant against such production would be incorrect, and would artificially increase its cost. The overhead is therefore allocated at lower rates to the civilian production, the mass-consumption products, and those not included in the commodity and gross production. After estimating the overhead on these items, the remaining amount of overhead is charged to finished defense production. In our example, the shop overhead is allocated to this production to the extent of STAT and the plant overhead to the extent of 100%. The overhead is further distributed

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4. Distribution of Overhead Expense by Plan for 1956

Designation of Product	Production Wage Fund with Bonus-Progressive Payment, in Thousand Rubles	Overhead: Shop Expense: For Year, in Thousand Rubles	Overhead: Shop Expense: % of Production Wages	Overhead: Plant Expense: For Year in Thousand Rubles	Overhead: Plant Expense: % of Production Wages
Product A	9 009	18 018	200	9 009	100
Group Sets for Product A (1 : 10)	891	1 782	200	891	100
Group Sets for Product A (1 : 20)	500	1 000	200	500	100
Spare Parts, Separate, for Product A	500	1 000	200	500	100
Other defense production	100	200	200	100	100
Total	11 000	22 000	200	11 000	100
Civilian production	2 200	2 200	100	550	25
Articles of mass consumption	700	700	100	175	25
Other commodity production	300	200	200	100	100
Special tooling	1 500	2 250	150	—	—
Losses from spoilage	100	200	200	—	—
Services for capital construction	300	375	125	125	41,8
Work not entering into gross production	400	500	125	100	25
Installation expense	300	600	200	—	—
Crating and packing not entering into production cost of aircraft	100	125	125	100	100
Total	16 900	29 150	172,5	12 150	71,9

Distribution of Overhead by Quarters of 1956

Quarter	Number of Nominal Aircraft	Wages in Thousand Rubles	Shop Expenses Entering into Commodity Output: %	Shop Expenses Entering into Commodity Output: Amount, in Thousand Rubles	Plant Expenses Entering into Commodity Output: %	Plant Expenses Entering into Commodity Output: Amount, in Thousand Rubles
I	20	2166				
II	25	2047	Uniformity by quarters has been arbitrarily assumed			
III	27	2071				
IV	15	1069				
Total for 1956	87	7353	200	14,706	100	7353

by quarters, depending on the quarterly productive wage fund (cf. Table in Item 4).

The production wage fund is planned allowing for the growth of the load of production in the plan period by comparison with its load in the preceding period. In our example, the total productive wage fund in the plan year amounts to 16,900,000 rubles. The same wage fund in the year 1955 amounted to 15,000,000 rubles. Consequently, the plan provides for a growth of wages by 1,670,000 rubles, or by 11.26%, with a 25% growth of gross production. This indicates the growth of the load of production, and shows that the growth of labor productivity is in advance of the growth of wages. On comparing the indices of the report and plan years, the tightening of the estimated standard times should be taken into account and the corresponding conversion factors should be used.

IV. Special Expense

A. Special tooling (starting from the standard of writeoff per aircraft) 60 thousand rubles

B. Special expense:

In thousand rubles

1. Wages for the flight complement 3
2. Fuel and lubricants for tests 5

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3. Technical documentation 0.5

4. Upkeep of airfield 10

5. Expenses for static tests of units and airframe, etc. 3.5

C. Other expense (broken down into elements)

Total special expense per aircraft...85 thousand rubles

Special expenses are estimated on the basis of the current standards, specifications for the delivery of production, and estimates. There is no firm technique for determining the standards of writeoff of special tooling, just as in the case of building costs, but they are established annually by agreement with the Gosplan USSR and the purchaser.

VII. Expenses for Flight Services

Designation of Product	Unit of Measurement	Program in Physical Units	Production Wages, in Thousand Rubles		Proportion in % of Total Production Wages	Amount of Reserve for Long-Service Payments	
			Per Unit of Production	For Entire Output		Per Unit	For Entire Output
Aircraft	Units	100	90.09	9009	82	24.6	2460
Group Sets	%		13.91	1391	13.4		402
Spare parts, retail	%		5	500	4.5		135
Other defense production	Thousand rubles		1	100	0.1		3
				11,000	100		3000

V. Building Costs, Written off in Two Years at a Standard of Writeoff of 40,000 Rubles per Aircraft.

VI. Expenses for Crating, Packing and Shipment of Aircraft by Air 4000 Rubles

In practice, most aircraft construction enterprises show under this item only the cost of fuel and lubricants, carrying the cost of fabricating the crating and packing on the corresponding items of the estimate.

VIII. Expenses Connected with Loss due to Spoilage

1. The loss due to spoilage and warranty work, according to the 1955 report, amounts to 4.5 thousand rubles per aircraft.

This includes:

First quarter, 6000 rubles,

Second quarter, 5000 rubles,

Third quarter, 4000 rubles,

Fourth quarter, 3000 rubles.

Plan for 1956 per aircraft .... 3000 rubles

a) for production spoilage .... 1500 rubles

b) for maintenance of operating personnel of plant repair shop, employed at the purchaser's installations for instruction and observation of aircraft operation ... 1500 rubles.

On the basis of the above estimates, the wholesale price of the aircraft can then be estimated.

Estimate of Wholesale Price for Aircraft A Produced by Plant No. ... in 1956

No.	Type of Expense	Unit of Measurement	Amount of Expense
1	Primary materials	Thousand rubles	130
2	Semifinished goods	Thousand rubles	26.5
3	Finished components	Thousand rubles	178.5
	Total material expense	Thousand rubles	335

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No.	Type of Expense	Unit of Measurement	Amount of Expense
4	Base pay for productive workers	Thousand rubles	89.1
5	Shop expense	Thousand rubles	179.8
6	Same	%	202
7	General plant expense	Thousand rubles	89.1
8	Same	%	100
9	Supplements for long service	Thousand rubles	24.6
10	Special expense, including special tooling	Thousand rubles Thousand rubles	85 60
11	Shipment and delivery	Thousand rubles	4
12	Building cost	Thousand rubles	40
13	Expense of operational maintenance personnel	Thousand rubles	1.5
14	Loss due to spoilage	Thousand rubles	1.5
15	Other expense	Thousand rubles	-
16	Plant production cost	Thousand rubles	849.6
17	Nonproductive expense (0.75%)	Thousand rubles	6.4
18	Total production cost	Thousand rubles	856
19	Planned sinking fund (3%)	Thousand rubles	26
	Wholesale price		882
	Analysis of wages:		
a)	Labor cost for piece work	Thousands of standard-hours	32.8
b)	Labor cost for time work	Thousands of man-hours	1
	Total hours		33.8
c)	Average category of work		4.8

No.	Type of Expense	Unit of Measurement	Amount of Expense
d)	Pay rate, per wage scale	Rubles and kopecks	2.20
e)	Extra pay by progressive bonus system	Rubles and kopecks	0.47
	Cost per hour	Rubles and kopecks	2.67

Section 7. Record and Analysis of Fulfillment of Plan of Production Cost

The systematic record and analysis of the productive economic activity assists the managers of enterprises in improving the technique, organization, and economy of production, in timely elimination of possible shortcomings, and in a fuller utilization of the production reserves, for fulfillment and overfulfillment of the State plan.

The record of the production cost and the estimate of the actual production cost of the forms of production should ensure:

a) Timely and complete reflection of the actual expenses in the record;

b) Control over correct utilization of raw materials, production materials, and wage funds;

c) Verification of fulfillment of the plans for production cost;

d) Interpretation of the results of the productive activity of the enterprise, shops, and services.

The estimates of the production cost of the finished products of aviation technology and the record of production expenses are generally kept by series of aircraft. Under the series method of record, all production expenses are charged to the series, while the report production cost per article is determined by the total cost for the series, divided by the number of aircraft in the series.

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At present, the norming method of recording is being introduced. This is more

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convenient and permits an operative regulation of the fulfillment of the plan for production cost. The norming method is based on establishing consumption standards for all elements of the estimate of each form of production. In this method of calculation, two primary documents are used: the labor cost and wage card and the chart of applicability of materials. Both documents are adapted for processing and grouping the standards at the machine computer station.

On the basis of the norming documentation, the norm estimates and price lists are worked out for all parts, units, and assemblies of the primary products; for the commodity units (technological sets) used as planning and recording units in intershop operative planning; for the machine-sets of the shops; for the group sets of spare parts. In the norming method, a daily record is kept of deviations from the standard expenses for production laid down by the plant, and the causes of these deviations are noted. The report estimate, constructed by the norming method, shows the expenses under the current standards, the amounts of deviations from the standards, the amounts of deviations due to changes in the standards, and the grand total expense, i.e., the actual production cost. For proper analysis, the planning and recording of the expense must have been conducted under a single classification.

The actual production cost of the output is determined, under the norming method of estimation, by adding to or subtracting from the norm production cost, for each item of the estimate, any deviation from the current standards (saving -, excess spending +) as well as the changes made in the standards.

The enterprise prepares a monthly report on fulfillment of the plan for production cost, indicating the total production cost of the entire commodity production and of its comparable part, the relative contribution of the comparable production, the plans and actual percentage of reduction of production cost and of production expense by items of the estimate sheet.

Table 87 is an example of such an estimate sheet.

The analysis of the fulfillment of the plan for production cost of output is

Table 87

No.	Wages	Cost of Production of Comparable Commodity Production in Prices of the Base Year, in Thousand Rubles	Cost of Production of Comparable Commodity Production in Prices of the Plan Year, in Thousand Rubles	Absolute Saving Due to Decrease of Costs in Thousand Rubles	Savings from Reduction of Production Cost, in % of Production Cost of Comparable Production of Base Year (col.5 : col.3)	Savings from Reduction of Production Cost, in % of Total Production Cost of Base Year
1	2	3	4	5	6	7
1	Primary materials	1381,2	1314,6	−66,6	−4,8	−0,7
2	Plant-produced semifinished goods	1950,1	1631,6	−318,5	−16,3	−3,5
3	Recoverable Waste (Subtracted)	22,7	4,7	−18,0	−79,3	−0,2
4	Wages, Basic	1229,2	971,8	−257,4	−20,9	−2,8
5	Wages, additional	61,3	61,3	—	—	—
6	Supplements to wages	93,2	79,5	−13,7	−14,7	−0,1
7	Development expense for new production	490,9	442,2	−48,7	−9,9	−0,5
8	Depreciation of special-purpose tools and attachments	321,6	590,5	+268,9	+83,6	+2,9
9	Shop expense	1982,0	1495,2	−486,8	−24,6	−5,3
	This includes expense connected with operation of equipment	1004,9	749,5	−255,4	−25,4	−2,8
10	Plant expense	1090,1	803,4	−286,7	−26,3	−3,1
11	Loss due to Spoilage	360,6	73,3	−287,3	−79,6	−3,2
12	Nonproductive expense	109,8	—	−109,8	−100	−1,2
13	Plant production cost of comparable commodity production	9047,3	7458,7	−1588,8	−17,6	−17,4
14	Nonproductive expense	99,9	45,7	−54,2	−54,2	−0,6
15	Total production cost of comparable commodity production	9147,2	7504,4	−1642,8	−18,0	−18,0

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conducted for each element of the production cost estimate and for the individual items of the estimate of each form of the article, taking account of the change in the volume of output, and is performed by the method of detecting deviations from the established standard and the factors determining these deviations in a positive or negative direction. Table 88 gives an example of the analysis of the production cost of the product, for each of its forms. Table 89 is an example of the analysis of the fulfillment of the plan to reduce the production cost of the output. The analysis is concluded with a recommendation of measures to ensure a further reduction in the production cost of the output.

Section 8. Elaboration of the Plant Assignment Down to the Shops and Production Sections

The assignments prescribed by the technical-industrial-financial plan of the enterprise are elaborated and brought down to each shop in the form of a quarterly plan. The planning and production department elaborates the data of the quarterly plan for the shop for each month, starting from the results of fulfillment of the plan for the previous month.

The activity in each primary production shop is planned and recorded by the following economic indices: volume of gross production, expressed in standard-hours or in standardized wages (except the coating, heat-treatment, and shipping shops, which have a short production cycle); the volume of the commodity production in standard-hours or in standardized wages, and in series estimates by machine-sets, assemblies or aircraft; the consumption standards of primary materials by major articles; the output of gross production per workman and per 1000 rubles of fixed assets; the wage fund by categories of workers; the standard consumption of auxiliary materials, the depreciation of low-cost inventory and tools; the loss due to spoilage (only in the report); the losses and overages of material commodity values (only in the report); the sum of the deviations from the standards of material consumption by principal articles (only in the report). The shop, in turn, reduces the

Table 88

Designation of Product	Output in Pieces, per Report	Production Cost in Thousand Rubles				Deviation From Plan	
		Per Plan		Per Report		Thousand Rubles	%
		Per Unit Object	Entire Quantity	Per Unit Object	Entire Quantity		
A	1250	100	125,000	97	121,250	-3750	-3
B	850	90	76,500	86	73,100	-3400	-4.45
C	500	110	55,000	105	52,500	-2500	-4.55
Total:	-	-	256,500	-	246,850	-9650	-3.75

indices of its plan to each productive department and section, taking account, in so doing, of the results of their operation during the past month. The primary purpose of the economic plan of the department or section is most fully to reveal and utilize the internal reserves of production. For this reason, the economic plan of the department or section includes indices depending only on the results of its own work. Such indices are: the productive program with respect to commodity production, expressed in standard-hours or in standardized wages; the number of production workers; the wage fund of production workers, including the bonuses under the progressive system; the foreman's fund for bonuses to outstanding workmen; the idle time of workmen (only in the report); the number of workmen not meeting the standards (only in the report); the loss due to spoilage and other losses (only in the report).

The monthly assignment is issued by the superintendent of the shop to the senior foreman 4 - 5 days before the beginning of the plan month. The senior foreman details the technical-economic plan by shifts, and the shift foreman by work stations. Such concrete indices as production list and number of parts to be processed, and the monthly standard output of product in pieces and in hours, are brought down to; and specified for, each workman. Such indices become the object of the socialist competition among the workmen. In each shop the Party, communist youth, and labor union organizations ensure the active participation of the collective in the improvement of the plan indices. This active participation of the masses is reflected in the discussion of the plans at production conferences, in the specific obligations assumed by each worker of the shift, in rationalizing suggestions, and in the dissemination of advanced methods of work.

Section 9. Features of Planning and Estimating the Production Cost of Experimental Work

A development enterprise is financed primarily out of the State budget. For the planned year, instead of a technical-industrial-financial plan, a schematic plan of research and experimental work is prepared, accompanied by a corresponding estimate of expense, justified by specific calculations.

The expense estimate is the financial expression of the schematic plan. It reflects all the expense of the development enterprise for staging the research, experimental, designing and productive work during the plan period (Table 90). The volume of the work is calculated in standard-hours. The cost of one standard-hour is taken from the standard Tables.

For observance of a regime of economy at the development enterprise, it is necessary, on the basis of mechanization and improved organization of labor, to reduce systematically the cost of the standard-hour, the labor cost of the work, the shop and plant overhead, and the expense of primary and auxiliary materials.

The schematic plan unifies the schematic of the development design office and contains the assignments received by the development design office from the central administration and from the purchasers, the projects advanced by the units of the development design office, and those that have been carried over from the plan of the previous year (Table 91).

The schematic plan should include projects vital to the national economy; the

Table 89

Designation of Products	Production Cost per Unit of Product, in Rubles: Average for Report Year	Production Cost per Unit of Product, in Rubles: By Plan	Plan for Output of Comparable Production: Number of Articles	Total Production Cost of Output, in Thousand Rubles: By production cost of previous year	Total Production Cost of Output, in Thousand Rubles: By planned production cost	Assignment on Reduction of Production Cost: Saving in thousand rubles	Assignment on Reduction of Production Cost: In %
A	1000	900	5000	5000	4500	500	-10.0

Designation of Products	Report on Output of Production: Number of Articles	Total Production Cost, in Thousand Rubles: By reported production cost of previous year	Total Production Cost, in Thousand Rubles: By actual production cost	Actual production cost per product	Performance of Assignment for Reducing Production Cost: Amount of saving in thousand rubles	Performance of Assignment for Reducing Production Cost: In %
A	2500	2500	2400	960	100	-4.0

Designation of Products	Analysis of Fulfilment of Assignment — Actual Output by Production Cost, in Thousand Rubles: Of past year	By plan	Fulfilment of plan	Assignment on Reduction of Production Cost of Actual Output — Per Plan: Saving in thousand rubles	Per Plan: In %	Actual: Saving in thousand rubles	Actual: In %
A	2500	2250	2400	250	-10.0	100	-4.0

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Table 90

Plan Estimate of Expense for Development Work Aircraft Construction Enterprise for 195 ..

No.	Type of Work	Workers Assigned	Dates of Execution				Volume of Work in Stand. hrs		Cost of Stand. hr. in rubles		Amount of Wages for Development Design Office		Amount of Expense for Outside Workers		Cost of Materials and Semi-finished Goods	Cost of Finished Components	Total Expense	Remarks
			Beginning		End													
			Designing	Production	Designing	Production	Designing	Production	Designing	Production	Designing	Production	Designing	Production				

Table 91

Project Plan of Research and Development of Aircraft Construction Enterprise for 195 ...

No.	Type of Work (Title of Project)	Workers Assigned	Dates of Execution		Percent of Technical Completion as of 1 Jan 195 ...	Work Load in 1000 Stand. hrs		Rough Estimate of Cost in 1000 Rubles			Total	Source of Financing	Remarks
			Beginning	End		In Development Design Office	In Production	For Development Design Office	For Production	For Outside Workers			

dissipation of forces and resources on numerous projects must not be allowed. The plan should ensure complete and uniform utilization of the equipment and personnel of the development design office and provide for maximum economy of resources at all stages of the development production.

For each project, its director prepares a working plan, necessary for the correct organization of the work and for the control of its execution.

Table 92

Designation of Stages	Person Responsible for Stages	Dates		Labor Cost and Wages					
				Eng.-Tech. Personnel		Workmen		Total	
		Beginning	Termination	Man-Months	Pay in 1000 Rubles	Man-Months	Wages in 1000 Rubles	Man-Months	Wages in 1000 Rubles

The preparation of the plan begins with the indication of the content of the work, the labor cost, and the wage fund for each stage of the project (Table 92)

The dates of beginning and end of the stages are fixed, allowing for the possibilities of organizing the work on a wide front and the parallel and parallel-sequence performance of their parts. This is reflected in the graph or work on the project.

To permit timely placement of outside order by the department of supply for materials, semifinished goods, and finished components required for work on the project, a requisition is drawn up indicating the characteristics and the quantity required. A similar requisition is made for instruments, equipment, and installations.

To ensure timely issue of orders to the subdivisions of the development enterprise, the plan specifies the work to be performed by the shops, laboratories, etc.

Table 93

Estimate of Work on Project

Stage No.	Labor Cost in Man-Hours	Production Wages	Pay for Flight Tests	"No-Personnel Available" Fund	Materials	Aircraft, Engines, and Instruments Purchased	Cash Expenditure	Services of Subcontracting Subdivisions	Per Contracts with Industry	Shop Expense	Plant Expense	Bonus Fund	Total Cost
Estimated cost (in 1000 rubles)													
1 ...													
...													
6 ...													
Estimated totals:													
Actual cost of work (in 1000 rubles)													
Months													
January													
...													
December													
Total expense for year													

This allows the planning department to determine the load on the development production facilities, laboratories, and teams, and to pinpoint the dates of beginning and end of the work on each project.

The work to be done by outside organizations is enumerated, for the timely placement of outside orders. This allows timely placing of orders and finalizing of the pertaining contracts.

For the testing operations, the plan for a project indicates the type of tests, the amount of work they involve, and the dates they are to be performed. This allows the inspection department, the laboratory, or the flight station to do the work preparatory to the tests in good time.

Finally, the project may include work which the team itself is not in a position to perform and for which outside workers must be used. For this purpose, provision must be made for expenditures from the "no-personnel available" pay fund.

After all these estimates have been made, the plan for the project is delivered to the planning department, which estimates the work involved. The cost of the project is estimated by project stages and by months. This is necessary for timely financing of the work and for control over the correct utilization of the funds on the project (Table 93).

The financing and records of the work on the project are handled by the accounting department on the basis of the project plan and its calculations. On conclusion of work, a report and annotation on the project are prepared. The reports and statements on the acceptance of the work, indicating the quality of its performance and the economic effectiveness of its introduction into industry, are annexed. For a prototype aircraft or engine, the results of the plant and State tests are indicated.

CHAPTER XXII

FINANCIAL PLAN OF THE ENTERPRISE

The financial plan of the enterprise reflects the assignments on rate of profit, rate of turnover of working assets, and contributions to the State budget and shows, in terms of monetary units, the volume of the productive and nonproductive activity of the enterprise, its requirements for funds, and the sources from which they are to be obtained.

The State, making use of the financial plan, organizes its control of the activity of the enterprise on a ruble basis.

The financial plan of the enterprise includes an estimate of its requirements for own working assets, a plan of realizing production and of distributing surplus, an estimate of requirements for borrowed working assets (a credit plan), and a statement of income and expense.

Preparation of the financial plan requires consumption standards of the working assets, estimates of production cost of gross and finished product, and estimates of expense and receipts for the nonindustrial services of the enterprise.

Section 1. Estimate of Requirements of Enterprise for Own Working Assets

The working assets of an enterprise are divided into own and borrowed, into standardized and unstandardized.

The own working assets are allocated by the State to the enterprise in the amount of its minimum requirements. The additional or temporary needs of the enterprise for working capital, connected, for instance, with the need for building up seasonal inventories of raw materials and fuel, are covered by borrowed funds, credits from the State Bank, for the use of which the bank makes a definite charge (interest) to the enterprise. This procedure stimulates the most rational utilization, and the accelerated turnover, of the working capital.

[redacted]

The standardized working assets cover the expenditures of the enterprise on its industrial activity. The standardized working assets consist of the productive inventories of fuel, primary and auxiliary materials, semifinished goods and purchased components, crating, spare parts for current repairs of equipment and buildings, low-cost and depletable inventory and tools, special tools and special attachments, work in process, finished components in warehouses, and funds for the expenditures in future periods for preparation and development of new production.

The unstandardized working assets are not related to the productive cycle; they include the balance of funds, funds in the process of settlement with purchasers and suppliers, and the balances of finished products shipped. The enterprise does not use its own working capital to meet these expenses.

The standards for the standardized working assets are established on the basis of the entire volume of gross production. The production estimate is the basic factor for their determination, besides the day standards. The standards for work in process, special tooling, and deferred charges are taken in complete correspondence with the data of the production estimate.

The day standard is established for the stocks of materials in accordance with the length of the procurement cycle Cy_{proc}; for work in process, in accordance with the length of the productive cycle Cy_p; for finished production in stock, in accordance with the cycle of realization Cy_r.

The consolidated day standard of working assets is equal to the length of the industrial (economic) cycle Cy_{ec}: STAT

[redacted] $Cy_{proc} + Cy_p + Cy_r$ STAT

The standard in terms of money is expressed for each form of working assets by the formula

$$O = \frac{EP \cdot D_o}{D_{p.p}}$$

where O is the absolute value of the standard of the given type of working assets;

EP is the expense according to production estimate for the given type of working assets;

Table 94

Designation of Principal Items of Working Assets	Expenses Per Production Estimate, in Thousand Rubles	Standard, in Days	Formula for Estimate $\frac{EP \cdot D_o}{D_{p.p}}$	Amount of Working Assets, in Thousand Rubles
Working assets in balance of primary materials	8 000	45	$\frac{8000 \times 45}{360}$	1000
Working assets in balance of auxiliary materials	3 500	60	$\frac{3500 \times 60}{360}$	583
Working assets in balance of fuel	2 000	60	$\frac{2000 \times 60}{360}$	333
Working assets in balance of work in process	38 000	33	$\frac{38\,000 \times 33}{360}$	3483
Working assets in balance of finished products (etc.)	38 000	12	$\frac{38\,000 \times 12}{360}$	1266
Total standardized working assets				6665

D_o is the standard in days for the given type of working assets;

$D_{p.p}$ is the length of the planned period, in days.

On the basis of this formula, the standard of working assets can be calculated for each form of such assets (Table 94).

The standards for working assets in supplies of fuel, materials, semifinished goods, and finished components are calculated for each of these groups on the basis of the standard consumption per day in the planned period, the length of the procurement cycle, and the standards of warehouse supplies.

The standard of working assets for work in process includes the cost of materials, purchased semifinished goods, and finished components, and also (to a certain percentage), the transportation and procurement expense, the basic wages, and the shop and plant overhead.

The standard of working assets for finished products in the warehouse is determined by multiplying the total production cost of the average daily output of finished production by the cycle of realization, i.e., by the number of days necessary for shipping the finished product and for finalizing the bills and loans for it at the State Bank.

No standard of working assets is established for the shipment of finished products, since the equivalent of the finished production is loaned by the State Bank against the shipping documents and the corresponding invoices or vouchers (for the time necessary for the purchasers to pay the bills for the goods shipped).

The total standard of own working assets of the enterprise O may be calculated in consolidated form by means of the formula

$$O = Cy_{ec} \cdot O_d$$

where O_d is the day standard of working assets of the enterprise.

It follows from this formula that, in order to reduce the amount of working assets required by an enterprise, the economic cycle must be shortened, and the consumption standards of the working assets per unit of production must be reduced. Bearing these requirements in mind, the standard of working assets is calculated for each quarter, and their turnover coefficient is established.

The difference between the established standard at the end and at the bSTATning of the plan period shows the growth or loss of working assets being planned.

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The coefficient of rate of turnover of working assets K_t shows how much finished product must be realized per ruble of working assets:

$$K_t = \frac{C_{r.p}}{O_{mean}}$$

where $C_{r.p}$ is the sum of realized finished product, at wholesale price (without the turnover tax) for the given period;

O_{mean} is the mean amount of assets turned over during the same period.

The smaller the day standard of working assets D_o, the greater will be the number of turnovers n_o of the working capital during the planned period, and the more effective, consequently, will be its utilization.

Hence the rate of turnover, or number of turnovers, will be

$$n_o = \frac{360}{D_o}.$$

For each form of standardized working assets, a consumption standard is established for the enterprise, i.e., the minimum amount of working assets sufficient for the normal conduct of production at the level of organization attained and for the assigned program. The production program is always being increased, and the level of organization of the enterprise is always rising; therefore, the amount of working assets is subject to annual adjustment. The continuous improvement of the technique and organization of production makes it feasible to plan the acceleration of the turnover of working assets every year.

The enterprise usually finds it necessary to have additional own working assets in view of the increase of the stable liabilities, of the proceeds from the liquidation of retired property, of the free profits, and of the financing from the state budget. The growth of stable liabilities is due to the increase in the minimum accrued liabilities of the enterprise, due to wages, long-service bonuses, and social security transfers, and due to the advances received from purchasers in accordance with the stage of completion of the objects. For example, let the workmen have been paid on the 5^{th} of the month for work performed from the 16^{th} to the 30^{th} of the

preceding month. The enterprise has already regularly received funds from the 16^{th} to the 30^{th} of the same preceding month, representing proceeds of the realization of the same production, and including amounts for wages payable only on the 5^{th} of the month following such receipt. In this case, the wages accrued up to the 5^{th} have become a reserve of the enterprise, augmenting its working capital.

If working assets are formed at the enterprise, in amounts exceeding its requirements for working assets according to the plan, the excess working assets are withdrawn by the superior organization or are transferred by the enterprise to the State budget.

The free (net) income is the principal source for covering the needs of the enterprise for working assets and represents the balance of total net income after deducting the payments to budget account, to the enterprise fund, and to the funds for producing articles of mass consumption from plant waste.

Section 2. Plan of Realization of Production and Distribution of Net Income

The plan of production realization discloses the total production cost of all realized production, the amount for which the finished production is realized, at wholesale prices, the amount of net income from the realization of production, and the rate of profit of the enterprise.

The plan of realization of production and distribution of the net income is prepared at aircraft enterprises by the method of direct calculation.

When the plan is prepared, it is made to reflect the influence of any change in the balance of finished production, any change in the distribution of production according to the method of its realization, and any change in the planned production cost of the product.

The change in the balance of commodity production between the beginning and the end of the plan year establishes the amount of annual commodity production realized during the plan year, AP_r. This amount is equal to

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$$AP_r = AP_1 + AP - AP_2$$

where AP_1 is the balance of annual production of the past year, brought forward for realization in the plan year;

AP is the finished production manufactured in the plan year;

AP_2 is the balance of finished production of the plan year, to be realized in the year following the plan year. This includes the finished production for which the documentation for procuring a loan from the State Bank has not yet been finalized; the finished production for which funds from the purchaser have not yet been transferred to the clearing account of the enterprise.

The form of the production to be manufactured exerts an influence on the amount of net income transferred by the enterprises to the State budget. No turnover tax is collected on finished products representing means of production utilized in other branches of the national economy. Consequently, aircraft construction enterprises pay no turnover tax on the aircraft manufactured. These enterprises transfer to the State budget a part of their net income in the form of the turnover tax on the realized production of articles of mass consumption. As distinguished from profit, the turnover tax is fully transferred to the State budget immediately after production has been realized.

Since the amount of net income of the enterprise depends on the degree of fulfillment of the production plan and of realization of the production as well as on the **fulfilment** of the plan of reduction of production cost, it follows that any change in the planned production cost of the product during the plan period will increase or decrease the amount of the expected net income. Moreover, the amount of net income is also affected by items of net income or loss of the preceding year first appearing in the plan year; by the net income or loss from the operation of the housing and communal system (nonindustrial activity); by the net income that reflects the write-off of liabilities in connection with the statute of limitation; and by the losses from natural disasters, from uncollectable accounts, and from unsuccessful experiments.

Forms of Net Income and Planned Distribution. The net income of the enterprise is divided into two parts, of which one remains with the enterprise, while the other is transferred to the centralized State fund. The necessity of these two forms (parts) of net income is due, on the one hand, to the system of unsubsidized independent cost accounting, and on the other hand, to the need of the Socialist economy for the centralization of a considerable portion of the net income of its enterprises.

The net income remaining with the enterprise is distributed as follows:

1. A total of 1 - 6% of the planned net income and an additional 20 - 50% of the amount of overplan net income is transferred to the enterprise fund. The total amount of the transfers to the enterprise fund must not exceed 5% of the annual wage fund of the industrial production personnel, converted on the basis of the actual volume of output of commodity production.

2. Another part of the net income, namely the income received from the realization of mass-consumption articles manufactured from plant waste, is completely transferred to the fund for articles of mass consumption. Out of this fund, the profits up to 25% are spent for bonuses and the cultural and daily needs of the workers of the enterprise, while the rest of this income goes to develop the production of products from plant waste.

3. A part of the net income is used for building up the enterprise's own working assets, as they increase.

4. A part of the net income goes to amortize the long-term credit granted by the State Bank for the introduction of new techniques.

A part of the funds is transferred to the Industrial Bank, to finance capital expenditures.

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The centralized net income of the State, in the form of transfers from the profits, wage supplements, for social security payments, etc., form that part of the product created by labor for society, which is collected from the enterprises and concentrated in monetary form in the hands of the State, to be used for general national purposes. Most of the centralized net income of the State at present is received in the form of what is known as the "turnover tax". The amount of the turnover tax depends on the volume and assortment of the realized product and is determined in advance in the price of the product in the form of a strictly fixed share of the surplus.

Section 3. Credit Plan

The credit plan shows the need of the enterprise for credit and the sources from which it is obtained.

It is forbidden to arrange credit for the enterprise on the account of suppliers or purchasers. The enterprise can obtain credit only by the receipt of funds from the State Bank, which makes short-term loans to the enterprise in the following cases:

1) To finance above-normal stocks of material values, due to seasonal features of work (procurement of peat, coal, molding sand), due to operating conditions of transportation (navigation season), or the conditions of interplant cooperation (simultaneous delivery of a large lot);

2) To finance over-normal balance of work in process due to causes not depending on the enterprise (increase of program, stretch-out of deliveries);

3) To finance over-normal balance of finished product due to overfulfillment of plan, transportation difficulties, and other causes not depending on the enterprise;

4) To finance production shipped, prior to the due date of payment for it, and to finance measures in preparation for seasonal work, and expenses for organized

Table 95

Statement of Income and Expense for 1956

No.	Income	In Thousand Rubles	No.	Expense	In Thousand Rubles
1	Receipts from realization of production at wholesale prices of the industry (including the turnover tax)	170,679	1	Expenses allocable to realized production	154,714
2	Including profit	15,695	2	Planned growth of own working assets	8935
2	Working assets on account of redistribution of assets between plants	-	3	Collection of excess working assets under procedure for redistribution between plants	5900
3	Financing of research and experimental work (on account of commercial expenses)	180	4	Transfers to enterprise fund	313
			5	Transfers to fund for articles of mass consumption	-
4	Growth of minimum accrued indebtedness for wages and social security payments	128	6	Amortization of loans for development of new technique	136
5	Growth of other stable liabilities (customer's advances on degree of completion, deferred charges, etc.)	-	7	Capital investments	2000
			8	Major overhauls	5245
6	Proceeds of realization of retired property	300	9	Expenses on research work	430
			10	Upkeep of kindergartens	1200
7	Excess (+), shortage (-) of own working assets at beginning of plan period	+790	11	Training of personnel of mass occupations	160
	Initial balance of funds in special account of State Bank	40	12	Expenditures of housing-communal system	3200

8	Income from housing-communal system	3200		Final balance of funds in special account at State Bank	100
9	Collections from parents for upkeep of kindergartens	360		Total expense	182,333
10	Contract receipts for research work	100		Of the total amount of expense, the following items are covered by income redistributed within the enterprise:	
	Total income	175,777		a) capital work financed from depreciation account	2000
	Excess of expenditure over income	-		b) major overhaul, financed on account of depreciation transfers	5245
				Total cost, less expense covered by income distributed within the enterprise	175,088
				Excess of income over expenditure	689

Mutual Relations with State Budget

	Payments to Budget			Appropriations from Budget	
1	Transfers from profits	1569	1	For growth of own working assets	-
2	Turnover tax	270	2	For capital investment	-
3	Withdrawal of excess working assets	-	3	For training personnel of mass occupation	160
	Total payments to budget	1839	4	For research and experimental work	250
	Excess of payments over appropriations from budget	589	5	For kindergartens	840
				Total appropriations from budget	1250
				Excess of appropriations over payments to budget	-

recruiting of labor power.

The State Bank grants long-term credits to the enterprise for a term of up to 2 - 3 years to meet the cost of introduction of new techniques and improvment of technology. On account of these credits, the enterprise may acquire new equipment, organize line production, etc. The credits are amortized by the enterprise out of the overplan profits received in the current year. In recent years, the amortization of credits received has been on account of the planned profit and is being included in the balance sheet of assets and liabilities.

The State Bank does not finance expenses on substandard materials, frozen assets spoilage removed from production, unmarketable production, and production in incomplete sets, i.e., the bank will advance funds to cover expenses due to poor work of the enterprise.

The enterprise pays the bank interest on loans. Provision for these expenses is made in the credit plan and in the production estimate under the category of general plant overhead.

Section 4. Statement of Income and Expense

The statement of income and expense reflects all forms of the planned income and expense of the enterprise, its interrelation with the State budget, and the expected results of industrial and nonindustrial activity during a given plan year. The contents of the statement of assets and liability are given in the example presented (Table 95). The balance sheet consists of two parts. One part reflects the operation of the enterprise as to its income and expense; the other part reflects, in the transfers and appropriations, the interrelations between the enterprise and the State budget.

The industrial activity of the enterprise is the major item in the balance sheet. The excess of receipts from the realization of production over the expenditure for its production shows the magnitude of the expected profit of the enterprise.

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Table 96

No.	Forms of Working Assets	Standard of Working Assets in Effect During the Report Period	Actual Assets during Period under Analysis	Deviation of Actual Assets from Current Standards	Possible Reduction of Existing Working Assets	Necessary Amount of Working Assets
1	Raw materials and primary materials	1 000	1 200	+200	200	1 000
2	Purchased semifinished goods	—	—	—	—	—
3	Auxiliary materials	583	500	—83	50	450
4	Fuel	333	350	+17	50	300
5	Crating	248	200	—48	—	200
6	Spare parts for current maintenance	550	500	—50	50	450
7	Low-cost and depletable tools, inventory, etc.	2 000	2 200	+200	200	2 000
8	Work in process	3 500	3 770	+270	270	3 500
9	Finished production	1 266	1 500	+234	234	1 266
10	Deferred charges	1 000	1000	—	—	1 000
	Total	10 480	11 220	+740	1054	10 166
11	Production to be realized at wholesale prices of enterprise	36 000	35 000	—	—	36 000
12	Number of turnovers	3,43	3,12	—	—	3,55
13	Length of turnover (in days)	104,9	112,2	—	—	102,2

Reproduction is reflected in the balance sheet by the expenditures on capital construction, major overhaul, and training of personnel of the mass occupations.

Distribution is reflected in the balance sheet by the income of the enterprise and its distribution.

The nonindustrial activity, as an activity appearing on an independent balance sheet, is reflected in the principal balance sheet mainly in the form of profit or loss from the nonindustrial activity of the enterprise.

In the balance sheet, each expense item is correlated with the corresponding income items.

In order to understand the portion of the financial statement that reflects the interrelations between enterprise and State budget, it must be remembered that its credit side represents income for the State, but expense for the enterprise. On the other hand, its debit side represents expense for the State, but income for the enterprise. For this reason, the credit side of the statement indicates the payments made by the enterprise to the State treasury. The debit side of the statement indicates the amount received by the enterprise from the State treasury. The more profitable the operation of the enterprise, the greater will be the amount of the payments from the enterprise that go into the State budget.

Section 5. Analysis of the Fulfillment of the Financial Plan

The analysis of the fulfillment of the financial plan must show the manner in which the enterprise observes financial discipline, the efficiency with which the independent unsubsidized cost accounting is applied, and the effectiveness of utilization of financial resources.

The analysis of the utilization of the standardized working assets shows the efficiency of utilization of the working assets and indicates the possibility of cutting standards for all stages of production and of releasing working assets. STAT

Table 96 is an example of such an analysis.

Table 97

Analysis of Fulfillment of Plan of Realization of Production and Stockpiling (All Monetary Values are Arbitrary)

Period of Analysis	Commodity Production					Growth of Balances of Commodity Production, in 1000 Rubles			Realization of Commodity Production, in Thousand Rubles					Accumulations, in 1000 Rubles			Profit Rate in %		Reserves, in Thousand Rubles			
	In Planned Assortment, at Planned Production Cost, in Thousand Rubles	In Actual Assortment at Planned Production Cost, in Thousand Rubles	Fulfillment of Plan of Output of Production in Volume and Assortment, in %	In Actual Assortment at Actual Cost of Production in Thousand Rubles	Deviation of Actual Cost of Production from Its Planned Amount, in %	Planned Amount, at Planned Production Cost	Planned Amount, at Planned Production Cost	Planned Amount, at Actual Production Cost	Planned Amount, at Planned Production Cost (Col.2 Less Col.7)	Actual Amount, at Planned Production Cost (Col.3 Less Col.8)	Planned Amount, at Planned Production Cost (Col.5 Less Col.9)	Planned Amount in Planned Assortment at Current Wholesale Prices of Enterprise	Actual Amount in Actual Assortment at Current Wholesale Prices of Enterprise	Per Plan (Col.13 Less Col.10)	On Actual Amount at Planned Production Cost (Col.14 Less Col.11)	On Actual Amount at Actual Production Cost (Col.14 Less Col.12)	Per Plan	Actual	On Account of Fulfillment of Plan for Output of Production (Col.15 Less Col.16)	On Account of Fulfillment of Plan on Production Cost (Col.16 Less Col.17)	On Account of Fulfillment of Plan on the Change of Balances of Finished Product	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	35000	34000	97,3	35000	+2,8	1000	950	1000	34000	33050	34000	36000	35000	2000	1950	1000	5,9	2,9	.50	950	—	1000

The analysis of the utilization of the unstandardized working assets allows establishing the correctness of use of bank credit, the justification for the over-plan supplies, the timeliness of payment of the accounts payable, and the timeliness of the collection of the accounts receivable.

The analysis of the fulfillment of the plan of realization of production and stockpiling makes it possible to determne the influence, on the rate of profit of the enterprise, of the fulfillment of the plan with respect to quantity, assortment, and production list of the output of finished product and with respect to its production cost and the changes in its balance (Table 97).

The analysis of the nonindustrial activity shows the degree of accuracy to which this activity has been organized and the extent to which it pays for itself.

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CHAPTER XXIII

OPERATIVE PLANNING OF PRODUCTION

Section 1. Purpose of Forms and Methods of Planning

Planning at industrial enterprise includes not only the preparation of the technical-industrial-financial plan but also the operative planning of production, which is a continuation and concretization of the technical-industrial-financial plan and represents the system of organization of the productive process in time.

The operative planning is made up of calendar planning and dispatching.

Calendar planning consists in detailing the quarterly production program of the enterprise prescribed by the technical-industrial-financial plan, by months, decades, weeks, days, and shifts, and reducing its indices to terms of the workers assigned.

Dispatching consists in the centralized operative management of the performance of the monthly, decade, weekly, and shift-day plans.

The primary task of the operative planning of production is to ensure a smooth, rhythmic operation of all productive units of the enterprise and the uniform output of product by a graph established in advance.

At enterprises with mass- and large-lot production, rhythmic operation finds its reflection in the daily output of the same amount, or of a uniformly increasing amount, of production in accordance with a shift or hourly graph.

At enterprises with medium-lot or small-lot production, rhythmic operation finds its reflection in the output of the finished product, the aircraft series, at the dates established by the daily graph.

In single-type production enterprises, rhythmic operation finds its reflection in observance of the stage-by-stage cycle graphs of manufacture of each finished product, and in the output of finished products on the dates prescribed by the decade, monthly, or quarterly graph.

In rhythmic operation, uniformity in the output of production according to graph must be combined with performance of the plan for completeness of sets, quality, assortment and production cost.

The realization of operative planning of production must encourage the observance of proportionality, coordination, and uniformity in the work of all units of production, the steady growth of the yield of product from each unit of equipment and from each square meter of productive area, the systematic shortening of the productive cycle, the maintenance of the work stations in a state of constant readiness for the fulfillment of the shift-day plans, and the fulfillment of the plan in each shift, at each work station and section, and in each shop.

The operative planning is divided into intershop and intrashop.

Intershop operative planning of production is directed toward assurance of smooth and uniform operation of the primary producing shops. The fundamental bases of the intershop operative planning of production are the consolidated calendar plan of output of production of the enterprise and the backlog of orders. The intershop operative planning includes the development of the operative-planning standards, the mutual coordination of the contents and periods of the calendar plans of the shops of the primary and auxiliary production, and the plantwide services, the preparation and issue to the shops of the monthly calendar plan, the current intershop production control, the dispatching and operative record of the fulfillment of the calendar plan by the shops.

Depending on the type of production, on the production list of the aircraft being manufactured, and on their stability in production, the intershop cal[redacted] planning may be accomplished by the order method, the part method, the direction and

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lead method, the design-units method, and by the technological-sets method.

The order method is characterized by the calendar planning and dispatching, in production, of the dates of the start and output of parts for each order. This method is used primarily in piece production, which is distinguished by small and variable-unit orders. In piece production, i.e., in turning out multipart aircraft, the order method is supplemented by the method of planning by design units. In this case, the basic unit of calendar planning is the design unit. The order method in aircraft building is used for planning the production of the shops of the auxiliary production, but in the primary producing shops only for single small orders with a small list of components.

The part method consists in issuing to the primary production shops a quarter or monthly production program for each part designation, and in keeping an operative record over the start, output, and manufacturing reserve of each part. Part-by-part

Table 98

Direction No.	Nos. of Shops through which the Parts of a Single Direction Pass Successively				
First direction	1	5	7	20	35
Second direction	1	5	7	25	35
Third direction	1	-	7	20	35
Fourth direction	1	5	-	20	35

planning is widely used in mass production, while in series production, the method is economically expedient for articles with a relatively small production list of parts, for instance, in aircraft-engine manufacture. In aircraft building, part-by-part planning is inapplicable, because of the complexity and economic irrationality of planning the start and output of each part, in view of the many thousand parts involved in the production list.

As an exception, some aircraft construction enterprises are using part-by-part

planning for the most labor-consuming and critical parts and units with a long manufacturing cycle, and for standard parts when fabricated for delivery to the warehouse.

The direction and lead method is characterized by the fact that the basic planning and recording unit is represented by the set of parts or units of one assembly, following the same flow-sheet-direction and arriving at the final assembly at the same time (Table 98).

The value of the lead taken for the fabricating and processing shops is usually equal to the monthly program of the consumer shop. The monthly lead has a number of advantages for the fabricating shop and for the consumer shop:

1) It allows the fabricating shops to operate more uniformly and relieves them of the need to adapt their shift-day assignments to the monthly requirements of the consumer shop;

2) It allows each shop to construct its own program of start-output, to select the size of the lots and to establish the priority of the starts of workpieces or parts in production, on the basis of the maximum load on equipment and the rational utilization of the time of the workmen;

3) It allows considerable simplification of the intershop planning, since it is no longer necessary to plan and control the start-output of the parts production list by days.

This method of planning is inherent in series production, and is used in aircraft building at a number of enterprises. The method of planning by directions also has several shortcomings. Thus, the amount of work in process is considerably increased, while the unit of delivery to be planned is a whole direction, i.e., an excessively long production list of parts. In order to establish, within each direction, delivery units of commodity production that are smaller and more convenient for intershop planning, the method of planning by design units or technolSTATl sets is introduced.

The method of intershop calendar planning by design units and technological sets is widely used in aircraft manufacture. The nature, economic advantages, and disadvantages of these methods have already been discussed in detail.

Intershop calendar planning with respect to primary production is handled by the planning and production department, while the dispatching is a function of the production and dispatching department.

Intrashop operative planning is directed toward ensurance of smooth and uniform operation of the sections and work stations of the shop. Intrashop operative planning includes refinement of the monthly program of the shop and distribution of the work prescribed among the departments and sections, preparation and issue to the department and shops of calendar monthly plan-graphs and shift-day assignements, and dispatching and operative record of the fulfillment of the plan in the shop. Intrashop operative planning is accomplished in the shop by the production and dispatching office which, depending on the form of the productive structure of the departments and sections of the shop, uses various methods in preparing the respective monthly calendar plan-graphs.

For single-item production lines whose product goes directly to the consumer shop, the production and dispatching office prepares a calendar plan in the form of a graph, representing an extract from the monthly plan of the planning and production department, in which the shift-day assignments for starts and output of product are scheduled by days of the month.

For lines whose output is delivered to other production lines inside the shop, the calendar plan is estimated by the chain method. The estimate begins with the assembly line delivering the assembled unit to the consumer shop, and ends with the production lines processing the parts entering into that unit.

For multi-item production lines and departments with chain layout of equipment and a small production list of parts, the production and dispatching office sets up a calendar-month plan in the form of a standard plan based on the observance of se-

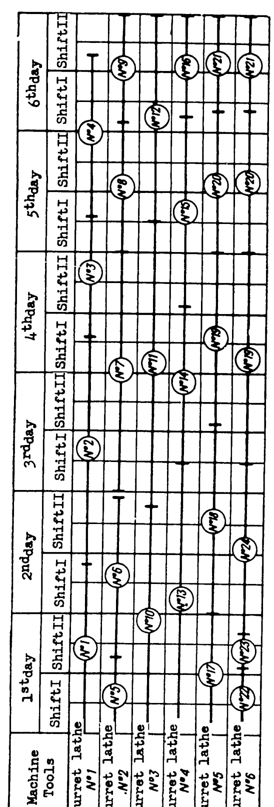

Fig.125 - Standard Plan

The figures in the circles indicate the number of the parts of which a batch is being processed during the given period

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quence and periodicity in the start-output of lots of parts during the course of each month. Figure 125 shows the standard plan of a section with weekly recurrence of the start-output of lots of parts.

For departments with a large production list of parts or units, a calendar plan for the month is prepared in the form of a graph, indicating for each part the program of output, in series count and quantitative count, as well as the delivery dates of the lots or series of the parts.

In all types of production, under operative-calendar planning, in estimating the program of the shops and sections and the load of the work stations, the achieved overfulfillment of the current standards and the planned future growth of labor productivity are taken into account.

Section 2. Calendar Planning of Piece Production

Piece production is planned by orders. The start-output dates of orders must be so coordinated as to ensure complete and planned increasing load of all shops during the year and the output of various forms of product according to an established graph.

In the aircraft industry, the piece-production enterprises include development enterprises. Their work is organized on the basis of the directive graph of production preparation, in which the execution of the designing, experimental, technological, and productive work in the construction of a new aircraft are all mutually coordinated with respect to date of execution. The development enterprise opens a special order account for each new aircraft, to which the production expense on the construction of the prototype is charged. For the purposes of operative-calendar planning in development aircraft manufacture, however, a smaller unit is taken, namely the design unit. The set of the parts going into the design unit constitutes the basic unit of intershop operative calendar planning, and of the recording of work at the development design office and the experimental production organization.

The plan estimates, in piece production, are made up of the following work steps:

Preparation of the order for starting which consists in determining what parts can be built with the existing tooling, what parts require special tooling, and by what date they will be delivered to the primary production shops. If the order contains intricate parts, passing through processing in various shops, such parts are first put into production.

The estimates of volume are prepared by estimating the equipment necessary to fill the order by the date set.

The amount of equipment required, or the number of work stations necessary, is determined by the formula

$$N_{req} = \frac{T}{Cy \cdot F_{act}\left(1+\frac{K_{p.s.}+K_{l.p.}}{100}\right)},$$

where T is the labor cost of work on order in standard-hours (taken from the flow sheet);

Cy is the period of manufacture of the order, expressed in months (in conformity with the period fixed by the contract);

F_{act} is the actual time fund per unit of equipment per month.

The number of work stations obtained by the estimate is refined by forms of work and is then compared with the possibilities of each shop.

A volume-cycle graph for the order is then prepared (Fig.126), showing for each shop the volume of work in standard-hours, the forms and number of work stations required to meet the order, the number of shifts worked and the dates of performance of the order, taking account of the performance of the work by the parallel-sequence method. The graph is prepared on the basis of the date the order is to be met, i.e., from the final stage of production running back to its initial stages.

A summary volume-calendar graph is also prepared, including all the v... of work on the orders in the program; this graph is necessary for coordinating the

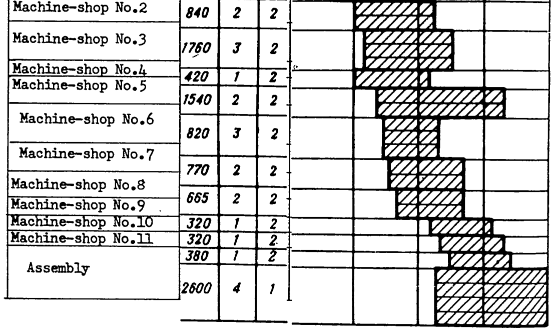

Fig.126 - Volume-Cycle Graph of Filling Order (For Single-Unit Production)

orders with respect to time. The basis for the volume-calendar estimates on the program is provided by the backlog of orders accepted for production and the volume-cycle graphs by orders, which are matched with the assigned personnel in time so as to ensure uniform load of the equipment and to meet the deadline for each order. In

Table 99

Monthly Program-Assignment of Shop

Order No.	Designation	Process Units		Designation of Parts Entering Into Subassembly	Standard-Hours Per Unit	Assignment for Month				Volume of Work in Standard-Hours	Deliveries by Decades of Month		
		Drawing No.	Designation			In Pieces	Who Will Perform the Work	% Completion: At Beginning of Month	% Completion: At End of Month		In First	In Second	In Third

preparing the summary graph, an economical version must be found, to avoid conflicts in scheduling when different orders are scheduled for processing at the same time on the same equipment, and also to avoid gaps in supply to the work stations. For this purpose, corrections are applied to the graphs of individual orders. During the actual manufacturing operations, the consolidated graphs must be corrected monthly on the basis of the results of plan fulfillment.

The monthly program of each shop in primary production is prepared by the planning and production department of the plant on the basis of the volume-cycle graphs of the execution of orders. In this case, the planning and production department refines the production list and the volume of work to be done for the given month on each order, takes account of the data on the fulfillment of the program in the preceding month and of the new orders. Table 99 gives a form for the monthly shop program.

The dispatching department checks every shop daily for the technological preparation of the orders for production start-up, and in the process of filling the order, for its movement from shop to shop. The execution of the work on the order is checked by periods. In addition, the cost of production is checked by the volume of work performed, as shown on the graph (Fig.127).

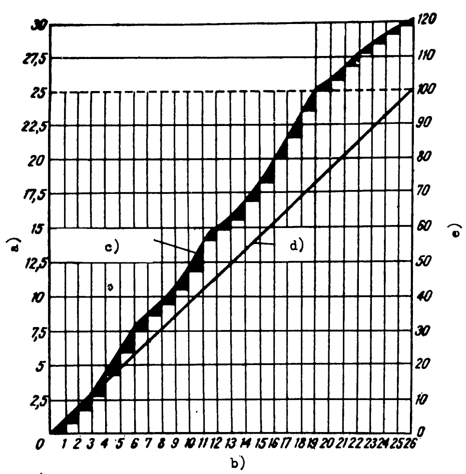

Fig.127 - Graph of Record of Fulfillment of Program on Volume of Work in Piece Production

a) Volume of deliveries in thousands of standard-hours; b) Days of the month; c) Actual performance; d) Plan; e) Volume of delivery in %

The production and dispatching office of the shop details the monthly program over the course of each order, determining the volume of the work and the time of

manufacture of each part. After refining the program, the office distributes the work prescribed among the production sections and makes a volume estimate to check its calculations. The volume estimate includes an estimate of the actual time fund of each group of uniform equipment; an estimate of the time needed to perform the production assignment, broken down by kinds of work corresponding to the existing equipment; and a development of the organizational-technical measures for increasing the throughput capacity of the sections and improving the coefficients of utilization of equipment and productive areas.

On the basis of the refined volume estimates, the production and dispatching office of the shop issues a monthly calendar plan to each work shop, 5 to 6 days before the beginning of the month. This plan is a consolidated plan for the execution of the work on the orders decade-by-decade or week-by-week. The foreman details this plan by shifts and reduces the shift assignment to terms of the workmen, in the form of work orders indicating the amount of work and the conditions of its payment.

An operative record, in piece production, is kept on the following items:

Records of materials, workpieces, tooling, and the documentation for each order or subassembly, maintained by the production and dispatching office of the plant on the basis of the warehouse reports;

Record of the output of the workmen, on the basis of the work cards or the route sheets, finalized in either case by the shop inspection office;

Record of spoilage by operations, on the basis of notices of spoilage or work cards;

Record of the movement of the order or subassembly by shops and sections, on the basis of the graph;

Record of stoppage of the equipment and workmen, from the stoppage sheets.

In development aircraft production, the calendar-month plans are prepared by the department of production and dispatching on the basis of the results of fulfillment of the directive graph of designing and constructing the prototype aircraft. The calendar-month plan of each of the primary shops shows the decade of the month, the subassemblies, and the shop to which they are to be delivered. In this case, for any parts and subassemblies in whort supply whose manufacture lags behind the graph or which are replaced by parts of a different design, the days and even the shifts for delivery are indicated within the decades. This obliges the foreman and dispatcher of the shop to place special controls on the manufacture of scarce parts or subassemblies.

When a development production organization is manufacturing several aircraft of different designs, the subassemblies to be built in each decade are separately enumerated for each aircraft in the monthly plan.

The work on the preparation on the calendar-month plans of the production and dispatching department is conducted in close contact with the group planning the preparation of production in the department of the chief technologist. This group prepares a shop distribution schedule for each subassembly, indicating the flow sheet for the subassembly and its component parts. The workers of the production and dispatching department use this flow sheet as guide in preparing the monthly calendar plan and in determining the list of the parts to be built in the given shop.

Section 3. Calendar Planning of a Series Aircraft Production

In aircraft manufacture, there are a number of factors determining the system of calendar planning.

The frequent changes in aircraft design and the frequent replacement of designs leads to the production of aircraft in series; the fact that the parts production list contains many thousands of items results in their combination into lead groups; the line assembly of the aircraft results in the need for a setwise supply of parts and subassemblies to the line; the processing of parts and subassemblies in lots

demands the selection of the most rational lot size.

The design changes to be introduced in an aircraft are assigned to a given series. These changes are sometimes so considerable as to change the production list and dimensions of many parts entering into a single technological set. The series count does not allow the mixing of parts, subassemblies, major assemblies, and aircraft of different series if they differ in design. Consequently, in aircraft manufacture, the series represents a group of aircraft of the same design. The type series contains the minimum number of aircraft; in working on these aircraft, the series enterprise refines both the tooling and the aircraft design. The maximum number of aircraft per series is found during the period when the series production has been completely broken in. A series of light aircraft usually comprises more aircraft than a series of medium aircraft, and a series of medium aircraft, in turn, contains more units than one of heavy aircraft. There are no standards for the number of aircraft in a series, and the enterprise divides the production program into series at its own discretion. At aircraft construction plants, the operative record of the program on starting, leads, and output is handled in the series count and by serial numbers. The shops deliver their production to one another in series and serial number counts, which ensures timely control of the observance of the complete set closing of each series.

The specialization of enterprises for the output of aircraft of one type, and the change-over of the production to the standard recording methods, allows the planners to abandon the unwieldy series method of recording, and to change over to recording aircraft output by serial numbers.

Under the conditions of aircraft manufacture, where the labor cost of the assembly-riveting and the assembly-fitting work may amount to 50% of the total labor cost of the aircraft, and the monetary outlay for this work may reach 60% of its total production cost, the maintenance of the correct length of the lead and of completeness of sets in deliveries, at each stage of production, is an important

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prerequisite for a rhythmic output of the aircraft.

The intershop calendar planning of series aircraft manufacture includes the development of standards for planning: establishment of the master production list; estimation of the duration of the manufacturing cycle of the aircraft and of the lead group; estimation of the start-up of production by the shop for the plan month; finalization of the monthly program for the shops, and the operative record of its fulfillment.

The starting data for intershop calendar planning are: the quarterly plan for the output of finished production by the enterprise; the set of drawings of the article and the current modifications from the drawings; the set of process planning charts; the schematic diagram of assembly and the system of lead groups constructed in accordance with this; the summary of standards for the article, for each process set, and for the primary producing shops. These data are received by the planning and production department from the series design office, the departments of the chief technologist, and the department of labor organization and wages. In addition, the planning and production department itself formulates standards for the lead groups and manufacturing cycles of the parts of the master production list, summaries of the performance by the shops of the program for the preceding month, summaries on the provision of parts of the master process sets for each lead group, and standard samples of the set-completion schedules for each delivery production-list of all supplier shops. For the supplier shop, such a schedule is also an order for the setwise production and delivery of products in the plan month. On the basis of the specimen set-completion schedule of the planning and production department, each shop makes up working copies of the set-completion schedules, and finalizes from them the delivery of their production to the consumer shops.

At an aircraft construction enterprise, the planning and production department performs the intershop calendar planning of the master production list, which includes the aircraft, its major assemblies, the master and component process sets, as

well as the most labor-consuming parts or subassemblies, for instance, the beams of stressed bulkheads or the spar caps. An enumeration of the other parts entering into each process set is made by the production and dispatching office of the primary production shop. This simplifies the intershop planning and makes it possible for the planning and production department to perform a more realistic control of fulfillment of the production program by the shops.

The production cycle of the aircraft is determined graphically and consists of the sum of cycles of all stages of the primary production, taking account of their parallel and parallel-sequence performance. Since the forms of production organization of the various stages differ, the technique of calculating the length of the cycles of the stages will also differ. For example, in all stages of aircraft assembly, the line form of production organization predominates; consequently, the length of the assembly cycles of the units, compartments, major assemblies, and aircraft are determined by the cycle graphs of assembly (Fig.128). Since the assembly work is conducted on a wide front, and simultaneously in several shops, only the cycle of the shop with the longest assembly cycle should enter into the length of the aircraft manufacturing cycle.

For example, assembly of the wing, fuselage, and empennage is handled in parallel, in three independent major assembly shops. The manufacturing cycle of the aircraft thus does not include the sum of the assembly cycles of these major components but only the cycle of assembly of the major component with the longest cycle, let us say the fuselage. In all the processing shops, the parts and units are produced in lots. The length of the cycle for each processing shop is determined by the period of recurrence of all its production list. If the shop works in weekly, monthly, and bimonthly lots, and the parts of the entire production list pass through its equipment once every two months, then the production cycle of such a shop will be equal to two months. With parallel operation of several processing shops working on a single stage of production, only the longest cycle of that shop

Nos of Assembly Combinations	Nos of Assembly Assignts	Installation Nos.	Brief Content of Assembly Assignments	Labor Cost in Stand.Hrs	Number of Persons workg. at the Same Time	Cycle of Assembly Assignments	Assembly Cycle																			
							1st Day				2nd Day				3rd Day				4th Day				5th Day			
							Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2	
							Cumulative Total of Hours of Work																			
							4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
I	1		Installation and fixing of upper, lower, and side panels of Bulkhead No.21. Attachment of bonding and skin along spars, contr.rivets		2	4	■																			
	2		Install.of bulkheads No22 and 23 and tail compartmt. Drilling and riveting tail compartment and bulkheads 22 and 23 to spars		2	4		■																		
			etc.																							
IX	35		Installing fuel hatch. Countersinking holes and bolting hatch		2	4																	■			
	36		Submission of fuel hatch to inspection			4																		■		
	37		Eliminating defects after technical examination of F-2 compartment. Delivery to shop inspection office.		2	4																	■	■		
			Total		66																					

Fig.128 - Cycle Graph of Assembly of Compartment F-2

enters the cycle of aircraft production. For example, in the fabricating stage, the foundry, forging, nonferrous sheet-metal shaping, and profiling shops operate in parallel, so that only the cycle of the sheet-metal shaping shop enters into the aircraft cycle, in view of the fact that the period of recurrence of its entire production list is the longest of all.

In accordance with the steady manufacturing cycles of the article, the planning and production department estimates the lead standards for the work of the shops.

The lead standards for the work of the shops are necessary for the planning of timely delivery of the parts, units and major components to the final aircraft assembly line. The larger the number of shops through which the part passes, and the longer its cycle within each shop, the earlier will it be started in production by comparison with the parts passing through a smaller number of shops and operations. To protect the consumer shops from a break in the timely starts of lots owing to the disturbance of the period of delivery by the manufacturing shops, an emergency (reserve) lead is also added to the cycle lead. The larger the aircraft output, the smaller will be the reserve lead in time and the larger the lead in number of aircraft. The lead may be expressed in days and in aircraft. The lead in aircraft OP_c in its general form is calculated by the formula

$$OP_c = n_c OP_d,$$

where n_c is the average daily output of aircraft;

OP_d is the lead in days in all stages of production.

Concretely, for each day of production, the lead in days is estimated for the output and for the starts.

For instance, the lead in output of the fabricating shop is equal to

$$OP_{o.f} = Cy_{pro} + R_f - R_o + OP_f$$

where Cy_{pro} is the cycle of processing of a batch in the processing shop; STAT

R_f is the period of processing of a lot in the fabricating shop, in days;

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R_o is the period of processing of a batch in the processing shop, in days;

OP_f is the reserve lead between fabricating and processing shops.

The lead of the start of the fabricating shop is

$$OP_{s.f} = OP_{o.f} + Cy_f$$

where Cy_f is the cycle of the batch in the fabricating shop.

Features of Estimation of Lead Groups in Aircraft Manufacture. In order to plan in larger units, the details in aircraft building are combined into design or technological sets, and these sets in turn into lead groups. A lead group is a set of leading or component sets for all of which the same times of delivery to the consumer shops have been established. The estimate of lead groups is based, on the one hand, on the cycle graph of the shops of final and major assembly, which is constructed to span the consolidated stages of assembly, stages that have been called leading sets, and, on the other hand, on the production cycle of parts and units constituting the production list of the component sets. For this reason, the lead groups are divided into groups covering the assembly shops and the pertaining master process groups and into groups covering the fabricating and processing shops, and the pertaining component process or design sets.

The number of lead groups covering the assembly work is determined by the degree to which the aircraft assembly is broken down or detailed into main stages of assembly. For example, the assembly of a multi-engine aircraft is usually broken down into the following six stages: 1) final aircraft assembly; 2) preliminary aircraft assembly; 3) outside-jig assembly and installation of assemblies; 4) assembly of major component in assembly jig; 5) assembly of compartments (or sections) of the major assembly; 6) assembly of the units: spars, rib panels, performed in independent shops. Corresponding to these six stages, six lead groups are set up. The assembly of a single-engine aircraft is less differentiated, and is usually broken down into five stages: 1) final assembly of the aircraft; 2) preliminary

assembly of the aircraft; 3) major assembly outside of assembly jig; 4) major assembly in assembly jig; 5) unit assembly. Corresponding to these five stages, five lead groups are set up.

The number of lead groups covering the fabricating and processing shops is determined by the number of such shops (except the heat-treating shops and the coating shops) through which the part must pass before entering the assembly and there becoming a part of the leading process set. On assigning the parts from the fabricating and processing shops to lead groups, two primary attributes are used as starting points: the number N_s of fabricating and processing shops through which the part passes before entering the assembly, and the stage of assembly OP_c to which the part is supplied. The lead group of the part OP_d is found from the formula:

$$OP_d = N_s + OP_c$$

Example. A part passes through processing in the fabricating and machine shops, from which it is fed to the stage of assembly of the fuselage framework. According to the diagram of lead groups, the stage of assembly of the fuselage framework is assigned to the third lead group. In this case, the part will be assigned to the fifth lead group ($OP_d = 2 + 3 = 5$).

The system of lead groups is established as follows: By adding the assembly and processing leads, the total number of lead groups is found. From these lead groups, all the leading and component process sets are found. Further, for each lead group the number of days by which it must lead the group preceding it is established. For this purpose, the cycle of the airfield shop, as the shop of the delivery of the commodity production, is subtracted from the aircraft production cycle, and the remaining cycle is divided into equal or multiple periods, lasting from 6 to 12 days. Such periods, depending on the type of aircraft, should be from 6 to 12 in number. An approximate diagram of the construction of the lead groups is given in Table 100. A larger number of periods complicates the production STATing.

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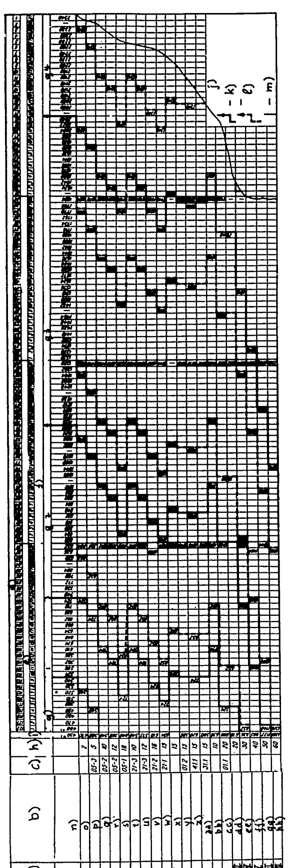
Planning-Control Graph for January Plan



*450,460, etc.: Serial numbers of aircraft (example)

Fig.129 - Control Graph of Assembly

a) Lead group; b) Designation of technological set (T.K.); c) T.K. Nos.; d) Number of days from output of aircraft; e) December, January, February, March; f) Rate of output per day; g) Ten aircraft 1 fourteen aircraft 2 sixteen aircraft 3 eighteen aircraft 4 twenty aircraft; h) Lead in days, counting from output of aircraft; i) Actual lead of output; j) Legend; k) Lines of changes in pace; l) Lines assuring monthly programs of sets of work in progress; m) Monthly programs; n) Shipping department; o) Flight-testing station; p) Final assembly; q) Preliminary assembly (painting); r) Preliminary assembly; s) Fuselage planking; t) Wing (painting); u) General assembly of wing; v) Skin of wing; w) Assembly of wing sections; x) Control surfaces; y) Engine frame; z) Landing gear; aa) Fin and stabilizer; bb) Component T.K. of second lead group; cc) Fuselage framework; dd) Component T.K. of lead group III; ee) Component T.K. of lead group IV; ff) Component T.K. of lead group V; gg) Component of T.K. of lead group VI; hh) Component T.K. of lead group VII

The significance of the diagram of lead groups consists in the fact that this diagram, together with the diagram of the process sets, forms the basis for intershop calendar operative planning and allows the planning and production departments and the dispatcher department to subordinate the work of each shop to the general plant requirements. Each shop is obligated to deliver its production in process sets, observing the sequence and periods of delivery that have been established for each lead group.

In this connection, it is important to recall that the lead groups establish only the periods of output (delivery) of the process sets, but do not establish the start-up times of the parts for the same set. The start-up times of the set of the parts for each process set are established directly by the producing shop, starting from the period assigned to it (from the date of delivery of the parts to it by the supplier shops, to the output of the finished parts according to the lead graph), the manufacturing cycle of the lot of parts of a given designation, and the economy of loading the equipment with it. The observance of these conditions ensures the setwise supply of the assembly shops, their rhythmic operation, and the output of aircraft in conformity with the established graph.

The lead groups are estimated from the series count of the delivery of the aircraft by the airfield shop according to the graph, the standard lead in days, the daily program of aircraft output, and the size of the series adopted. For instance, with 20 aircraft in the series, and a program of output of one aircraft a day up to the seventh series, and of two aircraft a day from the seventh series on, we obtain the series count of delivery of commodity production by the primary shops of the enterprise as shown in Table 101.

In order rapidly to establish the monthly program of each shop, with the dates of delivery of production for each lead group, the planning and production department uses a control graph (Fig.129) and an overlay.

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The overlay, when placed on the output date of the aircraft, as indicated on the

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control graph, shows the times of delivery of the master and component process sets for each lead group.

On the basis of the lead standards, the planning and production department estimates the monthly operative plans of the shops for start and output of lots of parts and units.

The starts and output of production by the shops for the plan month are estimated by the planning and production department on the basis of the refined quarterly program. A production output program is estimated for each shop, allowing for the planned growth of aircraft output. For instance, the program of aircraft output for February is fixed at 25, and for June at 100 aircraft. Then, with a total aircraft manufacturing cycle of 5 months, the program for the February output for the airfield shop will be set at 25 aircraft, but for the sheet-metal shaping and fabricating shop, at 100 sets, since the blanks started in February must, after 5 months, i.e., in June, support the airfield shop output program of 100 aircraft. Consequently, the program of each shop in one and the same month will differ for different lead groups, according to the distribution of aircraft output by months of the year. In addition to the growth of the product output, the calculation of the monthly program takes account of the data on the fulfillment of the program in the preceding month, of the production cycle, of the condition of the intershop and intrashop manufacturing reserves of work in progress and the number of parts necessary to replace rejected parts and units. Bearing all these situations in mind, the program of the primary shops is calculated under a procedure opposite to that of the course of the manufacturing process, according to the scheme: airfield shop - final assembly shop - major assembly shops - section and unit assembly shops - processing shops - fabricating shops - warehouses.

The program and output of the airfield shop corresponds to the commodity output of the enterprise in the plan month. The program of starts of the aircraft shop takes account of its program of output and the reserve necessary to the shop for

Table 100

Approximate Scheme of Construction of the Lead Groups

Lead Group 8	Lead Group 7	Lead Group 6	Lead Group 5	Lead Group 4	Lead Group 3	Lead Group 2	Lead Group 1	
Parts and Blanks Passing Through Two Shops for Work								
					Wing Assembly Shop			
For Lead Group 5	For Lead Group 4	For Lead Group 3	For Lead Group 2	For Lead Group 1	Part and Unit Assembly of Wing	Assembly of Wing Inside and Outside of Assembly Jig		
	Parts and Units Passing Through One Shop for Work							
	For Lead Group 5	For Lead Group 4	For Lead Group 3	For Lead Group 2	For Lead Group 1			
		Parts and Units Coming Directly for Performance of Work						
		For Lead Group 5	For Lead Group 4	For Lead Group 3	For Lead Group 2	For Lead Group 1		
					Empennage Shop			
					Assembly of Empennage			

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				Landing Gear Shop: Manufacture of Parts and Assembly of Units of Landing Gear		Landing Gear Shop: General Assembly and Testing of Landing Gear			
				Fuselage and Wing Center Section Shop		Preliminary Assembly Shop		Final Assembly Shop	Airfield Shop
				Part and Unit Assembly of Fuselage and Wing Center Section	Assembly of Fuselage and Wing Center Section in Outside/Assembly Jig	Filling of Fuselage and Wing Center Section before Jointing	Mounting of Wingless Aircraft	Final Assembly of Object	Testing and Delivery of Objects of Purchaser
Lead in Working Days from Output and Delivery of Finished Object to the Purchaser	88	76	64	52	40	28	16	8	-
Production Cycle in Working Days from Start of Object	12	24	36	48	60	72	84	92	100
Cycle of Operation for Each Lead Group taken Separately	12	12	12	12	12	12	12	8	8

Table 101

No. of Lead Group	Production Cycle in Days, beginning with Lead Group I	Size of Emergency Reserve Stock in Days, beginning with Lead Group I	Total Lead, in Days	Daily Output of Aircraft	Standard Lead, in Aircraft	Consecutive (Serial) Count of Aircraft	Count of Series Nos. and Nos. of Aircraft in Series on Delivery*
Airfield				1	8	8	$\frac{1}{8}$
I	5	3	8	1	8	16	$\frac{1}{16}$
II	14	6	20	1	20	28	$\frac{2}{8}$
III	23	9	32	1	32	40	$\frac{2}{20}$
IV	32	12	44	1	44	52	$\frac{3}{12}$
V	41	15	56	1	56	64	$\frac{4}{4}$
VI	50	18	68	1	68	76	$\frac{4}{16}$
VII	59	21	80	2	$68+(12\times2)=92$	100	$\frac{5}{20}$
VIII	68	24	92	2	$92+(12\times2)=116$	124	$\frac{7}{4}$

* The Nos. of the series are shown in the numerator, and the Nos. of the aircraft in the denominator.

testing the aircraft carried over to the commodity production for delivery the following month.

The output program of the final aircraft assembly shop must satisfy the output program of the airfield shop for the following month, and the replenishment of the reserve in the airfield shop. The output program of the assembly shop $N_{a.s}$ is calculated by the formula

$$N_{a.s} = N_{a.st} + (Z_{a.sh.n} - Z_{a.sh\ act})$$

where $N_{a.st}$ is the atart program of the airfield shop;

$Z_{a.sh.n}$ is the normal size of the reserve at the airfield shop, in units, at the end of the plan month;

$Z_{a.sh.act}$ is the actual size of the reserve at the airfield shop, in units, at the beginning of the plan month.

The program of the assembly shop in production starts $N_{s.ass}$ is calculated by the formula

$$N_{s.ass} = N_{a.s} + (Z_{ass.sh.n} - Z_{ass.sh.act})$$

where $Z_{ass.sh.n}$ is the normal size of the intrashop reserve in the assembly shop at the end of a plan period;

$Z_{ass.sh.act}$ is the actual size of the intrashop reserve in the assembly shop at the beginning of the plan month.

A general rule may be derived for calculating the program of all these shops. The program of output of the manufacturing shop is determined by the program of starts of the consumer shop plus the restoration to standard of the intershop lead (reserve). The program of starts of the manufacturing shop is determined by its output program plus the restoration to standard of the intrashop lead (reserve).

Important functions of the planning and production department and the dispatching department are: timely verification of the readiness of the shops for performance of the assigned program; verification of conformity of the program of each shop to its throughput capacity; verification of supply of the work stations with tooling, materials, and workpieces (cf. Tables 62 and 102). The office of calendar planning of the planning and production department makes the preliminary check estimates on

the state of fulfillment of the program on the 15^{th} of the month preceding the plan month, and covers the period of calendar planning for 45 days, i.e., the second half of the current month and the entire period of the plan month. This preliminary estimate is corrected after determining the results of fulfillment of the plan for the past month, i.e., on the first and second of the plan month.

The planning and production department finalizes the monthly programs of the shops in the form given in Table 103. This program has the form of the calendar plan graph in which, for each item of the master production list, the following information is shown: the series count on the output (delivery) at the beginning of the plan month and at its end; the amount of production, expressed in aircraft or in sets, that must be manufactured during the month; the standard time per aircraft, taking account of the overfulfillment of the current standards, and of the total labor cost of the program for the month.

The program of the airfield shop and the shops of final and major assembly are given in the form of a graph with a uniform, smoothly rising or smoothly declining production output by days of the month.

For the processing and fabricating shops, the production is distributed uniformly over the decades of the month, starting from the lead groups and the corresponding sequence of delivery of sets. Such a program is in the form of a calendar graph which shows the following information separately for each consumer shop: monthly number, in series count, of the starts and output of process sets, and distribution of these T.K. by their delivery dates to the consumer shops (to the 10^{th}, 20^{th}, and 30^{th} of the plan month). Usually the lead in the major assembly shops over the preliminary and final aircraft assembly shops amounts to 7 - 14 days, depending on the number of aircraft being produced.

The plan of the fabricating shops is built up with a large lead over the shops consuming its production. Here the minimum value of the lead is determined by the period of deliveries of lots of workpieces (usually from one to three months).

Table 102

Production and Dispatching Department				Estimate of Load on Equipment of shop No. ________ under Production Program for ________ (Month) 195____																			
				Equipment Load by Groups of Equipment																			
				Turret Lathes		Lathes		Horizontal Milling Machines		Vertical Milling Machines		Profiling Machines		Longitudinal Milling Machines		Drilling Presses		Grinding Machines		Tool-Grinding Machines		Total	
Lead Group	No. of T.K. or Part	Consumer Shop	Number of Sets	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours	Standard Time for Set, in Hours	Time for Program, in Hours

Table 103

Production and Dispatching Department								Production Program of Shop No. ______ for Month Month, 195____											
Consumer Shops	No. of Lead Group	No. of T.K.	Designation of T.K., units, assemblies, and Work to be Done	Series Count: To Beginning of Plan Month	Series Count: To End of Plan Month	Number, in Units	Standard Time per Production Unit, in Hours	Total Labor Cost, in Standard-Hours	Distribution of T.K., Units, Assemblies, and Work to be Done by Days of Their Delivery to the Consumer Shops		Starts and Deliveries by Days of Month: 1	2	3	4	5	6	...	30	31
									Plan, in Cumulative Totals, in Units	Starts									
										Outputs									
									Actually Manufactured, in Cumulative Totals, in Units	Starts									
										Outputs									
									Series Count in Cumulative Tot.	Starts									
										Outputs									

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In preparing the program for multiproduct fabricating and processing shops, which are not in a position to start and put out T.K.'s monthly for all lead groups, the program will show only those T.K.'s and leading parts to be delivered in the given month for each lead group. For the mutual coordination of the plans of the shops, plan-graphs of the supplier shops are usually issued to each consumer shop, or the planning and productive department may indicate in the plan-graph of the consumer shops when lots of workpieces (whether parts or major components) will be delivered, what shops will make such deliveries, and for what series of aircraft, so as to ensure timely starts.

The operative record of the fulfillment of the production program is handled as follows:

In the airfield shop, the dispatcher department daily verifies and records the number of aircraft received from the final assembly shop, prepared for flight, flight-tested, and delivered to the purchaser. The data of this record are reflected in a special graph (Fig.130).

In the final assembly shop, the dispatcher department daily verifies and records the complete setwise provision with major components and units of the fitting assembly (Fig.131), the movement of the aircraft through the fitting assembly, the number of aircraft passing from the assembly line and submitted to the inspection department and the purchaser's representatives, and the number of aircraft delivered to the airfield (Fig.132).

In the major assembly shops, the dispatcher department daily verifies and records the complete-set provision of the major assembly shop; the number and series of the major components placed in the assembly jig; the number and series of the major component that has passed onto the line of assembly outside the assembly jig; the number of major components submitted to the shop inspection office, and the number of major components delivered to the intermediate or final aircraft assembly shop.

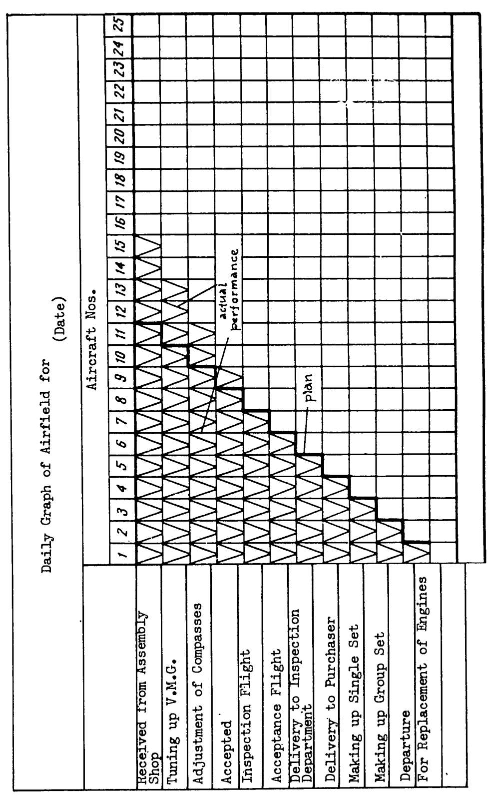

Fig.130 - Graph of Production Record by Aircraft Shop

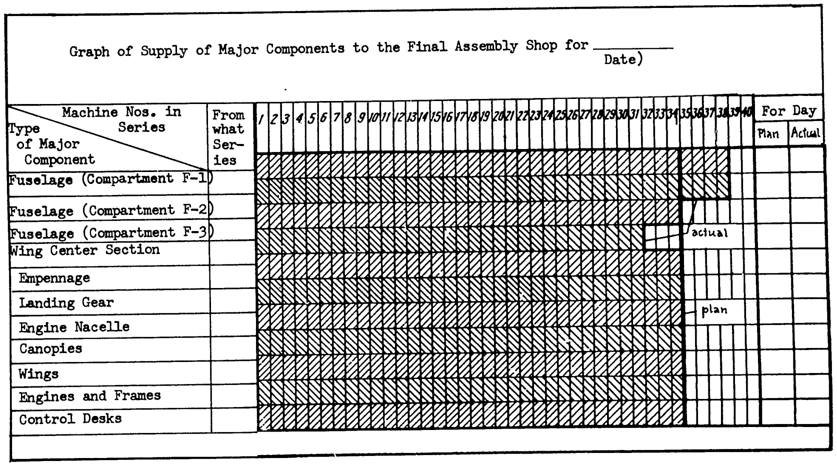

Fig.131 - Graph of Supply of Major Components to the Final Assembly Shop

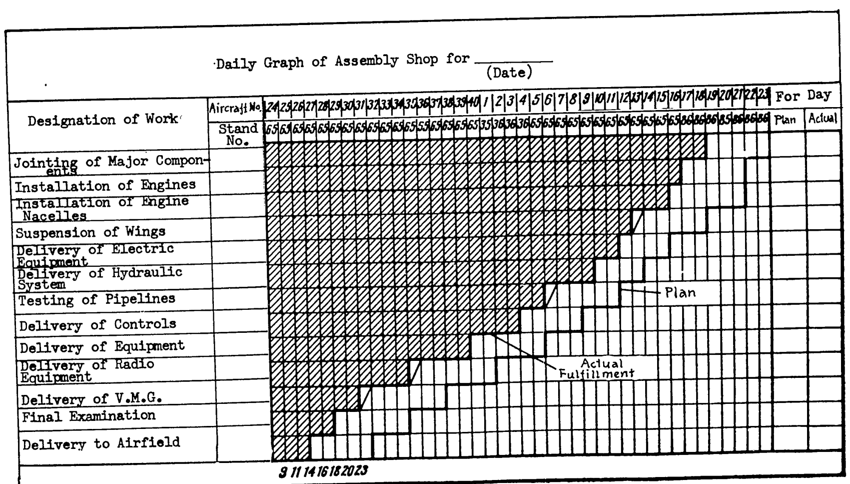

Fig.132 - Graph of Cost of Production Output of Aircraft by Final Assembly Shop

At the fabricating and processing shops, the dispatcher department daily verifies and records the complete setwise delivery of the component sets by lead groups, by directions (consumer shops), and by series. The basis for this record is provided by the daily dispatcher reports of the shops, confirmed by delivery notes and verified by the shops accepting the production. The most operative form of control is that under which the planning and production department checks not only the dates of delivery of the production but also the dates of the timely setwise start of lots into production.

The intrashop calendar planning in aircraft building consists in detailing the monthly production program received from the planning and production department, and in calculating the economic size of the lots of parts, in making check volume estimates by departments and by production sections, in preparing monthly production programs and shift-day plans (assignments) to the shop departments, and in the operative record of their fulfillment.

The detailing of the monthly program consists in establishing, by the production and dispatcher office of the shop, the size of the lot and the date of its start-output for each part entering into the design set or process set shown in the program. The degree of detailing of the program depends on the productive structure of the sections of the shop.

If each section of the fabricating-stamping or machine shop is specialized to perform uniform operations, for example, turning or milling and if equipment of the same type is concentrated in the section for proper performance of such work (e.g., only turning or only milling equipment) then, with such a productive structure of the sections, the production and dispatching office of the shop must coordinate the operation of the sections with respect to time and must give a certain lead to the work of the turning section with respect to the milling section, and to the milling section with respect to the grinding or fitting section.

If each section in the fabricating-stamping and machine shops is specialized

to process units of one or several assemblies and is equipped to perform all operations on these (except for heat-treating and coating), then in that case the work of the production and dispatching office is considerably simplified, and consists in indicating the schedule of the units and of the component parts for those units that are to be manufactured in the section in each decade of the month. The times of manufacture of the parts and units, by days and shifts of the decades, are established by the senior foreman of the department, starting out from the provision for the decade plan in materials, tools, drawings of the parts, and flow sheets.

A characteristic feature of fabricating, processing and intermediate shops of series aircraft enterprises is the processing of parts in lots that recur in start and output. In series production, the number of equal-type workpieces, parts, or units, simultaneously started in production, is called a basic lot.

The transport lot should be differentiated from the basic lot. The transport lot is a part of the basic lot. Under the parallel-sequence method of processing, each basic lot is divided into smaller transport lots, which are delivered from one work station to the next.

In order to determine the optimum size of a lot of parts, the expenses due to increasing the lot size must be compared with the advantages obtained from increasing the equipment load.

Increasing the size of the lot raises the labor productivity of the workmen, increases the time of useful life of the equipment, and simplifies the planning. At the same time, increasing the size of the lot leads to an increase in the working assets invested in the work in process, which adversely affects the economic indices of the operation of the enterprise.

In the textbook literature, the size of a lot is found roughly from the allowable percentage of time lost in resetting the equipment. The size of a lot is calculated from the formula

$$n = \frac{T_{s.c}}{T_p K}$$

where n is the size of the lot of parts, in units;

$T_{s.c}$ is the setup-cleanout time for a lot of parts;

T_p is the piece time;

K is the coefficient of allowable loss of time for resetting the equipment (in aircraft building, usually 0.05 - 0.07).

A disadvantage of this formula is that it employs only a single factor as basis of its estimate, namely, the utilization of equipment, as a function of the value of $T_{s.c}$. This formula does not take account of the increased expense due to the increase in work in process. In reality, the coefficient of equipment loading and the length of the cycle do not increase in the same proportion when parts are processed in lots. This will be clear from the formula:

Fig.133 - Graph of Calculating the Growth of Cycles and Coefficients of Equipment Loading

$$Cy = \frac{\Sigma T_{s.c}}{1 - \eta}$$

where Cy is the cycle of a lot of parts in days, shifts, hours;

$\Sigma T_{s.c}$ is the sum of setup-cleanout time for a set of parts processed on the machine tool;

η is the coefficient of equipment loading.

The cycle of processing a lot of parts increases more rapidly than the increase in equipment loading. This spread becomes particularly great when the equipment is loaded by more than 80%. For instance, when the load increases from 80 to 90%, i.e., by only 10%, the cycle increases by 200% (Fig.133).

It follows that in processing lots an increase in the machine loading is economically expedient up to a certain limit, when the value of the work in process does not exceed the value of the part of the machine unutilized in time (i.e., of its value). In aircraft building, the data obtained by the formula

$$n = \frac{T_{s.c}}{T_{p.k} K}$$

are used only for the preliminary calculations. This is explained by the fact that this formula for calculating a lot does not relate the size of the lot to the period of its recurrence in production, does not subordinate the size of the lot to the program of aircraft output, and thus does not guarantee the provision of parts for the assembly. Besides this, in fabricating and processing shops, in view of the thousands of parts produced there and the different times for setting up the equipment, if the size of the lots were to be calculated by the above formula, there would be such an immense difference in the sizes of the lots as to lead to confusion in production. For this reason, in aircraft building, the determination of the size of lots is based on organizational factors, which are not always amenable to mathematical calculation but are of decisive importance for the normal course of production. Thus, in aircraft production, the sizes of lots of parts are so chosen as to correspond to the weekly, decade, monthly, etc. starts. The size of such a lot is calculated by the formula

$$n = R_c \cdot N_{mean\ p}$$

where R_c is the pace of recurrence of a lot, in days, in a series-production shop (at intervals of a month, at intervals of two months, etc.);

$N_{mean\ p}$ is the average daily program of parts (or units) ensuring the output of aircraft in the month when the given lot of parts arrives at the final assembly shop.

Such a calculation relates the size of the lot to the period of its recurrence in production and at the same time subordinates the lot to the primary task, namely that of meeting the requirements of the assembly shop for parts.

It is desirable to have a number of parts in a lot such that the time of their processing will be a multiple of the shift. In operations where the changing of the tool takes a considerable time, the time taken by the processing of a lot should be equal to, or a multiple of, the time of service of the tool between regrindings. The part should be handled, in all operations, in lots of the same size.

The production cycle of a lot is the period necessary for the processing, transport and inspection of a lot of parts for all the operations inside the shop, including the operations of heat treatment or coating, performed in the same or other shops. Without knowing the production cycle of a lot of parts, the starting time of each batch and the necessary volume of work in process cannot be exactly determined. The production cycle of a lot depends mainly on the following four factors: on the number of part-operations assigned to a work station, on the number of parts in a lot, on the method of delivering a lot from one work station to the next, and on the sequence of starts in production of the parts covered by the production list of the department or section.

The larger the number of different parts assigned to each work station, the greater will be the loss of time for resetting the equipment, the more difficult will it be to manage a section, and the larger will be the lots of parts to be handled under these conditions.

The more parts there are in a lot, the more productive will be its manufacturing cycle. In order to shorten the cycle of the lot under these conditions, an attempt must be made to replace the sequence performance of operations on the lot of parts by parallel and sequence-parallel performance. The NIAT recommends a simple and practical method of establishing the length of the manufacturing cycle of a lot for fabricating and processing shops. This method is based on standards prescribing the relation between the cycle of the part and the number of part-operations assigned to one work station (Table 104).

Table 104

Standards of Length of Production Cycles

I. Sheet-Metal Layout and Fabricating Work, and Hand Working of Parts (Finishing after Stamping, Chipping and Cleaning of Castings, etc.)

Standard	Number of Part-Operations Per Work Station				
	5 – 25	26 – 50	51 – 75	76 – 100	101 or more
Average length of cycle of one operation, in days	0.6	0.8	0.9	1.0	1.2

II. Stamping, Forging, and Forming of Parts

Standard	Number of Part-Operations Per Work Station				
	5 – 25	26 – 50	51 – 75	76 100	101 or More
Average length of cycle of one operation, in days	1.5	1.8	2.0	2.2	2.5

III. Machining of Parts

Standard	Number of Part-Operations Per Work Station					
	5 – 10	11 – 15	16 – 20	21 – 30	31 – 40	41 or More
Average length of cycle of one operation, in days	1.5	1.8	2.1	2.3	2.4	2.5

IV. Assembly of Units at Benches and Manufacture of Welded Units

Standard	Number of Assembly Assignments Per Work Station				
	2 – 3	4 – 6	7 – 10	11 – 15	16 or More
Average length of cycle of one assembly assignment, in days	1.0	1.1	1.2	1.3	1.4

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In assembly shops, the assembly cycle for a compartment, major component, or aircraft are established from cycle graphs.

In aircraft building, where the production list of parts numbers many thousands, it is impossible to estimate the production cycle for each part. For this reason, in each section of the fabricating and processing shops, the most typical leading parts are selected, and the cycle is calculated from these on the basis of experiments or standard Tables.

The principal disadvantage of the methods described in the literature for determining the length of the processing cycle for lots of parts is the fact that all of them take each detail individually, without connecting it with other parts, while the value of the inter-operation layover, which in series production amounts to 50 - 75% of the length of the cycle, also depends on the order in which the parts are started in the section.

Under the conditions of series production, where many parts with sharp fluctuations in operating times are assigned to each production section, the next work station will have no stoppage in this case if its operating time is equal to or longer than the operating time of the preceding work station. If, however, the length of the operating time of the next work station is shorter than the operating time of the preceding work station, then a stoppage of the machine tool, while waiting for the processing at the preceding work station to be finished, is unavoidable. In order to avoid stoppage of equipment due to differences in operating time, the lots of parts to be started up in the next shift in series aircraft building are selected for each machine tool in such a way that the total processing time for one or several lots of parts will completely load the operation of the given machine tool during the shift. This procedure somewhat increases the intermachine layover time of a parts lot, but makes up for this by eliminating the idle time of workmen and equipment inside the shift.

A volume check estimate by equipment groups is made to find whether the equip-

ment if the sections will pass the program assigned to the shop, and what the load of the equipment will be in this case. On the basis of the check estimates, the production and dispatching office distributes the work more precisely among the sections, to provide for uniform loading of the equipment.

On the basis of the monthly plan and the volume check estimates, the production and dispatching office of the shop sets up the monthly program for each department (or workshop) and each section. In setting up the program, the planner takes into consideration the state of the manufacturing reserves for each item, the priority of the delivery of sets, and the necessary leads between the departments of the shop. The more rhythmically the shops operate, the smaller will be this lead (or manufacturing reserve). In calculating the monthly plans for the departments, every effort is made to observe strictly the established assignments of parts to the work stations; to increase the time of useful life of the equipment; to increase the labor productivity of the workmen; and to cut the length of the cycle of processing or assembling the article. The monthly calendar plans for the departments are established, with allowance for the production list of parts and the features of the production of the shop. Let us consider these features for each group of uniform shops.

The fabricating shops are characterized by the large number of workpieces with short operating times. Under these conditions, a rational utilization of equipment and a rhythmic output of production can be obtained only if the section production lists of workpieces are cut down. This is accomplished by:

1. Dividing the production list of workpieces into lots started once a month, once every two months, and once every three months. Exceptions are made only with respect to workpieces using large amounts of materials, such as the aircraft skin, starting them several times a month.

2. Organization of departments or sections on the product principle, and their specialization to process a set of groups of typical workpieces.

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3. Assignment of a definite production list of workpieces to each shift of the

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section. With a large production list of workpieces, an effort must be made to plan the equipment load by the method of standard sets of products. For this purpose, at each section, the maximum period of recurrence of the start-output of its production list is established. This maximum period is divided into minimum multiple periods, e.g., into decades. For instance, with a total maximum period of recurrence of the entire production list in two months, and a minimum in ten days, the department will have $\frac{60}{10} = 6$ minimum periods of recurrence. If workpieces with a different starting period are assigned to the department, for instance, with a two-month, a one-month, and a ten-day period, than with six minimum fabrication periods having a ten-day starting cycle, there will be six sets in all; the workpieces with a monthly cycle will go only into two sets, say into the first and fourth or into the third and sixth. The workpieces with a two-month starting cycle will go into only one of the six sets. A production-list set will be composed of parts whose grouping thus takes account of the uniformity of the manufacturing process, of the process set, of the lead group, and of the consumer shop. By this method, the foreman is given the initiative in the start-output of the sets of workpieces by shifts of the period of recurrence. If, for any reason, the planned workpiece cannot be started in production in a given shift, then, in view of the supply of tools and materials, the foreman may start up another workpiece from the same standard set, and for the remaining shifts of the period of recurrence he may prepare all that is necessary for starting the remaining production list of the set.

Within the standard production-shift set, the workpieces are grouped according to the condition of their simultaneous start, which ensures a more economical utilization of the equipment and starting materials. For instance, in the sheet-metal shaping departments, the workpieces are grouped by forming groups; this allows a saving of metal and a reduction in the time on the setup and processing of the blanks. For instance, if the group sheet-metal shaping chart includes seven blanks and two of each blank go on the aircraft, then if a stack of 10 sheets is simultaneously processed on the machine, the monthly program for the output of 125 aircraft can be fulfilled in (125 × 2) : 10 = 25 runs, while in the case of individual shaping it will take (125 × 2 × 7) : 10 = 175 runs. In the stamping departments, in punching and bending, the workpieces are classified by size, and standard production-list sets of blanks are assigned to each die block, ensuring the loading of the press without changing the die block during the entire course of the decade or week (Table 105).

Table 105

No. of Parts Entering Into Set	Number of Parts Per Aircraft	Standard Time for Set of Parts for One Aircraft	Number of Parts for Monthly Program of 150 Aircraft	Standard Time, in Minutes: Piece Standard for Lot	Standard Time, in Minutes: For Machine Setup	Standard Time, in Minutes: Total	Time Fund of Press in Minutes for Two-Shift Operation F_p and Coefficient of Loading of Press K_p for Each Set
First Set for 6 Days, Die Bed (Die Block No.1)							
1 - 11	2	0.6	300	180	30	210	$F_p = 6 \times 8 \times 2 \times 60 \times 0.95 = 54{,}720$ min
1 - 12	1	0.35	150	52.5	20	72.5	$K_p = \frac{56{,}000}{54{,}720} = 1.02$
etc.							
	Total Labor Cost per Set in Min					56000	

A number of die blocks are assigned to each press in such a manner that the total labor cost of the workpieces to be processed on the press will equal the monthly fund of operating time of the press.

Example. A section is processing monthly lots. Two die blocks (Nos.1 and 2) are assigned to a press and have a labor cost, for the shift program of die block No.1 of 100 hours, and of die block No.2 of 98 hours. Under these conditions the press, with the die block No.1 will process the parts of 100 : 8 = 12.5 shifts, i.e., from the 1st to the 15th of the month, and with die block No.2, the nSTAT 96 : 8 = 12 shifts, i.e., from the 16th to the end of the month, observing this cycle every month.

The workpieces in the stamping workshop for bending operations should be classified by bending radii, and in operations of deep drawing, should be based on the minimum time loss for resetting of the press.

In selecting the cycle of start-finish of a lot, the cycle of operation of the consumer shop must be taken into account. For example, the workpieces from the milling department are delivered to the stamping shop, which handles monthly lots. Consequently, there is no sense for the milling department to handle smaller lots.

The processing shops of an aircraft building enterprise are distinguished by a large production list of parts. In setting up a monthly plan for these, the production list and the number of parts assigned to the work stations are taken into account.

For sections with an extensive and inconstant production list of parts, the production and dispatching office of the shop sets up a monthly plan-graph showing the parts (or units) to be produced in each decade of the month. At the same time, the size of the lot, in absolute and series count, is indicated for each part. The foreman further refines the output of the parts by days and shifts of the decade, starting from the supply of materials and tools for the decade plan of the department.

There is also a different method of preparing the monthly calendar plans, which is the one usually recommended in the literature. Under this method, the production and dispatching office indicates to each department of the shop, not the decade but the days of the month, on which the lots or parts of each designation are to be delivered. To distribute the entire production list of parts of a department over the days of the month, the production and dispatching office sets up a plan-graph on the basis of matched primary and auxiliary graphs. The primary graph indicates, for a parts lot, the cycle, dates, and period of recurrence of the lot, and also shows the shifts in which the lot is to be processed, indicating the specific machines of

each shift, through which the lot is to pass (Fig.134a). The auxiliary graph is set up to prevent a coincidence of the dates of processing different lots on the same machine tool, or an irregular loading of the equipment during the course of the month (cf. Fig.134b). By comparing the data of the two graphs, the most rational

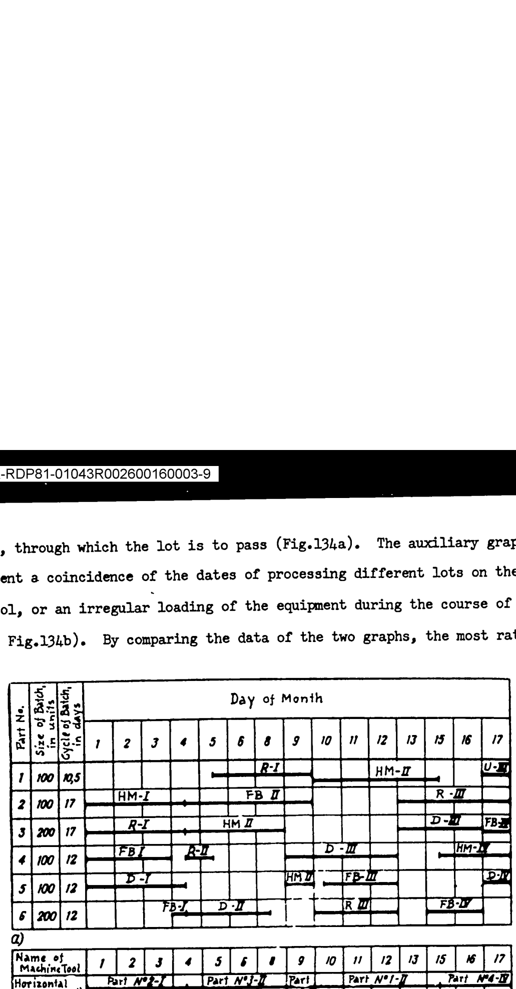

Fig.134 - Matched Graphs

a - Primary; b - Auxiliary

version of start-output is found, at which a short batch cycle is at the same time associated with high equipment loading. In setting up the graphs, the piece time and setup-cleanout time per lot are taken into account.

For the product-process and chain sections, specialized to handle a small production list of typical parts, the monthly plan-graph is prepared in the form of a standard plan. To work without breaks by such a graph, it is necessary to make careful preparations and to provide each machine tool and each shift with everything necessary.

The monthly plans of the heat-treating shop and the coating shop are prepared on the basis of the monthly graphs of delivery of production by the delivering shops. From these graphs the production and dispatching office selects the delivery dates of lots of parts for the heat-treatment shop or the coating shop, and aligns them, in time, so as to ensure uniform loading of the furnaces, baths, and chambers. A simplified method may also be used in preparing the plan. Here the planning and production department of the shop sets up planned standard periods of processing a lot of parts (or of their typical representatives) by the heat-treatment or other intermediate shop. These standards are expressed in shifts and hours. According to how these standard periods are met by the intermediate shop, it can be determined how they meet the deadlines for processing the lots.

In the shops of the unit, major, preliminary, and final assembly shops, the production list of the articles is rigidly assigned to the section, and the chain and line forms of work organization predominate. Monthly plan-graphs for the assembly sections are prepared in the form of a standard plan for multiproduct sections at which the units are assembled in lots; and in the form of a daily graph of product output for sections with a small production list.

The program assignment for the plan month is issued to the shops by the planning and production department not later than the 25^{th} or 26^{th} of the current month. During the period from the 1^{st} to the 3^{rd} of the plan month, the plan is refined.

Shift-day planning is the final and concluding stage of intraplant planning. The primary task of shift-day planning is to familiarize each workman with the State plan, to organize coordinated and uniform work at the work stations, and to fulfill the plan for each work station during each shift.

The monthly program of a section is detailed by the planner, under the instructions of the senior foreman, for each shift foreman, for each work station, and for each shift (Table 106). A shift assignment of a section, in two-shift operation,

should amount to not less than 1/50 of the monthly plan for starting parts in production and for delivery of the finished production by the section.

The timely start of a lot of parts into production, in conjunction with the timely and careful preparation of the shift assignment for each work station, is a

Table 106

Shift Assignment to Foreman ________ for Shift ________ 195____

No. of Machine Tool (or Work Station)	Part		No. of Operation	No. of Series (or Order)	Standard Time per Piece	Assigned to Shift		No. of Primary Document	Surname of Operator	Performed in Shift				Inspector's Note on Completion of Assignment
	Designation	No.				Piece	Standard Hours			No. of Time Sheet	In Units	In Standard Hours	% of Completion	

guarantee for the sucessful operation of the section and represents the best method of coping with the "boom-slump" pattern of irregular work. For this reason, particular attention must be paid to the supply and preparation of each work station for each shift. The shift-day assignment of the section is delivered by the dispatcher to the material warehouse and tool crib of the shop, and to the shop machinist for preparing the work stations for the following shift. At the end of the shift, the shift foreman report to the senior foreman who, in turn, reports to the shop superintendent on the fulfillment of the shift-day plan.

The primary record, in series production, is kept according to a number of indices. The record of work performed during the shift is kept for each section on the basis of the shift assignments, attested by the foreman and the inspector of the

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shop inspection office. The results of the output for the shift of each worker is entered by the planner in the graph of the record of the setwise performance of the program by the shift foreman, indicating the causes of, and the specific persons responsible for, the nonfulfillment of the shift assignment at individual work stations. At advanced plants, the shift-day assignments and the record of their fulfillment are combined with the work order. Such a record indicates the degree of

Graphic Record of Delivery of Parts by Shop No.

Consumer Shop	Lead Group	Process Set and Component Details in It: No.	Designation	In Aircraft	In Group Set	Supply on 1st Day of Month	Series No.10 (4 8 12 16 20 24 28 32 36 40)	G/K
No.20	III		Parts of Propeller-Engine Group				30/XI	
			Part A	2	1	-	15/XI; 30/XI	
			Part B	3	-	-		28/XI
			Part C	1	-	-	5/XI; 30/XI	

Legend:

Delivery of process sets (T.K.) to Consumer Shop According to Plan
Actual delivery of parts to stockroom of own shop
Actual delivery of parts to consumer shop

Fig.135 - Graph of Record of Delivery of Part by a Shop

rhythm in the operation of individual workmen, and of the section as a whole, over the course of a month, and, accordingly, may be used in establishing the amount of the bonus for fulfillment of the shift-daily assignments.

The record of performance of the monthly production program is kept in the shop with respect to the following principal indices: amount and set-completeness of commodity production, volume of gross production, and rhythm of fulfillment of the

program. The record of fulfillment of the plan on commodity production by the shop with respect to amount and set-completeness is reflected in graphs (Fig.135), filled out on the basis of the delivery vouchers. The record of fulfillment of the programs for gross production and for rhythm of operation is kept in standard-hours for each day, and in cumulative totals from the beginning of the month for each department and section, on the basis of the shift assignments, witnessed by the foreman and inspector of the shop inspection office (Fig.136).

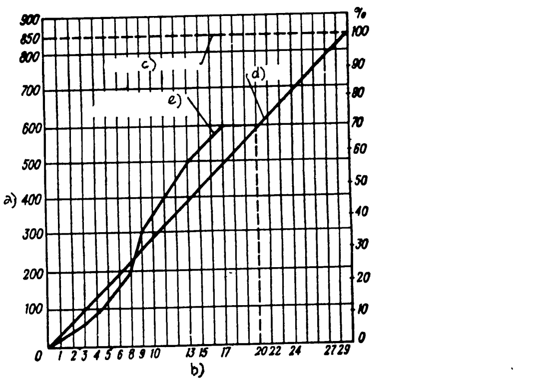

Fig.136 - Graph of Record of Delivery of Production, in Cumulative Totals

a) Labor cost in standard-hours; b) Days of month; c) Monthly plan; d) Plan; e) Actual delivery of production

The record of the supply of the shop with materials, parts, and component finished articles needed to complete the set is kept in the shop stores on the basis of record cards, and in the production and dispatching office of the shop on the basis of the graph of setwise provision. The account card is kept separately for each type-size of material, or for each part or unit, and shows their intake and outgo.

Table 107

Workshop No.	Article No.	Size of Lot	Route Sheet No. ____ "__" ____ 195__	Additional Route Sheet					Part	
				Date	Card No.	Quantity	From Operation No.	Signature	Designation	No.

Material or Semifinished Goods							Final Acceptance by Shop Inspection Office					Delivered to Finished-Parts Store		
Designation, Mark, Size	Unit of Measurement	Standard		Actual Output	Date	Storeman's Signature	Date	Sound	Rejects	Notice No.	Signature	Date	Number, Spelled Out	Signature
		Per Piece	For Lot											

Operation		Category of Work	Standard				Issued for Work to				Accepted by Shop Inspection Office					Stamp of Intermediate Store	Work Order No.
			Setup-Cleanout Time (PZV)		Piece Time												
No.	Designation		Time	Rate	Time	Rate	Date	Name, Given Name and Middle Name of Operator	Number	Operator's Receipt	Date	Sound	Rejects	Notice No.	Stamp		

The record of spoilage is kept on the basis of spoilage notices and of summaries of spoilage for the day. The record of stoppages is kept from the stoppage sheets. The record of work in process is kept on the basis of the record charts for each part-operation, with a periodic verification of the physical existence of the work in process by means of an inventory.

The record of arrival and departure of workmen is kept, under a centralized procedure, by time keepers stationed in the corridors.

The primary documentation used in the shop, in operative planning in series production, includes a number of documents.

The work order (work card) serves as the document for finalizing the wages of the workmen. The work order is made out by the work-order clerk of the production and dispatching office of the shop for each workman, for each form of work indicated in the shift assignment. Such an unwieldy system complicates the calculations. For this reason, advanced shops use weekly bi-weekly cumulative work orders in which only the new work is entered every month.

The route sheet is a means of recording parts in a lot and does not replace the work order. The route sheet in the fabricating and processing shops is made out for each lot of parts and accompanies it from the first operation to the last. Table 107 gives the form of the route sheet. The route sheet gives the quantity of materials, workpieces or parts put into process, and the inspector indicates the operator by whom the operations have been performed, the number of parts processed, and the number rejected. The parts finished in the processing and accepted by the inspection service are delivered to the warehouse together with the route sheet, on which the number of parts delivered is entered. The information on the output is transcribed by the record clerk, from the route sheets, into the cumulative work orders of the operators and into the route ticket in which the work in process is recorded (by parts for each shift), together with the time of useful work and the time loss of each operator. One of the plants in the fabricating-stamping shops has introduced a plan-card for repeated use in place of route sheets which are used only once. This has reduced the amount of work of the machine computing station by one million operations a month.

The report on the shift output is a document recording the output of the work of the operators of a section. The report may, at the same time, serve as the primary document for computing the wages of the operators. The basis for preparation of the report is the shift assignment of the section and the route sheets selected for it. The shift assignment-report is made out by the work-order clerk of the production and dispatching office at the same time he makes out the work orders or the route sheet. The shift report, finalized by the foreman and inspector, is returned to the work-order clerk who enters the report in the control record book of program fulfillment. The control reports are recorded by series and numbers of the aircraft, which prevents cases of double entry and payment of shift reports for one and the same work. The shift report is delivered from the production and dispatching office to the shop labor organization office for checking the standards and rates and goes from there to the accounting office for payment.

The intershop work order serves to finalize and record the parts delivered for intermediate processing to other shops.

The voucher-report finalizes the delivery of finished products by the shop.

The rating plate or sheet is made out in assembly shops for each newly assembled major component or complete aircraft. The number on the rating sheet corresponds to the number of the aircraft series. The forms for the rating sheet are printed in the print shop from a sample route sheet, prepared and witnessed by the technological and control offices of the shop. The identification sheet is issued to the foreman against receipt. The bosses of the crews performing the installations and the inspectors accepting the installations of the major component must sign the rating sheet. When the assembly of the major component (or aircraft) has been completed, the rating sheet is finalized by the foreman and returned to the production

and dispatching office for entry in the daily report on the completion of work by major components. The rating sheet is then delivered for safekeeping to the shop inspection office.

Section 4. Calendar Planning of Mass Production

In mass production, the operative planning of starts and outputs is conducted for each part to ensure uninterrupted operation of the production lines and rhythmic output of the aircraft.

The standard-calendar estimates in mass-line production include establishing the pace of the production line, regulation of its work, of the standard of work in process in the form of intraline and interline manufacturing reserves, and of the cycle of the article.

Intraline reserves are stored on the production line and are divided into technological, transport, turnover, and emergency reserves.

The technological reserve is necessary for a simultaneous beginning of work at all work stations of the production line, and consists of the supply of workpieces, parts, and units directly in processing or inspection at the work stations of the line.

To start work simultaneously, it is necessary to have at least one workpiece at each work station of the production line. The technological reserve, once formed at the beginning of the development of the line, is later constantly self-renewing. At the end of a shift there remains at least one workpiece at each work station, which ensures a simultaneous beginning of work in the following shift at all work stations. The size of the technological reserve may be calculated by the formula

$$Z_{tech} = \sum_{1}^{m} N_{w.s}\, n$$

where m is the number of operations in the line;

$N_{w.s}$ is the number of work stations per operation;

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n is the number of parts simultaneously delivered from one work station to the next.

The transportation intraline reserve is the supply of parts on the transport facilities between the adjacent work stations of the line. This reserve makes it unnecessary for the operator to keep constantly track of whether the part has arrived in proper time from the preceding work station. The size of the reserve, when the line works on a conveyor or transporter, is calculated by the formula

$$Z_{tr} = \frac{L}{l} n,$$

where L is the length of conveyor;

l is the distance between centers of two assembly zones or objects;

n is the number of parts on the section of conveyor between two assembly zones.

The turnover (replenishing) reserve between two adjacent operations is necessary for maximum loading of the work stations that have an operating time considerably shorter than the pace of the line. The extent of this reserve Z_o is calculated by the formula

$$Z_o = \frac{TC_2}{t_2} - \frac{TC_1}{t_1},$$

where T is the operating period of adjacent machine tools, other conditions being equal (shift, half-shift);

C_2 is the number of machine tools on the operation with the shorter operating time;

t_2 is the working time of the short operation;

C_1 is the number of machine tools performing the operation with the longer working time;

t_1 is the working time of the longer operation.

Example. On a line with a pace of 20 min, the length of the 6th operation is 20 min and that of the 7th operation 10 min. Under these conditions, the reserve for the shift before the 7th operation is equal to

$$Z_o = \frac{480 \cdot 1}{10} - \frac{480 \cdot 1}{20} = 24 \text{ pieces}$$

The turnover reserve, once set up, is automatically replenished in each subsequent shift.

The emergency (stand-by) reserve is necessary when the equipment is taken out of service for routine maintenance, when spoilage occurs, and in cases where the parts are processed on a single equipment. Advanced enterprises build up emergency reserves only for the time when the equipment is taken out of service for routine maintenance. Even this reserve may be dispensed with if the maintenance of the equipment is handled at the end of the production line, or during a special preparatory shift. The next production line may be supplied from the interline reserve. The total value of the intraline reserve Z_{tot} of the production line is equal to

$$Z_{tot} = Z_{tech} + Z_{trans} + Z_o + Z_c$$

Interline (intershop) reserves consist of the stockroom supplies and, according to purpose, are divided into transport, turnover, and emergency (stand-by).

The transport interline reserve is required for a timely delivery of parts from one production line to the next, and consists of the supply of parts on the transport facility connecting either two adjacent production lines, or a warehouse with a production line. The size of the intershop transport reserve is calculated:

a) When the lines are connected by a continuous transport facility, by the formula

$$Z_{tr.int} = \frac{L}{l} n\eta$$

where η is the coefficient of utilization of transport with respect to the load;

b) When the lines are connected by an intermittent transport facility, by the formula

$$Z_{tr.int} = \frac{R_{tr}}{r} \leqslant Q_{tr}$$

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where R_{tr} is the interval of transport trips between the lines;

r is the pace of the delivering line;

Q_{tr} is the load-carrying capacity of the transport facility, in units.

An interline turnover (stock) reserve is necessary when the number of shifts operated by adjacent lines differs and when parts are delivered to a production line from a series section.

When adjacent production lines work a different number of shifts, the interline turnover reserve $Z_{t.m}$ is calculated by the formula

$$Z_{t.int} = N_{part}\,(S_{gr} - S_{sm})$$

where N_{part} is the shift program of the production line working a greater number of shifts;

S_{gr} is the number of shifts on a line working the greater number of shifts;

S_{sm} is the number of shifts on a line operating the smaller number of shifts.

On delivery of parts or workpieces to a production line from a series department, it is important to know the lot size and the starting interval between lots of parts in the series section. For instance, if a workpiece is started twice a month in semimonthly lots in a series section of the forging shop, then the production line of the machine shop processing these rough forgings must have a supply to last at least two weeks. Consequently, the size of the interline turnover reserve for the production line, when the parts are delivered from series sections, is equal to

$$Z_{t.int.} = R \cdot n_c,$$

where R is the period of time between the deliveries of two lots from a series section, expressed in shifts;

n_c is the number of parts required by the production line.

The interline emergency (stand-by) reserve is formed between production lines

to take care of any increase in their productivity or of any delay in the delivery of workpieces, parts, units, from the feeding production line or series section. The size of the interline emergency reserves is calculated by the formula

$$Z_{em.int} = \frac{t_{res}}{r}$$

where t_{res} is the reserve time for deviation from the plan and pace, in minutes.

This time is taken as equal to: 1) for a reserve between lines in the same shop, up to 1/2 shift; 2) for a reserve between processing and assembly shops, from 1 to 4 shifts; 3) for a reserve between the fabricating and processing shops, from 2 to 10 shifts (Bibl.30).

The total value of the interline reserves is equal to their sum:

$$Z_{tot.int} = Z_{tr\ int} + Z_{t.int} + Z_{em.int}$$

The interline reserves are kept either in the warehouses or on platforms in front of the first operation of the production line.

The length of the processing cycle of a part (or the length of the assembly of a unit) on a production line, with piecewise delivery from operation to operation, is determined by the formula

$$C_y = \frac{r \cdot m}{60},$$

where r is the pace of the production line, in min;

m is the number of operations on the production line.

The length of the processing cycle of a part (or the length of the assembly of a unit) on a production line, when the parts are delivered in transport lots, will be equal to

a) For synchronized operations:

$$C_y = \frac{rm}{60}\,p$$

b) For unsynchronized operations:

$$Cy = (n - p) \frac{T_{u,k}}{N_{r\ int} T_k S} \text{main} + \sum_{1}^{m} n_{tr} \frac{T_{u.k}}{N_{r\ int} T_k S} + \frac{mt_{m.o}}{T_k S}$$

<u>The monthly operative-calendar plan</u> of production output is prepared for the primary shops by the planning and production department, on the basis of the quarterly assignment, corrected for the results of the fulfillment of the program for the past month, the obligations additionally included in the plan of the enterprise, and the data of the operative record on the change in manufacturing reserves.

The monthly program of the shop is calculated for each part designation by the chain method, in an order opposite to the course of the manufacturing process. The program is calculated for each production line, for output and for starts. The output program of the production line N_{out} is calculated by the formula

$$N_{out} = N_{start} + N_{add} + (Z_{int\ s.n} - Z_{int\ s\ act})$$

where N_{start} is the program of start of the production line process in the course of the manufacturing process, in units;

N_{add} is the additional assignment for production of the production line of parts (units, etc.) going into spare parts or into the finished production of the enterprise;

$Z_{int\ s.n}$ is the normal size of interline (intershop) reserve at the end of the plan month, in units;

$Z_{int\ s.act}$ is the actual size of the interline reserve at the beginning of the plan month, in units.

The program of production output of the production line of the producer is subordinated to, making due provision for the program of output of the consumer-production line.

The program of start of the production line N_{start} is calculated by the formula

$$N_{start} = N_{out} + (Z_{1.n} - Z_{1.act}) + N_{rej}$$

where $Z_{l.n}$ is the normal size of the intraline reserve, in units;

$Z_{l.act}$ is the actual size of the intraline reserve, in units;

N_{rej} is the number of possible rejects on the line.

The program of starts of the production line is subordinated to providing for the uninterrupted output of the production of this line.

In this way, the calculations are conducted for each shop or production line, running from the assembly shops to the processing shops, from the processing shops to the fabricating shops. The program of starts of the processing shops is an assignment to the material warehouses to provide the production with materials. Table 108 gives a schedule of the estimate of the monthly program of the shops by the chain method, on the basis of the formulas presented. This estimate ensures the mutual coordination between the programs of the shops and is used under the conditions of normal operation of mass production.

The calendar distribution of the program by days of the plan month consists in establishing the daily assignment for starts and output of objects of each designation. This assignment may provide for uniform output of production by days or months, or for stepwise-increasing output by ten-day periods or weeks of the month. In the latter case, each decade establishes its own shift-day output, and consequently, also its own production-line pace. Those sections of mass production where the parts are processed in lots receive a program indicating the size of the lots for each part and the dates of their output.

<u>Intrashop Operative Planning</u>. In mass production, the major assembly shops receive a program from the planning and production department in the form of a graph of the shift-day output of major components; the processing shops receive their program in the form of a calendar graph of starts and output of each part increased by days of the month. The role of the production and dispatching office of the shop consists in detailing the program for the production lines of the shop.

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The shift-day assignments in line production with a uniform output of product

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during the course of the month are established once, when the program is received. The results of the performance of the shift assignments are known to the operators from the results of the work of the production line for each hour and each shift. The work on the production line is organized according to an hourly graph. The record of the line's work in an hourly graph makes it possible for the dispatcher, foreman and operator to follow, hour by hour, the course of the fulfillment of the shift assignment, rapidly to detect any lag, and to take measures to eliminate such a lag. The organization of the work on an hourly graph disciplines the work of the line.

The output of all work stations of the production line for the shift is recorded by the number of parts accepted by the inspector from the last operation. The acceptance of the production is finalized by a delivery voucher, on whose basis the report clerk enters the quantity of production accepted for the shift in the schedule of the output record of the workman of that shift. The total output of the workman of the lines for the month is pin-pointed by inventories of the actual balances of the production reserve at their work stations on the first day of each month. The data of the inventory are compared with the data of the operative or accounting method. For this purpose, the production accepted from the line during the month and the spoilage finalized during the same period, are deducted from the number of workpieces started on the line during the course of the month. The book balance must be equal to the actual balance, i.e., to the inventory data. If they do agree, this means that the output for the month has been correctly shown. When uniform operations on a conveyor line are performed by several workmen, the operative record is accomplished by the aid of checks. The workman has a set of checks, and puts his check on the conveyor together with the part he has processed. The inspector accepting the part puts the checks into special cash-boxes. The record clerk or distributing clerks of the section periodically removes the checks from the cash box, counts them, and enters the output in the personal account card of

Table 108

Schedule of Estimate of Output and Starts for Parts Manufactured from Forgings

			Estimate of Delivery of Parts to Assembly						Estimate of Output and Starts of Parts in Machine Shop										Estimate of Output and Starts of Forgings in the Forging Shop*									
Part No.	Designation of Part	Number Per Aircraft	Number for All Aircraft to be Produced	Normal Line Reserve of Shop	Actual Manufacturing Reserve of Shop	Required for Change of Manufacturing Reserve in Shop (Col.5 ± Col.6)	Residue of Parts in Shop	Required for Start into Assembly (Col.4 + Col.7 + Col.8)	Normal Manufacturing Reserve of Parts in Stock	Actual Manufacturing Reserve of Parts in Stock	Required for Change of Manufacturing Reserve of Stock (Col.10±Col.11)	For Spare Parts	Output of Machine Shop (Col.9 + Col.12 + Col.13)	Normal Line Manufacturing Reserve of Shop	Actual Manufacturing Reserve of Shop	Required for Change of Manufacturing Reserve in Shop (Col.15±Col.16)	Residue of Parts in Shop	Starts in Machining (Col.14 + Col.17 + Col.18)	Normal Manufacturing Reserve of Forgings in Stock	Actual Initial Manufacturing Reserve of Forgings in Stock	Required for Change of Manufacturing Reserve of Stock (Col.20±Col.21)	Output of Rough Forgings at Outside Sources	Output of Forging Shop (Col.19 + Col.22 + Col.23)	Normal Manufacturing Reserve of Shop	Actual Manufacturing of Reserve of Shop	Required for Change of Manufacturing Reserve in Shop (Col. 25 ± Col.26)	Residue of Parts in Shop	Starts in Stamping (Col.24 + Col.27 + Col.28)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

* Analogous calculations are made for other intermediate shops.

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the workmen.

The control over the course of production is accomplished by the planning and dispatching system for the given operative record, and consists in control over the condition of the manufacturing reserves, over the fulfillment of the plan by each line, and over its uninterrupted supply with workpieces, parts, and tools. The output of the production in each line is noted on graphs kept by the record group of the planning and production department, the dispatcher of the shop, and the foreman of the line. The graph indicates the output of production, by hours or by days, in cumulative totals. The record of receipt of workpieces on the line and the delivery of finished parts from the line is finalized by vouchers or by route stubs. The record of spoilage is handled from the spoilage notices and the record of stoppages, from the stoppage sheets. The record data on the balances of manufacturing reserves are verified by an inventory at each end of the month.

Section 5. The Dispatcherizing of Production

The dispatcher system consists in the continuous control over the preparation for production and its flow as well as in current operative dispositions to ensure a rhythmic production flow and production output according to the established graph. The basic principles of the dispatcher system are: planning, operativeness, and centralization.

Planning is expressed in conducting the dispatcher system on the basis of monthly and shift-day plans. The planning of the dispatcher system involves the use of preventive measures that permit no deviations from the plan, the ensurance of timeliness of provision of the work stations with materials, tools and maintenance, and the observance of the starting and output times of the batches.

The operativeness of the dispatcher service consists in effecting a systematic control over the course of the productive process, in immediately eliminating any deviations noted or formed in the normal course of production, and in coordinating

the operation of the shops. Each shop must operate with a lead over the shop that follows it in the flow sheet, so as to ensure delivery of parts and units not later than the times established by the delivery graph. The operativeness of the dispatcher system is based on the concreteness of management and the wide information on the status of work in every unit of the enterprise.

The centralization of the dispatcher system consists in its conduct from a single center, the dispatcher department, and in all units of the production, obeying a single purpose, namely the fulfillment by the enterprise of the shift-day assignment for the output of finished production.

The dispositions taken by the chief or shift dispatcher of the enterprise to re-establish the original plan in case of any deviations, or to prevent the appearance of such deviations, are binding on all shop superintendents and department superintendents of the enterprise; within the shop, the corresponding dispositions of the chief of the production and dispatcher office are likewise binding.

The control over the production flow begins with a determination of the supply for the program of starts. This control is effected by the dispatcher department through the dispatcher system of the auxiliary shops and through the plantwide services, according to the graphs of delivery of the tooling, of the equipment maintenance, and of the arrival of materials at the primary producing shops.

In mass production and large-lot production, with the continuous starting of one and the same articles, the dispatcher control of the primary production is accomplished by the aid of shift and hourly graphs of the starts and production output.

The operative control in series production is effected by the dispatcher on the basis of the calendar graph of assembly and of the daily graphs for the leading production list.

In piece production, the dispatcher service controls the performance of the production flow by the aid of record cards kept for each order.

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Besides the control over fulfillment of the program by each shop, the dispatcher system also effects control over the intershop transfers and the status of the manufacturing reserves in production. In mass production, this is realized by means of the standard scheduling of deliveries; in series production, by means of the calendar plan of starts and output of parts lots and of the set-completion graph; and, in piece production, by the aid of identification tags for each order.

In an aircraft construction enterprise, the leading production list is used by the dispatcher for keeping his graph of the shift-by-shift supply of the shop with the necessary assemblies or process sets. Figure 137 shows, as an example, a graph from which the chief dispatcher daily records and controls the placement of the aircraft on the main conveyor, the delivery of aircraft to the airfield, tests at the airfield, and shipment of the production to the purchaser.

The operative disposition consists in a coordination of the shift-day assignments, in the verification of their supply with all that is necessary, in the control and record of their fulfillment, in the detection and elimination of deviations from the shift-daily assignments.

The operative disposition over production is effected by the dispatcher system on the basis of the shift-day plan which is prepared on the scale of the entire enterprise by the chief dispatcher; on the scale of a shop, by the chief of the production and dispatcher office; and on the scale of the departments, by the planner-dispatcher, and is approved in each unit by the production superintendent, shop superintendent, and senior foreman concerned.

<u>Organization of the Dispatcher's Work</u>. The dispatcher department has a central dispatcher desk (Fig.138), attended by dispatchers and operators. The enterprise dispatcher on duty maintains constant contact, through the plantwide switchboard, with the shop dispatchers, controls the course of the fulfillment of the shift-day plan by shops, receives current information from the shops and services, and issues the necessary instructions to them. The dispatcher on duty keeps the dispatcher

daybook in which he enters all inquiries and all dispositions issued to the shops, and notes the measures whose fulfillment must be verified. The assistant of the dispatcher on duty is the operator who deputizes for the dispatcher while the latter is making his round of the shops.

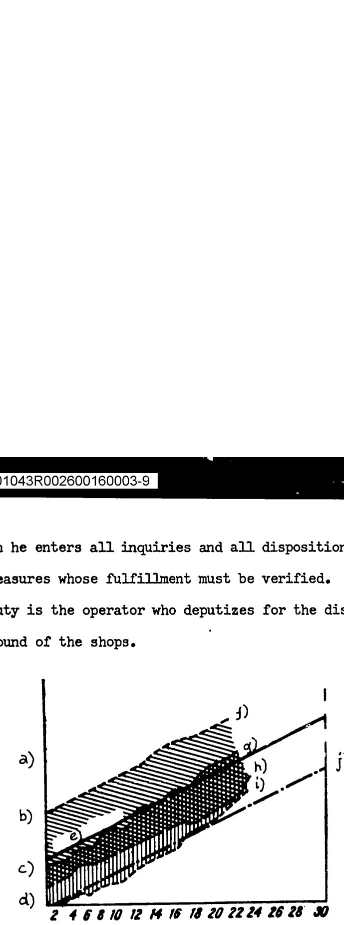

Fig.137 - Graph of Record of Delivery of Finished Product

a) Number of aircraft; b) On main conveyor; c) In test; d) In shipment; e) Assembly plan; f) Start on main conveyor; g) Actual delivery from assembly; h) Tested and delivered; i) Actually shipped; j) Shipping plan

There is a dispatcher service in the organization of each shop. The shift dispatcher of the shop checks the flow of the preparations for the performance of the work indicated in the graph and the performance of this work; takes measures to prevent any breaks in the plan; accepts instructions from the central dispatcher desk; and reports to the enterprise dispatcher on duty on the course of the fulfillment of the shift-day plan for his shop.

In large shop departments there are planner-dispatchers whose duties include the preparation of the shift-day assignments, the distribution of the assignments over the work stations, the preparation of the hourly graphs, and the opera- STAT

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preparation of production. These tasks are performed by the planner-dispatcher under the direction of the senior foreman.

The production superintendent and the chief dispatcher conduct dispatcher conferences with the superintendents of the shops and services, at which the course of the fulfillment of the monthly plan-graph is considered. The same type of instructive conferences are held at the shop by the shop superintendent and the foremen. The preparation of the materials and topics for the conference is handled by the dispatcher system.

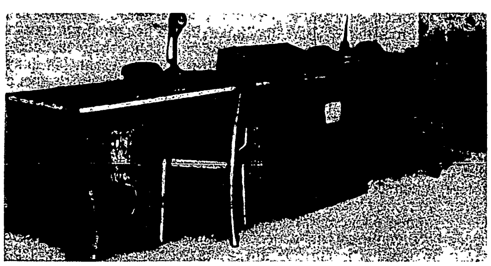

Fig.138 - View of Central Dispatcher Desk

Technical Management Facilities. To save time in operative calendar planning, wide use is made of mechanization means and graphs. For example, to estimate the size of the lots, manufacturing reserves, cycles, and leads, the use of nomograms, Tables, and computers is recommended.

To estimate the equipment loading, the use of nomograms with sliding scales, billing machines, printing computers, and analytic computers is suggested.

For preparation of the requisitions for materials and tools, the use of production-list-addressing machines and billing machines is recommended.

For calculating the productive programs and the corresponding volume-calendar estimates, printing computers and analytic computers are used.

To link the dispatcher with the shops, departments, and stores, plantwide switchboards are used. Over such a switchboard, the dispatcher can talk simultaneously with several shops and can hold plantwide dispatcher conferences. The director, chief engineer, and other managers of the enterprise have desk switchboards which serve for prompt and direct two-way communication with the subscriber, and for simultaneous conversations with two or three stations.

For automatic recording of the flow of the productive process, automatic computers are used at enterprises with mass production or large-lot production. The data on the numbers of accepted and rejected products are constantly fed from the counters to the recording board of the central dispatching office, throughout the entire shift. Where the acceptance of the production is not handled by automatics, the inspection point is connected by a direct line with the central dispatcher's office, which also systematically receives information on the number and designations of the production accepted. The dispatcher desks at the shops and at the main warehouses of the enterprise are provided with means of communication and recording. The development of television and automation opens great possibilities for automation of the operator control and for remote control of the production process flow.

Productive Stockrooms. The productive stockrooms are under the direct control of the planning and dispatching departments. In accordance with their subordination and the service scale of the production, such stockrooms are divided into intershop, shop, and section.

Intershop stockrooms are designed to store intershop manufacturing reserves, especially emergency reserves, and mainly supply the assembly shops with such reserves. Such stockrooms include the central storage of standard parts, which is usually under the chief dispatcher.

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The shop stockrooms are divided into material, set, intermediate, and finished-

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product stores. Material stockrooms are set up at all shops receiving materials, forgings, castings and stampings from the central material warehouses. The function of the stockroom is to receive, store, and record materials, forgings, castings, and stampings and to issue them to the work stations in accordance with the shift-day assignment.

Set stockrooms are established in the machine-assembly, fitting-assembly, and finishing shops.

The function of the set stockroom is to receive parts from the sections of its shop or from other shops, to make these parts up into process sets, and to deliver such sets to the assembly department of its own shop or another shop. The set stockrooms in the fabricating and machine-assembly shops work in this same way. In the heat-treating shop, the set stockrooms receives lots of parts from the machine shop and makes them up into sets in accordance with the shift-day assignment and the throughput capacity of the furnaces. After the heat treatment, the stockroom again makes up sets of the parts into the same lots in which they were received from the machine shops.

The finished-product stockrooms (shop shipping departments) are organized in the shops to store the parts or units whose processing has been finished in the shop and which are to be delivered to the store of a consumer shop, or to the central store of standard parts.

The finished production is accepted by the store from the production sections of the shop on delivery vouchers signed by the foreman and inspector of the section. One copy of the voucher is delivered to the production and dispatcher office of the shop for recording the fulfillment of the program by the sections, while the second copy remains at the stockroom.

The parts or units are stored in the stockroom on racks with shelves, cubbyholes, or boxes, containing plates with the number of the part or unit stored there. The racks, shelves, and cubbyholes are given serial numbers which are shown on the

record cards. Sometimes the racks are grouped by consumer shops.

The parts and units are delivered to the consumer shop with delivery vouchers.

The section or intermediate stockrooms (PROSK) are organized for storing the interoperation manufacturing reserves needing further treatment in the given section, or for delivery to a different section of the shop, or to a different shop, to perform such operations as heat treatment, coating, etc.

The clerk of the intermediate stockroom accepts such a lot of parts or units, not yet completely processed, together with the routing documentation, a route sheet, or shift report of the inspector. The lot accepted is placed in the rack of the shift boss from whom it was received.

The stockroom clerk prepares the lot for issue from the stockroom on the basis of the shift-day assignment of the senior foreman and places the lot of parts in the rack of the shift foreman who is to handle the treatment of these parts. The lot of parts is accompanied by the same documents on which it entered the stockroom. One of the most important functions of the clerk of an intermediate stockroom is to check the set-completeness of the lots and their timely start-up. On the basis of the shift-day assignment, the stockroom clerk supplies each work station with its material. In this case, the first shift of the stockroom prepares the work stations for the second shift, and handles the current servicing of the first shift, while the second shift handles the preparation of the work stations for the first shift, and handles the current servicing of the second shift. It is expedient to make the wages of the foreman dependent on the timely supply of materials and semifinished goods to the work stations.

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